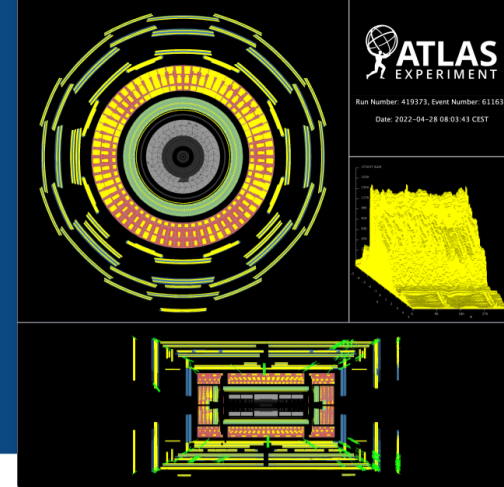




# ATLAS LAr Calorimeter Commissioning for LHC Run 3

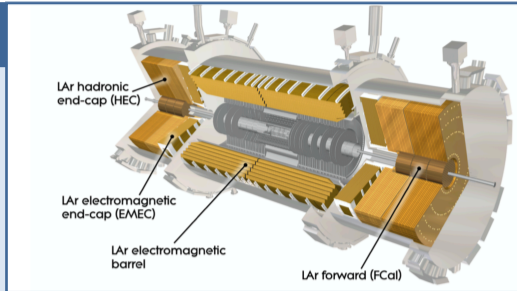
## LHCP 2022 - May 16-20



During Run 3, LHC will operate at higher luminosities with respect to Run 2, and the centre-of-mass energy will reach 13.6 TeV. In order to cope with consequently enhanced pile-up conditions, the Liquid Argon trigger readout electronics have been upgraded during the Long Shutdown (LS2) as part of the Phase-I Upgrade. The readout granularity has been increased to ensure better topological discrimination between electromagnetic and hadronic shower shapes at L1 trigger level, thus allowing to improve online objects identification, pile-up subtraction and energy resolution.

### The Liquid Argon Calorimeter

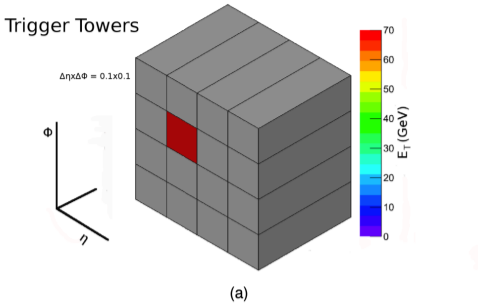
- Electrons, photons and jets identification and reconstruction
- Sampling calorimeter, LAr as active medium
- Four sub-detectors:
  - Electromagnetic Barrel**, EMB ( $|\eta| < 1.5$ ): lead absorber in accordion geometry
  - Electromagnetic end-caps**, EMEC ( $1.4 < |\eta| < 3.2$ ): lead absorber in accordion geometry
  - Hadronic end-caps**, HEC ( $1.5 < |\eta| < 3.2$ ): copper absorber
  - Forward Calorimeter**, FCal ( $3.1 < |\eta| < 3.2$ ): copper and tungsten absorber
- LAr signals are inputs to level-1 trigger (L1Calo)



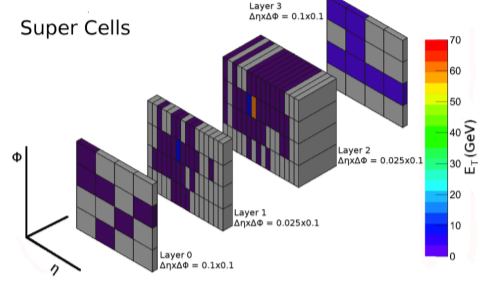
### Phase-I Upgrade: motivation

- Make trigger effective against new pile-up conditions
- Trigger Towers  $\rightarrow$  **Super cells**:
  - Granularity increased by up to a factor 10
  - Four longitudinal layers
  - $\Delta\eta \times \Delta\phi$  down to  $0.025 \times 0.1$  in the front and middle layer of EMB and EMEC
  - Improved electron - jet discrimination and energy resolution
- Keeping Run 2  $E_T$  threshold, while staying within trigger bandwidth (100kHz)

