A “vector finder” approach to track reconstruction in the Inner Tracking System of MPD/NICA

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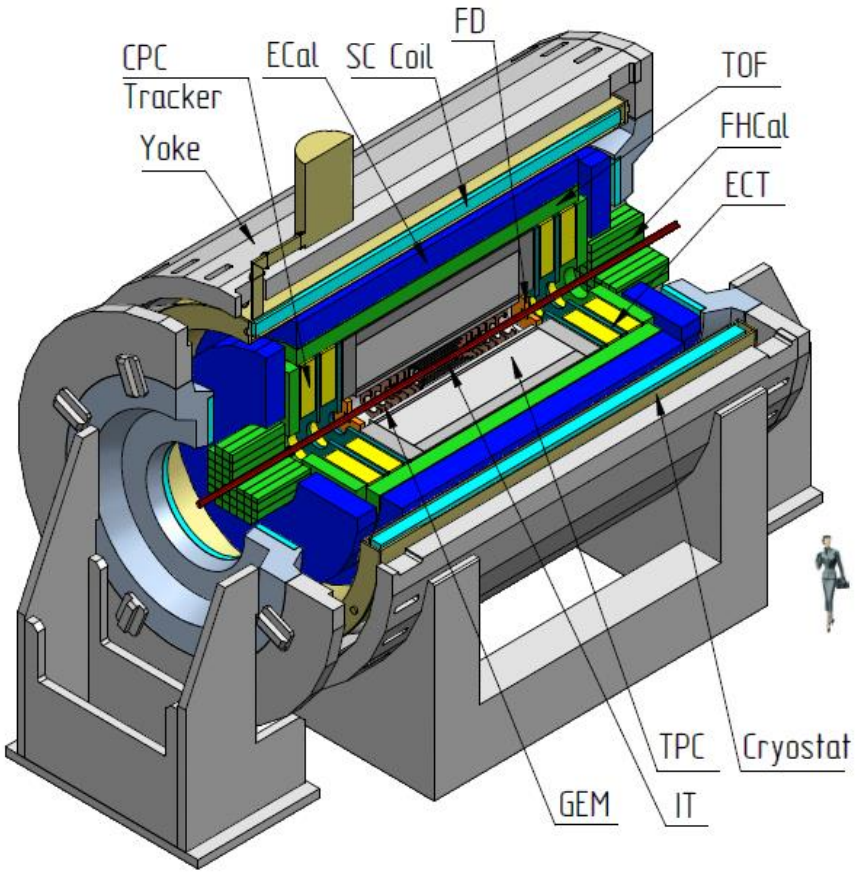
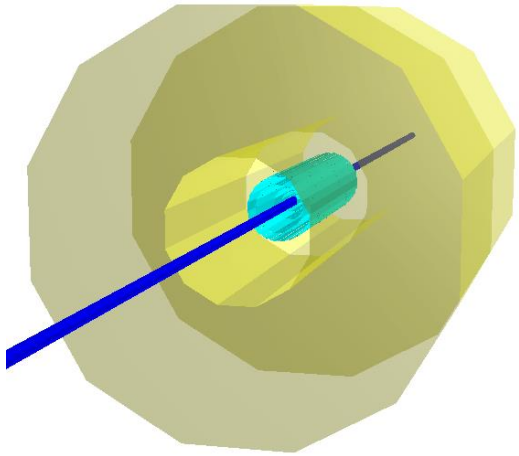
Outline

- Introduction
- Vector Finder approach
- Algorithm performance for Box and UrQMD generators
- TPC and ITS track matching
- Conclusion

