Study of the ATLAS barrel calorimeters response to pions using 2004 combined test beam data

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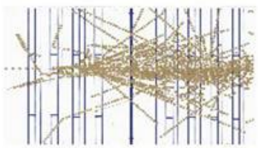
On behalf of the ATLAS TileCal collaboration



CALOR 2006 – Chicago

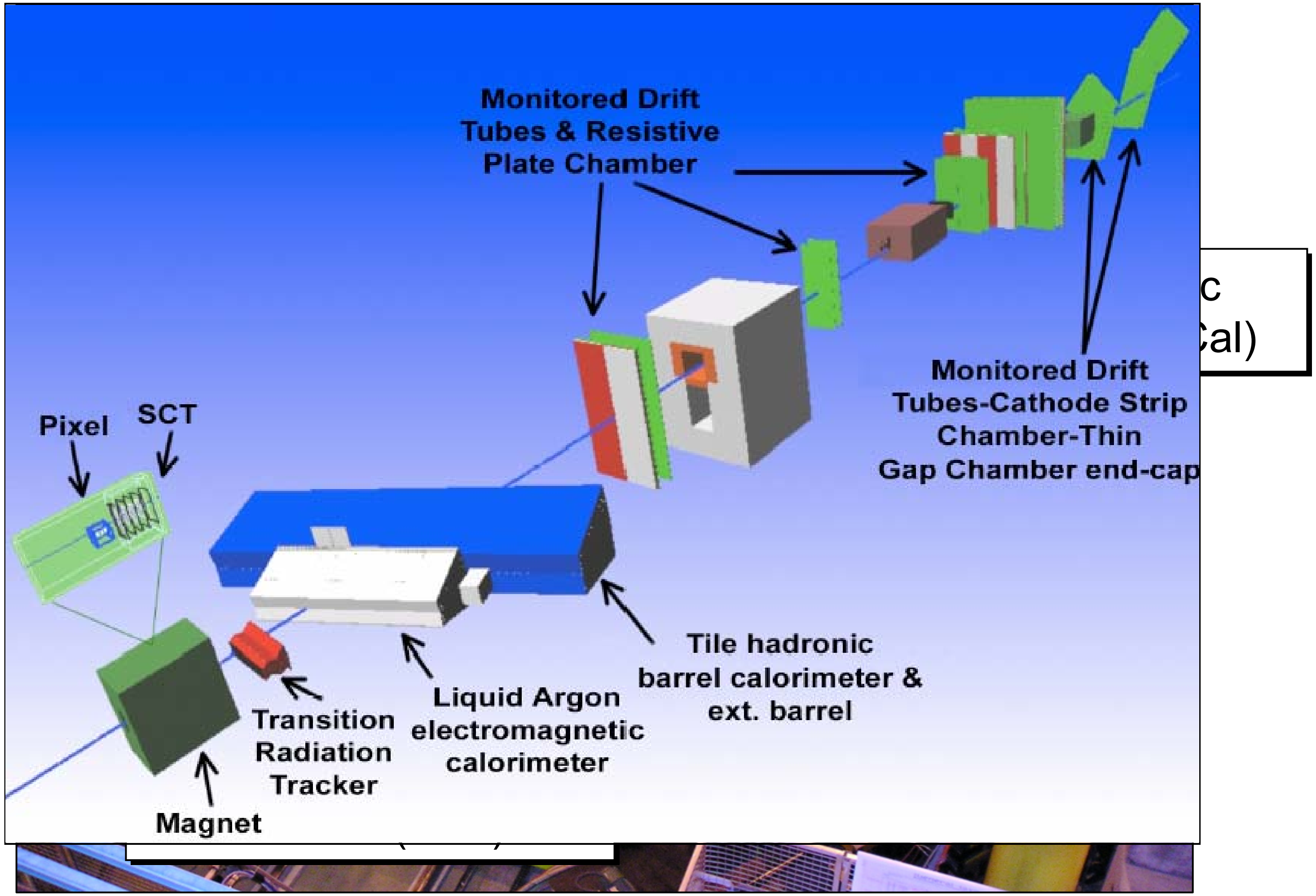
Outline

- The combined calorimetry setup at 2004 test beam
- Study of pions starting to shower in the hadronic calorimeter
- Study of pions showering both in the electromagnetic and hadronic sectors
- Study of low energy pion response (E<10 GeV)

The results can be used in ATLAS to establish the jets absolute energy scale : tuning of the simulation on the test beam results

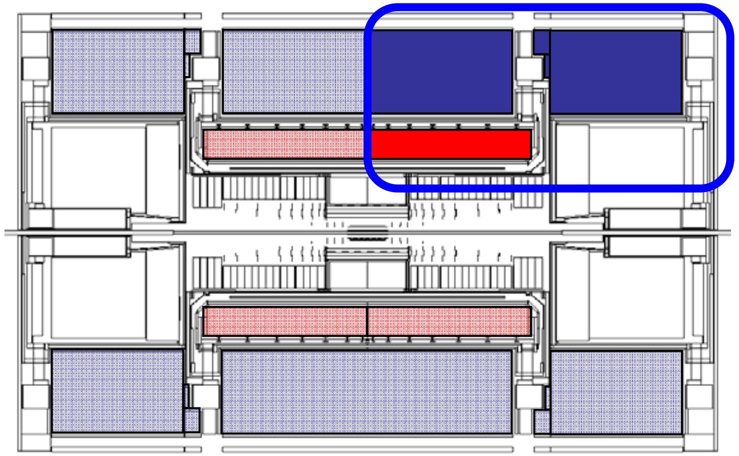
2004 Combined test-beam

- Integration of a realistic ATLAS combined slice to test combined detector performance



