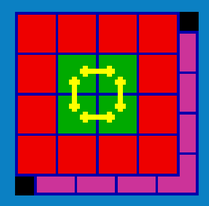
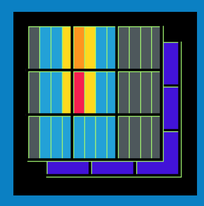
The Phase-1 Upgrade of the ATLAS Level-1 Calorimeter Trigger

Damir Raßloff

Kirchhoff-Institute for Physics, University of Heidelberg, Germany

On behalf of the ATLAS collaboration





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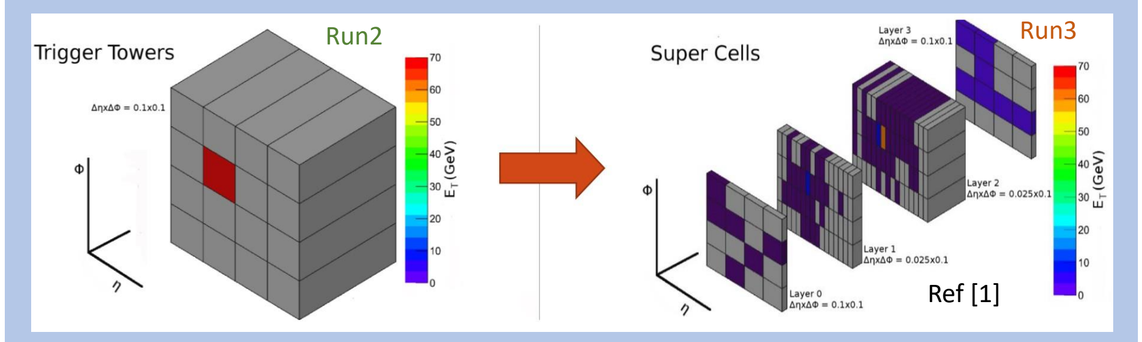
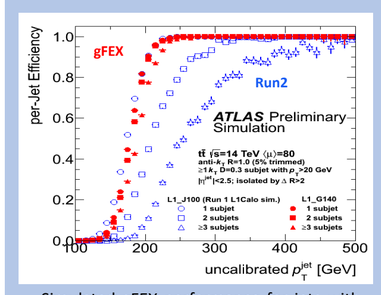
Motivation

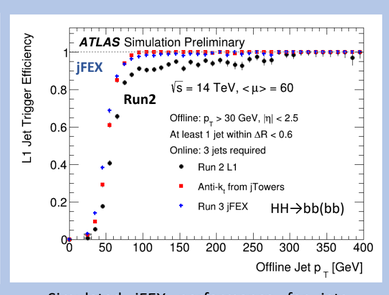
- Challenging pileup environment
- New LArg electronics: 10x higher granularity with super-cells
- Improved L1Calo algorithms benefit from higher granularity, higher resolution and shower shape information resulting in better performance



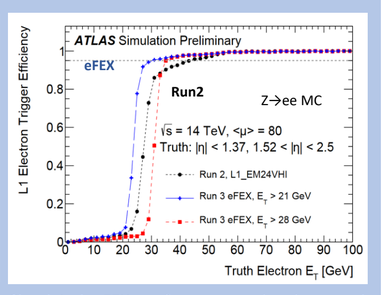
Simulation Studies



Simulated gFEX performance for jets with substructure. Ref[3]



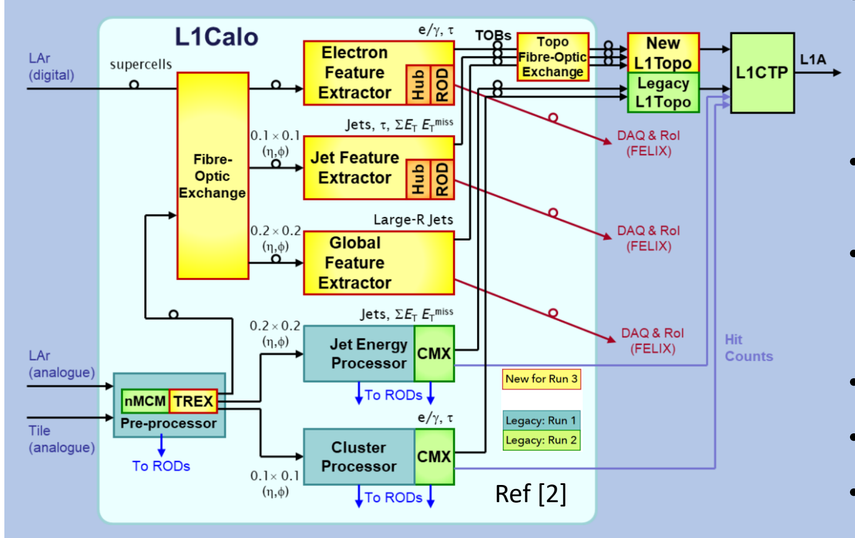
Simulated jFEX performance for jets with nearby jets. Ref[4]



