ATLAS Electromagnetic Calorimeter Testbeam Results

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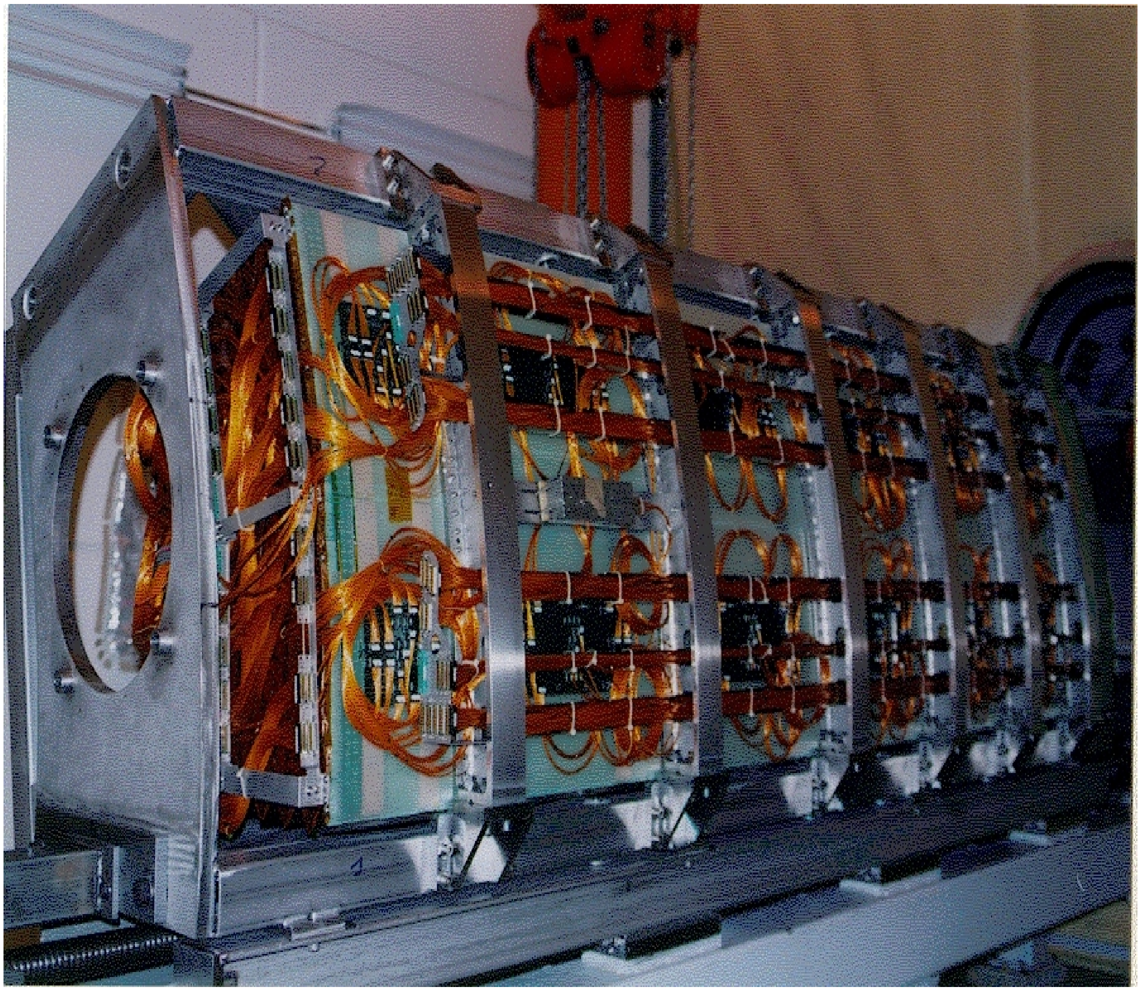
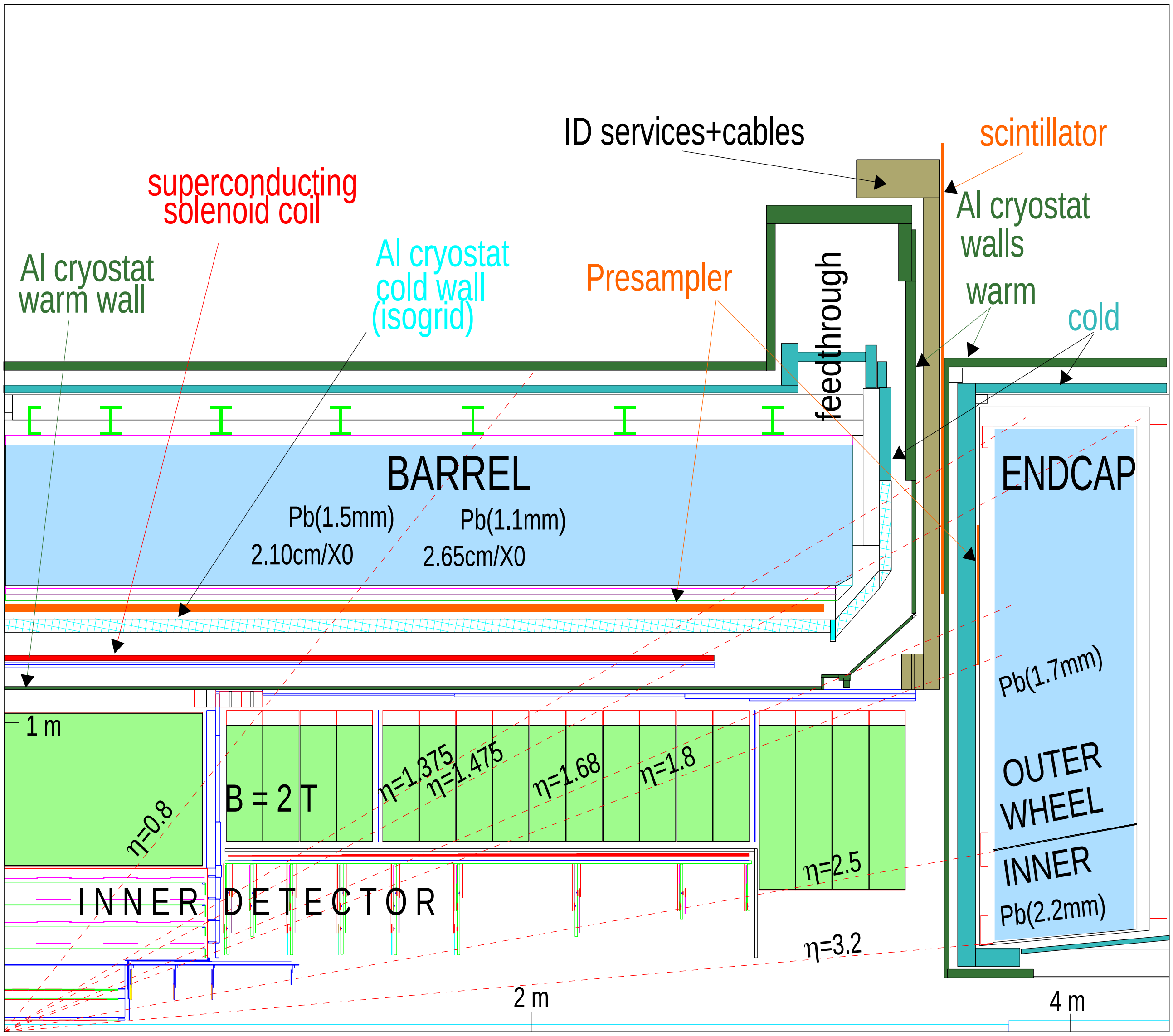
On behalf of the **ATLAS Liquid Argon Community**



