G4 (OSCAR_1_4_0) Validation of CMS HCal

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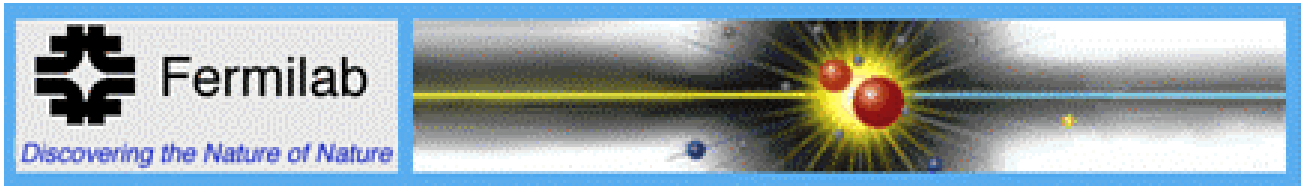
Fermilab

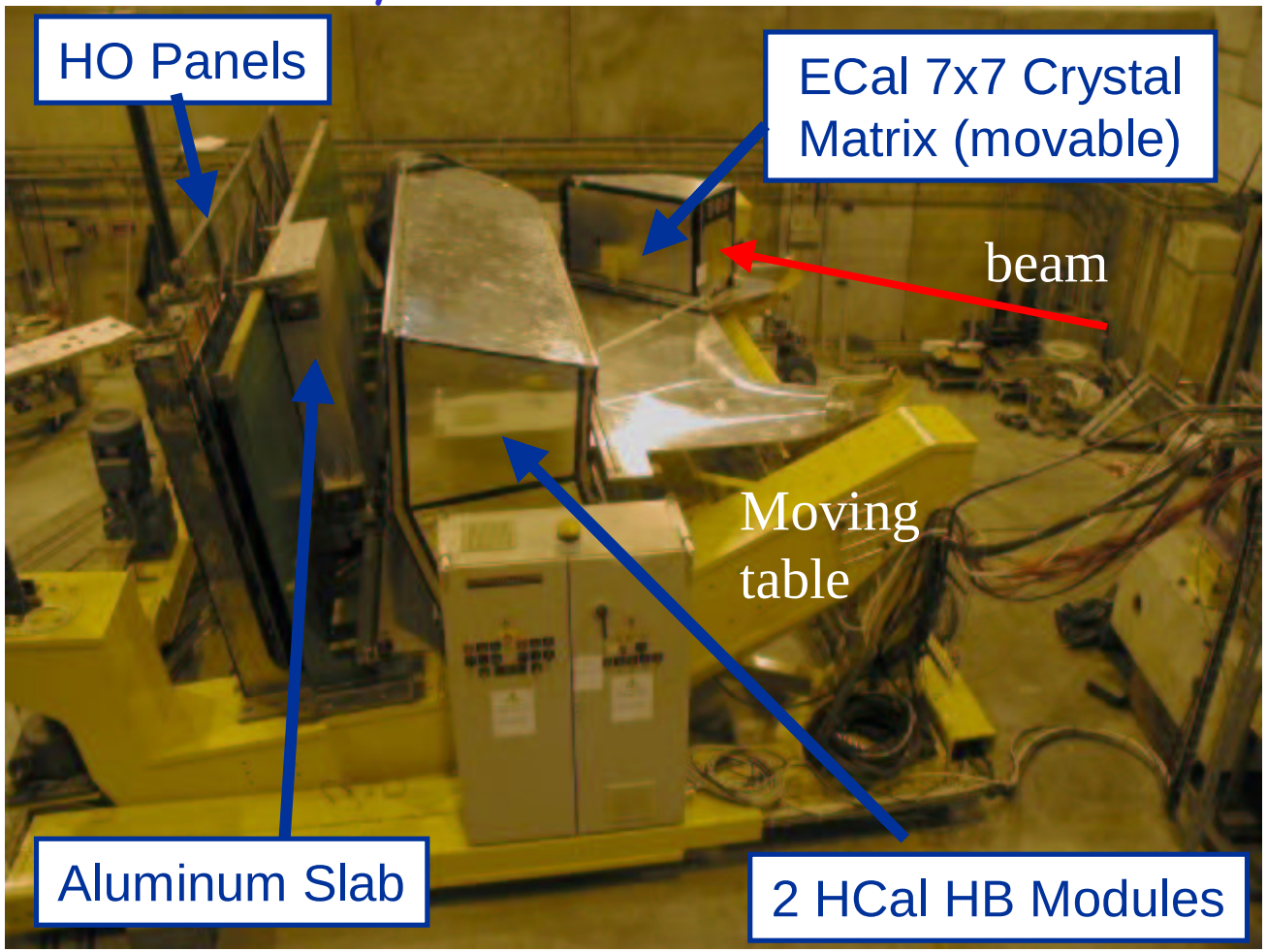


General Description

- Simulate HCal test beam 2002 setup using OSCAR_1_4_0, physics list 1.8
- Includes beam line (trigger scint. tiles, wire chambers), ECal box, HB, HO, aluminium slab (representing magnet), iron (muon) layer
- Mimic the data analysis, including calibration from electrons (ECal) and pions (HB): study resolution, response (linearity), transverse shower profiles
- Compare with data measurements for G4 validation

HCal 2002 Test Beam

Small scale experiment to demonstrate that HCal works:
49 ECal crystals, 144 HB channels, 16 HO channels.

