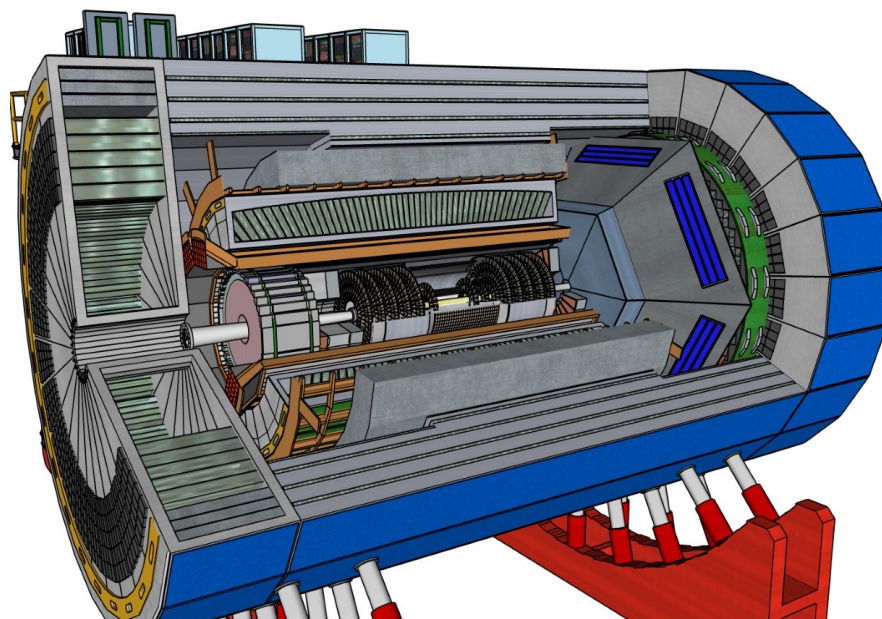




EIC Comprehensive Chromodynamics Experiment

Or Hen, Tanja Horn, John Lajoie
for the ECCE Consortium

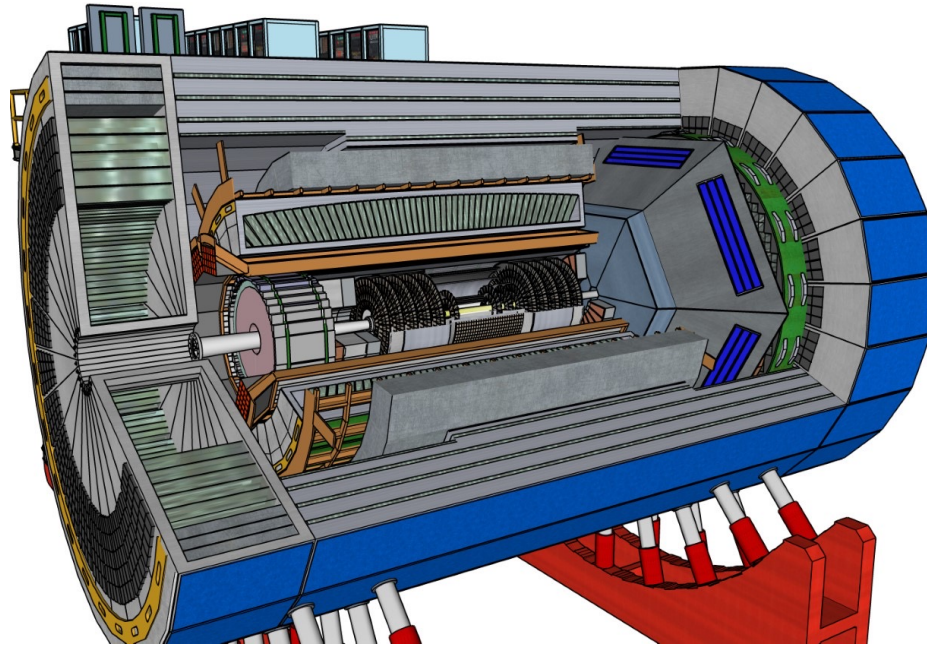


What's €CCCE€?

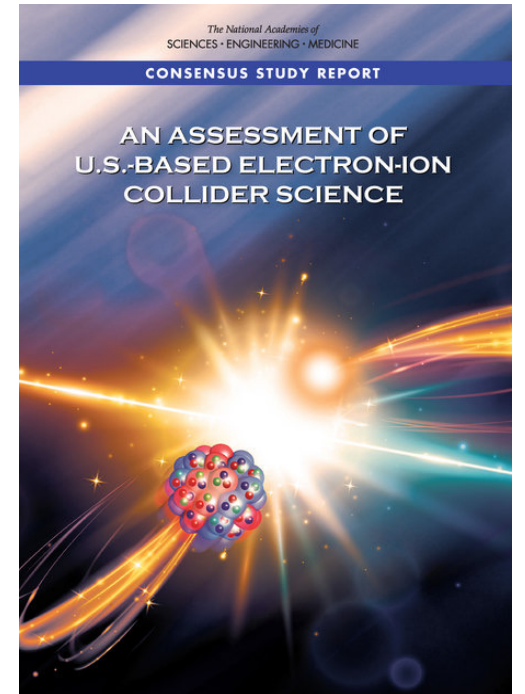
Scientist from
80 institutions



Designing (&
building!) a detector



To deliver on EIC
science mission



What's ECCE ?

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

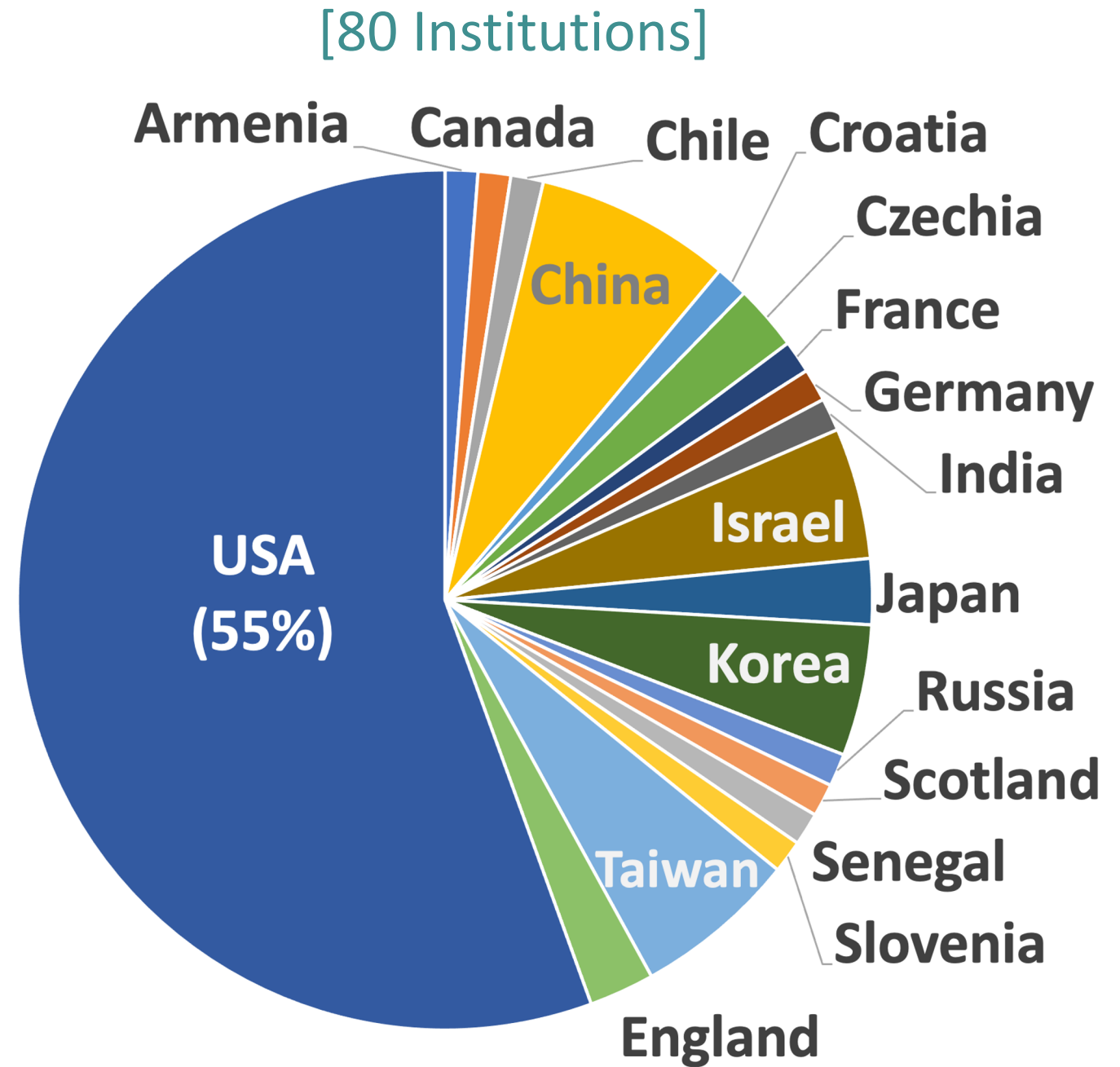
What's ECCE ?

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

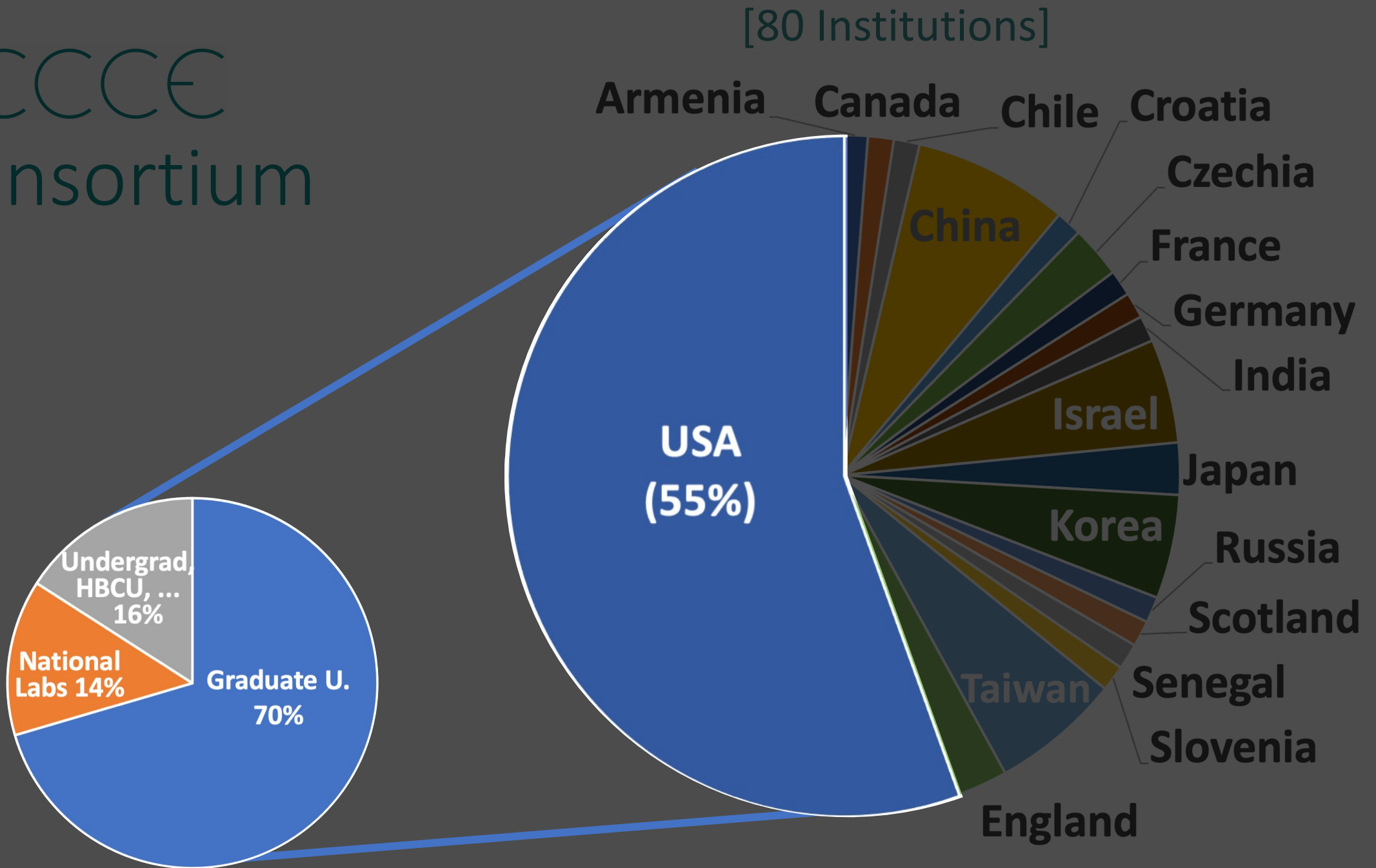
Guiding principles:

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

CCCE Consortium

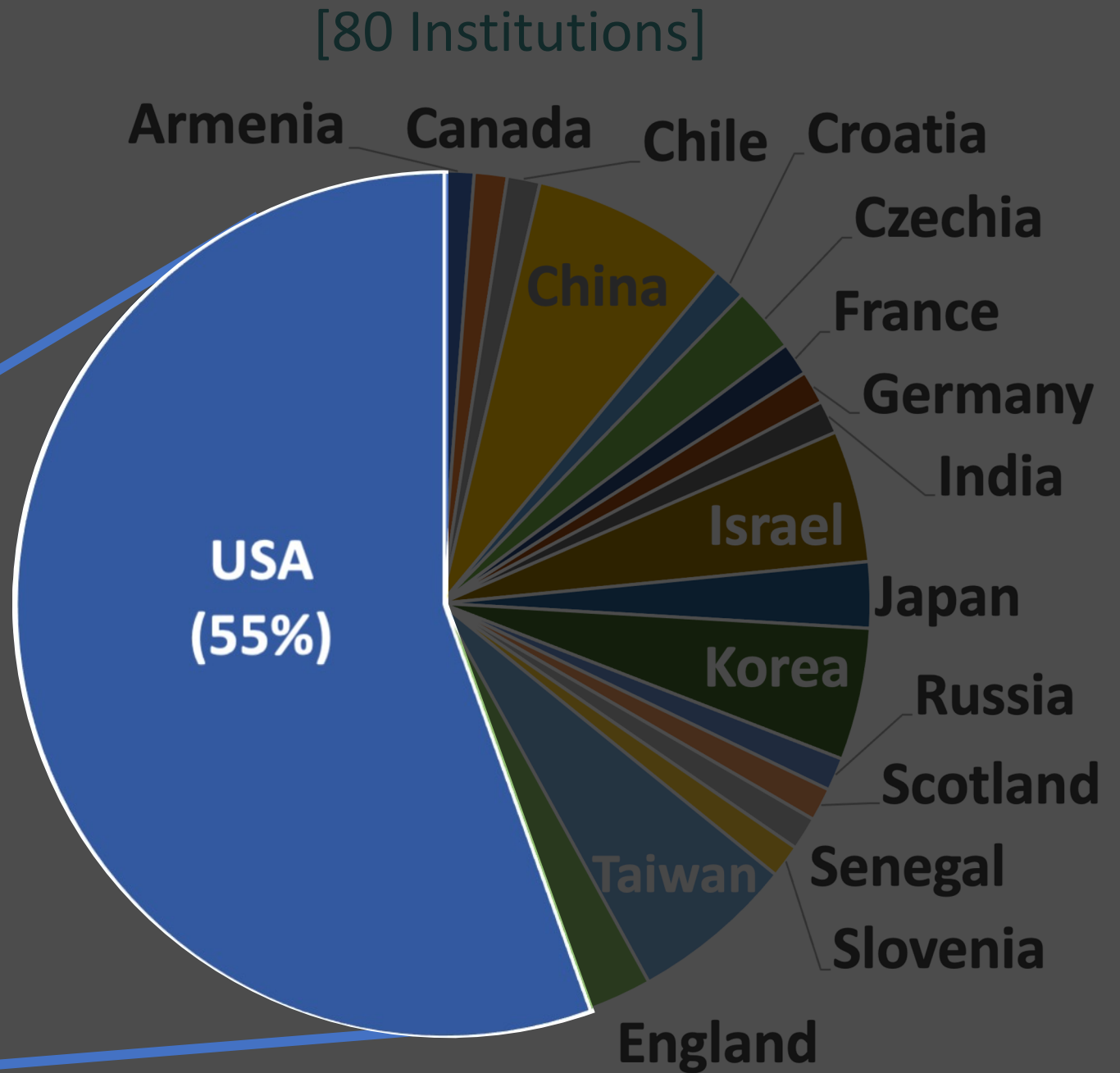
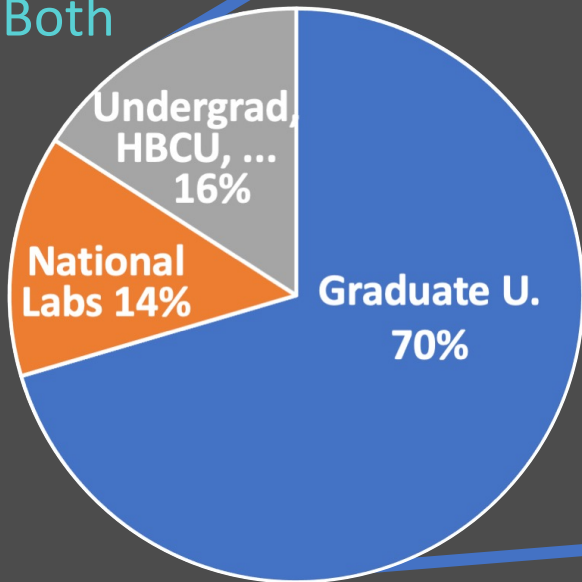


CCCE Consortium

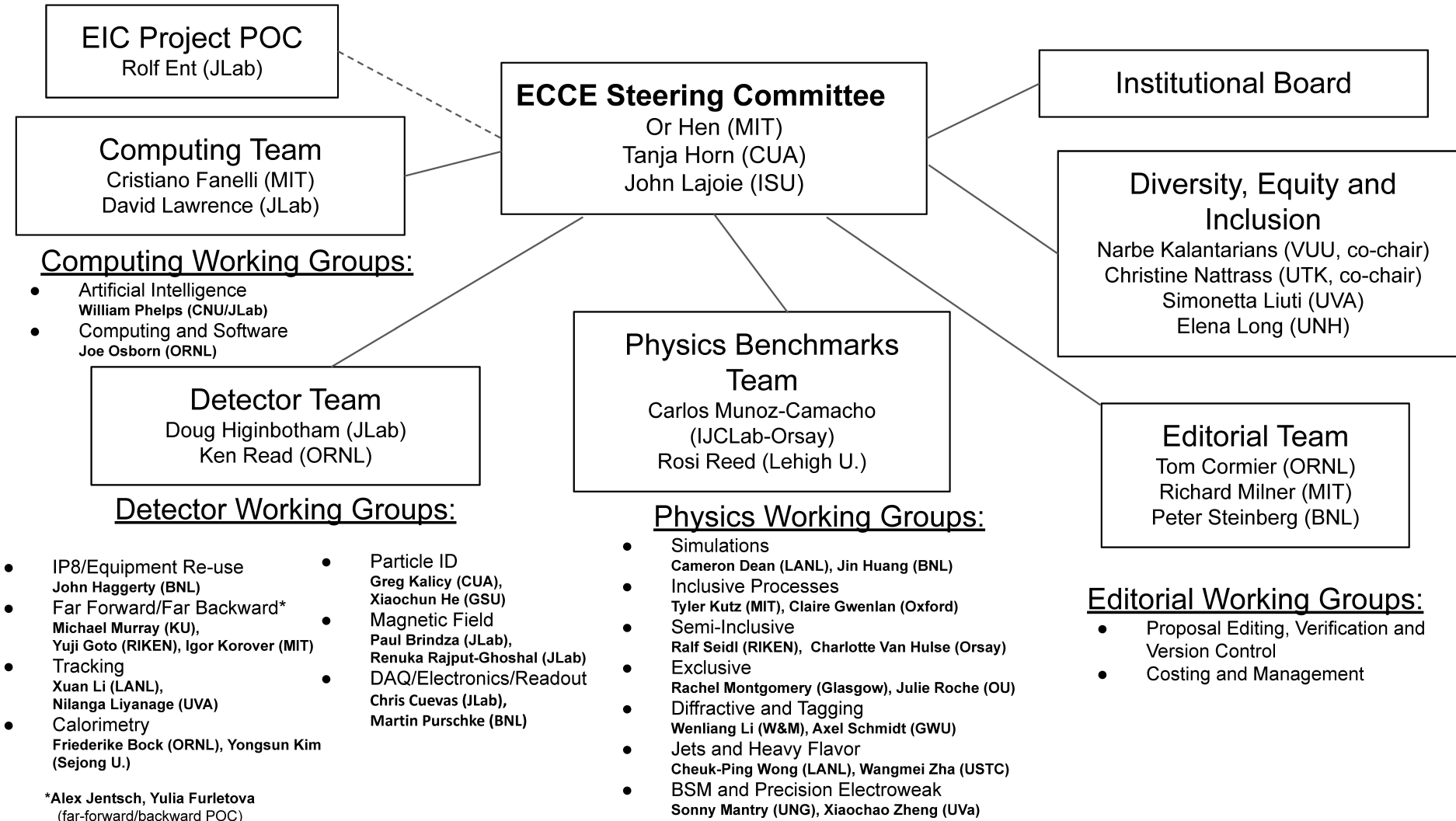


CCCE Consortium

Background /
Experience:
50% 'RHIC'
40% 'JLab'
10% Both



ECCE Consortium



Website:

