Upgrade of ATLAS Hadronic Tile Calorimeter for the High Luminosity LHC

Oleg Solovyanov on behalf of the ATLAS Tile Calorimeter

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  - LV and HV power supplies
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  - Assembly, tests and installation
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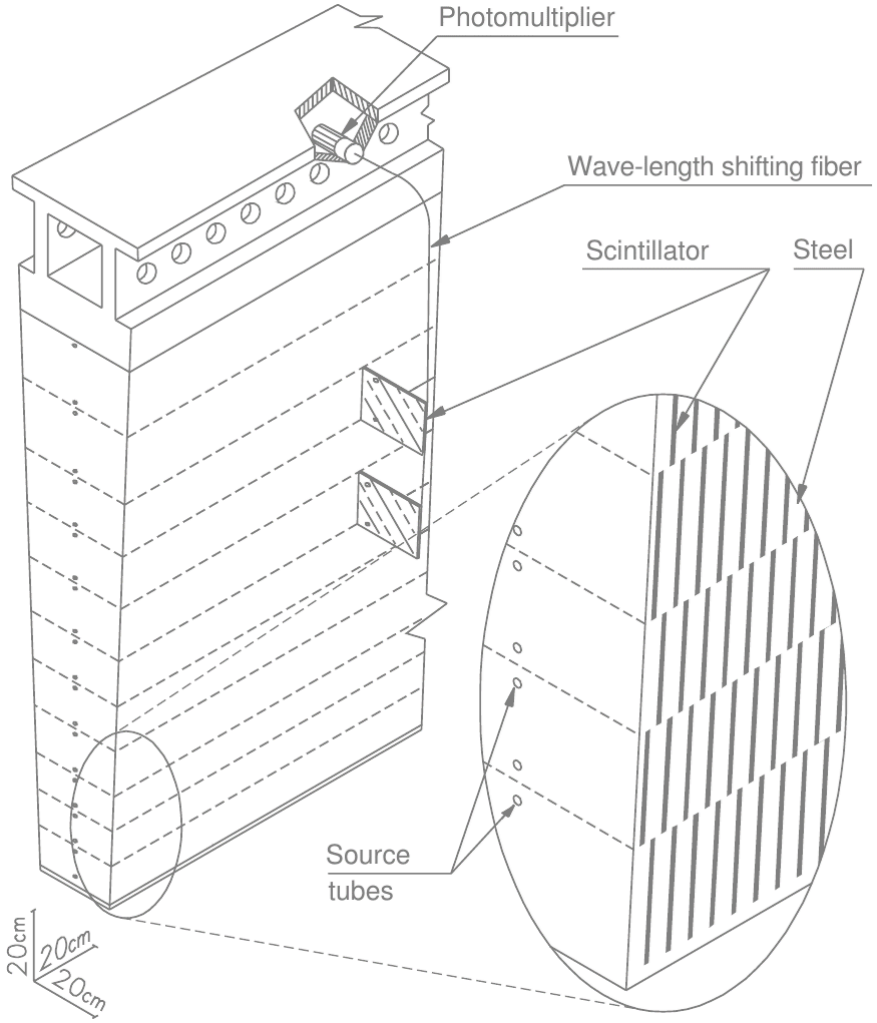
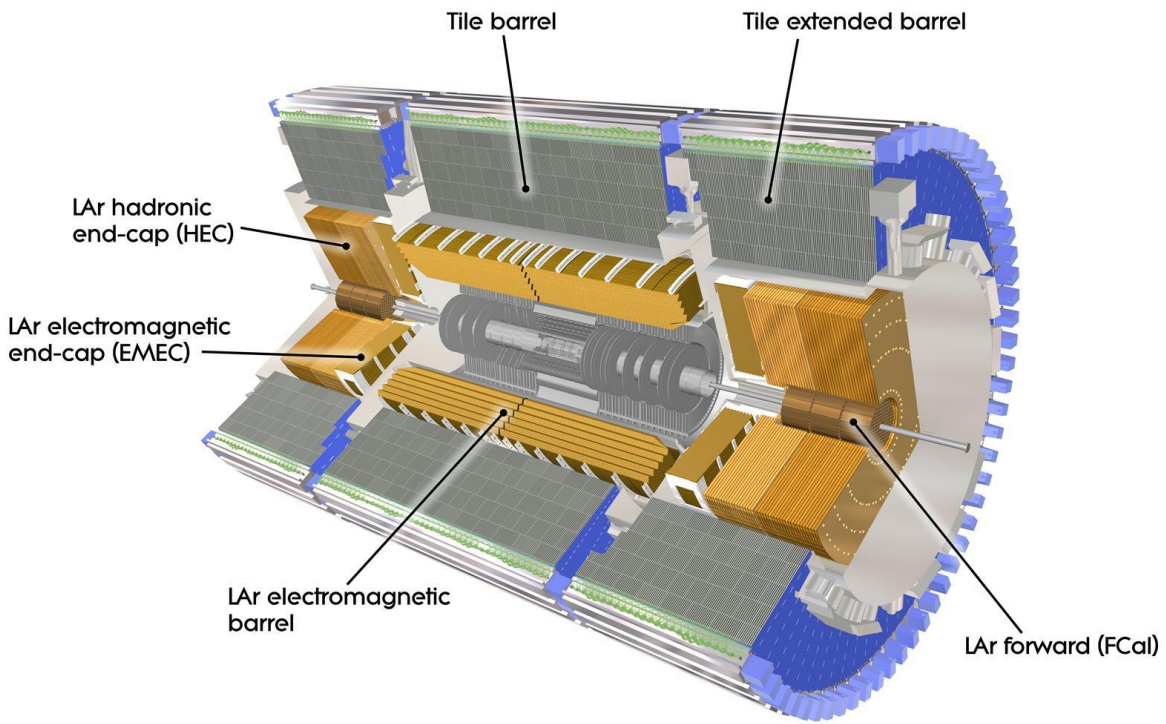
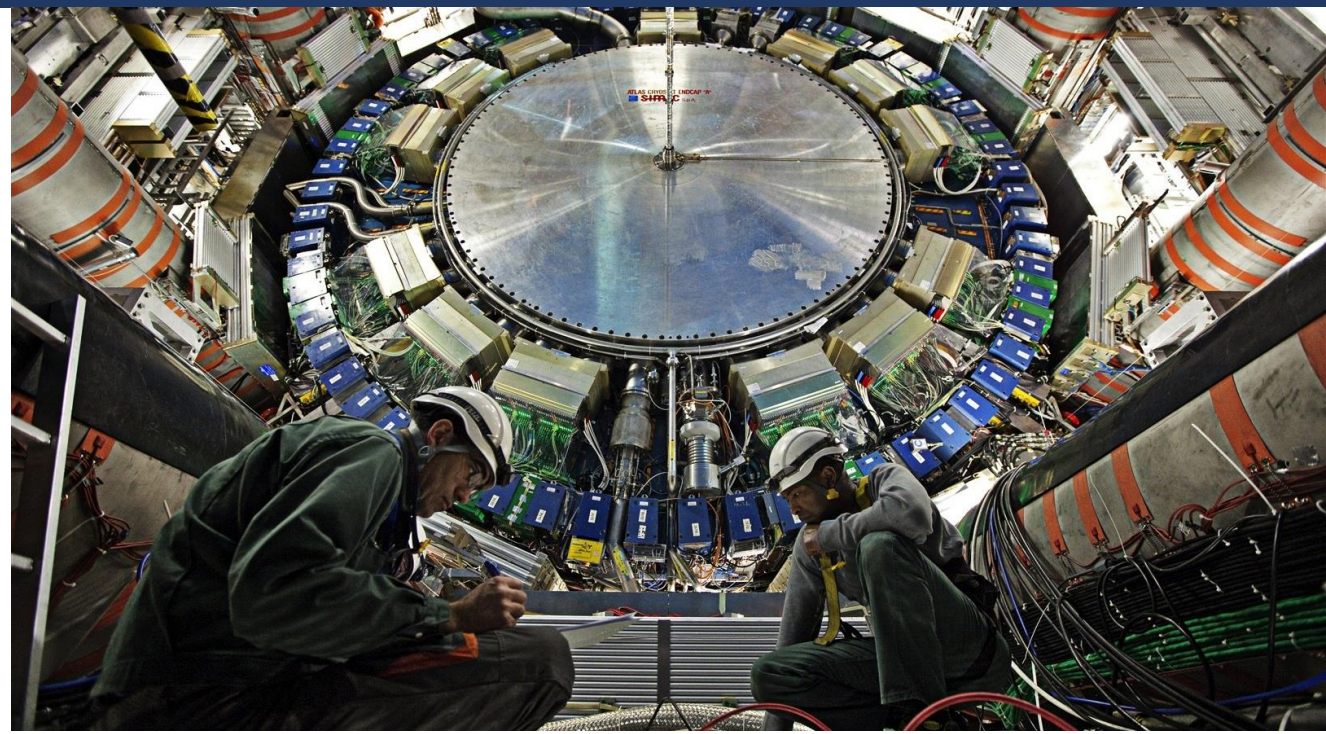
- Summary



