Barrel calorimeter conceptual work

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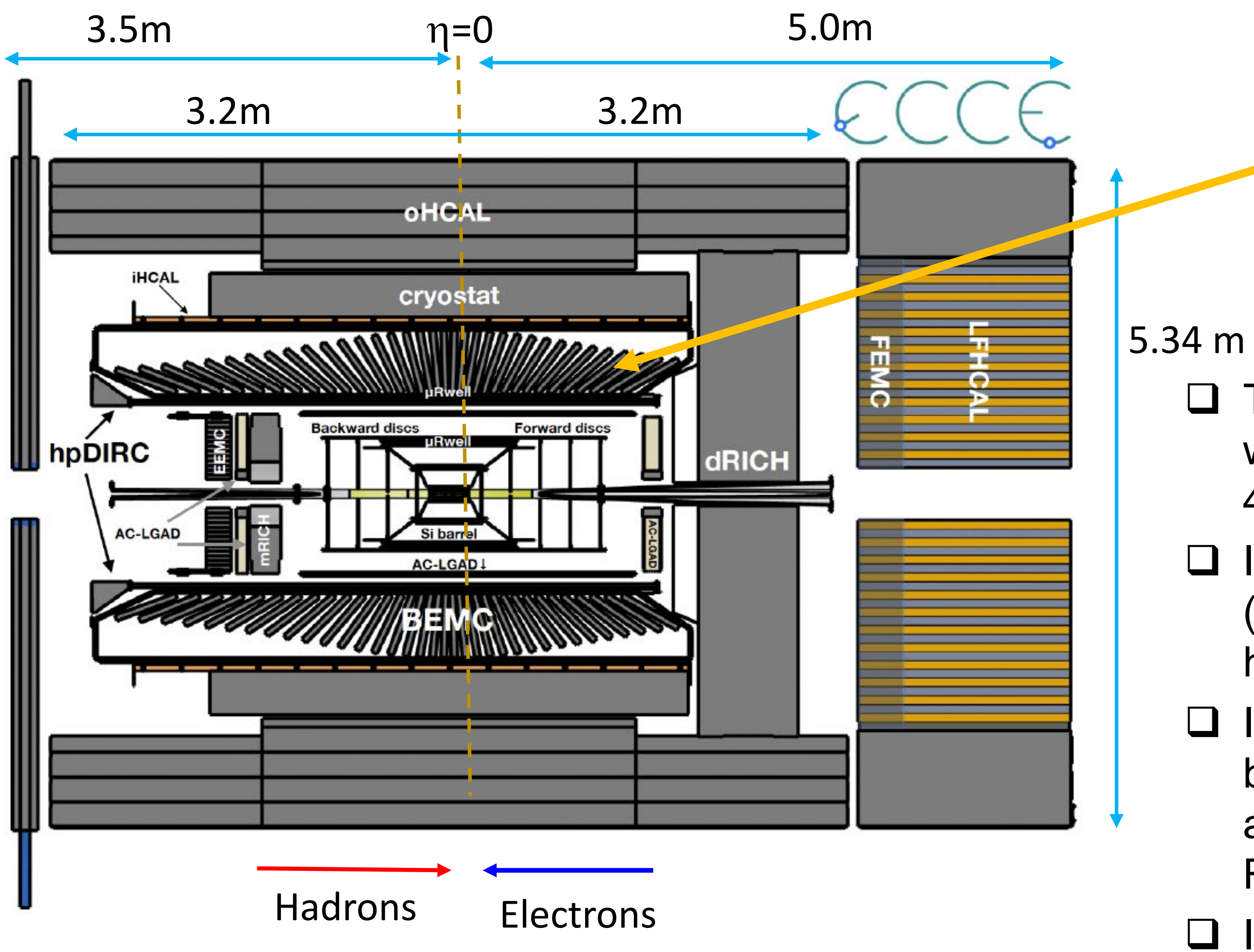
THE CATHOLIC UNIVERSITY OF AMERICA

Jefferson Lab

The barrel EMCal in the ECCE Reference Detector



Barrel ECAL(BEMC)

Homogeneous, projective calorimeter based on SciGlass, cost-effective alternative to crystals

- The barrel is one of the largest sub-detectors with 8000 homogeneous scintillator blocks of 45.5cm length (and ~10cm radial readout space)
- It is extended in the negative rapidity direction (with η coverage from -1.7 to +1.3) to provide hermeticity with the backward ECal.
- In the backward direction hermeticity is provided by the combination of barrel, backward ECals, and mRICH complements (3σ e/h up to 2 GeV) . Readout and supply lines are included.
- In the forward direction the barrel EMCal faces much higher range of particle rates across the acceptance of the forward endcap

Overview of Barrel EMCal Specifications

- Coverage: $-1.7 < \eta < 1.3$
  - R_{min}=80cm
  - R_{max}=125.5cm (i.e., glass blocks are 45 cm long → 17 X0)
  - Electronics:125.5cm < R < 134cm
  - Outer support: 134cm < R < 140cm
  - Length along z= 445m (192.5cm(start) < z < 252.5cm (end))
- Egamma: 0.1 – 35 GeV
- Energy resolution (based on simulation): 2.5%/SqrtE + 2.7%/E + 1.5%
- Maximum Annual dose at top luminosity
  - EM: ~3 krad/year (30 Gy/year)
  - Hadron: 10^10 n/cm2
- Signal dynamics: 2 V dynamic range

