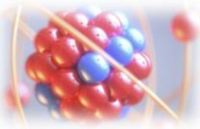


Exploring the limits of nuclear existence

Deuk Soon AHN
(안득순)
with CENS Collaborations

Center for Exotic Nuclear Studies(CENS), IBS

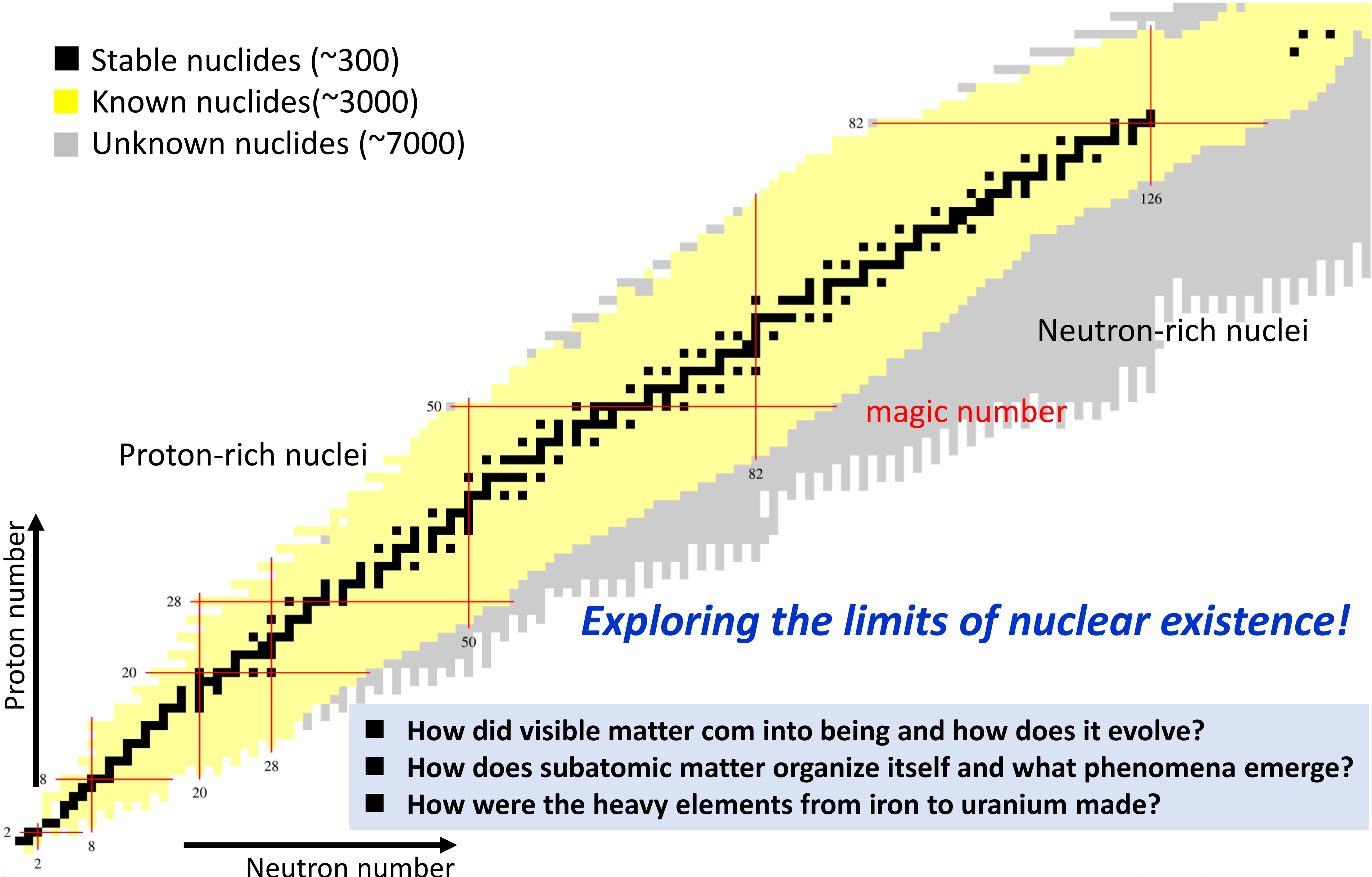
CENTER FOR EXOTIC NUCLEAR STUDIES
기초과학연구원
Institute for Basic Science

Outline

- Exploring the limit of particle stability
- What we need to study for RI beam production?
- Open discussions for current LAMPS setup
- Survey

Exploring the limit of particle stability

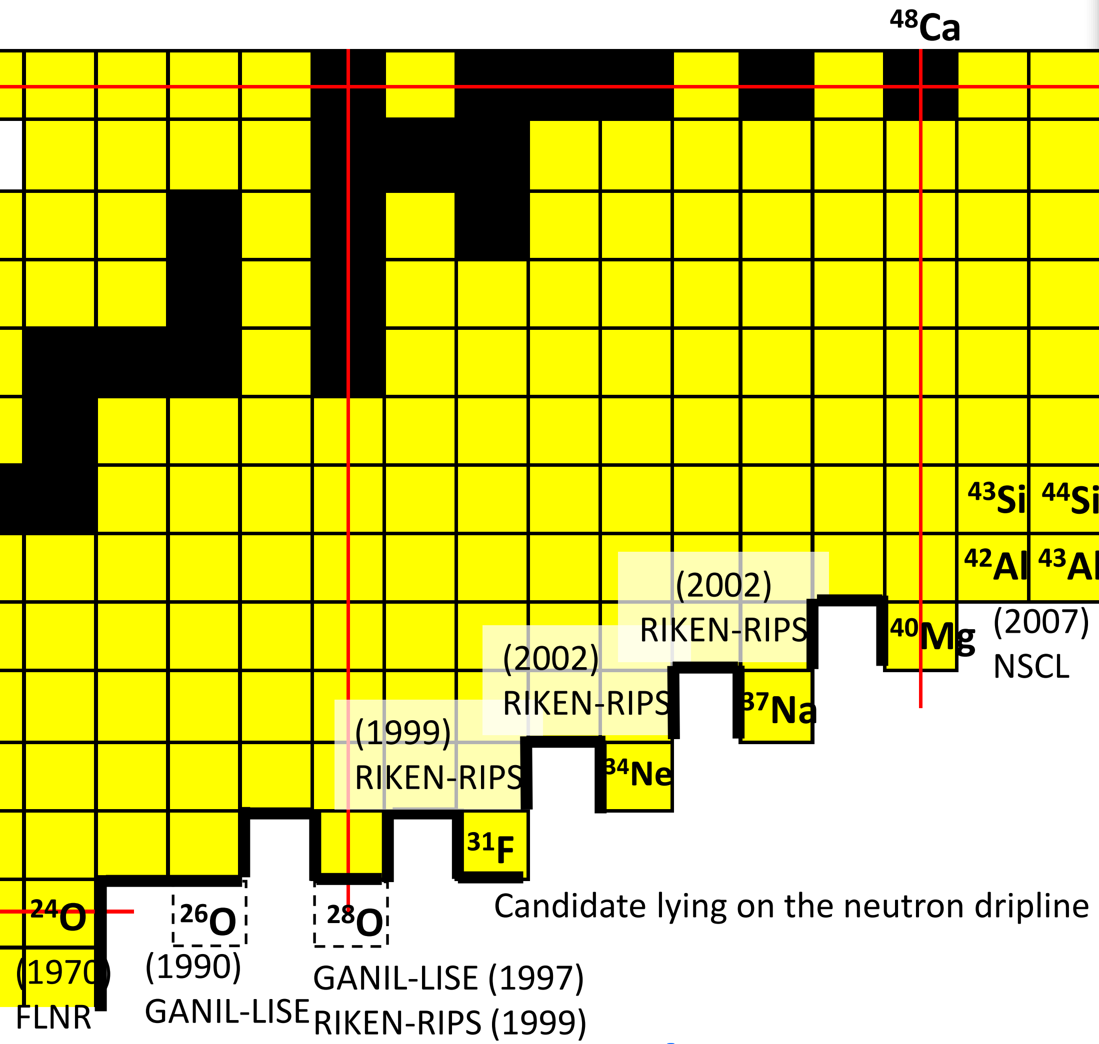
Chart of Nuclides



Exploring the limits of nuclear existence!

- **How did visible matter com into being and how does it evolve?**
- **How does subatomic matter organize itself and what phenomena emerge?**
- **How were the heavy elements from iron to uranium made?**

Status of neutron dripline



✓ ^{25,26}O :
Guillemaud-Mueller, *et al.* Phys. Rev. C41,937 (1990)

✓ ^{28}O :
O. Tarasov *et al.*, Phys. Lett. B409,64 (1997)
H. Sakurai *et al.*, Phys. Lett. B448, 180 (1999)

✓ ^{31}F :
H. Sakurai *et al.*, Phys. Lett. B448, 180 (1999)

✓ ^{34}Ne, ^{37}Na, ^{43}Si :
M. Notani *et al.*, Phys. Lett. B542,49 (2002)

✓ ^{44}Si :
O. Tarasov *et al.* Phys. Rev. C75, 064613 (2007)

✓ ^{40}Mg, ^{42,43}Al :
T. Baumann *et al*. Nature 449, 1022 (2007)

Where is neutron dripline for Fluorine and Neon?

The neutron dripline has been experimentally established up to oxygen. (20 years ago)

Location of neutron dripline

RIKEN RIBF experiment with BigRIPS collaborations

D.S.Ahn *et al.*, Physical Review Letters 123, 212501(2019)

PHYSICAL REVIEW LETTERS 123, 212501 (2019)

Editors' Suggestion | Featured in Physics

Location of the Neutron Dripline at Fluorine and Neon

D. S. Ahn,[1] N. Fukuda,[1] H. Geissel,[5] N. Inabe,[1] N. Iwasa,[4] T. Kubo,[1,*,†] K. Kusaka,[1] D. J. Morrissey,[6] D. Murai,[3] T. Nakamura,[2] M. Ohtake,[1] H. Otsu,[1] H. Sato,[1] B. M. Sherrill,[6] Y. Shimizu,[1] H. Suzuki,[1] H. Takeda,[1] O. B. Tarasov,[6] H. Ueno,[1] Y. Yanagisawa,[1] and K. Yoshida[1]

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[2]*Department of Physics, Tokyo Institute of Technology, 2-12-1 O-Okayama, Meguro, Tokyo 152-8551, Japan*
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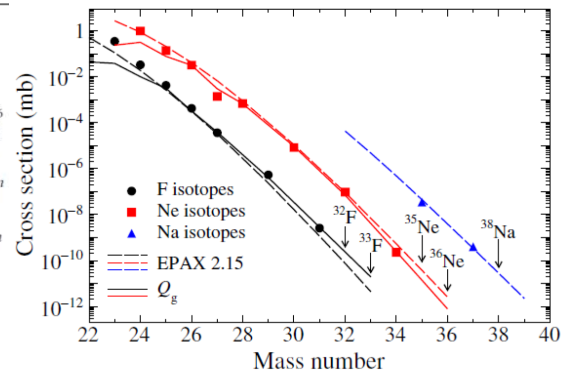
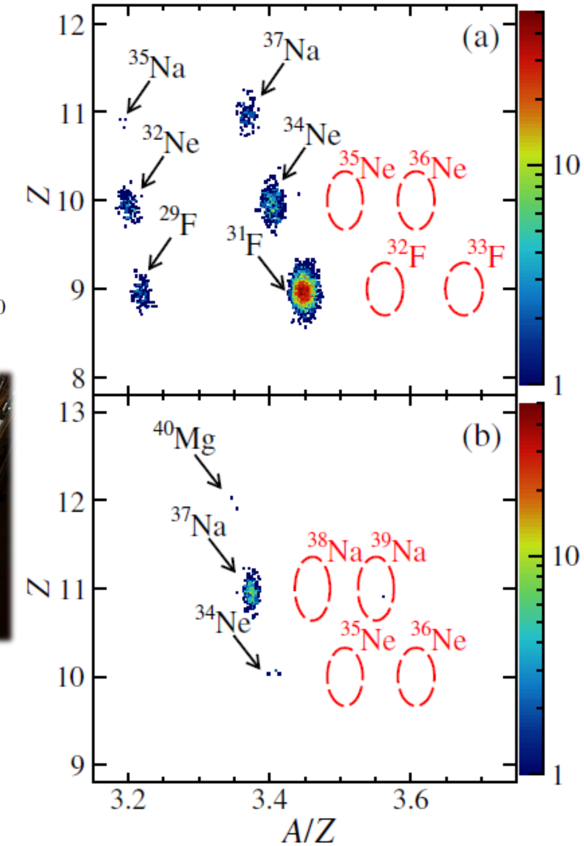
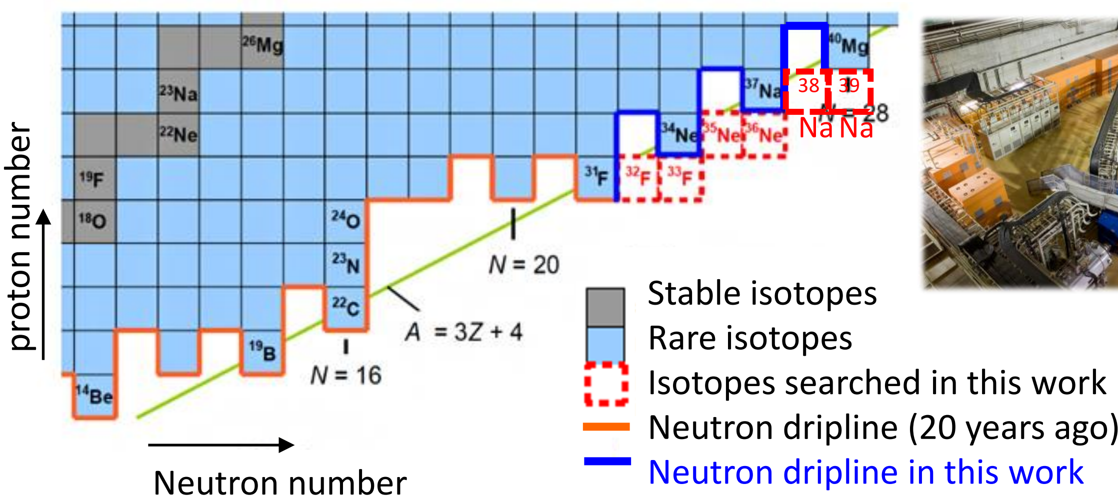
[4]*Department of Physics, Tohoku University, 6-3, Aramaki Aza-Aoba, Aoba-ku, Sendai, Miyagi 980-8578, Japan*
[5]*GSI, Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany*
[6]*National Superconducting Cyclotron Laboratory, Michigan State University, 640 South Shaw Lane, East Lansing, Michigan 48824, USA*