<https://www.ecce-eic.org/>

Mailing Lists:

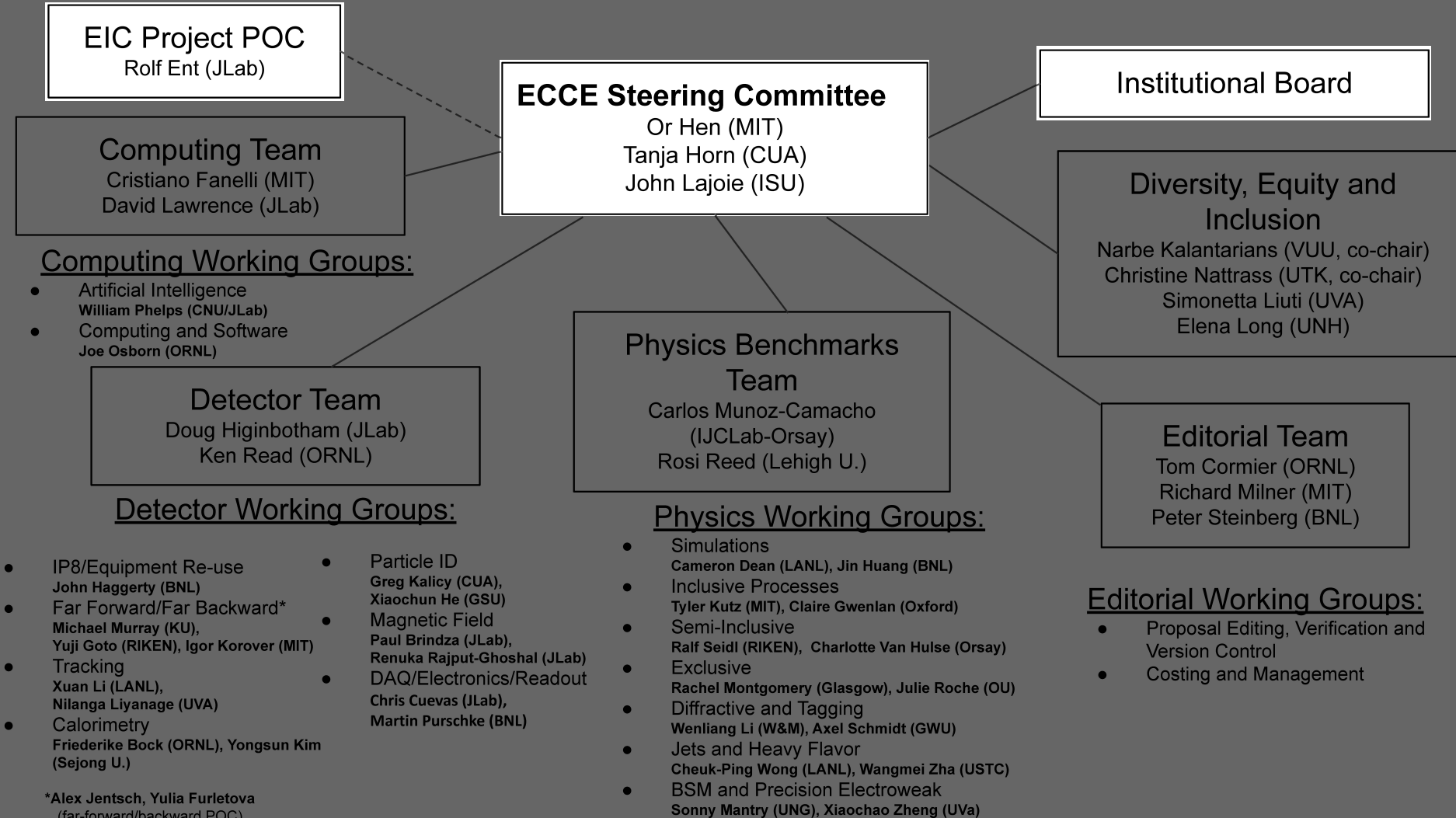
<https://lists.bnl.gov>

- ecce-eic-public-l
- ecce-eic-ib-l
- ecce-eic-dei-l
- ecce-eic-det-l
- ecce-eic-phys-l
- ecce-eic-prop-l

Indico:

<https://indico.bnl.gov/category/339/>

ECCE Consortium



Website:

<https://www.ecce-eic.org/>

Mailing Lists:

<https://lists.bnl.gov>

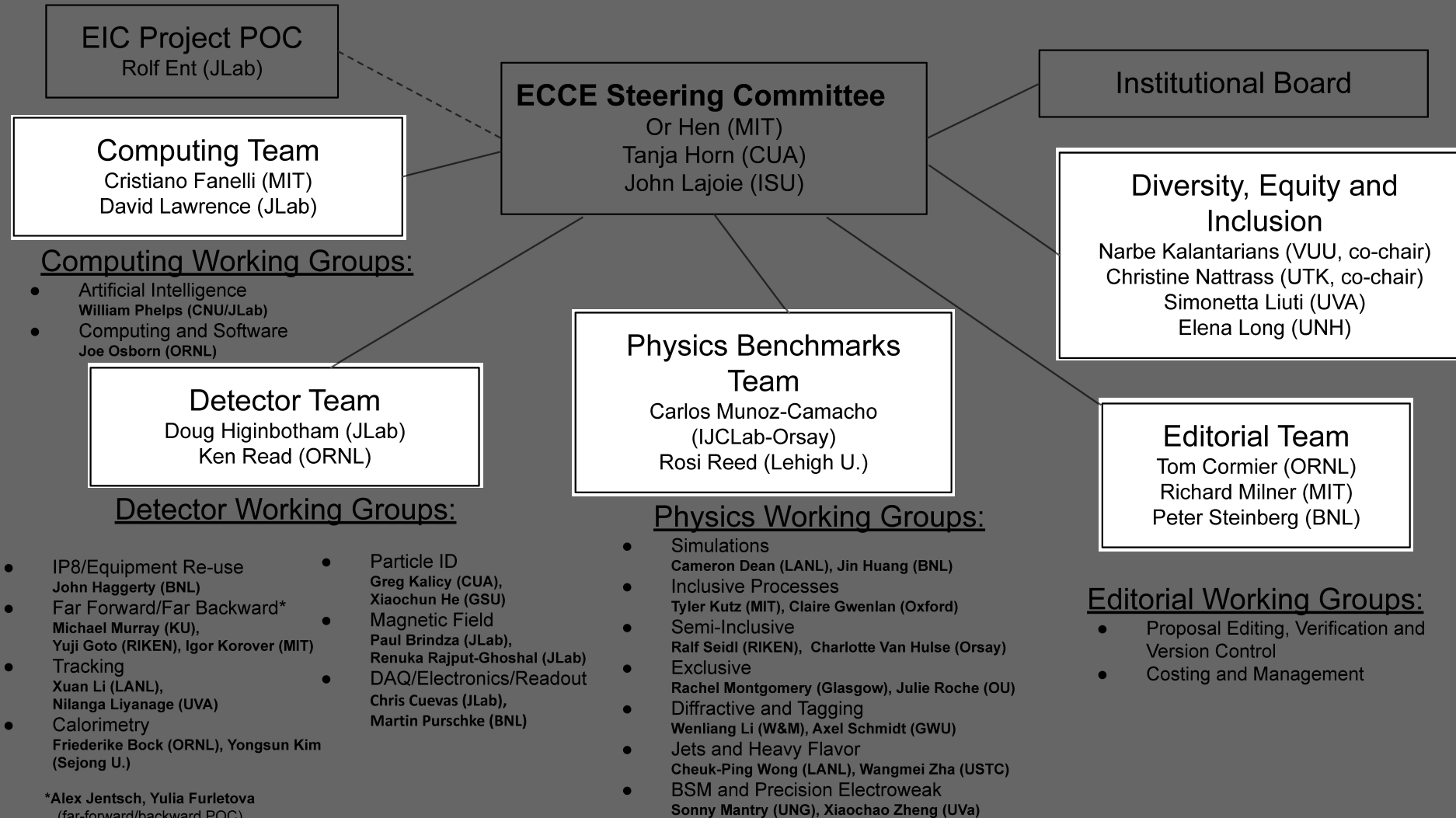
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- ecce-eic-dei-l
- ecce-eic-det-l
- ecce-eic-phys-l
- ecce-eic-prop-l

Indico:

<https://indico.bnl.gov/category/339/>

*Alex Jentsch, Yulia Furletova
(far-forward/backward POC)

ECCE Consortium



Website:

<https://www.ecce-eic.org/>

Mailing Lists:

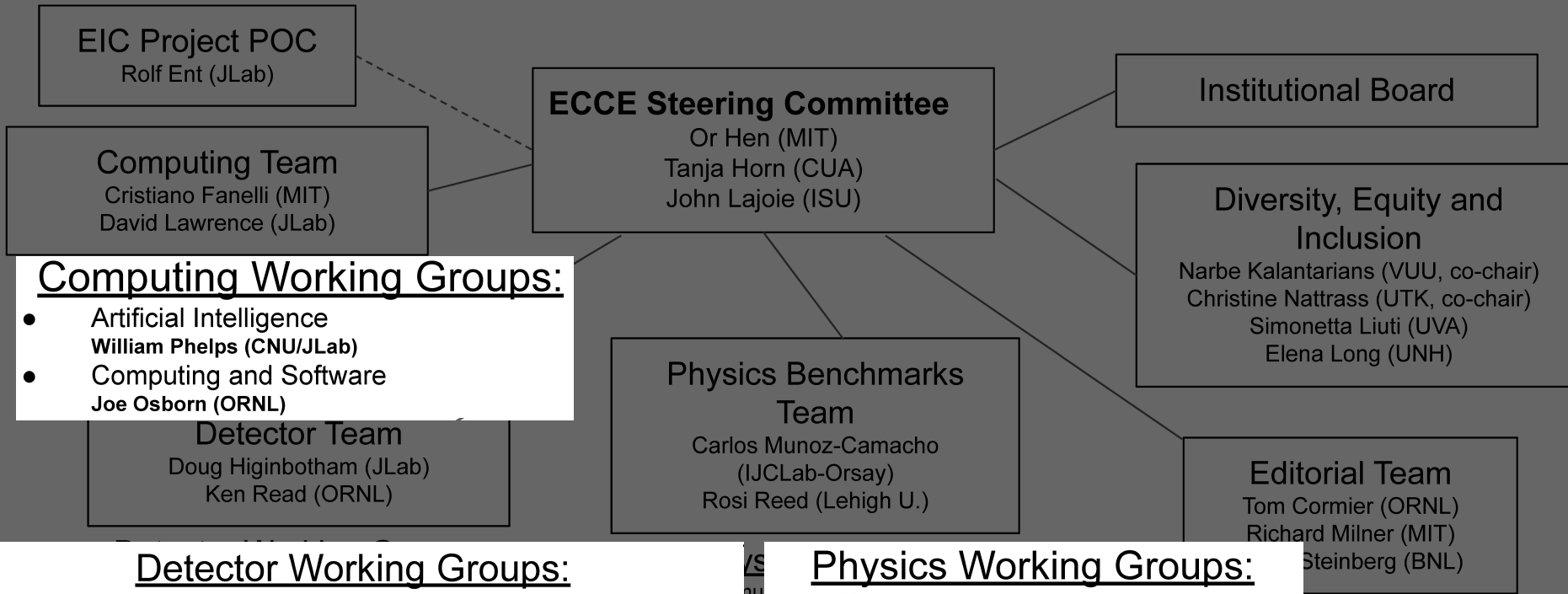
<https://lists.bnl.gov>

- ecce-eic-public-l
- ecce-eic-ib-l
- ecce-eic-dei-l
- ecce-eic-det-l
- ecce-eic-phys-l
- ecce-eic-prop-l

Indico:

<https://indico.bnl.gov/category/339/>

ECCE Consortium



Computing Working Groups:

- Artificial Intelligence
William Phelps (CNU/JLab)
- Computing and Software
Joe Osborn (ORNL)

Detector Team

Doug Higinbotham (JLab)
Ken Read (ORNL)

Detector Working Groups:

- | | |
|--|--|
| <ul style="list-style-type: none"> • IP8/Equipment Re-use
John Haggerty (BNL) • Far Forward/Far Backward*
Michael Murray (KU),
Yuji Goto (RIKEN), Igor Korover (MIT) • Tracking
Xuan Li (LANL),
Nilanga Liyanage (UVA) • Calorimetry
Friederike Bock (ORNL), Yongsun Kim (Sejong U.) | <ul style="list-style-type: none"> • Particle ID
Greg Kalicy (CUA),
Xiaochun He (GSU) • Magnetic Field
Paul Brindza (JLab),
Renuka Rajput-Ghoshal (JLab) • DAQ/Electronics/Readout
Chris Cuevas (JLab),
Martin Purschke (BNL) |
|--|--|

*Alex Jentsch, Yulia Furletova
(far-forward/backward POC)

Physics Working Groups:

- Simulations
Cameron Dean (LANL), Jin Huang (BNL)
- Inclusive Processes
Tyler Kutz (MIT), Claire Gwenlan (Oxford)
- Semi-Inclusive
Ralf Seidl (RIKEN), Charlotte Van Hulse (Orsay)
- Exclusive
Rachel Montgomery (Glasgow), Julie Roche (OU)
- Diffractive and Tagging
Wenliang Li (W&M), Axel Schmidt (GWU)
- Jets and Heavy Flavor
Cheuk-Ping Wong (LANL), Wangmei Zha (USTC)
- BSM and Precision Electroweak
Sonny Mantry (UNG), Xiaochao Zheng (UVa)

Editorial Working Groups:

- Proposal Editing, Verification and Version Control
- Costing and Management

Website:

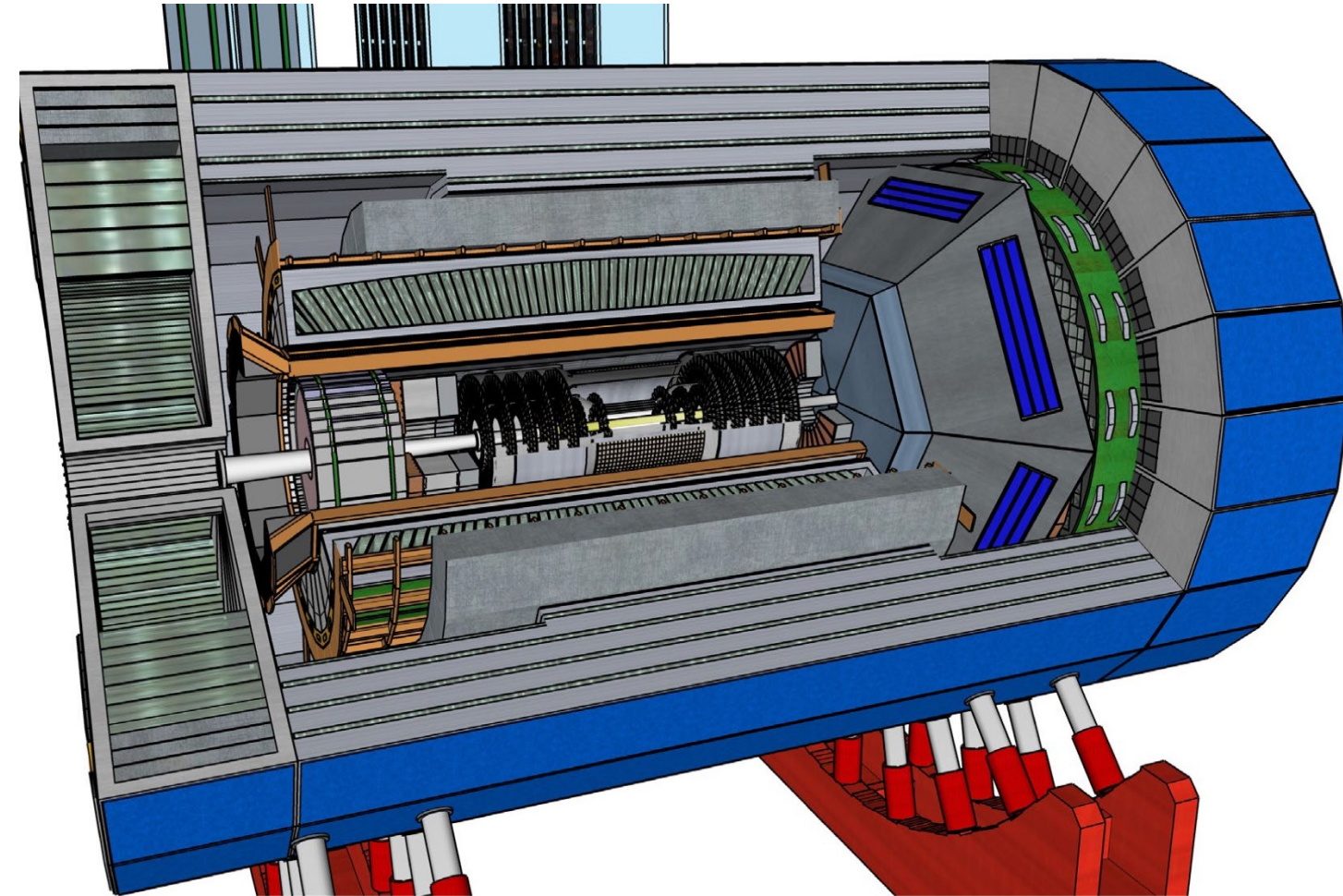
<https://www.ecce-eic.org/>

Mailing Lists:

<https://lists.bnl.gov>

- ecce-eic-public-l
- ecce-eic-ib-l
- ecce-eic-dei-l
- ecce-eic-det-l
- ecce-eic-phys-l
- ecce-eic-prop-l

◡◡◡◡◡ Detector Layout



ELECTRON ENDCAP

Tracking: Si discs + Large area μ RWELL

Electron Detection:

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

h-PID: mRICH & AC-LGAD

HCAL: Fe/Sc (STAR re-use)

CENTRAL BARREL

Tracking: MAPS Si + μ RWELL
(design under optimization)

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

h-PID: hpDIRC & AC-LGAD

HCAL: Fe/Sc (sPHENIX re-use)

