Global track and vertex reconstruction in the BM@N experiment

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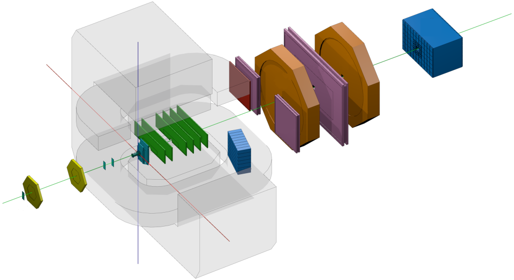
JINR & SPBU

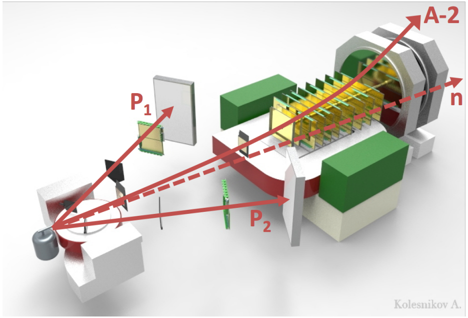
RFBR Grants for NICA

Two setups: BM@N & SRC

BM@N



SRC



Similar geometries ⇒ similar approaches

Vertex finder components

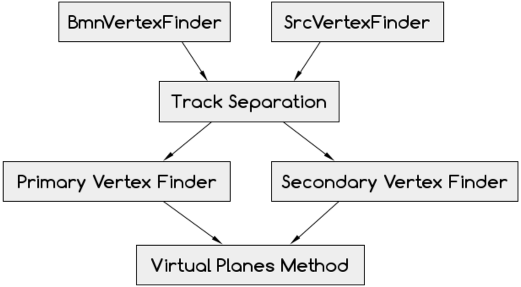
Track separation

BM@N setup:

- Extrapolate all tracks to Z-coordinate of target
- Check if track is in "beam region" or not and mark it with corresponding flag

SRC setup:

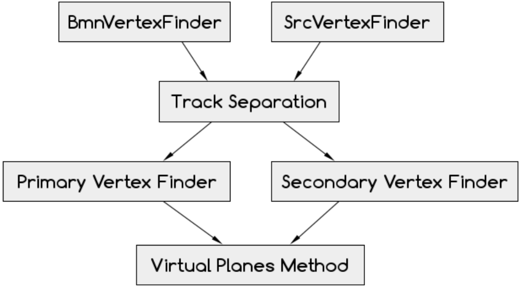
- Check if global track has upstream part



Vertex finder components

Primary vertex finder

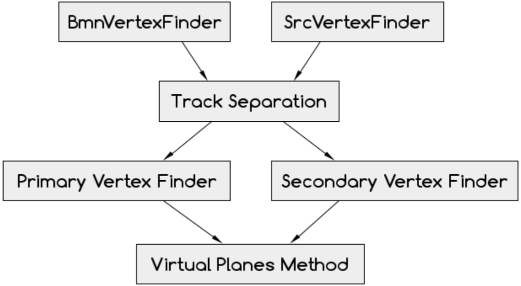
- At least two primary tracks are necessary
- Reconstruct primary vertex for tracks marked as primary by virtual planes method
- Z position of found vertex has to be within range (R)
- Extrapolate tracks belonging this vertex to found Z_{PV} and calculate X_{PV} and Y_{PV}



Vertex finder components

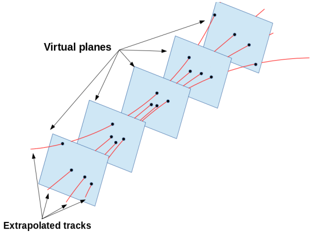
Secondary vertex finder

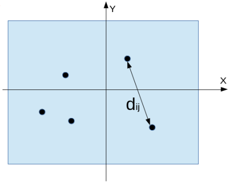
- At least two secondary tracks are necessary
- Reconstruct secondary vertex for tracks marked as secondary by virtual planes
- Extrapolate tracks belonging this vertex to found Z_{SV} and calculate X_{SV} and Y_{SV}

