On π^+, π^- identification in Ar run

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The main goal of the analysis

- Identifying $\pi^{\pm}$, $K^{\pm}$
- Estimation of the π, K mesons production cross section

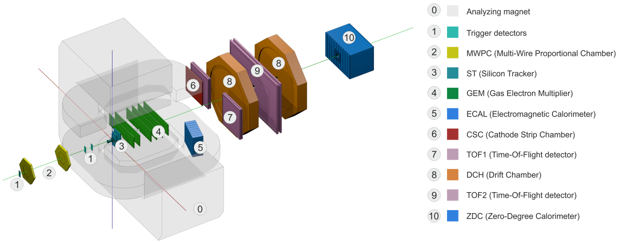
Outline

- Particle identification in the BM@N experiment
- Filtering experimental data
- Comparison of Monte Carlo data and experiment
- Adding realistic effects to event simulation
- Summary

Current BM@N Run-7 geometry

Silicon + GEM (Gas Electron Multiplier)

Allows to reconstruct the momentum along the trajectories of charged particles. Rigidity $= p/q$

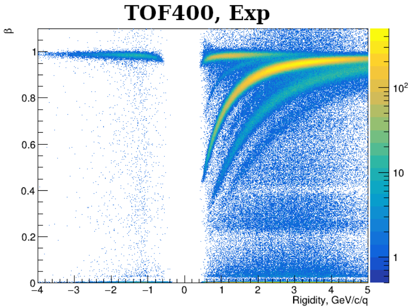


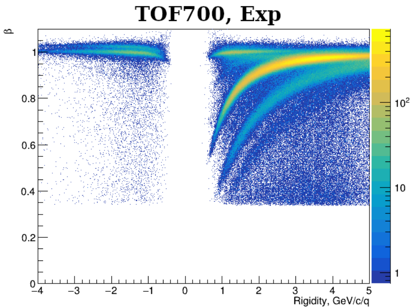
TOF(Time-Of-Flight detectors

Allows to calculate the velocity taking into account the measurement of the time. $\beta = l/tc$

Exp data

- Beam: Ar @ 3.2 AGeV
- Target: C, Al, Cu, Pb, Sn





Experimental data are noisy therefore selection procedures are needed

Filtering experimental data

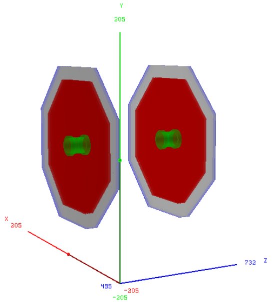
Selection criteria for reliable experimental tracks:

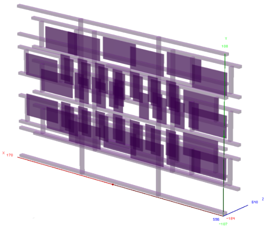
- Vertex in range
  $V_x \in (-2, 4)$cm; $V_y \in (-6, -1)$cm; $V_z \in (-5, 5)$cm.
- Minimum 1 hit in silicon stations and min 4 hits in GEM.
- The track is confirmed in the first drift chamber

For the TOF detector, we associate the track with the hit, and for the DCH with the track segment

Alignment algorithm

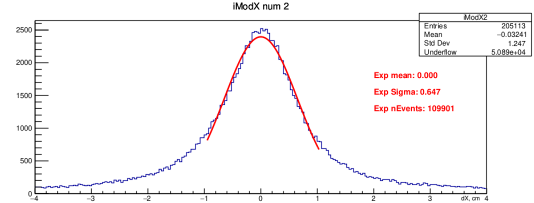
- Propagate each track to the detector plane
- Create all track-to-hit (track-to-track) connections
- Fit residuals and get $\mu_x, \mu_y, \sigma_x, \sigma_y$

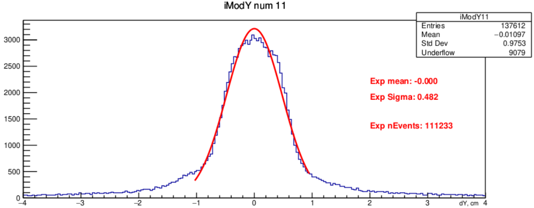




Coordinate and time calibrations for TOF

The TOF700 detector was aligned for each **module separately**.



