sPHENIX Offline Tracking Software

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Tracking software

From A. Frawley's Talk
https://indico.bnl.gov/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=2359

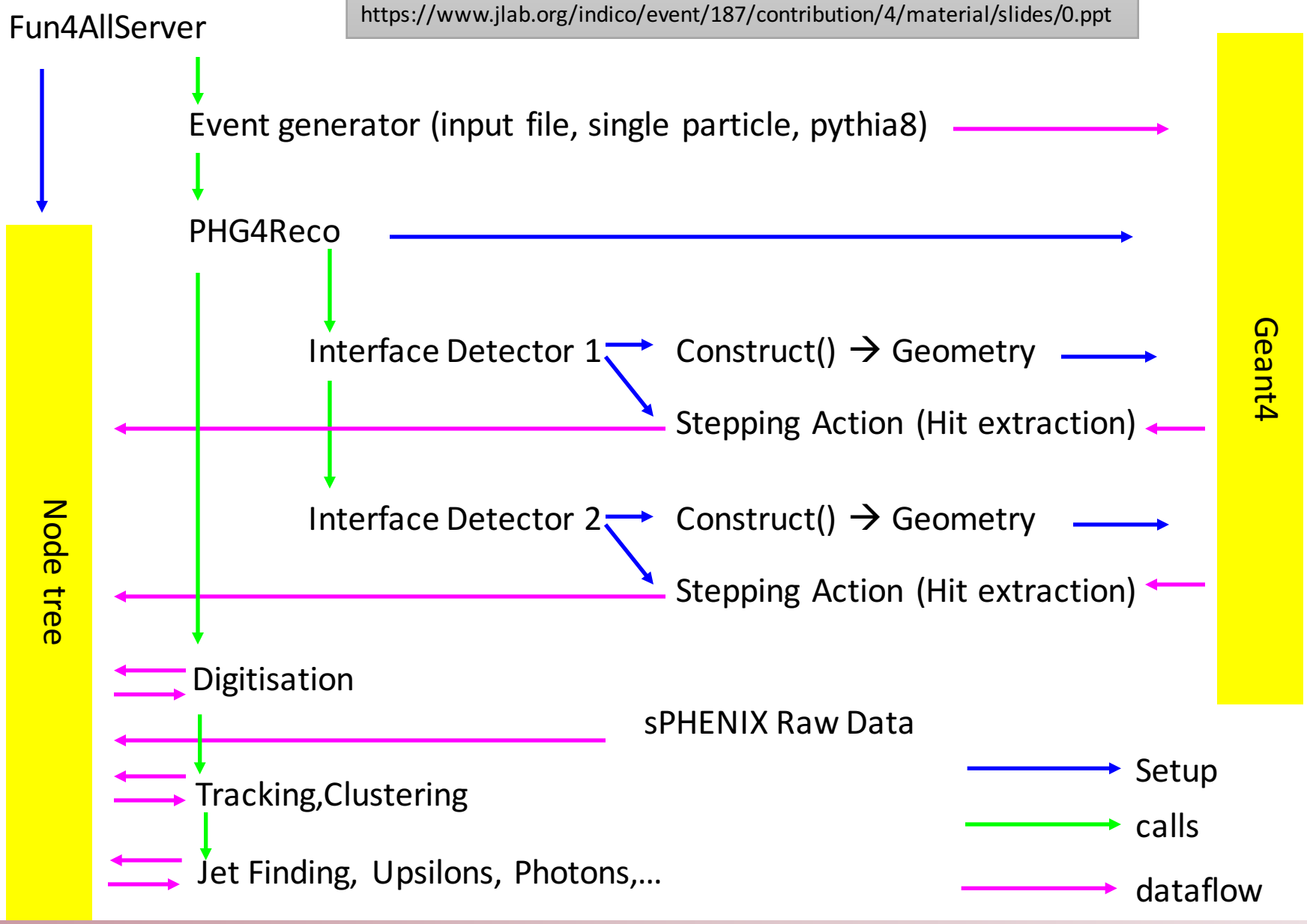
Start with G4 hits with energy loss, multiple scattering
- Digitize cell energy, apply threshold
- Cluster cell hits, apply threshold, estimate position uncertainties
- Clusters are input to tracker

Track:
- Hough transform to find tracks in helix parameter space
- Kalman filter to fit tracks
- Ghost rejection to reject duplicate tracks with poorer χ^2

Evaluation module to gather and crosslink diagnostic information
- Truth hits
  - With link to truth track
- Truth tracks
- Reconstructed track details
  - With link to dominant truth track
- Reconstructed clusters
  - With links to associated truth hits, truth track, reconstructed track

Ful4All frame work for sPHENIX

C. Pinkenburg's Talk:
https://www.jlab.org/indico/event/187/contribution/4/material/slides/0.ppt



PHG4Detector and PHG4Hits

class PHG4CylinderSubsystem : PHG4DetectorSubsystem : PHG4Subsystem : SubsysReco

- PHG4Detector* GetDetector()
- PHG4SteppingAction* GetSteppingAction()

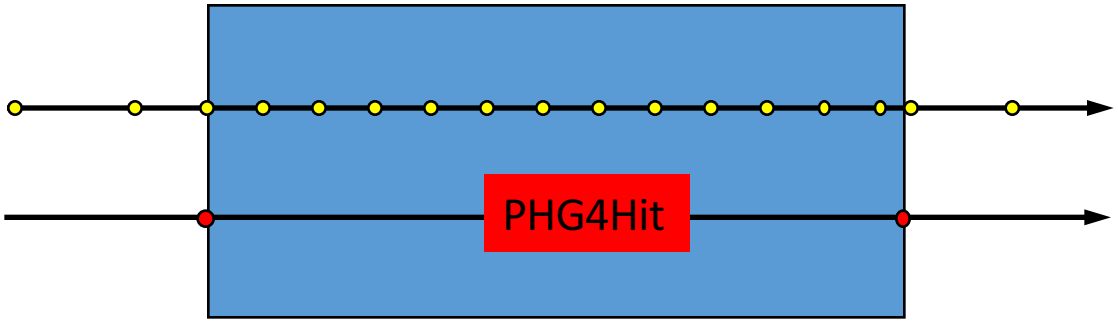
PHG4CylinderDetector : PHG4Detector

- Construct(G4LogicalVolume* world); // Implement the G4 geometry here

PHG4CylinderGeom

- Geometry related utilities.
- E.g. get detector parameter; translation from local to global.

PHG4Hit



Digitization

class PHG4CylinderCellReco : SubsysReco

- Position digitization
- PHG4HitContainer $\Longrightarrow$ PHG4CylinderCellContainer
- The TPC charge distortion is applied in this step

class PHG4SvtxDigitizer : SubsysReco

- Energy digitization
- PHG4CylinderCellContainer $\Longrightarrow$ SvtxHitMap

class PHG4SvtxClusterizer : SubsysReco

- Cluster nearby SvtxHits
- SvtxHitMap $\Longrightarrow$ SvtxClusterMap

Track finding and track fitting

class PHG4HoughTransformTPC : SubsysReco

- SvtxClusterMaps ⟹ SvtxTrackMap, SvtxVertexMap
- A master peace by A. Dion, maintained by M. McCumber later.

