# Development of the Vector Finder Toolkit for track reconstruction in the BM@N/NICA experiment

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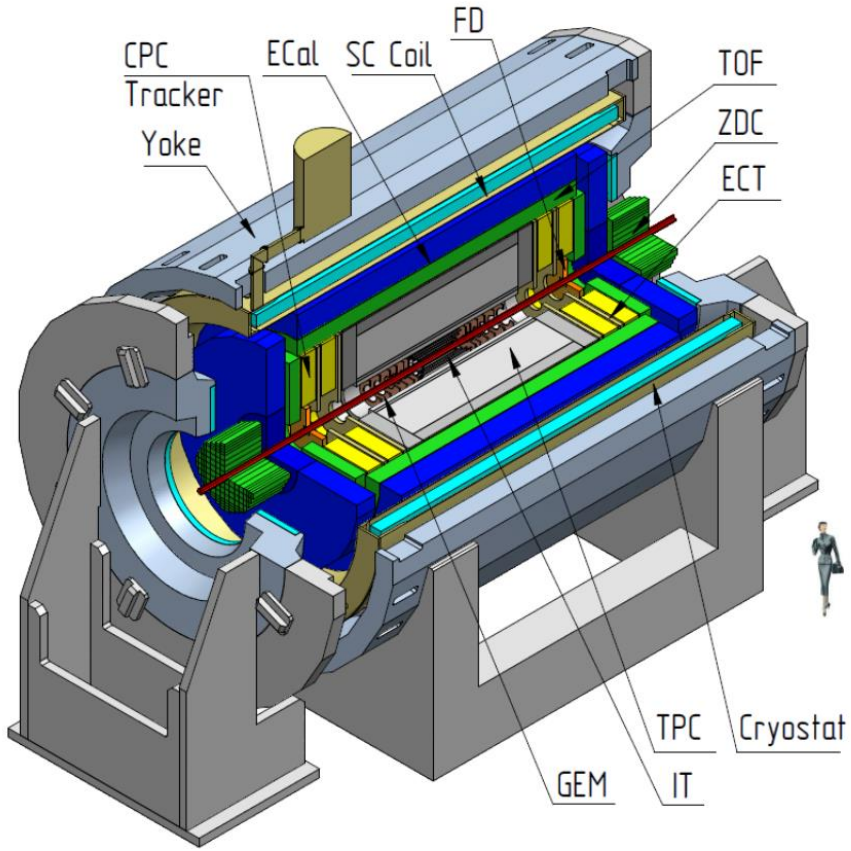
# Outline

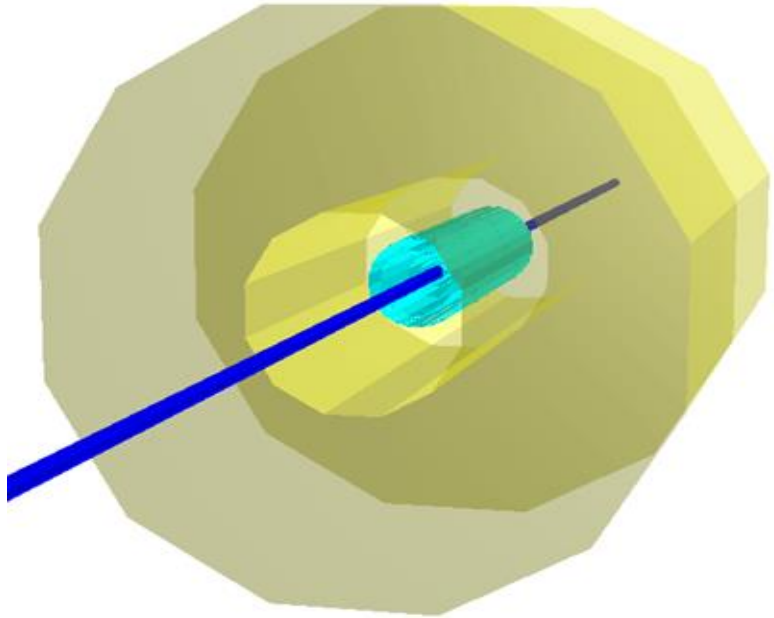
- Introduction
- Vector Finder toolkit for ITS of MPD/NICA
- Vector Finder adaptation for BM@N/NICA
- Reconstructible track features
- Preliminary track reconstruction performance
- Conclusion and future plans

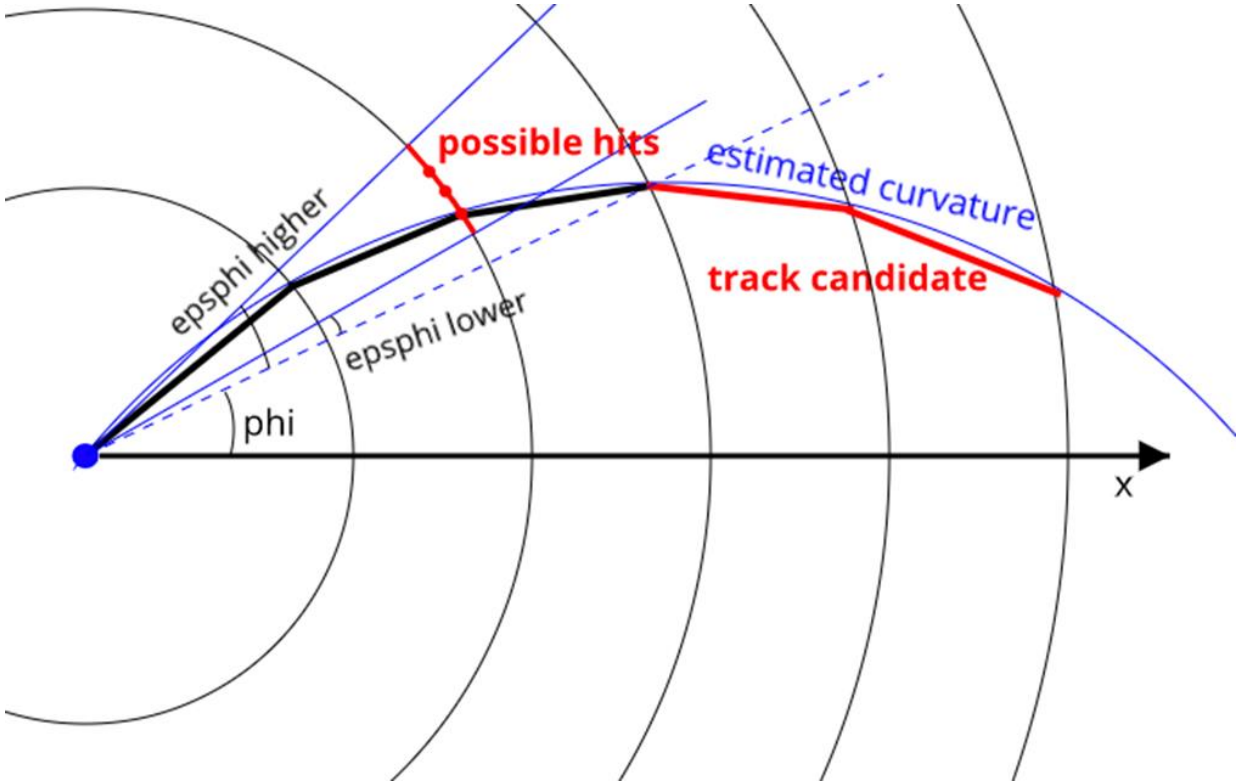
Originally Vector Finder toolkit was developed for Inner Tracking System of MPD/NICA



# Vector Finder toolkit for ITS of MPD

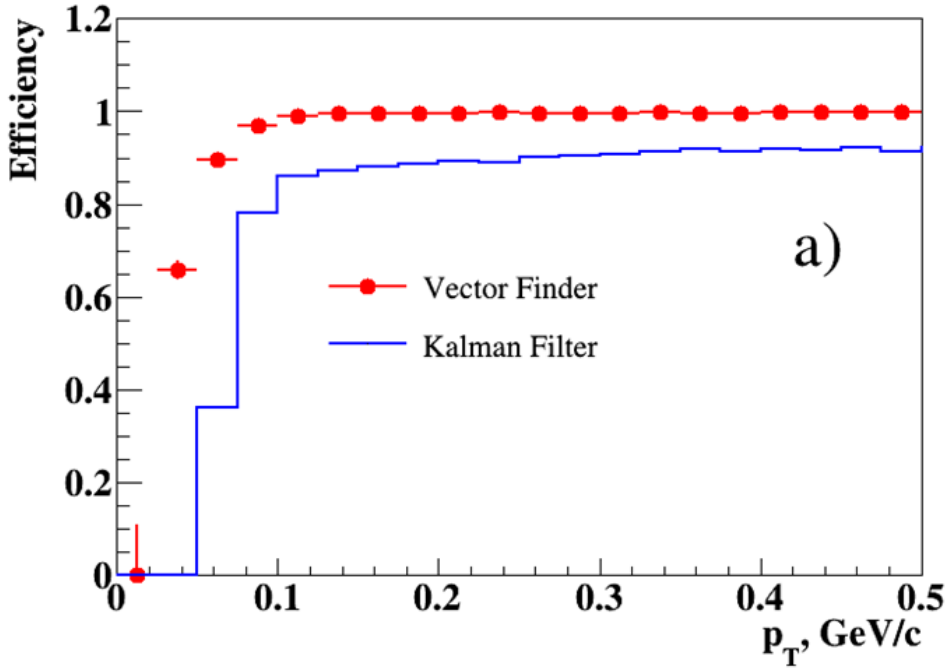
Vector Finder toolkit showed promising results on model data (GEANT + UrQMD)