(Received 28 March 2019; published 18 November 2019)







- The neutron dripline has been confirmed up to neon for the first time since ^{24}O was confirmed to be the dripline nucleus nearly 20 years ago.
- The observation of one event for ^{39}Na seems to suggest the existence of bound ^{39}Na.

Discovery of ^{39}Na

RIKEN RIBF experiment with BigRIPS collaborations

PHYSICAL REVIEW LETTERS **129,** 212502 (2022)

Editors' Suggestion | Featured in Physics

D.S.Ahn *et al.*, Physical Review Letters 129, 212502(2022)

Discovery of ^{39}Na

: for the first time in twenty years.

Discovery of ^{39}Na

D. S. Ahn,[1,*] J. Amano,[3] H. Baba,[1] N. Fukuda,[1] H. Geissel,[5] N. Inabe,[1] S. Ishikawa,[4] N. Iwasa,[4] T. Komatsubara,[1] T. Kubo,[1,†] K. Kusaka,[1] D. J. Morrissey,[6] T. Nakamura,[2] M. Ohtake,[1] H. Otsu,[1] T. Sakakibara,[4] H. Sato,[1] B. M. Sherrill,[6] Y. Shimizu,[1] T. Sumikama,[1] H. Suzuki,[1] H. Takeda,[1] O. B. Tarasov,[6] H. Ueno,[1] Y. Yanagisawa,[1] and K. Yoshida[1]

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[4]*Department of Physics, Tohoku University, 6-3, Aramaki Aza-Aoba, Aoba-ku, Sendai, Miyagi 980-8578, Japan*
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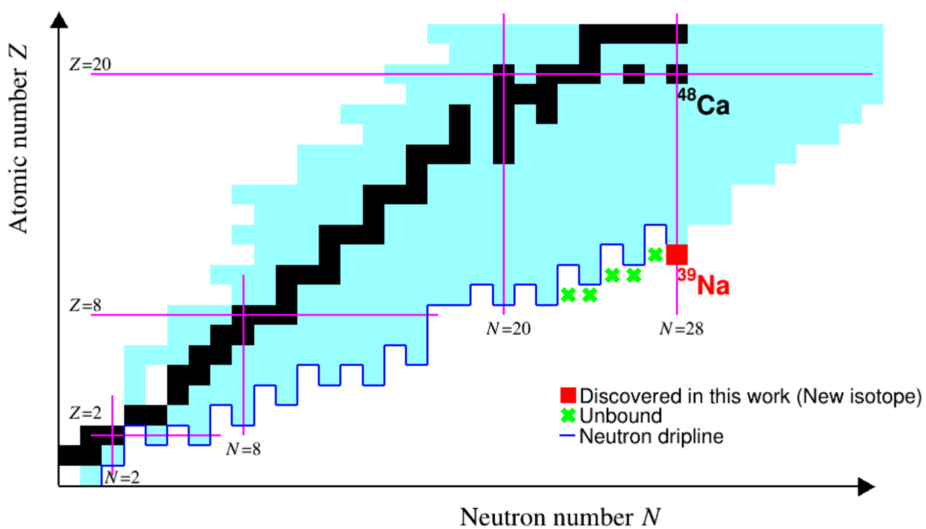

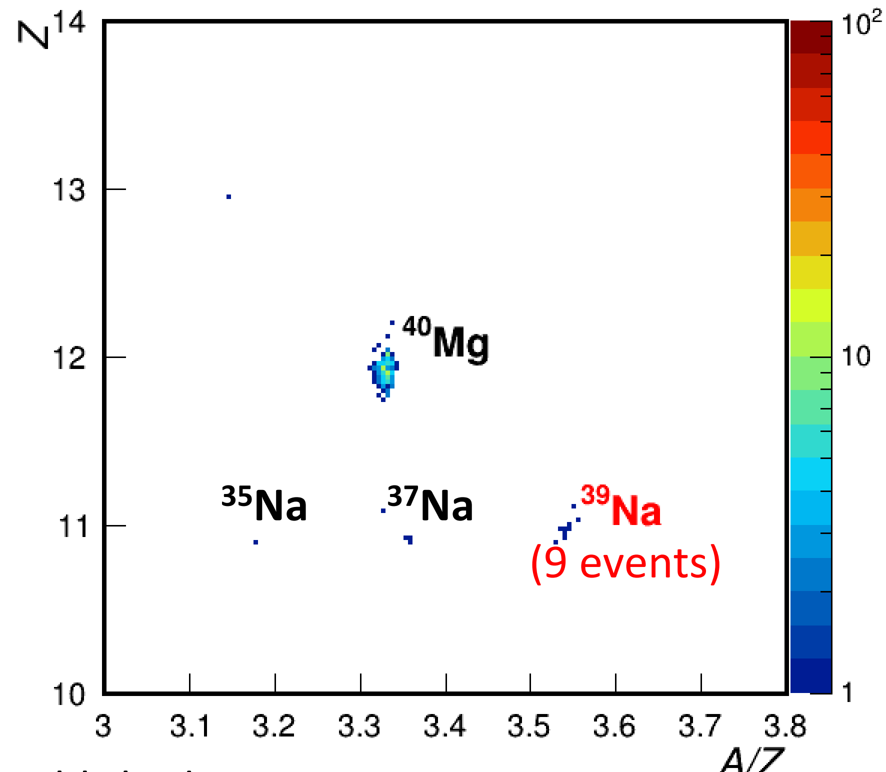

- The neutron dripline has been experimentally established up to neon.
- The heaviest bound nuclei for Na isotopes confirmed so far ^{39}Na.
- Dripline of Na isotopes is located at/beyond *N*=28.

Recent research activities (FRIB)

FRIB Day one experiments

-

FRIB

PHYSICAL REVIEW LETTERS 129, 212501 (2022)

Editors' Suggestion | Featured in Physics

Crossing $N = 28$ Toward the Neutron Drip Line: First Measurement of Half-Lives at FRIB

H. L. Crawford[1,*] V. Tripathi,[2] J. M. Allmond,[3] B. P. Crider,[4] R. Grzywacz,[5] S. N. Liddick,[6,7] A. Andalib,[6,8] E. Argo,[6,8] C. Benetti,[2] S. Bhattacharya,[2] C. M. Campbell,[1] M. P. Carpenter,[9] J. Chan,[5] A. Chester,[6] J. Christie,[5] B. R. Clark,[4] I. Cox,[5] A. A. Doetsch,[6,8] J. Dopfer,[6,8] J. G. Duarte,[10] P. Fallon,[1] A. Frotscher,[1] T. Gaballah,[4] T. J. Gray,[3] J. T. Harke,[10] J. Heideman,[5] H. Heugen,[5] R. Jain,[6,8] T. T. King,[3] N. Kitamura,[5] K. Kolos,[10] F. G. Kondev,[9] A. Laminack,[3] B. Longfellow,[10] R. S. Lubna,[6] S. Luitel,[4] M. Madurga,[5] R. Mahajan,[6] M. J. Mogannam,[6,7] C. Morse,[11] S. Neupane,[5] A. Nowicki,[5] T. H. Ogunbeku,[4,6] W.-J. Ong,[10] C. Porzio,[1] C. J. Prokop,[12] B. C. Rasco,[3] E. K. Ronning,[6,7] E. Rubino,[6] T. J. Ruland,[13] K. P. Rykaczewski,[3] L. Schaedig,[6,8] D. Seweryniak,[9] K. Siegl,[5] M. Singh,[5] S. L. Tabor,[2] T. L. Tang,[2] T. Wheeler,[6,8] J. A. Winger,[4] and Z. Xu[5]

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[11]*Brookhaven National Laboratory, Upton, New York 11973, USA*
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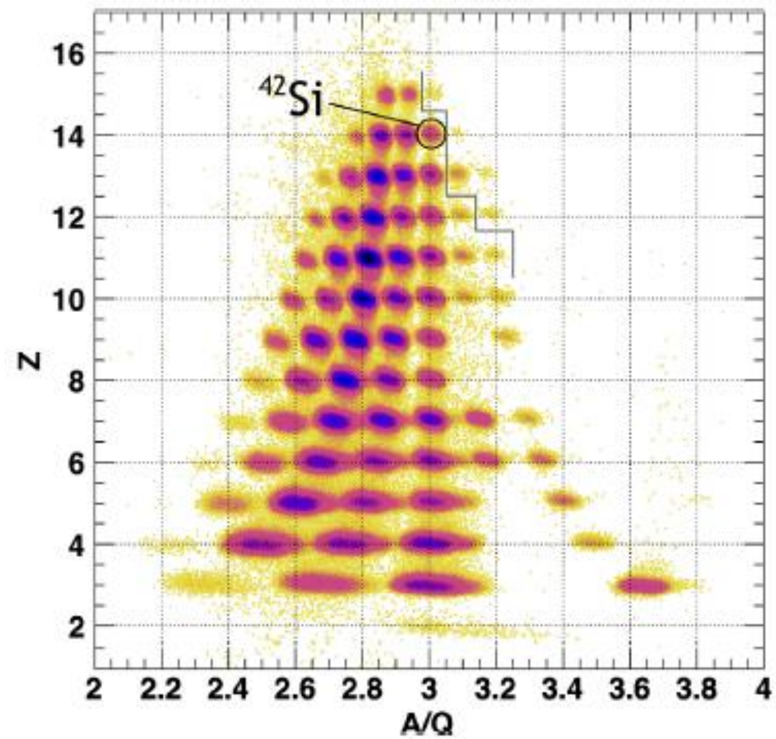
(Received 19 July 2022; accepted 14 September 2022; published 14 November 2022)

New half-lives for exotic isotopes approaching the neutron drip-line in the vicinity of $N \sim 28$ for $Z = 12$–15 were measured at the Facility for Rare Isotope Beams (FRIB) with the FRIB decay station initiator. The first experimental results are compared to the latest quasiparticle random phase approximation and shell-model calculations. Overall, the measured half-lives are consistent with the available theoretical descriptions and suggest a well-developed region of deformation below ^{48}Ca in the $N = 28$ isotones. The erosion of the $Z = 14$ subshell closure in Si is experimentally confirmed at $N = 28$, and a reduction in the ^{38}Mg half-life is observed as compared with its isotopic neighbors, which does not seem to be predicted well based on the decay energy and deformation trends. This highlights the need for both additional data in this very exotic region, and for more advanced theoretical efforts.



New five half-lives of ^{45}P, ^{43}Si, ^{40,41}Al, ^{38}Mg were measured.

