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Electron Ion Collider in China

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Outline

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III. Summary

I. Introduction

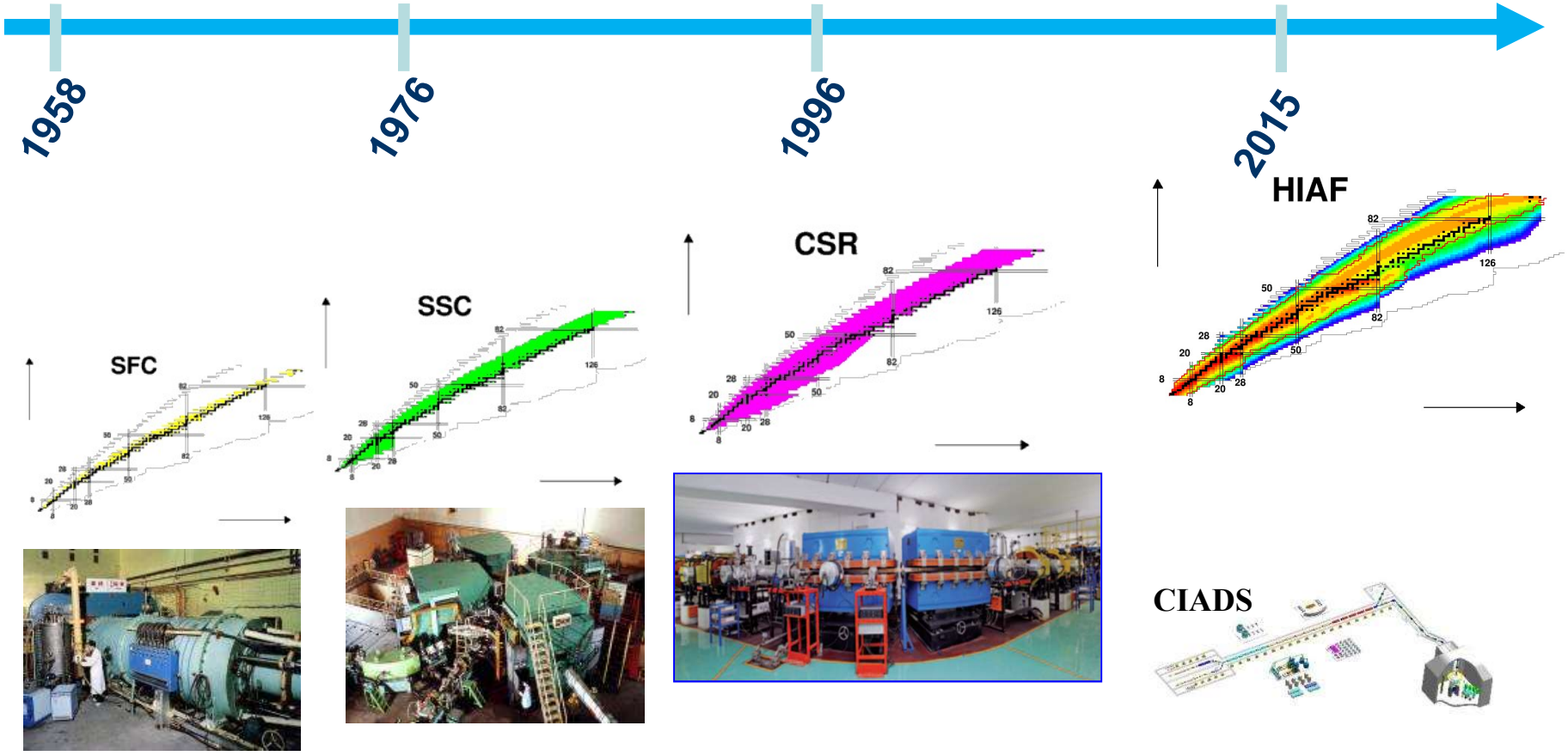
- In China, the large-scale experimental facilities are still in the preliminary stage
- **Three types of machines in China:**

1. The e+e- collider at the Institute of High Energy Physics (IHEP), Beijing
2. p - Ions (fixed target) for nuclear structure research in IMP, Lanzhou
3. **No** electron – Ions collider (**EIC**) for the study of nucleon structure

- These three types of facilities are non-inter-replaceable ,but complementary

IMP Facilities History

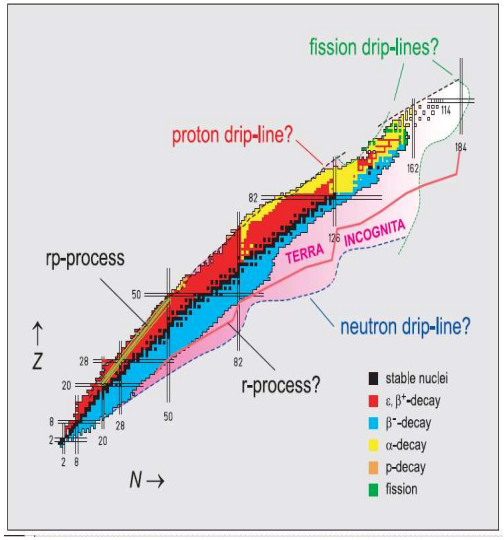
Institute of Modern Physics (IMP)



High Intensity heavy-ion Accelerator Facility (HIAF)

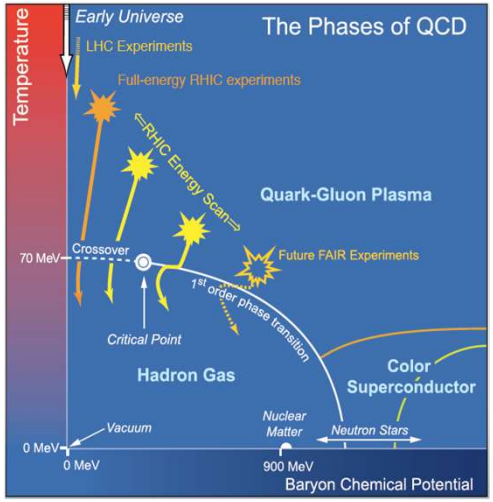
Nuclear Physics Machines in IMP

Nuclear Structure



CSR

QCD Phase digram



CEE (CSR External Target)
HIAF

Nucleon Structue

EicC: Eic in China

II. Why EIC?

- DESY, JLab and the COMPASS: experimental data
- New theoretical frameworks for the tomography of quarks and gluons in the nucleon
- Electron Ion Collider (EIC) **will be the most effective machine for the study of the quark and gluon distributions in nucleon and nuclei**
- The proposed EIC machines include eRHIC at the BNL, JLEIC at JLab in U.S. and LHeC at CERN in Europe
- In China: **EicC: Eic in China**

HIAF and EicC

Very preliminary!!

