OSCAR/G4 Simulation of the 2002 Hcal Test Beam

V. Daniel Elvira

JetMET Meeting

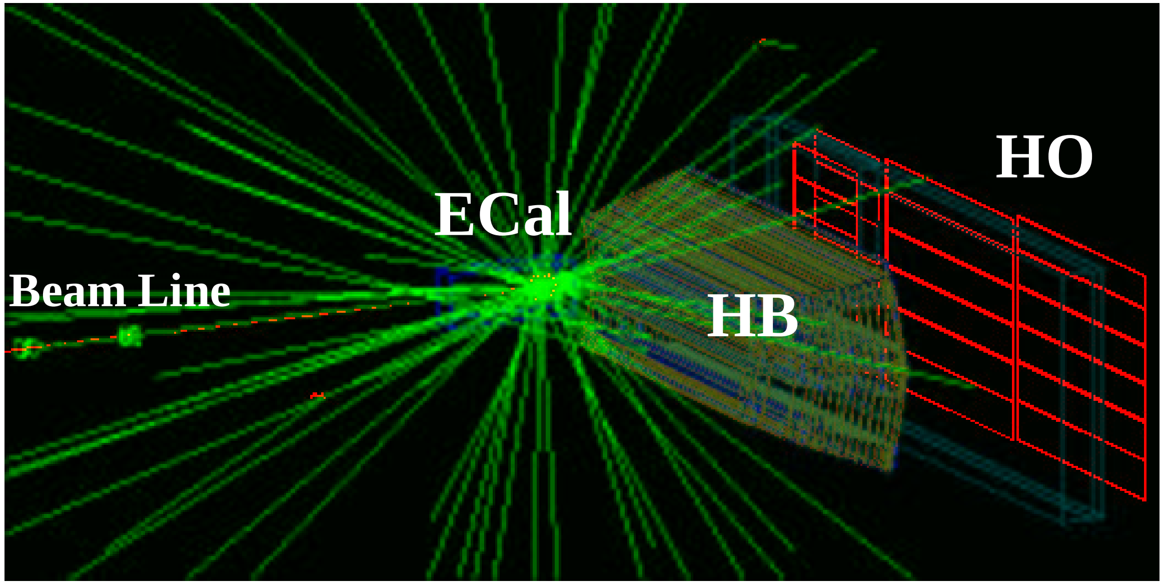
Motivation

- Validation of GEANT4-OSCAR towards the data challenge
- Understanding of the successive Hcal test beam experiments (02,03,04)

Started using OSCAR_1_4_0 (G4.4.1), physics list 1.8 (October 2001), default cuts: 1 cm production cuts

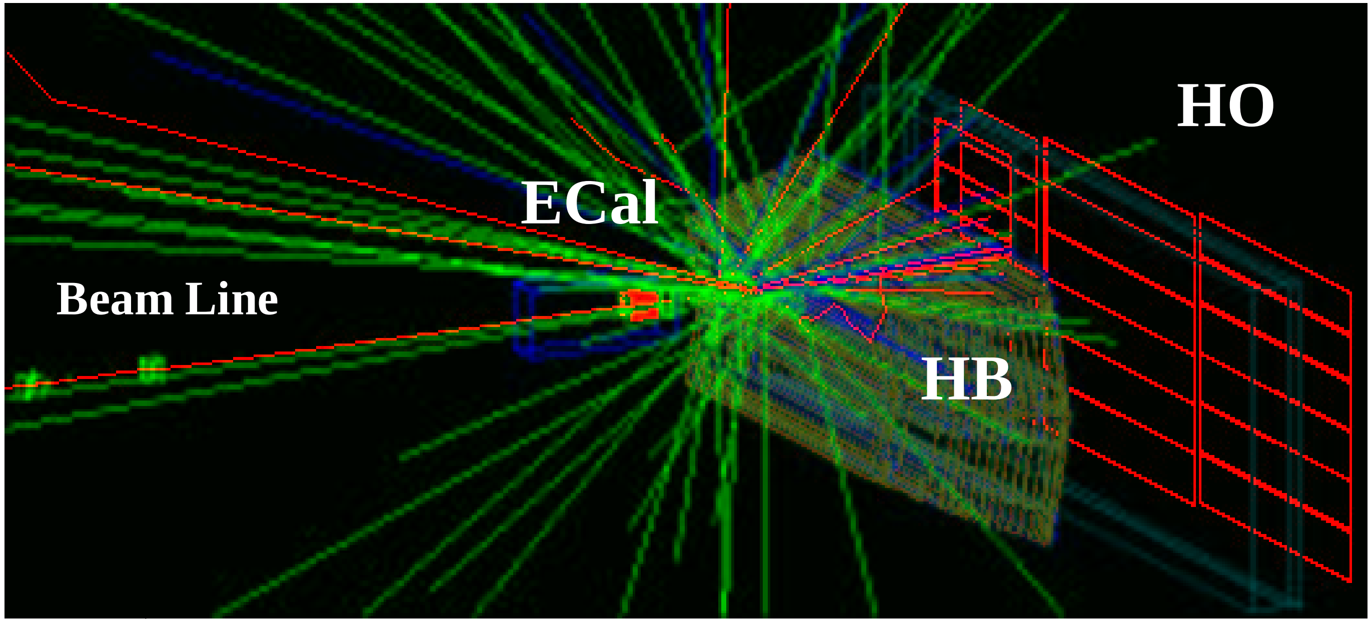
- Beam Line System (trigger tiles & wire chambers)
- Customized Ecal (7x7 Crystal Matrix in aluminum box)
- HCal from OSCAR_1_4_0 library
- Customized HO
- BL and Ecal translation & rotation capability
- Incorporate Root analysis package
- Study energy resolution, linearity, shower profiles

Visualization



Angle view of the full TB02 detector

10 GeV electron



100 GeV pion

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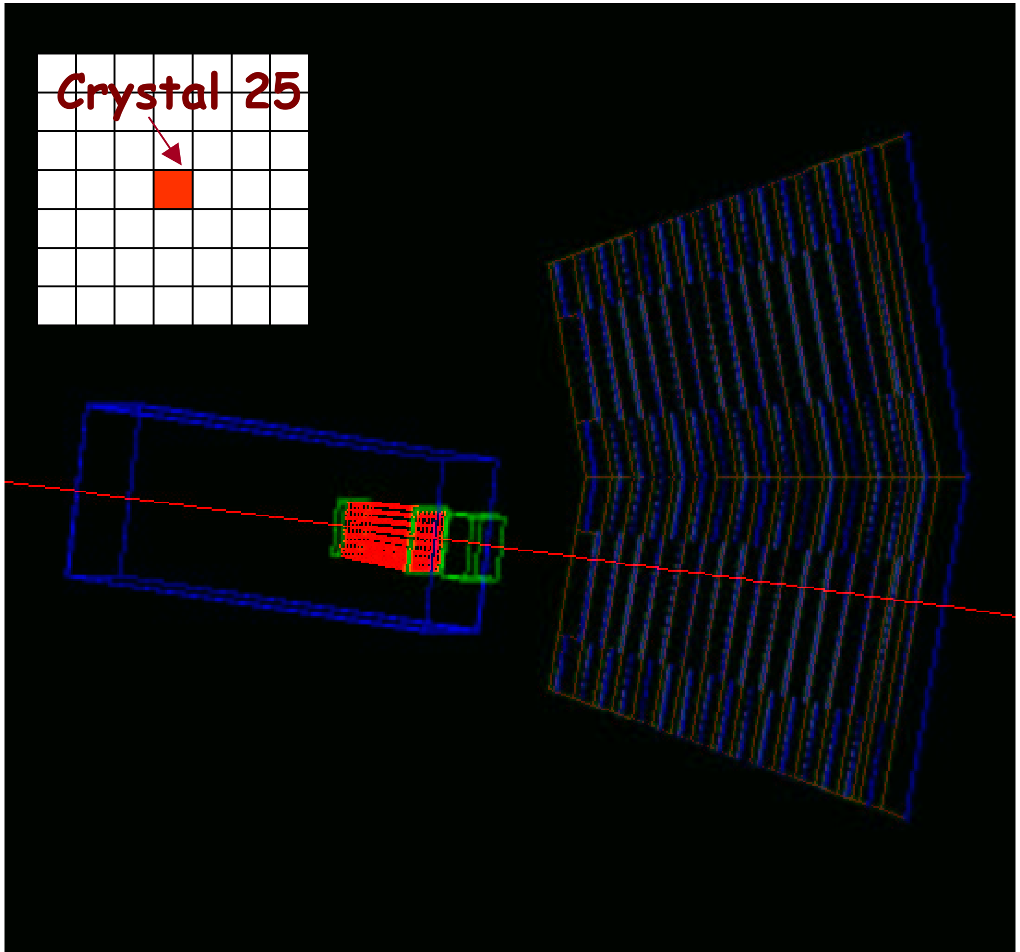
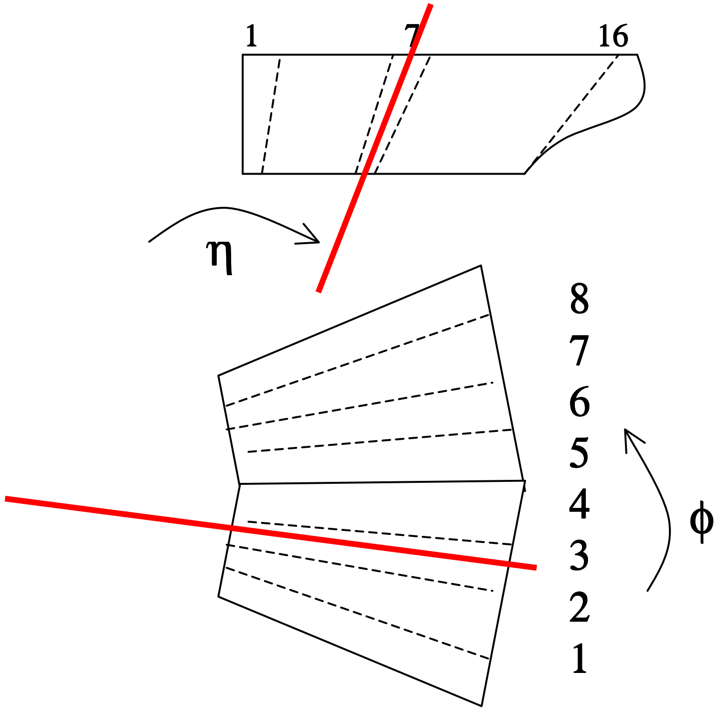
MC Analysis: mimic data analysis

Based on 1-5,000 π^- events onto the $(\eta,\phi)=(7,3)$ tower of the HB and crystal 25 of the ECal matrix



Should be tower (9,4) !