H.L.Crawford *et al.*, Physical Review Letters 129, 212501(2022)

Recent research activities

FRIB Day one experiments

Featured in Physics | Editors' Suggestion

FRIB

Crossing $N = 28$ Toward the Neutron Drip Line: First Measurement of Half-Lives at FRIB

H. L. Crawford *et al.*

Phys. Rev. Lett. **129**, 212501 (2022) – Published 14 November 2022

Physics Viewpoint: Probing the Limits of Nuclear Existence

Show Abstract +

H.L.Crawford *et al.*, Physical Review Letters 129, 212501(2022)

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RIKEN NISHINA CENTER

Discovery of ^{39}Na

D. S. Ahn *et al.*

Phys. Rev. Lett. **129**, 212502 (2022) – Published 14 November 2022

Physics Viewpoint: Probing the Limits of Nuclear Existence

Show Abstract +

D.S.Ahn *et al.*, Physical Review Letters 129, 212502(2022)

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VIEWPOINT

Probing the Limits of Nuclear Existence

Yorick Blumenfeld

CNRS/IN2P3, IJCLab, University of Paris-Saclay, Orsay, France

November 16, 2022 • *Physics* 15, 177

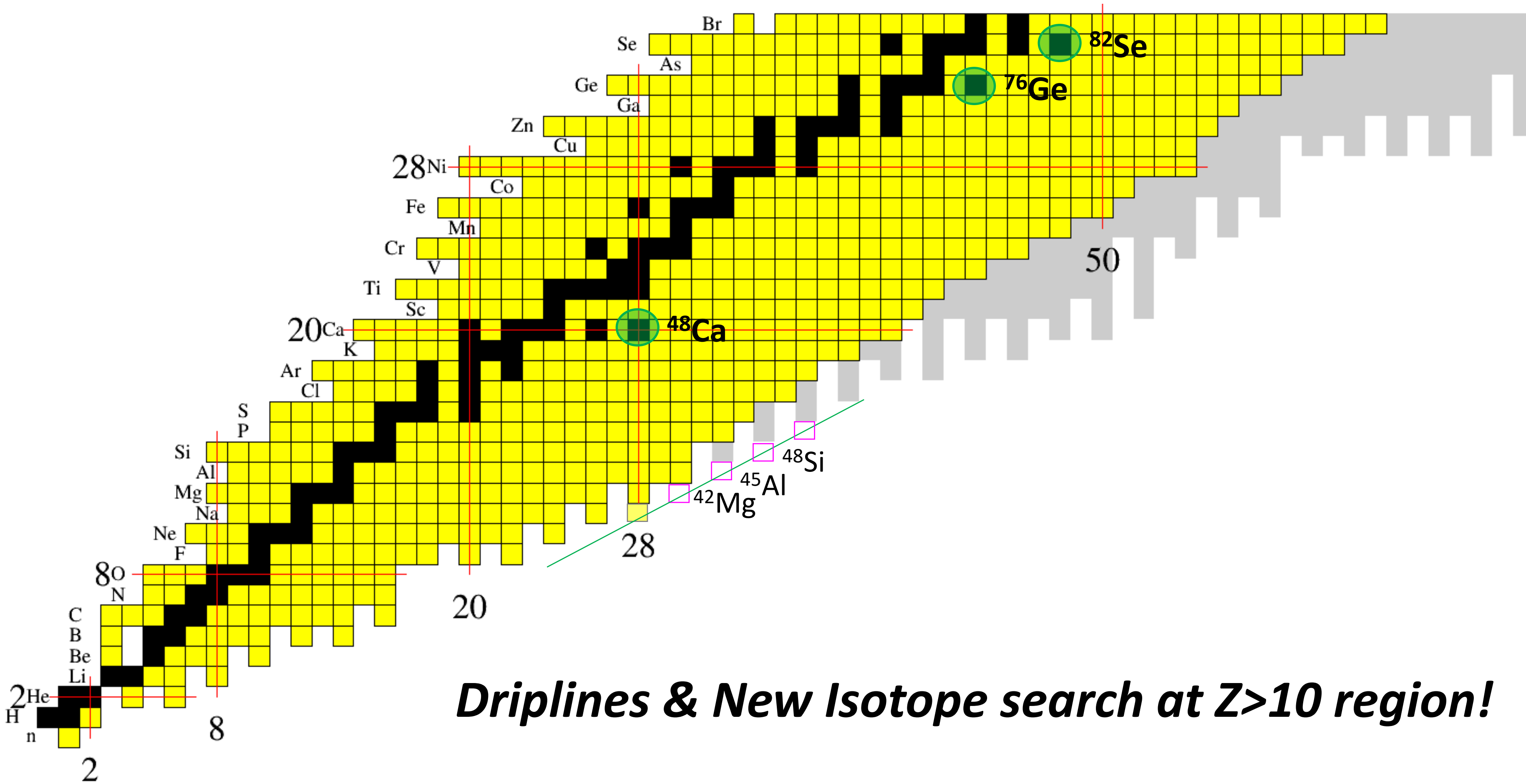
Researchers have discovered the heaviest-known bound isotope of sodium and characterized other neutron-rich isotopes, offering important benchmarks for refining nuclear models.

APS/Alan Stonebraker

Figure 1: Segrè chart showing bound isotopes for elements between nitrogen and phosphorous. Ahn and colleagues have discovered sodium-39, which is likely the dripline isotope for sodium [1]. Crawford and co-workers have measured five previously unknown isotope lifetimes [2]. Show Less

Discovered the heaviest-known bound isotope of sodium and characterized other neutron-rich isotopes, offering important benchmarks for refining nuclear models.

Search for driplines

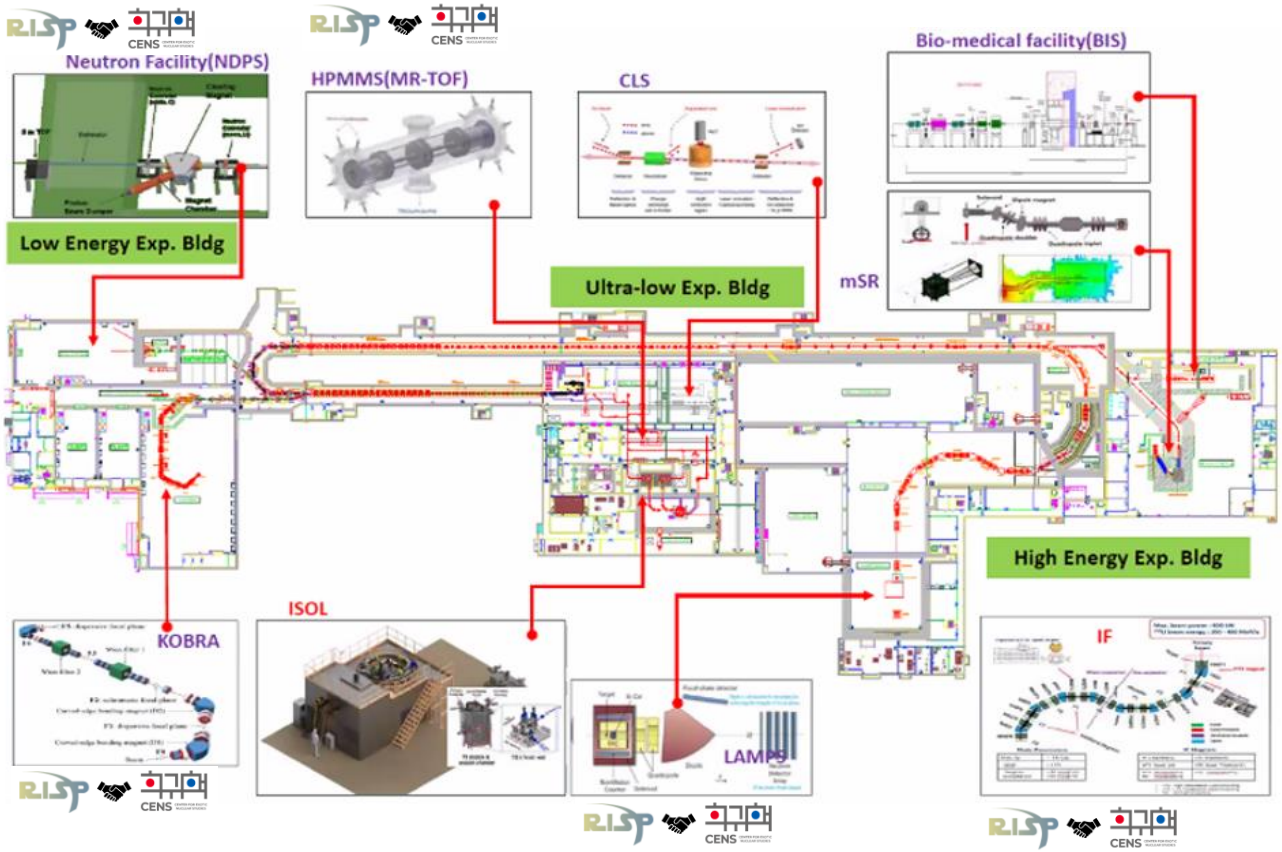


Driplines & New Isotope search at Z>10 region!

- **Locating the neutron dripline continues to be an important challenge for new-generation facilities** and the neutron-dripline search will continue to **play an important role in the nuclear structure** at extremely neutron-rich conditions.
- These results **provide a key benchmark for nuclear mass models and nuclear structure.**
- Development of much more primary beam species are necessary to expand the nuclear chart.

What we need to study for RI beam production?

RAON and domestic collaborations



Man-power exchange
Joint studies

Preparation of research topics and sharing specification of the facilities and detectors

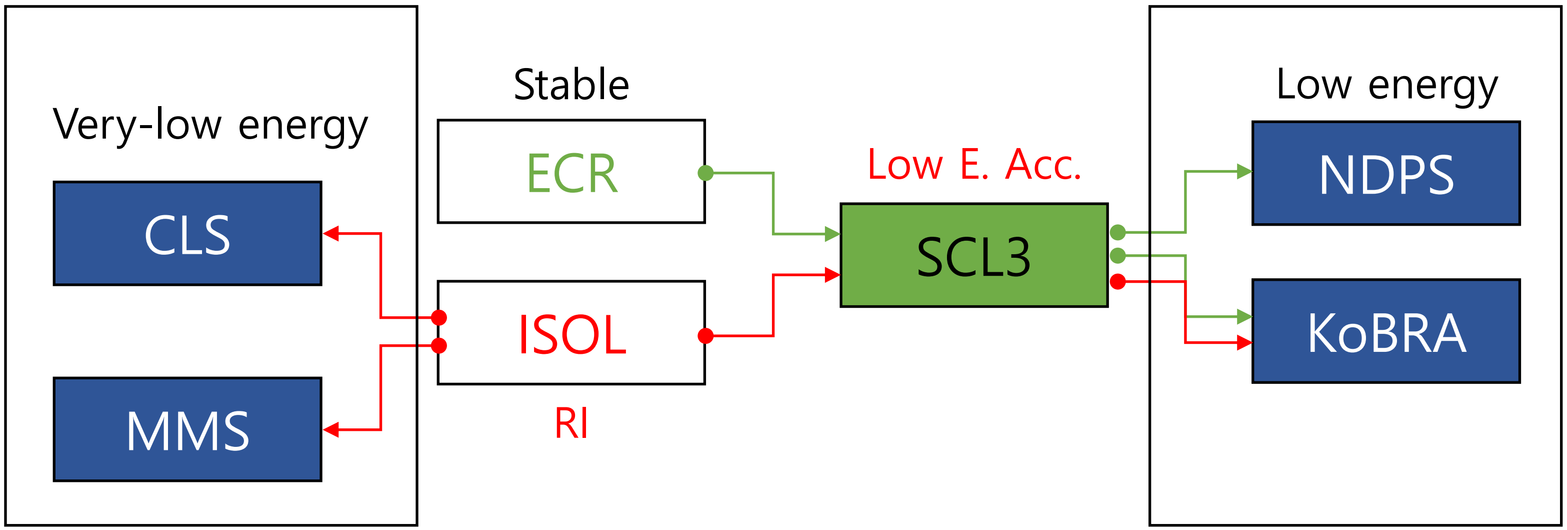
Beam mode for very-low and low energy

Very-low energy utilization research: Study on basic physical quantity of rare isotopes
- MMS(Mass Measurement System
- CLS(Collinear Laser Spectroscopy)

Low energy utilization research: Study on properties of atomic nucleus
- KoBRA(Korea Broad Acceptance recoil spectrometer and apparatus)
- NDPS(Nuclear Data Production System)

High energy utilization research: Study on state of atomic nucleus matter
- LAMPS(Large Acceptance Multi-Purpose Spectroscopy) , IF(In-Flight)

<Beam mode for very-low/low energy>



Broad energy range, variety and high intensity of RIBs will be available at RAON.

