Parameter Exploration for Realistic Seeding - Resolutions

By Emma Yeats

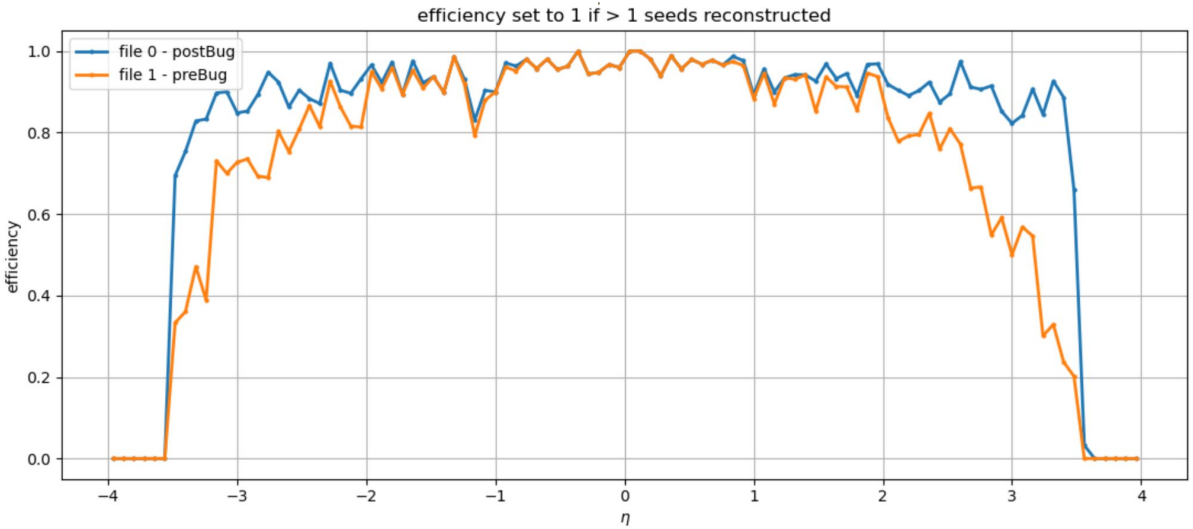
Recap of Updated Parameters

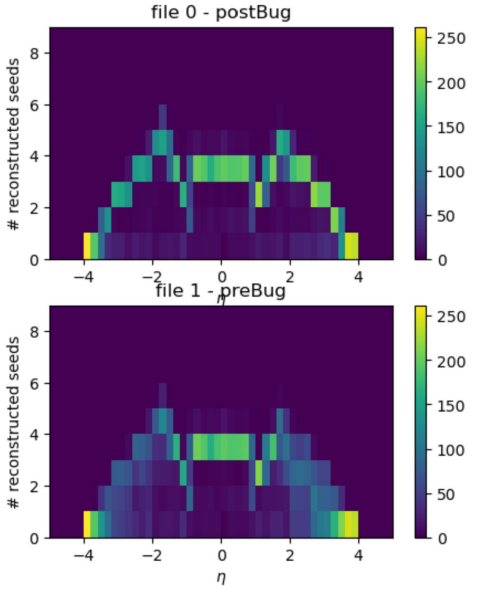
Parameter	Description	EICrecon default	Y.S. Lai's default	My New Default
bFieldInZ	z component of magnetic field	1.7 T	1.7 T	1.7 T
rMax	Maximum r value to look for seeds	500 mm	440 mm	440 mm
rMin	Minimum r value to look for seeds	33 mm	33 mm	33 mm
zMin	Minimum z value to look for seeds	-800 mm	-1500 mm	-1500 mm
zMax	Maximum z value to look for seeds	800 mm	1700 mm	1700 mm
beamPosX	Beam offset in x	0	0	0
beamPosY	Beam offset in y	0	0	0
deltaRMinTopSP	Min distance in r between middle and top SP in one seed	1 mm	50 mm	**10 mm**
deltaRMinBottomSP	Min distance in r between middle and bottom SP in one seed	1 mm	50 mm	**10 mm**
deltaRMaxTopSP	Max distance in r between middle and top SP in one seed	400 mm	220 mm	**200 mm**
deltaRMaxBottomSP	Max distance in r between middle and top SP in one seed	400 mm	220 mm	**200 mm**
collisionRegionMin	Min z for primary vertex	-300 mm	-250 mm	-250 mm
collisionRegionMax	Max z for primary vertex	300 mm	250 mm	250 mm
cotThetaMax	Cotangent of max theta angle	16	16.54	**27.29**
minPt	Min transverse momentum	100	100 MeV/cotThetaMax	100 MeV/cotThetaMax
maxSeedsPerSpM	Max number of seeds a single middle space point can belong to - 1	1	0	0
sigmaScattering	How many standard devs of scattering angles to consider	5	5	5
radLengthPerSeed	Average radiation lengths of material on the length of a seed	0.1	0.1	0.1
impactMax	Max transverse PCA allowed	20 mm	3 mm	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 T	0.1

Recap of Updated Parameters

Study produced an overall efficient setup! There are a few more parameters I can look at, especially after the recent units change in the pt calculation. But fixing the bug in EICrecon increased the efficiency.

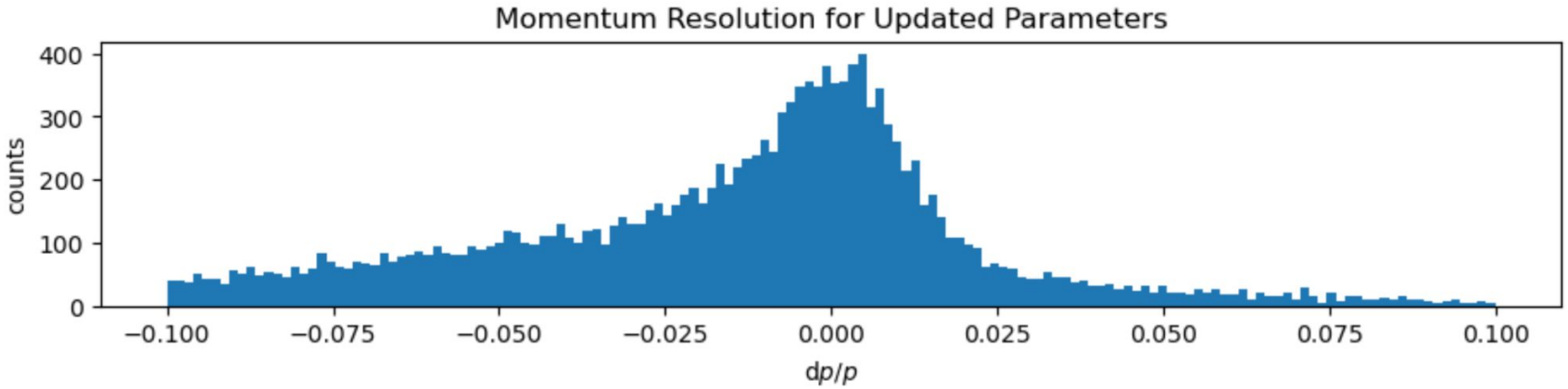
I now have other resolution plots to share (dΘ, dΦ)





