eRD16: Forward/Backward Tracking at EIC using MAPS Detectors

G. Contin, X. Dong, L. Greiner, B.V. Jacak (project leader), P. Jacobs, S. Klein, Y.S. Lai, C. Loizides, G. Odyniec, M. Ploskon, A. Schmah, E. Sichtermann (contact person), J. Thomas, I. Velkovsky, H. Wieman, N. Xu

Nuclear Science Division
Lawrence Berkeley National Laboratory
1 Cyclotron Road
Berkeley, California 94720

Abstract:

We propose to continue development of tracking station concepts with silicon-sensors near the collision vertex to detect the hadrons and scattered electrons which are produced at forward and backward angles in e-A collisions. Disks of thinned-silicon sensors (MAPS) detectors will be laid out, including the conceptual design for the arrangement of electronics and conventional services (cooling, power, and readout) and their integration with the central barrel tracking subsystems. We will also continue R&D on low-mass cables that utilize aluminum traces.

EIC Generic Detector R&D
Advisory Committee Mtg.
ANL, July 6, 2016

Outline

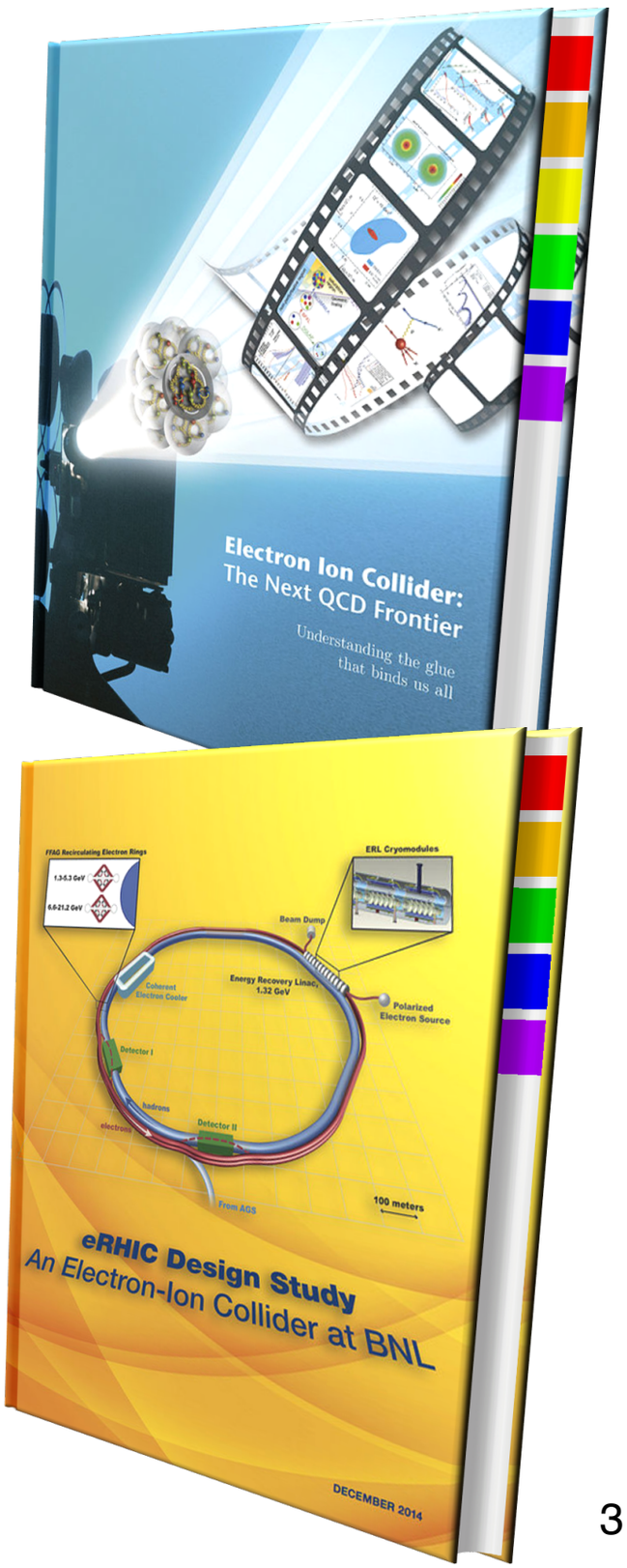
- Introduction
  - RNC
  - Tracking at forward and backward angles
- Simulation progress
  - Aluminum conductors
- Next steps and request

RNC - EIC Physics

EIC science case - arXiv:1212.1701
arXiv:1409.1633

LBNL/RNC has contributed to both,
- spin physics case,
- eSTAR detector simulations,

Gluon-dense matter is a common theme of interests in RNC.

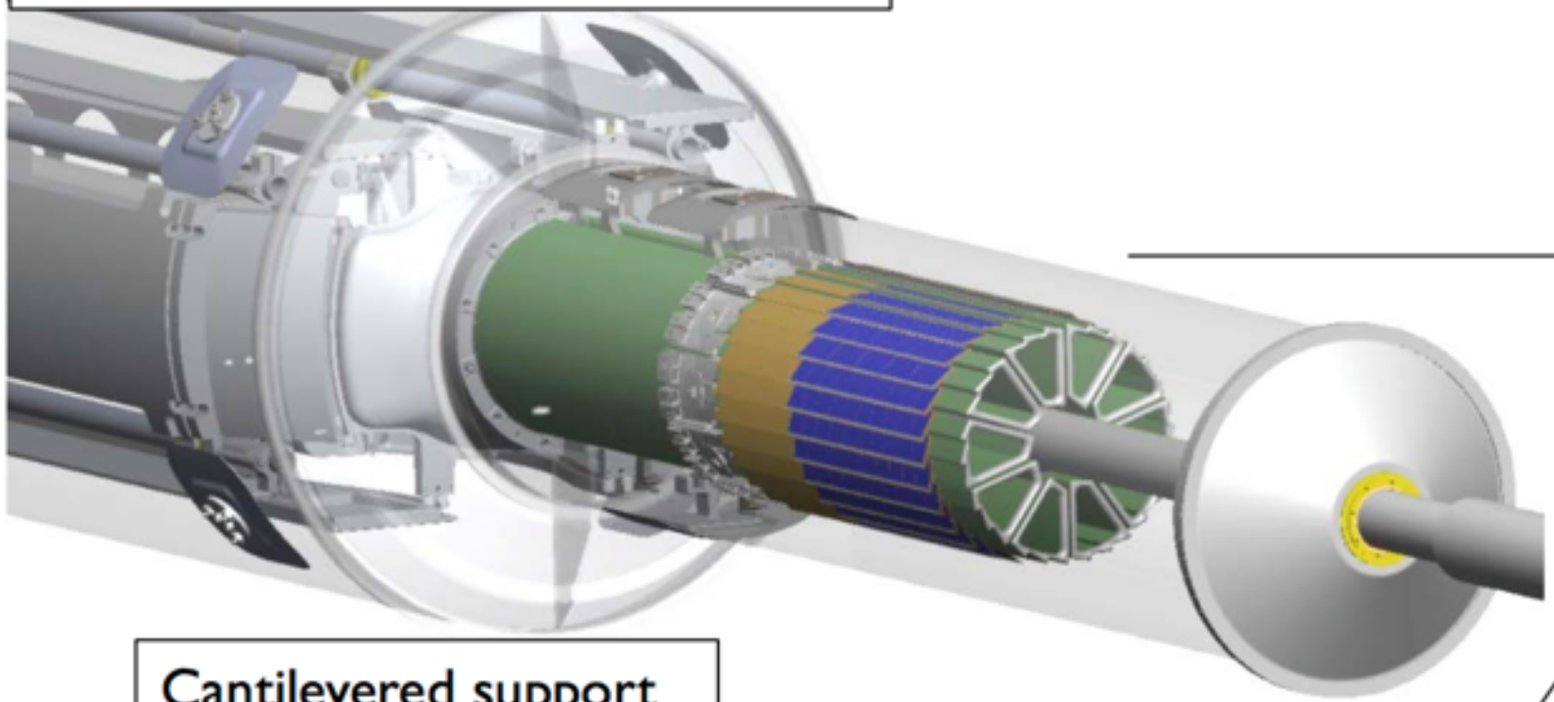


RNC - STAR HFT-PXL

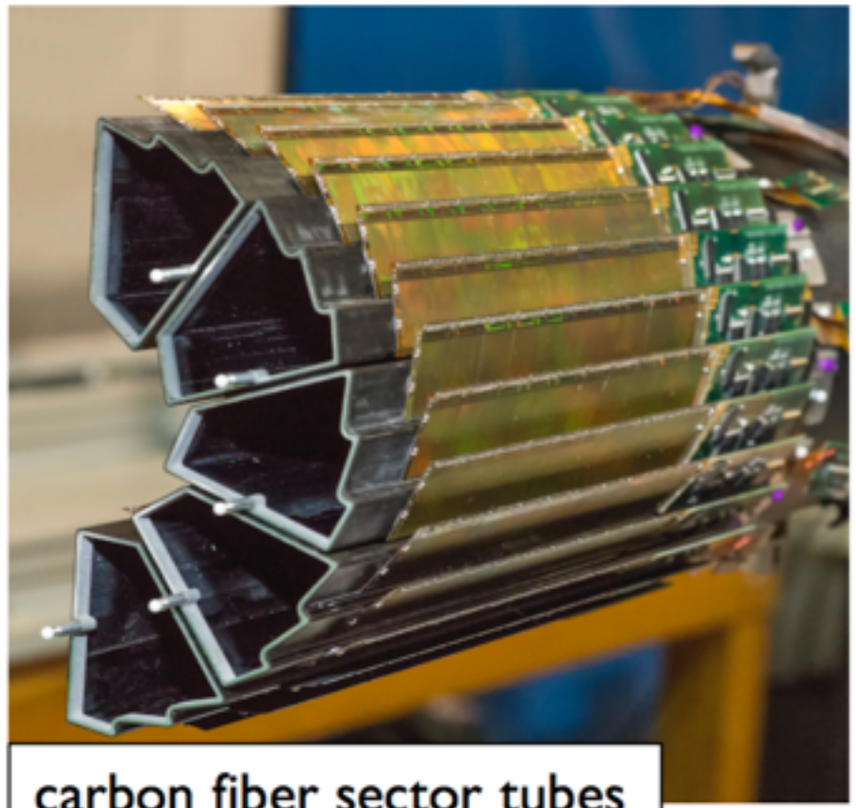
10 sectors total
5 sectors / half
4 ladders / sector
10 sensors / ladder