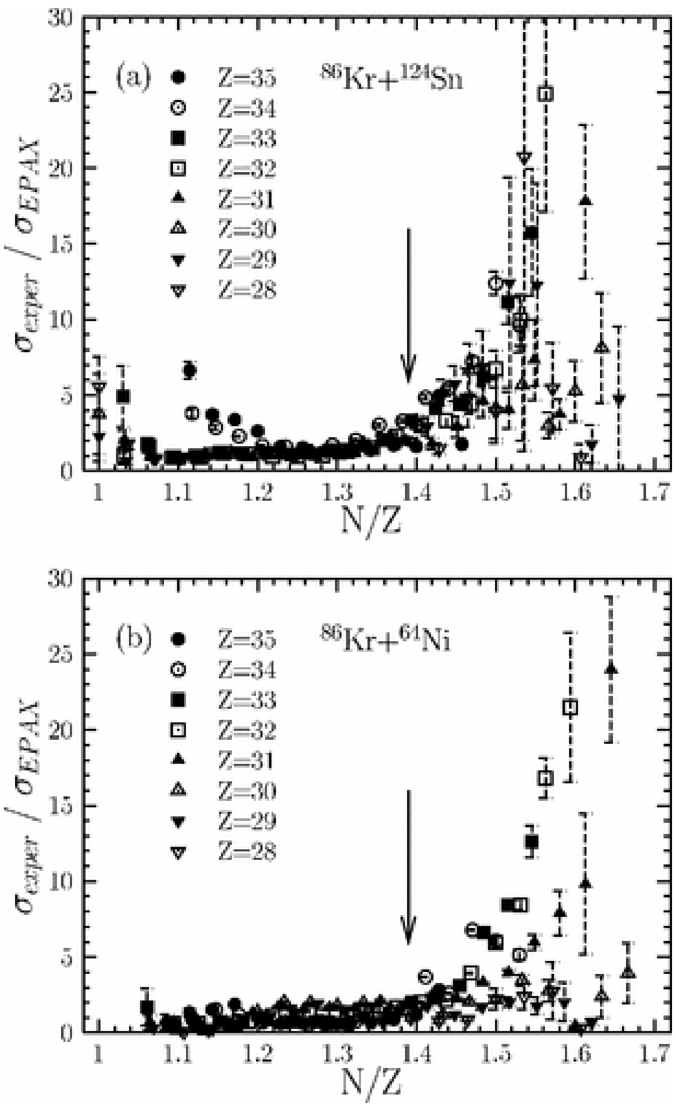
Consideration before the experiment

Need to more study and techniques for RI beam production and experiment.

- **Physics interest**
  - What is importance of physics? What we can measure?
- **Primary beam**
  - Which primary beam provides the largest yields?
- **Target**
  - Which target provides the largest yields?
- **Secondary beams**
  - The production yields of secondary beams realistic or estimated with appropriate cross sections?
- **Detector**
  - Which detector is the best for PID? (purity, energy, resolution,..)
  - There are many problems or difficulties can be happen for the experiment. →detector development
- **Which detector is the best for PID? (purity, energy, resolution,..)**
  - technical problems or difficulties to perform the proposed experiment
  - Safety issues, enough space to place user's equipment

→Consideration the priority for the proposed/to be proposed experiment

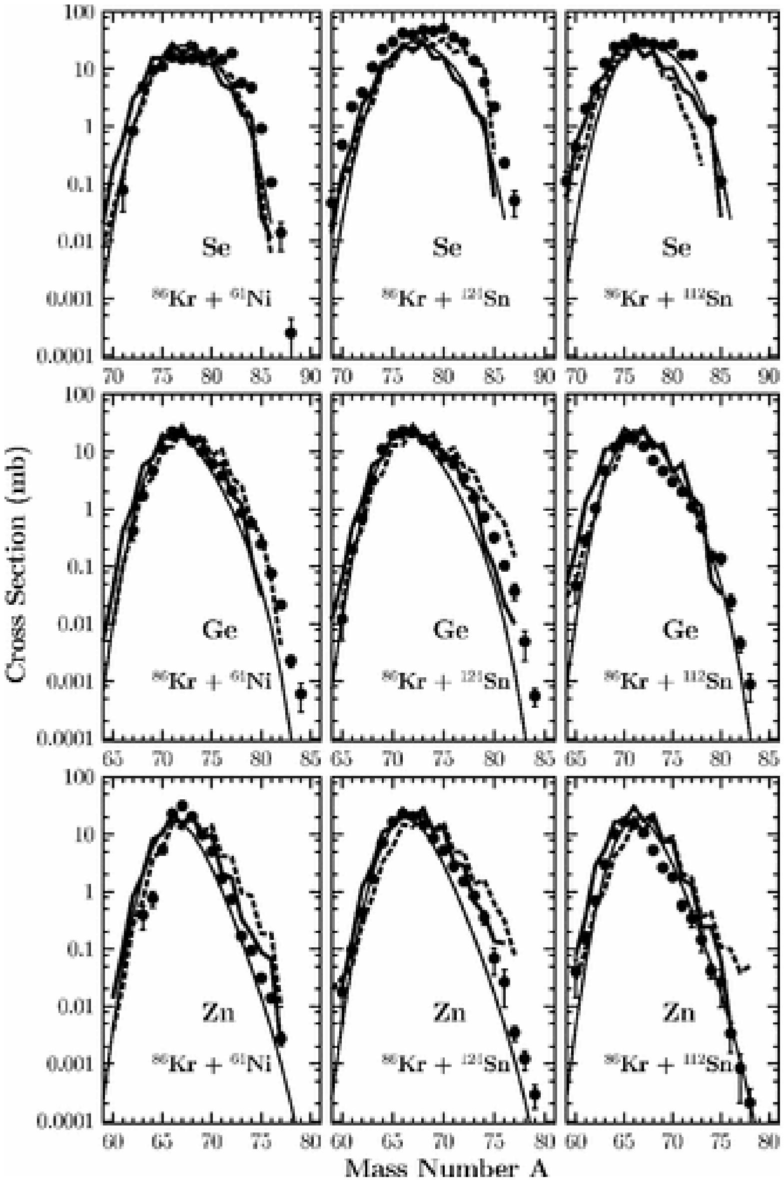
Comparisons with data and EPAX



G. A. Souliotis *et al.*, Phys. Rev. Lett. 91, 022701

Ratio of measured cross sections of projectile residues from ^{86}Kr (25 MeV/u) on ^{124}Sn and ^{64}Ni target with respect to EPAX expectations

Comparisons with data and calculations



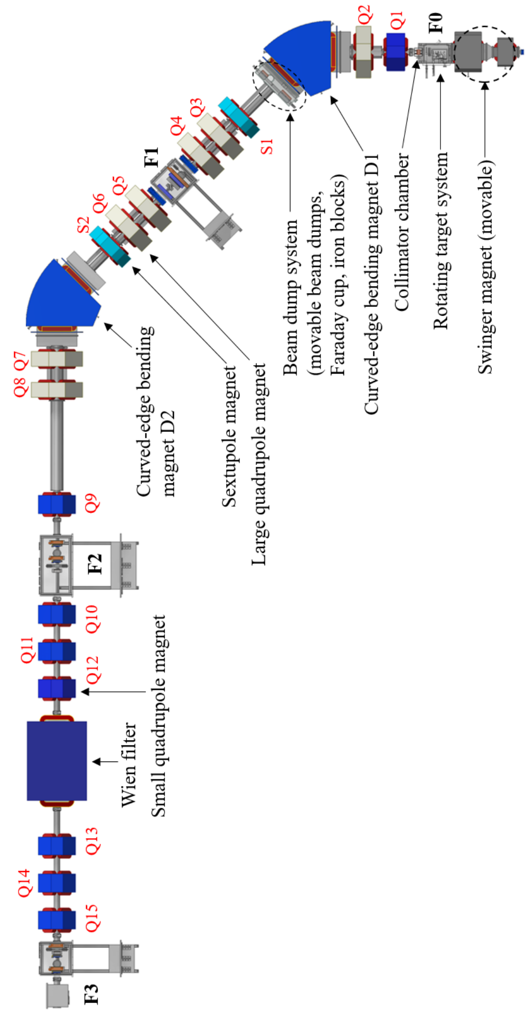
G. A. Souliotis *et al.*, Phys. Rev. Lett. 91, 022701

Comparison of experimental mass distributions of Se (Z=34), Ge (Z=32), and Zn (Z=30) from 86Kr (25 MeV/nucleon) on 64Ni, 124Sn, and 112Sn

Deep Inelastic Transfer/GEMINI calculations
with neutron and proton density distributions
without
EPAX2

CENS Letter of Intent for KoBRA experiments

No	Title
1	Study on neutron-deficient nuclei using proton-induced fusion-evaporation
2	3n fusion-evaporation reactions to study MEDs in Tz=-3/2 nuclei
3	Fusion Reaction Studies related to Stellar Evolution
4	The study of lifetime of isotopes near doubly magic N=Z nuclei 40 Ca
5	Optical model potential studies using stable beams at KoBRA
6	Decay spectroscopy and fast-timing measurements by using KHALA at RAON
7	High-resolution in-beam γ-ray experiments at RAON
8	Internal conversion electron spectroscopy
9	Spectroscopy of proton, neutron and alpha emitters
10	RI experiments probing isospin symmetry
11	Charge-exchange (p,n) reaction in inverse kinematics on light exotic nuclei along the neutron drip line
12	High-resolution study of spin-isospin responses of N=Z exotic nuclei
13	Measurement of production cross sections

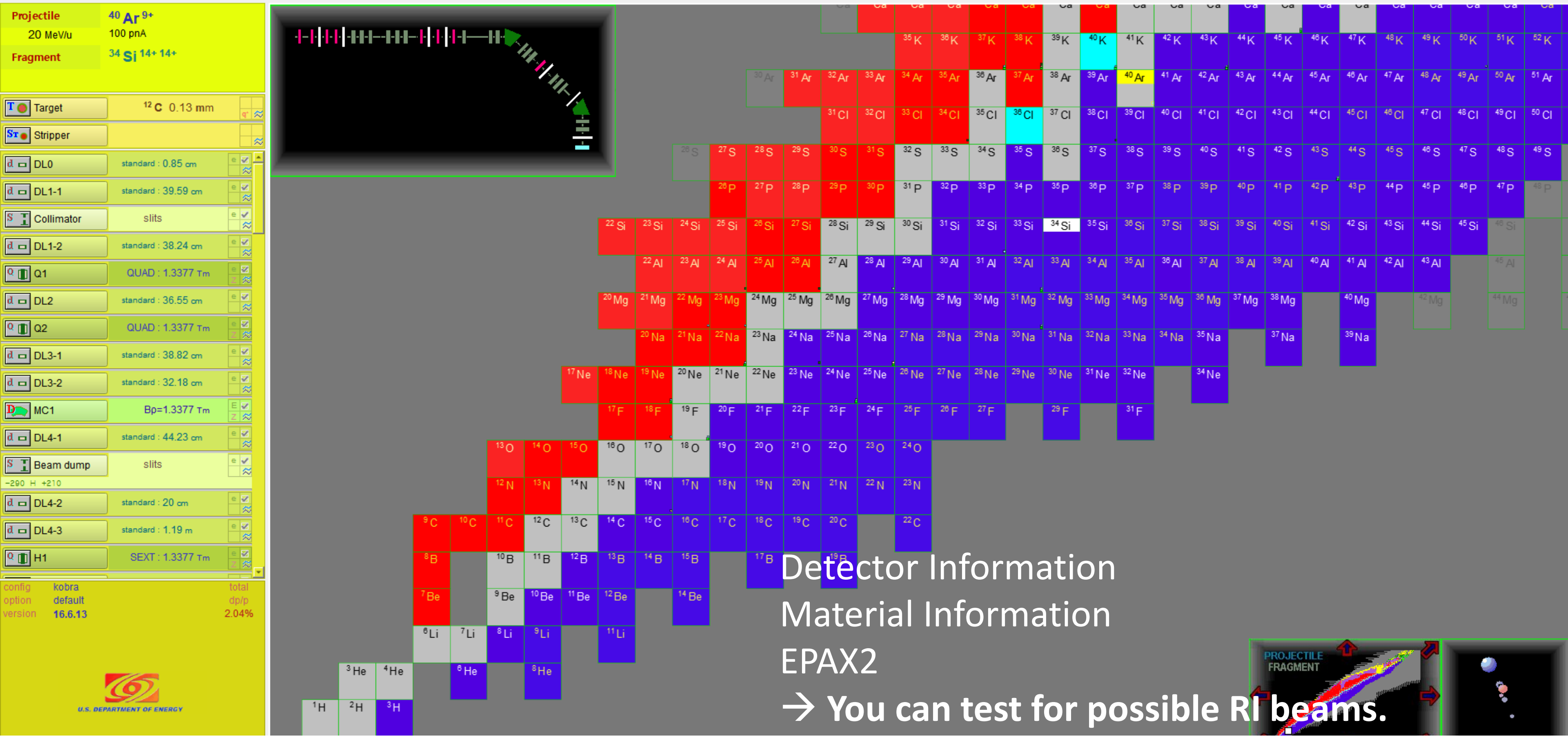


CENS Letter of Intent for KoBRA experiments

No	Title	Primary beams	Secondary beams
1	Study on neutron-deficient nuclei using proton-induced fusion-evaporation	$^{16}O, ^{20}Ne$	$^{14-16}F$, $^{18-20}Na$
2	3n fusion-evaporation reactions to study MEDs in Tz=-3/2 nuclei	$^{16}O, ^{20}Ne$	^{29}S, ^{37}Ca
3	Fusion Reaction Studies related to Stellar Evolution	$^{40}Ar, ^{20}Ne$	-
4	The study of lifetime of isotopes near doubly magic N=Z nuclei 40 Ca	^{40}Ca	-
5	Optical model potential studies using stable beams at KoBRA	$^{40}Ar, ^{22}Ne$	^{22}Ne
6	Decay spectroscopy and fast-timing measurements by using KHALA at RAON	$^{40}Ar, ^{48}Ca, ^{70}Zn$	$^{30-32}Ne, ^{31-35}Mg, ^{33-37}Si, ^{47-51}Ar$, $^{51-56}Ca, ^{55-59}Ti, ^{61-63}Cr$
7	High-resolution in-beam γ-ray experiments at RAON	$^{40}Ar, ^{48}Ca, ^{70}Zn$	$^{30-32}Ne, ^{31-35}Mg, ^{33-37}Si, ^{47-51}Ar$, $^{51-56}Ca$, $^{55-59}Ti, ^{61-63}Cr$
8	Internal conversion electron spectroscopy	p, α, ^{40}Ar, ^{58}Ni, ^{70}Zn, ^{84}Kr	^{32}Mg, ^{34}Si, $^{60-70}Ni$, ^{62}Zn, ^{82}Kr
9	Spectroscopy of proton, neutron and alpha emitters	^{12}C ^{16}O ^{20}Ne ^{58}Ni	^{9}Li, ^{16}C, ^{17}N, ^{13}O, ^{53}Co, ^{54}Ni
10	RI experiments probing isospin symmetry	$^{12}C, ^{78}Kr$	N~Z nuclei
11	Measurement of production cross sections	$^{40}Ar, ^{20}Ne, ^{16}O$	various RI

