

Activity of the Korean community for EIC

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Future Collider Workshop
2021.08.26



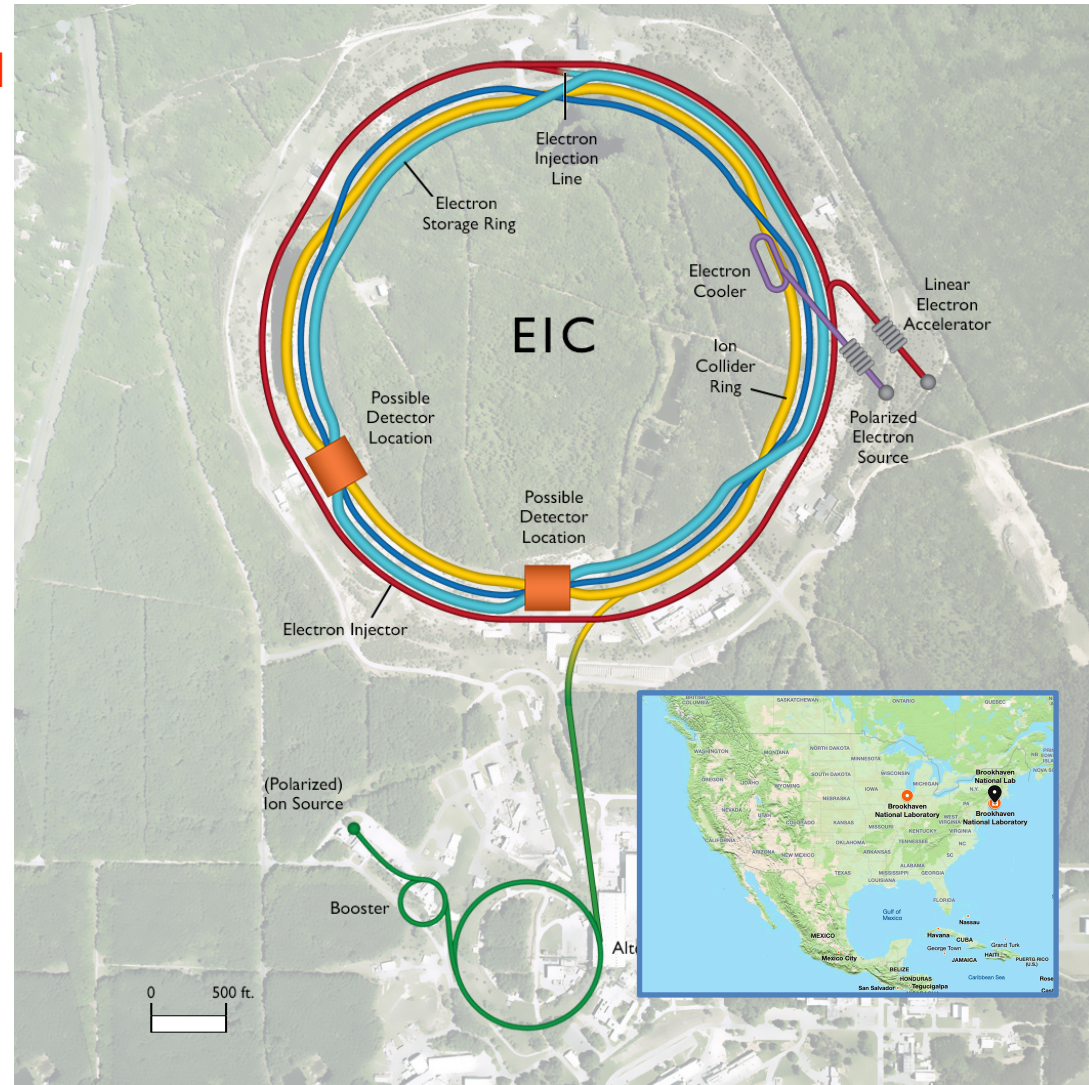
Electron Ion Collider (EIC)

World's first collider for polarized e+p and e+A collider

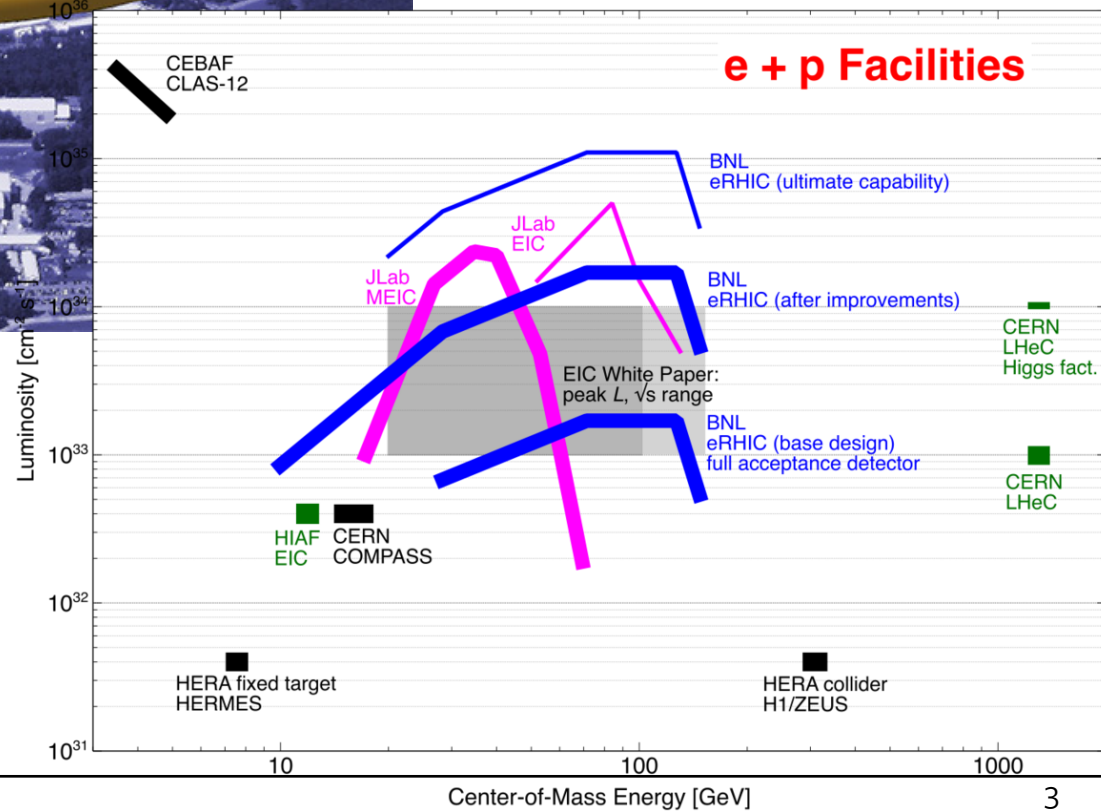
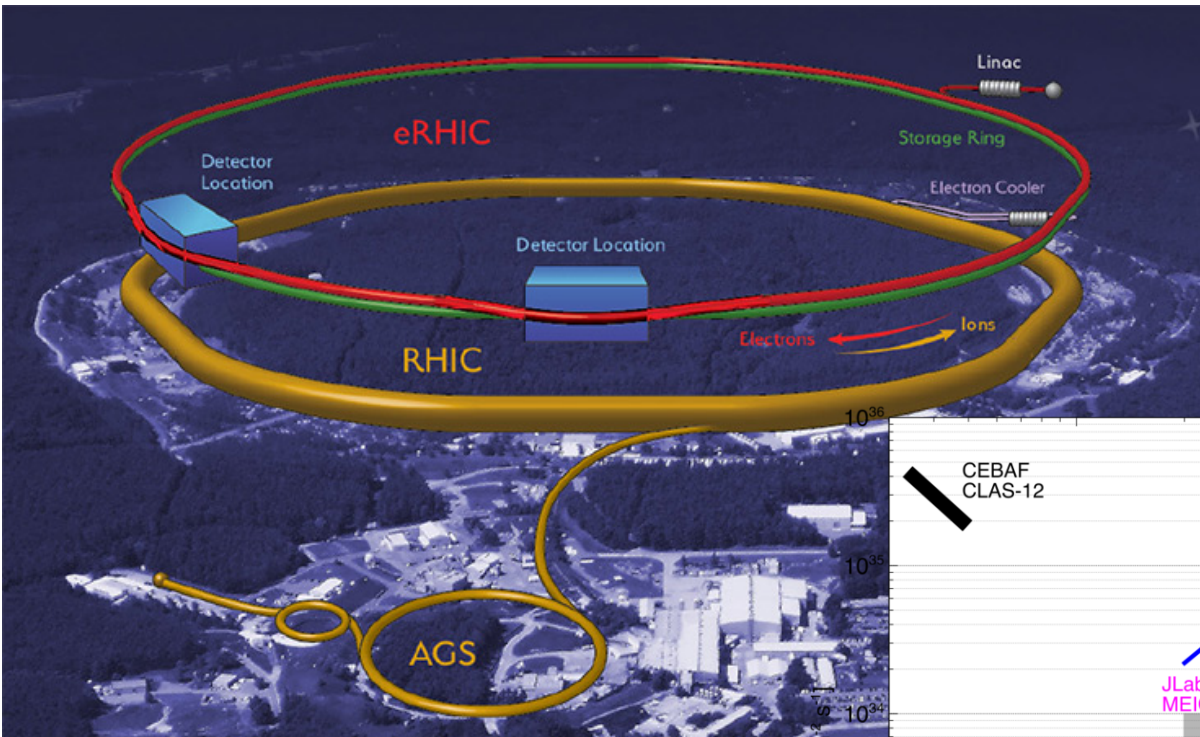
- High luminosity $\sim 10^{34} \text{ cm}^{-2}\text{s}^{-1}$
- E_{cm} = up to $\sim 100 \text{ GeV}$
- 2+ interaction points
- To be constructed at BNL in ~ 2030

