Electron-Ion Collider in China

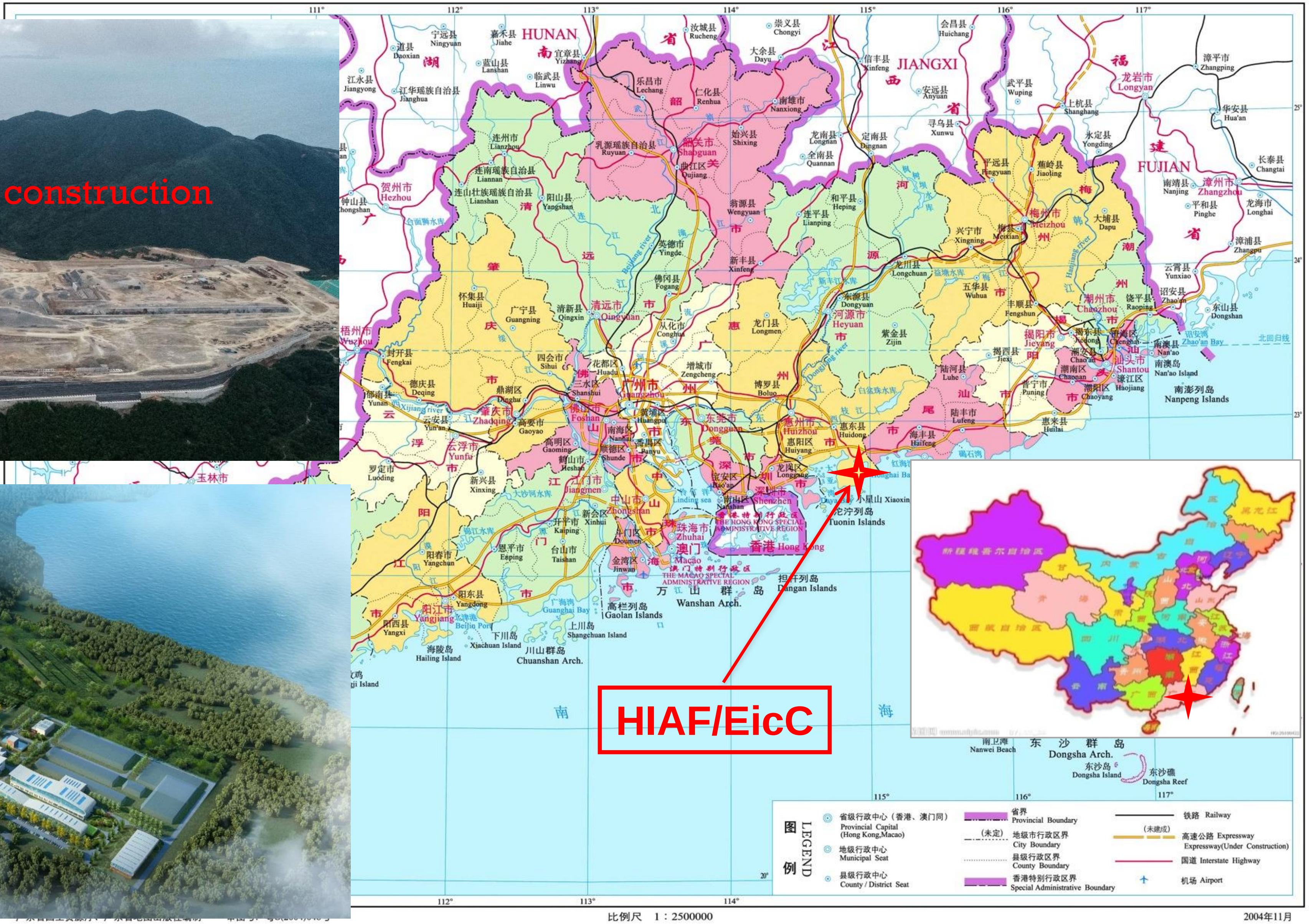
Yuxiang Zhao (Institute of Modern Physics, Chinese Academy of Sciences)

On behalf of the EicC working group

Outline

- General introduction of the Electron-Ion Collider in China
- Physics highlights
- Project status
- Summary