- Vote: fill the Helix Hough space histogram
- Cluster: get track seed from blobs in the Hough space
- findTracks: finalize from the Hough track seed:
  - sPHENIXTrackerTPC : HelixHough
    - n_layers < 10 : findTracksBySegments()
    - else : findTracksByCombinatorialKalman();
      - CylinderKalman : HelixKalman

- coresoftware/offline/packages/HelixHough

class PHG4KalmanFitter : SubsysReco

- SvtxTrackMap ⟹ SvtxTrackMapRefit
- SvtxVertexMap ⟹ SvtxVertexMapRefit
- Kalman Filter based on GenFit2
  - https://github.com/GenFit/GenFit
  - Realistic material effect and realistic magnetic field
- Vertexing based on RAVE (temp)
  - https://rave.hepforge.org

Evaluator

SvtxEvaluator : SubsysReco

- SvtxEvalStack
  - SvtxTrackMap, SvtxVertexMap, etc $\Longrightarrow$ Evaluation ROOT NTuples

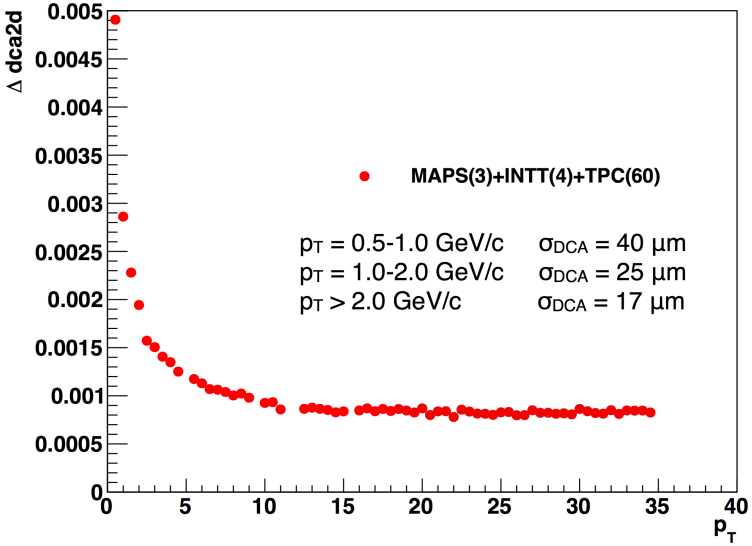
- ROOT NTuples contains crosslink diagnostic information for clusters, tracks, vertices, etc.

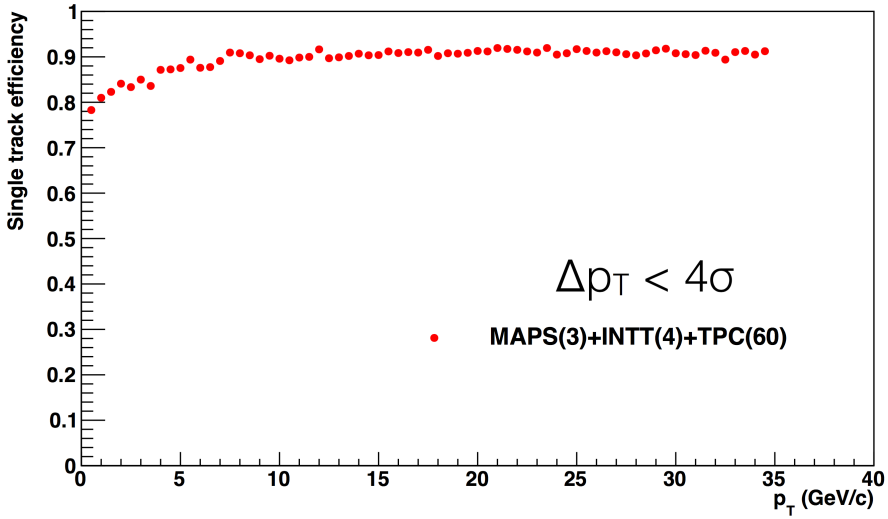
Macro that steers all the modules:

- https://github.com/sPHENIX-Collaboration/macros/blob/master/macros/g4simulations/G4_Svtx_maps%2BIT%2Btpc.C

DCA2d and tracking efficiency

From A. Frawley's Talk
https://indico.bnl.gov/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=2359





For the heavy flavor jet tagging study, we are focusing on the low pT region, 0.5~1.5 GeV. Where the DCA2d core sigma is ~40micron and tracking efficiency is ~80% (pT matching method)

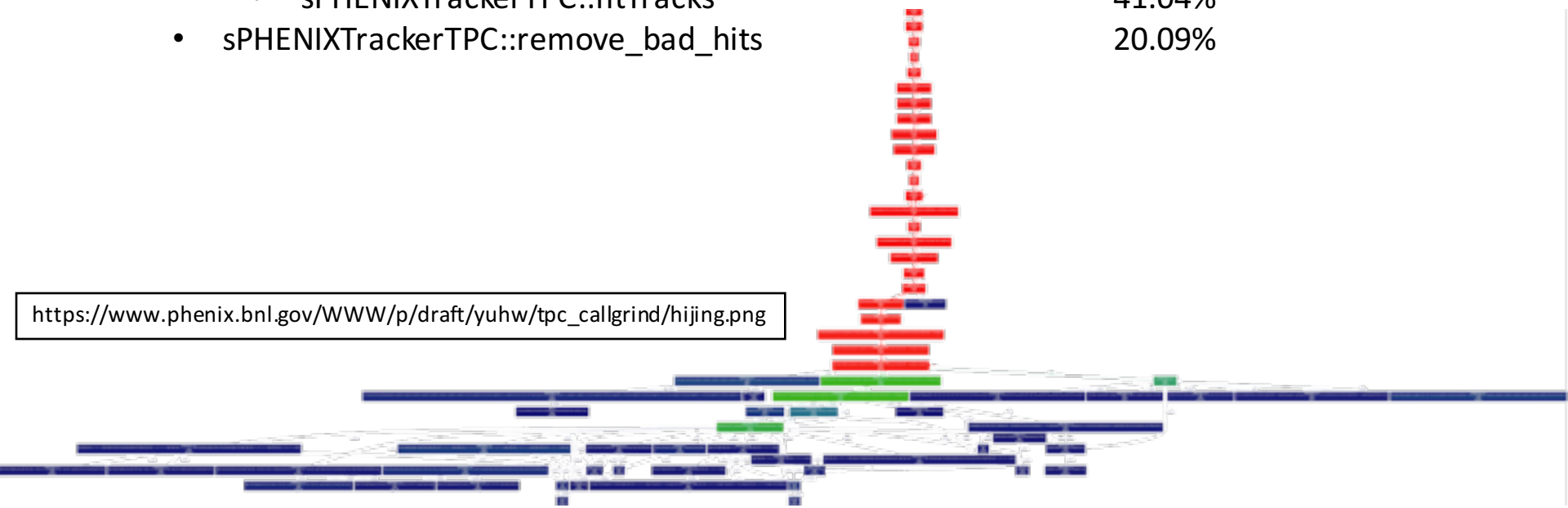
Profiling for Central Hijing

Thanks to C. Pinkenburg!

The current tracking takes ~30min to process 1 central Hijing embedding events.

sPHENIXTrackerTPC::full_tracking_and_vertexing	97.61%
• HelixHough::vote	34.42% (15.84%)
• • HelixHough::fillBins	9.83%
• HelixHough::makeClusters	12.22%
• sPHENIXTrackerTPC::findTracks (X 3.1M times)	48.18%
• • sPHENIXTrackerTPC::findTracksByCombinatorialKalman	48.15%
• • • sPHENIXTrackerTPC::fitTracks	10.65%
• • • • sPHENIXTrackerTPC::fitTracks	41.04%
• • • sPHENIXTrackerTPC::remove_bad_hits	20.09%

https://www.phenix.bnl.gov/WWW/p/draft/yuhw/tpc_callgrind/hijing.png



MAPS+INTT+TPC Hijing 200k sample

Thanks to C. Pinkenburg!

- 20 GeV Jets embedded in 0-4fm central Hijing events.

