



Studies On H8 MDT Barrel Simulation

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Outlines

- Software framework
 - Simulation
 - Digitization
 - Reconstruction
- Experimental setup
- The sagitta “puzzle”
 - Beam tuning
 - G4 VS real data
- Useful exercise
 - Tube T0 shifts
 - Energy loss
- Conclusions & Plans

Software Configuration

- Athena release 8.8.0 was used
- Simulation & Digitization
 - CTB-G4-Sim version 00-02-08
 - G4 version 06-02-patch-01 : after some G4 bugs related to multiple scattering
 - Two digitization methods were tested:
 - “MDT_Response_DigiTool”: Detailed simulation of MDT response including cluster size fluctuations and diffusion
 - “RT_Relation_DigiTool”: external R-t relationships and resolution curves are used
- Track reconstruction
 - “Moore” was used for pattern recognition and track fitting
- The same version of NOVA database was used in simulation and reconstruction
 - NOVA version NovaCvnSvc.Version=6 (amdb a.04)

Simulation, Digitization & Reconstruction

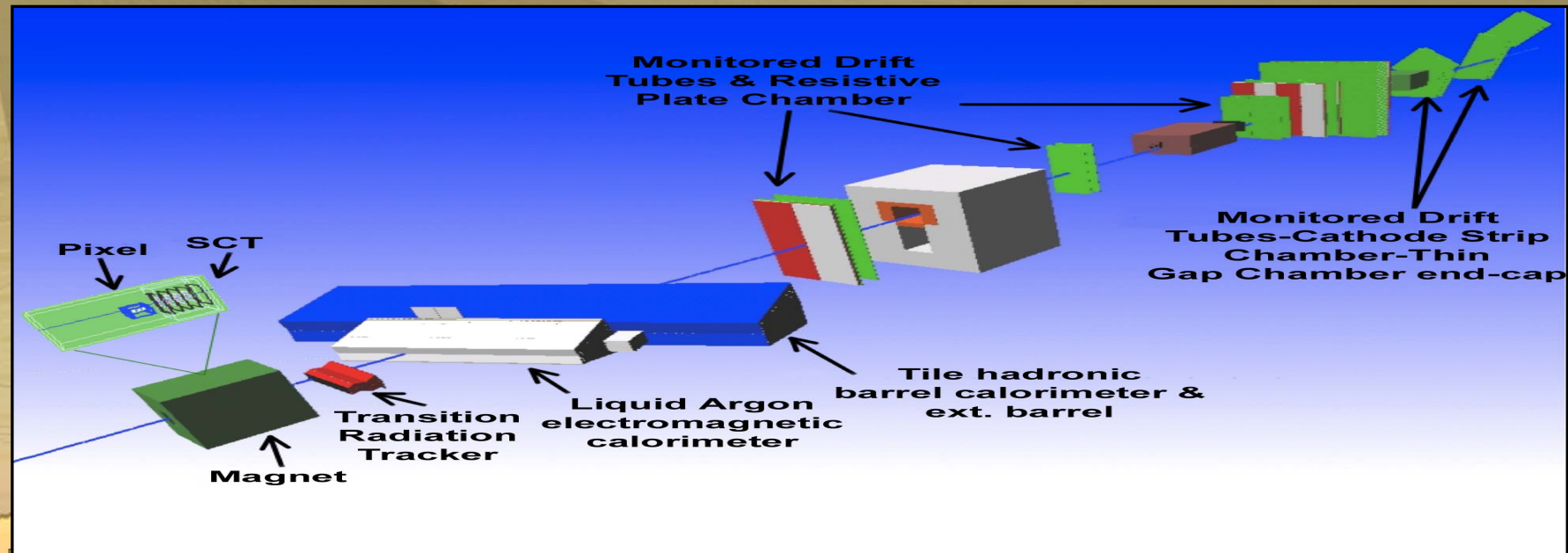
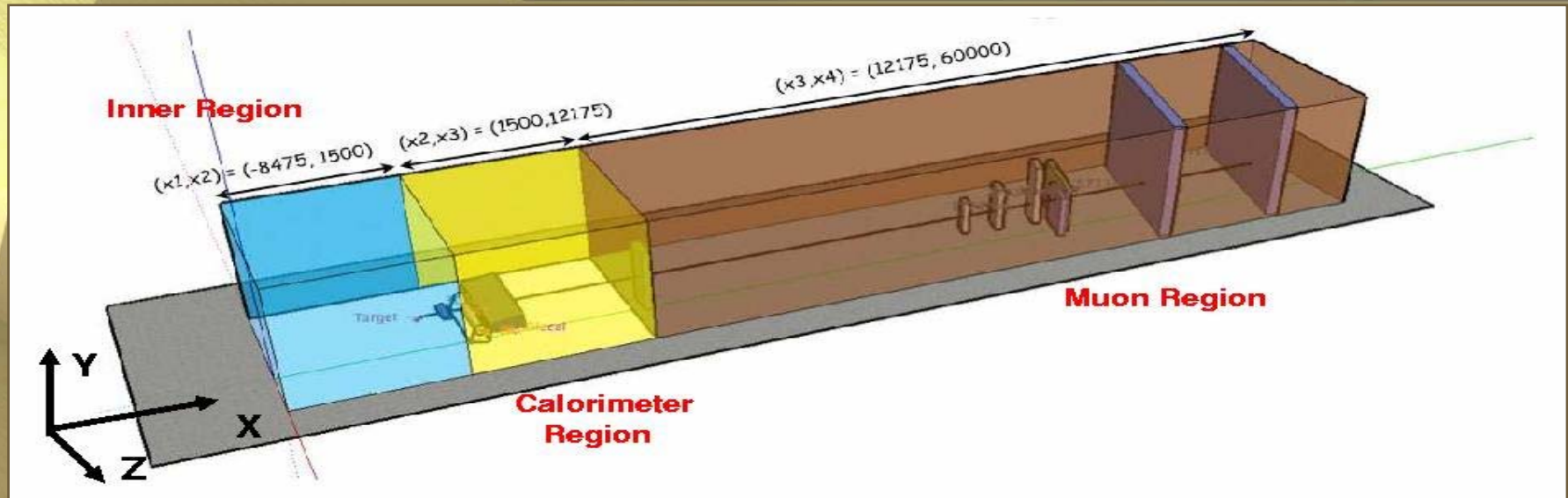
- Simulation:
 - The “ParticleGenerator” was used to produce single muons
 - Energy and direction of particles tuned on real data
 - Only MDT chambers are active
 - Best way to avoid uncertainties due to other sub-detectors
 - Analysis using different “thresholds”
 - A cut on energy released by muons in gas is applied at the simulation stage
- Digitization
 - “*RT_Relation_DigiTool*”: different resolution curves according to the selected threshold
 - R-t and resolution curves from 2003 X5 data (thanks to Ludo)
 - “*MDT_Response_DigiTool*”: number of PE is properly chosen
- Reconstruction
 - Same R-t relationships used for digitization

$$PE(th) = \frac{thr(mV)}{1.65(mV/PE)}$$

**From MDT-ASD parameter settings
Ver 1.04**

-36 mV	22 PE	594 eV
-40 mV	24 PE	648 eV
-44 mV	27 PE	730 eV

Experimental Set-Up

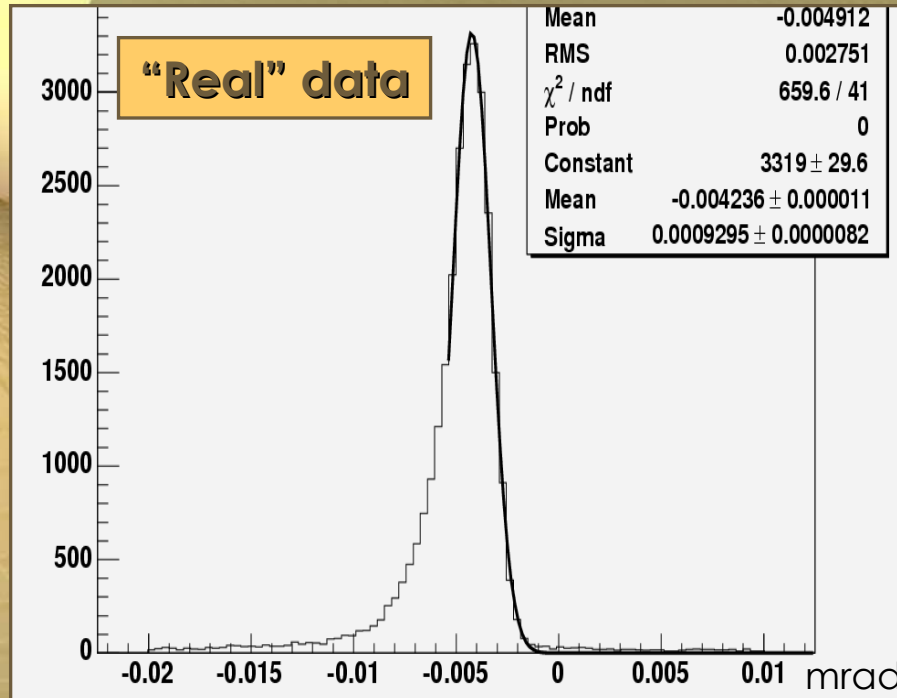


The Sagitta “Puzzle”