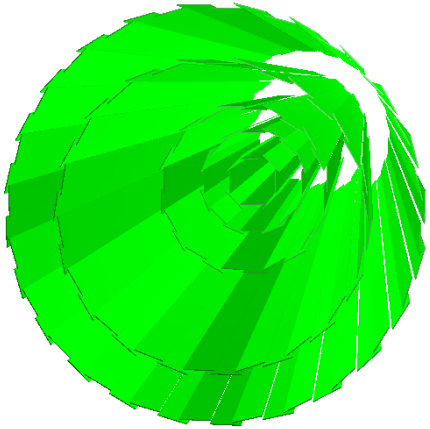
MPD, TPC&ITS geometry



MPD/NICA general design scheme

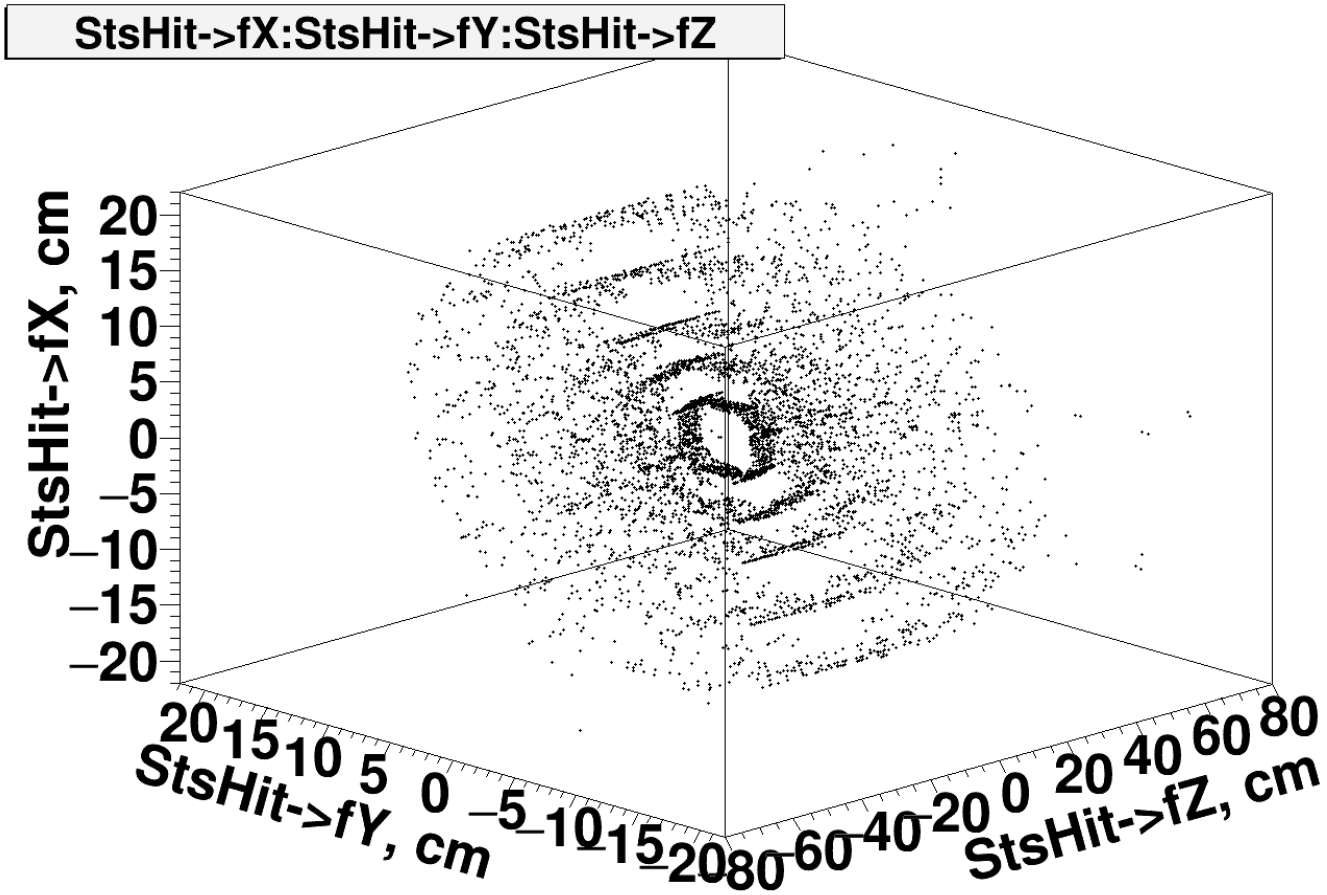


TPC and ITS geometry



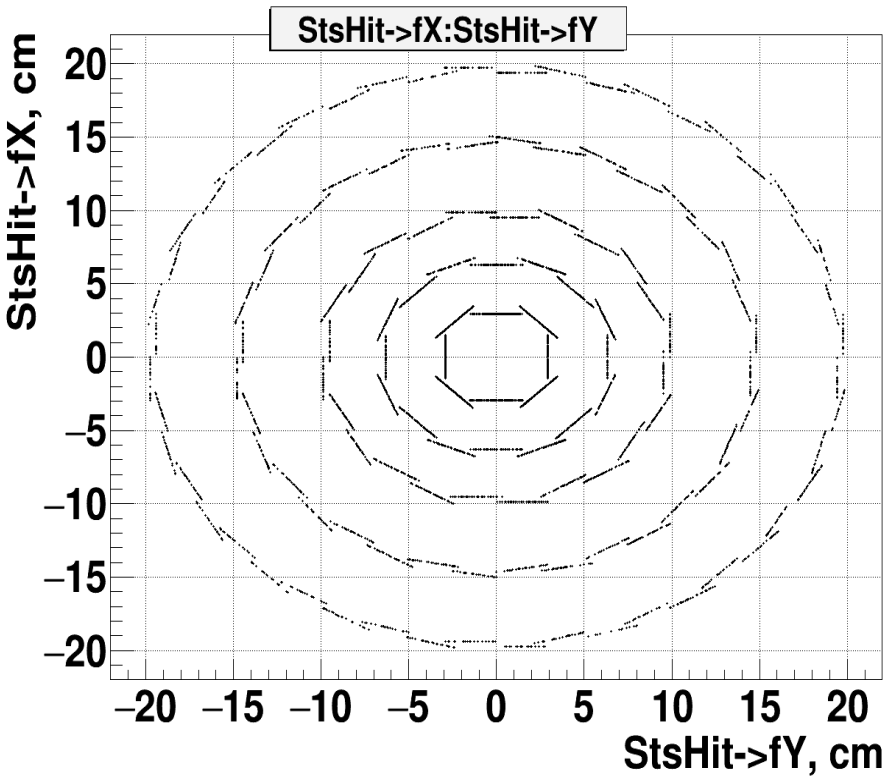
5-layer ITS geometry

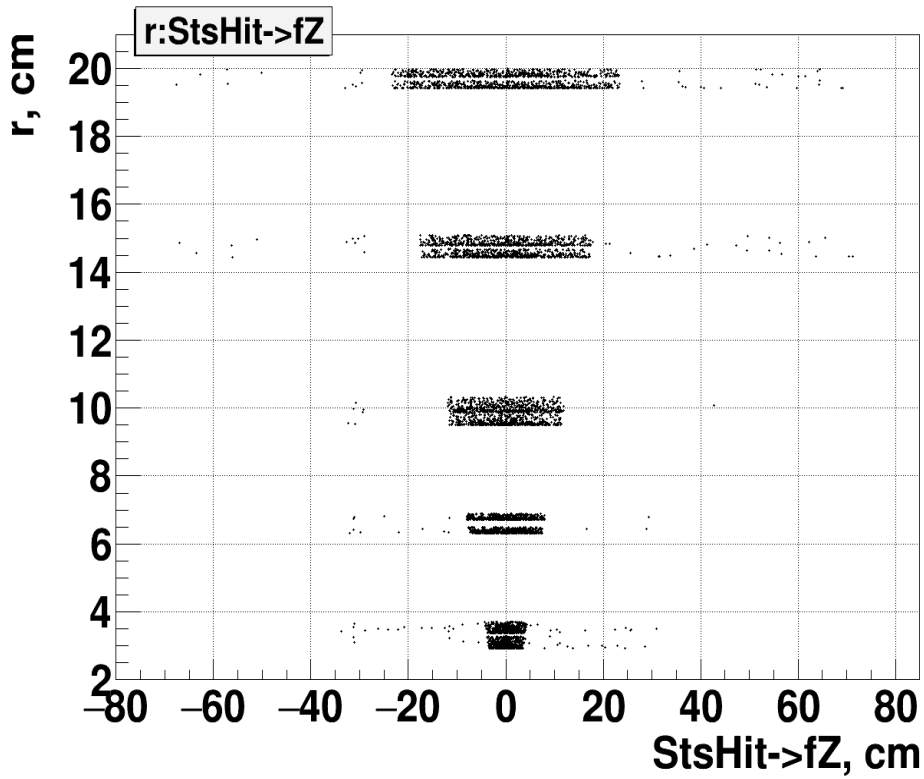
ITS 3D hit picture



1000 track event with pt range 0.02 – 2.0 GeV/c

ITS hit projections



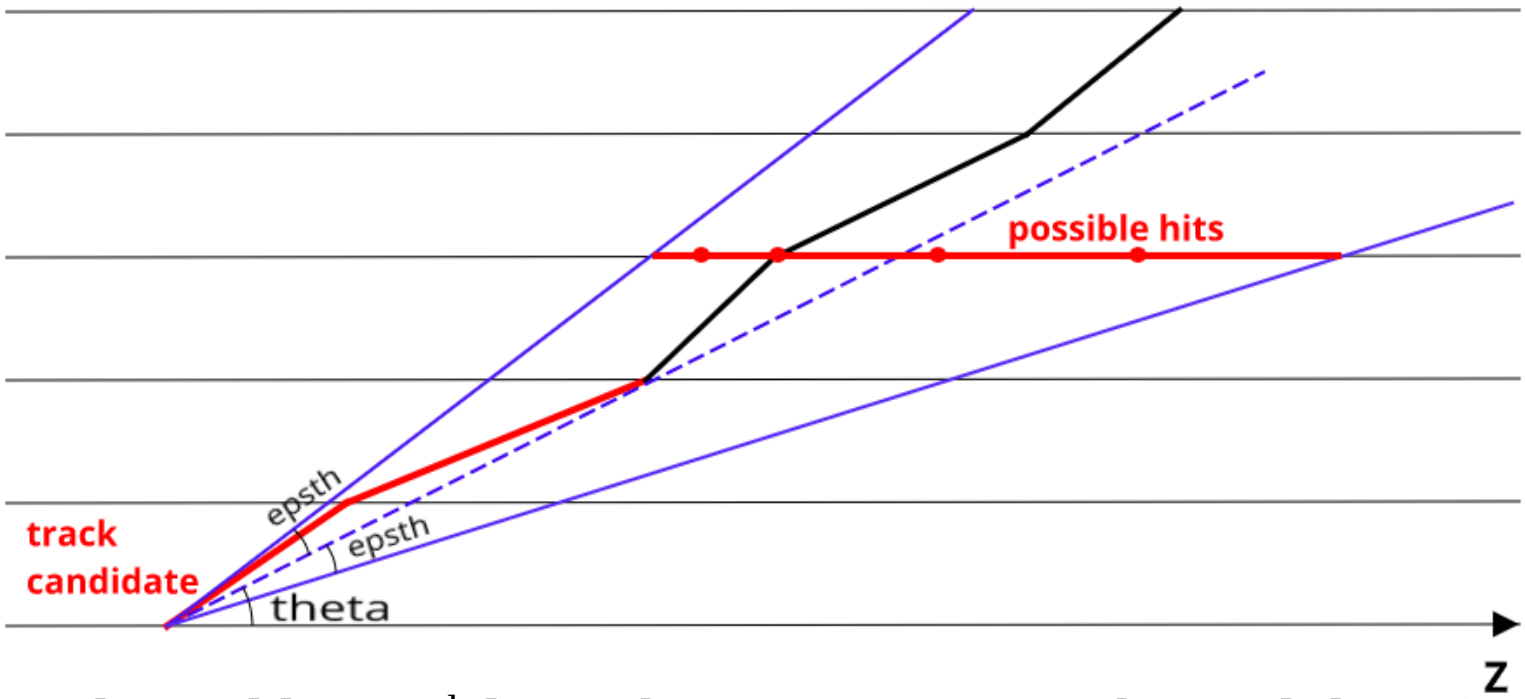


3D hit picture projections: transverse (left) and longitudinal (right)

