Performance of the Tile Calorimeter Demonstrator system for the ATLAS Phase-II Upgrade

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ATLAS EXPERIMENT

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- ATLAS hadronic calorimeter, iron as absorber and plastic scintillator as active material. Scintillation light is collected to photomultiplier tubes (PMTs) through wavelength shifting fibers and a total of ~**10,000 PMTs are used. (Figure 1)**
- In order to cope with the **increased luminosity**, a completely new on-detector and off-detector electronics are being developed, aiming for **increased trigger rates** and high-performance data acquisition.
- The **TileCal Demonstrator** is designed to **evaluate** the **detector performance** with new readout electronics without compromising the present data taking.

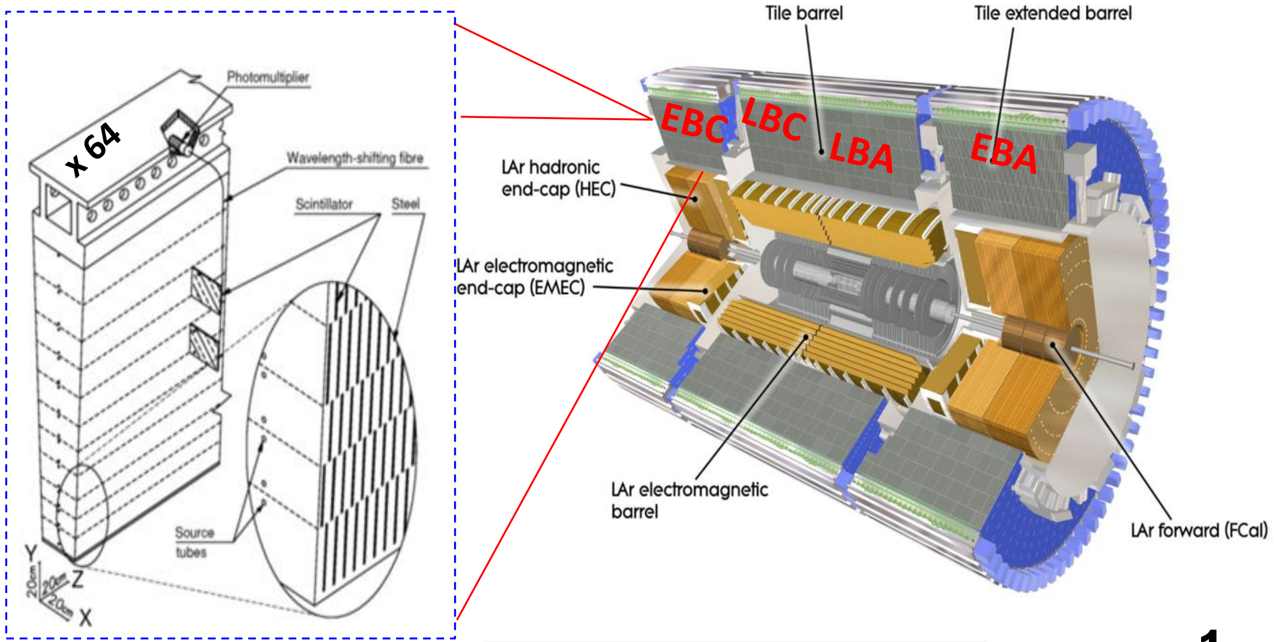


Figure 2) ATLAS Tile Calorimeter structure

Phase-II Upgrade Demonstrator and readout chain

- The Demonstrator modularizes a **legacy TileCal Drawer** in four Mini-drawers (MDs), each MD (Figure 2) serves up to 12 channels consisting of **12 Photomultiplier (PMTs)**, **12 Front-End Boards (FEBs)**, **An Adder based board**, a **Daughterboard (DB)** (**Figure 2**)

- The data is sent off-detector to be stored in pipelines, reconstructed and triggered-out by: **Tile Preprocessors (TilePPr) that receives legacy TTC (Timing Trigger and Control) commands and triggers, DCS (Detector Control Systems) commands, and sends the triggered data to the legacy ROD (Read Out Driver).** (**Figure 3**)