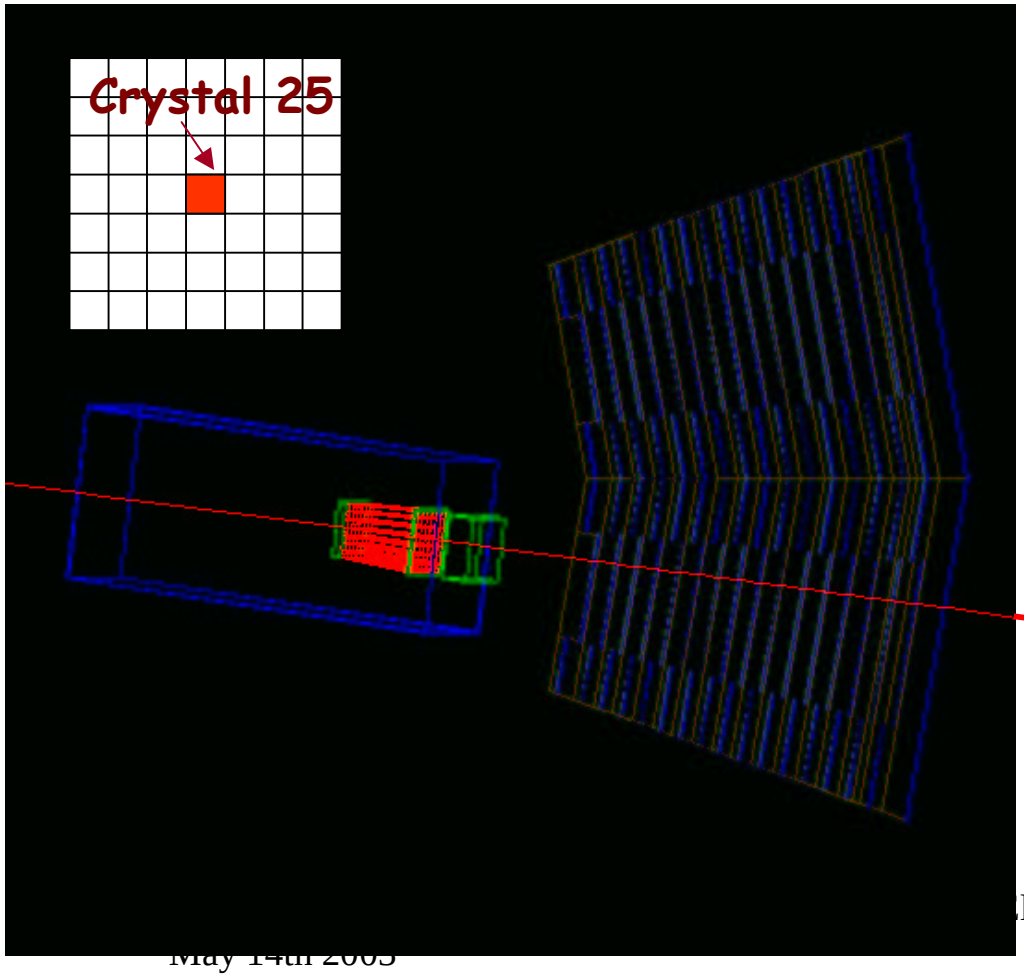


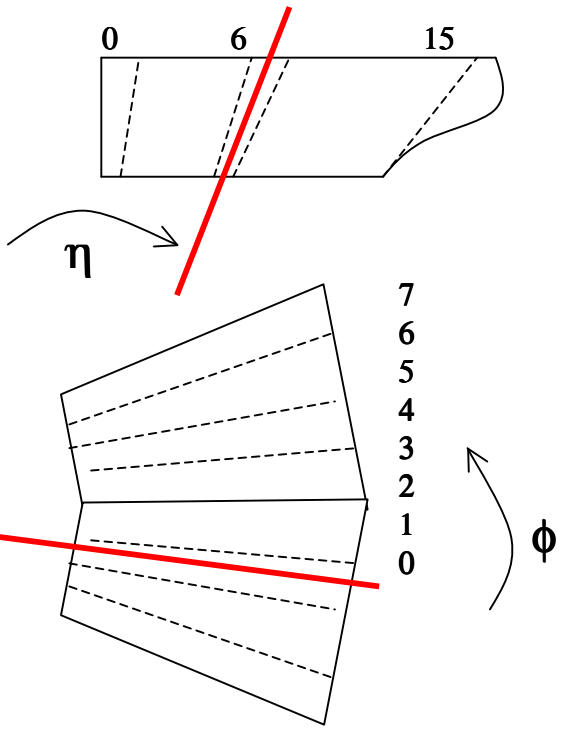
Over 100 Million Events!

μ^-: 225 GeV
e^-: 20,30,50,100 GeV
π^-: 20,30,50,100, 300 GeV

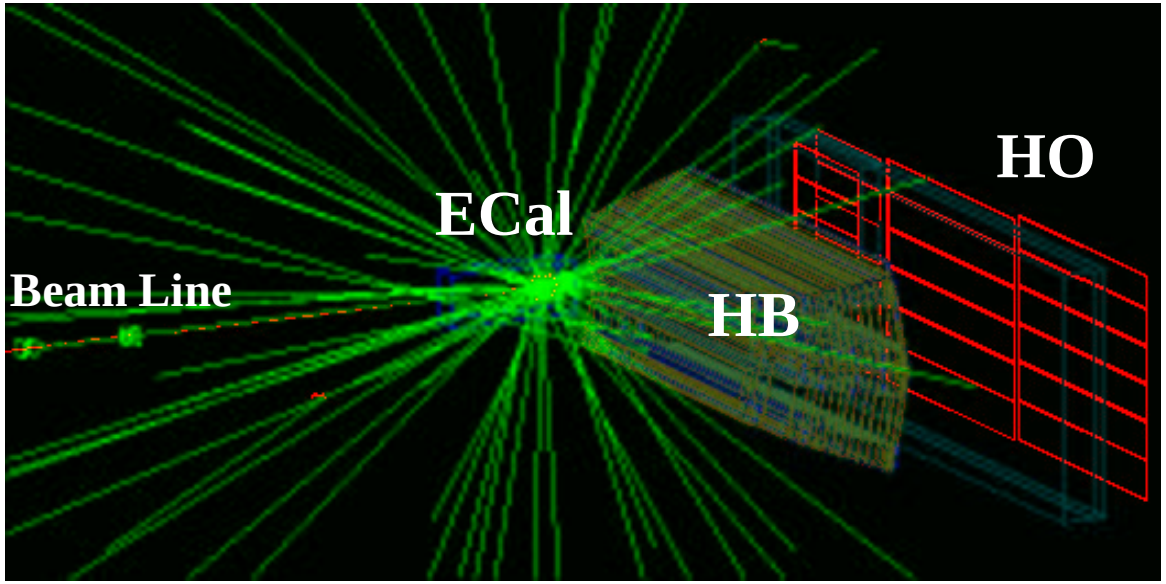
TB02 Simulation (OSCAR/G4)

