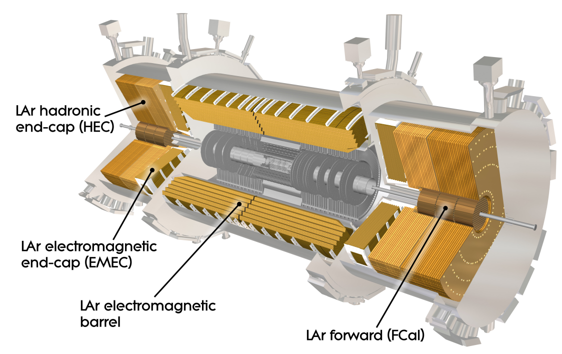
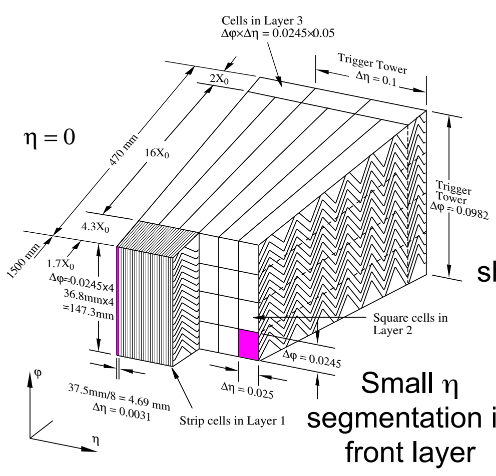
ATLAS Liquid Argon Calorimeter Performance in Run 1 and Run 2

The ATLAS detector collected 27 fb^{-1} of data at centre-of-mass energies of 7 and 8 TeV during LHC Run 1 and 3.9 fb^{-1} at 13 TeV during Run 2 in 2015. The well calibrated and highly granular Liquid Argon (LAr) calorimeter achieved its design goals during these periods, both in terms of energy measurement and direction resolution. This poster presents an overview of the LAr calorimeters successful performance, operation, monitoring and data quality during LHC Runs 1 and 2.

Sampling calorimeter with lead/ copper absorbers and LAr active medium.

→ Provides EM calorimetry out to |η|<3.2 & hadronic calorimetry from 1.5<|η|<4.9.

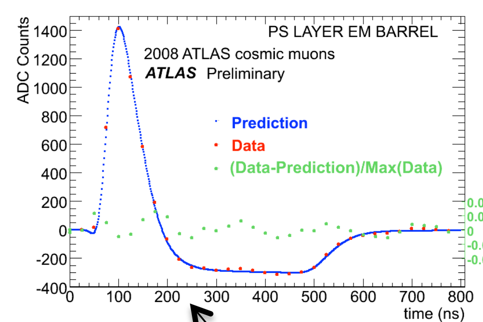




Accordion geometry → full φ coverage

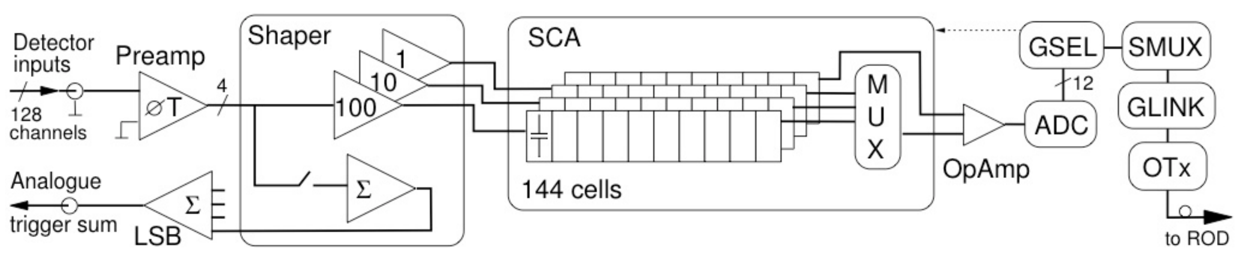
Majority of shower contained in middle layer

Small η segmentation in front layer



Signal pulse measured in 2008 cosmics

Electronics readout onto **Front End Board**
1524 FEBs, 128 channels/FEB



Trigger tower building

Store signal awaiting L1 trigger decision

Following L1 accept 4/32 samples read out for physics/ calibration

Data taking efficiency and data quality

LAr DQ efficiency in Run 1 and 2	
2011	96.7%
2012	99.1%
2015	99.4%

LAr calorimeters have consistently high efficiency, operating with DQ efficiency of 99.4 % during 2015

