

C2R2 Annual Workshop 2021

Nuclear Research Activities at CENS

Sunghoon(Tony) Ahn
CENS, IBS

November 18th, 2021

On be half of CENS members



C2R2 Annual Workshop 2021

Nuclear Research Activities at CENS

1. Center for Exotic Nuclear Studies (CENS)

2. Properties of Unstable Nuclei

3. Nuclear Research Activities at CENS

4. Project Timeline Update

5. Collaboration Efforts

6. Summary

CENS Organization

2021.08.04.



Kevin Insik Hahn

**CENS
Director**

**Advisory
Committee**

<https://www.ibs.re.kr/cens/>



Nuclear Astrophysics

Group Leader

- Nucleosynthesis
- r-process, rp-process nuclei
- Collaboration and utilization of KoBRA
- Nuclear Spectroscopy

Nuclear Structure

Group Leader

4 group leaders
3 senior researchers
9 postdocs
6 students
2 secretaries
+ 2 more members soon

Nuclear Reaction

Group Leader

Nuclear Theory

Group Leader

- Reaction Calculations
- Low Energy Nuclear Physics
- Nuclear Structure Models
- QRPA & DQRPA Models

- ✓ Kevin Insik Hahn (2019.12.16.)
- ✓ Dahee Kim, Sunji Kim (2020.02.01.)
- ✓ Tae-Sun Park (2020.03.01.)
- ✓ Jongwon Hwang (2020.04.01.)
- ✓ Joochun Jason Park (2020.04.16.)
- ✓ C.B. Moon, B. Moon (2020.09.01.)
- ✓ Sunghoon (Tony) Ahn (2020.10.01.)
- ✓ Zeren Korkulu, Laszlo Stuhl (2020.11.01.)
- ✓ Soonchul Choi (2020.11.16.)

- ✓ Sunghan Bae, Soomi Cha, Eunjin In (2021.03.01.)
- ✓ Qiang Zhao (2021.04.30.)
- ✓ Xesus PEREIRA-LOPEZ (2021.06.15.)
- ✓ Deuk Soon Ahn (2021.10.01)
- ✓ Myungkuk Kim (2021.10.15)

CENS Nationalities and Playgrounds

Nationalities

- *Canada*
- *Hungary*
- *South Korea*
- *Turkey*
- *USA*
- *China*
- *Spain*

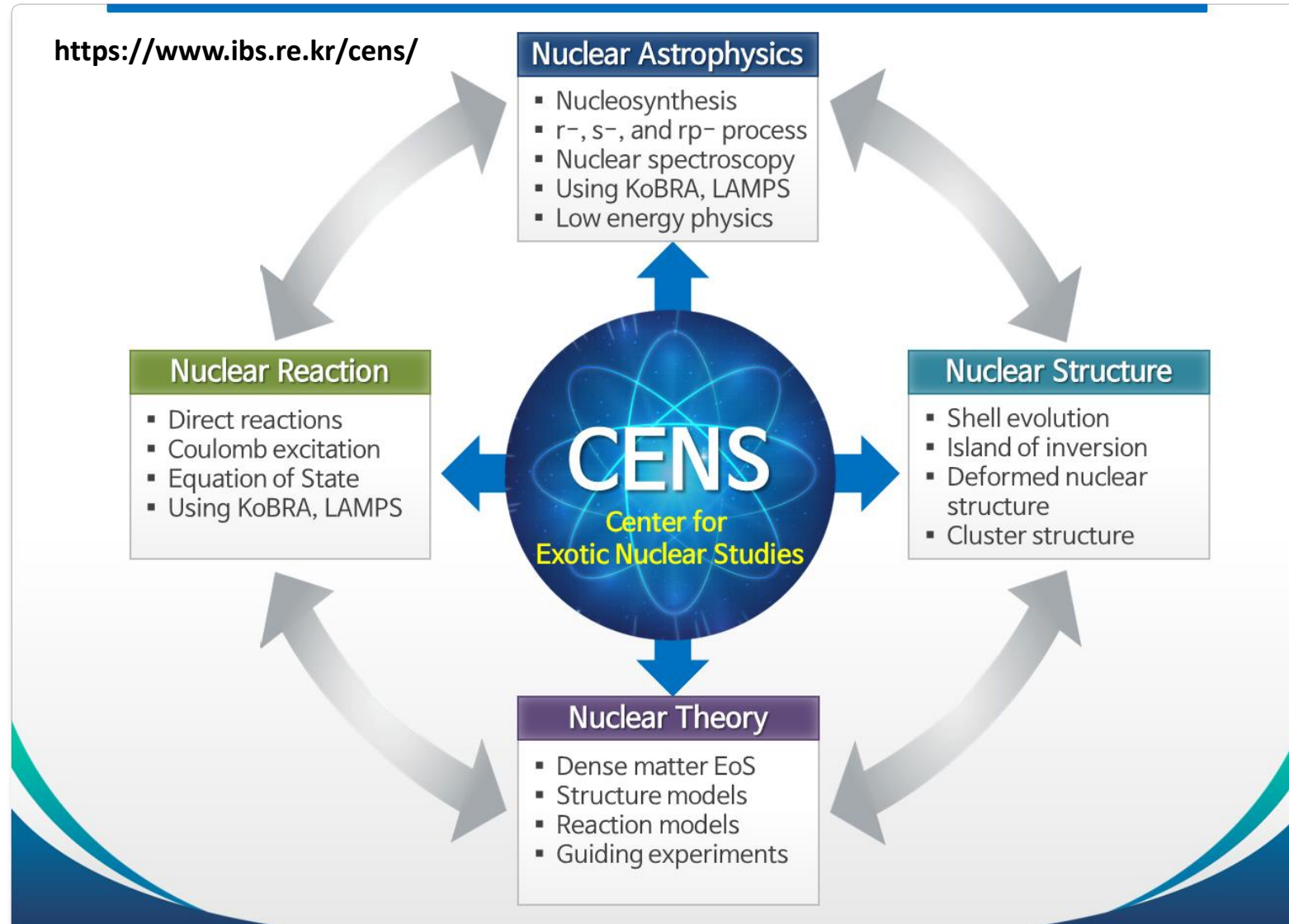
- *Vietnam*

RIB Facilities

- *RIBF (Japan)*
- *CRIB/CNS (Japan)*
- *ATOMKI (Hungary)*
- *HIE-ISOLDE (Switzerland)*
- *GANIL (France)*
- *TRIUMF (Canada)*
- *TAMU (USA)*
- *FRIB (USA)*
- *ANL (USA)*

