Preliminary Results on the ATLAS Liquid Argon EM Calorimeter

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- Structure of the calorimeter
- Test beam results
- Construction status

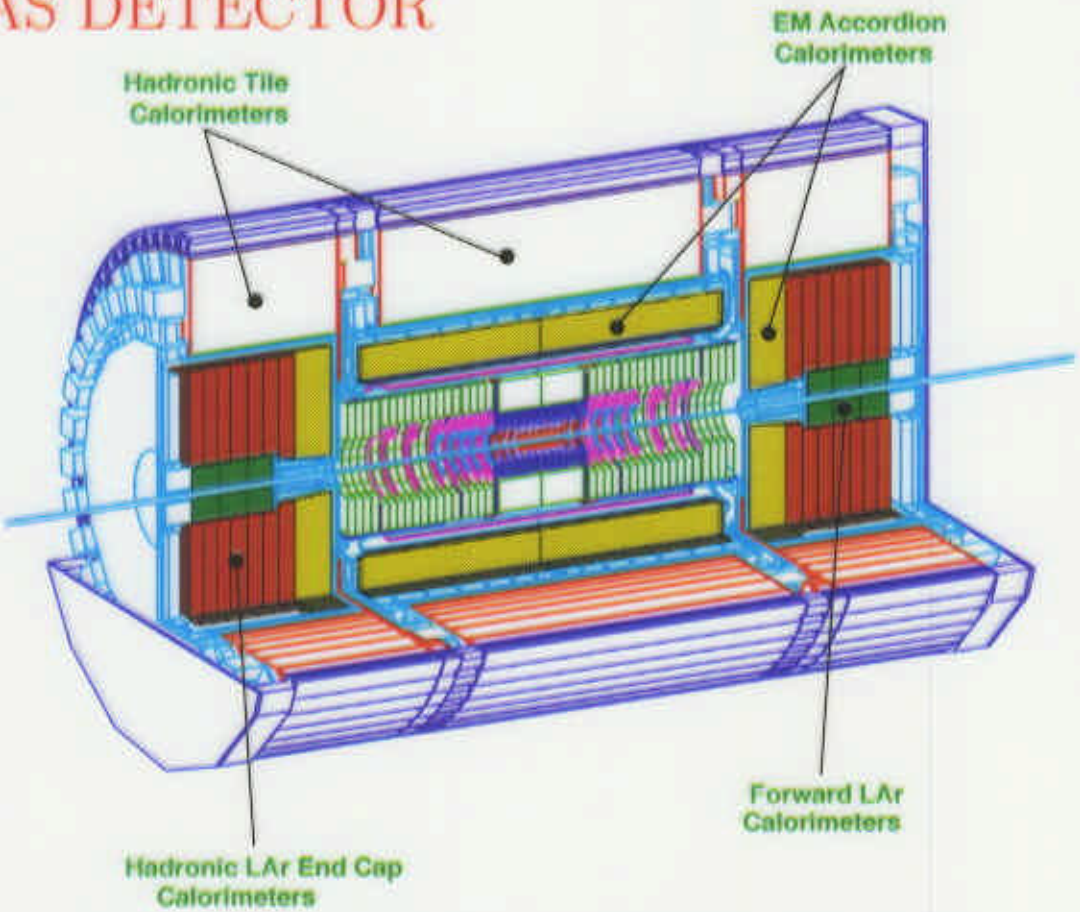
ATLAS Detector

LHC physics

- Achieve Standard Model Physics : Higgs search, CP violation, ...
- Extend SM to SUSY
- Hints for new physics (Z', W')

→ Detector to reconstruct and identify b, τ, e, μ, γ, $\not{E}_T$

ATLAS DETECTOR



1m I

(Toroidal magnet and muon chambers not drawn)

- Benchmark channels ____ $H \to \gamma\gamma$ and $H \to Z\,Z^* \to 4e$

→ Good electromagnetic energy resolution (~ 1% at 100 GeV)

