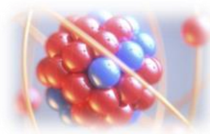


국내 및 국외 희귀핵 연구의 현황 및 전망

Deuk Soon AHN
(안득순)
with CENS Collaborations

Center for Exotic Nuclear Studies(CENS), IBS

희귀핵 CENS CENTER FOR EXOTIC NUCLEAR STUDIES ibs 기초과학연구원 Institute for Basic Science

1

CENS 비전과 목표

희귀 핵 연구단
(Center for Exotic Nuclear Studies)

비전

- 세계적 수준의 핵물리 연구 선도
- 미지 영역의 핵물리 연구를 통한 기초과학의 진보 및 확산

연구목적

- 국내외 핵물리 연구의 허브 구축을 통한 세계적 연구 수행
- 대형 첨단 검출 장치 구축 및 활용 주도

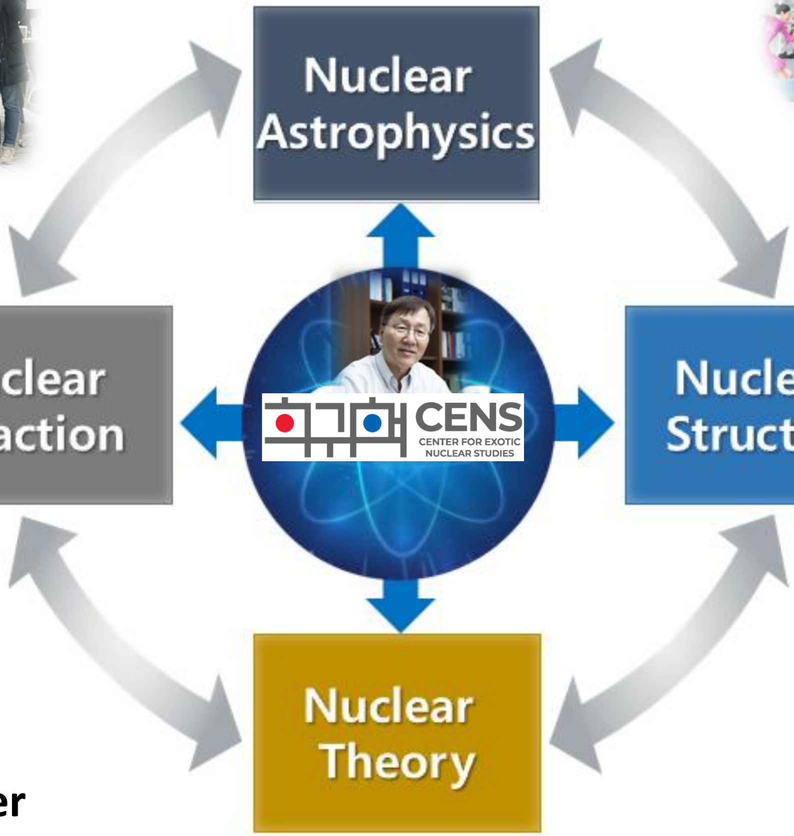
연구목표

- 희귀 핵 기본 성질 연구
- 폭발적 천체 핵반응 이해
- 무거운 원소의 기원 연구
- 새로운 희귀 동위원소 발견

발전목표

- (1단계) 안정선 근방 가벼운 핵 반응 및 특성 탐구
- (2단계) 안정선에서 떨어진 비대칭 핵 관련 실험 수행 및 연구
- (3단계) 양성자 및 중성자 존재 한계선 근방의 희귀 핵 특성 연구
- (4단계) 새로운 희귀 핵 발견 및 특성연구와 무거운 핵의 기원 및 핵합성 과정 규명

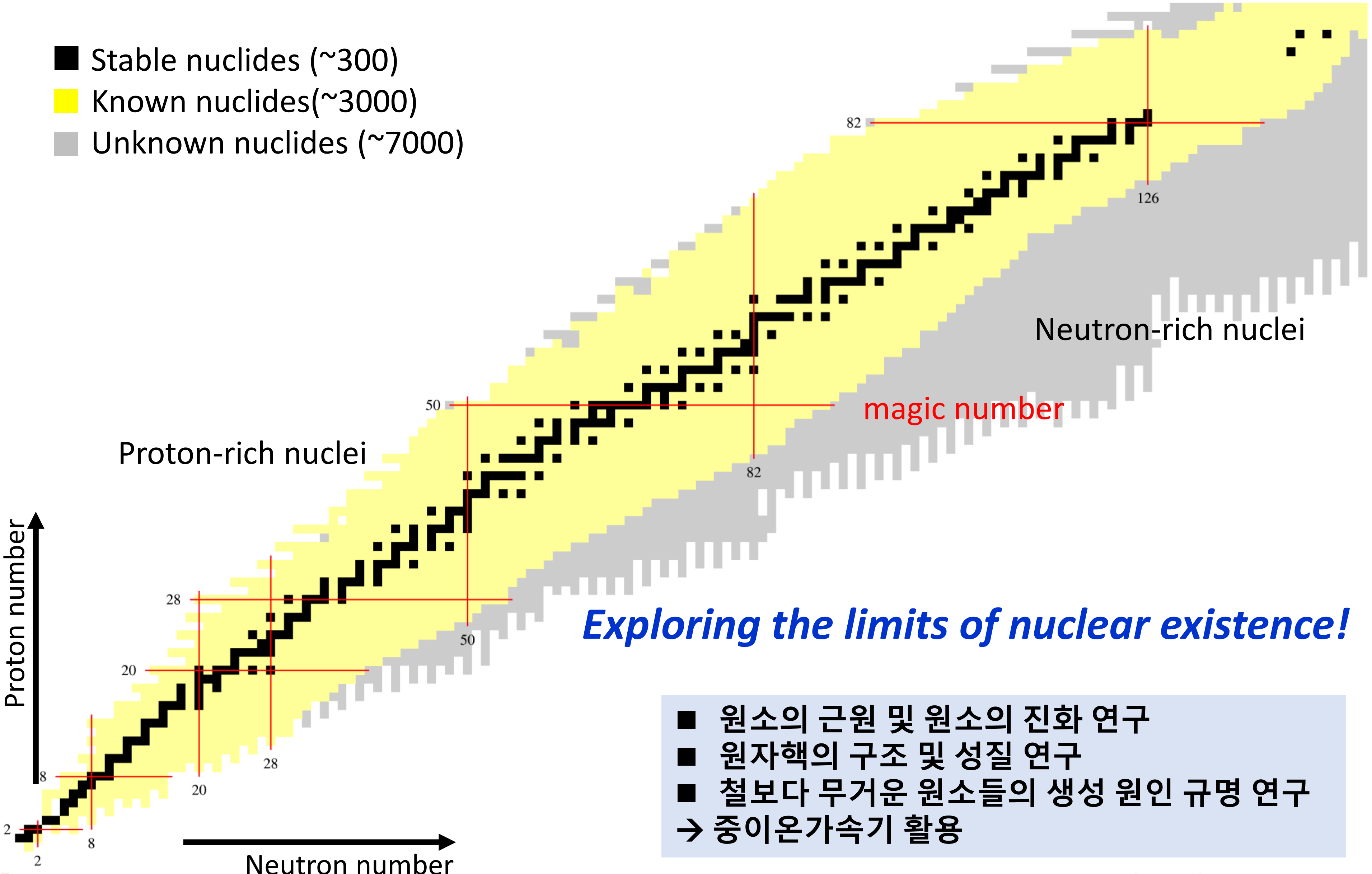
CENS 조직도



4 group leaders
3 senior researchers
13 postdocs
2 senior research engineer
6 students
2 administration staff
+ more members soon

