Track reconstruction studies with background

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(for the track reconstruction WG)

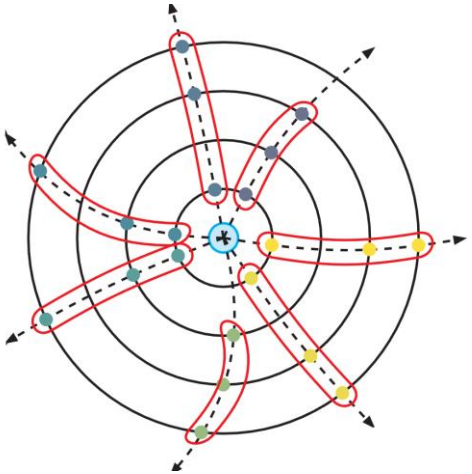
Motivation

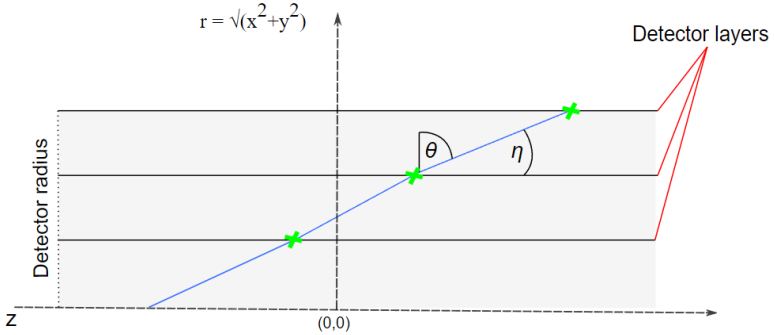
- We now have a set of parameters for seeding and tracking which work well for single-particle simulations, as well as for DIS events.
- The next question is how robust the track reconstruction is when we embed background into the signal events. We have done this for single-particle events, and we have some ongoing studies for DIS events.
- For these studies, we use the default npsim steering file (set the physics list, production thresholds, etc…), as well as the default set of EICRecon parameters.

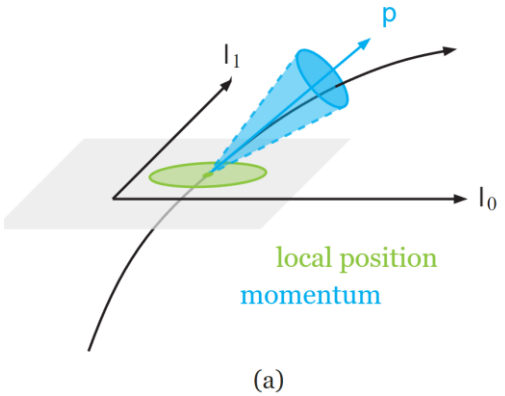
ACTS Orthogonal seeder

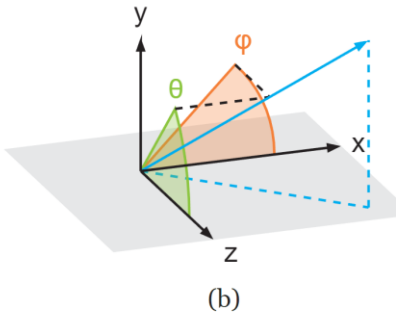
The seeder outputs a set of seeds, with each seed consisting of 3 space points. The seeds need to fulfill certain expectations for a particle moving in a uniform magnetic field. The seed finder and seed filter settings configure the allowed search region and tolerances.

For a given seed, the space points are then fit to determine initial track position and direction which is passed to the Combinatorial Kalman Filter (CKF) tracking algorithm.



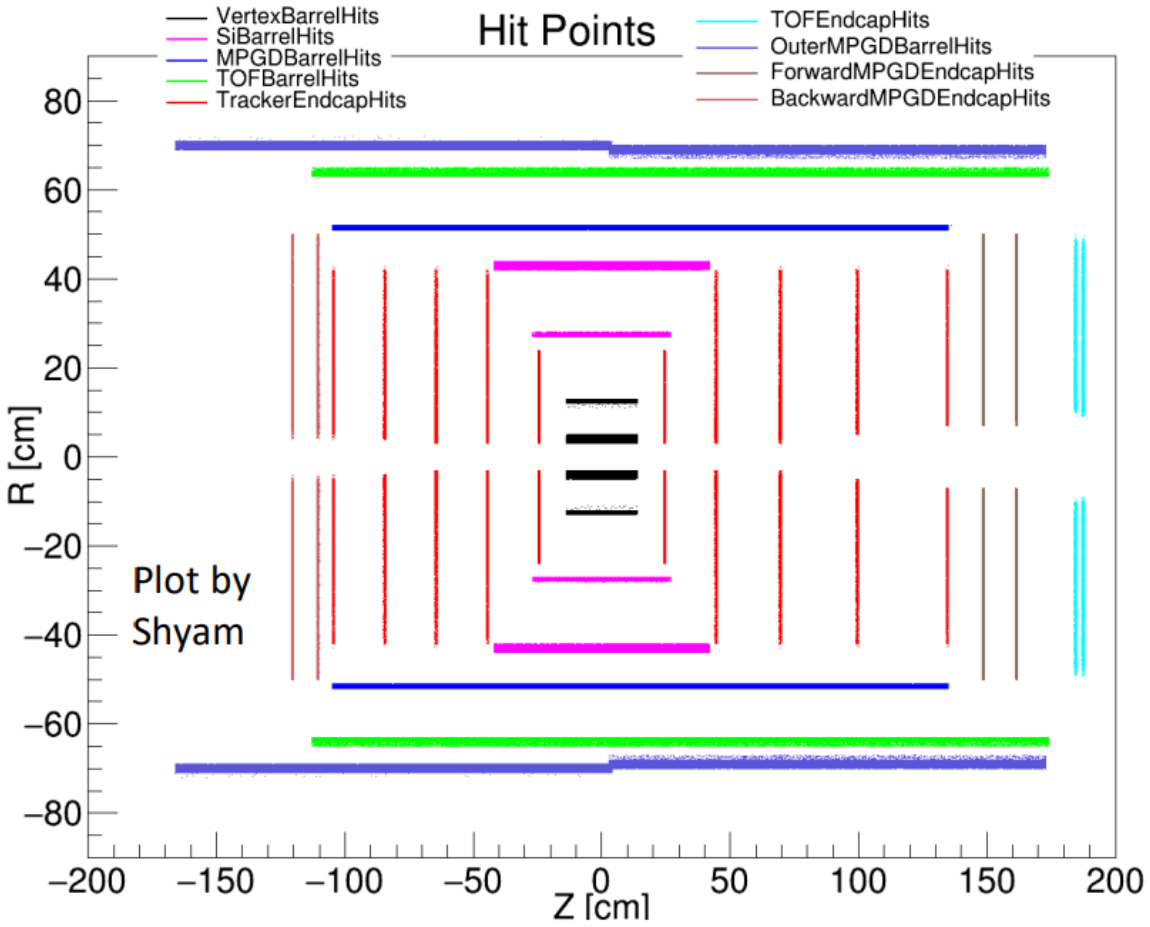






https://acts.readthedocs.io/en/latest/tracking.html
https://acts.readthedocs.io/en/latest/core/seeding.html#seeding-core

