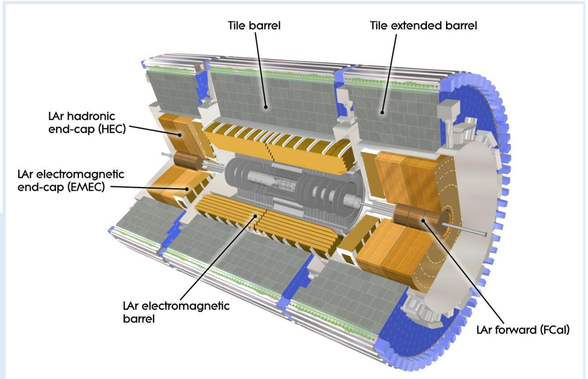
ATLAS Tile Calorimeter Charge Injection System (CIS) and L1Calo

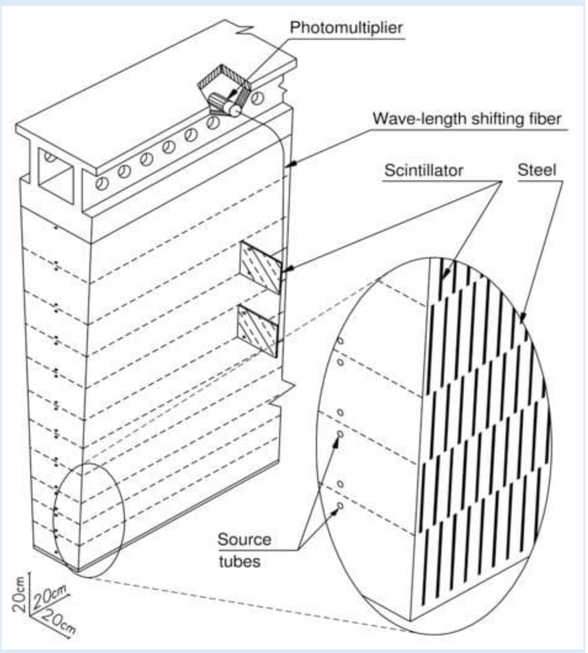
Mengyang Li and Peter Camporeale of The University of Chicago
ATLAS Collaboration Week (February 13-17, 2023)

INTRODUCTION

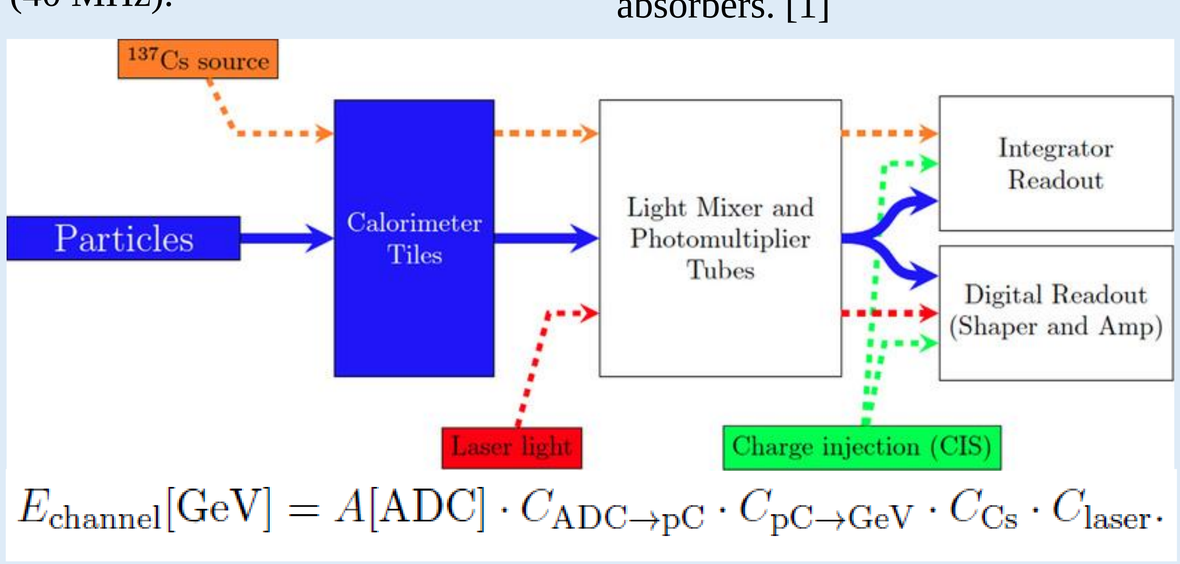
The Tile Calorimeter is a central sampling hadron calorimeter of the ATLAS experiment. It provides information to reconstruct hadrons, jets, taus, missing transverse energy, assists in muon identification and provides inputs to L1 trigger. Light produced by particles going through scintillator is converted into electric charge by the photomultiplier tubes (PMTs). Depending on its value, signal is processed in high or low gain, with ratio of amplification equal to 64:1, respectively. Ten-bit digitizers sample and convert analog signal into digital output at the current LHC rate of bunch crossing (40 MHz).