Highly parallel system

Mechanical support with kinematic mounts (insertion side)

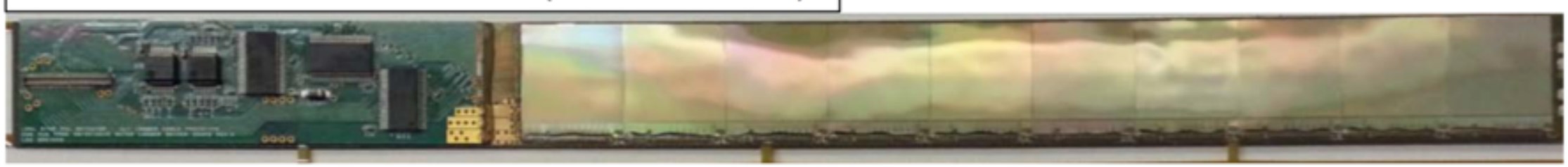


Cantilevered support



carbon fiber sector tubes
(~ 200 μm thick)

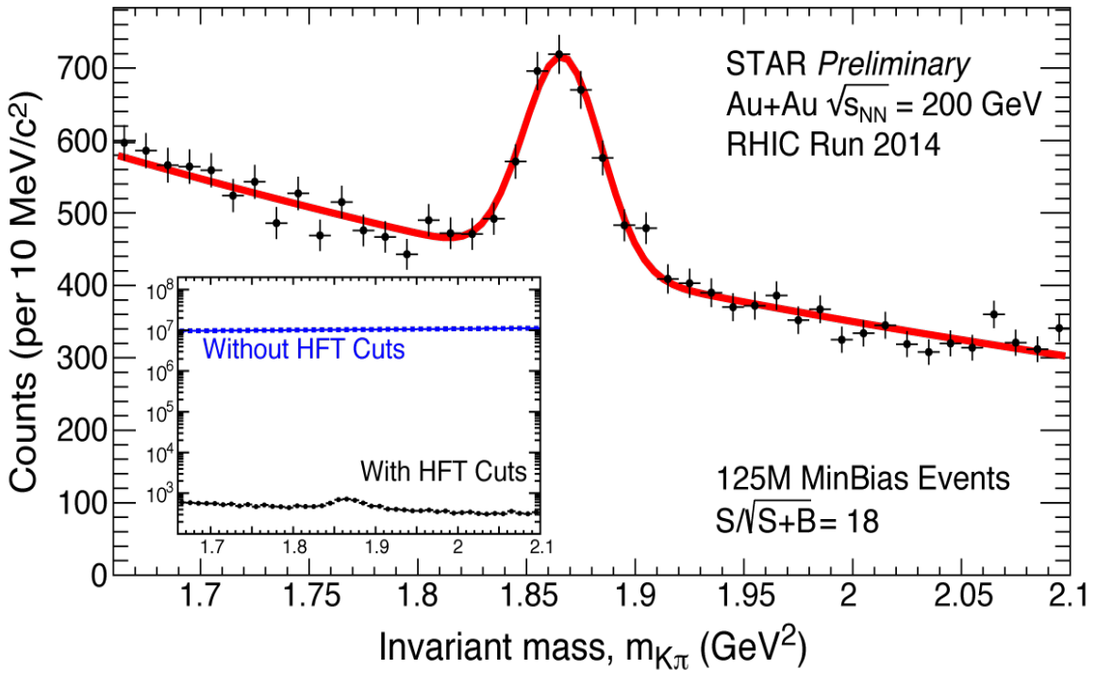
Ladder with 10 MAPS sensors (~ 2×2 cm each)

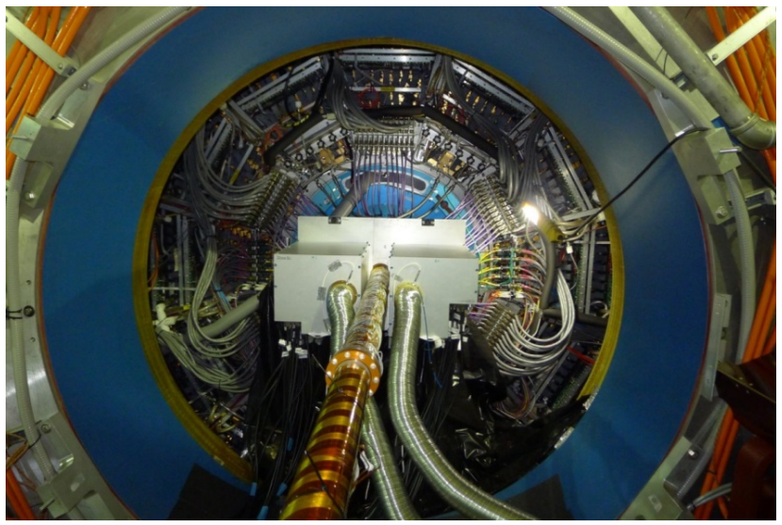


Courtesy G. Contin (LBL-RNC), for the STAR collaboration, QM2015

RNC - STAR HFT-PXL

First large scale MAPS based vertex detector at a collider experiment.





PXL inserted into STAR, cabled and working in 24 hours

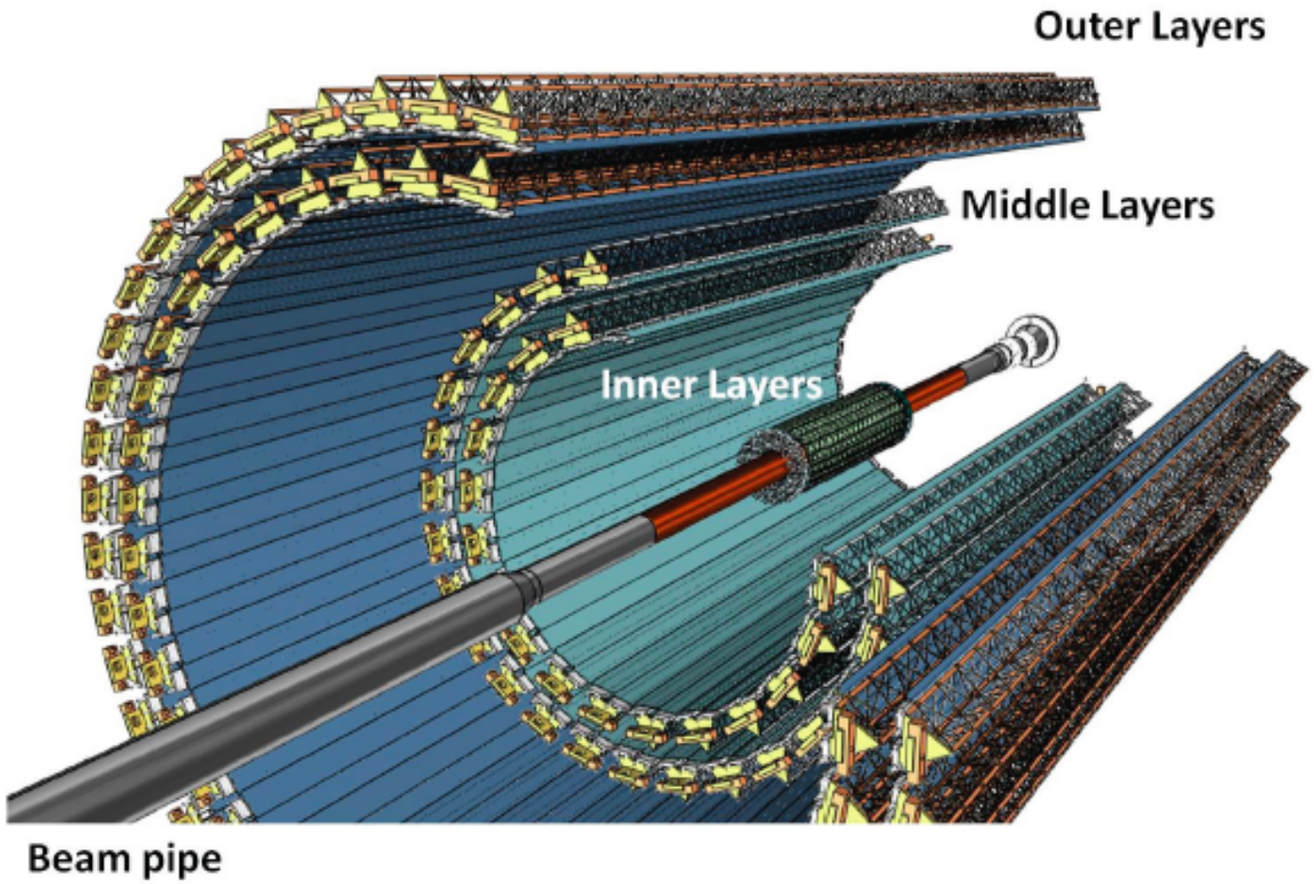
RNC scope:

Full simulation and optimization.

