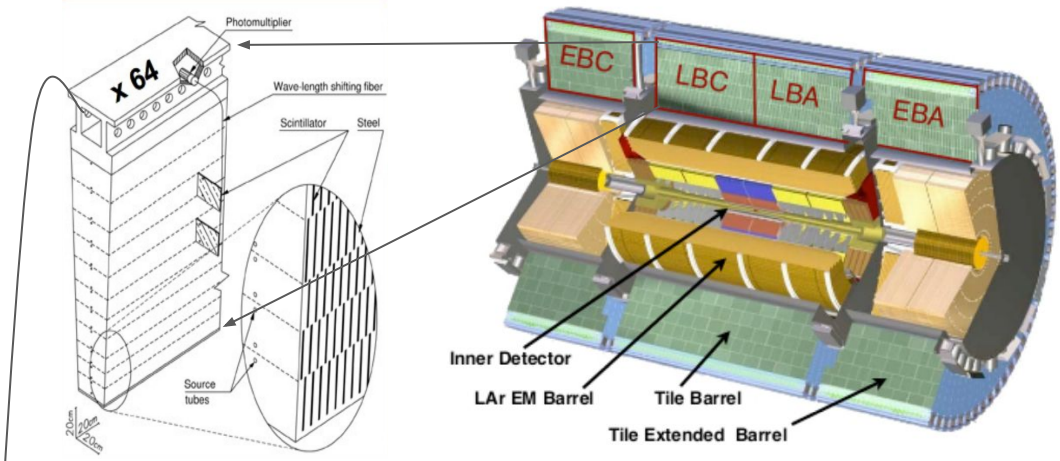
HL-LHC Upgrades to the ATLAS Hadronic Tile Calorimeter Readout Electronics

Katherine Dunne
for the Stockholm University TileCal Group
Swedish Particle Physics Meeting
November 23—25, 2020

Stockholm University

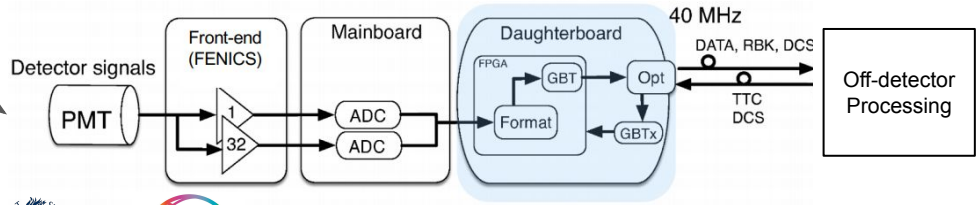
ATLAS EXPERIMENT

The ATLAS Hadronic Tile Calorimeter



Daughterboard: Tile readout-out link

- Control & readout interface for the upgraded TileCal front end systems



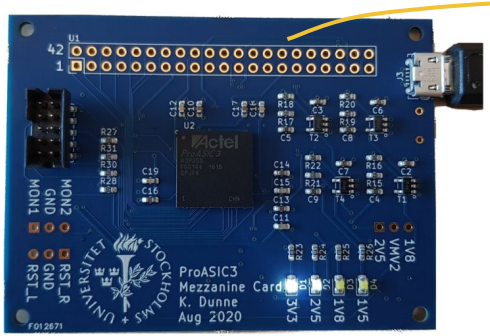
The High-Luminosity LHC Era

- TileCal essential for measurement of jet/missing energy, jet substructure, electron isolation, and triggering
- Increase in luminosity makes HL-LHC challenging in terms of radiation hardness and triggering
- Phase-II trigger system redesigned with fully digital trigger to improve selectivity
  - access to digital info from each calorimeter cell with low noise and accurate energy calibration
- Electronic components must be replaced to survive higher radiation environment

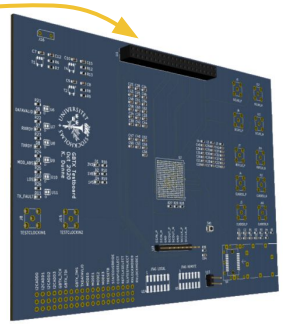
Daughterboard Upgrades

- Migration to Kintex Ultrascale (KU) FPGAs
  - Single Event Latch-Up (SEL) observed in Ultrascale+
- New remote JTAG interface design using FPGAs (ProASIC3)
  - Improved reliability, buffering, voltage translation
- DC-DC regulation w/ failsafe power-up sequencing, improved monitoring, and over-current protection
- Optimized routing of ADC data & clocks to FPGA banks for better timing performance