HADRON ENDCAP

Tracking: Si discs + Large area μ RWELL

PID: dual-RICH & AC-LGAD

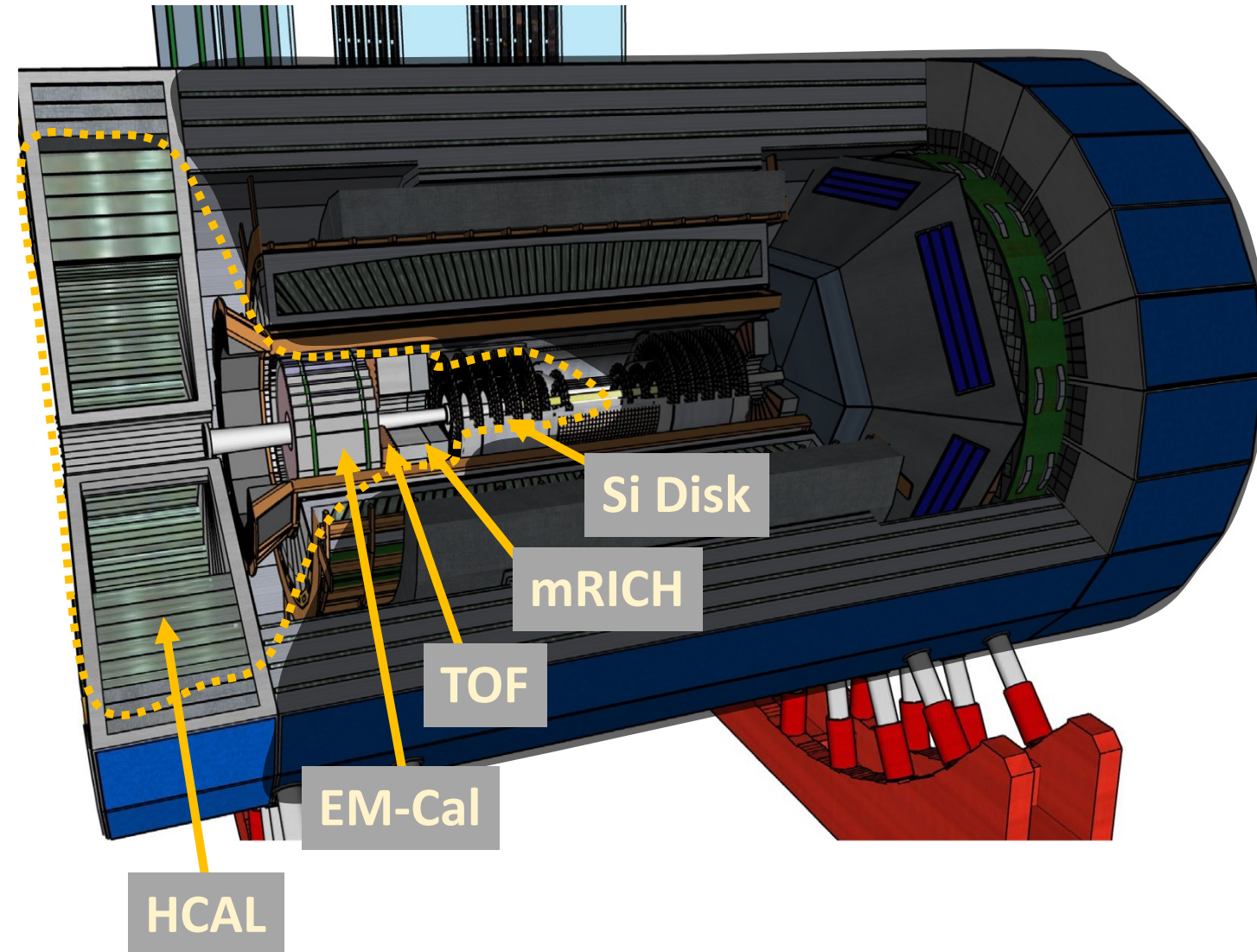
Calorimetry:

Standard Pb/ScFi shashlik (PHENIX re-use)

Long. sep. HCAL

(other options under study)

☺☺☺☺☺ Detector Layout



ELECTRON ENDCAP

Tracking: Si discs + Large area μ RWELL

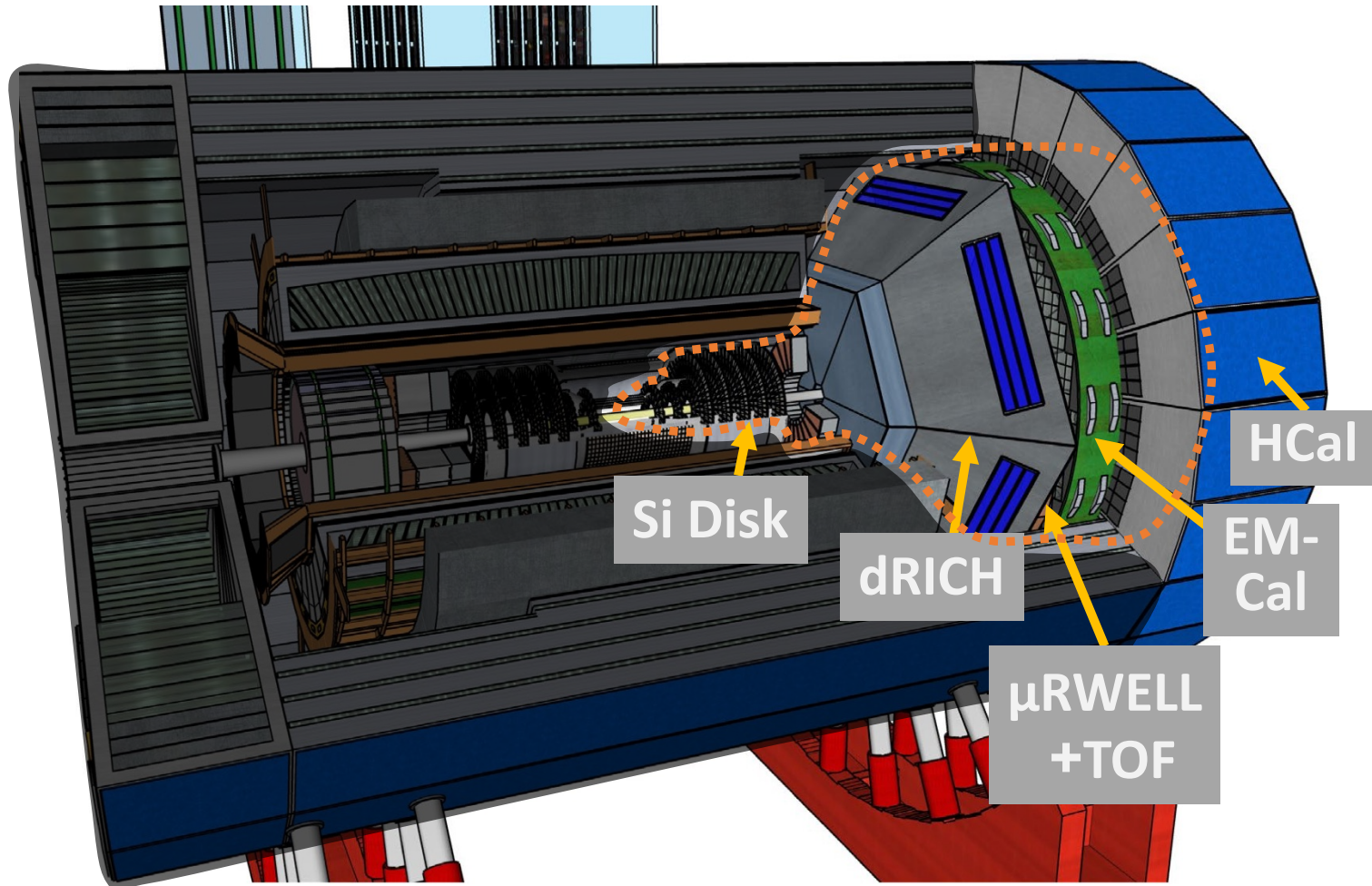
Electron Detection:

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

h-PID: mRICH & AC-LGAD

HCAL: Fe/Sc (STAR re-use)

◡◡◡◡◡ Detector Layout



HADRON ENDCAP

Tracking: Si discs + Large area μ RWELL

PID: dual-RICH & AC-LGAD

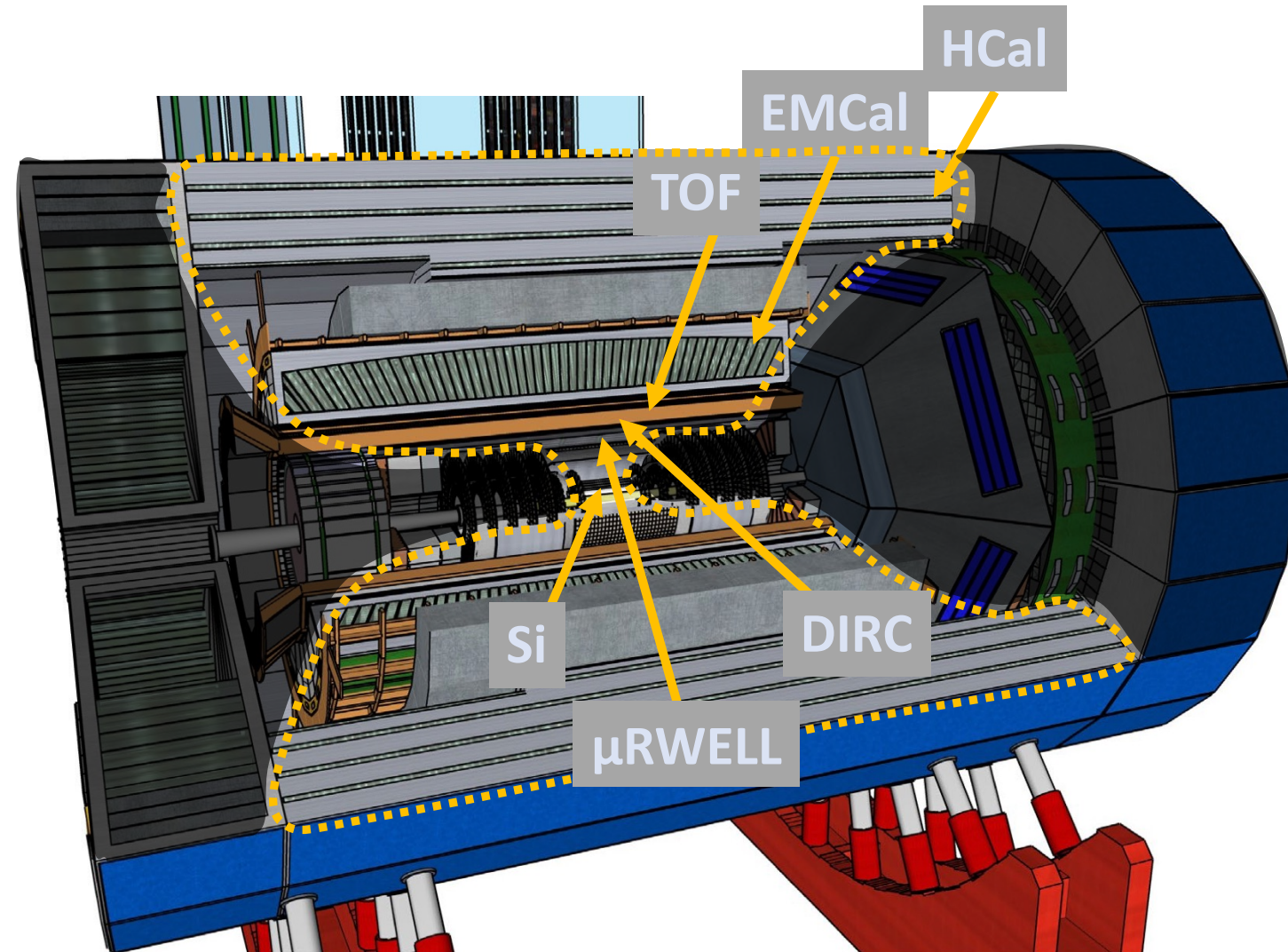
Calorimetry:

standard Pb/ScFi shashlik (PHENIX re-use)

long. sep. HCal

(other options under study)

☺☺☺☺☺ Detector Layout



CENTRAL BARREL

Tracking: MAPS Si + μ RWELL

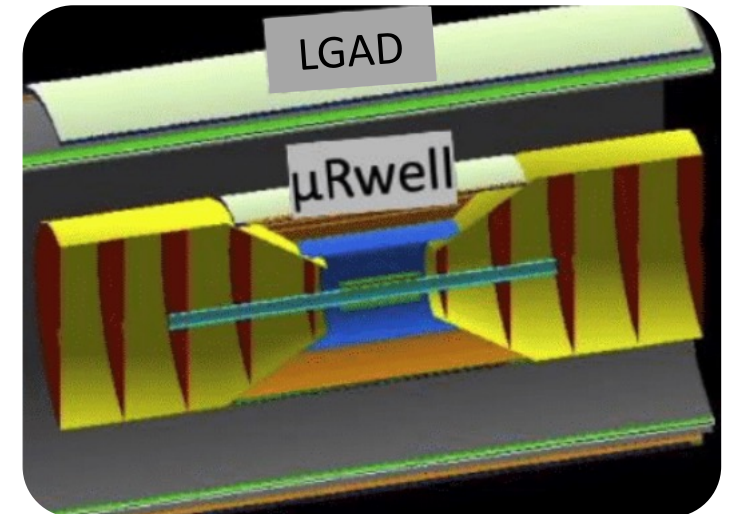
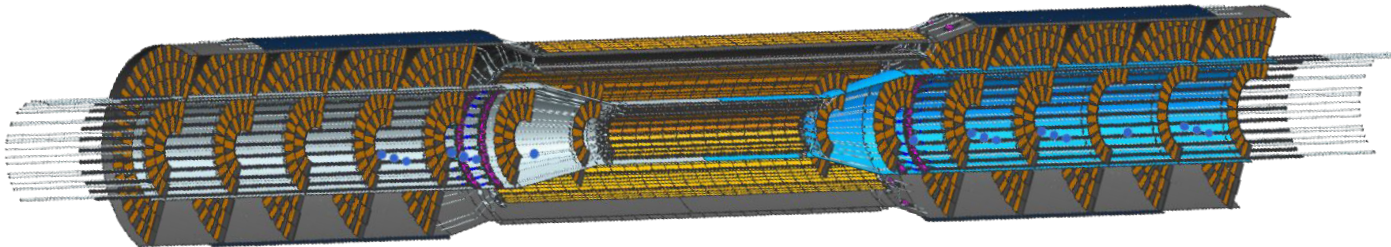
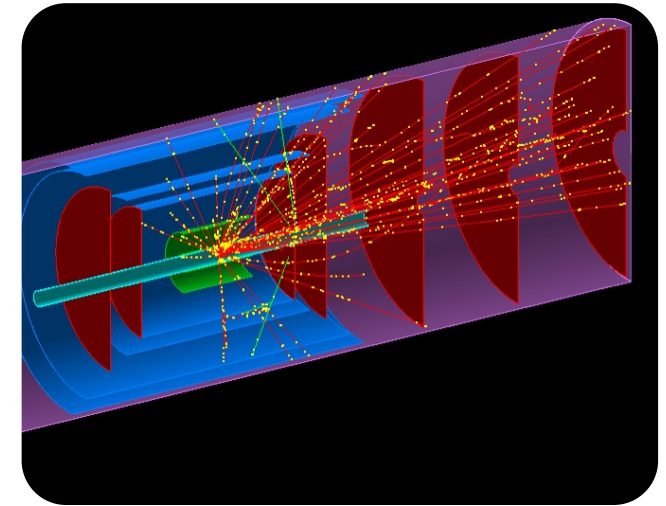
Electron PID: SciGlass (alt: PbGl or W(Pb)/Sc shashlik)
(plus instrumented frame)

h-PID: hpDIRC & AC-LGAD

HCAL: Fe/Sc (sPHENIX re-use)

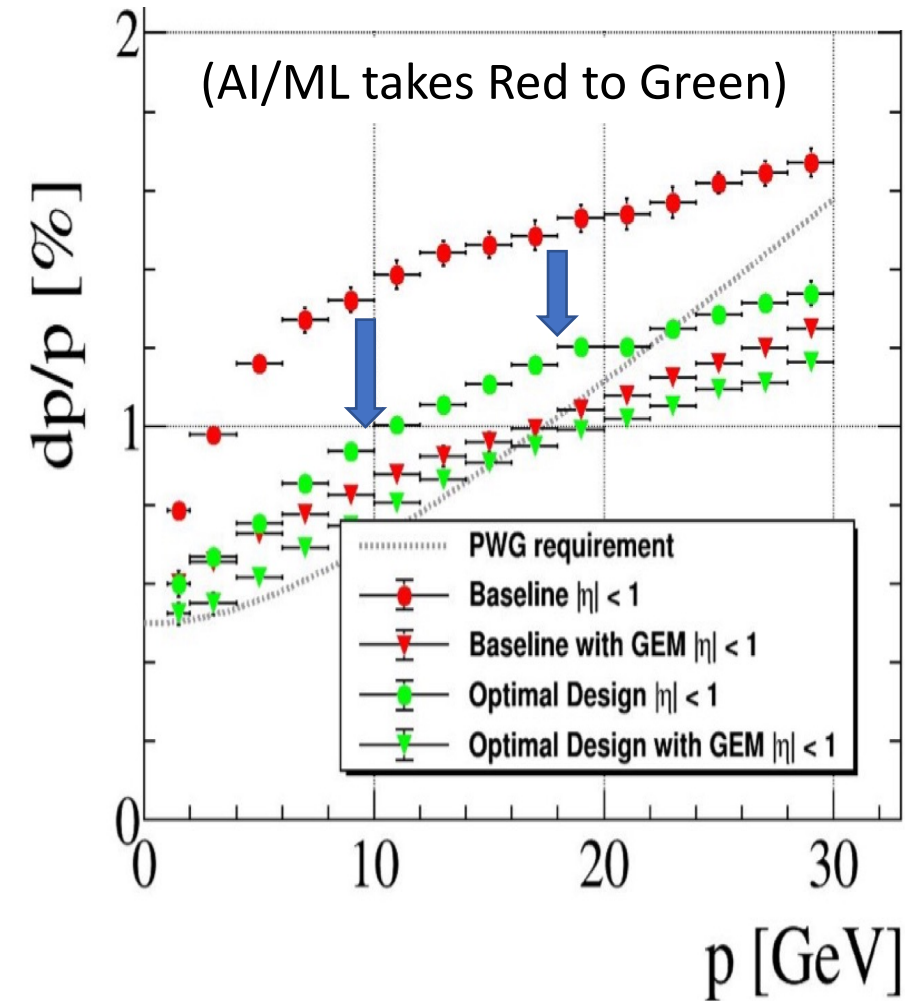
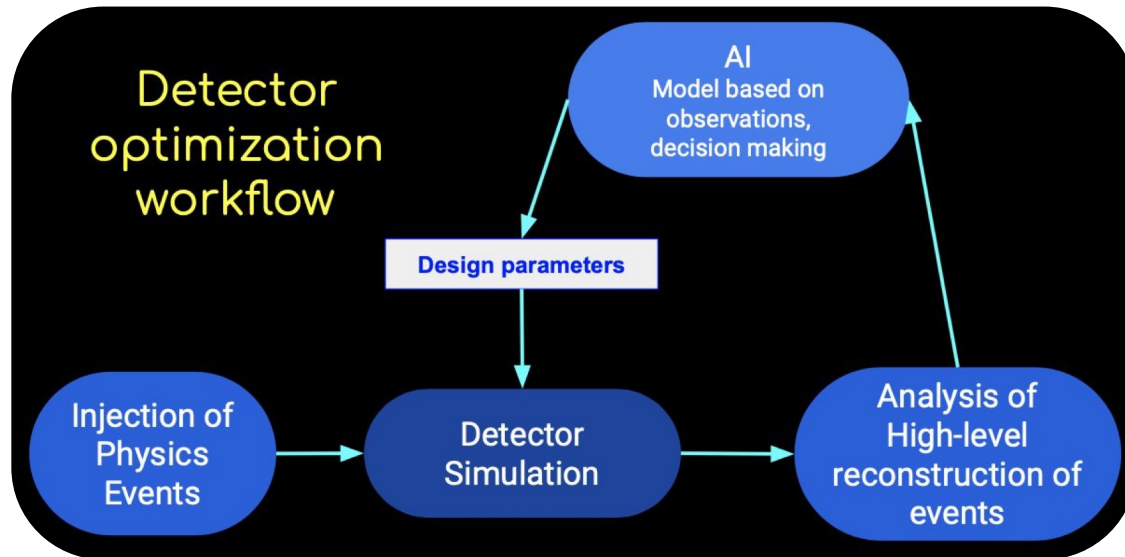
Tracking

- Baseline Layout:
 - Barrel: Silicon tracker (2 double layers) + AC-LGADS & μ RWELL around DIRC
 - Endcaps: Silicon disks + AC-LGADS & μ RWell around calorimeters
- AI/ML pipeline for optimizing tracker design



