Overview of the Readout Electronics LAr Phase-II upgrade

Elio Desbiens – McGill University
Supervisors: Brigitte Vachon, Raphaël Hulsken, Clément Camincher

Summer Student Presentations 2024

Introduction

The goal of my project: develop **readout tools** to help test the ATLAS LAr Phase-II (new) electronics.

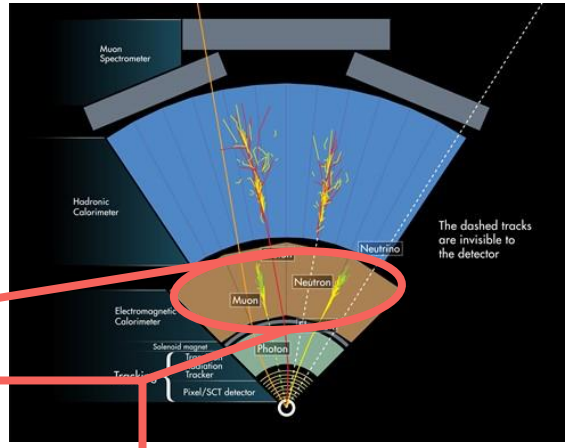
First tool: analyze the test-stand data and extract useful information from the noise.

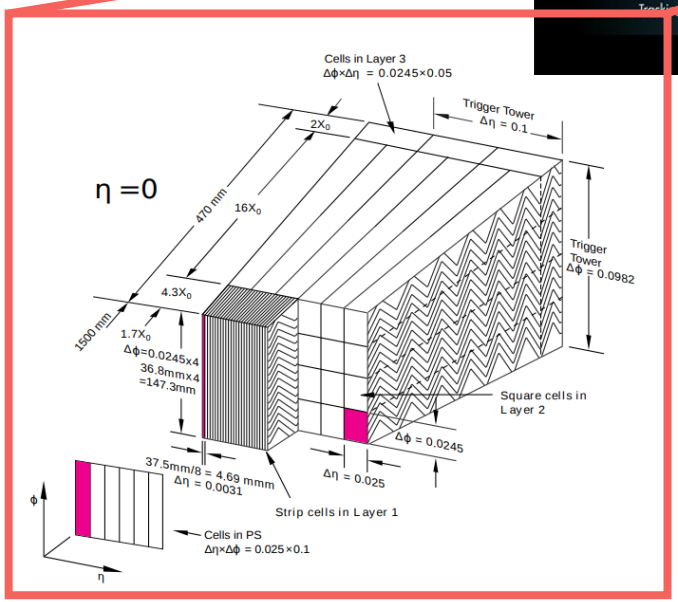
- The data we use is preliminary.

Second tool: decode the data.

