Effect of simple track-quality cuts on SR background

Barak Schmookler

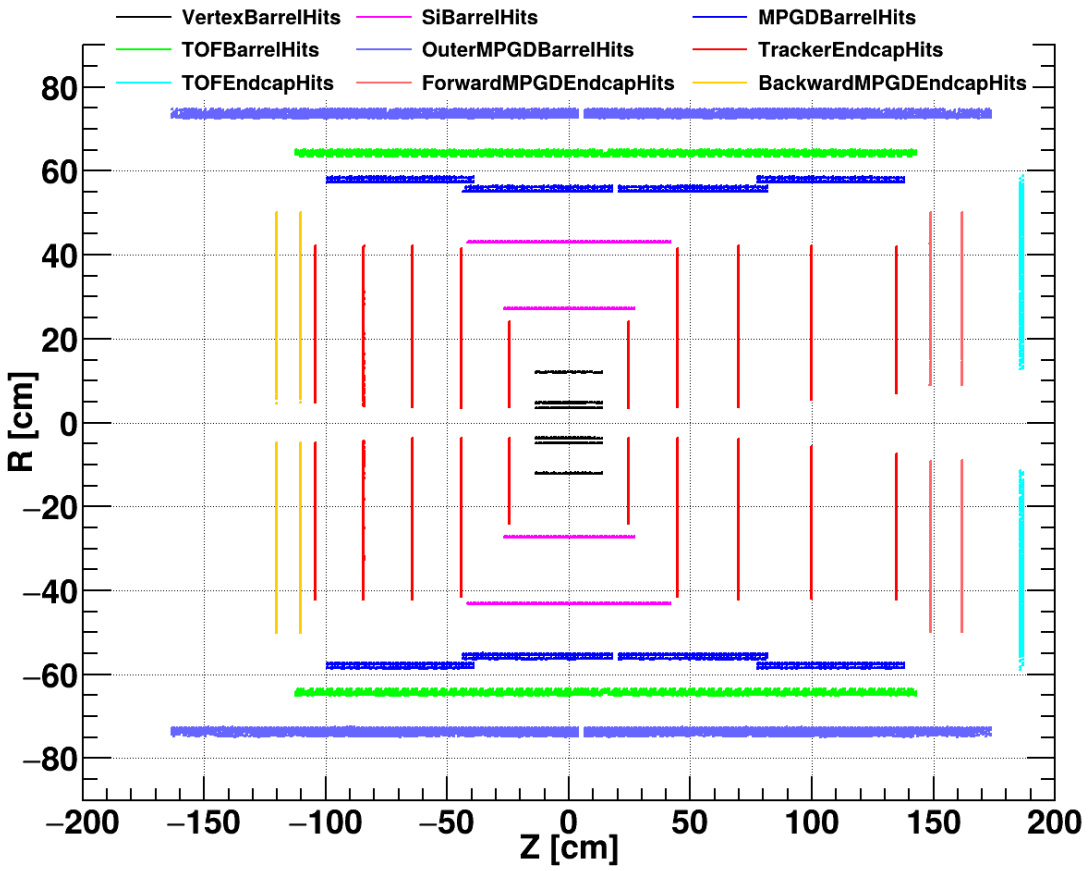
Files used

- I used the following files (which are located on NERSC):
  1. *rec_bgmerged_forced_18x275_noSR_n1000.root*: This simulates 1000 time frames (2 us each), with a DIS event ($Q^2 > 1$ GeV^2) included in each time frame. The synchrotron radiation background **is not included** in this file. We know from our previous studies that the proton-gas and electron-gas backgrounds have only a small impact on the reconstructed track distributions.
  2. *rec_bgmerged_forced_18x275_n1000.root*: This simulates 1000 time frames (2 us each), with the same DIS event ($Q^2 > 1$ GeV^2) included in each time frame as for the file above. The synchrotron radiation background **is included** in this file. So, this represents the situation with all backgrounds included.

Quantities studied

- I first look at the seed level. I check the number of seeds found per event (i.e., per 2 us time window). I then plot the polar angle distribution of the seeds.
- I then look at the reconstructed track level. I plot the polar angle distribution of the reconstructed tracks. I do this first without any additional track-selection criteria applied, followed by the application of a simple track quality cut.
- I then compare the reconstructed track polar angle distribution to that of the generated charged particles coming from the DIS signal event.

