SuperFGD electronic

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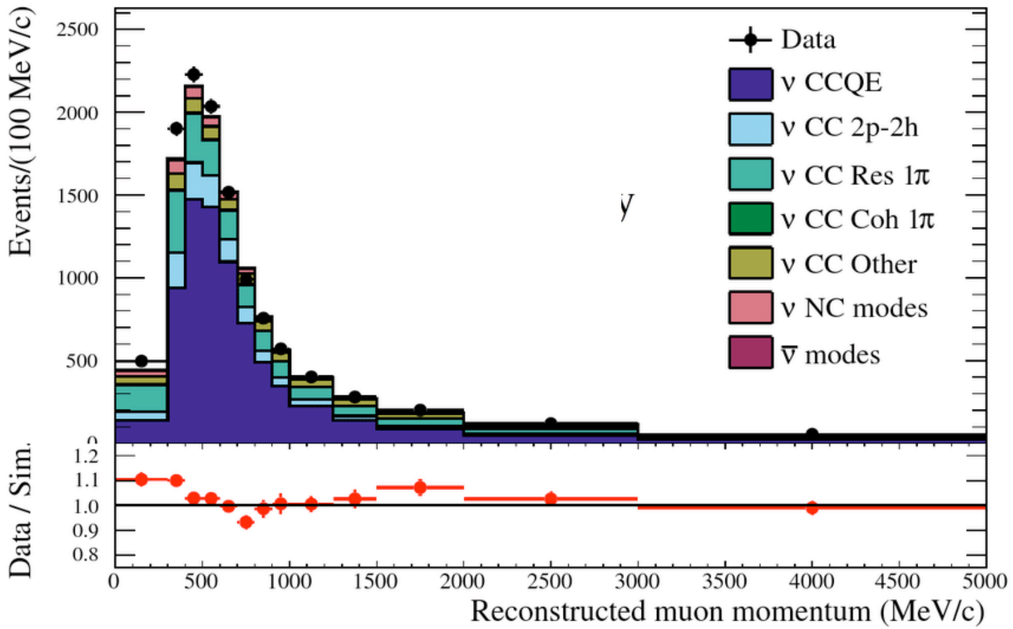
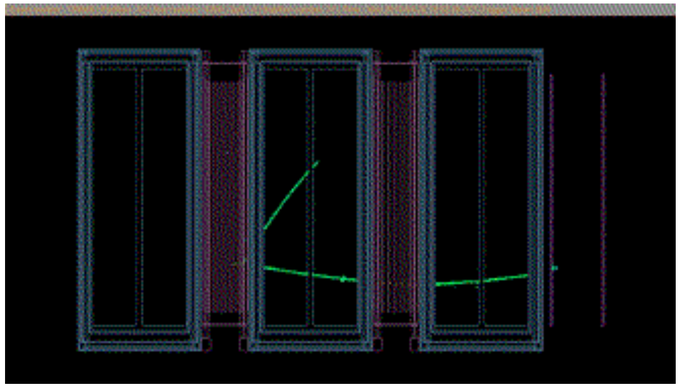
T2K EXPERIMENT: NEAR DETECTOR (ND280)

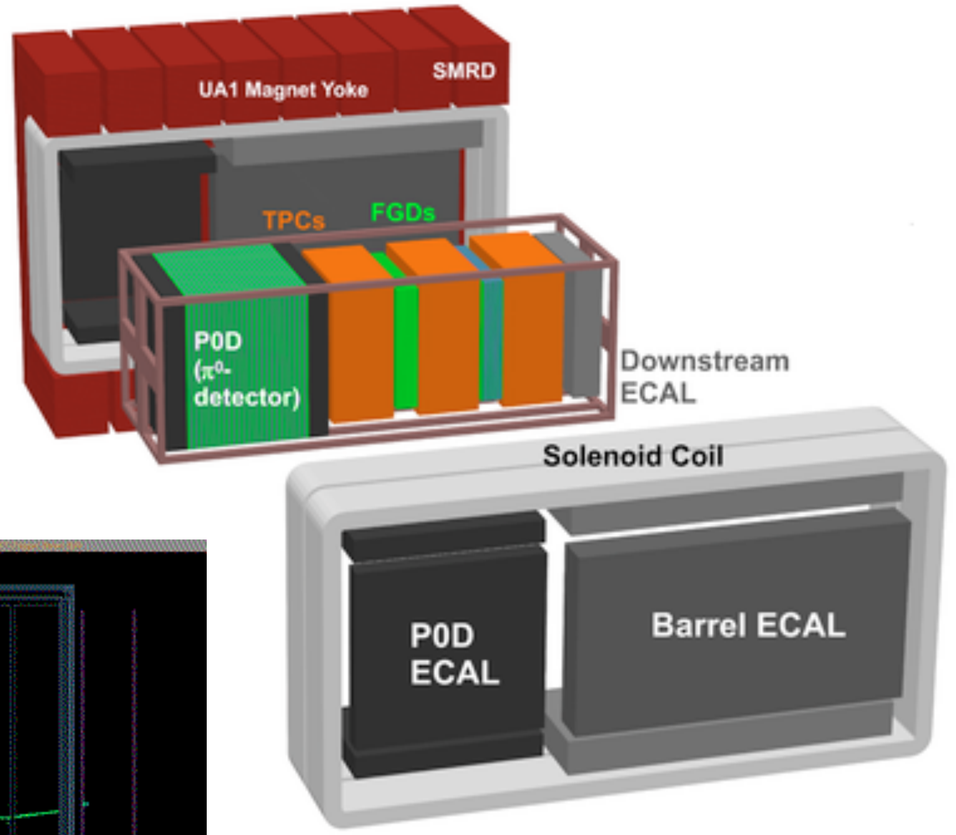
- Near detector ND280 is designed to constrain the neutrino flux⊗cross-section

- The tracker includes 2 Fine Grained Detectors (FGD) and 3 Time Projection Chambers (TPC)
  => measure the momentum of charged particles and particle identification.