연구 분야별 연계와 협력 강화, 전략적 분야 집중 등을 위해 연구 클러스터 체제도입

Chart of Nuclides

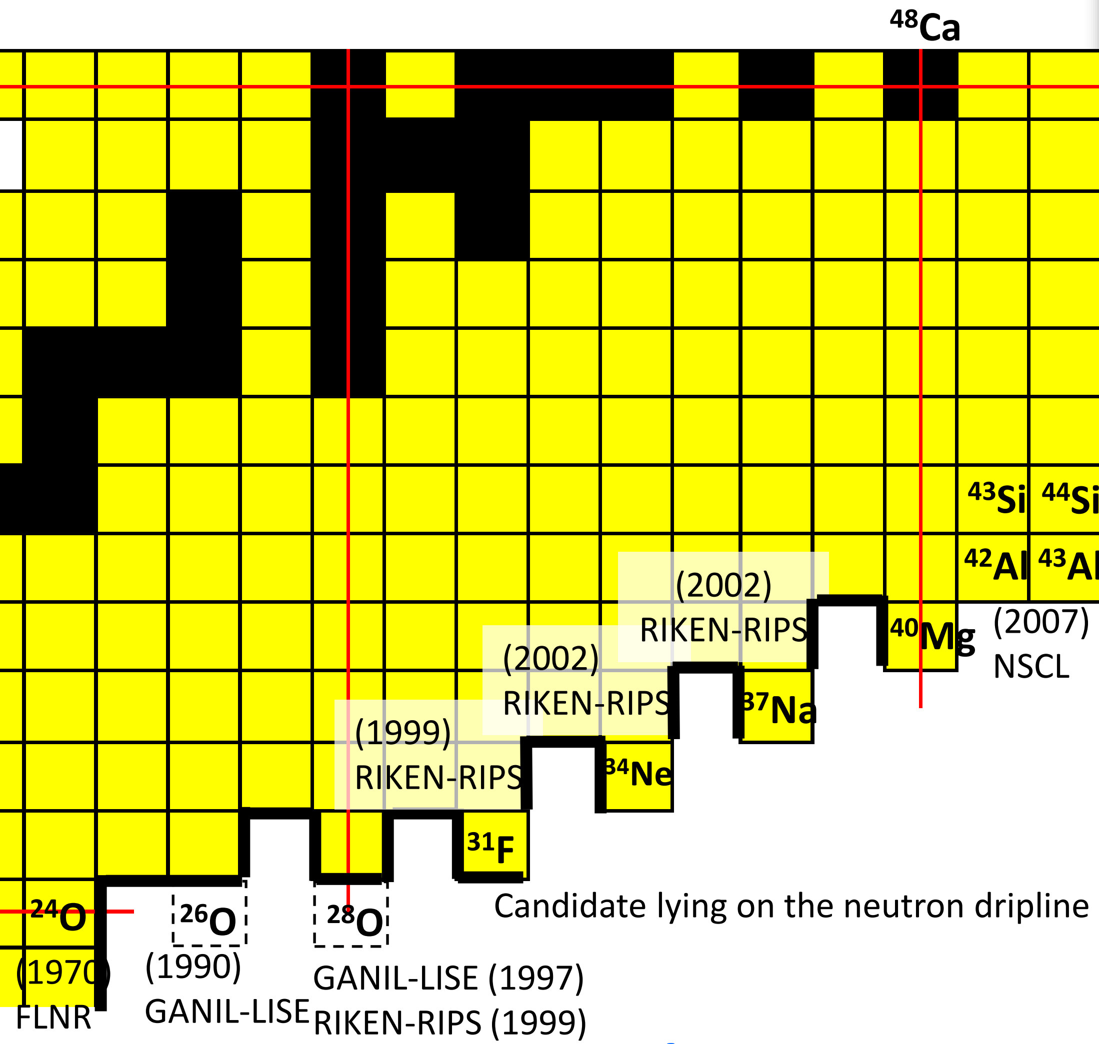


Exploring the limits of nuclear existence!

- ■ 원소의 근원 및 원소의 진화 연구
- ■ 원자핵의 구조 및 성질 연구
- ■ 철보다 무거운 원소들의 생성 원인 규명 연구

→ 중이온가속기 활용

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

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

PHYSICAL REVIEW LETTERS 123, 212501 (2019)

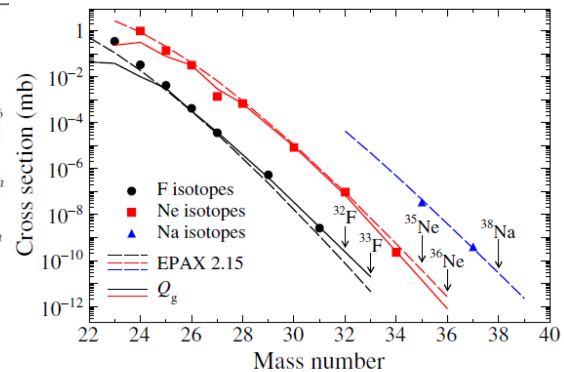
Editors' Suggestion Featured in Physics

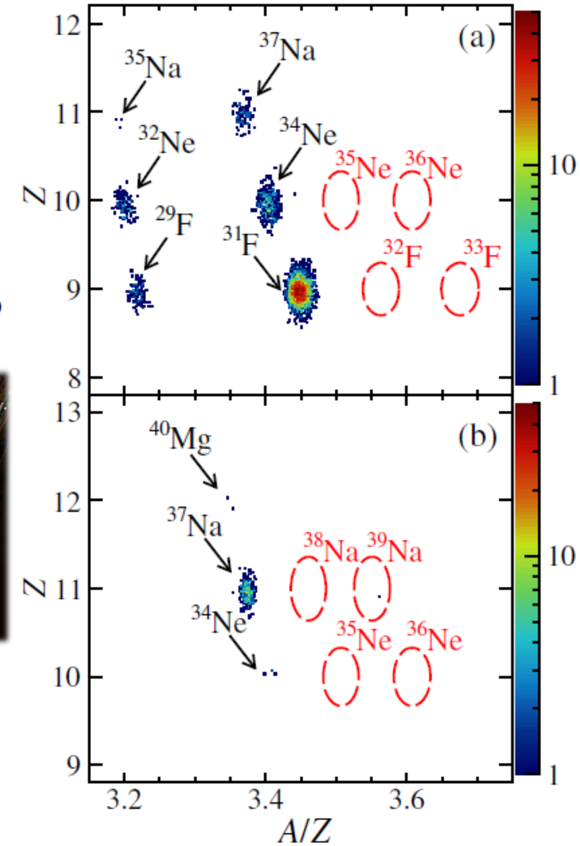
Location of the Neutron Dripline at Fluorine and Neon

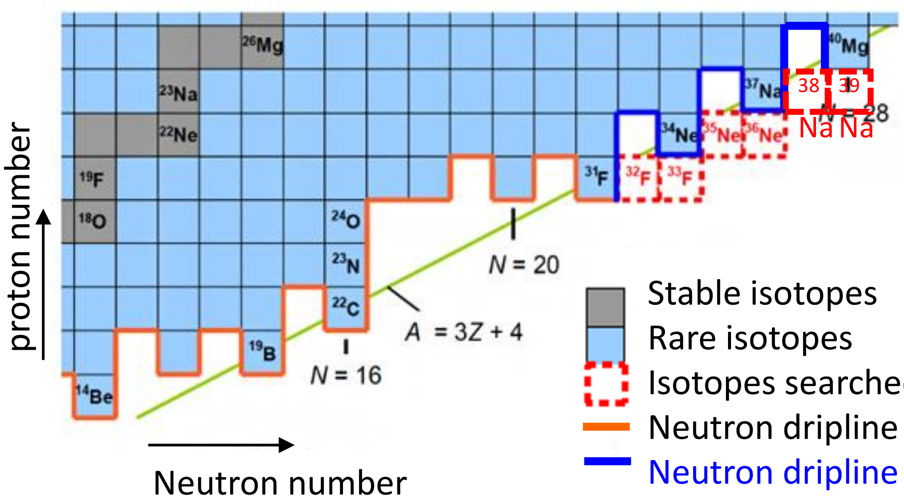
D. S. Ahn,[1] N. Fukuda,[1] H. Geissel,[5] N. Inabe,[1] N. Iwasa,[4] T. Kubo,[1,*,†] K. Kusaka,[1] D. J. Morrissey,[6] D. Murai,[3] T. Nakamura,[2] M. Ohtake,[1] H. Otsu,[1] H. Sato,[1] B. M. Sherrill,[6] Y. Shimizu,[1] H. Suzuki,[1] H. Takeda,[1] O. B. Tarasov,[6] H. Ueno,[1] Y. Yanagisawa,[1] and K.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

[1]RIKEN Nishina Center for Accelerator-Based Science, RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan
[2]Department of Physics, Tokyo Institute of Technology, 2-12-1 O-Okayama, Meguro, Tokyo 152-8551, Japan
[3]Department of Physics, Rikkyo University, 3-34-1 Nishi-Ikebukuro, Toshima, Tokyo 171-8501, Japan
[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

