Cylindrical Tracking in Fun4All

- Cylindrical surfaces have 2 resolutions that can be set for smearing: phires and lonres

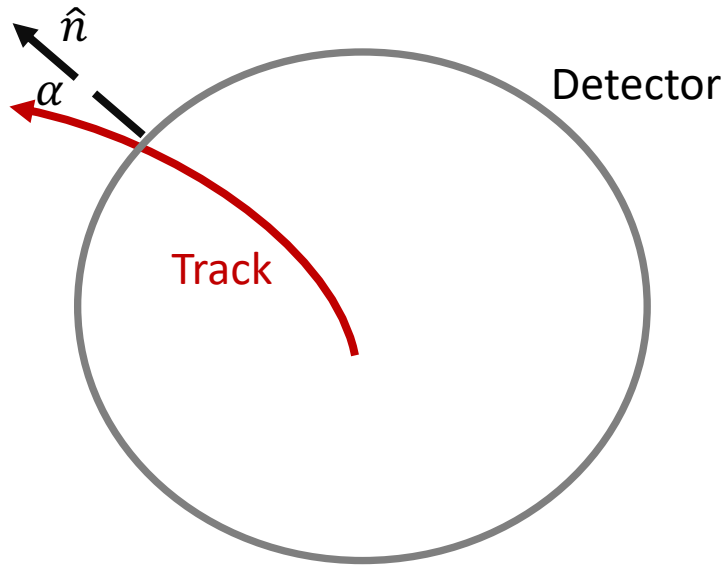
```
TRACKING::FastKalmanFilter->add_phg4hits(string("G4HIT_") + string(Form("RWELL_%d", ilyr)),  //      const std::string& phg4hitsNames,
                                         PHG4TrackFastSim::Cylinder,                        //      const DETECTOR_TYPE phg4dettype,
                                         1. / sqrt(12.),                                    //      const float radres,
                                         phires,                                            //      const float phires,
                                         lonres,                                            //      const float lonres,
                                         1,                                                 //      const float eff,
                                         0,                                                 //      const float noise
                                         RWELL::nom_driftgap[ilyr]);                        //      driftgap size
TRACKING::FastKalmanFilter->add_cylinder_state(Form("RWELL_%d", ilyr), RWELL::nom_radius[ilyr]);
```

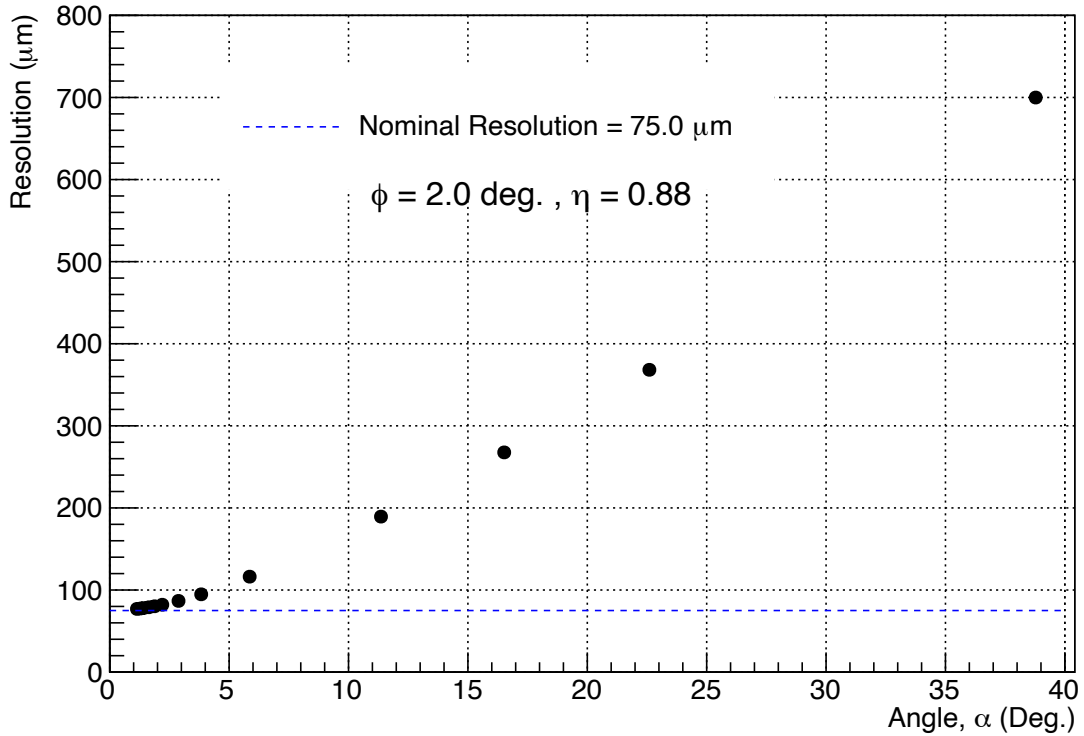
```
PHGenFit::PlanarMeasurement* PHG4TrackFastSim::PHG4HitToMeasurementCylinder(
    const PHG4Hit* g4hit, const double phi_resolution,
    const double z_resolution)
{
  TVector3 pos(g4hit->get_avg_x(), g4hit->get_avg_y(), g4hit->get_avg_z());

  TVector3 v(0, 0, 1);

  TVector3 u = v.Cross(TVector3(pos.X(), pos.Y(), 0));
  u = 1 / u.Mag() * u;

  double u_smear = 0.;
  double v_smear = 0.;
  if (m_SmearingFlag)
  {
    u_smear = gsl_ran_gaussian(m_RandomGenerator, phi_resolution);
    v_smear = gsl_ran_gaussian(m_RandomGenerator, z_resolution);
  }
  pos.SetX(g4hit->get_avg_x() + u_smear * u.X());
  pos.SetY(g4hit->get_avg_y() + u_smear * u.Y());
  pos.SetZ(g4hit->get_avg_z() + v_smear);

  PHGenFit::PlanarMeasurement* meas = new PHGenFit::PlanarMeasurement(pos, u, v, phi_resolution,
                                                                      z_resolution);
```

Angle Dependent Resolution: phires

Angle Dependent Resolution (σ_α)

- Simplified implementation. The angle should be the angle in the plane perpendicular to the direction that the readout strips run along.