Proposed method

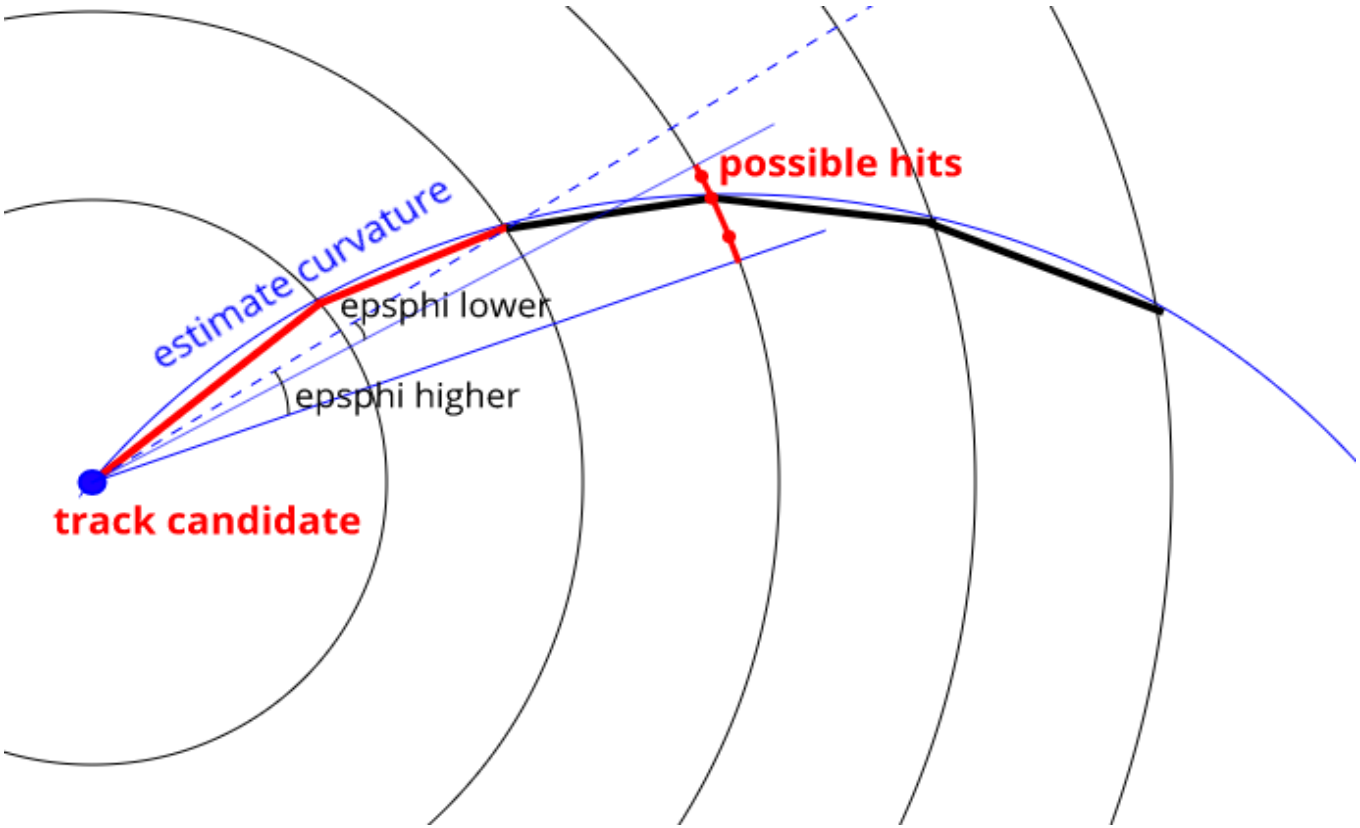
Vector Finder – a prior - constrained combinatorial search method (combines hits with angular positions which can exist in actual particle tracks)

Track scheme with angles (longitudinal)



Example: Adding 3^{d} layer hit to current track candidate (red). Angle delta *epsth* is preset. Area where possible hits are searched for, is highlighted with red and bordered with blue lines.

Track scheme with angles (transverse)

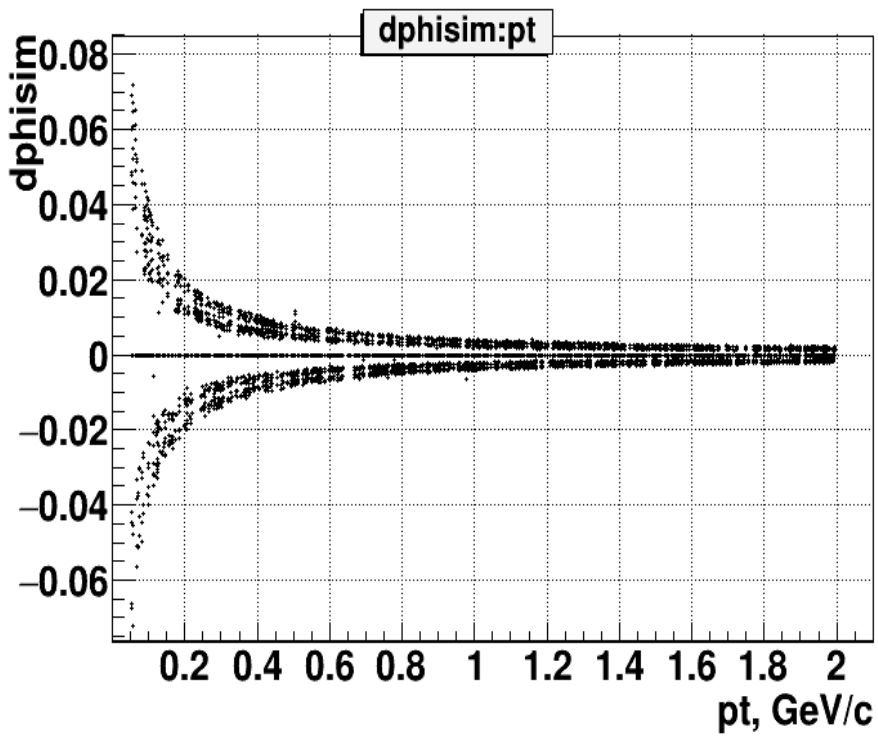


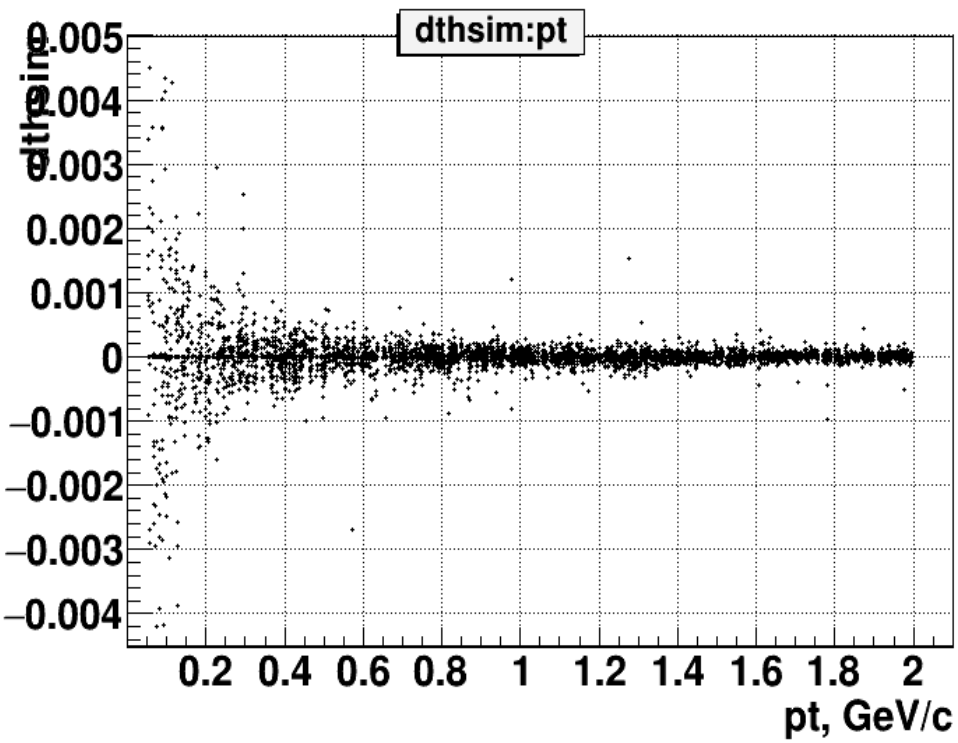
Example: Adding 3^{d} layer hit to current track candidate (red). Angles *epsphi*, lower and upper, depend on momentum, which is estimated based on track curvature for track candidate. Area where possible hits are searched for, is highlighted with red and bordered with blue lines.

