Muon reconstruction and updates

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THE OHIO STATE UNIVERSITY

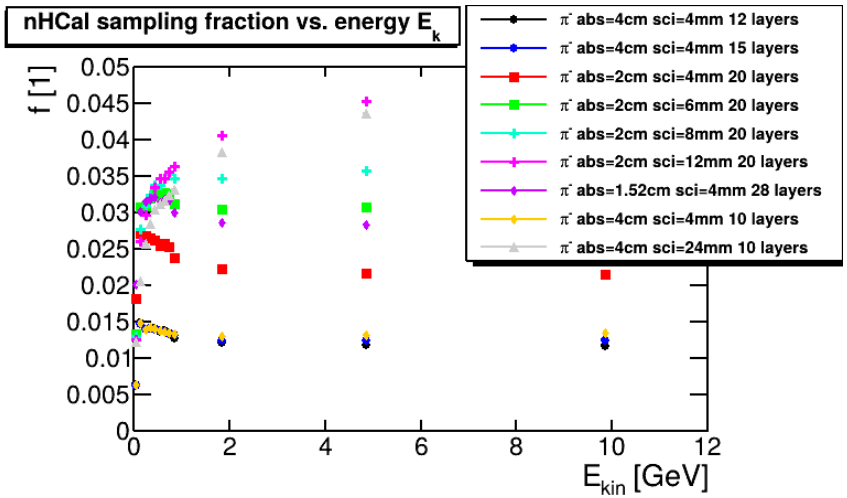
Outline

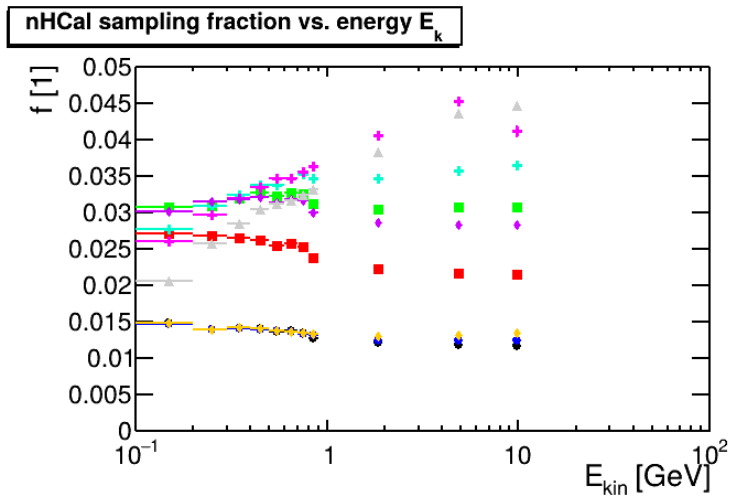
Updates - sampling fraction

$$f_s = \frac{\sum E_{scint}}{E_k}$$

- Sampling fraction calculated by filling a TProfile with a ratio of sum of energy deposits in scintillator tiles E_{scint} over kinetic energy of incoming particle
- calculates correct e/h response ratios
  - same method as used in beam tests (kinetic energy as a reference)
  - this is not the case when using sum of energy deposits in steel and plastic in the denominator (LFHCAL method)
    - missing energy for pions
- made all geometry versions $5\times$ thicker ($\lambda/\lambda_0 > 10$)