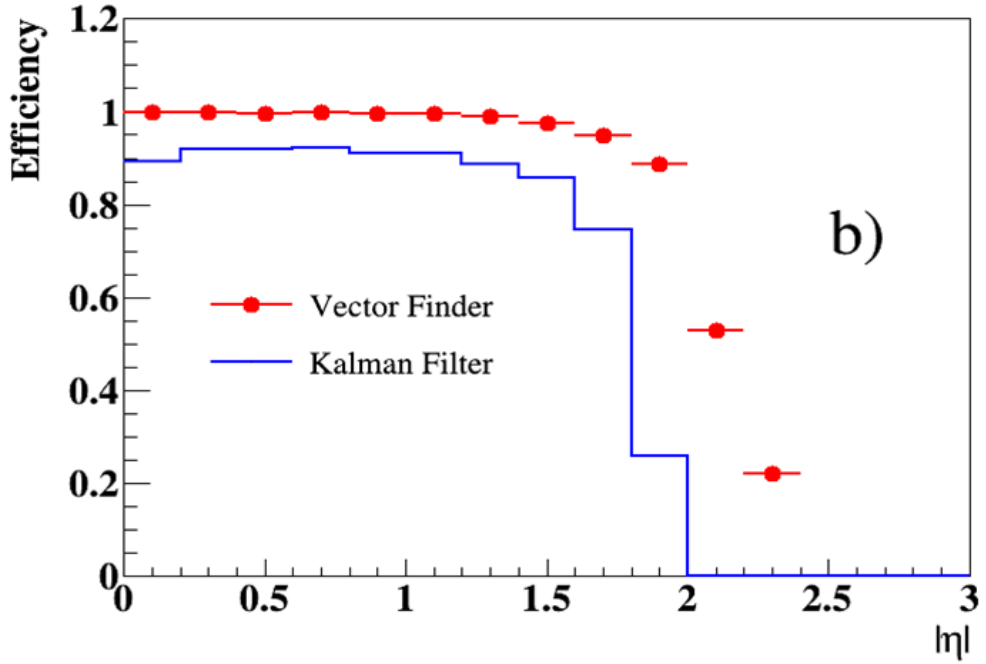




# Vector Finder performance for MPD (1)

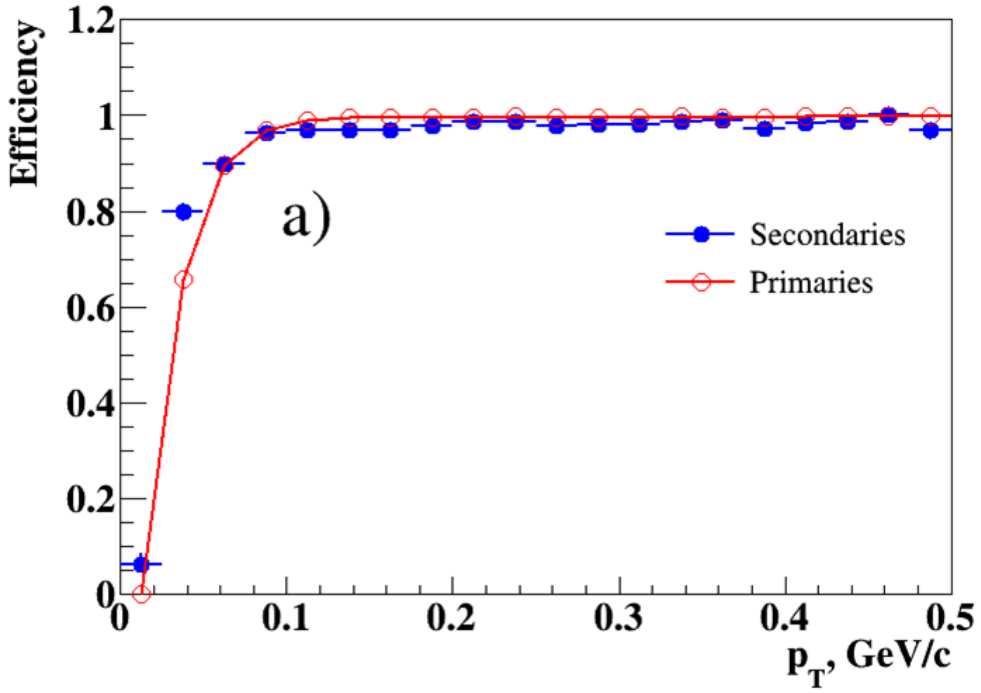
Algorithm was tested on 100-event set of central Au+Au collisions at $\sqrt{s_{NN}}$ = 9 GeV/c for evenly distributed layer geometry

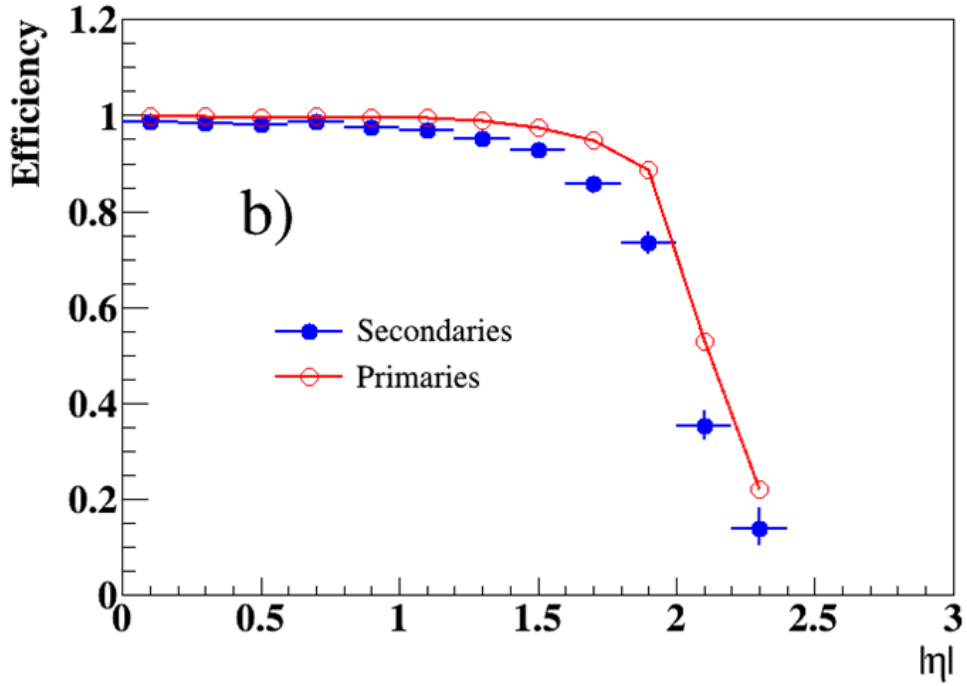


# Vector Finder performance for MPD (2)

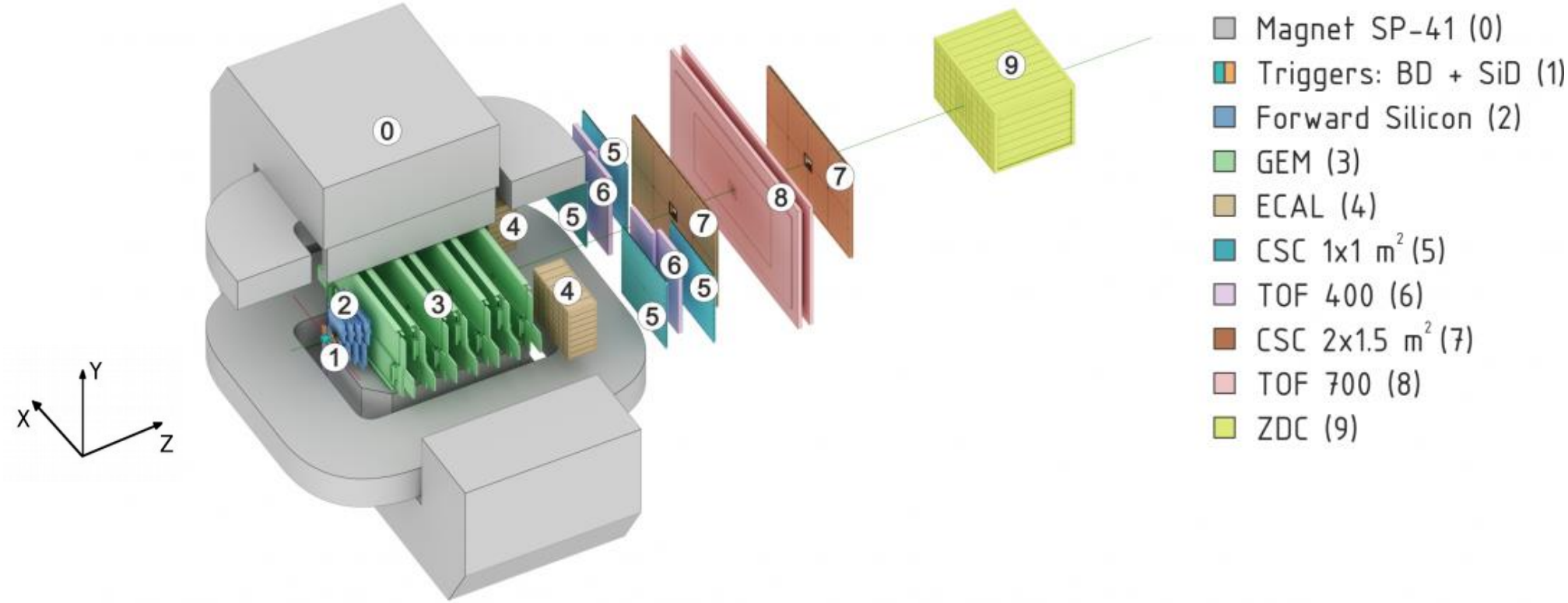
Algorithm was tested on 100-event set of central Au+Au collisions at $\sqrt{s_{NN}}$ = 9 GeV/c