- Geometry of barrel and end-cap calorimeters and tested modules
- Noise and cross-talk measurements
- Response to muons
- γ / π° separation
- Response to electrons
- Module production, conclusion

Calorimeter Geometry

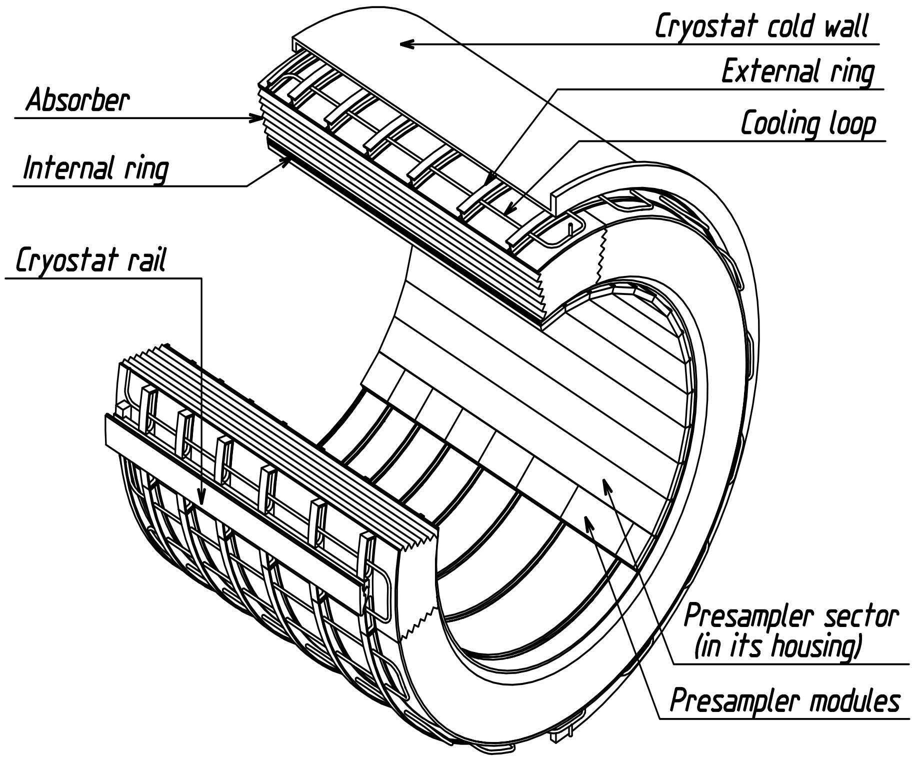


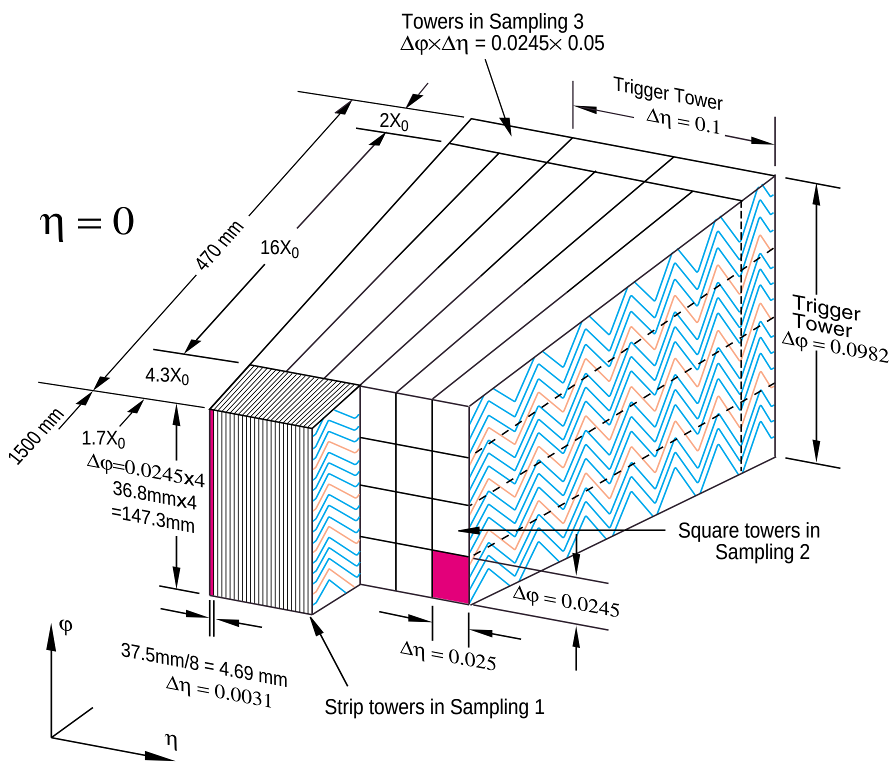
⇒ liquid argon calorimeter with Pb absorbers + liquid argon presampler.