- *RAON (South Korea)*

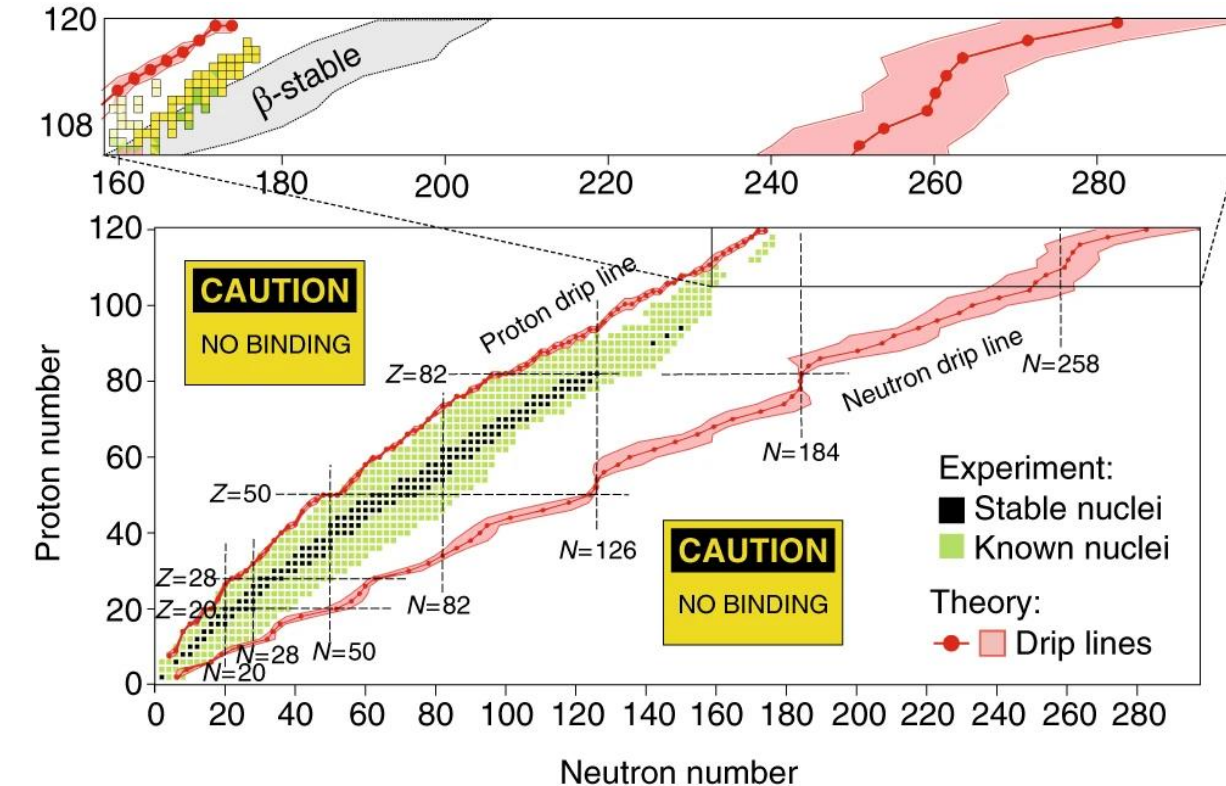
CENS Objectives



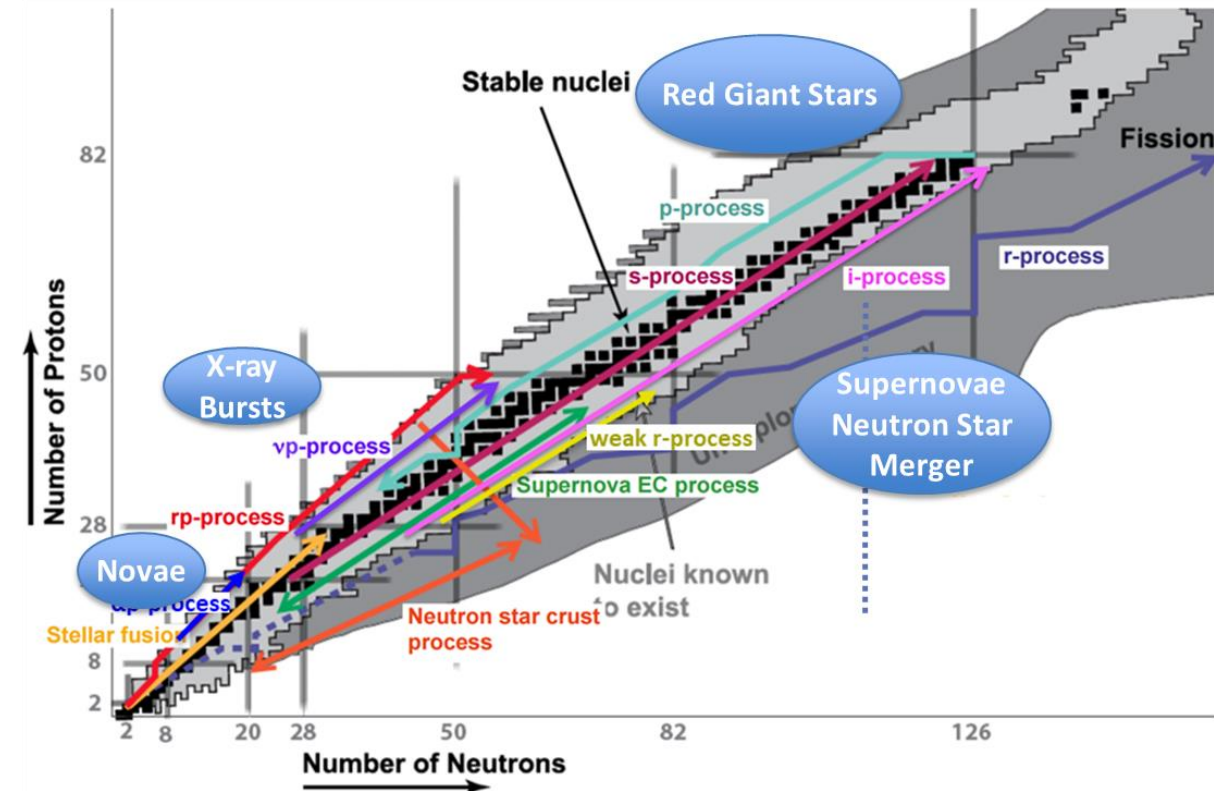
**CENTER FOR
EXOTIC NUCLEAR STUDIES**

Chart of Nuclei

- **Properties of Nuclei:** mass, Q -value, $T_{1/2}$, P_n , level densities, reaction rates, level structure, magic number and drip line



