LHCb Muon detector alignment with cosmics

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On behalf of the LHCb collaboration

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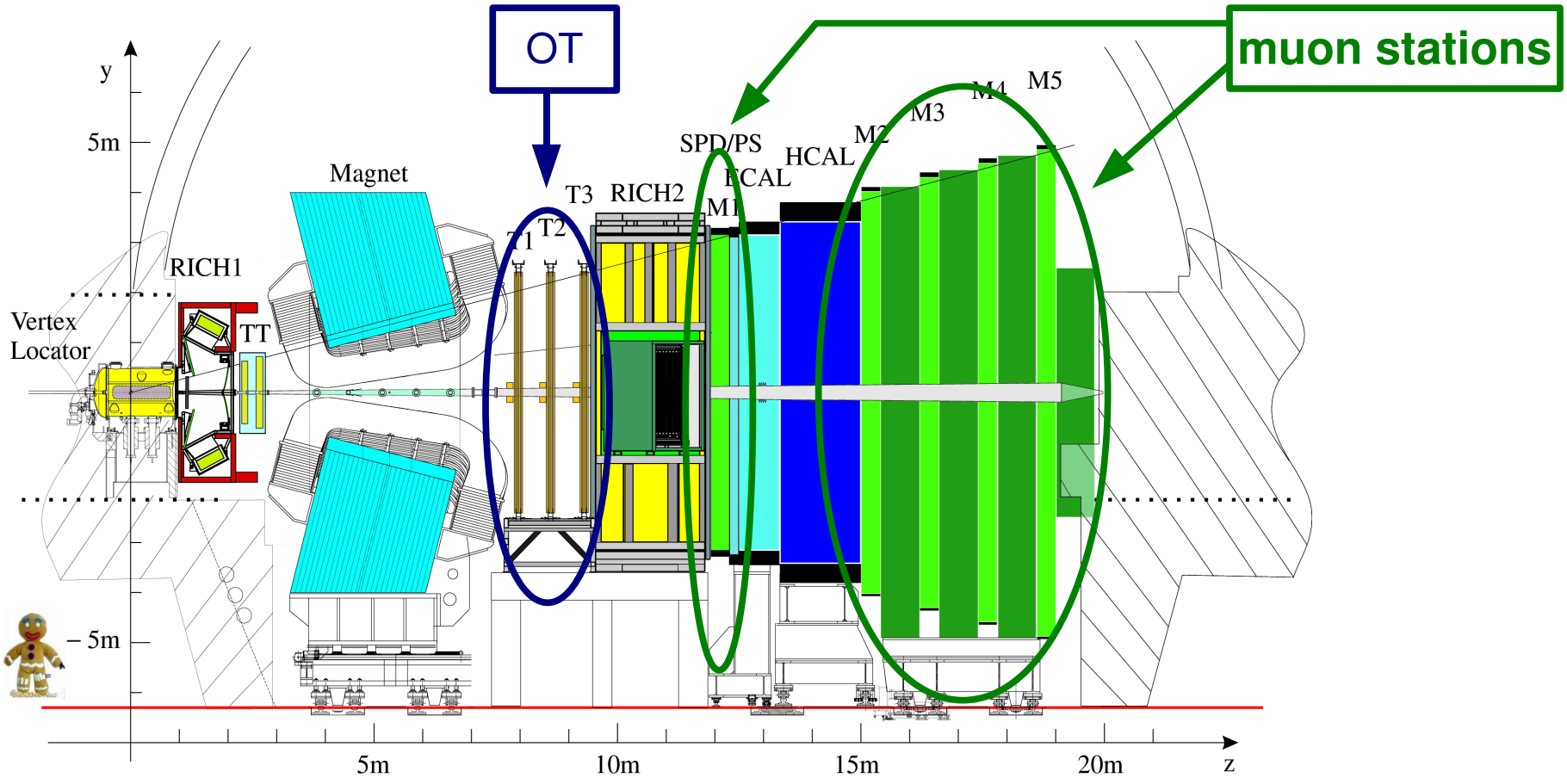
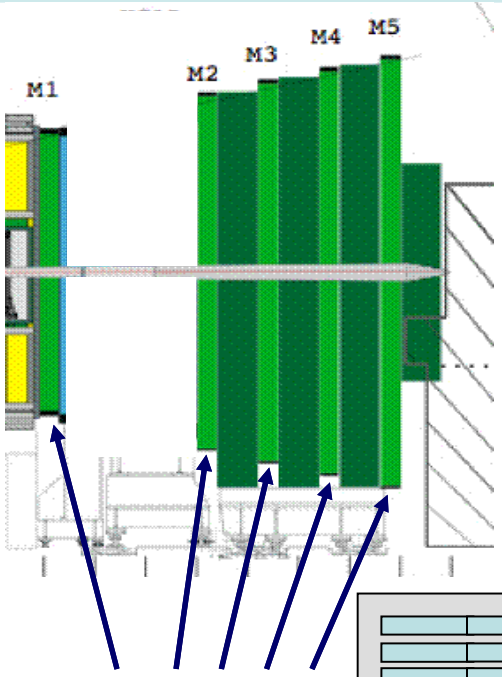
Outline