Calorimeter = **barrel calorimeter** ($|\eta| \leqslant 1.5$) + **end-cap calorimeter** ($1.375 \leqslant |\eta| \leqslant 3.2$)

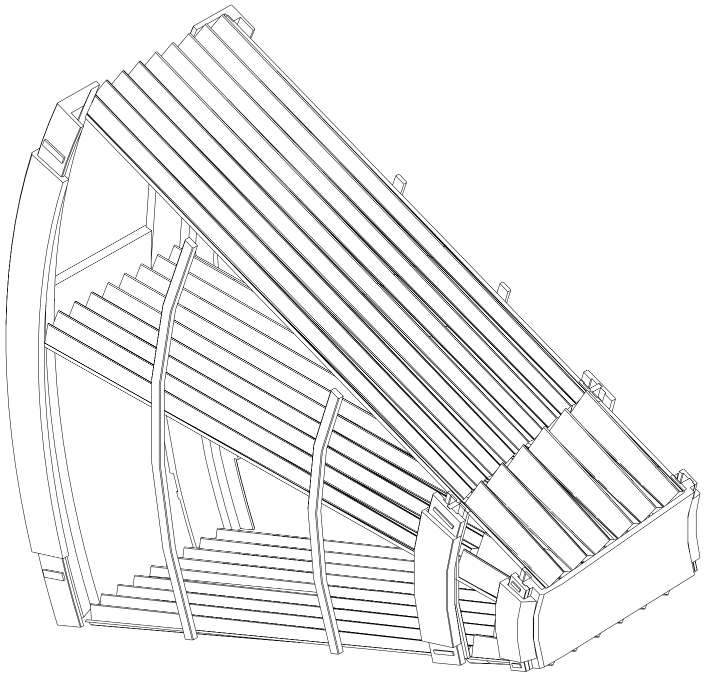
Presampler = **barrel presampler** ($|\eta| \leqslant 1.5$) + **end-cap presampler** ($1.5 \leqslant |\eta| \leqslant 1.8$)

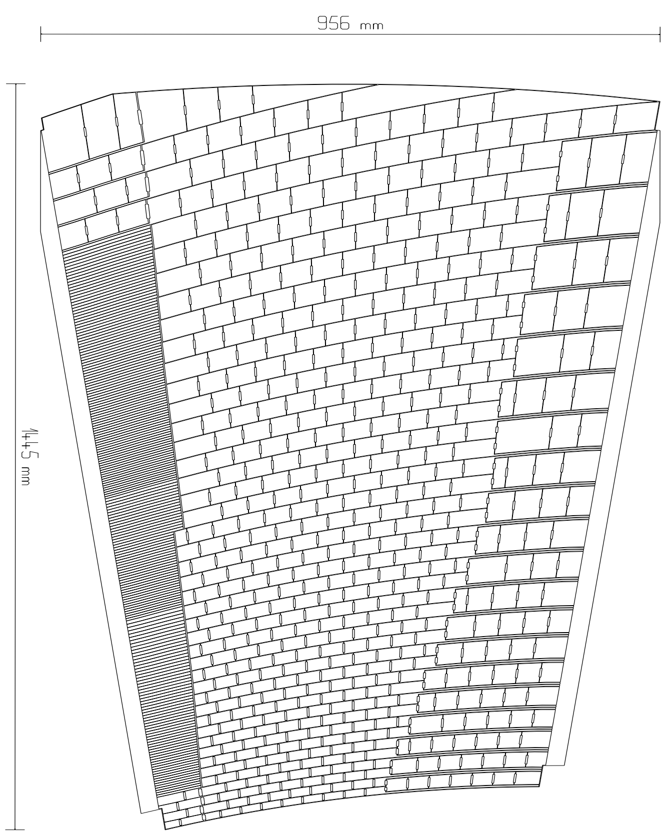
The Barrel Electromagnetic Calorimeter



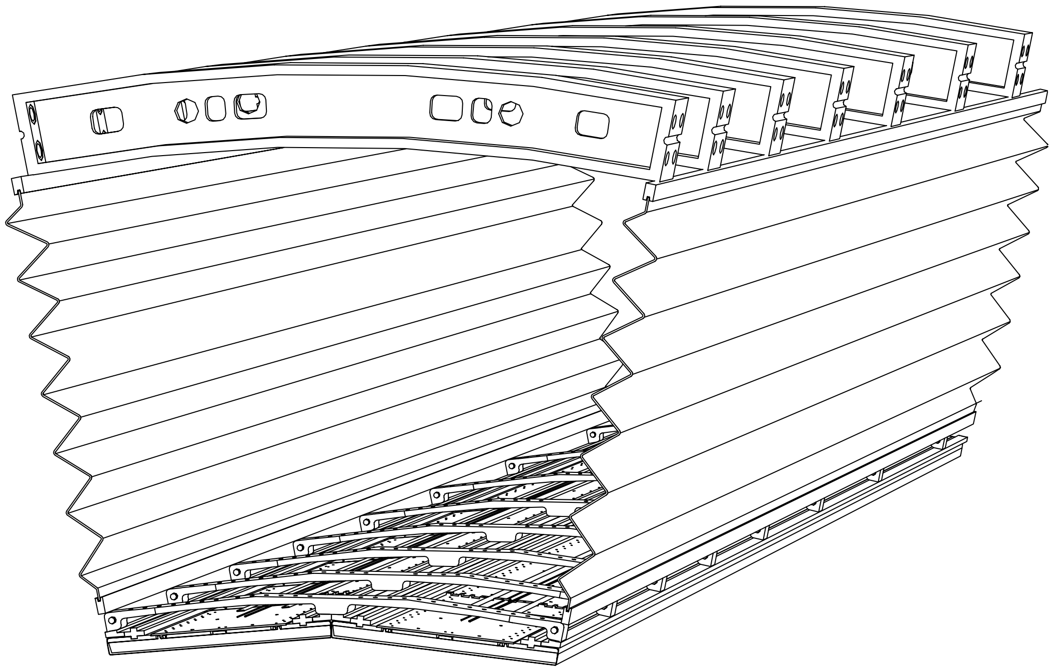


The End-Cap Electromagnetic Calorimeter





Barrel Calorimeter Module-0



- Coverage: 1/16 of the ϕ coverage, half barrel in z.
- Two lead thicknesses: 1.5mm ($|\eta| < 0.8$) and 1.1mm ($0.8 < |\eta| < 1.5$)
- $\sim$ 75% of the channels equipped
- $\sim 1X_0$ at η=0 in front of the calorimeter
- Upgrade of **summing and mother** boards in 2000
- Upgrade of HV as well as testbeam equipment...

