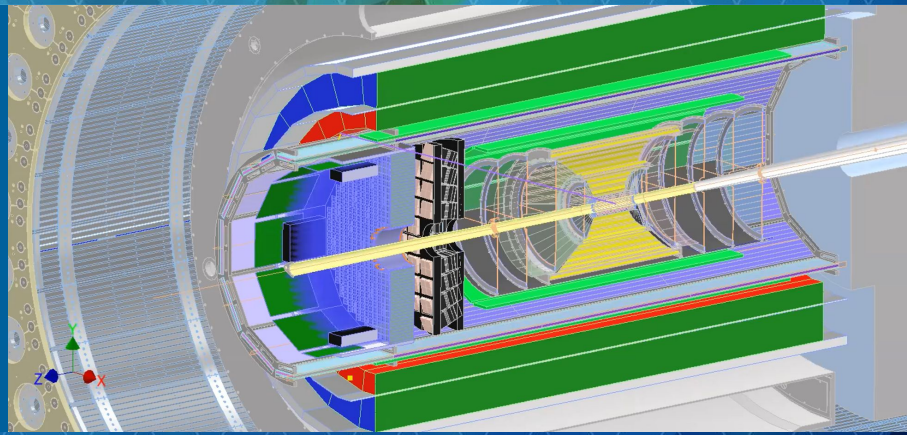
ePIC Barrel ECal

SImulation Updates



Maria Zurek, 05/09/2023

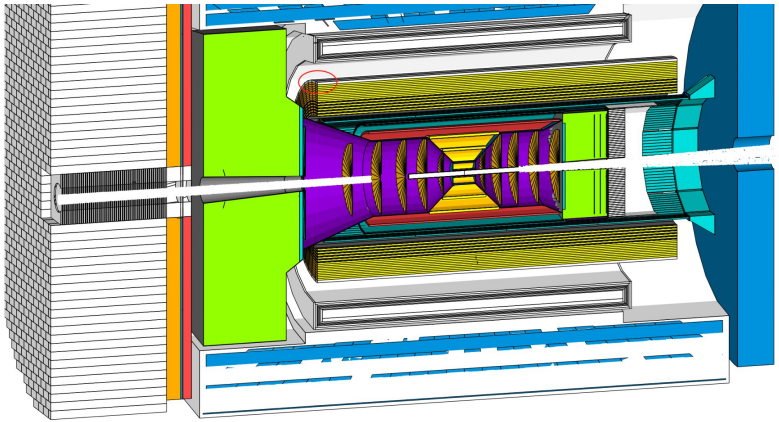
Updates

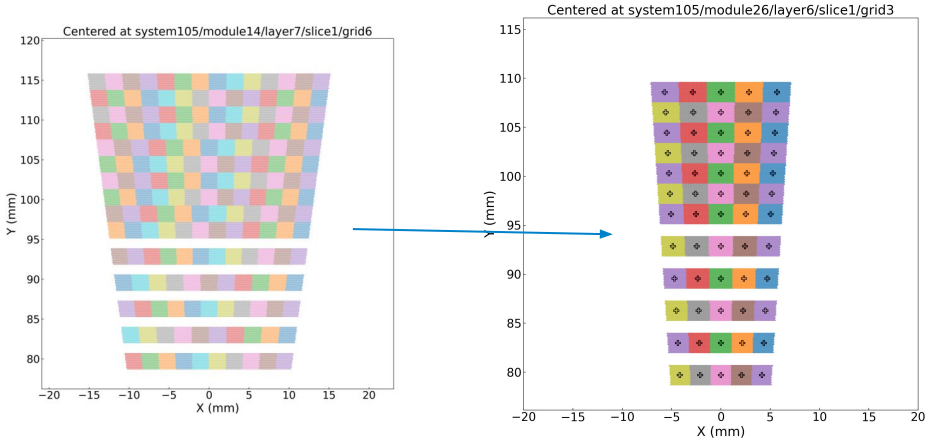
Geometry:

1. 48 Staves - ✅
2. 3 cm aluminum plate in the back - ✅
3. Readout grid scheme - ✅
4.

Reconstruction:

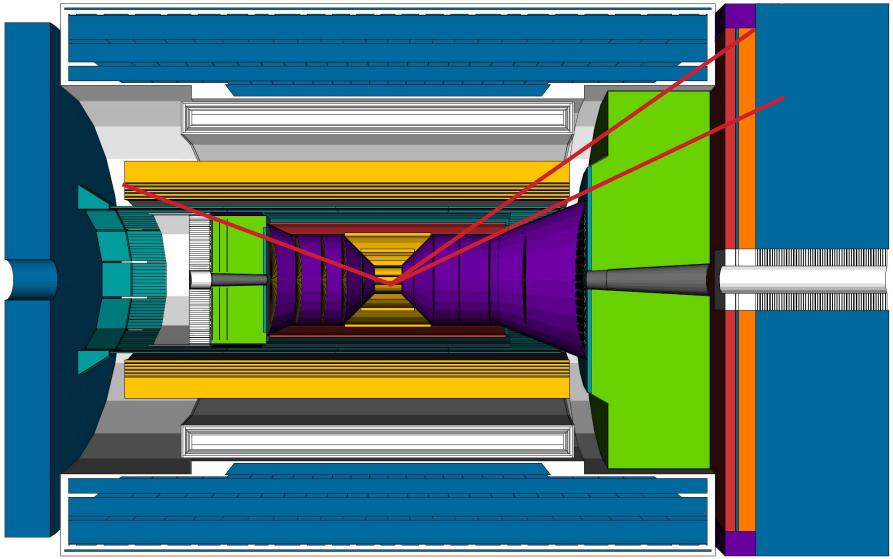
1. Sampling fraction adjustment - in progress
2. Threshold on single readout grid - in progress
3.

