Studies on MS Performance with 2009 Cosmics Data

Several people involved:

Igor: See yesterday presentation

Ahmimed, Eve, Niels, Peter, Egge: two presentations in this meting

Fabio: this talk

MRATF publication on 2008-2009

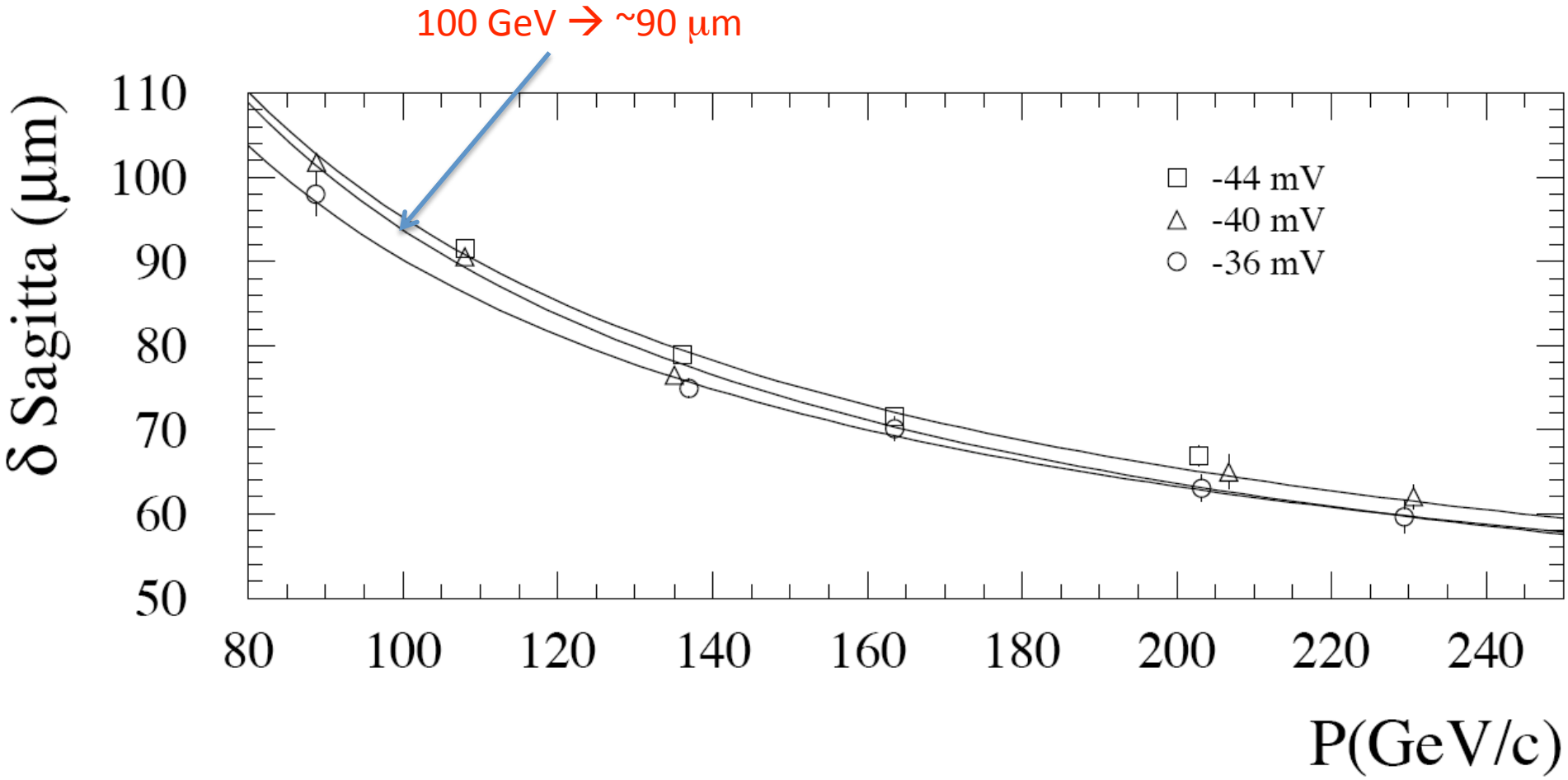
- Draft 1 of the paper attached to the agenda: it contains many performance studies based on cosmic data analysis
- http://agenda.infn.it/getFile.py/access?contribId=0&resId=0&materialId=paper&confId=1821

Outline

- Introduction on Sagitta and Momentum Resolution for BARREL
  - Alignment Expectations: sagitta mean values
  - "Expected" Sagitta and P resolution
- Sagitta studieds on Cosmics
  - Sagitta resolution vs P(ID)
- Momentum Studies on Cosmic
  - Uses ID as reference
- Conclusions

Introduction: Sagitta Resolution

- Sagitta Resolution contributions from 2 terms
  - $\sigma s(P) = K0/P \oplus K1$
  - K0 Multiple Scattering ~ L/4 x 13.6(MeV) √(x/X0)
  - K1 Intrinsic resolution:
    - [tube-resol.+alignment+calibration+ cham-geometry…] ~ 60um
  - Does NOT depend on B-field and Energy-Loss before MS
    - → Study part of P MS resolution contribution



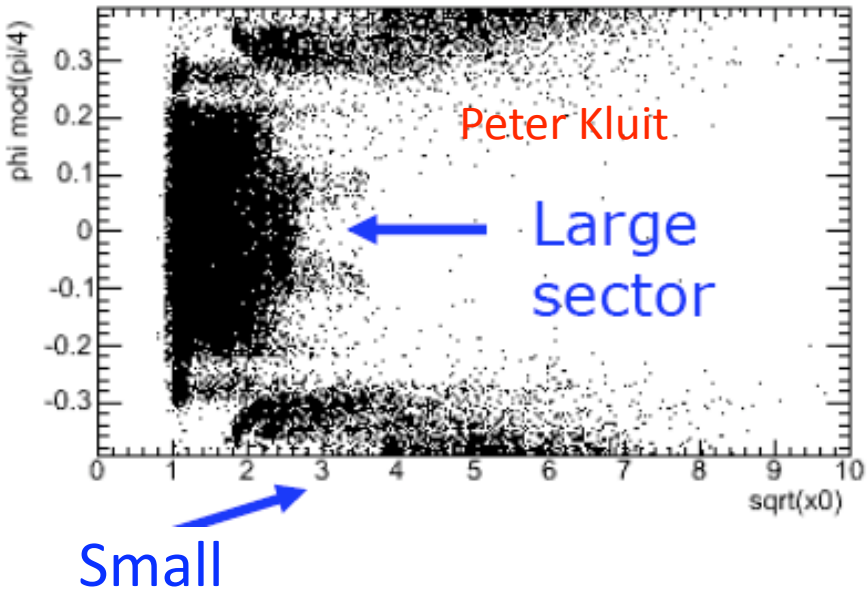
Published on NIM A: Measured in H8 Large Sector (only BML material)

K0 = 9 mm x GeV → √x/X0 ~ 0.5

K1 = 50 μm (Perfect alignment + very limited region)

What do we expect in ATLAS: Barrel ?

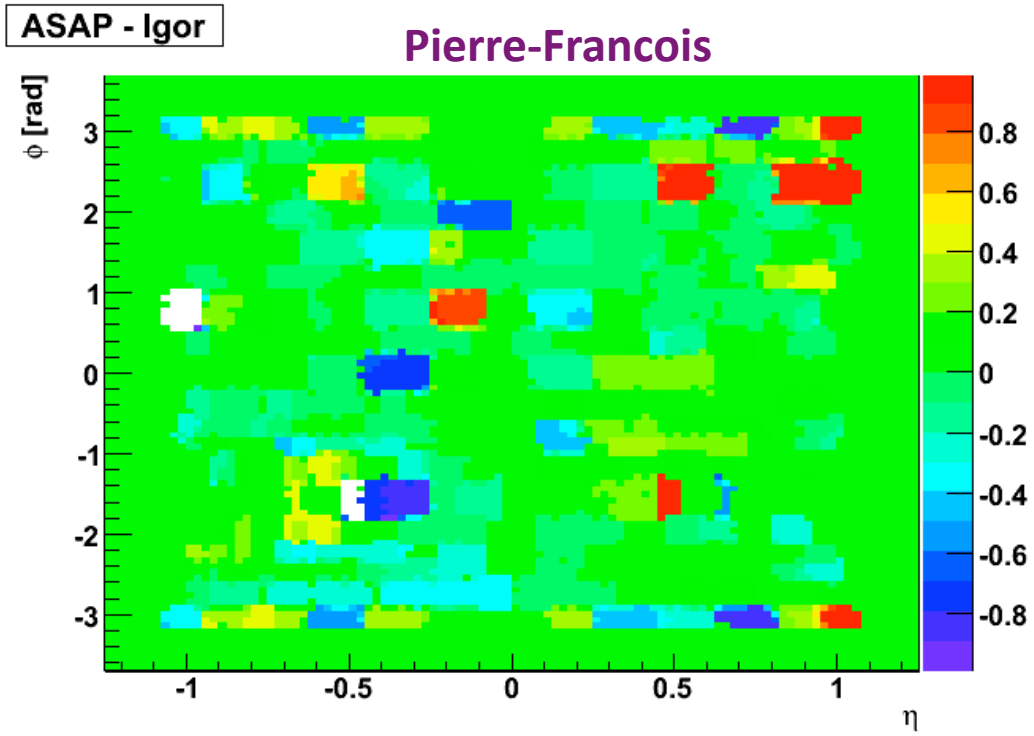
- K0 Multiple Scattering much larger in Small Sectors:
  - Small sectors:
    - √(x/X0) ~1.5 → Small
    - L ~ 6.0 m → Small
  - Large Sectors
    - √(x/X0) ~0.7 → Large
    - L ~ 4.5 m → Large
  - $K0_{Large}$ ~ 11 mm x GeV
  - $K0_{Small}$ ~ 28 mm x GeV

