Emulsion Test Beam first results

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On behalf of Napoli emulsion group

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New elements in respect to OPERA were tested

- New emulsions produced in Nagoya lab
  - Different emulsion base material (unexpected effects found)
  - Different layers thickness
  - Different emulsion handling
- Emulsion spectrometer in a magnetic field
  - Different geometry (15 mm instead of 1 mm gap)
  - Different accuracy requirements: 1 micron resolution over cm scale (1/10000) instead of 1 micron over mm scale (1/1000) in OPERA
- Emulsion to electronic detector matching
  - Different coordinate resolution in the detectors, no angular information in TT, no time information in emulsion
- Higher signal tracks density expected in SHiP
- Fast scanning with a new scanning system
  - Speed of 80 cm/h instead of 20/h

Exposures Summary

- At PS (Sep 2015)
  - ECC (OPERA-like brick) exposure with high density in magnetic field @ different angles
  - CES (Compact Emulsion Spectrometer) exposure with different density and angles
  - Matching between emulsions and Micromegas chambers
  - In collaboration with Napoli Atlas group

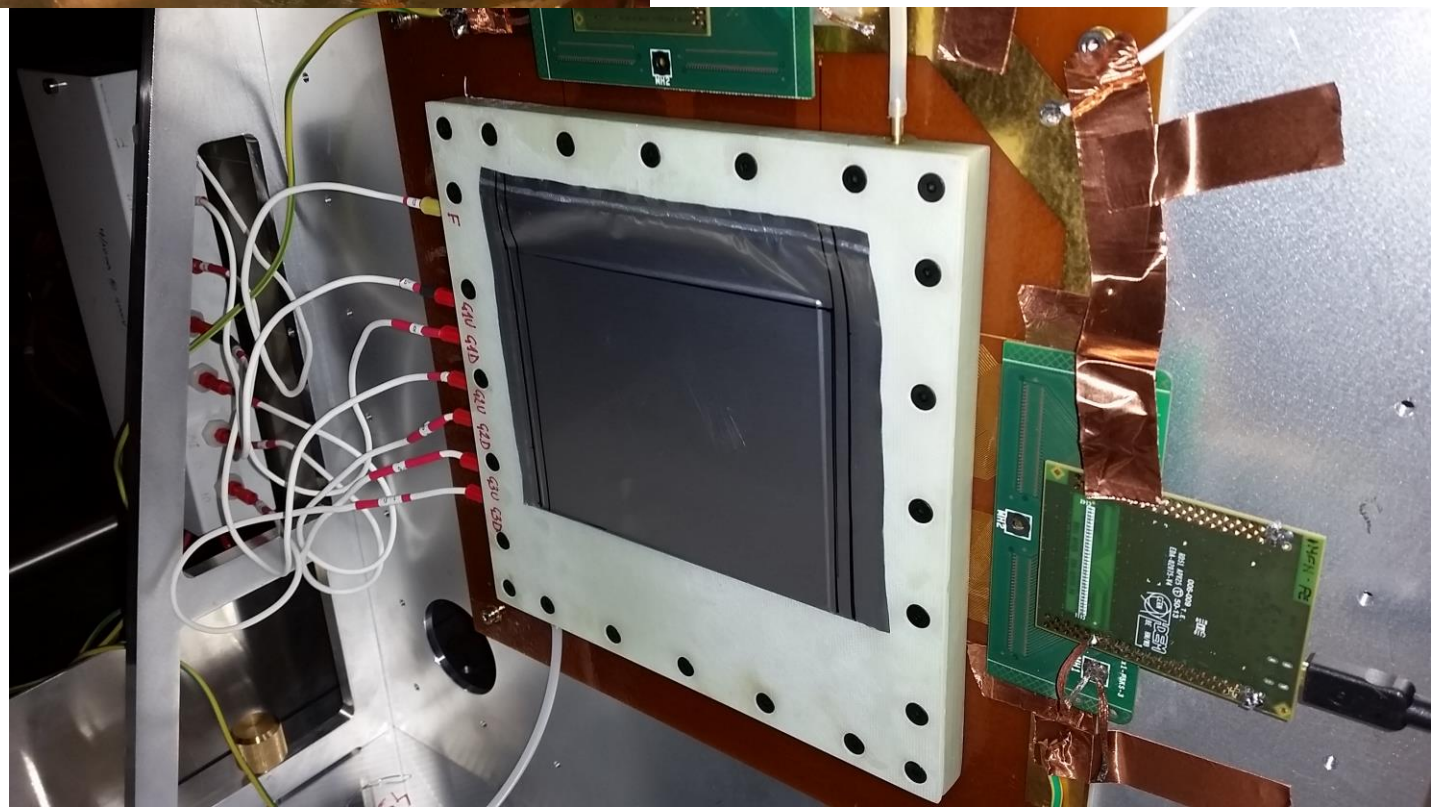
- At the SPS (Oct 2015):
  - Matching between emulsions and GEM
  - CS (emulsion doublets), ECC and CES was exposure together with GEM at different angles and magnetic field
  - In collaboration with Frascati GEM group

MNP17 at T9 (PS)

CES inside the magnet

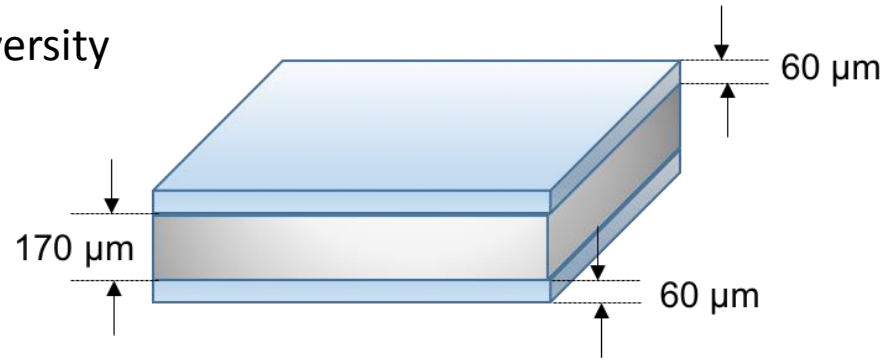
TT installed Inside Goliath magnet at East Area (SPS)

CS attached to GEM



Emulsion Films

- Emulsion films produced in Nagoya University



- Film dimensions
  - Surface: 125 mm x 100 mm
  - Total thickness: 290 µm
    - Emulsion Layer: 60 µm
    - Plastic Base: polystyrene : 170 µm

- New emulsion gel developed in Nagoya University
    - Grain density: 50 grains/100 µm (higher than OPERA films)

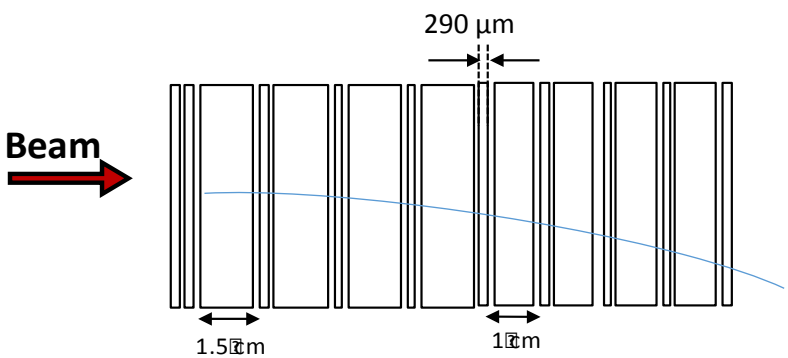
- Emulsion production
  - Emulsion poured in middle August 2015 and cut by hand
  - Shipped to CERN by plane
  - Total amount of emulsion films produced: 120
  - Emulsion films used in the test beam: 91