Algorithm steps

- Initial track candidates are built from hits on the first layer of detector
- For detector layers 2 – 5:
  1) Build hit multimap for longitudinal and transverse angles
  2) For each track candidate:
     - Estimate particle momentum *pt* if possible (layers 3-5)
     - Calculate longitudinal and transverse angle cuts and extract corresponding hits from multimaps
     - Find intersection of hit sets obtained after cuts
     - For each hit in the resulting hit set create track candidate for current detector layer

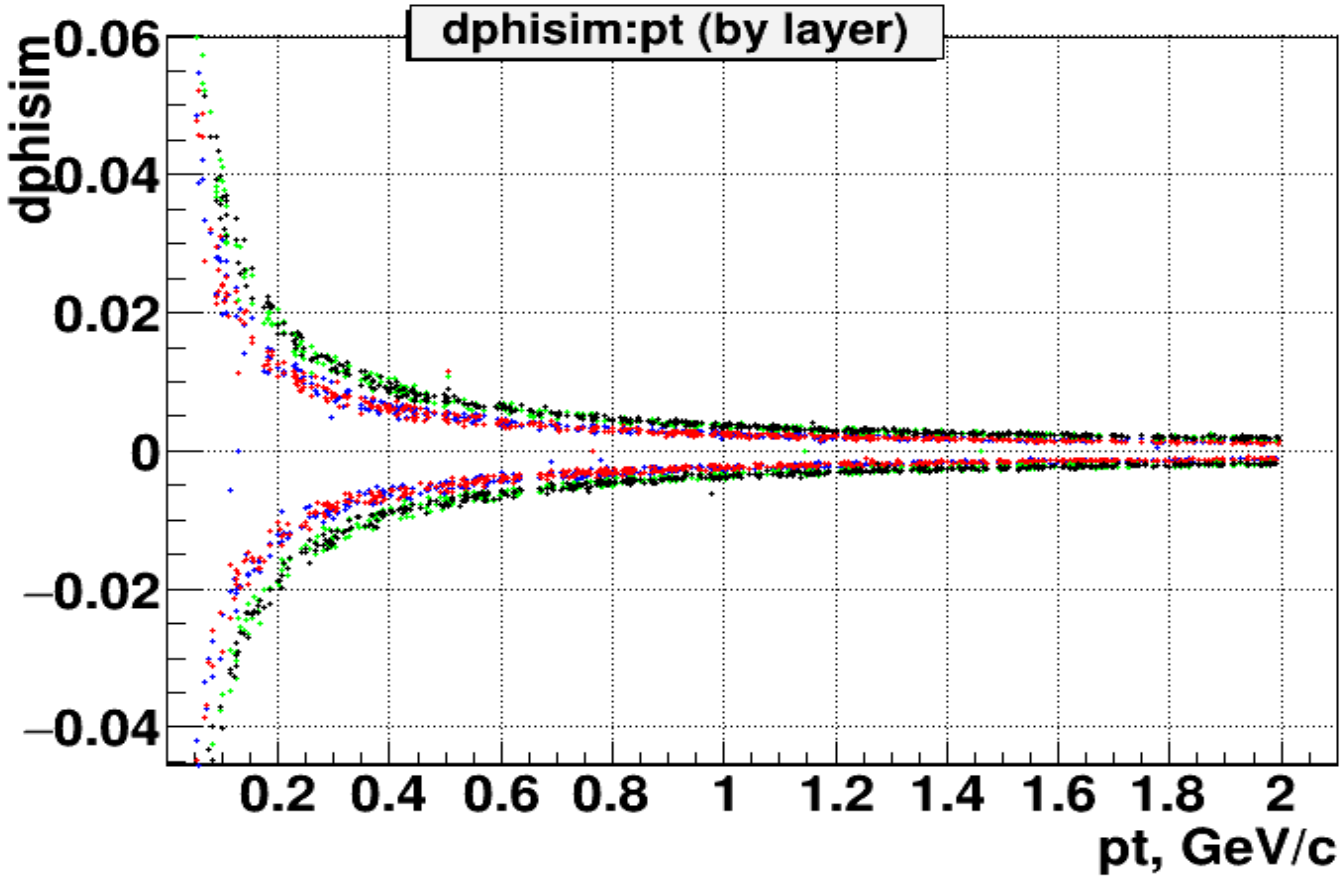
Angle delta dependencies on pt





- Left plot shows that delta between transverse angle on current layer and previous one is inversely proportional to particle transverse momentum, due to track curvature in the magnetic field
- Right plot shows that there is no such evident dependency for longitudinal angle delta, except some widening at low *pt* due to multiple scattering

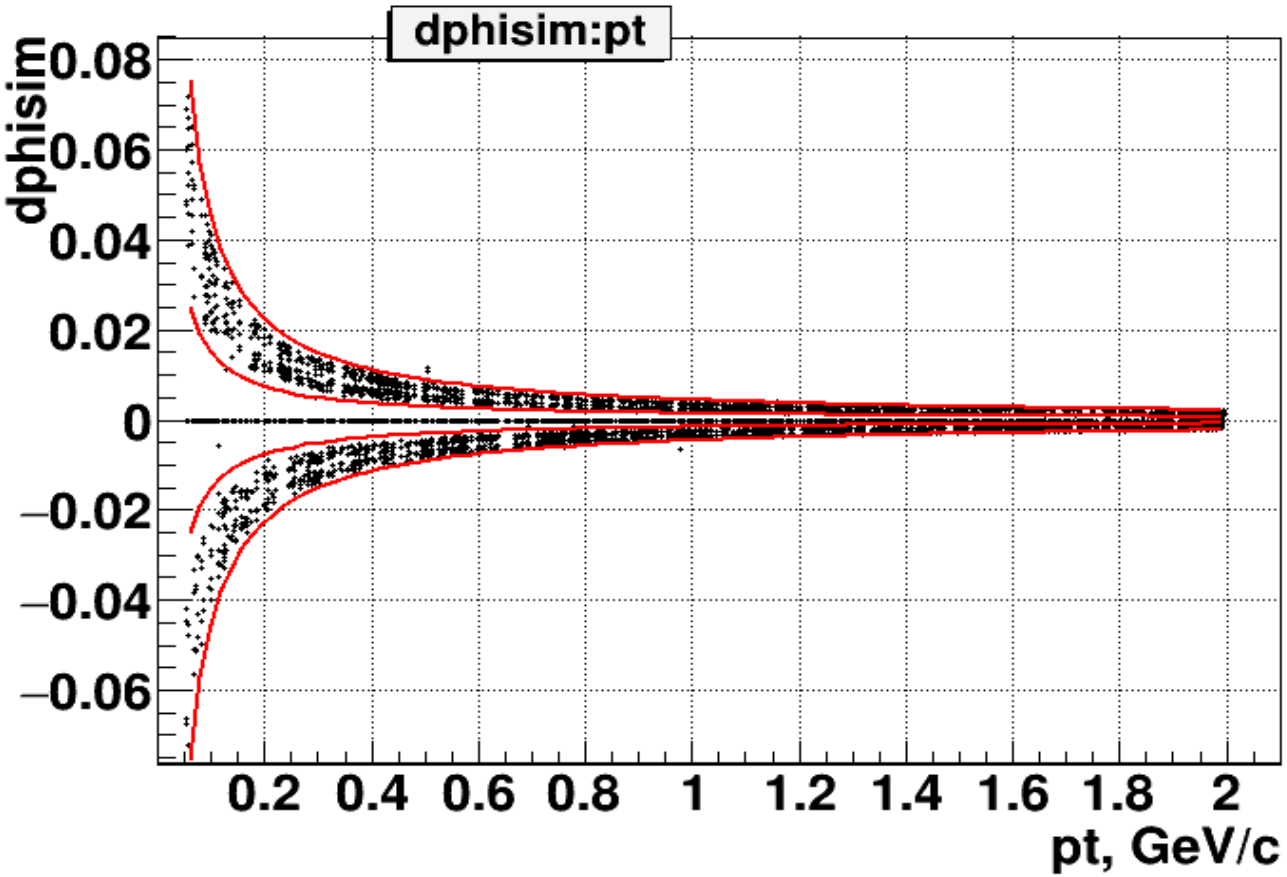
Transverse angle delta distribution by layer



