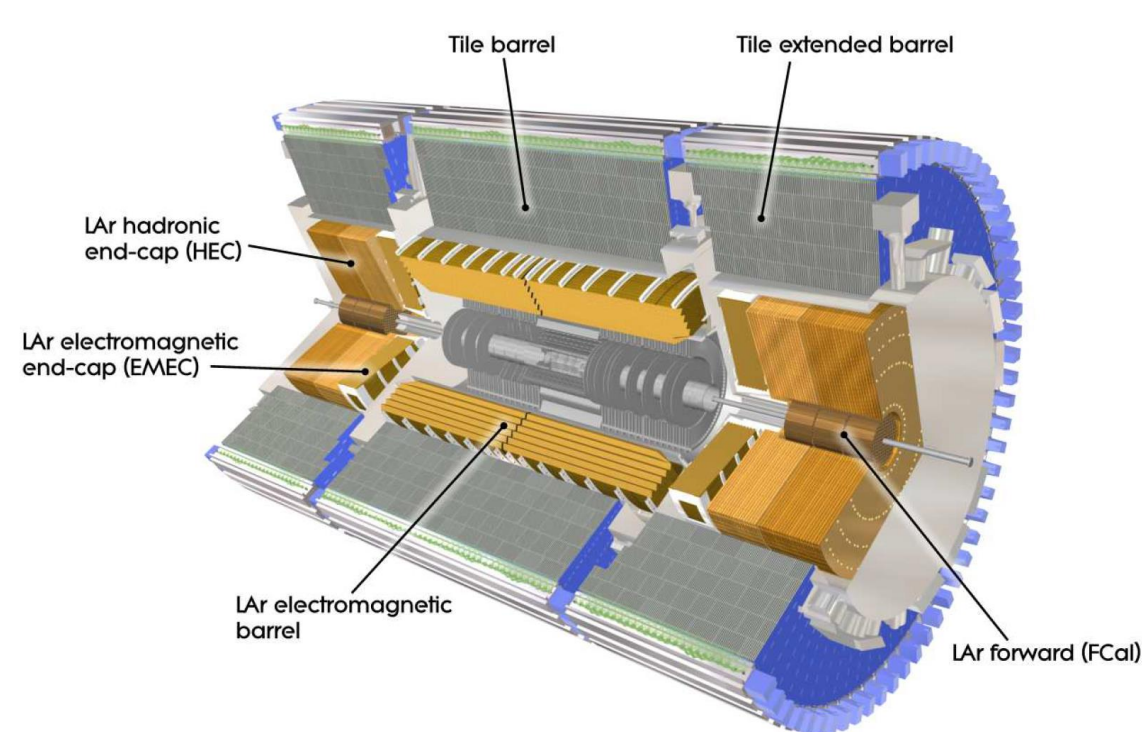


Upgrade of ATLAS Hadronic Tile Calorimeter for the High Luminosity LHC

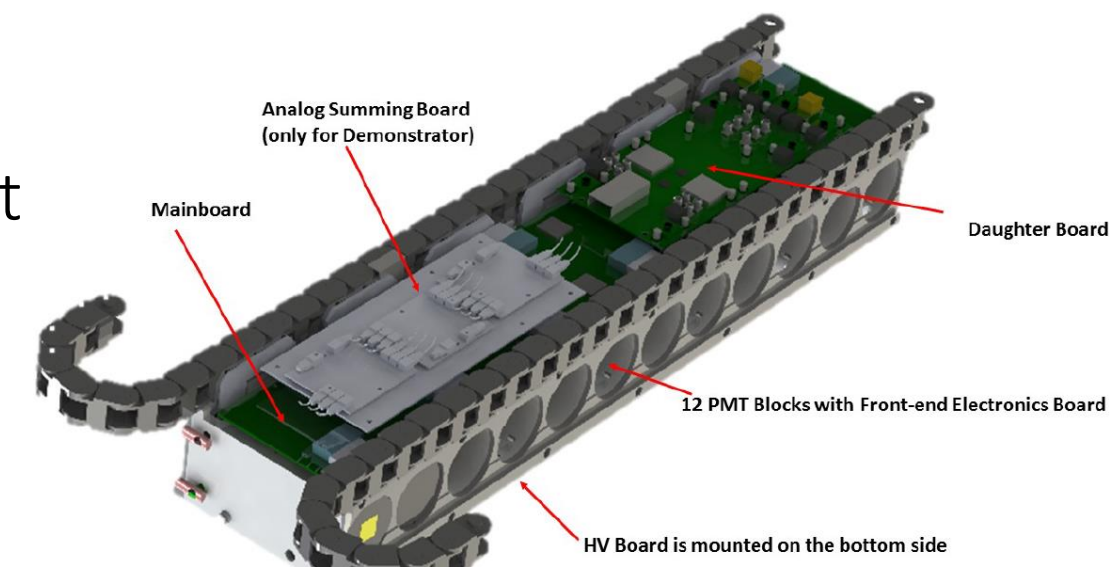
Antonio Jesús Gómez Delegido on behalf of the ATLAS Tile Calorimeter system



