Development of the Vector Finder toolkit for track reconstruction in MPD ITS

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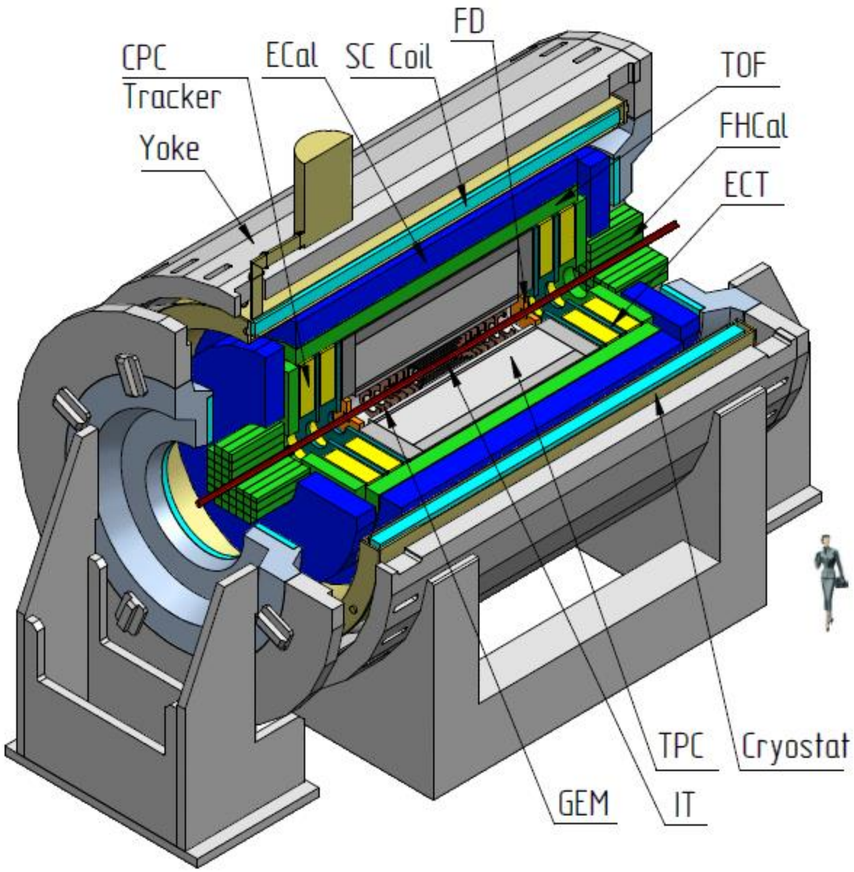
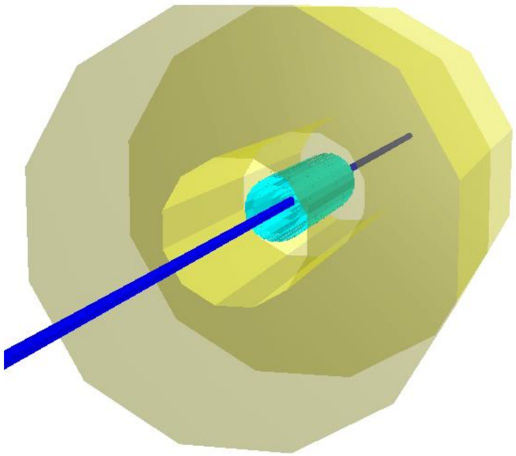
Outline

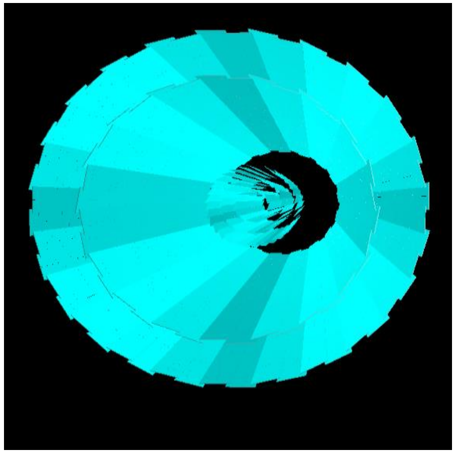
- Introduction
- ITS geometry
- Vector Finder approach
- Vector Finder tuning for secondary tracks
- Algorithm performance for track reconstruction
- TPC and ITS track matching
- Conclusion