- **Priority/possibility on the proposed experiment**
- **Beam condition (ex. Required energy, beam intensity, purity…)**

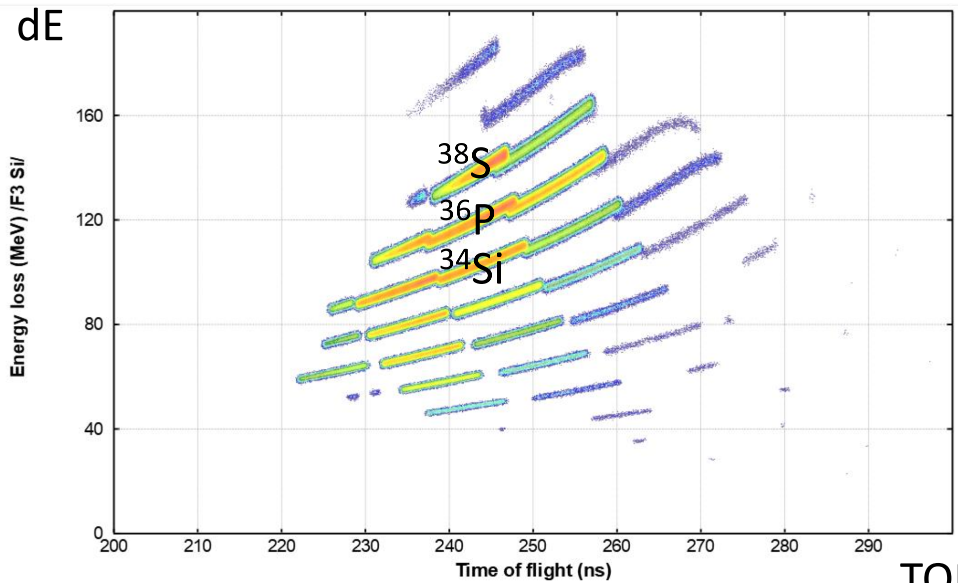
LISE++ file

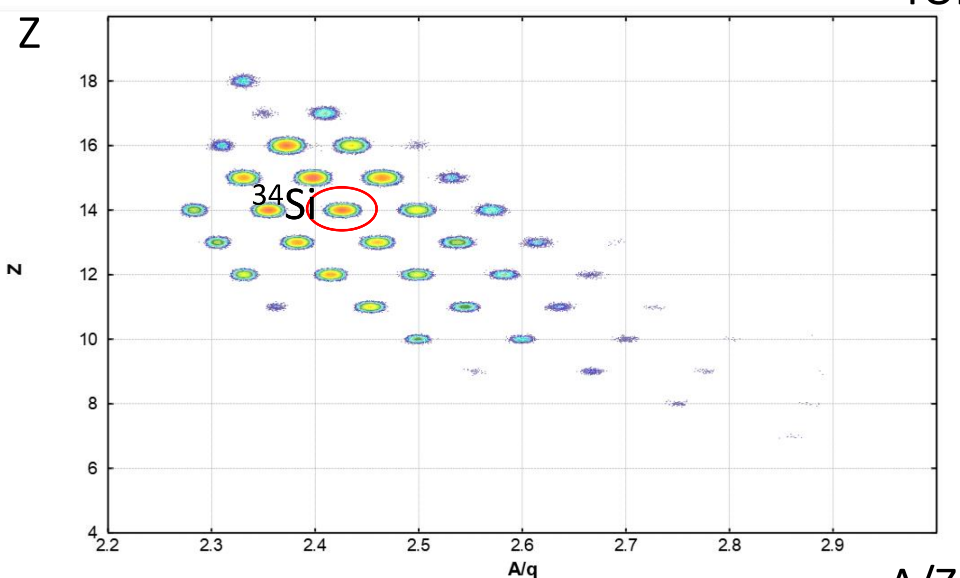


Detector Information
Material Information
EPAX2
→ You can test for possible RI beams.

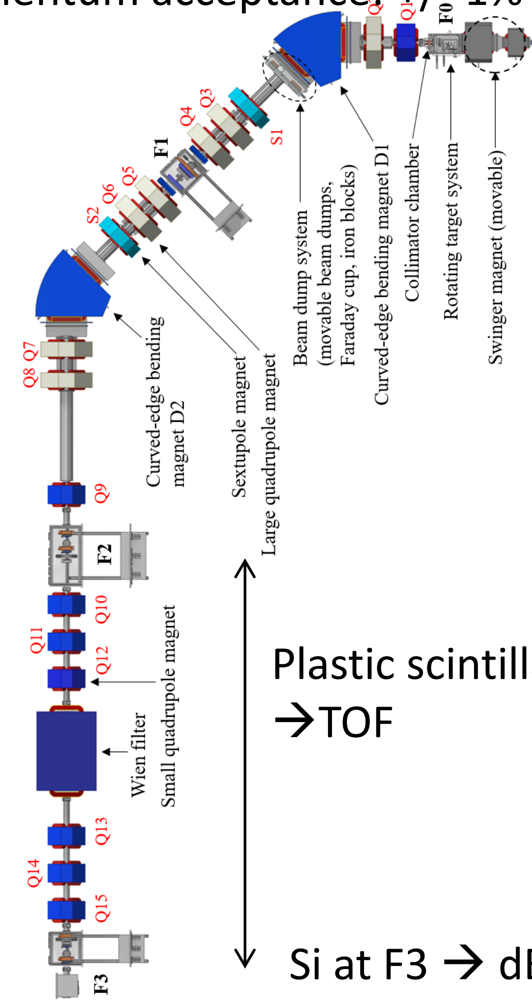
In the preparation for LISE++ file
with D.S.Ahn, J.W.Hwang, S.Ahn, D.Kim with KoBRA collaboration

Particle Identification





Primary beam: ^{40}Ar
Target :^{12}C (or ^{9}Be)
Energy: 20MeV/u
Momentum acceptance: +/- 1%



Plastic scintillators (F2-F3)
→TOF

Si at F3 → dE

Summary

Plan for KoBRA experiment

Very Preliminary

1 Step

- Optical model potential studies using stable beams at KoBRA
  - Fusion reaction studies related to stellar evolution
    - 3n fusion-evaporation reactions to study MEDs in Tz=-3/2 nuclei

2 Step

- Decay spectroscopy and fast-timing measurements by using KHALA at RAON
  - The study of lifetime of isotopes near doubly magic N=Z nuclei ^{40}Ca
    - Internal conversion electron spectroscopy
      - Spectroscopy of proton, neutron and alpha emitters
        - RI experiments probing isospin symmetry
          - High-resolution in-beam γ-ray experiments at RAON

1 Step – 2 Step

- Systematic measurement of production cross sections using the KoBRA spectrometer
- Study on neutron-deficient nuclei using proton-induced fusion-evaporation

Research and Development for RI beam production

Data analysis

Particle identification (High accuracy)

Production yield

Production cross sections

Particle identification

Isomer tagging

Circuit/detector tuning

Calibration

Ion optics

Experiment

→ Physics results

Optimization of RI beams

Yield

High purity beam

Optimized energy

Experimental setup

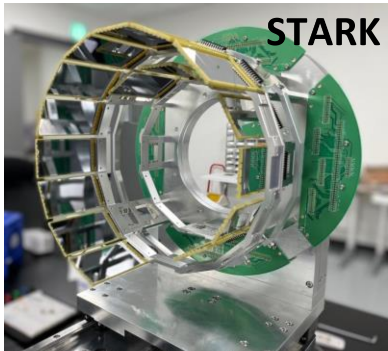
$LISE^{++}$ simulation

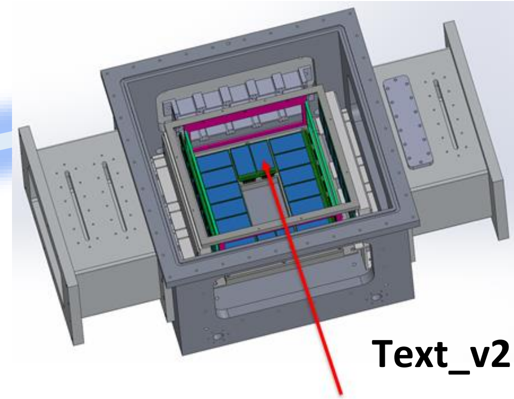
Detector setup and operation

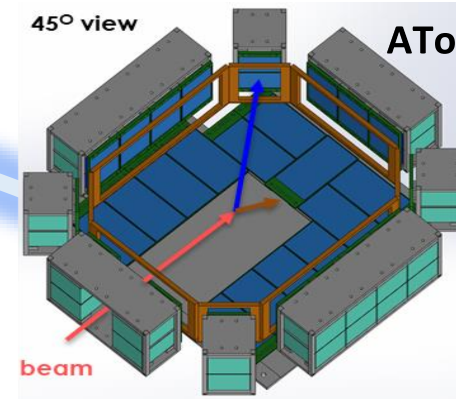
Noise suppression

- RI beam production
- RI beam transport (centering, focusing, optics)
- Maintenance and development for beamline detectors
- Operation management for RI beam production
- …

CENS Detector Development







Decay Spectroscopy Station

A New Plunger Device

Detector System for Internal Conversion Electrons

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For those kinds of detector,
high resolution, high performance, high efficiency are required.

Beam PID

Diagnostics System

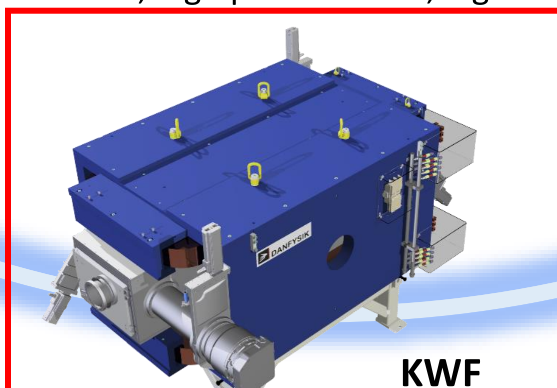
DL-MCP

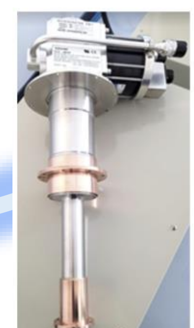
GAGG Scintillator

Liquid Organic Scintillator

MUSIC/IC

Gas Jet Target





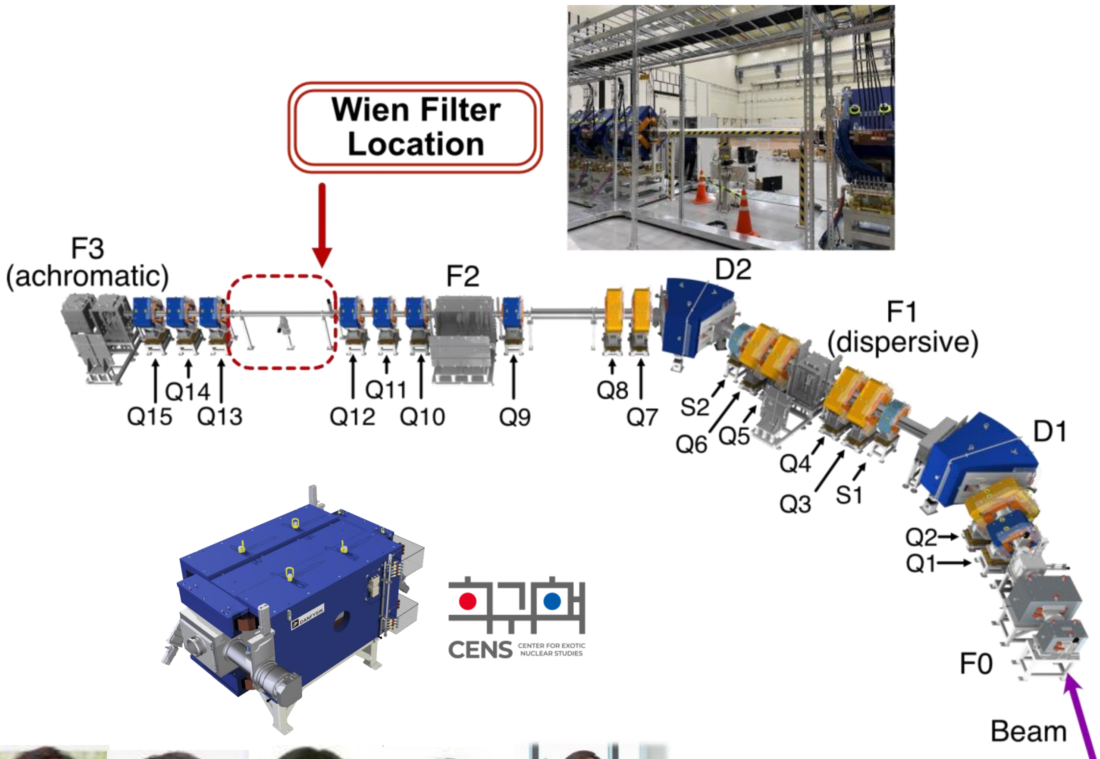
CryoSTAR

Detector development is required for rare isotope science.