Central calorimetry in 2004 combined testbeam

ATLAS setup

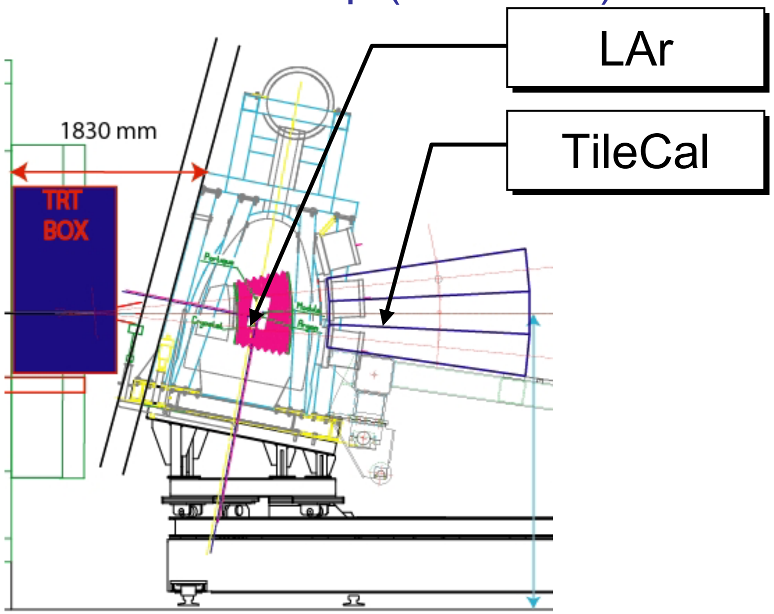


- **EM (LAr)** : Liquid Ar/lead ⇒ in a cryostat

  1 preshower + 3 longitudinal layers ($24X_0$)
- **HAD (TileCal)** : scintillating tiles/iron

  3 longitudinal compartments (9.2λ)

Testbeam setup (side view)