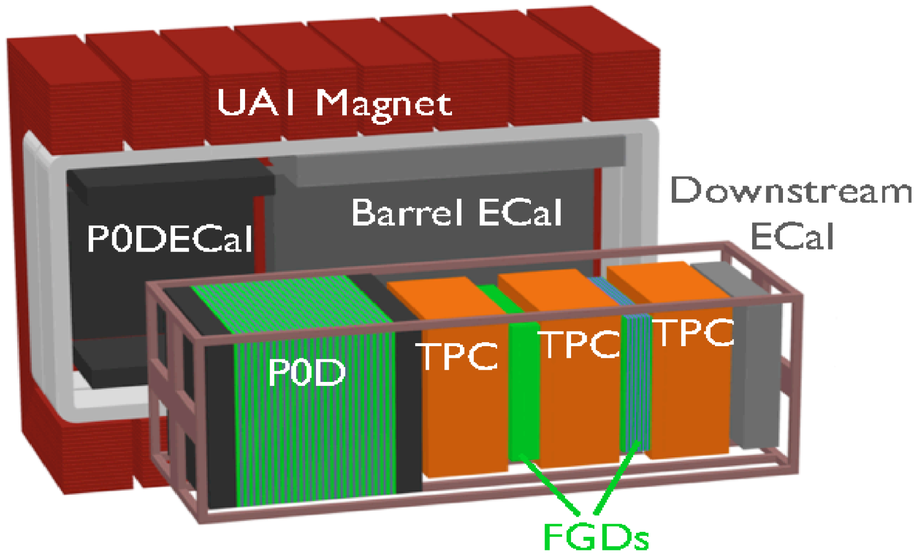


QE event at ND280

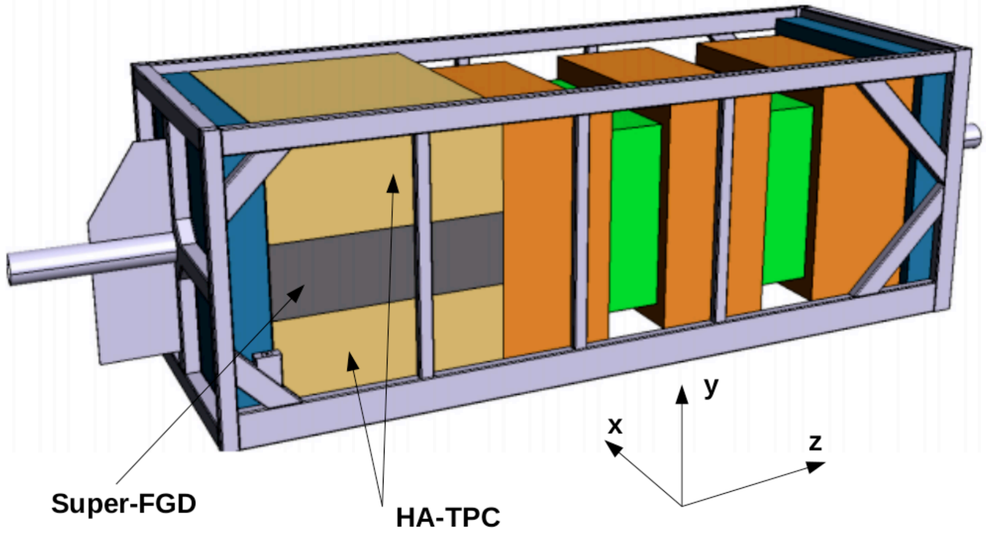


ND280 configuration

UPGRADED NEAR DETECTOR ND280: CONFIGURATION

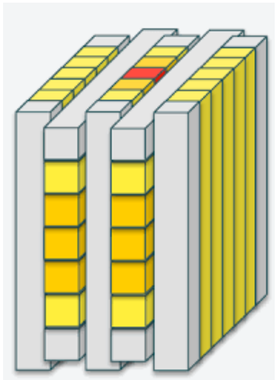


Upgrade

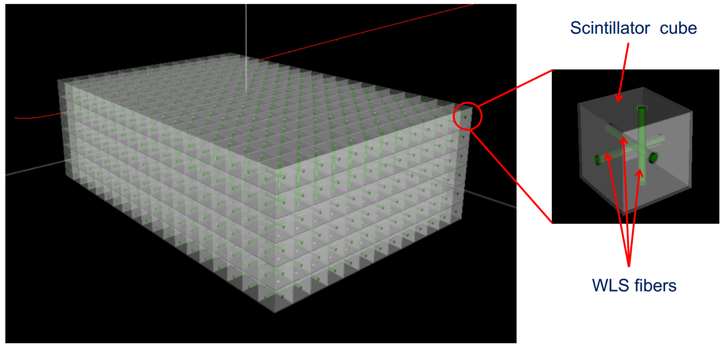


- Super-FGD: 2 million 1 cm^3 scintillator cubes with 3D readout => 2 tons of fully active target