ATLAS Liquid Argon Calorimeter Phase-II Upgrade

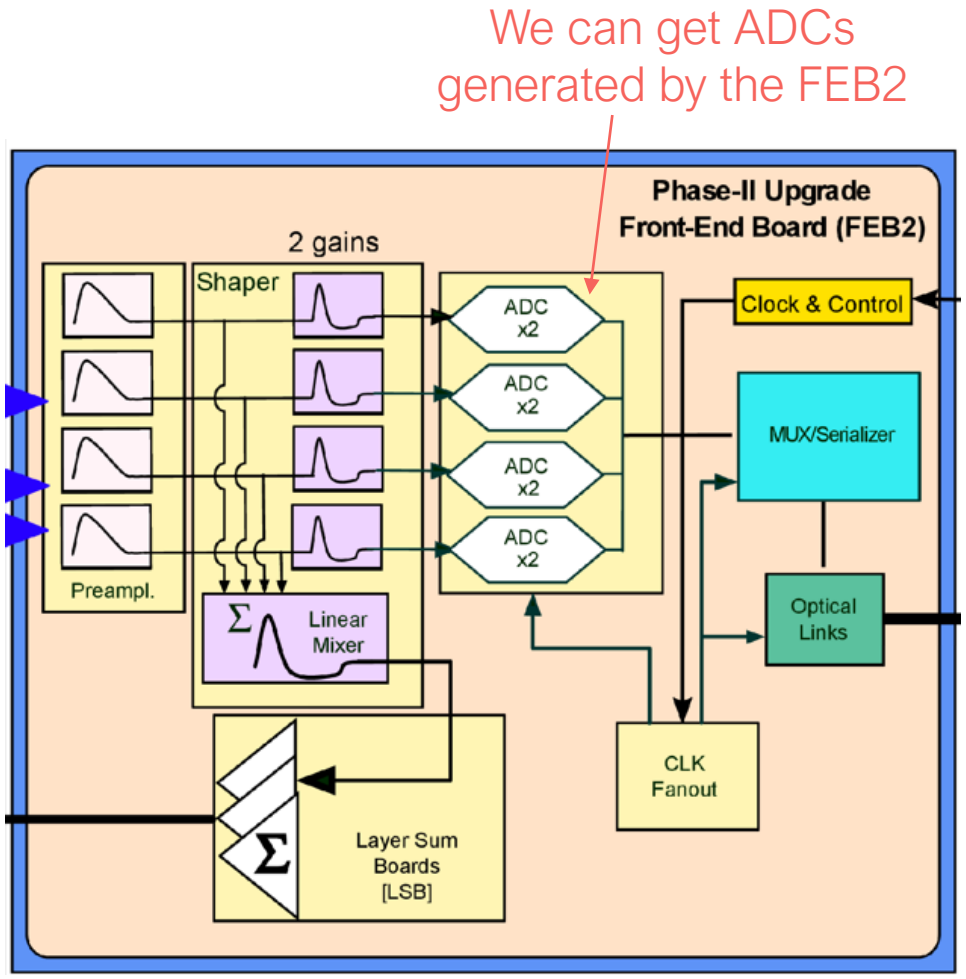
- In the ATLAS detector, the electromagnetic calorimeter is a Liquid Argon calorimeter.
- The LHC is upgraded to a higher luminosity (HL-LHC):
  - → More collisions at the same time;
  - → Requires better trigger system to remove pileup.
- To be able to read the full granularity at a higher trigger rate, we need to change the whole readout system.





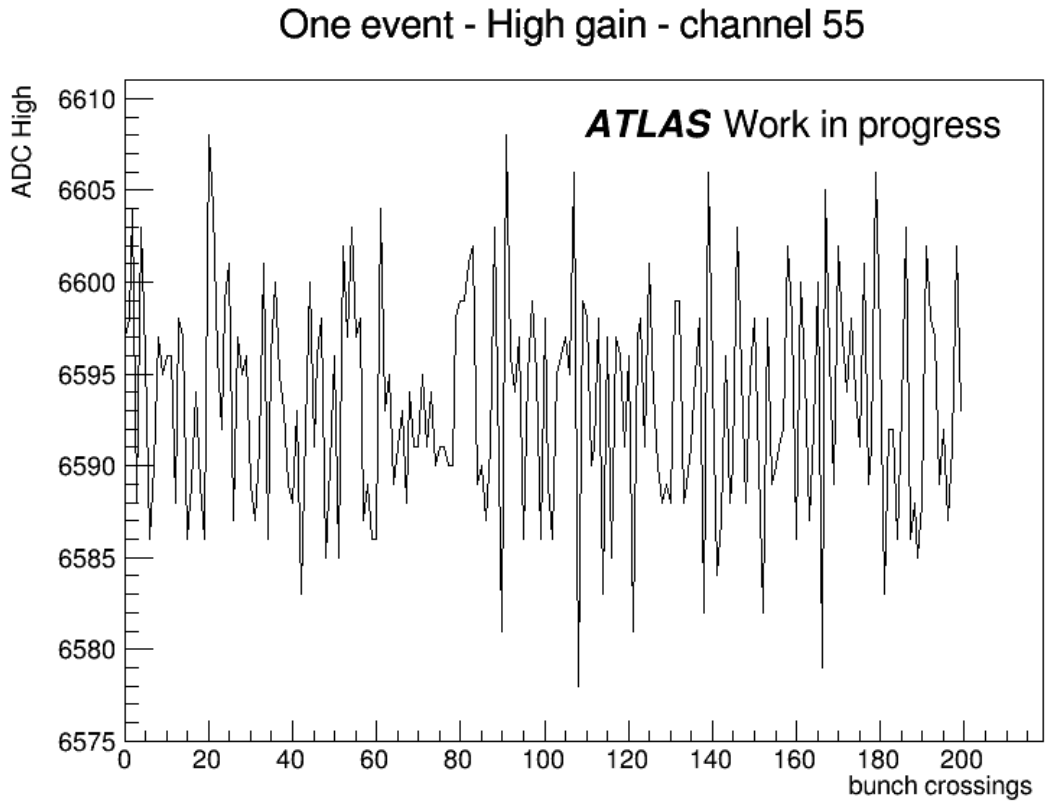
Front-End Boards (FEB2)