EicC-I New construction

- polarization ion source
- Siberia snake for FRing
- e injector

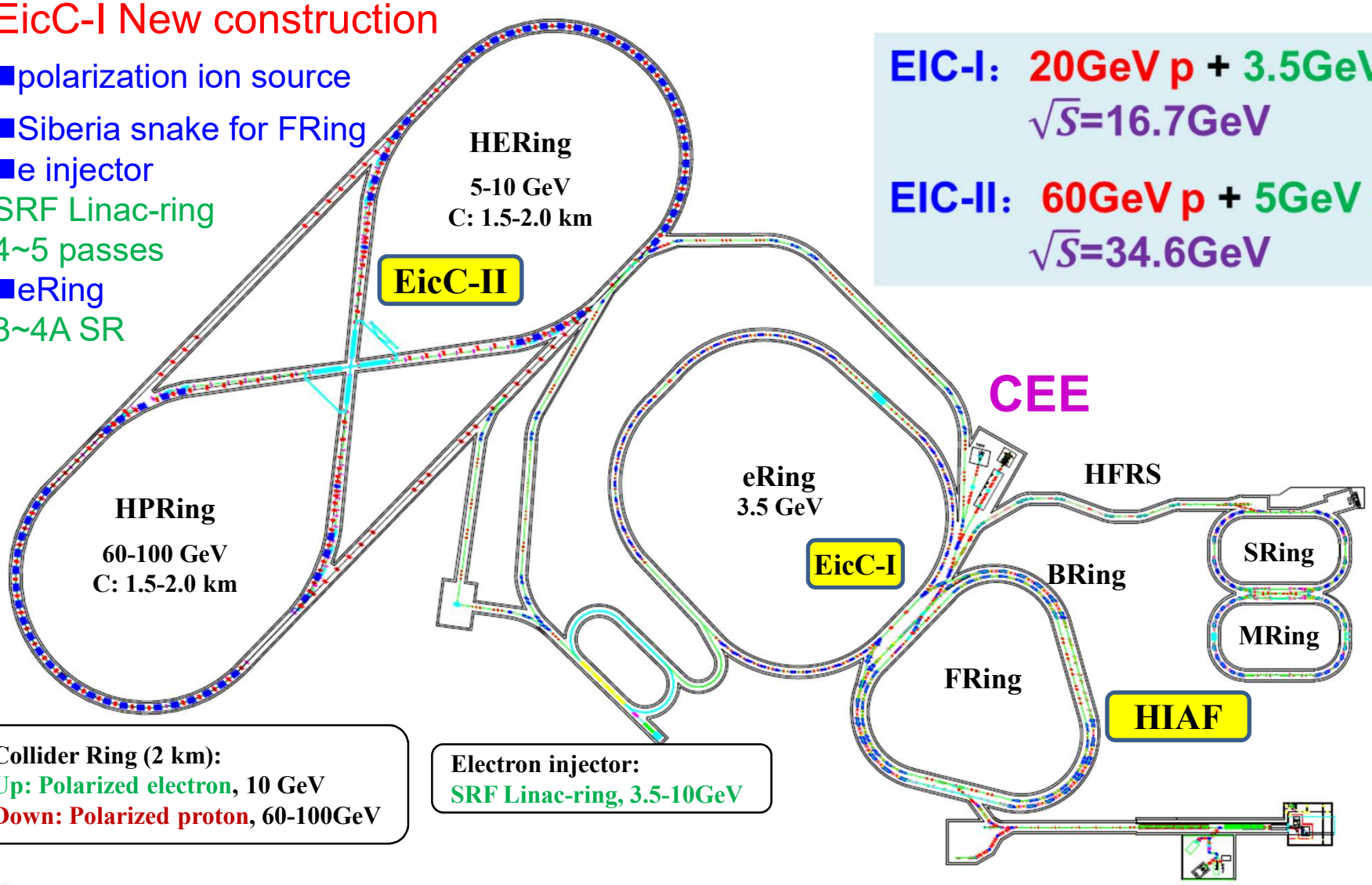
SRF Linac-ring
4~5 passes

- eRing

3~4A SR

EIC-I: 20GeV p + 3.5GeV e
$\sqrt{S}$=16.7GeV

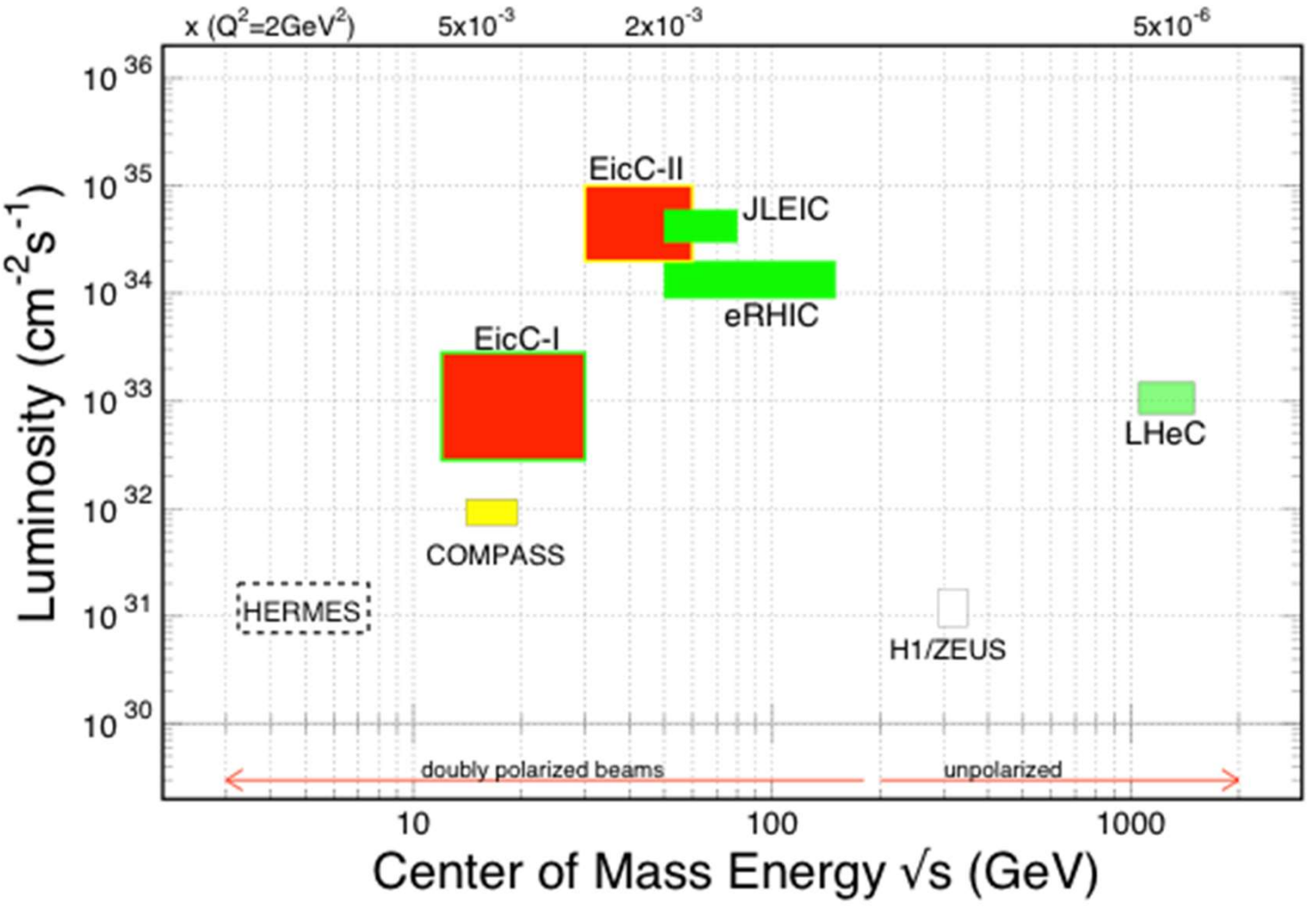
EIC-II: 60GeV p + 5GeV e
$\sqrt{S}$=34.6GeV



