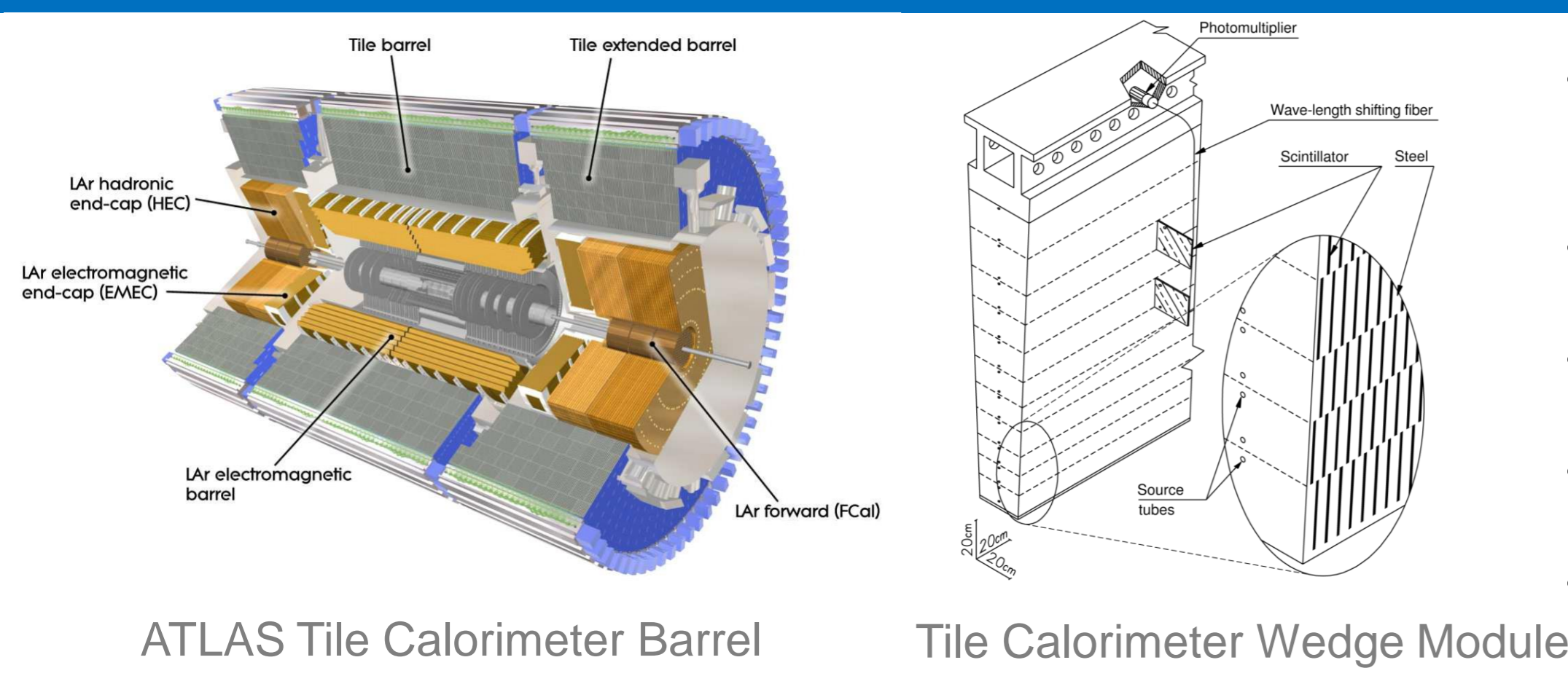
