# EicC and its computing needs

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On behalf of the EicC Discussion Group

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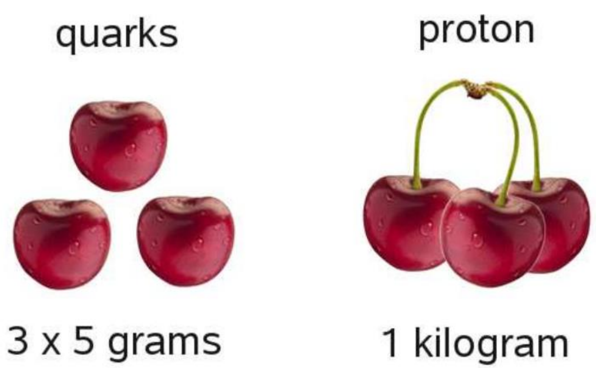
# Outline

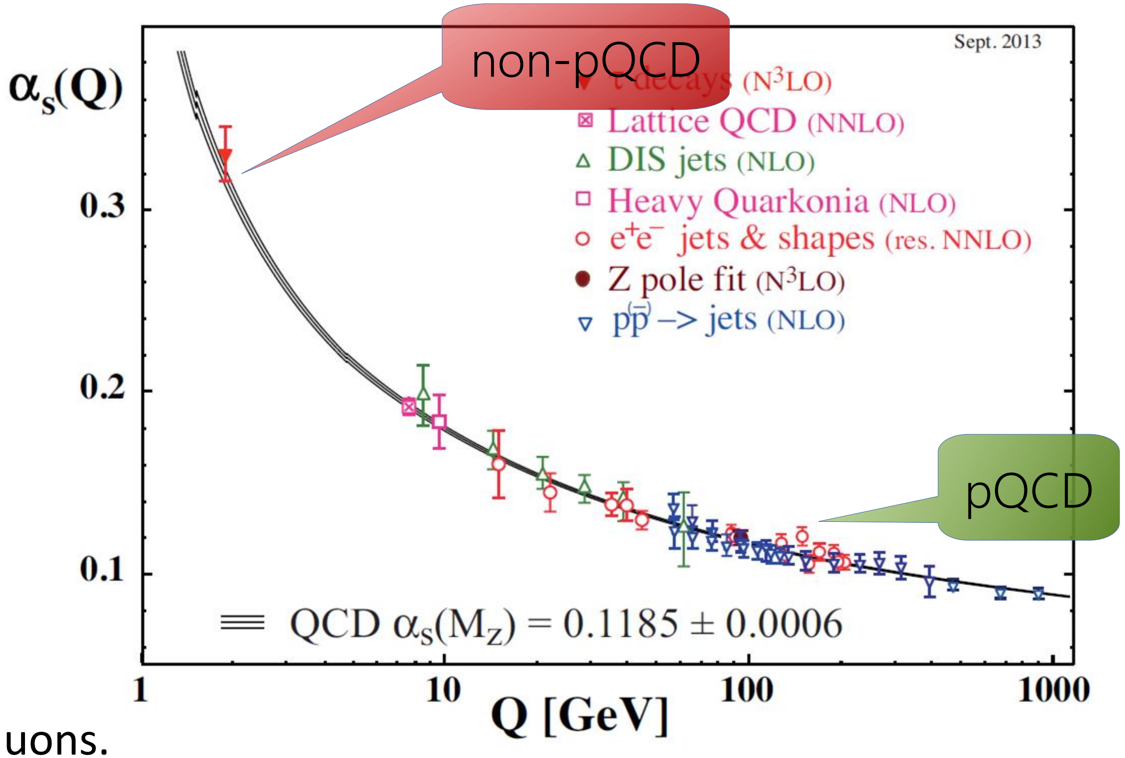
- Introduction
- Computing needs in EicC
- Status of EicC
- Summary

# Introduction

- QCD is successful (in general). More than 90% of visible matter in nature governed by strong interaction QCD.

- But not perfect yet. Some fundamental problem to be addressed



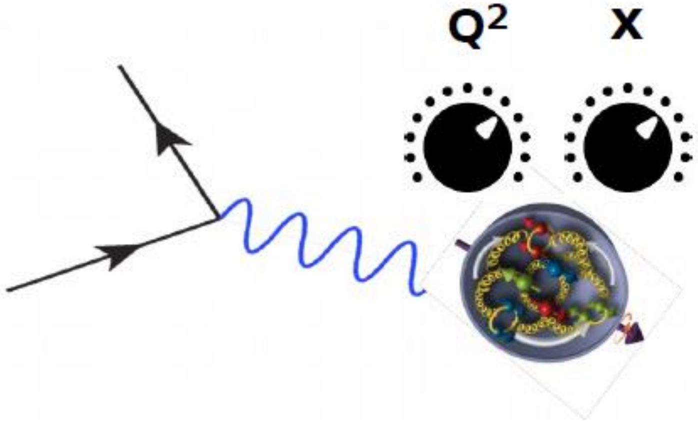



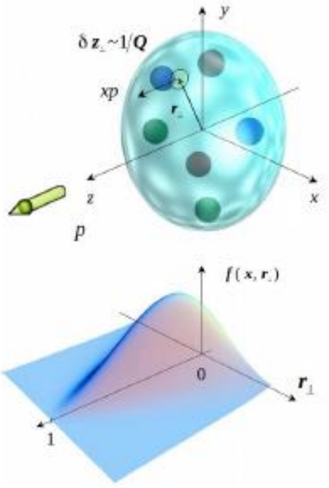

  - the origin of the mass and spin.
  - the mechanism for confinement of quarks and gluons.

- Exploring the internal structure of the nucleon is one path.

# Introduction

- How to explore the internal structure of the nucleon?
  - spin of nucleon
  - mass of nucleon
  - role of gluons
  - confinement
  - …