Layer 2 – blue, Layer 3 – red

Layer 4 – green, Layer 5 – black

Transverse angle cuts



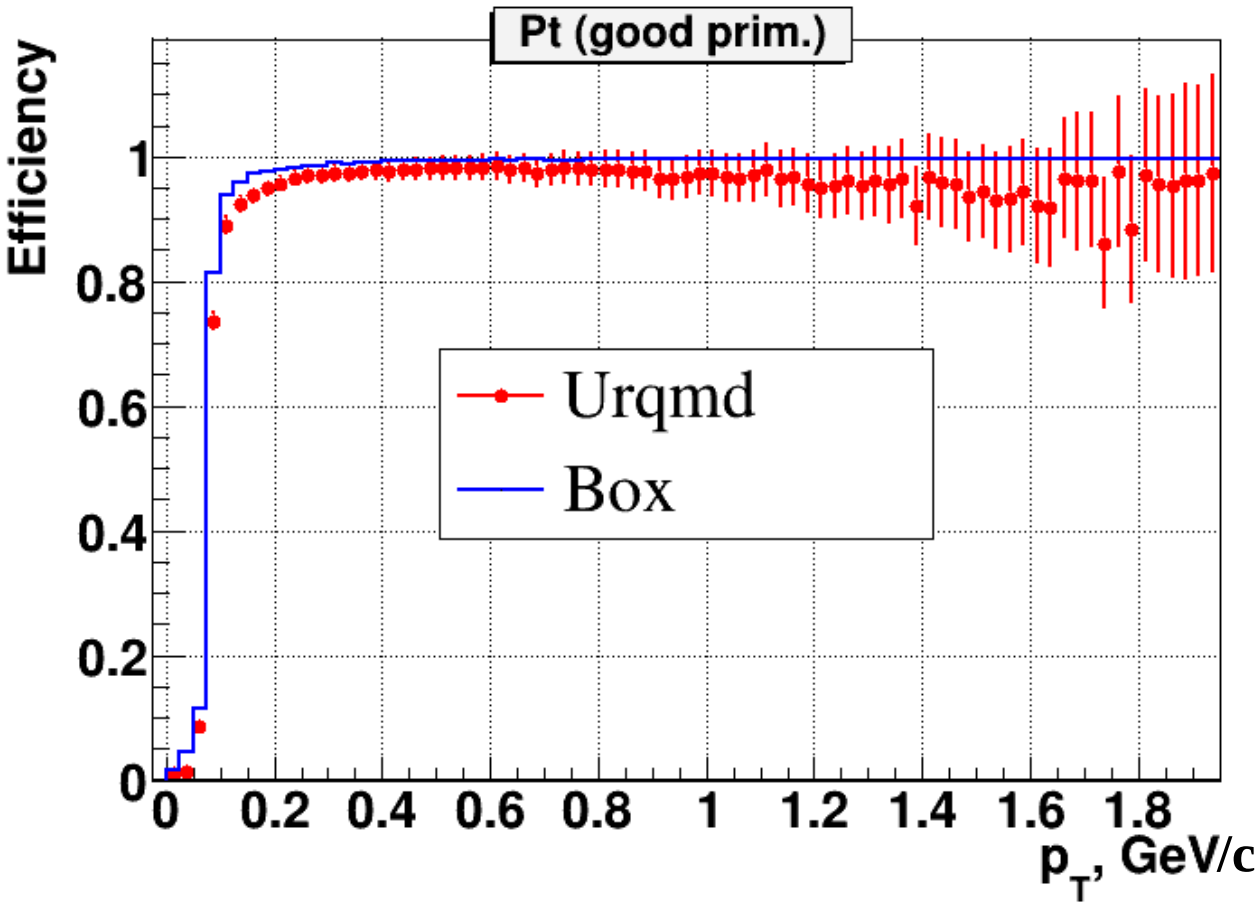
- Upper cut: *eps* = ± *4.5e-3 / pt*
- Lower cut: *eps* = ± *1.5e-3 / pt*

Event generators

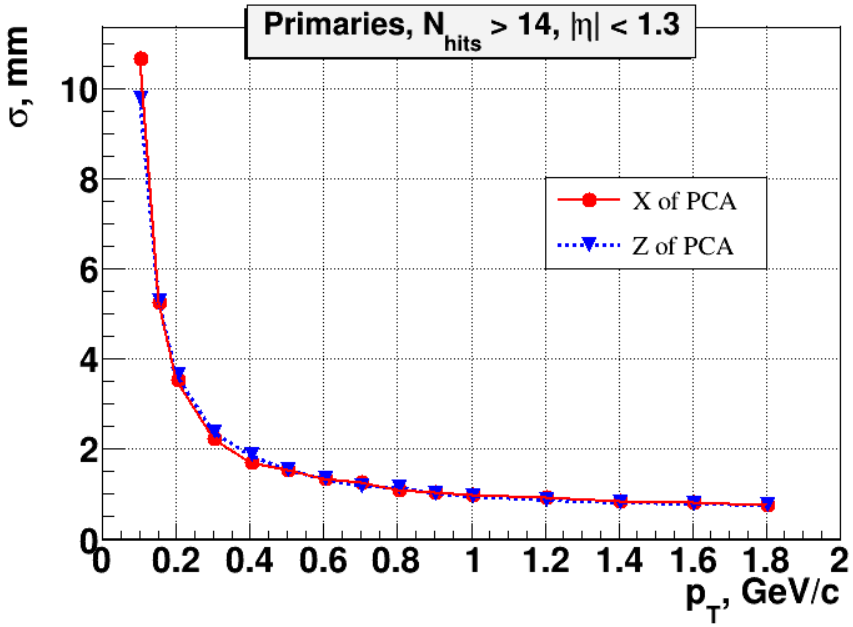
Box – FairBoxGenerator of muons – μ^- and μ^+
500 μ^-, 500 μ^+ per event, Pt range from 0.02 to 2.0 GeV/c, polar angle from 40 to 140°