Simulated eFEX performance using improved jet discrimination for electrons. Ref[4]

The ATLAS Level-1 Calorimeter Trigger (L1Calo) in Run3

The ATLAS Level-1 Calorimeter Trigger (L1Calo) is a hardware-based system that identifies events containing calorimeter-based physics objects, including electrons, photons, taus, jets, and missing transverse energy. In preparation for Run 3, when the LHC will run at higher energy and instantaneous luminosity, L1Calo is currently implementing a significant programme of planned upgrades. The existing hardware will be replaced by a new system of FPGA-based feature extractor (FEX) modules.

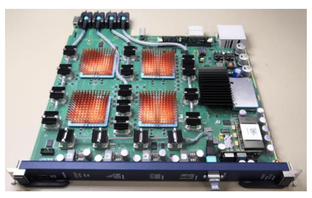


- 3 new feature identification systems:
  - electron Feature Extractor (eFEX)
  - jet Feature Extractor (jFEX)
  - global Feature Extractor (gFEX)
- Upgraded Level-1 Topological (L1Topo) processor
- New readout interfaces: L1Calo ReadOut Driver (ROD) & Front-End Link eXchange (FELIX)
- Tile Rear Extension (TREX) module
- Fiber-Optic eXchange (FOX)
- Run 2 legacy L1Calo system will run in parallel with Phase-1 system at the beginning of Run 3

New L1Calo Hardware and Infrastructure

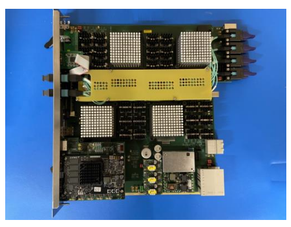
electron Feature Extractor (eFEX)

- 24 modules in 2 ATCA shelves
- Benefits from better granularity of LArg
- Identifies electrons, photons & taus
- Production & installation in progress



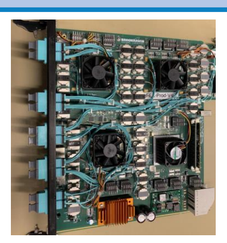
jet Feature Extractor (jFEX)

- 6 ATCA modules
- Identifies taus, large-R & small-R jets and forward electrons at Level-1
- Computation of missing E_T & sum E_T



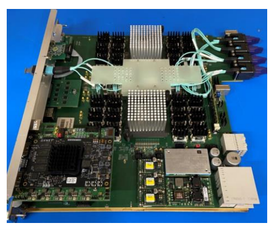
global Feature Extractor (gFEX)

- 1 ATCA module
- Information from the entire calorimeter
- Identifies large-R jets
- Computation of missing E_T & sum E_T



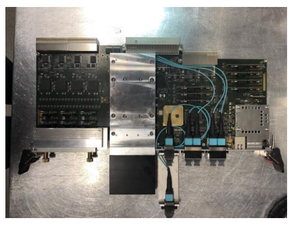
Level-1 Topological Trigger (L1Topo)

- 3 ATCA modules
- Inputs from FEXes & L1 Muon
- Uses topological algorithms & multiplicity trigger



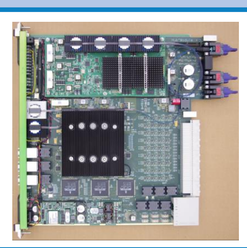
Tile Rear Extension (TREX)

- 32 VME modules in 2 Tile crates
- Physical extension of Run 2 PPMs
- Provides digitized data from Tile to the new FEXes & to the legacy system