MPD/NICA general design scheme

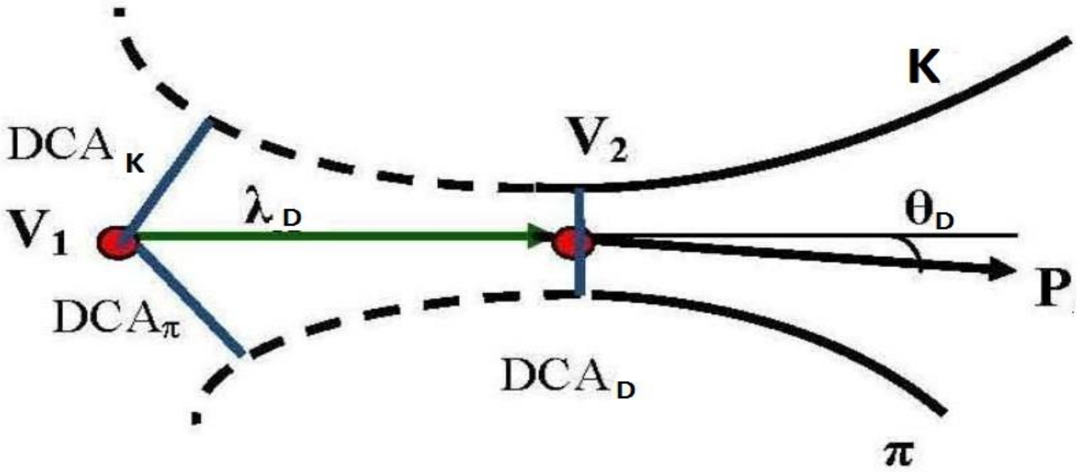


TPC and ITS geometry



5-layer ITS geometry

Charmed D-meson detection by vertex detector

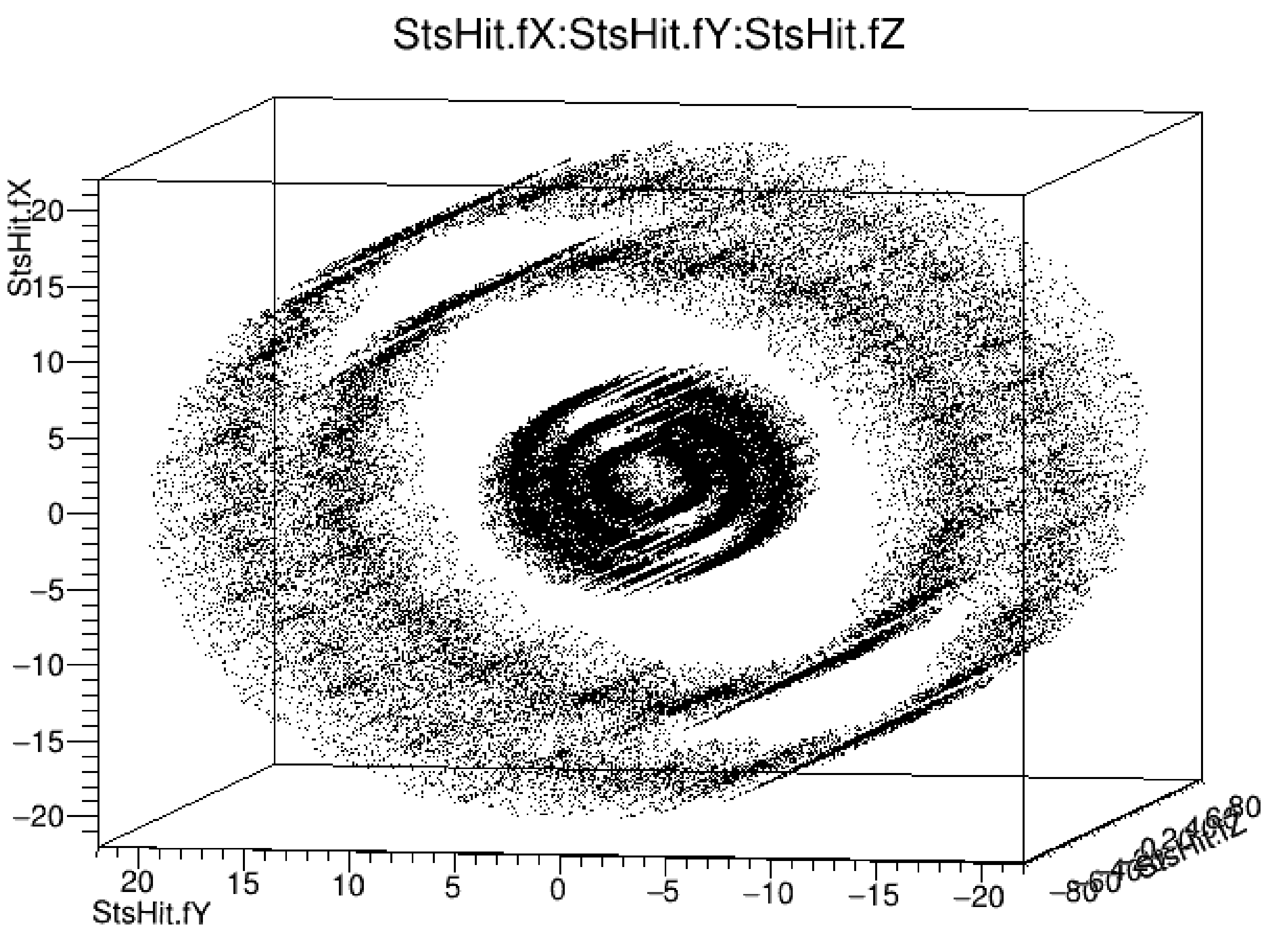


$D^0 \rightarrow K^- + \pi^+$, $\tau c = 123\ \mu m$ $D^+ \rightarrow K^- + \pi^+ + \pi^+$, $\tau c = 312\ \mu m$

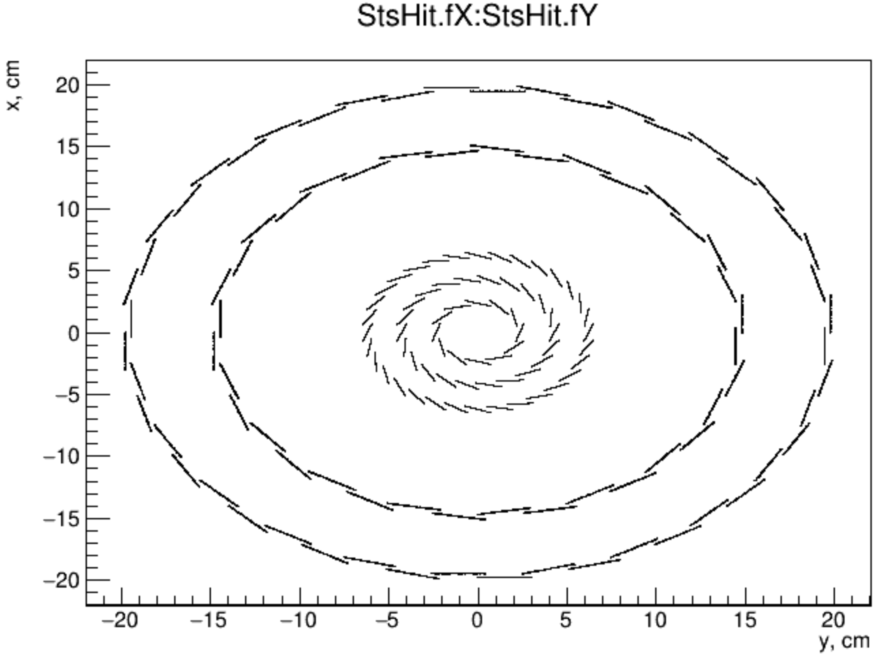
Reliable identification of short-lived charmed particles can be performed by determining the invariant mass of their decay products. So, for high-efficient reconstruction of decay vertices V_2 near the interaction point V_1 the vertex detectors with high pointing resolution are needed.

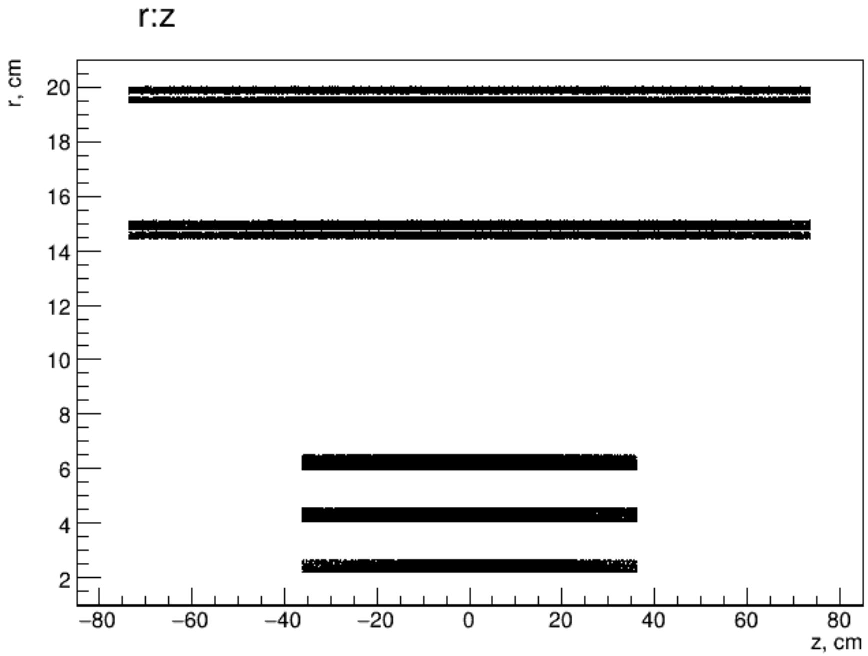
*Taken from V. Kondratev's talk at this conference

