

EIC Activities in Japan

EIC Asia Workshop @ RIKEN Wako

March 16th, 2023

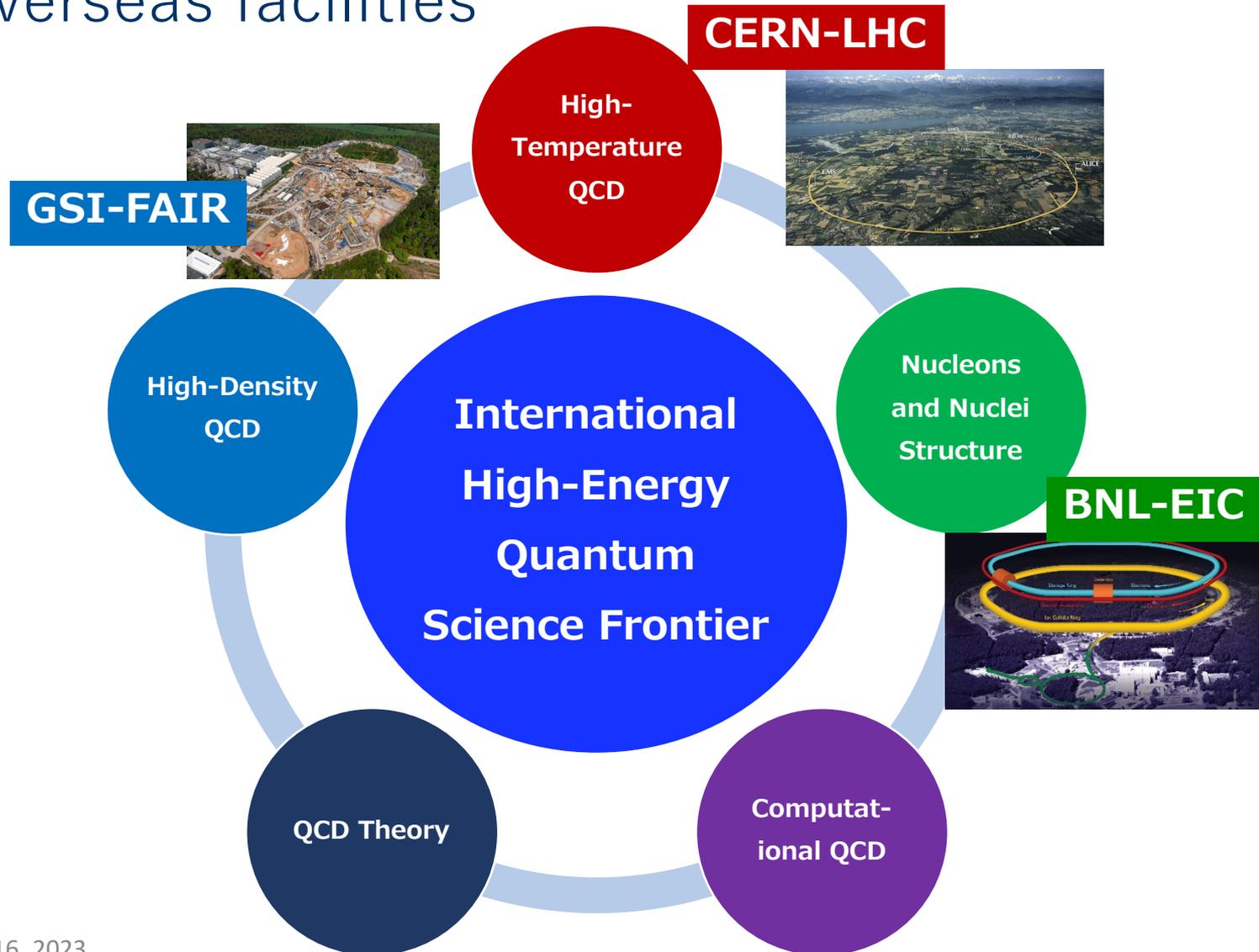
Yuji Goto (RIKEN/RBRC)

EIC-Japan activities

- 2019: Science Council of Japan Master Plan 2020 proposal of EIC
 - Collaboration including nuclear-physics community and high-energy community
 - Core institutions: Yamagata and RIKEN
 - Participating institutions: Kobe, Nihon, KEK, etc.
- 2020: Yellow Report
- 2020.5: eRD27 “developing a high resolution ZDC for the EIC”
- 2020.11: Expression of Interest (EOI) from EIC-Japan
- 2021.3-12: Call for detector proposal from the EIC project
 - EIC-Japan group participates in the ECCE detector consortium
- 2022: Science Council of Japan “Medium- and Long-term Research Strategy for Science” for "Future Science Promotion Initiative"
 - EIC project proposal submitted as a part of the “International High-Energy Quantum Science Frontier: QCD research at overseas facilities”
 - Prof. Gunji (CNS, Univ. of Tokyo) leading the proposal
 - Including LHC, FAIR, EIC, etc. and Theory