End-Cap Calorimeter Module-0

- A module: 1/8 of the ϕ coverage
- Two lead thicknesses: 1.7 mm ($1.4 < |\eta| < 2.5$) and 2.2 mm ($2.5 < |\eta| < 3.2$)
- Presampler coverage: up to $|\eta| = 1.8$
- Inner wheel fully equipped
- Outer wheel half equipped

Collected Data Samples

Barrel Module

- Module-0 beam tests in '99 and '00,
- $\sim$ 50 million events collected,
- Calibration data (gains, pedestals, pulse shapes),
- Energy scans (5 $\rightarrow$ 287 GeV) at 7 points,
- Large area of the calorimeter scanned,
- Many dedicated studies: high intensity runs, runs at the limit between the 2 electrodes, extra amount of upstream material, etc.

End-cap Module

- Module-0 beam tests in '99,
- $\sim$ 30 million events collected,
- Calibration data,
- Energy scans at 12 points in η,
- Position scan (160 cells),
- Dedicated studies: HV scans, study of the inter-wheel region, extra amount of upstream material, etc.

Noise and Cross-talk Levels

Noise measurements (High Gain)

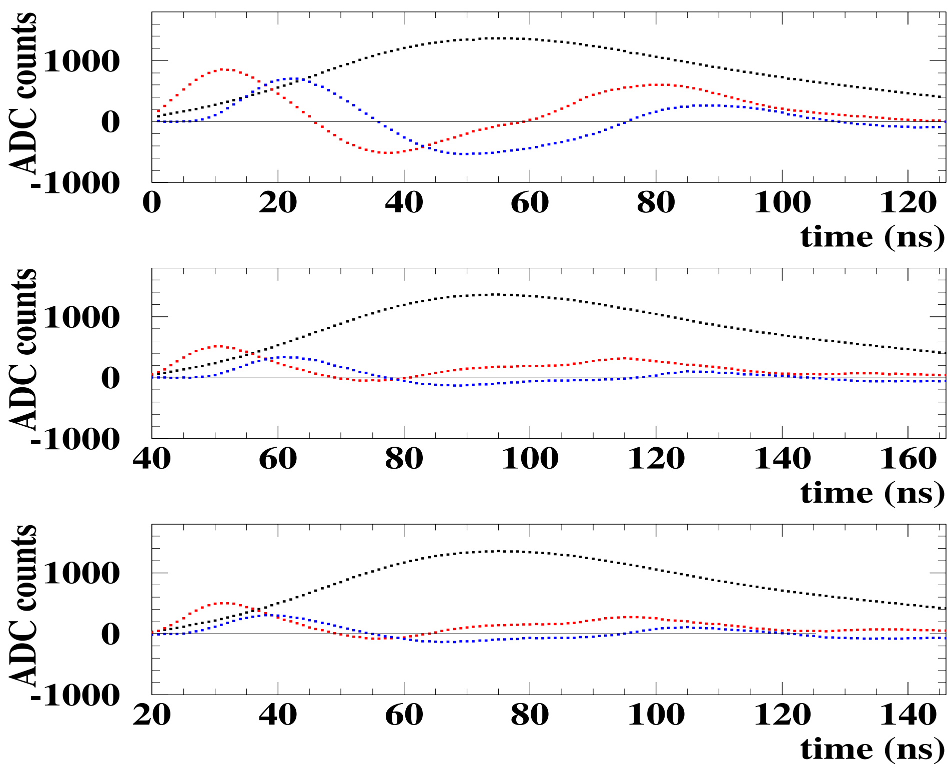
55-60MeV / cell (PS),
15-18MeV / cell (Strips),
40-50MeV / cell (Middle),
30-45MeV / cell (Back)

Noise in an ATLAS cluster: $\sim$ 280 MeV (250 MeV of incoherent noise).
Reduction with **optimal filtering** by a factor 1.7

Cross Talk Level

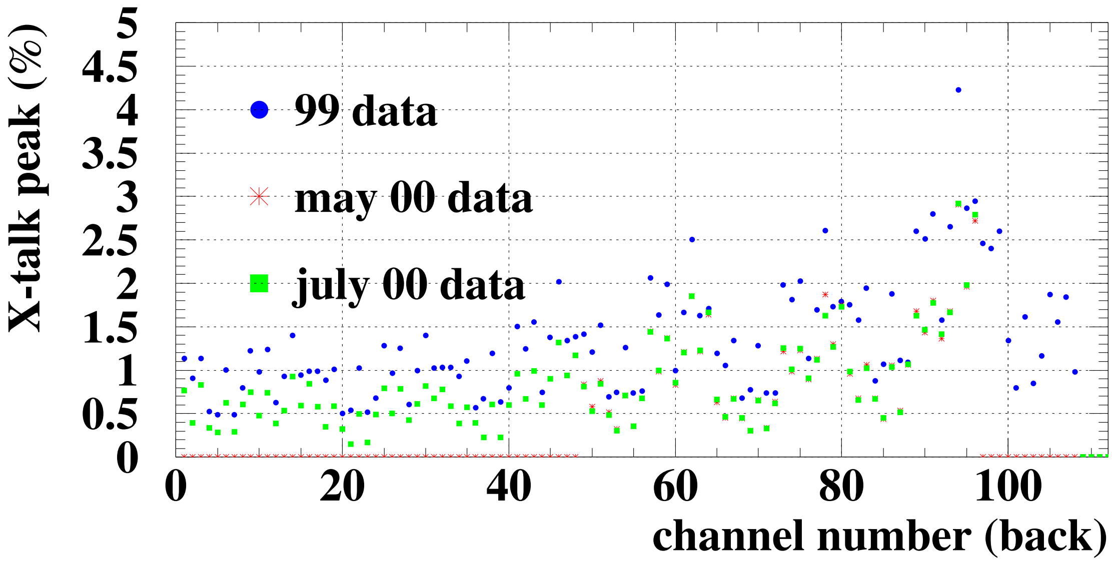
Strip-strip cross-talk: 4% for neighbour strips (OK for γ / π° separation)
Other average cross-talks smaller than 1%
Long distance x-talk at the level of 0.1%

(X-talk signals $\times$ 30)



Signal in Middle, cross talk in middle and back compartments.