Where we are talking about…Huizhou(惠州) in Guangdong province

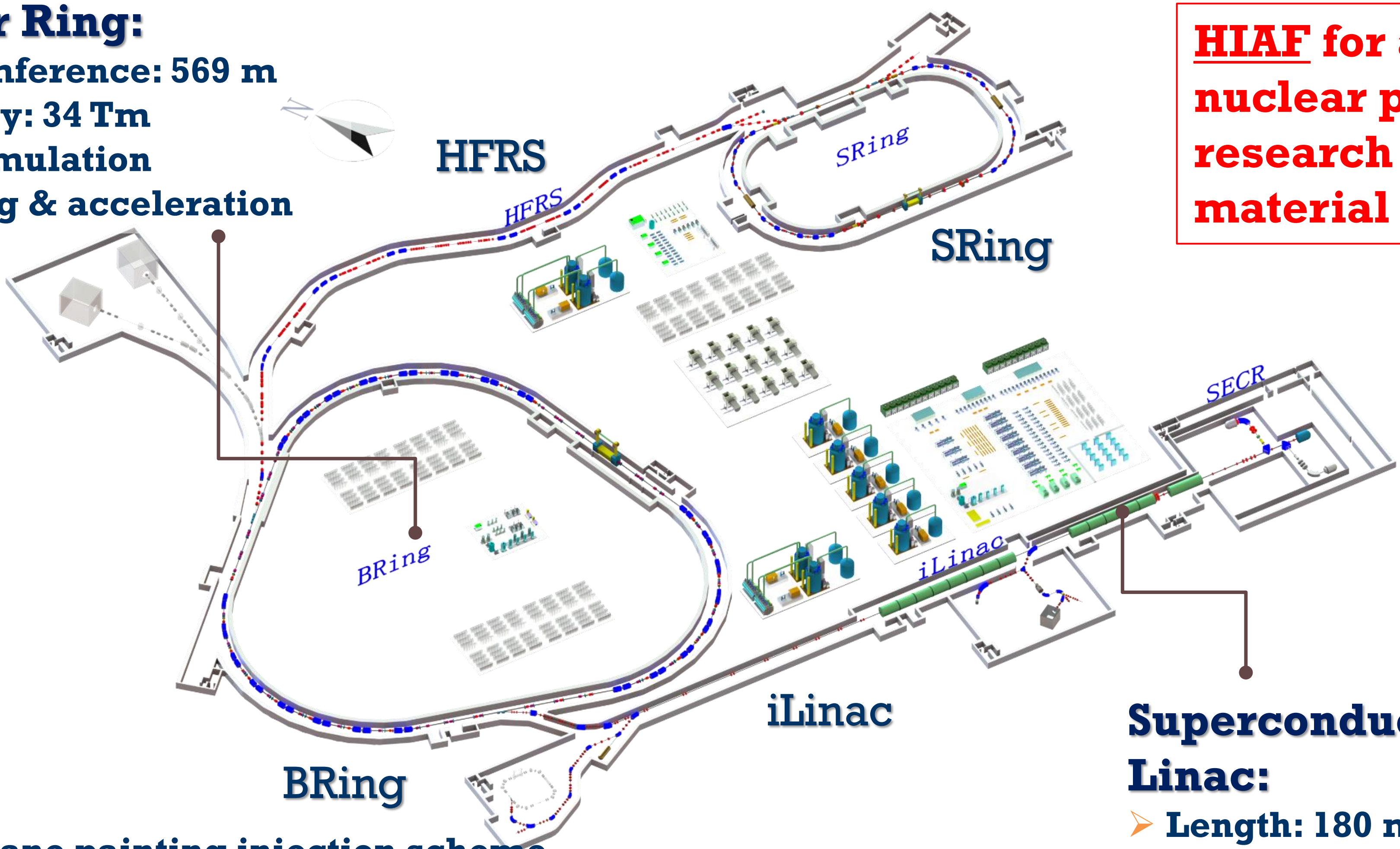


High Intensity heavy-ion Accelerator Facility (HIAF)

HIAF total investment: 2.5 billion RMB

Booster Ring:
- Circumference: 569 m
- Rigidity: 34 Tm
- Aaccumulation
- 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

Electron Ion Collider in China, EicC

EicC white paper (arXiv: 2102.09222)

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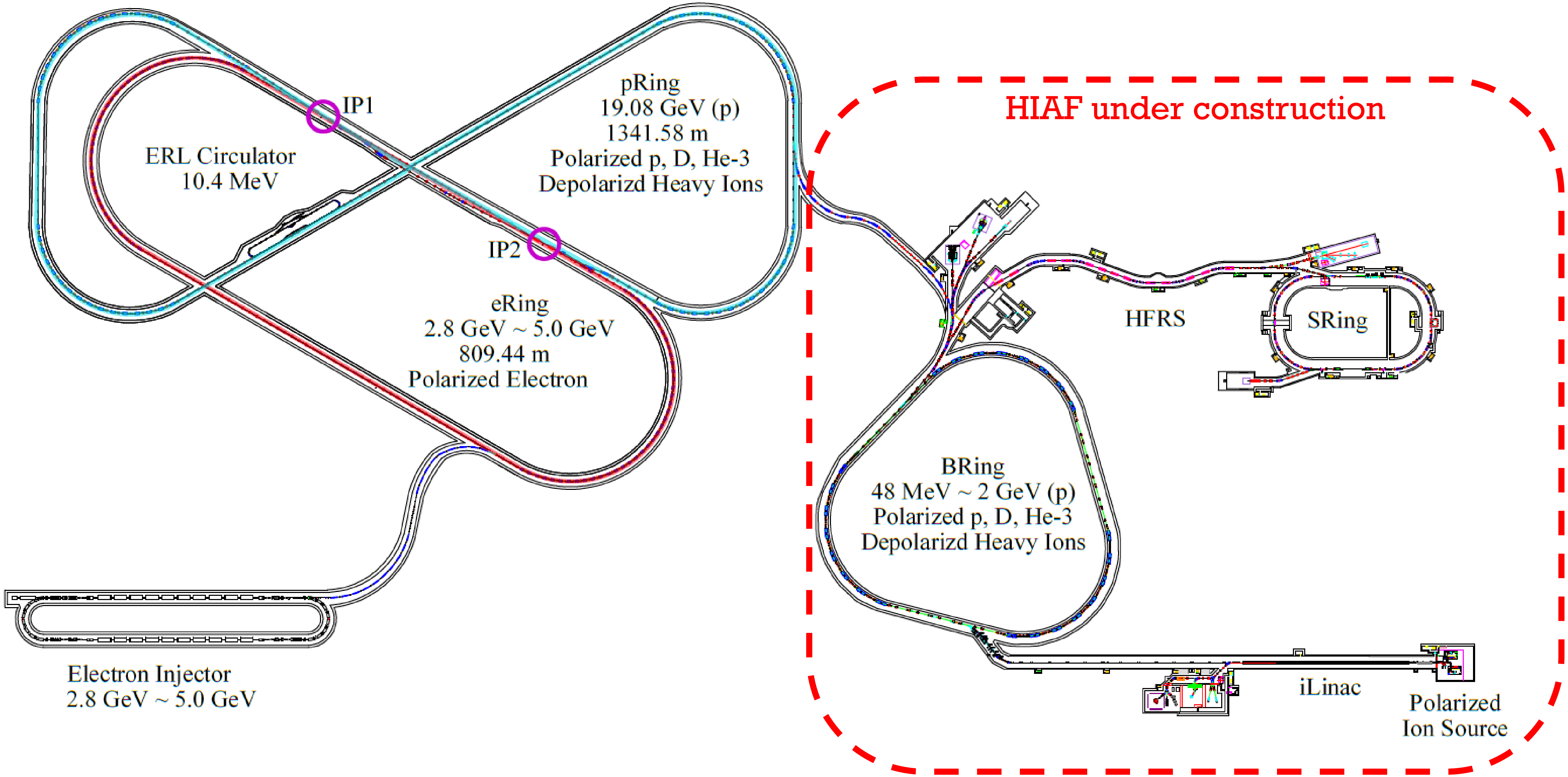
REPORT

Electron-ion collider in China

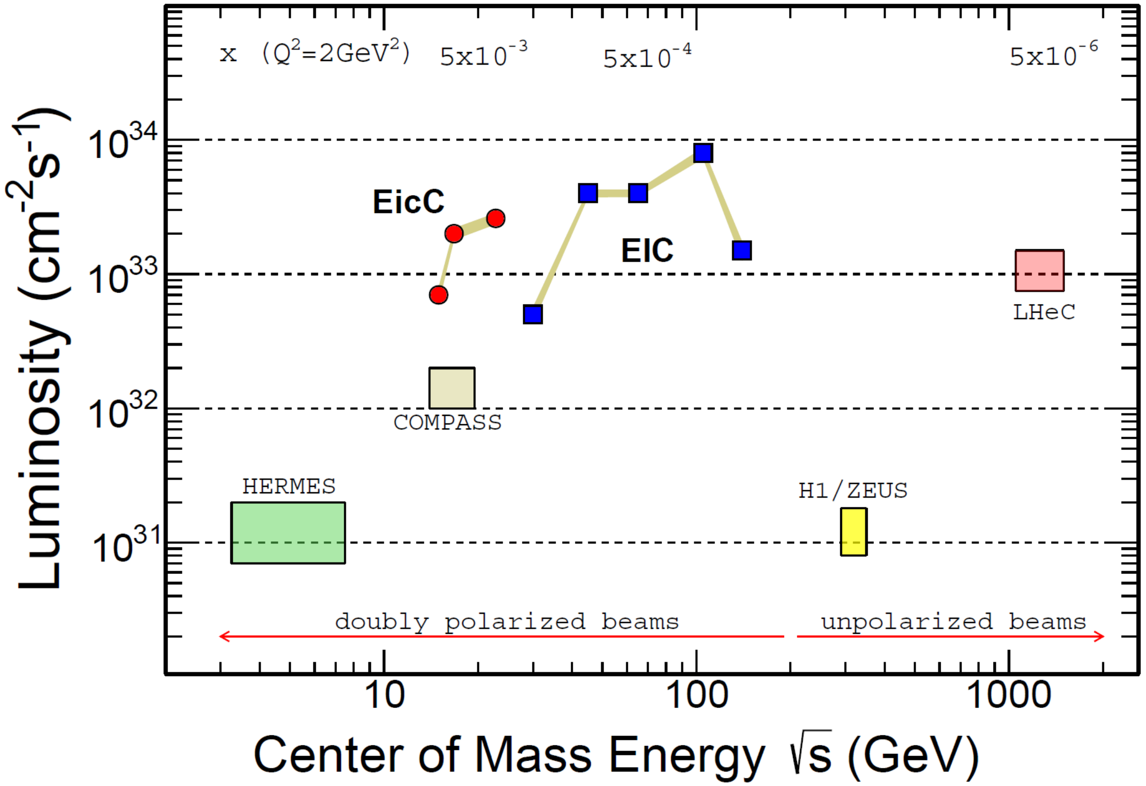
Now we have 46 institutes and >100 physicists