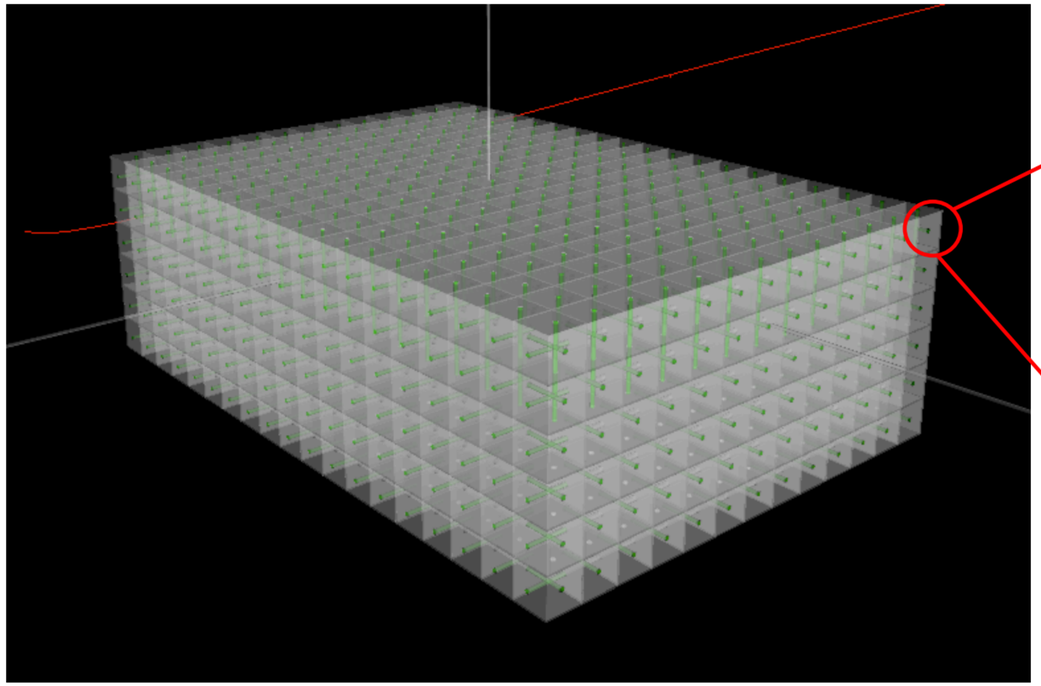
Current FGD

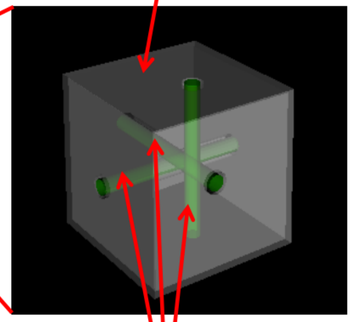


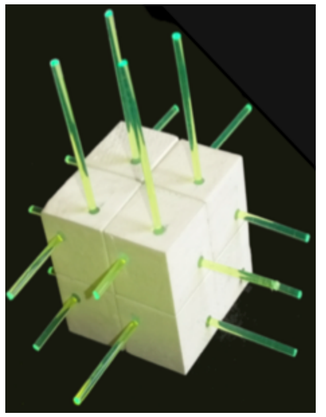
Upgraded Super-FGD

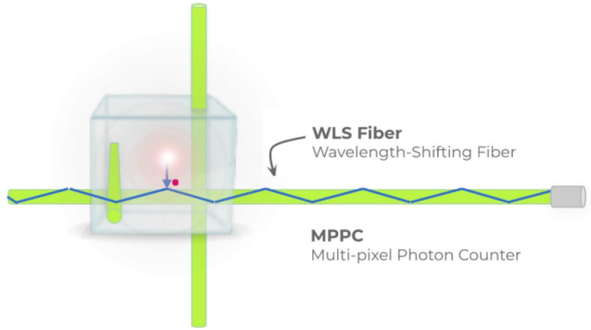


SUPER FGD DETECTOR







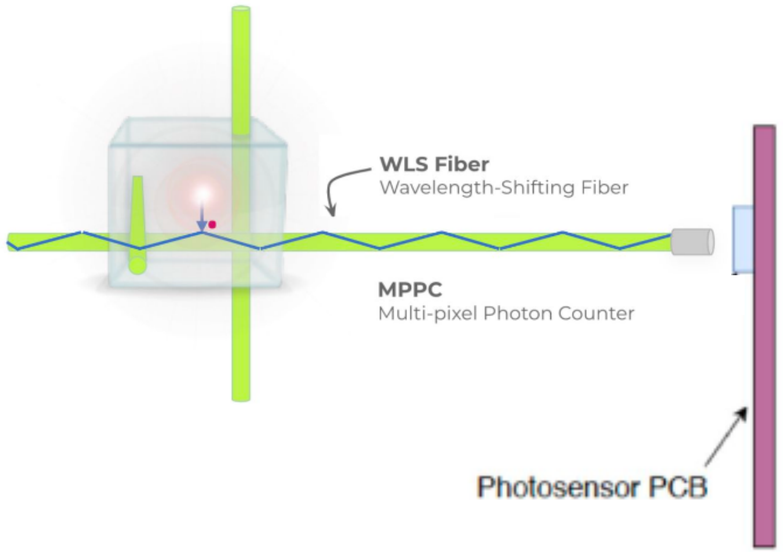


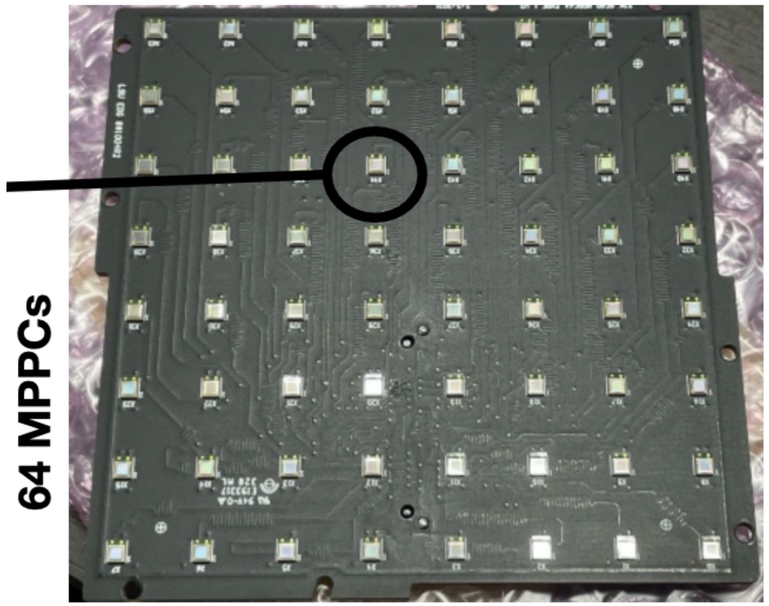
- Super-FGD: 192 × 192 × 56 scintillator cubes cubes (2 million) with 3D readout => 2 tons of fully active target

- Wavelength shifting (WLS) fibers are used to collect light from scintillator cubes. (70 km of WLS fiber in total)

- One end of them is connected with Multi-Pixel Photon Counter (MPPC) the other end is mirrored.
  => 58,368 channels.

SUPER FGD DETECTOR READOUT

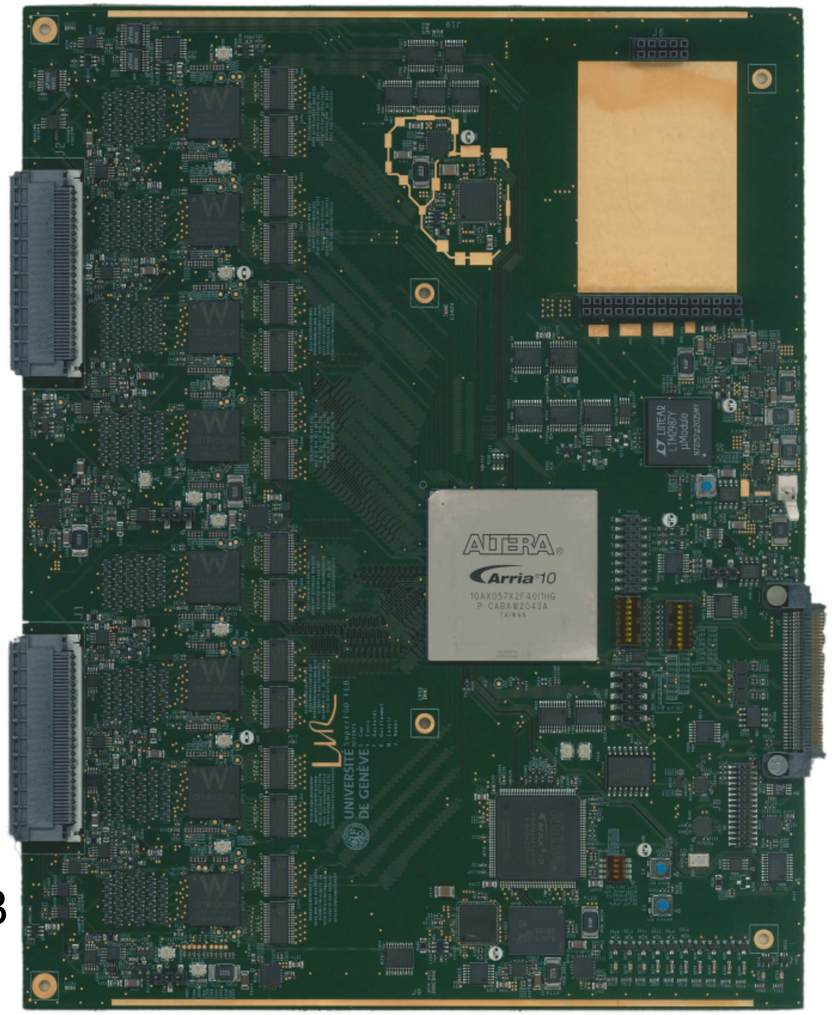




64 channels

X4 MPPC => 1 FEB

Front-End Board (FEB)

