Track Reconstruction in the SRC Experiment

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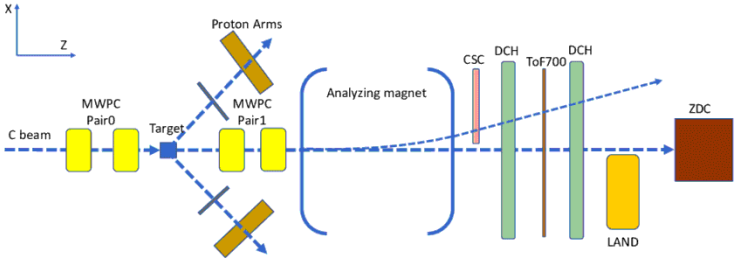
on behalf of BM@N collaboration

14/10/2019

Scheme of the SRC setup



Four specific regions for tracking:

- Proton arms (2 GEM + 2 ToF)
- Before magnet region (2 MWPC + 3 Silicon planes)
- Inside magnet region (6 GEM planes)
- After magnet region (CSC + ToF + 2 DCH)

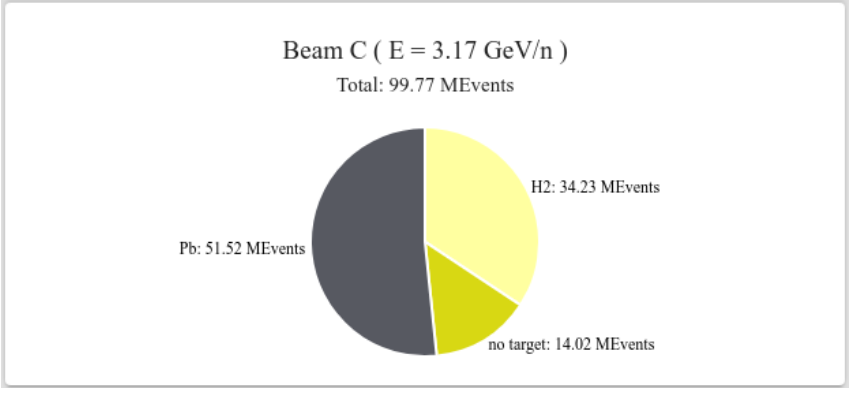
Event reconstruction in SRC

General goal:
Reconstruct global tracks from target to DCH + tracks in arms + PID

Particular tasks:

1. Track reconstruction inside magnet
2. Matching tracks in downstream direction
3. Matching tracks in upstream direction
4. Track reconstruction in arms
5. Particle identification by ToF, common charge and momentum

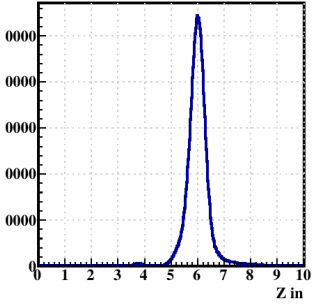
Input data

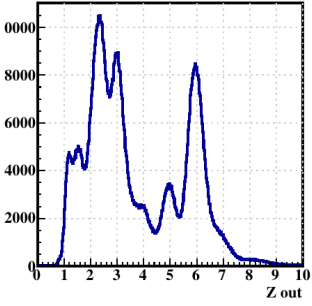


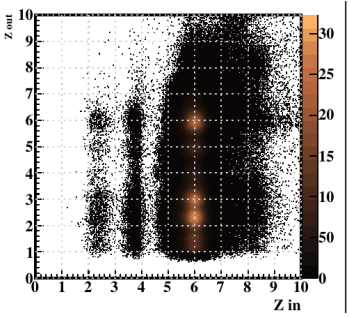
Presented analysis is done on 5 MEvents with Interaction Trigger

Input data

Two counters before target give total input charge (Zin) of event
Two counters after target give total output charge (Zout) of event







Inside Magnet

Inside magnet

Unified approach to reconstruct tracks both for the BM@N setup and for the SRC setup:

1. reconstruct 3D points of detector response (hits)
2. create cells (two connected hits on a different planes)
3. select cells by their slope
4. create track-candidates (cells connection w.r.t slope difference)
5. select candidates by number of hits (minimal limit is 4 hits)
6. fit candidates by Circle approximation
7. refit candidates by Kalman Filter in forward and backward directions
8. select candidates by shared hits (no common hits)

