Center for Frontiers in Nuclear Science

Stony Brook University

CORE Simulations in Fun4All

Outline

- ❑ Implementation of CORE Geometry in Fun4All
- ❑ Momentum Resolution Analysis
- ❑ Combined Track and EMCal Analysis
- ❑ Summary, code availability and next steps

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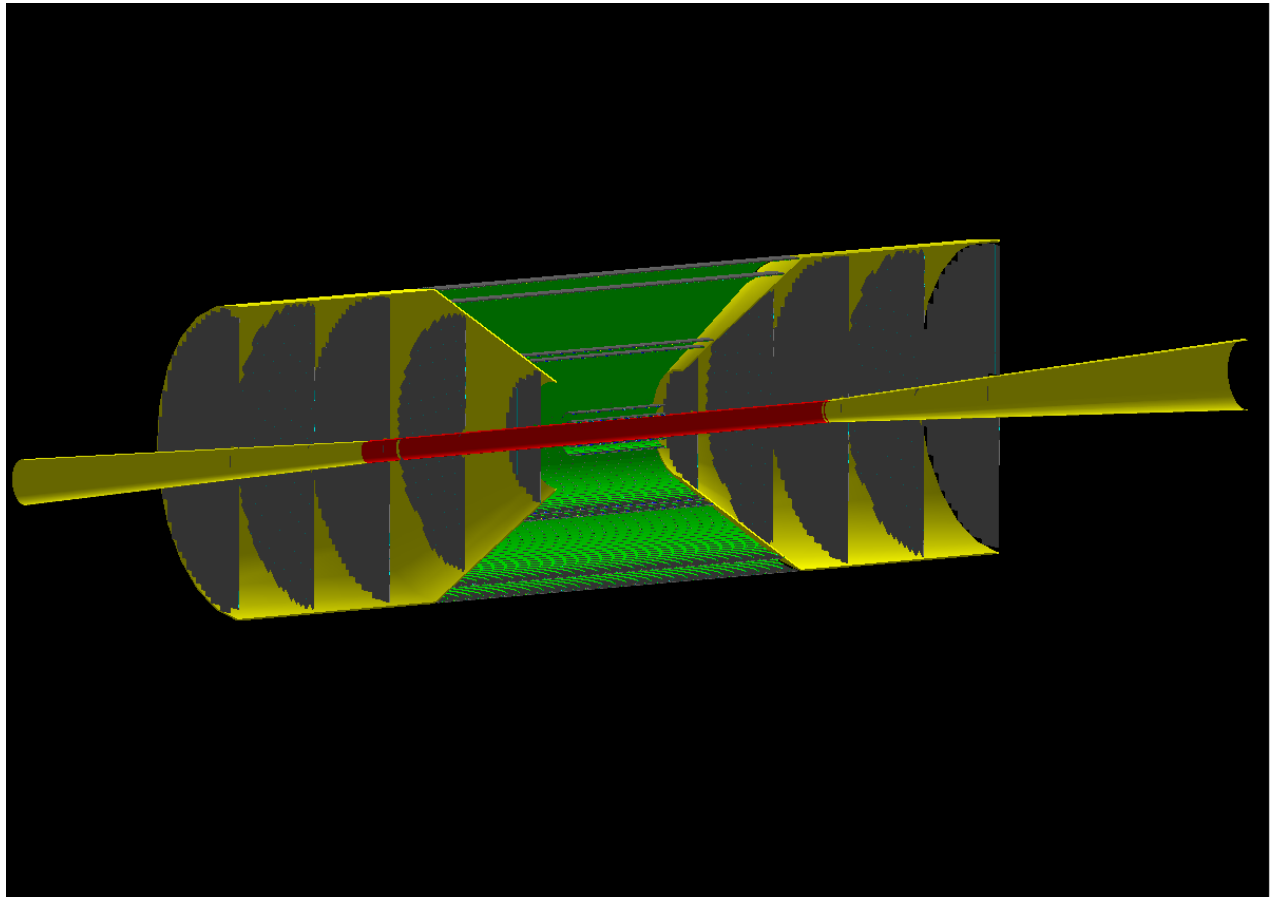
Why we chose the Fun4All framework

- The Fun4All framework allows one to implement the geometry and material of detector components in a straightforward, modular fashion.
- Implementations of specific detectors (such as the all-silicon tracker developed by the eRD25 consortium) have already been implemented.
- The simulation is run through ROOT macros and directly integrates many of the event generators needed for EIC studies.
- There exists reconstruction and analysis modules for many of the detector types. I will give some examples at the end of this presentation.