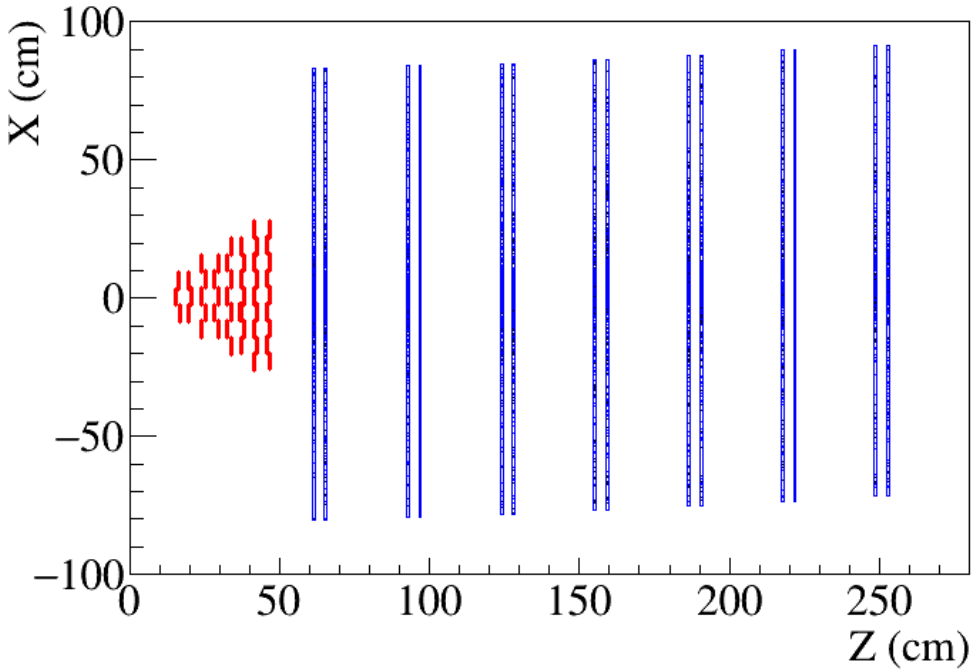
# BM@N/NICA configuration

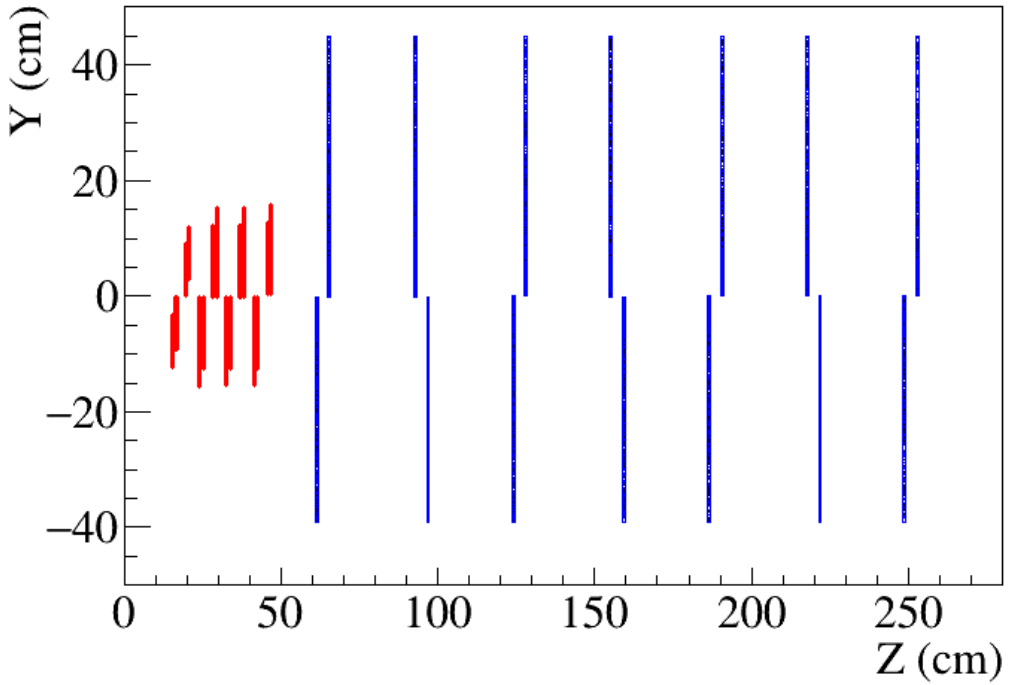
BM@N is the fixed target experiment at NICA with hybrid tracking system consisting of 4 layers of double-sided microstrip silicon sensors (2) and 7 planes of GEM detectors (3)



# BM@N Forward Silicon and GEM projections

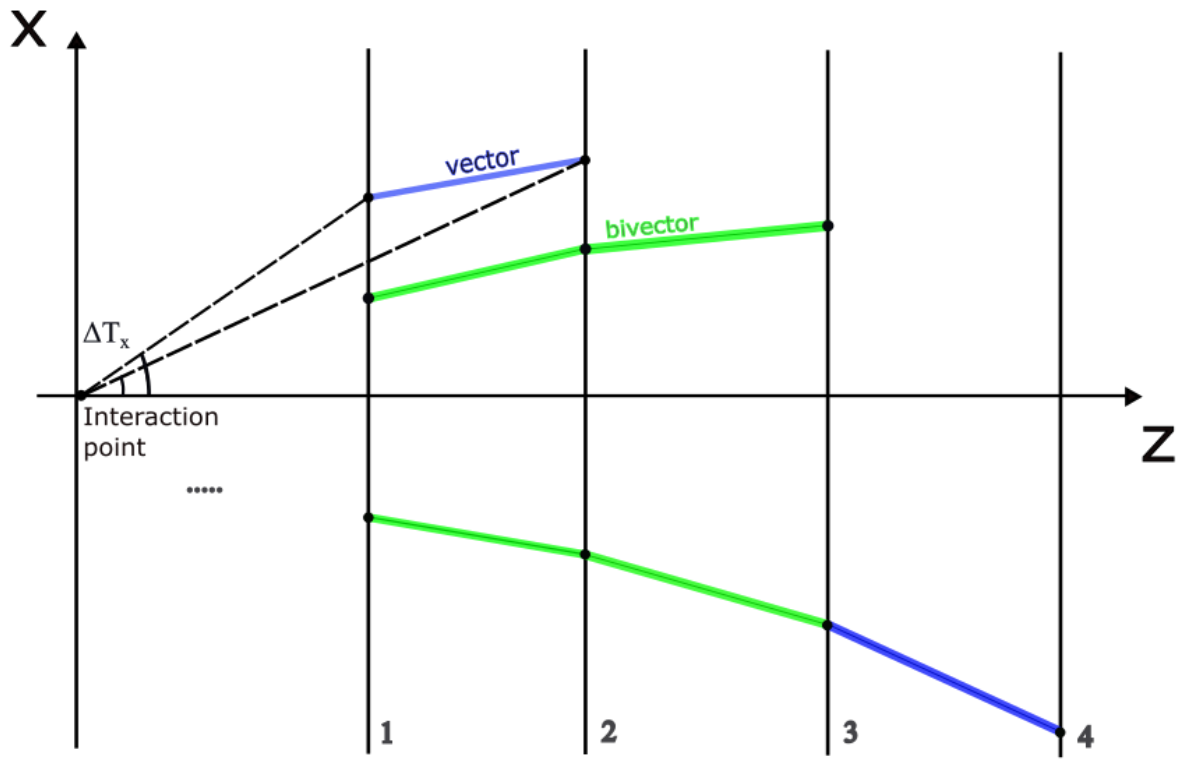
Monte Carlo point positions in the BM@N tracking system in different projections



# Vector Finder adaptation for BM@N

Longer track candidates are formed by adding vectors to current candidates. Corresponding bivector should also be available in bivector collection. $\chi^2$ is used as a stopping criteria when adding new hits.



