Far-Forward Detector Working Group: Intro and Overview

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For the EPIC Collaboration and the FF DWG

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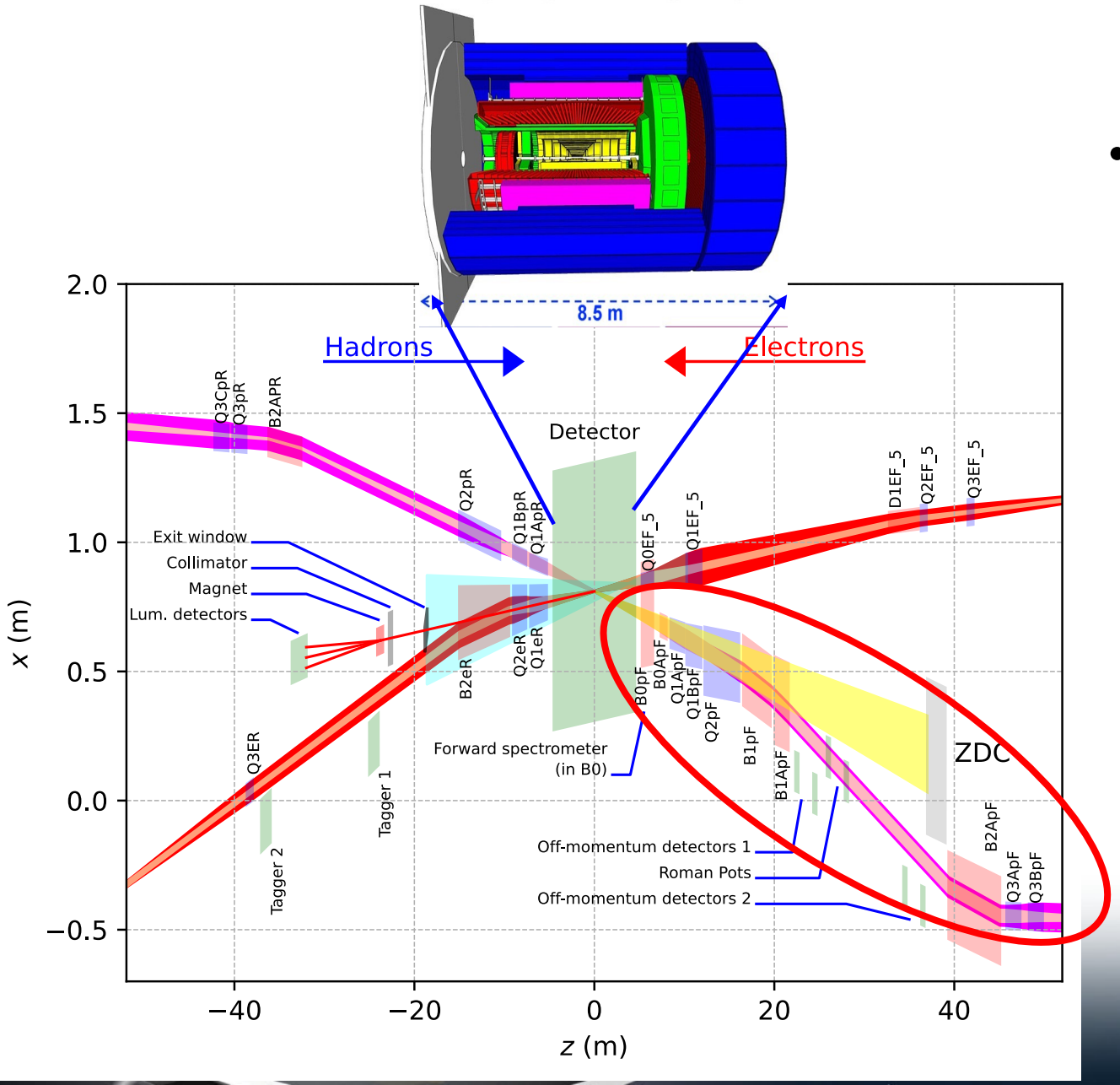
ePIC Collaboration Meeting
January 9th to 11th, 2023
Jefferson Lab

BROOKHAVEN NATIONAL LABORATORY Jefferson Lab U.S. DEPARTMENT OF ENERGY | Office of Science

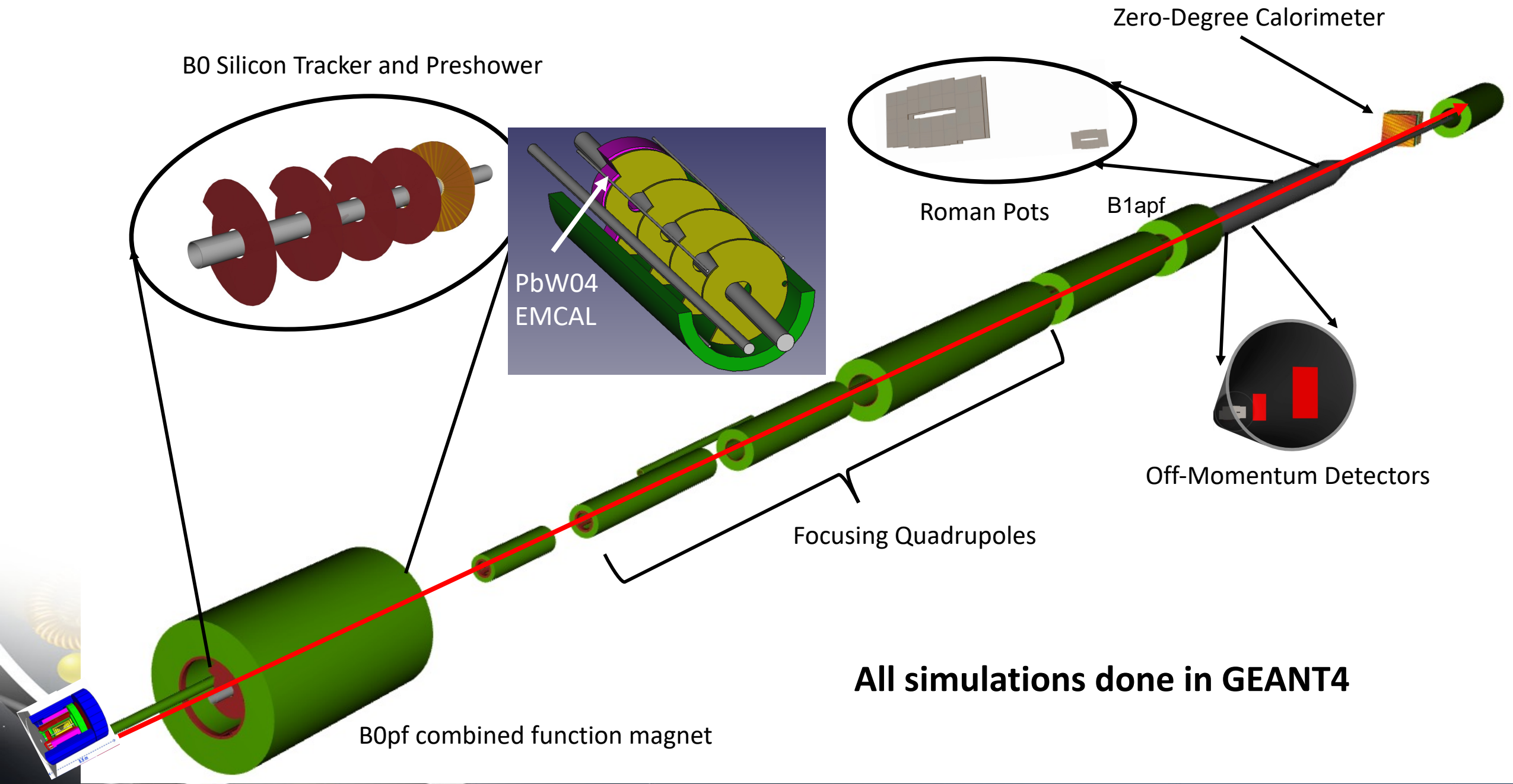
The ePIC Detector



- Detectors integrated into the beamline on both the hadron-going (**far-forward**) and electron-going (**far-backward**) direction.
  - Special considerations for the machine-detector interface.

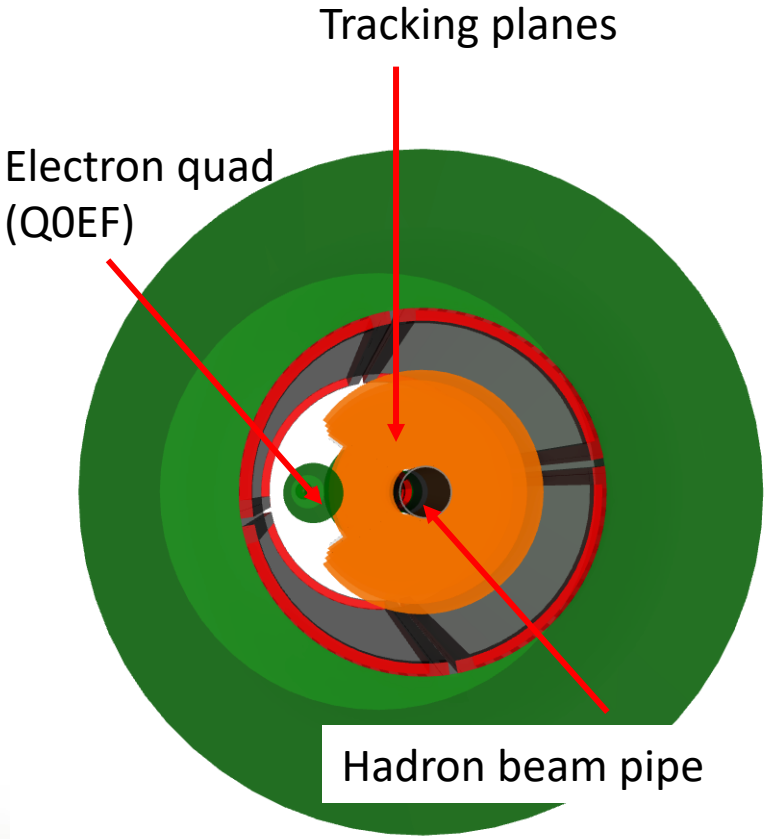
The far-forward system functions almost like an independent spectrometer experiment at the EIC!