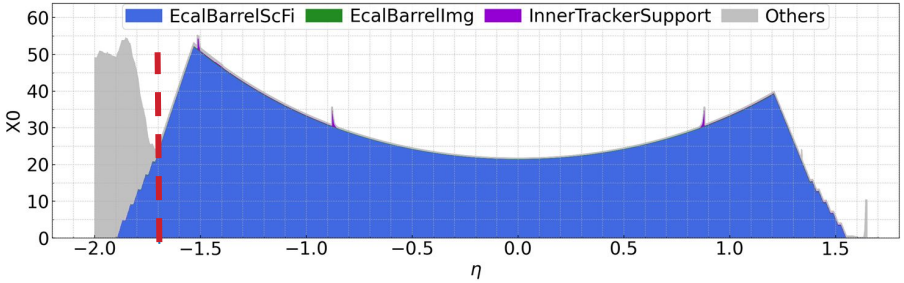




Simulation Work - Overlap

1. Can we tapper detector on side, are there any gaps between EEEMC and Barrel ECAL





1. Check if the geometry agrees with project database - ✅ (for Barrel)
2. Do material scan for checked geometry (also with 2 cm air gap for AstroPix) - ✅
3. Check energy resolution for the steepest angle in both direction
4. Other parameters to check: position resolution, e/pi? TBD

Dimensions - Project Question

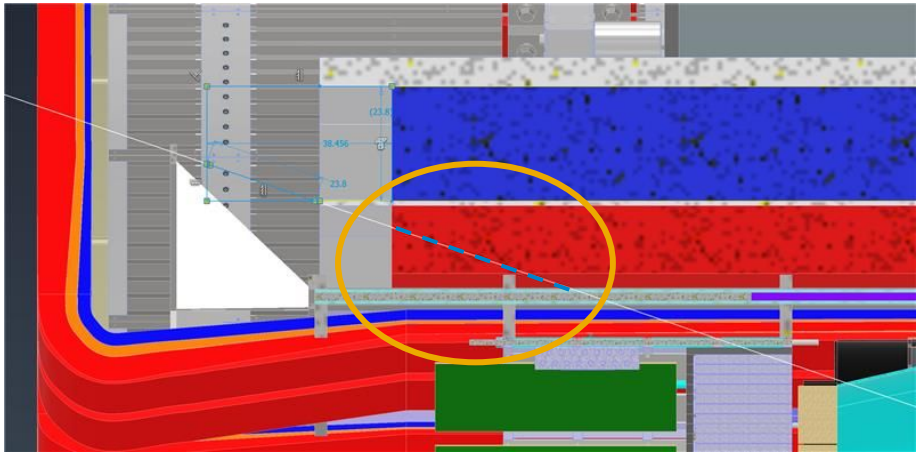
- Inner radius 78.25 cm fixed
- Total length: in model right now 435 cm this does not guarantee any good overlap with backward ecal and forward Ecal, see figures below. In such a configuration the particles would only go through the imaging part.

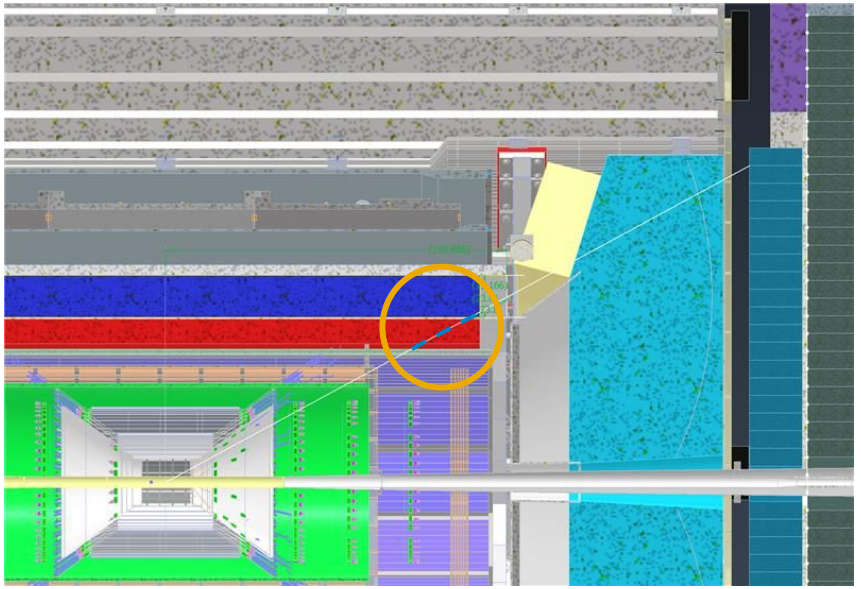
To have overlap in both direction with the EEECal and fECal by at least one block one needs to increase the length of the barCal

