Recent Activities of ANPhA (Asian Nuclear Physics Association)

Byungsik Hong (Korea University)
Chair of ANPhA

IUPAP WG9 Annual General Meeting 2023
Palais de Papes, Avignon, France, June 3, 2023

https://asiannuclearphysic.wixsite.com/anpha

Overview of ANPhA

- Short history
  - Three preparatory meetings in Tokyo (2008), Seoul (2009), and Beijing (2009)
  - Establishment of the organization in Beijing, July 18, 2009
  - Original member countries/region (8)
    - Australia, China, India, Japan, Korea, Mongolia, Taiwan, and Vietnam
  - Objectives
    - To strengthen "***Collaboration***" among Asian nuclear research scientists through the promotion of nuclear physics and its transdisciplinary and applications
    - To promote "***Education***" in Asian nuclear science through mutual exchange and coordination
    - To ***coordinate*** among Asian nuclear scientists by actively ***utilizing existing research facilities***
    - To discuss ***future planning*** of nuclear science facilities and instrumentation in Asia

Overview of ANPhA

- Regular activities
  - Annual board meeting together with either ANPhA Symposium or Conference

  - During the pandemic ANPhA continued the online meetings and ANPhA Symposia
- Return to the in-person meeting in 2023

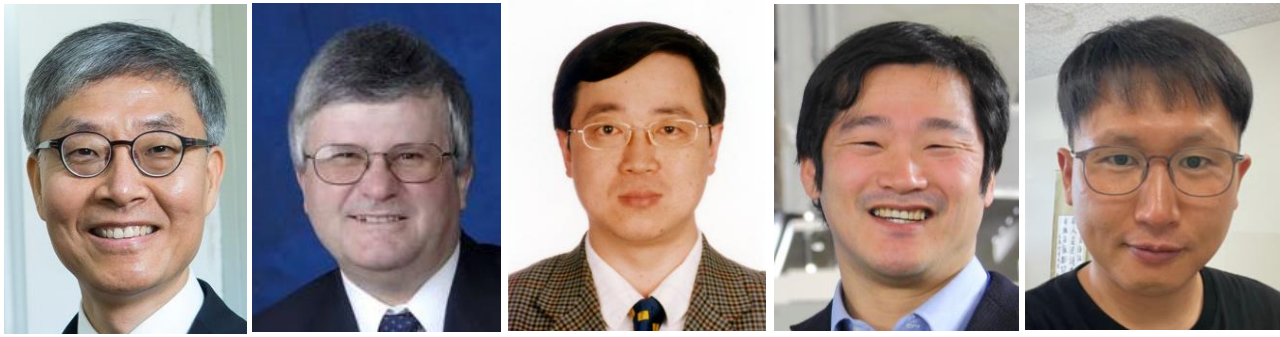
	Date	Location	Symposium	Comments
1st	Jul. 18, 2009	Beijing, China		
2nd	Jan. 17, 2010	Tokai, Japan	1st ANPhA Symposium	
3rd	Oct. 02, 2010	Seoul, Korea	2nd ANPhA Symposium	
4th	Apr. 30, 2011	Lanzhou, China	3rd ANPhA Symposium	
5th	Nov. 27, 2011	Hanoi, Vietnam	ISPUN2011	
6th	Aug. 04, 2012	Adelaide, Australia	4th ANPhA Symposium	
7th	Apr. 27, 2013	Taipei, Taiwan	5th ANPhA Symposium	
8th	Feb. 19, 2014	Kolkata, India	6th ANPhA Symposium	
9th	Nov. 07, 2014	Ho Chi Minh, Vietnam	ISPUN2014	
10th	Oct. 24, 2015	Gyeongju, Korea	7th ANPhA Symposium	
11th	Nov 24, 2016	Sendai, Japan	8th ANPhA Symposium	
12th	Sep. 24, 2017	Halong City, Vietnam	ISPUN2017	
13th	Sep. 13, 2018	Beijing, China	9th ANPhA Symposium	
14th	Jun. 29, 2019	Jeju Island, Korea	10th ANPhA Symposium	
15th	Dec. 11, 2020	Hong Kong, China	11th ANPhA Symposium	Online
16th	Dec. 03, 2021	Beijing, China	12th ANPhA Symposium	Online
17th	Nov. 17, 2022	Beijing, China	13th ANPhA Symposium	Online

Overview of ANPhA

- Establishment of the Division of Nuclear Physics (DNP) in Association of Asia Pacific Physical Societies (AAPPS) in the 33rd Council meeting in Brisbane, Australia on Dec. 4, 2016.

- Past Chairs
  - ↓ Hideyuki Sakai, Japan (2009-2011)
  - ↓ Yanlin Ye, China (2012-2014)
  - ↓ Dong-Pil Min, Korea (2014-2016)
  - ↓ Kazuhiro Tanaka, Japan (2017-2019)
  - ↓ Weiping Liu, China (2020-2022)

Overview of ANPhA

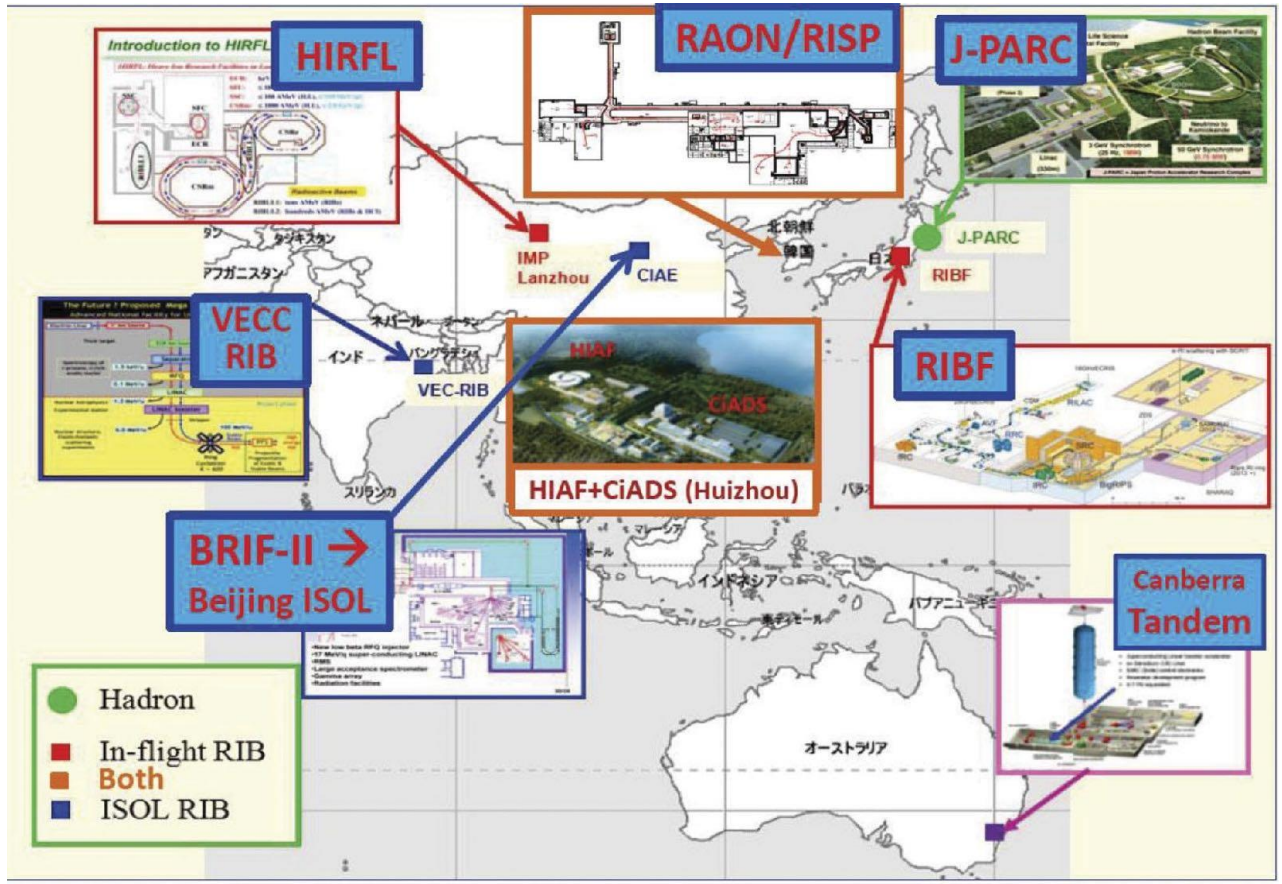


Chair | Vice Chairs | Secretary

- **Current management (2023-2025)**
  - Chair: Byungsik Hong (Korea)
  - Vice Chairs: Anthony Thomas (Australia), Guoqing Xiao (China), Tomohiro Uesaka (Japan)
  - Secretary to Chair: Yongsun Kim (Korea)
- **Board members (12 member countries/region)**
  - Australia: Anthony Thomas (Univ. of Adelaide)
  - China: Furong Xu (Peking Univ.), Guoqing Xiao (IMP), Yugang Ma (Fudan Univ.), Bing Guo (CIAE)
  - India: Avinash C. Pandey (IUAC), Sumit Som (VECC), Vandana Nanal (TIFR)
  - Japan: Kazuhiro Tanaka (KEK), Atsushi Hosaka (RCNP), Hirokazu Tamura (Tohoku Univ.), Tomohiro Uesaka (RIKEN)
  - Korea: Byungsik Hong (Korea Univ.), Jin-Hee Yoon (Inha Univ.), Eun-Joo Kim (Jeonbuk Nat. Univ.)
  - Taiwan: Wen-Chen Chang (Academia Sinica)
  - Vietnam: Phan Viet Cuong (VINAGAMMA)
  - Myanmar: Nyein Wink Lwin (Univ. of Mandalay)
  - Kazakhstan: Kairat A. Kuterbekov (Eurasian Nat. Univ.)
  - Hong Kong (China): Jenny Hui Ching Lee
  - Mongolia: To be determined
  - The Philippines: Denny Lane Sombillo (Univ. of the Philippines)

Overview of ANPhA

- White paper of ANPhA
  - Catalog of Accelerator Facilities in Asia-Pacific region
  - https://kds.kek.jp/indico/category/1706/
  - Existing and planned accelerators for NP in Asia



Nuclear Physics News (2020) feature article

Ten Years of the Asian Nuclear Physics Association (ANPhA) and Major Accelerator Facilities for Nuclear Physics in the Asia Pacific Region

Anthony W. Thomas[1,6], Andrew E. Stuchbery[1,7], Weiping Liu[2,8], Guoqing Xiao[2,9], Yugang Ma[2,10], Jun Cao[2,11], Avinash C. Pandey[3,12], B. K. Nayak[3,13], Sumit Som[3,14], Kazuhiro Tanaka[4,15], Tohru Motobayashi[4,16], Hirokazu Tamura[4,17], Atsushi Hosaka[4,18] and Byungsik Hong[5,19]

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[2]*ANPhA, China*
[3]*ANPhA, India*
[4]*ANPhA, Japan*
[5]*ANPhA, Korea*
[6]*University of Adelaide, ANPhA Vice Chair, Australia*
[7]*Australian National University, Australia*
[8]*CIAE, ANPhA Chair, China*
[9]*IMP-CAS, ANPhA Board Member, China*
[10]*Fudan University, ANPhA Board Member, China*
[11]*IHEP, China*
[12]*IUAC, ANPhA Board Member, India*
[13]*BARC-TIFR, ANPhA Board Member, India*
[14]*VECC, ANPhA Board Member, India*
[15]*KEK, ANPhA Board Member, Japan*
[16]*RIKEN, ANPhA Vice Chair, Japan*
[17]*Tohoku University/JAEA, ANPhA Board Member, Japan*
[18]*Osaka University/JAEA, ANPhA Board Member, Japan*
[19]*Korea University, ANPhA Vice Chair, Korea*

1. Introduction

Establishment of ANPhA

On 18 July 2009, the Asian Nuclear Physics Association (ANPhA) [1] was officially launched in Beijing by representatives from China, Korea, Japan, and Vietnam.

The main objectives of ANPhA are clearly indicated in its bylaws:

1. to strengthen *collaboration* among the Asian communities in nuclear research through the promotion of basic nuclear physics and its applications,
2. to promote *education* in the Asian nuclear science communities through mutual exchange and coordination of resources,
3. to encourage *coordination* among the Asian nuclear scientists for active utilization of existing research facilities, and
4. to *discuss future planning* of the nuclear science facilities and instrumentation among member countries.

