News from ANPhA

Kazuhiro Tanaka (KEK), Chair of ANPhA (Asian Nuclear Physics Association) and the chair of DNP, AAPPS.
• **Asian Nuclear Physics Association**
  – Launched in **2009**
  – Central organization representing Nuclear Physics in Asia Pacific.

• **Eight membership countries and regions**
  – 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

• **ANPhA plays the role of Division of Nuclear Physics of AAPPS.**
  – ANPhA Chair should be the chair of DNP-AAPPS.
• Practically, **ANPhA** is an organization to discuss and pursuit issues in Asian nuclear physics community at present.

• The most recent (12th) **ANPhA Board meeting** was held in Halong City, Vietnam in Sept. 24, 2017 with ISPUN17 Symposium. Next BM will be held in Beijing in the fall in 2018.

• **Next AAPPS Council meeting** will be held in Kuala Lumpur, Malaysia on December 3rd, 2017 in conjunction with **International Meeting for Frontier of Physics (IMFP2017)** which will be held in December 3-7 at KL.

• **ANPhA** is organizing **ANPhA Awards for young Scientists** for ANPhA supported meetings.

• Preparation of **ANPhA White Paper** is under progress.
ANPhA Board meetings:
Mostly once a year with either symp. or conf.

12th ANPhA Board meeting in Halong Bay, Vietnam in Sept. 24, 2017 held with ISPUN17 Symposium
From ANPhA 2017 BM

• Special report on NuPECC LRP (30 min.)
  – Angela BRACCO (30)

• The terms of the chair and vice chair were extended to 3 years (2 years at present).
  – The term starts on January 1\textsuperscript{st}.
  – The term of the present chair was extended to December 31\textsuperscript{st} in 2019 (1 year extension).
  – The chair elect will be elected in the next BM, which will be held in the Autumn in 2018. He/She will be a vice chair until the end of 2019.
• Formal approval of the change of the board members
  – India:
    • Alok Chakrabarti → Amitava Roy (Director of VECC, Kolkata)
    • Vivek Datar → Alok Saxena (Head, Nuclear Physics Div., BARC, Mumbai)
  – Vietnam:
    • Dao Tien Khoa → Phan Viet Cuong, (Director of the nuclear physics center of IOP, Hanoi)
• Increase of the number of board members from India (2→3)
  – Dr. Dinakar Kanjilal (Director of IUAC)
• Status of White Paper (Tanaka)

• Discussion on Future direction of ANPhA (and AAPPS-DNP)
  – Possible steps toward LRP (?) based on the Special meeting on "Ten years of ANPhA" at KL (APPC) or at Pohang (APCTP) in 2019?

• Next meeting
  – Autumn 2018 in Beijing
ANPhA/DNP-AAPPS: Current EXCO Officers

• Chair
  Kazuhiro Tanaka
  (KEK)

• Vice Chair
  Weiping Liu
  (CIAE, China)
  Tohru Motobayashi
  (RIKEN, Japan)
  Anthony Thomas
  (Univ. of Adelaide, Australia)

• Secretary
  Hirokazu Tamura
  (Tohoku Univ)
ANPhA/DNP-AAPPS: Executive Committee (EXCO)

- Australia
  Anthony Thomas (Univ. of Adelaide)

- China
  Furong Xu (Peking Univ.)
  Guoqing Xiao (IMP)
  Weiping Liu (CIAE)
  Yugang Ma (SINAP)

- India
  Alok Saxena (BARC)
  Dinakar Kanjilal (IUAC)*
  Amitava Roy (VECC)

- Japan
  Kazuhiro Tanaka (KEK)
  Atsushi Hosaka (RCNP, Osaka Univ.)
  Tohru Motobayashi (RIKEN)
  Hirokazu Tamura (Tohoku Univ.)

- Korea
  Myeong-Ki Cheoun (Soongsil Univ.)
  Byungsik Hong (Korea Univ.)
  Kevin Insik Hahn (Ewha Womans Univ.)

- Mongolia
  TBA

- Taiwan
  Henry Tsz-king Wong (Academia Sinica)

- Vietnam
  Phan Viet Cuong (Director of the nuclear physics center of IOP, Hanoi)

As of September 24, 2017
* To be confirmed
The first ANPhA awards for young Scientists, at CNSSS, Aug. 29, 2017

Yasuhiro UENO (Tokyo), "Precision Test of Bound-State QED via the Spectroscopy of Muonium Hyperfine Structure"
The second ANPhA awards for young Scientists, at ISPUN17, Sept. 15-30, 2017

• Jack Bishop (University of Birmingham):
  – Experimental investigation of alpha-gas signatures.

• Martha Liliana Cortés (RIKEN):
  – Shell evolution for N=40 isotones towards $^{60}$Ca: First spectroscopy of $^{62}$T.

• Shun Furusawa (RIKEN):
  – Equations of state including full nuclear ensemble and weak interaction rates in core-collapse supernovae.
ANPhA White Paper

• Now 29 Accelerator Facilities for Nuclear Physics in Asia Pacific are listed
• Data will be updated by the end of 2017.
• Critical analysis of the present data will be made for future facility planning and for possible future international collaboration.
• Data will be open on Web after the updates. However you can see the present data at KEK Indico system; https://kds.kek.jp/indico/category/1706/