Cross Talk Measurements

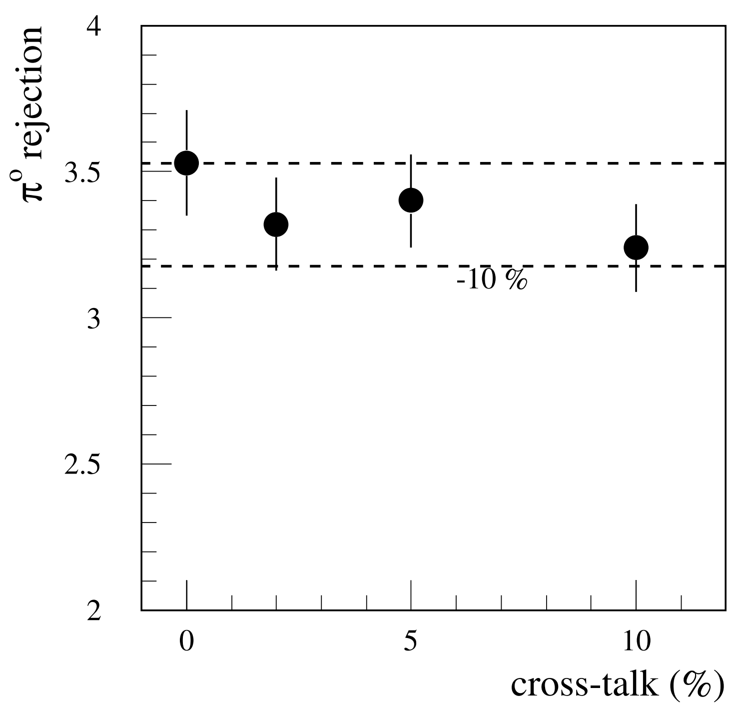


New boards installed for 2000 testbeams:

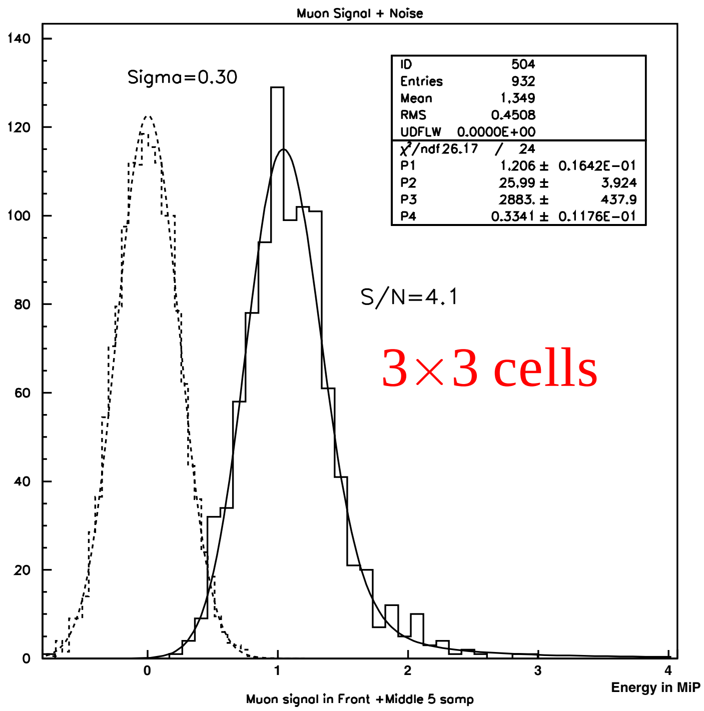
⟹ smaller coherent noise,

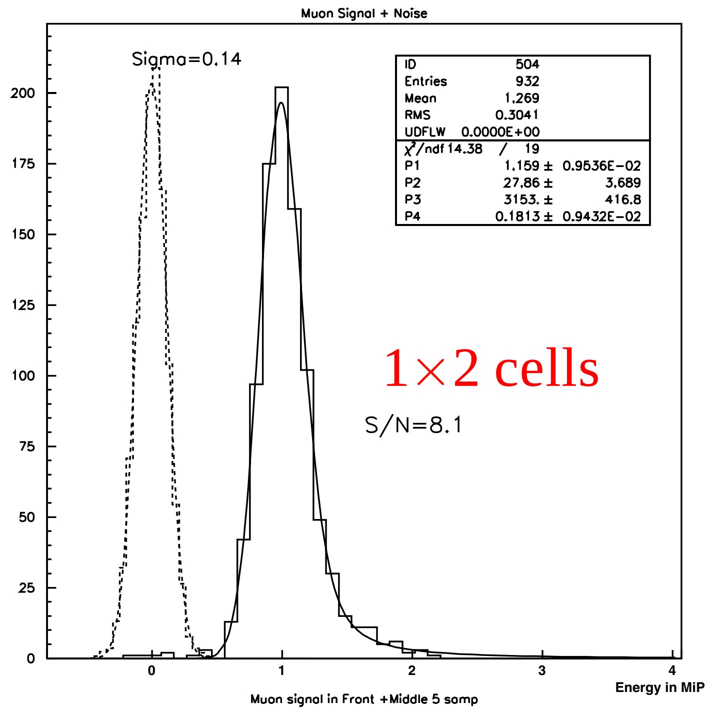
⟹ inductive cross-talk reduced by 1.5 compared to 1999.

γ/π° rejection versus cross-talk in strips



Response to Muons





Muon Cluster:

Cells pointed by the **beam chambers**
3 strips in the **front layer**,
1×2 cells (in $\eta \times \phi$) in **middle layer**.