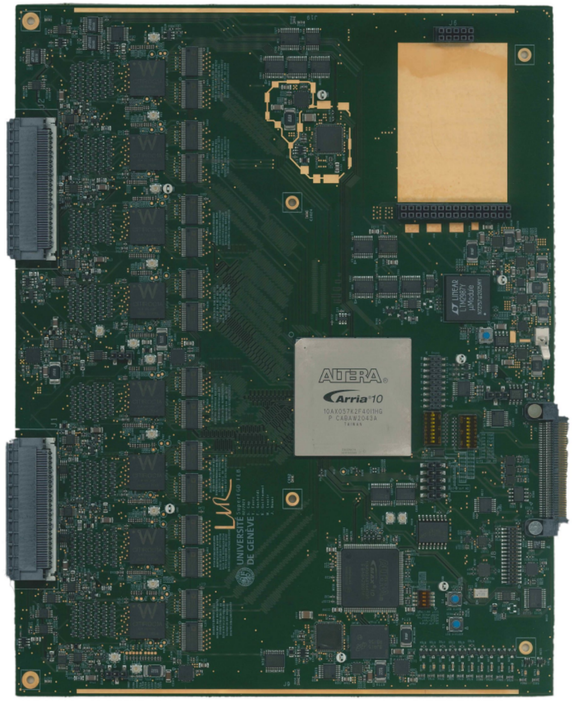


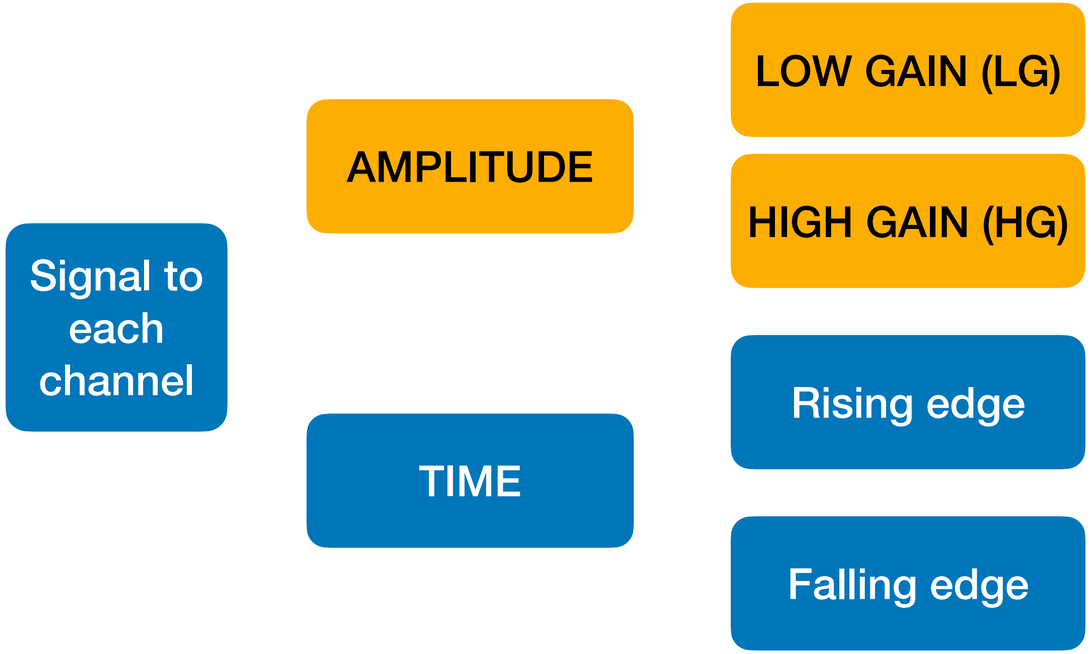
256 channels

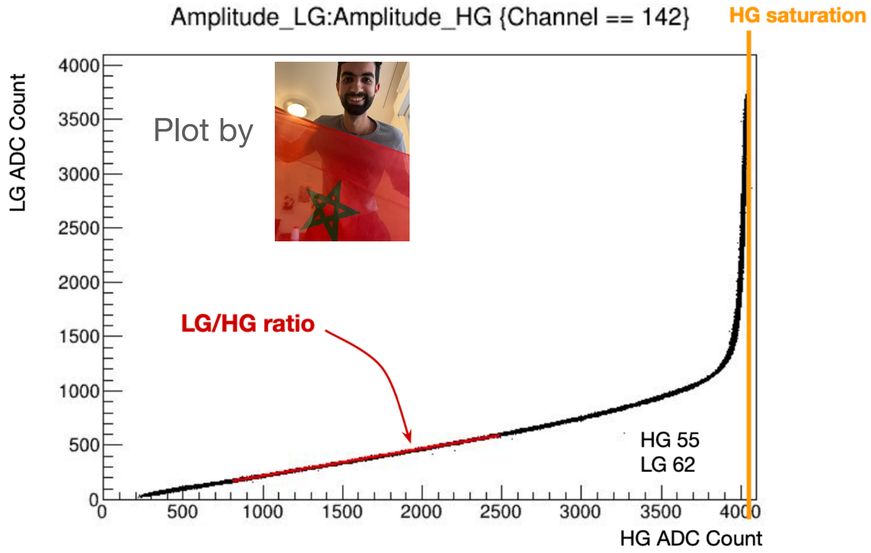
FRONT-END BOARD (FEB)

- The FEB is the heart of the electronic system.
- The baseline design is structured around the CITIROC (Cherenkov Imaging Telescope Integrated Read Out Chip) readout chip. CITIROC
- Each CITIROC can read 32 channels => 256 channels for 1 FEB.
- For each channel, the input is handled by two independent signal paths:
  - Low gain (LG) path
  - High gain (HG) path