⇒ Notes for Google Chrome Users,
⇒ Please find the username and password at the “click for the password” on the page which you can find after closing the popup window to login.
<table>
<thead>
<tr>
<th>Town</th>
<th>Institute</th>
<th>Facility</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canberra, Australia</td>
<td>Australian National University (ANU), Heavy Ion Accelerator Facility</td>
<td>BTANL</td>
<td>15MV Tandem accelerator + superconducting Linear Accelerator</td>
</tr>
<tr>
<td>Beijing, China</td>
<td>Beijing Tandem Accelerator Nuclear Physics National Laboratory</td>
<td>BTANL</td>
<td>15 MV tandem accelerator, 100 MeV 20 μA proton cyclotron, ISOL</td>
</tr>
<tr>
<td>Shanghai, China</td>
<td>Shanghai Laser Electron Gamma Source</td>
<td>SLEGS</td>
<td>0.4-20 MeV BCS γ-ray source based on Synchrotron Radiation Facility</td>
</tr>
<tr>
<td>Jinping, China</td>
<td>China Jinping underground Laboratory (CJPL), JINPING UNDERGROUND NUCLEAR</td>
<td>CJPL / JUNA</td>
<td>400 kV accelerator (Ion species of Stable nuclei: H to He), Max. Energy: 400 kV*q, Beam Intensity: up to 2.5 emA</td>
</tr>
<tr>
<td>Lanzhou, China</td>
<td>Heavy Ion Research Facility in Lanzhou</td>
<td>HIRFL</td>
<td>SSC cyclotron: K=450 and full ion acceleration CSRm booster synchrotron 12.2 Tm</td>
</tr>
<tr>
<td>Huizhou, China</td>
<td>Heavy Ion Accelerator Facility, Institute of modern Physics</td>
<td>HIAF</td>
<td>Heavy-Ion Linac, Booster-ring ~1GeV/u and Ring spectrometer (Phase 1). Compressor ring ~5GeV/u and Energy Recovery Linac.</td>
</tr>
<tr>
<td>Huizhou, China</td>
<td>China Initiative ADS</td>
<td>CIADS</td>
<td>The 250 MeV and 10mA (maximum beam current) CW mode superconducting proton LINAC</td>
</tr>
<tr>
<td>Mumbai, India</td>
<td>Bhabha Atomic Research Centre - Tata Institute of Fundamental Research</td>
<td>BARC-TIFR</td>
<td>14MV heavy ion tandem + superconducting linac (PLF: Pelletron LINAC Facility)</td>
</tr>
<tr>
<td>New Delhi, India</td>
<td>Inter-University Accelerator Centre</td>
<td>IUAC</td>
<td>15MV heavy ion tandem + superconducting linac</td>
</tr>
<tr>
<td>Kolkata, India</td>
<td>Variable Energy Cyclotron Centre</td>
<td>VECC</td>
<td>VECC K130 cyclotron (p,o), K500 Superconducting Cyclotron</td>
</tr>
<tr>
<td>Chiba, Japan</td>
<td>Heavy Ion Medical Accelerator, National Institute of Radiological Sciences</td>
<td>HIMAC</td>
<td>High energy heavy ion beams, up to 800 MeV/u, supplied by linear accelerators and two synchrotron rings.</td>
</tr>
<tr>
<td>Tokai, Ibaraki, Japan</td>
<td>J-PARC (Nuclear and Particle Physics Facility)</td>
<td>J-PARC</td>
<td>High Intensity Accelerators, 400MeV LINAC, 3GeV RCS, 50GeV MR</td>
</tr>
<tr>
<td>Osaka, Japan</td>
<td>Research Center for Nuclear Physics, Osaka University</td>
<td>RCNP/LEPS</td>
<td>Cyclotron complex (K140 AVF + K400 Ring) Laser-electron back-scattered photon facility at SPring-8 site, 2.4 and 2.9 GeV.</td>
</tr>
<tr>
<td>SPring-8 site, Hyogo, Japan</td>
<td>Laboratory of Advanced Science and Technology for Industry</td>
<td>NewSUBARU</td>
<td>Laser Compton Scattering Gamma-ray Beam Source (1 - 76 MeV)</td>
</tr>
<tr>
<td>Wako, Saitama, Japan</td>
<td>RIKEN Nishina Center for Accelerator-Based Science, RI Beam Factory</td>
<td>RIBF</td>
<td>Heavy Ion Linac and several big Ring Cyclotrons (Max K=2500MeV), Big Rips Projectile Isotope Separator</td>
</tr>
<tr>
<td>Town</td>
<td>Institute</td>
<td>Facility</td>
<td>Characteristics</td>
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<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fukuoka, Japan</td>
<td>Kyushu University, Center for Accelerator and Beam Applied Science</td>
<td>FFAG synchrotron and tandem accelerator</td>
<td></td>
</tr>
<tr>
<td>Tokai, Ibaraki, Japan</td>
<td>Japan Atomic Energy Agency (JAEA), Tandem Accelerator Facility</td>
<td>20MV tandem accelerator and superconducting linac booster.</td>
<td></td>
</tr>
<tr>
<td>Tsukuba, Ibaraki, Japan</td>
<td>University of Tsukuba, Tandem Accelerator Complex</td>
<td>UTTAC</td>
<td>6 MV tandem accelerator / 1 MV Tandetron accelerator</td>
</tr>
<tr>
<td>Sendai, Japan</td>
<td>Tohoku University, Cyclotron and Radioisotope Center</td>
<td>CYRIC</td>
<td>K110 and K12 cycrotrons</td>
</tr>
<tr>
<td>Sendai, Japan</td>
<td>Research Center for Electron-Photon Science, Tohoku University</td>
<td>ELPH</td>
<td>60 MeV High Intensity ELECTRON Linac, 1.3 GeV Booster Electron Synchrotron for GeV tagged photon beams</td>
</tr>
<tr>
<td>Gyeongsangbuk-do, Korea</td>
<td>Korea Multi-purpose Accelerator Complex</td>
<td>KOMAC</td>
<td>100 MeV and 20 MeV Proton linac</td>
</tr>
<tr>
<td>Seoul, Korea</td>
<td>Korea Institute of Science and Technology (KIST), The Accelerator Laboratory</td>
<td>2MeV and 6 MV tandetron accelerators</td>
<td></td>
</tr>
<tr>
<td>Seoul, Korea</td>
<td>Korea Heavy Ion Medical Accelerator at Korea Institute of Radiological and Medical Sciences (KIRMAS)</td>
<td>KIRAMS</td>
<td>AVF cyclotron for 50MeV protons</td>
</tr>
<tr>
<td>Jeollabuk-do, Korea</td>
<td>Advanced Radiation Technology Institute</td>
<td>15-30 MeV 500microA Proton Cycrotron</td>
<td></td>
</tr>
<tr>
<td>Seoul, Korea</td>
<td>National Center for Inter-Universities Research Facilities Electrostatic Ion Accelerator</td>
<td>3.3MV HVEE(High Voltage Engineering Europa) 4130-Tandetron AMS/MPS</td>
<td></td>
</tr>
<tr>
<td>Daejeon, Korea</td>
<td>Rare isotope Accelerator complex for ON-line experiments (RAON), Institute for Basic Science (IBS)</td>
<td>RAON</td>
<td>Superconducting Driver Linac (proton: 600MeV, 660 microA, HI: 200MeV/u), Superconducting Post Linac (HI: 18.5 Mev/u), Cyclotron: (proton 70 MeV, 1mA)</td>
</tr>
<tr>
<td>Hsinchu, Taiwan</td>
<td>Graduate Institute of Nuclear Science (INS) National Tsing Hua University (NTHU)</td>
<td>INS / NTHU</td>
<td>3MV Van de Graaff (KN) Accelerator, 3MV Tandem accelerator (NEC 9SDH-2), open air 500kV accelerator</td>
</tr>
<tr>
<td>Hanoi, Vietnam</td>
<td>Tandem machine at Hanoi University of Natural Science</td>
<td></td>
<td>1.7MV Tandem Pelletron,</td>
</tr>
<tr>
<td>Hanoi, Vietnam</td>
<td>Military Central Hospital 108</td>
<td></td>
<td>30 MeV 300 microA proton cyclotron</td>
</tr>
</tbody>
</table>
News from Major Accelerator Facilities in Asia Pacific

• Australia
  – Australian National University The Heavy Ion Accelerator Facility -> Underground Laboratory

• China
  – HIRFL->HIAF (Heavy Ion Research Facility in Lanzhou -> High Intensity Heavy Ion Accelerator Facility)
  – BTANL (Beijing Tandem Accelerator Nuclear Physics National Laboratory) -> Beijing ISOL
  – Juna in Jinping

• India
  – Mumbai ( BARC and TIFR)
    • 14 MV Pelletron coupled to SC Linac (PLF: Pelletron LINAC Facility)
  – Delhi ( IUAC: Representing all the university users)
    • 15 MV Pelletron coupled to SC Linac
  – Kolkata ( VECC and SINP)
    • K=130 Cyclotron , K=500 SC cyclotron(not fully operational)

• Korea
  – RISP (Rare Isotope Science Project)

• Japan
  – J-PARC->Hd-ex (Japan proton Accelerator Research Complex -> Hadron Hall Extension)
  – RIBF (Radioactive Ion Beam Facility)
• Neutron beams to characterise detectors both in terms of their response to background radiation and to determine quenching factors.