Based on 1-5,000 π^- events onto the $(\eta,\phi)=(6,2)$ tower of the HB and crystal 25 of the ECal matrix



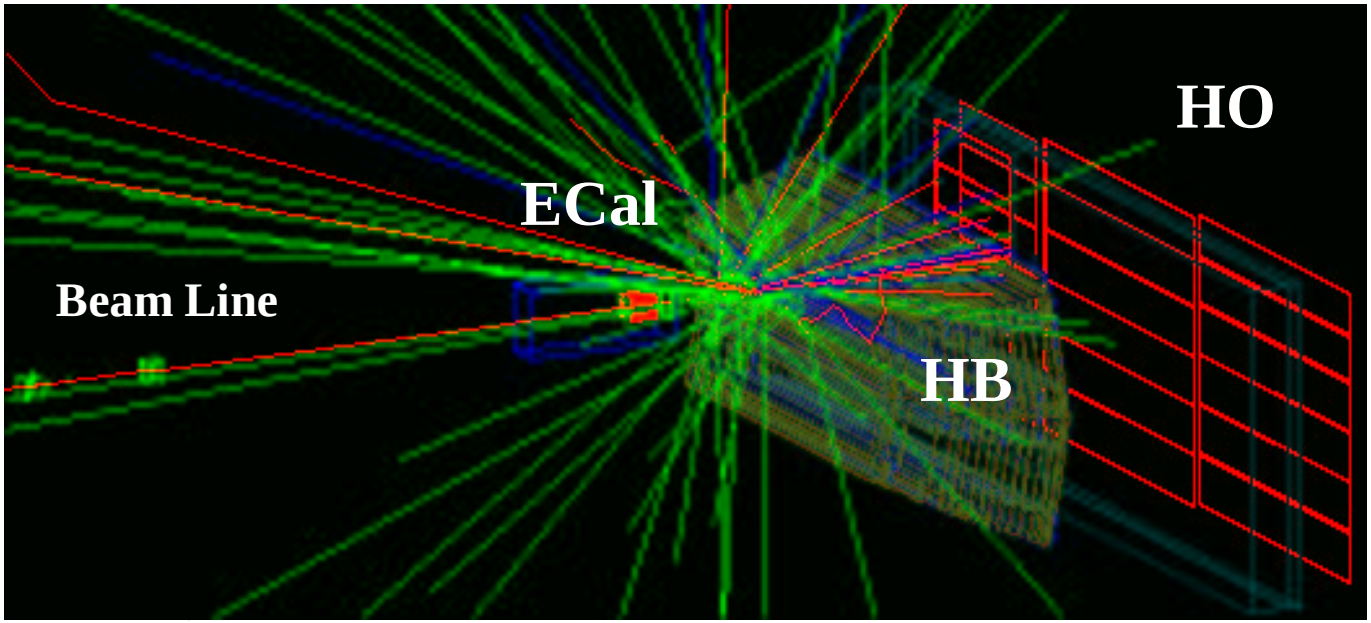


TB02 Simulation (OSCAR/G4)



Angle view of the full TB02 detector

10 GeV electron



100 GeV pion

Improved M.C. Simulation

$$E^{\pi}_{corr} = 122 * E^{HB}_{5x5} + 1.05 * E^{ECal}_{3x3}$$

Calibration factors (already there in previous presentation)

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

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

$$E^{HB}_{scint} \longrightarrow E^{HB}_{scint} + 0.1 * E^{HB}_{scint}\ MeV * Rand$$