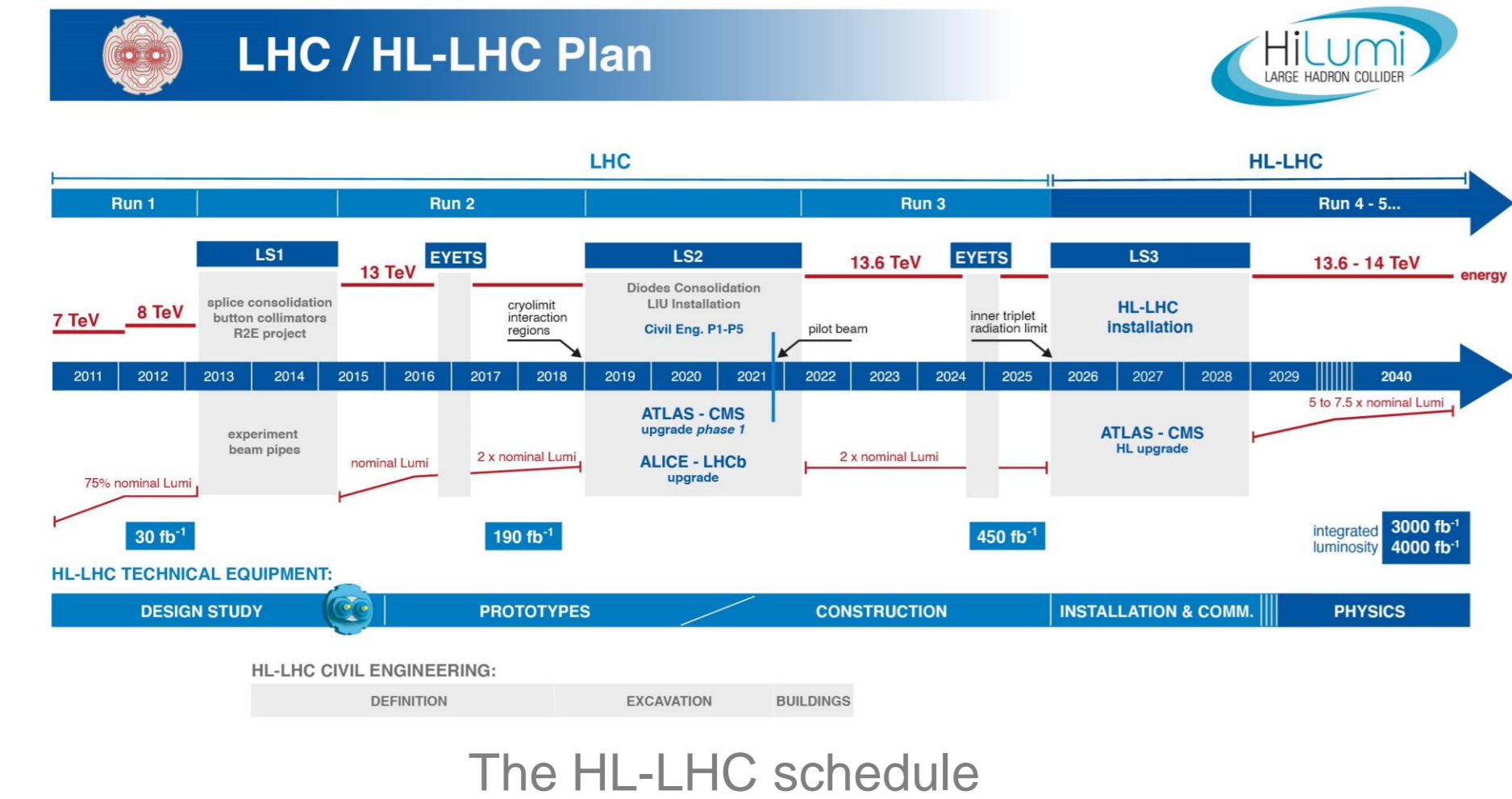