ATLAS Calorimetry

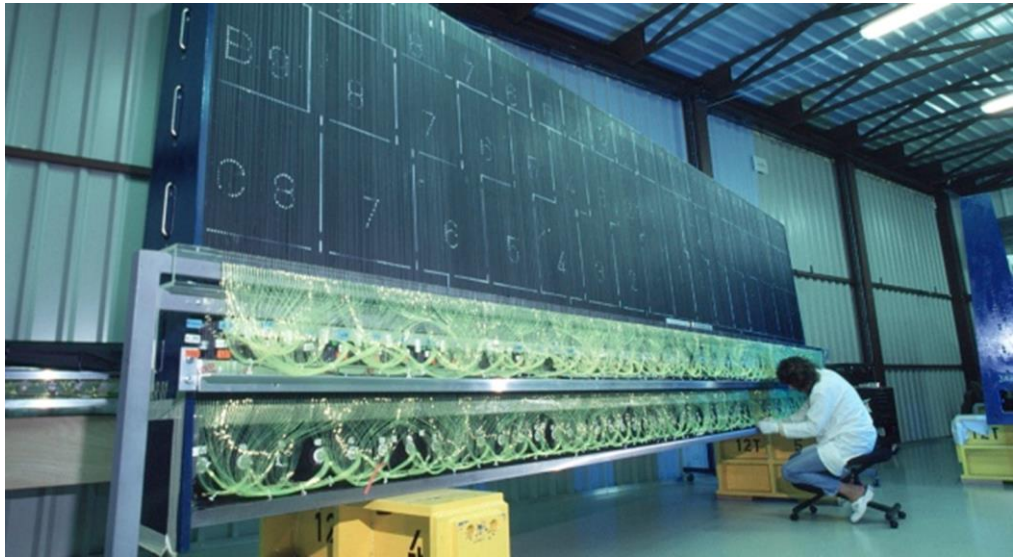


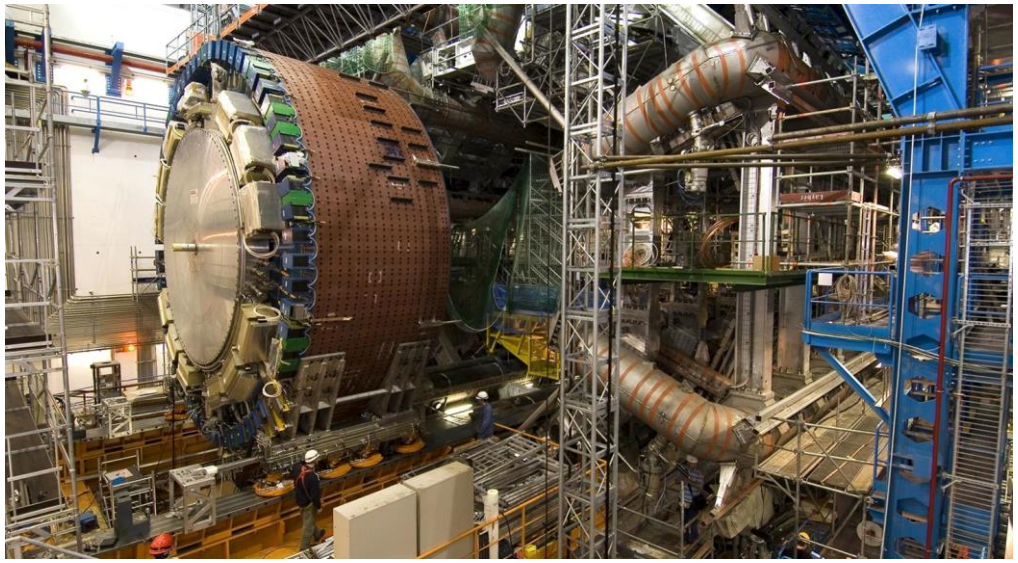


- Complete replacement of the on-detector electronics to meet new radiation, trigger and readout performance criteria
- High-performance FPGA, complex firmware, high-speed optical links
- New off-detector electronics, new power supplies

Tile Calorimeter

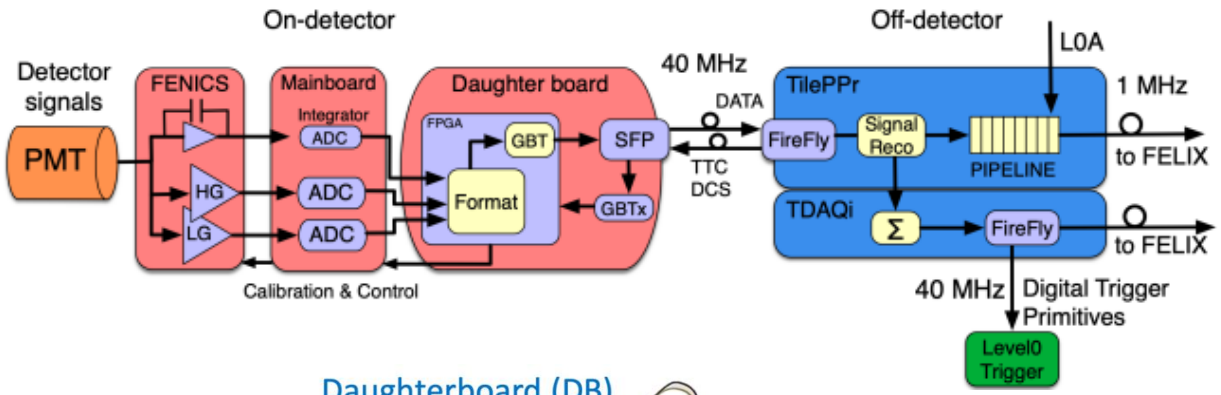
- Hadron non-compensating sampling calorimeter
  - Steel as absorber
  - Scintillating tiles as active medium
  - Design resolution for jets $\Delta E/E = 50\%/\sqrt{E}+3\%$
- Three longitudinal layers, total thickness of about 7λ
- Long barrel $|\eta|<1.0$, extended barrel $0.8<|\eta|<1.7$
- 0.1x0.1 $\Delta\eta x\Delta\phi$ cell granularity
- 3 mm thick trapezoidal shape scintillating tiles (PSM, BASF polystyrene + dopants) oriented perpendicular to beam axis, wrapped in Tyvek® paper
- Readout via green WLS fibres (Kuraray Y11(200)MSJ) connected to both short edges of scintillating tiles
- Hamamatsu R7877 PMTs, located in a module's girder, collect light from the fibre bundles