The Far-Forward Detectors

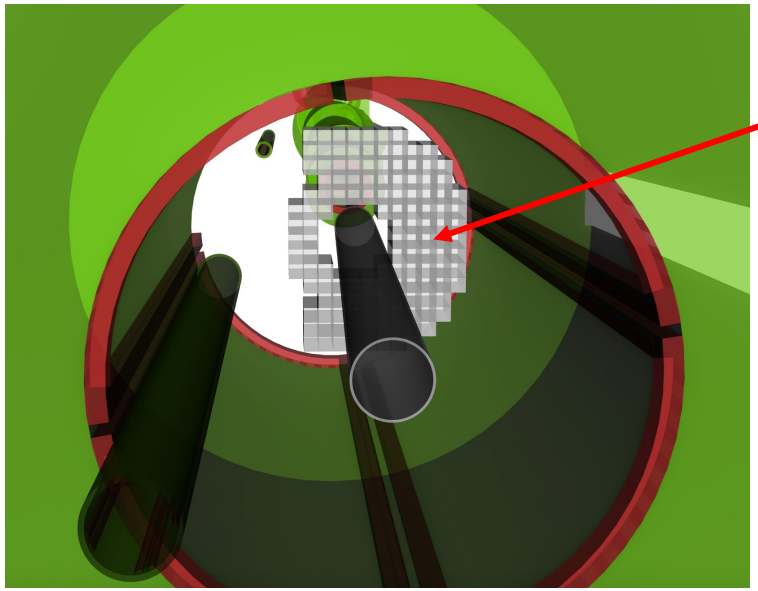


All simulations done in GEANT4

B0 Tracking and EMCAL Detectors



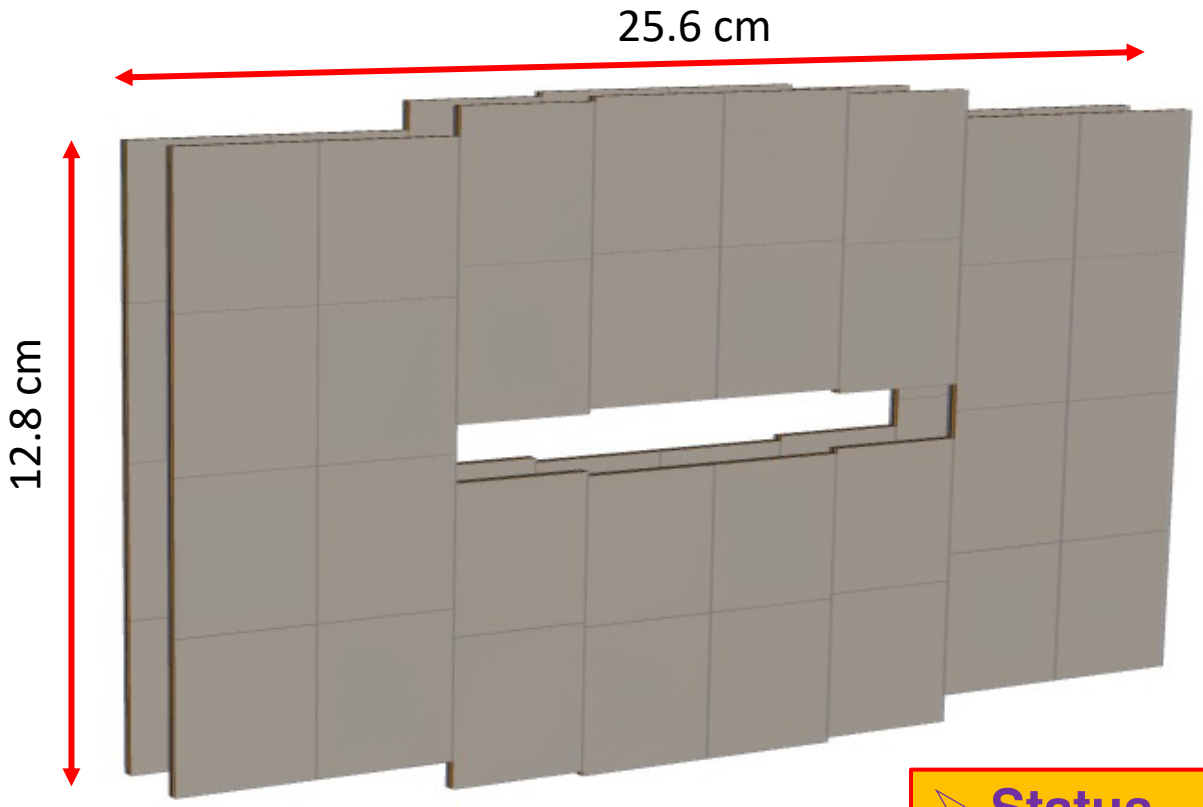
ePIC DD4HEP Simulation



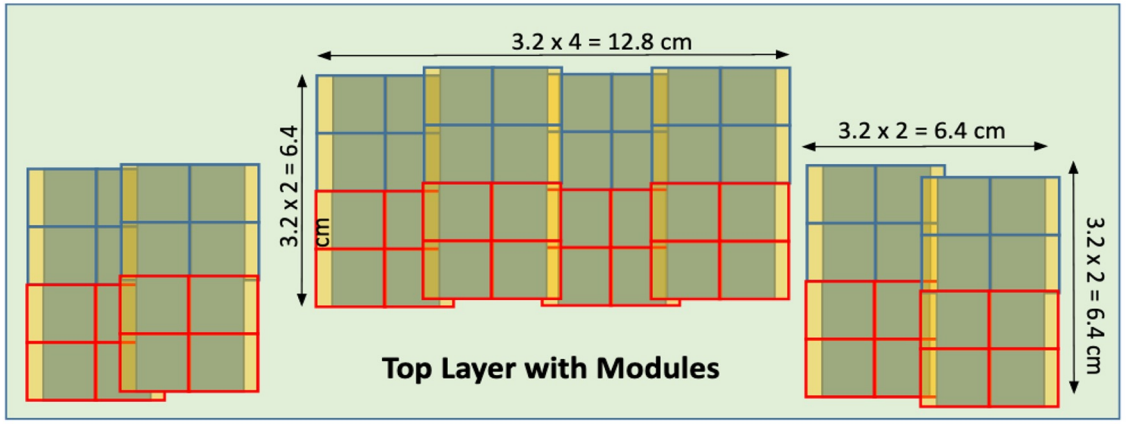
- **Technology choices:**
  - **Tracking: IT3 or ITS2 MAPS (3 layers) + AC-LGADs (1 layer; in middle)**
  - **PbWO4 EMCAL or silicon preshower, depending on available space in final B0pf magnet design (pending).**

- **Status**
  - ✓ **Basic geometry implemented! (EMCAL – Sakib Rahman; tracking – A. Jentsch)**
  - ✓ **Simple tests complete (see Sakib's and Michael's talks next for more details).**
  - ✓ **Stand-alone simulations have demonstrated tracking resolution.**
    - **https://indico.bnl.gov/event/17905/**
    - **https://indico.bnl.gov/event/17622/**