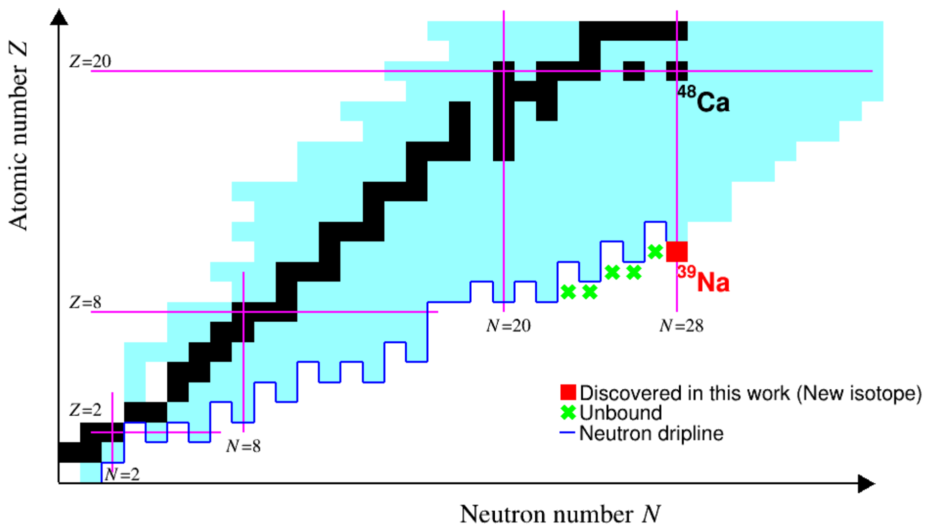
RIKEN RIBF experiment

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

Discovery of ^{39}Na

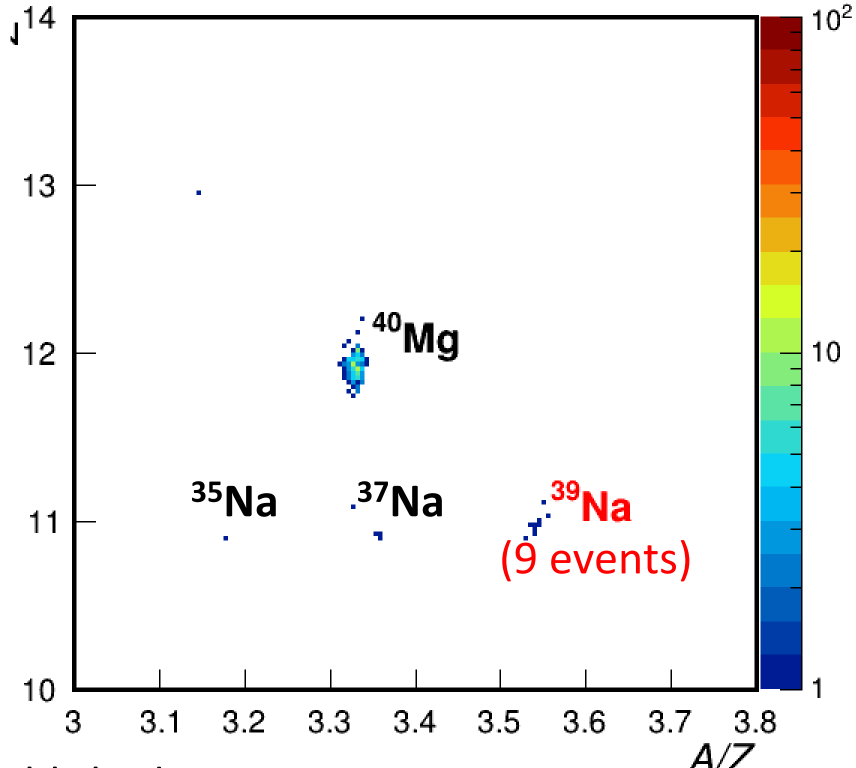
D. S. Ahn,[1,*] J. Amano,[3] H. Baba,[1] N. Fukuda,[1] H. Geissel,[5] N. Inabe,[1] S. Ishikawa,[4] N. Iwasa,[4] T. Komatsubara,[1] T. Kubo,[1,†] K. Kusaka,[1] D. J. Morrissey,[6] T. Nakamura,[2] M. Ohtake,[1] H. Otsu,[1] T. Sakakibara,[4] H. Sato,[1] B. M. Sherrill,[6] Y. Shimizu,[1] T. Sumikama,[1]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

[1] *RIKEN Nishina Center for Accelerator-Based Science, RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan*
[2] *Department of Physics, Tokyo Institute of Technology, 2-12-1 O-Okayama, Meguro, Tokyo 152-8551, Japan*
[3] *Department of Physics, Rikkyo University, 3-34-1 Nishi-Ikebukuro, Toshima, Tokyo 171-8501, Japan*
[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*



Discovery of ^{39}Na

: for the first time in twenty years.



- 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.

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

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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.

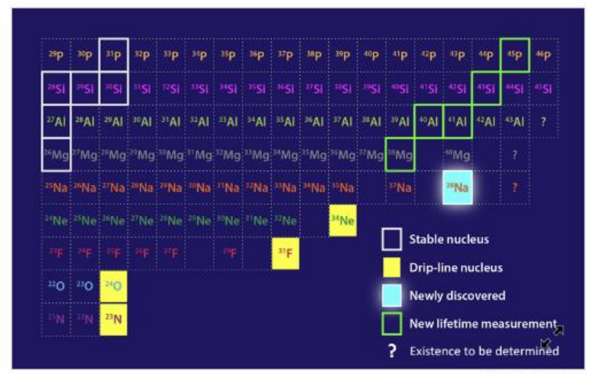


Figure 1: Segrè chart showing bound isotopes for elements between nitrogen and phosphorous. Ahn and colleagues have discovered sodium-39, which is likely the dripline isotope for sodium [1]. Crawford and co-workers have measured five previously unknown isotope lifetimes [2]. **Show Less**

Research activities

J.Park, D.S.Ahn et al.
with international collaborations

PHYSICAL REVIEW C **102**, 014304 (2020)

Spectroscopy of ^{99}Cd and ^{101}In from β decays of ^{99}In and ^{101}Sn

J. Park,[1,2,*] R. Krücken,[1,2] A. Blazhev,[3] D. Lubos,[4,5,6] R. Gernhäuser,[4] M. Lewitowicz,[7] S. Nishimura,[5] D. S. Ahn,[5] H. Baba,[5] B. Blank,[8] P. Boutachkov,[9] F. Browne,[5,10] I. Čeliković,[7,11] G. de France,[7] P. Doornenbal,[5] T. Faestermann,[4,6] Y. Fang,[12] N. Fukuda,[5] J. Giovinazzo,[8] N. Goel,[9] M. Górska,[9] H. Grawe,[9] S. Ilieva,[13] N. Inabe,[5] T. Isobe,[5] A. Jungclaus,[14] D. Kameda,[5] G. D. Kim,[15] Y.-K. Kim,[15,16] I. Kojouharov,[9] T. Kubo,[5] N. Kurz,[9] Y. K. Kwon,[15] G. Lorusso,[5] K. Moschner, D. Murai,[5] I. Nishizuka,[17] Z. Patel,[5,18] M. M. Rajabali,[1] S. Rice,[5,18] H. Sakurai,[5,19] H. Schaffner,[9] Y. Shimizu,[5] L. Sinclair, P.-A. Söderström,[5] K. Steiger,[4] T. Sumikama,[17] H. Suzuki,[5] H. Takeda,[5] Z. Wang,[1] H. Watanabe,[21] J. Wu,[5,22] and Z. Y. Xu

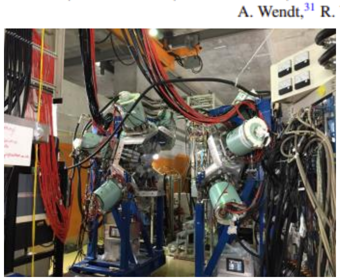
^{99}Cd와 ^{101}In의 새로운 에너지 준위, 스핀 및 패리티를 세계 최초로 측정

PHYSICAL REVIEW C **103**, 034320 (2021)

B.Moon, C.-B.Moon, D.S.Ahn et al.
with international collaborations

Nuclear structure of Te isotopes beyond neutron magic number $N = 82$

B. Moon,[1,2] A. Jungclaus,[3,*] H. Naïdja,[4] A. Gargano,[5] R. Lozeva,[6,7] C.-B. Moon,[1,†] A. Odahara,[8] G. S. Simpson,[9] S. Nishimura,[2] F. Browne,[2,10] P. Doornenbal,[2] G. Gey,[9,11,2] J. Keatings,[12] G. Lorusso,[2] Z. Patel,[2,13] S. Rice,[2,13] M. Si,[7] L. Sinclair,[2,14] P.-A. Söderström,[15,2] T. Sumikama,[2] J. Taprogge,[3,16,2] H. Watanabe,[2] J. Wu,[2,17] Z. Y. Xu,[18] A. Yagi,[8] D. S. Ahn,[2,19] H. Baba,[2] F. L. Bello Garrote,[20] S. Bönig,[21] R. Daido,[8] J. M. Daugas,[22] F. Didierjean,[6] F. Drouet,[9] Y. Fang,[8] N. Fukuda,[2] R. Gernhäuser,[23] B. Hong,[24,25] E. Ideguchi,[26] S. Ilieva,[21] N. Inabe,[2] T. Ishigaki,[8] T. Isobe,[2] H. S. Jung,[27] D. Kameda,[2] I. Kojouharov,[28] T. Komatsubara,[2] T. Kröll,[21] T. Kubo,[2] N. Kurz,[28] Y. K. Kwon,[29] C. S. Lee,[27] P. Lee,[27] Z. Li,[17] A. Montaner-Pizá,[30] S. Morimoto,[8] K. Moschner,[31] D. Mücher,[23] D. Murai,[32] M. Niikura,[2,18] H. Nishibata,[8] I. Nishizuka,[33] R. Orlandi,[34,35] H. Sakurai,[2,18] H. Schaffner,[28] Y. Shimizu,[2] K. Steiger,[23] H. Suzuki,[2] H. Takeda,[2] K. Tshoo,[29] Zs. Vajta,[36] A. Wendt,[31] R. Yokoyama,[37] and K. Yoshinaga[38]



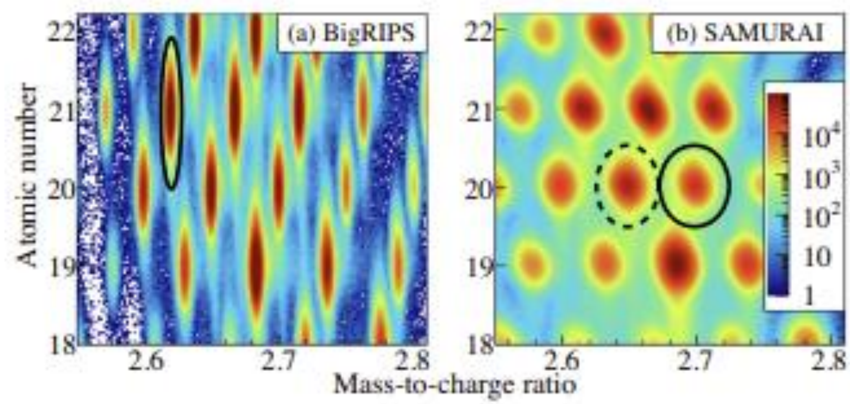
세계 최초로 베타 붕괴를 통한 ^{137}Te의 핵구조 연구

K.I.Hahn, L.Stuhl, D.Kim et al.
with international collaborations

PHYSICAL REVIEW LETTERS **126**, 252501 (2021)