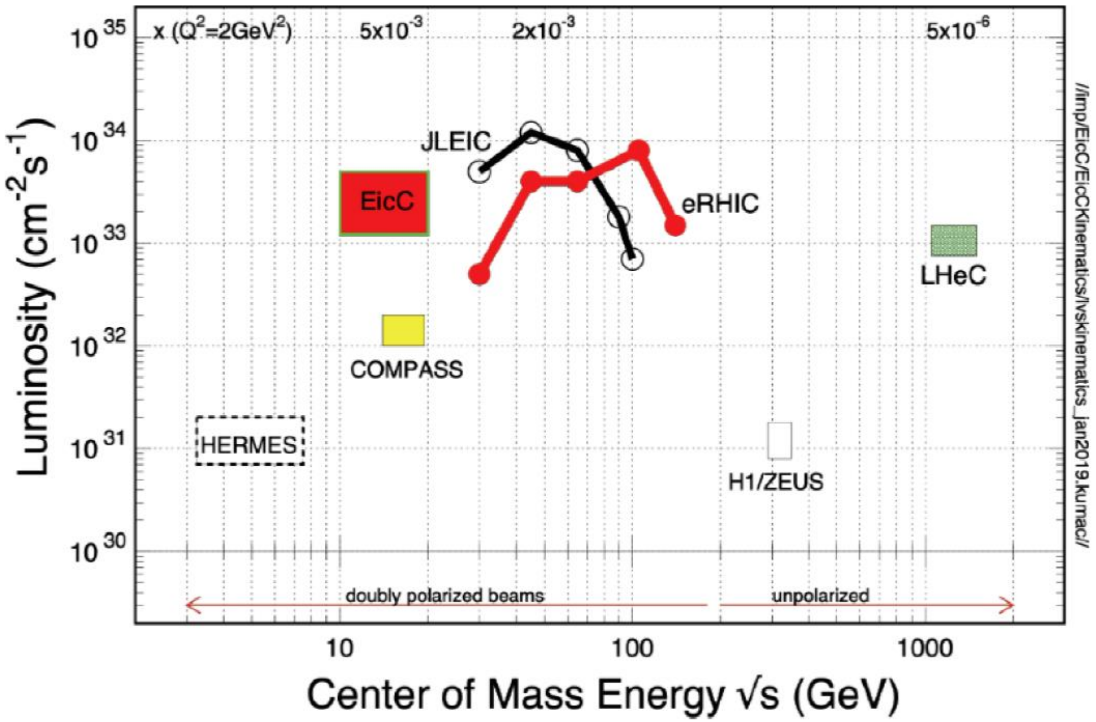




- Electron Ion Collider (EIC), regarded as a “super electron microscope”, can provide the clearest image inside the nucleon.

# Facilities Landscape

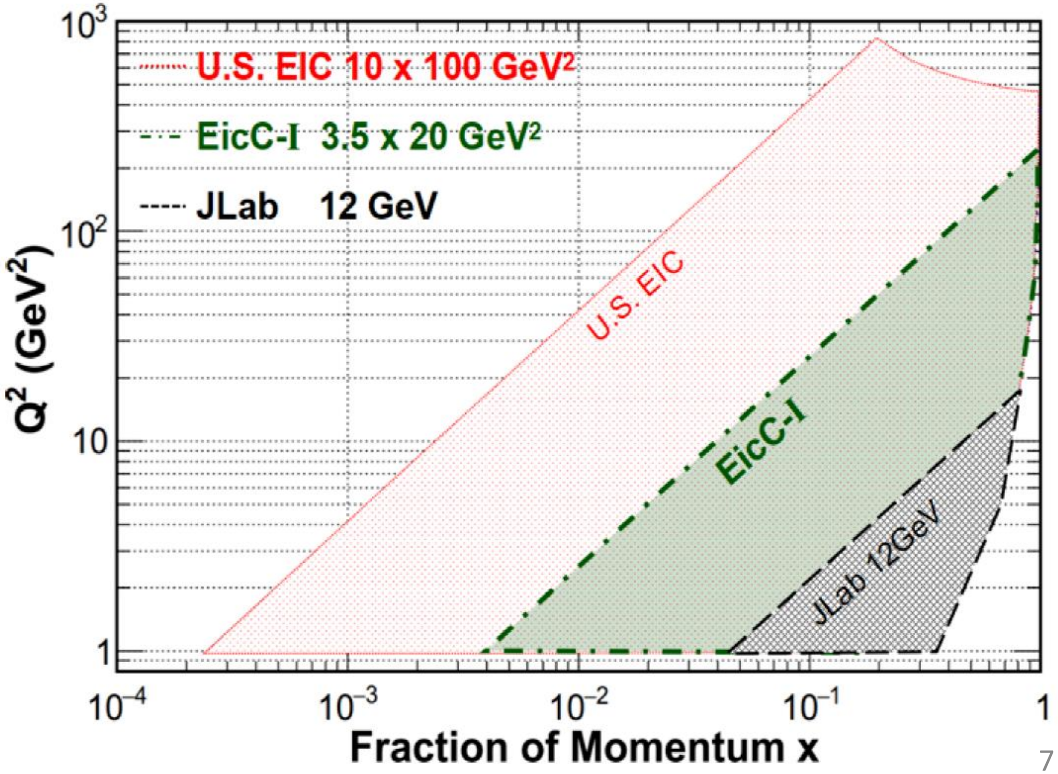
# Location of EicC

# Machine Kinematics




EicC, √s : 15 ~ 20 GeV

- Focus on nuclear physics
- B-quark hadron production



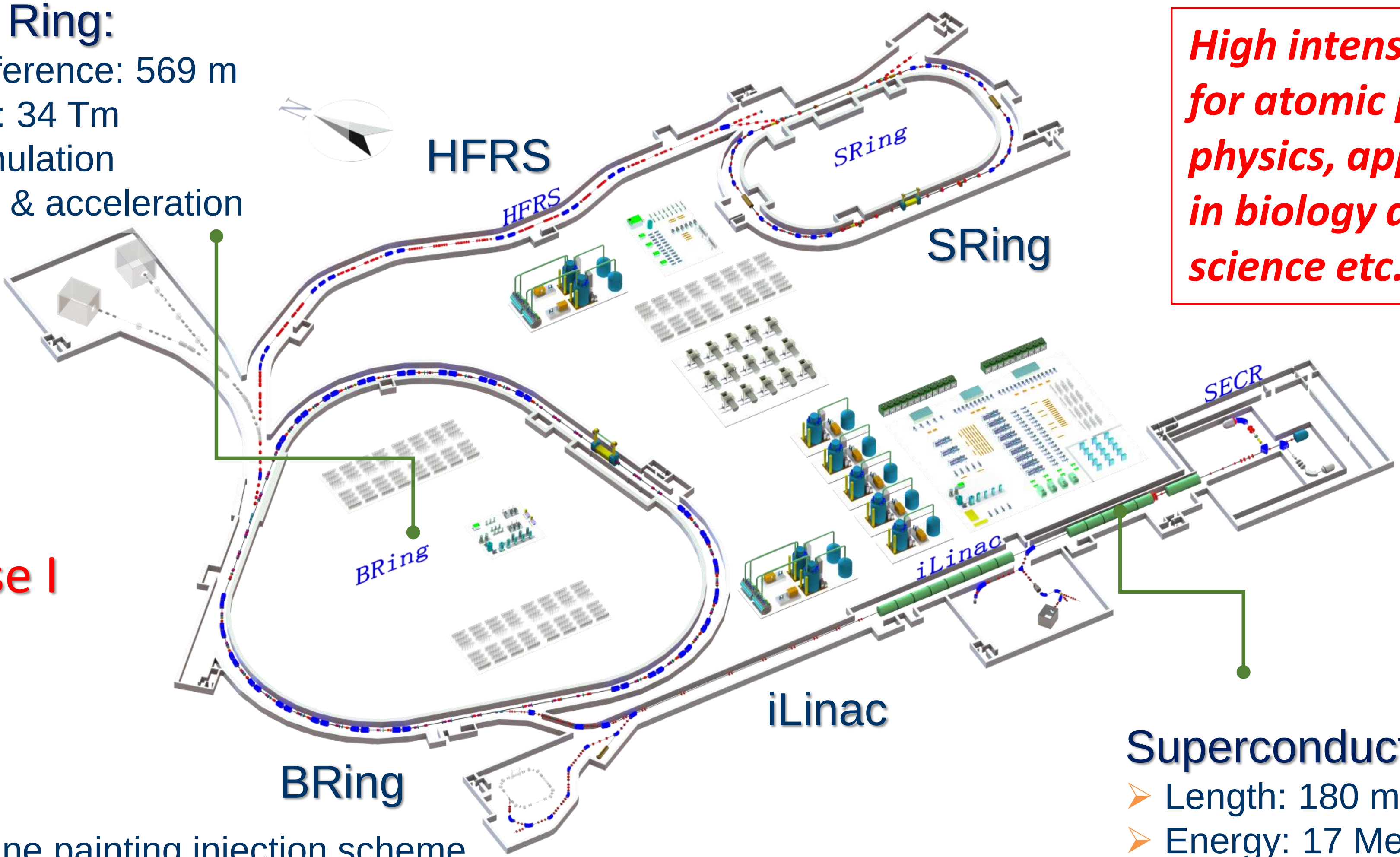

| Facilities | Main goals |
|---|---|
| JLab 12 GeV | Valence quark |
| EicC | Valence and Sea |
| US and Europe EIC | gluon |