- Library:

https://github.com/HaiwangYu/coresoftware/tree/b_jet_tagging_pro_01
Same as sPHENIX:master @ Jan. 19, 2017

- Macros:

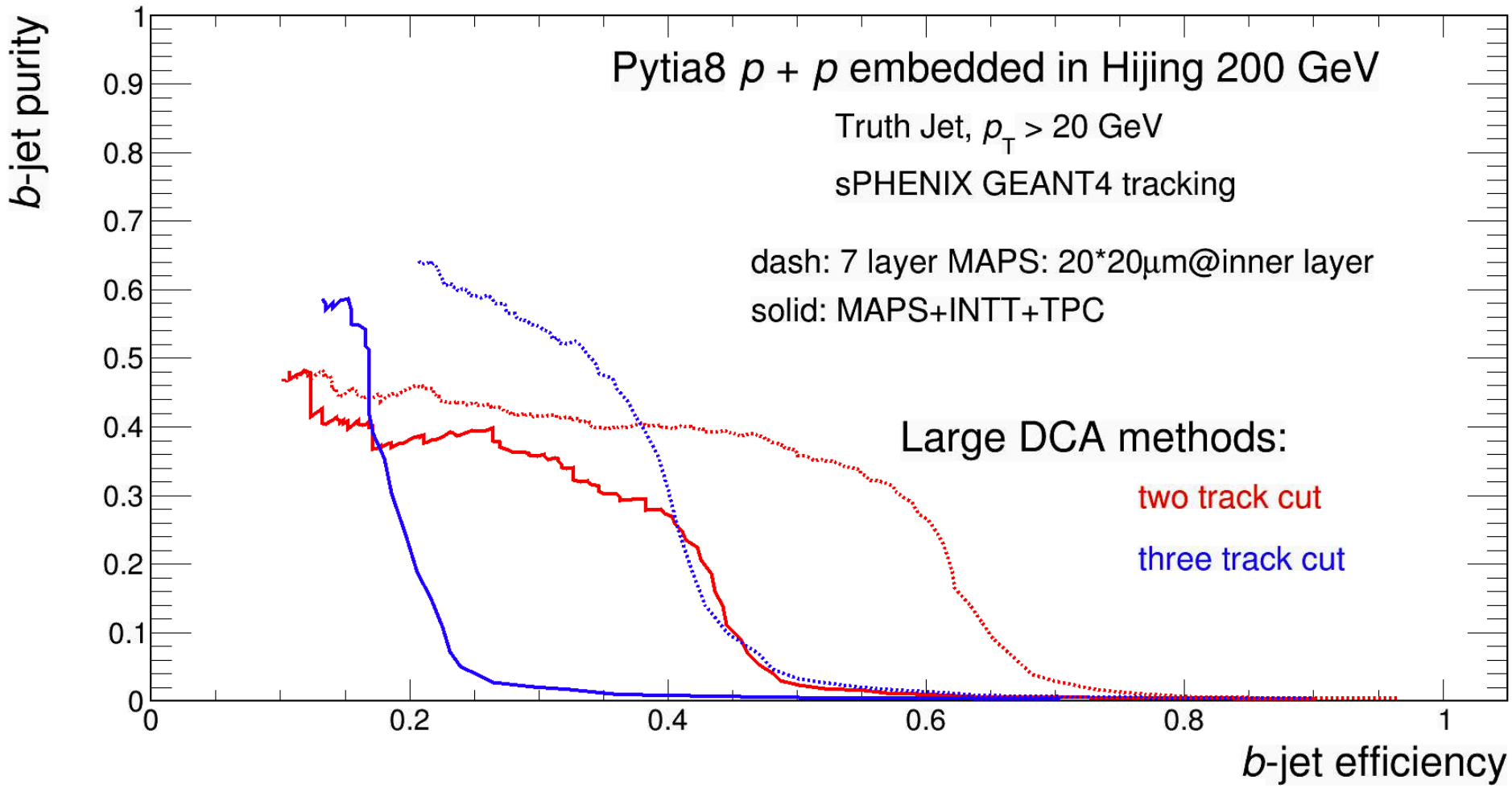
https://github.com/HaiwangYu/macros/tree/b_jet_tagging_pro_01

- TPC reco::do_charge_distortion = false; //Isolate this for now with future studies
- PHG4Reco::save_DST_geometry = true; //For GenFit refitting

- Output location:

- /sphenix/user/yuhw/taxi/BJetTagging/output/tracking_1/hijing_pro_1_anatrain_part_?/SvtxTracks_*.root

MAPS+INTT+TPC vs. 7-layer MAPS configuration

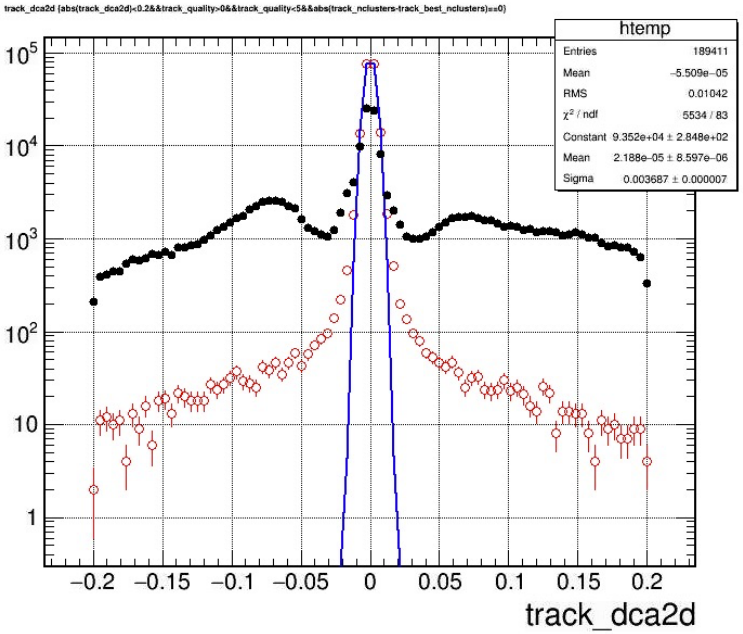


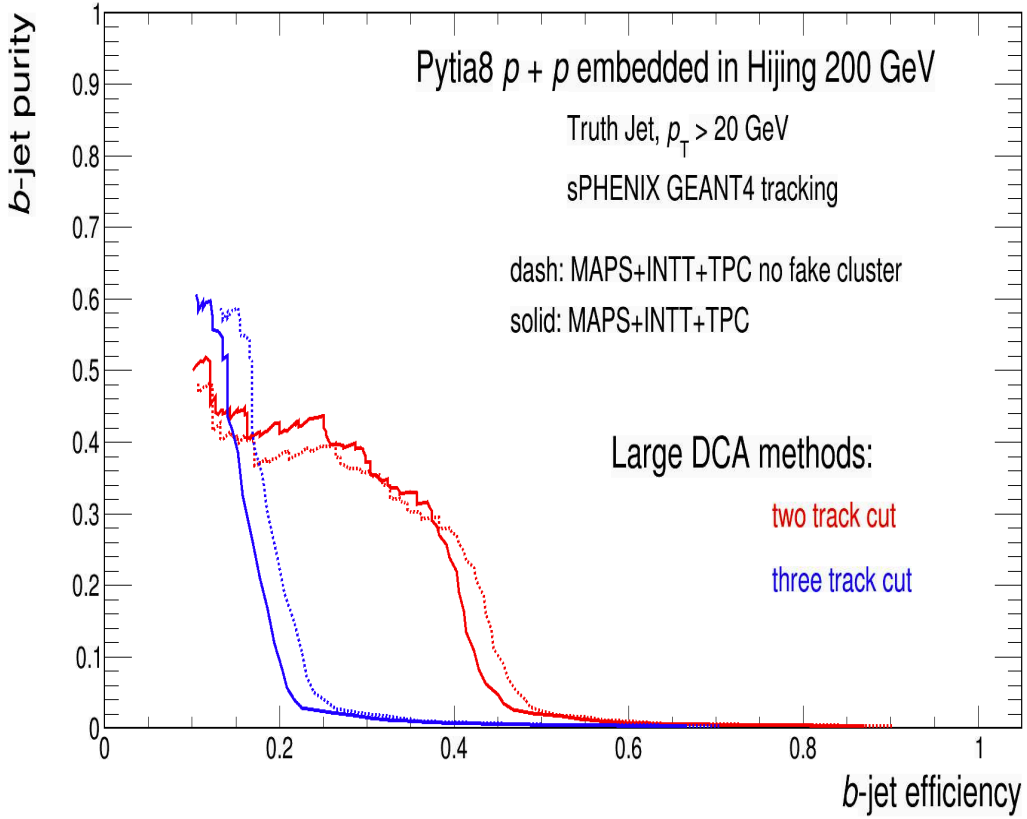
details on the 7-layer MAPS results:

https://indico.bnl.gov/getFile.py/access?contribId=8&sessionId=0&resId=0&materialId=slides&confId=2641