Front-End Board (FEB) 256 channels



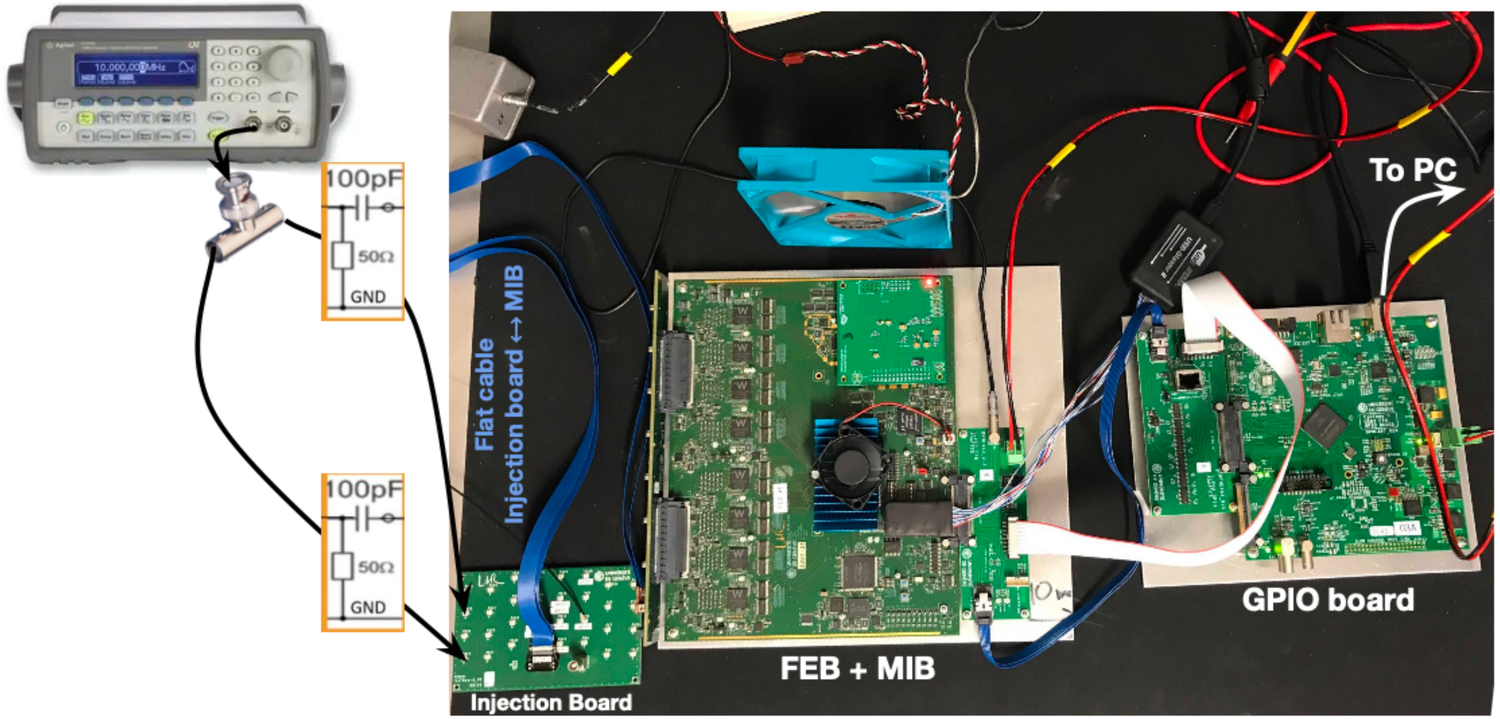




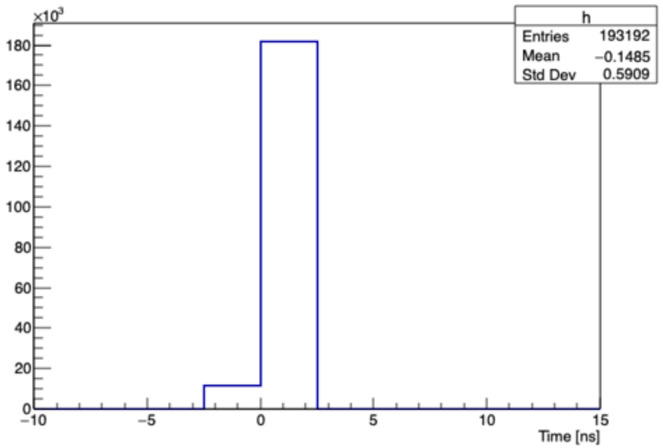
TIMING MEASUREMENT FOR FEB

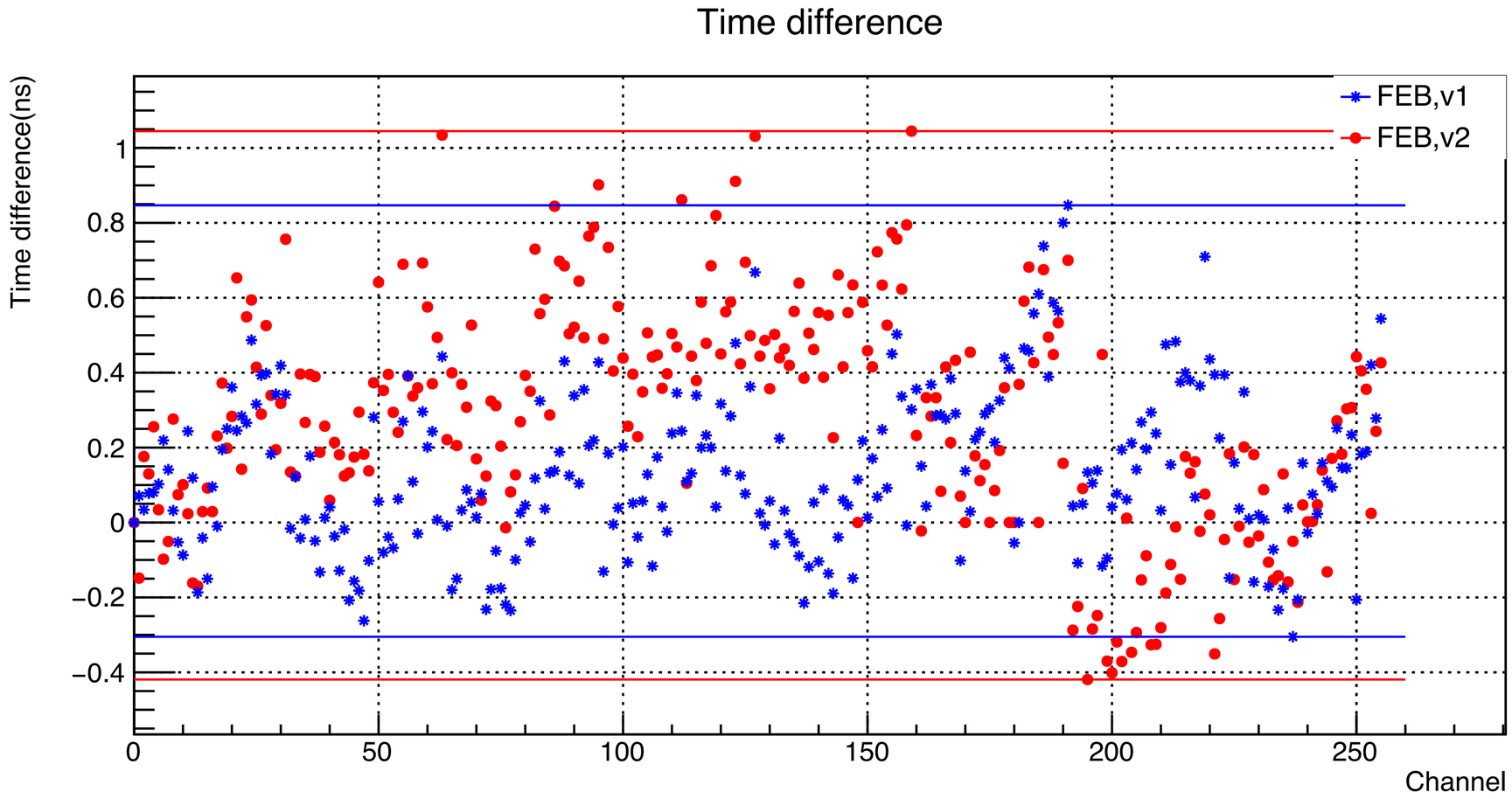
- The idea of this test is originally from Jaafar.
- GPIO: auxiliary board that allow us to use the FEB without a complete set up.
- The goal of this test is to see the time difference while reading the same signal between channels

Setup



TIMING MEASUREMENT RESULT

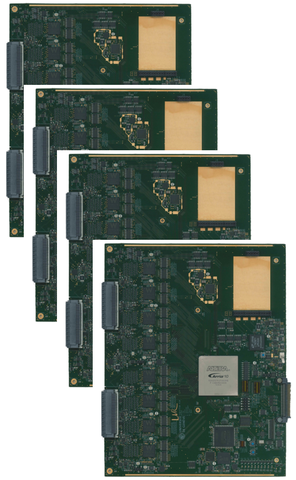


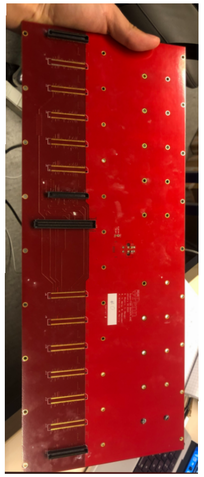


- The results from FEBv2 have larger range => to be checked again with different FEB
- All the analysis codes are inherited from Jaafar. Thanks a lot Jaaf ^.^

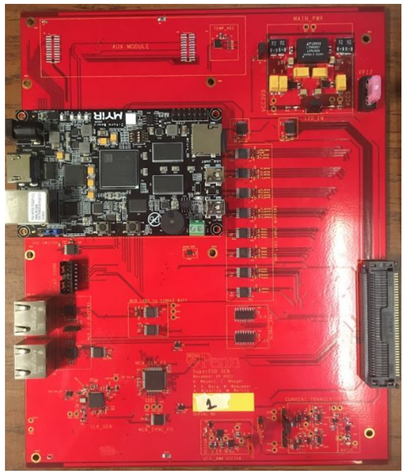
THE VERTICAL SLIDE TEST (VST)