Pairing Forces Govern Population of Doubly Magic ^{54}Ca from Direct Reactions

F. Browne,[1,*] S. Chen,[2,1,3] P. Doornenbal,[1] A. Obertelli,[4,5,1] K. Ogata,[6,7] Y. Utsuno,[8,9] K. Yoshida,[9] N. L. Achouri,[10] H. Baba,[1] D. Calvet,[5] F. Château,[5] N. Chiga,[1] A. Corsi,[5] M. L. Cortés,[1] A. Delbart,[5] J-M. Gheller,[5] A. Giganon,[5] A. Gillibert,[5] C. Hilaire,[5] T. Isobe,[1] T. Kobayashi,[11] Y. Kubota,[1,8] V. Lapoux,[5] H. N. Liu,[5,12] T. Motobayashi,[1] I. Murray,[13,1] H. Otsu,[1] V. Panin,[1] N. Paul,[5] W. Rodriguez,[14,1,15] H. Sakurai,[1,16] M. Sasano,[1] D. Steppenbeck,[1] L. Stuhl,[8,29] Y. L. Sun,[5] Y. Togano,[17] T. Uesaka,[1] K. Wimmer,[16,1,†] K. Yoneda,[1] O. Aktas,[12] T. Aumann,[4,18] K. Boretzky,[18,1] C. Caesar,[4,18,1] L. X. Chung,[19] F. Flavigny,[13] S. Franchoo,[13] I. Gasparic,[20,4,1] R.-B. Gerst,[21] J. Gibelin,[10] K. I. Hahn,[22,29] M. Holl,[4] J. Kahlbow,[4] D. Kim,[22,29] D. Körper,[18] T. Koiwai,[16] Y. Kondo,[23] P. Koseoglou,[4,18] J. Lee,[2] C. Lehr,[4] B. D. Linh,[19] T. Lokotko,[2] M. MacCormick,[13] K. Miki,[4,24‡] K. Moschner,[21] T. Nakamura,[23] S. Y. Park,[22,29] D. Rossi,[4,18] E. Sahin,[25] F. Schindler,[4] H. Simon,[18] P-A. Söderström,[4] D. Sohler,[26] S. Takeuchi,[23] H. Törnqvist,[4,18] J. Tscheuschner,[4] V. Vaquero,[27] V. Wagner,[4] S. Wang,[28] V. Werner,[4] X. Xu,[2] H. Yamada,[23] D. Yan,[28] Z. Yang,[1] M. Yasuda,[23] and L. Zanetti[4]



^{54}Ca 바닥 상태의 spectroscopic factor에서 pairing interaction이 강하게 나타나는 현상

Research activities

nature

Article

Observation of a correlated free four-neutron system

https://doi.org/10.1038/s41586-022-04827-6
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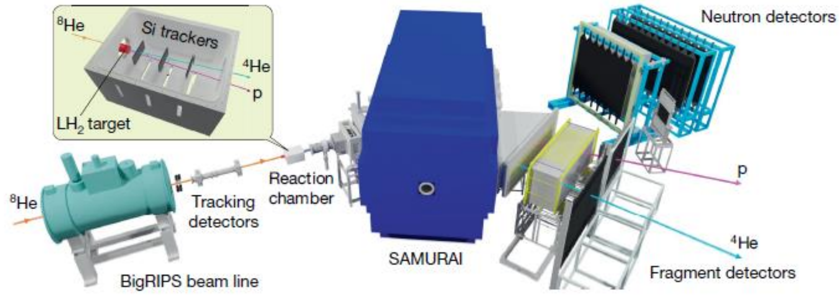
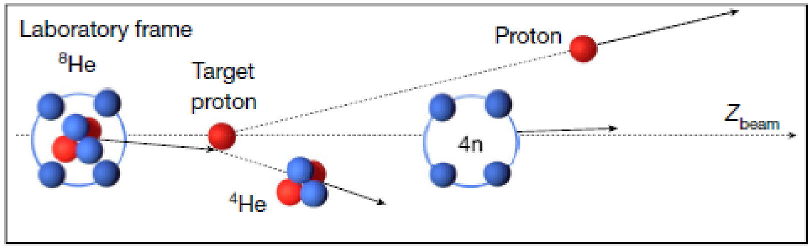
Published online: 22 June 2022
Open access
Check for updates

M. Duer[1✉], T. Aumann[1,2,3], R. Gernhäuser[4], V. Panin[2,5], S. Paschalis[1,6], D. M. Rossi[1], N. L. Achouri[7], D. Ahn[5,16], H. Baba[5], C. A. Bertulani[8], M. Böhmer[4], K. Boretzky[2], C. Caesar[1,2,5], N. Chiga[5], A. Corsi[9], D. Cortina-Gil[10], C. A. Douma[11], F. Dufter[4], Z. Elekes[12], J. Feng[13], B. Fernández-Domínguez[10], U. Forsberg[6], N. Fukuda[5], I. Gasparic[1,5,14], Z. Ge[5], J. M. Gheller[9], J. Gibelin[7], A. Gillibert[9], K. I. Hahn[15,16], Z. Halász[12], M. N. Harakeh[11], A. Hirayama[17], M. Holl[1], N. Inabe[5], T. Isobe[5], J. Kahlbow[1], N. Kalantar-Nayestanaki[11], D. Kim[16], S. Kim[1,16], T. Kobayashi[18], Y. Kondo[17], D. Körper[2], P. Koseoglou[1], Y. Kubota[5], I. Kuti[12], P. J. Li[19], C. Lehr[1], S. Lindberg[20], Y. Liu[13], F. M. Marqués[7], S. Masuoka[21], M. Matsumoto[17], J. Mayer[22], K. Miki[1,18], B. Monteagudo[7], T. Nakamura[17], T. Nilsson[20], A. Obertelli[1,9], N. A. Orr[7], H. Otsu[5], S. Y. Park[15,16], M. Parlog[7], P. M. Potlog[23], S. Reichert[4], A. Revel[7,9,24], A. T. Saito[17], M. Sasano[5], H. Scheit[1], F. Schindler[1], S. Shimoura[21], H. Simon[2], L. Stuhl[16,21], H. Suzuki[5], D. Symochko[1], H. Takeda[5], J. Tanaka[1,5], Y. Togano[17], T. Tomai[17], H. T. Törnqvist[1,2], J. Tscheuschner[1], T. Uesaka[5], V. Wagner[1], H. Yamada[17], B. Yang[13], L. Yang[21], Z. H. Yang[5], M. Yasuda[17], K. Yoneda[5], L. Zanetti[1], J. Zenihiro[5,25] & M. V. Zhukov[20]

A long-standing question in nuclear physics is whether chargeless nuclear systems can exist. To our knowledge, only neutron stars represent near-pure neutron systems, where neutrons are squeezed together by the gravitational force to very high densities. The experimental search for isolated multi-neutron systems has been an ongoing quest for several decades[1], with a particular focus on the four-neutron system called the tetraneutron, resulting in only a few indications of its existence so far[2–4], leaving the tetraneutron an elusive nuclear system for six decades. Here we report on the observation of a resonance-like structure near threshold in the four-neutron system that is consistent with a quasi-bound tetraneutron state existing for a very short time. The measured energy and width of this state provide a key benchmark for our understanding of the nuclear force. The use of an experimental approach based on a knockout reaction at large momentum transfer with a radioactive high-energy ^{8}He beam was key.

K.I.Hahn, D.S.Ahn, L.Stuhl, D.Kim, S.Kim et al. with international collaborations



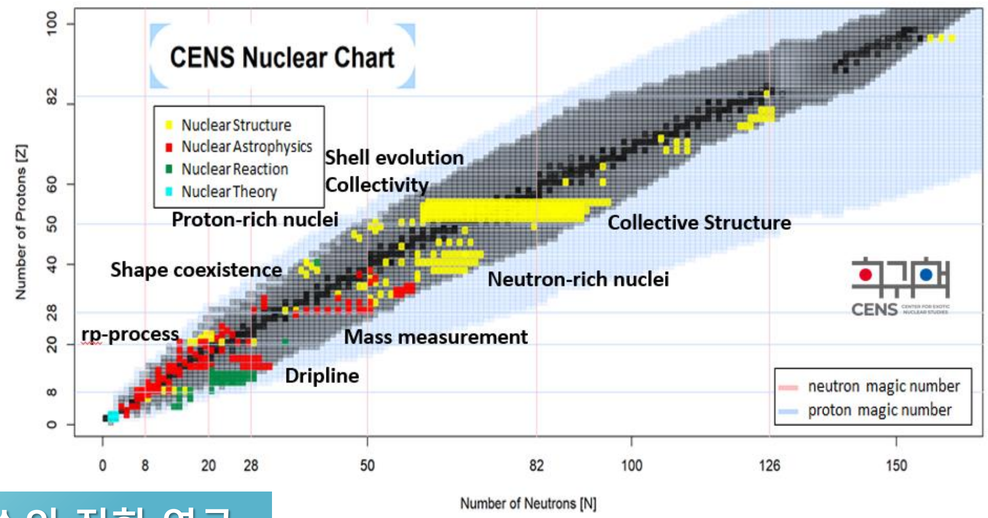


4개의 중성자만으로 이루어진 기묘한 원자핵 관측

CENS nuclear chart for Rare Isotope Science

우주 및 원소의 기원과 희귀핵 특성 연구

Mass, Q-value, $T_{1/2}$, P_n, level structure, level densities and reaction rates