Parameterization: $\sigma_\alpha = \sqrt{\frac{d^2}{12}\tan^2\alpha}$

- $\hat{n} = (\cos\phi, sin\phi\ , 0)$, for cylindrical geometry detector
- $\alpha = Asin\left(\frac{\vec{p}_T \times \hat{n}}{|\vec{p}_T| \cdot |\hat{n}|}\right)$, p_T = Transverse momentum
- d = drift gap

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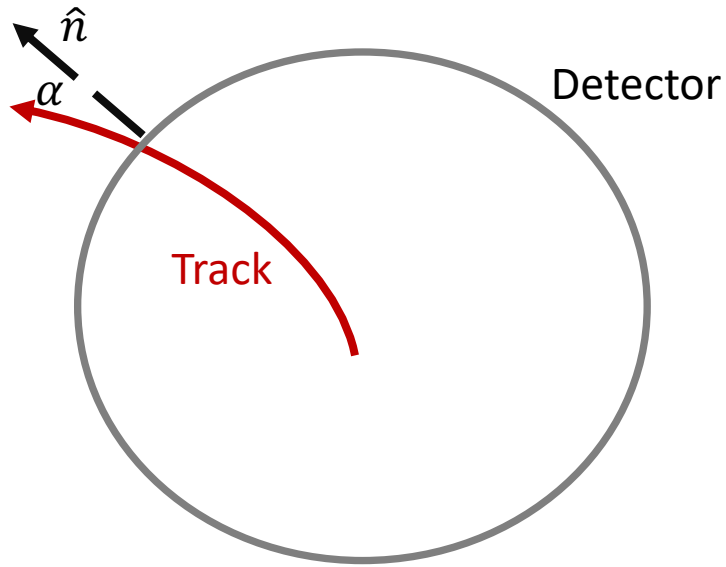

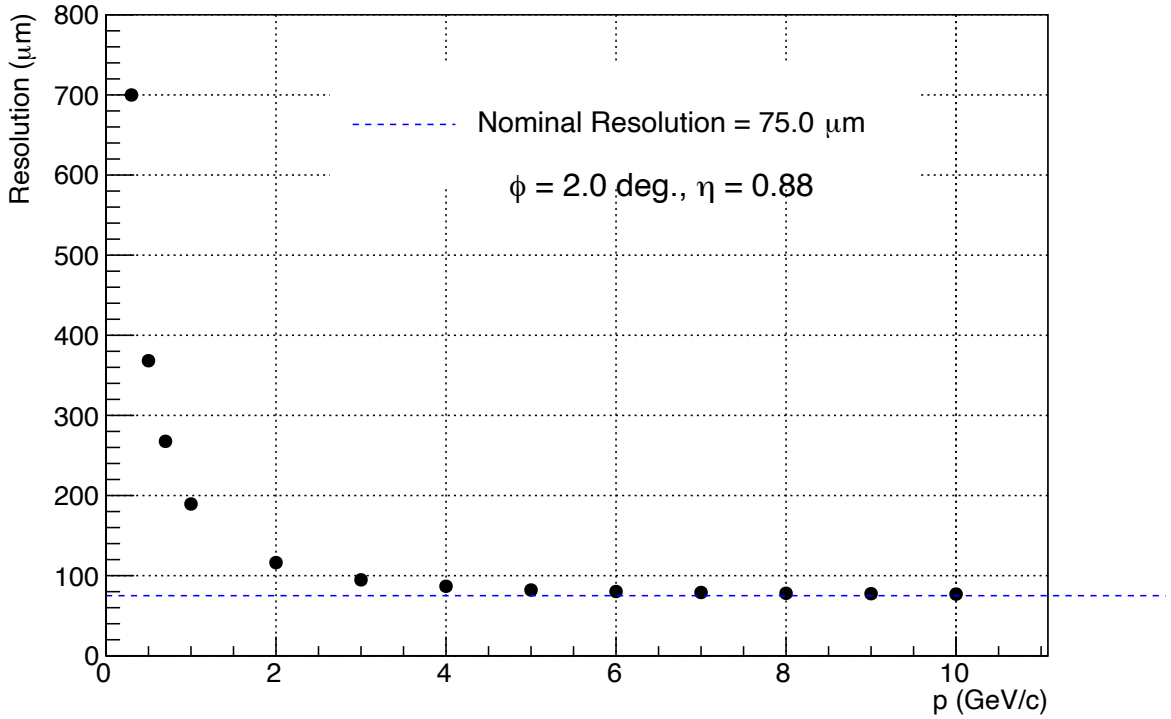

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- d = drift gap

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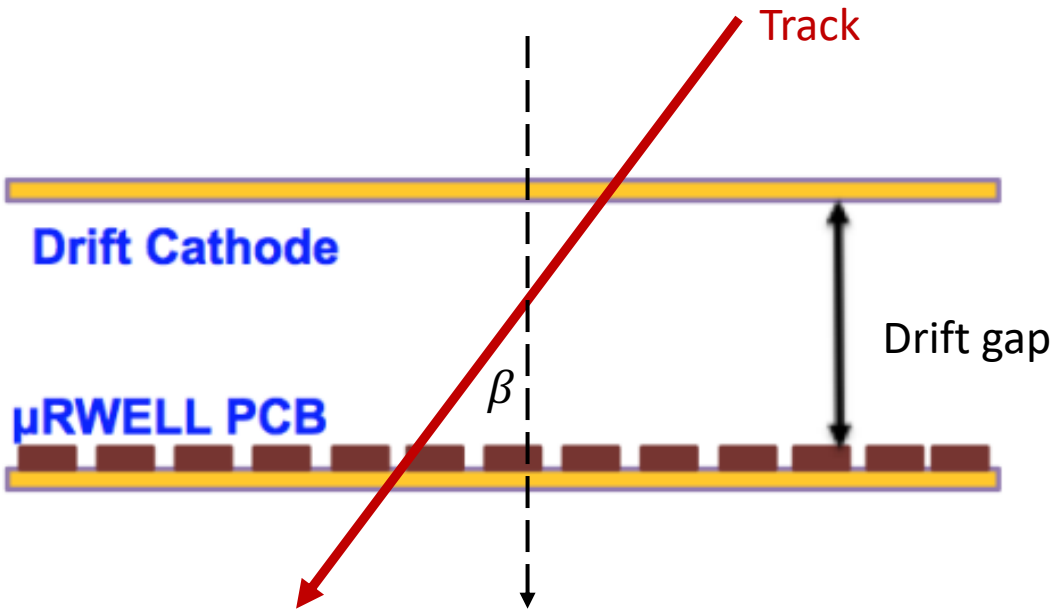
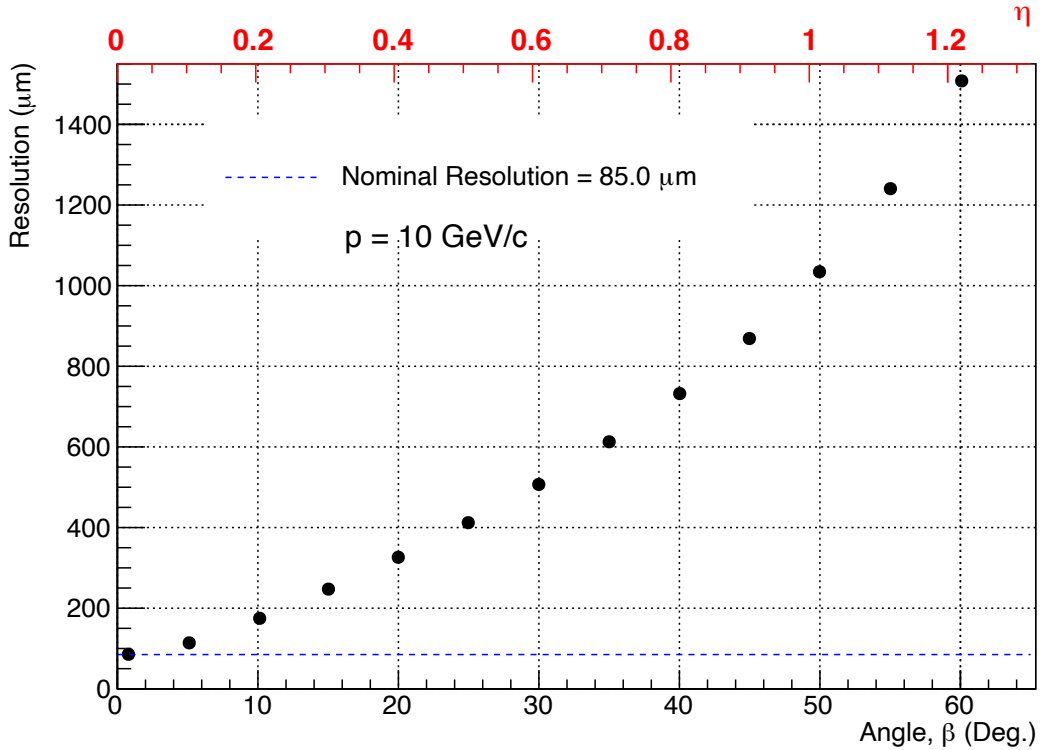
Angle Dependent Resolution: lonres

