

# On the AMS-02 Tracker Alignment

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- Alignment Procedure
- Alignment by Straight Sea Level Muons (Data)
- Alignment Accuracy Verification by MC
- Summary
- To Be Done
  - Full Tracker Alignment
  - Study Straight Low Orbit Cosmic Ray (p,He) Alignment;
  - Alignment on Sensor Level;
  - Curved Tracks Alignment Monitoring;

- The idea of the method is to fit the measured coordinates to 5 or 6 parameters trajectory , and then to try to minimize the sum of  $\chi^2$  by varying the layers/ladders/sensors positions and rotations<sup>1</sup>.
- Fitting algorithm is based on the original work of J.C. Hart and D.H. Saxon, NIM 220 (1984) 309. Fits 5/6 pars straight/curved tracks.
- Element (Layer/Ladder/sensor/) is assumed to be a rigid body with known dimensions and 6 degrees of freedom: 3 shifts and 3 rotations<sup>2</sup>.
- Minimization is done by iterations, when the ladder parameters are calculated from the residuals of previous iteration.

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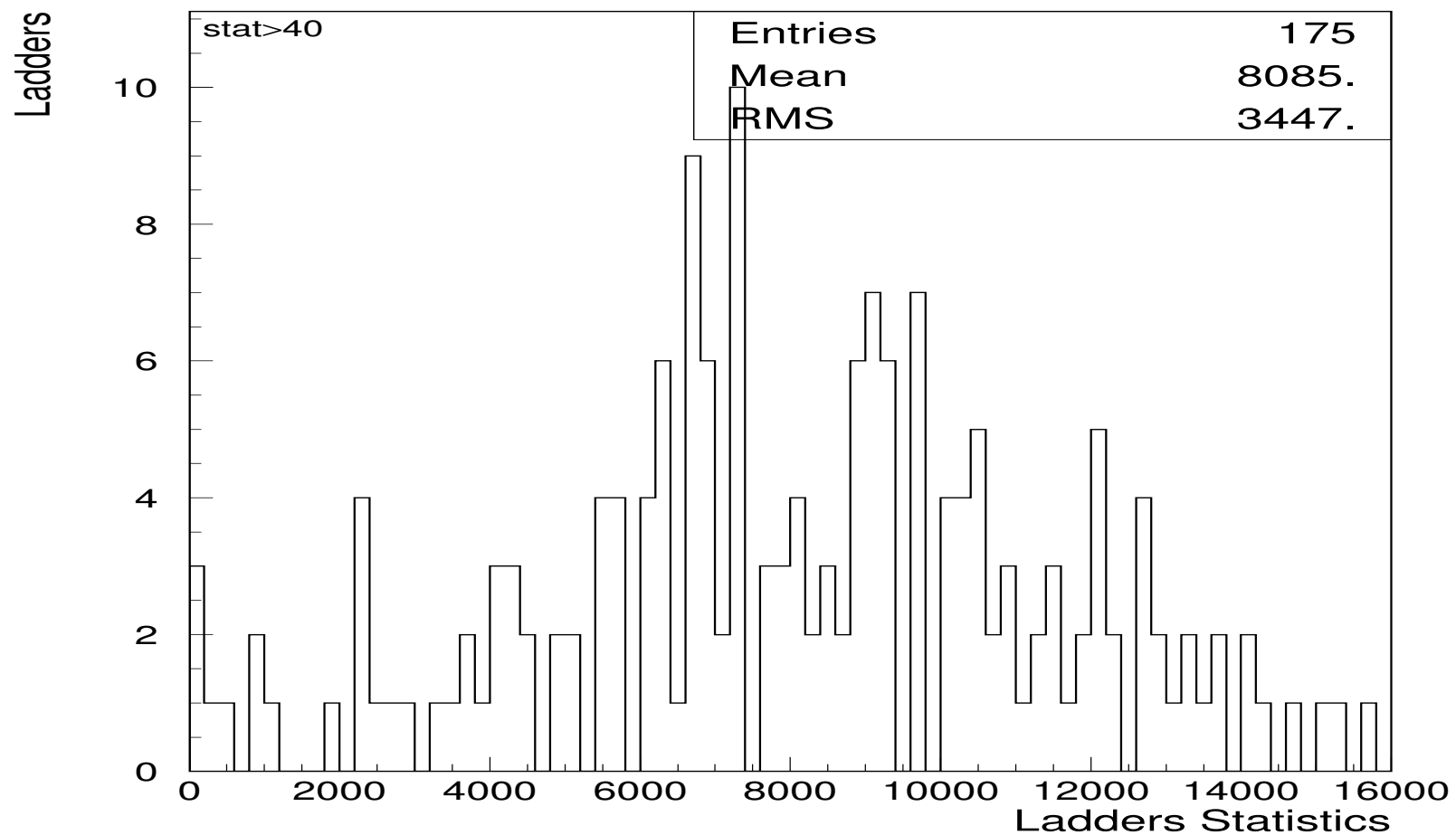
<sup>1</sup>pitch,roll,yaw representation used  
<sup>2</sup>No Boundary Conditions Imposed