Seed finding using the ACTS orthogonal seeder

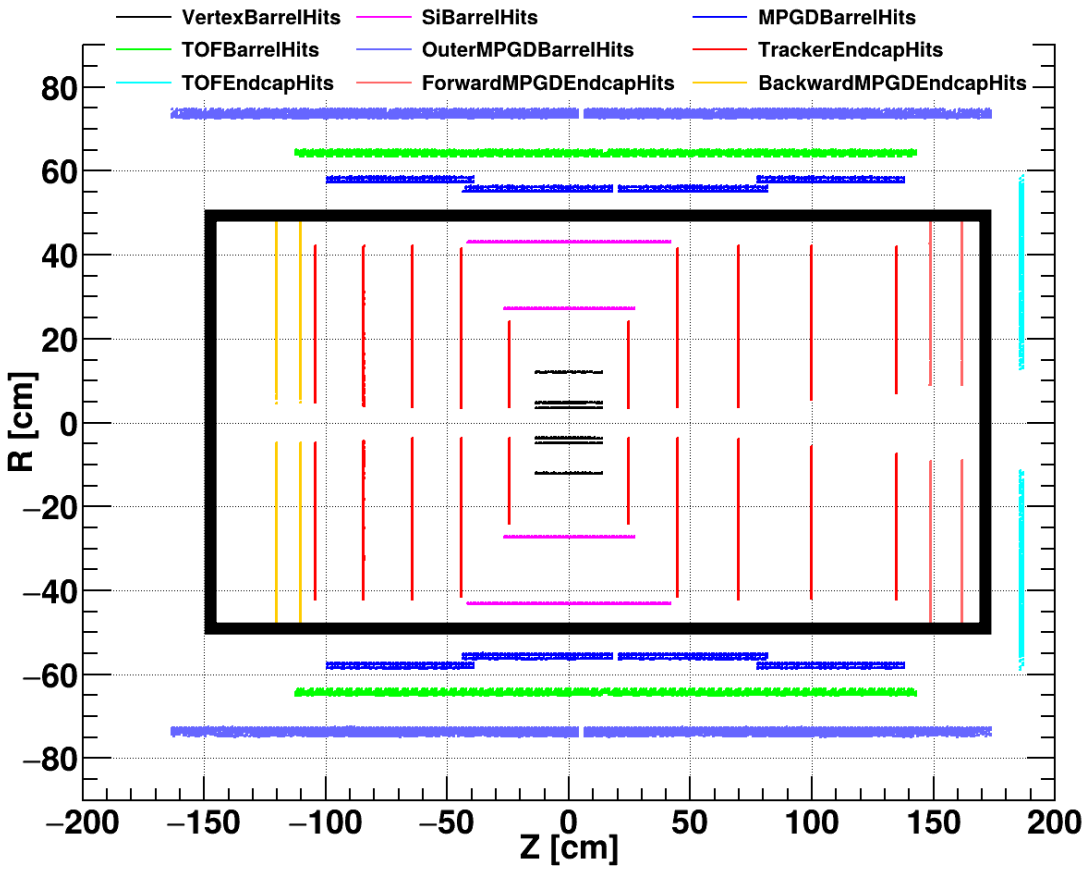


ACTS seed finder and filter parameters

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

Seed finding using the ACTS orthogonal seeder

We search for seeds in part of our tracking volume – that is in our MAPS silicon pixel detectors.



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Seed duplicates – particles have multiple seeds