International High-Energy Quantum Science Frontier

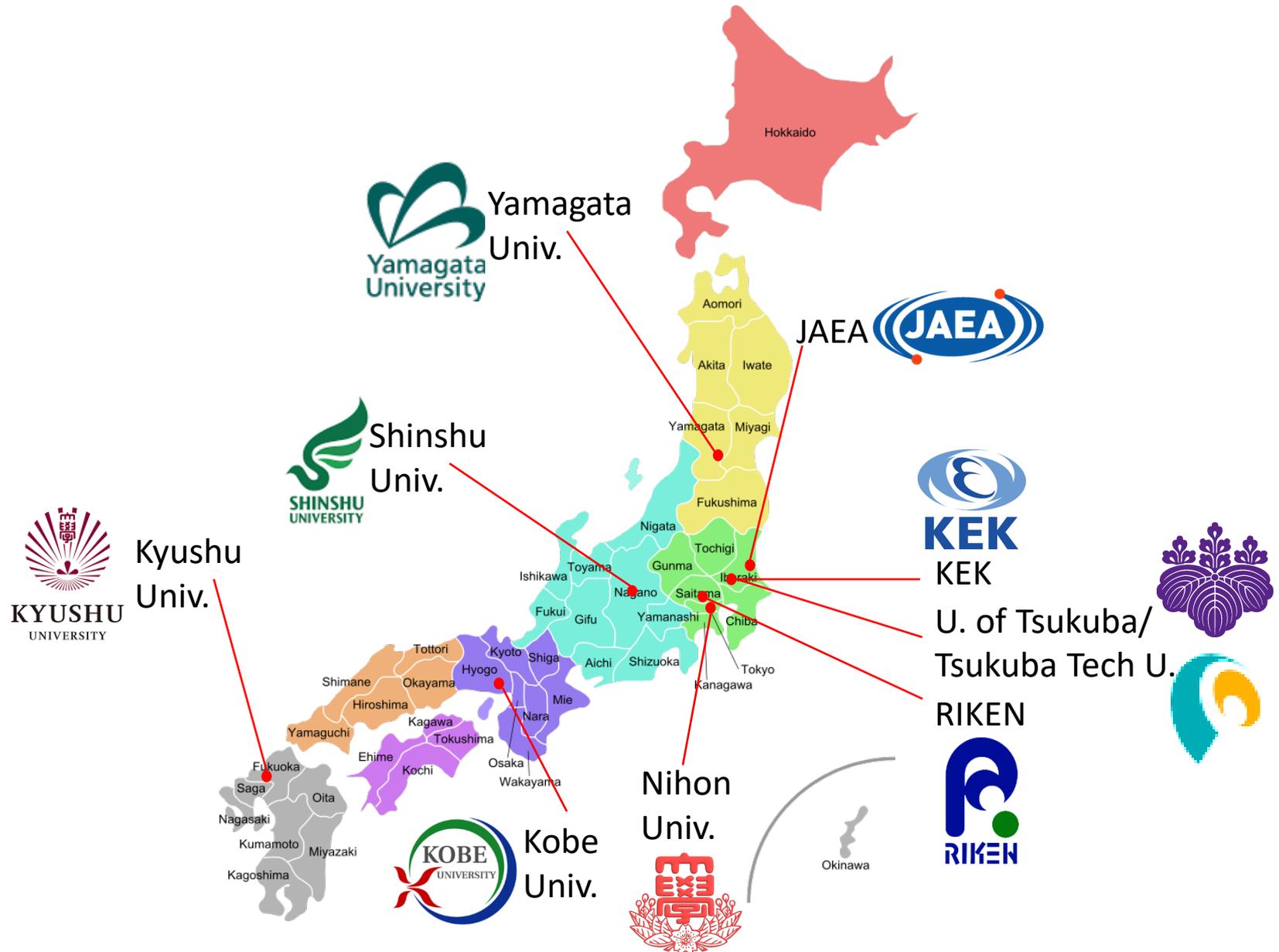
- Promote QCD research to be developed at overseas facilities



EIC-Japan activities

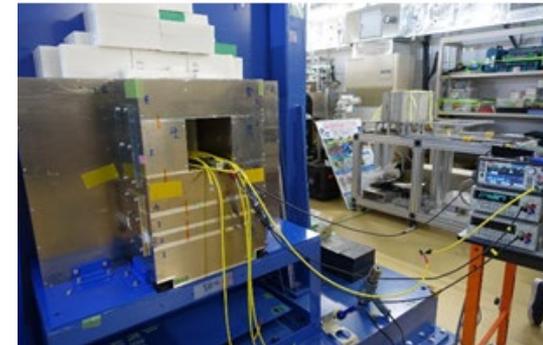
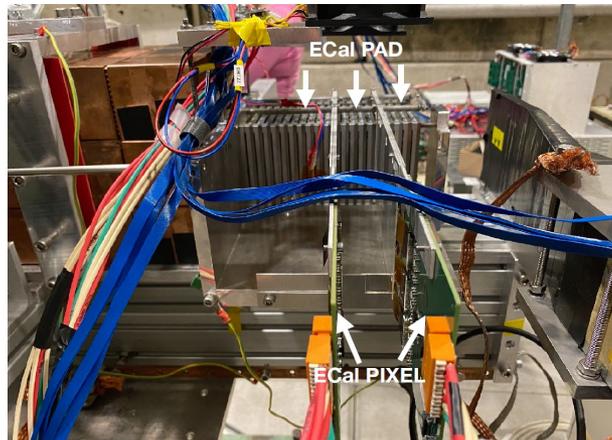
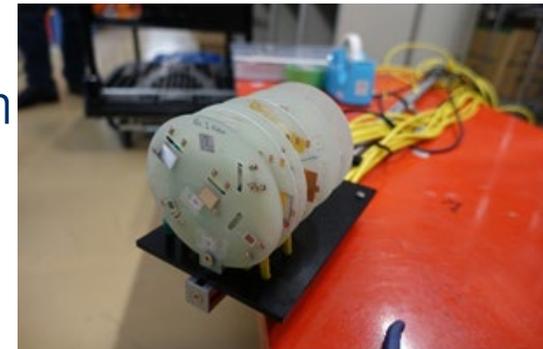
- This proposal to the Science Council of Japan to be a third pillar with J-PARC extension and RIBF upgrade, granted in Japanese Nuclear Physics Committee
- **Discussion of cooperation with Asian groups**
 - 2022.11.2-4 APCTP Workshop on the Physics of EIC (Incheon, Korea)
 - 2022.11.18 EIC Meeting in NCU (Taiwan)
 - 2023.3.16-18 EIC Asia Workshop at RIKEN Wako (This Workshop)