- Processes with small cross-sections → need for high $\int \mathcal{L} dt$

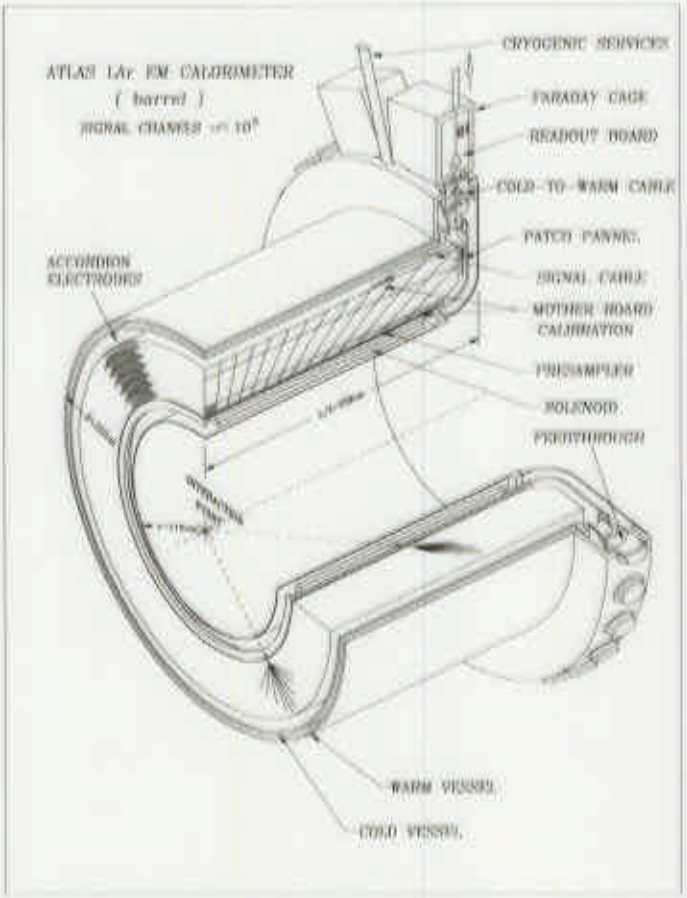
- High collision rate (~20 events every 25 ns) → Fast response

- High level of background radiation → Radiation hardness

- Build a calorimeter in hostile environment

BARREL

2 half barrels : $\eta = -1.4 \rightarrow +1.4$
$|z| < 320$ cm
140 cm $< r <$ 200 cm
2 $\times$ 16 modules
3.4 tons each



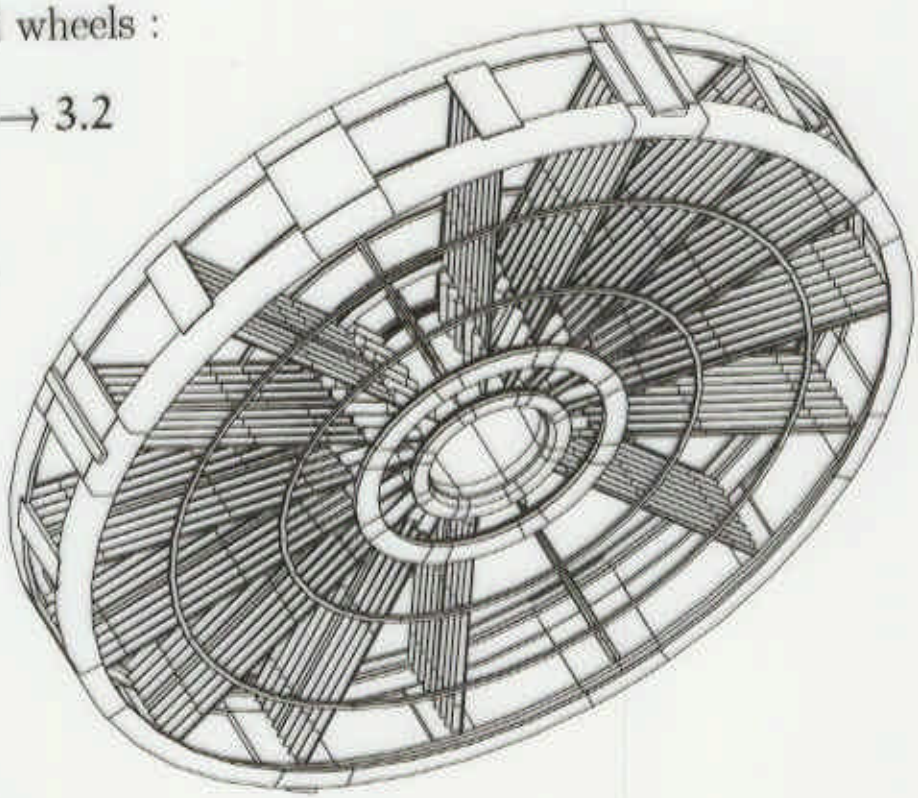
END CAPS

2 end cap with 2 coaxial wheels :