Alignment

For special runs without magnetic field:

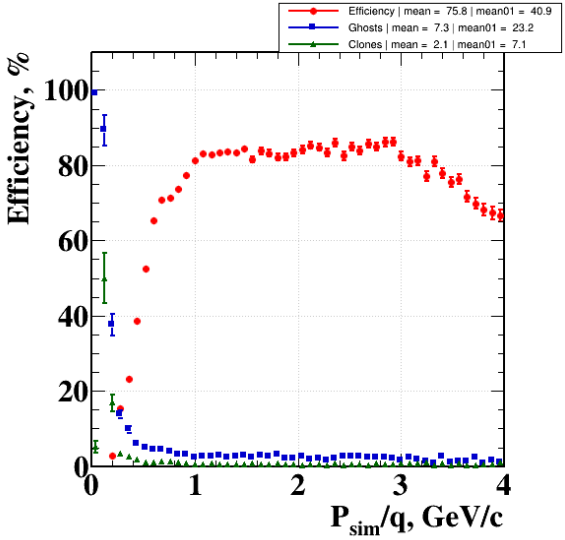
- Reconstruct straight tracks
- Fit track over its hits by straight line
- Calculate residuals from track to hits for each station (ResX)
- Move all hits on station to ResX/2
- Do again

Lorentz shifts estimation

Iterative algorithm:

- Reconstruct track-candidates
- Set rigidity to 8 GeV/(qc)
- Fit track over its hits by Kalman Filter with fixed rigidity
- Calculate residuals from track to hits for each station (ResX)
- Move all hits on station to ResX/2
- Do again

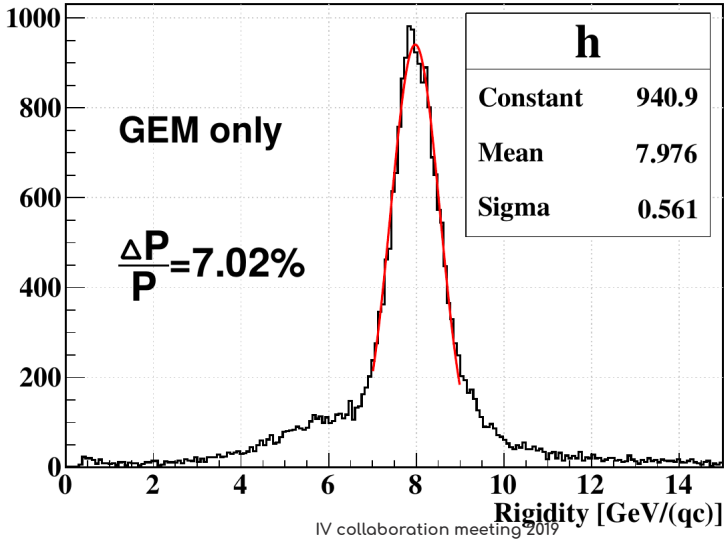
Efficiency on ArPb (Simulated data)



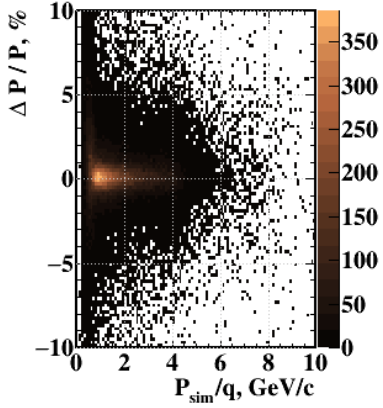
- Reconstructable tracks (N_{MC}): MC-track with more then 3 points
- Reconstructed tracks (N_{rec}): All reconstructed tracks
- Well tracks (N_{well}): Reconstructed tracks more then 60% of hits corresponded to same MC-track
- Wrong tracks (N_{wrong}): Reconstructed tracks less then 60% of hits corresponded to same MC-track
- Split tracks (N_{split}): Reconstructed tracks corresponded to same MC-track
- Efficiency: $\frac{N_{well} - N_{split}}{N_{MC}} \cdot 100\%$
- Percent of ghosts: $\frac{N_{wrong}}{N_{rec}} \cdot 100\%$
- Percent of clones: $\frac{N_{split}}{N_{rec}} \cdot 100\%$