Homogeneous Design based on PANDA

PANDA

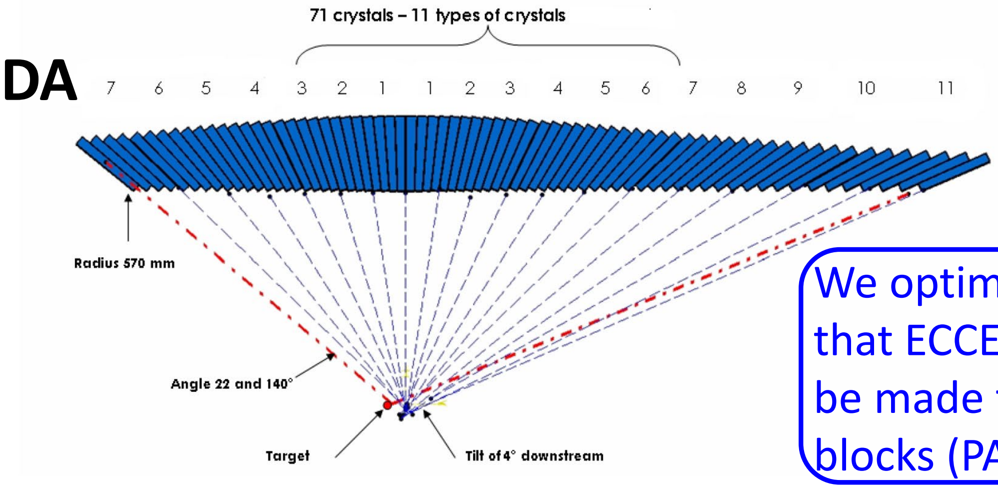


Figure 5.4: Crystal arrangement of the barrel along the beam axis. Positions of the different crystal types are indicated. Due to the mirror symmetry, 11 types are sufficient instead of 18.

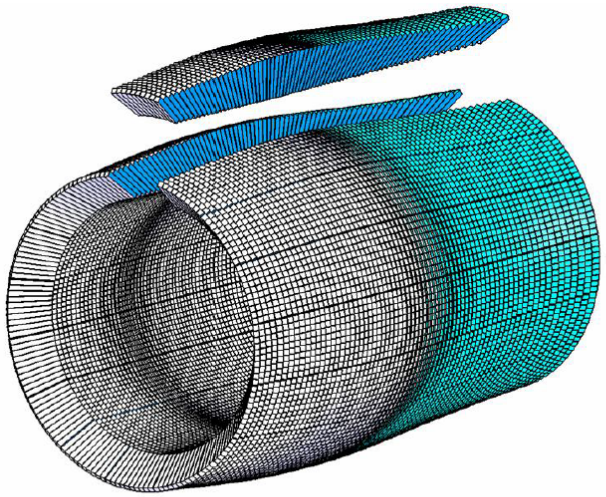
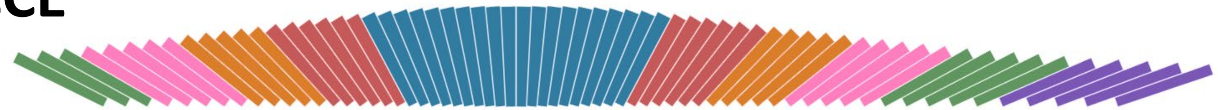


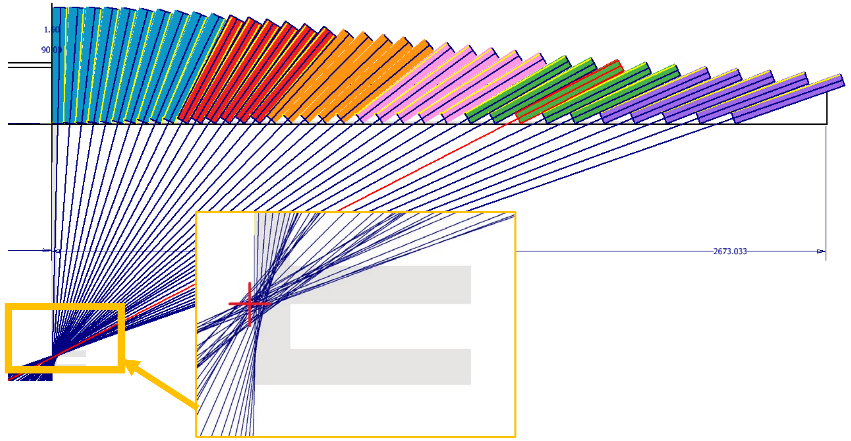
Figure 5.5: View of the total barrel volume with a separated single slice of 710 crystals. A slice covering 1/16 of the barrel volume.

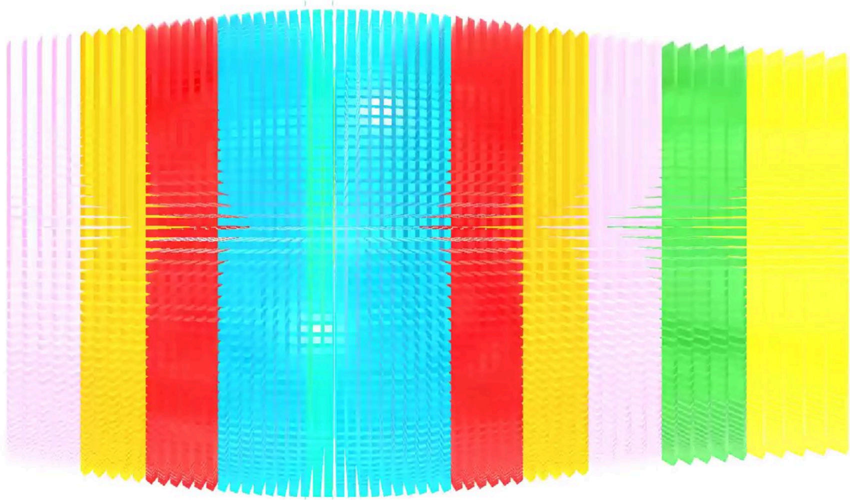
ECCE

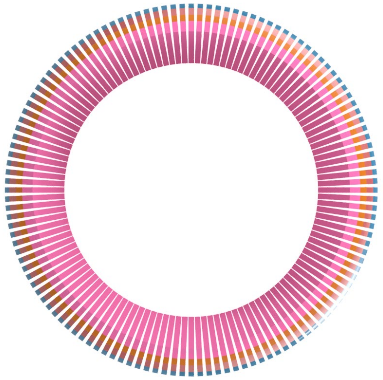
Based on realistic CAD design (CUA)