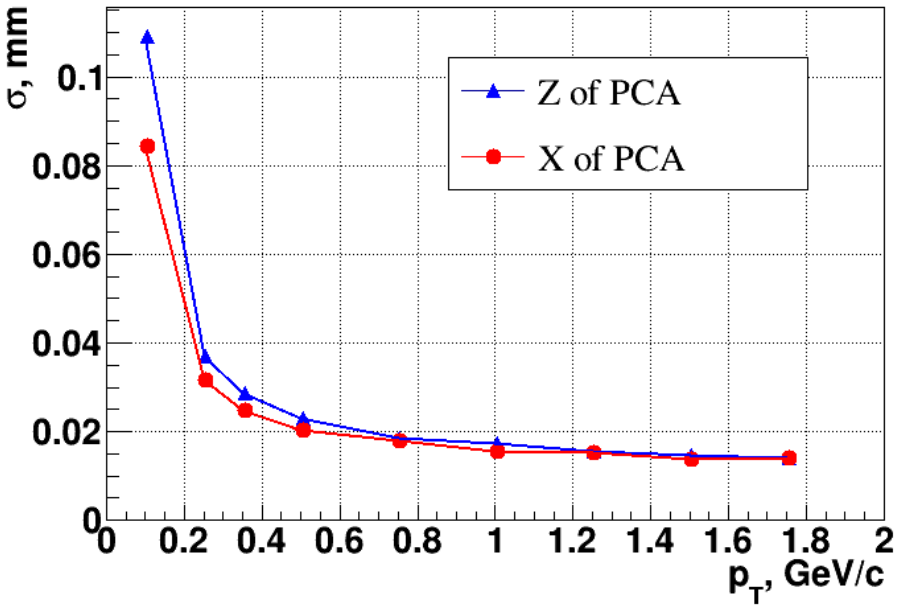
UrQMD – central Au+Au collisions at sqrt(s) = 9 GeV

Efficiency dependence on Pt



Coordinates of PCA versus Pt

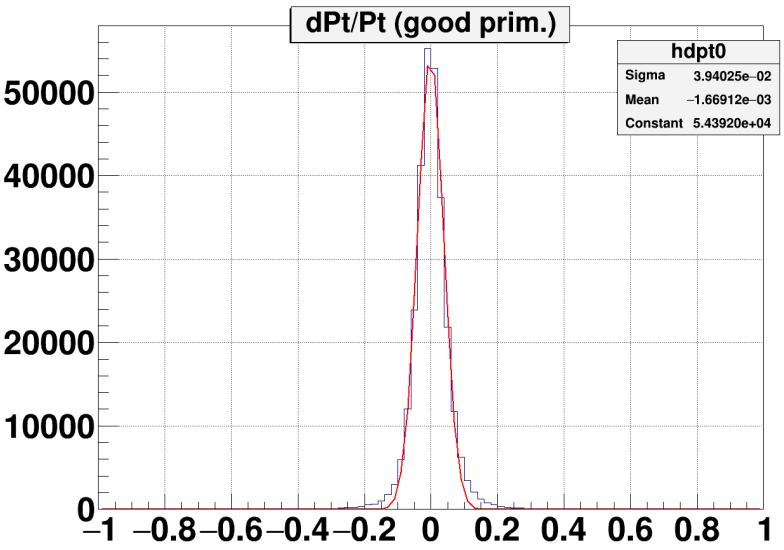


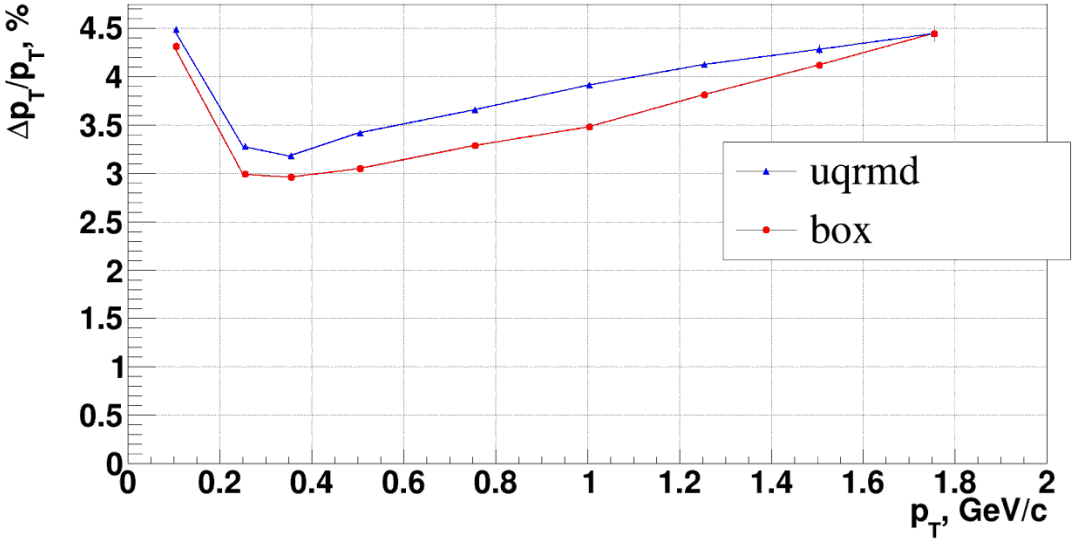


Left – TPC (Kalman filter based approach)
Right – ITS (Vector Finder approach)

