Electron-ion collider in China (EicC)

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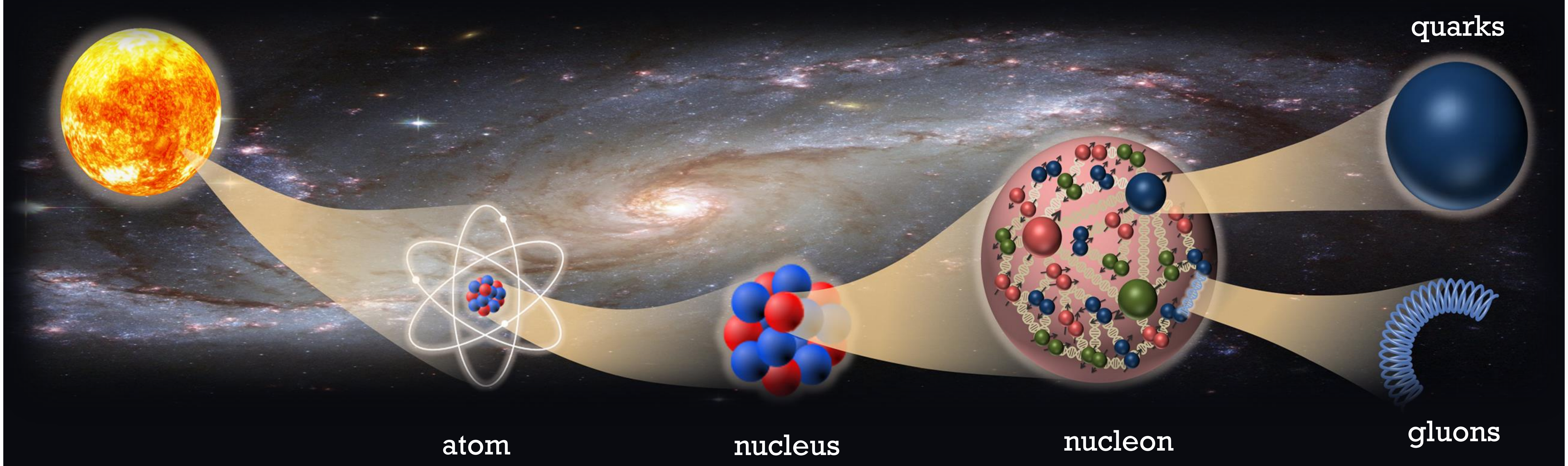
Outline

- Introduction
- Physics highlights
- Detector conceptual design
- Summary

Do we understand the building blocks of our visible world?

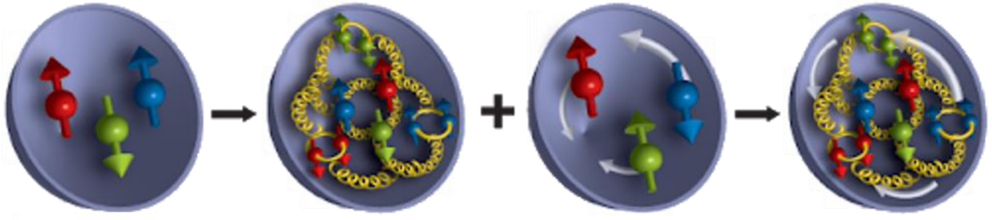


Open questions:

→How do quarks + gluons as well as their interactions make up a nucleon?

→How can the nucleon's emergent property be explained at quarks and gluons' degree of freedom?

Gell-Mann quark model



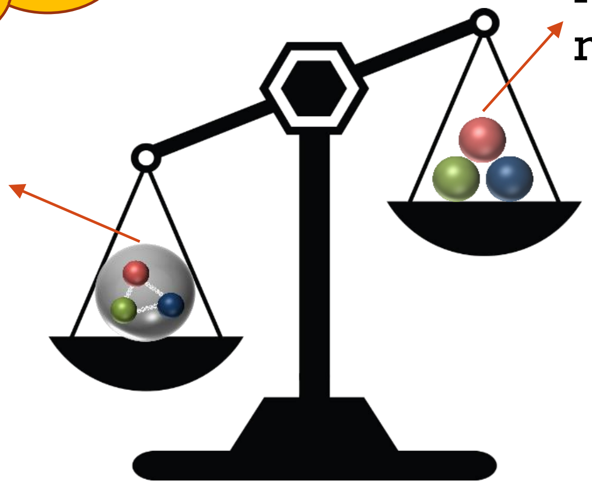
1970s 1980s/2000s Now

spin

Spin decomposition:

$$S_{tot} = \frac{1}{2} = \underbrace{\frac{1}{2}\Delta\boldsymbol{\Sigma}}_{\text{Quark spin}} + \underbrace{\Delta \boldsymbol{G}}_{\text{Gluon Spin}} + \underbrace{\boldsymbol{\mathcal{L}}_q}_{\text{Quark OAM}} + \underbrace{\boldsymbol{\mathcal{L}}_g}_{\text{Gluon OAM}}$$

mass

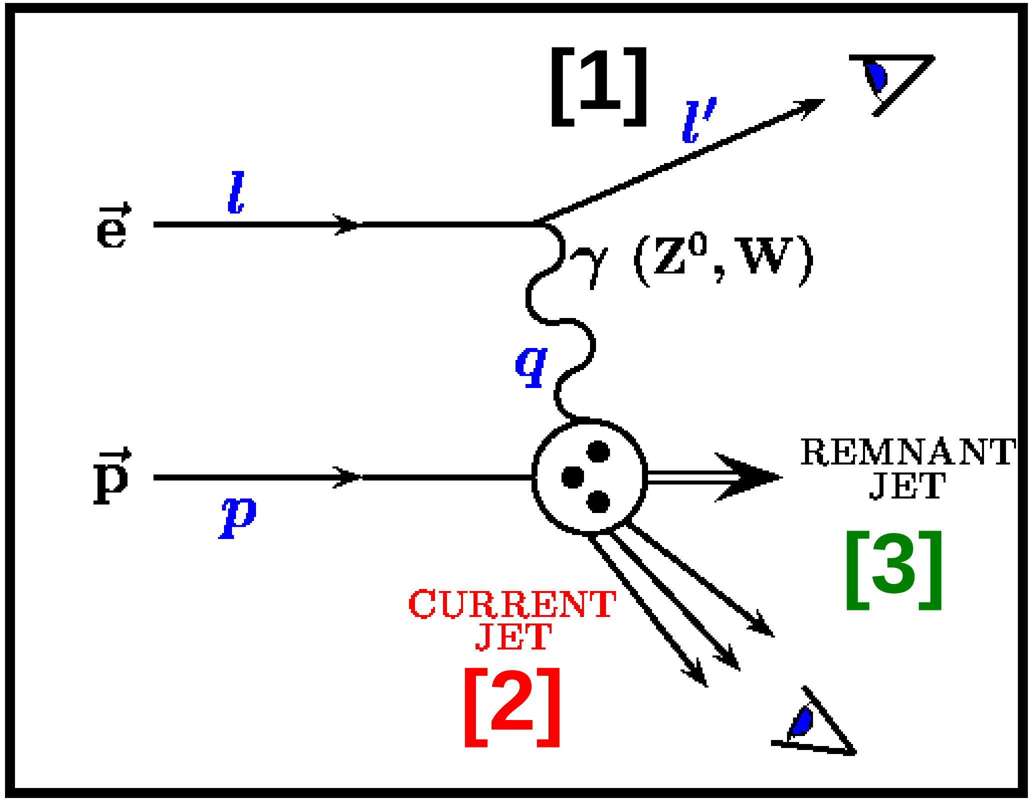


Mass decomposition:

$$M = \underbrace{M_q}_{\text{Quark energy}} + \underbrace{M_m}_{\text{Quark mass}} + \underbrace{M_g}_{\text{Gluon energy}} + \underbrace{M_a}_{\text{Trace anomaly}}$$

Experimentally… we need to determine each of the above contributions

Lepton-Nucleon Scatterings



QED tool to study QCD nature of the nucleon

$$Q^2 = -q^2 = sxy$$

$$x = \frac{Q^2}{2p\cdot q}$$

$$y = \frac{p\cdot q}{p\cdot l}$$

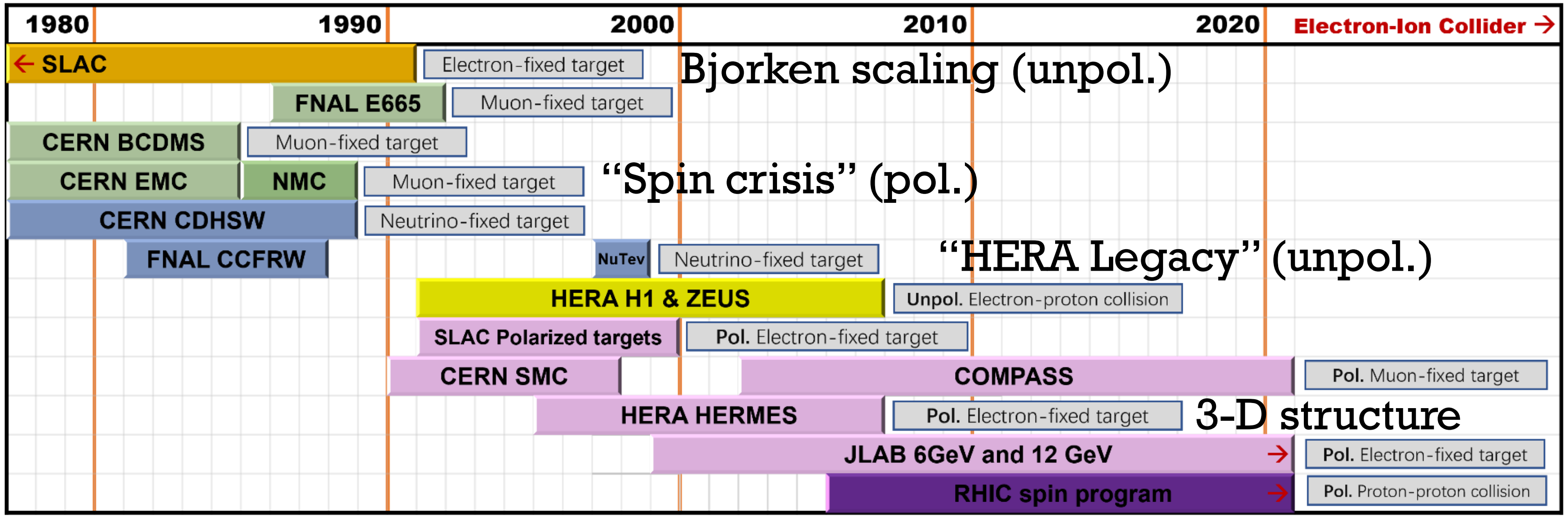
$$s = 4E_e E_p$$

$$W = (q+p)^2$$

- QED probe is clean
- α_{EM} ~1/137 with broad Q coverage
- One-photon exchange approximation: ~1% accuracy
- Detection scale is determined by Q^2: 200 MeV ~ 1fm

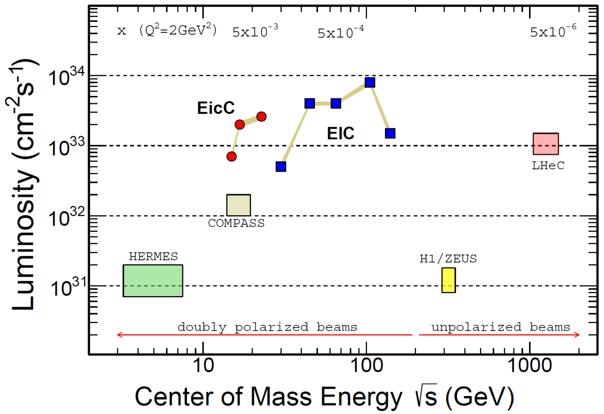
Observe scattered electron/muon	[1]	→ **inclusive**
Observe current jet/hadron	[1]+[2]	→ **semi-inclusive**
Observe remnant jet/hadron as well	[1]+[2]+[3]	→ **exclusive**

Why we need an Electron-Ion Collider



Electron-Ion Collider：

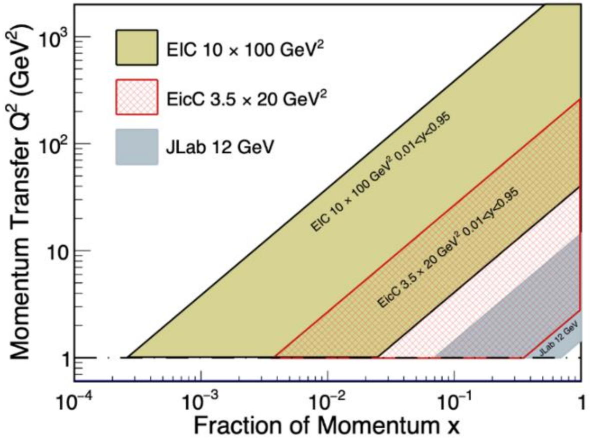
1. Polarized beams (first time)
2. High lumi.（100-1000 x HERA）
3. High polarization ~70%
4. Full detector coverage



Quotation from "Why we need an EIC" by *Raju Venugopalan, 2021*

Only feasible with a polarized EIC

1. **Nailing down the quark and gluon spin content of the proton**
2. **Three dimensional images of the internal structure of hadrons**
3. **Exploring the terra incognita of the nuclear quark-gluon landscape**
4. **Discovery and characterization of universal gluon matter?**



Electron Ion Collider in China…Huizhou(惠州) in Guangdong province

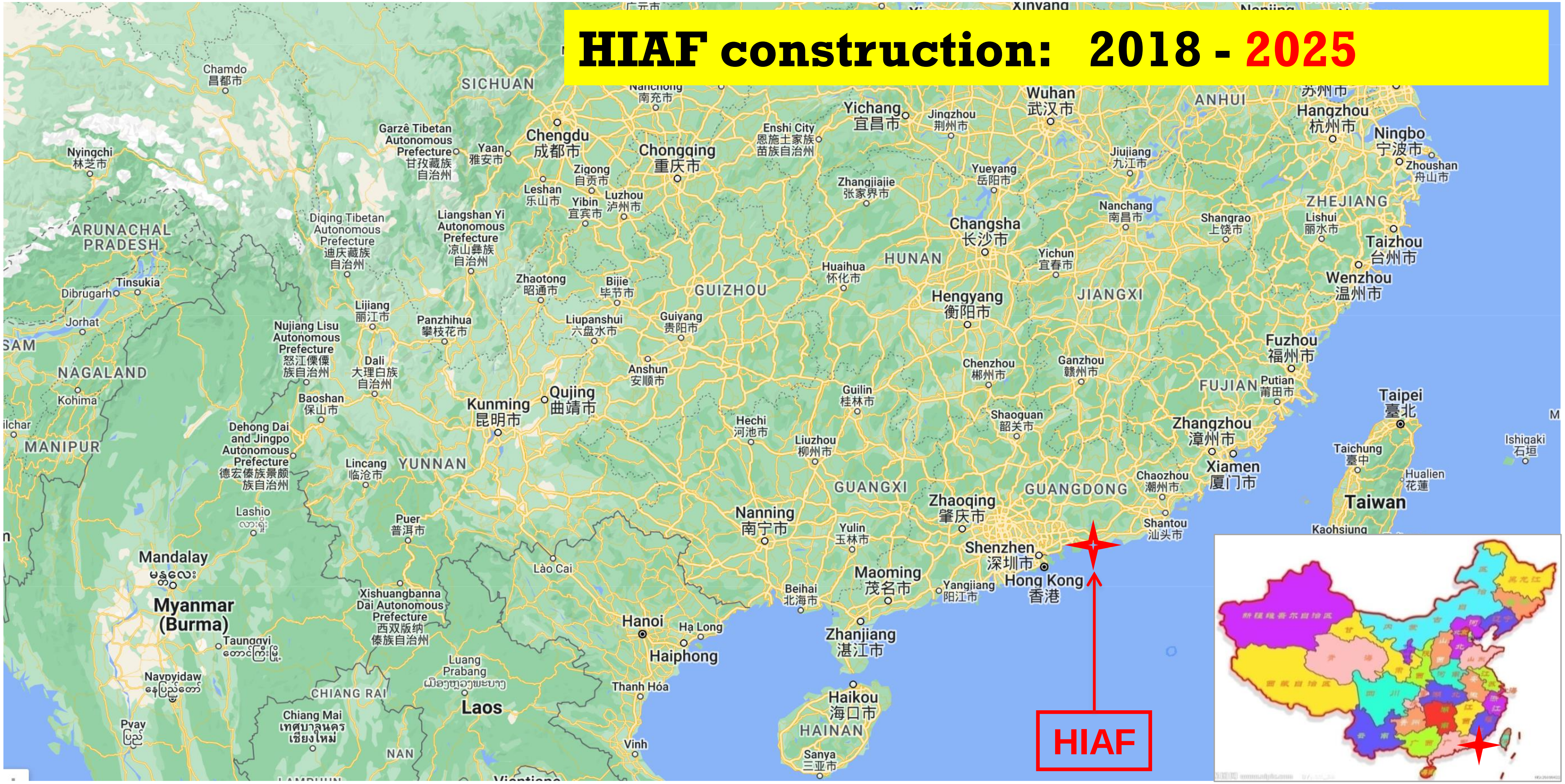
HIAF under construction

EIC in China

Electron Ion Collider in China, EicC

Location: Huizhou, Guangdong

HIAF construction: 2018 - 2025

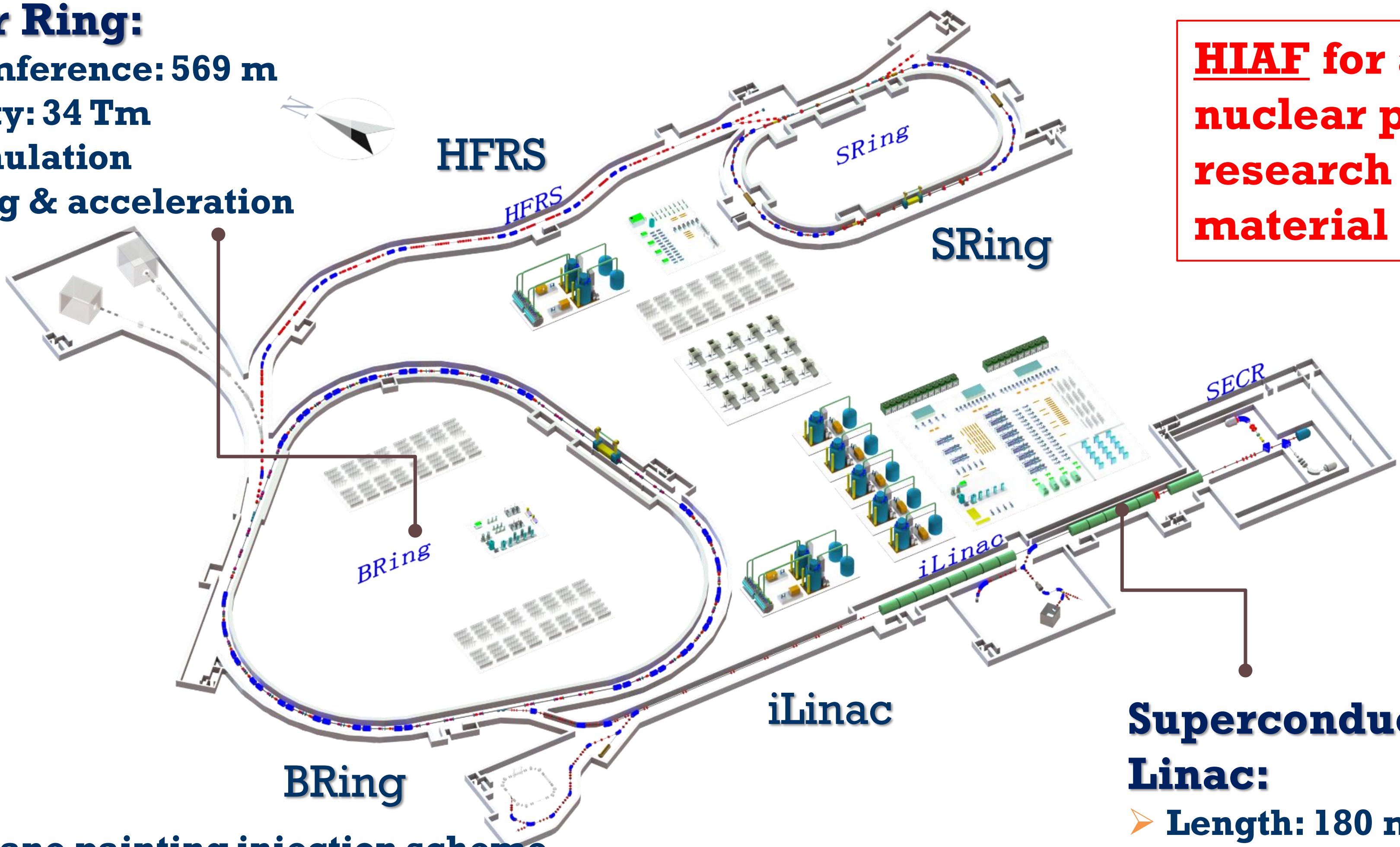


High Intensity heavy-ion Accelerator Facility (HIAF)

HIAF total investment: 2.5 billion RMB (Funded)

Booster Ring:
- Circumference: 569 m
- Rigidity: 34 Tm
- Accumulation
- Cooling & acceleration

HIAF for atomic physics, nuclear physics, applied research in biology and material science etc.



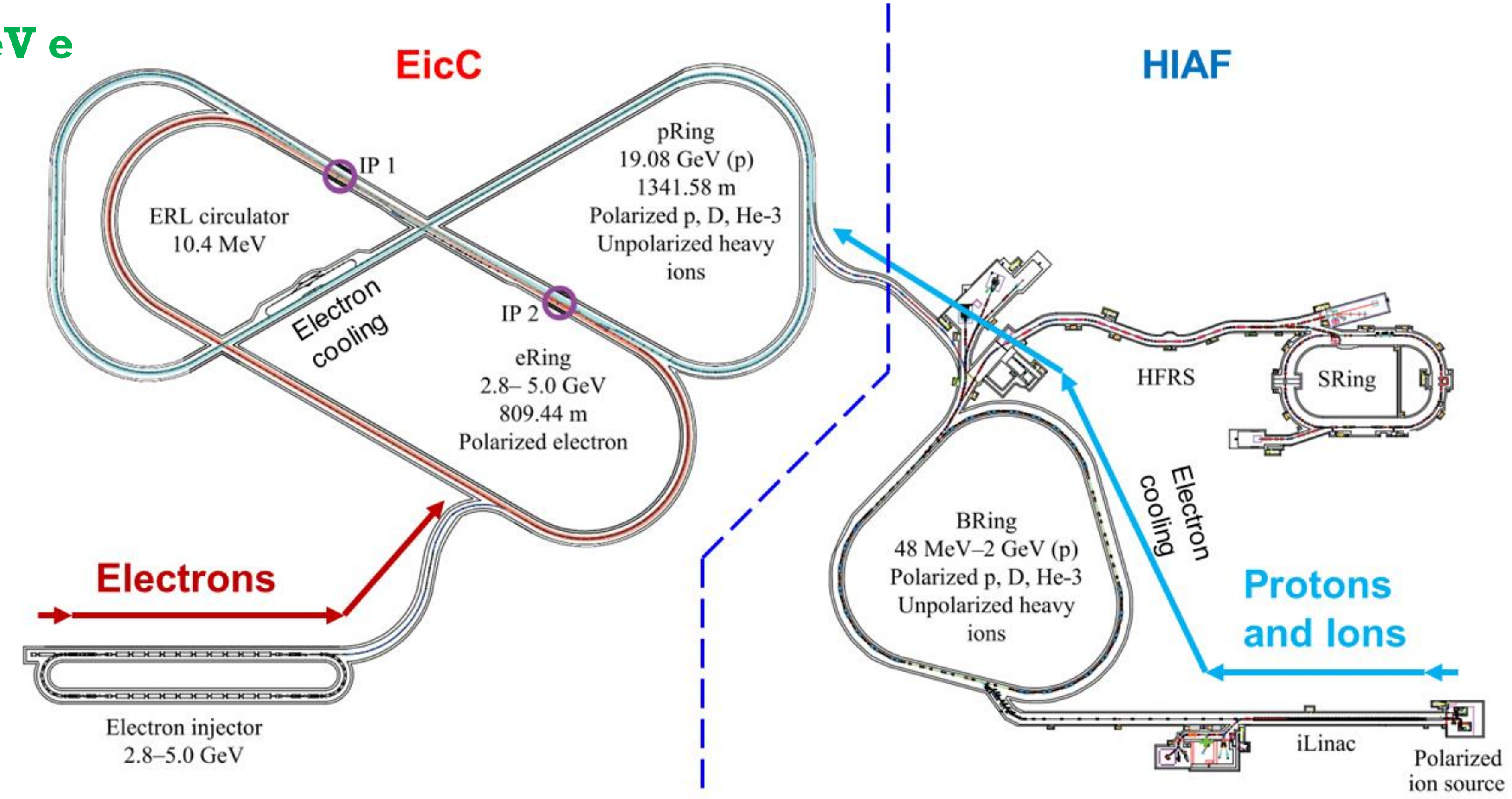
- Two-plane painting injection scheme
- Fast ramping rate operation

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

EicC Accelerator complex layout

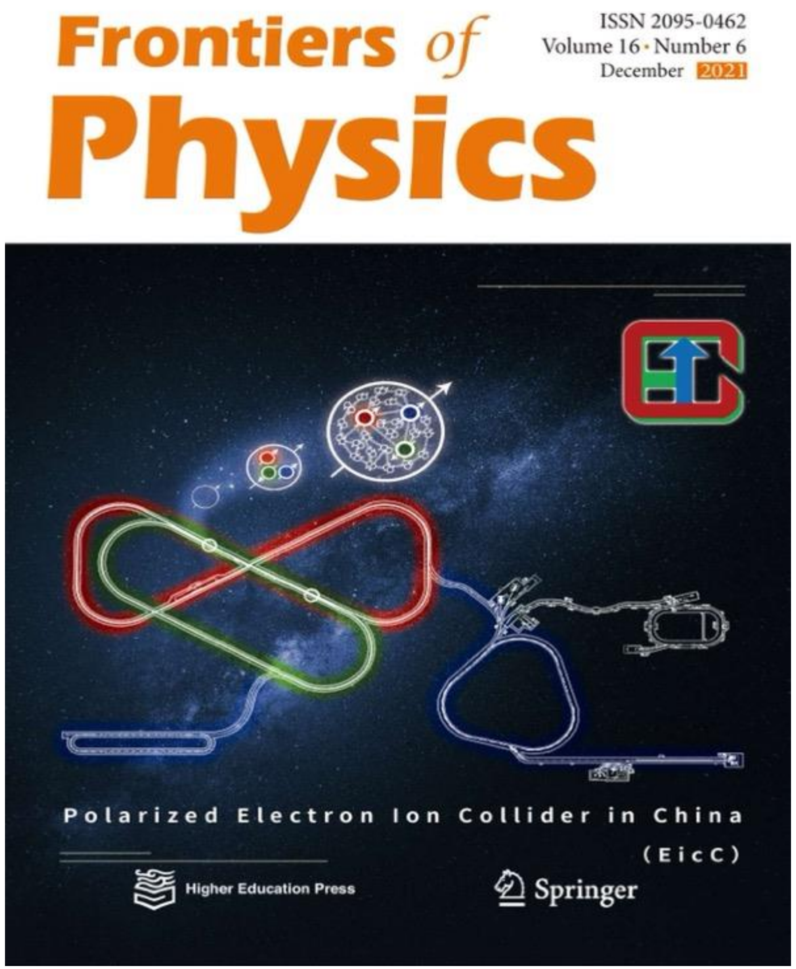
- **20 GeV p + 3.5 GeV e**
- $\sqrt{S}$: **16.7GeV**
- **High Lumi.:**

  2-4 x10^{33} cm^{-2}s^{-1}
- **Polarized beams**



EicC white paper (arXiv: 2102.09222)

Published in the *Frontiers of Physics* (2021)



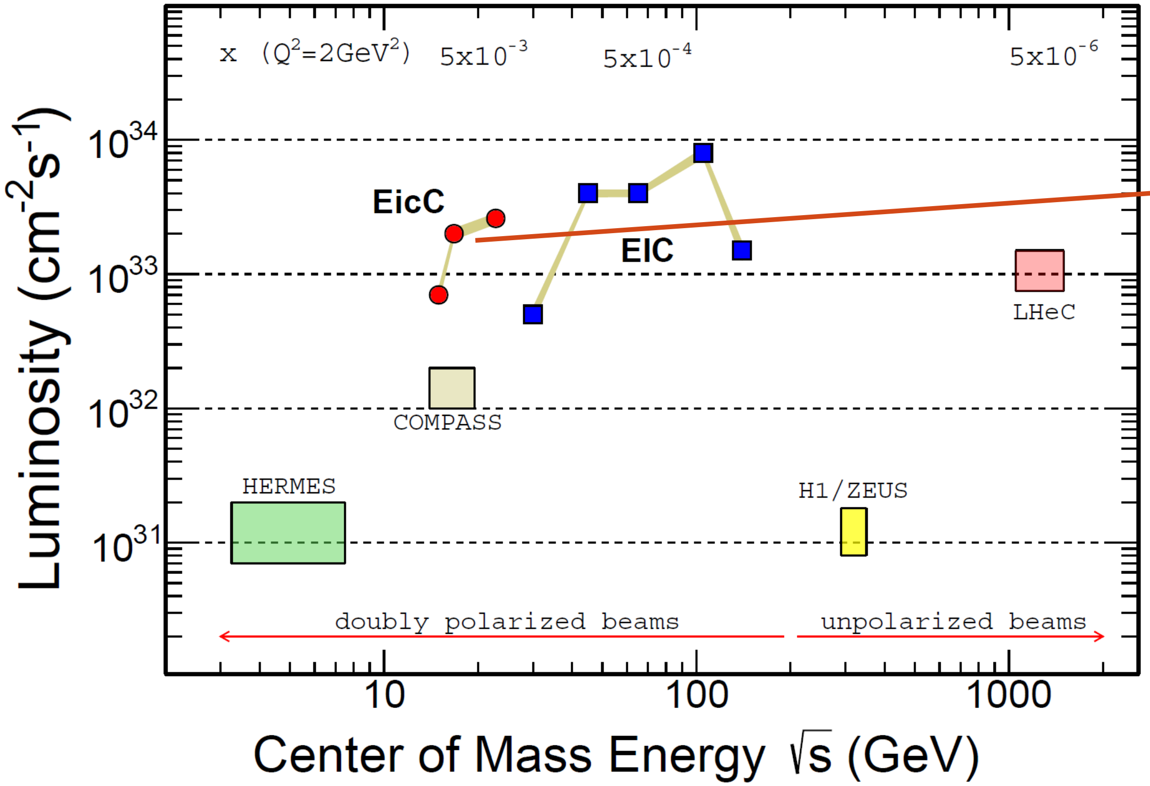
https://link.springer.com/article/10.1007/s11467-021-1062-0

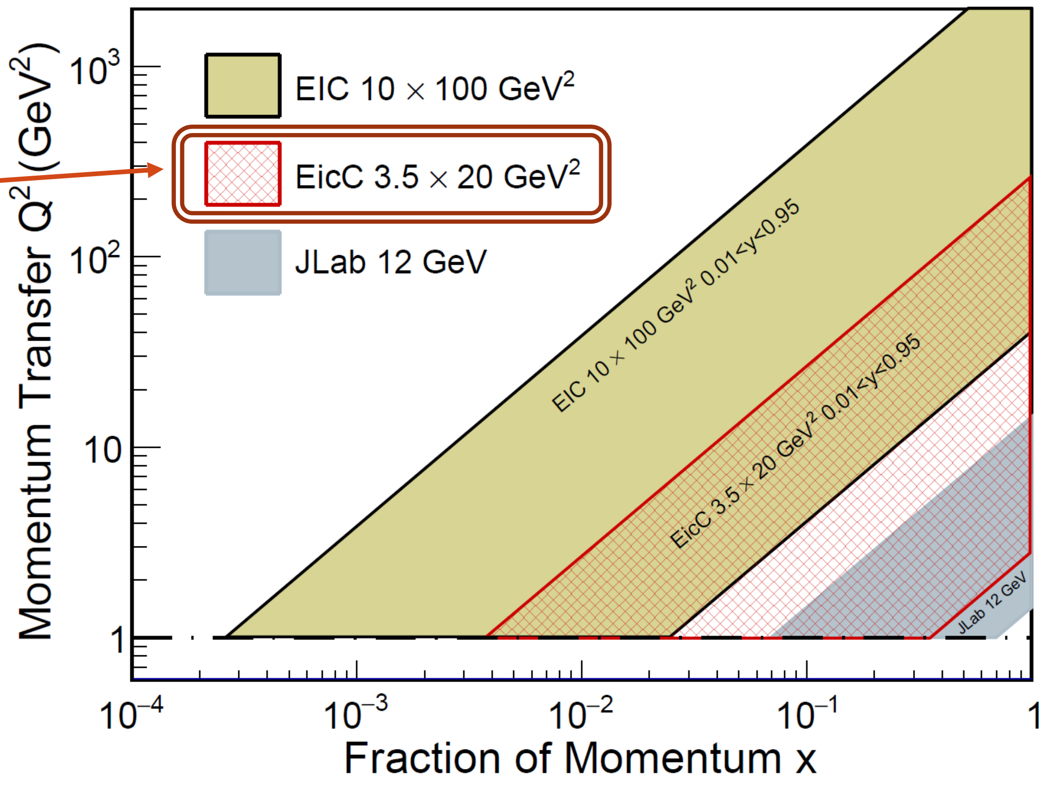
- Spin structure of the nucleon: 1D, 3D
  - polarized electron + polarized proton/light nuclei
- Partonic structure of nuclei and the Parton interaction with the cold nuclear environment
  - unpolarized electron + unpolarized various nuclei
- Quarkonium with c/cbar, b/bbar
- Origin of the proton mass study via J/Psi and Upsilon near-threshold production

Detector + Accelerator preliminary design

46 institutes and >100 physicists

EicC parameters

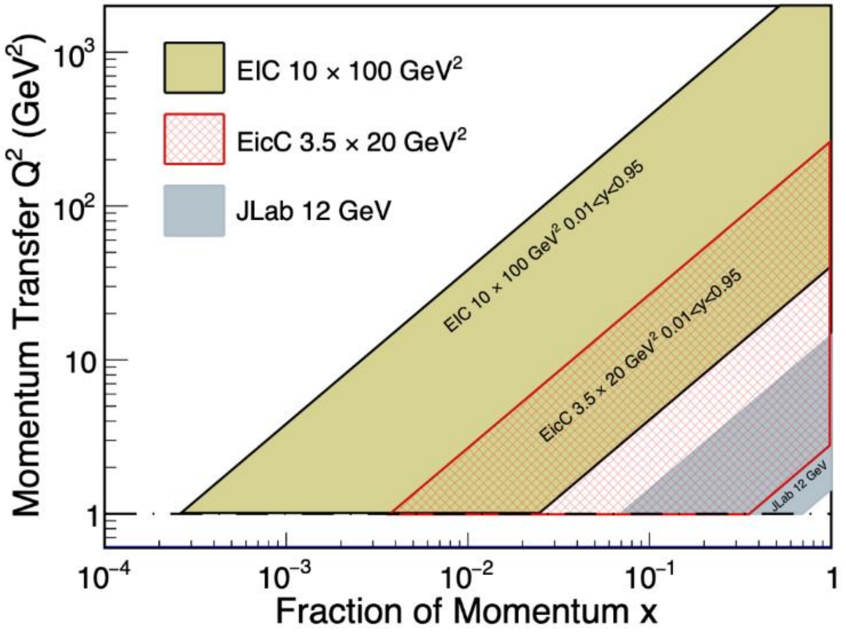


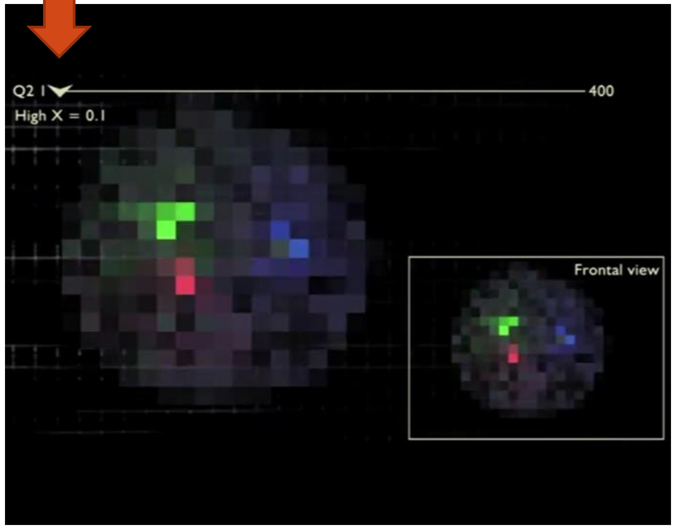


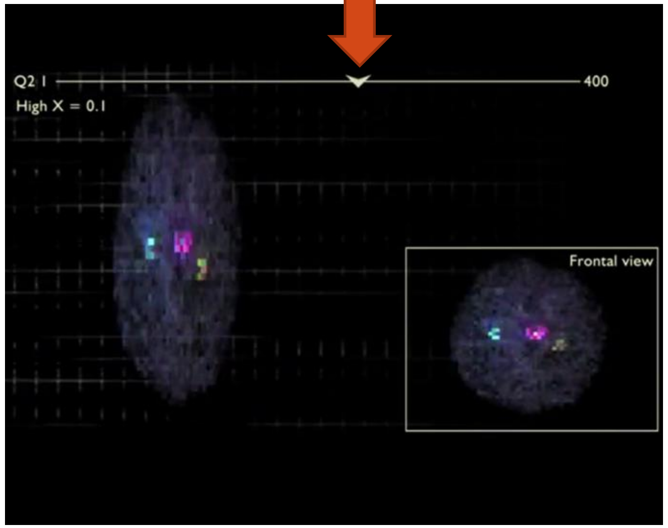
- EicC covers the kinematic region between JLab experiments and EIC@BNL
- EicC complements the ongoing scientific programs at JLab and future EIC project
- EicC focuses on moderate x and sea-quark region

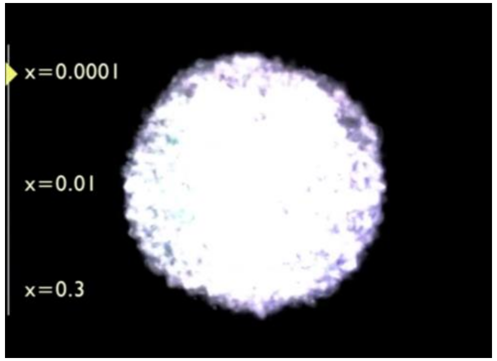
Kinematic region VS physics

See a video at:
http://eicug.org/

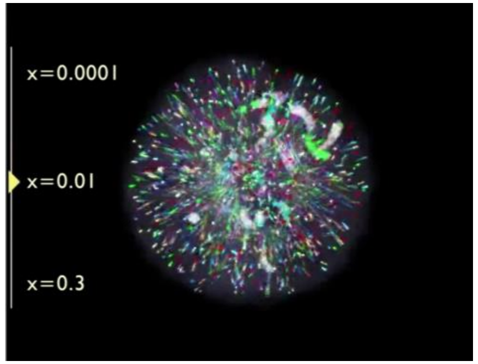




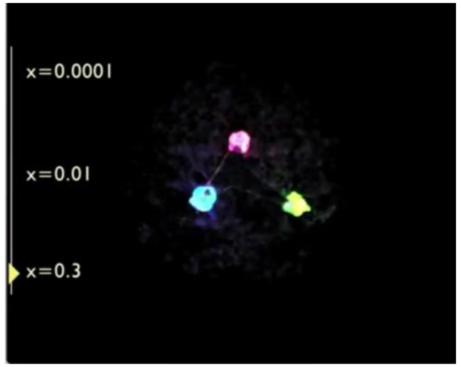




Gluon dominates



Gluon + sea quarks

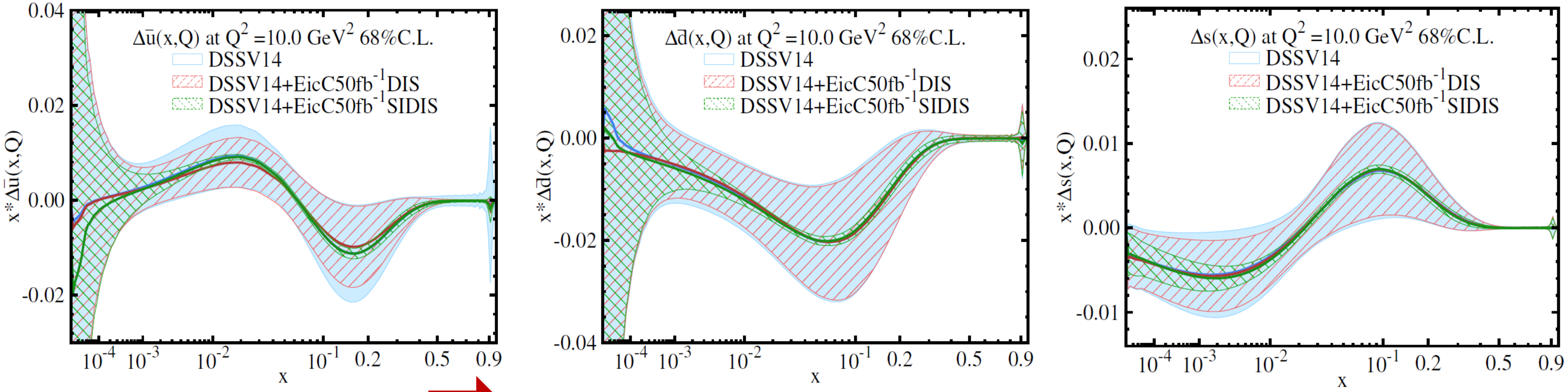


Valence quarks

- Different x → different picture
- Broad Q^2 coverage:
  - ➢ QCD evolution
  - ➢ Non-perturbative → perturbative

EicC and EIC-helicity distribution via SIDIS (1D spin)

D. Anderle, T. Hou, H. Xing, M. Yan, C. -P. Yuan, Y. X. Zhao, JHEP08, 034 (2021)



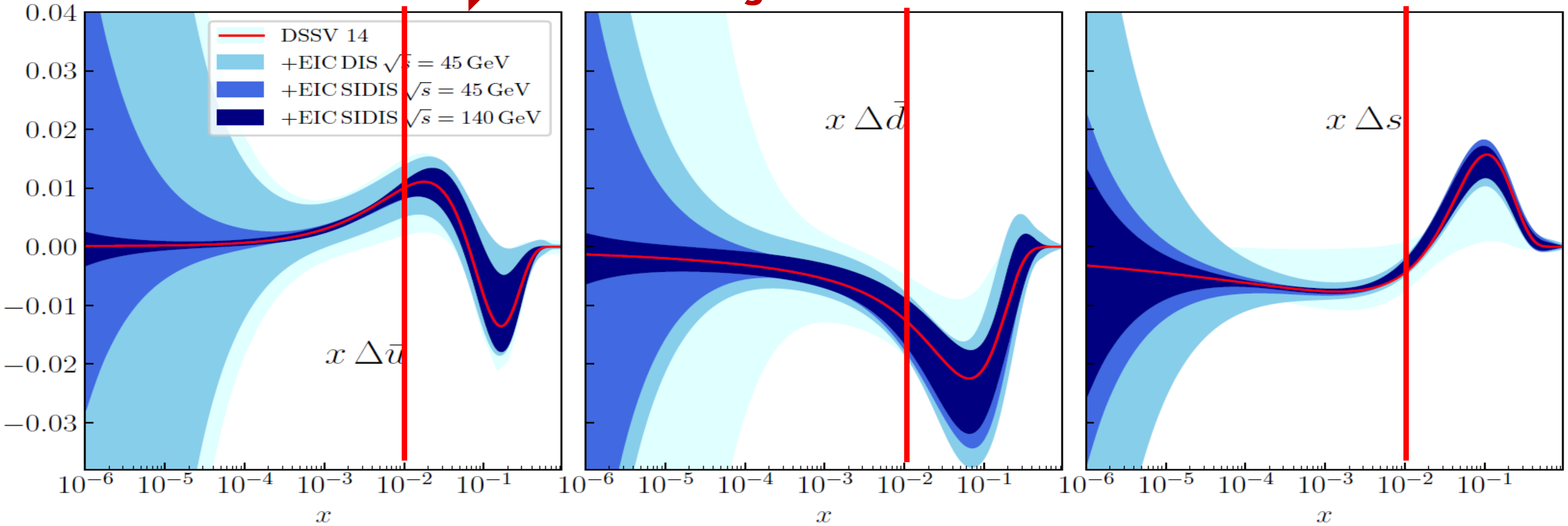
An NLO study

EicC white paper

complementary

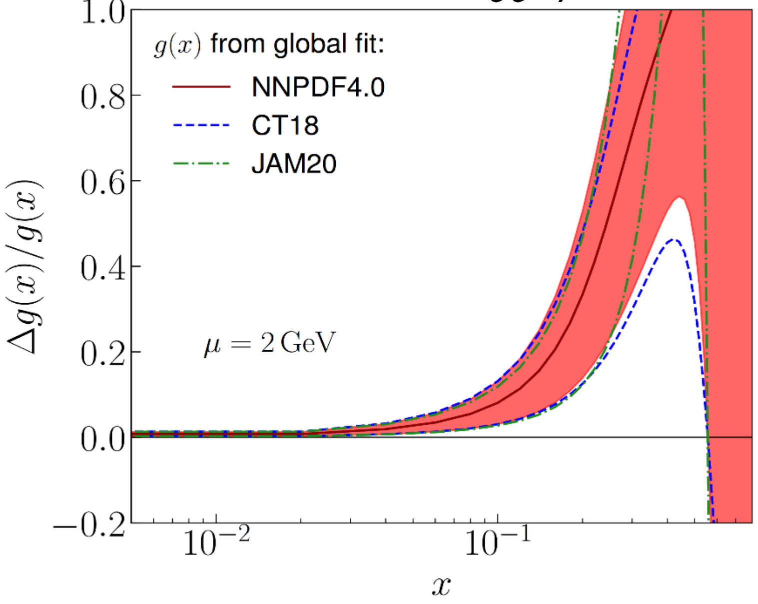
EIC Yellow Report

EicC coverage

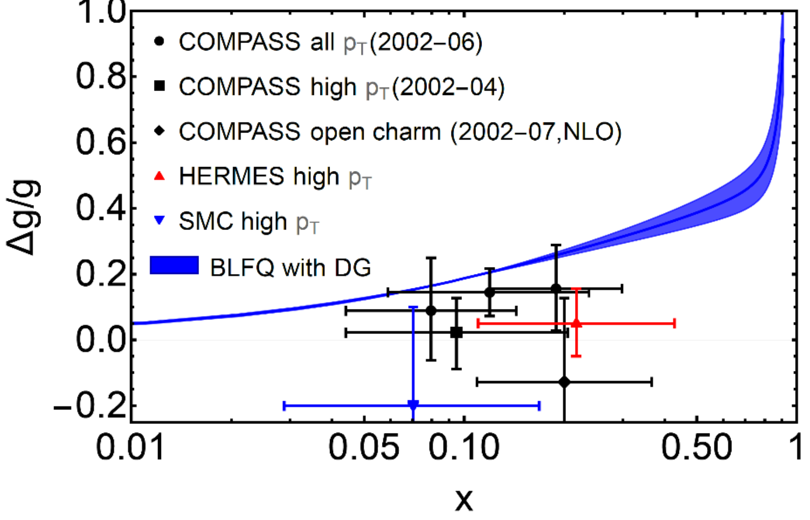


EicC and EIC-gluon polarization (at large x)