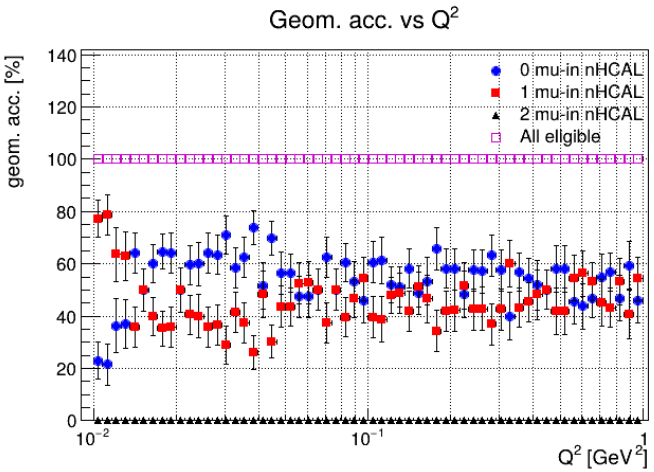
Updates - sampling fraction

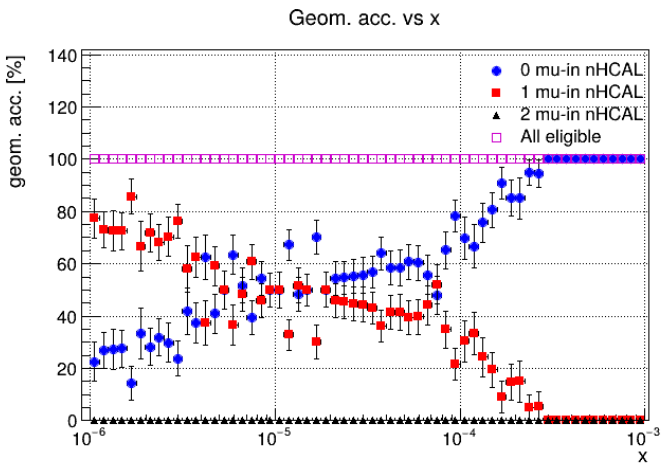


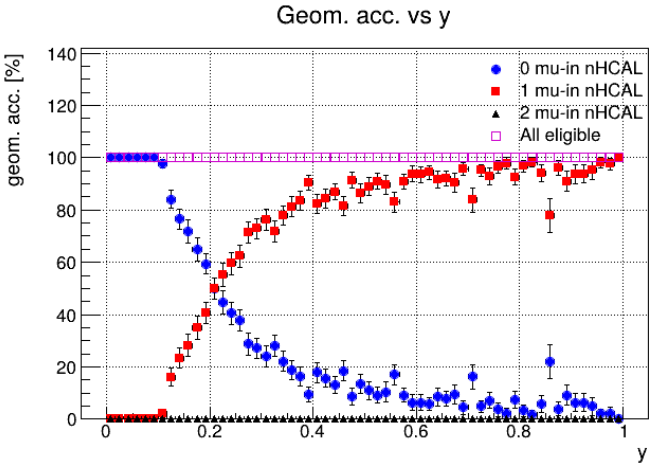


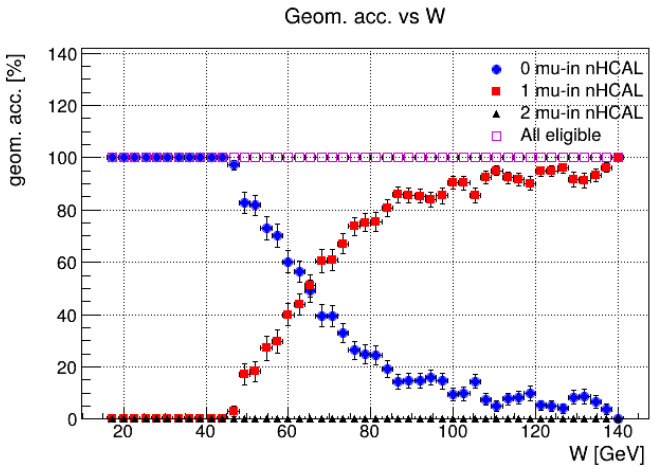
- Added 10 layers of 4 cm steel and 2.4 cm scintillator