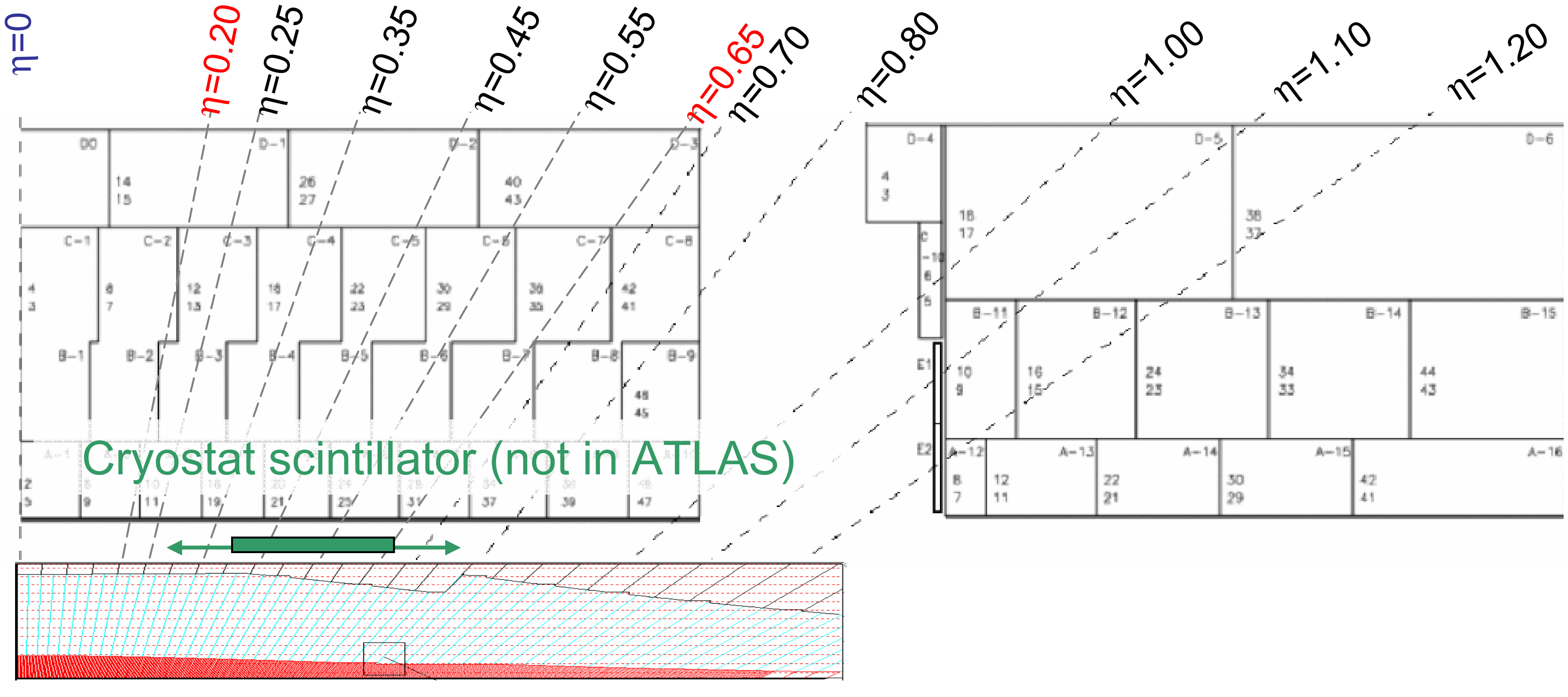
- **LAr**

  coverage : $0<\eta<1.4$ $-0.2<\varphi<0.2$
- **TileCal**

  coverage : $0<\eta<1.2$ $-0.15<\varphi<0.15$

Data sample and energy reconstruction

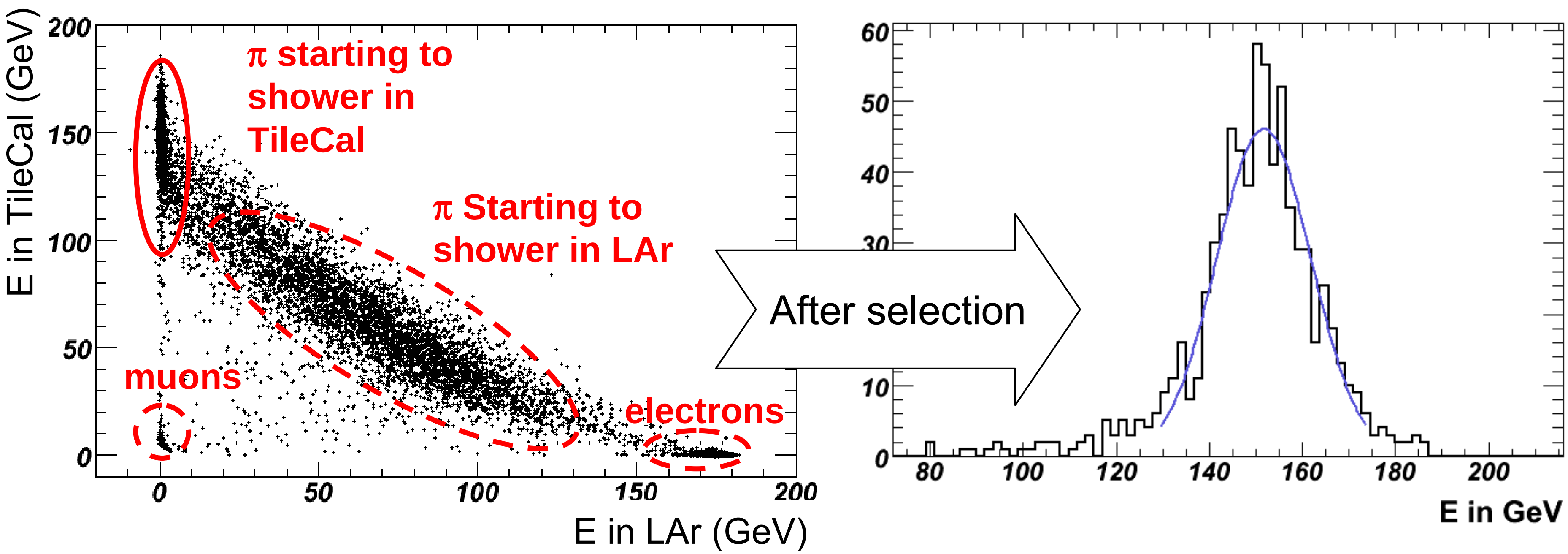
- **Pions sample**
  - High energy pion sample : 50 to 350 GeV, η=0.2 to 1.2
  - Low energy pion sample : From 1 to 9 GeV, η=0.2 to 0.65
- **Energy reconstruction**
  - Both calorimeters calibrated at the electromagnetic scale
  - Reconstruction of energy in a ΔηΔφ=0.4×0.4 window (ΔηΔφ=0.4×0.3 in TileCal)



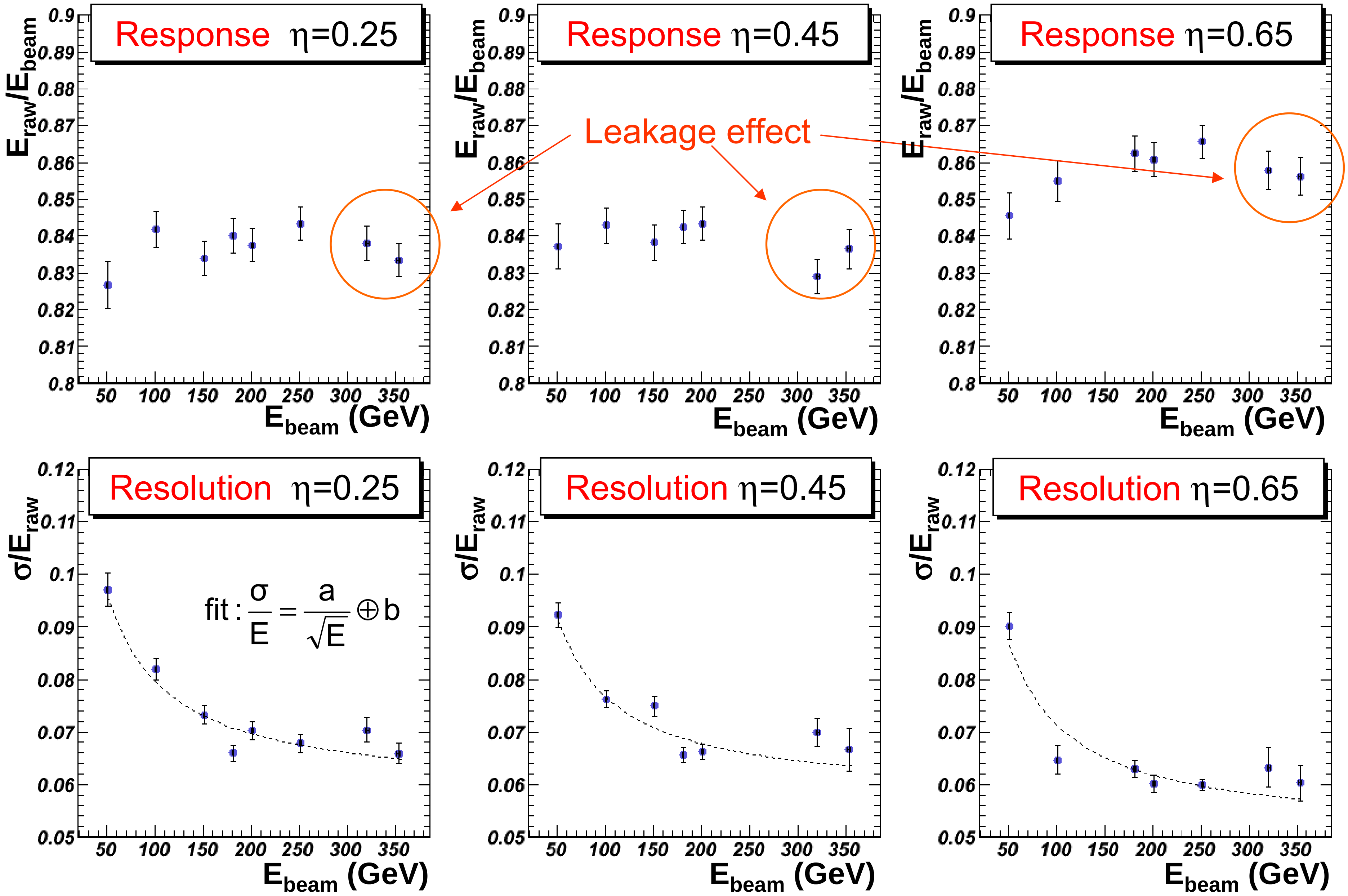
Study of pions starting showering in TileCal: (I) selection