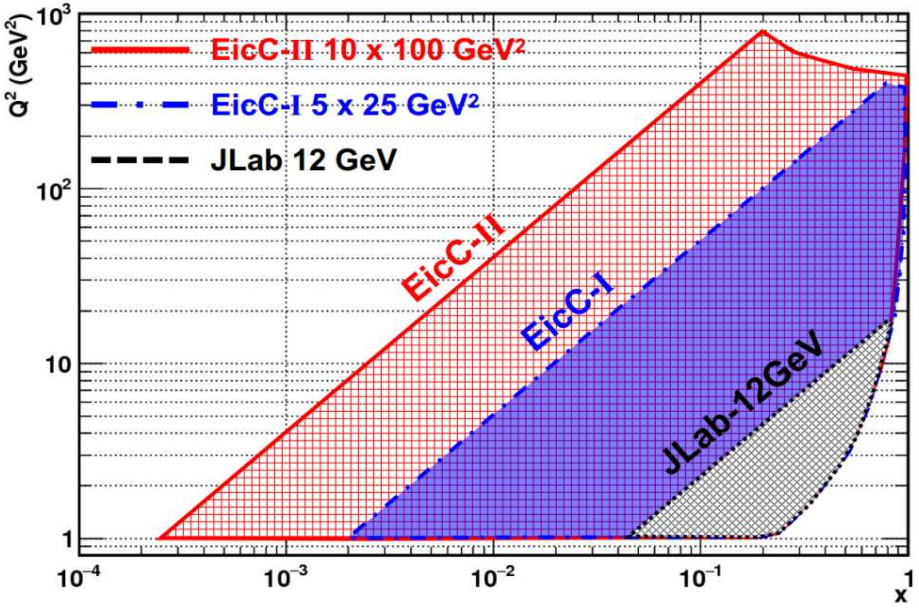
Collider Ring (2 km):
Up: Polarized electron, 10 GeV
Down: Polarized proton, 60-100GeV

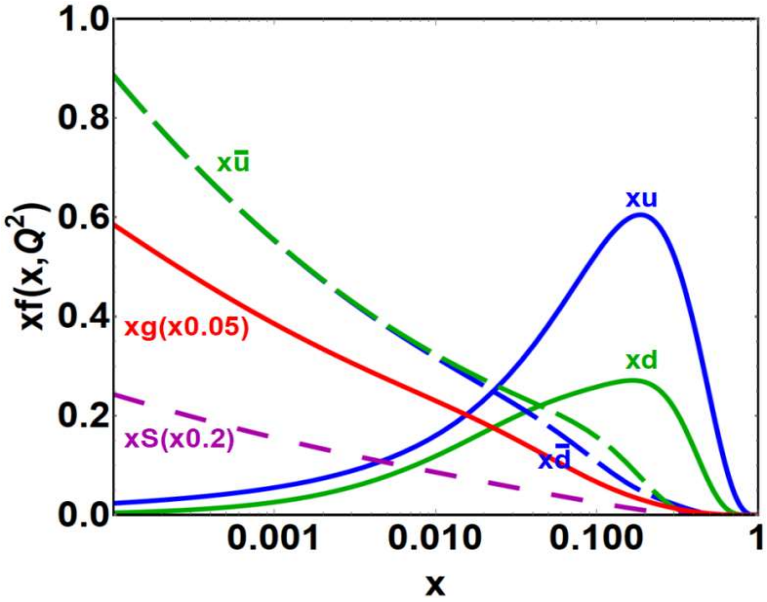
Electron injector:
SRF Linac-ring, 3.5-10GeV

EicC and Other ep Facilities



EicC vs. Jlab: Machine Kinematics





Compare the kinematic ranges of EicC with JLab 12 GeV

Facilities	Main goals
JLab 12 GeV	Valence quark
EicC-I	Valence and Sea quark
EicC-II	Sea quark and gluon

EicC-I Main Physics Goals

The EicC-I covers the range of sea quark region

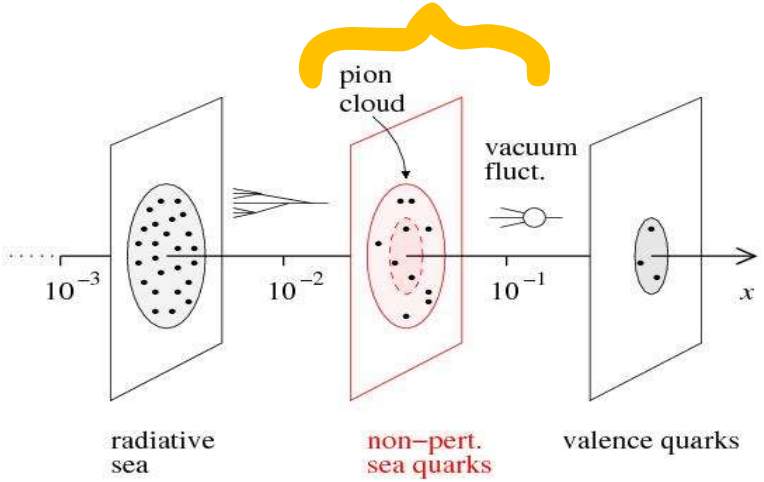
1. High precision quantitative measurements sea quarks 1D structure
2. High precision quantitative measurements sea quark TMD
3. High precision quantitative measurements sea quark GPD
4. Explore hadronization mechanisms
5. Systematic studies of baryon states with bottom flavor