ArXiv:2211.15587



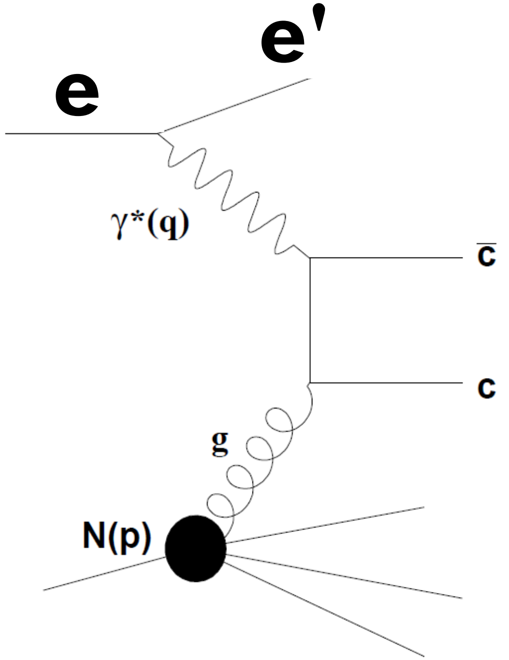
ArXiv:2209.08584

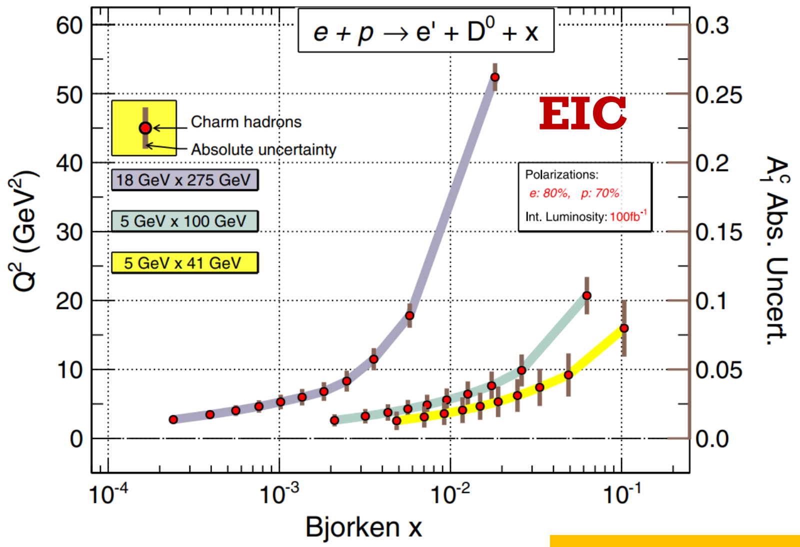


D. Anderle , X. Dong, …, E. Sichtermann, …, F. Yuan, Y. X. Zhao , Phys. Rev. D104, 114039 (2021)

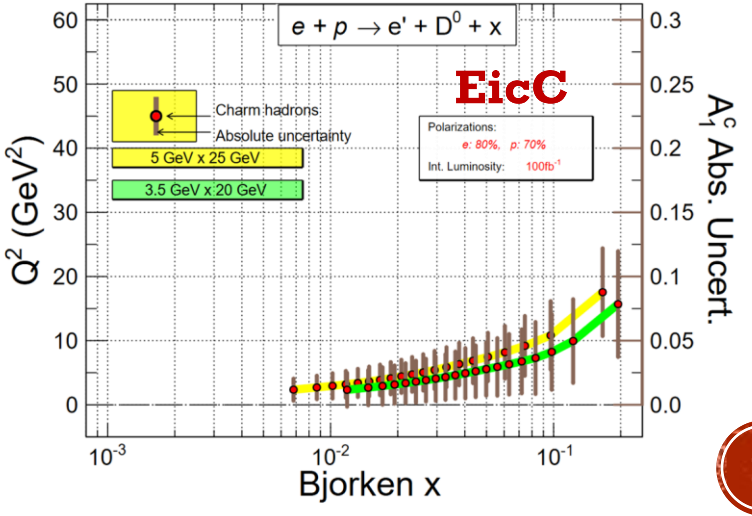
$$A_{LL}^{\vec{e}+\vec{p}\to e'+D^0+X} = \frac{d\sigma^{++} - d\sigma^{+-}}{d\sigma^{++} + d\sigma^{+-}}$$

$$= \frac{1}{P_e P_p} \frac{N^{++} - N^{+-}}{N^{++} + N^{+-}}$$





complementary



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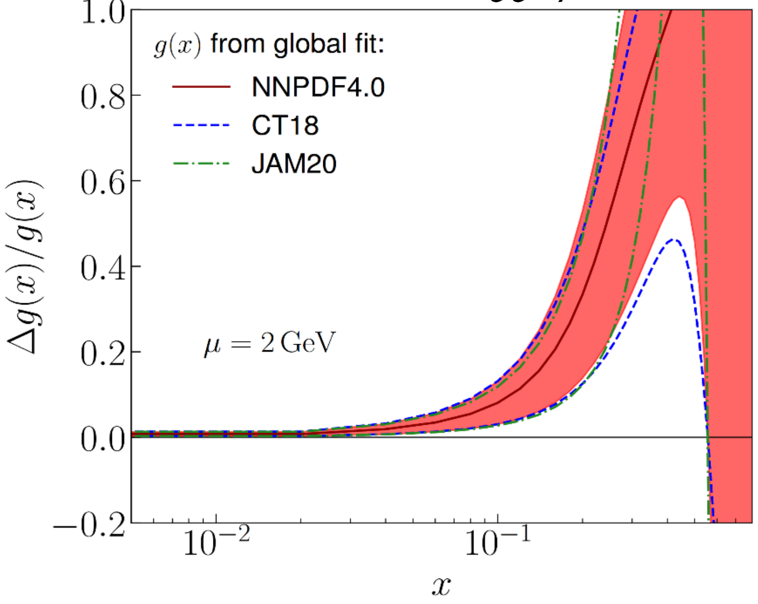

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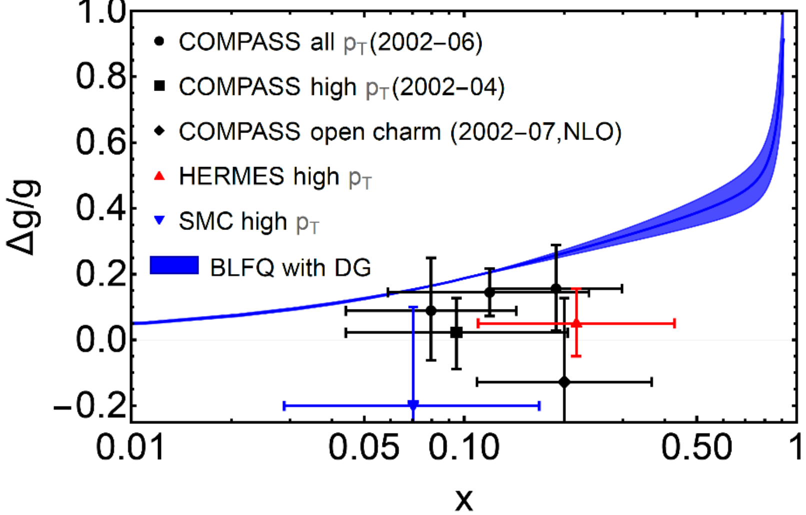

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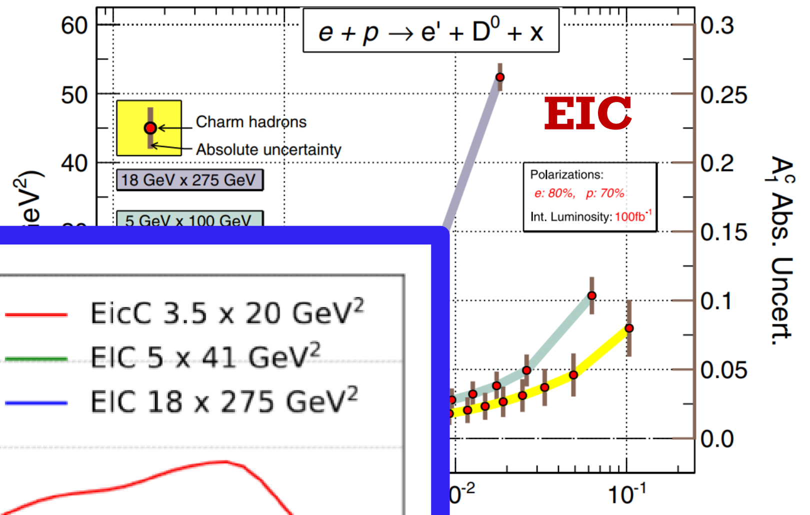
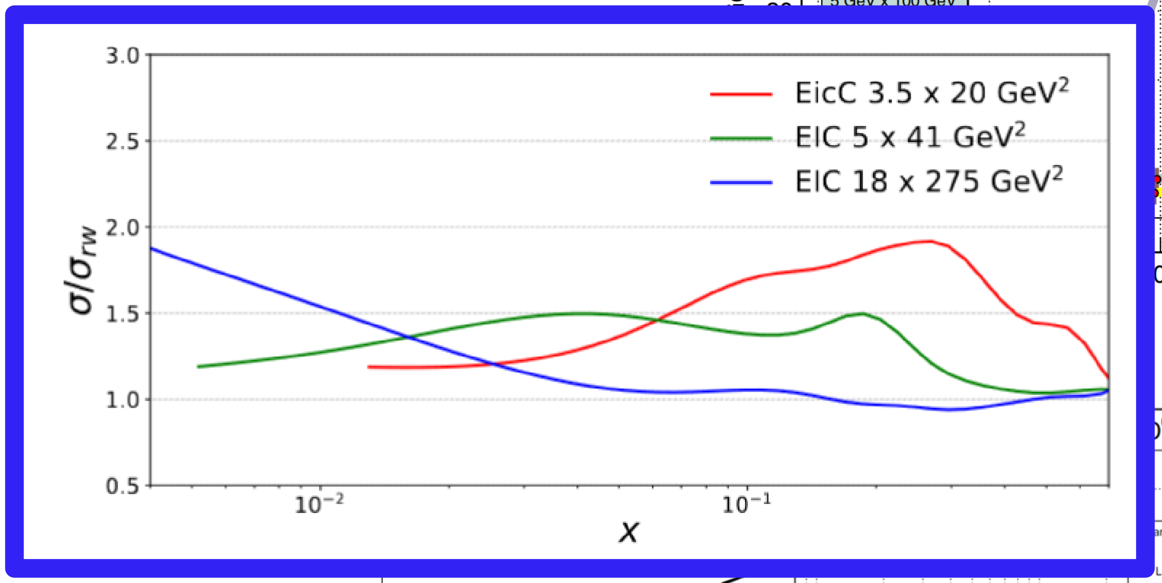
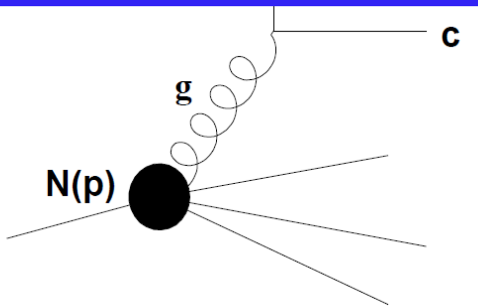
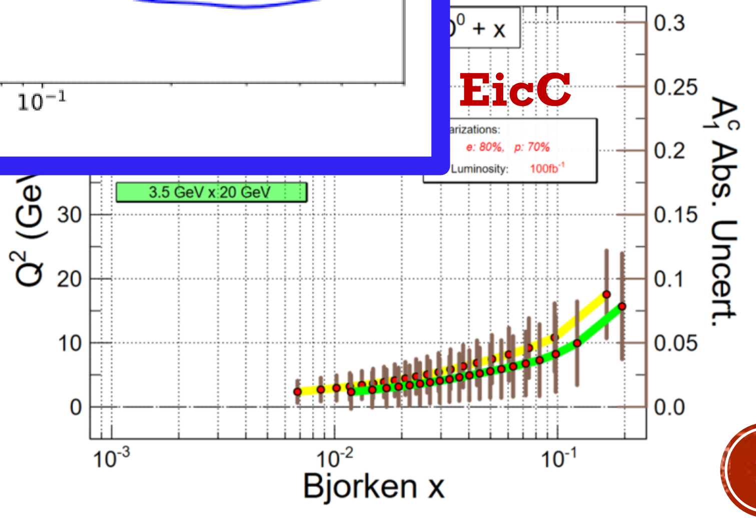
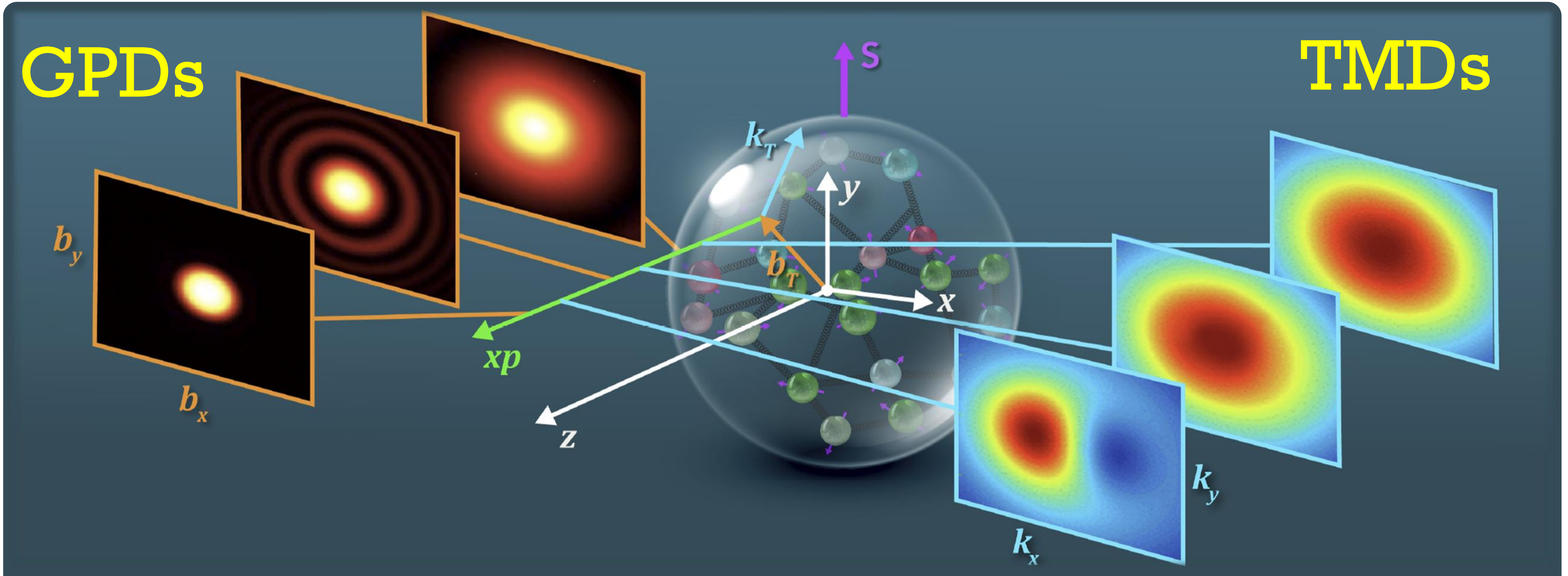




complementary





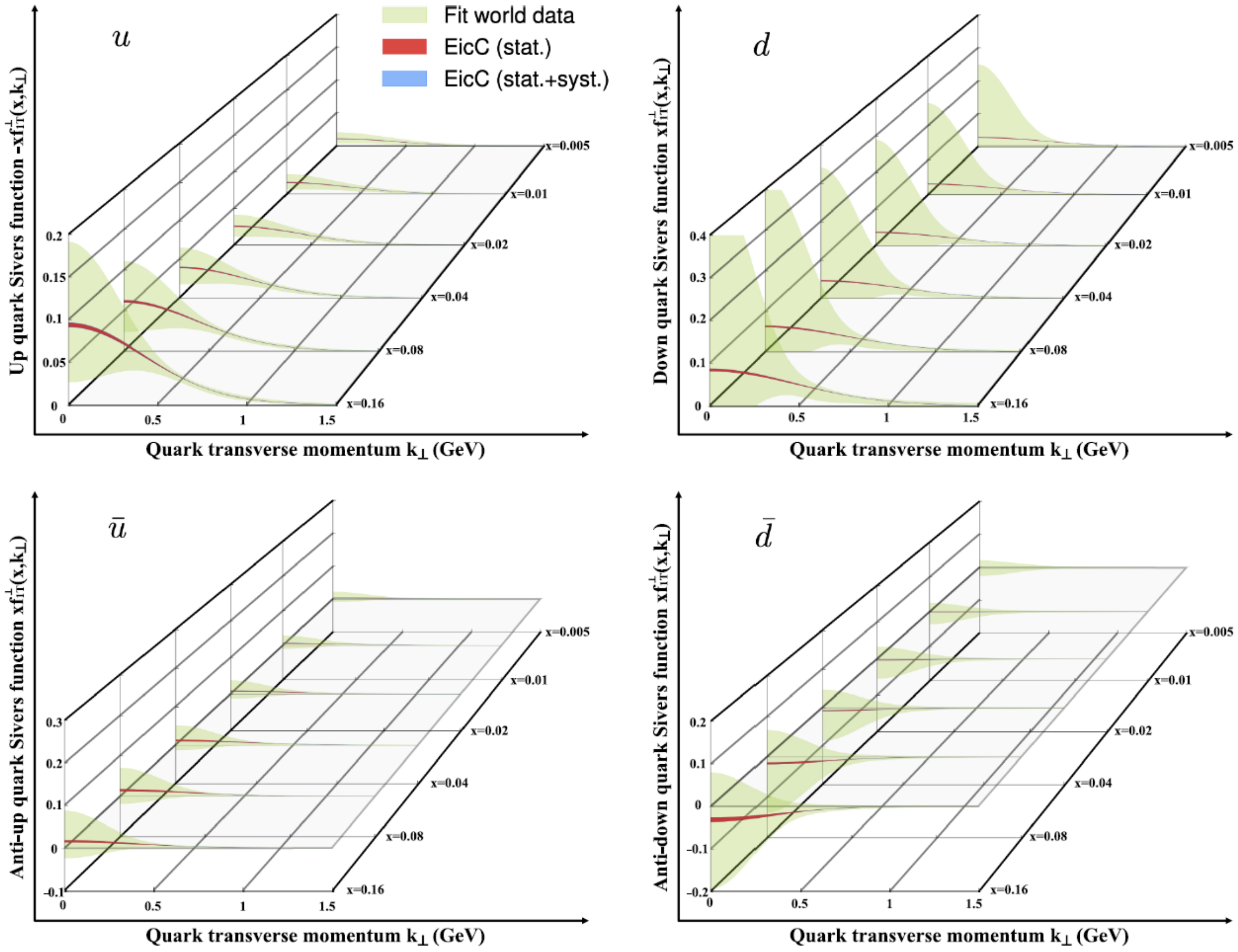


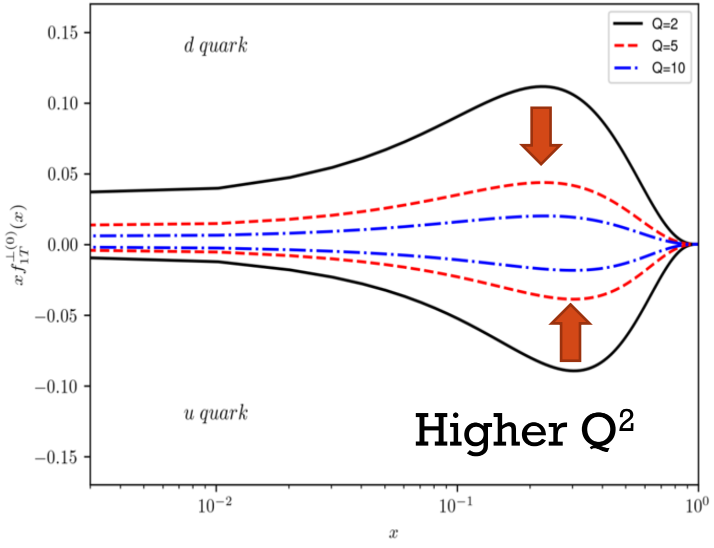
GPDs: deformation of Parton's spatial distribution when hadron is polarized

TMDs: deformation of Parton's confined motion when hadron is polarized

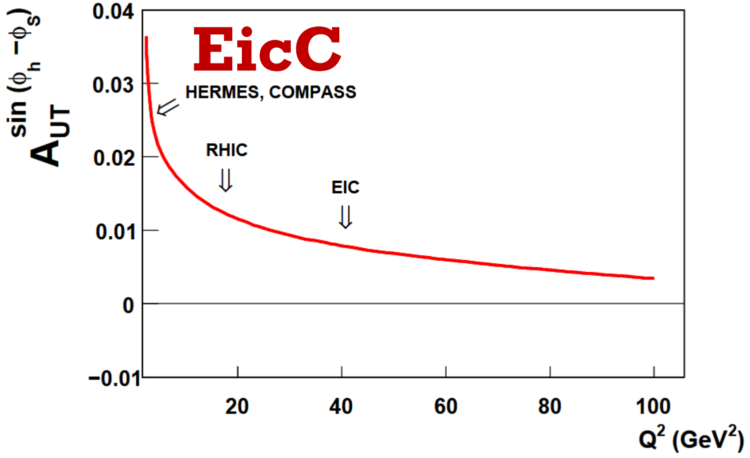
EicC and EIC-Sivers TMDs

C. H. Zeng, T. B. Liu, P. Sun, Y. X. Zhao, PRD106.094039 (2022)





S. Aybat et. al. Phys. Rev. Lett 108, 242003 (2012)

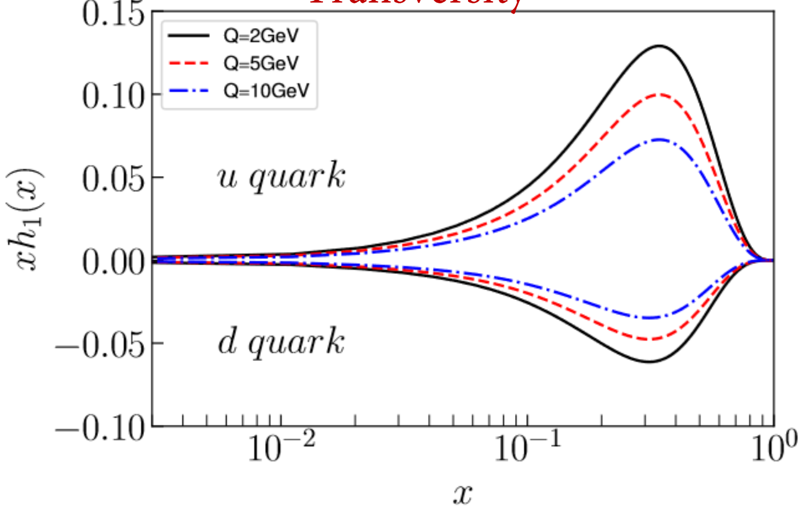


1. Higher Q^2, smaller effect
2. Smaller x, smaller effect

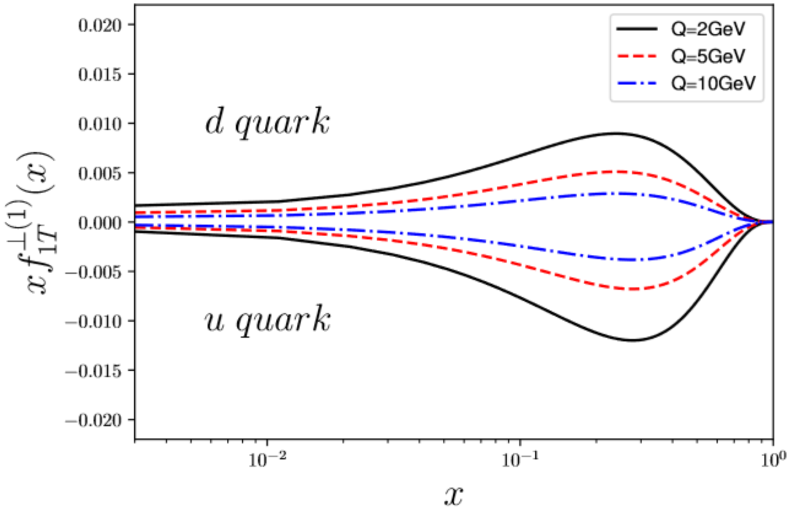
complementary

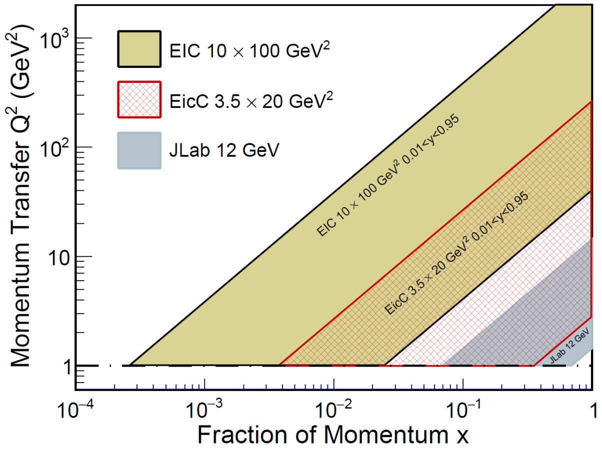
More words on TMDs study

Transversity

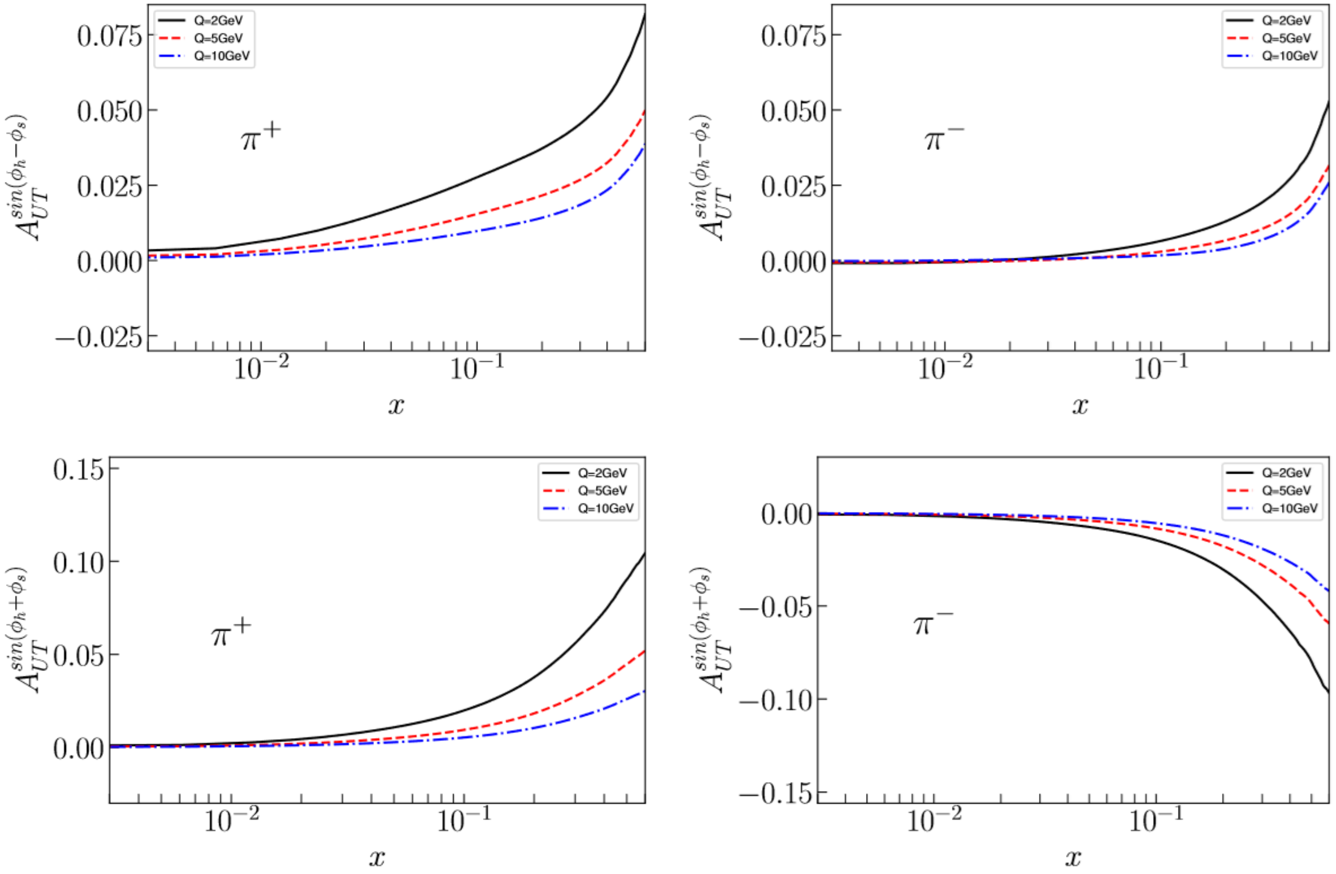


Sivers



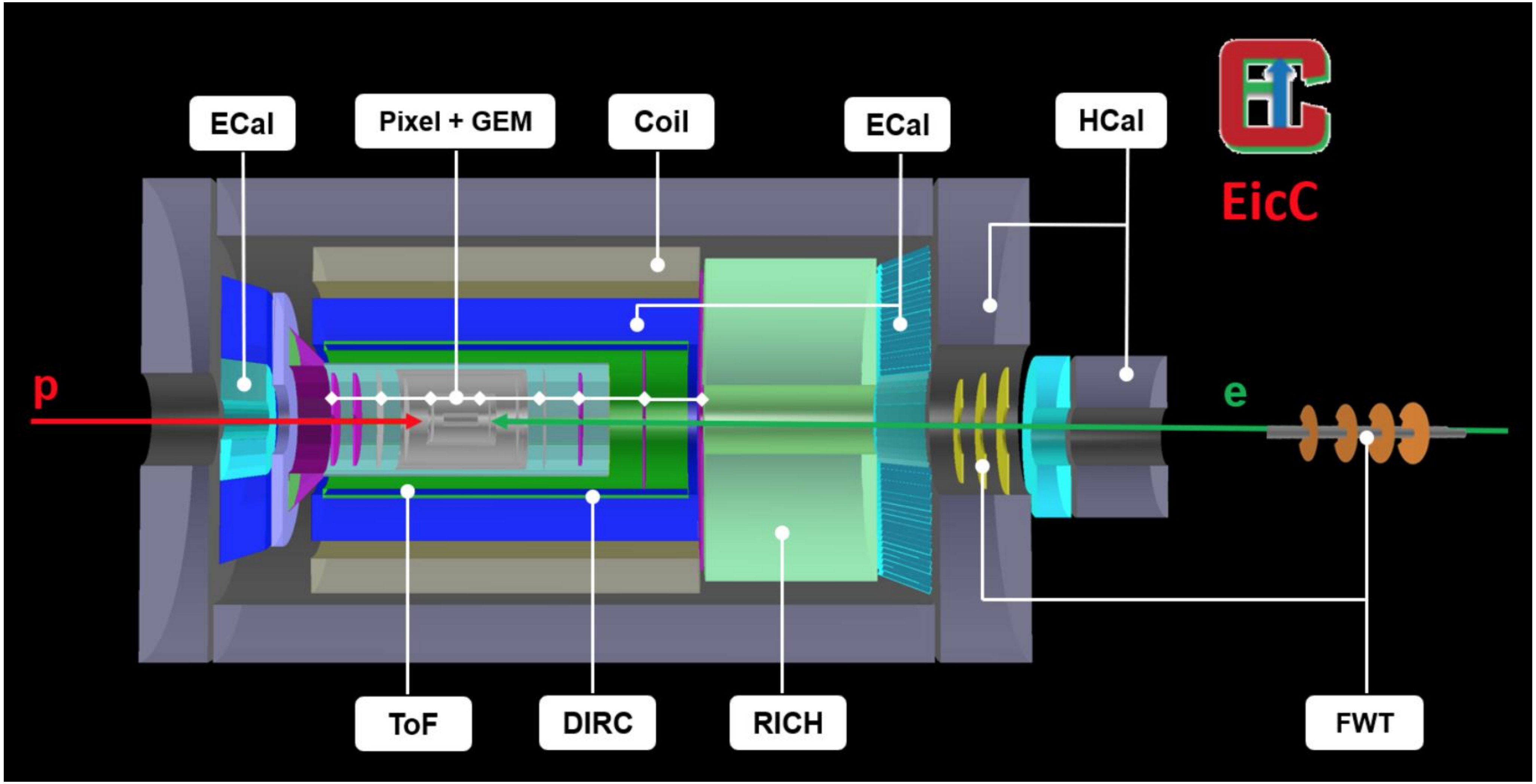


Observables



For TMDs study: We need a moderate-energy EIC but with high luminosity

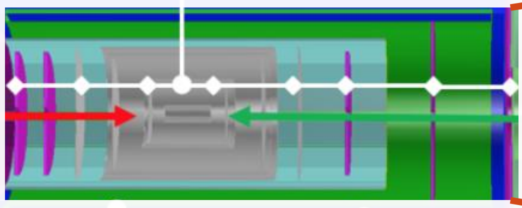
EicC detector design



EicC detector design

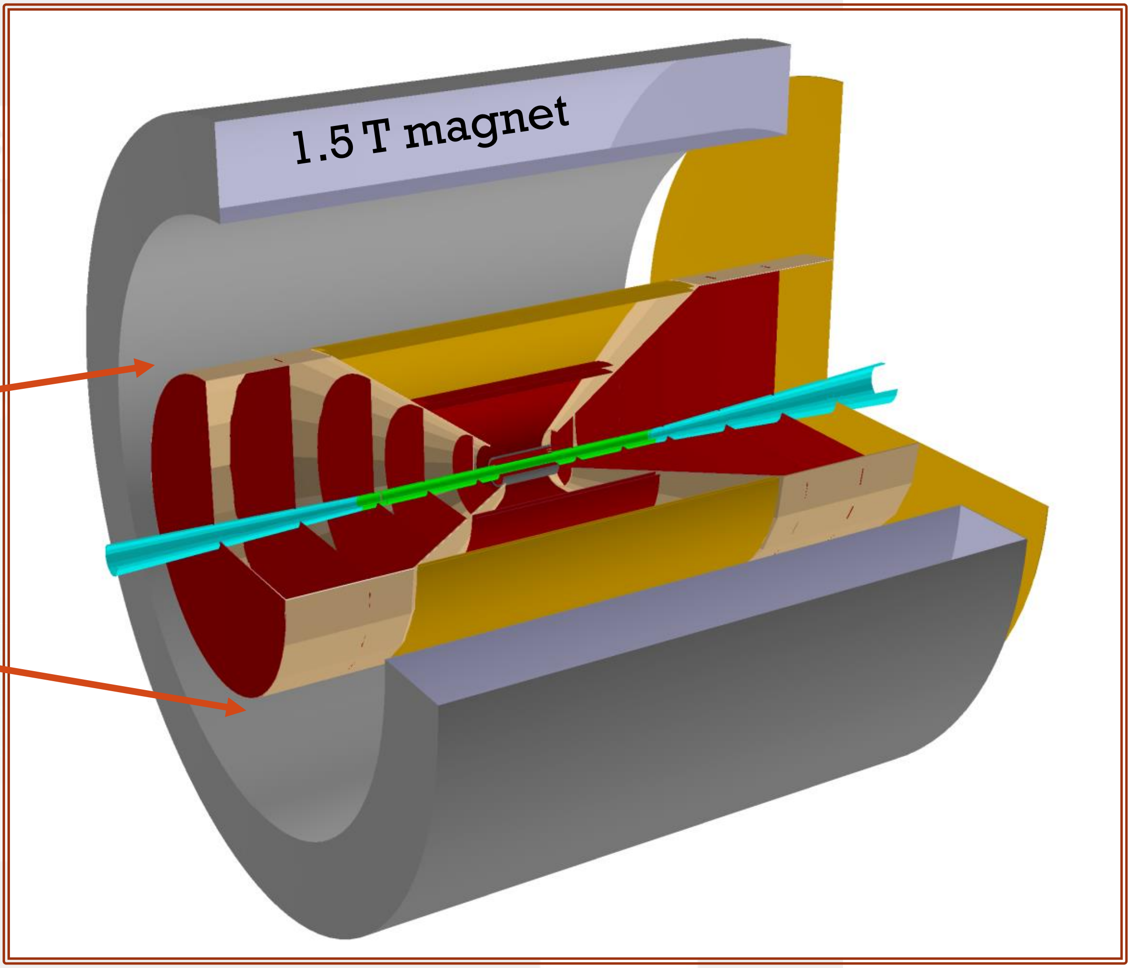
Tracking: Silicon + MPGD

R(cm)	Length(cm)	Pixel Pitch(μm)	Material Budget (X/X0 %)	Tech
3.30	28.0	20	0.05	MIC7
4.35	28.0	20	0.05	MIC7
5.40	28.0	20	0.05	MIC7
34.85	90.61	25	0.85	MIC6
38.15	90.61	25	0.85	MIC6
65.50	174.88	150(rϕ)x150(z)	0.40	MPGD
67.50	174.88	150(rϕ)x150(z)	0.40	MPGD



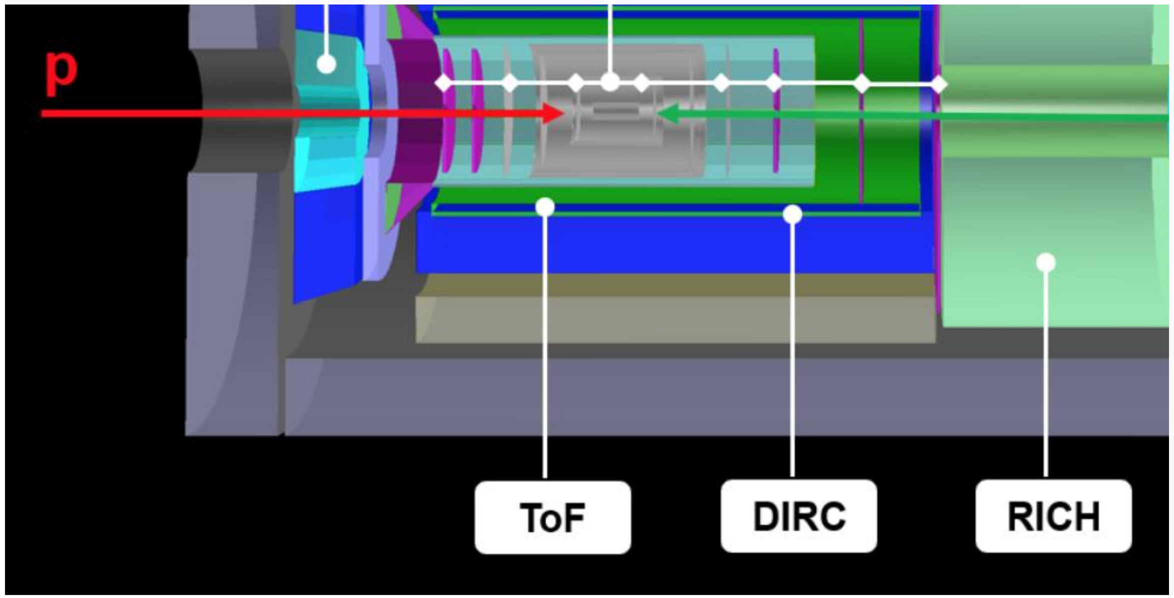
In R(cm)	Out R(cm)	Z(cm)	Pixel Pitch(μm)	Material Budget (X/X0 %)	Tech
3.18	18.62	25	25	0.42	MIC6
3.18	36.50	49	25	0.42	MIC6
3.47	55.00	73	25	0.42	MIC6
5.08	67.50	103.65	25	0.42	MIC6
6.58	67.50	134.33	25	0.42	MIC6
8.16	150.00	165.00	50(rϕ)x250(r)	0.26	MPGD

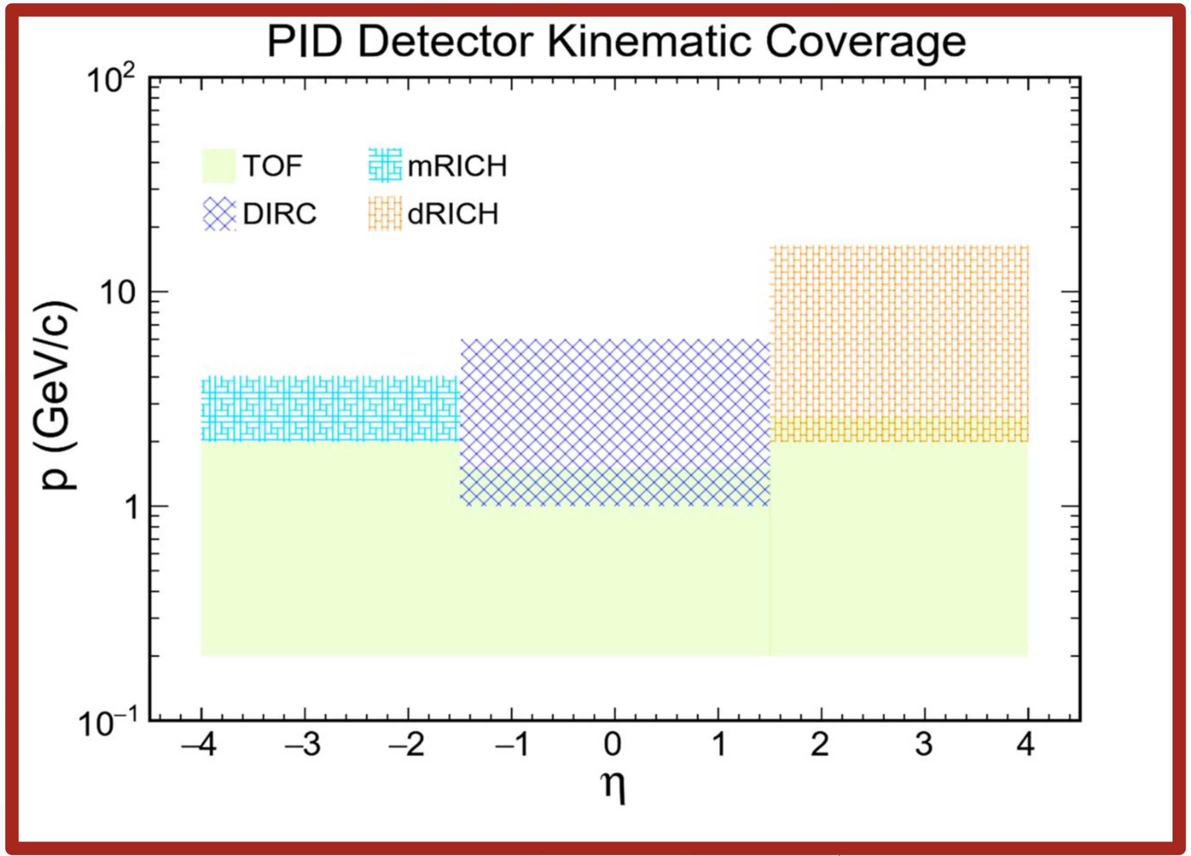
In R(cm)	Out R(cm)	Z(cm)	Pixel Pitch(μm)	Material Budget (X/X0 %)	Tech
3.18	18.62	-25	25	0.42	MIC6
3.18	36.50	-49	25	0.42	MIC6
3.18	55.00	-73	25	0.42	MIC6
3.95	67.50	-109.0	25	0.42	MIC6
5.26	67.50	-145.0	25	0.42	MIC6



EicC detector design

PID: ToF + (DIRC + RICH)