Physics programs

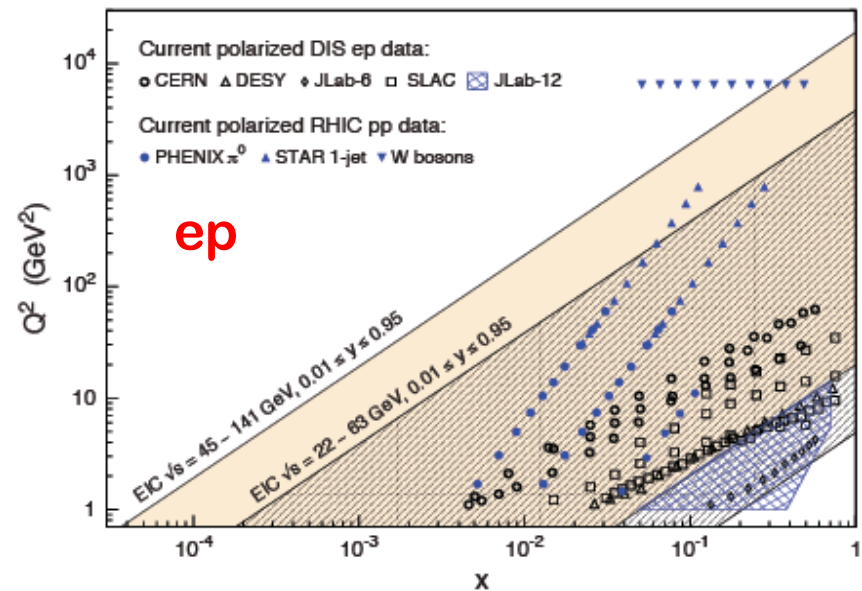
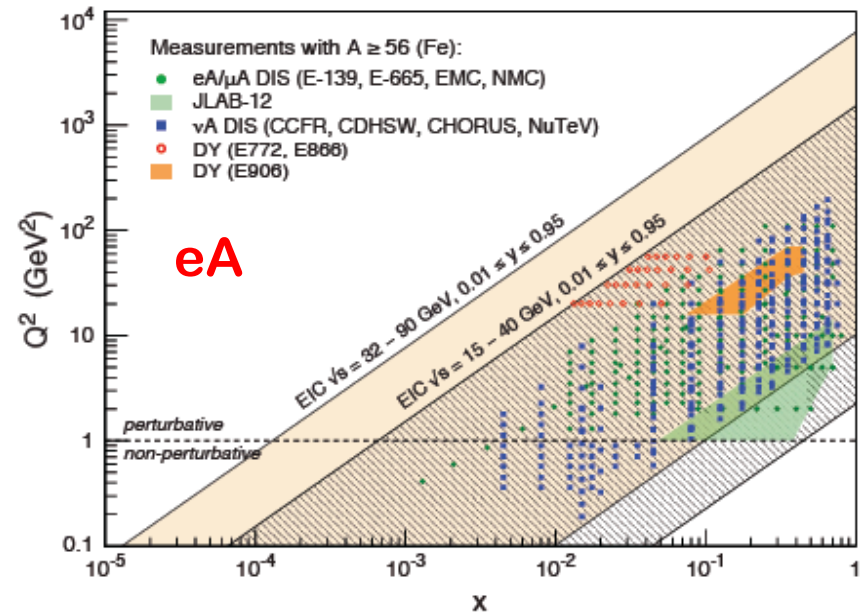
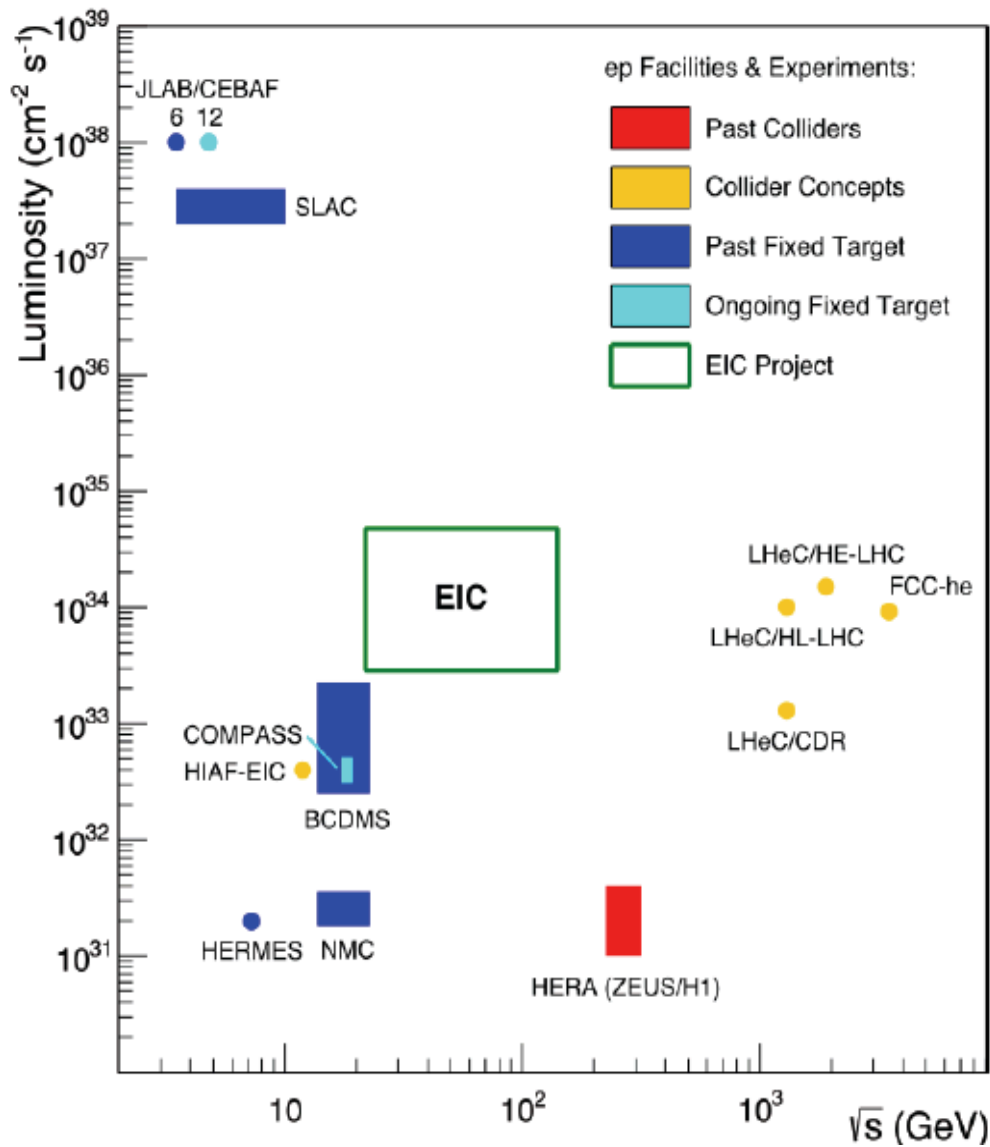
- Origin of nucleon mass
- Origin of nucleon spin
- Properties of dense parsonic systems