- The LHCb Muon detector
- Data sample and track selection
- Results on cosmics
- MonteCarlo study
- OT-Muon matching
- Conclusions

The LHCb detector

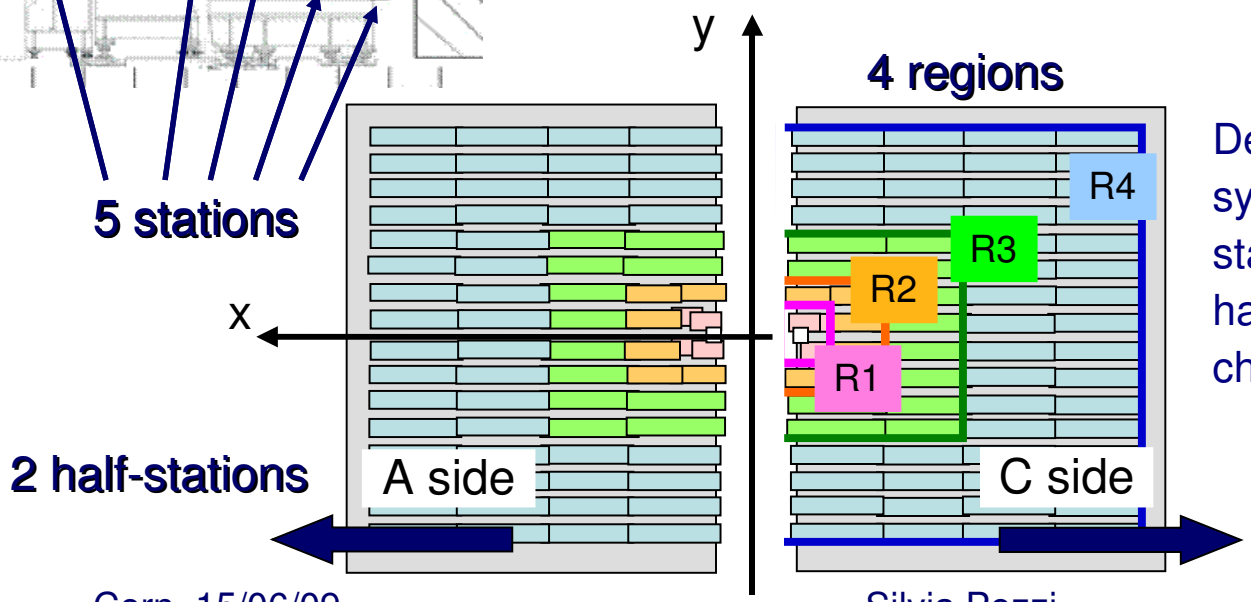


The Muon detector



- 5 stations
- 2 halves, 4 regions per stations
- different segmentation in X and Y in different regions
- different segmentation in X in different stations
- 2D read out (pad), X and Y measured independently