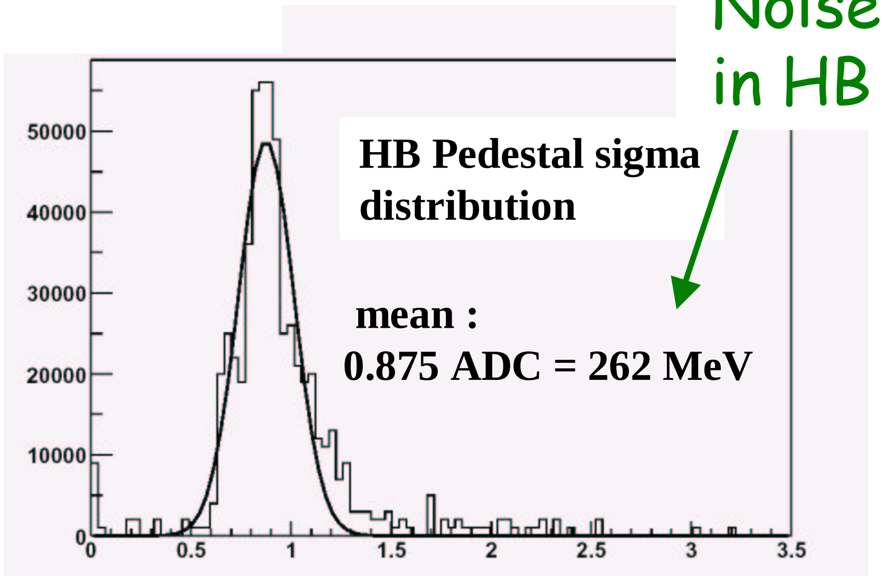


MC Analysis: Calibration & Noise

HCal calibration with 50 GeV pions on HB only: less than 1% of the energy in scintillators (5x5 matrix)

ECal calibration with 100 GeV electrons on Ecal only: ~95% of the energy is contained (3x3 matrix)

Noise in HB



$$E^{\pi}_{corr} = 121.5 * E^{HB}_{5x5} + 1.05 * E^{ECal}_{3x3}$$

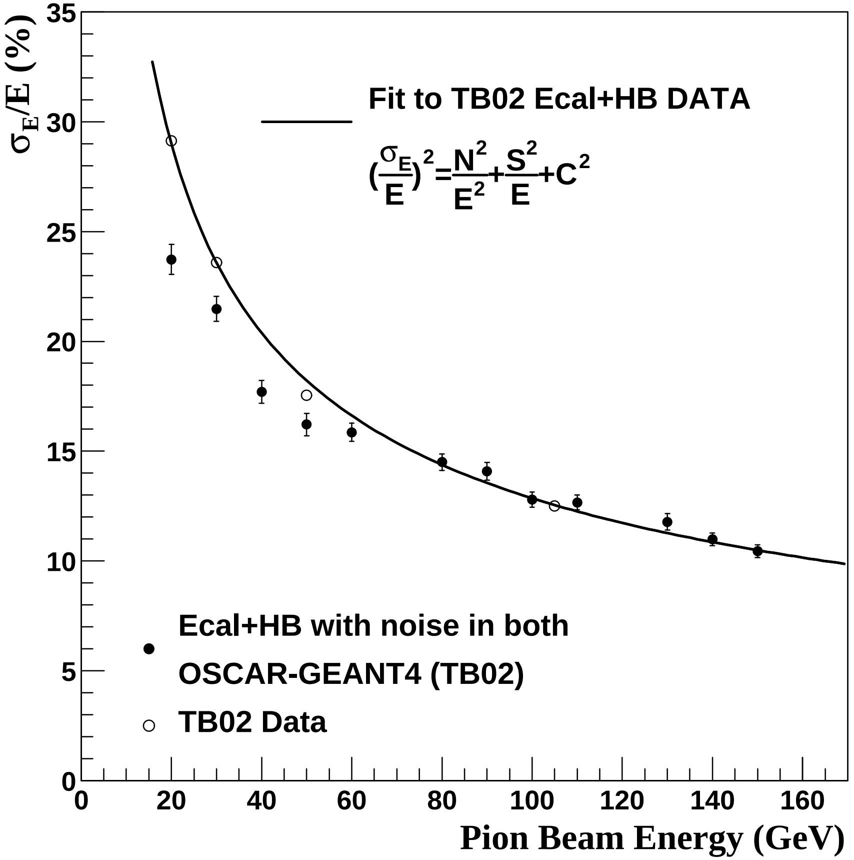
Calibration factors

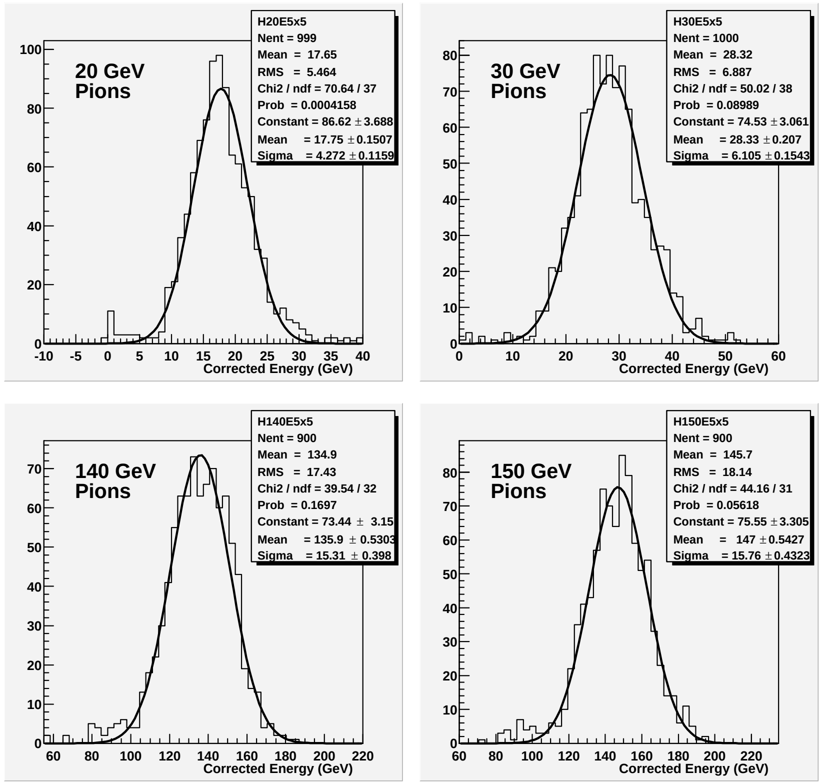
$E^{ECal}_{tower} \rightarrow E^{ECal}_{tower} + 115$ MeV * Rand ← Electronic Noise

$E^{HB}_{scint} \rightarrow E^{HB}_{scint} + 0.1 * E^{HB}_{scint}$ MeV * Rand ← Long. Non-uniformity

$E^{HB}_{tower} \rightarrow E^{HB}_{tower} + 262$ MeV * Rand ← Electronic Noise

Pion Energy Resolution

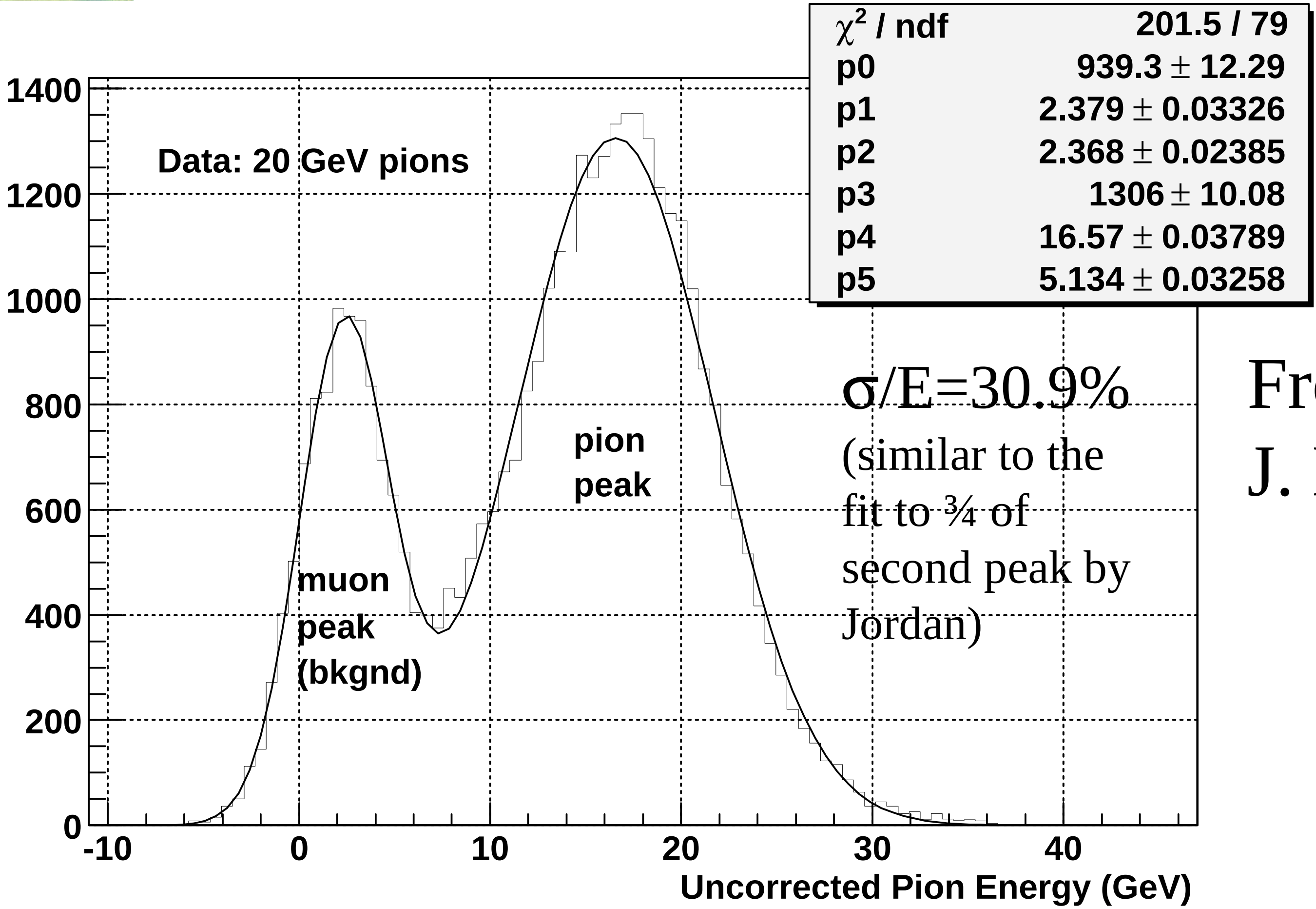




M.C. & data agreed above ~70 GeV but M.C gave increasingly better resolution at lower energies (20% difference at 20 GeV)

But what's the uncertainty in the data analysis? (need for M.C physics validation)