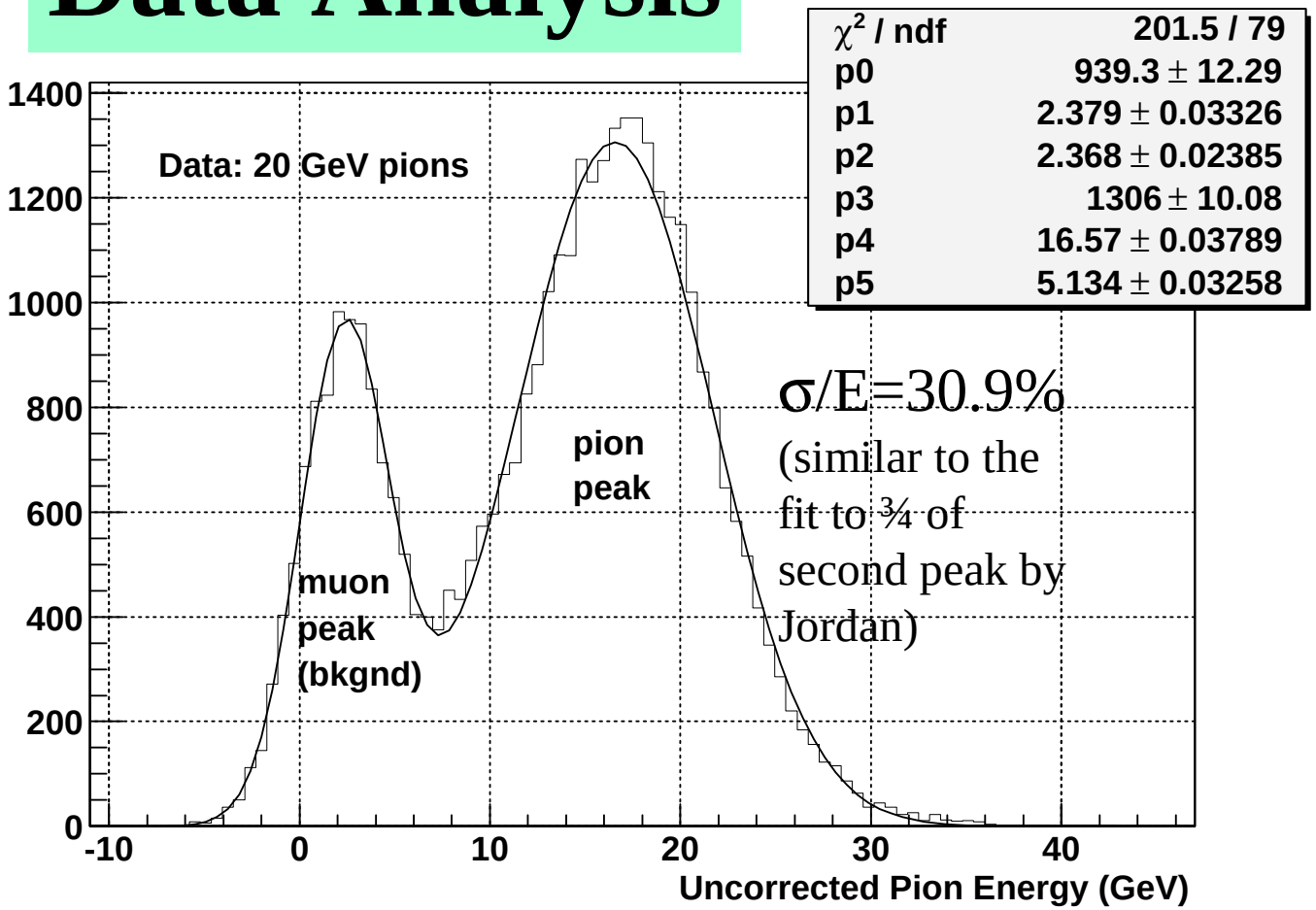
Long. Non-uniformity

$$E^{HB}_{tower} \longrightarrow E^{HB}_{tower} + 262\ MeV * Rand$$

Electronic Noise

- 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

Data Analysis

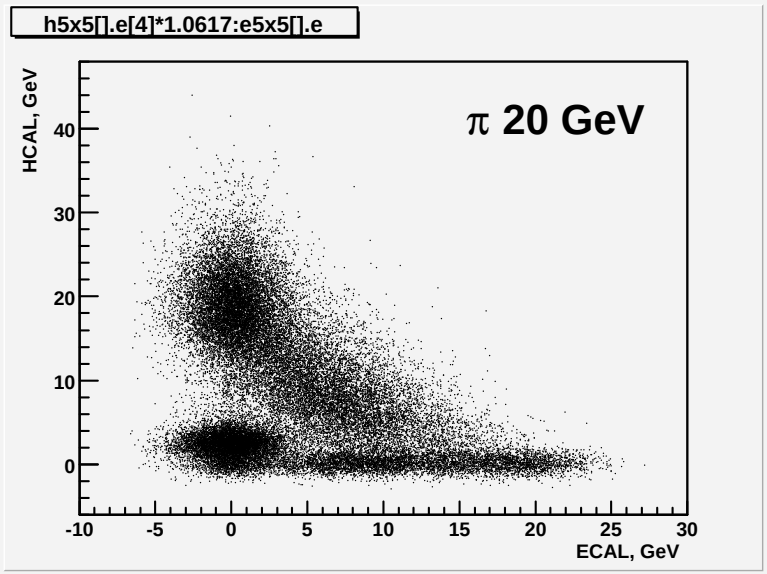


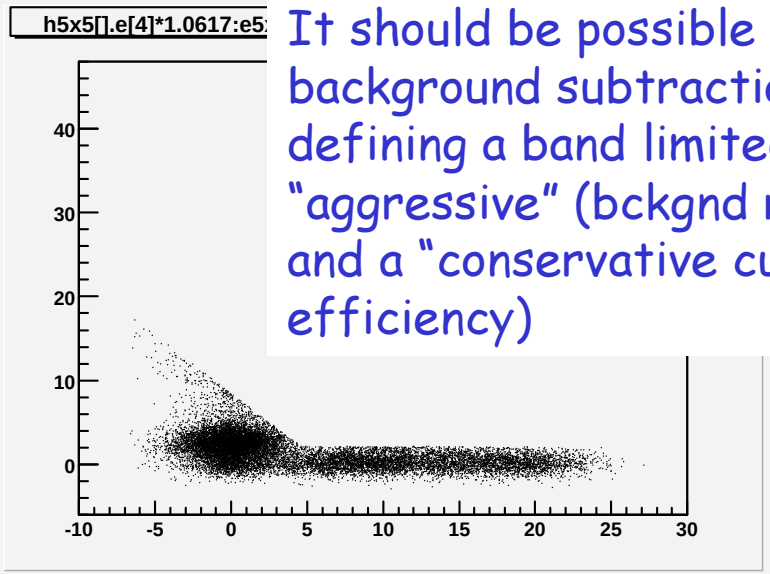
Data analysis: sources systematic errors:

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

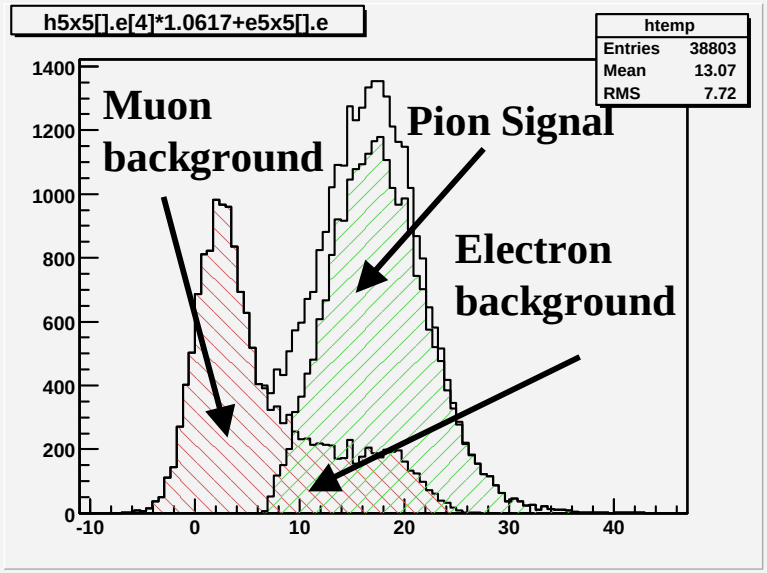
TB02: π σ_E/E and e/π

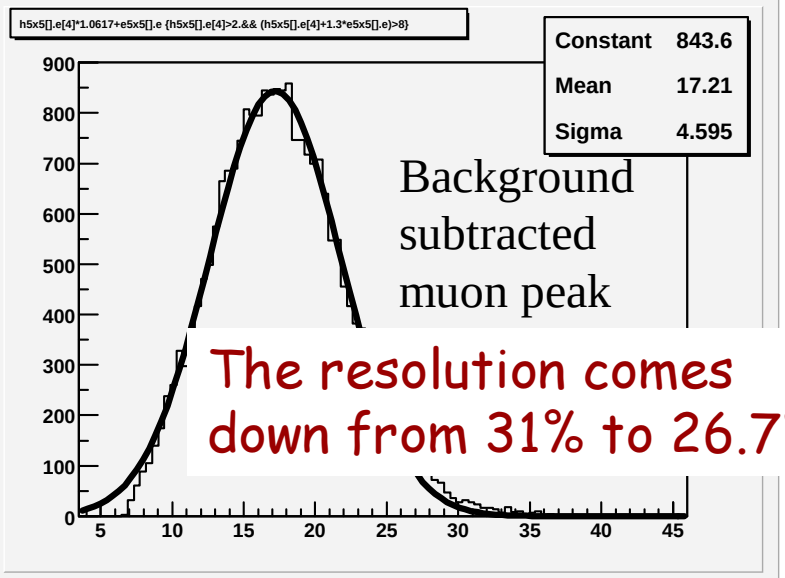
From J.Damgov





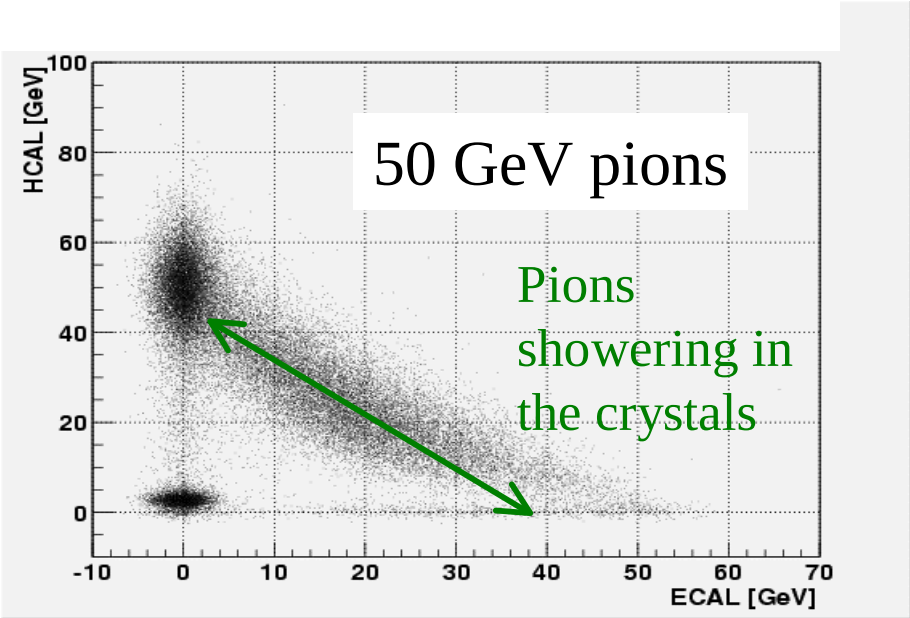
It should be possible to estimate background subtraction error by defining a band limited by an "aggressive" (bckgnd rejection) and a "conservative cut" (signal efficiency)



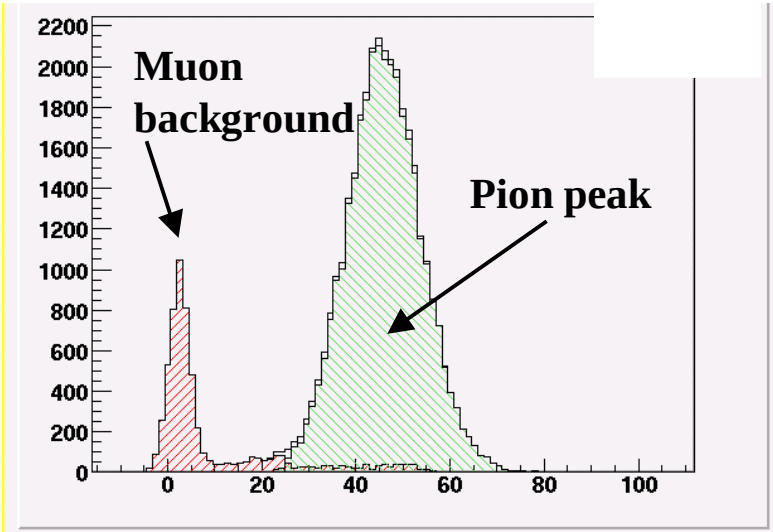


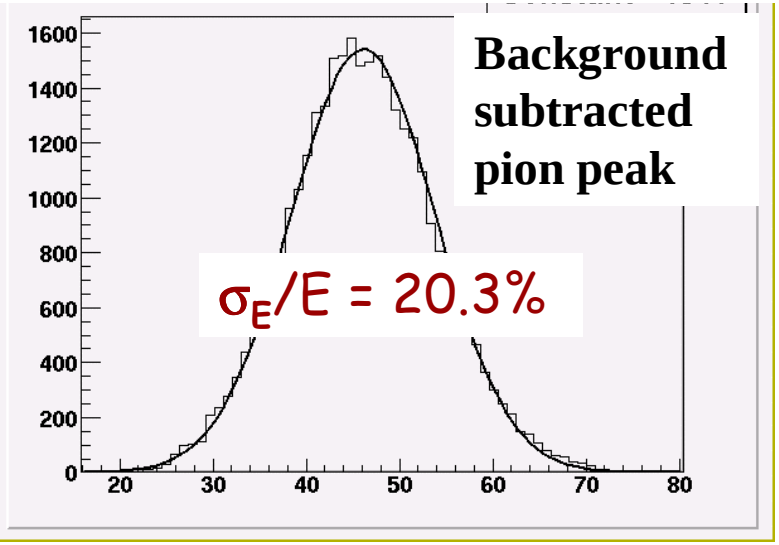
The resolution comes down from 31% to 26.7% !