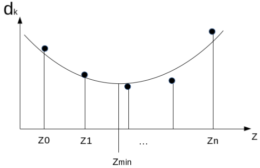


Virtual planes method

1. Extrapolate reconstructed tracks to set of $\{z_k\}_0^{N_{planes}}$ by Kalman Filter around initial estimation: $Z_v^{init} - R < z_k < Z_v^{init} + R$
2. Calculate distance between each pair of points on plane k: $d_{ij}^k = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$
3. Calculate mean distance for each plane: $d^k = \sum d_{ij}^k / N_{pairs}$
4. Fit $d^k(z_k)$ by parabolic function and find z_{min}
5. Reduce R by factor speed: $R = R/speed$
6. Repeat 1-5 until required accuracy is achieved



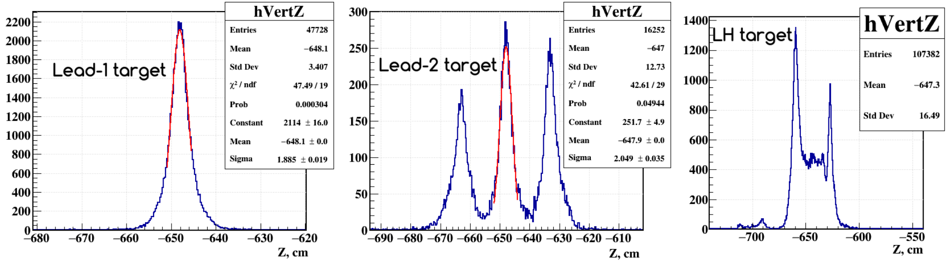




Vertex in the SRC runs

For the SRC setup three types of targets were used:

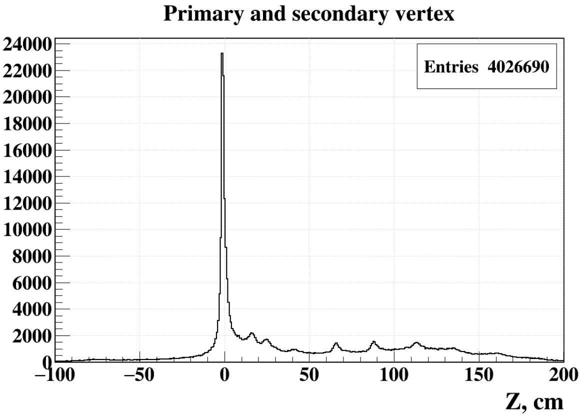
- one lead plane for calibration
- three lead planes for calibration
- liquid hydrogen barrel as a physics target



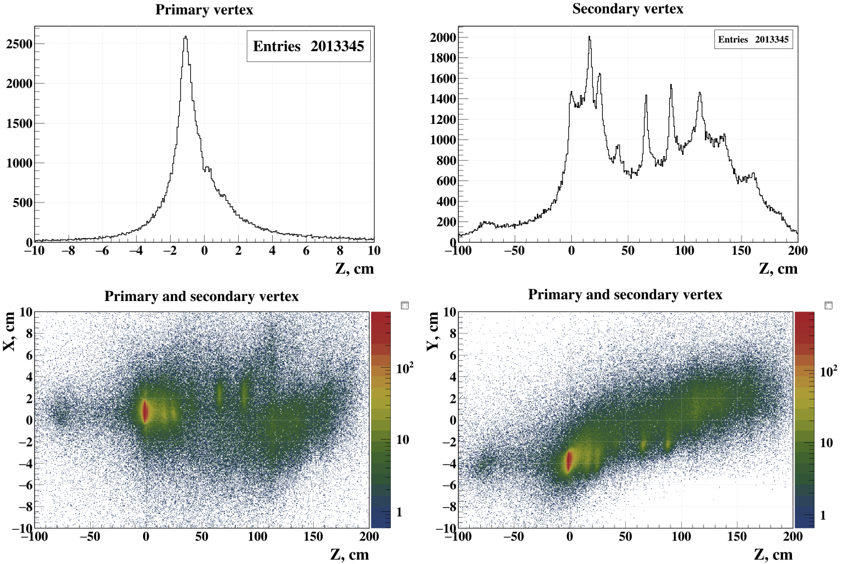
Vertex in the BM@N runs

For the BM@N setup the set of targets was used: C, Al, Cu, Sn, Pb

Z distribution of reconstructed vertices for Ar+Pb (BD > 3)



Vertex in the BM@N runs



Tuning strategy

Algorithm input parameters:

- Range to search primary vertex in (Range)
- Number of virtual planes (Planes)
- Range reduction rate (Speed)

Control parameters:

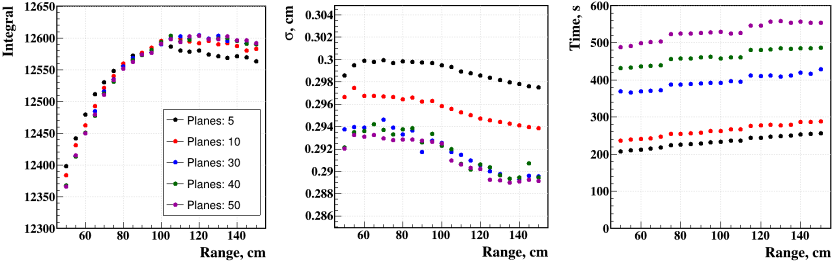
- Number of found vertexes in $-3\text{cm} < z < 3\text{cm}$ (Integral)
- Width of Gaussian fit (σ)
- Work time (Time)

Main idea:

Scan algorithm over input parameters to maximize Integral and minimize σ and Time.

Output parameters dependencies on number of virtual planes and search range for range reducing rate 1.5

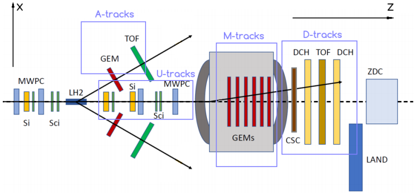
Sample: $\approx 10^6$ events of Ar+Sn (BD > 3)



Global tracking components

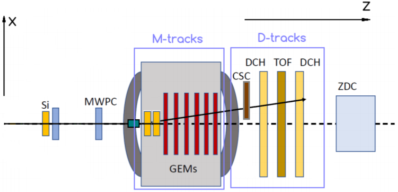
SRC setup

- Upstream detectors: 3 Silicon + 2 MWPC ⇒ U-tracks
- Detectors inside magnet: 6 GEM ⇒ M-tracks
- Downstream detectors: 1 CSC + 1 TOF + 2 DCH ⇒ D-tracks
- Detectors in arms: 2 GEM + 2 TOF ⇒ A-tracks



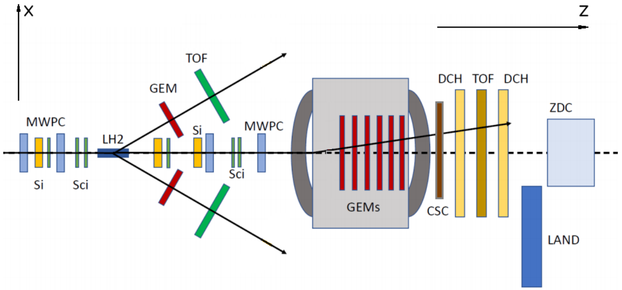
BM@N setup

- Detectors inside magnet: 3 Silicon + 6 GEM ⇒ M-tracks
- Downstream detectors: 1 CSC + 2 TOF + 2 DCH ⇒ D-tracks



Common algorithm of matching

Step 1. Alignment

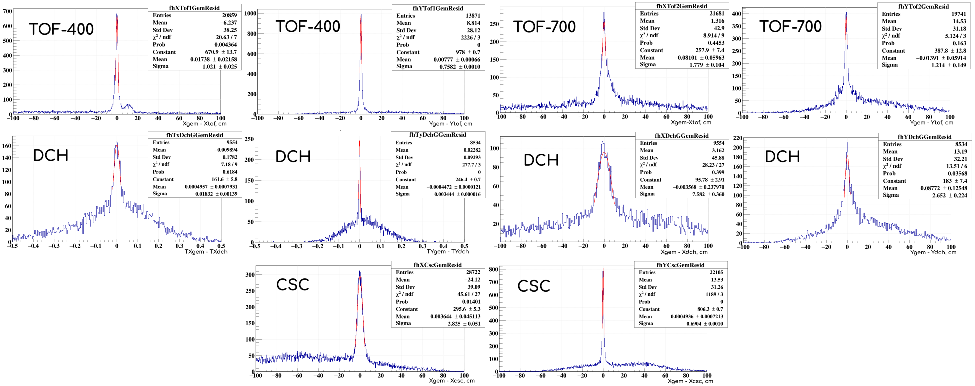


- Propagate each M-track to plane with hits
- Create track-to-hit (all-to-all) connections
- Calculate and fit residuals $\rightarrow$ $\mu_x, \mu_y, \sigma_x, \sigma_y$
- Shift all hits by μ_x, μ_y

The main question: What to fix?