Seed finding in updated tracking configuration



ACTS seed finder and filter parameters

Parameter	Description	Value
bFieldInZ	z component of magnetic field	1.7 T
rMax	Maximum r value to look for seeds	440 mm
rMin	Minimum r value to look for seeds	33 mm
zMin	Minimum z value to look for seeds	-1500 mm
zMax	Maximum z value to look for seeds	1700 mm
beamPosX	Beam offset in x	0
beamPosY	Beam offset in y	0
deltaRMinTopSP	Min distance in r between middle and top SP in one seed	**10 mm**
deltaRMinBottomSP	Min distance in r between middle and bottom SP in one seed	**10 mm**
deltaRMaxTopSP	Max distance in r between middle and top SP in one seed	**200 mm**
deltaRMaxBottomSP	Max distance in r between middle and top SP in one seed	**200 mm**
collisionRegionMin	Min z for primary vertex	-250 mm
collisionRegionMax	Max z for primary vertex	250 mm
cotThetaMax	Cotangent of max theta angle	**27.29**
minPt	Min transverse momentum	100 MeV/cotThetaMax
maxSeedsPerSpM	Max number of seeds a single middle space point can belong to - 1	0
sigmaScattering	How many standard devs of scattering angles to consider	5
radLengthPerSeed	Average radiation lengths of material on the length of a seed	0.1
impactMax	Max transverse PCA allowed	3 mm
rMinMiddle	Min R for middle space point	20 mm
rMaxMiddle	Max R for middle space point	400 mm
bFieldMin	min B field	0.1