- The ATLAS Tile Calorimeter (TileCal) is the central hadronic calorimeter of the ATLAS experiment. Plays a crucial role in the measurement of jets and missing transverse energy.
- Sampling calorimeter formed by scintillating tiles as active medium and iron plates as absorbers. Formed by 256 modules with equal width. Tiles are read out by photomultiplier tubes (PMT). In each module, readout cells are defined grouping fibers from individual tiles to the same PMT.
- The High Luminosity LHC (HL-LHC) will deliver instantaneous luminosities 5-7 times higher than the LHC nominal value. High pile-up conditions, trigger rates and radiation doses motivate TileCal upgrade.

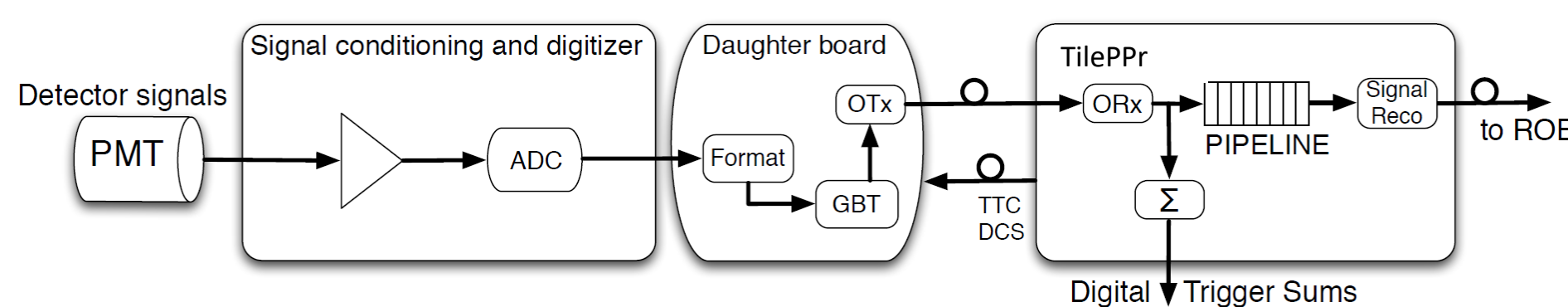
1. Mechanics and power distribution

- Modular design** for the super-drawers (SD), build by mechanically linked Mini-Drawers (MD) that hold PMTs and front-end electronics. New design facilitates installation and maintenance.
- High Voltage (HV) distribution system** provides HV to individual PMTs with good stability. Regulation of HV will be implemented off-detector to avoid radiation damage. Each HV regulation board provides 48 outputs for individual PMTs.
- Low voltage (LV) distribution system** provides power to front-end electronics in 3 stages. Bulk 200 VDC voltage is distributed to split boxes (1 box per 32 SD), then DC-DC converters (1 per SD) supply 10 VDC for the FE electronics. Finally, Point-Of-Load regulators (2 per SD, redundancy) on electronics Mainboard provide each component with the different needed voltages. All elements of the LVPS system are tested to be radiation hard for large doses. Monitoring of the system via Embedded Local Monitoring Board.