Pavle Tsotskolauri on behalf of the ATLAS Tile Calorimeter system  
Tbilisi State University, Tbilisi, Georgia, pavle.tsotskolauri@cern.ch

## The ATLAS Tile Calorimeter

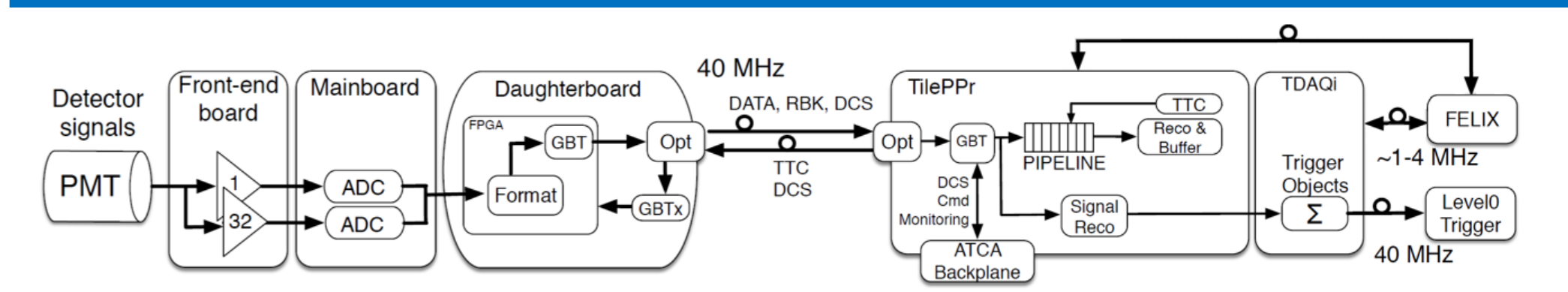


- Tile Calorimeter is a sampling calorimeter constructed of steel and plastic scintillator plates and which is located at the central section of the hadronic calorimeter of ATLAS.
- 460,000 scintillators are read out by 9,985 PMTs (Photomultiplier Tube).
- Divided into four barrels: two long barrels and two extended barrels.
- 256 Super-drawers constitute the full detector in four barrels, each having 64 wedges.
- Measurement of hadrons, jets, missing energy, jet structure, electron isolation, triggering (including muon information).