Table by Emma

Seed finding in updated tracking configuration

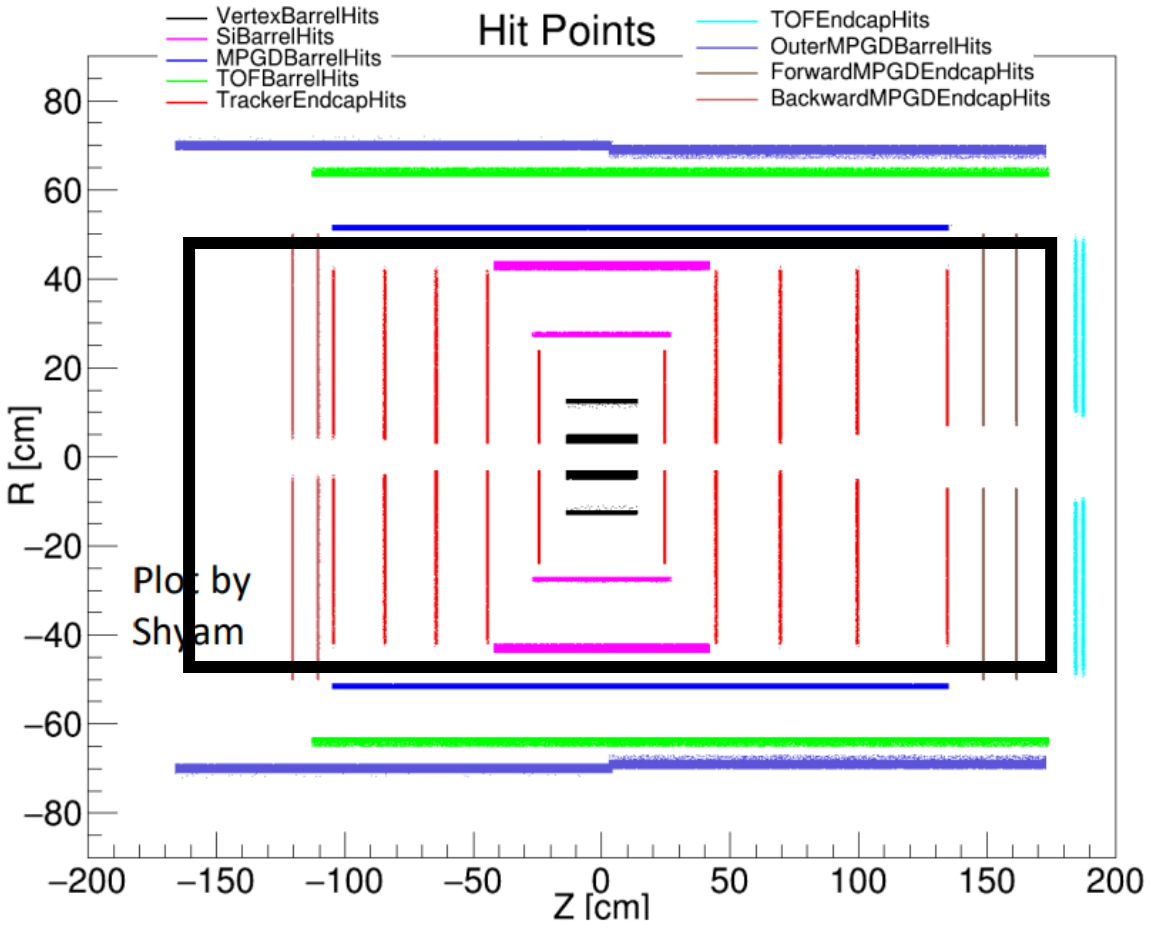


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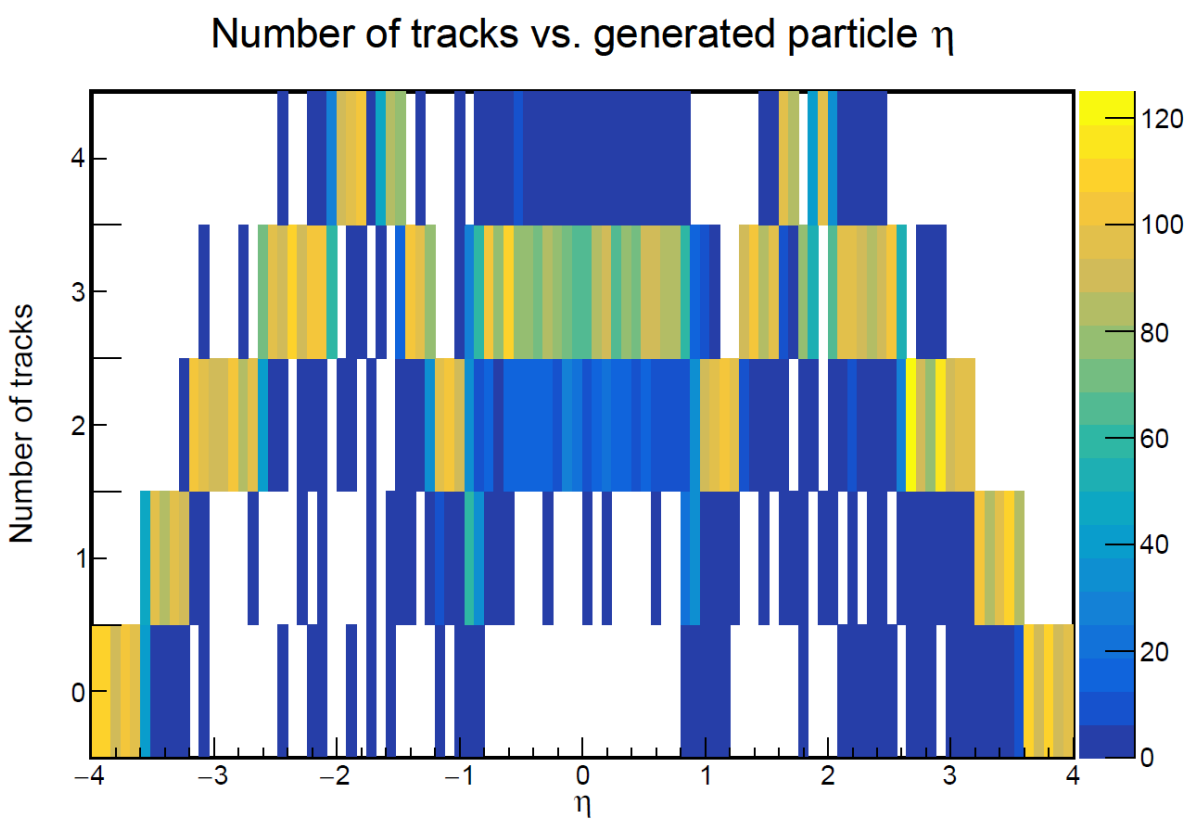
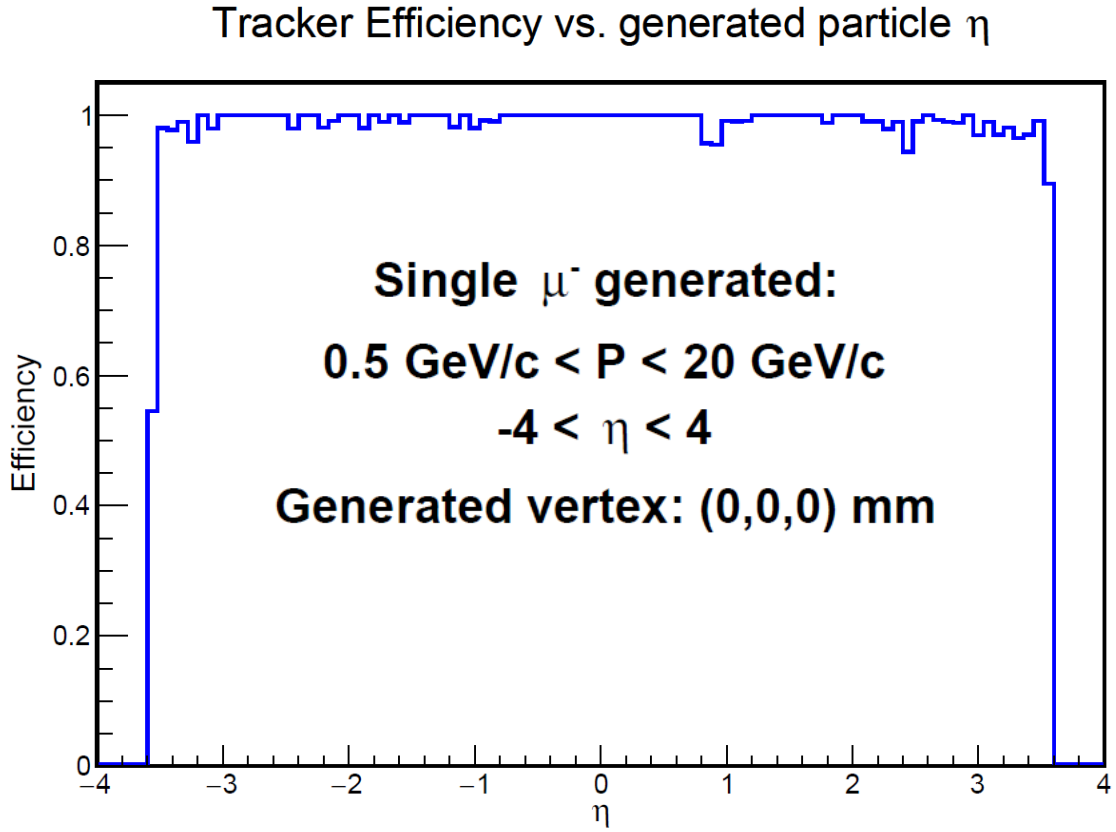
Table by Emma

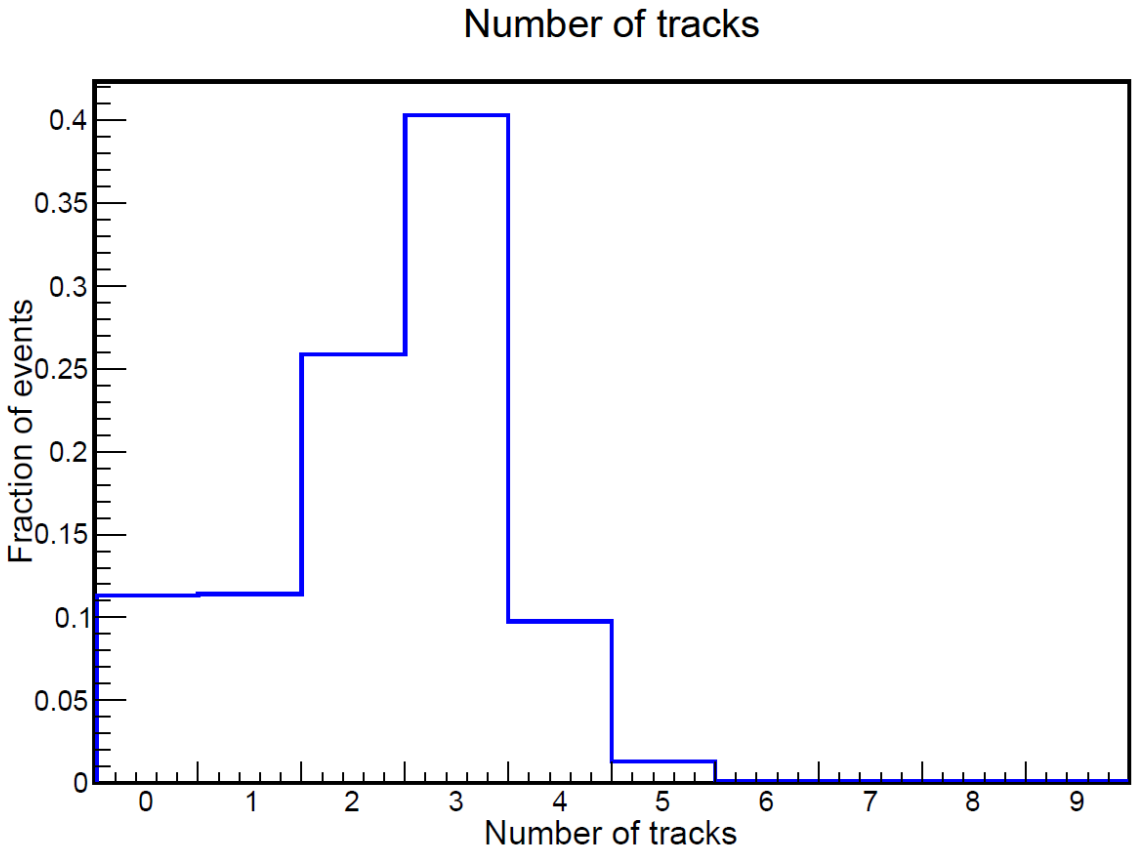
Tracking efficiency/multiplicity





An efficient event is defined as one where at least one track is found. We get a single track per seed in EICRecon since we only save the trajectory with the longest branch (*trackTips.front()*).

Why do we see many events with 3 seeds/tracks?



ACTS seed finder and filter parameters

Parameter	Description	My New Default
bFieldInZ	z component of magnetic field	1.7 T
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Why do we see many events with 3 seeds/tracks?

