The Phase-1 Upgrade of the ATLAS Level-1 Calorimeter Trigger

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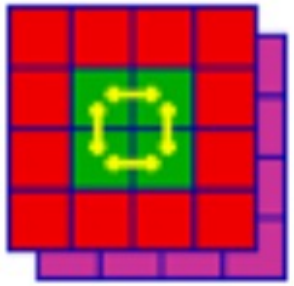
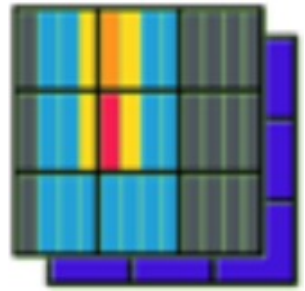
INDIANA UNIVERSITY

ATLAS EXPERIMENT

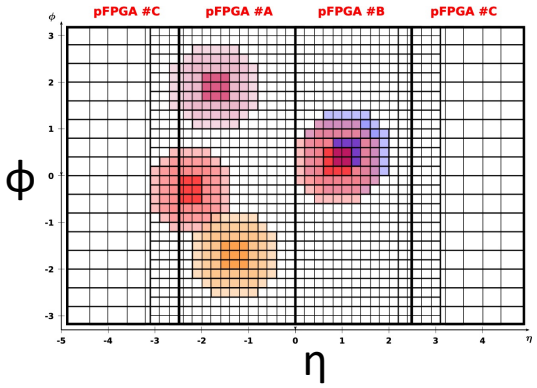




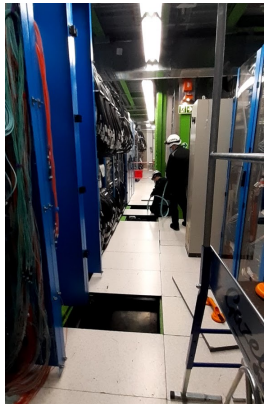
Overview

The ATLAS Level-1 Calorimeter Trigger (L1Calo):

L1Calo is a hardware-based trigger system that processes real-time (40 MHz) data from the Liquid Argon (LAr) and Tile calorimeters to identify physics objects such as electrons, photons, jets, and missing transverse energy.

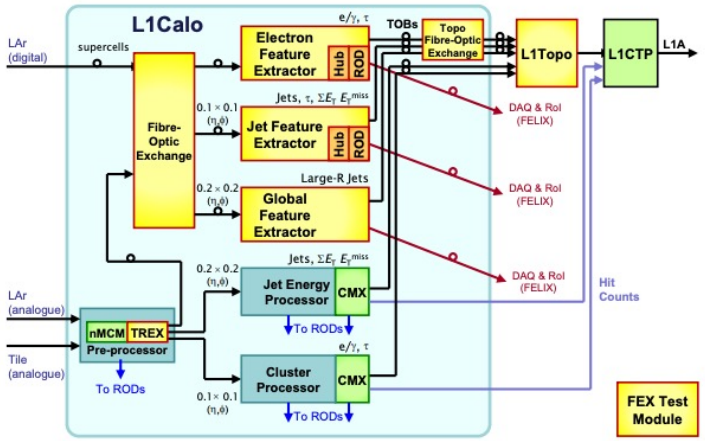


L1Calo lives at LHC Point 1, near ATLAS



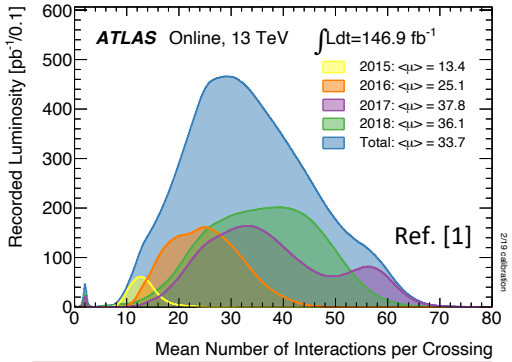
L1Calo in Run 3:

- Phase-1 upgrade will introduce new Feature Extractor hardware alongside the legacy Cluster Processor and Jet Energy Processor, as well as new infrastructure
- The beginning of Run-3 will have the legacy Run-2 L1Calo system operating alongside the new Phase-1 upgrade hardware



Upgrade Motivation:

- Manage increasingly challenging pileup environment
- Improve L1Calo algorithms to reduce Level-1 rate without throwing away interesting physics
- Bridge the gap to Phase-II upgrades and HL-LHC operation

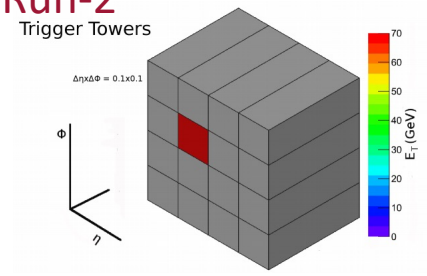


Reminder: $\langle\mu\rangle_{\text{Run-2}} = 33.7$!

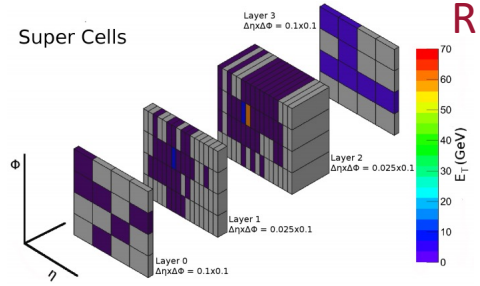
Upgrade Features:

- Digital system
- Higher granularity than Run-2 gives new opportunities at Level-1:

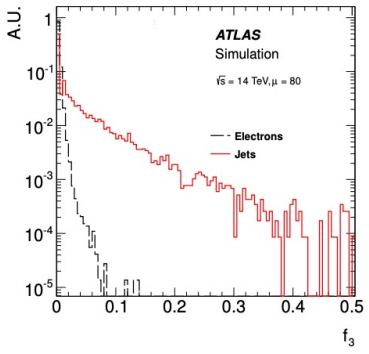
Run-2

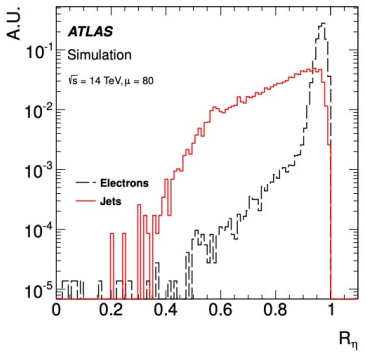


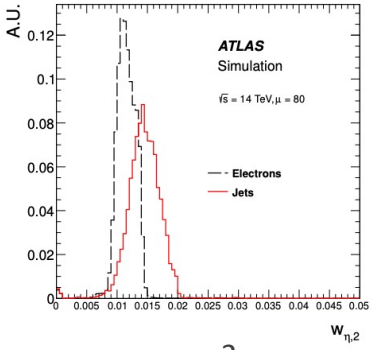
Run-3



Ref. [2]

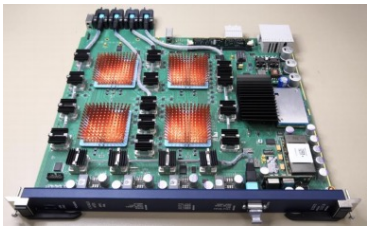




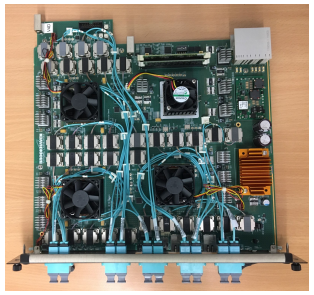


New Hardware and Infrastructure

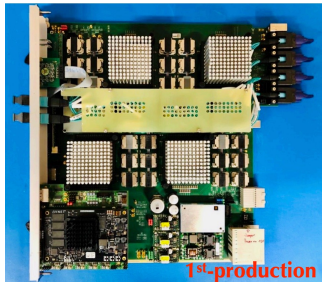
Electron Feature Extractor (eFEX)
- Full calorimeter granularity
- e/γ and tau
- Hardware - ATCA:
  - 5x Xilinx Virtex7
- Production in progress!