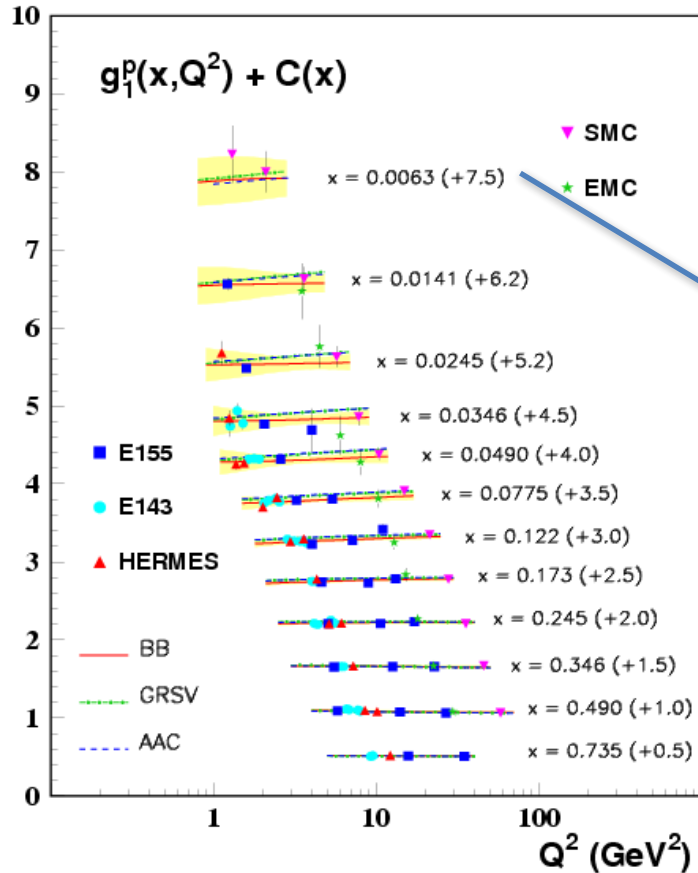
Why at BNL?



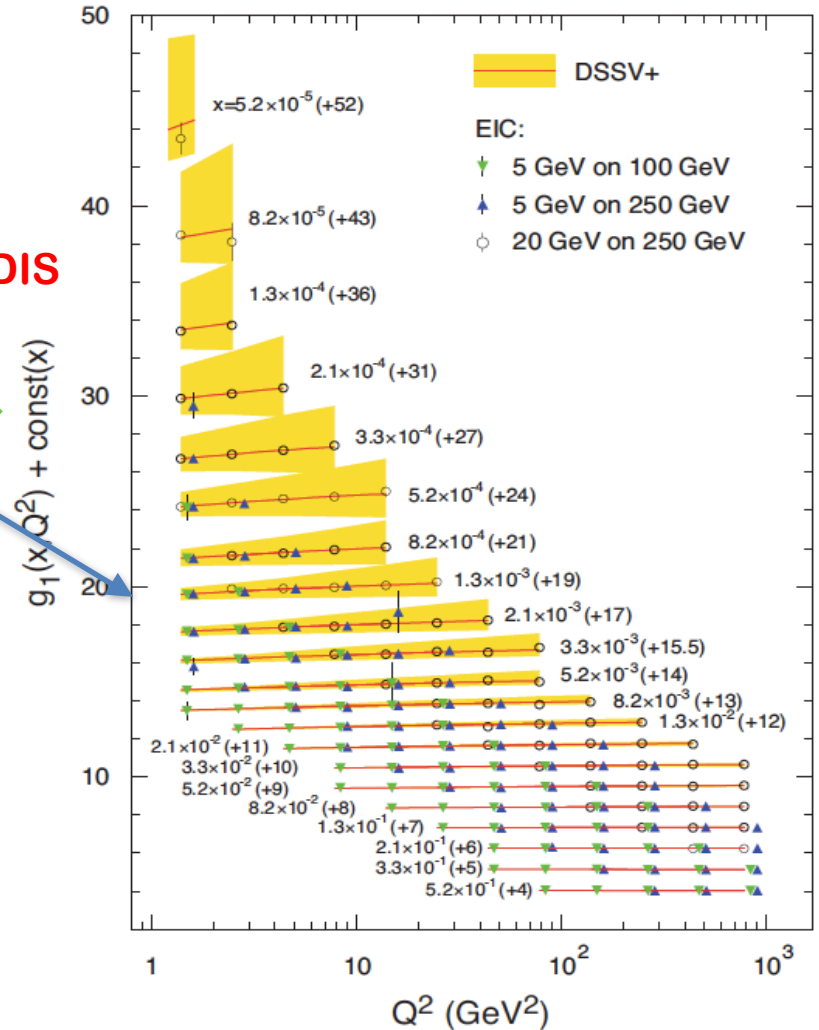
Deep(est) inelastic scattering



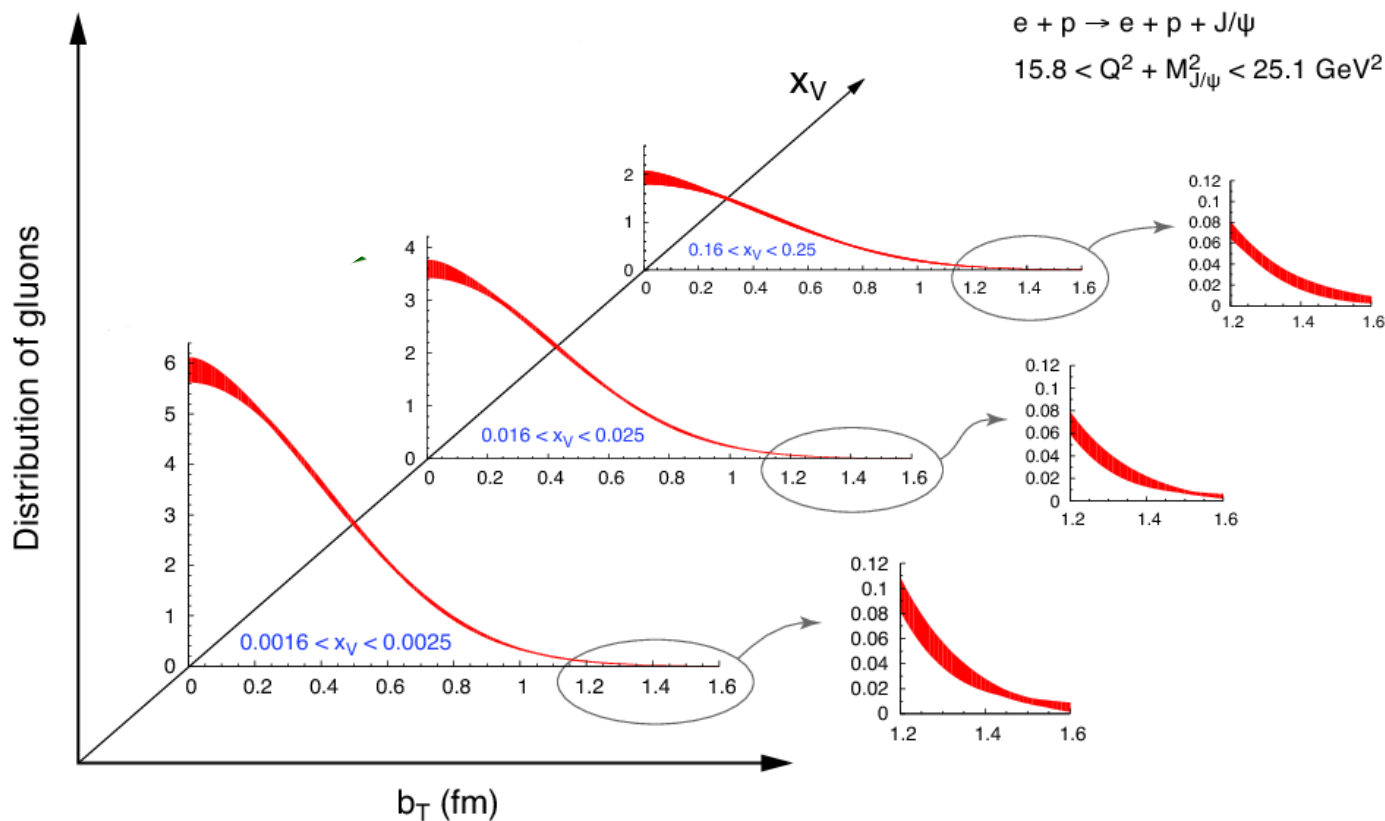
Unprecedented precision for proton spin structure



