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Book of Abstracts

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The study of the 24Mg(α,p)27Al reaction rate by using Solenoid Spectrometer for Nuclear AstroPhysics

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Understanding the ^{24}Mg(α,p)^{27}Al reaction rates under the conditions of explosive environments is essential for astrophysicists to model and simulate X-ray bursts accurately. It is believed that the reaction plays an important role in understanding the final abundances of ^{34}S and ^{30}Si, and the total nuclear energy of X-ray bursts. To better understand the reaction rates, we utilized the Solenoid Spectrometer for Nuclear AstroPhysics (SSNAP) at the University of Notre Dame. Although the spectrometer system was originally built for transfer reaction studies in inverse kinematics, we used the system to measure the ^{24}Mg(α,p)^{27}Al reaction in order to demonstrate the feasibility of using SSNAP for compound nucleus reaction measurements with light charged particle beams.

By using an alpha particle beam from the FN tandem accelerator and ^{24}Mg solid targets located in a 5 Tesla superconducting solenoid, the excitation function of the ^{24}Mg(α,p)^{27}Al reaction was measured over the energy range of $E_{c.m}$= 3.0 −4.4 MeV. A total of 43 alpha beam energies ranging from 2.8 MeV to 5.2 MeV were used. Recoiling protons from the reaction were detected by position sensitive silicon detectors installed along the beam axis. Details of the experiment and the current status of data analysis will be presented.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

2

Performance tests of HWR superconducting cavities

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The performance test is shown for half-wave resonator (HWR) cavities. Quality factor, resonance frequency, Lorentz force detuning (LFD), pressure sensitivity, and surface resistance are measured for the HWR cavities. The properties of superconducting cavities are studied, and BCS resistance measurement is shown in this paper.ance measurement is also shown in this paper.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

3

Bunch Spacing for the FEL Generation with Laser Heater, Collimators, and Slotted Foils at PAL-XFEL

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High current electron bunches with the lower emittance and slice energy spread are required to generate the intense XFEL. However, it is difficult to maintain the emittance and slice energy spread during the bunch compression at magnetic bunch compressors (BC). The current peaks in the head and tail of compressed bunches spoil the core slices by the wakefield and coherent synchrotron radiation. We suppress these collective effects by the bunch spacing with various devices. The head and tail slices can be eliminated by collimators in the BCs. The negative effects from the head and tail slices are strongly suppressed to dilute them by the intense laser heating or slotted foils. In this paper, we present the FEL improvement by the bunch spacing with the laser heater, collimators, and slotted foils. Also, we present the FEL spectrum and duration control by these devices.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

4

Investigation of the ID effect on the ring parameters of Korea-4GSR

Author: Gyeongsu Jang[1]

Co-authors: Jaehyun Kim [2]; Jaeyu Lee [2]; Jimin Seok [2]

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In the synchrotron radiation storage ring, insertion devices are employed to provide an appropriate light to the beam users. With this insertion devices, the ring parameters are changed. The change can be estimated from the relation between the synchrotron radiation integrals and the ring parameters. This estimation method is applied to the Korea-4GSR with the early stage beam line plan. The result shows that emittance can be reduced 14.6% from the insertion device effects.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

5

Development of 3 GHz Constant Gradient Traveling Wave Accelerating Structure

Authors: Hoon Heo[1]; Hyoung-Seock Seo[2]

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We developed a 3 GHz constant gradient traveling wave accelerating structure for Korea multipurpose synchrotron accelerator project. This accelerating structure has 84 regular accelerating cells and two coupling cells. The coupler is designed to reduce the dipole and quadrupole field components by adapting the quasi-symmetric coupler holes connected with the shorted dummy wave guide. We present the details of the design features and preliminary test results

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

6

Search for Dark Photons Using Future Electron-positron Collider Beams Based on Machine Learning

Authors: Kihong Park[1]; Kyungho Kim[2]; Alexei Sytov[3]; Kihyeon Cho[1]

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Based on machine learning, we have searched for dark photons using future electron-positron accelerators/detectors, which includes Circular Electron Positron Collider (CEPC)/CEPC, Future Circular Collider (FCC-ee)/Innovative Detector for Electron-positron Accelerator (IDEA), and International Linear Collider (ILC)/International Large Detector (ILD). The signal modes are e+e- ⟶ A'A' and e+e- ⟶ A'A'ɣ where dark photon A'decays into a muon pair. We have used MadGraph5 to generate Monte Carlo (MC) events using a simplified dark matter model. We have found the dark photon mass at which the cross-section is the highest for each accelerator to obtain the maximum number of events. Using the parameterized response of the detector simulation of Delphes, we have studied the sensitivity of signal modes at each accelerator/detector. The dominant background processes are e+e-⟶μ+μ-μ+μ- and e+e-⟶μ+μ-μ+μɣ. The background events are generated using MadGraph5 with the Standard Model. To suppress background events, we have performed machine learning using Toolkit for Multivariate Analysis (TMVA). The Boosted Decision Tree (BDT) method is used for improving the ratio of signal to background. In conclusion, we show the detection efficiency of each

accelerator/detector. The results will help searching dark photons at the future electron-positron collider beams.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

7

Multi-physics analysis of the frequency tuner for the 3rd harmonic superconducting cavity

Author: Junyoung Yoon[1]

Co-authors: Eiji Kako [2]; Hee-Su Park [1]; Yeo-dong Yoon [1]; Eun-San Kim [3]; Jun-ho Han [1]

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[3] *Korea Universigy*

The bunch lengthening by the 3rd harmonic cavity reduces the collisions of electrons and increases the Touschek lifetime of the 4th generation storage ring. The prototype niobium cavity is a passive type with an elliptical double-cell geometry and receives accelerating power from the beam. The operating temperature and frequency are 4.5 K and 1500 MHz, respectively. To adjust the resonant frequency of the cavity, the frequency tuner changes the cavity cell length at cryogenic temperature. The total length of the niobium cavity can extend by railways and taper parts of the tuner, which move by the shaft and thread bars assembled with the cryogenic motor. The CST analysis determines the tuning range of the cavity. The required force and travel length of the tuner are determined by the ANSYS analysis. We perform the multi-physics analysis to analyze the allowable stress and frequency change of the niobium cavity. We will present the multi-physics analysis results of the frequency tuner and the superconducting cavity.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

8

Development of Control System for the RFT-30 Cyclotron

Author: Young Bae Kong[1]

Co-authors: Jong Chul Lee [1]; Jin Sik Ju [1]; Joo Young Ahn [1]; Jeong Hoon Park [1]; Min Goo Hur [1]

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An RFT-30 cyclotron is a 30 MeV proton accelerator and is currently used for radioisotope development and fundamental researches. The RFT-30 cyclotron requires improvement since the control

system has the problem such as performance degradation and equipment aging. Especially, the control system plays an important role in the RFT-30 cyclotron. The cyclotron system control is a difficult task since it is highly non-linear and complex for beam tuning. In this work, we propose a Experimental Physics and Industrial Control System (EPICS) based control system for the RFT-30 cyclotron. The EPICS IOC(Input Output Controller) server is constructed with Asyn and StreamDevice. For easy operation of the cyclotron system, we develop the EPICS based autonomous control system using State National Language (SNL), which is a domain specific programming language that smoothly integrates with EPICS base. The improved control system can enhance the system stability and then provides the human operator with easy operation for the RFT-30 cyclotron.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

9

Development of EPICS based Control System for Cyclotron Ion Source

Author: Young Bae Kong[1]

Co-authors: Jeong Hoon Park [1]; Jin Sik Ju [1]; Jong Chul Lee [1]; Joo Young Ahn [1]; Min Goo Hur [1]

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A ion source system is now currently being designed for 35 MeV cyclotron. Ion source control is a difficult task since it is highly non-linear and complex for source tuning. In this work, we propose a Experimental Physics and Industrial Control System(EPICS) based control system for the cyclotron ion source. The EPICS IOC(Input Output Controller) server is constructed with Asyn and Stream. For easy operation of the ion source system, we develop the EPICS based autonomous control system using State National Language(SNL), which is a domain specific programming language that smoothly integrates with EPICS base. The new ion source control system will be used for the verification of the new 35 MeV cyclotron development.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

10

Suppression of major detuning parameters of Korea-4GSR

Author: Jaehyun Kim[1]

Co-authors: Gyeongsu Jang [1]; Jaeyu Lee [1]; Jimin Seok [1]

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Korea-4GSR is a greenfield electron storage ring of 4 GeV electron energy and 800 m circumference. The ring exploits hybrid seven-bend achromat (H7BA) design to suppress natural emittance. Extensive optimization study result in dynamic aperture large enough to adopt off-axis injection scheme and Touschek lifetime as long as that of 3rd generation electron storage ring. This paper presents suppression of major detuning parameters using multi-objective particle swarm optimizer (MOPSO) and Accelerator Toolbox (AT). The approach is not based on particle tracking simulation but extraction of detuning parameters from a major Twiss parameters, which is advantageous for a ring of large circumference.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

12

Feasibility study of normal tissue sparing effect in proton minibeam radiation therapy: animal experiment

Authors: Dohyeon Kim[1]; Young Kyung Lim[1]

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Introduction: Proton minibeam radiation therapy (pMBRT), utilizing a multi-slit collimator (MSC), has undergone preclinical evaluation through animal experiments. This study aims to ascertain the efficacy of pMBRT in terms of its ability to spare normal organs, utilizing biological analysis.

Materials and Methods: Proton beam irradiation was carried out on two mouse groups except a control group (0 Gy). Each group was irradiated by proton broad beam and minibeam, respectively. A dose of 8.5 Gy was delivered to both femurs of mice in every group. The femurs were harvested from half of the mice in each group one week after beam irradiation, and viable bone marrow cells were enumerated. After two months, the same cell counting procedure was carried out for the remaining mice. Proton minibeam could be generated by the MSC, and the spatially fractionated dose distributions could be measured at various depths using radiochromic EBT3 films. Real-time dosimetry was performed during beam irradiation using an ion chamber positioned in the downstream of mouse to ensure precise dose delivery. In the MSC, the slit width and center-to-center distance were adjusted to the values of 1.5 mm and 4.0 mm, respectively, and its thickness and the available field size were set at 100 mm and 35 × 35 mm^2, respectively. Longitudinal beam divergence was also considered in the MSC.

Results: Comparative analysis was conducted, assuming the survival rate of bone marrow cells in the control group to be 100%. On average, 39% of bone marrow cells survived in the broad beam group, whereas in the minibeam group, the survival rate significantly increased up to 95.6%. The cells in the minibeam group survived 2.5 times more than those in the broad beam group. This superior trend persisted in the samples harvested two months later. This finding strongly validates the superior normal tissue sparing effect of proton minibeam compared to the conventional broad beam.

Conclusion: Our study showed the effectiveness of pMBRT utilizing a multi-slit collimator through animal experiments. Importantly, the significant disparity in bone marrow cell survival rates between the conventional broad beam and minibeam groups demonstrates the excellent normal tissue preservation of pMBRT.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

13

Study of Neutron Generation and Dosimetry in Ultra-High-Dose-Rate Proton Beam

Author: Sang-il Pak[1]

Co-authors: Seohyeon An [1]; Chae-on Kim [1]; Wang Shin Hwang [1]; Jeong Mun Son [1]; Se Byeong Lee [1]

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In recent years, ultra-high-dose-rate proton beam therapy has emerged as a promising approach for precision cancer treatment, delivering highly concentrated doses of radiation to tumors while minimizing damage to surrounding healthy tissues. However, this innovative technique has raised concerns regarding the potential generation of secondary neutrons, which can contribute to unwanted dose deposition in healthy tissues and increase the risk of secondary malignancies. This study aims to comprehensively investigate neutron generation and dosimetry in the context of ultra-high-dose-rate proton beam therapy.
The study findings reveal valuable insights into the neutron generation process within the ultra-high-dose-rate proton beam environment. The neutron fluence and energy spectra demonstrate distinct characteristics, shedding light on the underlying mechanisms responsible for neutron production. Dosimetric evaluations were performed to assess the potential impact of secondary neutrons on healthy tissues, providing essential data for treatment planning optimization.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

14

Cooling Channel Plug insertion method for plug brazing of Radio Frequency Quadrupole

Author: Kyunghyun KIM[1]

Co-authors: Hae Seong Jeong [2]; HAN SUNG KIM [3]; HYEOK JUNG KWON [3]; Sang pil Yoon [2]; Seong Gu Kim [3]; Won Hyeok Jung [2]

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Radio frequency quadrupole (RFQ) with 200 MHz has been fabricated and commissioned at the Koera Multi-purpose Accelerator Complex (KOMAC). RFQ manufacturing procedure is consisted with 2

steps of high vacuum brazing and various times of machining. In the plug brazing it is critical process for releasing the stress of RFQ and blocking the end point of cooling channel. We have an experience of the failure of vacuum tightness after the plug brazing and unbalanced melting of filler metal on the surface of plug brazing points. The inserting the plug to the cooling channel with keeping alignment is pivotal factor for success of plug brazing with the vacuum tightness. In this paper the cooling channel insertion method for plug brazing is explained.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

15

Low energy beam line simulation for injection line of RFT-30 cyclotron

Author: Jongchul Lee[1]

Co-authors: Min Goo Hur [1]; Young Bae Kong [1]; Jinsik Ju [1]; Jooyoung Ahn [1]; Jeong Hoon Park [1]

[1] *Korea atomic energy research institute*

The low energy beam transport (LEBT) system is one of important system for the beam transmission efficiency in the cyclotron. The external multicusp ion source was installed to generate high beam current of negative hydrogen ion, and there are beam line components, such as beam buncher, einzel lens and solenoid magnet, etc.. Because the injected beam characteristics depends on the current of ion source, the operating condition of LEBT system should be controlled with consideration of various beam currents. Nowadays we are upgrading the targetry system for mass production of radio isotope, so the higher beam current is required at the ion source. The LEBT beam optic has been analyzed for reducing the beam loss from ion source to main magnet.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

16

Test of AC magnet system for beam wobbling effect in RFT-30 cyclotron

Author: Jongchul Lee[1]

Co-authors: Young Bae Kong [1]; Min Goo Hur [1]; Jinsik Ju [1]; Jooyoung Ahn [1]; Jeong Hoon Park [1]

[1] *Korea atomic energy research institute*

An AC magnet generates alternating magnetic field by using AC coil current, so the beam irradiation area can be controlled. In the RFT-30 cyclotron system, the AC magnet is applied for increasing

the beam spot size at the target position. Two dipole AC magnets were designed for wobbling the beam trajectory in x, y axis, and coil currents can be applied with raster and circular waveform, respectively. AC magnets were manufactured by laminating the electrical steel plate (thickness 0.5 mm) in order to reduce the AC loss. The magnetic field was measured by hall sensor in the mid plane, and wobbling effect was checked by proton beam irradiation.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

17

Optimization of Graphitization Procedure for Accelerator Mass Spectrometer with Standard Materials

Author: Seung Won Lee[1]

Co-authors: Sae-Hoon Park [1]; Yu-Seok Kim [1]

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Accelerator Mass Spectrometry (AMS) is not only employed for chronological dating, but also holds significant prominence in a variety of fields including environmental studies, geology, archaeology, biomass analysis, and the medical field. For analysis utilizing AMS, sample graphitization is essential, and many institutions (research laboratories, universities, companies, etc.) have established their own graphitization procedure which they employ. Dongguk University aims to enhance the precision of sample analysis by using a Turbo Molecular Pump (TMP) to establish a high vacuum and employing preheating. The objective is to optimize graphitization procedure, thereby reducing time consumption and streamlining processes. To validate this endeavor, the paper will present findings obtained through the examination of oxalic acid, IAEA-certified samples, and blank samples.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

18

Simulation Study of Carbon and Oxygen Plasma Production for a RF Ion Source Using COMSOL Multiphysics

Author: Sae-Hoon Park[1]

Co-author: Yu-Seok Kim [1]

[1] *Dongguk University*

RF driven plasma features a simple structure, high plasma density for various versatile apllications for ion beam irradiation, ion mass spectrometry. For these purposes, various types of ion beams

are needed to modeling of RF ion source allow for the simulation study ana analysis predicting the performance of unbuilt instrument not yet for new applications. In this paper, the production of carbon and oxygen in RF ion source is investigated by numerical simulation code. A 2-D discharge of plasma is modelling with the plasma module of COMSOL Multiphysics, using a various reaction data. The simulations have been done with a carbon and oxygen plasma using COMSOL code.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

19

Optimization the AMS for Korean Heritage 14C Dating in NRICH

Author: Min-Ji Kong[1]

Co-authors: Kim Youngeun [1]; Sujin Park [1]

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In 2021, NRICH (National Research Institute of Cultural Heritage) in Daejeon, South Korea installed the new AMS (Accelerator Mass Spectrometer), which is MICADAS made by Ionplus, Switzerland. It can measure 14C+ ion using the tandem accelerator up to 200 kV. This system will be utilized studying about optimization for radiocarbon dating of Korean heritage together with AGE3 system which was installed in 2019. Before radiocarbon dating with specimen, for the stable and effective dating, we analyzed the standard materials and studied about measurement condition optimization. The standard samples, NIST 4990C (Ox2), IAEA-C8 and C7 are used in this test, and the phthalic acid consisted by dead carbon was used for measure the system background. The purpose of this study is to analyze the difference of error according to measuring time and find appropriate measurement conditions by reviewing the minimum measuring time and comparing the measured data to reference data. In the future, we will carry out optimizing the system, verifying the data accuracy and precision, and ensuring reliability of results.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

No

20

Design Study of S-band Photocathode Gun

Authors: Woo Jun Byeon[1]; Chang-Ki Min[2]

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We performed the design and simulation of an S-band photocathode gun that can operate in both single-bunch and multi-bunch modes. The electron gun had a resonant frequency of 2997.56 MHz, was designed using the SUPERFISH code, and obtained electromagnetic characteristics with the CST program. Simulations of beam dynamics were performed using the ASTRA program when a bunch has energy of 4 MeV at the gun. During this analysis, the solenoid field and space charge effects were considered in the simulation. Detailed results will be provided in the presentation.

This research were supported in part by the korean Government MSIT(Multipurpose Synchrotron Radiation Construction Project).

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

21

Development of a Digital Star-Shot Analysis System for Proton Beam utilizing Raspberry Pi

Authors: Ji Hye Han[1]; Kwanghyun Jo[2]

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In order to ensure accurate delivery of treatment beams in radiotherapy, precise measurement of the radiation isocenter is crucial. However, the conventional method for quality assurance, which involves star-shot analysis, requires improvement in terms of digitalization and finding the reference point (i.e., laser isocenter). To address these limitations, we developed a radiation isocenter verification system that utilizes a plastic scintillator (PI-200) and a Raspberry Pi equipped with a camera module and analysis software implemented through a Python-based graphic-user interface (GUI).

Our system records proton beam irradiation and extracts star-lines from real-time streaming data to generate a single star-shot image by combining the star-lines at each gantry angle. We employed the Pylinac open-source python library to analyze the image and compute the minimum circle radius and radiation isocenter position. To validate our results, we compared our measurements with those obtained from the Gafchromic EBT3 film using multiple proton star-shots.

Our system demonstrated accurate and automated star-shot analysis for clinical proton beams, effectively eliminating the need for radiochromic film. The average minimum circle radius was 0.41 mm for our system and 0.28 mm for the EBT3 film. Furthermore, the average isocenter distances from the laser center were (-0.65, -0.98) mm for our system and (-1.01, -0.36) mm for the EBT3 film. Additionally, the average position differences between the radiation isocenter and DR center were (-0.52, 0.13) mm for our system.

Overall, our system provides a precise, automated, and cost-effective alternative to conventional film-based methods for radiation isocenter verification, enabling more accurate treatment beam delivery in radiotherapy.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

22

New Geant4 simulation model of X- and gamma-rays production by electron and positron beam in oriented crystals

Authors: Alexei Sytov[1]; Laura Bandiera[2]; Kihyeon Cho[3]; Giuseppe Antonio Pablo Cirrone[4]; Susanna Guatelli[5]; Viktar Haurylavets[6]; Soonwook Hwang[3]; Vladimir Ivanchenko[7]; Luciano Pandola[4]; Gianfranco Paternò[2]; Anatoly Rosenfeld[5]; Victor Tikhomirov[6]

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X- and gamma-rays production in oriented crystals is a very promising radiation source for various innovative applications, in particular, a positron source for future lepton colliders, a radiation source for radiotherapy and nuclear physics as well as is an essential process in an ultracompact electromagnetic calorimeter for high-energy experiments. A suitable simulation tool, capable to simulate both radiation physics and an entire experimental setup is one of the main challenges towards the development of these applications.
We present a new simulation model implemented into the Geant4 simulation toolkit [1] which potentially overcomes this challenge. It allows one to simulate the generation of X-ray and gamma-rays by ultrarelativistic electrons and positrons moving at a small angles w.r.t. crystallographic axes or planes and uses at the same time a rich Geant4 library of physics to simulate an entire setup.

[1] J.Allison et al., NIM A 835, 186-225 (2016).

A. Sytov is supported by the European Commission TRILLION GA 101032975. We acknowledge partial support of the INFN through the MC-INFN project. This work is also supported by the National Supercomputing Center with supercomputing resources including technical support.

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Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

23

E336 Experiment at SLAC FACET-II on beam-driven plasma wakefield acceleration in structured solids: status and prospects

Authors: Robert Ariniello[1]; Laura Bandiera[2]; Gianluca Cavoto[3]; Sébastien Corde[4]; Xavier Davoine[5]; Henrik Ekerfelt[6]; Frederico Fiuza[6]; Max F. Gilljohann[4]; Laurent Gremillet[5]; Alexander Knetsch[6]; Yuliia Mankovska[4]; Bertrand Martinez[7]; Aimé Matheron[4]; Henryk Piekarz[8]; Ilaria Rago[3]; Pablo San Miguel Claveria[4]; Vladimir Shiltsev[8]; Doug Storey[6]; Alexei Sytov[9]; Peter Taborek[10]; Toshiki Tajima[10]

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Plasma wakefield acceleration in structured solids (nanotubes and crystals) can produce extremely high acceleration gradients exceeding 1 TeV/m. The nuclei-free space in nanotubes or crystals can be exploited both to produce plasma waves and to accelerate charged particles, simultaneously focusing them within their channel and almost avoiding their collisions with ions.
We do the simulations of plasma waves using the PIC code CALDER.
We present the progress and the prospects of the E336 Experiment [1] at SLAC FACET-II Facility on beam-driven plasma wakefield acceleration in structured solids.

[1] R. Ariniello et al., Snowmass'2021 AF6: Advanced Acceleration Concepts, arXiv: 2203.07459

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Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

24

Synchrotron XRD Study of Whewellite Components of Ginseng

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[2] *Daejeon University*

Research on food and agriculture (including soil) using synchrotron radiation is very rare in Korea. By sharing the results of measuring and analyzing components of Korean ginseng and other food products using the synchrotron XRD technique, it is hoped that synchrotron techniques will be actively used in various research fields such as agriculture, health, and archeology as well as material-oriented synchrotron research in Korea.