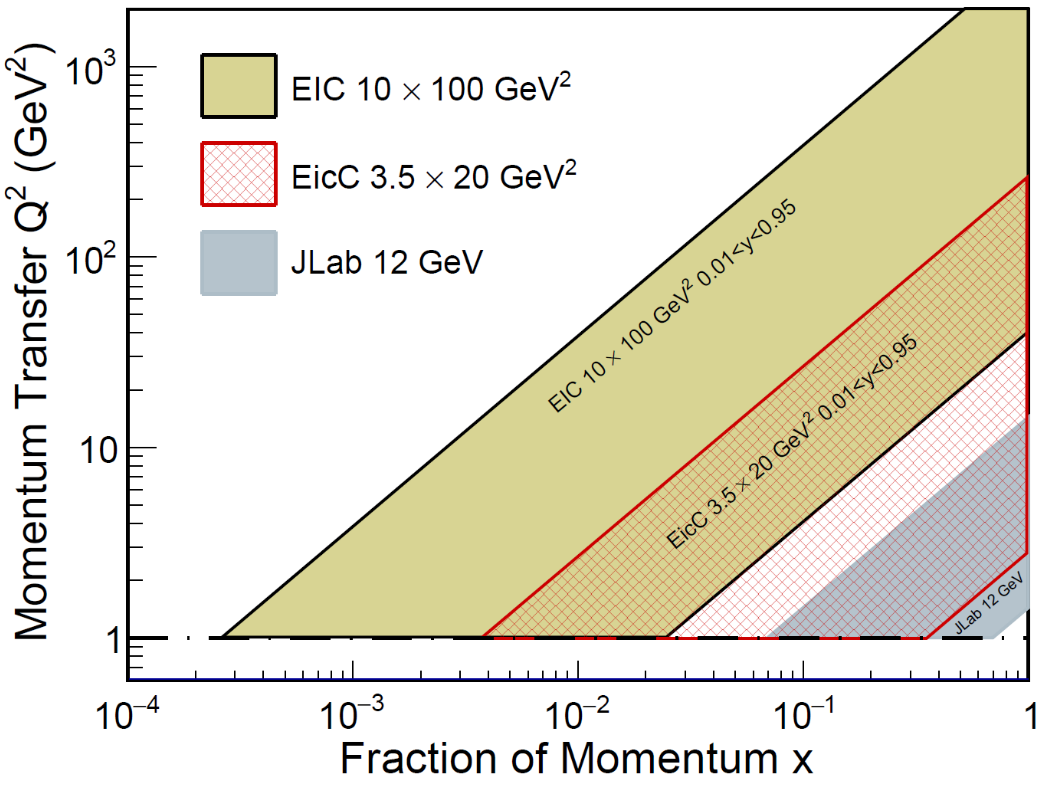
Daniele P. Anderle[1], Valerio Bertone[2], Xu Cao[3,4], Lei Chang[5], Ningbo Chang[6], Gu Chen[7], Xurong Chen[3,4], Zhuojun Chen[8], Zhufang Cui[9], Lingyun Dai[8], Weitian Deng[10], Minghui Ding[11], Xu Feng[12], Chang Gong[12], Longcheng Gui[13], Feng-Kun Guo[4,14], Chengdong Han[3,4], Jun He[15], Tie-Jiun Hou[16], Hongxia Huang[15], Yin Huang[17], Krešimir KumeričKi[18], L. P. Kaptari[3,19], Demin Li[20], Hengne Li[1], Minxiang Li[3,21], Xueqian Li[5], Yutie Liang[3,4], Zuotang Liang[22], Chen Liu[22], Chuan Liu[12], Guoming Liu[1], Jie Liu[3,4], Liuming Liu[3,4], Xiang Liu[21], Tianbo Liu[22], Xiaofeng Luo[23], Zhun Lyu[24], Boqiang Ma[12], Fu Ma[3,4], Jianping Ma[4,14], Yugang Ma[4,25,26], Lijun Mao[3,4], Cédric Mezrag[2], Hervé Moutarde[2], Jialun Ping[15], Sixue Qin[27], Hang Ren[3,4], Craig D. Roberts[9], Juan Rojo[28,29], Guodong Shen[3,4], Chao Shi[30], Qintao Song[20], Hao Sun[31], Paweł Sznajder[32], Enke Wang[1], Fan Wang[9], Qian Wang[1], Rong Wang[3,4], Ruiru Wang[3,4], Taofeng Wang[33], Wei Wang[34], Xiaoyu Wang[20], Xiaoyun Wang[35], Jiajun Wu[4], Xinggang Wu[27], Lei Xia[36], Bowen Xiao[23,37], Guoqing Xiao[3,4], Ju-Jun Xie[3,4], Yaping Xie[3,4], Hongxi Xing[1], Hushan Xu[3,4], Nu Xu[3,4,23], Shusheng Xu[38], Mengshi Yan[12], Wenbiao Yan[36], Wencheng Yan[20], Xinhu Yan[39], Jiancheng Yang[3,4], Yi-Bo Yang[4,14], Zhi Yang[40], Deliang Yao[8], Zhihong Ye[41], Peilin Yin[38], C.-P. Yuan[42], Wenlong Zhan[3,4], Jianhui Zhang[43], Jinlong Zhang[22], Pengming Zhang[44], Yifei Zhang[36], Chao-Hsi Chang[4,14], Zhenyu Zhang[45], Hongwei Zhao[3,4], Kuang-Ta Chao[12], Qiang Zhao[4,46], Yuxiang Zhao[3,4], Zhengguo Zhao[36], Liang Zheng[47], Jian Zhou[22], Xiang Zhou[45], Xiaorong Zhou[36], Bingsong Zou[4,14], Liping Zou[3,4]