Tracking + AI

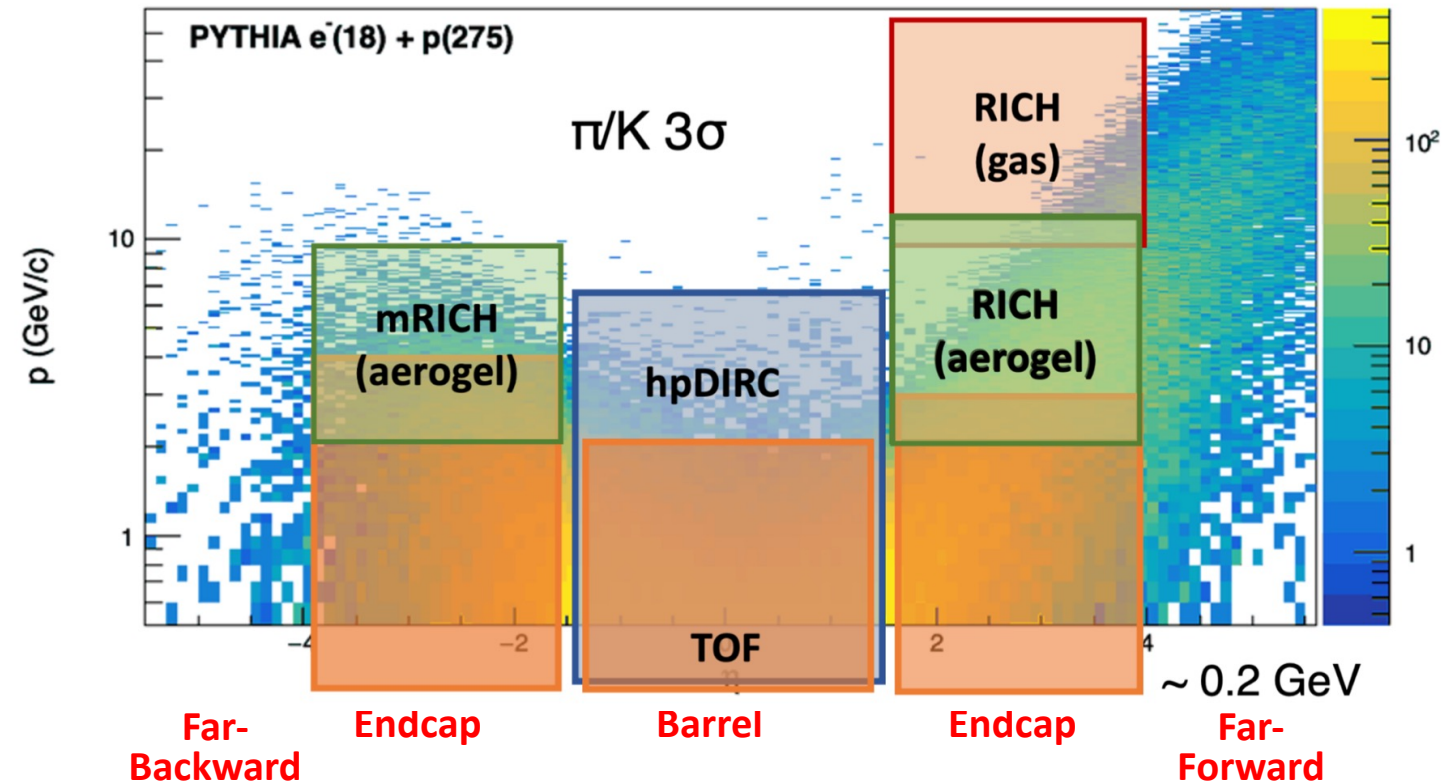
Multidimensional tradeoff optimization for multiple criteria (momentum, angle & pointing res., reconstruction efficiency, ...)



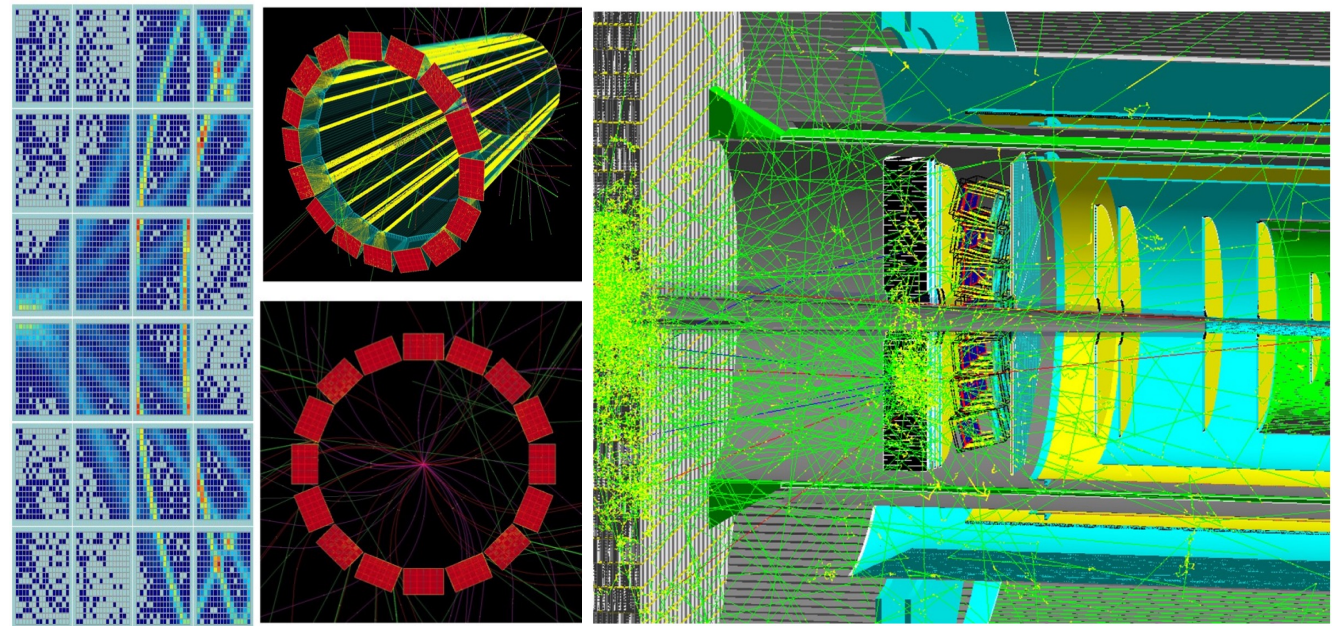
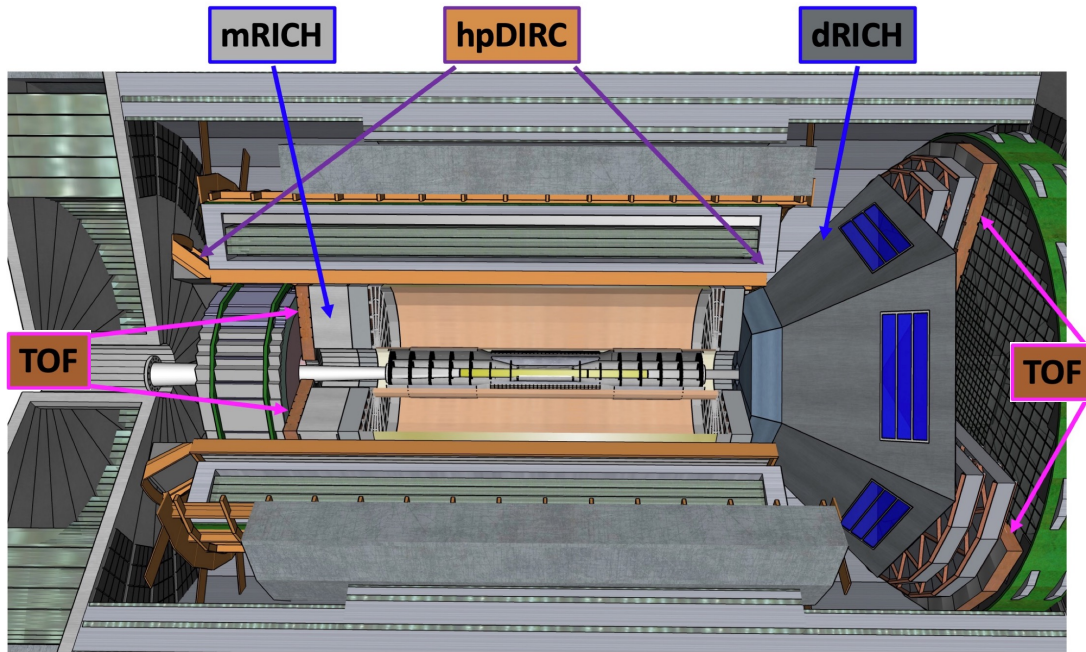
CCCE PID

- Largely based on YR studies
- Combination of Cerenkov, Calorimetry & TOF
- Full G4 Implementation
 - ⇒ Performance studies underway
 - ⇒ Optimizing TOF

(AI/ML optimization here as well!)



CCCE PID



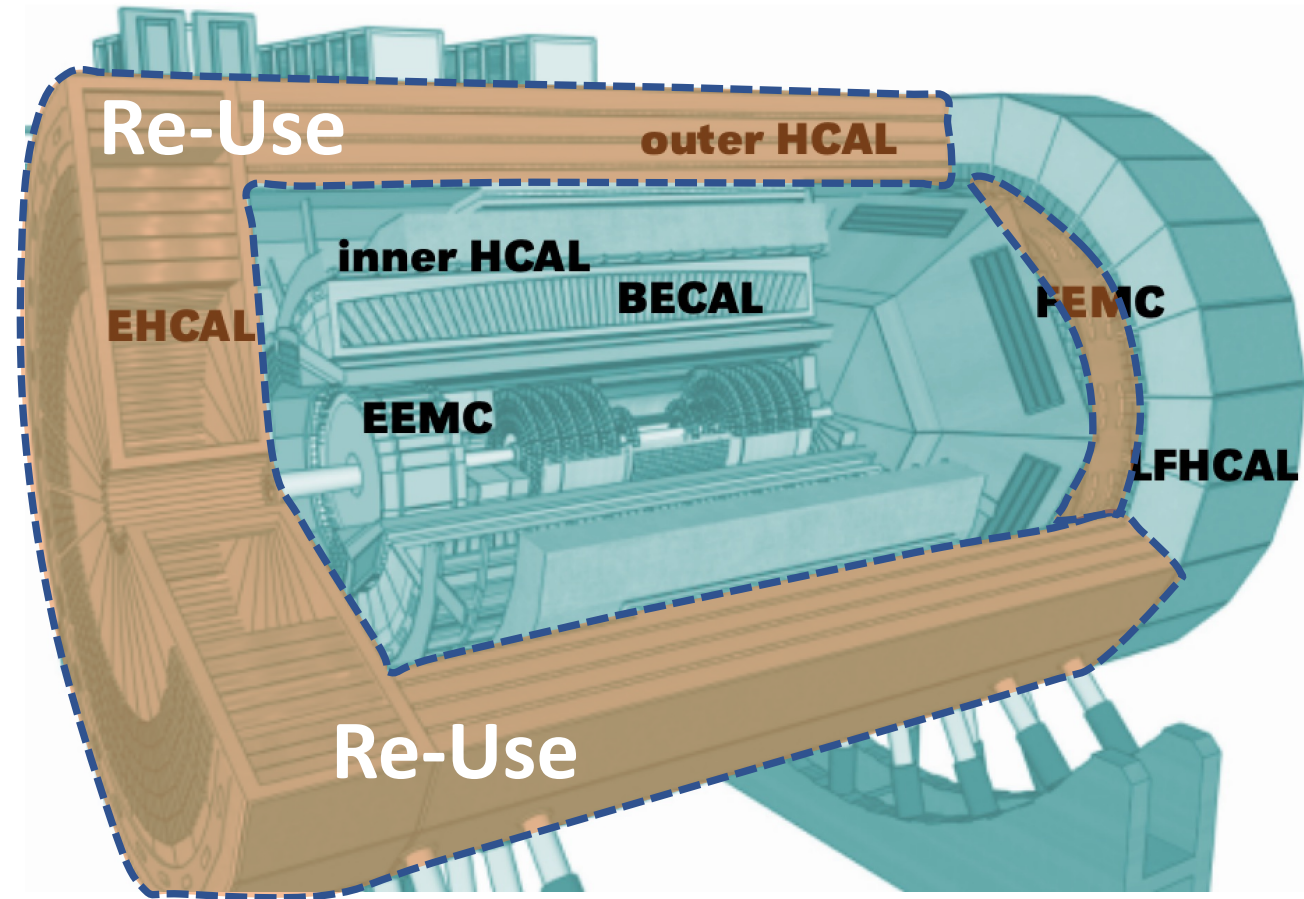
Calorimetry

Re-use:

- STAR forward & sPHENIX outer HCal
- Re-use PHENIX Shalikh EMCal (\w upgraded readout)

New:

- Homogenous EMCal (SciGlass)
- Inner Hcal (barrel EMCal support frame)
- Backward EMCal (PbWO₄ + SciGlass)
- Longitudinally separated forward HCal
[Alt / upgrade: forward DREAM Cal]



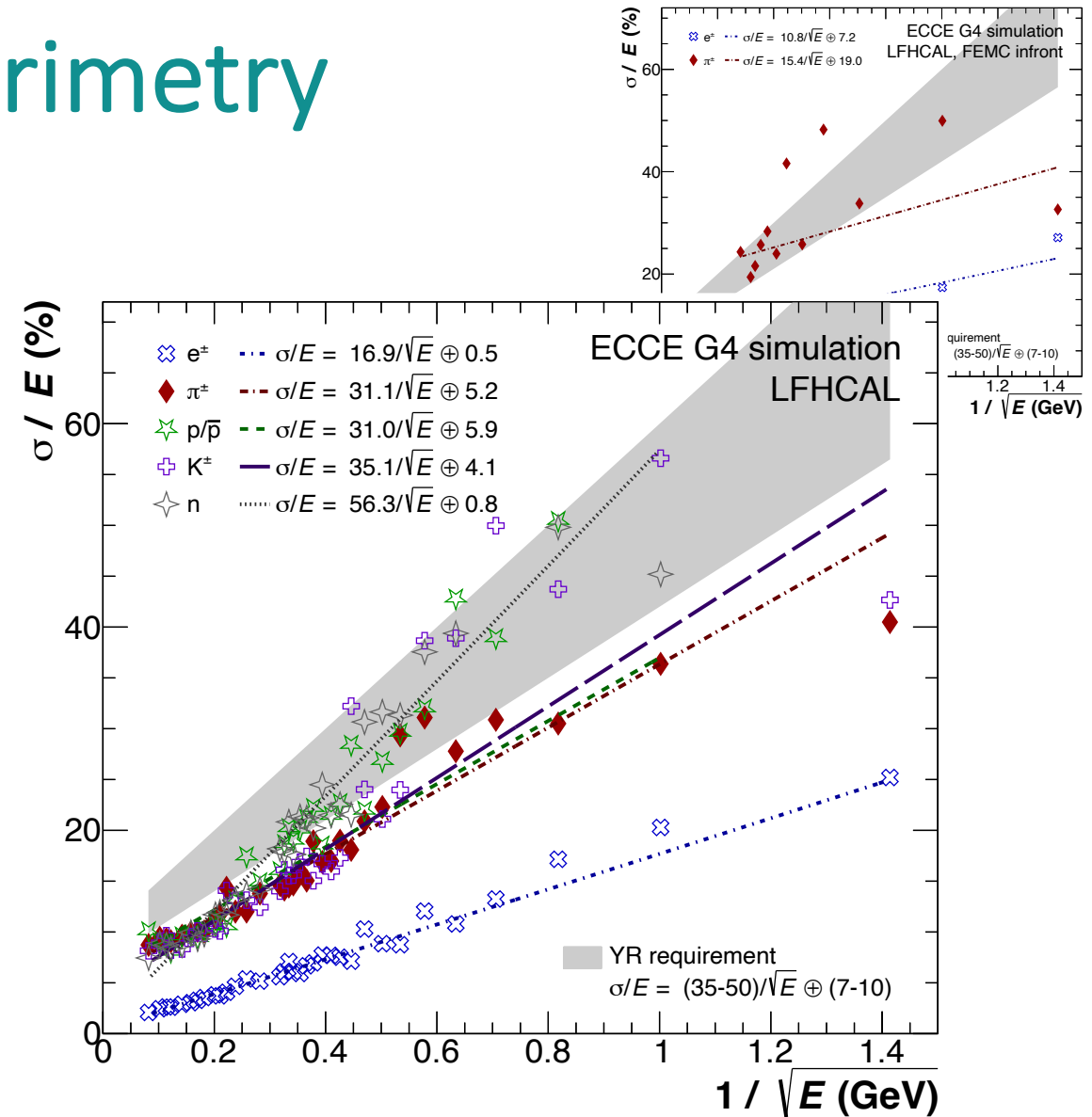
CCCE Calorimetry

Re-use:

- STAR forward & sPHENIX outer HCal
- Re-use PHENIX Shalik EMCal (\w upgraded readout)