Types of emulsion assembling

- CS (Changeable Sheet) – emulsions films doublet without spacer enclosed inside an envelope sealed under vacuum
- ECC (Emulsion Cloud Chamber) – emulsions interleaved with dense spacers (1 mm lead) tightly assembled together
- CES (Compact Emulsion Spectrometer) – emulsions interleaved with low density spacer (15 mm Rohacell in this test)

Measurement of momenta and charge in magnetic field

Exposure at CERN

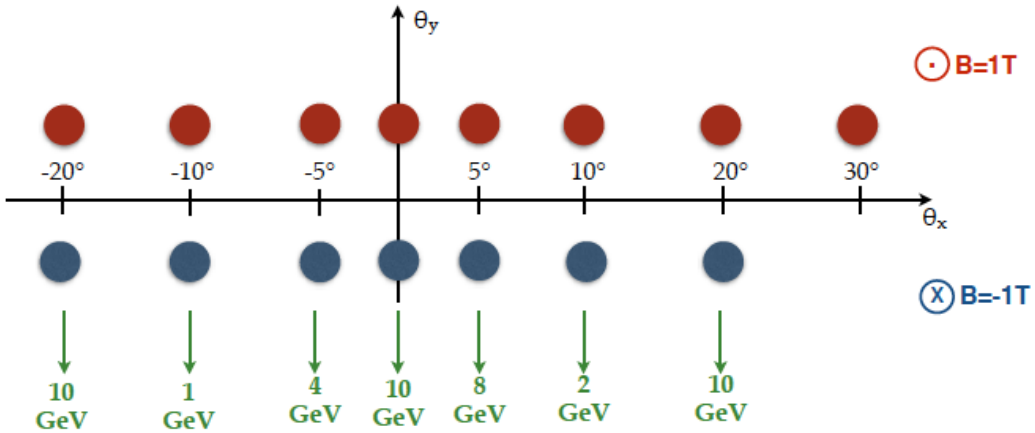


First time with Passive Material !

=Rohacell

=Emulsion Film

Target: CES (10 emulsion films interleaved with Rohacell plates)

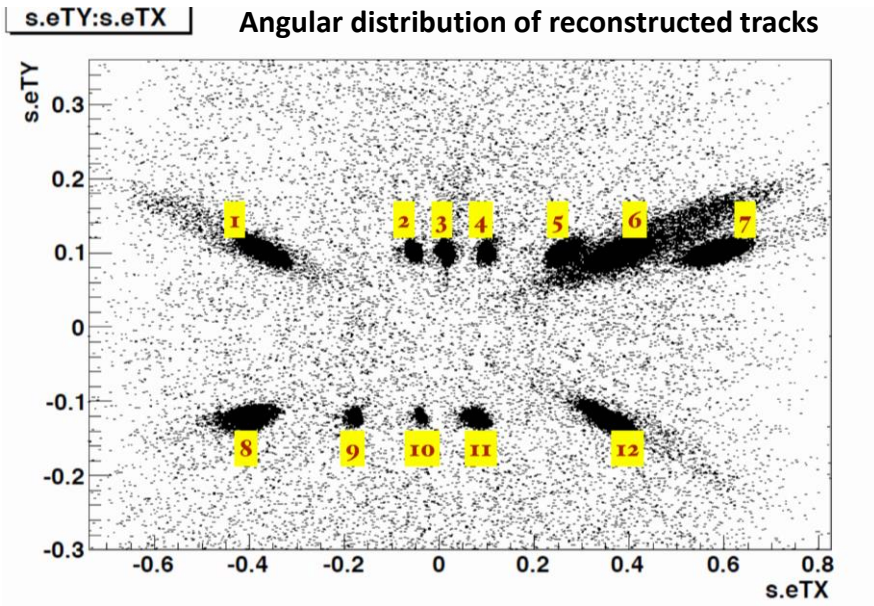


Beam exposure:

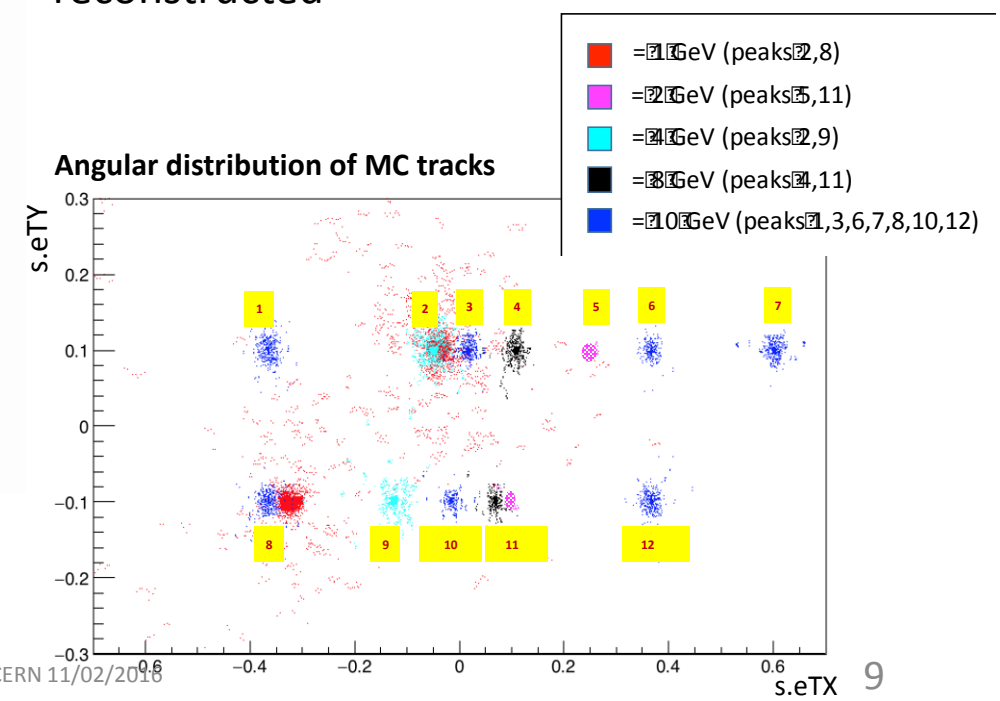
- High density: 104 tracks/cm^2/angle
- Magnetic field: 1T, -1T
- 15 angles, 5 momenta

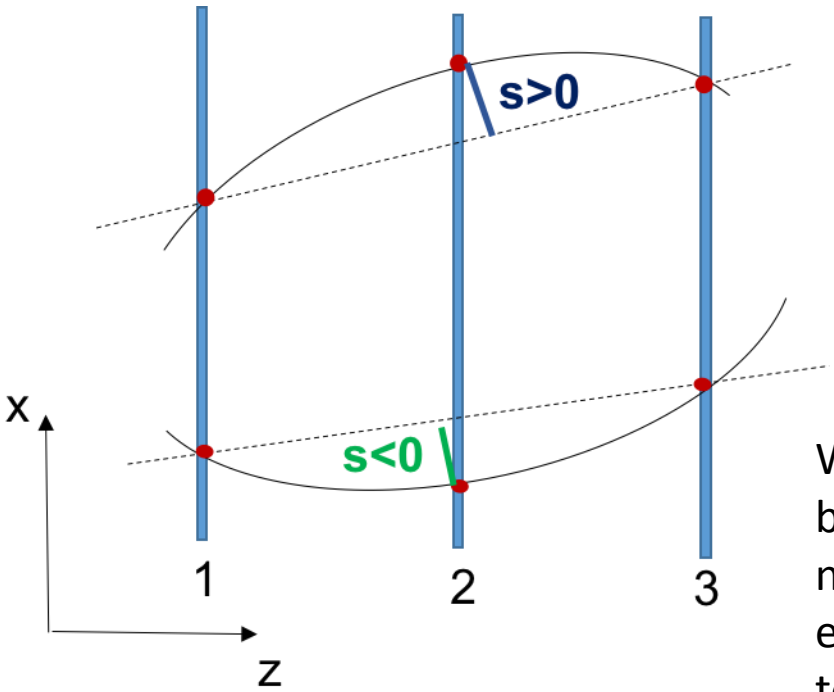
Measurement of momenta and charge in magnetic field