ITS 3D hit picture



ITS hit projections



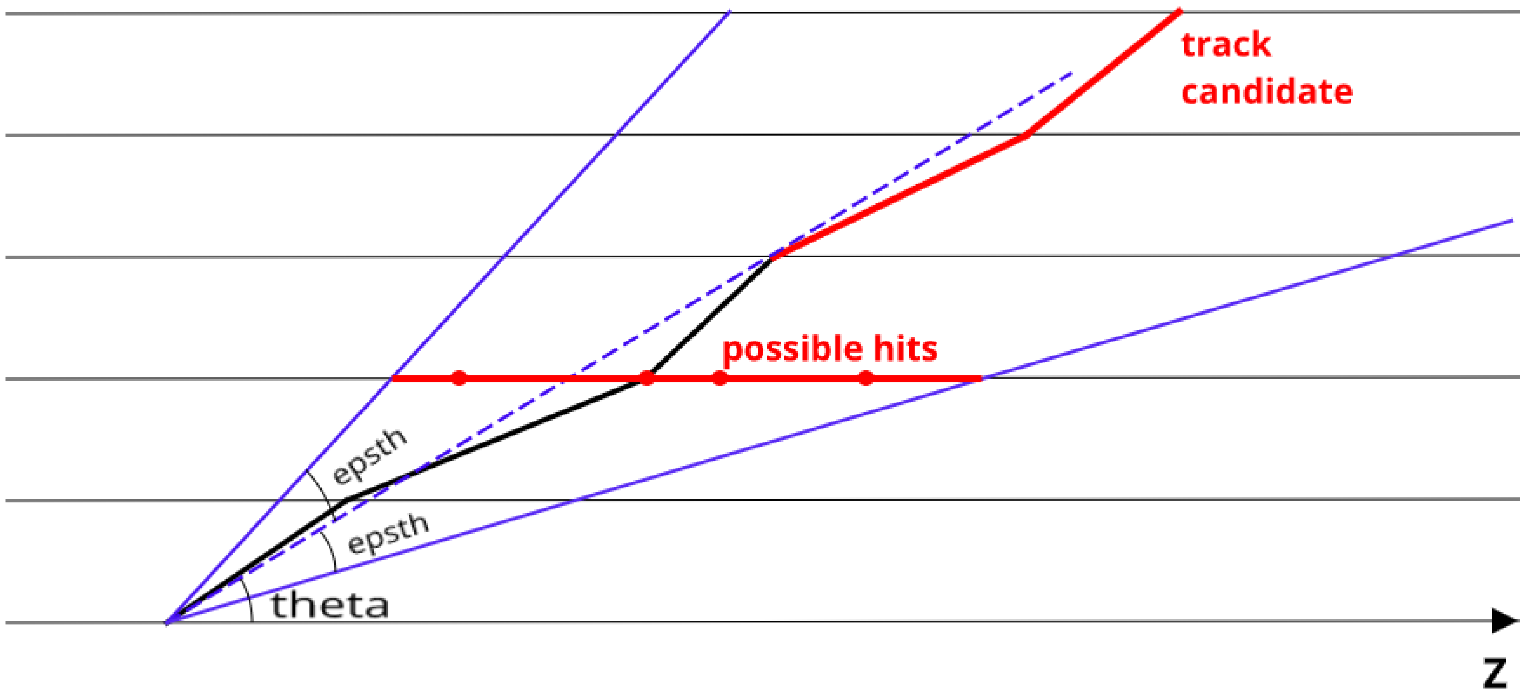


3D hit picture projections: transverse (left) and longitudinal (right)

Vector Finder approach

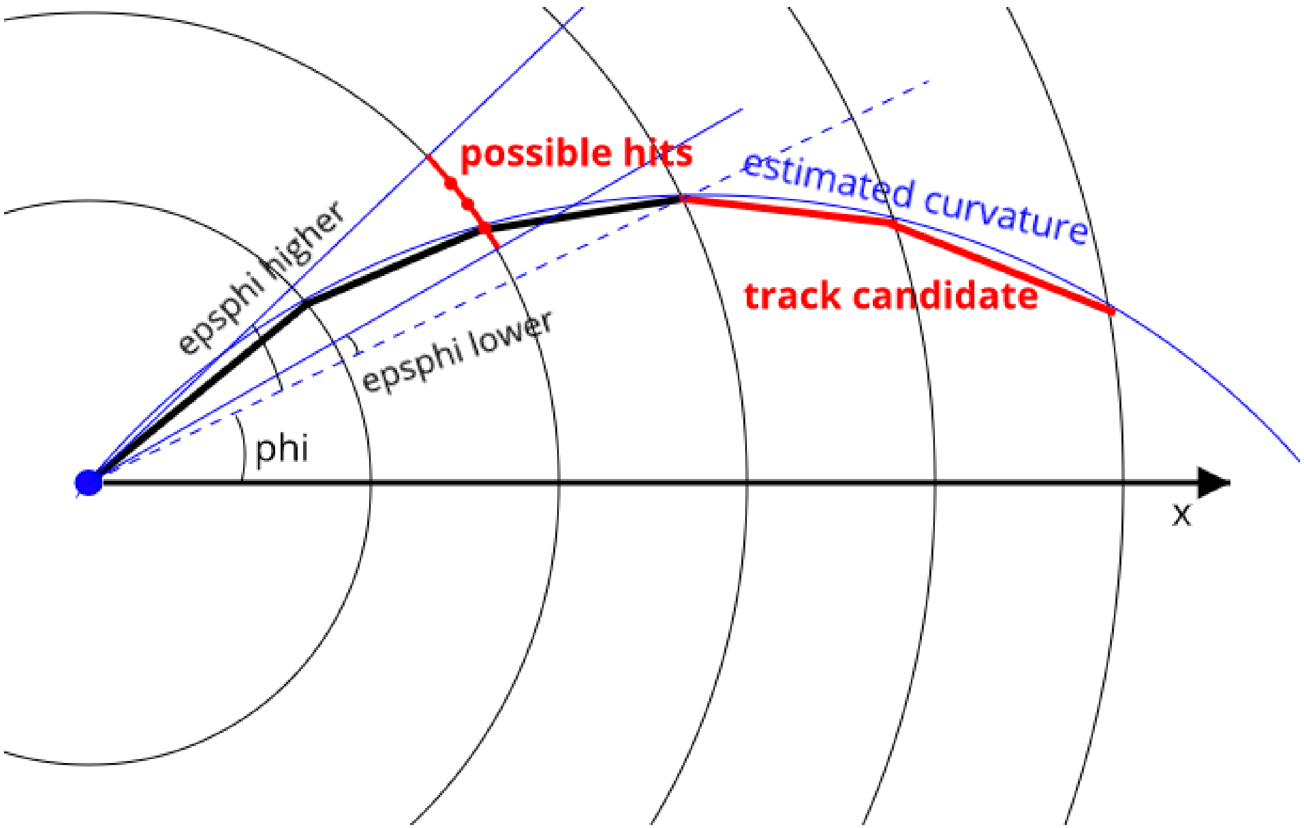
Vector Finder – a prior - constrained combinatorial search method (combines hits with angular positions which can exist in actual particle tracks)

Longitudinal projection for primary track



In longitudinal projection track is close to a straight line going through the interaction point