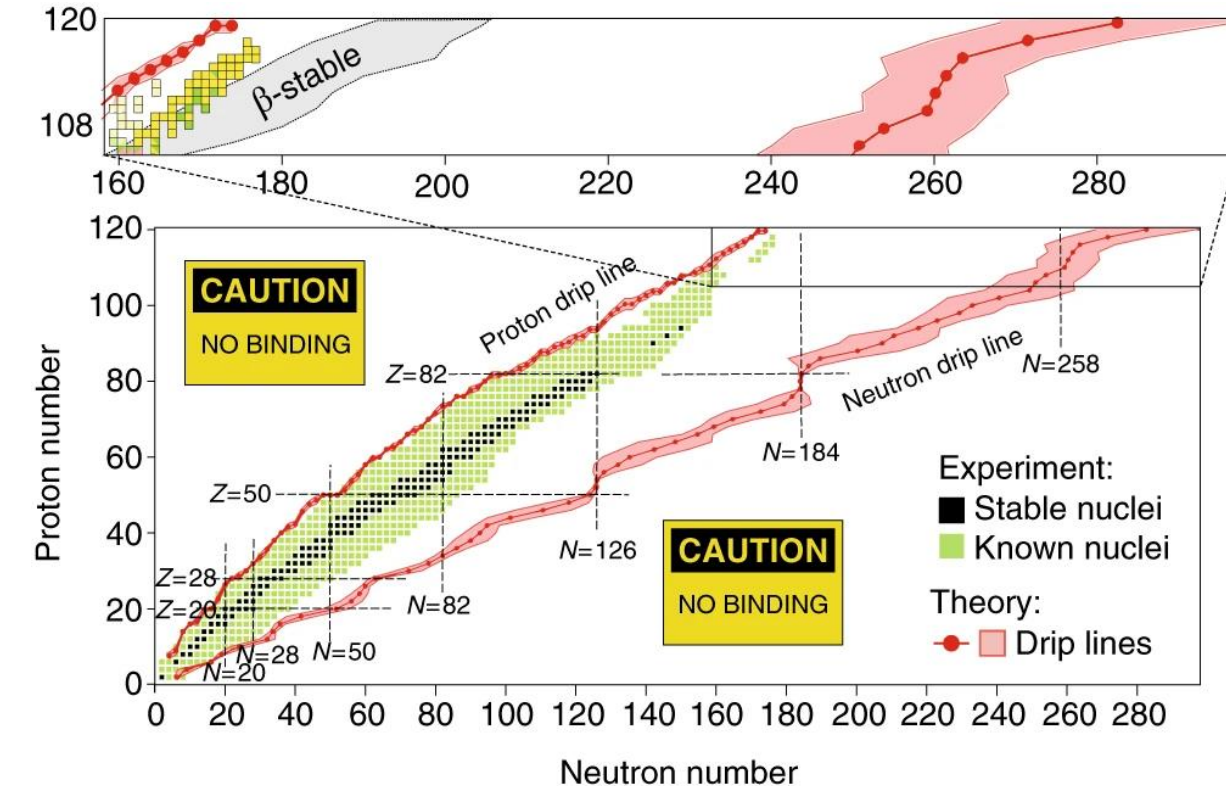
Landscape of nucleon-bound nuclei as a function of Z and N.
W. Nazarewicz, 2018



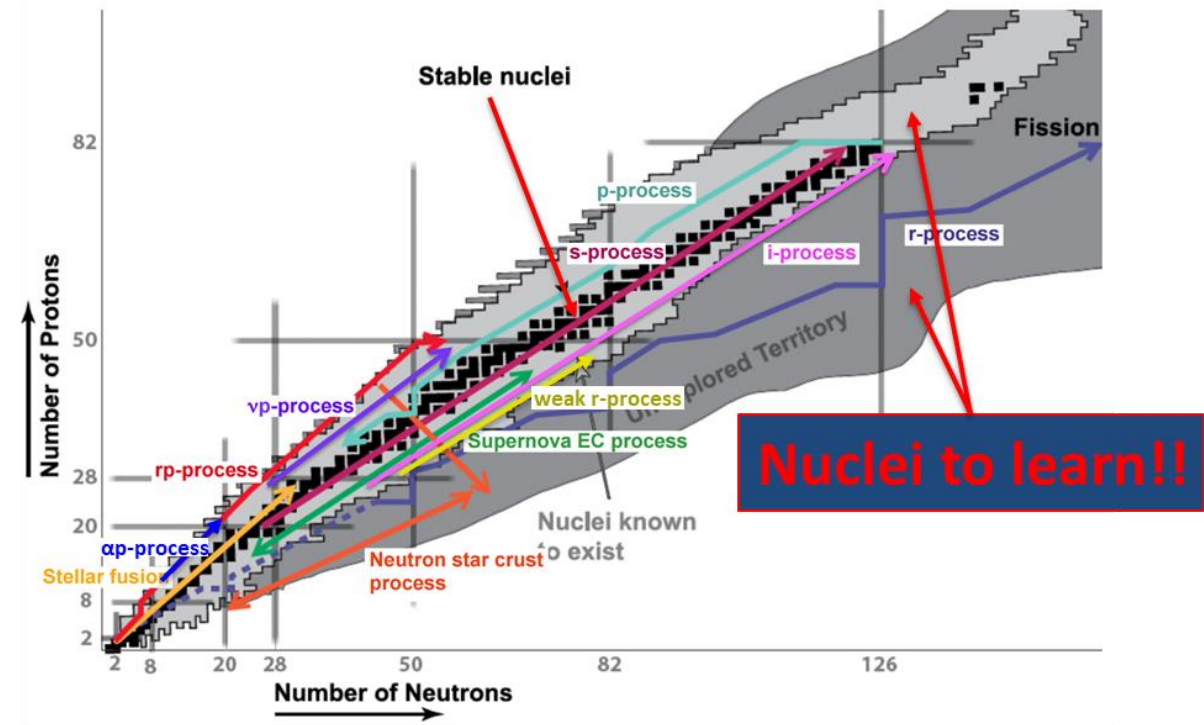
Schematic overview of the nuclear processes on nuclear chart
H. Schatz, 2016