Hardware alignment, precision of 1mm



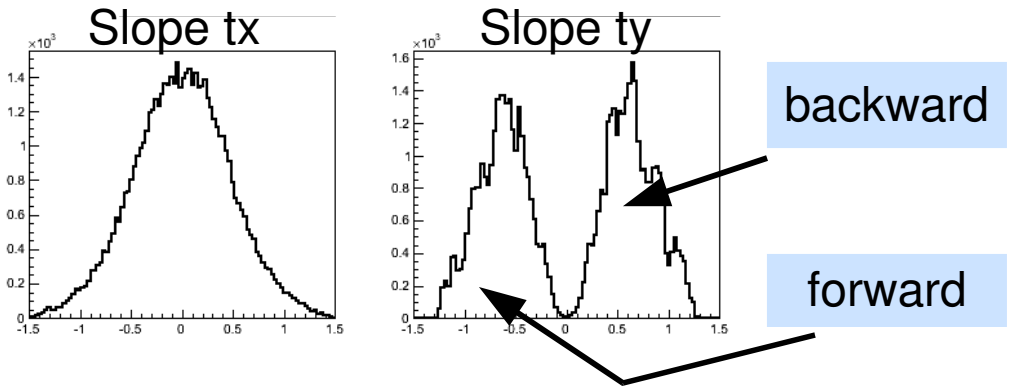
Detector element hierarchy:
system,
station,
half-station,
chamber

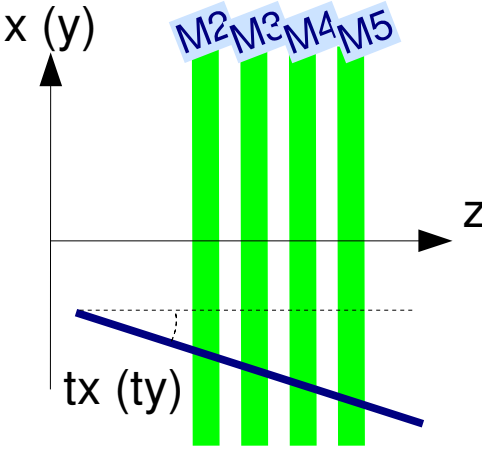
Smallest pad:
6.3 x 31.0 mm^2
(M2R1)

Biggest pad:
248 x 309 mm^2
(M5R4)

Data sample and track selection

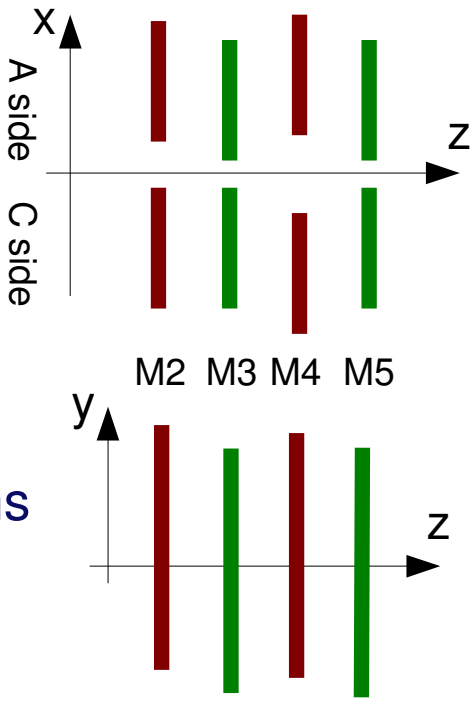
- 9 runs taken in Sept-Oct '08 triggered by the calorimeter and/or Muon
- B = 0
- Only M2 - M5 installed
- Noisy channels removed in acquisition
- Remaining noisy channels removed before the reconstruction
- Tracks reconstructed with a NeuralNetwork algorithm, requiring at least 3 hits per track
- → 130 k tracks used in the alignment





The Alignment method

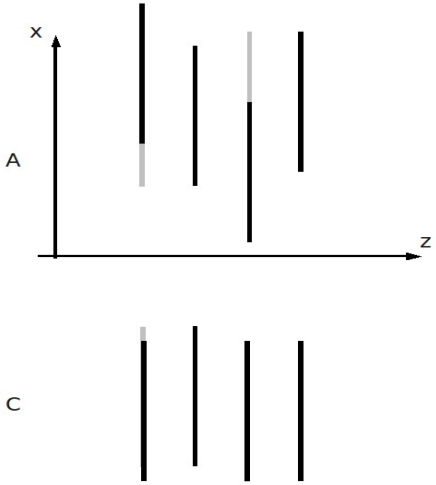
- Alignment method using Kalman fitted tracks
  (see W. Hulsbergen's talk)
- Aligning half-stations
- Local alignment
  - cosmic rays passing only through the muon stations
    → 2 stations fixed to fix a system of reference
  - Muon system used to determine the tracks
    → measurement sampling due to the big pad size
- For this study we have fixed stations M3-M5 to the survey measurements to fix global position and shearing