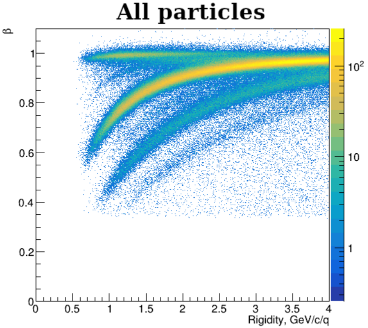


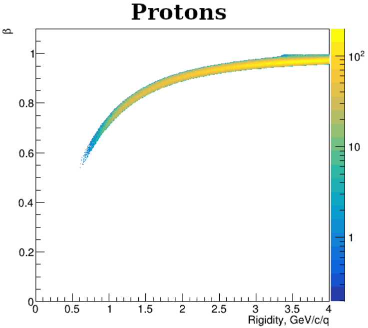
Time calibration

After the coordinates were aligned, the time was calibrated
From $\delta\rho$ and δt calculate δm

$$\beta_{min} = \frac{\rho}{\sqrt{\rho^2 + (m + \delta m)^2}}; \beta_{max} = \frac{\rho}{\sqrt{\rho^2 + (m - \delta m)^2}}$$

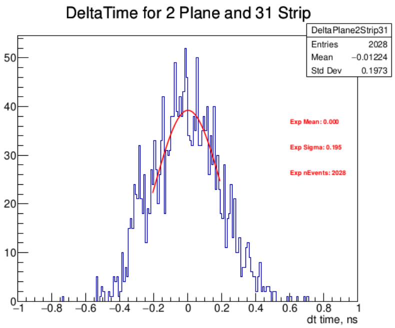
Select protons in the range $\beta_{min} < \beta < \beta_{max}$

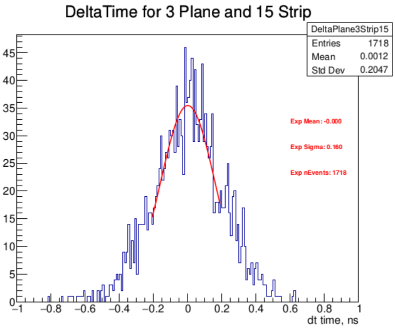




Calculate and fit residuals

$$\Delta t = \frac{L}{c}\sqrt{1+\left(\frac{m}{p}\right)^2} - t_{exp}$$

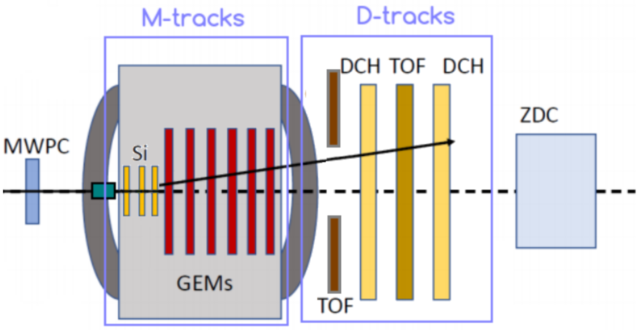




Track selection algorithm

Re-extrapolating

Propagate the inner track through its hits in silicon and GEM.



Track selection algorithm

Matching

Tracks from the magnet are matched with the DCH tracks and hits in the TOF detector.
At this stage, we use the σ_x and σ_y obtained from the alignment procedure.

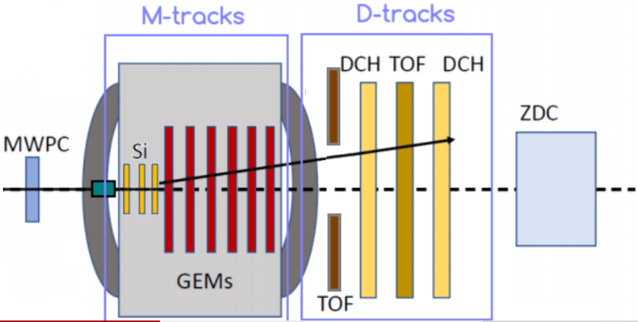
- The track is extrapolated to each hit (track) in the detector plane
- Calculate residuals $\Delta X = x_{track} - x_{hit}; \Delta Y = y_{track} - y_{hit};$
- Find the nearest hit (track) in $\pm 3\sigma_x$ and $\pm 3\sigma_y$

