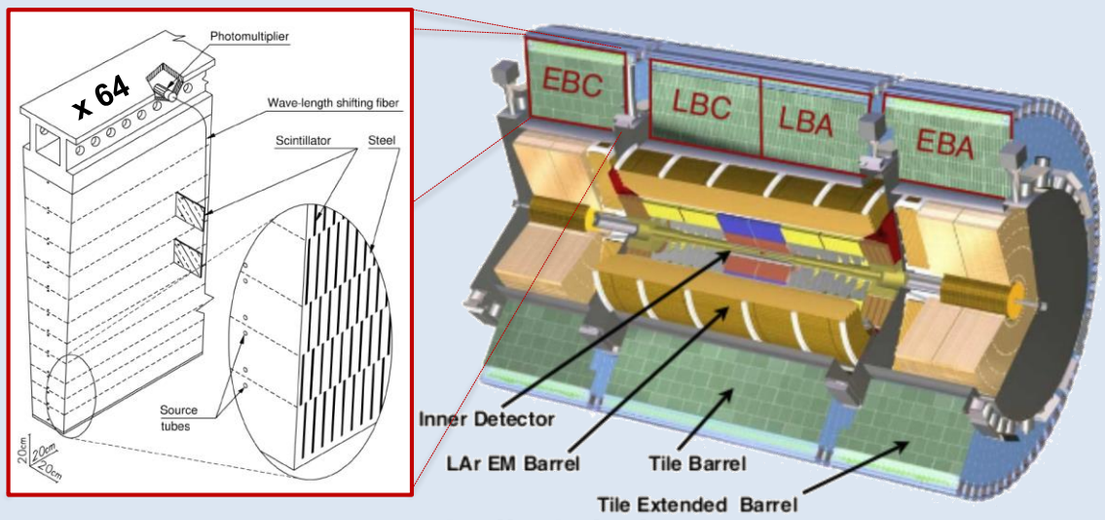
Data acquisition and Software for the ATLAS Tile Calorimeter Phase-II Upgrade Demonstrator

After a series of upgrades, the High Luminosity LHC (HL-LHC) will have an average luminosity of 5-7 times larger than the LHC design value. The readout electronics of the ATLAS Tile Calorimeter (TileCal) will undergo a substantial upgrade during the phase II upgrade to accommodate the HL-LHC requirements. The TileCal Demonstrator is designed to evaluate the detector performance with new readout electronics without compromising the present data taking.

ATLAS Tile Calorimeter

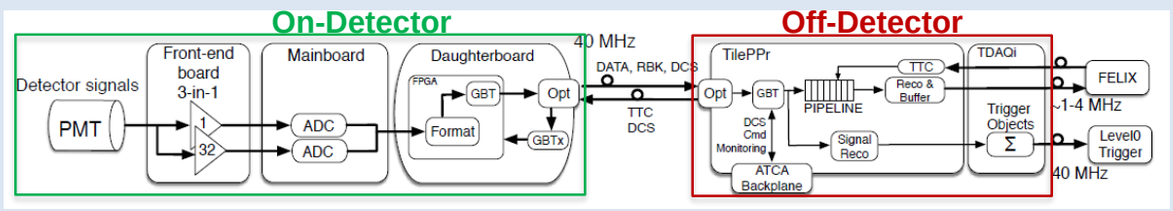


ATLAS Tile Calorimeter

- Two barrel and two extended barrel modules, each consists of 64 detector wedges
- Sampling hadronic calorimeter, iron as absorber and plastic scintillator as active material.
- Scintillation light is collected to photomultiplier tubes (PMTs) through wavelength shifting fibers.
- A total of ~10,000 PMTs used.

TileCal Phase II Upgrade Readout Electronics

- The on-detector electronics are modularly located in extractable Super-Drawer, each of which contains 4 identical Mini-Drawers and covers one detector wedge.
- Each Mini-Drawer houses up to 12 PMT blocks, including HV base board and the analog readout front-end electronics, one MainBoard and one DaughterBoard.
- The MainBoard digitizes the front-end two-gain outputs at 40 MHz.
- The DaughterBoard concentrates data and interfaces between on- and off-detector electronics with redundant optical links.