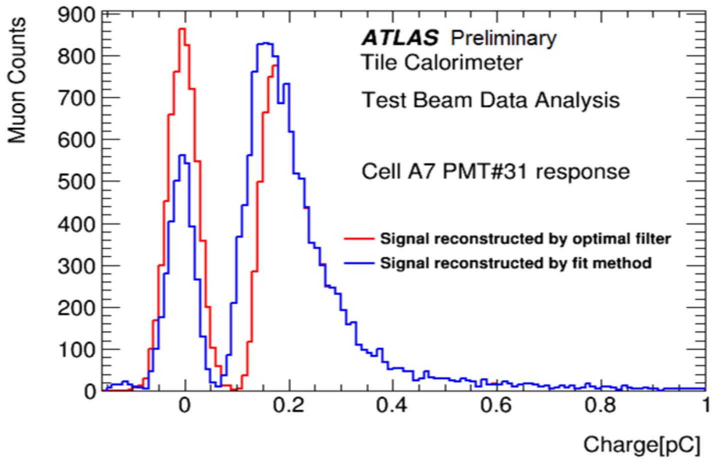


Figure 3a) Muon signal reconstructed using Fit method and Optimal Filter when 150GeV muons are hitting LBC – Demonstrator, at -90 ° (cell A7 PMT#31 response).

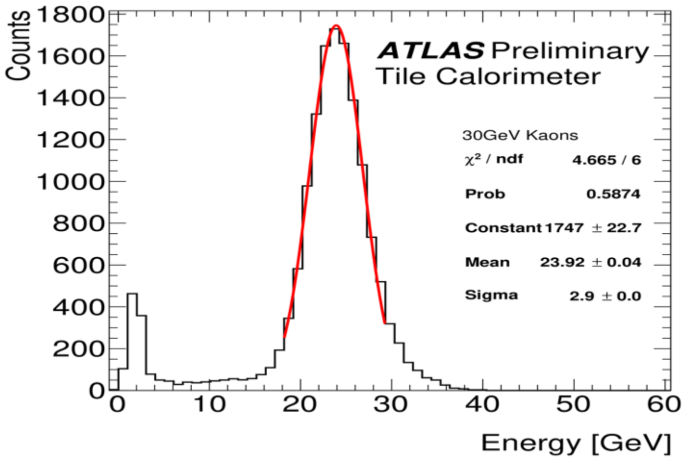
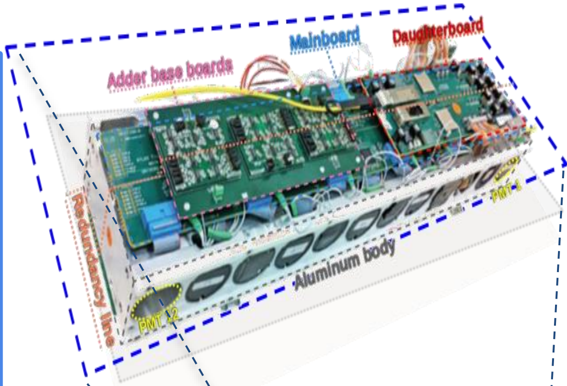


Figure 3b) Distribution of the measured energy for 30 GeV kaons. The Gaussian function fit, performed in the range ±2σ centred on the peak value is shown. The low-energy tail is due to longitudinal energy leakage. The low energy peak is due to muons.

Main goals of Demonstrator analysis:

(i) pedestal, stability over long periods, (ii) stability of the noise, (iii) timing, (iv) PMT Response variation.



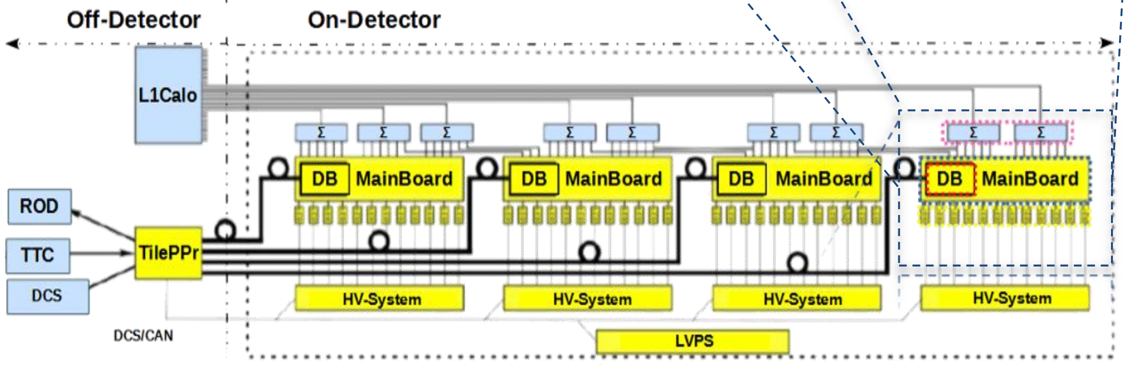


Figure 2) Tile Demonstrator

- The Demonstrator was inserted inside the ATLAS detector in June 2019. Laser calibration pulse in empty bunches and cosmic events were successfully recorded.