Di-muon geometrical acceptance



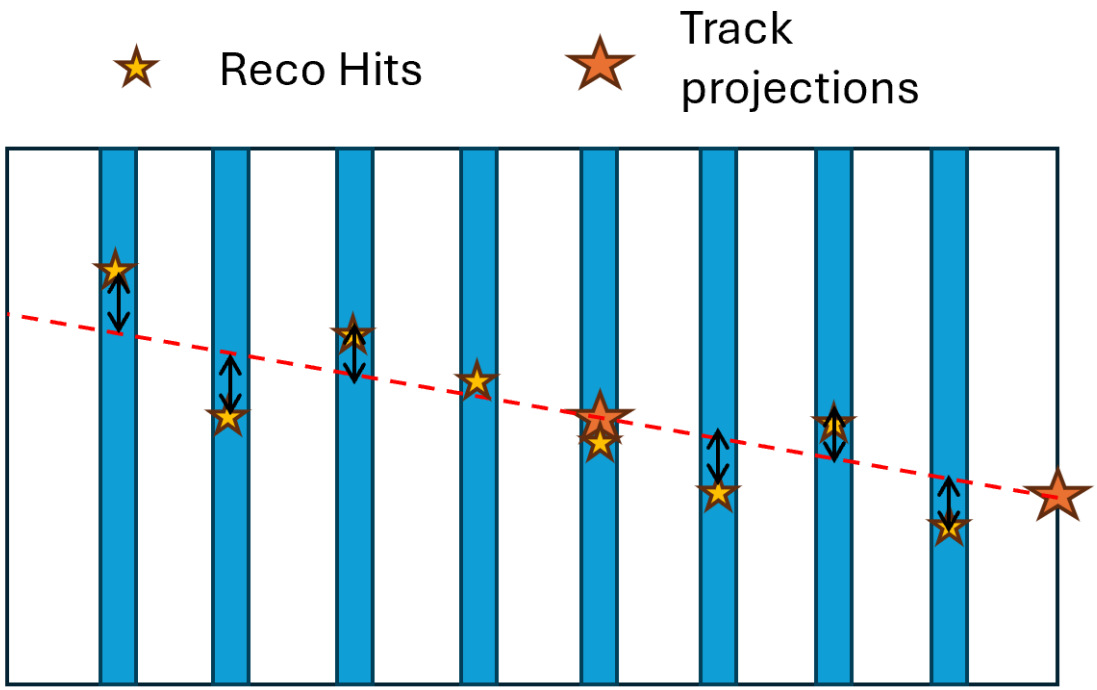






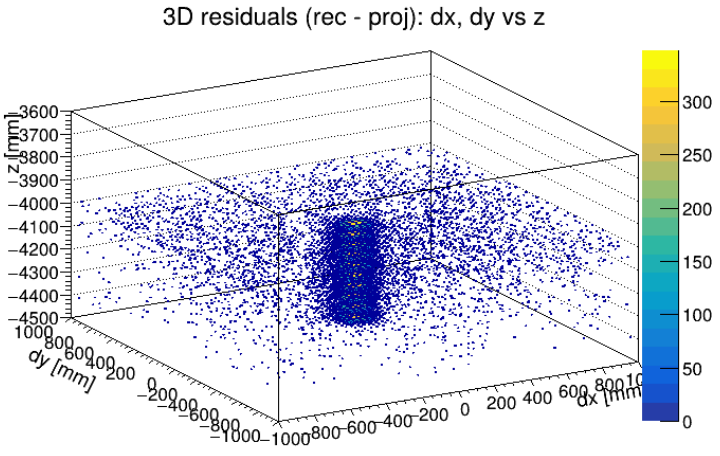
- Reconstructed kinematics (default)
- Uncertainties included
- *nHCal* needed to get 2x statistics