MAPS+INTT+TPC, reject tracks with fake clusters

Black: all tracks
Red: reject tracks with fake clusters



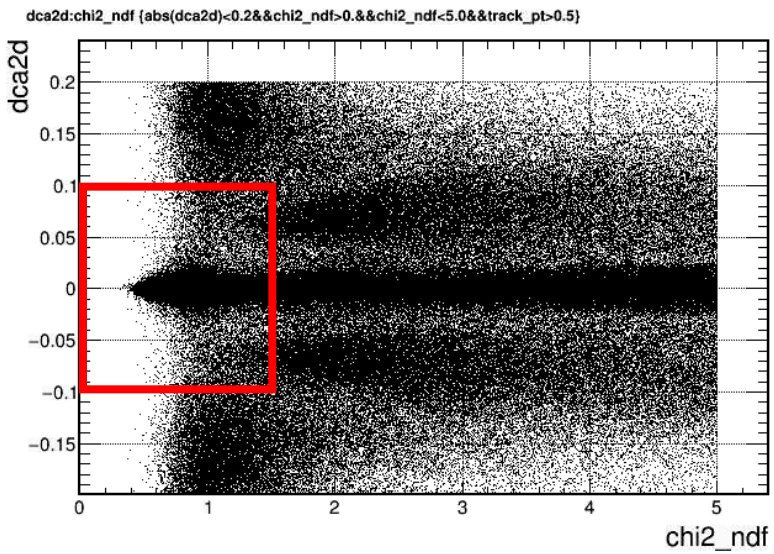


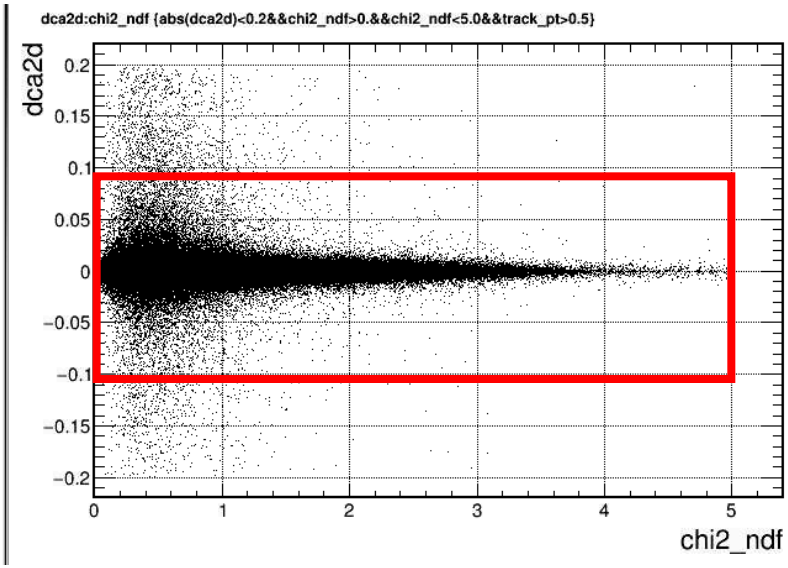
Track selection

MAPS+INTT+TPC

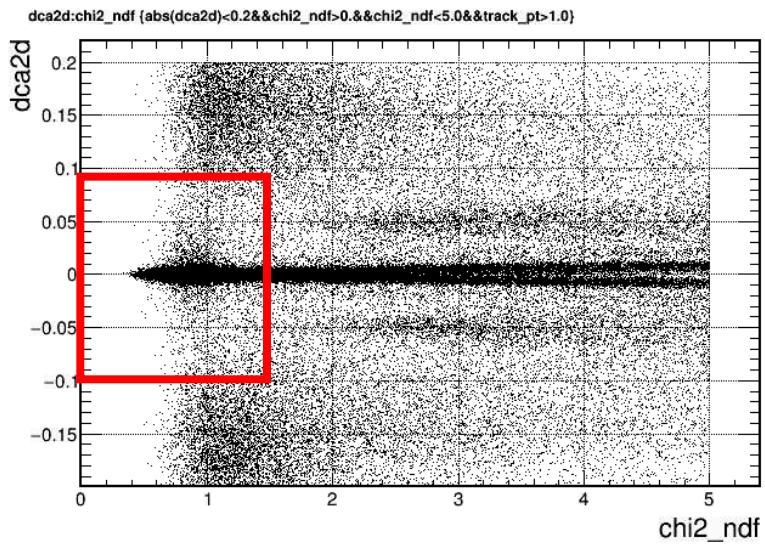
7-Layer MAPS

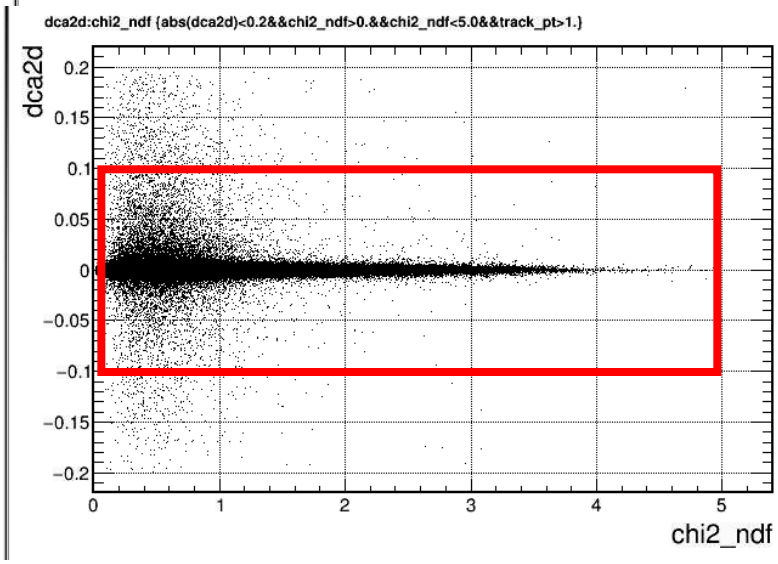
pT>0.5





pT>1.0

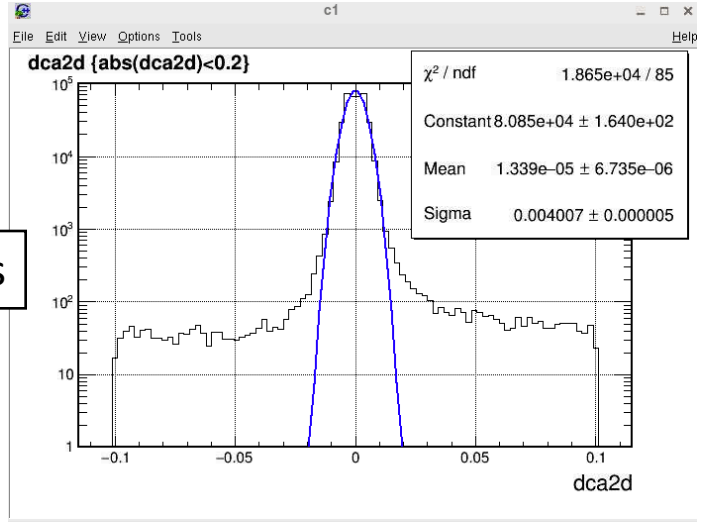




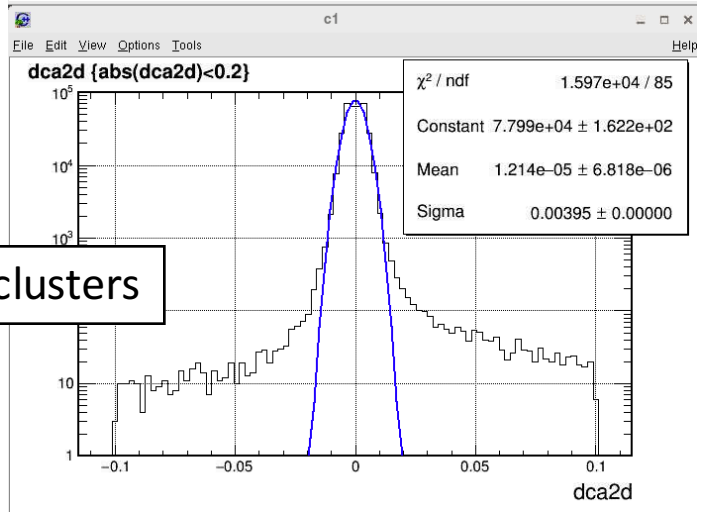
DCA2d

MAPS+INTT+TPC

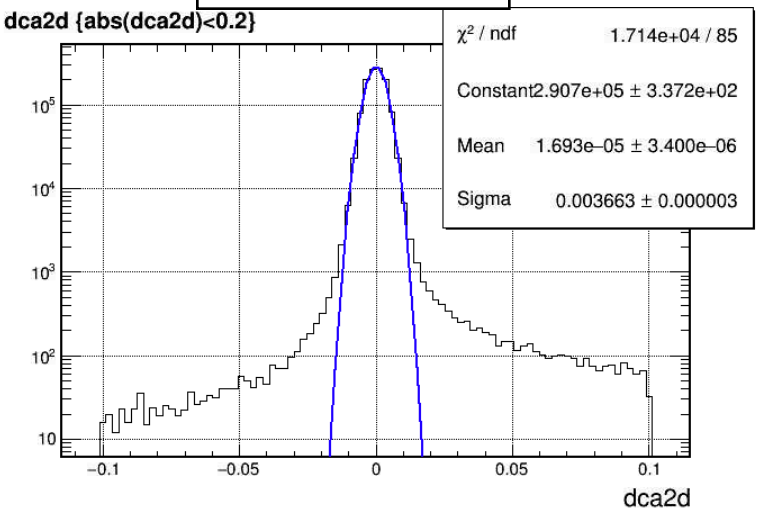
All tracks