- On-detector;
- 128 calorimeter cells per Front-End Boards;
- Total of 1524 FEB2 in LAr calorimeter;
- Serializer chips receive Analog-to-Digital Converter (ADC) outputs;
- Serialized data is sent to off-detector electronics through optical links.



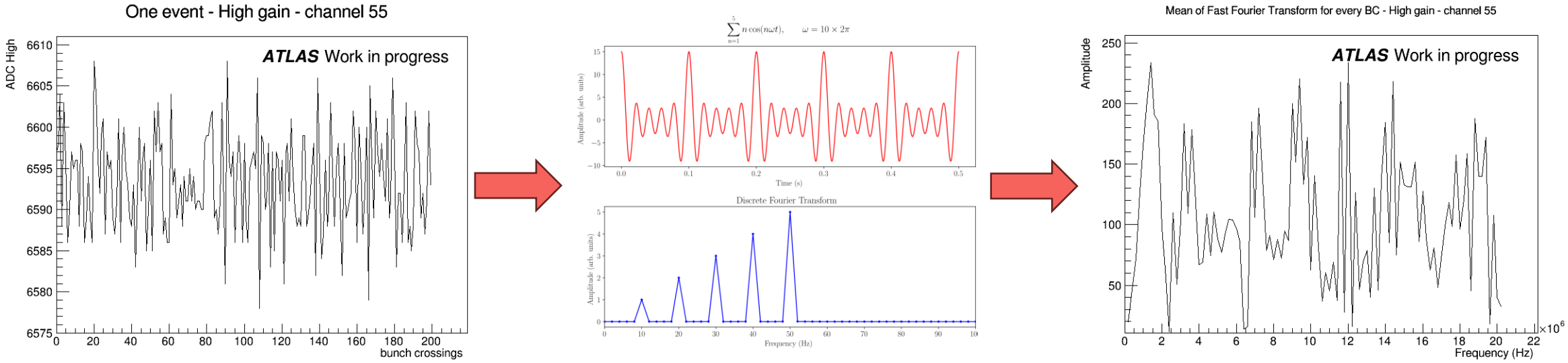
The First Tool: Noise Analysis

- This is an example of the data we get from the FEB2, for what we define as “one event” → 200 bunch crossings;
- Only white noise, no collisions here;
- We want to analyze the white noise coming from the FEB2 to verify that there are no disturbing frequencies.