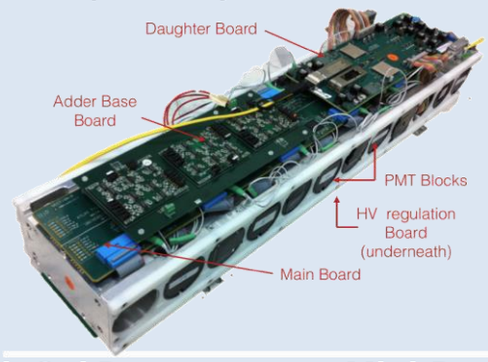


TileCal Phase II Upgrade Readout Electronics

- The TileCal PreProcessors (TilePPr) receives digitized data from Daughterboard and reconstructs energy.
- Energy information is transferred to the Phase II Level 0 Trigger system via the TDAQ interface (TDAQi) module through low- and deterministic-delay data links for every bunch crossing.
- In parallel, the digitized data will be stored in pipeline memories waiting for the trigger decision and the selected event data will be transferred to the ATLAS DAQ system.

TileCal Phase II Upgrade Demonstrator

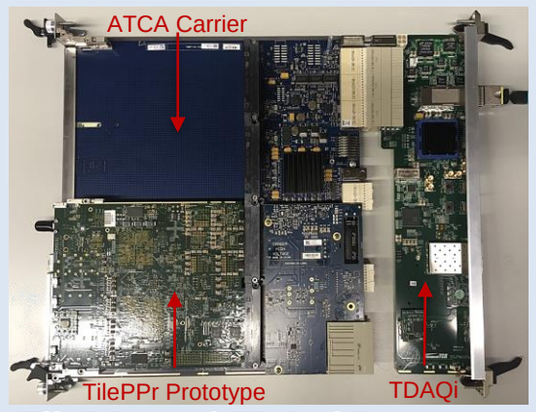
- To evaluate the new readout electronics while preserving compatibility with the current system.



TileCal Demonstrator Mini-Drawer

On-Detector electronics and power supplies
- Close to the final design
- Analog Adder Board provides analog summed signal for legacy Level 1 Trigger system

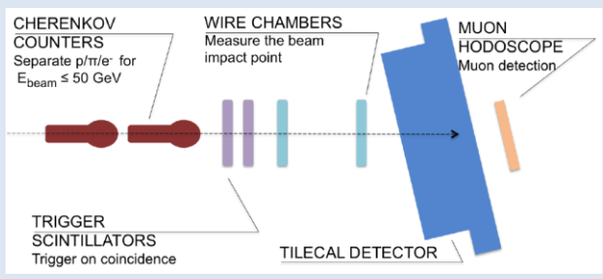
Off-Detector electronics
- Each TilePPr Prototype represents 1/8 of the final TilePPr module.
- Interfaces with both FELIX and legacy ROD system