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

Parameter	Description	My New Default
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**
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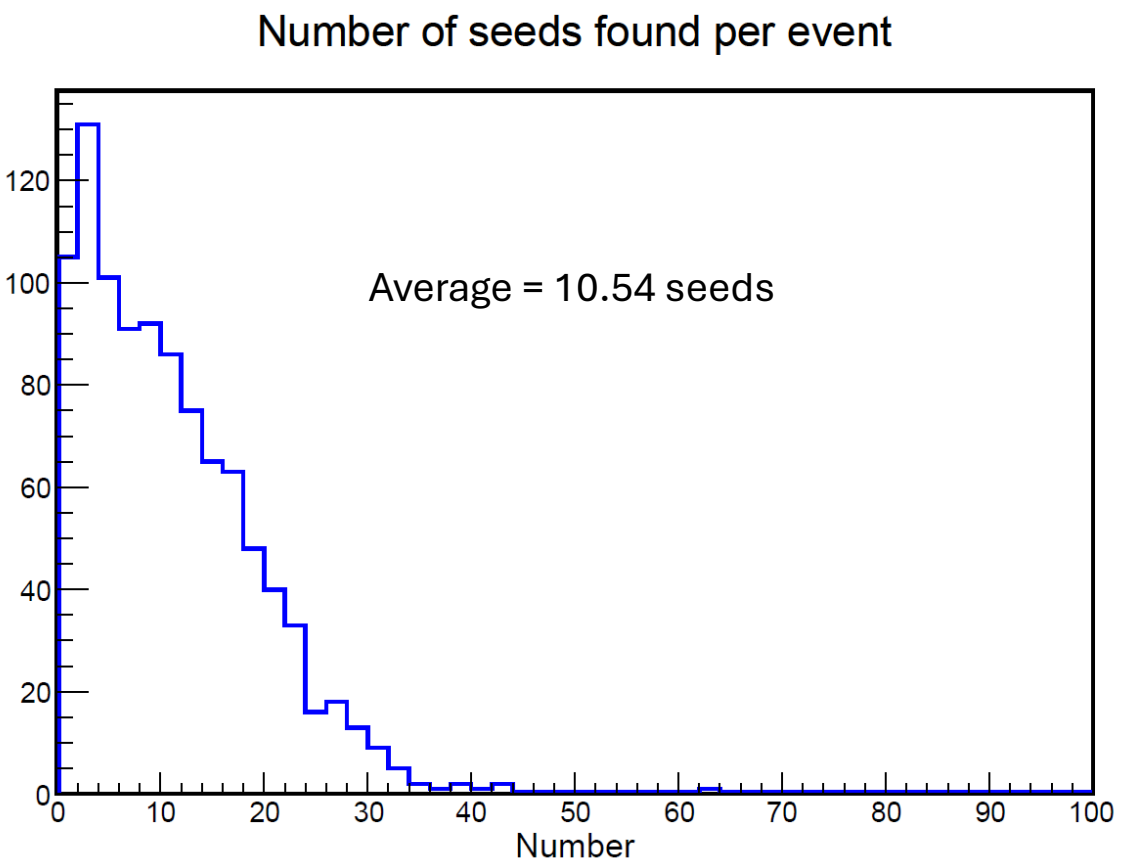
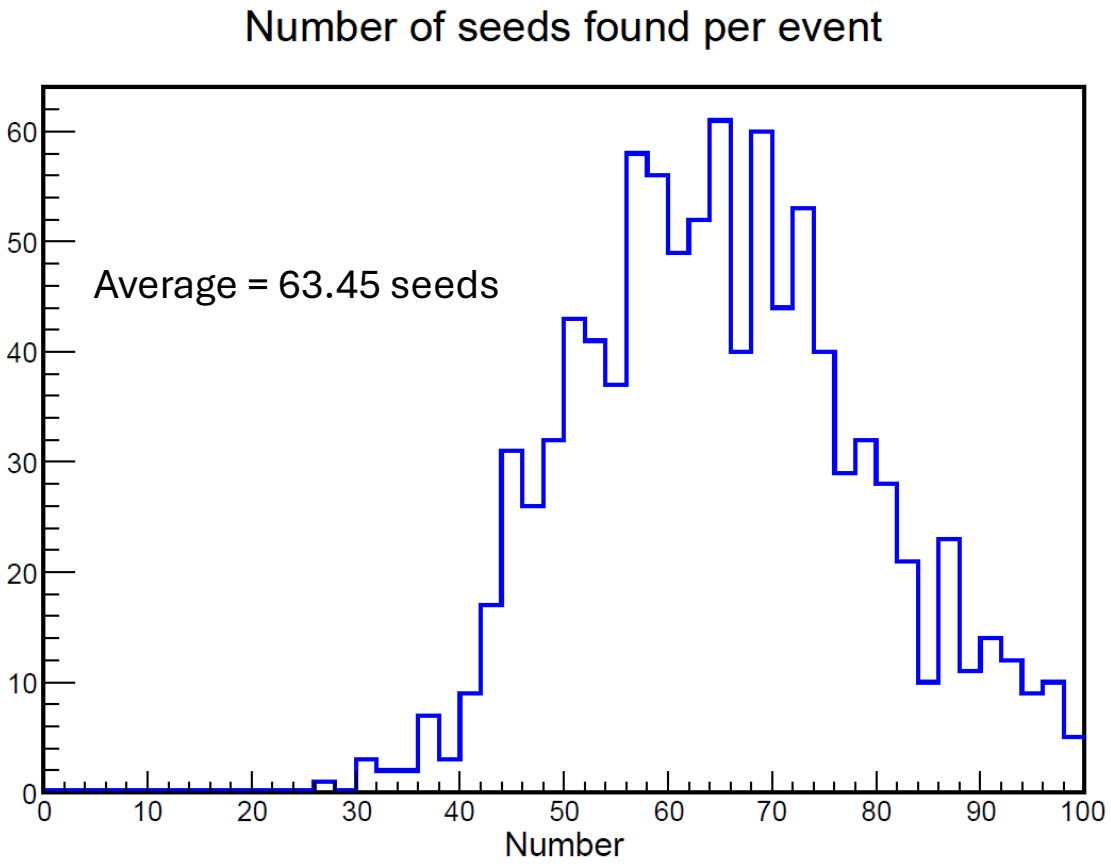
Number of seeds found per event (i.e. per time frame)

