Primary hit processing in cylindrical GEM tracker of the BESIII experiment

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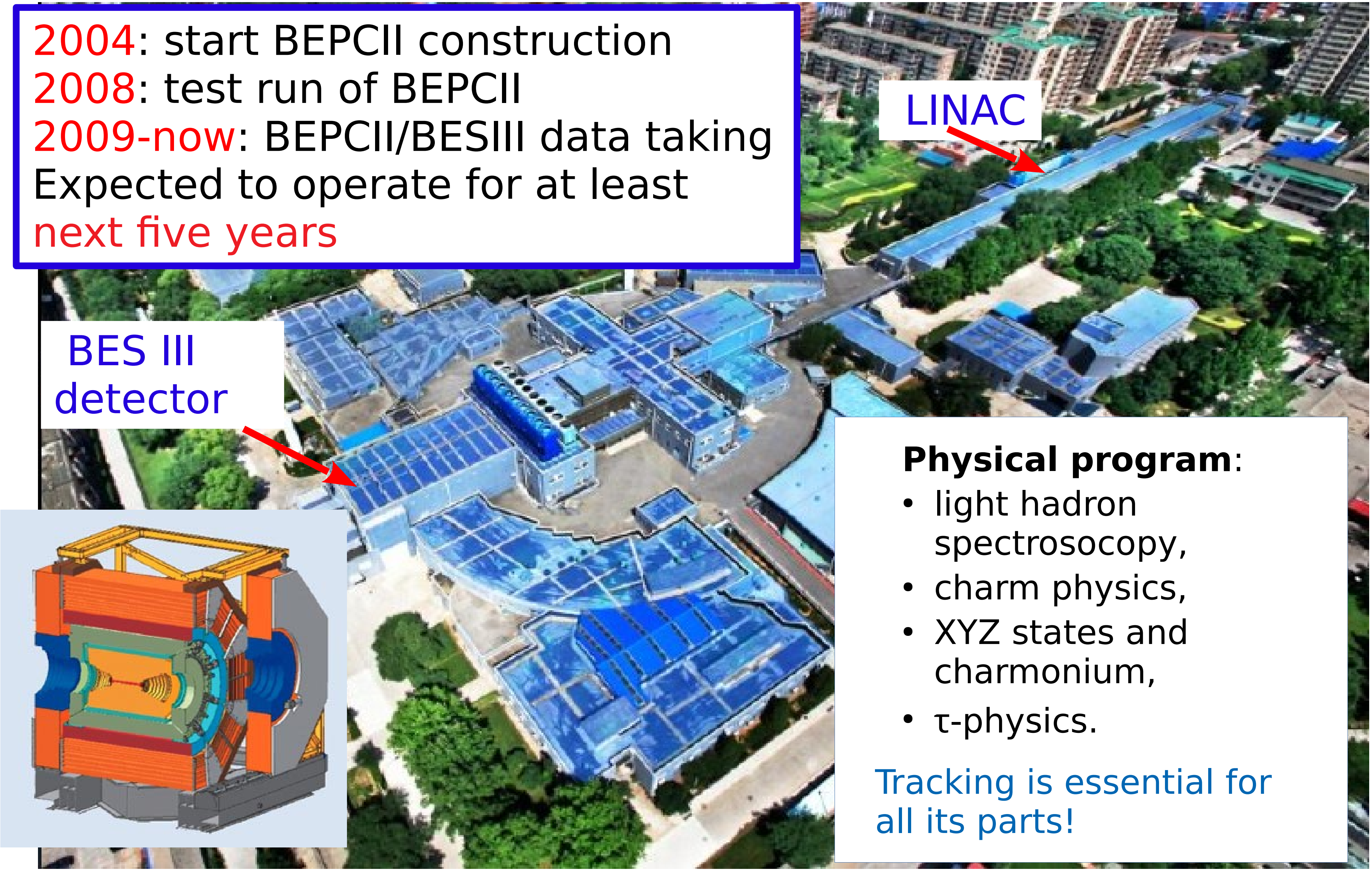
BESIII