Noise Analysis – Fast Fourier Transform

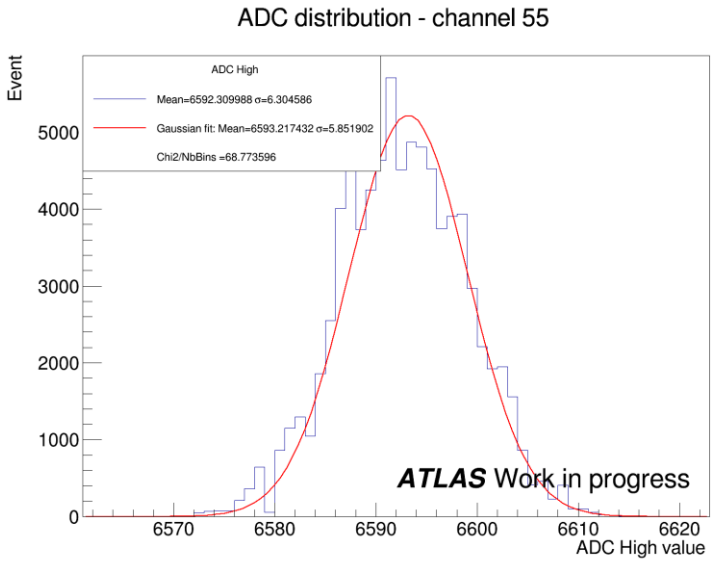
- The Fast Fourier Transform is an algorithm to do a Fourier analysis on a discrete dataset;
- It converts the original signal from the time domain to the frequency domain;
- We can then observe if a particular frequency is more important.



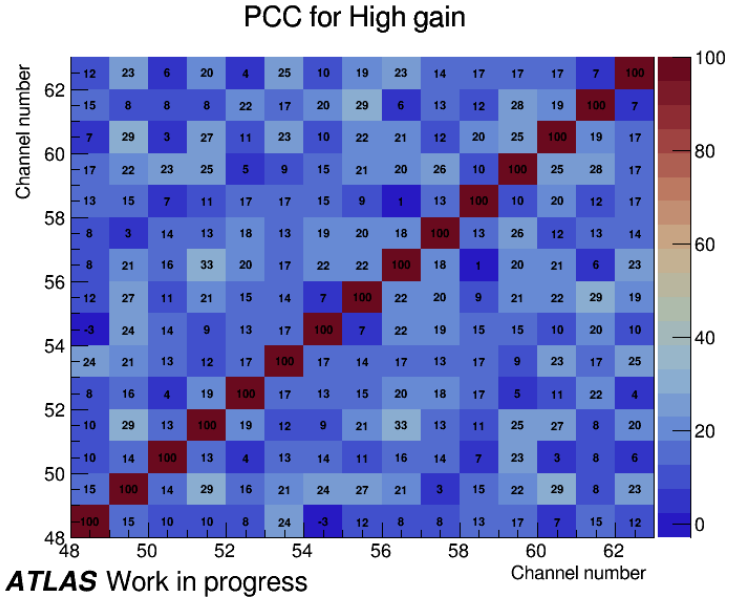
Noise Analysis – Other Plots

Other plots can also be useful to analyze the noise:

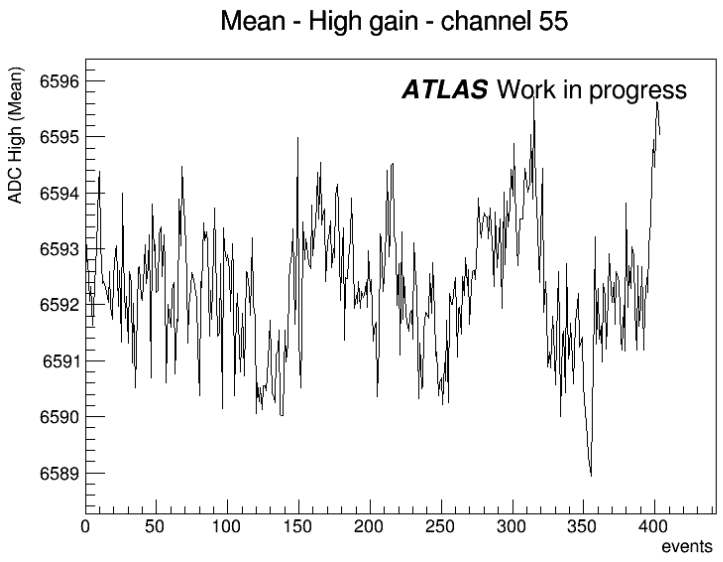
Distribution of ADC values



Pearson Correlation Coefficient



Mean on bunch crossings of all events



The Second Tool: Decoding

The noise analysis is possible because we decoded the raw data beforehand.