• Very low/rare nuclear processes that are background to DM searches.

• Long term plan → underground accelerator for very rare astrophysical processes.

• AMS: Radionuclide isotope ratios through atom counting with atomic mass spectroscopy
Brief Progress Chinese nuclear physics community in 2017

Weiping Liu

China Institute of Atomic Energy

(ANPhA Vice Chair)

Aug. 13, 2017
Large scale facility plan

- Heavy ion facility **HIAF** granted with feasibility permit by national commission.

- ADS transmutation facility **CiADS** granted with feasibility permit by national commission.

- Jinping deep underground lab and Beijing ISOL project listed in national 5 years plan, with construction plan submitted.
Ongoing project progress

- Jinping nuclear astrophysics experiment **JUNA**, ground test get proton beam of 260 keV and 3 mA on May 27.

- **ADS R&D**: get proton beam of 26.1 MeV and 12.4 mA pulsed beam on June 5.

- **Beijing Rare Ion Facility BRIF** is scheduled to deliver its first Tandem accelerate ISOL beam by Sept. 2017.
Non-accelerator science project

- Jinping Xe dark matter project PandaX-II, get 1st round evaluation in NSFC (science foundation), with the world record of current PandaX sensitivity by 54.1 ton-day.

- Jinping Ge dark matter project CDEX-II, get another funding support from MOST (science ministry).

- Jiangmen reactor neutrino observatory is under construction, with the funding from CAS by amount of 1.1 B RMB.

- Large scale cosmic ray observatory LHAASO, is under construction in Daocheng, Sichuan.

Jiangmen 20 KT tank
Institute anniversary

• **Institute of Modern Physics Lanzhou** is celebrating its 60 year anniversary on Aug. 18, 2017.

• **Beijing Tandem Accelerator** is celebrating its 30 year anniversary on July. 2017.
JUNA : Jinping underground nuclear astrophysics

JUNA I: 400kV accelerator
- H\(^+\), \(^4\)He\(^+\): 400keV, 10mA
- \(^4\)He\(^{2+}\): 800keV, 2.5mA

JUNA II: 4MV accelerator
- Heavy ions

CDEX
- PandaX

JUNA 实验厅
- 14m X 14m X 50m

CJPL-II, 300,000 m\(^3\)
China Jinping underground laboratory (CJPL)

Comparison of underground labs

- Vertical
- Horizontal

Lab space (m³)

Lab. cosmic ray level (a/m²)

- 600m Soudan, USA
- 700m Y2L, Korea
- 800m Canfranc, Spain
- 1000m Kamioka, Japan
- 1100m Boulby, UK
- 1400m INO, India
- 1400m LNGS, Italy
- 1500m DUSEL, USA
- 1600m Baksan, Russia
- 1700m Modane, France
- 2100m SNO
- 2400m CJPL, China

300,000 m³

CJPL-II layout

Ground facilities

beam with 40 KV and 20 mA

Tandem for test experiment

solid and gas detector and electronics

CJPL low background facility

Target and shielding

Contribution by Tao Li (IMP)

Rotation target tested 30/8/16
## Detailed 5+ year time table

<table>
<thead>
<tr>
<th>Period/Task</th>
<th>Accelerator</th>
<th>Laboratory</th>
<th>Experiment</th>
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</thead>
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<tr>
<td>2015 Q1-Q2</td>
<td>design, layout</td>
<td>layout</td>
<td>simulation, physics</td>
</tr>
<tr>
<td>2015 Q3-Q4</td>
<td>parts fabrication</td>
<td>on site study</td>
<td>background, test</td>
</tr>
<tr>
<td>2016 Q1-Q2</td>
<td>ion source, tube</td>
<td>design</td>
<td>background, prototype</td>
</tr>
<tr>
<td>2016 Q3-Q4</td>
<td>assemble</td>
<td>detailed design</td>
<td>target test</td>
</tr>
<tr>
<td>2017 Q1-Q2</td>
<td>beam on ground</td>
<td>design</td>
<td>fabrication</td>
</tr>
<tr>
<td>2017 Q3-Q4</td>
<td>ground tuning</td>
<td>construction</td>
<td>ground test</td>
</tr>
<tr>
<td>2018-2019</td>
<td>underground</td>
<td>shield setup</td>
<td>$^{19}\text{F}(p,a)^{16}\text{O}$, $^{25}\text{Mg}(p,g)^{26}\text{Al}$</td>
</tr>
<tr>
<td>2018-2019</td>
<td></td>
<td>new detector</td>
<td>$^{13}\text{C}(a,n)^{16}\text{O}$</td>
</tr>
<tr>
<td>2019-2020</td>
<td></td>
<td></td>
<td>$^{13}\text{C}(a,n)^{16}\text{O}$, $^{12}\text{C}(a,g)^{16}\text{O}$</td>
</tr>
<tr>
<td>2020-2022</td>
<td></td>
<td></td>
<td>$^{12}\text{C}(a,g)^{16}\text{O}$</td>
</tr>
</tbody>
</table>
News from India

• Prepared by
  – Dr. Amitava Roy, New Director of VECC, Kolkata.
  – Dr. Alok Saxena, Head of the Nuclear Physics Division at BARC (Bhabha Atomic Research Centre), Mumbai.
Three Major Accelerator Centres in India

Mumbai (BARC and TIFR)
14 MV Pelletron coupled to SC Linac (PLF: Pelletron LINAC Facility)

Delhi (IUAC: Representing all the university users)
15 MV Pelletron coupled to SC Linac

Kolkata (VECC and SINP)
K=130 Cyclotron, K=500 SC cyclotron (not fully operational)

The Thrust Areas:
Low and High Energy Nuclear Physics using Accelerator and Reactor; Nuclear Data
Indigenous development of accelerators, detector and instrumentation
Use National Facilities, International Facilities like Legnaro National Laboratory, Ganil, CERN, BNL, FAIR ....
EXPERIMENTAL FACILITIES AT BARC-TIFR PLF (Mumbai)

General purpose scattering chamber

8 CLOVER gamma array is being setup for reactor based work at DHRUVA Reactor

Indian National Gamma Array (INGA) at PLF, Mumbai

Charged Particle Array setup at PLF, Mumbai

(a) View of the CPDA setup in the LINAC beam hall at TIFR
(b) Experiment using 10 nos of detector telescopes mounted inside the vacuum chamber.
Facilities for fusion-fission study at IUAC (Delhi)

Fission fragment mass distribution measurement using MWPC time of flight set-up inside scattering chamber