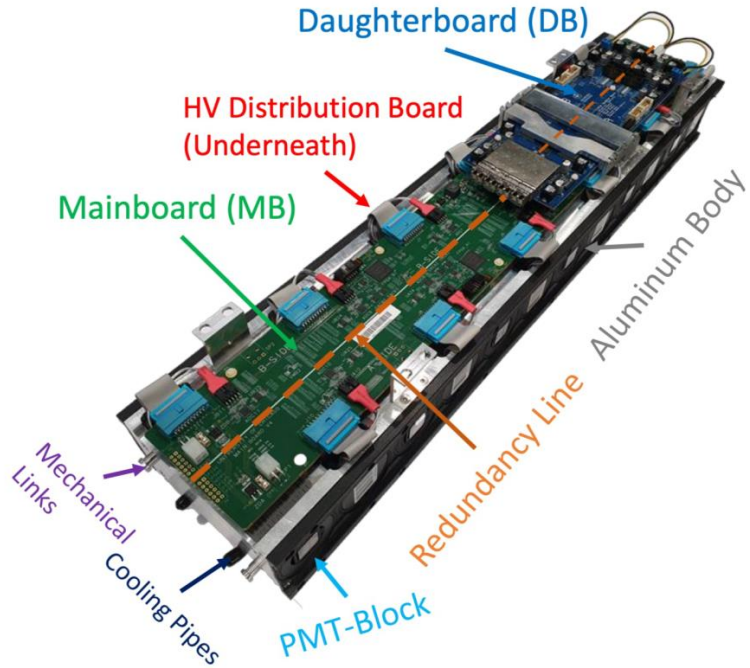




Tile Calorimeter HL-LHC Upgrade Overview

- New on- and off-detector electronics
- 40 MHz continuous data read-out
- Fully digital trigger output for L0
- Improved radiation hardness and redundancy
- New mechanical supports for front-end electronics
- Replacement of 10% of PMTs
- New power supplies for HV and LV
- Upgraded calibration systems
- Production phase in many areas, some already completed and delivered





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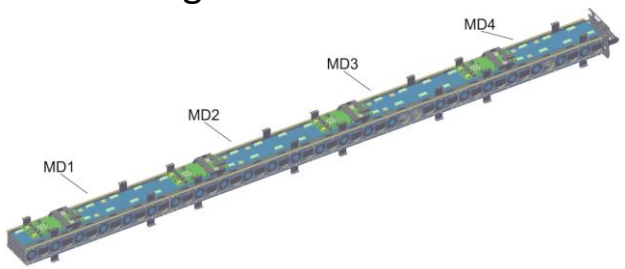
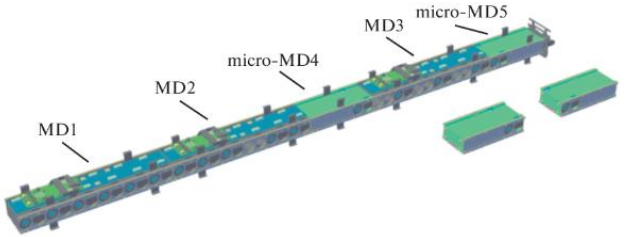
Mechanics

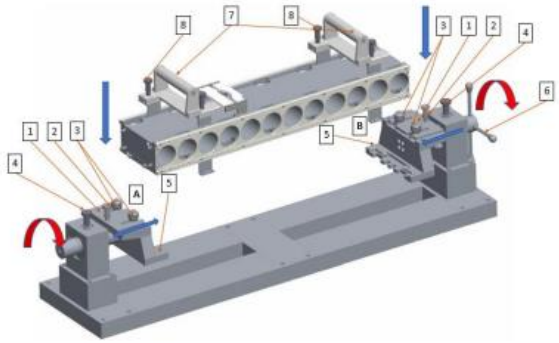
- PMTs and on-detector electronics are housed in “drawers”
- New design have 4 mini-drawers (MD)
  - Robust mechanical links
  - New cooling system
  - Special design of micro-drawers for extended barrels
  - Special installation tooling
  - Simplifies installation and maintenance
- Services and tooling
- Production complete and delivered

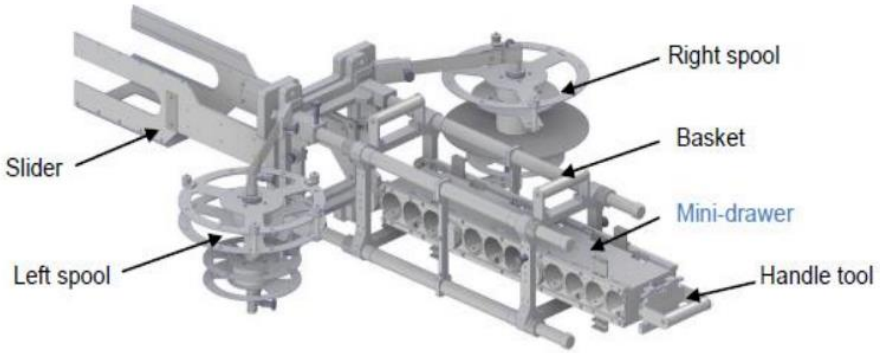
Long barrel mechanics



Extended barrel mechanics

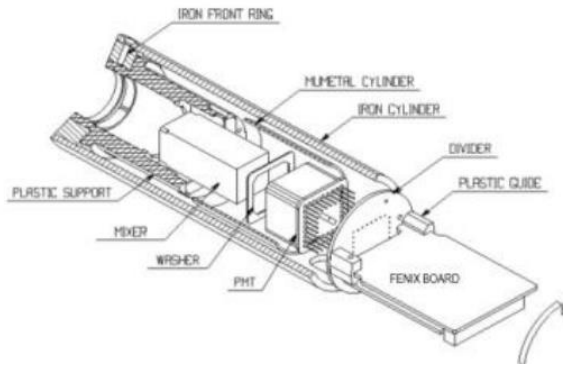


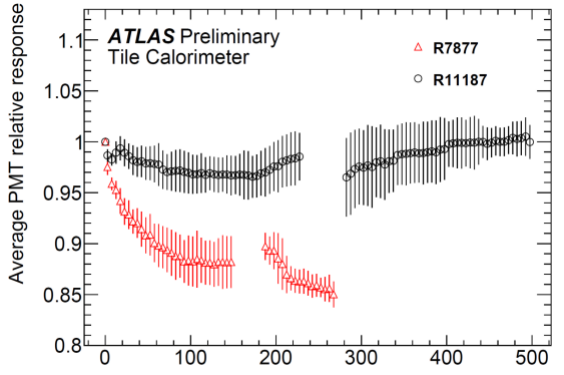




PMT and HVAD

- 10% of the most degraded PMTs will be replaced by an improved version – Hamamatsu R11187
  - Production and certification on-going
- Passive high voltage dividers will be replaced with active dividers, more stable at high currents for HL-LHC
  - Production complete and delivered
- PMT block test bench
  - Prototype finished
  - Production to start soon