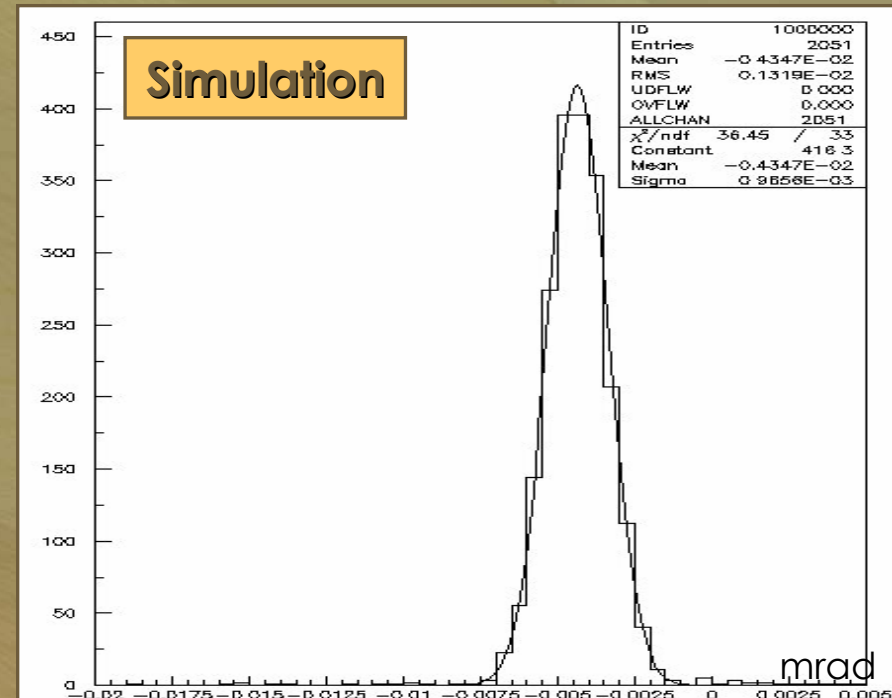
- During the data taking period some runs were acquired at different beam energies
 - Good chance to compare simulation results with real data
 - Energy scan $230 \div 80$ GeV
 - See talk by Silvia Ventura for momentum measurement
- Strategy
 - Simulate muons with beam energy and geometrical distribution in agreement with real data
 - Estimate the sagitta width and compare it to real data results

Beam Tuning - Incident Angle

Angle in the XZ plane measured in the BIL chamber



Mean: 4.2 mrad
Sigma: 0.93 mrad



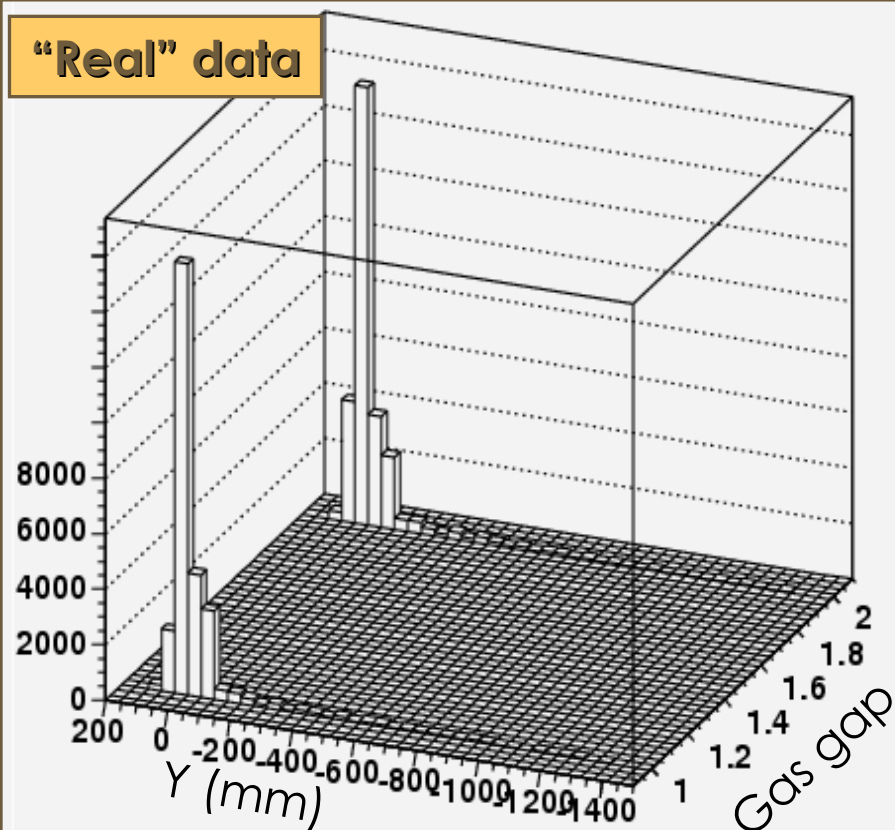
Mean: 4.3 mrad
Sigma: 0.97 mrad

The tail in real data is due to the magnet bending power

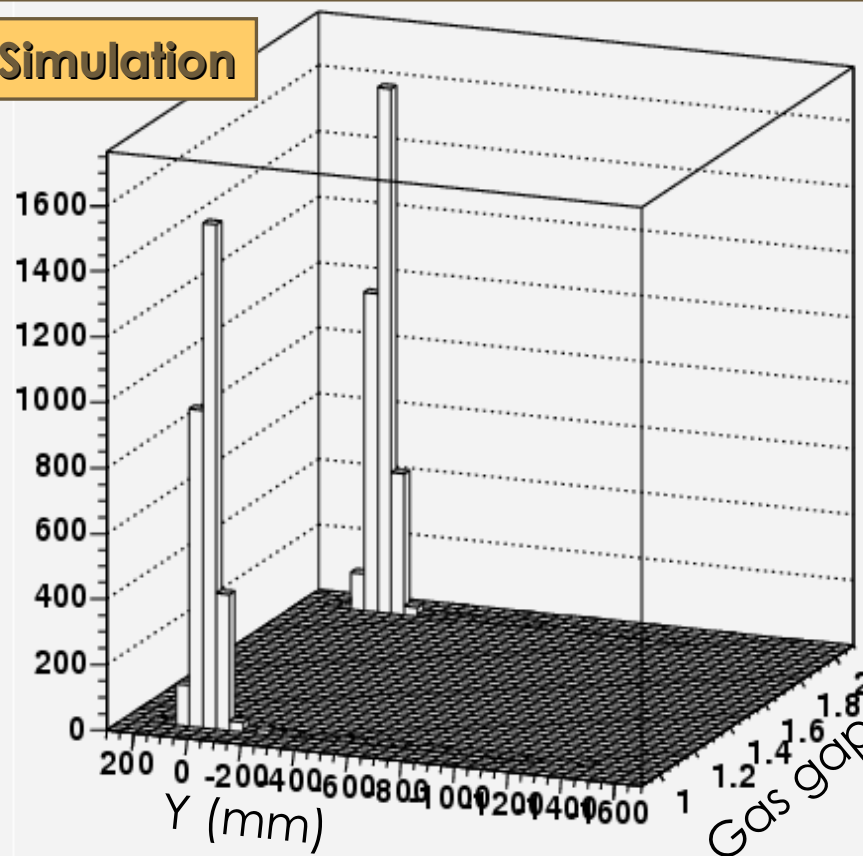
Beam Tuning - Y Coordinate

Beam profile on BML RPC phi strip (2 gas gaps visible)