EicC Accelerator complex layout



EicC Specs





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

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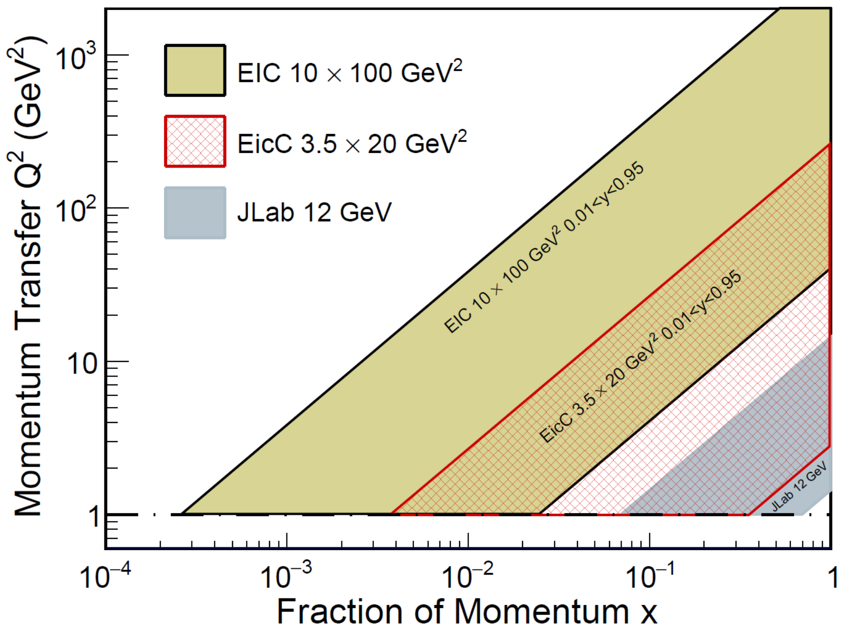
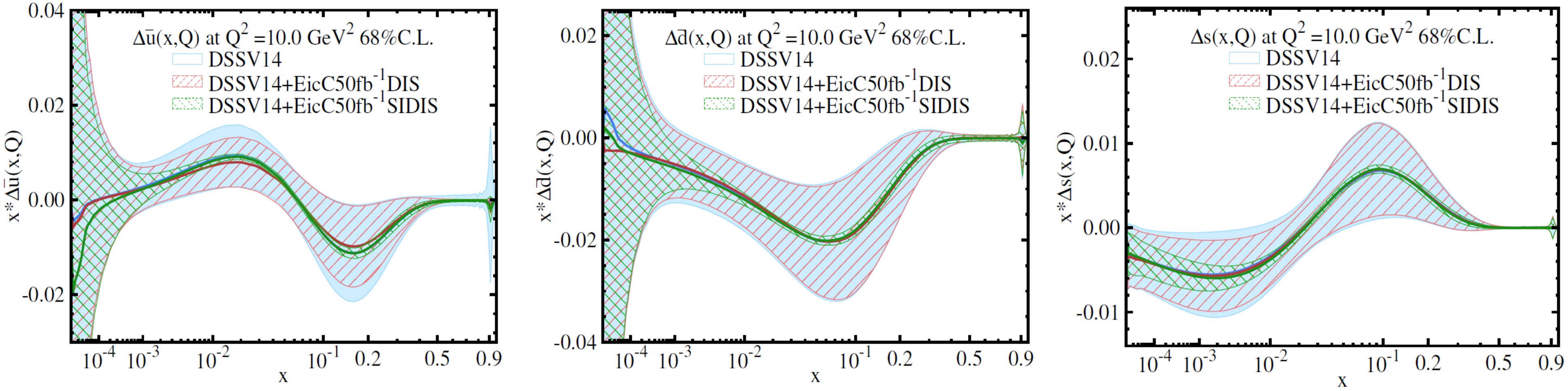
Highlighted physics topics



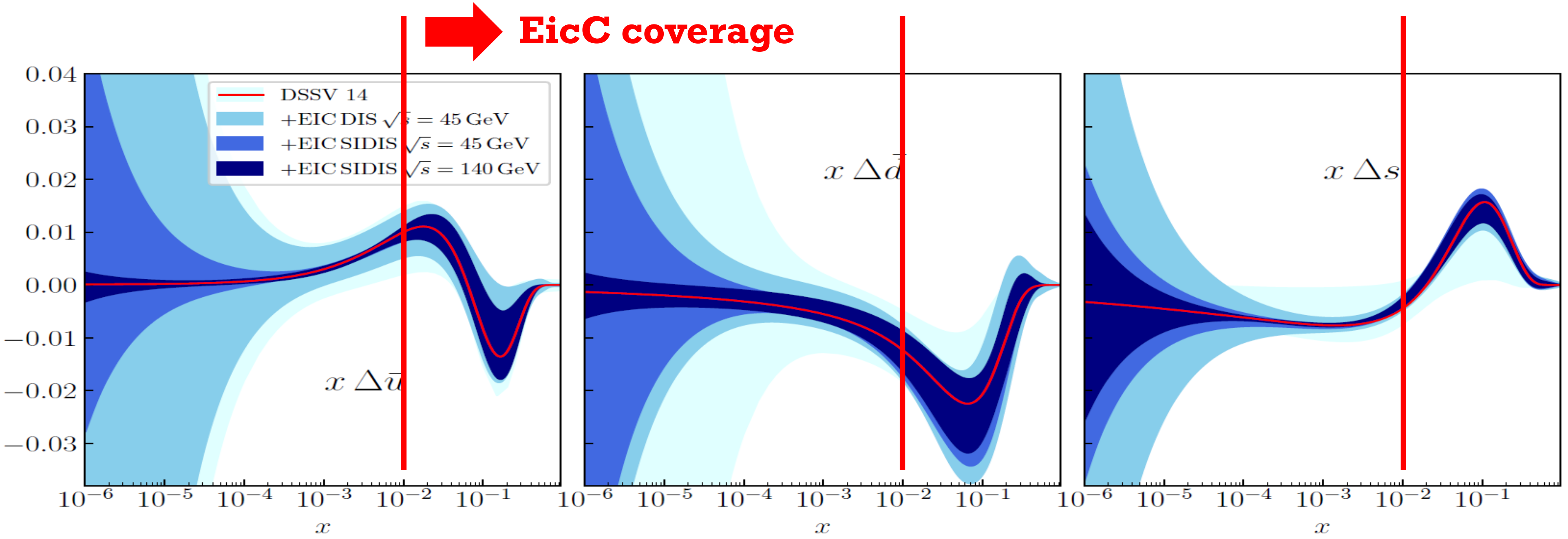
- Spin structure of the nucleon: 1D, 3D
  - ➢ polarized electron + polarized proton/light nuclei
- Partonic structure of nuclei and the parton interaction with the nuclear environment
  - ➢ unpolarized electron + unpolarized various nuclei
- Exotic states with c/cbar, b/bbar (BESIII community in China)
- Origin of the proton mass study via heavy quarkonium near-threshold production