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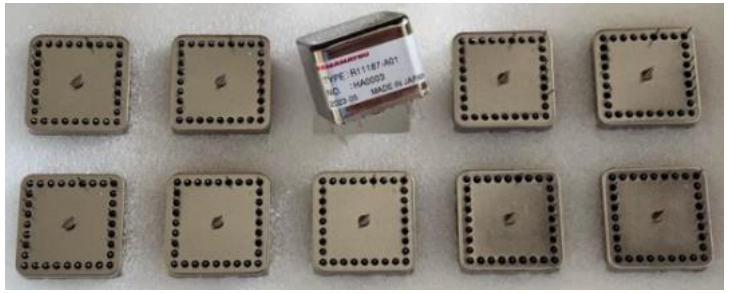
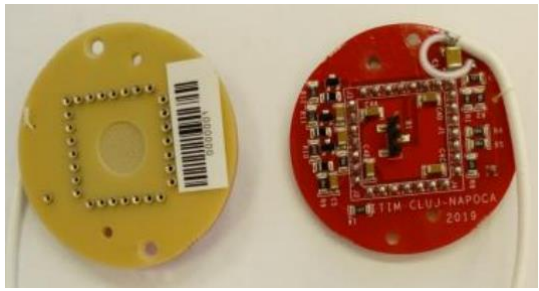
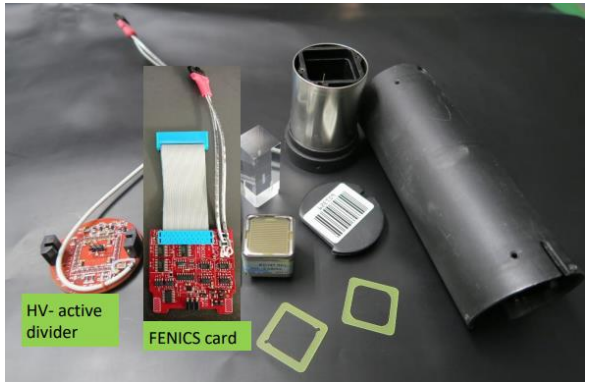
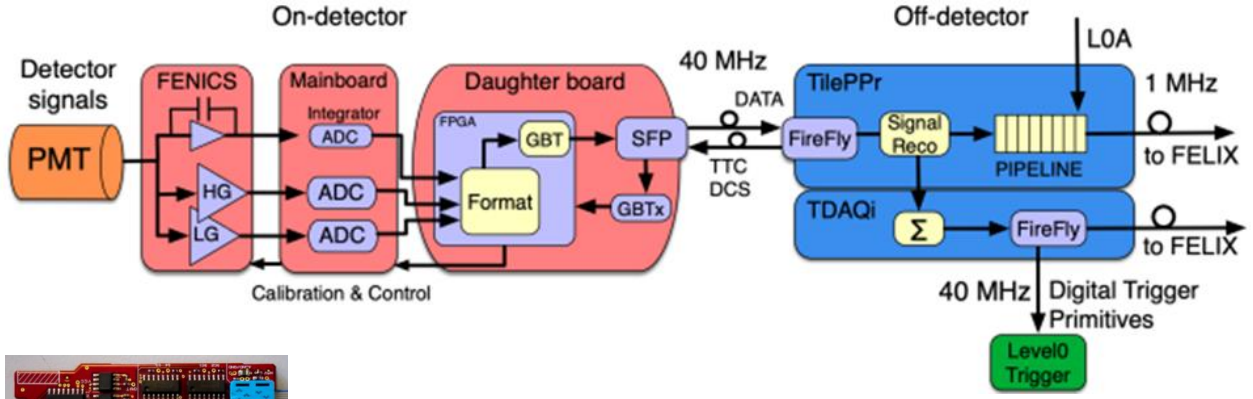