Comments on Data Analysis



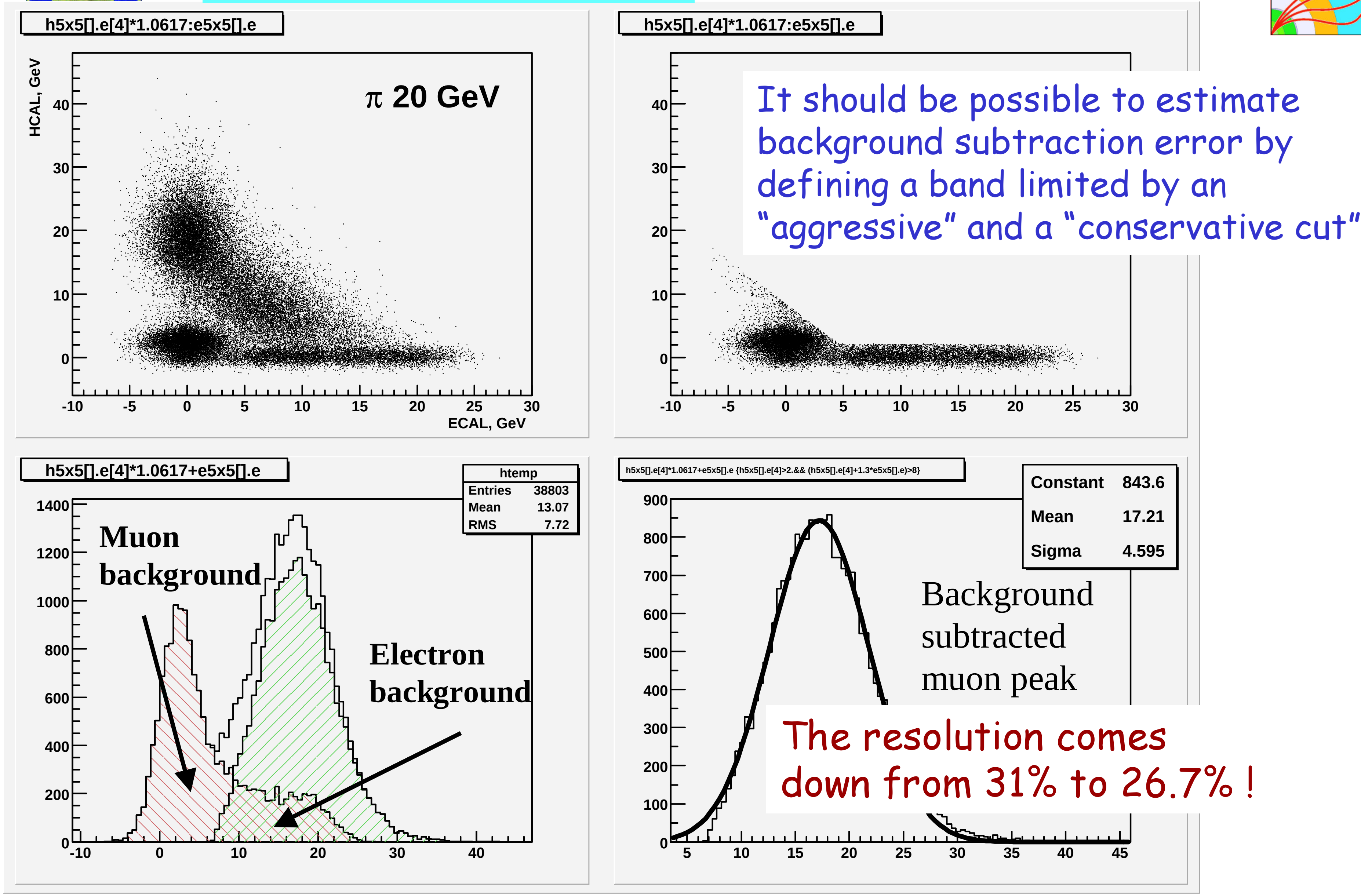
From
J. Damgov

Data analysis: sources systematic errors:

- muon (pion decay) & electrons (from scrapping?) backgrounds
- calibration

Data Analysis

From J.Damgov

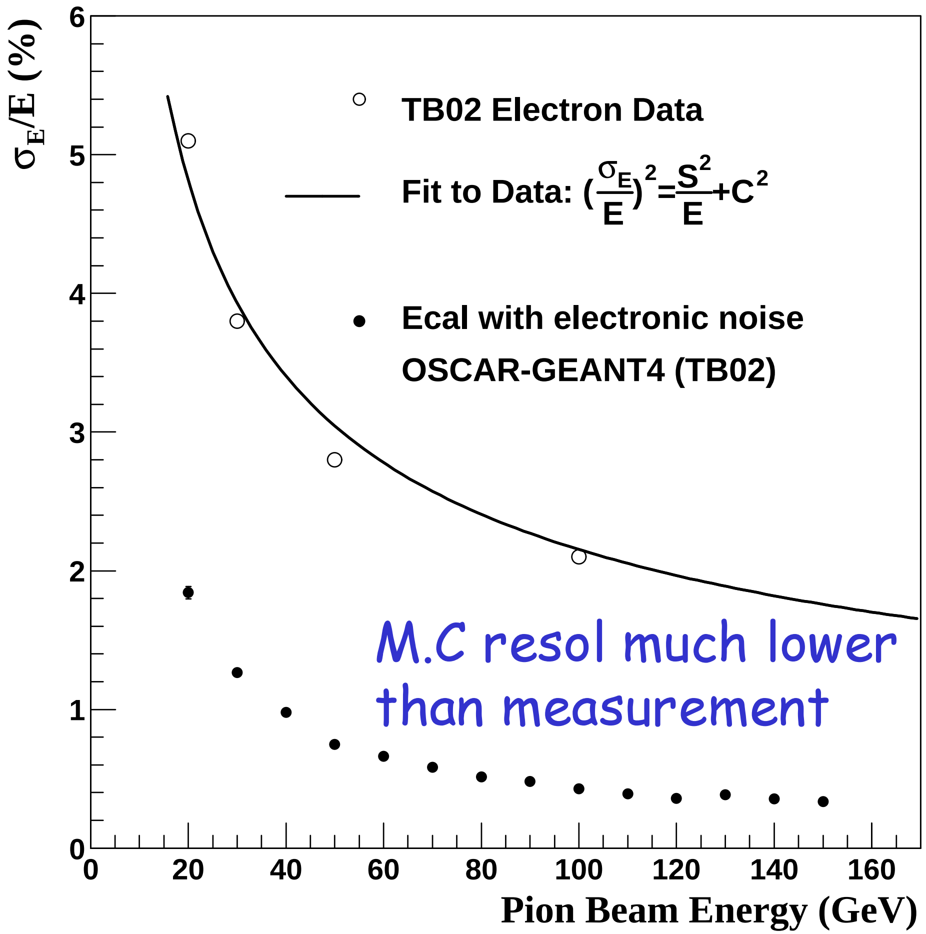


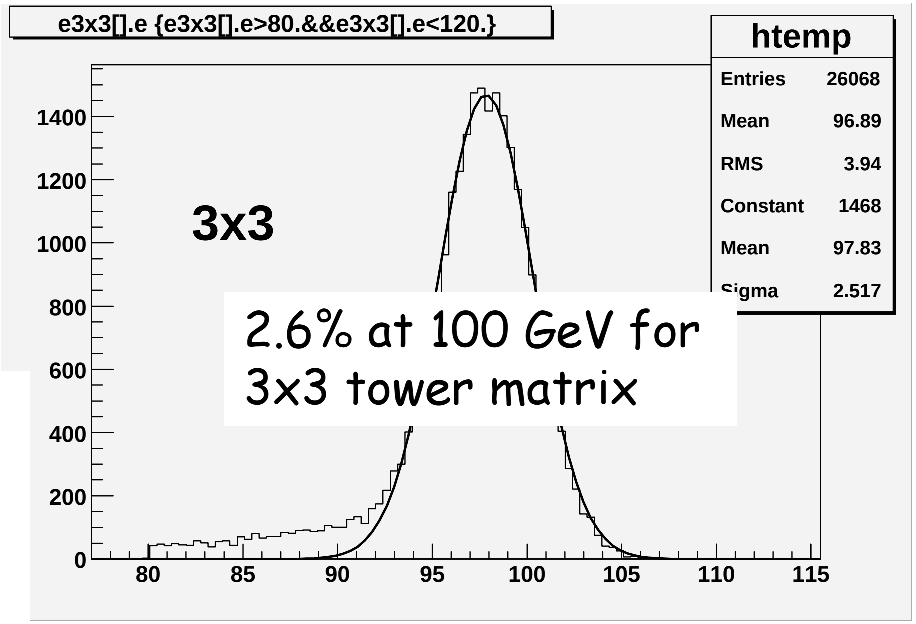
Data & MC e^- Resolution

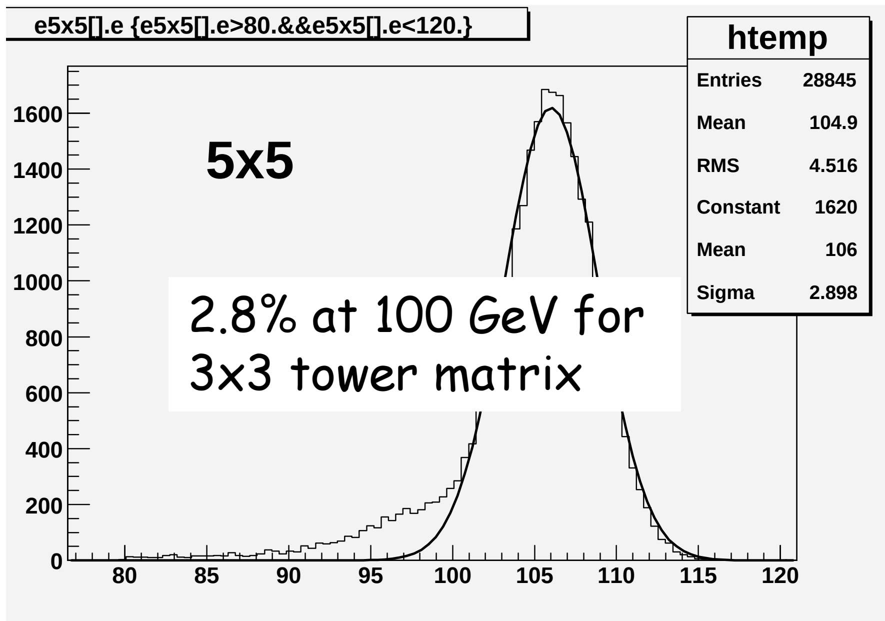
E^{ECal}_{tower} E^{ECal}_{tower} + 115 MeV * Rand