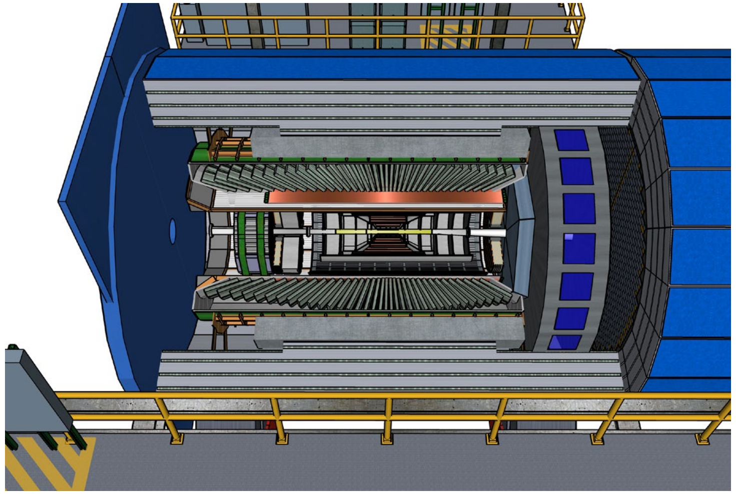
We optimized the geometry so that ECCE barrel calorimeter can be made from 6 families of blocks (PANDA has 11 families)







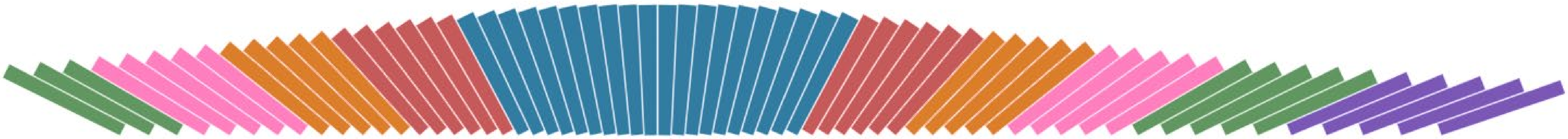
Concept Design and Consistency with Reference Detector 1 Model



Concept Design (Autodesk Inventor model) – J. Crafts

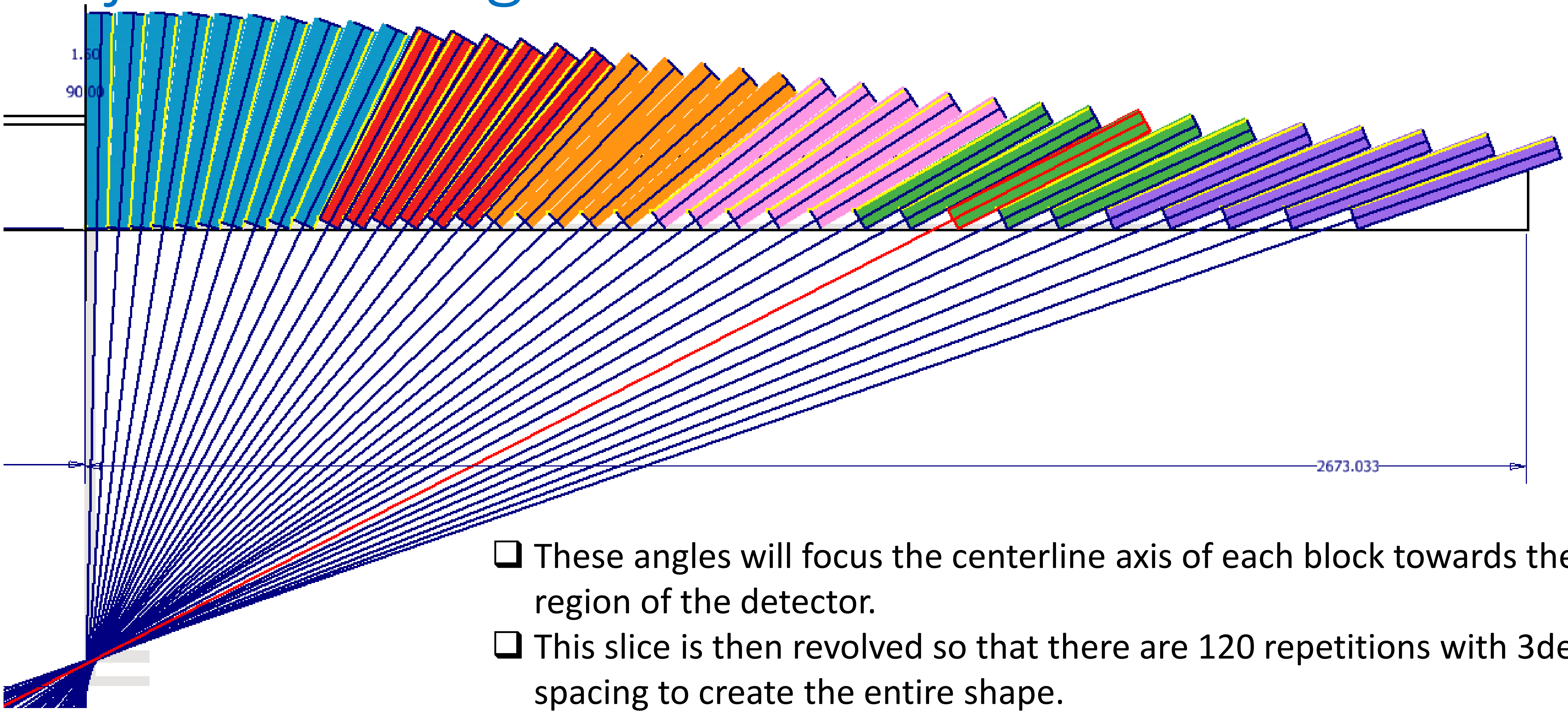
- Confirmed with Walt that the concept design dimensions are in agreement with the radius lengths and midsections of the Barrel EMCal
- With these measurements constructed the individual wedges in a shape of each sci-glass block with the angles allowing for the sweep of the angle in the long axis.
- Each color corresponding to a specific shape of the block, currently there are six "families" of blocks.