- OpenMP based automatic parallel processing was used to speed up the calculations.
- Good events with TRD and Tracker tracks and no visible interactions are used for the alignment. Tracker tracks cuts on number of hits and chi2 are also applied. Typical values are 7 hits per track and  $\chi^2 < 1000$ .

## Alignment by Straight Sea Level Muons (Data)

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$\approx 170\text{k}$  events was used for the alignment (7+ hits)



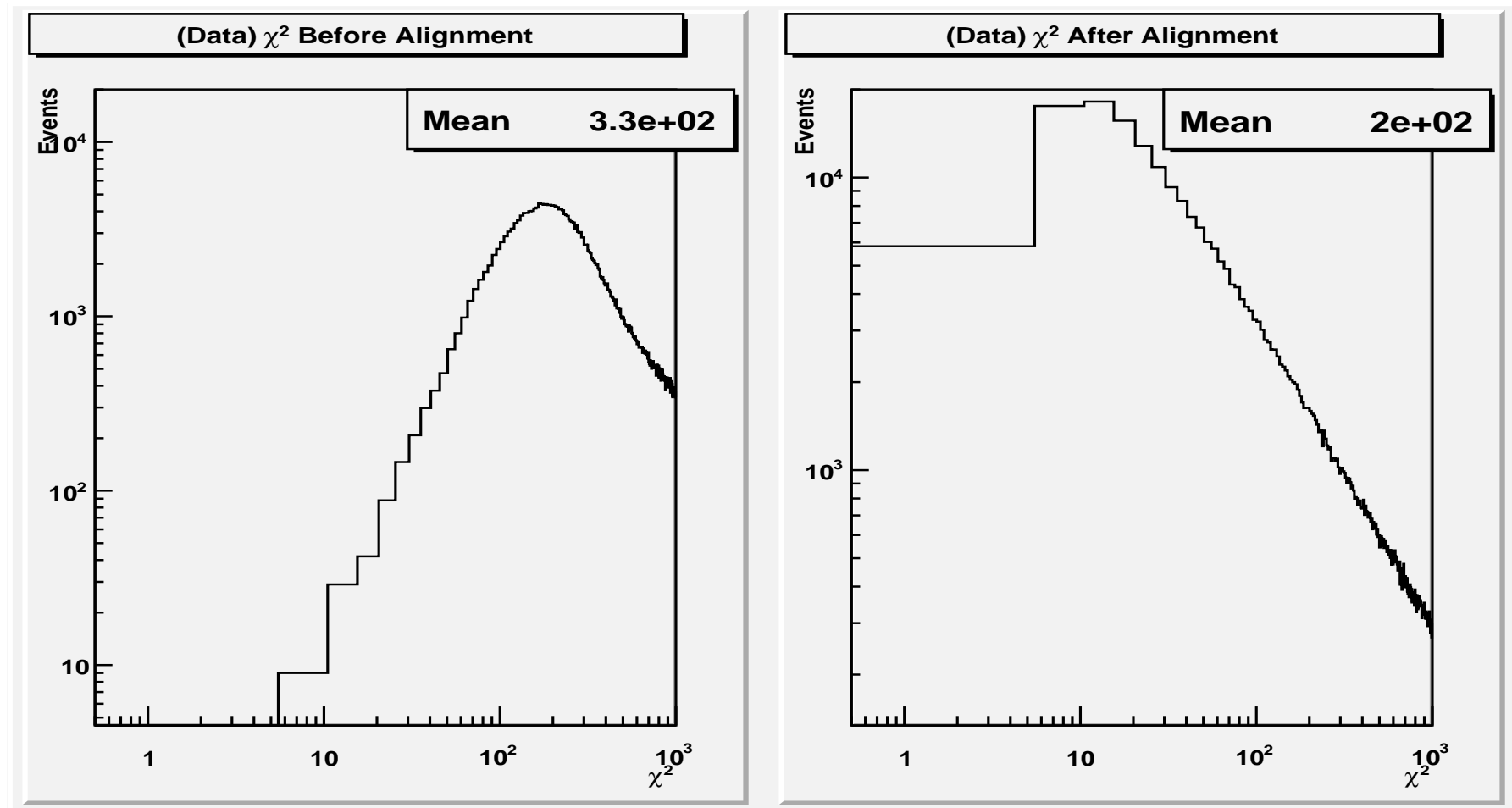
## Alignment by Straight Sea Level Muons (Data)