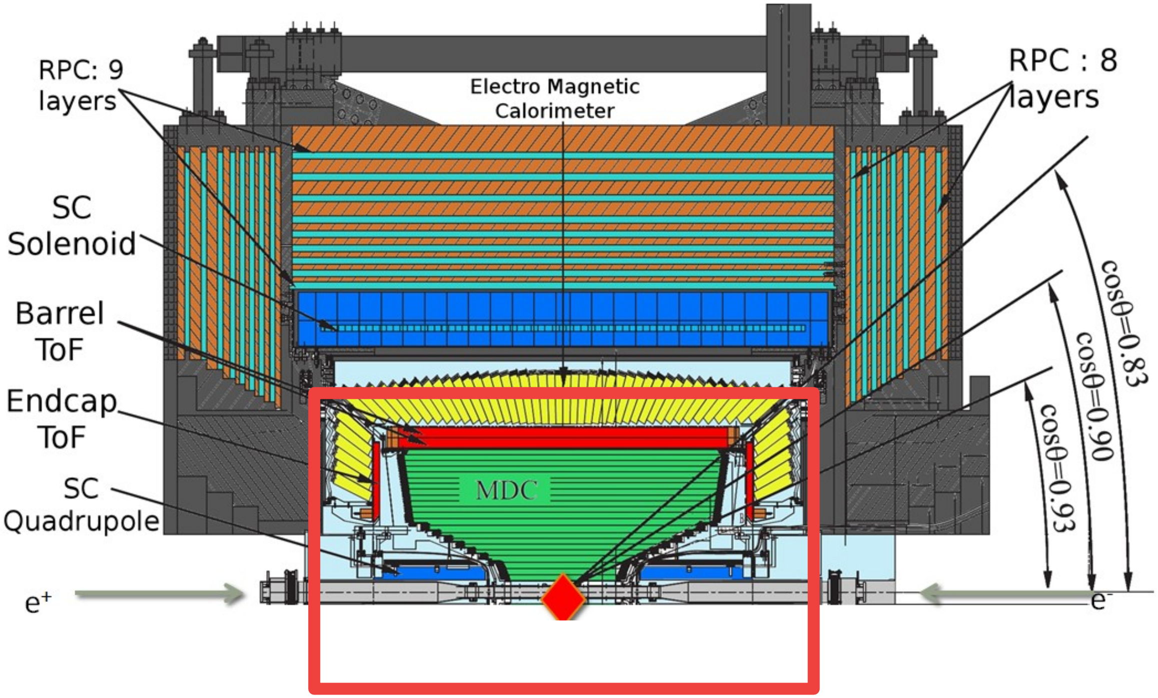
2004: start BEPCII construction
2008: test run of BEPCII
2009-now: BEPCII/BESIII data taking
Expected to operate for at least next five years

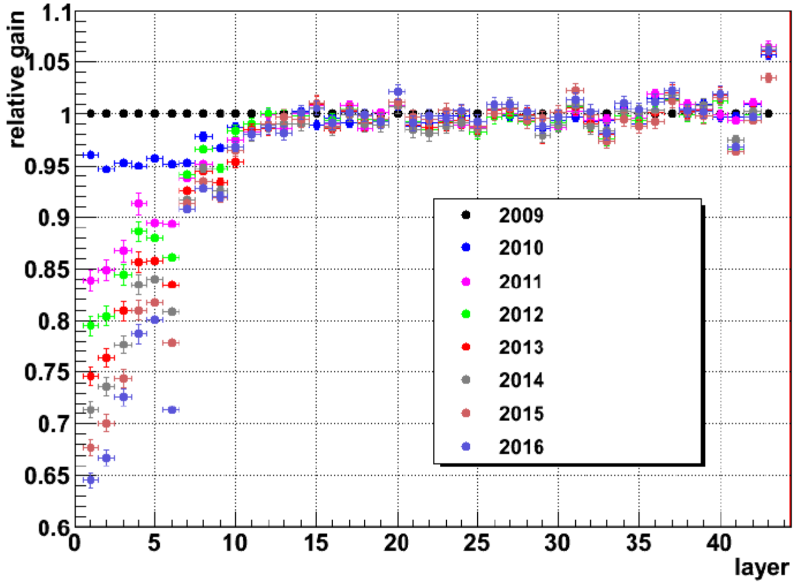


Physical program:
- light hadron spectrosocopy,
- charm physics,
- XYZ states and charmonium,
- τ-physics.

Tracking is essential for all its parts!

Main Drift Chamber (MDC)





MDC:

- 43 Layers (8 in the Inner Tracker)
- Resolution: 130μm (r-φ) and 2mm (z)

Inner layers suffer from huge beam-related background.