Spin structure of the nucleon-helicity distribution



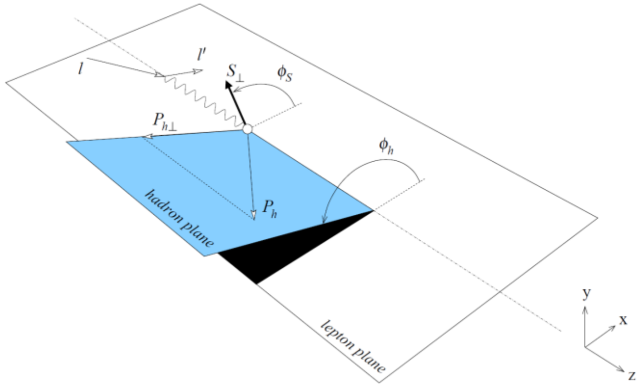
A NLO impact study
See arXiv:2103.10276

EicC white paper



EIC Yellow Report

Spin structure of the nucleon-TMDs



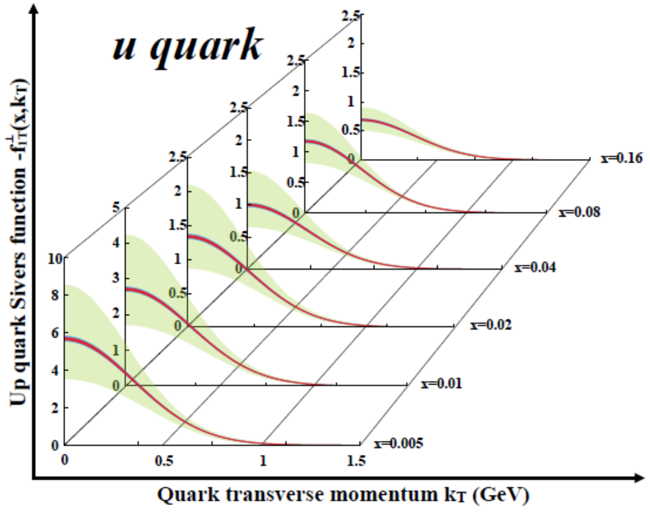
u/d Sivers EicC vs world data

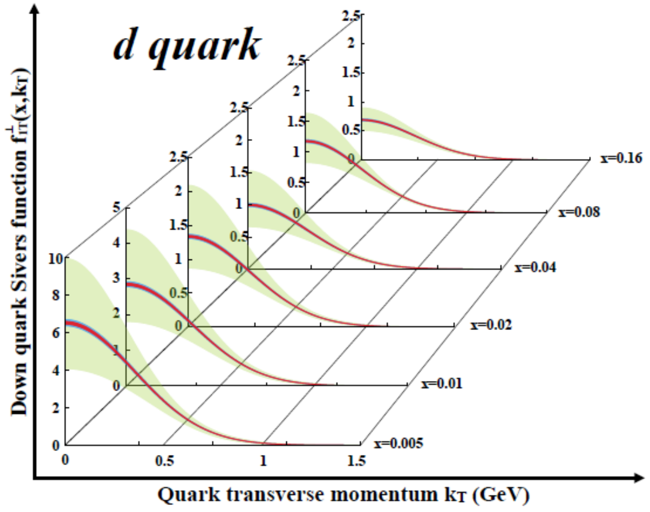
LO analysis

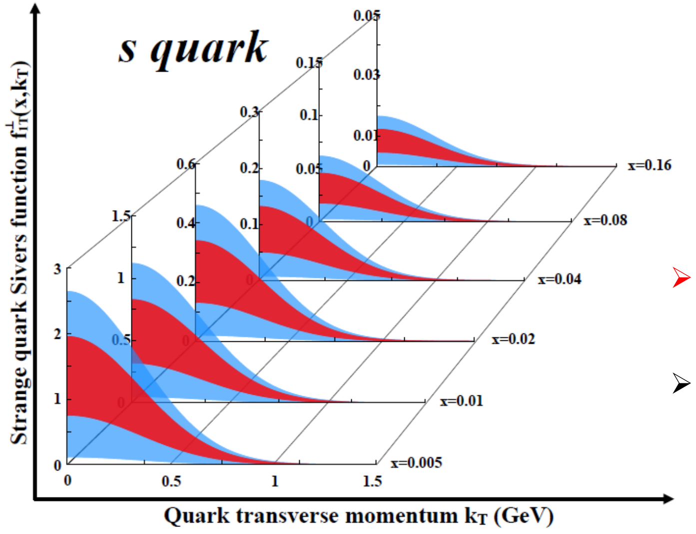
EicC SIDS data:

- Pion(+/-), Kaon(+/-)
- ep: 3.5 GeV X 20 GeV
- eHe-3: 3.5 GeV X 40 GeV
- Pol.: e(80%), p(70%), He-3(70%)
- Lumi: ep 50 fb^{-1}, eHe-3 50 fb^{-1}

EicC, precise measurements.







Green: Current accuracy

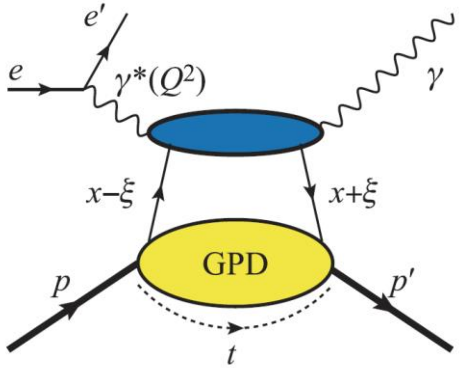
Red: stat. error only

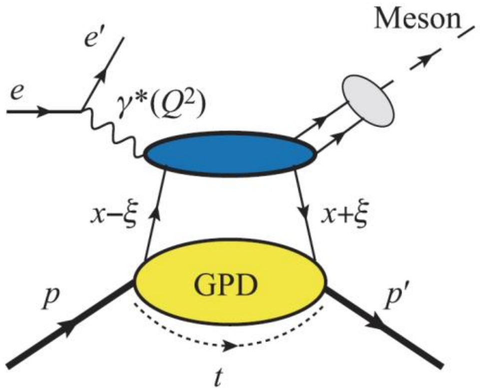
Blue: sys. Error included

- sea quark Sivers function dynamically generated via Spin depenendent odderon
- leads to a unique predication for s-quark: quark and anit-quark Sivers functions flip sign

H. Dong, D. X. Zheng, J. Zhou, 2018

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)