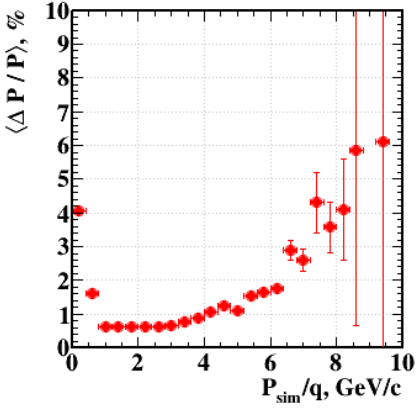
Momentum resolution

Special run without target

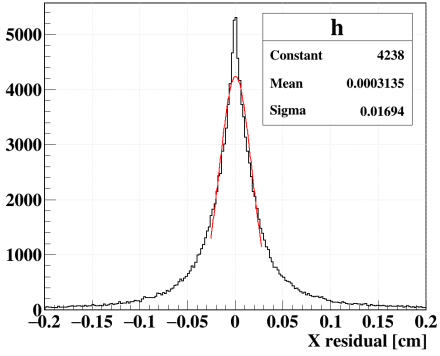


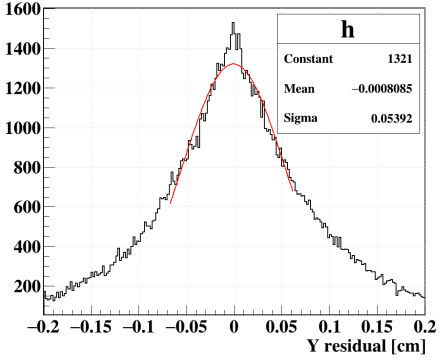
Momentum resolution on ArPb (Simulated data)





Residuals


h
Constant 4238
Mean 0.0003135
Sigma 0.01694
X residual [cm]

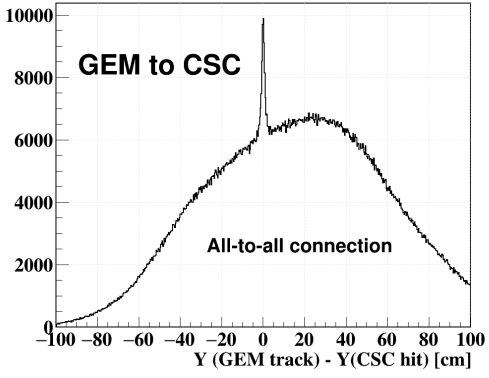

h
Constant 1321
Mean −0.0008085
Sigma 0.05392
Y residual [cm]

Downstream Matching

Common algorithm of matching

Step 1. Alignment:

- Propagate each 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



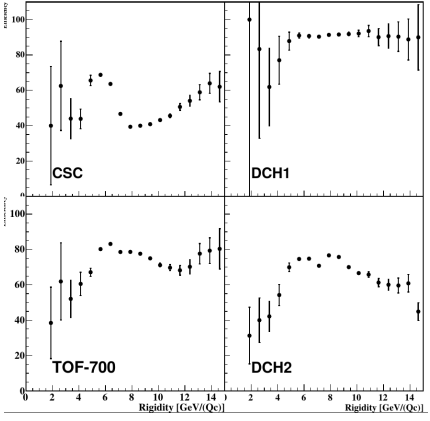
Common algorithm of matching

Step 2. Matching:

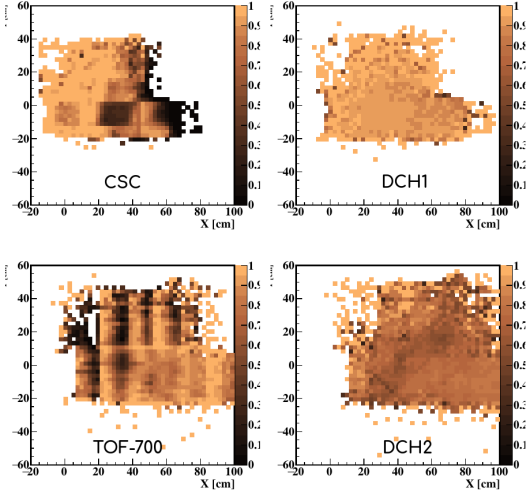
- Propagate each track to plane with hits
- Find the nearest hit in $\pm 3\sigma_x$ and $\pm 3\sigma_y$
- Update track parameters by connected hit information:
  - Track length
  - Last position, T_x, T_y at last position, Momentum
  - Covariance matrix
  - χ^2
  - Number of hits, NDF
  - Velocity (β) for TOF-700