- **Selection of events**
  - rejection of muons and electrons
  - mip-like signal requested in all the layers of the LAr calorimeter
  - mip-like signal requested in the cryostat scintillator (to reject showers that start in the cryostat outer wall)

Example : 180GeV beam at η=0.35



Study of pions starting showering in TileCal: (II) results



Study of pions starting showering in TileCal: (III) conclusions

- Systematic effects due to the uncertainty on the beam energy and to the selection cuts have been considered
  - The uncertainty on the response is ≈1% (dominated by statistical error)
  - The uncertainty on the resolution is <6% (dominated by statistical error)
- About resolution : $\frac{\sigma}{E} = \frac{a}{\sqrt{E}} \oplus b$

η=	0.25	0.35	0.45	0.55	0.65
Sampling term a ($GeV^{1/2}$)	0.54 ± 0.03	0.52 ± 0.02	0.50 ± 0.03	0.47 ± 0.03	0.50 ± 0.03
Constant term b (%)	5.8 ± 0.2	5.7 ± 0.3	5.7 ± 0.2	5.4 ± 0.2	5.1 ± 0.1

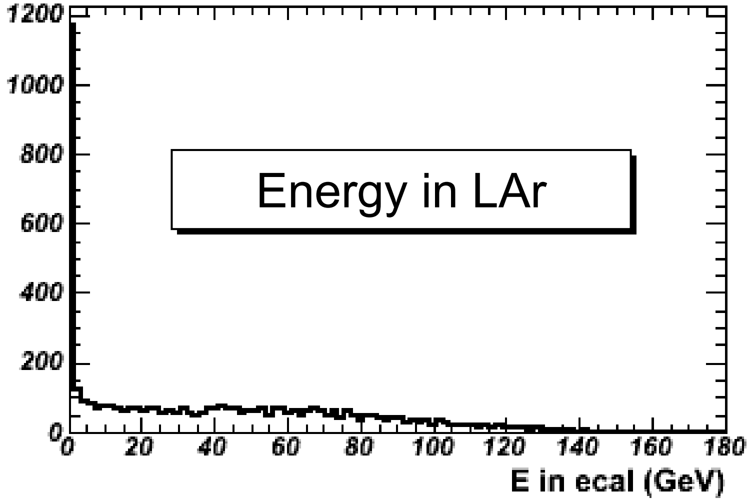
These are raw data results : no leakage corrections and no layer or cell weighting techniques have been applied

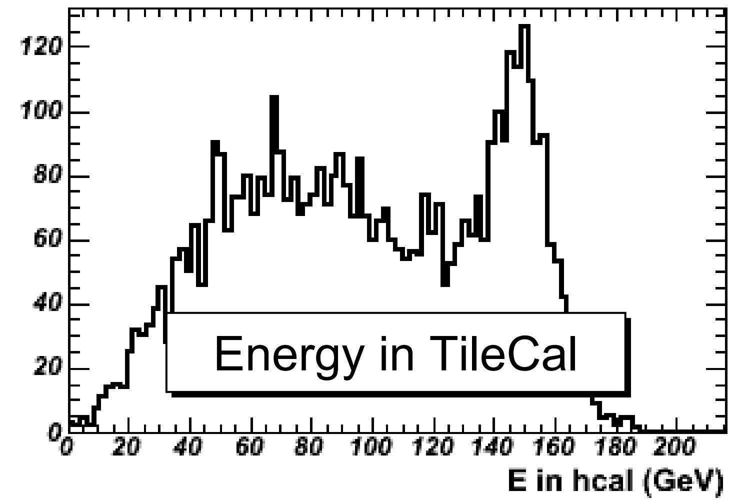
Results are compatible with previous TileCal standalone test beams