Angle Dependent Resolution (σ_β)

- Simplified implementation. The angle should be the angle in the plane perpendicular to the direction that the readout strips run along.





Parameterization: $\sigma_\beta = \sqrt{\frac{d^2}{12}\tan^2\beta}$

- $\hat{n} = (\cos\phi, sin\phi\ , 0)$, for cylindrical geometry detector
- $\beta = Asin\left(\frac{\vec{p}\times\hat{n}}{|\vec{p}|\cdot|\hat{n}|}\right), p =$ momentum
- d = drift gap

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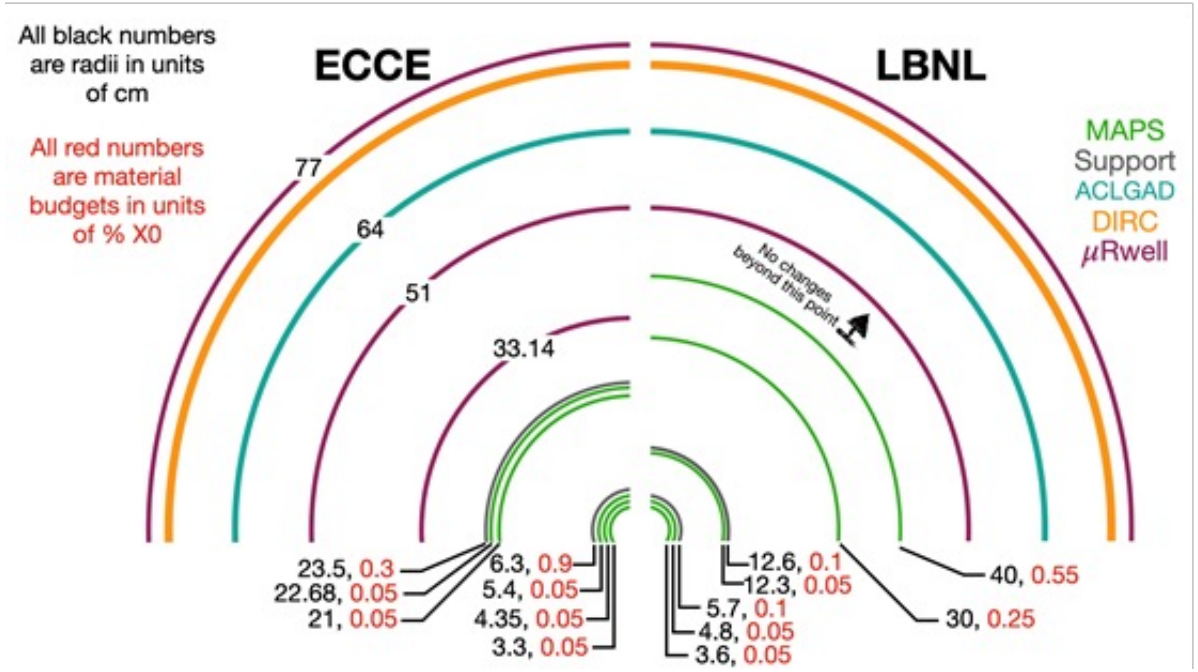
Simulation Comparisons

RefSim:

- Modifies barrel configuration based on LBNL suggestion
  - One MPGD tracking layer and One MPGD layer behind the DIRC (as defined in ECCE proposal)
    - Use fixed $55\ \mu m$ resolutions
    - Too low material budget

MPGDMat:

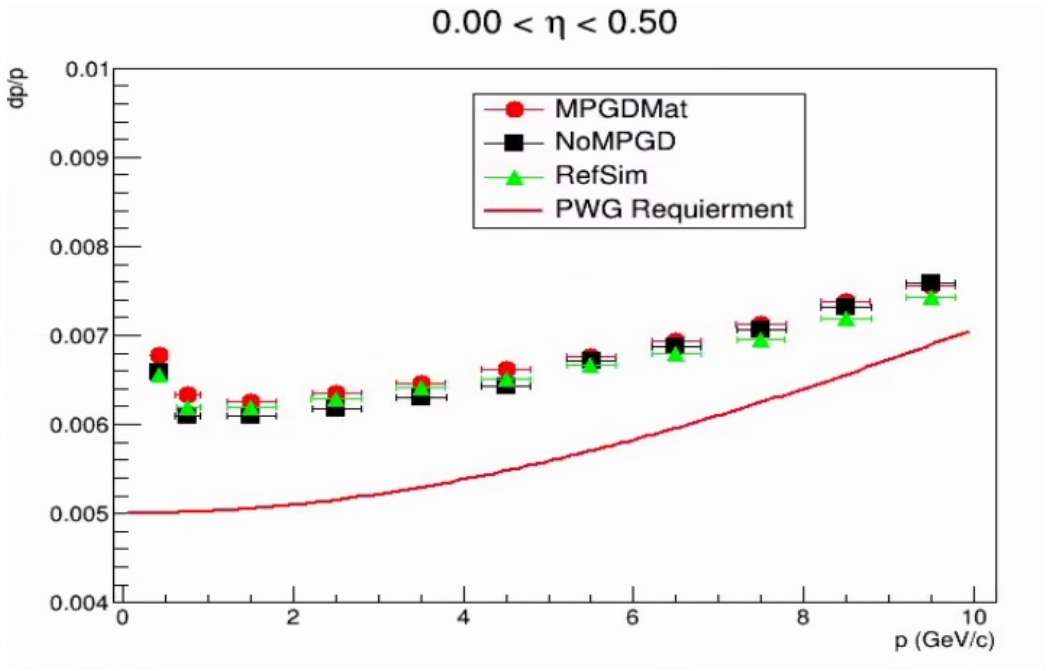
- MPGD R-Phi and Z resolutions parameterized based on angle (see here)
  - R-Phi resolution worst at low momentum (more track bending)
  - R-Phi resolution dominates momentum reconstruction
  - Nominal resolutions at $75\ \mu m$
  - 3mm Drift gap
  - Modified MPGD material budget to be 1% X0 + gas (drift gap)