Interest in contributing to ZDC



Interest in contributing to ZDC

- ECCE/EPIC ZDC (Zero-Degree Calorimeter) design
 - Simulation, performance evaluation
 - Shimizu-san (RIKEN/JSPS) handing over to Po-Ju Lin (Academia Sinica)
- ALICE-FoCal-E technology: Tungsten/Silicon
 - Led by Univ. of Tsukuba (Prof. Chujo)
 - Development and evaluation with test beams
- Radiation tolerance test by neutron irradiation
- RIKEN, Tsukuba, Tsukuba Tech, Kobe, Shinshu, Yamagata, JAEA, Nihon, Kyushu, KEK

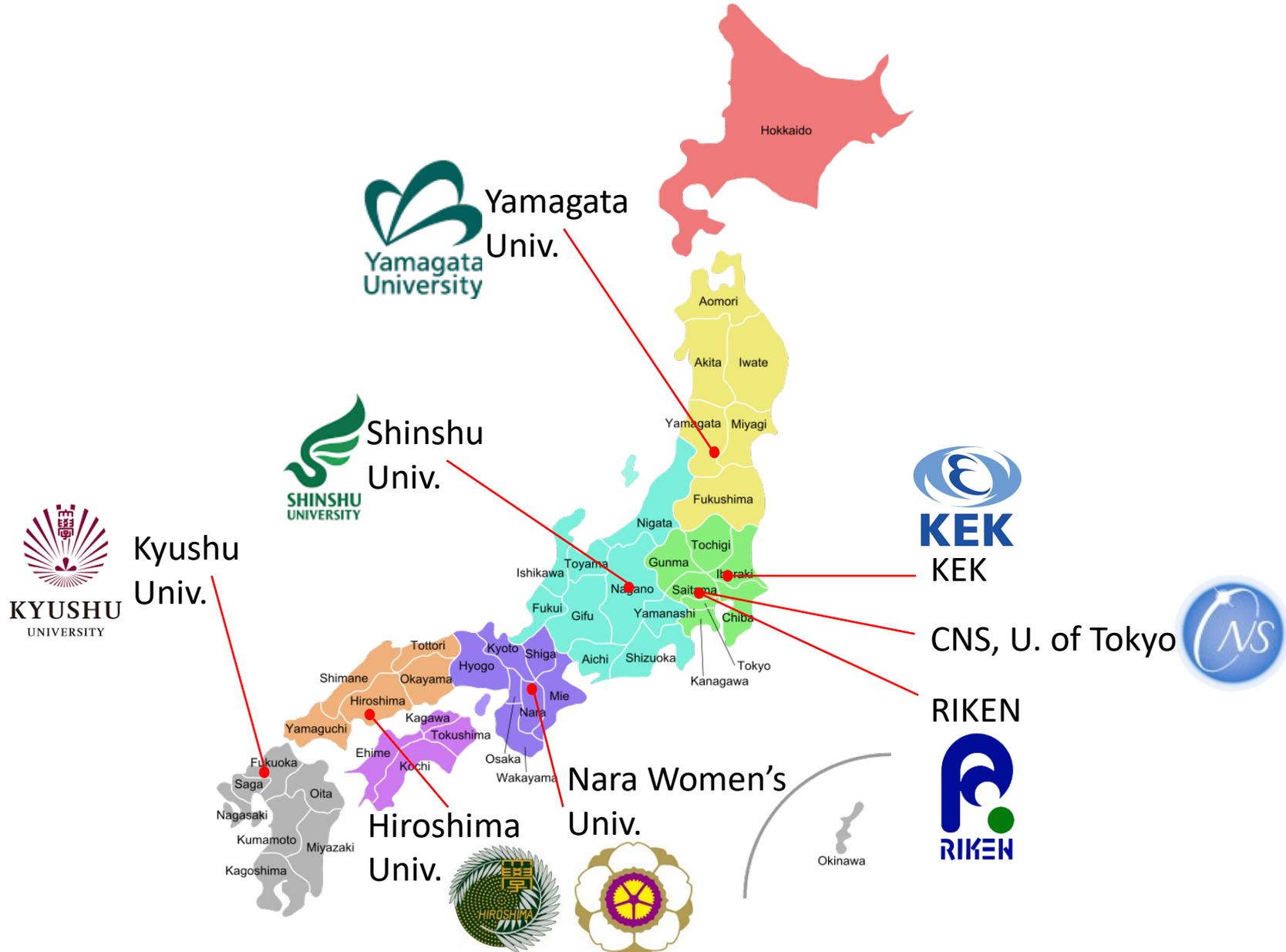


ECCE/EPIC ZDC

ALICE FoCal-E R&D
with test beams

Neutron irradiation
at RIKEN RANS

Interest in contributing to AC-LGAD Barrel



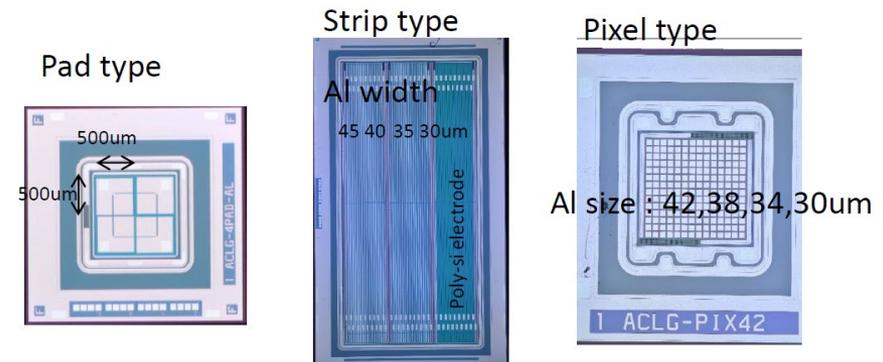
Interest in contributing to AC-LGAD Barrel