According to the brief summary report prepared by Prof. Hideyuki Sakai, which appeared in *Nuclear Physics News* [2], entitled "Establishment of the Asian Nuclear Physics Association (ANPhA)," the story of the first days of ANPhA was as follows:

… Initially, the need of an organization like ANPhA was raised from time to time at the meetings of the Commission on Nuclear Physics (C12) of the International Union of Pure and Applied Physics (IUPAP) as well as at its

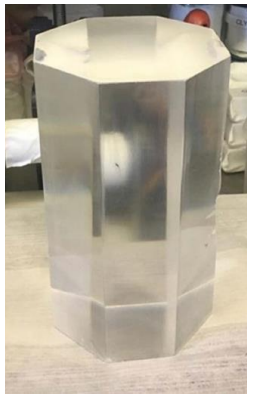
News from Australia

from Anthony W. Thomas

- Stawell Underground Physics Laboratory (SUPL)
  - Construction of a new underground Lab. completed in 2022

News from Australia

- SABRE South Collaboration
  - A new dark matter searching group (46 members across 5 institutions)
  - To measure the model independent modulation signal for dark matter caused by relative motion of the Earth through galactic halo
  - Expect to reach 5σ discovery sensitivity to a DAMA-like signal within two years

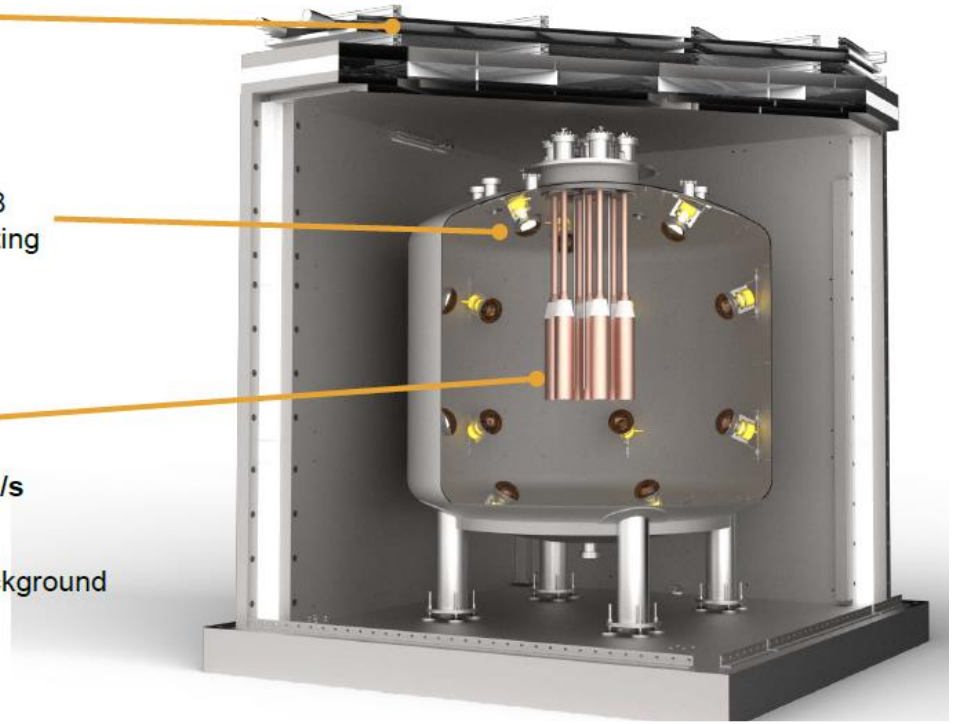


ToF Muon System
9.6 m^2 x 5 cm EJ200
R13089 PMT x 16 @ 3.2 GS/s

Veto System
12k litres Linear Alkyl Benzene + PPO & Bis-MSB
Stainless steel, non-thoriated welds, lumirror coating
Oil-proof base R5912 PMT x 18 @ 500 MS/s

DM Target Detector
NaI(Tl) Crystals
R11065 low radioactivity PMT x ~14 @ 500 MS/s

Key requirement to understand modulation in background contributions - requires particle ID. e.g. μ/γ/n.

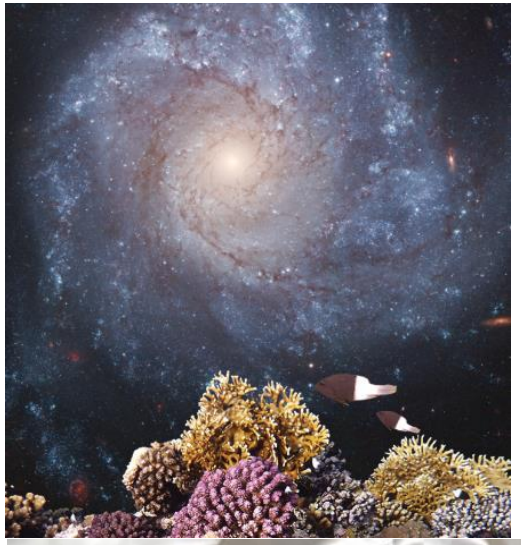


17,000 litres LAB scintillator base from Nanjing via JUNO/IHEP.

JUNO LS properties [6]
- Photon attenuation > 20 m
- $^{238}U/^{232}Th/^{40}K$ $<10^{-17}$ g/g

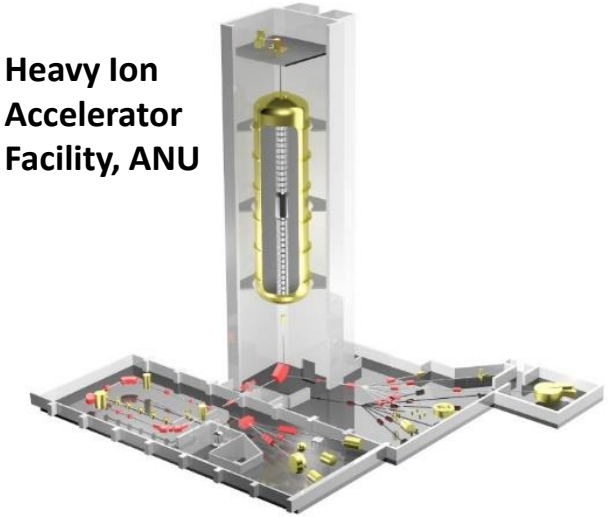
News from Australia

Look at deep sea Fe/Mn crusts for extraterrestrial ^{60}Fe and ^{244}Pu

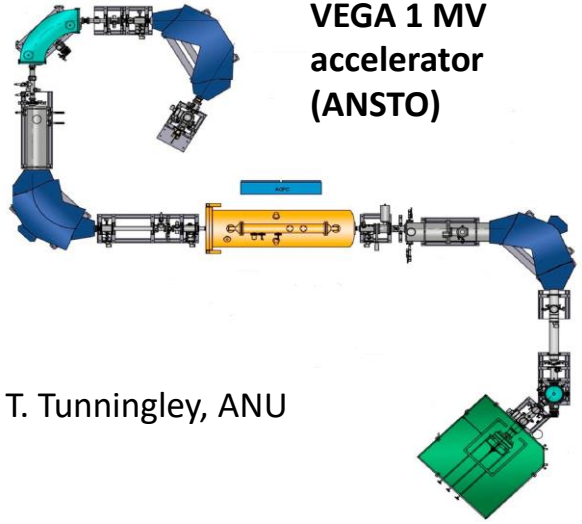


Lead composite image credit: Pinwheel-Shaped Galaxy by NASA, ESA, The Hubble Heritage Team, (STScI/AURA) and A. Riess (STScI) and Red Sea Coral Reef by Wusel700.

Heavy Ion Accelerator Facility, ANU

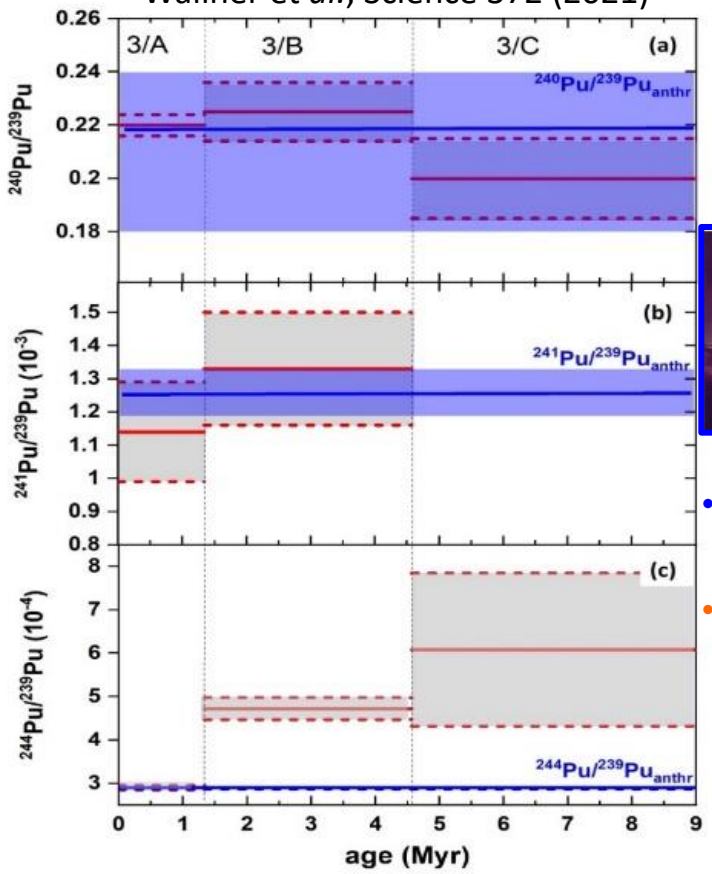


VEGA 1 MV accelerator (ANSTO)



T. Tunningley, ANU

Wallner et *al.*, Science 372 (2021)



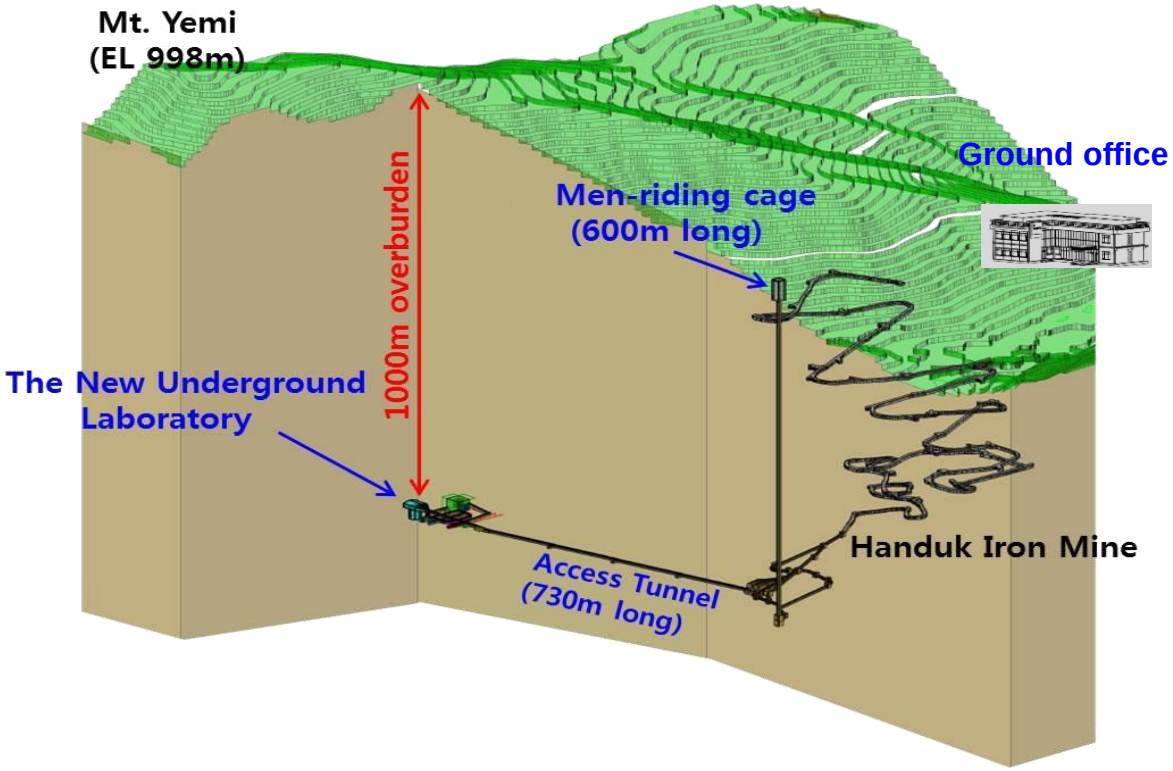
- **Blue: Pu ratio (man-made)**
- **Red: Pu ratio (measured by ANSTO)**