- In electron going direction: 38 cm
- In hadron going direction: 15 cm
- total length 295 cm + 192 cm = 487 cm

this numbers need to be verified by simulations, Note: on both sides one would have an additional ~10 cm for the

Dimensions





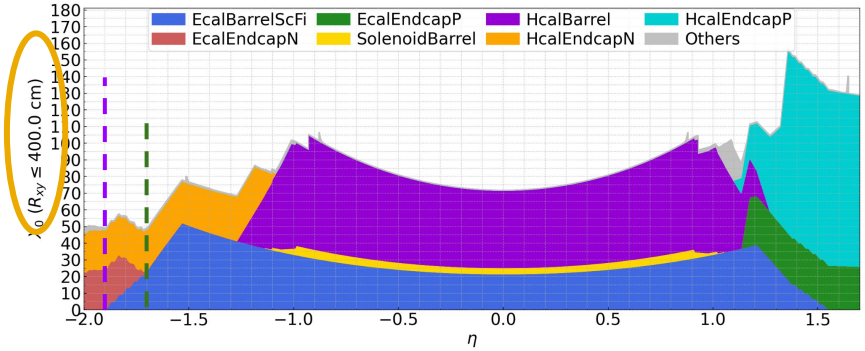
1) **Imaging part includes Pb/ScFi (2 cm between each imaging layer)**
2) **Particles traveling at small theta angle travel through more material that at eta = 0**

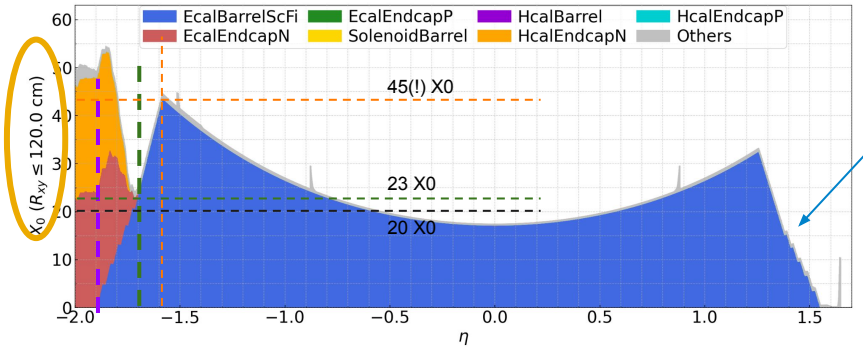
We do not consider Imaging and SciFi/Pb parts as separate detectors, rather it's a SciFi Detector (21.45/17.1 X0 at eta = 0) with imaging shelfs distributed inside

Dimensions

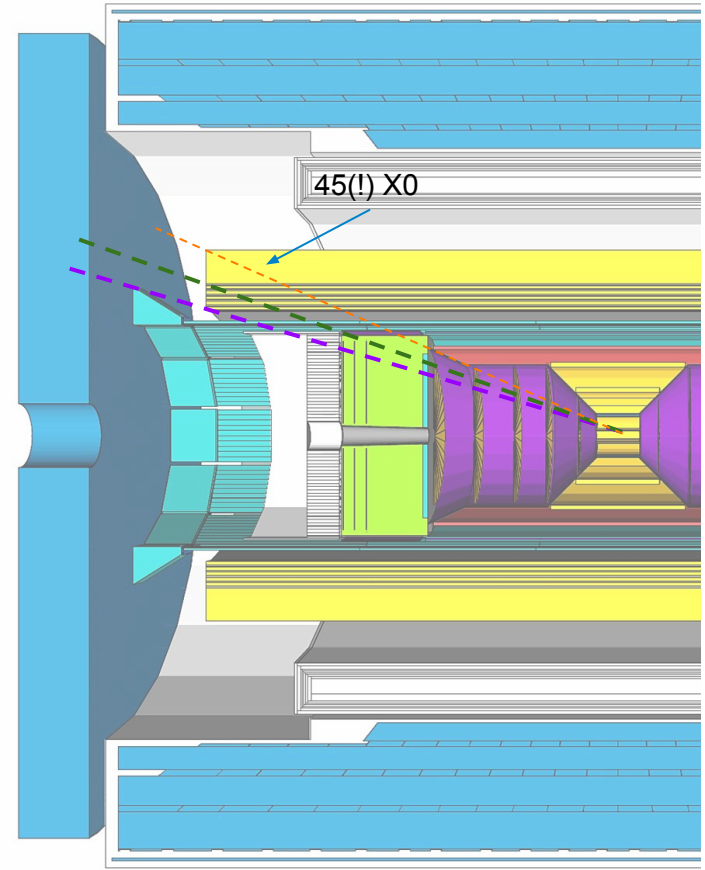
To do: Contact Carlos and ask if the endcap dimensions are as in CAD