Momentum Resolution

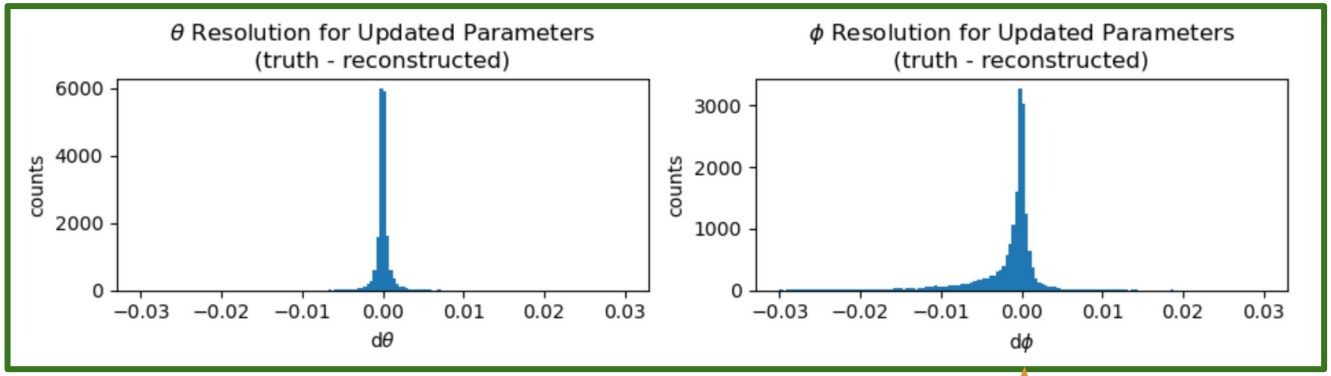
Momentum resolution for updated parameters shown below:



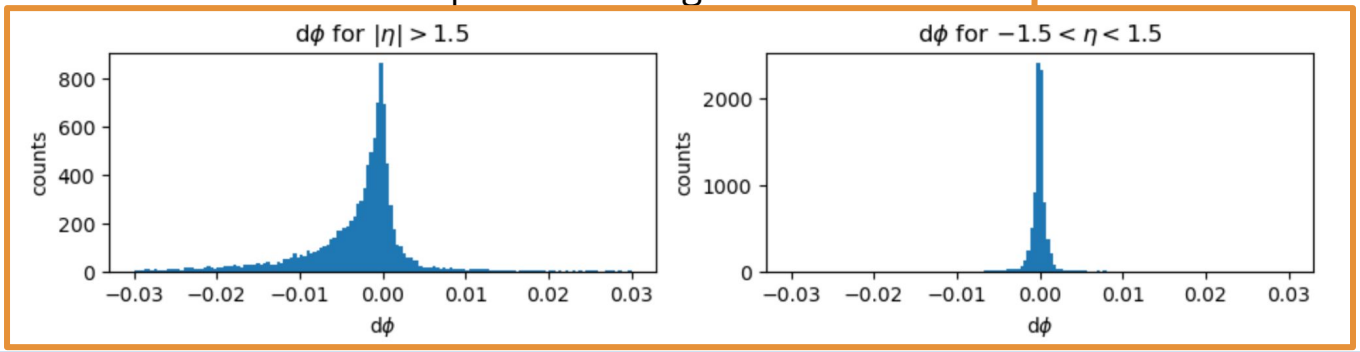
(now centered at zero after units issue was fixed in ACTS)

Resolutions for θ and Φ

Resolutions dθ and dΦ for Updated Seed Parameters



Phi Resolutions for Seperate Eta Regimes



dΦ now looks relatively good after fixing the seed phi reconstruction (as described by Barak).

I plan to separate the data into more bins so we can view the effect clearly. But this is a first look

Next up

- Seed resolution plots for distance of closest approach.
- I am still working on increasing the statistics by separating the efficiency study into regions in pT:
  - 0 - 0.6 GeV, 10000 events
  - 0.6 - 2 GeV, 10000 events
  - 2 - 10 GeV, 10000 events
- Generate new plots for dΦ after separating data into bins of pT and η

Old Stuff

Introduction/Recap

Continuing Rey's recent study on parameter optimization for the realistic seeder.

Two main results are discussed:

- a quick update on the bug found in EICrecon
- my studies on varying parameters for realistic seeding and how they were changed by the bug

I will also show the updated optimal parameters.

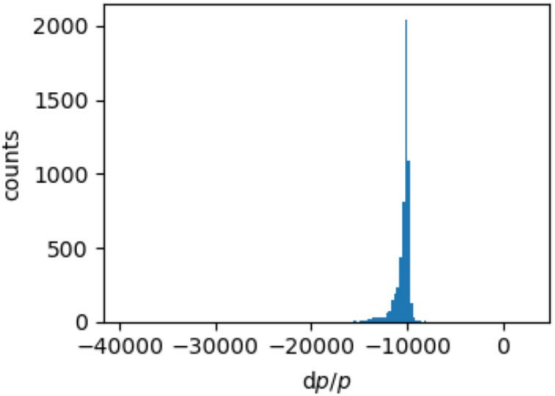
All plots from the same sample: 10k single pions thrown with $p \in [0,10]$ GeV/c (uniformly distributed) and $\eta \in [-4,4]$ (Brycecanyon, ACTS 21.1)

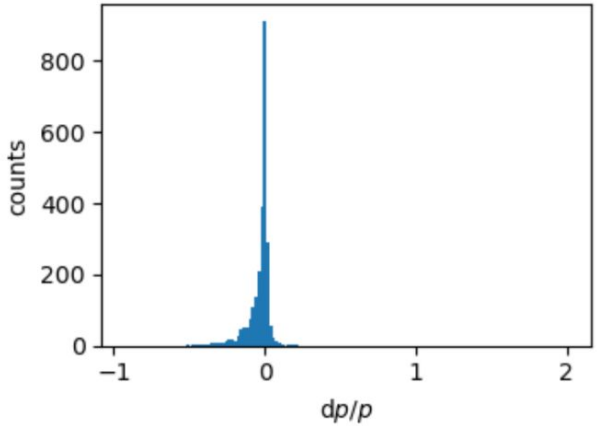
Update on EICRecon Bug

After a bug was found by Barak and Rey, EICRecon recently updated the pt calculation:

```
97        float pt = 0.3 * R * (m_cfg.m_bFieldInZ * 1000) / 100.;
```

```
97        float pt = R * m_cfg.m_bFieldInZ; // pt[GeV] = R[mm] * B[GeV/mm]
```





The only other change is we found that ACTS units passed at the command line level do not get properly interpreted by ACTS. Now, only the number is read in, and the attached unit gets ignored.

We now obtain better momentum resolutions! The resolution is centered at zero, but we still need to investigate why it favors one side (future work).