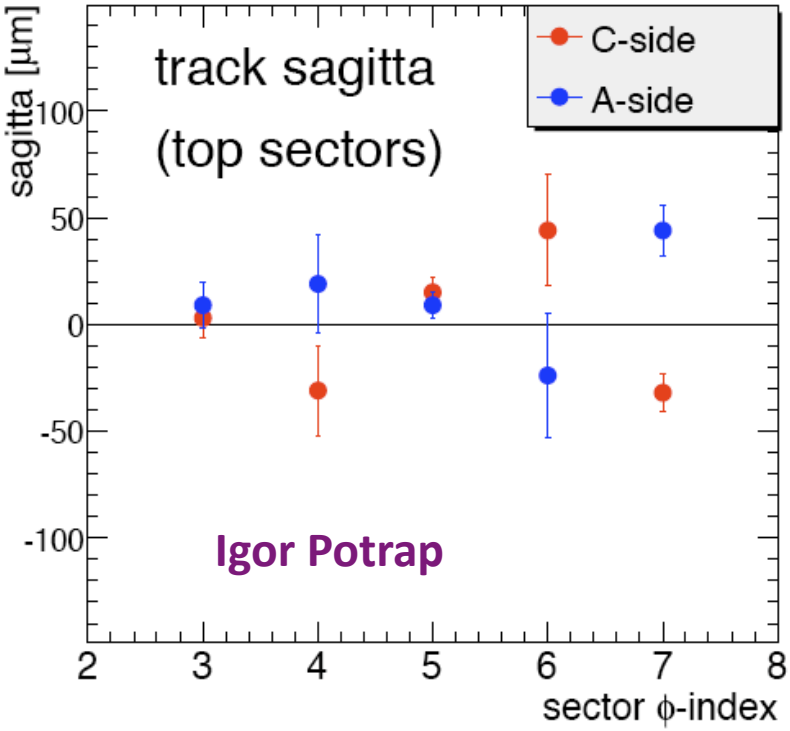


- K1 cosmics dominated by alignment + calibrations + … ?
  - Use recent run 121737 (July) to measure it

Expected Alignment Performance

Alignment based on straight tracks from Run 113860 + Optical in Relative Mode





Optical Relative corrections for run 121737 (both runs have B-field OFF) ~0.3-1 mm

Igor Checks on Run 121737
On average <sag> for sectors 3→7 and 11→15
Single towers ~ 50-250um

Sagitta Resolution: Method description

- Use run 121737 - Toroid=OFF + Solenoid=ON:
  - Pμ measured by ID
  - Alignment from Tracks (run) + optic-relative mode
  - Measure sagitta resolution for I-M-O segments measured in MS vs Pμ and fit for K0 and K1

Sagitta run 121737: MS segments

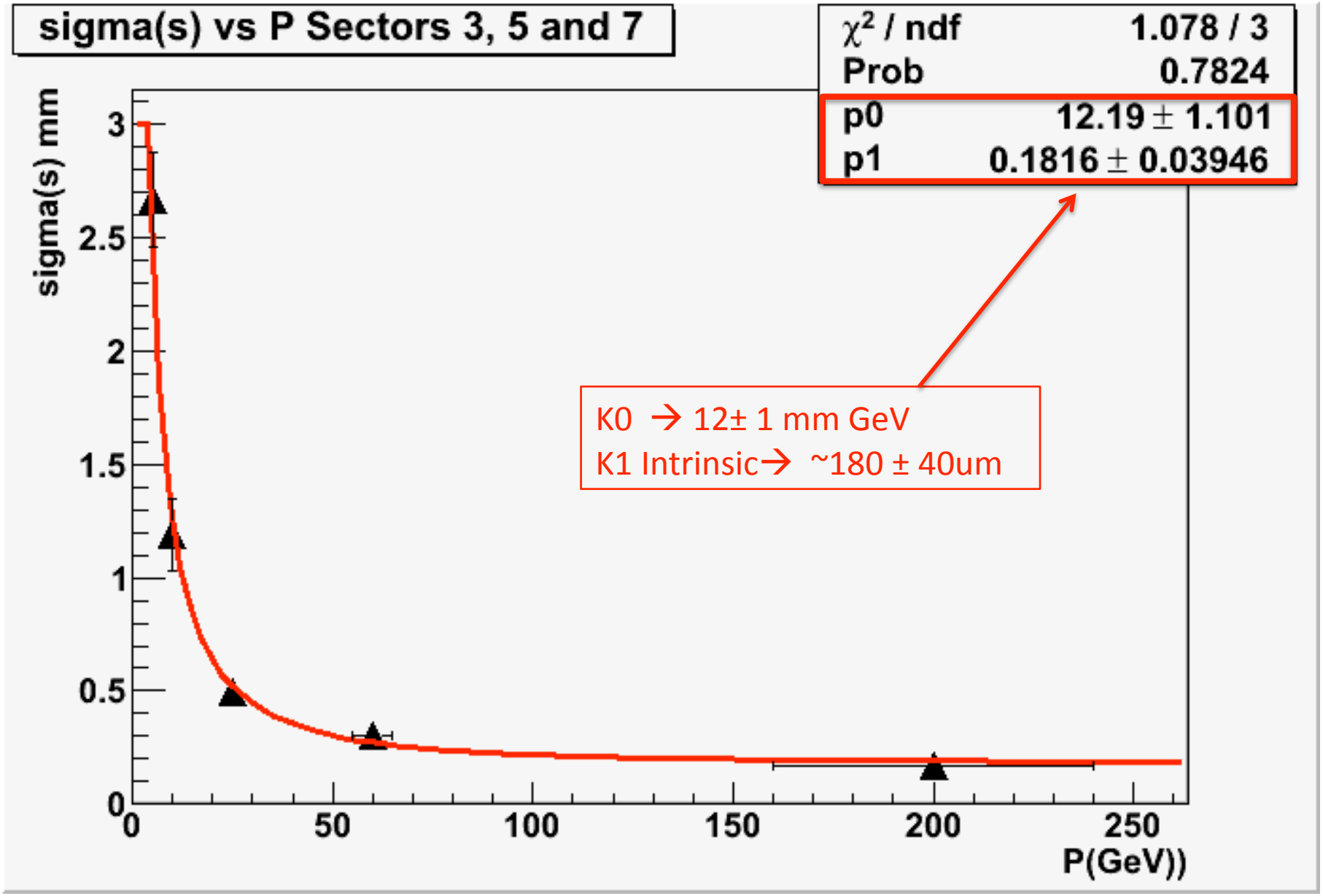
- Used calibration ntuples
  - Re-processed by Kevin with new Constants from Tracks(113860)+OpticalRelative
- Select segments from MOORE: quality cuts have impact on results !:
  - N-MDT hits ≥ 5 (BM, BO)
  - N-MDT hits ≥ 7 (BI)
  - N-RPC hits ≥ 3
  - Chi-2 < 1.
  - ==1 Segment same sector in I, M and O (Top Sectors)

  Processed ~3.3 M events RPCwBeam Stream

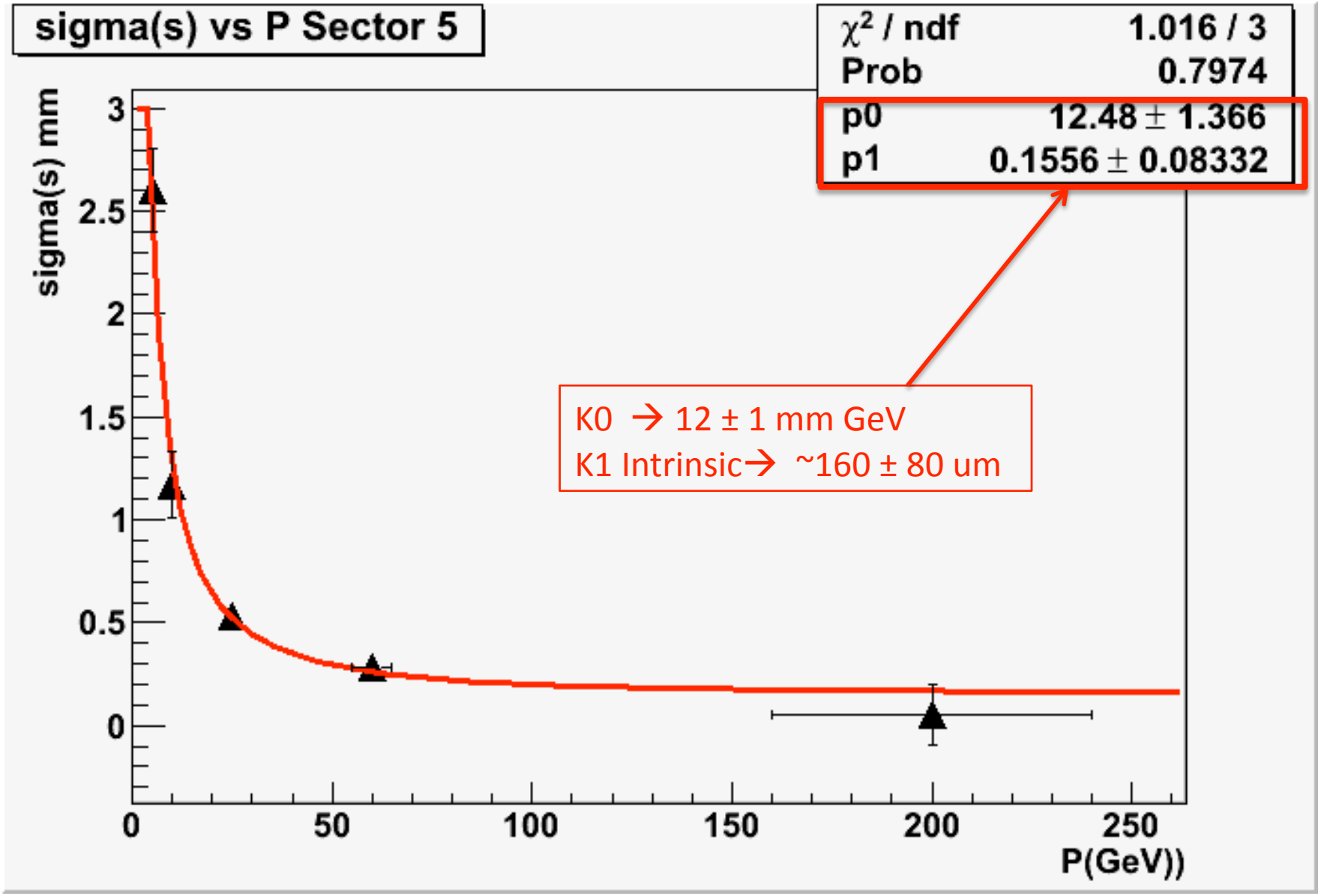
Sagittas run 121737

- Select Inner Detector Tracks (loose quality)
  - |d0|< 1000 mm
  - |z0|< 1000 mm
  - Chi-2/ndf < 5.
  - N-hits>100
  - P_μ = [P(ID)+ 3 GeV] to take into account E-loss
- 3.3M events Left → 1000 muons
- Make 5 bins in P: Bin Center → <P>
- Fit sagitta resolution (single Gaussian fit OK) in each P bin