A cut-away drawing of the ATLAS inner detector and calorimeters. [1]



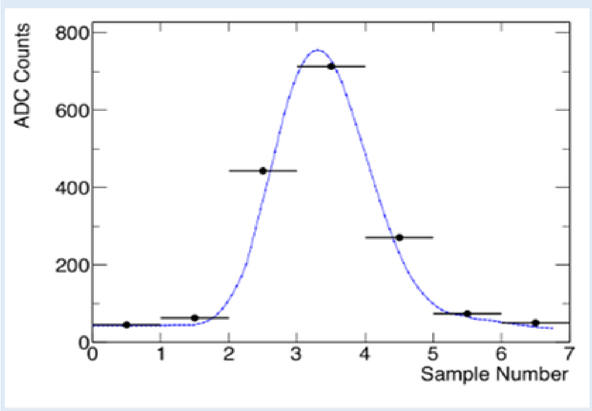
A module of the tile calorimeter, with plastic scintillators and steel absorbers. [1]

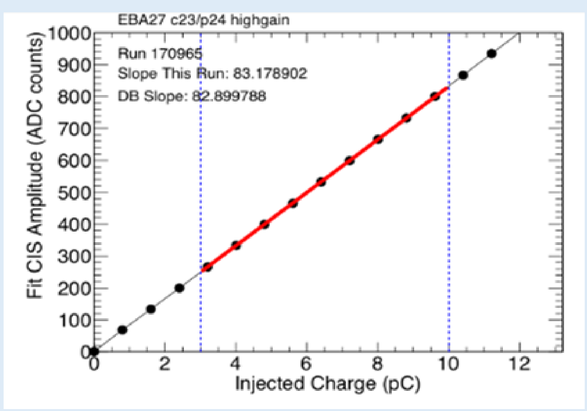


Equation of particle energy reconstruction and flow diagram of the TileCal calibration tools: Cesium, Laser, and Charge Injection systems (CIS), and Integrator System readout [2]

CIS CALIBRATION PROCESS

The charge injection system injects a pulse of known charge in every channel and records the output in ADC counts. For each fixed charge, CIS repeats the charge injection in each channel and fits the mean amplitude. The results of the fit yield the $C_{ADC\to pC}$ conversion factor (CIS constant), converting ADC counts to pC.

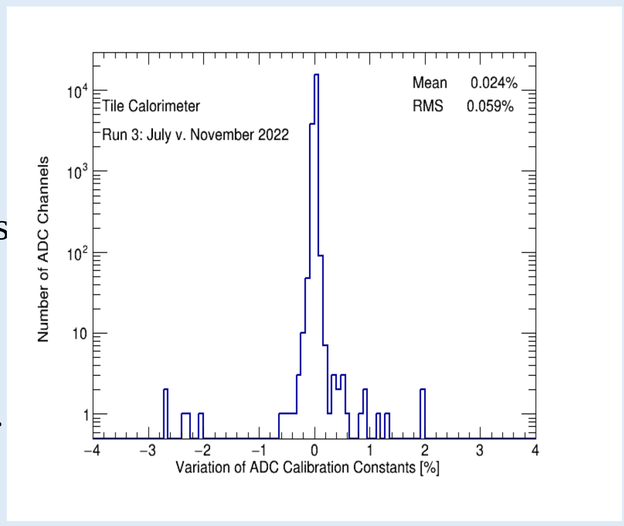




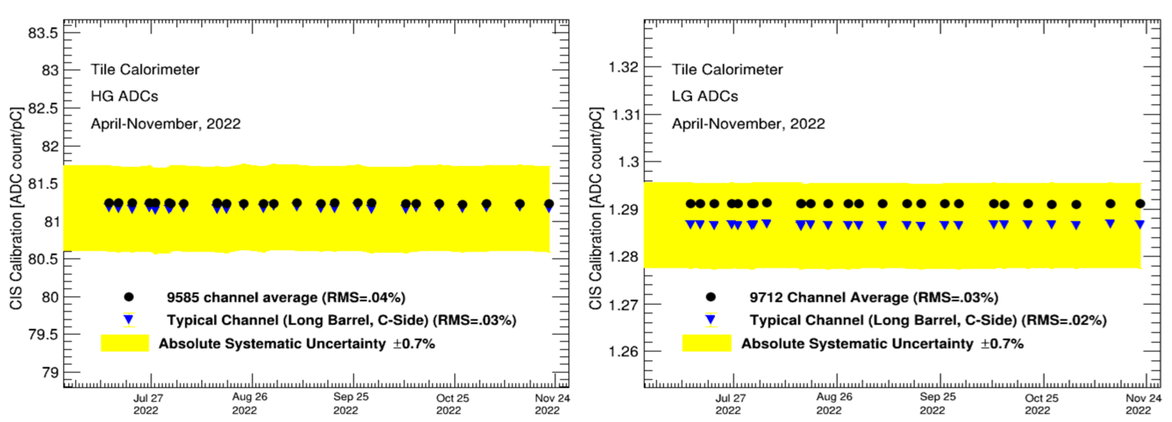
Analog CIS pulse shape fit to 7 samples (left); fit of mean reconstructed amplitude over a range of injected charges (right) [3]