"Real" data

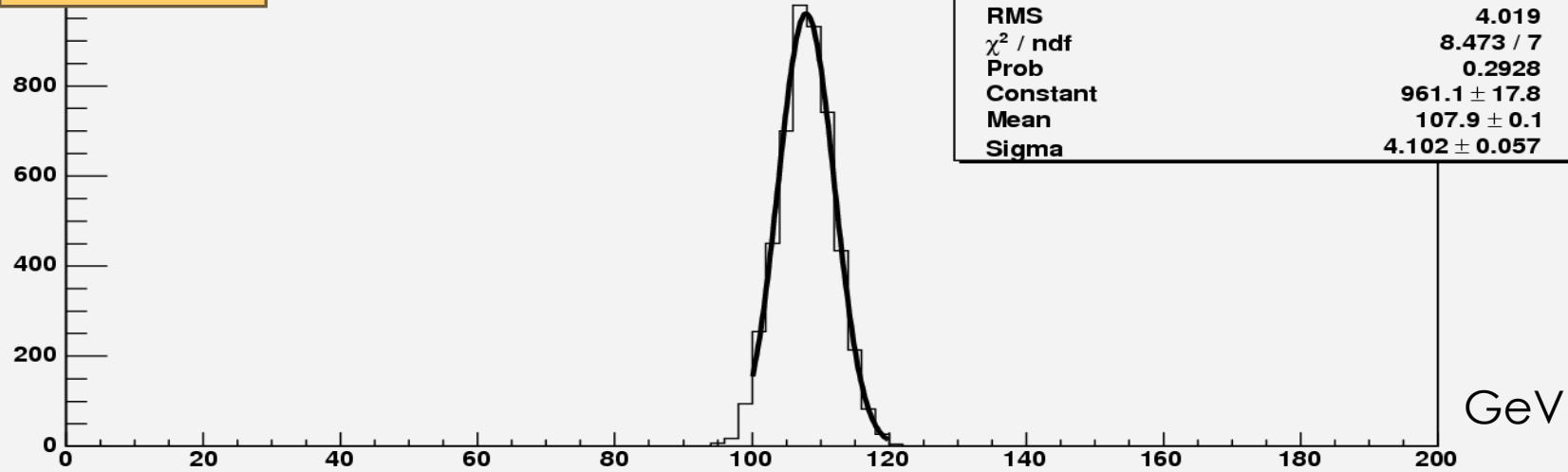


Simulation

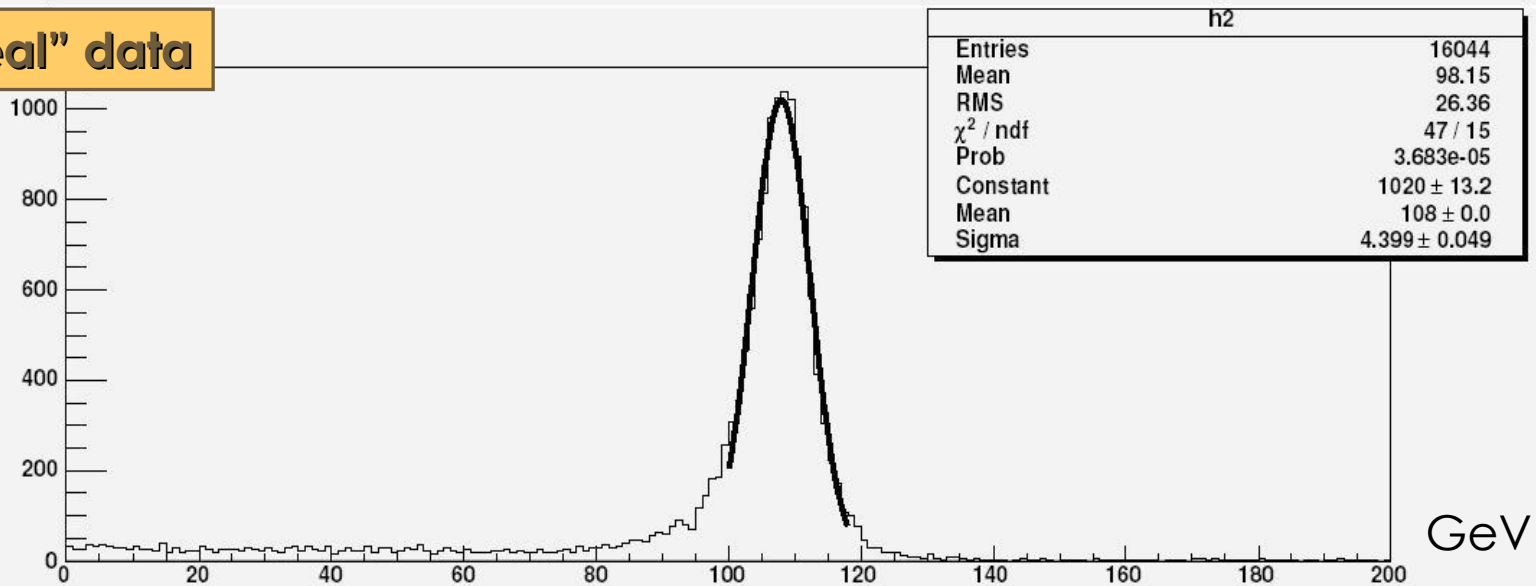


Beam Tuning - Beam Energy

Simulation

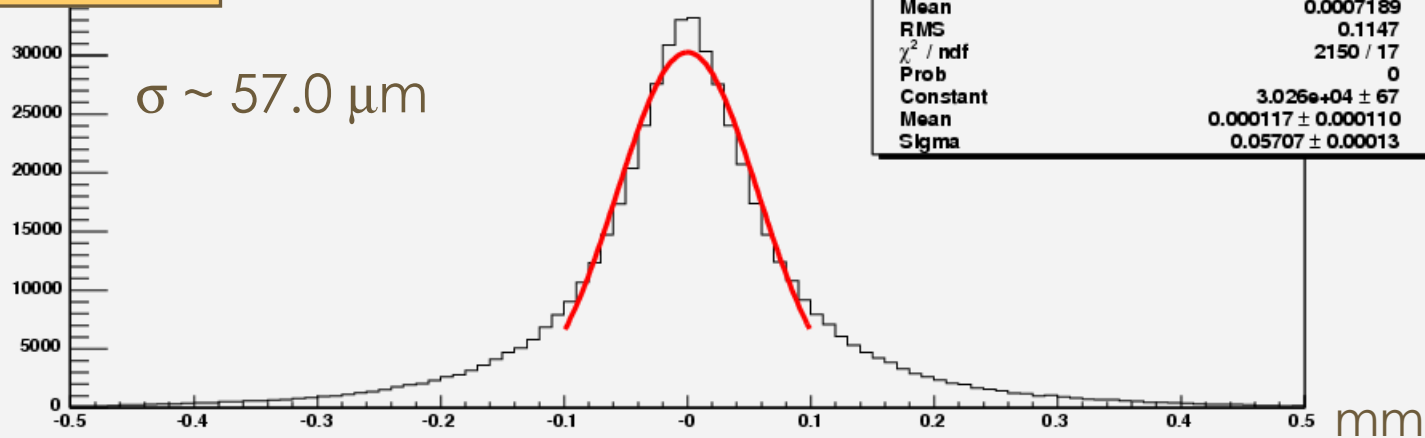


"Real" data

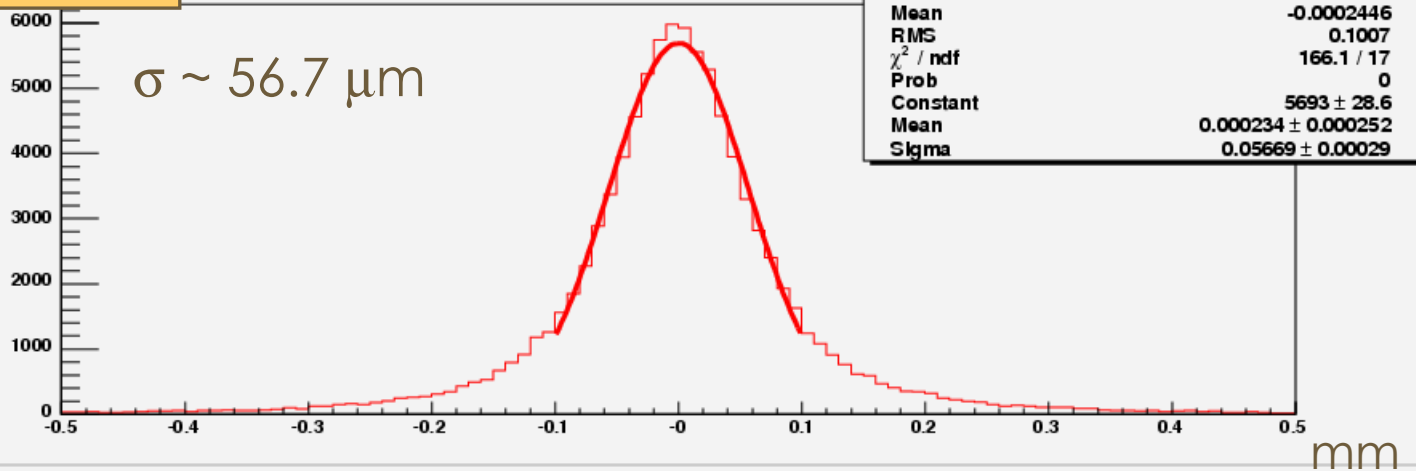


Just a check - Residuals

"Real" data



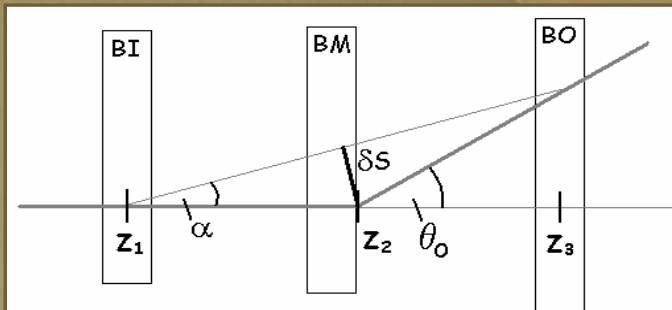
Simulation



Sagitta Evaluation



- Segments are fitted in each station
- Three superpoints are calculated
- Sagitta: distance of the BML superpoints from BIL/BOL straight line