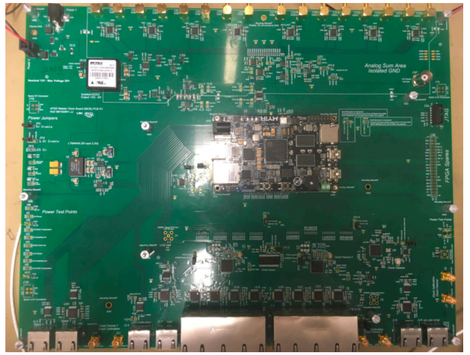
THE VERTICAL SLIDE TEST (VST) SET UP

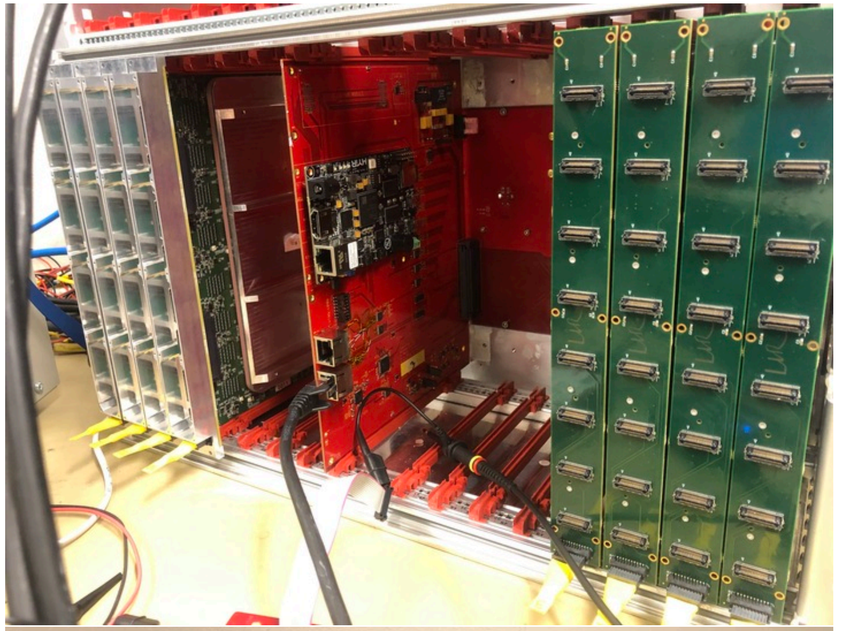


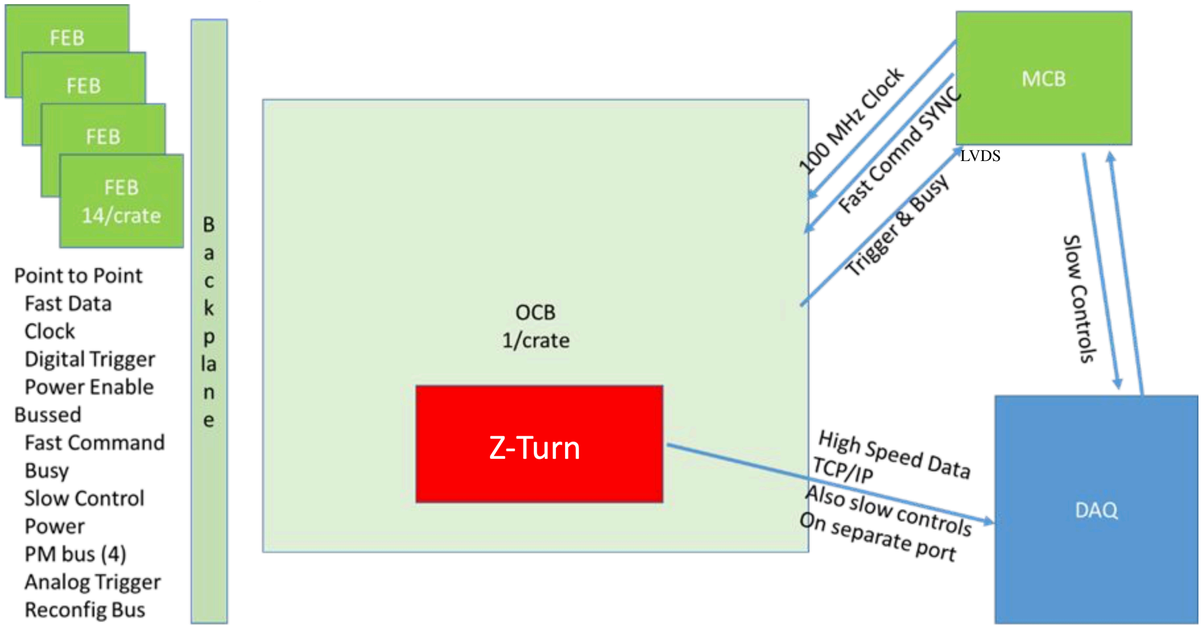


The whip

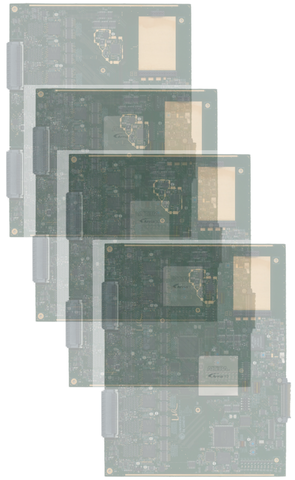




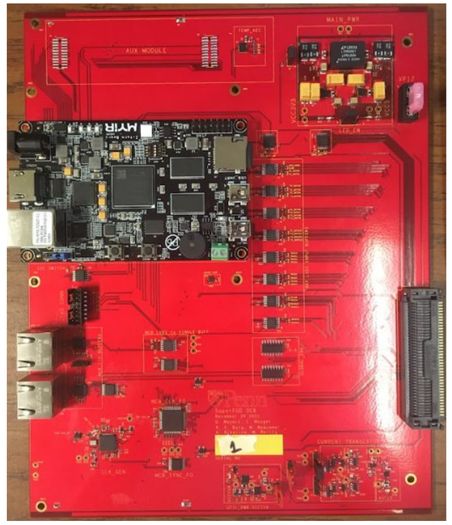


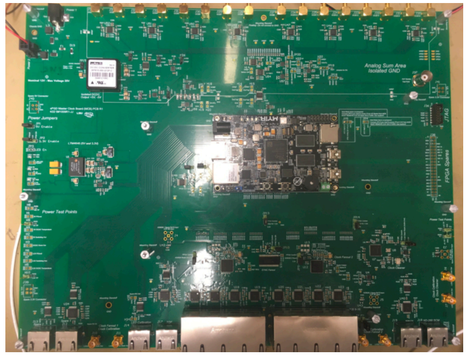


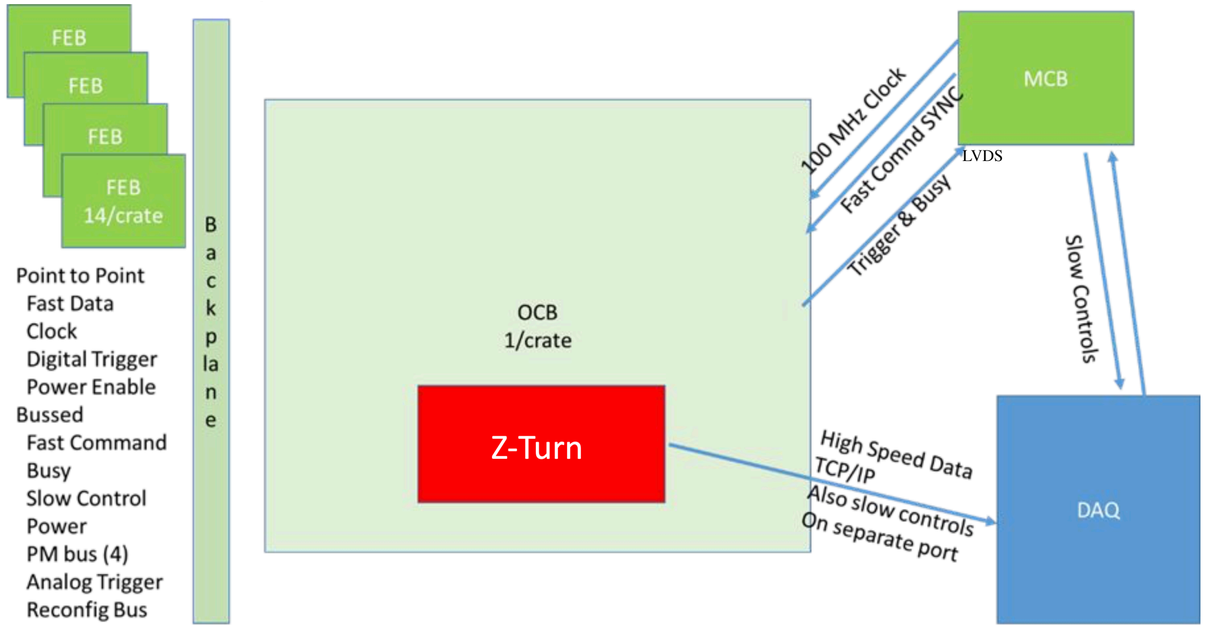
OPTICAL CONCENTRATOR BOARD (OCB)



The whip

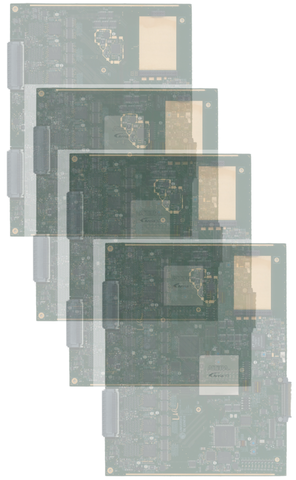