No fake clusters



7-Layer MAPS



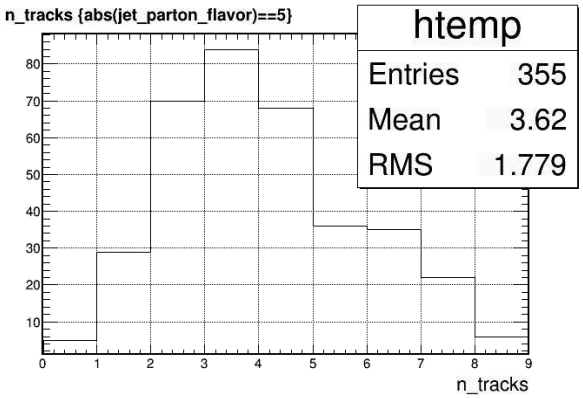
Tracks in the jet cone, efficiency

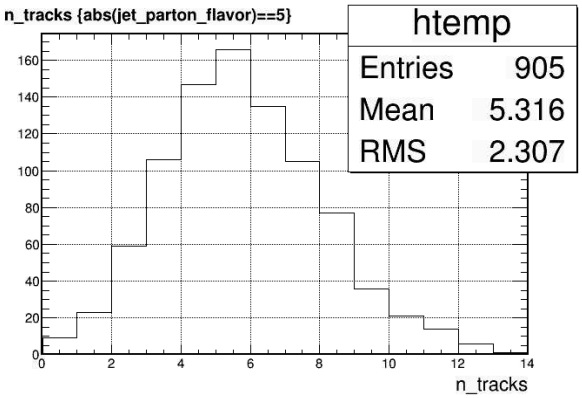
track chi2/ndf < 1.5
|track dca2d| < 1 mm
track pT > 1.0 GeV

MAPS+INTT+TPC

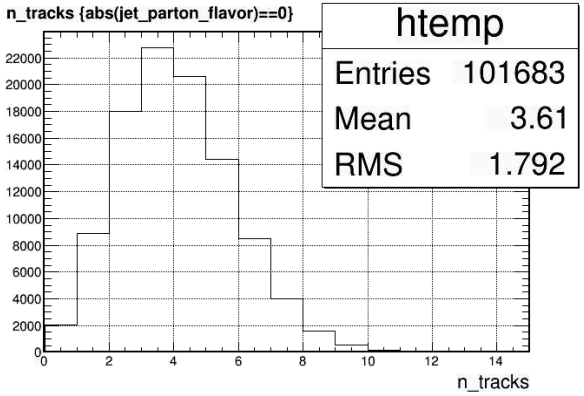
7-Layer MAPS

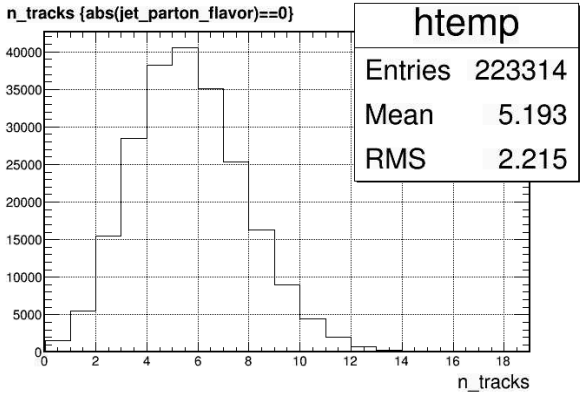
b-jet





l-jet



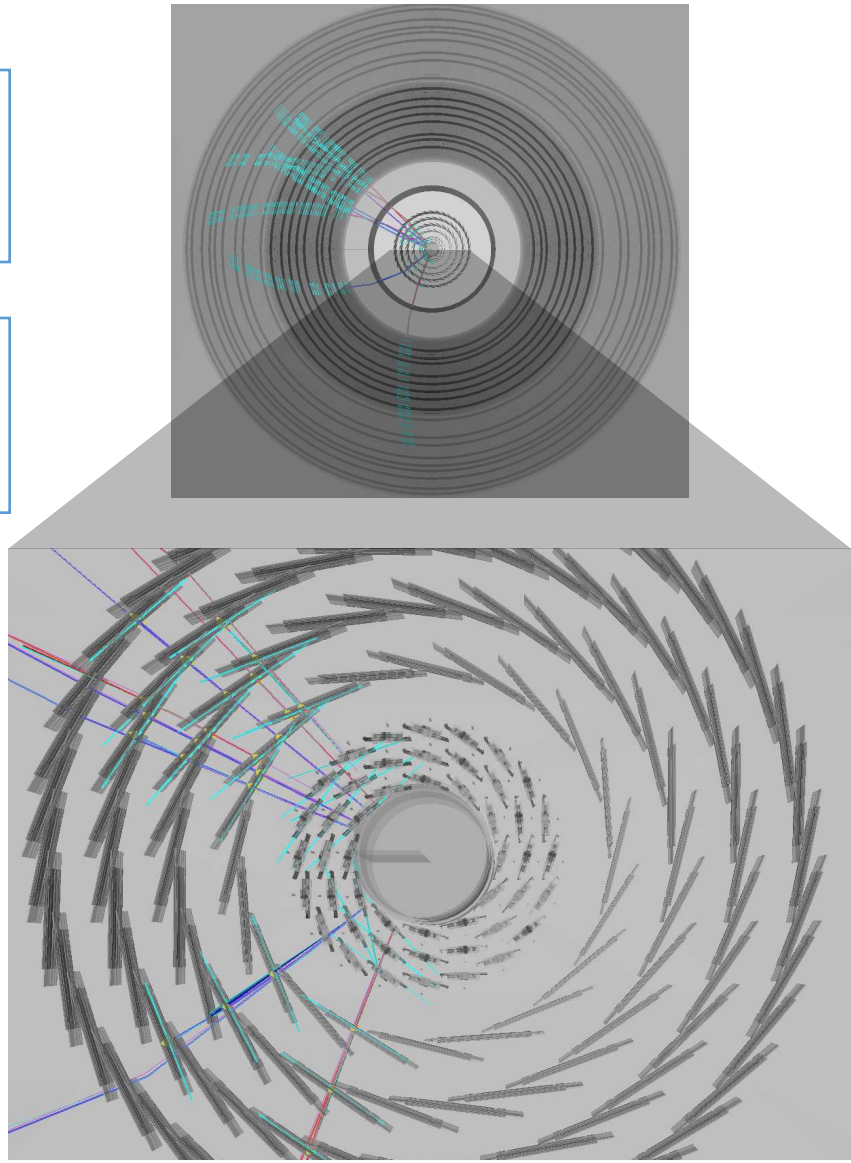


Laddered geometry for MAPS+INTT

Laddered MAPS by A. Frawley
- https://github.com/sPHENIX-Collaboration/coresoftware/pull/218

