PROCEEDINGS OF SCIENCE

ATLAS Liquid Argon Calorimeter Commissioning for LHC Run 3

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Liquid argon (LAr) sampling calorimeters are employed by ATLAS for all electromagnetic calorimetry in the pseudo-rapidity region $|\eta| < 3.2$, and for hadronic and forward calorimetry in the region from $|\eta| = 1.5$ to $|\eta| = 4.9$. In the first LHC run a total luminosity of 27 fb^{-1} has been collected at center-of-mass energies of $7 - 8$ TeV. After detector consolidation during a long shutdown, Run-2 started in 2015 and about 150 fb^{-1} of data at a center-of-mass energy of 13 TeV was recorded. With the end of Run-2 in 2018 a multi-year shutdown for the Phase-I detector upgrades was begun. As part of the Phase-I upgrade, new trigger readout electronics of the ATLAS Liquid-Argon Calorimeter have been developed. Installation began at the start of the LHC shut down in 2019 and is expected to be completed in 2020. A commissioning campaign is underway in order to realise the capabilities of the new, higher granularity and higher precision level-1 trigger hardware in Run-3 data taking. This contribution will give an overview of the new trigger readout commissioning, as well as the preparations for Run-3 detector operation and changes in the monitoring and data quality procedures to cope with the increased pileup.

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1. Introduction

The ATLAS detector [1] is one of two general purpose detectors at the LHC, consisting of several sub-detectors including trackers, calorimeters and muon spectrometers. The majority of ATLAS calorimeters are sampling calorimeters that use LAr as the active material. LAr electromagnetic calorimeters in the barrel and endcap regions have accordion-shaped structures with lead absorber plates to enable full azimuthal coverage. The hadronic endcap calorimeter employs a conventional parallel plate design using copper plates and the forward calorimeter has a paraxial electrode structure with copper and tungsten as absorber materials [2].

Readout electronics of LAr calorimeters consist of on-detector and off-detector components, the former being responsible for creating "trigger tower" signals. Trigger towers are formed by summing calorimeter cell signals across longitudinal layers in segments of $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ and are sent to lowest level trigger processor, referred to as L1Calo trigger system, which selects events of interest.

2. Phase-I Upgrade

Readout electronics of LAr calorimeters are currently being upgraded as part of the ATLAS Phase-I upgrade. The objective of the upgrade is to replace trigger tower signals with finer-granularity "supercell" signals that include longitudinal shower information and have a finer resolution in η for signals in some of the calorimeter layers. This will improve object discrimination capability at trigger level which in turn allows for maintaining the trigger p_T threshold constant despite planned future increases in luminosity.

Figure 1 shows the schematics of LAr calorimeter readout electronics as it would be after the Phase-I upgrade which involves installation of new readout components, shown in red boxes in the figure. Note that the legacy trigger readout will be maintained operational during Run 3. The first new component is the layer sum board (LSB) whose job is to produce the new finer cell signal sums. The LSB is placed on a larger board called front-end board (FEB) which has been in use since Run 1. Therefore, installation of LSBs requires removal of all existing FEBs from the experimental cavern and refurbishing them with the new LSBs prior to their re-installation in the cavern.

Unlike in Runs 1 and 2 where signals were digitized off-detector, in Run 3 the digitization needs to be preformed on-detector. This will be achieved by the new LAr Trigger Digitizer Board (LTDB) which is also responsible for forming layer sums similar to those in Run 2. These summed signals are subsequently sent to legacy readout in order to keep legacy trigger readout system functional. Since LTDBs require additional slots on the baseplanes, new baseplanes have been designed to route supercell signals as well as trigger tower signals for maintaining legacy trigger readout.

Finally, the new LAr Digital Processing System (LDPS), located off-detector, will be responsible for receiving digital signals from LTDBs and processing them to extract E_T and timing of the hits. These information will then be sent to L1Calo trigger system at 40 MHz.