TB02 Data

Electronic noise







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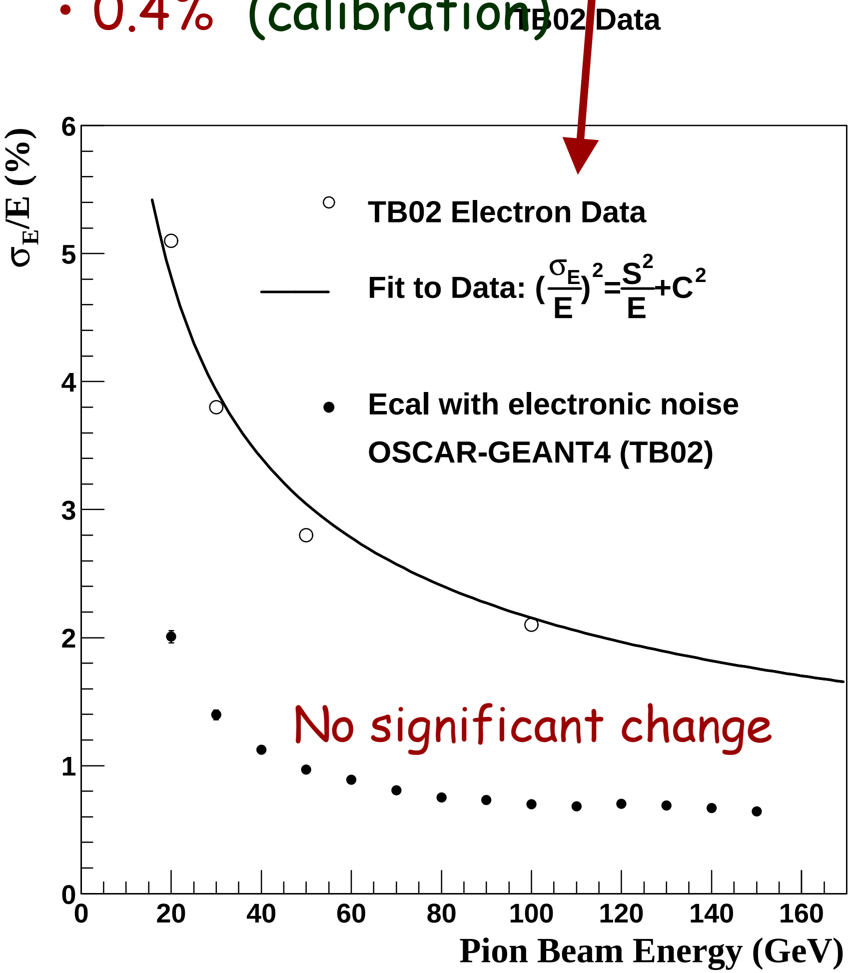
Data & MC e^- Resolution

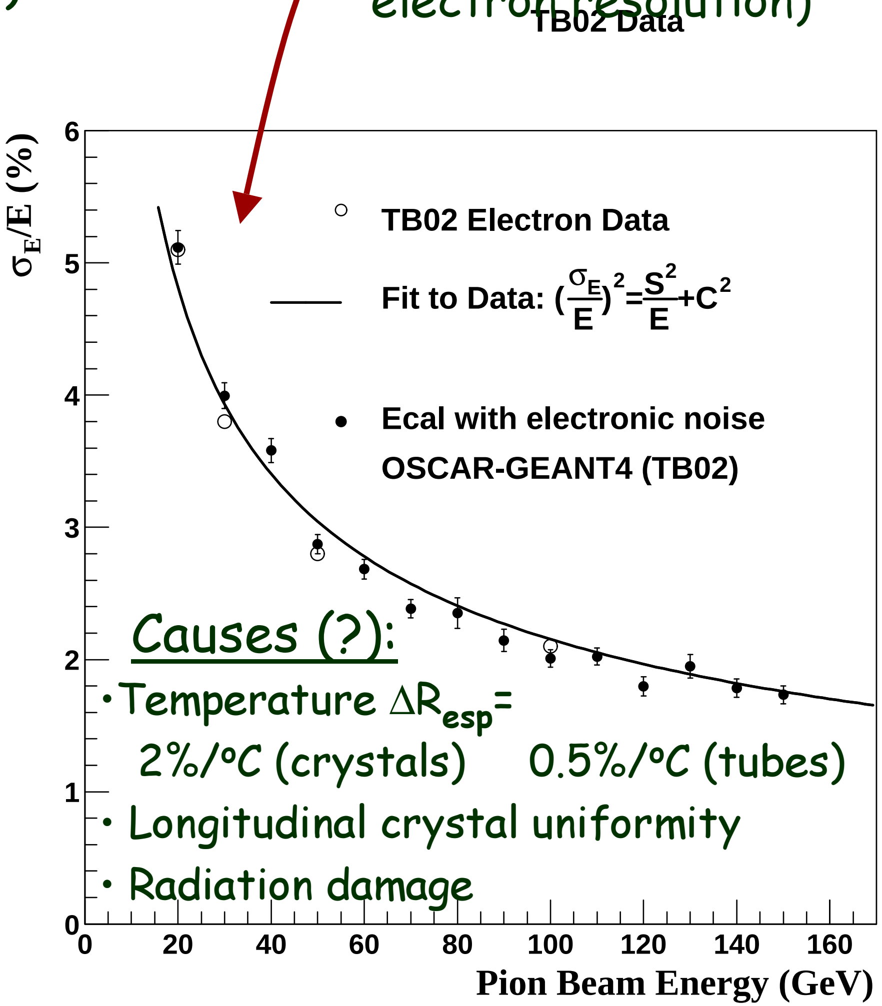
- $E^{ECal}_{tower} \rightarrow E^{ECal}_{tower}$ + 115 MeV * Rand (noise)
- 2.3%/ sqrt(E_{ele}) (photo-statistics)
- 0.3% (longitudinal non-uniformity)
- 0.4% (calibration)

$E^{ECal}_{tower} \rightarrow E^{ECal}_{tower} + \sigma_{match}$ * Rand

(To match the measured electron resolution)



No significant change



Causes (?):

- Temperature ΔR_{esp}= 2%/°C (crystals) 0.5%/°C (tubes)
- Longitudinal crystal uniformity
- Radiation damage

Improved M.C. Simulation

$$E^{ECal}_{tower} \longrightarrow E^{ECal}_{tower} + \sigma_{match} * \mathrm{Rand}$$

(To match the measured electron resolution-much worse than M.C.)

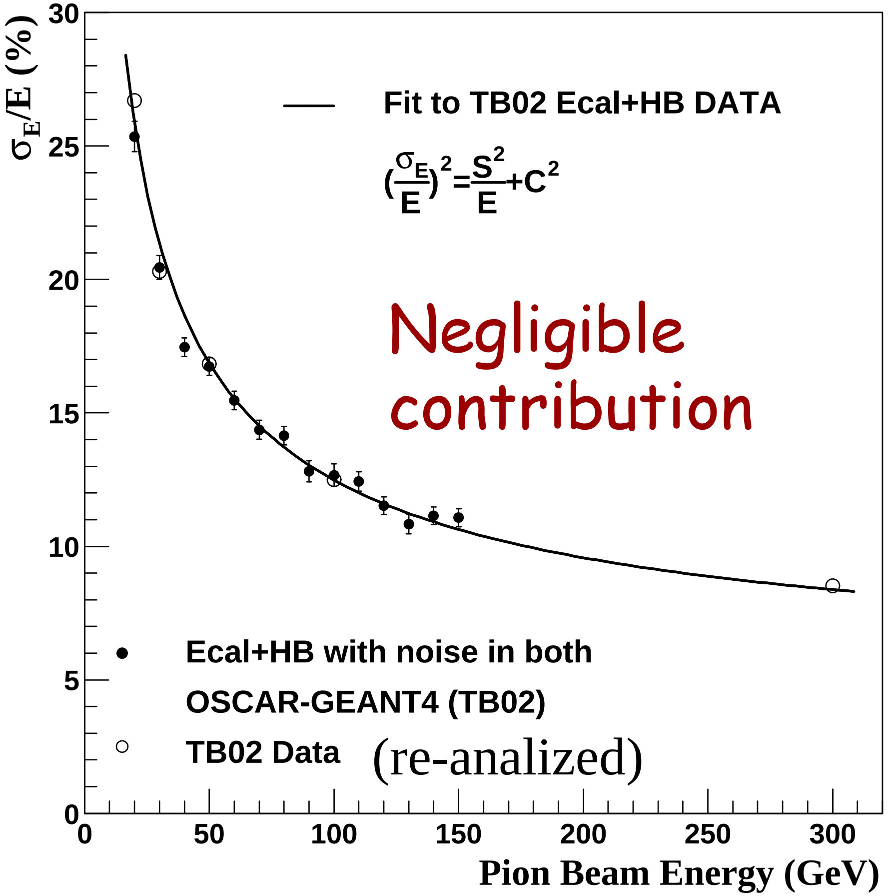
- Add more energy points at 10, 25, 200, 250, 300 GeV (in addition to 20, 30, 50, 100, 150 GeV)