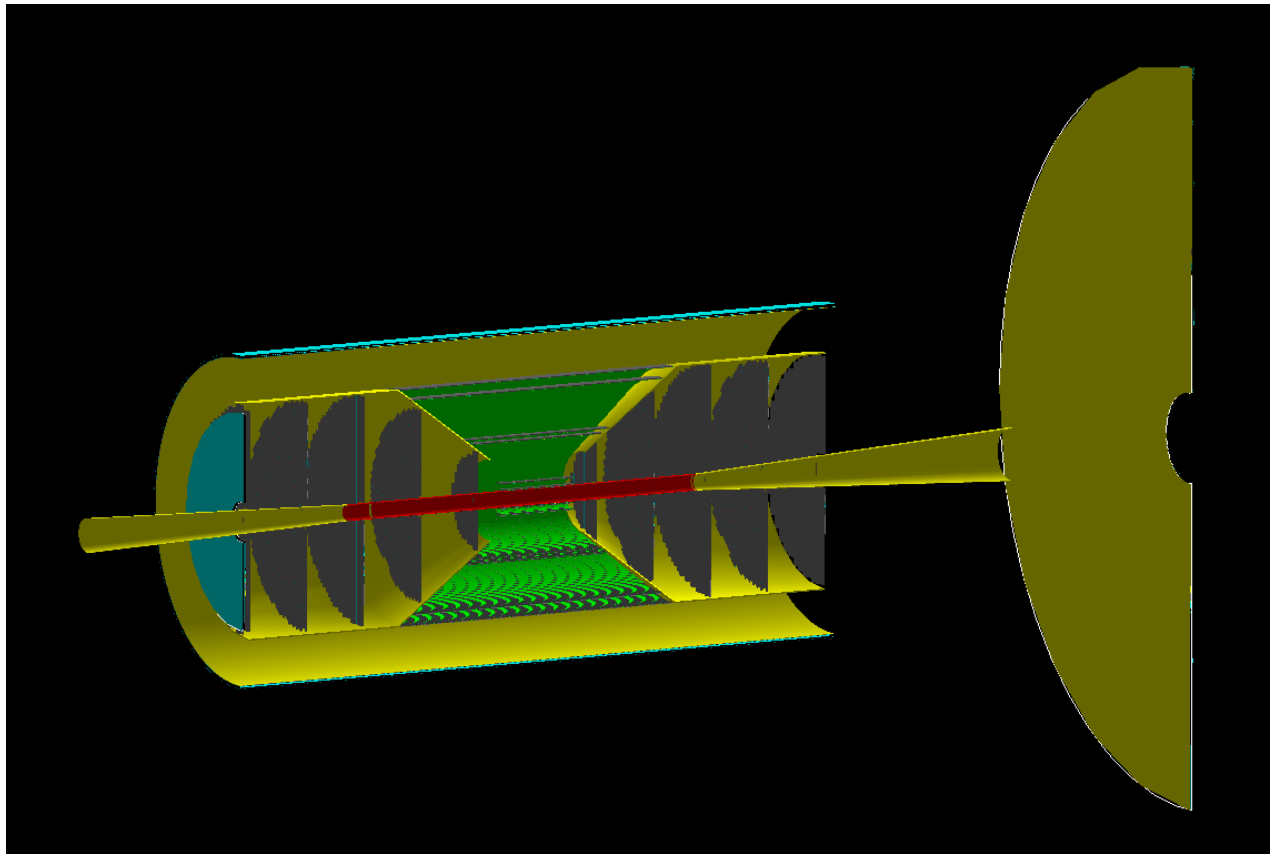
All-silicon tracker

- The all-silicon tracker developed by the eRD25 consortium forms the central part of the CORE design.
- The tracker's half-length in z is approximately 122 cm. The radius is about 44 cm.
- The all-Si tracker geometry was previously implemented in Fun4All. Read-out and analysis of the detector is done using a fast-tracking module.



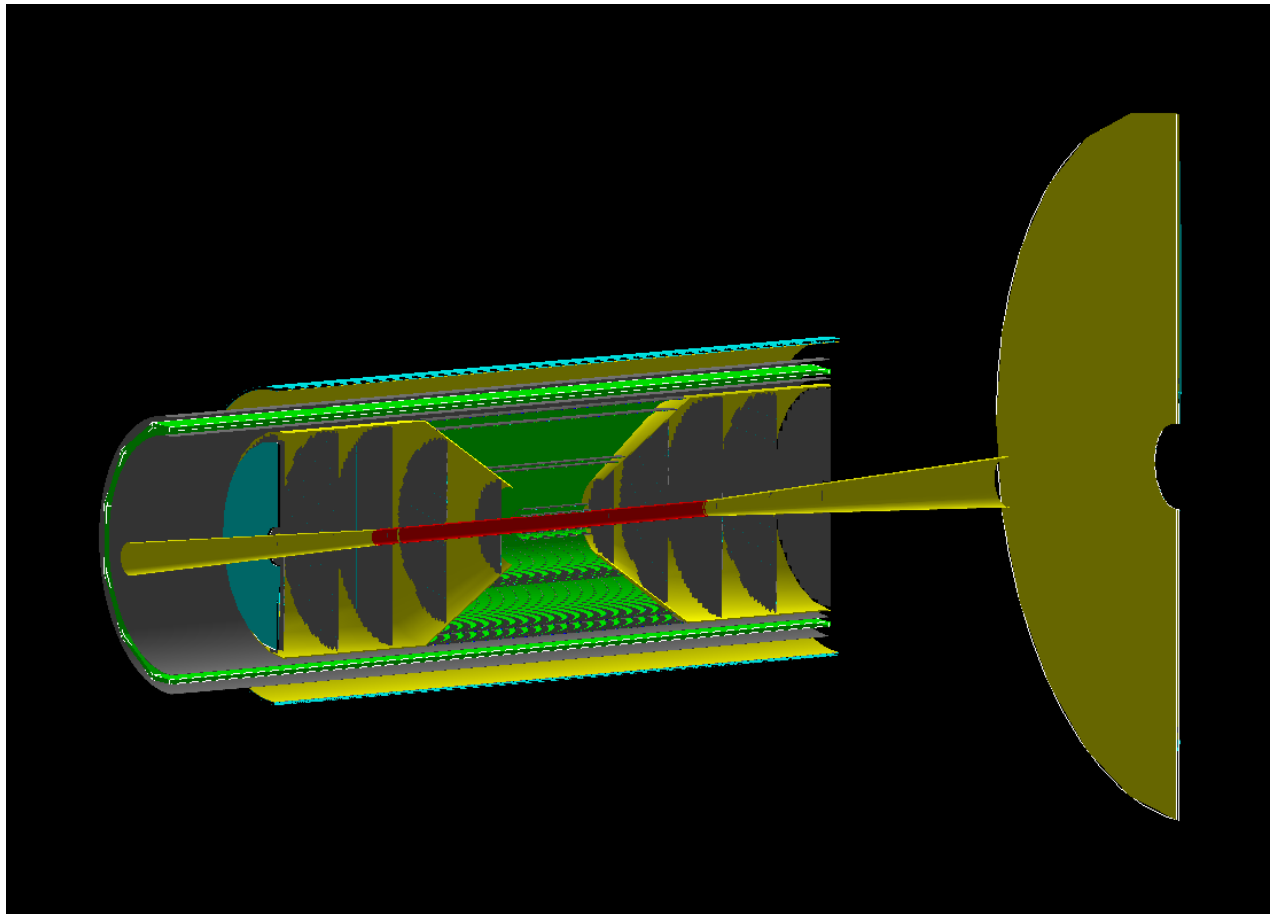
LGAD or GEM Detectors

- Three silicon sensors (LGADs) are implemented:
- Forward sensor:
  - z = +275 cm; η = (1.45,3.5); thickness = 85 um
- Backward sensor:
  - z = -123 cm; η = (-3.5,-1.85); thickness = 85 um
- Barrel sensor:
  - r = 60 cm; half-length = 125 cm; thickness = 85 um
- Hit information can be (by setting a flag) incorporated into the fast-tracking module. Right now, no timing information is being read-out.