TB02: π σ_E/E and e/π

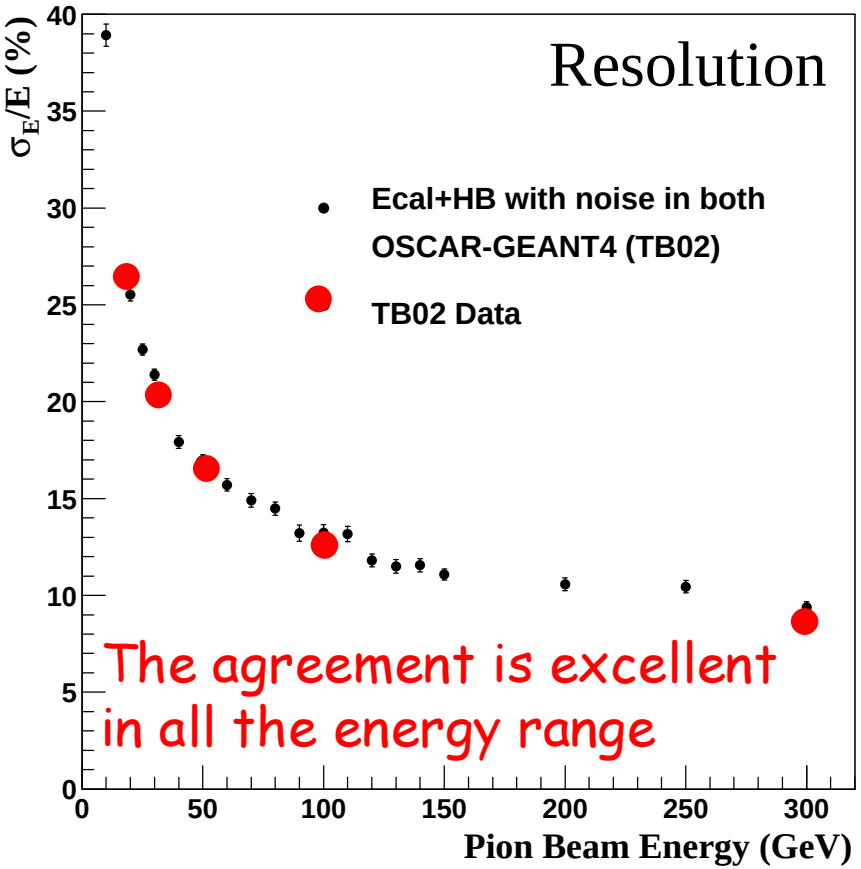


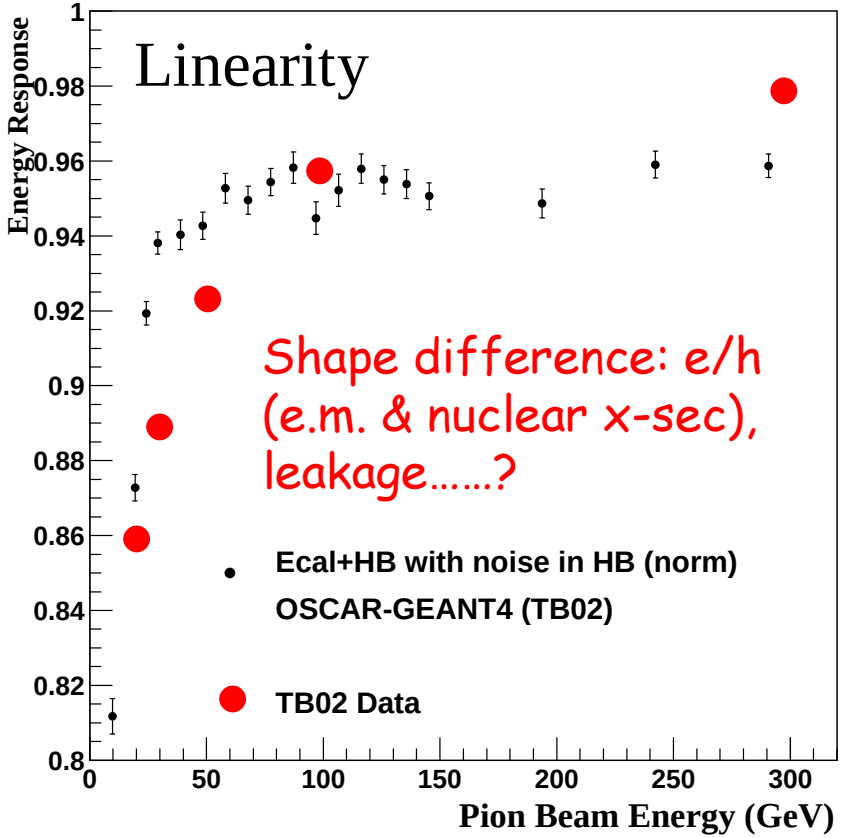
Data energy resolution for 50 GeV pions (almost negligible background close to the pion peak)