# Prior constraints

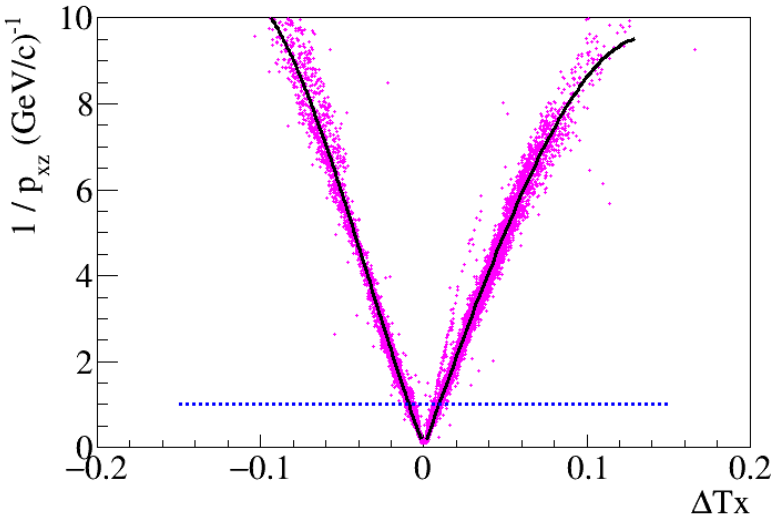
Priori constraints were obtained on Monte Carlo simulation of the setup with GEANT particle transport, using simulated Xe + CsI minimum bias interactions at $\sqrt{s_{NN}}$= 3.296 GeV produced by DCM-SMM event generator.

# Prior constraints

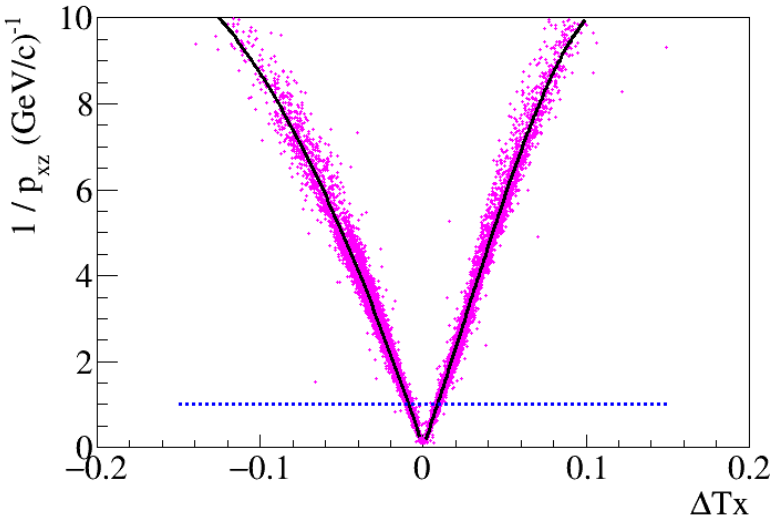
$\Delta T_x$ acceptance window if defined for:

- different station pairs (where it's possible to create vector)
- different $T_x^{init} = tan(X^{init}/Z^{init})$ value (binned)
- $1/p_{xz}$ cutoff for estimated momentum

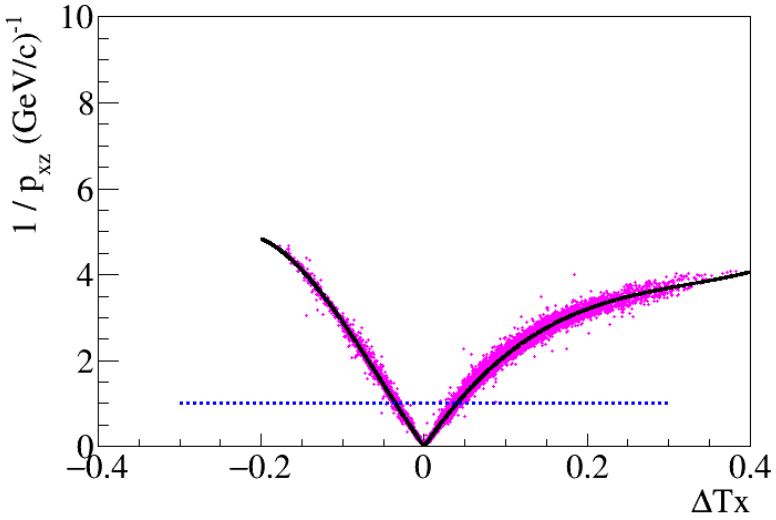
and is fitted by 4th degree polynomial (parameters are stored)




Stations 2 and 3, $T_x^{init} = -0.05$




Stations 2 and 3, $T_x^{init} = 0.15$

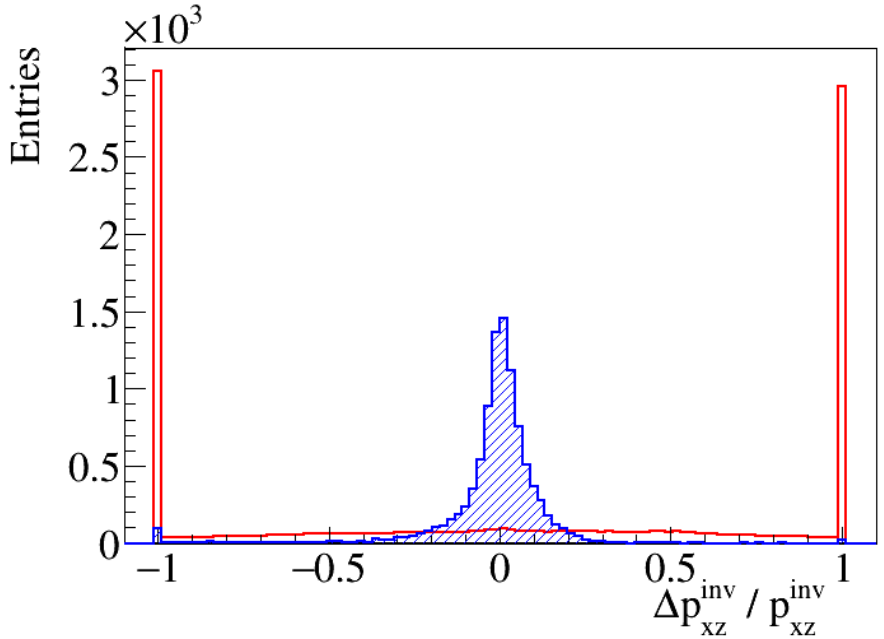



Stations 6 and 7, $T_x^{init} = 0.35$

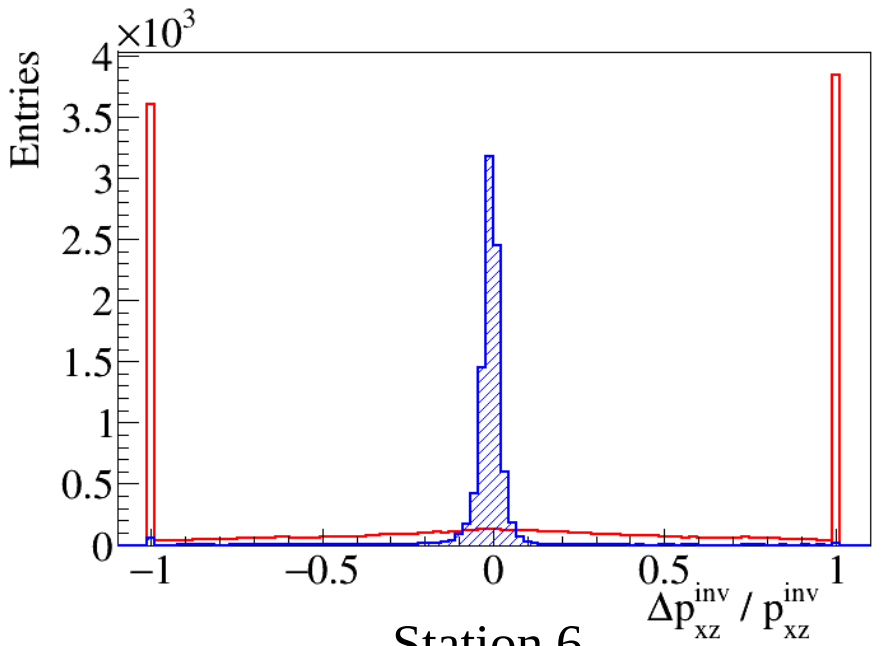
# Prior constraints

Relative difference of inverse track momentum estimate for two vectors in a bivector. Wrong bivector count (red) scaled by a factor of 1/200 for station 3 (left plot) and by 1/500 for station 6 (right plot).

$$\Delta p_{xz}^{inv}{}_{12} / p_{xz}^{inv}{}_{12} = \left(p_{xz}^{inv}{}_{1} - p_{xz}^{inv}{}_{2}\right) / \left(\left|p_{xz}^{inv}{}_{1}\right| + \left|p_{xz}^{inv}{}_{2}\right|\right)$$