Transverse projection for primary track

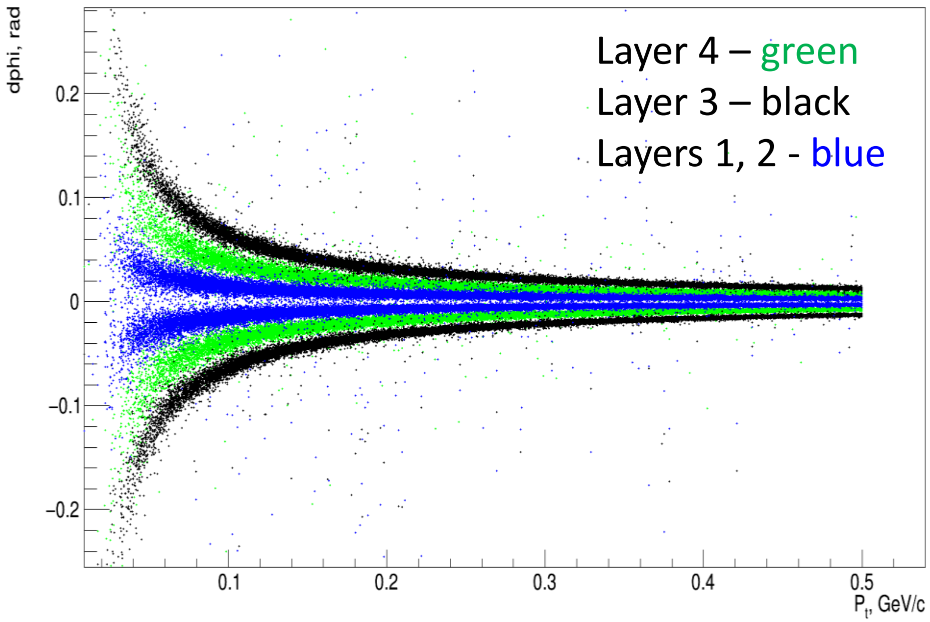


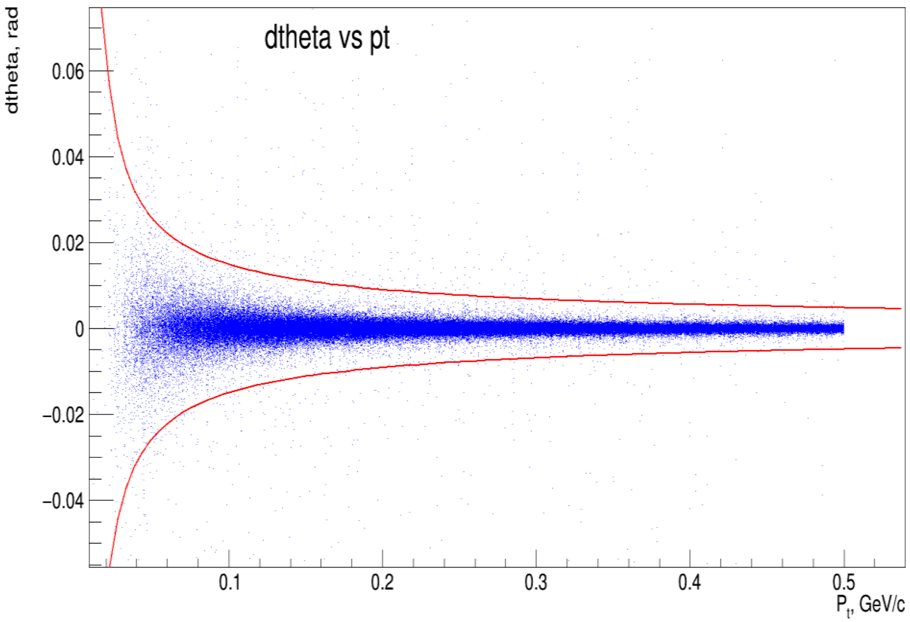
In transverse projection track is close to a circle arc going through the interaction point, due to magnetic field

Algorithm steps

- Initial track candidates are built from hits on the last layer of detector
- For detector layers 4 – 1:
  1) Build hit multimap for longitudinal and transverse angles
  2) For each track candidate:
     - Estimate particle momentum *pt* if possible (layers 3-1)
     - 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

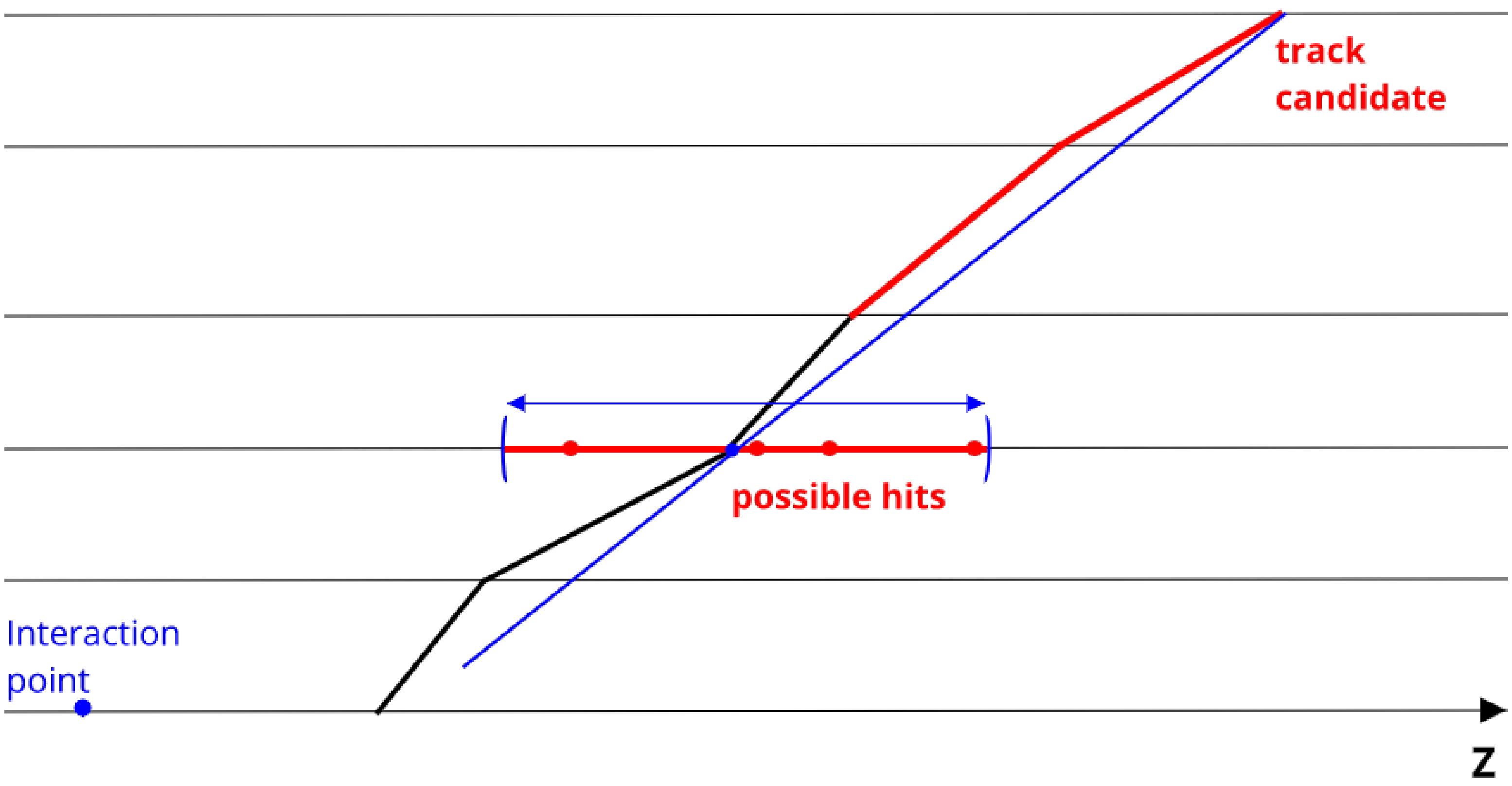
Angle delta dependencies on pt (1)