Ginseng, one of the perennial plants discovered more than 5,000 years ago in the mountainous regions of Manchuria, has been cultivated and researched since the 1800s in recognition of its pharmacological effects in North America (USA and Canada) as well as Asian continents such as Korea. Since the emitted light is hundreds of thousands of times stronger than conventional laboratory X-rays and has a very good resolution, even small amounts of components can be distinguished and analyzed. Whewellite, a mineral abundant in ginseng, was measured and analyzed by Synchrotron XRD.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

No

26

Status of Korea-4GSR impedance modeling

Author: Jimin Seok[1]

Co-authors: Gyeongsu Jang [2]; Ho-Sun Choi [1]; Jaehyun Kim [3]; Jaeyu Lee [4]; Taekyun Ha [1]

[1] *PAL*

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[3] *Pohang Accelerator Lab (PAL)*

[4] *Pohang Accelerator Laboratory*

A multi-purpose synchrotron radiation project is currently underway to construct the next-generation storage ring at Ochang, known as Korea-4GSR. Due to the high magnetic field gradients, the beam produced is expected to achieve a brightness approximately 100 times higher than that of the previous generation storage rings. However, these high magnetic gradients result in small aperture sizes in the vacuum components, which can potentially lead to beam instabilities through impedance effects. The accurate estimation of the impedance of the vacuum components has become crucial in order to prevent undesired beam instabilities at Korea-4GSR. Here, we present an analysis of the impedance of the vacuum components in Korea-4GSR using both analytical and numerical tools.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

27

Analysis of Coupled-Bunch Mode Instability Induced by Resistive Wall Impedance at Korea-4GSR

Author: Jimin Seok[1]

Co-authors: Gyeongsu Jang [2]; Jaehyun Kim [3]; Jaeyu Lee [4]

[1] *PAL*

[2] *POSTECH*

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[4] *Pohang Accelerator Laboratory*

Beam instabilities arising from impedance effects have been a topic of concern in storage rings. In 4th generation storage ring, the reduced aperture size amplifies the impedance of the ring, thereby increasing the potential for beam instabilities, including microwave instabilities, head-tail instabilities, and coupled-bunch mode instabilities (CBMI). To address these issues, the Korea-4GSR project has implemented HOM damped normal conducting cavities to effectively mitigate longitudinal CBMI. However, the concern remains about transverse CBMI induced by resistive wall impedance which cannot be as effectively mitigated using techniques like the HOM damper. In this study, we present an investigation into transverse CBMI at Korea-4GSR using both analytical and numerical approaches.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

28

Re-evaluation of Shielding Ability and Induced Radioactivity of KSTAR Facility with Increasing Neutron Yields

Author: UkJae Lee[1]

Co-authors: Hee-Seock Lee [1]; Hee-Soo Kim [2]; Nam-Suk Jung [1]

[1] *Pohang Accelerator Laboratory*

[2] *Korea institute of Fusion Energy*

Korea Superconducting Tokamak Advanced Research (KSTAR) is installed second NBI (Neutral Beam Injection) to increase plasma density and the graphite divertor is changed to tungsten divertor for reducing heat load. Based on these changes, KSTAR has a plan for increasing the neutron yield per one shot operation as two times higher. Therefore, radiological evaluation about existing building structure and KSTAR with increased the neutron yield per shot is conducted.
The shielding analysis is conducted about plasma experimental room, activation calculation of tokamak components, air activation inside of KSTAR building and residual dose assessment at major working area. According to the shielding analysis results of plasma experimental room, the weekly and annual dose at the working area at outside of building do not exceed the criteria. The maximum dose rate in working area in the tokamak is 2.16E+03 μSv/h at surface PFC. However, the dose rate is reduced as background level at 1 month after operation.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

29

A study on the breakdown characteristics of vacuum under external magnetic field

Author: Jonggi Hong[1]

Co-authors: Jang-Hee Yoon [2]; Jiho Lee [3]; Jin Yong Park [2]; Jung-Woo Ok [2]; Jungbae Bahng [4]; Seoung Jun Kim [2]; Taekyu Lee [2]

[1] *Korea Basic Science Institute(KBSI)*

[2] *Korea Basic Science Institute*

[3] *Pusan National University*

[4] *Kangwon National University Hospital*

The particle accelerators produced worldwide are used for industrial applications. In particular, the Electron Cyclotron Resonance Ion Source (ECRIS) designed with consideration for magnetic fields to confine plasma and electric fields for ion beam extraction under vacuum conditions. In this case, the breakdown voltage decreases by increasing the magnetic flux density and the position of the breakdown minimum is shifted due to the magnetic field. Therefore, it is important to observe and analyze the breakdown characteristics of vacuum in an external magnetic field to design an electrically reliable accelerator component. In this paper, the breakdown voltages with respect to the electrode distance were examined under an external magnetic field. Sphere-to-plane and sphere-to-sphere electrode systems are used to examine the breakdown characteristics according to the field utilization factor. Also, the experimental results are analyzed by a finite element method.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

30

Defect Evolution in Graphene Induced by He+ and He++ ion beam Irradiation

Authors: Junhyeok Seo[1]; Sunmog Yeo[2]; Young jun Yoon[3]; Jun Mok Ha[2]

Co-author: Kibeom Kim [1]

[1] *Hannam University*

[2] *Korea Atomic Energy Research Institute, Korea Multi-purpose Accelerator Complex*

[3] *Andong National University*

Although defects exhibit undesirable properties, researchers can harness them to customize materials with desired properties through exquisite control. Particularly in 2D materials like graphene, composed of a single layer of carbon atoms, defects exert a significant influence on the properties of such materials, even in the face of minor fluctuations in conditions such as ion beam irradiation. In this study, the evolution of defects in graphene is scrutinized by contrasting the impacts of 60 keV He++ and 120 keV He+ irradiation at equivalent doses. As the dose increases for both 60 keV He++ and 120 keV He+ irradiation, D peaks around ~1350 cm-1 increase, examined by Raman spectroscopy. Nevertheless, the D peak induced by 60 keV He++ irradiation is more pronounced than that generated by 120 keV He+ irradiation. Based on this data, a discussion on the fundamental origins of this phenomenon is presented.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

31

Simulation Study on Electron Beam Injection of Compact-Size Electron Storage Ring

Author: Jun Ho Ko[1]

Co-authors: Jang-Hui Han [1]; Juho Hong [1]

[1] *Pohang Accelerator Laboratory*

The Pohang Accelerator Laboratory constructed the compact-size synchrotron facility to generate an extreme ultraviolet (EUV) light source which is called the PAL-EUV. The PAL-EUV facility consists of a photo-cathode RF gun, an S-band linear accelerator, a racetrack shape booster synchrotron, and a storage ring synchrotron. In this paper, we introduce the parameters of the PAL-EUV, the single bunch simulation result of the PAL-EUV booster synchrotron, and the electron bunch injection simulation result of the PAL-EUV storage ring synchrotron.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

32

Luminescence properties of rare earth ion doped sulfates

Author: M. J. Jeong[1]

Co-author: Yunsang Lee [1]

[1] *Soongsil University*

We investigated the emission properties of Ce3+ doped BaSO4 (BaSO4:Ce) nanoparticles synthesized by co-precipitation method. The Rietveld refinement analysis of the X-ray diffraction pattern revealed that BaSO4:Ce were synthesized well without any impurity. Upon the photo-excitation at 247 and 267 nm, BaSO4:Ce showed two intense emission peaks at 300 and 320 nm which were assigned to the transitions of 5d $\rightarrow$ 2F5/2 and 2F7/2 of Ce3+ ions. Interestingly, we observed the modulation of the photoluminescence intensity by controlling the photo-excitation wavelength and the irradiation time. In addition, the optically stimulated luminescence and thermoluminescence characteristics were identified in the low Ce3+ doping concentration region. These novel luminescent properties were attributed to the defect states originating from the doping of Ce3+. Our results suggested that BaSO4:Ce nanoparticles prepared by co-precipitation method has good properties for dosimeters as well as UV phosphors.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

33

Simulations on multi-bunch instability due to the resistive wall wakes in 4GSR by mbtrack2-cuda

Author: Keon Hee Kim[1]

Co-author: Eun-San Kim [1]

[1] *Korea University*

For 4th generation light sources, a low emittance storage ring is required. To effectively operate such a storage ring with low emittance, it is imperative to minimize the radius of the beam pipes. Nonetheless, the reduced radius of these beam pipes leads to elevated resistive wall instability. Hence, a thorough exploration of resistive wall instability for a 4th generation storage ring (4GSR) is significantly important. To investigate the influence of the resistive wall instability, it is necessary to conduct multi-bunch simulations. However, these multi-bunch simulations demand a substantial amount of simulation time. Thus, we have developed a program named mbtrack2-cuda, designed to carry out GPU parallel computations for studying the collective effects due to multi-bunch beam instabilities. With the utilization of this simulation code, we analyze the influence of resistive wall instability on 4GSR.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

34

Calibration of button-type Beam Position Monitor via BPM test bench

Author: GeunWoo Kim[1]

Co-authors: Siwon Jang [2]; Eun-San Kim [1]

[1] *Korea University*

[2] *Pohang Accelerator Laboratory*

Beam Position Monitor (BPM) is a non-destructive diagnostic instrument in accelerator technology, measuring invaluable for real-time beam position monitoring during accelerator operations. Recently, we embarked on the development of BPM specifically designed for electron accelerators to compose beam diagnostic systems. After the fabrication of BPM, it requires a calibration process, making it challenging to employ immediately in accelerator beam diagnostic experiments. To address this, we developed an efficient mobile BPM test bench. Utilizing essential calibration data, such as the electrical offset, we tested and calculated to find the best solution for BPM sensitivity, and we obtained BPM calibration results. Our results demonstrate that experiment results are one of the optimal sensitivity consequences. Now, we intend to apply these results to actual accelerator beam position measurements.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

35

Developing Flow of Single Stretch Wire Magnet Measurement Method, Result Analysis, and Comparison with Hall Probe

Author: JONGMO HWANG[1]

Co-authors: Eun-San Kim [1]; Jungbae Bahng [2]

[1] *Korea University*

[2] *Kangwon National University Hospital*

We have been developing Single Stretch Wire(SSW) magnet measurement system for small aperture magnets. We have been testing a 30T/m quadrupole with an effective length of 120mm and an aperture of 54mm on the test bench which we set to get repetitively uniform results. We analyzed measured values to get magnetic field harmonics and how much the results are uniform.
We are going to compare the result with the Hall probe magnet measurement system with a special rotating stage to measure radial direction magnetic flux Br. As a usual methods, scaned cartesian coordinate component Bx, By also be used to get harmonics by coordinate transformations. By comparing the result we could ascertain the measured data and the SSW test bench itself.
In this paper, we are going to show the build flow of SSW. Since the measuring wire and voltmeter were closed circuitry, they work as an antenna. Noise control when measuring and noise reduction post-processing after measuring were important to reveal the allowed harmonics that were designed to be 2*10^-3 times smaller than the major signal.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

36

Design of a compact 50 MeV cyclotron for industrial and medical applications.

Author: Hee Jin Cho[1]

Co-authors: Keon Ho Kim ; Oleg Karamyshev ; Chong shik Park ; Bong Hun Oh ; Jin Joo Go ; Tae Gyun Ha ; Garam Hahn ; Seungyong Hahn ; Seong Hee Park ; Seung Hwan Shin

[1] *Korea University*

A compact 50 MeV cyclotron has been designed for industrial and medical applications. In order to achieve a compact design, several reasonable concepts were applied in the design, such as using higher harmonic frequency as the operating RF frequency and incorporating a double steps sector

for a higher magnetic field. In this presentation, we will describe and discuss the detailed design results and applications of the designed cyclotron.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

37

100 MeV Proton beam diagnostics for RI production at KOMAC

Author: Yu-Mi Kim[1]

Co-authors: Myung-Hwan Jung [1]; Won-Je Cho [1]; Gwang-il Jung [1]; Kwon-Soo Chun [1]

[1] *Korea Atomic Energy Research Institute*

In Korea Multi-purpose Accelerator Complex (KOMAC) of Korea Atomic Energy Research Institute (KAERI), a proton LINAC for 20 MeV and 100 MeV is in operation and provides the proton beam for various applications since 2013. A radioisotope (RI) production beam line has developed in 2015 and the commissioning started in 2016. Recently, a beam diagnostics system for high proton beam currents was designed in the target room 101 (TR101) for the radioisotope (RI) production. The beam diagnostic system includes a 4-sector collimator and Faraday cup to measure the position and current of the proton beam, and an AC current transformer (ACCT) for real-time monitoring. Considering the long beam irradiation for RI production, the system was designed to be moved up and down using a cylinder for beam QA only. The control system of beam diagnostics was designed to be integrated with the EPICS IOC operating in other target rooms. In this paper, we would like to present the details of the beam diagnostic system of the TR101 for 100 MeV RI production.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

38

Upgrade of timing system application for beam gate control at KOMAC linac

Author: Young-gi Song[1]

Co-authors: Hyeok-jung Kwon [1]; Jae-ha Kim [1]; Sung-yun Cho [1]

[1] *KOMAC/KAERI*

A total of 10 beam lines were designed for KOMAC LINAC, and four beam lines currently provide the user with beams.The accelerator is characterized in that the beam, rf, and diagnostic equipment are synchronized. The KOMAC proton accelerator operates an event timing system to synchronize ion sources, RF, modulators, and beam diagnostics from a reference frequency of 300 MHz. Timing

conditions of each equipment are set and changed according to an operation scenario. In accelerator tuning for beam service, beam size and flux adjustment occur frequently according to beam requirements for beam target samples. In order to operate accelerator devices and beam services more efficiently, the application was upgraded to control the pulse output of the timing system.The application added the function of automatically stopping when the beam pulse reaches the required flux and solving the beam repetition rate limit within the rf repetition rate.
This paper describes the application implementation and test results that can operate accelerator and beam services more efficiently by improving the timing system.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

39

Time-Lapse Micro-Computed Tomography at Beamline 6C of the Pohang Light Source-II

Author: Seob-Gu Kim[1]

Co-authors: JaeHong Lim [1]; Junwoo Kim [1]; Yong Sung Park [1]

[1] *PLS-II Beamline Department, Pohang Accelerator Laboratory, POSTECH*

Time-lapse micro-computed tomography is a technique that repeatedly scans an object to obtain a sequence of three-dimensional images. It is used to study the object's structural changes over time. At Beamline 6C Bio Medical Imaging of the Pohang Light Source-II, the technique is implemented by feeding pulse signals generated from the rotation stage at regular angular intervals into the trigger input of a camera. A 180-degree sample rotation, which comprises a single scan, is followed by transfer of X-ray projection images to a storage server, which then gives the rotation back for the next cycle. Alternatively, a sample is rotated continuously as X-ray projections taken at regular angular intervals are stacked in the local memory, until either the memory is full or the limit of rotation of the rotation stage is reached. After transfer of the X-ray projections, the entire sequence is segmented in chunks of a 180-degree rotation for reconstruction. The latter mode allowed over 100 scans with a pixel resolution of 0.65 μm taken in every 4 s using a monochromatic X-ray beam at the beamline.

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Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

Yes

40

Control and Monitoring System for IF magnets of the RAON Accelerator

Author: Yonghwan Kim[1]

Co-authors: Do Gyun Kim [2]; Seok-jin Choi [3]

[1] *RISP*

[2] *Institute for Basic Science*

[3] *Institube for Basic Science*

After the IF magnets and the power supplies for the magnets were installed, the development of a remote control and monitoring system for initial testing in the field was required. We developed EPICS IOC (Input and Output Controller) and GUI (Graphical User Interface) for operation and status monitoring of electromagnets. The IF magnet power supplies consists of three types of power supplies manufactured by different manufacturers, and each power supply has a difference in interface functions and operation conditions. When integrated and implemented in one GUI screen, it is designed to have a unified configuration so that users do not get confused due to the difference in the function of each power source. A basic test of the IF magnets was done using the developed control system.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

41

Overview of Korea-4GSR Magnet System

Authors: Dong-Eon Kim[1]; Hyung-Suck Suh[1]; InWoo Chun[1]; Young-Gyu Jung[1]

[1] *Pohang Accelerator Laboratory, POSTECH*

A 4th generation storage ring based light source is being developed in Korea since 2021. It features < 100 pm rad emittance, about 800 m circumference, 4 GeV e-beam energy, full energy booster injection, and more than 40 beamlines which includes maximu 24 insertion device (ID) beamlines. This machine requires about ~1300 magnets including dipole, longitudinal gradient dipole, transverse gradient dipole, sextupoles, and correctors. Recently, technical design of the most magnets have finished. In this report, the current status and design efforts for Korea-4GSR are summarized.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

42

In-Vacuum Undulators for the First Phase Beamlines of the Korea-4GSR

Author: Changwan Ha[1]

Co-authors: Dong-Eon Kim [2]; Ki-jeong Kim [1]; JaeHong Lim [1]; Jehan Kim [1]

[1] *Pohang Accelerator Laboratory*

[2] *Pohang Accelerator Laboratory, POSTECH*

The Korea-4GSR is a new synchrotron radiation facility that is being planned in Ochang, Chungbuk, South Korea. It will store 4-GeV electrons with an emittance of 62 pm•rad and will feature one of three types of in-vacuum undulators (IVUs) for its first phase hard X-ray beamlines: IVU20, IVU22, or IVU24. These IVUs differ in their undulator spatial period ($_u$), with IVU20 having a $_u$ of 20 mm, IVU22 having a $_u$ of 22 mm, and IVU24 having a $_u$ of 24 mm. All three IVUs share a common framework that is 3 meters long and can adjust the gap size between 5 mm and 18 mm. The fundamental or first harmonic photon energy at the lowest gap is 2.6 keV for IVU20, 1.8 keV for IVU22, and 1.3 keV for IVU24. IVU20 is noted for its small beam divergence (σ'), which is less than 10 μrad above 5 keV. This leads to the highest coherent flux among the three IVUs, of 10^{11} photons/s/0.1%-bandwidth/mA at 6.5 keV; the brilliance amounts to 10^{19} photons/s/mm^2/$mrad^2$/0.1%-bandwidth/mA. However, its spectrum misses a range between 7.4 keV and 8.1 keV, which is unachievable with odd harmonics by adjusting the gap size. IVU24, on the other hand, ensures continuous spectral coverage thanks to its more closely spaced harmonics. However, its coherent flux is approximately half that of IVU20, and it places a greater burden on beamline optics with a total power of 18 kW, compared to less than 13 kW for IVU20. IVU22 falls in between IVU20 and IVU24 in terms of beam characteristics and ensures spectral continuity.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

Yes

43

Direct Comparison of Structural, Electrical, and Optical Properties of Metal-Insulator-Transition of Ion-implanted VO2

Authors: In-Hui Hwang[1]; Young-Woo Park[2]; Sunmog Yeo[3]; Sang-Wook Han[2]

[1] *Argonne National Laboratory*

[2] *Jeonbuk National university*

[3] *KOMAC*

VO2 is a typical metal-to-insulator transition (MIT) material with the critical temperature (Tc) of ~70 oC accompanied by a first-order structural phase transition (SPT). For practical applications of VO2, accurately controlling Tc is required using artificial parameters. We examined the electrical and local structural properties of hydrogen (H) and nitrogen (N) ion implanted VO2 (H-VO2 and N-VO2) films using temperature-dependent resistance and X-ray absorption fine structure (XAFS) measurements at the V K edge. H and N ions with the flux of 1013-1015 ions/cm2 and the energy of 100 –300 keV were vertically implanted to the films. The I-V and in-situ XAFS were simultaneously measured on H-VO2 and N-VO2 films and directly compared. XAFS measurements revealed that the structural disorder as well as bond lengths of V-O and V-V pairs on VO2 were significantly changed when ions were implanted. The Tc of VO2 was lowered by 10 oC for both heating and cooling, compared to that of untouched VO2. The transition region of VO2 was expanded by ion implanted. The electrical property changes of ion-implanted VO2 was mainly caused by structural property changes because no changing effects were observed. The Tc values of the H-VO2 and N-VO2 films considerably depend on the flux and the energy of H and N ions. This study showed that the Tc of VO2 can be controlled by proper ion implantation.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

44

Project management of the Korea-4GSR Project according to the Total Project Cost Management Guidelines

Author: Iksu Mok[1]

[1] *PAL, POSTECH*

Pohang Accelerator Laboratory is in charge of designing(R&D) and constructing accelerators and beamlines as a joint R&D institution for the Korea-4GSR Project. What is different from the project management so far is that it must be managed according to the Total Project Cost Management Guidelines, which are guidelines of the Ministry of Strategy and Finance. Accordingly, three design adequacy reviews are conducted in the design stage, and government reporting and reduction of the winning bid difference are required for all thousands of parts contracts. The main points of the design adequacy review for each stage, the response progress, and the case of the successful bid difference are shown, and the main points in other accelerator construction projects are shown, and improvement plans are presented.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

45

Comparison of Beam Characteristics using Ar and Ne Beams in RAON Injector

Author: Ji-Ho Jang[1]

Co-authors: Dong-O JEON [1]; Hyung Jin KIM [1]

[1] *IBS, IRIS*

The RAON injector consists of LEBT (low energy beam transport), RFQ (radio-frequency quadrupole) and MEBT (medium energy beam transport). It accelerates ion beams from proton to uranium up to 500 keV/u and injects the beam into a superconducting linac, SCL3. Beam commissioning using Ar beam has been completed, and beam commissioning using Ne beam is in progress. In this brief study, beam characteristics are compared for Ar and Ne beams in a RAON injector.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

46

Status of 4GSR Beam Position Monitor system

Author: Siwon Jang[1]

Co-authors: Bokkyun shin [1]; Dong Cheol Shin [1]; Garam Hahn [2]; Jung Yun Huang [1]; Gyujin Kim [1]; Donghyun Song [1]; Woojin Song [3]; Jaehyun Kim [4]; Changbum Kim [2]; Dotae Kim [1]

[1] *PAL*

[2] *Pohang Accelerator Laboratory*

[3] *POSTECH*

[4] *Pohang Accelerator Lab (PAL)*

The Ochang 4GSR, a fourth-generation light source storage ring accelerator, is under construction with the aim of starting operations in 2027. The 4GSR beam position monitor system is a key diagnostic device for storage rings, and many studies are underway to develop and achieve goals.
The antenna of the beam position monitor, the most important parts of BPM, is currently being developed in two versions, and beam position monitor electronics is also being developed in time.
In the presentation, the current status of the 4GSR beam position monitor system will be described.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

47

Beam Optics Study on KAHIF MEBT

Authors: Sangbeen Lee[1]; Jungbae Bahng[2]

Co-authors: Dae-Sik Chang [1]; Dong Won Lee [1]; Kihyun Lee [1]; Seunghyun Lee [1]

[1] *Korea Atomic Energy Research Institute*

[2] *Kangwon National University Hospital*

As an ion beam irradiation facility, KAERI Heavy ion Irradiation Facility (KAHIF) has been constructed at KAERI, Daejeon. The facility is being utilized for research the nuclear fusion materials and nuclear reactor materials, especially structural material study. The dedicated accelerator system could produce ion beams up to 1.0 MeV/u with 300 uA. In KAERI, a few projects are proposed based on KAHIF accelerator system. One of the major projects is providing the metal beam, Fe ion. In order to deliver the stable Fe ion beam, the beam optics is studied and the results are presented in this paper.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

48

Dosimetric Characteristics of 6 MV X-band LINAC cavity

Authors: Sangbeen Lee[1]; Seunghyun Lee[1]

Co-authors: Donghyup Ha [2]; Jaegi Lee [1]

[1] *Korea Atomic Energy Research Institute*

[2] *Sungkyunkwan University*

An X-band linear accelerator (LINAC) system for radiation therapy has been developed. This system is designed to utilize a dual-head gantry radiotherapy system by Sungkyunkwan university. The electron acceleration cavity is planned to generate 6 MV photon beam with 70 mA peak current using peak power of 1.7 MW RF power. After the beam commissioning of this LINAC system, the dosimetric test results are measured which is including percentage depth dose and profiles. The measurement results of percentage depth dose are discussed with the percentage depth dose simulation results.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

49

Impacts of microgravity and space radiation exposure on human health: from cellular evaluation to human

Author: Su-Geun Yang[1]

Co-author: Kyung-Ju Shin [2]

[1] *Inha University College of Medicine*

[2] *Inha Univ.*

The exposure to space microgravity and radiation has significant implications for human health during space missions. Microgravity can lead to muscle and bone loss, cardiovascular deconditioning, and alterations in the immune system. Cosmic radiation, consisting of high-energy particles from the sun and beyond, can damage DNA and increase the risk of cancer and other health issues. Space travelers are exposed to higher radiation levels outside Earth's protective atmosphere and magnetic field. Overall, addressing the health impacts of microgravity and radiation exposure is essential for the success of long-duration space missions. Ongoing research and advancements in technology aim to develop countermeasures and safeguards to protect the well-being of astronauts during extended space travel. My presentation focuses on mitochondrial ROS accumulation and genomic instability under space microgravity and radiation and suggests therapeutic countermeasures.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

50

Deep learning for quality enhancement of proton beam profiles measured using phosphor screen and cooled CMOS camera

Author: GWANG IL JUNG[1]

Co-authors: Young-Seok Hwang [1]; Yu-Mi Kim [2]; Eun-joo Oh [1]; Jun Mok Ha [1]; Jimin Lee [3]

[1] *KAERI, KOMAC*

[2] *KAERI, KOMAC)*

[3] *UNIST*

The Korea-Multi-Purpose Accelerator Complex (KOMAC) operates a 100 MeV proton linear accelerator, providing a high flux proton beam at the TR103, a genral-purpose irradiation facility. Ensuring uniform irradiation of sample with protons is critical, necessiating confirmation of beam profile uniformity through the quality assuracne (QA) process. To address this, a real-time and in-situ proton beam profile monitoring system was recently introduced and tested at the TR103. This system includes a P43 phosphor screen and TE-cooled CMOS camera, wihch captures images of the emitted light from protons. Howerver, since this system is installed in-air, various factors introduce noise and saturation, thereby degrading the quality of the beam profiles. In this study, we employed the U-net, a deep learning architecture, to effectively restore noisy and saturated beam profiles to approximate their true beam profiles. We conducted experiments comparing the results with measurements obtained from Gafchromic film.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

52

Slit-scanner for 4-dimensional phase space reconstruction

Author: Chang-Kyu Sung[1]

Co-author: Bokkyun shin [1]

[1] *PAL*

There is a need for characterizing a particle distribution within the transverse 4-dimensional phase space. When generating the electron beam from the photo-injector, for instance,
the axial magnetic field at the photocathode magnetizes the electron beam, leading to the coupling of the horizontal and vertical dynamics in the transverse motion. As the correlation between the horizontal and vertical motions can degrade the photoinjector optimization for the low emittance electron production, a comprehensive understanding of the full transverse or 4-dimensional (4D) phase space becomes imperative.
To facilitate the reconstruction of the 4D phase space, the most valuable method is the pepper-pot system consisting of the 2-dimensional array of holes. This approach, however, has limitations when applied to the low emittance electron beam due to the technical issues, associated with the measurement resolution.
It is proposed that the slit-scan method, which is typically used for the projected 2D phase space reconstruction, can be extended for the 4D phase space reconstruction with the specialized data processing technique. Furthermore, by adopting the suggested technique, it becomes feasible to construct the infinitesimally thin slit structure, which offers the improved resolution, as it minimizes the signal-to-noise ratio.

The data processing technique based on the tracking simulation will be presented. And the experimental plan at the PAL e-LABs will be discussed with an application of this system on the photoinjector optimization with the artificial intelligence.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

53

Designe of Klystron and Modulator System for 4GSR Linac

Author: Soung Soo Park[1]

Co-author: Sang-hee Kim [2]

[1] *Pohang Accelerator Laboratory, POSTECH*

[2] *Pohang Accelerator Laboratory*

The 4GSR is scheduled to consist of a 4GeV storage ring and booster ring and a 200MeV linear accelerator. The 200MeV required for the linear accelerator was designed with two sets of 175 MW modulator and two sets of 3GHz 70MW klystrons. The 4GSR construction is scheduled to begin in 2021 and be completed by December 2027. We plan to use 2 sets of klystron and pulse modulators used as an energy source to accelerate electrons in the 4GSR linear accelerator. The specifications of the 175MW modulator are beam voltage of 387kV, beam current of 452A, repetition rate of 60 Hz, pulse width of 5.5uS, pulse flattness of 0.5% and PFN voltage stability of less than 0.01%. In this paper, we would like to present the design of a 175MW modulator and 70MW klystron using a high-precision high-voltage power supply.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

54

Design and Implementation of a LLRF System for RAON SCL3

Author: Hyojae Jang[1]

Co-authors: Myung Ook Hyun [2]; Yoochul Jung [3]; Youngkwon KIM [4]

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[2] *Rare Isotope Science Project / Institute of Basic Science*

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Recently the installation of the low energy section (SCL3) of a heavy ion accelerator RAON has been finished. The first beam commissioning with QWR section (SCL31) of this linear accelerator was finished last year, and the commissioning for the remained part of the accelerator, HWR section (SCL32) was done in last May. The purpose of RAON accelerator is the generation of rare isotope by ISOL (Isotope Separation On-Line) and its acceleration for the nuclear physics experiment. The operating RF frequency for SCL3 are 81.25 MHz and 162.5 MHz. Each cavity will be controlled independently to accommodate the acceleration of the various A/q ions. For the RF operation, the FPGA-based LLRF has been developed. Two kind of control technologies are used for the operation of LLRF. FPGA based digital processing technique is used for the control of the RF and EPICS is used to monitor the RF parameter and to operate the LLRF. In this presentation the status and test result of RAON LLRF controller will be described.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

55

Proton beam irradiation researches for mutation breeding of useful plants

Author: Si-Yong Kang[1]

[1] *Kongju National University*

Proton beam irradiation researches for mutation breeding of useful plants

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Heavy ion beams with high liner energy transfer (LET) and high relative biological effectiveness (RBE) have been reported to show higher mutation frequency and spectrum than low LET radiations (gamma and x rays). The KOMAC (Korea Multi-Purpose Accelerator Complex) under the KAERI was constructed in Gyeongju in 2013 and then has been provide 45 MeV and 100 MeV proton beam irradiation service. We have been researched for setting the irradiation condition of 100 MeV proton beam of the KOMAC for mutation breeding. We analyzed the LD30, LD50, and RD50 values in response to proton ions and gamma-rays using 20 plant species. The seeds of 19 species were irradiated, and growth responses were measured one month after planting, except for cymbidium, for which in vitro rhizomes were irradiated. Resistance to proton ions and gamma-rays was observed in Chinese cabbage, watermelon, and melon, while Japanese atractylodes, naked barley, and lentil were susceptible. Plants belonging to the Brassicaceae and Cucurbitaceae families were highly resistant to radiation, and plants belonging to the Compositae and Poaceae families were highly susceptible. The biological effectiveness of proton ions was greater than that of gamma-rays in 16 plant species, indicating that they could be used as a discriminative radiation source to induce mutations compared with gamma-rays. In addition, we investigated the phenotypes and whole genome sequences of Arabidopsis M2 lines derived by irradiation with proton beams and gamma-rays, to determine unique characteristics of proton beams in mutagenesis. We found that mutation frequency was dependent on the irradiation doses of both proton beams and gamma-rays. There were no significant differences between the total mutation rates in groups derived using proton beam or gamma-ray

irradiation at doses that had similar impacts on survival rate. However, proton beam irradiation resulted in a broader mutant phenotype spectrum than gamma ray irradiation, and proton beams generated more DNA structural variations (SVs) than gamma-rays. These results show that protons have unique characteristics in mutagenesis that partially overlap with those of low-LET gamma-rays and high-LET heavy ions in different respects.