Demonstrator status and test results

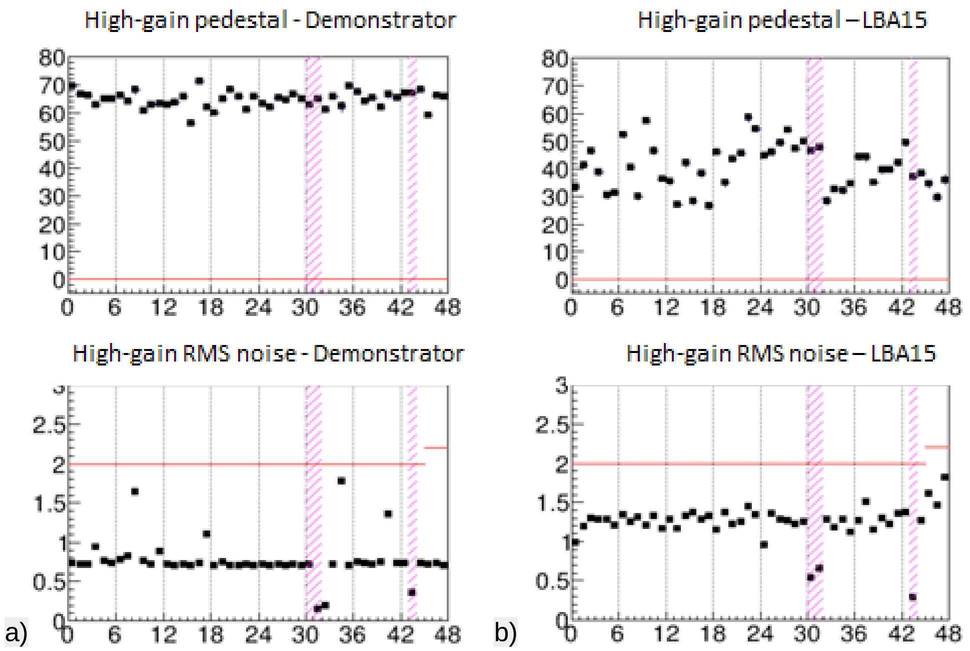


Figure 4) pedestal averages and noise for the Demonstrator channels together with the ones for the legacy super-drawer LBA 15 channels