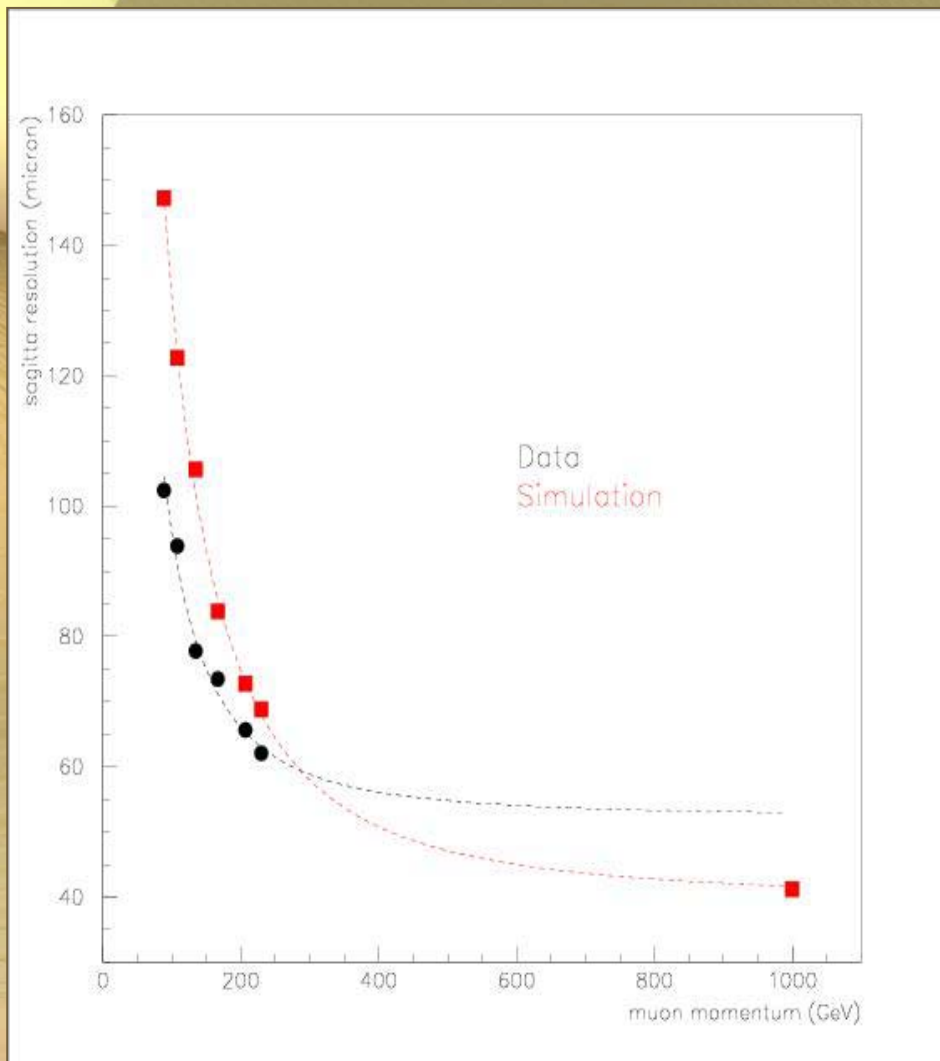


$$\sigma(S_{m.s.}) = \frac{(Z_2 - Z_1)(Z_3 - Z_2)}{(Z_3 - Z_1)} \tan \theta_0$$

$$\theta_0 = \frac{13.6 \text{ MeV}}{p} \sqrt{x/X_0} [1 + 0.0038 \ln(x/X_0)]$$

$$\sigma = \sqrt{P_1^2 + (P_2 / p)^2}$$

Initial problems...

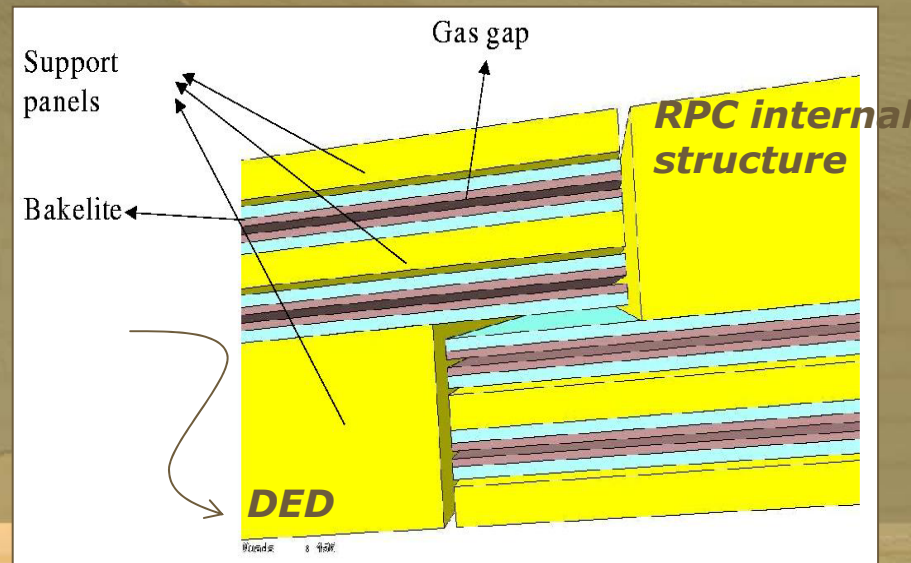


- From simulation fit
 $x/X_0 = 60\%$
- From real data
 $x/X_0 = 27\%$

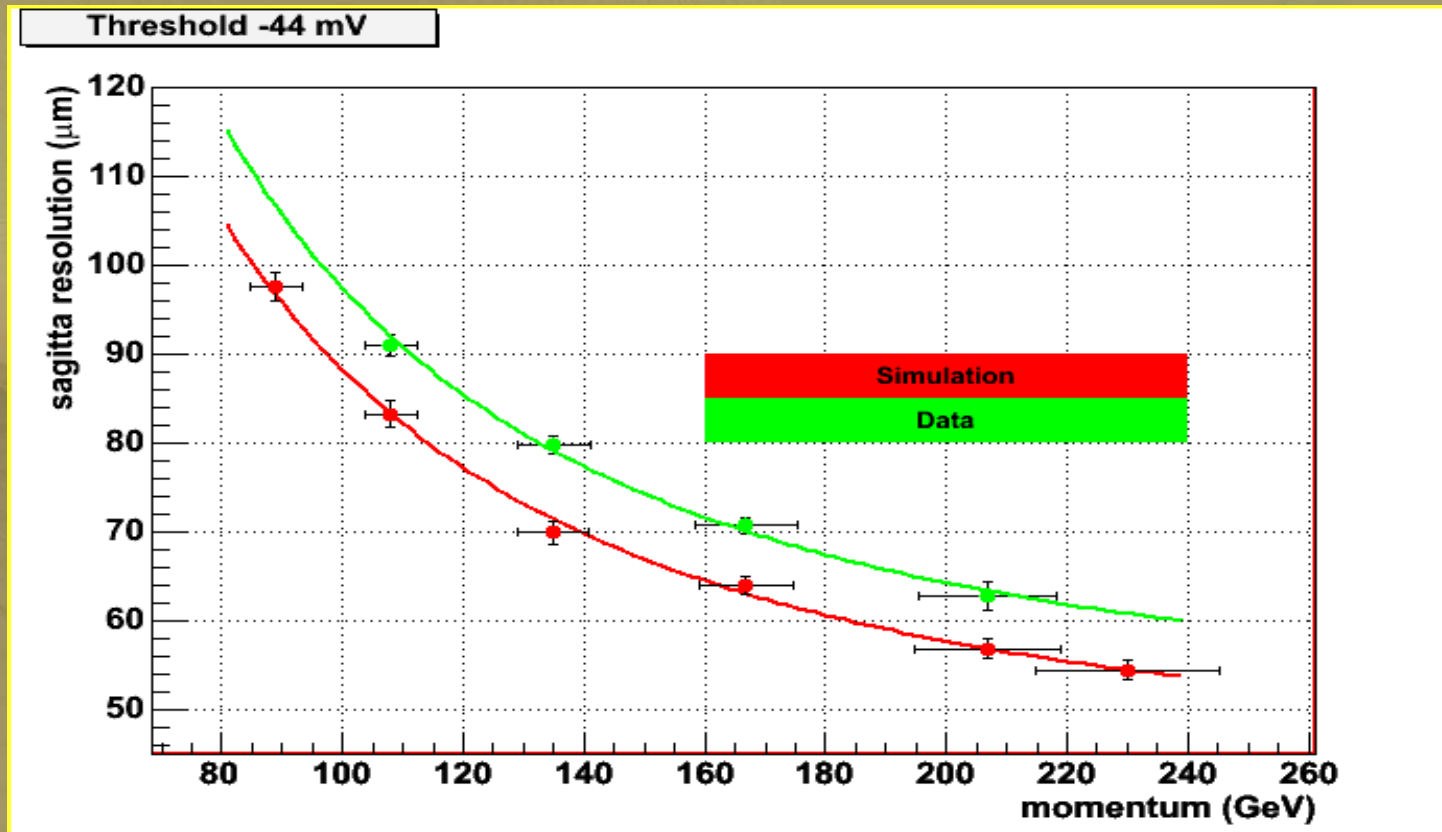
Additional 33% of material

...resolved

- The strategy was to remove all the materials and look at the impact on the sagitta width
 - Better results when removing RPVC
 - RPVC (density 1.2 g/cm^3) associated to the DED support ($\sim 5 \text{ cm}$ thick equivalent to $\sim 3 \text{ cm}$ of Al)
 - DED support actually made of "foam" (density 0.155 g/cm^3)
- Now material densities and description checked for all the muon system
- Problem fixed (thanks to Stefania Spagnolo) with correct material description
 - MuonGeoModel version MuonGeoModel-00-01-34