Neutron detector array for measuring neutron multiplicity in coincidence with fission fragments
Heavy Ion Reaction Analyzer (HIRA) at IUAC, New Delhi

Fusion reactions around Coulomb barrier
Multi-nucleon transfer reactions around Coulomb barrier
ER-gated spin distributions and high spin spectroscopy
Microsecond isomer search
Production and use of secondary RIB, $^7$Be, using direct reactions in inverse kinematics
Future Plans/ Upcoming facilities

• ECR Injector for the SC Linac (Delhi) (in progress)
• ECR Injector based HI accelerator (Mumbai) (Design and Development)
• Low Energy High Intensity Proton Accelerator (LEHIPA) - 20 MeV Proton Accelerator - (Mumbai) (in progress)
• FRENA - 3 MV Accelerator for Astrophysics (installation in progress Kolkata)
• SC K=500 cyclotron - (Beam trials) (Kolkata)
• ANURIB - National RIB (Design and Development) (Kolkata)
• India Based Neutrino Observatory (INO)
• Antineutrino detection setup at DHRUVA
• GEM subsystem upgrade of CMS detector at CERN
Status of Nuclear Physics Research in Korea

Byungsik Hong
(Korea University)
Construction Status of RAON

1. A construction company was selected in September, 2016.
2. The construction and civil engineering for RAON (Rare isotope Accelerator complex for ON-line experiments) has begun.
3. The ground breaking for accelerators and experimental buildings was done on Feb. 13th this year.
SRF Test Facility @ KAIST Munji Campus

- Test facilities for superconducting RF cavities and modules
- Facility List

① Cavity test pit
(SRF Cavities performance test)

② Module test bunker*
(SRF Modules performance test)

③ Clean Room
(Clean assembly & Inspection)

④ Cryogenic Plant
(Liquid He, Liquid N₂)

⑤ SCL Demonstration
(ECRIS+LEBT+RFQ+MEBT+1 QWR)

* 1st QWR Module has been tested successfully in May.
## QWR Cryomodule Test Result

QWR cryomodule test bunker

Thermal heat load (9.9 watt @ 6.1 MV/m)

### Performance test for QWR cryomodule

<table>
<thead>
<tr>
<th>Reference</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal heat load</td>
<td>&lt; 25 W @ 4.2 K, 6MV/m</td>
</tr>
</tbody>
</table>

August 2017  
WG9
Target Module Performance Test
- Primary & Secondary Vacuum Test
- Quick & Remote Connection/Disconnection
- High Voltage Discharge
- Pillow Seal, QDS, Special All Metal Gate Valve

Hot Cell Performance Test
- Coupling & Decoupling of Target Chamber in Target Module
- Target Chamber Exchange
- Target Module Moving System (Rot. & Up/Down)
- Manipulator Jig & Tools

Crane Interface Device Performance Test
- Alignment / Twist Locking / Interlock
ISOL TIS Module & Hot-cell Mock-up
*TIS Module is installed in vacuum chamber
* Load TIS Module to the Hot-cell
* Inside Hot-cell & Manipulator
Milestone of RAON/RISP in 2017

1. Cryomodule test for QWR and HWR
   → Mass production

2. Cavity test for SSR
   → Cryomodule test planned in early 2018

3. Beam extraction from SCL demo (1 QWR)

4. Test of ISOL Target Ion Source (TIS)
   Module in Hot-cell Mock-up is going well!
Accelerator facilities for nuclear physics in Japan - 1

- **Nishina Center, RIKEN**
- **K2600 RIBF** (Heavy ion (RIB))
- **Research Center for Electron Photon Science, Tohoku University (ELPH)**
- **1.2GeV electron stretcher**
- **SPRING-8 (RIKEN/JASRI)** (8GeV e-Synchrotron)
- **RCNP, Research Center for Nuclear Physics, Osaka University**
- **K400 Cyclotron**
- **HIMAC at National Institute of Radiological Sciences**
  - **800MeV/A Synchrotron**
  - **heavy ion (therapy)**
- **J-PARC, KEK/JAEA**
  - **30GeV Proton Synchrotron**
  - **π, K, μ, n, (ν)**

...
Future Plans (~5 years) of Nuclear Physics in Japan

*Endorsed by Japanese Nuclear Physics Executive Committee, 2016*

- **J-PARC (KEK)**
  - Hadron/nuclear physics w/hadron beams -> Hadron Hall extension
  - Fundamental Physics/Particle physics with muons
    -> mu-e conversion (COMET), $g-2$

- **RIBF (RIKEN)**
  - Expand neutron-rich heavy element productions to transuranium
  - Production of superheavy Z=119 and beyond
    -> RIBF upgrade for intensity x30

- **ELPH (Tohoku) and LEPS@SPring-8 (RCNP Osaka)**
  - Hadron Physics with electron beams -> Detector/Beam upgrades

- **High Energy Heavy Ion Collision (LHC, RHIC, J-PARC)**
  - QGP properties, QCD phase diagram, High density matter
    -> ALICE upgrade, s-PHENIX/STAR upgrade, J-PARC-HI R&D

- **Nuclear Theory**
  - Hadrons via Lattice QCD, Nuclear structure via Monte Carlo Shell Model, etc.
    -> 9 projects with K computer and beyond
Hadron Hall for Counter Experiments with 150kW SX

J-PARC
Japan Proton Accelerator Research Complex

Bird's eye photo in January 2016
J–PARC Upgrade for Nuclear & Particle Physics

Science Council of Japan selected this one of 27 Major Projects of Japan

COMET-II ($\mu - e$ conversion)

46M$
RIBF – a new generation RIB facility in operation with world highest capability of providing RI beams

RIPS (1990-)
~50 MeV/nucleon

BigRIPS (2007-)
~200 MeV/nucleon

160 M$ for light nuclei (1986-)

345 MeV/nucleon up to U (2006-)

Sendai

Nov. 2016
RIBF upgrade plan submitted to Science Council of Japan (146M$)

- Helium refrigerator
- Super conducting Cavity 500kW
- 28GHz Super Conducting ECR Ion Source
- RI production

32M$ FY2016 Supplement

12M$ RRC refurbishment

103M$
Hadron Hall Extension Project: chosen as one of the top 28 big projects (Status in June 2017)

• **The Science Council of Japan** selected the hadron hall extension project of J-PARC as one of the top 28 major projects selected this year. The selection was made in every three years.
  