η : $1.4 \rightarrow 2.5$ and $2.5 \rightarrow 3.2$

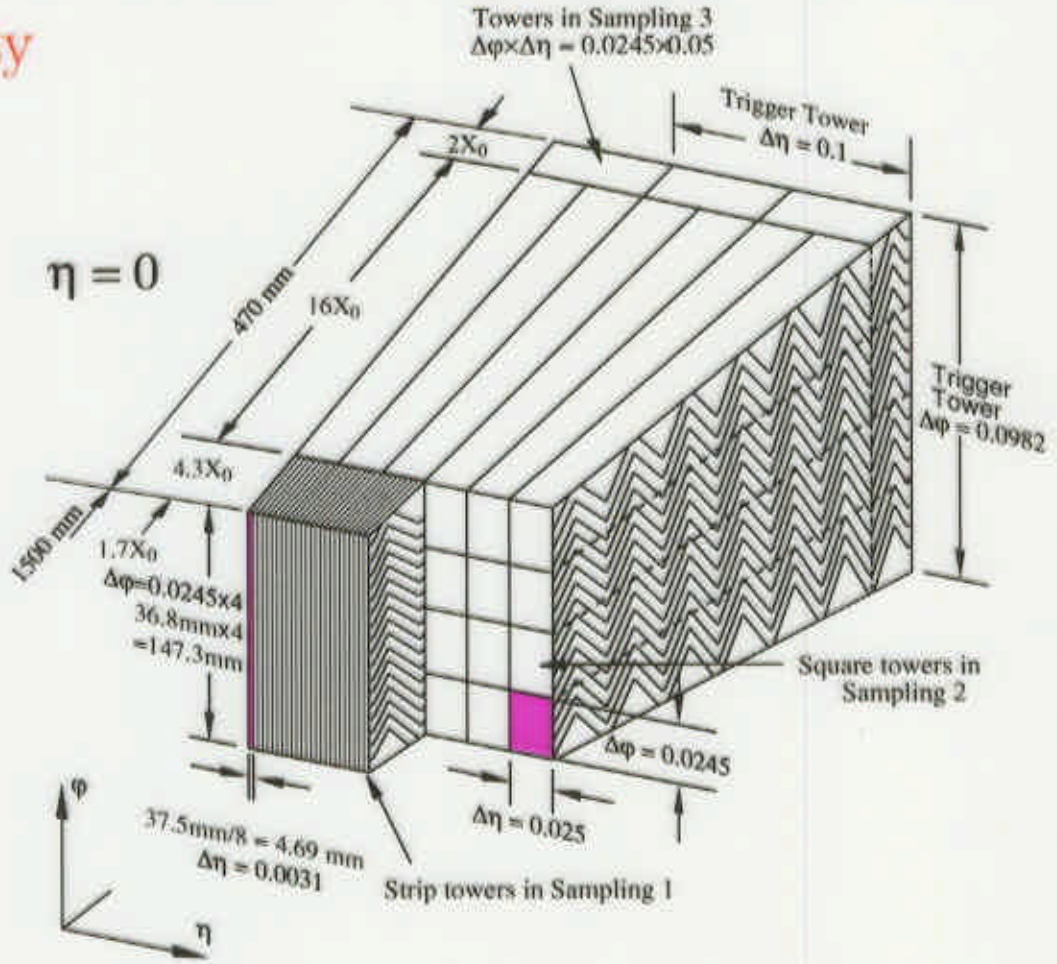
$30\ \text{cm} < r < 205\ \text{cm}$

$365\ \text{cm} < |z| < 415\ \text{cm}$



8 modules per end-cap

Hermiticity



e/γ/π^0/jet separation

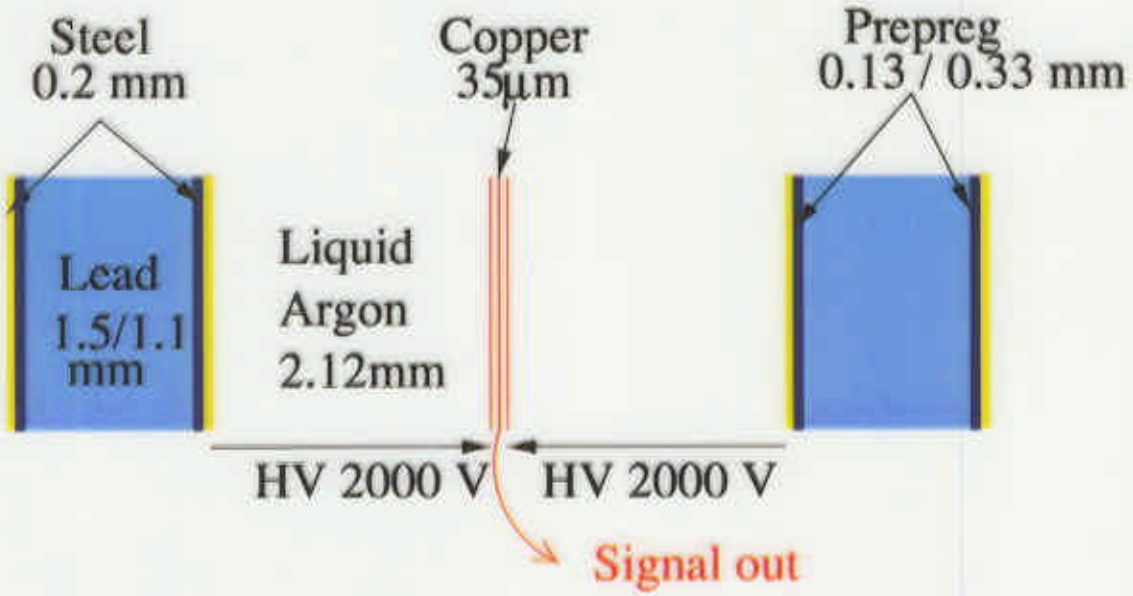
High granularity + longitudinal segmentation
→ 3 compartments + Presampler ($\eta < 1.8$)