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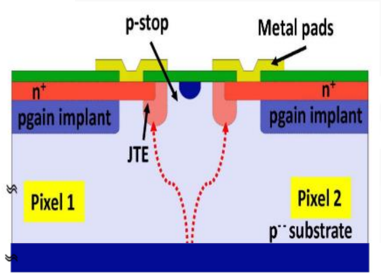
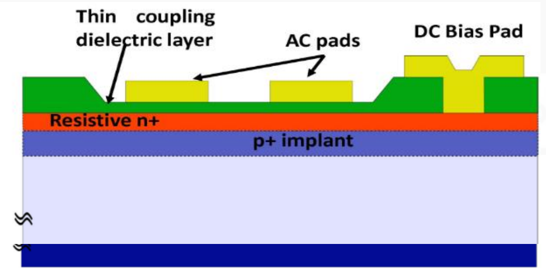
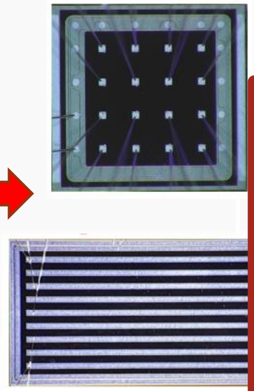
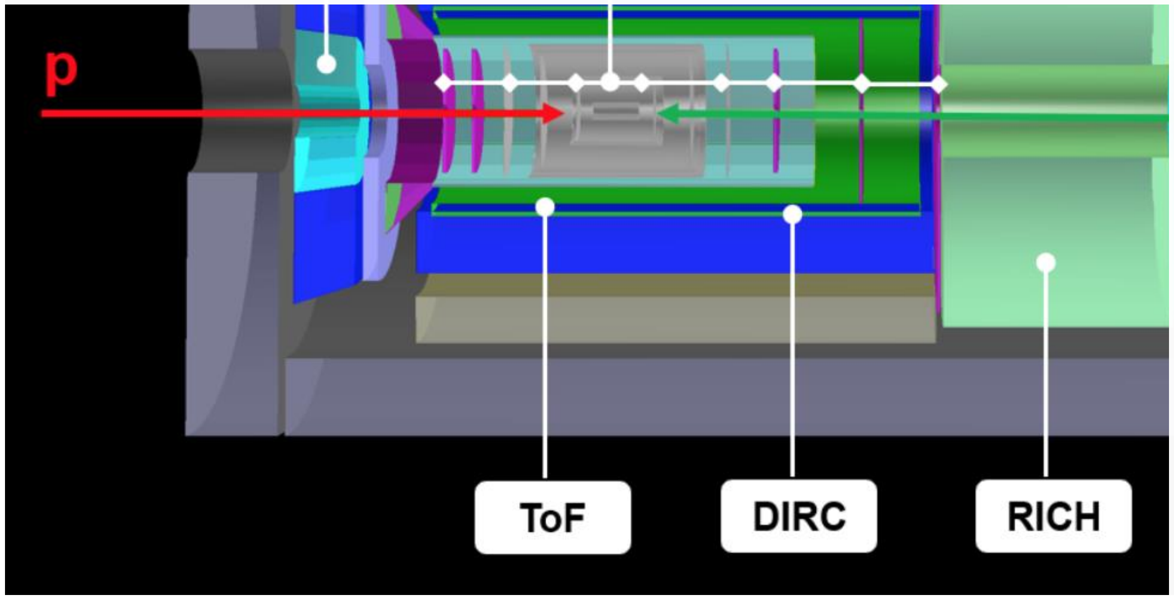


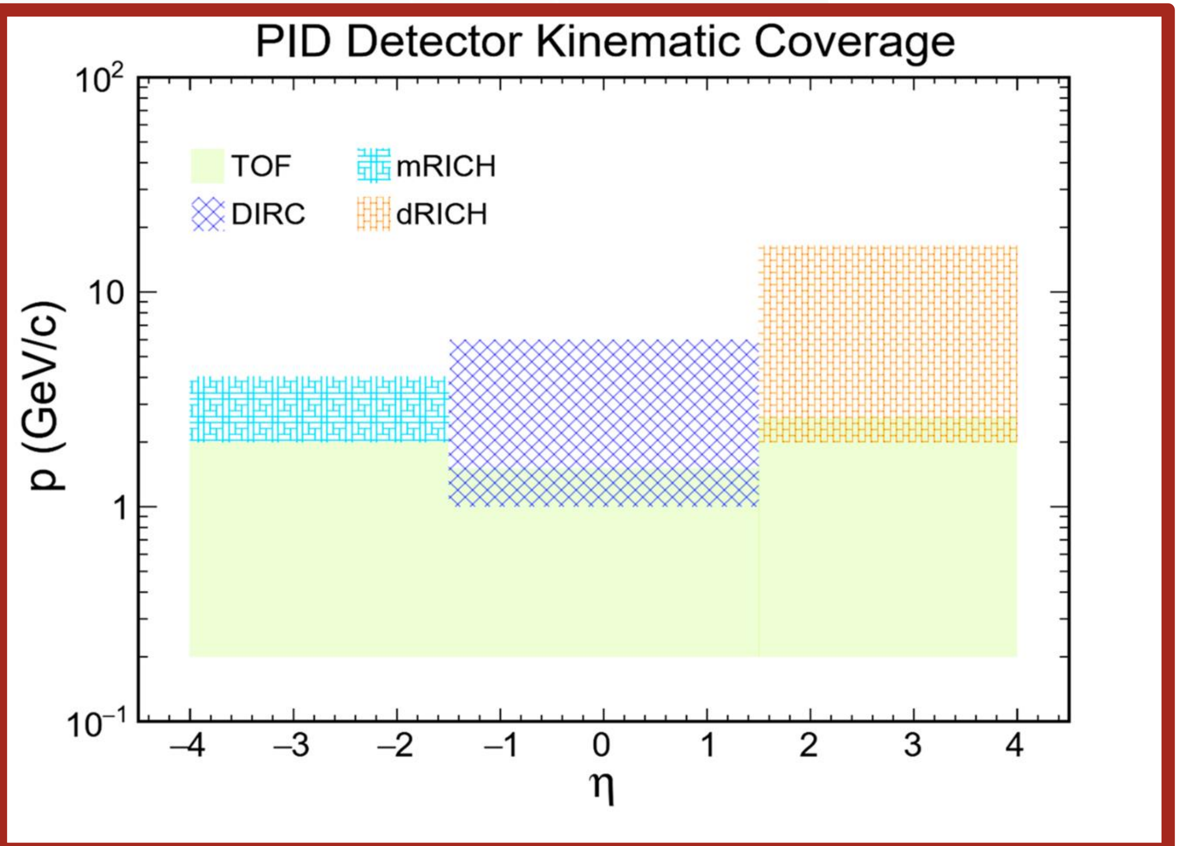
DC-LGAD



AC-LGAD

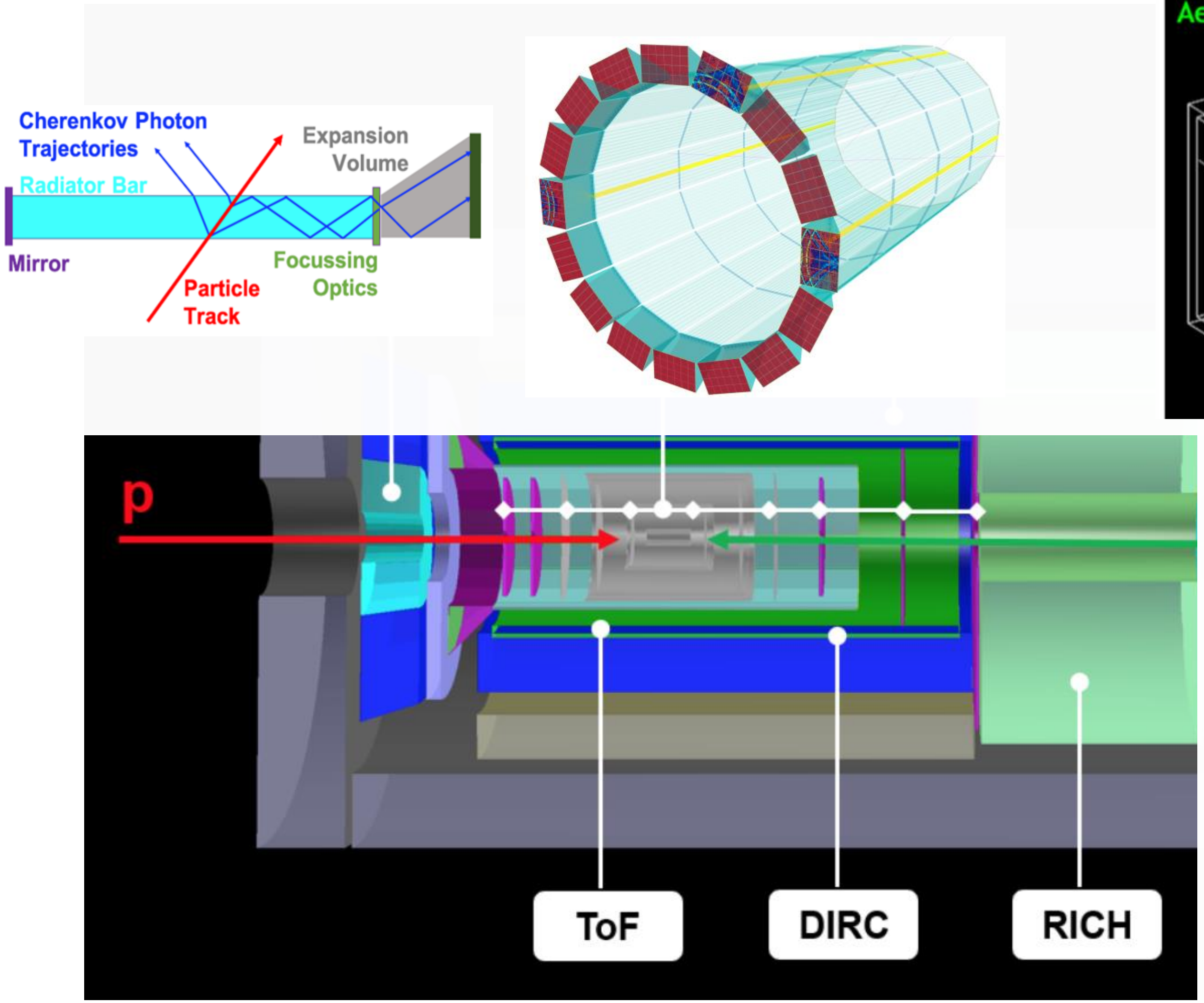


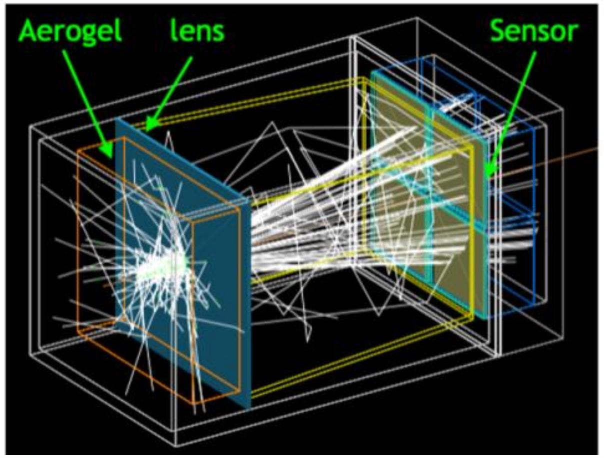


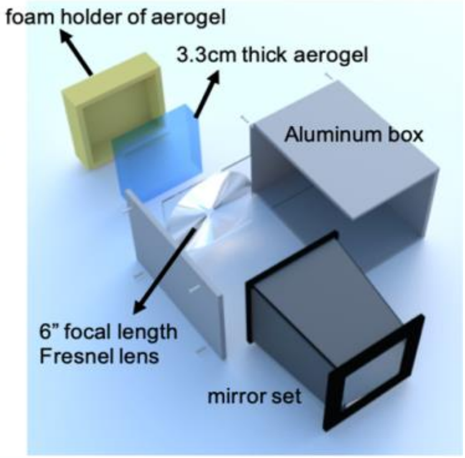


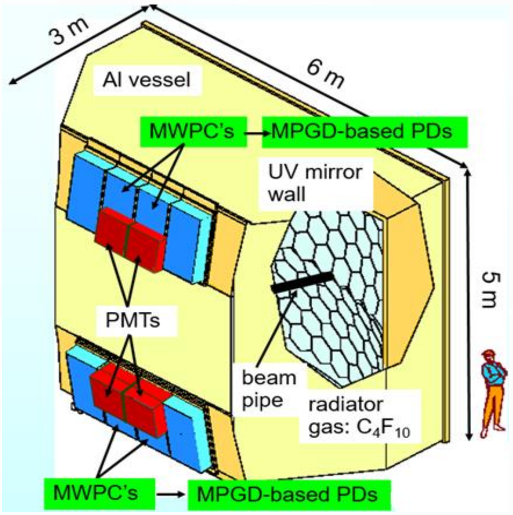
EicC detector design

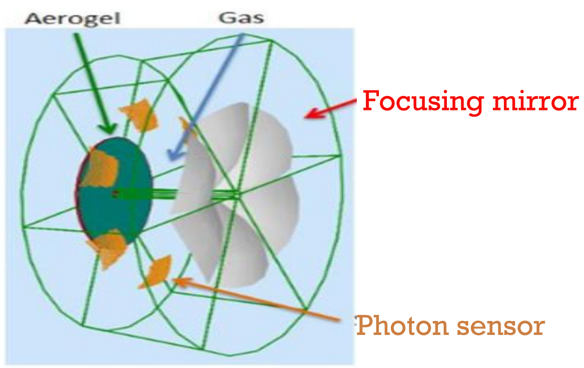
PID: ToF + (DIRC + RICH)





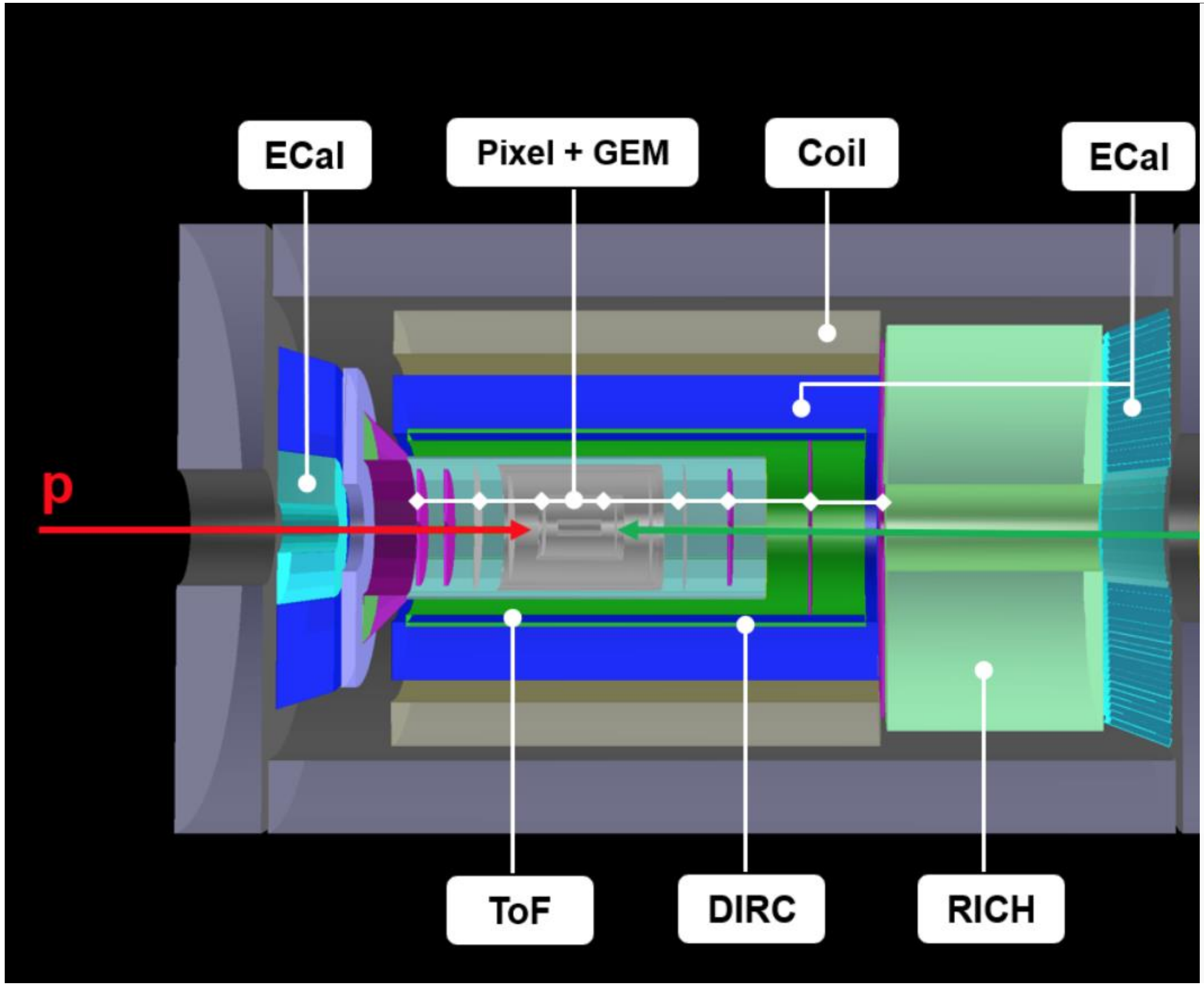


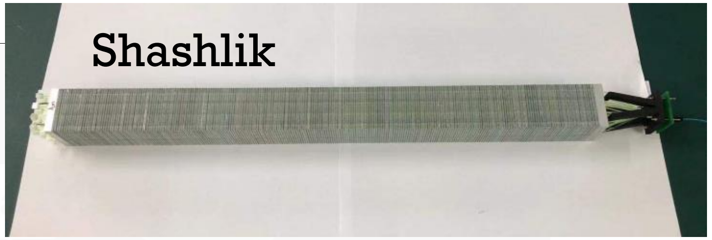


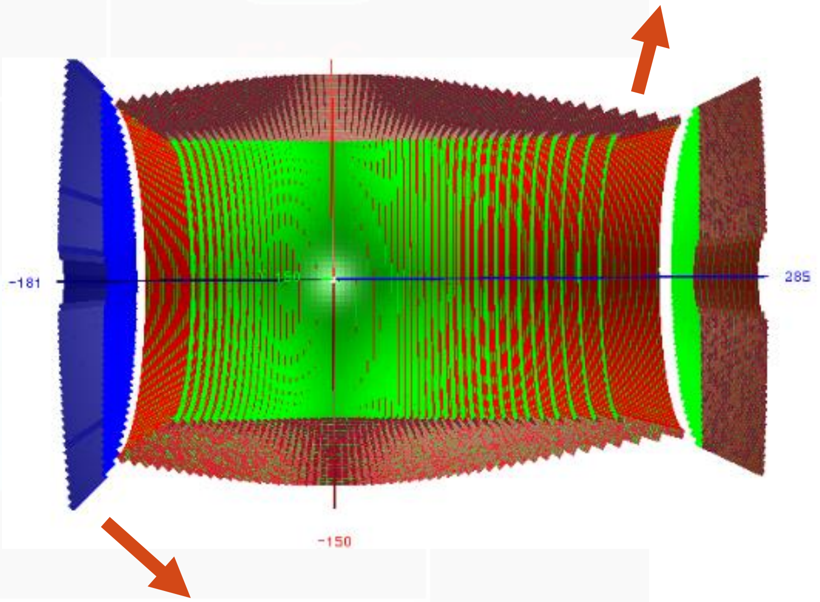


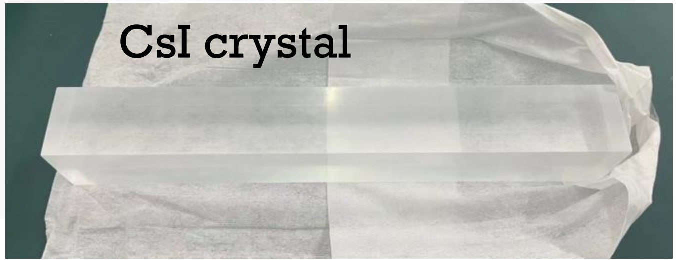
EicC detector design

Ecal: Shashlik + CsI crystal



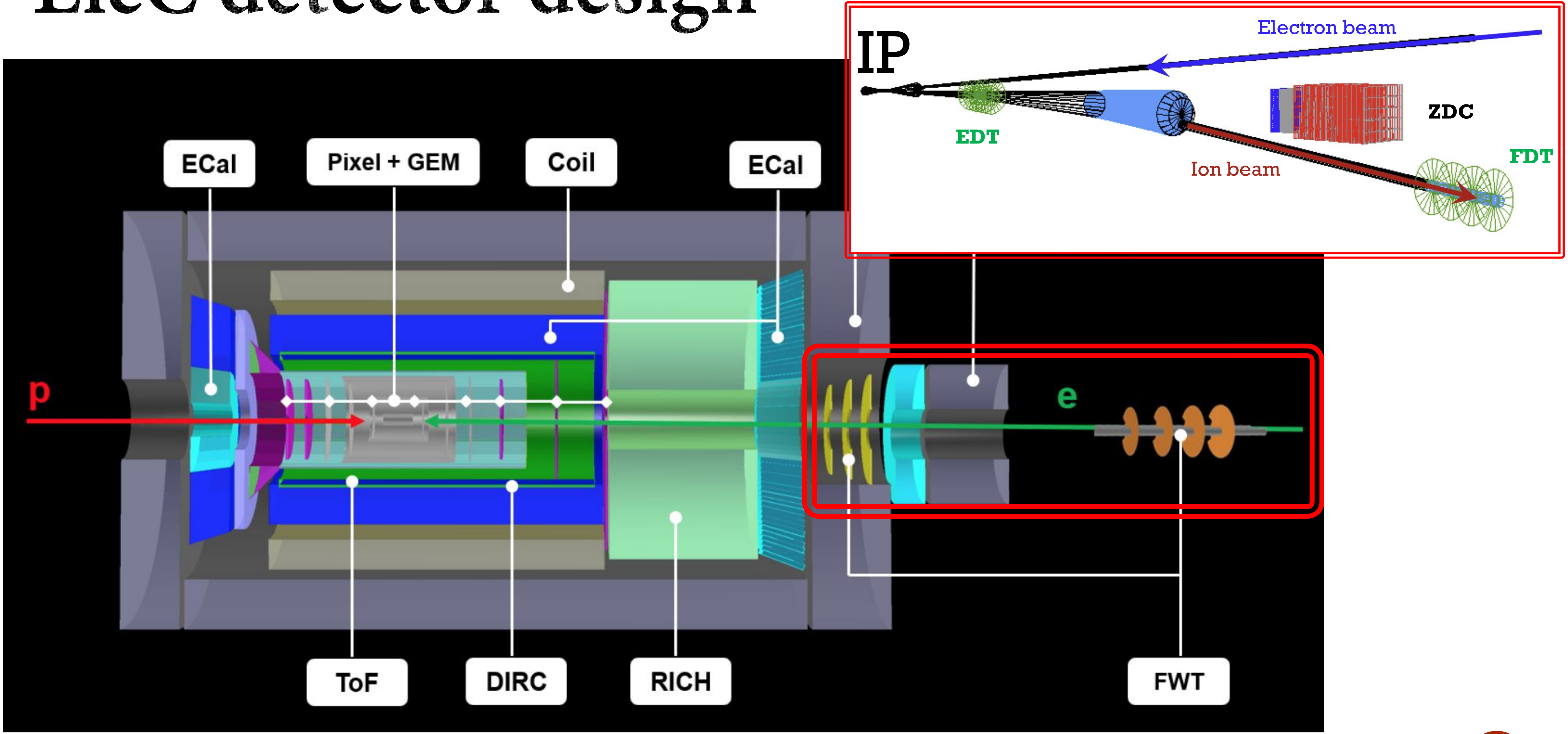




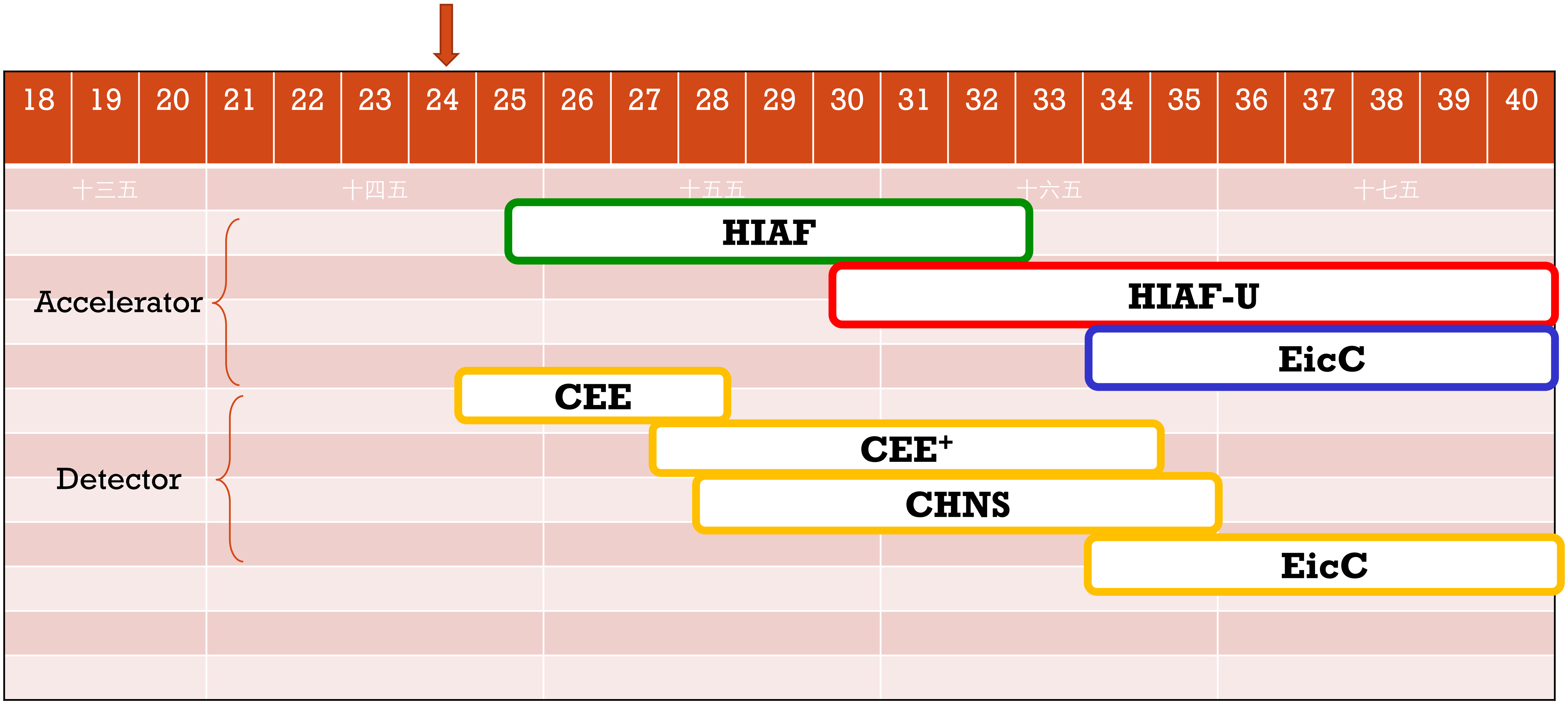


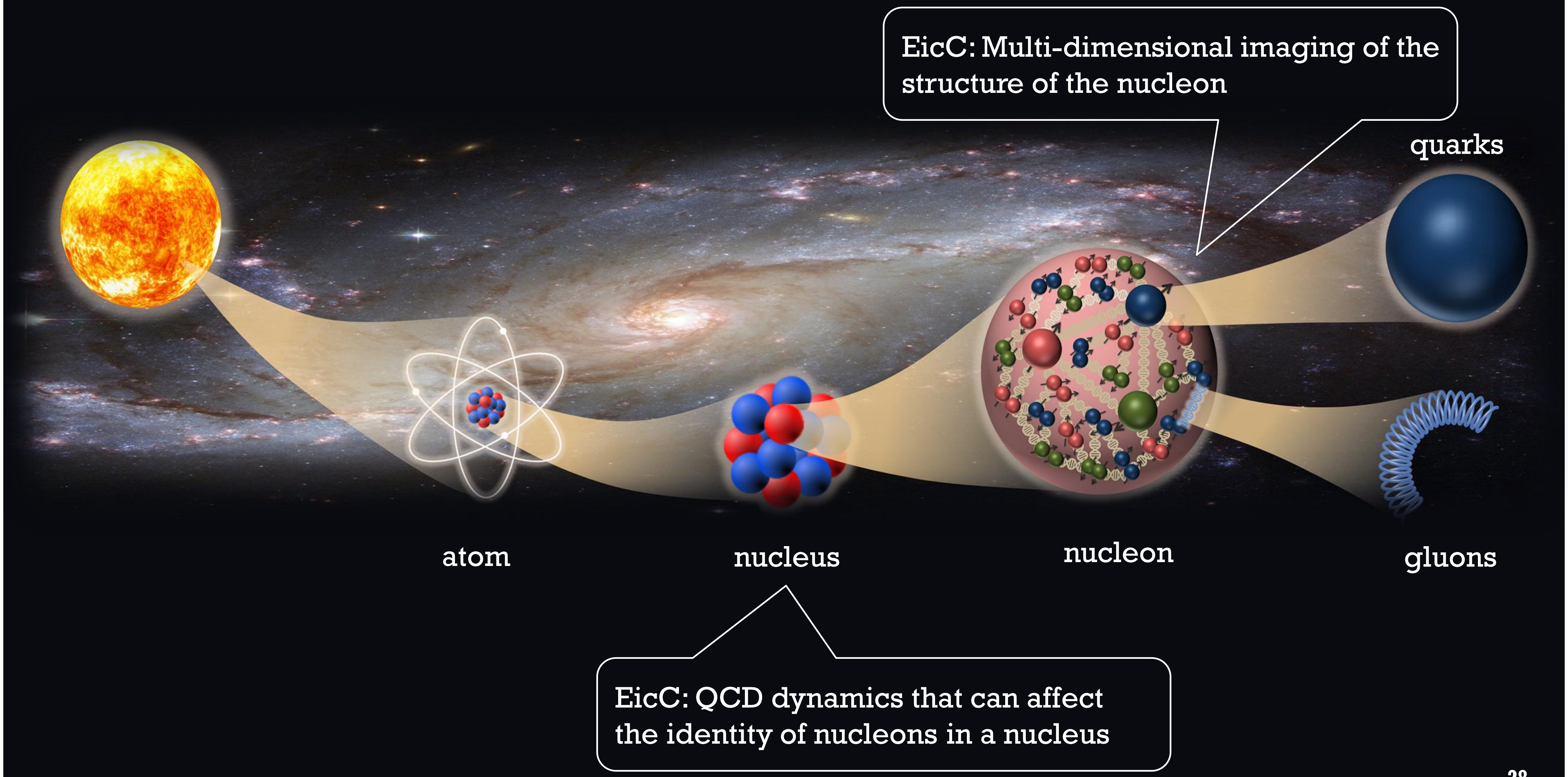
EicC detector design

Far-Forward detector



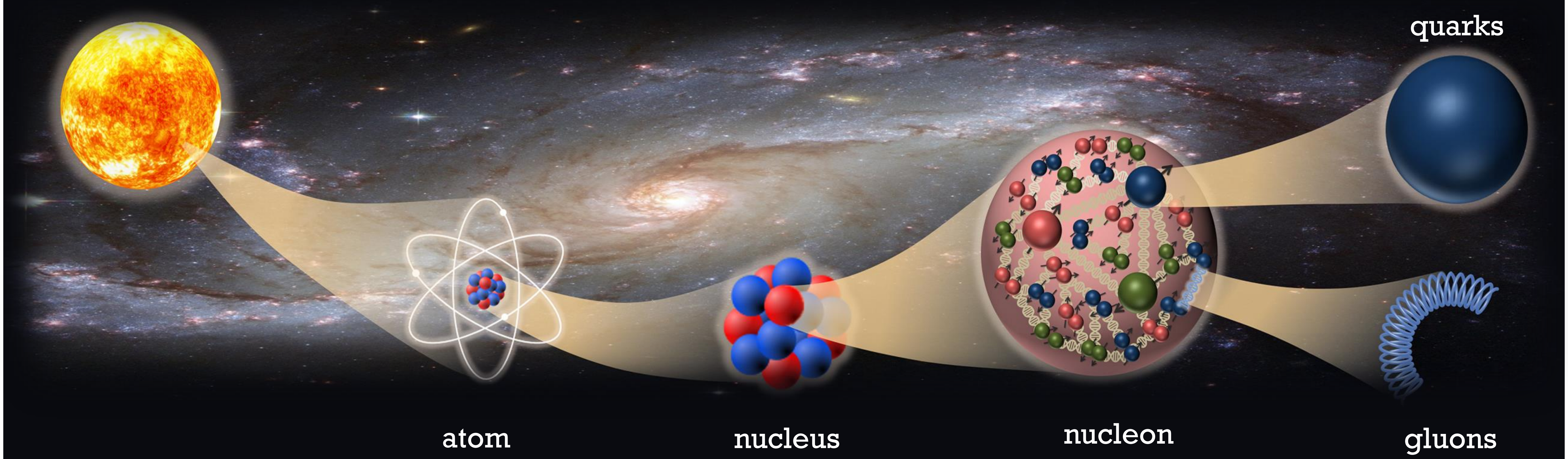
Timeline


18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
十三五
十四五
十五五
十六五
十七五
Accelerator
Detector
HIAF
HIAF-U
EicC
CEE
CEE+
CHNS
EicC


EicC: Multi-dimensional imaging of the structure of the nucleon
quarks
atom
nucleus
nucleon
gluons
EicC: QCD dynamics that can affect the identity of nucleons in a nucleus

Physics: Understand the inner structure of the visible world

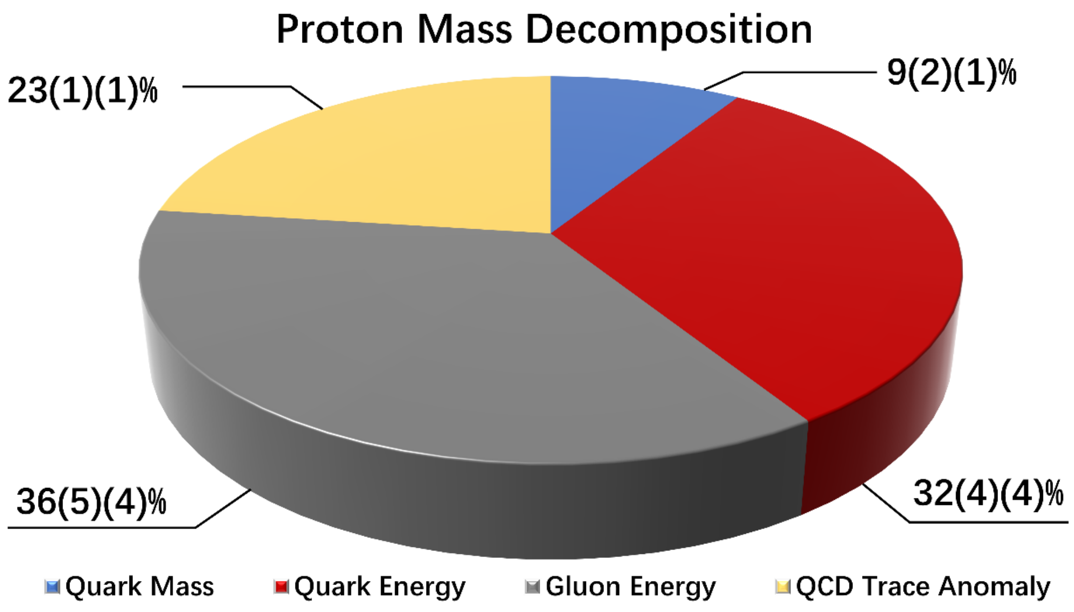
Detector: Push for the development and application of cutting-edge technology



Backups

Proton mass study

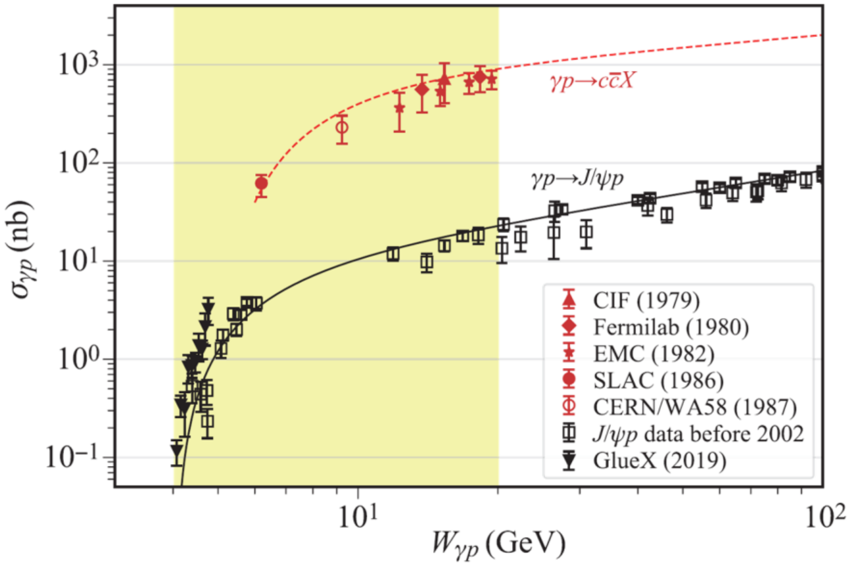
Lattice QCD calculation
Phys. Rev. Lett. 121 (2018) 21, 212001



- **Quark energy** and **gluon energy** constrained by PDFs
- **Quark mass** via πN low energy scattering
- **Trace anomaly** via threshold production of J/Psi and Upsilon ?

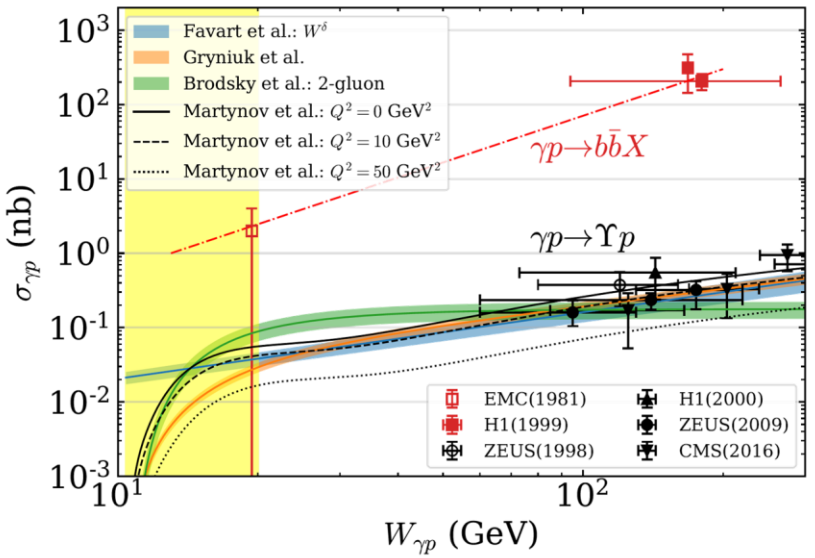
One of the hot topics under discussions

Near threshold J/Psi production



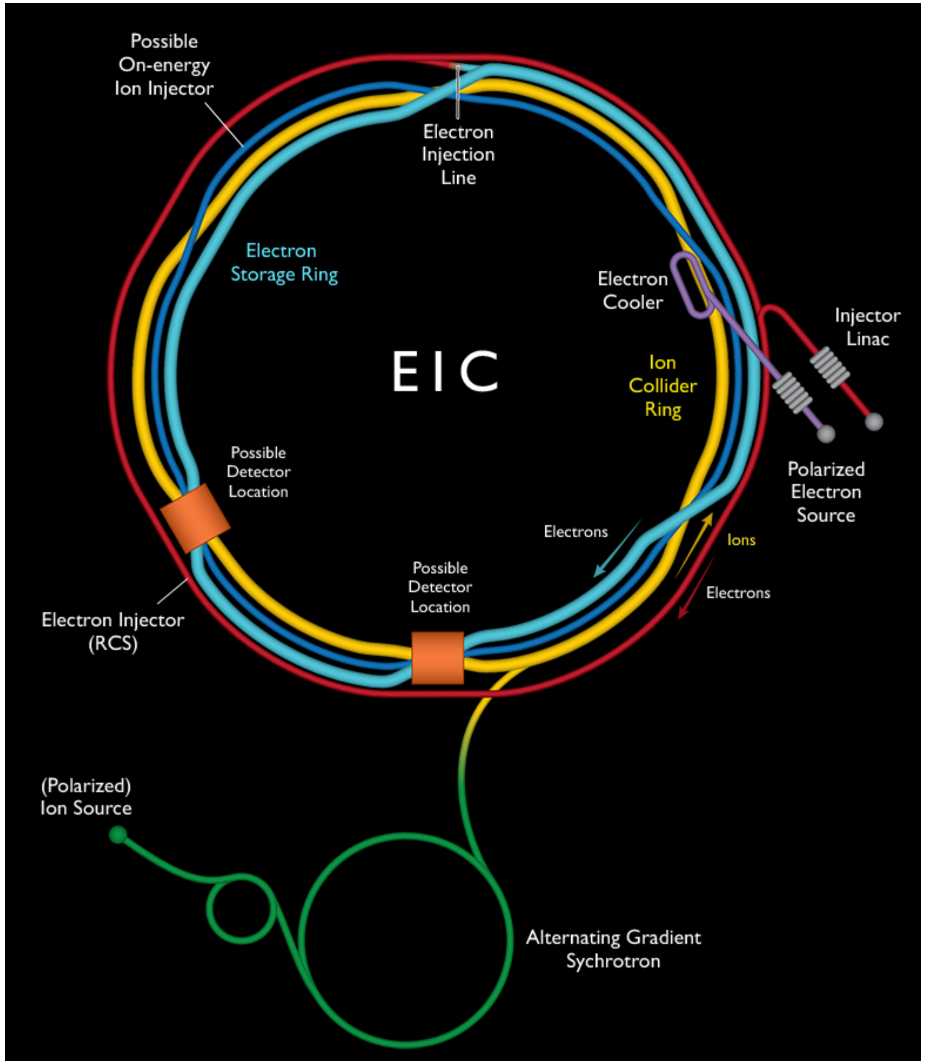
JLab & EicC & EIC

Near threshold Upsilon production



EicC & EIC

US EIC at Brookhaven National Laboratory



EIC website:
https://www.bnl.gov/eic/

ePIC collaboration (1st interaction point):
https://wiki.bnl.gov/EPIC/index.php?title=Collaboration

EIC User group:
https://www.eicug.org/

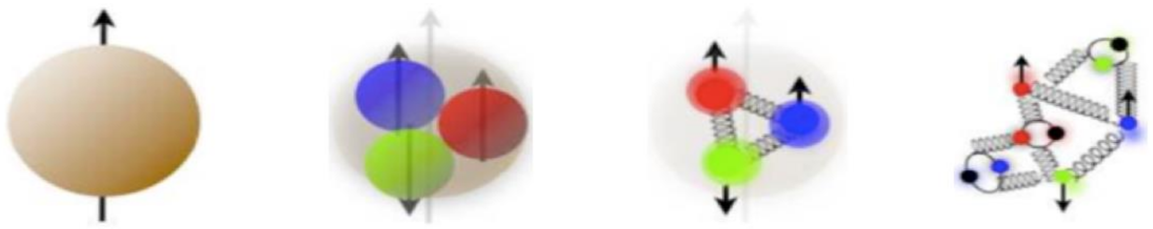
EIC whitepaper:
https://arxiv.org/abs/1212.1701

EIC yellow report:
https://arxiv.org/abs/2103.05419

EIC Conceptual Design Report:
https://www.osti.gov/biblio/1765663/

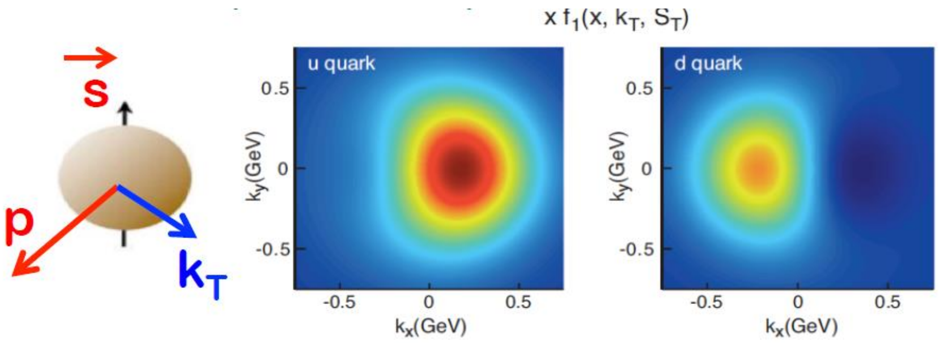
Open Questions driving the spin physics

- How do quarks/gluons + their dynamics make up the proton spin?



Helicity distributions + orbital contribution

- How is proton's spin correlated with the motion of the quarks/gluons?



Deformation of parton's
confined motion
When hadron is polarized?

→ **TMDs!**

- How does proton's spin influence the spatial distribution of partons?

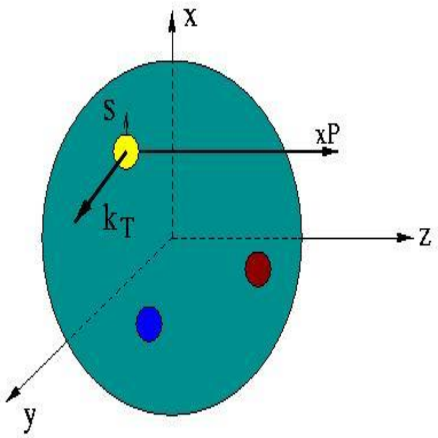
Deformation of parton's
spatial distribution
When hadron is polarized?

→ **GPDs!**

Unified view of nucleon structure

$W_p^u(x,k_T,r)$ *Wigner distributions* **(X. Ji)**

5D Dist.