If we have a particle at mid-rapidity which hits layers L0, L1, L2, L3, and L4, then we can make the following combinations:

1. L0,L1,L2
2. L0,L2,L3
3. L0,L3,L4
4. ✖ L0,L1,L3
5. ✖ L0,L1,L4
6. ✖ L0,L2,L4
7. ✖ L1,L2,L3
8. ✖ L1,L2,L4
9. ✖ L1,L3,L4
10. ✖ L2,L3,L4

ACTS seed finder and filter parameters

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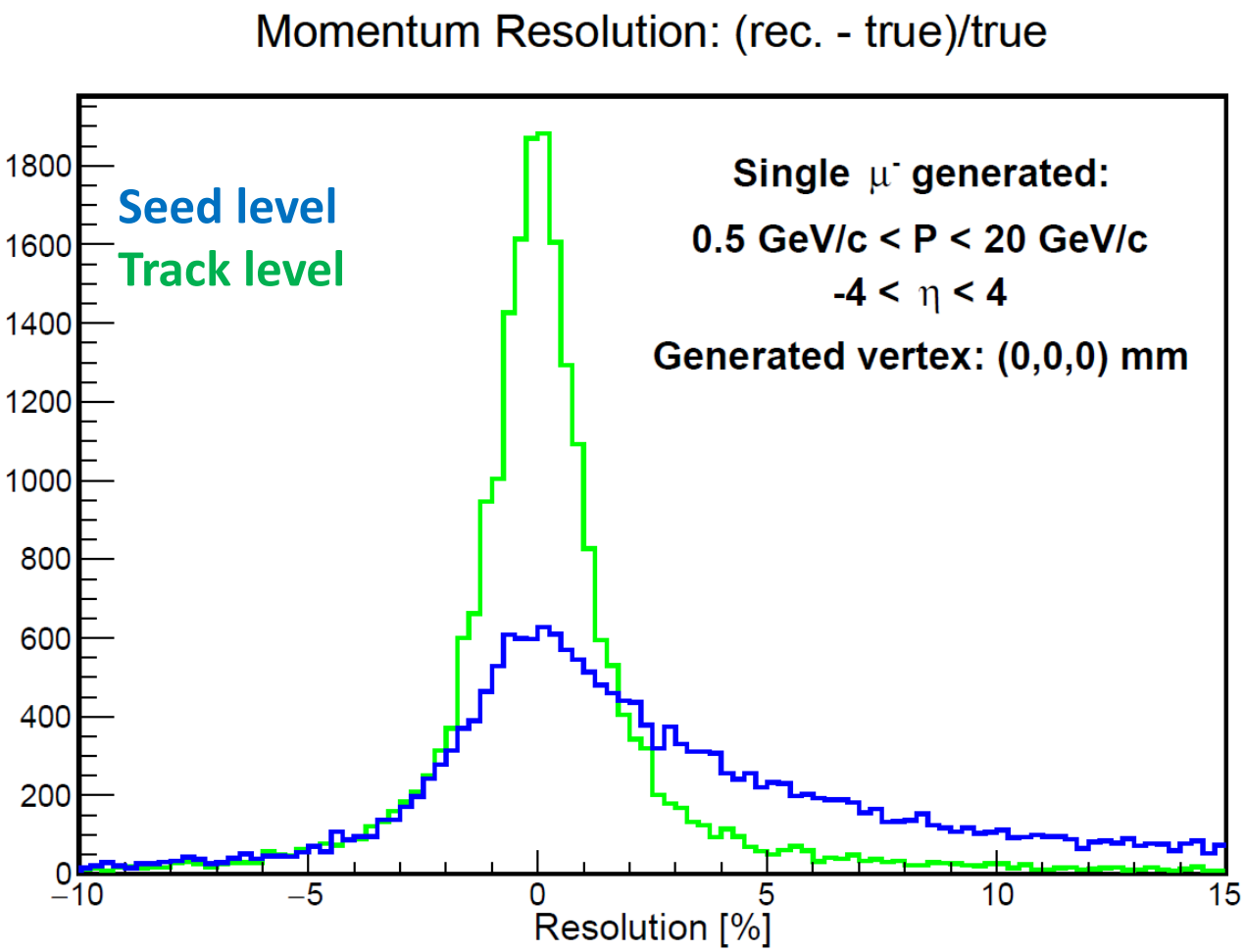
Track reconstruction



For these 10,000 single-particle events:

Total number of found tracks = 22980

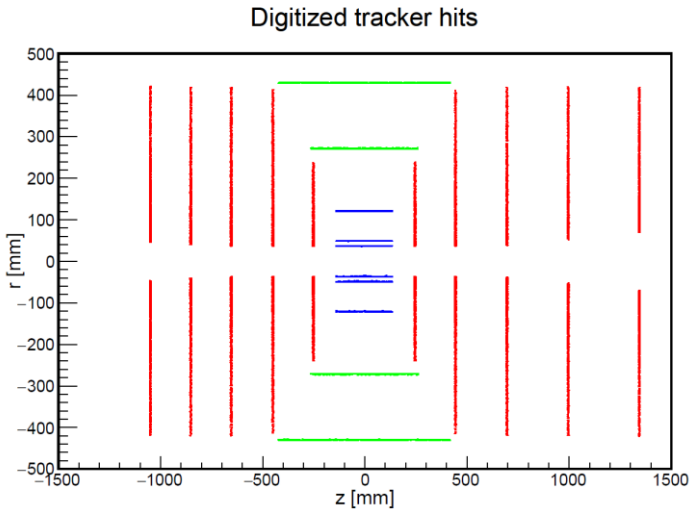
Matching tracks to generated particle based on momentum (10%) and theta and phi angle (10 mRad):

Total number of found tracks matched with generated particle = 21237

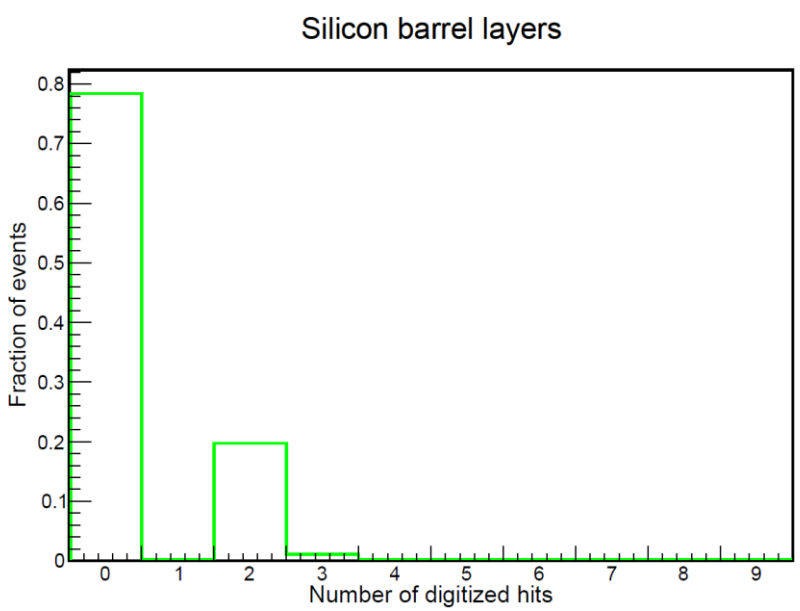
Background mixing

- For each of the 10,000 single-particle events shown above, we mix in three backgrounds – synchrotron radiation (SR), hadron-gas (h-gas), and electron-gas (e-gas) events – and run the mixed HepMC3 file through our detector simulation and reconstruction.
- We use a 2us time slice and take the background rates for the 10x100 eP beam energy setting. Details on the backgrounds can be found here: https://wiki.bnl.gov/EPIC/index.php?title=Background
- The SR can add 5-20k particles per slice; there will be an h-gas event once every three slices on average; and there will be 6 e-gas events per slice on average.