# High Intensity heavy-ion Accelerator Facility

## Booster Ring:

- Circumference: 569 m
- Rigidity: 34 Tm
- Aaccumulation
- Cooling & acceleration

***High intensity ion beams for atomic physics, nuclear physics, applied research in biology and material science etc.***




Phase I

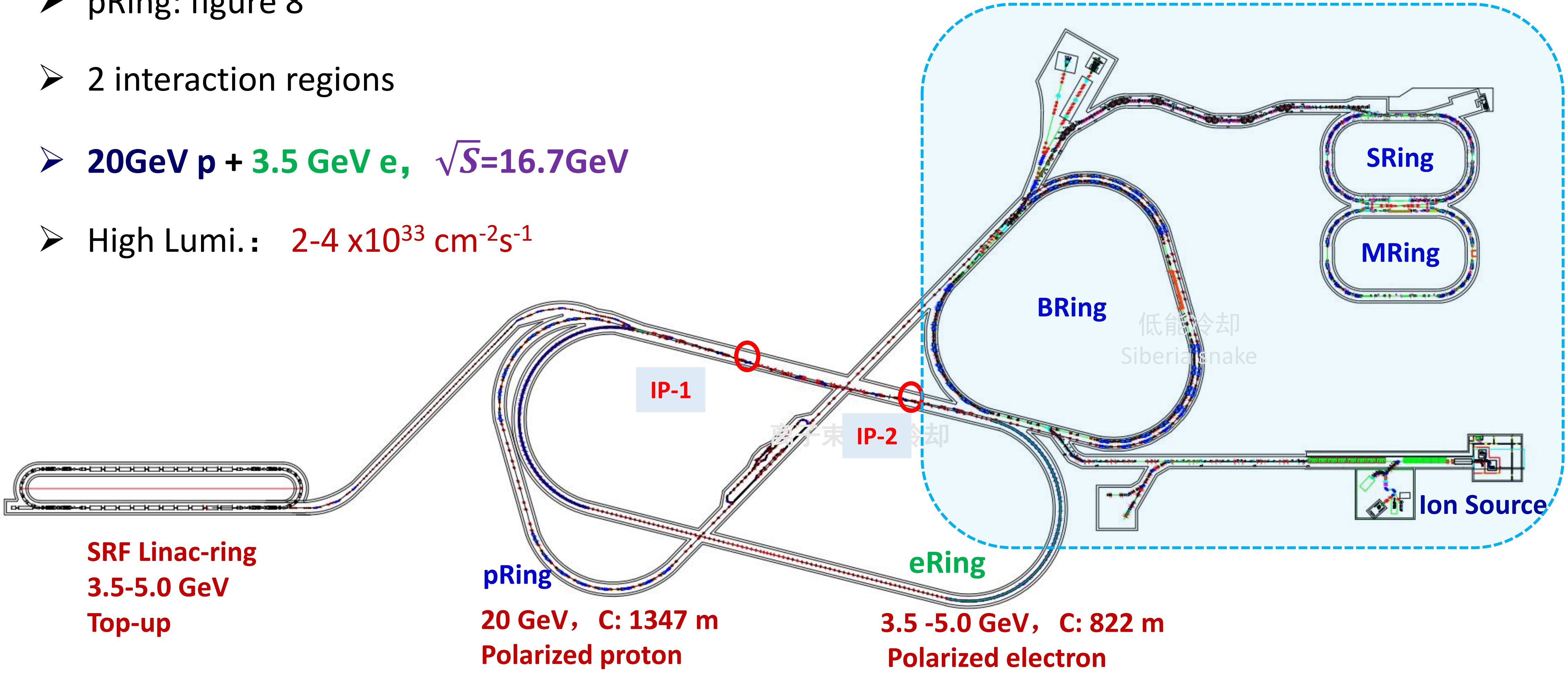
- Two-plane painting injection scheme
- Fast ramping rate operation

## Superconducting Ion Linac:

- Length: 180 m
- Energy: 17 MeV/u ($U^{34+}$)
- CW and pulse modes

# EicC accelerator complex overview

- pRing: figure 8
- 2 interaction regions
- **20GeV p + 3.5 GeV e，** $\sqrt{S}$**=16.7GeV**
- High Lumi.： $2\text{-}4 \times 10^{33}\ cm^{-2}s^{-1}$