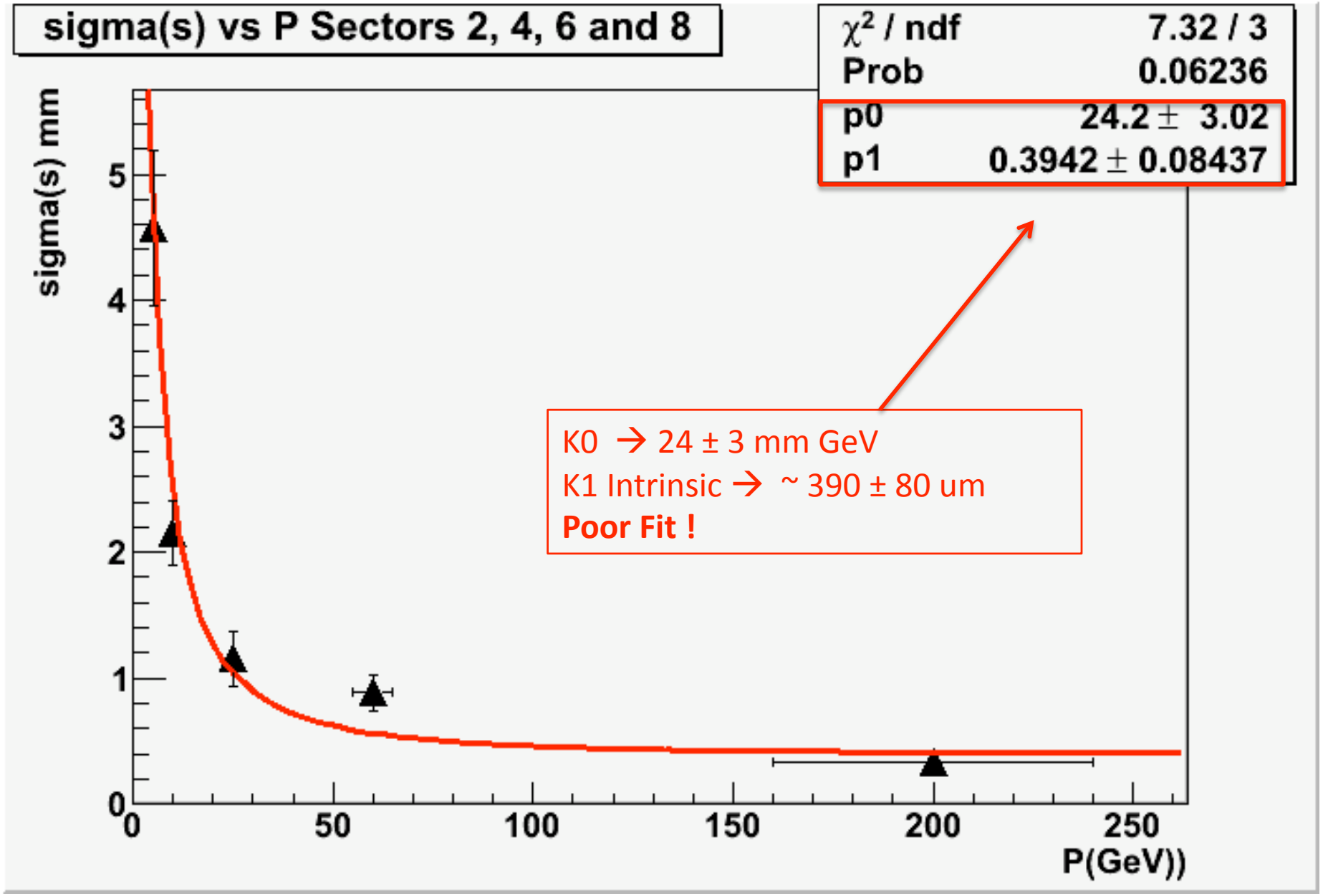
Large Sector: 3, 5 and 7



Large Sector: 5 ONLY



Small Sectors: 2, 4, 6 and 8



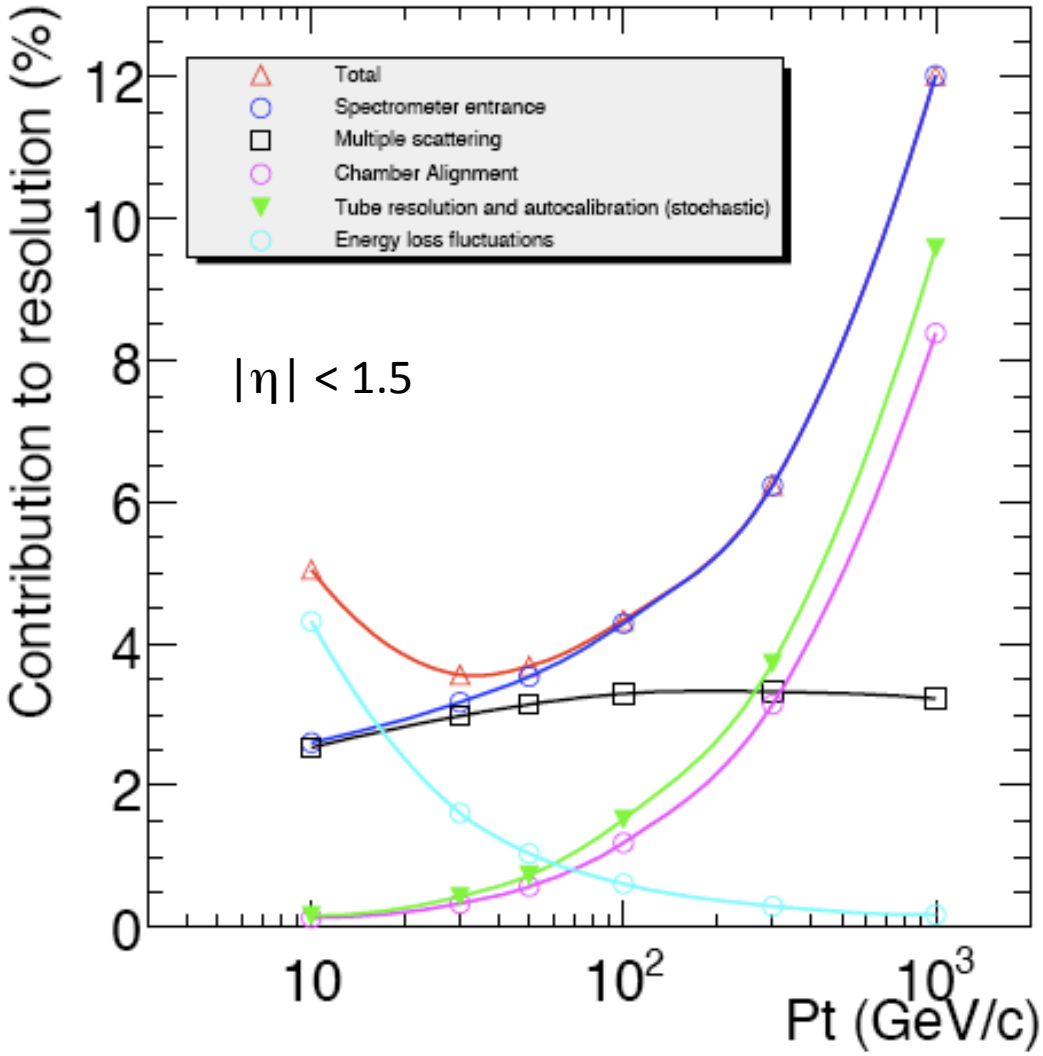
Conclusions on sagitta resolution

- Multiple Scattering term look reasonable
- Intrinsic term at the level of 150-300 μm
  - Best sector5: ~100-150 um
- On COSMICS: quality requirement on segments very important (correct t0-refit, outliers,..): intrinsic term going down from 250 to 150 um just changing cut on segment χ^2
- Waiting for FINAL reprocessing of run 121737 with better calibration to converge on a single number

Momentum scale and resolution

- Method:
  - Run 121080 Toroid=ON + Solenoid=ON
  - Pt(μ) measured by ID as reference
  - Plot the relative difference [Pt(MS)-Pt(ID)]/Pt(ID)
  - Study MS Pt-resolution vs Pt after subtracting expected ID resolution

Expected in ATLAS: From CSC notes



10 GeV 5% → E- Loss fluctiations
100 GeV 4% → Mul. Scatt.
1 TeV 12% → σ(s) ~ 60um

Crude Parameterization:

Res. = P_0 Pt + P_1 + P_2/Pt
Intr. MS E-loss

E-Loss ~ 0.450 GeV
MS ~ 3.5%
Intrinsic Sagitta ~ 60um

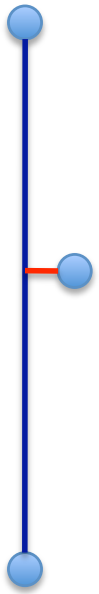
P resolution: Naïve estimate 1

$$P_t(GeV) \approx \frac{\int BdL(Tm) \times L(m) \times 0.3}{8 \times s(m)}$$

$$\frac{\sigma(P_t)}{P_t} = \sigma(s) \times \frac{8 \times P_t}{\int BdL(Tm) \times L(m) \times 0.3} \oplus \frac{\sigma(E - Loss)}{P_t}$$

$$\sigma(s) = \sigma(s)_{MS} \oplus \sigma(s)_{Intrinsic}$$

$$\sigma(s)_{MS} \sim \frac{L \times 0.0136}{2 \times P(GeV)} \times \sqrt{\frac{x}{X0}}$$



$$\frac{\sigma(P_t)}{P_t} = \left[\sigma(s)_{Intrinsic} \times \frac{8 \times P_t}{\int BdL(Tm) \times L(m) \times 0.3}\right] \oplus \left[\frac{0.0136}{2} \times \sqrt{\frac{x}{X0}} \times \frac{8}{\left(\int BdL(Tm)\right) \times 0.3}\right] \oplus \left[\frac{\sigma(E - Loss)}{P_t}\right]$$

$$\frac{\sigma(P_t)}{P_t} = P_0 \times P_t \oplus P_1 \oplus \frac{P_2}{P_t}$$

To simplify assumed Barrel $P_t \sim P$
Error on **B** neglected (<1% ?)