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

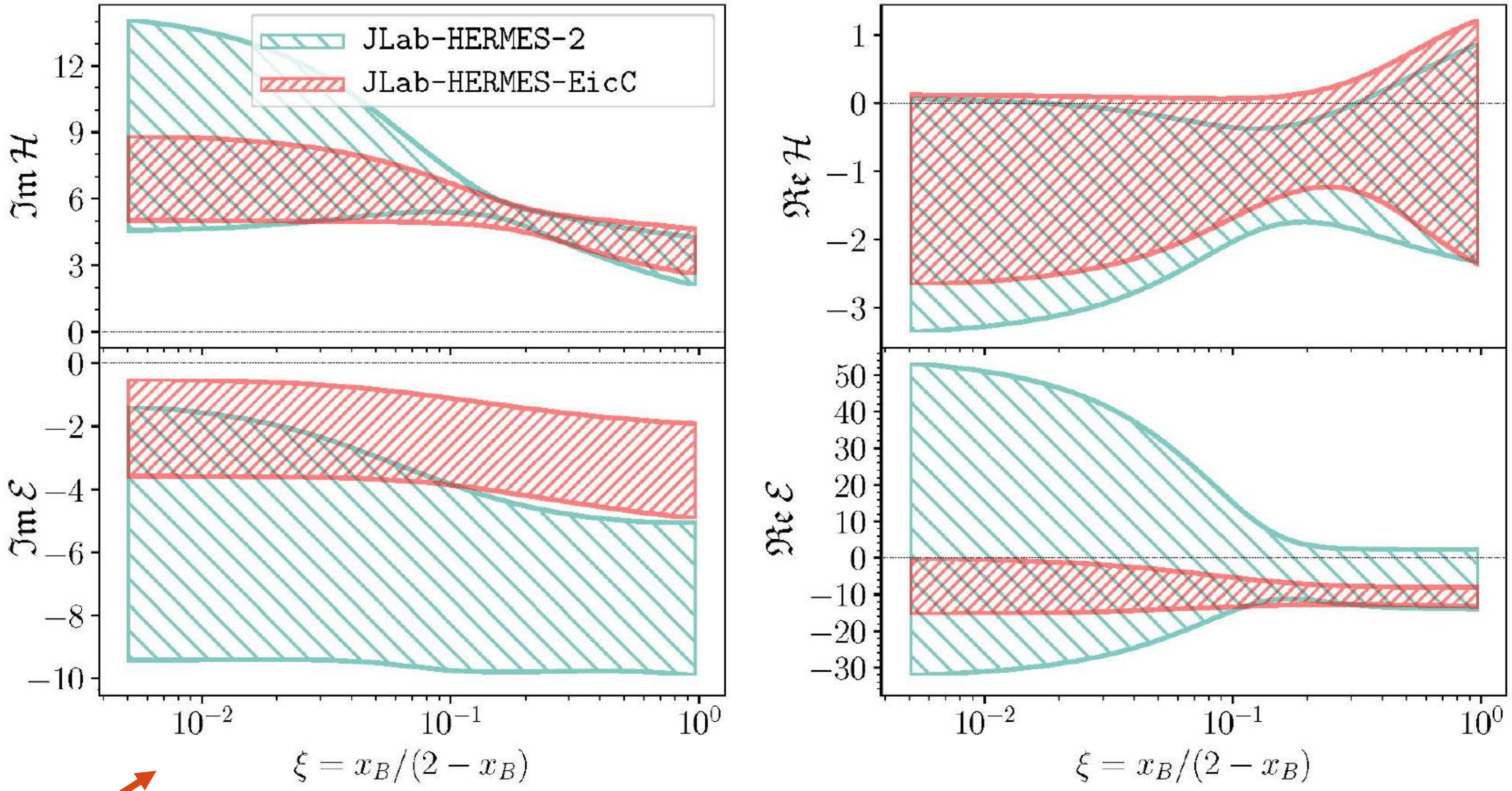
Unpolarized beam, transverse target (tTSA)

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

Polarized beam, longitudinal target (DSA)

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

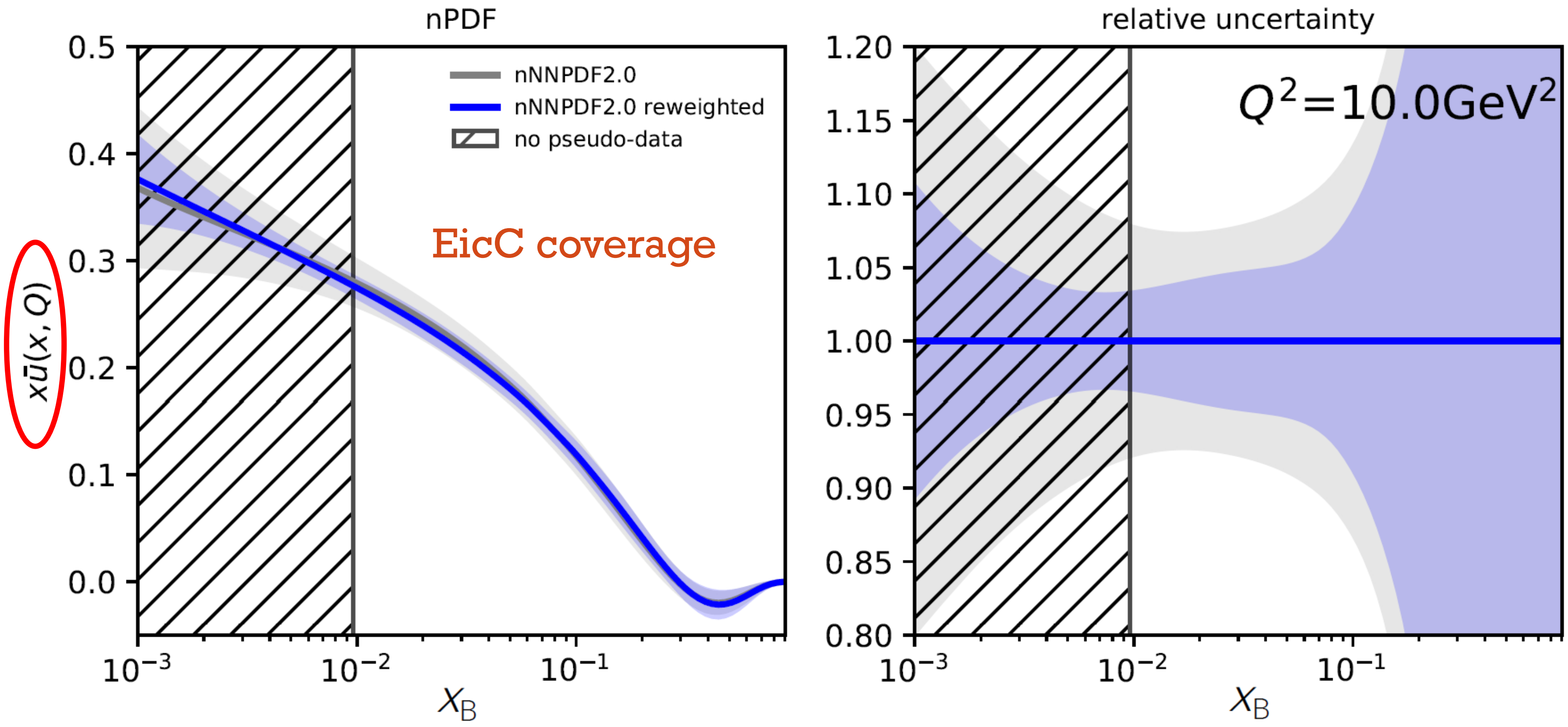
The extraction of CFF with neural network methods [Kumericki, 19]