- Construction of AC-LGAD (Low-Gain Avalanche Detector) Barrel based on our past experience of PHENIX VTX silicon detector construction and present experience of sPHENIX INTT silicon detector construction
- HPK LGAD development by KEK group (Prof. Nakamura)
 - To be combined with some readout ASIC
- RIKEN, Hiroshima, Nara Women's, Shinshu, Yamagata, CNS Tokyo, Kyushu, KEK
 - Yano-san (Hiroshima) started the simulation calculation



sPHENIX INTT construction

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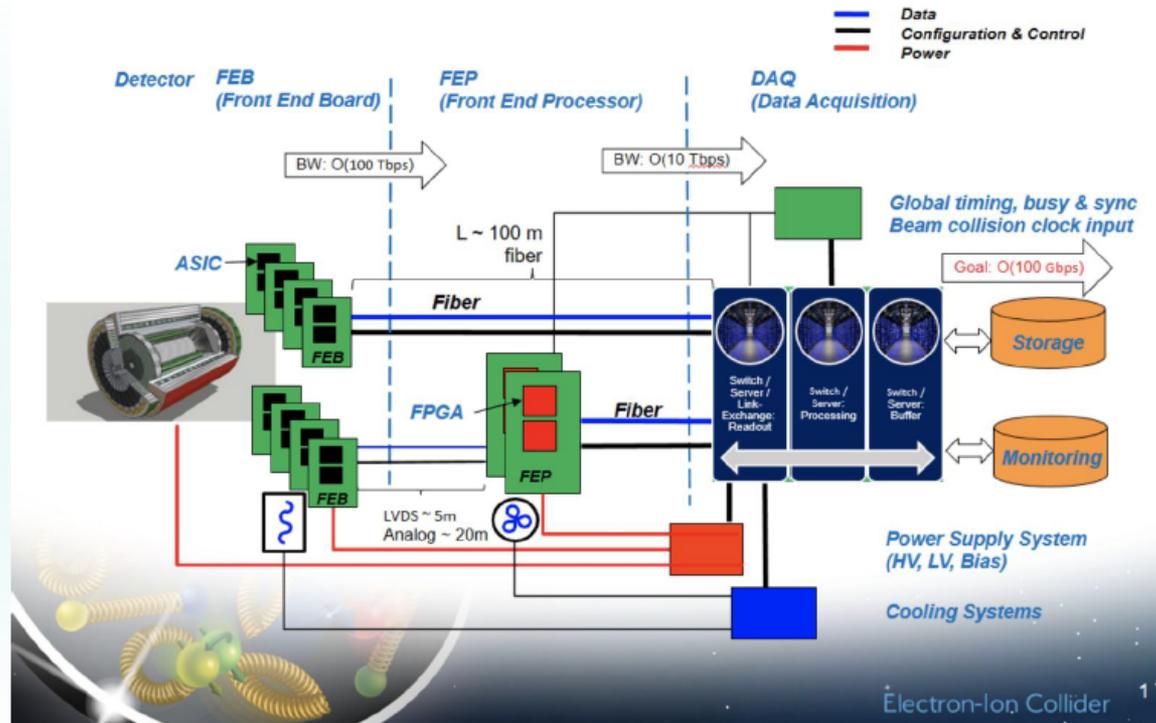


HPK LGAD development

Interest in contributing DAQ

- ▶ Free Streaming Readout and (near) real-time processing
 - ▶ Will be a future standard DAQ system