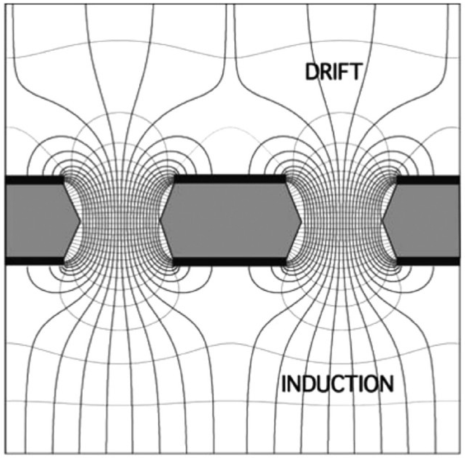
MDC gain (JINST 12 (2017) no.07, C07038)

Inner part of MDC to be replaced with cylindrical GEM

NIM A614, 345(2010)

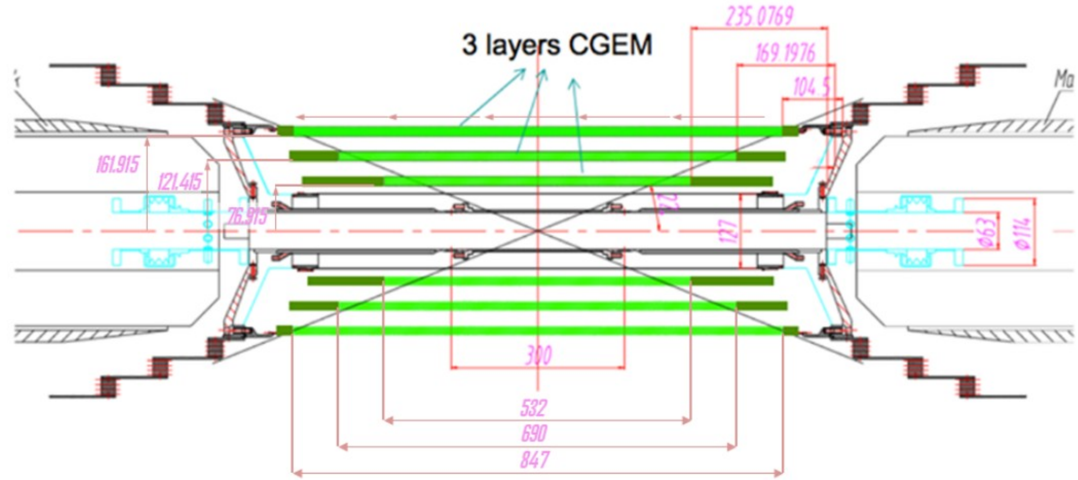
Cyclindrical GEM (CGEM)

GEM: gas electron multipliers



Nucl.Instrum.Meth. A805 (2016) 2

JINST 12 (2017) no.07, C07038



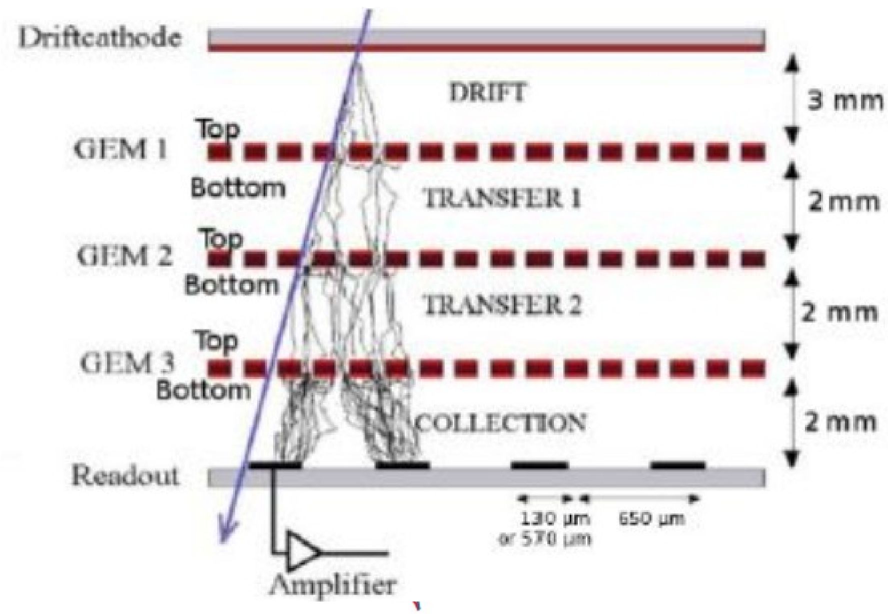


Fig.: Mezzardi, FAIRNESS 2016

Each CGEM layer has 2 readout layers (XV) for 2D hit coordinates (stereo angles: 45.9º, -33.1º, 33.0º).