Scanning of the CES emulsions in the Napoli Emulsion Laboratory



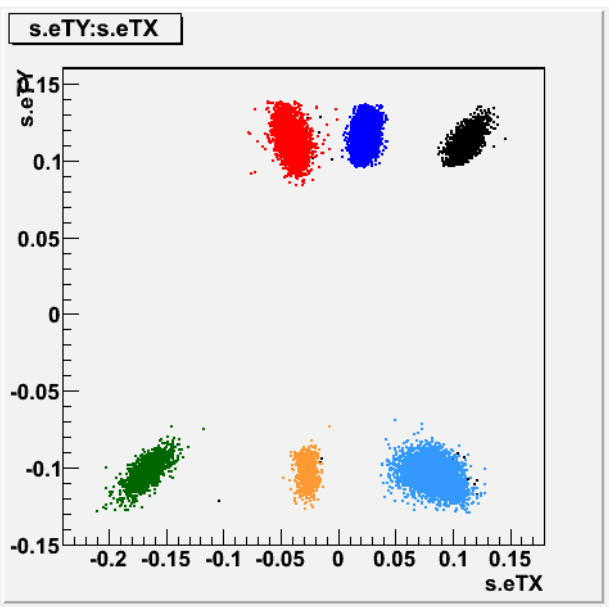
The fragment of data 2x3 cm was scanned on 10 plates, tracks reconstructed

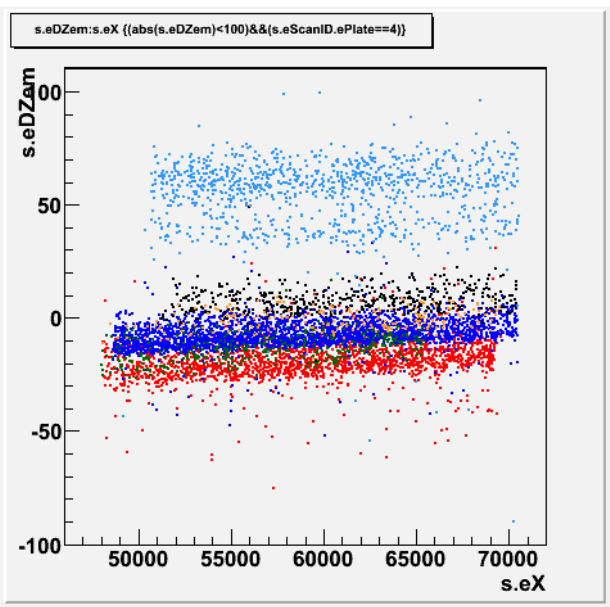


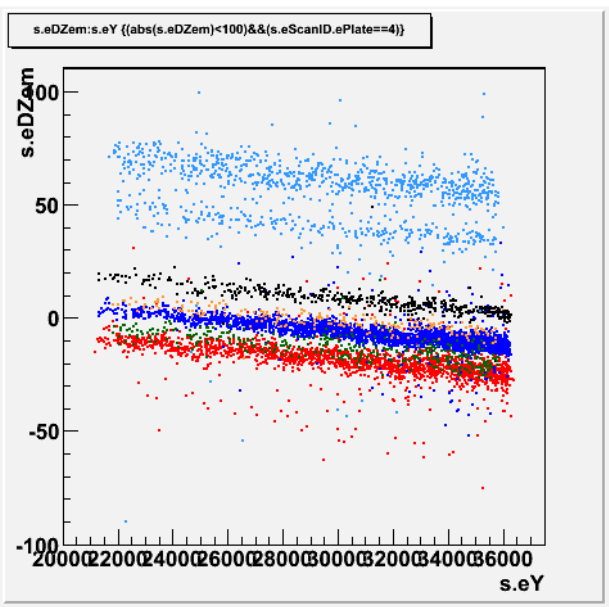


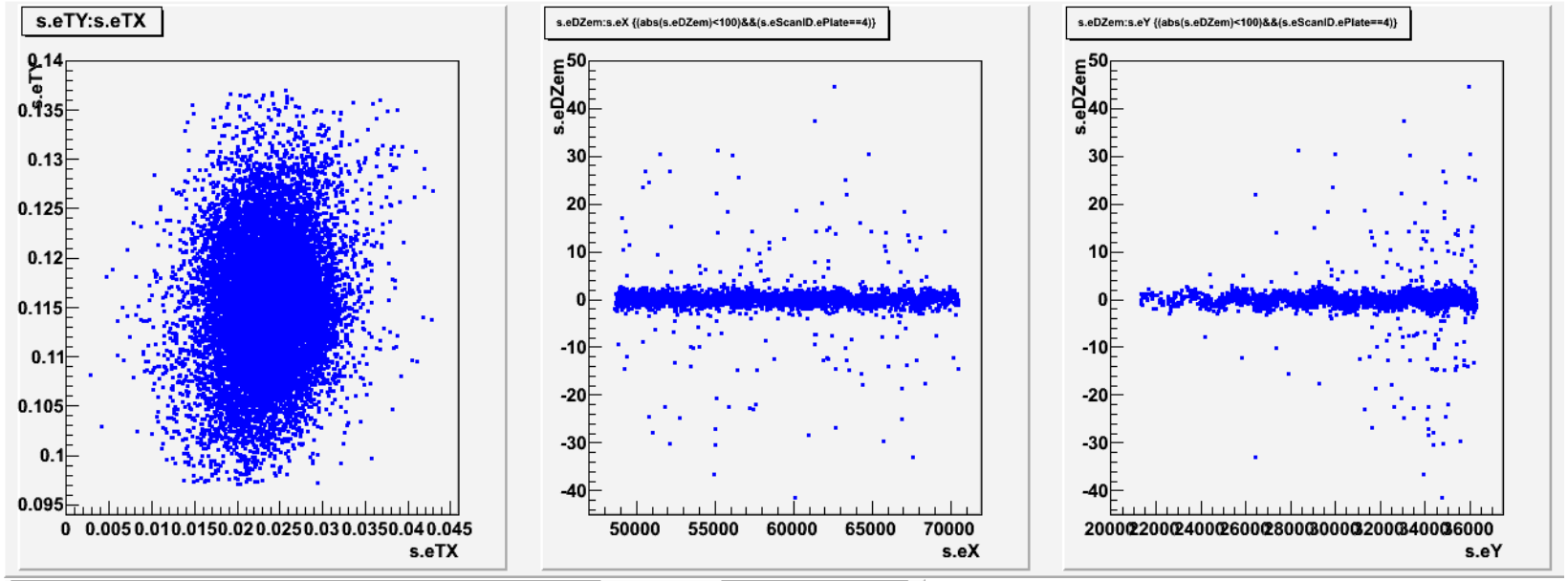
P (GeV/c)	<sgt> (μm)
1	35
2	17
4	8.8
8	4.4
10	4.2