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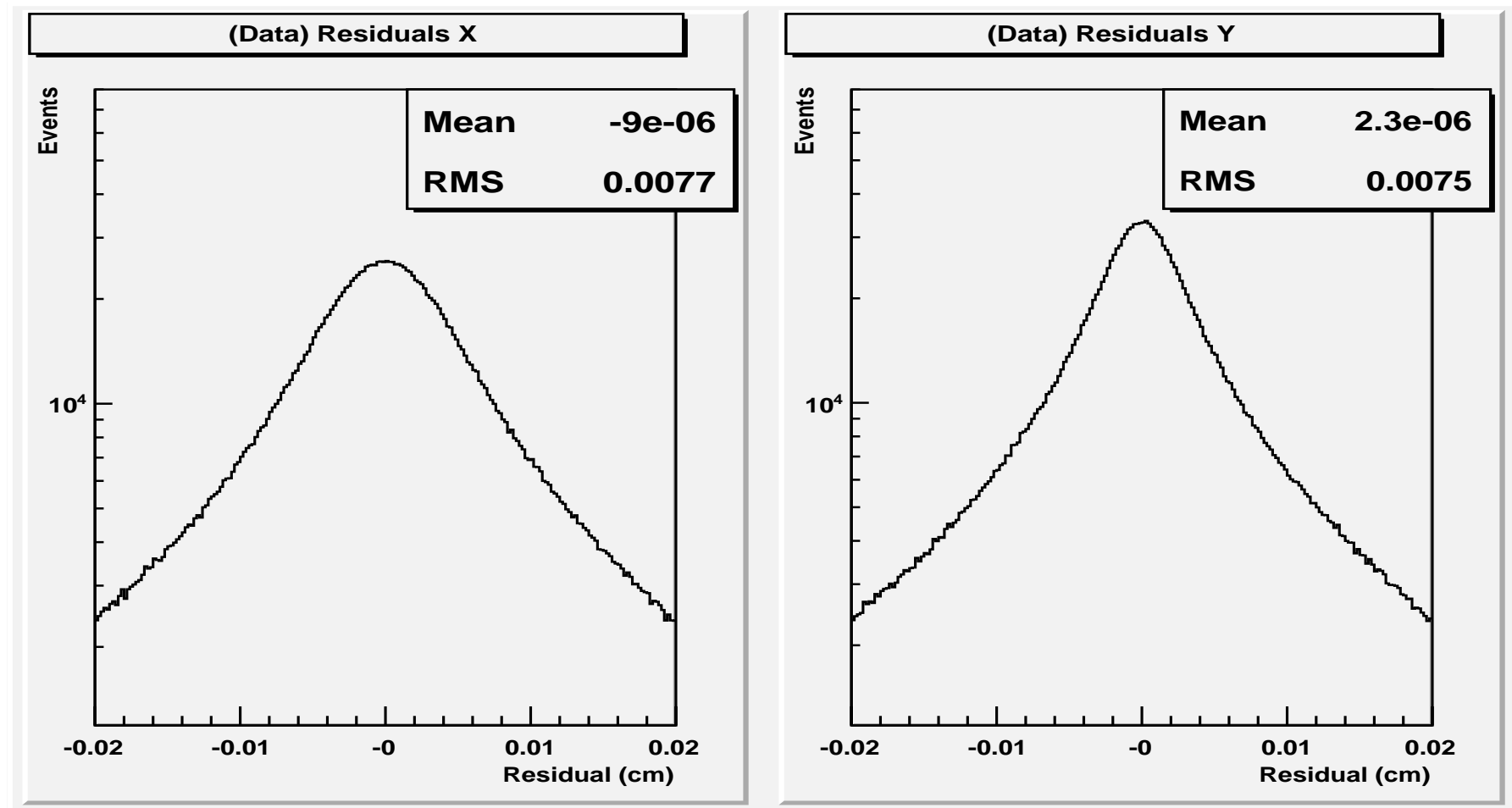
### Chi2 Monitoring:

Iter	<Chi2>	Events*2 Chi2<1000
0	358.102355240588	325694
1	222.871146523617	339128
2	214.222645976555	339980
3	211.746567436276	340274
5	210.052136491272	340412
28	207.693559915567	340692

## Alignment by Straight Sea Level Muons (Data)



# Alignment by Straight Sea Level Muons (Data)



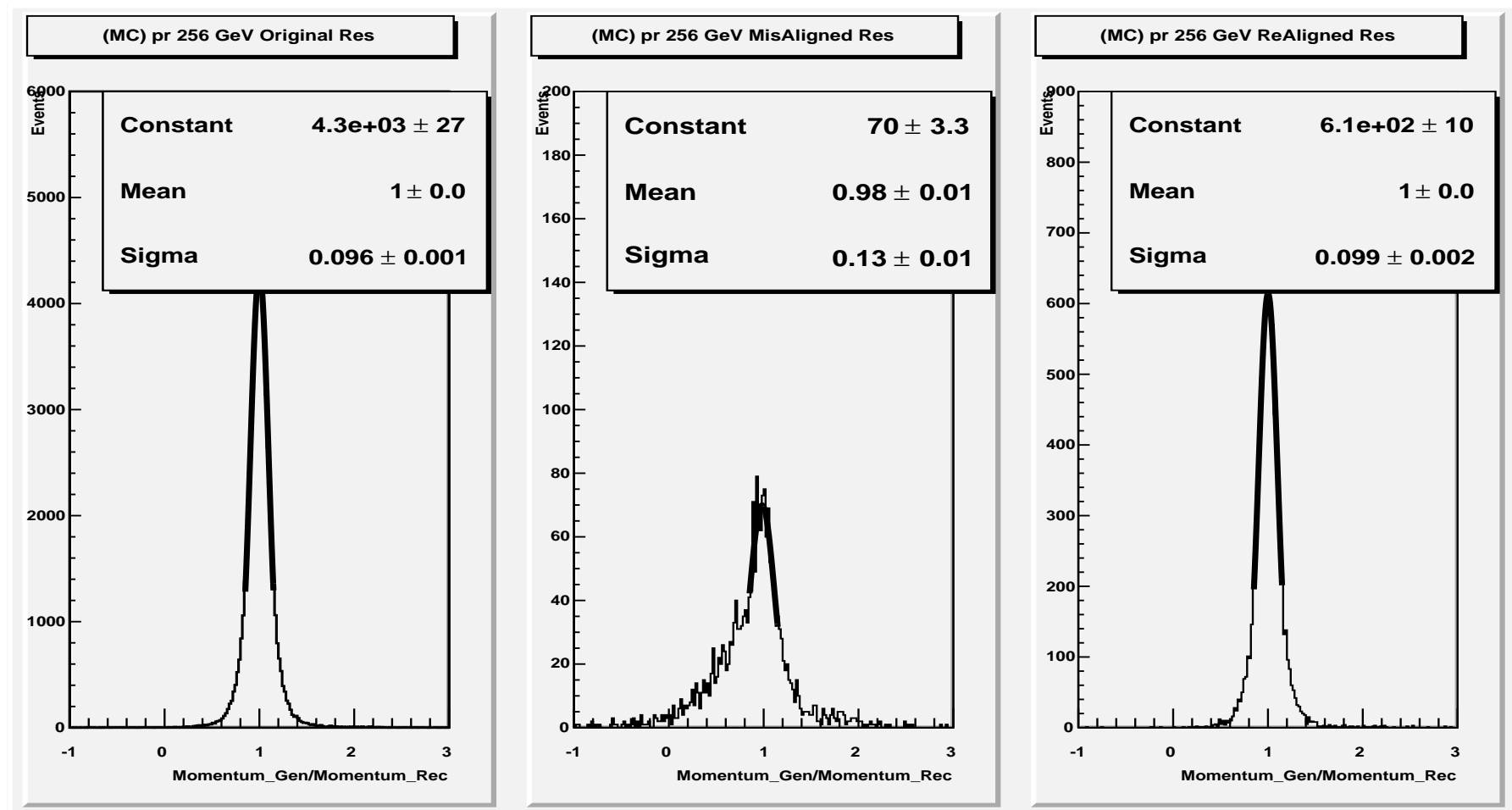
The produce alignment file was taken as input for the MC simulation. Firstly The MC data were generated according the Data alignment matrix and reconstructed using default(zero) matrix. The very same procedure as for the data were applied to realign them. About 1,500,000 events used for alignment.

#### Chi2 Monitoring:

Iter	<Chi2>	Events*2 Chi2<1000
0	308.548129500040	3084880
1	150.606710878586	2865486
2	146.960072015589	2867082
3	145.805039448026	2867622
4	145.473294179940	2867882
5	145.251085130079	2868036
9	144.839121066860	2868118
10	144.780078426140	2868088
11	144.761943020309	2868158
12	144.737858127424	2868180
24	144.644542803510	2868292