PCA – point of the closest approach to the interaction point

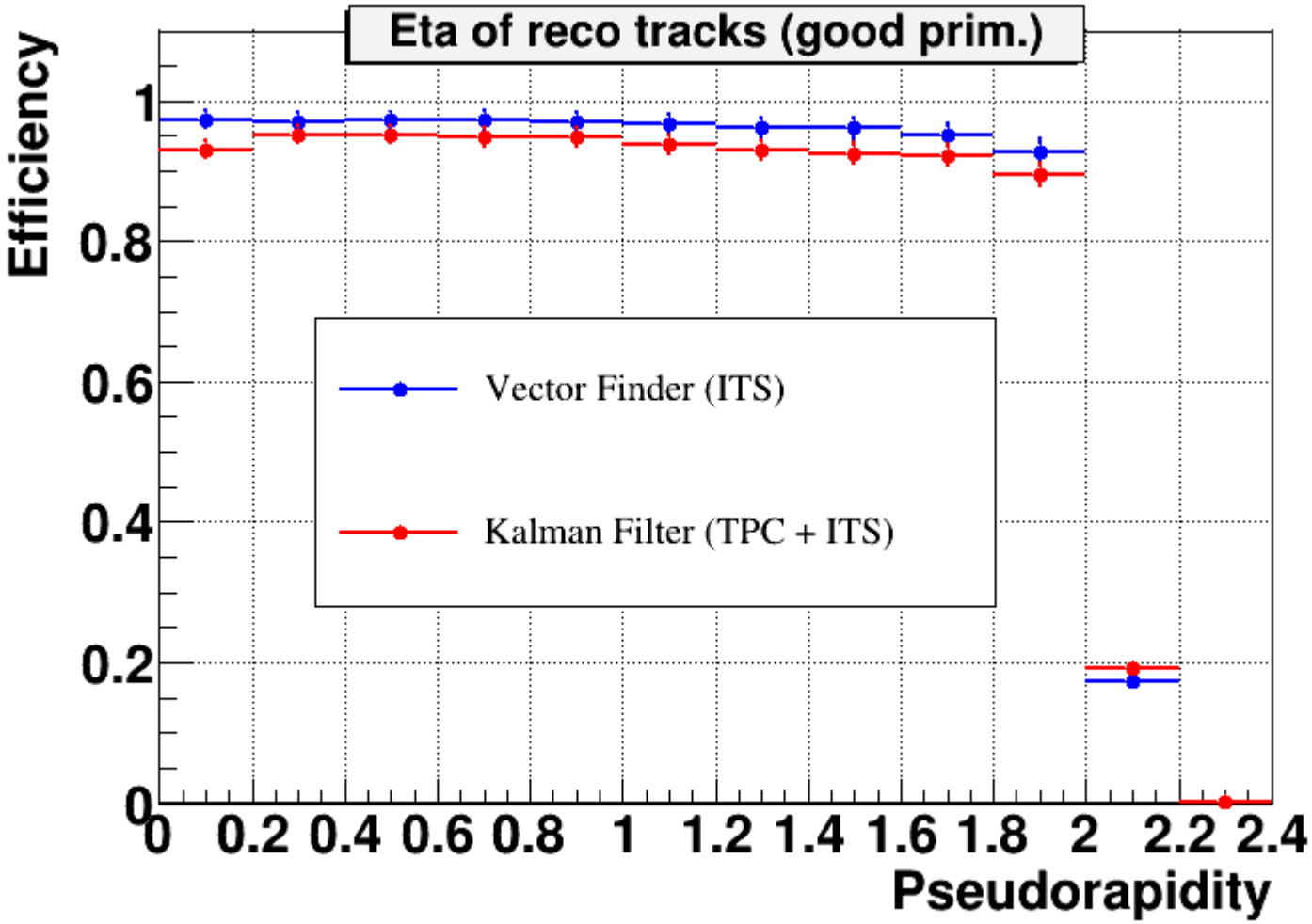
dPt/Pt (gauss fit) and dependence on Pt



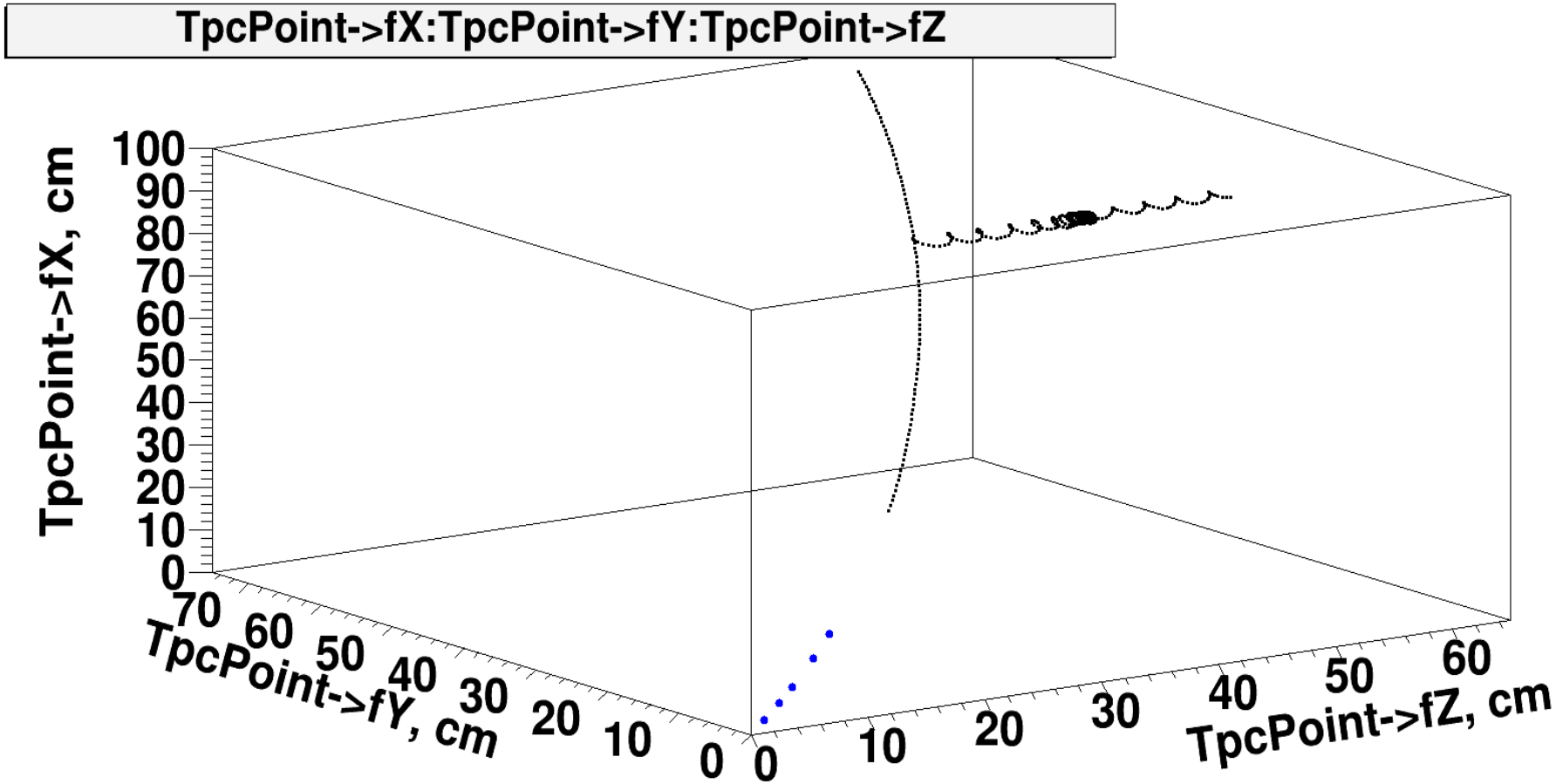


dPt/Pt — relative transverse momentum resolution (momentum reconstruction accuracy)

Efficiency dependency on Pseudorapidity



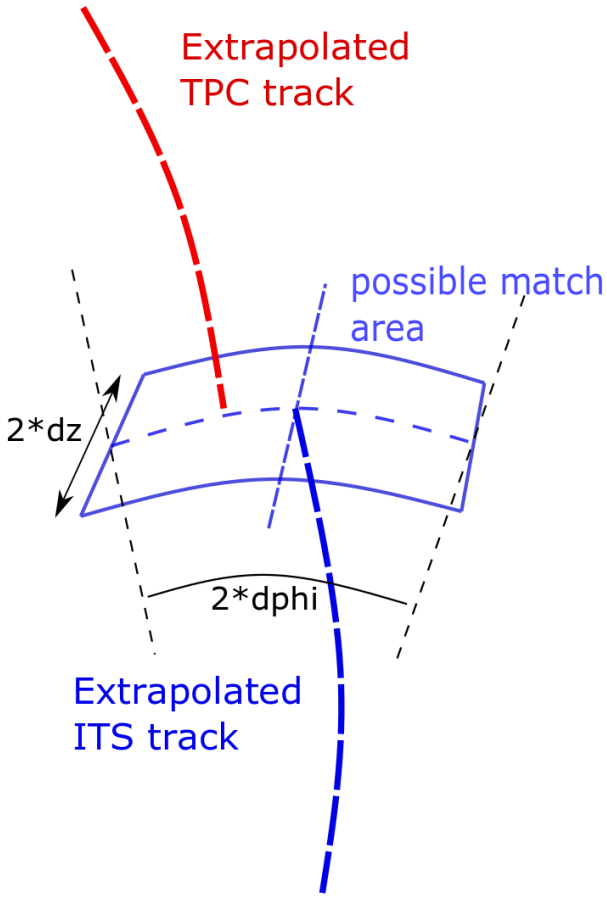
TPC and ITS track matching



TPC and corresponding ITS tracks at 150 MeV

Matching algorithm

1. Propagate TPC and ITS tracks to a cylinder at distance of 27.0 cm from beam line
2. Update track parameters and receive corresponding values of z and phi
3. For each ITS track find a set of TPC tracks with z and phi parameters lying in preset window of ITS track parameters
4. Matched track is created by adding ITS hits to TPC track if they are “good” (if ITS hit adds less than 10.0 to summary Chi2 value, it’s considered “good”)
5. If no TPC track was found within window, ITS track is added standalone