Without synchrotron radiation background included



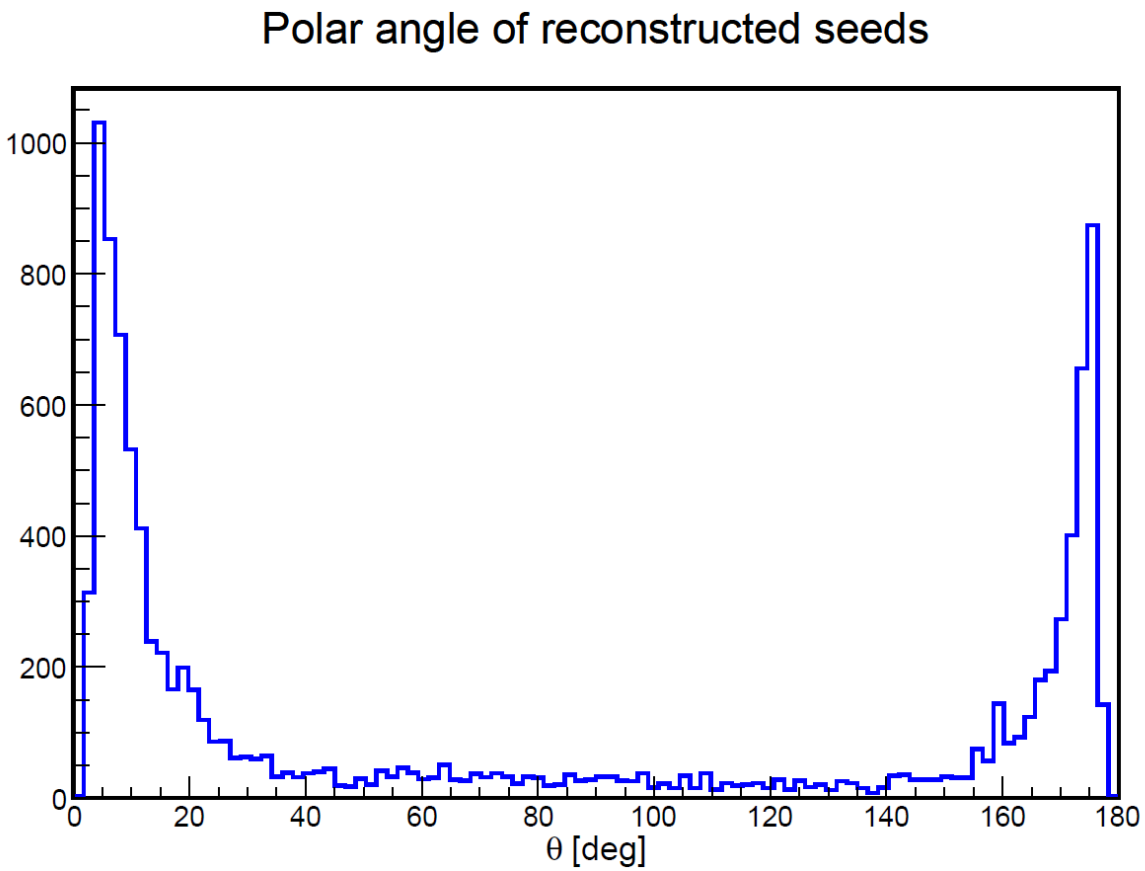
With synchrotron radiation background included



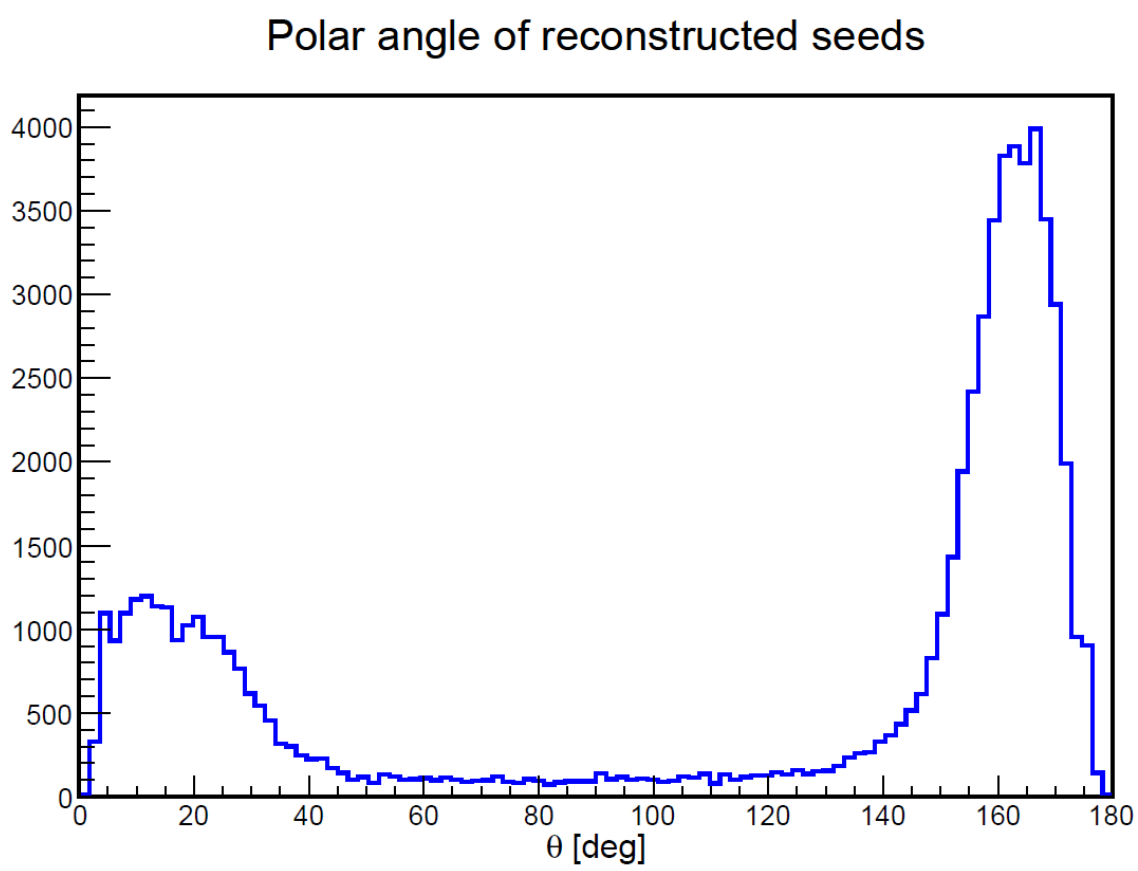
We see a factor of six more seeds when we include SR background in the simulation