# EicC Main Physics Goals

- Nucleon structure

    1-D picture: PDFs,

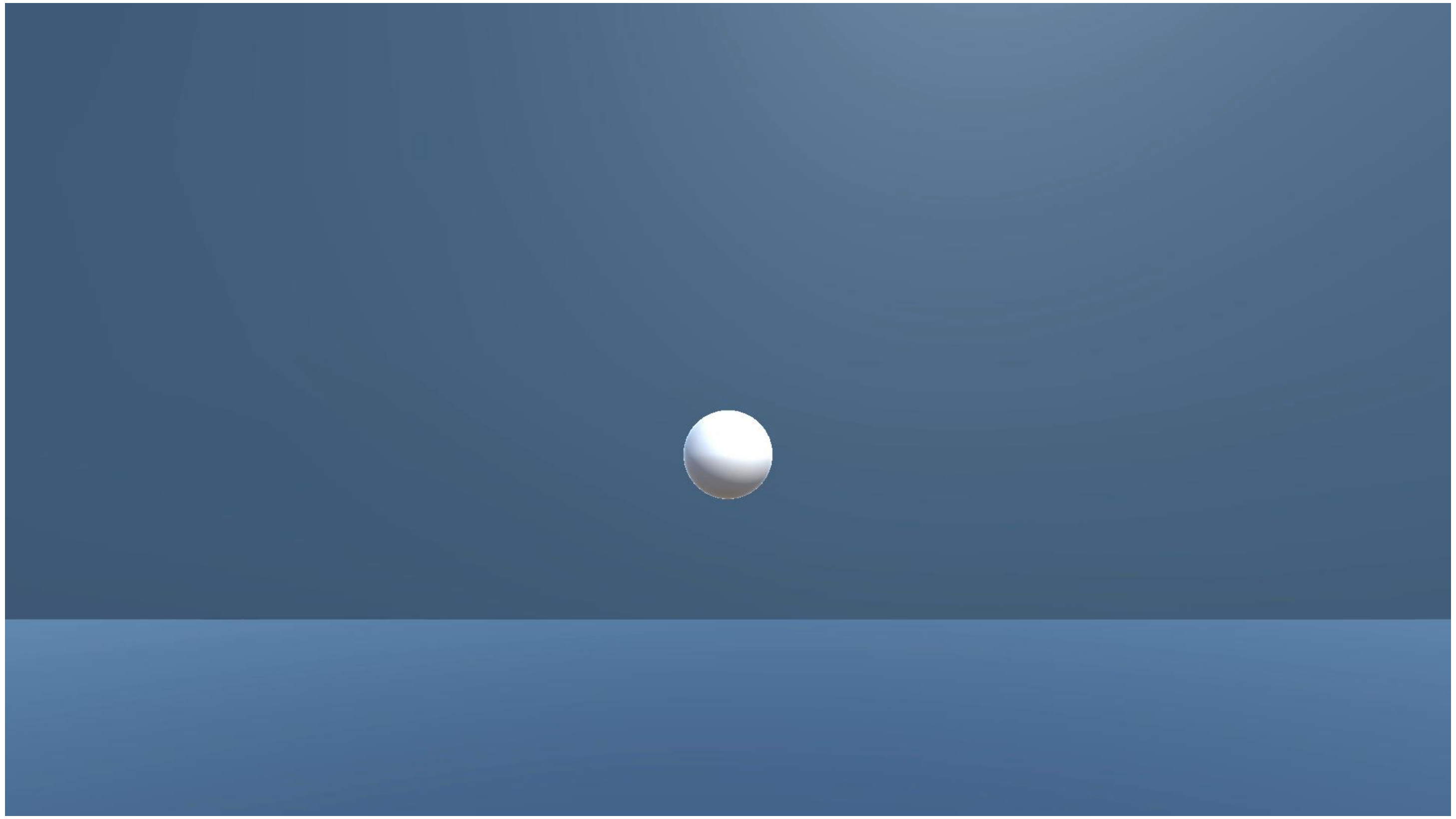
    3-D momentum maps: TMDs,

    3-D spatial maps:  GPDs

- Proton mass

- pi/K structure function

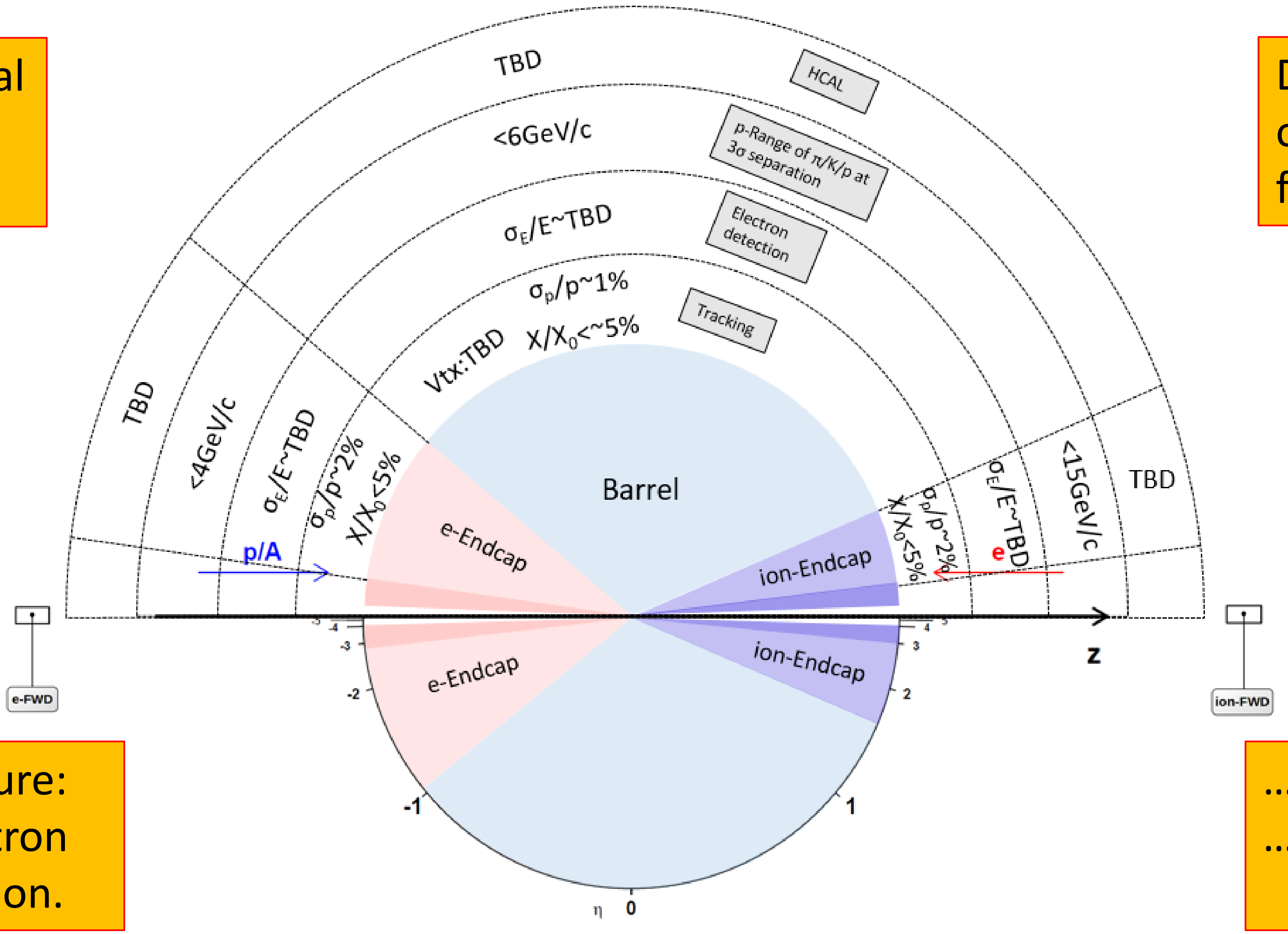
- Hadron spectroscopy



# EicC detector requirements

SIDIS: very general requirement.