Parameter Exploration

Parameter Descriptions

Parameter	Description	EICrecon default	Y.S. Lai's default
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beamPosX	Beam offset in x	0	0
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deltaRMinTopSP	Min distance in r between middle and top SP in one seed	1 mm	50 mm
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cotThetaMax	Cotangent of max theta angle	16	16.54
minPt	Min transverse momentum	100	100 MeV/cotThetaMax
maxSeedsPerSpM	Max number of seeds a single middle space point can belong to - 1	1	0
sigmaScattering	How many standard devs of scattering angles to consider	5	5
radLengthPerSeed	Average radiation lengths of material on the length of a seed	0.1	0.1
impactMax	Max transverse PCA allowed	20 mm	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 T

Parameters fixed based on the geometry

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rMinMiddle	Min R for middle space point	20 mm	—
rMaxMiddle	Max R for middle space point	400 mm	—
bFieldMin	min B field	—	0.1 T

Parameters I studied

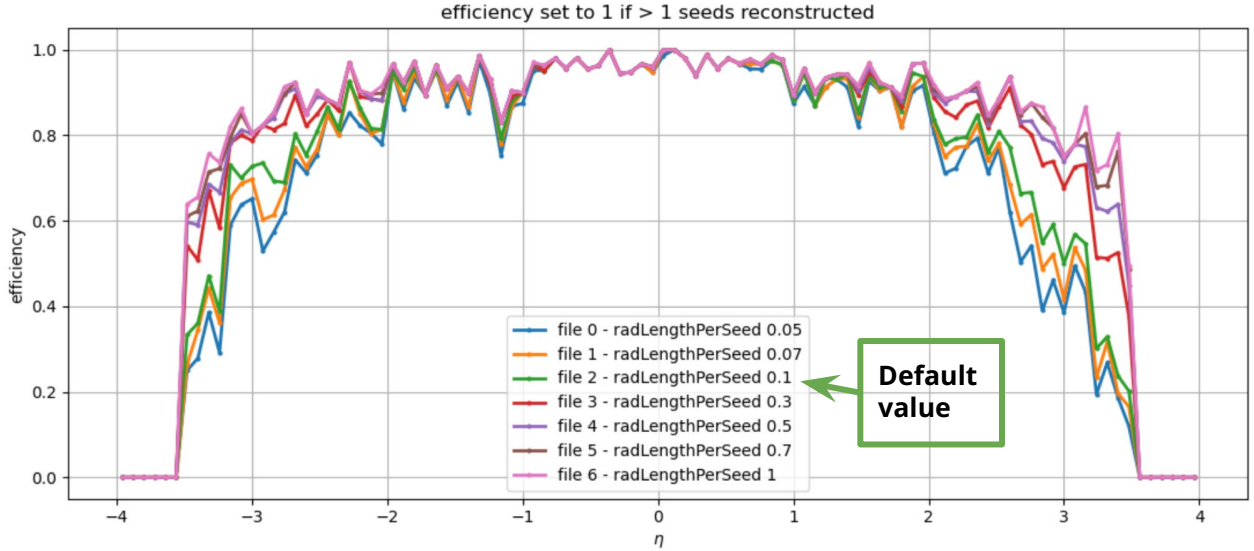
Parameters Chosen For Discussion

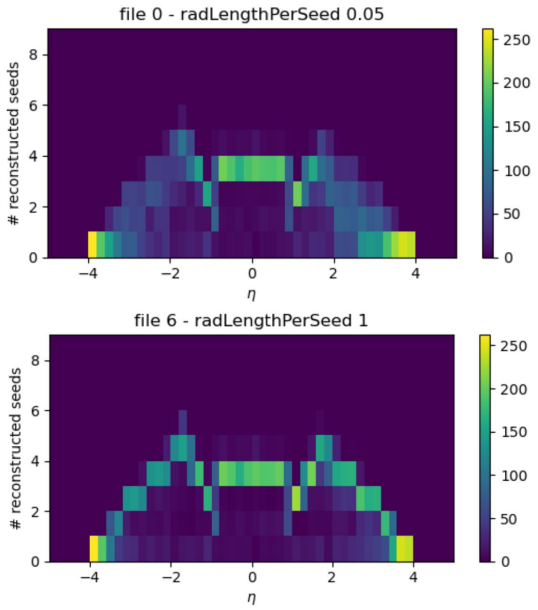
Before this bug was discovered, I had found one parameter in particular that was responsible for increasing the efficiency in the far eta regime (radLengthPerSeed). I will discuss its behavior briefly just to explain the sudden efficiency jump you'll see in that region.

Several of the parameters' behavior did not change after the bug was fixed, like deltaRMinSP, deltaRMaxSP, cotThetaMax, and more. However some changed after the fix, including radLengthPerSeed and sigmaScattering, that once had a larger impact on the efficiency and now do not.

radLengthPerSeed (pre-Bug)

Old Plot!



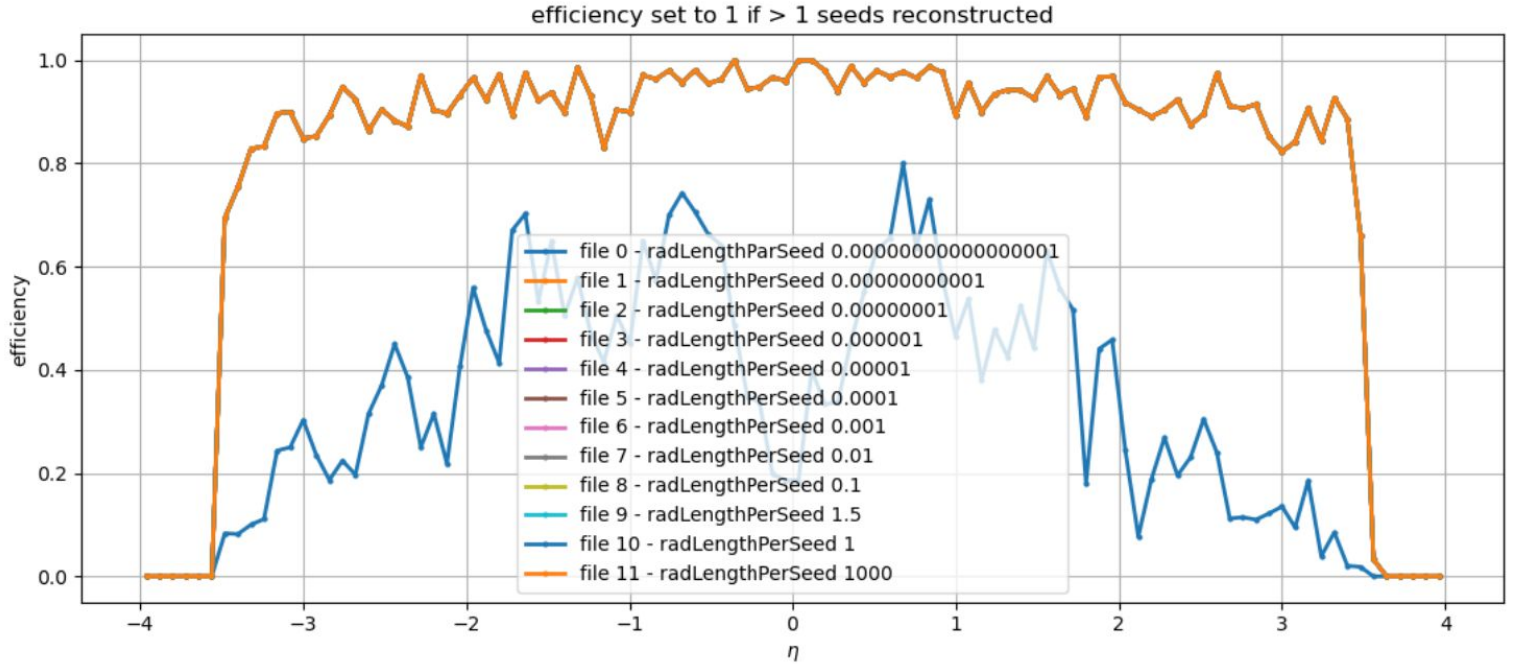


Average radiation lengths of material on the length of a seed.

I initially varied this parameter from 0.01% to 1%. These plots were calculated before the bug was fixed, and shows where the sudden increase in efficiency comes from. It is less sensitive post-Bug, and I found that this increase in efficiency now happens around ~1e-16.