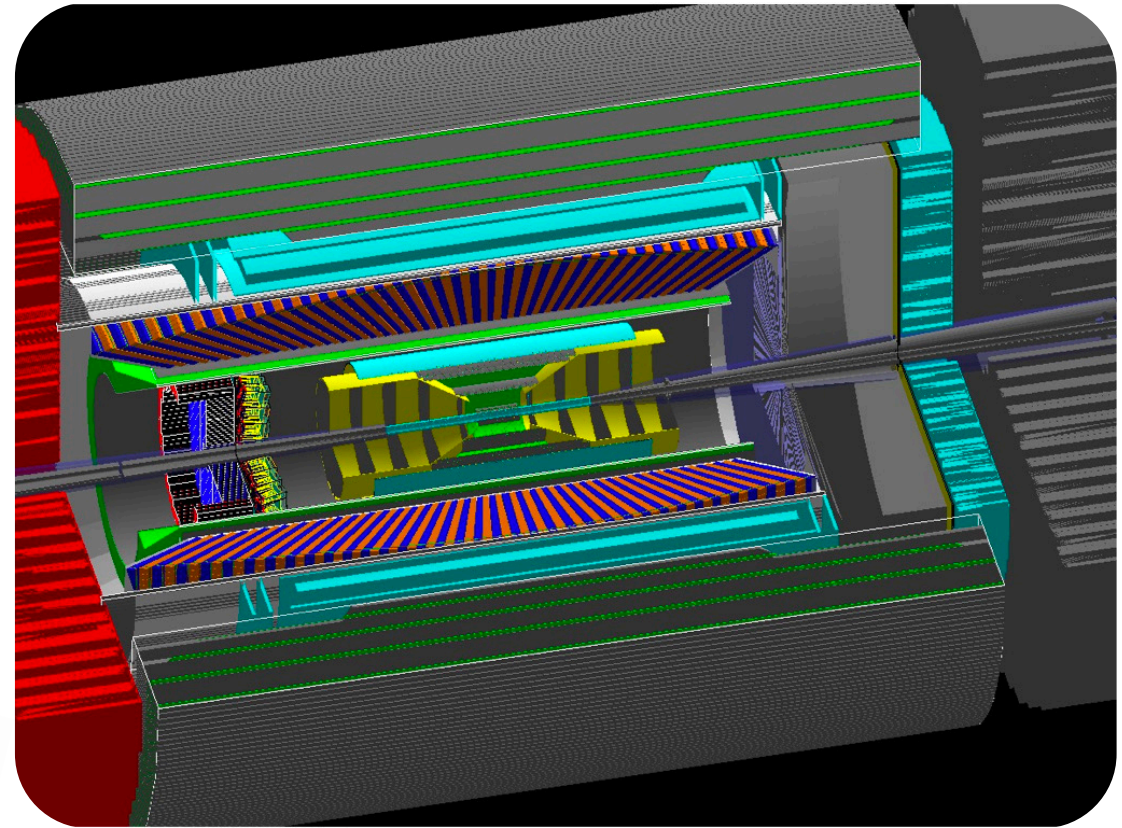
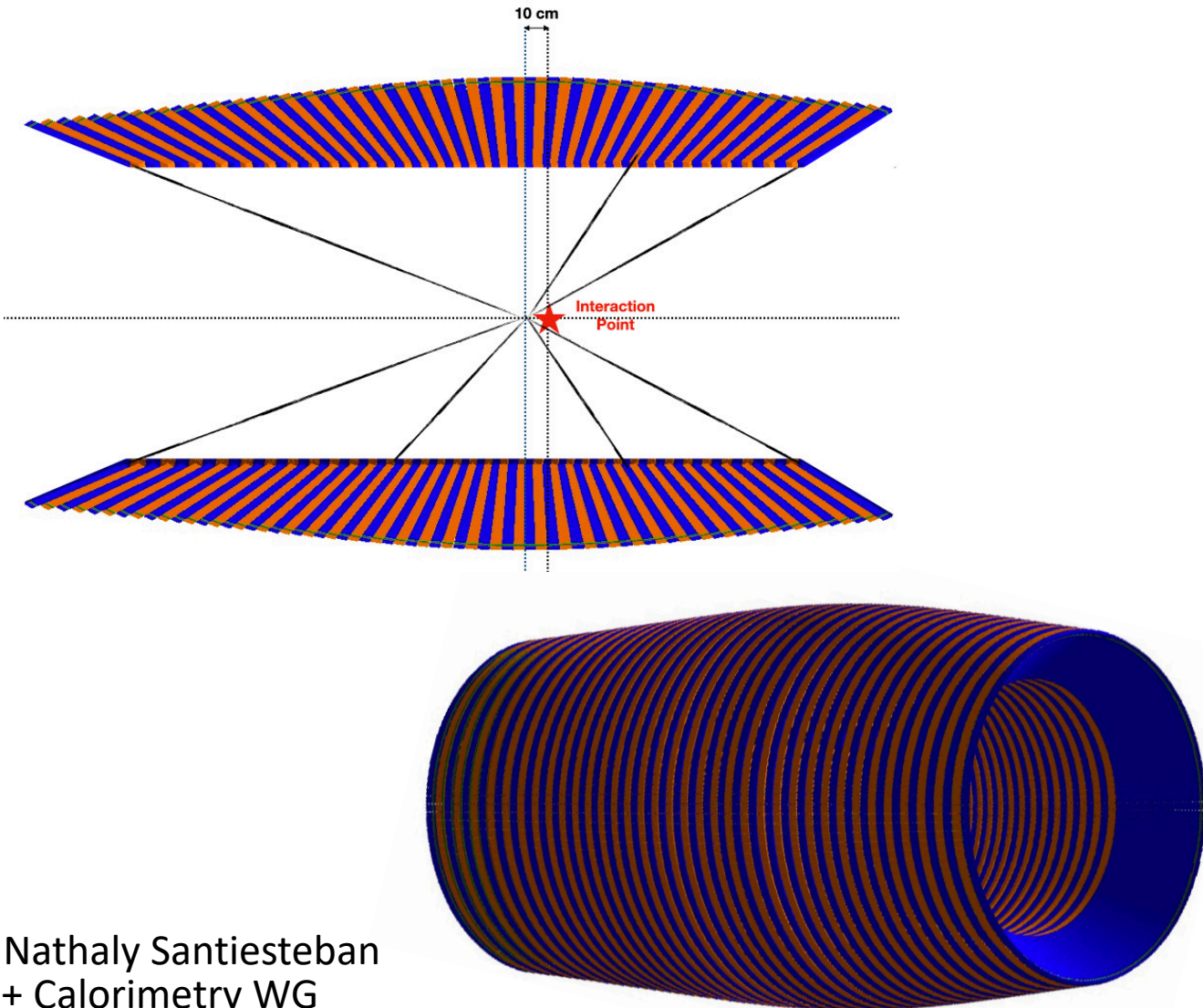
New:

- Homogenous EMCal (SciGlass)
 - Inner Hcal (barrel EMCal support frame)
 - Backward EMCal (PbWO₄ + SciGlass)
 - Longitudinally separated forward HCal
- [Alt / upgrade: forward DREAM Cal]



Calorimetry

Projective EM-Cal already implemented: ☺

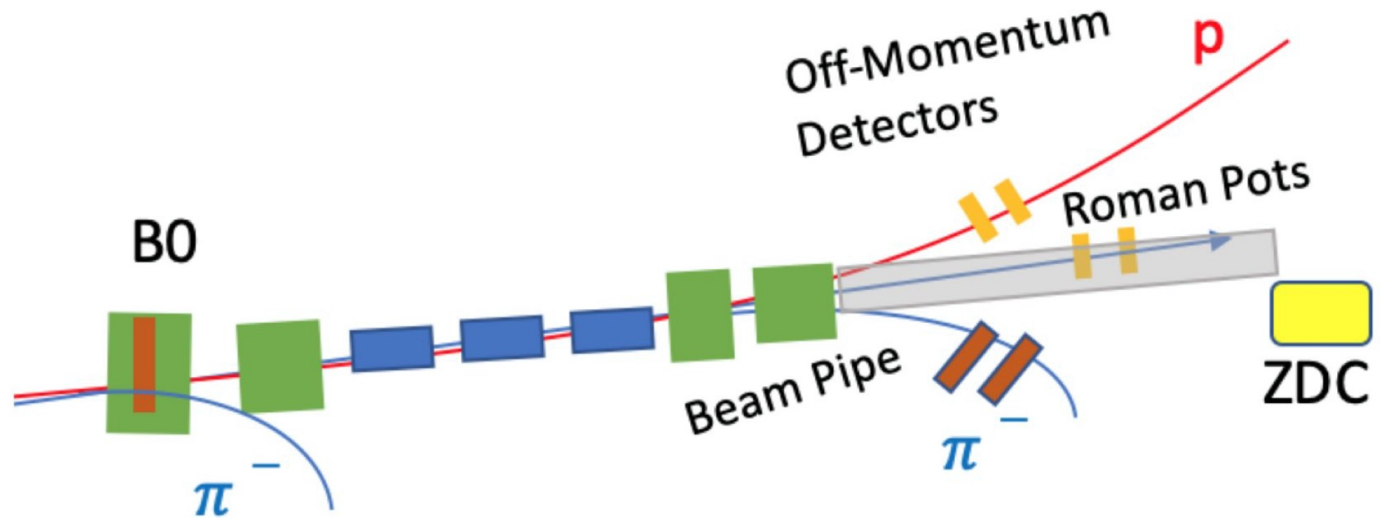


Far Forward / Back

FAR FORWARD DETECTORS

- ZDC – **Si/W & PWO (SciGlass)**
- Roman Pots – **Silicon sensors, AC-LGADs**
- Off-momentum det. – **Silicon sensors**
- B0-trackers – **MAPS & timing layers**

Lepton polarimetry
hadron polarimetry

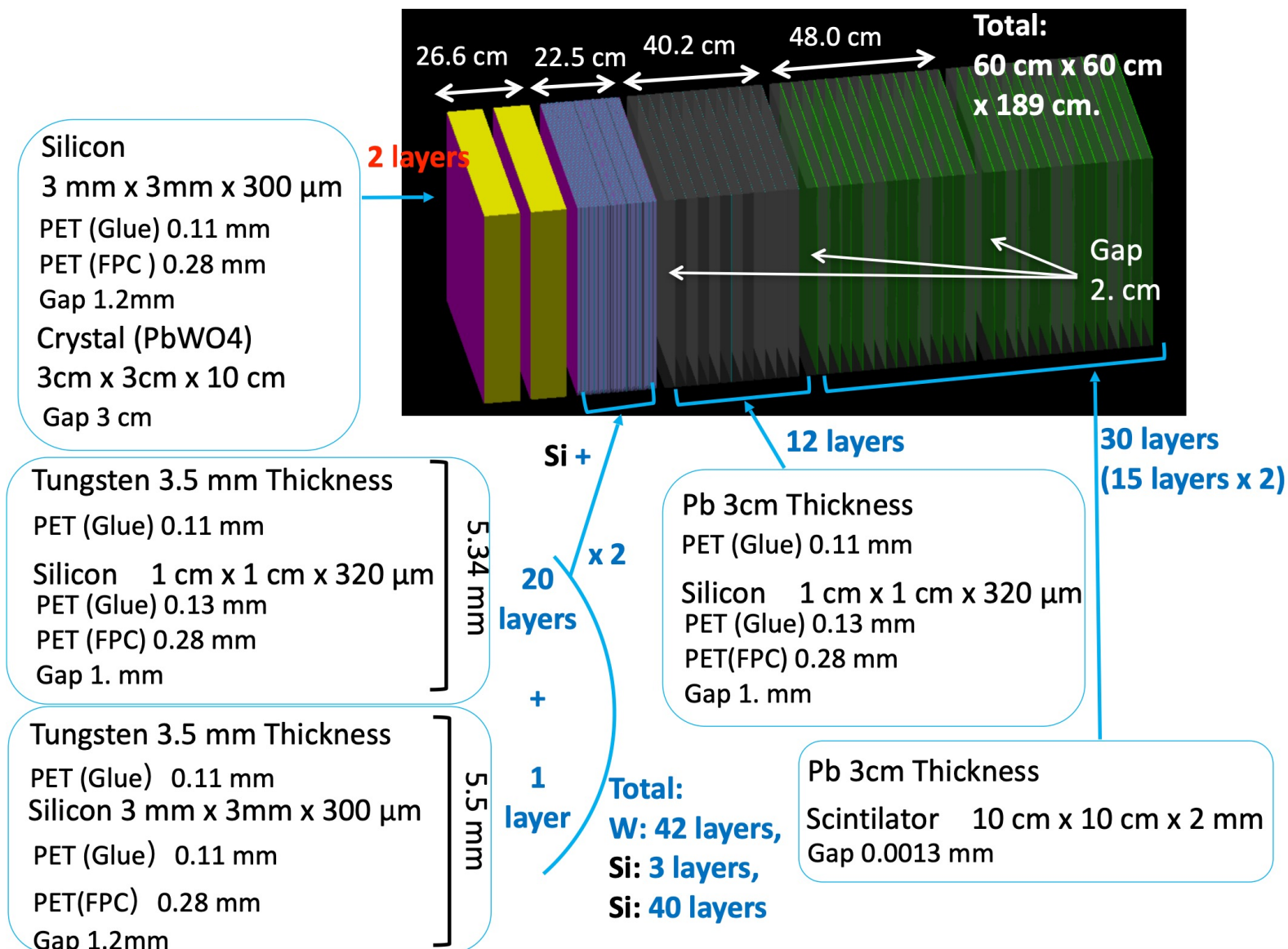


FAR BACKWARD DETECTORS

- low- Q^2 tagger
 - Lumi-detector
- Lepton polarimetry
hadron polarimetry

Participating in coordinated meetings between all proto-collaborations, organized by EIC PM.

ZDC Example



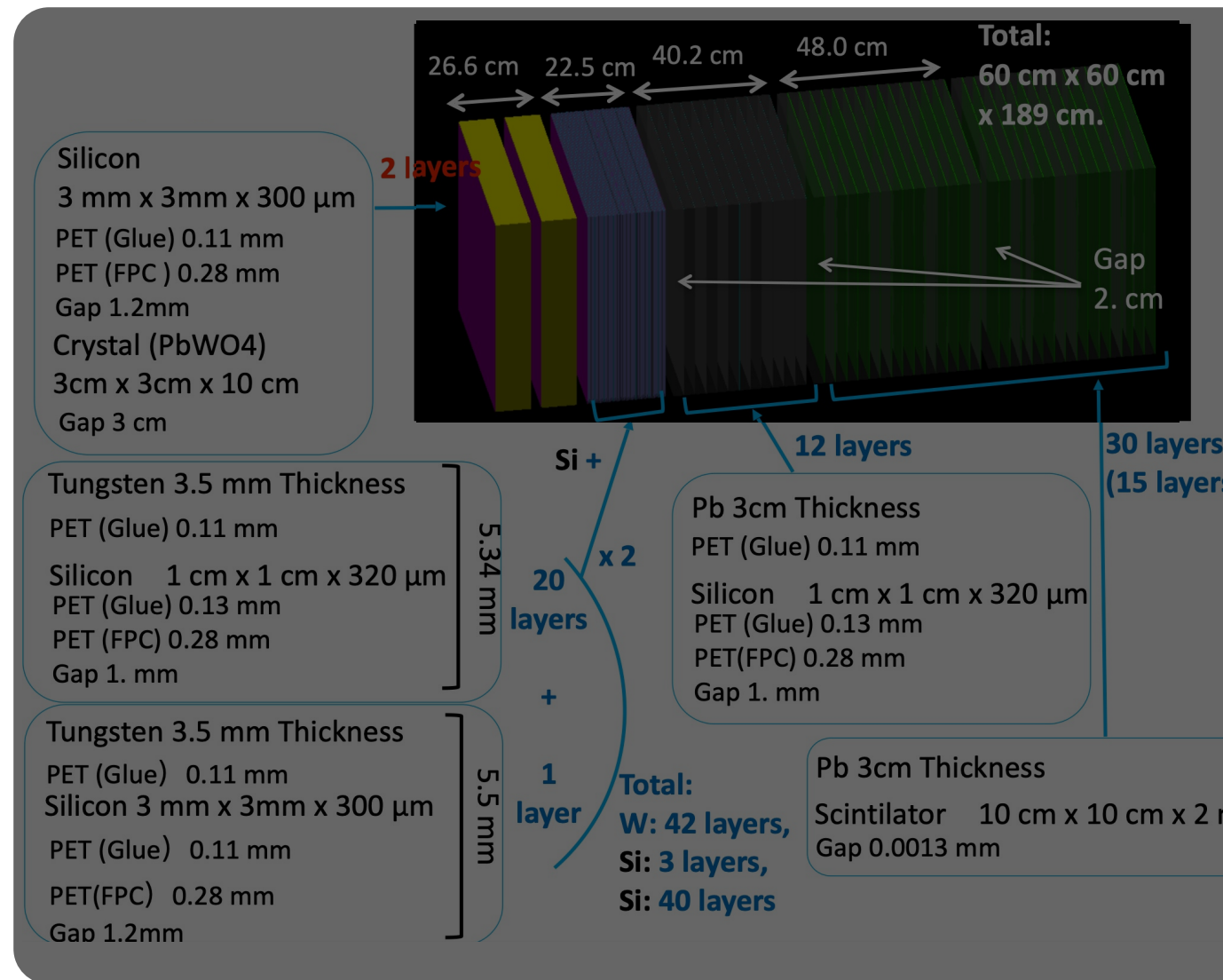
ZDC Example

Optimizing for:

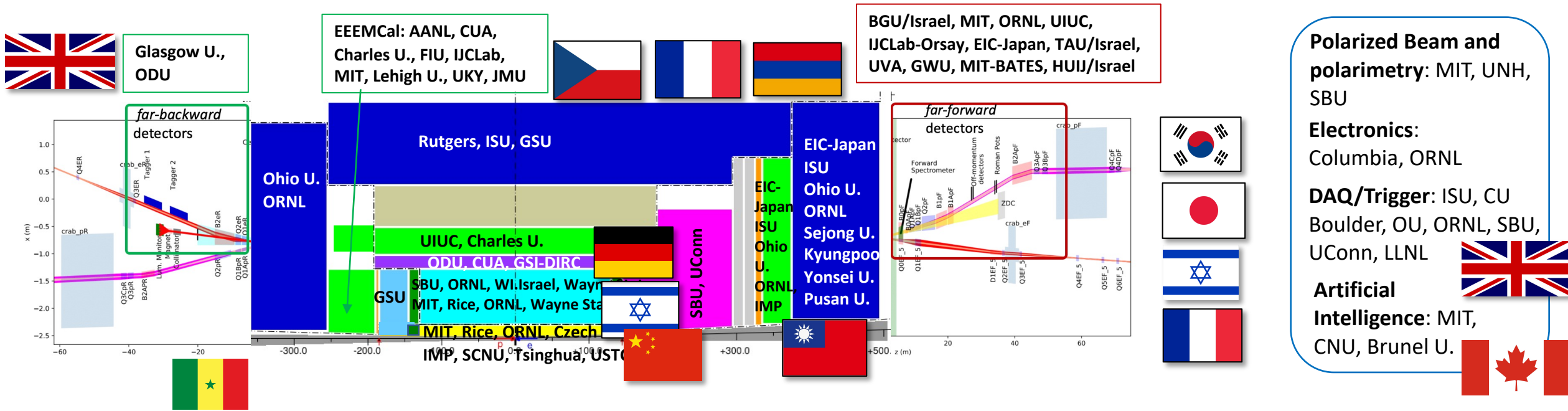
- Neutron / photon separation
- Energy reconstruction
- Position resolution

Recent improvements:

- Reduced Crystal size
($10 \times 2 \text{ cm}^2 \rightarrow 7 \times 2 \text{ cm}^2$)
- Reduced layers (W/Si, 42 \rightarrow 30)
- Adding charged particle veto



International Interests



CENTRAL

Tracking:

- Silicon: China, Czech Republic, Japan

Calorimetry

- PWO and SciGlass: Czech Republic, Armenia, France
- Forward Calo/Dual Readout: China, Japan, South Korea

Particle ID

- DIRC: GSI/Germany

FAR FORWARD – FAR BACKWARD

- Roman pots: France
- Off momentum: Israel
- ZDC: Japan
- Luminosity monitors: Israel
- Low Q2 tagger: UK

CCCE Mechanical Integration

Electron Endcap EMCal

- Initial concept (Josh Crafts, CUA)
- Frame & cooling system (IJCLab-Orsay)

DIRC

- Re-use concept (CUA, GSI)
- Support structure (GSI)

Barrel EMCal Support

- Various options EMCal (Josh Crafts, CUA)
- Impact on support structure and frame (MIT)

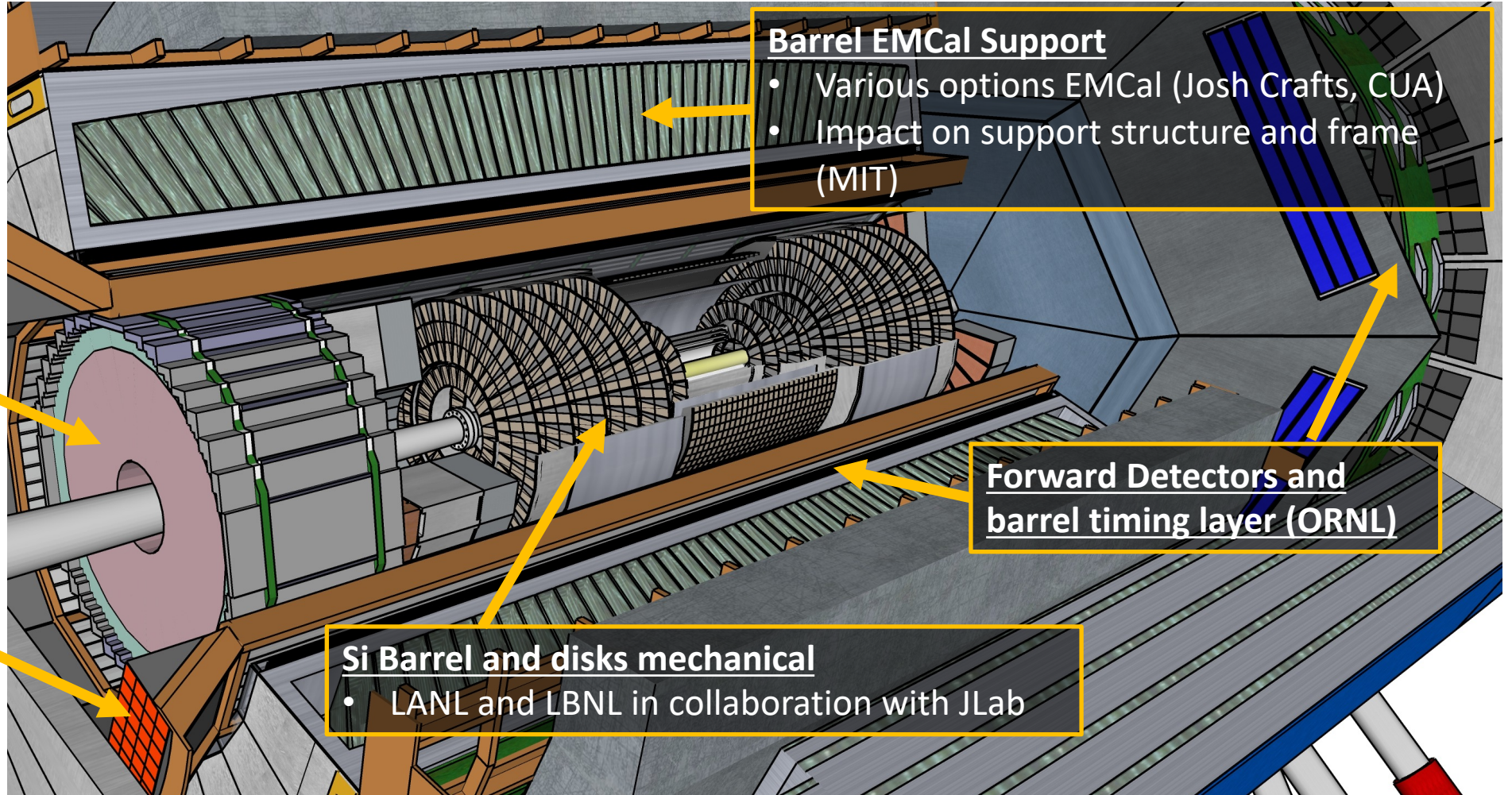
Forward Detectors and barrel timing layer (ORNL)