- HL-LHC will deliver ten-times integrated luminosity (3000-4000 fb<sup>-1</sup>)
- Major upgrade to its on- and off- detector electronics
- 200 simultaneous proton-proton interactions per bunch crossing.
- Fully digital calorimeter trigger with higher granularity and precision.
- Radiation tolerant electronics
- Improved reliability and redundancy.

## Upgrade of the Tile Calorimeter



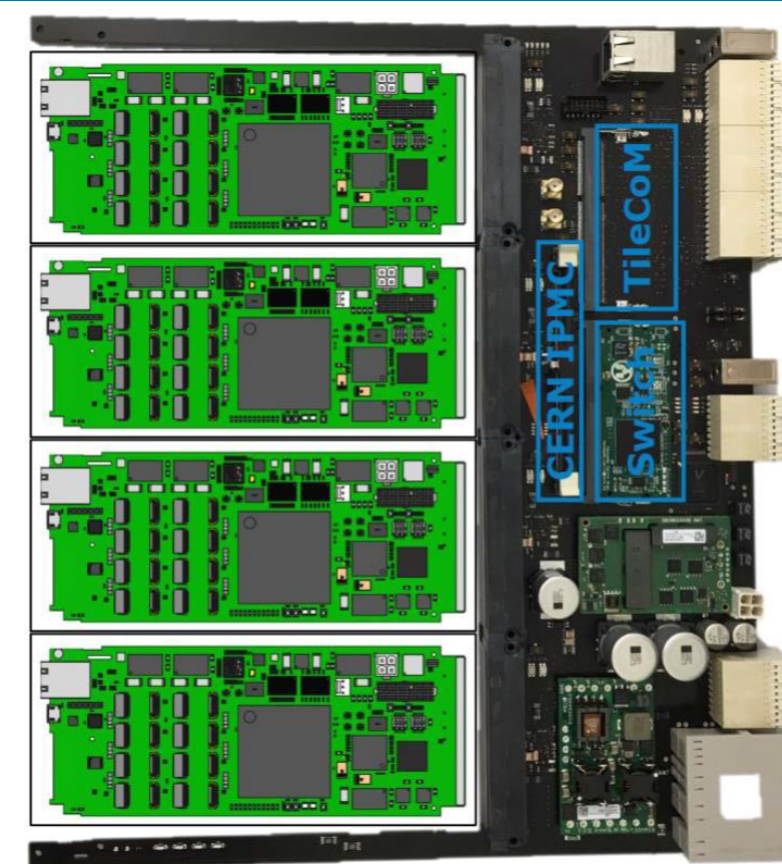
- Upgraded **super-drawer** consists four independent readout elements, **mini-drawers – Reliability**
- Each **mini-drawer** is split into two independent sides with independent power, data and monitoring links – **Redundancy**

	Current System	Upgraded System
Level 1 Trigger	Analog Sum	Fully Digital
Pipeline memory	On-Detector	Off-Detector
Number of fibres	256	2048
Link bandwidth	800 Mbps	9.6 Gbps
Back-end Input bandwidth	6.4 Gbps	1 Tbps
Back-end output bandwidth to DAQ	3.2 Gbps	40 Gbps

- New trigger system will have access to the digital information with a low level of electronic noise and accurate energy calibration.
- Computed trigger objects from the Tile cells will be transmitted to the ATLAS trigger system at 40 MHz with maximum latency of about 1.7μs