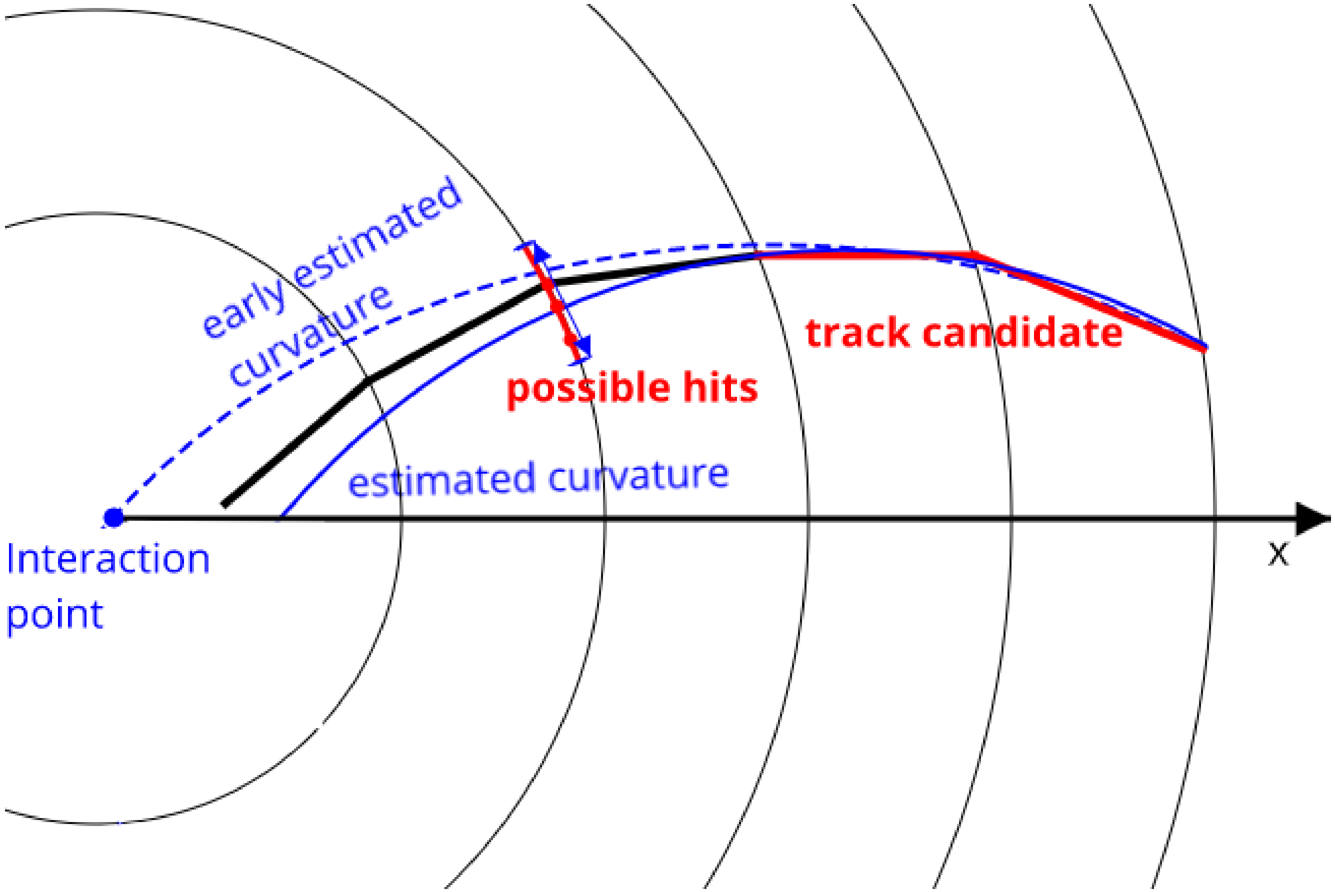
- Delta between transverse angle on current layer and previous one is layer-dependent and is inversely proportional to particle transverse momentum, due to track curvature in the magnetic field
- There is no such evident dependency for longitudinal angle delta, except some widening at low *pt* due to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

Longitudinal projection for secondary track



- Track doesn’t go through the interaction point, so theta cannot be used for defining cuts, so we use *Z* coordinate instead

Transverse projection for secondary track



- Pt estimation should avoid using interaction point as an additional hit when possible

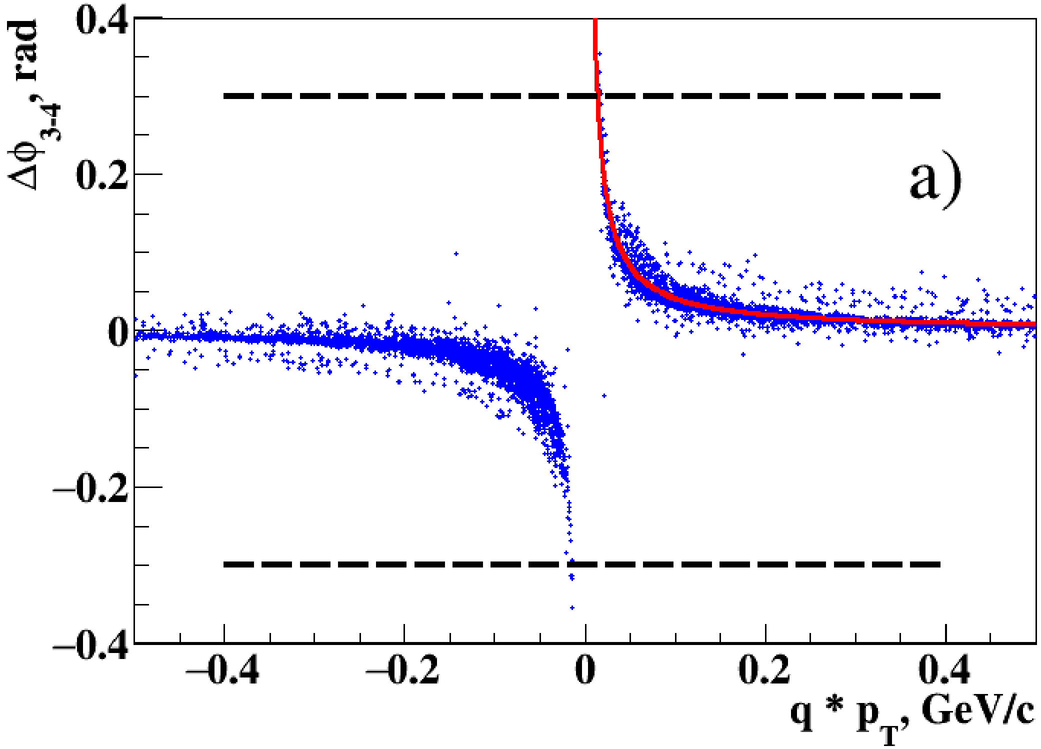
Secondary track algorithm tuning (1)

- Z coordinate for possible hit area on next layer is estimated by linear extrapolation, using Z coordinate on current and previous layers and corresponding radii, using formula (if previous layer exists):

$$Z_{next} = Z_{curr} + \frac{Z_{prev} - Z_{curr}}{r_{prev} - r_{curr}} \cdot (r_{next} - r_{curr})$$