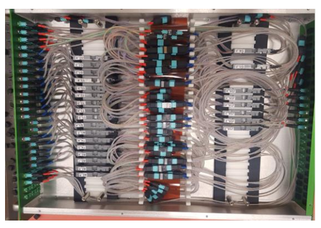
Hub & Readout Driver (ROD)

- 7 ATCA modules
- Provides timing & trigger information to eFEX, jFEX & L1Topo
- Buffers readout data & sends it to FELIX



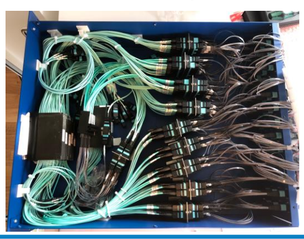
Fiber-Optic Exchange (FOX)

- 6 FOX boxes
- ~ 7500 fibers
- Map calorimeter inputs to FEXes



Topo-Fiber-Optic Exchange (Topo-FOX)

- 1 Topo-FOX box
- ~1500 fibers
- Map FEX & L1Muon inputs to L1Topo

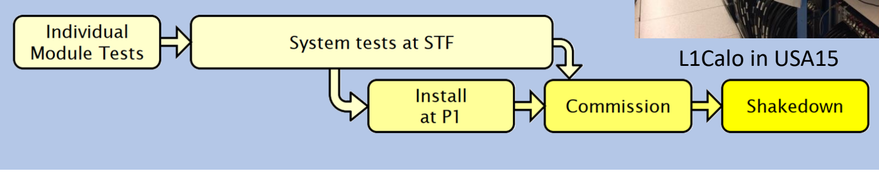


Installation & Commissioning

Surface Test Facility (STF)

- Fully equipped test-rig at CERN
  - ATCA shelves for eFEX, jFEX, gFEX, L1Topo, LAr & L1Muon
  - VME crate for PPM, TREX & TTC
  - Full DAQ infrastructure available
- Ongoing module specific hardware, software & firmware tests
- Successful combined slice tests with all modules
  - Synchronous readout & event building
  - Transmission through all modules

L1Calo in USA15

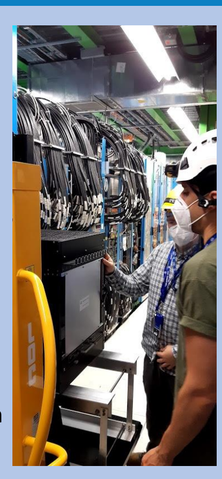


Installation status in ATLAS

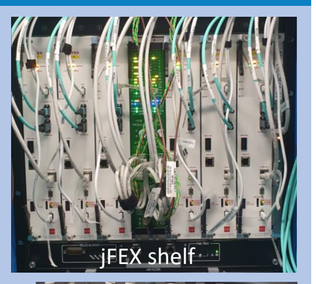
- gFEX (1/1), jFEX (6/6) & L1Topo (3/3) fully installed
- 1 eFEX (12/24) shelf fully populated
  - Remaining boards in production (to come soon)
- Hub & ROD (5/7) installed
  - 2 remaining boards will be installed with eFEX modules for the second eFEX crate
- All TREX (32/32) modules installed
- FOX boxes installed & connected
- Topo-FOX box installed & connected

FOX installation

TREX VME crate



ATCA shelf installation in USA 15



Commissioning in ATLAS

- Installed Phase-1 systems succesfully integrated in ATLAS run control software
- Successful integration with Calorimeters
- Fiber mapping, connectivity and bit-error rate checks
- Parasitic tests with FEXes during special runs (splashes, pilot beam, etc)
- TREX running stably in ATLAS up to 100 kHz readout
- Re-commissioning of legacy system in parallel

Reference:

[1] ATLAS Collaboration, Technical Design Report, ATLAS Liquid Argon Calorimeter Phase-I Upgrade, CERN-LHCC-2013-017 ; ATLAS-TDR-022

[2] ATLAS Collaboration, Technical Design Report for the Phase-I Upgrade of the ATLAS TDAQ System, CERN-LHCC-2013-018, ATLAS-TDR-023

[3] https://twiki.cern.ch/twiki/bin/view/AtlasPublic/JetTriggerPublicResults#Global_Feature_Extraction_gFEX_P

[4] https://twiki.cern.ch/twiki/bin/view/AtlasPublic/L1CaloTriggerPublicResults

ATLAS EXPERIMENT