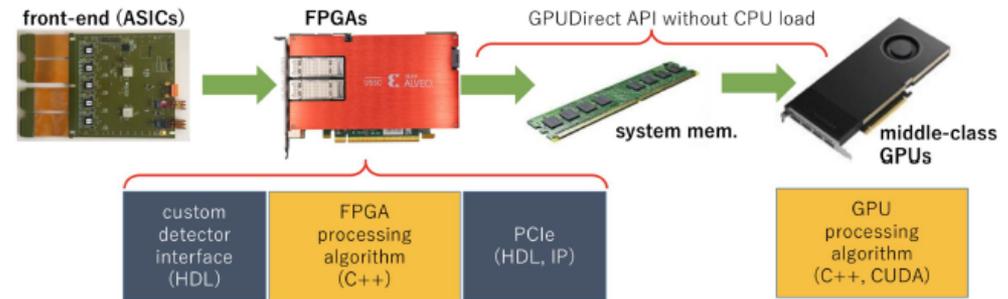
EIC Streaming Readout Architecture



Interest in contributing DAQ

Plans for ePIC

- Data processing and software trigger using hardware acceleration (FPGA, GPU, CPU)



EPIC Electronics / DAQ

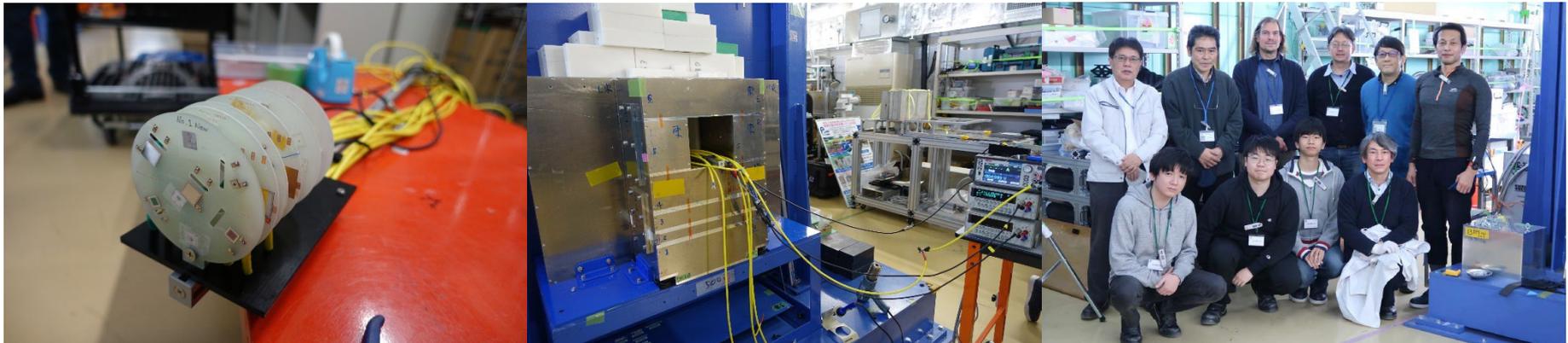
Standard Component Names and Functions

Name	Sensor	Adapter	Front End Board (FEB)	Readout Board (RDO)	Data Aggregation Module (DAM)	Computing
Sharing	Detector Specific	Detector Specific	Detector Specific	Few Variants	Common	Common
Function	-Multi-Channel Sensor	-HV/Bias distribution -HV divider -Interconnect routing	-Amplification -Shaping -Digitization -Zero Suppression	-Communication -Aggregation -Formatting -Data Readout -Config & Control -Clock & Timing	-Computing Interface -Aggregation -Software Trigger -Clock & Timing -Config & Control	-Data buffering and sinking -Run Control -Calibration Support -QA / Scalers -Collider Feedback -Event ID/Building? -Software Trigger -Monitoring
Attributes	-MAPS -AC-LGAD -MCP-PMT -SIPM -LAPPD	-Sensor Specific -Passive	-ASIC/ADC -Discrete -Serial Link	-FPGA -Fiber Link	-Large FPGA -PCIe -Potentially Ethernet	

Any collaboration is more than welcome!

RANS Neutron Irradiation Test

- RIKEN RANS
 - 7MeV proton beam, $100\mu\text{A}$, 6×10^{13} proton/s
 - Maximum current stable produced about $40\mu\text{A}$
 - Neutron 5MeV max, 10^{12} neutron/s from the Be target
 - 2cm from the target: 10^8 neutron/cm²/s
- 2022.3.3-4 first irradiation test
- 2023.3.7-8 second irradiation test
 - Tested FoCal-E Pad p-type/n-type baby-chip/MPD, APD/SiPM for readout of crystal calorimeter
 - Monitored by MPD from Kyushu Univ., Indium foil, and thermistor

