ACTS Tracking For Muon Collider

Karol Krizka

September 10, 2021

MCC Notes

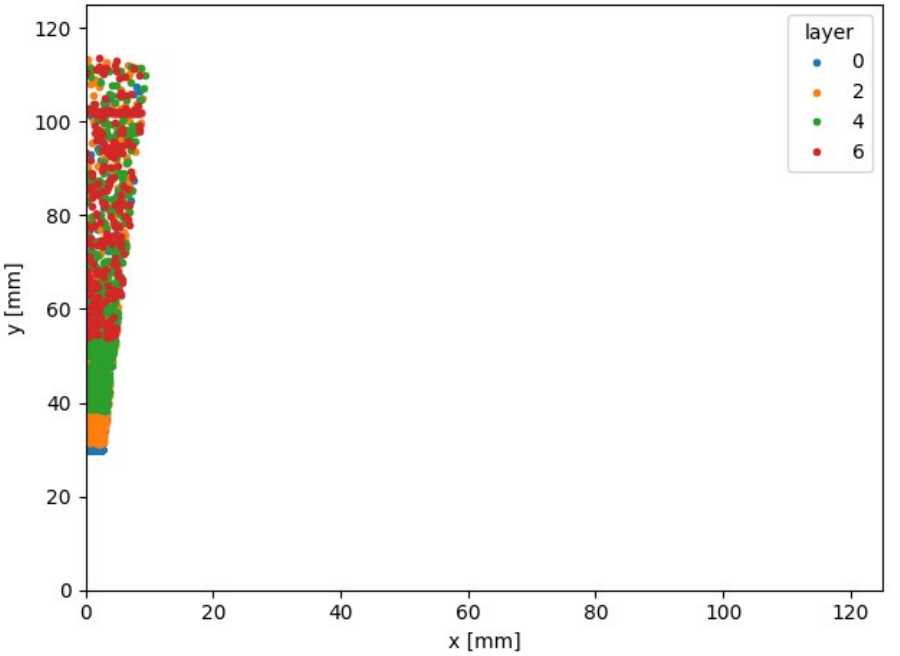
Seed Selection Studies

Two samples:

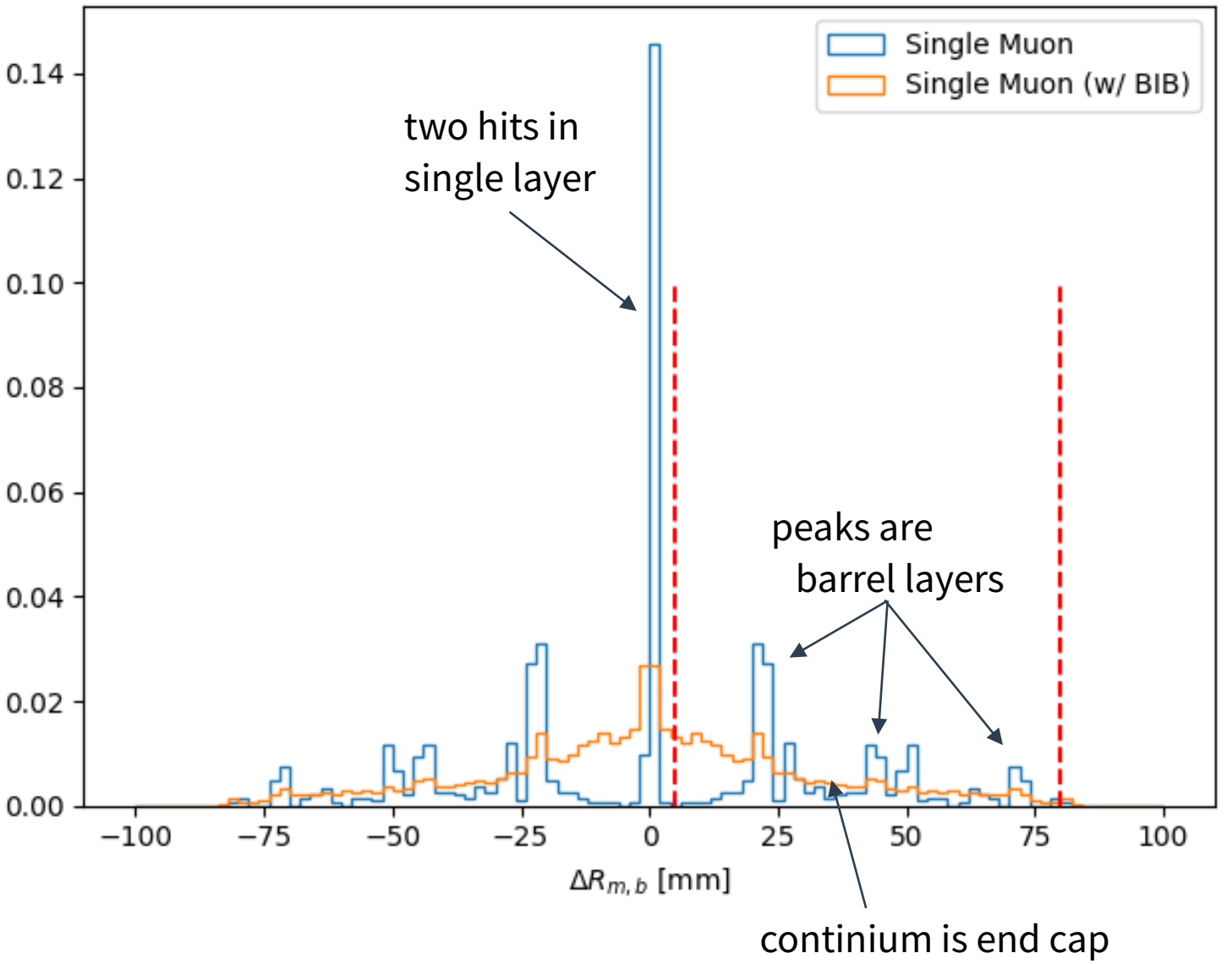
- Single muon
- *One event* of singlue muon with BIB overlay

Hit Preselection:

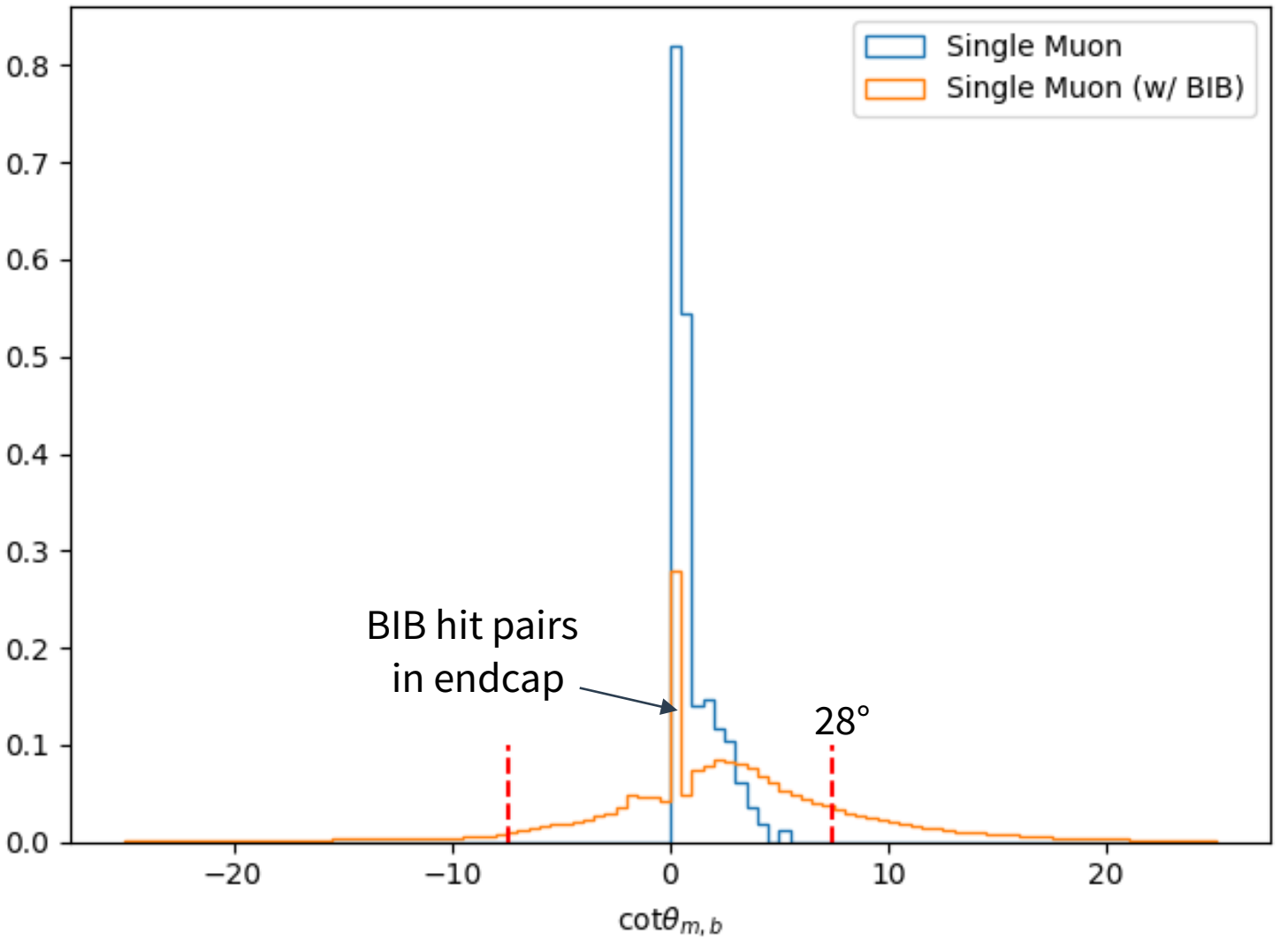
- $z_{hit} > 0$
- 5° cone in transverse plane
- Inner part of doublet in vertex
- Usual “digitization” + timing cuts