Si Barrel and disks mechanical

- LANL and LBNL in collaboration with JLab

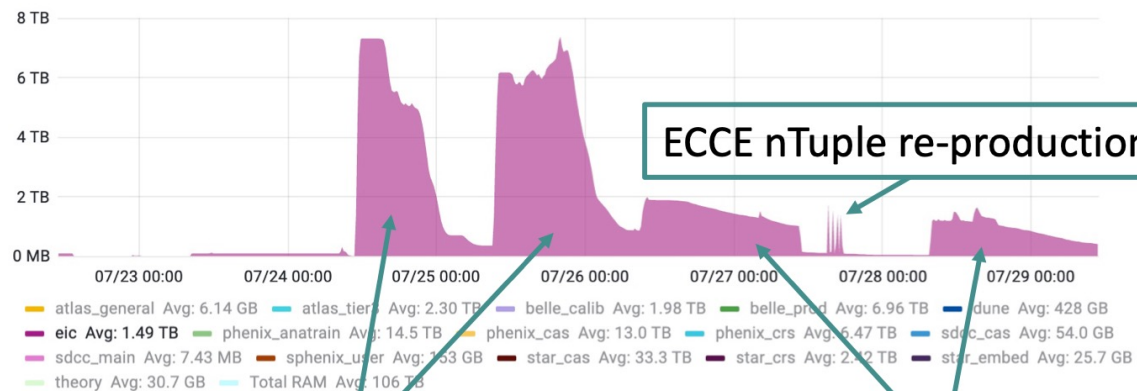
EIC Project :

- Barrel EMCal support & universal frame for DIRC, backward EMCal, mRICH, etc.
- Forward Hadron Calorimeter, with maintenance model (looking at similar for the backward HCal)



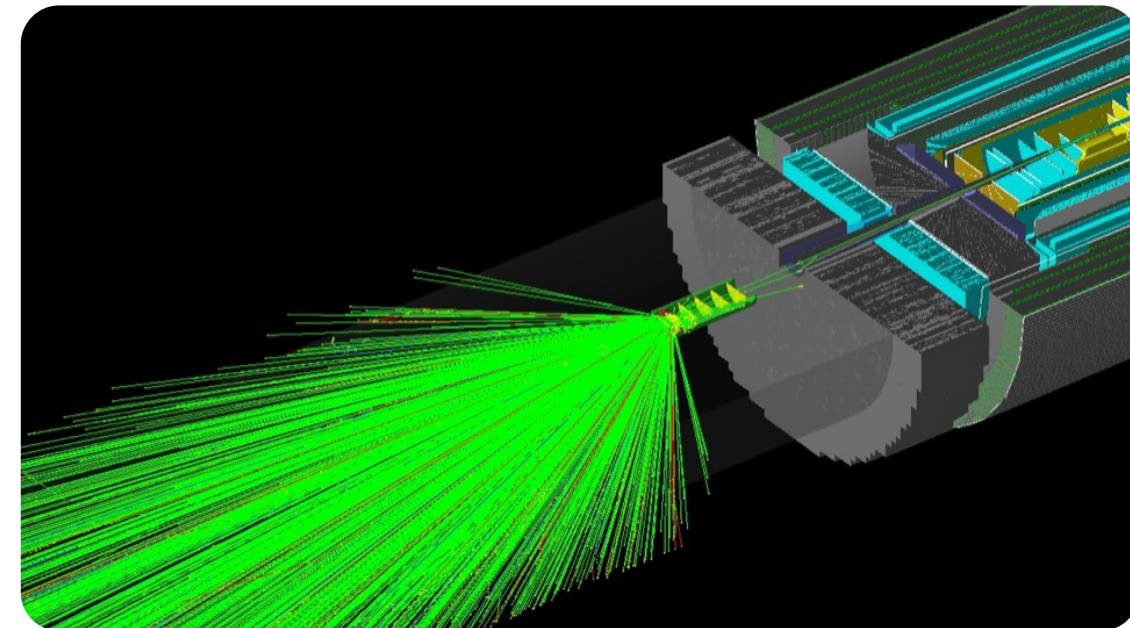
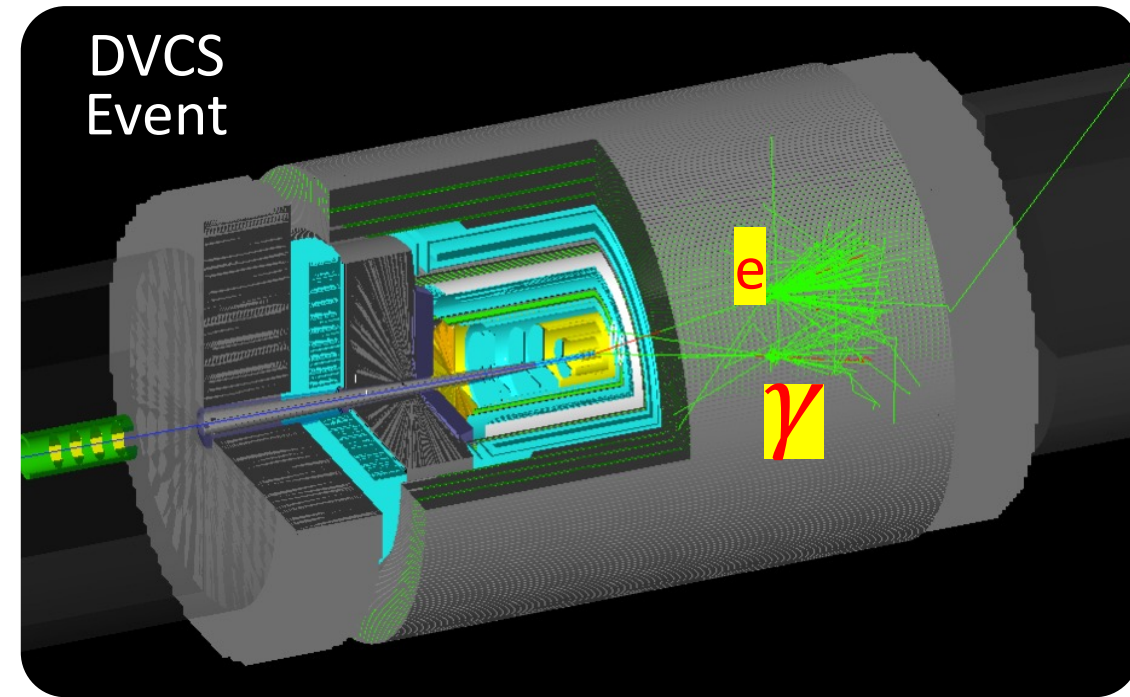
CCCE Geant Simulations

- Full implementation in Fun4All.
- Setup running on BNL, JLab, BATES, OSG
- Completed 1st large-scale campaign (particle gun + physics generators)
- *150M events on tape!*



Large event production for ECCE

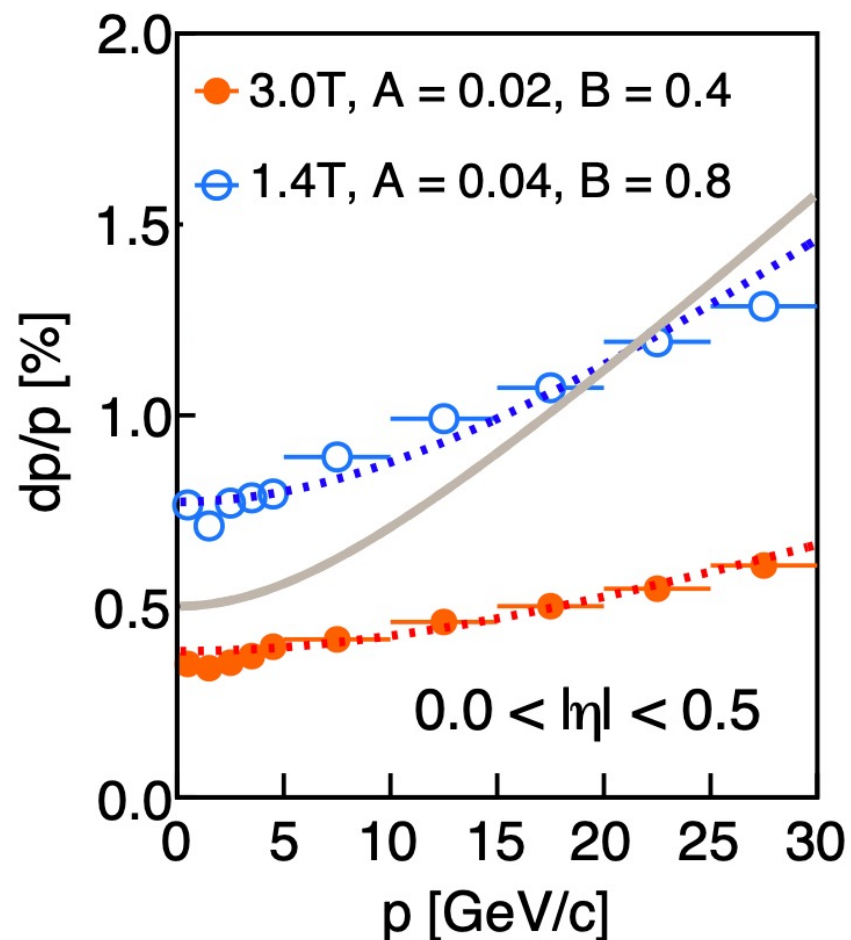
Not ECCE production



So... Can we do it with 1.5T?

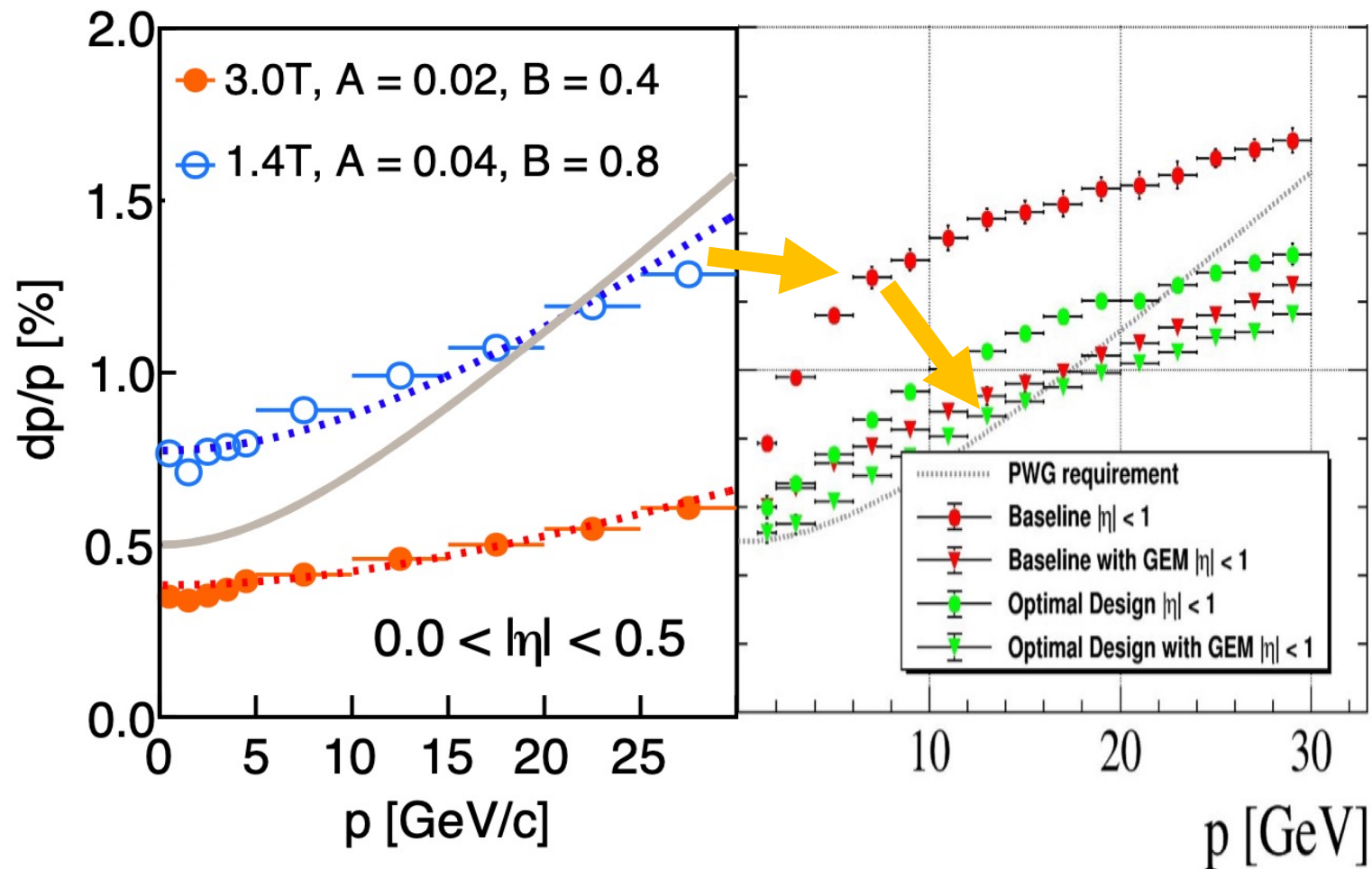
So... Can we do it with 1.5T?

YR was a great start...



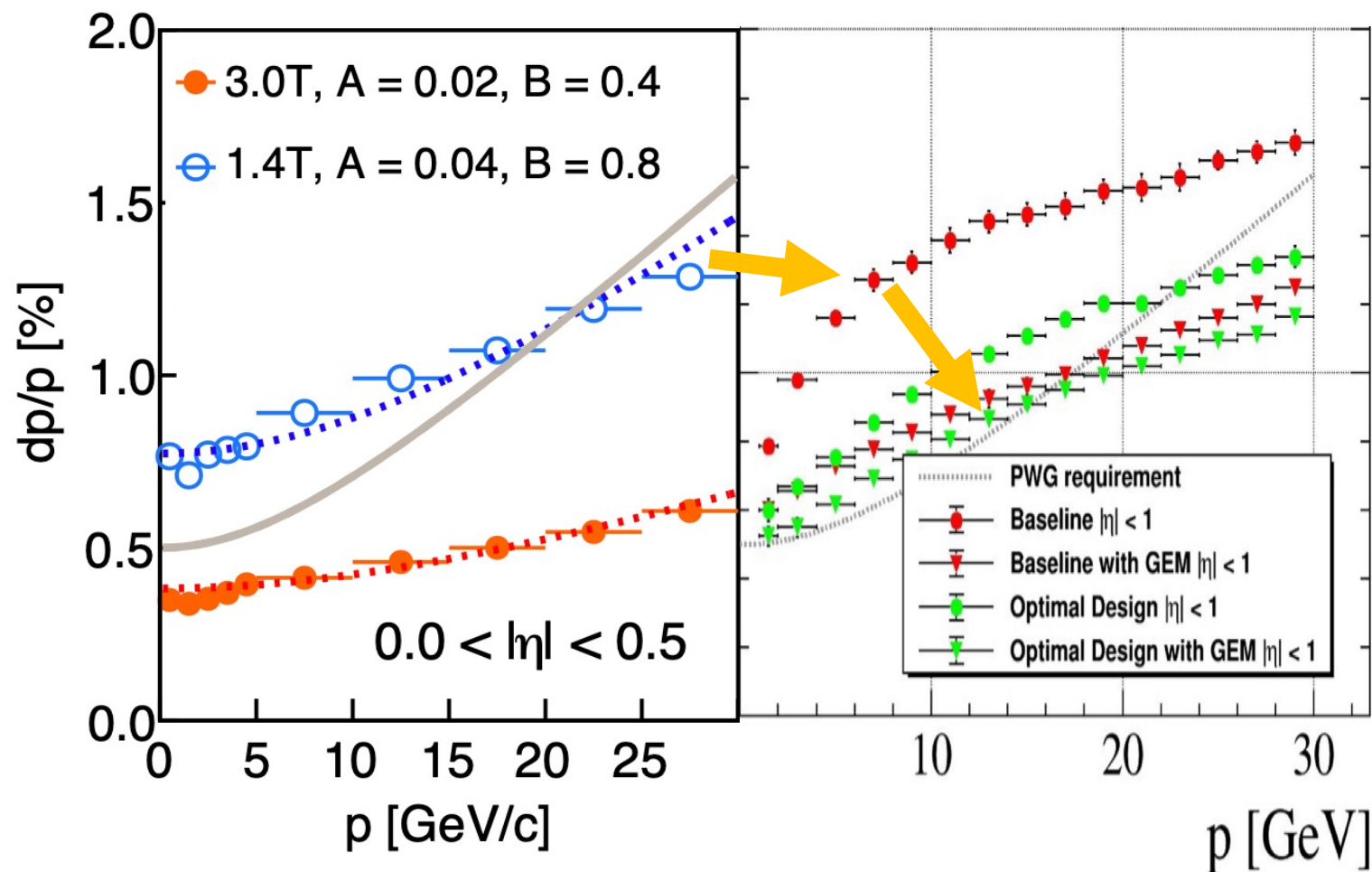
So... Can we do it with 1.5T?

YR was a great start... many developments since



So... Can we do it with 1.5T?