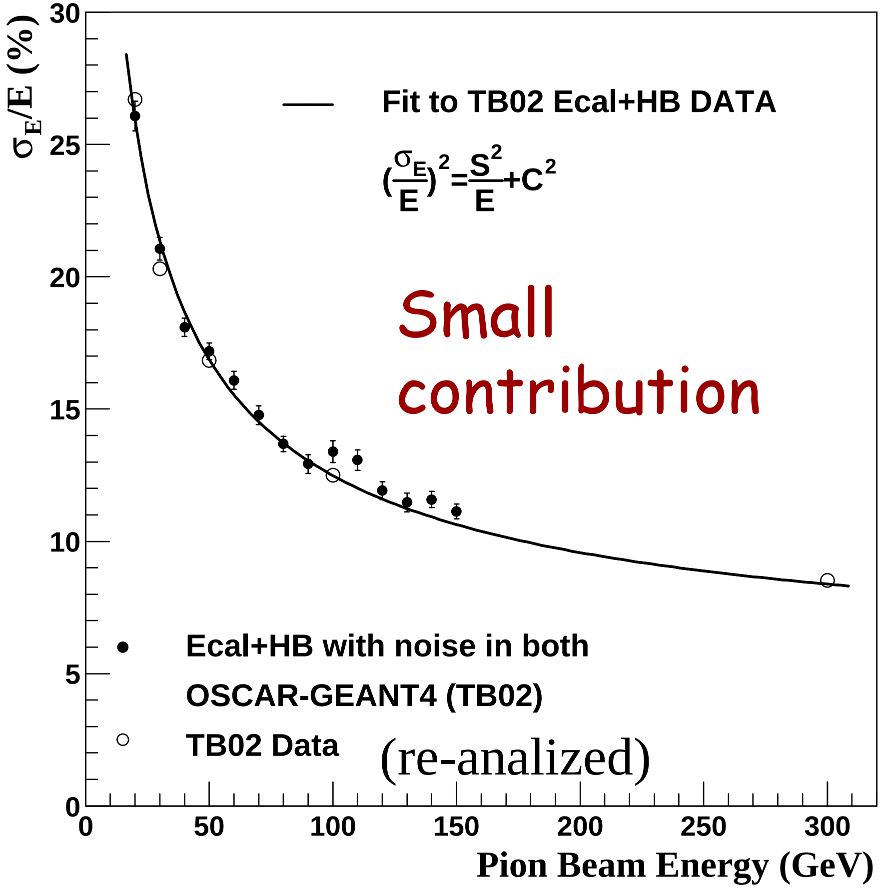
- 5 times more statistics 10-30 GeV

Improved Analysis: Pions

All known contributions to ECal and HB resolutions added

Ecal resolution "matched" to data measured e⁻ resolution

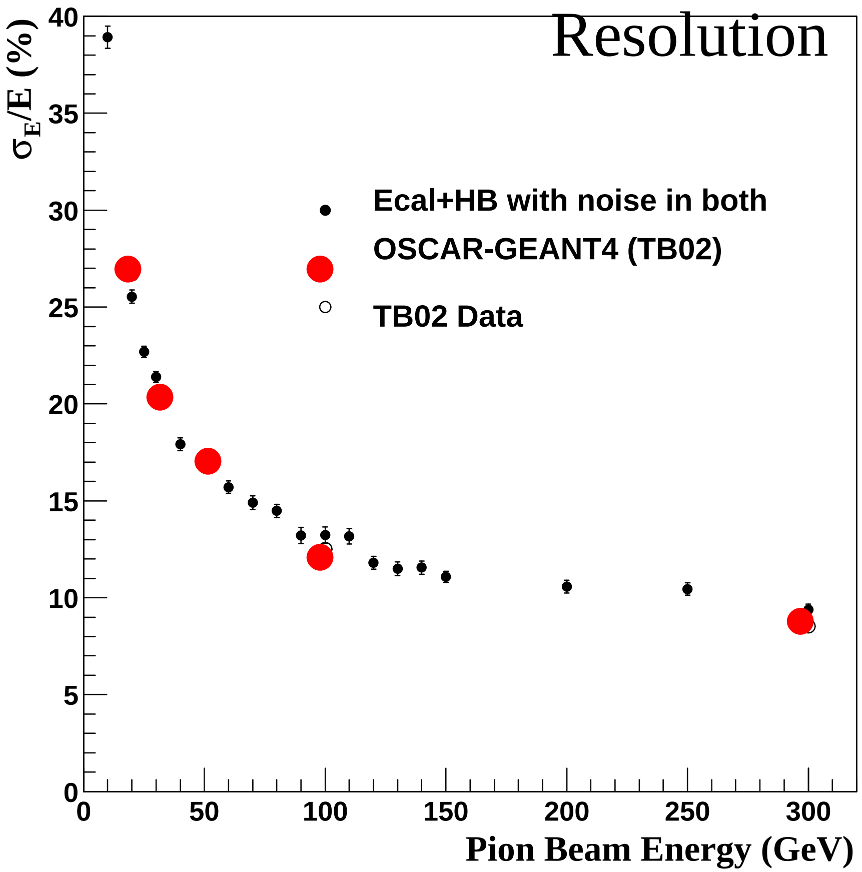


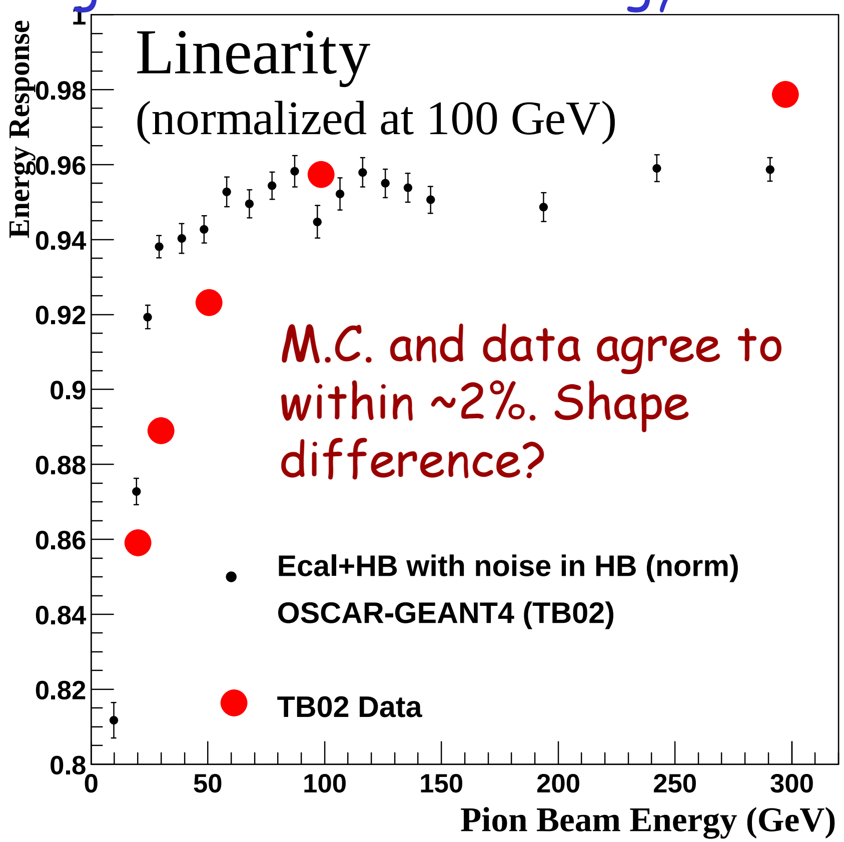


Very good agreement between OSCAR/G4 and data

Improved Analysis: Pions

Add more energy points at below 20 and above 150 GeV:
10, 25, 200, 250, 300 GeV, and higher stats as low energy





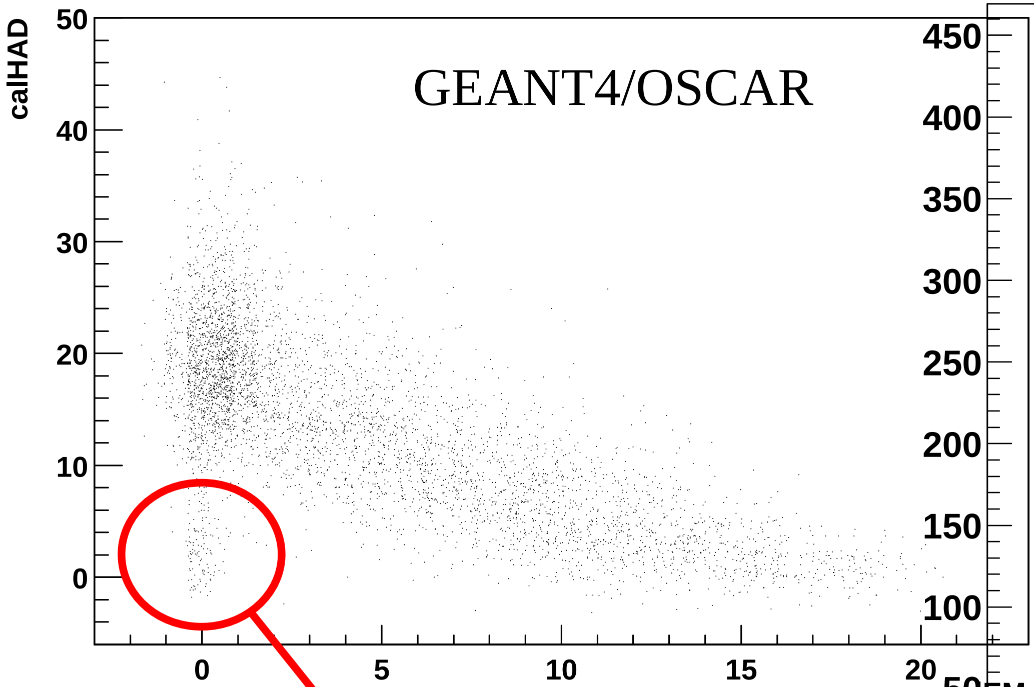
Resolutions: M.C. & data agree very well

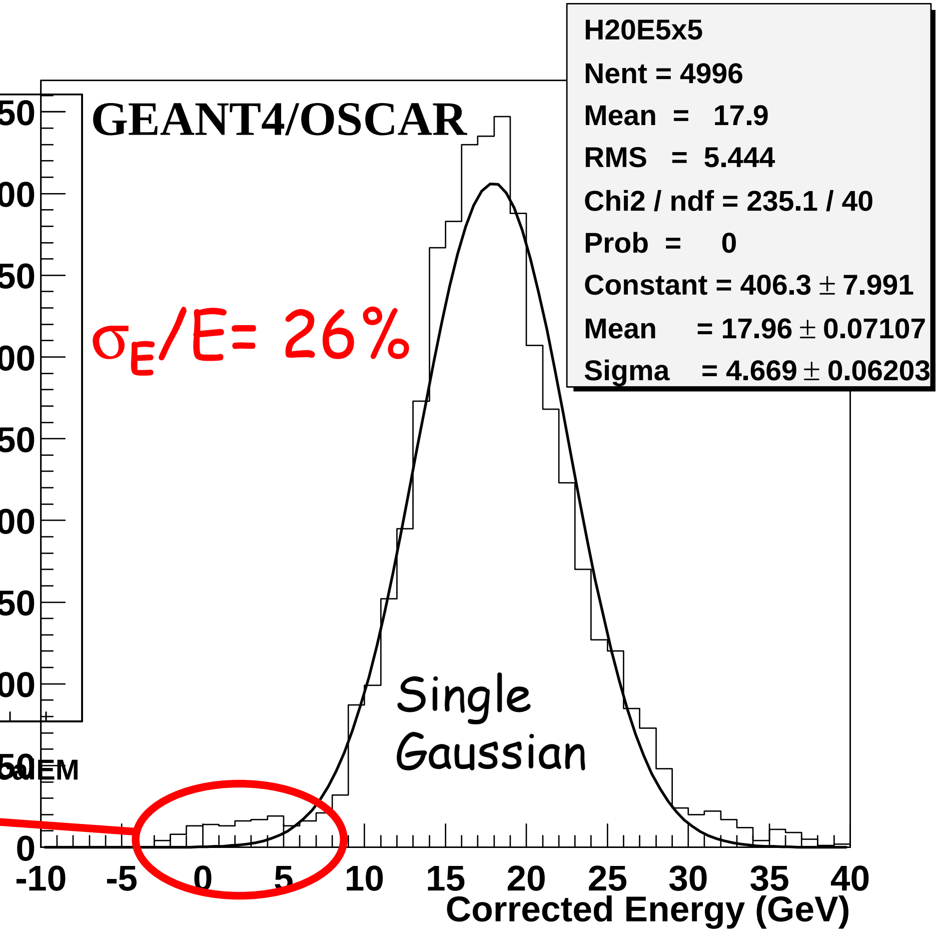
Source of discrepancy could be e/h (e.m. & nuclear x-sec), punch through (shower length) ?