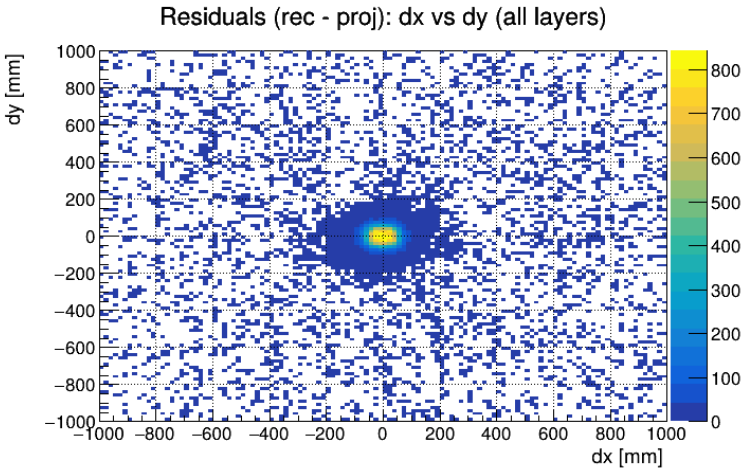
Projections and distances

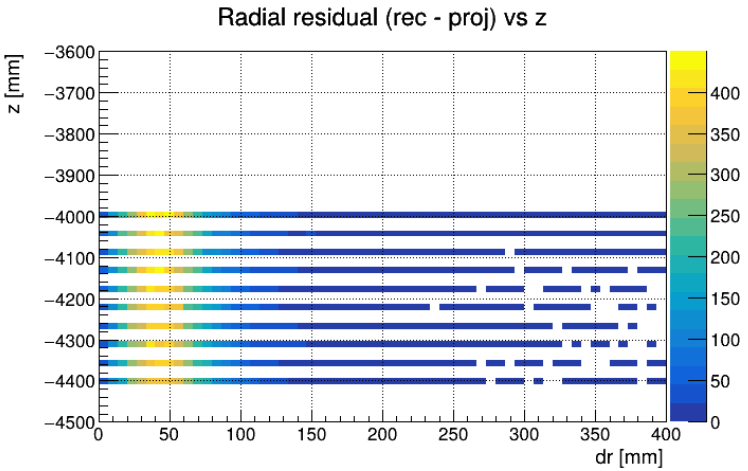


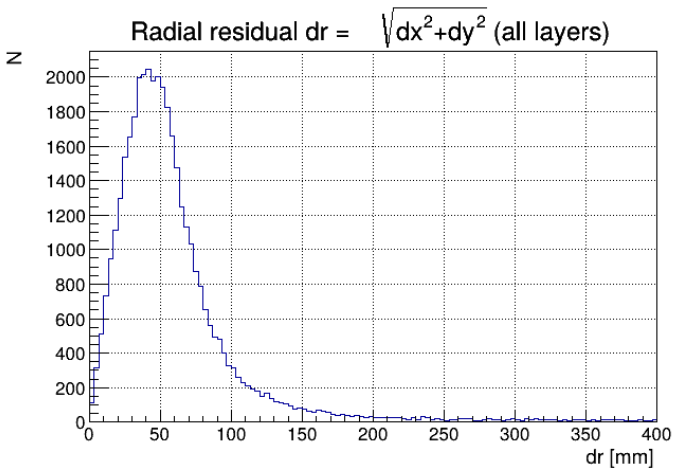
- Updated projection method across the layers
- Requiring both projections to $-395\,\mathrm{cm}$ and $-410\,\mathrm{cm}$ layers
- Connected the 2 projections with a straight (red dashed) line to calculate distance to reco hits
  - Good enough approximation
  - Uncertainties negligible due to small momentum uncertainties
  - Potentially too small: $\frac{\Delta p}{p} \approx 0.1\%$ instead of $\frac{\Delta p}{p} \approx 1\%$ (design documents)
  - May be a momentum resolution issue