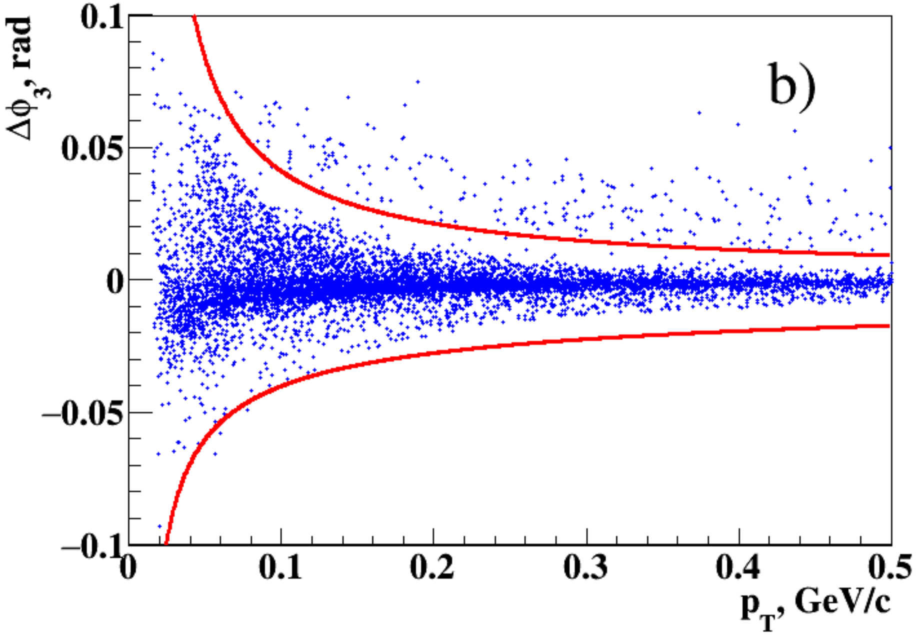
- Transverse angle phi can be estimated using circle arc propagation, which requires at least 3 hits in track candidate. Thus, we have to use primary vertex as additional track hit to produce first estimation

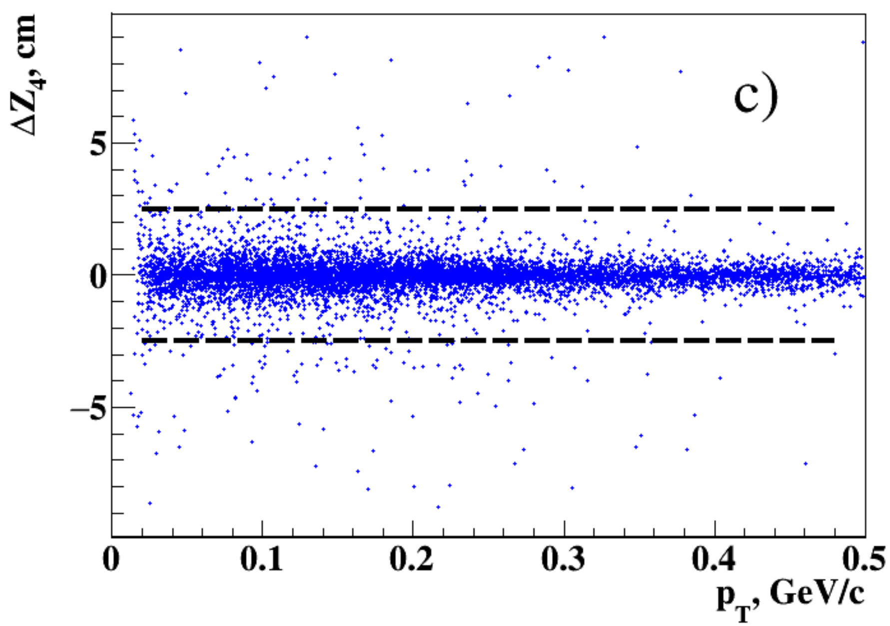
Secondary track algorithm tuning (2)



a) Azimuthal angle difference between layers 4 and 3 for secondary particles and ~1/Pt function fit

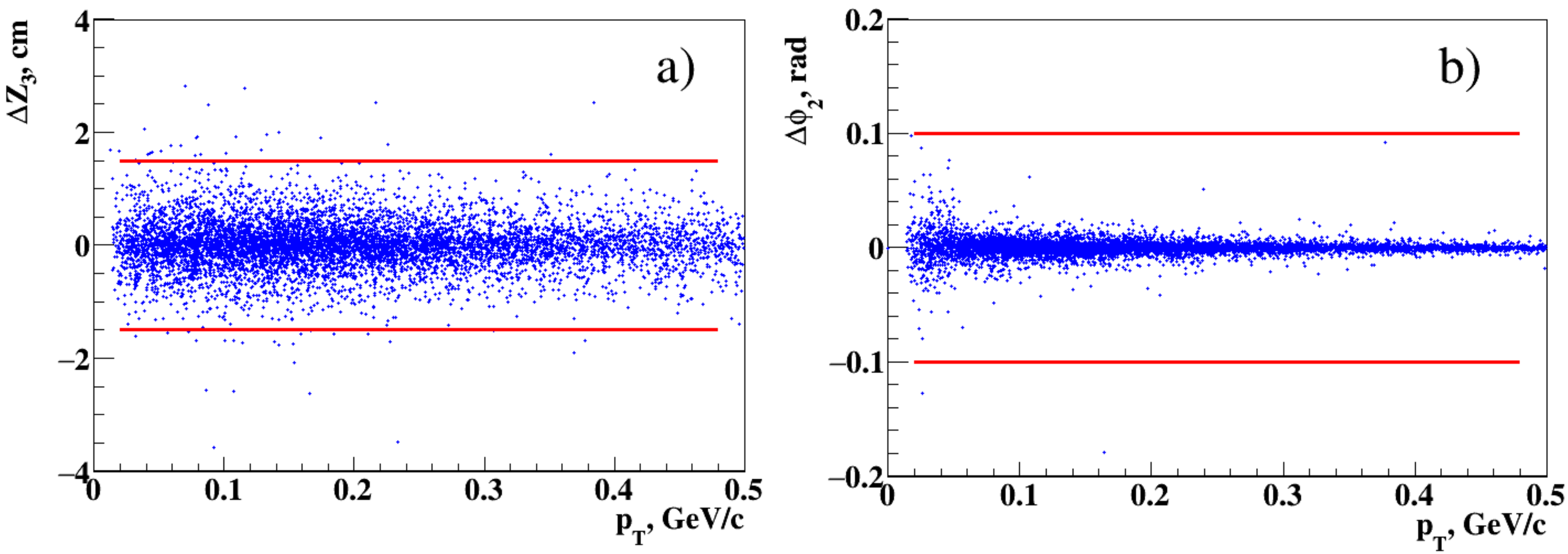
Secondary track algorithm tuning (3)





b) dphi vs Pt estimated using circle arc propagation with primary vertex for secondary particles on layer 3