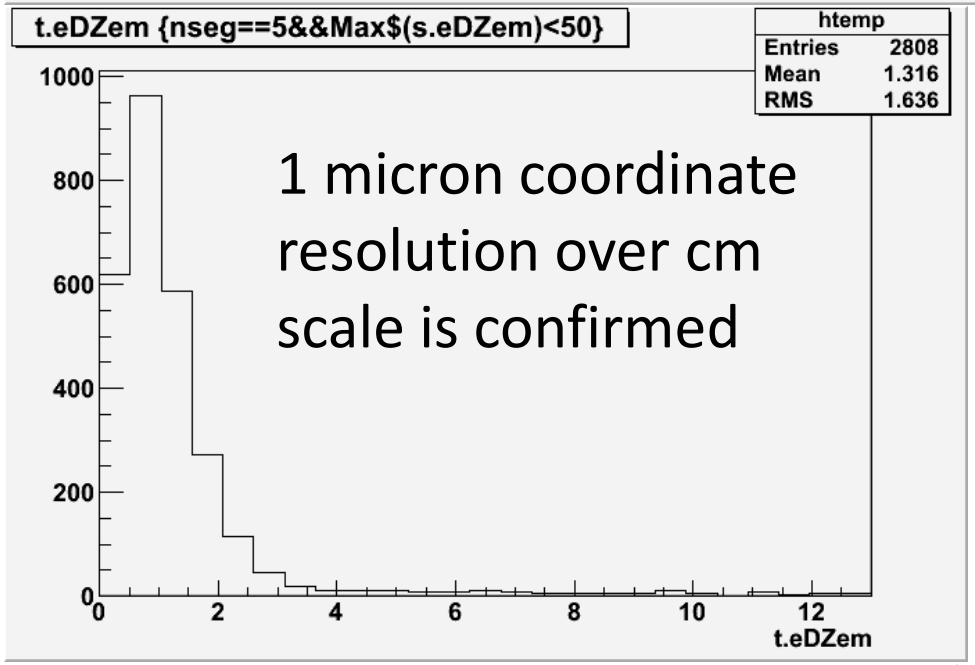
We can separate different beams
but the absolute values of sagitta appeared to be not correct and some position-dependent effects are present when all peaks reconstructed together





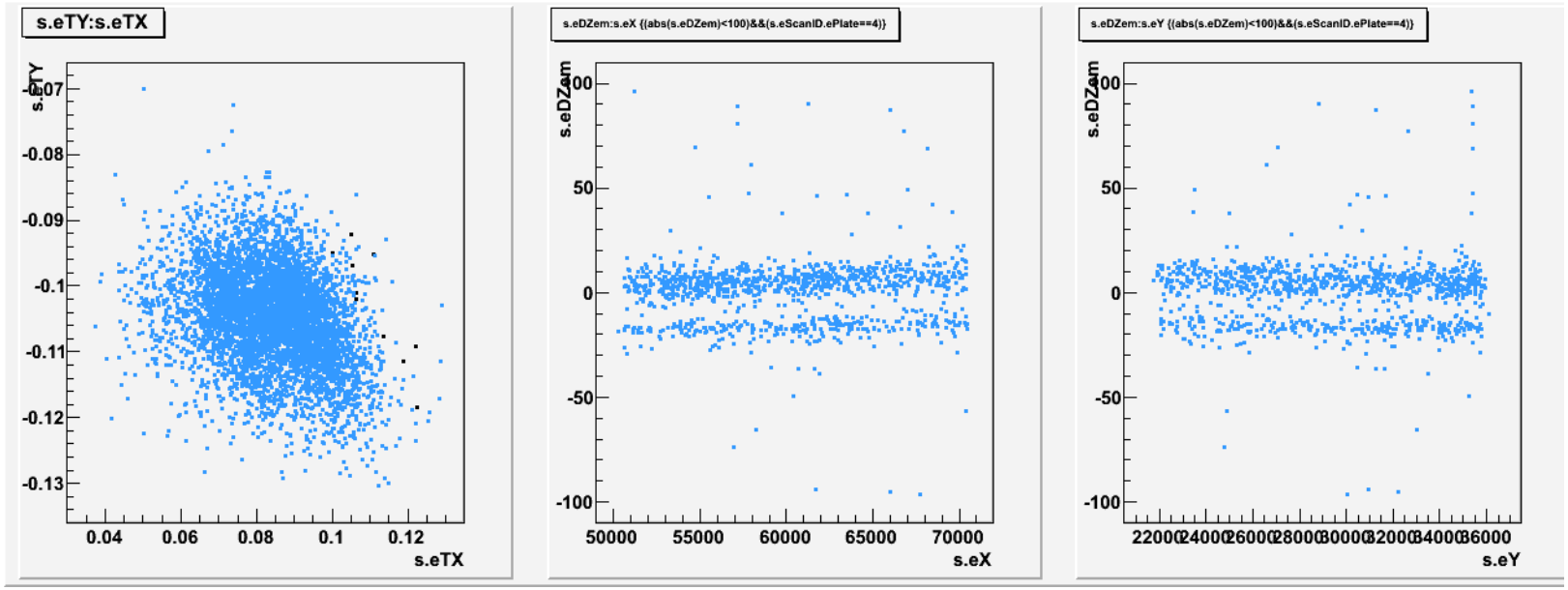


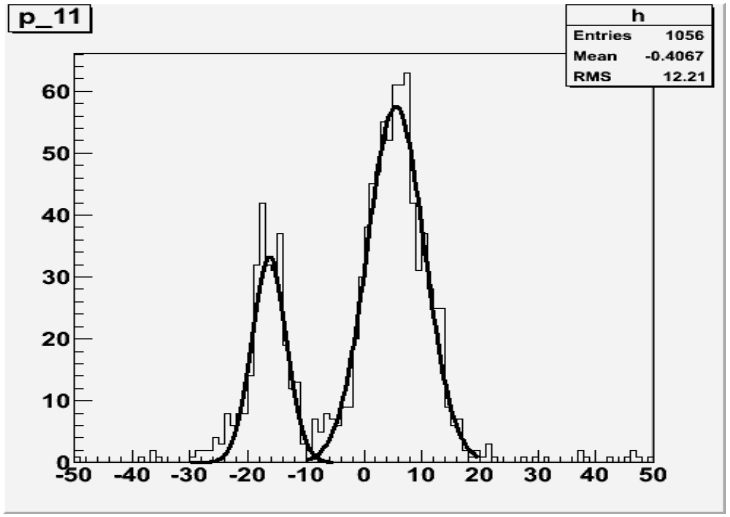




1 micron coordinate resolution over cm scale is confirmed

10 GeV beam
The position ("sagitta") resolution is measured with the accuracy of about 1 micron on the area of 2x3 cm^2





8 Gev 2 Gev

Two momentum (8 and 2 GeV) with the same angle clearly separated

Tracks reconstruction without magnetic field (OPERA like)

- Started from 3D segments reconstructed in each plate with the accuracy of about 1 micron in position, and of 3 mrad in angle
- Plate to plate alignment procedure is performed using passing-through tracks
  - Assumed that the tracks in medium are straight
  - Assumed that the emulsions are flat and parallel
- Alignment procedure optimize
  - gap between emulsions (deltaZ)
  - Calculate the affine transformation between segments patterns that can be decomposed as shift(XY), rotation, scaling(XY)
- After the alignment tracking is performed by segments extrapolation and track following using Kalman Filter