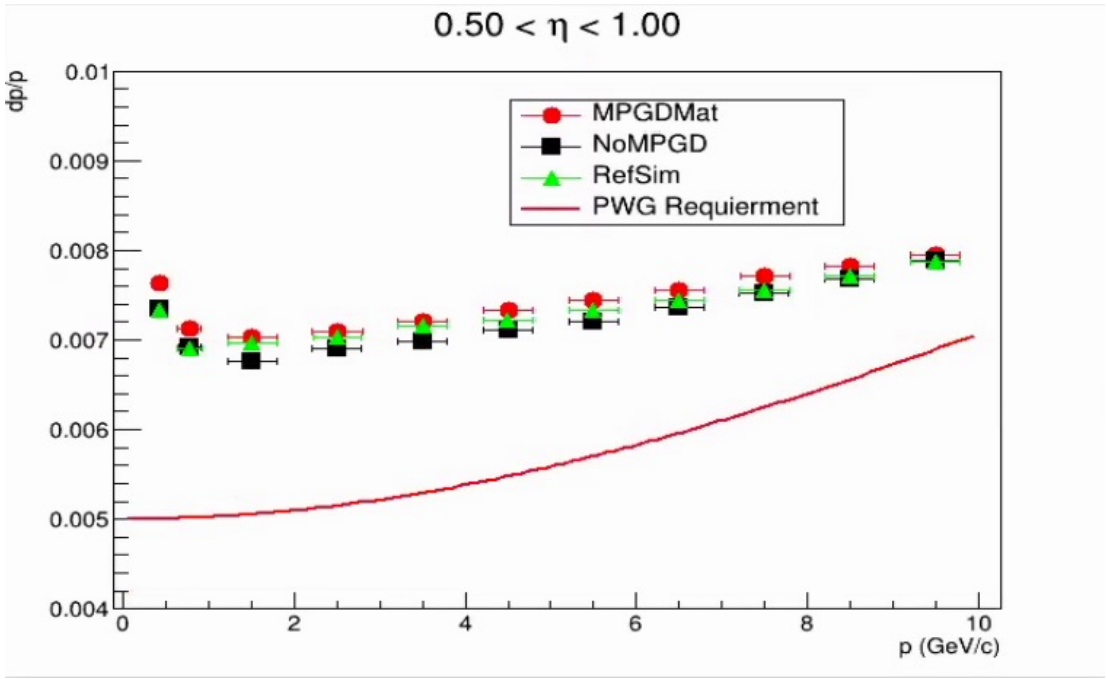


NoMPGD:

- Modifies barrel configuration based on LBNL suggestion
  - Removes MPGD layers

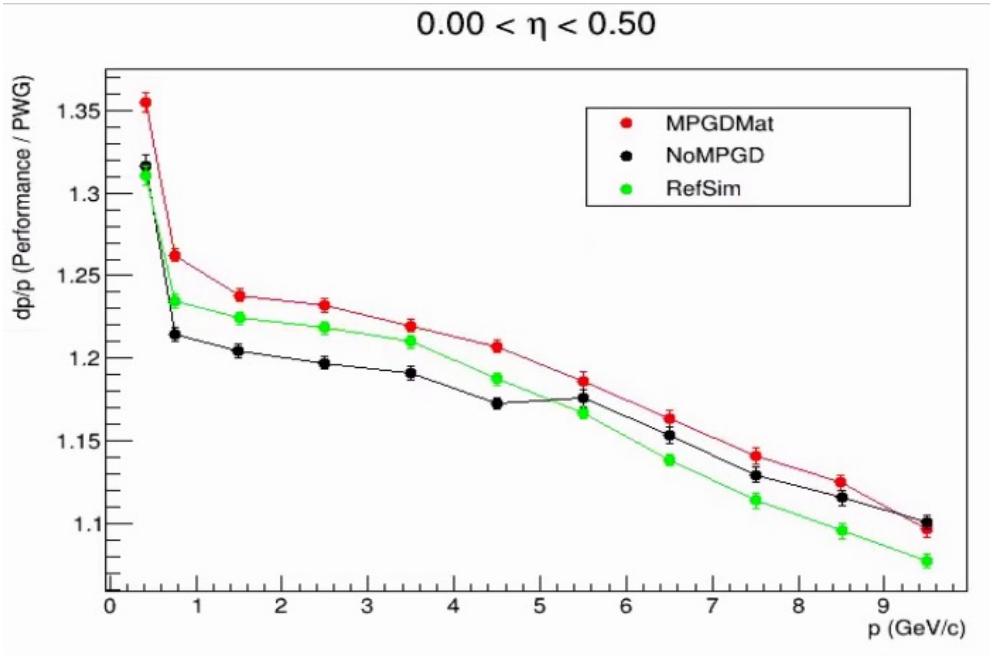
Simulation Comparisons

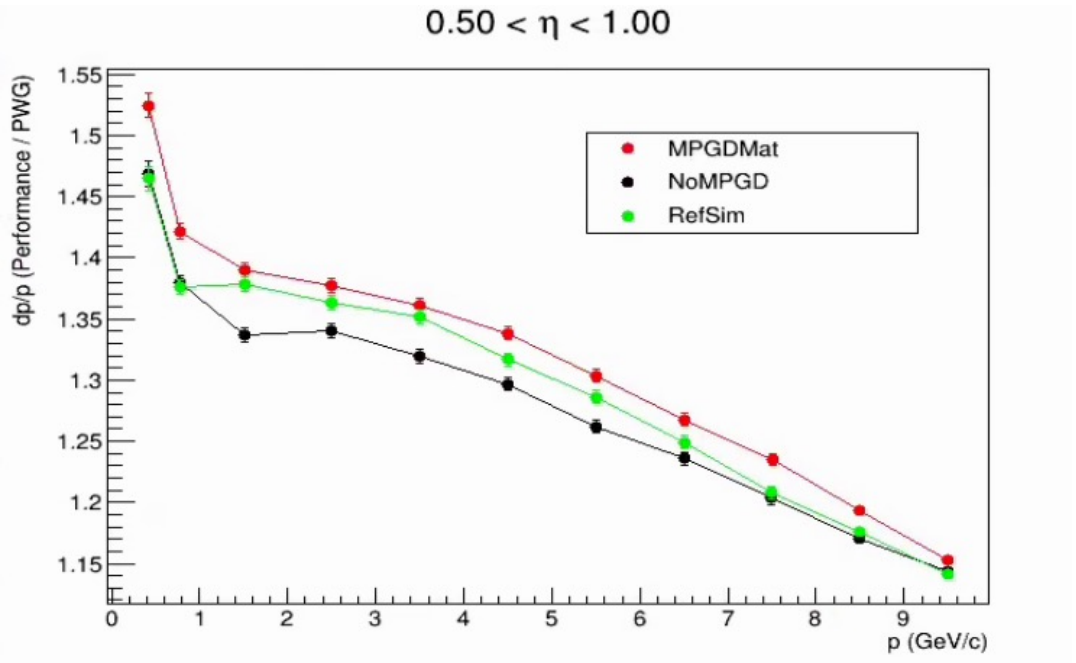




- Momentum performance is still far from PWG requirement
- Performances are
- No MPGDs in the configuration generally performs better at lower momentum (related to material reduction) and slightly worse at higher momentum relative to the LBNL reference
  - Removing MPGD layer will reduce the number of hits used for track reconstruction.
- Similar behavior for negative eta.