$\xrightarrow{d^3r}$ **TMD PDFs** $f_1^u(x,k_T)$, .. $h_1^u(x,k_T)$

$\xrightarrow{d^2k_T\, dr_z}$ **GPDs/IPDs**

3D imaging

TMD PDFs $\xrightarrow{d^2k_T}$ PDFs

GPDs/IPDs $\xrightarrow{d^2r_T}$ PDFs

GPDs/IPDs $\xrightarrow{\text{dx \& Fourier Transformation}}$ Form Factors

PDFs
$f_1^u(x)$, .. $h_1^u(x)$

1D

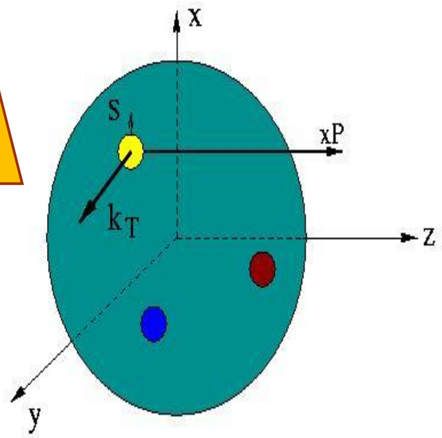
Form Factors
$G_E(Q^2)$,
$G_M(Q^2)$

Unified view of nucleon structure

$W_p^u(x,k_T,r)$ *Wigner distributions* (X. Ji)

5D Dist.

d^3r $\quad$ $d^2k_T\, dr_z$



TMD PDFs
$f_1^u(x,k_T)$, ..
$h_1^u(x,k_T)$

GPDs/IPDs

3D imaging

dx & Fourier Transformation

d^2k_T $\quad$ d^2r_T

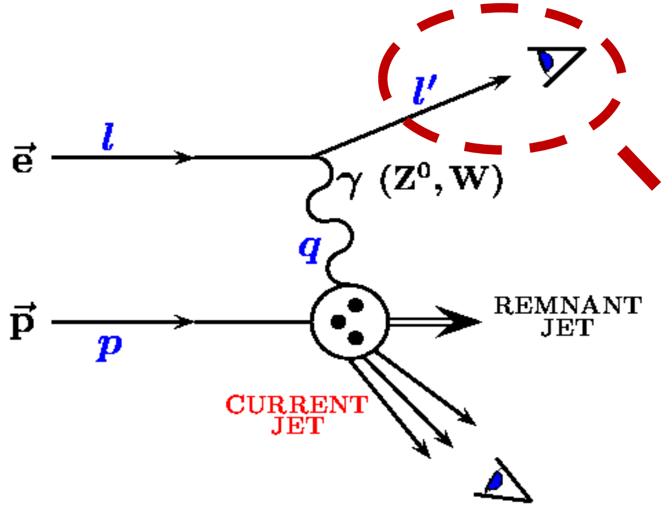
PDFs
$f_1^u(x)$, .. $h_1^u(x)$

1D

Form Factors
$G_E(Q^2)$,
$G_M(Q^2)$

Experimentally

Structure functions and PDFs : Polarized case



$$\frac{d\Delta\sigma}{dx\,dy} = \lambda \cdot \frac{e^4}{4\pi^2 Q^2} \cdot \left[\left(1 - \frac{y}{2} - \frac{y^2}{4} \cdot \gamma^2 \right) \cdot g_1 - \frac{y}{2} \cdot \gamma^2 \cdot g_2 \right]$$

$$d\sigma = d\bar{\sigma} \pm d\Delta\sigma$$ beam/target helicity flips

Only scattered leptons are detected

Experimental observables

A_{LL} , A_{LT} (A_1, A_2)

$Q^2 << M_Z^2$

Polarized structure functions

g_1 , g_2

Quark-Parton Model
QPM

PDFs

Polarized pdfs

Helicity distribution

$\Delta q = q^{\uparrow}(x) - q^{\downarrow}(x)$

$$g_1(x) = \frac{1}{2} \sum_q e_q^2 \Delta q(x).$$

Flavor decompositions

- With pure γ exchange in inclusive DIS:

Hmm … No third kind of nucleon … No…

$$g_1^P = \frac{1}{2}\left(\frac{4}{9}(\Delta u+\Delta\bar{u})+\frac{1}{9}(\Delta d+\Delta\bar{d})+\frac{1}{9}(\Delta s+\Delta\bar{s})\right)$$
$$g_1^n = \frac{1}{2}\left(\frac{1}{9}(\Delta u+\Delta\bar{u})+\frac{4}{9}(\Delta d+\Delta\bar{d})+\frac{1}{9}(\Delta s+\Delta\bar{s})\right)$$

- Assumption: SU(3) flavor symmetry
  - ✓ Additional inputs from β-decay of neutron and hyperons

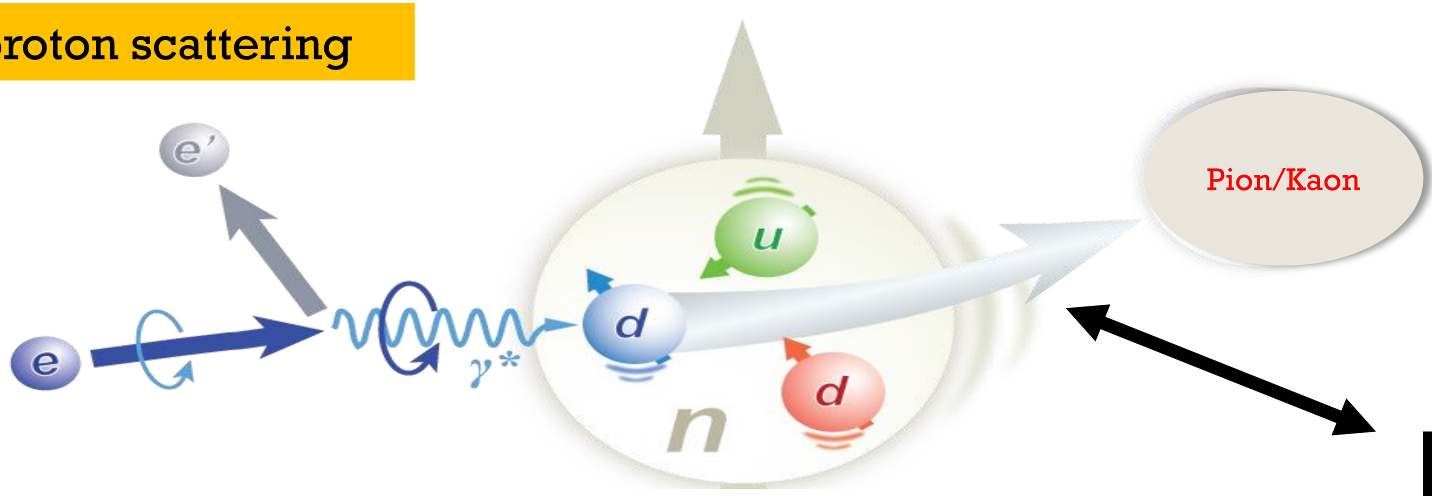
Δu + Δd -2 Δs   Δu + Δd

A way out:

SIDIS measurements: with the initial quark flavor tagged
Fragmentation Functions needed

SIDIS processes for flavor decompositions

Electron-proton scattering



Fragmentation Functions

Experimental observable: polarized structure functions g1

input

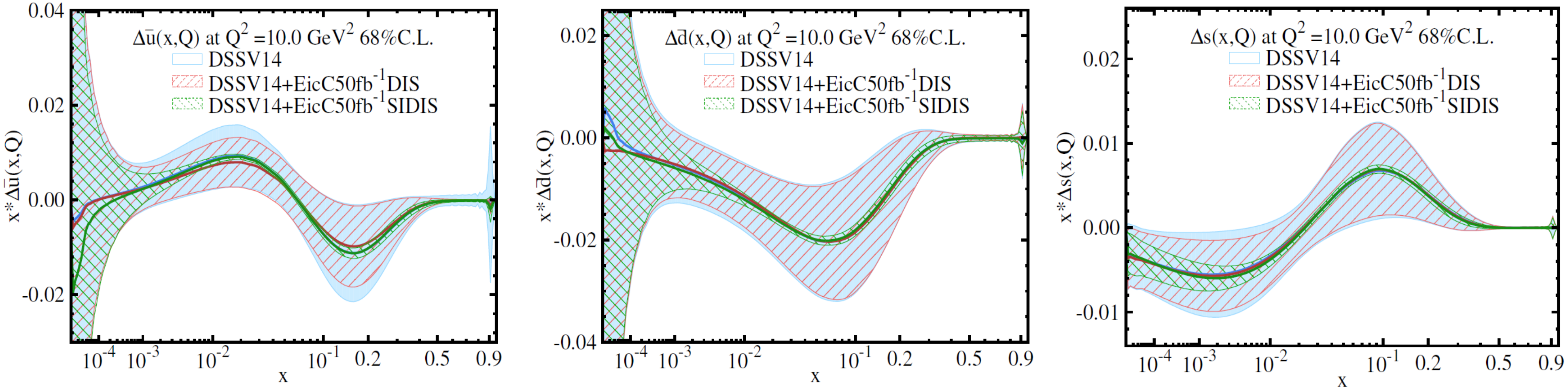
input

$$g_1^h(x,Q^2,z) = \frac{1}{2}\sum_q e_q^2 \left[\Delta q(x,Q^2) D_q^h(z,Q^2) + \Delta\bar{q}(x,Q^2) D_{\bar{q}}^h(z,Q^2)\right]$$

Leading Order picture

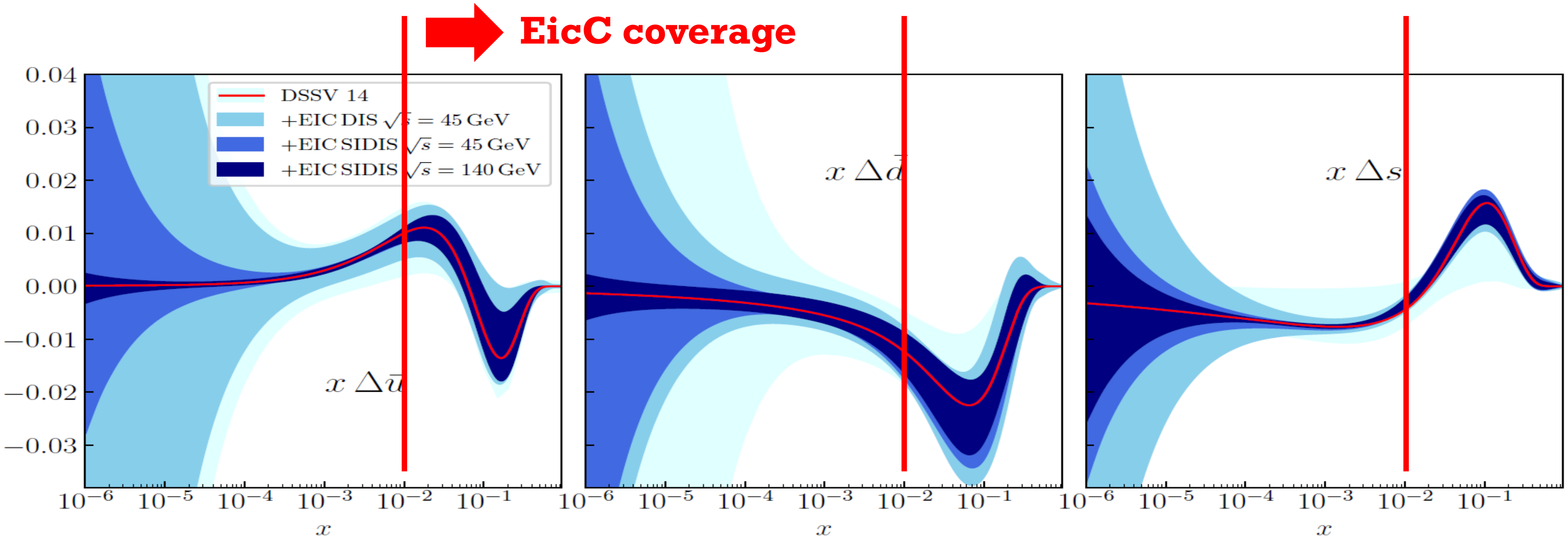
Extracted nucleon structure information: polarized PDFs (helicity distribution)

Spin of the nucleon-helicity distribution



A NLO impact study
See arXiv:2103.10276
JHEP08(2021)034

EicC white paper



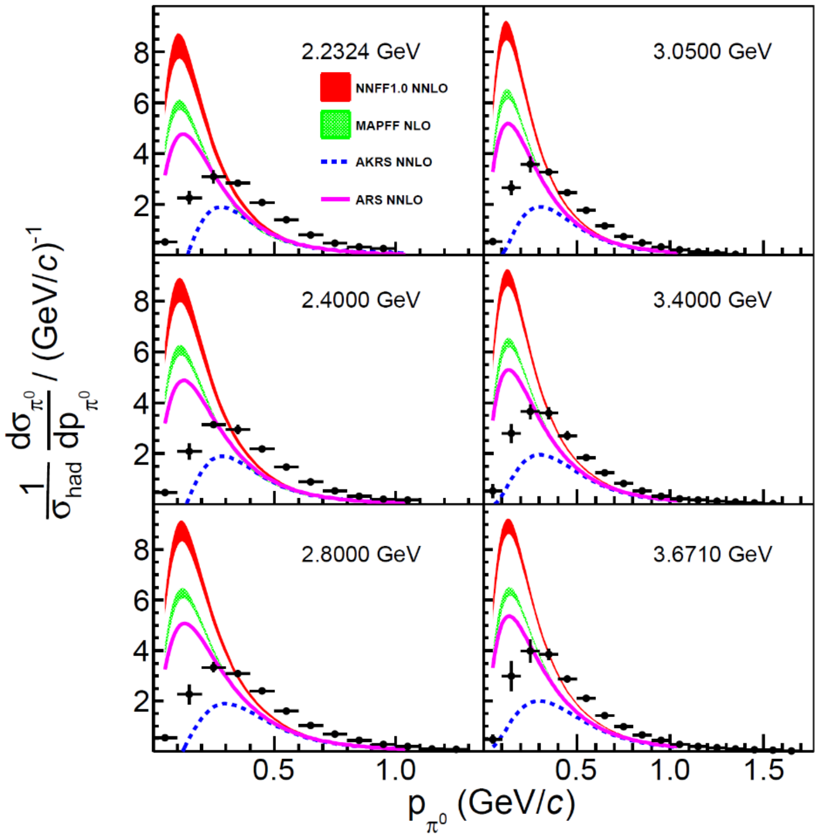
EIC Yellow Report

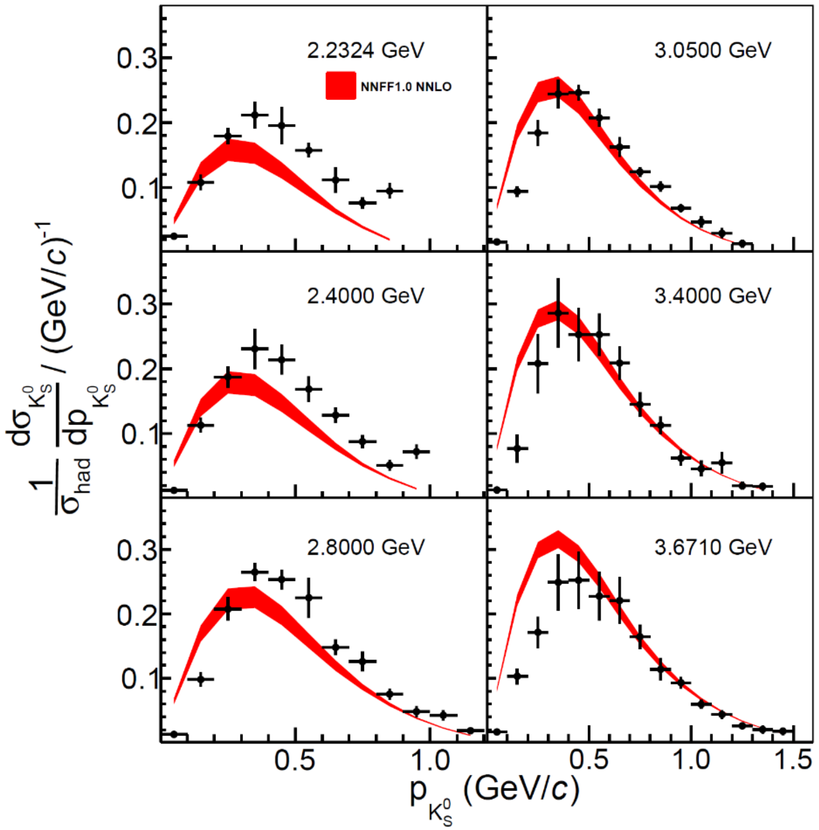
Multiplicity measurements at BESIII

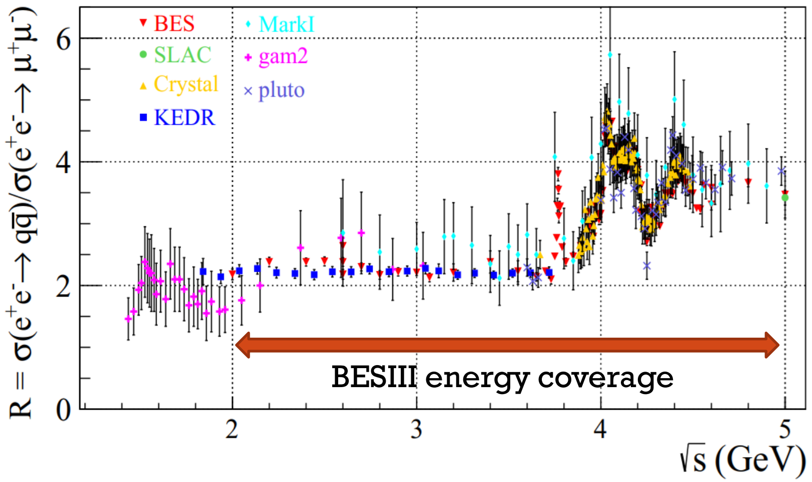
Multiplicity: $\boxed{\frac{1}{\sigma_{tot}(e^+e^- \to\ hadrons)} \frac{d\sigma(e^+\,e^- \to h\ +\ X)}{d\ P_h}}$ $\sim\ \sum_q e_q^2 D_1^{h/q}(z)$ at LO

h is a particular type of hadron such as π^0, $\pi^{+/-}$, $K^{+/-}$ …

- First precision measurements at BESIII: **Phys. Rev. Lett. 130, 231901 (2023)**
- Analyses of many other final states are ongoing → provide inputs for future EIC

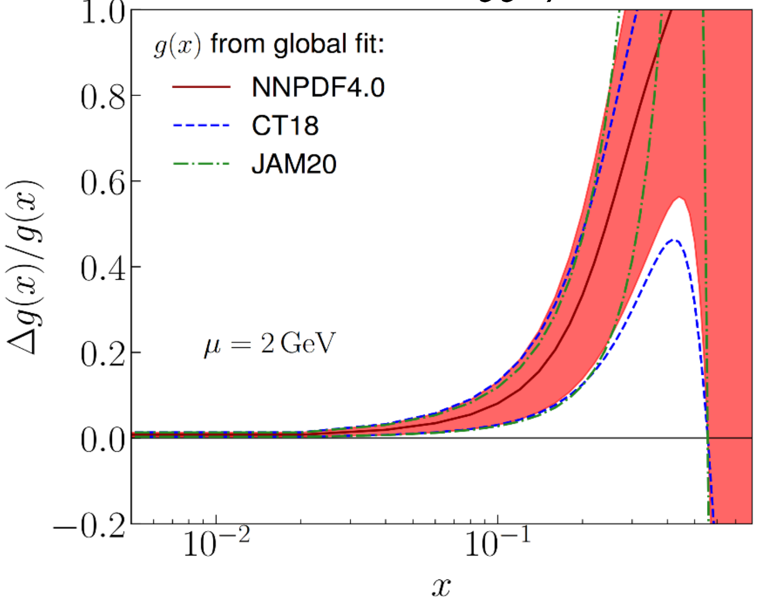




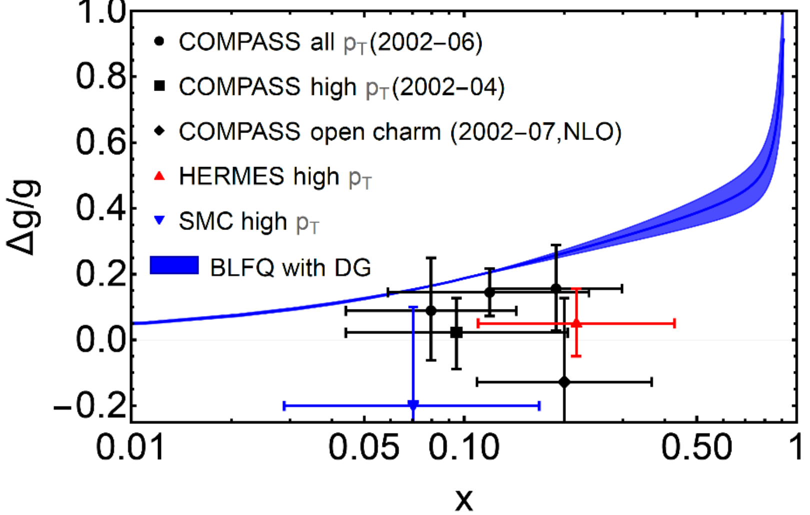


EicC and EIC-gluon polarization (at large x)

arXiv:2211.15587



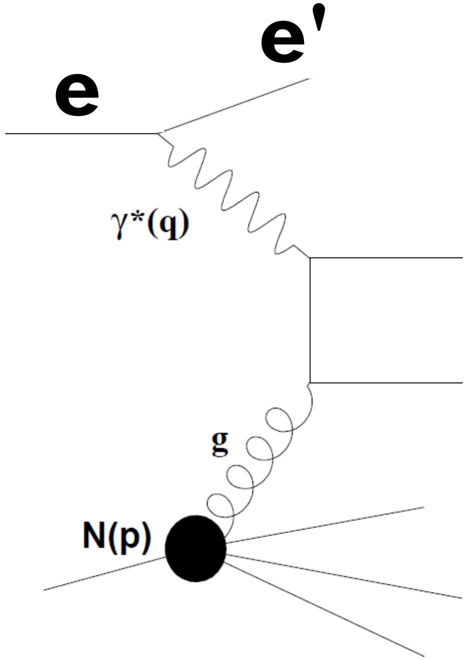
arXiv:2209.08584

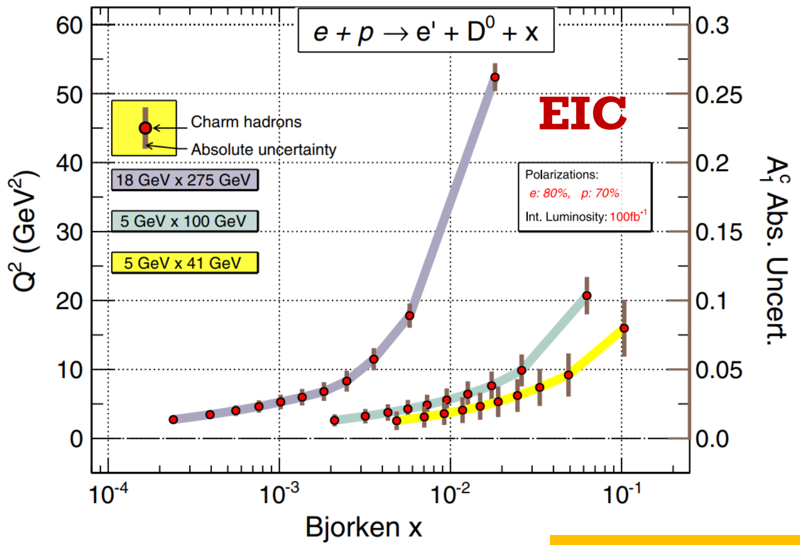


D. Anderle , X. Dong, …, E. Sichtermann, …, F. Yuan, Y. X. Zhao Phys. Rev. D104, 114039 (2021)

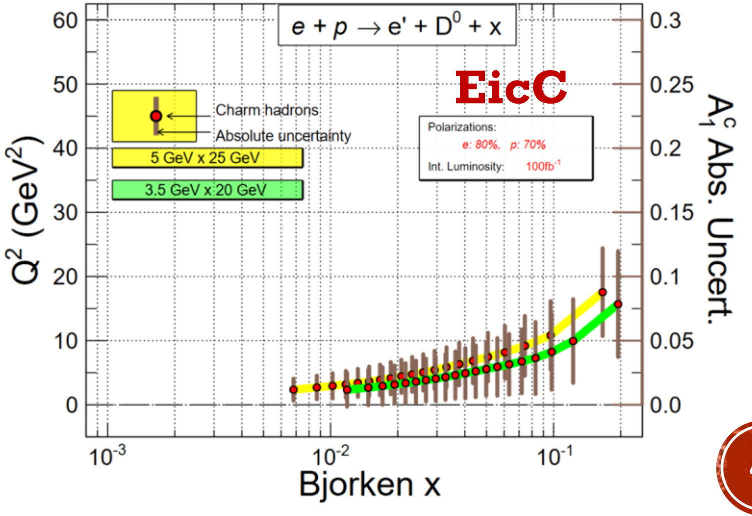
$$A_{LL}^{\vec{e}+\vec{p}\to e'+D^0+X} = \frac{d\sigma^{++} - d\sigma^{+-}}{d\sigma^{++} + d\sigma^{+-}}$$

$$= \frac{1}{P_e P_p} \frac{N^{++} - N^{+-}}{N^{++} + N^{+-}}$$





complementary

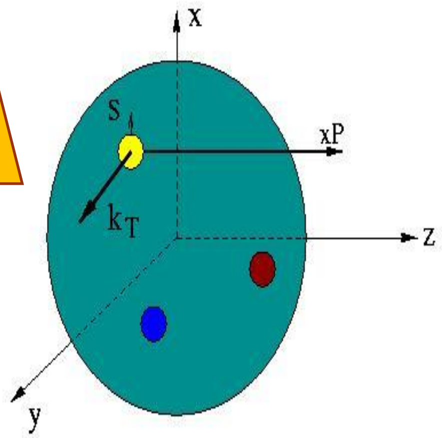


Unified view of nucleon structure

$W_p^u(x,k_T,r)$ *Wigner distributions* **(X. Ji)**

5D Dist.

d^3r | $d^2k_T\,dr_z$



TMD PDFs
$f_1^u(x,k_T)$, ..
$h_1^u(x,k_T)$

GPDs/IPDs

3D imaging

d^2k_T

d^2r_T

dx & Fourier Transformation

PDFs
$f_1^u(x)$, .. $h_1^u(x)$

1D

Form Factors
$G_E(Q^2)$,
$G_M(Q^2)$

Experimentally

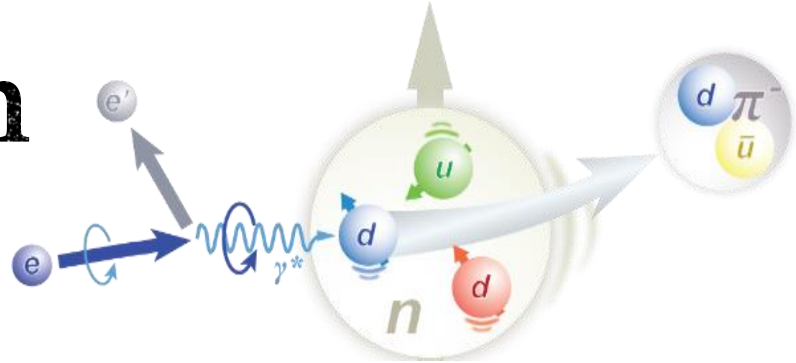
Leading-Twist TMDs

		Quark polarization		
		Unpolarized (U)	Longitudinally Polarized (L)	Transversely Polarized (T)
Nucleon Polarization	U	$f_1 =$		$h_1^{\perp} = \quad - \quad$ Boer-Mulders
	L		$g_1 = \quad - \quad$ Helicity	$h_{1L}^{\perp} = \quad - \quad$ Worm Gear
	T	$f_{1T}^{\perp} = \quad - \quad$ Sivers	$g_{1T} = \quad - \quad$ Worm Gear	$h_1 = \quad - \quad$ Transversity $h_{1T}^{\perp} = \quad - \quad$ Pretzelosity

Nucleon Spin *Quark Spin*

Survive the k_T integration, yield 1D pdfs

TMDs in SIDIS Cross Section



$$\frac{d\sigma}{dx\,dy\,d\phi_S\,dz\,d\phi_h\,dP_{h\perp}^2} = \frac{\alpha^2}{xyQ^2}\,\frac{y^2}{2(1-\varepsilon)}\,\cdot$$

f_1 =

Boer-Mulder $h_1^{\perp}$ =

$h_{1L}^{\perp}$ =

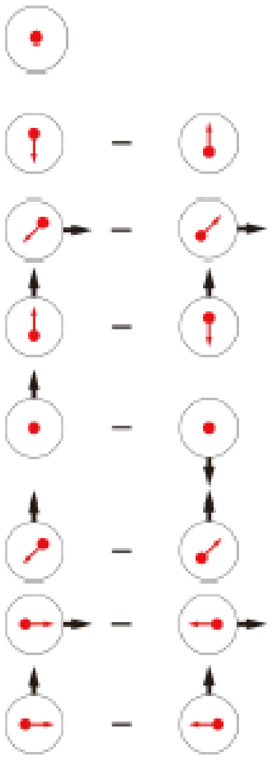
Transversity h_{1T} =

Sivers $f_{1T}^{\perp}$ =

Pretzelosity $h_{1T}^{\perp}$ =

g_1 =

$g_{1T}^{\perp}$ =



Unpolarized

$$\{F_{UU,T} + \ldots$$

$$+\,\varepsilon\cos(2\phi_h)\cdot F_{UU}^{\cos(2\phi_h)} + \ldots$$

Polarized Target

$$+\,S_L[\varepsilon\sin(2\phi_h)\cdot F_{UL}^{\sin(2\phi_h)} + \ldots]$$

$$+\,S_T[\varepsilon\sin(\phi_h+\phi_S)\cdot F_{UT}^{\sin(\phi_h+\phi_S)}$$

$$+\sin(\phi_h-\phi_S)\cdot(F_{UT}^{\sin(\phi_h-\phi_S)} + \ldots)$$

$$+\,\varepsilon\sin(3\phi_h-\phi_S)\cdot F_{UT}^{\sin(3\phi_h-\phi_S)} + \ldots]$$

Polarized Beam and Target

$$+\,S_L\lambda_e[\sqrt{1-\varepsilon^2}\cdot F_{LL} + \ldots]$$

$$+\,S_T\lambda_e[\sqrt{1-\varepsilon^2}\cos(\phi_h-\phi_S)\cdot F_{LT}^{\cos(\phi_h-\phi_S)} + \ldots]\}$$

S_L, S_T: Target Polarization; λ_e: Beam Polarization

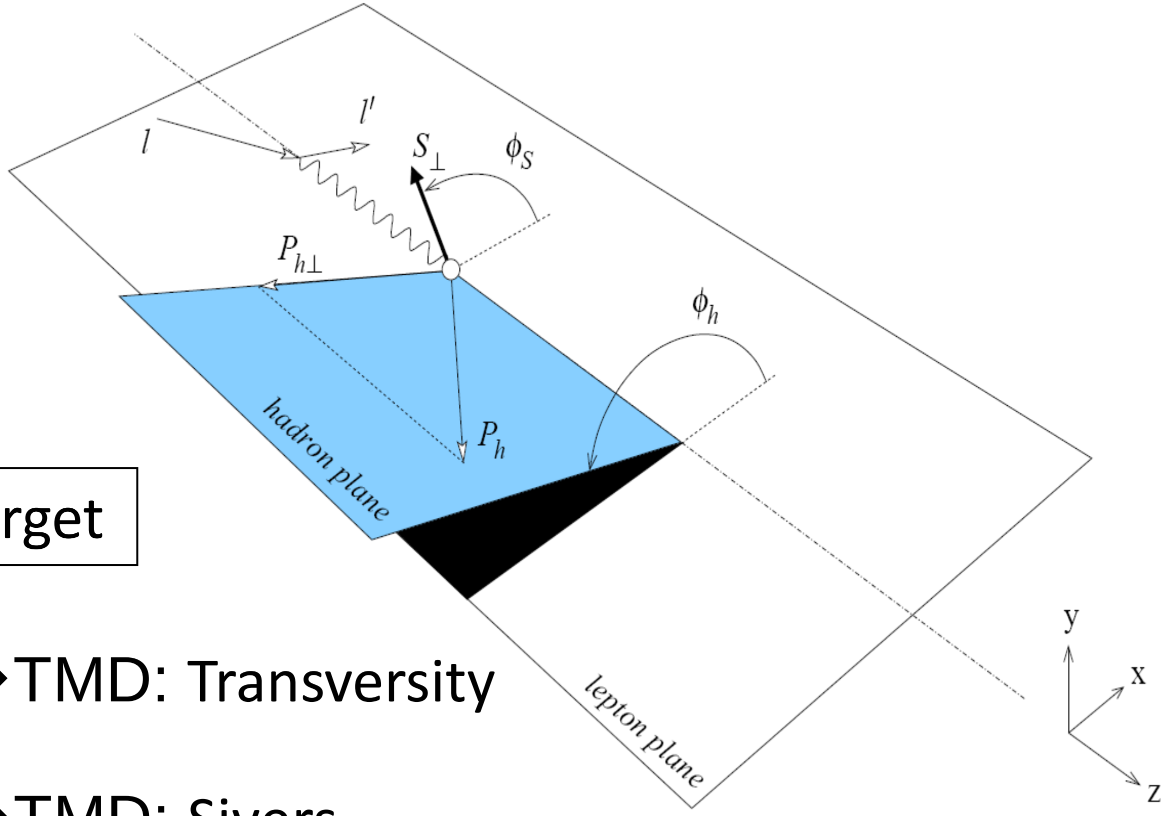
Target SSA, beam-target DSA measurements

Separation of Collins, Sivers and Pretzelosity through azimuthal angular dependence

$$A_{UT}(\varphi_h^l, \varphi_S^l) = \frac{1}{P}\frac{N^{\uparrow} - N^{\downarrow}}{N^{\uparrow} + N^{\downarrow}}$$

$$= A_{UT}^{Collins}\sin(\phi_h + \phi_S) + A_{UT}^{Sivers}\sin(\phi_h - \phi_S)$$

$$+ A_{UT}^{Pretzelosity}\sin(3\phi_h - \phi_S)$$



UT: **U**npolarized beam + **T**ransversely polarized target

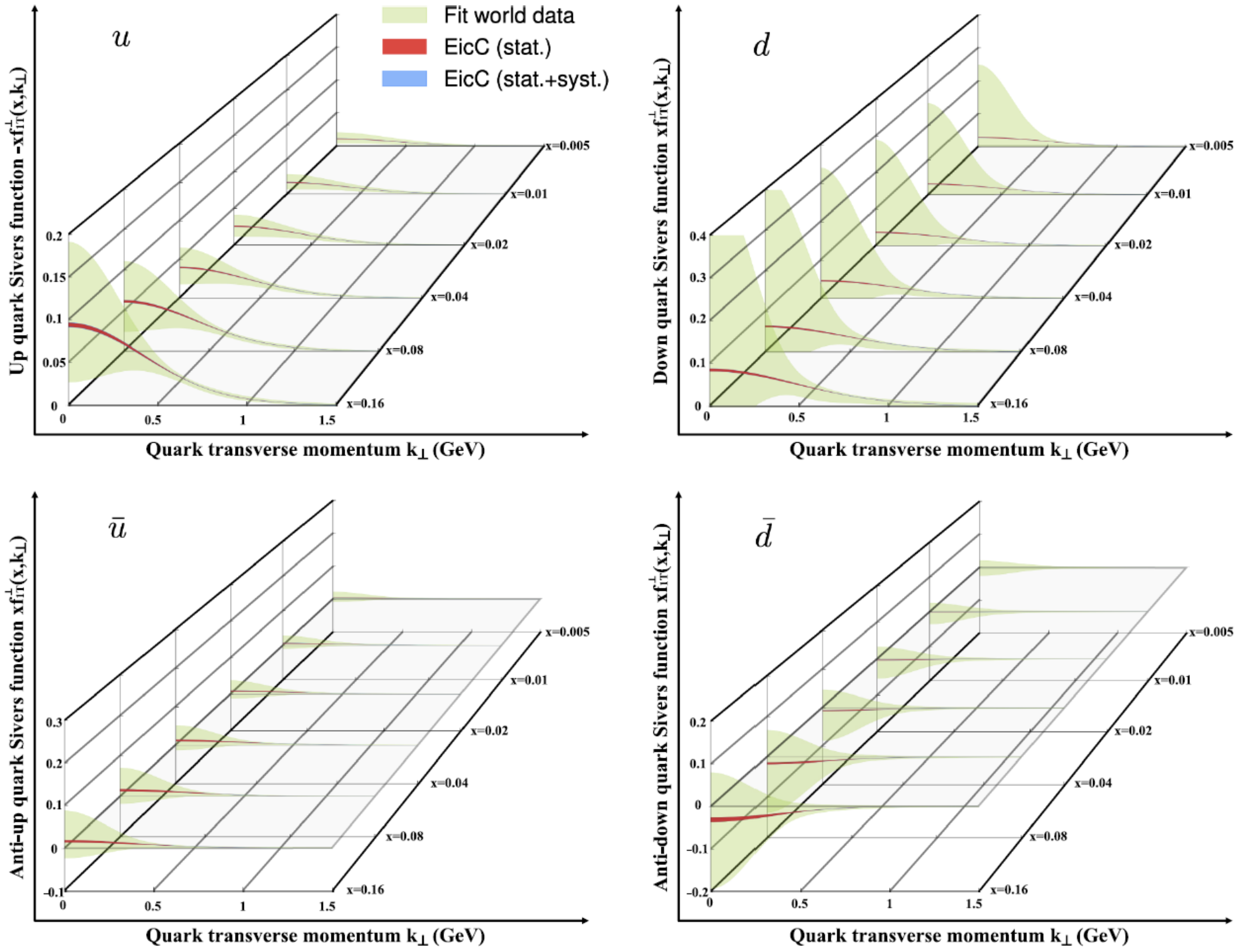
$A_{UT}^{Collins} \propto \langle \sin(\phi_h + \phi_S) \rangle_{UT} \propto h_1 \otimes H_1^{\perp}$ → TMD: Transversity

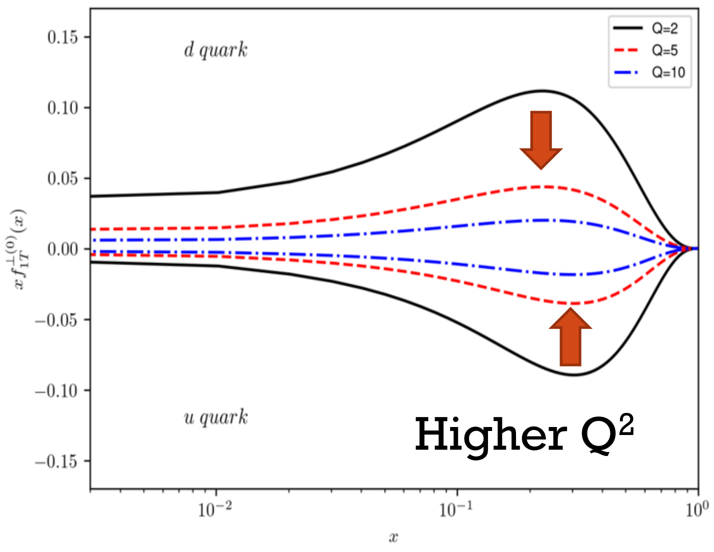
$A_{UT}^{Sivers} \propto \langle \sin(\phi_h - \phi_S) \rangle_{UT} \propto f_{1T}^{\perp} \otimes D_1$ → TMD: Sivers

$A_{UT}^{Pretzelosity} \propto \langle \sin(3\phi_h - \phi_S) \rangle_{UT} \propto h_{1T}^{\perp} \otimes H_1^{\perp}$ → TMD: Pretzelosity

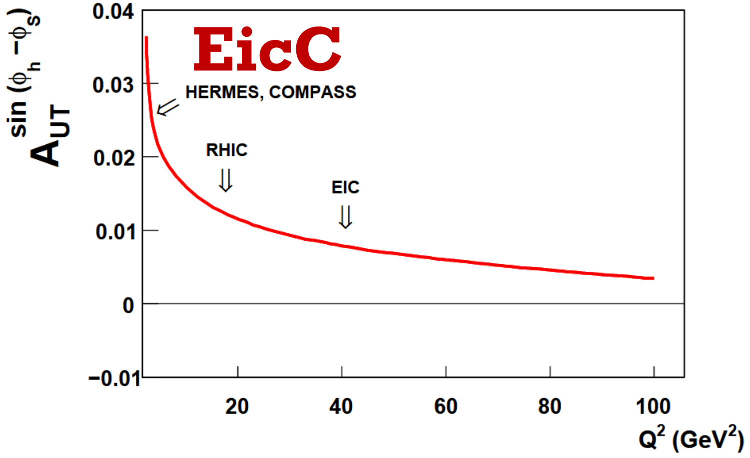
EicC and EIC-Sivers TMDs

C. H. Zeng, T. B. Liu, P. Sun, Y. X. Zhao, PRD106.094039 (2022)





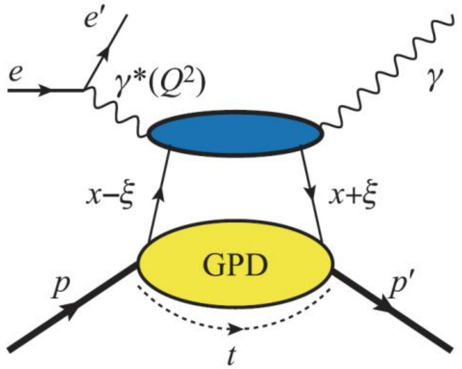
S. Aybat et. al. Phys. Rev. Lett 108, 242003 (2012)

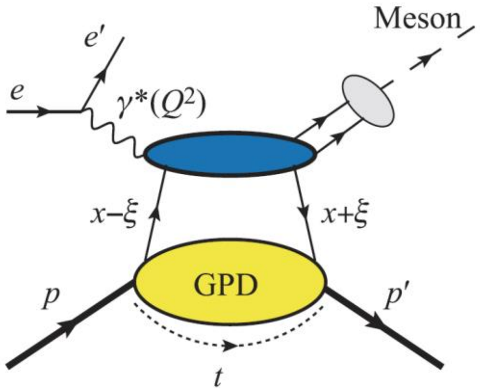


1. Higher Q^2, smaller effect
2. Smaller x, smaller effect

complementary

Spin structure of the nucleon-GPDs





Polarized beam, unpolarized target (SSA)

$$A_{LU}^{\sin\phi} \propto \frac{y\sqrt{1-y}}{2-2y-y^2}\sqrt{\frac{-t}{y^2Q^2}} \times x_B \mathcal{I}m\left[F_1\mathcal{H} + \xi(F_1+F_2)\widetilde{\mathcal{H}} - kF_2\mathcal{E} + ...\right](x_B, t, Q^2),$$

Unpolarized beam, longitudinal target (lTSA)

$$A_{UL}^{\sin\phi} \propto \frac{\sqrt{1-y}}{2-y}\sqrt{\frac{-t}{y^2Q^2}} \times x_B \mathcal{I}m\left[F_1\widetilde{\mathcal{H}} + x_B(F_1+F_2)(\widetilde{\mathcal{H}} + \frac{x_B}{2\mathcal{E}}) - x_B kF_2\widetilde{\mathcal{E}} + ...\right](x_B, t, Q^2),$$

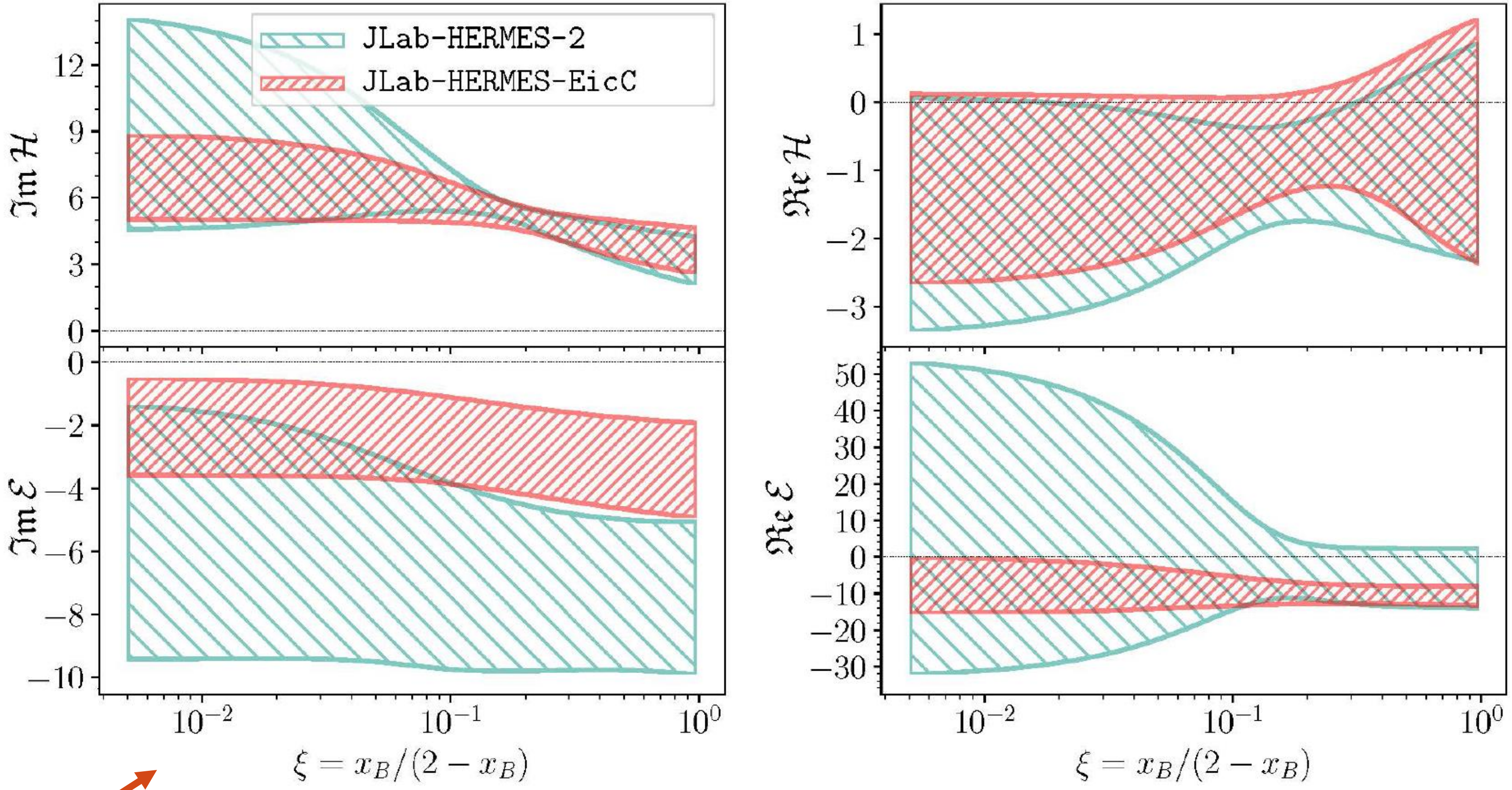
Unpolarized beam, transverse target (tTSA)

$$A_{UT}^{\sin(\phi-\phi_S)\cos\phi} \propto \frac{\sqrt{1-y}}{2-y}\frac{-t}{2yM_NQ} \times x_B \mathcal{I}m\left[F_1\mathcal{H} + \xi(F_1+F_2)(\widetilde{\mathcal{H}} + \frac{x_B}{2}\mathcal{E}) - \xi kF_2\widetilde{\mathcal{E}} + ...\right](x_B, t, Q^2),$$