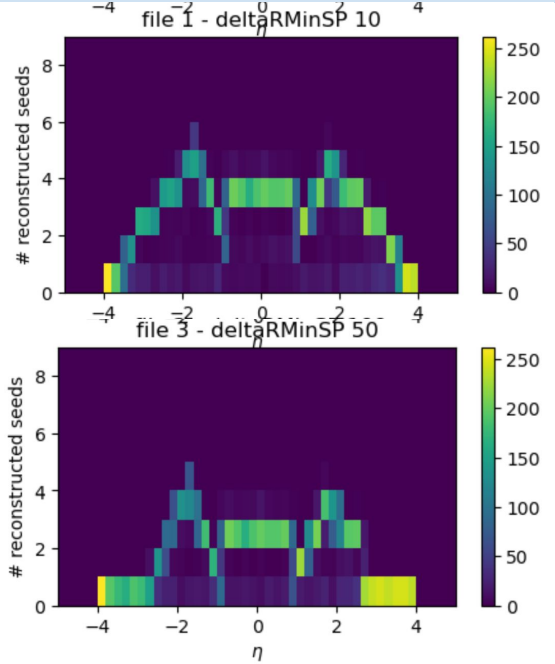
radLengthPerSeed (post-Bug)

(we can see it no longer really has an effect, and we can revert to the default, radLengthPerSeed==0.1)



Now we look at the parameters that remained sensitive.

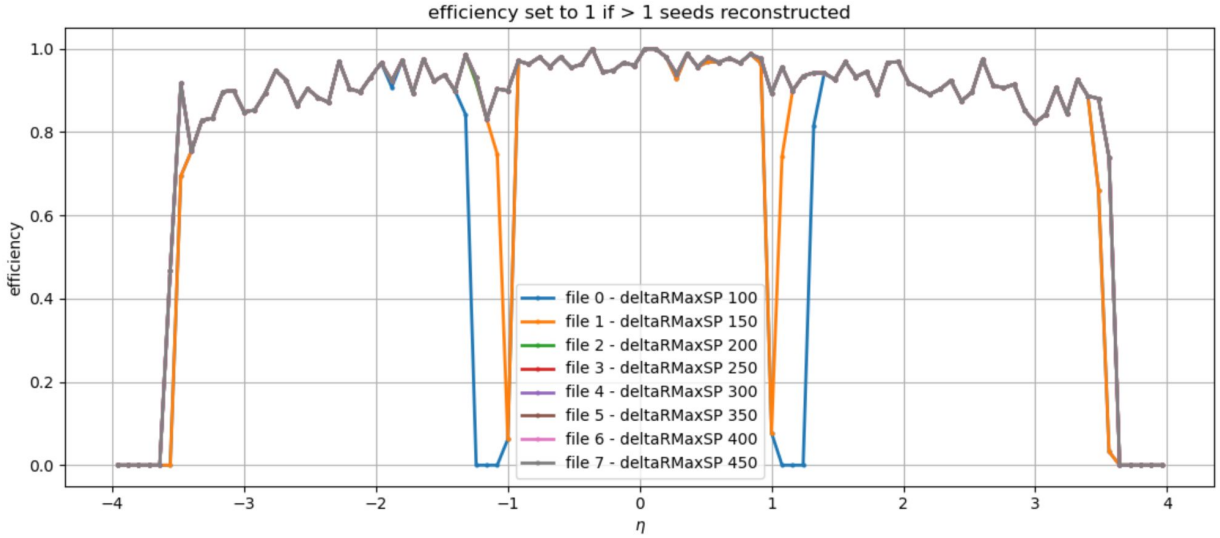
DeltaRMinTop/BottomSP (post-Bug)

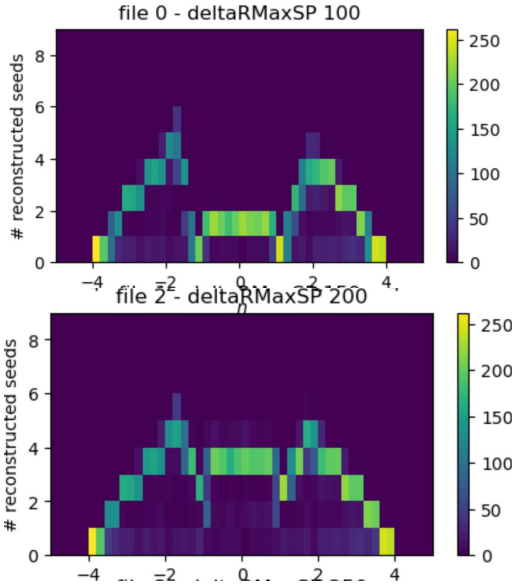


Minimum distance in r between the Middle and Top/Bottom SP in one seed.

We see that ≤10 mm is ideal, and also doesn't increase the number of reconstructed seeds too much.

deltaRMaxTop/BottomSP (post-Bug)

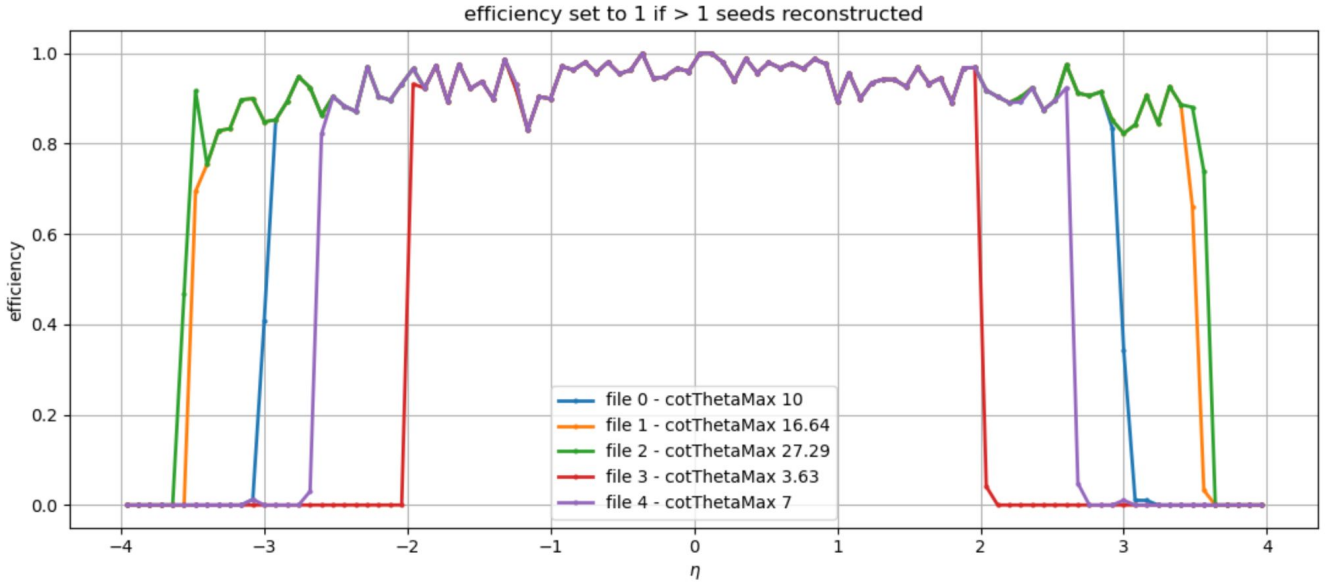




Maximum distance in r between Middle and Top/Bottom SP in one seed.

We see this should be set ≥200 mm.