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Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

56

Measurement of environmental radioactivity for RAON using HPGe detector and LSC

Author: Danhye Gil[1]

Co-authors: Beomyeol Beak [1]; Jongwook Kim [1]; IN-SEOK HONG

[1] *IBS*

The Rare isotope Accelerator complex for ON-line experiments (RAON) has been built for providing beam of exotic rare isotope of various energies at the Institute for Basic Science (IBS). The activation was evaluated by the MCNP simulation in the facility design process, which guarantees the radiation safety on this facility.
To ensure the additional radiation safety, the radiation is monitored inside and outside of the facility during operation of the RAON. The inside of the facility is monitored in real-time using the Radiation Monitoring System (RMS) composed of the various types of the detectors. In addition, we measure the radioactivity of soil and groundwater around the facility. The soil is sampled in the 5 designated locations around the facility and the groundwater sample is taken from the 8 collecting wells in the facility.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

57

Optimization studies for the Beam Test Stand (BTS) at KOMAC and future research plan

Author: Emre Cosgun[1]

Co-authors: Seok-Ho Moon [1]; Dong-Hwan Kim [2]; Seung-Hyun Lee [2]; Han-Sung Kim [2]; Moses Chung [1]

[1] *UNIST*

[2] *KOMAC*

Optimization studies for a 2.45 GHz ion source and a 1 MeV/n radio-frequency quadrupole (RFQ) have been performed to increase the beam transmission ratio of the Beam Test Stand (BTS) at the Korea Multi-purpose Accelerator Complex (KOMAC). In this study, a front-end simulation is carried out, which includes an ion source, an LEBT (Low Energy Beam Transport) line, and an RFQ. The ion source configuration consists of a three-electrode design, generating a proton beam with parameters of 10 mA current and 25 keV energy. Various extraction configurations are systematically explored to evaluate phase space distribution and transport efficiency through the LEBT. Besides, the proton beam fraction and magnetic field effect on the beam are investigated during extraction. Finally, 200 MHz RFQ error studies are conducted, and tolerance limits are determined. In future studies, various beam diagnostics will be applied to characterize the beam, and the front-end simulation results will be compared with the experimental results.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

58

Design and Optimization Study of the Electron Linear Accelerator for the Korea Photon Source Using Multi-Objective Genetic Algorithm

Authors: Chanmi Kim[1]; Chong Shik Park[2]

Co-authors: Chang-Ki Min [3]; Eun-San Kim [4]; Seong Hee Park [4]; Seunghwan Shin [5]; Woo Jun Byeon [5]

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[4] *Korea University*

[5] *Pohang Accelerator Laboratory*

In the development of the injector system for the Korea Photon Source, we conducted a comprehensive beam dynamics simulation to optimize the design of the electron linear accelerator. To achieve this, we employed the Multi-Objective Genetic Algorithm (MOGA) to improve the beam line configuration. The primary objectives of this optimization study were to minimize energy spread and transverse emittance at the linac end. We also considered design constraints related to beam size, bunch length, transmission rate, and average energy. Subsequently, we performed an error study to assess whether the design selected through MOGA was operationally acceptable. This research aims to enhance the efficiency and performance of the electron linear accelerator for the Korea Photon Source, contributing to its successful operation in the field of synchrotron radiation science.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

59

Performance test of SCL3 cryomodules for RAON

Author: Youngkwon KIM[1]

Co-authors: Danhye Gil [2]; Heetae Kim [1]; Hoechun Jung [3]; Hyojae Jang [2]; Jaehee Shin [3]; Jong Wan Choi [3]; Jongdae Joo [3]; Juwan Kim [2]; MINKI LEE [4]; Moo Sang Kim [3]; Yong Woo Jo [3]; Yoochul Jung [5]

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The Rare isotope Accelerator Complex for ON-line Experiments (RAON) has been built for providing beam of exotic rare isotope of various energies at the Institute for Basic Science (IBS). The low energy linac (SCL3) is composed of 22 Quarter wave resonator (QWR) cryomodules and 34 Half wave resonator (HWR) cryomodules. The total number of QWR and HWR cavities are 22 and 106, respectively. The performance test of the cryomodules were done in the SRF test facility. The main factor for the acceptance was the total thermal load of cryomodule. The requirement of the total thermal load of QWR cryomodule, HWR cryomodules A and HWR cryomdoules B were 20 W at 4.2 K, 14 W at 2.05 K and 26 W at 2.05 K, respecvitely. Also, the characteristics of cavities such as df/dp and LFD were measured and the operation test of tuner were done. In this paper, the test facility is introduced and test procedure and test results are reported in detail.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

60

Study of beam injection and ramping efficiency for Korea-4GSR booster synchrotron

Author: Yumi Lee[1]

Co-authors: Eun-San Kim [1]; Seong Hee Park [1]; Seunghwan Shin [1]; Bong Hoon Oh [1]; Chong Shik Park [2]; Jaeyu Lee [3]; Jaehyun Kim [4]

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[4] *Pohang Accelerator Lab (PAL)*

The Korea fourth-generation storage ring (Korea-4GSR) has been proposed in order to generate high-performance photon beams and consists of a storage ring, a booster synchrotron, a linac, and 40 beamlines. The evolutions of beam parameters such as beam emittance, energy spread, etc. occur during the ramping process. Thus, the studies for effective beam injection into the booster synchrotron and beam parameter variations during thousands of turns after entering the booster synchrotron are needed to meet the designed requirements of a low emittance storage ring. This paper presents the results of the influence of beam parameters after beams with various errors are injected into the booster synchrotron.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

62

Ongoing RF System Design for the 4th-Generation Storage Ring in KOREA

Author: BongHyuk CHOI[1]

Co-authors: ChanKyeong Lee [1]; Inha Yu [1]; Insoo Park [1]; Junghoon Kim [1]; Mujin Lee [1]; Myung-Hwan Chun [1]; Sehwan Park [1]; Yongseok Lee [1]; Yonguk Sohn [2]; Youngdo Joo [1]; YunCheol Kim [1]

[1] *Pohang Accelerator Laboratory*

[2] *Korea Basic Science Institute*

The project to construct a 4th-Generation Storage Ring(4GSR) in Ochang, South Korea, by 2027 has been in progress since mid of 2022. The current phase involves drafting the Technical Design Report (TDR), with plans to complete it by the end of 2023.
The storage ring will be 799.297 m in circumference and the booster ring will be 772.893 m in circumference and will be installed in the same tunnel.
To provide brighter radiation, emittance is targeting 61.57 pm-rad. By storing electrons in a storage ring from the linear accelerator through the booster, we plan to get a maximum beam current of 400 mA.
To accelerate the injected 200 MeV electrons in the booster ring stably up to 4 GeV, we plan to install three PETRA type 5-cell cavities. To reach 4 GeV, an 80 kW SSPA (Solid State Power Amplifier) will be applied, along with the control of two plunger tuners and RF voltage through LLRF.
For the storage ring, a single-cell cavity with normal conducting properties was chosen considering operational advantages. ten EU-HOM (Higher Order Mode) damped cavities suitable for the 4GSR configuration will be installed. Like the booster ring, the HPRF will also use SSPA and is planned to have a power rating of 150 kW, considering margins. Like the booster, the LLRF will also be designed in-house at Pohang Accelerator Laboratory (PAL) and manufactured by an external partner.
To increase beam lifetime and reduce impedance, the consideration of an active type 3rd harmonic cavity is also in progress.
In this paper, we will discuss the current specifications of the RF system and the reasons behind the chosen specifications

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

63

Scanning Transmission X-ray Microscopy Study on Low Dimensional Magnetic Systems

Author: Wondong Kim[1]

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Scanning transmission x-ray microscopy(STXM) combined with variable polarization of incident X-ray has been a powerful spectro-microscopical tool to investigate the fine magnetic properties of low dimensional magnetic systems such as layered magnetic materials and magnetic thin films systems. In this talk, I will present two recent results which highlight the power of STXM. First, we applied the STXM to the investigation of layer-dependent magnetic properties of Van der Waal magnetic materials NiPS3. NiPS3 has an antiferromagnetic order in its bulk state, and the existence of long-range magnetic order in a few atomic layer thickness has been of great interest recently. By using a cryo-STXM facility at Canadian Light Source, we examined the long-range antiferromagnetic order of NiPS3 flakes and observed clear X-ray magnetic linear dichroism signals at bi-layer thicknesses only below the Neel temperature. Second, we investigate the evolution of magnetic domain structures of Co/Pt thin films under electric fields, utilizing X-ray magnetic circular dichroism measured at the STXM end-station of beamline 10A2 of PLS II. To focus on the magnetic domains near the spin reorientation transition thickness near 1 nm Co thickness, wedge-type Co thin films having a 0.3~2 nm thickness range were prepared on the 4 nm Pt layers grown on SiN x-ray windows. For the samples with a Pd layer inserted between the Co and the MgO layer, we observed a drastic evolution of domain structures near the spin reorientation transition from maze-type domain to well-aligned stripe domain for the sample, when electric fields were applied from top to bottom electrode. The origin of stripe domain formation will be discussed in the comparison of previous reports.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

Yes

64

Current Status of the 4GSR Control System

Author: Seung-Hee Nam[1]

Co-authors: Wooseong Cho [1]; Jinsung Yu [1]; Geongyeong Mun [1]; Sohee Park [1]

[1] *Pohang Accelerator Laboratory, POSTECH*

A new Fourth Generation Synchrotron Radiation source (4GSR) is scheduled to be built in Ochang, South Korea by 2027. 4GSR is one of the important instruments for large-scale scientific experiments and research. The technical design review for 4GSR is currently underway and is expected to be completed in 2023. The 4GSR accelerator control system is a core equipment for large-scale scientific experiments and research, and stability and reliability are very important. The 4GSR accelerator control system consists of an EPICS-based distributed control system and consists of an operator interface, network, and hardware interface. The operator interface is controlled using a GUI from a Linux or Windows-based workstation. This workstation can be located anywhere on the facility network and can create and change control displays, access alarm handlers, archivers, interactive control programs, custom code, and more. The network implementation for this uses fiber-based Ethernet and is connected through a hub. EPICS IOC provides direct control and I/O interface to the accelerator's subsystems. This allows users to directly control and monitor subsystems. Groups implementing 4GSR controls aim to design systems with high connectivity, availability, reliability, ease of use, scalability, and flexibility. To this end, hardware and software development is underway, and we will report on the design progress of the system and discuss future plans.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

65

Simulations of beam-based alignment at RAON SCL2

Author: Hyunchang Jin[1]

Co-author: Jang-Min Han [1]

[1] *Institute for Basic Science*

The RAON accelerator has low-energy and high-energy superconducting linear accelerator sections to achieve 200 MeV/u uranium beam energy. In these sections, the machine imperfections and the beam instabilities can induce unexpected beam loss, and it can lead to significant damage of accelerator devices. To prevent these effects, various beam dynamics studies have been carried out, and the simulations for the beam-based alignment to prevent the sudden beam loss have been also carried out. Here we will present the results of beam-based alignment simulations at the high energy accelerator section (SCL2) of the RAON accelerator.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

66

Current Status of the Fast Orbit Interlock System for 4GSR

Author: Jinsung Yu[1]

Co-authors: Seung-Hee Nam [2]; Wooseong Cho [2]; Geonyeong Mun [3]; Sohee Park [2]; Eun-San Kim [4]

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[4] *Korea University*

The new 4th Generation Synchrotron Radiation Source (4GSR) will be built in Ochang, South Korea by 2027. 4GSR accelerators are important equipment for large scientific experiments and research and are currently undergoing technical design review. The Fast Orbit Interlock system (FOI) refers to a system in which the beam detects a normal orbit departure situation inside the storage ring and triggers an interlock signal during accelerator operation. The core of this system is to quickly judge the situation and stop the beam quickly because the out of orbit of the beam during accelerator operation causes peripheral failure and radiation emission over the allowable amount. The system will collect and compute data at 375 kHz intervals, report progress in the design, which includes a series of processes to protect peripherals in case of beam orbital departure, and discuss future plans.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

67

Projectile fragmentation simulation with SQMD

Author: Kyungil Kim[1]

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Projectile fragmentation is a complicated scheme to produce rare isotopes. One can understand the fragmentation through a two-step process: the production of primary fragments by colliding and de-excitation of these fragments. The excitation energies of primary fragments are essential to understanding the connection between two processes. In this study, we discuss the method to define the excitation energy of primary fragments from QMD calculation and compare the de-excited fragments using a statistical model. Then, we compare the rare isotope production methods IF with U fragmentation and IF+ISOL with neutron-rich isotope fragmentations.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

68

RF Reference Distribution System for RAON Linac

Author: Kyungtae Seol[1]

Co-authors: Doyoon Lee [2]; Kitaek Son [2]; Sangyoon Bae [2]

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The heavy-ion accelerator of the Rare Isotope Science Project (RISP) in Korea has been developed. There are three types of SRF cavity, which are 81.25MHz quarter-wave resonator (QWR), 162.5MHz half-wave resonator (HWR), 325MHz single-spoke resonator (SSR). There are 22 QWRs and 102 HWRs in the superconducting linac#3 (SCL3), and 69 SSR1s and 144 SSR2s in the superconducting linac#2 (SCL2). The RF reference distribution system must deliver a phase reference signals to all low-level RF (LLRF) systems and BPM systems with low phase noise and low phase drift. The frequencies of RISP linac are 81.25MHz, 162.5MHz and 325MHz, and there are 130 LLRF systems and 60 BPMs respectively for SCL3, and 240 LLRF systems and 70 BPMs for SCL2. 81.25 MHz signal is chosen to the reference frequency, and 1-5/8"rigid coaxial line is installed with temperature control. This paper describes the design and test results of the RF reference distribution system such as reference frequency, phase noise on master oscillator, phase stability and temperature influence, and reference line attenuation.

This work was supported by the Rare Isotope Science Project which is funded by the Ministry of Science, ICT and Future Planning (MSIP) and the National Research Foundation (NRF) of the Republic of Korea under Contract 2011- 0032011

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

69

Amorphous Palladium: Janus Electrocatalysis

Author: jeonghyeon kim[1]

Co-author: Sang-Il choi [1]

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Recently, noble metal-based amorphous nanomaterials are intensively investigated due to their desirable electrocatalytic properties. Till now, the studies for amorphization mechanism and catalytic pathway of noble metal-based amorphous nanomaterial received less interest in the relevant fields because of an undetermined phase diagram and an absence of a general synthesis method. Herein, we adjusted the crystallinity of palladium by controlling the hydridization kinetics. The developed amorphous Pd nanoparticle (a-Pd) was characterized with synchronized X-ray to elucidate long-range-order and local structures. Electrochemical characterization of a-Pd showed unique electrochemical behavior that good catalytic performance for reduction reactions completely inert for oxidation reactions, noted as 'Janus catalysis'. In-situ X-ray diffraction and X-ray absorption fine structure studies revealed that novel Pd-X phase on the surface of a-Pd played a role of Janus active site. This research has been performed as Project Open Innovation R&D(OTSK_2022_036) and supported by K-water

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

70

Complete Ethanol Electrooxidation with Rh Single-Atom Decoration on Pt Nanocubes

Author: Saehyun Park[1]

Co-author: Sang-Il Choi [1]

[1] *Department of Chemistry and Green-Nano Materials Research Center, Kyungpook National University*

Direct ethanol fuel cells are attracting growing attention as portable power sources due to their advantages such as higher mass-energy density than hydrogen and less toxicity than methanol. However, it is challenging to achieve the complete electrooxidation to generate 12 electrons per ethanol, resulting in a low fuel utilization efficiency. Herein, we report unalloyed single atomi'c, partially oxidized Rh on the Pt nanocube surface as the electrocatalyst to completely oxidize ethanol to CO2 at a record-low potential of 0.35 V. In situ X-ray absorption fine structure measurements and density functional theory calculations reveal that the single-atom Rh sites facilitate the C–C bond cleavage and the removal of the *CO intermediates. This work not only reveals the fundamental role of unalloyed, partially oxidized SAC in ethanol oxidation reaction but also offers a unique single-atom approach using low-coordination active sites on shape-controlled nanocatalysts to tune the activity and selectivity toward complicated catalytic reactions.
This research has been performed as Project Open Innovation R&D(OTSK_2022_036) and supported by K-water

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

71

Initial RF Control of SCL3 in RAON

Author: Yoochul Jung[1]

Co-authors: Heetae Kim [2]; Hyojae Jang [1]; Juwan Kim [1]; Sungmin Jeon [3]; Youngkwon KIM [2]

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The full installation of the low energy section (SCL3) in RAON accelerator was completed last year, 2022, although the high energy section (SCL2) still needs time to be finished. Initial RF control of SCL3 was carried out to accelerate Ar9+ beams. The SCL3 section consists of two different types of cryomodules, front QWRs and rear HWRs. In case of QWR, the Ar9+ beams were accelerated through the five QWR cryomodules with the beam energy of 0.7 MeV/u last October, 2022, and then, almost all QWR cryomodules (19 out of 22) were operated to deliver Ar9+ beams with the beam energy of 2.47 MeV/u at the end of 2022. In case of HWR, almost all HWR cryomodules were successfully operated to deliver Ar9+ beams with the beam energy of 17.6 MeV/u, at the end of May, 2023, although a few cavities were excluded due to the unstable control.
In this presentation, how all SCL3 section were conditioned to deliver Ar9+ beams and what problems occurred during the RF control together with how these problems were figured out in terms of LLRF (low level RF) control, SSPA (Solid State Power Amplifier) power supply, cavity tuning, and cryogenic microphonics.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

72

Development of Tb3+ Doped Silicoborate Scintillating Glass for X-ray Detection and Imaging Applications

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X-ray imaging is a medical imaging technique that uses X-rays to create images and has a crystal scintillator, which is a part of the X-ray imaging system. However, crystal is a long making process and high cost. Glass material is the one choice for developing and replacing crystals. Therefore, this research aims to develop Tb3+ doped silicoborate glass to be used as scintillation materials in X-ray imaging. The silicoborate glass doped with different amounts of Tb3+ in the composition of xTb2O3-7.5Gd2O3-40Na2O-5SiO2-(47.5-x)B2O3 where varying Tb2O3 from 0, 1, 2, and 3 mol%. The xTb:7.5Gd glasses were prepared by conventional melt quenching technique and studied characterization of each property. The density and molar volume increase with increasing Tb2O3. Fourier transform Infrared spectra (FTIR) results point out that the majority of the BO3 borate group. The xTb:7.5Gd glasses absorbed photons in UV-visible and near-infrared regions. The results of photoluminescence and X-ray induced luminescence reveal significant emission occurring at 544 nm (5D4⟶7F5). The photoluminescence quantum yield (PLQY) of 3Tb:7.5Gd glass shows the highest value at 30.85%. The scintillation efficiency of 3Tb:7.5Gd glass was 109% of bismuth germanate (BGO) crystal. CIE chromaticity of xTb:7.5Gd glasses shows the color coordinates in green region. The decay time owing to Tb3+ emission is 2.418ms for 3Tb:7.5Gd glass. The spatial resolution of the X-ray imaging study was 10 lp/mm. These results suggest that 3 mol% of Tb2O3 doped silicoborate glass is capable of being a scintillation material applied in the X-ray imaging system.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

73

Development in scintillation performance of CsI(Tl) crystal with Ba2+ co-doping

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CsI(Tl) crystal co-doped with various concentrations of Ba (0.0, 0.05, and 0.1 mol%) was grown using a two-zone vertical Bridgman furnace. The effect of co-doping on the scintillation properties of the crystals was studied to evaluate their potential for use as scintillation materials for radiation detection and imaging applications. Powder X-ray diffraction (XRD) data were investigated for structural characterization of co-doped CsI(Tl:Ba) crystals. The emission spectrum of grown crystal under X-rays excitation presents the wavelength of emission around 540 nm at room temperature. The

scintillation performance of grown CsI(Tl) and CsI(Tl:Ba) crystals was studied via the pulse height spectra and scintillation decay time under 137Cs gamma. The results indicated that the scintillation light yield ranged from 66,000±6,600 to 67,000±6,700 photons per MeV for Ba concentrations between 0.05 and 0.1 mol%. The primary scintillation decay time ranged from 790 to 850 ns. Moreover, the imaging application was confirmed by X-rays synchrotron at SLRI, Thailand.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

74

Conceptual Design of the High Energy Microscopy Beamline at the Korea 4th Generation Storage Ring

Author: Jae-Hong Lim[1]

Co-authors: Yong Sung Park [1]; Ki-Jeong Kim [1]; Jong Hyun Kim [1]

[1] *Pohang Accelerator Laboratory*

Korea 4th Generation Storage Ring (Korea-4GSR), a new synchrotron radiation facility planned in Ochang, Chungbuk, South Korea, will host a beamline for X-ray projection imaging and computed tomography, known as the High Energy Microscopy beamline. This beamline will use a 2-Tesla bending magnet to produce a fan beam with a critical energy of 21 keV for X-ray imaging between 5 keV and 100 keV. Monochromatization will be supported up to 40 keV, while beyond that, a polychromatic beam will be used. The sample mount will be positioned 100 m from the source, where the beam size will be 200 mm horizontally and >8 mm in full width at half-maximum (FWHM) vertically. The sample-to-detector distance can extend up to 20 m. The subtended source angle seen from the sample mount is 0.1 μrad, which limits the point spread to smaller than 2 μm along the entire sample-to-detector distance. The microscopic image formation will feature strong phase contrast, as the transverse coherence length is greater than 124 μm within the photon energy range of the beamline. Images as large as the beam size will be captured using a high aspect ratio detector made of an array of high-resolution cameras.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

Yes

75

Uniform heating of a cm-thick, dense aluminum sample with an energetic carbon ion beam

Authors: Seongmin Lee[1]; Suji Jo[1]; Woosuk Bang[1]

Co-author: Chiwan Song [1]

[1] *GIST*

In the context of heating materials, there are instances where targeted heating of specific regions is desirable, while in others, uniform heating throughout the material is desired. Among various heating mechanisms, utilizing energetic protons or ions (such as laser-driven or accelerator-driven) to transfer their kinetic energy to a dense sample offers the capability to heat the sample rapidly to high temperatures (>10,000 K). In this presentation, we will show a straightforward method to determine the ion energy spectrum required to achieve a desired temperature profile. As an example, we will show its applicability for uniform heating of a cm-thick, dense sample. With Monte Carlo simulations using SRIM and GEANT4, we find that a GeV-scale carbon ion beam can heat a 1-cm-thick aluminum sample very uniformly. We will present two distinct ion energy distributions that can achieve near-perfect uniform heating of the sample. Furthermore, we will discuss the required ion fluences to achieve temperatures beyond 10,000 K.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

No

76

A Study on absorbed energy measurement using a Photo-polymerized polymethyl methacrylate (PMMA) based Plastic Scintillator for Proton Beams Dosimetry.

Author: gwangsoo kim[None]

Co-authors: HongJoo Kim [1]; Sunghwan Kim [2]

[1] *Department of Physics, Kyungpook National University*

[2] *Department of Radiology, Cheongju University*

Radiation therapy with surgery and chemotherapy is a representative cancer treatment method in modern medicine. Recently, many kinds of research on the clinical application of hadron radiation therapy, such as proton carbon, have been performed. Moreover, various studies are being conducted to determine the absorbed dose in the volume of cancers. In this study, a dosimeter system was developed using a PMMA-based plastic scintillator to evaluate the absorbed dose of the human body during proton radiation therapy. The plastic scintillator was based on PMMA, 2,5 diphenyloxazole (PPO) was used as the primary scintillator, and 1,4-Bis(5-phenyloxazol-2-yl) benzene (POPOP) as the wavelength shifter. An Iraque 819 photo-initiator and a mercury lamp light polymerized the PMMA plastic scintillator. The energy dependence data of the 45 MeV proton beam by a plastic scintillator was acquired using the photomultiplier tube. Increasing the thickness of the aluminum degrader decreased proton energy incident to the plastic scintillator. The scintillation characteristics can be evaluated according to the proton energy. Simulation data of absorbed energy were obtained by Geant4 Monte Carlo simulation and compared with the experiment result.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

Yes

77

Design of a High-Aspect Ratio Detector for the High Energy Microscopy Beamline at Korea-4GSR

Author: YONGSUNG PARK[None]

Co-author: Jae-Hong Lim [1]

[1] *Pohang Accelerator Laboratory*

The High Energy Microscopy (HEM) beamline is a station for synchrotron radiation X-ray micro-computed tomography at the planned Korea-4GSR. It will illuminate an object at 100 m from the source with a fan beam that is 200 mm wide and 10 mm high. The X-ray projection images with an aspect ratio of 20:1 will be captured by an array detector consisting of five X-ray microscopes with a pixel resolution of less than 5 μm. The image quality of the five microscope units should be consistent for seamless image stitching. We present a detector design that aligns the microscope units to reconstruct the entire field of view.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

Yes

78

Treatment planning based on dual-layer computed tomography for carbon ion radiotherapy and dose recalculation using Monte Carlo simulation

Author: Euntaek Yoon[1]

Co-authors: Chang Heon Choi [2]; Jong Min Park [1]; Jung-in Kim [2]; Seongmoon Jung [2]

[1] *Seoul National University*

[2] *Seoul National University Hospital*

Background and Purpose:
In particle therapy, dual-energy computed tomography (DECT) is recognized for its ability to reduce uncertainty in range prediction. This study aims to establish a procedure for generating a carbon ion treatment plan using dual-layer computed tomography (DLCT), a type of DECT, and verifying it using the TOPAS Monte Carlo (MC) code.

Methods:
In this study, we utilized matRad, an open-source treatment planning toolkit. Relative electron density (ED) and effective atomic number (Zeff) images were acquired from the Philips IQon Spectral CT, a DLCT scanner. Employing a tissue decomposition method based on DECT and considering a parallel comparison pencil beam algorithm (PBA)-based dose calculation alongside MC simulation, the elemental composition and mass density of each voxel were determined. Material information specific to each pixel was then converted into relative stopping power (RSP), and an optimized treatment plan was generated using the matRad. Finally, MC dose calculations were performed using the generated plan and the image's material information. The MC simulation was executed with the TOPAS code and its in-house developed extension.