Roman “Pots” and Off-Momentum Detectors @ the EIC



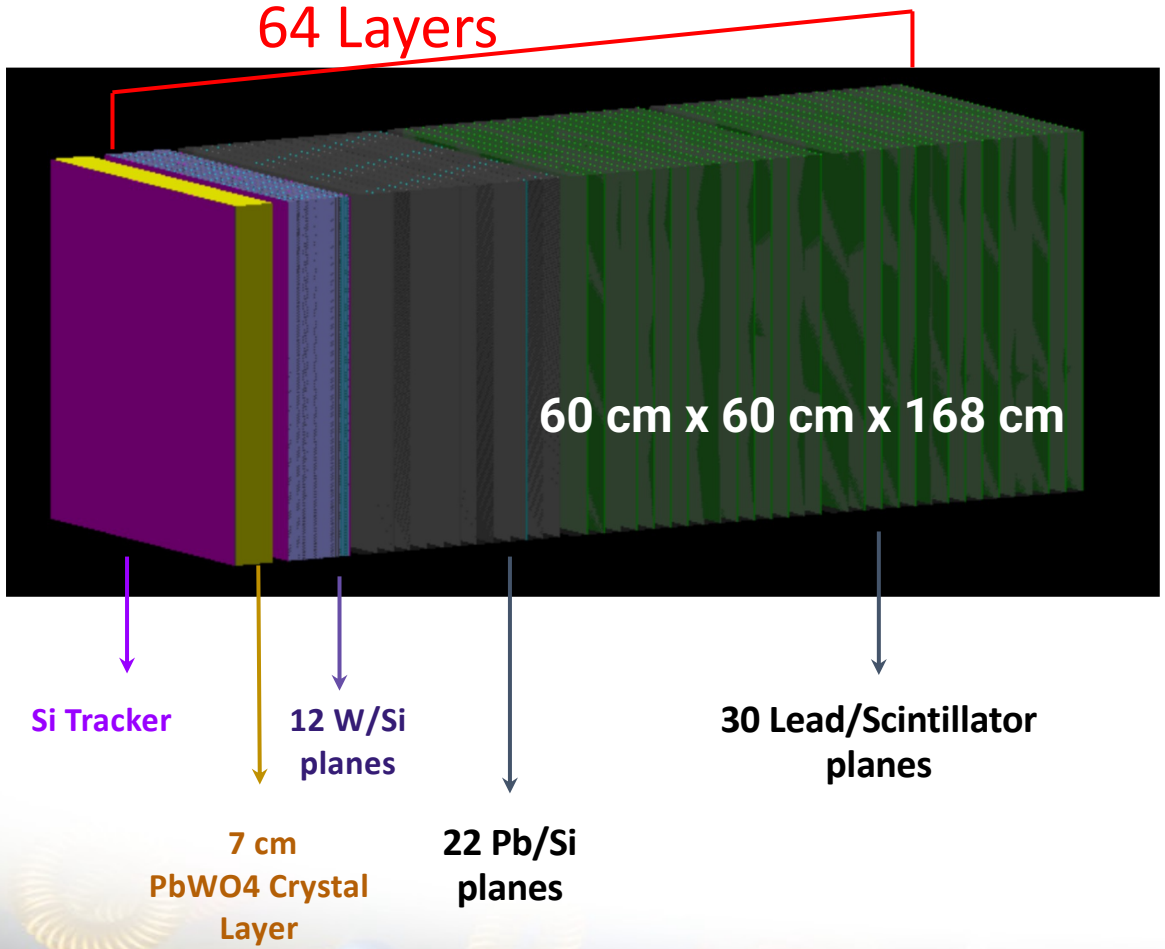
DD4HEP Simulation



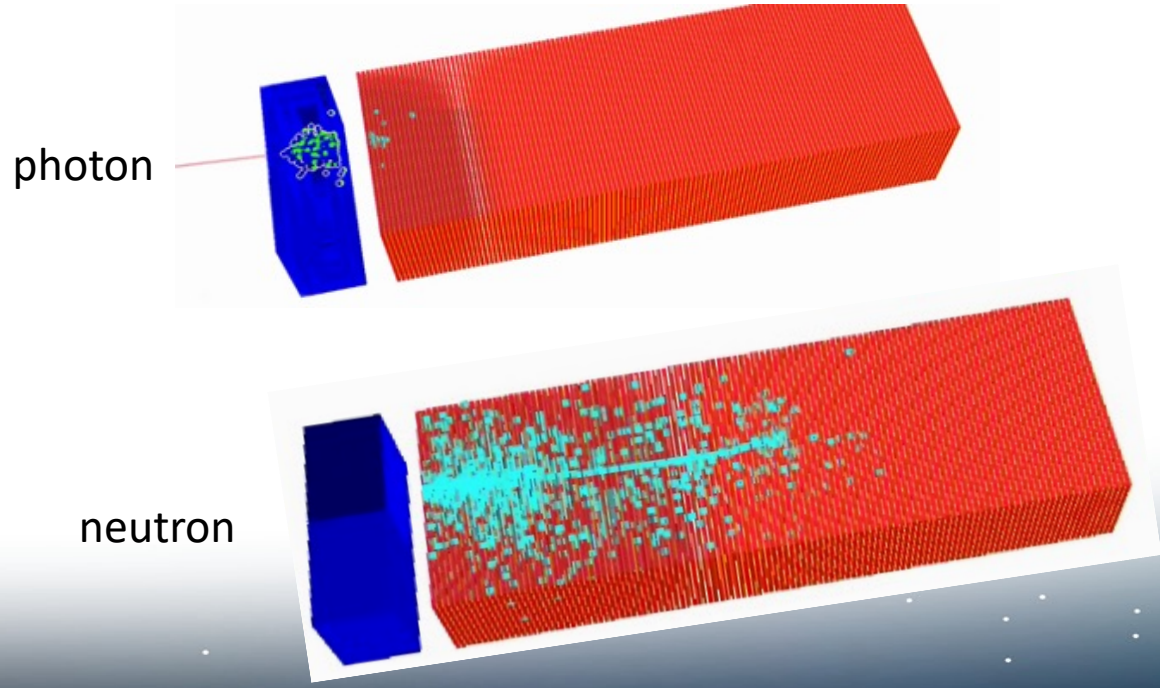
- **Technology**
  - 500um, pixilated AC-LGAD sensor provides both fine pixilation.
  - “Potless” design concept with thin RF foils surrounding detector components.

- **Status**
  - ✓ **Basic geometry implemented! (A. Jentsch)**
  - ✓ **Simple tests complete – lots of work needed on reconstruction algorithm.**
  - ✓ **Some issues found in reconstruction that are being worked-out now (see backup).**
  - ✓ **Approved generic R&D to develop reco code!**

Zero-Degree Calorimeter



- **Zero Degree Calorimeter (modified ALICE FoCal design):**
  - **30 m from IR**
  - **Detect spectator neutrons (HCAL) & photons (EMCAL)**
  - **Acceptance: +4.5 mrad, -5.5mrad**
  - **Position resolution ~1.3mm at 40 GeV**
  - **Resolutions meet requirements from Yellow Report**



Credit to Shima Shimizu (Kobe U. , Japan)

See talk by Lynn Wood for some updates on imaging.

Summary and Takeaways

- All FF detector acceptances and detector performance well-understood with currently available information.
  - **Numerous impact studies done! (**Yellow Report, Detector proposals, and stand-alone studies)
  - **Final technology choices identified, along with suitable alternate designs for risk mitigation.**

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- **Focus now is on two fronts:**
  - ✓Continued study and refinement of DD4HEP simulations (in particular, reconstruction).
  - ✓Work with machine experts on integration (e.g. shielding, support structure, impedances).

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Email me or any other FF convener if you have any questions: ajentsch@bnl.gov

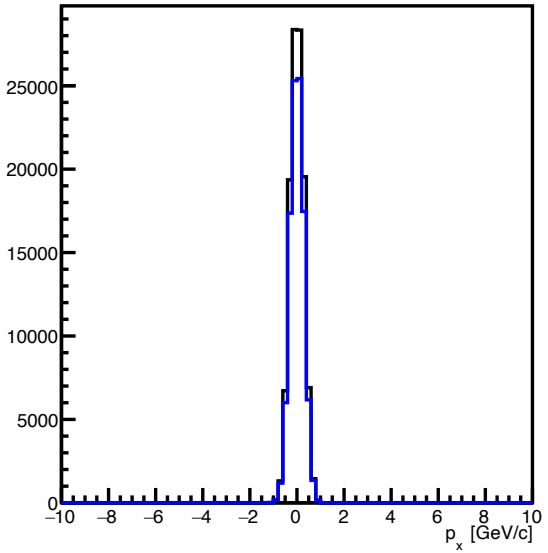
Want to get involved?? Join our meetings and learn how!

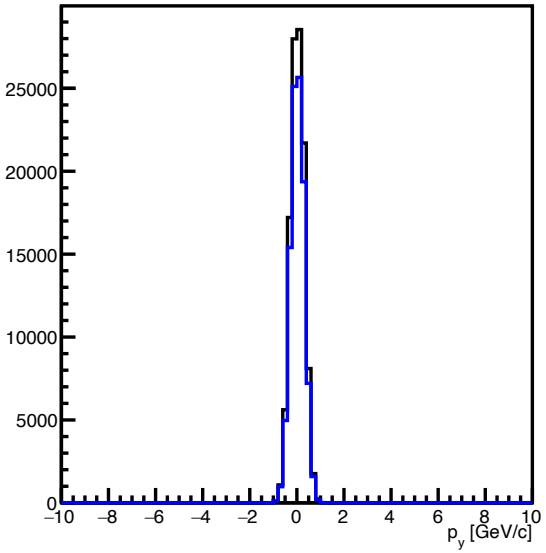
Meeting time: Tuesdays @ 9am EDT (bi-weekly, or weekly, as needed)
Indico: https://indico.bnl.gov/category/407/
Wiki: https://wiki.bnl.gov/eic-project-detector/index.php?title=Collaboration
Email-list: eic-projdet-FarForw-l@lists.bnl.gov
Subscribe to mailing list through: https://lists.bnl.gov/mailman/listinfo/eic-projdet-farforw-l

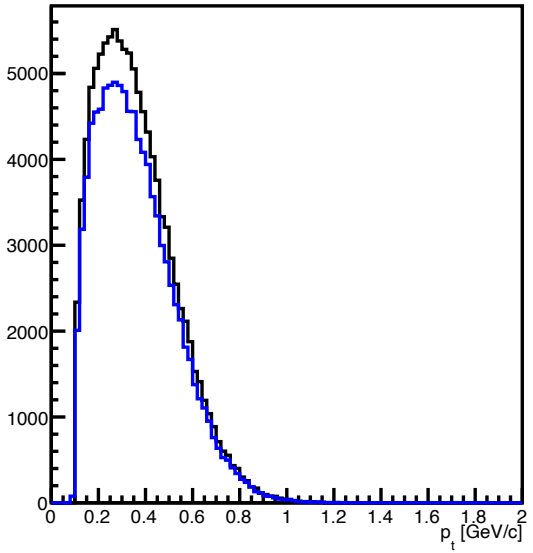
Backup

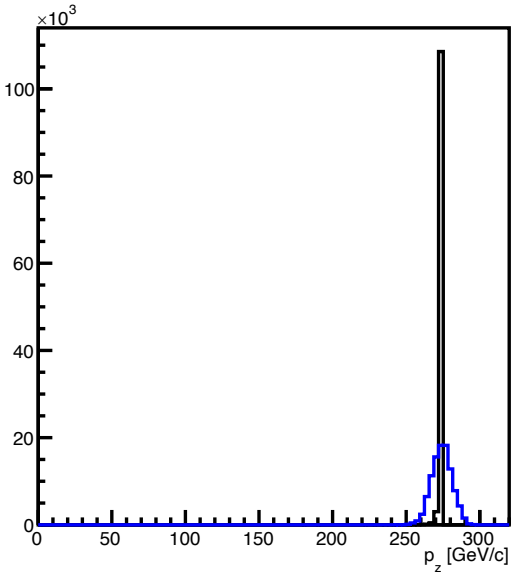
Simulation Campaign Results – DVCS

MC + "**smeared FF**" (fast smearing)





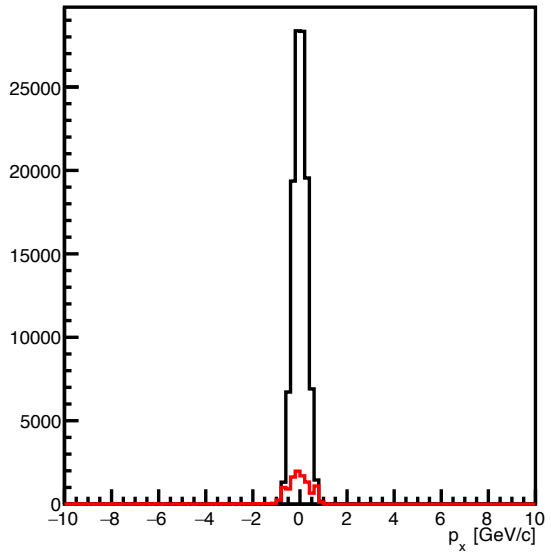


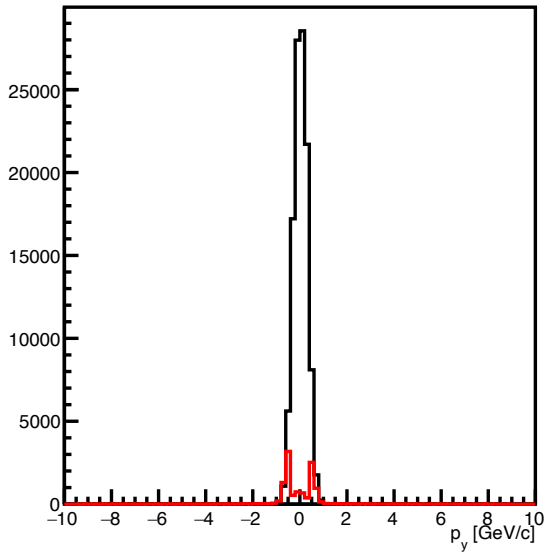


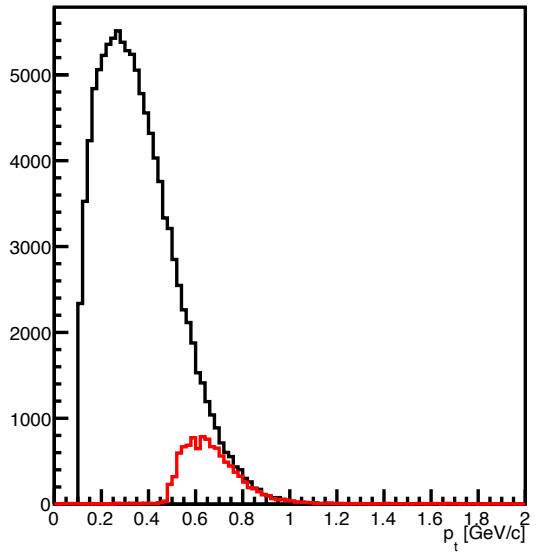
- "Fast smearing" plugin works as it should.
  - Acceptances from previous simulations, smearing a rough average (not parametrized).
- Useful for main detector studies where a FF proton needs to be tagged/reconstructed while full reco is debugged (**see next slide; see Sakib's talk for B0**).
  - E.g. for exclusivity studies.
- Crossing angle removed.