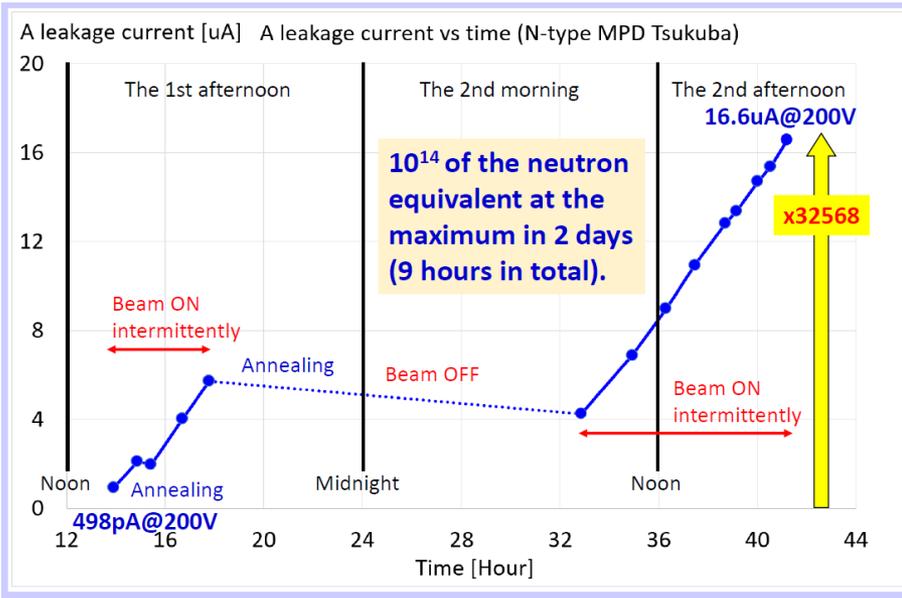


RANS neutron irradiation test

- 10^{14} neutron/cm² at the maximum in 2 days, 9 hours in total
- Recorded online a leakage current of the n-type MPD (monitor photo-diode)
- Comparison of the C-V characteristics of the n-type MPD before and after the irradiation
 - Full-depletion voltage: 35V → 85V

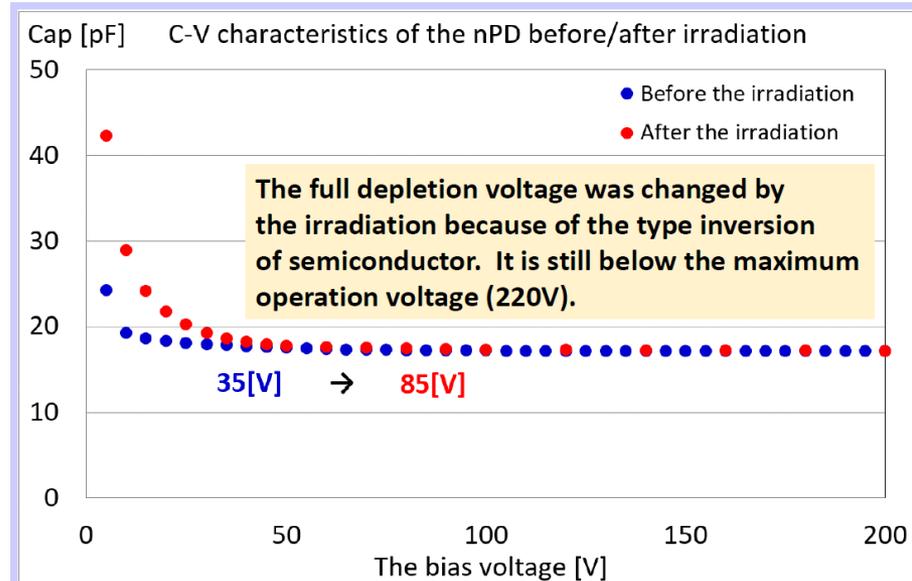
Inaba-san's slides

The n-substrate monitor PD



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The C-V characteristics of n-substrate MPDs



AC-LGAD discussion

- 2022.10 discussion at VERTEX 2022 conference in Tateyama
- 2022.11 discussion of the US-Japan Science and Technology Cooperation Program in High Energy Physics
 - 2022.12 submitted by Prof. Miyachi (Yamagata Univ.) and Dr. Tricoli (BNL)
 - Dr. Tricoli to provide test boards to Hiroshima Univ, RIKEN, and Taiwan group (coming soon)

AC-LGAD Test Setup

To be provided from BNL

To be prepared by users

PC Ubuntu 22.04
Python or C/C++
TCP/IP Client

C/C++ base DAQ software
(IJCLAB&Omega)
Ubuntu 22.04

Ethernet

EIC-ROC0

AC-LGAD(BNL)