Simulation Comparisons





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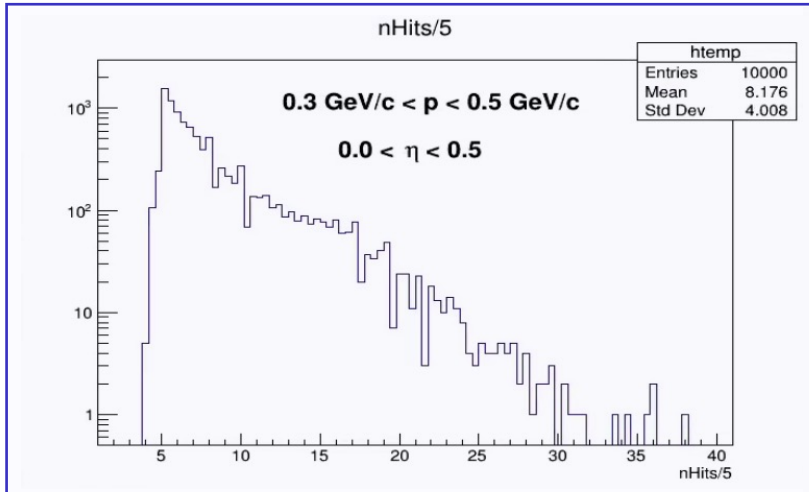
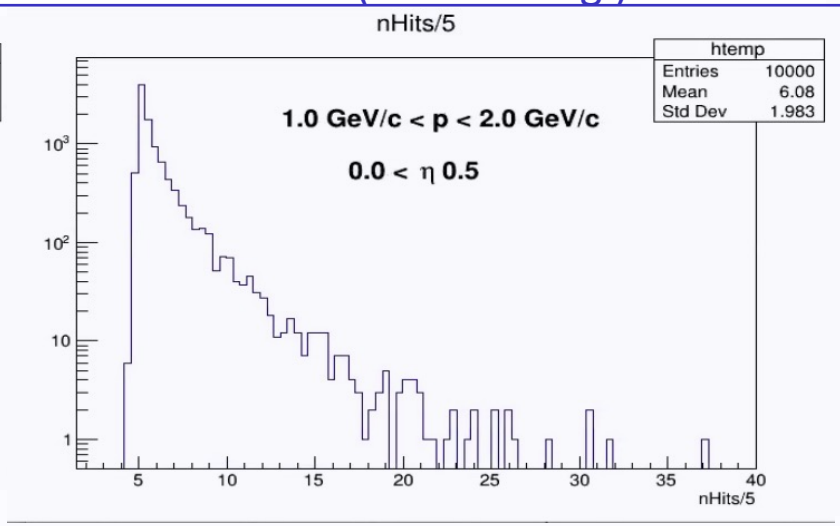
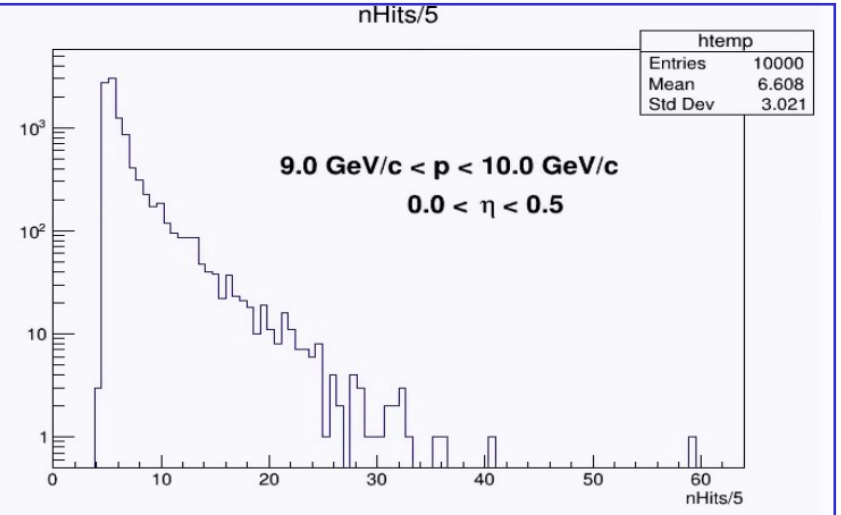
Tracks and Hits: $0.0 < \eta < 0.5$

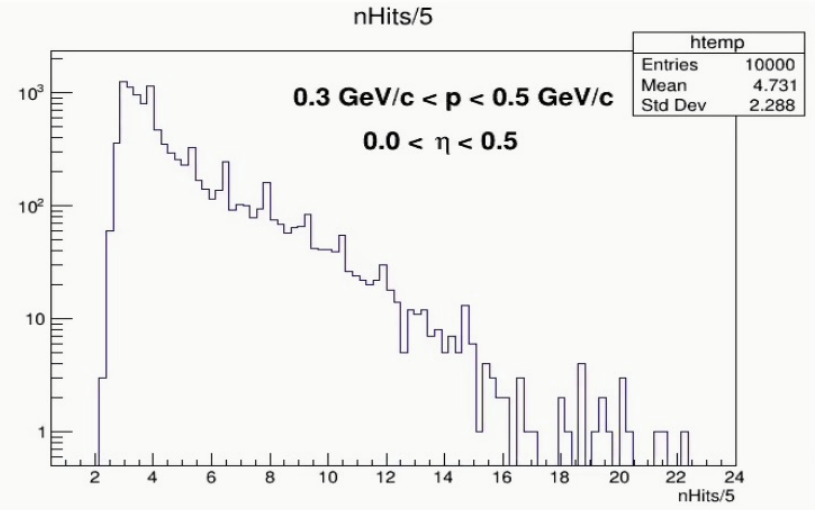
Reference (LBNL Config.)