Segmented electrodes

$$S0 : \Delta\eta \times \Delta\varphi \times \Delta X_0 = 0.0253 \times 0.1 \quad \times 2$$
$$S1 : \Delta\eta \times \Delta\varphi \times \Delta X_0 = 0.003 \times 0.1 \quad \times 4$$
$$S2 : \Delta\eta \times \Delta\varphi \times \Delta X_0 = 0.025 \times 0.025 \times 18$$
$$S3 : \Delta\eta \times \Delta\varphi \times \Delta X_0 = 0.050 \times 0.025 \times 2 - 12$$

Signal Shape

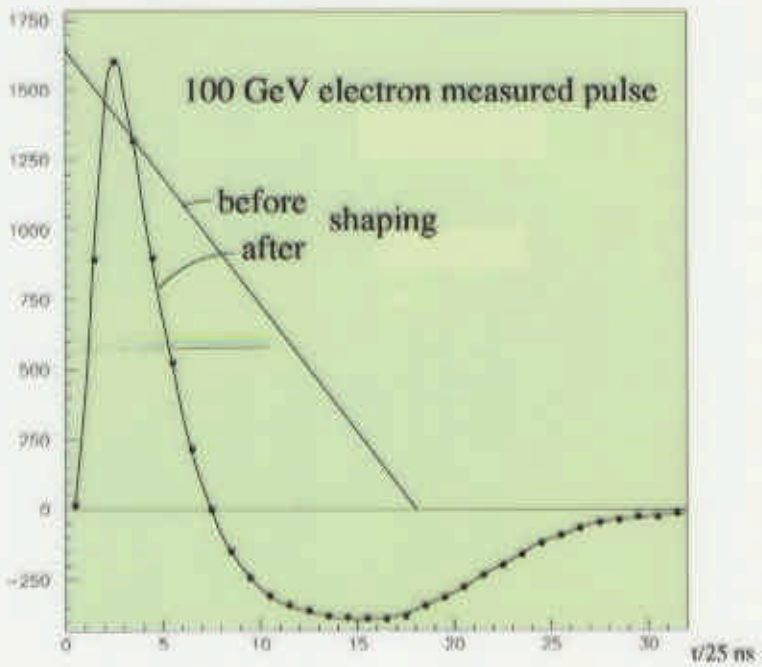
Gap structure



- Triangular signal $t_d \sim 450$ ns $I(t = 0) \sim 2.5\ \mu A\ GeV^{-1}$

Analog signal processing

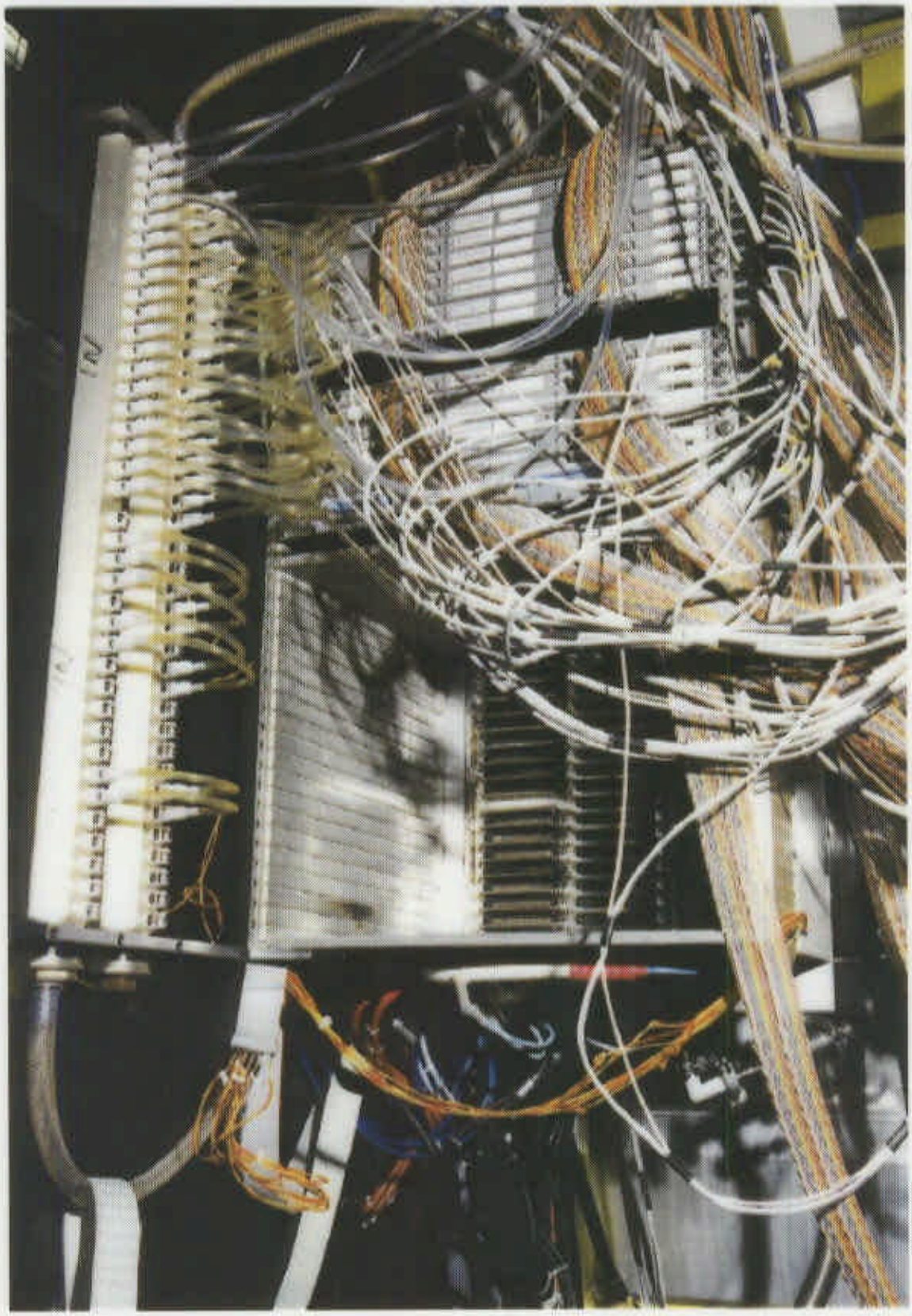
- Preamplifier
- CR-RC^2 shaping ($t_p \sim 50$ ns)
- Sampled at 40 MHz (LHC frequency)
- Stored into an analog memory