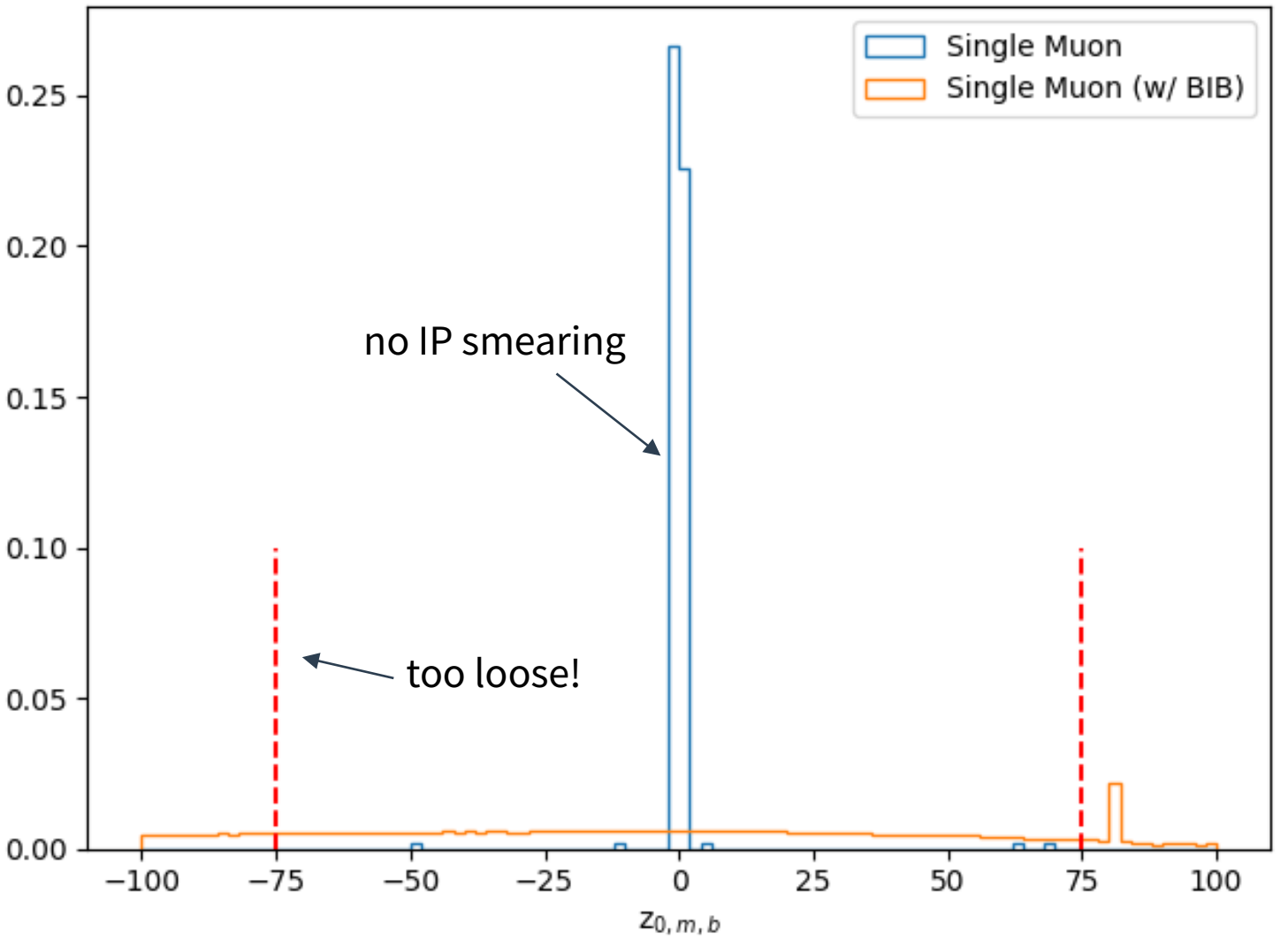
Distance Between Hits



Forward Angle



Collision Point



Will tighten to ±1 mm around IP.

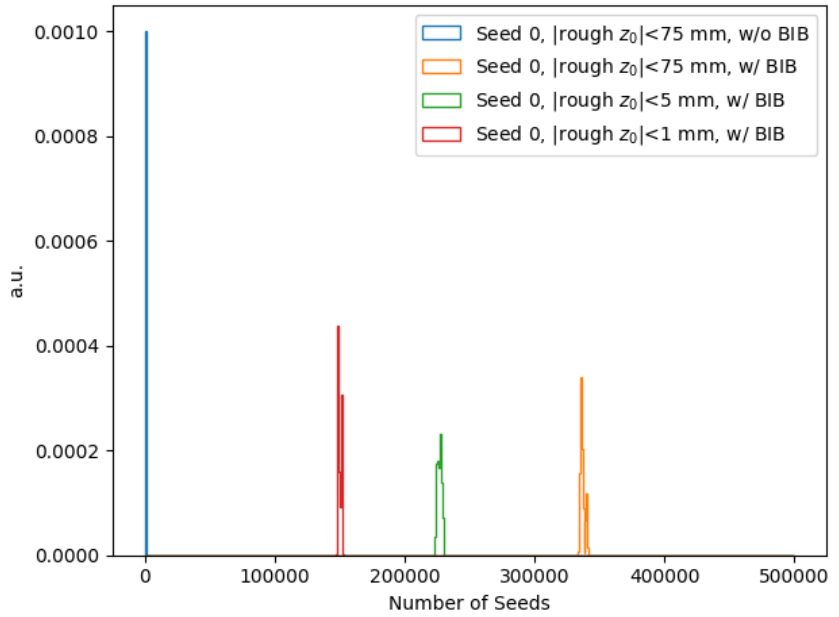
Other Seed Selections

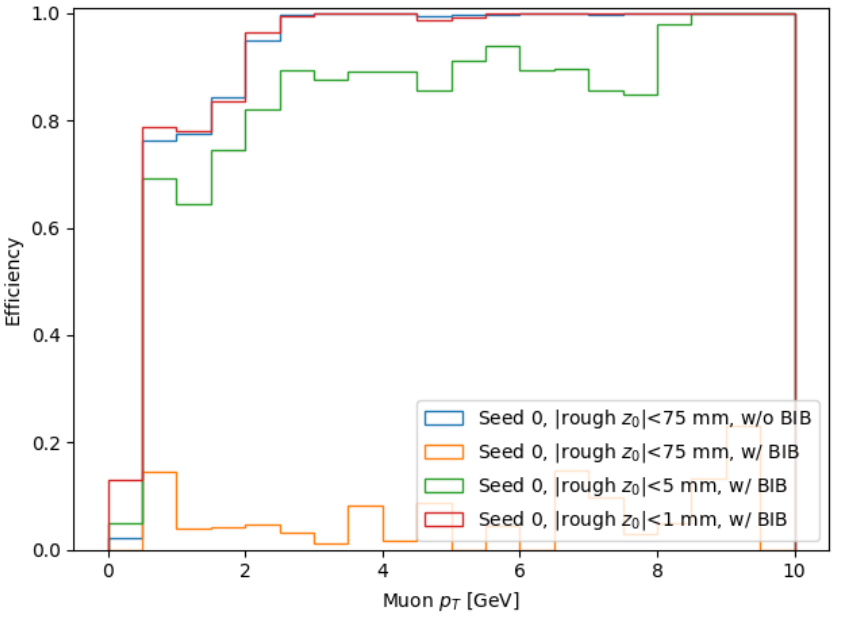
Not shown…

- **Also skipping seed overlap removal**
  - Require one 1* seed with same middle hit
  - Non trivial reduction of seed count

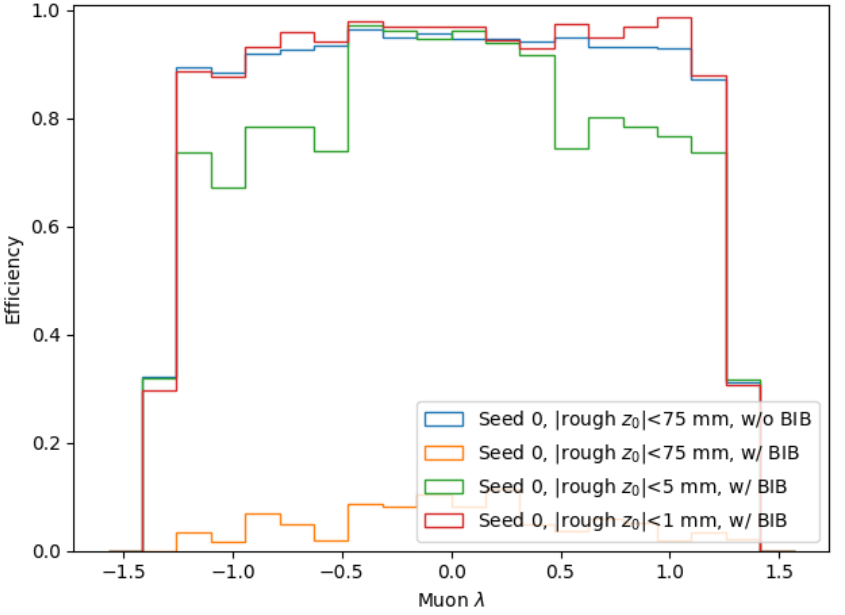
* configurable

Effect of Tigher "z_0" Seed Cut





- **"Small" reduction in N_{seeds}**
- **Improved seeding efficiency**
  - Easier seed overlap removal?
- **Big improvement in runtime.**
  - Easier seed overlap removal?