## The Tile PreProcessor

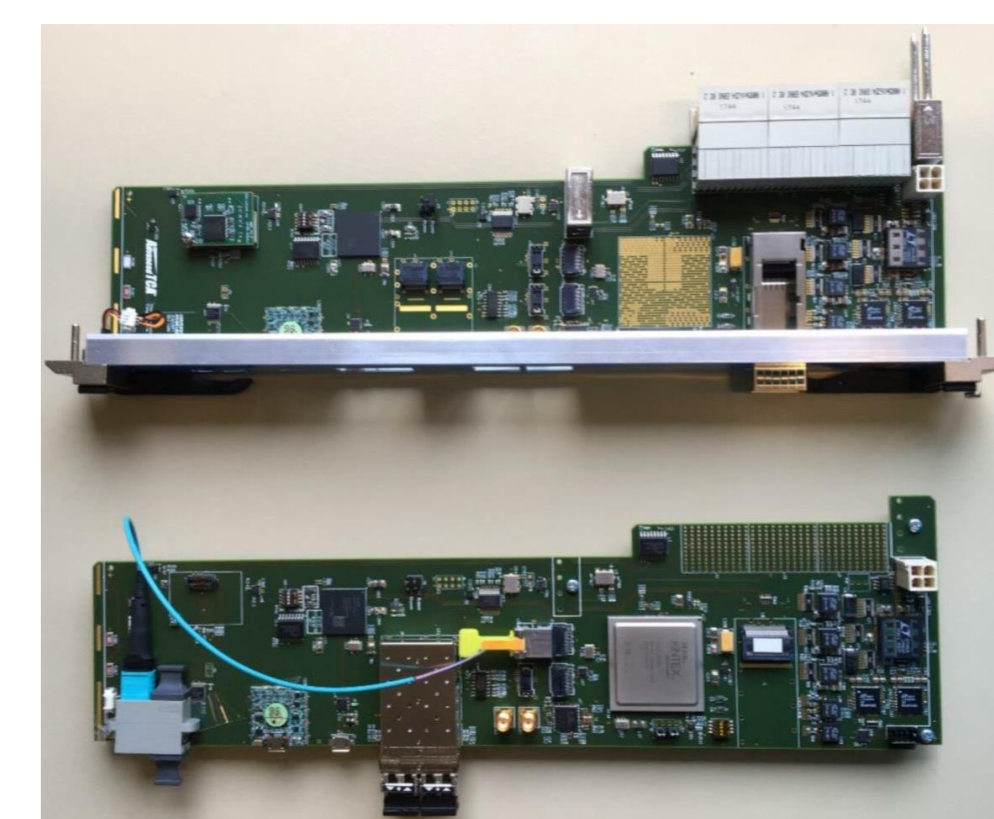
- Core element of the off-detector system
- The Tile PreProcessor performs the cell energy reconstruction per each bunch crossing (40 MHz) and transmits the reconstructed energy to the TDAQi. In parallel the PPRs will transmit triggered data to the FELIX system.
- Phase-II PreProcessor is implemented in full size ATCA format.
- LHC clock distribution, control and configuration.
- 32 PPR ATCA blades in total, each one composed of 4 Compact Processing Modules (CPM) and 1 Carrier Base Board (ACBB).



ATCA Carrier

## Trigger and DAQ interface

- Receives cell energy data from PPR at 40 MHz.
- ATCA standard RTM Module.
- Interface with Trigger Processors and the Front-End Link eXchange (FELIX).
- Trigger formation, cell selection and sorting.



TDAQi

## The Tile Demonstrator

### PreProcessor

- Interface between Front-end electronics and ATLAS data acquisition system.
- Storing data in pipelines until trigger decision.
- Energy reconstruction.
- 40MHz data input