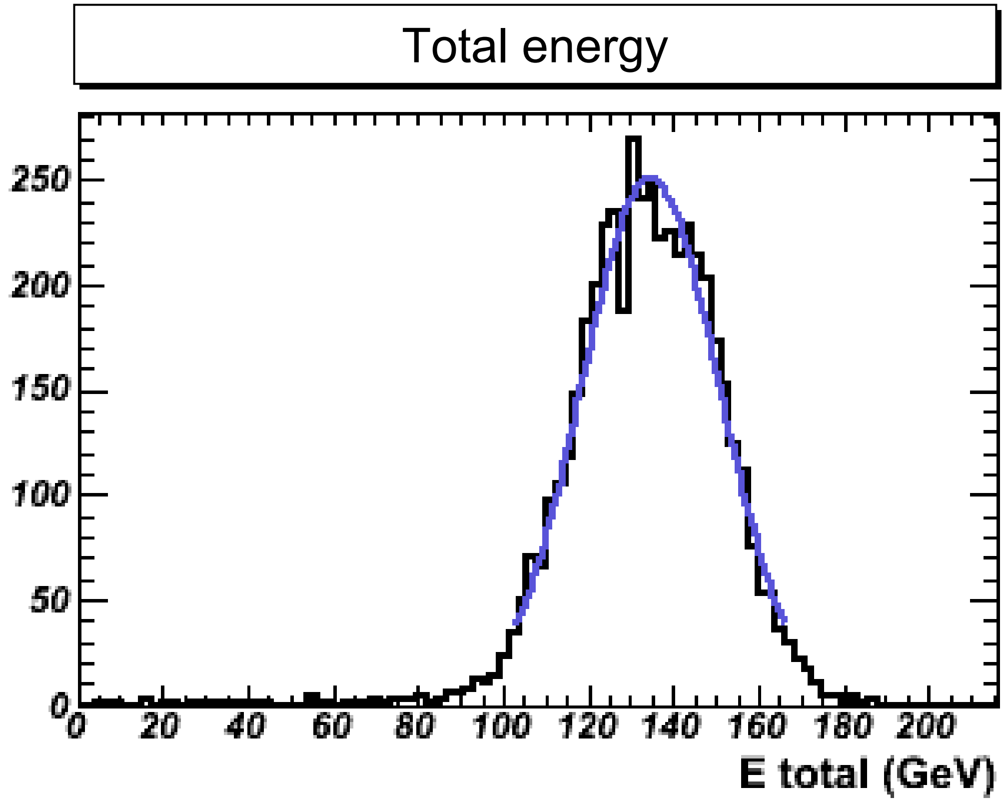
Combined response to π : (I) selection

- **Total energy = E(LAr) + E(TileCal) (both calibrated at the electromagnetic scale)**
- No correction for cryostat energy loss, leakage, non-compensation...

