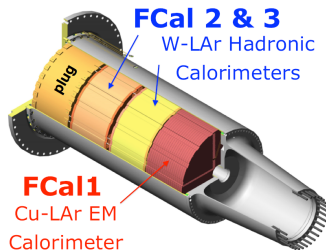


Performance of the ATLAS Forward Calorimeters in First LHC Data

Dag Gillberg, on behalf of the
ATLAS Liquid Argon Calorimeter Group



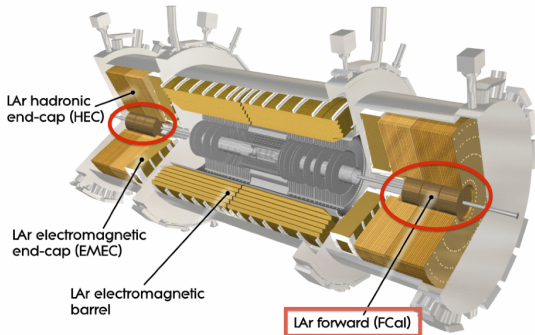
Carleton
UNIVERSITY

The ATLAS Forward Calorimeters (FCal)

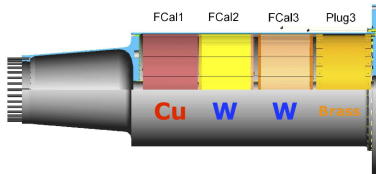
- Covers very forward region:
 $3.1 < |\eta| < 4.9$
- Designed to operate in very high rate environment:
Large noise from pileup

Motivation

- Improve reconstruction of **missing transverse energy**
- Tag forward jets (e.g. **VBF**→Higgs)
- Forward physics



Layer	Absorber	LAr gap	$N_{\text{electrodes}}$	N_{channels}
FCal1	Cu	$269 \mu\text{m}$	24,520	2,016
FCal2	W	$376 \mu\text{m}$	20,400	1,000
FCal3	W	$508 \mu\text{m}$	16,448	508



Design of the FCal

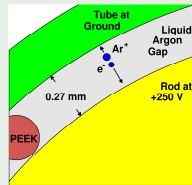
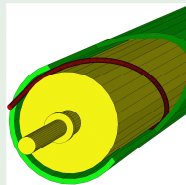
Requirements

- Adequate E_T resolution with **small non-Gaussian tails** ($\sigma E/E = 1/\sqrt{E} + 0.1$)
- **Fast response** in order to minimize noise from pileup, $\mathcal{O}(25 \text{ ns})$
- **Radiation hardness** – cope with design luminosity of $\mathcal{L} = 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ at $\sqrt{s} = 14 \text{ TeV}$:
In FCal: **7 TeV/evt**, 45 Watts

Placement

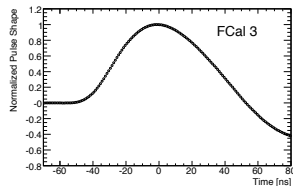
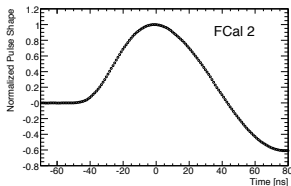
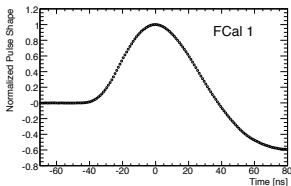
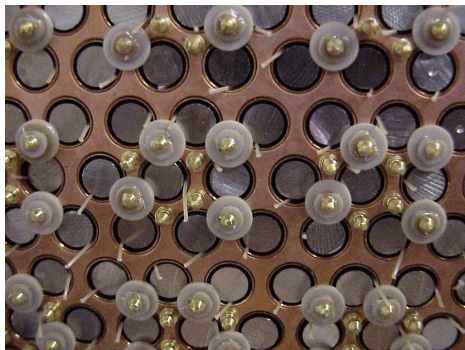
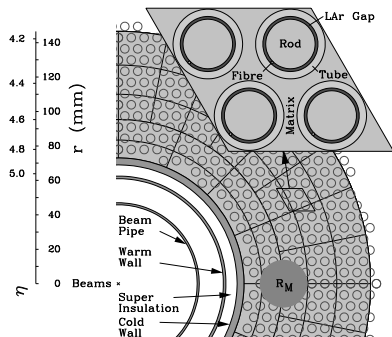
Original idea: FCal at $z = 15 \text{ m}$ from IP
Chosen location: **inside endcap**, $z = 5 \text{ m}$
→ **Smooth transition** from other calorimeters
→ Natural **shielding** for muon system
→ Less upstream material
→ But **more radiation** ($\times 9$)