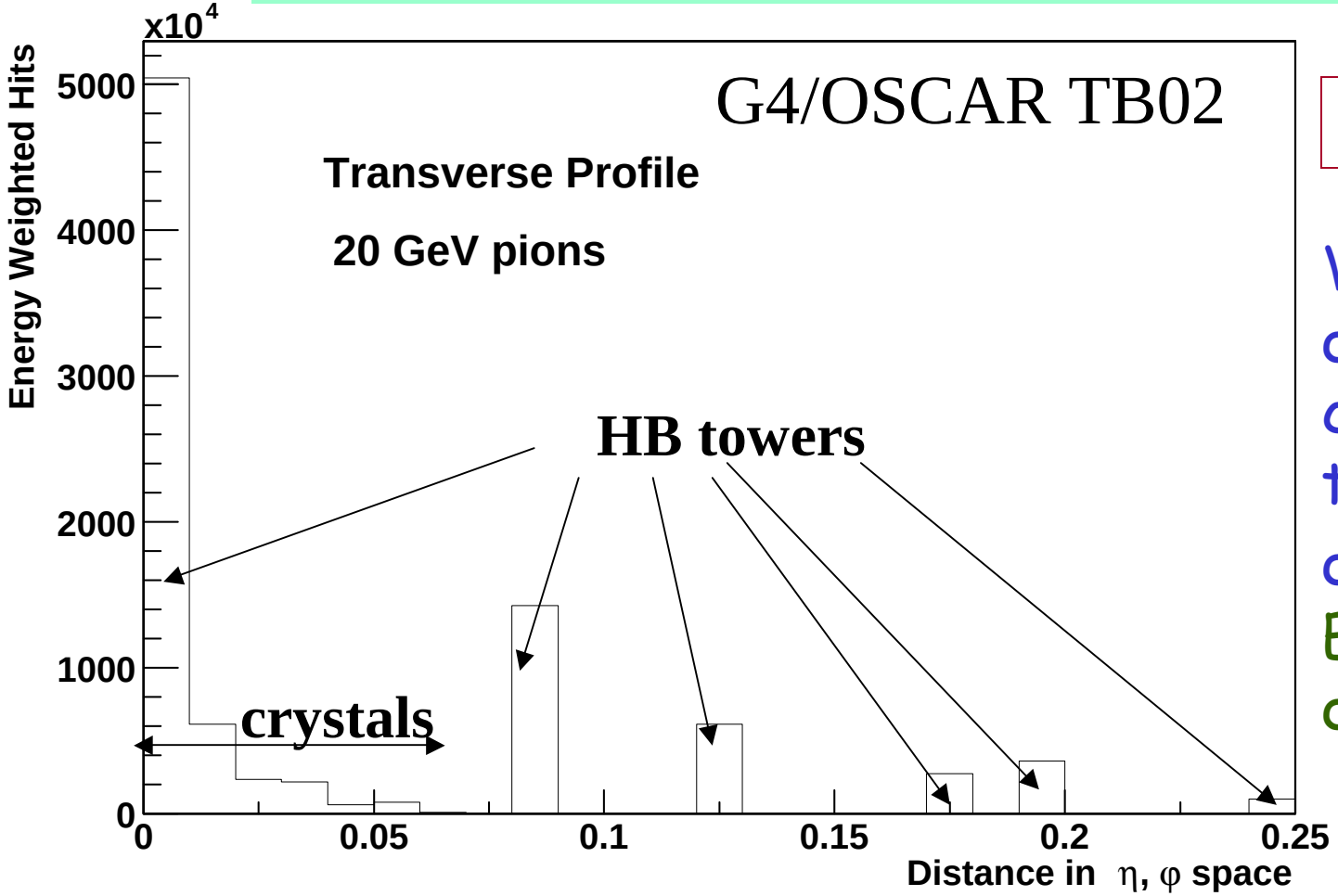
TB02: π σ_E/E and e/π





Data systematic error analysis in progress → Validate GEANT4 physics models

Transverse Shower Profile



Fill (D, E)

With D: distance of crystal/tower to the pion direction

E: energy deposition

Future: remove ECal, add integrated profiles, longitud. profile studies, HO fraction & compare with OSCAR CMS & CMSIM (Salavat), and TB data (Jordan)

Summary & Plans

- TB02 OSCAR_1_4_0 fully functional. Validation studies in progress, for week data uncertainties are essential.
- Need to port the simulation to OSCAR_2, hopefully for next CMS week in June

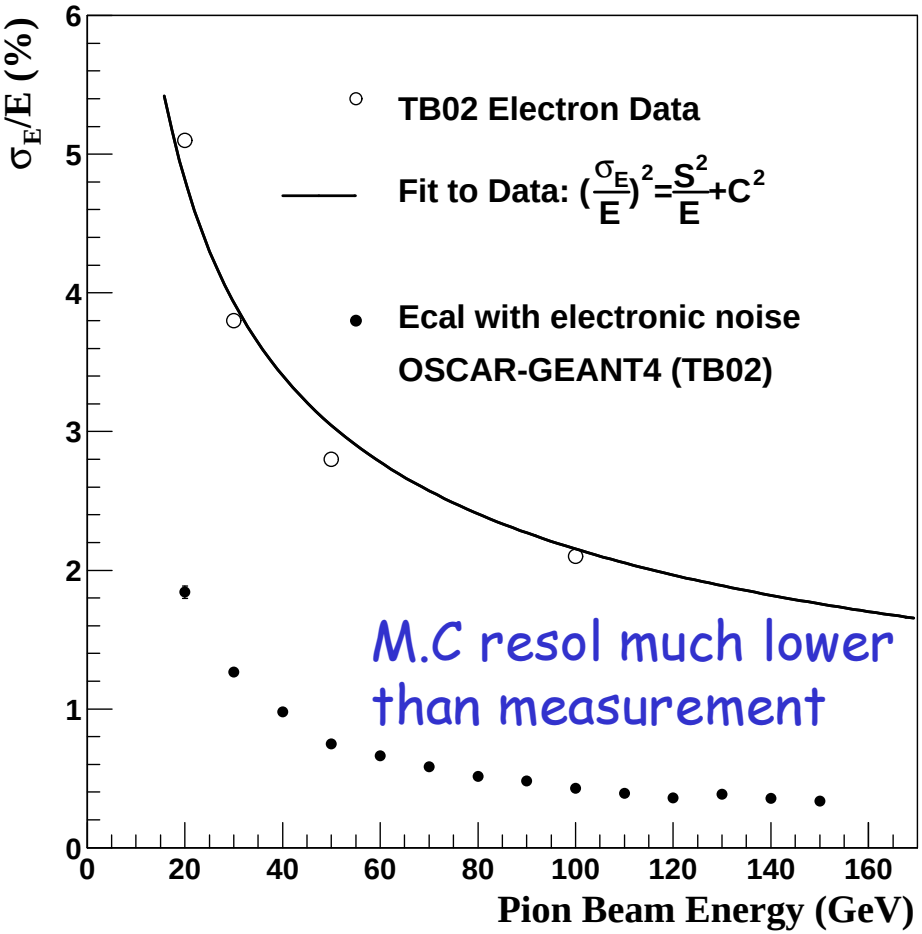
  fighting technical problems related to translation to XML, among other things
- Document on TB02 M.C. simulation by July