**Polarized DIS
at EIC**

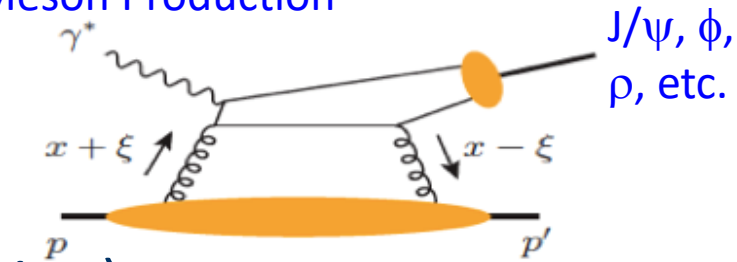


Tomography of nuclei

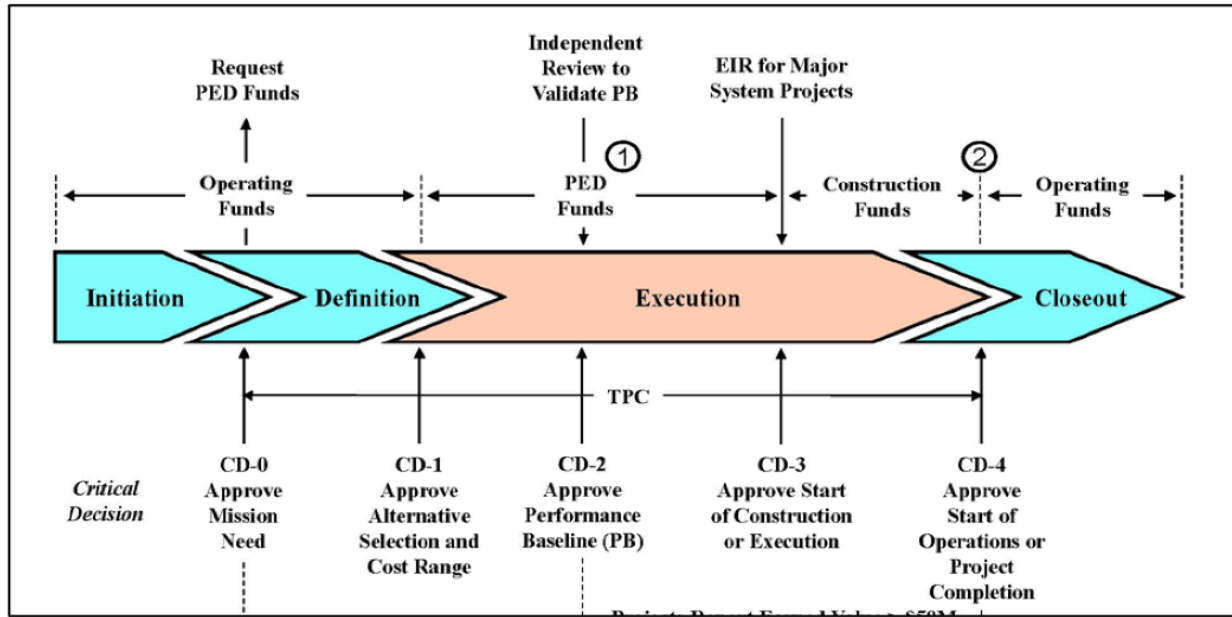


- GPD : generalized parton distribution
- Imaging gluons with 3 degrees-of -freedom
- Probed by mesons in DVCS(deeply virtual compton scattering)