CIS CONSTANT STABILITY IN RUN 3

CIS runs are taken 2-3 times per week during data taking and technical stops to monitor the conditions of the Tile electronics. While instabilities in the electronics can cause shifts of the individual channel calibrations of up to 0.7%, these jumps are rare and are generally corrected within a month. In Run 3 from March to November 2022, we had stable constants in each channel (figure on the right) and the detector as a whole (figures below) over time.



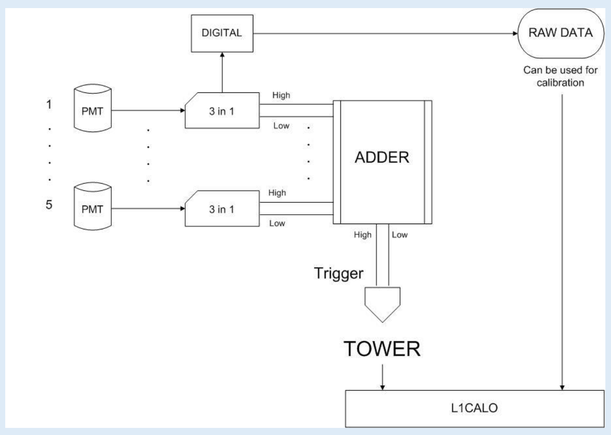
Number of individual channel percentage change of CIS constant in Run 3 period



CIS constant average over Run 3 period from April to November 2022, in High Gain (Left) and Low Gain (Right)

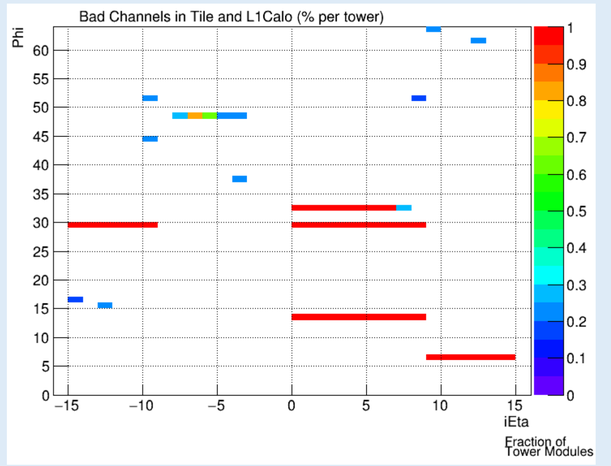
L1CALO AND TILE IN RUN 3

The Level 1 Calorimeter Trigger (L1Calo) uses Tile trigger towers as inputs during data taking. Tile and the L1Calo take combined calibrations to monitor response of trigger towers and compare directly to the response of the electronics. To monitor photomultiplier tubes (PMTs) that contribute to a bad trigger tower, Tile performs PMT scans. To simulate PMT signals, the calibration uses CIS to inject charges to one PMT at a time



Schematic of PMTs and Trigger Towers in Tile and L1Calo [4]

We identify two types of bad channels: no gain (less than 10% response) and half gain (between 10% and 50% response). We compare these channels to those flagged by L1Calo through other calibrations. Bad channels are marked for possible maintenance interventions during technical stops.



Map of fraction of bad PMT channels per tower in Tile from PMT Scan 441888. Red regions correspond to modules off during the PMT scan.

References: 1. ATLAS Collaboration 2013 Approved Detector Reference Figures And Schematics URL https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ApprovedDetectorReferenceFiguresAndSchematics
2. Calibration and Performance of the ATLAS Tile Calorimeter, Krystsina Petukhova and on behalf of the ATLAS Collaboration 2019 J. Phys.:Conf. Ser. 1390 012107
3. Tile CIS Calibration URL https://twiki.cern.ch/twiki/bin/view/Atlas/TileCisCalibration
4. Tile Trigger Bad Channels URL https://twiki.cern.ch/twiki/bin/viewauth/Atlas/TileTriggerBadChannels