Wirebonded

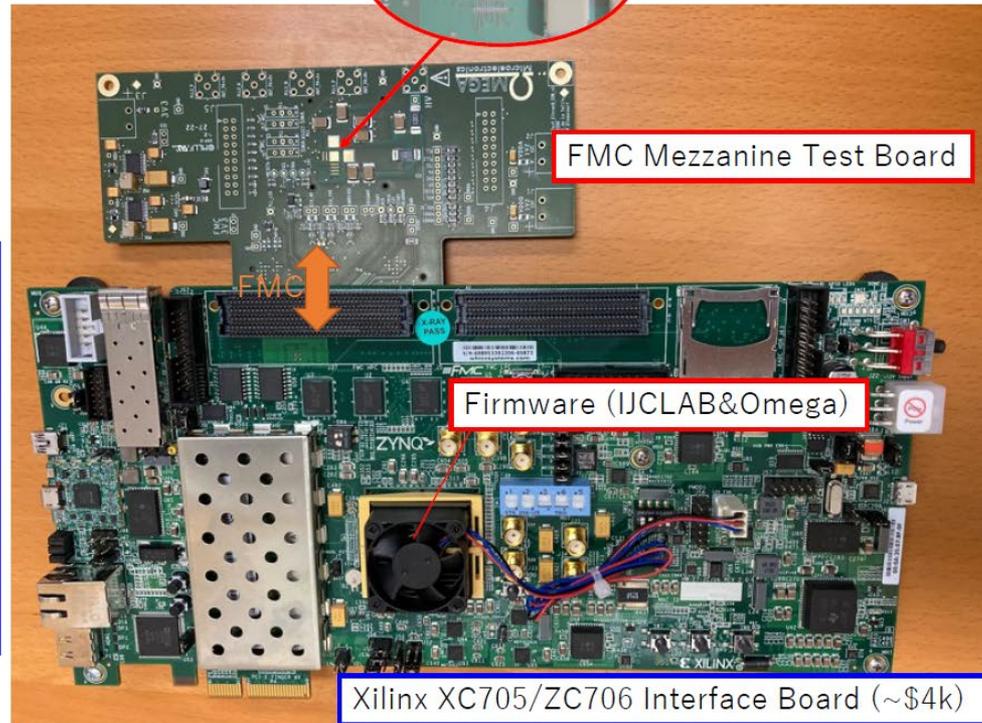
Nakagawa-san's
slides

FMC Mezzanine Test Board

FMC

Firmware (IJCLAB&Omega)

Xilinx XC705/ZC706 Interface Board (~\$4k)



AC-LGAD discussion

- 2022.11.30 BNL Facility Tour by Dr. Tricoli

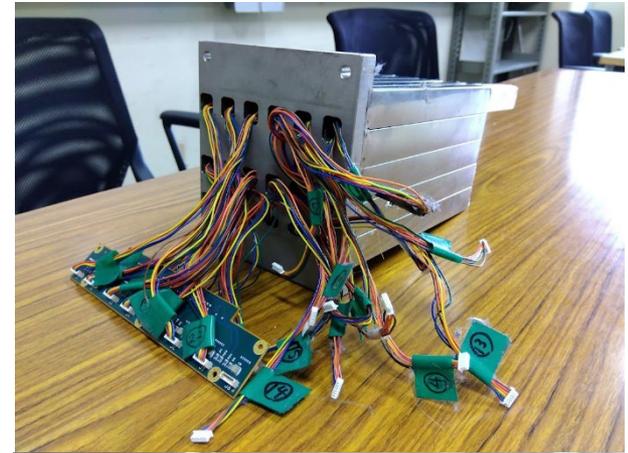


- 2022.12.15 KEK Facility Tour by Prof. Nakamura (KEK)



Crystal Calorimeter

- ALICE-Phos PWO prototype
 - Hiroshima Univ.
 - 2cm x 2cm x 18cm
 - APD readout
 - Shipped to RIKEN
- LYSO crystal by Taiwan group
 - Offer from Taiwan Group for test module production, simulation calculation, etc.
- Considering evaluation using a test beam



Summary

- Significant progress in 2022 EIC-Japan activities
- “International High-Energy Quantum Science Frontier: QCD research at overseas facilities” submitted to Science Council of Japan "Future Science Promotion Initiative"
- Discussion of EIC cooperation with Asian groups
- Interest in contributing to ZDC, AC-LGAD Barrel and free streaming DAQ system of the ePIC experiment

Backup Slides

EIC Activities in Japan

- Interest in contributing to ZDC
- Interest in contributing to AC-LGAD Barrel
- Interest in contributing to Free Streaming DAQ system (Gunji)