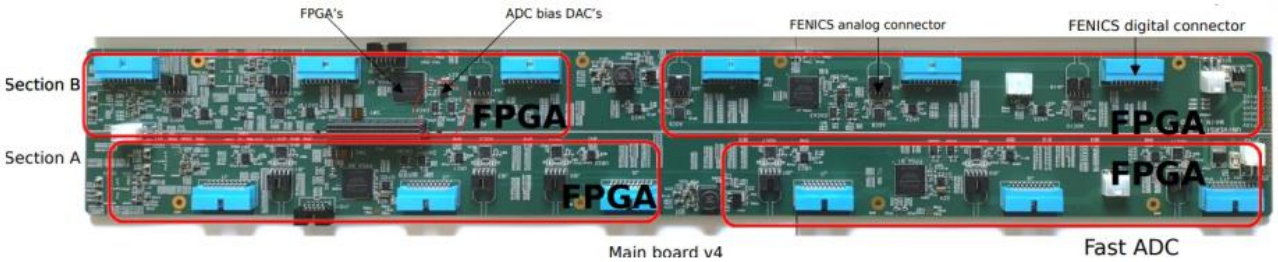


On-detector electronics

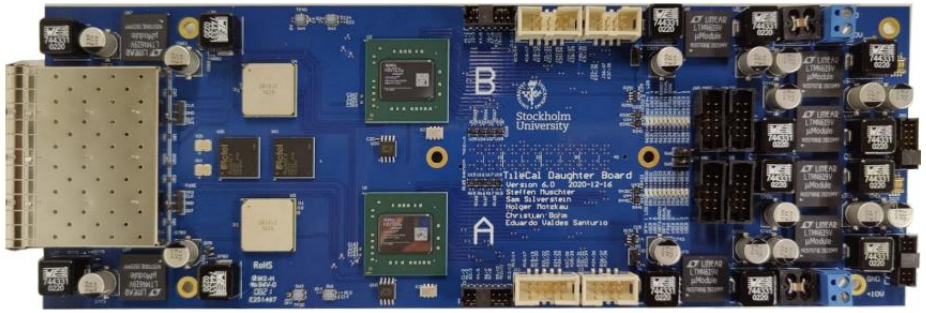


FENICS2

MBv4



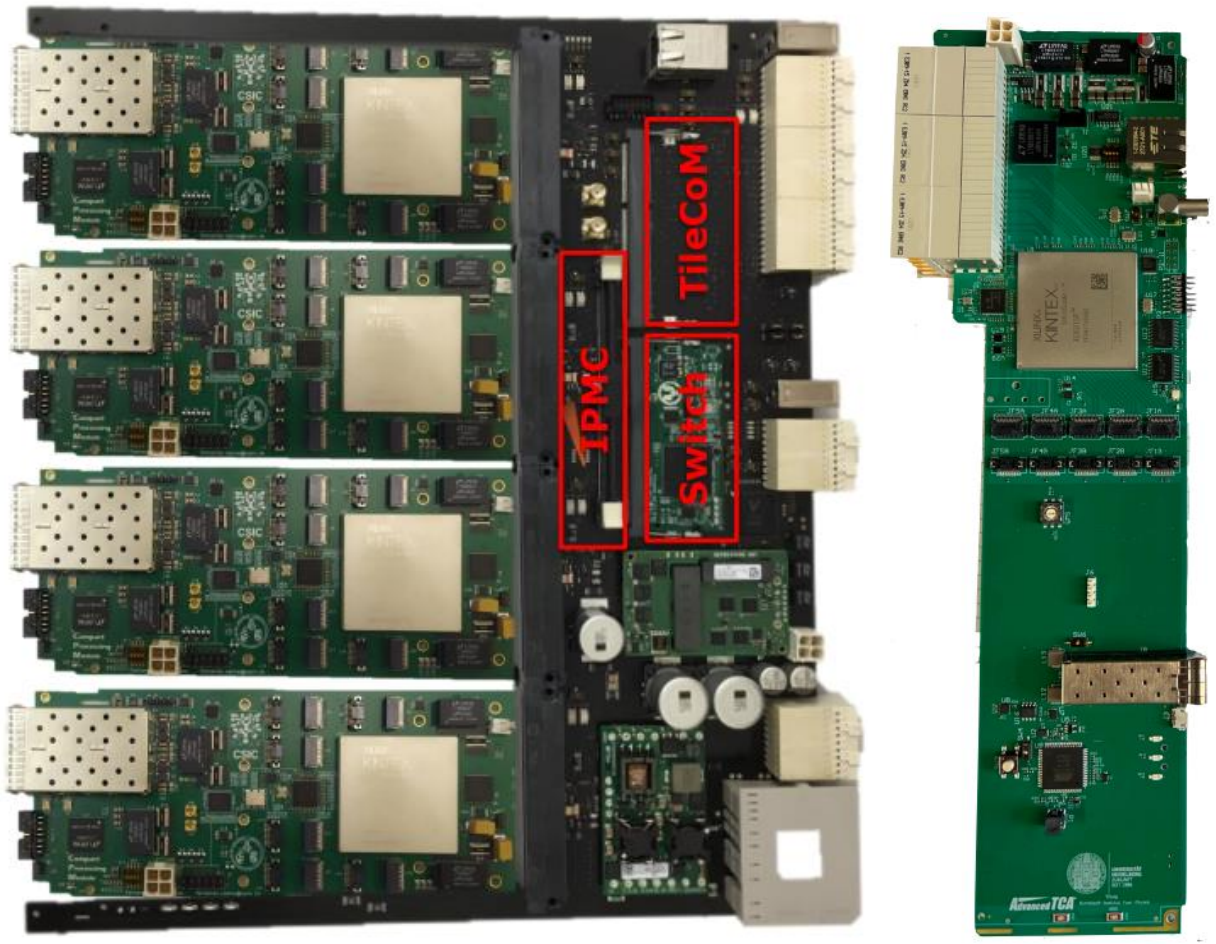
DB6v3



- FENICS front-end board
  - Two gains with 1:40 ratio, 0.2->1000pC
  - Slow integrating channel
  - Embedded charge injection calibration
  - Production and certification on-going
- MainBoard
  - Process and control 12 channels
  - Fast 12-bit 40Ms/s ADCs
  - Connects to DaughterBoard
  - Production complete
- DaughterBoard
  - Collects and sends digitised data to the off-detector electronics via optical links
  - GBT protocol at 9.6 Gb/s, using SFP+
  - Kintex Ultrascale FPGA
  - Final prototype DB6v4 is being produced