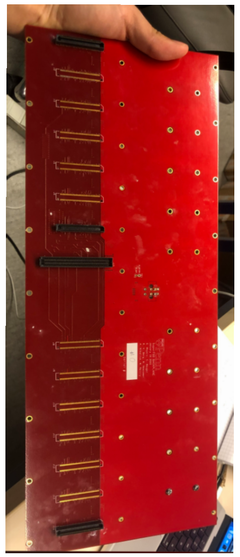


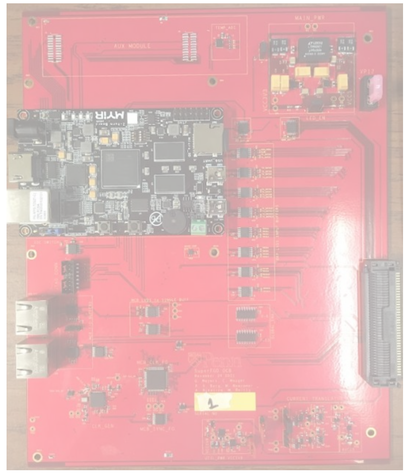


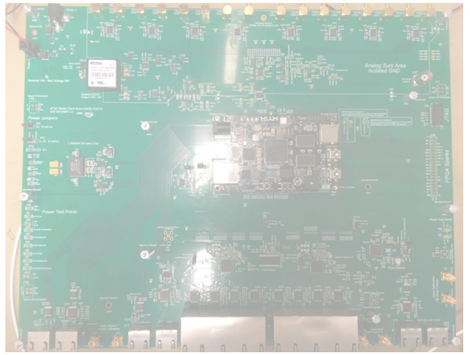
- The primary function of the Optical Concentrator Board (OCB) in the sFGD electronics system is to move and organise digital data and commands.
- The DAQ and slow control systems are connected to 14 FEBs in a sFGD crate via the OCB.
- Moreover, OCB functions as a link between the MCB and the 14 FEBs.