The decoding is done in three parts:

- Part 1: Mapping building → know which data corresponds to which FEB2 channel;
- Part 2: Data readout with the mapping, and writing ROOT file;
- Part 3: Formatting needed for calibration to adjust FEB2:
  - The readout chain is still a work in progress, that is why we need specific data for calibration.

Conclusion

- With HL-LHC, the ATLAS detector needs some upgrades;
- Liquid Argon group is working on upgrading the electronic readouts;
- Make sure there is no important defects:
  - ✓ Analyze the noise coming from the boards;
  - ✓ Develop an efficient decoder.

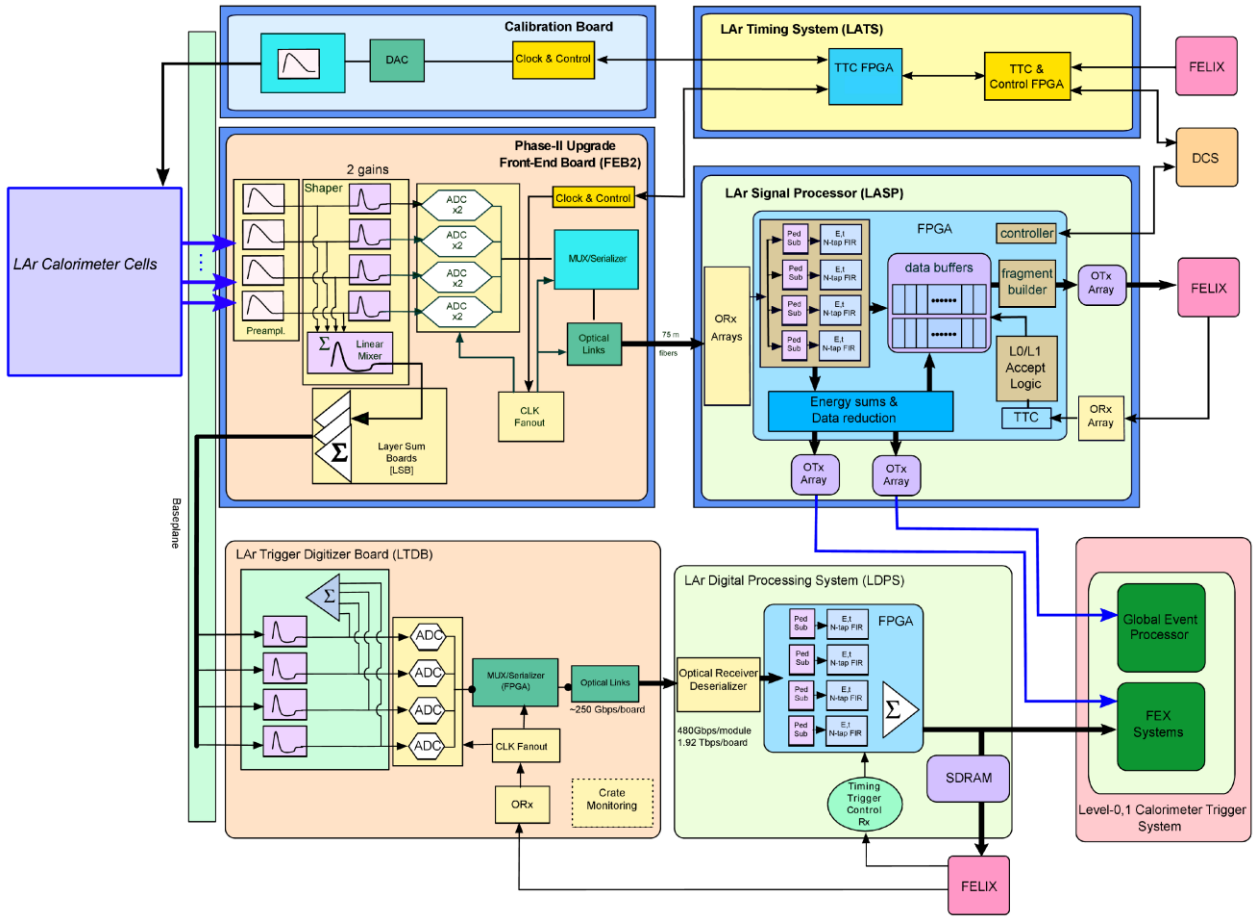
References

- The ATLAS Collaboration. (2018). ATLAS Liquid Argon Calorimeter Phase-II Upgrade Technical Design Report. (CERN-LHCC-2017-018 ATLAS-TDR-027) https://cds.cern.ch/record/2285582/files/ATLAS-TDR-027.pdf?version=2
- Supervisors: Brigitte Vachon, Raphaël Hulsken, Clément Camincher

Backup slides

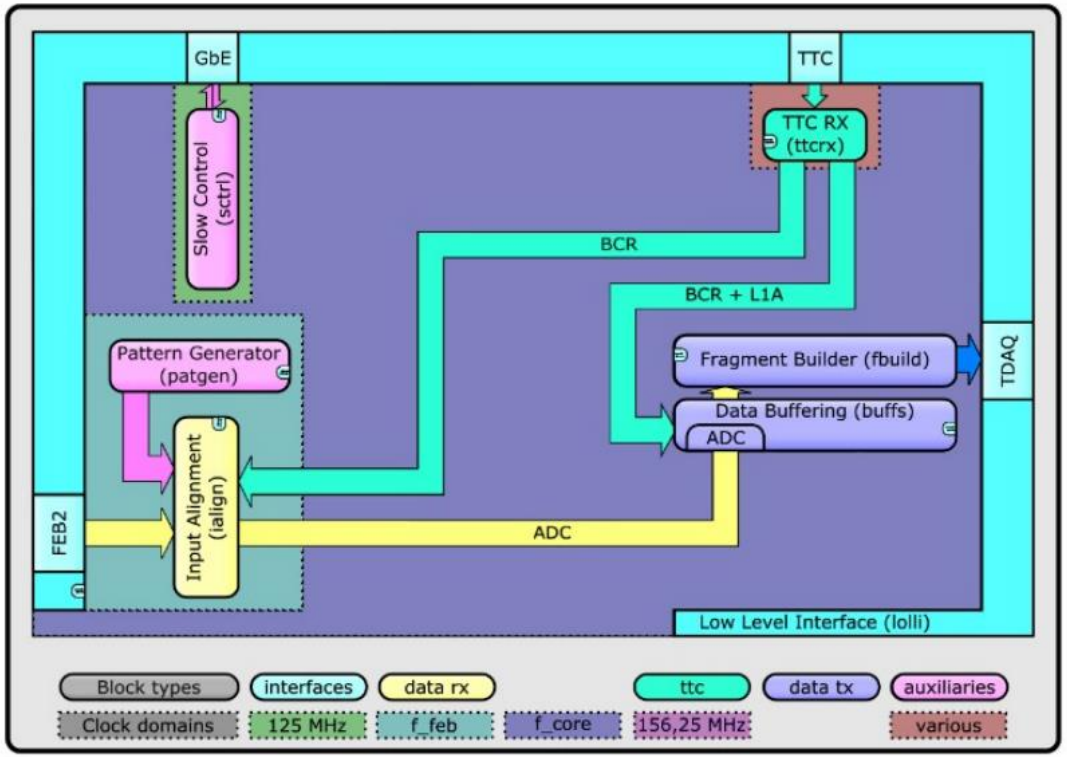
Phase-II Upgrade

- Circled in blue are the new hardware between Phase-I and Phase-II
- I'll go over FEB and LASP