Material scan through the ePIC geometry
(for 17.1 X0 of the ScFi/Pb)





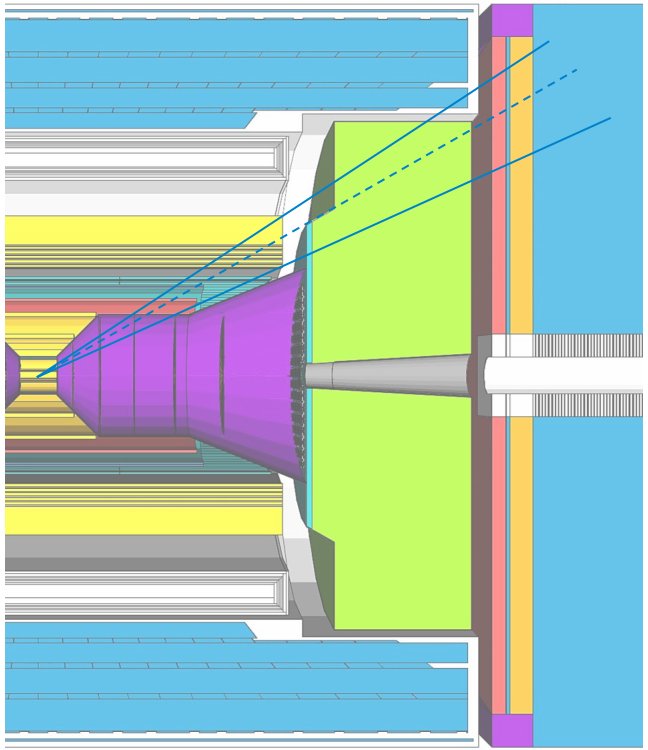
step-like structure from ScFi/Pb layers in between AstroPix layers

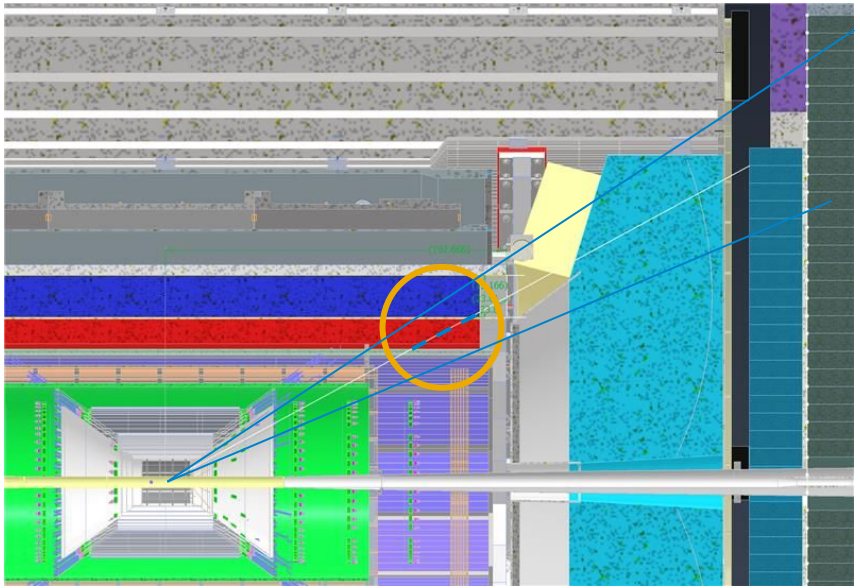


Dimensions

These regions looks very different in simulation and CAD (dimensions of EndcapEMCAL)

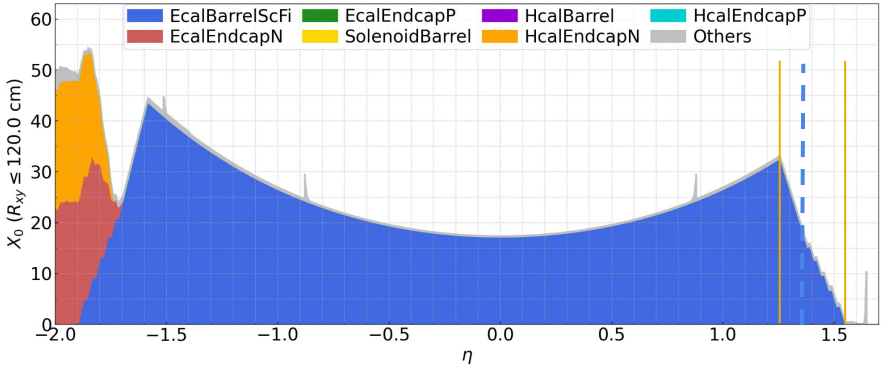
- BECAL is put in simulations according to menagerie - ✅