YR was a great start... many developments since

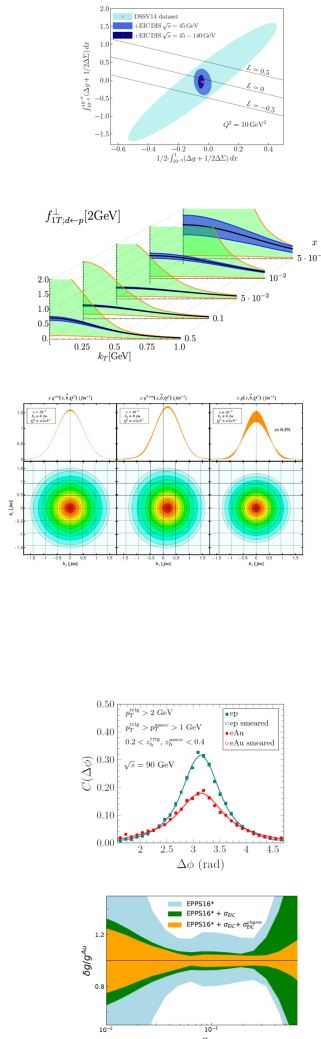


Getting close to YR specs

**Able to deliver
on NAS science!**

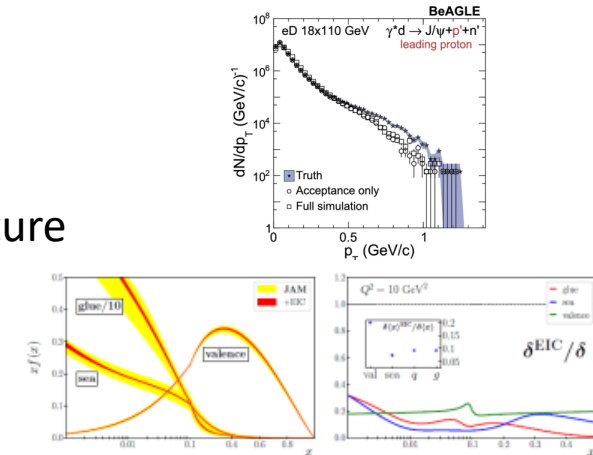
Studies to demonstrate EIC NAS Study, Yellow Report physics

- Origin of Nucleon Spin
- Confined motion of partons
- 3D imaging of quarks and gluons
- Nucleon mass
- High gluon densities in nuclei
- Quarks and gluons in the nucleus

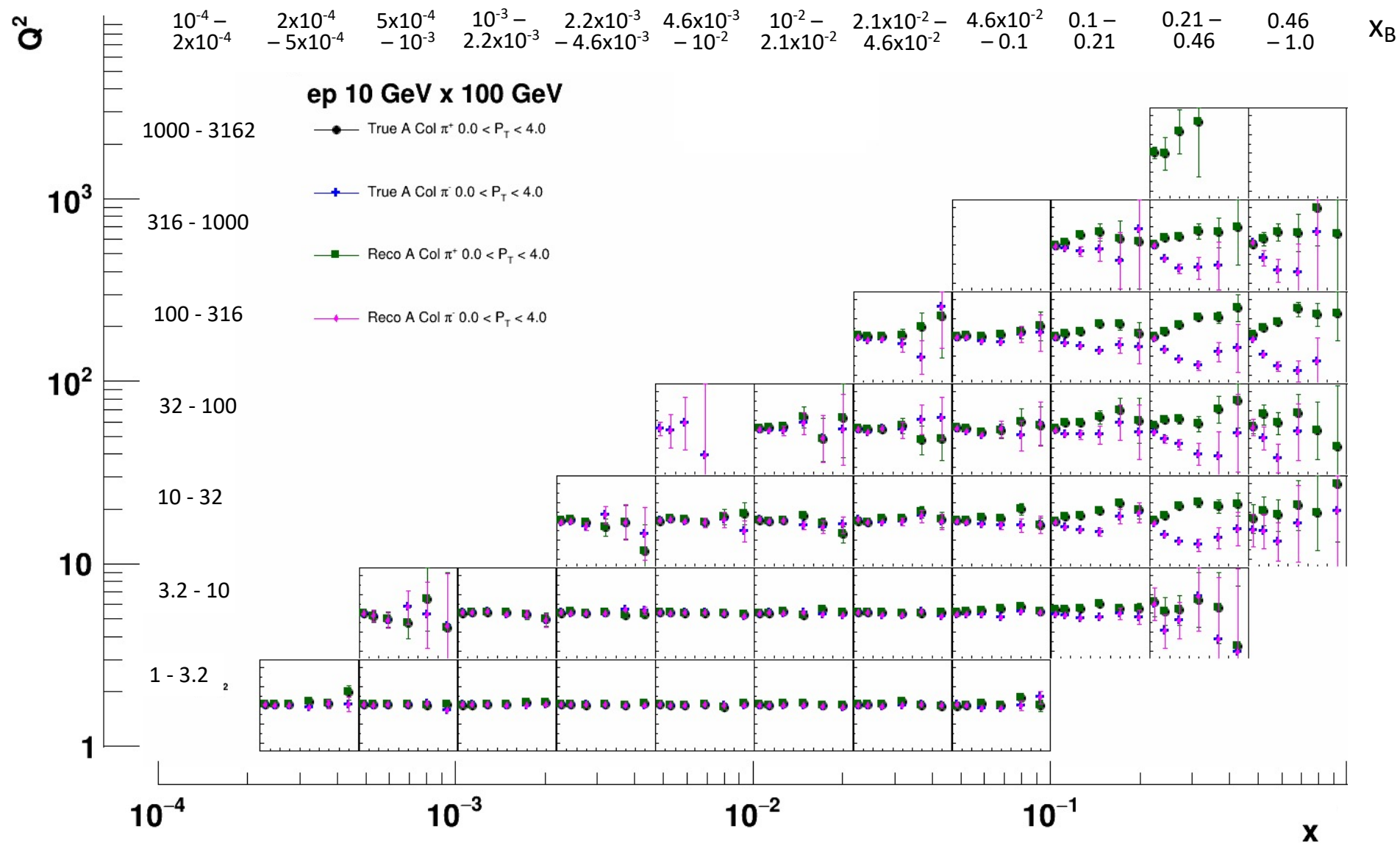


Studies to show unique ECCE strengths

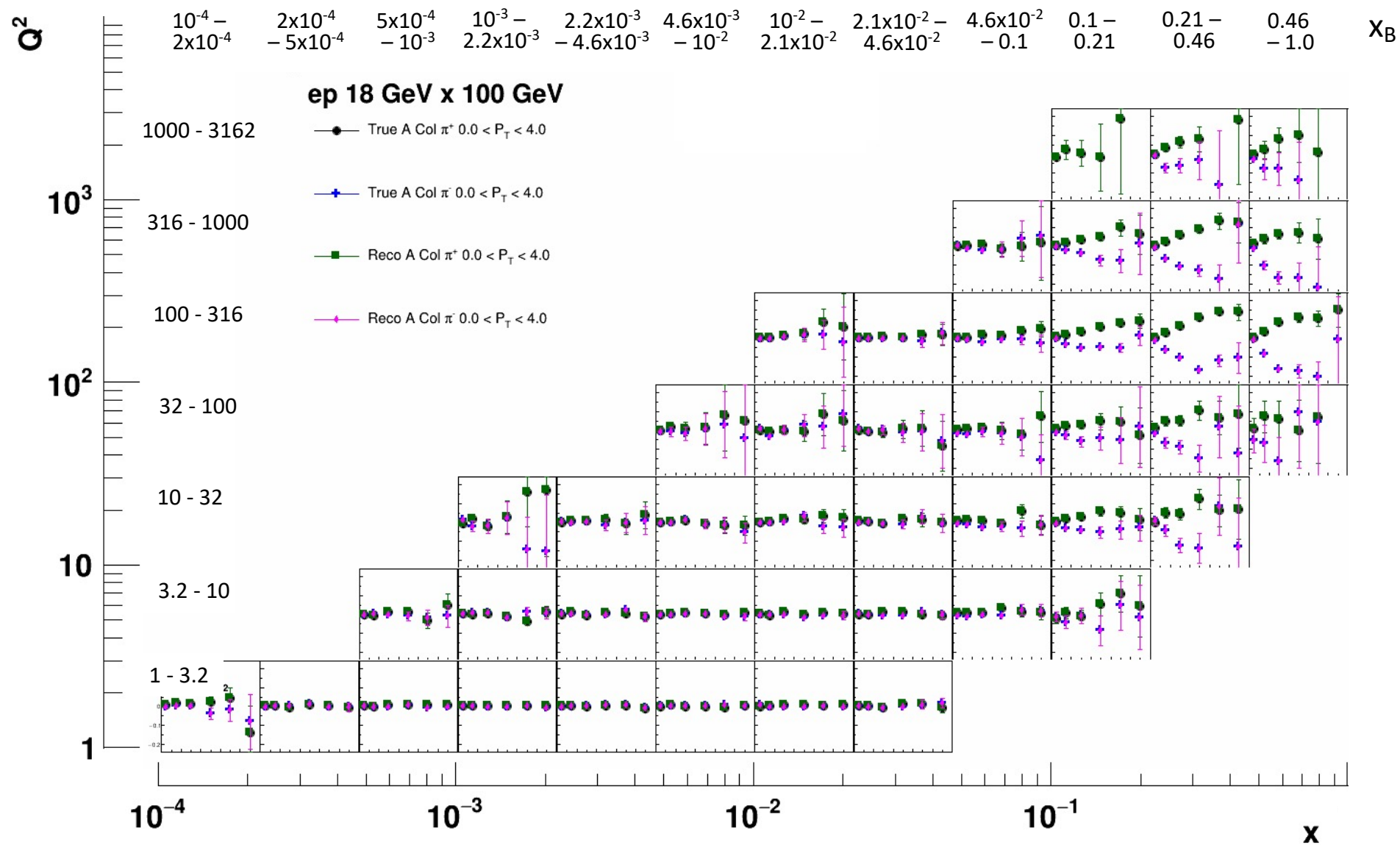
- Light-ion tagging
- Pion/Kaon structure
- Diffractive jets?
- Nuclear modifications and in-medium evolution
 - D/D* reconstruction and heavy-flavor in jets.



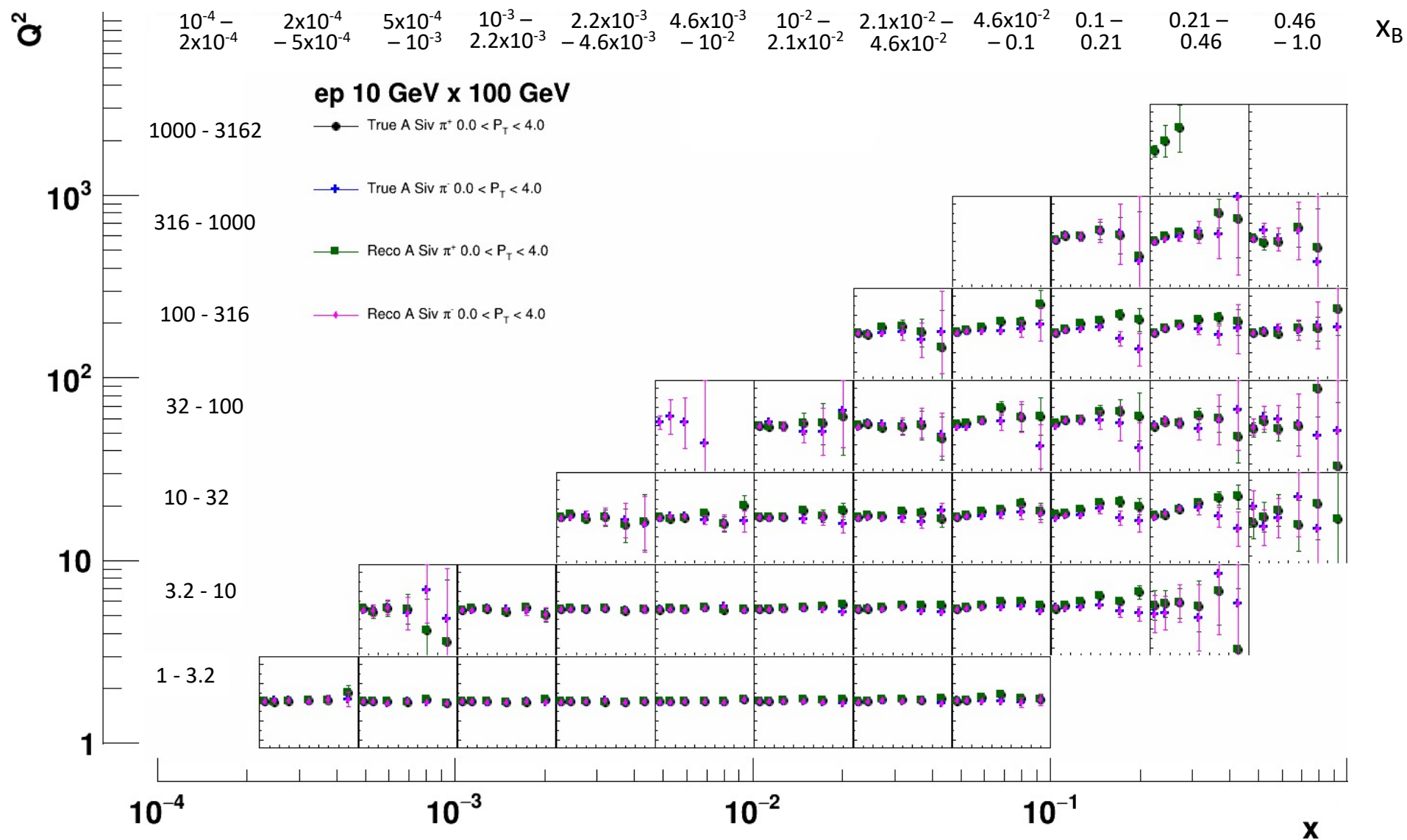
SIDIS Collins Asymmetries



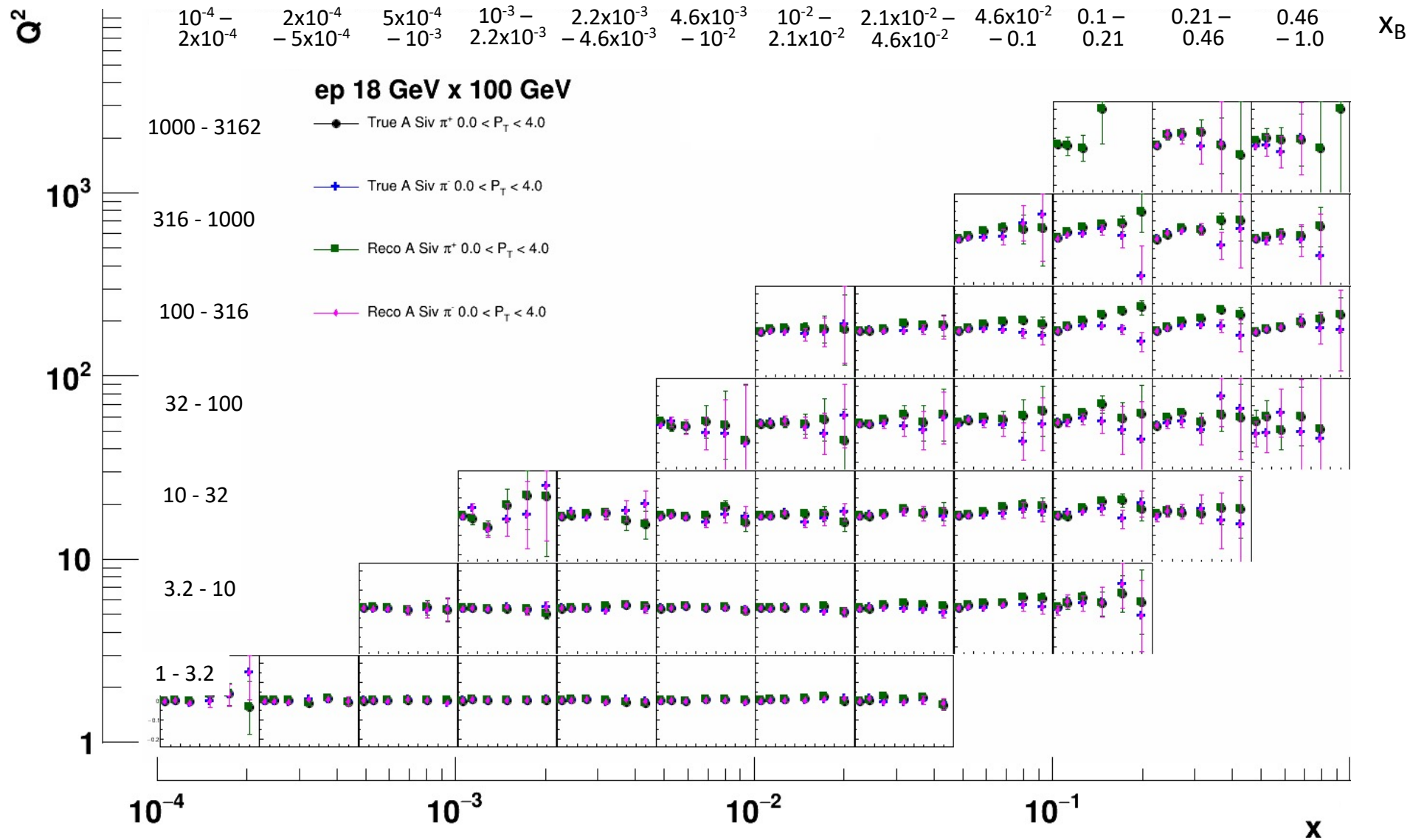
SIDIS Collins Asymmetries



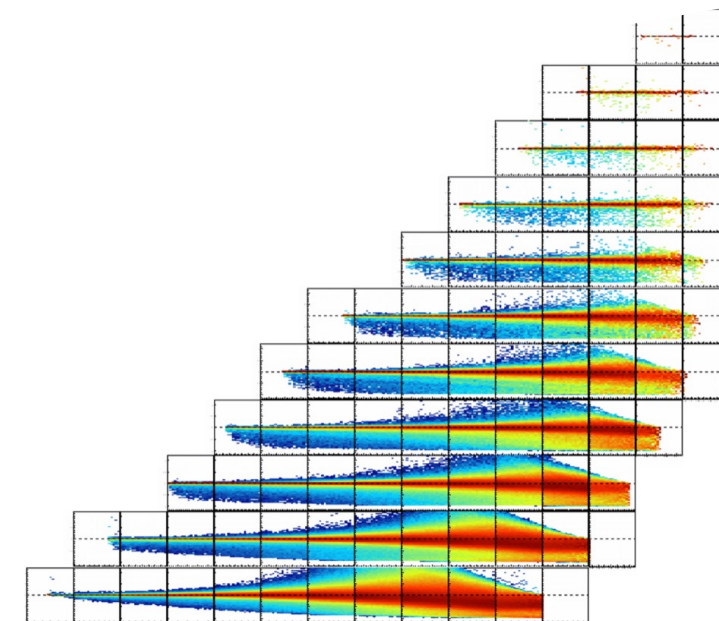
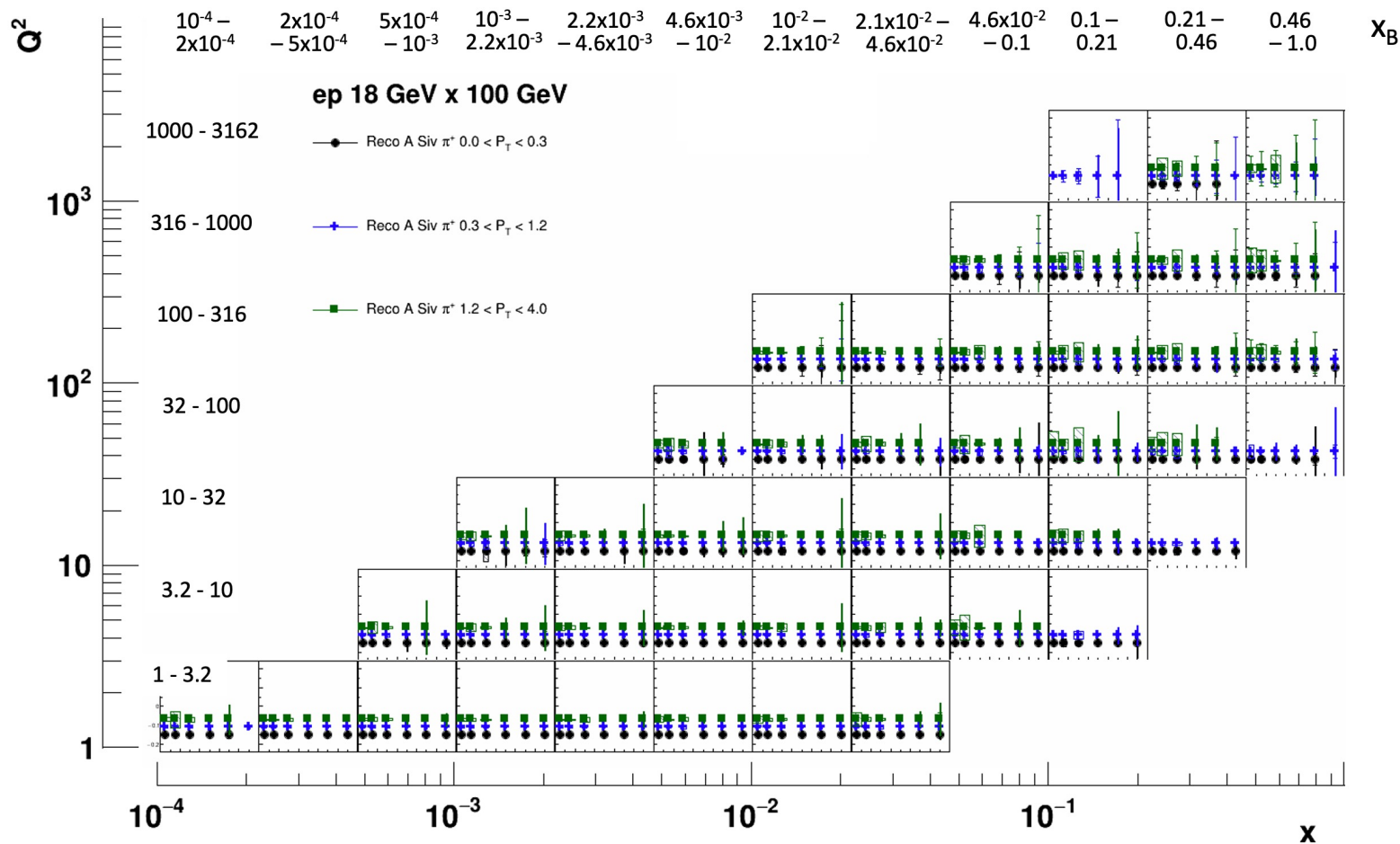
SIDIS Sivers Asymmetries