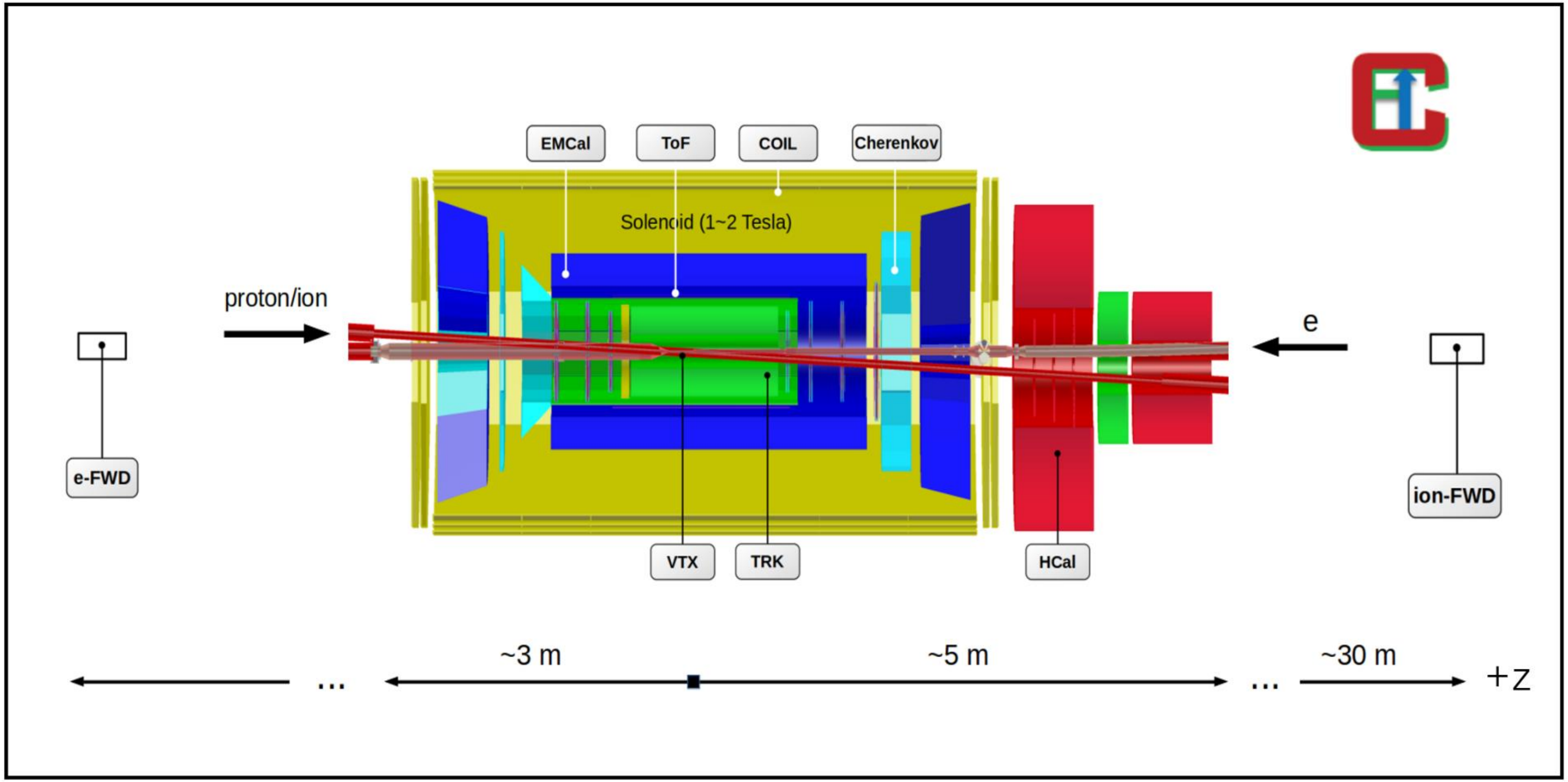
DVCS: detection of proton at forward direction.




Pion/Kaon structure: detection of neutron at forward direction.

…
…

# EicC detector conceptual design




Very first design; detector options are open.

# Computing need in EicC – Storage estimation

- e: 3.5 GeV/c  p: 20 GeV/c
- L = (2~4)*$10^{33}$ $cm^{-2}s^{-1}$
- Rate: 20~40 kHz
- Multiplicity: ~ 8 charged, ~ 7 neutrals
- Event size: (detector dependent)

  O(10) kByte/s (rough estimate)
- Data rate: 100~200 MByte/s
- Might be streaming readout.

Assume an duty factor of 0.3-0.5, 6 months of running/year,

If all these data to storage:

1. Raw data:

   (0.3~0.5)*(100~200)MB/s *(6*30*24*3600s)

   = 0.5~1.5 PB/year
2. MC.

   Same statistics (or double) as Raw data

   = (0.5~1.5 PB/year)

# Computing need in EicC – Storage estimation

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- Might be streaming readout.

3. Rec data?

If reconstruction is quick, analysis starts from raw data. No extra large storage is needed. Otherwise, reconstruction data need (~ few PB/year)

4. In real-time, a storage as buffer needs not much, ~O(100) TB

Roughly, a storage of O(10) PB/year for EicC is required, assume all 20 kHz data to be saved.

# Computing need in EicC – CPU requirements

- e: 3.5 GeV/c  p: 20 GeV/c
- $L = (2\sim4)*10^{33}\ cm^{-2}s^{-1}$
- Rate: 20~40 kHz
- Multiplicity:  ~ 8 charged, ~ 7 neutrals
- Event size: (detector dependent)

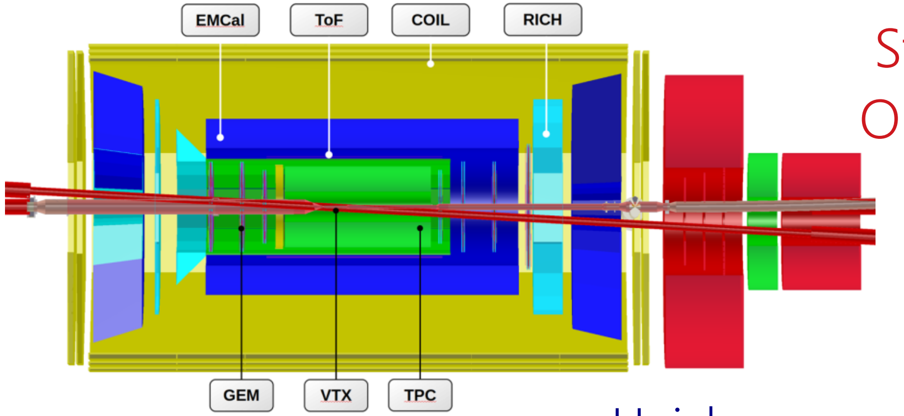
  O(10) kByte/s (rough estimate)
- Data rate:  100~200 MByte/s
- Might be streaming readout.

CPU cores at other experients:

BES3 (10000)  PANDA (66000)  GlueX(10000)

- Time to simulate one event, depend on how good we want the simulation to be:    O(1) s
- Time to reconstruct one event:  O(1) s
- Reconstruction usually done 2 ~ 3 iterations
- Totally, ~100000 cores needed. (estimation with today's CPU)

# EicC computing layout concept




Streaming
O(100)MB/s

Huizhou

Local computing resource


Network: High bandwidth
To permanent storage

TMD?

GPD?