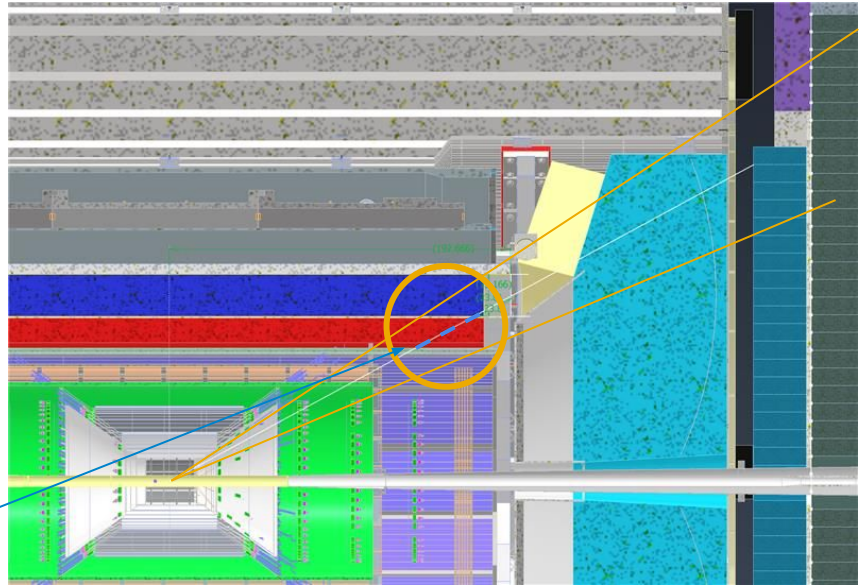




Dimensions

These regions looks very different in simulation and CAD (shape of RHIC, dimensions of EndcapEMCAL, shape of tracker?) - BECAL is put in simulations according to menagerie





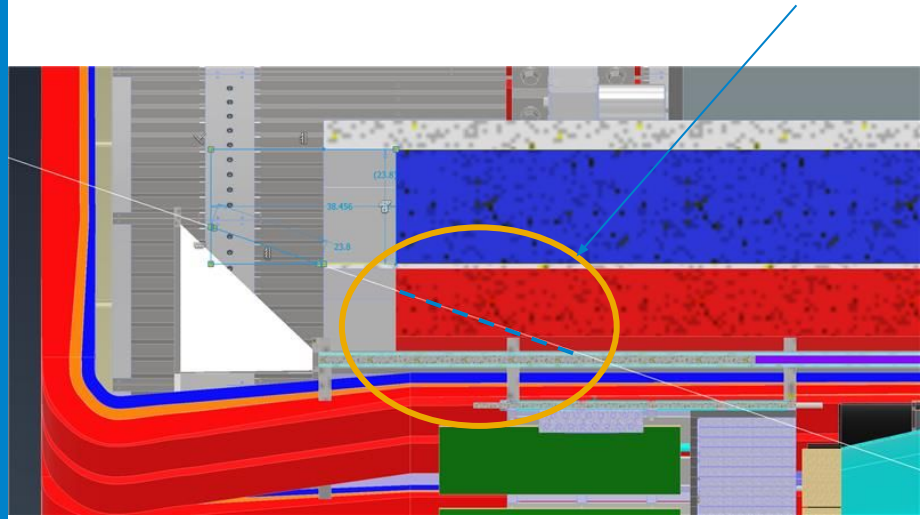
Ends after 6th SciFi layers

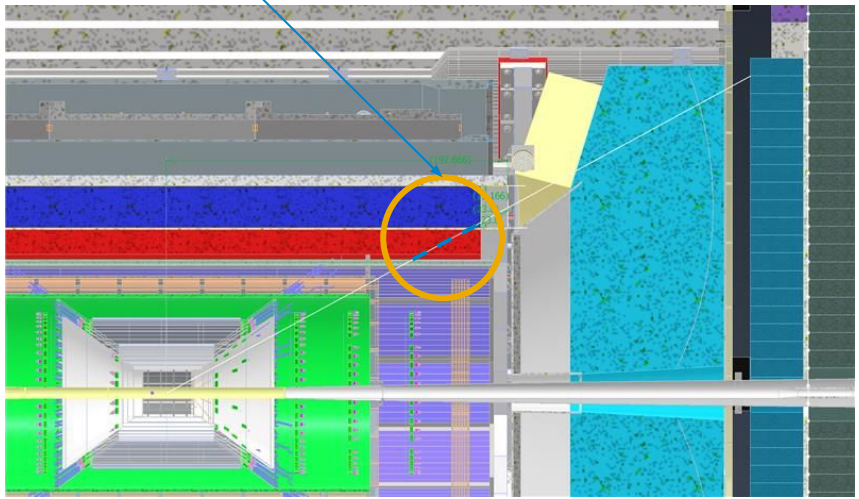
Edge Dimensions

From Menagerie Tables:

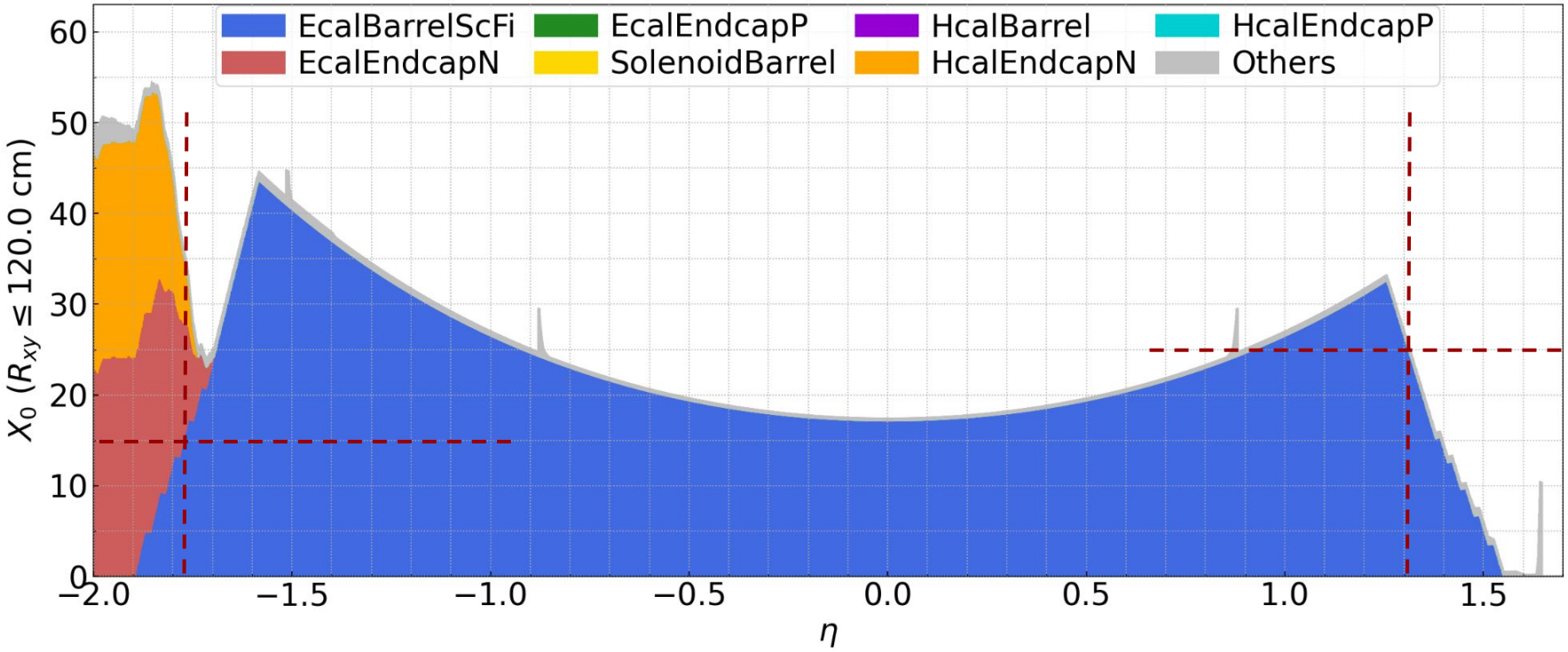
- negative ecal front face at z -174 cm, up to r = 63 cm
- positive ecal front face at z 329.5 cm, up to r = 195 cm
- backward block size = 2 cm, forward module size = 2.5 cm