# Alignment Accuracy Verification by MC

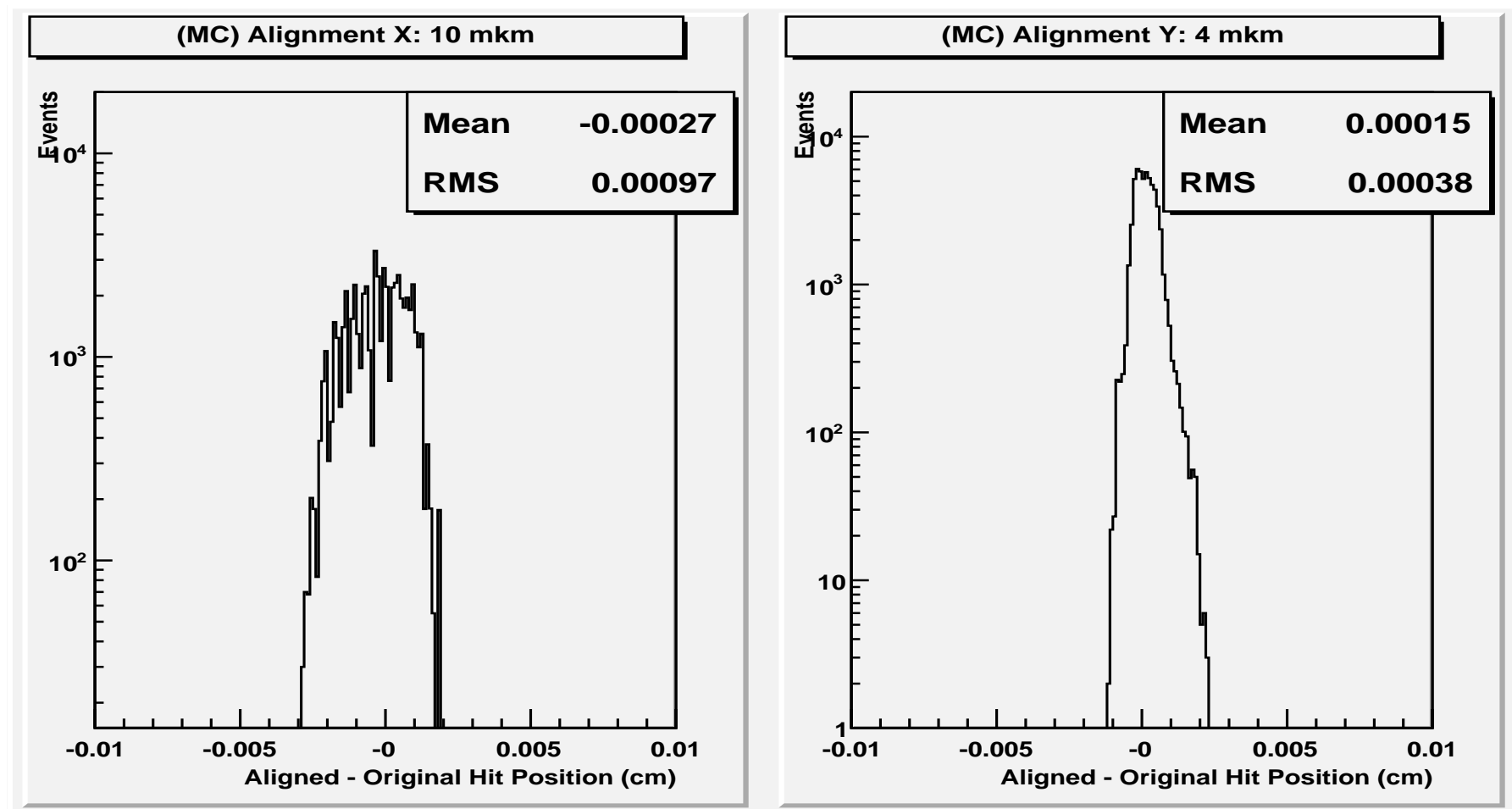
Verification by high energy (256 GeV) protons



Comparing resolutions residual y misalignemnt is  $\approx 5\mu$ .

# Alignment Accuracy Verification by MC

Indeed compare the difference between original and realigned hits we see x misalignment  $10 \mu$ , y misalignment  $4 \mu$



Alignment of AMS Tracker with  $O(10\mu)$  accuracy<sup>3</sup> in bending projection seems to be possible using straight tracks from sea level muons (to be verified with high statistics complete tracker data & high energy test beam data.)

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<sup>3</sup>Taking into account the  $5\mu$  average misalignment of sensors inside ladders and possible ladders bending and twisting

- Full Tracker (192 ladders) alignment using Sea Level Muons;
- Full Tracker alignment using Straight Low Orbit Cosmic Ray (p,He);
- Study of the Possibility of Alignment on Sensor Level;
  - Requires  $O(100)$  more statistics;
  - Greatly relaxes ladder rigid body requirement;
- Study of the Possibility of alignment/alignment monitoring by Curved Tracks;