T1: Sea Quarks 1D Structure

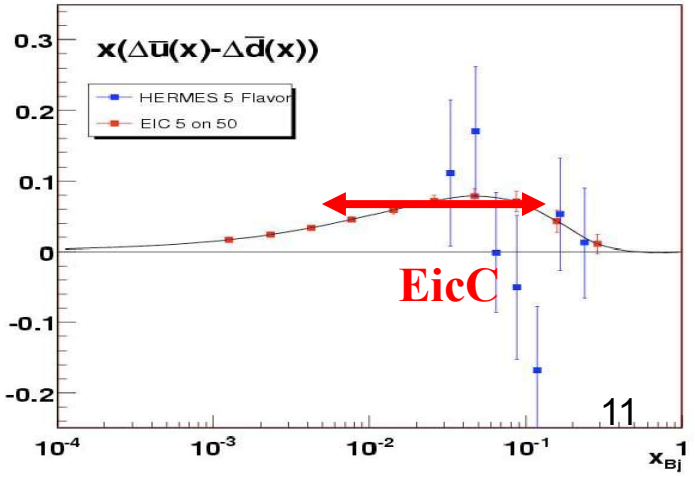
- **Sea quarks are poorly known!**
  - **Without EIC: large uncertainties in nuclear sea quarks and gluons**
  - **With EIC: significantly reduces uncertainties: Wide coverage in x,Q2**
- **EicC, combination of energy and luminosity**

Significant improvement for Δubar, Δdbar from SIDIS

Unique opportunity for Δs



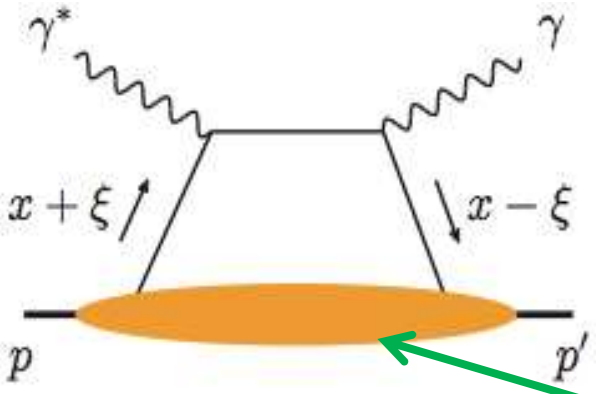
Sea Quark Polarization



T2: GPD Study at EicC

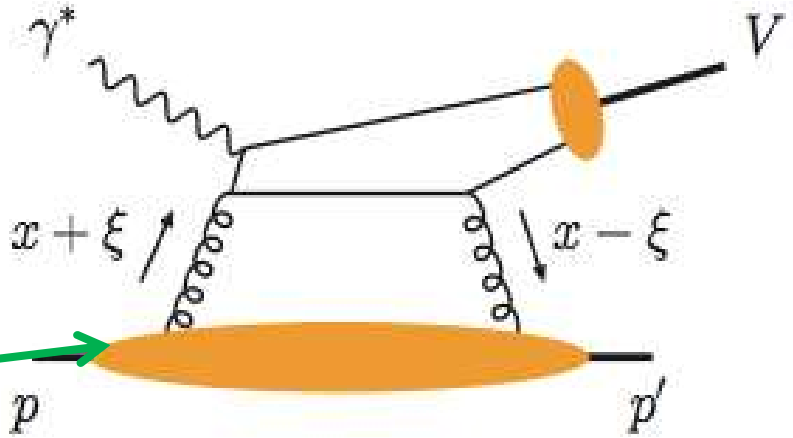
- Two ways to study GPD: DVCS vs. DVMP
  - DVCS: Low energy
  - DVMP: needed by flavor decomposition: energy reaches $Q^2 >$ 5~10 GeV^2, scaling region for exclusive light meson production
- JLab12 energy is not high enough to have clean meson deep exclusive process
- **EicC: significantly increase the range for DVCS; Unique opportunity for DVMP (pion/Kaon)**

DVCS



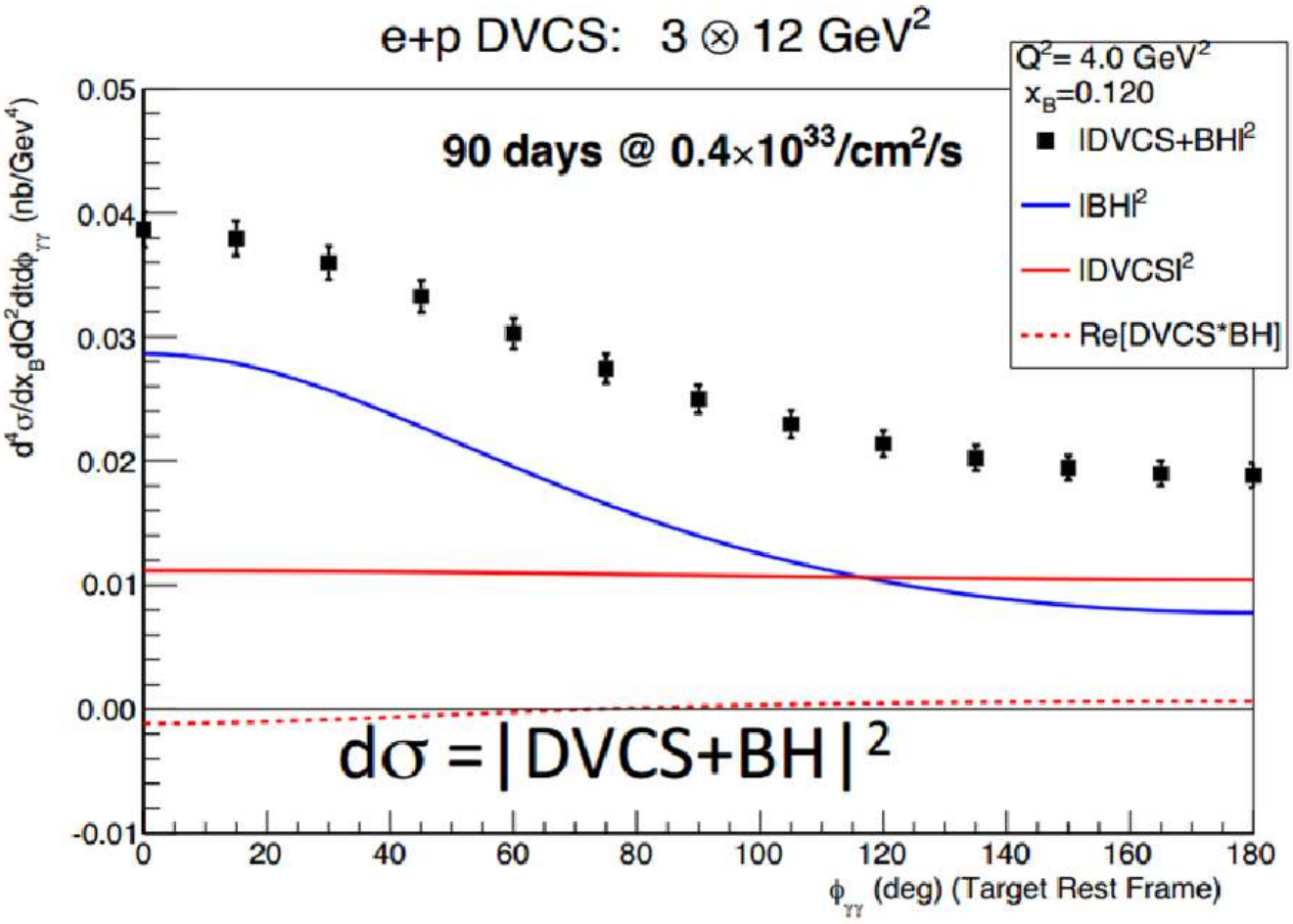
GPD

DVMP



DVCS simulations

Statistic error for EicC is small!