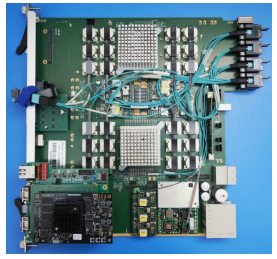
Global Feature Extractor (gFEX)
- Entire calorimeter on one board
- Large-R jets
- Missing E_T and ΣE_T
- Hardware - ATCA:
  - 3x Xilinx Virtex Ultrascale+
  - 1x Xilinx Zynq Ultrascale+
- Production complete!



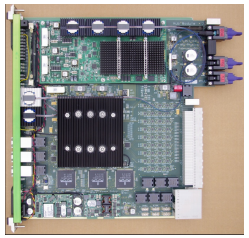
Jet Feature Extractor (jFEX)
- Large and small-R jets
- Missing E_T and ΣE_T
- tau
- Hardware - ATCA:
  - 4x Xilinx Ultrascale+
  - 1x Xilinx Zynq Ultrascale+
- Production in complete!



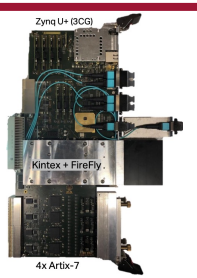
Level-1 Topological Trigger (L1Topo)
- Topological combinations of FEX + L1Muon trigger objects
- Hardware - ATCA:
  - Xilinx Ultrascale+
- Production in progress!



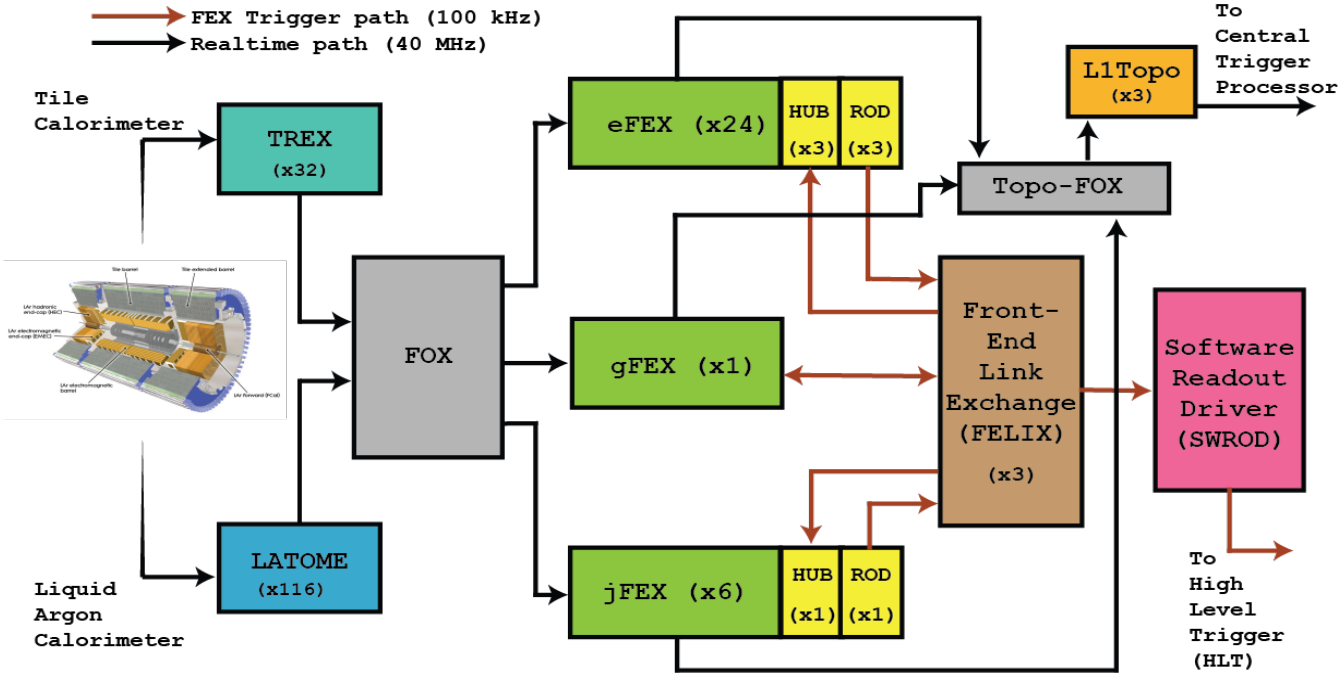
HUB+Readout Driver (ROD)
- ATCA based
- Exchange trigger and timing information with modules in one shelf
- Aggregate and buffer data sent along the trigger path for one shelf
- Production complete!