P resolution: Naïve estimate 2

$$\frac{\sigma(P_t)}{P_t} = \left[\sigma(s)_{Intrinsic} \times \frac{8 \times P_t}{\int BdL(Tm) \times L(m) \times 0.3}\right] \oplus \left[\frac{0.0136}{4} \times \sqrt{\frac{x}{X0}} \times \frac{8}{\left(\int BdL(Tm)\right) \times 0.3}\right] \oplus \left[\frac{\sigma(E-Loss)}{P_t}\right]$$

$$\frac{\sigma(P_t)}{P_t} = P_0 \times P_t \oplus P_1 \oplus \frac{P_2}{P_t}$$

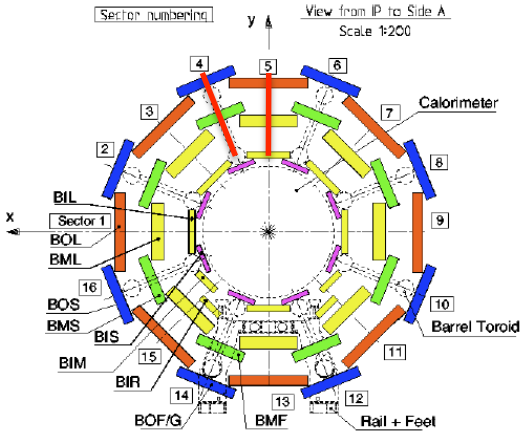
Very simplified Example :

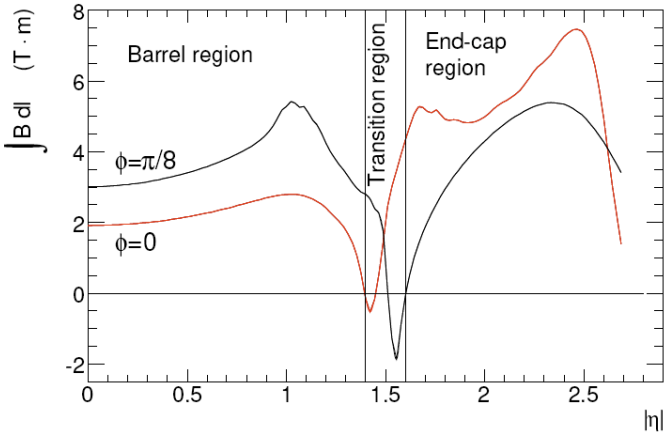
$L - Sectors \rightarrow L \sim 4.5m \qquad \int BdL(Tm) \times L \sim 2.0 \qquad \sqrt{\frac{x}{X0}} \sim 0.7$

$s - Sectors \rightarrow L \sim 6.0m \qquad \int BdL(Tm) \times L \sim 3.5 \qquad \sqrt{\frac{x}{X0}} \sim 1.6$

$L - Sectors \rightarrow P_0 \sim 0.000180 \rightarrow 18\%@1TeV \qquad MS \rightarrow P_1 \sim 3.2\%$

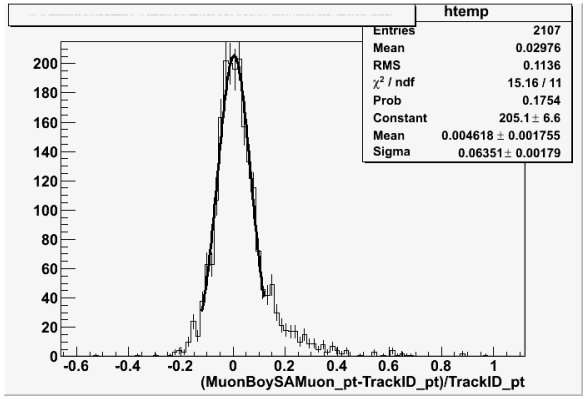
$s - Sectors \rightarrow P_0 \sim 0.000076 \rightarrow 7.6\%@1TeV \qquad MS \rightarrow P_1 \sim 4.1\%$

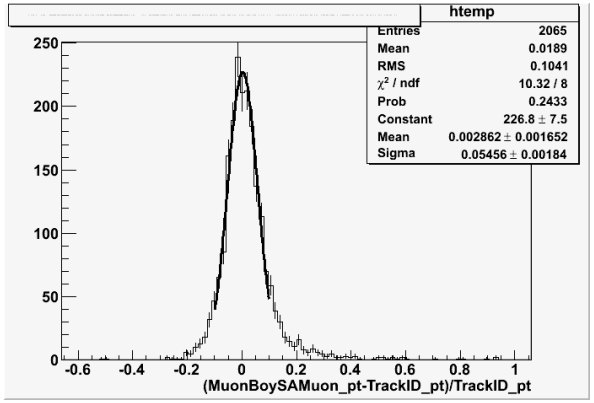


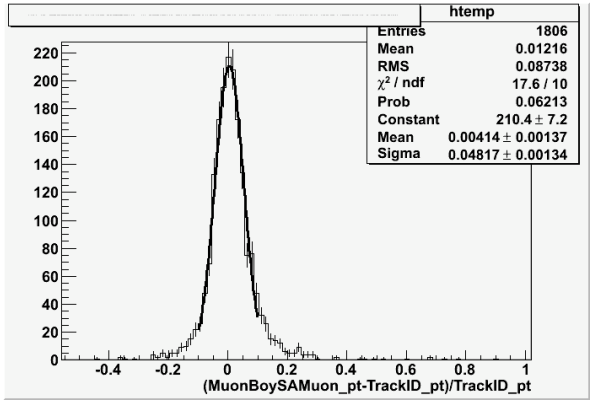


Results from Cosmics run 121080

- Use DP3D produced from AOD by Fabrizio Petrucci run 121080 → 2M ID-cosmic stream events
- Track selection (all sectors accepted):
  - MS - **MuonBoySA** tracks at IP:
    - Pt > 4 GeV ; 23>nMDT>16; nRpcPhi>2 ;
    - |d0| < 1m ; |z0| < 1m , chi2/ndf < 2 ; $|\eta|<1$
  - ID tracks:
    - Pt>2 GeV; nTRT>16; n(SCT+Pixel)>6 ; $|\eta|<1$
    - |d0| < 0.5m ; |z0| < 0.75m , chi2/ndf < 1 ; $\theta=(90\pm25)^\circ$
- 15K Muons selected:
  - Fit $\sigma(P)/P$ in 8 Pt bins with single-Gaussian fit