Design



- Long and skinny electrodes:
~ 5 mm diameter, ~ 45 cm deep
arranged **parallel** to the beam line
- Very narrow LAr gaps:
→ **Fast readout**
→ Avoids ion buildup
- Dense material (tungsten) for FCal2,3
→ **limits** hadronic **shower spread**
→ compact, still **10 λ** (28 X_0 FCal1)
→ placed deeper: less neutron albedo
→ heavy: 2 $\times$ 12 tonnes

FCal electrode arrangement and pulse shapes

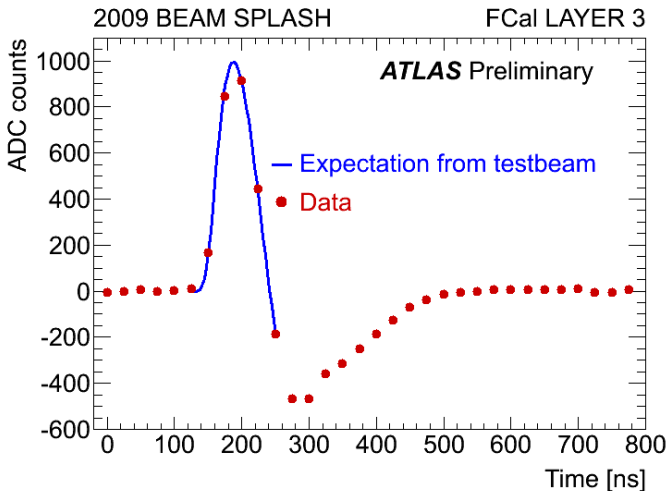


Pulse Shape

- **Fast response** due to small LAr gaps
- **Good agreement** in data with expected pulse shape derived from beam test
- **Optimal filtering** technique used to derive the amplitude A and timing τ of the pulse

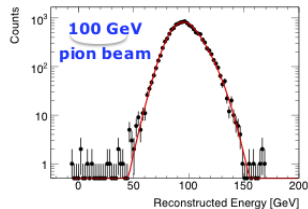
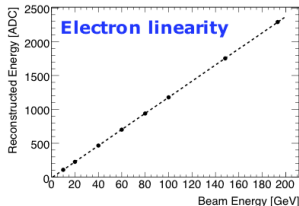
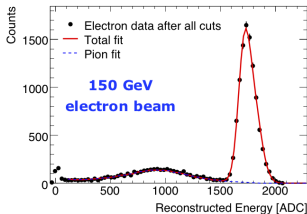
$$A = \sum_{i=1}^5 a_i S_i$$

$$A\tau = \sum_{i=1}^5 b_i S_i$$



Example of a signal pulse in the second hadronic layer recorded in beam splash data.

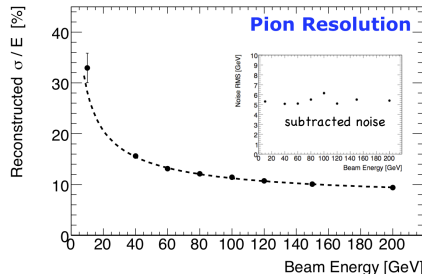
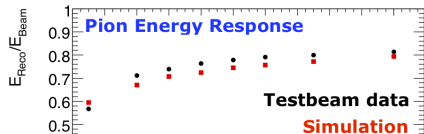
Results from beam test



- Pion and electron beam tests with E_{beam} in the range 10–200 GeV
- Studies of shower shapes, clustering, hadronic weights, etc.
- **Noise subtracted resolution:**