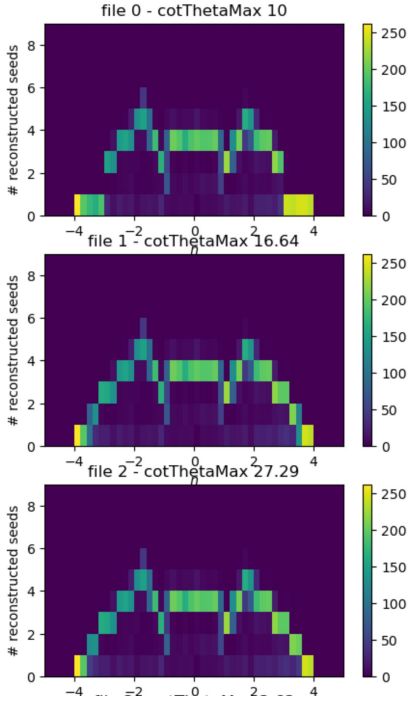
cotThetaMax (post-Bug)



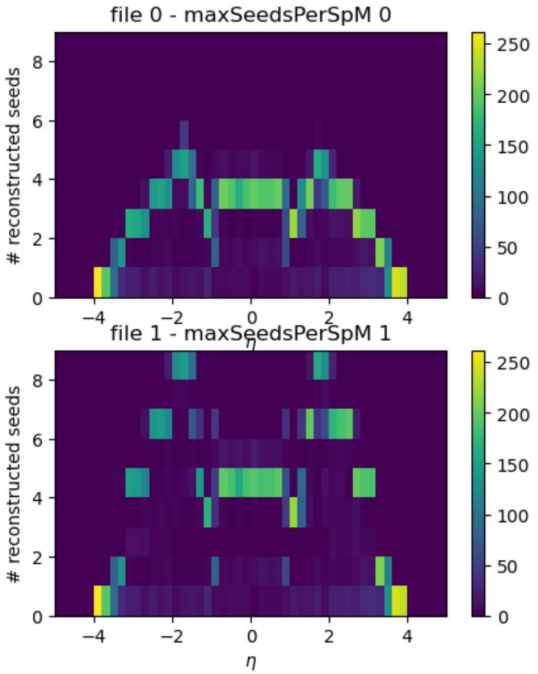
$\cot(\theta_{max})$	θ_{max} [°]	η_{max}
0.52	62.5	0.5
1.18	40.4	1
3.63	15.4	2
10.02	5.70	3
16.54	3.46	3.5
27.29	2.10	4

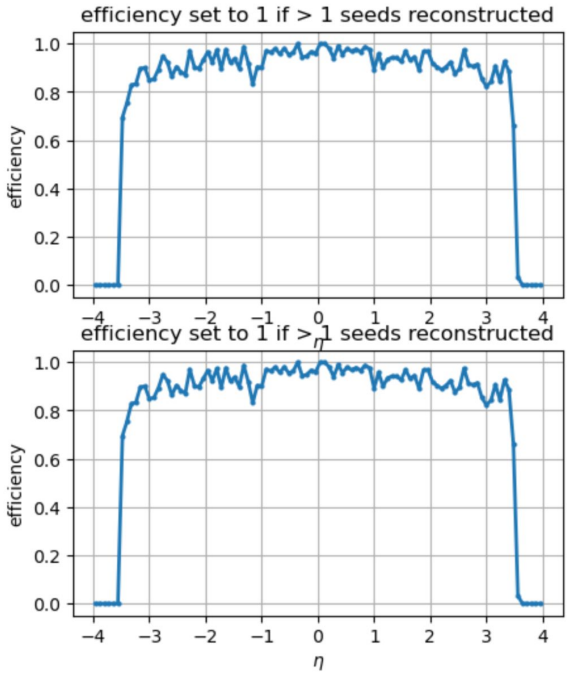
Cotangent of the maximum theta angle.

27.29 is best, but I am still working to see why the full eta regime is not covered (future work).



maxSeedsPerSpM (post-Bug)



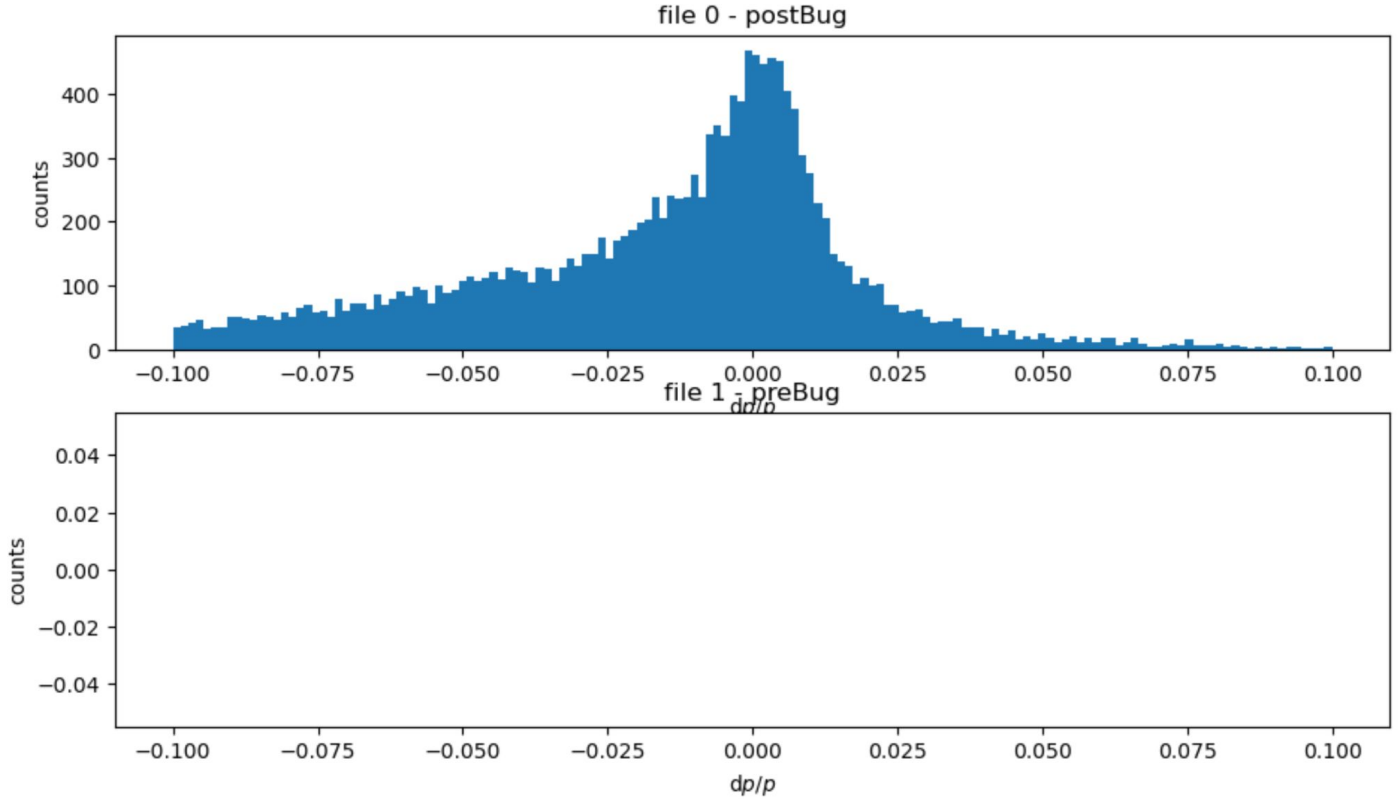


The max number of seeds a single middle spacepoint can belong to (-1)