Results:
The DLCT-based carbon ion treatment plan for an abdominal cancer patient was successfully generated, and MC dose calculations were conducted. The results were compared using dose-volume

histogram (DVH) parameters. The D95 values for the plan and MC were 3.19 Gy[RBE] and 3.17 Gy[RBE], respectively, while the D5 values were 3.62 Gy[RBE] and 3.75 Gy[RBE].

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

No

79

Fabrication of clamps for preventing vacuum leakage of RF rotary joint

Authors: Sang Jin Lee[1]; Seung Wook Kim[1]; Wung-Hoa Park[1]; Hyun Kim[1]; Sang Koo Kang[1]; Kyoung Won Jang[1]; Dong Hyeok Jeong[1]; Heuijin Lim[1]

Co-author: Manwoo Lee [1]

[1] *Dongnam Institute of Radiological & Medical Sciences*

The electron linear accelerator developed by the Dongnam Institute of Radiological & Medical Sciences (DIRAMS) emits electron beams fixed in the horizontal direction. However, the vertical irradiation is also required for precise experiments in cell and small animal irradiation for preclinical research. Therefore, we design an accelerator that can change the irradiation beam direction by adding a RF rotary joint that can rotate from 0 to 180 degrees. Before proceeding with the design, the vacuum leakage of the rotary joint was evaluated. In the case of vacuum leakage, nitrogen gas was injected up to 2 bar and the leakage level over time was observed. As a result, on average, it took about 90 minutes to lose 0.5 bar and about 220 minutes to lose 1.0 bar. In order to reinforce the waveguide connection, a way to seal the rotary joint was sought. A silicone O-ring was manufactured to fit the size of the rotary joint. A clamp for fixing the O-ring was manufactured in-house, and the clamp was fixed to the rotary joint by using the top-bottom and left-right bolting methods. It was confirmed that when nitrogen was injected at 2 bar, it decreased by about 0.1 bar over 7 days. The problem with the gas leakage part has been solved and is expected to be mounted on an electron accelerator. However, there is a disadvantage that the rotary joint cannot be rotated while the clamp is installed. Further research on this part will be conducted in the future to establish an radiation irradiation system with the electron accelerator that can utilize the rotational function of the rotary joint even if the clamp is installed. (This work was supported by the Dongnam Institute of Radiological & Medical Sciences (DIRAMS) grant funded by the Korea government (MSIT). (No. 50493-2023))

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

80

Design of C-band Magnetron Test Bench

Authors: Seung Wook Kim[1]; Sang Jin Lee[1]; Sang Koo Kang[1]; Hyun Kim[1]; Wung-Hoa Park[1]; Kyoung Won Jang[2]; Dong Hyeok Jeong[1]; Manwoo Lee[1]

Co-author: Heuijin Lim [1]

[1] *Dongnam Institute of Radiological & Medical Sciences*

[2] *Dongnam Institute of Radiological and Medical Sciences*

Electron linear accelerators (LINACs) are widely used in the medical, industrial and various research fields. Since the Dongnam Institute of Radiological and Medical Science (DIRAMS) has been developing and operating several types of C-band standing-wave LINAC, the components of the LINAC had to be of high quality and operate with reliable functionality. For quality control and quality assurance for magnetrons, waveguides, pulse & heating power systems, and monitoring systems, a C-band magnetron test bench has designed and built. The test bench consists of a magnetron (5712±10 MHz), a directional loop-coupler, a 4-port circulator, three dummy loads, a rotary joint, waveguides, a water-cooling system, a high-voltage pulse modulator (50 kV, 120 A), a high-power heating system (570 VA), a control and monitoring system etc. For waveguide study, the waveguide with a port for injection of SF6 gas was fabricated using the CNC machines and brazing facility of the DIRAMS. A rotary joint capable of rotating 180 degree was connected with a dummy load and it will be studied for the RF transmission and gas shielding under the rotation. This test bench is expected to contribute improving the stability of the C-band magnetron and LINAC system to be developed by DIRAMS in the future. (This work was supported by the Dongnam Institute of Radiological & Medical Sciences (DIRAMS) grant funded by the Korea government (MSIT). (No. 50493-2023))

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

81

Enhanced Radiophotoluminescence in Silver-doped phosphate glass

Authors: JAEYOUNG CHO[1]; Hongjoo Kim[2]

[1] *KYUNGPOOK NATIONAL UNIV.*

[2] *Kyungpook National Univ.*

Commercial silver-doped phosphate glass plays a crucial role in personal, environmental, and clinical dosimetry due to its promising characteristics. These include linear radiophotoluminescence (RPL) intensity in response to ionizing irradiation doses, resistance to fading effect, data accumulation capabilities, and measurement repeatability. The composition of commercial GD-352M glass encompasses phosphate and silver, along with lithium, sodium, and aluminum to enhance its stability and properties.
This study aimed to synthesize silver-doped phosphate glass variants in the laboratory, incorporating different glass network-modifying oxides such as Na2CO3, NaBr, and NaCl. We then conducted a comprehensive comparison of their properties with those of commercial GD-352M glass. Our investigation encompassed the analysis of emission, excitation, and sensitivity properties for both synthesized and commercial glasses, both before and after X-ray irradiation.
Following X-ray irradiation, we observed a 600 nm emission peak at a 310 nm excitation peak for the synthesized glass. The sensitivity of the synthesized glass was assessed by comparing it to the sum of emission peaks.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

Yes

82

Calorimetry with low energy protons

Author: Sehwook Lee[1]

[1] *Kyungpook Natl. Univ.*

Calorimeters are the spirit of particle physics experiments. They measure the energy of particles and their characteristics. In hadron calorimetry, protons from the nuclear reaction are the dominant particles that contribute to the calorimeter signal in the energy measurement. In this talk, I will present a way to investigate the role of protons in hadron calorimetry using low-energy proton beams.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

Yes

83

Influence of low-energy ion irradiation on superconductors

Author: Soon-Gil Jung[1]

Co-authors: Chorong Kim [2]; Duong Pham [3]; Harim Jang [3]; Hye-Ran Jeon [2]; Jaekwon Suk [4]; Jung Min Lee [3]; Sunmog Yeo [5]; Tae Jong Hwang [6]; Tusong Park [3]; Won Nam Kang [3]; Yoonseok Han [3]

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[6] *School of General Education, Yeungnam University, Republic of Korea*

In general, a disorder in materials is not desirable because it prevents studying the intrinsic properties of the material. A disorder in superconductors, however, has attracted great interest for its usage to probe the mechanism of superconductivity and to control superconducting critical properties, such as critical temperature (Tc), upper critical field (Hc2), and critical current density (Jc). Low-energy ion irradiation primarily induces an atomic lattice displacement together with Frenkel defect caused by elastic scattering between injected ions and atoms in the target material. Although Tc of superconductors is suppressed with increasing the dose level, both Hc2 and in-field Jc can be improved due to the enhanced impurity scattering and flux pinning property. In this talk, we will discuss the advantages of low-energy ion irradiation in the study of superconducting properties based on various results obtained with support from KOMAC.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

84

MRTOF-MS in the RAON Mass Measurement System

Authors: Geonhee Oh[1]; Jun Young Moon[2]; Kyoungho Tshoo[3]; Taeksu Shin[None]

[1] *Institute for Rare Isotope Science (IRIS), Institute for Basic Science (IBS)*

[2] *Institute for basic science*

[3] *RISP/IBS*

Nuclear mass is important for understanding the nuclear synthesis pathways in various stellar environments, thereby having an impact on the isotope abundance data collected from astronomical observatories. The RAON (Rare isotope Accelerator complex for ON-line experiments) is deploying its state-of-the-art Mass Measurement System (MMS), specifically utilizing the Multi Reflection Time of Flight - Mass Spectrometer (MRTOF-MS), for such intricate mass measurements. Located in the ISOL beam line, our MRTOF-MS system utilizes a helium-buffer gas catcher to thermalize RI beams of low energy, under 60 keV. The system has been optimized to maintain low emittance of ion bunches, with the MRTOF analyzer achieving a high resolving power of around 100,000 in less than 10 ms. We will discuss recent updates in system optimization, specifically focusing on improvements made for RI beam transportation from the ISOL system. As we prepare for the commissioning phase, it will discuss also highlight our roadmap for the calibration and testing procedures that are forthcoming. The MRTOF-MS at RAON is poised to significantly contribute to the domains of nuclear physics, astrophysics, and fundamental symmetry tests by offering an unprecedented level of precision in rare isotope mass measurements.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

85

Design and Performance Study of Diagnostics System for a Hot-cathode Electron-gun

Authors: Sang Koo Kang[1]; Manwoo Lee[1]; Sang Jin Lee[1]; Dong Hyeok Jeong[1]; Kyoung Won Jang[1]; Hyun Kim[1]; Tae Woo Kang[1]; Seung Wook Kim[1]

Co-author: Heuijin Lim [1]

[1] *Dongnam Institute of Radiological & Medical Sciences*

The Dongnam Institute of Radiological and Medical Science (DIRAMS) has built and operates the electron LINACs for preclinical study. A diode-type thermionic electron-gun with a dispenser cathode was chosen for DIRAMS LINACs. It was designed and fabricated considering a beam current, a waist position and a beam envelope well-matching with an accelerating column. An electron-gun diagnostics system was proposed to measure beam profile according to longitudinal direction from the anode of electron-gun. This system is composed of a vacuum chamber, an electron gun support, a wire scanner, control & monitoring devices, a HV pulse modulator, and a heating power system.

The vacuum chamber can be evacuated to a high vacuum up to 10-9 torr by attaching ion pumps and also can move in the electron gun scanning direction for waist position measurement. The chamber allows to measure the distance from the cathode surface up to 30 mm. This minimum distance can be determined by the structure of gun's anode. The cathode temperature was measured by the micro-pyrometer and the CMOS camera. The wire scanner is attached to the top of the vacuum chamber at an angle of 45 degree, and the inner wire fork moves in a straight line and the wire fork has two tungsten wires in the direction of 45 degree to scan the beam profile of the X and Y axes. Electrons collected from the wires were measured using an electrometer or an current transformer, and a program to control the measuring and moving devices was implemented with LabVIEW software. The electron gun verified by the diagnostics system was integrated in the DIRAMS LINAC and the performance study is being conducted to build an advanced electron gun verification system including the Faraday-cup. (This work was supported by the Dongnam Institute of Radiological & Medical Sciences (DIRAMS) grant funded by the Korea government (MSIT). (No. 50493-2023))

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

86

Large enhancement of magnetic moment in nitridated CeFe12

Authors: Hyoungjeen Jeen[1]; Jun Kyu Park[2]; jaekwang lee[1]

[1] *Pusna National University*

[2] *Korea Atomic Energy Research Institute*

Ion implantation has been widely used for semiconductor processing because it can effectively incorporate ions into crystal lattices without severe thermal damage. In addition, the choices of ion type, beam energy and/or dose allow precise control of the depth profile and concentration. With these advantages, nitridation via ion beam is a promising method to form nitrides. In this talk, using the first-principles density functional theory calculations, we find that nitrogen atoms are selectively incorporated into particular atomic site, and then induce the strong hybridization and indirect ferromagnetic coupling between N and Fe(8f) atoms, resulting in the enhancement of ferromagnetism of CeFe12 epitaxial thin film.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

87

Tuning of thermoelectric and electrical properties of 2D materials by using ion irradiation

Authors: Hyuk Jin Kim[1]; Young Jun Chang[1]

[1] *University of Seoul*

Defect engineering in two-dimensional materials have been widely used to modify electronic, optical, and thermal properties, as well as improve devices'functionality and performance. Ion irradiation, as one of the defect engineering techniques, offers the advantage to finely tune electrical properties, implant dopants at selective region, and fabricate nanostructures by adjusting ion acceleration energy and dose. Here, we present findings on the enhancement of electrical and thermoelectric properties of 2D materials through the high energy proton and helium ion irradiation. We observed enhancements of the thermoelectric power factor resulting from an increase in the electrical conductivity at the optimal dose of 1015cm-2 and revealed that irradiation-induced selenium vacancies played an important role in changing the thermoelectric properties. To understand the irradiation-induced defects, we discuss complementary experimental analysis, such as X-ray diffraction, transmission electron microscopy, and Raman spectroscopy.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

88

Investigation of Round beam formation and Emittance exchange by applying resonance coupling in Korea-4GSR lattice

Authors: Junha Kim[1]; Jaehyun Kim[2]; Moses Chung[1]

[1] *UNIST*

[2] *Pohang Accelerator Lab (PAL)*

In the 4th generation storage ring (4GSR), the horizontal emittance is below 100 pm. In this range, scattering effects significantly increase due to the high charge density within a bunch. To address this issue, intentional coupling between horizontal and vertical motions can be applied to create a round beam. This round beam effectively mitigates scattering effects within a bunch and allows for a larger beam current compared to a flat beam. Furthermore, the round beam offers advantages for certain X-ray imaging applications due to its excellent spatial resolution.

Additionally, the dynamic aperture of the 4GSR is considerably more constrained than that of the 3rd generation storage ring (3GSR) due to stronger nonlinear effects. To tackle this challenge, the community has proposed the emittance exchange injection technique, which is based on resonance coupling within the booster ring. This approach effectively reduces the horizontal beam size during injection by fully interchanging the horizontal and vertical emittances of the beam. Consequently, this process significantly enhances injection efficiency.

We will investigate these beam manipulation schemes, primarily focusing on different resonance coupling methods, within the Korea-4GSR lattice using Accelerator Toolbox simulations.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

89

Highly charged ion extraction beamline study for the UNIST-EBIT

Author: Je Hwan Han[1]

Co-authors: Bokkyun shin [2]; Emre Cosgun [1]; Kyounghun Yoo [3]; Moses Chung [1]; SungNam Park [4]

[1] *UNIST*

[2] *PAL*

[3] *IRIS / IBS*

[4] *UNIST(Ulsan National Institute of Science and Technology)*

Highly charged ions (HCIs) are currently utilized in numerous fundamental and applied sciences, including astrophysics, dark matter search, optical clocks, semiconductor lithography, and quantum dot fabrication, to name just a few examples. At UNIST, a tabletop electron beam ion trap (EBIT) has been developed for creating and studying HCIs. The UNIST-EBIT can produce an energy-tunable electron beam up to 8 keV and compresses with 72 permanent magnets (up to 0.84 T). The UNIST-EBIT is designed to produce up to highly charged Fe ions.
Optical clocks based on HCIs have recently gained significant attention in the scientific community. HCIs have a compact electron cloud because the distance between electrons and nuclei becomes closer. This makes the energy level structure of HCIs less sensitive to external perturbations. As a result, HCIs are being studied for future optical atomic clocks with an uncertainty level as low as 10^{-19} or even lower. The UNIST-EBIT can also provide various HCIs for optical clock applications. To use EBIT as an ion source, ion-beam optics for extraction is required. To realize an optical ion clock based on HCIs, specific ions need to be re-trapped in a Paul trap at the end of the beamline. The HCI beam transmits to the end through charge selection and deceleration processes. Charge selection methods include Wien filters, electrostatic benders, and bending magnets. A deceleration system should be equipped before the re-trapped region such as the Pulsed Drift Tube (PDT). For this purpose, designing an extraction beamline along with an initial extraction experiment of Ar ions from the EBIT is underway. To extract Ar ions, we consider constructing an automatic control system with the Experimental Physics and Industrial Control System (EPICS). In this work, we present the recent progress of the UNIST-EBIT for such future experiments.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

90

Local Structural Properties of Oriented CoO Films

Authors: Cheng-Jun Sun[1]; In-Hui Hwang[1]; Jun-Ho Kang[2]; Liliana Stan[1]; Sang-Wook Han[2]

[1] *Argonne National Laboratory*

[2] *Jeonbuk National university*

Rock-salt CoO is a p-type semiconductor and its Néel temperature is close to room temperature. CoO-based compounds are known as promising systems for renewable energy harvest with high efficiency. CoO with catalytic and exchange bias properties can be widely used for industrial applications. In this paper, we report high-quality stable CoO(111) and (100) films epitaxially grown on c-cut (0001) and r-cut ($10\bar{1}2$) α-Al2O3 substrates, respectively, using radio-frequency sputtering deposition. X-ray diffraction (XRD) measurements revealed that the CoO films had a rock-salt structure (Fm3m) with lattice constants of 4.2477 Å and 4.2617 Å for film grown on (0001) and (101

¯2) α-Al2O3 substrates, respectively. CoO films with the best crystal quality were grown at a substrate temperature of ~700 oC. XRD measurements of CoO(111) films indicated a lack of structural residual strain, whereas CoO(100) films had substantial amounts of structural strain. X-ray reflectivity (XRR) and transmission electron microscopy measurements showed neither oxygen vacancy nor defects in both CoO(111) and (100) films. XRR revealed that the mean electron density of the CoO films was nearly identical to a pure CoO and that the films were considerably stable under the atmosphere.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

91

Neutron beam as an experimental probe for studying spin dynamics in high-Tc superconductors

Author: Jitae Park[1]

[1] *Technical University of Munich*

Spin dynamics is one of the key elementary excitations in a solid state matter, hosting a number of emergent quantum states such as unconventional superconductivity or a quantum spin liquid phase. One quite applicable way to investigate those magnetic fluctuations in a single crystalline compound is to utilize a neutron as an experimental probe: Comparing the energy and moment of neutrons before/after the interaction with a target sample, one can map out its magnetic dynamics throughout a wide range of energy and momentum space. In this talk, I will first introduce the most widely used neutron spectroscopy for investigating low-energy spin excitations, known as a triple-axis spectrometer and a time-of-flight spectrometer, then present comprehensive experimental data of magnetic excitation studies in the high-Tc superconductors and finally discuss its physical implication in understanding the underlying mechanism of the unconventional superconductivity.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

92

A new analytical separation method for the superposed γ-ray spectra in 68Zn(p,2p)67Cu and 68Zn(p,2n)67Ga reactions

Author: Jun Kue Park[1]

Co-authors: Myung-Hwan Jung [1]; Hye Min Jang [1]; Won-Je Cho [1]

[1] *KOMAC/KAERI*

67Cu is one of the representative radioactive isotopes that is used as theranositic radionuclide. In this talk, we introduce a new analytical peak separation analysis for superposed ¬γ-ray peaks on 67Cu and 67Ga to measure the 68Zn(p,2p)67Cu and 68Zn(p,2n)67Ga reactions. Unlike in most previous works employing a radiochemical separation to measure them, we have for the first time developed a new peak separation analysis which is enabling us to exempt the radiochemical process, thus prohibiting the uncertainty it makes. The newly developed analytical method can universally be applied to separate the superposed ¬ γ -ray spectra of any two nuclides, especially superior in separating the nuclides with different half-lives. Here, we present new cross-section data up to 100 MeV coming from this separation analysis using a 100 MeV proton accelerator that has been operating at KAERI in Gyeongju, Korea.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

93

Boron Neutron Capture Therapy in Korea

Author: Hyo Jung Seo[1]

[1] *DAWONMEDAX*

Boron Neutron Capture Therapy (BNCT) is a therapeutic approach that utilizes boron and neutrons. In the early stages of investigation, the sole source of neutrons for BNCT was a nuclear reactor. However, since 2016, DAWONSYS, Co., Ltd. and DAWONMEDAX, Co., Ltd. have collaborated with esteemed institutions such as the Pohang Accelerator Laboratory, Korea Atomic Energy Research Institute, Korea Basic Science Institute, Gachon University, and Gachon University Gil Medical Center to undertake a project titled "The Development of a Proton linear accelerator (linac) based Boron Neutron Capture Therapy (A-BNCT) System." The outcome of this project was the successful creation of a comprehensive BNCT system suitable for clinical application. The study encompassed various components, including a proton linac, a beryllium target, beam shape assembly, radiation safety and licensing, optimized facilities, boronophenylalanine (BPA) drug products, a treatment planning system (TPS), dosimetry protocols for neutron and γ-ray radiation, biological experiments, clinical protocols, and qualified test methods for system verification and validation. Notably, the Gachon University Gil Medical Center, National Cancer Center, and Seoul St. Mary's Hospital have initiated a phase I/IIa clinical trial targeting patients with recurrent high-grade glioma. Three patients have already undergone BNCT as part of this trial, and an active compassionate therapy program has been implemented, resulting in the treatment of three additional patients. Furthermore, a clinical trial focusing on head and neck cancer has recently been established.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

Yes

95

GeV-scale neutral electron-positron pair beams produced with high-energy bremsstrahlung photons

Authors: Youhwan Noh[1]; Jaehyun Song[1]

Co-authors: Mohammad Mirzaie [2]; Calin Ioan Hojbota [2]; Hyeong-il Kim [1]; Seongmin Lee [1]; Junho Won [1]; Hoon Song [1]; Chiwan Song [1]; Chang-Mo Ryu [2]; Chang Hee Nam [2]; Woosuk Bang [1]

[1] *GIST*

[2] *IBS*

Electron-positron pair plasmas, characterized by the mass symmetry of oppositely charged particles, have distinct characteristics, and they are often observed in astrophysical phenomena. In laboratory settings, these pairs have been created by irradiating high-Z converters with either direct laser pulses or laser-accelerated electron beams. In this presentation, we will show a new approach to create charge-neutral, GeV-scale electron-positron beams using bremsstrahlung gamma rays. In our recent experiment using the 4 PW laser at CoReLS, IBS, we accelerated electrons to over 2 GeV. These energetic electrons were used to generate high-energy bremsstrahlung gamma rays, which subsequently produced electron-positron pairs in a lead converter via the Bethe-Heitler process. The energy spectra of produced pairs were nearly identical throughout the entire energy range, spanning from 10 MeV to 1.8 GeV. These measurements show excellent agreement with the Geant4 Monte Carlo simulations.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

No

96

Thermal analysis of front end vacuum components for IVU24 beamline at the Korea 4th Generation Storage Ring

Authors: Seung-Nam Kim[1]; Yeong-Deok Yun[1]; Yong-Sung Park[1]; Jae-Han Kim[1]; Jae-Hong Lim[1]; Ki-Jeong Kim[1]; Hyo-Yoon Kim[1]

[1] *PAL/POSTECH*

Korea-4GSR is a 4th-generation accelerator that operates at 4 GeV and was designed to create a high energy photon source. The vacuum system of the front end is located between a storage ring and beamline. High heat load components have hence been customized to meet the requirements of beamline users and account for the thermo-mechanical limints of materials. In this study, we performed an analysis of thermal stress of the components based on finite element analysis using a constant distribution of peak power density with GlidCop Al-15 as materials.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

97

Effect of proton beam radiation on cell survival in drug resistant MCF-7 breast cancer cells

Authors: Sushma Maharjan[1]; Min-Gu Lee[1]; Kyu-Shik Lee[1]; Kyung-Soo Nam[1]

[1] *Dongguk University*

Proton beam therapy (PB) holds promise as a cancer treatment with precise targeting and minimal damage to healthy tissue. However, its effects on chemoresistant breast cancer cells remain poorly understood. This study explored PB's impact on six breast cancer cell lines: MDA-MB-231 (MDA), MCF-7 (MCF), and their doxorubicin-resistant (DR) and paclitaxel-resistant (PR) cells. Cell viability and survival were assessed via MTT and colony-forming assays. Western blot analysis provided insights into potential mechanisms. Parent cells exhibited significant survival reduction, even at low PB doses, signifying the therapy's efficacy. In contrast, drug-resistant cells displayed maximal cytotoxicity at high PB doses, suggesting a promising strategy for their targeting. Elevated p-H2AX expression in MDA, MDA-DR, and PR cells indicated PB-induced DNA damage. Remarkably, DNA repair mechanisms, represented by RAD51 and Ku80, remained largely unaffected, except for a slight increase in survivin. PB also affected cell cycle regulators (p21, cyclin D1, and cyclin B1) in all cells, while p21 disappeared in resistant cells. Apoptosis-related proteins (PARP, Bcl-xL, and BAX) remained unchanged. In MCF, MCF-DR, and PR cells, PB reduced p-H2AX in parent cells but had no effect in resistant cells. DNA repair and apoptosis-related proteins exhibited similar stability. Interestingly, PB effects on cell cycle regulators were similar to the above cells. In summary, PB impacted parent cells significantly, while resistant cells displayed cytotoxicity at high doses. Distinct DNA damage and cell cycle responses were observed without significant effects on DNA repair, apoptosis, autophagy, or necroptosis. Further research is necessary to fully comprehend these mechanisms.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

98

A Feasibility of 11C Radioisotope Production from Boron Nitride (BN) Targets for the Hadron Therapy

Authors: Jaehong Kim[1]; Youngho Park[2]; Sangrok Kim[3]

[1] *IRIS / IBS*

[2] *KRISS*

[3] *KIRAMS*

An external beam radiation therapy using a 11C radioisotope beam has been considered owing to the advantage of the PET-imaging capability and the treatment of cancers. Because radioisotope 11C is a positron emitter (half-lifetime = 20.4 min), the therapy can be combined with online PET imaging, enabling in-vivo range verification of the therapeutic radioisotopes. An isotope separation on-line (ISOL) type target system with two porous boron nitride (BN) disks can produce sufficient quantities (approximately 109 ions/s) of 11C ions. Recently, the ISOL facility, including an electron beam ion source (EBIS), has been successfully installed and has been operating at IBS. EBIS can be used for stripping electrons of radioactive carbon ions after extracting them from the BN targets.
The 11C radioisotope is produced by the nuclear reaction from the BN target with energetic protons. The proton energy range of 4–20 MeV is chosen to maximize the 11C activity and to reduce other impurities. The target operates at 1,500 ℃ to release the 11C radioisotopes from the BN disks. The production yield resulting from two 1.5-mm thick BN targets having 50 % porosity irradiated with a 20 MeV proton beam can be satisfied by applying the hadron therapy.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

99

Structured Assessment of Carbon-ion Radiotherapy in treating cancers.