Centered all-to-all distributions

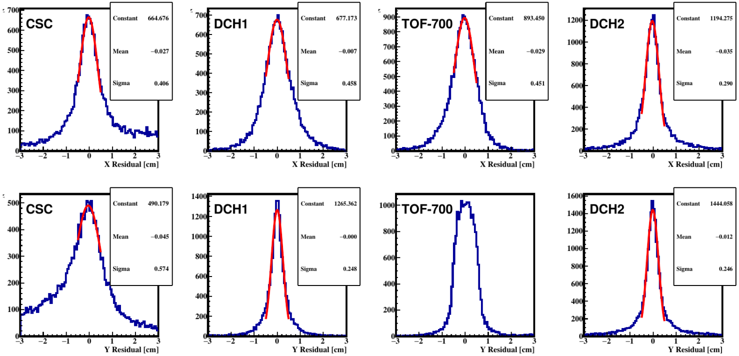
Examples for BM@N



Common algorithm of matching

Step 2. Matching:

- Propagate each track to plane with hits
- Find the nearest hit in $\pm 3\sigma_x$ and $\pm 3\sigma_y$
- Update track parameters by connected hit information

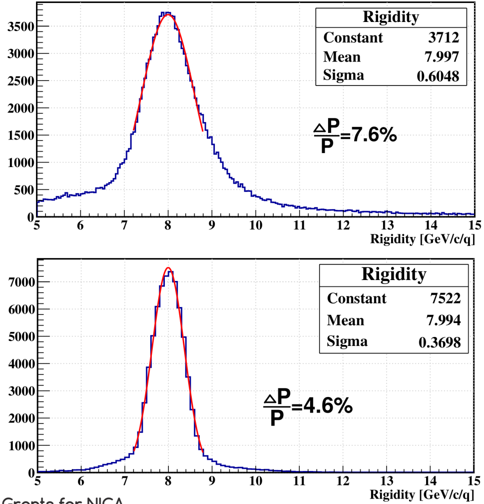


How does global tracking help?

Momentum resolution in the SRC

- U-tracks give an input angle to the magnetic field region
- D-tracks give an output angle from the magnetic field region
- M-tracks give an integral of the magnetic field along the trajectory
- Momentum can be refined by

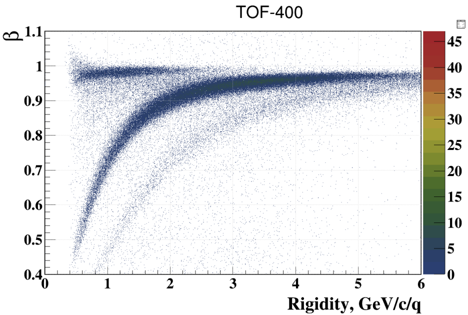
$$\frac{p}{q} = \frac{0.3 \cdot \int B dl}{\alpha_{out} - \alpha_{in}}$$



How does global tracking help?

Particle identification in the BM@N

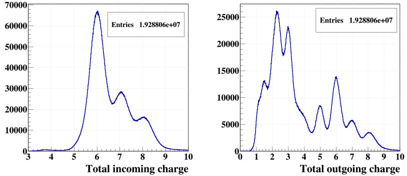
- Combination of time-of-flight and length of trajectory gives velocity
- Combination of velocity and momentum gives mass
- TOF detector and GEM planes gives particle identification

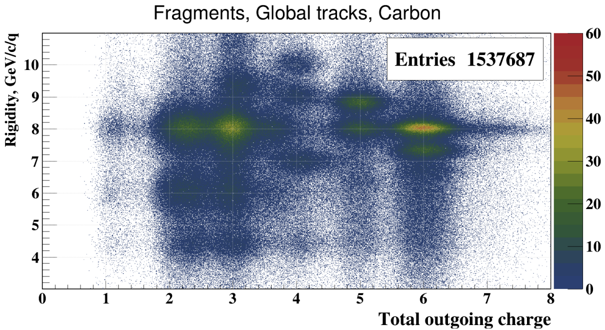


How does global tracking help?

Fragment identification in the SRC

- Amplitudes of BC triggers give total charge of event
- Combination of momentum and total charge gives fragment identification





Summary

- The algorithms of vertex finder and global tracking were described
- The corresponding classes were integrated into reconstruction chain and implemented into BmnRoot software
- Positive results for BM@N and SRC setups were achieved
- Tuning of the VF algorithm was performed for Ar+Sn (BD > 3)

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Thank you!