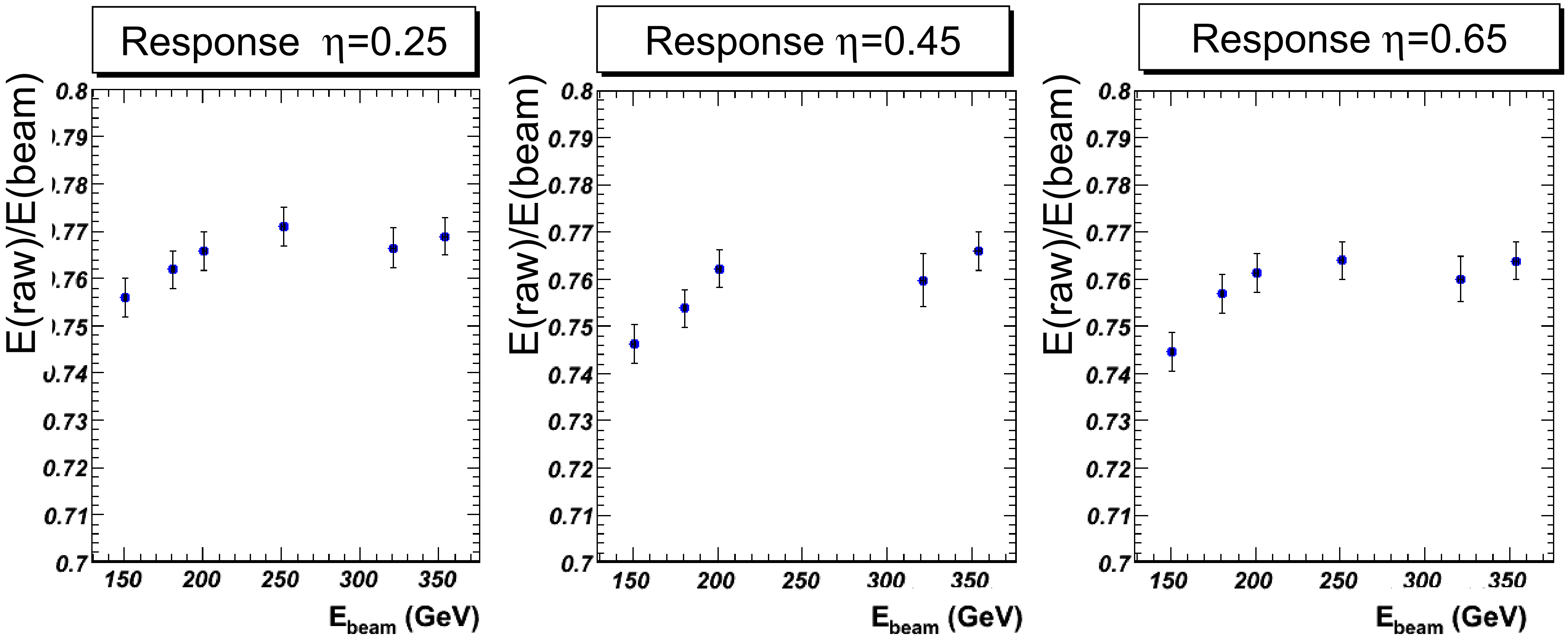
Example : 180GeV beam at η=0.35







Combined LAr+TileCal response to π : (II) results

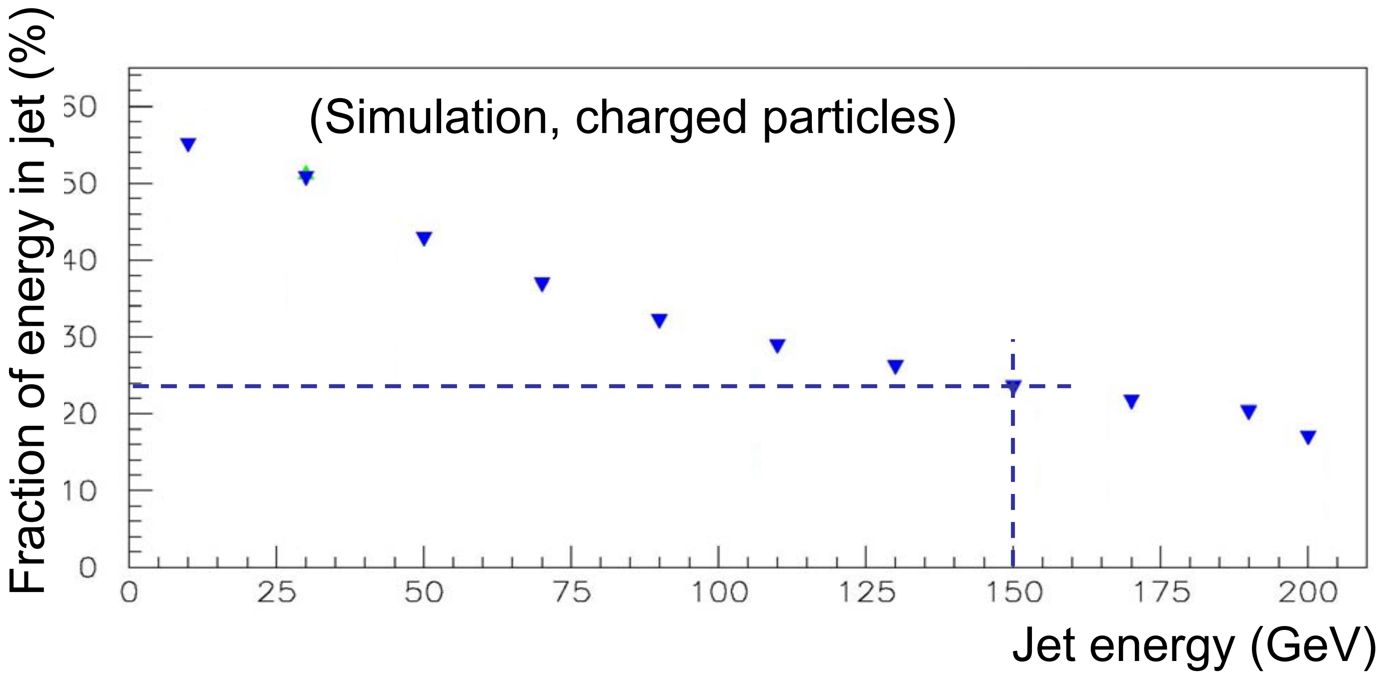


Typical behavior of a non-compensating calorimeter

- Uncertainty on E(raw)/E(beam) : ≈0.5% (dominated by error on beam energy)