Seeds: polar angle distribution

Without synchrotron radiation background included



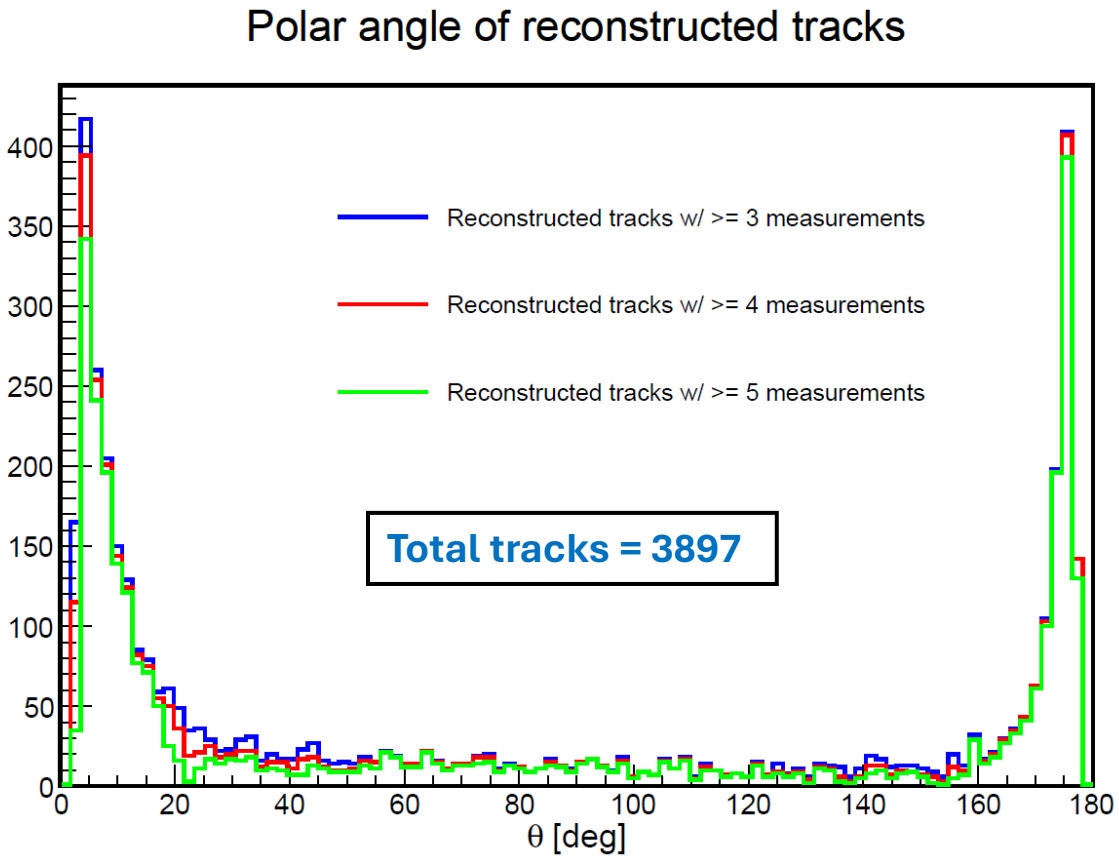
With synchrotron radiation background included