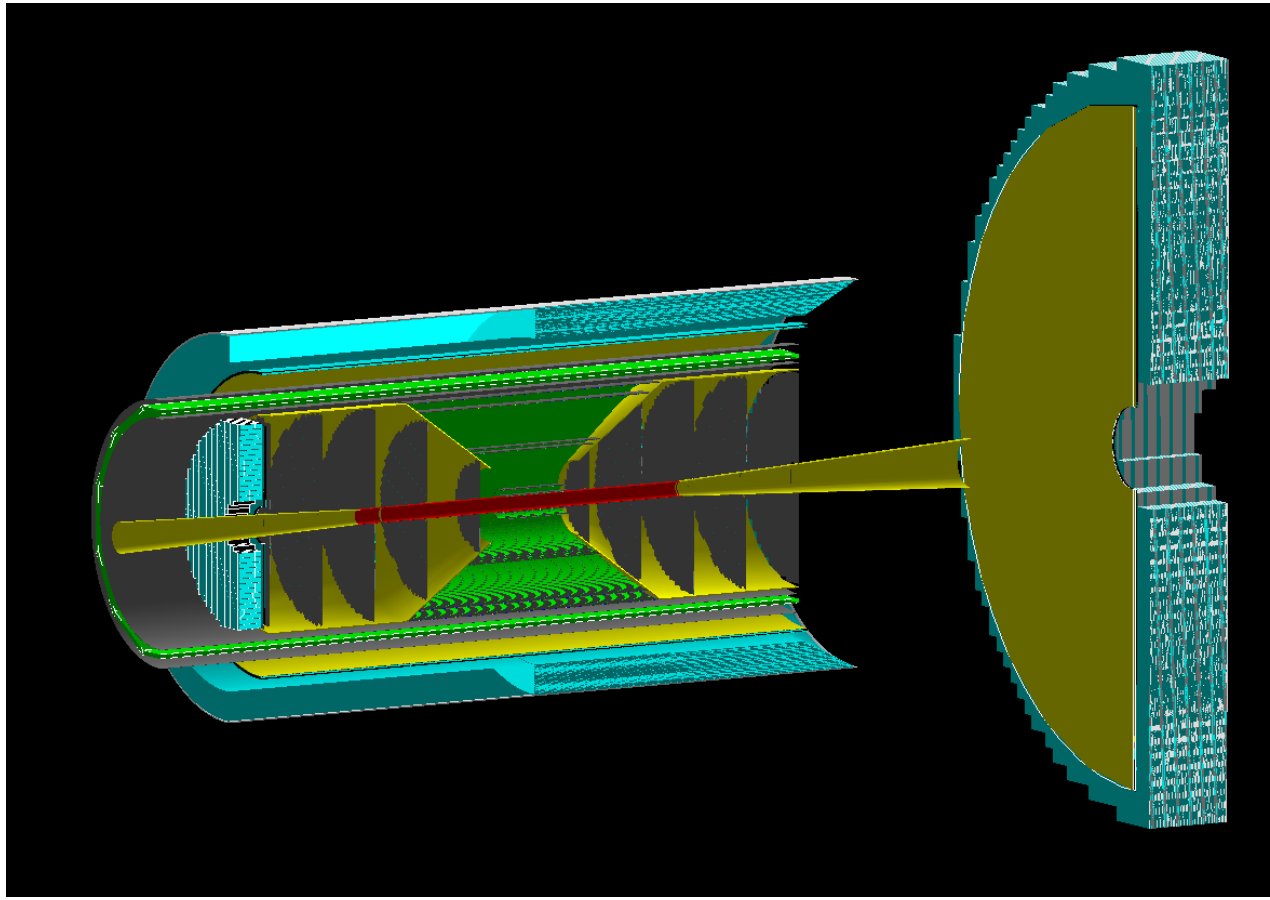
DIRC Detector

- The barrel DIRC Cherenkov detector geometry is implemented (eRD14 consortium).
- It consists of 12 quartz-radiator sectors with thickness of 1.7 cm and extending over z = (-171, +121) cm.
- The radiator is surrounded by inner and outer aluminum layers of thickness ~1mm.
- Expansion volumes have not been implemented.
- Only the geometry has been implemented as of now.