Only with this azimuthal angular modulation

Another CFF impact study with PARTONS group is ongoing

Nuclear PDFs study with ion beam



With only a few hours of running

Proton mass study

Mass decomposition [Ji, 95]

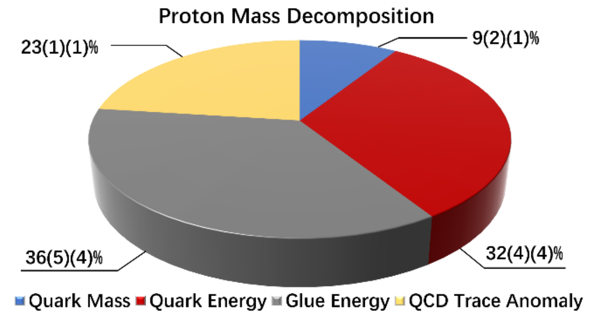
$$M = \underbrace{M_q + M_m}_{\text{Quark}} + \underbrace{M_g + M_a}_{\text{Gluon}}$$

M_q : quark energy

M_m : quark mass (condensate)

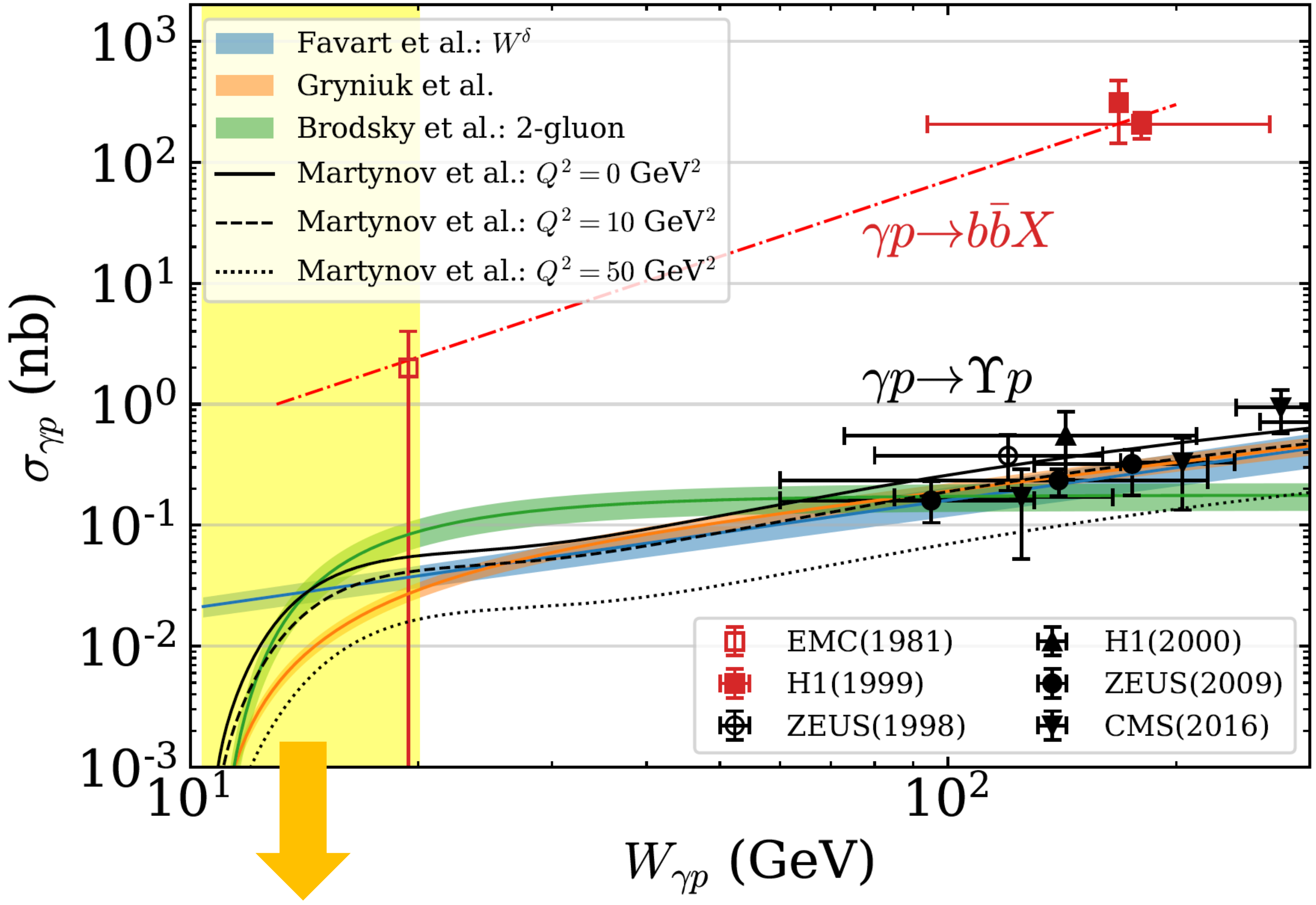
M_g : gluon energy

M_a : trace anomaly



Lattice 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



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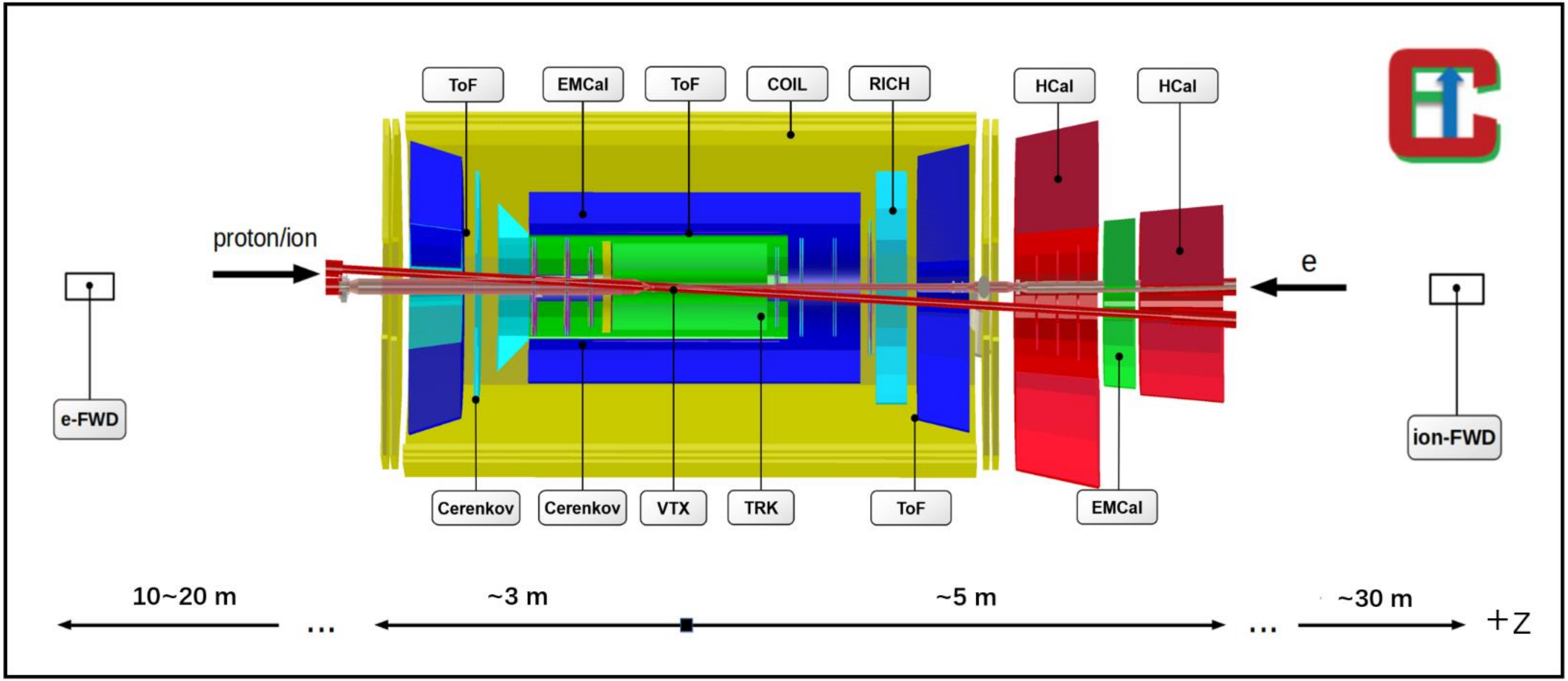
EicC detector considerations

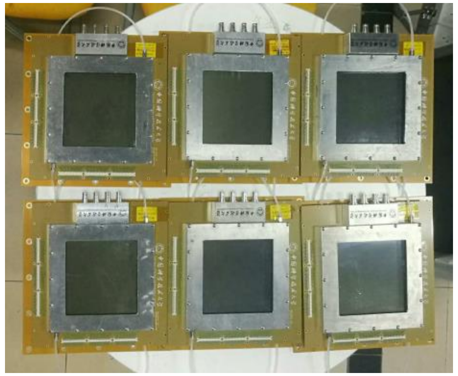


Full Geant4 simulation is ongoing

Detector R&Ds

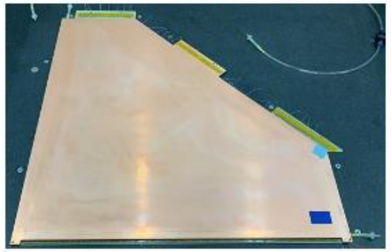
Clean rooms of ISO6 and ISO7 (in total of 200 m²) for detector assembling

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

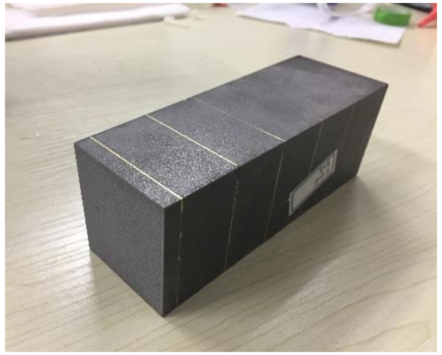


sTGC detector

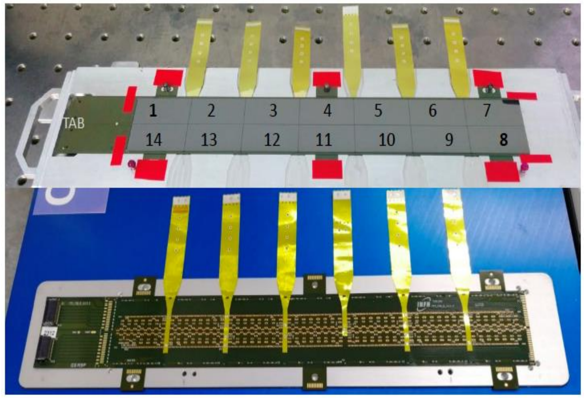
~55cm * 55cm pentagon