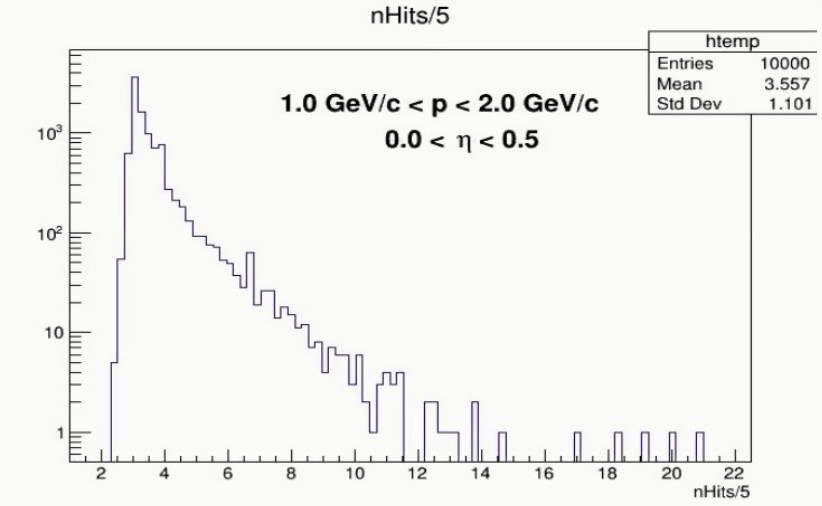


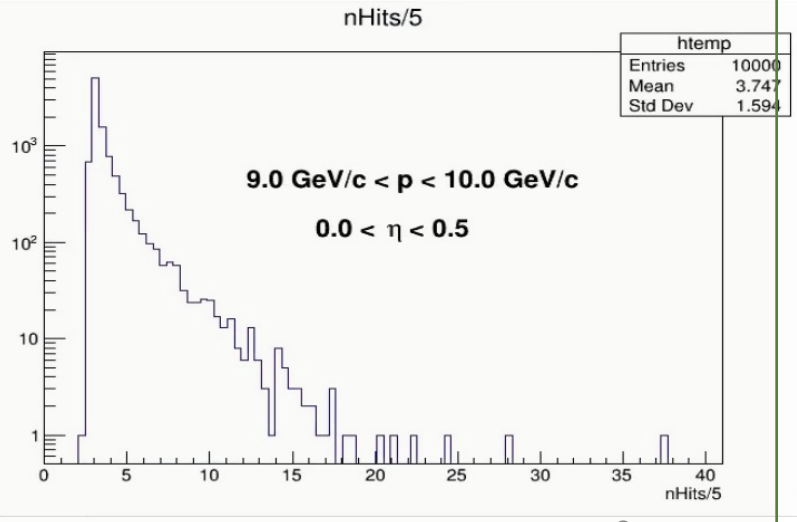




No MPGDs

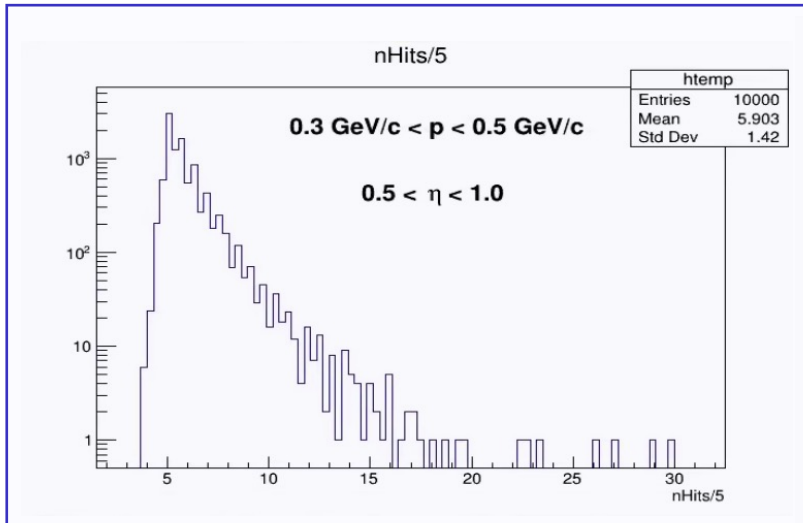


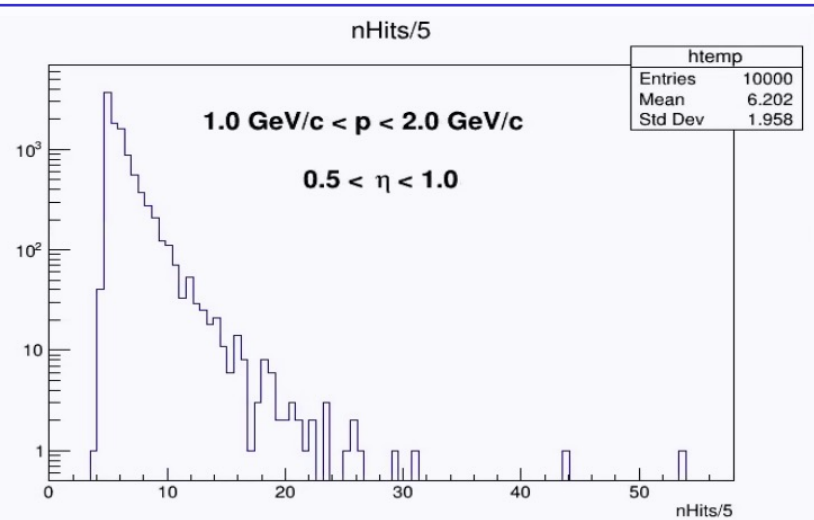


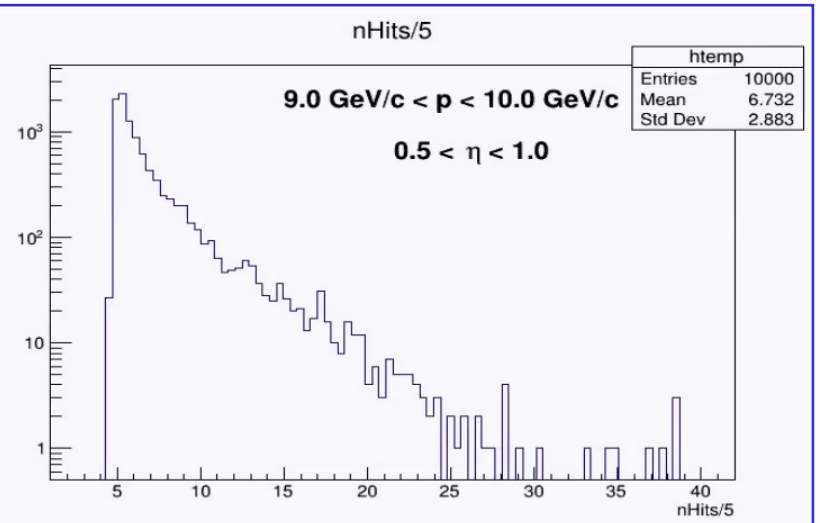


Tracks and Hits: $0.5 < \eta < 1.0$

Reference (LBNL Config.)