Meson Production



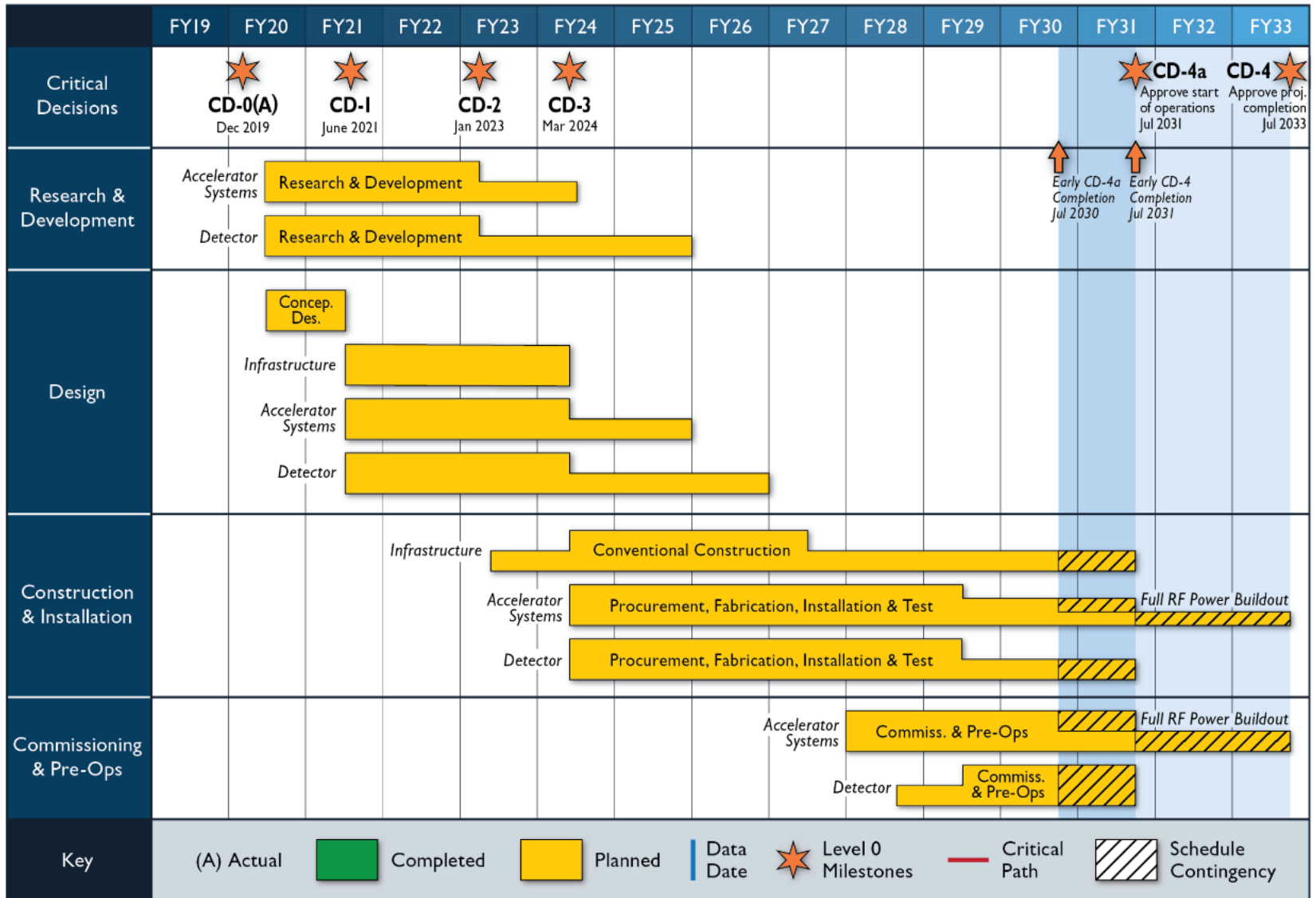
DOE approval schedule



- CD-1 approved in July 2021

Level 1 Milestones	Reportable Milestone Date
CD-0 Approve Mission Need	Q1FY20(A)
CD-1 Approve Alternative Selection and Cost Range	Q3FY21
CD-2 Approve Performance Baseline	Q2FY23
CD-3 Approve Start of Construction	Q3FY24
Early CD-4a Completion	Q4FY30
CD-4a Approve Start of Operations or Project Completion	Q4FY31
Early CD-4 Completion	Q4FY31
CD-4 Approve Start of Operations or Project Completion	Q4FY33

Construction Timeline



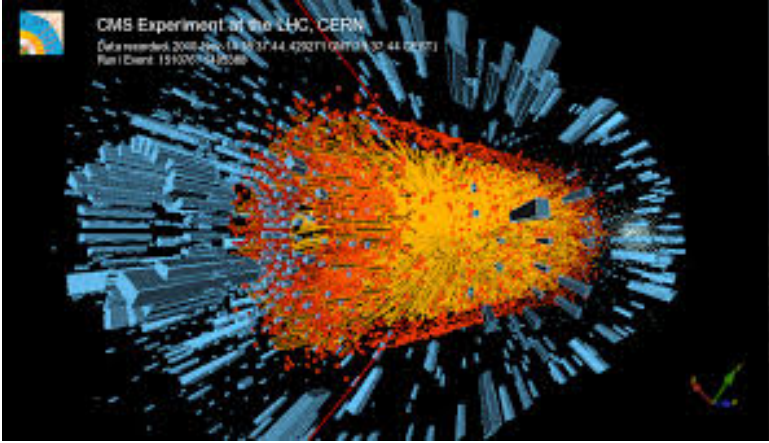
Korean nuclear physics groups



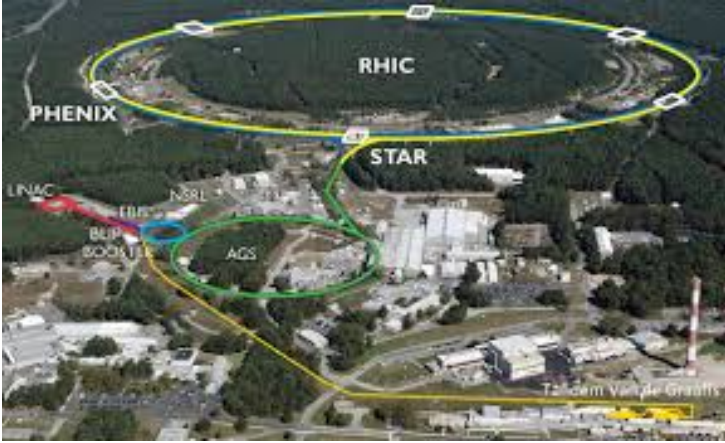
- Korean groups working for relativistic heavy ion collision experiments ($\sqrt{s_{NN}} > O(10) \text{ GeV}$)

Korean heavy ion physicists are involved in...

CMS, ALICE



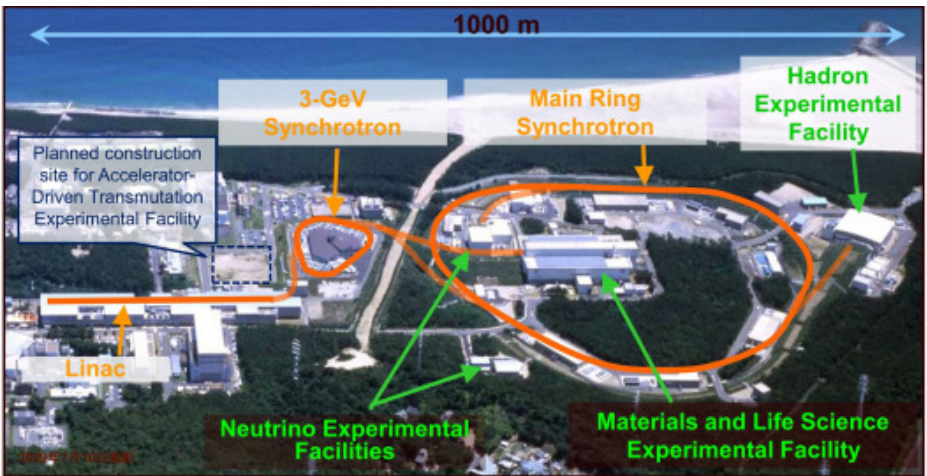
PHENIX, sPHENIX, RHICf



JLab



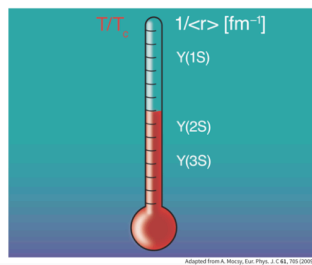
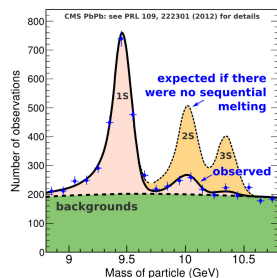
J-PARC



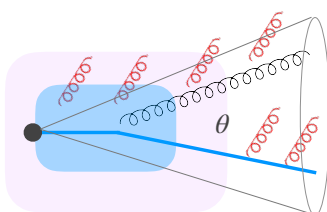
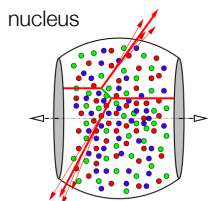
Interest of Korean heavy ion physicists

Hard Probes

Quarkonia modification

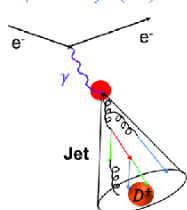


Jet quenching

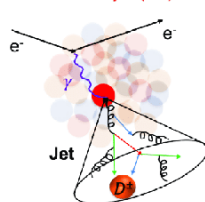


Heavy flavor

$$e^- + p \rightarrow e^- + jet(D^\pm) + X$$

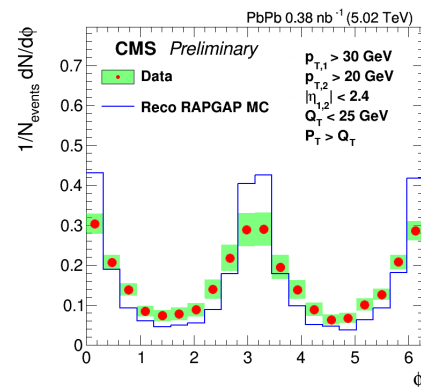


$$e^- + Au \rightarrow e^- + jet(D^\pm) + X$$

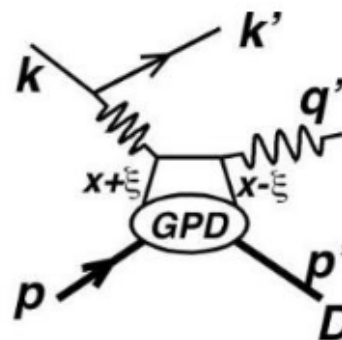


Electromagnetic probes

Photo-production in UPC



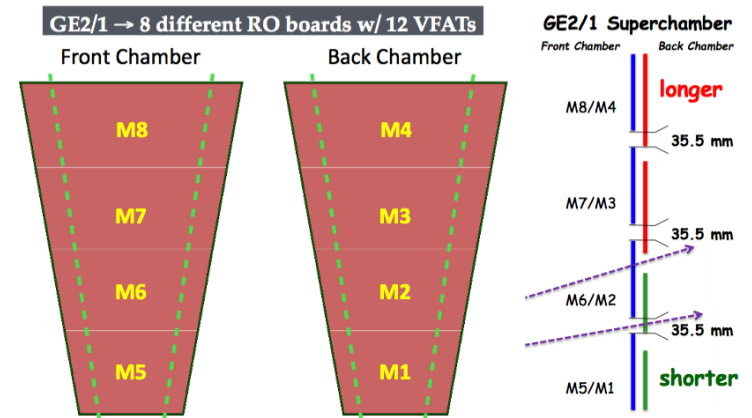
Electron scattering



Precedent contribution for international collaboration

RPC gap production for CMS

- A longstanding hardware activity from 1990s by Korean high energy & nuclear physics groups