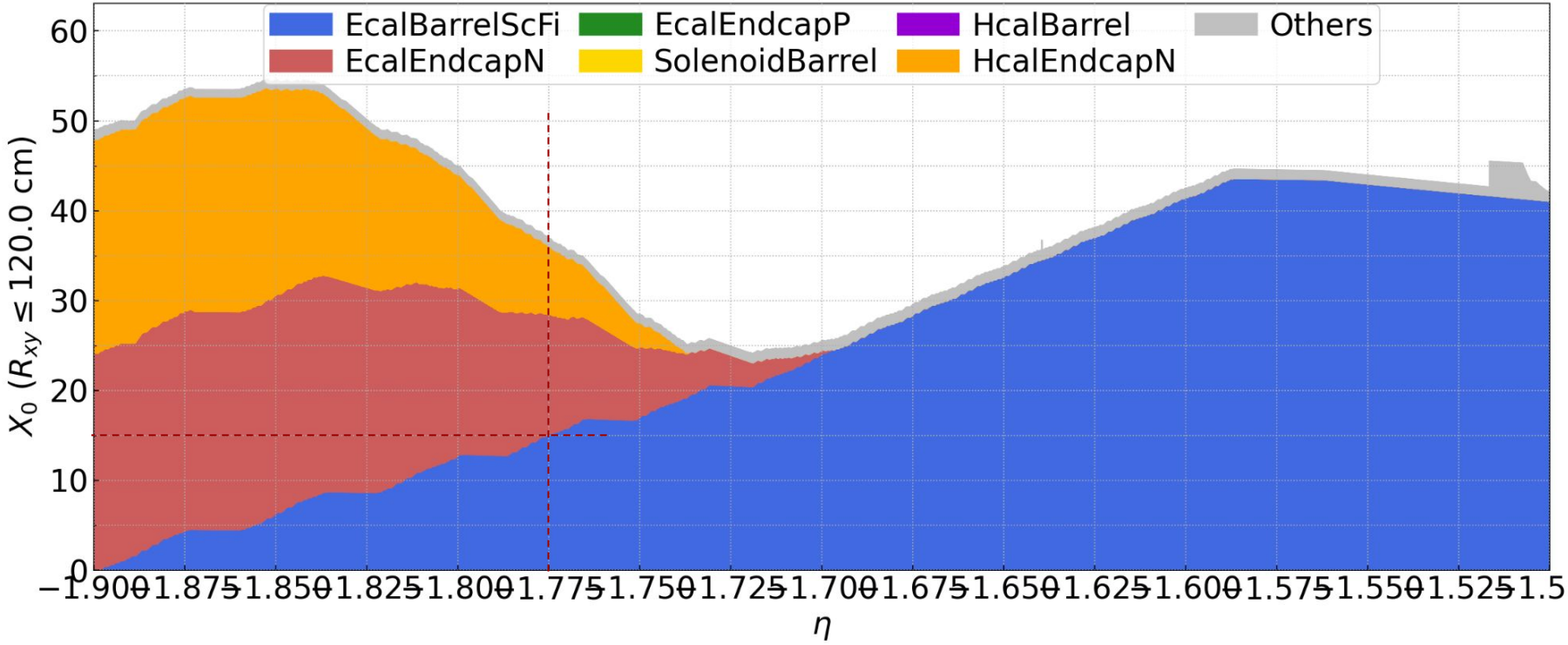
η = -1.77 and +1.31 for those lines assuming *one block size less than maximum radius*





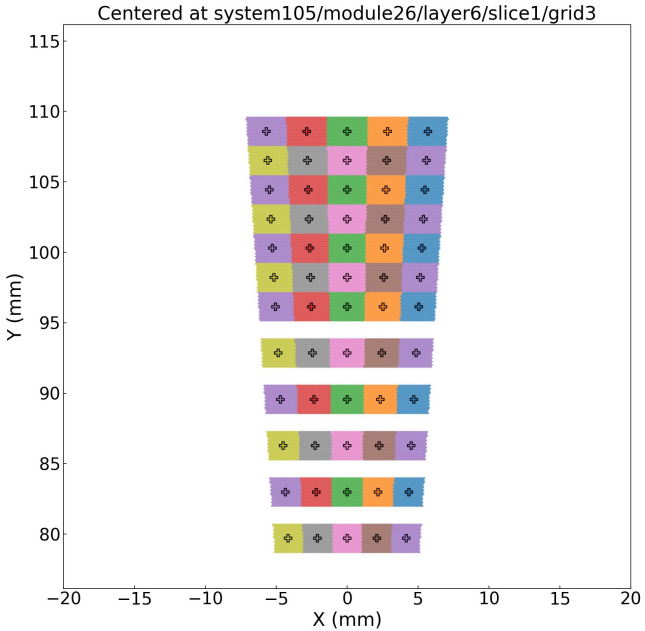
η = -1.77 and +1.31


EcalBarrelScFi
EcalEndcapN
EcalEndcapP
SolenoidBarrel
HcalBarrel
HcalEndcapN
HcalEndcapP
Others
X_0 ($R_{xy} \leq 120.0$ cm)
η
60
50
40
30
20
10
0
−2.0
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5


EcalBarrelScFi
EcalEndcapN
EcalEndcapP
SolenoidBarrel
HcalBarrel
HcalEndcapN
Others
X_0 ($R_{xy} \leq 120.0$ cm)
0
10
20
30
40
50
60
−1.900
1.875
1.850
1.825
1.800
1.775
1.750
1.725
1.700
1.675
1.650
1.625
1.600
1.575
1.550
1.525
1.500
η

Simulation Work - Short Scale

2. Can we make detector less deep (~ 18 X0) - photon resolution, e/pi, hadron reconstruction



Now 15 layers with 17 rows of fiber in = ~21.4 X0 at eta = 0

- Drop 2(?) layers (2*1.43 X0)
- Check energy resolution for gammas in the whole range
- Check response to hadrons (neutrons)
- Is there anything else we may think will be affected

How much fiber?