  – From these 28 big projects, 10~15 big projects will be selected by **Council for Science & Technology (CST) in MEXT** (Funding agency in Japan) and will appear in **MEXT's "Road Map"**. The budget approval will be made only on these "Road Map“ projects.
"Big projects" in NP, HE and Space

- **4 New projects were selected by SCJ + 1 (added by CST)**
  - Hadron Hall Extension + \(\mu e\) conversion exp. + \(g-2/\mu\)EDM
  - HyperKAMIOKANDE + Neutrino Beam Power Upgrade
  - HL-LHC
  - LiteBIRD (Light satellite for the studies of B-mode polarization and Inflation from cosmic background Radiation Detection)
  - SPICA (Space Infrared Telescope for Cosmology and Astrophysics)

- **4 On-Going projects (financed!)**
  - High Intensity J-PARC (750kW for \(\nu\), 100kW for SX)
  - Super KEK-B
  - KAGRA (Kamioka Gravitational wave detector, Large-scale Cryogenic Gravitational wave Telescope)
  - 30m Telescope (TMT)
ROADMAP Projects selected by CST

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  • HyperKAMIOKANDE + Neutrino Beam Power Upgrade
  • HL-LHC
  • LiteBIRD (Light satellite for the studies of B-mode polarization and Inflation from cosmic background Radiation Detection)
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  • 30m Telescope (TMT)
Hadron Hall Extension Project: Rejected from MEXT’s Roadmap!
No Nuclear Physics Project is in MEXT’s Roadmap

捲土重来！

• Gather strength for a renewed attack!
<table>
<thead>
<tr>
<th></th>
<th>Beams</th>
<th>Asia</th>
<th>Europe</th>
<th>America</th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Hot QCD</strong></td>
<td>A+A</td>
<td>--</td>
<td>LHC(ALICE)</td>
<td>RHIC</td>
<td>Missing Asian? J-PARC-HI for dense matter?</td>
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<tr>
<td><strong>Cold QCD</strong></td>
<td>hadron</td>
<td>J-PARC +Hdex HIRFL+HIAF</td>
<td>FAIR(SIS100)</td>
<td>--</td>
<td>Missing American?</td>
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<tr>
<td></td>
<td>e-</td>
<td>Spring-8 ELPH</td>
<td>MAMI</td>
<td>JLAB-12GeV</td>
<td>1+many</td>
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<td>collider</td>
<td>(BES-III) (Belle-II)</td>
<td>NICA</td>
<td>eRHIC (eIC)</td>
<td>1 in the world?</td>
</tr>
<tr>
<td><strong>Many body Problem (RI Beam)</strong></td>
<td>PF</td>
<td>RIBF upgrade HIRFL+HIAF</td>
<td>GSI/FAIR</td>
<td><strong>FRIB</strong></td>
<td>Good competitions!!</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>RISP</td>
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<td></td>
<td>ISOL</td>
<td>BTANL ANURIB</td>
<td>SPIRAL2 SPES HIE-ISOLDE</td>
<td><strong>ARIEL-2</strong></td>
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<td>Super ISOL</td>
<td>Beijing- ISOL</td>
<td>EURISOL</td>
<td>--</td>
<td><strong>FRIB upgrade?</strong></td>
</tr>
</tbody>
</table>
Partial Summary for White Paper?
(very personal views of KHT)

• Major accelerator facilities for nuclear physics in Asia Pacific were briefly reviewed.
• Most of Asian facilities are now World Class facilities.
• However, we did not construct high energy heavy-ion colliders in Asia Pacific for Hot QCD studies.
• We have many big medium energy heavy-ion (RI beam) facilities in AP and their future extension projects. However, Physics opportunity should not be similar!?
• In recent years, RIBF facility in Japan is one of the world leading nuclear physics facilities in the RI beam intensity and scientific output.
• Now RI beam facility is changing/expanding from projectile fragmentation (PF) facility to the target ion source (ISOL) facility. Final goal is “Super ISOL”.
• We have only one facility for electromagnetic probes (LEPS) in AP.
• J-PARC is becoming the KAON factory in the world? However FAIR SIS100 will catch us up soon.
• How about baryon rich nuclear matter physics in AP, i.e. J-PARC-HI, and/or HIAF phase II? Which or Both? It depends on Physics.......
backup
News from India

• Prepared by Dr. Amitava Roy, New Director of VECC, Kolkata and Dr. Alok Saxena, Head of the Nuclear Physics Division at BARC (Bhabha Atomic Research Centre), Mumbai.
Three Major Accelerator Centres in India

Mumbai (BARC and TIFR)
14 MV Pelletron coupled to Pb based SC Linac facility (PLF)

Delhi (Representing all the university users)
15 MV Pelletron coupled to Nb SC Linac

Kolkata (VECC and SINP)
K=130 Cyclotron, K=500 SC cyclotron (not fully operational)

The Thrust Areas:
Low and High Energy Nuclear Physics using Accelerator and Reactor; Nuclear Data
Indigenous development of accelerators, detector and instrumentation

Use National Facilities, International Facilities like Legnaro National Laboratory, Ganil, CERN, BNL, FAIR ....
Experimental facilities and Nuclear Physics Research Activities at VECC

- Charge particle detector array
- MWPC
- VENUS and VENTURE array
- Neutron Detectors
- Segmented Clover
- Penning Ion trap
- Gamma Multiplicity Filter
- LAMBDA Detector array

Experimental facilities and Nuclear Physics Research Activities at VECC
Recent studies:

**Studies on GDR using LAMDA array**
- Study of dependence of GDR width at high temperatures
- Probing clustering phenomena in atomic nuclei using GDR as a tool
- Jacobi shape transition
- Systematic study of isospin mixing

**Studies on nuclear level density using neutron detector**
- Effect of angular momenta
- Effect of collectivity
- Shell effect and its damping

**Fission studies using MWPCs**
- Fission dynamics
- Fusion-fission vs. Quasi fission
- Physics related to Super Heavy Elements (SHE)

**International Collaborations:**
- FAIR NUSTAR (GSI, Germany)
- DST-RFBR project, JINR, DUBNA
- AGATA Expt., GANIL, FRANCE
- PARIS collaboration (FAIR)

**Studies using Charged Particle detector**
- Fragments emission mechanisms
  - Fusion-fission, DIO, DI, QE etc.
  - Deformation of nuclei using LCP as probe
  - Cluster structure studies
    - Hoyle state,
    - Other cluster states of $^{12}$C
    - Hoyle analogue states and excited states of Hoyle analogue states in other nuclei
- Effects of clustering in fragments emissions

**Gamma ray spectroscopic studies using VENUS, INGA and other setup:**
- Spectroscopy of heavy nuclei
- Complete spectroscopy of nuclei using lifetime and quadrupole moment measurement
  - a. In beam prompt spectroscopy to study nuclei in $A \sim 130$ region
  - b. Decay spectroscopy of radio-chemically separated fission fragments around $^{132}$Sn
- Study of long lived beta decaying isomers using beta-gamma coincidence measurement
- High spin states, evolution of deformation, new modes of excitations
\[ \eta/s \text{ for finite nuclear matter} \]

Experiment at VECC


\[ \eta/s \text{ remains within (2.5-6.5)} \frac{\hbar}{4\pi k_B} \]

for finite nuclear matter

Study of cluster formation in atomic nuclei via GDR decay:


Long lived beta decaying isomer in \(^{150}\text{Pm} \rightarrow (\alpha + ^{150}\text{Nd})\)

Experiments with INGA

\(^{198}\text{Pt}(^7\text{Li}, 5n)^{200}\text{Tl}\)

150Pm \rightarrow (\alpha + 150Nd)

\[^{169}\text{Tm}(^32\text{S}, ^32\text{S}')^{169}\text{Tm}^*\]

Return of backbending in \(^{169}\text{Tm}\)

Soumik Bhattacharya et al, PRC 95, 014301 (2017)

Md. A. Asgar et al., PRC 95,031304(R) (2017)

T. Bhattacharee et al. NIM A 767, 10(2014).
Exploring fission valleys of pre-actinides

Evidence of fadeout of collective enhancement in nuclear level density

Direct vs. Sequential decay of the Hoyle state

A. Chaudhuri et al; PRC 94, 024617 (2016)

A. Chaudhuri et al; PRC 92, 041601 (2015) (R)

A. Chaudhuri et al; PRC 91, 044620 (2015)

K. Banerjee et al.
PLB 772, 105 (2017)

P. Roy et al., PRC 88, 031601 (2013) (R)

T. K. Rana et al., PRC 88, 021601(R) (2013)

Survival of cluster structure at high excitation

S Manna et. al., PRC 94, 051601( (2016)(R)
Electron cloud trapped in VECC Penning Ion Trap and observed using indigenously developed resonant detection electronics setup.