Full system design including R&D into MAPS sensors with IPHC Strasbourg.

Full construction including RDO electronics, firmware, software, commissioning and analysis.

ALICE ITS Upgrade



- 7 layers
- 10 m^2 of silicon
- Installation in early 2019
- X/X_0 ~ 0.3% (inner layers)
- X/X_0 ~ 0.8% (outer layers)

Anticipated use of CERN-developed MAPS sensors, ALPIDE:

Dimensions:	15mm x 30mm
Pixel pitch:	28μm x 28μm
Integration time:	8-10μs
Power consumption:	39mW/cm^2

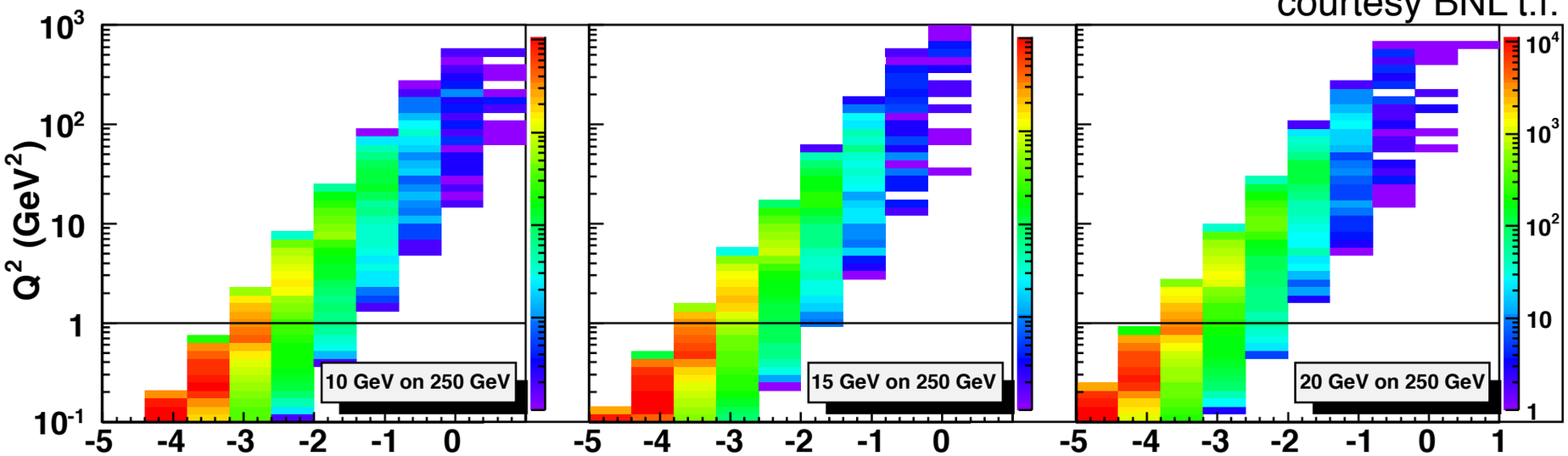
TDR: http://iopscience.iop.org/0954-3899/41/8/087002/

<u>RNC scope:</u>

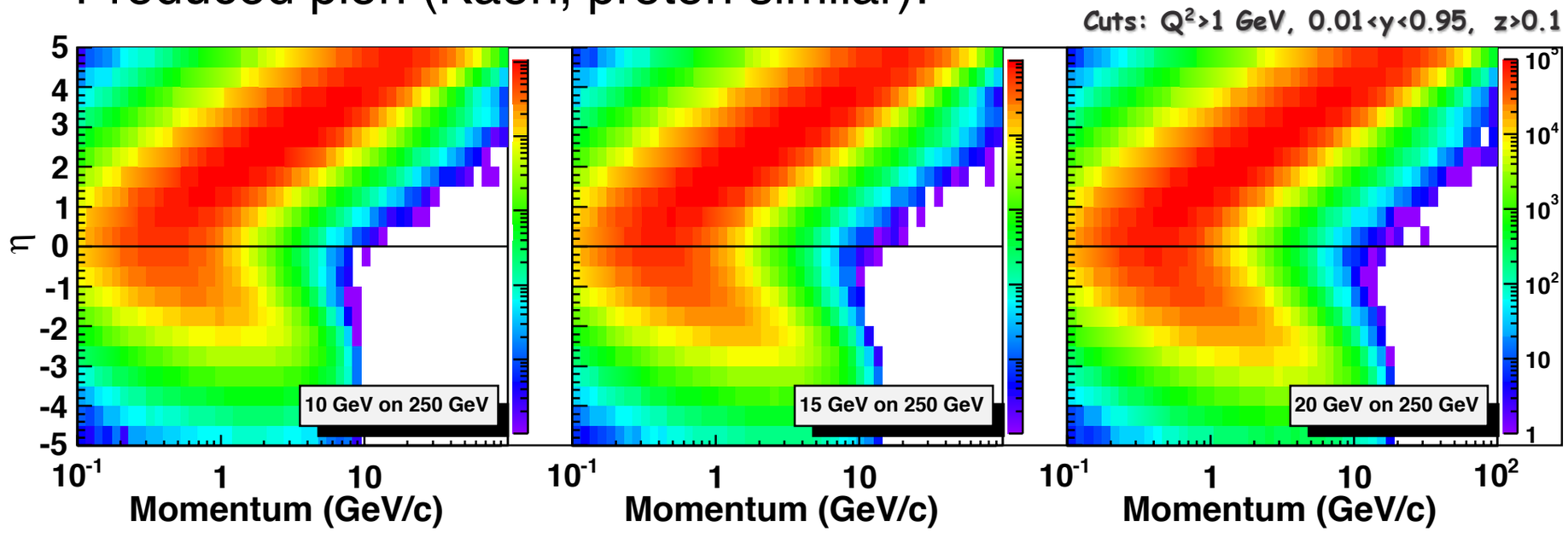
middle layer staves,
readout & power,
mechanics (with LBL engineering)

EIC - DIS particle distributions

Scattered electron:

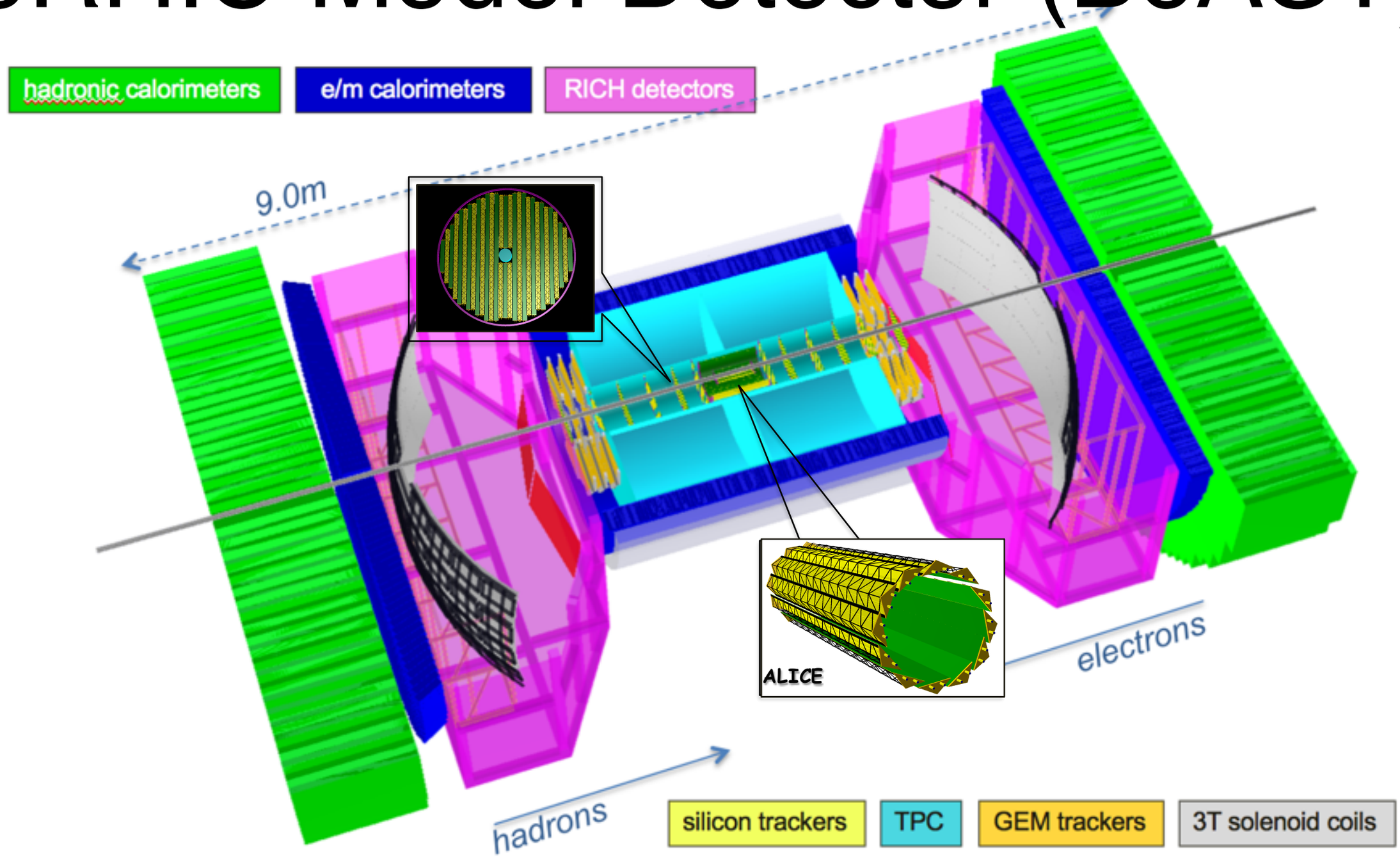


Produced pion (Kaon, proton similar):



drive acceptance, PID and other requirements.