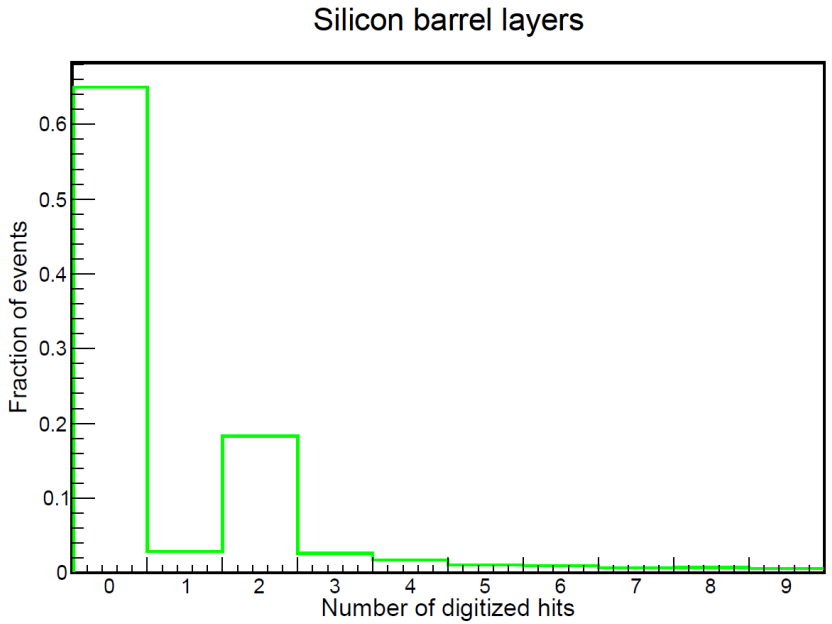
Digitized hits in the silicon tracking detectors