Author: Eun Ho Kim[1]

[1] *Daegu Catholic University*

Carbon ion radiation therapy (CIRT) is an advanced radiation therapy (RT) commercially accessible that offers new avenues for enhancing cancer treatment and research. Because of its noteworthy physical and biological advantage, CIRT can eradicate tumor cells more effectively and extensively. Since CIRT has so far been applied to essentially all forms of malignant tumors, it has exhibited promising viability, safety, and little toxicity, proving that it promises a range of potential growth and applicability. Additionally, in an effort to bolster the biological impact of CIRT, researchers are examining related sensitizing compounds to boost their performance in eliminating tumors. As a consequence, this research has garnered a great deal of interest. I attempted a methodical assessment of CIRT's reasoning, merits, clinical uses, and sensitizing drugs. Besides offering data references and support for heavy ion therapy, I suggest that this study will assist researchers and medical doctors interested in CIRT, sensitizing drugs, and radiotherapy in better systematic and speedier comprehension of their prerogatives

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

100

Synthesis and Patterning Process of Carbon Nanomaterials by Ion-beam Irradiation

Author: Jun Mok Ha[1]

Co-authors: Young Jun Yoon [1]; In Mok Yang [1]; Yong Seok Hwang [1]; Chan Young Lee [1]; Jae Kwon Suk [1]; Jun Kue Park [1]; Sunmog Yeo [1]

[1] *KOMAC/KAERI*

A fantastic two-dimensional (2D) carbon material, graphene, has recently attracted remarkable attention due to its wide range of possible applications in transistors, supercapacitors, gas sensors, solar cells, and flexible displays. Because of its promising potential applications, not only graphene but also graphene based nanostructures such as graphene nanoribbons and epitaxial graphene have been also widely studied. Graphene quantum dots (GQDs) which indicate graphene sheets less than tens of nanometer attracted researchers because they exhibit unique optical and electronical properties due to quantum confinement and edge effects. GQDs have many advantages compared with other carbon nanomaterials because they have outstanding biocompatibility, low toxicity, good solubility, and high surface area which lead them to have versatile applications: sensors, bio-imaging, drug delivery, and photo-catalysts.
Generally, GQDs are formed through top-down approaches by cutting, exfoliation, and cage-opening carbonic precursors such as graphite, graphene, graphene oxide, fullerenes, and carbon fiber, into smaller pieces using chemical methods. The methods have their unique advantages, but they typically require the use of strong oxidants (such as KMnO4 and KClO3) and acids (such as H2SO4, HNO3, and HCl) which limited GQDs (synthesized by conventional chemical methods) to apply to

utilization in bio-fields. Furthermore, currently, there is still no universal approach for the preparation of GQDs without byproduct and well-size and property controlled GQDs.
Here, we present a study on synthesis and patterning process of carbon nanomaterials by ion-beam irradiation. Ion-beam irradiation is a simple and convenient route to highly pure GQDs. After fabrication of GQDs, only GQDs remained without any impurities and byproducts. Moreover, this approach provides a simple way to pattern GQDs by irradiating Fe ions on the selected region.

Acknowledgement
This work has been supported through National Research Foundation (NRF) of Korea (No. 2018R1D1A1B07050951) and KOMAC operation fund of KAERI by MSIT (Ministry of Science and ICT).

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

No

101

The Facility for Rare Isotope Beams: Technologies and First experience of Beam operation

Author: Ting Xu[1]

[1] *FRIB/MSU*

Upon its completion in early 2022, the Facility for Rare Isotope Beams (FRIB) established itself as the leading rare isotope user facility. The achievement of this status was made possible through the innovation and implementation of various cutting-edge technologies during the facility's design, construction, and commissioning phases. These technologies encompassed a state-of-the-art superconducting linear accelerator for heavy ions, a high-power liquid lithium charge stripper, and the ability to simultaneously accelerate multiple charge states, a high-powered production target, and a three-stage fragment separator.
This presentation will delve into the technical development efforts during the technical construction. Furthermore, it will cover the initial two years of operational experience on hardware performance and the advancements in beam development for the successful delivery of rare isotopes.

Work supported by the US Department of Energy Office of Science under Cooperative Agreement DE-SC0000661 and DE-SC0023633

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

105

Proton Therapy: Present Advancements and Future Innovations

Author: Youngyih Han[1]

[1] *Samsung Medical Center*

Ab beams have been utilized in cancer treatment for over 32 years, and numerous technological advancements have been made to enhance clinical outcomes by delivering more accurate and conformal doses to target cancer cells while minimizing exposure to normal tissues. State-of-the-art intensity-modulated proton therapy is currently the prevailing treatment technique in proton facilities worldwide, and the number of proton therapy facilities has seen rapid growth in recent years. Therefore, in this talk, we will review the current advancements in proton therapy techniques and forecast the emergence of new technologies.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

106

Basic research on controlling gas permeability and changing antimicrobial properties of metal ion implanted polymers

Author: Chan Young Lee[1]

Co-authors: JaeKeun Kil [2]; BomSok Kim [2]; ChoRong Kim [3]; JaeKown Suk [3]; InMok Yang [3]

[1] *KAERI*

[2] *RADPION*

[3] *KAERI(Korea Atomic Energy Research Institute)*

A basic study was conducted on the control of gas permeability and application of antimicrobial materials by comparing copper (Cu+) ion implantation treatment before and after. Polycarbonate samples were irradiated with copper ion beams at 50 keV, 1×10^15 #/cm^2, and 1×10^16 #/cm^2, and the antimicrobial properties were tested before and after ion implantation treatment.
As a result of the copper ion implantation treatment, the gas permeability was significantly reduced, and the antimicrobial test confirmed that the reduction rate was 99.9% to <10 CFU/mL after 24 hours in the 50 keV, 1×10^16 #/cm^2, condition, and the antifungal test result for the 50 keV, 1×10^15 #/cm^2 condition confirmed that the result was reduced to “0” after 4 weeks.
Through this study, we have secured results on the antibacterial properties of polymers using copper ion implantation method, and in the future, we will check whether ion implantation with other metals (Mg, Ti, Cr) that do not have antibacterial properties shows antibacterial properties.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

107

Visualizing quantum materials using hard x-ray techniques

Author: Seo Hyoung Chang[1]

[1] *Department of Physics, Chung-Ang University*

Quantum materials originated from electron-electron correlation have been intensively investigated due to their scientific interests. Many researchers have tried to search for new insight and intriguing material systems, such as antiferromagnet-based spintronics and energy conversion in transition metal oxides. Here, we introduce an experimental approach based on resonant x-ray scattering [1-3]. Using the techniques, we systematically investigated emergent properties of quantum materials, e.g., ruthenate and iridate. Our studies also can offer a comprehensive understanding based on the theoretical calculations combined with advanced hard x-ray scattering techniques. Moreover, we were able to visualize structural and (anti)ferromagnetic domains of thin films and single crystals. We propose that the techniques combined with electric field can explore and create new phases and emergent physical properties.

[1] T. Choi et al., Adv. Mater. 34 2200639 (2022)
[2] B. Sohn et al., Phys. Rev. Res. 3 023232 (2021)
[3] G. Kwon et al., ACS Catal. 11 10084 (2021)

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

No

108

Accelerator-Based Radioisotope Production Facility at KOMAC

Authors: Jun Kue Park[1]; Jae Sang Lee[1]; Hyeok-Jung Kwon[1]

[1] *KOMAC/KAERI*

In this talk, we introduce the facilities operating at KOMAC. Recently, a 100 MeV proton accelerator has been trying to expand its application for radioisotope production, as well as the radiation hardness test for semiconductors. Among various applications, we here focus on the radioisotope production facility that is now being developed for theranositic radionuclides such as 67Cu and 64Cu. Further, we address a recent study for a new peak separation analysis for superposed ¬ɣ-ray peaks on 67Cu and 67Ga to measure the 68Zn(p,2p)67Cu and 68Zn(p,2n)67Ga reactions. The new peak separation analysis enables us to exempt the radiochemical process, thus prohibiting the uncertainty it creates. We present new cross-section data up to 100 MeV obtained from this separation analysis using a 100 MeV proton accelerator.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

109

The baseline of the radiation safety for the RAON accelerator

Author: Danhye Gil[1]

Co-authors: Beomyeol Baek [2]; IN-SEOK HONG [1]; JongWook Kim [1]; Kyung-Ha Jo [1]; keun-soo yang

[1] *IBS*

[2] *Institute for Basic Science*

RAON is high-energy hadron machine that can accelerate uranium ions. Because Korean researcher and nuclear safety government have never experience this machine, it needs profound study for radiation safety. High power targets such as 400kW(200MeV/u) of the IF and up to 50kW(70MeV for protons) of ISOL are used. These targets can induce high activation in concrete, air, cooling water, machine parts and need robust remote handling in target areas. Especially, use of uranium material can induce fission products which contaminate ISOL target system and IF beam dump. It needs a long-term storage space of the solid radioactive wastes until ready to transfer to the national disposal site due to generation of radioactive waste containing actinides. We studied various reactions with beams and targets to be analyzed. It needs to find correct simulation codes and conditions.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

110

The radiation monitoring system (RMS) for the RAON accelerator

Author: JongWook Kim[1]

Co-authors: Beomyeol Baek [2]; Danhye Gil [1]; IN-SEOK HONG [1]; Kyung-Ha Jo [1]; keun-soo yang

[1] *IBS*

[2] *Institute for Basic Science*

The radiation monitoring system (RMS) is a system that systematically monitors the level of residual radiation from a radiation facility or device, contamination such as radiation generated by the operation of an accelerator, and air or wastewater discharged outside the facility. RMS includes a gas and liquid radioactivity monitoring system that monitors the concentration of radioactivity in exhaust and drainage discharged outside the facility and the concentration of radioactivity in the working space inside the facility. It consists of a regional radiation monitoring system that monitors the spatial dose rate in the heavy ion accelerator facility and an environmental radiation monitoring system that monitors the radiation level in the boundary area of the facility. The heavy ion accelerator's RMS does not exceed the radiation worker's dose limit inside the facility and manages the dose at a limit of 10 mSv per year. Continuous monitoring is carried out to sustain below the dose limit and the emission limit of radioactive materials for the public at the site boundaries of the facility.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

111

The personal safety & interlock system (PSIS) for the RAON accelerator

Author: Beomyeol Baek[1]

Co-authors: Danhye Gil [2]; IN-SEOK HONG [2]; JongWook Kim [2]; Kyung-Ha Jo [2]; keun-soo yang

[1] *Institute for Basic Science*

[2] *IBS*

The personal safety & interlock system (PSIS) is one of the main safety facilities in the operation of the heavy ion accelerator, and is a safety device system to ensure the safety of radiation workers as well as other visitors from abnormal operations and accidents. PSIS provides the central control center with a function to monitor the accessibility and operation of the entrance in connection with the radiation monitoring system, control and monitoring system, and the high-level radiation area is operated in free access mode, restricted access mode, and prohibited mode.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

112

Development and Status of the In-Flight Fragment Separator of RAON

Author: Jang Youl Kim[1]

Co-authors: Chong Cheoul Yun [1]; Do Gyun Kim [1]; Eunhee Kim [1]

[1] *Institute for Basic Sceince*

The Rare isotope Accelerator complex for ON-line experiments (RAON) is a heavy ion accelerator facility that provides both stable and rare isotope (RI) beams for basic and applied science research. The in-flight fragment (IF) separator of RAON is under development as a key device for RI beam production. In order to efficiently produce RI beams by using in-flight fission of uranium beams as well as projectile fragmentation reactions, the IF separator is designed to have angular acceptance and momentum resolution of ±40 mrad and ±3%, respectively. The IF separator consists of a target, beam dump, magnets, and detector systems. The high-power target and beam dump for the 80 kW primary beam were fabricated using graphite. The IF magnet system consists of a total of 8 dipole magnets, 15 sets of quadrupole magnet triplet, 2 sextupole magnets, and power supply systems. Fabrication and field installation of the IF magnet system has been completed. In addition, detectors for particle identification (PID) and data acquisition (DAQ) systems were installed at the focal planes of the IF separator. The development status of IF separator is briefly introduced.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

No

113

Recent progress of Nuclear Data Production System at RAON

Authors: Cheolmin Ham[1]; Kyoungho Tshoo[2]; Sangjin Lee[3]; Seong Jae Pyeun[4]; Kwangbok Lee[5]; C. Akers[6]; Mijung Kim[2]; Jae Cheon Kim[3]; Minsik Kwag[4]; Donghyun Kwak[None]; Dong Geon Kim[7]; CheongSoo LEE[3]; Jaesung Kim[8]; Youngouk LEE[9]; Taeksu Shin[None]; Seung-Woo Hong[10]

[1] *Institute of Basic Science*

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[3] *IBS*

[4] *RISP, IBS*

[5] *RISP*

[6] *IRIS/IBS*

[7] *Hanyang University*

[8] *Institute for Basic Science*

[9] *KAERI*

[10] *Institute for Rare Isotope Science, IBS*

A fast neutron facility, called Nuclear Data Production System (NDPS), was constructed for nuclear science and applications at RAON (Rare Isotope Accelerator complex for ON-line experiments) in Korea. NDPS provides neutron beams not only for nuclear data measurements but also for other applications. NDPS is designed to provide both white and mono-energetic neutrons, using 98 MeV deuteron and 20 –83 MeV proton beams with a thick graphite and thin lithium targets, respectively. Neutron energy is determined by employing the time-of-flight (TOF) technique, along with a pulsed deuteron (or proton) beam with a repetition rate of less than 200 kHz. Fast neutrons are produced in the target room and are guided to the TOF room through a 4 m long neutron collimator consisting of iron and 5 % borated polyethylene. In the TOF room, a gas-filled Parallel Plate Avalanche Counter (PPAC) with a Th-232 layer and EJ-301 liquid scintillation detectors are installed to measure the neutron flux. The beam commissioning for NDPS is scheduled for 2024. The recent progress of NDPS will be reported, together with our plan.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

114

Design for HEBT vacuum system of the RAON

Author: Hyungjoo Son[1]

[1] *Institute for Basic Science*

The heavy ion accelerator is an experimental facility that can generate various rare isotopes by accelerating heavy ions, from protons to uranium. The beam that accelerates heavy ions and passes through the high-energy transmission section (HEBT) is designed to obtain beam energy (200 MeV, beam output 400 kW). The Institute for Rare Isotope Science (IRIS) successfully transmitted the Ar+9 beam to the KoBRA facility, a low-energy experiment facility, in November 2022. The beam that passes through the low-energy acceleration section SCL3 is delivered to the high-energy experiment facility through the high-energy acceleration section (SCL2) and the HEBT section. The high-energy acceleration section and HEBT section are scheduled to be built through a second-stage R&D project. In this paper, the vacuum system design of the HEBT section is discussed.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

115

Utilization of proton beams at KOMAC for testing prototype detectors

Author: Sanghoon Lim[1]

[1] *Pusan National University*

The proton accelerator facility at KOMAC is actively used in various research and has many potential applications. One application of proton beams is to test prototypes of particle detectors for experiments of particle and nuclear physics, such as the LAMPS experiment at RAON and the ALICE experiment at the LHC. However, due to the large irradiation area and high beam intensity, it is challenging to utilize the proton beams for testing particle detectors, which usually require evaluating the performance of single particles. To do that, collimators and shields can be used to reduce the size of proton beams and neutron background produced from the interaction between beams and the collimator. Additional studies with targets will also be helpful to utilize scattered protons to reduce the rate further. An extensive Monte Carlo simulation study using GEANT4 has been performed to optimize the experimental setup for primary and scattered protons. In this presentation, testbeam using proton beams at KOMAC for testing prototypes of particle detectors and related simulation studies will be introduced.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

Yes

116

Beam dynamics study for achieving the leading performance of compact UED machine

Author: Ji-Gwang Hwang[1]

[1] *Gwangneung-Wonju National University*

X-ray Free Electron Laser essentially demands a kilometre-long linear accelerator for obtaining high-brilliance hard X-ray, however, a recently proposed compact UED machine which uses electron beams as probes can achieve the goal at laboratory-scale apparatuses. Various approaches have been studied to achieve optimal performance in UEDs that utilize normal-conducting or superconducting cavities. In this presentation, we summarize various methods proposed in previous studies and propose our new method.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

117

Present Status of Linear IFMIF Prototype Accelerator (LIPAc) and Future Plans

Author: Kai Masuda[1]

[1] *National Institutes for Quantum Science and Technology*

The Engineering Validation and Engineering Design Activities for the International Fusion Materials Irradiation Facility (IFMIF/EVEDA) are being pursued under the Broader Approach agreement between EURATOM and the Japanese government. Since the IFMIF requires an accelerator with unprecedented performances to provide D+ beams of 40 MeV, 125 mA (x2 lines) in CW, the feasibility is being tested with the Linear IFMIF Prototype Accelerator (LIPAc), which is under commissioning in Rokkasho, Japan within the EU-JA collaborative framework. The LIPAc consists, in its final configuration, of a 100 keV injector and the world longest 5 MeV RFQ accelerator, followed by re-buncher cavities and an HWR-SRF linac, ending in a Beam Dump designed to stop the world highest deuteron current of 125 mA CW at 9 MeV. In the course of stepwise installation and beam commissioning of the LIPAc, the present beam commissioning phase aims at validations with 125 mA D+ beams at 5 MeV from the RFQ before installation of the SRF Linac. This paper will present the status and recent results from the LIPAc beam commissioning and the future plans.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

118

LINAC-driven epithermal neutron beam for boron neutron capture therapy

Author: Young-soon Bae[1]

[1] *DawonMedax*

Boron neutron capture therapy (BNCT) has been attractive radiation cancer therapy as a new radiation modality because it can selectively destroy cancer cells while maintaining the healthy state of surrounding normal cells. Many clinical trials have demonstrated significant BNCT treatment efficacy using neutron beams from research reactors in early BNCT clinical studies. However, nuclear reactor technology cannot be scaled to sites in hospitals delivering patient treatment. Therefore, compact accelerator-based neutron sources that could be installed in many hospitals are under development or have even been commissioned at many facilities around the world. DawonMedax (DM) developed a 10 MeV, 20 kW radio-frequency (RF) LINAC-based neutron system for BNCT, and it is installed and under operation for human clinical trials in Songdo, Incheon. It provides the highly efficient production of an epithermal neutron beam with an optimized neutron energy spectrum range of 0.5 eV ~ 10 keV from a 10-MeV and 20-kW proton beam and the beryllium target. The epithermal

neutron flux is higher than 1 x 10^9 n/cm^2s at the irradiation port after neutron beam moderation by beam shaping assembly (BSA). Further, during exposure to epithermal neutrons, all other unintended radiation is controlled to levels recommended by International Atomic Energy Agency (IAEA). So far, we treated total nine patients having recurrent malignant gliomas in brain for the dose limited toxicity (DLT) clinical phase including compassionate treatments. This paper presents the characteristics and key technologies of DM LINAC-driven neutron source for BNCT and preview of clinical results.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

119

Optical Dosimetry of 100 MeV Proton in KOMAC using PMMA Scintillator

Author: Sunghwan KIM[1]

Co-authors: Gwangsoo KIM [2]; Hong Joo KIM [2]

[1] *Cheongju University*

[2] *Kyungpook National University*

Proton beam therapy garners significant attention in cancer treatment due to its ability to concentrate radiation on cancer cells, providing superior spatial dose distribution compared to X-ray therapy. The main advantage of proton beams lies in their characteristic Bragg Peak, which occurs when the medium absorbs the protons. Because of the Bragg peak, the radiation dose to normal tissues surrounding the cancer is reduced. In proton beam therapy, evaluating the absorbed dose and the maximum range of the proton beam is very important. In this study, a tissue-equivalent plastic scintillator based on PMMA was developed for optical radiation dosimetry. This scintillator was used to evaluate the maximum range, dose distribution, and other parameters of the proton beam. The 100 MeV proton beam from KOMAC was digitized using an optical camera to capture the luminescence phenomenon in the plastic scintillator. The images were then corrected for geometric deformation, vignetting, and dose calibration. Image analysis was performed using ImageJ 1.52a, and energy dependence, range analysis, and dose evaluation of the PMMA scintillator were determined. Furthermore, this system has the advantage of providing 2D visualization of individual radiation fields, with potential application for quality assurance of complex, time-varying fields. This makes it an invaluable tool in modern radiation therapy, where precision and accuracy are paramount.

Acknowledgements
This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Ministry of Science and ICT (MSIT) (NRF-2021R1F1A1059687), and thanks to the staff of the KOMAC for the excellent operation and their support during the experiment.

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Reference
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[2] Fukushima Y, Hamada M, Nishio T, et. al., Development of an easy-to-handle range measurement tool using a plastic scintillator for proton beam therapy. Phys Med Biol. 2006; 51: 5927–36.
[3] Ponisch F, Archambault L, Briere TM, et. al. Liquid scintillator for 2D dosimetry for high-energy photon beams. Med Phys. 2009; 36: 1478–85.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

Yes

120

Current status of SNUH Heavy Ion Treatment Gijang Center

Author: Kyung Su Kim[1]

[1] *Seoul National University Hospital*

The Seoul National University heavy ion treatment Gijang Center is currently in progress with the goal of initiating patient treatment in 2027. This project is a joint effort involving the Ministry of Science and ICT, the National Research Foundation, Busan City, Gijang-gun, and Seoul National University Hospital. The goal of our project is research and treatment of intractable cancer, establishment of basic research infrastructure, and training of professional personnel. Therefore, we aim to improve the national medical welfare and quality of life by developing heavy ion treatment technology for incurable cancer.
SNUH contracted with Toshiba and DK Medical consortium to install the heavy ion medical accelerator on August 31, 2020. We plan to begin construction on an additional building for the rotating gantry in this year.
The heavy ion therapy system is a fully integrated system for the clinical delivery of heavy ion beam therapy using carbon and helium ions. The heavy ion therapy system has been operating a maximum 430 MeV/u (carbon), 230 MeV/u (helium) accelerator and peripheral systems such as two injector, beam transport system and clinical delivery room. The system supports fast pencil beam scanning delivery method in the compact superconducting rotating gantry room and fixed treatment room. In addition, it has a plan to be used for research purpose. It is hoped that the introduction of the heavy ion therapy system will greatly help treat cancer patients in Korea.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

No

121

Engineering Design of a 350 MHz Radio-Frequency Quadrupole for KOMAC

Author: HAN SUNG KIM[1]

Co-authors: Dae-Il Kim [1]; Dong-Hwan Kim [1]; Hyeok-Jung Kwon [1]; Seung-Hyun Lee [1]

[1] *KOMAC, KAERI*

A 350-MHz radio-frequency quadrupole (RFQ) is used for the proton beam bunching, focusing, and initial acceleration up to 3 MeV in KOMAC 100-MeV linac. The currently used one was developed in 2003 and has been operated for about twenty years. Due to the aging problem, especially the electrode surface damage from arcing, the RFQ showed a gradual decrease in beam transmission efficiency. Therefore, we decided to develop a new RFQ to replace the old one. The basic design

parameters were based on the existing one and determined by the PARMTEQ and the SuperFish code. A full 3-dimensional RFQ model was produced, and the electromagnetic field analysis was performed using the CST Studio Suite. The details of the design study on the new RFQ will be given in this presentation.

This work was supported through KOMAC operation fund of KAERI by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIT) (KAERI-524320-23).

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

122

Status of the RAON heavy ion accelerator

Author: Yeonsei Chung[1]

[1] *IRIS/IBS*

RAON is a heavy ion accelerator facility in Korea that focuses on rare isotope science by producing and accelerating Rare Isotope Beams (RIBs). The facility produces a variety of RIBs using both In-Flight (IF) Fragmentation and Isotope Separation On-Line (ISOL) methods. RAON's main feature is that it can produce more exotic RIBs by combining ISOL and IF methods. The IF system is driven by a superconducting Linac to accelerate heavy ions. The ISOL system, on the other hand, is driven by a 70 MeV proton cyclotron. After more than 10 years of construction, the low-energy superconducting Linac has been successfully commissioned. And the ISOL system for RIB production was also commissioned.
In this conference, we will present the current status of the RAON heavy ion accelerator, including the results of low-energy superconducting Linac beam commissioning and RIB production results of the ISOL system.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

123

Therapeutic effect of a proton beam on metastasis and survival and its mechanism of action in various cancer cells

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Proton beam therapy is an advanced radiotherapeutic tool. However, its mechanism of action on metastasis and survival in cancer cells has not been fully elucidated. Therefore, we evaluated the effect of a proton beam on metastasis and survival and revealed its mechanism of action. First, we investigated the effect of a proton beam on metastasis in cancer cells. The result showed that the proton beam inhibited 12-O-tetradecanoylphorbol-13-acetate (TPA)-induced metastatic potential in breast cancer cells and hepatic cancer cells. Furthermore, the proton beam down-regulated the TPA-induced expression of cyclooxygenase-2 (COX-2) and the phosphorylation of Akt, JNK and NF-□B in breast cancer cells, demonstrating the suppression of metastatic potential through inhibition of the Akt/JNK/ NF-□B axis pathway. Next, we assessed the effect of proton beam irradiation on cell survival in hepatic cancer cell and pancreatic cancer cells. We observed that the proton beam irradiation induced G2/M cell cycle arrest at both 24 h and 48 h post-irradiation. Additionally, we found the induction of p-H2A.X and p21 expression, along with an increase in ERK and p38 phosphorylation in HepG2 hepatocellular carcinoma cells. Moreover, colony forming assay showed a significant decrease in HepG2 cell colonies following proton beam irradiation in a dose-dependent manner, indicating that the cell cycle arrest led to cell death. In addition, we analyzed biological response in Capan-1 and Panc-1 pancreatic cancer cells against proton beam irradiation. The result showed that Capan-1 cells were more sensitive to proton beam than Panc-1. However, the increases in p-H2A.X and p21 expression were observed in both Capan-1 and Panc-1 cells, implying that p-H2A.X and p21 did not contribute to determining the sensitivity to proton beam. In addition, RAD51 expression in Capan-1 cells was decreased dose-dependently following proton beam irradiation, but the effect was not observed in Panc-1 cells. In contrast, survivin transcription was significantly upregulated by proton beam in Panc-1. The results suggest that RAD51 and survivin are potent markers for determining sensitivity to proton beam irradiation. Taken together, although the mechanism of action of proton beam may vary depending on the type of cancer cells, present investigation evidence that proton beam therapy is an effective radiotherapy approach with anti-metastatic effects in cancer.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

124

Design study of Scanning Magnets for FLASH Proton Therapy

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[1] *National Cancer Center Korea*

[2] *Pohang Accelerator Laboratory*

[3] *Hanyang University*

FLASH radiotherapy, a technique that irradiates tumors with a beam having a very high dose rate (> 40 Gy/s) compared to the conventional beam (~ 0.1 Gy/s), is currently undergoing extensive research for clinical application. However, using the pencil beam scanning (PBS) method to irradiate human organs with a FLASH proton beam presents challenges. Specifically, the PBS nozzle at the National Cancer Center Korea (NCCK) faces significant limitations in scanning speed and field size. Designing a new PBS nozzle for FLASH is therefore crucial to address these challenges, especially the need for rapid scanning and irradiation of larger field areas. To ensure its practical application, the nozzle was designed for compatibility with the NCC cyclotron's experimental beamline. We present beam optics calculations, magnet modeling, field analysis, and 3D tracking. According to beam optics calculations, the scanning nozzle can produce proton beams with spot size ranging from 4 to 10 mm (1 σ) at the isocenter. To cover a 16 cm × 16 cm area, the scanning magnets have pole gaps of 5 cm in the x direction and 10 cm in the y direction, respectively. The scanning magnets achieve maximum field inductions of 0.139 T and 0.152 T, respectively, with good field ratios of 91.12 % and 76.36 % within a 0.5 % difference limitation. In terms of scanning speed, we determined scanning speed of 96

m/s (crossline) and 9.6 m/s (inline), which are faster than current NCC PBS nozzle scanning speed of 21 m/s (crossline) and 3 m/s (inline). Furthermore, 3D tracking confirmed that the scanning magnets effectively cover the designated scanning area.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