Speeding up CKF

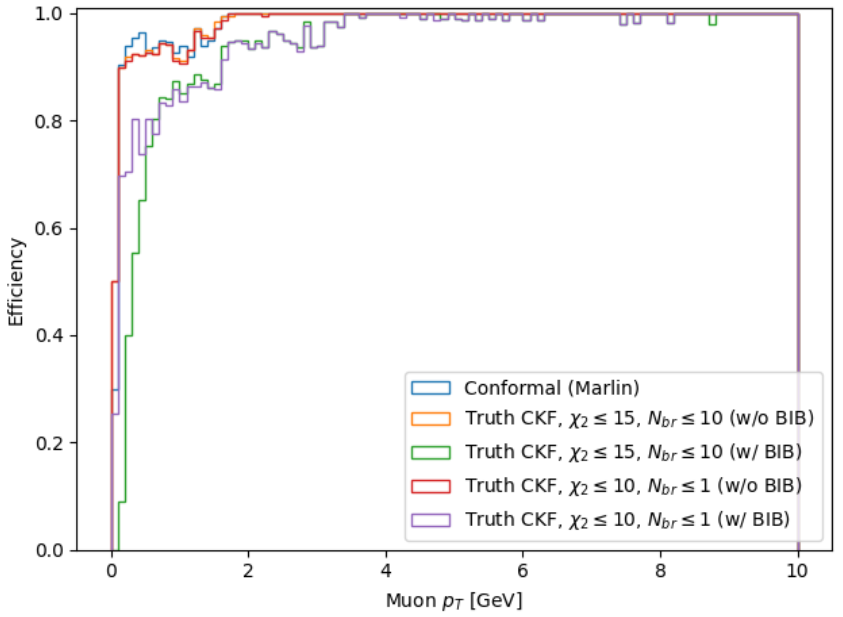
Two parameters to tune:

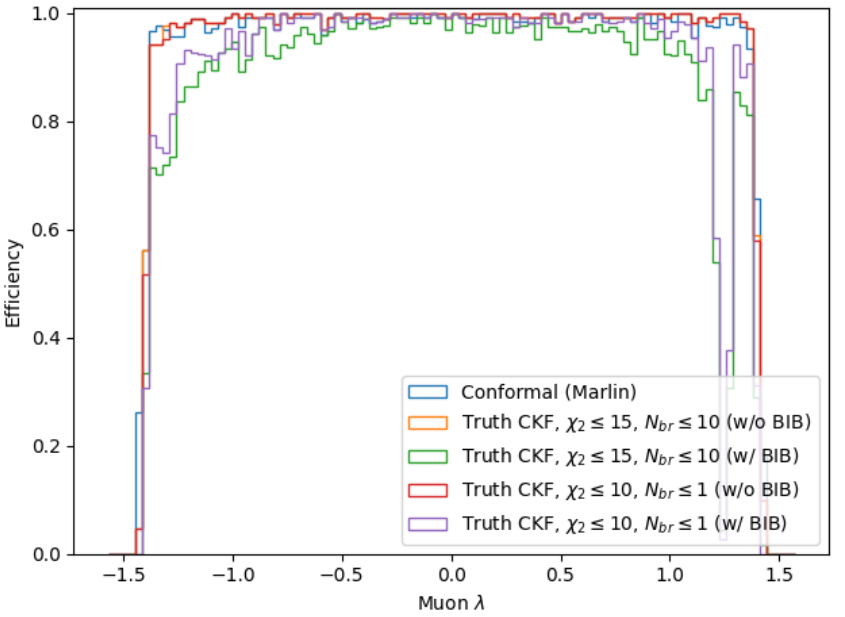
- Search window (χ^2) in each layer (default: 15)
- Number of branches in each layer (default: 10)

Tightening both to 10,1 results in 4 min / event run time!

- **ACTS dev's also suggest "outside in" CKF**
  - Starting with less dense outer layers means less branching at start.
  - Interesting idea, on TODO list

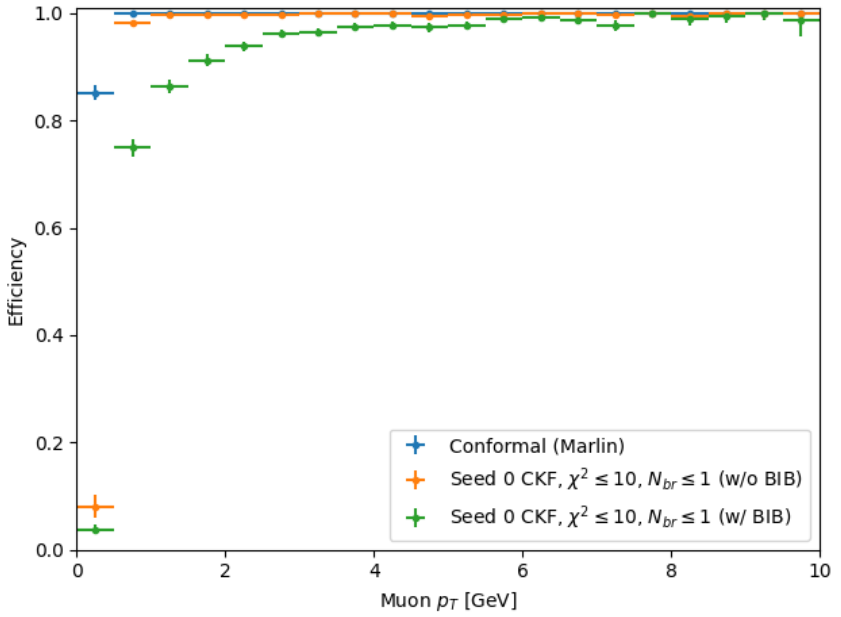
Tightening CKF Settings

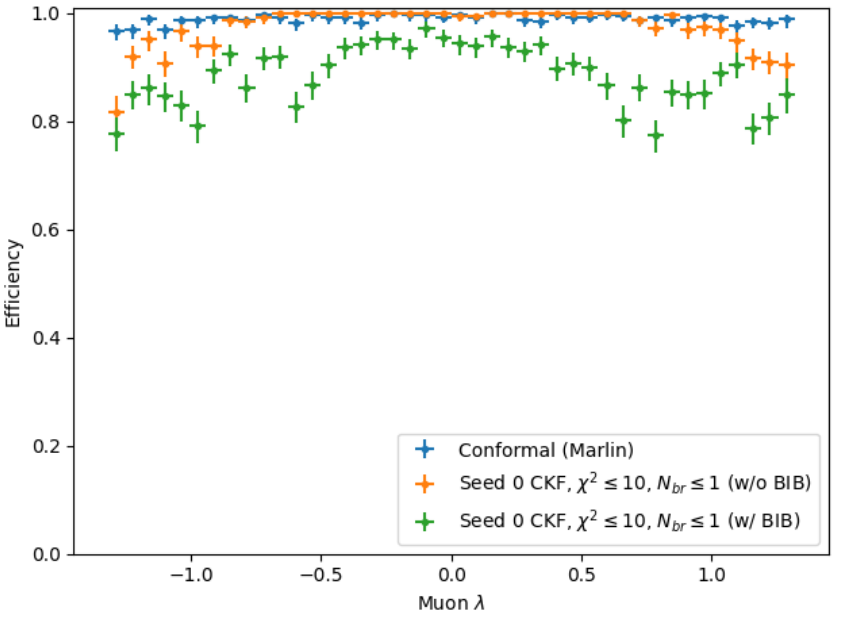




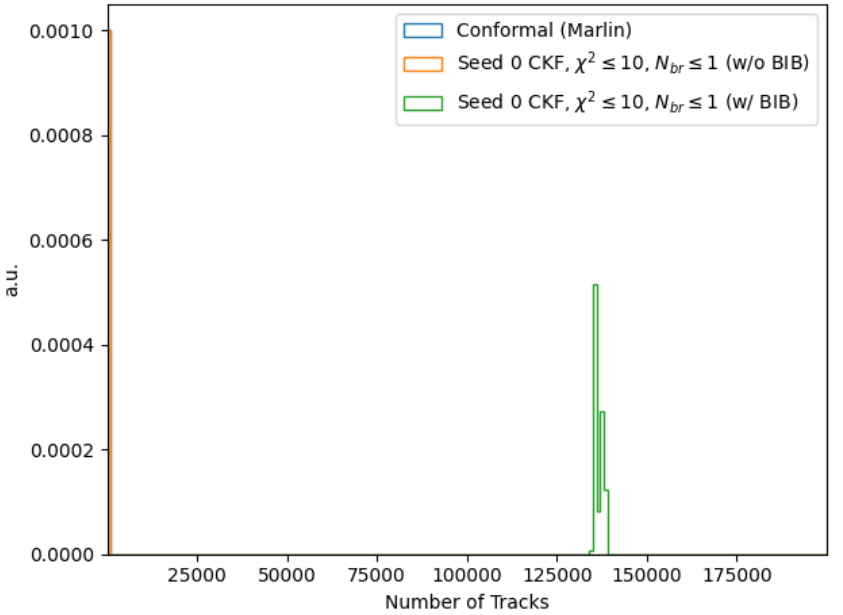
- **The "default" settings have a good tracking efficiency**
- **No loss in efficiency after tightening χ^2 w/o BIB**
  - N_{br} has no effect ← one hit per layer
- **Reduced efficiency after tightening N_{br} w/ BIB**
  - Mainly forward region with large hit density