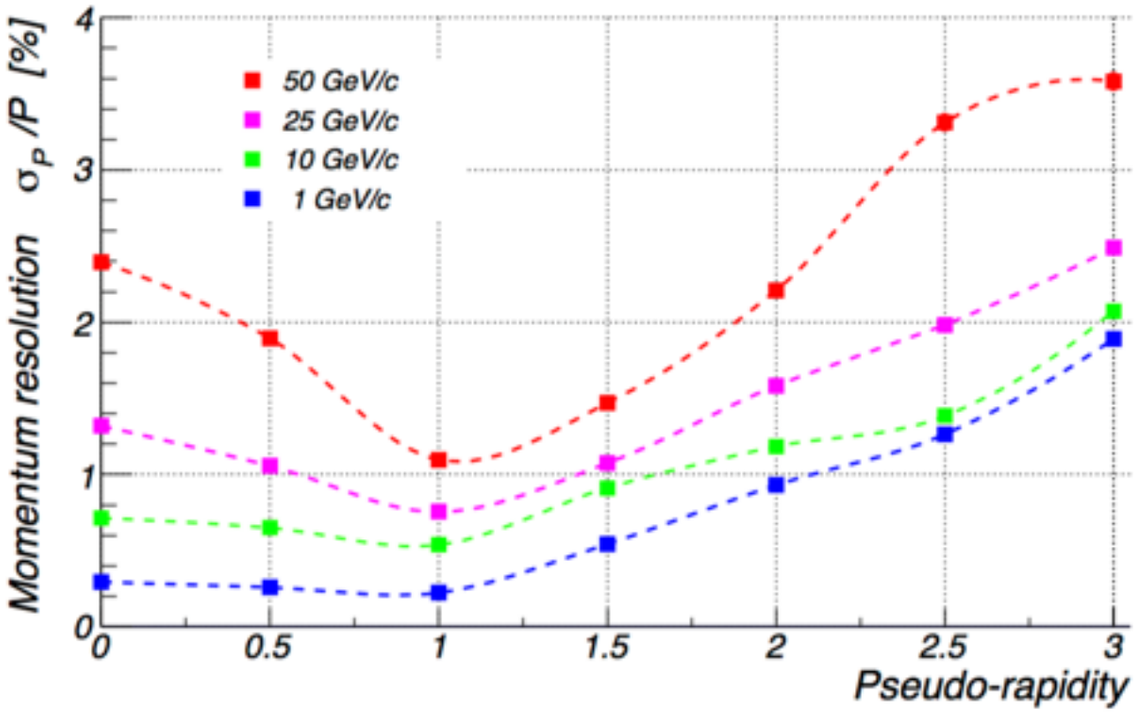
eRHIC Model Detector (BeAST)



E.C. Aschenauer, A. Kiselev, et al.

MAPS-based Si; minimize bremsstrahlung, resolutions, and also vertexing.

eRHIC Model Detector (BeAST)



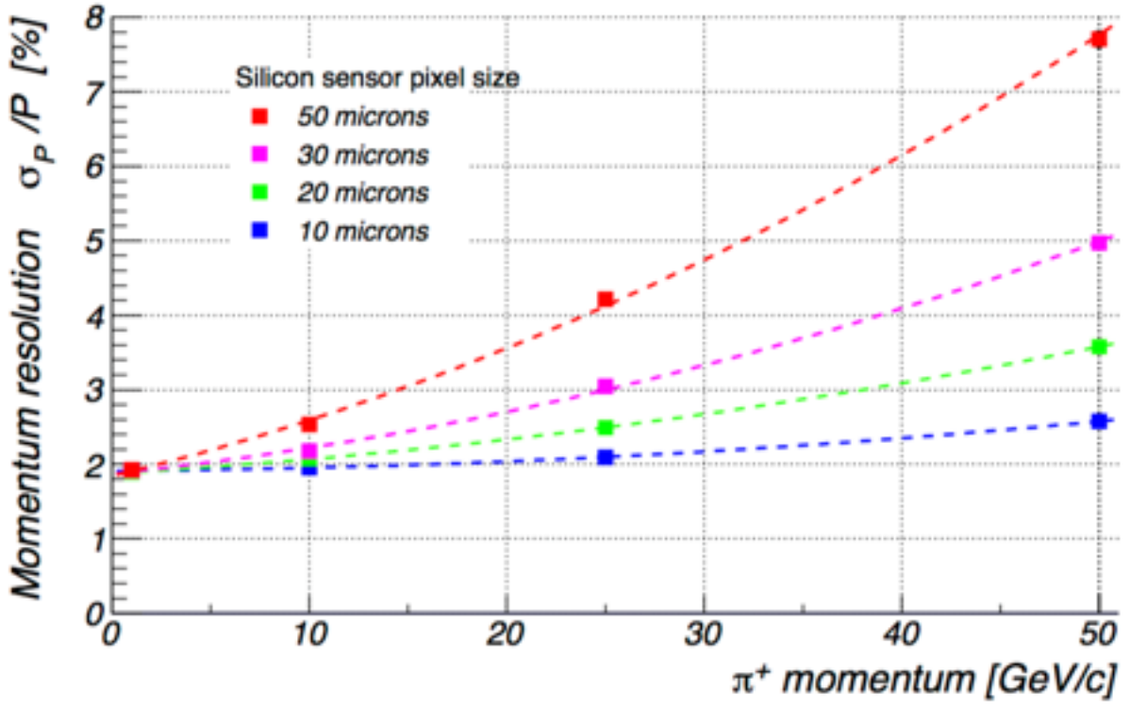
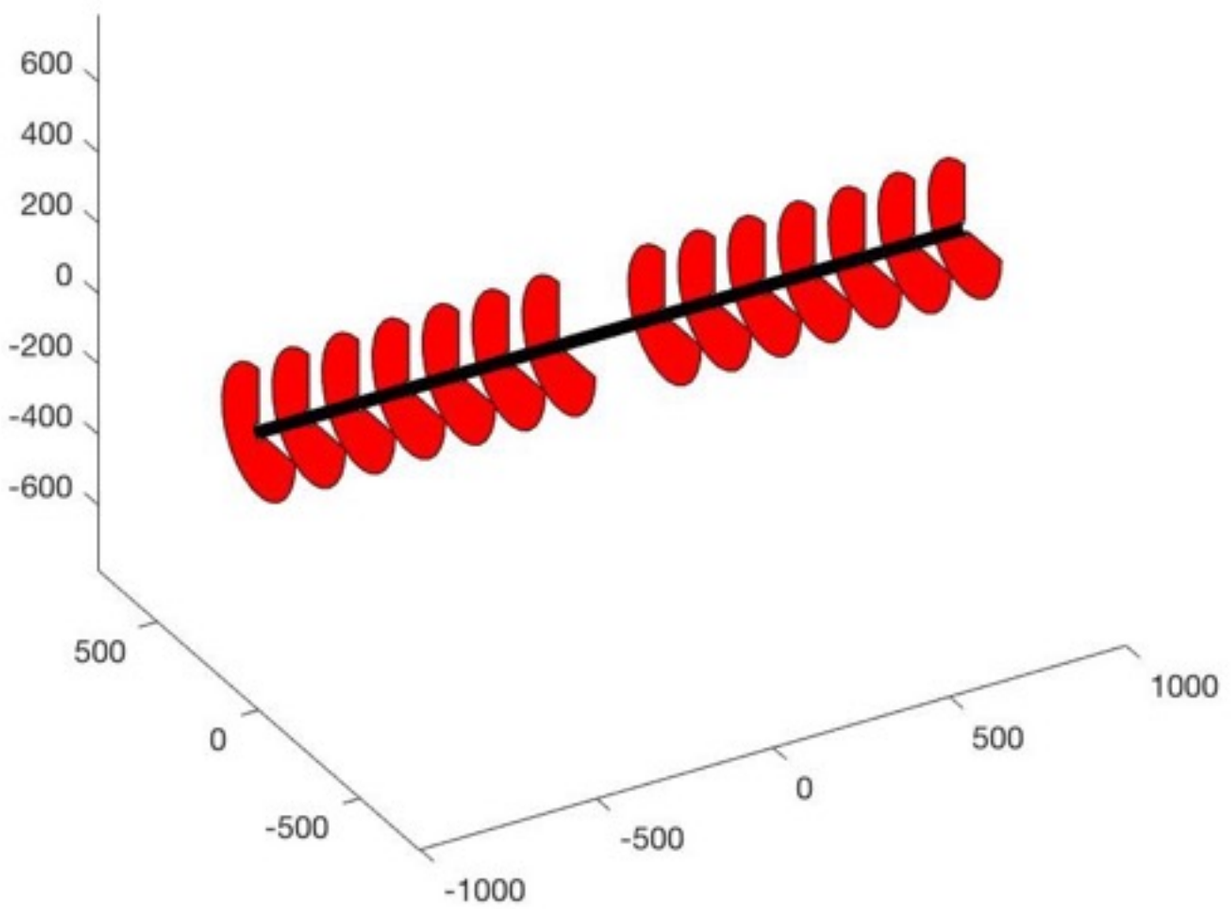


Figure 4-8: Left panel: expected momentum resolution of the baseline eRHIC detector as a function of pseudorapidity. Right panel: forward tracker momentum resolution at η = 3 vs secondary hadron momentum for various values of MAPS forward tracker pixel size.