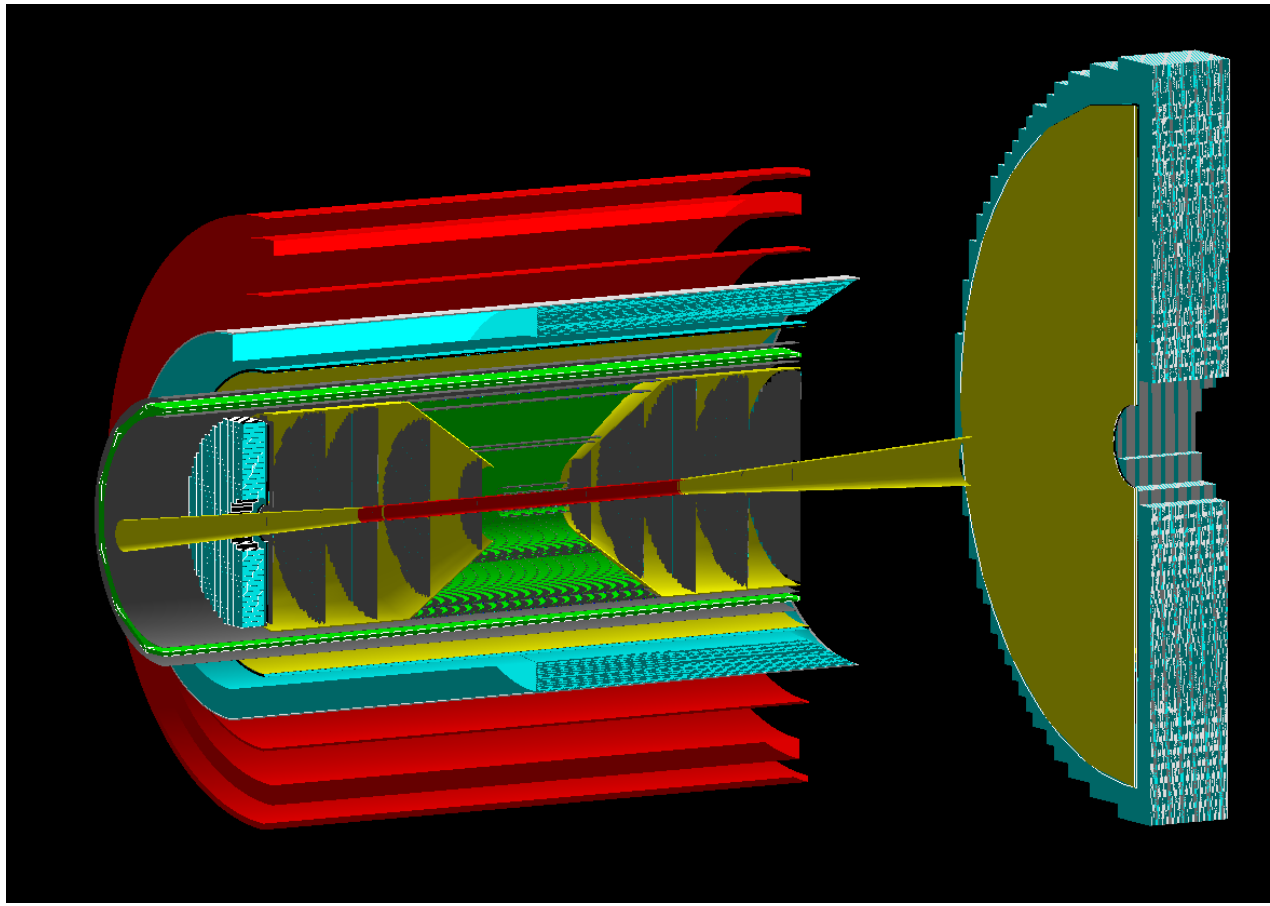
Electromagnetic Calorimeters

- There are three EMcal systems implemented:
  - The forward EMcal contains PbSc towers of width and height 5.535 cm and length 36.5 cm. It is centered at z = +300 cm and has an outer-radius of 155 cm.
  - The backward EMcal contains PbWO4 towers of width and height 2 cm and length 10 cm. It is centered at z = -130 cm.
  - For the barrel EMcal, the inner radius is 65 cm and the thickness is 11.8 cm. The negative η side is PbWO4 and extends down to z = -140 cm. The positive η side consists of 40 layers: PMMA as the active part, and W-powder absorber.
- There is a framework for reading-out and digitizing the tower hits, and for forming energy clusters.