Systematic Studies (I)

Use of M.C. to study bias in data measurement & background subtraction cut effects

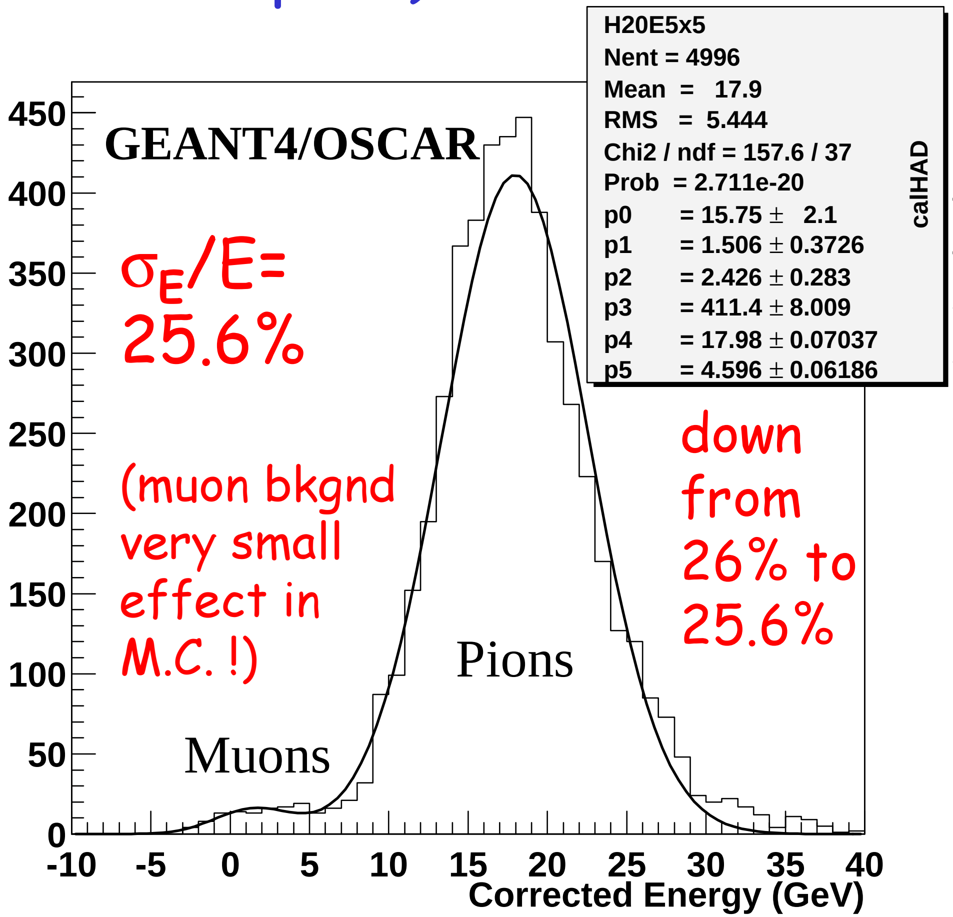
Is the M.C. derivation also biased due to muon background?





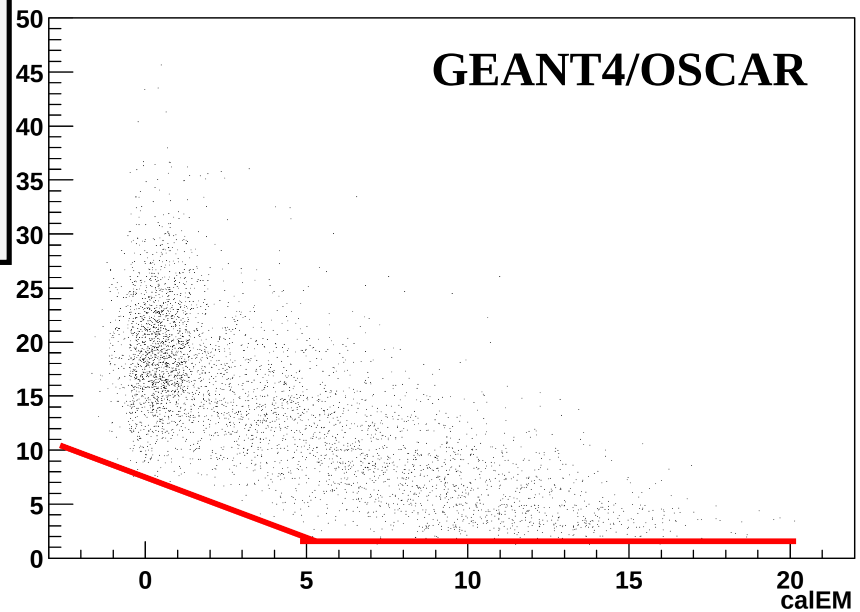
Systematic Studies (II)

Fit double Gaussian (independently pion & muon peak)

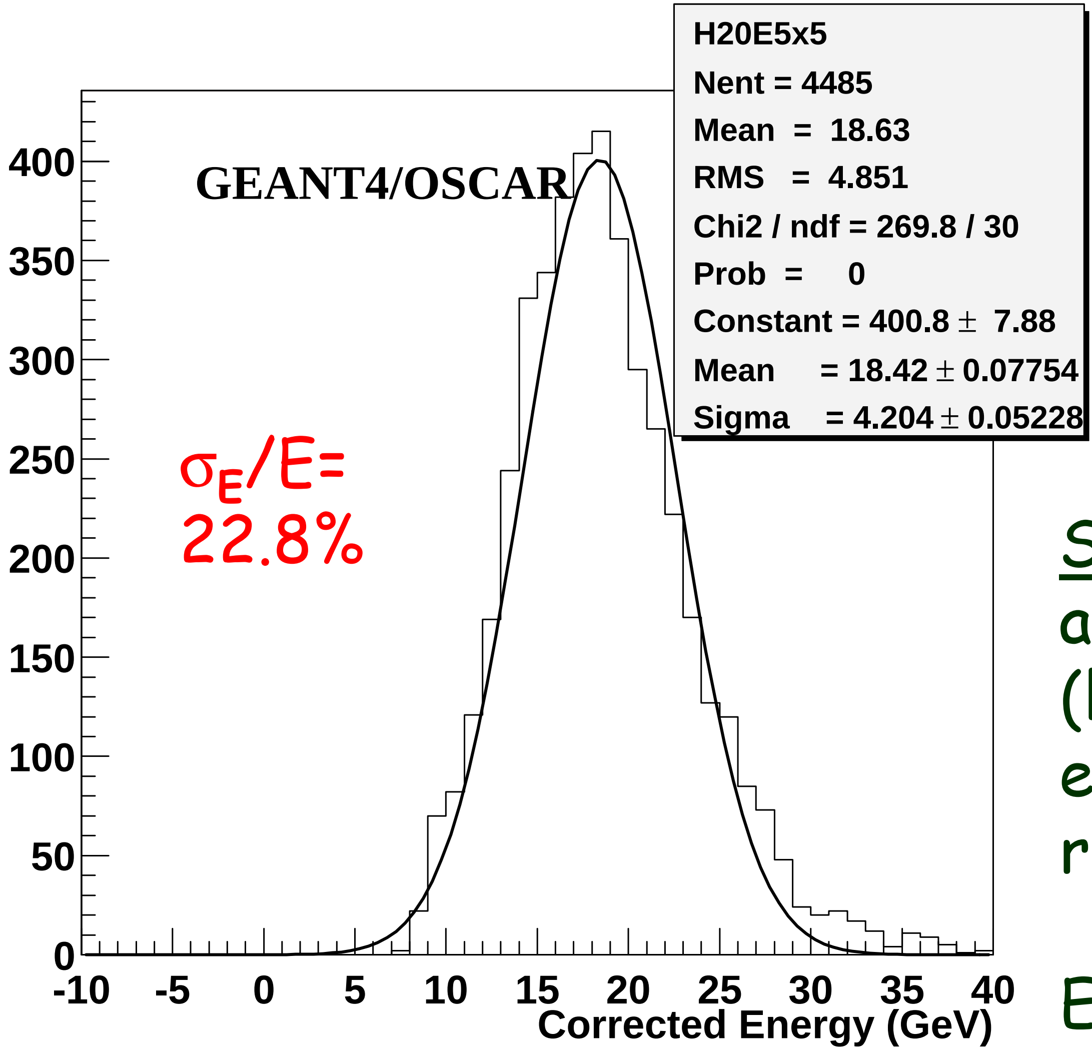


What if I apply the same cut as in the data ?

$E_{hcal}>2$ GeV & $(E_{hcal}+1.3*E_{em})>8$



Systematic Studies (III)



The cuts applied to the data remove a non-negligible fraction of the pion signal:

In M.C: σ_E/E= 25.6 reduced to 22.8%

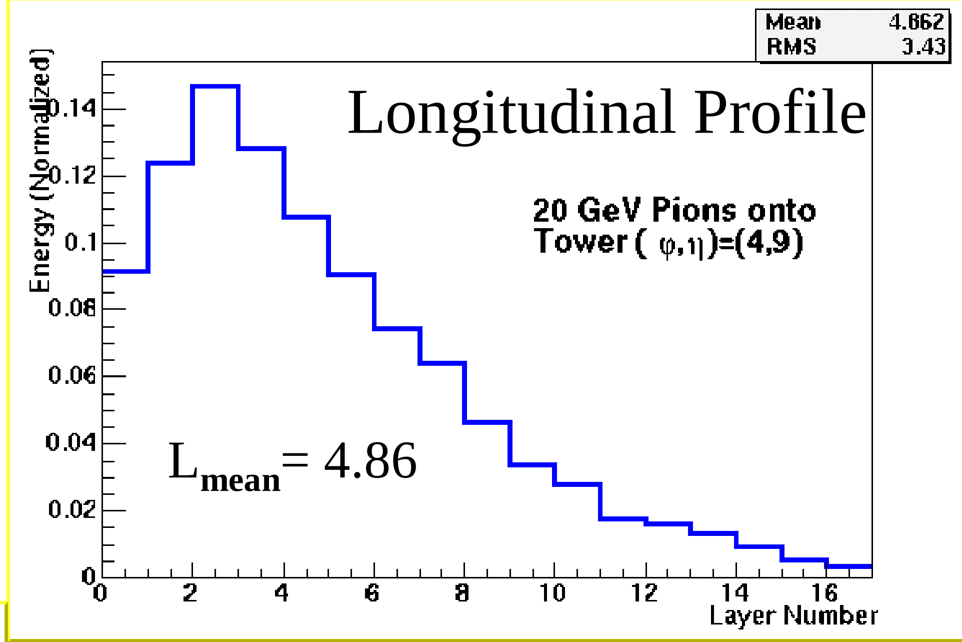
Solution: measure a band around this nominal value (limited by maximum efficiency & maximum rejection)