KoBRA Wien Filter

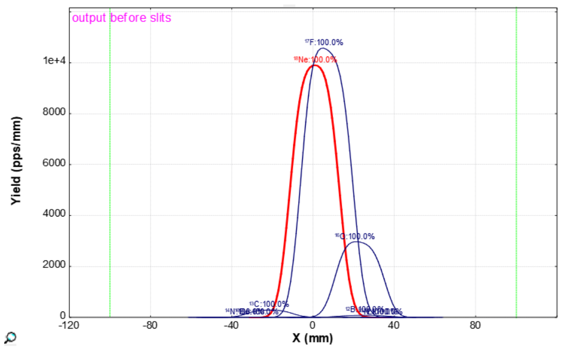
Ion optical component

: Filtering out impurities **by selecting ions with a velocity**

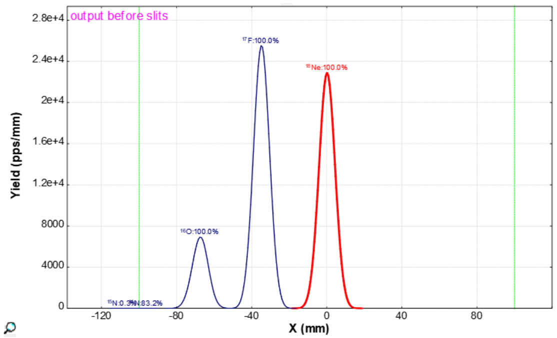


S.Ahn, J.W.Hwang, D.Kim, D.S.Ahn and K. Hahn
with RISP collaboration

Without WF

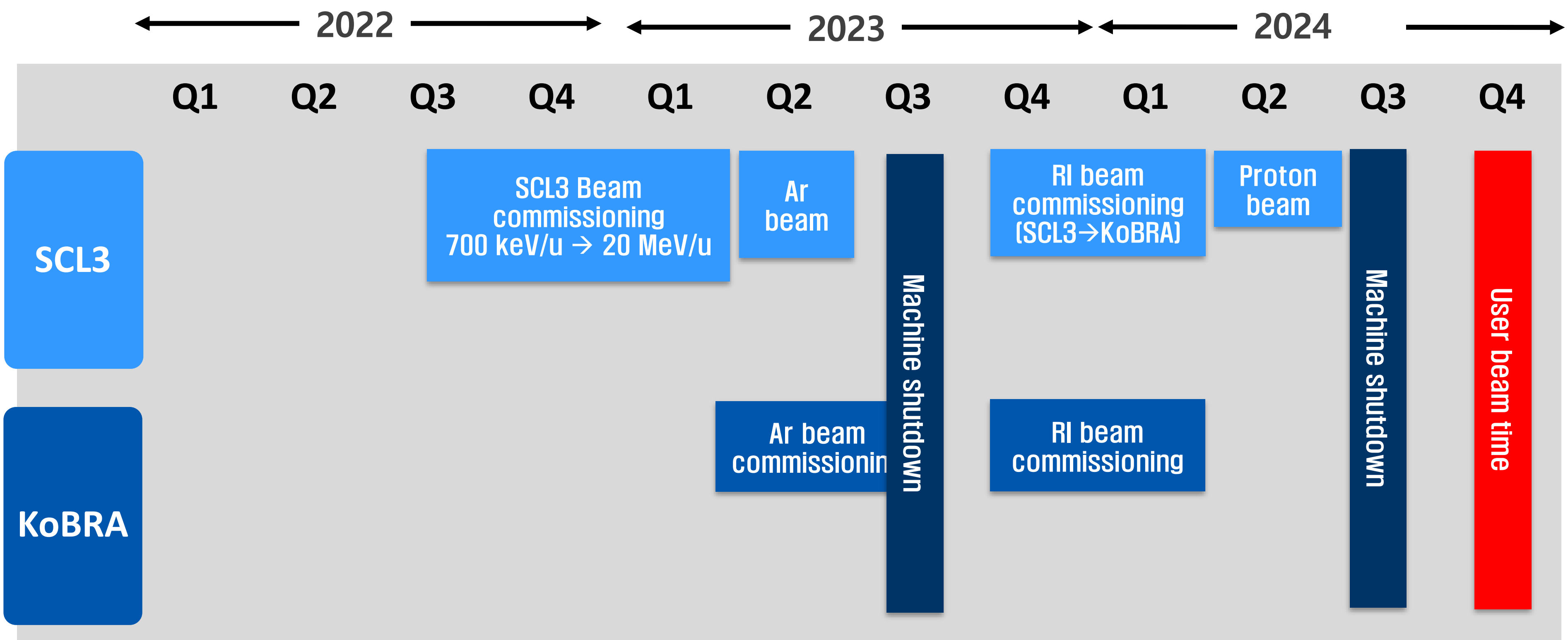


With WF (E = 2 kV/mm)



Clear separation and **better focusing**.

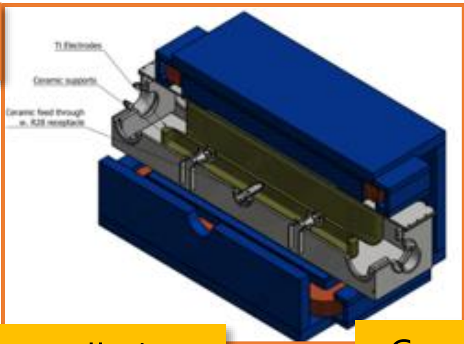
Schedule for beam commissioning



Schedule for beam commissioning(wien filter)

	2022 Q1	2022 Q2	2022 Q3	2022 Q4	2023 Q1	2023 Q2	2023 Q3	2023 Q4	2024 Q1	2024 Q2	2024 Q3	2024 Q4
SCL3			SCL3 Beam commissioning 700 keV/u → 20 MeV/u			Ar beam	Machine shutdown	RI beam commissioning (SCL3→KoBRA)		Proton beam	Machine shutdown	User beam time
KoBRA						Ar beam commissionin	Machine shutdown	RI beam commissioning			Machine shutdown	User beam time

Wien Filter



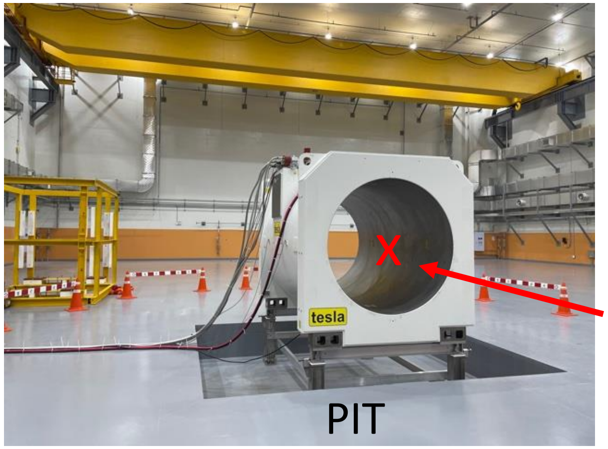
Installation

Commissioning

Open discussions for current LAMPS setup

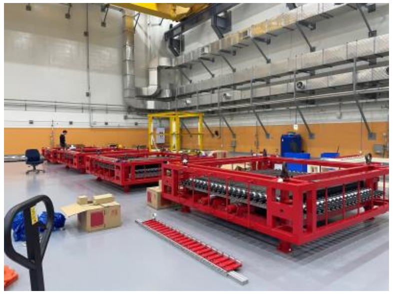
Current status of LAMPS

Enough space



I thought there are enough space to perform experiments....

Why we need PIT???



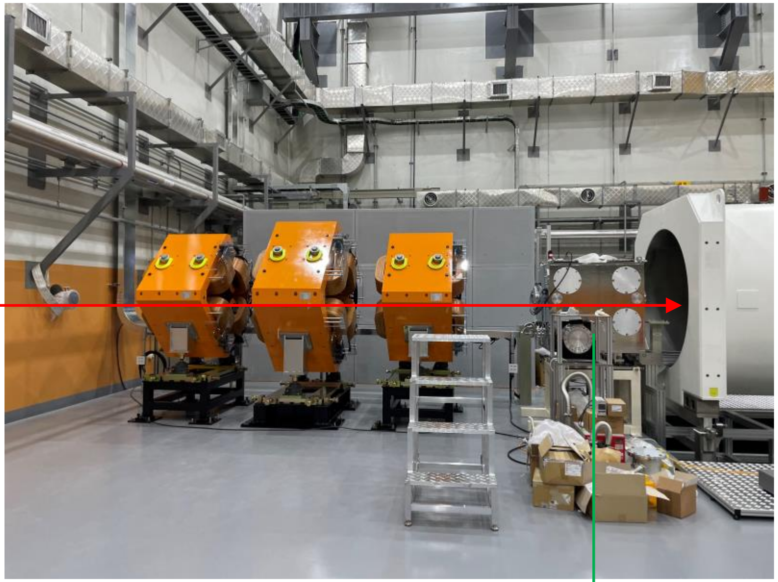
Current status of LAMPS

IF area

beam

LAMPS area

beam



Vacuum chamber
(start counter, MWDC, veto)

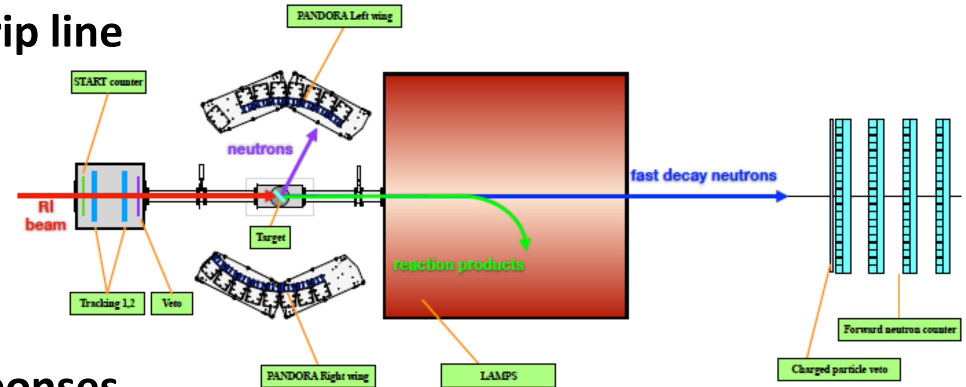
Q magnets are ready for IF and LAMPS.
But, alignment is not finished.

Not enough space for experimental setup

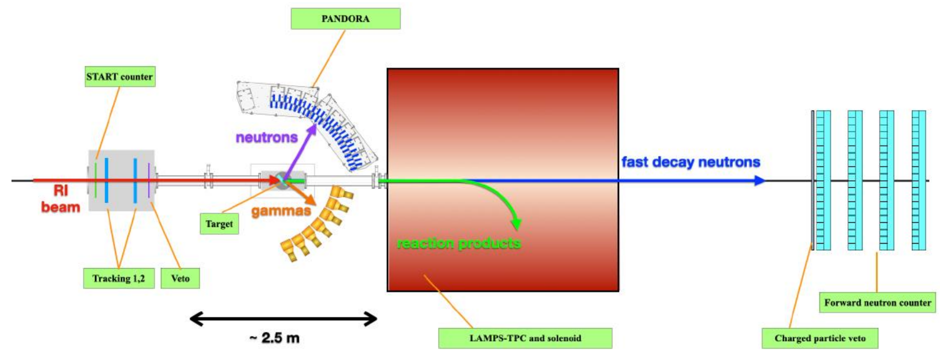
Proposed experiment for LAMPS

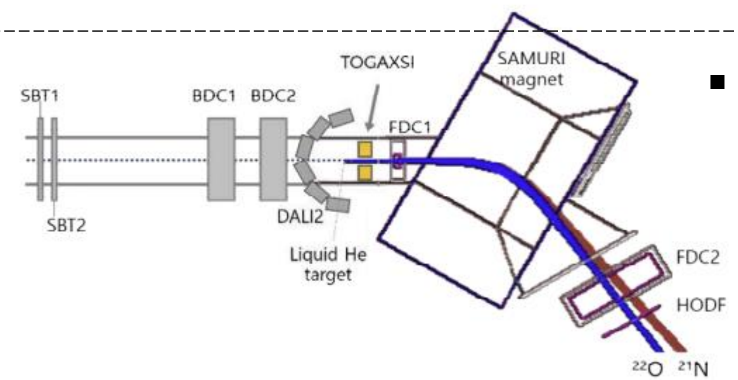
L.Stuhl, Z.Korkulu, D.S.Ahn

- **Charge-exchange (p,n) reaction in inverse kinematics on light exotic nuclei along the neutron drip line**



- **High-resolution study of spin-isospin responses of N=Z exotic nuclei**





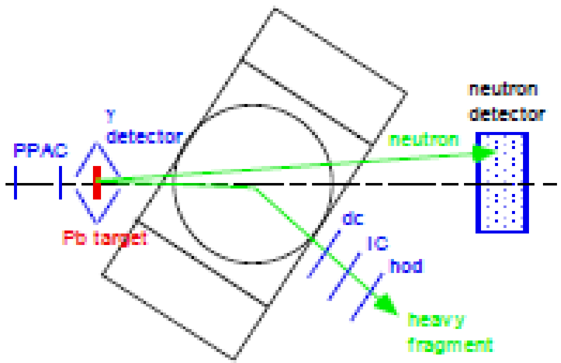
- **Reduction factor study at large isospin asymmetry using the (a,ap) reaction (S.Kim's RIKEN PAC proposal)**

RIKEN SAMURAI experiment
S.Kim will be submitted to RIKEN-PAC.