Hit distributions



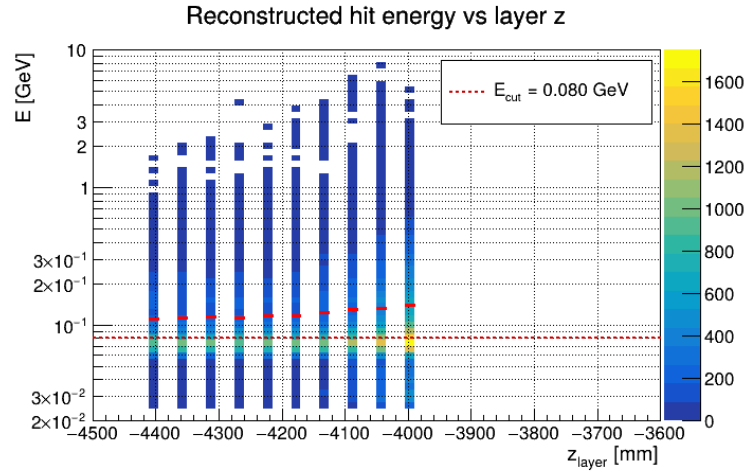


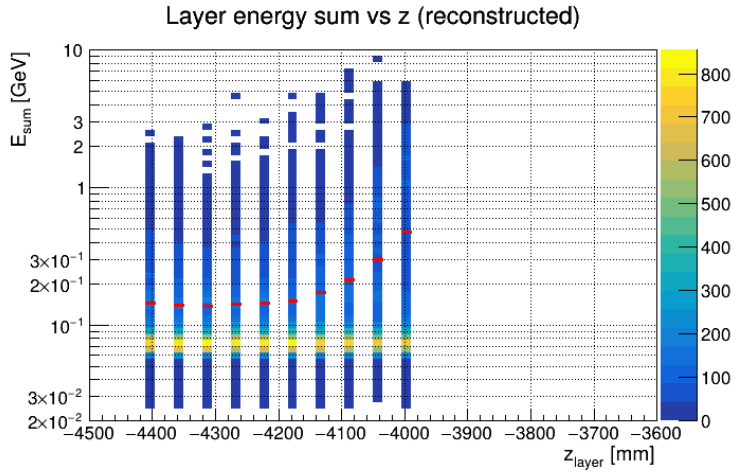


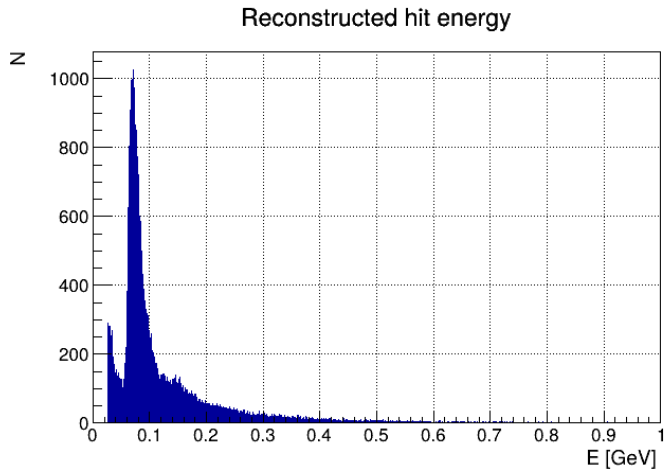


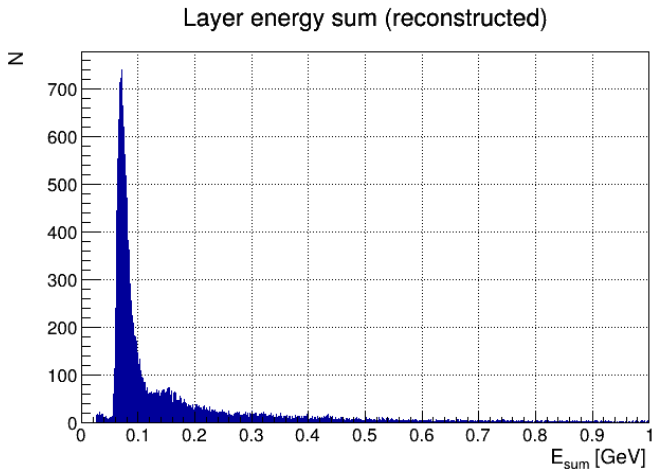
- Look ok

Hit energy



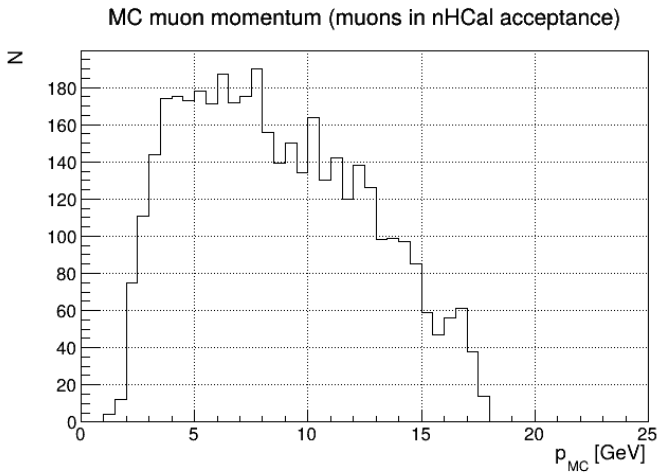


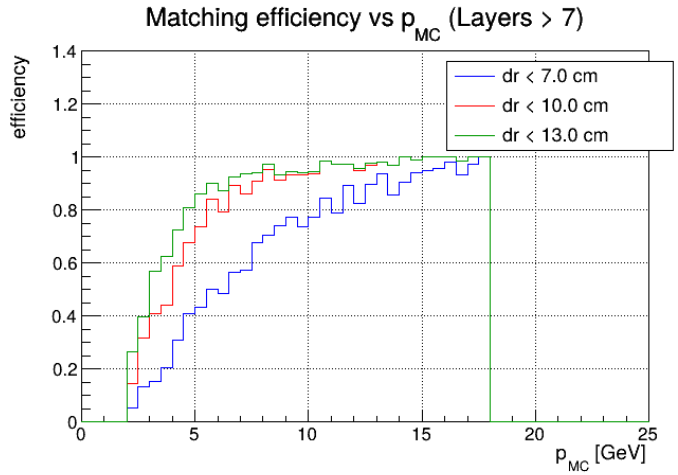


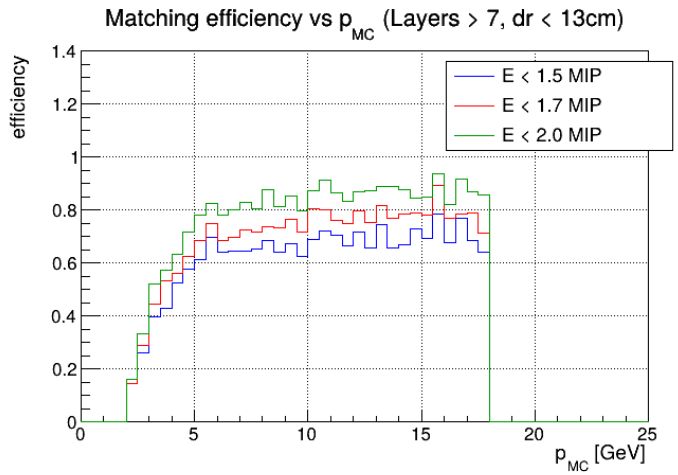


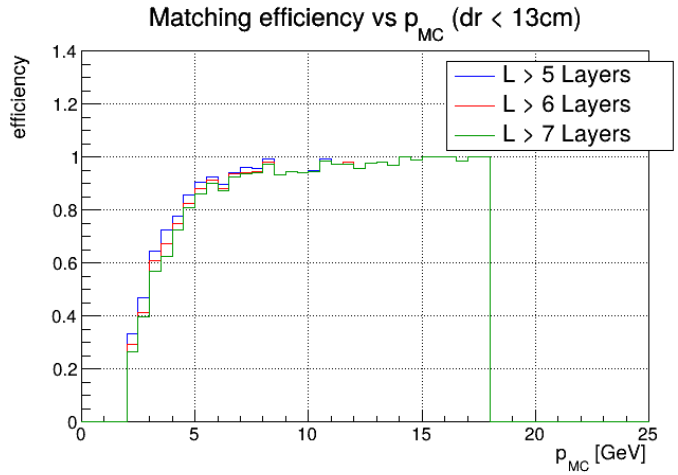
- Reconstructed hits are corrected with sampling fraction by eicrecon
- Old value of sampling fraction 0.95% hardcoded in eicrecon
  - `https://github.com/eic/EICrecon/blob/fb6eb58a755d55c8c6bfe9708c70bed316de6db8/src/detectors/EHCAL/EHCAL.cc#L67`