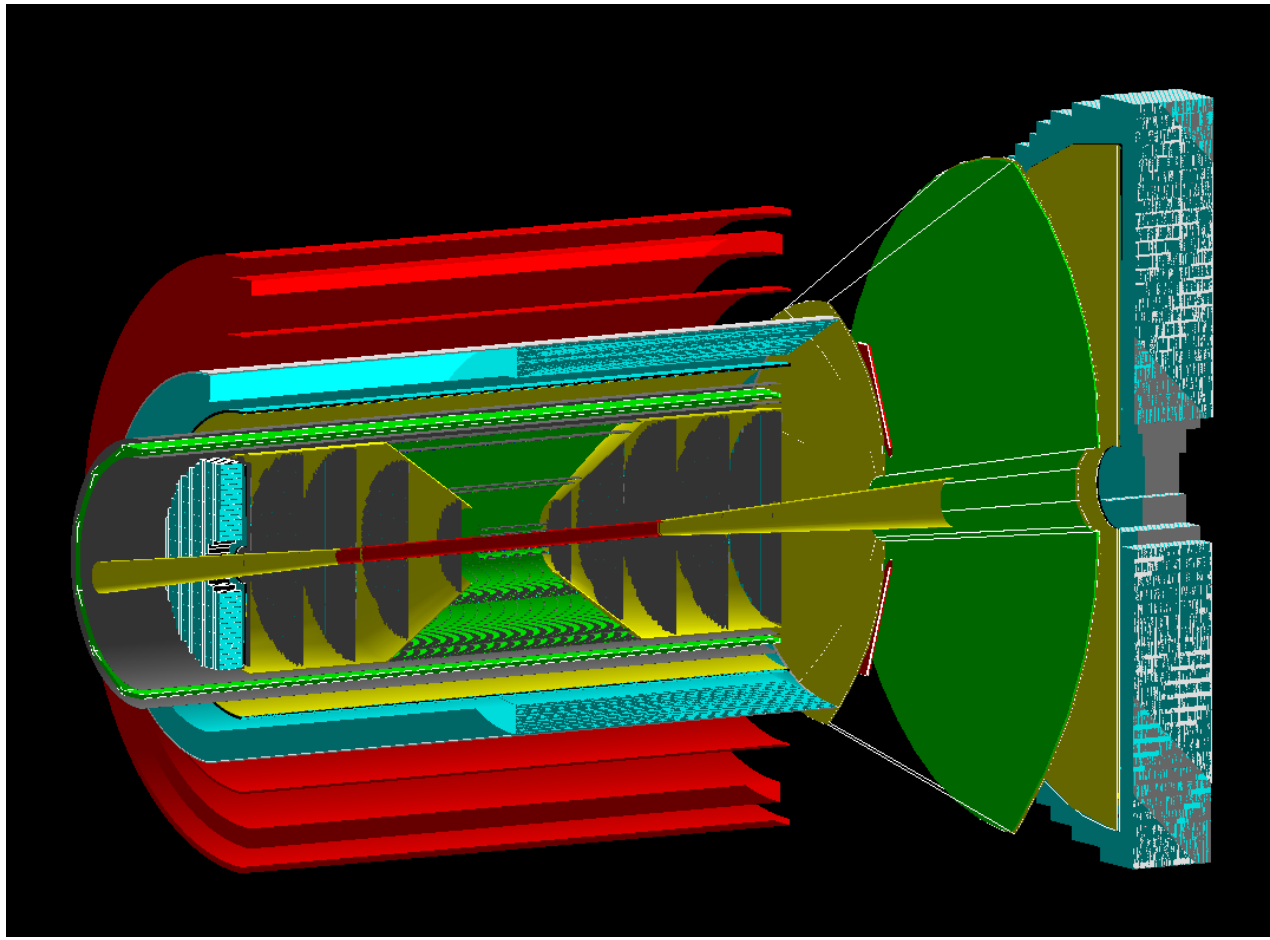
Solenoid Magnet

- The magnet extends from a radius of 90 cm out to 122.5 cm. The half-length of the magnet is 125 cm. The geometry consists of an inner and outer cryostat, and magnetic coil. The material is aluminum-5083.
- This is (roughly) consistent with the *ZEUS* magnet.
- The magnetic field is currently implemented as a uniform solenoidal field, which can be set to any strength. In the simulation, the field is implemented separately from the magnet – this is, one can remove the magnet material and keep the field.