125

On-site Installation for SCL3 Cryomodules

Author: Yangho Lee[1]

Co-authors: Chuljin Choi [2]; Jongwan Choi [2]

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[2] *Institute for Basic Science*

The superconducting accelerator, RAON is a heavy ion accelerator composed of a series of cryomodule(CM) and warm section(WS). The low-energy section such as SCL3 consists of QWR type CM 22 units, HWR-A type CM 13 units, and HWR-B type CM 19 units. Each warm section consists of a pair of quadrupole magnets, a vacuum chamber (or beam diagnostic chamber, CM#1~6), and a beam transfer pipe. In particular, lifting and moving bulky CMs is very careful and difficult due to the narrow work space and long distance during the installation process, but it is also the most important and challenging task in our project. we considered several ideas for a CM mobility, including commercial delivery carts, transport vehicles and air caster equipment, but due to site conditions (size & space), cost and delivery schedule, they could not be applied. Therefore, among several alternatives considered, we decided to carry out the manual work ourselves using assistant wheels and heavy-loads casters by our internal team consist of researchers and engineers. For expecting successful and efficient work performance, although it was a difficult decision due to our lack of previous installation experience, we chose a simple and intuitive method with safety as the top priority. First half in this presentation, we sequentially describe the entire beam-line installation process for delivery-seating-interconnection-alignment-vacuum of Heavy CM combined with WS in SCL3 tunnel. and the second half show you how to move lots of heavy CMs using auxiliary devices. As a result, the installation tasks were successfully accomplished without any delay or safety issues and with significant cost savings.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

126

Scintillation characteristics and proton response of NaI:Tl crystals grown by Vertical Gradient Freeze method

Author: Lam Truc[None]

Co-authors: Hongjoo Kim [1]; Thanh Luan Nguyen [2]

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NaI:Tl are widely used in various radiation detection and imaging applications. It has high light output and fast decay time, making it ideal for use in high energy physics experiments, nuclear medicine imaging, and gamma-ray spectroscopy. The required size of the crystal for those purposes is usually between three to five inches in diameter. Despite various methods of growth being used, they have shown a number of limitations when grow big size crystal. To effectively avoid these problems, Vertical Gradient Freeze (VGF) method is a reasonable approach because of its simplicity and the stationary state of the crystal in the growth process. In this study, the luminescence properties and proton response of NaI: Tl grown by a self-developed VGF furnace were investigated as evidence of the performance of the method.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

127

Characteristics of radiography system based on CMOS camera

Author: Duc Ton Nguyen[1]

Co-authors: D. Joseph Daniel [2]; Hongjoo Kim [3]

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[2] *Department of Physics, Kyungpook National University*

[3] *Kyungpook National Univ.*

Recently, radiography has received considerable attention for its novel applications in homeland security, science, and related fields. This report outlines the characteristics of a radiographic system developed from a digital camera. The system was built using the Raspberry Pi HQ camera and optical elements, while thin films were prepared as scintillation screens and then tested with ambient light/X-ray beam. Using the Slanted-Edge methodology, the Edge/Line Spread Functions were deduced, which enabled extracting the Modulation Transfer Function (MTF). In addition, Noise Power Spectrum (NPS) was extracted and then allowed to estimate the Detective Quantum Efficiency (DQE). The obtained results show that the developed system would be used to resolve objects up to 150 lp/mm in ambient light. This suggests that the system has promising applications in scientific and medical fields, where high-resolution imaging is often required. We plan to study the imaging with the proton beam at KOMAC in the near future.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

128

Efficient X-ray Shielding Using Metal-Organic Framework and Bismuth Halide Composites

Authors: Nazmul HOSSAIN[1]; Junghwan KIM[1]

Co-authors: Dae-Seong KWON ; Seok-Gyu KANG ; Shanmugam MAHALINGAM [1]

[1] *Pukyong National University*

X-ray is one of the most widely utilized radiations in medical diagnosis, therapy, industrial inspection, and academic research. However, long-term exposure to X-rays can cause fatal effects on humans such as cancer. In this work, we have successfully developed efficient X-ray shielding materials by compositing gadolinium (Gd)-based metal-organic framework (MOF) and bismuth iodide. The Gd-MOF and bismuth iodide formed an intimate interface and composites, thereby resulting in a high attenuation cross-section for X-ray radiation. Consequently, the developed materials exhibited highly efficient X-ray attenuation. In addition, they are also lightweight, flexible, and environmentally friendly.
Keywords: Gd-MOF, Bismuth Halide, radiation, X-ray shielding.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

No

129

Lightweight and efficient X-ray-shielding materials using sulfated cerium oxide and bismuth halide composites

Authors: Junghwan Kim[1]; SHANMUGAM MAHALINGAM[1]

Co-authors: Dae-Seong Kwon [1]; Seok-Gyu Kang [1]

[1] *Pukyong National University Busan, Republic of Korea*

Lead is the most widely used X-ray-shielding material, but it is heavy (density ≈ 11.34 g/cm3) and toxic. Therefore, the replacement of Pb with lightweight, ecofriendly materials would be beneficial, and such materials would have applications in medicine, electronics, and aerospace engineering. However, the shielding ability of Pb-free materials is significantly lower than that of Pb itself. To maximize the radiation attenuation of non-Pb-based shielding materials, a high-attenuation cross-section, normal to the incoming X-ray direction, must be achieved. In this study, we developed efficient X-ray-shielding materials composed of sulfated cerium oxide (S-CeO2) and bismuth halides. Crucially, the materials are lightweight and mechanically flexible because of the absence of heavy metals (for example, Pb and W). Further, by pre-forming the doped metal oxide as a porous sponge matrix, and then incorporating the bismuth halides into the porous matrix, uniform, compact, and intimate composites with a high-attenuation cross-section were achieved. Owing to the synergetic effect of the doped metal oxide and bismuth halides, the resultant thin (approximately 3 mm) and lightweight (0.85 g·cm−3) composite achieved an excellent X-ray-shielding rate of approximately 92% at 60 kV, one of the highest values reported for non-heavy-metal shielding materials.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

No

130

X-ray and Proton Beam Induced Luminescence in Tb doped Phosphate Glasses

Authors: Amos V. Ntarisa[1]; Duy Quang Nguyen[2]; Faizan Anjum[2]; Hongjoo Kim[3]; Jik lee[4]; Saha Sudipta[5]; Thanh Luan Nguyen[2]

[1] *Department of Mathematics, Physics and Informatics, Mkwawa University College of Education, Iringa, Tanzania*

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In this study, we investigated phosphate glasses doped with terbium (Tb) ions with the composition 56P2O5:30Na2O3:5Al2O3:8Gd2O3:1Tb4O7 under both proton and X-ray beam excitation. These glasses were prepared using the melt and quench method. Scintillation properties were examined under X-ray and proton beam irradiation and compared. Under both types of irradiation, we observed two major emission peaks corresponding to the transitions 5D3 ⟶ 7FJ (at 480–510 nm, blue region), 5D4 ⟶ 7FJ (at 535–565 nm, green region). The dominant green emission is attributed to the presence of Tb^{3+} dopants. Notably, after X-ray irradiation, a change in the sample's color was observed, suggesting a potential limitation in the radiation hardness of Tb-doped phosphate glass. To explore the reversibility of this change, we conducted an annealing process. Furthermore, we examined the transmittance spectra to gain insights into the absorption characteristics of these glasses and investigated the photoluminescence properties before and after irradiation. Our results highlight the unique properties of Tb-doped phosphate glasses, making them valuable materials in various applications, including radiation physics and medical physics. These glasses find potential use in radiation detectors, dosimetry, radiography, biomedical imaging, and other related fields.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

131

Development of magnet system for the In-Flight Fragment Separator of RAON

Author: Do Gyun Kim[1]

Co-authors: Chong Cheoul Yun [2]; Jang Youl Kim [2]; Sukjin Choi [1]; Yonghwan Kim [3]

[1] *Institute for Basic Science*

[2] *Institute for Basic Sceince*

[3] *RISP*

An in-flight fragment (IF) separator for the heavy ion accelerator facility RAON (Rare isotope Accelerator complex for ON-line experiments) is under development. IF separator is a key device for producing rare isotope beams for nuclear science research and applications. The IF separator consists of a target, beam dump, magnet system and detector system. The IF magnet system consists of 8 dipole magnets, 6 quadrupole magnets, 13 sets of quadrupole magnet triplet, 2 sextupole magnets. High field and large aperture quadrupole magnets are required to accommodate the high angular acceptance of the IF separator, for which low and high temperature superconducting (LTS and HTS) magnets are used. In the high radiation region near the IF target and beam dump, warm iron HTS quadrupole magnets are used to reduce the cold mass and effectively remove large radiation heat loads at ~40K. In the other region, cold iron LTS quadrupole triplets are used. Eight dipole magnets and one sextupole magnet are normal conducting (resistive) magnets. Fabrication and installation of the IF magnet have been completed and machine commissioning testing is in progress. The development status of magnet system of the IF separator is briefly introduced.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

132

Implementation of Web Applications for improving KOMAC operation

Author: Sungyun Cho[1]

Co-authors: Hyeok-Jung Kwon [2]; Jae-ha Kim [2]; Young-gi Song [2]

[1] *KOMAC, KAERI*

[2] *KOMAC/KAERI*

The KOMAC operates a 100 MeV linear proton accelerator. The integrated control system is implemented using the Experimental Physics and Industrial Control System (EPICS). The Graphical User Interface (GUI) is developed by CS-Studio (CSS), allowing operators to control and monitor device operation parameters in a codeless environment within the Control Room (CS). KOMAC has developed web applications to assist operators and manage automatically system. In this paper, we introduce the web services for data logging, backup, and monitoring. We currently offer services such as Process Variables (PVs) API for web, Putlogger, Alarm logger, Archiver management page, and data analysis tool.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

133

Assessment of the beam characteristics of a linear electron accelerator for the modification to the apparatus suitable for pulse radiolysis

Authors: Hoje Kwon[1]; Jangho Ha[1]; Youngbae Kong[1]

[1] *Advanced Radiation Technology Institute, Korea Atomic Energy Research Institute*

Pulse radiolysis is a very convenient method to study the mechanism and kinetics of chemical reactions. And, this technique can be exploited in many research areas such as polymer engineering, environment engineering, biotechnology, toxicology, nuclear engineering, chemistry, and so on. Therefore, up to now, there has been installed and utilized a number of facilities for the pulse radiolysis-based researches all over the world ever since the early 1960s.
In this paper, both the beam characteristics and the feasibility for the pulse radiolysis application of the 10 MeV linear electron accelerator located in the irradiation facility in KAERI-ARTI were evaluated in order to determine the alteration possibility of the purpose of use of the linac.
For the estimation of the beam characteristics, some properties such as beam diameter, beam energy, pulse width and pulse repetition period were examined. With regard to the feasibility test for pulse radiolysis, the periodicity of the extracted atmospheric beam was measured by using the scintillator connected with an oscilloscope.
The results show the adaptation possibility of the 10 MeV electron irradiator to one fit for pulse radiolysis.

Keywords : pulsed electron beam, pulse radiolysis, radiation chemistry

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

134

Simulation Study of Neutron Production for NDPS at RAON

Authors: Jaesung Kim[1]; Kyoungho Tshoo[1]; Cheolmin Ham[1]; Sangjin Lee[1]; Young-Ouk Lee[2]; CheongSoo Lee[1]; Seong Jae Pyeun[1]; Kwangbok Lee[1]; Charles Akers[1]; Mijung Kim[1]; Jae Cheon Kim[1]; Minsik Kwag[1]; Donghyun Kwak[3]; Dong Geon Kim[4]; Taeksu Shin[1]; Hyung-Jin Shim[5]

[1] *Institute for Rare Isotope Science, Institute for Basic Science*

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[5] *Seoul National University*

Nuclear Data Production System (NDPS) is one of the experimental systems at the Rare isotope Accelerator complex for ON-line experiments (RAON). It provides high-energy neutrons up to tens of MeV. The primary objective of NDPS is to accurately measure the neutron-induced nuclear cross sections, particularly for the neutron energy extending up to tens of MeV region. A beam commissioning of NDPS is scheduled for 2024. Ion beams, such as H, 2H, 16O, and 40Ar, are accelerated from SuperConducting Linac 3 (SCL3) and transported to the NDPS target room. High-energy neutrons will be produced by bombarding an ion beam into the neutron production target at the NDPS target room and delivered to users for the experiments.
For the preparation of forthcoming beam commissioning, simulation studies are performed to calculate neutron productions using the Monte Carlo particle transport codes, namely MCNPX, FLUKA and PHITS. By analyzing the simulation results of various combinations of the ion beams target materials and comparing with available benchmark measurements, an optimal pairing of ion beam and target is proposed for the beam commissioning.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

135

Progress of 4th Generation Korea Photon Source

Authors: Insoo Ko[1]; Younguk Sohn[1]

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Multipurpose Synchrotron Radiation, KPS is designed as a research infrastructure to increase the localization rate of core materials and parts with high overseas dependence and contribute to the improvement of related industrial competitiveness, while at the same time securing technology that can quickly respond to national and social problems such as the spread of COVID-19. It is expected for the multi-purpose radiation accelerator to greatly contribute to securing basic science research capabilities such as physics, chemistry, and bioengineering as well as industrial applications such as convergence and advanced materials and parts, secondary batteries, semiconductors, and new drug development.
The project started on July 2021, by the host organization of Korea Basic Science Institute, KBSI and by co-host of Pohang Accelerator Laboratory, PAL. At present, the accelerator and beamlines are on the last moment of technical design and also the accelerator building and user facility are on the process of engineering design. The construction will start at the second half of 2024, while the site preparation by the local government of Chung-cheong Bukdo will be done early 2024, next year. This short briefing will provide the detail progress of the KPS.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

136

Modulation of Proton Beam Irradiation on Energy Metabolism of TPA-induced HT-29 cells

Authors: Sung Suk Jung[1]; Yoon Dam Seo[1]; Yun Hee Shon[1]

[1] *Bio-Medical Research Institute, Kyungpook National University Hospital*

A Proton radiotherapy has been established as a highly effective modality used in the local control of tumor growth. Although proton radiotherapy is used worldwide to treat several types of cancer clinically with great success due to superior targeting and energy deposition, the detailed regulatory mechanisms underlying the functions of proton radiation are not yet well understood. To determine the effects of proton beams on mitochondrial energy metabolism, we investigated: mitochondrial DNA mass; the gene expression of mitochondrial transcription factors, functional regulators, and dynamic-related regulators; and the phosphorylation of the signaling molecules that participate in mitochondrial biogenesis. Both the mitochondrial DNA/nuclear DNA ratio and the mitochondria staining assays showed that proton beam irradiation increases mitochondrial biogenesis in 12-O-tetradecanoylphorbol-13-acetate (TPA)-induced aggressive HT-29 cells. Simultaneously,

proton beam irradiation increases the gene expression of the mitochondrial transcription factors PGC-1α, NRF1, ERRα, and mtTFA, the dynamic regulators DRP1, OPA1, TIMM44, and TOM40, and the functional regulators CytC, ATP5B and CPT1-α. Furthermore, proton beam irradiation increases the phosphorylation of AMPK, an important molecule involved in mitochondrial biogenesis that is an energy sensor and is regulated by the AMP/ATP ratio. Based on these findings, we suggest that proton beam irradiation inhibits metastatic potential by increasing mitochondrial biogenesis and function in TPA-induced aggressive HT-29 cells.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

138

Characterization of liquid scintillators in a mono-energetic neutron field utilizing an accelerator

Authors: HyeoungWoo Park[1]; Shinchul Kang[1]; Jungho Kim[1]; Hyeonseo Park[1]; Joong Hyun Kim[1]; Young Soo Yoon[1]

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Neutrons are a primary source of single event effects (SEEs) in electronic devices. However, their effects have been largely ignored due to their low cross section for interacting with matter. Recent technical advances in quantum computing, autonomous vehicles, and space travel have increased the risk of SEEs from neutrons. Liquid scintillators are a promising method for measuring fast neutrons. Cosmic ray-induced neutrons are in the energies greater than 20 MeV. The signal in a liquid scintillator depends on the neutron energy and the size of the scintillator due to multiple scattering. In this paper, we investigated the size and signal of a liquid scintillator suitable for measuring high energy neutrons induced by cosmic rays. We characterized commercially available 1-, 2-, and 3-inch liquid scintillators in an accelerator-based mono-energetic neutron field at the Korea Research Institute of Standards and Science. The energy of the liquid scintillator was calibrated using Compton edge measurements using standard sources of Cs-137 and Na-22 and Geant4 simulations. The deuterium beam of the accelerator can induce a mono-energetic in deuterium-deuterium (DD) and deuterium-trivial (DT) reactions at 2.45 MeV and 14.8 MeV, respectively. The two mono-energetic neutrons were measured using liquid scintillators, and the gamma background was excluded using the pulse shape discrimination (PSD) method to collect neutron signals.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

139

Instrumentation and control based on DDC for utility system of RAON facility

Authors: Sunghwa Jung[1]; Donggun Lee[1]; Yonggu Han[1]

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RAON is a large science research facility and the utility system supplying stable HVAC/RI exhaust, DI/PCW, CDA, power is important to maintain optimal equipment condition of the accelerator.

The utility I&C system consists of main CCMS(Central Control & Monitoring System), local area DDC(Direct Digital Control) panel and field devices has been installed and tested its performance on site. The goal of this system is control the utility measuring value such as temperature, humidity, flow, pressure, level, and electric conductivity in required interface range. Also the interlock to PSIS, EPICS should be provided for facility alarm. To obtain reliable continuity of utility supply, closed functional loop control logic has been programmed and verified. This paper summarizes structure, network, graphic user interface of utility I&C system at RAON and explain some measured real time trend analysis in PID control.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

140

Current Status of the Beam Position Monitoring System Upgrade at the KOMAC 100 MeV Proton Linac

Authors: Sangpil Yoon[1]; Seung-Hyun Lee[2]; Young-gi Song[3]; Hae-Sung Jeong[1]; Han-Sung Kim[2]; Hyeok-Jung Kwon[3]

[1] *KAERI(KOMAC)*

[2] *KOMAC*

[3] *KOMAC/KAERI*

Beam Position monitor (BPM) is the essential beam diagnostic instrument for the accelerator operation. In the past, we used the commercial analog front-end for the beam position measurement. But the commercial products were dedicated to the analog signal processing to obtain the beam position. And then it is difficult to customize the correlation factor, position offset and so on. Thus we started to develop the new beam position monitoring system, which is able to measure the beam position, beam phase, beam current at same time. At 2022, the development of the new analog front-end and the FPGA based digitizer was completed. This year, new beam position monitoring system was applied for beam position monitoring of the linear accelerator section partially. In this paper, the current status of the beam position monitoring by using the new system and the future plans are will be described in detail.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

141

FPGA algorithm of Beam instruments for Fast Protection System

Author: Jangwon Kwon[1]

Co-author: eunhoon Lim [2]

[1] *Korea university / IBS*

[2] *Korea University*

Rare isotope Accelerator complex for ON-line experiment (RAON) is designed to accelerate heavy ions, including uranium, oxygen, and argon, with a maximum energy of 200 MeV/u for uranium beams. The stable operation of this accelerator is important to ensure the accurate trajectory of the accelerated ions. However, equipment failure or instability can result in unintended beam trajectories, potentially damaging the device due to direct heat from the ion beam. To prevent this damage, a fast protection system that blocks the beam quickly is important. AC-Current Transformer(ACCT), mTCA-based Data Acquisition (DAQ) and Beam Position Monitor (BPM) electronics are used to inform the fast protection system of the beam status in real time. Because each device stores postmortem data, the cause of an error that occurred in a short period of time before fast protection is activated is identified. This poster shows the measurement details and signal generation algorithm of each beam diagnostic device created for rapid protective operation of the RAON heavy ion accelerator.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

142

Characterization of the proton test beamline at KOMAC

Author: Seunghyun Lee[1]

Co-authors: HAN SUNG KIM [2]; HYEOK JUNG KWON [2]; Sangpil Yoon [3]

[1] *Korea Multipurpose Accelerator Complex, Korea Atomic Energy Research Institute*

[2] *KOMAC, KAERI*

[3] *KAERI(KOMAC)*

Several beamlines of a 100 MeV linac are under operation at Korea Multi-purpose Accelerator Complex, KOMAC. We have a test beamline for proton beam characterization. The beam parameters such as twiss parameters, emittance and momentum spread are measured in the beamline via Quad scan method. For the momentum spread, we used two experimental beamlines which are separated by a bending magnet; one straight and another test beamline bent at 45 degree. The beam envelop was measured without and with dispersion by the bending magnet from straight and bent beamlines respectively. The increase of the beam size by the dispersion is obtained and then converted into the momentum spread of the beam. In this paper, we introduce the beamline elements and report the beam characterization in detail with simulation studies.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

143

Beam Loss Measurement during SCL3 Commissioning at RAON

Author: eunhoon Lim[1]

Co-author: Jangwon Kwon [2]

[1] *Korea University*

[2] *Korea university / IBS*

The Rare-isotope Accelerator complex for ON-line experiment (RAON) is a heavy ion accelerator with a maximum beam power of 400 kW. In Superconducting Linear Accelerator 3 (SCL3), the U beam is accelerated to 18.5 MeV/u and the others have higher energies. Beam loss monitoring systems are required to protect accelerator devices. For this purpose, 53 beam loss collectors (BLCs) and 1 beam loss monitor (BLM) were installed at SCL3. BLC consist of the circular electrode with a beam collimator, which is installed in the SCL3 beam diagnosis chamber. If a beam escapes 19 mm from its center, the BLC measures the escaped beam current. BLM is a plastic detector that measures radiations such as neutrons and gamma-rays, which are generated when a beam deviates from its orbit and collides with a pipe or other device. Each device is integrated control by EPICS and can be monitored and controlled through GUI of CS-Studio. This poster shows the construction and preliminary testing results of beam loss devices during beam commissioning.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

144

OPERATION OF RAON CRYOGENIC CONTROL SYSTEM IN SCL3 FIRST COOL-DOWN

Authors: Seojeong Kim[1]; Taekyung KI[1]

Co-authors: MINKI LEE [2]; Mijeong Park [1]; Sang Gil Lee [1]; Inmyong Park [1]; Jaehee Shin [1]

[1] *Institute for Basic Science*

[2] *RISP*

Last year, beam commissioning was successfully conducted in the RAON superconducting LINAC 3 (SCL3). For cooling down the superconducting LINAC, the liquid helium was supplied by our cold box from September 7th, 2022. In order to control thousands of actuators, the cryogenic control system was constructed by the combination of EPICS and PLC control system, and the cryogenic system was operated by CSS user interface. In this paper, the cool-down and warm-up sequences and the overall operation modes are introduced. Then, the operation strategies during the slow cool-down and the fast cool-down is described in detail. Finally, the first cool-down results and the issues during the cool-down will be explained by analyzing the operation data.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

145

Implementation of Accelerator preparedness solution for beam services at KOMAC

Author: Jae-Ha Kim[1]

Co-authors: HYEOK JUNG KWON [2]; Sungyun Cho [2]; Young-gi Song [3]

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Korea Multi-purpose Accelerator Complex has been operating a 100 MeV proton linear Accelerator and various subsystems such as vacuum system, RF system and cooling system has been installed to facilitate LINAC operation. To ensure the accelerator operates reliably and meets user-demanded beam requirements, effective management of the LINAC and its associated system is imperative. Consequently, an accelerator preparedness solution for beam services has been implemented. We have established a system for verifying and changing magnet settings to transmit a beam with a specific energy. Additionally, and automatic control system for gate valves based on the target room, a beam interlock system capable of turning the beam ON/OFF based on PSIS and RMS conditions have been implemented. Furthermore, we have enabled the monitoring of the status of these system through a beam preparedness state monitoring system. This paper describes the implementation of accelerator preparedness solution for beam services at KOMAC.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

146

Control System for the Cryogenic System of RAON SCL3 Based on EPICS

Author: Mijeong Park[1]

Co-authors: Seojeong Kim [2]; Yong Jun Choi [1]; Yonghak Kim [1]; CHANGWOOK SON [2]; Sang-Gil Lee [1]; Moosang Kim [3]

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[3] *IBS/IRSI*

The Rare Isotope Accelerator complex for ON-line experiments (RAON) in South Korea is a facility designed for rare isotope research. The RAON Control System relies on the Experimental Physics and Industrial Control System (EPICS), a distributed soft real-time control system widely used in scientific instrumentation. The cryogenic system comprises various devices and actuators from various manufacturers, all installed within the accelerator area, which is a radiation-controlled zone. Engineer access to this area is hindered by both distance restrictions and radiation. We have developed a control system for the cryogenic system, utilizing EPICS, enabling remote monitoring of actuator statuses and their control through CSS. This paper explains the control system designed for RAON SCL3's cryogenic system.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

147

Design and Implementation of interlock system for the injector for RAON

Author: Yujung Ahn[1]

[1] *Institute for Basic Science*

RAON (Rare Isotope Accelerator complex for On-line experiments), the heavy-ion linear accelerator dedicated to advancing basic science or nuclear science with RI (rare-isotope) beams, successfully completed beam commissioning for its low-energy section using an argon beam in May 2023. During the beam commissioning process, issues, such as malfunctions in the vacuum gauge and pump of the injector, emerged, and these challenges highlighted the importance of the alarm system for operators and the interlock system to equipment protection from unforeseen events. In this paper, we present the logic designs for the interlock system of the injector that prioritizes equipment protection in the event arising during operation.
The injector of RAON physically consists of the ECR-IS, LEBT, RFQ, MEBT, beam diagnostics, and the RF system, and all these sections are integrated and controlled using EPICS (Experimental Physics & Industrial Control System), which is a distributed real-time control system developed to ensure stability, flexibility, and scalability of the control system. Based on the EPICS-based soft IOC, the interlock logics of the injector for RAON were designed to collect signals originating from anomalies related to malfunctions or status of equipment in the system, and to operate according to the predetermined protective sequences swiftly and efficiently. This paper delves into the operational sequences, controlled parameters, and the considerations behind the design of interlock logic. Additionally, we developed an integrated GUI interface using CSS (Control System Studio) to monitor the interlock status and alarms.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