Response to low energy pions : (I) motivations

- Low energy particles (E<10GeV) have an important contribution in jets

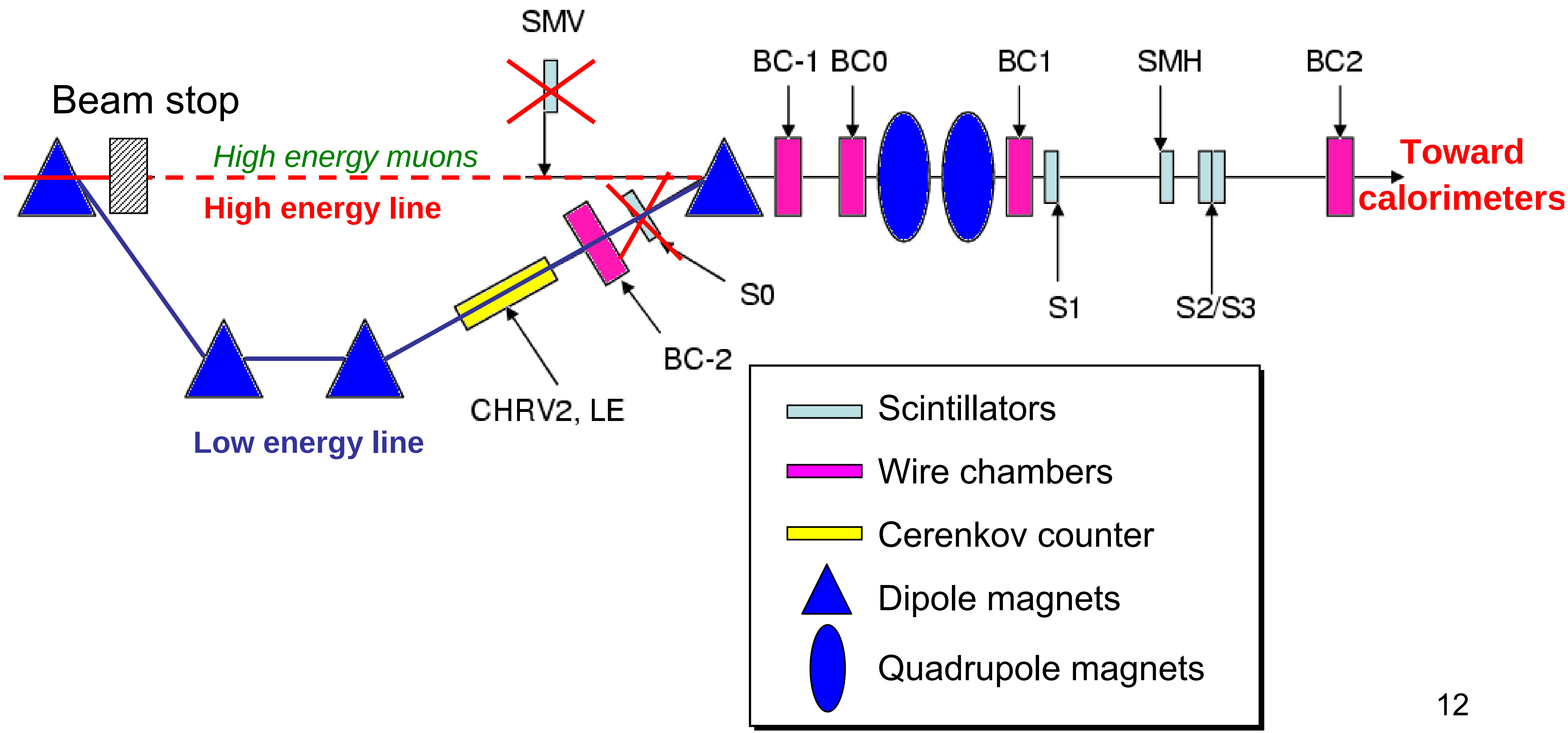


Ex : For a 150GeV jet, 25% of the energy is brought by <10GeV particles

- A good knowledge of the calorimeter response to low energy particles is needed

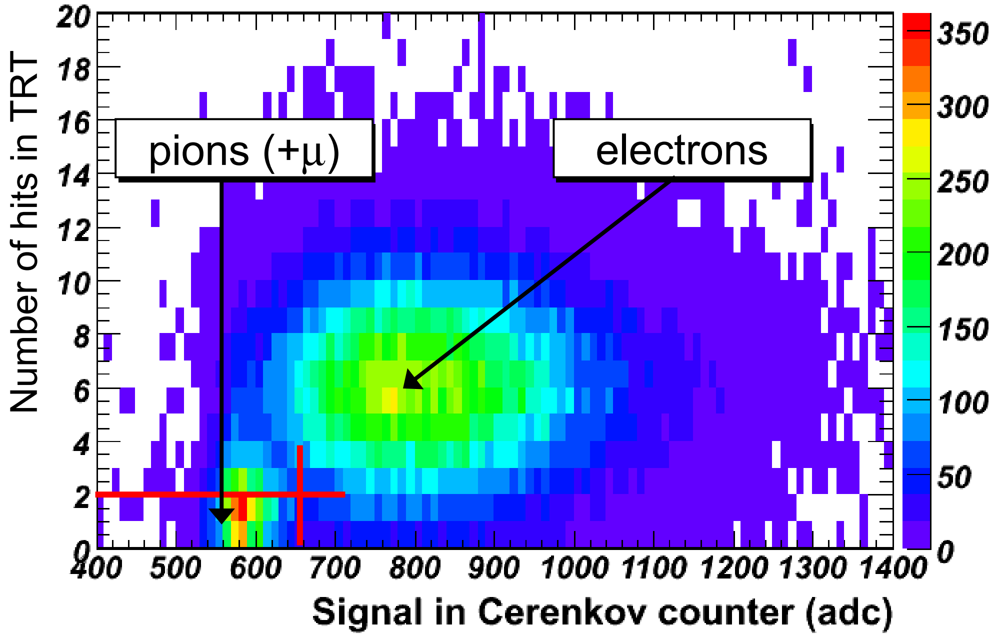
Response to low energy π : (II) beam line

- η = 0.2 to 0.65
- Energy = 1 GeV to 9 GeV
- Beam composition : low energy π, low energy e, decay μ, high energy μ



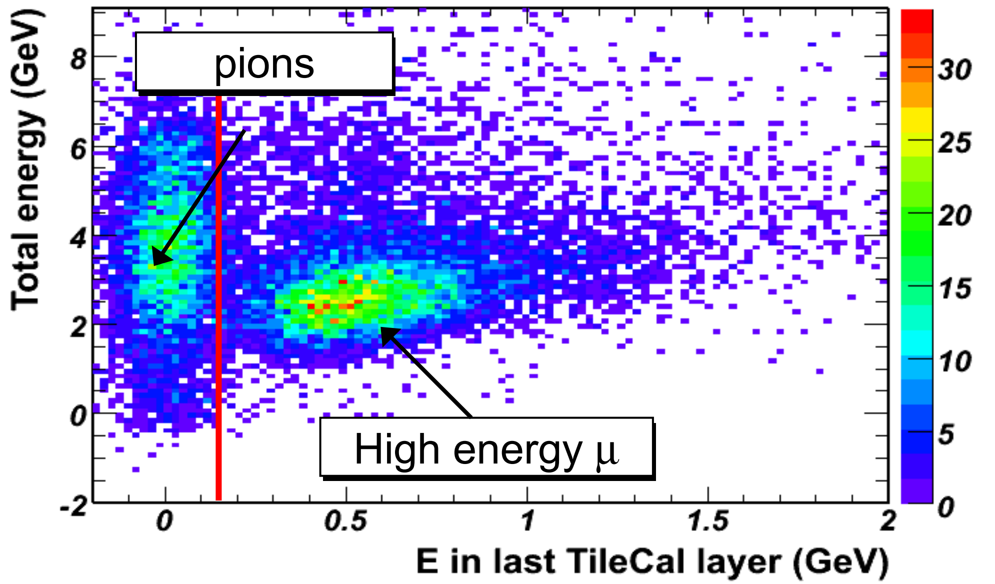
Response to low energy π : (III) selection