Ladderd INTT by G. Mitsuka
- https://github.com/sPHENIX-Collaboration/coresoftware/pull/219

Could be used in the full proposal.



Summary

- The tracking simulation software for cylindrical MAPS+INTT+TPC is ready to use and showed good performance. Things needs to be improved:
  - Speed: fine tuning of the zoom profile? Adapt Star's tracking software?
  - Low momentum tracking efficiency

- A sample of 200k Pythia 20GeV Jet embedded in Hijing events almost finished production:
  - /sphenix/user/yuhw/taxi/BJetTagging/output/tracking_1/hijing_pro_1_anatrain_part_?/SvtxTracks_*.root

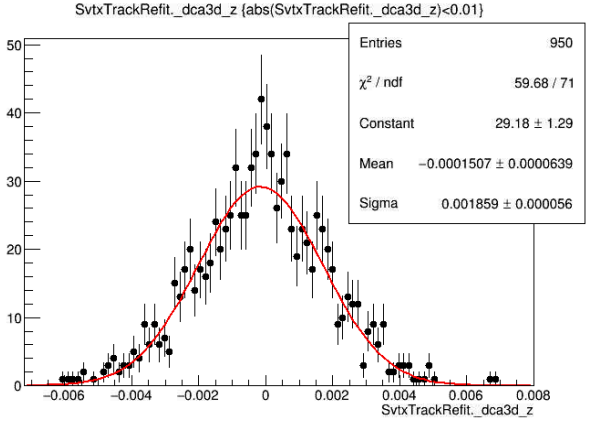
- b-jet tagging for MAPS+INTT+TPC: large DCA track counting method
  - The DCA shape, core width, tail is comparable with the 7-layer MAPS
  - However the number of tracks reconstructed within the jet cone decreased to 70% of the 7-layer MAPS and that hurt the performance by 20%.

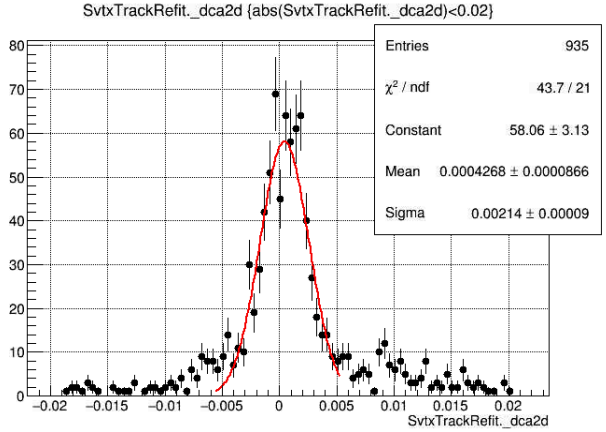
- The laddered geometry was implemented and under testing. Planning to use in the full proposal.

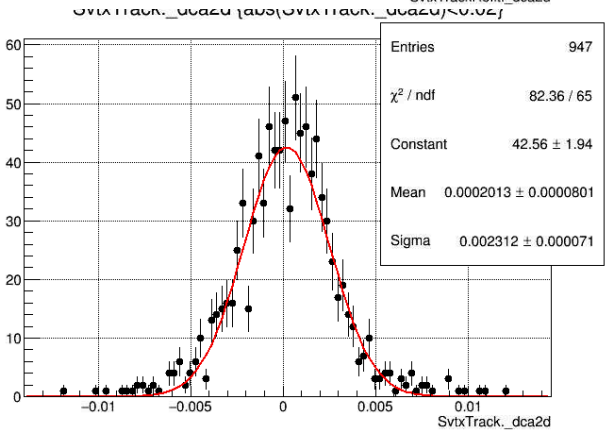
Backups

Laddered MAPS+INTT+TPC DCA3d

2GeV







Helix Hough Zoom Profile

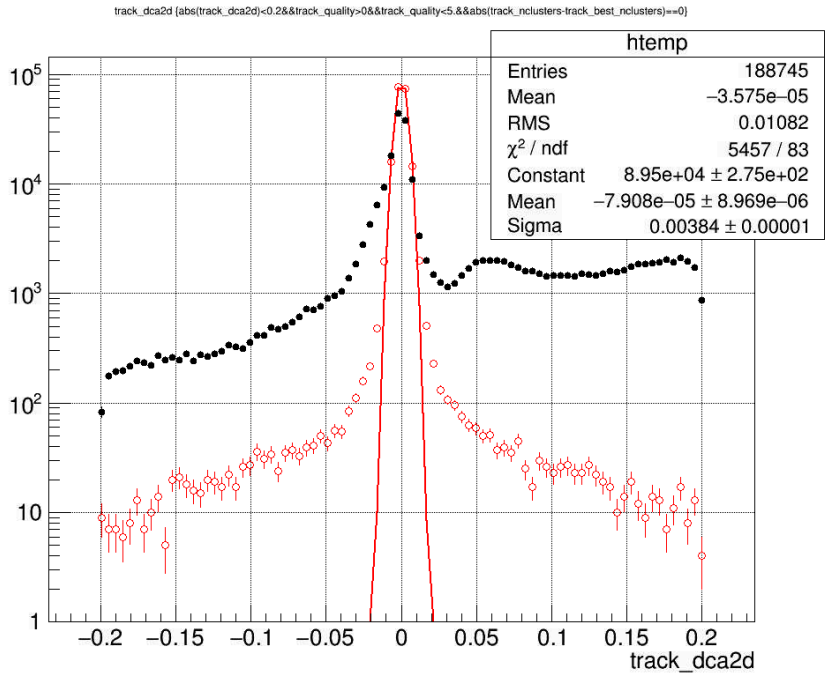
```
HelixRange top_range( 0.0, 2.*M_PI,            // center of rotation azimuthal angles
                      -0.1, 0.1,  // 2d dca range
                      0.0, kappa_max,          // curvature range
                      -0.9, 0.9,               // dzdl range
                      -0.1, 0.1);   // dca_z range
```

https://github.com/sPHENIX-Collaboration/coresoftware/blob/master/simulation/g4simulation/g4hough/PHG4HoughTransformTPC.C#L797