Projective Design

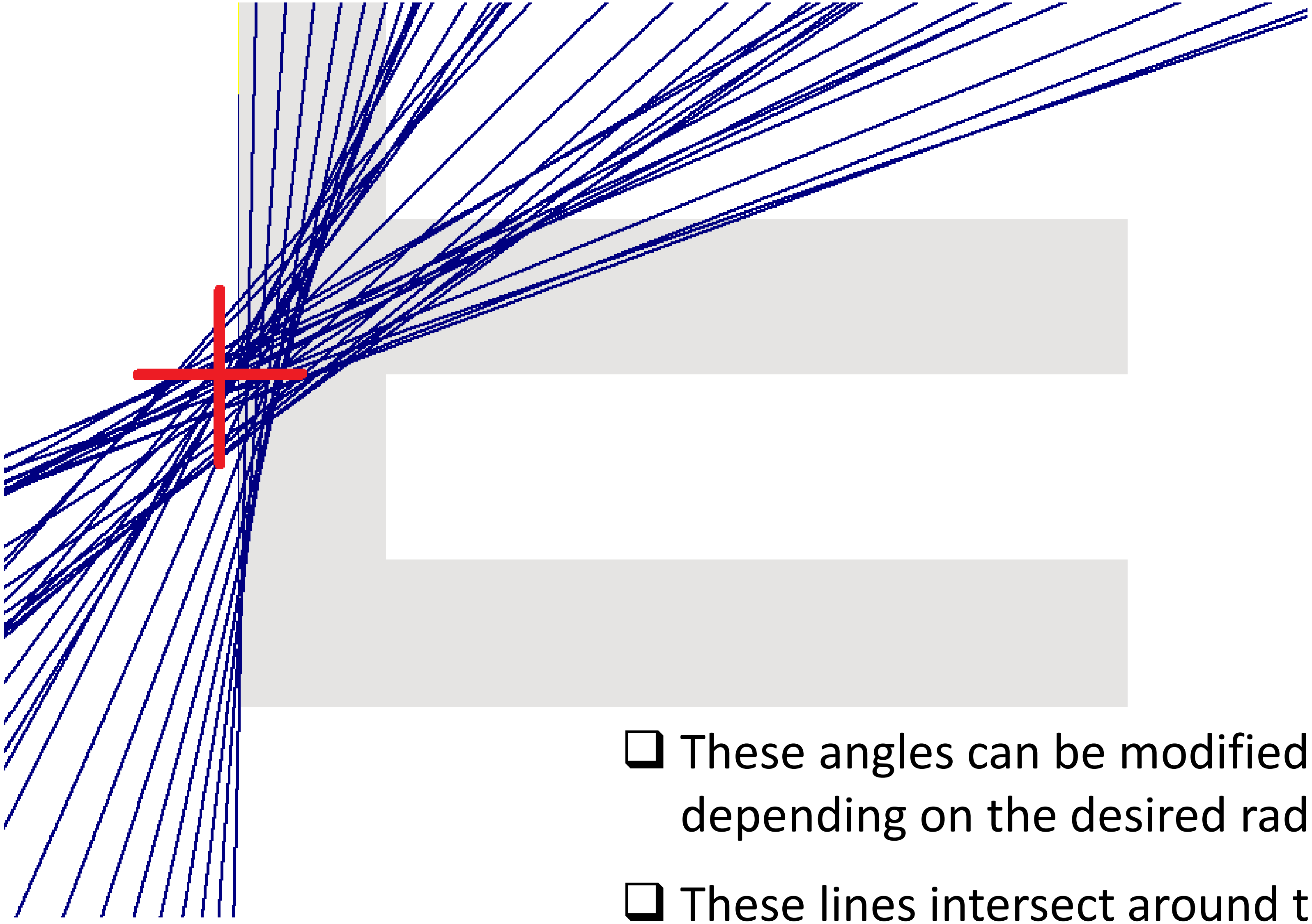


Expanding from the "midline" of the detector and decreasing in end width. There is a 1mm spacing maintained between the angled surfaces, and while there does appear to be a more significant gap visually, the size is 1mm.