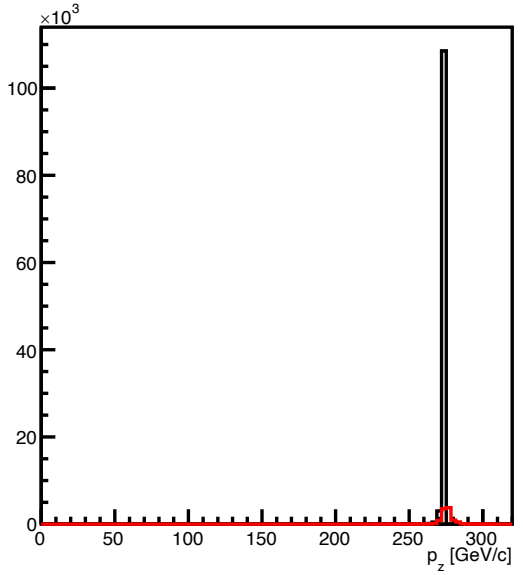
Simulation Campaign Results – DVCS

MC + "**Roman Pots Reco**"



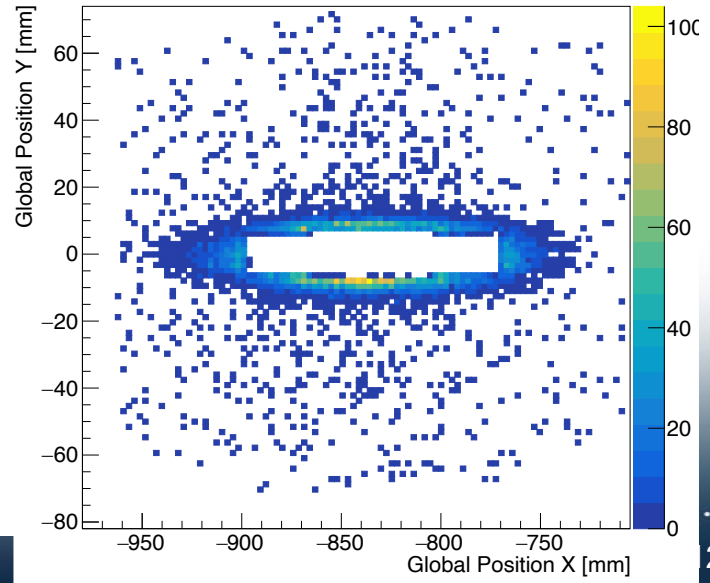






- Reconstruction is ***not working*** in EICRecon – px and py = 0.0, pz = exactly beam momentum.
  - **Under investigation.**
- I have written an afterburner into my analysis code (will make it available today) which performs the reconstruction with the ***real hits*** (it literally does exactly what the EICRecon code is supposed to do).
  - This is what you see above – real reconstruction with the real hits, done at the analysis stage.
- Acceptance is about 10%, which indicates that something is not working properly with the settings for the 10σ position.