M3 and M5 fixed, aligning
M2 and M4 halves
in x and y
w.r.t. M3 and M5

Results

- **Translations in X and Y:**
  - A side compatible with a shearing in the X-Z plane AND a displacement of M5 of 7 mm
  - C side compatible with the survey measurements in X
  - Y compatible with survey measurements



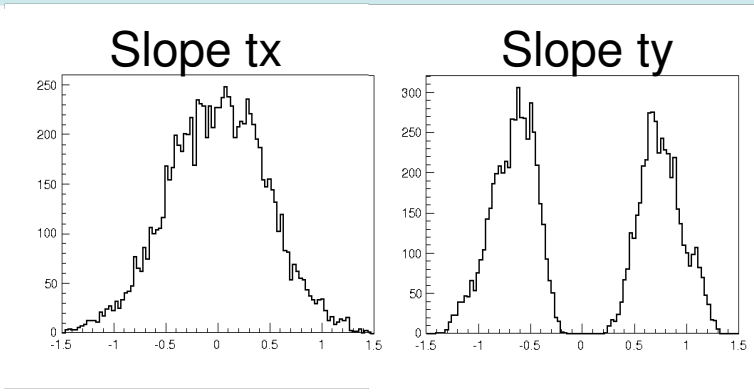
- **Rotations aroud Z:** O(0.1 mrad), compatible with survey

	Survey x (mm)	Tx (mm)	Survey y (mm)	Ty (mm)	Survey Rz (mrad)	Rz (mrad)
M2 A	+9.0 ± 1.0	+11.97 ± 0.17	0.0 ± 1.0	-0.38 ± 0.50	0.0 ± 0.5	-0.16 ± 0.11
M2 C	+9.0 ± 1.0	+ 9.68 ± 0.15	0.0 ± 1.0	+1.12 ± 0.45	0.0 ± 0.5	-0.04 ± 0.10
M4 A	+10.0 ± 1.0	+ 5.56 ± 0.20	0.0 ± 1.0	+0.28 ± 0.32	0.0 ± 0.5	-0.21 ± 0.09
M4 C	+10.0 ± 1.0	+ 9.93 ± 0.20	0.0 ± 1.0	+0.44 ± 0.32	0.0 ± 0.5	+0.04 ± 0.09

- A MonteCarlo sample was produced for cross check and study of systematics

Performance on simulated data

- Simulated 1.5 M single muons
- Null misalignment in input
- Require the track extrapolation to fall in the calorimeter volume (cosmics are triggered by calorimeter)
- → 40 k tracks used in the alignment