Projective Design

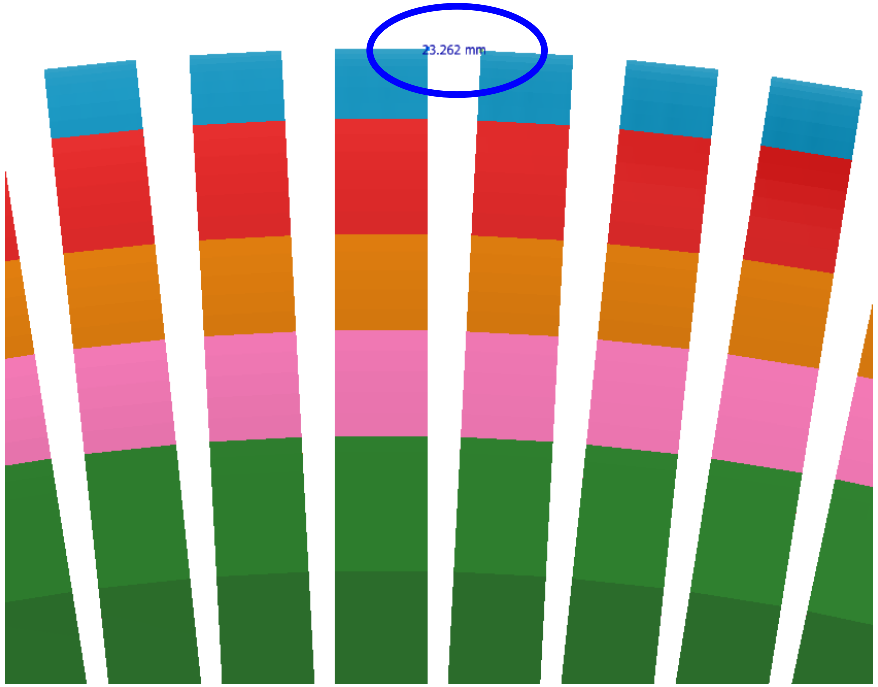


- These angles will focus the centerline axis of each block towards the central region of the detector.
- This slice is then revolved so that there are 120 repetitions with 3deg spacing to create the entire shape.
- In the current whole volume there are 2400 of the blue family, 1440 red, 1200 orange, 1200 pink, 960 green, and 600 purple for a total of 7800 individual blocks - that would imply 4 block wide "bins" to allow for 30 radial wedges each containing 260 blocks.

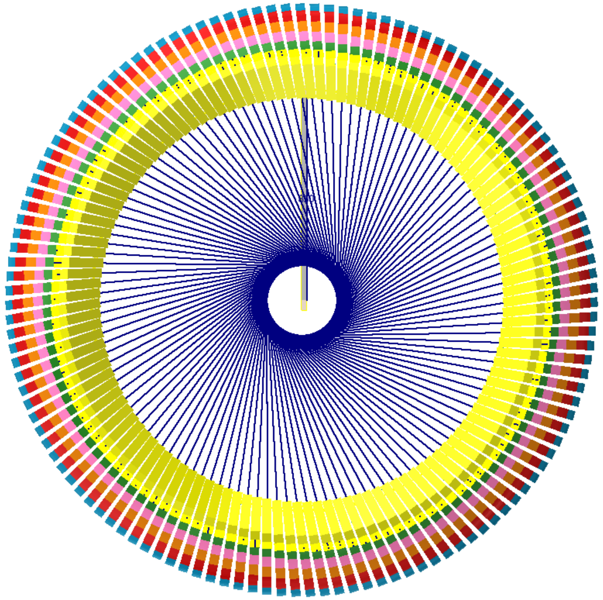


- These angles can be modified and can shift the focus point depending on the desired radius.
- These lines intersect around the central point of the rotation (the grey part is piece for establishing the axis of rotation to generate the complete shape).

- ❑ Currently these blocks do not have any flaring in the radial direction, which corresponds to a 23mm gap at the end of the blocks.



- ❑ This can either be remedied by
  - introducing an expansion in the radial direction or by
  - adopting a rotated geometry.
- ❑ Currently working on what angles can be utilized to introduce an expansion in the radial direction and still maintain the current "families", hopefully not subdividing them further.