BNL EIC task-force developed framework and simulations,
a point of contact for our, so-far mostly separate, studies.

Simulation Progress



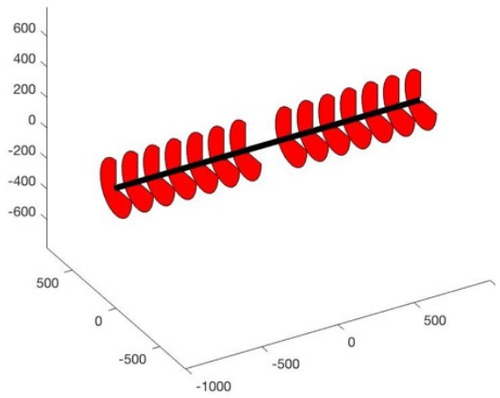
- Tool originally developed for ILC studies (Regler et al, 2008),
- Helix track model,
- Multiple scattering,
- Full track reconstruction from digitized hits using a Kalman filter.

Model of a BeAST-like configuration: 7 equidistant disks, each of X_0~0.3% thickness, on either side of the IP in a 3T solenoidal field. 22mm inner disk radius, 180mm outer radius. 1mm thin Be beam-pipe with a 15mm radius.

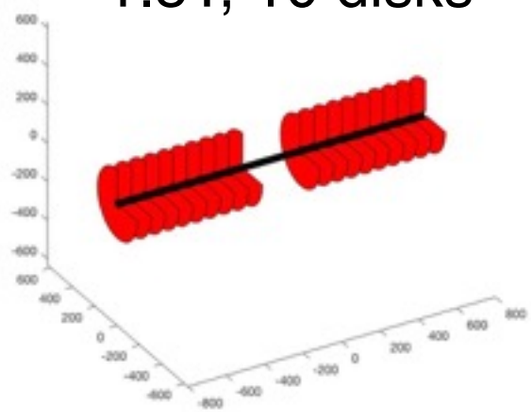
Work done with UCB student Velkovsky since ~February.

Simulation Progress

3T, 7 disks

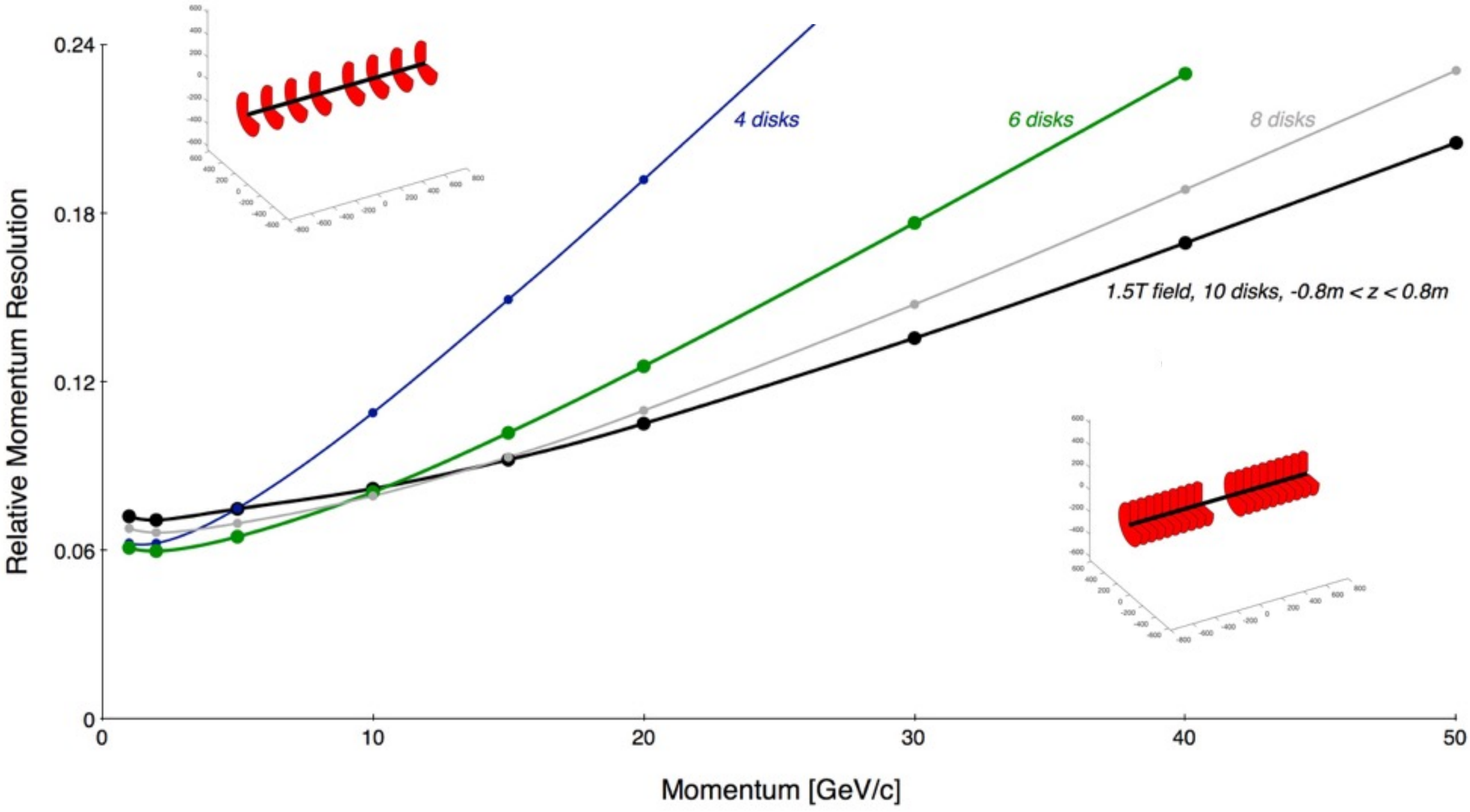


1.5T, 10 disks



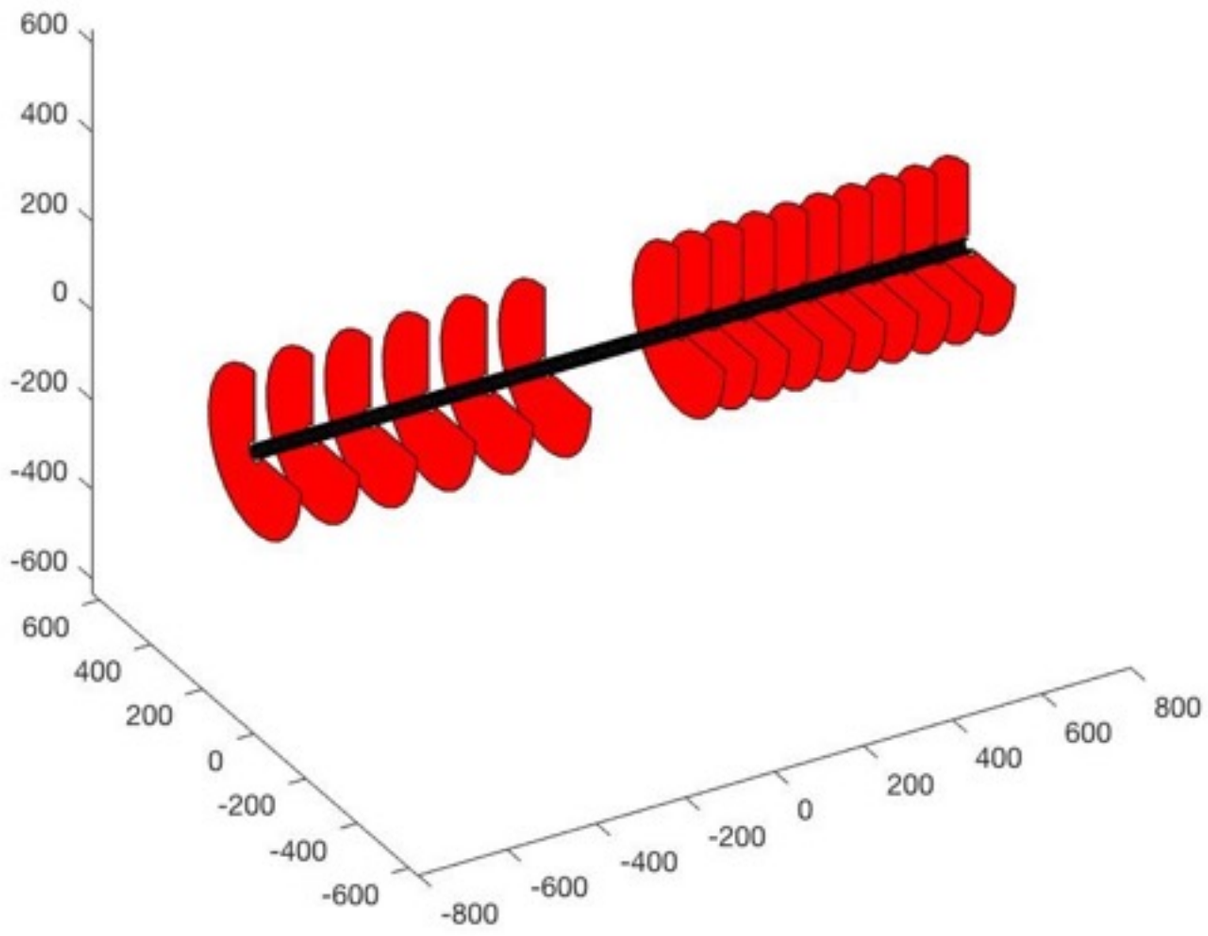
Results for the 3T BeAST-like configuration establish contact with BNL task-force simulations; 1.5T results are new. Eta=3 here.