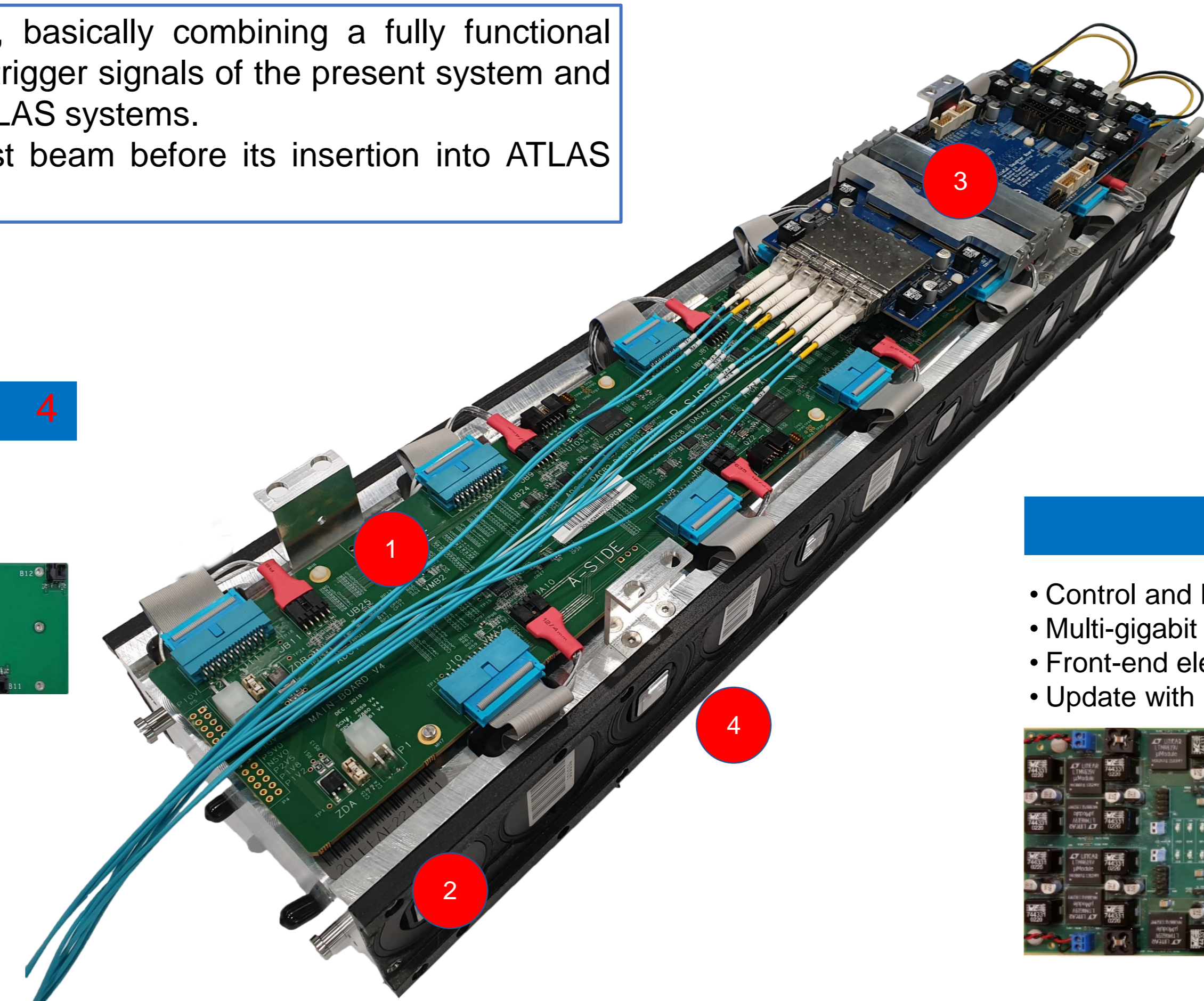
- The Demonstrator is a hybrid prototype, basically combining a fully functional Phase-II read-out system with the analog trigger signals of the present system and other legacy interfaces with the current ATLAS systems.
- The module was intensively tested at test beam before its insertion into ATLAS during LS2 where it will stay for Run 3.

### HV Distribution Board (underneath)

- Delivers high voltage to 12 PMTs
- Individual control over each PMT blocks
- Voltage monitoring and data reporting.

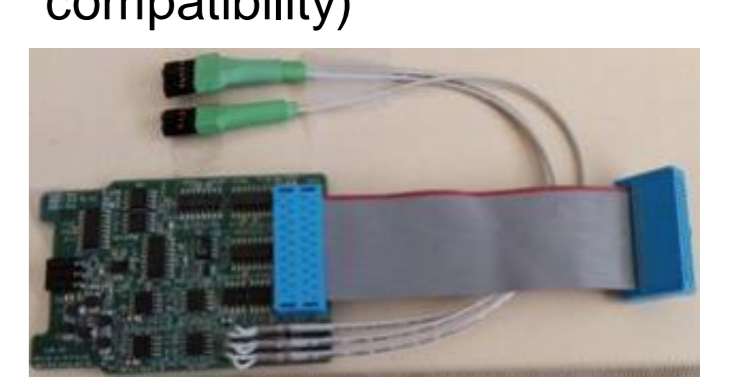
### MainBoard Final Version (V4)

- Communication between 3-in-1 cards and Daughterboard
- Timing, Charge Injection
- Data digitization
- Low voltage control



### PMT Blocks / 3-in-1 Card

- Amplification of scintillating light signal received via the wavelength shifting fibers
- Fast readout with two gains
- Integrated slow readout
- Analog trigger (for backward compatibility)