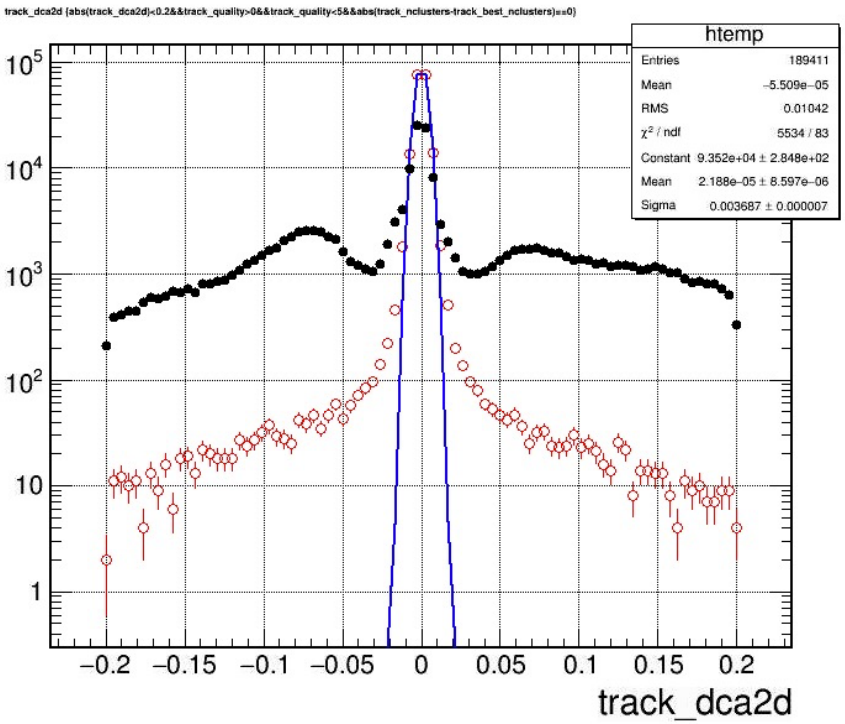
DCA2d tail

Black: all tracks
Red: reject tracks with fake clusters

Original



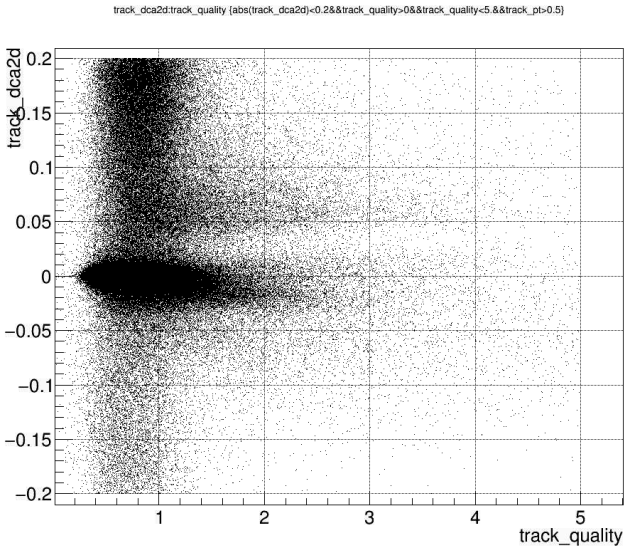
Refitting

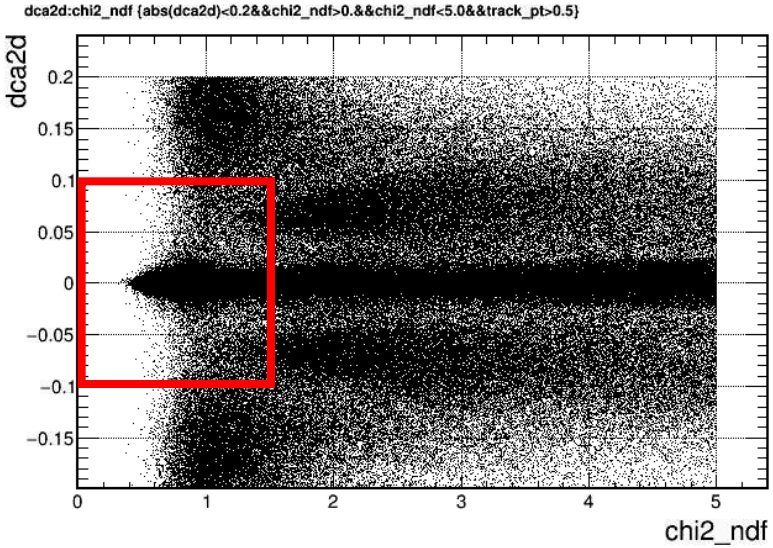


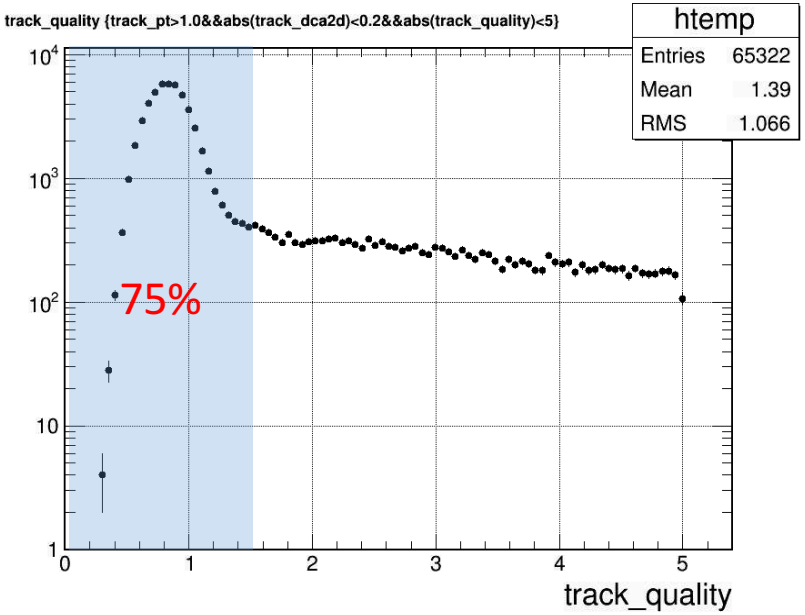
Original

Refitting

pT>0.5

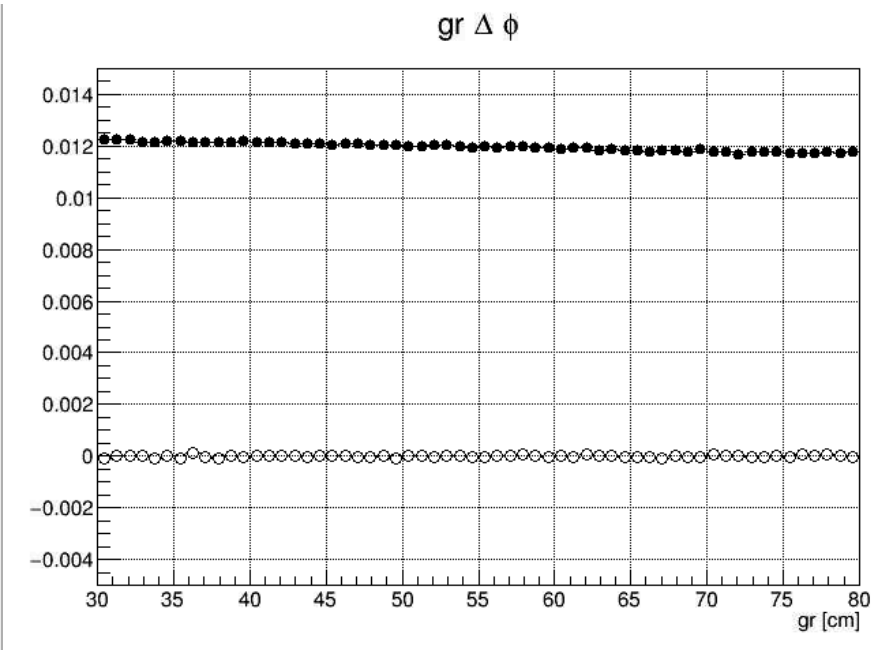