  - Real one for old default is $\approx 1.5\%$
  - Needs to be updated for each chosen geometry

Di-muon reconstruction efficiency









- All issues fixed now
- Efficiency looks reasonable
- requiring matched hits across large fraction of layers still has high efficiency
- Efficiency drops at low-p

Summary

- Fixed issues with muon detection efficiency
- Ready to be put as a benchmark

BACKUP

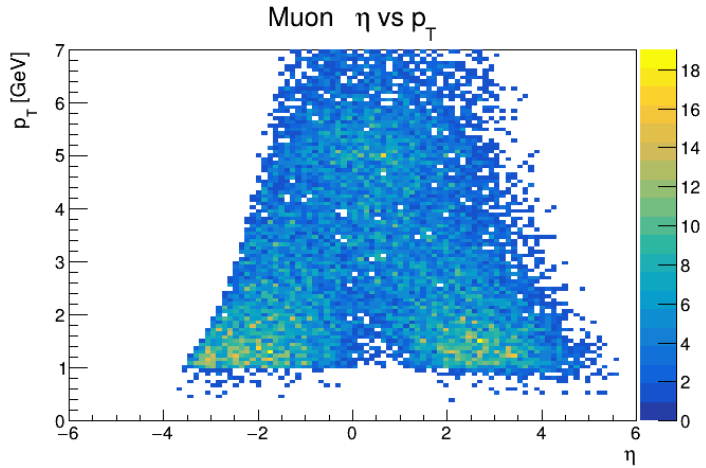
Di-muon reconstruction - PYTHIA simulation

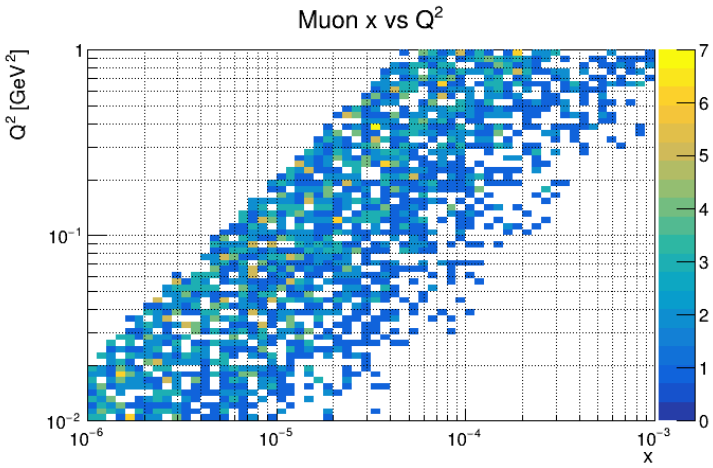
- $e + p$ collisions at $18 \times 275\ \mathrm{GeV}$
- Repository here: `https://github.com/lkosarz/dimuonPythia`