LAr Signal Processor (LASP)

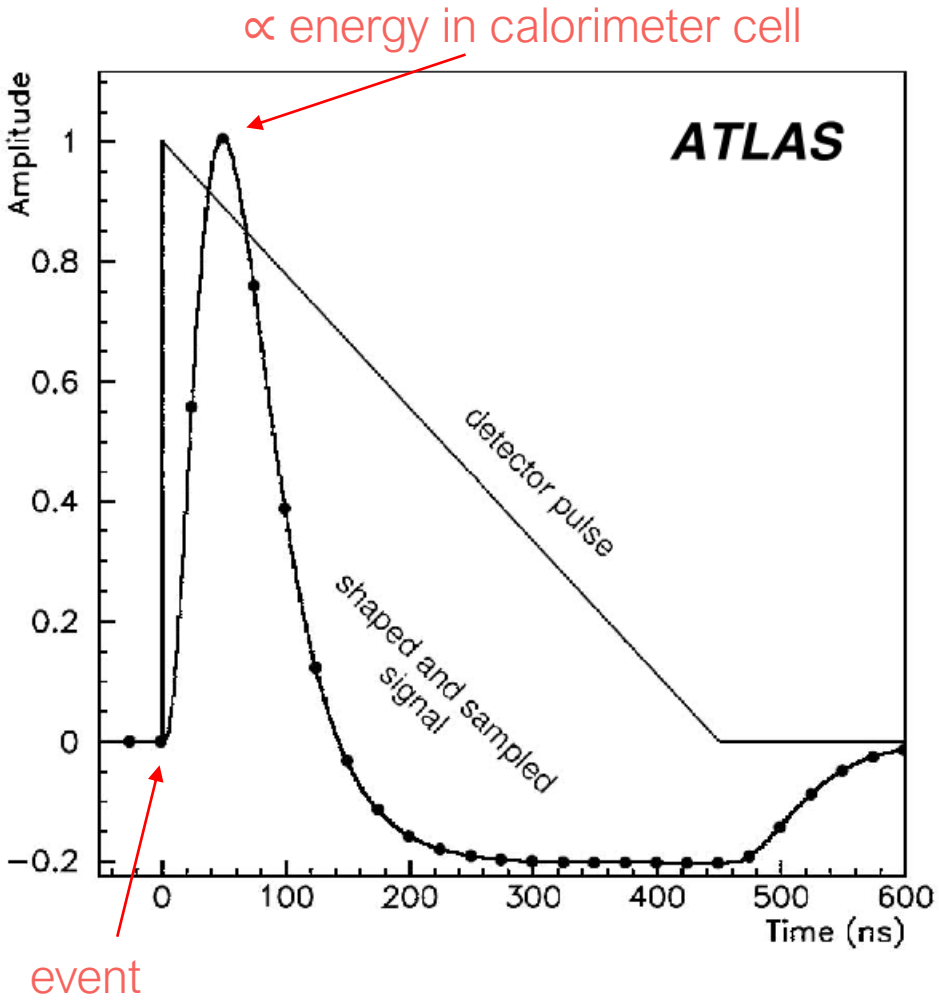
- Off-detector
- ialign aligns in time the data that comes from physical links
- fbuild formats the data
- Data for analysis is sent to readout system (TDAQ)