Mechanical Design based on PANDA

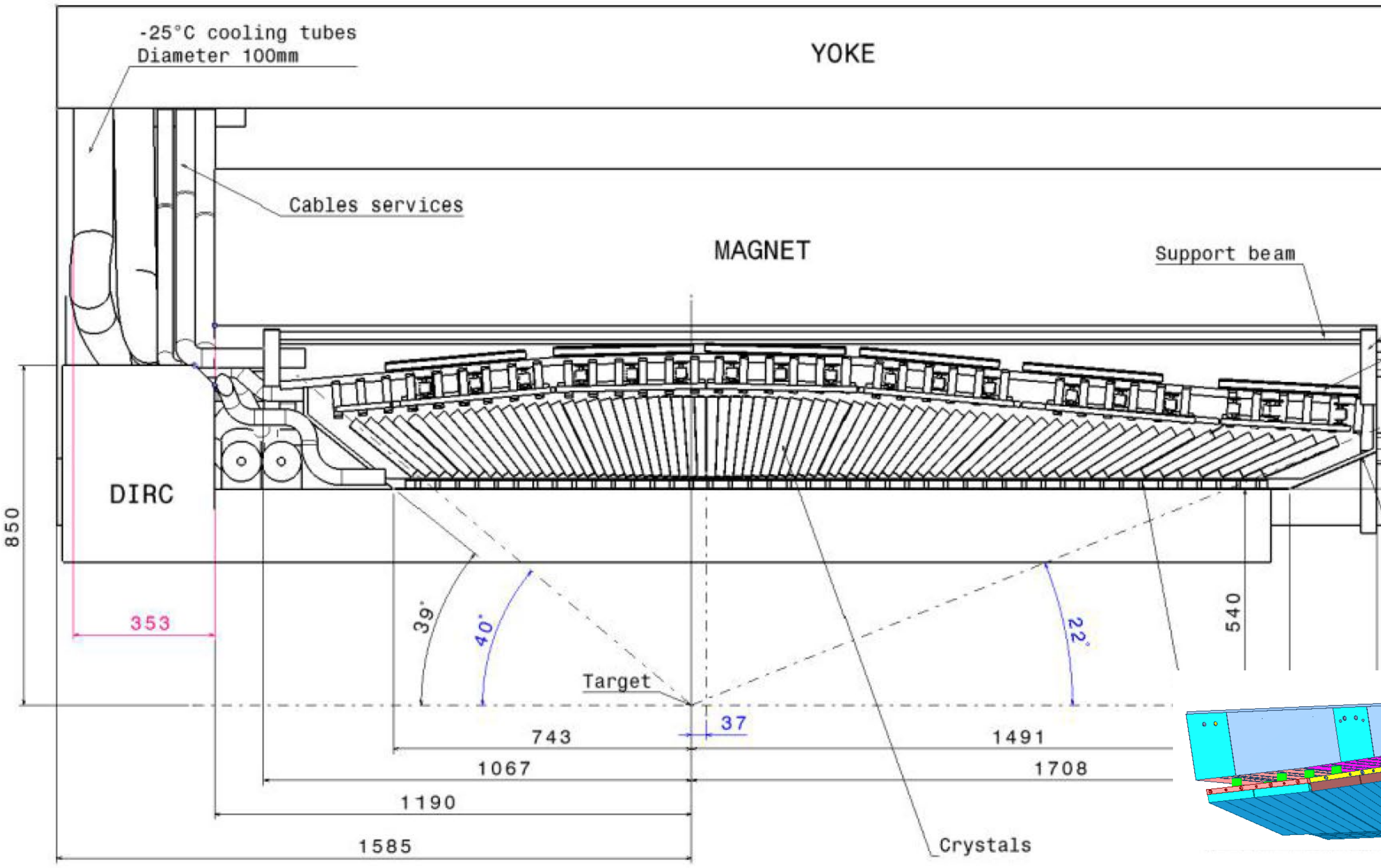


Figure 5.26: Dimensions of one slice.

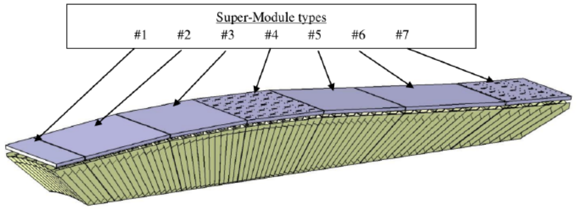
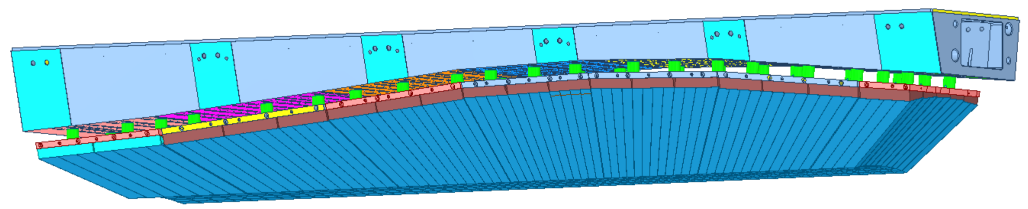
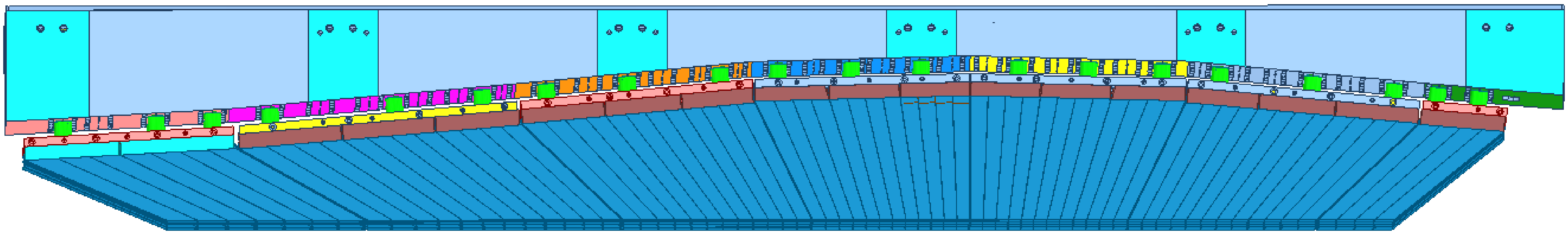


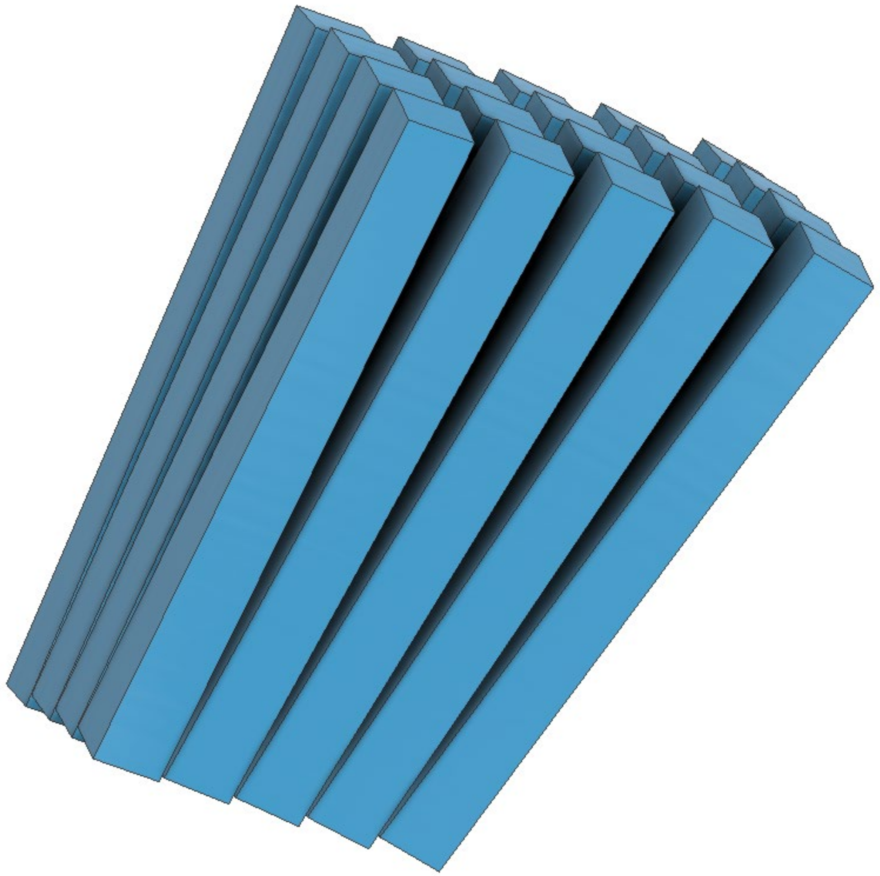
Figure 5.9: Modular structure of a slice.