Track selection algorithm

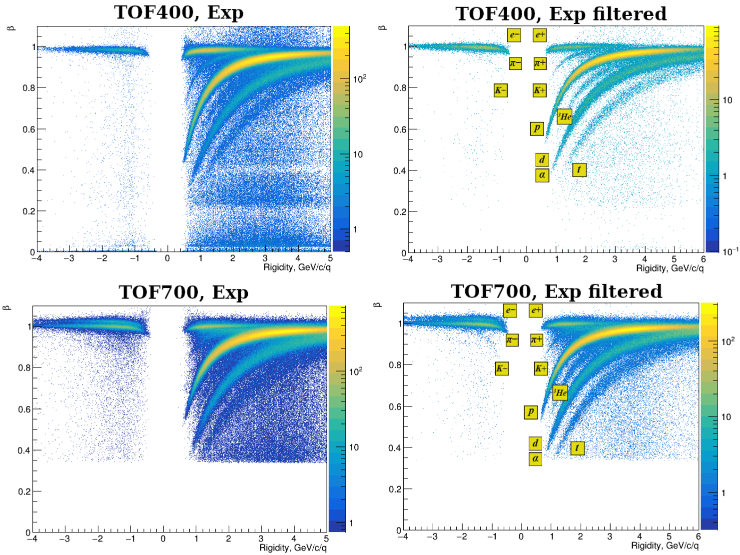
Back propagation

Extrapolate track from TOF detector to the vertex.

- Get time of flight from a TOF hit
- Calculate velocity $\beta = l/tc$
- Save track parameters if it belongs to the vertex range



Before/After

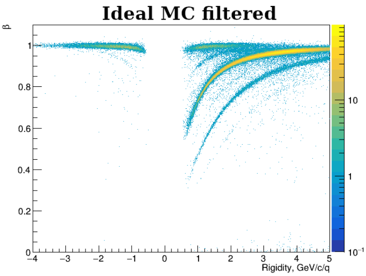


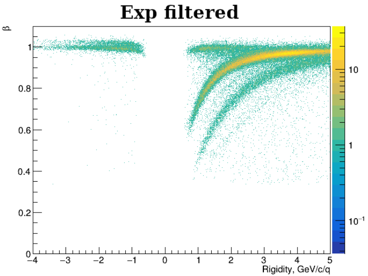
Exp and MC comparison parameters

We will compare MC (blue line) and Exp (red line) on the Ar + Cu data.

Data parameters

- Number of hits in Silicon and GEM tracks
- Station efficiency
- Residuals





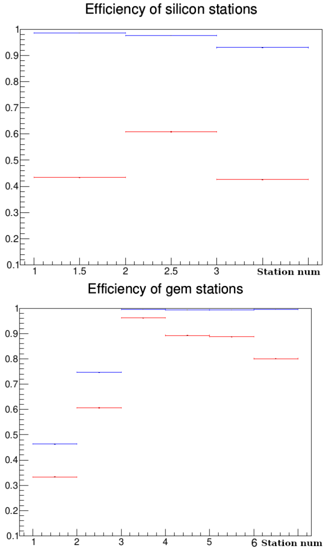
Comparison of Exp and MC

Monte Carlo

- Generator: DCMSMM
- System: Ar + Cu
- Energy: 3.2 AGeV
- Selected tracks only

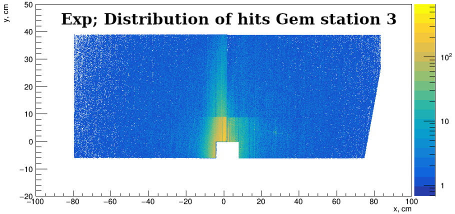
Exp data

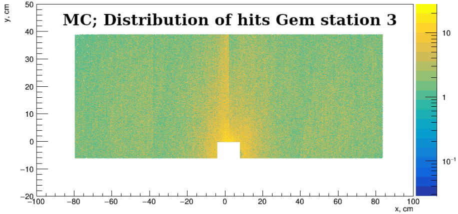
- System: Ar + Cu
- Energy: 3.2 AGeV
- Selected tracks only



How to reduce efficiency?