T3:TMD Study at EicC

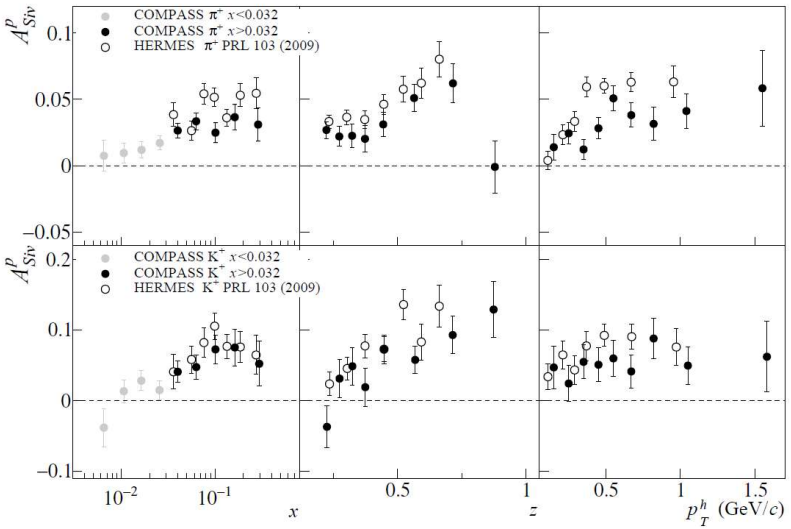
- **JLab12: Semi-incl DIS in valence region**

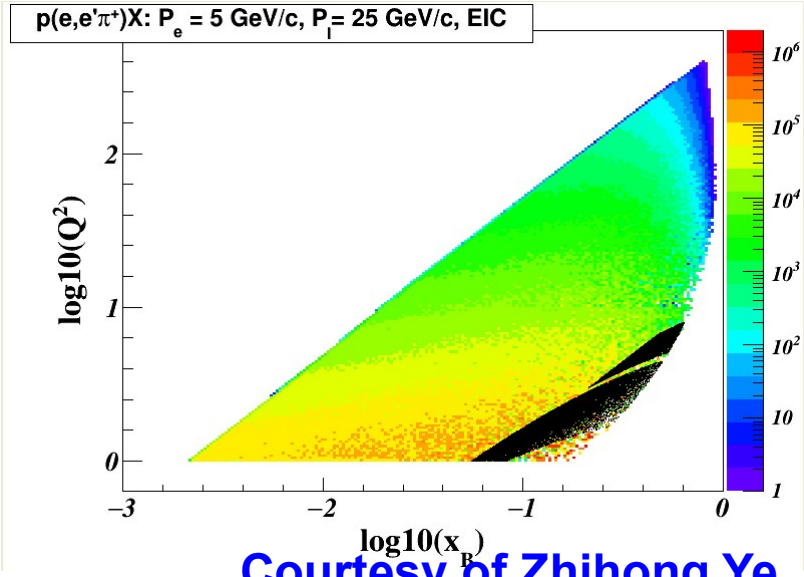
  Precise observables, but limited phase space

- **EicC: Wide kinematic range for SIDIS**

1. High precision quantitative measurements of all the quark TMDs in the valence region
2. Significant increase in Q^2 range for valence region: energy reach Q^2 ~40 GeV^2 at x ~ 0.4
3. Unique opportunity for TMD in "sea quark" region: reach x ~ 0.01