Chart of Nuclei

- **Properties of Nuclei:** mass, Q -value, $T_{1/2}$, P_n , level densities, reaction rates, level structure, magic number and drip line



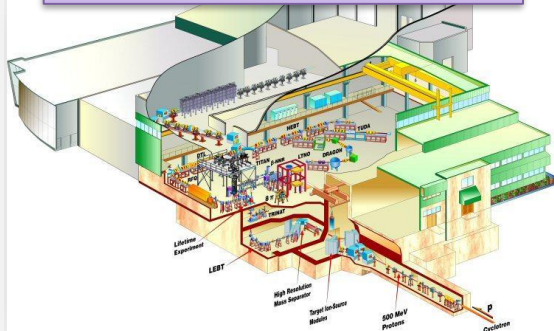
Landscape of nucleon-bound nuclei as a function of Z and N.
 W. Nazarewicz, 2018



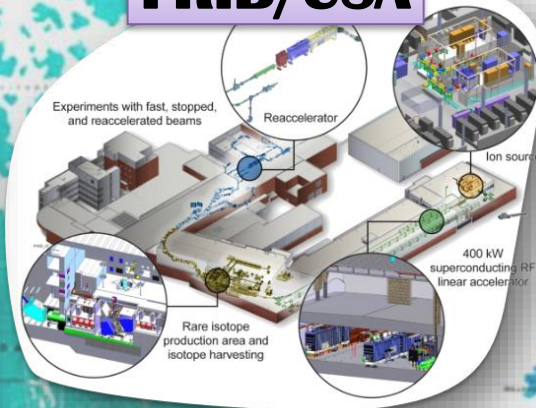
Schematic overview of the nuclear processes on nuclear chart
 H. Schatz, 2016

Rare Isotope Beam Facilities

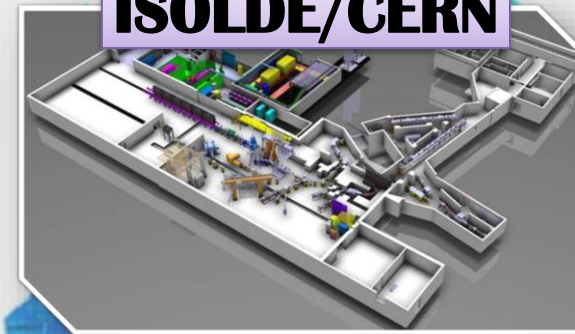
TRIUMF/CANADA



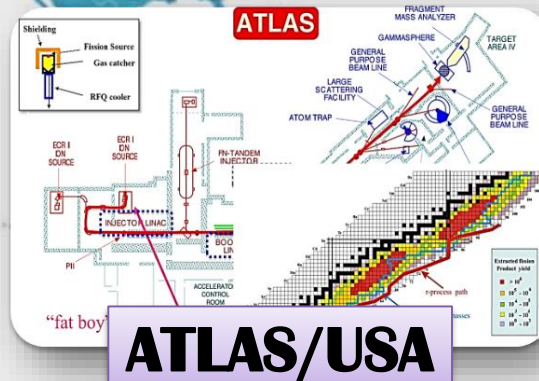
FRIB/USA



ISOLDE/CERN



RIKEN/JAPAN



ATLAS/USA

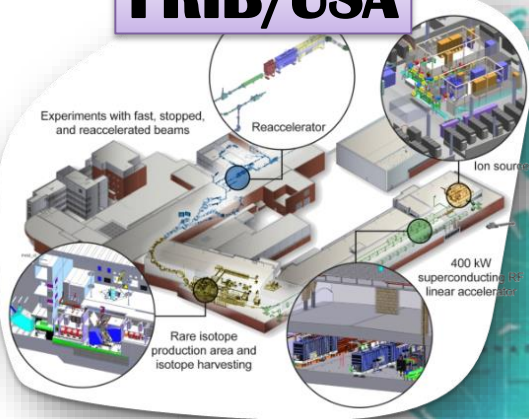
RAON/KOREA



M. Kwon (2019)

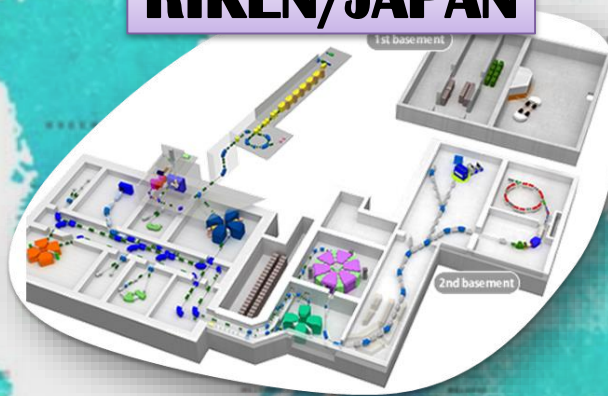
Research Proposals at RIB Facilities

FRIB/USA



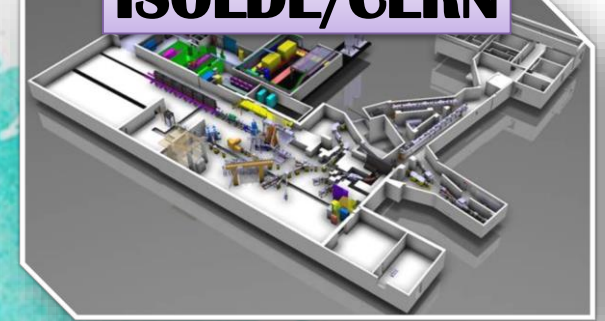
- **FRIB Day One Proposals:**
 - ✓ 3 proposals and one LoI submitted
 - ✓ 2 proposals and one LoI accepted