c) dz vs Pt estimated using primary vertex for secondary particles on layer 4

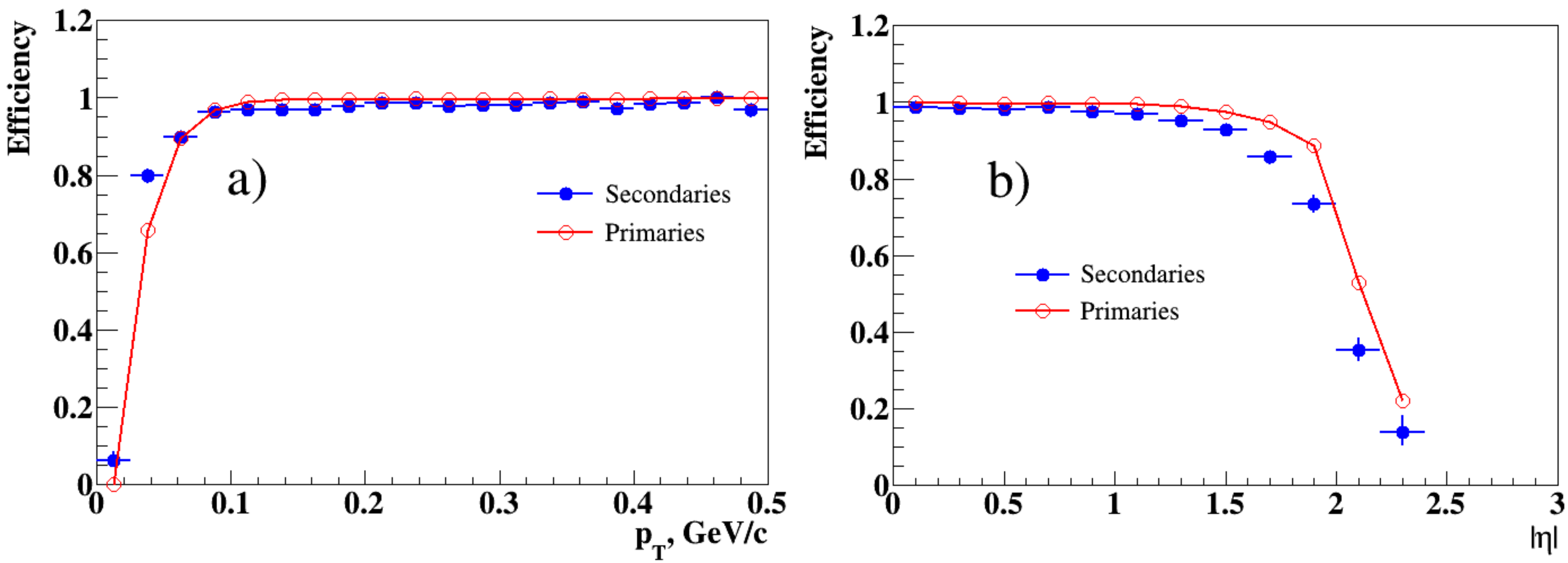


a) dz vs Pt estimated using linear extrapolation for secondary particles on layer 3

b) dphi vs Pt estimated using circle arc propagation for secondary particles on layer 2

Vector Finder performance (1)

- Algorithm was tested on 100-event set of central Au+Au collisions at sqrt(s) = 9 GeV/c

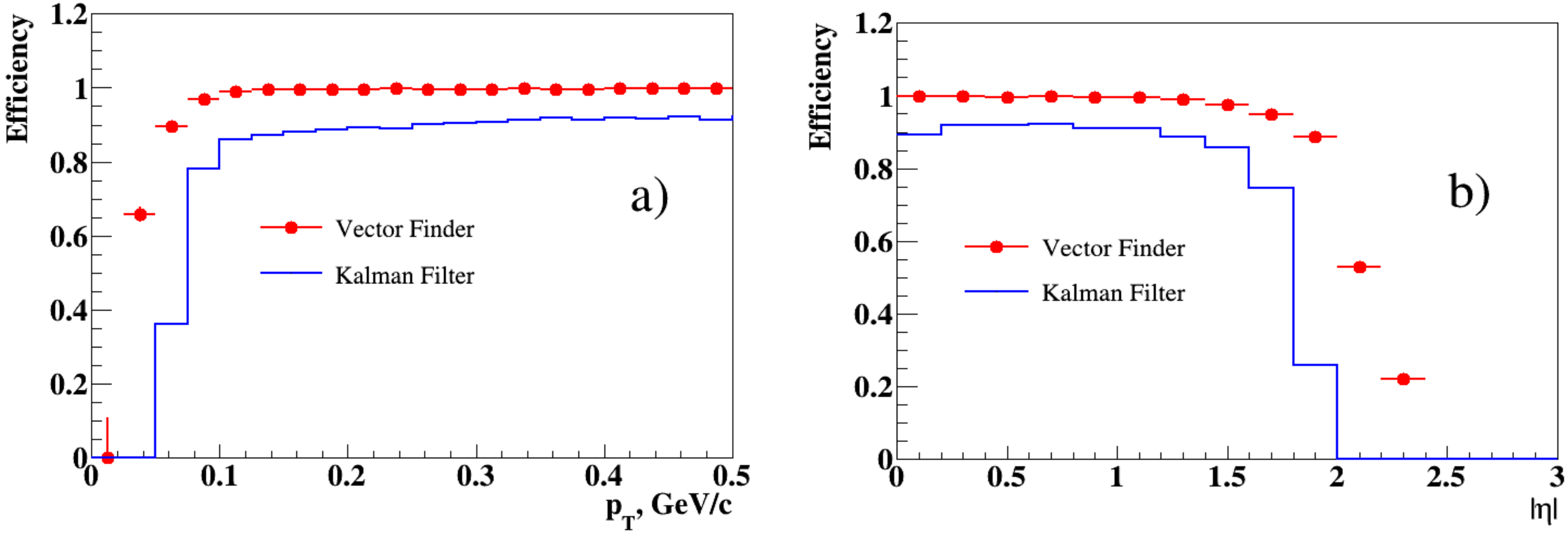


Efficiency for primary and secondary track reconstruction for evenly distributed layer geometry