Indigenously developed 19 pin cryogenic feedthrough

Low noise amplifier

Helical resonator

Designed and developed at VECC

Penning Ion trap assembly

TWO RING MAGNETS ENCLOSING FIVE ELECTRODE TRAP ASSEMBLY

FEP: Field Emission Point for electron generation
• Experimental Facilities for
  - Nuclear physics
  - Atomic physics
  - Condensed matter physics and material science
  - Radioisotopes production
  - Production of track-etch membranes
  - Low flux Protons irradiation damage studies
  - Secondary neutron production
  - Accelerator Mass Spectrometry

• Users
  - BARC
  - TIFR
  - SINP & VECC, DRDO, ISRO and other research & educational institutions.
EXPERIMENTAL FACILITIES AT BARC-TIFR PLF

Charged Particle Array setup at PLF, Mumbai

General purpose scattering chamber

8 CLOVER gamma array is being setup for reactor based work at DHRUVA Reactor

Indian National Gamma Array (INGA) at PLF, Mumbai
Facilities for fusion-fission study at IUAC

Fission fragment mass distribution measurement using MWPC time of flight set-up inside scattering chamber

Neutron detector array for measuring neutron multiplicity in coincidence with fission fragments
Heavy Ion Reaction Analyzer (HIRA) at IUAC, New Delhi

Fusion reactions around Coulomb barrier
Multi-nucleon transfer reactions around Coulomb barrier
ER-gated spin distributions and high spin spectroscopy
Microsecond isomer search
Production and use of secondary RIB, $^7\text{Be}$, using direct reactions in inverse kinematics

Multi-nucleon transfer mass spectrum for $^{28}\text{Si} + ^{94}\text{Zr}$ entrance channel
Sub-barrier fusion cross-section explained using Coupled Channels approach for $^{16}\text{O} + ^{174}\text{Yb}$ system
$S_{17}(0)$ factor extracted using $^7\text{Be}$ secondary RIB in inverse kinematics
- 50 Bakelite RPCs and 200 Cu cooling sets supplied to CMS experiment at CERN for RE4 upgrade (improve trigger efficiency)
- RPCs played a crucial role in Higg’s Discovery
  - Collaborators: NPD-BARC, MD&PDD-BARC & Panjab University, Chandigarh
  - Benefits:
    - RPC experience directly benefits the INO programme
    - Large Area detectors for Cargo Scanning via Muon Tomography

- Single Mask GEM foil development in India (RD51 Collaboration)
  - Collaborators: NPD-BARC, CERN, M/s Micropack Bangalore
  - Benefits
    - Free transfer of patented technology from CERN
    - GEMs have excellent position & timing resolution
    - Ideal for Medical Imaging with high granularity

- Heavy Ion Studies with CMS data from LHC and PHENIX data from RHIC
  - 10 Leading Int. Publications in last 2 years from NPD-BARC
  - Benefits
    - Development of Analysis Software & Computational Techniques

RE4 successfully commissioned at CMS @ CERN

RPCs & Cu cooling (NPD & MD&PDD)

Single Mask GEM Foil Development in India

NPD-BARC, Trombay Colloquium
Typical Research Activities

- **Fusion dynamics**
- **Fission dynamics** (neutron and charged particles emission, fragment angular, mass and total kinetic energy distributions)
  - Dynamical hindrance, Nuclear level density \[\text{Phys. Rev. Lett. 110, 062501 (2013)}\]
- Fission fragment spectroscopy using reactors and accelerators, INGA experiments, \[\text{Phys. Rev. C 96, 014315 (2017)}\]
- Nuclear Data with direct and surrogate method, \[\text{Phys. Rev. C 93, 021602(R) (2016)}\] Nuclear Data Physics Centre of India (About 350 entries to EXFOR database), N_TOF studies at CERN
- Development of Monte Carlo nucleon transport codes, GEANTV, MONC
- Nuclear Collisions at high energy, \[\text{Phys. Lett. B770, 357 (2017)}\].
Typical studies from INGA

- **Shape evolution in 66Ga** – *PRC 96, 054330 (2017)*
- **High spin γ-ray spectroscopy in 41Ca** – *PRC 94, 054312 (2016)*
- *Candidates for twin chiral bands in 102Rh* - *PRL 112, 052501 (2014)*
- **Negative-parity high-spin states and a possible magnetic rotation band in 135Pr** – *PRC 92, 054325 (2015)*
- **High spin spectroscopy and shape evolution in 105Cd** – *PRC 91, 024319 (2015)*
- **Evidence for octupole correlation and chiral symmetry breaking in 124Cs** – *PRC 92, 064307 (2015)*
- **Band structures in 99Rh** – *JPG 41, 105110 (2014)*
- **A new high spin isomer in 195Bi** – *EPJA 51, 153 (2015)*
# Studies in Nuclear Astrophysics at SINP: experimental and theoretical efforts

## Experimental

- Indirect methods in Nuclear Astrophysics-
  - Cluster transfer, breakup and ANC technique.
  - Coulomb breakup

- Facility for experimental Nuclear Astrophysics (FRENA): 3MV Tandetron
  Civil work for installation of the machine in full swing

## Theoretical

- Nuclear reaction modelling- Continuum Discretized Coupled Channel (CDCC) and Asymptotic Normalisation Constant method
  - R-matrix theory analysis of capture reaction
  - Shell model studies of neutron – rich exotic nuclei on the r-process path: new shell closure predicted

## Developmental work for utilization of FRENA

- Detector testing: background suppression
- Implanted Target preparation, development and characterization
- Gas detector development
- Offline gamma array installation – digital data acquisition testing
The $^{55}$Fe$(n,p)$ cross-section as a function of equivalent neutron energy along with various evaluation results and EMPIRE-3.2.3 calculations.
Future Plans/ Upcoming facilities