Matching Efficiency

Efficiency (CSC example):
N(GEM+DCH1+TOF700+DCH2) / N(GEM+CSC+DCH1+TOF700+DCH2)
Tracks in denominator without CSC update

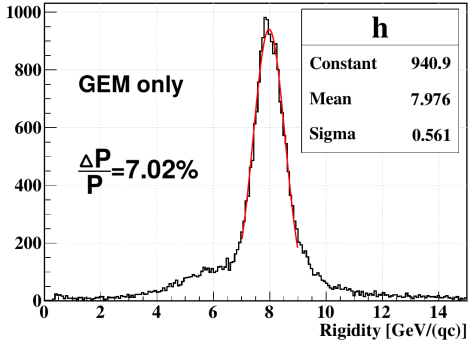


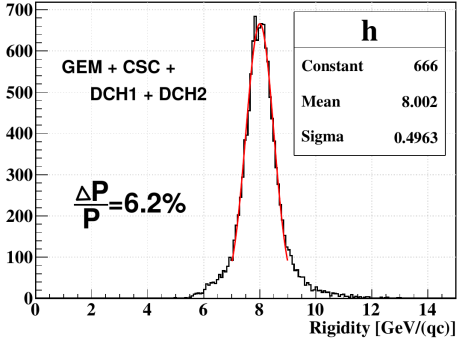
Matching Efficiency



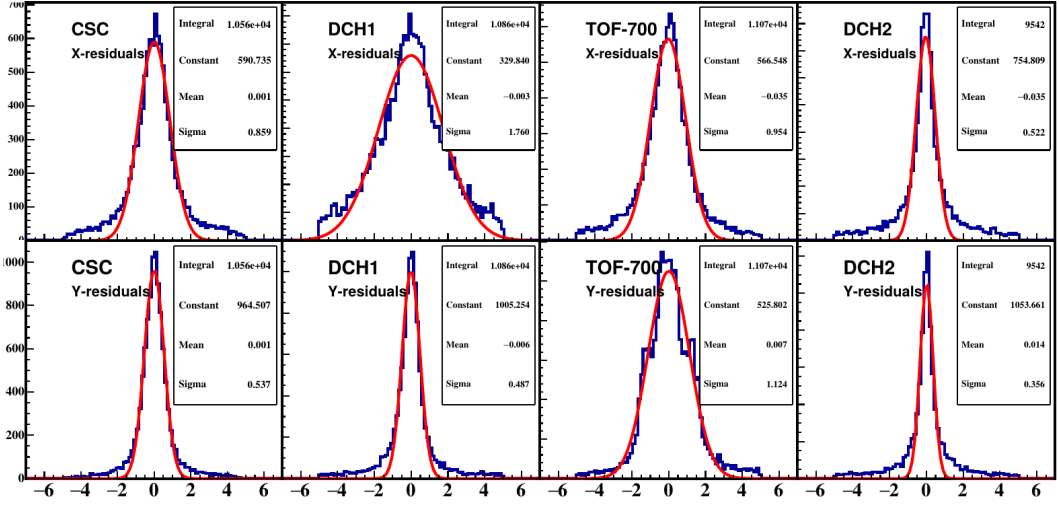
Momentum Resolution

Special run without target



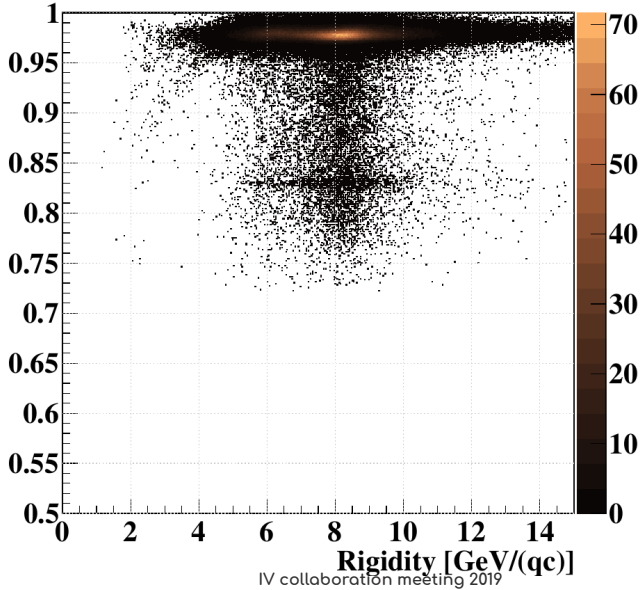


Residuals


CSC
X-residuals
Integral 1.056e+04
Constant 590.735
Mean 0.001
Sigma 0.859
DCH1
X-residuals
Integral 1.086e+04
Constant 329.840
Mean −0.003
Sigma 1.760
TOF-700
X-residuals
Integral 1.107e+04
Constant 566.548
Mean −0.035
Sigma 0.954
DCH2
X-residuals
Integral 9542
Constant 754.809
Mean −0.035
Sigma 0.522
CSC
Y-residuals
Integral 1.056e+04
Constant 964.507
Mean 0.001
Sigma 0.537
DCH1
Y-residuals
Integral 1.086e+04