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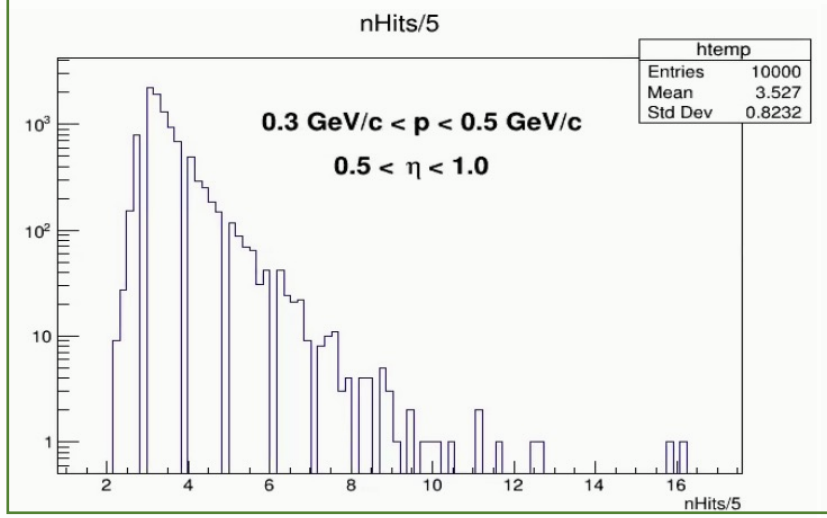
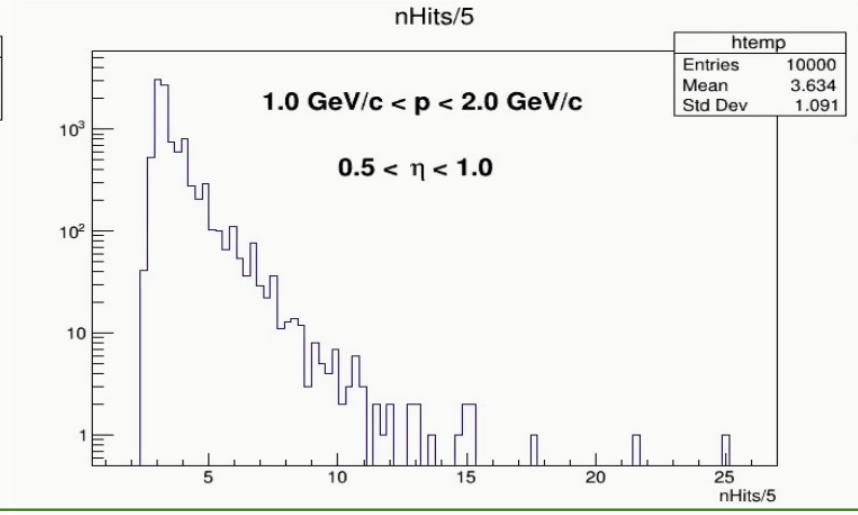
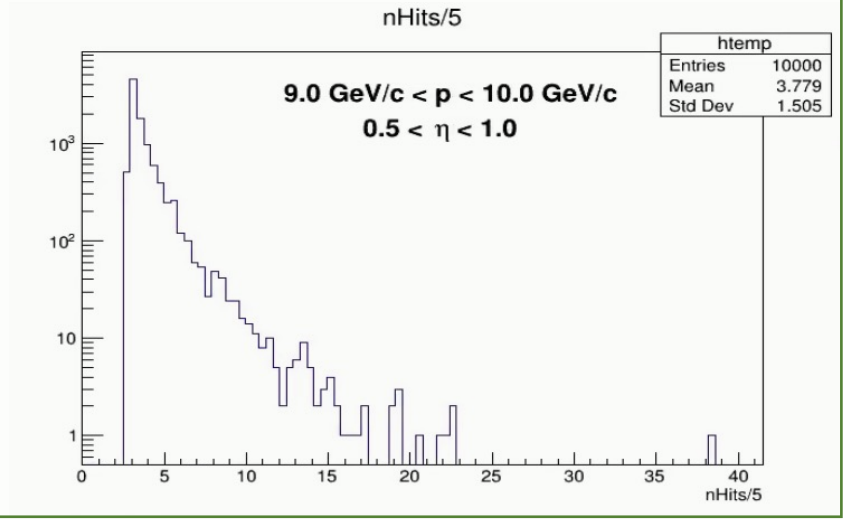
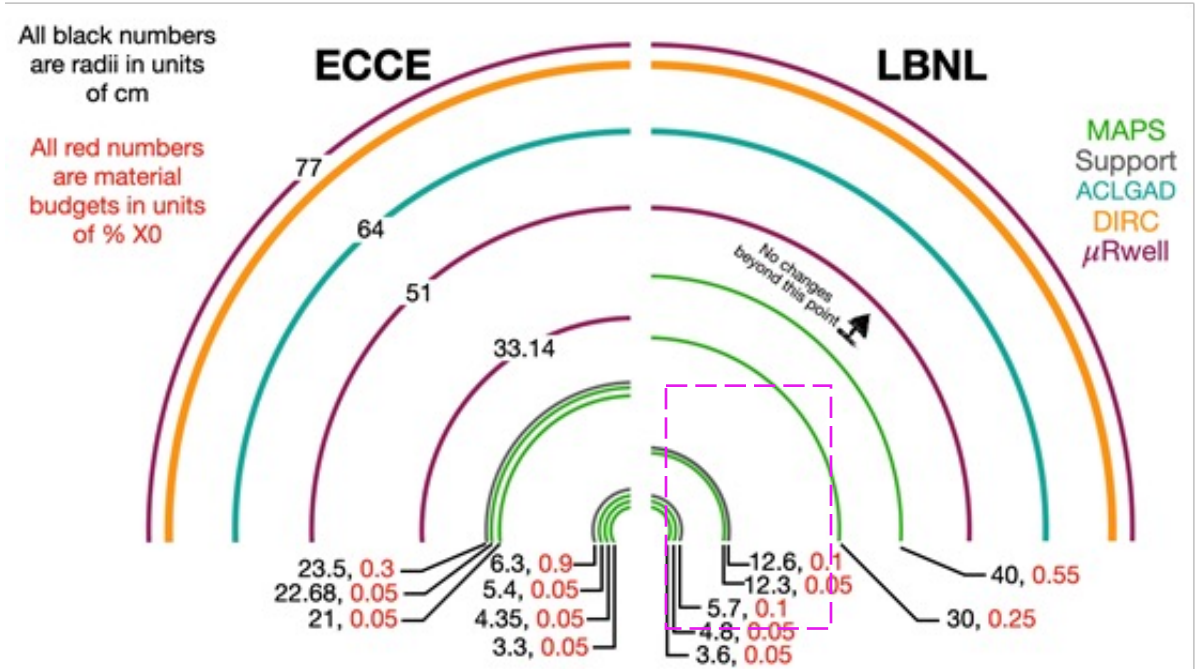