148

Current Status of KoBRA for Rare Isotope Production at RAON

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Co-authors: Kyoungho Tshoo [2]; Donghyun Kwak [3]; Gyoungmo Gu [4]; Jae Cheon Kim [2]; Jaehwan Lee [5]; Jaesung Kim [6]; Jongwon Hwang [7]; Joochun Park [7]; Kevin Insik Hahn [7]; Kwang-Bok Lee [2]; Laszlo Stuhl [7]; Mijung Kim [2]; Minsik Kwag [2]; Sangjin Lee [2]; Seong Gi Jo [2]; Seong Jae Pyeun [2]; Seung-Woo Hong [2]; Sohyun Kim [8]; Soomi Cha [2]; Sunghan Bae [7]; Sunghoon Ahn [7]; Sunji Kim [7]; Taeksu Shin [2]; Xesus Pereia-Lopez [7]; Yong Hyun Son [9]; Yong Kyun Kim [10]; Young-Ouk Lee [11]; Youngju Cho [9]; Youngseub Jang [5]; Yunghee Kim [7]; Zeren Korkulu [7]; Byul Moon [7]; Chaeyoung Lim [12]; Chanhee Kim [8]; Charles Ackers [2]; Cheolmin Ham [2]; Cheong Soo Lee [2]; Deuk Soon Ahn [7]

[1] *Hanyang University*

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[4] *CENS, SKKU*
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[6] *IRIS, SNU*
[7] *CENS*
[8] *SKKU*
[9] *CENS, SNU*
[10] *HYU*
[11] *KAERI*
[12] *IRIS, KU*

The Institute for Rare Isotope Science (IRIS) has developed a multi-purpose experimental instrument, called KoBRA (Korea Broad Acceptance Recoil Spectrometer and Apparatus) as part of the RAON facility in Korea. Primary beams are produced by the Electron Cyclotron Resonance (ECR) ion sources or the Isotope Separation On-Line (ISOL) system at the RAON facility. These beams are then delivered to KoBRA at energies of $1 - 40$ MeV per nucleon via the Superconducting Linear Accelerator 3 (SCL3) to produce secondary rare isotope beams.. Secondary RI beams can be produced by quasi-projectile fragmentation reaction, and KoBRA will be utilized to generate these RI beams for the studies of nuclear reaction, nuclear structure, and nuclear astrophysics.
Currently, KoBRA is in the phase of beam commissioning, with a focus on producing rare isotope beams at an energy of about 20 MeV per nucleon. The initial test delivering a stable ion beam of ^{40}Ar was successfully conducted in June 2023. This presentation includes an overview of the recent activities executed during KoBRA's beam commissioning stage, together with the result of rare isotope production.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

149

4D Visualization of the Light-induced Coherent Magnon by an X-ray Free Electron Laser

Author: Sae Hwan Chun[1]

[1] *PAL-XFEL*

Ultrafast optical manipulation of magnetic phenomena is an exciting achievement of mankind, expanding one's horizon of knowledge towards functional non-equilibrium states. The dynamics acting on an extremely short timescale push the limit of detection, and ultimately require four-dimensional (4D) views, i.e., 3D space and 1D time to keep sight of the evolving magnetic structure thoroughly. We introduce time-resolved resonant magnetic X-ray diffraction with an X-ray free electron laser to accomplish the 4D visualization of a light-induced coherent magnon. The trajectory of antiferromagnetic precession in a Y-type hexaferrite manifests a photoinduced effective magnetic-field that lasts long after the photoirradiation, being attributed to nonthermal inter-site electron transfer among the magnetic ions. With the unprecedented capability of direct quantifying the field for the photoexcitation above the band gap, we find a remarkable amplification of the photomagnetic effect reaching an order of magnitude higher than that below the gap with the same laser fluence. This result illuminates a highly energy-efficient route to achieve substantial photoinduced field in antiferromagnetic dielectrics desired for optospintronics applications. The X-ray methodology established in this work has no restriction on net-magnetization, offering a great capability to uncover ultrafast magnetic phenomena in every class of magnets.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

No

150

Performance Study of Solid-State Switching Module Application for DIRAMS 6-MW Pulse Modulator

Authors: Heuijin Lim[1]; Hyun Kim[1]; Dong Hyeok Jeong[1]; Kyoung Won Jang[1]; Sang Koo Kang[1]; Sukho Ahn[2]; Tae-Hyun Kim[3]; Chan-Hun Yu[3]; Hyoung-Suk Kim[3]; Sung-Roc Jang[3]

Co-author: Manwoo Lee [1]

[1] *Dongnam Institute of Radiological & Medical Sciences*

[2] *Pohang Accelerator Laboratory*

[3] *Korea Electrotechnology Research Institute*

The 6-MeV C-band electron linear accelerator (LINAC) was constructed in 2015 at the Dongnam Institute of Radiological & Medical Sciences (DIRAMS) and has been operating with a 6-MW pulse modulator on a thyratron-switched pulse-forming network (PFN) which is commonly used in the LINACs. The thyratron was used for a high voltage switch which transferred the amount of energy stored in the capacitors of the PFN into a magnetron and an electron-gun. The solid-state switching module in series with insulated gate bipolar transistors (IGBTs) was proposed to replace the thyratron and designed with a maximum voltage of 20 kV, a maximum current of 2 kA and a repetition rate of 250 Hz for the DIRAMS 6-MW pulse modulator. This switching module was built with a size of 350x643x500 mm3 and installed in place of the thyratron inside the modulator cabinet. The turn-on timing of switching module was synchronized with the discharging timing of the PFN. Since the thyratron consists of a hot cathode and several control grids, additional heater power supplies are required for cathode heating and reservoir heating. By help of solid-state switching module, these heater power supplies, controllers and the connected interlock points were removed. It was tested with the resistive load system and the magnetron up to a switching voltage of 9.2 kV and a repetition rate of 250 Hz. The performance test showed the similar results comparing with the thyratron. The DIRAMS 6-MeV LINAC has been working with this solid-state switching module since Aug. 2023 and providing the stable beam for preclinical studies. (This work was supported by the Dongnam Institute of Radiological & Medical Sciences (DIRAMS) grant funded by the Korea government (MSIT). (No. 50493-2023))

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

151

RF simulation study of C-band magnetron for DIRAMS linear accelerator

Author: Wunghoa Park[1]

Co-authors: Sang Jin Lee [2]; Dong Hyeok Jeong [2]; Heuijin Lim [2]; Sang Koo Kang [3]; Hyun Kim [2]; Seung Wook Kim [2]; Kyoung Won Jang Jang [4]; Manwoo Lee [5]

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[5] *DIRAMS*

A magnetron is a device used to generate high RF power. It is widely used in various applications, such as medical linear accelerators, radar systems, microwave ovens, and ion deposition devices. The linear accelerators at Dongnam Institute of Radiological & Medical Sciences (DIRAMS) use a C-band magnetron with a resonance frequency of 5712 MHz. In order to develop a C-band coaxial magnetron for use in the DIRAMS accelerator, we have conducted a simulation study on a magnetron with 32 vanes and a resonance frequency of 5712 MHz, using an eigenmode solver. A particle tracking solver has used to determine the operational characteristics of hot electrons emitted from the cathode in a magnetic field. The structure of the magnetron has been optimized for a resonance frequency of 5712 MHz using the eigenmode solver when the electric field is in the pi mode. After optimizing the structure, the operating conditions for the hot electrons to reach the anode have been investigated using a particle tracking solver. When a voltage of -50 kV is applied between 1.8 cm of cathode radius and 0.5395 cm of distance between the cathode and the vane, the hull-cutoff of the magnetic field strength is 0.156 T. If the magnetic field strength exceeds the hull-cutoff, electrons will not be able to reach the anode. The particle tracking solver shows that the trajectory of the hot electron reaches the anode when the magnetic field strength was 0.15 T. These simulation results will be used to optimize the structure of the magnetron and determine the magnitudes of the electric and magnetic fields. The upcoming research will focus on maximizing the output RF power by studying thermal conductivity, output power, RF window geometry, and Q-factor. (This work was supported by the Dongnam Institute of Radiological & Medical Sciences (DIRAMS) grant funded by the Korea government (MSIT). (No. 50493-2023))

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

152

Electronic structure investigation and structural analysis of He-implanted Cu3Co2SbO6 thin film

Authors: Changhee Sohn[1]; Gyehyeon Kim[1]; Miju Park[1]

Co-author: Uksam Choi [1]

[1] *Ulsan national institute of science and technology*

The materialization of Kitaev quantum spin liquid (KQSL) has been the subject of intense investigation due to its exotic excitations and highly entangled phase. Cu3Co2SbO6 (CCSO), a Co-based 2D honeycomb layered delafossite compound, stands out as a promising candidate material. However, bulk CCSO exhibits zigzag antiferromagnetic order owing to the presence of trigonal distortion in the CoO6 octahedron. In this study, we introduce “Hellium (He) ion implantation” to mitigates the trigonal distortion of CoO6 octahedra in CCSO. X-ray Diffraction revealed an elongation of the lattice constant along the c-axis in He-ion-doped CCSO thin films. Additionally, soft X-ray absorption spectroscopy presents a reduced Integrated intensity in linear dichroism of CoO6 octahedron as the level of He-ion doping increased, demonstrating a decrease in trigonal distortion. Furthermore, UV

ellipsometry measurements showed a decrease in the Néel temperature with increasing He-ion doping, establishing a clear correlation between trigonal distortion and the magnetism of CCSO thin films. These collective findings suggest that He-ion doping in thin films allows for the manipulation of the spin Hamiltonian, providing a new platform for implementing Kitaev spin liquid.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

153

Performance test of a LaBr3(Ce) detector array for high-energy gamma-ray measurement

Authors: Sungjune Lee[1]; Jung Keun Ahn[1]

Co-authors: ByungYong Yu [2]; Weon Cheol Lim [2]; JaeYeoul Kim [2]

[1] *Korea University*

[2] *KIST*

We developed a LaBr3(Ce) detector array for measuring high-energy gamma rays from nucleosynthesis reactions near 10 MeV. The prototype array comprises 10 LaBr3(Ce) detectors on the faces of a truncated cuboctahedron structure. Each LaBr3(Ce) crystal has a diameter of 50 mm and a length of 75 mm. The prototype array uses 2-inch photomultiplier tubes to detect scintillation light. We initially commissioned the array prototype using radioactive sources, including 60Co and AmBe. We tested the detector performance using proton-capture gamma rays from Al(p, gamma)Si reaction in Ep=2.03–2.08 MeV with the KU target station at the tandem accelerator facility, KIST. We also investigated excited states in 28Si near Ep =2044 and 2057 MeV. This paper will present the performance of the LaBr3 detector array in high-energy gamma-ray measurement.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

154

Development of THz corrugated wakefield structures

Authors: Gwanghui Ha[1]; Hyung-sup Kong[2]; Jong Hyun Kim[2]; Seunghwan Shin[3]

Co-authors: Ho Jae Kwak [2]; Jina Kim [2]; Seung-hwan Kim [2]

[1] *Northern Illinois University*

[2] *Pohang Accelerator Laboratory*

[3] *Korea University*

We designed and fabricated THz corrugated structures through a collaborative research with Korea University, Northern Illinois University and Argonne National Laboratory. Two of THz strucrutres were beam tested and measured wakefield properties in ANL. We present our methods for fabricating very small structures and beam test results. And we introduce applications where THz structures can be utilized, such as THz sources in the GW power range or accelerator columns with electric fields at the GV/m level.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

155

Cumulative dose evaluation method in a 100 MeV proton accelerator facility

Authors: Kye-Ryung KIM[1]; Yong-Sub Cho[2]; Sangpil Yoon[3]; Seunghyun Lee[4]

[1] *KOMAC, KAERI*

[2] *Korea Atomic Energy Research Institute*

[3] *KAERI(KOMAC)*

[4] *Korea Multipurpose Accelerator Complex, Korea Atomic Energy Research Institute*

Construction of the 100 MeV proton accelerator of the KAERI (Korea Atomic Energy Research Institute)'s KOMAC (Korea Multi-purpose Accelerator Complex) was completed at the end of 2012, and it has been providing proton beam services for beam use research in various fields since 2013. As proton accelerator operation and beam service times increase, the need for cumulative dose evaluation in DTL tanks, beamline magnets, and tunnel concrete surfaces installed inside tunnels and beamline halls is increasing. Currently, several RMS (Radiation Monitoring Systems) are installed within the accelerator facility for radiation safety management, but the intervals between installation locations are wide and they are mainly operated to record average dose values at regular time intervals. Since the 100 MeV proton accelerator is operated with a pulse width of 0.05 to 1 msec, it is necessary to apply various methods that can solve the limitations of RMS in order to evaluate the cumulative dose through accurate measurement of the radiation dose that occurs momentarily during operation. After installing Gafchromic films and alanine pellets at various points within the 100 MeV proton accelerator facility and measuring the dose values at each location after operating the accelerator for a certain period of time, the applicability and improvement plan of the cumulative dose evaluation method within the accelerator facility were reviewed. In this presentation, we will report the results.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

156

A new and simple Rubidium-82 generator column manufacturing method

Authors: JIN SU KIM[1]; Joycie Shanmugiah[1]; Jung Young KIM[1]; Kye-Ryung KIM[2]; Kyo Chul LEE[1]; Sangjin HAN[1]; Sangpil Yoon[3]; Yong Jin LEE[1]; Yong-Sub Cho[4]

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[2] *KOMAC, KAERI*

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[4] *Korea Atomic Energy Research Institute*

The Korea Multi-purpose Accelerator Complex (KOMAC) of Korea Atomic Energy Research Institute (KAERI) is developing an Rb-82 generator for diagnosing myocardial disease in cooperation with the Korea Institute of Radiological and Medical Sciences (KIRAMS). Previously, high purity Strontium-82 (Sr-82) solutions were mainly used to manufacture Rubidium-82 (Rb-82) generator columns. High purity Sr-82 is obtained through a separation and purification process from Rubidium Chloride (RbCl) irradiated with a high-energy proton beam, which requires the use of 6 M Hydrochloric acid (HCl) and an evaporation concentration process. These processes are very dangerous because they use strong acidic solutions, and the evaporation and concentration process is a time-consuming process. Additionally, loss of Sr-82 during the process of dissolving the evaporation-concentrated powder is unavoidable. In this presentation, we will discuss a new process that can solve the difficulties of the existing Rb-82 generator column manufacturing process. We cover a method of manufacturing an Rb-82 generator column by applying a process of adsorbing Sr-82 to the generator column by passing a buffer solution in which the RbCl target is dissolved through the column instead of adsorbing a high-purity Sr-82 solution to the Rb-82 generator column.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

157

Status Update of SRF Cavities and Cryomodule Development for the PIP-II Linac at Fermilab

Author: Donato Passarelli[1]

[1] *Fermilab*

The PIP-II project has the scope to upgrade the existing Fermilab's accelerator complex to deliver the most intense high-energy beam of neutrinos for the international Deep Underground Neutrino Experiment (DUNE) at the Long Baseline Neutrino Facility (LBNF). It is based on a proton superconducting linac that comprises of five different Superconducting Radio Frequency (SRF) cavity types: 162.5 MHz half wave resonator (HWR), 325 MHz single spoke resonators type 1 and type 2 (SSR1, SSR2), low-beta and high-beta 650 MHz elliptical 5-cell cavities (LB650, HB650). This presentation offers an update on the progress in cavity and cryomodule design, fabrication, processing, and testing, with a focus on SSR2 cavities and cryomodules.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

158

Performance Evaluation of a 70 MeV H- Cyclotron as a Proton Driver for an ISOL System

Author: Yeong Heum YEON[None]

Co-authors: Seong Jin Heo [1]; Hee-Joong Yim [1]; Dong Jun Park [1]; Wonjoo Hwang [2]; Jaewon Jeong ; Takashi Hashimoto [1]; Kyounghun Yoo [3]; Jongwon Kim [4]; Jinho Lee

[1] *IBS*

[2] *Rare Isotope Science Project*

[3] *IRIS / IBS*

[4] *RISP/IBS*

Following the successful completion of a 70 MeV, 50 kW beam test lasting 6 hours during the site acceptance test in the beam dump, a 70 MeV cyclotron was inaugurated in January 2023 for a six-month operation, with a dedicated focus on the production of Radioactive Ion (RI) beams within an Isotope Separation On-Line (ISOL) system. The initial phase of experimentation entailed precise targeting, ensuring uniformity and stability, of a 100-watt proton beam onto the initial Silicon Carbide (SiC) target. This phase encompassed a characterization and comprehensive performance analysis of the proton beam, leveraging an array of measurement instruments, including wire-grid devices, Faraday cups, and collimators within the proton beam module.

Subsequently, an extensive series of experiments was executed, employing SiC targets, with the overarching objective of scrutinizing RI generation outcomes. This was achieved through systematic variations in proton beam power and shape, encompassing configurations involving both wobbled and non-wobbled proton beams. Furthermore, comprehensive experiments were conducted with SiC targets, thoroughly investigating the results of radioactive isotope (RI) generation, while concurrently modifying proton beam power and shape, encompassing both wobbled and non-wobbled modes. Notably, the final optimized proton beam dimensions were determined to be Full Width at Half Maximum (FWHM) X: 13.5 mm and Y: 10.5 mm for non-wobbled beams, and FWHM X: 4.58 mm and Y: 3.2 mm for beams with a 25% wobbling component, tailored to fit a 20 mm size target.

Currently, the operational power level is being sustained at 1 kW, with ongoing deliberations aimed at augmenting the output to harmonize with the evolving demands imposed by the ISOL system.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

159

Design of a fast faraday cup for ion beam bunch length measurement

Author: Donghyun Kwak[None]

Co-authors: Cheolmin Ham [1]; Kyoungho Tshoo [1]; Moses Chung [2]; Taeksu Shin [1]; gidong Kim [1]

[1] *IRIS*

[2] *UNIST*

Ion beams with energies up to a few tens of MeV/nucleon will be delivered to the low energy experimental systems of the Rare Isotope Accelerator Complex for ON-line Experiments (RAON): the Korea Broad Acceptance Recoil Spectrometer and Apparatus (KoBRA) and the Nuclear Data Production System (NDPS). To measure the bunch length near production targets of the low energy experiment systems without causing beam disruption, we optimized and manufactured capacitive pick-up monitors for install upstream of the production targets.
In order to validate the bunch length measurement capabilities of the capacitive pick-up monitor, an experiment with bunched ion beams is planned to prove whether the pick-up monitor can successfully measure the bunch length. For the experiment, a fast faraday cup was designed to measure sub-nanosecond bunch lengths of a beam, mitigating signal distortion due to impedance variations between the coaxial connector and the beam collision region.
This presentation discusses the design methodology and simulation results of the fast faraday cup developed to measure the bunch shape of positively charged hydrogen ion beams with energies in the tens of MeV range and sub-nanosecond bunch lengths.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

160

Data Archiving Systems in RAON

Author: Sang-gil Lee[1]

Co-authors: CHANGWOOK SON [2]; HyunMan Jang [1]; Mijeong Park [1]; Yong Jun Choi [1]; Yonghak Kim [1]

[1] *IBS/IRIS*

[2] *Institute for Basic Science*

The Rare Isotope Accelerator complex for ON-line experiments (RAON) in South Korea is a facility designed for rare isotope research. The RAON Control System relies on the Experimental Physics and Industrial Control System (EPICS), a distributed soft real-time control system widely used in scientific instrumentation.
The data archiving system is a core system for accelerator operation, and research for improving reliability and integrity is important.
The RAON Control System requires various setting values for each device for the control of the accelerator, stores a variety of data that occurs during the operation of the accelerator, and uses the Archive Appliance to build a data storage system as a way for storing this data.
We are building a storage system for a data storage system. The storage system collects data from the RAON Control System through the redundant Archiver Appliance from the main storage, and the data collected through RamDisk is stored in data storage after a certain amount of time for fast data collection and accurate data storage. Data storage is designed and built to allow about 200,000 PV data to be stored. These main storages are building separate main storage and backup storage for redundancy for data backup, and are conducting weekly backups of data from the main storage. The data storage system started its first run in 2022 and successfully stored data from RAON's first beam test in 2022 and various beam tests in 2023.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

161

X-ray Imaging Characteristics of the Beamline 6C Bio Medical Imaging of the Pohang Light Source-II

Authors: Junwoo Kim[1]; Seob-Gu Kim[1]

Co-author: Jae-Hong Lim [1]

[1] *Pohang Accelerator Laboratory*

Beamline 6C Bio Medical Imaging at the Pohang Light Source-II is a station for synchrotron radiation X-ray micro-computed tomography. The beam emitted from a multipole-wiggler is trimmed, attenuated, and monochromatized before illuminating an object. The projection image is recorded using a detection scheme that converts the X-ray image into a visible-light image, which is then magnified and captured by an optical microscope. For image conversion, a single-crystal (garnet) scintillation screen is used. Here, we assess the image quality in terms of noise characteristics and the spatial resolutions. Two types of scintillation screens (LuAG:Ce and GAGG:Ce) with two different thicknesses (50 μm and 100 μm) are compared. The spatial-frequency domain analysis suggests that the spatial resolutions were more or less identical, while GAGG:Ce featured a better signal-to-noise ratio thanks to its two-times higher light yield. A scientific CMOS (complementary metal-oxide semiconductor) camera at the beamline was seen to accumulate electronic noise for longer exposure. Both trimming and attenuation of the beam were found to affect the image quality, which was observed by measuring the point spread of the imaging as a function of object-to-scintillation screen distance.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

Yes

162

Operation Status of KOMAC Linac

Author: HYEOK JUNG KWON[1]

[1] *KOMAC, KAERI*

100 MeV proton linear accelerator (linac) has been operating since 2013 at Korea Multi-purpose Accelerator Complex (KOMAC). Nowadays, 4 beam lines are routinely used to supply proton beam to users. In addition, neutron beam line starts user service after pilot operation. 10 year operation results in several technical issues including vane erosions of the radio-frequency quadrupole (RFQ) and faults of the quadrupole magnet inside drift tube. In this paper, operation status and technical issues of KOMAC 100 MeV proton linac are discussed.

This work was supported through KOMAC operation fund of KAERI by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (KAERI-524320-23).

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

163

Status of PLS-II and PAL-XFEL

Author: Changbum Kim[1]

[1] *Pohang Accelerator Laboratory*

Pohang Accelerator Laboratory (PAL) runs a third-generation synchrotron radiation facility, PLS-II, and a hard X-ray free-electron laser in PAL, PAL-XFEL, for user services. In PLS-II, three cryomodules of the superconducting RF system are essential to provide RF power for 400 mA beam current. However, one cryo module developed a vacuum leak at the end of 2022 and was exchanged with a spare unit in the summer maintenance of 2023. In addition, two accelerating columns were exchanged with spare parts to increase the beam energy of the PLS-II linac. On the other hand, self-seeded FEL is actively used for the user experiment in PAL-XFEL. The energy scan with self-seeded FEL is also available in the range of ±2% photon energy. In this talk, the status of PLS-II and PAL-XFEL will be presented.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

164

Study on temperature-dependent scintillation of a pure LaCl3 crystals for the fast neutron spectroscopy

Authors: Seon-Woo Ahn[1]; H. J. Kim[1]; Thanh Luan Nguyen[1]; Duy Quang Nguyen[None]; Quoc Vuong Phan[1]; J.Y. Lee[1]; Uk-Won Nam[2]; Won-Kee Park[2]; Jongdae shon[2]; Young-Jun Choi[2]; Sukwon Youn[3]; Sung-Joon Ye[3]; Sunghwan Kim[4]

[1] *Kyungpook National University*

[2] *Space Science Division, Korea Astronomy and Space Science Institute*

[3] *Seoul National University*

[4] *Cheongju University*

The National Aeronautics and Space Administration (NASA) is gearing up for the Artemis mission to land a human-crewed spacecraft on the lunar in 2025. Ensuring the astronauts' safety is paramount; therefore, measuring the radiation dose affecting the human body on the lunar surface is essential. The lunar's unique environmental conditions further complicate this concern. To accurately calculate the radiation dose originating from this neutron field, measuring the energy distribution of fast neutrons on the lunar surface is essential. Since the temperature of the lunar surface varies significantly, we need to consider detector performance with different temperatures. We have developed a pure LaCl3 crystal scintillator with excellent pulse shape discrimination (PSD) capability to separate between gamma, proton, and alpha signals. This feature makes it easy to remove gamma backgrounds. In addition, the 35Cl(n, p)35S and 35Cl(n, α)32P reactions allow us to measure neutron energy accurately from fast neutron interactions with 35Cl. To determine the suitability of this scintillator on the lunar surface, we studied the temperature-dependent changes in scintillation properties of the LaCl3. We first placed a 2-inch PMT in a refrigerator whose temperature can be

changed from -30 to +30 degrees Celsius and measured single photoelectrons to determine the temperature dependence of the PMT's gain, then combined this PMT with 1 cm3 cubic and 1.5" Φ × 1.0" LaCl3 to measure the gain-corrected light yield, energy resolution, and decay time with different temperature. We also used a fast neutron source at 252Cf to measure the PSD performance with different temperatures.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

165

Design and Calibration of Advanced Particle Dosimeter and Spectrometer (APDS) for Space Charged Particle Radiation

Author: Sung-Joon Ye[1]

Co-authors: Sukwon Youn [1]; Uk-won Nam [2]; Won-Kee Park [2]; Jongdae Sohn [2]; Sunghwan Kim [3]; Hongjoo Kim [4]; Insoo Jun [5]

[1] *Seoul National University*

[2] *Korea Astronomy and Space Science Institute*

[3] *Cheongju University*

[4] *Kyungpook National University*

[5] *Jet Propulsion Laboratory*

High-energy charged particles in space can cause severe health risks to the human body. To analyze the charged particle radiation environment in space and evaluate its effects on the human body, an Advanced Particle Dosimeter and Spectrometer (APDS) is being developed to measure charged particles on the lunar surface and various satellite orbits. The APDS was designed as a stacked structure of Si + CsI + Si to measure the proton spectrum with a wide energy range. The Si-detector on the front side was designed to measure the proton energy spectrum of 1 to 10 MeV and the LET spectrum with a wide range of up to 1,000 keV/μm to evaluate the biological effects of various heavy ions from hydrogen to iron. The CsI scintillator and the Si-detector on the rear side were designed to measure the proton energy spectrum of 10 to 100 MeV and over 100 MeV, respectively. A Monte Carlo simulation using a particle transport code and measurements using proton beams were conducted to verify the design of the APDS and calibrate the instrument. The response of the APDS to 1 to 500 MeV protons and the channel response of each detector were obtained through the MCNP simulation. The energy calibration of the APDS was performed using 30 and 40 MeV proton beams in KIRAMS.

This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korea government (MSIT) (NRF-2017M1A3A4A01077173, NRF-2017M1A3A4A01077220 and NRF-2020M1A3B7040417, NRF-2020M1A3B7108845).