Polarized beam, longitudinal target (DSA)

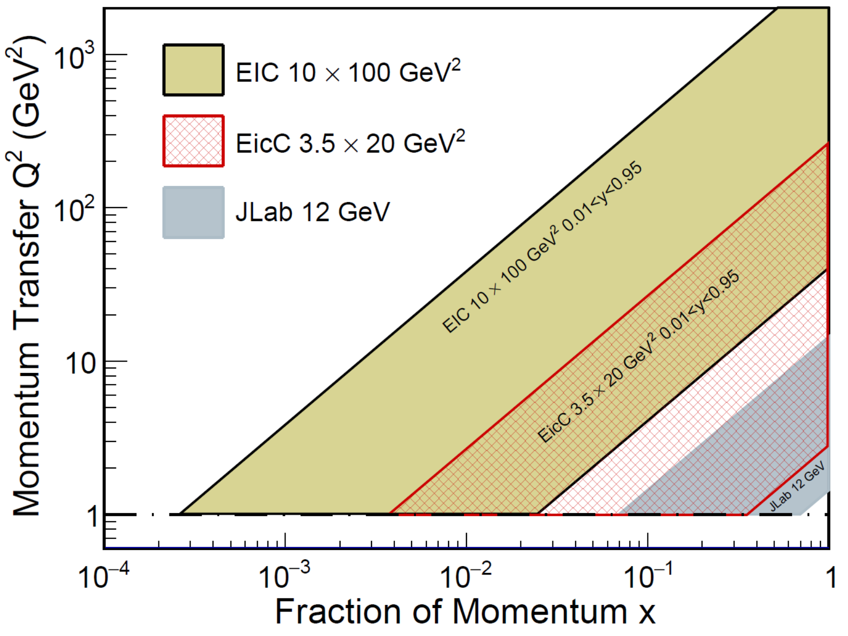
$$A_{LL} \propto (A + B\cos\phi)\, Re\left[F_1\mathcal{H} + \xi(F_1+F_2)(\mathcal{H} + \frac{x_B}{2}\mathcal{E}) + ...\right],$$

The extraction of CFF with neural network methods [Kumericki, 19]



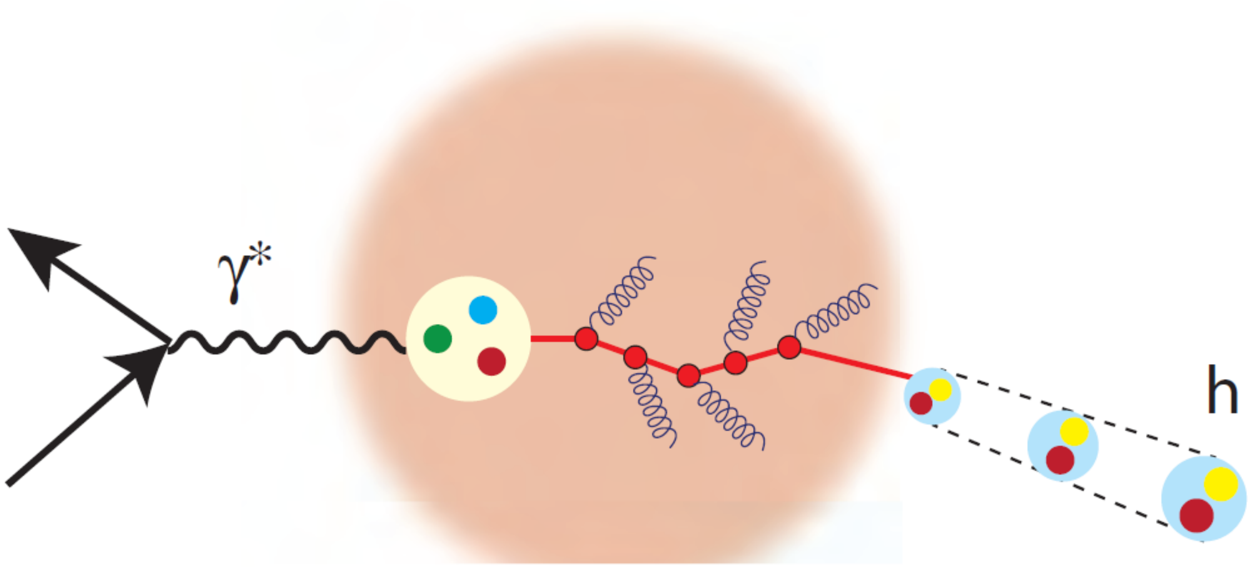
Only with this azimuthal angular modulation

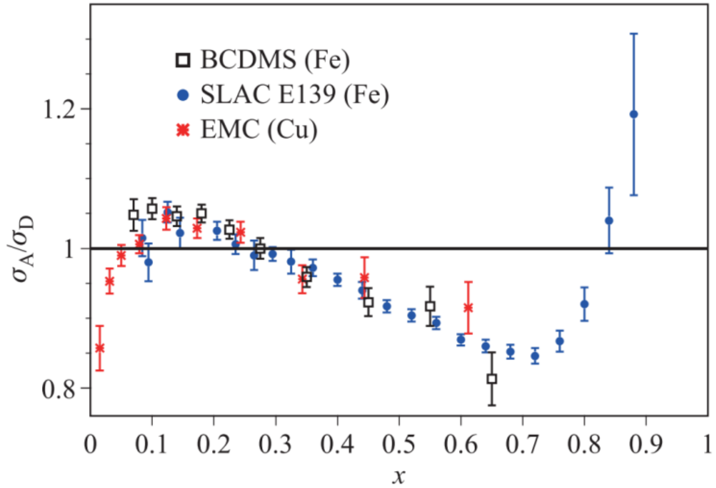
Highlighted physics topics



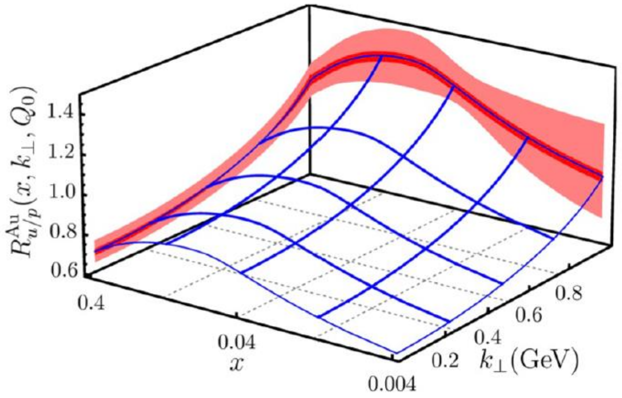
- Spin of the nucleon: 1D, 3D
  - polarized electron + polarized proton/light nuclei
- Partonic structure of nuclei and the parton interaction with the nuclear environment
  - unpolarized electron + unpolarized various nuclei
- Exotic states with c/cbar, b/bbar (BESIII community in China)
- Mass of the nucleon

"old" and long standing problems for cold nuclear matter effect





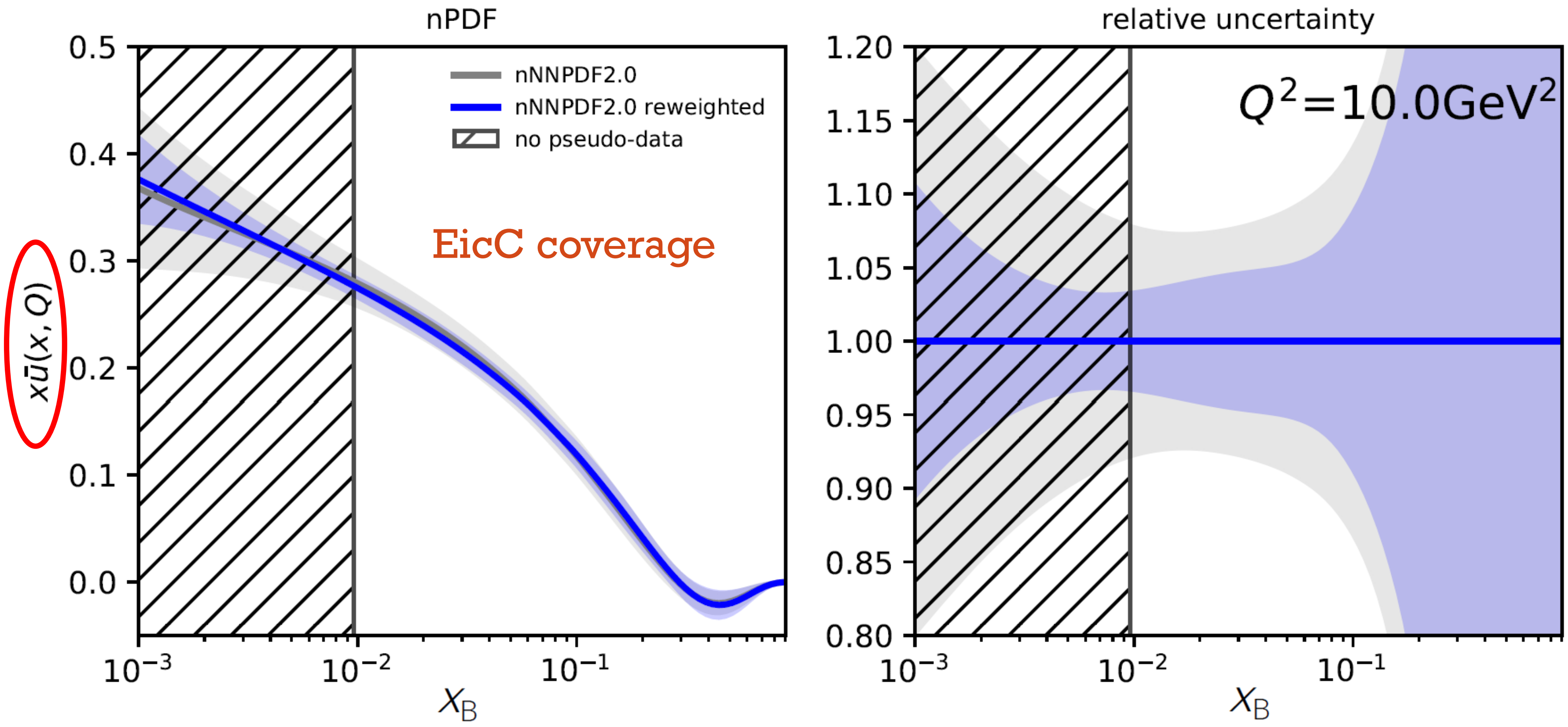
$$R^{\mathrm{Au}}_{u/p}(x, k_\perp, Q_0) = \frac{f^{\mathrm{Au}}_{u/p}(x, k_\perp, Q_0)}{f_{u/p}(x, k_\perp, Q_0)}$$



- Initial state parton distribution in nucleus (nPDFs)
- Intermediate state parton propagating in nuclear medium (energy loss, broadening…)
- Final state hadronization (hadron transport, FFs…)

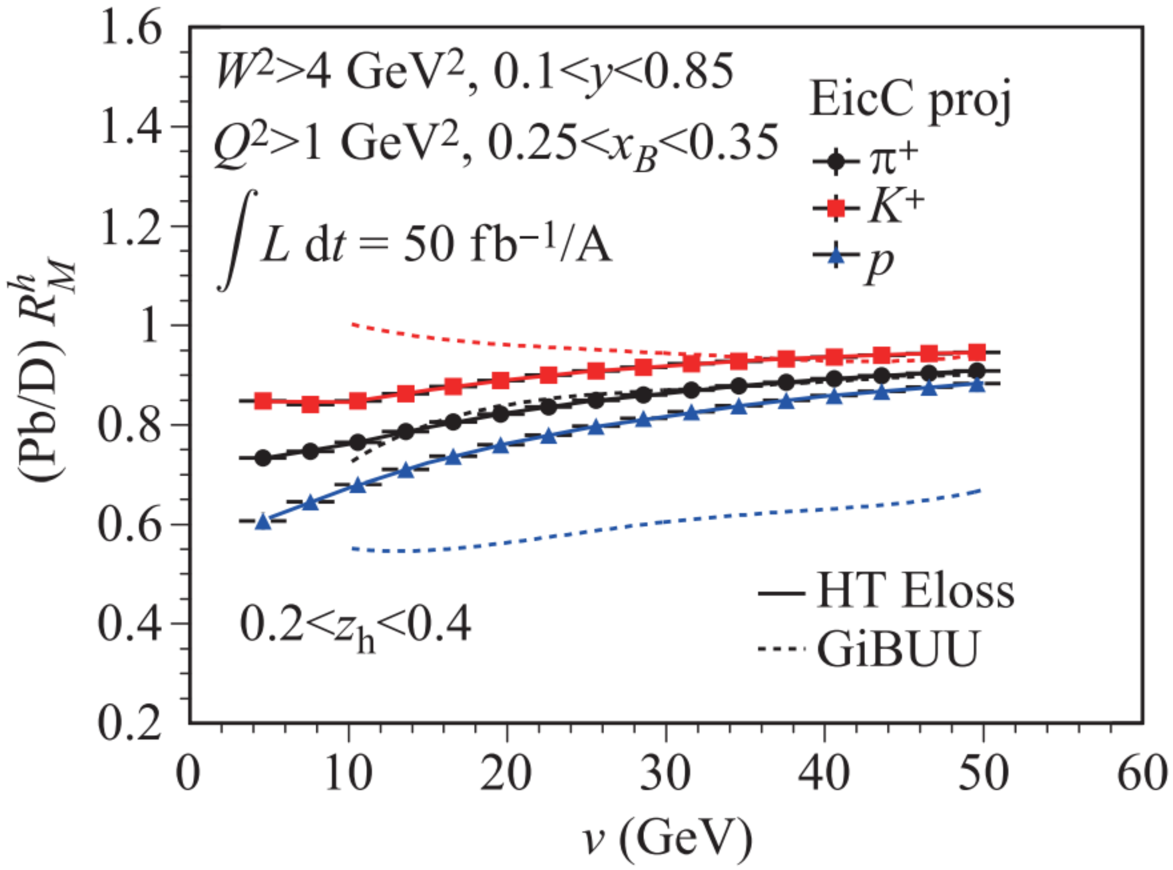
arXiv:2107.12401

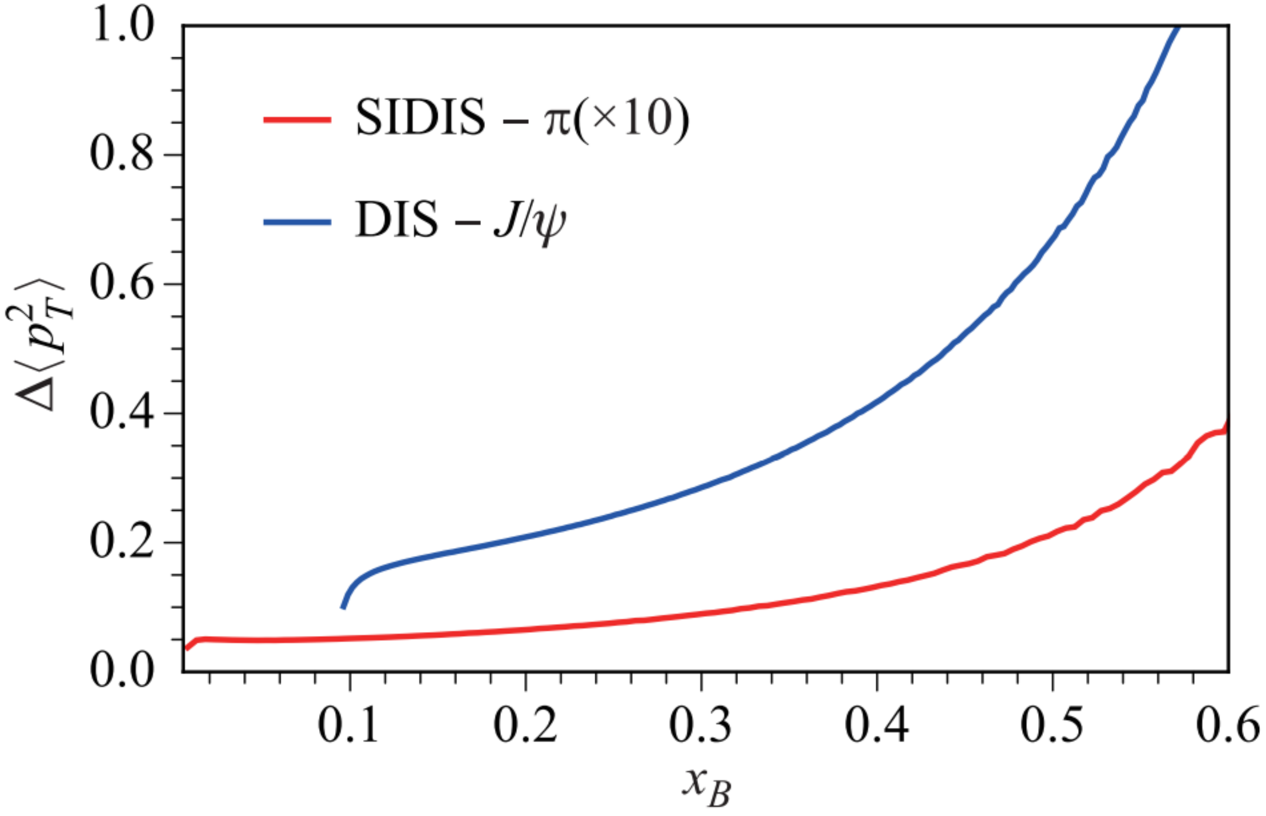
Nuclear PDFs study with ion beam



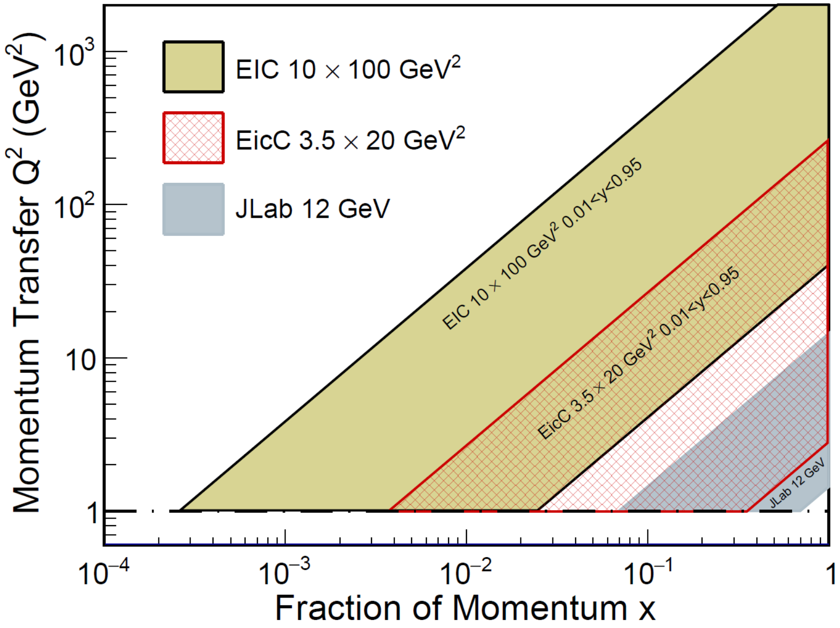
With only a few hours of running

Nuclear medium effect for parton propagation and hadronization





Highlighted physics topics



- Spin of the nucleon: 1D, 3D
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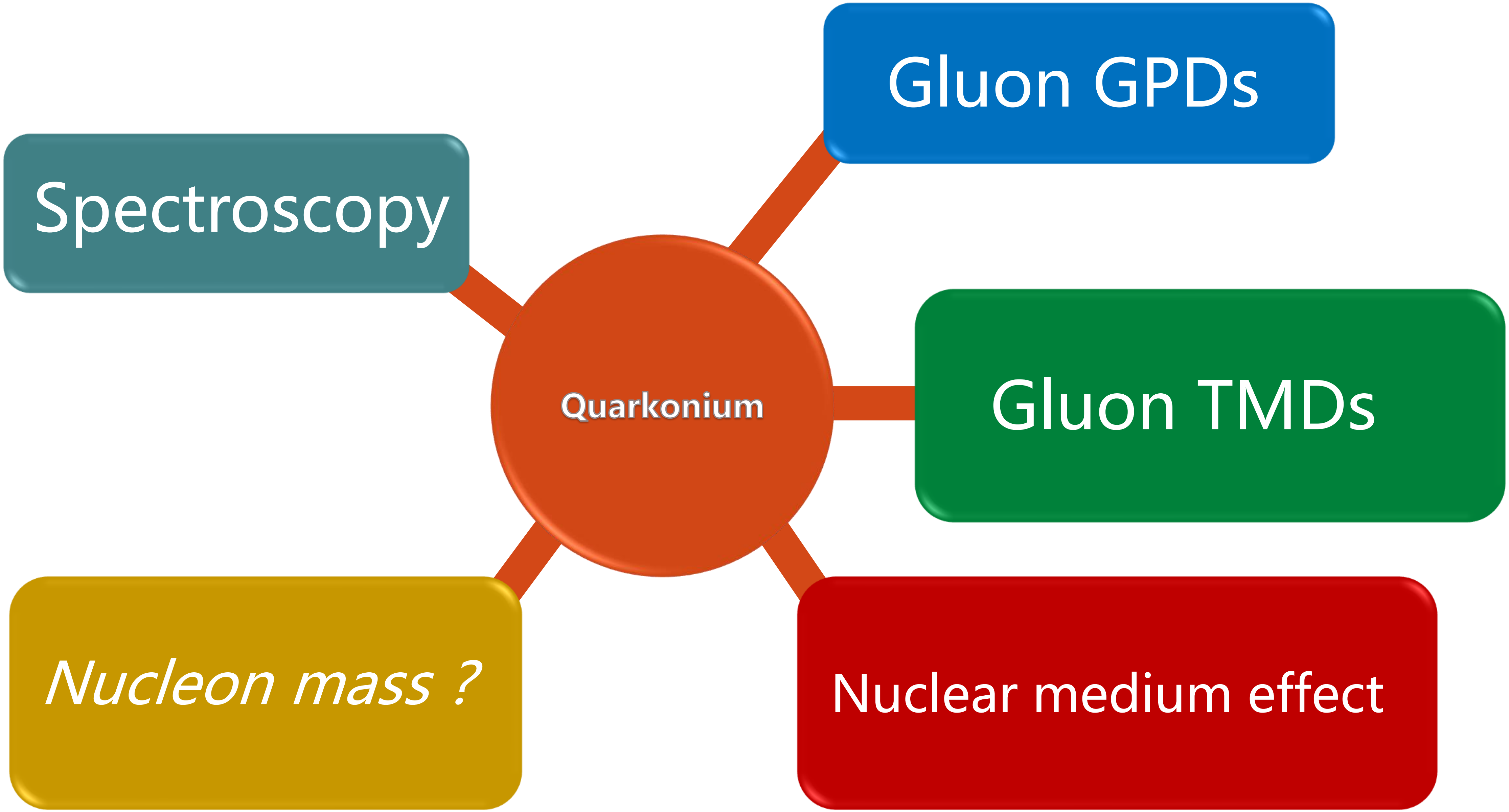
- Partonic structure of nuclei and the parton interaction with the nuclear environment
  - unpolarized electron + unpolarized various nuclei
- Exotic states with c/cbar, b/bbar (BESIII community in China)
- Mass of the nucleon

Quarkonium as a probe



J/Psi production at EicC

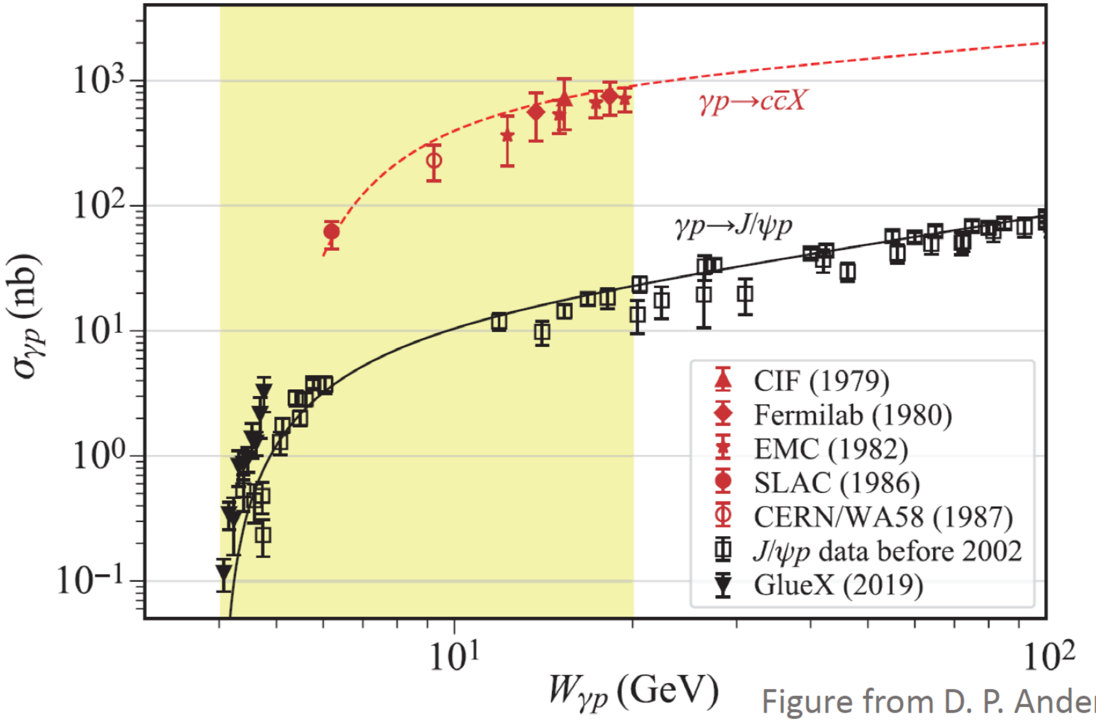


Figure from D. P. Anderle et al. Front.Phys.16(2021)64701

For W=10-20 GeV,

- Photoproduction: $\sigma(\gamma p \to J/\psi p) \sim O(10\text{ nb})$, (no resonant enhancement considered), $\sigma(\gamma p \to c\bar{c}X) \sim 50\sigma(\gamma p \to J/\psi p)$
- Leptoproduction: cross sections are roughly two orders of magnitude (α) smaller
- For an integrated luminosity of 50 fb^{-1}, no. of J/ψ is $\sim O(10^7 - 10^8)$; many more open-charm hadrons D and Λ_c

Upsilon production at EicC

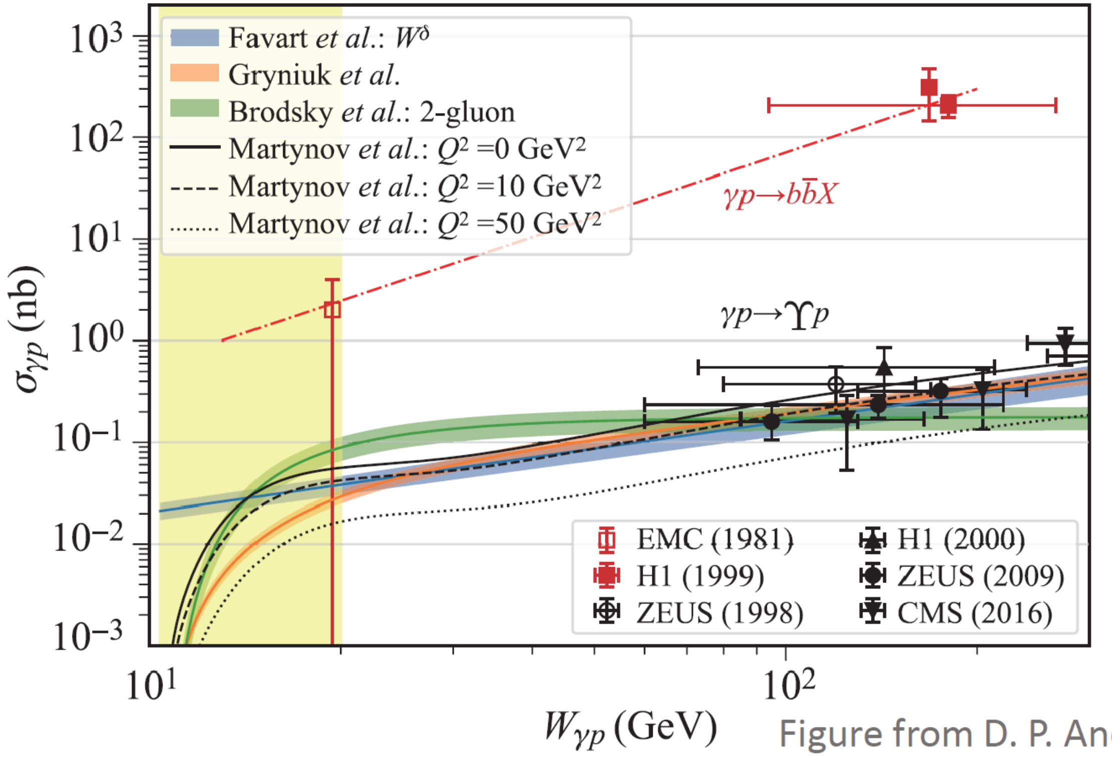


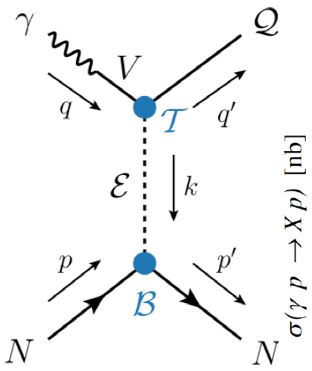
Figure from D. P. Anderle et al. Front.Phys.16(2021)64701

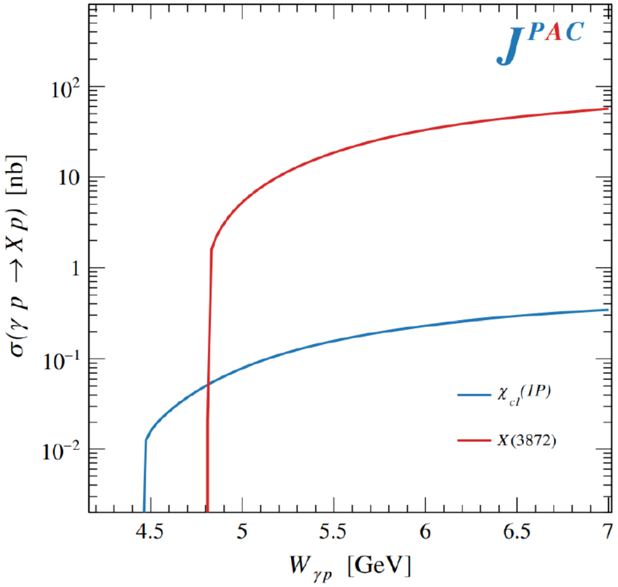
For W=15-20 GeV,

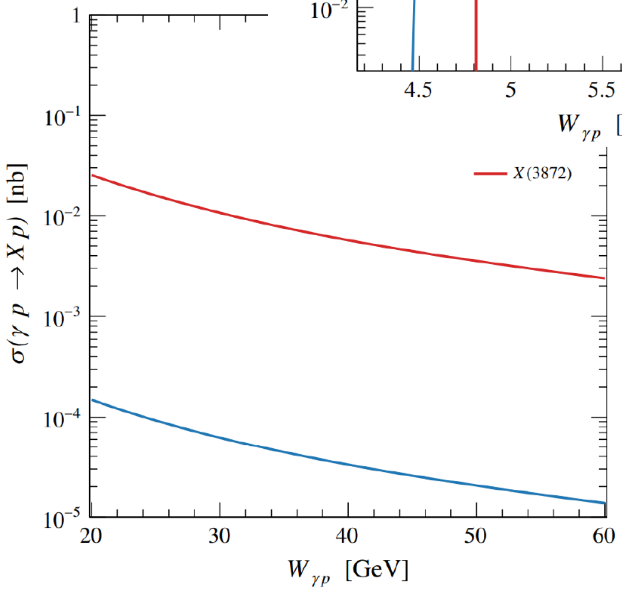
- Photoproduction: $\sigma(\gamma p \to \Upsilon p) \sim O(10\ \text{pb})$ (no resonant enhancement considered), $\sigma(\gamma p \to b\bar{b}X)$ is about two orders higher
- Electroproduction: roughly two orders of magnitude (α) smaller, $\sim O(0.1\ pb)$
- For an integrated luminosity of 50 fb^{-1}, no. of Υ is $\sim O(10^4)$;

Exotic states production at EicC

- Cross section estimates for exclusive reactions assuming VMD (highly model-dependent)





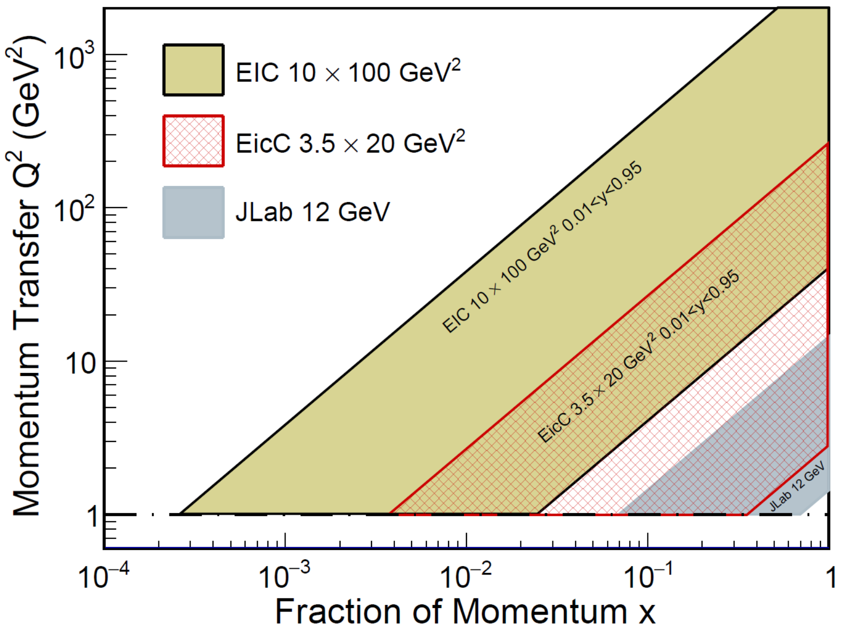


JPAC, PRD102(2020)114010

➢ Estimated events for EicC (50 /fb)

Exotic states	Production/decay processes	Detection efficiency	Expected events
$P_c(4312)$	$ep \to eP_c(4312)$ $P_c(4312) \to pJ/\psi$ $J/\psi \to l^+l^-$	~30%	15–1450
$P_c(4440)$	$ep \to eP_c(4440)$ $P_c(4440) \to pJ/\psi$ $J/\psi \to l^+l^-$	~30%	20–2200
$P_c(4457)$	$ep \to eP_c(4457)$ $P_c(4457) \to pJ/\psi$ $J/\psi \to l^+l^-$	~30%	10–650
P_b(narrow)	$ep \to eP_b$(narrow) P_b(narrow) $\to p\Upsilon$ $\Upsilon \to l^+l^-$	~30%	0–20
P_b(wide)	$ep \to eP_b$(wide) P_b(wide) $\to p\Upsilon$ $\Upsilon \to l^+l^-$	~30%	0–200
$\chi_{c1}(3872)$	$ep \to e\chi_{c1}(3872)p$ $\chi_{c1}(3872) \to \pi^+\pi^- J/\psi$ $J/\psi \to l^+l^-$	~50%	0–90
$Z_c(3900)^+$	$ep \to eZ_c(3900)^+ n$ $Z_c^+(3900) \to \pi^+ J/\psi$ $J/\psi \to l^+l^-$	~60%	90–9300

Highlighted physics topics



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- Mass of the nucleon

Proton mass study

Mass decomposition [Ji, 95]

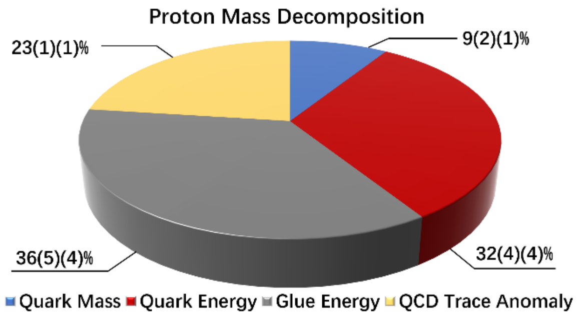
$$M = \underbrace{M_q + M_m}_{\text{Quark}} + \underbrace{M_g + M_a}_{\text{Gluon}}$$

M_q : quark energy

M_m : quark mass (condensate)

M_g : gluon energy

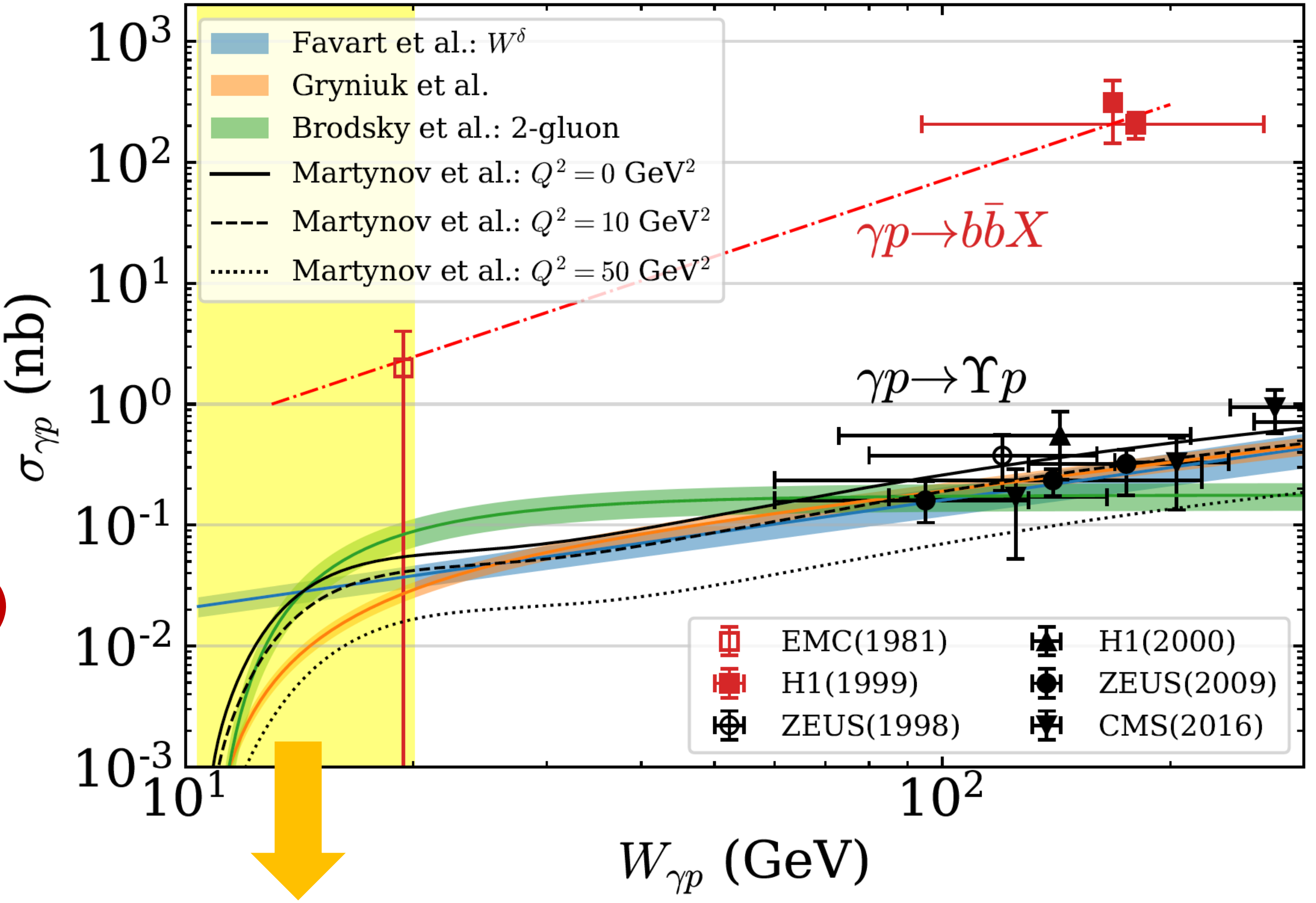
M_a : trace anomaly



Lattice QCD calculation by Yang et al, 2018

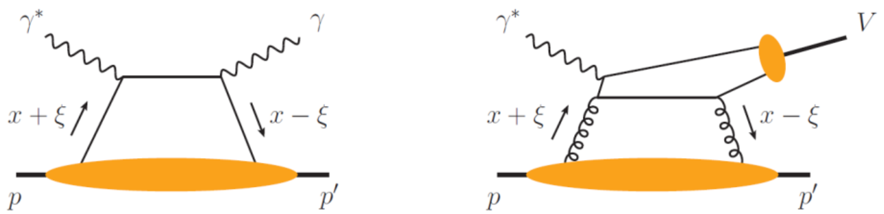
- M_q and M_g constrained by PDFs.
- M_m via πN low energy scattering.
- M_a via threshold production of J/Ψ (8.2 GeV; JLab) and Υ (12 GeV);
- Threshold requires low CoM energy. (Low y at EIC).
- Complementarity between EicC (and EIC) and lattice. Guideline

?



EicC coverage

Proton mass study



GPDs 研究

Mass decomposition [Ji, 95]

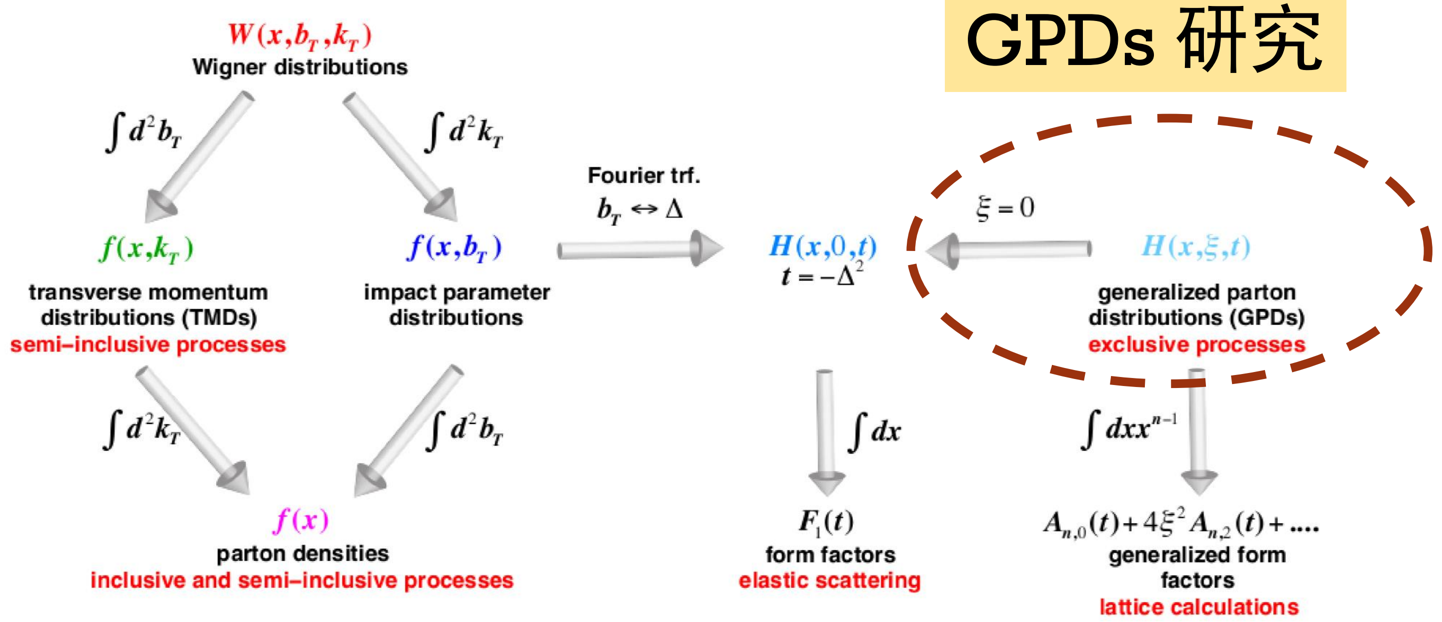
$$M = \underbrace{M_q + M_m}_{\text{Quark}} + \underbrace{M_g + M_a}_{\text{Gluon}}$$

M_q : quark energy

M_m : quark mass (condensate)

M_g : gluon energy

M_a : trace anomaly



- M_q and M_g constrained by PDFs.
- M_m via πN low energy scattering.