RIKEN/JAPAN



- **Year 2020:**
 - ✓ 7 proposals submitted
 - ✓ 5 proposals of spokesperson
 - ✓ One accepted
- **Year 2021:**
 - ✓ 4 proposals submitted
 - ✓ 4 proposals of spokesperson

ISOLDE/CERN



- **One proposal submitted and accepted**

TAMU/USA

GANIL/France

ATOMKI/HUNGARY

JYVASKYLA/FINLAND

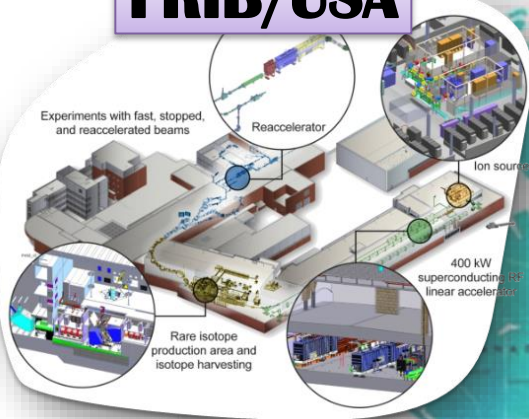
IFIN-HH/ROMANIA

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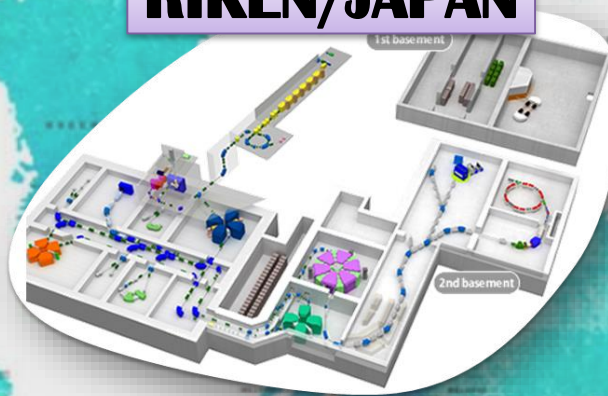
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Research Proposals at RIB Facilities

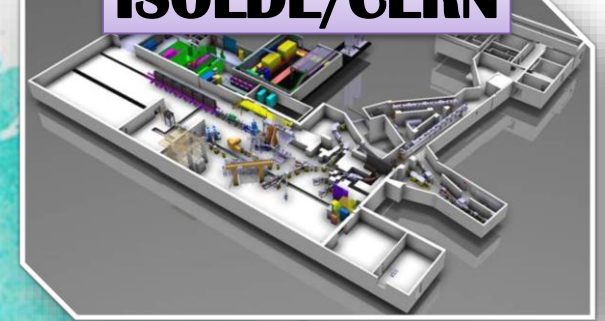
FRIB/USA



RIKEN/JAPAN



ISOLDE/CERN



• FRIB Day One Proposals:

- ✓ 3 proposals and one LoI submitted
- ✓ 2 proposals and one LoI accepted

• Year 2020

- ✓ 5 proposals submitted
- ✓ 1 proposal accepted
- ✓ 1 person

- One proposal submitted and accepted



TAMU/USA

GANIL/France

ATOMKI/Hungary

WASKYLA/Finland

IFIN-HH/Romania

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Letters of Intent at RAON

RAON/KOREA

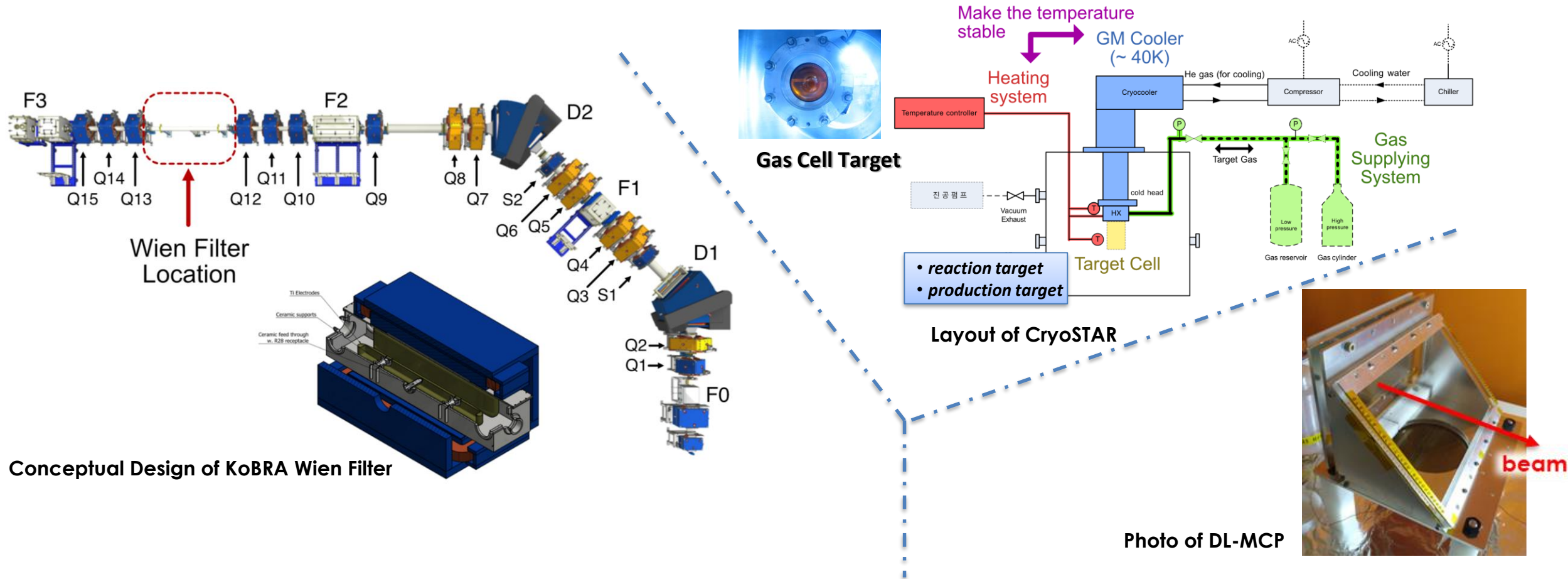


No	Title	Spokesperson	Beams	Station
1	Study on neutron-deficient nuclei using proton-induced fusion-evaporation	Jongwon Hwang	Stable/RI	KoBRA
2	3n fusion-evaporation reactions to study MEDs in $T_z = -3/2$ nuclei	Xesus Pereira Lopez	Stable/RI	KoBRA
3	Fusion Reaction Studies related to Stellar Evolution	Sunghoon Ahn	Stable/RI	KoBRA
4	The study of lifetime of isotopes near doubly magic $N=Z$ nuclei ^{40}Ca	Yung-Hee Kim	Stable	KoBRA
5	Optical model potential studies using stable beams at KoBRA	Dahee Kim	Stable	KoBRA
6	Decay spectroscopy and fast-timing measurements by using KHALA at RAON	Byul Moon	RI	KoBRA
7	High-resolution in-beam γ -ray experiments at RAON	Byul Moon	RI	KoBRA
8	Internal conversion electron spectroscopy	Joochun Park	RI	KoBRA
9	Spectroscopy of proton, neutron and alpha emitters	Joochun Park	RI	KoBRA
10	RI experiments probing isospin symmetry	Xesus Pereira Lopez	RI	KoBRA
11	Charge-exchange (p,n) reaction in inverse kinematics on light exotic nuclei along the neutron drip line	Laszlo Stuhl	RI	LAMPS
12	High-resolution study of spin-isospin responses of $N=Z$ exotic nuclei	Laszlo Stuhl	RI	LAMPS

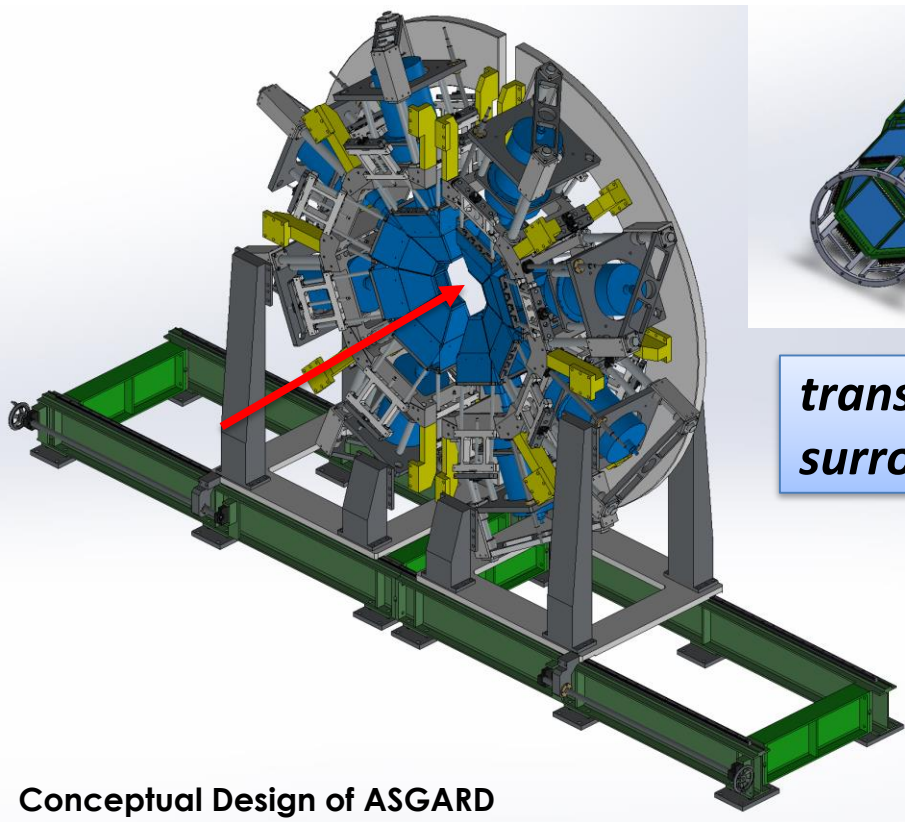
New Major Apparatus Developments

Devices for Rare Isotope Science!

Low Beam Intensity, Efficiency, Energy/Angle Resolution, Fast Timing, Low Threshold and so on..



New Major Apparatus Developments

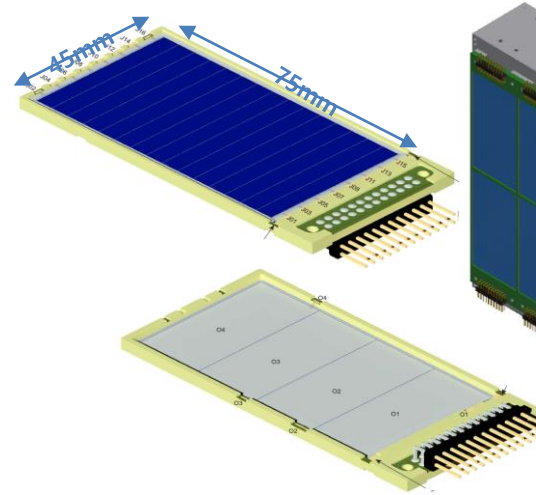


Conceptual Design of ASGARD

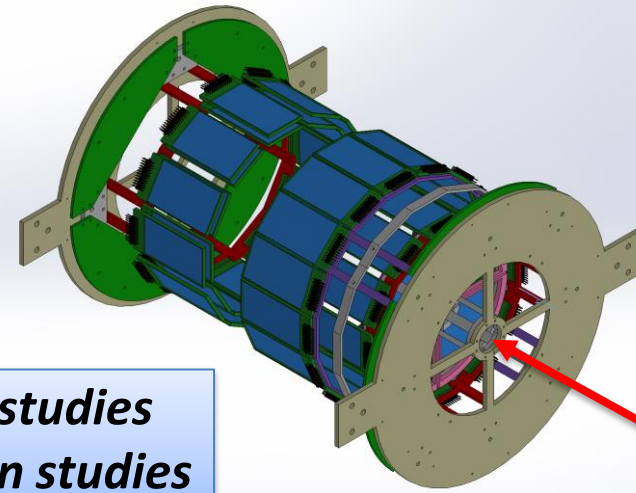


STARK Jr.