3. Installation and Commissioning Status

The production of all LSBs, new baseplanes and LDPS boards is complete. At the time of the poster presentation, the LTDB production was ongoing but was delayed due to COVID-related lab

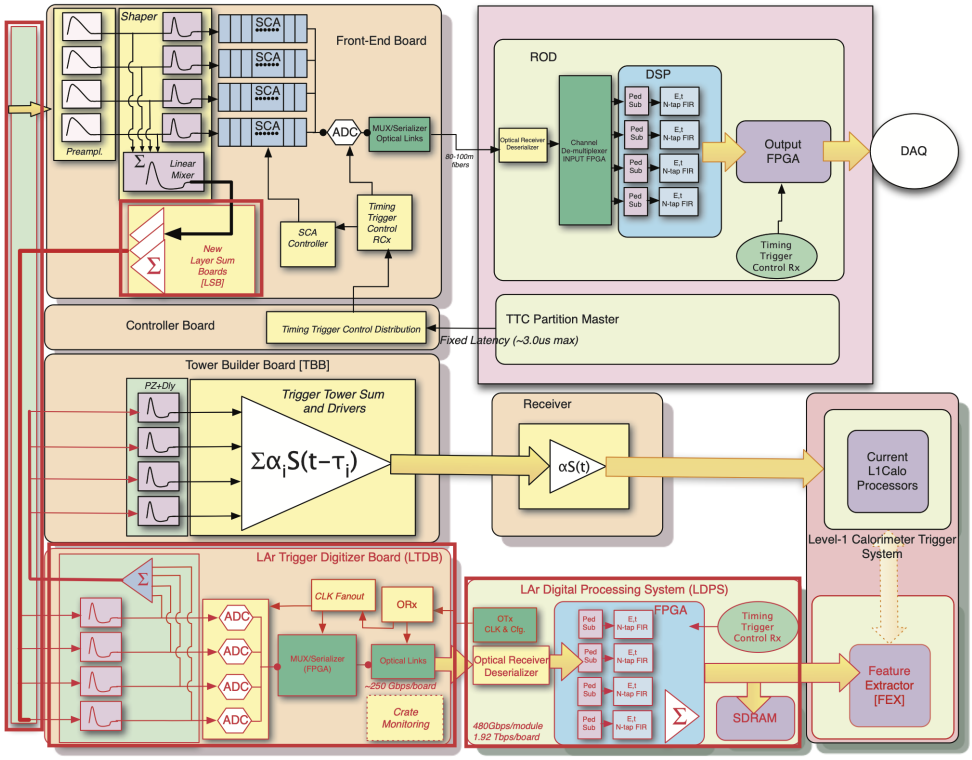

Figure 1: Schematic block diagram of LAr calorimeters' readout electronics after the Phase-I upgrade. The new components are indicated in red [3].

closures. Replacement of baseplanes and refurbishment of FEBs with new LSBs were progressing well. The installation was interrupted by CERN closure due to COVID outbreak, however it was resumed shortly thereafter. As of this poster presentation, 33 LTDBs and 4 units of LDPS were installed. Figure 2 shows the installation status for different sections of LAr calorimeters.

Commissioning of newly installed electronics involves validating three readout paths. For validating the main readout path, FEBs refurbished with new LSBs are tested through coherent noise measurement and validation of calibration parameters. In order to ensure the efficacy of legacy trigger readout path, L1Calo gain and timing scans of trigger towers are taken and compared to reference values from Run 2. Finally testing of new trigger readout path is done by calculating the energy and timing of calibration pulses.

4. Conclusion

The upgrade of ATLAS LAr calorimeters in preparation for Run 3 is in progress. Despite the delays due to COVID-related interruptions, the production of new components is nearly complete and the installation is continuing on schedule. The installation of new components is followed by testing main readout as well as the legacy and new trigger readouts, which have so far been performing as expected.