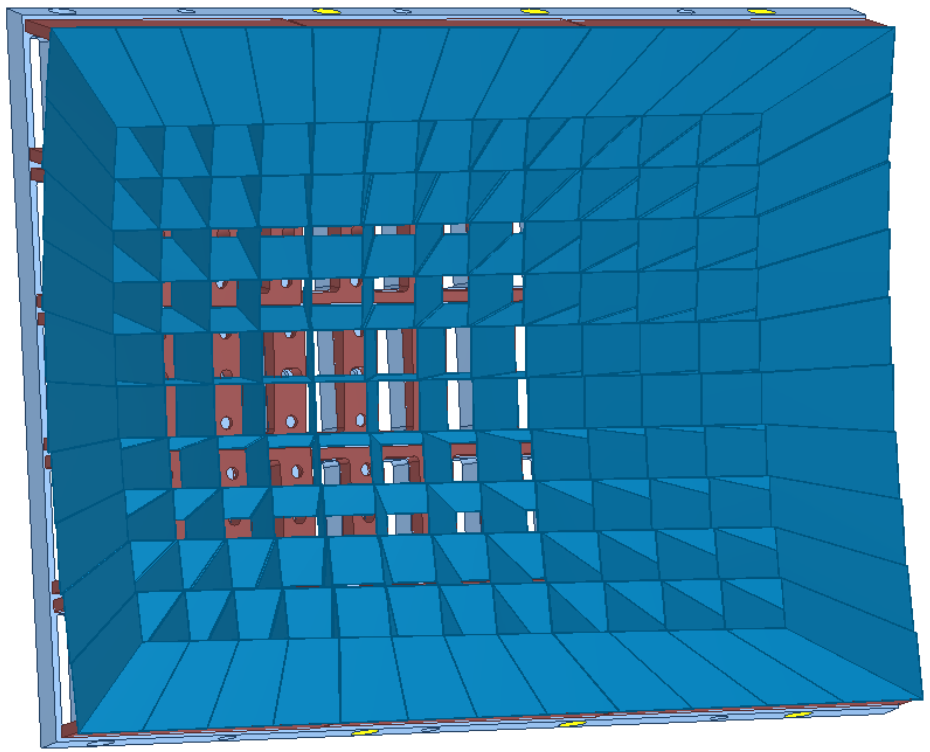
PANDA



EIC (starting point)