Readout modes:

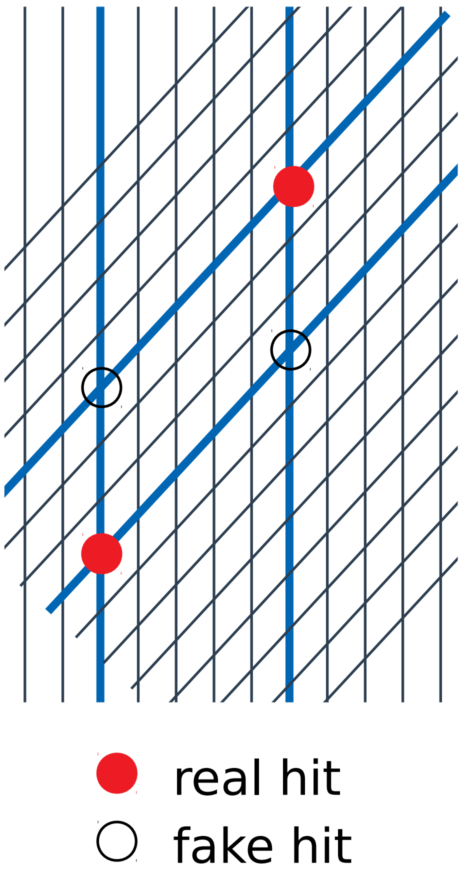
- **binary (digital),**
- charge centroid,
- μTPC.

Fake hits

Hit is a reconstructed point where charged particle intersects the detector plane.

Strip detectors when determining 2D hit positions suffer from combinatorial ambiguities (fake hits).

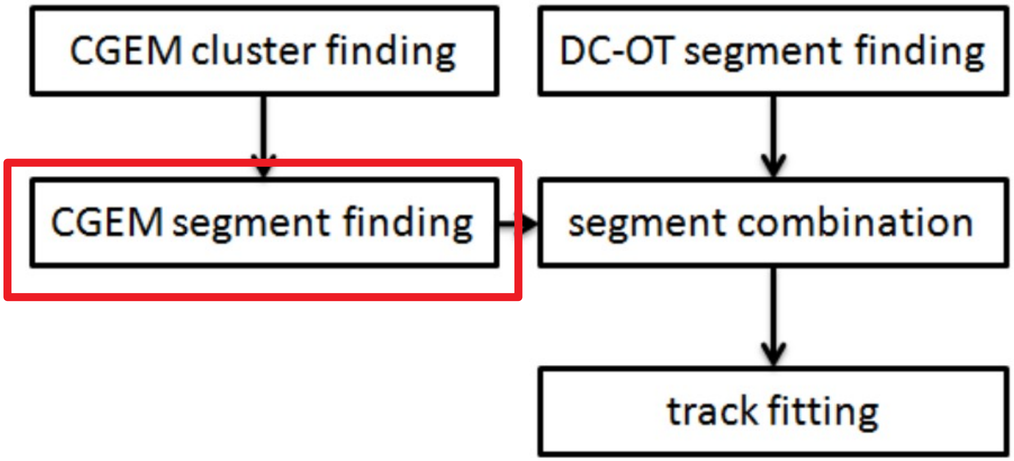
For a high track number fake hits significantly complicate track reconstruction.