Checking track quality

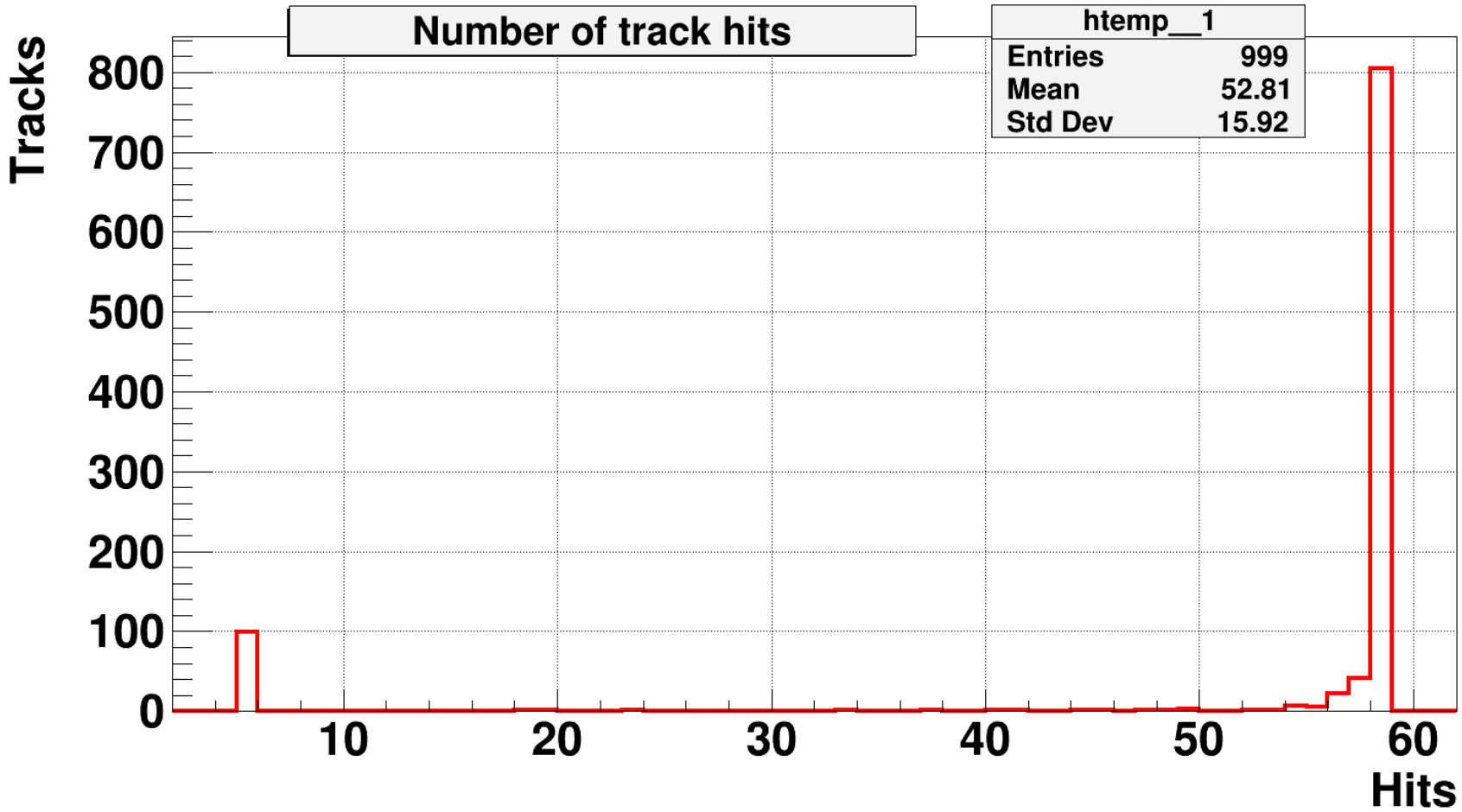
Having more hits in final matched track is more valuable than having little Chi2, so we need quality function.

$$qual = -\left(hitnumber + {}^{\min(Chi2,\,100.0)}/_{101.0}\right)$$

Where:

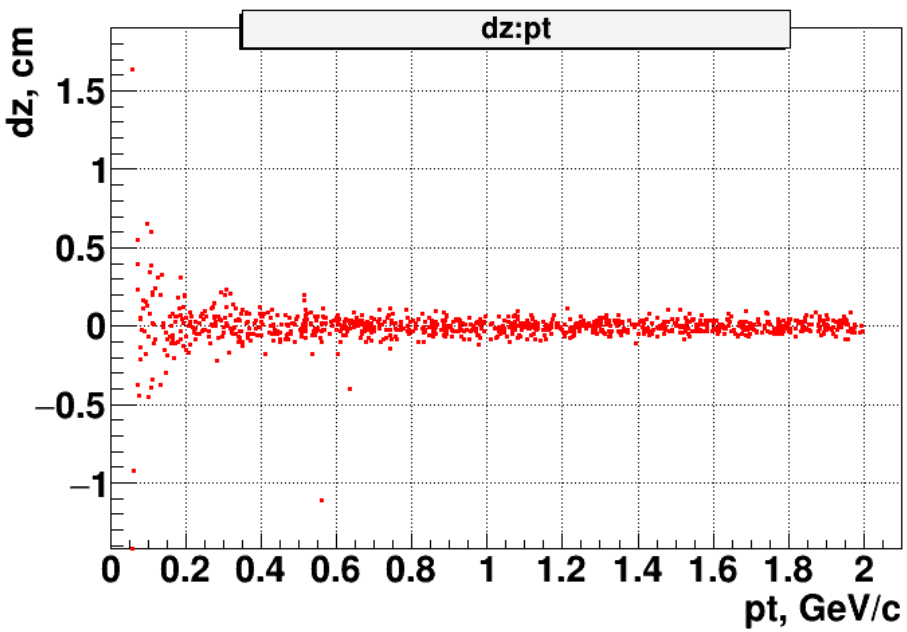
- ***hitnumber*** is number of hits for matched TPC + ITS track
- ***Chi2*** is for ITS-only track

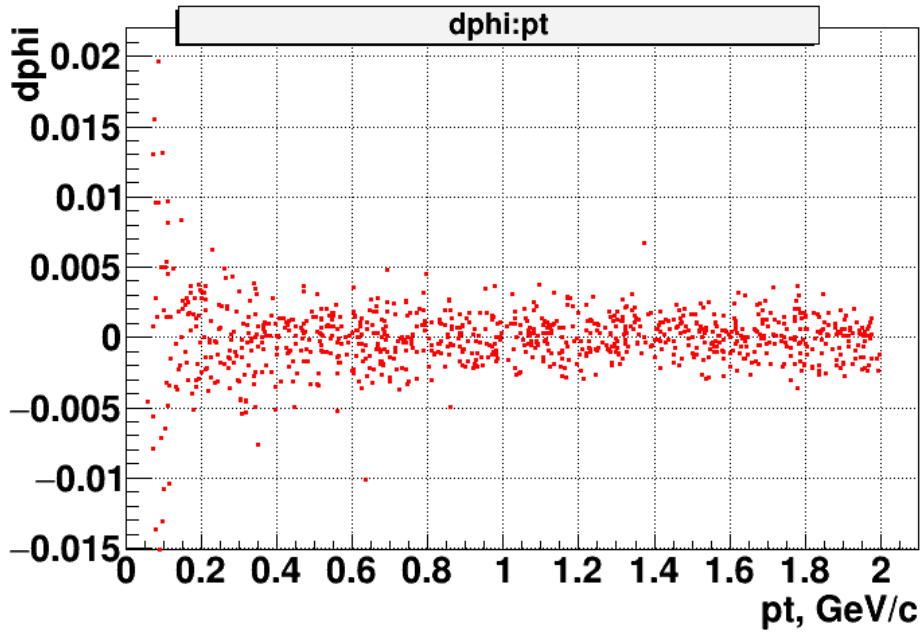
Some Matching results (1)



Number of hits per track after matching

Some Matching results (2)





dz and ***dphi*** on 27.0 cm radius cylinder from interaction point

Summary and next steps

- Stand-alone ITS track reconstruction using Vector Finder approach has been developed and implemented
- It improves track reconstruction efficiency as compared with the TPC-based tracking
- ITS significantly improves track position uncertainty near the interaction point
- Combined ITS + TPC track reconstruction using track matching algorithm was implemented.
- Track reconstruction algorithm tuning for secondary particles is to be done next

Acknowledgements

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