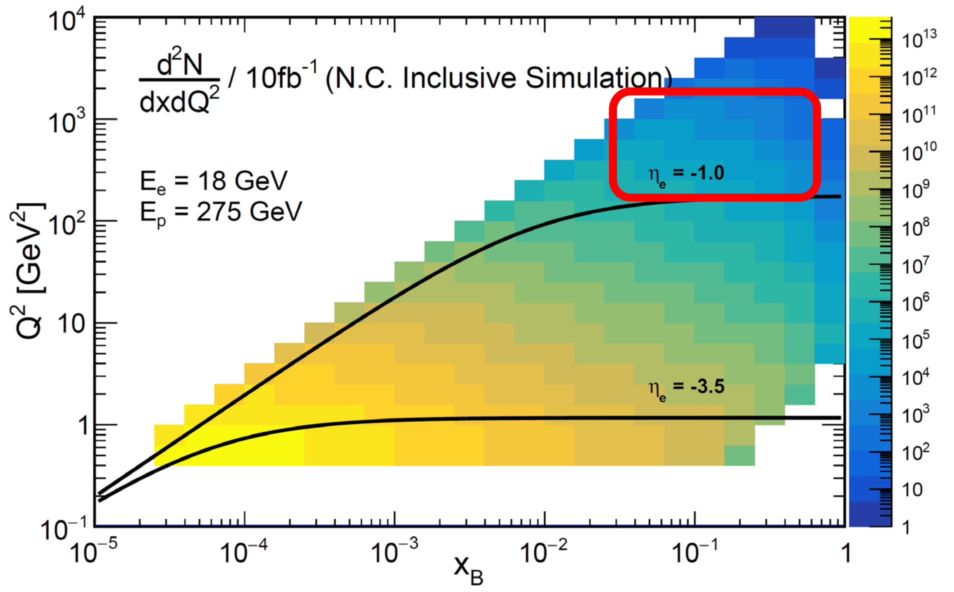




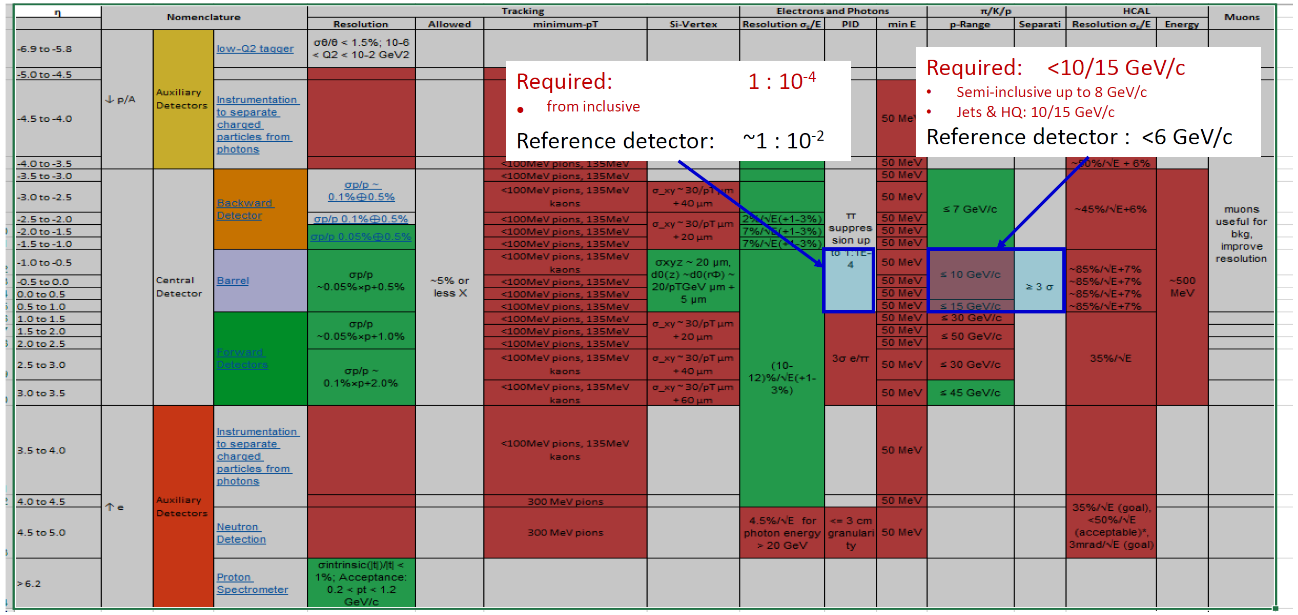
Introduction

Scattered electron kinematics measurement is essential at the EIC

- ❑ High precision, hermetic detection of the scattered electron is required over a broad range in η. Particularly in the backward-going direction over an energy range from 0.1 to tens of GeV
- ❑ In ECCE, we emphasize this also for the barrel EM calorimeter choice driven by high-x and high-Q^2 science drivers.
- ❑ Scintillating glass was chosen to provide comparable energy resolution to PbWO4 crystals at significant lower cost



From Yellow Report



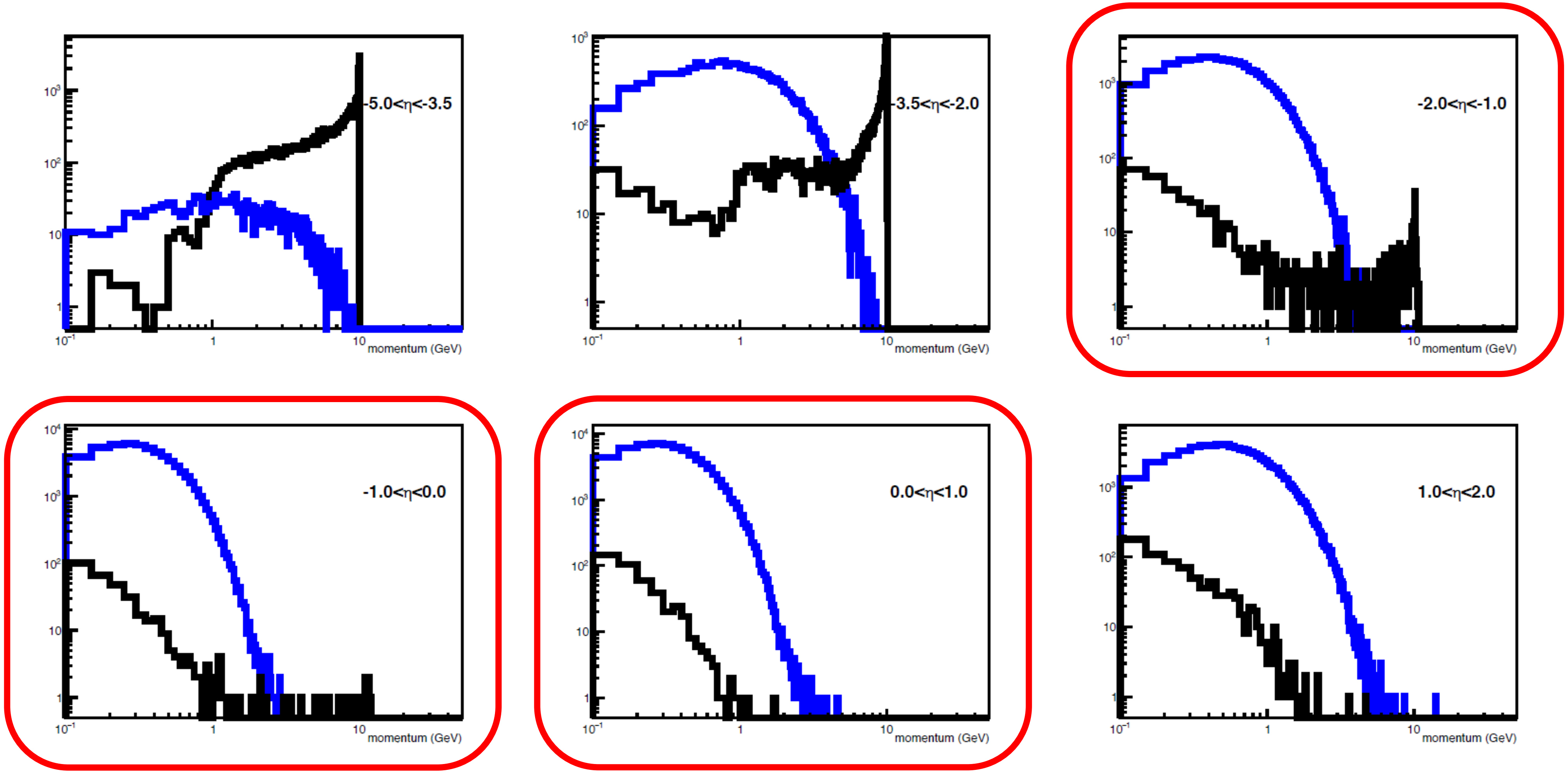
Requirements

- ❑ Good energy resolution
- ❑ e/h separation up to 10^{-4}

e/π SEPARATION

NEEDS

ΔG needs pi/e 10^{-3} , A_{PV} needs pi/e 10^{-4} in η bins -2 to 1



10 x 100 GeV Pion/e- Ratio (Work by **Hanjie Liu**)