Gravitational Form Factors

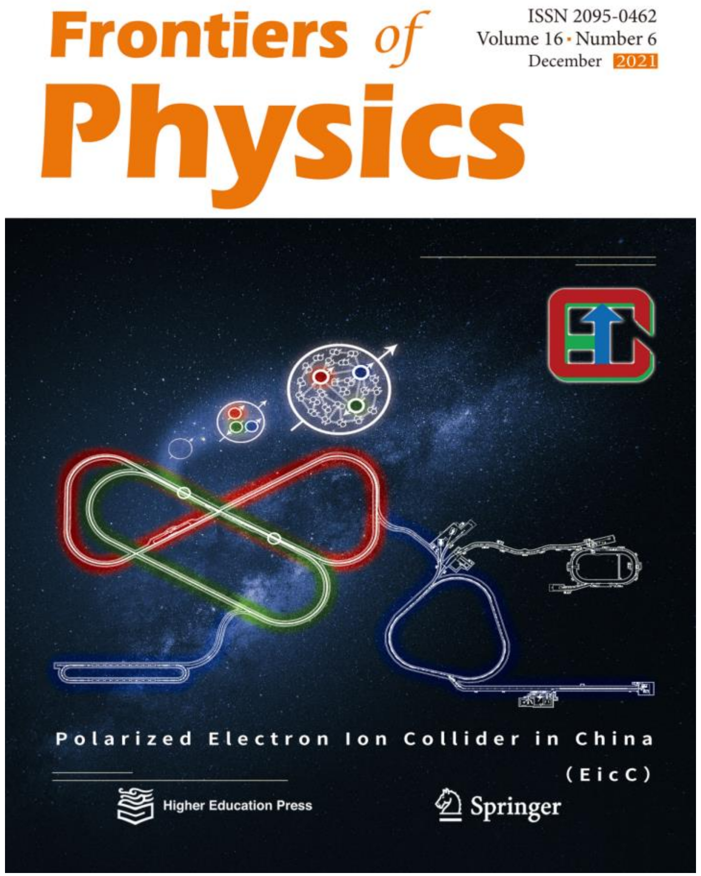
Defining Ma related observables…ongoing efforts

Outline

- General introduction
- Physics highlights
- Project status
- Summary

Towards Conceptual Design Report (CDR)

EicC white paper



CDR preparation

Volume I: Accelerator

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1 Overview of EicC
1.1 The Science Goals and the Requirements for EicC
1.2 EicC Design Concept
1.3 Beam Parameters and Luminosity
1.4 Ion Accelerator Complex Design
1.5 Electron Accelerator Complex Design
1.6 Staged Electron Cooling for Ions
1.7 The Interaction Region Design
1.8 Overview Summary

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2.2 Luminosity lifetime
2.3 Collective Effects and Beam Stabilities
2.4 Space Charge Effects
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3.2 Formation of EicC Ion Beams
3.3 Polarized Ion Source
3.4 iLinac
3.5 Booster Ring
3.6 pRing
3.7 Beam Synchronization
3.8 Polarization and Polarimetry

4 Electron Accelerator Complex
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4.3 Electron Injector
4.4 eRing
4.5 Synchrotron Radiation and Beam Parameters
4.6 Polarization and Polarimetry

5 Electron Cooling
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5.2 Medium Energy Electron Cooler
5.3 ERL Based High Energy Electron Cooler
5.4 Novel cooling scheme development

Volume II: Physics and Detectors

Contents

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1.2 Three-dimensional tomography of nucleons
1.2.1 TMDs
1.2.2 GPDs
1.3 Nucleon mass
1.4 Partonic structure of nucleus
1.5 Exotic hadronic states
1.6 Structure of light pseudoscalar mesons

2 Physics requirements and detector concept
2.1 Physics requirements
2.1.1 Particle multiplicity and event rate
2.1.2 Scattered electron
2.1.3 Charged hadron identification
2.1.4 Small angle detection
2.2 Detector concept

3 Tracking system
3.1 Vertex detector
3.2 Time projection chamber
3.3 All silicon tracker
3.3.1 All silicon tracker layout
3.3.2 Detector simulation and reconstruction
3.3.3 Tracking and vertexing performance
3.4 Endcap disk

4 PID system
4.1 Detector consideration
4.2 Time of flight detector
4.2.1 MRPC
4.2.2 DIRC-based TOF
4.3 Cherenkov detector
4.3.1 DIRC
4.3.2 Module RICH

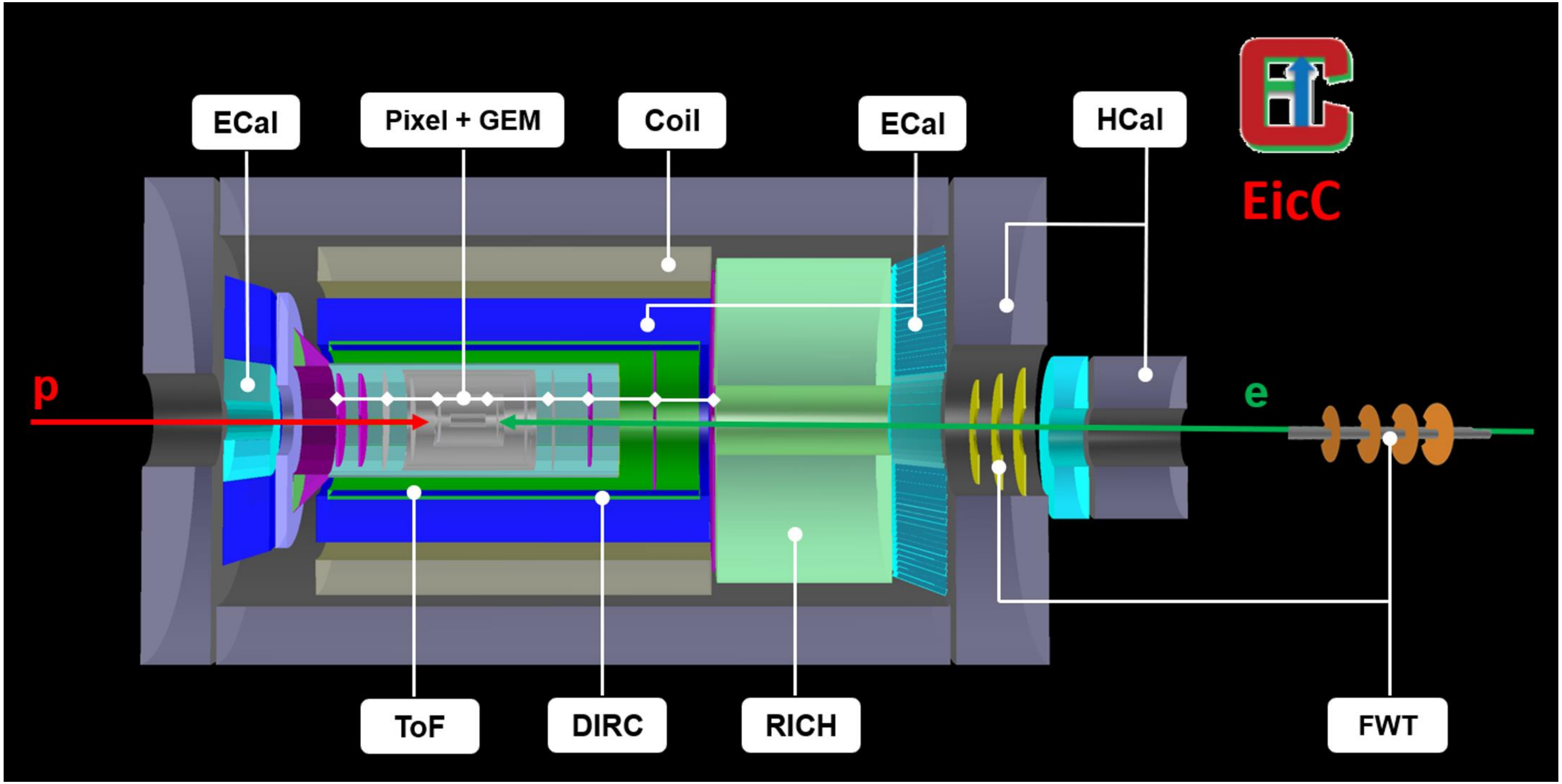
5 Calorimetry
5.1 Design consideration
5.2 Shashlik-type EMCal
5.2.1 Module design and simulation
5.2.2 Energy and spatial resolution
5.2.3 Detector layout
5.3 Crystall EMCal
5.4 HCal

...

Working groups

Accelerator	Physics	Detector
1) EicC Accelerators	1) 1D spin	1) Vertexing + tracking
2) Ion Sources	2) 3D spin (TMDs + GPDs)	2) PID
3) Ion Machine	3) Exotic states	3) Calorimetry
5) Electron Machine	4) EHM and proton mass	4) IR + Magnet
5) Polarization	5) Nuclei	5) Luminosity and polarimetry
6) Electron cooling	6) LQCD	6) Forward detector
7) IR	7) DSE	7) DAQ
8) Common System	8) New ideas: (1) Jets (2) Heavy flavor observable (3) Fragmentation function	8) Simulations
		Software: EicCRoot
EicC CDR Volume I	**EicC CDR** Volume II	

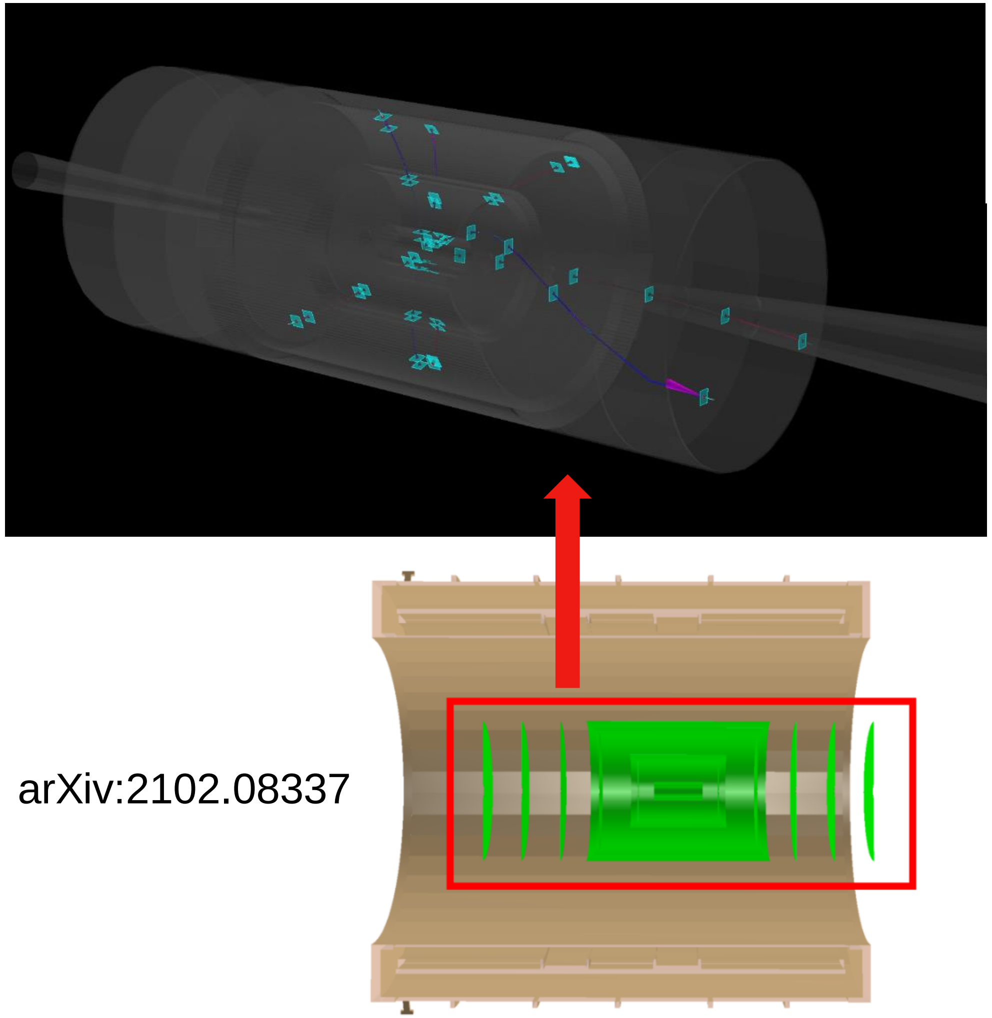
EicC detector considerations



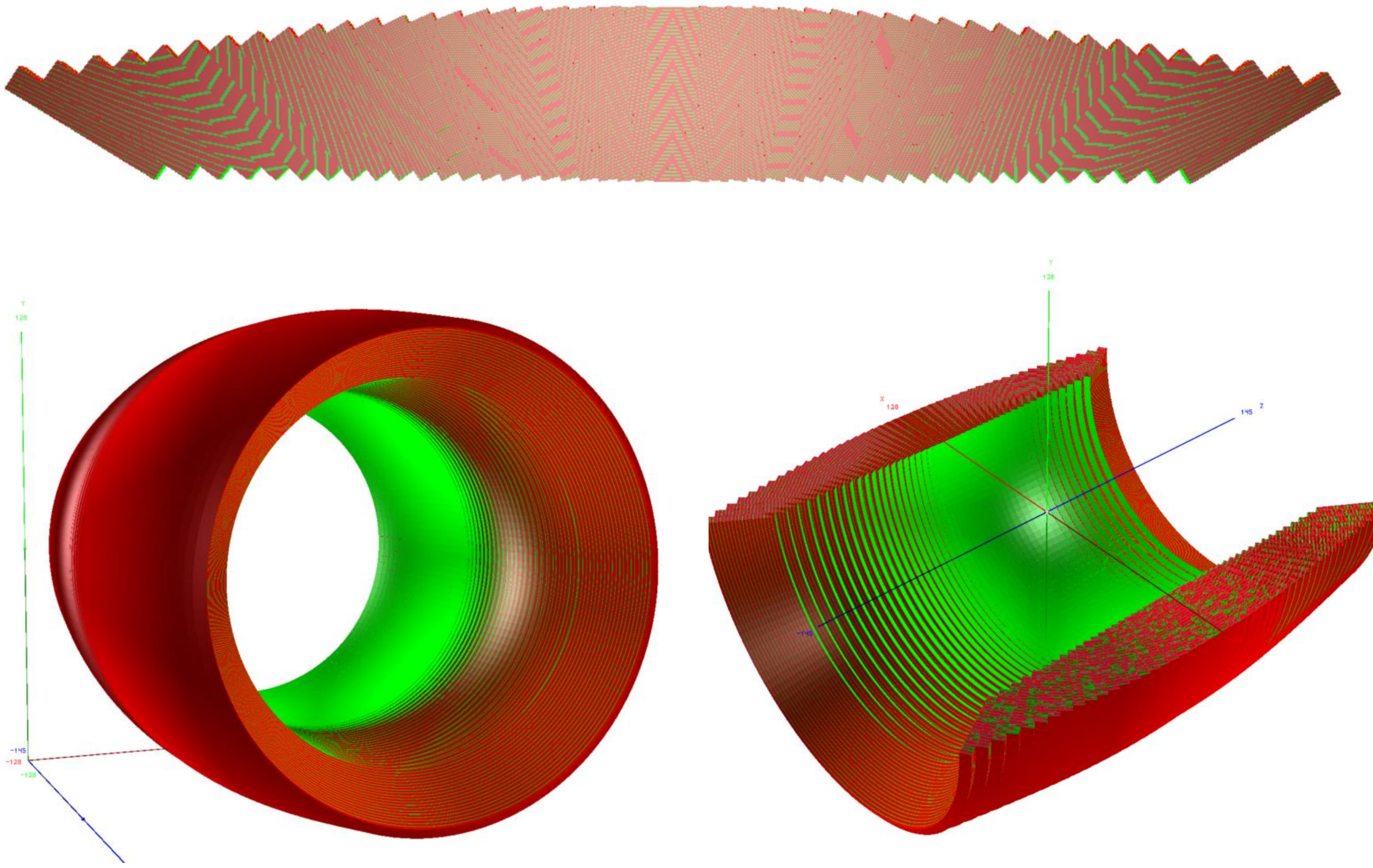
Detailed full Geant4 simulation is ongoing

Subsystem simulations---an example

Tracking with all-silicon or Si+MPGD design



arXiv:2102.08337



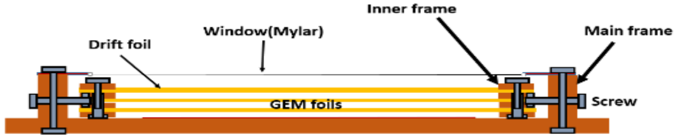
Calorimetry system

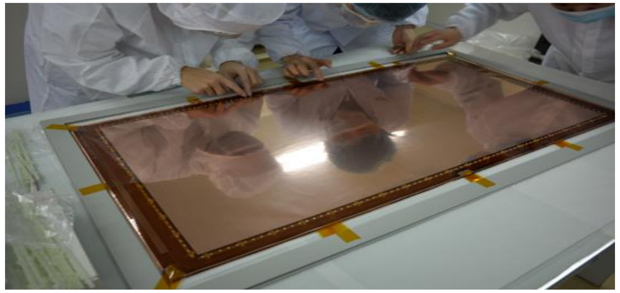
Detector R&Ds

Clean rooms of ISO6 and ISO7 (in total of 200 m²) for detector assembling

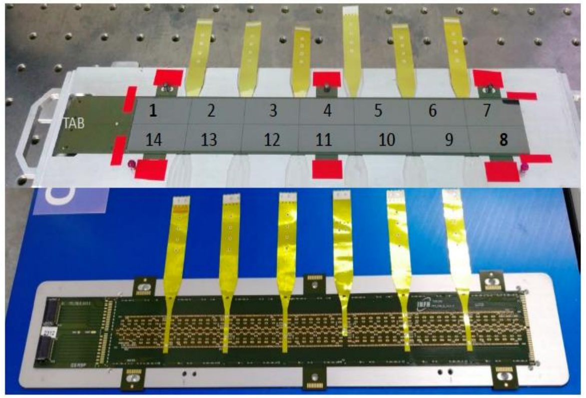
- 25cm x 25 cm Micromegas mass production
- R&D on 0.4m x 0.4m

1m x 0.5 m GEM (self-stretching)



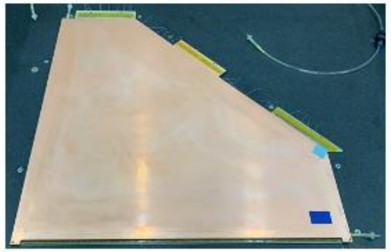


ALICE style ITS2 MAPS pixel detector

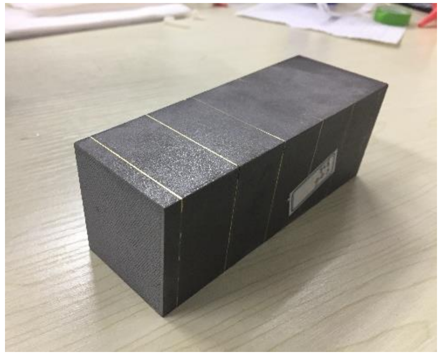


sTGC detector

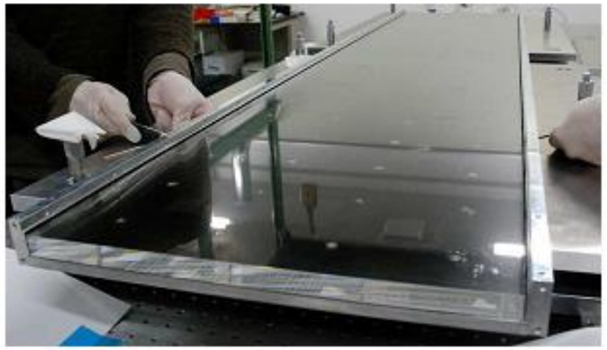
~55cm * 55cm pentagon



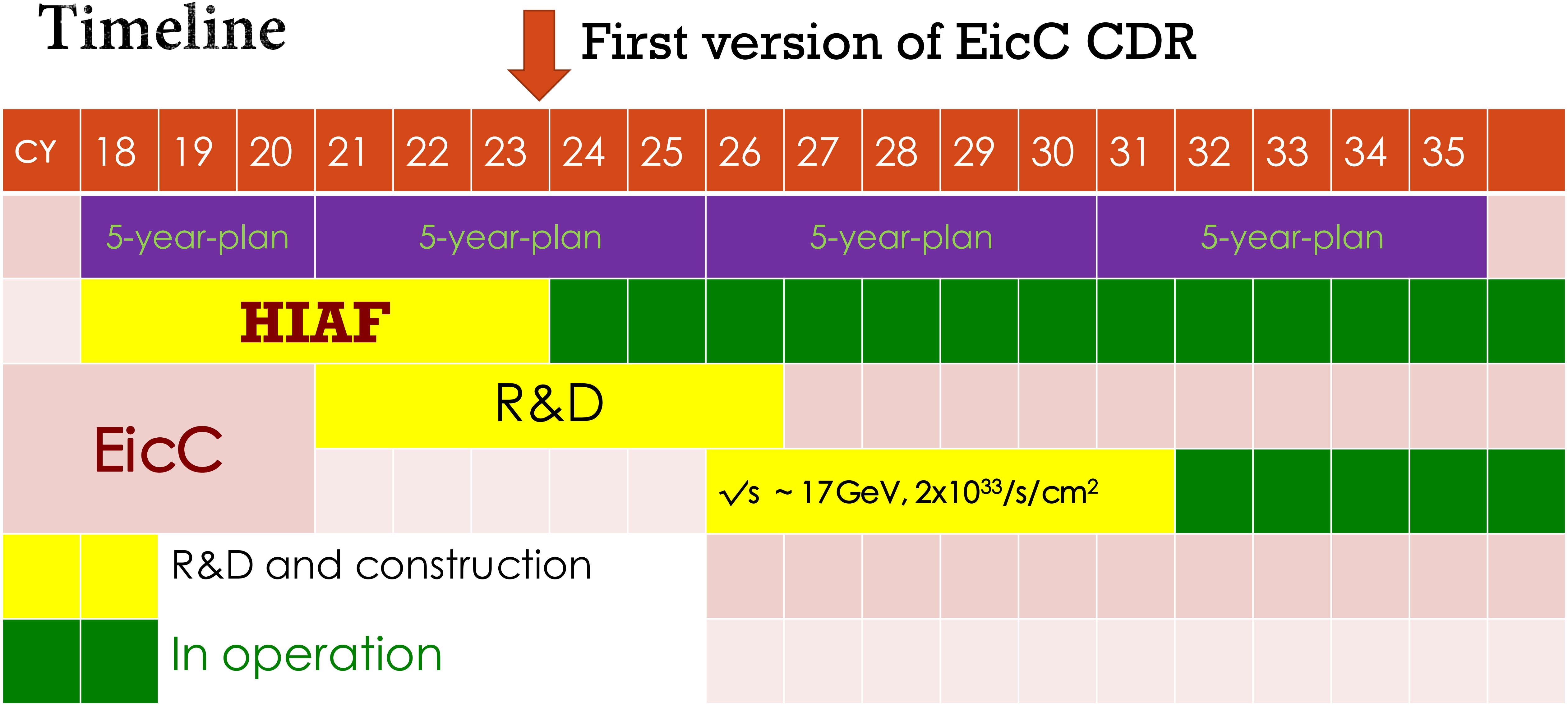
Shashlyk and W-powder+ScFi EMCal



DIRC prototype



Timeline


First version of EicC CDR
CY
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34
35
5-year-plan
5-year-plan
5-year-plan
5-year-plan
HIAF
EicC
R&D
√s ~ 17GeV, 2x10^33/s/cm^2
R&D and construction
In operation

To follow our regular meetings/workshops

- For subscription to the **eicc_member** mailing list, please do it in the following link:

http://lists.ustc.edu.cn/sympa/subscribe/eicc_member?previous_action=info

- For subscription to the **eicc_physics** mailing list, please do it in the following link:

http://lists.ustc.edu.cn/sympa/subscribe/eicc_physics?previous_action=info

- For subscription to the **eicc_detector** mailing list, please do it in the following link:

http://lists.ustc.edu.cn/sympa/subscribe/eicc_detector?previous_action=info

- For subscription to the **eicc_accelerator** mailing list, please do it in the following link:

http://lists.ustc.edu.cn/sympa/subscribe/eicc_accelerator?previous_action=info

Thanks

and

<u>you are more than welcome to join the effort!</u>

Backups

EicC Detector Overview

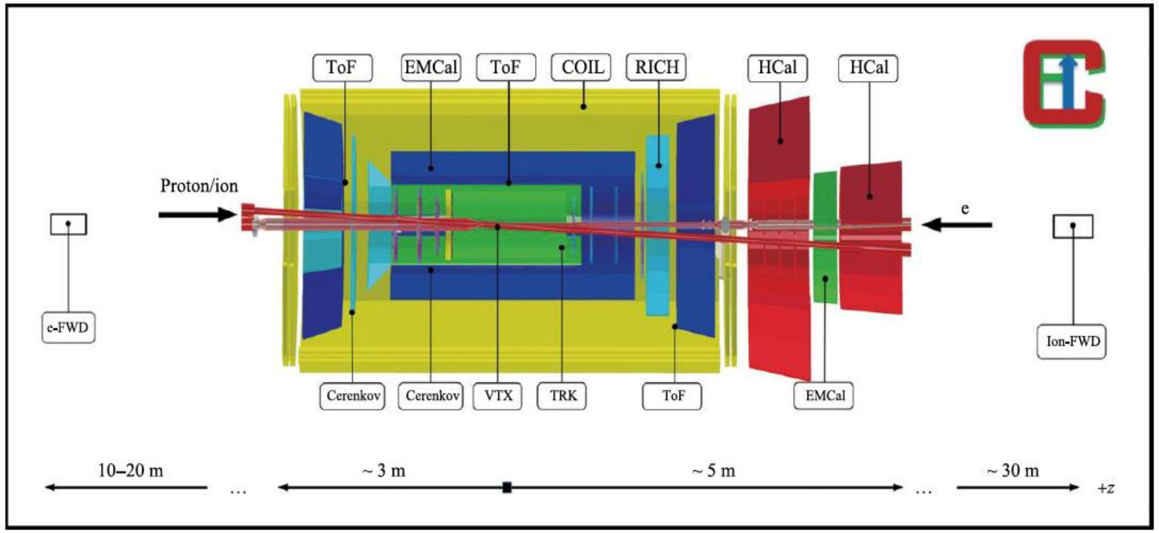
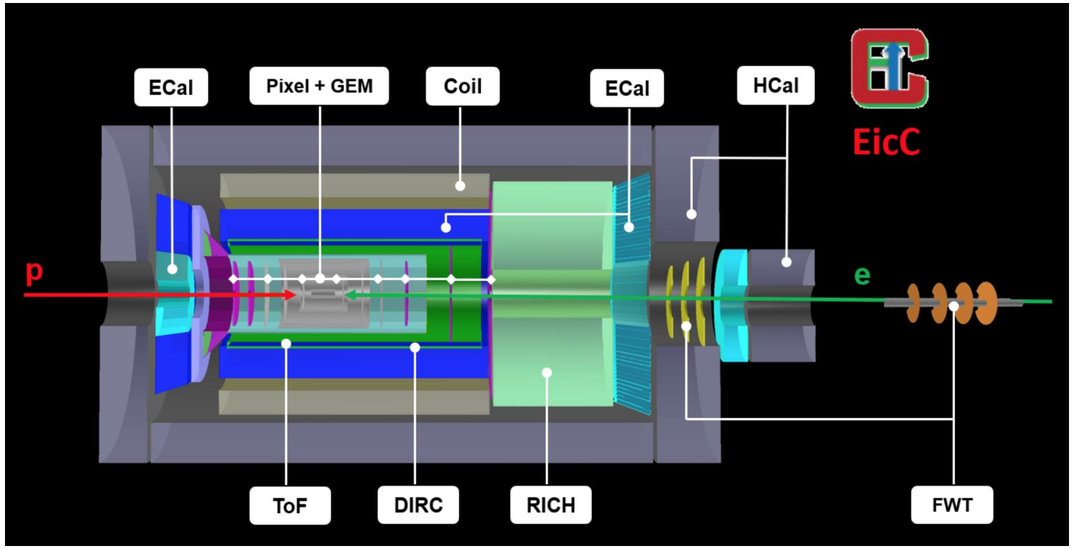


Fig. 4.10 Conceptual design of the EicC detector.



- Subsystems to realize the EicC physics goals:

  1) Vertex & tracking detectors
  2) PID detectors
  3) Calorimeters
  4) Far Forward detectors
  5) Luminosity monitor & Polarimetry
  6) DAQ
  7) Simulation & software

- **Questions need to be addressed:**

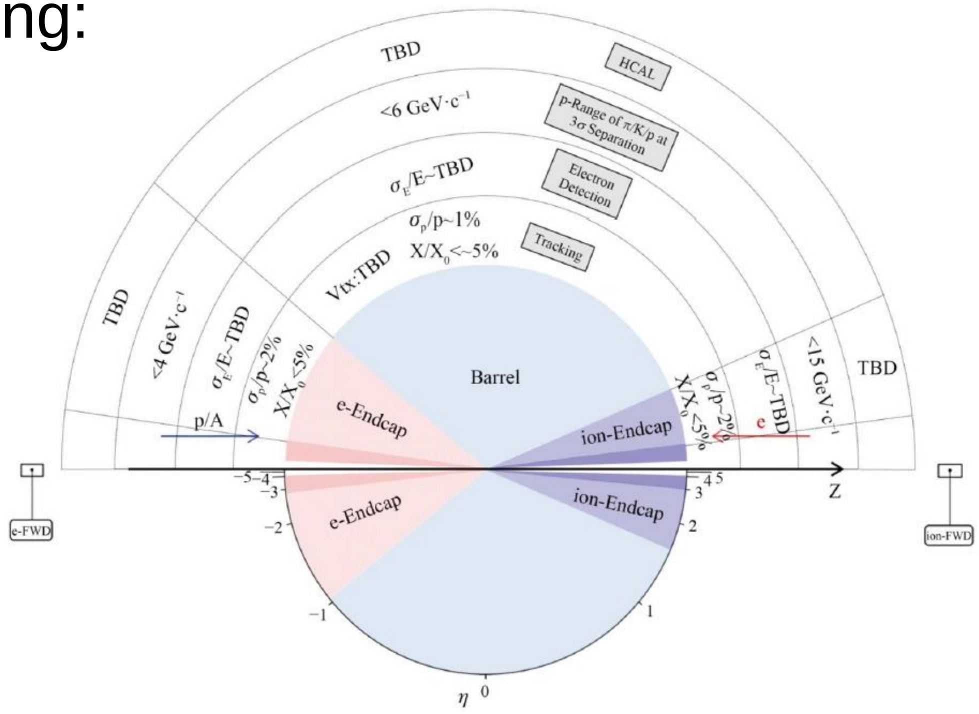
  - Targeted resolutions
  - Technology candidates
  - Simulation results
  - R&D activities or plan
  - Inputs to DAQ

1. Vertex and tracking detector

Yuming Ma, Aiqiang Guo, Yutie Liang, Yuxiang Zhao (IMP)

- Physics requirements for EicC tracking:

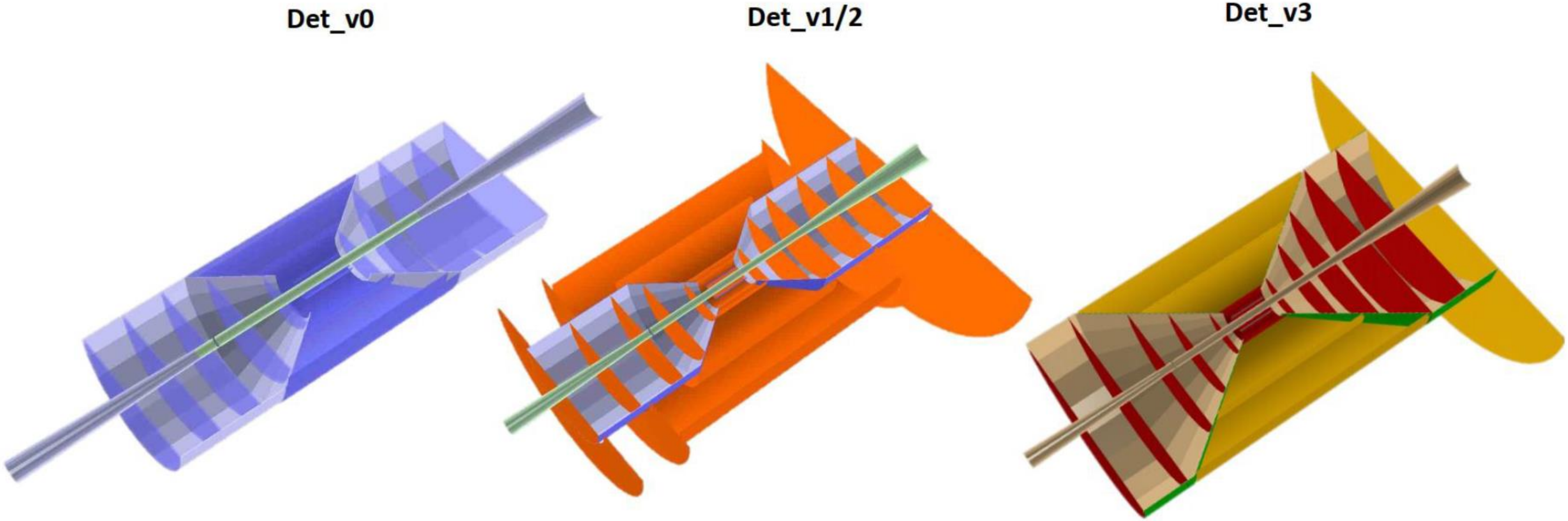
  - Assume B ~ 1.5 T
    - Barrel ($-1 < \eta < 1.6$):
      - σ(p)/p ~ 1% @ 1GeV; X/X0 <5%
    - E-endcap ($-3 < \eta < -1$):
      - σ(p)/p ~ 2% @ 1GeV; X/X0 <5%
    - P-endcap ($1.6 < \eta < 3$):
      - σ(p)/p ~ 2% @ 1GeV; X/X0 <5%



Front. Phys. 16(6), 64701 (2021)

Evolution of the EicC tracker design

-Yuming Ma



- All-silicon based on ITS2

- Silicon+MPGD Hybrid design
- Silicon: vertex ITS3 + tracker ITS2
- Only the pixel size is different for v1/v2

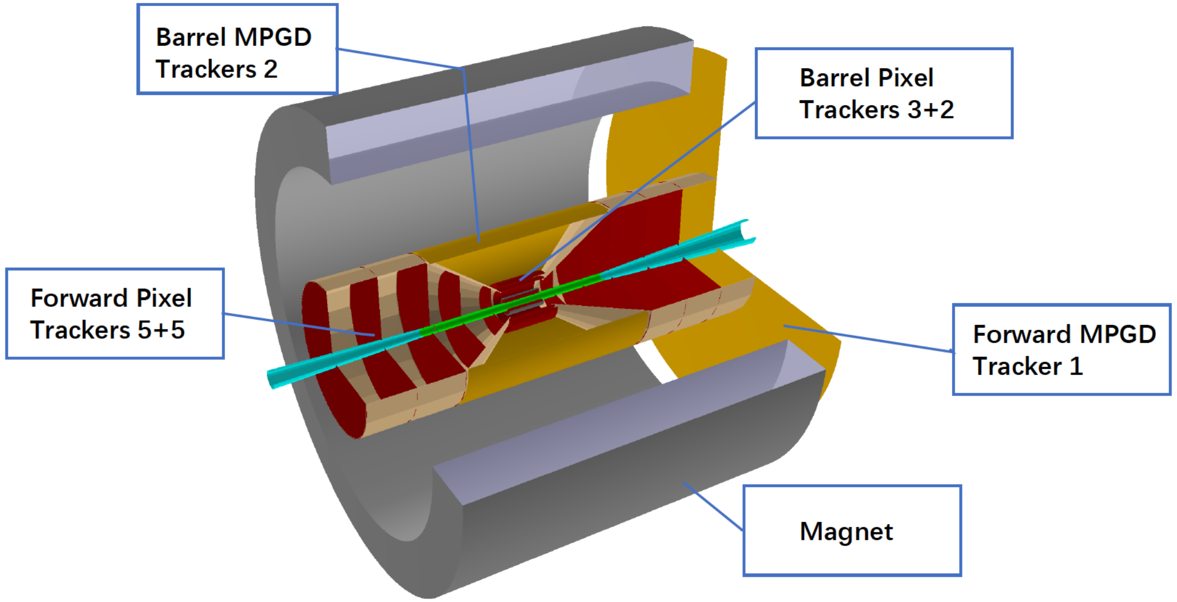
- Silicon+MPGD Hybrid design
- Silicon: ITS3
- Geometry is Optimized

✓ Further dedicated optimization of the scale and structure recently based on Det_v3

Performance with new tracking design

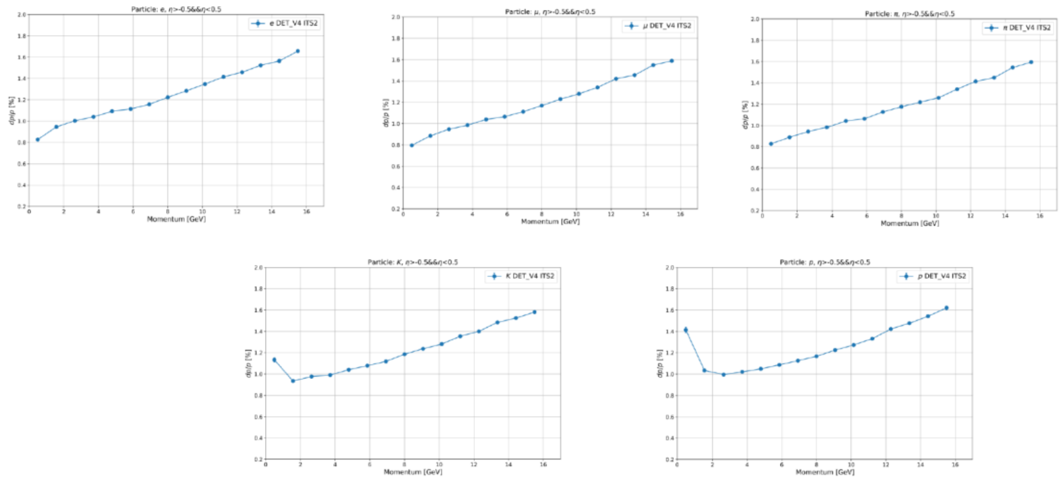
-Yuming Ma

The New Design

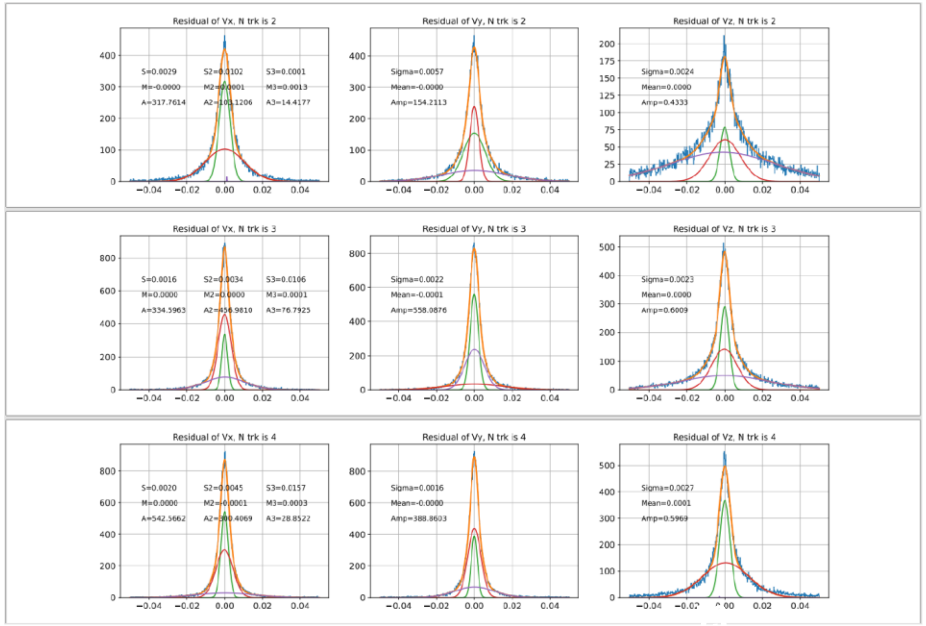


- Size of silicon detector: Solved.
  - Radius of Barrel: 77.56 cm -> 55 cm
  - Barrel MPGD : 4 Layers -> 2 Layers
  - The size of Si: ~70%
  - The size of MPDG: ~35%
- Only optimized by single track events: Solved.
  - Inclusive MC sample was applied
- The Layer number and radius (position) are not optimized properly
  - Optimized for lower momentum tracks based on EicC physical requirements.