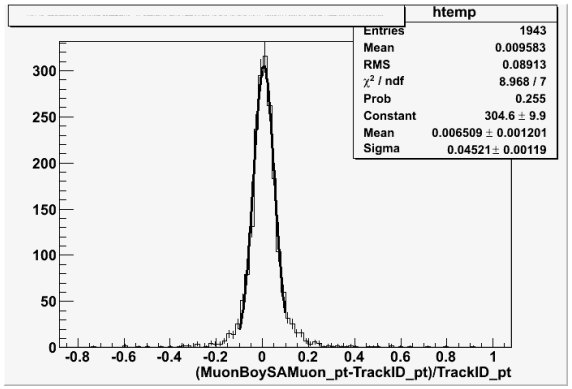


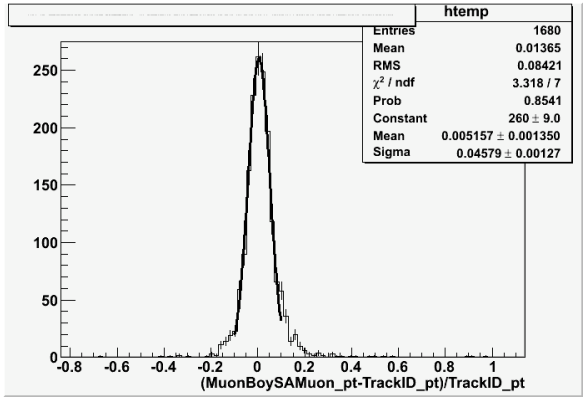


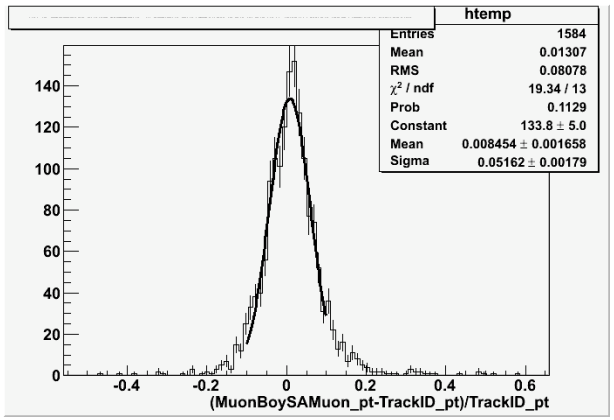
Run 121080

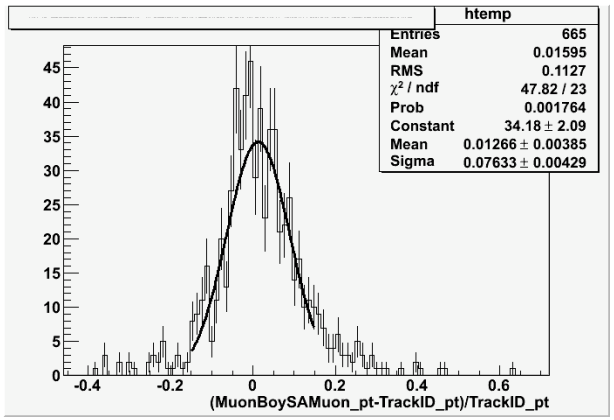
Reasonable Fit: 2 sigma core

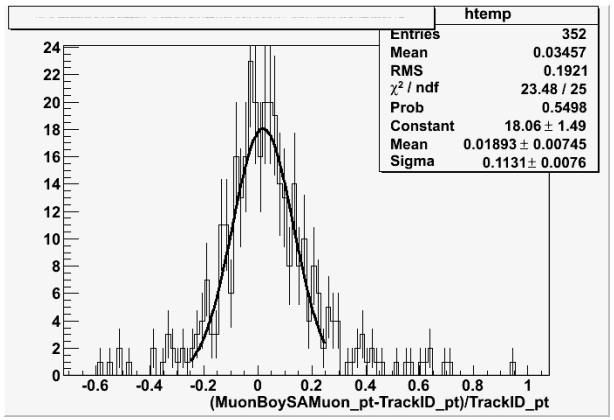
Some non gaussian tails



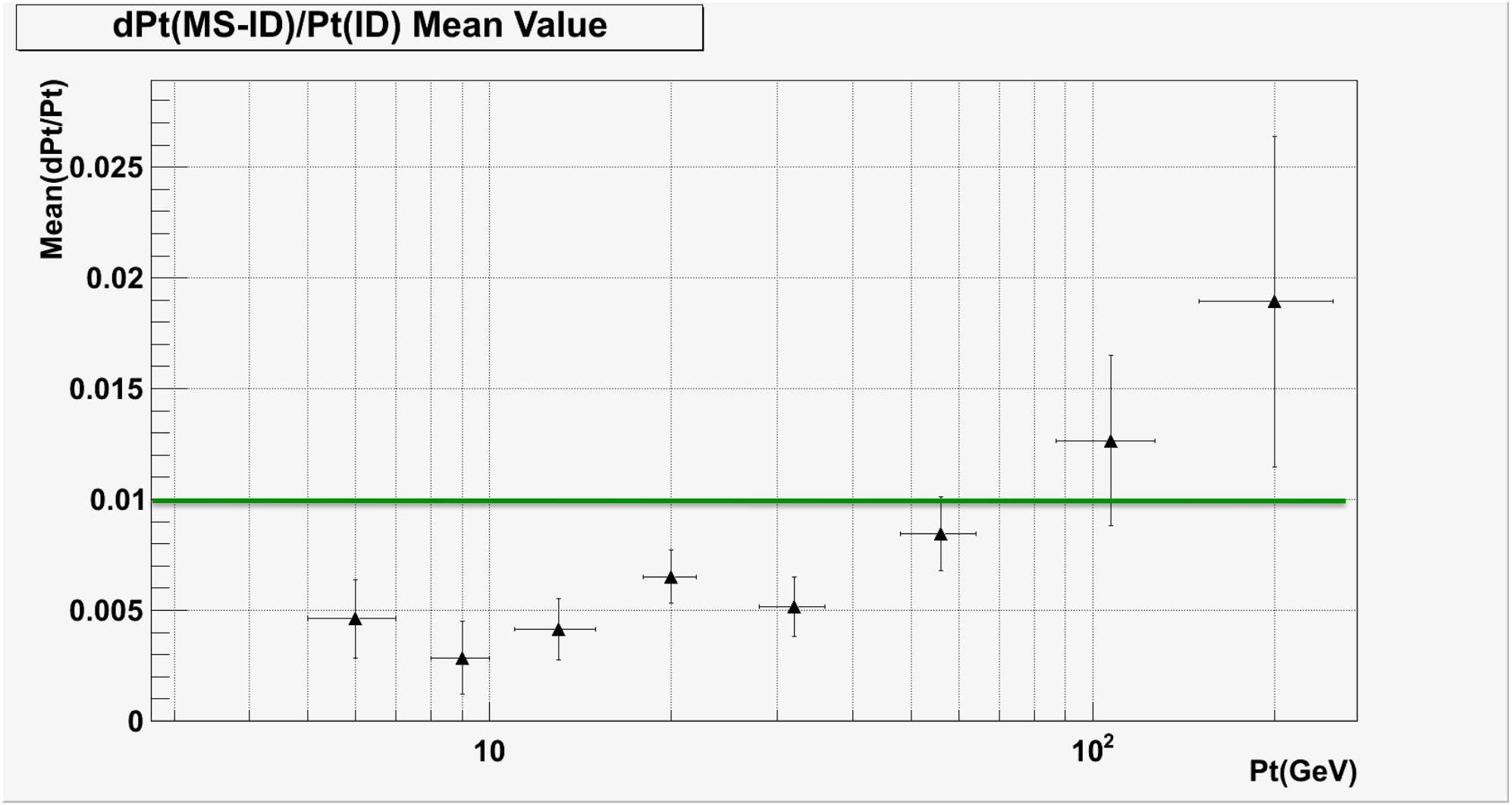






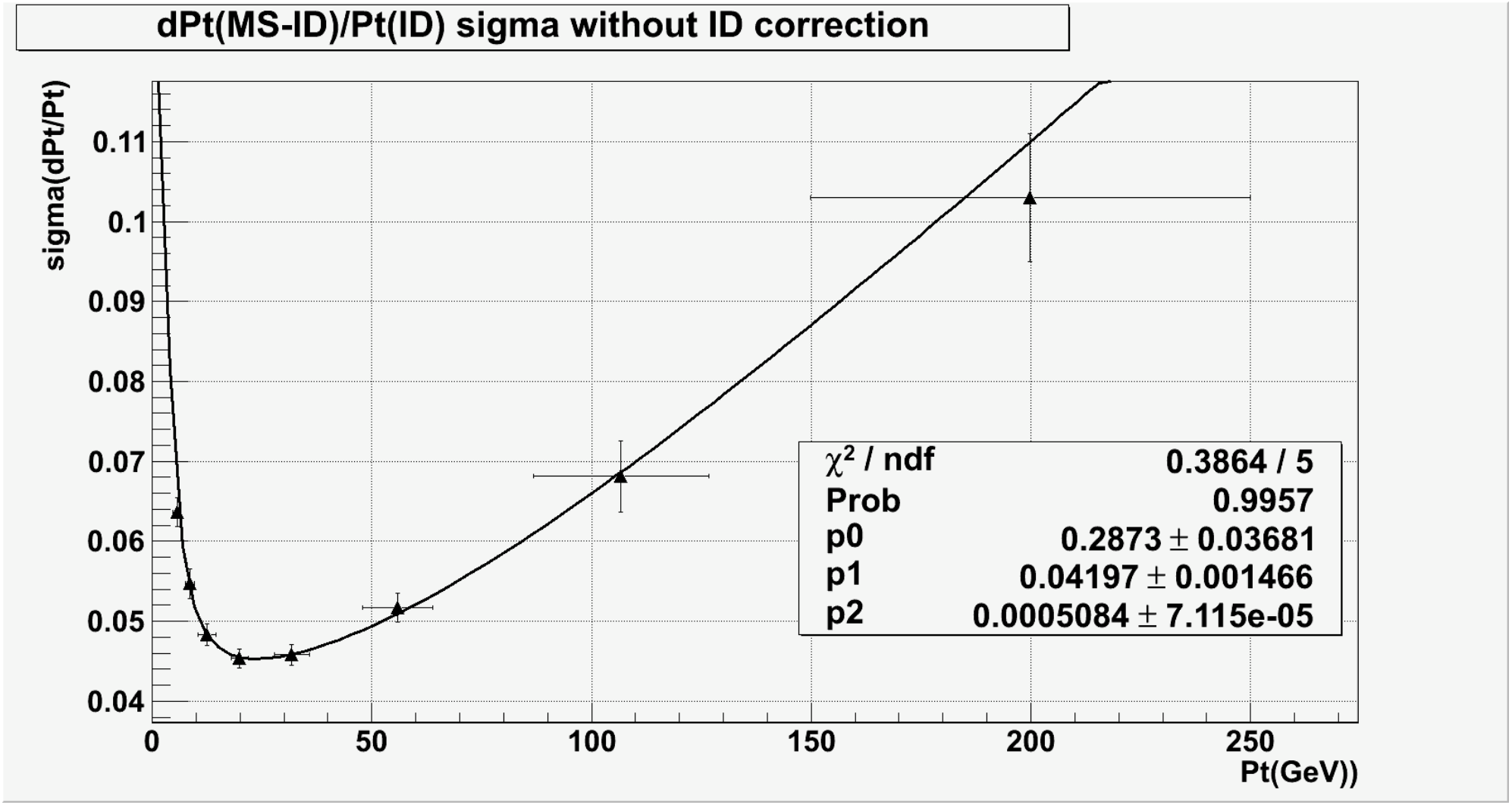


<[Pt(MS)-Pt(ID)]/Pt(ID)>



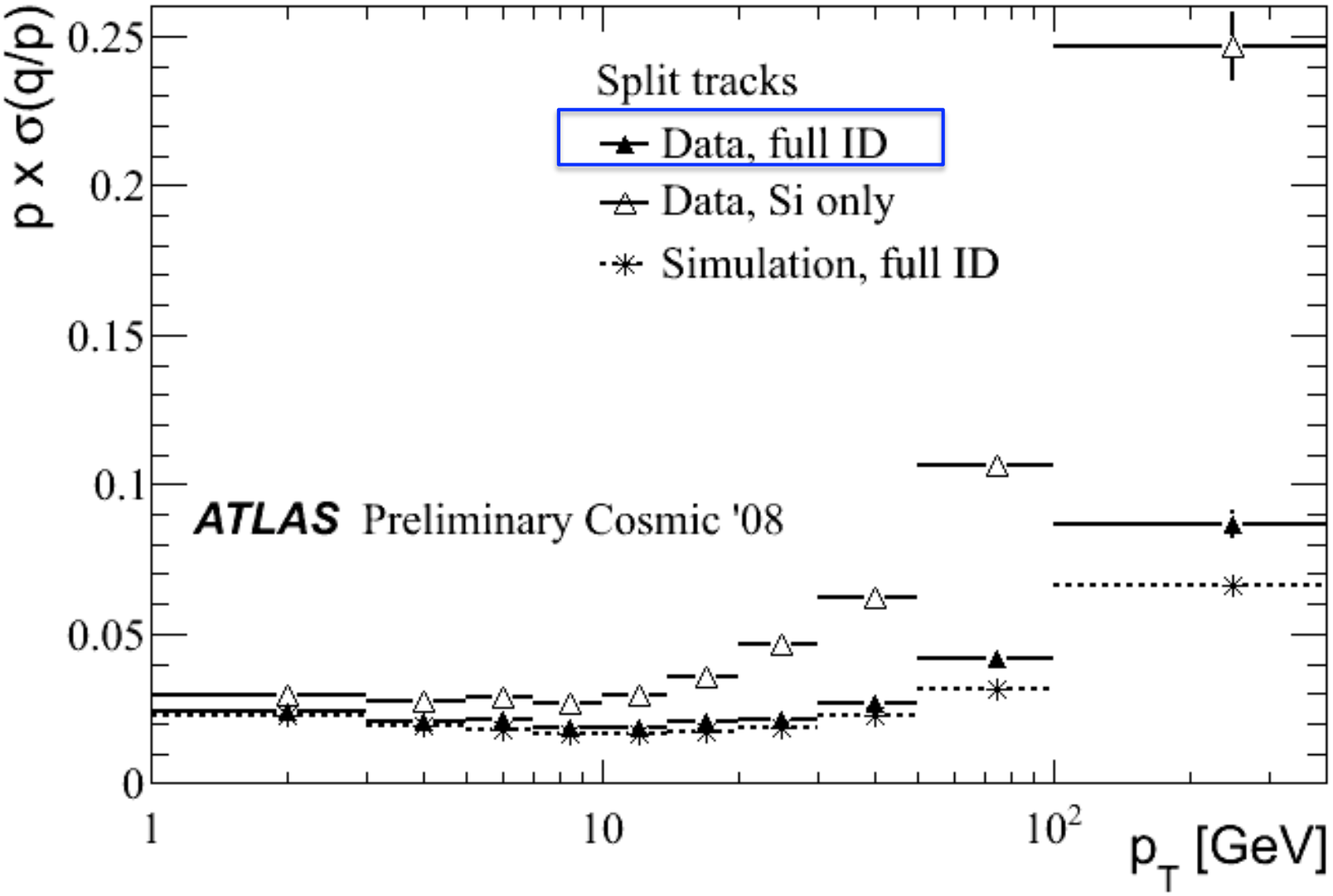
Mean-Pt=Pt-SCALE Agreement with ID at <1% up to 100 GeV !