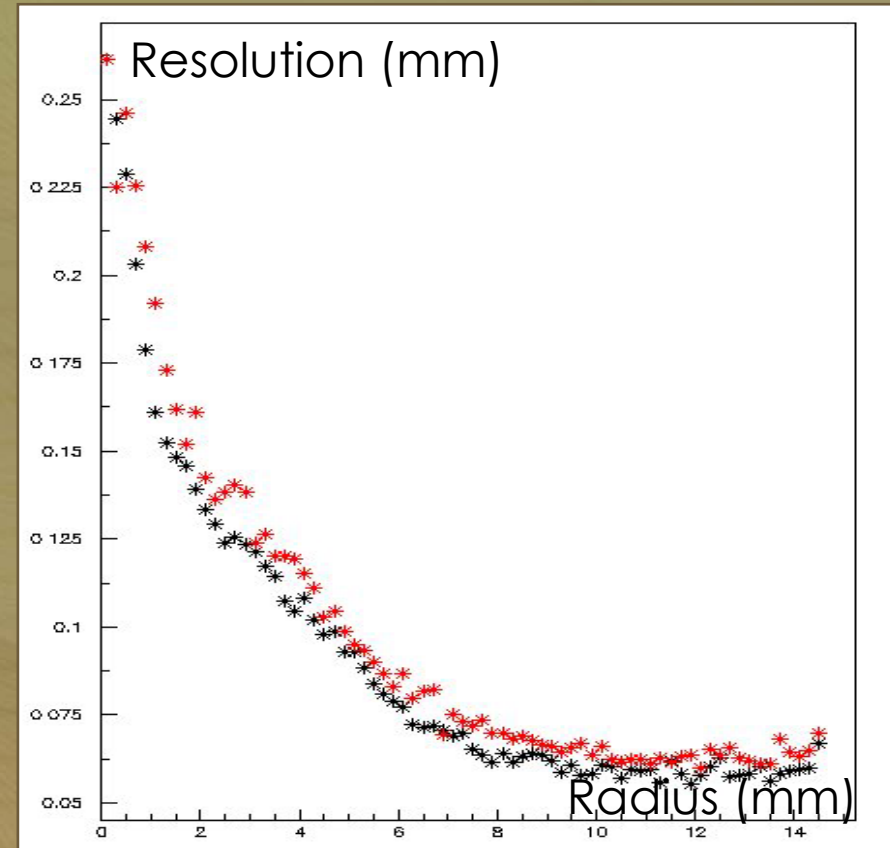
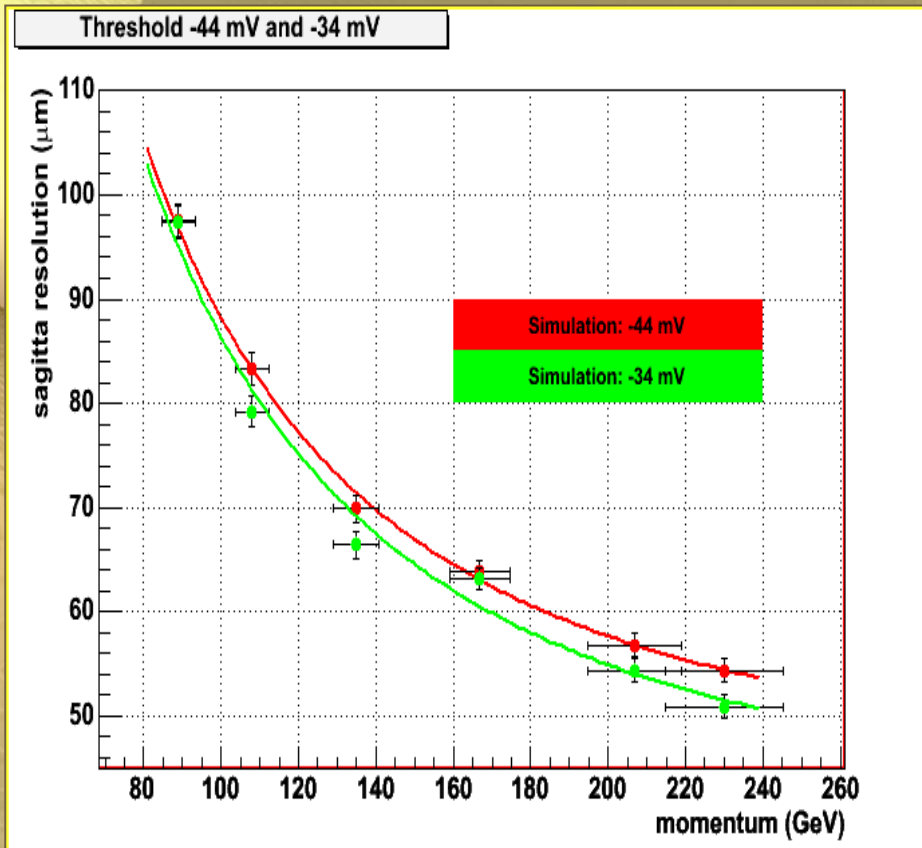
Sagitta Resolution: "RT_Relation_DigiTool"



SIMULATION
Intrinsic Res: $(42.9 \pm 2.3) \mu\text{m}$
 x/X_0 : $(29.8 \pm 2.5) \%$

DATA
Intrinsic Res: $(48.4 \pm 4.4) \mu\text{m}$
 x/X_0 : $(33.5 \pm 4.4) \%$

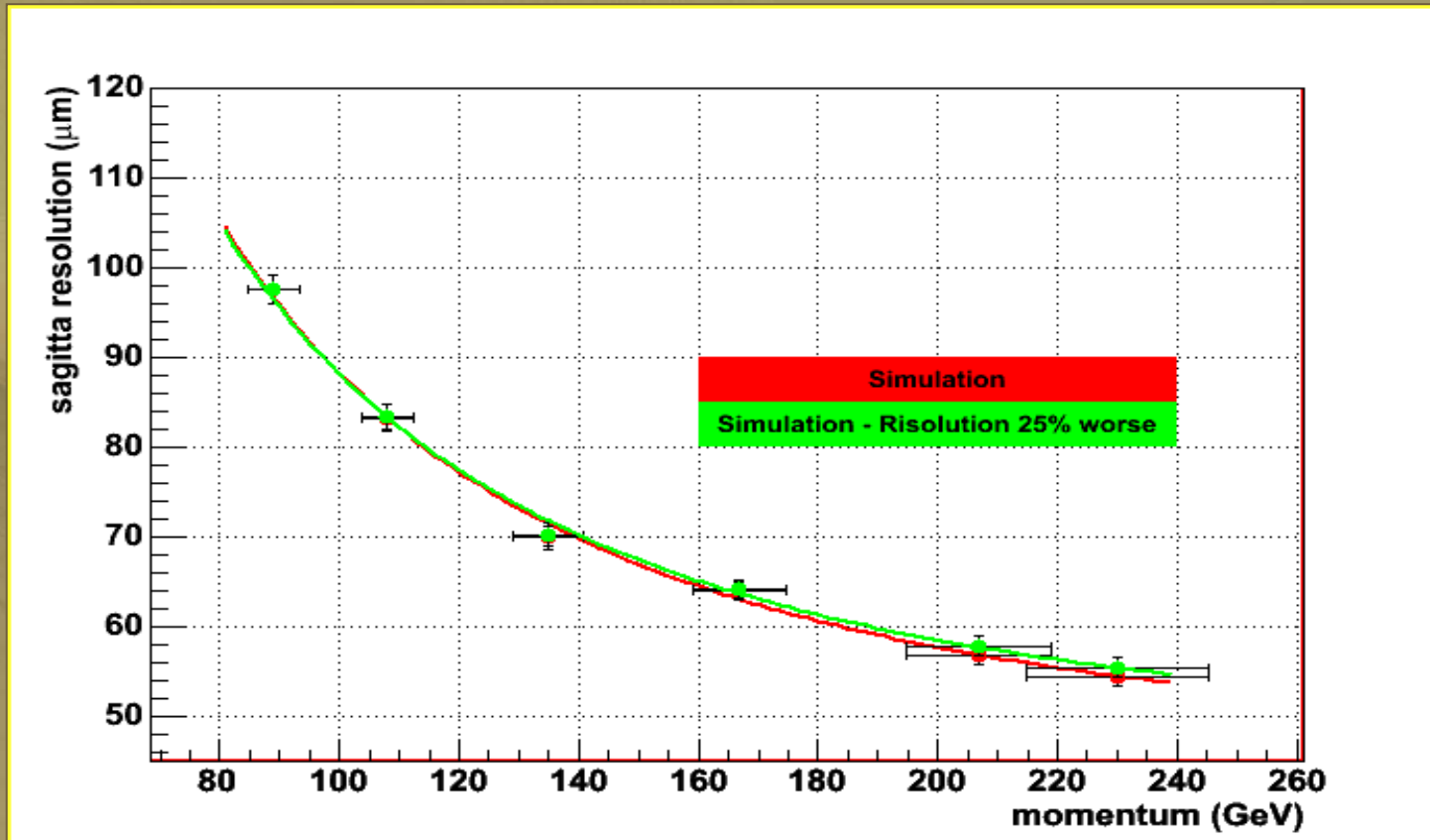
Sagitta Resolution: "RT_Relation_DigiTool"