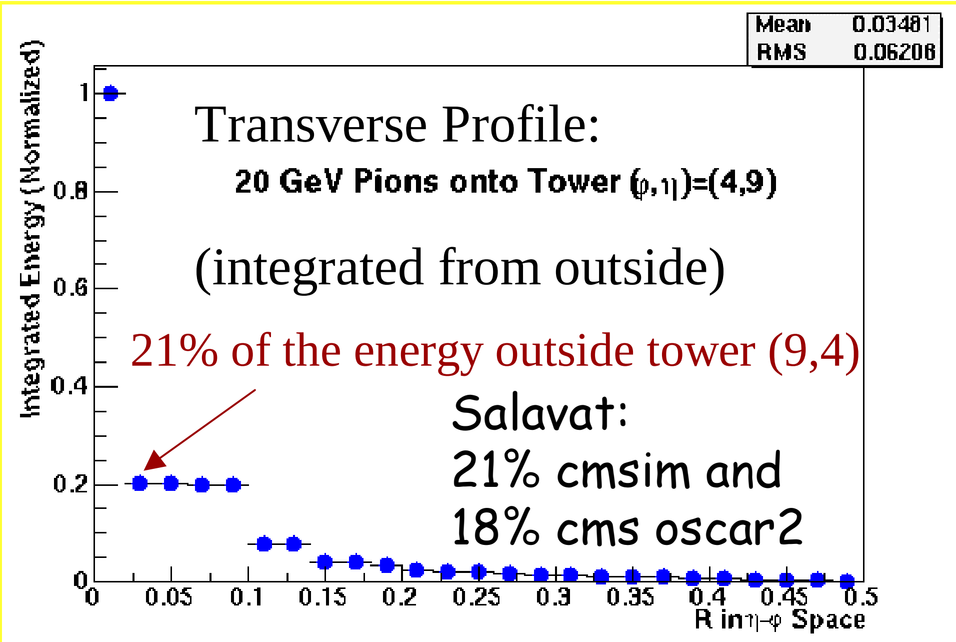
Error shouldn't be more than +-3% for 20 GeV π

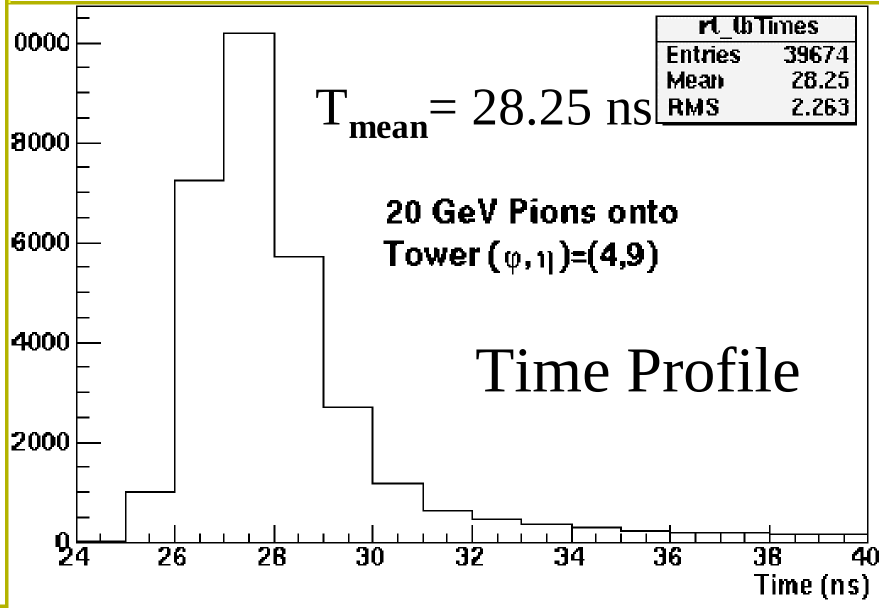
Pion Shower Profiles: 20 GeV

20 GeV pions onto HB tower: $(\eta,\phi)=(9,4)$

Long. Prof. is: $E_{\text{scint layer}}$ fraction (area normalized)



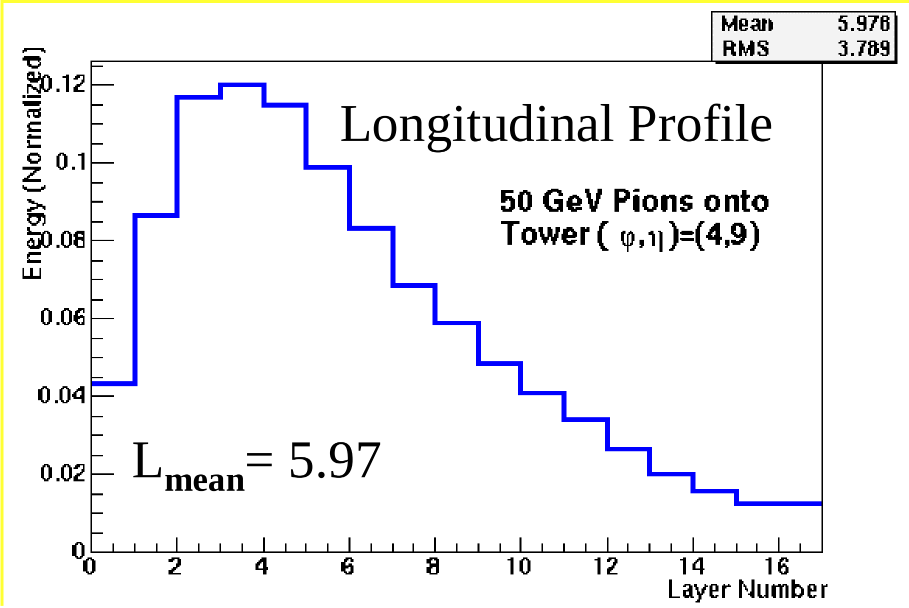


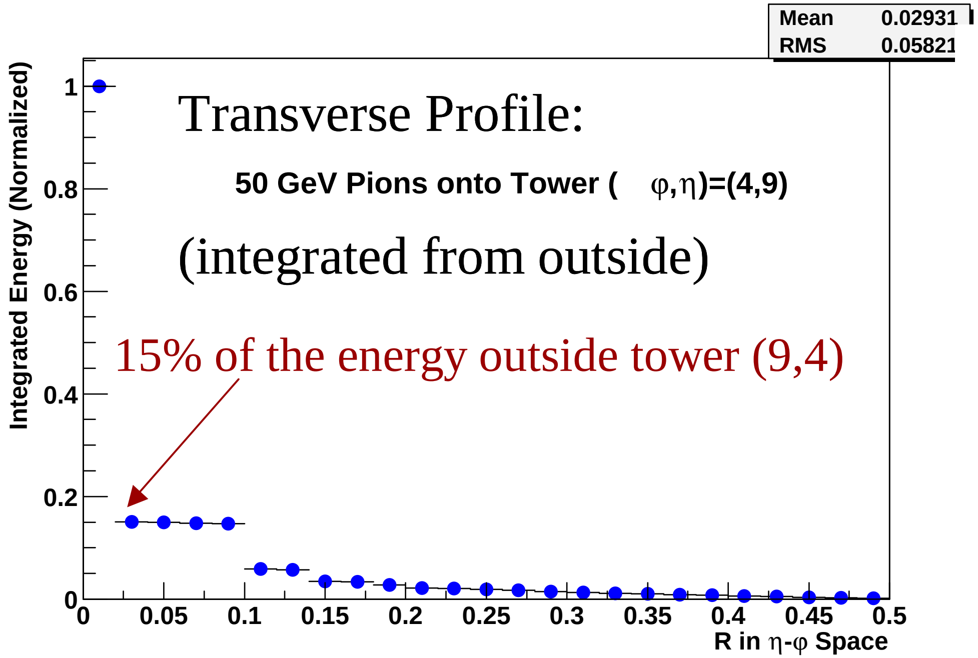


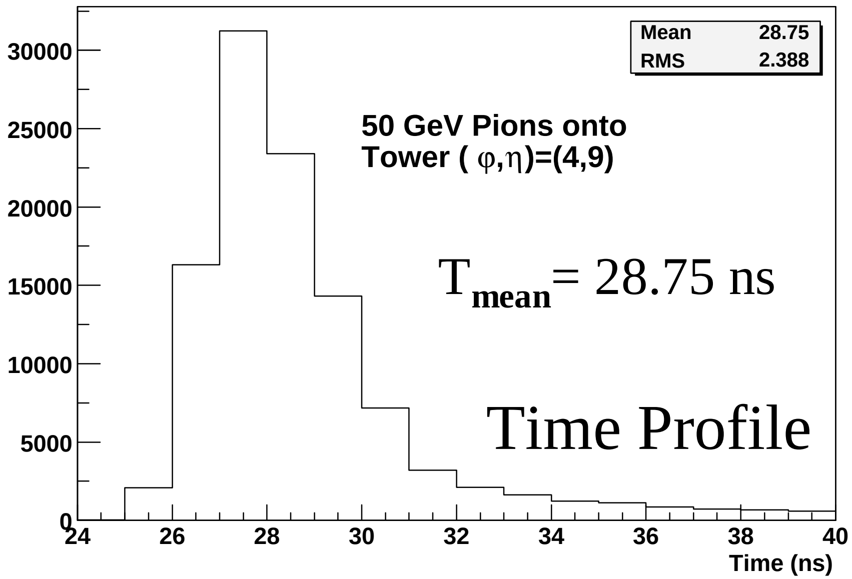
Pion Shower Profiles: 50 GeV

50 GeV pions onto HB tower: $(\eta,\phi)=(9,4)$

Long. Prof. is: $E_{scint\ layer}$ fraction (area normalized)