2. Electronics

- Divided into front-end and back-end electronics.
- Radiation hardness required for the front-end electronics. TileCal upgrade wherever possible implements architectural redundancy to minimize data loss during operations.



2.1. Front-end electronics

PMTs

- Replacement of most radiated ones.
- Equipped with High Voltage Active Dividers (HVADs) to distribute power among dynodes and maintain linearity and precision on energy scale.

Front-end boards

- FENICS cards provide shaping and amplification to PMT signals.
- Fast readout (physics, 2 gains, dynamic range from 200 fC to 1000 pC) and slow readout (Cs calibration and luminosity monitoring, 6 gains).

Mainboard (MB)

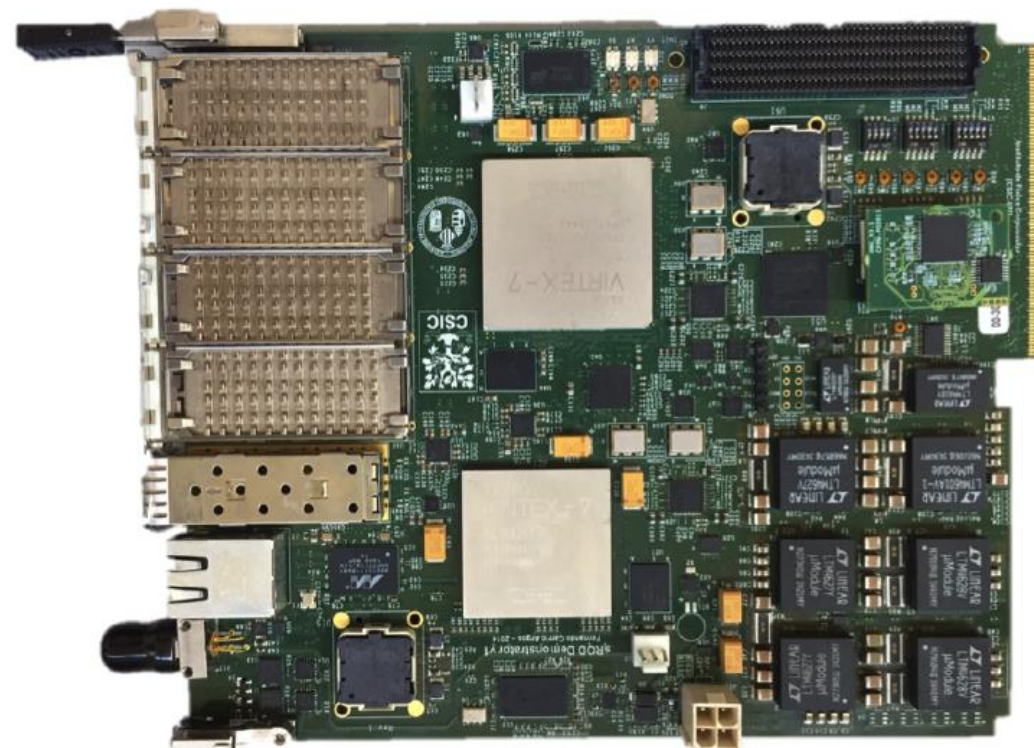
- Digitization of data from up to 12 PMTs
- Sends data to daughterboard and controls FENICS configuration.

Daughterboard (DB)

- Responsible for high speed communication (4.8/9.6 Gbps) with back-end electronics.
- Distributes LHC clock and control and configuration commands.