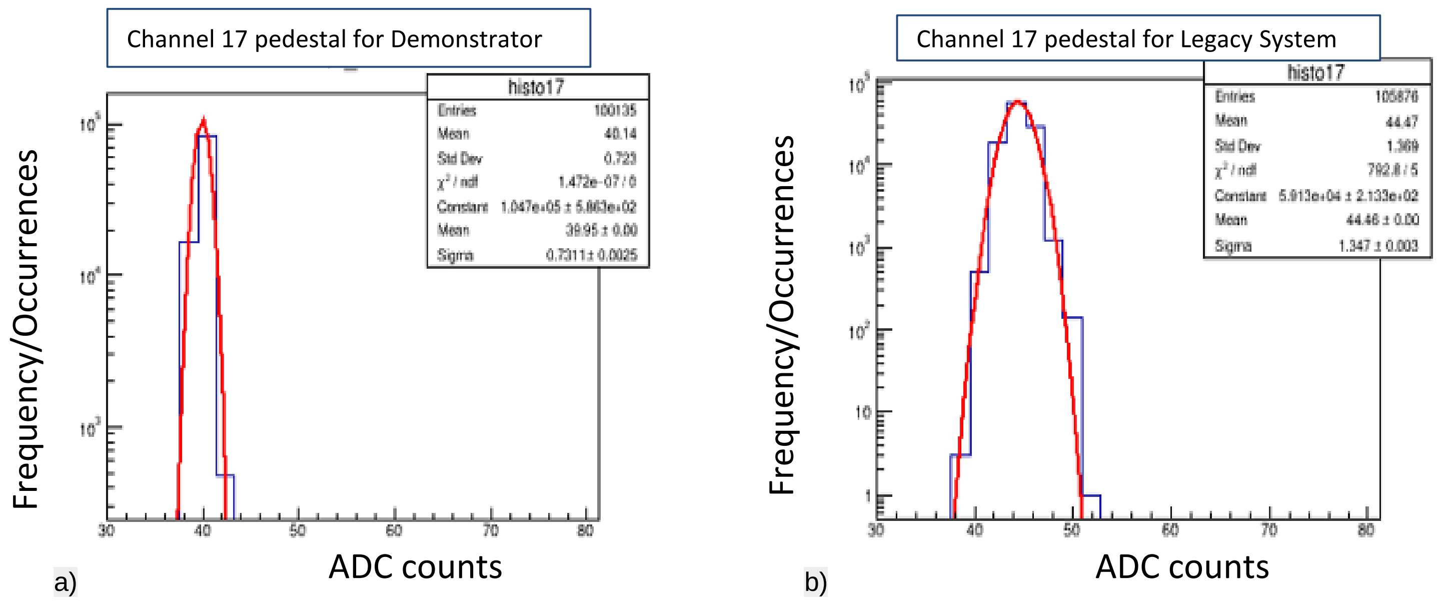


Figure 5 Channel 17 pedestal distributions for a) the Demonstrator and b) the Legacy system LBA 15; the Gaussian function fit performed on the pedestal measurements is shown using the red line

- The pedestal value is estimated in special calibration runs and it is subtracted from the received digital samples. Digitized ADC samples for each channel *i* can be expressed as $y_i=ped_i+Ag(t_i+T)+n_i$, where ped is the signal pedestal, A is the true amplitude, g(t) is the normalized reference pulse shape at time t, *T* corresponds to the phase between the expected and measured times, and n_i is the background noise.
- Pedestal tests showed slightly lower noise in the demonstrator for April run 2021 (**Figure 4, 5**).
- The Demonstrator readout was fully integrated in the TDAQ software with very stable links (**Figure 5**).