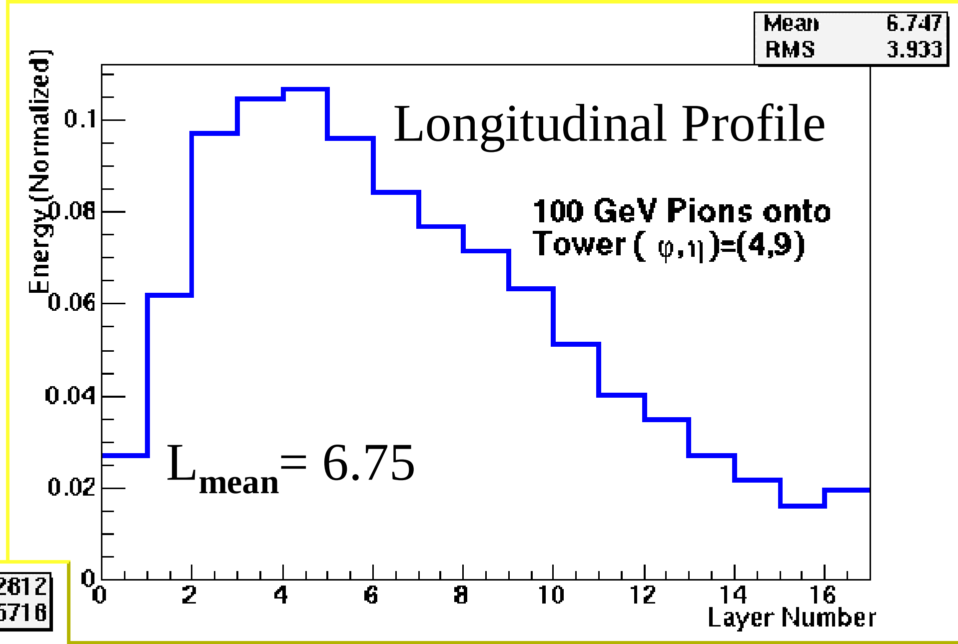
Pion Shower Profiles: 100 GeV

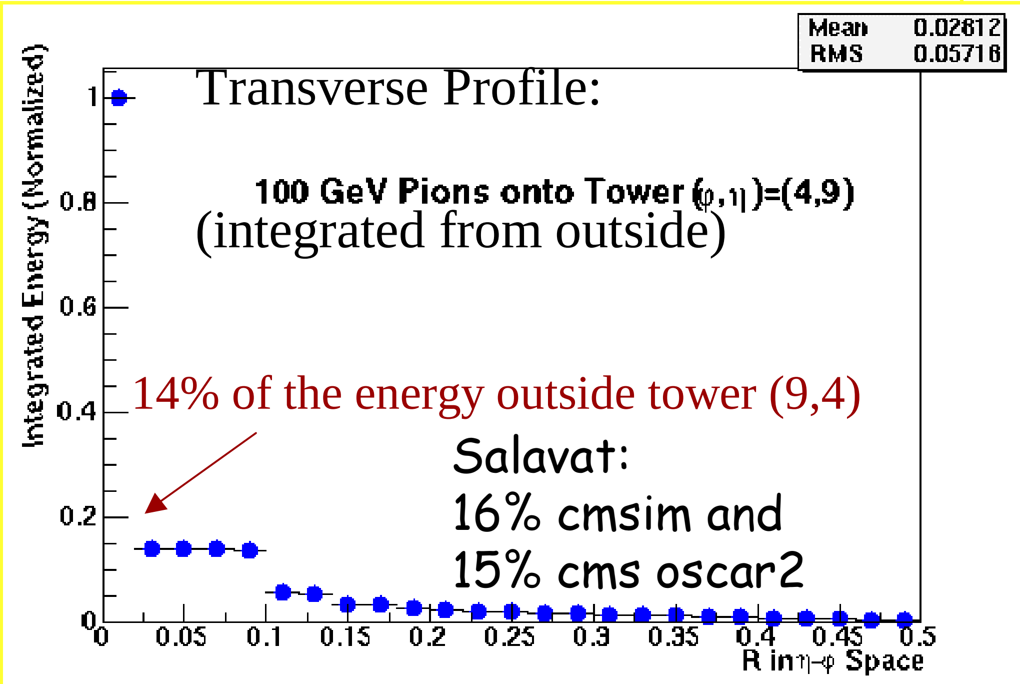
100 GeV pions onto HB tower: $(\eta,\phi)=(9,4)$

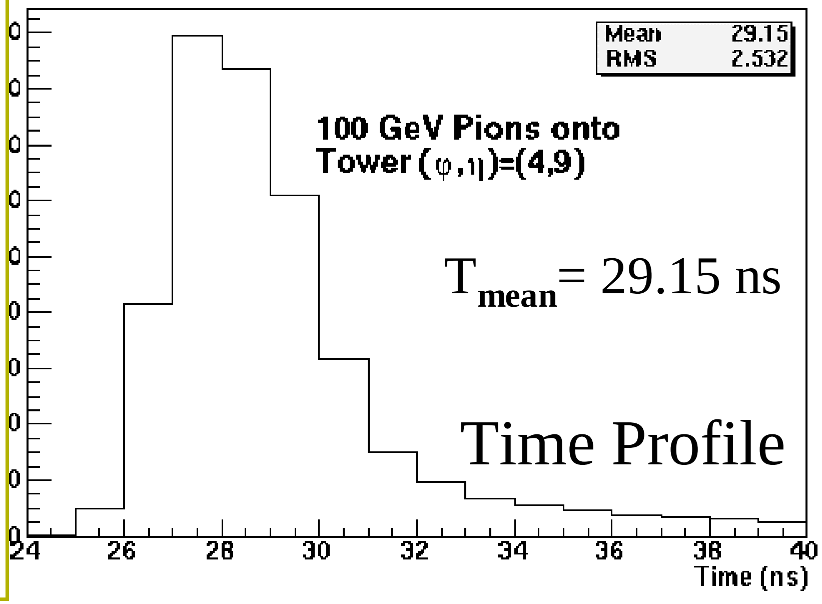
Long. Prof. is:

$E_{scint\ layer}$ fraction

(area normalized)







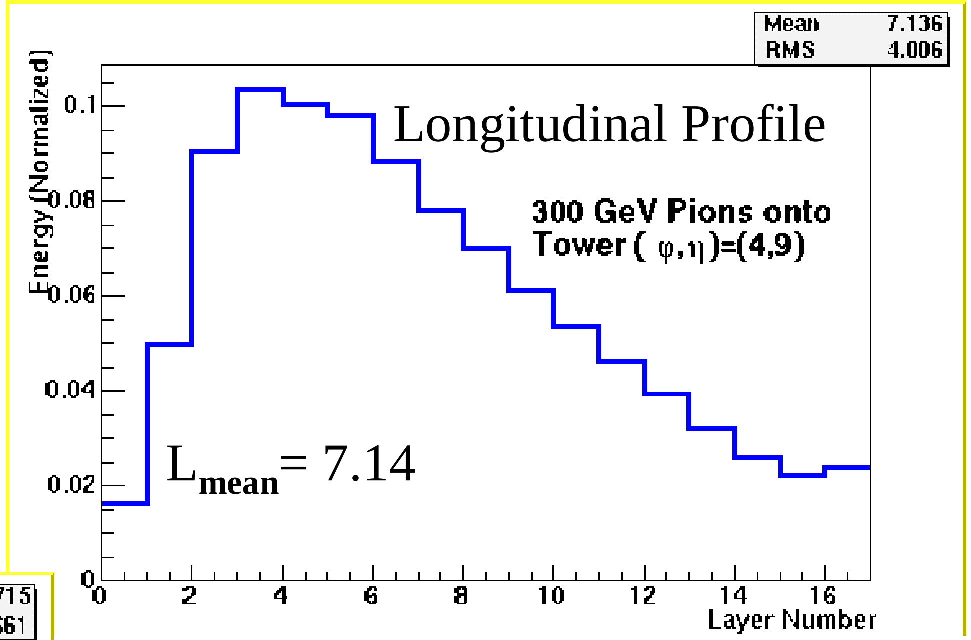
Pion Shower Profiles: 300 GeV

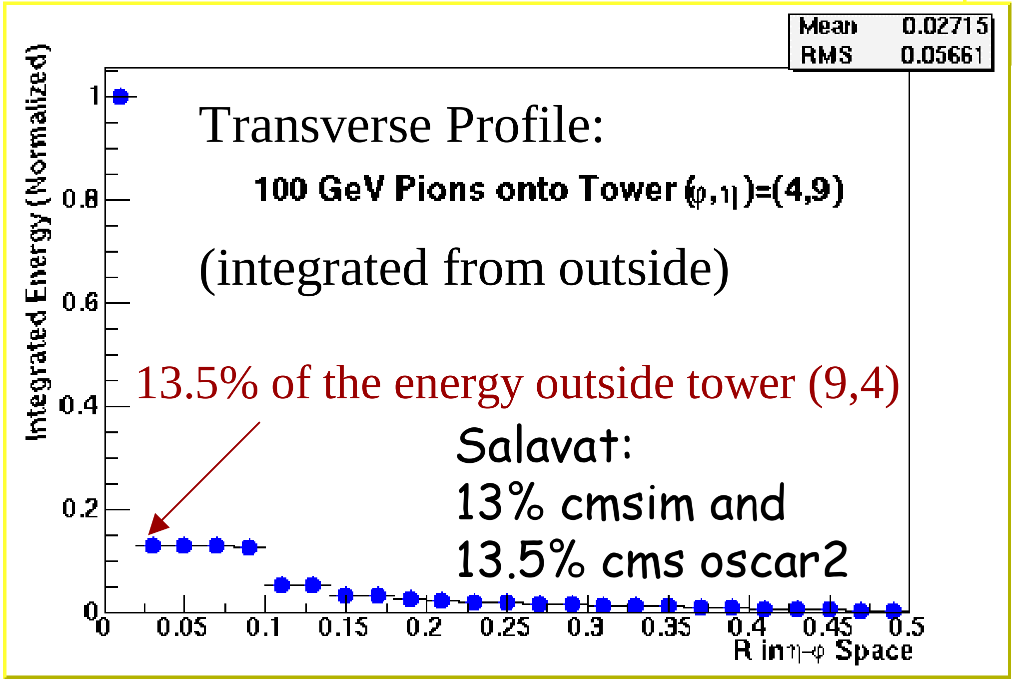
300 GeV pions onto HB tower: $(\eta,\phi)=(9,4)$

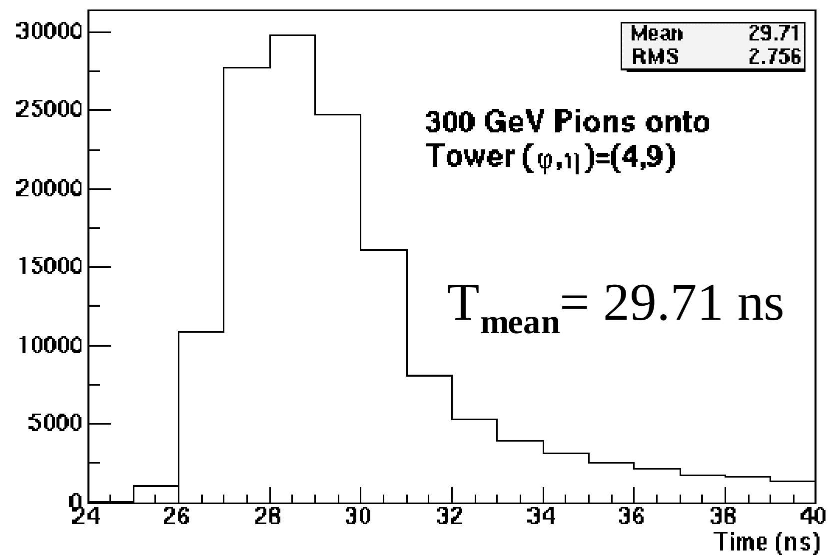
Long. Prof. is:

$E_{scint\ layer}$ fraction

(area normalized)







Technical Issues

- Started migration to OSCAR2.
  - Used ToAscii package to translate G4 geometry to XML files (thanks P.Arce & M. Liendl)
  - Need to produce one per sub-detector to use library Hcal
  - Still to implement analysis package, play with cuts & physics lists
- Delay due to lxplus6 decommissioning since Thurs 22nd jobs pending, crashes (run iteratively in the bckgnd)
- LXPLUX6 replaced by a few "migration nodes" on Friday 30th. It will allow a smother transition to OSCAR2.

Conclusions

Significant progress since last CMS week in February

Need to:

- Understand data systematics (Jordan?)
- Complete OSCAR1 to OSCAR2 transition
- Play with cuts, physics lists
- Physics validation conclusions (TB02) & document