Full Tracking Chain

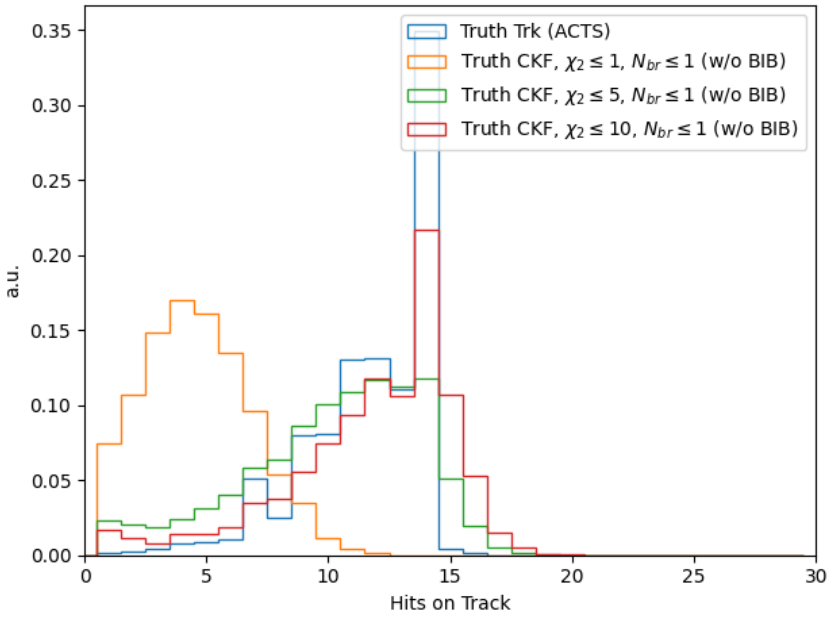


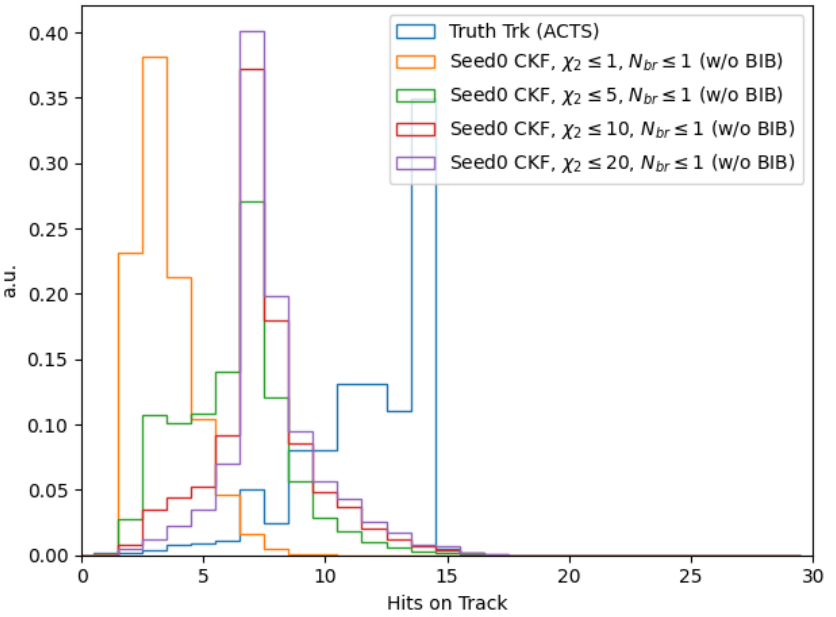


- **Processor took 4 min / event**
  - Very reasonable!
- **OK efficiency**
  - Some duplicates…
- **LOT of fakes**

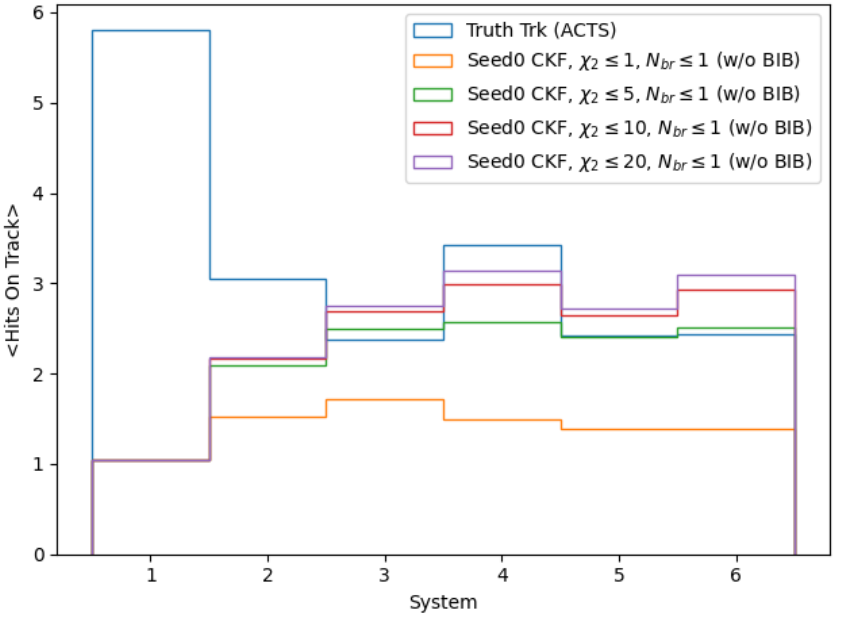


Hits Found by CKF

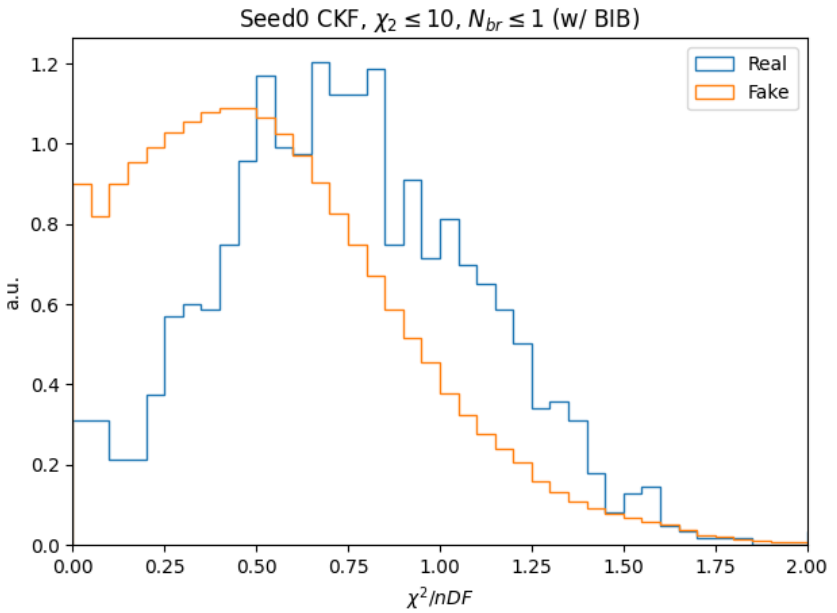


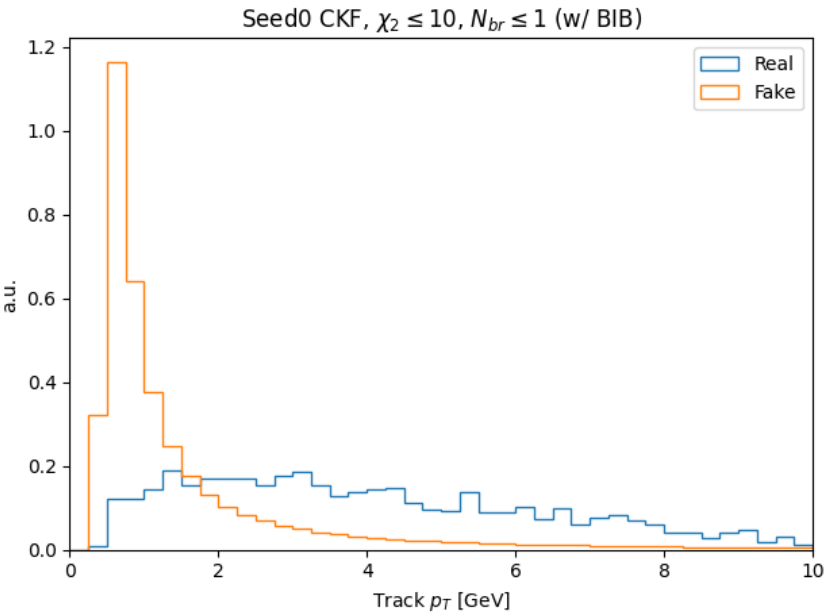


- **Need $\chi^2 \leq 10$ to get "all" hits**
- **Missing hits in vertex**
  - ACTS bug with seeding volume? #926