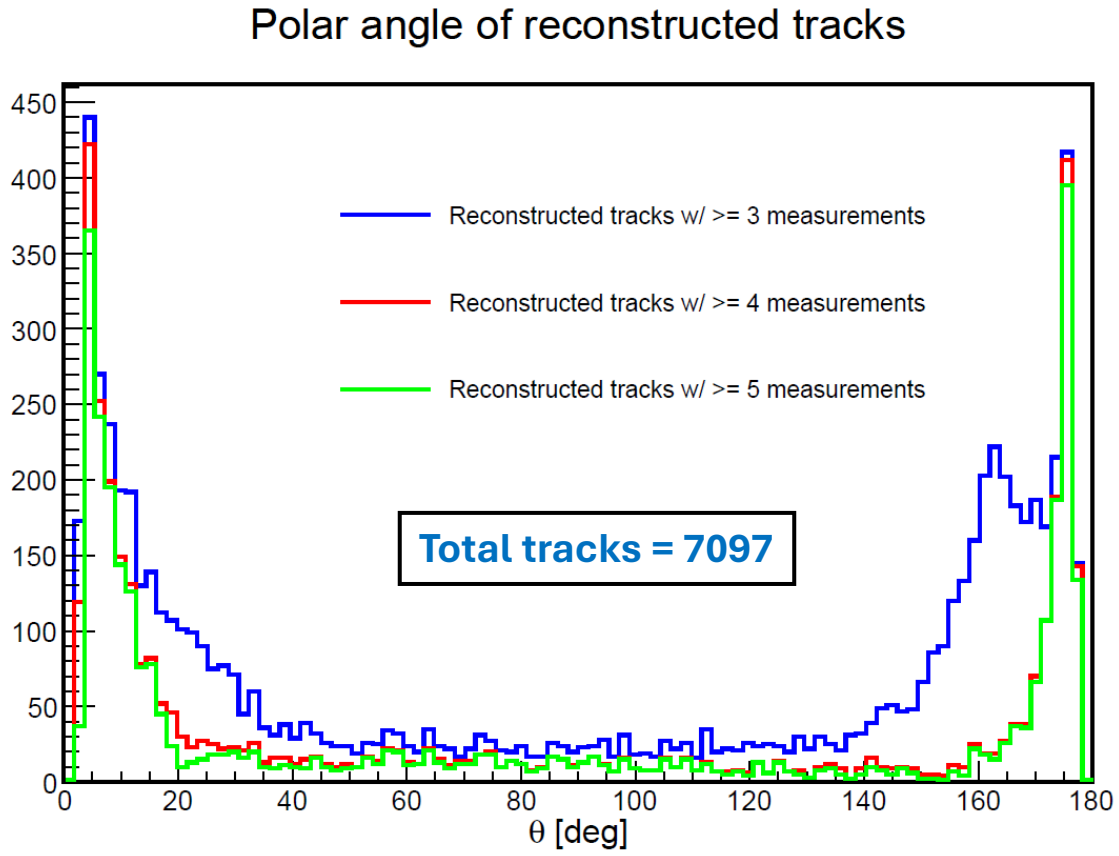
When SR background is included, the largest increase in the number of seeds is towards the electron-going direction.

Reconstructed tracks: polar angle distribution

Without synchrotron radiation background included



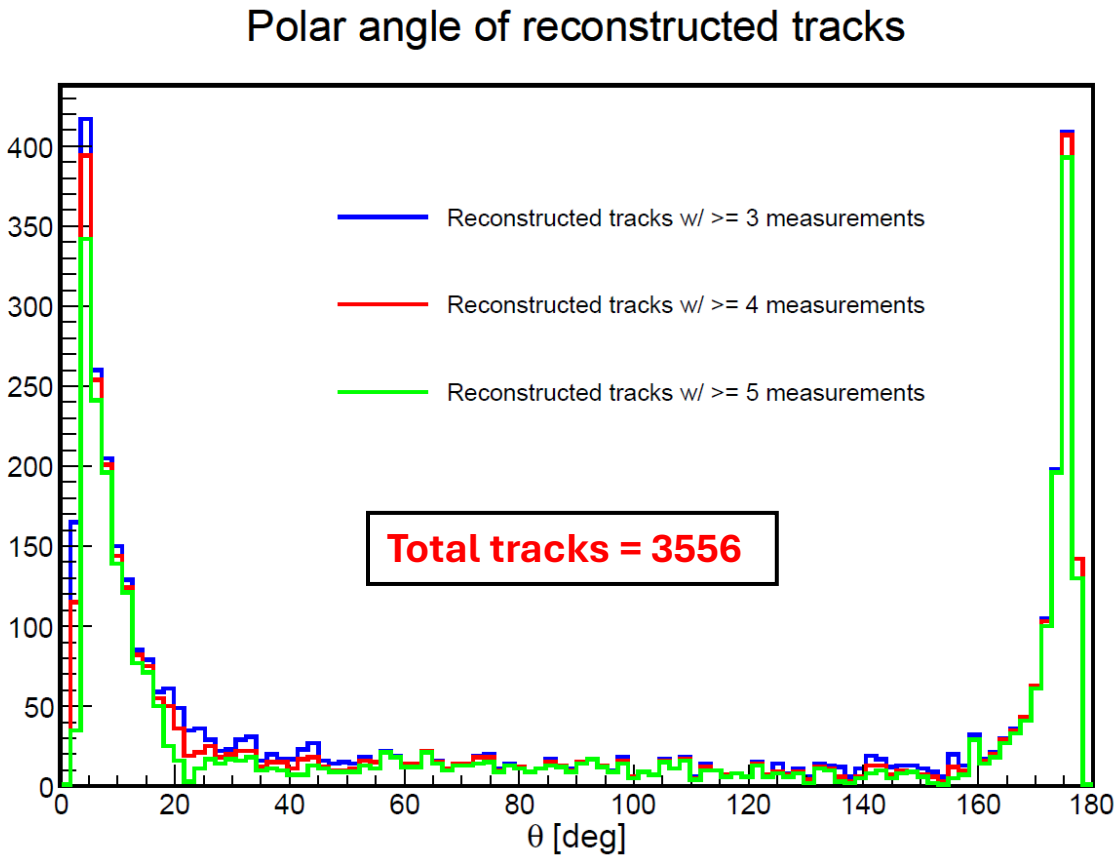
With synchrotron radiation background included