- Found ^{60}Fe & ^{244}Pu in the crust
- Both are coming from space (extraterrestrial)
- 2 or more supernovae events within ~10 Myr
- Exact origin of ^{244}Pu remains unclear.
- ^{60}Fe and ^{244}Pu deposited on Earth constrain the *r*-process yields of recent nearby supernovae

News from Korea

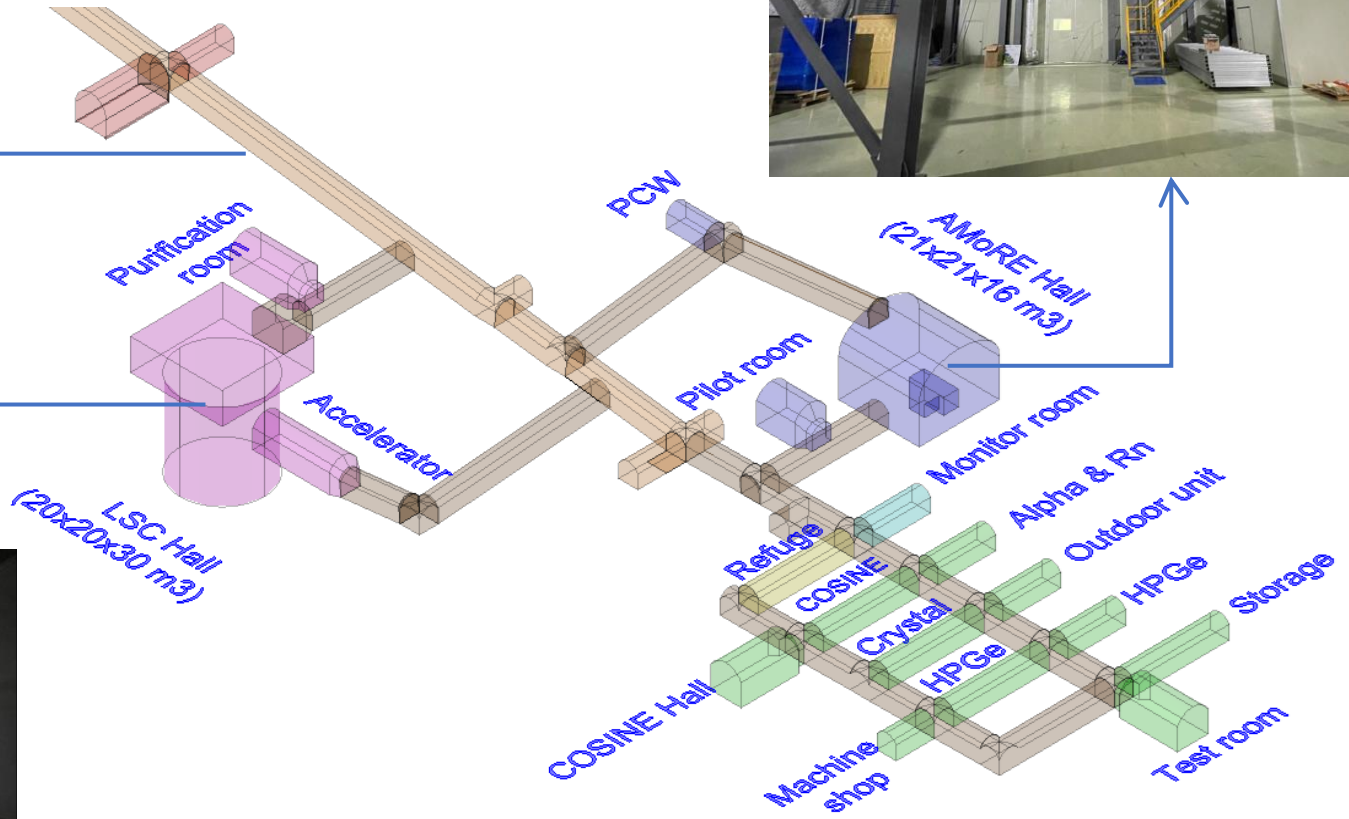
from Yeoungduk Kim

- Yemilab: a new underground Lab.
  - Y2L (700 m deep) constructed in 2003 to house KIMS dark matter search experiment
  - Yemilab (1000 m deep) constructed in 2022
    - Two access ways: ramp-way and men-riding cage



News from Korea

- Experimental area of Yemilab
  - Operated by Center for Underground Physics (CUP) of IBS
  - Lab. space > 3000 m^2, 2.5 MW electricity
  - Rn-free air supplying system, Class 100 clean room
  - Open to other researchers at IBS

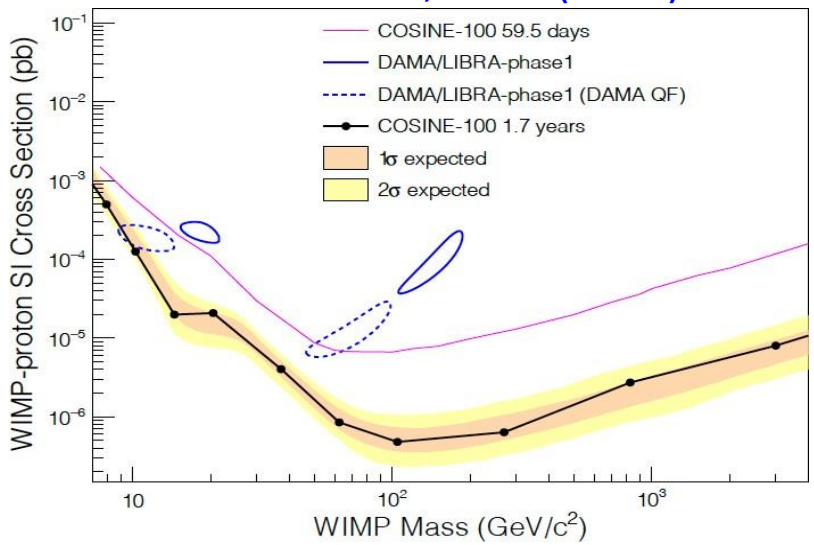


News from Korea

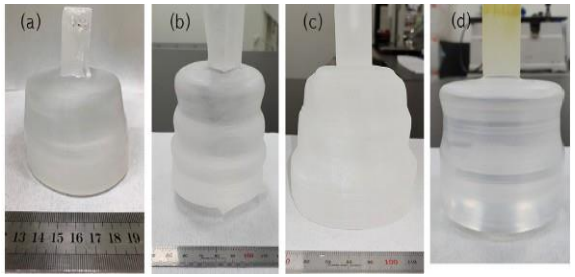
Dark matter search

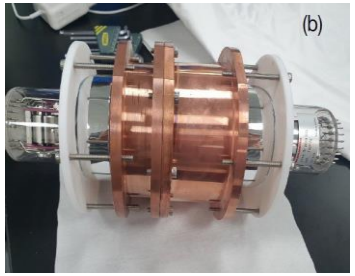
- COSINE-100 experiment @ Y2L
  - Collaboration : Yale, CUP, Sheffield, San Paulo
  - DAMA/LIBRA annual modulation of standard halo model is rejected.

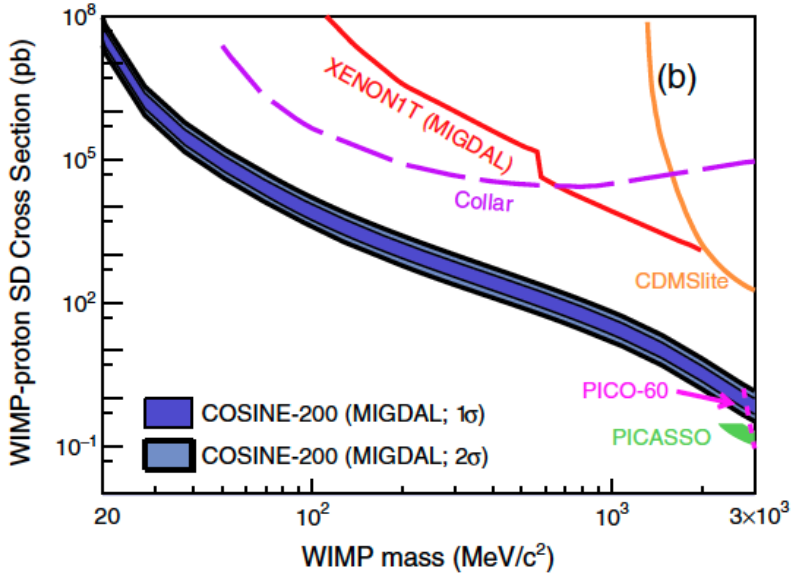
Sci. Adv. 7, 2699 (2021)



- COSINE-200 experiment @ Yemilab
  - Ultra-low background NaI crystals developed
  - Aims a world best limit for low-mass WIMP-proton spin-dependent interaction
  - Expect to begin in 2025



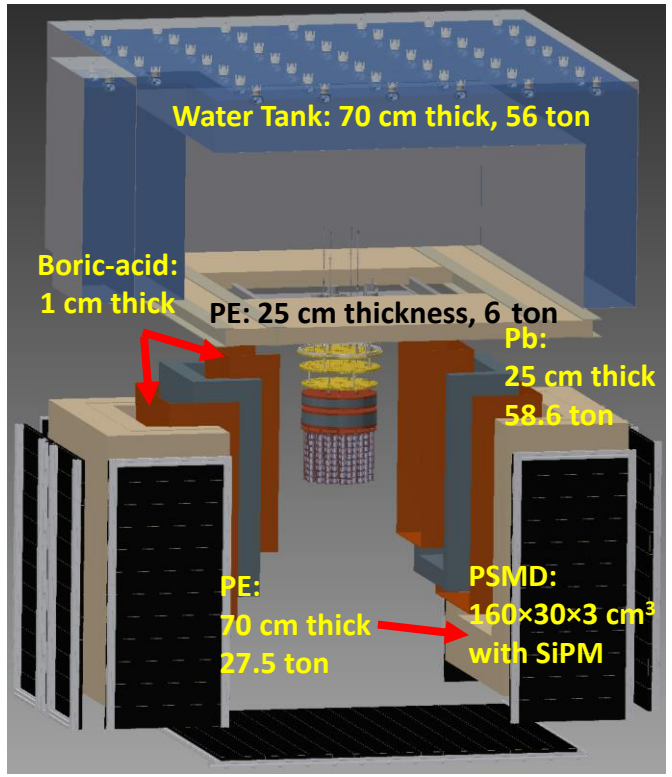




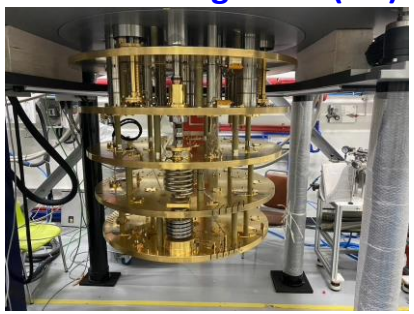
News from Korea

Neutrinoless double beta decay

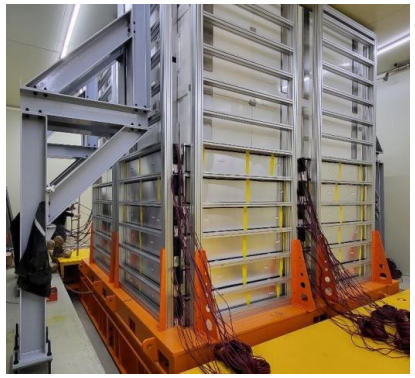
- AMORE-II experiment @ Yemilab
  - 100 kg of ^{100}Mo for 5 years to reach $T_{1/2}^{0\nu} > 4.5 \times 10^{26}$ years
  - $Li_2{}^{100}MoO_4$ crystals in 5 and 6 cm cylinder (~400 crystals)
  - Both phonons and photons measured by MMC+SQUID sensors
  - DR inside shielding of 25cm Pb + 70cm of PE and water
  - Muon veto detectors installed
  - 90-crystal run from 2023/full scale (100 kg of ^{100}Mo) run from early 2025