Constant 1005.254
Mean −0.006
Sigma 0.487
TOF-700
Y-residuals
Integral 1.107e+04
Constant 525.802
Mean 0.007
Sigma 1.124
DCH2
Y-residuals
Integral 9542
Constant 1053.661
Mean 0.014
Sigma 0.356

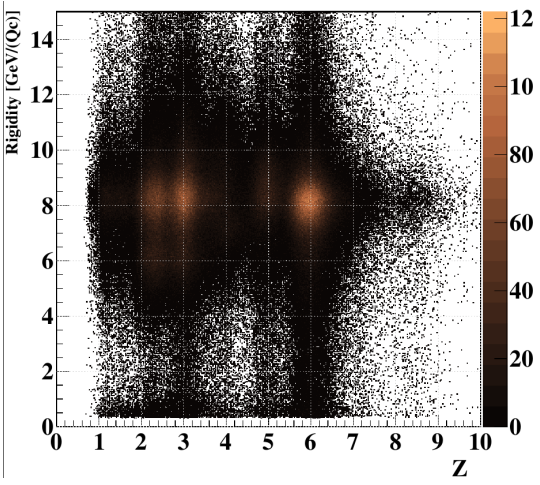
Particle Identification

Time-of-flight approach



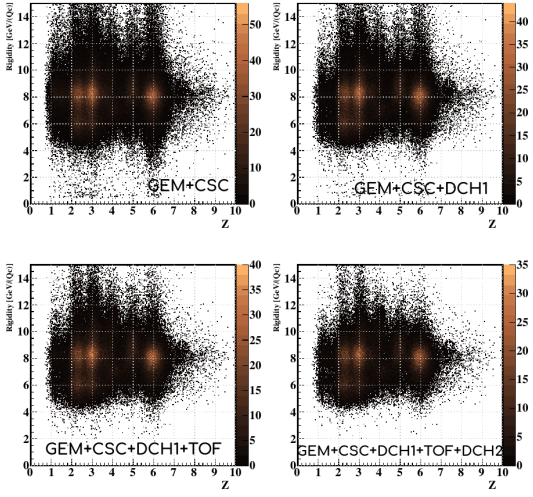
Momentum-Charge approach

No cuts for used detectors



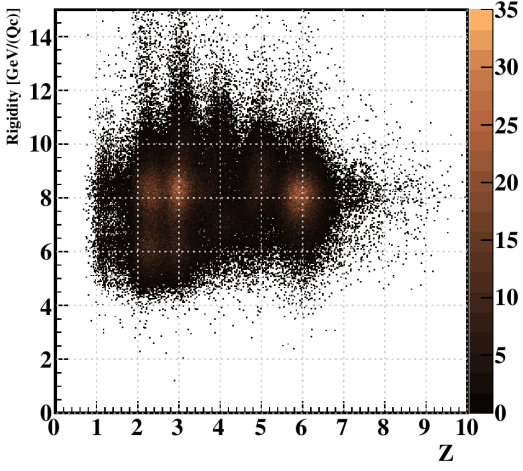
Momentum-Charge approach

Different detector cuts used



Momentum-Charge approach

GEM+CSC+DCH1+TOF700+DCH2



Summary

- Unified tracking is implemented for SRC inside magnet region
- Momentum resolution around 2-8 % achieved
- Matching in downstream direction is done
- Outer detectors give significant improvement for parameters of global track
- First attempt to PID implementation is done