- ECR Injector for the SC Linac (Delhi) (in progress)
- ECR Injector based HI accelerator (Mumbai) (Design and Development)
- Low Energy High Intensity Proton Accelerator (LEHIPA) – 20 MeV Proton Accelerator (Mumbai) (in progress)
- FRENA – 3 MV Accelerator for Astrophysics (installation in progress Kolkata)
- SC K=500 cyclotron – (Beam trials) (Kolkata)
- ANURIB – National RIB (Design and Development) (Kolkata)
- India Based Neutrino Observatory (INO)
- Antineutrino detection setup at DHRUVA
- GEM subsystem upgrade of CMS detector at CERN
Recent works on Nuclear Theory
at
Variable Energy Cyclotron Centre,
Kolkata
Microscopic Calculations of Fission Fragment Yield Distribution in Spontaneous Fission

Multidimensional Potential energy surface calculated at T=0 using Density Functional Theory

Calculation took ~14M CPU hours in High Performance Computers

Mass (left) and charge (right) distributions of the heavier fission-fragment of $^{240}$Pu
Shaded regions indicate model-dependent error

a predictive framework to describe spontaneous fission yields of a heavy nucleus

Nuclear Liquid gas phase transition: A new proposed signature:

Canonical Thermodynamical Model

\[
d\frac{M}{dT} vs T \ (\text{Multiplicity Derivative})
\]

\[
\text{M}: \text{ total multiplicity from nuclear fragmentation at intermediate energies}
\]

\[
T: \text{ temperature}
\]

(Rapid communication and Editor’s suggestion)
Bimodality in largest cluster probability distribution from transport model calculation:-

- Most important signature for nuclear liquid gas phase transition.
- Studied by Boltzmann-Uehling-Uhlenbeck (BUU) model.
- Bimodal behavior obtained for the first time from any transport calculation for central collision.

Studied Reaction $A_p=40$ on $A_t=40$  
No. of Events-500, Time= 300 fm/c

Status: Work is completed.

Formulation of a transformation relation between grand canonical and canonical ensembles in two component thermodynamical model:

Statistical models @ Clusterization from phase space calculation

Very accurate and successful for explaining multifragmentation reactions

Canonical model is physically more acceptable for intermediate energy heavy ion reaction.

Grand canonical model calculation is much simpler.

Requirement of ensemble transformation relation for finite nuclei and its successful application important observables

\[ R_{c}(\langle N_{0}\rangle_{fn, f_{z}}, \langle Z_{0}\rangle_{fn, f_{z}}) \approx R_{ge}(f_{n}, f_{z}) - \frac{1}{2} \sigma_{n}^{2} \frac{\partial^{2} R_{ge}}{\partial (N_{0})^{2}} \langle N_{0}\rangle_{fn, f_{z}} + \langle Z_{0}\rangle_{fn, f_{z}} - \frac{1}{2} \sigma_{z}^{2} \frac{\partial^{2} R_{ge}}{\partial (Z_{0})^{2}} \langle N_{0}\rangle_{fn, f_{z}} + \langle Z_{0}\rangle_{fn, f_{z}} \]

Status: Work is completed.

Landau quantization and mass-radius relation of magnetized White Dwarfs

• For EoS of White Dwarfs, the pressure is provided by the relativistic degenerate electrons only while the energy density both electrons (with its kinetic energy) and atomic nuclei contribute.

• For magnetized White Dwarfs, electrons, being charged particles, occupy Landau quantized states. This changes the EoS, which, in turn, changes the pressure and energy density.

• The mass-radius relations for non-magnetized & magnetized White Dwarfs are obtained by solving the Tolman-Oppenheimer-Volkoff equations. Surface magnetic field is kept at $10^9$ Gauss estimated by observations while central magnetic field goes up to maximum $10B_c = 4.414 \times 10^{14}$ Gauss (theoretical limit).

• The masses of non-magnetic White Dwarfs remain within Chandrasekhar’s limit of $1.4 \, M_\odot$ but for magnetized White Dwarfs it increases with central magnetic field and goes far beyond Chandrasekhar’s limit.

• The high-density behavior of neutron star matter obtained from DDM3Y interaction satisfies constraints from the observed flow data of heavy-ion collisions.

• The neutron star properties agree with the recent observations of the massive compact stars.

• The density, pressure and proton fraction at the inner edge separating the liquid core from the solid crust of neutron stars are determined thermodynamic stability conditions:

\[ \rho_t = 0.0938 \text{ fm}^{-3}, \quad P_t = 0.5006 \text{ MeV fm}^{-3} \quad \text{and} \quad x_{p(t)} = 0.0308, \text{ respectively} \]

These results for pressure and density at core-crust transition together with the observed minimum crustal fraction (1.4% -1.6%) of the total moment of inertia provide a new limit for the radius of the Vela pulsar: \( R > 4.10 + 3.36M/M_\odot \) kms. Present calculations suggest that this fraction can be at most 3.6% due to crustal entrainment because of Bragg reflection of unbound neutrons by lattice ions.

The masses and radii of non-rotating and rotating configurations of pure hadronic stars mixed with self-interacting fermionic Asymmetric Dark Matter are calculated within the two-fluid formalism of stellar structure equations in general relativity. The Equation of State (EoS) of nuclear matter is obtained from the density dependent M3Y effective nucleon-nucleon interaction. We consider dark matter particle mass of 1 GeV. The EoS of self-interacting dark matter is taken from two-body repulsive interactions of the scale of strong interactions. We explore the conditions of equal and different rotational frequencies of nuclear matter and dark matter and find that the maximum mass of differentially rotating stars with self-interacting dark matter to be $1.94 M_{\odot}$ with radius 10.4 kms.

Ref: S. Mukhopadhyay, D. Atta, K. Imam, D.N. Basu, C. Samanta

arXiv: 1612.07093 Communicated
Status of Nuclear Physics Research in Korea

Byungsik Hong
(Korea University)
Division of Nuclear Physics in the Korean Physical Society

- HIM: Relativistic Heavy-Ion Collisions
  ▷ ALICE, CMS, PHENIX, STAR
- LENS: Low-Energy Nuclear Science
  ▷ RAON, RIBF, NSCL
- HaPhy: Hadron Physics
  ▷ J-PARC, CEBAF

Chair: B. Hong
Secretary: H. J. Lee
ANPhA Committee: M. K. Cheoun, K. I. Hahn, B. Hong,
Executive Committee:

HIM
- K. S. Jeong
- K. J. Kwak
- M. J. Kweon

HaPhy
- S. H. Choi
- S. I. Nam
- Y. Oh

LENS
- K. Chae
- Y. Kim

Applications
- K. Cho
- K. B. Lee

International Relations
- Y. K. Kwon
- H. J. Lee

August 2017
Korea in ALICE

- Analysis topics
  - Multiplicity \((dN/d\eta)\) distribution in \(pp\)
  - Path-length dependence of \(R_{AA}\)
  - Flow using two-particle correlations
  - Anisotropy of \(\Lambda\)s
  - Heavy-flavor production and \(R_{AA}\) of \(c, b \rightarrow e + X\) and \(b \rightarrow e + X\)
  - Hyperon (\(\Sigma, \Xi\)) production from \(pp\) to \(PbPb\)
  - Pomeron reactions in \(pp \rightarrow 4\pi\)
  - Lattice calculation for \(\Upsilon\)s at finite \(T\)