Tile Rear Extension (TREX)
- Provides digitized inputs to the FEXes from the Tile calorimeter
- Hardware - Custom VME rear extension:
  - 1x Xilinx Zynq Ultrascale+
  - 4x Xilinx Artix-7
  - 1x Kintex Ultrascale
- Production + installation complete!



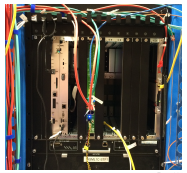
Fiber-Optic Exchange (FOX)
- Patch bay to route fiber optic signals from calorimeters-to-FEX
- Patch bay to route fiber optic signals from FEX-to-L1Topo (aka Topo-FOX)
- Production complete!



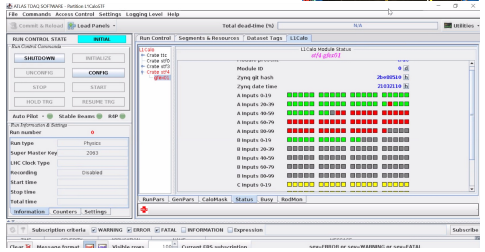
Installation and Commissioning

Test Rig - B4 Surface Test Facility (STF)

Production Hardware Under Test!

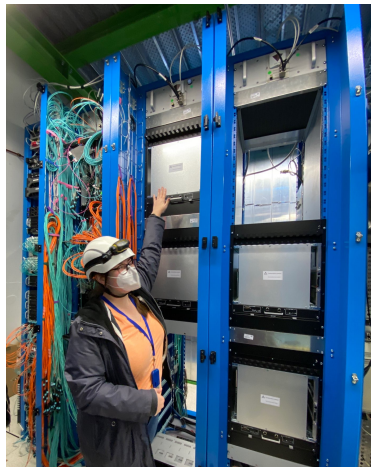


Full L1Calo slice, with timing, trigger and DAQ



Firm- and Software Development Ongoing!

Installation at USA15 in Progress!



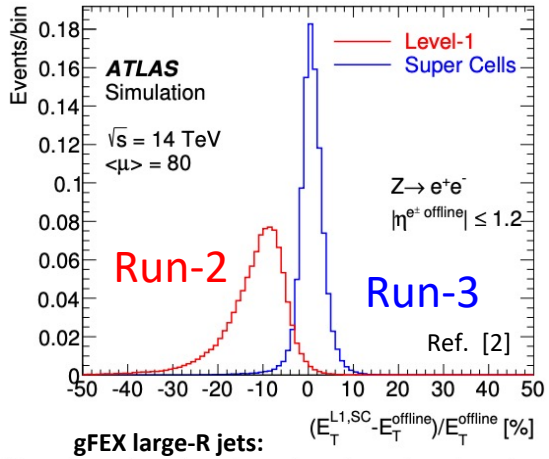
FEX and L1Topo racks and shelves installed!