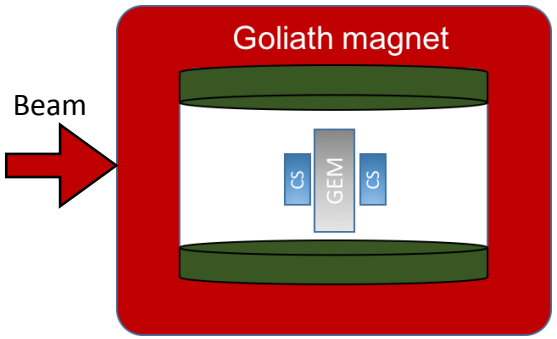
In case of CES this procedure appeared not sufficient

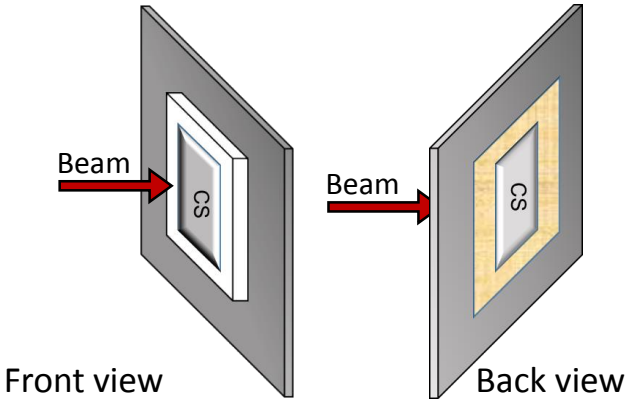
- We found that the global corrections does not converge well
- If we work peak by peak we reach the 1 micron accuracy on the sagitta measurement as it expected
- If we reconstruct globally different angles (even that without magnetic field) together the position-dependent effects appears
- Explanation we found is that the spacer was not sufficiently flat so one of our basic assumptions does not work
- Rohacell plates thickness as specified by producer is 15+-0.2 mm, this does not guarantee the gap uniformity over the scanned area
- Two possible solutions:
  - Software – we add tilt correction algorithm (under development)
  - Hardware – make spectrometer layers precisely flat (the preferred one)

Emulsions and GEM exposure

Setups:

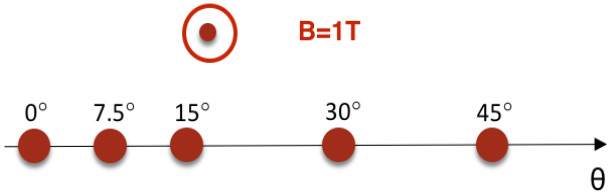
1. 2 CS doublets attached on GEM upstream and downstream surfaces in magnetic field