Single muon only

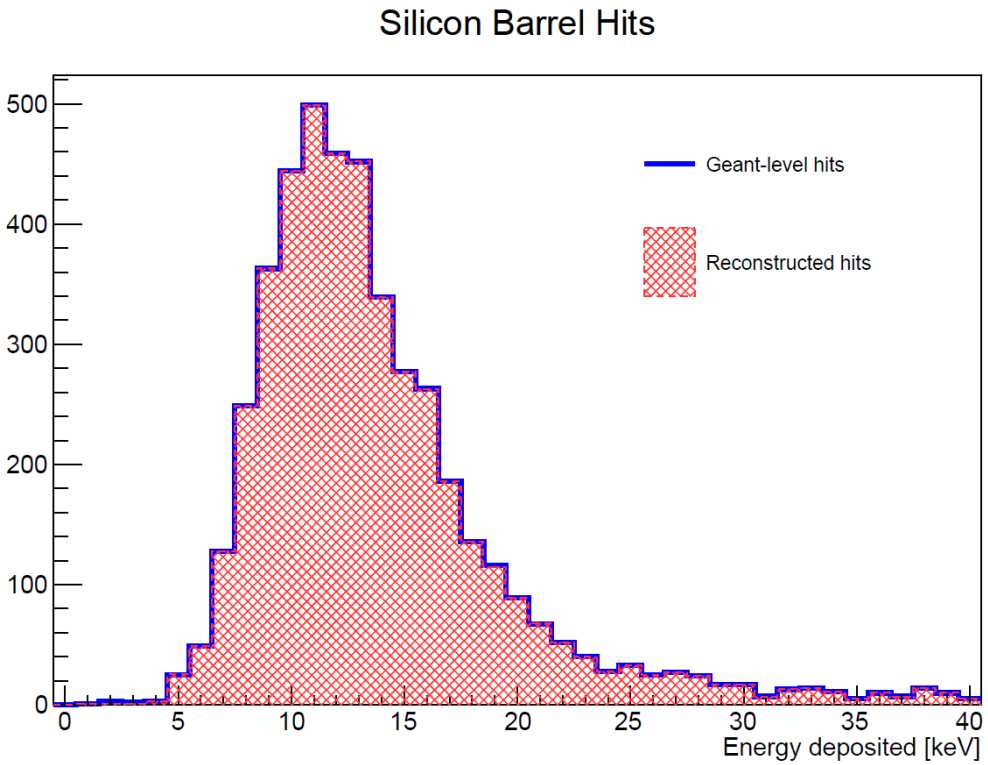


Single muon + background

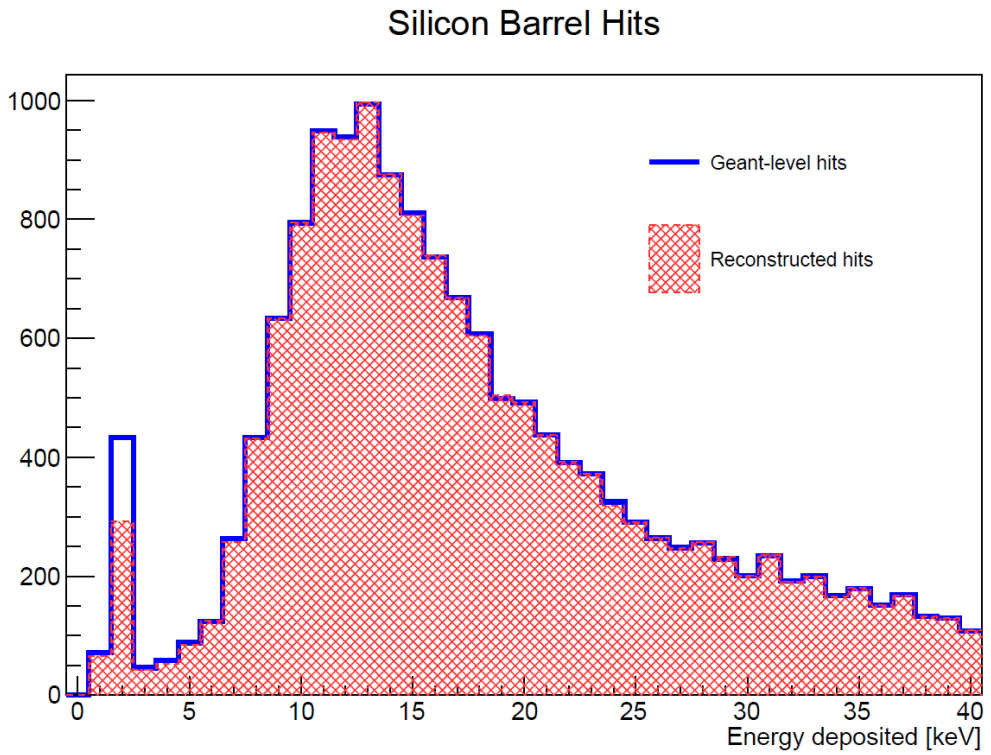


Energy deposit in the silicon tracking detectors

Single muon only



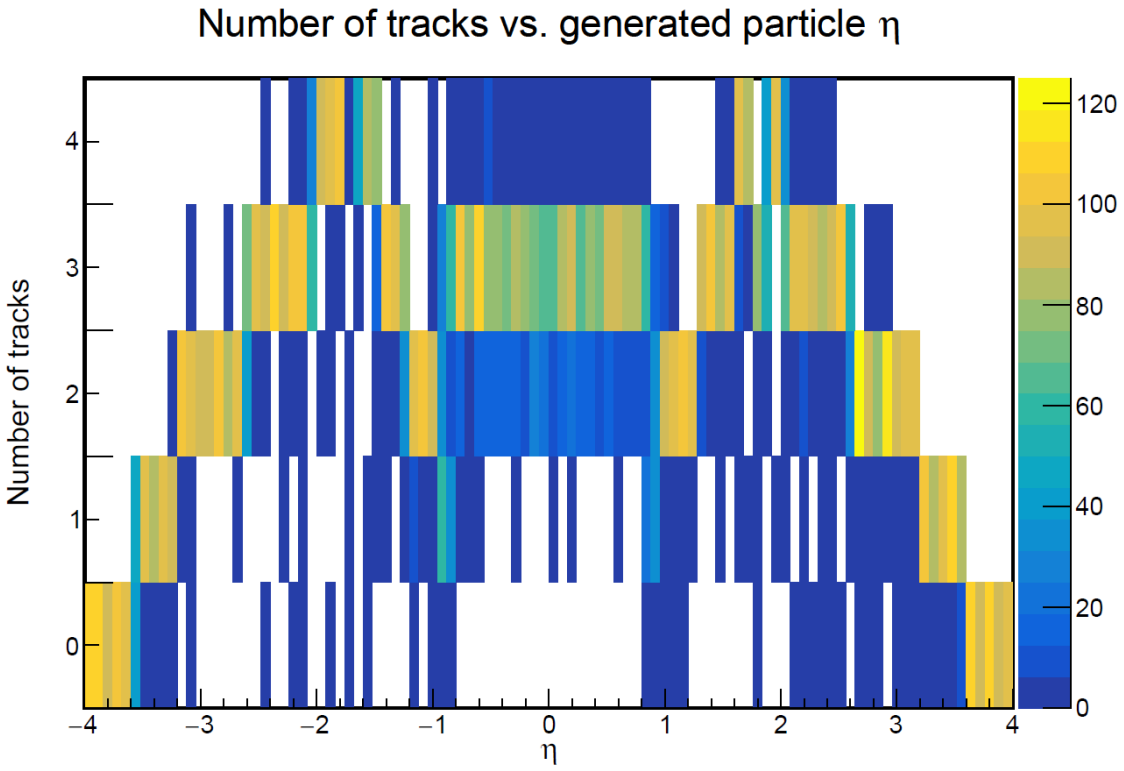
Single muon + background



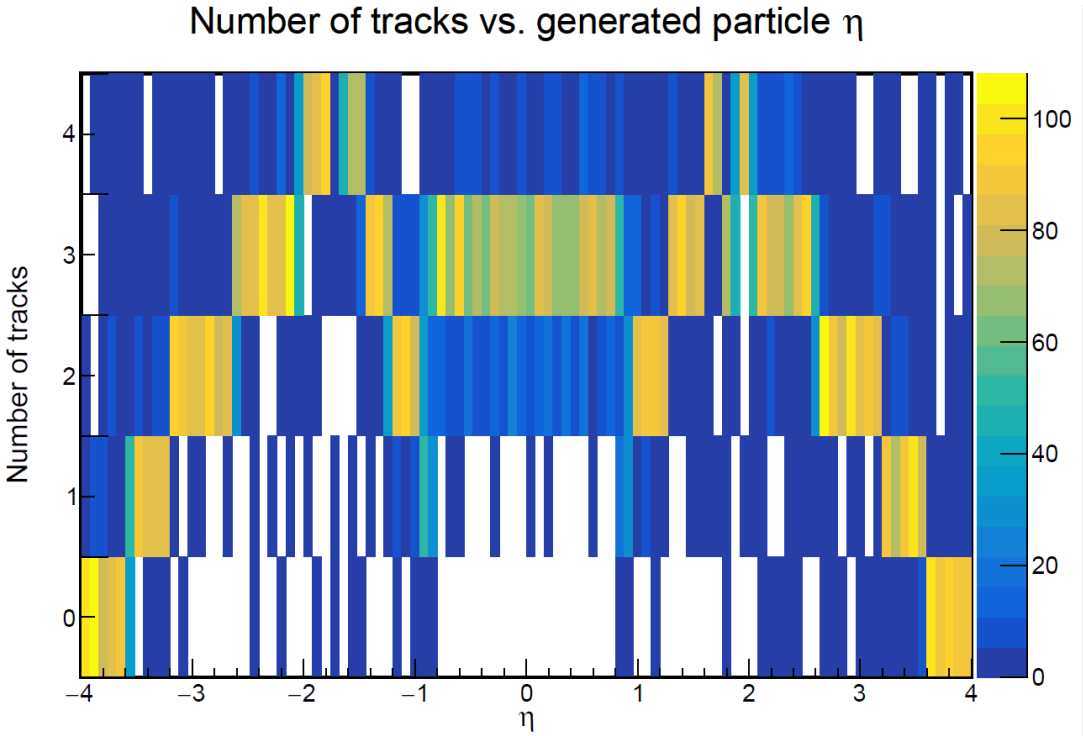
These simulations were run last week. Updates were made to the thresholds in npsim and EICRecon this week.

Track reconstruction with background

Single muon only



Single muon + background



Track reconstruction with background

Single muon only

For 10,000 events:

Total number of found tracks = 22980

Matching tracks to generated muon based on momentum (10%) and theta and phi angle (10 mRad):

Total number of found tracks matched with generated particle = 21237

Single muon + background

For 10,000 events:

Total number of found tracks = 26196

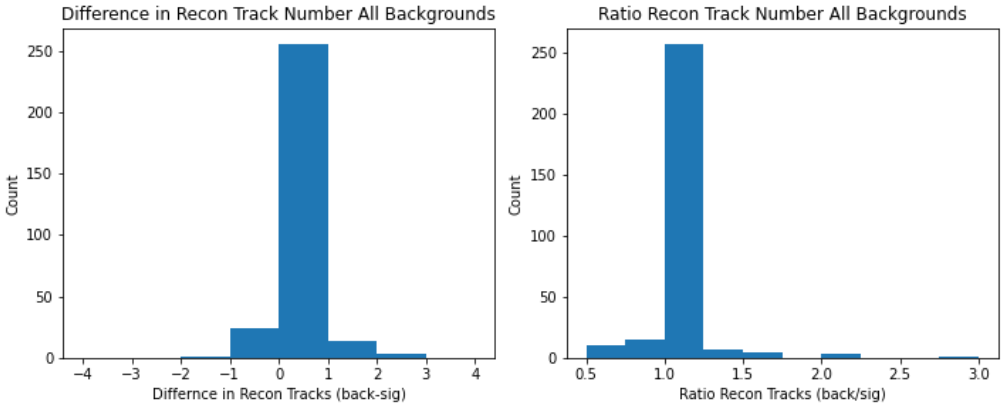
Matching tracks to generated muon based on momentum (10%) and theta and phi angle (10 mRad):

Total number of found tracks matched with generated particle = 20648

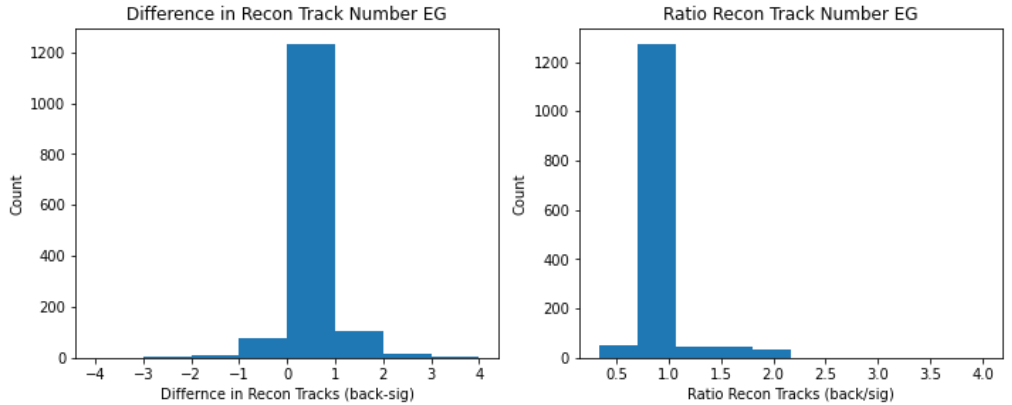
We now have some track quality information – chi-square, number of measurements, etc. – written out to the standard EICRecon output. But we have not used these in the results shown here.
We also hope to add associations between the track measurements and the Geant-level particle info.