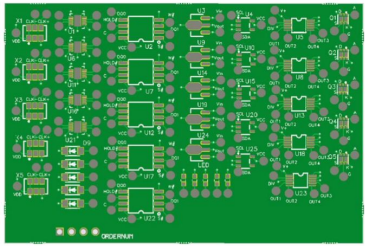
Upgrade Test Boards



ProASIC3 Mezzanine Board

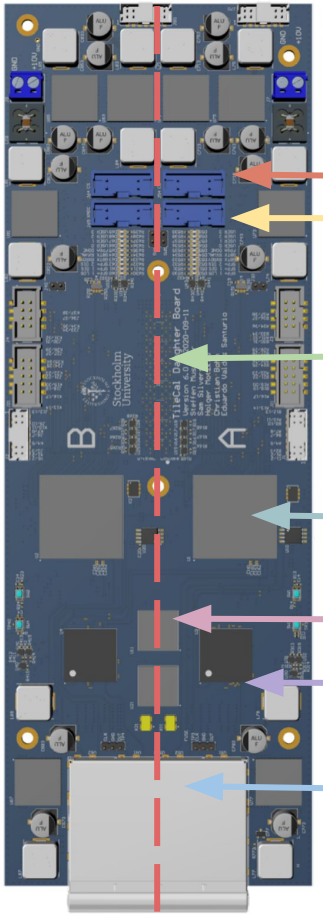


GBTx Test Board



Aux Component
Irradiation Board

Daughterboard v6



2 independent sides

Power Regulation

2x Cs interfaces

2x xADC interfaces

400 pin FMC interface with MB

2x Kintex Ultrascale (KU)

2x ProASIC3

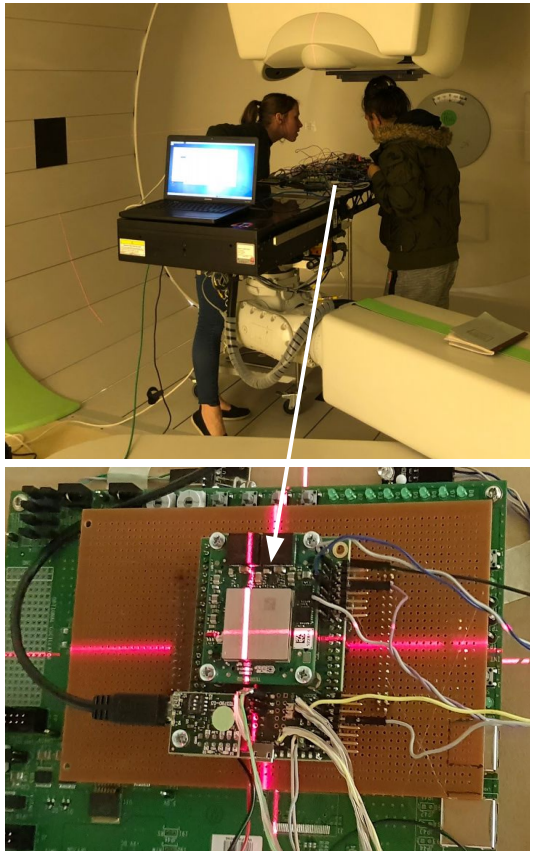
2x GBTx

Fiber transceivers
4x9.6 Gbps uplink
2x4.8 Gbps downlink

Power Regulation

SEU / SEL Tests

- FPGAs tested w/ 226 MeV proton beam at IFJ Krakow
- Fluence: 1.11E+12 p/cm^2
- KU SEU rate: 166 SEU/1.4E+9 p/cm^2
  - Negligible disruption to HL data taking
  - Not all FPGA logic used, Triple Mode Redundancy, Xilinx Soft Error Manager
- No latch-up observed (SEL)



Upcoming Irradiations

- NIEL at Ljubljana TRIG A Mark II
  - 9E+12 n/cm^2 (1 MeV equivalent)
- TID at Stockholm U. facility
  - 15 kRad + annealing

Daughterboard Production

- 1085 DBs will be produced
- 896 installed in ATLAS
- Small batch to be produced this year
- Final Design Review completed 2021
- Stockholm U. ATLAS Production Lab:
  - 2 test benches, for production testing and debugging in parallel
  - Burn-in oven capacity up to 40 DBs, with temperatures up to 85C