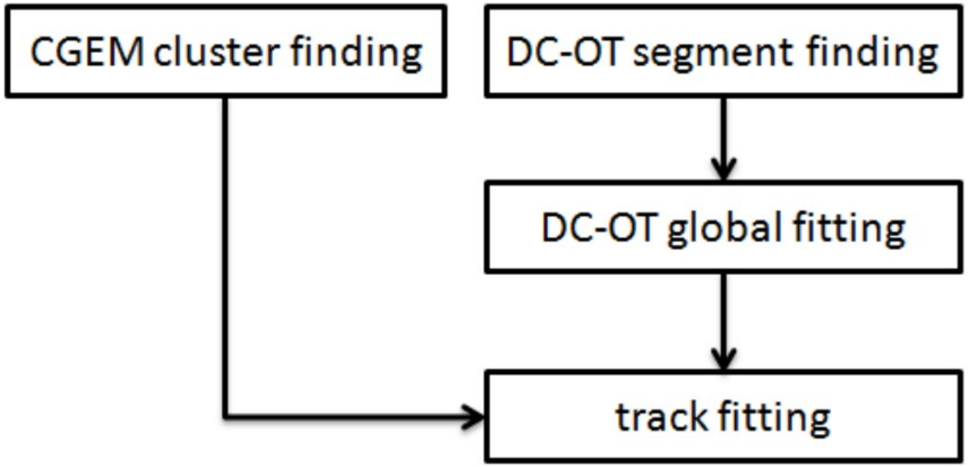
Tracking

Flow diagrams from “BESIII Cylindrical GEM Inner Tracker Conceptual Design Report”, 2014

Desirable



Available

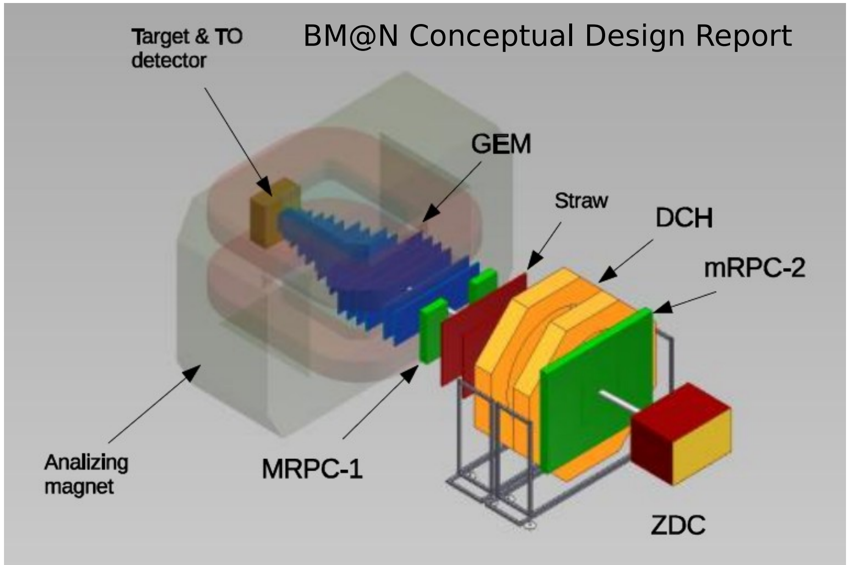


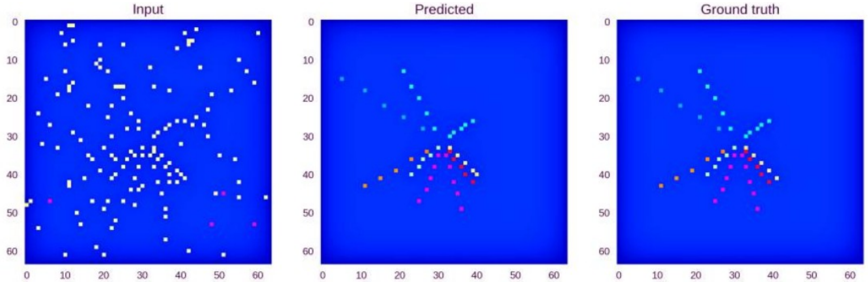
Deep learning for track recognition

The very recent neural network-based approaches of arXiv:1812.03859 suggested for BM@N can be also adapted to BESIII.

The typical BESIII charged track multiplicity is relatively small, but events in the internal layers suffer from huge beam-related background.

BM@N





arXiv:1812.03859

Clustering simulation

Generator → Geant4 → Digitization → Clustering

Generator

Multiplicity:
up to 8 charged tracks for ψ(3770) → $D^0\overline{D}^0$

Geant4

CGEM geometry

Digitization

Currently does not include:

- non-uniform charge sharing between strips
- diffusion and Lorentz angle,
- no threshold,
- beam-related background and noise.