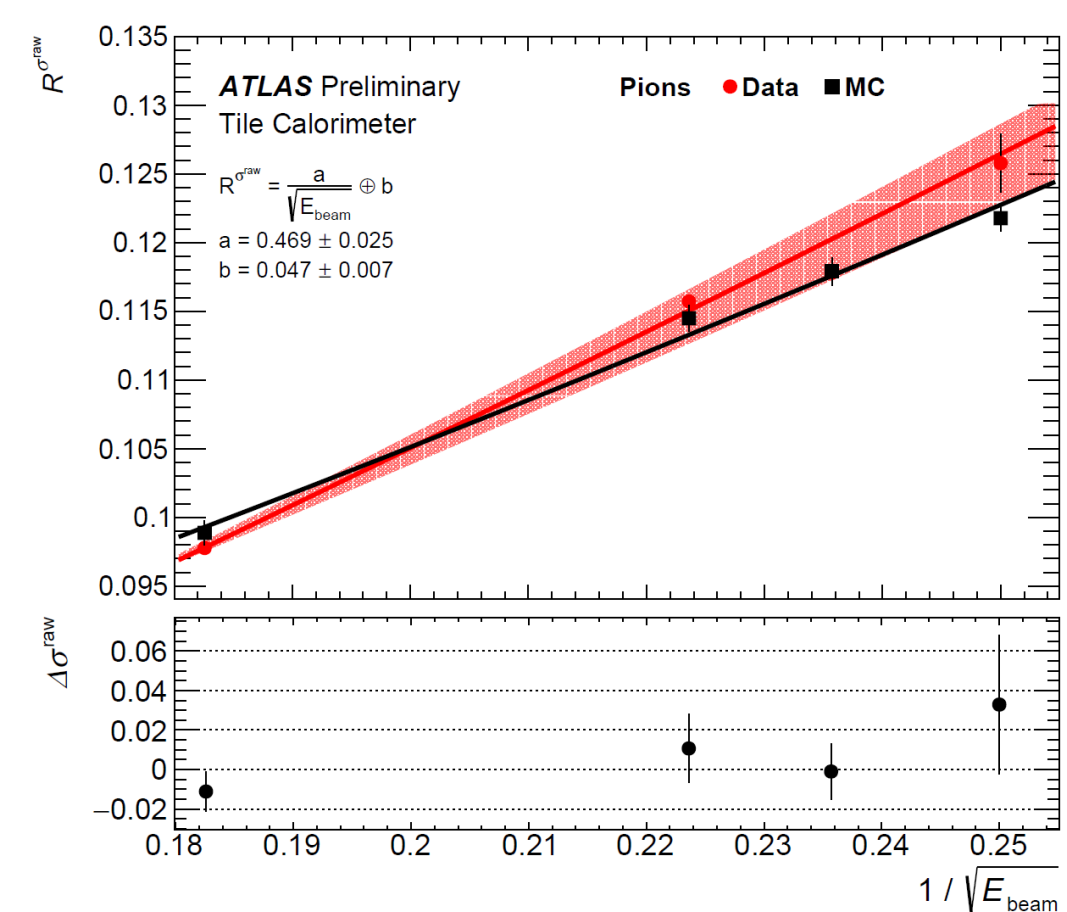
2.2. Back-end electronics

- The PreProcessor (PPr) receives data from DB, reconstructs pulse amplitude and time, buffers data and builds trigger object.
- PPr based on ATCA carrier board and four Compact Processing Modules (CPM). Each CPM is able to process data from two TileCal modules.
- If event is triggered, transmits data to Front-End Link eXchange system (FELIX)
- The CPMs transmit data to the Trigger and Data AcQuisition Interface (TDAQi), which compute digital trigger objects.
- This allows for a more granular and precise trigger system.



3. Test beams and demonstrator

- Several test beam campaigns since 2015 to validate TileCal upgrade.
- Fractional resolution as a function of $1/\sqrt{E_{beam}}$ obtained with pions shown below. Good agreement between data from test beam and MC.
- Demonstrator module with backward compatibility inserted into the ATLAS detector in July 2019. Stable performance with lower noise level than legacy modules.



4. Conclusions

- Several upgrades to adapt TileCal to the HL-LHC conditions.
- All parts prototyped and tested in test beam campaigns and demonstrator.
- Project on schedule for the installation in ATLAS during LHC long shutdown 3.

References

- ATLAS Collaboration. Technical Design Report for the Phase-II Upgrade of the ATLAS Tile Calorimeter. ATLAS-TDR-028 CERN-LHCC-2017-019 (2018)
- ATLAS Collaboration. Approved Tile Calorimeter Plots. <https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ApprovedPlotsTile>