원소의 근원 및 원소의 진화 연구

- 양성자와 중성자의 핵합성으로 이루어진 원자핵의 구조 및 특성 이해
- 희귀핵의 존재 한계선 연구

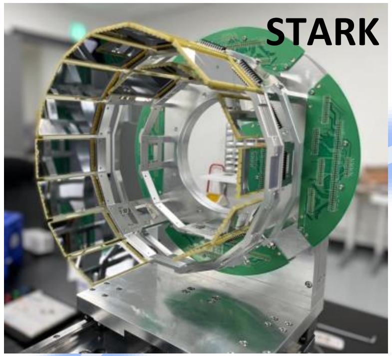
원자핵의 구조 및 성질에 대한 연구

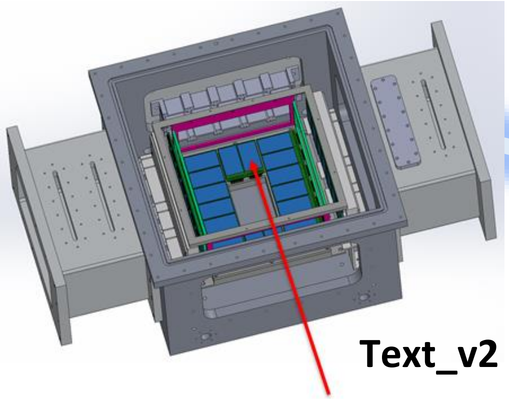
- 안정선에서 벗어난 희귀핵의 구조 및 특성을 이해
- 에너지 준위, 알파클러스터, 핵합성, 핵의 크기, 반감기 등

원소들의 생성 원인 규명

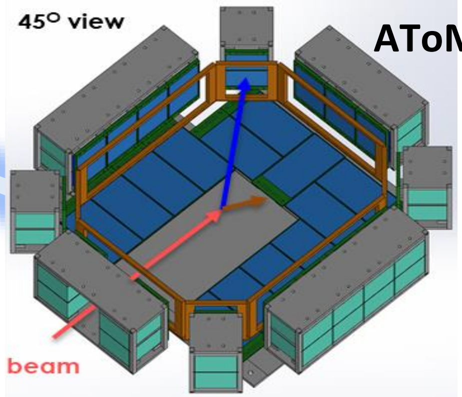
- 여러가지 핵합성 과정의 정확한 이해와 관측 결과 재현
- 질량, 반감기, 준위밀도, 핵반응율 등 핵합성 과정 계산의 부정확도 높음.

CENS Detector Development





Text_v2



Decay Spectroscopy Station

A New Plunger Device

Detector System for Internal Conversion Electrons

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

Beam PID

Diagnostics System

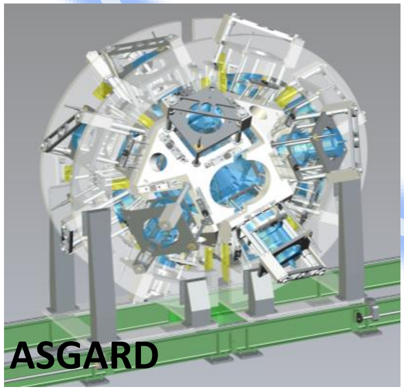
DL-MCP

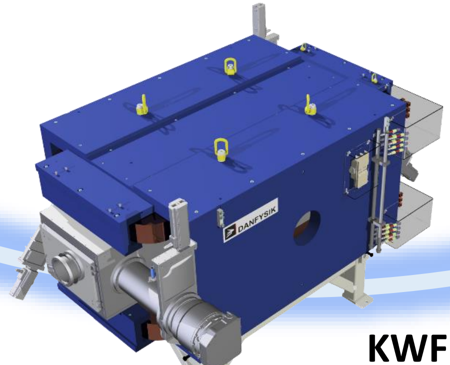
GAGG Scintillator

Liquid Organic Scintillator

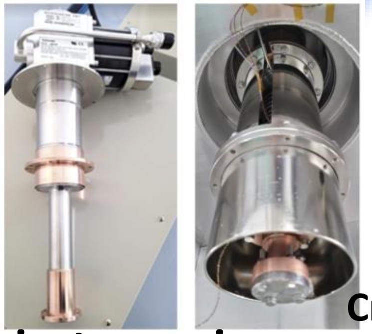
MUSIC/IC

Gas Jet Target





KWF



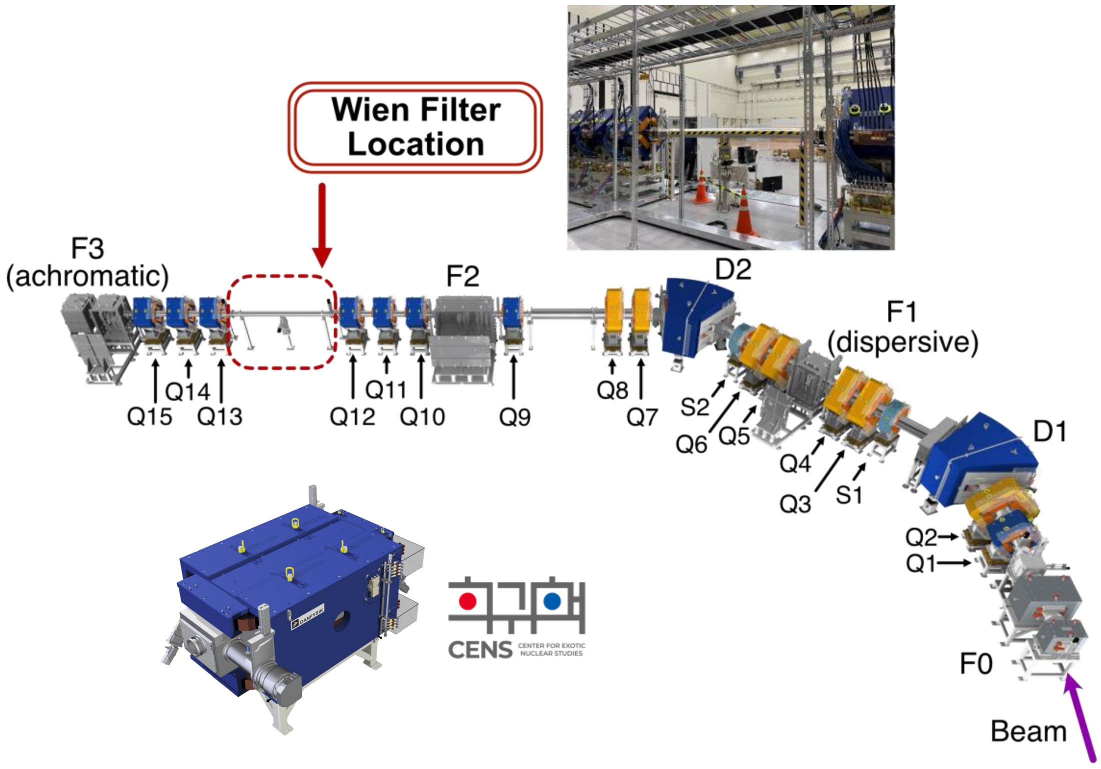
CryoSTAR

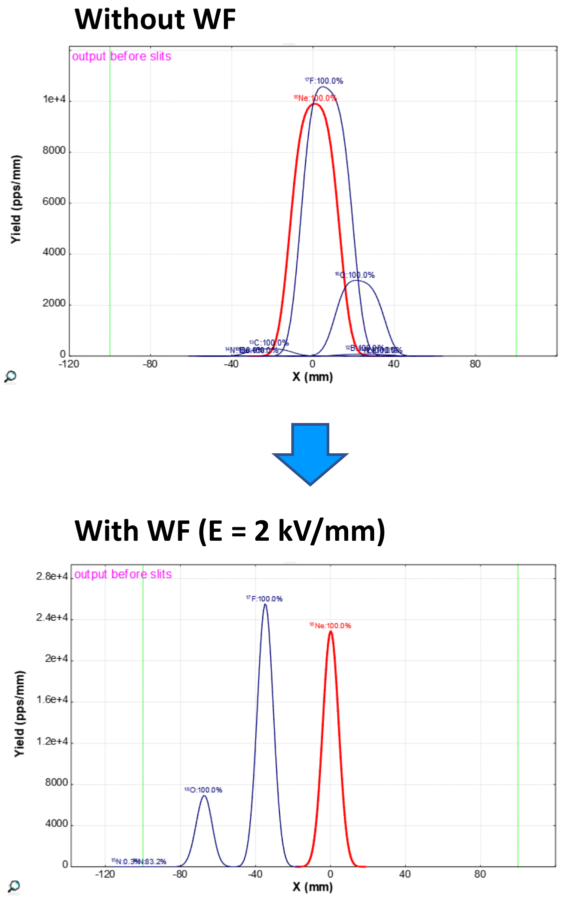
Detector development is required for rare isotope science.