Readout

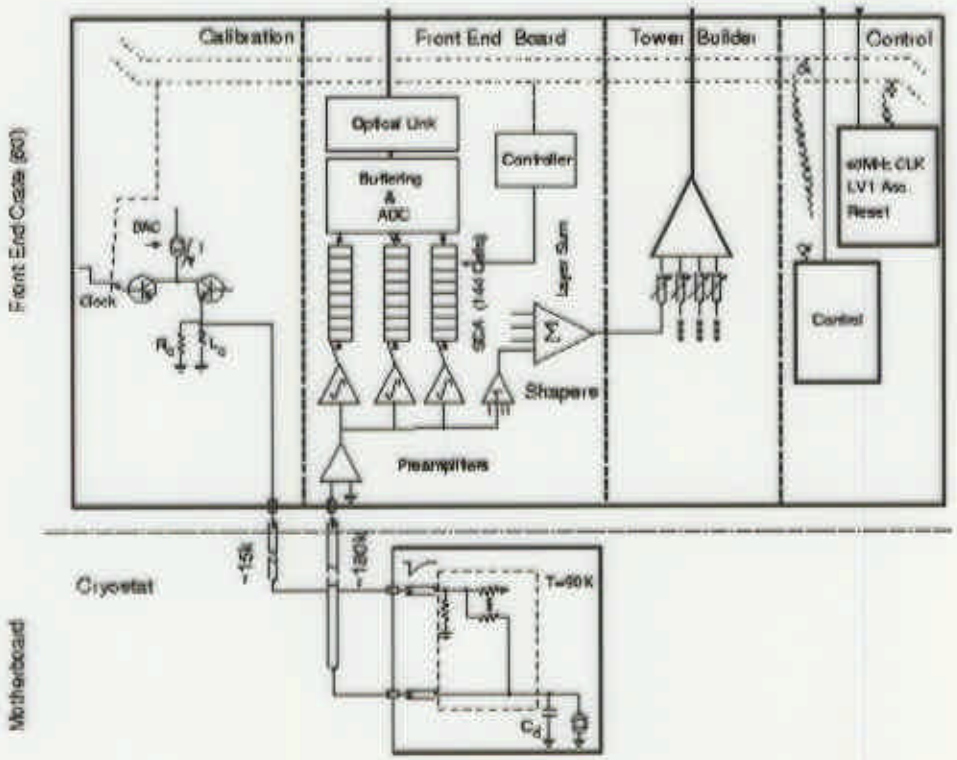
- High radiation level → no electronics in the cold

Signals sent to Front End Crates sitting in the barrel-endcap crack



FRONT END BOARDS

preamps, shapers, analog memories, ADCS



- Dynamic range 10 MeV-1 TeV (17 bits) HIGH MED LOW
→ Signal sent into 3 shapers/memories with gains 100 : 10 : 1
→ 12 bit ADC. Automatic gain choice at digitization time