Low density: 50 tracks/cm^2/angle

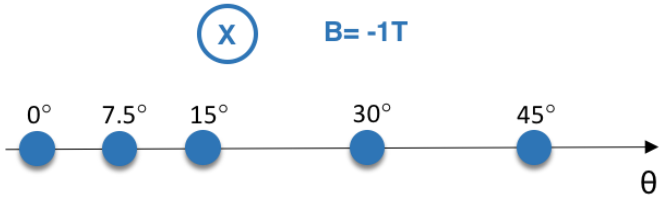
Exposure 1

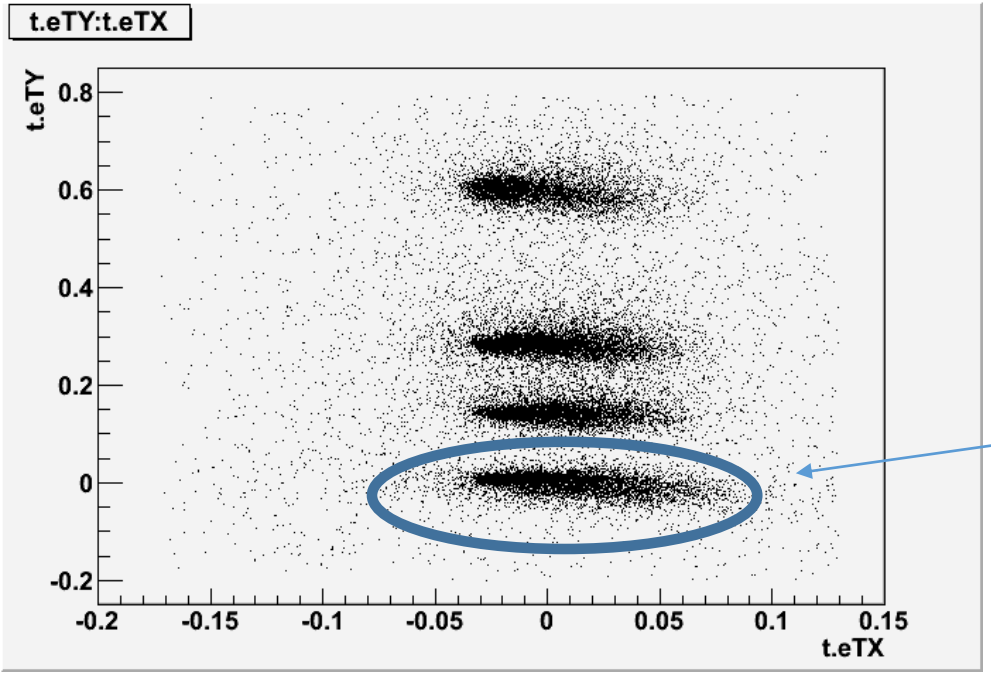


Target: 2 x CS
Magnetic Field: + 1T

Exposure 2

Target: 2 x CS
Magnetic Field: -1T



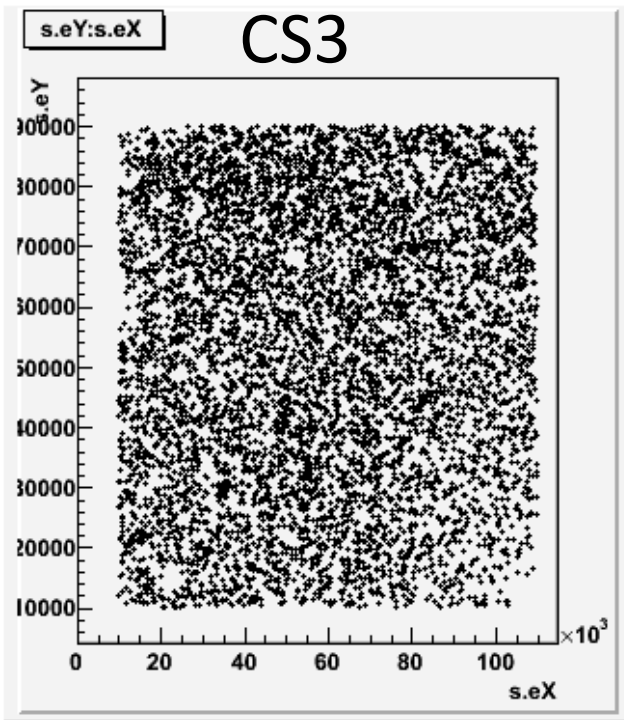


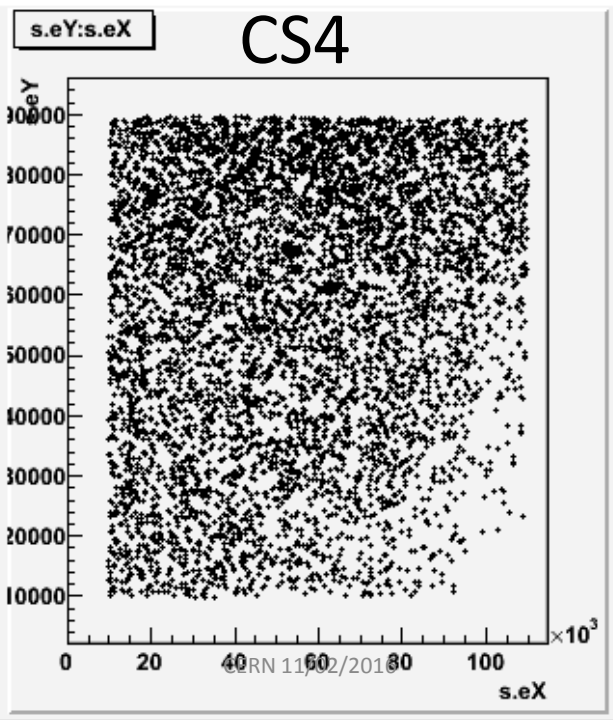
Each CS consists of 2 emulsion plates
Each plate has 2 sensitive layers
The surface of each layer is 10x12 cm^2

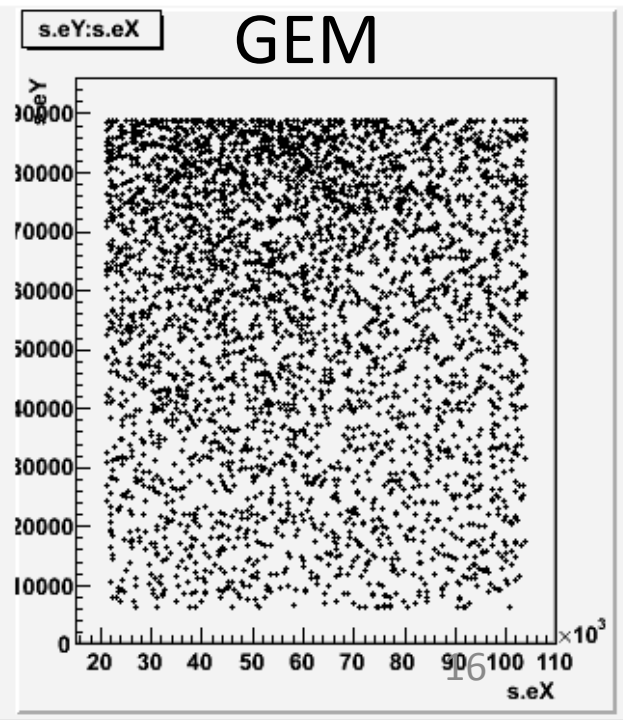
The full surface was scanned and track matching done in all 4 layers of each CS