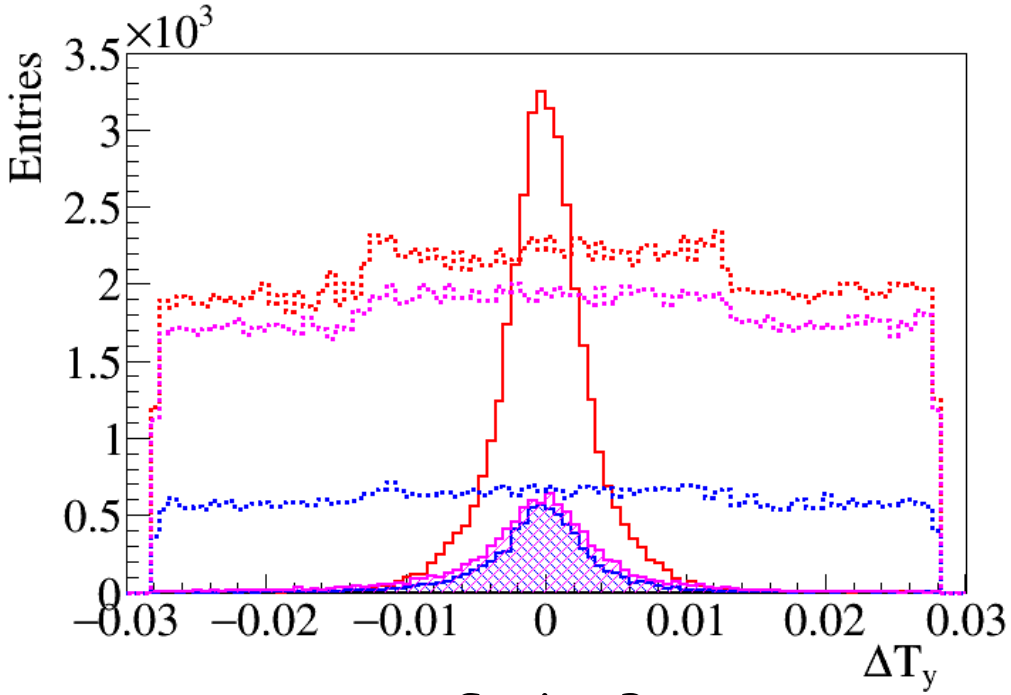

Station 3



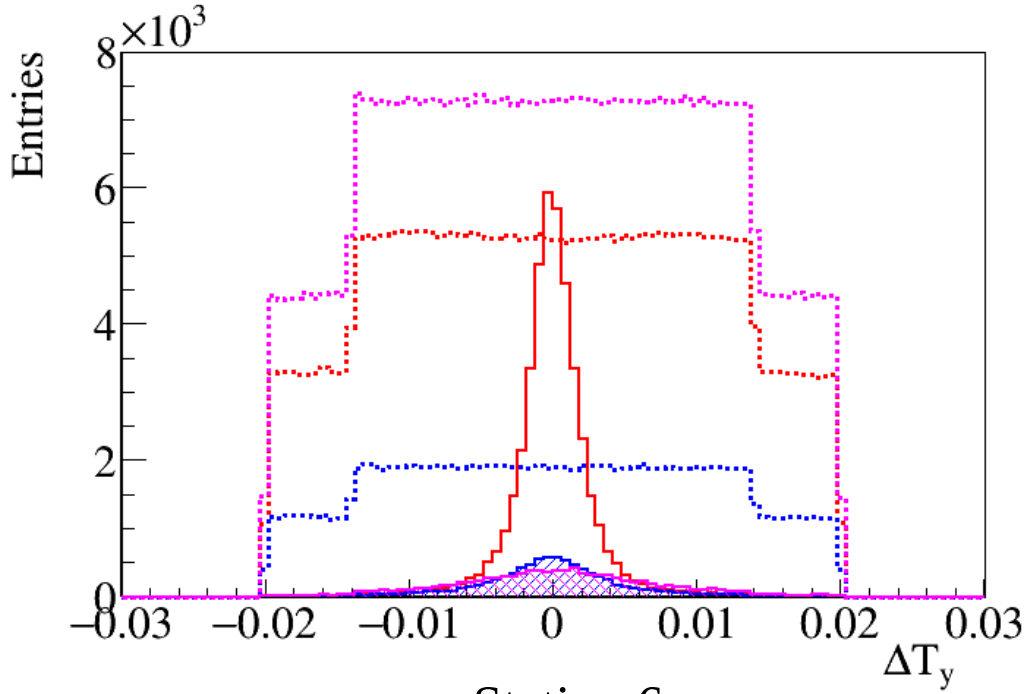

Station 6

# Prior constraints

Tangent difference of vector initial and terminal hit angular positions (YZ plane) for different algorithm pass: Pass 1, Pass 2, Pass 3
Wrong combinations (dashed lines) scaled by a factor of 1/5