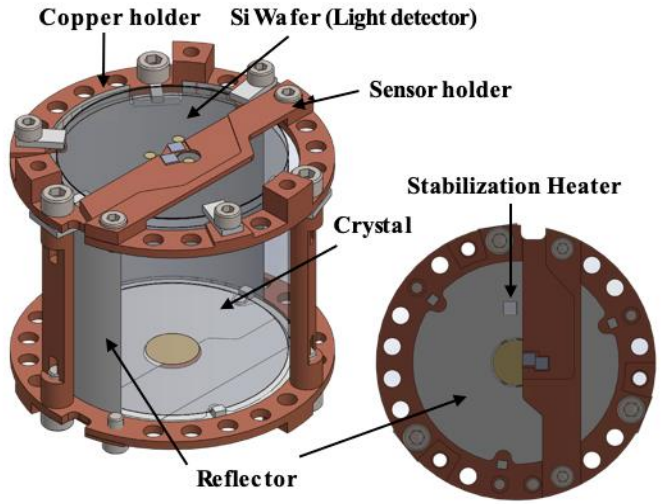


Dilution refrigerator (DR)

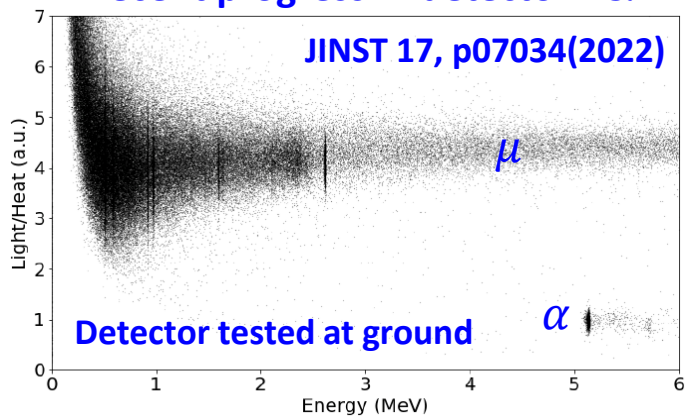


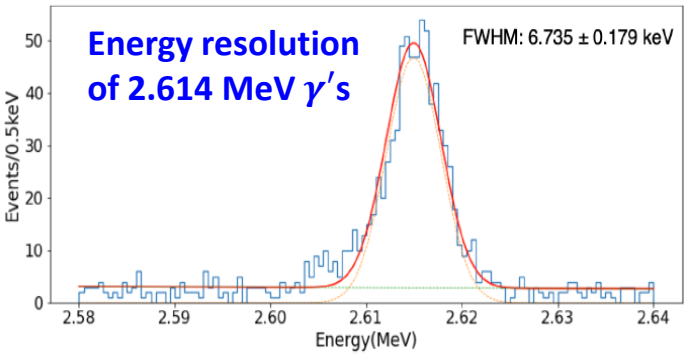
Installed muon detectors





Recent progress in detector R&D

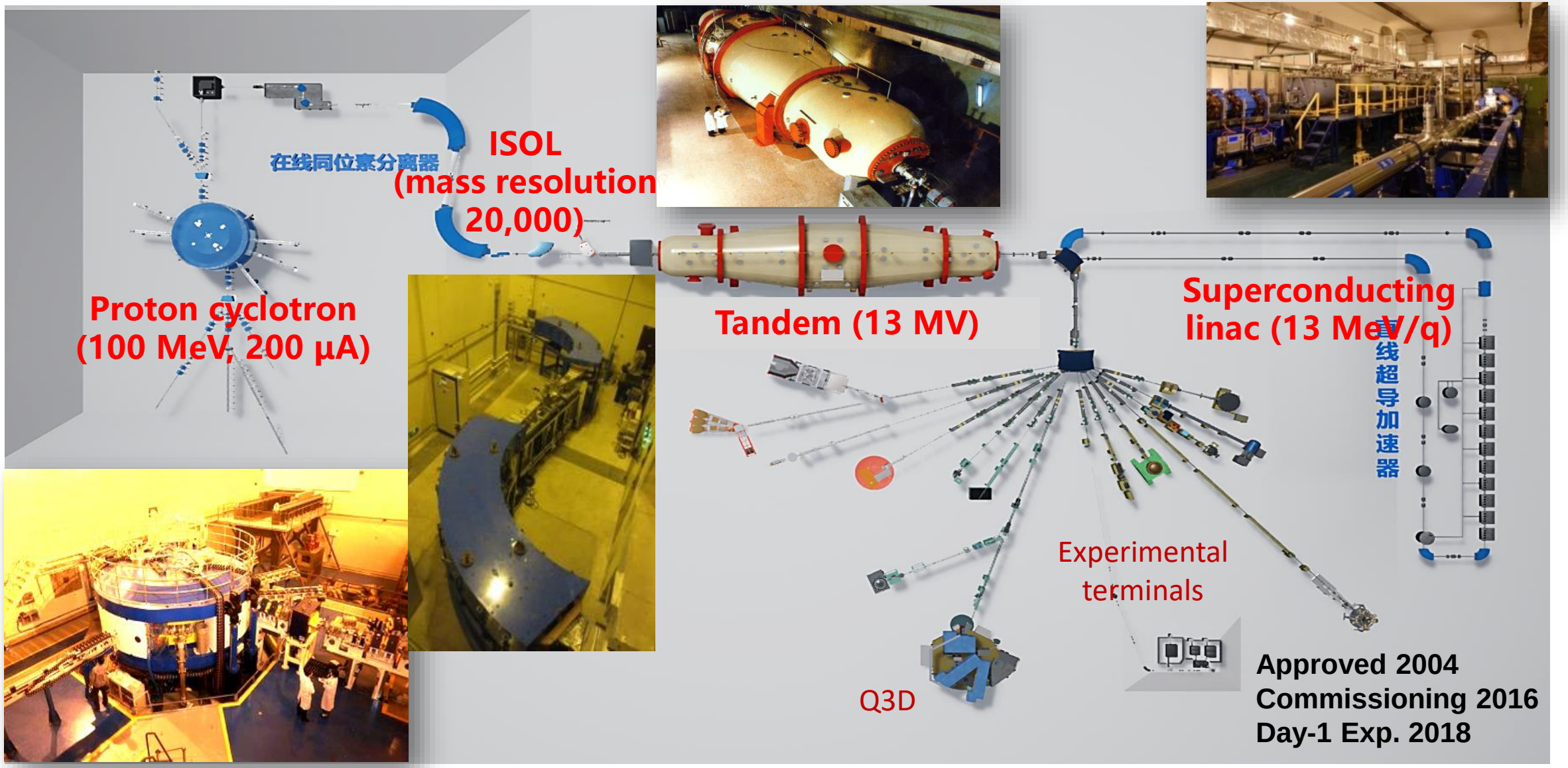




News from China

from Bing Guo

Beijing Radioactive Ion beam Facility (BRIF) @ CIAE



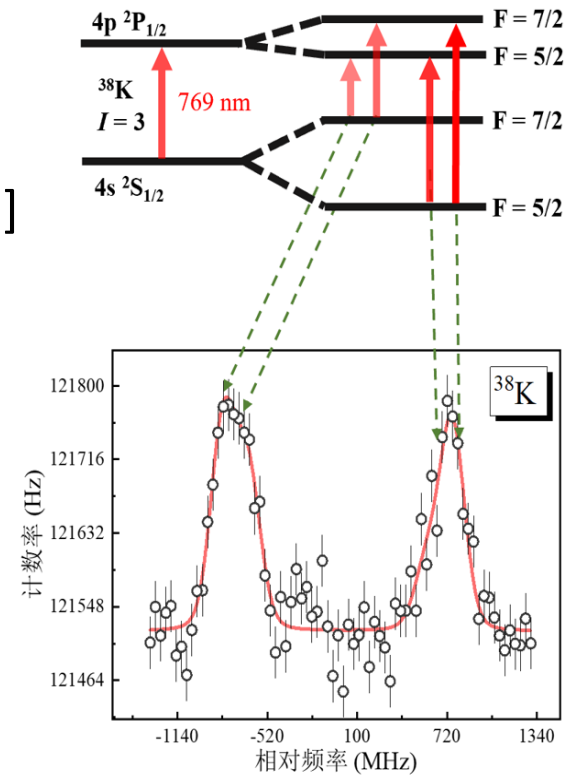
News from China

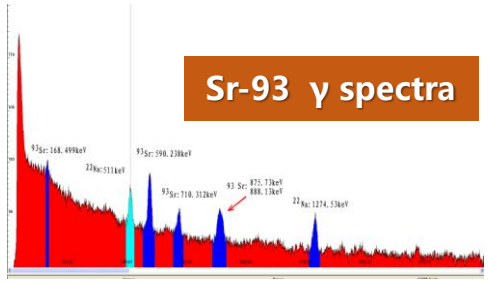
Beijing Radioactive Ion Beam (BRIF) @ CIAE

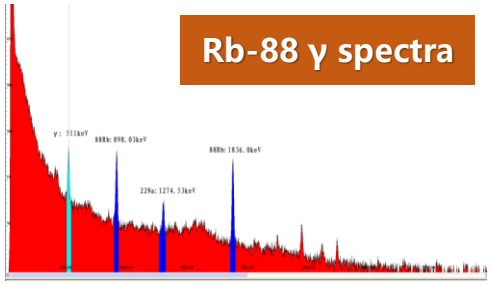
- Production of fission fragments (Rb, Sr, etc.) RIBs
- Number of RIB types: 24 → 55
- The shortest half-life of RIB with ISOL: 0.45 sec → 0.17 sec
- Beam intensity: $10^3 \sim 10^{10}$ pps

- First RIB Expt.: 3 $\beta - \gamma - \alpha$ exotic decays in ^{20}Na [PRC103, L011301 (2021)]
- First Expt. with the post-accelerated Na beams on ^{40}Ca target [NST32, 53 (2021)]
- First CLS Expt. [NIMA1032, 166622 (2022)]