The first matching with GEM was attempted for the peak at 0 angle

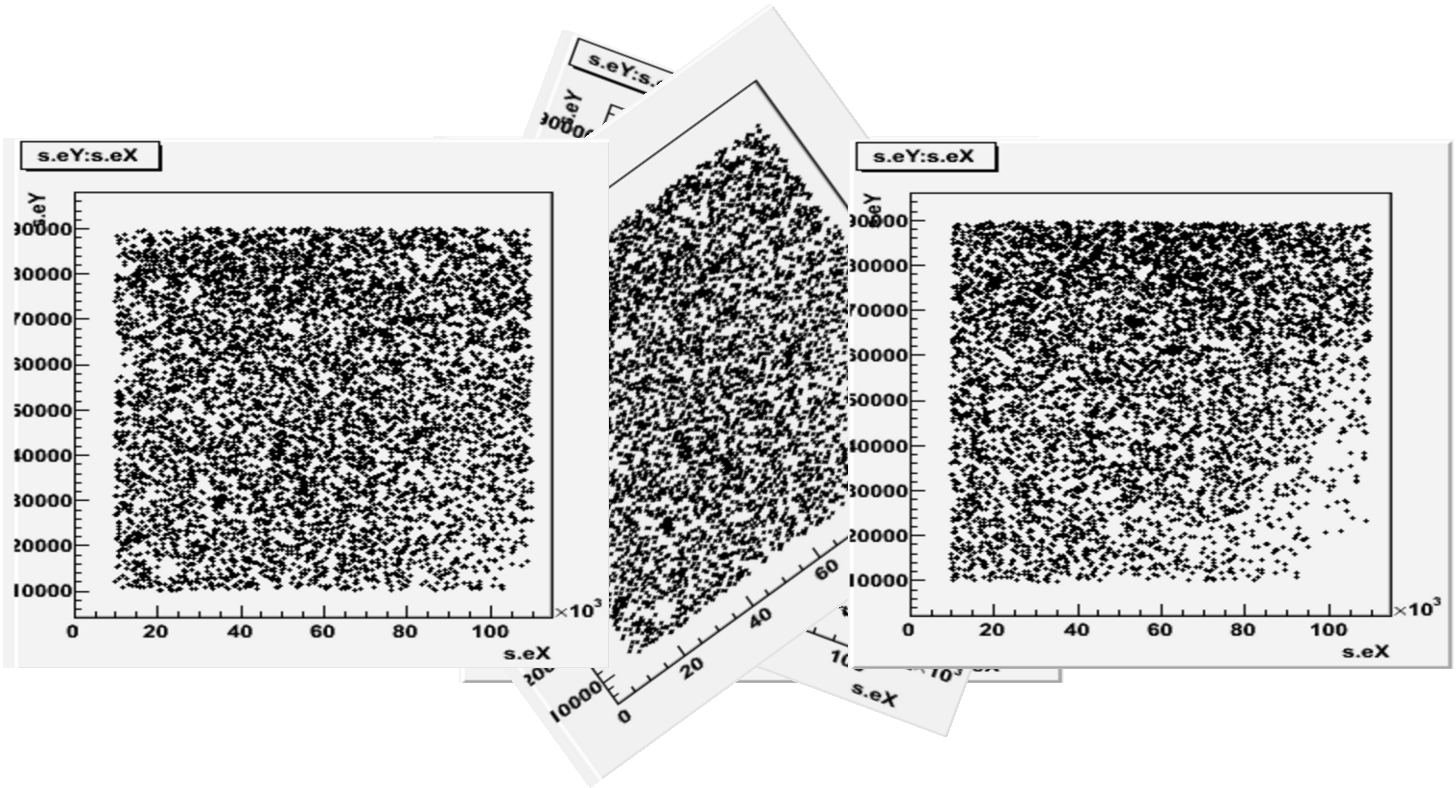
GEM data provided by Frascati group





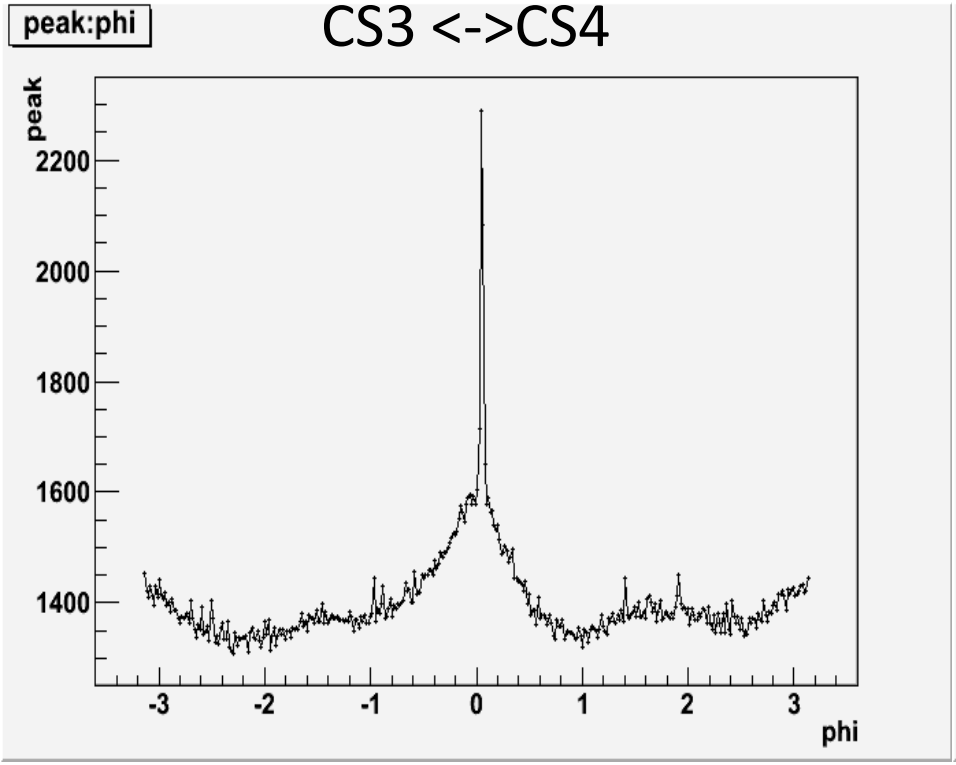


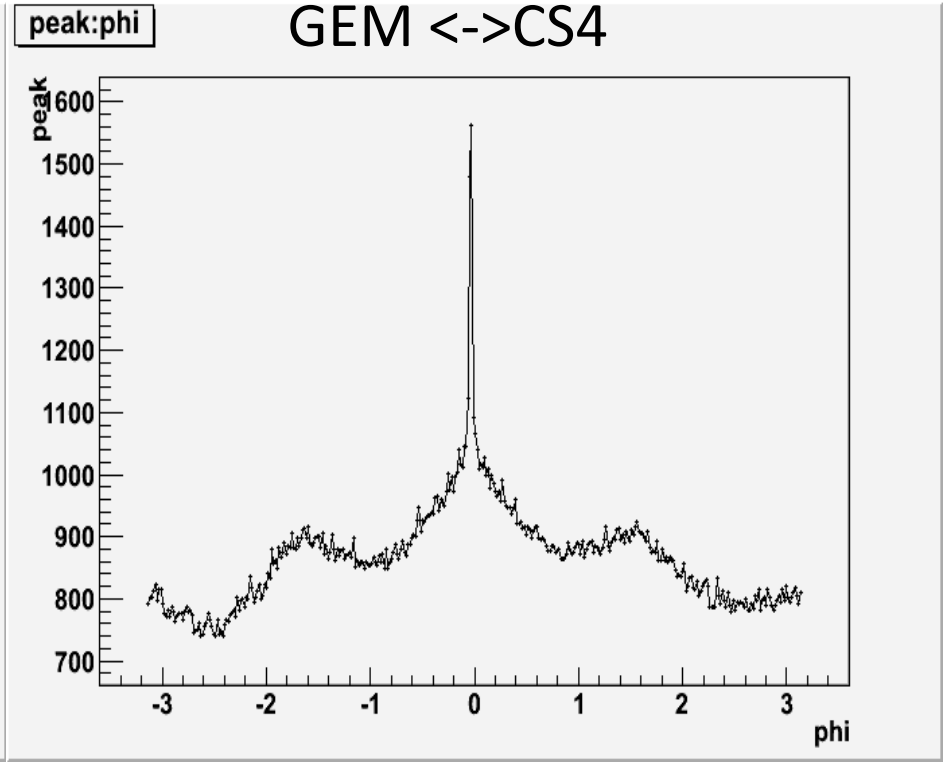
Pattern matching between 2 patterns – “alignment” procedure

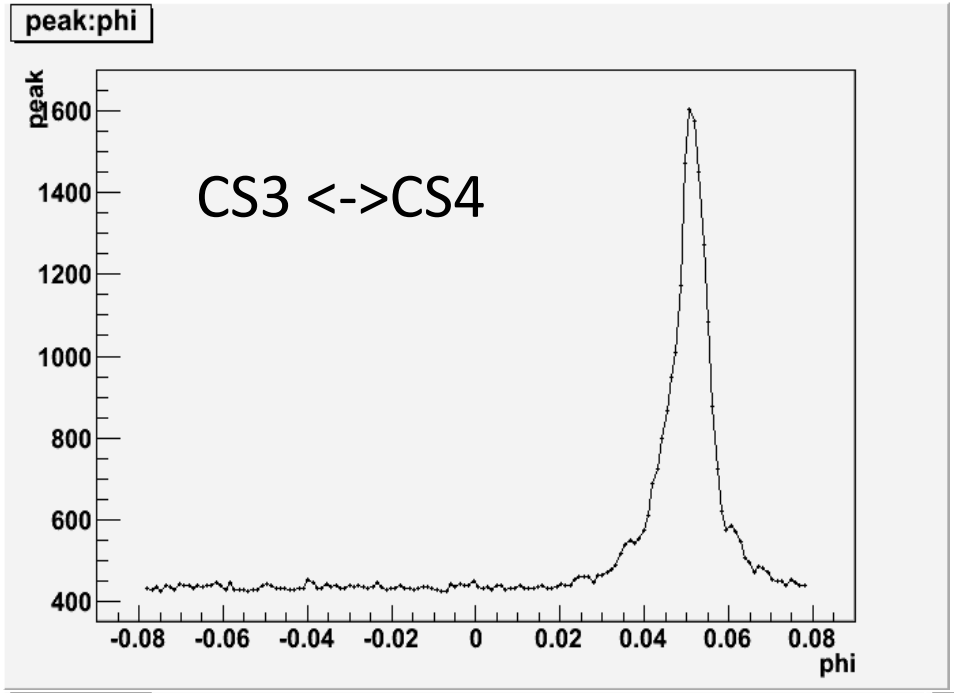


Matching between Emulsions and GEM

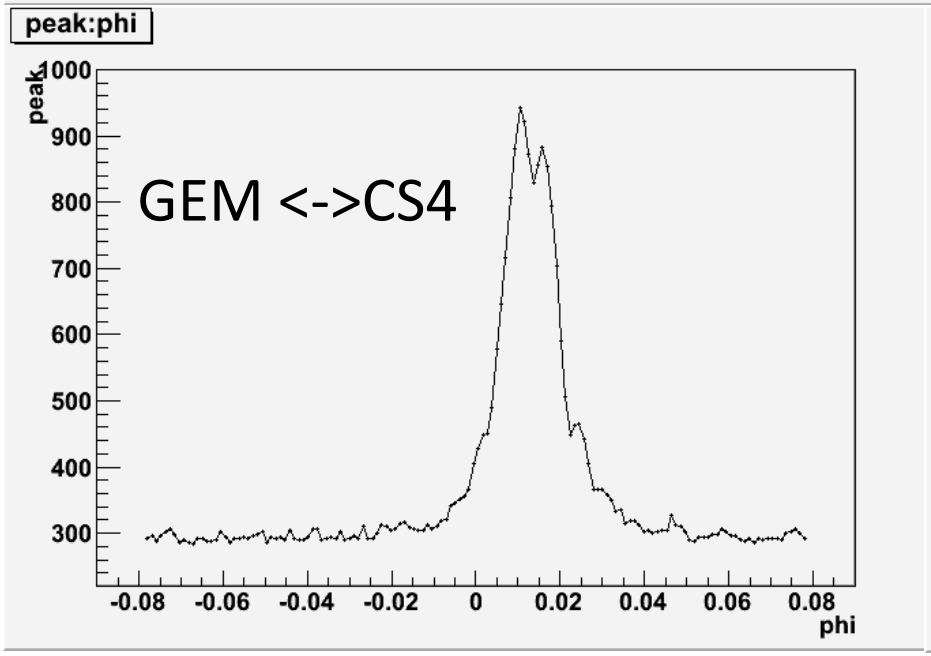
"Total alignment" was developed for this case
Offset range in XY: +-10 mm
Angular range +- Pi
Position acceptance 500 microns