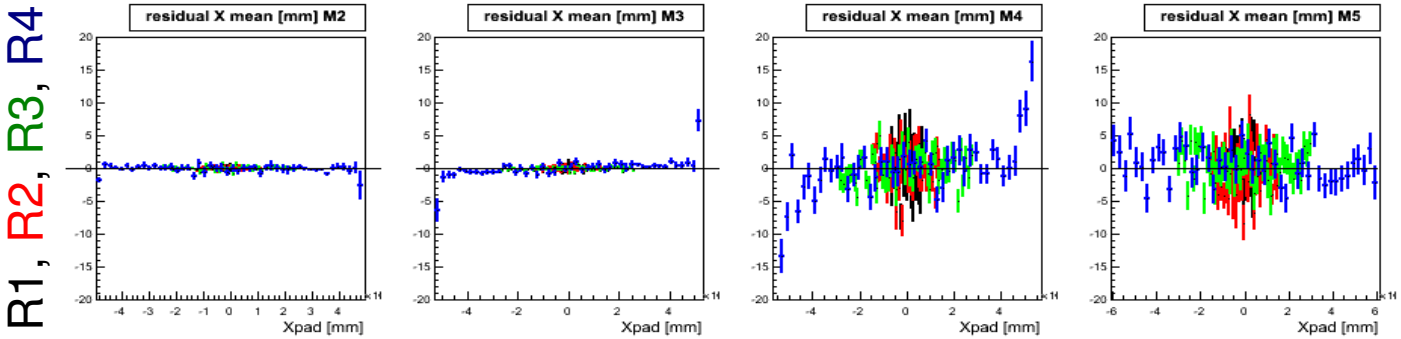


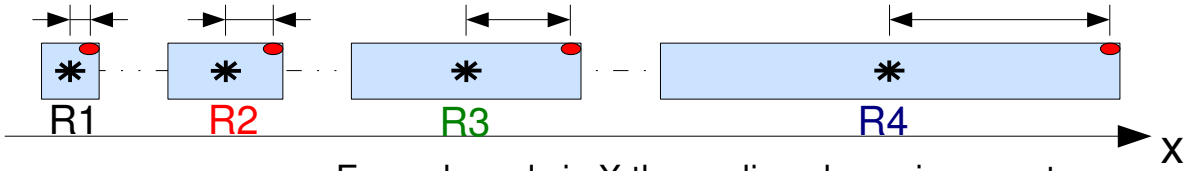
	Input x (mm)	Tx (mm)	Input y (mm)	Ty (mm)	Input Rz (mrad)	Rz (mrad)
M2 A	0.0	-0.09 ± 0.28	0.0	-1.98 ± 0.83	0.0	0.28 ± 0.20
M2 C	0.0	+0.51 ± 0.28	0.0	-1.40 ± 0.82	0.0	0.02 ± 0.21
M4 A	0.0	+0.16 ± 0.38	0.0	+0.88 ± 0.63	0.0	-0.22 ± 0.16
M4 C	0.0	+0.04 ± 0.38	0.0	+1.14 ± 0.63	0.0	-0.19 ± 0.17

- **Translations in X and Y:** compatible with the null input misalignment
- **Rotations around Z:** compatible with the null input misalignment
- On simulated data the algorithm works as expected

MonteCarlo, systematics

- Residual <hit-fit>
  - “jumps”, due to the sampling
  - “S” shape, due to the distribution of cosmics on the stations
- This can be a problem aligning single chamber