σ([Pt(MS)-Pt(ID)]/Pt(ID)



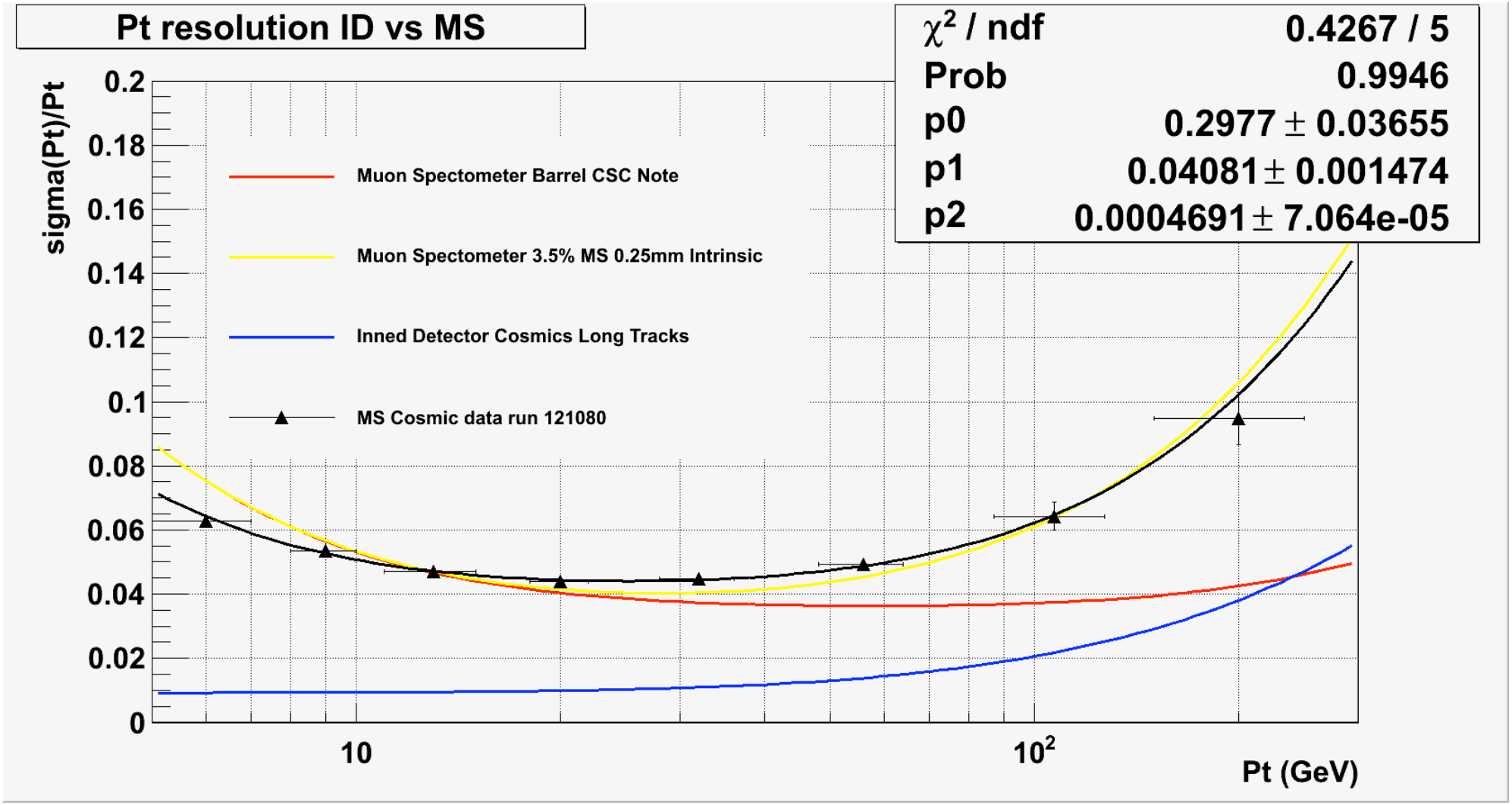
Before Subtracting ID resolution

ID resolution



* ID resolution: **2,5% up to 50 GeV - 3% at 60 GeV - 5% at 100 GeV – 7% 200 GeV**
BUT for "LONG track" they claim scale as L^2 → factor 4 SMALLER → Negligible

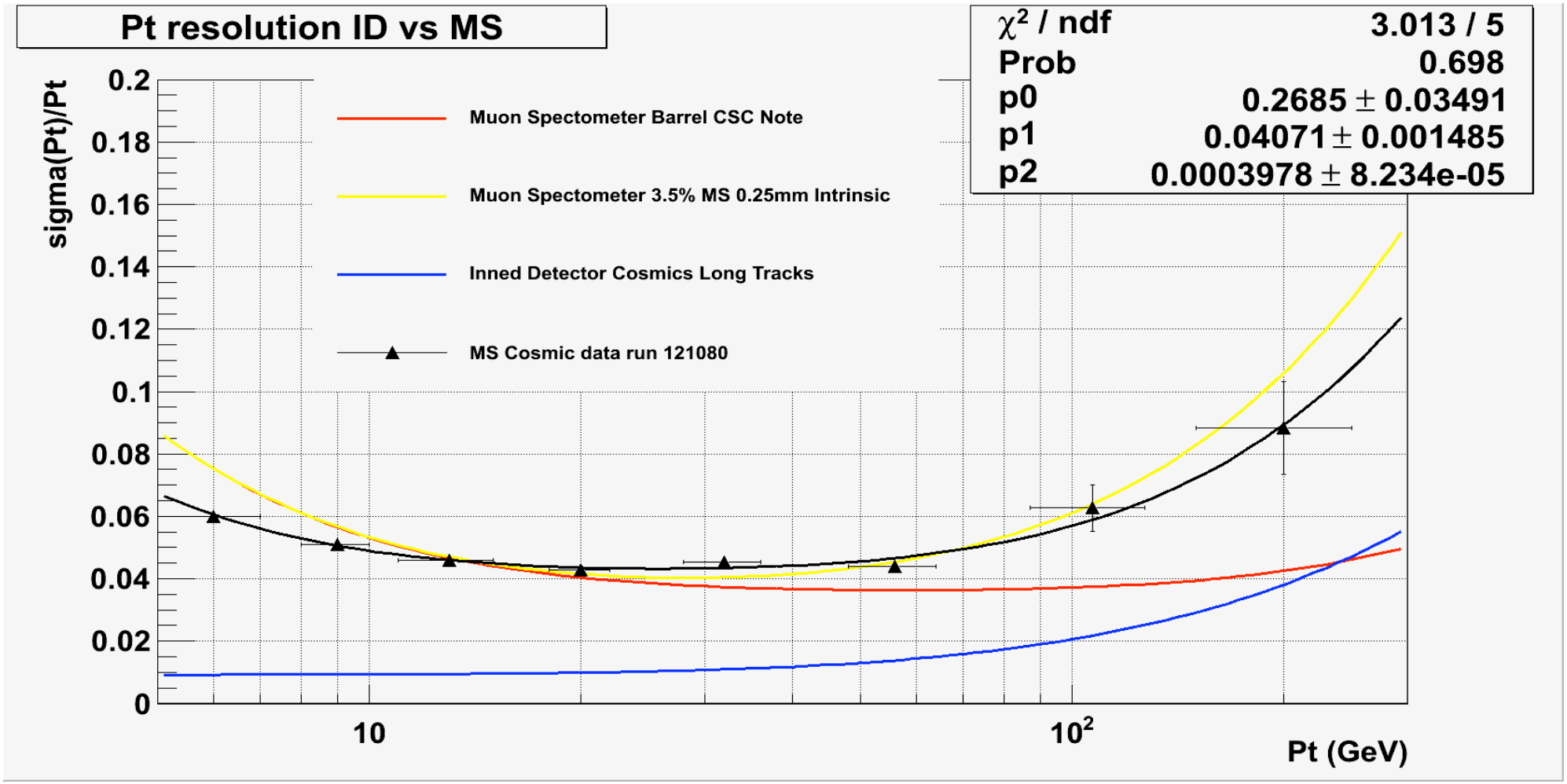
Resolution FIT: All sectors



- Energy Loss Error = 300 ± 40 MeV
- MS = 4.1 ± 0.1 %
-Intrinsic resolution = (4.6 ± 0.7) x 10^{-4} → ~40% @ 1 TeV

Up to 50 GeV very close to expected Performance !

Resolution FIT: Sector 5+13



- Energy Loss Error = 270 ± 30 MeV
- MS = 4.1 ± 0.1 %
- Intrinsic resolution = (4.0 ± 0.8) x 10^{-4} → 40% @ 1 TeV Only a factor 2 w.r.t. CSC ?

Conclusions 1

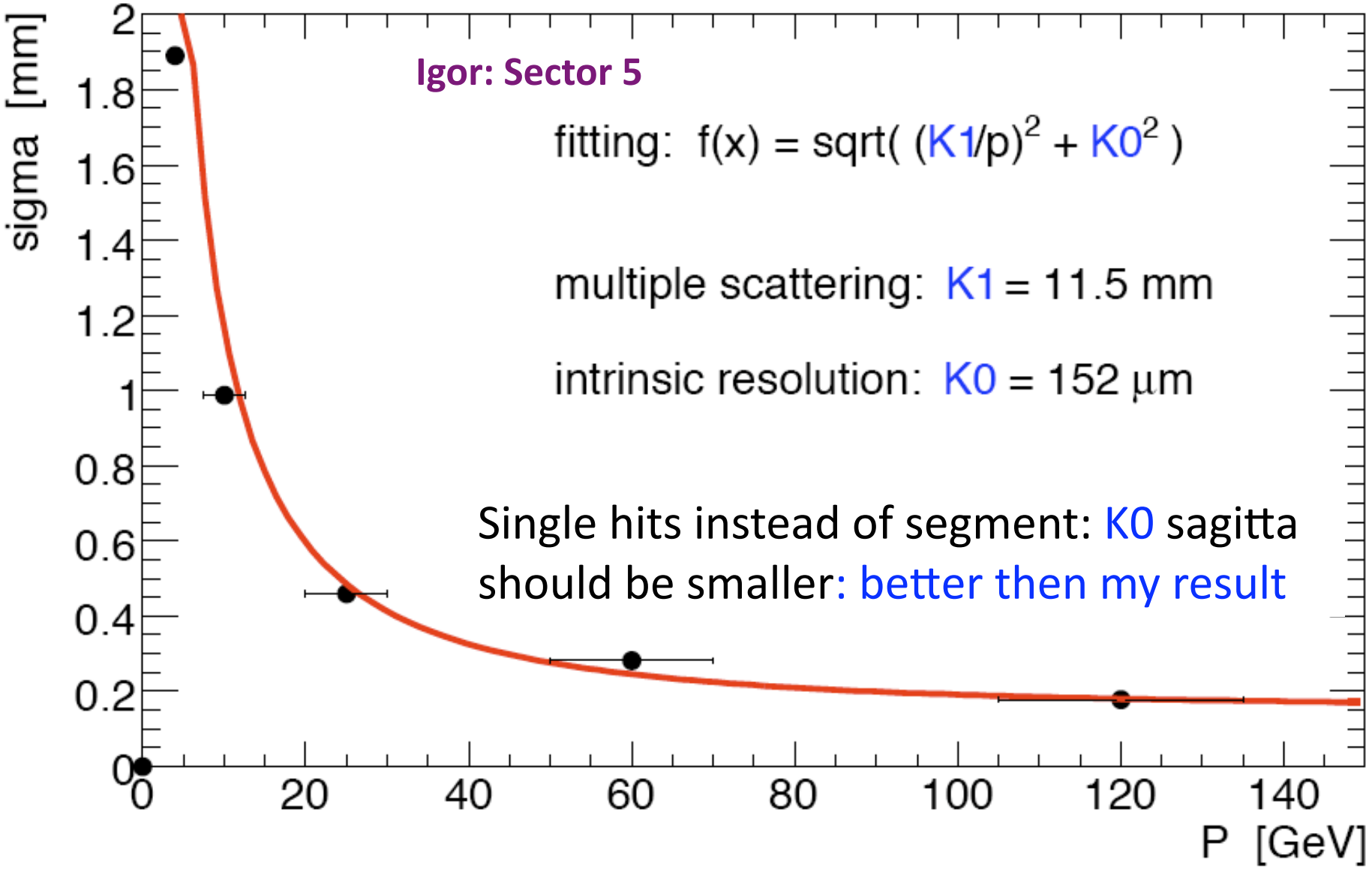
- Sagitta studies in Barrel:
  - Alignment concept in Barrel tested for runs 121737 seems to work at least at 50-300 μm (for movements ~0.2-1mm)
  - Resolution Approaching 150-200 μm at high-Pt for some sectors: probably alignment is NOT the only contribution (calibrations, segment reconstruction quality, ..)
  - Resolution still quite large for small sectors (not understood) ?
- P-scale in agreement with ID at 1-2% level: OK at this stage