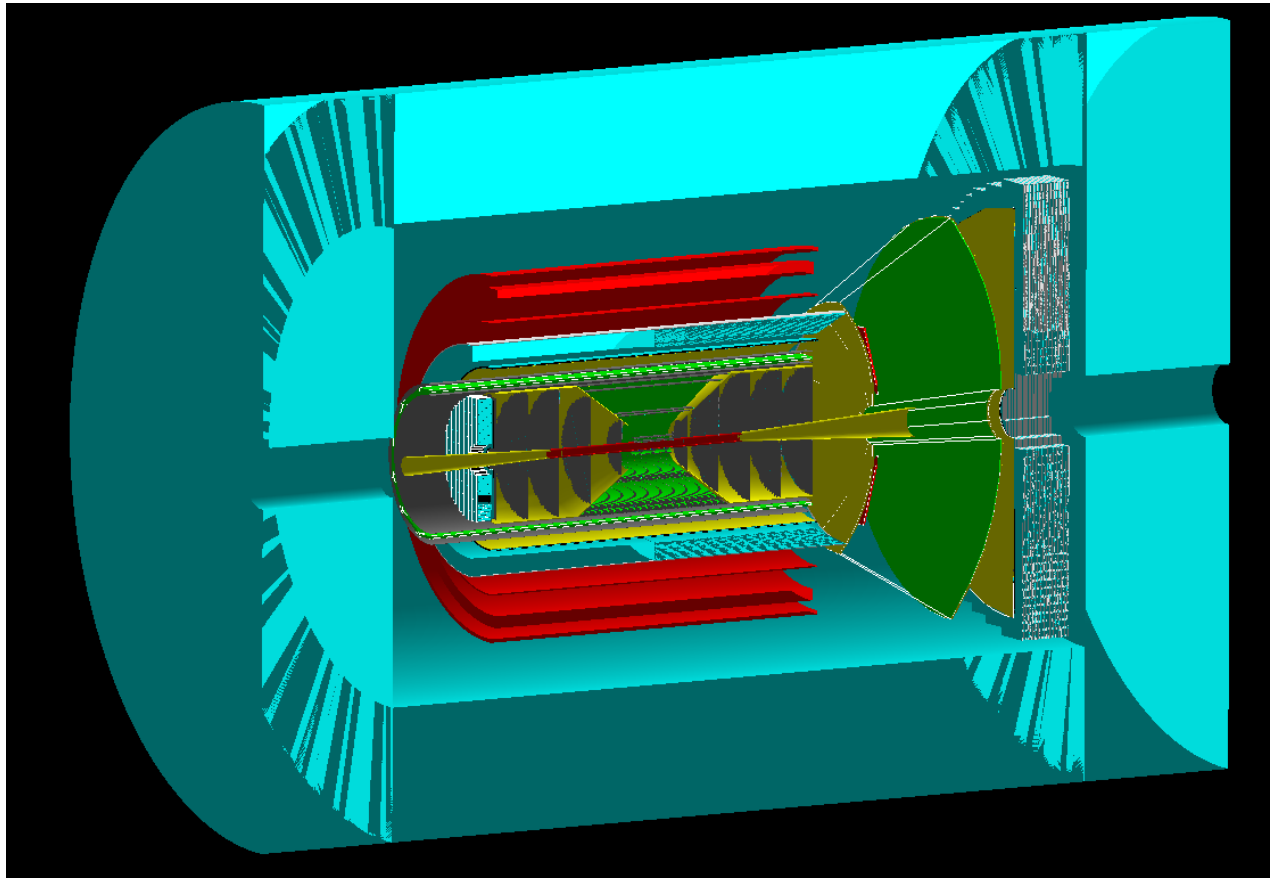
(Gas) RICH Detector

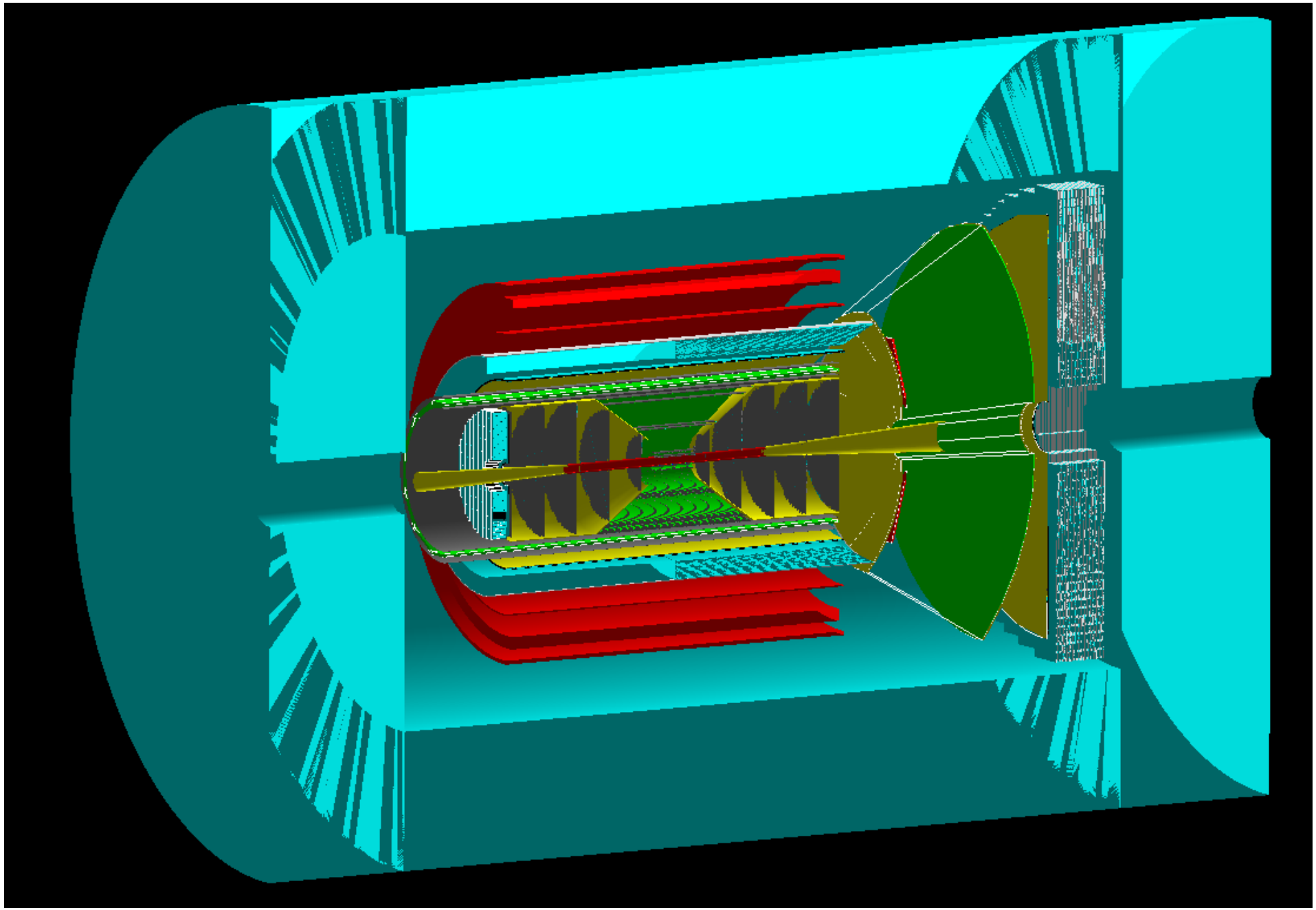
- Dual-radiator RICH with outward-reflecting mirrors should go in the forward endcap (eRD14 consortium)
- Currently, the geometry of the gas RICH from the *ePHENIX* detector is used as a placeholder.