Simulation Progress



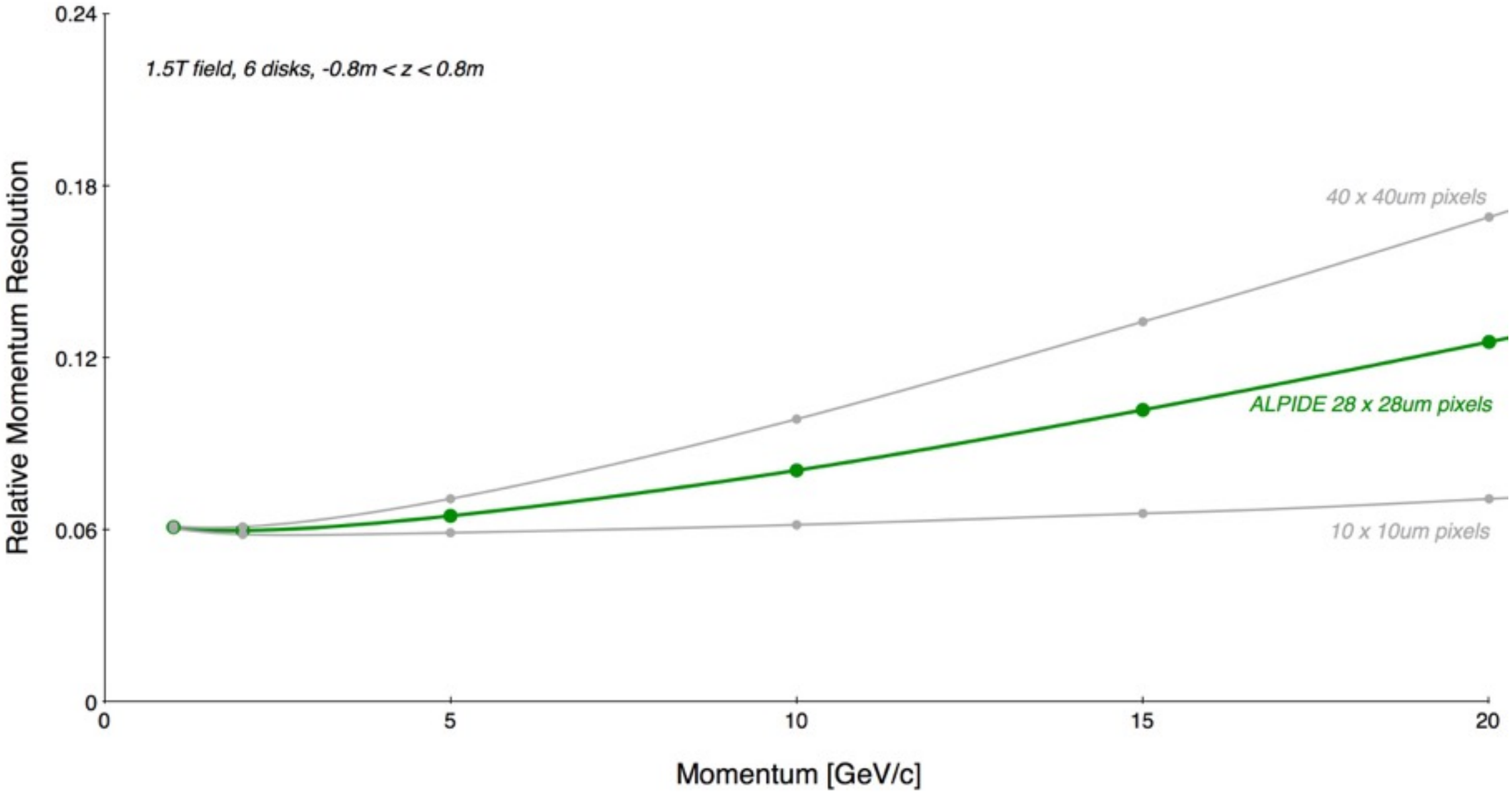
Anticipated behavior for large momenta; a larger number of disks results in better resolution. At lower momenta, the lower material budget of a smaller number of disks results in better performance.

Simulation Progress



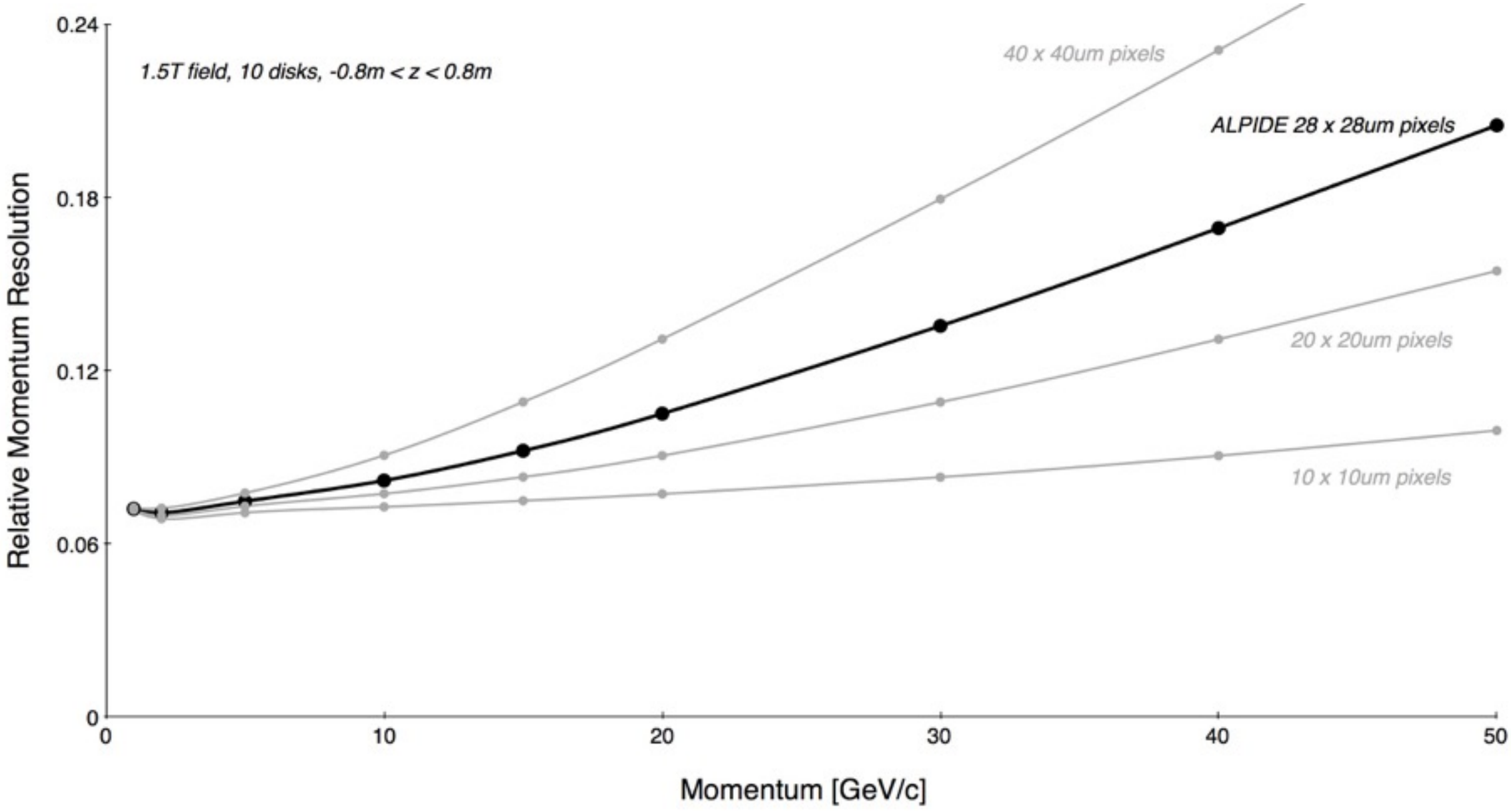
- Momenta in the forward electron direction are typically lower than in the forward hadron direction,
- Simulated momentum resolutions then suggest tracking concepts with different number of disks on either side of the IP,
- Qualitatively consistent with asymmetric implementation at HERA.