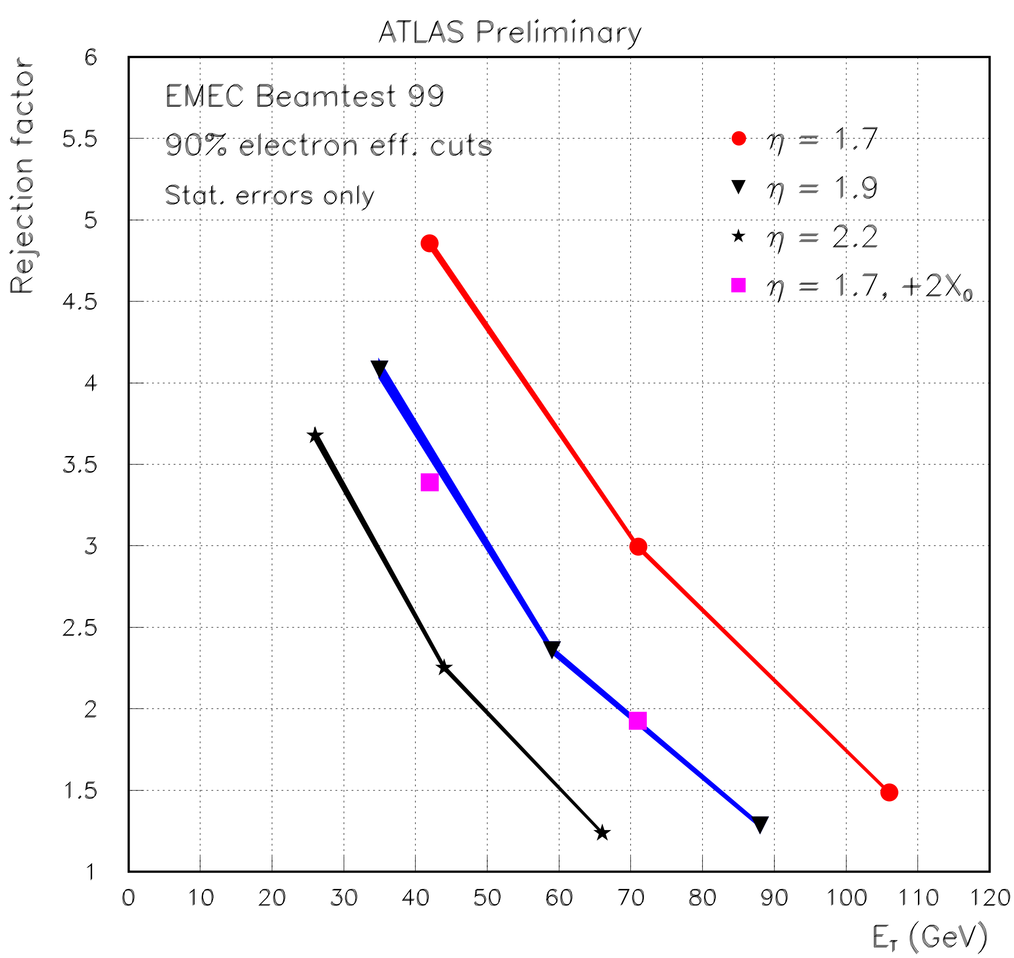
High signal to noise ratio since using beam chambers.
Most probable energy deposited is the same in the 3×3 and 1×2 clusters.

γ / π° Separation

Method

- Combine two electrons from the '99 End-Cap tests respecting $\pi^\circ \longrightarrow \gamma\gamma$ kinematics.
- Carried out in the three different strip granularity regions of the end-cap: $\eta = 1.7, 1.9, 2.2$
- Separation variables based on the shape of the shower.

Rejection factor for 90% efficiency on electrons



Photon data taken in barrel in '00

Energy Resolution for Electrons

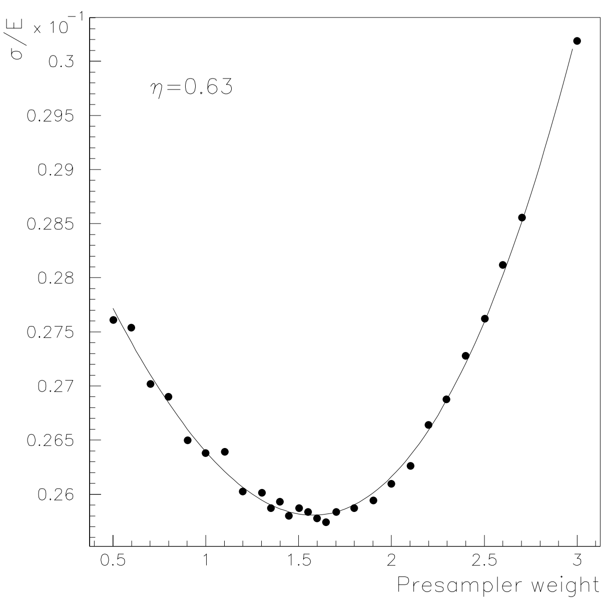
Calorimeter Cluster:

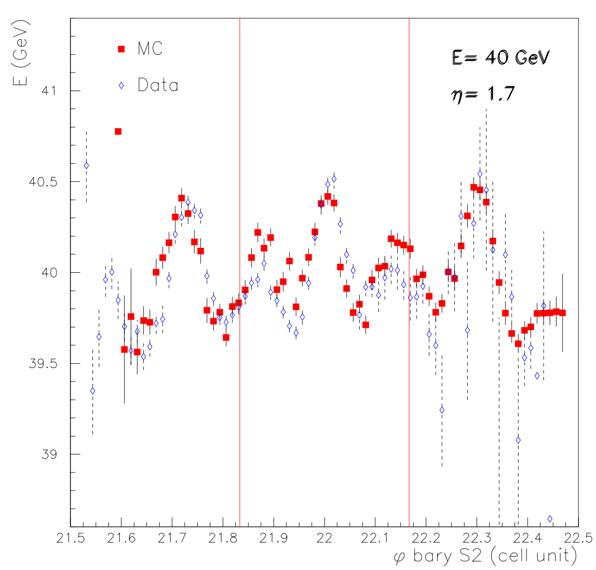
3×3 cells in **middle layer**
$\pm$ 7 strips to $\pm$ 11 strips in the **front**, depending on η
Back layer used only for electrons with E $>$ 50 GeV
3 cells in **presampler**