Physics analysis

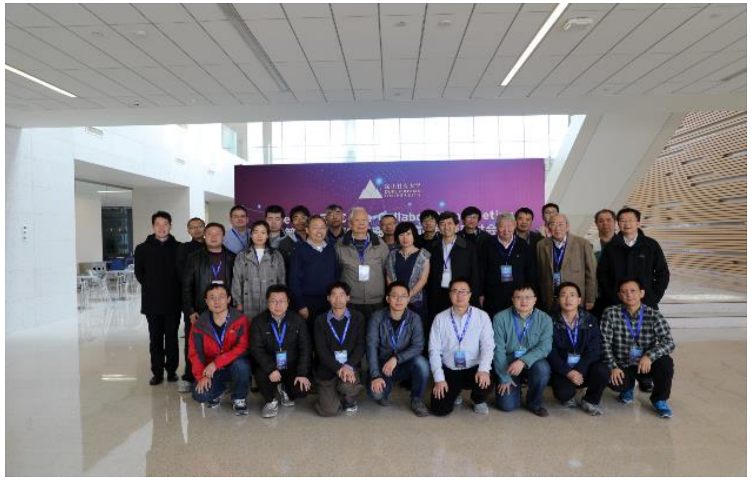

Worldwide

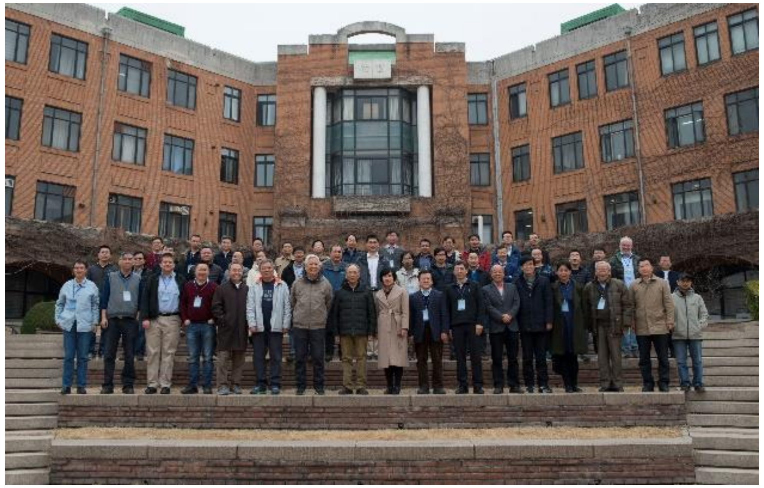
Huizhou/
GuangZhou?

PC farms: CPU cores +
Many PB storage

# EicC Status







4 pre-Collaboration meetings up to now.

Discussions on:
physics programs, simulations accelerator, detector.

EicC white paper will be submitted to the government by the end of 2019,
put project in line in the next 5-year-plan (2021-2025)

# Summary

- EicC, a future polarized electron ion collider based on HIAF.
- Main physics programs: spin and 3D structure of nucleons.
- EicC, a challenging computing need.

  Storage of O(10) PB ,

  CPU of ~100000 cores (today’s estimation).
- Computing technology improvement expected.

# Electron Ion Collider in China

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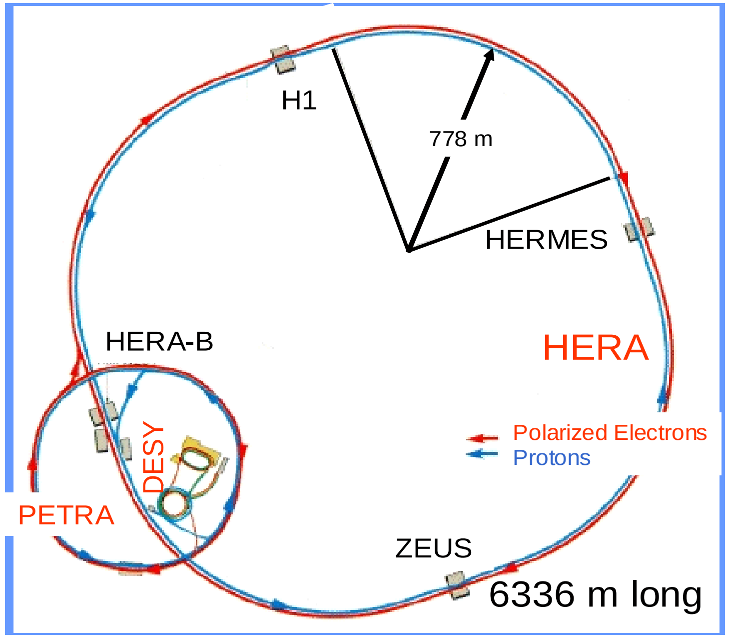
中科院近代物理研究所

# Thank You

# 德国-HERA: 国际首台 EIC 装置




| | | Lepton | Proton |
|---|---|---|---|
| **Energy** | GeV | 27.5 | 920 |
| **Intensities** | mA | 60 | $180 \times 10^{11}$ |
| **Magnetic field** | T | 0.15 | 1.5 |
| **Acc. voltage** | MV | 130 | 2 |
| **e-polarization** | % | 50 to 70 | -- |

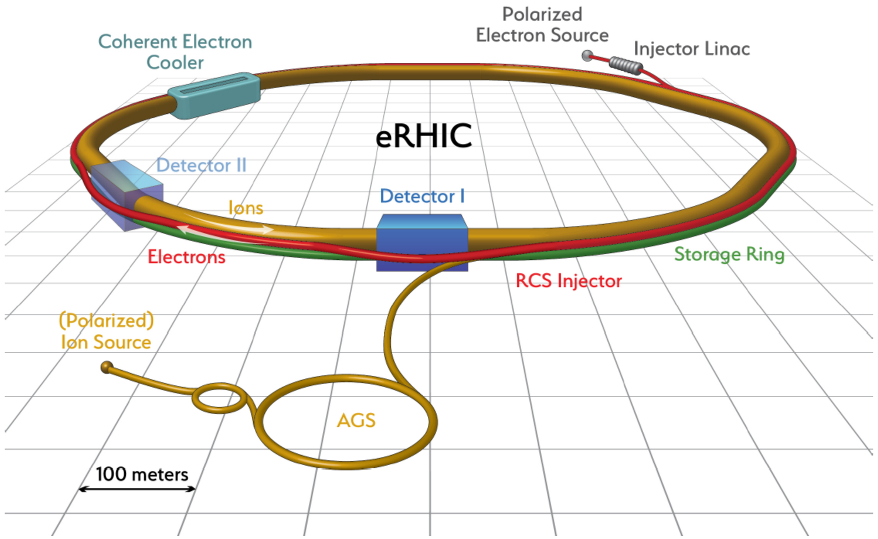
**Final luminosity**
**$(1.5 \text{ to } 5) \times 10^{31}\ cm^{-2}s^{-1}$**

**A Ring-Ring (polarized) Lepton-Proton collider with 320 GeV CM energy**

1981 Proposal
1984 Start construction
1991 Commissioning, first Collisions
1992 Start Operations for H1 and ZEUS,
➔ 1st exciting results with low luminosity
1994 Install East Spin Rotators
➔ Longitudinal polarized leptons for HERMES
1996 Install 4th Interaction region for HERA-B
1999 High Luminosity Run with electrons
2000 High efficient luminosity production:100 /pb/y
2001 Install luminosity upgrade,
Spin Rotators for H1 and ZEUS
2003 Longitudinal polarization in high energy collisions
2007 End of a highly successful program

**Tunnel: 5.2 m diameter**

# 美国-BNL: eRHIC


| | Nominal Design (with cooling) | | Risk Mitigation (no cooling) | |
|---|---|---|---|---|
| Species | p | e | p | E |
| Bunch frequency [MHz] | 112.6 | | 56.3 | |
| Bunch intensity [10^11] | 0.6 | 1.5 | 1.05 | 3.0 |
| Number of bunches | 1320 | | 660 | |
| Beam current [A] | 1 | 2.5 | 0.87 | 2.5 |
| Rms norm. emit. h/v [um] | 2.7/0.38 | 391/20 | 4.1/2.5 | 391/95 |
| Rms emittance h/v [nm] | 9.2/1.3 | 20/1 | 13.9/8.5 | 20/4.9 |
| β* h/v [cm] | 90/4 | 42/5 | 90/5.9 | 63/10.4 |
| IP rms beam size h/v [um] | 91/7.2 | | 112/22.5 | |
| IR rms angular spread h/v [urad] | 101/179 | 219/143 | 124/380 | 179/216 |
| b-b parameter (/IP) h/v | 0.013/0.007 | 0.064/0.099 | 0.015/0.005 | 0.1/0.083 |
| Rms bunch length [cm] | 5 | 1.9 | 7 | 1.9 |
| Rms energy spread, 10^-4 | 4.6 | 5.5 | 6.6 | 5.5 |
| Max space charge parameter | 0.004 | neglig. | 0.001 | neglig. |
| IBS growth time tr/long, h | 2.1/2.0 | | 9.2/10.1 | |
| Polarization, % | 80 | 70 | 80 | 70 |
| Hourglass and crab crossing factor | 0.87 | | 0.85 | |
| **Peak luminosity [10^33 cm-2s-1]** | **10.1** | | **4.4** | |
| **Integrated luminosity/week, fb$^{-1}$** | **4.51** | | **1.12** | |