TMD Sivers From COMPASS and HERMERS

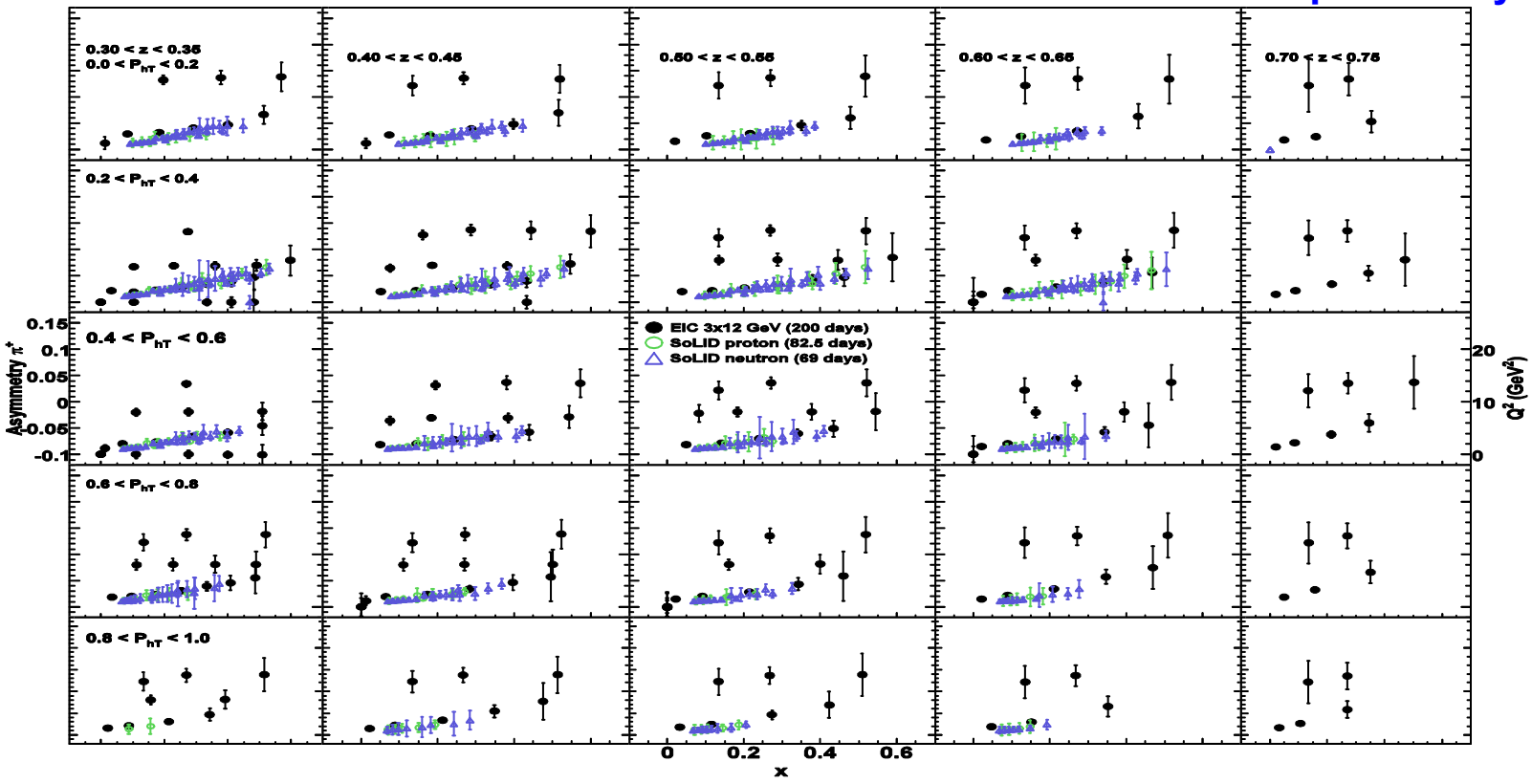




Courtesy of Zhihong Ye

The TMD simulation: Projections for SIDIS Asymmetry π^+

JLab 12 and future Electron Ion Collider are complimentary

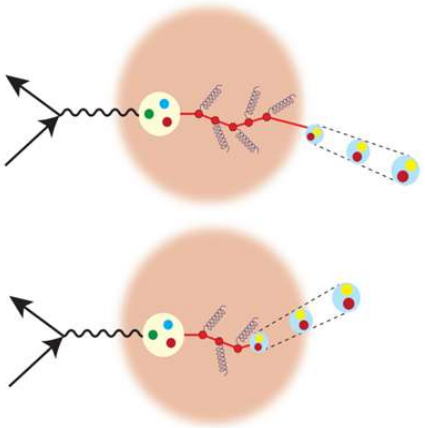


By Gao's group@Duke

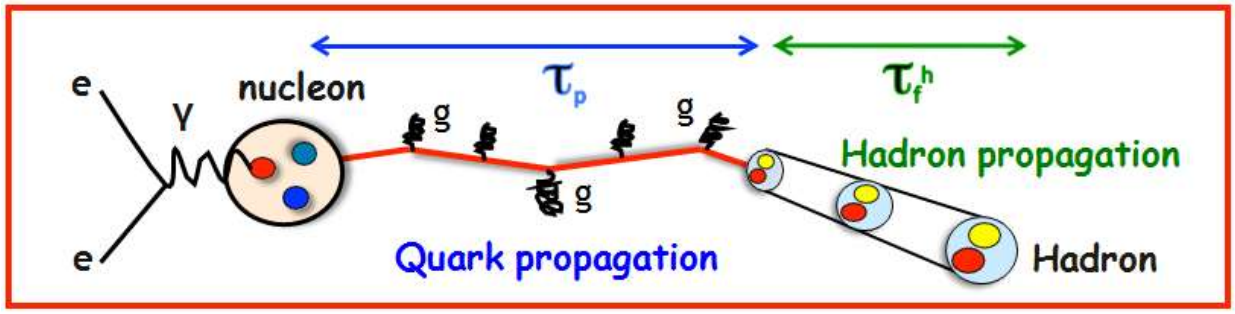
- JLab SoLID and EicC sea quarkTMD Sivers
- **Black**: EicC 3 x 12 GeV，4×10^{32} $cm^{-2}s^{-1}$, 200 days；
- circle：SoLID proton target，10^{35} $cm^{-2}s^{-1}$, 82.5 days；triangle：SoLID neutron target ，10^{35} $cm^{-2}s^{-1}$, 69 days
- EicC has similar measurements for valence with SoLID
- EicC sea quark TMD

T4: Hadronization

- Due to the non-perturbative nature, hadronization has been always the challenging processes for QCD calculations
  - Phenomenological models can not describe the whole set of experimental results: **New and more precise measurements are required**



The emergence of hadrons from color charge



HADRONIZATION IS A DIRECT MANIFESTATION OF CONFINEMENT

- at high energies: Hadron forms outside the medium
- at low energies: Hadron forms inside the medium

EicC study hadronization both inside and outside the medium

T5: Systematic Studies of Baryon States with Heavy Flavor

- Tens of exotic states have been observed in the current machines, but their nature is still unclear; some of them are only observed in a specific process
- For the study of **Baryon States with bottom quark ,** EicC's advantages:

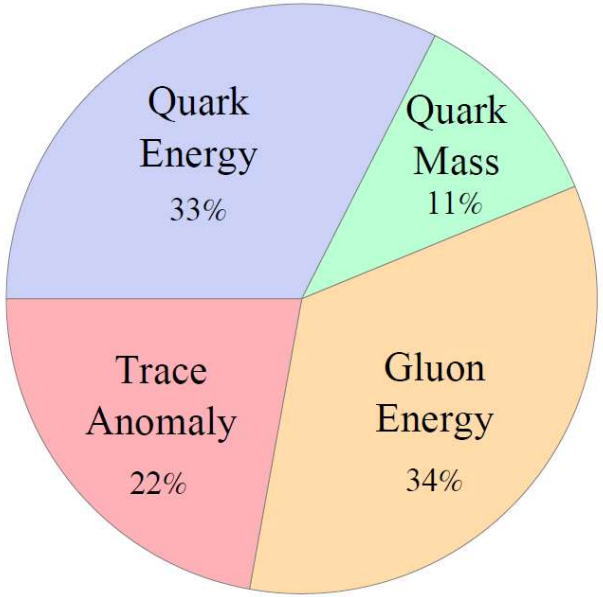
1. larger cross section comparing to e+e- collision
2. smaller background comparing to pp and ppbar collision
3. Especially, the polarized EicC can well pin down the quantum number of the observed particles

- **So, EicC can:**

1. Search for **Hidden** "bottom pentaquarks"
2. Search **for Open Bottom Baryons**
3. Search for other exotic particles, such as dibaryon, etc.