Roman_pots_occupancy_map

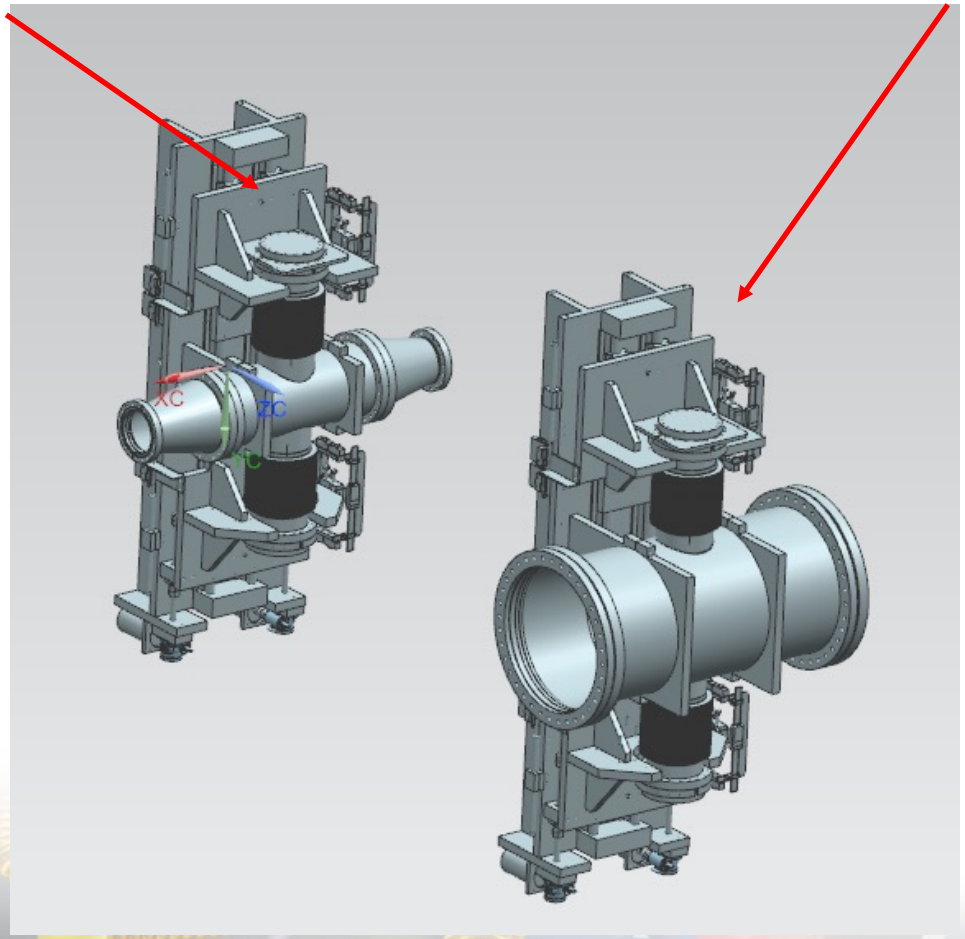


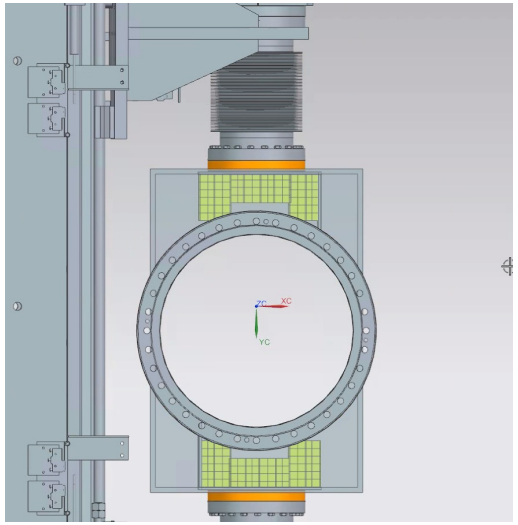
Roman Pots and Off-Momentum Detectors

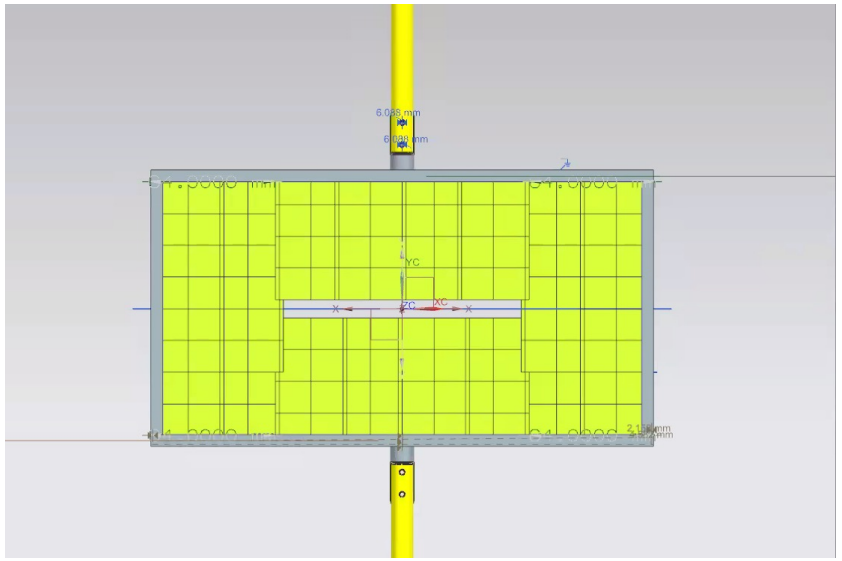
Initial step file inspired by STAR

Updated model in NX with different beamtube size

Credit: Ron Lassiter



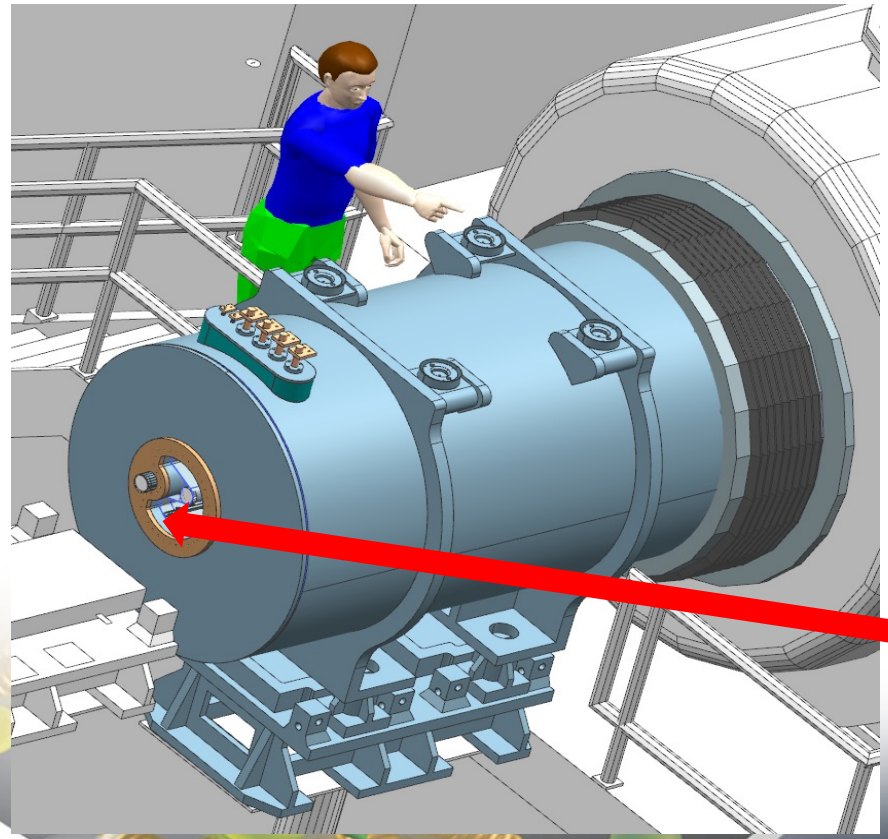


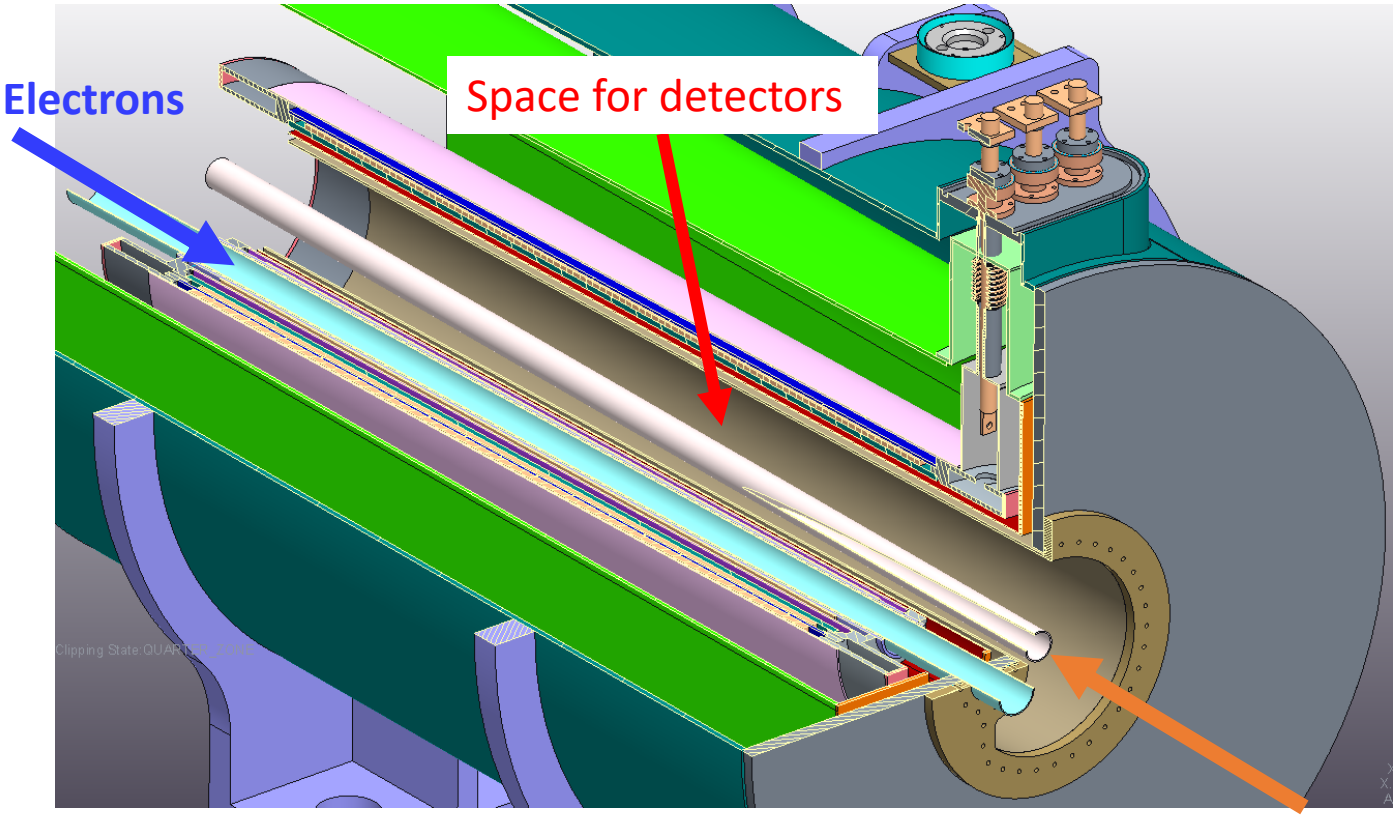


Work underway to evaluate impedances and integrate design considerations to mitigate impacts.

B0 Detectors

- Charged particle reconstruction and photon tagging.
  - Precise tracking (~10um spatial resolution).
  - Fast timing for background rejection and to remove crab smearing (~35ps).
  - Photon detection (tagging or full reco).



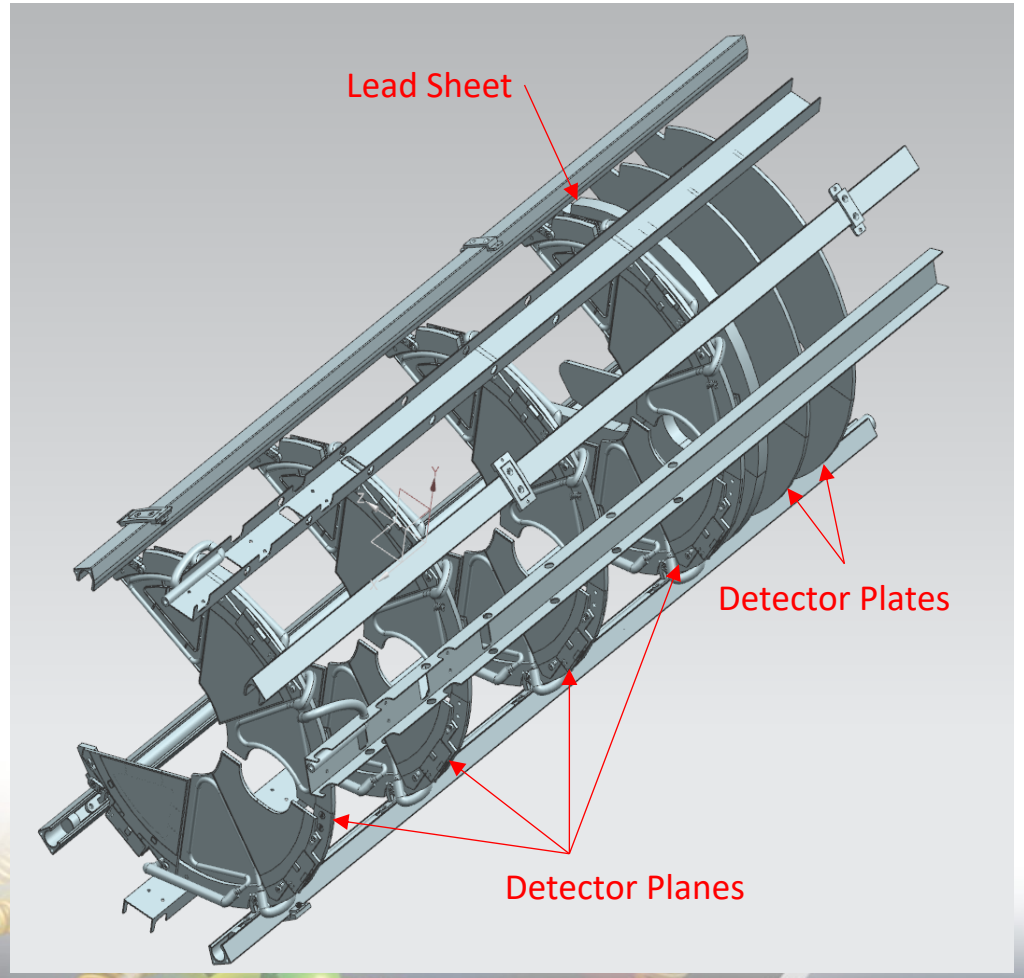


This is the opening where the detector planes will be inserted

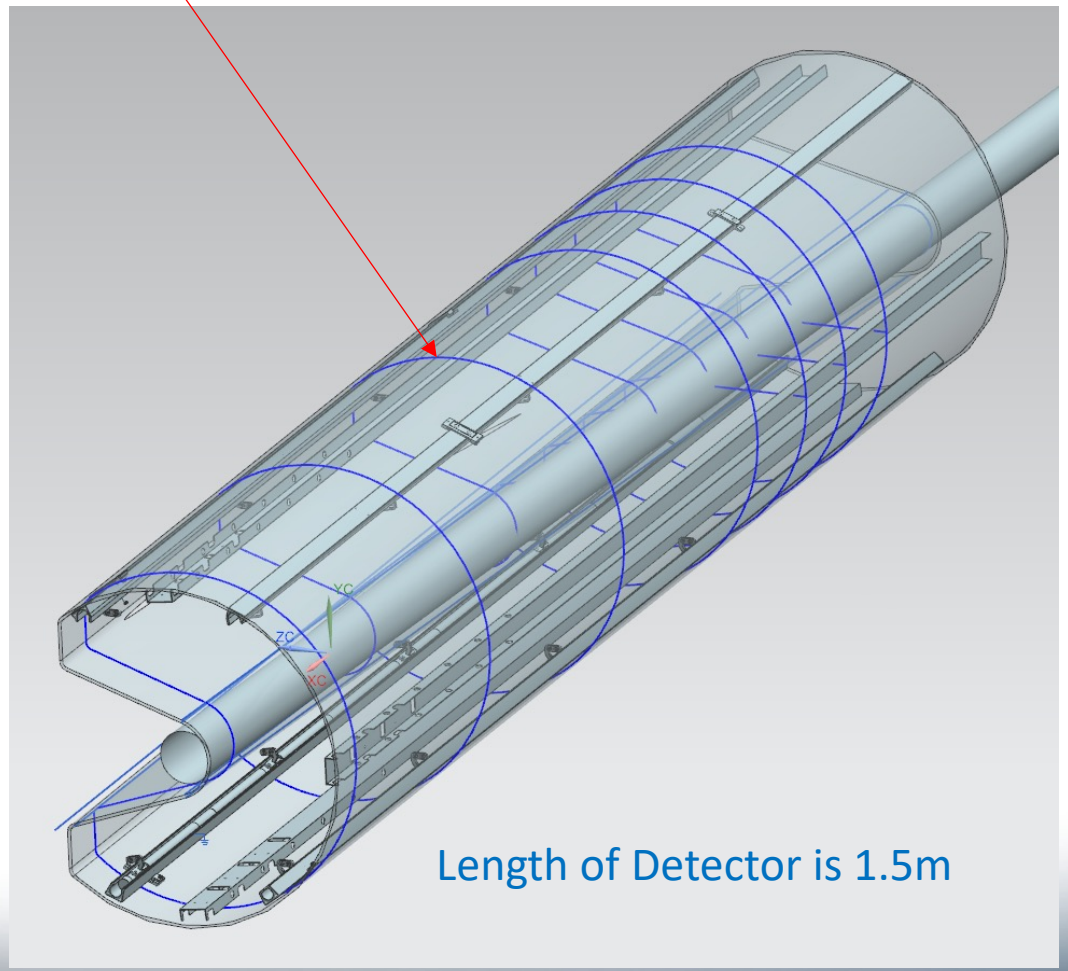
Preliminary Parameters:
229.5cm x 121.1cm x 195cm
(**Actual length will be shorter**)