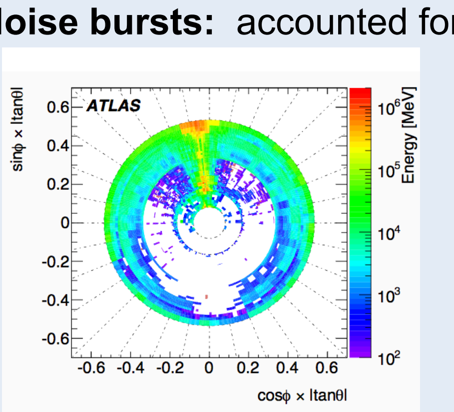
Operational channels: 99.9%

Noisy channels: automated procedure to identify and flag bad channels

High voltage trips: accounted for 0.38% of data loss in 2015 (compared with 1.0% in 2012)

→ New high voltage power supplies installed to cope with temporary intolerable increase in current

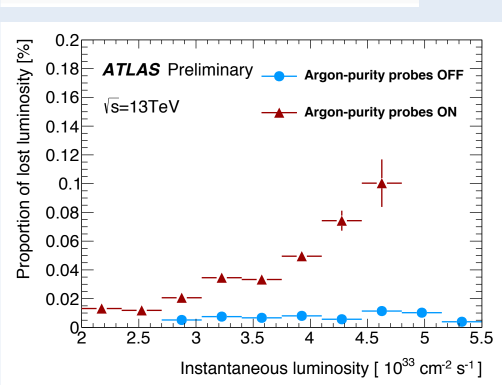
Noise bursts: accounted for 0.02% of data loss in 2015



- Bursts of coherent noise, most common in the EMEC
- Observed during collision data-taking
- Identified using based on number of cells/FEB with E>3σ and number of events with bad quality factor

$$Q = \sum_{i=1}^{5} (s_i - ped - A(g_i - \tau g_i'))^2$$

Quantify compatibility of signal pulse with expected physics pulse shape



- Efficiently cleaned defining a time window veto period of 50ms around ≥ 2 noise burst candidates (reduced from 250ms during 2012)
- Expect further reduction in data loss during 2016 running with LAr purity HV switched off during collisions

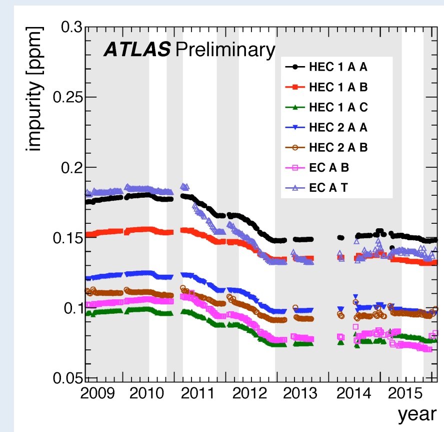
Liquid Argon purity

Impurity very stable over time

Measured outside of collision data-taking to avoid contamination from ionising radiation

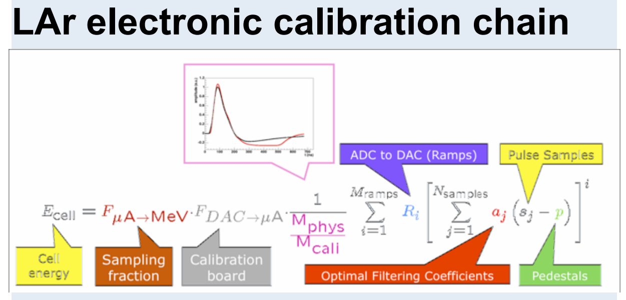
EMB
200 ppb

EMEC
140 ppb



Electronic calibration

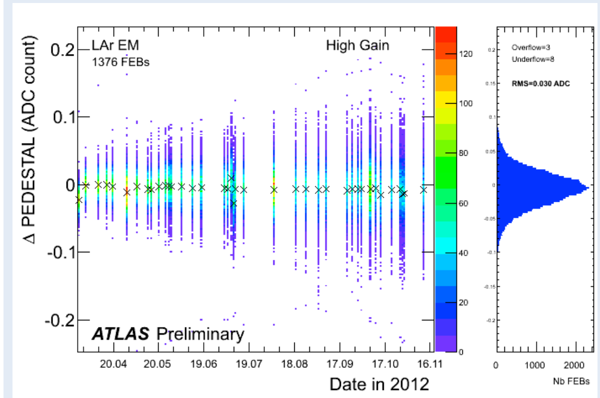
LAr electronic calibration chain



ADC counts to raw cell energy

Daily electronic calibrations to measure:

- Gain
- Pedestal and noise
- Calibration pulse shape (weekly)