EicC: Study non-perturbative gluon

- Proton mass budget: about 22% comes from trace anomaly
- We know very little about it



●JLab 12: J/ψ production near threshold

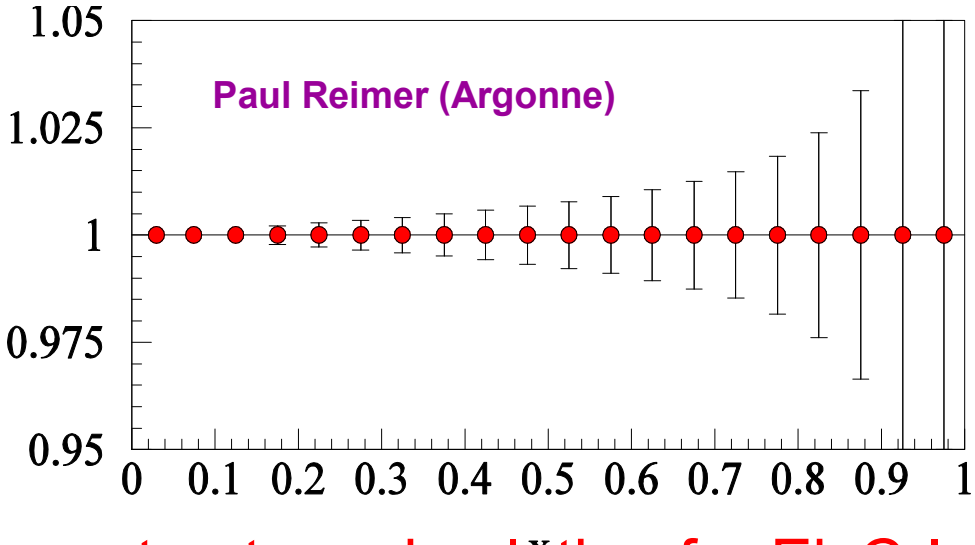
- Shed light on the low energy J/ψ-nucleon interaction (color Van der Waals force): Prediction of J/ψ-Nuclei bound state
- Shed light on the trace anomaly : **proton mass**

●EicC: precision measurement Upsilon near threshold： the heavier mass of the bottom should help suppress the theoretical systematic uncertainties

S. J. Brodsky, E. Chudakov, P. Hoyer and J. M. Laget, Photoproduction of charm near threshold, Phys. Lett. B498 (2001) 23–28, [hep-ph/0010343].

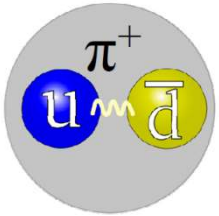
π/K Parton Distribution Function in Valence Region

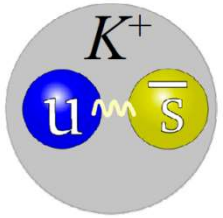
- **Nucleons** and the lightest mesons –**pions and kaons**
- We should know their structure functions



π structure simulation for EicC-I

➢3 GeV e and 12 GeV p; Luminosity: 5 x 10^{32} /cm^2/s; Time:10^6 seconds





Meson PDFs: a second QCD test

- EicC will be able to extract π PDFs with a high precision
- Together with the Kaon PDFs, will provide benchmark tests of theoretical calculations, such as Lattice QCD and the DS equations

EicC-I Summary: neucleon strucutre

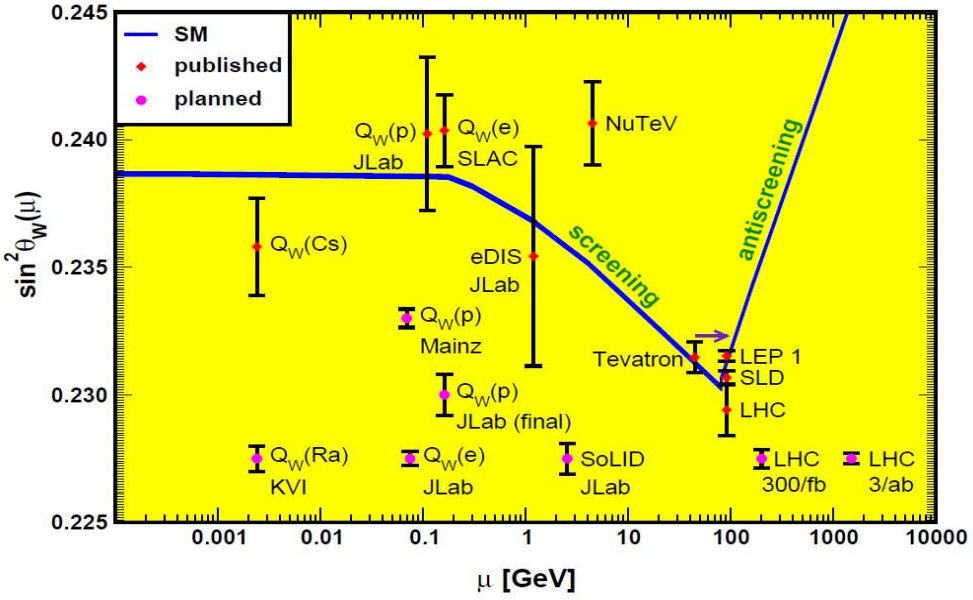
- High luminosity of EicC: to study the nucleon structure
- We have started the simulations on the EicC-I physics goals 1-3. The preliminary results show that the EicC-I has unique advantages comparing to the existing and planning fixed target experiments, especially in the polarized cases
- **Baryon States with Heavy Flavor**
- EicC-I also has the potential to make important contributions to other topics, such as the structure functions of pion and kaon, etc.

It is very promising that our physics goals can be achieved

EicC-II main physics goals

- **Higher precision measurement of sea quark**
- **Precise measurements of the gluons and sea quarks in the nucleon**
- **Search for new physics beyond standard model through:**

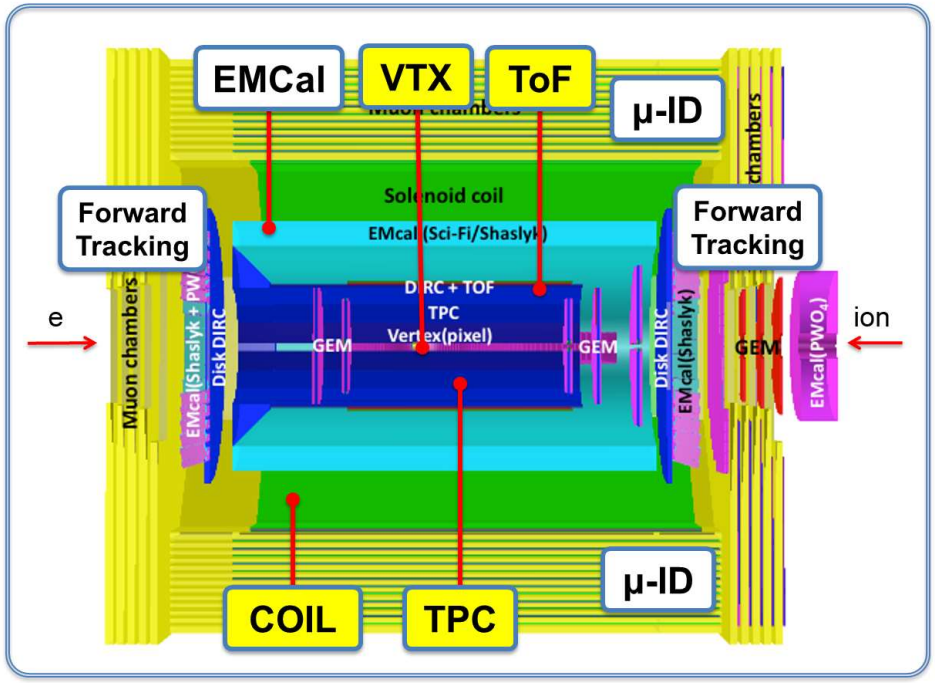
1. High precisely measurements of charged lepton flavor violation (CLFV) processes $e^- + p \rightarrow \mu^+ + X$, $e^- + p \rightarrow \tau^+ + X$
2. High precisely measure the weak mixing angle at Q: 10 ~ 50 GeV