B0 Detectors in CAD

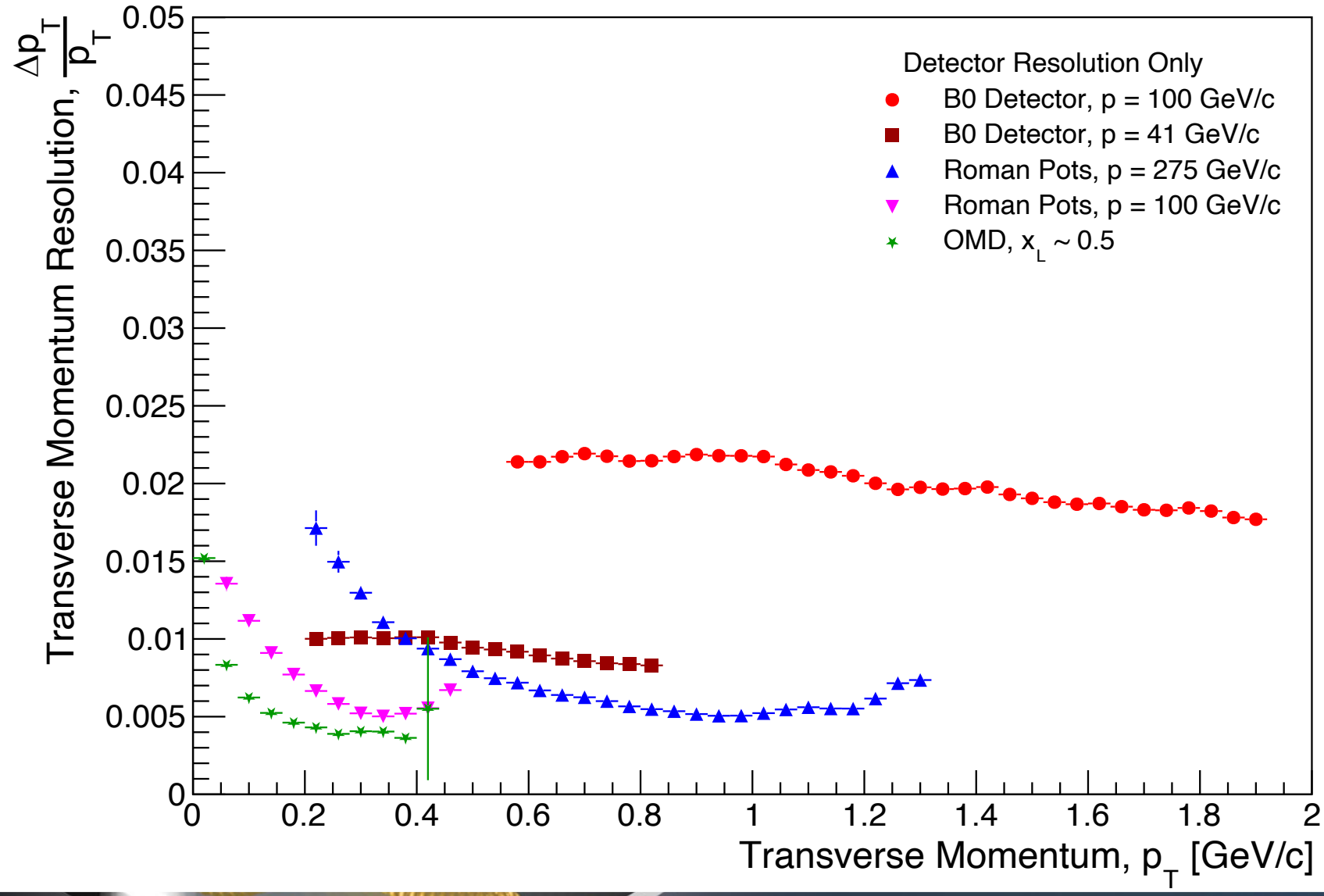
Credit: Ron Lassiter and Karim Hamdi



Blue lines represent where element locations are along beamline

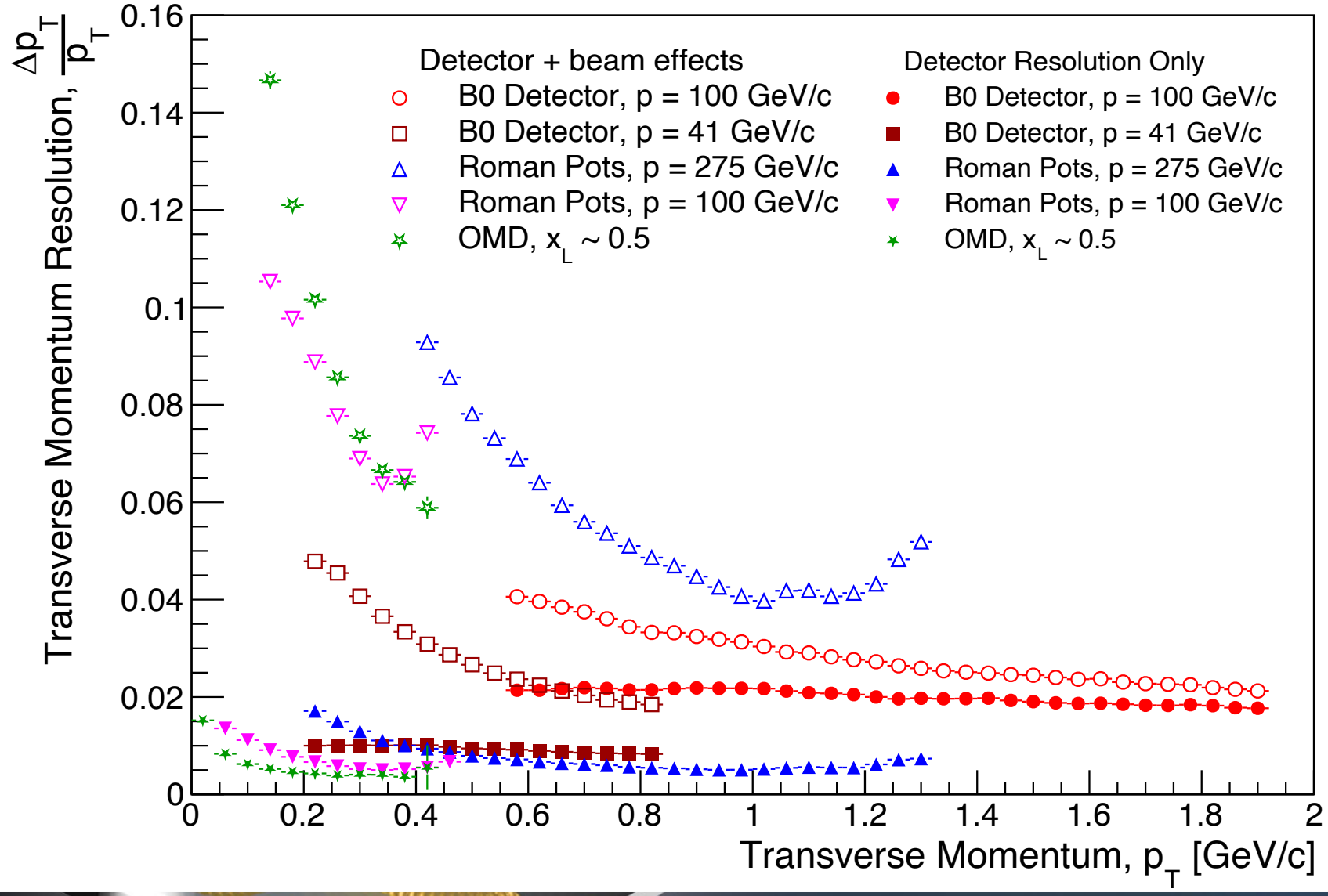


Summary of Detector Performance (Trackers)



- Includes realistic considerations for pixel sizes and materials
  - More work needed on support structure and associated impacts.
- Roman Pots and Off-Momentum detectors suffer from additional smearing due to improper transfer matrix reconstruction.
  - This problem is close to being solved!