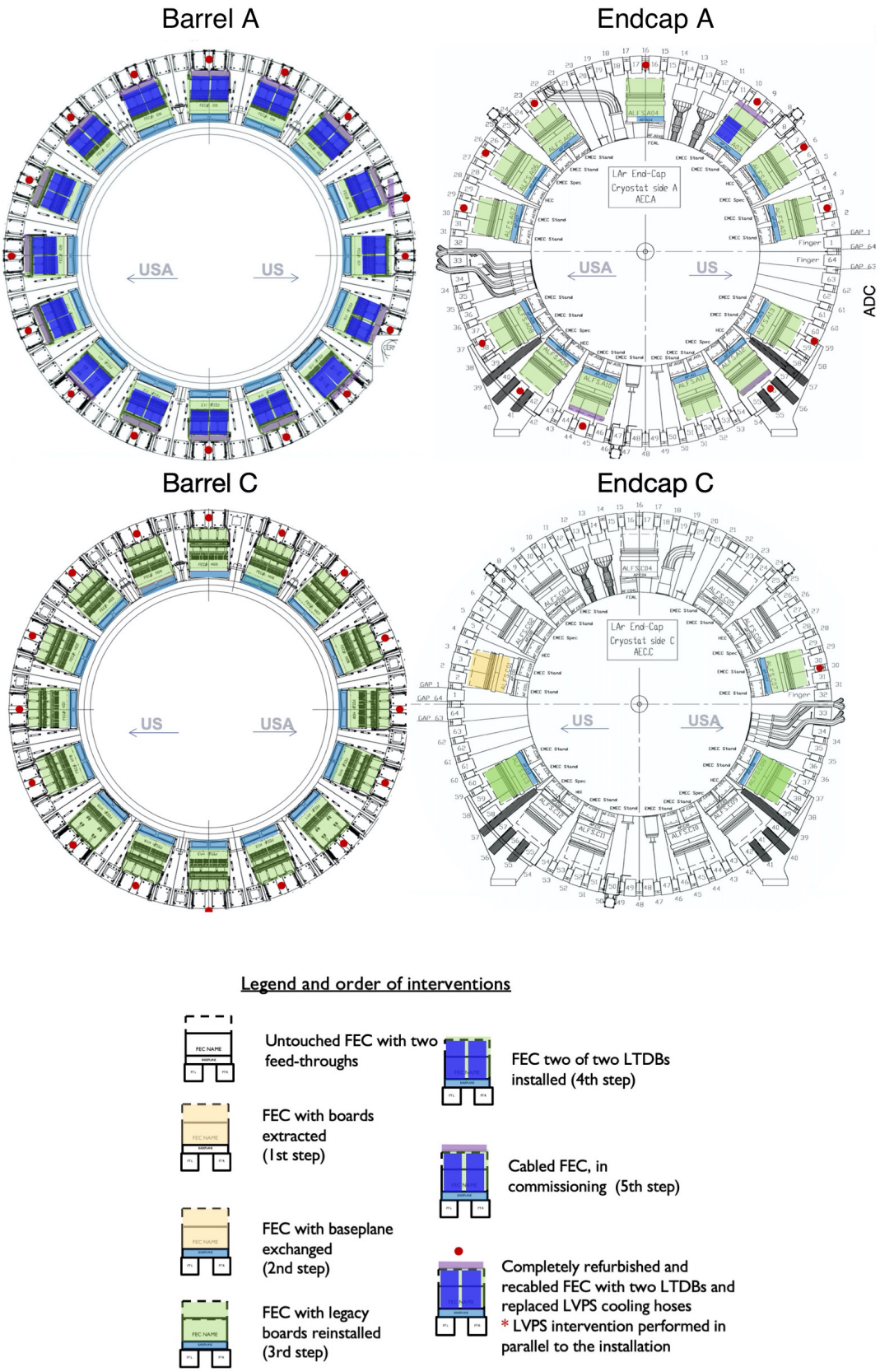

Figure 2: Schematics showing installation status for each of the calorimeter crates in the barrel and endcap regions for sides A and C. The colors of the crates in the schematics are described in the legend below, which also details the order of steps involved in the refurbishment process.

References

[1] ATLAS collaboration, *The ATLAS Experiment at the CERN Large Hadron Collider*, *JINST* **3** (2008) S08003.

[2] ATLAS collaboration, *ATLAS Liquid Argon Calorimeter: Technical Design Report*, CERN-LHCC-96-41.

[3] ATLAS collaboration, *ATLAS Liquid Argon Calorimeter Phase-I Upgrade Technical Design Report*, CERN-LHCC-2013-017.