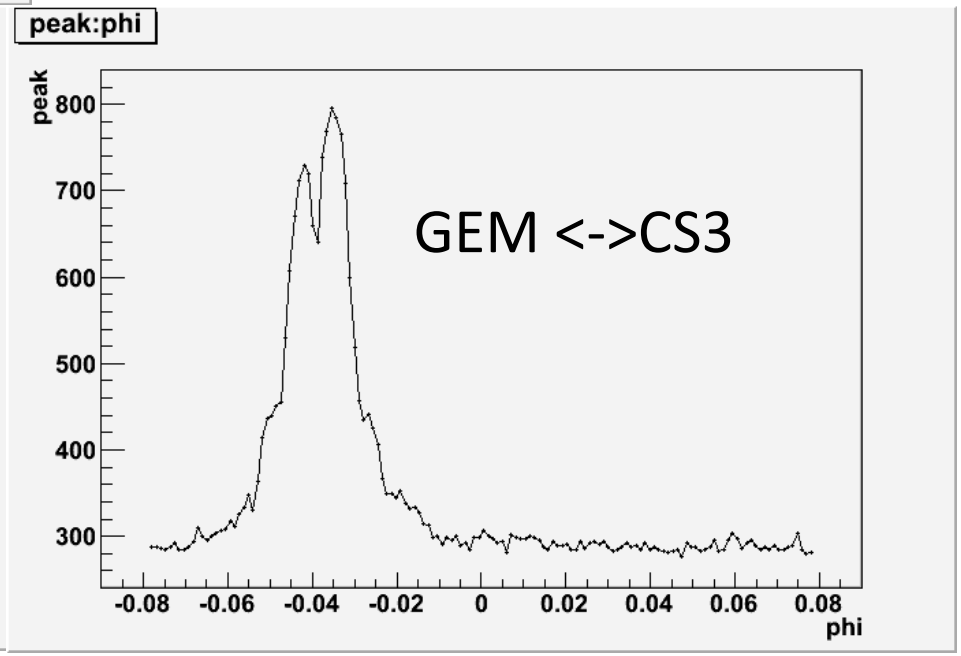




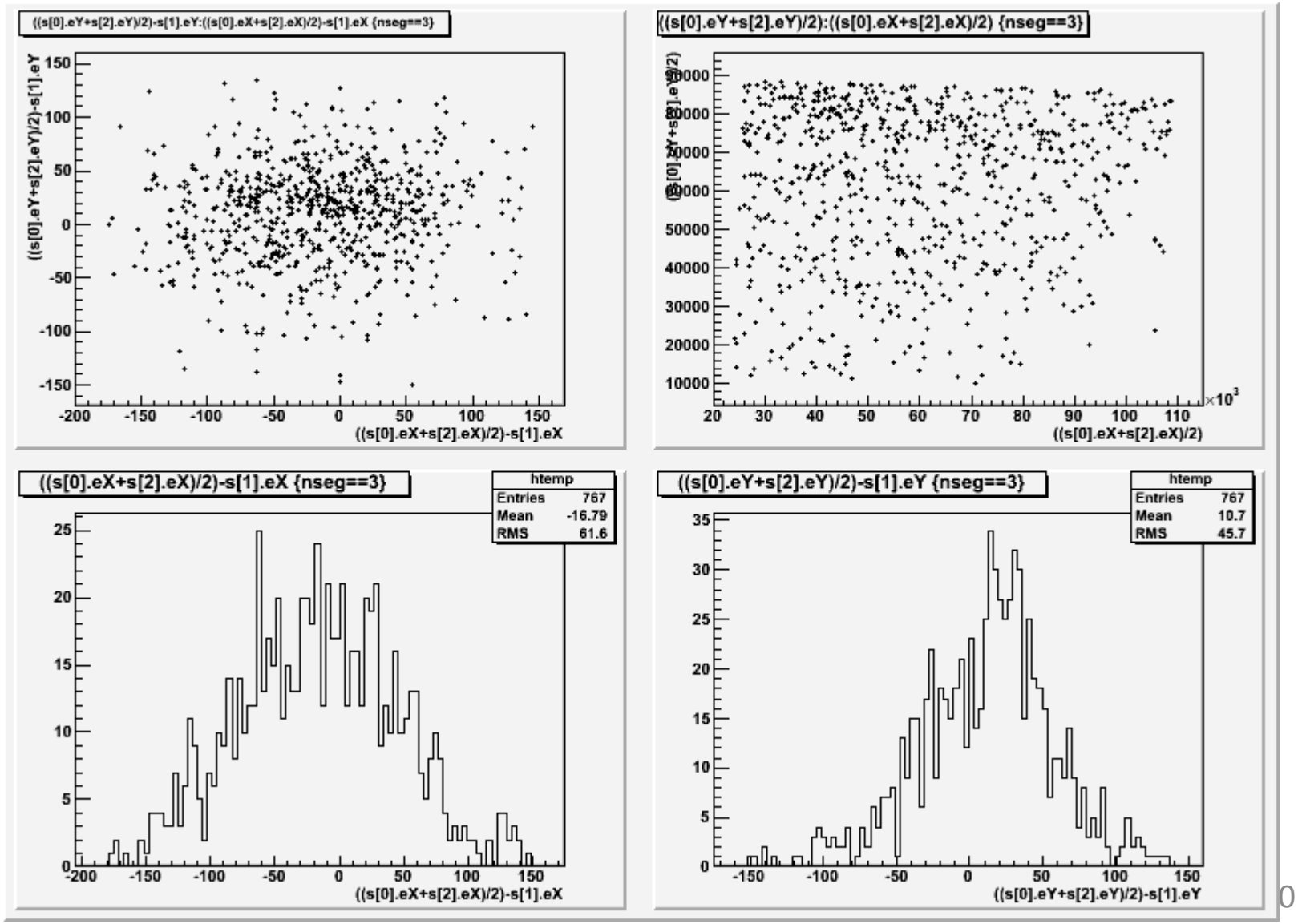


"Total alignment"
Offset range in XY: +-10 mm
Angular range +- 0.08
Position acceptance 250 microns





Common tracks are reconstructed in CS3-GEM-CS4 (preliminary data with hard cuts)



Conclusion

- CES: emulsion position resolution is sufficient for resolving > 10 GeV momentum at 3 cm base, but the mechanical construction should be improved to obtain reliable absolute values
  - Software compensation of mechanical inaccuracy is possible in case of sufficient calibration sample (straight high momentum tracks) – under development
  - We plan also to test the different and more precise mechanical solution
- Emulsion – GEM matching is verified to be good at 0 angle and B=0
- To do for GEM-emulsion data:
  - matching resolution and efficiency study
  - Analyze all data sets with different angles and B
  - Matching with CES and ECC assemblings
- Micromegas data set has to be analyzed yet