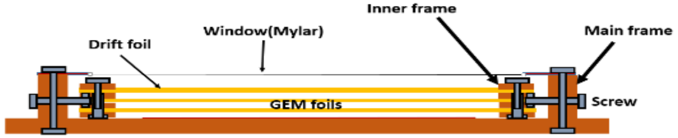
Shashlyk and W-powder+ScFi EMCal

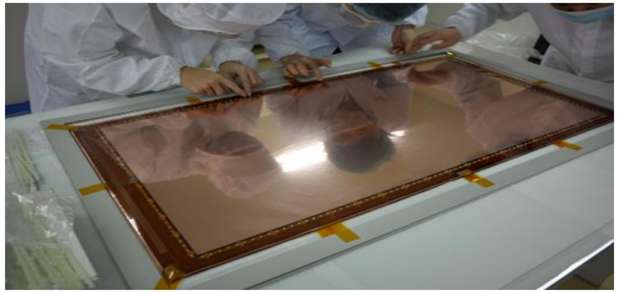


ALICE style ITS2 MAPS pixel detector

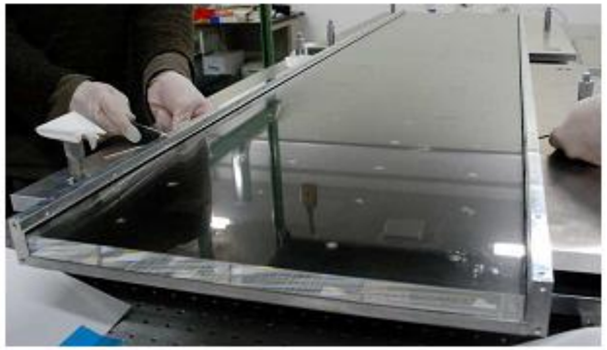


1m x 0.5 m GEM (self-stretching)





DIRC prototype



Timeline

We are here (↓ 21)

CY	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
	5-year-plan			5-year-plan					5-year-plan					5-year-plan					
	HIAF																		
EicC				R&D															
									$\sqrt{s}$ ~ 17GeV, $2x10^{33}/s/cm^2$										

R&D and construction

In operation

Summary

- EicC is briefly introduced
  - ➢EicC focuses on sea-quark/gluon related study at moderate/large-x region
  - ➢EicC can help to tackle the issue of the trace anomaly contribution to the proton mass at the Upsilon threshold
- More physics topics are under study and development
- Full Geant4 simulation and detector R&Ds are ongoing

- **EicC complements EIC physics program at higher energy**

Thanks and you are more than welcome to join us


Office area will be available in the end of 2021