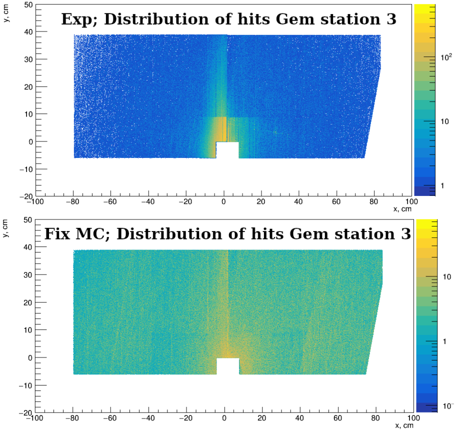
The efficiency of a station depends on 1)Tracks passed through the station and 2) Tracks in acceptance.





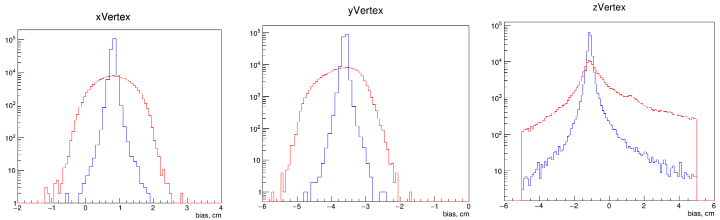
Adding dead strips

- A list of non-working strips was received
- Strips from this list were disabled during the simulation stage.

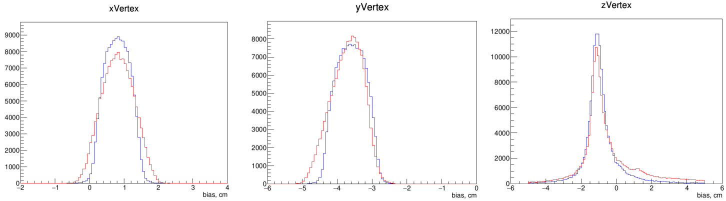


Smearing vertex

Initially, the peaks of the vertex coordinates are very **narrow and high**.

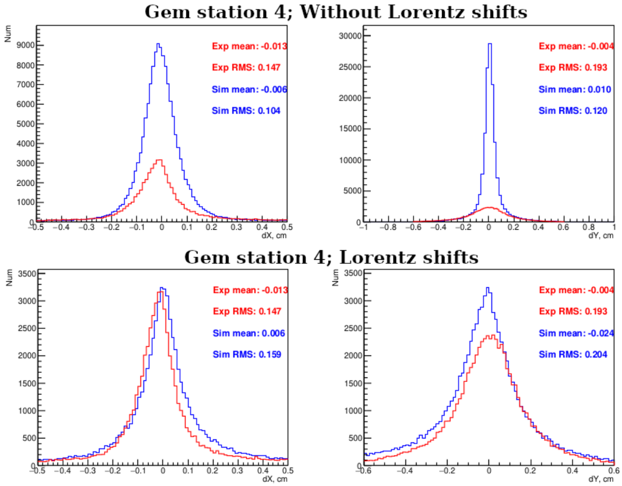


The vertex width was **obtained from experimental data.**



Lorentz shifts

Lorentz shifts simulate the displacement of electron avalanches in a magnetic field. Residuals become wider.



Comparison of Exp and MC

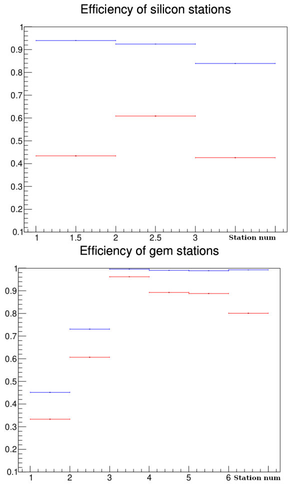
Monte Carlo efficiency remains high...