### Trigger Towers



### Super Cells



### Phase-I Readout electronics Upgrade

#### Baseplane

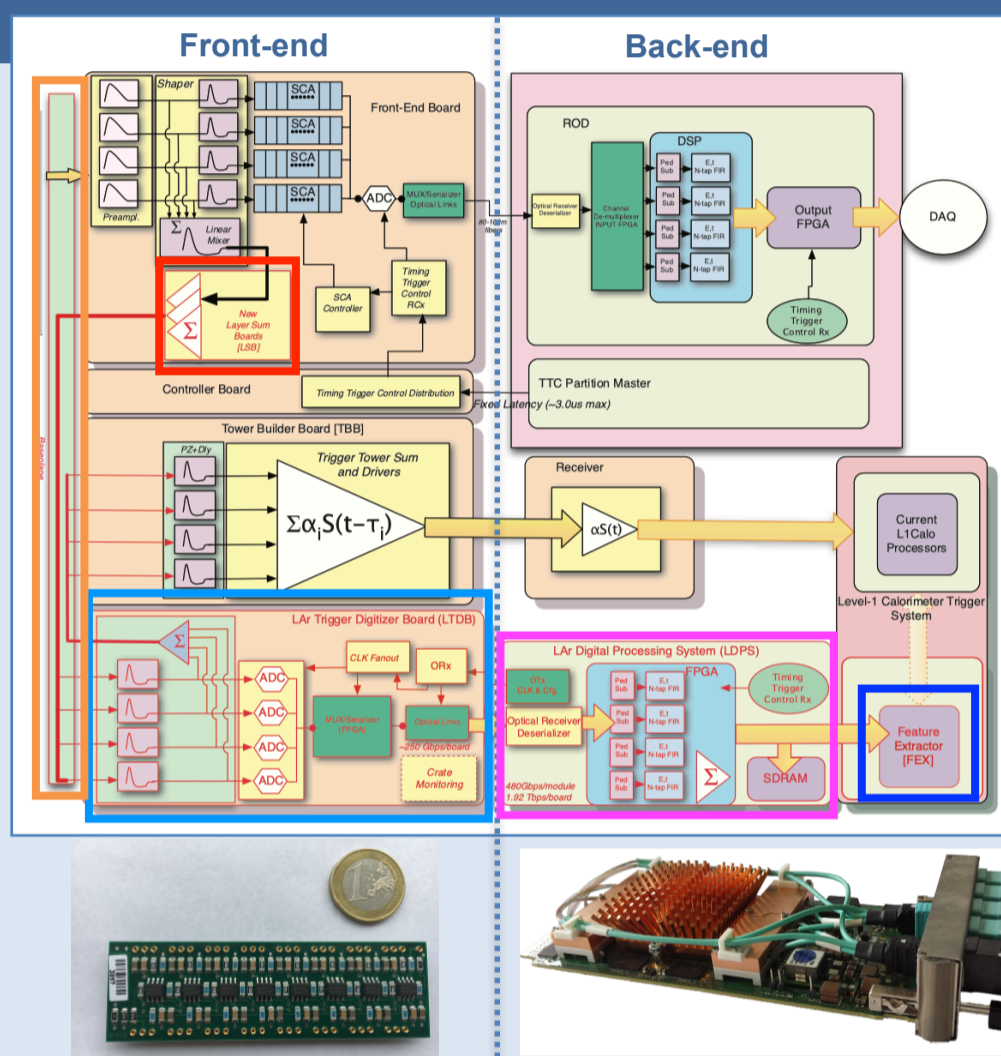
- 114 new baseplanes, to handle increased number of signals due to finer trigger segmentation
- Host LTDB and route signals from LSB to LTDB
- Route signals to Tower Builder Board (TBB) to keep the legacy (Run 2) L1 trigger operational

#### Layer Sum Boards (LSB) :

- 2 LSB on each FEB (Front-End Board)
- Analog sums of LAr cells signals to build Super Cells (SC)

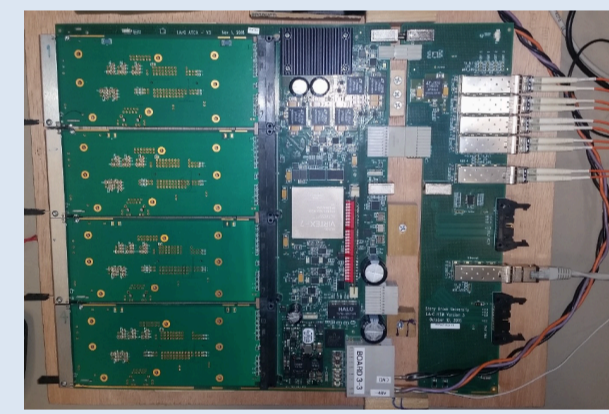
#### LAr Trigger Digitizer Boards (LTDBs) :