Simulation Progress



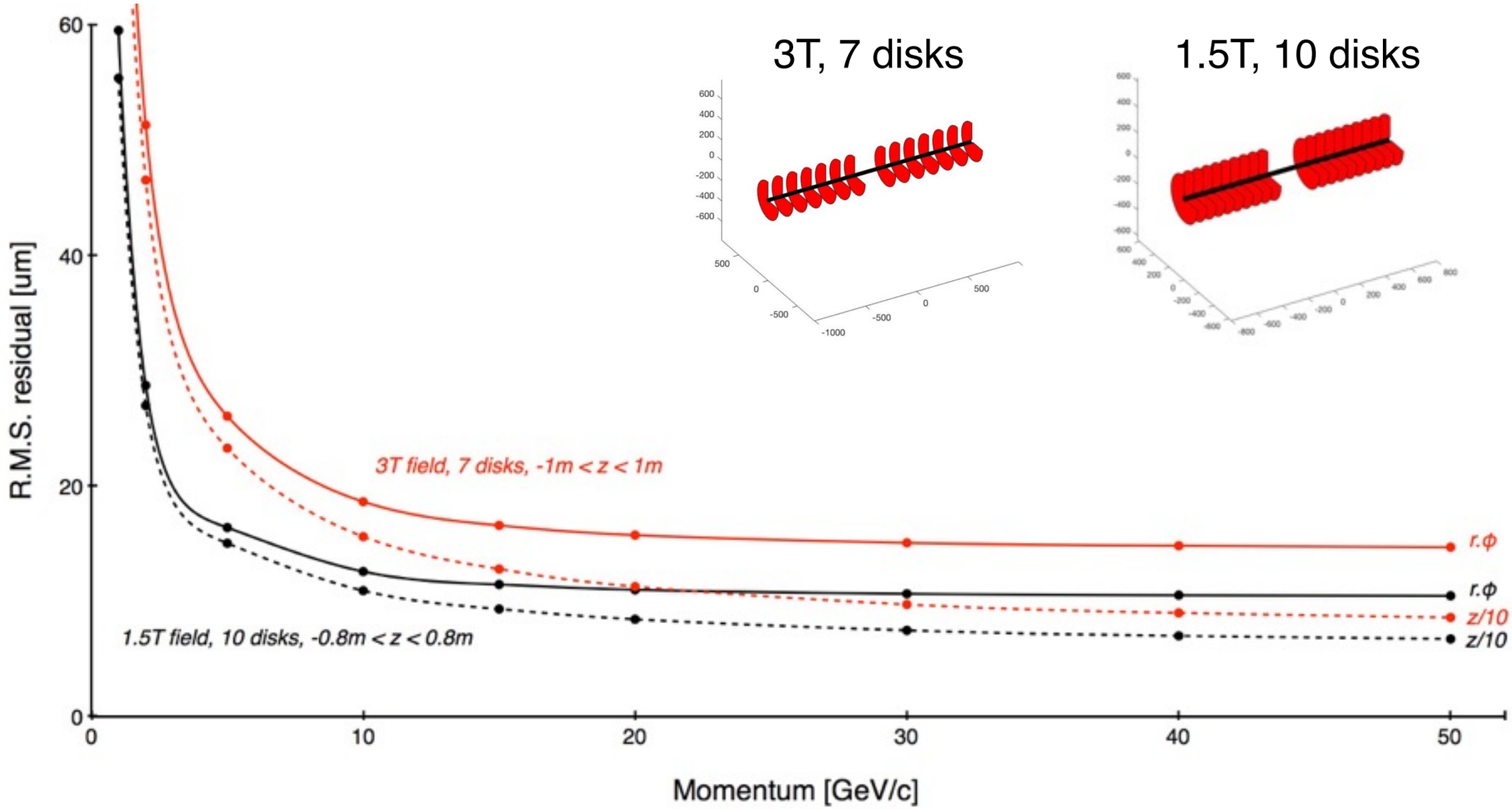
Low-momentum performance is substantially the same for a choice of pixel-sizes in the range of 10x10um to 40x40um (with a realistic beam-pipe).

Simulation Progress



Continue ALPIDE sensor evaluation for use at EIC.

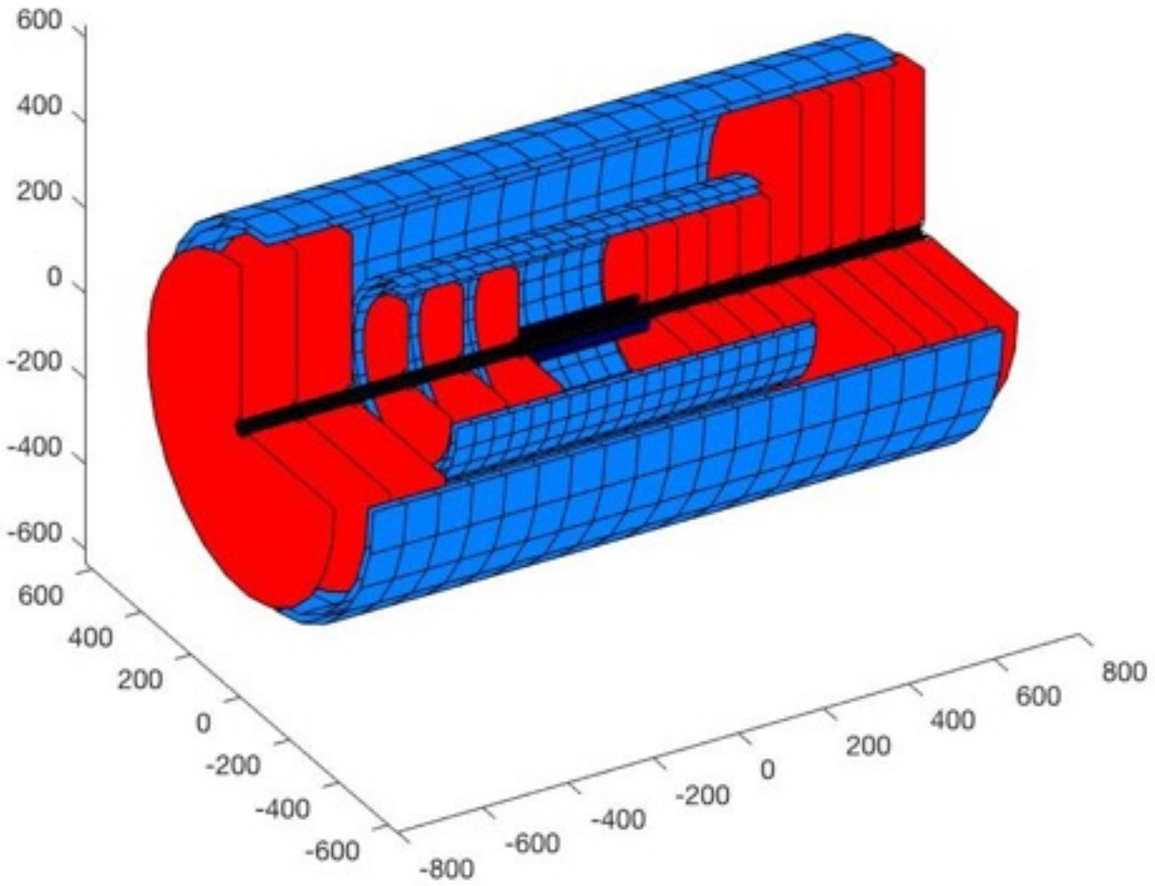
Simulation Work in Progress

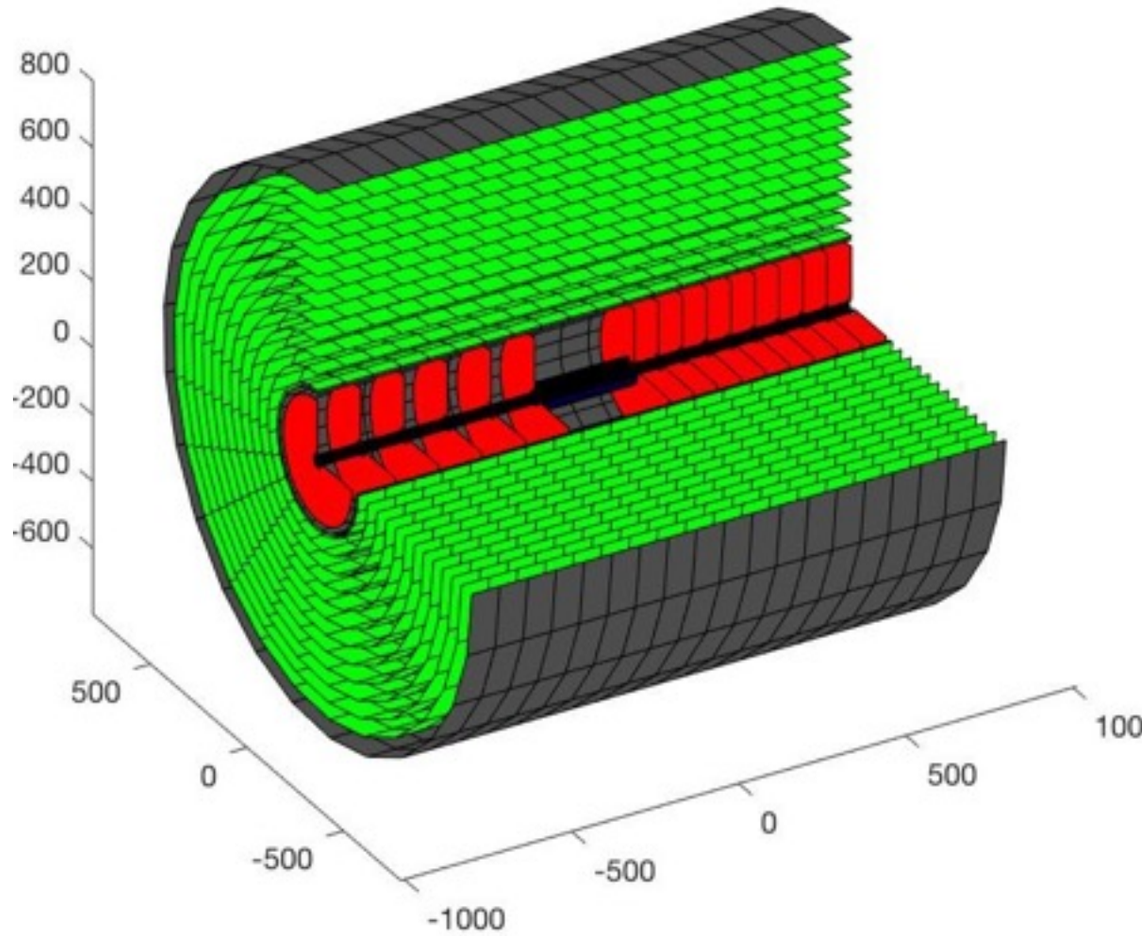


Single-track R.M.S. residuals projected at the beam-pipe; a step towards displaced vertices.