Hadronic Calorimeter / Flux Return

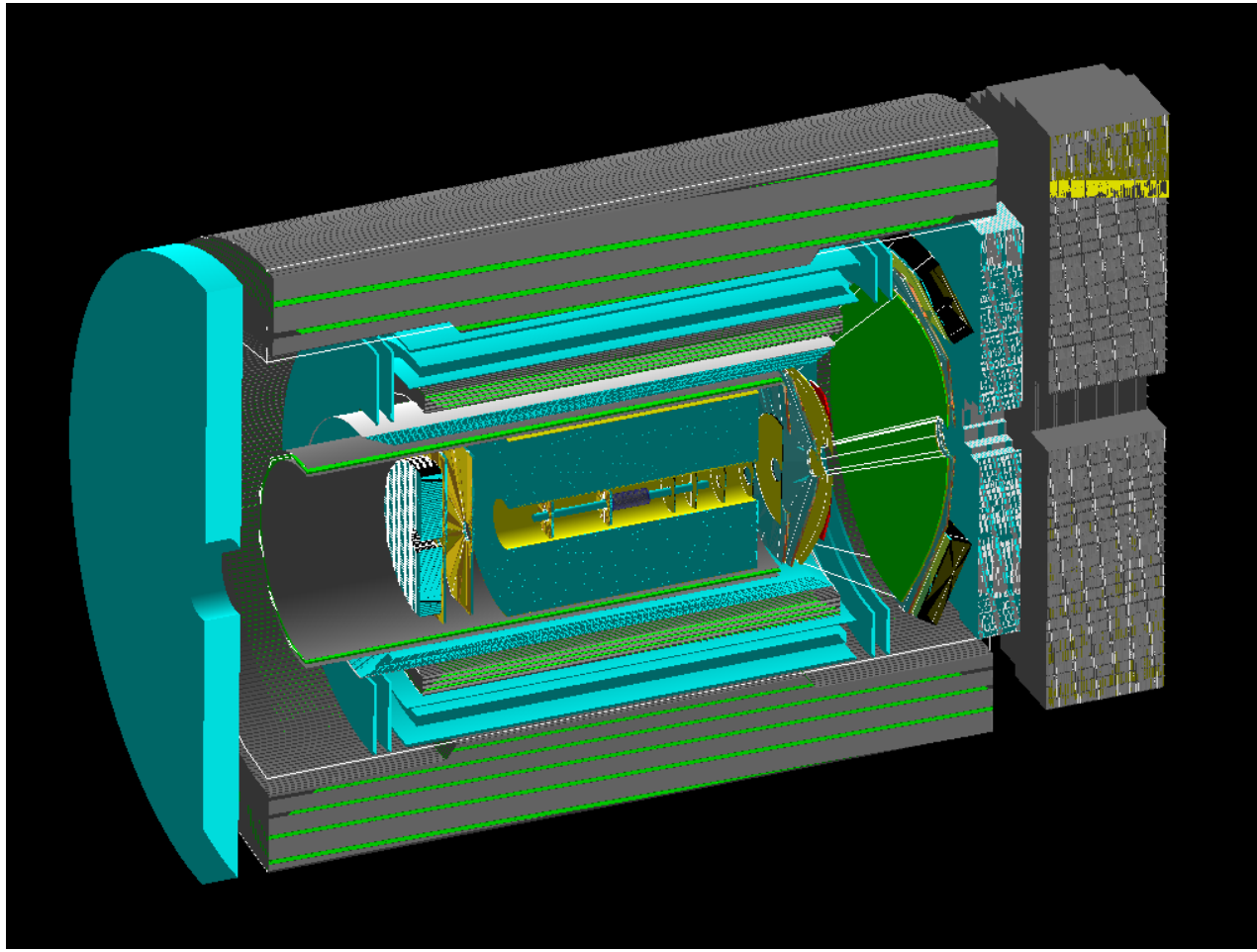
- The geometry of the hadronic calorimeter / flux return has been implemented with passive steel-1006.
- The material extends from z = -300 cm to z = + 440 cm. The outer-radius is 250 cm.