HFS spectra of unstable ^{38}K by CLS



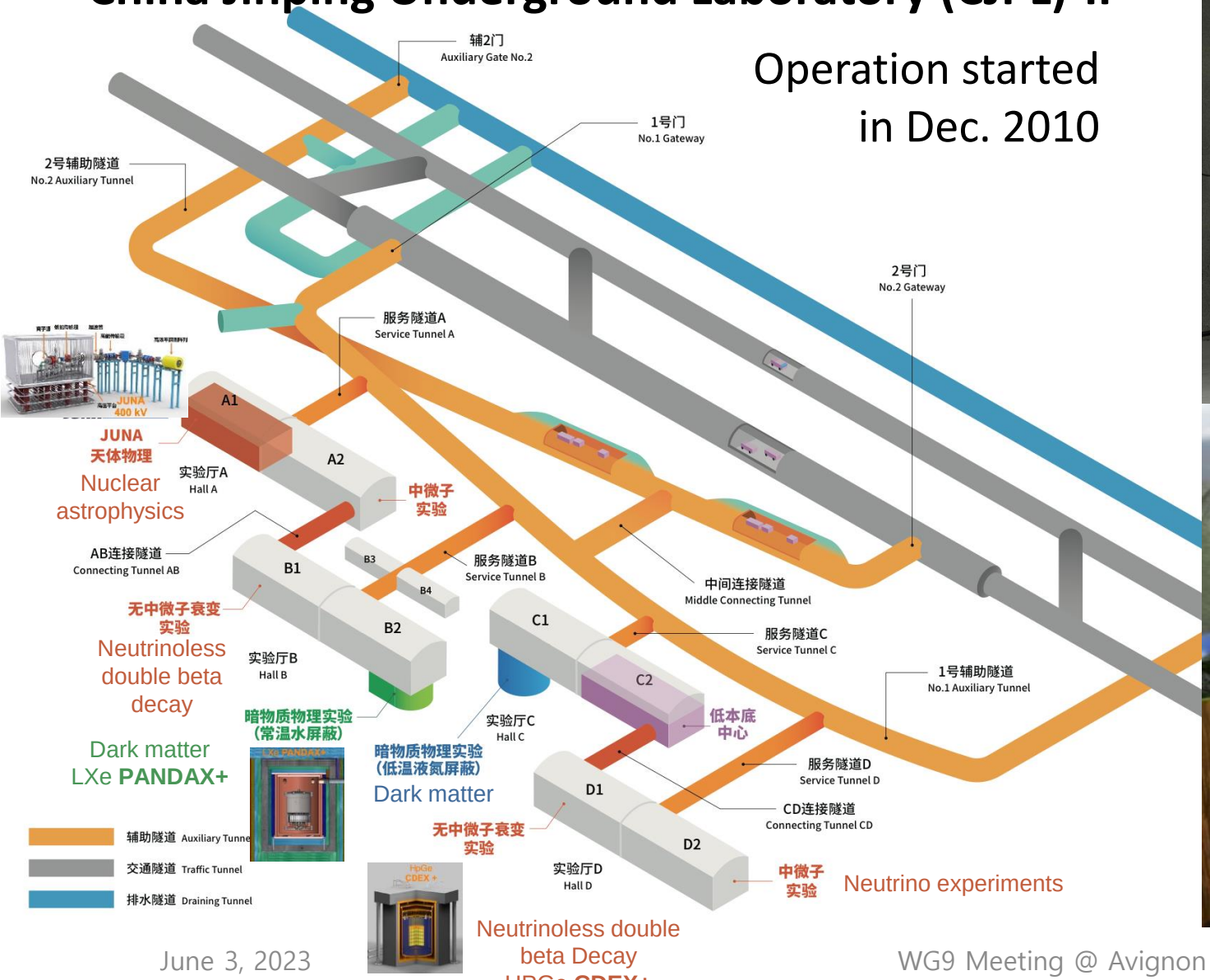


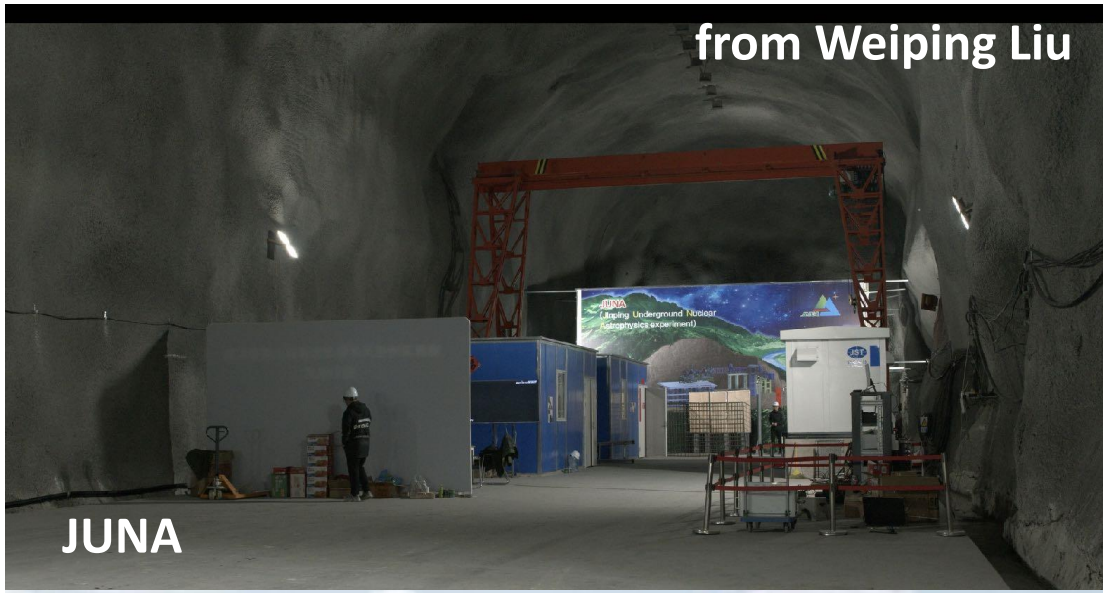


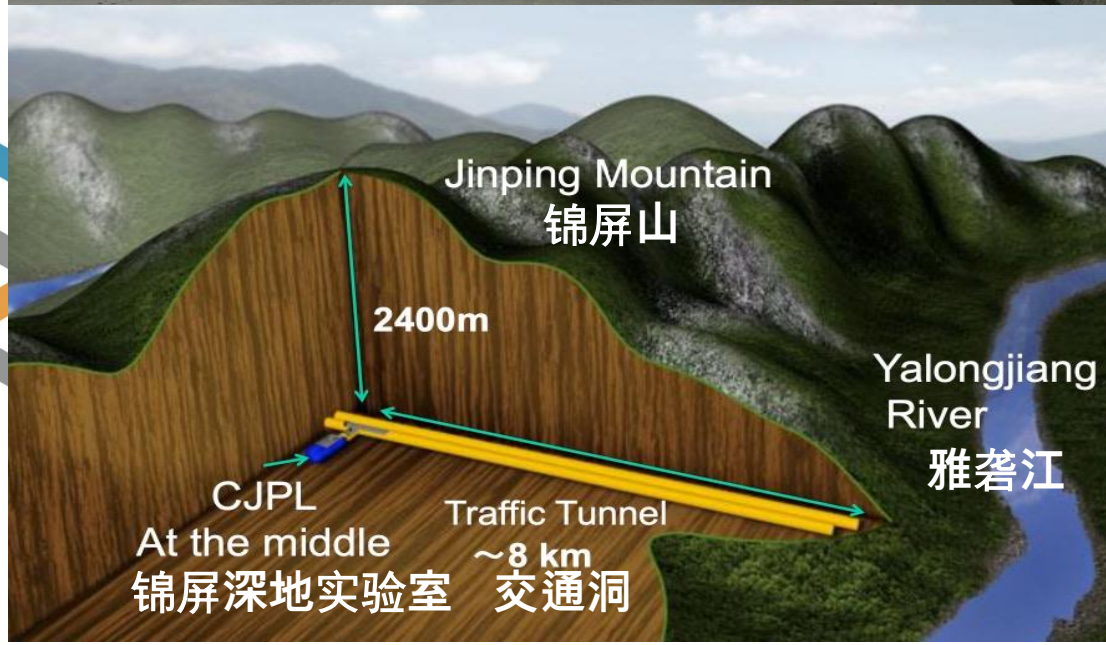
News from China

China Jinping Underground Laboratory (CJPL)-II

Operation started in Dec. 2010



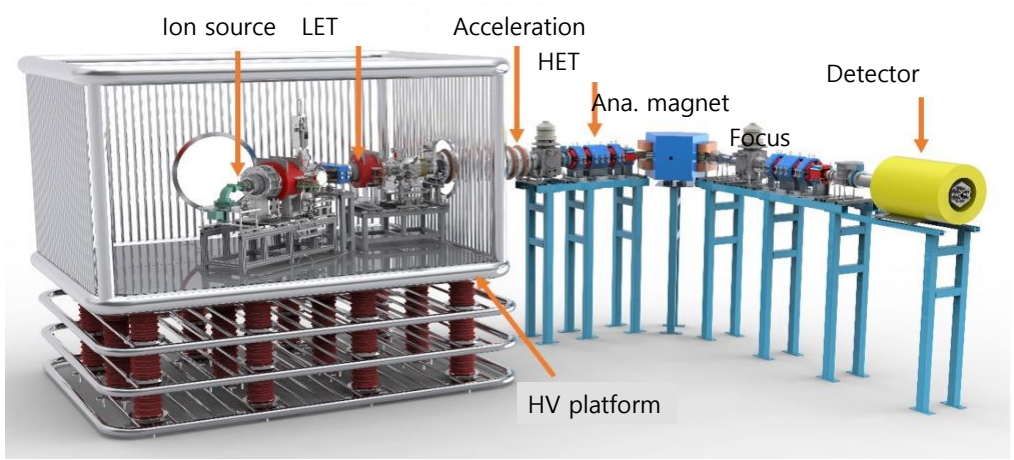




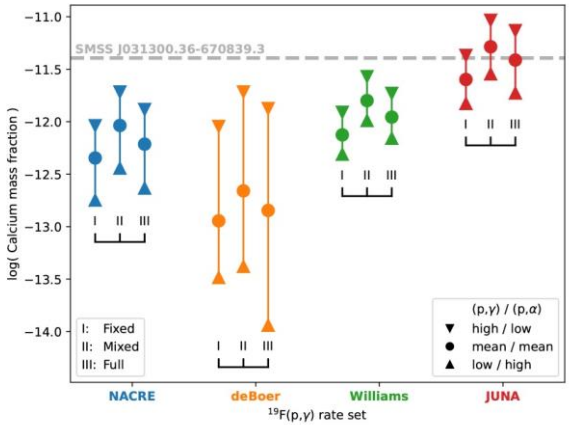
News from China

Highlights of JUNA for nuclear astrophysics

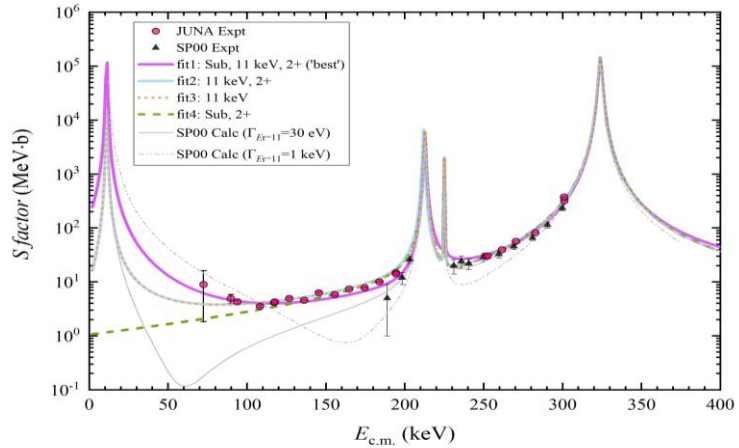
W.P. Liu, et al., Sci. China 59, 5785 (2016)



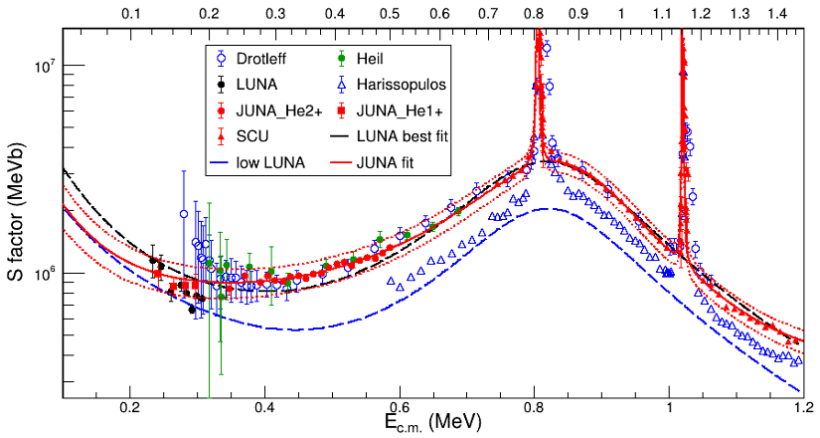
(News & Views) $^{19}F(p,\gamma)^{20}Ne$: L.Y. Zhang, J.J. He*, W.P. Liu*, et al., Nature 610, 656 (2022) Explain Ca in the oldest star!



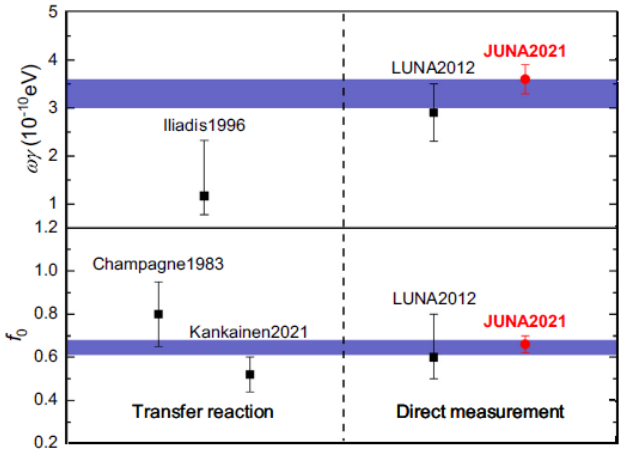
(Editor suggestions) $^{19}F(p,\alpha\gamma)^{16}O$: L.Y. Zhang, et al., PRL 127, 152702 (2021)



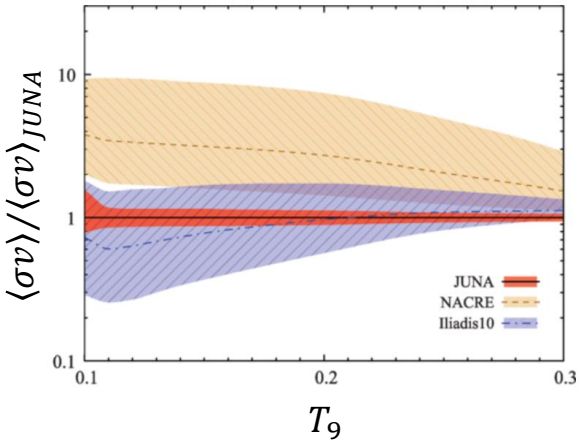
$^{13}C(\alpha,n)^{16}O$: B.S. Gao, et al., PRL 129(2022)132701



(Cover results) $^{25}Mg(p,\gamma)^{26}Al$: J. Su, et al., Sci. Bull. 67, 125 (2022)



$^{18}O(\alpha,\gamma)^{22}Ne$, L.H. Wang, W.P. Liu*, PRL 130, 092701 (2023)