Efficiency is consistent, but the number of reconstructed seeds doubles after maxSeedsPerSpM==0.

backup

Momentum Resolutions in Greater Detail



Figuring Out the Units

Pt is calculated by equating lorentz and centripetal forces.

$$m\frac{v^2}{R} = q_e\,(v \times B) \rightarrow p[GeV/c] = 0.3 * R[m] * B[T]$$

This is where pt is calculated in EICRecon - two bugs here!

```
97        float pt = 0.3 * R * (m_cfg.m_bFieldInZ * 1000) / 100.;
```

Overcompensating for a factor of 1000 and 0.3 (already included in acts)

constexpr double **Acts::UnitConstants::T** = 0.000299792458

$$\frac{0.3}{1000} = T$$

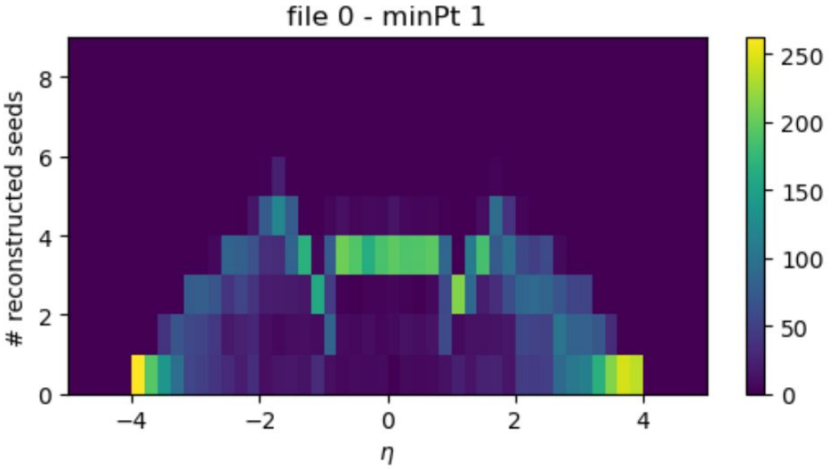
R is expected in cm (but acts default is mm)

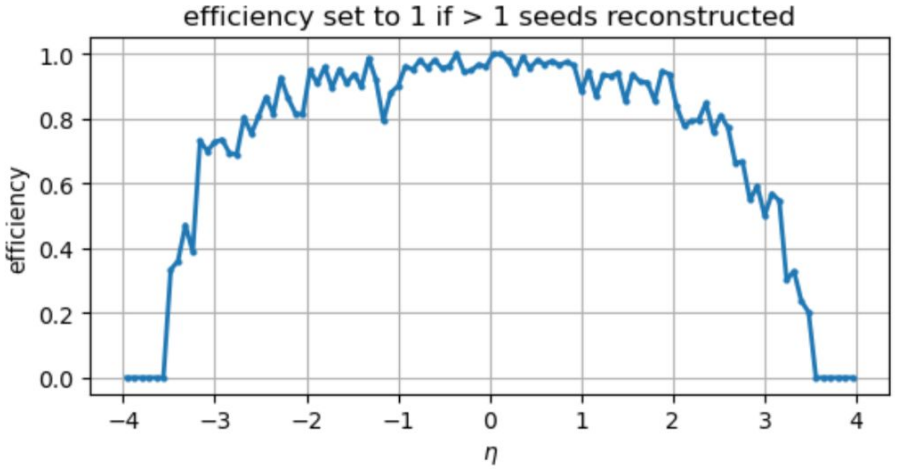
constexpr double **Acts::UnitConstants::mm** = 1.0

constexpr double **Acts::UnitConstants::GeV** = 1.0

So this pt definition is currently taking in R[cm] and B[kT]

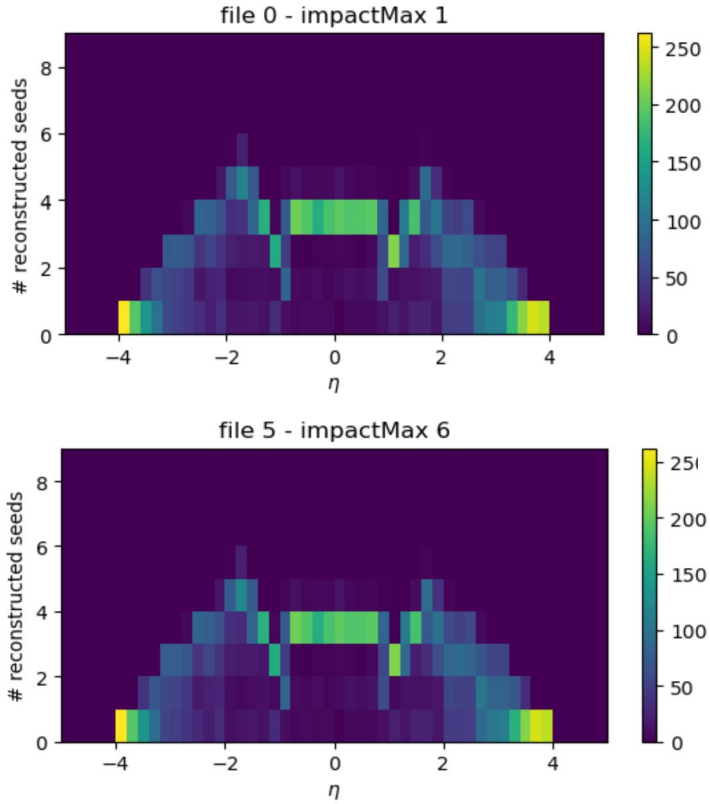
minPt

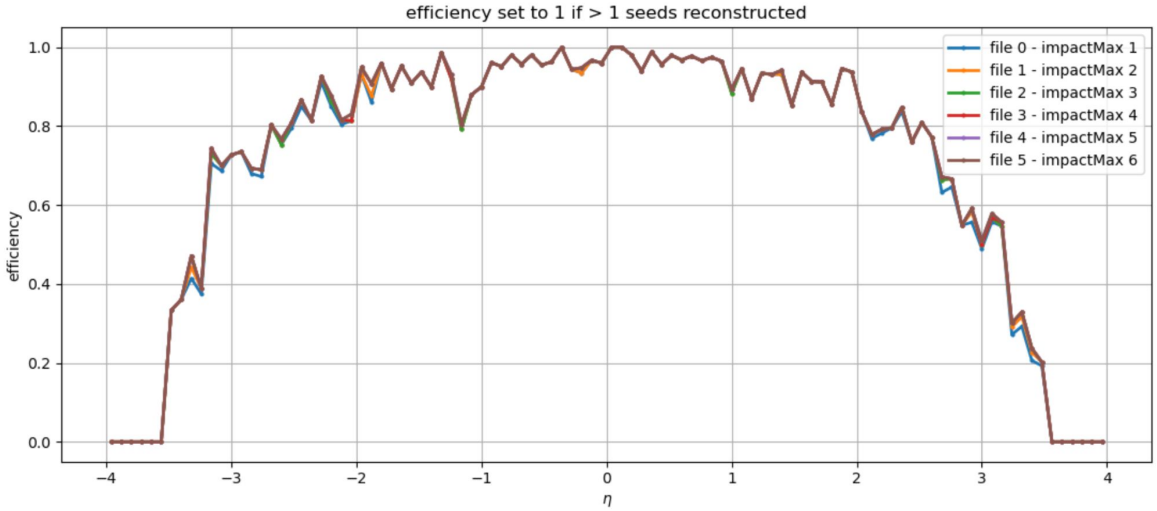




Parameter Values: 1,5,6,8,10 (default ==5). No effect on efficiency or #reconstructed seeds in the region varied, could increase values further move to backup