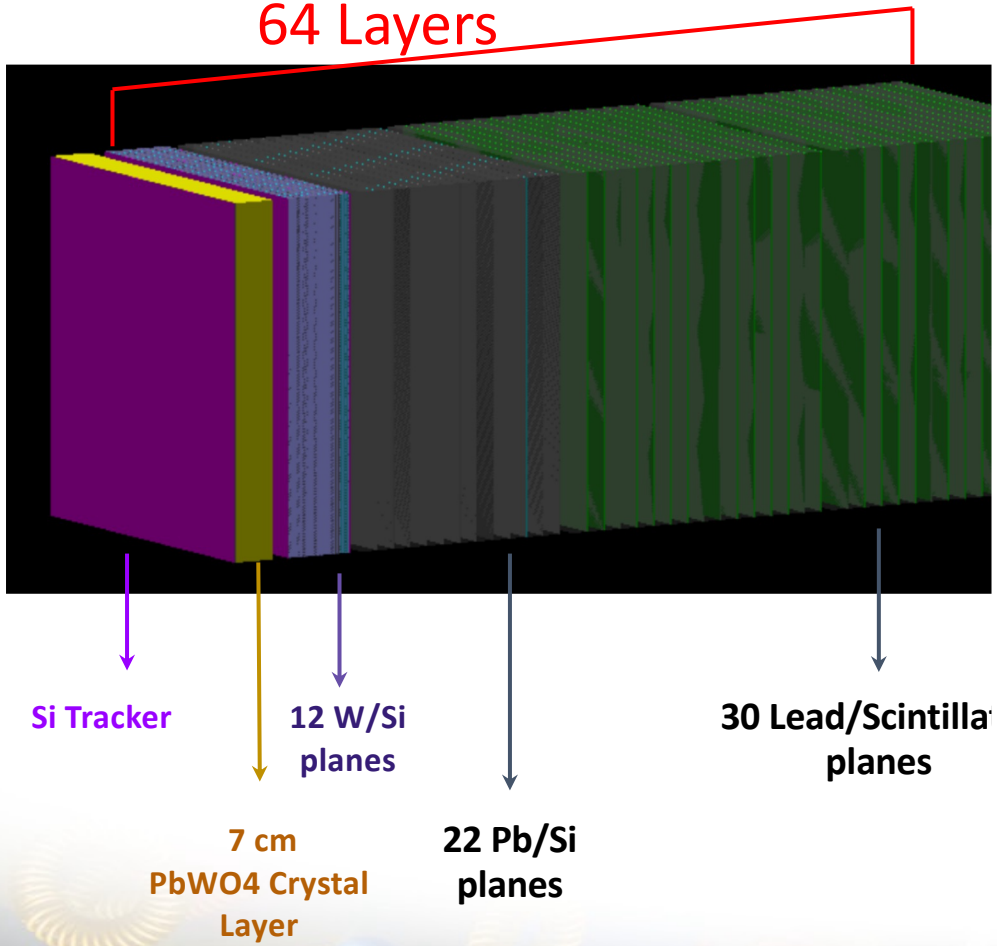
Summary of Detector Performance (Trackers)



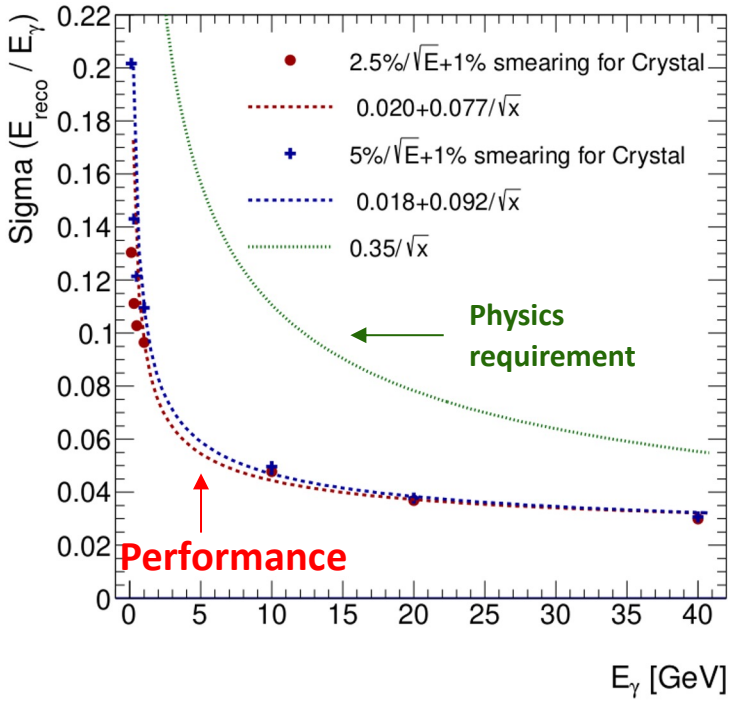
- All beam effects included!
  - Angular divergence.
  - Crossing angle.
  - Crab rotation/vertex smearing.

Beam effects the dominant source of momentum smearing!

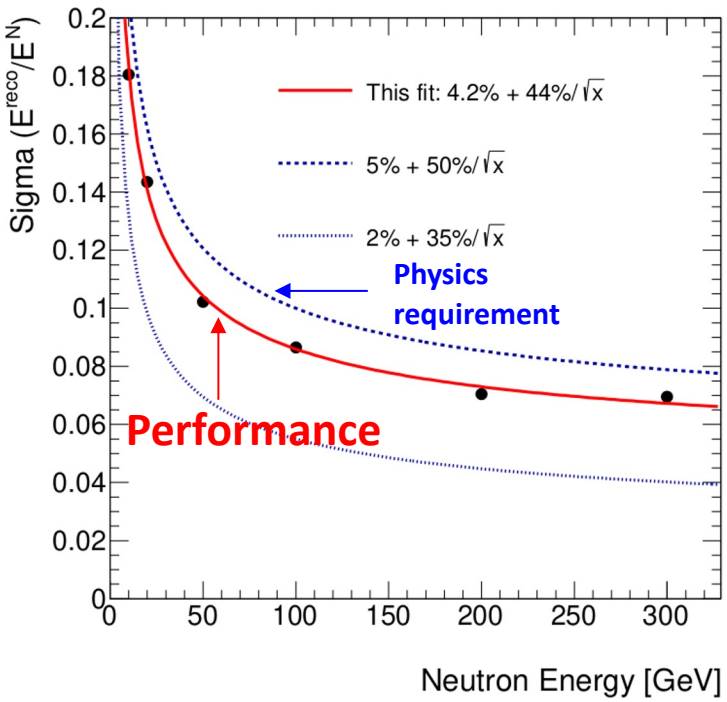
Zero-Degree Calorimeter



Photon energy resolution



Neutron energy resolution



Credit to Shima Shimizu (Kobe U. , Japan)