Corrections:

Lateral energy leakage out of the cluster,
ϕ-modulation,
Weight energy in back compartment,
Presampler weight,
(Response versus time)

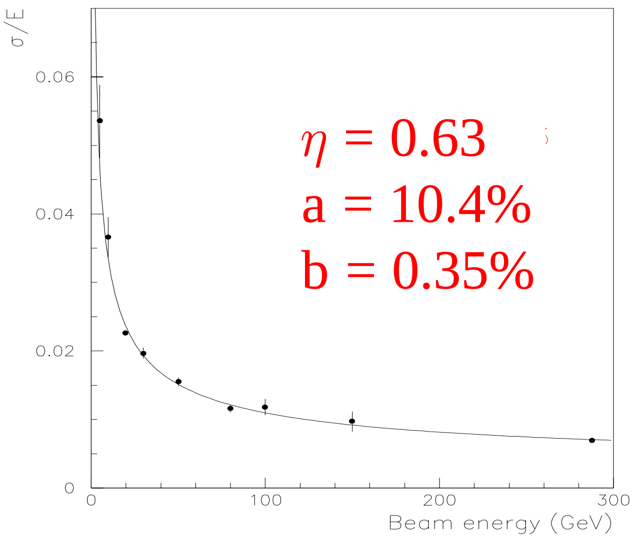
$$E = \beta(\alpha E_{Presampler} + E_{Strips} + E_{Middle} + \gamma E_{Back})$$

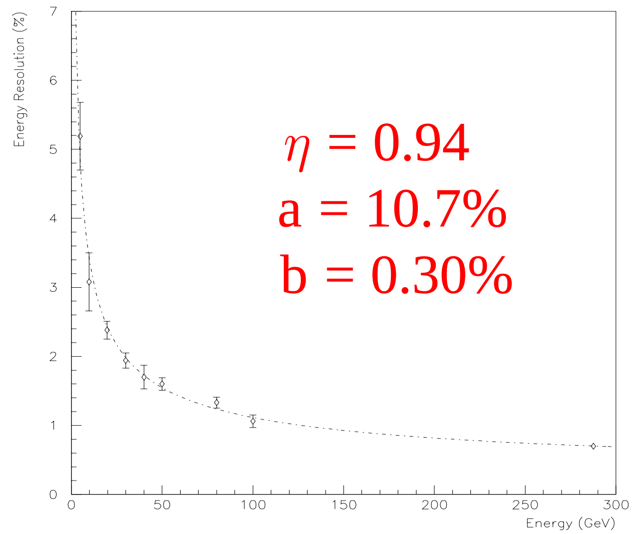


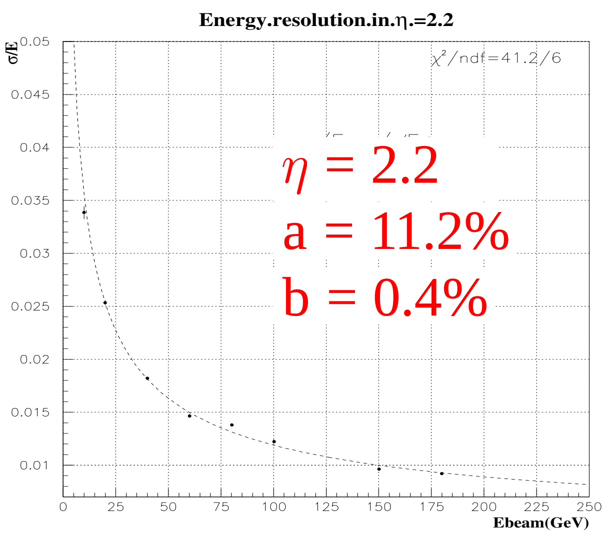


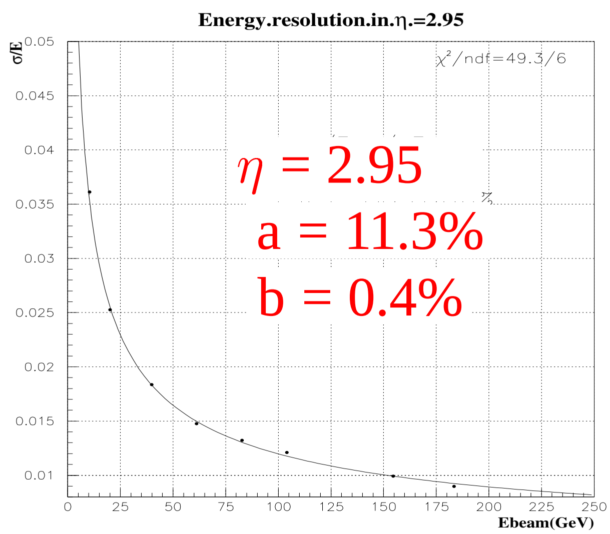
Energy Resolution versus Electron Energy at various η