Performance



Vertex resolution

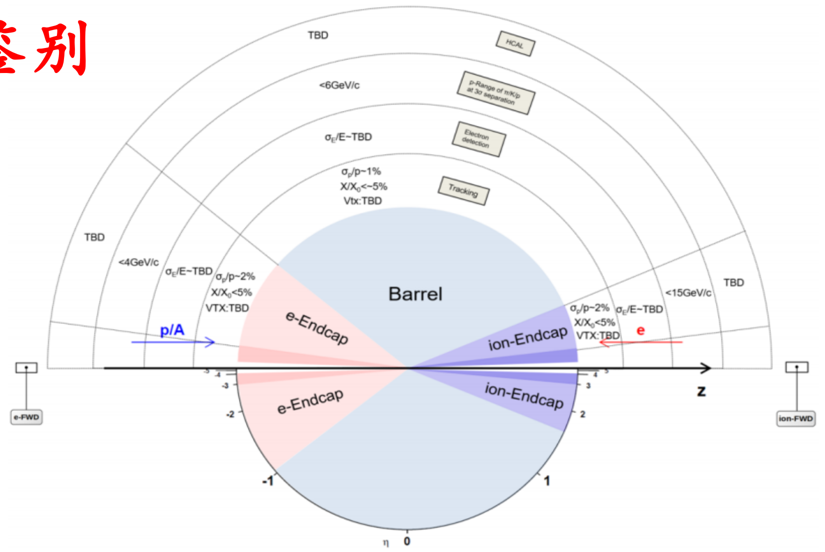


2. PID detectors

- Xin Li (IMP)

实现EicC实验中高亮度、大动量范围的带电粒子鉴别

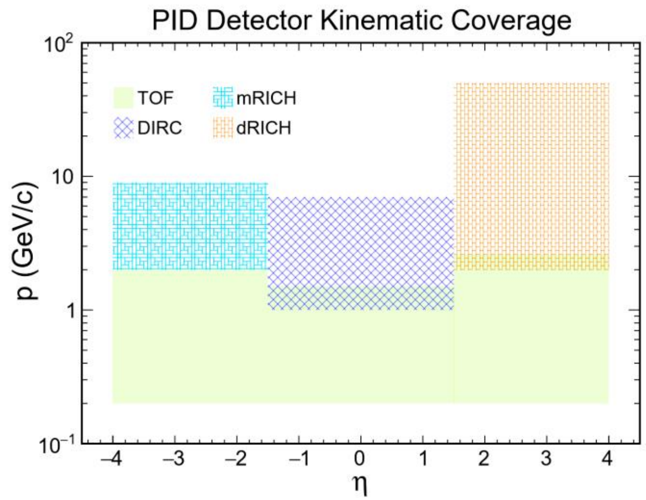
- ➢ 快速响应和超高分辨
- ➢ 结构紧凑，抗辐照



PID探测器方案：

- ➢ 桶部：内反射切仑科夫探测器（DIRC）
- ➢ 端盖：环形成像切仑科夫探测器（mRICH、dRICH）
- ➢ 低动量（<1GeV/c)：MPRC、LGAD

PID momentum coverage:
<4 GeV/c at e-Endcap;
<15 GeV/c at ion-Endcap ;
<6 GeV/c at Barrel



不同粒子鉴别探测器覆盖动量范围

端盖PID探测器

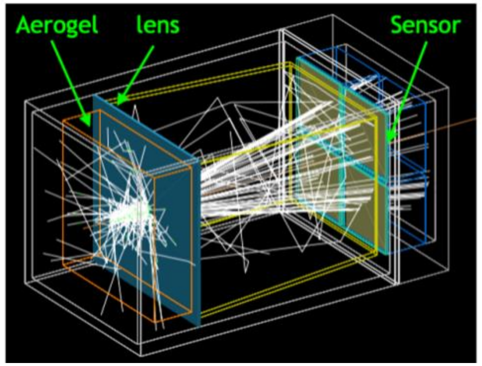
- Xin Li (IMP)

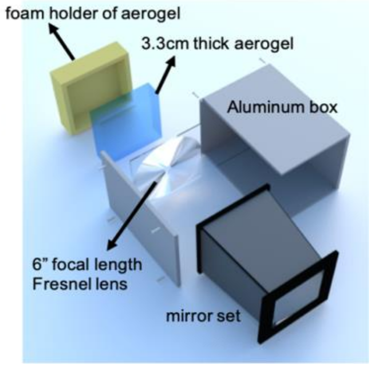
Modular RICH是一种基于气凝胶的切仑科夫探测器。它利用菲涅耳透镜产生聚焦作用以提高粒子分辨能力（菲涅耳透镜聚焦对透射光波长范围具有限制作用，可减小瑞利散射效应）。其结构紧凑灵活，可以在末端安装高精度PMT测量飞行时间信息，进而提高其PID能力。

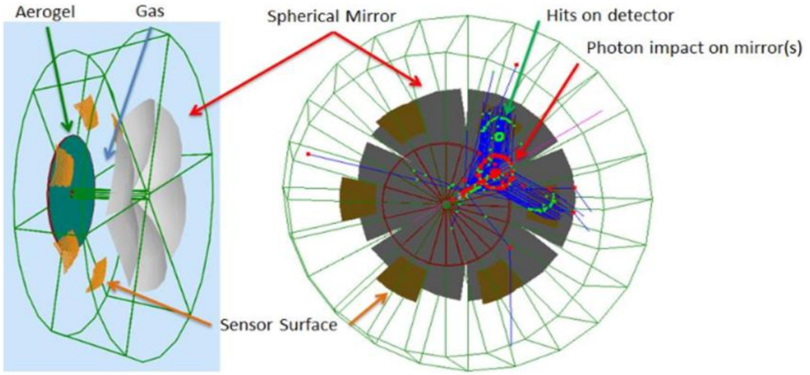
Dual RICH则包含两种不同折射率的辐射体，因此能够覆盖更大动量范围。由于气凝硅胶辐射体可覆盖低动量区，在中等动量区与气体辐射体覆盖范围重叠，因此dRICH测量范围不存在中间“空白区”。

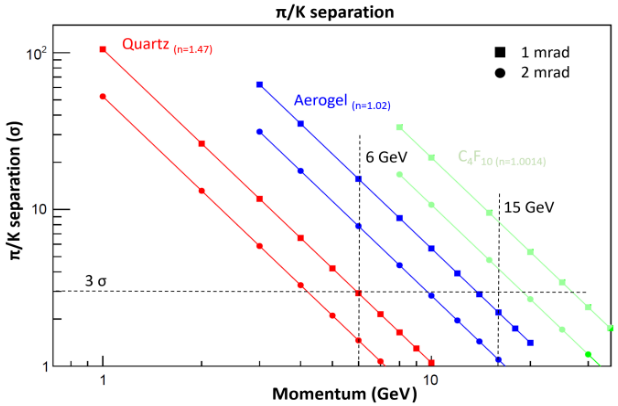
预期目标：

- Modular RICH实现3σ π/K分辨范围 ~6 GeV/c（径迹角分辨~1mrad）
- 采用气凝胶+气体辐射体（C_2F_6）dRICH探测器，预期可达15GeV/c的3σ π/K分辨。
- 目前方案调研中









桶部PID探测器

- Xin Li (IMP)

内反射切仑科夫探测器（DIRC）：

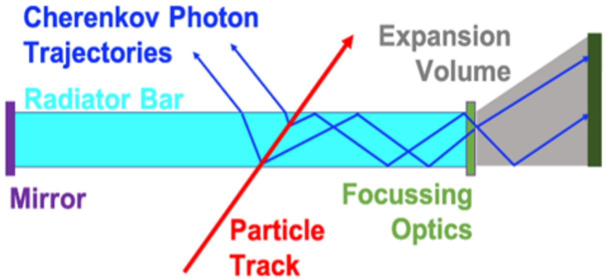
不同带电粒子激发的切仑科夫辐射角不同，基于这一原理的DIRC探测器通过测量不同粒子激发切仑科夫光的传输时间和出射角度不同进行粒子鉴别。

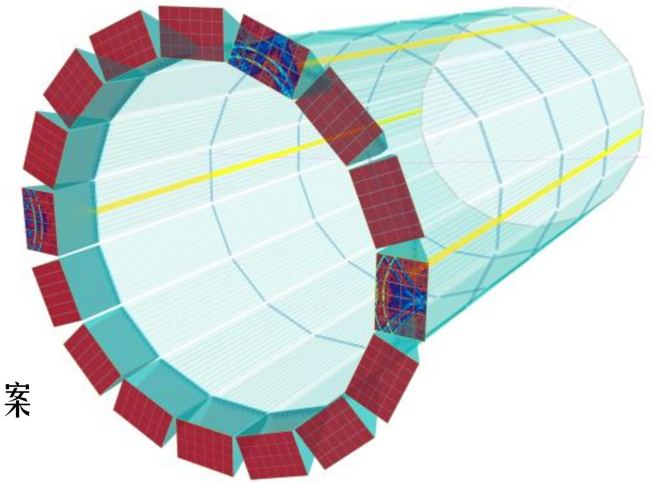
预期目标：

- 采用熔融石英作为切仑科夫辐射体，MPC-PMT作为光电探测阵列，作为紧凑型桶部探测器实现高动量（1~6GeV/c）的粒子鉴别
- 为此需要~1mrad的角分辨，以及皮秒量级的时间分辨（<100ps)
- 多通道皮秒定时电子学的配套研发

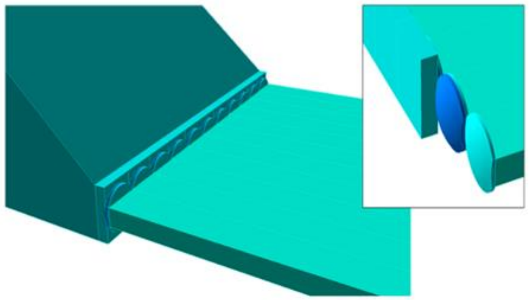
研究进度：

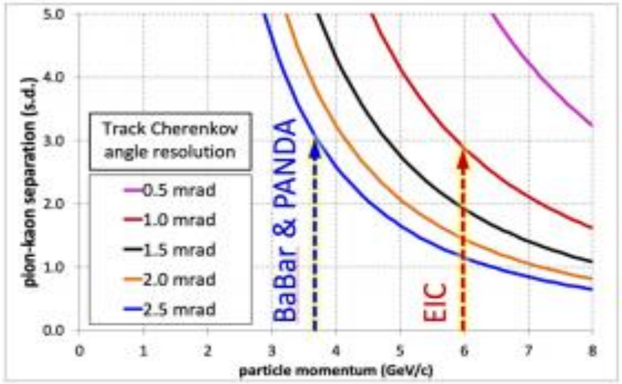
参考PANDA和EIC的桶部DIRC探测器设计，模拟完成DIRC初步方案，小尺寸DIRC原型制作中





桶部DIRC方案

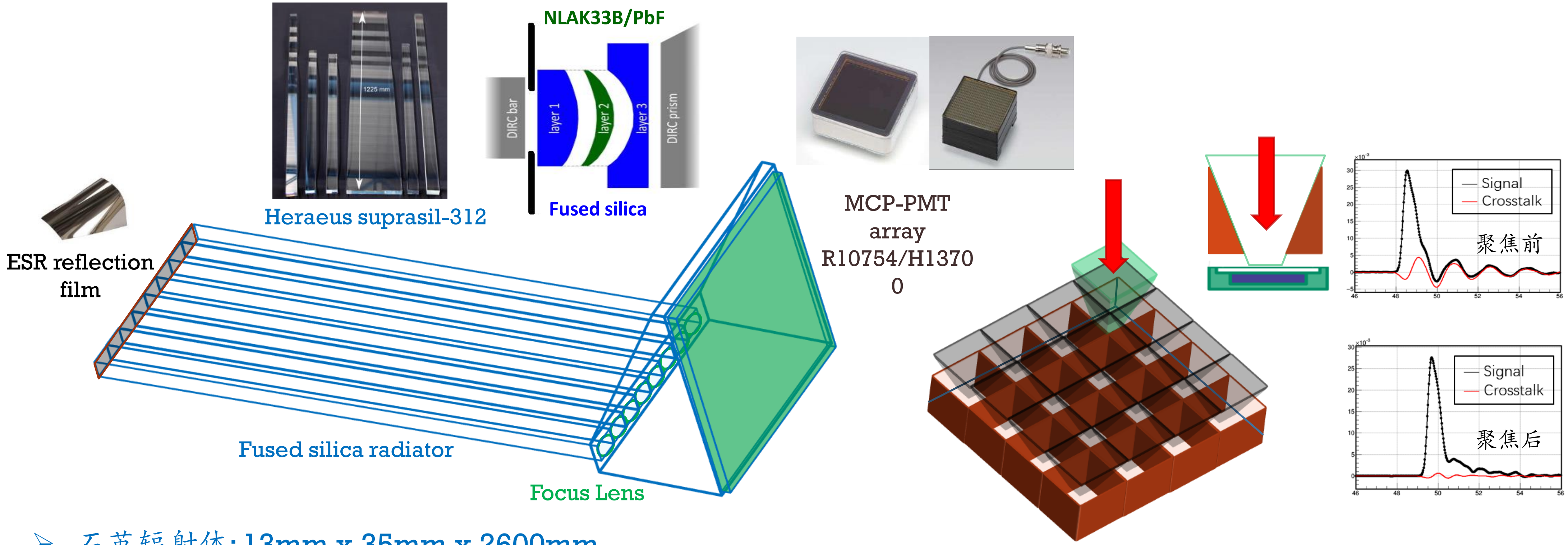




PANDA和EIC的DIRC粒子鉴别范围

桶部DIRC方案

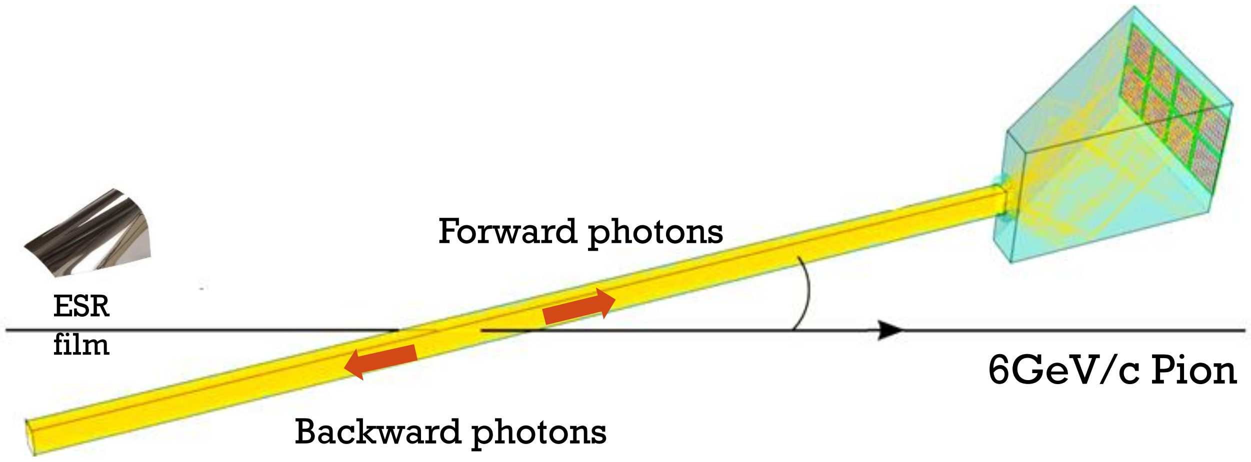
- Xin Li (IMP)

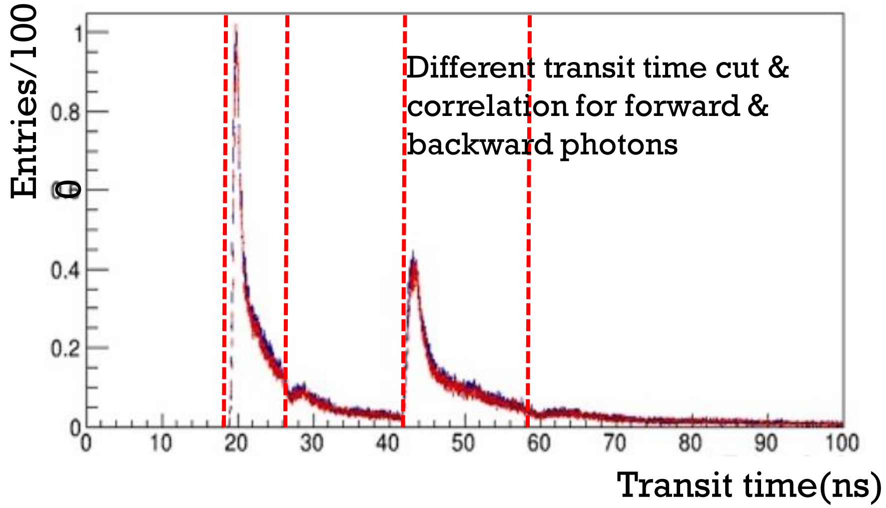


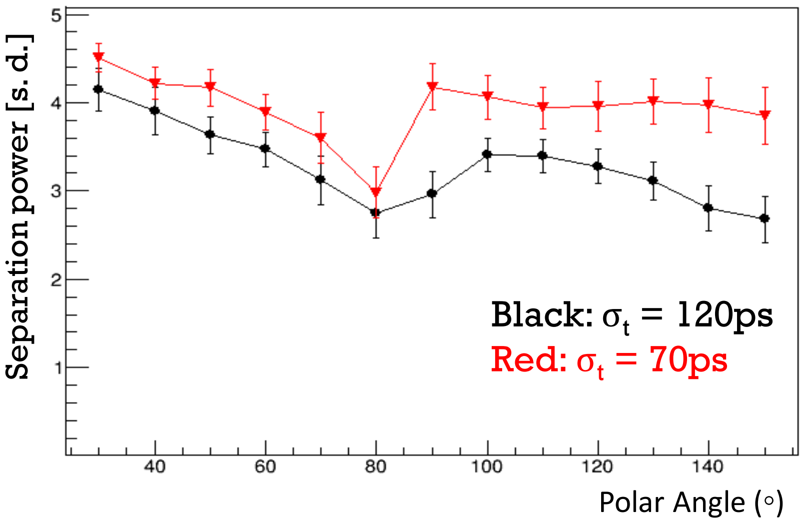
- 石英辐射体: 13mm x 35mm x 2600mm
- 梯形光导: (30mm+220mm) x 320mm x 300mm
- MCP-PMT: 滨松 R10754 (5.75mm, 4x4 Pixel) / H13700 (3mm, 16x16 Pixel)
- 聚焦透镜: 3-layer lens (fused silica + NLAK33B glass) curvature radius: 30◦, 30/7.5cm, 厚度1cm
- 微型光导：漏斗形光导(厚度2~3mm)连接梯形光导和单个PMT像素单元，消除PMT边框死区和减小串扰影响

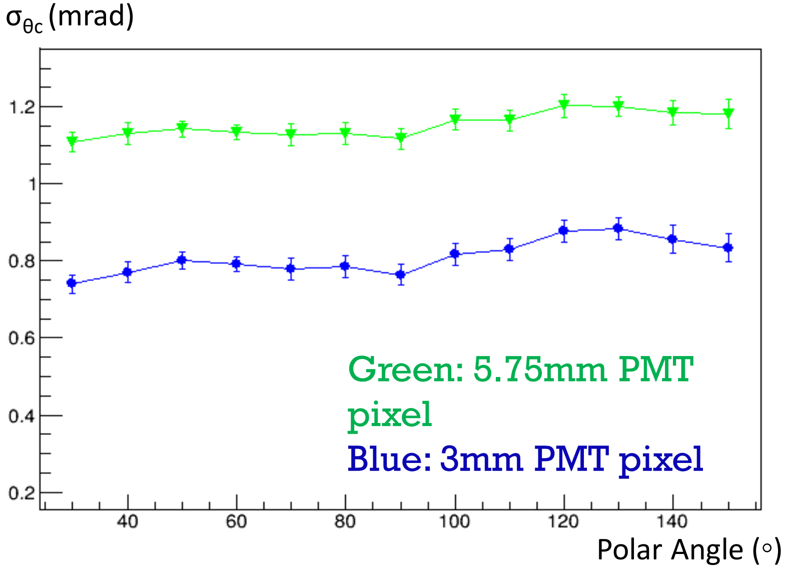
单块DIRC角分辨和PID性能模拟

- Xin Li (IMP)





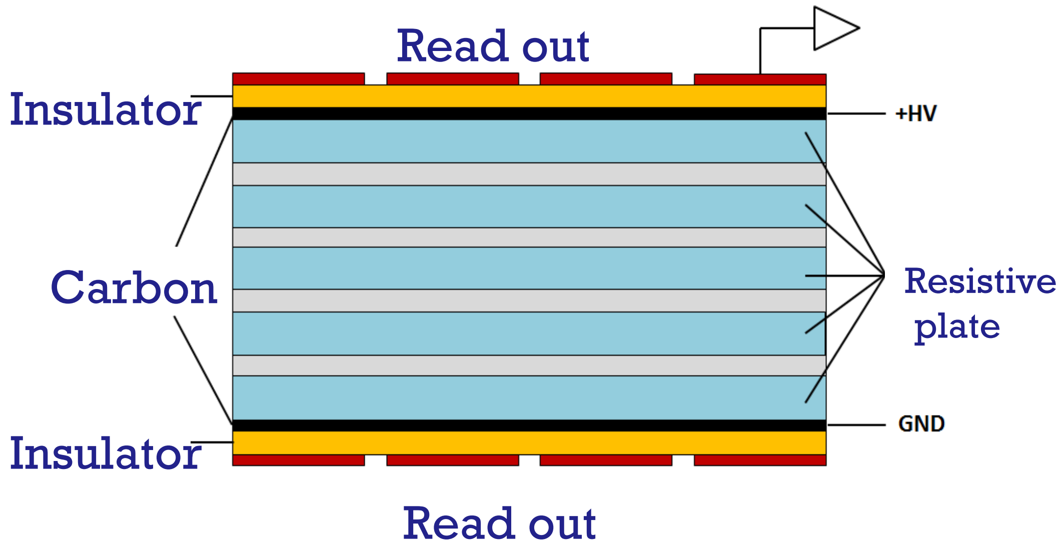




- 前后向出射光子分开进行传输时间甄别和切仑科夫辐射角重建
- 不同位置分辨PMT（R10754/13370）对应的DIRC角分辨(~1mrad)；角分辨~1mrad时，不同时间分辨对应的6GeV/c π/k分辨能力随粒子入射角的变化(>3σ)。

MRPC/TOF PID at low momentum

- Yi Wang (Tsinghua)



MRPC structure

Standard parameters:

Resistivity of glass: ~10^{12} Ω.cm

Working gas: 90%Freon+5%iso-butane+5% SF6

Time resolution <100ps

Efficiency >95%

Charge: a few PC

Dark current: a few nA

Noise ~1Hz/cm^2

Rate <100 Hz/cm^2

Large area, low cost

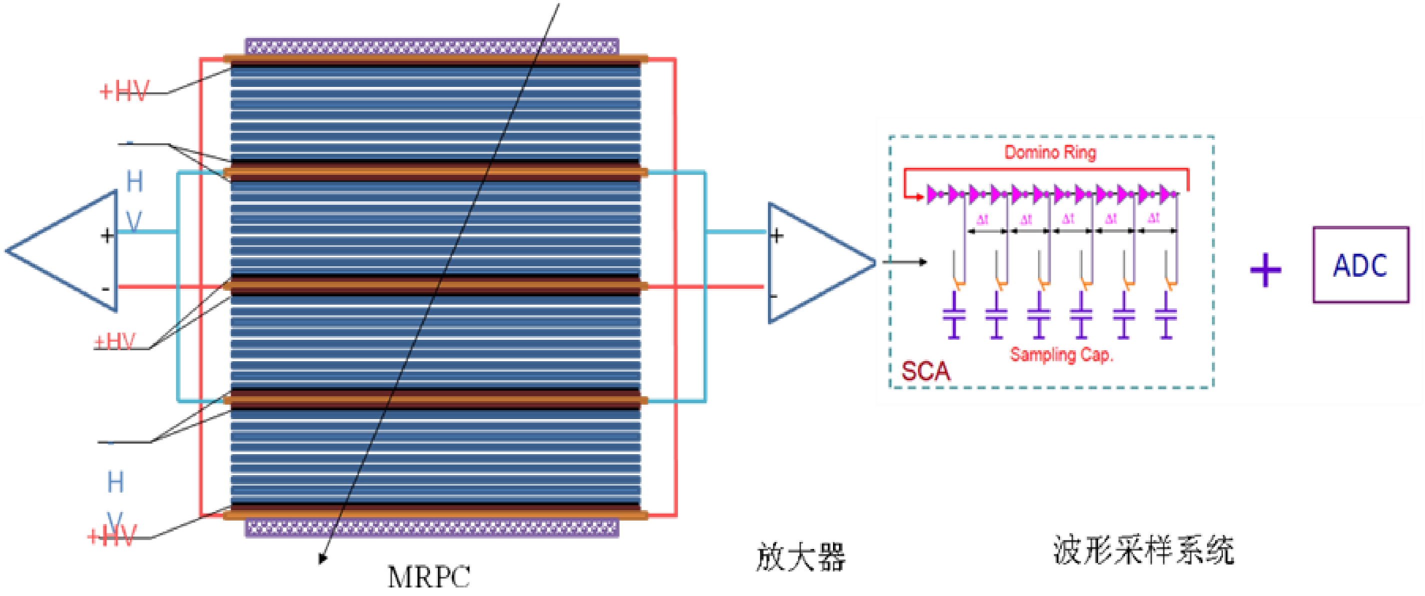
TOF PID:

π /k ~1.6 GeV/c,

(π,k)/p ~ 3.0 GeV/c

Toward 20ps resolution: narrow gap MRPC

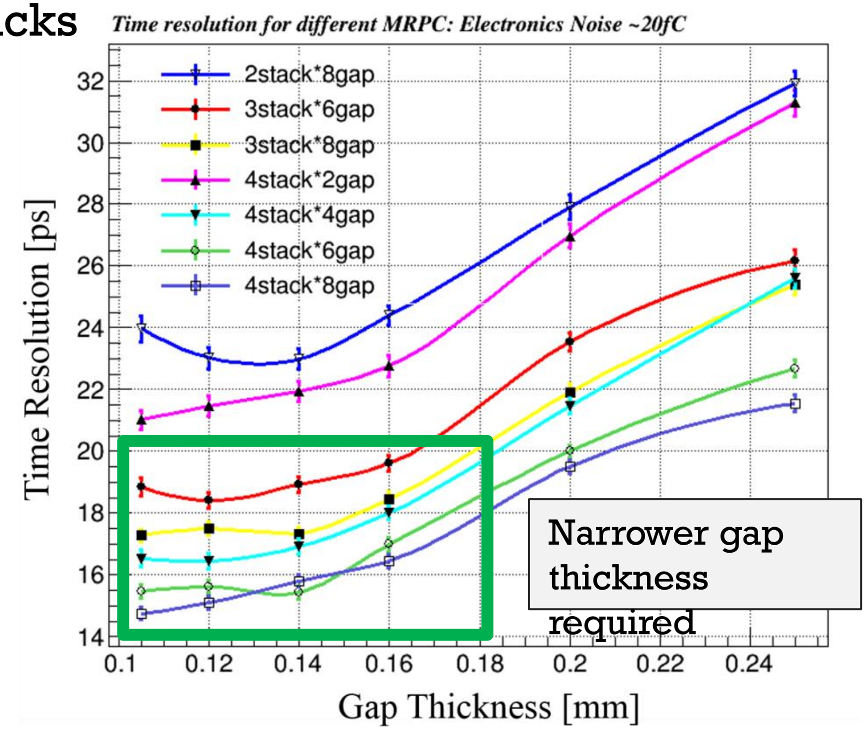
- Yi Wang (Tsinghua)



$$\sigma_{TOF} = \sqrt{\sigma_{MRPC} + \sigma_{electronics}}$$

σ_{TOF} <20 ps， the intrinsic resolution of narrow gaps MRPC is around 15ps， so the time jitter of readout electronics <13~15 ps。

- Simulation indicates proper ways to design the gap thickness and arrange the stacks



σ_{MRPC} <20 ps， the gas gap: <0.18mm

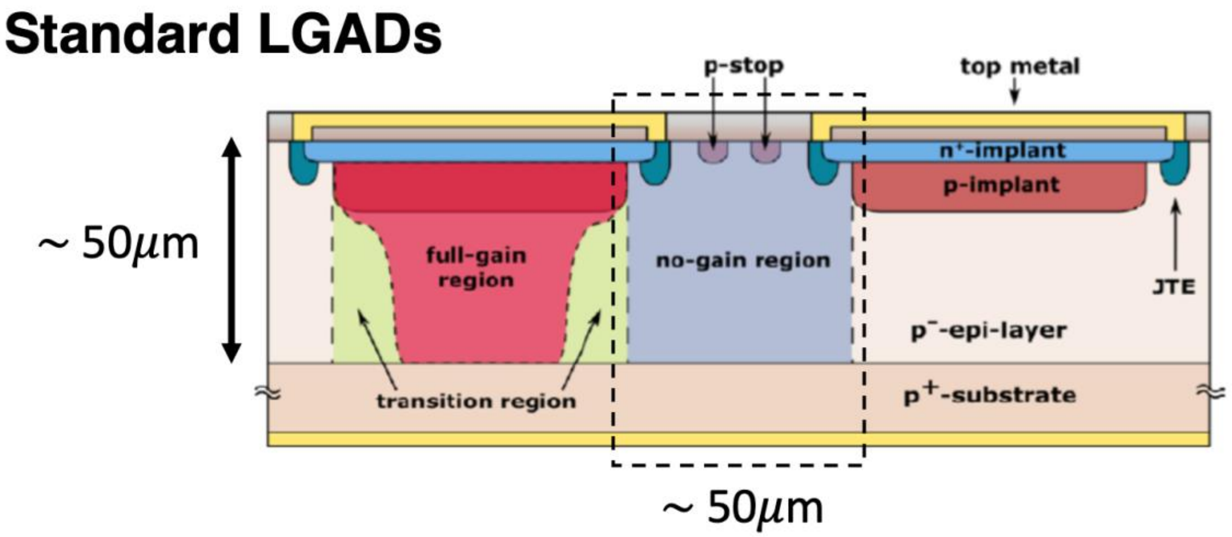
gap number: >16

LGAD Reference

低增益雪崩探测器(LGAD)： 一种超快响应硅探测器。通过半导体中局部雪崩放大产生具有快速上升沿的信号脉冲，进行高时间分辨的粒子鉴别。相比MRPC，它的结构更紧凑，测量飞行时间之外还可提供高分辨粒子径迹位置信息。

预期目标：

- 实现低动量（0.1~2GeV/c)的带电粒子鉴别
- 皮秒量级的高时间分辨（~30ps）。
- LGAD的像素探测单元尺寸可达几十um，提供高精度粒子径迹重建信息。



- CMS Endcap Timing Layer
  - Size: 1.3×1.3 mm^2
    - Sensor and chip are bundled together
  - Timing resolution: ~30-50 ps
    - Last for the whole HL runs
  - Radiation-hard: ~2×10^{15} n_{eq}/cm^2
  - Thickness: 2.25cm/layer

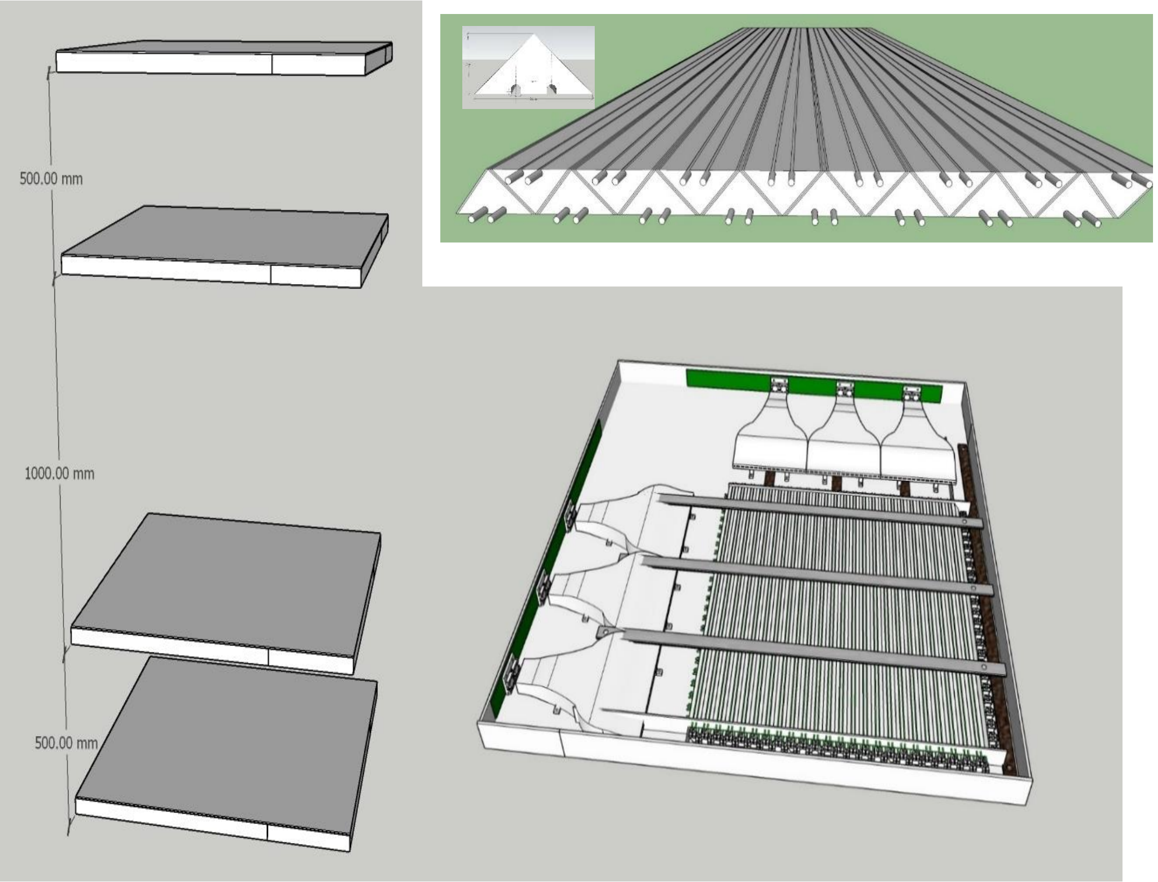
- **EicC Barrel**

Radius ~80cm (try to achieve 50cm)

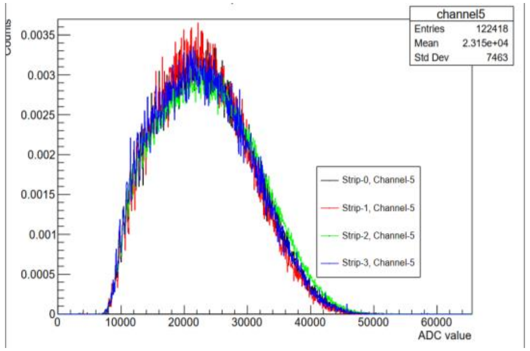
Time resolution ~20ps

[arXiv: 2003.04838]

Cosmic Ray Platform



*Cooperation with the EicC USTC group



不同批次闪烁体的发光效率

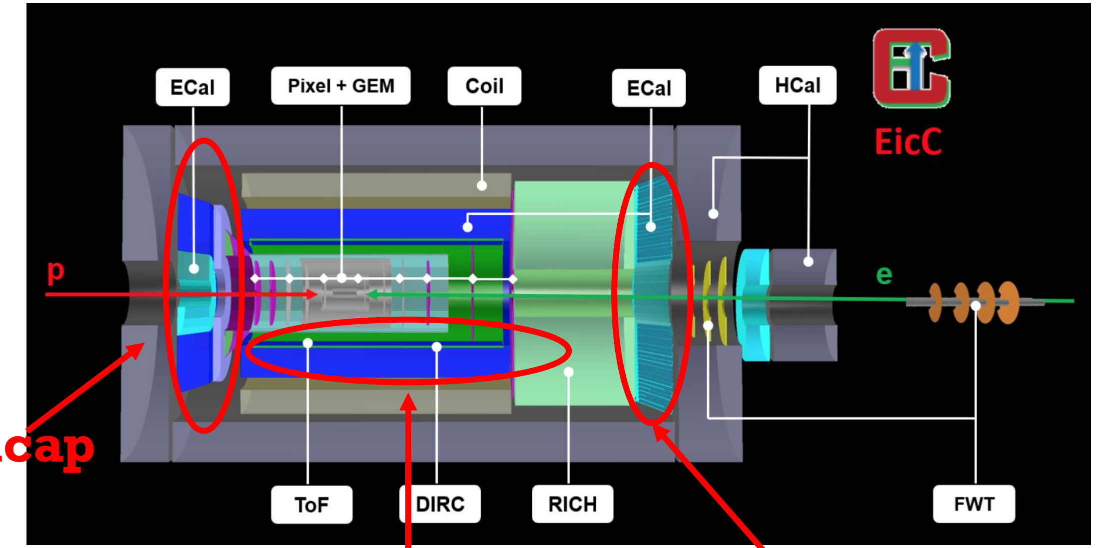
- **宇宙线测试平台：闪烁体 + SiPM, 8 layer (4 layer for x, y each), 探测面积 50cm x 50cm**
- **One layer：3 module + 1 electronics**
- **One module：16块EJ-200 + 32根光纤 + 8 SiPM**
- **位置分辨~1mm, 时间分辨<100ps**

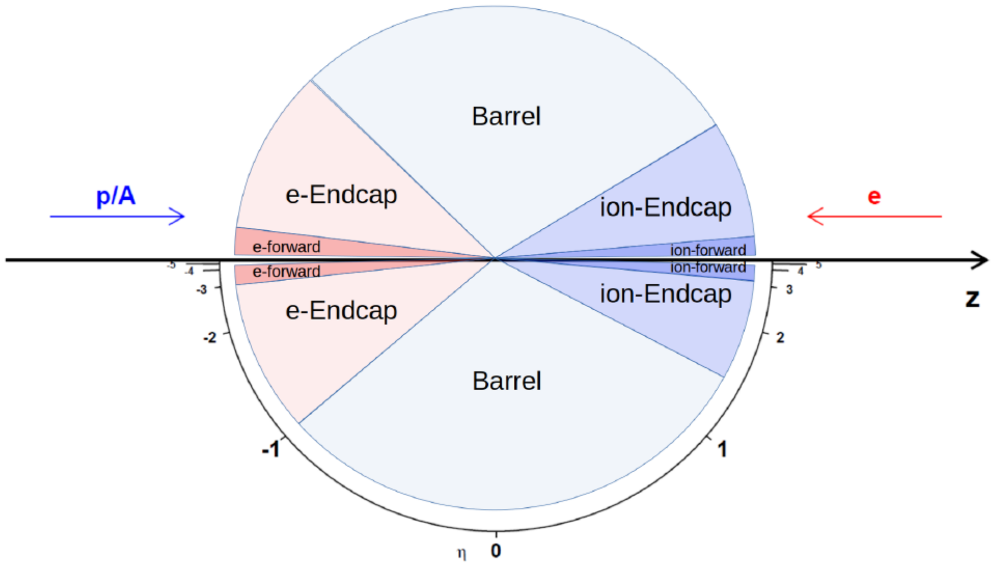
3. Calorimeter system for EicC

Ye Tian, Dexu Lin/ (IMP)

Basical ECal special requirement:

- **E-endcap:** good low energy resolution
- **Barrel:** short radius, good angle resolution
- **Ion-endcap:** angle resolution, π^0 reconstruction, PID.



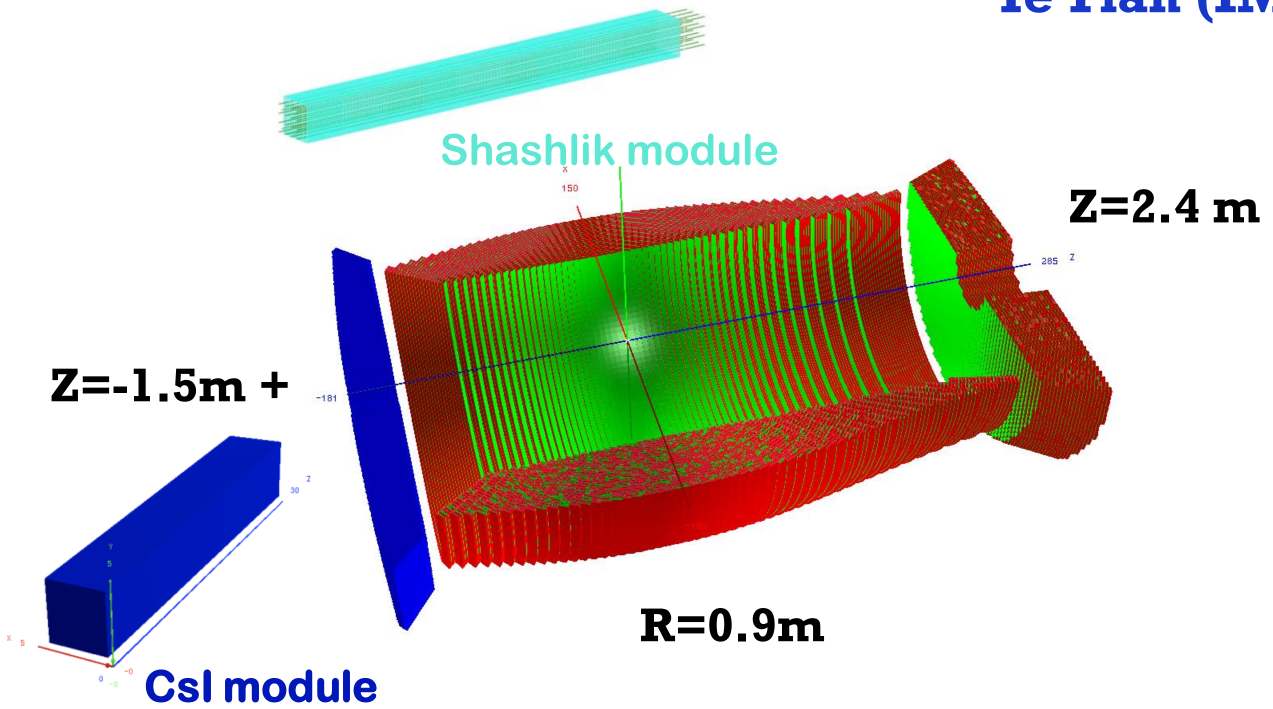


Detector	Pseudorapidity	Angle(degree)
Ion-Endcap	3	5.7
	1.5	25.2
Barrel		
	-1	139.6
e-Endcap		
	-3	174.3

Ye Tian (IMP)

Ecal Design in Simulation

- General design of whole Ecal Detector.
- CsI is applied in e-endcap, Shashlik style is applied in both barrel and ion-endcap
- **The actual distances** of the two endcaps to IP depend on the available space of the EicC design



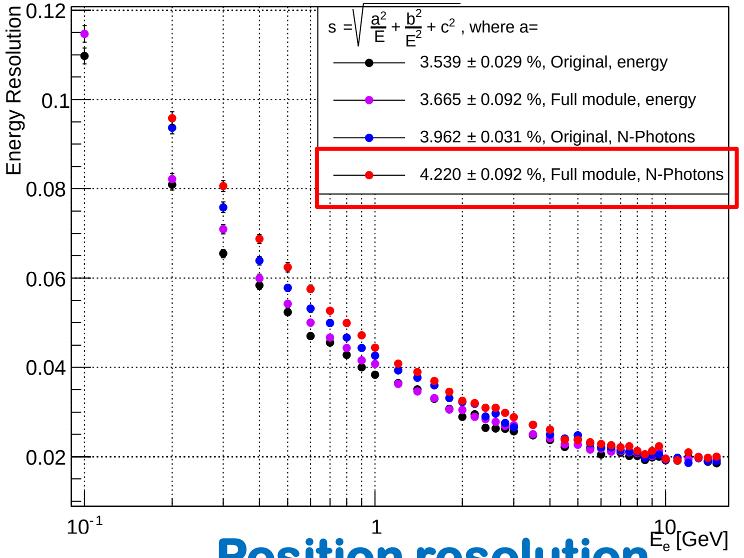
	EMC	type	z/r[m]	Length[cm], X_0	Coverage[cm]	pseudorapidity	Tower size
EicC	e-endcap	**CsI**	**Z=-1.5**	30, $16X_0$	15.0<r<128	(-3.0, -1.0)	4.0*4.0(front)
	barrel	**Shashlik**	**R=0.9**	45, $16X_0$	-105.8<z<187.5	(-1.0, 1.5)	4.0*4.0 (front)
	Ion-endcap	**Shashlik**	**Z=2.4**	45, $16X_0$	24.0<r<113	(1.5, 3.0)	

Module (7x7) array simulation result

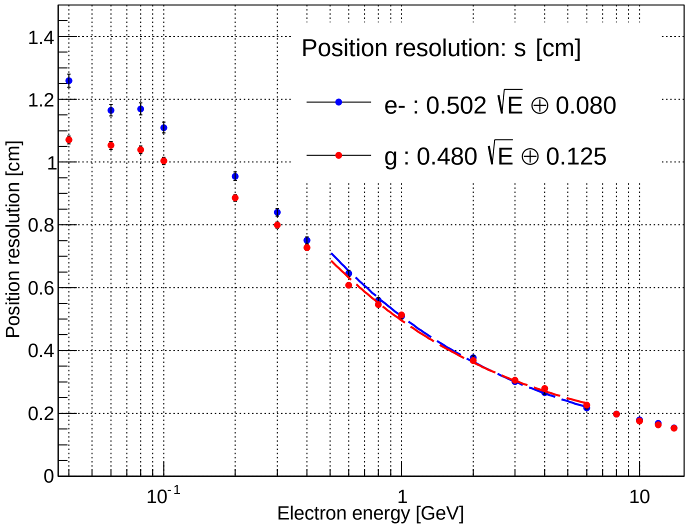
Ye Tian (IMP)

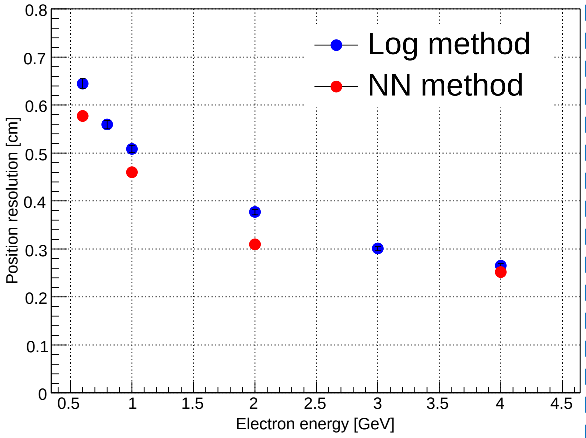
Shashlik simulation result

Energy resolution



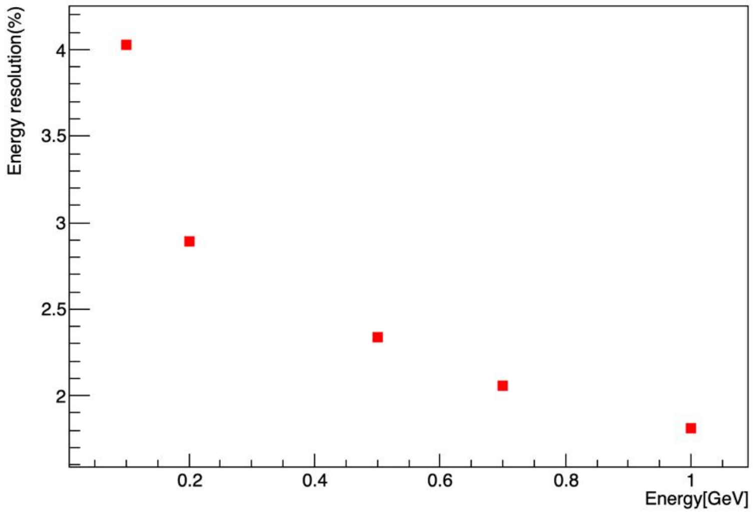
Position resolution



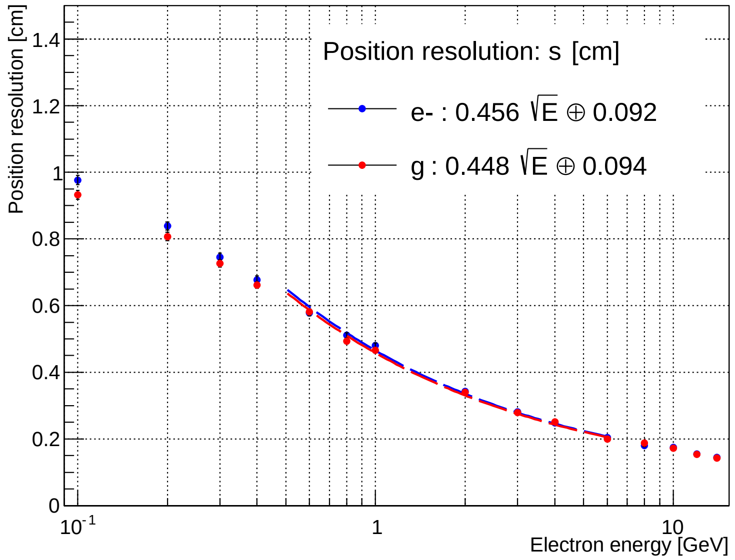


CsI simulation result

Energy resolution



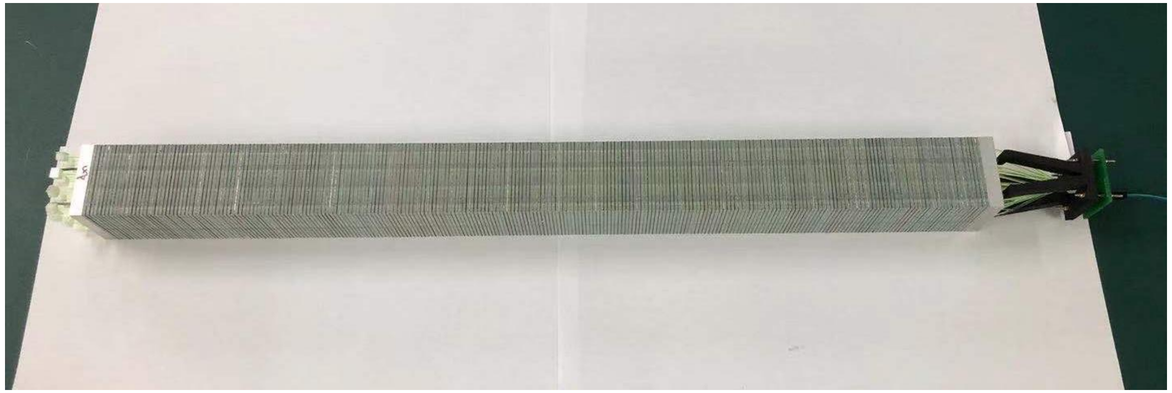
Position resolution



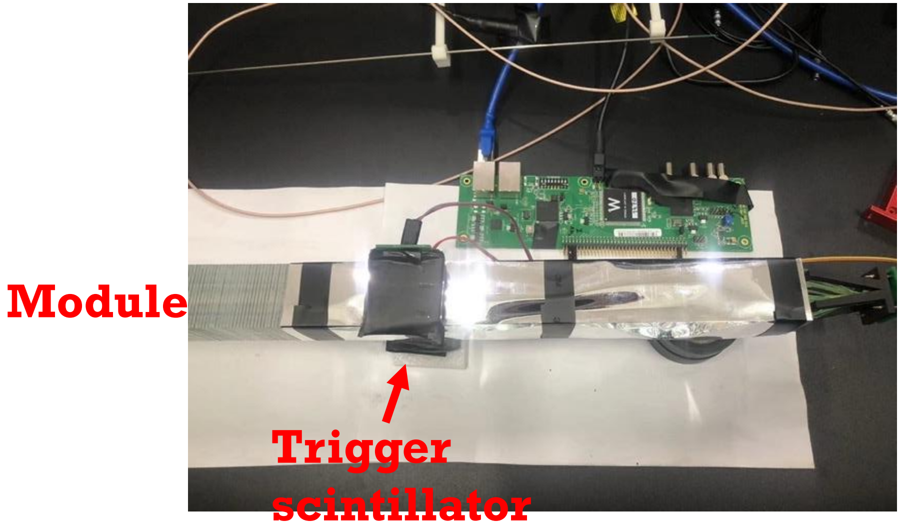
Shashlik ECal cosmic ray test result

Ye Tian (IMP)