EIC-Japan activities

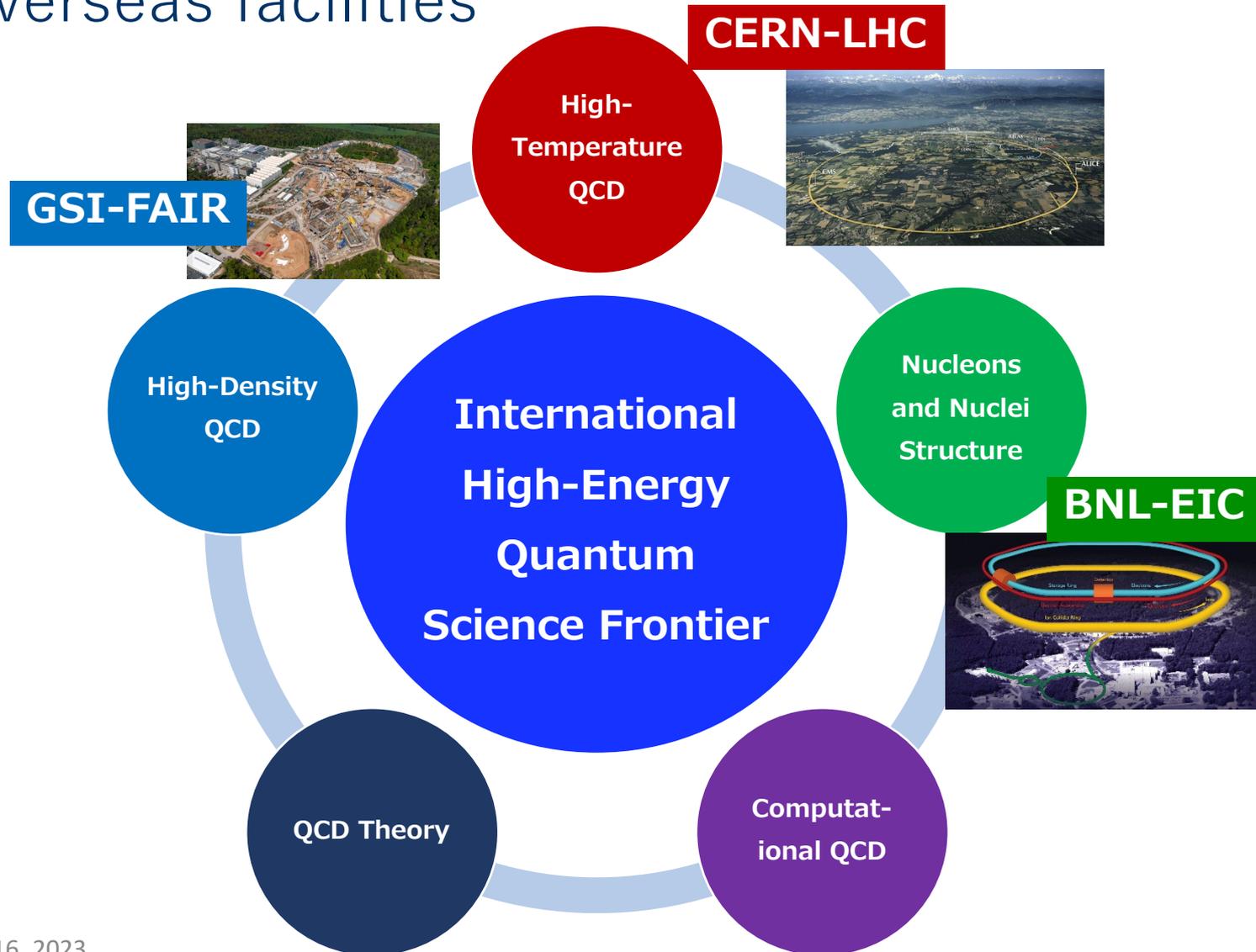
- 2015.4: EIC Letter of Interest from Asian countries
 - 20 participants from Japan: RIKEN, Yamagata, Tokyo Tech, Juntendo, KEK, Kyorin, Kyoto, Niigata, Tohoku, Tokyo Science
 - 7 from China, 3 from India, 4 from Korea
 - To support EIC for NSAC Long Range Plan 2015
- 2019: Science Council of Japan Master Plan 2020 proposal of EIC
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 - Prof. Gunji (CNS, Univ. of Tokyo) leading the proposal
 - Including LHC, FAIR, EIC, etc. and Theory
- This proposal to the Science Council of Japan to be a third pillar with J-PARC extension and RIBF upgrade, granted in Japanese Nuclear Physics Committee
- Dr. Koyasu (head of RIKEN Cluster for Pioneering Research) agreed to host this proposal
 - Leading international-collaboration experiments on a long-term basis at overseas facilities
 - Development of common technologies (detector, data processing, and computation technologies)
 - Cooperation between domestic experiment and theory communities
 - Cooperation among experiments according to project trends
 - A major international-collaboration center connecting Japan, Europe, and the U.S.
 - International circulation of cutting-edge knowledge, technology, and people, and human resource development for the next generation

International High-Energy Quantum Science Frontier

- Promote QCD research to be developed at overseas facilities



EIC-Japan activities

- 2022.5: Akiba-san's grant application to "Fund for the Promotion of Joint International Research"
 - Selected for hearing, but unfortunately not accepted
 - To be applied again for next year
 - Following this discussion, CNS, U. Tokyo (Gunji) and Hiroshima U. (Shigaki) joined EIC
- 2022.9: Visit to MEXT
 - Office for Particle and Nuclear Research Promotion, Basic and Generic Research Division, Research Promotion Bureau: Mr. Ishikawa (Director), Mr. Morikawa (Unit Chief), Ms. Kumagai (Senior Specialist)
 - Attendance: Goto, Akiba (RIKEN), Miyachi (Yamagata U.), Shigaki (Hiroshima U.), Yamazaki (Kobe U.)
 - Absence: Gunji (CNS, U. of Tokyo)
 - Presentation and discussion on EIC project, EIC User Group, EPIC collaboration, EIC-Japan group, and the Resource Review Board (RRB)

EIC-Japan activities

- **Preparing for RRB Meeting**
 - DOE forms RRB (Resource Review Board) for experimental program (detector construction)
 - Committee of representatives of national funding agencies
 - Representatives of national funding agencies are invited to participate
 - Individual discussion and individual response
 - 2022.10 Pre-RRB Meeting (Zoom)
 - 2022.11 DOE-NP face-to-face meeting with national funding agencies (Washington, DC)
 - 2023.4 First RRB Meeting (to be held in Long Island)
- **Discussion of cooperation with Korea and Taiwan (Asian) groups**
 - 2022.11.2-4 APCTP Workshop on the Physics of EIC (Incheon, Korea)
 - 2022.11.18 EIC Meeting in NCU (Taiwan)
 - 2023.3.16-17 (3.18 optional extra day) EIC Asia Meeting to be held at RIKEN Wako
- **Prof. Gunji (CNS, Univ. of Tokyo) will lead the EIC-Japan**
 - Young PI with strong leadership and a long-term commitment to the EIC project
 - 2023.1.5 Visit to MEXT by Prof. Gunji and Prof. Nakano (RCNP, Osaka Univ.) to be continuing discussions

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