Conclusions 2

- P-resolution:
  - ✓ E-loss term seems better than expected (200 MeV)
  - ✓ MS term of the order of 3-4% : OK
  - ✓ Sector-5 Intrinsic term approaching 150 um or better
  - ✓ For several sectors compatible with 200um
  - ✓ For cosmics quality of segments and tracks play a role: still margin for improvements – optimization of recons. Parameters
  - ✓ Still very difficult to KNOW and/or to USE right calibration and alignment in reconstruction !
  - ✓ Below 40 GeV very close to NOMINAL performance but for limited detector region

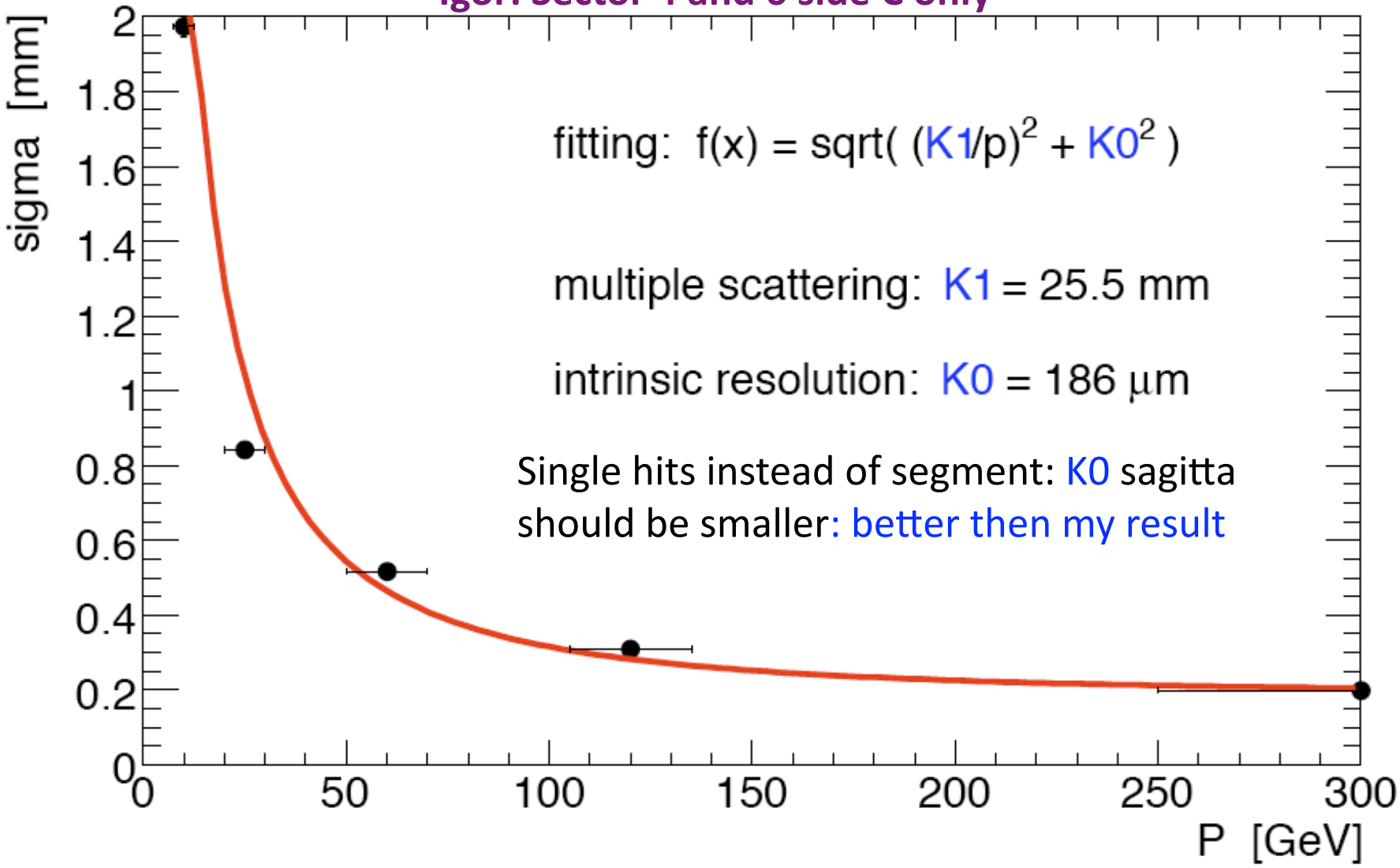
Spare Slides

Sagitta analysis from Igor:
RPC time corrections+ better r(t)



Sagitta analysis from Igor:
RPC time corrections+ Better r(t)

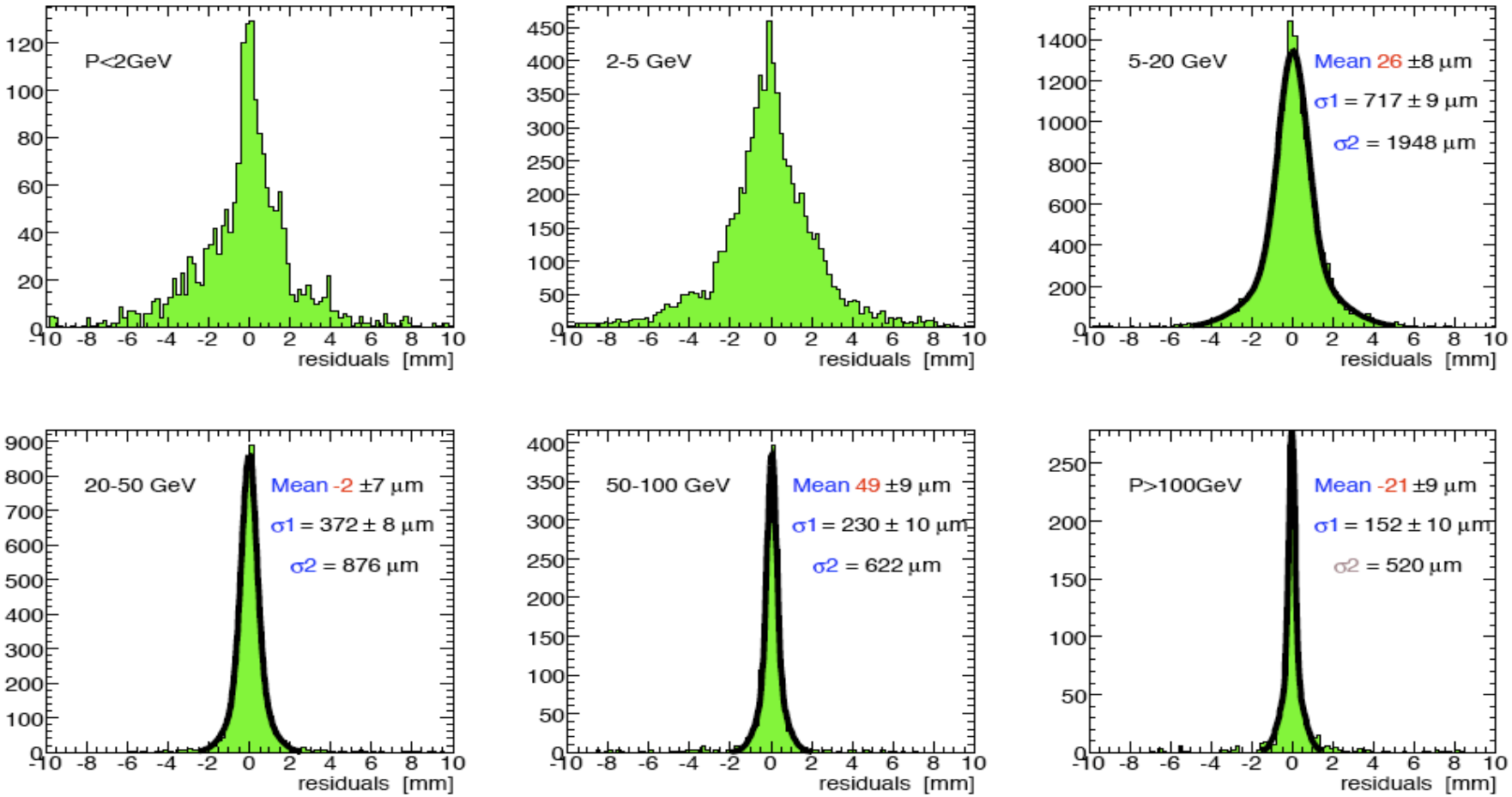
Igor: Sector 4 and 6 side C only



Results from Igor Sector 5

Sector 5 (A+C sides):