Demonstrator status, test results and conclusion

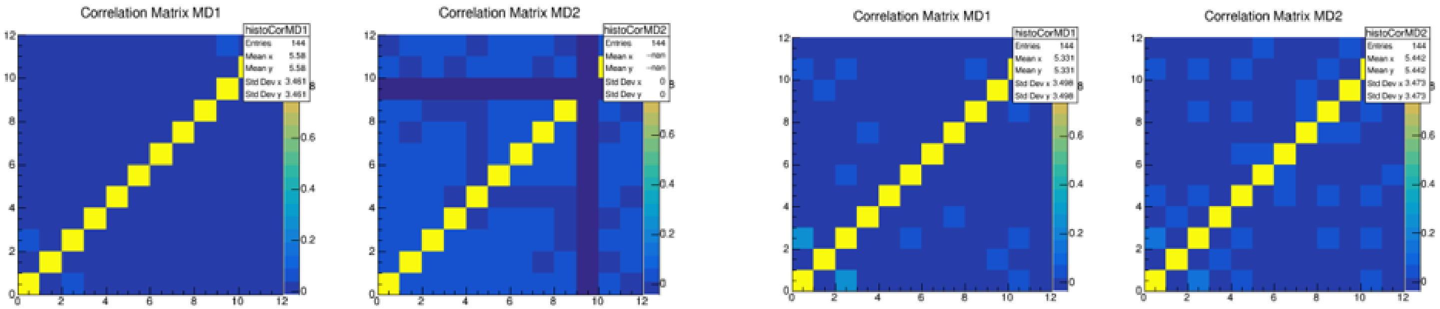


Figure 6) Correlation analysis for the Demonstrator pedestal distributions

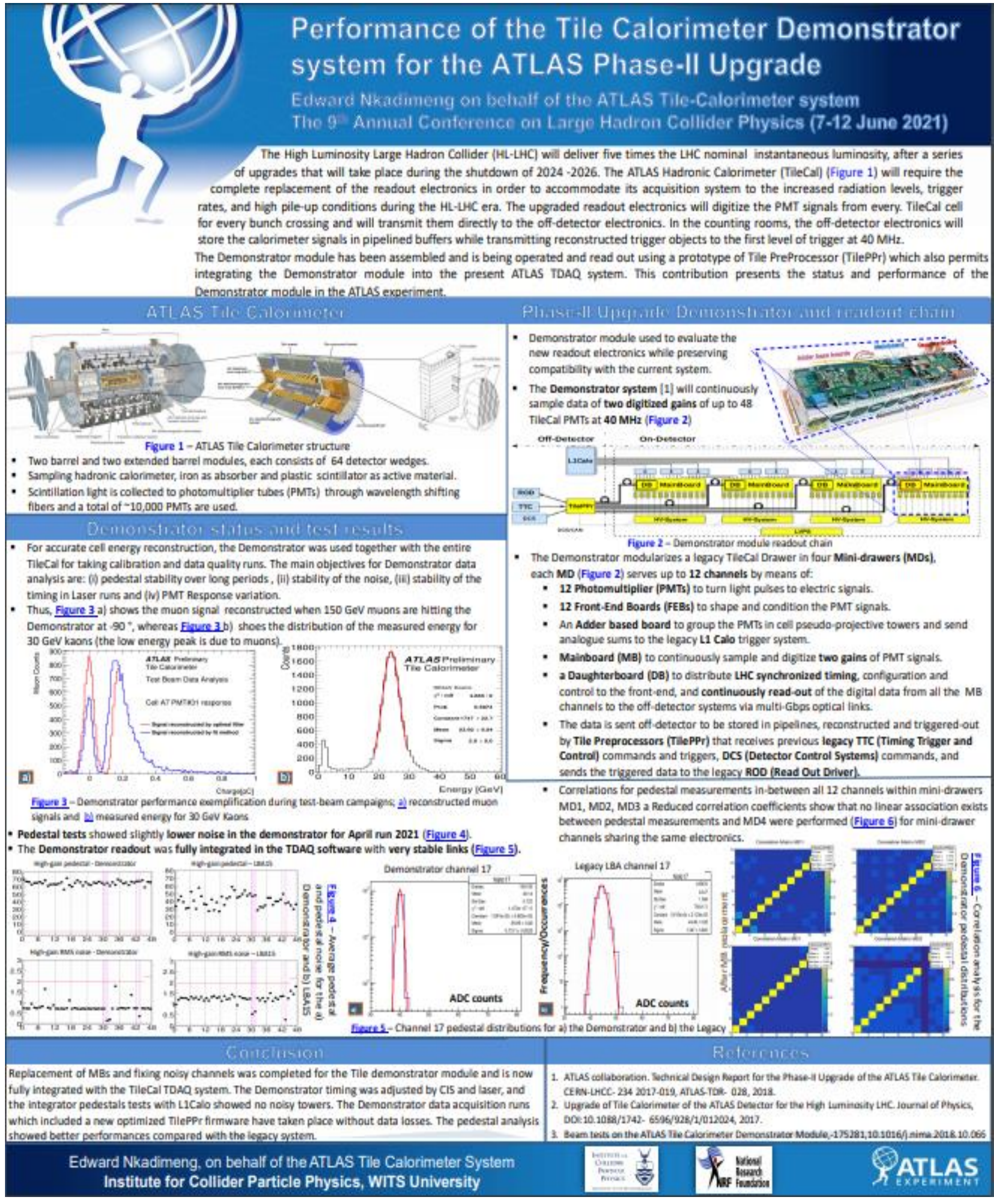
- Correlations for pedestal measurements in-between all 12 channels within mini-drawers MD1, MD2, MD3 a Reduced correlation coefficients show that no linear association exists between pedestal measurements and MD4 were performed (**Figure 6**) for mini-drawer channels sharing the same electronics.

Conclusion/Summary

- Replacement of MBs and fixing noisy channels was completed for the Tile demonstrator module and is now fully integrated with the TileCal TDAQ system.
- The Demonstrator data acquisition runs which included a new optimized TilePPr firmware have taken place without data losses. The pedestal analysis showed better performances compared with the legacy system.

References

1. ATLAS collaboration. Technical Design Report for the Phase-II Upgrade of the ATLAS Tile Calorimeter. CERN-LHCC- 234 2017-019, ATLAS-TDR- 028, 2018.
2. Upgrade of Tile Calorimeter of the ATLAS Detector for the High Luminosity LHC. Journal of Physics, DOI:10.1088/1742- 6596/928/1/012024, 2017.
3. Beam tests on the ATLAS Tile Calorimeter Demonstrator Module,-175281,10.1016/j.nima.2018.10.066



Poster Link: https://indi.to/KryHB