- Hardware contributions
  - Inner Tracking System (ITS) upgrade

- Some highlights on hardware in the next slides
Inner Tracking System Upgrade

- **Characterization of pixel chip (Inha and PNU)**
  - Lab. & beam tests at PAL and KOMAC

- **Mass chip test (Inha, PNU and Yonsei)**
  - Test 60k pixel chips (’17.01 ~ ’18.01)

- **Module assembly (Inha & PNU)**
  - Assemble ~400 modules (’17.05 ~ ’18.04)
Inner Tracking System Upgrade

- Goals of new ITS design
  - Improve the vertex resolution (x3)
  - High efficiency and $p_T$ resolution (x10)
  - Fast readout: 50 kHz (PbPb), 400 kHz (pp)
  - Fast insertion/removal

- Features of new ITS

<table>
<thead>
<tr>
<th></th>
<th>Current ITS</th>
<th>New ITS</th>
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</thead>
<tbody>
<tr>
<td># of layers</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Inner radius</td>
<td>3.9 cm</td>
<td>2.3 cm</td>
</tr>
<tr>
<td>Pipe radius</td>
<td>2.9 cm</td>
<td>1.9 cm</td>
</tr>
<tr>
<td>Innermost layer thickness</td>
<td>1.14% $X_0$</td>
<td>0.3% $X_0$</td>
</tr>
<tr>
<td>Innermost layer pixel size</td>
<td>50x425 $\mu m^2$</td>
<td>28x28 $\mu m^2$</td>
</tr>
<tr>
<td>Max. PbPb readout</td>
<td>1 kHz</td>
<td>100 kHz</td>
</tr>
</tbody>
</table>

MAPS: Monolithic Active Pixel Sensor Technology
Korea in CMS

☐ Analysis topics
  – Quarkonium production in pPb and PbPb
  – Azimuthal anisotropy of quarkonium in PbPb
  – Upsilon production in PbPb
  – B production in pPb
  – Isolated photons in PbPb
  – Jet-photon correlation in PbPb
  – Pomerons in ultraperipheral collisions

☐ Hardware contribution
  – Forward RPC upgrade
  – High-rate muon trigger with GEM

☐ Some highlights on hardware in the next slides
**Current RPC System in CMS**

**Endcap RPCs**
- 2 wings (RE+, RE-)
- 4 stations (RE1, RE2, RE3, RE4) in each wing
- Covering $0.92 < \eta < 2.1$

**Barrel RPCs**
- 6 stations (layers)
- Fully covering up to $\eta = 0.8$
- Partially covering up to $\eta \sim 1.2$

**Diagram:**
- 4th Station via PHASE I upgrade (2014)
- High-\(\eta\) Forward RPCs (<2024)
- Low-\(\eta\) Forward RPCs
- Endcap RPCs: 2 wings (RE+, RE-)
- Barrel RPCs: 6 stations (layers)
- Covering up to $\eta = 0.8$ and partially up to $\eta \sim 1.2$

---

August 2017

WG9
Phase II: Upgrade of CMS RPC

- Current ENDCAP composed of 4 RPC stations covering \(1.1 < \eta < 1.6\)
  - Trigger efficiency of the muon system is still low due to absence of the RPC in \(1.6 < \eta < 2.4\) range.

![Efficiency graph](image)

- Completion of 36 RE3/1 and 36 RE4/1 RPCs together with GE0, GE1/1, and GE2/1, before LS3 (2024).
  - 2015 – 2017: Confirmation of detector technology
  - 2017 – 2018: Pre-productions
  - 2019 – 2023: Detector productions, installation, and integrations
R&D for high-$\eta$ CMS RPCs

200-mCi $^{137}$Cs at Korea University
Current activity = 5.55 GBq
Maximum $\gamma$ rate at 37 cm~1.4 kHz cm$^{-2}$

H4 beam line at GIF++
Activity = 1.4 TBq ($^{137}$Cs)
Maximum $\gamma$ rate at the test position~1.5 kHz cm$^{-2}$
Layout of RAON
Construction Status of RAON

1. A construction company was selected in September, 2016.
2. The construction and civil engineering for RAON (Rare isotope Accelerator complex for ON-line experiments) has begun.
3. The ground breaking for accelerators and experimental buildings was done on Feb. 13<sup>th</sup> this year.
SRF Test Facility @ KAIST Munji Campus

- Test facilities for superconducting RF cavities and modules
- Facility List

① Cavity test pit
   (SRF Cavities performance test)

② Module test bunker*
   (SRF Modules performance test)

③ Clean Room
   (Clean assembly & Inspection)

④ Cryogenic Plant
   (Liquid He, Liquid N$_2$)

⑤ SCL Demonstration
   (ECRIS+LEBT+RFQ+MEBT+1 QWR)

* 1$^{st}$ QWR Module has been tested successfully in May.
QWR Cryomodule Test Result

QWR cryomodule test bunker

Thermal heat load (9.9 watt @ 6.1 MV/m)

<table>
<thead>
<tr>
<th>Performance test for QWR cryomodule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reference</strong></td>
</tr>
<tr>
<td>Thermal heat load</td>
</tr>
</tbody>
</table>

August 2017

WG9
Milestone of RAON in 2017

1. Cryomodule test for QWR and HWR
   → Mass production
2. Cavity test for SSR
   → Cryomodule test planned in early 2018
3. Beam extraction from SCL demo (1 QWR)
J-PARC E42 Experiment

- Search for H-dibaryon on proton pair via \((K^-, K^+)\) reaction
- \(K^-\) beams on the diamond target at 1.7 GeV
- Hyperon spectrometer at K1.8 beamline
  - HypTPC and superconducting Helmholtz Coil
HypTPC

Some features

- Gating grid
- Concentric pad plane (5768 pads)
- Position resolution: $< 300 \, \mu m$

- Triple GEM layers
- Gain $\sim 10^4$
- $\Delta p/p = 1\sim3\%$ for $\pi$ and $p$
Summary

1. Nuclear Physics Community in Korea
   – Relatively small, but active
   – Still growing, especially, with the RAON project

2. Experimental efforts
   – Active contribution to the data analysis
   – Significant contribution to the detector constructions for the last 10-15 years
     ▶ RPC and GEM for CMS @ LHC
     ▶ ITS for ALICE @ LHC
     ▶ Various detector components for KOBRA & LAMPS @ RAON
     ▶ TPC and SC magnet for E42 @ J-PARC
HI Accelerator scheme in J-PARC (preliminary)

In the RCS, more than $10^{11}$ U$^{86+}$ ions can be achieved without any significant beam losses.
J-PARC
(JAEA & KEK)

400 MeV H* Linac

HI linac & Booster

3 GeV RCS

50 GeV MR

NU

MLF

HD
Construction Status of High-\(p\) Beam Line at J-PARC HADRORN

- Branching point
- Lambertson Magnet
- Lambertson (Design)
- Beamline magnets
- In SY-HD Wall
- New Line
- Existing A-Line
- Spectrometer Magnet
- COMET & Control room
May 2017, Beam Dump (Iron Part) Completed

- Beam Dump
- FM Magnet
- SKS Magnet

High-p Beam Dump