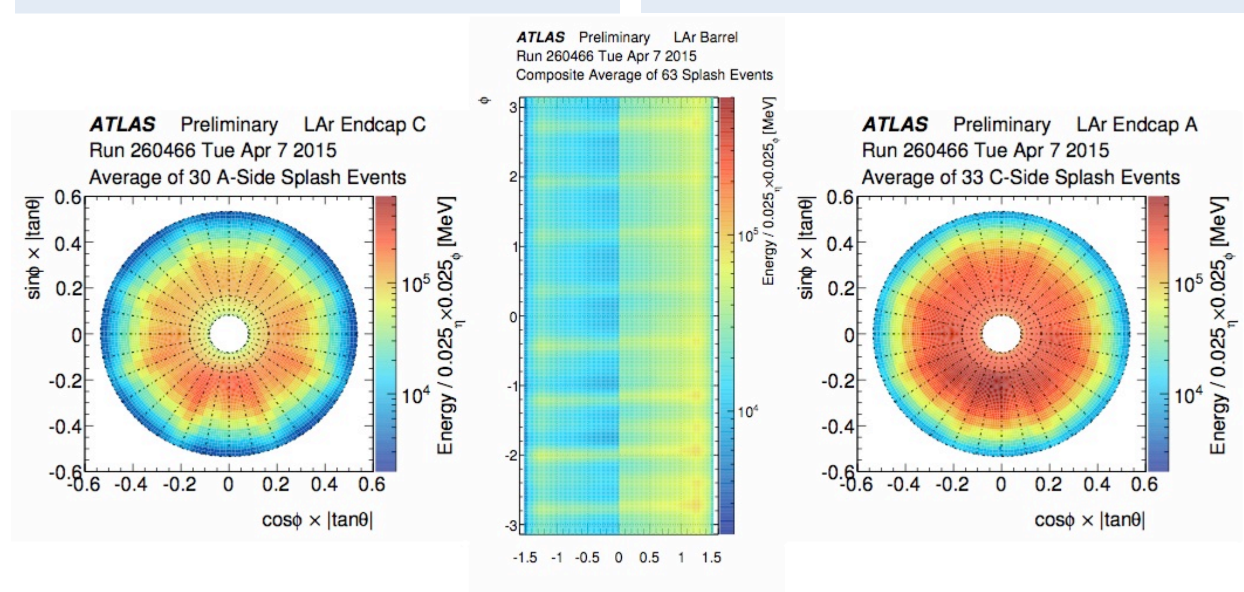


Pedestals stable in 2012 ~0.03 ADC

Energy flow

Average LAr cell energy sums

- On average 3.5 PeV recorded per event
- Eight-fold pattern from end-cap toroid magnets visible



Timing

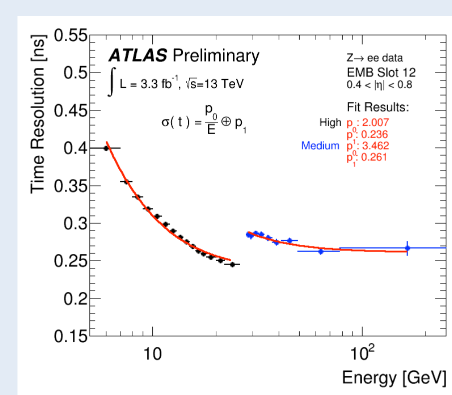
Time resolution as a function of energy in the EMEC

Good timing resolution important for cosmic rejection and long-lived particle searches

- Measured in Z→ee data sample
- Offline corrections measured in W→eν data events
- Data fit to functional form

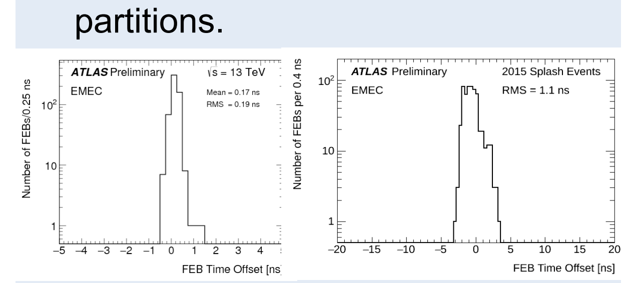
$$\sigma(t) = \frac{p_0}{E} \oplus p_1$$

- Assume LAr Calorimeter contributes only to the uncorrelated part of the constant term
- Overall contribution to the constant term of the time resolution 65 ps (170 ps) calculated in the EMEC (EMB)



Front end electronics timing

- Energy weighted time per FEB using a Gaussian fit of all channels using 1.6 fb-1 collision data at 13 TeV (lower left).
- Distributions are well centred for all partitions.



- FEB timing measured in April 2015 beam splash events (upper right) with time of flight corrections applied to account for splash events originating away from the interaction point

Emma Kuwertz, on behalf of the ATLAS Liquid Argon Calorimeter Group