Chin. Phys. C40 (2016) no.1, 016201

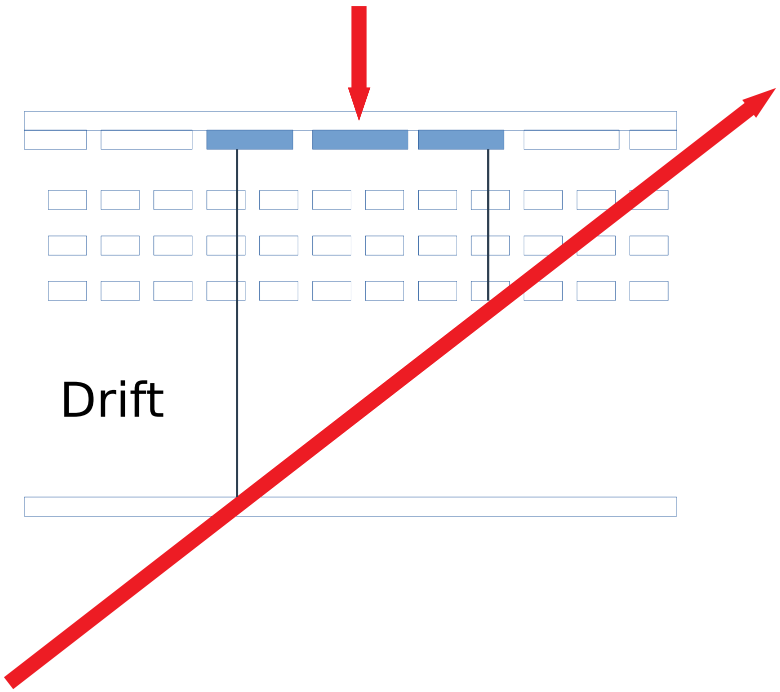
Standard BESIII simulation

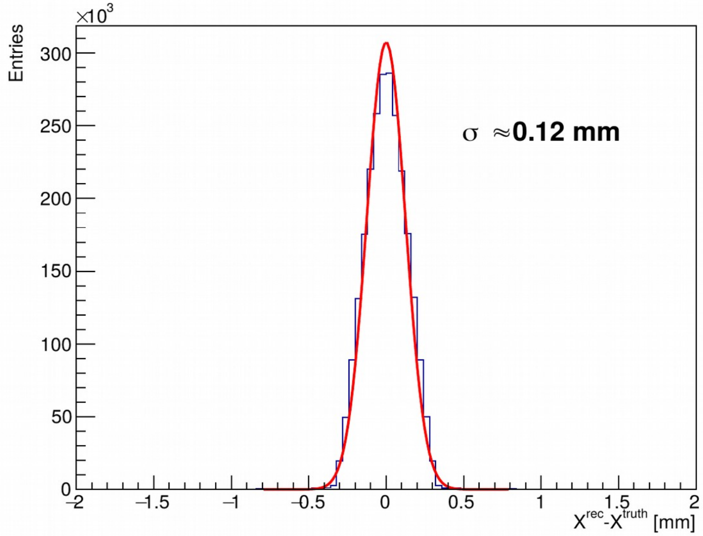
Clustering

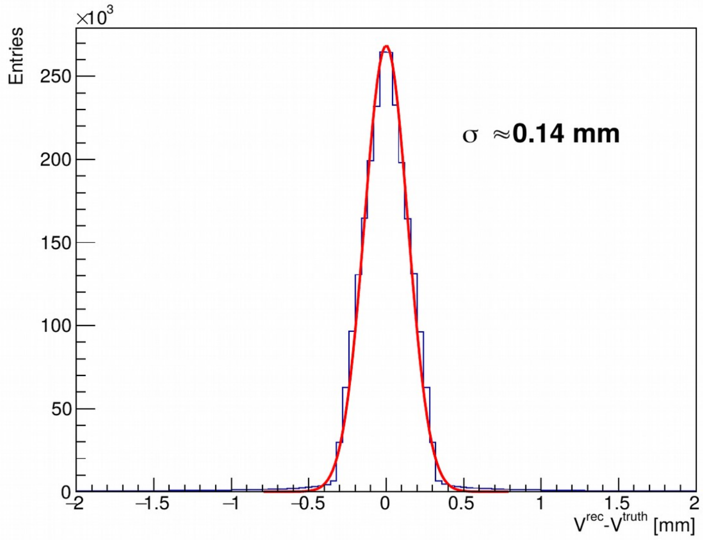
Reimplemented in this work to propagate MC-truth information about initial track.