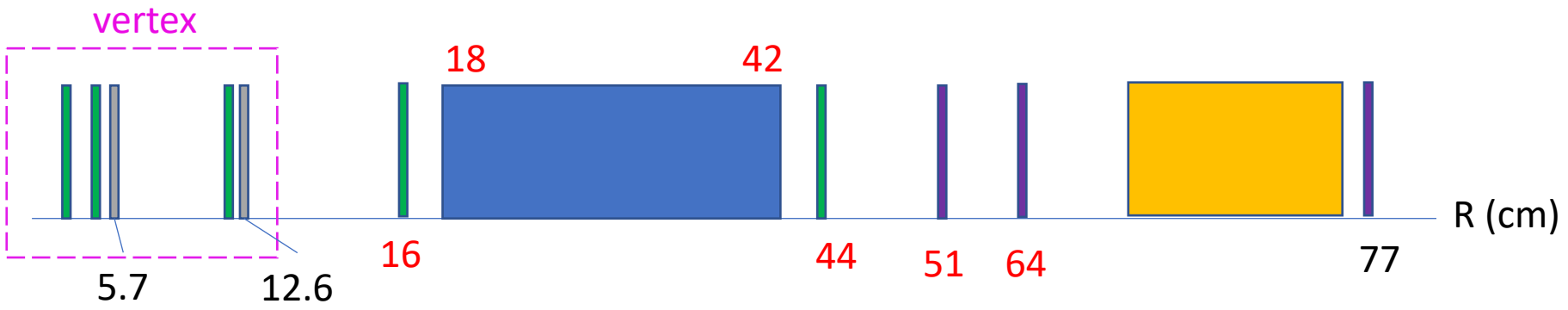




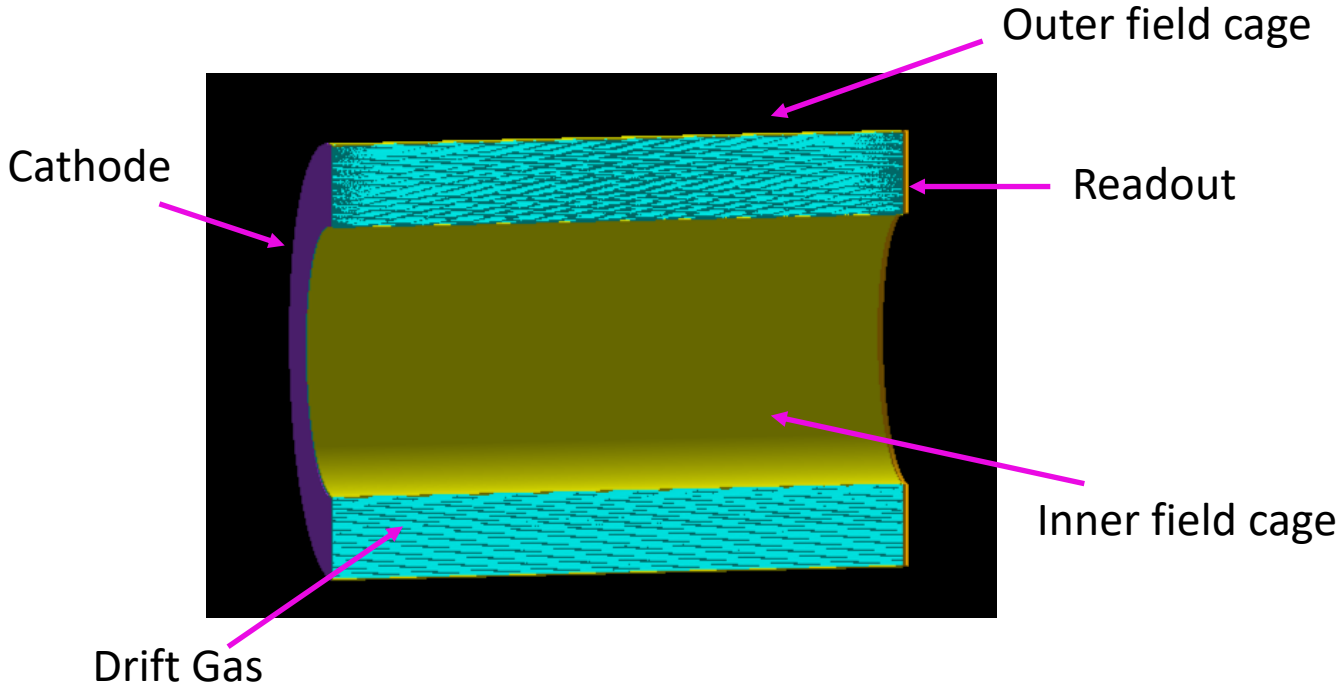
Simulation Next Steps

- Would like to see performance obtained with mini-TPC
- Configuration:
  - Keep LBNL inner Si setup (vertex)
  - What about other layers (see below)?

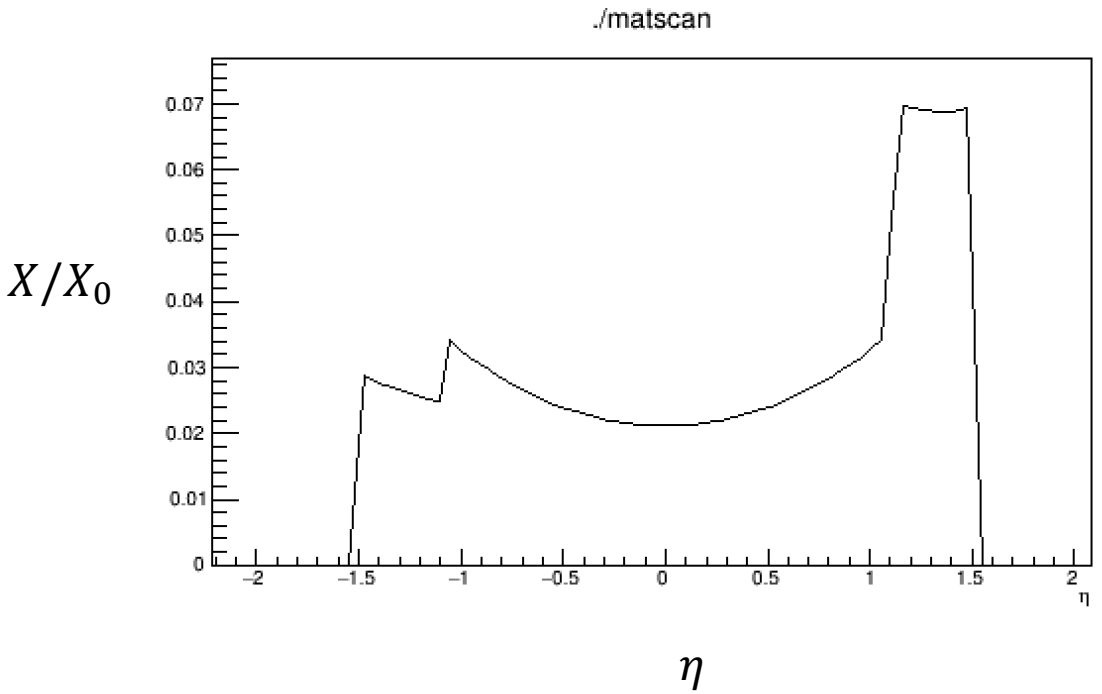




- A mini-TPC was briefly studied in Fun4All ATHENA configuration
  - For detector 1 drift volume will be larger, but does material make sense?



- Field Cage
  - 1% Kapton = 0.286 cm
- Drift Gas:
  - Drift: 23.5 cm -- 37.5 cm = 14 cm ?
  - 125 gas layers (hits) ?
  - Gas: P10
- Cathode (Backward):
  - 0.5% Kapton = 0.143 cm
- Readout (Forward):
  - 300 μm (Si) + 6.5 mm (FR4)
- Resolutions:
  - R-phi = 100 μm, z = 200 μm ?



Simulation Comparisons: Negative Eta