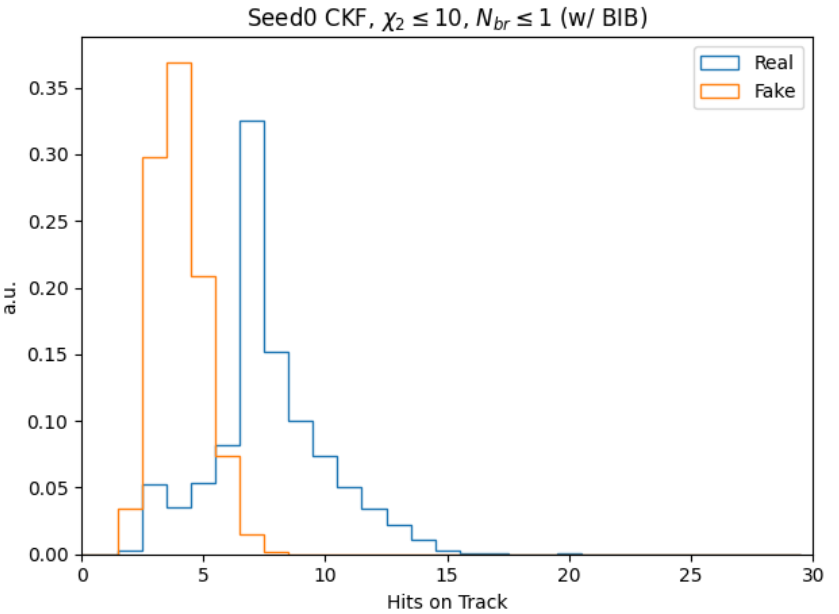


Removing Fakes

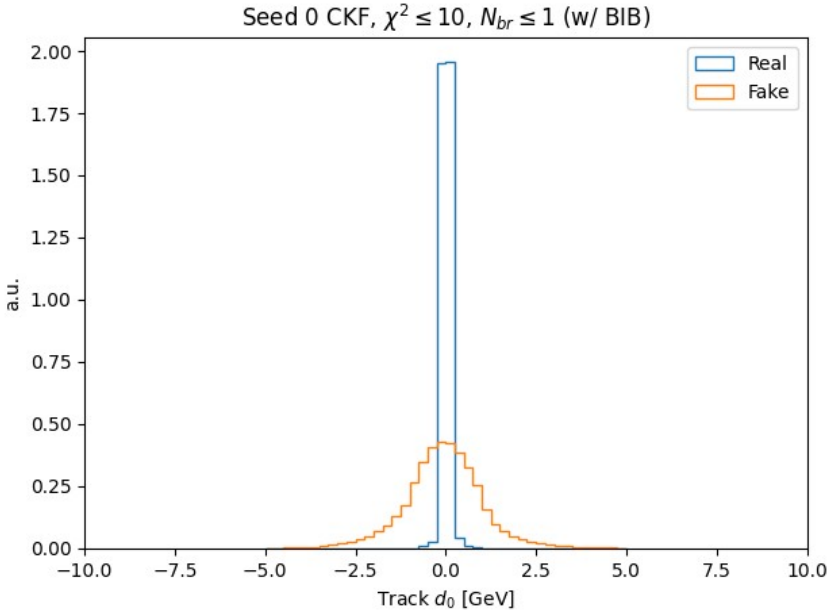


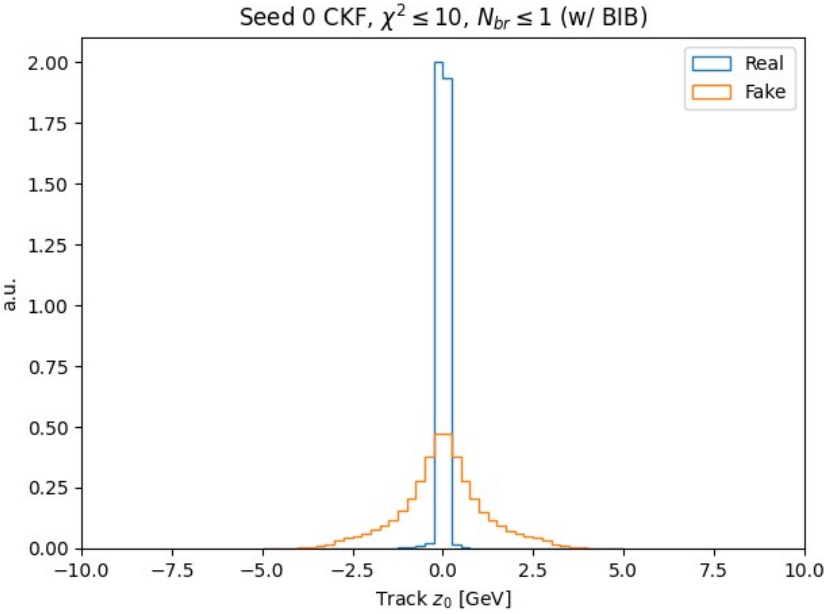


- **χ^2/nDF shows some separation**
- **Most fakes are at low p_T**
  - Cut out p_T<1GeV?
- **Most promising is N_{hits}>6**
  - Even better after #926 fixed?



Removing Fakes





- **Separation in reconstructed production vertex**
  - Ignore for now to not bias against secondary vertices

Other Topologies

Tested with the following samples:

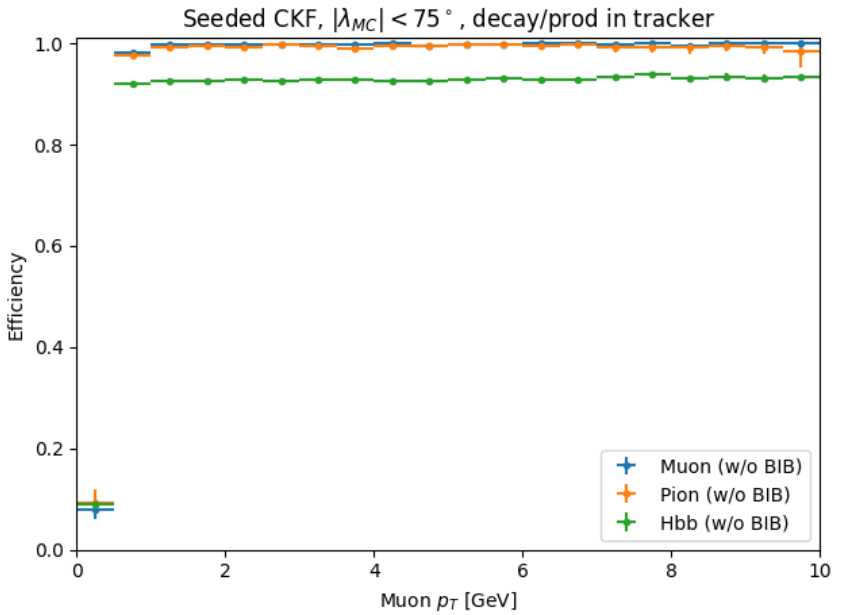
- Single muon (aka previous slides) → simplest case
- Single pion → look at material effects
- H→bb → displaced tracks

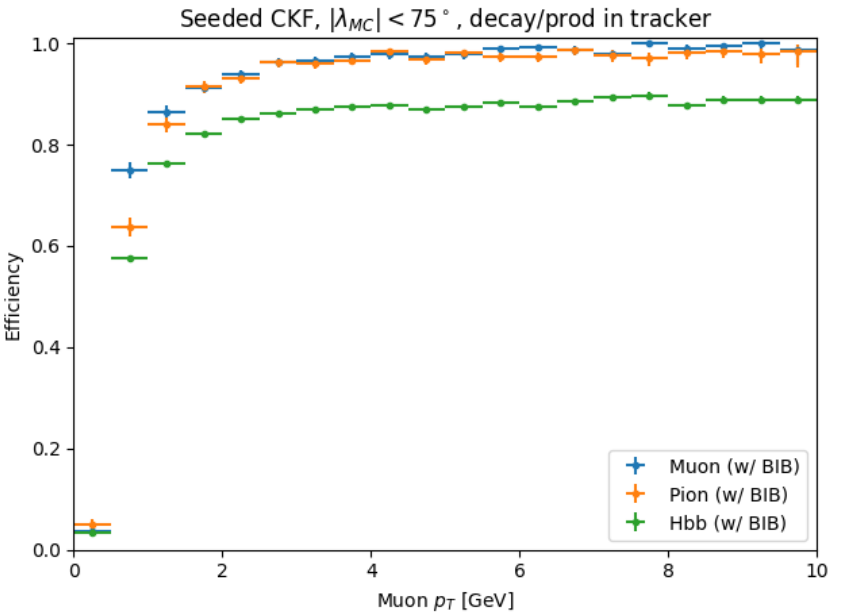
Tracker Acceptance:

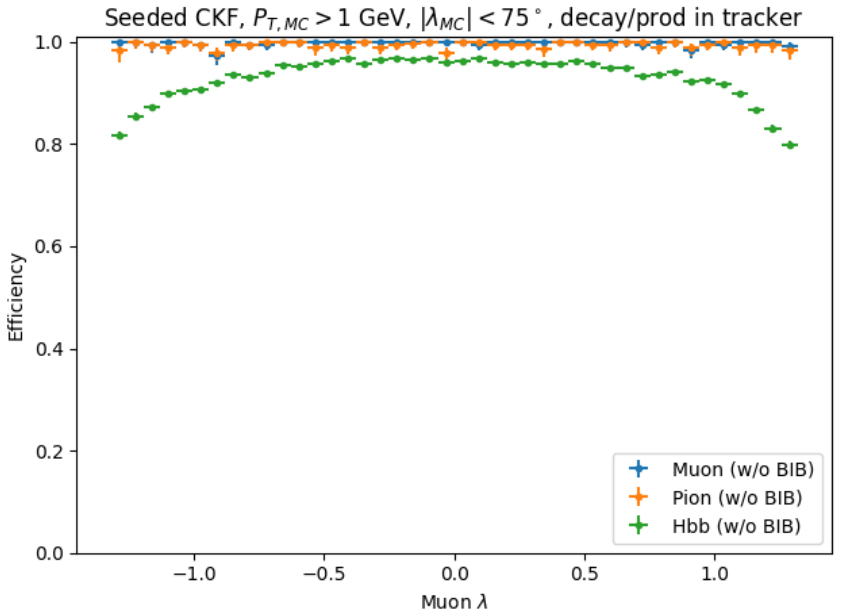
- Charged particle, $p_T > 1$ GeV, $|\lambda| < 75°$
- Generator status 1, not decayed in tracker, produced before first layer

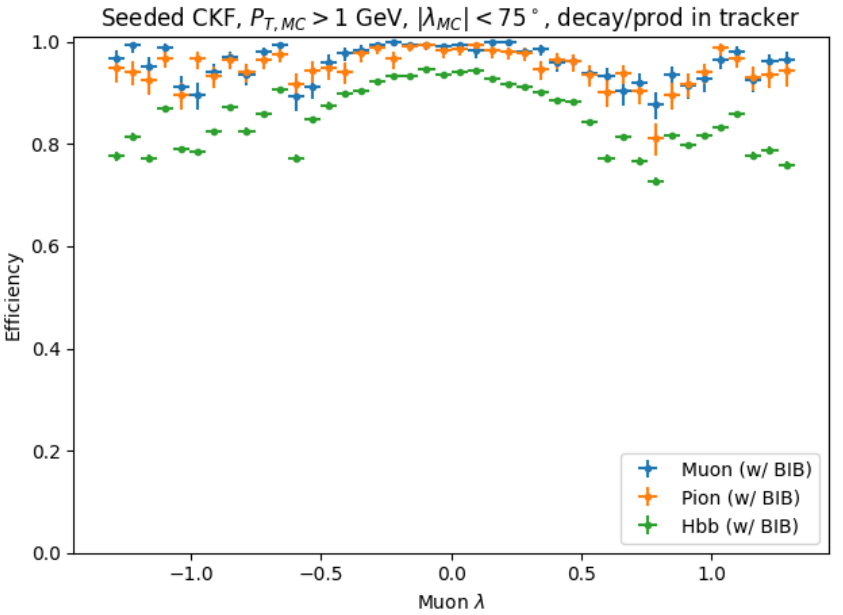
Tracker acceptance defines the denominator in efficiency plots.