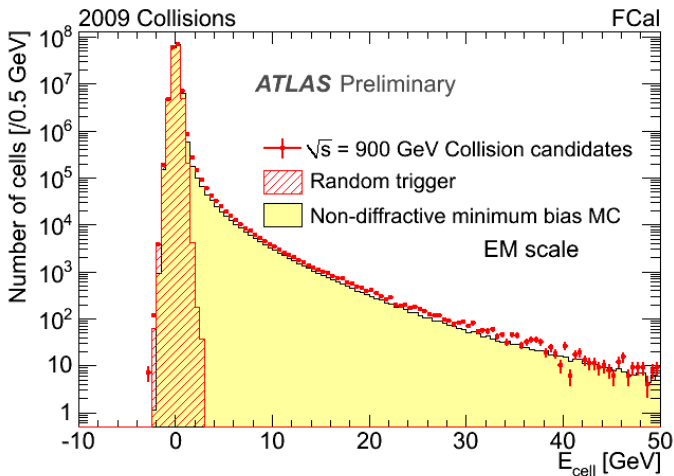
$$\frac{\sigma_E}{E} = \frac{S}{\sqrt{E/\text{GeV}}} \oplus C$$

	Beam Test	Requirements
e	S: 28.5%, C: 3.5%	S: 35%, C: 5%
$\pi^\pm$	S: 95%, C: 7.5%	S: 100%, C: 10%



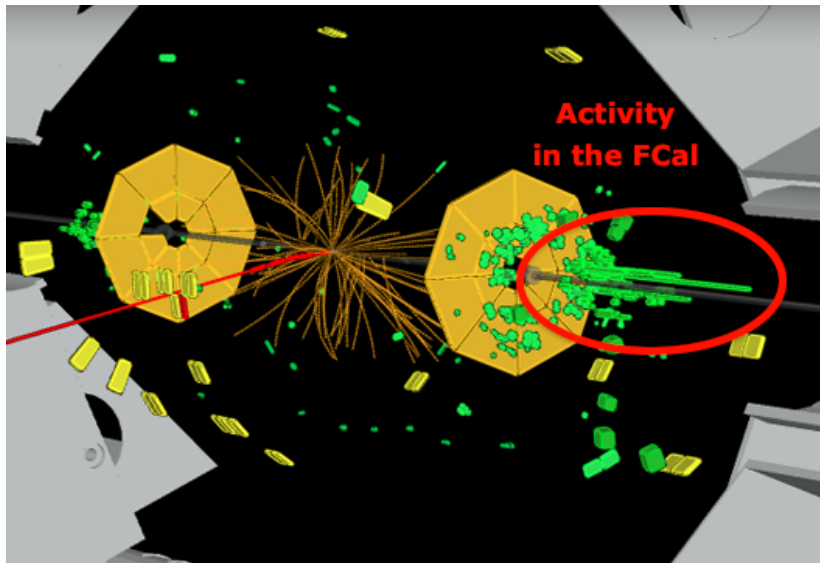
Cell energy distribution

Reconstructed FCal cell energies in 900 GeV collision data



- **Nice agreement** between data and simulation
- Distributions of jet properties, such as jet energy, transverse width and electromagnetic fraction are also in good agreement with Monte Carlo

Event Display



Position Measurement

- FCal close to the beam pipe
- Energy density **increases with η**



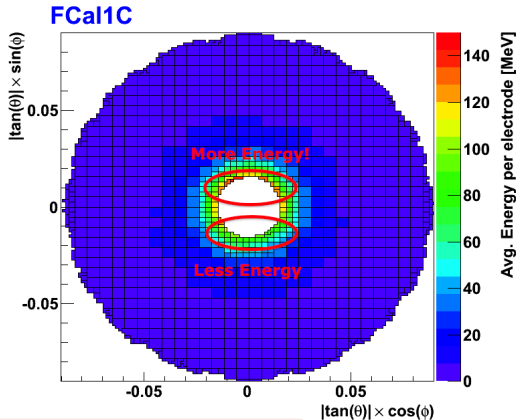
FCal sensitive to translations relative to the beam spot

Average energy per cell:

- **strongly depends on** the transverse distance to the beam spot, r_T (or η)
- ϕ symmetric around the beam spot
- roughly described by:

$$E_{\text{avg}} = k \cdot r_T^{-m}$$

Can measure location of the FCal by looking at E_{avg} over many events



First measurements indicate that the **FCal sits ≈ 2 mm low**
→ consistent with possible sag in support structure

Summary

The ATLAS Forward calorimeters

- Covers the forward region:
 $3.1 < |\eta| < 4.9$
- **Novel design** to operate under high radiation
- Performance in **beam tests** meets **design requirements**
- Pulse shapes agree very well with expectation
- Distributions of cell energies and jet properties in **first collision data** agree with MC expectations
- The position of the FCal can be measured in data

→ Important for precise $\cancel{E}_T$ and forward jet p_T reconstruction