Off-detector electronics

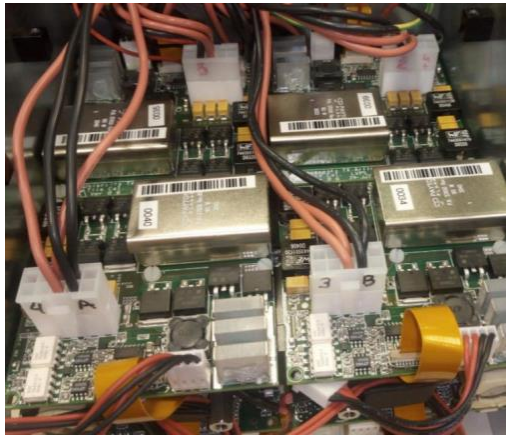
- Preprocessor (PPr) and TDAQi
  - CPM – compact processing module
  - Carrier – ATCA base-board to host CPMs
  - Kintex UltraScale+ FPGAs
  - Receives data from DaughterBoards
  - Calculates energy and time
  - Calculates trigger primitives
  - Sends data to L0 trigger and DAQ
- Several prototypes made
- Final design is being prepared

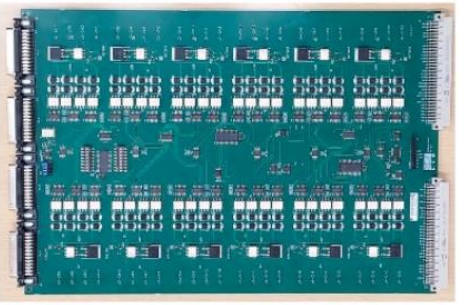


The PreProcessor module for the ATLAS Tile calorimeter at the HL-LHC

LV and HV power supplies

- Three-stage low-voltage (LV) system
  - Bulk 200V AC-DC
  - 10V DC-DC converters
  - Point-of-load regulators
  - Pre-production ongoing
- Remotely regulated high-voltage (HV)
  - <1kV over 100m cable for 10k channels
  - Remote regulation for individual channels, outside of high-radiation area
  - Hamamatsu HV supply units
  - Moving towards pre-production



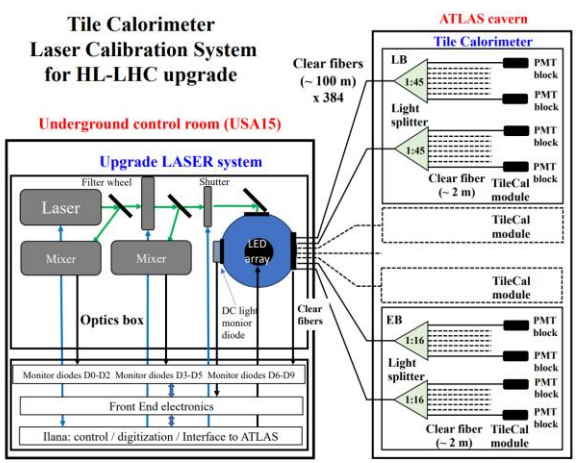


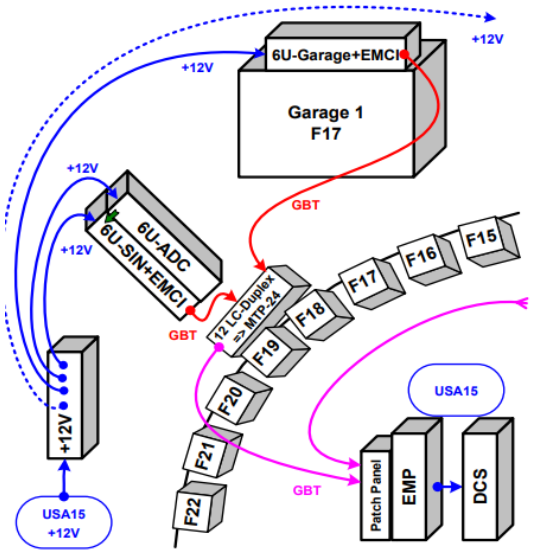
HV Remote board

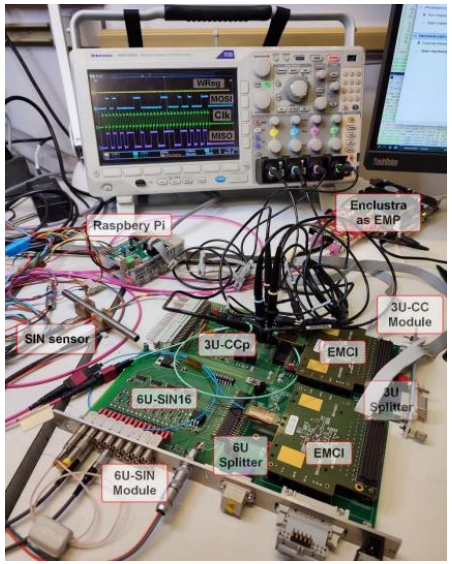
HV Supply Board

Calibration systems

- Calibration systems follows DAQ upgrade
- Laser calibration system for PMTs
  - New DAQ and control interface
  - Pile-up simulation via LED matrix
  - New optical line to mix pulsed and dc light
  - Final design and prototype tests
- Cs137 movable source
  - New on- and off-detector electronics using optical links
  - Updated hydraulics
  - Preparing for production