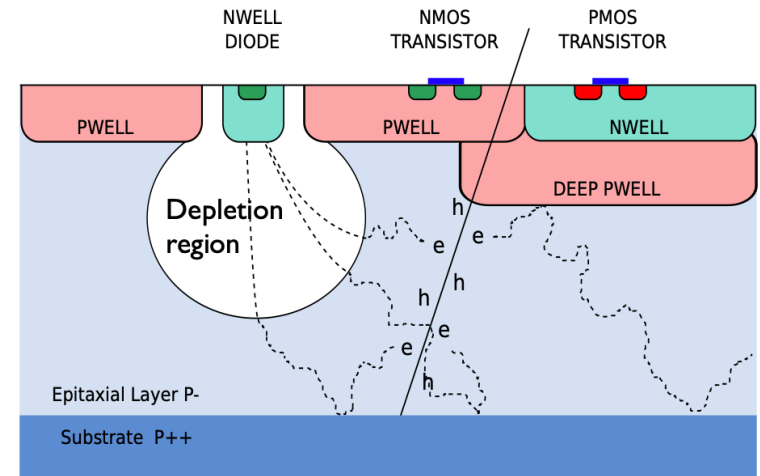


GEM foil for CMS

- CMS phase2 upgrade
- R&D from 2014 by K-CMS group

MAPS upgrade for ALICE ITS

- R&D for Pixel chip design and beam test
- Ko-ALICE groups - Inha Univ., Yonsei Univ., Pusan Natl. Univ.



Expression of Interest

- EOI for potential cooperation on the EIC program was called
- A consortium of 13 faculties from 9 Korean institutes was formed and submitted the EOI in Nov. 2020

Group	Devoted to	Institutions	Faculties
A	Forward Calorimeter	Korea University	Byungsik Hong Jung Keun Ahn
		Sejong University	Yongsun Kim
		Chonnam National University	Dongho Moon
B	Pixel Tracker	Jeonbuk National University	Eun-Joo Kim
		Pusan National University	Sanghoon Lim
		Yonsei University	Youngil Kwon
		Inha University	Minjung Kweon
C	Dual-Readout Calorimeter	Kyungpook National University	Hyon-Suk Jo Sehwook Lee
		University of Seoul	Jason Lee
		Yonsei University	Hwidong Yoo

Expression of Interest

Group A (Forward Cal)	R&D of forward calorimeters, including neutron detectors at the very forward region.
Group B (Pixel Tracker)	Development, test, and production of silicon pixel detector
Group C (Dual-Readout)	single component calorimeter technique including entire functionalities of both electromagnetic and hadronic calorimeters

- **Group A (forward calorimeter)**
 - Development of prototypes and electronics for the forward calorimeters, including the very forward neutron detector.
 - Inspired by the physics interest of the heavy ion groups involved in CMS, PHENX, and RHICf
 - Open to collaboration with other institutions (RIKEN, ISU, KU)

Expression of Interest

Group A (Forward Cal)	R&D of forward calorimeters, including neutron detectors at the very forward region.
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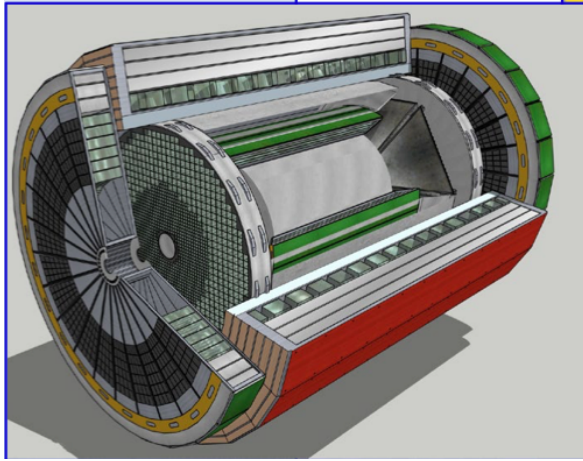
- **Group B (pixel tracker)**
 - R&D of silicon sensor and production
 - Institutions in this group have also been participating in sPHENIX and ALICE
 - Basic R&D infrastructures for ALICE ITS2 and ITS3 upgrade projects in Korea can be utilized for the EIC project as well.

Expression of Interest

Group A (Forward Cal)	R&D of forward calorimeters, including neutron detectors at the very forward region.
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Group C (Dual-Readout)	single component calorimeter technique including entire functionalities of both electromagnetic and hadronic calorimeters

- Group C (dual-readout)
 - Well established hardware facilities
 - HEP detector facility at Kyungpook Natl. Univ. (KNU)
 - DRC R&D center at Yonsei University
 - Supercomputing centers at KNU and Univ. of Seoul
 - Currently building prototype detector of dual-readout calorimeter
 - 5-year Funding for dual-readout R&D is secured (\$2M for 2020 - 2025)