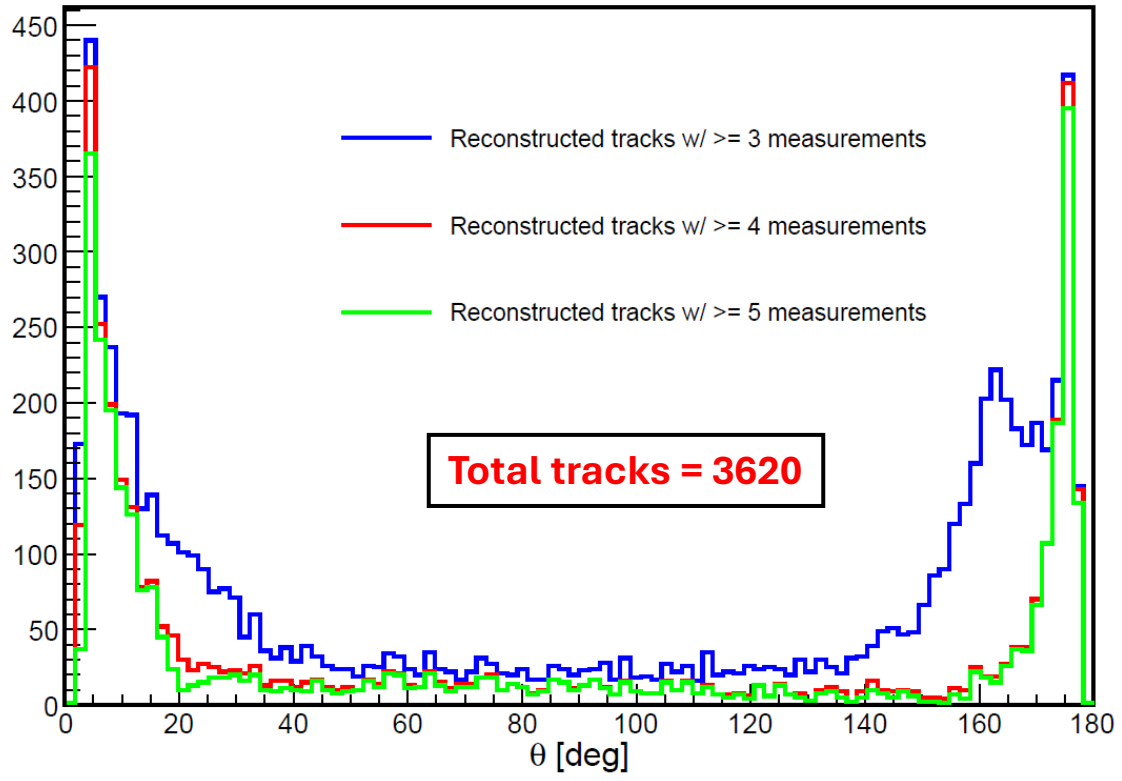
When we do the full track finding + fitting + ambiguity resolution, we see about a factor of 2 more tracks when we include the SR background.

Reconstructed tracks: polar angle distribution

Without synchrotron radiation background included



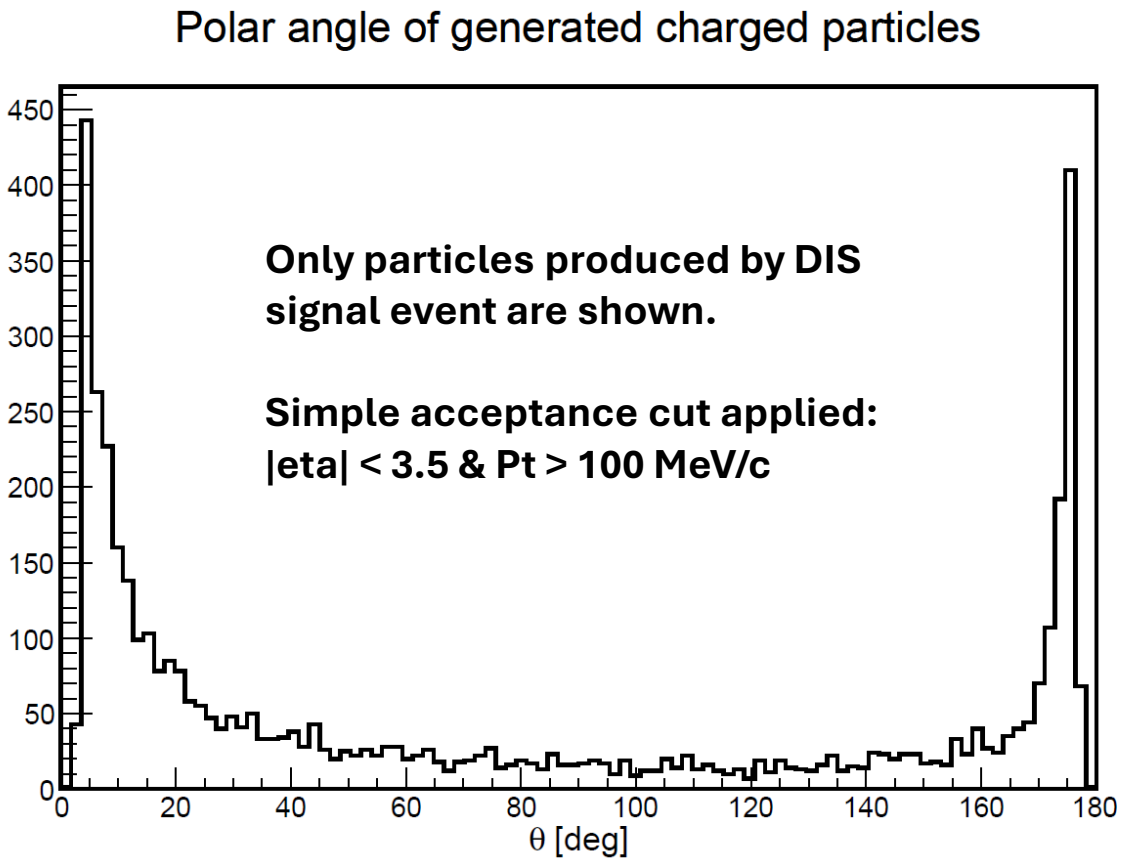
With synchrotron radiation background included