DIS + Background simulations

All Merged Events

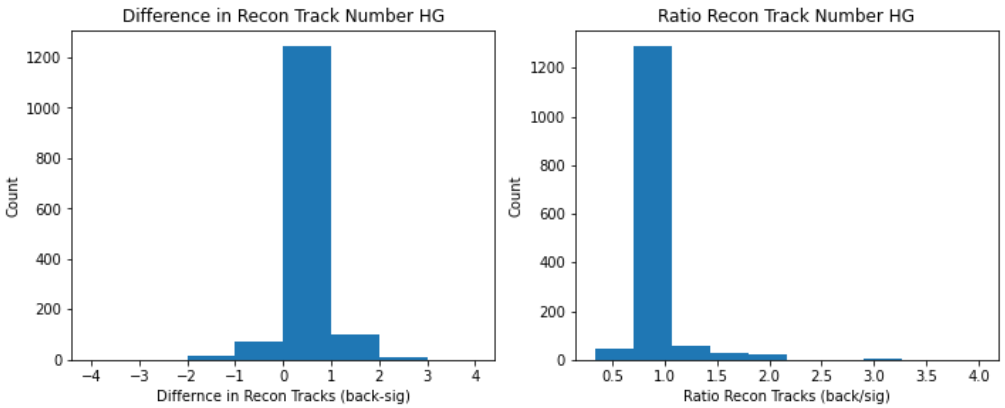


Electron Gas Merged Events

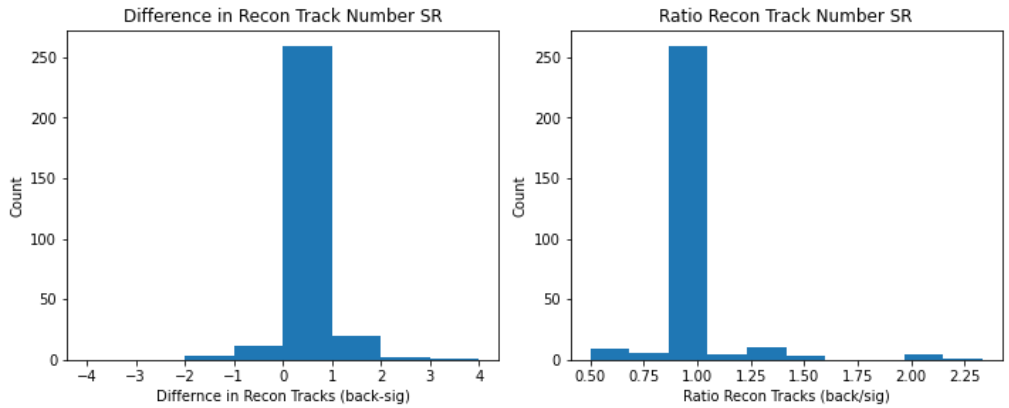


Work in Progress

Hadron gas Merged Events



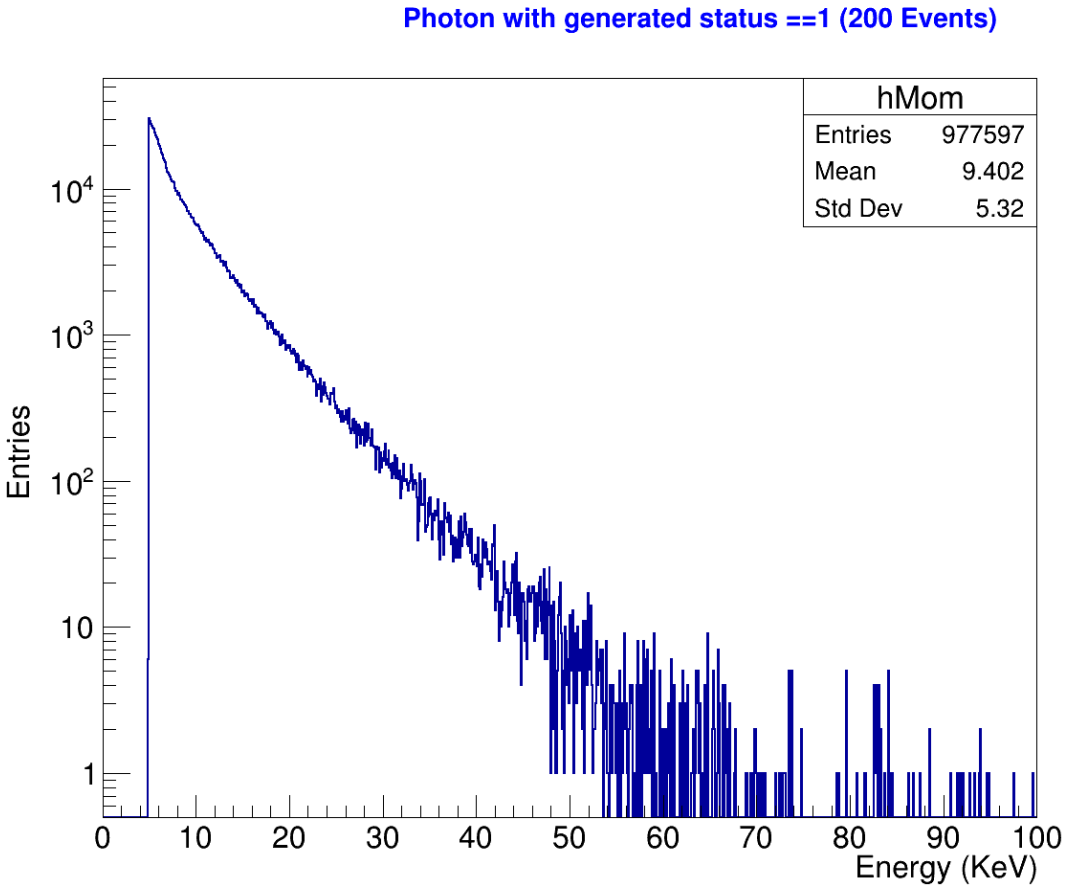
SR Merged Events

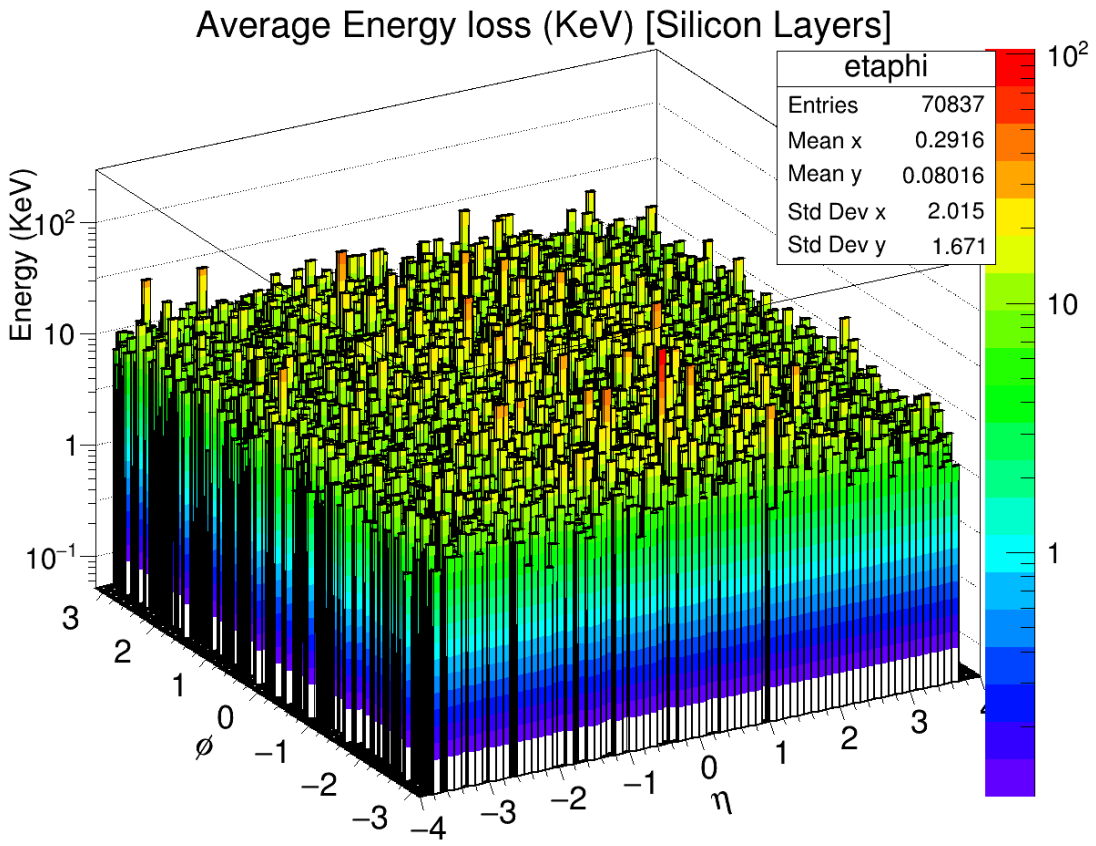


10x100 GeV Pythia8 + Background

Plots by Benjamen

Energy loss in silicon layers for DIS+background events

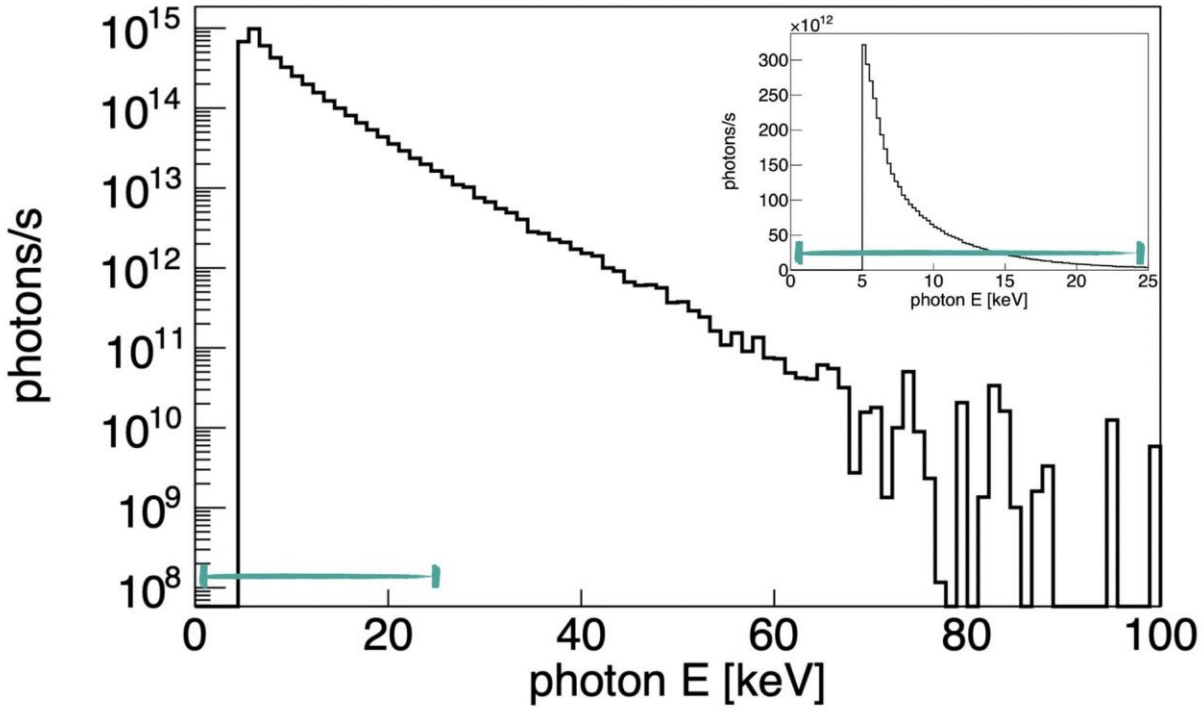




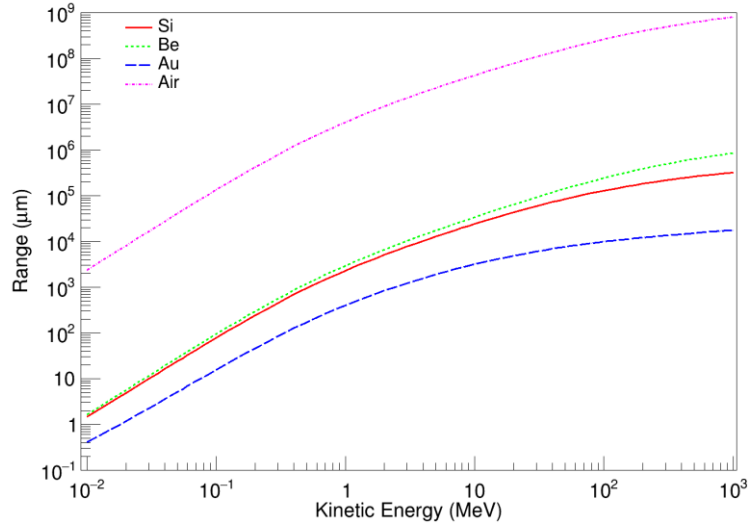
Plots by Shyam.

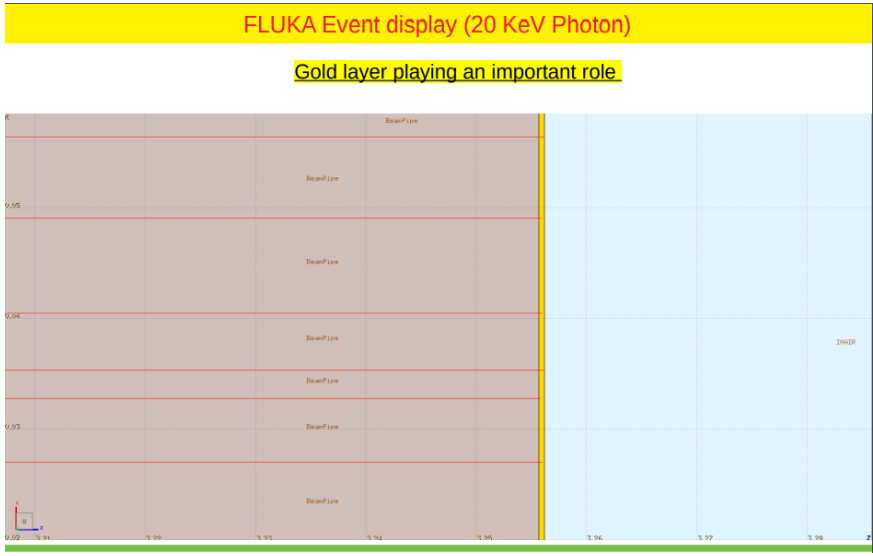
Synchrotron radiation spectrum

https://wiki.bnl.gov/EPIC/index.php?title=Synchrotron_Radiation



Plots by Shyam. Consistent with conclusions shown on wiki.





Summary

- We have performed some studies of the effect of background on the track reconstruction. We are working to develop additional machinery to characterize the effect of the background for single-particle and DIS events.
- We will continue to update these studies as the npsim settings and EICRecon thresholds are finalized, as well as when the Synchrotron radiation are updated.