EicC Challenge

- Polarized electron and proton beam
- Interaction region or collision region design
- EIC detector design and construction (for example: Forward tracking)

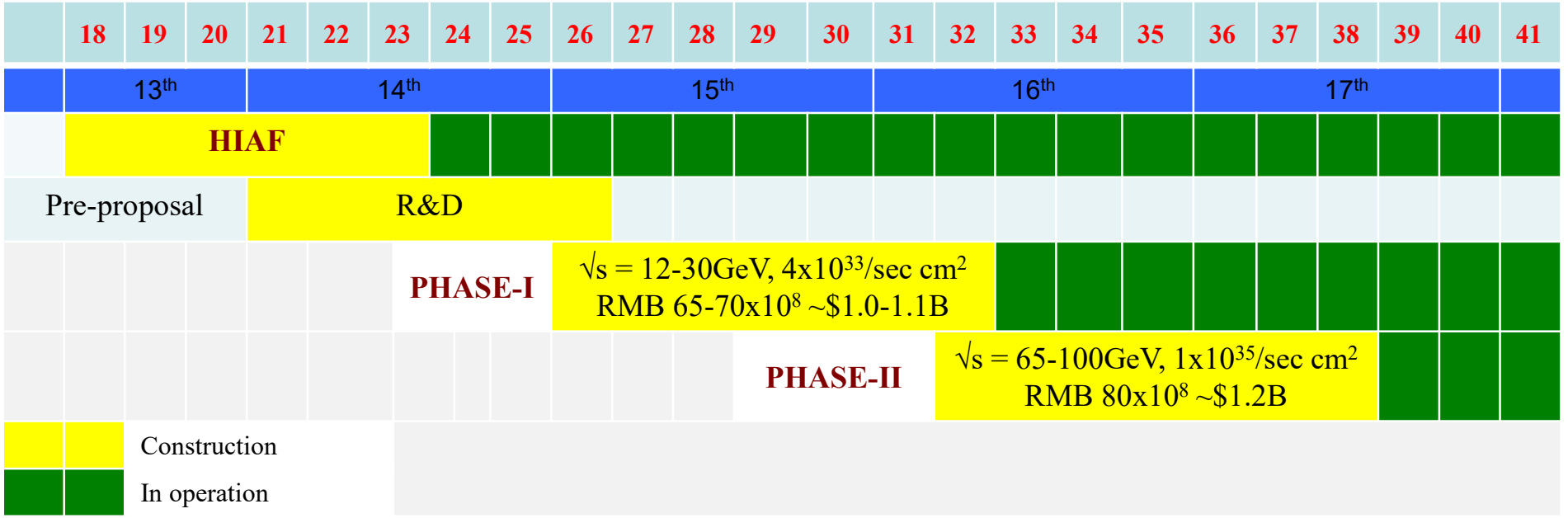
EicC Concept Detector



: **China has the technology**

: **Need international collaborators**

Path forward for the EicC



- This is NOT the final version
- The EicC program is still under designing and optimizing

Quark Matter Research Center (QMRC)

Experiment I:
- STAR, CBM, CEE
  QCD phase structure

Experiment II:
- EicC, JLab
  Nucleon structure

Experiment III:
- N*ν*DEx, DAR
  Nature of Neutrinos

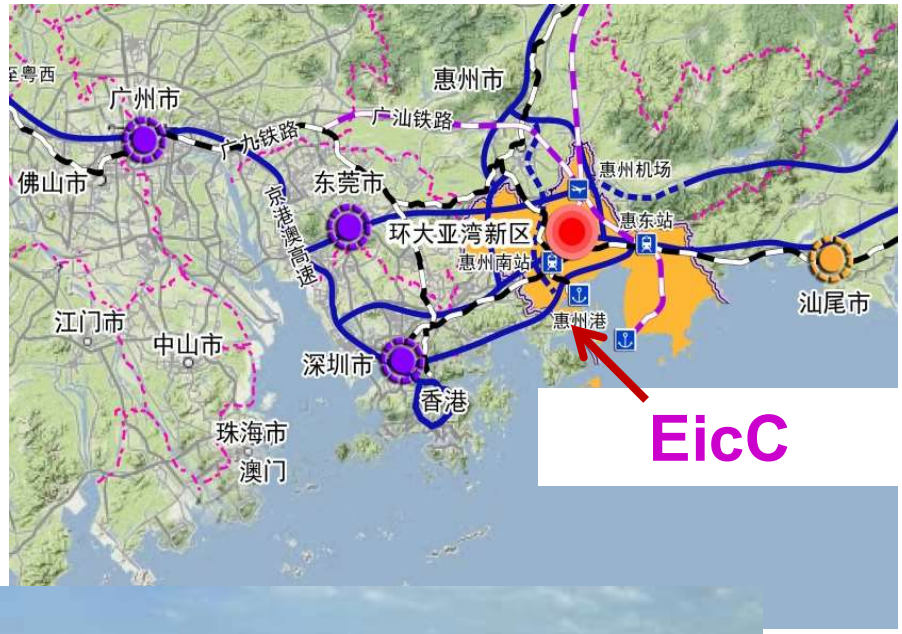
Nuclear Theory:
- Hydro, Fluctuations, ..
- Nucleon structure
- Nuclear structure

Detector Laboratory:
- Solid-state detector
- Gaseous detector

Computing Center:
- Data storage
- Simulations

- Many new positions are offered for both Theorists and experimentalists, including: permanent positions, postdoc, graduate students, visiting professors, etc.
- If you are interested in, please contact me by Email: xchen@impcas.ac.cn

EicC Location



Summary

- **EicC: Exciting physics at the frontier of QCD:**

1D and 3D imaging of quarks inside protons and neutrons,

Gluon content of matter, new physics

- **EicC is COMPLEMENTARY to JLab 12, U.S. and Europe's EIC**
  - **JLab12: Valence quark region**
  - **EicC: Sea quarks, gluons (Nuclear physics)**
  - **U.S. and Europe's EIC: Higher energy for gluon saturation (particle physics)**
- **International collaboration with the worldwide EIC experts**

Thank You !