Hits Found by CKF

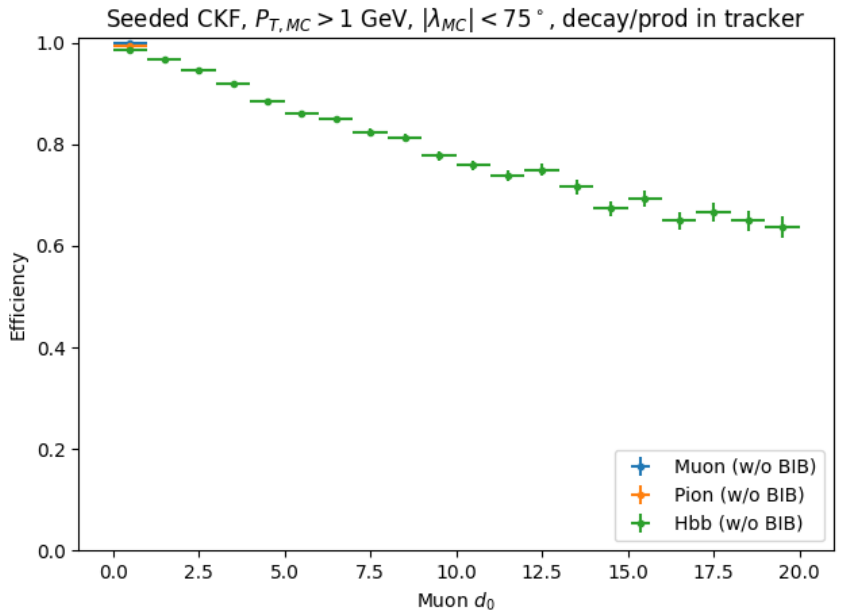


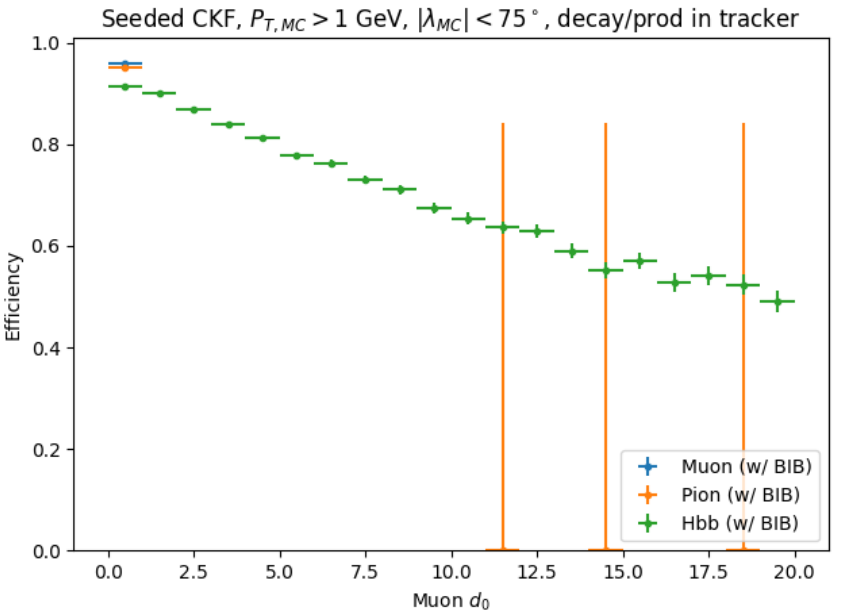


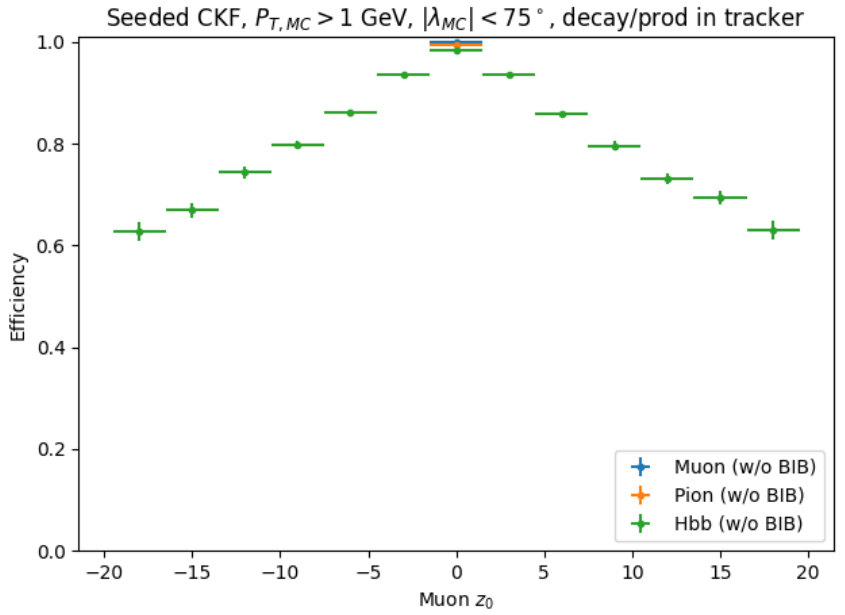


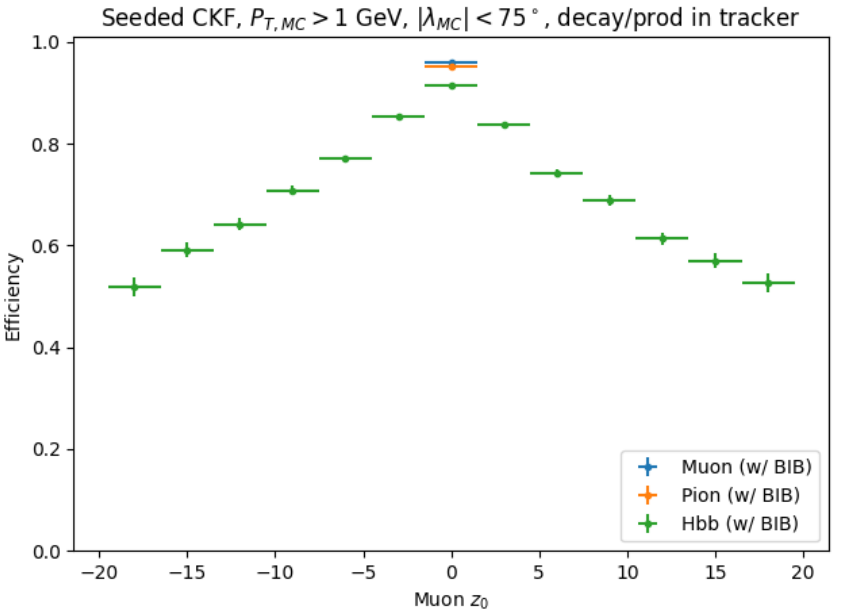


Hits Found by CKF





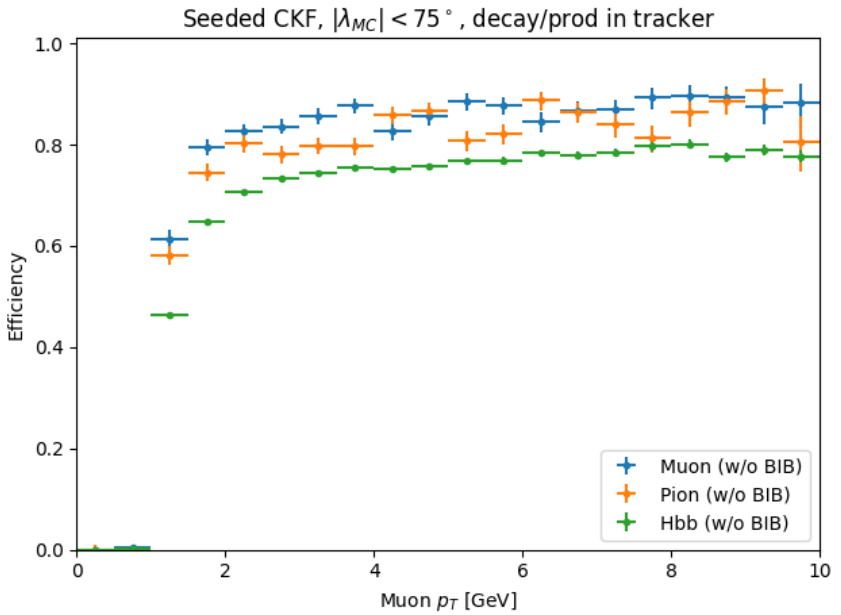


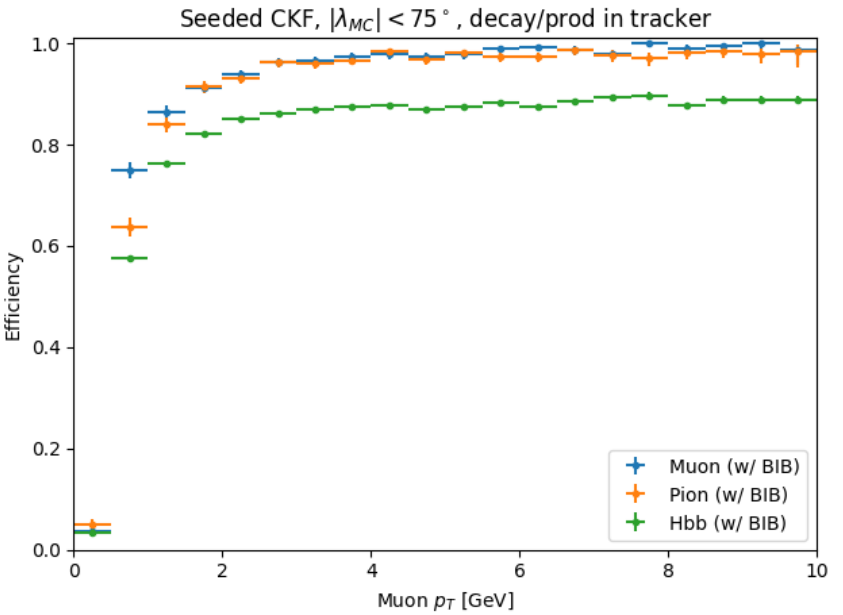


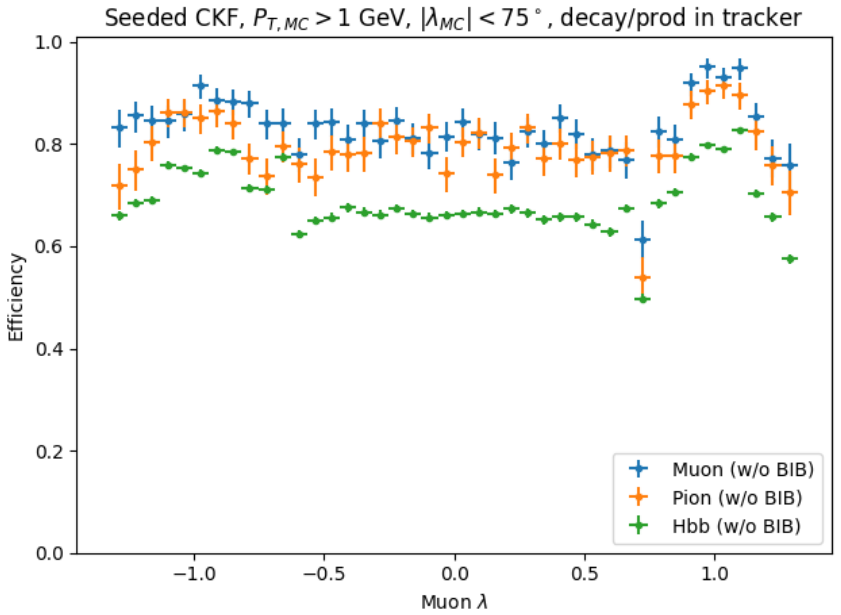
Removing The Fakes

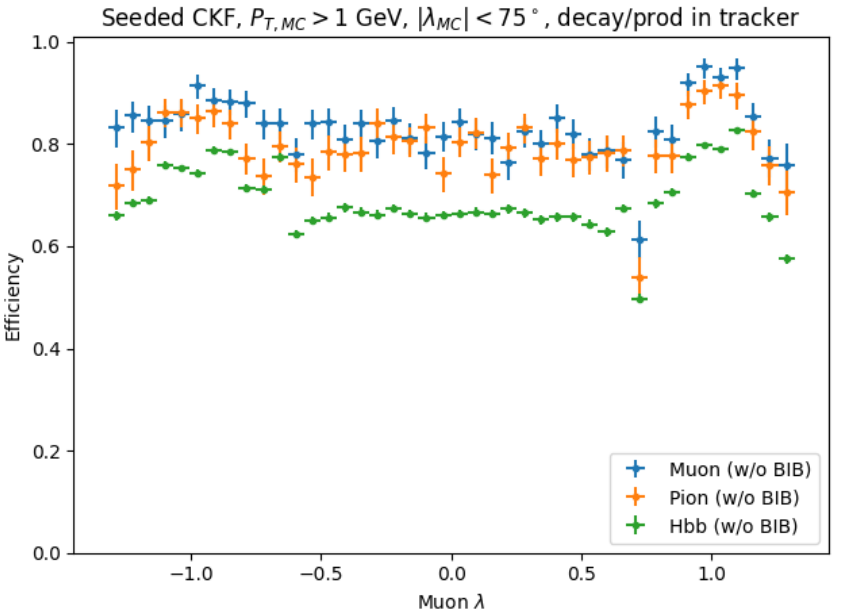
- Number of hits > 6
- Track p_T > 1 GeV