Started to investigate if/how to incorporate “RAVE” (vertex pkg).

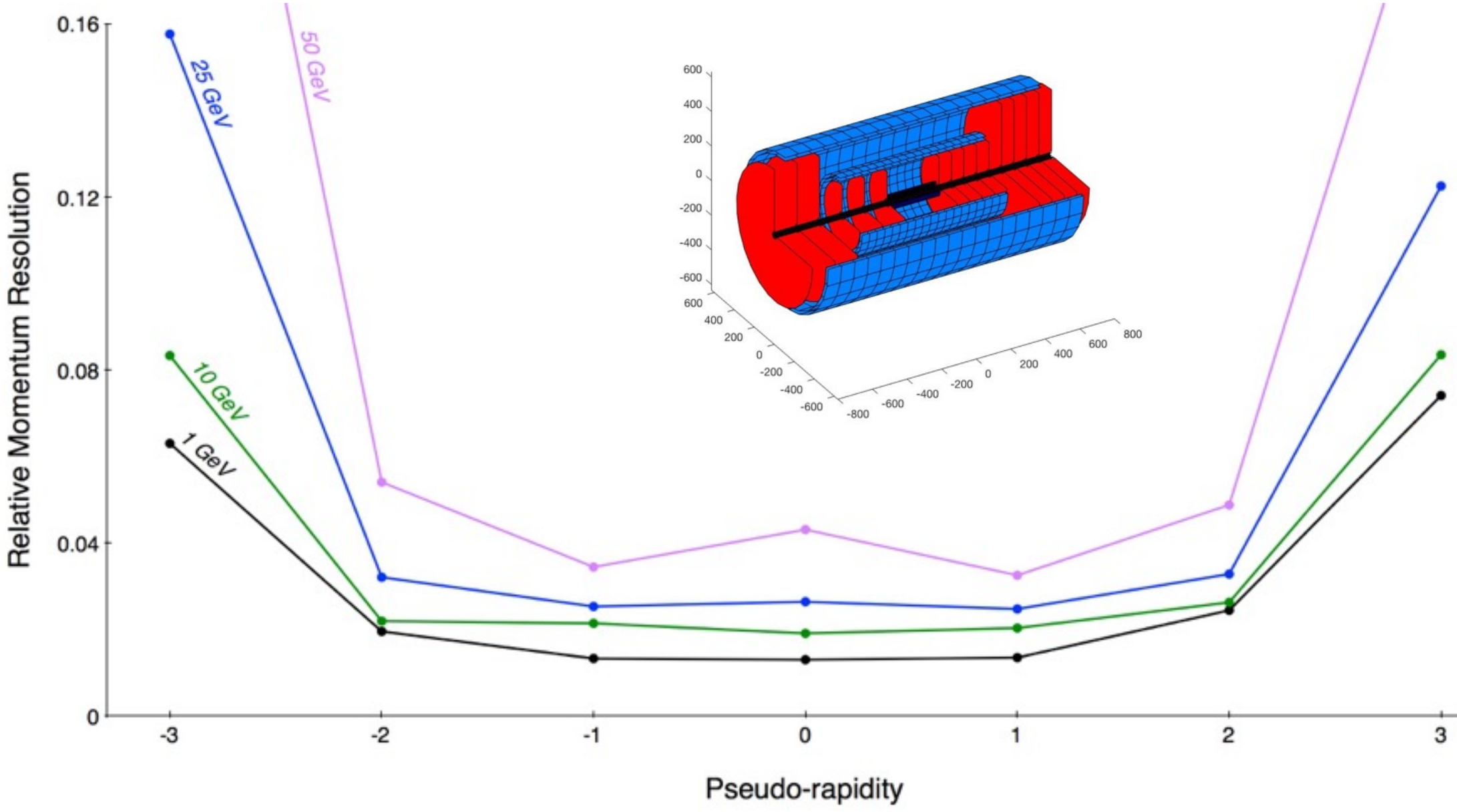
Simulation Work in Progress





Initial steps towards integrating forward/backward disk-trackers;
Left: disks integrated with a 7-layer ALICE-ITS “copy”,
Right: barrel and disks as an inner-tracker to a TPC.

Simulation Work in Progress



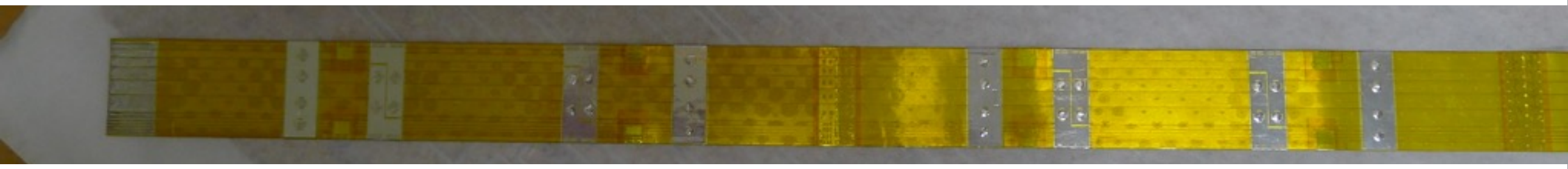
Very preliminary performance assessment for a hypothetical all-Si tracker (> 10m^2) in a 1.5T Solenoidal field. TPC+Si option in progress.

Low-Mass Conductors

- Low-mass conductors are a key part in developing a low-mass tracker; for example, the HFT conductors were the leading source of radiation length until a new detector copy was installed with Aluminum conductors,

- Mixed record from CERN, Kharkov, Industry - recent experience discussed at EIC R&D meeting past January,

- Recently, we have obtained 1.5m long conductors from CERN and Kharkov; we will test them shortly,



- ALICE-ITS is entering production stage; development synergies will cease to exist,

- Propose to build on past collaboration with Industry to attempt to develop a commercial Al flex cable option for disks.

Next Steps and Request

- Complete set of simulations proposed for the last cycle with the BNL-EIC task force framework (postdoc Yue Shi Lai),

---

- Continue independent simulations (Velkovsky),
  - optimization; disk radii, integration with barrel, etc.
  - displaced vertex capability in the hadron-going direction,

- Integration studies of disk and barrel with realistic infrastructure, requiring new simulations,

- New simulations to assess Si integration-time vis-a-vis the beam-crossing period(s),

- Study sensor-layout options for disk geometries,

- Seek to develop industrial production capability for low-mass conductors, in particular for disks,

- Request:

50% postdoc support	$ 83,616
student support	$ 8,276
M&S	$ 12,922
Total	$104,814

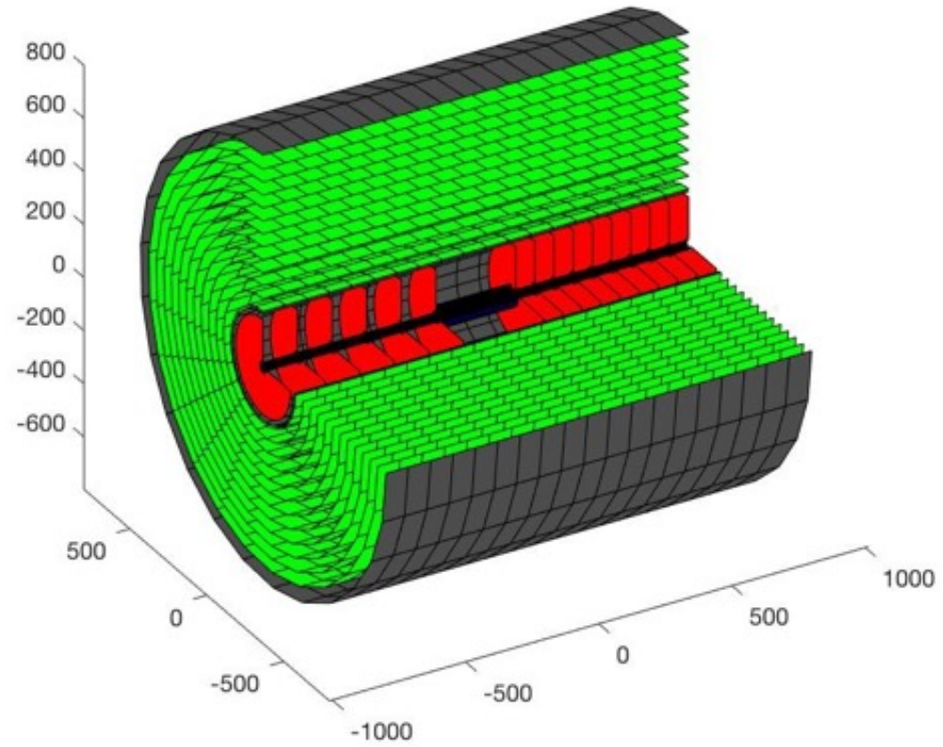
Closing Comments

We have:

- followed up on the committee's recommendation to establish contact and dialogue with eRD6 and eRD3, focusing on eRD6,

- discussed the idea of merging our efforts on the timescale of approximately one year; it would be too early to do this now,

- pursued opportunities for near-term strategic support for EIC at LBL with colleagues from multiple divisions;
  - scope is complementary and includes e.g. a comparative evaluation of MAPS and HV/HR-CMOS, and very forward tracking
  - anticipate to learn of outcome by late Summer 2016



We look forward to

- establishing contact also with the new (to EIC R&D) groups with interest in tracking,

- productive continuation of the EIC User Group Meeting.