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

No

166

PAL-XFEL upgrade plan

Author: Chang-Ki Min[1]

[1] *PAL/POSTECH*

The construction project of PAL-XFEL (done in 2015) was considered to be successful not only due to the on-time completion as the third one in the world, but also due to the superior upgrade of its basic performance from the previous generation. The basic performances are still in world class but there is big concerns about its basic limitation on beamtime and usability. In this presentation, to solve this limitations and to become a more practical and more useful lightsource, PAL-XFEL upgrade plan is described.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

167

Unveling the Nitrate Reduction Reaction Mechanism Using a Ruthenium Single-Atom Catalyst Model

Authors: Jungki Kim[1]; Jeonghyeon Kim[1]; Juhyun Cho[1]; Sang-Il Choi[1]

[1] *Kyungpook National University*

The nitrate reduction reaction (NO3RR) has emerged as a promising alternative to the environmentally unfriendly Haber-Bosch process (HBP), which involves high temperatures and pressures. NO3RR, an electrochemical process, efficiently reduces nitrogen and nitrate ions at ambient conditions, presenting a more environmentally friendly approach that avoids the need for hydrogen generated from non-sustainable sources. By utilizing an aqueous solution as a proton source to produce ammonia, NO3RR also offers enhanced energy efficiency when compared to HBP. Despite these advantages, NO3RR remains relatively underexplored compared to well-studied electrochemical reactions like the oxygen reduction reaction (ORR), oxygen evolution reaction (OER), and hydrogen evolution reaction.

Various reports have investigated single metal catalysts, among which ruthenium (Ru) clusters have exhibited the most promising results, achieving an impressive ammonia production rate of 19,890 μg/h/cm² and a Faradaic efficiency of 100% at -0.2 V (vs RHE). Additionally, non-single metal catalysts, like Ru1/Cu nanowires, have demonstrated even higher activity with an ammonia production rate of 76,512 μg/ㅎ ∗ cm² and a Faradaic efficiency of 95.6% at -0.135 V (vs RHE). Moreover, studies exploring iron single-atom catalysts, platinum-iridium alloy catalysts, copper catalysts, and other materials for NO3RR have contributed to a growing body of catalyst reports. Despite these efforts, the establishment of well-defined mechanisms for HER, ORR, and OER in NO3RR remains a crucial research gap.

In light of this, our research team aims to shed light on the mechanism of NO3RR through the synthesis of Ruthenium Single-Atom Catalysts (Ru-SAC) as a model catalyst. Ruthenium's recognized position as the most promising catalyst for NO3RR makes it an ideal candidate for this investigation."

This research has been performed as Project Open Innovation R&D(OTSK_2022_036) and supported by K-water

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

168

An electron paramagnetic resonance study of p-type oxide semiconductor with ion-beam irradiation

Authors: Gi Wan Jeon[1]; Yu-Mi Kim[1]; Jaekwon Suk[1]; Sunmog Yeo[1]; Jun Mok Ha[1]; In-mok Yang[1]; Chorong Kim[1]; Hye-Ran Jeon[1]; Jun Kue Park[1]

[1] *KOMAC/KAERI*

Oxide semiconductors are a promising material due to their wide band gap and low current leakage. However, the p-type oxide semiconductor exhibits inferior performance compared to the n-type oxide semiconductor. In this study, we investigate the behavior of electrons in p-type oxide semiconductors by performing electron paramagnetic resonance (EPR) experiments. We scrutinize the effect of N2 ion-beam irradiation on oxide semiconductors using EPR experiments and density functional theory calculations for theoretical support.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

169

Single-atom decoration on Pt nanocube particles for improve ammonia electrolysis

Authors: Juhyun Cho[1]; Jungki Kim[1]; Jeonghyeon Kim[1]; Saehyun Park[1]; Sang-Il Choi[1]

[1] *Kyungpook National University*

The ongoing global warming crisis, primarily fueled by the relentless surge in carbon dioxide emissions, has prompted extensive research into potential solutions. One notable exploration avenue involves utilizing ammonia electrolytic cells. Ammonia presents a compelling advantage as a carbon-free substance, boasting a superior energy density and greater ease of handling and transportation when compared to hydrogen. Unlike conventional systems reliant on organic reactants, these advanced devices offer a sustainable and environmentally friendly alternative, as they do not yield carbon dioxide as a byproduct. However, a significant challenge in developing these systems revolves around the ammonia oxidation reaction (AOR) ‘s stability at the anode. This reaction is susceptible to poisoning from N-species intermediates, specifically Nads and NOads. One promising avenue for mitigating this poisoning phenomenon involves the incorporation of transition metals into the catalyst. Although the precise mechanisms underpinning the enhanced resistance to poisoning remain elusive, numerous studies have indicated improved stability when introducing transition metals such as Ni, Cu, and Ru. In our research, we have taken a pioneering approach by introducing various transition metals at the atomic level onto a platinum nanocube, evaluating their efficacy in facilitating the ammonia oxidation reaction.
This research has been performed as Project Open Innovation R&D(OTSK_2022_036) and supported by K-water.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

170

Carbon-Ion Beam Irradiation and the miR-200c Mimic Effectively Eradicate Pancreatic Cancer Stem Cells

Authors: Sei Sai[1]; Eun Ho Kim[2]

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Purpose: The study investigated the molecular mechanisms that killed pancreatic cancer cells, including cancer stem cells (CSCs), by carbon ion beam irradiation alone or in combination with miRNA-200c under in vitro and in vivo conditions.
Methods: Human pancreatic cancer (PC) cells, PANC1 and PK45, were treated with carbon-ion beam irradiation alone or in combination with microRNA-200c (miR-200c) mimic. Cell viability assay, colony and spheroid formation assay, quantitative real-time PCR analysis of apoptosis-, autophagy-, and angiogenesis-related gene expression, xenograft tumor control and histopathological analyses were performed.
Results: The cell viability assay showed that transfection of the miRNA-200c (10 nM) mimic into pancreatic CSC (CD44+/ESA+) and non-CSC (CD44-/ESA-) significantly suppressed proliferation of both types of cell populations described above. Combining carbon-ion beam irradiation with the miRNA-200c mimic significantly reduced the colony as well as spheroid formation abilities compared to that observed with the treatment of carbon-ion beam alone or X-ray irradiation combined with the miRNA-200c mimic. Moreover, the combination of carbon ion beam irradiation and miRNA-200c mimic increased the expression of apoptosis-related gene BAX, autophagy-related genes Beclin-1 and p62, addition of gemcitabine (GEM) further enhanced the expression of these genes. In vivo data showed that carbon-ion beam irradiation in combination with the miRNA-200c mimic effectively suppressed xenograft tumor growth and significantly induced tumor necrosis and cavitation.
Conclusion: The combination of miRNA-200c mimic and carbon ion beam irradiation may be powerful radiotherapy that significantly kills pancreatic cancer cells containing CSCs and enhances the effect of carbon-ion beam irradiation compared to carbon-ion beam irradiation alone.

Abstract Fields:

KOPUA

Paper Submission Plan (for reference only):

171

Applications of Ion implanted Materials using a KIST 400 kV Accelerator

Authors: W. C. Lim[1]; B. Y. Yoo[1]; K. H. Chae[1]; J. Song[1]; T. Seong[2]

[1] *Advanced Analysis Center, Korea Institute of Science & Technology*

[2] *Department of Materials Science and Engineering, Korea University.*

As the industrial era moves into the information era, it is necessary to process and store a lot of data more quickly and reliably. In order to satisfy these needs, numerous studies on the development of new semiconductors are being conducted. In general, semiconductors have been prepared by implantation of B and P or As in silicon wafers. However, ion implantation is limited by the kinds of elemental ion beams available for research. This limits the utilization and scope of new materials. Therefore, an important facet of development is at the ion source, to produce a wide variety of elemental ion beams of sufficient intensity for the research and development. Ion implantation process reduces the influence of external contaminants, and is a low temperature process with good reproducibility. However, due to the limited kinds of elements that can be produced by most systems for ion implantation researches, development of new and novel materials has likewise been limited. Our team at the Korea Institute of Science and Technology (KIST) has conducted research into ion beam analysis and ion implantation using three accelerators of 0.4 MV, 2.0 MV, and 6.0 MV. In particular, we have increased the number of elements available on our 400 kV accelerator system until more than 30, including Li, Be, Na, Mg, Al, and Si.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

172

Methods of Electron Bunch Energy Modulation for Generation of Soft X-Ray Attosecond Free Electron Laser

Authors: K. Moon[1]; Myung-Hoon Cho[1]; Chi Hyun Shim[1]; Haeryong Yang[1]; Seong-Hoon Kwon[1]; Inhyuk Nam[1]

[1] *PAL/POSTECH*

X-ray free-electron laser technology with attosecond pulse duration relies on energy modulation of electron bunch. The energy modulation can be obtained by using a laser pulse which is superposed and
copropagates with the electron bunch within wiggler section or by coherent synchrotron radiation generated
from current peak of the bunch within wiggler section. Two methods can be distinguished by wiggler constant
 which can be adjusted with wiggler period and wiggler magnetic pole filed , and by bunch energy
distribution in beam comoving coordinate . We aim to investigate the characteristics of the bunch energy
modulation and the resultant free electron laser using simulations.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

173

SIRIUS, a 4th generation synchrotron light source in Brazil

Author: Liu Lin[1]

[1] *Brazilian Synchrotron Light Laboratory*

SIRIUS is a green-field 4th generation Synchrotron Light Source Facility based on a 3 GeV electron storage ring with 518 m circumference and 250 pm.rad emittance. It was designed, built, and is now being operated by the Brazilian Synchrotron Light Laboratory (LNLS/CNPEM). After completion of Phase-0 commissioning of the accelerators and first beamlines, SIRIUS is now open for external users, with 6 fully operational beamlines, 4 in scientific commissioning mode, and 4 in different stages of installation. We are going to introduce the SIRIUS accelerator parameters and their status in user's top-up operation mode, with important upgrades in the orbit feedback systems and reduction of transient perturbations to the stored beam during the injection process.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

No

174

Recent trends and developments in the field of accelerator physics and engineering for synchrotron light sources

Author: Timur Shaftan[1]

[1] *Brookhaven National Laboratory*

Light source community is rapidly evolving in the past decades, pushing towards reliable operations with highest brightness to meet growing demands from the users. The growth in reliability and capabilities is fueled by ongoing developments of concepts in accelerator physics and new technologies in engineering. This presentation is intended to provide an overview of recent developments and give a few highlights of new approaches in producing bright X-ray beams for advanced user applications.

Abstract Fields:

(ICABU WG3) Light Source Utilization

Paper Submission Plan (for reference only):

No

175

Machine Learning-based Anomaly Detection in Drift Tube Quadrupole Operation for the KOMAC Linac

Authors: DongHwan Kim[1]; Geunhyeong Lee[2]

Co-authors: Sungyun Cho [1]; Seunghyun Lee [1]; Dae-Il Kim [1]; Han-Sung Kim [1]; Hyeok-Jung Kwon [1]; Yu Yonggyun [2]

[1] *KOMAC, KAERI*

[2] *KAERI*

The KOMAC linear accelerator encompasses a Drift Tube Linac (DTL) structure for high-frequency acceleration of beam bunches accelerated from Radio-Frequency Quadrupole (RFQ). To achieve beam

focusing within the DTL tank, Drift Tube Quadrupoles (DTQs) are employed. However, over time, with prolonged usage, these components may experience performance degradation or even become inoperable. The EPICS Input/Output Controller (IOC) monitors the operational parameters of the power supplies responsible for the DTQ magnets. Any deviations from predetermined thresholds trigger either minor or major alarms, serving to alert the operator of potential anomalies. Nevertheless, this conventional methodology falls short in accounting for recent shifts in operational values, such as equipment aging or alterations in beam operating conditions. A machine learning-driven methodology offers the advantage of assimilating historical data pertaining to the magnet power supply. This enables the derivation of adaptive thresholds and facilitates the detection of anomalies. The study employed the LSTM (Long Short-Term Memory Network) Autoencoder deep learning model to interpret anomalies in DTQ magnets. It undertakes an in-depth Exploratory Data Analysis (EDA) encompassing six years of DTQ magnet operational data. By analyzing normal operational data from DTQ magnets, anomalies were calculated to detect potential failures. As a result, the potential for enhancing device maintenance and performance is feasible through the proactive prognostication of impending failures.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

Yes

176

Overview of a KAHIF-upgrade project for fusion/fission material irradiation research in KAERI

Author: Seunghyun Lee[1]

Co-authors: Dae-Sik Chang [1]; Dongwon Lee [1]; Ki-hyun Lee [1]; Sangbeen Lee [1]; Seok-Kwan Lee [2]

[1] *Korea Atomic Energy Research Institute*

[2] *Joongang Vacuum Co., Ltd*

The Korea Atomic Energy Research Institute has the KAHIF (Korea Atomic Energy Research Institute Heavy Ion Irradiation Facility) that can irradiate heavy ion beams including He, Ar, and Fe ions with high energy. To respond to the growing demand for fusion/fission material damage research caused by neuron beam irradiation, we are carrying out the KAHIF upgrade project.
This paper introduces the overview of the research project and mainly describes the improvement of the ECR ion source for Fe ion beam irradiation and the beam measurement system for quantitative ion beam evaluation.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

Yes

177

Initial beam conditioning of 14.5 GHz ECR Ion Source for RAON

Author: Jeongil Heo[1]

Co-authors: Hyung Jin KIM [2]; IN-SEOK HONG [3]

[1] *Institute for Basic science*

[2] *Institute for Basic Science*

[3] *IBS*

RAON(Rare isotope Accelerator complex for ON-line experiments) is a heavy ion accelerator that is being built in Daejeon, South Korea. RAON plans to operate a 28 GHz ECRIS(Electron Cyclotron Resonance Ion Source) with fully superconducting magnet and a 14.5 GHz ECR ion source with fully permanent magnet. The 14.5 GHz ECRIS was manufactured by PANTECHNIK and installed in our beam line in September 2020. Initial beam conditioning of the RAON accelerator will be performed using 14.5 GHz ECRIS. Conditioning using Argon, Oxygen, and Neon beams is planned to be performed for initial conditioning of the LEBT, RFQ, MEBT, SCL3, and KoBRA sections. Before conditioning each section, an experiment was performed on each beam at a 14.5 GHz ECR ion source through changes in RF power and gas mixing ratio. Beam current and emittance according to each parameter were measured and compared.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

178

Beam Diagnostics System for Korea 4GSR Injector LINAC

Authors: Bokkyun Shin[1]; Garam Hahn[1]

Co-authors: Changbum Kim [1]; Chanmi Kim [2]; Chong Shik Park [3]; Dong Cheol Shin [1]; Donghyun Song [1]; Dotae Kim [4]; Gyujin Kim [1]; Jaehyun Kim [1]; Jung Yun Huang [1]; Seunghwan Shin [5]; Siwon Jang [1]; Woojin Song [6]

[1] *Pohang Accelerator Laboratory*

[2] *korea univ.*

[3] *Korea University, Sejong*

[4] *PAL*

[5] *Korea University*

[6] *Postech*

The Korea 4GSR is a fourth-generation synchrotron light source planned for construction by 2027. The injector LINAC of the Korea 4GSR comprises an RF photocathode gun and four accelerator tubes to generate single bunch and multi-bunch pulse modes of electron beams, with charges of up to 3 nC, energies reaching 200 MeV, and emittance below 10 nm rad. The precise measurement of beam parameters of the LINAC, including charge, position, profile, energy, and emittance, is crucial. For those measurements, we configured a diagnostic system in the LINAC section, which includes six types of diagnostic devices: the Integrated Current Transformer, Faraday cup, beam position monitor, beam profile monitor, slit, and beam loss monitor to monitor beam losses.
We will present the motivation of the diagnostic system configuration, the specifications of each diagnostic device, and the accuracy of beam parameter measurements.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

179

The Current Status and Future Plan for the Race-Track Microtron for Particle Physics and Medical Applications

Author: Jisoo Kim[1]

Co-authors: Eun-San Kim [2]; Ho Jun Jeong [2]; HyangKyu Park [2]; Sang Hoon Nam [3]

[1] *Dept. of Accelerator Science, Korea University, Sejong, South Korea*

[2] *Korea University*

[3] *NAWOOPULSE TECH*

We got the Race-Track Microtron (RTM) donated from Helmholtz-Zentrum Berlin (HZB), which was previously used as the injector for the storage ring BESSY2. The RTM can increase the beam energy in 5.3 MeV increments, allowing energy extraction from 10.6 MeV to 53 MeV. Installation is underway to utilize the RTM in particle physics and medical application research. Currently, a new cooling system is being constructed, and the vacuum system is undergoing inspection. We would like to introduce the current status of the RTM and our future plans.

Abstract Fields:

(ICABU WG1) Accelerator Systems

Paper Submission Plan (for reference only):

No

180

Development Status of Beam Loss Monitor for Korea 4GSR

Author: Donghyun Song[1]

Co-authors: Bokkyun shin [2]; Changbum Kim [1]; Dong Cheol Shin [2]; Dotae Kim [1]; Garam Hahn [1]; Gyujin Kim [2]; Jaehyun Kim [3]; Jung Yun Huang [2]; Siwon Jang [2]; Woojin Song [4]

[1] *Pohang Accelerator Laboratory*

[2] *PAL*

[3] *Pohang Accelerator Lab (PAL)*

[4] *POSTECH*

This poster presents the development of beam loss monitors using scintillating fibers and CMOS cameras. Minimizing beam losses is important for maintaining beam quality, and continuous beam loss in specific locations can lead to permanent damage to the machine. Therefore, a beam loss monitor should be installed to ensure safety, machine protection, and beam quality. To measure beam loss in all areas of the booster ring and main ring, there was a need for a cost-effective beam loss detector capable of measuring multi-channel beam loss. We developed a beam loss monitor that comprises scintillation fiber detectors and a readout module utilizing a CMOS camera. The readout module has 25 channels and measures beam loss by detecting scintillation light from the detector. This poster describes the prototype development of the beam loss monitor, along with the measurement results obtained in PLS-II.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

181

Online bunch length monitor for Korea 4GSR using fast photodiode

Author: Woojin Song[1]

Co-authors: Bokkyun shin [2]; Changbum Kim [3]; Dong Cheol Shin [2]; Donghyun Song [2]; Dotae Kim [2]; Garam Hahn [3]; Gyujin Kim [2]; Jaehyun Kim [4]; Jung Yun Huang [2]; Siwon Jang [2]

[1] *POSTECH*

[2] *PAL*

[3] *Pohang Accelerator Laboratory*

[4] *Pohang Accelerator Lab (PAL)*

Providing bunch lengths and a filling pattern of the bunch train in real-time is one of the important challenges in beam instrumentation of the storage-ring-based light source. In particular, the time length and intensity information of the synchrotron light is useful to beamlines and their users who perform time-resolved experiments. We developed an online monitoring system that can measure bunch lengths and a filling pattern simultaneously by directly observing the synchrotron radiation with a fast photodiode and wide bandwidth digitizer. In this presentation, we present the development status of the online bunch length monitor for Korea 4GSR, the signal processing method and several machine study results in the PLS-II storage ring.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

182

The basic research on filamentless type metal ion sources development for industrialization

Author: Myung-Jin Kim[1]

Co-authors: Bom-Sok Kim [2]; Jae-Keun Kil [2]

[1] *RADPION Inc.*

[2] *RADPION lnc.*

RADPION lnc. is a company that can provide high-tech comprehensive solutions from semiconductors to future automobiles, military, and cultural industries based on ion beam convergence technology. Our company utilizes ion beam technology using gas ion beam to industry and is applied

to mass production in the semiconductor field. Currently, we are developing a metal ion source applicable to industrialization. The metal ion beam has many industrial applications such as antibacterial, mechanical, chemical property improvement, and antistatic, but it is difficult to apply to the industry because there is no metal ion source capable of extraction a large amount of metal beam for industrial application. In addition, due to the nature of the metal ion source, it is difficult to replace the type of metal and there are many restrictions on long-term use for industrial application. In consideration of industrialization, our company has developed and manufactured a filamentless type 40keV, 20mA class metal ion source, and is conducting a metal beam extraction test. After the beam was pulled out, Cu ions were confirmed through RBS analysis, and in the case of the sample irradiated with the Cu beam, it was confirmed that the antibacterial effect was expressed in the sample as a result of the analysis of the antibacterial properties. Currently, our company is conducting research to increase the amount of metal ions and the beam extraction area of the metal ion source developed for industrialization. Detailed research results will be presented.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

No

183

Current Status of Carbon ion therapy in Yonsei Cancer Center

Author: Jin Sung KIm[1]

[1] *Yonsei University College of Medicine*

Radiation therapy has perennially remained at the forefront of cancer treatment, steering through several evolutionary phases to ameliorate therapeutic outcomes and minimize adjacent normal tissue toxicity. Since its global installation post-1994, Carbon Ion Therapy has been bathed in the spotlight as a revolutionary therapeutic modality, persistently rendering therapy and showcasing superior characteristics when juxtaposed with conventional X-ray and proton therapies. This paper endeavors to meticulously explore the current status and prospective installation and commissioning of Carbon Ion Therapy at Yonsei Cancer Center, marking a notable commencement in the Korean medical landscape.

Korea has engaged in animated discussions regarding the adoption of Proton Therapy Machines and Carbon Ion Therapy Centers, envisaging potential advancements in radiation oncology. In April 2023, Yonsei Cancer Center proudly pioneered the initiation of Carbon Ion Therapy in Korea, marking a significant milestone in amplifying the precision and efficacy of radiation therapy within the country. Currently operational in a fixed-beam mode, the center foresees a future where treatment will be leveraged using a gantry, specifically utilizing superconducting magnets, to further enhance its capability and therapy precision.

This presentation intends to provide an exhaustive overview of the Carbon Ion Therapy apparatus' s current status at Yonsei Cancer Center. It will delineate its exemplary therapeutic achievements, comparisons with pre-existing modalities, and the tangible impacts it has thus far brought upon the cancer treatment paradigm in Korea. Further, it will proffer insights into the strategic developmental roadmap, harboring the expectation that Yonsei Cancer Center could potentially become a global beacon in advancing Carbon Ion Therapy in the future. This unfolding journey, imbued with challenges, learning, and triumphs, stands as a testament to the continual endeavors to uplift the standards and outcomes of cancer treatment on a global stage.

Abstract Fields:

(ICABU WG4) Particle Beam Utilization

Paper Submission Plan (for reference only):

No

184

FEL simulation of soft X-ray undulator line with modified FODO lattice at PAL-XFEL

Author: Chi Hyun Shim[1]

Co-author: Inhyuk Nam [2]

[1] *Pohang Accelerator Laboratory*

[2] *PAL/POSTECH*

The planar undulators primarily used in XFELs produce light with linear polarization and the polarization can be changed to the desired state by using proper polarizer. However, polarization control in the soft X-ray region is quite difficult because there are no suitable polarizers. Therefore, most XFEL facilities are trying to enable the polarization control in the soft X-ray region, and some facilities already have such capabilities. PAL-XFEL has also conducted research on the polarization control in the soft X-ray undulator line, but at that time, the focus was mainly on a study combining planar undulators and elliptically polarizing undulators (EPUs). Since the EPU currently used at XFEL facilities is shorter than the planar undulator used at PAL-XFEL, the FODO lattice can be varied when the EPUs are installed throughout the whole undulator line. Therefore, it is necessary to find the optimal configuration for this case and evaluate its performance. In this study, we estimate the performance of the undulator line with shorter FODO lattice for EPU by using the parameters of the electron beam at the soft X-ray undulator line of PAL-XFEL.

Abstract Fields:

(ICABU WG2) Beam Physics & Instrumentation

Paper Submission Plan (for reference only):

Yes

248

A Deep Learning Method for Predicting Proton Beam Range and Spread-Out Bragg Peak in Passive Scattering Mode

Authors: Young Kyu Lee[1]; Sang Hee Ahn[2]

Co-authors: Chankyu Kim [3]; Wonjoong Cheon [1]; Haksoo Kim [3]; Se Byeong Lee [3]; Young Kyung Lim [3]; Jong Hwi Jeong [3]; Young-Nam Kang [1]; Dongho Shin [3]

[1] *Department of Radiation Oncology, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea*

[2] *Department of Radiation Oncology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Republic of Korea*

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It is difficult to calculate monitor units in the proton treatment planning system due to the complexity of using this system in the double scattering mode of proton therapy. Moreover, the range and

spread-out Bragg peak (SOBP) values using the conversion algorithm (CONVALGO) provided by IBA (C_range, C_SOBP) are different from the actual measured range (M_range) and SOBP (M_SOBP) values. In this regard, the CONVALGO (FC) value (FC_range, FC_SOBP) should be measured according to the quality assurance (QA) of patient treatment, which requires physical effort and time. This study therefore aimed to reduce the time and effort spent on QA. The number of actual measured QA data points was increased from 1,833 to 5,475 through data augmentation. The predictive model was trained using six parameters (main option from B1 to B8, sub-option from 1 to 3, FC_range, FC_SOBP, M_range, M_SOBP), Main option, sub-option, M_range and M_SOBP were used as input values, and FC_range and FC_SOBP were used as lable. The trained model predicted the CONVALGO (PC) values of PC_range and PC_SOBP. The test dataset has 261 patient data that were not used for training. As an evaluation method, the C value predicted by the existing method and the PC value predicted by the predictive model using deep learning were compared with the FC value, which is the label value of the test set. Difference, mean absolute error (MAE), and root mean square error (RMSE) values were used for comparison. Compared to the FC value, the maximum difference was -2.2 mm for PC_range and -3.4 mm for C_range. The acceptable standard of patient QA in our institute is within 1 mm, and the number of data points that met the acceptable standard was 196 for PC_range and 191 for C_range. The maximum difference was 12.2 mm for PC_SOBP and 60 mm for C_SOBP. In both cases, the MAE results for the range were within 1 mm, except for option 8. For the MAE of PC_SOBP, options 1, 2, and 3 showed values within 1 mm. In the MAE of C_SOBP, the values were >1 mm for all options. Options 1 and 8 showed a difference between the MAE and RMSE of >10 mm. For the range, we achieved significant results with <1 mm error for most options, but the prediction of SOBP was not satisfactory. However, it could be useful as a model that suggests initial setting conditions, and because of the nature of deep learning, if a large amount of data are collected and retrained, the predictive model will be further improved.

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The 24Mg(α,p)27Al reaction measurement using Solenoid Spectrometer for Nuclear AstroPhysics (SSNAP)

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The ^{24}Mg(α,p)^{27}Al reaction was measured using the Solenoid Spectrometer for Nuclear AstroPhysics at the University of the Notre Dame in order to study the astrophysical ^{24}Mg(α,p)^{27}Al reaction rate. Alpha beams from the 10-MV FN tandem accelerator impinged on ^{24}Mg solid targets which were made using the vacuum evaporation method on ^{12}C foils. A total of 43 beam energies were used. Recoiling protons from the ^{24}Mg(α,p)^{27}Al reaction were detected using double-sided position sensitive silicon detector array mounted in the solenoid. Energies, times-of-flight, and flight distances of particles were measured for particle identification. Protons associated with a wide range of excitation energies E_x = 12.42 - 14.44 MeV in ^{28}Si were identified.

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