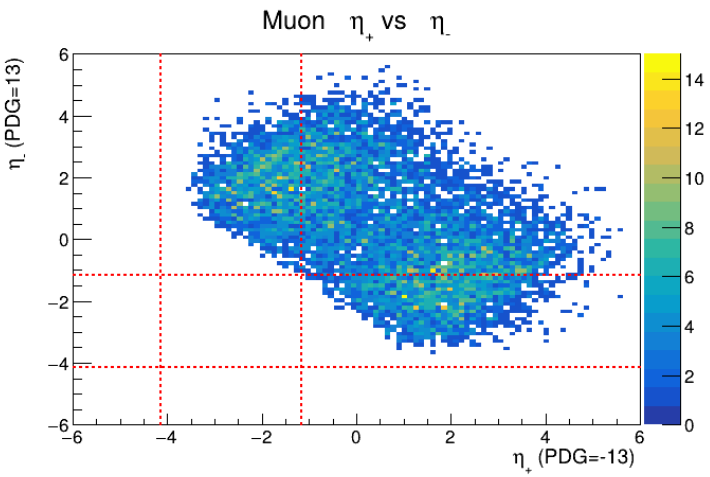
Listing: Simulation settings

```
# Enable equivalent photon approximation (EPA) for both beams
Photon:Q2Max = 1.0  ! Upper Q^2 limit for EPA photons (in GeV^2)
Photon:ProcessType = 4 ! 4 = direct-direct photons
#Photon:EPA = on

PDF:beamA2gamma = on ! EPA photon flux from beam A
PDF:beamB2gamma = on ! EPA photon flux from beam B

# Enable gamma-gamma -> mu+ -mu
PhotonCollision:gmgm2mumu = on

# Optional: Turn off other QED or QCD backgrounds if you want exclusivity
PartonLevel:ISR = off
PartonLevel:FSR = off
HadronLevel:all = off
```

Event kinematics

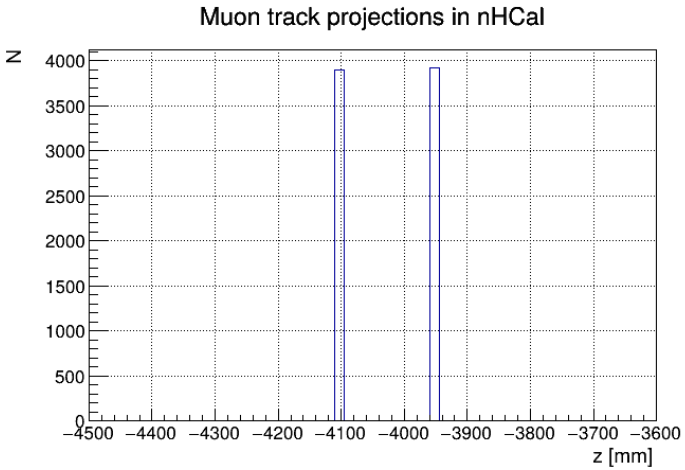


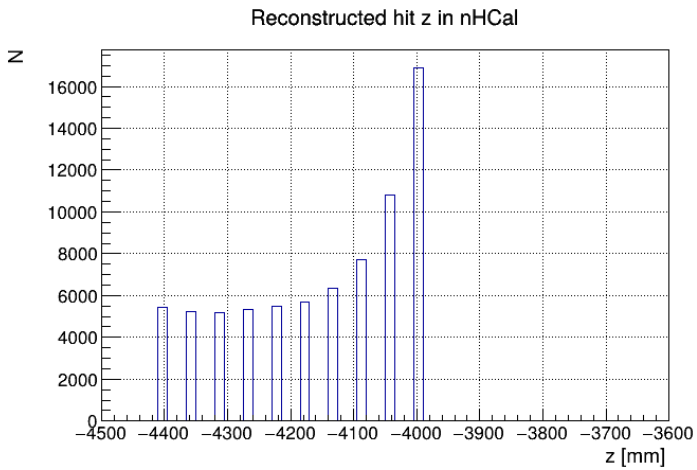




- At most a single muon within nHCal
- Reconstructed kinematics for photoproduced-dimuon events