transfer reaction studies
surrogate reaction studies

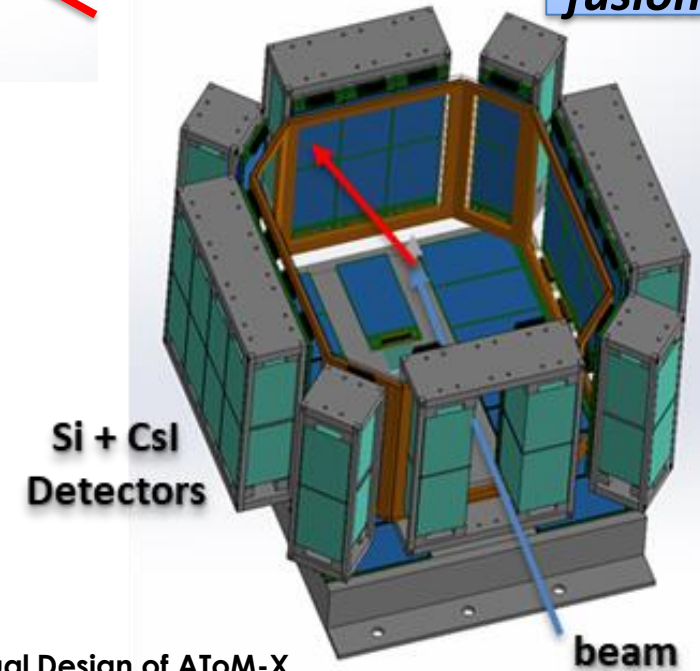


Newly designed silicon detector : X6



Conceptual Design of STARK

(p,p)
 (d,d)
 (α,α)
 (α,p)
 (α,n)
fusion



Conceptual Design of ATOM-X

CENS Project Timeline

	2020	2021	2022	2023		2024	2025
Wien Filter		KWF Purchase & installation at RAON		Test & Commissioning		Operation	
HPGe Detector Array	HPGe detector R&D Part 1 Purchase & installation		Test & Commissioning			Operation	
Silicon Detector Array	Silicon detector R&D Purchase & installation		Test	Purchase & installation	Test	Operation	
CENS AT-TPC		AT-TPC R&D Purchase & installation		Test	Operation		
CENS Cryo Gas Cell Target		Cryo Gas Cell R&D Purchase & installation		Test	Operation		
RAON Schedule	SCL3 Commissioning			SCL3 Test			
FRIB@MSU Schedule	Completion by 2022						
FAIR@GSI Schedule	Completion by 2025 (Phase 0 for R&D and core detector test experiments: 2018, 2019)						

plus

- ✓ **Beam PID and Diagnostics System**
- ✓ **Detector System for Internal Conversion Electrons**
- ✓ **A New Plunger Device and more.....**

Nuclear Theory Activities

- ✓ **Nuclear Reaction Studies using Cluster EFT:** Cross sections between nucleon and nucleus or among nuclei can be explained/described by the Cluster EFT.
- ✓ **Global Optical Potential Model for Stable/Exotic Nuclei**
- ✓ **Nuclear Matter Studies with Functional Renormalization Group (FRG):** The FRB theory can be applied to the equation of state of nuclear matter.
- ✓ **Many body interactions described by energy density functionals**
- ✓ **Nuclear Structure and Property Studies using Machine Learning:** To describe a ground or excited states of light nucleus using the variational principle and neural network wave function.

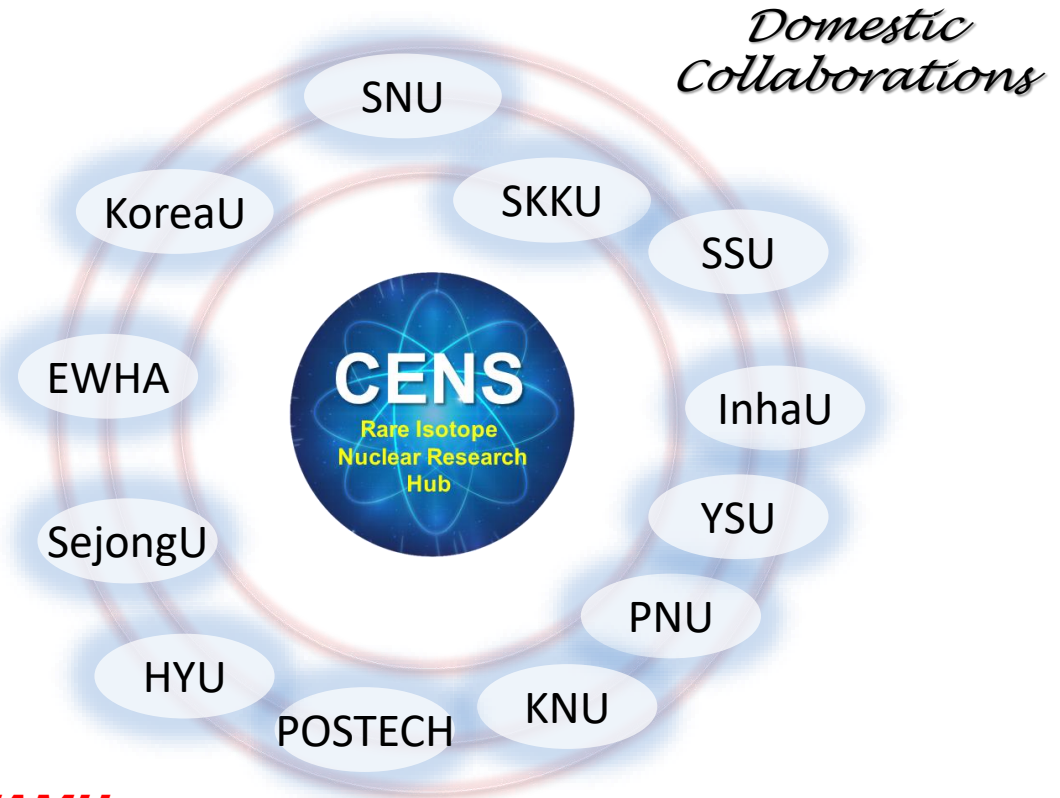
CENS = Rare Isotope Nuclear Research Hub