$$\frac{\sigma}{E} = \frac{a}{\sqrt{E}} \oplus c$$







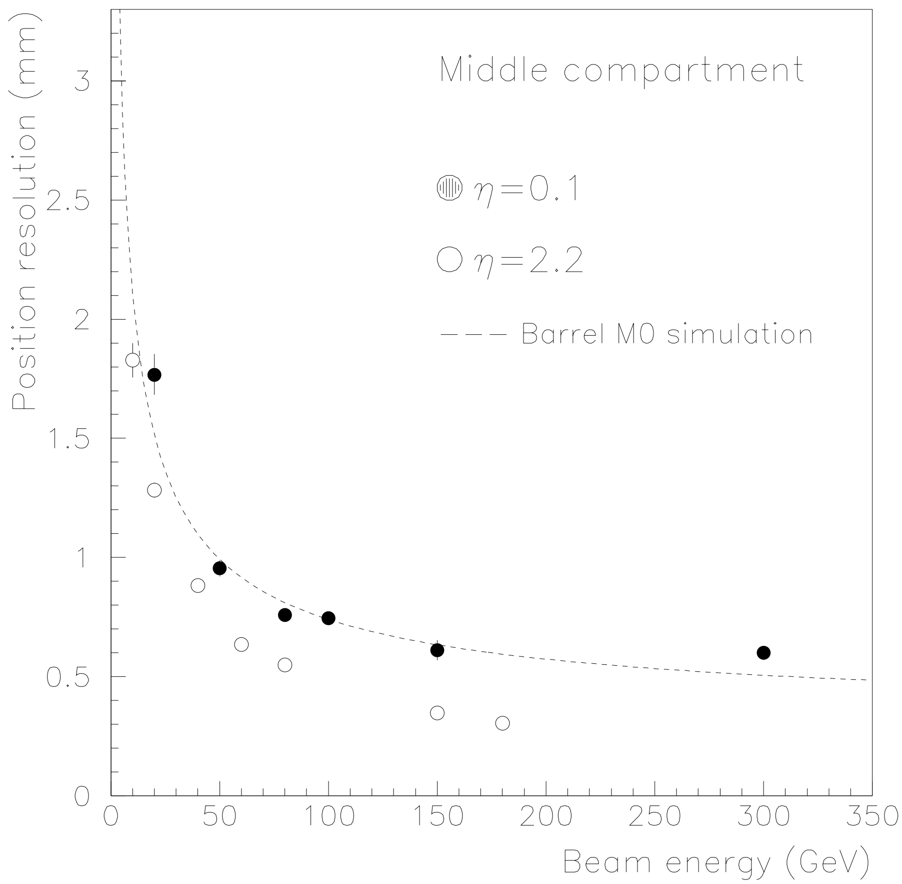


Noise in cluster and beam spread subtracted.

Position Resolution

Position resolution versus beam energy

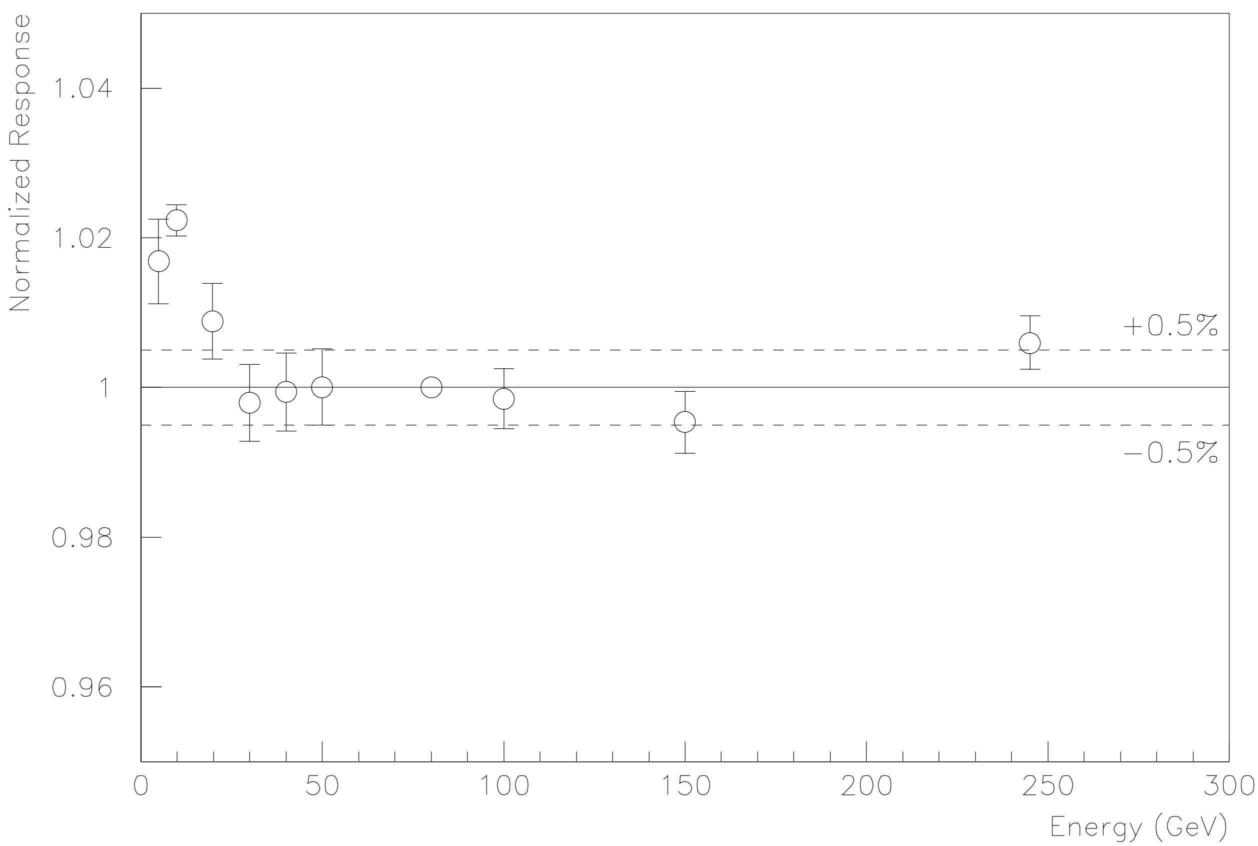
Determine position resolution by comparing:
position given by beam chambers and position given by calorimeter.



- Good agreement between simulations and testbeam measurements,
- Good agreement with earlier calculations (ATLAS Detector and Physics Performance TDR CERN / LHCC 99-14).

Linearity of the Calorimeter Response

- Compute the ratio: $E_{Reconstructed}/E_{Beam}$
- Normalise this ratio to its value at 80 GeV
- η = 0.94



- Same presampler weight for all energies
- Back compartment used for all energies above 50 GeV

Module Production

- Module qualification:
  1. Absorbers and electrodes controlled before module assembly,
  2. High voltage tests, sagging measurements during assembly,
  3. Overall module cross-check in the cryostat ($\sim$ 1 month)
- Stacking of modules has started
- $\sim$ 3 months per module
- 2 barrel and 2 end-cap modules to be tested in beam in 2001.

Conclusion

- Electromagnetic barrel and end-cap module-0 tested in '99 and '00
- Large fractions of the modules were equipped and tested
- Final ATLAS electronic chain performing well
- Measurements in beam show:
  1. Clear S/N separation for MiP
  2. γ/π° rejection factor of the order of 3
  3. Energy and position resolution performance as expected
- Module production started.