News from China

from Wenlong Zhan

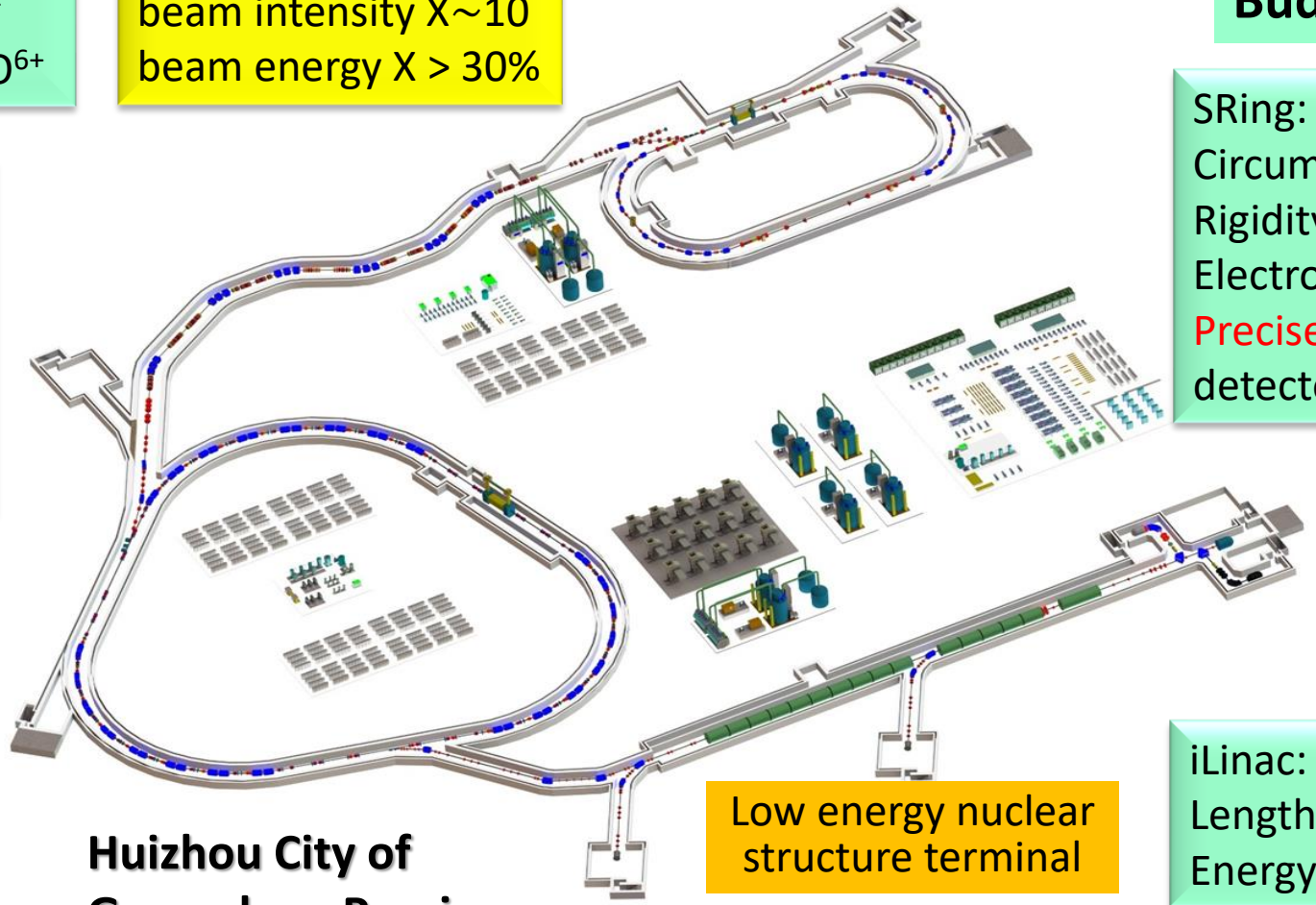
Heavy Ion Accelerator Facility (HIAF): 1st Phase

E_{B1}: 0.8 AGeV, 3×10^{10}ppp $^{238}U^{35+}$
1.75 AGeV, 7.5×10^{10}ppp $^{78}Kr^{19+}$
2.6~3.0 AGeV, 1.0×10^{11}ppp $^{16}O^{6+}$

After optimization,
beam intensity X~10
beam energy X > 30%

HIAF-I: 2018-2025
Budget: 1.6+1.2B CNY

External target station
High Energy Density Physics (HEDP)
Nuclear matter study - CEE
Hypernuclear physics
High energy irradiation



SRing: Spectrometer Ring
Circumference: 273 m
Rigidity: 15 → 20 Tm
Electron/Stochastic cooling
Precise measurement by two TOF detectors, four operation modes

SECRAL and FECR
28-45GHz,1.0emA (U^{35+})

BRing1: Booster Ring 1
Circumference: 600 m
Rigidity: 34 → 40 Tm
Large acceptance (200/100)
Two planes painting injection
Fast ramping rate (3-10 Hz)

Huizhou City of Guangdong Province

Low energy nuclear structure terminal

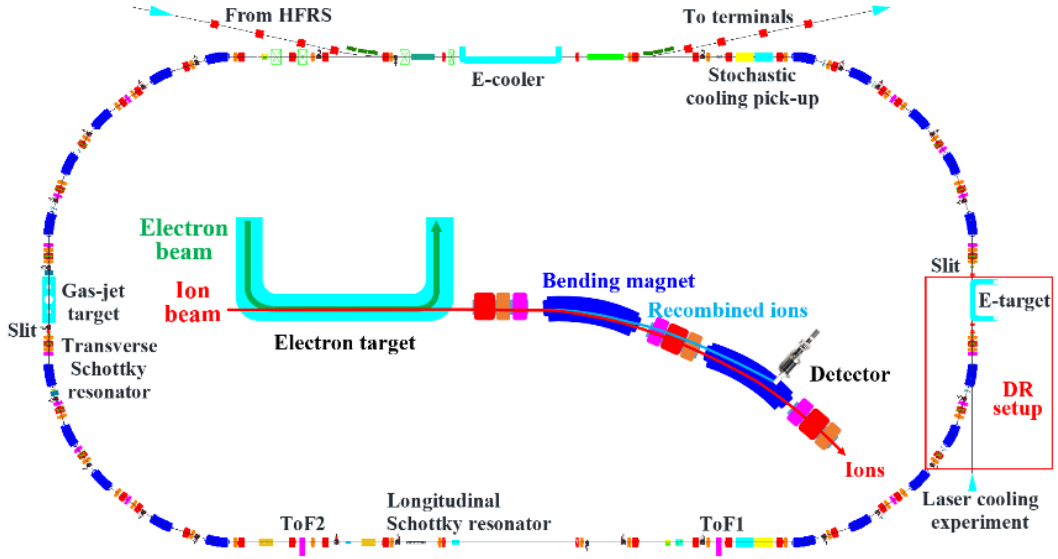
iLinac: Superconducting linac
Length: 100 m
Energy: 17~22 MeV/u ($U^{35+\sim46+}$)

News from China

Heavy Ion Accelerator Facility (HIAF)

- Beam physics study
  - Highest pulse beam
- ECR ion source
  - 45GHz 12T Nb_3Sn SECRIS under assembling
- Key technology development for HI synchrotron
  - 0.3 mm chamber for high vacuum
  - High-gradient magnetic alloy RF for fast injection, etc.
  - Active power source for high repetition rate
  - Results
    - Beam Intensity → X100
    - Repetition rate → ~10 Hz
    - Assembly time: years → months
    - Tuning: months → days
- HFRS for in-flight fragmentation of projectiles
- High Accuracy Spectrometer at SRing
- CEE R&D and fabrications

Laboratory	Facility	Desgin Inten.	Heavy Ion
BNL	AGS Booster		Au^{32+}
JINR	NICA Booster	4×10^{9}	Au^{32+}
GSI	SIS18	1.0×10^{11}	U^{28+}
FAIR	SIS100	4.0×10^{11}	U^{28+}
IMP	HIAF-SRing	$5/20\times10^{11}$	U/Bi $^{(35-45)+}$
IMP	HIAF-BRing-SRing	$1/5\times10^{12}$ $2/12\times10^{12}$	U/Bi $^{(35-45)+}$



News from China

News from Japan

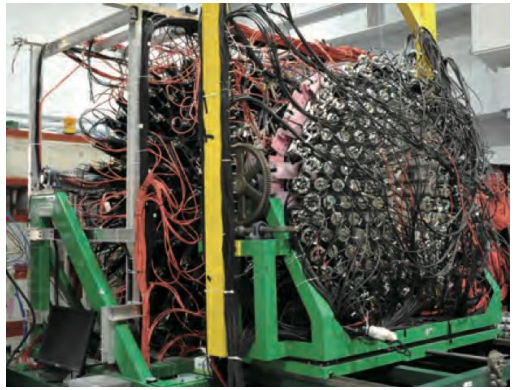
Research Center for Electron Photon Science (ELPH)

from Kazuhiro Tanaka

Neutral Kaon Spectrometer II

Strangeness nuclear physics
(Λ photoproduction near threshold)

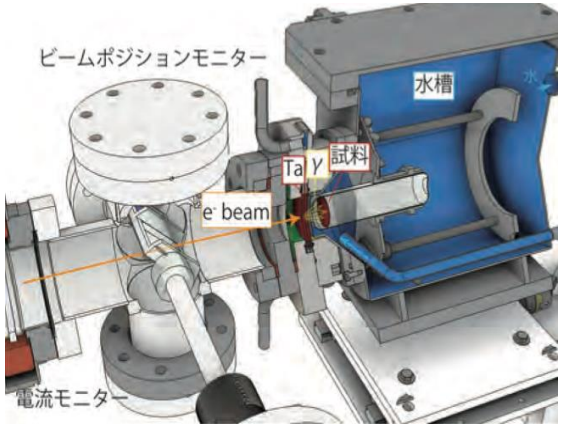
Multi-gamma ray detector system (FOREST)



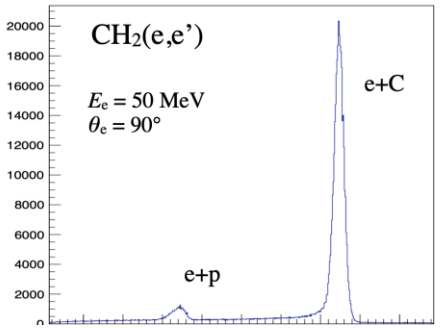
Hadron physics
(Search for dibaryon candidates)

High-intensity electron beam irradiation station

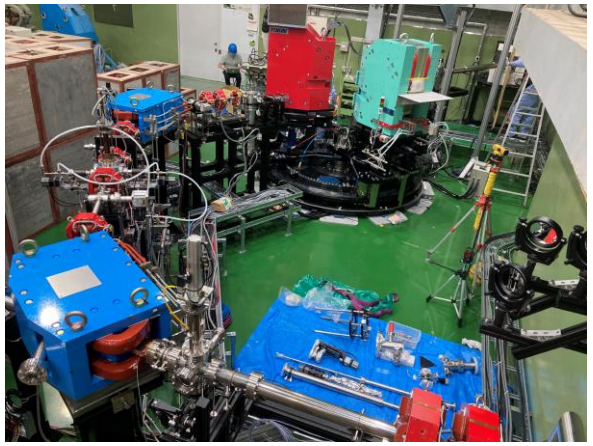
Wide variety of high-radiation RI production