SIMULATION -44 mV
Intrinsic Res: (42.9 +/- 2.3) μm
 x/X_0 : (29.7 +/- 2.5) %

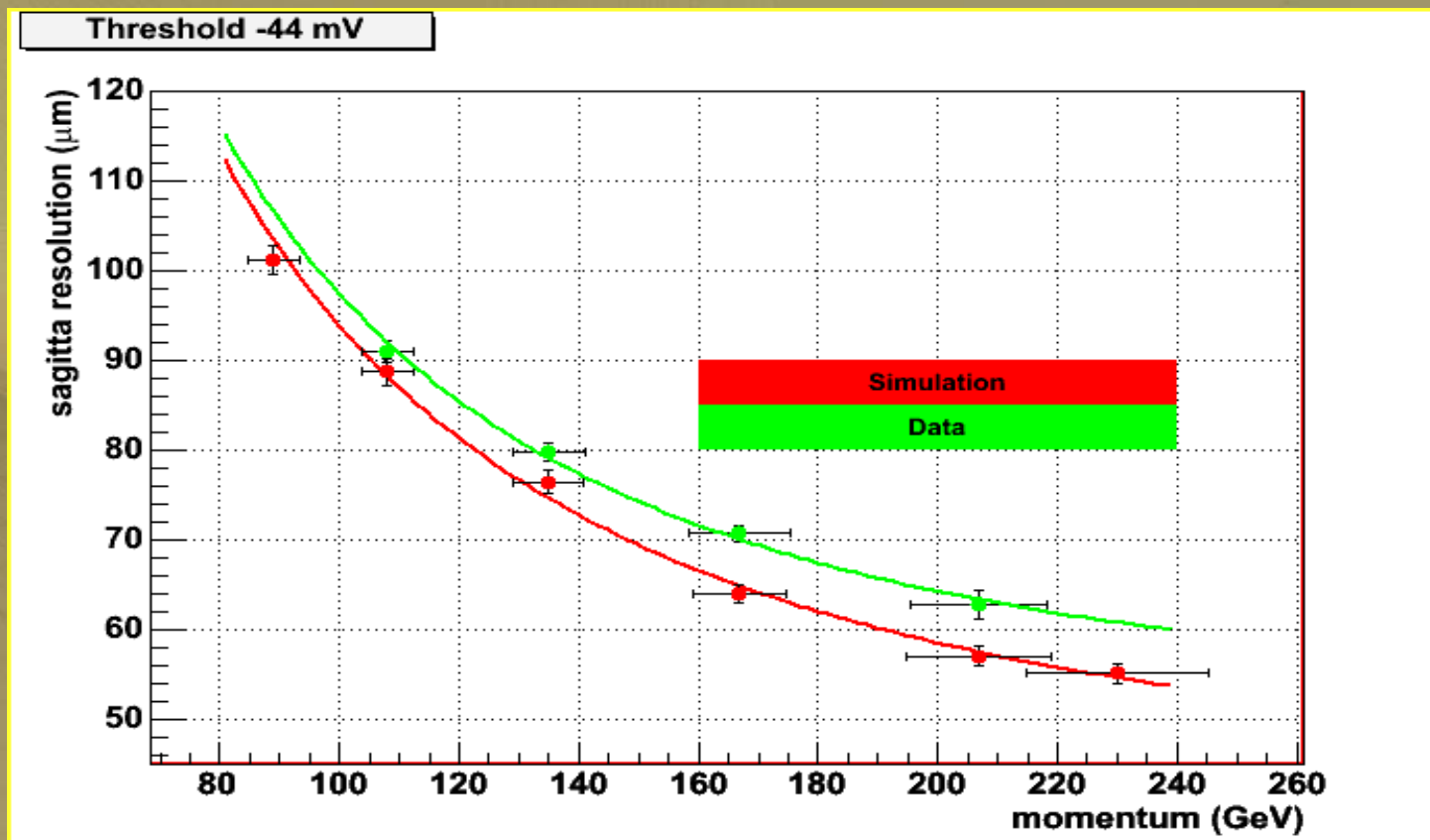
SIMULATION -34 mV
Intrinsic Res: (39.2 +/- 2.2) μm
 x/X_0 : (29.5 +/- 2.4) %

Sagitta Resolution: "RT_Relation_DigiTool"



Worsening by 25% the resolution **only in reconstruction** does not affect the sagitta resolution

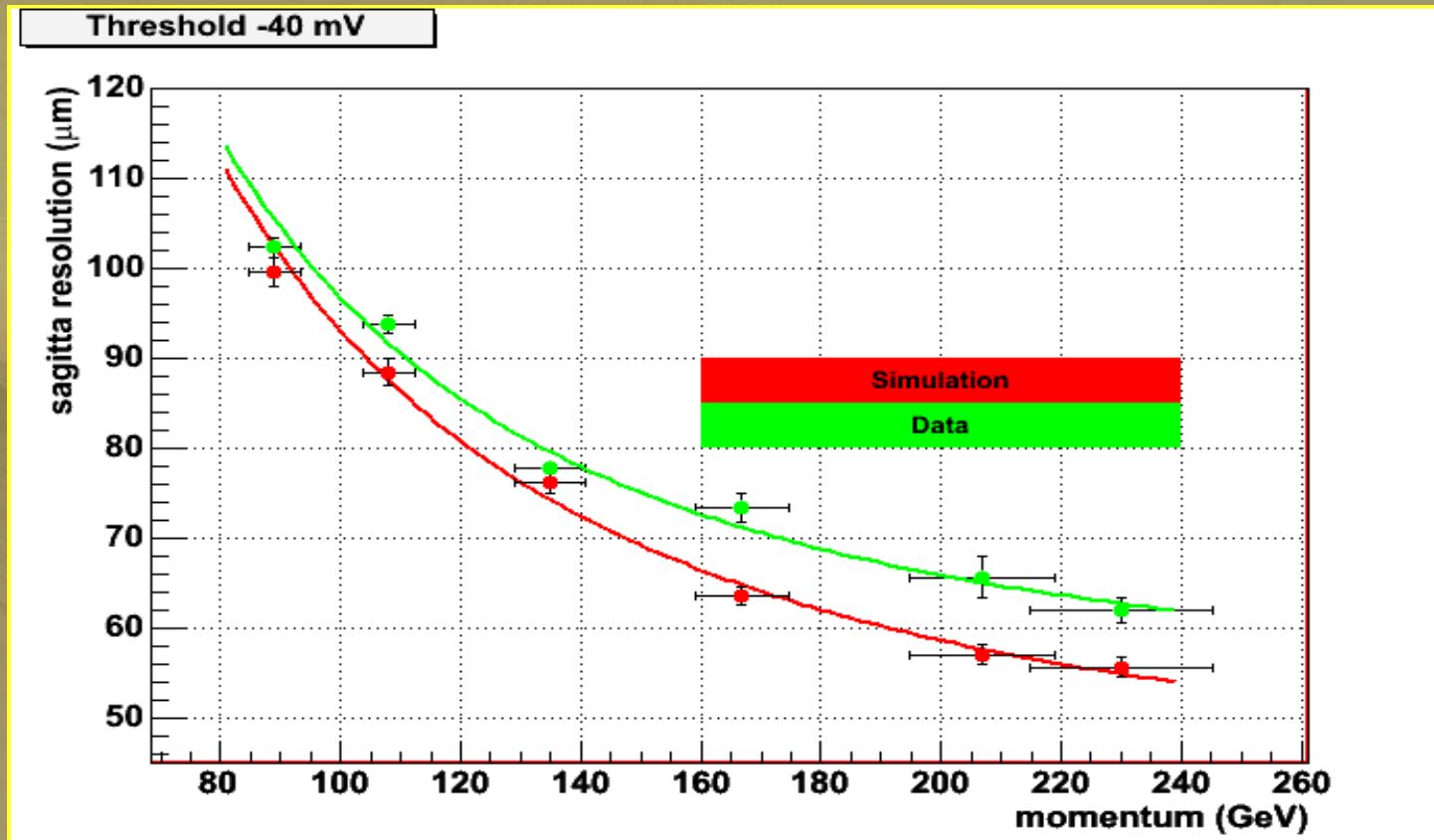
Sagitta Resolution: "MDT_Response_DigiTool"