电子环方案：ERL，NS-FFAG

质心能量: 255GeV/p + 15.9GeV/e

$\sqrt{S}$=126GeV

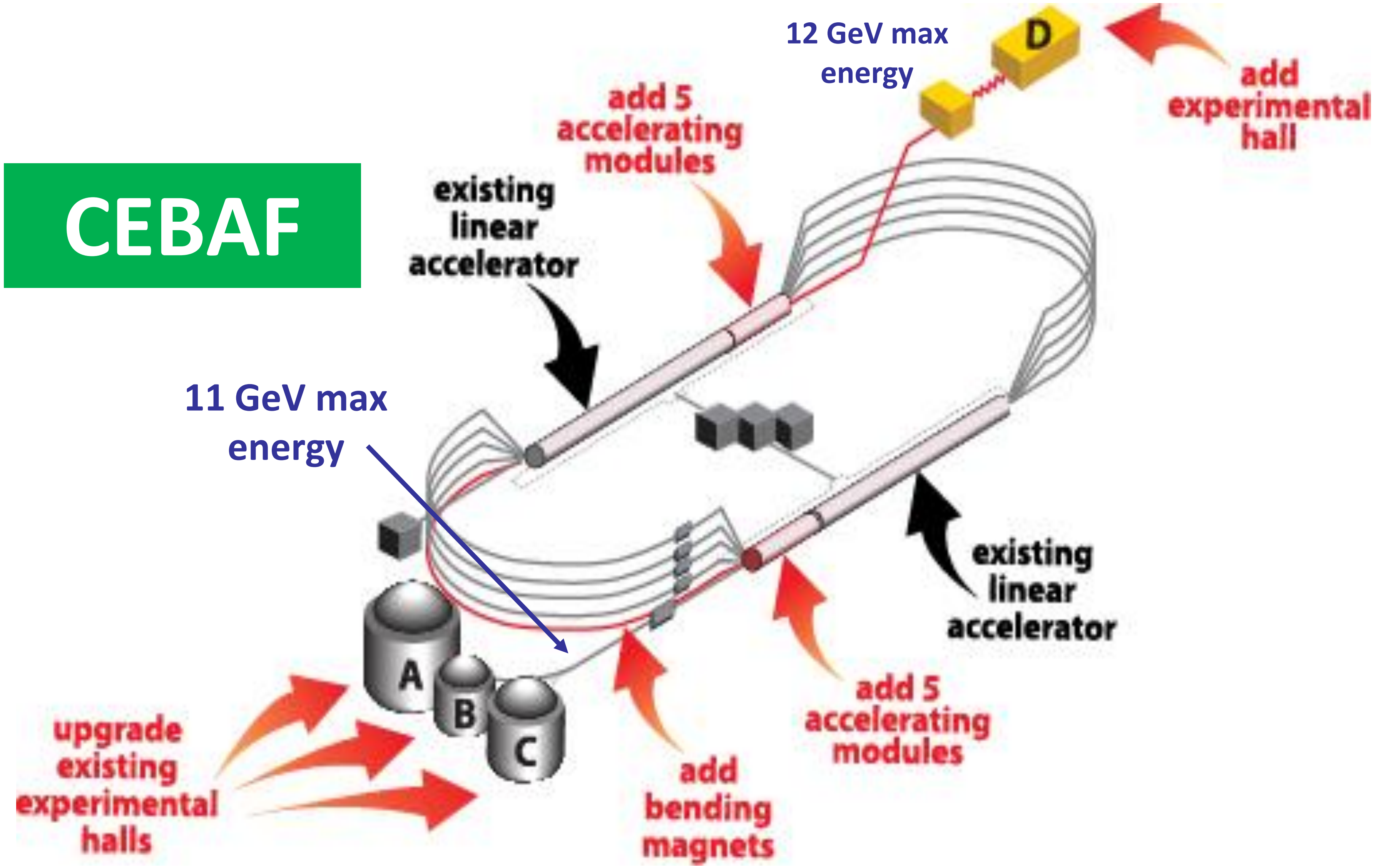
设计亮度：$4.4\times10^{33}$ $cm^{-2}s^{-1}$ –无冷却