- 124 new boards, each one digitizing up to 320 SC signals at 40MHz and transmitting them to Back-End through optical links
- High radiation tolerance
- Analog signal sums for legacy TBB



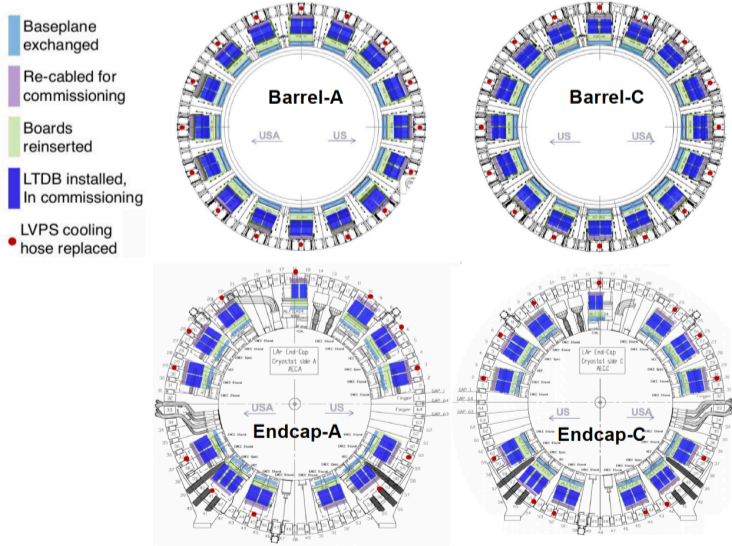
### LAr Digital Processing Blades (LDPBs)

- Located in underground area, close to layer detector, to minimize latency
- 3 ATCA (Advanced Telecommunications Computing Architecture) shelves hosting 30 LDPBs
- Each LDPB comprises:
  - 1 **LArC** (LAr Carrier): signals readout from LTDB and transmission of TTC signals (Trigger, Timing & Control) to LATOME
  - Up to 4 **LATOMES** (LAr Trigger prOcessing MEzzanines):  $E_T$  computation in high performance FPGA, and transmission to L1Calo System, after further processing by **FEX** (Feature EXtractor)
  - IPCM** (Intelligent Platform Management Controller) for monitoring



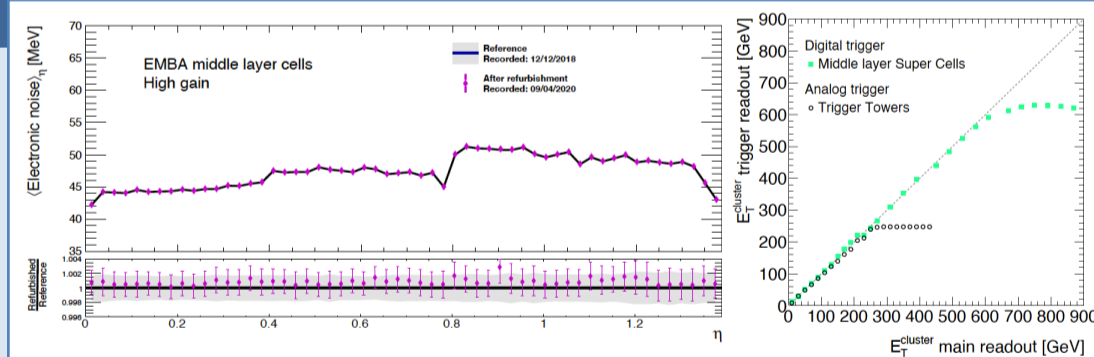
### Installation & Commissioning

- Installation of LTDBs and LDPBs completed, 1524 FEBs refurbished with LSBs, all cooling hoses replaced
- Legacy TTC (Trigger, Timing & Control) boards replaced with ALTI (ATLAS Local Trigger Interface) boards, which allow to run A and C side in parallel
- Control and monitoring infrastructure being updated