- Calibration : exponential signal simulating a physics signal

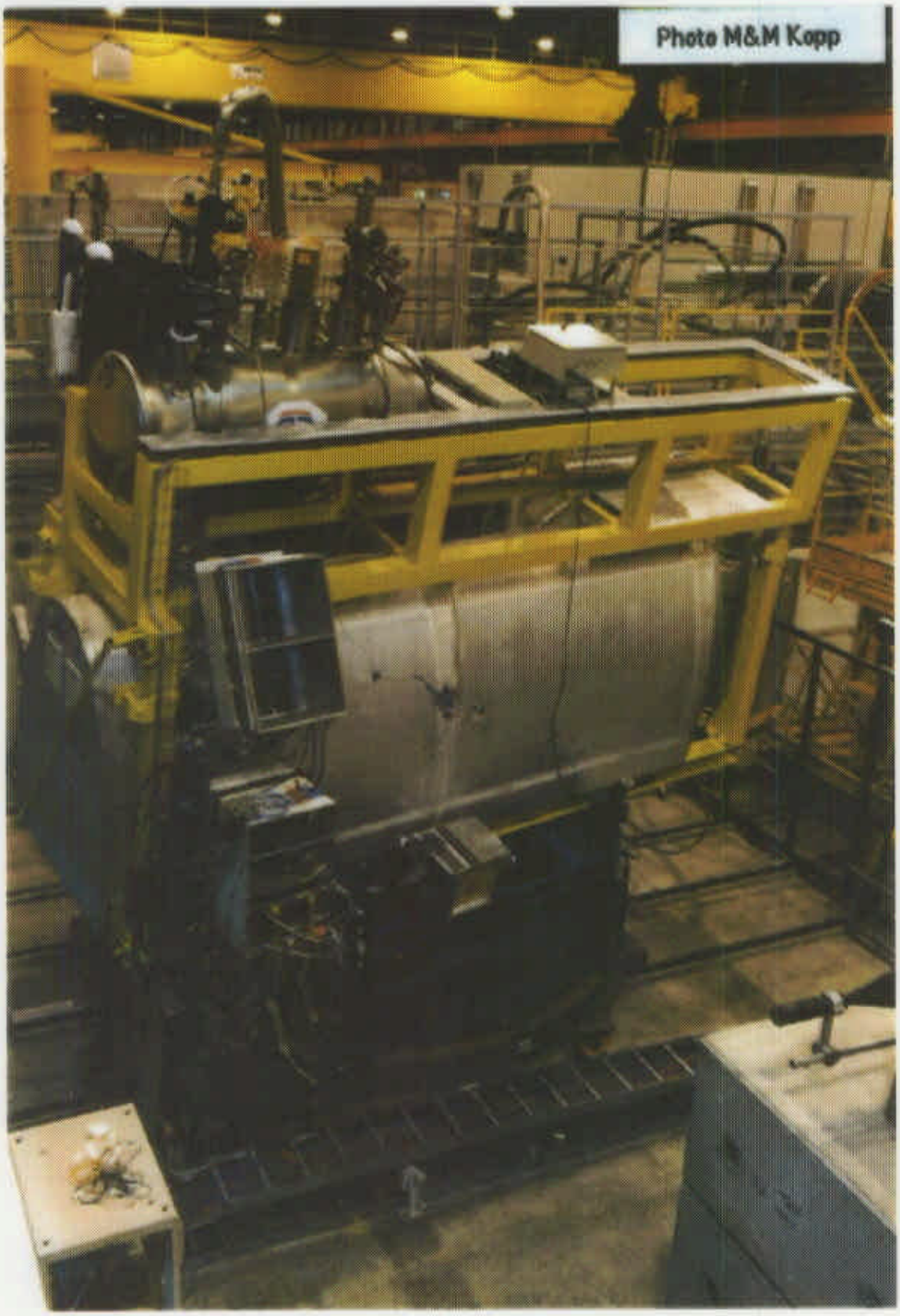
- 5 time samples sent to counting rooms in DSPs which perform optimal filtering

$$E = \sum_{i=1}^{5} a_i \times S_i$$

with a_i related to signal shape and autocorrelation matrix.
→ reduces electronic noise (factor ~ 1.7)
→ corrects for sampling off the peak