Hits Found by CKF

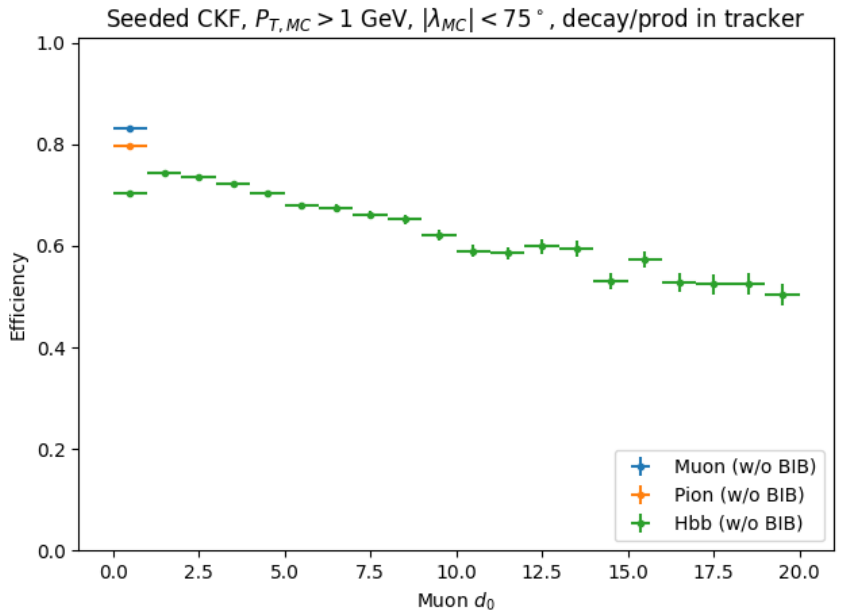


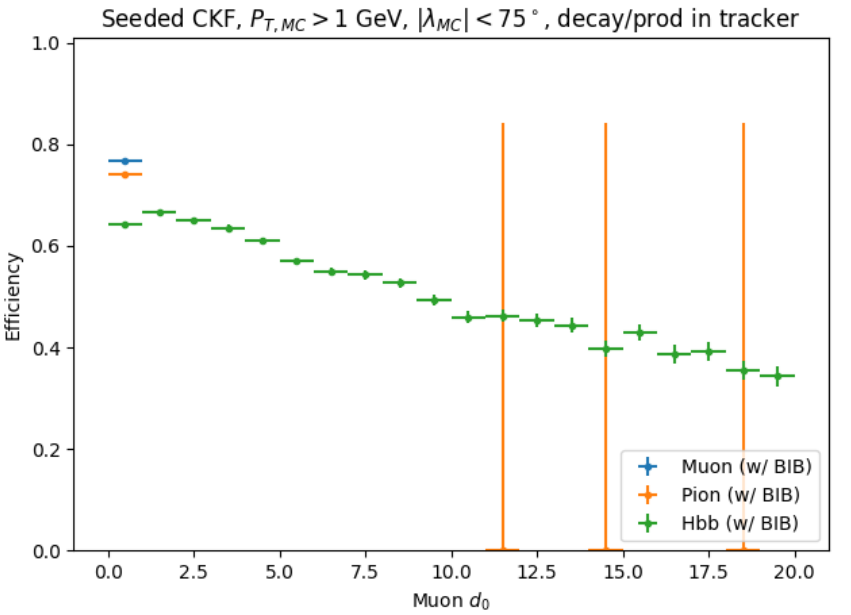


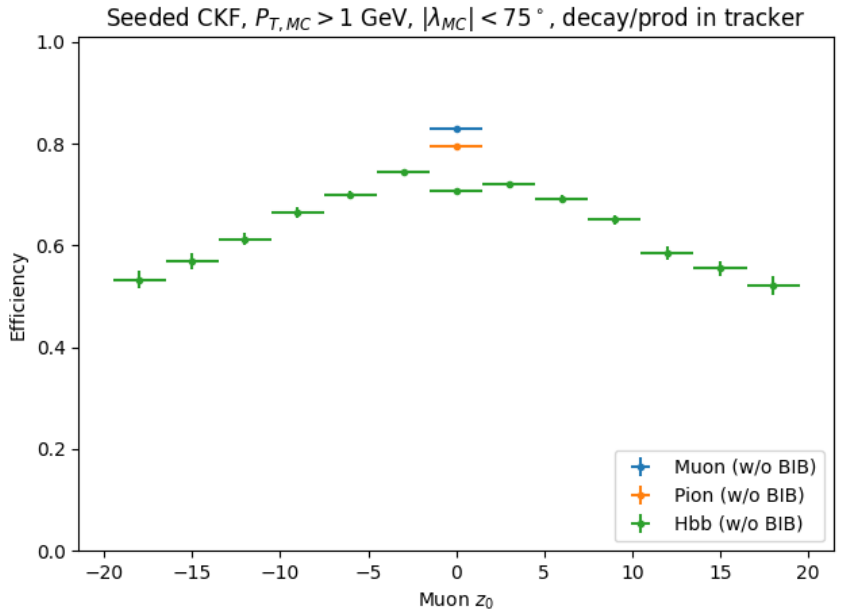


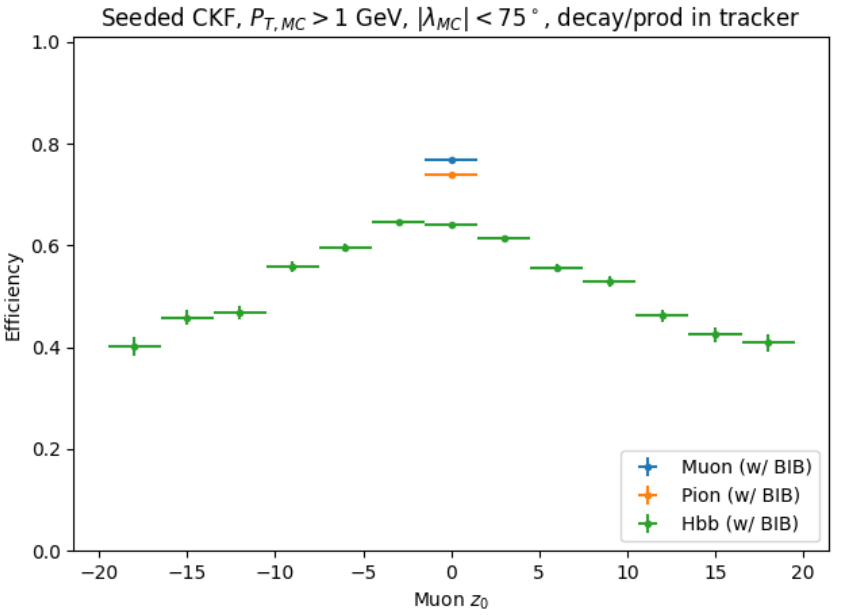


Hits Found by CKF

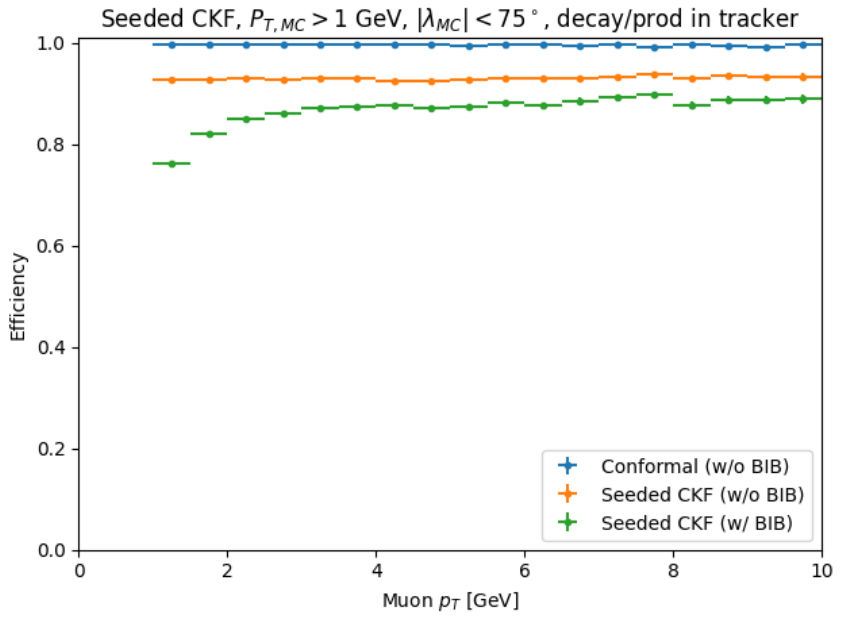


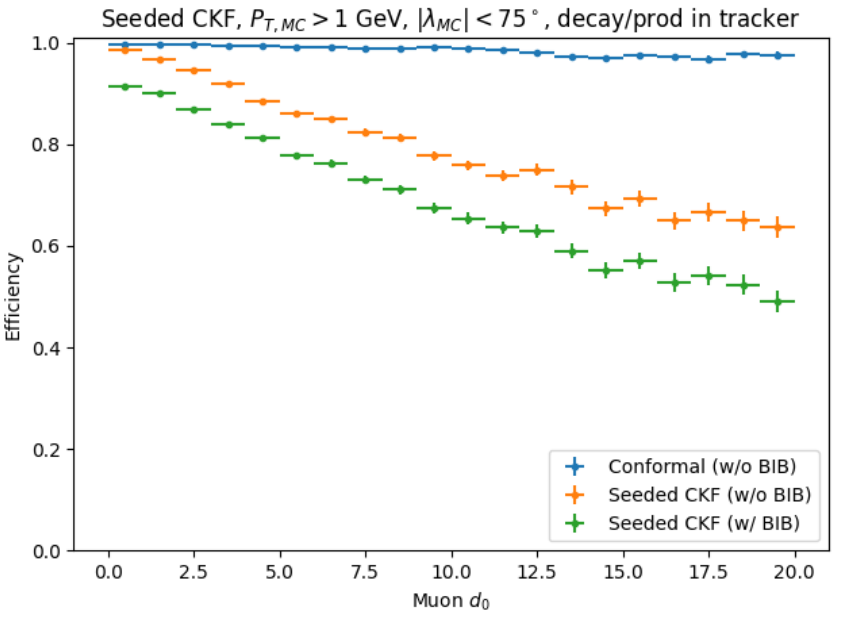




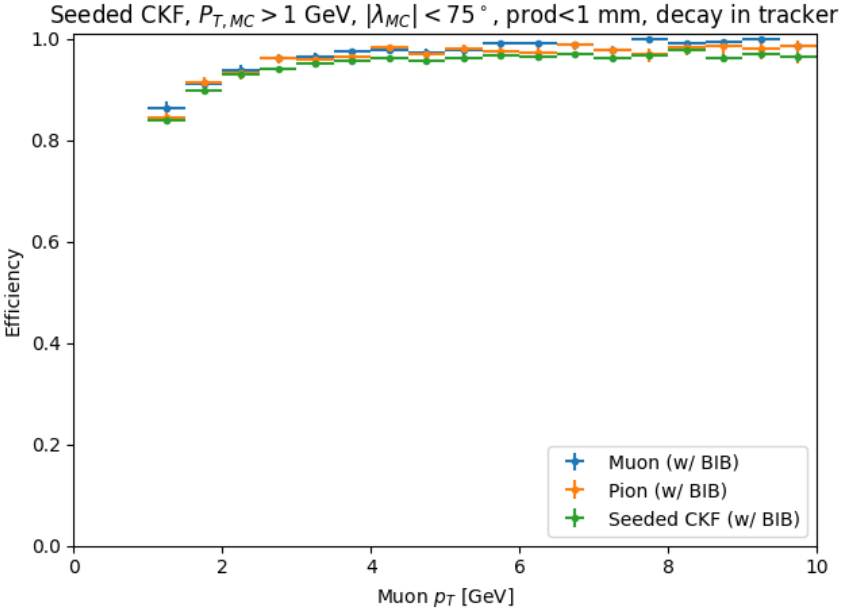


Comments on H→bb





- **No track cleaning in these plots**
- **Usable, but not ideal, efficiency for displaced tracks**
  - Result of tight seeding selection

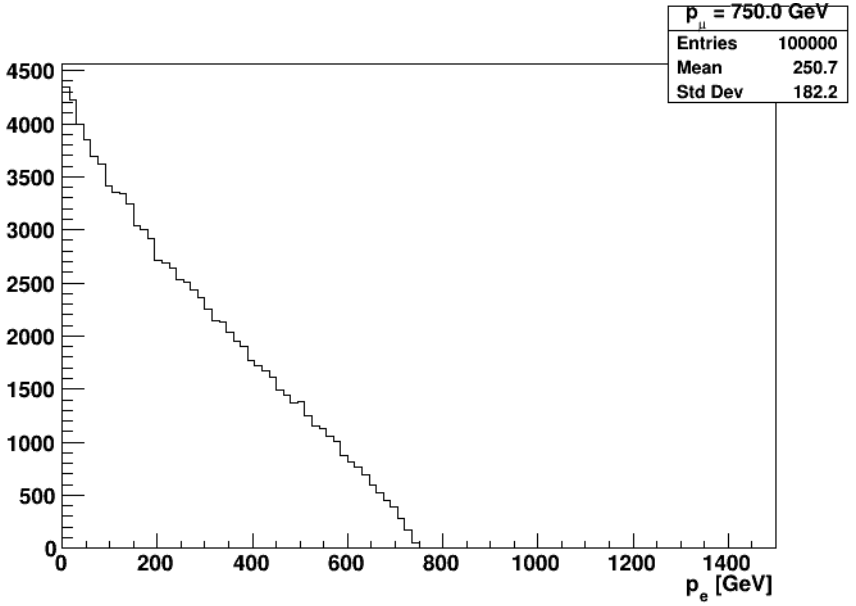


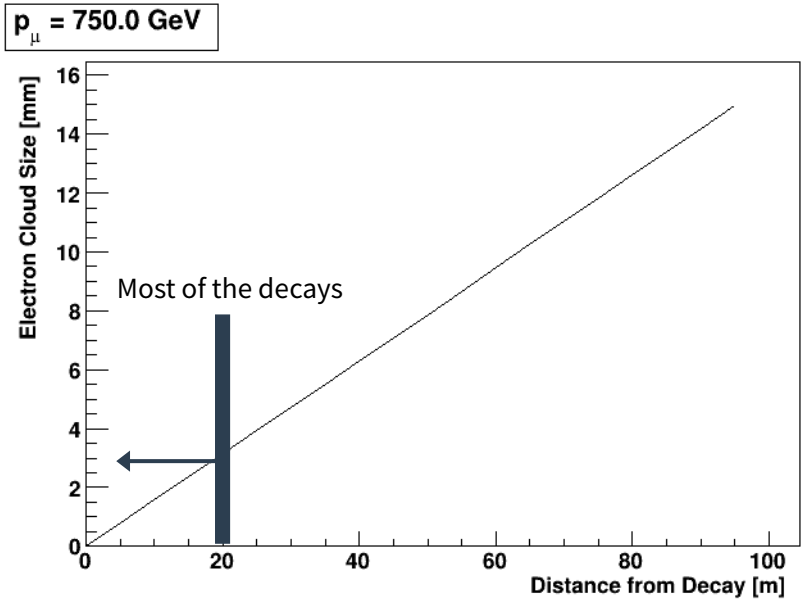
Conclusions

- **ACTS configuration that runs in 4 min / event in full BIB**
- **Key was to *heavily tighten* several settings**
  - *Starting point* for a future optimization
  - Surprisingly tracking efficiency not too bad (>80% for d_0<5mm)
- **Next include in MCC container for others to try out**
  - Currently missing extrapolation to calorimeter (used by pflow)
  - Meeting with Paolo + Nazar on Monday

BACKUP

Muon Decay Products





- **Simulated with TGenPhaseSpace**
- **Cloud is a bit smaller than nozzle**
  - Except possibly at the “narrowing” (not shown)