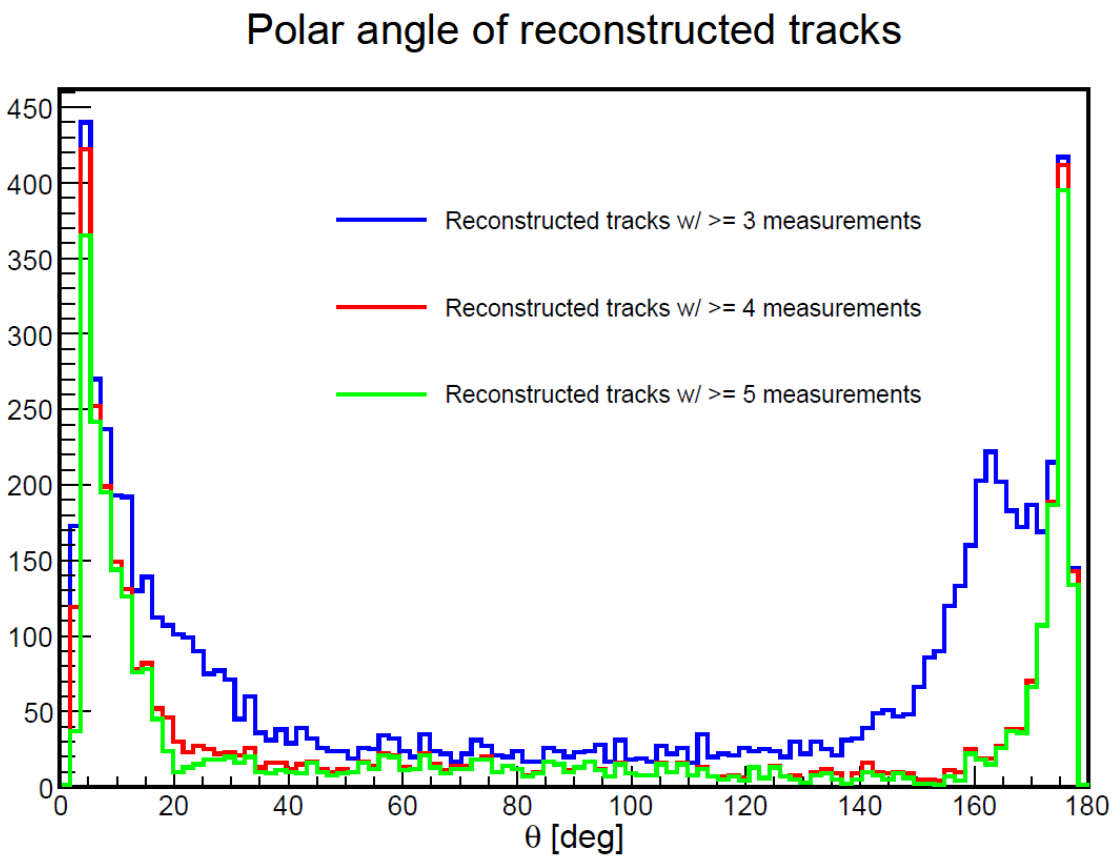
When considering tracks which have at least 4 measurement hits, we see that the number of tracks increases by less than 2% when we add the SR background. The polar angle distribution also looks very similar in both cases.

Reconstructed tracks: polar angle distribution

Generated charged particles from DIS signal event



With synchrotron radiation background included



When considering tracks which have at least 4 measurement hits, the polar angle distribution looks similar to the distribution of the generated charged particles that come from the DIS signal event.

Conclusions

- A very simple track-selection criterion on the minimum number of measurements can largely suppress excess tracks created by SR background hits in the tracking detectors.
- We can build on this study to perform more detailed tests of the impact of difference track quality requirements.
- Next steps on seeding level:
  1. Check if be can remove seeds that are associated with background particles without removing seeds associated with signal particles.
  2. Additional studies on low-momentum seeding inefficiencies