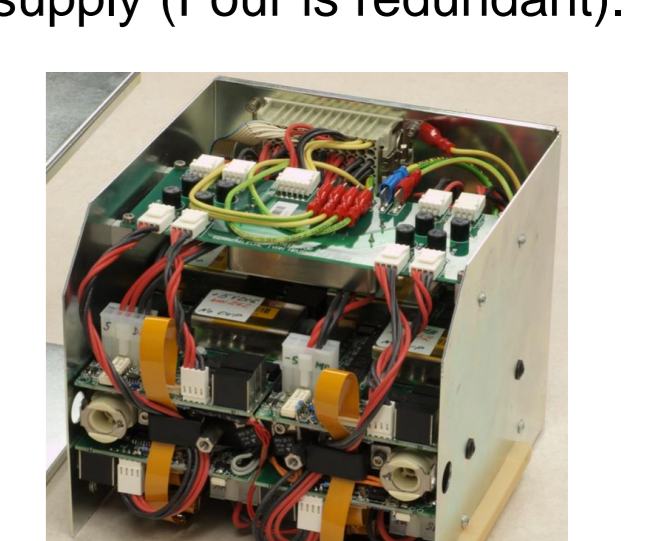


### Low Voltage Power Supply

- Power supply for Front-End Electronics
- Power monitoring
- Eight individual bricks with +10V supply (Four is redundant).

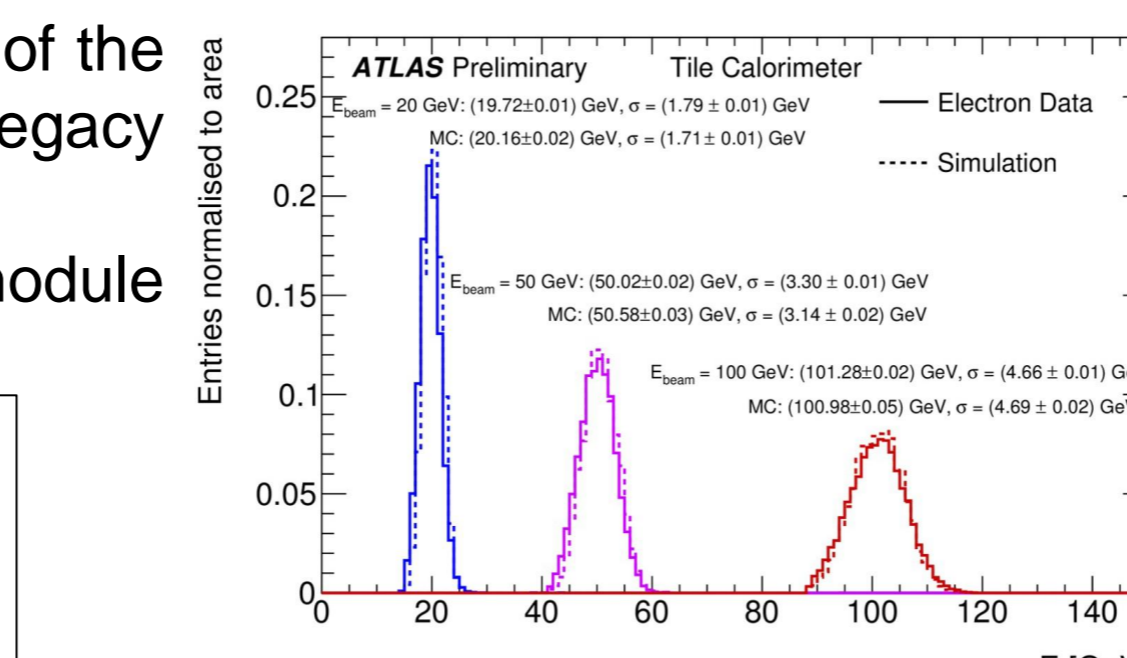
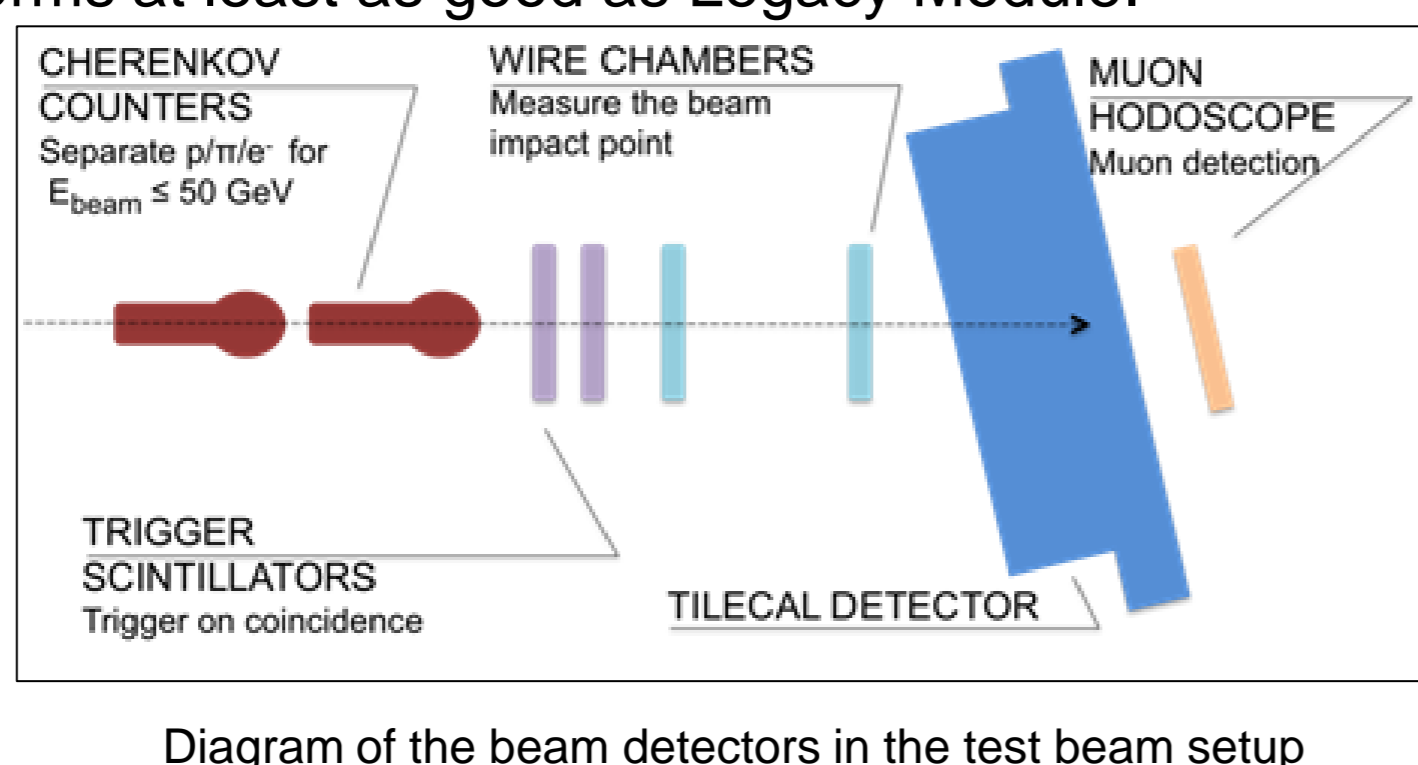
### DaughterBoard V4