Cluster finding and X-,V-residues

Cluster (binary mode):





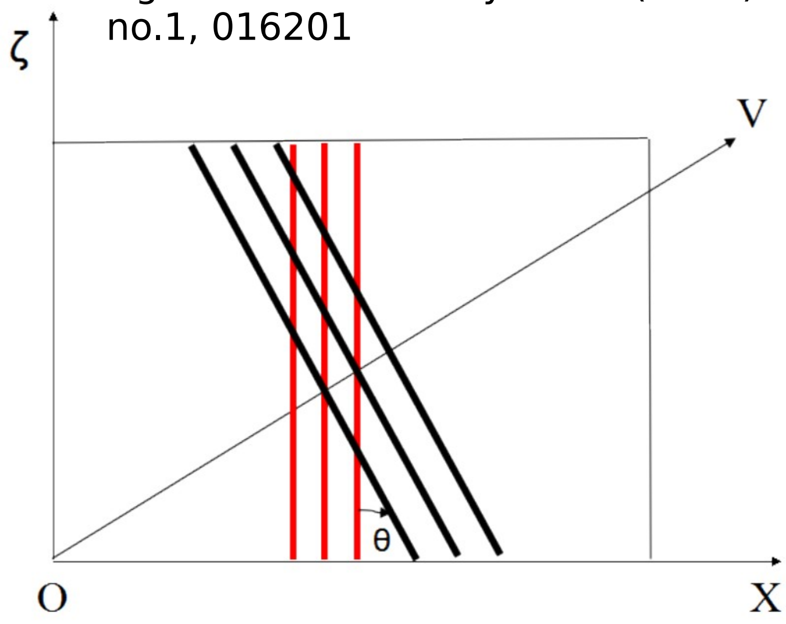


Simple digitization: projection to readout, that keeps φ and z constant.

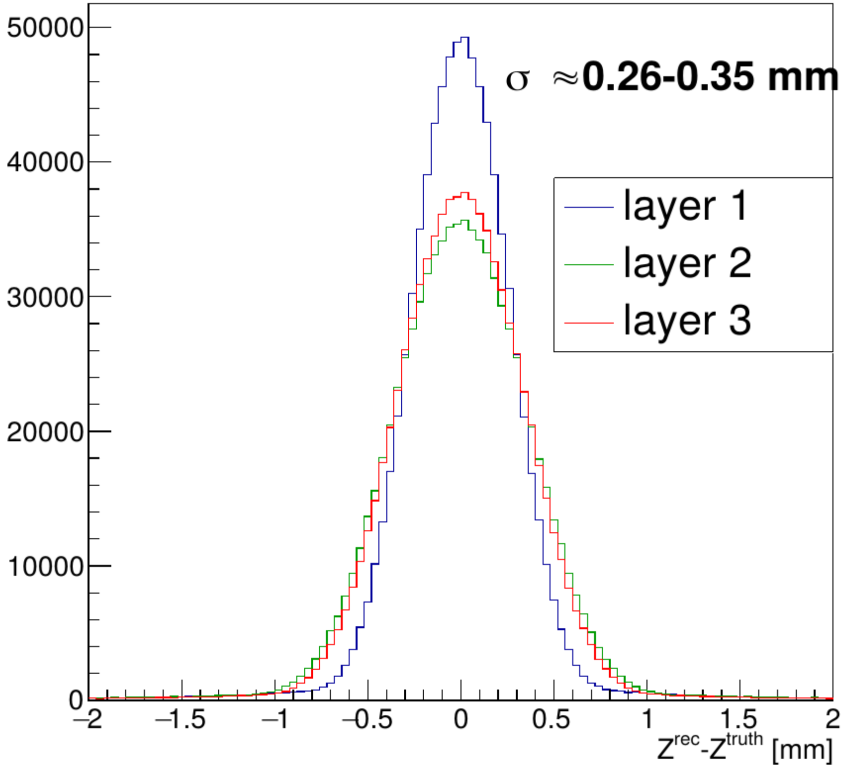
Coordinates is taken as average of fired strips centers: $X=(\sum_i X_i)/N$