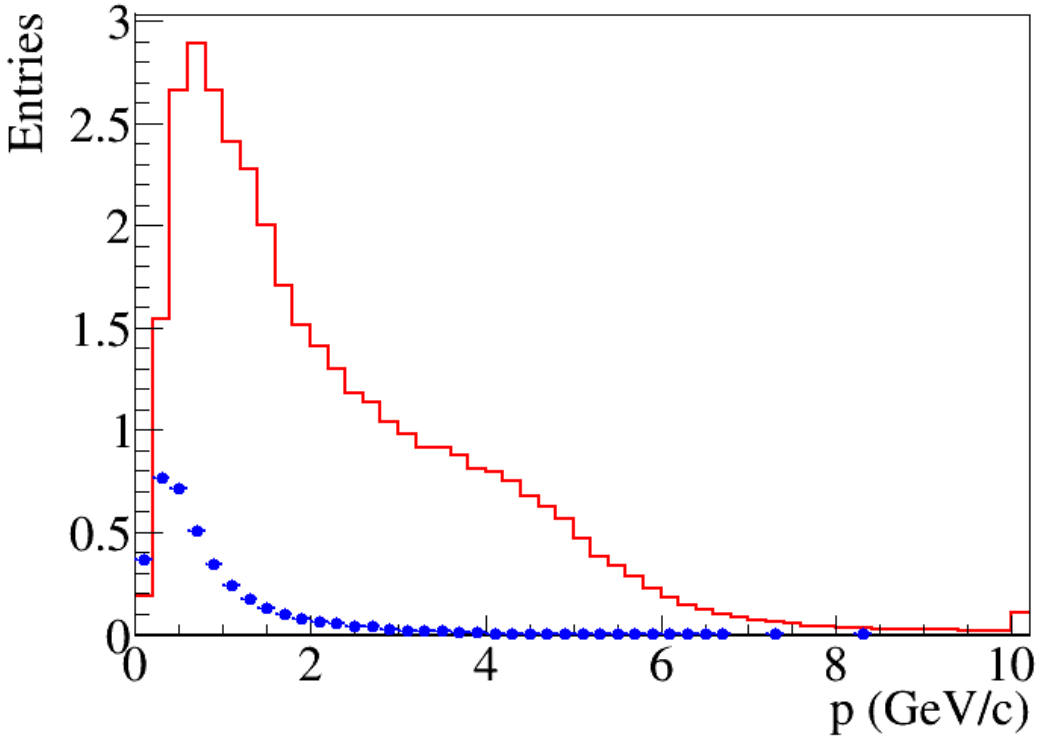

Station 3

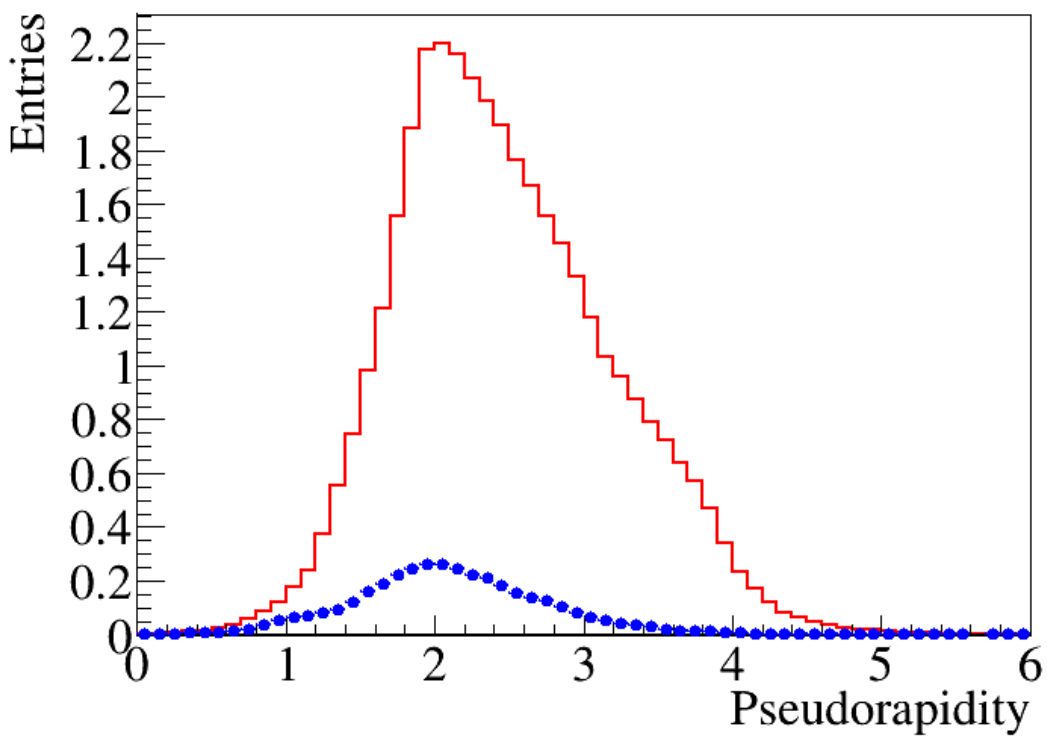



Station 6

# Reconstructible particle features

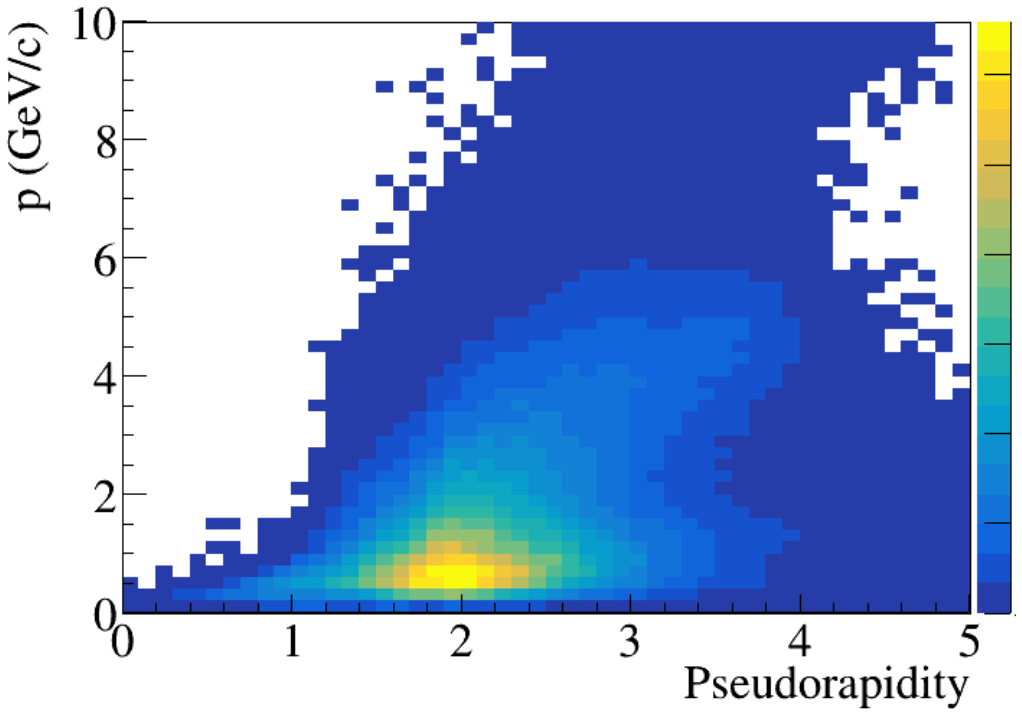
Momentum and pseudorapidity for primary (red) and secondary (blue) reconstructible particles: 4+ hits along the stations

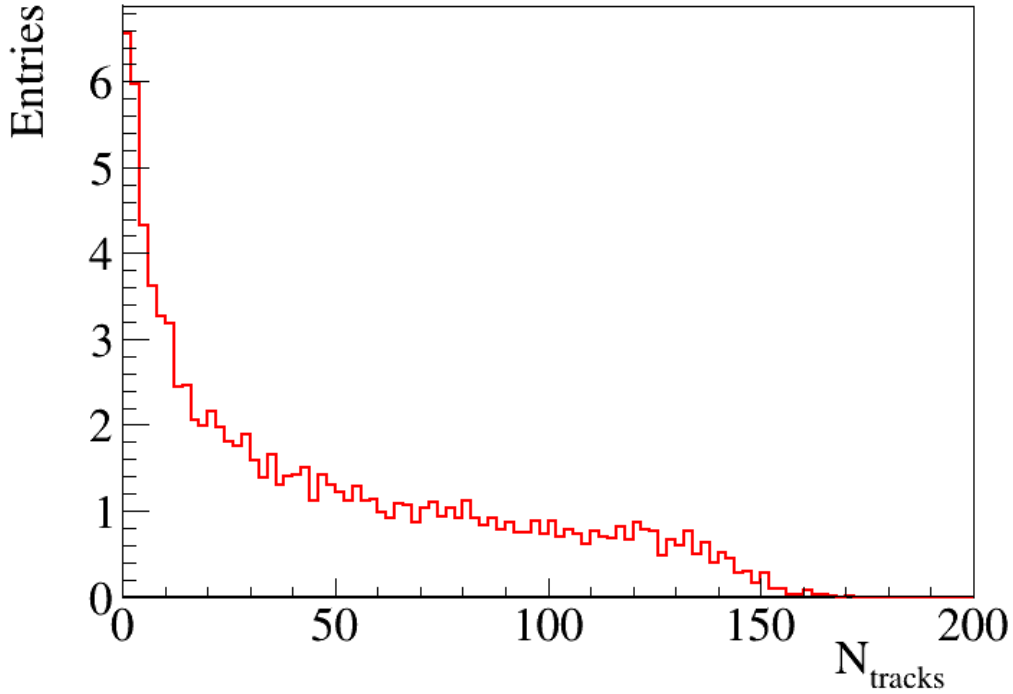


# Reconstructible particle features

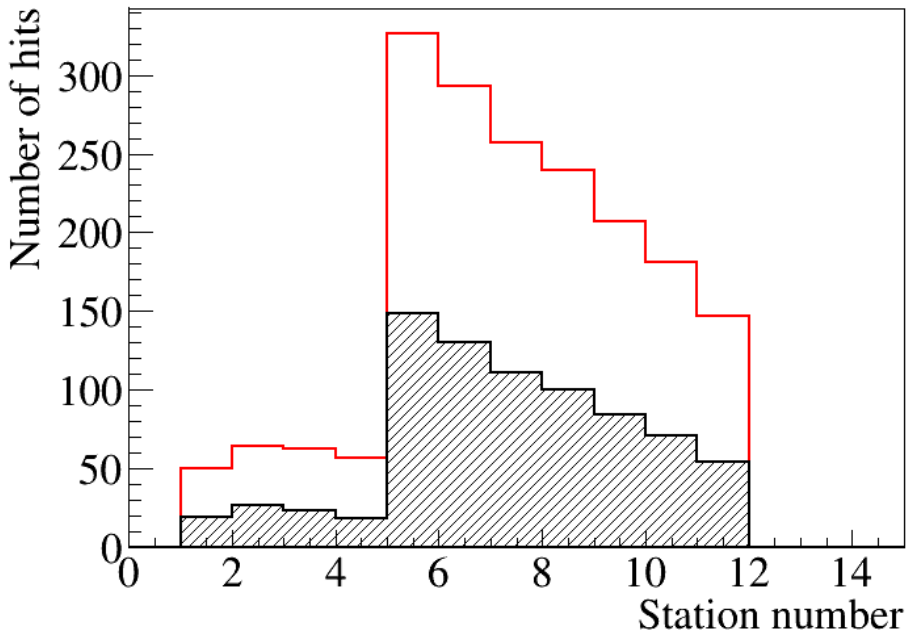
Phase space of reconstructible particles in momentum vs pseudorapidity (left), and multiplicity distribution (right)