SIMULATION
Intrinsic Res: (40.4 +/- 2.8) μm
x/X₀: (33.7 +/- 2.8) %

DATA
Intrinsic Res: (48.4 +/- 4.4) μm
x/X₀: (33.5 +/- 4.4) %

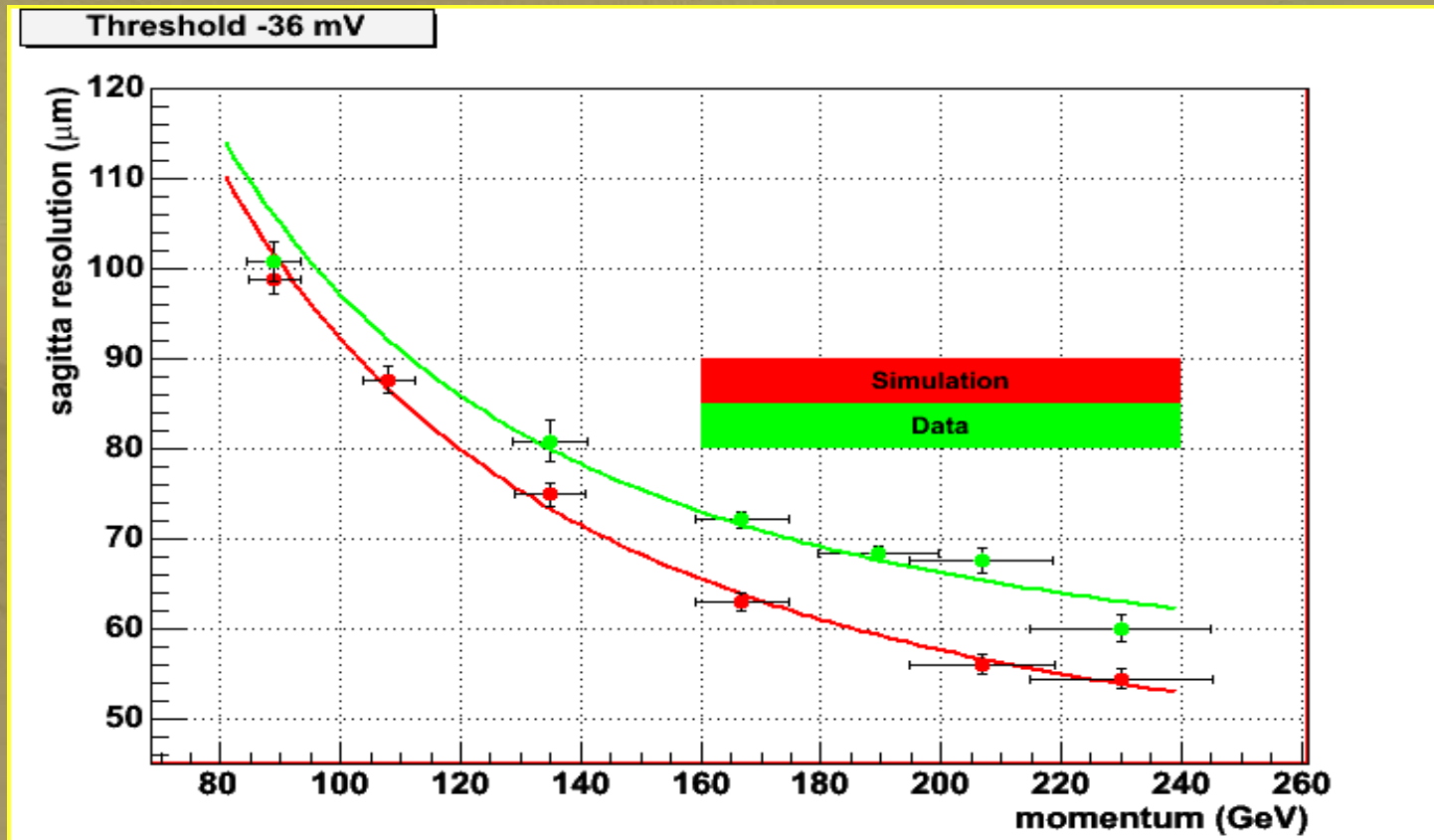
Sagitta Resolution: "MDT_Response_DigiTool"



SIMULATION
Intrinsic Res: $(41.2 \pm 2.7) \mu\text{m}$
 x/X_0 : $(32.6 \pm 2.7) \%$

DATA
Intrinsic Res: $(51.7 \pm 2.5) \mu\text{m}$
 x/X_0 : $(31.3 \pm 2.7) \%$

Sagitta Resolution: "MDT_Response_DigiTool"



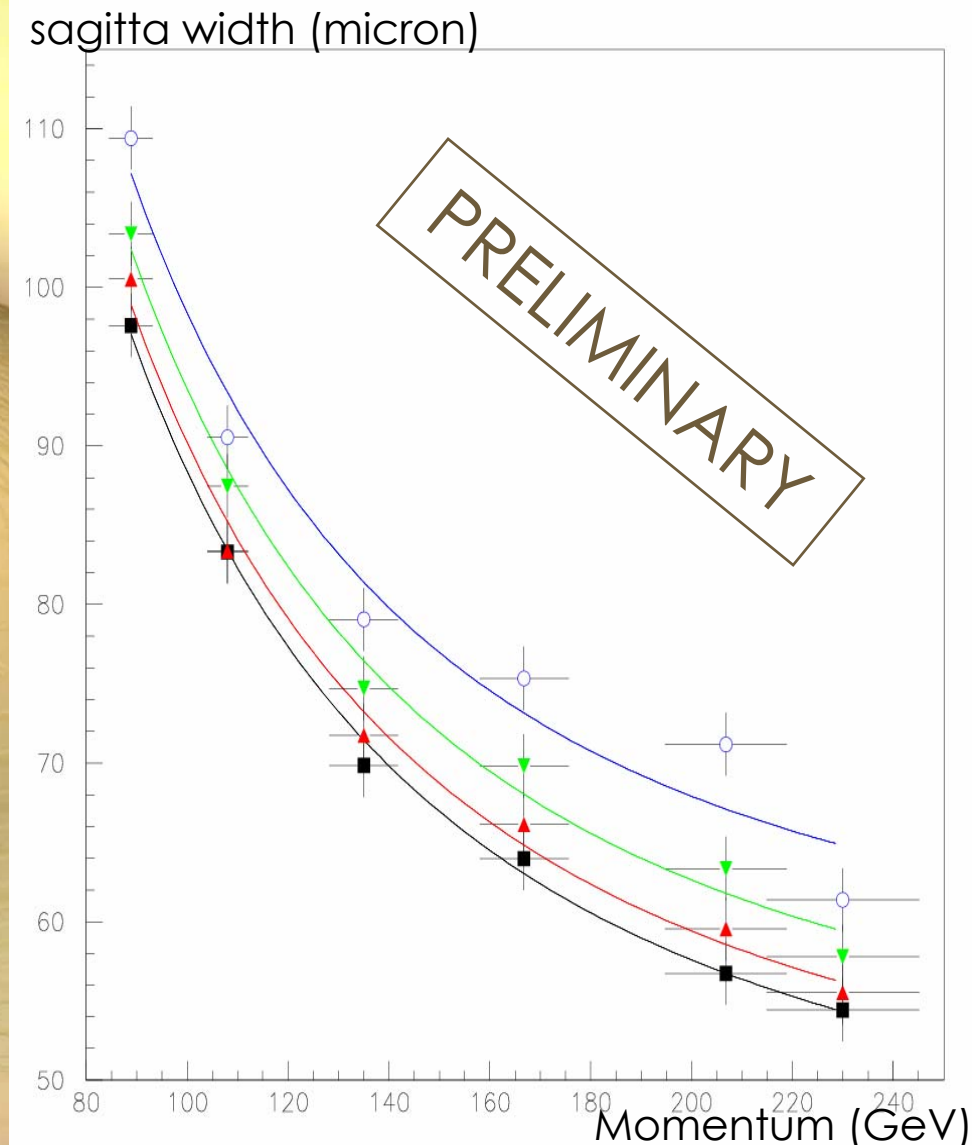
SIMULATION
Intrinsic Res: $(39.9 \pm 2.7) \mu\text{m}$
 x/X_0 : $(32.3 \pm 2.7) \%$