- ✓ Collaboration with other research centers for sharing limited resources
- ✓ Perform experiments at some of the existing RI facilities
- ✓ Joint equipment development projects with foreign institutions
- ✓ We will expand the international collaboration

International Collaborations



Domestic Collaborations



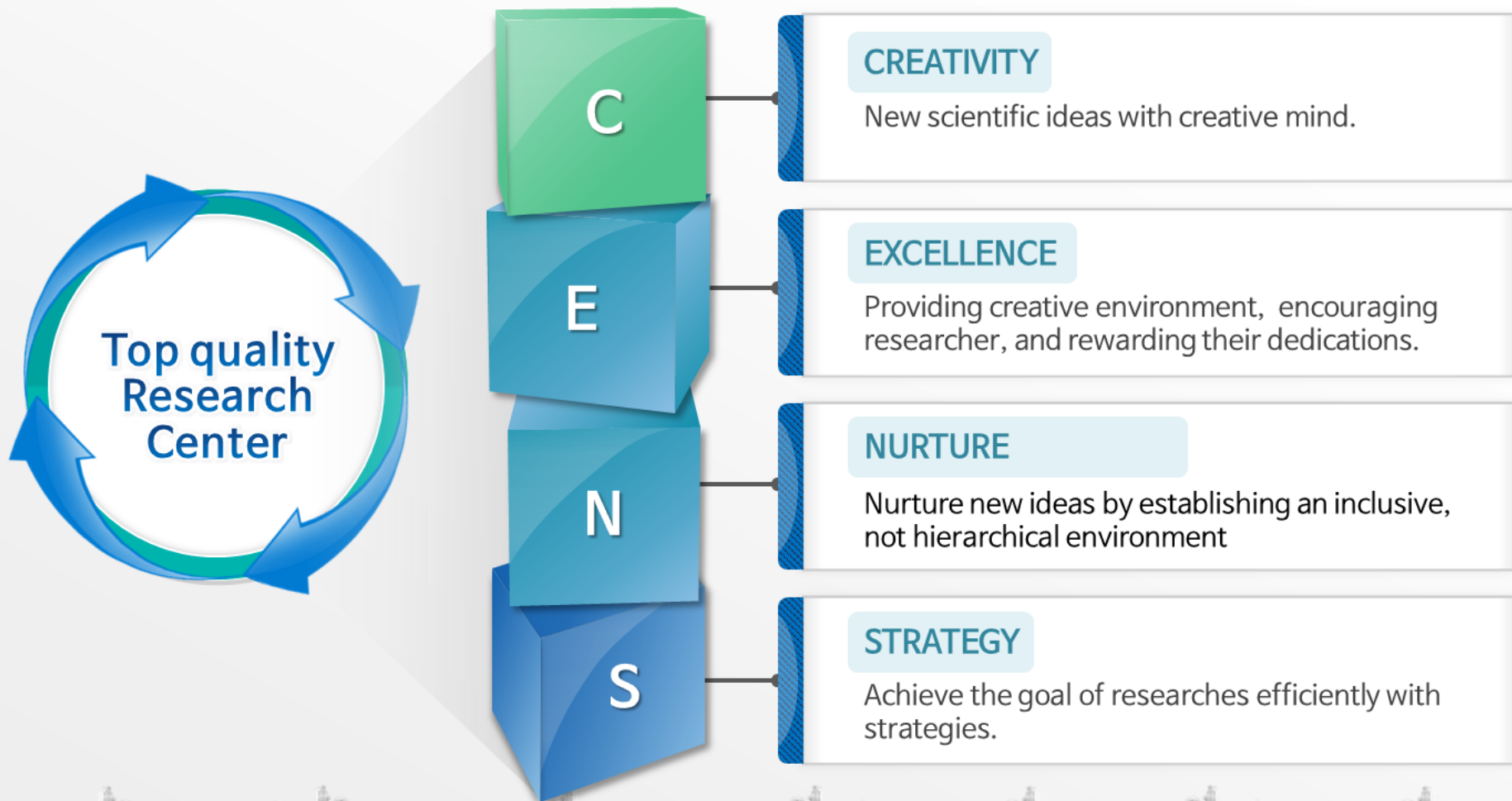
**MoU with
CNS, ATOMKI and TAMU**

**CENTER FOR
EXOTIC NUCLEAR STUDIES**

Summary

- While CENS is born in 2019 (only two years old), we are growing fast in terms of man power and research activities. We are the international nuclear research center!
- **We work hard on understanding properties of exotic nuclei which are important in nuclear structure/reaction and nuclear astrophysics by theories + experiments.**
- **We continue submitting many research proposals and letters of intent.**
- New major Apparatus for nuclear research experimental studies: **KoBRA Wien Filter, AToM-X, CryoSTAR, STARK, STARK Jr./ASGARD, DL-MCP and more.**
- New major Apparatus for nuclear research theoretical studies: **Cluster EFT, FRG, EDF and Machine Learning**
- Internal and School collaborations as well as international ones are critical to make successful achievements of CENS (**Rare Isotope Nuclear Research Hub**).

Center for Exotic Nuclear Studies



C2R2 Annual Workshop 2021

Thank you!

CENS, IBS:

K.I. Hahn, C.B. Moon, T-S. Park, D.S. Ahn, D. Kim, S. Kim, J. Hwang, J. Park, B. Moon, Z. Korkulu, L. Stuhl, S. Choi, S. Bae, S. Cha, E. In, Q. Zhao, X. PEREIRA-LOPEZ, M. Kim, C.Y. Park

Sungkyunkwan Univ.:

K.Y. Chae, M.J. Kim, C.H. Kim, and S.H. Kim

RISP, IBS:

K.H. Tshoo and M.S. Kwag

TAMU (USA), FRIB (USA), ORNL (USA), CEA (France), ATOMKI (Hungary), GANIL (France), RIKEN (Japan), BeihangU (China)

and YOU in the future!