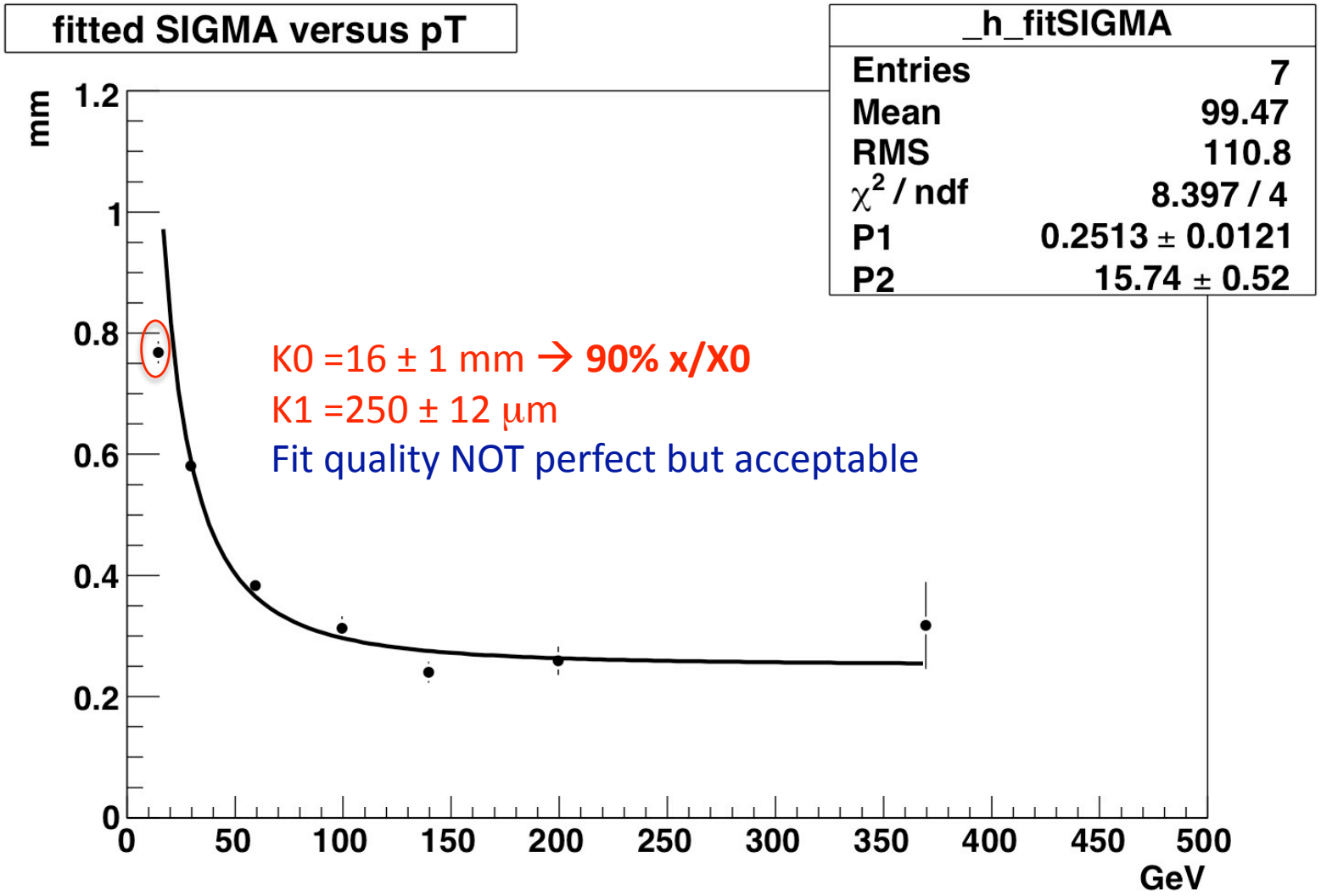
Igor Potrap



Hit resolution 150um → σ(s) intrinsic ~100um → better calibration used HERE !

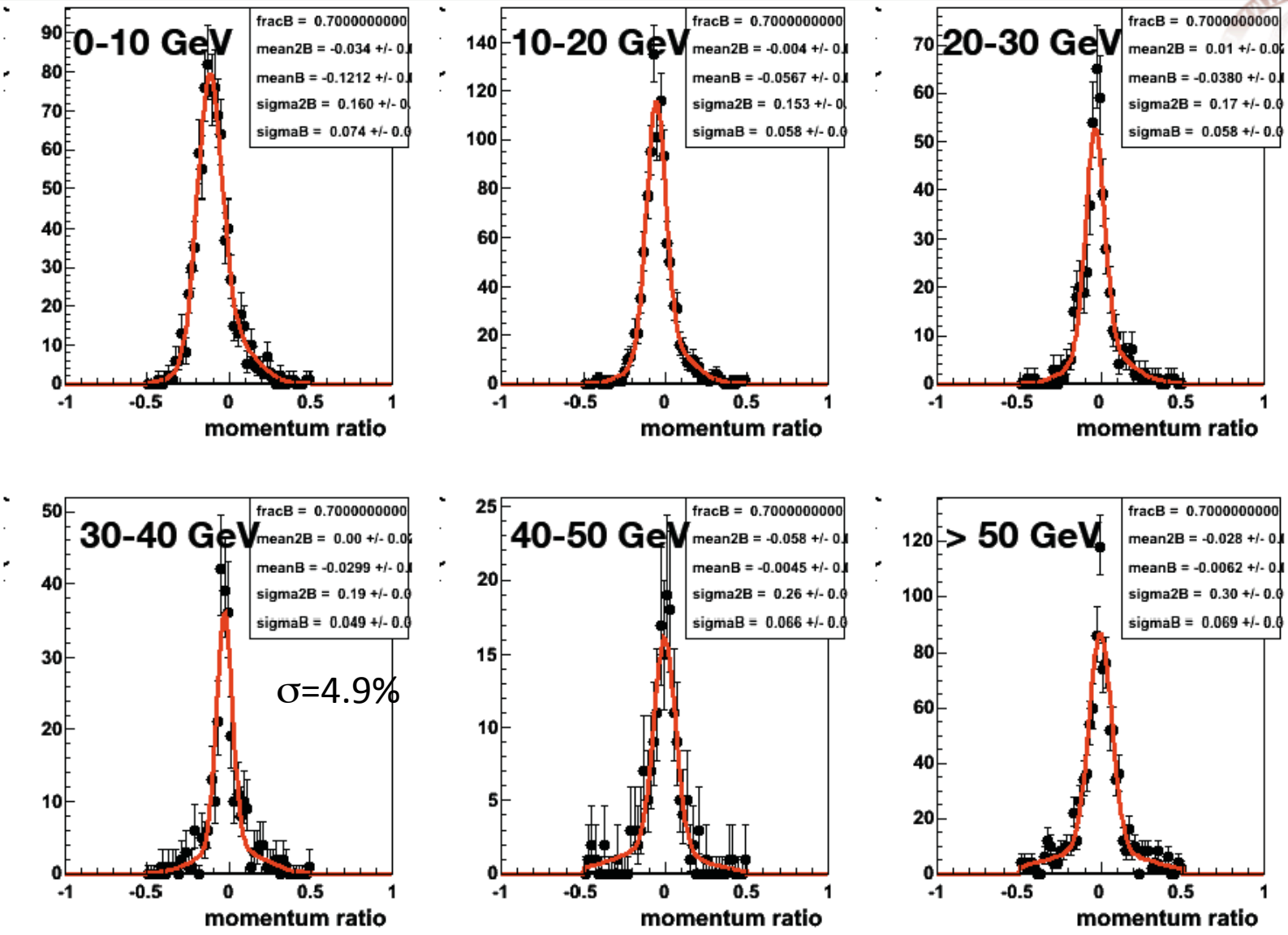
Kevin reprocessing this run with correct calibrations now

Egge Fits Sectors 3, 5 and 7



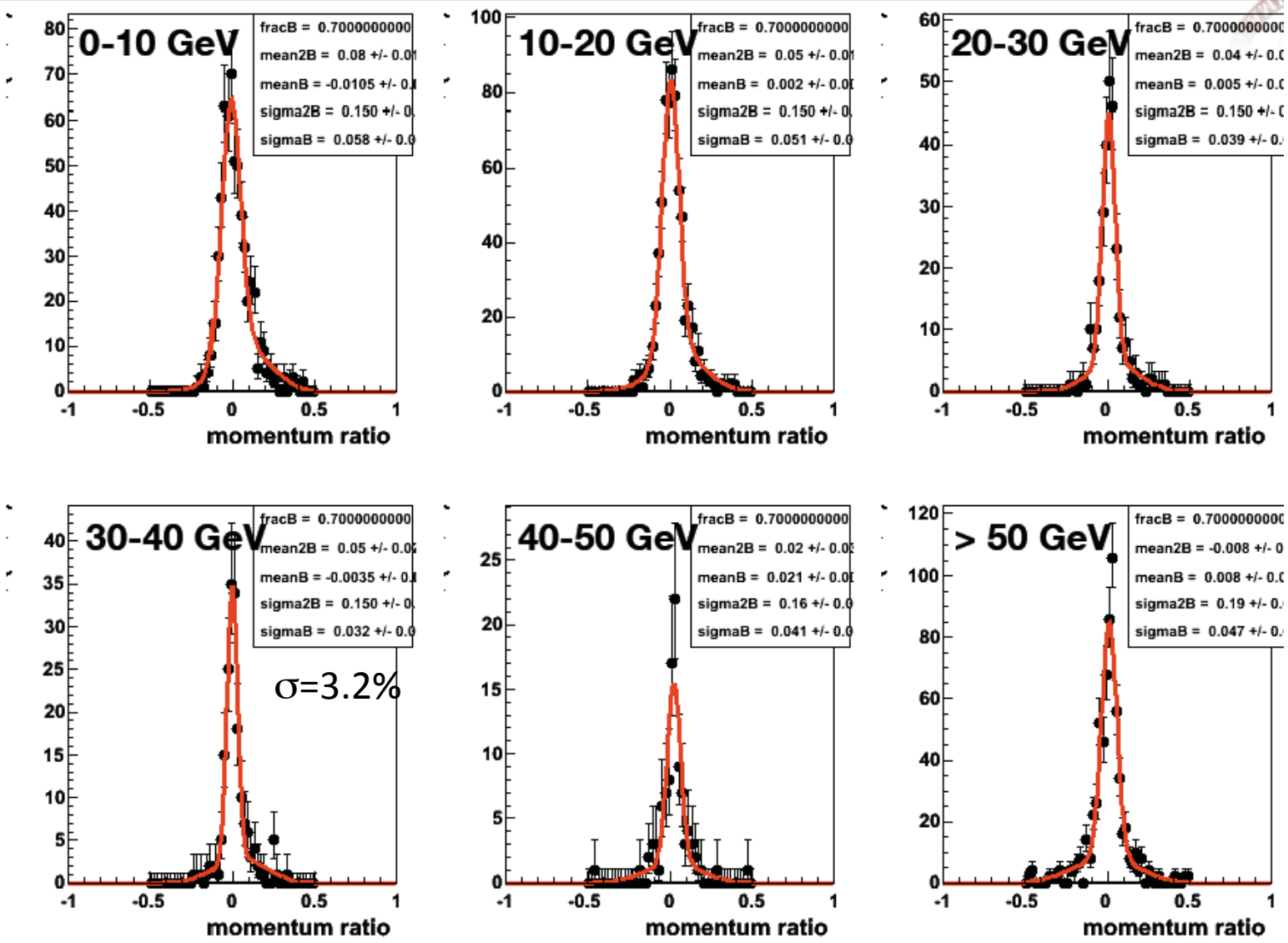
Dependency on track quality: Niels

ESD content



Dependency on track quality: Niels

Refit + error update + chi2 cut



Same Analysis on 91890 !!! Only Optical Absolute Alignment Corrections !!!

★E-loss 380 MeV

★Fit insensitive to MS (6% error)

★Intrinsic term 36 times larger than Nominal → **1.8 mm**