DATA
Intrinsic Res: $(51.9 \pm 2.8) \mu\text{m}$
 x/X_0 : $(31.6 \pm 4.1) \%$

Sagitta Resolution: Brief Summary

<i>Threshold</i>	<i>RT_Relation_DigiTool</i>	<i>MDT_Response_DigiTool</i>	<i>Data</i>	
<i>-44 mV</i>	<i>29.8 +/- 2.5</i>	<i>33.7 +/- 2.8</i>	<i>33.5 +/- 4.4</i>	<i>x/X₀ (%)</i>
	<i>42.9 +/- 2.3</i>	<i>40.4 +/- 2.8</i>	<i>48.4 +/- 4.4</i>	<i>Intr. Res. (μm)</i>
<i>-40 mV</i>	<i>-</i>	<i>32.6 +/- 2.7</i>	<i>31.3 +/- 2.7</i>	<i>x/X₀ (%)</i>
	<i>-</i>	<i>41.2 +/- 2.7</i>	<i>51.7 +/- 2.5</i>	<i>Intr. Res. (μm)</i>
<i>-36 mV</i>	<i>-</i>	<i>32.3 +/- 2.7</i>	<i>31.6 +/- 4.1</i>	<i>x/X₀ (%)</i>
	<i>-</i>	<i>39.9 +/- 2.7</i>	<i>51.9 +/- 2.8</i>	<i>Intr. Res. (μm)</i>
<i>-34 mV</i>	<i>29.7 +/- 2.4</i>	<i>-</i>	<i>-</i>	<i>x/X₀ (%)</i>
	<i>39.2 +/- 2.4</i>	<i>-</i>	<i>-</i>	<i>Intr. Res. (μm)</i>

Exercise - Tube T0 shift



The impact of wrong T0 values on sagitta resolution has been evaluated smearing the tube T0 in a gaussian way with mean value equal to zero and width equal to 1, 2 and 3 ns

$\sigma(\text{T0 smear})$
(ns)

Intr. Res.
(micron)

0

42.6 +/- 2.0

1

44.6 +/- 2.1

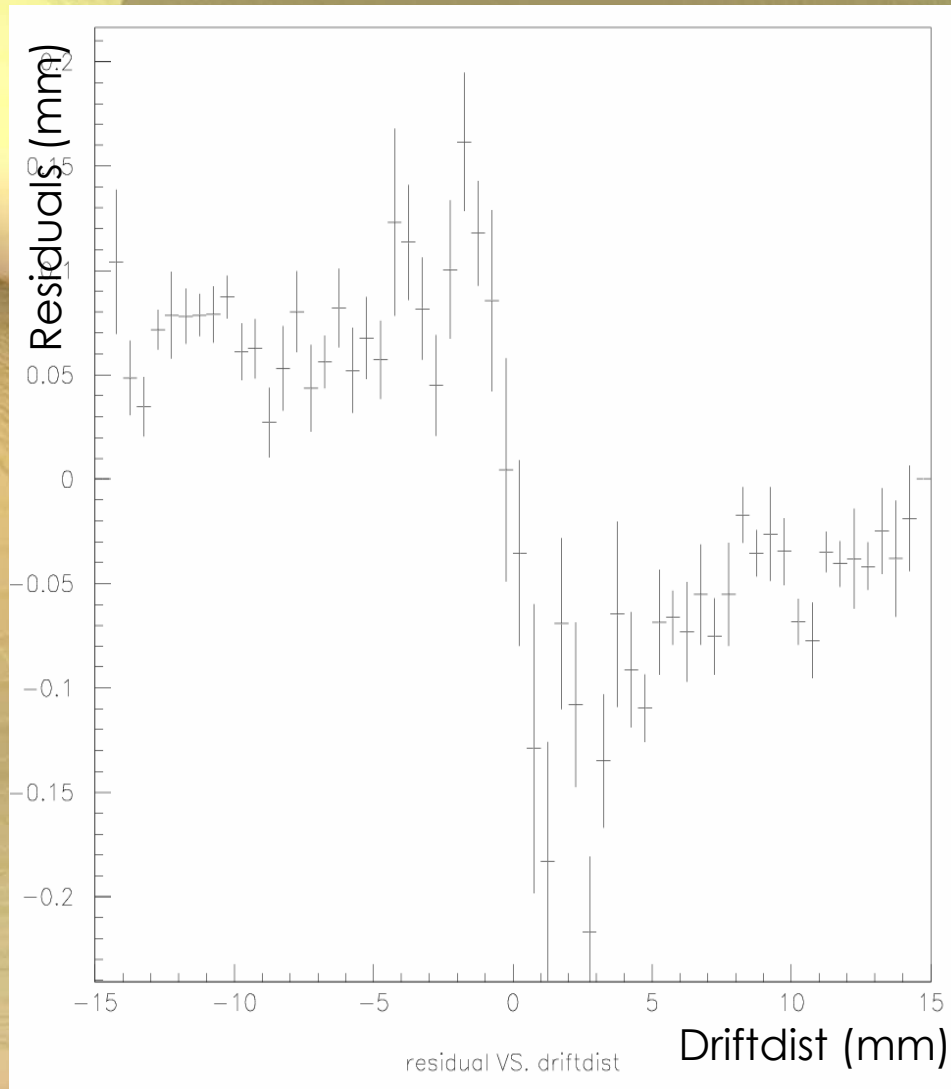
2

48.0 +/- 2.1

3

54.0 +/- 1.9

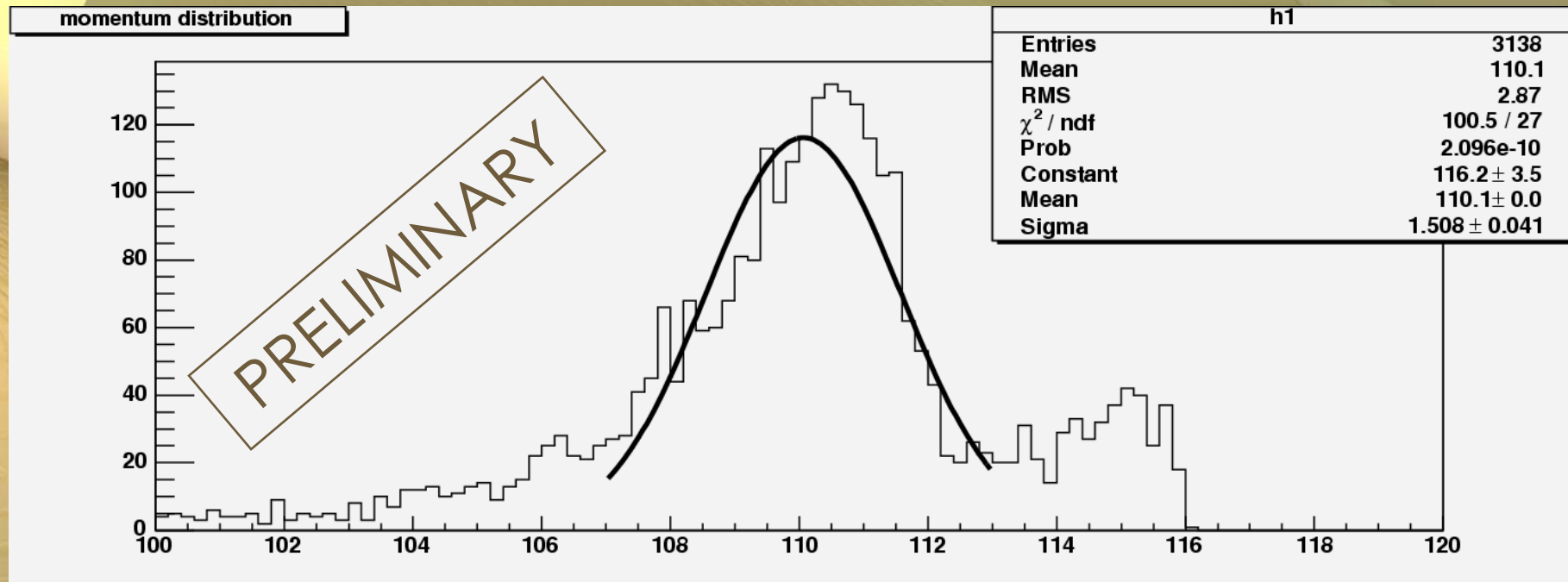
Exercise - Tube T0 shift



A 3 ns smearing clearly has an impact on tube residuals

Exercise - Energy Loss in All the Detectors

Muon energy at muon spectrometer entrance for a 120 GeV muon



- Very preliminary result
 - The material distribution of all the detectors should be checked
 - Strange peak at high momentum
 - Expected energy loss: 12 GeV corresponding to ≈ 6.5 m of iron (beam dump + tile + liquid argon)

Conclusions & Plans

- Conclusions
 - Comparison with TB data is useful in spotting, understanding and resolving simulation-related problems
 - Sagitta “puzzle” well understood and fixed
 - Correct muon spectrometer material description
- Plans
 - Implementation of noise for efficiency studies
 - Hodoscope runs for signal wire propagation
 - Simulation/data comparison with combined set-up
 - Misalignment studies
- ATLAS note in preparation
- Ntuples available in common scratch area
 - [/afs/cern.ch/atlas/testbeam/muontbh8/scratch09/CTB_G4Sim/recntuples](https://afs.cern.ch/atlas/testbeam/muontbh8/scratch09/CTB_G4Sim/recntuples)