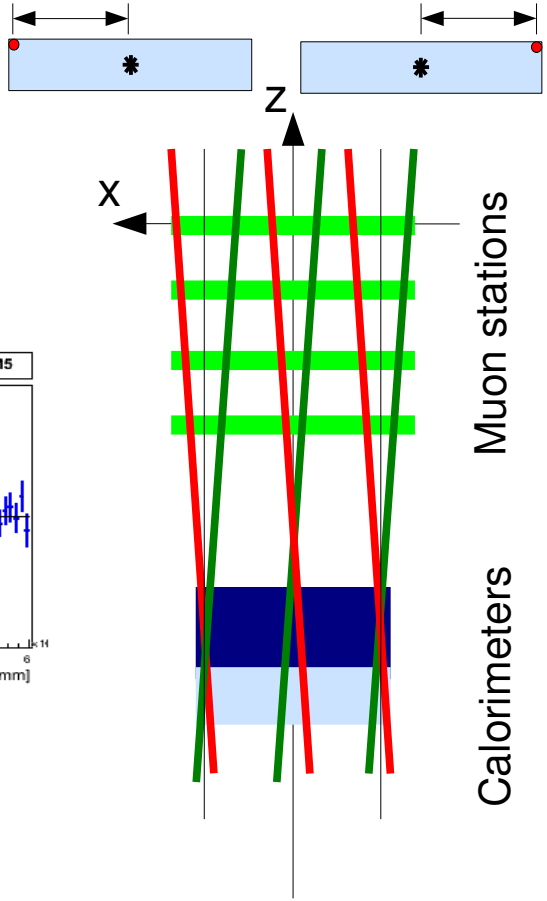




Example, only in X the scaling shown is correct

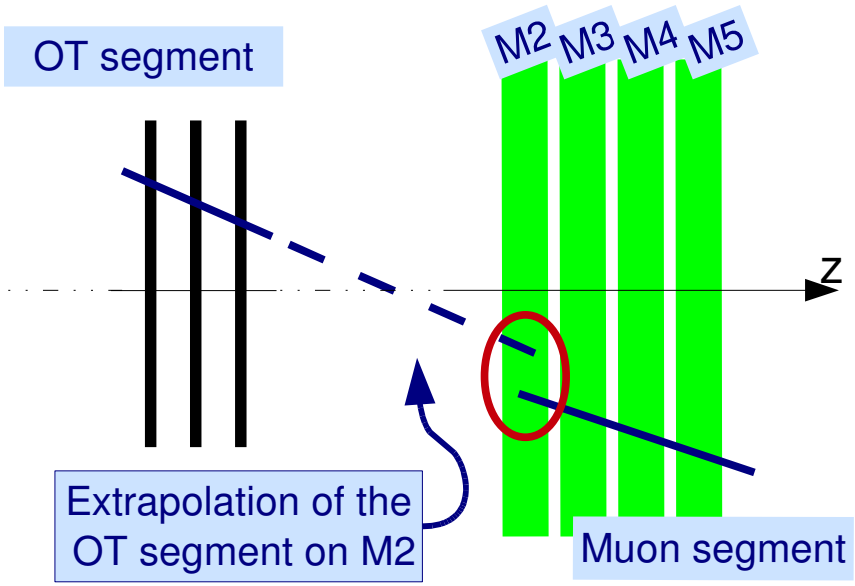
✳ Hit = read out position

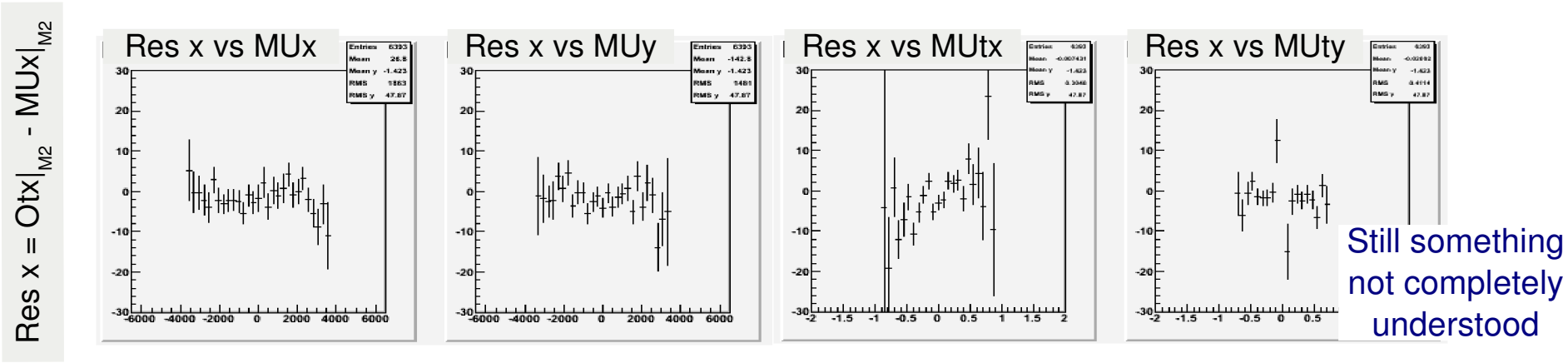
● Fitted track position



OT – Muon matching

- Matching between cosmic segments separately reconstructed in OT and Muon was performed
- Goal: aligning the Muon system respect to the OT, with more statistics and finer resolution (reduce sampling problem)
- As a first step we studied the residual distributions
- Alignment will come soon!





Conclusions

- We used cosmics to align the half-stations of the Muon system locally respect to the survey measurements
- The results fixing the stations M3 and M5 are
  - **Translations in X and Y**:
    - A side is compatible with a shearing in the X-Z plane and a displacement of M5 of 7±2 mm
    - C side is compatible with survey in X
    - Compatible with survey in Y
  - **Rotations around Z:** O(0.1 mrad), compatible with survey
- A MonteCarlo sample was simulated in order to study the systematics and the results are as expected compatible with the input (null) misalignment