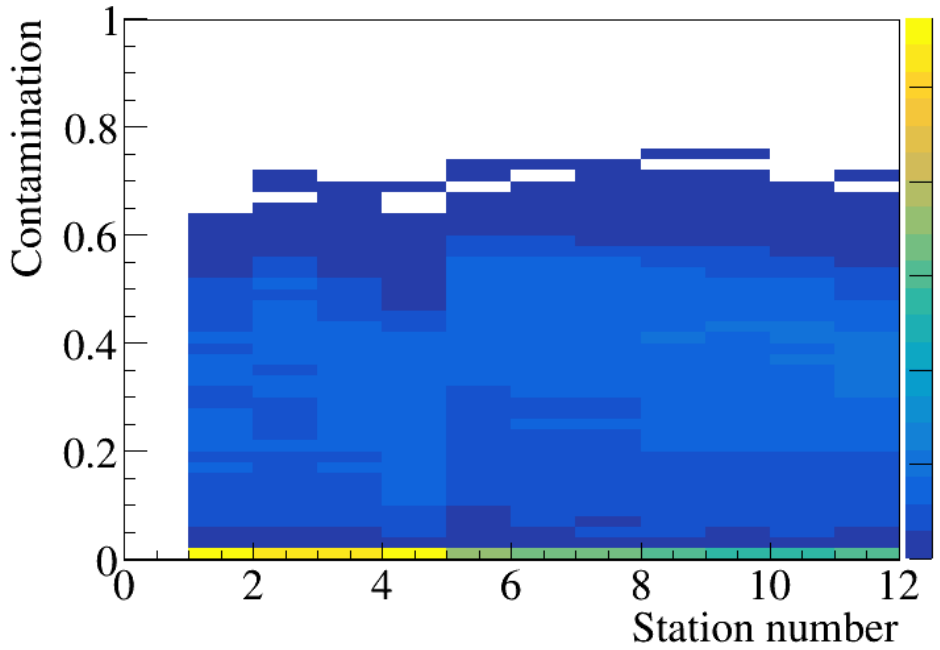


# Reconstructible particle features

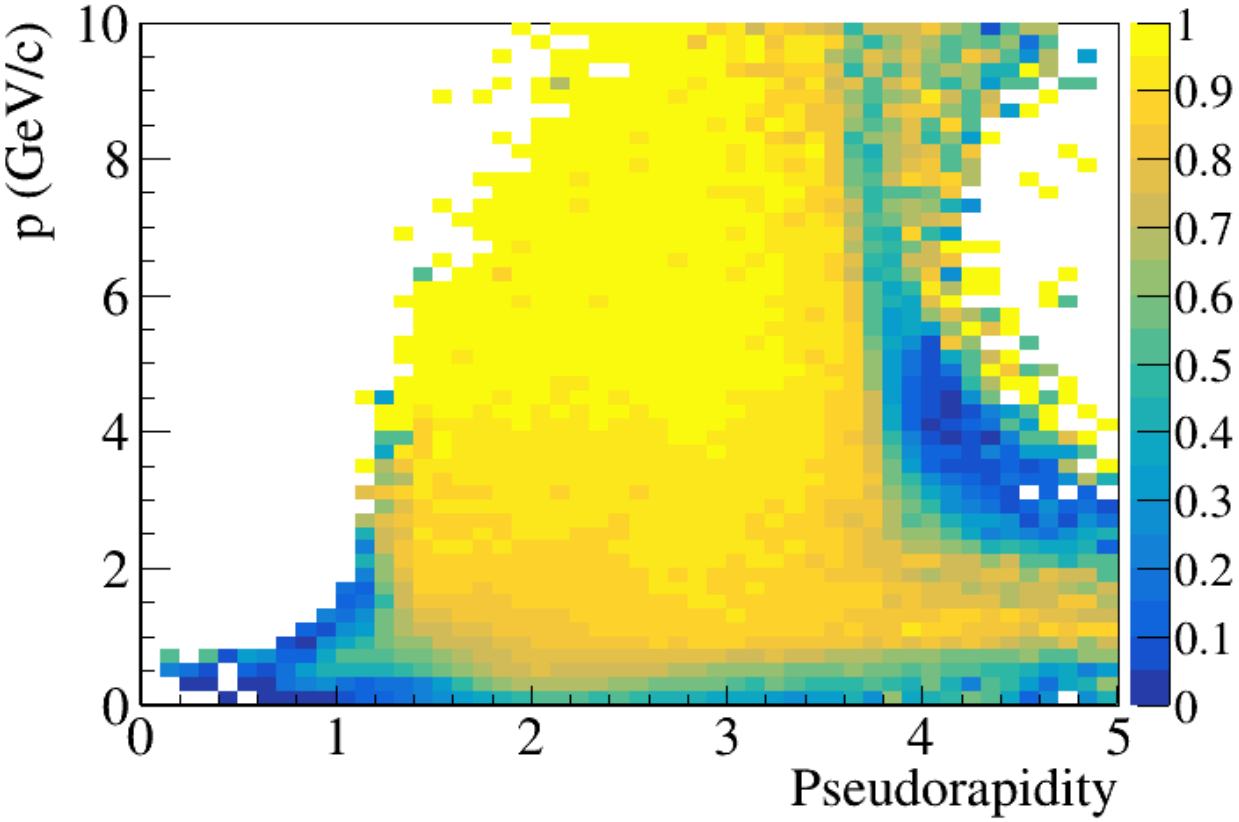
Average number of hits per station, including ghost hits (left) and hit contamination (right)



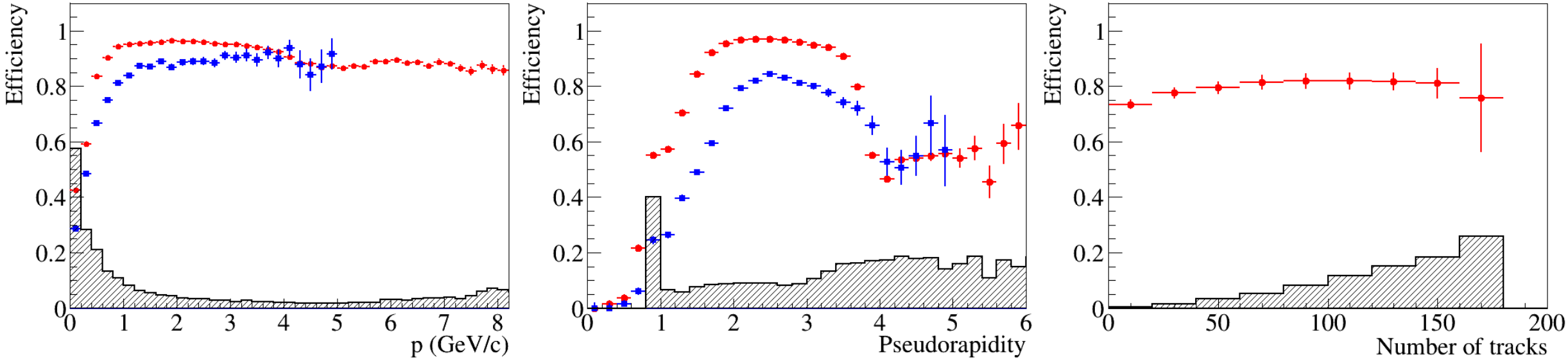
# Track reconstruction performance

Reconstruction efficiency for “good” (>50% hits from the same particle) tracks in the pseudorapidity – momentum plane



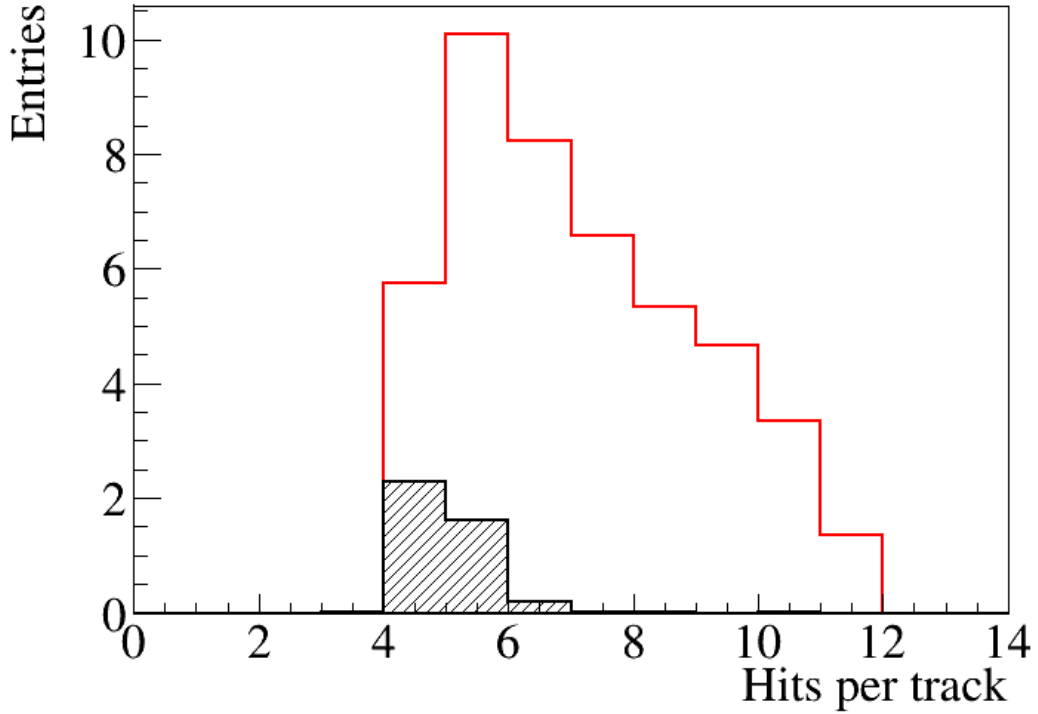
# Track reconstruction performance

Reconstruction efficiency for primary (red) and secondary (blue) tracks with ghost rate