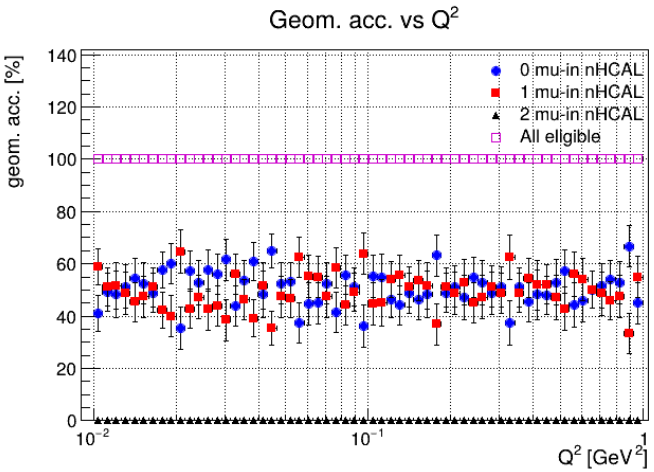
Projections and hits

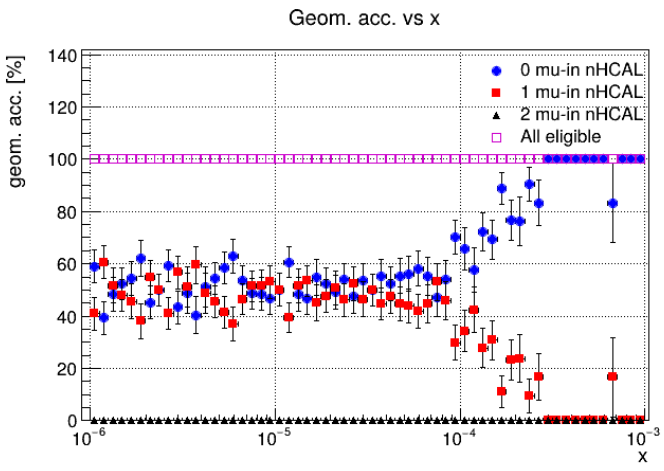


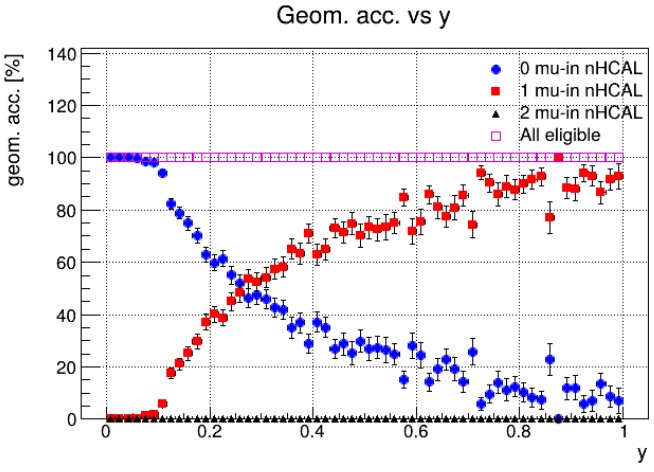


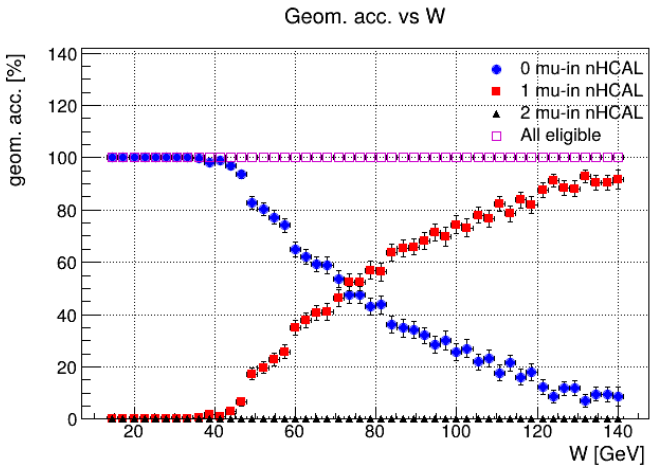
- Projections and hits look ok
- Can add more layers

Di-muon geometrical acceptance









- Simulated kinematics
- Uncertainties included
- *nHCal* needed to get 2*x* statistics