Monte Carlo

- Generator: DCMSMM
- System: Ar + Cu
- Energy: 3.2 AGeV
- Smearing Vertex
- Lorentz Shifts
- Dead strips

Exp data

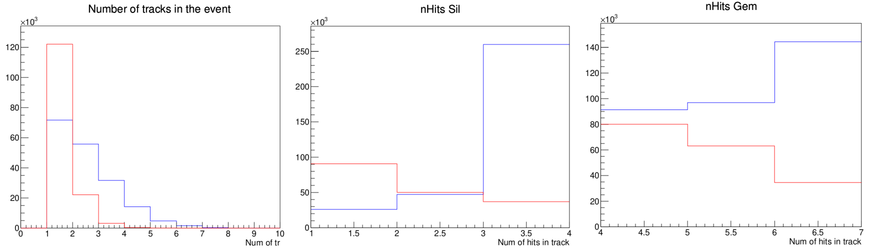
- System: Ar + Cu
- Energy: 3.2 AGeV



Reasons for high efficiency

Because we have a large number of "good" MC tracks that passed the selection.

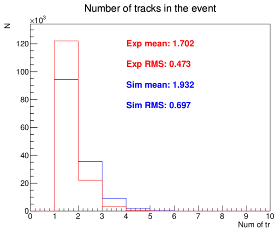
MC data is blue and Exp data is red

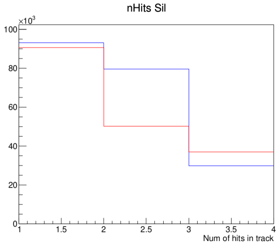


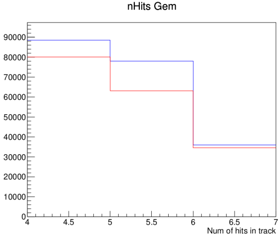
The experiment is dominated by events with one track, and in Monte Carlo there are many events with several tracks.

Disabling hits in reconstruction

Efficiency constant have been added to the reconstruction process.







If the randomly generated number is higher than the station constant, then the hit for this station is not recorded.

Comparison of Exp and MC

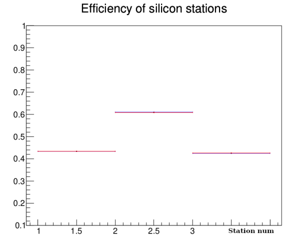
Monte Carlo's behavior repeats the experiment

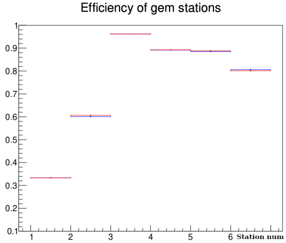
Monte Carlo

- Generator: DCMSMM
- System: Ar + Cu
- Energy: 3.2 AGeV
- Smearing Vertex
- Lorentz Shifts
- Dead strips, hits

Exp data

- System: Ar + Cu
- Energy: 3.2 AGeV





Summary

- Calibration of the detector by coordinates and time
- Algorithms for filtering experimental data have been implemented
- Realistic effects have been added to the modeling process
  - Smearing Vertex
  - Lorentz Shifts
  - Dead strips, hits
- Parameters of MC tracks inside the magnet repeat the experimental data.

Future plans

- Estimate efficiency of matching
- Identify π, K mesons in experimental data
- Evaluate the efficiency of detectors through simulation
- Normalize the number of identified particles to the efficiency of the detectors and tracking
- Evaluate yeilds of identified $\pi^{\pm}$, $K^{\pm}$

Thank you for the attention!

Backup

Efficiency calculation scheme

Silicon Tracks (Min 1 hit)

Gem Tracks (Min 4 hits)

$$\text{Efficiency}_i = \frac{\text{Numerator}_i}{\text{Denominator}_i}$$

if number of hits is min

if track in acceptance station i: Denominator_i++

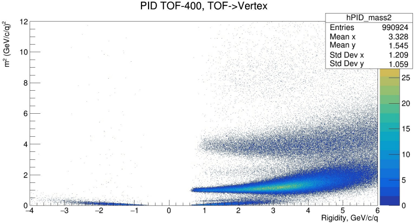
if the number of hits is greater than the min

if hit confirmed in station i: Numerator_i++; Denominator_i++

if track only in acceptance station i: Denominator_i++

Time calibration

Coordinate alignment only



Coordinate and Time Alignment