Z reconstruction and residues

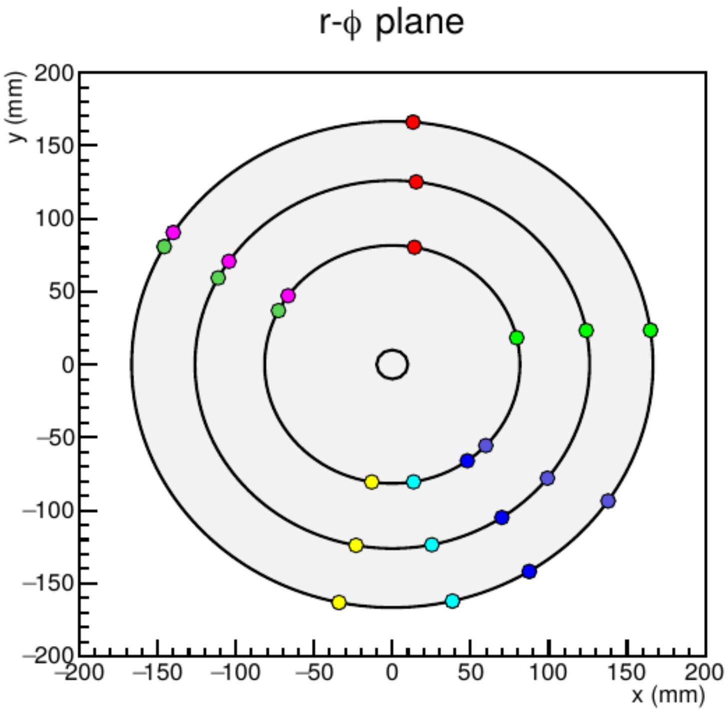
Figure from Chin. Phys. C40 (2016) no.1, 016201

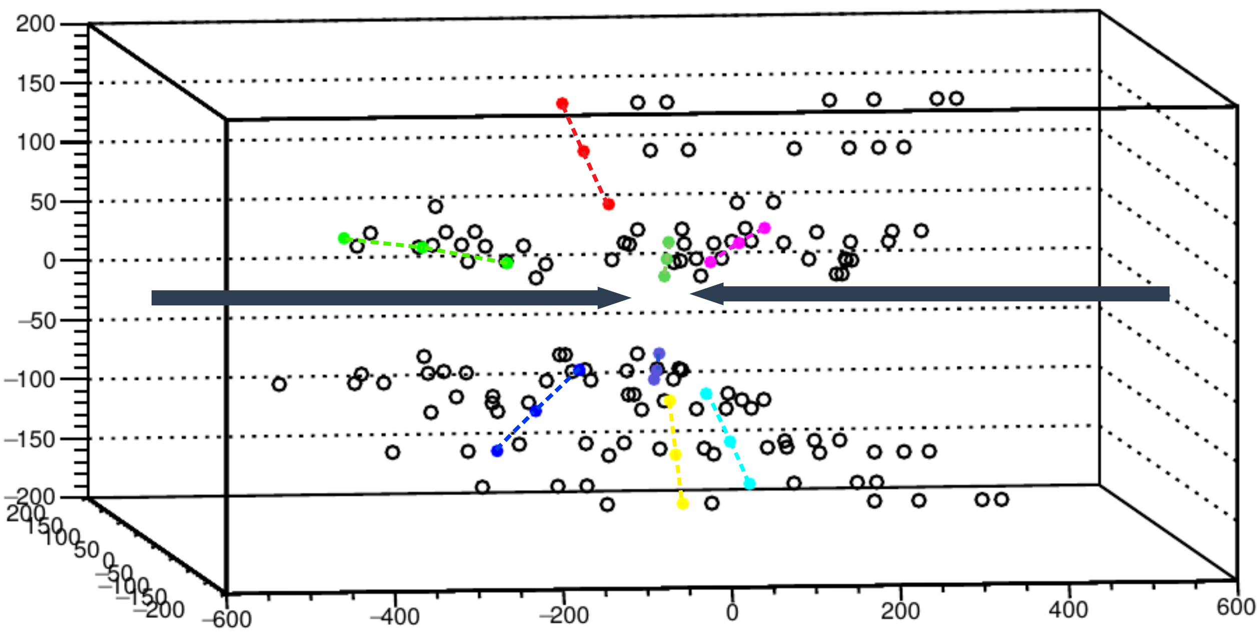


$$Z = (V - X\cos\alpha)/\sin\alpha$$



Example of a reconstructed event





Fake hits ○ and “real” hits ● in 3 CGEM layers

Fake hits are arranged along z-axis

Summary and outlook

We are able to simulate events in BESIII CGEM with a simplified model. Further work on simulation of beam-related background is needed.

Currently the simple and the least precise clustering algorithm is implemented. More advanced algorithms can be used, including the ones based on machine learning.

The next step is to resolve the problem of fake clusters will be addressed by adapting the algorithms of “deep tracking” developed for BM@N experiment. See talk by Pavel Goncharov tomorrow.