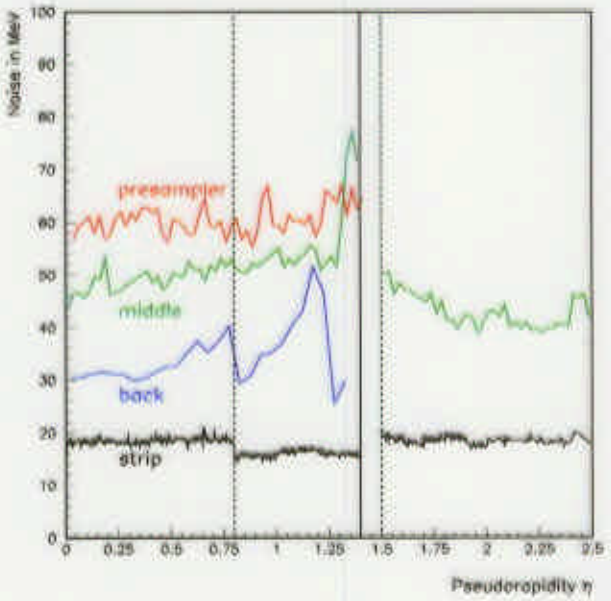
Test Beam

- Barrel and Endcap module 0 tested at CERN with 5-300 GeV electrons during summer 1999 + 2 weeks May 2000 + next August



Noise level

- 278 MeV in ATLAS-like cluster
- 251 MeV incoherent
- ~ 1.7 measured reduction with optimal filtering



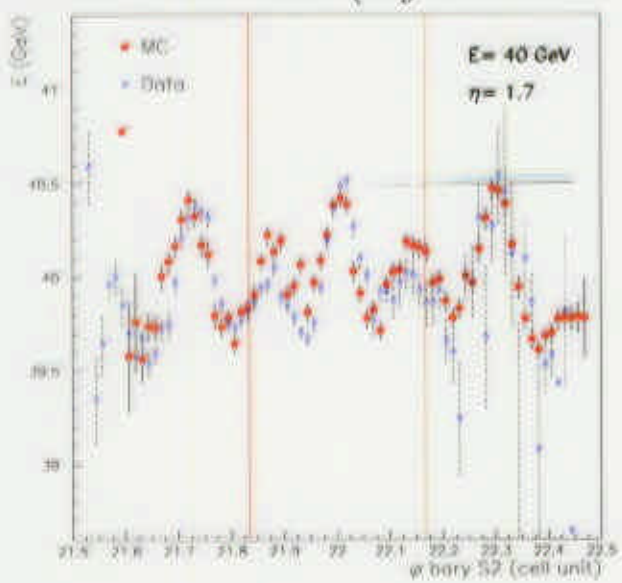
Energy reconstruction

$$E = \alpha E_{PS} + E_1 + E_2 + \gamma E_3$$

α to compensate for dead material in front of the calo ;
γ not critical ($\gamma = 0$ for $E < 50$ GeV)

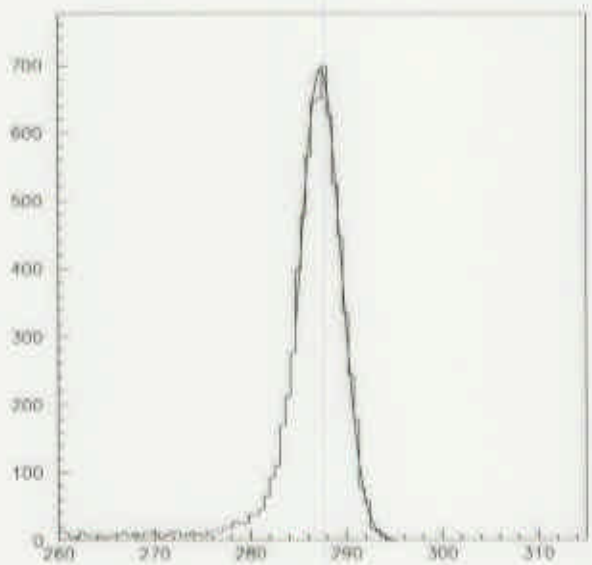
Corrections

- Shower lateral containment in η/φ
- Accordion φ modulation
- Time correction (asynchronous runs)