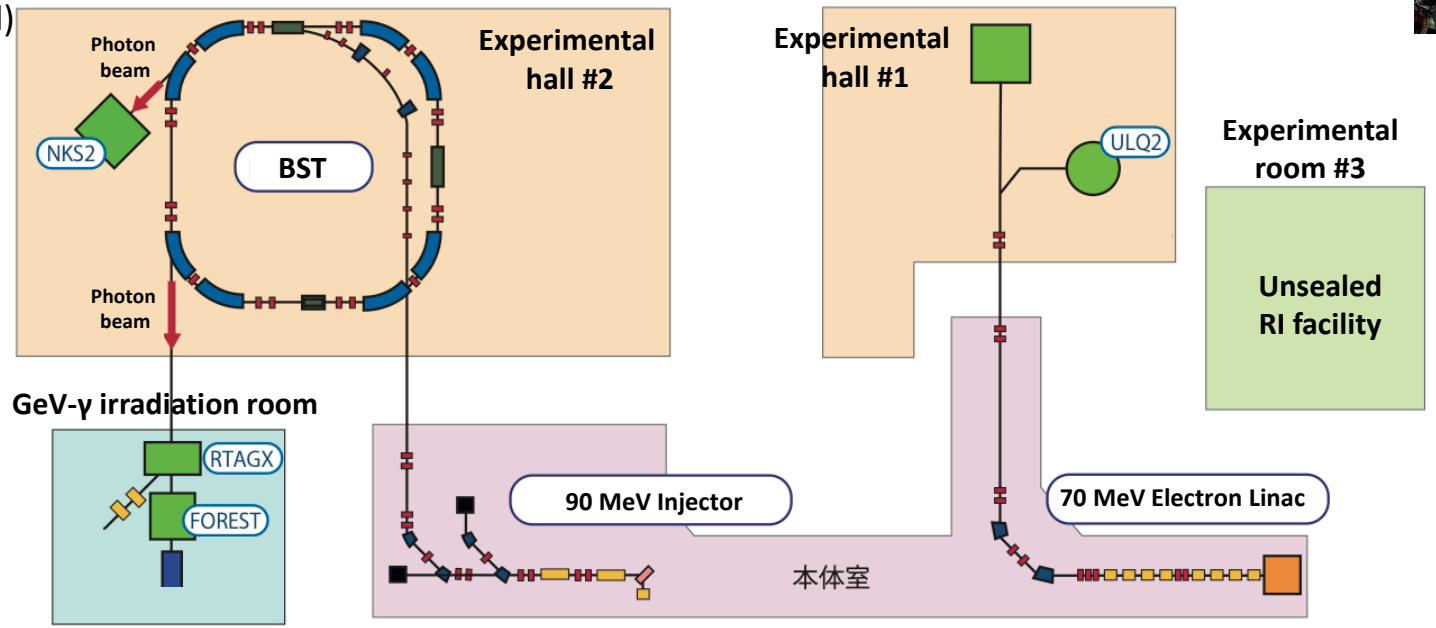


Toward precise measurement of proton charge radius



Spectrometer for Ultra-Low Q2 (ULQ2) electron scattering





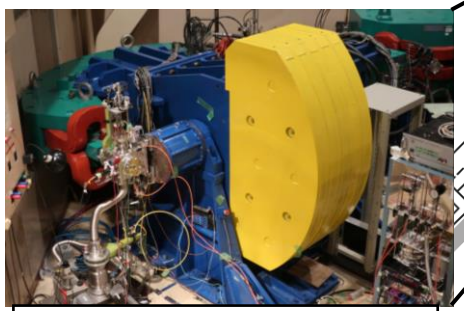
- On-going experiments
  - Proton charge radius (ULQ2)
  - Deuteron charge radius (ULQ2-d)
  - Neutron distribution radius in ^{208}Pb (LEEP)

News from Japan

Cyclotron and Radioisotope Center (CYRIC), Tohoku University

930 AVF cyclotron

- K number: 110 MeV
- Magnet
  - Weight: 200 t
  - Max Field: 19.6 kG
  - Max power: 230 kW
- RF
  - D-electrode: 2
  - Frequency: 11-22 MHz
  - Max voltage: 50 kV
  - Max power: 70 kW×2



Beam swinger system

Facility of the multipurpose use of cyclotrons

Irradiation system of quasi-monoenergetic neutrons

HM12 cyclotron

- Proton: 12 MeV, 60 μA
- Deuteron: 6 MeV, 30 μA
- Ion-source: PIG internal ion-source
- Beam port: 2

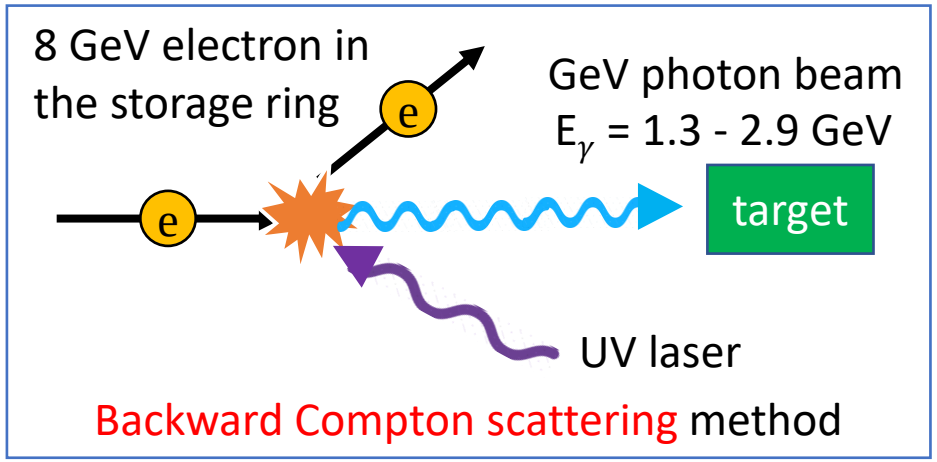
RI production system

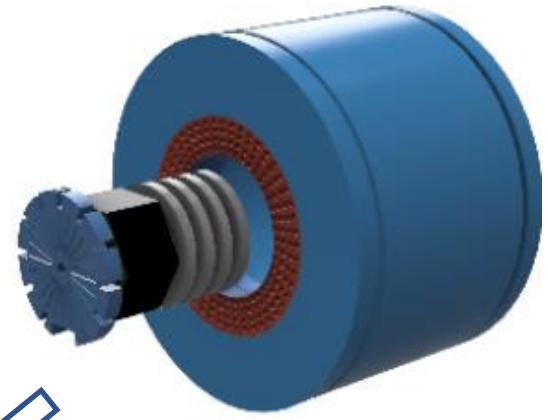
PET/CT

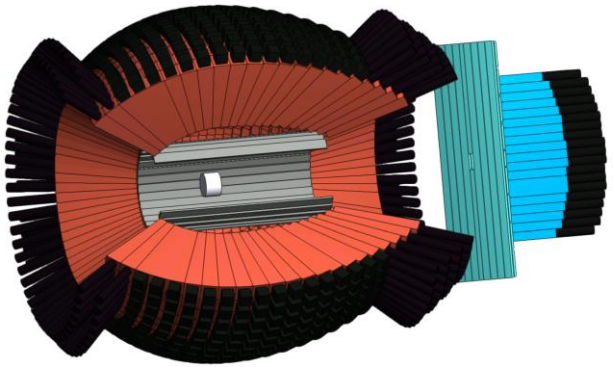
https://www.cyric.tohoku.ac.jp/en/

News from Japan

Laser-Electron-Photon facility (LEPS2) @ SPring-8 (2013-)

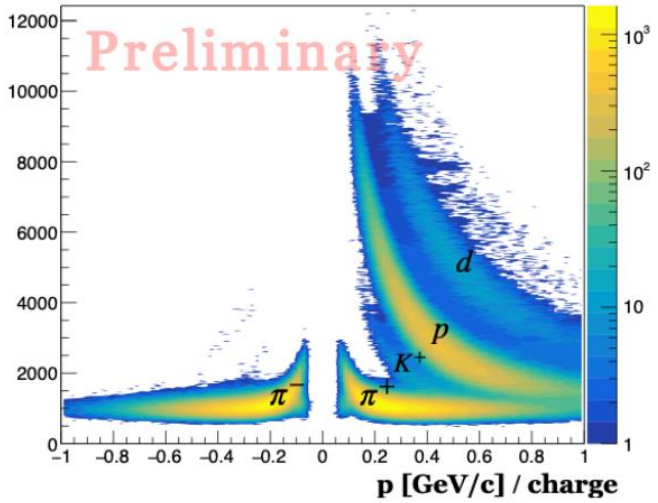






- **BGOegg experiment**
  - EM Calorimeter (1,320 BGO crystals)
  - Phase-2 upgrade with new forward calorimeter
  - Precise measurement of meson photo-production
  - Hadron properties inside nuclei
  - Data taking to study hadron properties inside nuclei with the Cu target will start in 2023 after the phase-2 upgrade.

- **Solenoid experiment**
  - Large spectrometer system for charged/neutral particles
  - Study of exotic hadrons: Pentaquark Θ^+, Mesonic nuclei $\Lambda(1405)$, etc.
  - Physics data taking started in Spring 2022.
  - Data analysis for various physics topics is in progress.



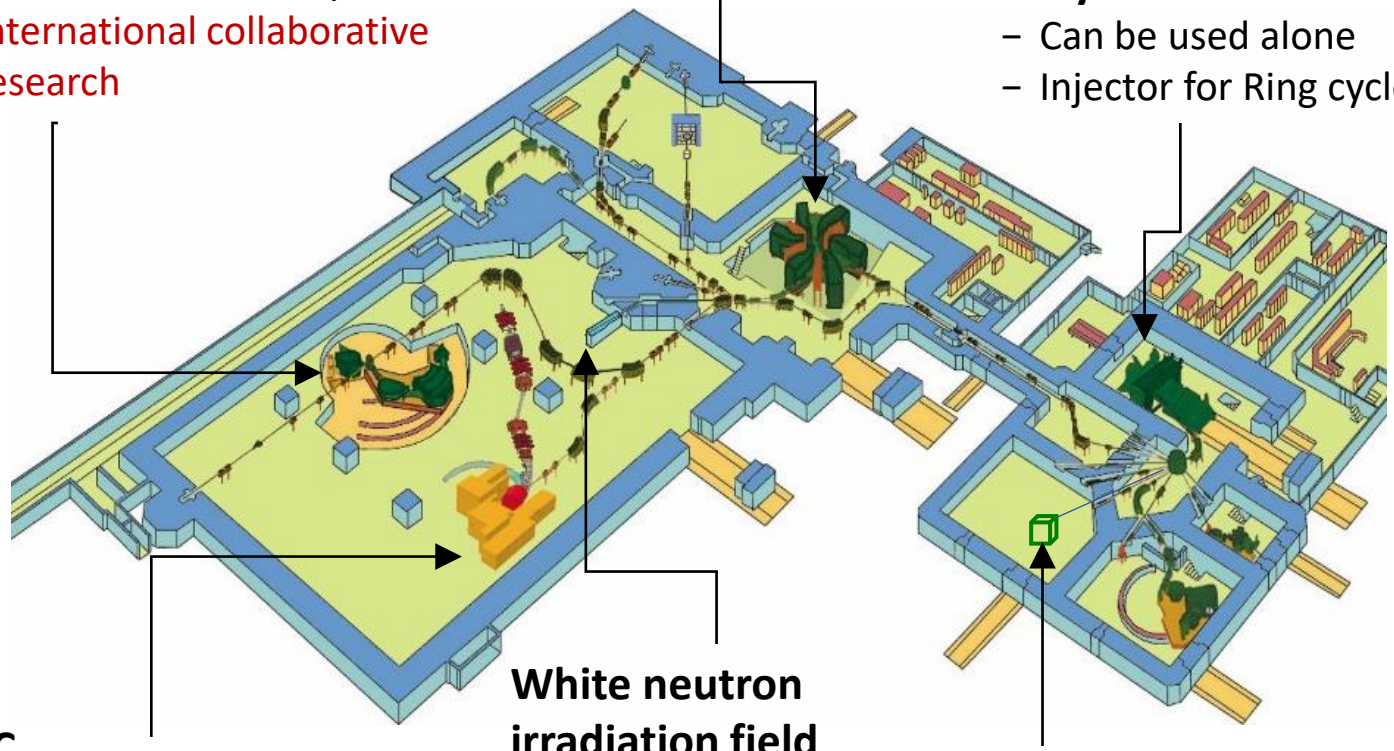
News from Japan

Research Center for Nuclear Physics (RCNP): Cyclotron facility

Grand Raiden
- Precision Nuclear Physics
- International collaborative research

Ring cyclotron

AVF cyclotron
- Can be used alone
- Injector for Ring cyclotron



MuSIC
- Continuous muon beam
- Interdisciplinary research

White neutron irradiation field
- Semiconductor software error evaluation

Short half-life radioisotope production
- Targeted alpha therapy

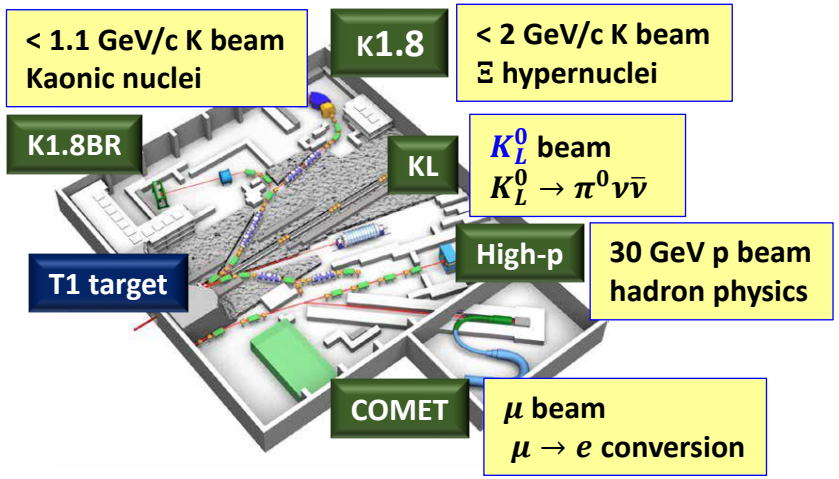
- Completion of the upgrade of AVF cyclotron
  - Beam delivery started in 2022
  - 10 times more beam intensity
- Independent use of AVF
  - Mass production of short-lived radio isotopes
  - ^{211}At to clinical trials of targeted alpha therapy
  - Promotion of a short-lived radio-isotope supply platform
- AVF + Ring cyclotron
  - Precision nuclear physics
  - Promotion of muon science
  - Semiconductor software error evaluation tests