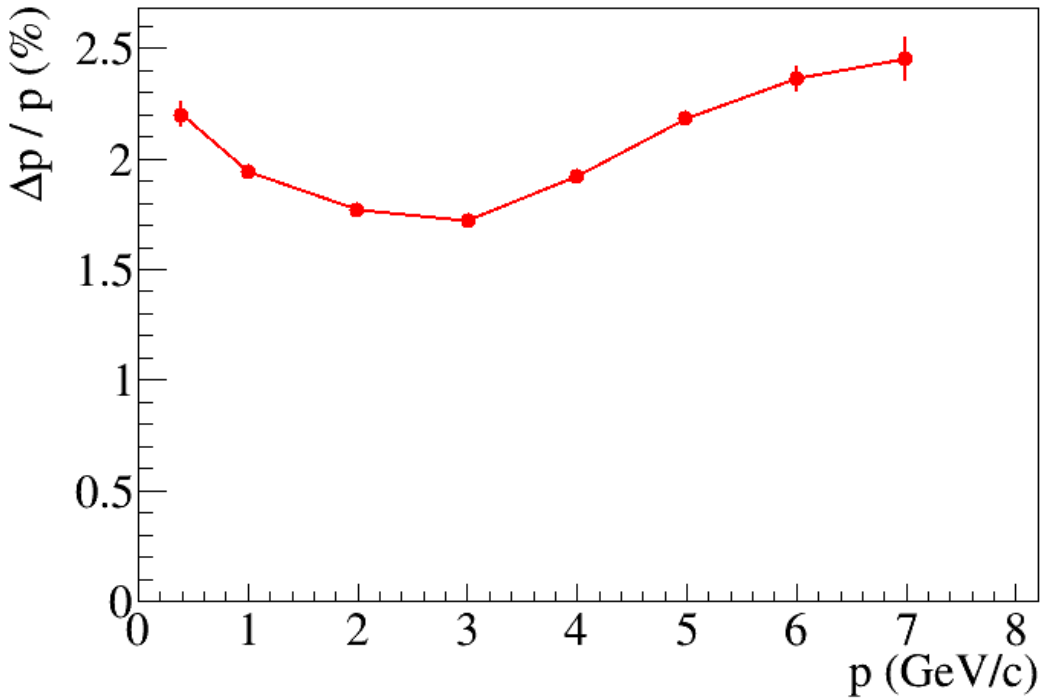
# Track reconstruction performance

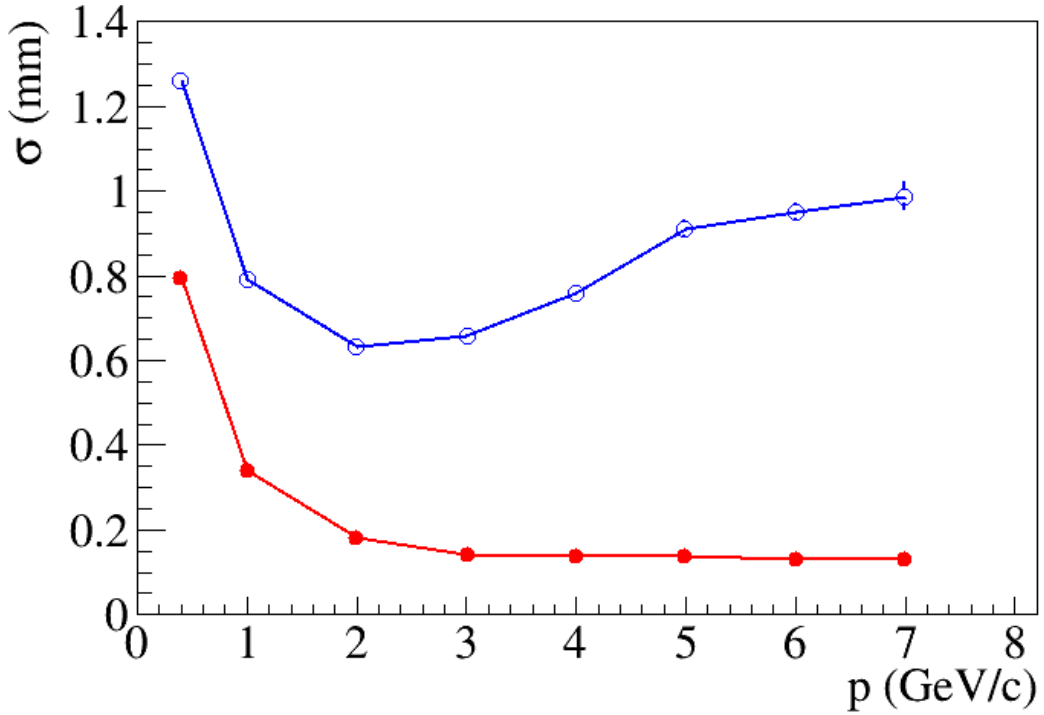
## Number of hits per track



# Track reconstruction performance

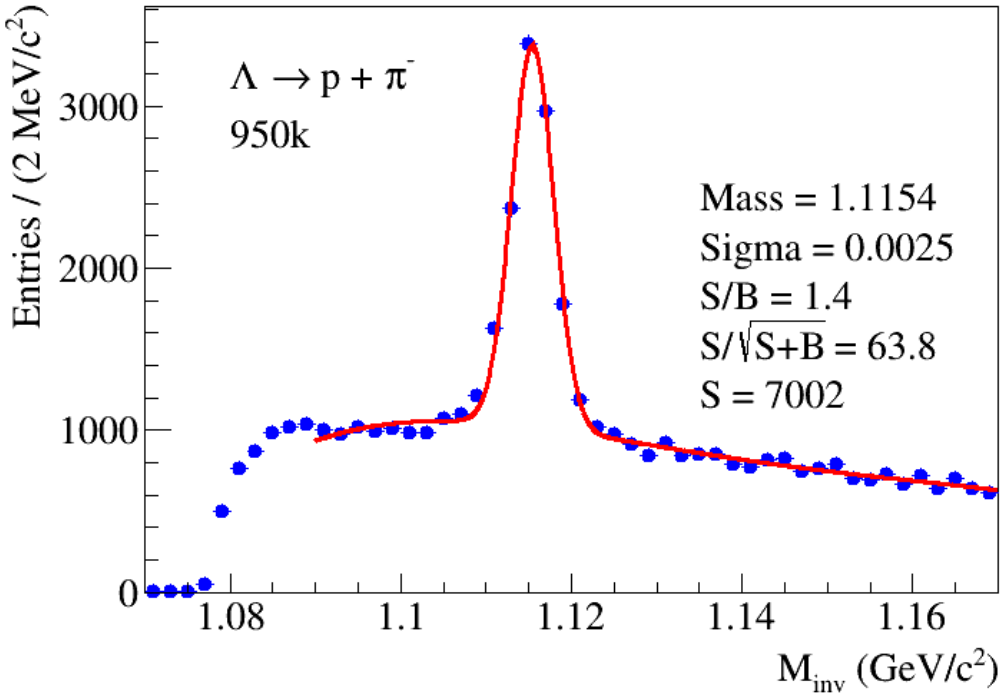
Relative momentum resolution vs momentum (left), track extrapolation uncertainty for X (red) and Y (blue) direction (right)

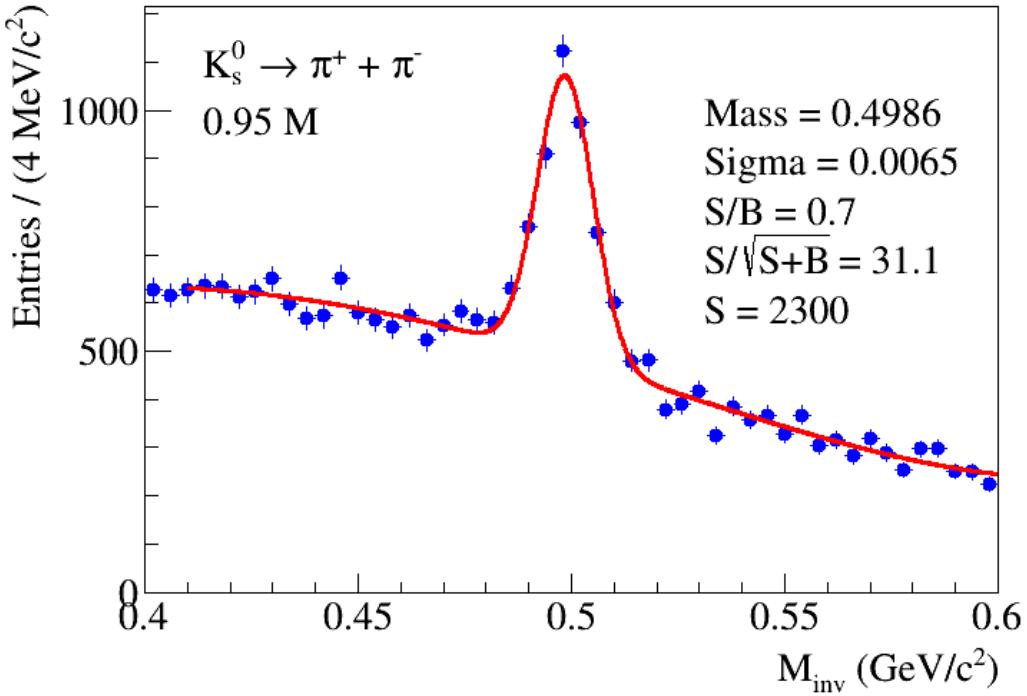


# Track reconstruction performance

Reconstructed invariant mass of $p+\pi^-$ and $\pi^++\pi^-$ after applying combinatorial background suppression. Histograms are fitted to a sum of a Gaussian and polynomial




Obtained on 950k events of Xe + CsI during 1st physics run of BM@N 12.2022-01.2023

# Conclusion

- Vector Finder toolkit was adapted for BM@N track reconstruction

- Possible candidate for universal tracking toolkit for NICA experiments?

Possible improvements

- TMVA / Machine learning for better cuts and ghost rejection

# Conclusion

Thank you for your attention!