- **π/e separation**
  - Cerenkov counter (not in ATLAS)
  - Transition Radiation Tracker (at equal energy more transition radiation x-ray produced by *e* than by *π*)

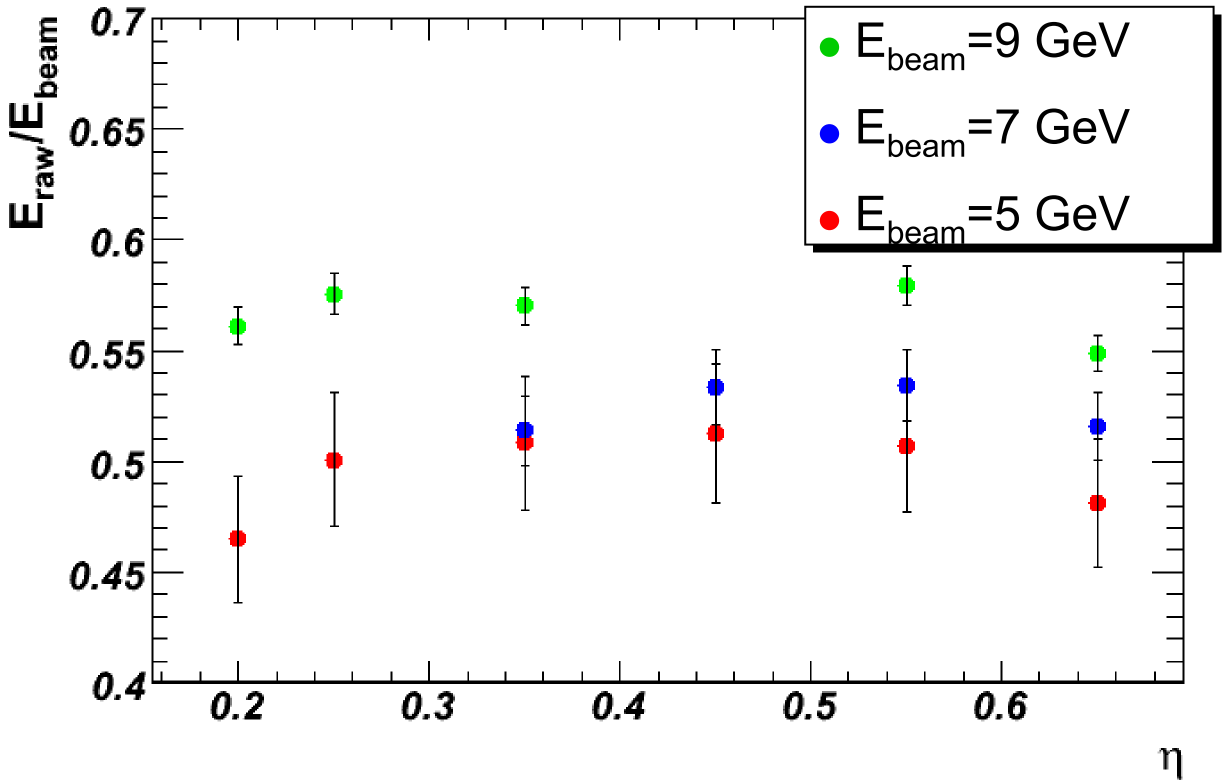


- **π/μ(high energy) separation**
  - Using the last TileCal compartment as a muon veto

⚠ above 5GeV some pions can deposit energy in the last TileCal layer but this effect can be easily reproduced in simulation



Response to low energy π : (IV) some results



- Uncertainty on the <u>reconstructed pion energy</u> (statistical error) :
  - from 1% at 9 GeV to 4% at 5 GeV
- Error on the beam energy has been considered : ≈0.3%
- Systematic effects of the beam setting and the selection cuts have to be studied.

Conclusions

- In this talk a determination of the responses of the central ATLAS calorimeter to pions is reported.
  - At energies larger than 50 GeV for TileCal Standalone (150 GeV for the combined data) the error is less than 1%. The systematic sources considered were the beam energy and the event selection.
  - At energies lower than 9 GeV the statistical error ranges from 1% at 9 GeV to 4% at 5 GeV.
- The results can be used in ATLAS to establish the jets absolute energy scale: tuning of the simulation on the test beam results.

Outlook

A possible calibration strategy in ATLAS

•**Analysis of the pion response in an "almost final" calorimeter set-up** (what has been shown in this talk)

In progress…

- Comparison of data with simulation
  - tuning and validation of simulation model
  - getting corrections for dead material, e/π, leakage…
  - study of the calorimeters performances for single pions

Longer term issues…

• Selection of single charged particles in ATLAS and comparison with simulation (tuned using TB data)

• Transport results to get a jet calibration in ATLAS