Detector Proposals for EIC

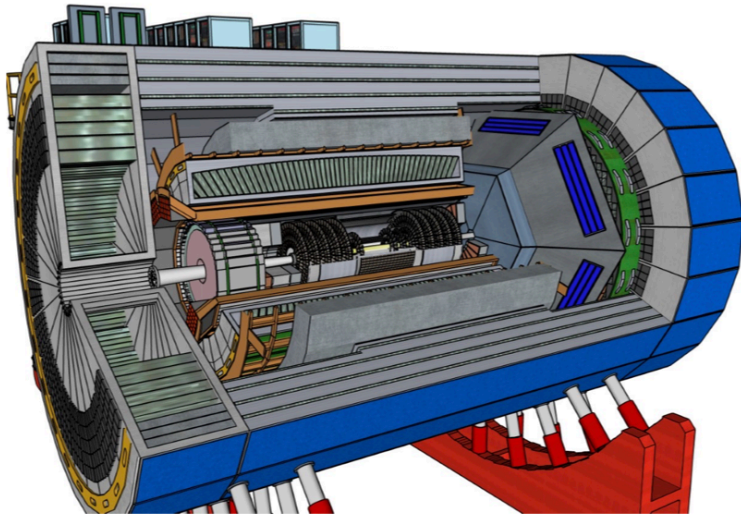


AHTENA

A Totally Hermetic Electron-Nucleus Apparatus

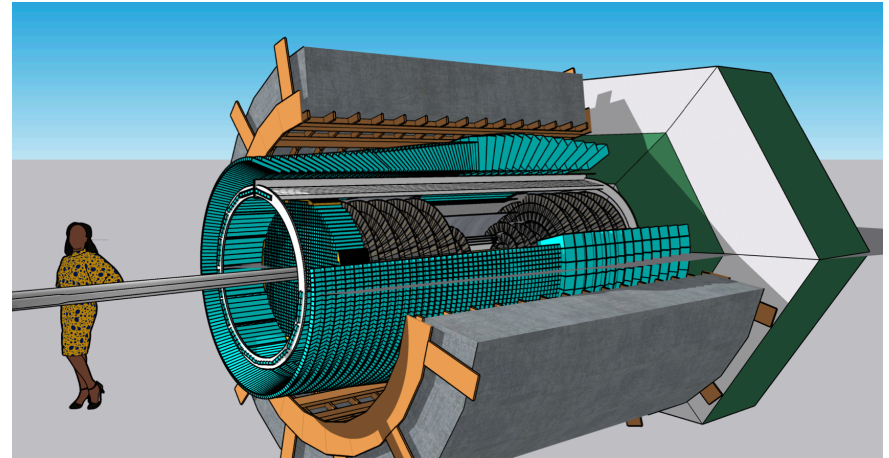
ECCE

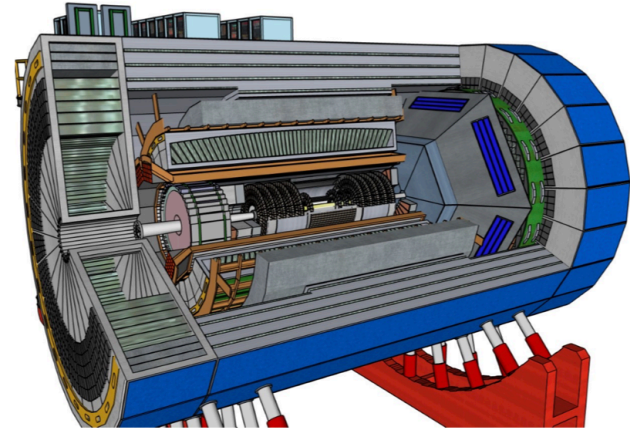
EIC Collider Experiment



CORE

a COmpact detectoR for the EIC





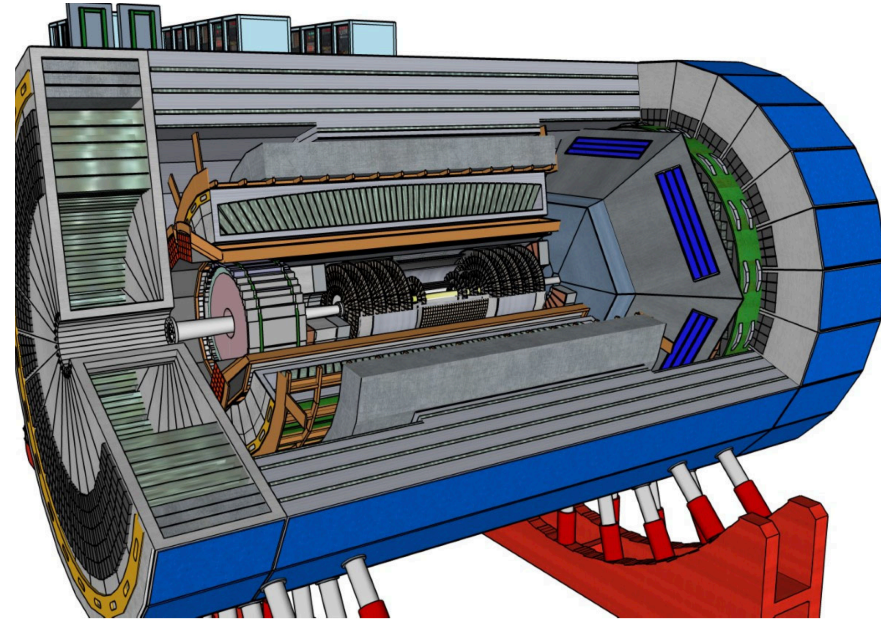
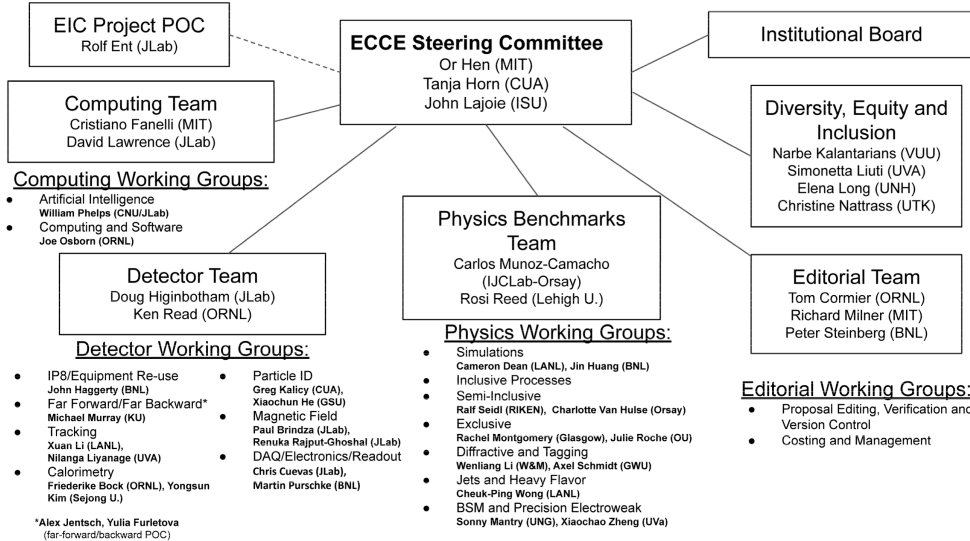
ECCE is developing a low-risk, cost-effective, flexible and optimized EIC detector, capable of delivering on the full EIC physics program!

Guiding principles:

- Reuse: 1.5T BaBar solenoid / detectors / infrastructure (as much as possible)
- Explore both EIC interaction regions (i.e. with/out secondary focusing)
- Respond to 'Detector 1' EIC call for proposals (i.e. ready for CD4a)
- Share & support community vision that the EIC science mission is best served by two detectors

[Group C] Participation in ECCE consortium

ECCE Consortium

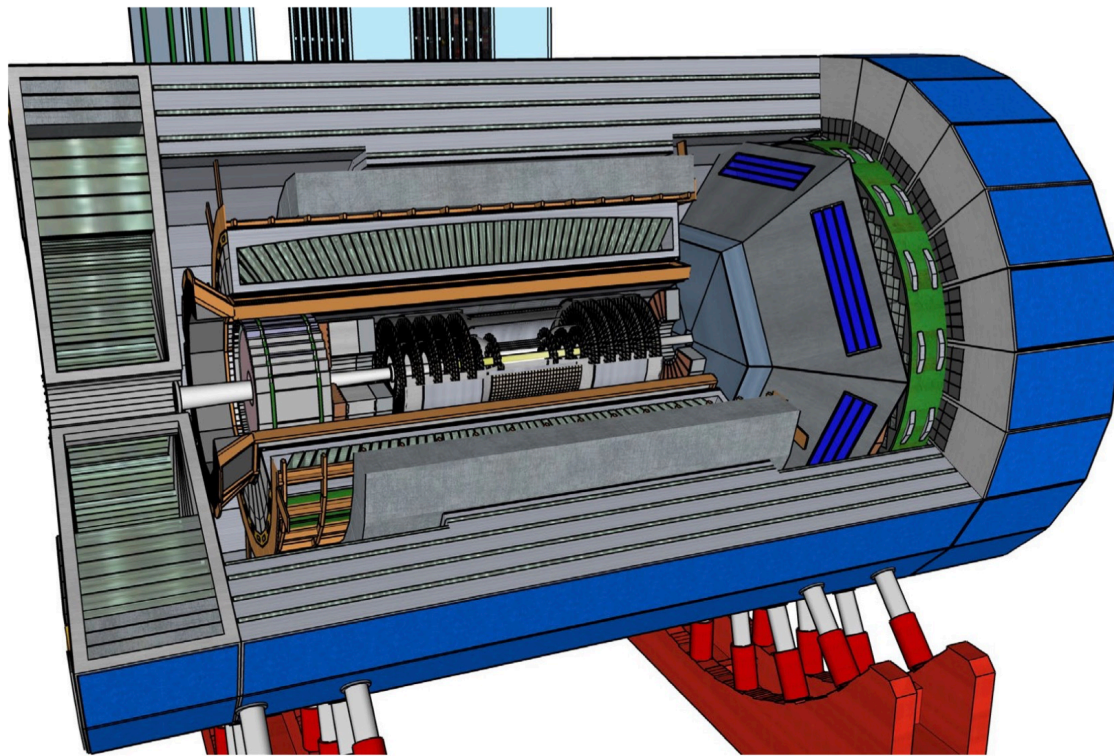


5/10/2021

ECCE 4th IB Meeting

- Proposed to build detector on the foundation of existing infrastructure at RHIC and JLab
- Korean Dual-readout team is actively involved in the forward calorimeter studies