Resolution

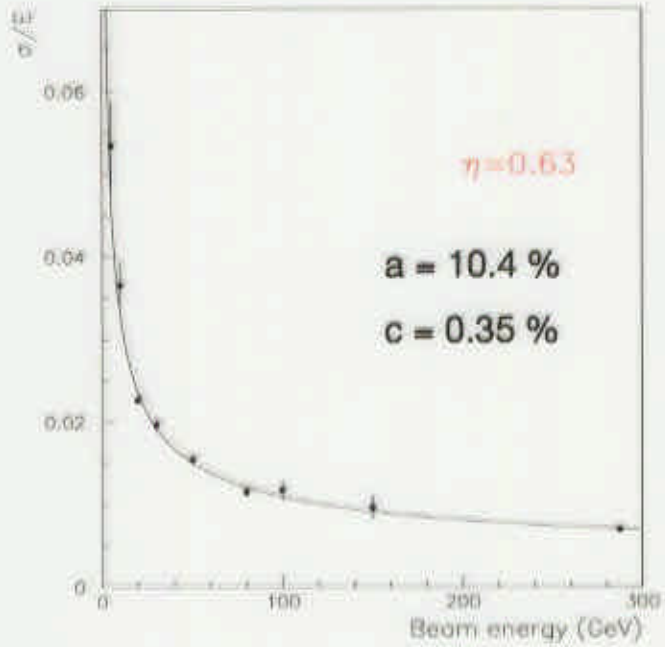
$\sigma/E = 0.7\%$ at $\eta = 287$ GeV

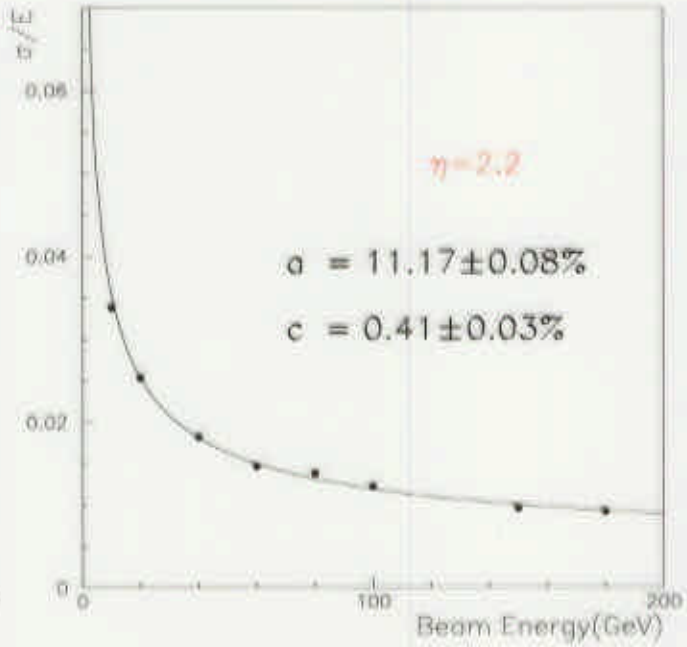


Energy Resolution

$$\frac{\sigma}{E} = \frac{a}{\sqrt{E}} \oplus c \quad \text{noise and beam spread subtracted}$$

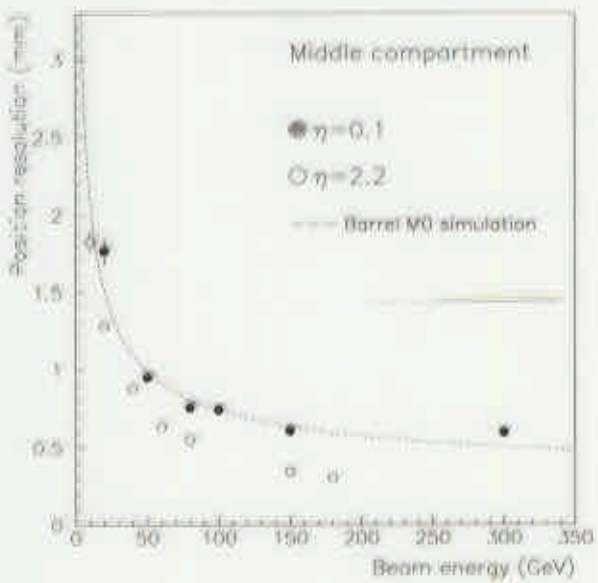
Expected $a = 10\%$ and $c = 0.4\%$

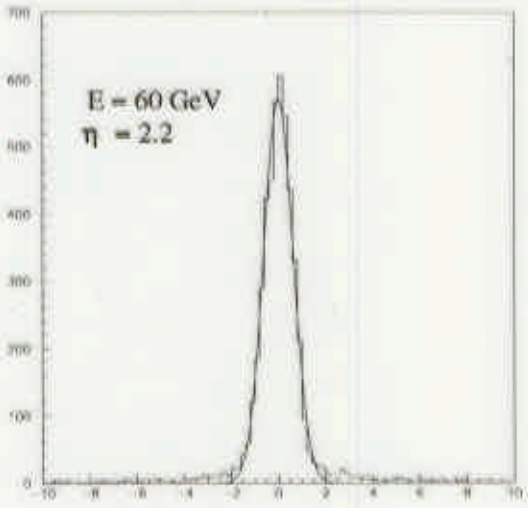




Barrel End Cap

Position Resolution





$\sigma_\eta = 570\mu m$ (after unfolding beam chambers)
In ATLAS conditions $\sigma_\eta \sim 400\mu m$

Conclusion

Module 0 Test

- Barrel and endcap modules 0 intensively tested during summer 1999
- Resolution in agreement with expectation
- Ongoing studies to assess calorimeter uniformity

Module Production

- Lead absorber and electrode production ongoing
- Module assembly starting
- Qualification

→ Absorbers and electrodes controlled before stacking
→ HV and sagging tests during stacking
→ After cabling, overall test of every module in LAr

- Plans : 3 months/module → Completion foreseen in 3 years from now