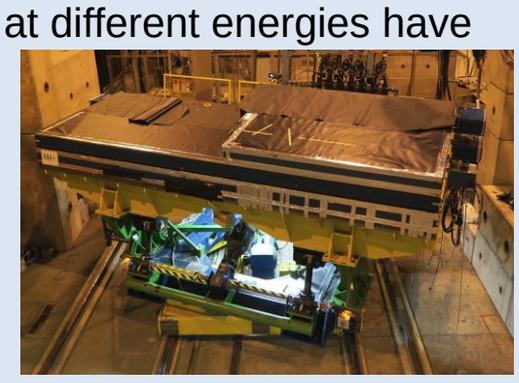
TilePPr and TDAQi Prototype

Test Beam Setup at CERN

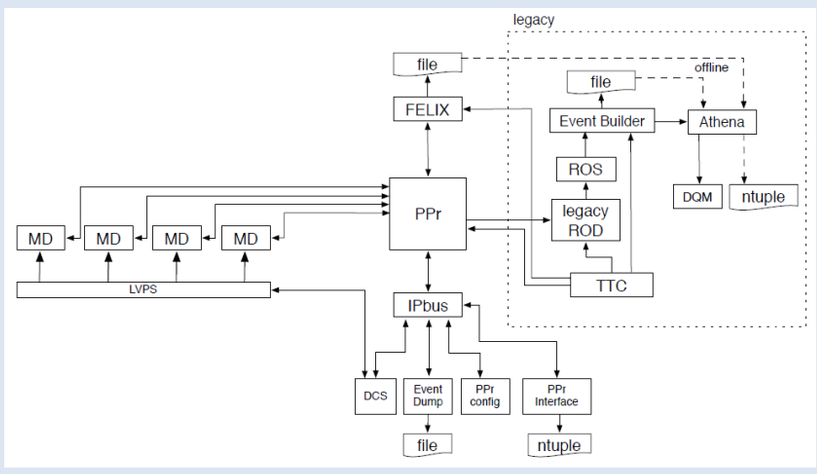
- To evaluate the performance of the detector with new electronics, several tests with different particle beams (electrons, muons and hadrons) at different energies have been performed.



Test beam setup



TileCal modules under test

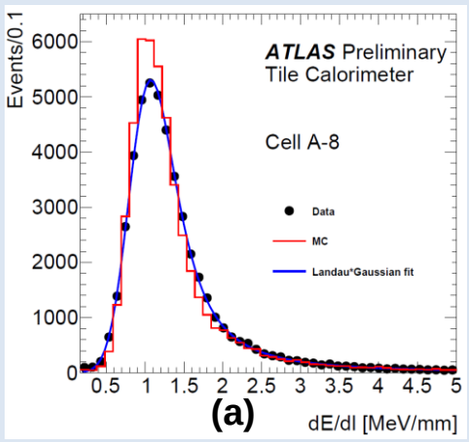


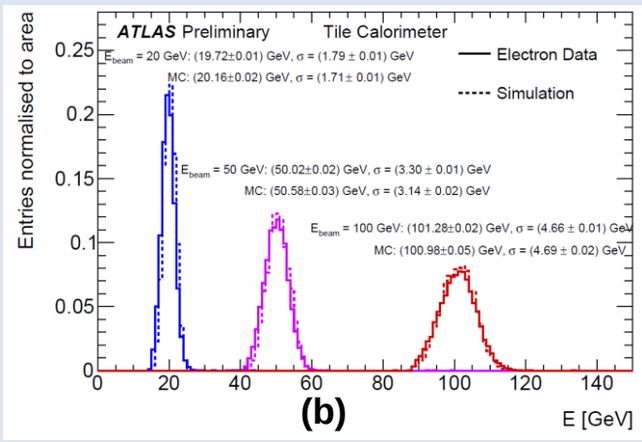
Demonstrator data flow

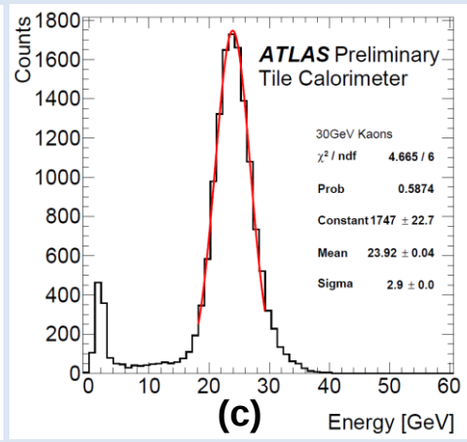
The TileCal data acquisition is controlled by the official ATLAS Trigger and DAQ (TDAQ) software. Additional packages have been developed to operate the demonstrator from the TDAQ Graphical User Interface (GUI).

Results using September 2017 Test Beam data

✓ TileCal performs well with the new readout electronics, and agreement between experimental and simulated data is achieved.







a) The energy loss per unit of crossed material ($\Delta E/\Delta \ell$) distribution for muons impinging a given calorimeter cell is obtained using test beam data and compared to simulation;

b) The total energy distribution in the A4-cell measured in data and simulation for electron beam;

c) The total energy distribution measured in data for hadron beam with identified kaons

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