ECCE Detector Layout



ELECTRON ENDCAP

Tracking: Si discs + Large area μ RWELL

Electron Detection:

- Inner: PbWO₄ crystals (reuse some)
- Outer: SciGlass (backup PbGI)

h-PID: mRICH & AC-LGAD

HCAL: Fe/Sc (STAR re-use)

CENTRAL BARREL

Tracking: MAPS Si + μ RWELL

(design under optimization)

Electron PID: SciGlass (alt: PbGI or W(Pb)/Sc shashlik)
(plus instrumented frame)

h-PID: hpDIRC & AC-LGAD

HCAL: Fe/Sc (sPHENIX re-use)

HADRON ENDCAP

Tracking: Si discs + Large area μ RWELL

PID: dual-RICH & AC-LGAD

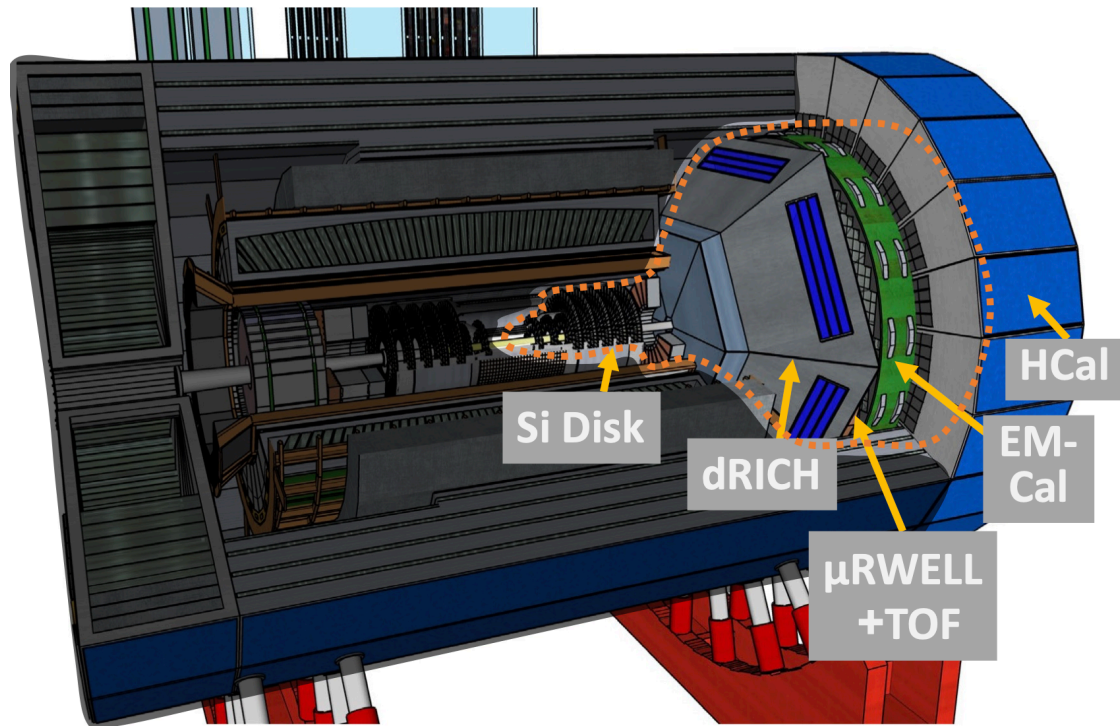
Calorimetry:

Standard Pb/ScFi shashlik (PHENIX re-use)

Long. sep. HCAL

(other options under study)

ECCE Detector Layout



HADRON ENDCAP

Tracking: Si discs + Large area μ RWELL

PID: dual-RICH & AC-LGAD

Calorimetry:

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long. sep. HCAL

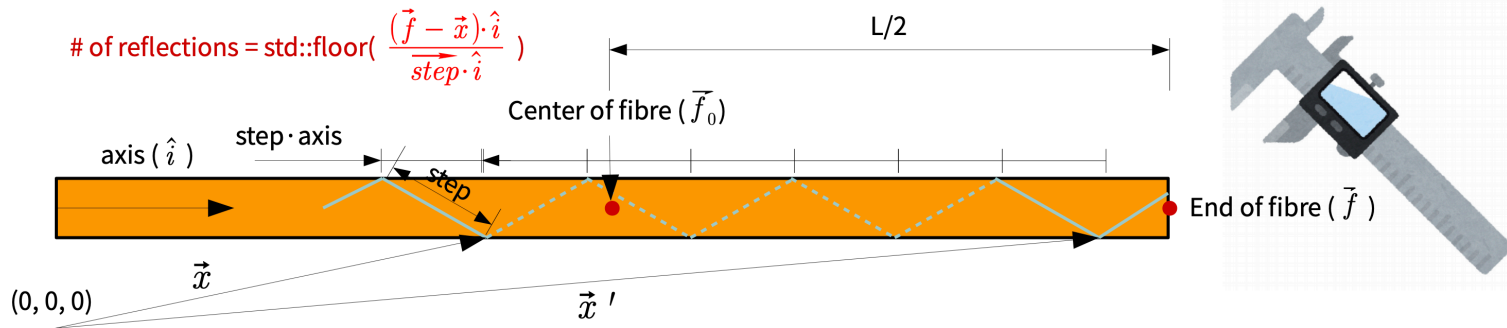
(other options under study)

Implementation of DRC in ECCE simulation

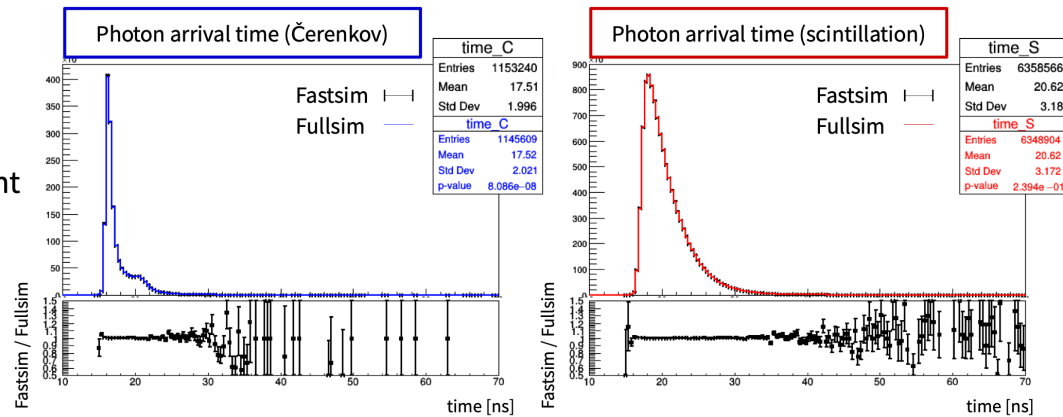
- Study of reconstruction performance for hadron and jet using fast simulation tool for DRC (H. Yoo)

Developing fast simulation for optical photon tracking

- Simulating photon propagation is necessary, but dominates CPU consumption
 - Yet, propagation of optical photons in fibres can be estimated, skipping full tracking
- Developing a fast simulation module presented at GEANT4 R&D meeting [\[link\]](#)



- Preliminary Fastsim model shows excellent agreement with Fullsim
 - Takes ~ 4 mins to simulate an event of 20 GeV e⁻
- more efforts for further improvement on-going



Summary

- The Korean nuclear physics society has big interest in the physics research with EIC
- 13 faculties in 9 institutes formed three subgroups for future contribution
 - Group A - forward and far-forward calorimeters
 - Group B - Silicon pixel tracker
 - Group C - Application of dual readout calorimetry
- To realize the EoI, we are ...
 - seeking for substantial funding for long-term R&D and significant contribution for EIC detector construction
 - initiating discussion in the nuclear physics division of KPS for the coordination of EIC participation and for the inflow of new manpower