Analysis example: tracking resolution in *ePHENIX*

- I'll give an example of an analysis I did using the *ePHENIX* detector. A similar analysis can be performed for the CORE implementation (and compared to the eRD25 results).
- The analysis calculates the momentum resolution of the 'out-of-the-box' tracker in the *ePHENIX* detector, and compares the results to the detector matrix values from the EIC Yellow Report.
- The fast-tracking module – which smears hits in the various detectors based on defined resolutions – was used for this study.



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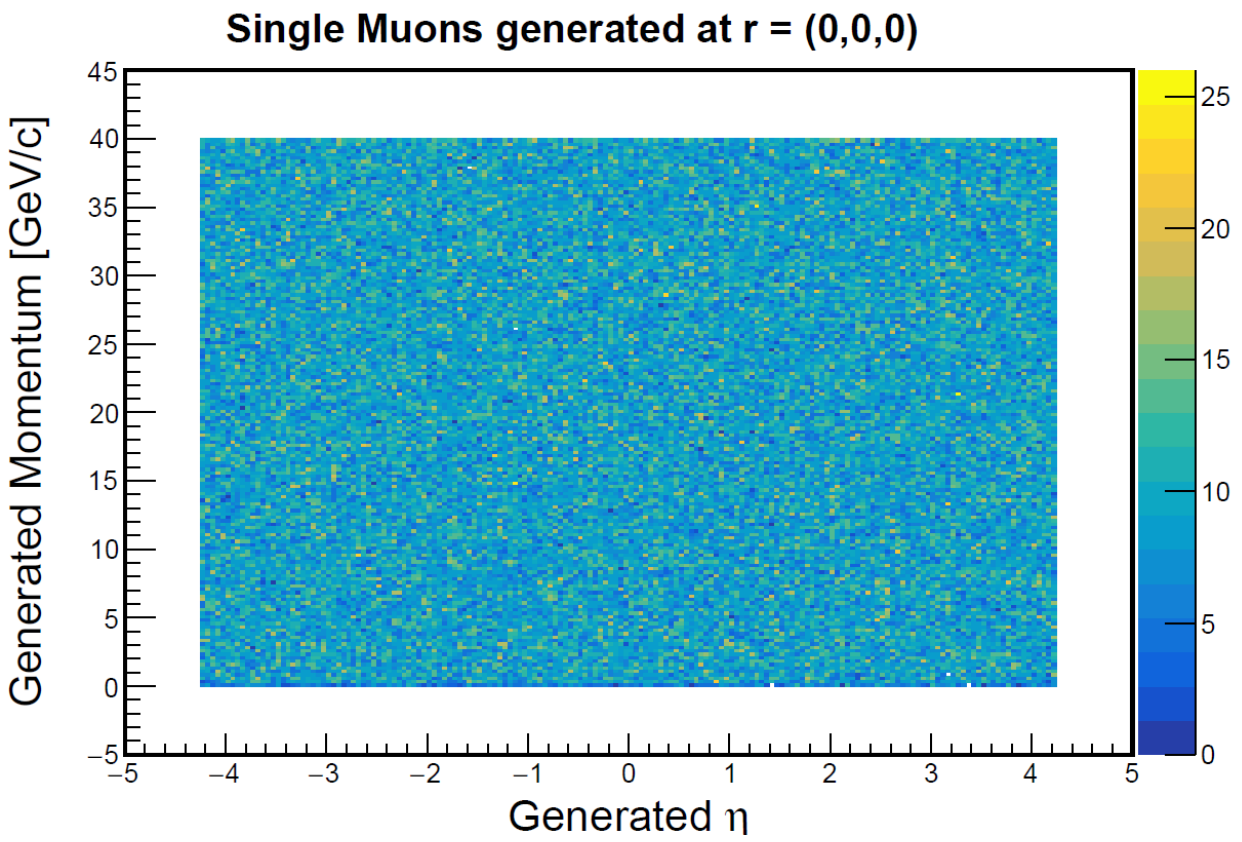
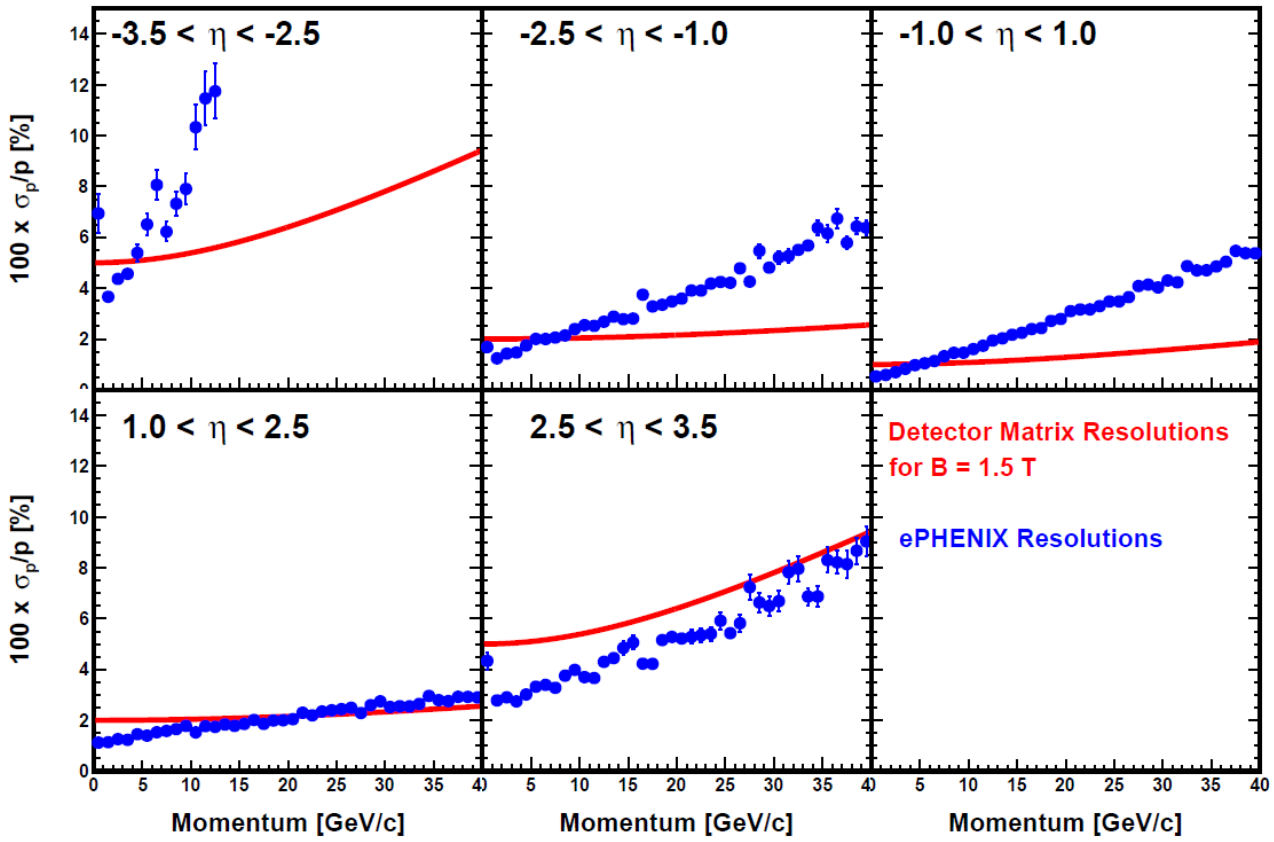
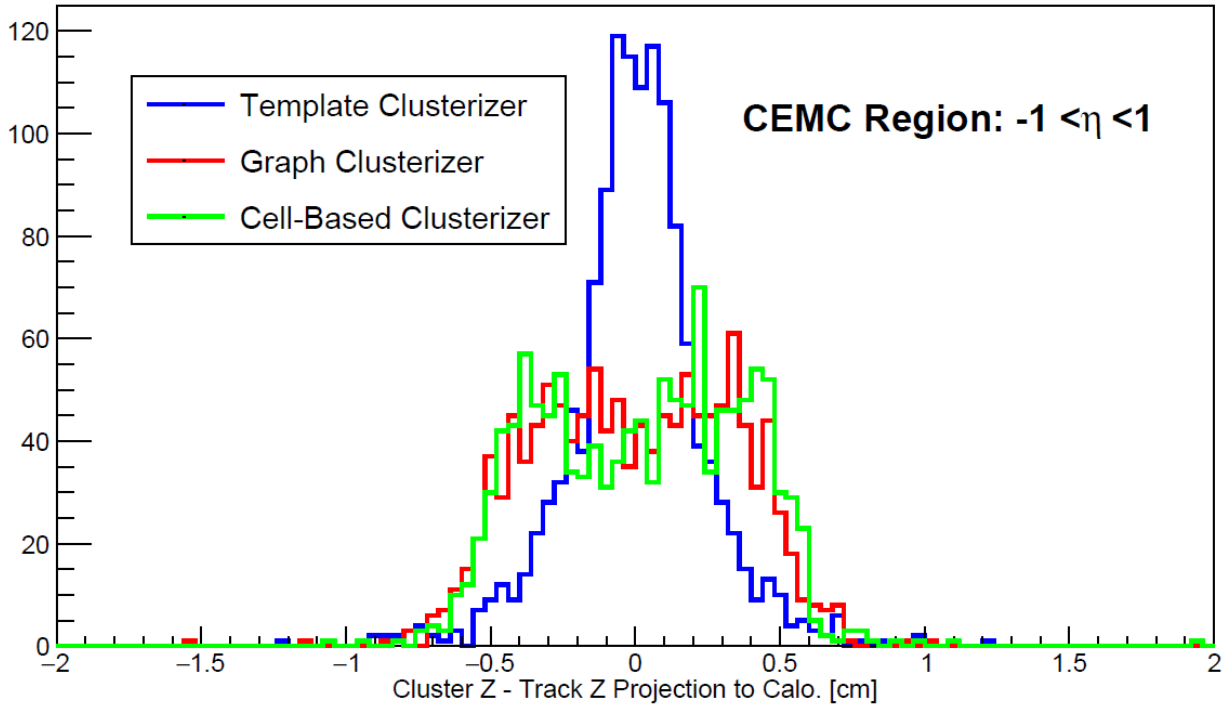




Analysis example: cluster&track matching in *ePHENIX*

- There are several ways to calculate the cluster position:
  1. The *GraphClusterizer* computes an energy-weighted position for the towers in the cluster
  2. The *TemplateClusterizer* attempts to correct the position for angle and shower depth. Based on *PHENIX* method…
  3. I added one extension to the *GraphClusterizer*. Instead of a single energy read-out for each tower, I now treat each cell separately – and then compute an energy-weighted position



Summary

- We have implemented a first version of the full CORE central detector in the Fun4All framework
- The simulation is ready to conduct basic studies similar to what I showed using the *ePHENIX* detector. We have to decide what studies we want to conduct.
- The code is currently stored on a personal GitHub repository. If possible, maybe we can move it here: https://github.com/eic/fun4all_eicmacros
- We should also consider placing analysis code in a central location