- Control and Data Collection
- Multi-gigabit Redundant communication
- Front-end electronics configuration
- Update with latest version (V6) is considered

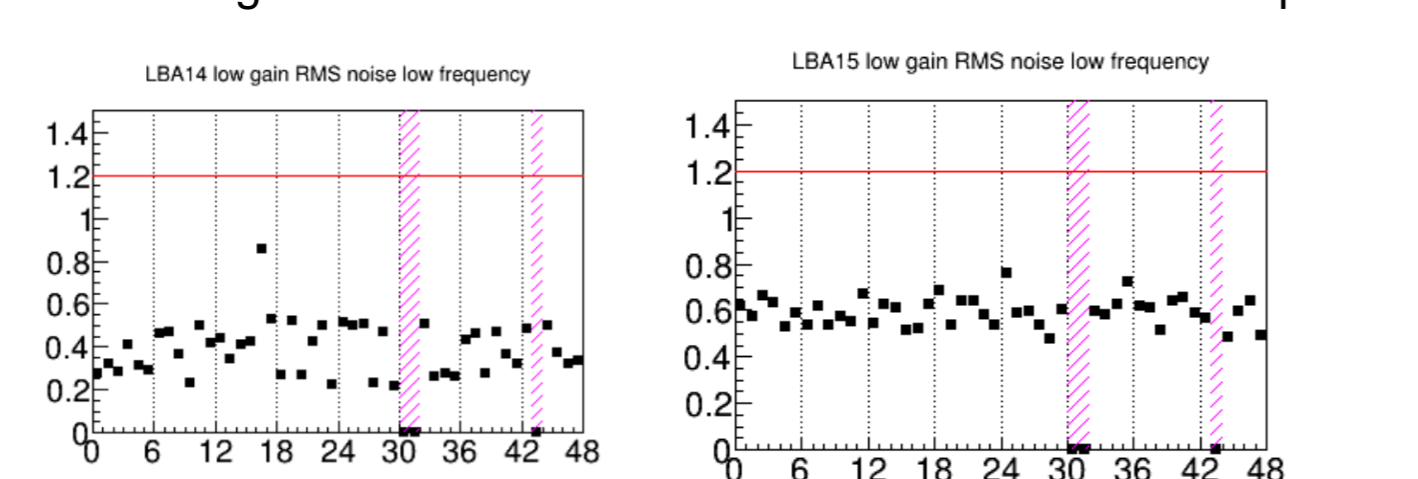
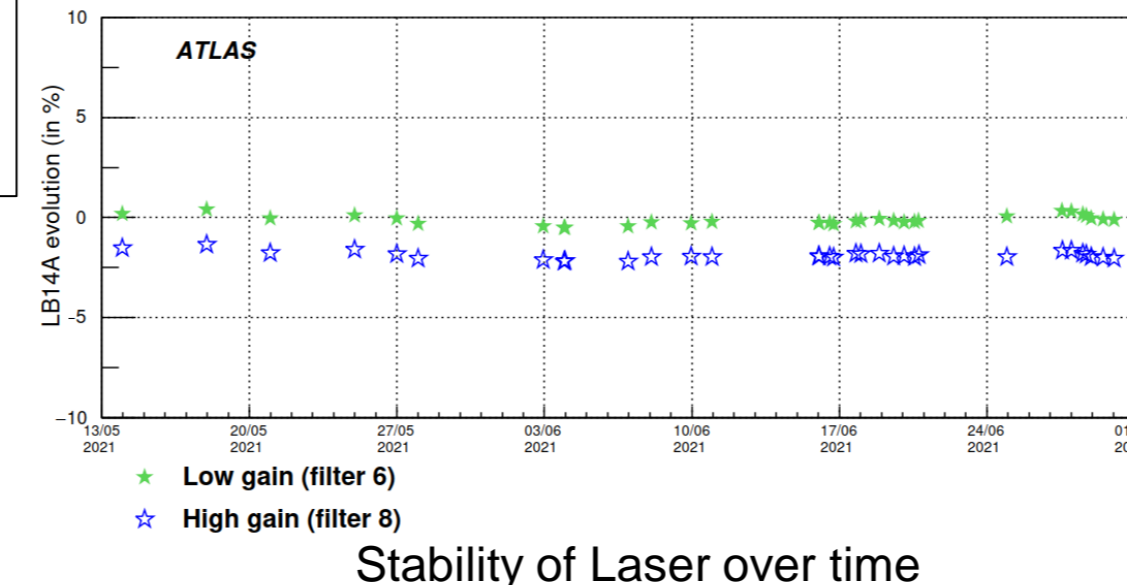


## Results from Test Beam and ATLAS Operation

- The goal of the test beam is to study the performance of the upgrade electronics and to compare it with the legacy system.
- Test beam results indicate that The Demonstrator module performs at least as good as Legacy Module.



Distributions of the total energy deposited in the calorimeter obtained using experimental and simulated electron data



Comparison of noise between The Demonstrator (LBA14) and Legacy Module (LBA15)

## PROMETEO Software



- PROMETEO software can test and verify correct functionality of the Tile Demonstrator subsystems.
- This is performed using software panels, dedicated to different tests like Pedestal, ADC Linearity, Charge Injection, LED Injection.

## Summary

- HL-LHC upgrade for Tile Calorimeter will feature completely modernized electronic modules, redundant and reliable design, fault tolerance, improved radiation tolerance.
- The Tile Demonstrator module is a prototype for upgraded readout system and it is compatible with current and legacy systems.
- The Tile Demonstrator is fully integrated in the ATLAS Trigger and Data Acquisition and Detector Control systems.
- It was extensively tested during several test beams from 2015–2021 and it demonstrated good performance.
- New tests will take place in November 2022 in order to continue with the validation and of the new on-detector and off-detector electronics.
- The Tile Demonstrator module was inserted in ATLAS in 2019, and it will be kept during the Run-3 period.

## Acknowledgments

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## Reference

- High-Luminosity Large Hadron Collider (HL-LHC): Technical design report, CERN-2020-010, <https://cds.cern.ch/record/2749422>
- The ATLAS Experiment at the CERN Large Hadron Collider, JINST 3 (2008) S08003, <https://cds.cern.ch/record/1129811>
- Technical Design Report for the Phase-II Upgrade of the ATLAS Tile Calorimeter, ATLAS-TDR-028, <https://cds.cern.ch/record/2285583>
- Upgrade of the ATLAS Hadronic Tile Calorimeter for the High Luminosity LHC, ATL-TILECAL-PROC-2020-009, <https://cds.cern.ch/record/2716325>