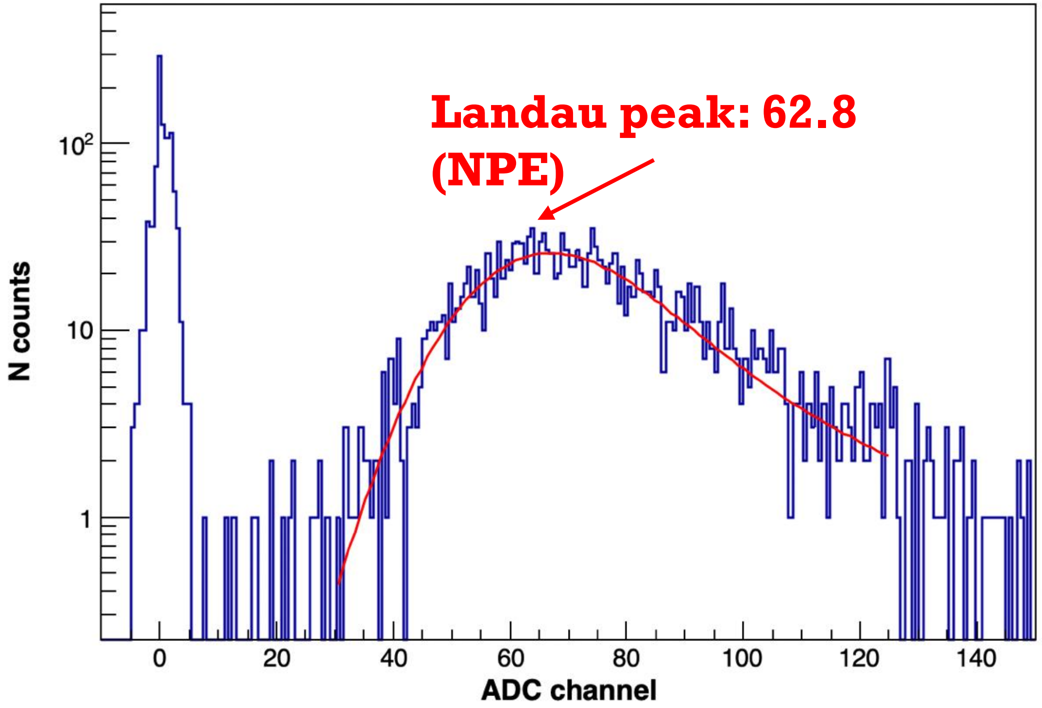
Assembled Shashlik module



Horizontal test setup



Horizontal cosmic ray NPE spectrum (PMT)

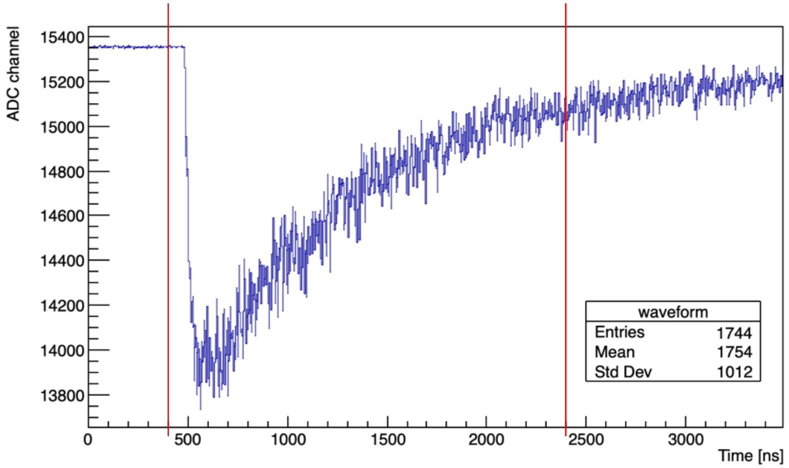


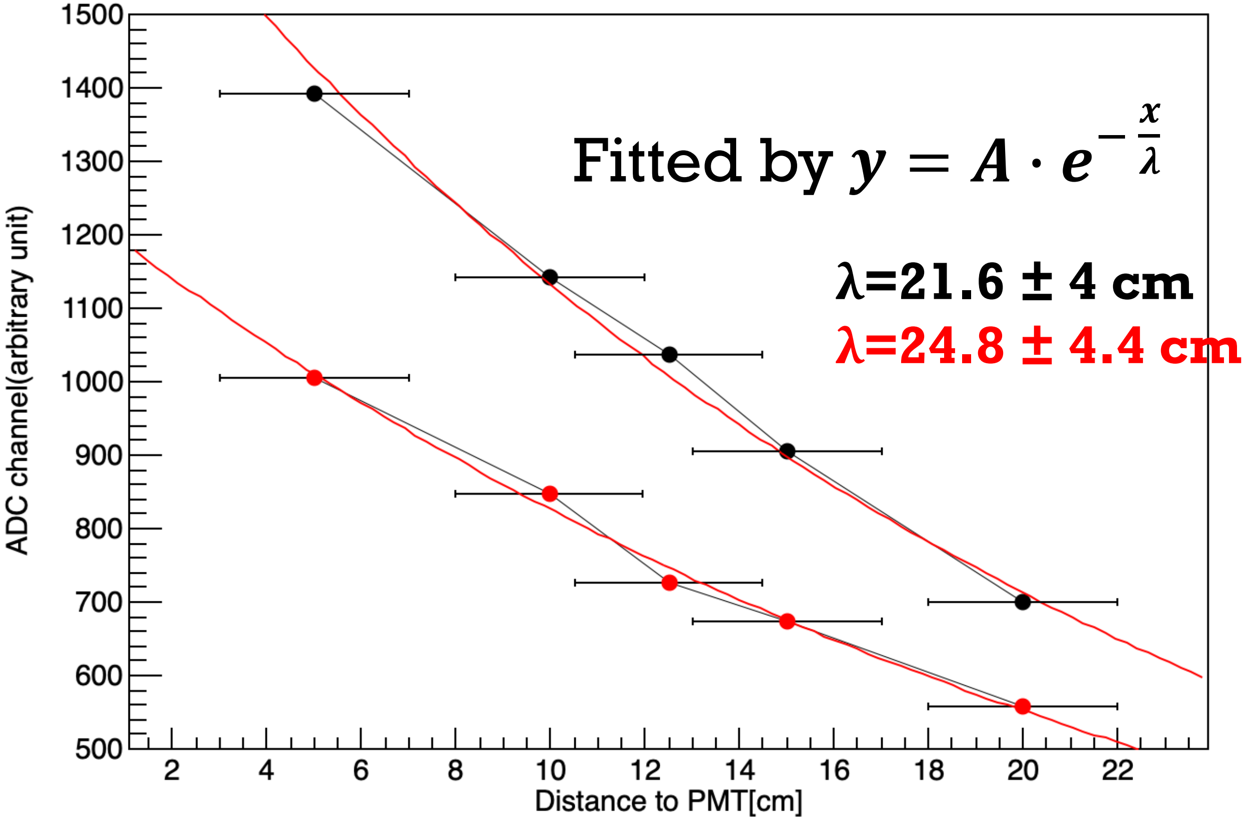
CsI(Tl) attenuation cosmic ray test

Ye Tian (IMP)

- The attenuation length is a main parameter of CsI(Tl), influence the uniformity of energy deposit
- Simulation shows muon deposit 22.3 MeV in CsI, created 1.1M photons.

Cosmic ray signal sample



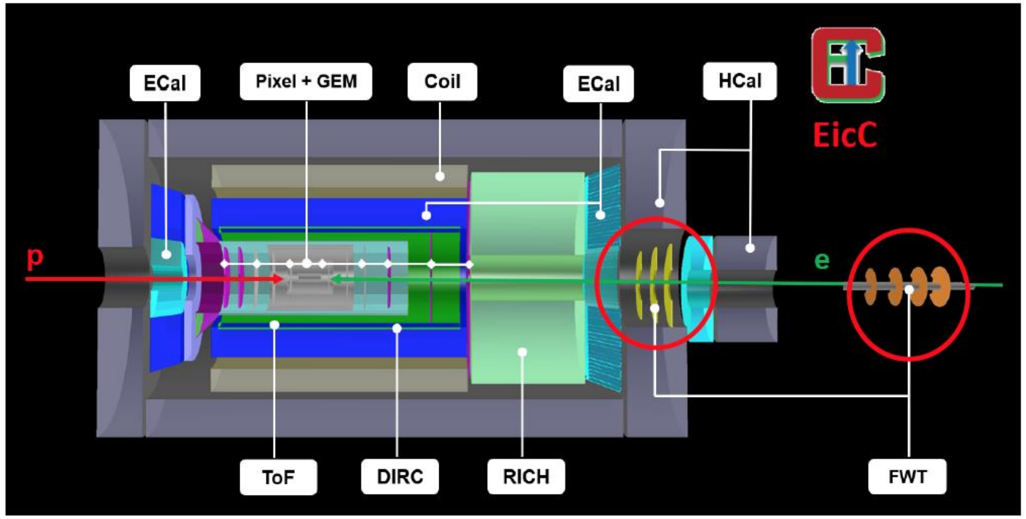


Short attenuation length confirmed, even though the appearance of crystal is transparent!

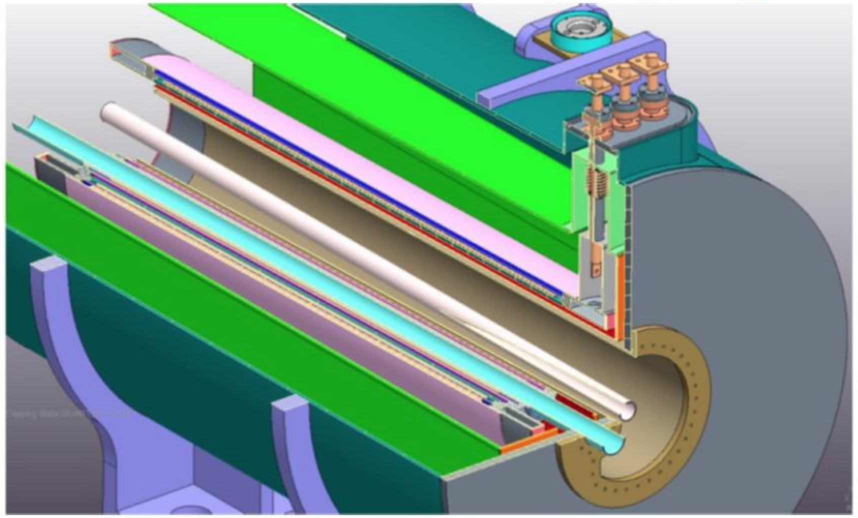
4. Far Forward Detectors

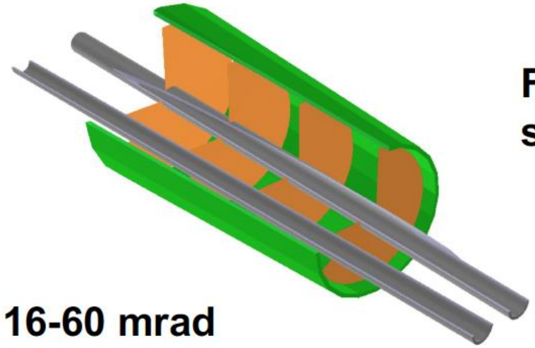
Weizhi Xiong(SDU), Yutie Liang (IMP)

EicC Far Forward Detectors

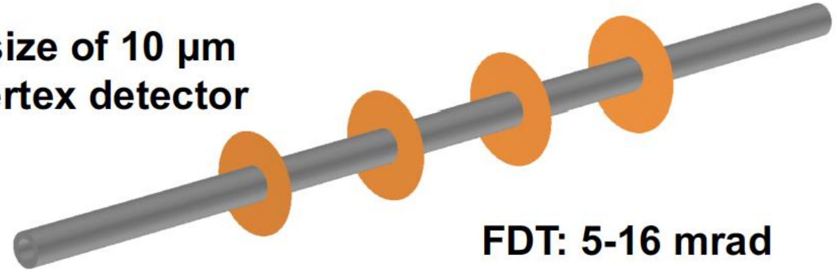


B0pf magnet





Four disks with pixel size of 10 μm same as the central vertex detector



EDT: 16-60 mrad

EDT (Endcap Dipole Tracking)

FDT: 5-16 mrad

FDT (Forward Dipole Tracking)

New Design of FF Beamline

Dipole 1: z = 5 m B = 2.52 T L = 0.8 m

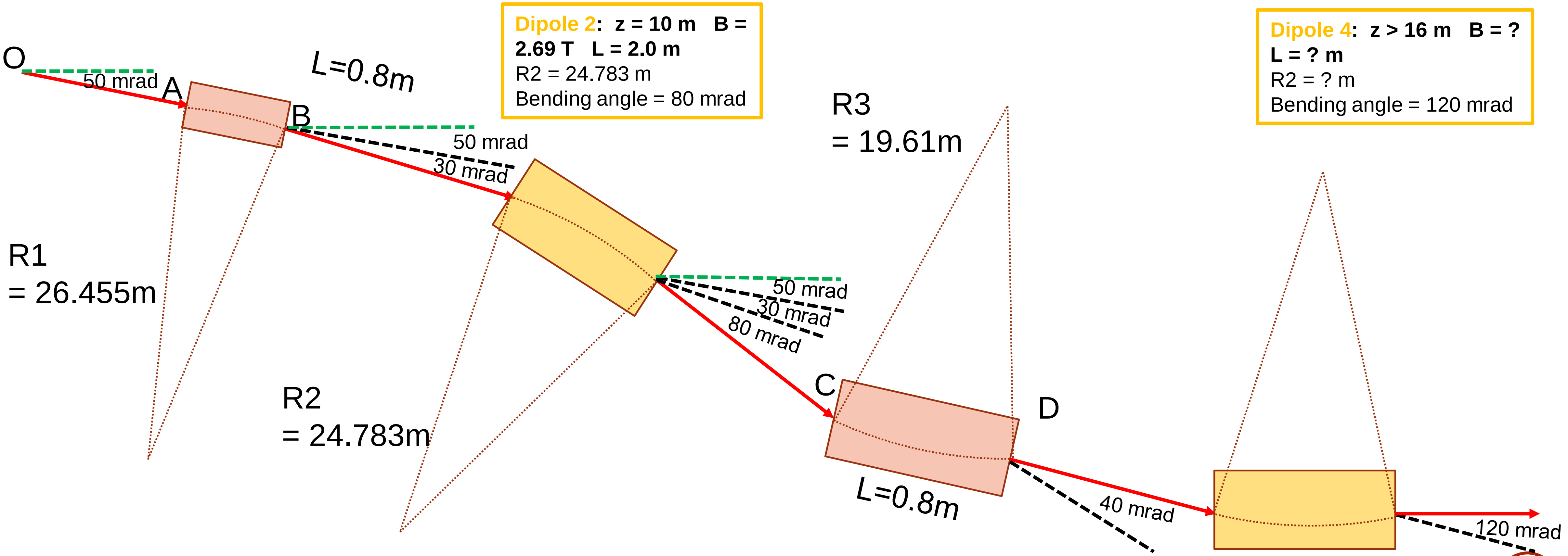
R1 = p*10/3./B1 = 20GeV*10/3./2.52 = 26.455 m

Bending angle = asin(L/R) = 0.03 rad = 30 mrad

Dipole 3: z = 15.4 m B = -3.4 T L = 0.8 m

R2 = p*10/3./B2 = 20GeV*10/3./2.69 = 19.61 m

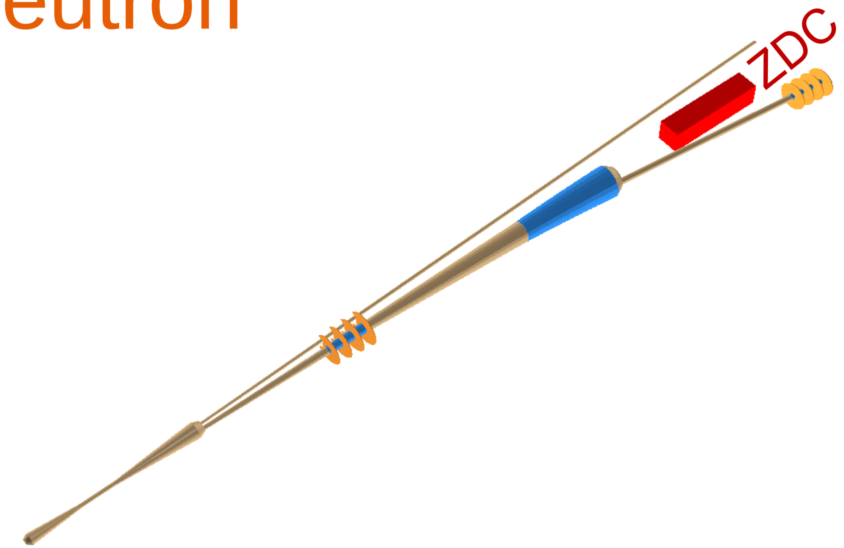
Bending angle = asin(L/R) ~ 0.04 rad = 40 mrad



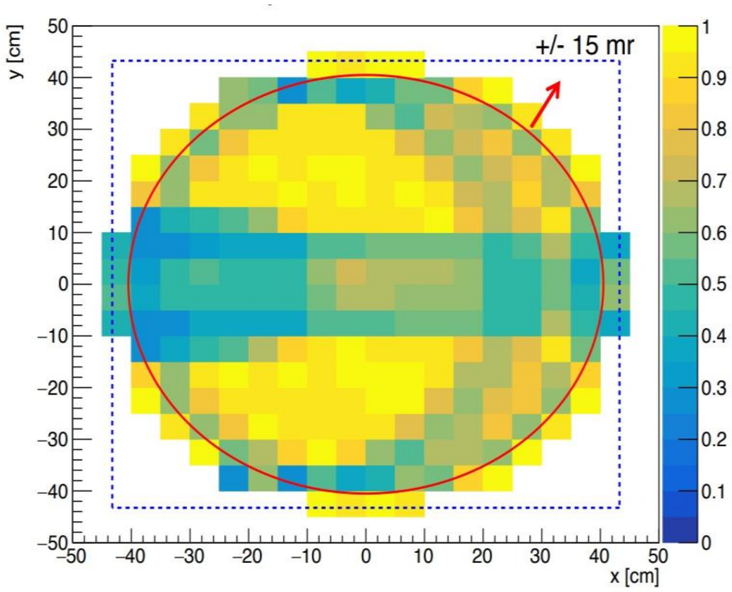
Slides from Yutie

Weizhi Xiong(SDU)

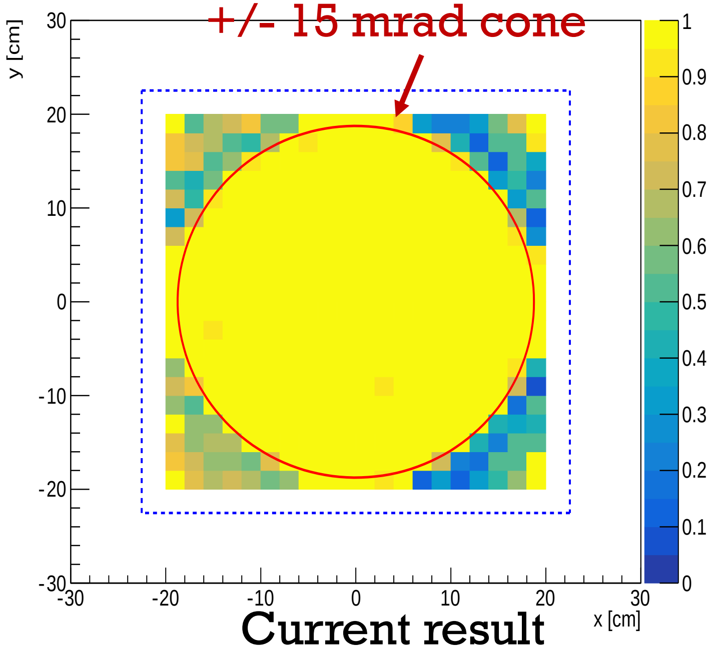
Material Effect for Neutron



- Current ZDC acceptance +/- 15 mrad, 13.5m from IP
- New beamline design effectively reduce all material effect due to beam pipe and air
- Plan to work on ZDC digitization and full detector response studies



Result shown in EicC 3rd CDR



Current result

5. Beam polarimetry & luminosity monitor

Boxing Gou (IMP), Jinlong Zhang(SDU), Yutie Liang (IMP)

- Proton beam polarimetry
- Electron beam polarimetry
- Luminosity measurement

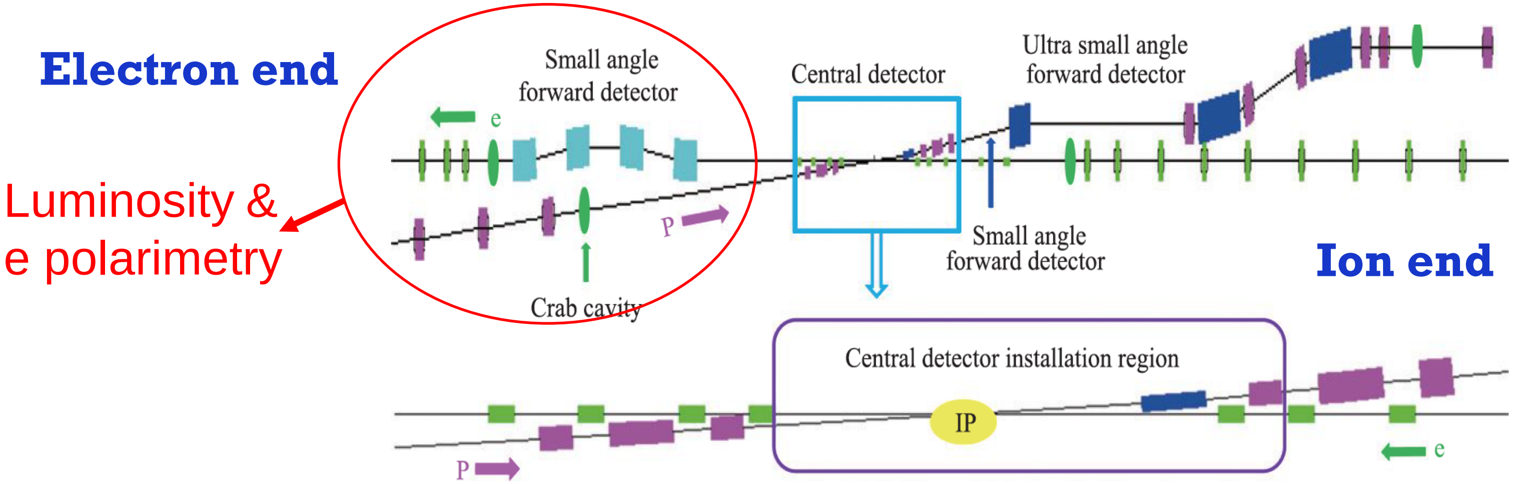
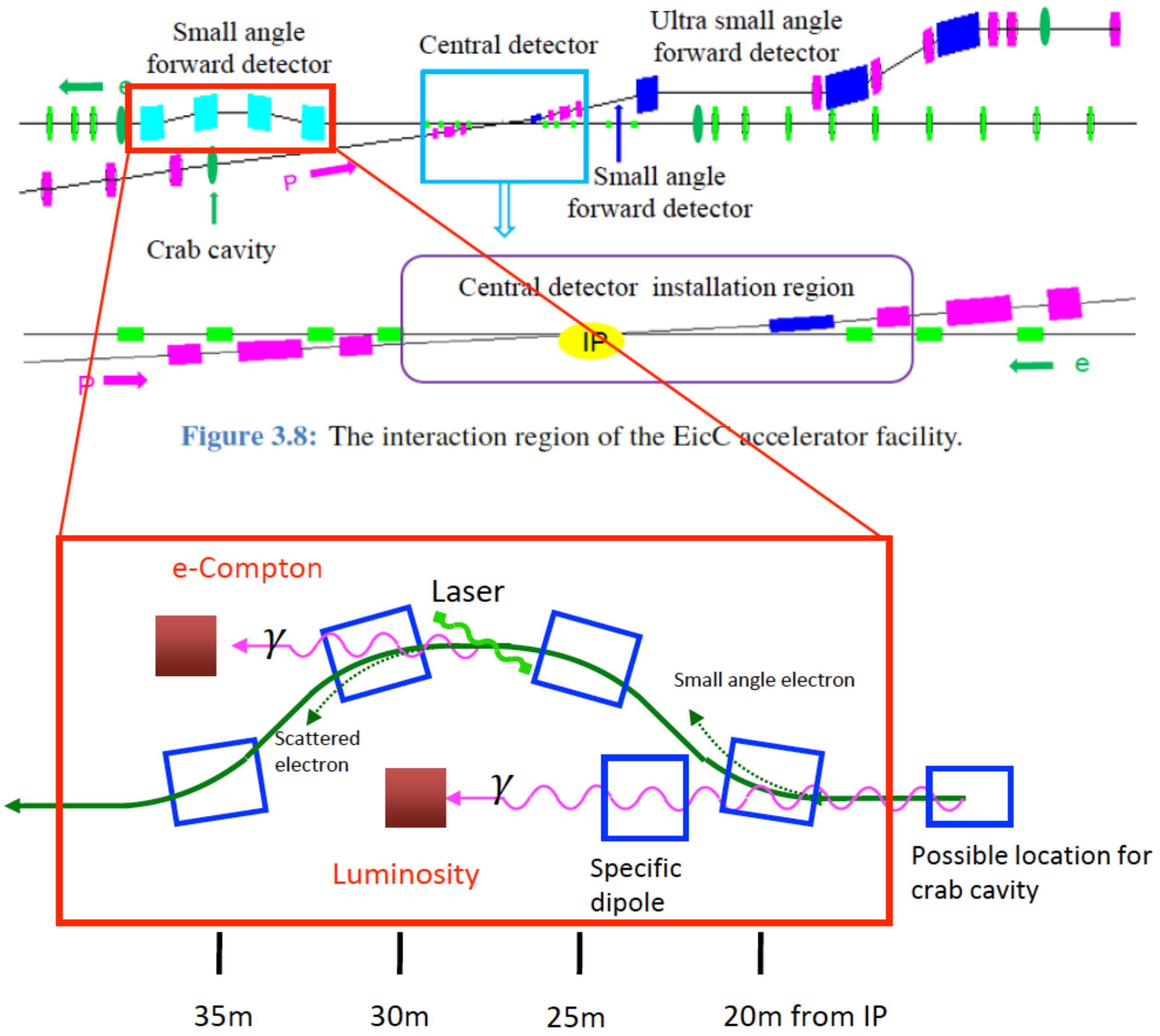


Fig. 3.8 The interaction region of the EicC accelerator facility.

Luminosity monitor and eCompton apparatus

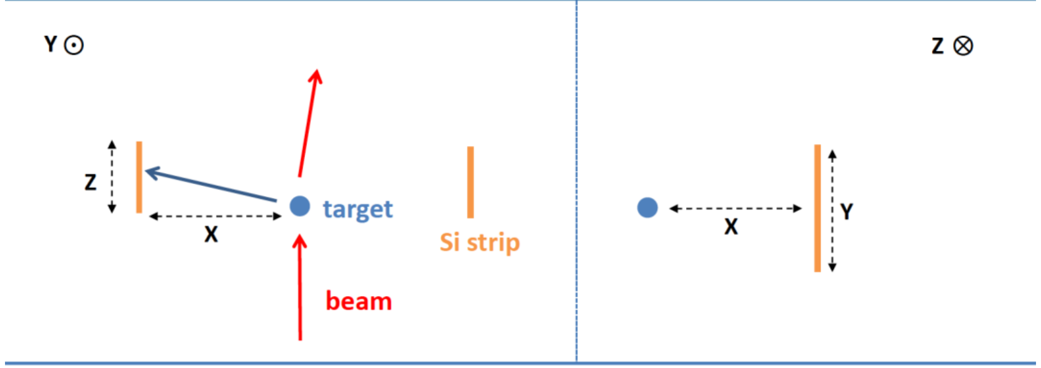
- Luminosity monitor and polarimetry are largely independent and essentially supportive "experiments"
- Relatively simpler subsystems but complex requirement overall e.g. coordination with accelerator, specific calorimeter and DAQ systems, etc.
- Geant4 simulation is ongoing



Recent studies on proton polarimetry

Boxing Gou (IMP)

The recoil proton detector – items to investigate

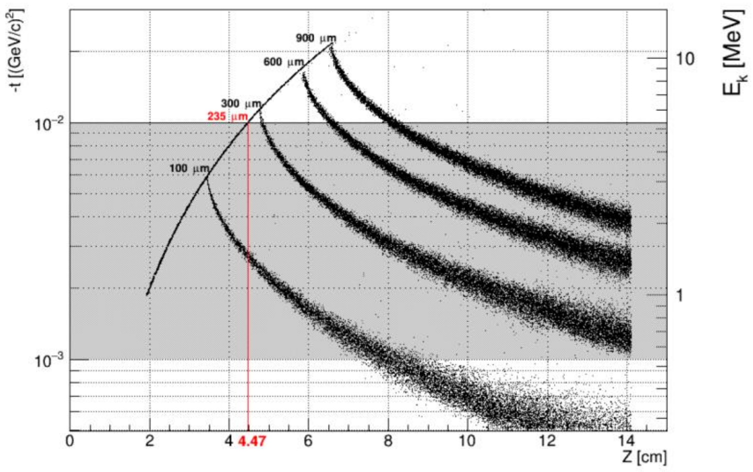


Two silicon strip detectors
- Horizontal position X
- Height (Y) and width (Z)
- Thickness

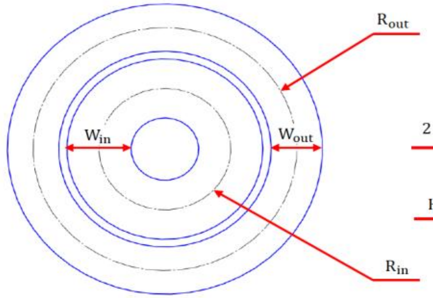
Polarization holding magnet
- Coil structure
- Current

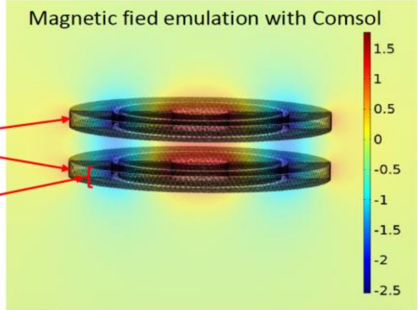
Beam-target overlap
- Beam transverse size
- Target thickness
- Bunch structure

Detection power vs thickness

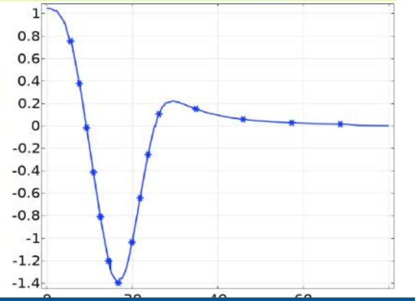


Holding magnet design



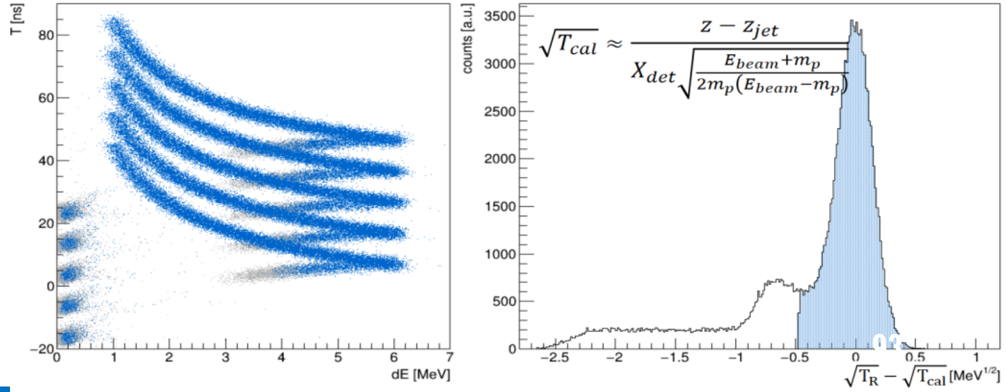


$2*Y_{coil}$	10.8 cm		
H_{coil}	7mm × 5 = 3.5 cm		
cable	7mm × 7mm / ϕ4mm		
I_{in}	360 A	I_{out}	360 A (TBO)
R_{in}	10.8 cm	R_{out}	21.6 cm
W_{in}	10.5 cm	W_{out}	8.4 cm
N_{in}	75=15*5	N_{out}	60=12*5



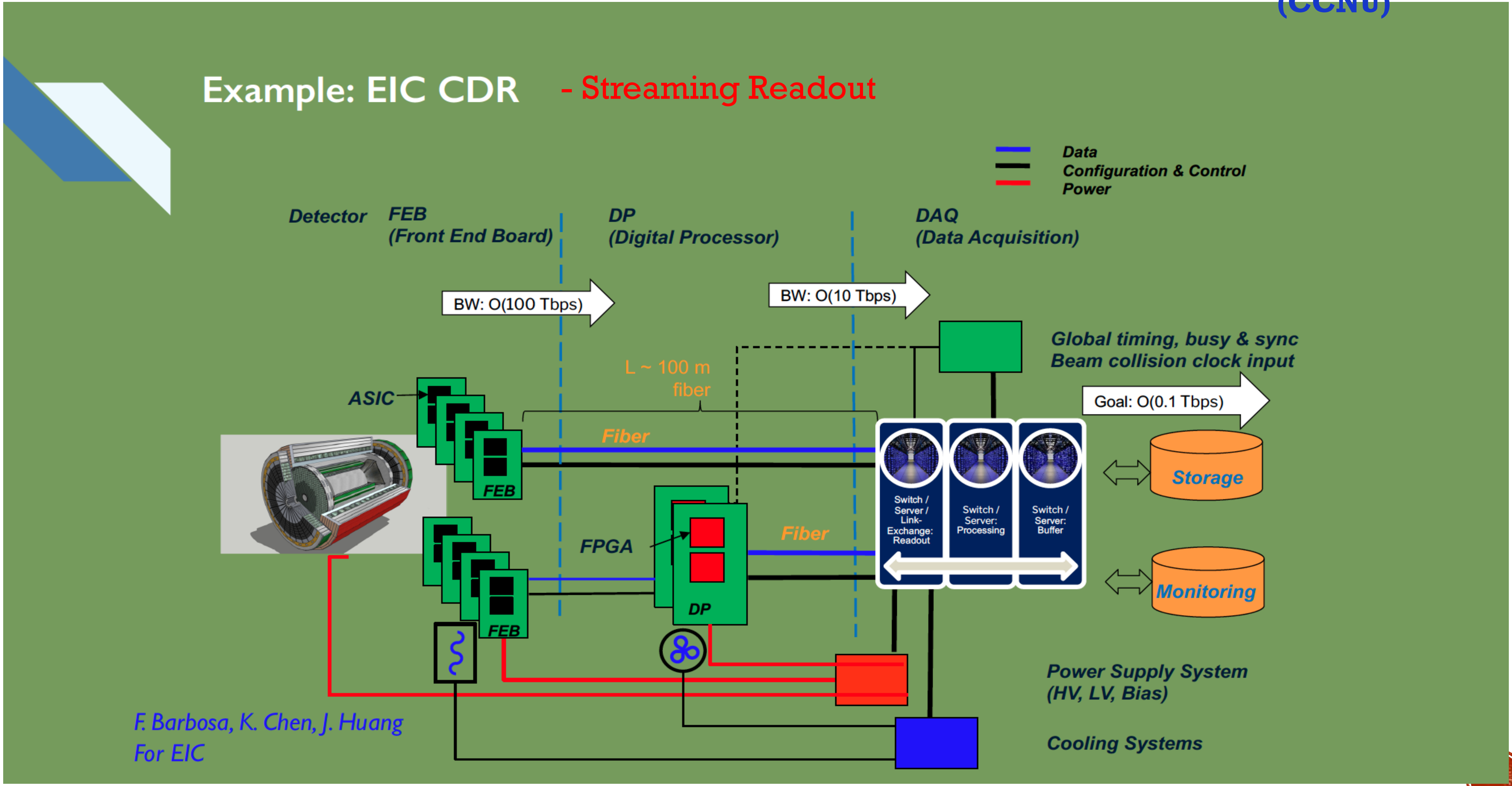
Simulation – event selection

- Elastic protons are selected by comparing measured(T_R) and calculated(T_{cal}) energy
- T_{cal} is calculated from the hit position(Z)
- Overlapped protons are rejected



6. DAQ design

Kai Chen (CCNU)



Plan towards CDR: Readout and DAQ

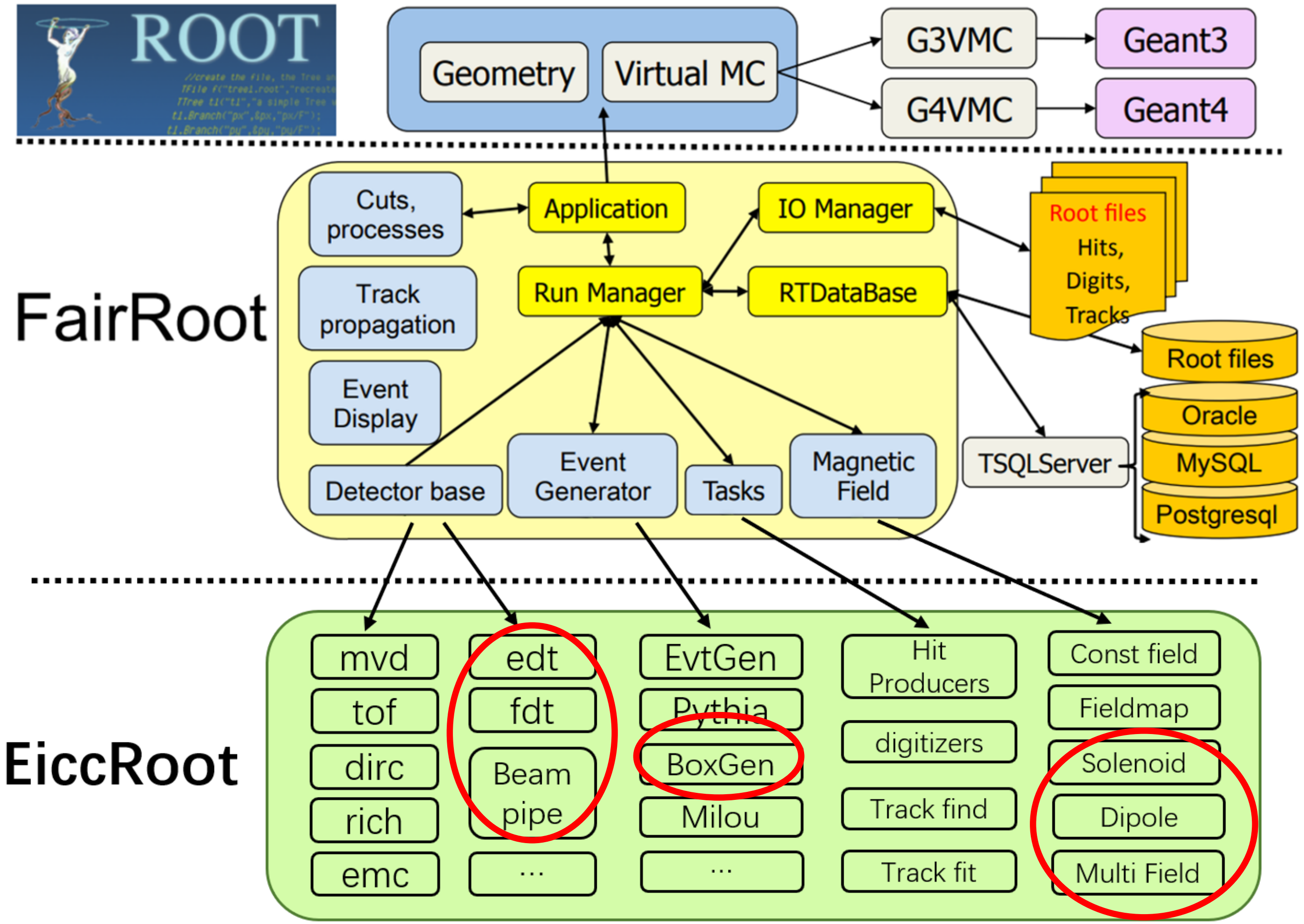
Kai Chen
(CCNU)

- **Collect information for each sub-detector**
  - *Needs input from all front-end subsystem*
  - *Channel numbers*
  - *Plan of readout electronics*
  - *Data format and size*
  - *Based on these information, we should start considering the overall architecture*
    - *In front-end, trigger or streaming readout?*
    - *In back-end, do we need hardware-based trigger?*
    - *Number of fiber optical links*
    - *Data bandwidth*
    - *Event size*
    - *Etc..*
- **Timing distribution system**
  - *Fan-out via DAQ downlinks*
  - *Embedded in commands & data stream, precision <10 ps*
- **Integrate with detector module & front-end readout electronics**
  - *Provide supports for readout (if needed)*
  - *Start the integration test as early as possible (Huizhou)*

7. Simulation framework & software

Yutie Liang (IMP)

Structure of EiccRoot



Top level: ROOT, Virtual MC, etc.

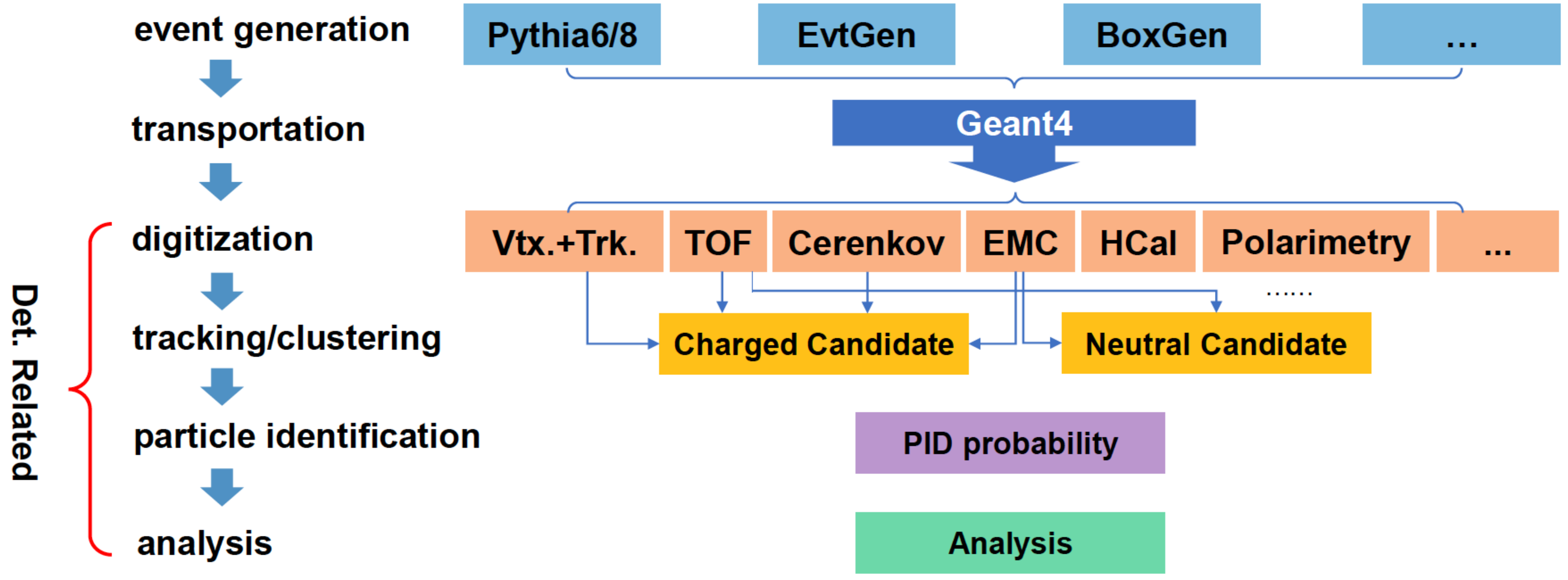
Middle level: FairRoot framework manages the general infrastructure with simulation and tasks

EiccRoot: implementation of the EicC detector sim. and rec. inside FairRoot framework

Yutie Liang (IMP)

EiccRoot Data flow

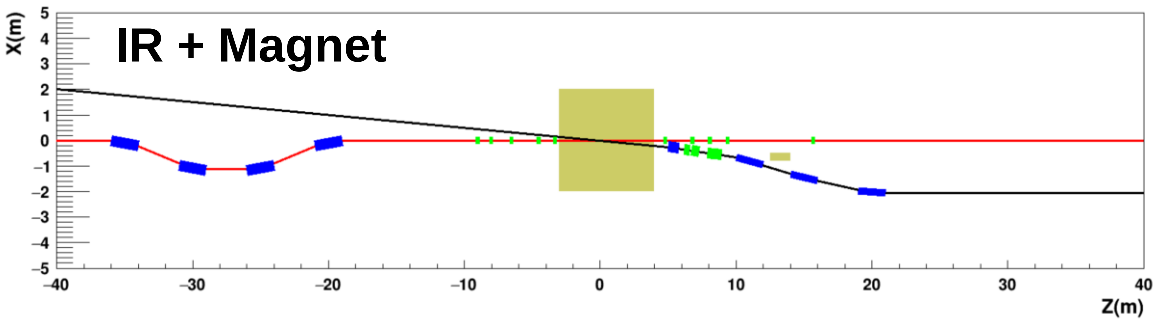
EiccRoot: implementation of EicC detector based on FairRoot



EicC software update & status

Yutie Liang (IMP)

- **Tracking, ECal, Forward detector packages in good shape**
- **EiccRoot_2.0.0 released with main updates of:**
  - Full magnetic fields (16 field maps) in the IR region
  - GenFit package adapted using field map service in EiccRoot
  - EiccBoxGenerator and EiccEvtGenHybrid updates
  - Complete beam pipe design from -40 to 20 meters



Central: solenoid

Ion Forward region: 3 dipoles + 3 quadrupoles

Electron Forward region: 4 dipoles + 5 quadrupoles