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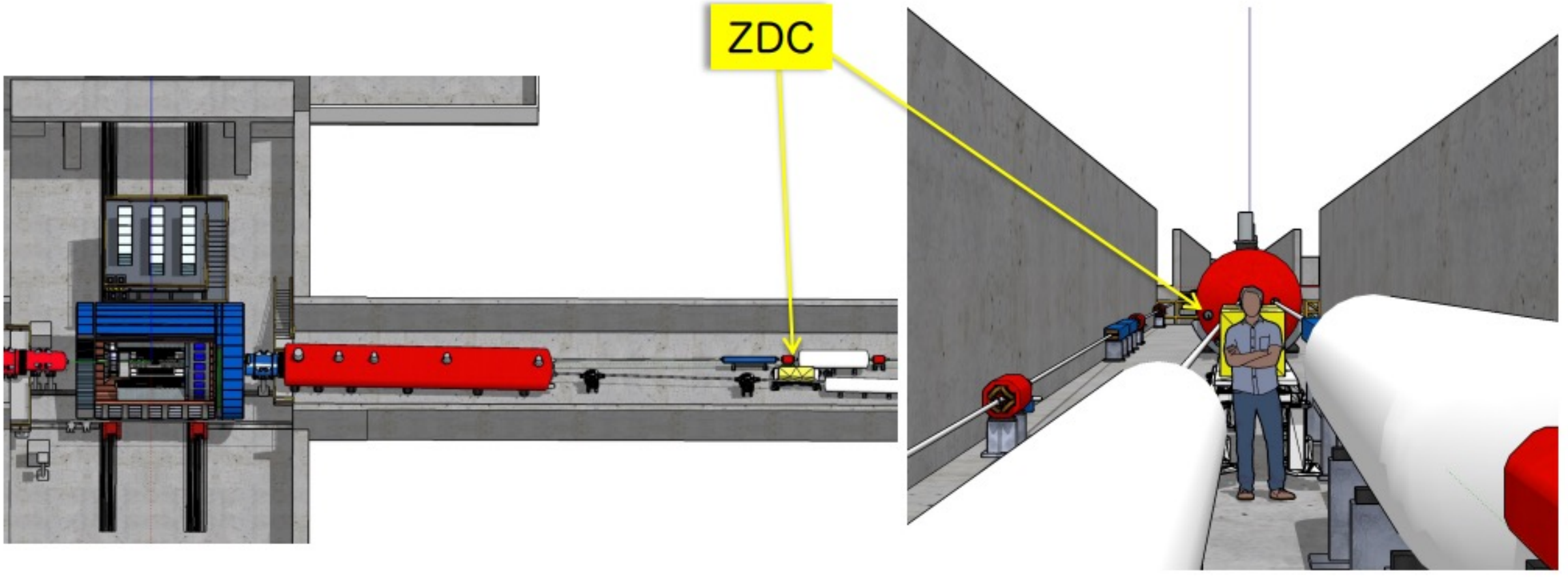
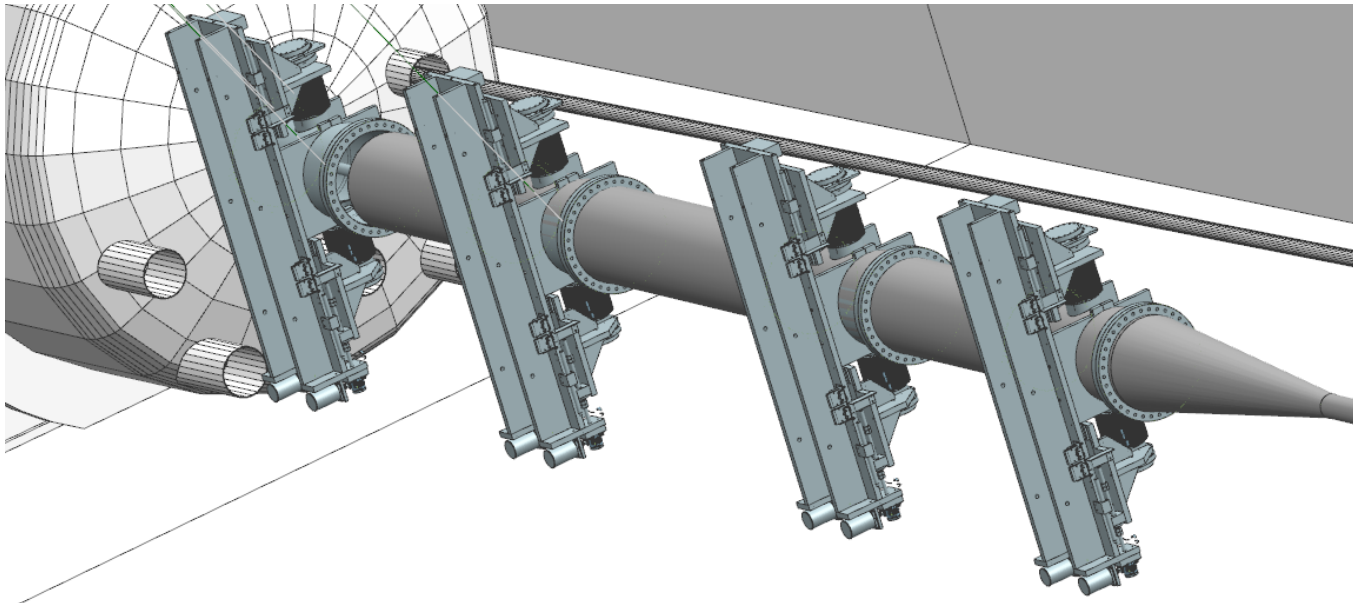
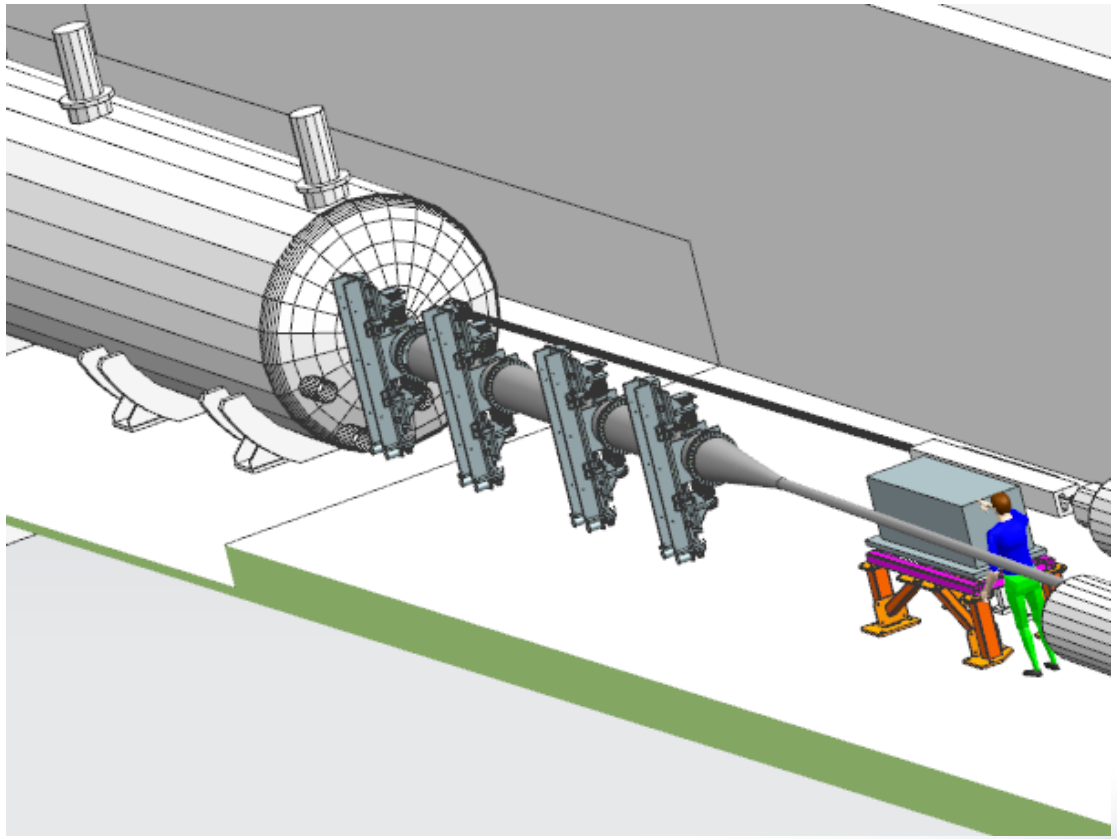
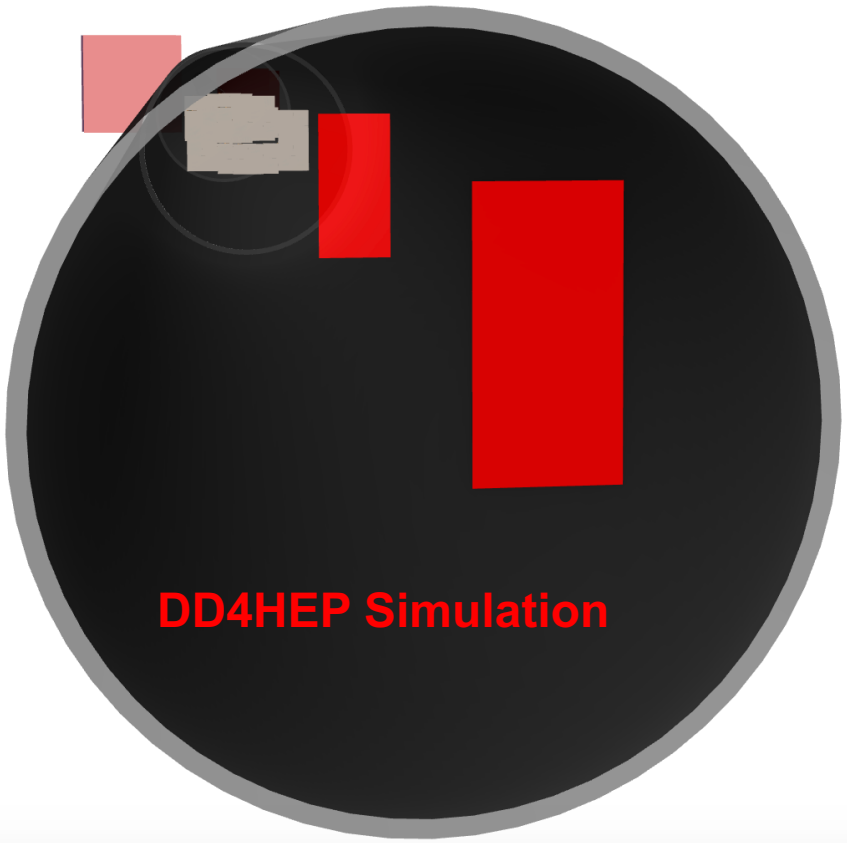


Preliminary CAD drawings of RP and OMD Supports and Magnet Cryostats





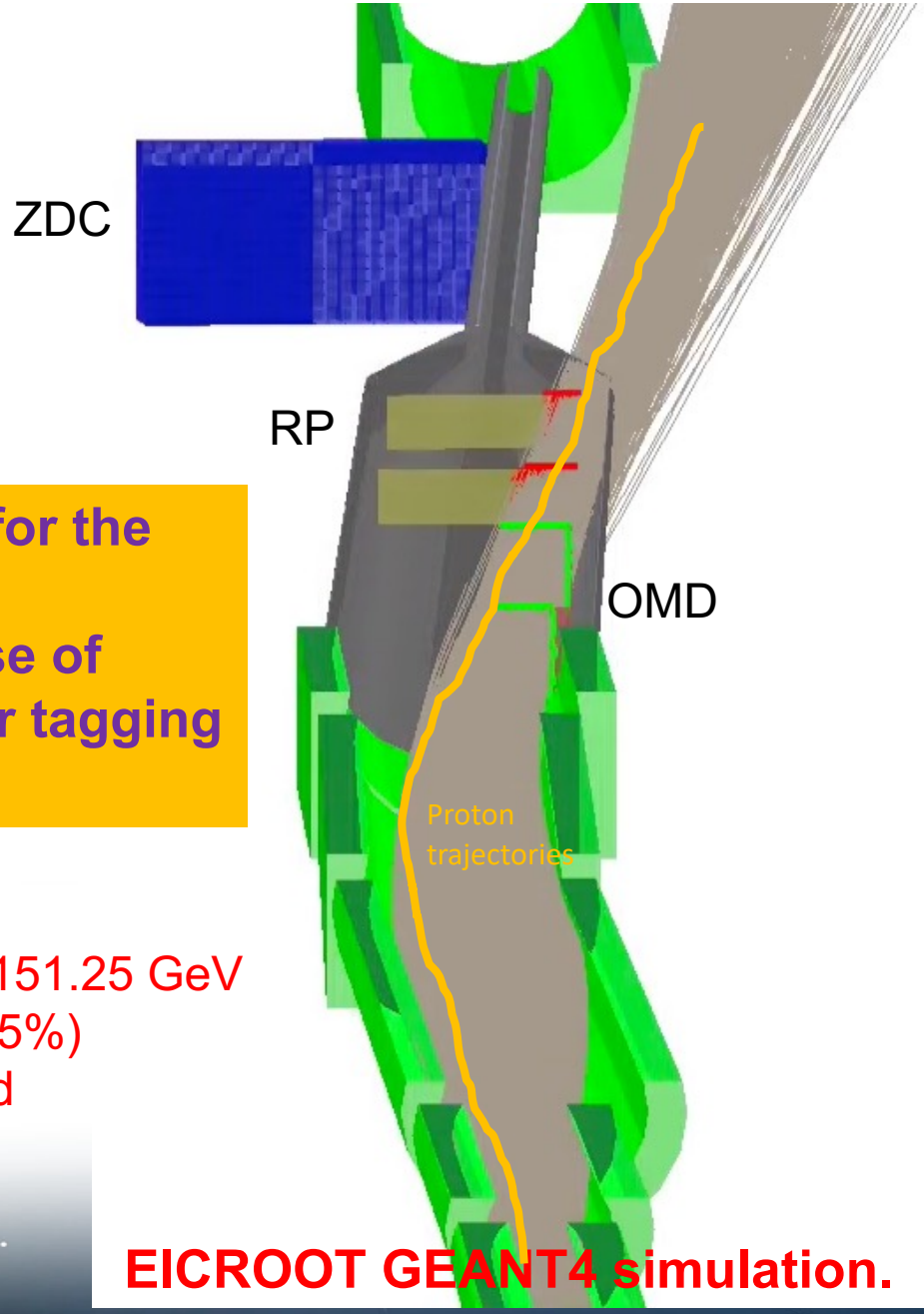
Off-Momentum Detectors



- **Same technology as for the Roman Pots.**
- **Need to also study use of OMD on other side for tagging negative pions.**

Off-momentum detectors implemented as horizontal ”Roman Pots” style sensors.

Protons
123.75 < E < 151.25 GeV
(45% < xL < 55%)
0 < θ < 5 mrad



EICROOT GEANT4 simulation.