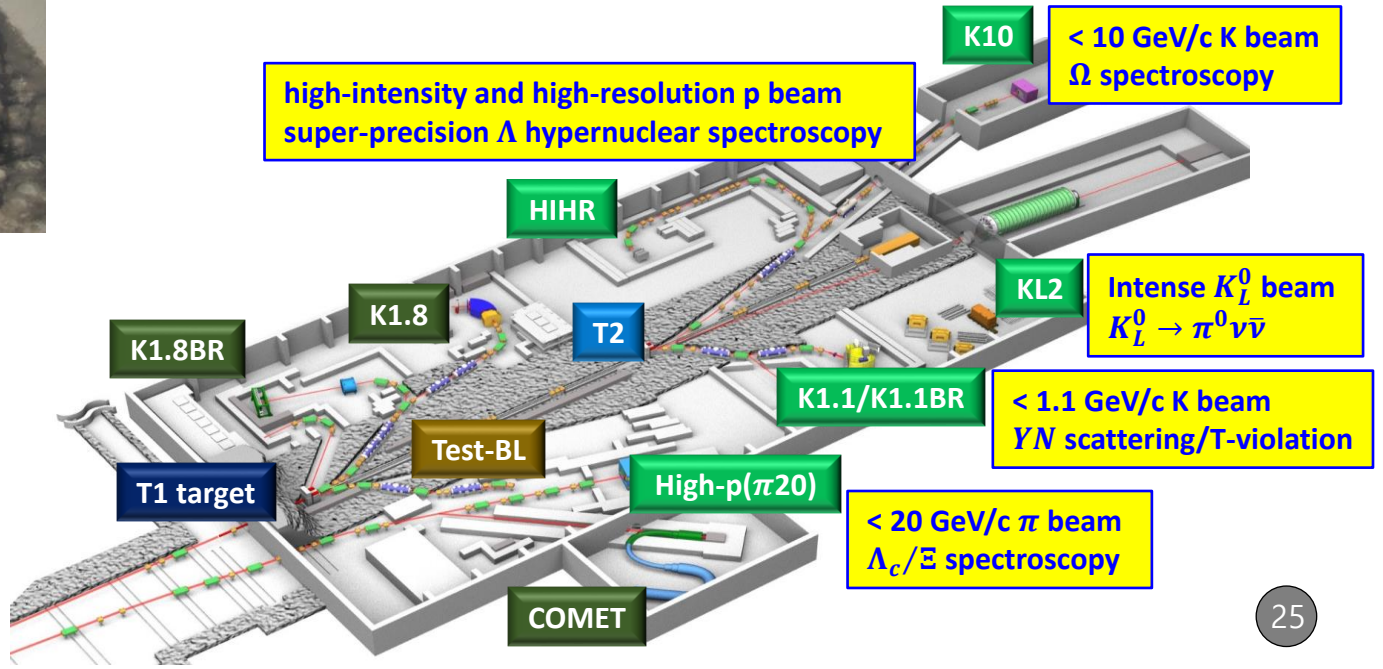
News from Japan

Japan Proton Accelerator Research Complex (J-PARC)

Present

Extended

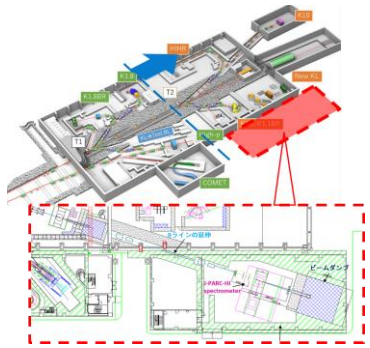




- **Hadron experimental facility extension**
  - Additional production target (T2)
  - Four more new beamlines (HIHR, K1.1/K1.1BR, KL2, K10)
  - Updated beamlines: High-p(π20), Test-BL

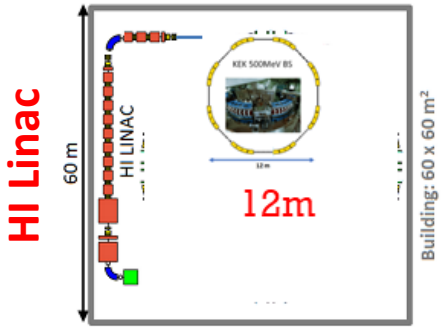
News from Japan

- Upgrade of J-PARC for heavy-ion beams
  - New heavy-ion injector (LINAC and BOOSTER)
  - New experimental area and spectrometers
- Staging plan
  - On-going
    - pA collisions using existing beam line and spectrometer (Main Physics topic: Vector meson measurements in e^+e^- decay modes)
    - Upgrades of the spectrometer for hadron measurements
    - Pilot data for heavy-ion physics
  - Phase I
    - New LINAC and **reuse of KEK-PS 500 MeV** booster
    - Upgrades of the existing spectrometer
    - Beam Intensity: 10^8 Hz for Au
  - Phase II
    - New booster and new spectrometer
    - Final configuration



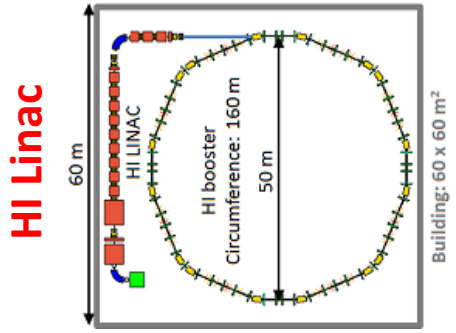
Phase I

Reused Booster Ring



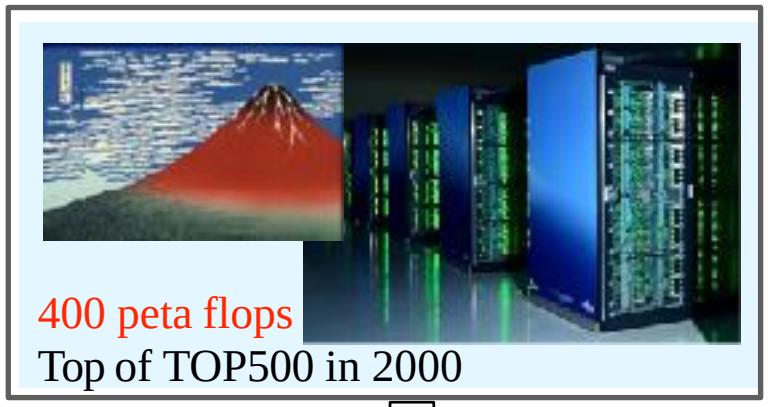
Phase II

HI Booster Ring



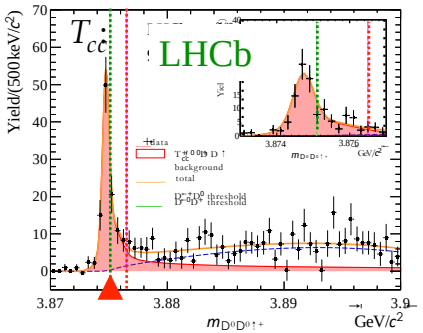
News from Japan

- Theory activities
  - First principle calculations by using Fugaku(富岳) supercomputer, and collaborations with experiments from RIKEN, RCNP, SPring-8, KEK, J-PARC, LHC…



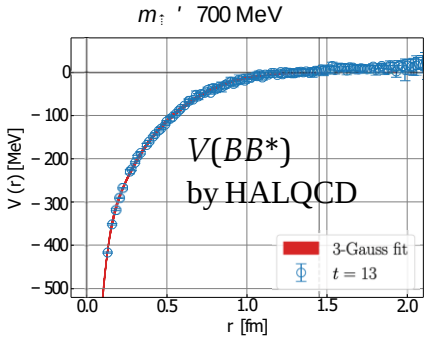
Lattice study for $P_Q P_Q^* \sim T_{QQ}$

Nature Commun. 13, 3351 (2022)



Very near the ***threshold***

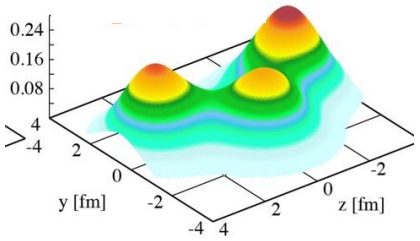
PoS LATTICE2022, 049 (2023)



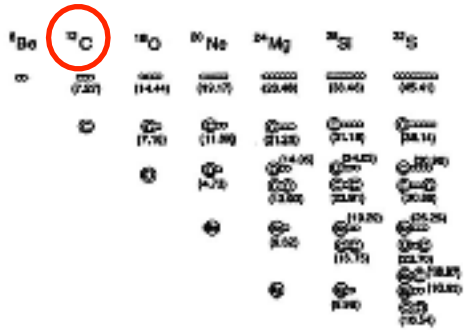
with chiral extrapolation
$E_B \sim 150\,\mathrm{MeV}$

State-of-the-art quantum many-body simulations

Hoyle state near ***threshold***



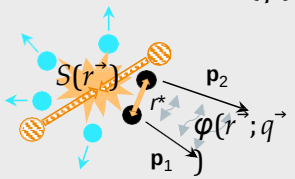
Nature Commun. 13, 2234 (2022)



K. Ikeda, Prog. Theor. Phys. 40, 277 (1968)

Femtoscopy for hadron interaction

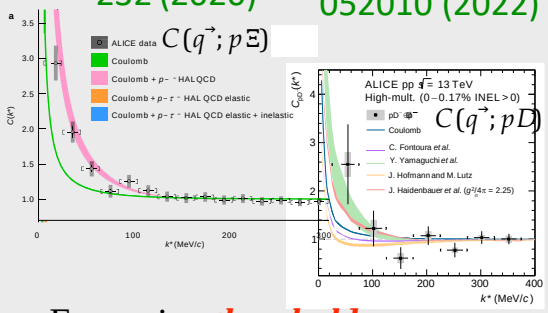
Correlation function $C(\vec{q})$



$$C(\boldsymbol{q}) = \frac{N_{12}(\boldsymbol{p}_1,\boldsymbol{p}_2)}{N_1(\boldsymbol{p}_1)N_2(\boldsymbol{p}_2)} = \int d\boldsymbol{r} S(\boldsymbol{r})|\varphi(\boldsymbol{r};\boldsymbol{q})|^2$$

Nature 588, 232 (2020)

PRD 106, 052010 (2022)



Extracting ***threshold*** parameters

News from Japan

- **Suwa Prize awarded to Prof. Kazuhiro Tanaka**
  - On March 1st, FAS (Foundation for High Energy Accelerator Science) awarded Prof. Kazuhiro Tanaka with the **Suwa Prize** (FAS Prize to award for Outstanding Research in High Energy Accelerator Science) for his achievements in the development of radiation-resistant magnets for high intensity accelerator facilities.

Summary

- The current report does not include, as they will be presented in the separate talks,
  - RAON at IBS in Korea (Prof. S.-W. Hong)
  - RIBF at RIKEN in Japan (Prof. H. Sakurai)

- Nuclear physics facilities in Asia having been constructed, commissioned, upgraded, or in the operation stage are
  - RIB accelerators: BRIF, JUNA, HIRFL, HIAF (China), RIBF, RCNP, CYRIC (Japan), RAON (Korea)
  - Hadron accelerators: HIAF (China), J-PARC, RCNP (Japan)
  - Photon & electron accelerators: ELPH, Spring-8 (Japan)
  - Underground facilities: SUPL (Australia), CJPL-II (China), Yemi Lab. (Korea)

- ***The Asia-Pacific region is very active in the nuclear-physics research with a lot of enthusiasm!***