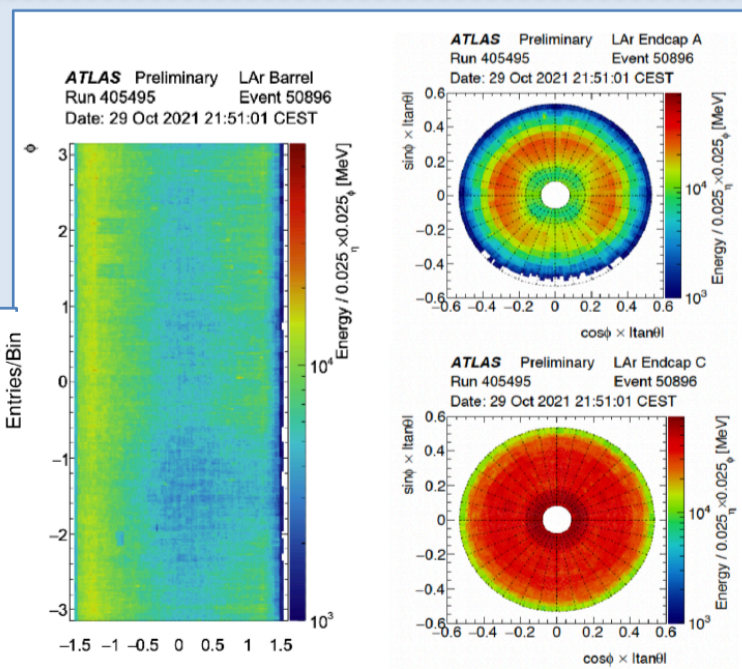
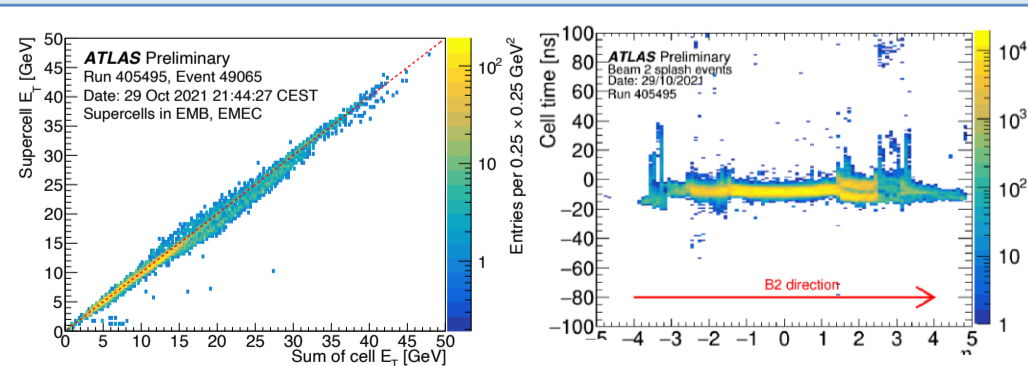
### Integration tests

- Mapping scans to check the connectivity of all channels
- Timing alignment
- Calibrations to validate pedestal values, pulse shape and gain linearity
- Similar noise level as before refurbishment



### Pilot Beam results

- The system has been operational during **Pilot Beam** in October, collecting splashes and test collisions data at 900 GeV
  - Good consistency between digital trigger and main readout energy
  - Good LAr cells coverage
  - Timing tests (FEB offset timing, LAr cells and SC timing uniformity)
- Operation also during **April Beam Splashes**: data analysis ongoing



### Conclusions

- Commissioning is now in its final steps: system in place and software and firmware update being finalized
- Good performance from Pilot Run data
- The system has been fully operational during Beam Splashes in April. Data analysis ongoing.
- LAr is ready for Run 3**

### References

[1] ATLAS Collaboration, The ATLAS experiment at the CERN Large Hadron Collider, JINST 3 (2008) S08003.  
 [2] ATLAS Collaboration, ATLAS Liquid Argon Calorimeter Phase-I Upgrade Technical Design Report, CERN-LHCC-2013-017, ATLAS-TDR-022.  
 [3] ATLAS Collaboration, LHC Pilot Run LAr Performance Plots, <https://twiki.cern.ch/twiki/bin/view/AtlasPublic/LArCaloPublicPilotBeam2021>  
 [4] ATLAS Collaboration, <https://twiki.cern.ch/twiki/bin/view/AtlasPublic/EventDisplayRun3Collisions>

