

ATLAS Tile Calorimeter calibration systems

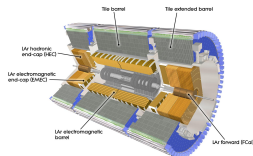


Figure: ATLAS inner detector and calorimeters.

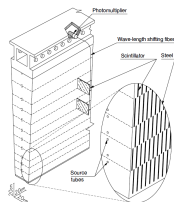


Figure: Layout of TileCal module.

- Single pion TileCal+LAr energy resolution $\frac{\sigma}{E} = \frac{52.05\%}{\sqrt{E}} \oplus 3.02\% \oplus \frac{1.59\%}{E}$
- PMT responses A_{PMT} are calibrated to **electromagnetic scale in energy reconstruction**
- $E_i = A_i \times f_{\text{ADC} \rightarrow \text{pC}} \times f_{\text{Cs}} \times f_{\text{laser}} \times f_{\text{GeV/pC}}$
Aim: achieving an accuracy on the PMT response variations at the **sub-percent-level** using laser

Upgrade of Laser Calibration System

- Laser system has been **upgraded** for LHC Run 2.
- **Newly designed** Laser system **commissioned** in Long Shutdown 1
- Achieved an accuracy on the PMT calibration at the **sub-percent-level**
- Re-designed optical system that distributes laser light more stable, correcting for **misalignment effects** and **mechanical vibrations**
- **Monitoring diodes** are **internally calibrated** using an α source/LED
- Electronics for system control and signal digitization optimized for **new LHC run conditions**
- **Characterization study** without offline corrections

Characterization study	old LaserI	new LaserII
stability of PMT/diode	1%	< 0.5%
stability of diode/ref.	1.1%	< 1%
stability electronics	0.3%	0.1%
linearity of electronics	1% – 2%	0.5%
light mixing non-uniformity	10%	< 5%