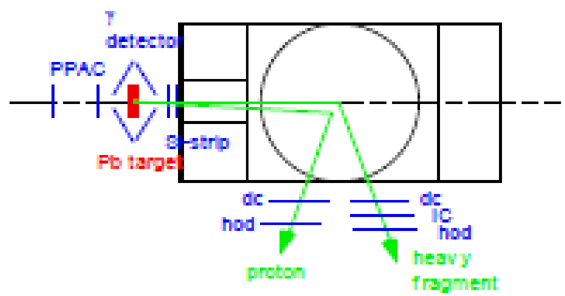
Experimental setup for various experiment

From Construction Proposal(SAMURAI,RIKEN RIBF)

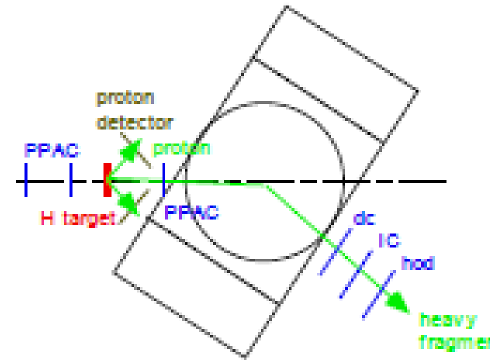
(γ,n) reaction: neutron-rich side



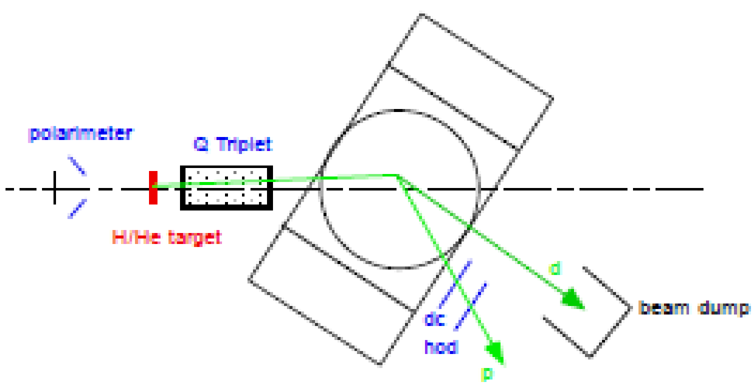
(γ,p) reaction: proton-rich side



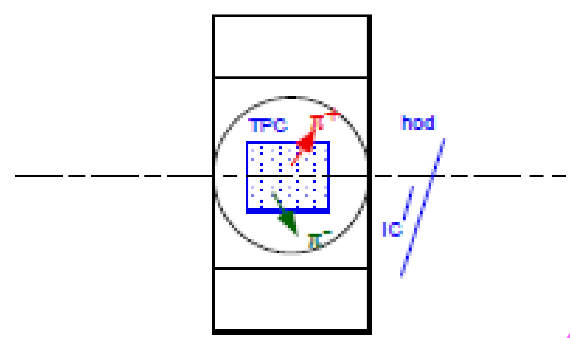
(p,p'), (p,2p) etc.



Pol. d-induced reaction

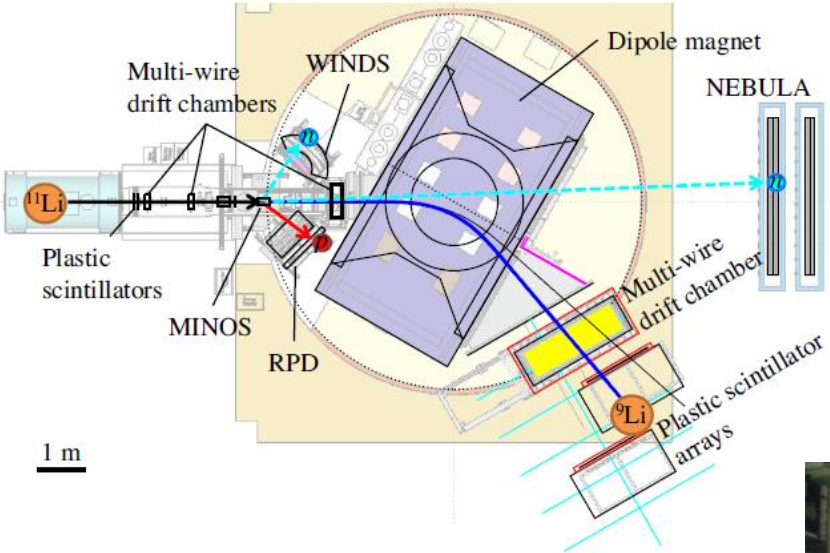


EOS measurement

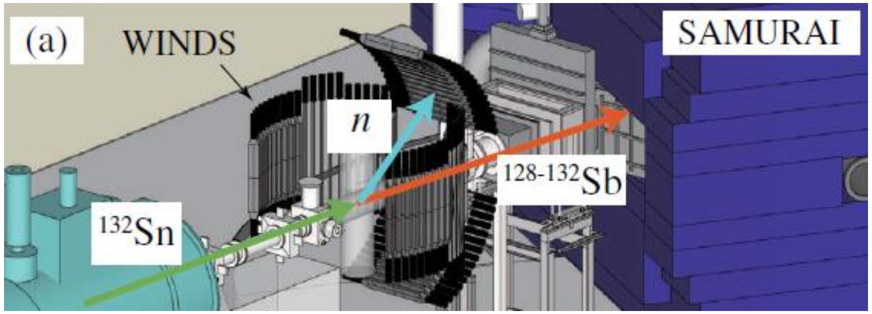


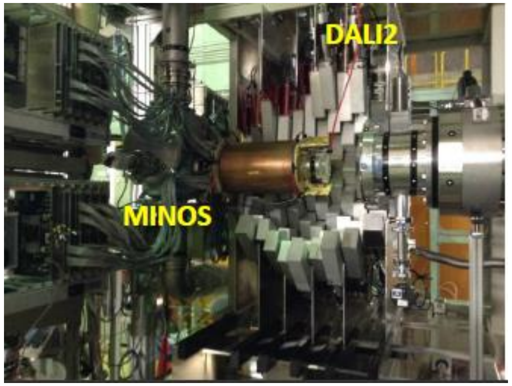
SAMURAI Experiments @ RIBF

Y. Kubota *et al.*, PHYSICAL REVIEW LETTERS 125, 252501 (2020)



J. Yasuda et al. Phys. Rev. Lett. 121, 13250 (2018)





Suggestions or possibilities

- ❖ LAMPS spectrometer is optimized for EOS experiment.
- ❖ The design and configuration of LAMPS should be considered to perform (p,p'), (p,2p), (p,γ),(γ,n), (p,n) at LAMPS.

- ❖ Different options and ideas to change the present setup
  - case 1) Move the solenoid to downstream (~35cm available?)
    Adjustment Q magnets(IF, LAMPS)
  - case 2) Make the pit on the downstream and move the solenoid (If pit is needed)
    Move the solenoid to downstream using new rails?
  - case 3) Move the magnet on the upstream side(~different room)
- ❖ Optics study? or New magnet? Target development?, ...

→ **We need to brainstorming to perform for various experiments.**

2022 **2023** **2024** **2025** **2026** **2027** **2028**

Now

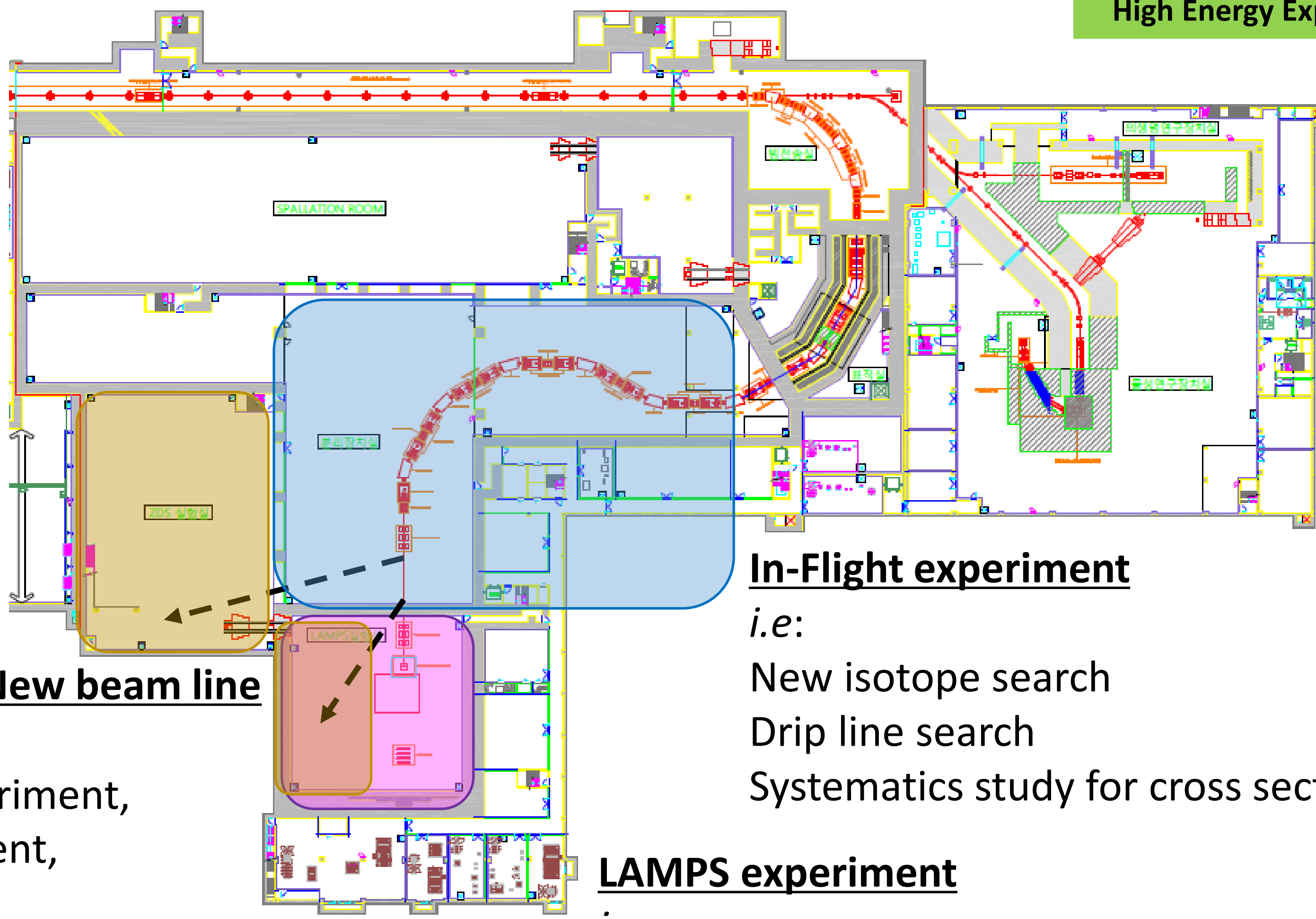
R&D for High E Acc.

Construction for High E Acc.