KoBRA Wien Filter

Ion optical component

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



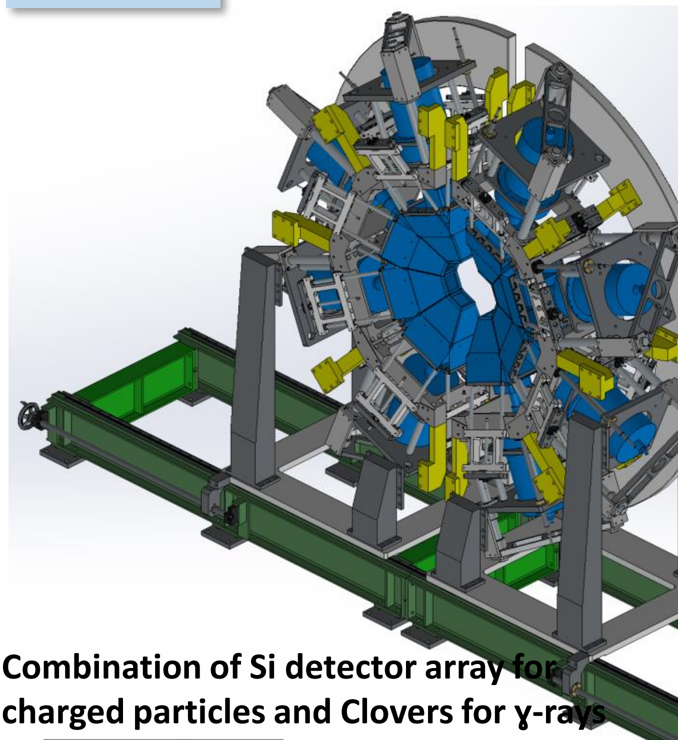


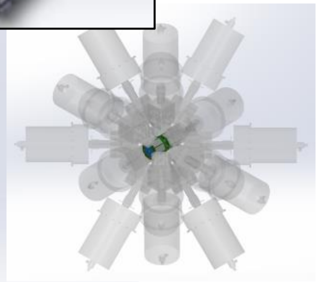
Clear separation and **better focusing**.

Array of Super clover GAmma-Ray Detector

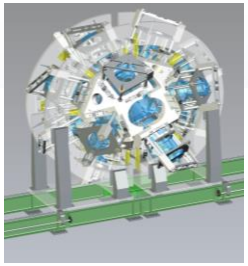
ASGARD

STARK Junior



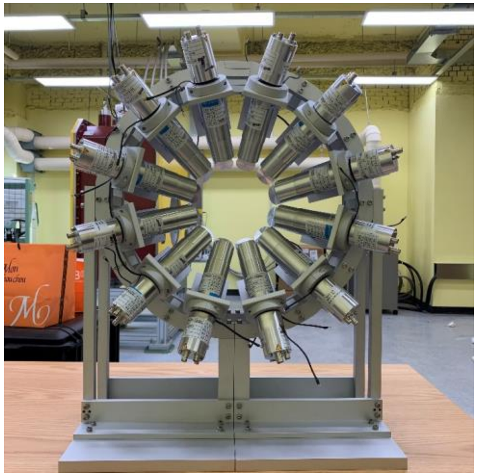


Combination of Si detector array for charged particles and Clovers for γ-rays

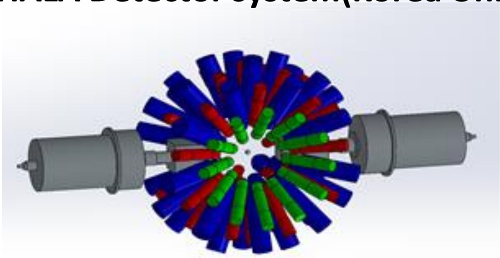


IDATEN

International Detector Assembly for
fast-Timing measurements of Exotic Nuclei Project



KHALA Detector system(Korea Univ.)



IDATEN Detector system 3D modeling
KAHLA (Korea Univ.), FATIMA
SNU KAHLA type $LaBr_3(Ce)$ detector(SNU)

The experiment will be performed at RIKEN RIBF.

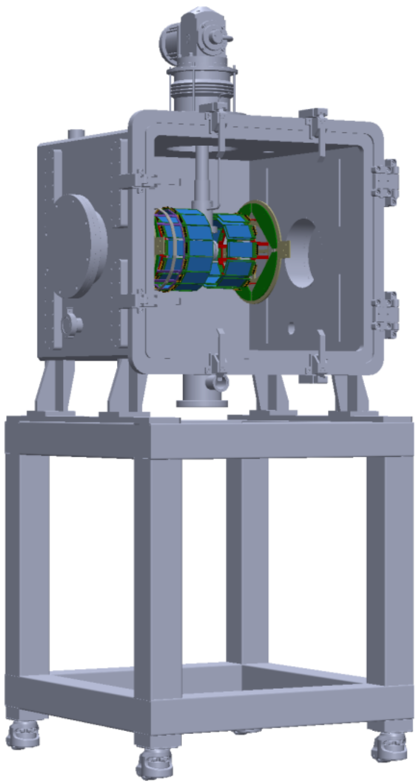
희귀 핵 구조 및 특성 이해 (에너지 준위, 알파클러스터, 핵합성, 핵의 크기 등)

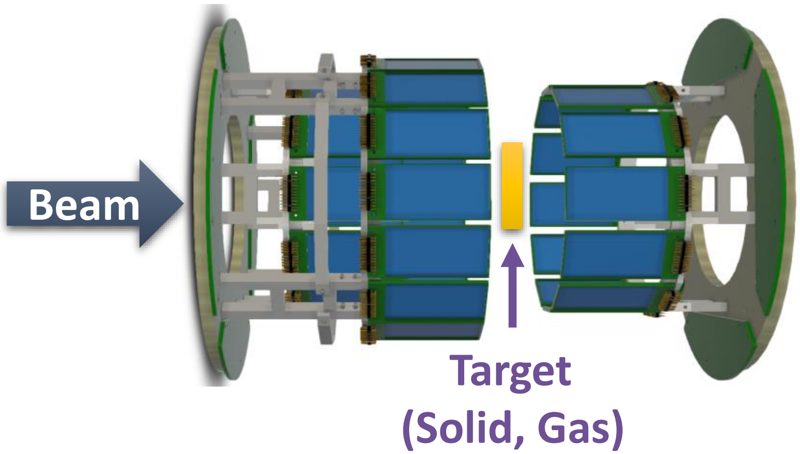
- 세계 유일의 단일 기관 대규모 클로버 검출기 시스템 ASGARD 초기 디자인 완료

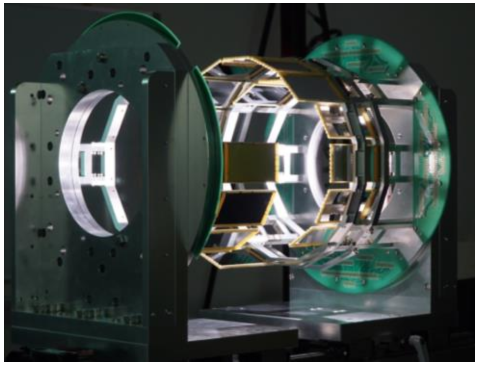
Development of position-sensitive silicon strip

STARK(Silicon Telescope Array for Reaction studies in inverse Kinematics)

- Powerful experimental method to study direct reaction experiments.
- One of the best tools to probe a broad range of nuclear properties
- Providing information into the nuclear structure of exotic nuclei







- Array consisting of 40 double-sided resistive silicon strip detectors.
- Barrel shaped a arrangement
- Wide angular coverage: 43° - 78° and 105° – 150°

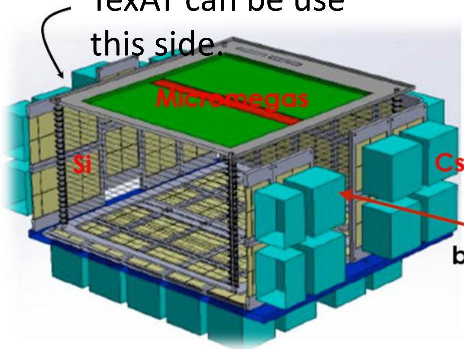
Measure energy, angular momentum, cross section, spectroscopic factor

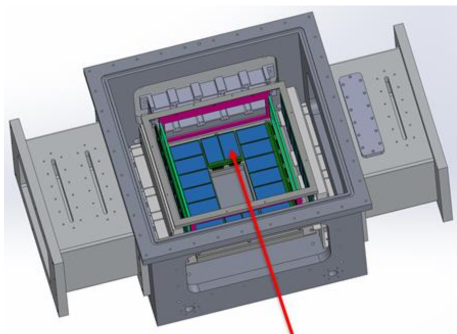
Large solid angle silicon detector array intended for direct reactions experiments.

TexAT_v2 and AToM-X

Micromegas + silicon detector array + CsI(Tl) detector array

TexAT_v2 (Upgrade of Texas Active Target TPC)



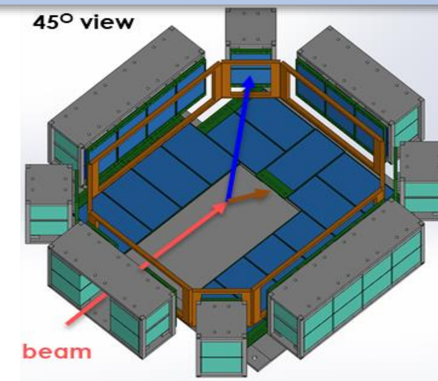


Detection efficiency is 4 times larger than TexAT.