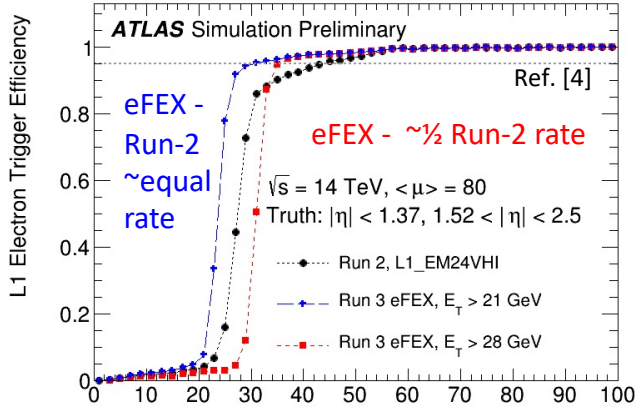
FOX installation Ongoing!

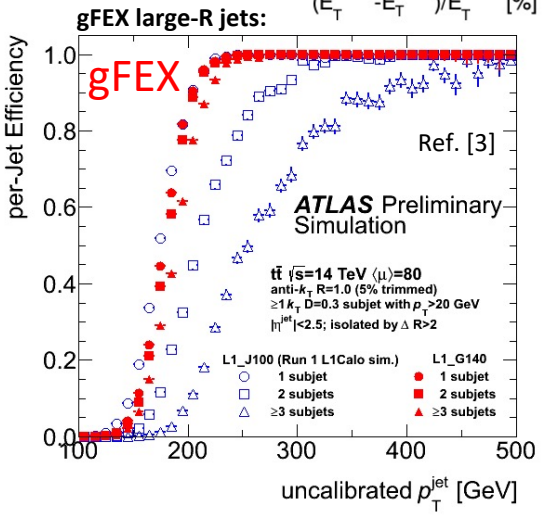
TREX installation complete!

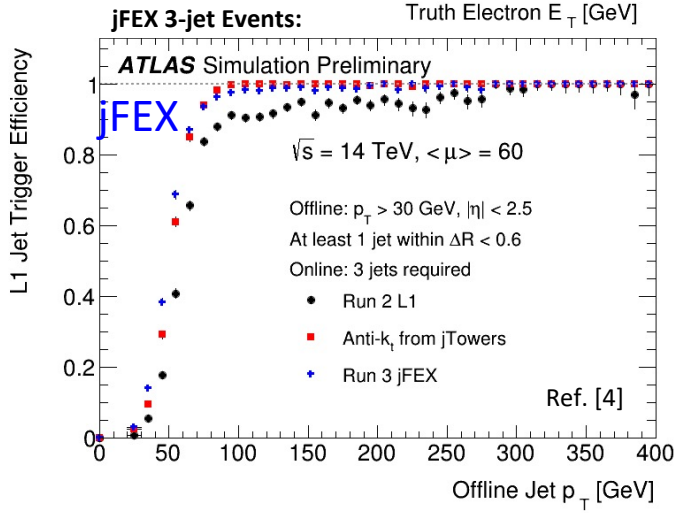
FEX installation beginning this Summer 2021!

Expected Performance









References

1. https://twiki.cern.ch/twiki/bin/view/AtlasPublic/LuminosityPublicResultsRun2
2. The ATLAS Collaboration, *ATLAS Liquid Argon Calorimeter Phase-I Upgrade : Technical Design Report.* CERN-LHCC-2013-017
3. https://twiki.cern.ch/twiki/bin/view/AtlasPublic/JetTriggerPublicResults#Phase_I_Upgrade_Performance_Plot
4. https://twiki.cern.ch/twiki/bin/view/AtlasPublic/L1CaloTriggerPublicResults#Performance_studies_of_the_ATLAS
5. The ATLAS Collaboration, *Technical Design Report for the Phase-I Upgrade of the ATLAS TDAQ System.* CERN-LHCC-2013-018

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