See my slides at Calo Meeting:
https://indico.bnl.gov/event/19383/

Simulation Work - Short Scale

3. Requirements for the SiPMs

- **What is the dynamic range one needs to cover (what pixel size do we need)**
  - From the Yellow Report DIS data we talk probably about the range 0.1 - 40 GeV in the range (-1.5 - 1.2 in eta)
  - This requires revisiting the GlueX studies of nb of phe and check simulation to see what is the max energy deposit in one readout cell for max and min energy
  - 700 phe/whole module
- **What is the impact of radiation damage of the SiPMs on you system**
  - What would be the threshold increase with radiation damage
- **What specs have you already determined and how? What needs still be determined**
- **How do your SiPM specs impact the readout electronics, especially the FEEs**
  - Probably a bit more difficult to answer, but if we know that specs are similar to the forward calo, we will probably be covered. (need to keep in mind our requirements for the timing resolution, though)

Information needed for DAQ Discussion

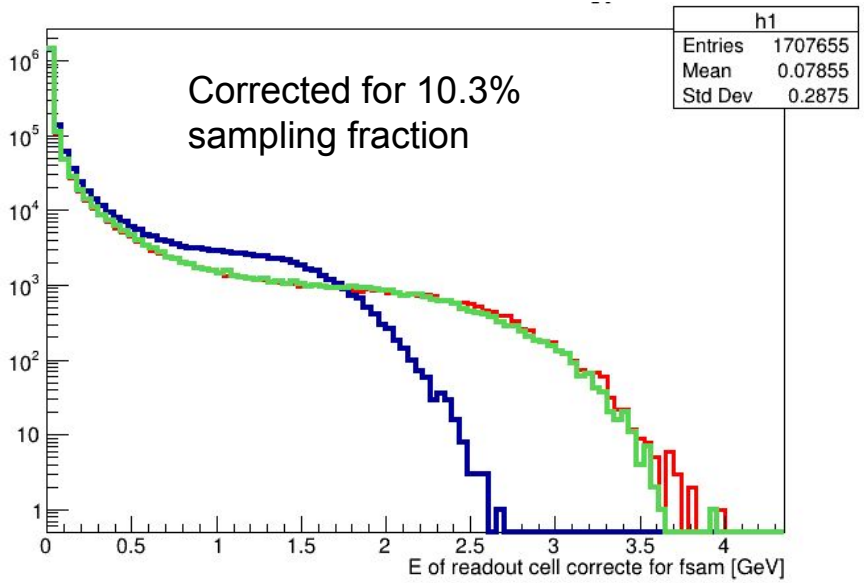
For both Imaging and SciFi/Pb layers check:

- Max dynamic range for a single readout unit (grid for SciFi/Pb and pixel for AstroPix) - high energy electrons, NC DIS files
- Max occupancy per readout unit and chip + integrated one - high energy electrons, NC DIS files
- Max rates per readout unit and chip + integrated one - high energy electrons, NC DIS files

Information needed for DAQ Discussion - SiPMs

dE of the single readout cell for

- photons at eta=0 (blue)
- e- (green) at eta = 1
- gammas (red) at eta = 1 for the high energy (~18 GeV)



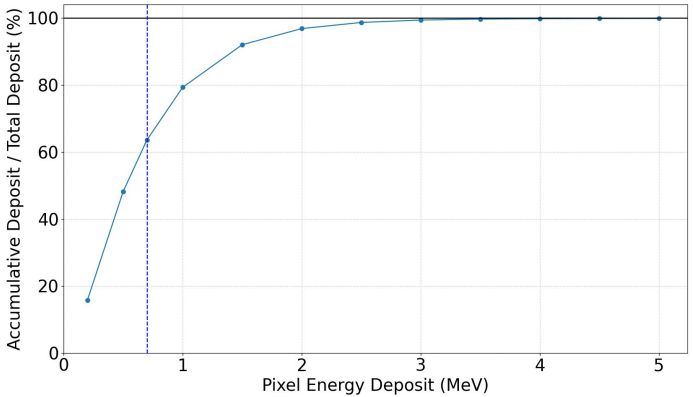

```
// digitization settings, must be consistent with digi class
    m_capADC=16384;
    m_dyRangeADC=750. * dd4hep::MeV;
    m_pedMeanADC=20;
    m_pedSigmaADC=0.3;


    // zero suppression values
    m_thresholdFactor=5.0;
```

Threshold on single cell:
((5x0.3)/16384)*750 = ~ 0.07 MeV

- Adjust threshold
- Rework readout summing scheme
- Look into the most extreme case for dynamic range

Information needed for DAQ Discussion - AstroPix

1. Low rates
   a. The expected hit rate for **all imaging layers together** is well below < 3 x 10^7 Hz
   b. This translates to a maximum hit rate per tracker stave (1 x 108 chips) < 36 kHz
2. Dynamic range (see plot for 2 GeV electron) **~ 3 MeV**
3. **Zero suppression threshold of 20 keV** well suited for EIC electromagnetic showers
4. Low Ionization radiation dose and neutron flux
   a. The maximum **ionizing radiation dose ~1 Rad/year** for the barrel region
   b. Max neutron flux is at the order of **10^8 neutrons/cm^2 per year**
5. Timing requirement: **driven by 10 ns bunch** crossing



Accumulative energy deposit to the total energy deposit for 2 GeV electrons.

- About 63% of the energy deposit was made through hits with deposit < 700 keV
- hits with deposit < 3 MeV contribute to 99% of the total energy deposit