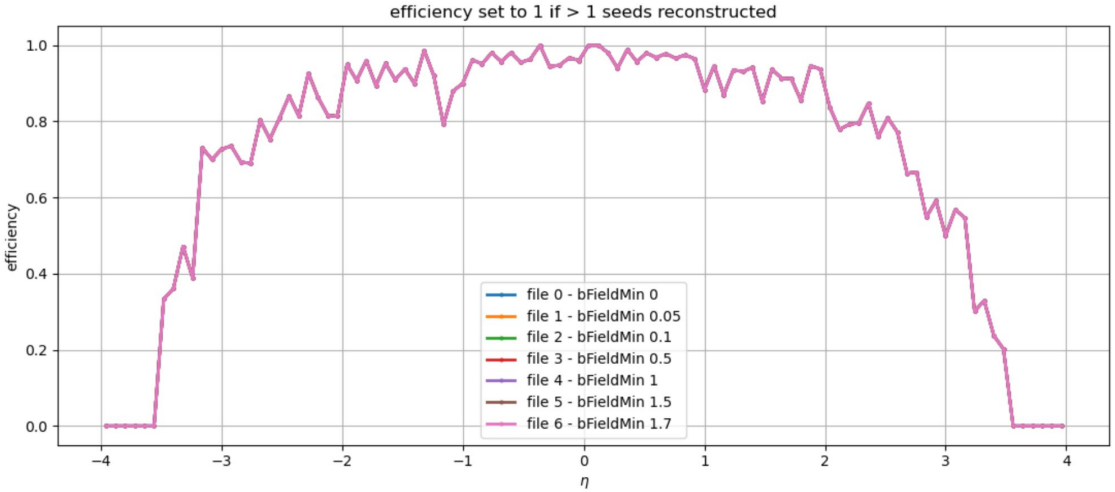
impactMax

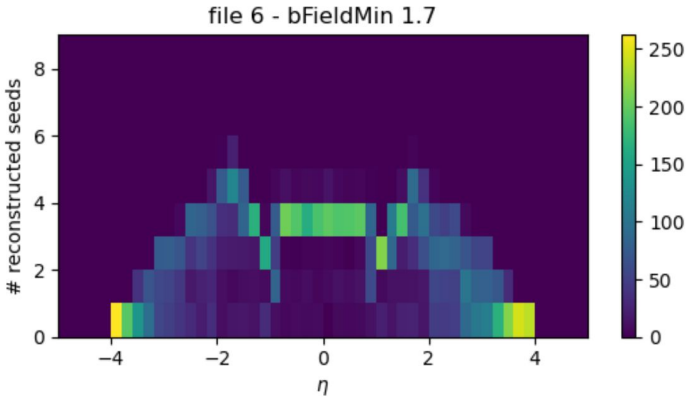




Values = 1,2,3,4,5,6. No notable differences in efficiency or #reconstructed seeds

bFieldMin

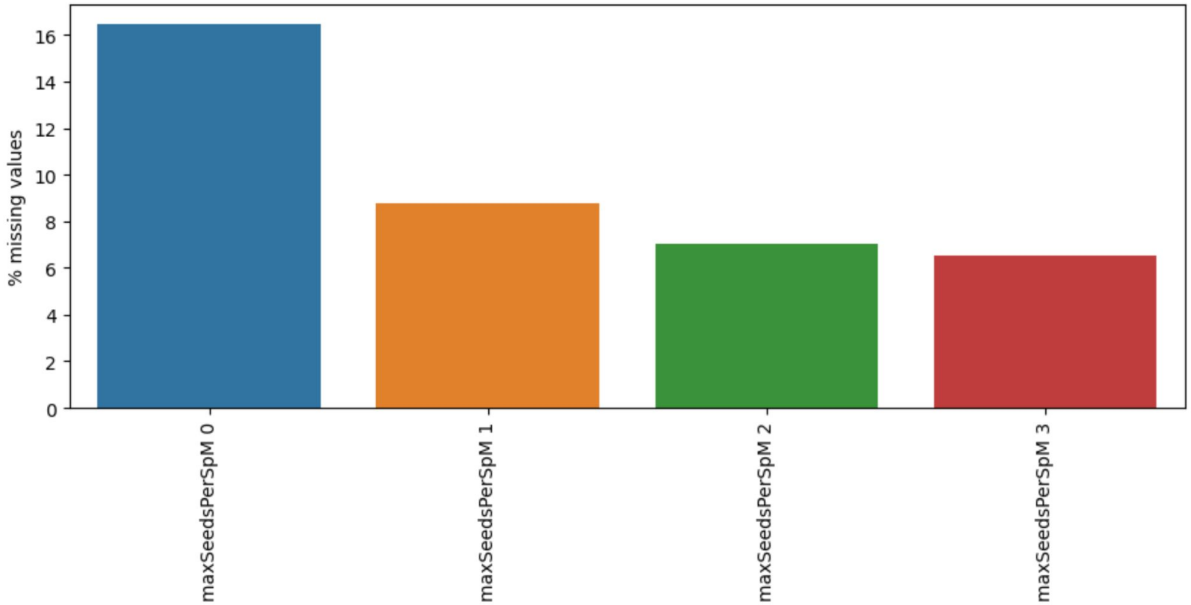




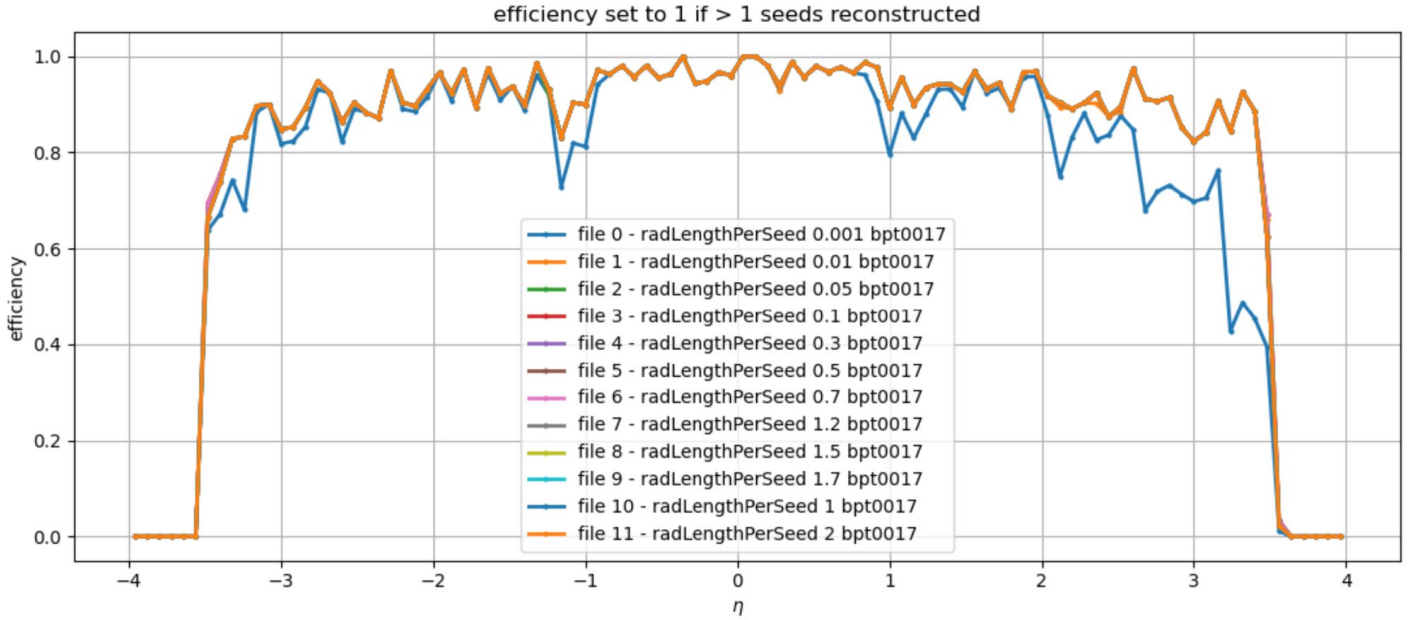
values=0,0.05,0.1,0.5,1,1.5,1.7 T … seemed to have no effect at all on efficiency or reconstructed seeds.