RIBF experiment
- Scheduled in Mar. 2023 (T. Ahn)
- $^{14}O(\alpha,p)^{17}F$ reaction

- Active area: 241(X) x 152(Y) x 135(Z) mm^3
- Portable Scattering chamber: 20”(X) x 13.5”(Y) x 20” (Z)
- Beam tracker (Micromegas) after the window for beam intensity and purity
- Silicon and CsI detectors wall for total energy of particles
- **Upgrade lead by collaboration between Texas A&M and CENS**

AToM-X
(Active Target for Multiple nuclear eXperiments)



- Active area: 256(X) x 180(Y) x 288(Z) mm^3
- Scattering chamber: similar to TexAT chamber to make portable!
- Target gas: CH_4, C_4H_{10}, CD_4, He/CO_2(98/2%) and CO_2
- Silicon and CsI detectors wall for total energy of particles
- Position sensitive strips on Si. Detector (X6) using resistive layer

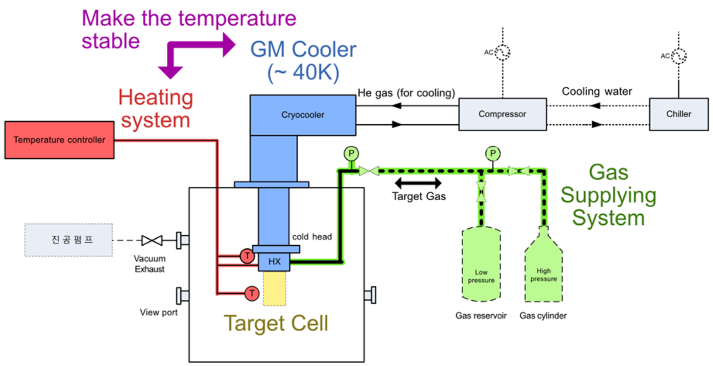
Time projection chamber (TPC) enables to provide 3D particle track information and measures its total energy deposition in Si and CsI(Tl).

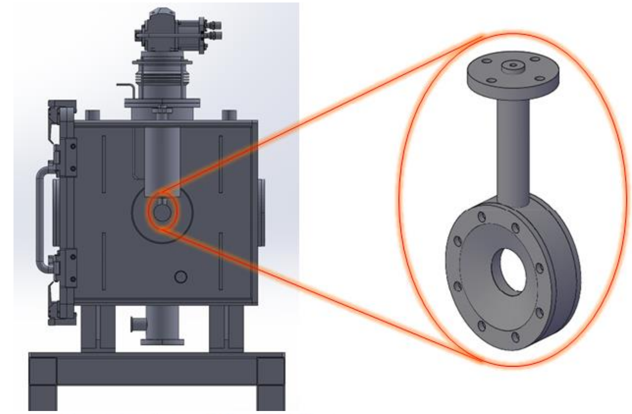
CryoSTAR(Cryogenic Stable Target)

Cryogenic targets in gas or liquid can reach higher densities at very low temperature than that in the room temperature, resulting in a large number of reaction yields in nuclear experiment.

Light element gases(H2, D2, ^{3}He, and ^{4}He) have often been used as a RI beam production target.

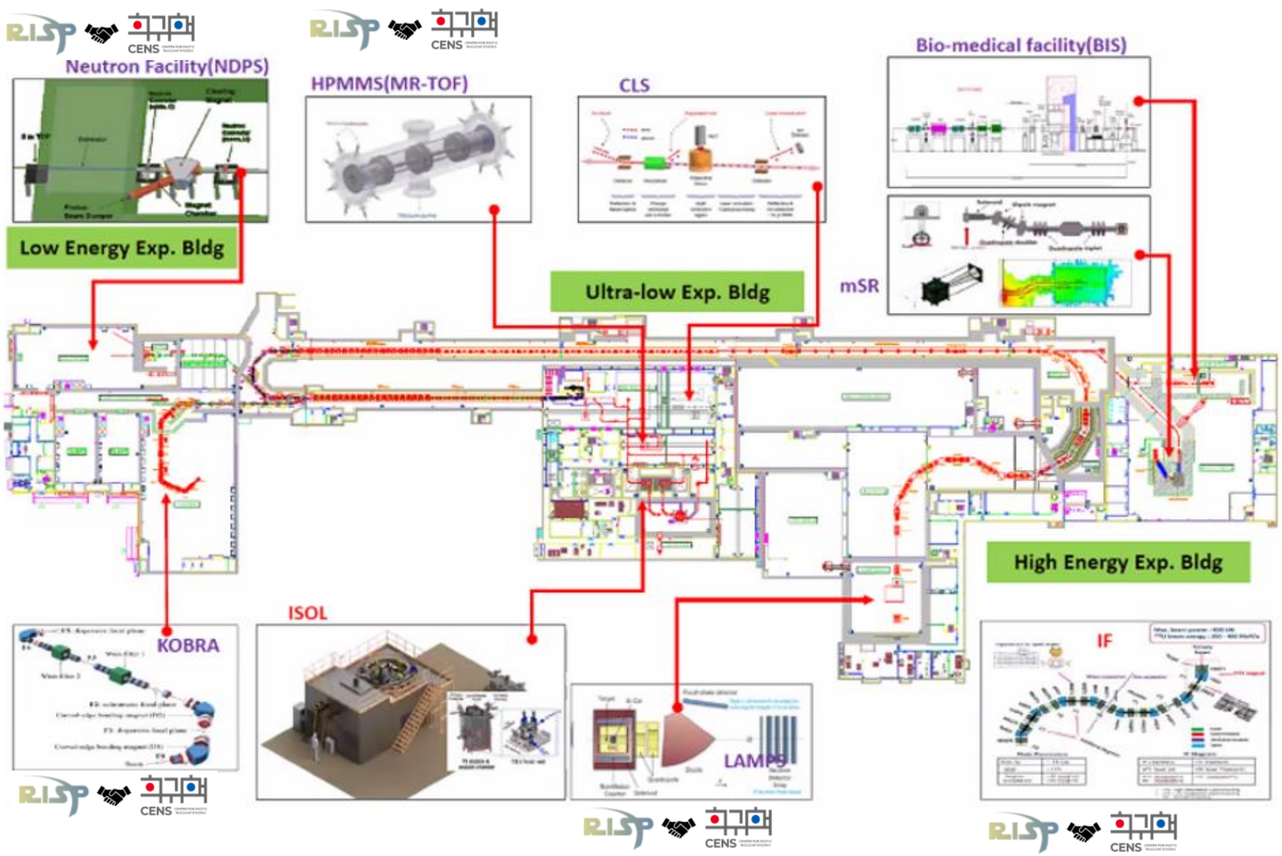
- Reaction target & Production target
- Thick and thermostable gas target is necessary for the production of intense RI beams





- Goals: 40 K, 0.3~2 atm of $H_2/D_2/^3He/^4He$ gas
- Reaction Gas Cell Dimensions: 3/6 mm thick, 20 mmD with Havar/Mo/Ti/Mylar window (2~50 um)