SIDIS Sivers Asymmetries

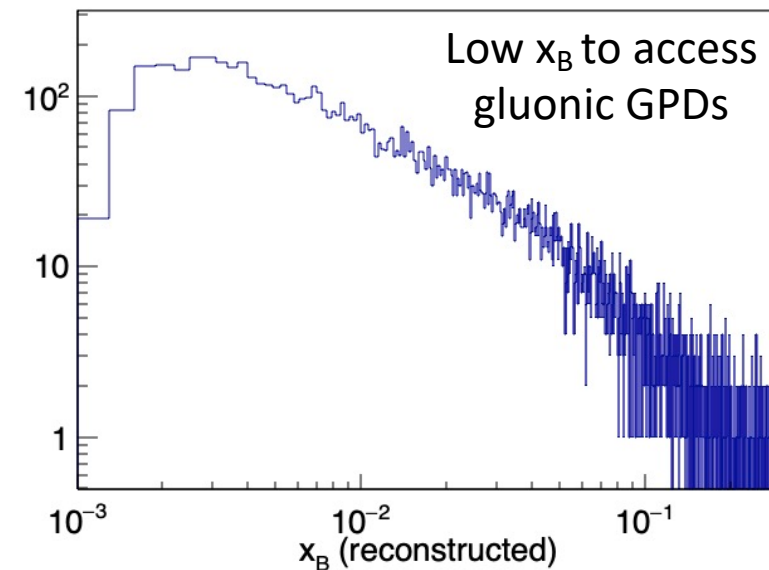
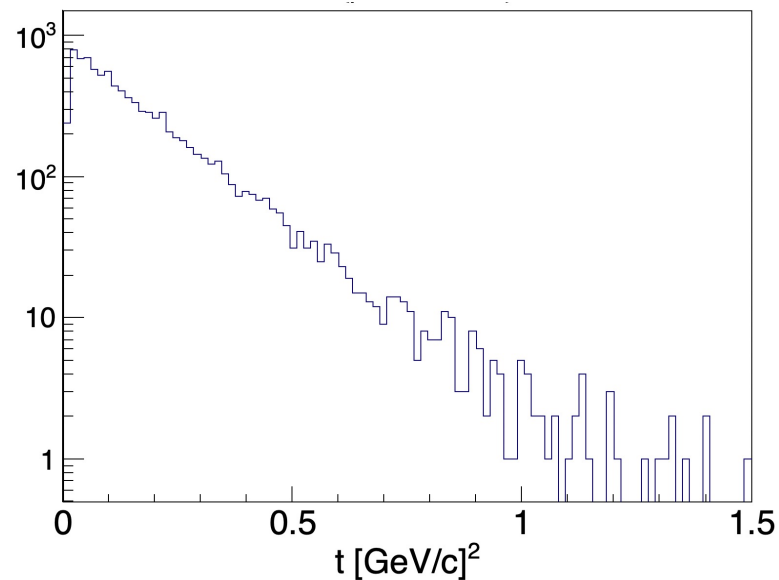
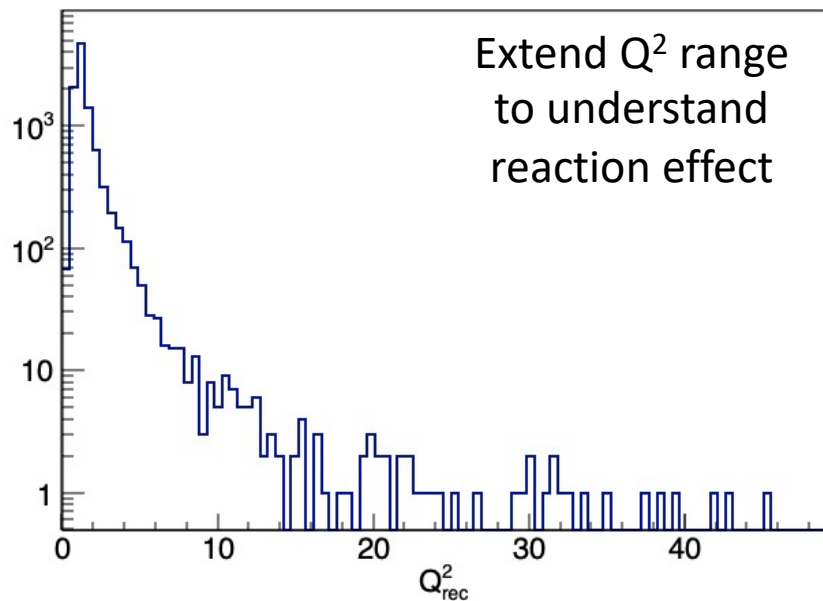


Uncertainties: 10 fb^{-1} statistics + systematics from reco-true deviation

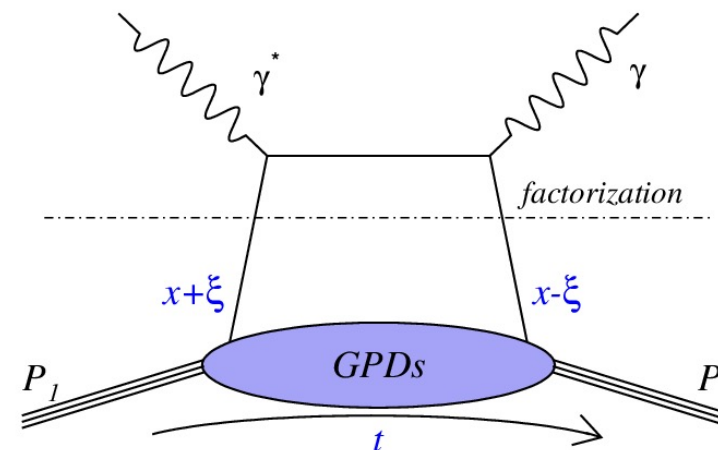


DVCS: $ep \rightarrow e'p'\gamma$

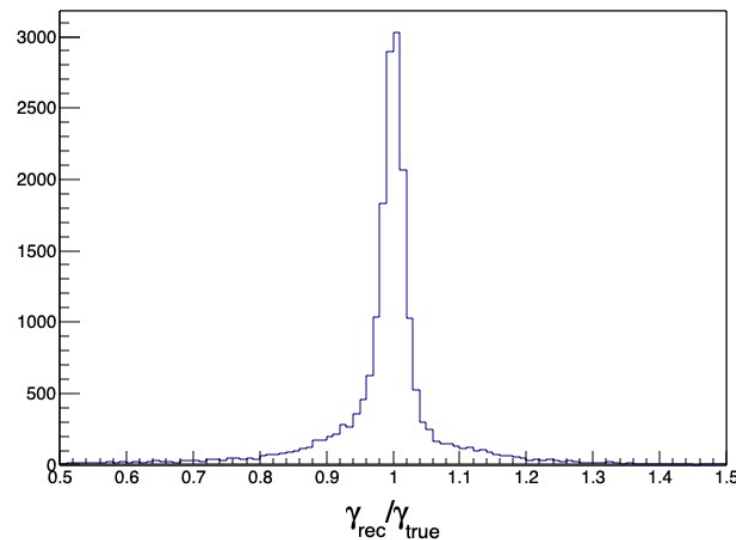
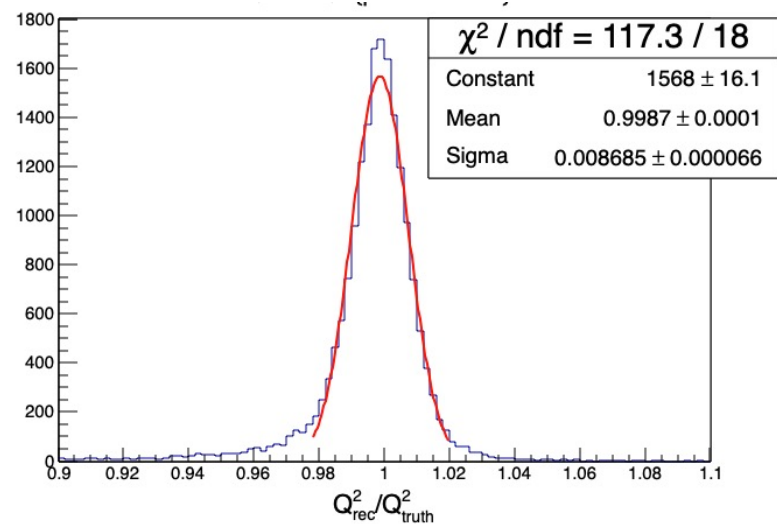
(5 x 41 GeV)



Understand
Acceptance,
Map Coverage

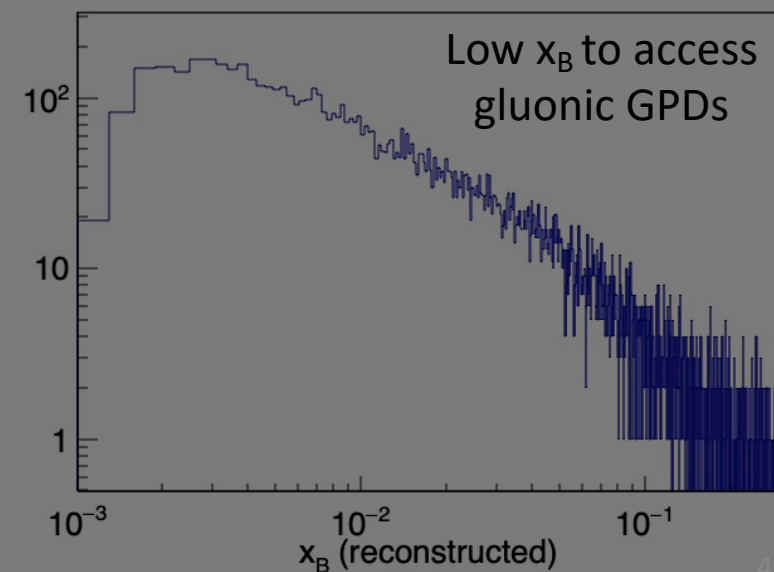
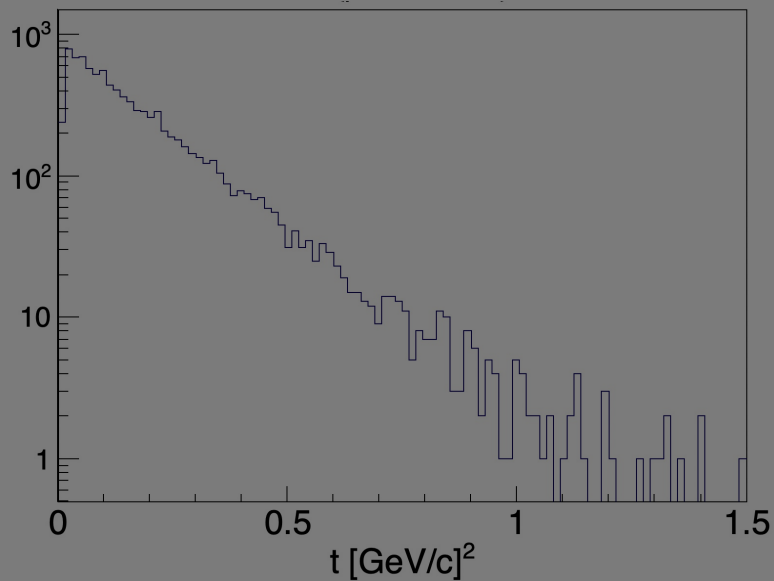
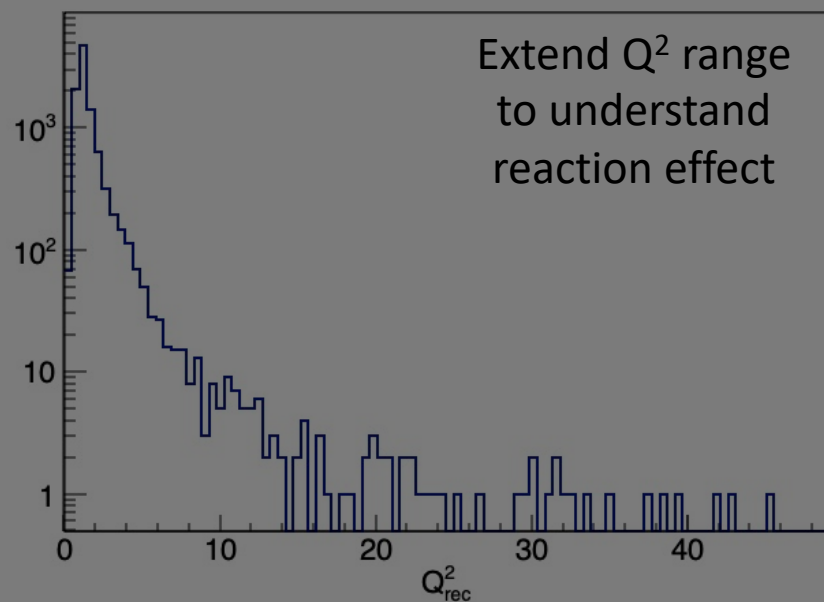


DVCS: $ep \rightarrow e'p'\gamma$



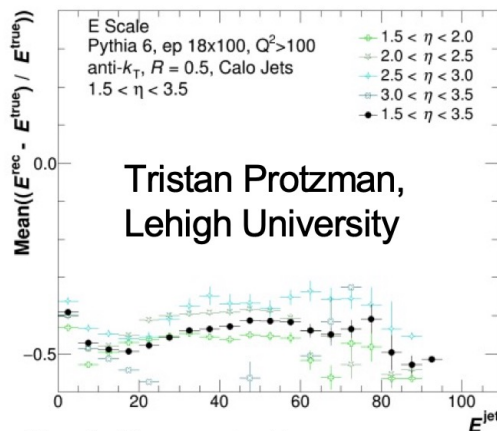
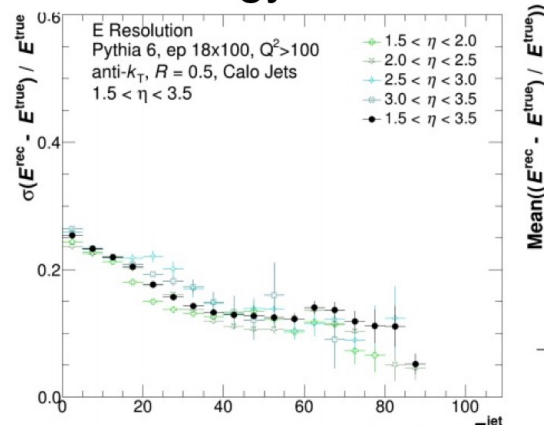
Reconstruction
studies

(5 x 41 GeV)



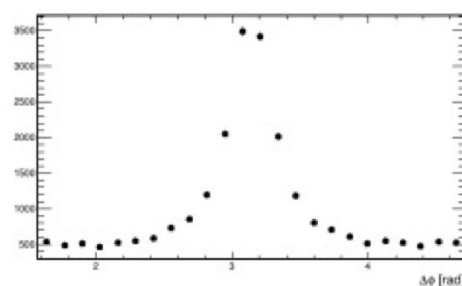
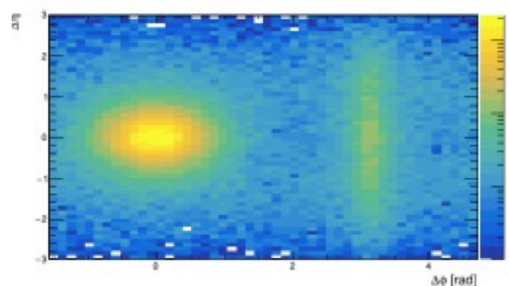
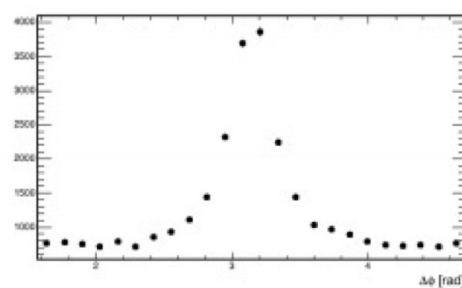
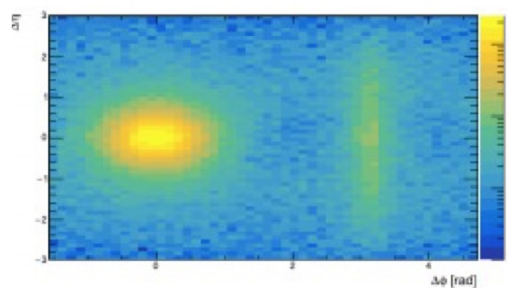
Jet Studies

Jet Energy Resolution



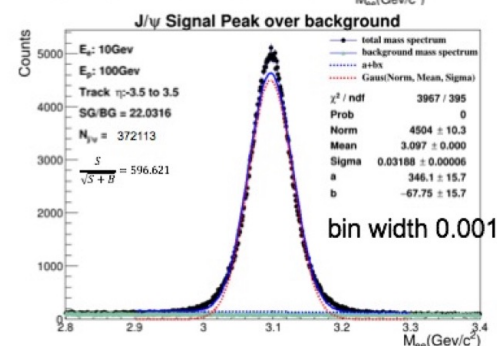
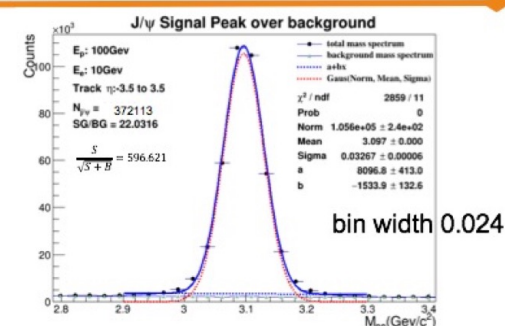
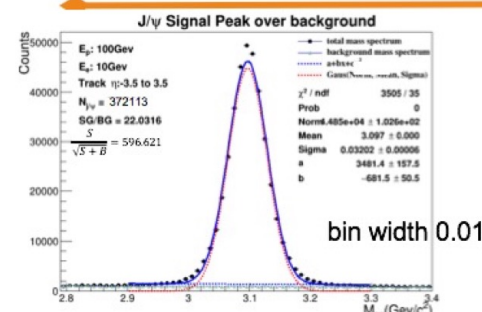
Tristan Protzman,
Lehigh University

2 Track Azimuthal Correlations



J/psi Reconstruction from First Simulation with Smearing

10 million events J/psi peak(event filter)



10million events
reaction selection
Matrix2B1.5T
Luminosity: 13.189 fb⁻¹
gaussian function may not fit the data well.

Future Highlights

☐ July 1st - Aug. 1st [1 month]:

- 1st Large scale simulations production **DONE** 😊

☐ Aug. 1st - Sep. 15th [1.5 months]:

- Analysis of simulation data to demonstrate physics performance.
- 2nd Large scale simulations production

☐ Sep. 15th - Nov. 1st [1.5 months]:

- All physics 'plots' are done.
- Final evaluation of technology selection based on physics studies results.
- Proposal narrative composition around simulation results & selected technologies.

☐ Nov. 1st - Nov. 30th [1 month]:

- Proposal review by external colleagues.
- Final edits

Conclusions

- The ECCE consortium consists of 80 institutions working to design the EIC project detector based around the BaBar solenoid
- ECCE plans to be ready for physics by EIC CD4a for start of machine operations.
- The physics program spans the entirety of that outlined in the NAS study and the Yellow Report
- The detector design process is fully underway, in tandem with a wide range of full physics simulations.
- **MANY ways to get involved!**

www.ecce-eic.org

Why ECCE ?

ECCE is a low-risk, cost-effective, flexible and optimized EIC detector!

- **Low risk** due to re-use of existing magnet and various detectors.
- **Cost-effective** due to magnet and detectors reuse.
- **Flexible and optimized** by studying both IRs and using full Geant4.
- **Most realistic detector to be ready by CD4a.**