Beam commissioning for IF, LAMPS, Decay exp. …

Possibilities for high energy beam line

High Energy Exp. Bldg



In-Flight experiment

i.e:

New isotope search

Drip line search

Systematics study for cross sections

Candidate for New beam line

i.e:

In-beam γ experiment,

Decay experiment,

ZeroDegree

LAMPS experiment

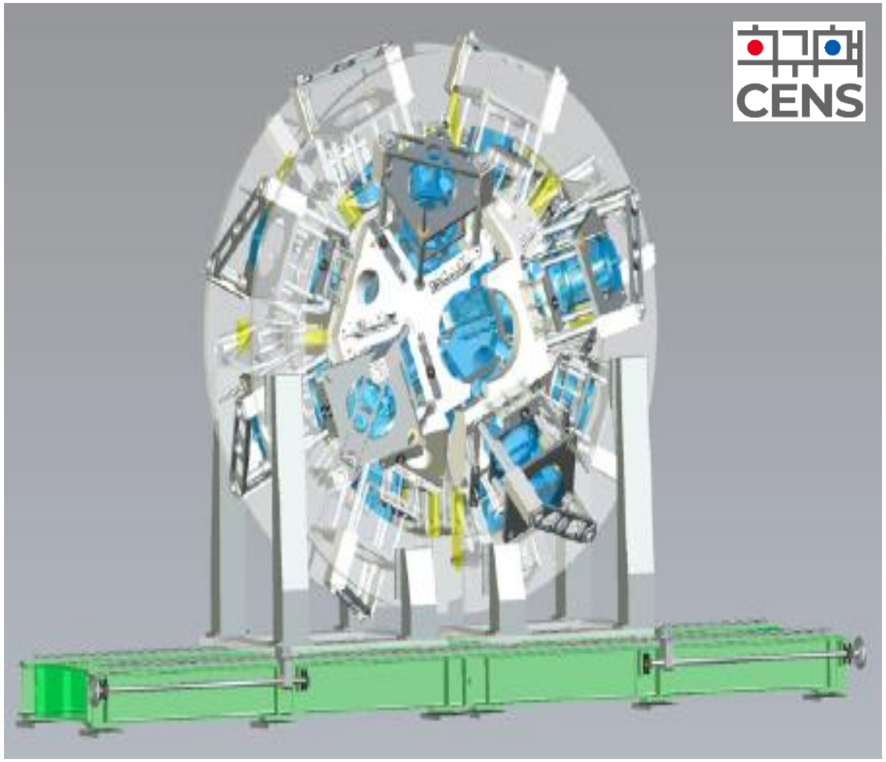
i.e:

EOS,

(p,p'), (p,2p), (p,γ),(γ,n), (p,n)

Detectors for future experiments

Detectors for in-beam γ–ray experiments



ASGARD(Array of Super clover Gamma-ray Detectors)

Detector for decay experiments

KHALA(Korea High-resolution Array of $LaBr_3$(Ce))

Survey for detector test beam line

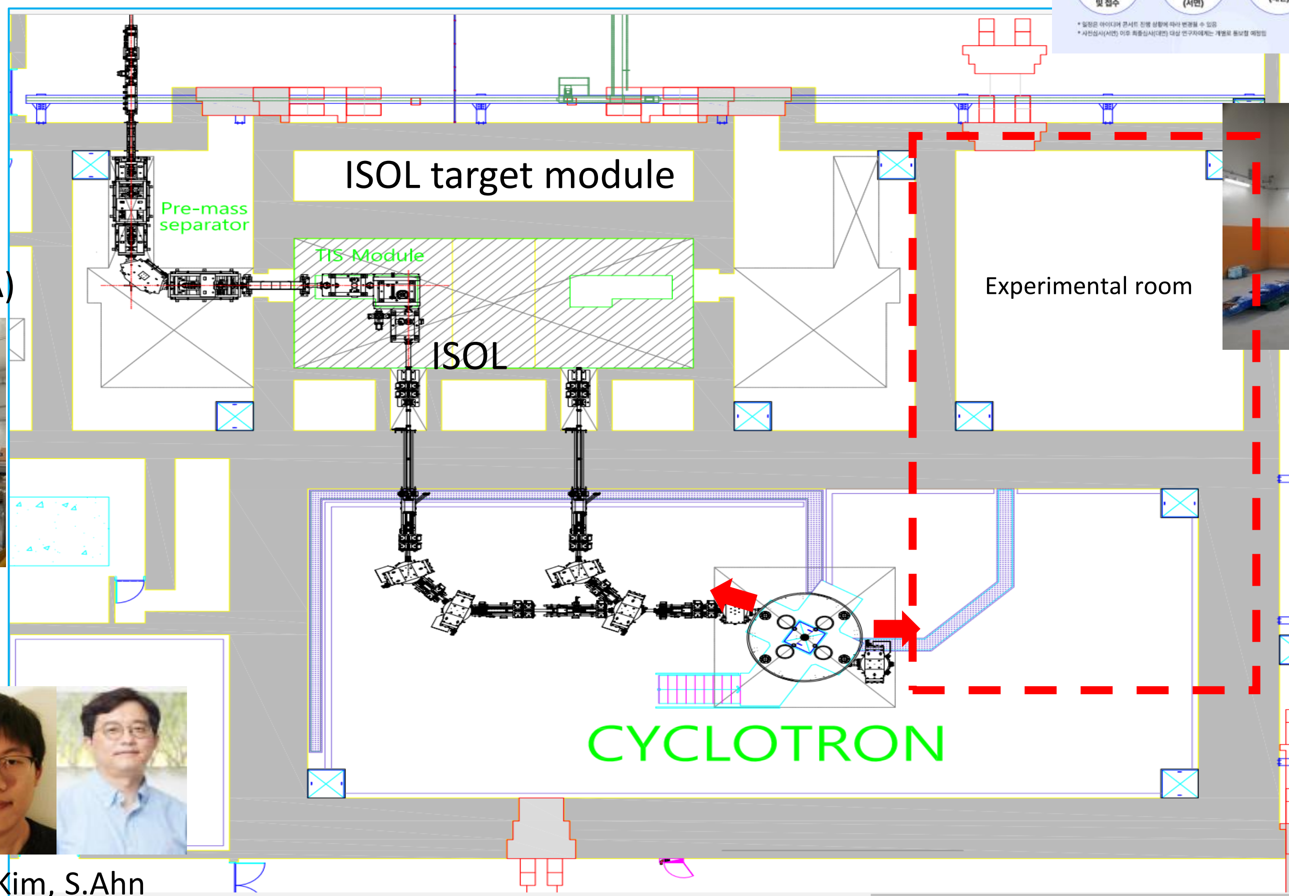
Test beamline using 70 MeV cyclotron facility @RAON

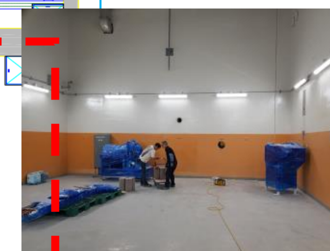
Many others test beamlines in the word

- Test beam line for detector performance
- Sample irradiation
- …

INNOPOLIS KOREA INNOVATION FOUNDATION

Cyclotron
(35~70MeV, 70kW, 1mA)





D.S.Ahn, J.W.Hwang, Y.H.Kim, S.Ahn
+ T.S.Shin, D.G.Kim, J.H.Kim. J.H.Lee + J.Y.Park, S.J.Kim, ..+ I.S.Kim, S.H,Kim

Survey

검출기 기술 구축 및 성능 검증을 위한 빔라인 개발 연구 수행을 위한 수요조사 및 개인정보 수집·이용 동의서

「개인정보 보호법」 제15조 제1항 제1호, 제17조 제1항 제1호, 제23조 제1호, 제24조 제1항 제1호에 따라 아래와 같이 개인정보의 수집, 이용에 관하여 귀하의 동의를 얻고자 합니다. 아래의 내용을 자세히 읽어보시고 동의 여부를 결정하여 주시기 바랍니다.

1. 수집 이용 목적	검출기 기술 구축 및 성능 검증을 위한 빔라인 개발 연구 수행을 위한 수요조사 및 개인정보 수집·이용
2. 수집 이용 항목	단체명, 성명, 직위명, 전화번호, 이메일주소
3. 보유 이용 기간	개인정보 수집 및 이용 목적 달성 시 3개월 이내 폐기
4. 동의·거부권리 및 거부에 따른 불이익	귀하께서는 위 개인정보 수집·이용에 대한 동의를 거부할 권리가 있습니다. 거부 시 불이익은 없습니다.

☐ 동의 ☐ 비동의

소속기관	
성명	(서명)
직위명	
전화번호	
이메일 주소	
일시	년 월 일

※ 본 조사는 중이온가속기연구소의 70MeV 양성자 사이클로트론(35~75MeV, 70kW)을 이용하여 핵물리 실험 수행전에 필수적인 검출기의 성능 테스트 및 검출기 기술개발을 위해 필요한 빔라인 개발 연구 수행을 위한 사전 수요조사입니다.

(기초과학연구원 희귀핵연구단)

정확한 조사를 위해 전 항목에 응답해주시면 감사하겠습니다. (전 항목 **다중 선택 가능**)

1. 중이온가속기 활용 영역을 선택하여 주십시오.
   ☐ 핵물리 실험 ☐ 고에너지 실험 ☐ 검출기 개발 ☐ 가속기 개발
   ☐ 응용 (바이오, 신소재 등등) ☐ 기타 ( )

2. 국내 가속기 실험시설을 이용한 경험이 있습니까?
   ☐ 있음 ☐ 없음

2.1. 국내 가속기 실험시설을 이용한 경험이 있는 경우 이용 용도를 간략하게 선택하여 주십시오.
   ☐ 핵물리 실험 ☐ 고에너지 실험 ☐ 검출기 테스트 ☐ 가속기 개발
   ☐ 응용 (바이오, 신소재 등등)

2.2 국내 가속기 실험시설을 이용한 경험이 있는 경우 가속기의 종류를 선택하여 주십시오.
   ☐ 한국원자력연구원(경주) 양성자가속기 ☐ 한국원자력연구원(정읍) 사이클로트론
   ☐ 국립암센터 사이클로트론 ☐ 한국원자력의학원 사이클로트론
   ☐ 포항 방사광 가속기 ☐ 기타 ( )

- 1 -

2.3 국내 가속기 실험시설 이용의 애로사항을 간략하게 선택하여 주십시오.
   ☐ 빔 에너지 불만족 ☐ 빔 사이즈 불만족 ☐ 빔 세기 불만족 ☐ 빔 안정성 불만족
   ☐ 원하는 빔 핵종의 부재 ☐ 빔 정보 부재 ☐ 빔 타임 신청 어려움 ☐ 기타 ( )

3. 해외 가속기 실험시설을 이용한 경험이 있습니까?
   ☐ 있음 ☐ 없음

3.1. 해외 가속기 실험시설 이용 경험이 있는 경우, 이용 용도를 선택하여 주십시오
   ☐ 핵물리 실험 ☐ 고에너지 실험 ☐ 검출기 테스트 ☐ 가속기 개발
   ☐ 응용 (바이오, 신소재 등등) ☐ 기타 ( )

3.2 국내 가속기 실험시설 대신 해외 가속기 실험시설을 이용한 이유를 선택하여 주십시오
   ☐ 필요한 빔 에너지 부재 ☐ 필요한 빔 사이즈 부재 ☐ 필요한 빔 핵종의 부재
   ☐ 빔타임 신청 어려움 ☐ 사용 가능한 빔라인 부재 ☐ 기타 ( )

3.3 해외 가속기 실험시설 이용의 애로사항을 선택하여 주십시오.
   ☐ 시설의 접근 어려움 ☐ 빔타임 신청 어려움 ☐ 시설 정보 부재
   ☐ 해외시설 출장비 부담 ☐ 장비 이동의 어려움 ☐ 기타 ( )

4. 중이온가속기연구소의 70 MeV 양성자 사이클로트론을 이용하여 검출기 기술 구축 및 성능 검증을 위한 다목적 활용 빔라인이 준비될 경우 활용할 의향이 있으십니까?
   ☐ 예 ☐ 아니오

4.1. 중이온가속기 연구소의 70 MeV 양성자 사이클로트론을 이용한 다목적 활용 빔라인이 준비될 경우 이용 용도를 선택하여 주십시오.
   ☐ 핵물리 실험 ☐ 고에너지 실험 ☐ 검출기 테스트 ☐ 가속기 관련 연구
   ☐ 응용 (바이오, 신소재 등등) ☐ 기타 ( )

4.2. 70 MeV 양성자 사이클로트론을 이용한 검출기 기술 구축 및 성능 검증을 위한 연구 빔라인이 준비될 경우 필요한 빔의 요구 사항을 선택하여 주십시오.
   ☐ 빔 에너지 변경 ☐ 빔의 사이즈 변경 ☐ 빔 세기 변경 ☐ 빔 반복 주파수
   ☐ 기타 ( )

4.3. 70 MeV 양성자 사이클로트론을 이용한 검출기 기술구축 및 성능검증을 위한 빔라인 개발 연구에 대한 건의 사항 및 기타의견 등을 자유롭게 기술하여 주십시오.

- 설문 조사에 참여해 주셔서 감사합니다.-

- 2 -

Summary

- **Exploring the limit of particle stability**
  - Introduce the recent research topics

- **Feasibility study of RI beam production**
  - What is the best way to produce more neutron-rich/proton-rich nuclei?
  - Production cross section measurements

- **Open discussion for LAMPS layout and test beamline**

We have to think about the commissioning experiment and prepare what we need to success for our experiment.

Thank you very much!