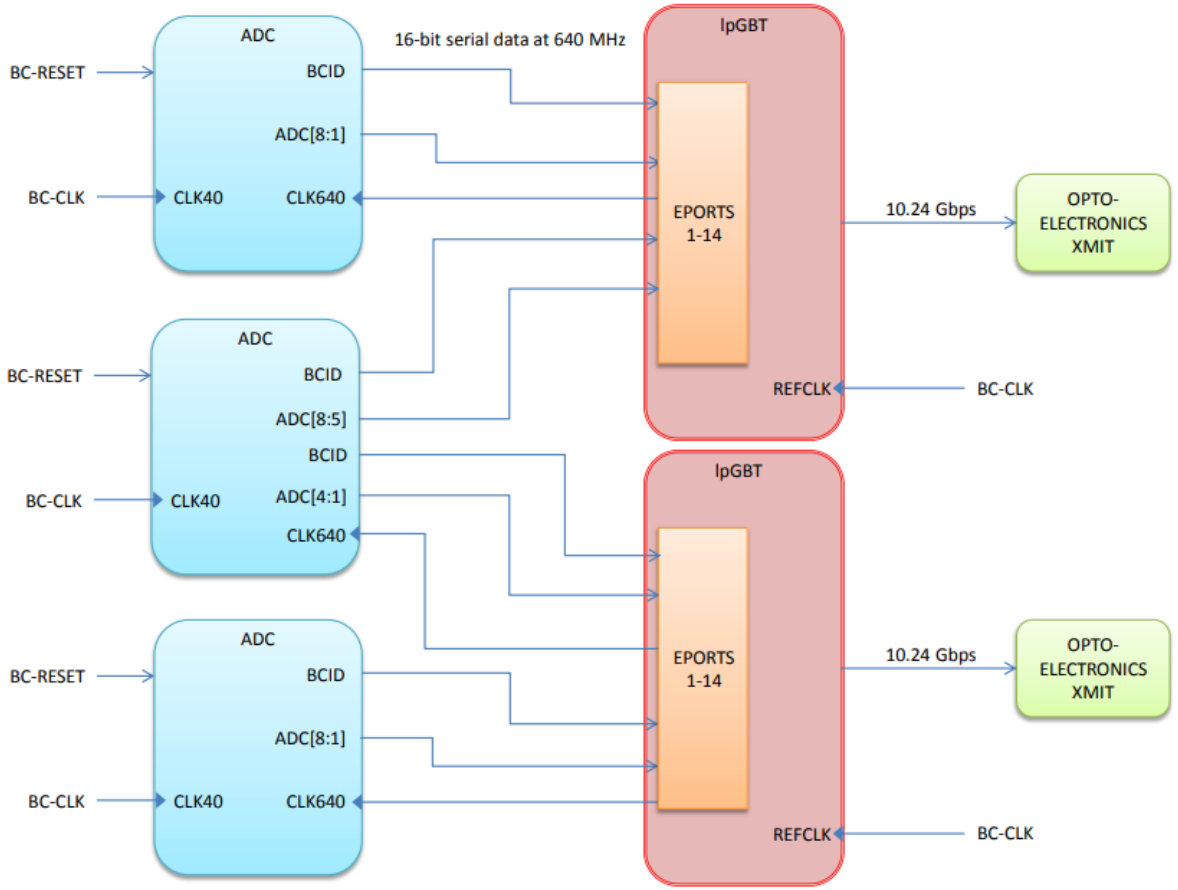
The Pulse

- Event happens at t=0
- We need a few bunch crossings to record the full pulse
- If another event happens before the end of the pulse, this is when we get pileup

One bunch crossing = 25ns



lpGBT


ADC
BC-RESET
BCID
ADC[8:1]
BC-CLK
CLK40
CLK640
16-bit serial data at 640 MHz
lpGBT
EPORTS
1-14
10.24 Gbps
OPTO-
ELECTRONICS
XMIT
REFCLK
BC-CLK
ADC
BC-RESET
BCID
ADC[8:5]
BCID
BC-CLK
CLK40
ADC[4:1]
CLK640
lpGBT
EPORTS
1-14
10.24 Gbps
OPTO-
ELECTRONICS
XMIT
REFCLK
BC-CLK
ADC
BC-RESET
BCID
ADC[8:1]
BC-CLK
CLK40
CLK640

ATLAS Liquid Argon Calorimeter

The electromagnetic calorimeter is part of the ATLAS detector. It handles detection and energy depositions of electrons and photons.
This calorimeter is a Liquid Argon calorimeter.