Number of Missing Values

Number of missing values - **the number of non-null entries in the generated branches can be larger than that in the reconstructed ones. These are cases in which no seed was reconstructed. Let's visualize this as the percentage of missing values**

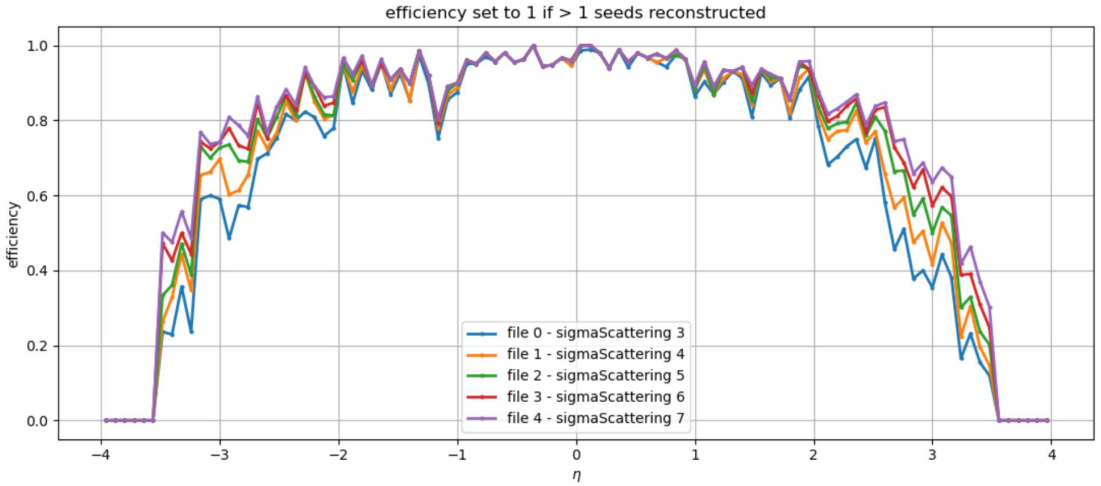


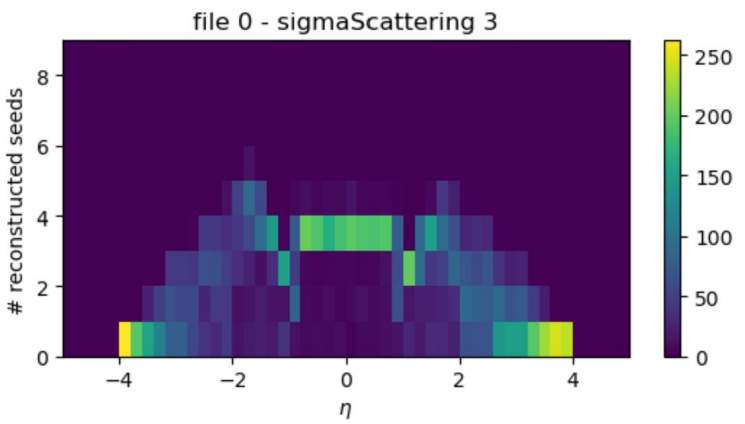
Varying rad length per seed after bField change



sigmaScattering

Old Plots





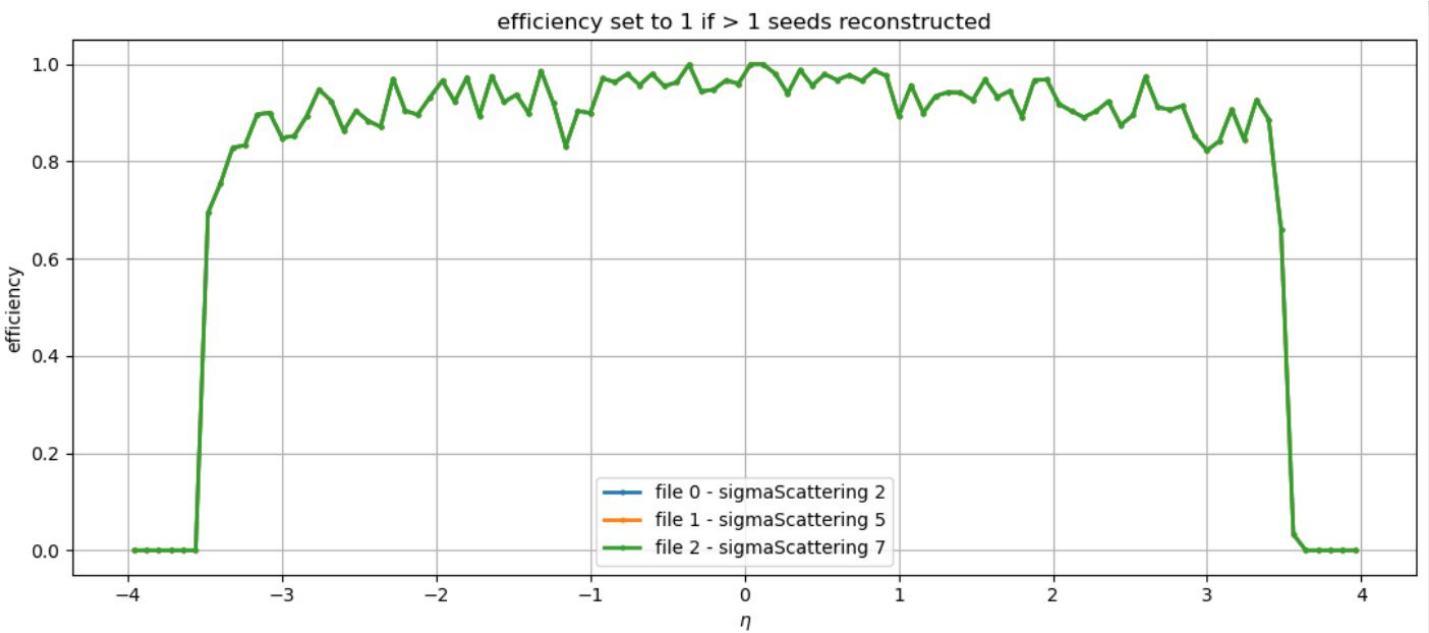
How many standard deviations in scattering angle are considered?

Overall we see that efficiency increases with increasing Sigma, with no effect on the number of reconstructed seeds.

This is important to keep in mind once a standard deviation is chosen for the detector later, that I have just kept my default at 5σ. Efficiency will decrease if a smaller σ is chosen.

sigmaScattering

No longer influences efficiency much post-Bug



radLengthPerSeed (post-Bug)