a) Efficiency vs Pt for secondary tracks at $|\eta| < 1.2$

b) Efficiency vs $|\eta|$ for secondary tracks at $|Pt| > 0.1$ GeV/c

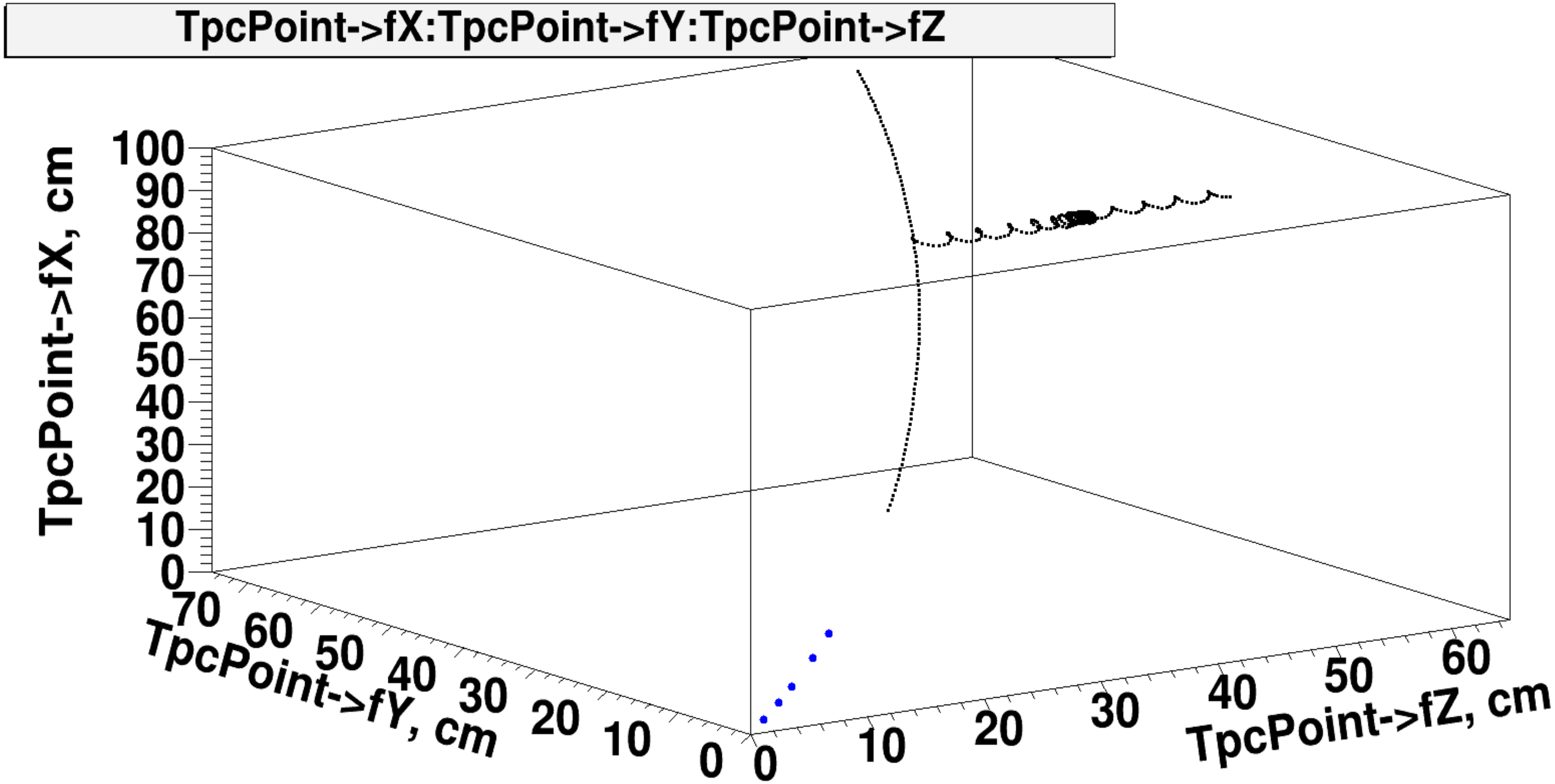
Vector Finder vs Kalman Filter efficiency comparison



a) Efficiency vs Pt at $|\eta| < 1.2$

b) Efficiency vs $|\eta|$ at Pt > 0.1 GeV/c

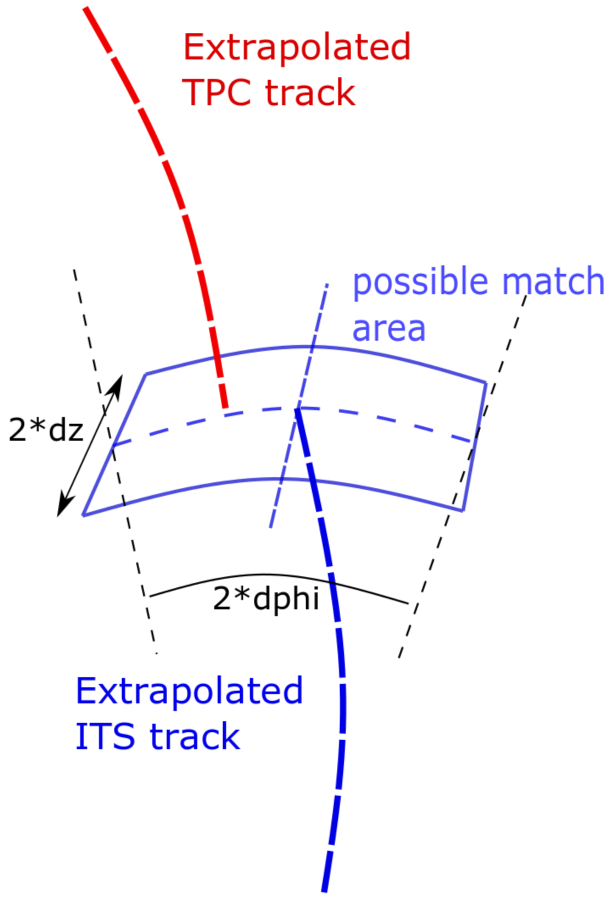
TPC and ITS track matching



TPC and corresponding ITS tracks at 0.15 GeV

Matching algorithm

1. Propagate TPC and ITS tracks to a cylinder between TPC and ITS
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

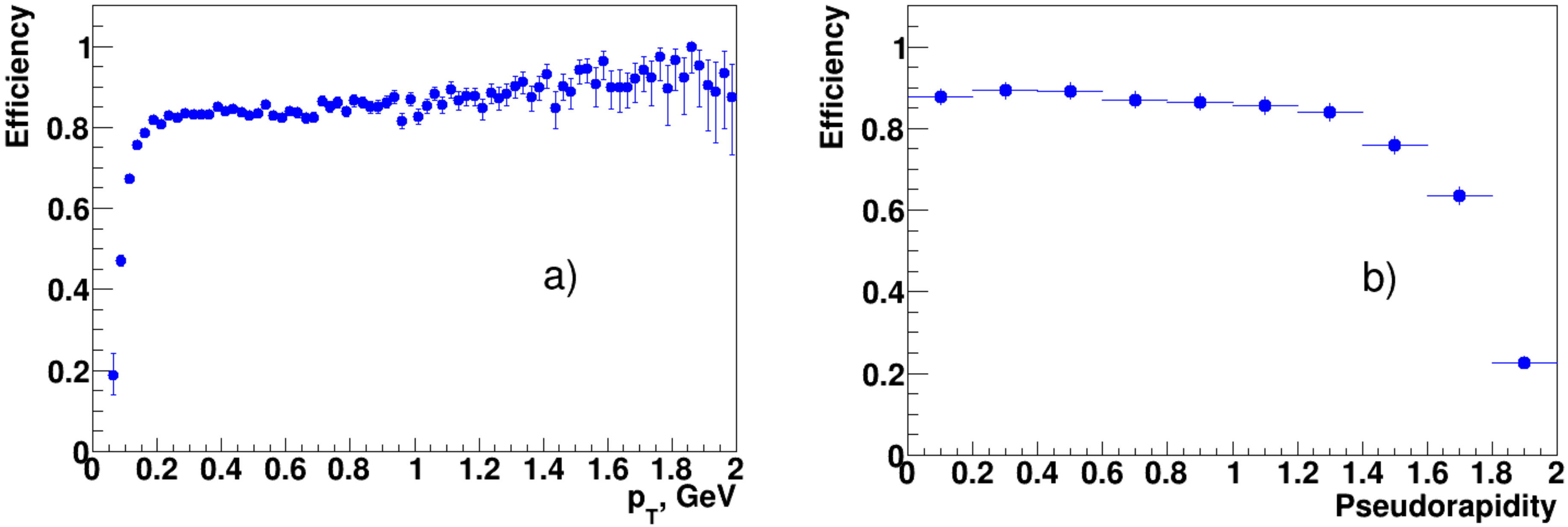
Having more hits in final matched track is more valuable than having little Chi2, so we need quality function.

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

Where:

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

Some Matching results (2)



a) Matching efficiency vs Pt for primary tracks at $|\eta| < 1.2$
b) Matching efficiency vs $|\eta|$ for primary tracks at $|Pt| > 0.1$ GeV/c

Summary and next steps

- "Vector Finder" track reconstruction algorithm was developed, based on combinatorial hit search
- Secondary track reconstruction method was developed
- Layer-dependent cuts for primary tracks were developed

- *Algorithm is being adapted to newer ITS geometry*
- *Track matching for secondary tracks and overall combined package is to be developed next*

Acknowledgements

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