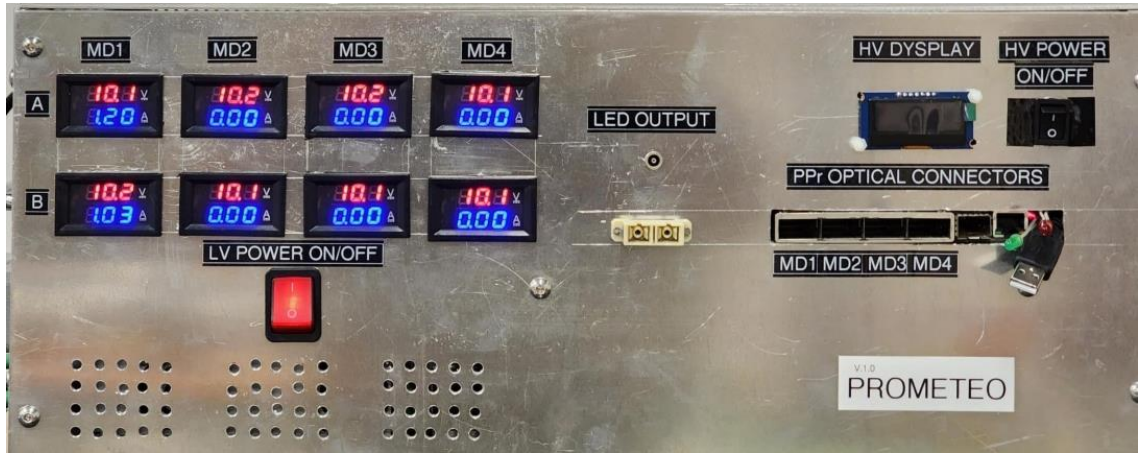






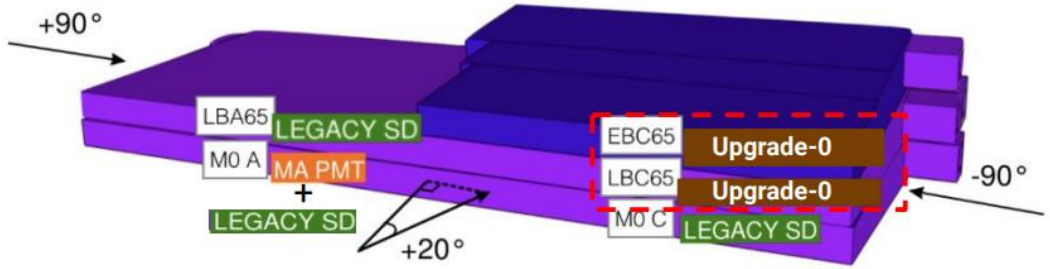
Assembly, tests and installation

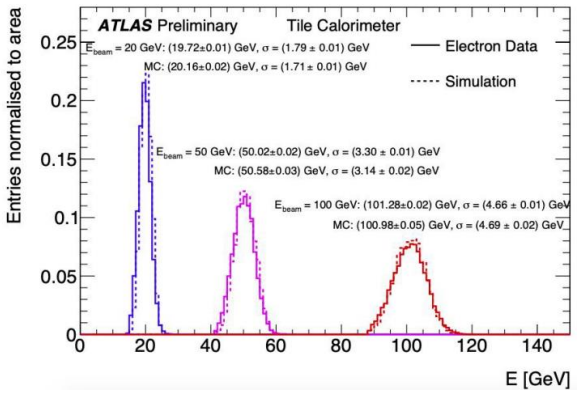
- Front-end electronics to be assembled from multiple components into super-drawers before installation
- PROMETEO portable test bench is used to certify the functionality and performance
- Test results and boards IDs saved in the installation database
- Production complete or on-going
- Assembly and installation plans have been prepared

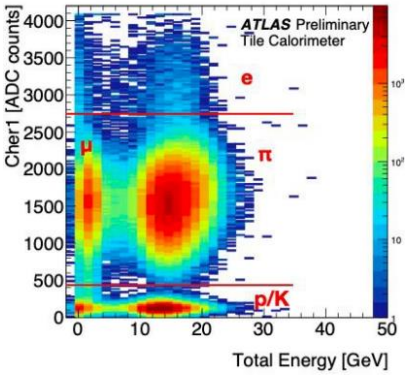


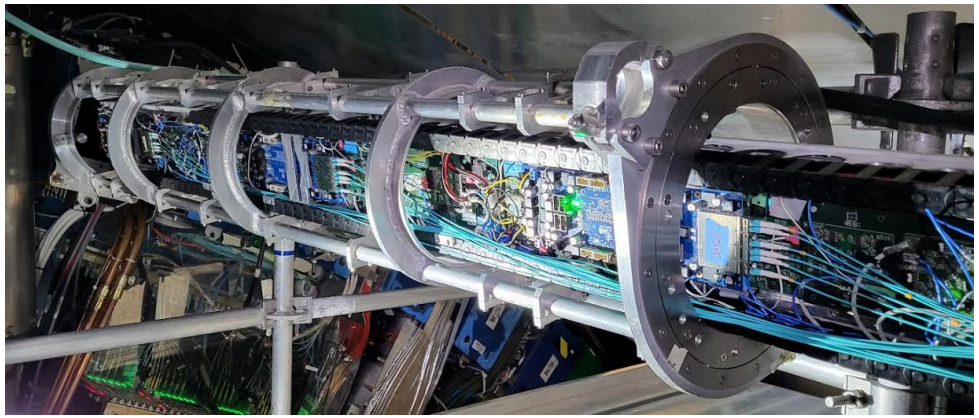
Test beams and demonstrator

- Test beams
  - Fixed target test beams of various particles and energies at SPS at CERN
  - Validate new electronics in more realistic conditions
  - Full slice tests
  - Performance measurements
  - Encouraging results
- Demonstrator
  - Backward-compatible hybrid demonstrator installed since 2019 on detector
  - In-situ performance tests
  - Training for future experts









Summary

- The HL-LHC programs challenges the detector and detector electronics in many aspects, including high radiation doses and high pile-up
- ATLAS Tile Calorimeter is undergoing a major upgrade of its on- and off-detector electronics to cope with new challenges of HL-LHC
- Many upgrade deliverables have been already produced
- Test beam campaigns help to validate new designs and involve new persons
- Upgrade demonstrator module is already taking data in ATLAS LHC, providing new information and training of future experts