$1.0\times10^{34}$ $cm^{-2}s^{-1}$-冷却

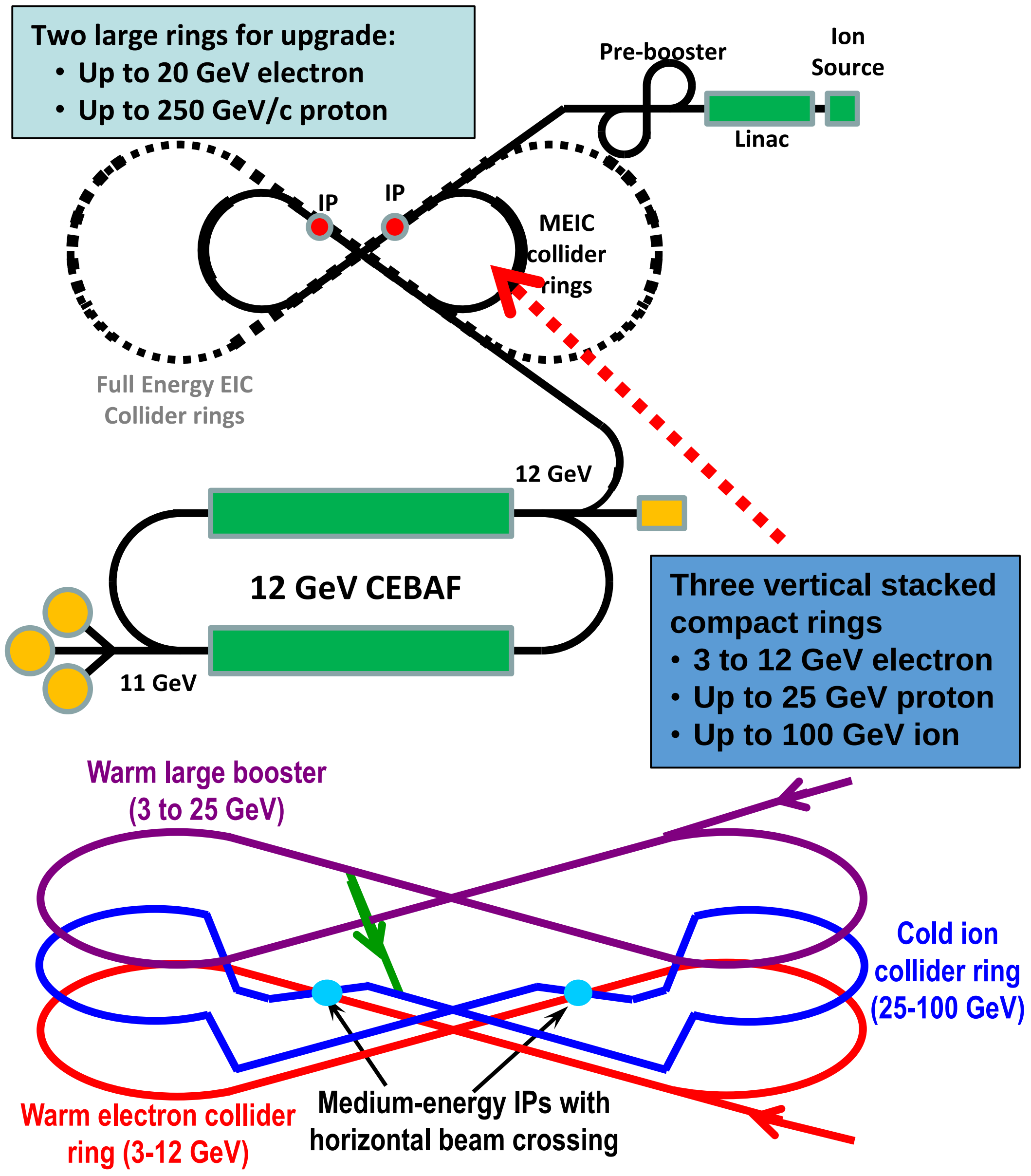
工程计划：2022-2025之间开建

# 美国-JLab: JLEIC

CEBAF



# 美国-JLab: JLEIC




## Present baseline: Ring-Ring

- Energy: 3-12 GeV e on 20-100 GeV p or up 40 GeV/u ion
- Polarized light ions (p, d, $^3$He), unpolarized ions up to A=200 (Au, Pb)
- New ion complex & two collider rings
- Up to 3 interaction points
- High polarization for both beams
- Conventional electron cooling
- Upgradable to 20 GeV electron, 250 GeV proton or 100 GeV/u ion

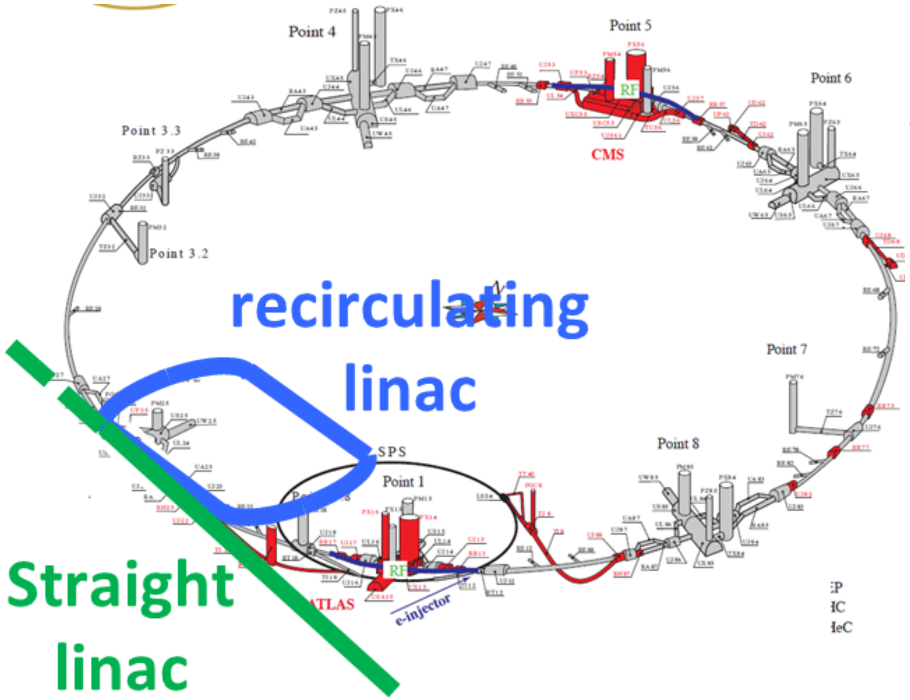
电子环方案：“8”字型环

质心能量：60-100GeV p + 3-12 GeV e

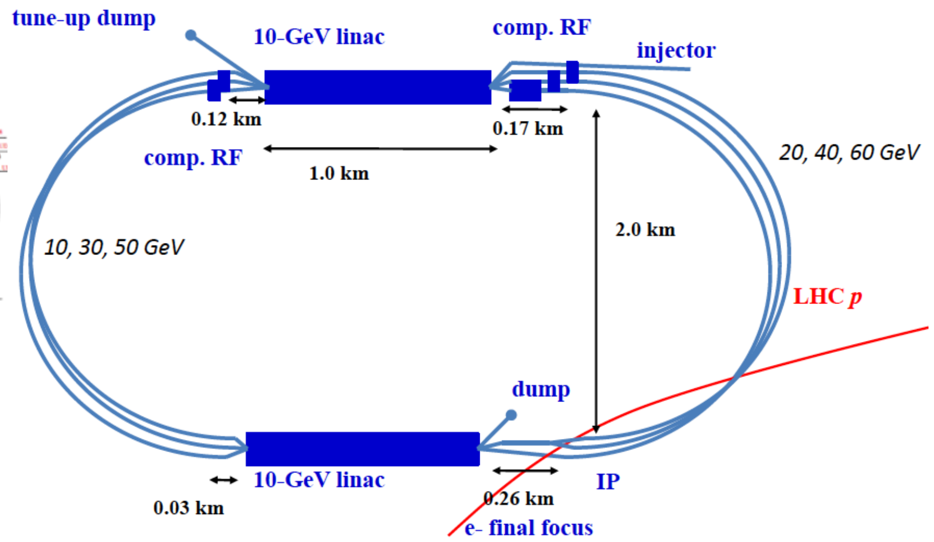
设计亮度：$5.6\times10^{33}$ cm$^{-2}$s$^{-1}$ $1.4\times10^{34}$ cm$^{-2}$s$^{-1}$

工程计划：2022-2025方案设计

# CERN: LHeC




电子环方案




| $10^{34}$ cm$^{-2}$ s$^{-1}$ Luminosity reach | | PROTONS | ELECTRONS |
|---|---|---|---|
| Beam Energy | GeV | 7000 | 60 |
| Luminosity | $10^{33}$cm$^{-2}$s$^{-1}$ | 16 | 16 |
| Normalized emittance $ge_{x,y}$ | mm | 2.5 | 20 |
| Beta Funtion $b^*_{x,y}$ | m | 0.05 | 0.10 |
| rms Beam size $s^*_{x,y}$ | mm | 4 | 4 |
| Beam Current | mA | 1112 | 25 |
| Bunch Spacing | Ns | 25 | 25 |
| Bunch Population | $10^9$ | $2.2*10^{11}$ | $4*10^9$ |
| Bunch charge | nC | 35 | 0.64 |

电子环方案：ERL circulator Ring

质心能量: 7 TeV p + 60 GeV e

设计亮度: $1.6\times10^{34}$ cm$^{-2}$s$^{-1}$

工程计划：2025-2035 方案设计