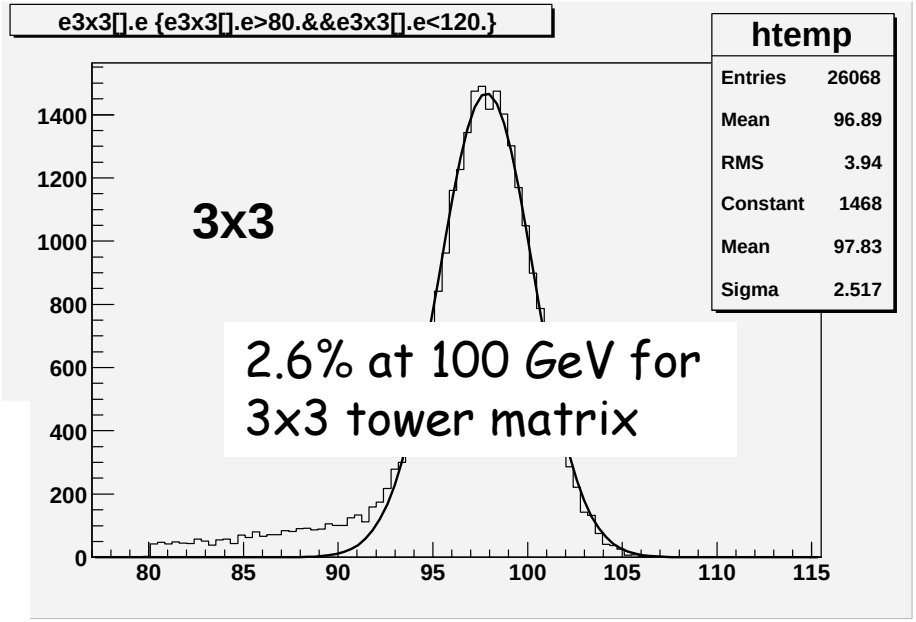
Data & MC Electron Resolution

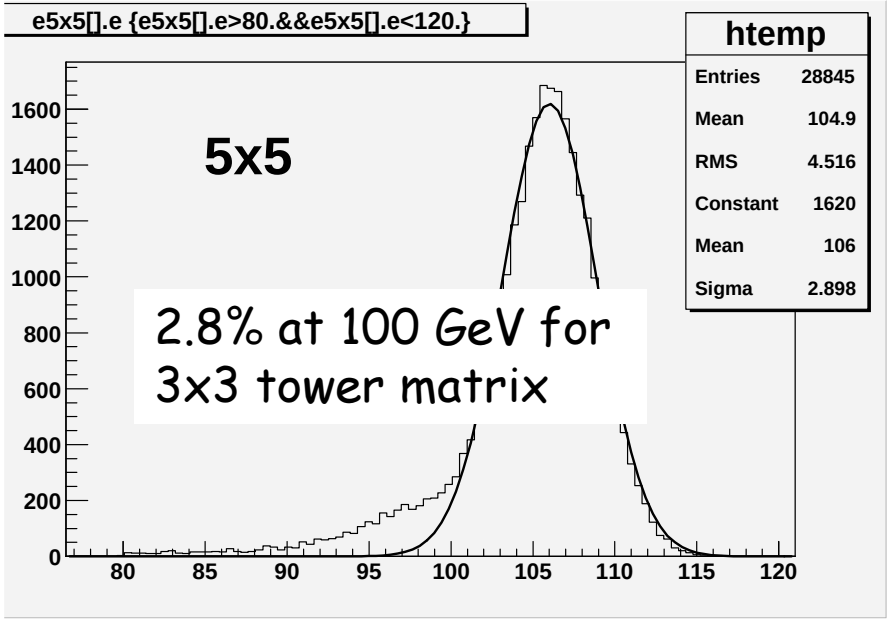
E^{ECal}_{tower} E^{ECal}_{tower} + 115 MeV * Rand

TB02 Data

Electronic noise







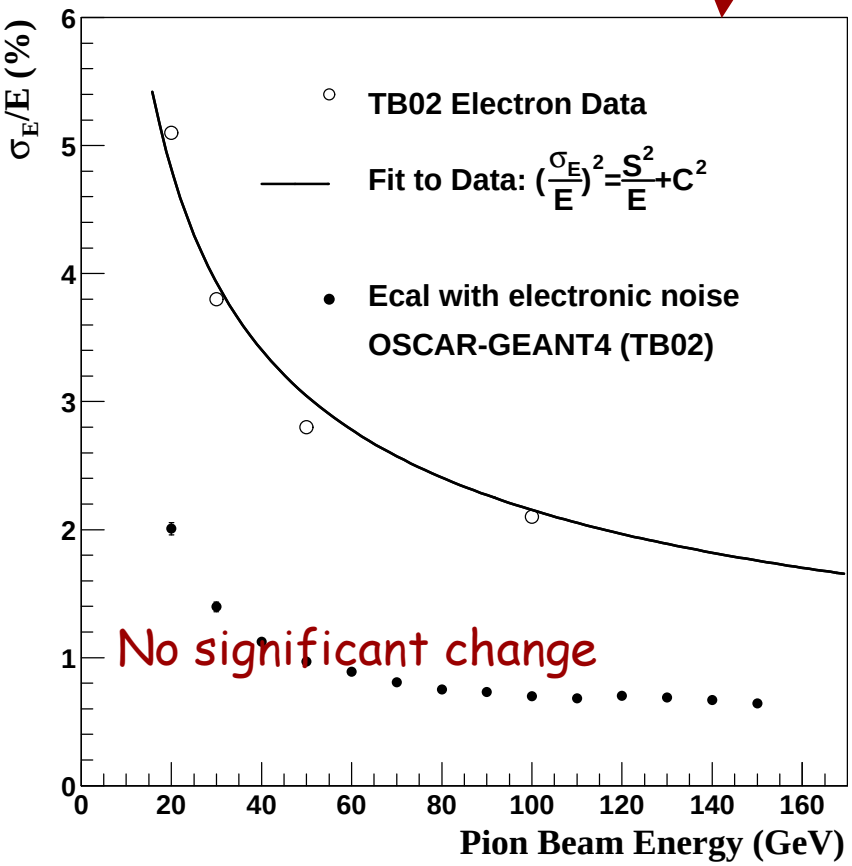
Other Contributions

- $E^{ECal}_{tower} \rightarrow E^{ECal}_{tower}$ + 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)

TB02 Data



TB02 Data