Collaborations with RAON and domestic

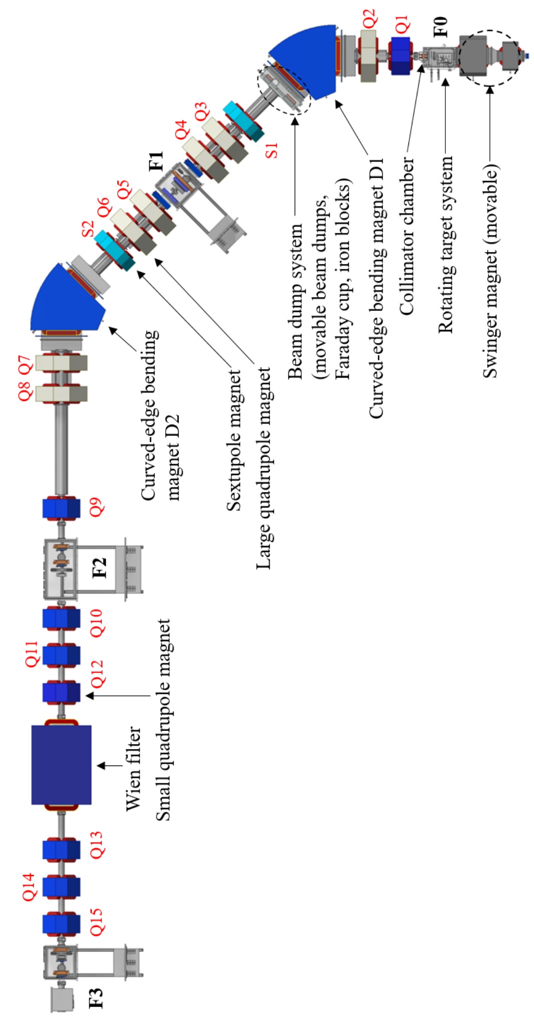


Man-power exchange
Joint studies

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

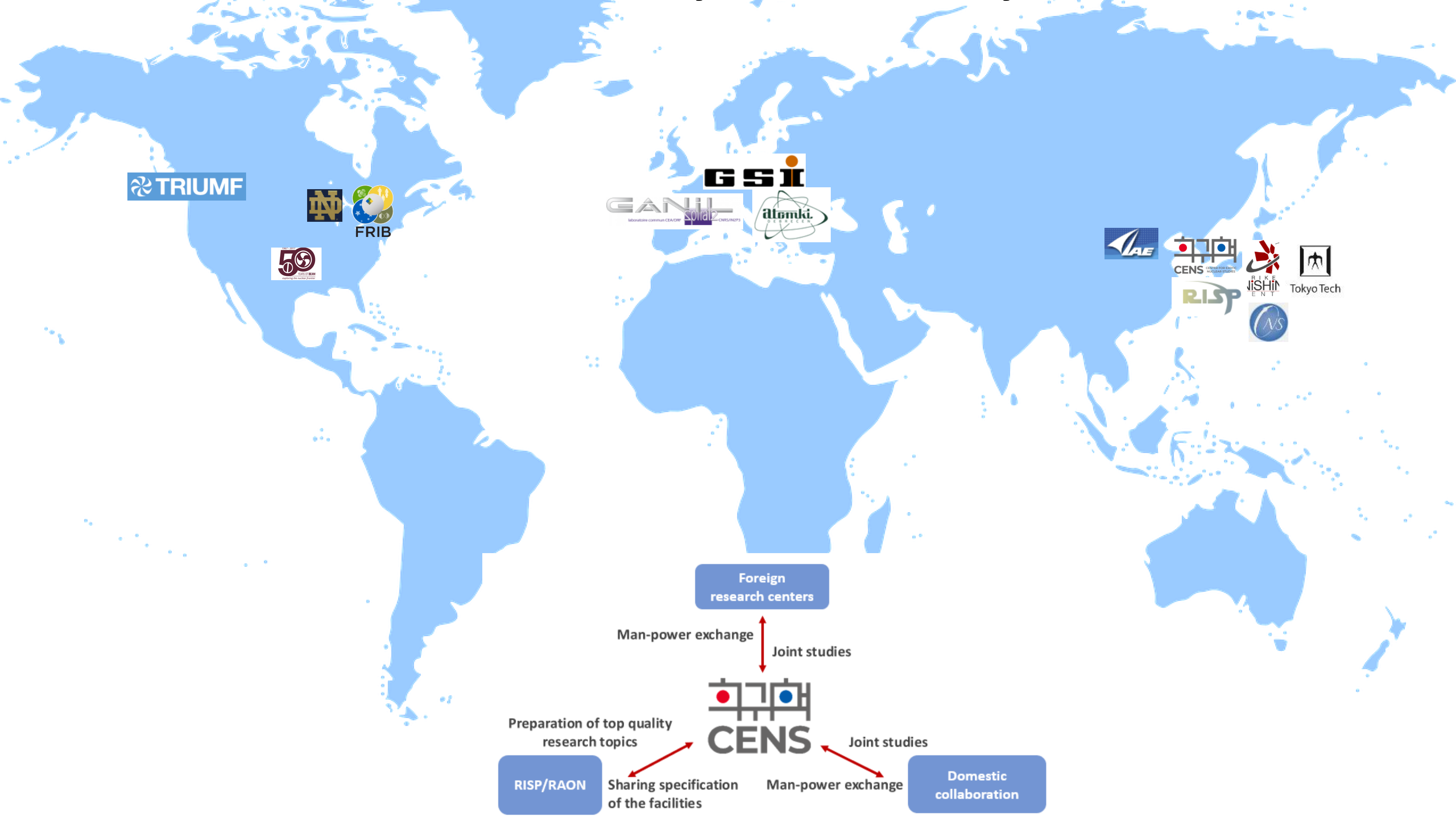
CENS Letter of Intent for KoBRA experiments

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



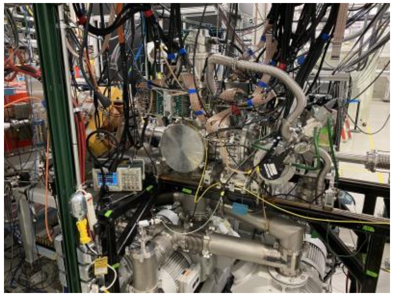
Domestic & International Collaborations

Connect the community internationally with CENS



Research activities in the world (Experiment,2022)

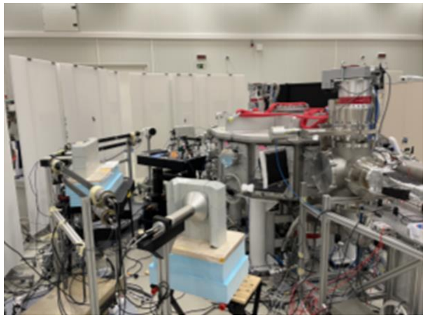
Fission reaction study with VAMOS++ spectrometer and PARIS detector (D.S.Ahn, Y.H.Kim, Y.J.Cho)



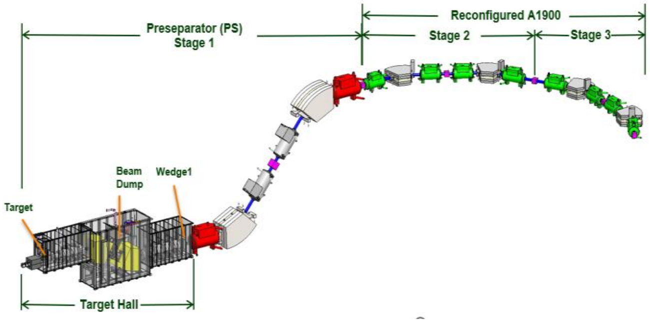
Measurement of $^{26}Al(\alpha,p)^{29}Si$ cross sections
MSU(K.I.Hahn, T.Ahn, J.W.Hwang)

Research for Equation of State using INDRA and FAZIA(E818), GANIL(S.J.Kim)

$^{86}Kr(\alpha,n)$ reaction in the weak r-process using MUSIC and LENDA,
MSU(T.Ahn, D.Kim,S.H.Bae)

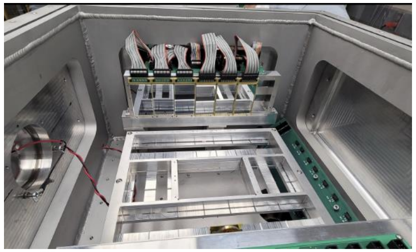


Yield of dd fusion neutrons induced by femtosecond laser shots,
ELI-ALPS (Z.Korkulu)



FRIB Beam commissioning with ARIS separator : ARIS beam development,
MSU FRIB (D.S.Ahn)

FRIB experiment, RIBF experiment,…



$^{14}O(\alpha,p)\,^{17}F$ reaction with TexT_v2,
Texas A&M (K.I.Hahn, T.Ahn, D.Kim, S.H.Bae, S.M.Cha, C.Y.Park)

Research proposals in the world

- FRIB Day One Proposals:
  - ✓ 3 proposals and 1 LoI submitted
  - ✓ 2 proposals and 1 LoI accepted
- Year 2022:
  - ✓ 1 proposals submitted and accepted

✓ 1 proposal submitted and accepted

✓ 1 proposal submitted and accepted

✓ 2 proposal submitted and accepted

- Year 2020:
  - ✓ 7 proposals submitted
  - ✓ 5 proposals of spokesperson
  - ✓ 1 proposal accepted
- Year 2021:
  - ✓ 7 proposals submitted
  - ✓ 4 proposals of spokesperson
  - ✓ 2 proposal accepted
- Year 2022: in preparation

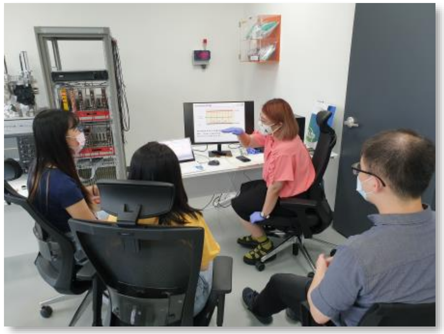
Submitted 29 proposals : Japan(14), Europe(10), USA(5)

Accepted 16 proposals: Japan(9), Europe(3), USA(3)

Spokespersons for 7 experiments

CSSU(CENS Summer School for Undergraduates)

Lectures + Practice + Hands-on Activities + RAON Facility Tour



Resources for all young students

INPC 2025

INPC 2025
ibs Institute for Basic Science
세계 최대규모 핵물리학 분야 국제회의, 과학 MICE 도시 대전 최초 개최
[충청뉴스 김용우 기자] 대전관광공사는 기초과학연구원 희귀 핵 연구단 및 지하실험 연구단과 협력해 2025 국제핵물리학컨퍼런스(International Nuclear Physics Conference, INPC)를 대전으로 유치하는 데 성공했다고 21일 밝혔다.
iNPC2022
Cape Town, South Africa
11일~16일 남아프리카공화국에서 개최된 INPC 2022 환영만찬에서 차기 개최지가 발표되고 있다(왼쪽에 기초과학연구원 희귀 핵 연구단 한인식 단장)
DAEJEON
METROPOLITAN CITY

Summary

❖ **해외 희귀동위원소 가속기 실험 시설을 활용한 다양한 핵물리 연구 수행**
- 해외 중이온가속기 실험 참여 및 공동연구 수행

❖ **첨단 검출 장치 구축 및 개발 프로젝트 진행**
- 클로버 검출기, 능동형 과녁 검출기, 원통형 다목적 실리콘 검출기, 속도분리기, 가스셀 타겟 등

❖ **국내외 중이온가속기 활용 연구 주제 제안 및 실험 참여**
- 총 28건의 실험제안서 제출 중 15개 실험 제안서 통과(7개는 희귀핵연구단 연구원이 실험책임자)
- RAON 저에너지 및 고에너지 빔라인을 활용한 실험 계획 수립 및 제안서 제출

❖ **연구단 내 독자적 핵물리 이론 그룹 구축을 통한 희귀핵 연구 수행**
- 핵성질과 핵물질의 세계적 수준의 연구를 위한 핵이론 모델 연구
- 핵물리 실험과 이론의 상호보완적 연구 수행

❖ **국제 공동 협력 추진 및 공동 연구 허브망 구축 추진**

❖ **우수 연구 인력 확보 및 젊은 연구자 육성을 위한 노력**

Thank you very much!