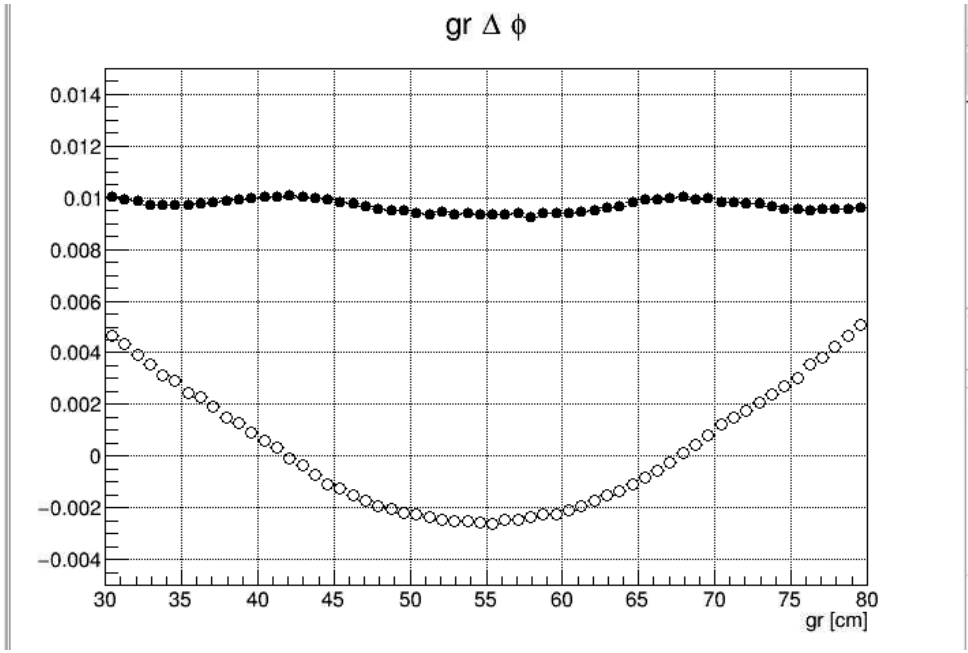


Cluster selection bias

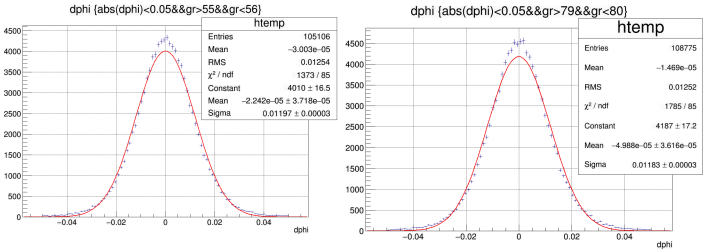
40GeV muon

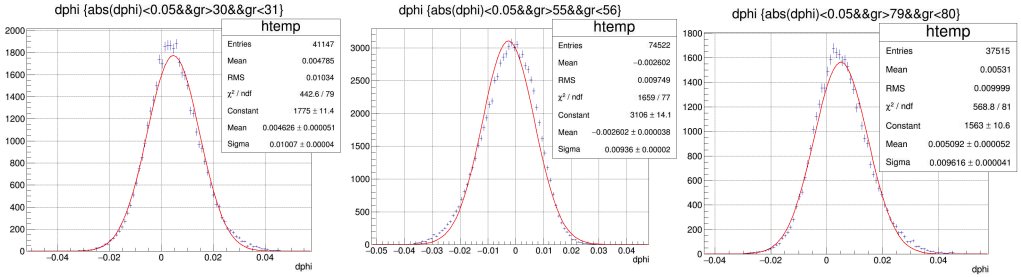


inclusive cluster eval

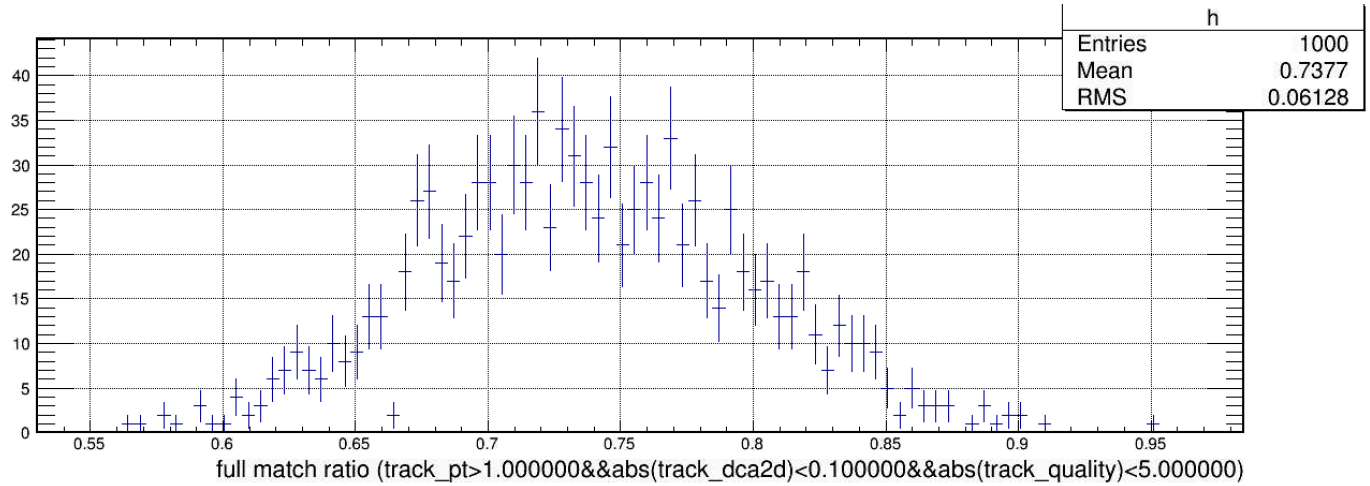
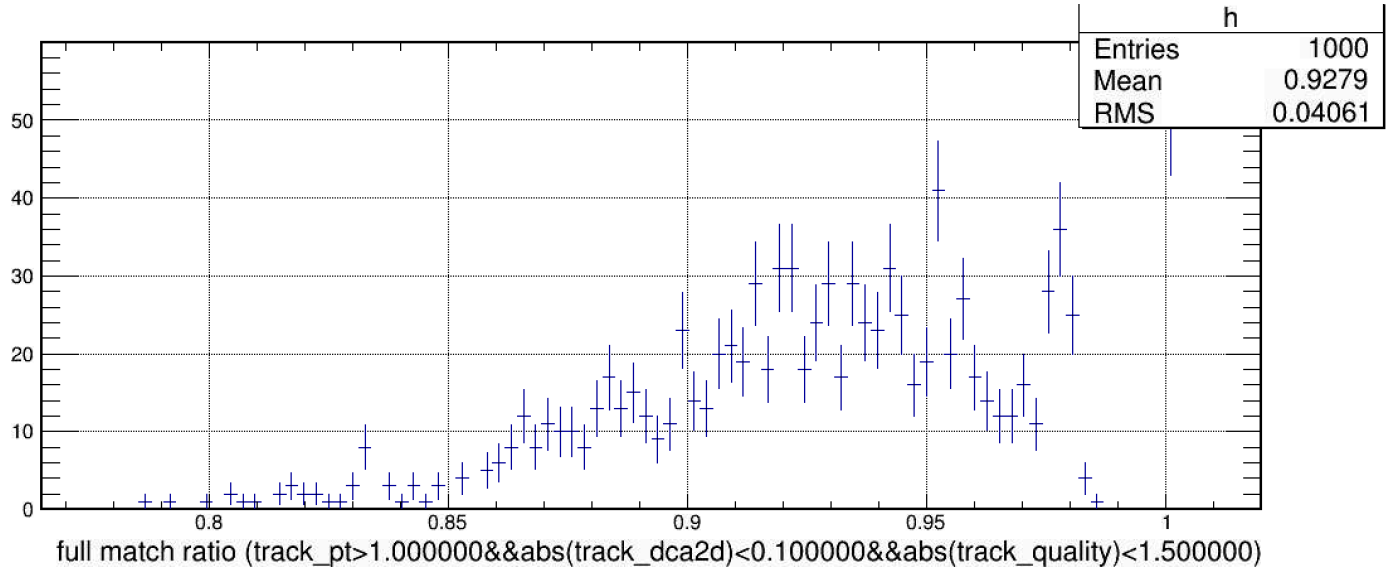


clusters used in track fitting





chi2/ndf<5



chi2/ndf<1.5