BACKPLANE

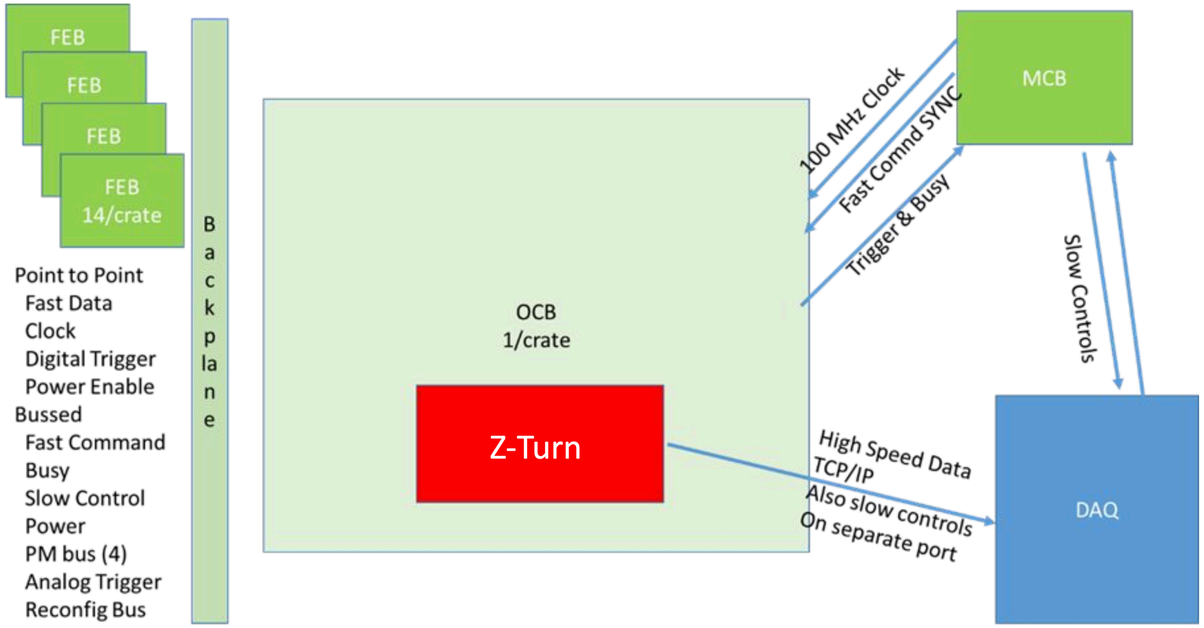




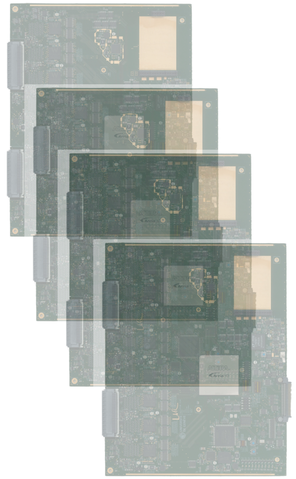


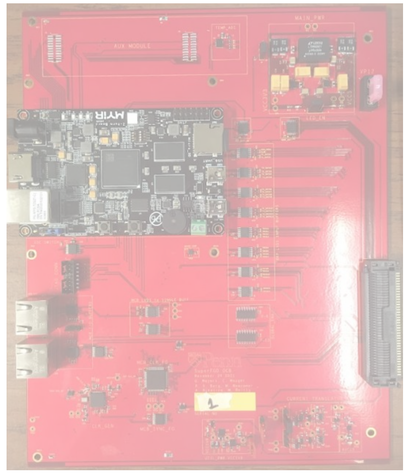


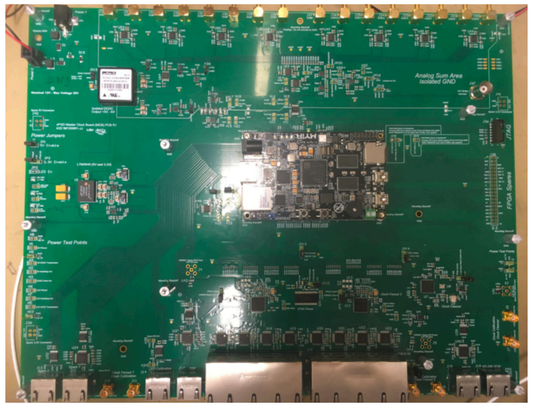
- Point-to-point and multi-drop signals that transit via the backplane make up the FEB - OCB communication.



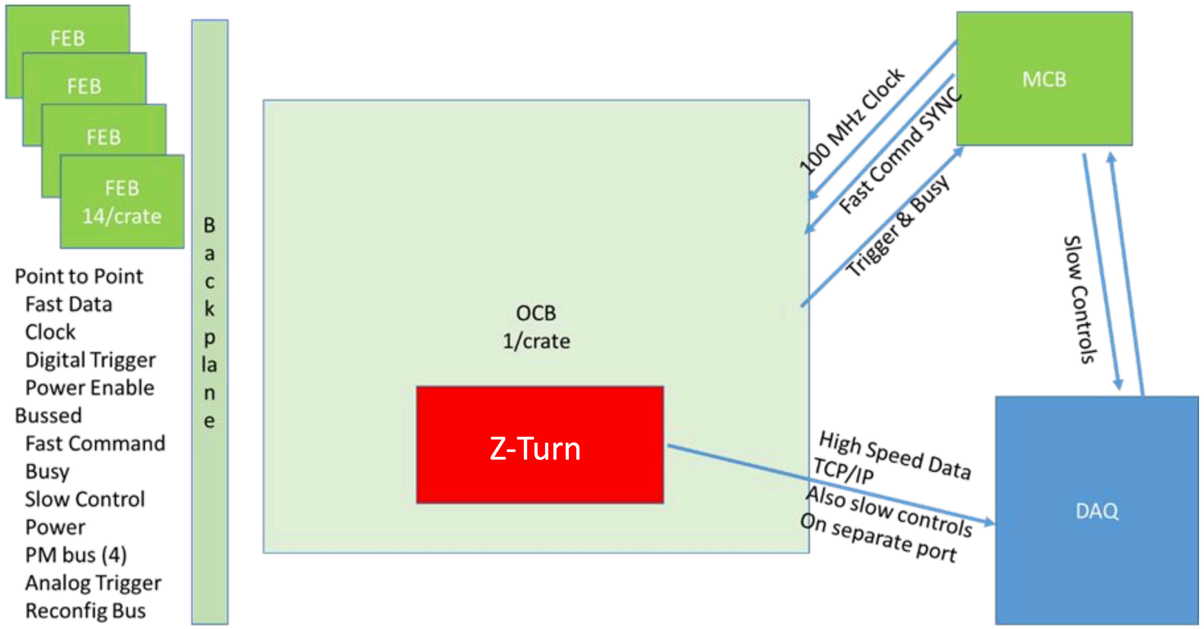
MASTER CLOCK BOARD (MCB)







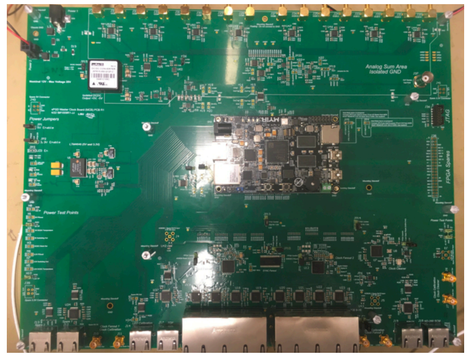
- MCB is used to send digital signals such as the clock, SYNC (GTS, gate, event number), trigger to OCB.



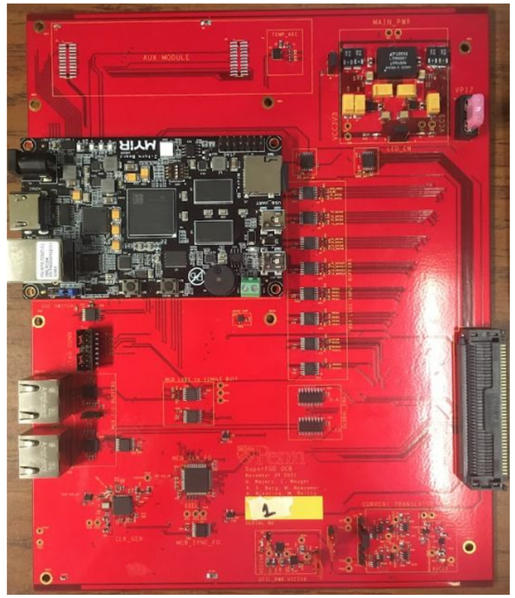
- Example of gate closing when OCB receives a trigger

SUMMARY OF RELATIONSHIP BETWEEN BOARDS

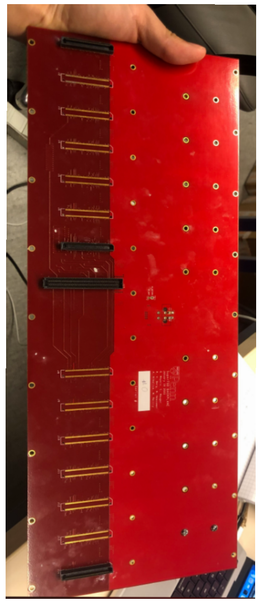
- In document: the FEB is the heart of the electronic system.
- In reality:



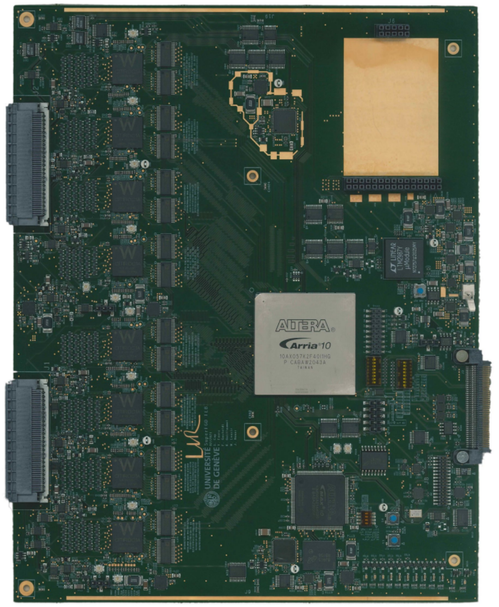
MCB: the OCB advisor



OCB: the master



Backplane: the whip



FEBs: the slaves

SUMMARY OF THE RESULTS FROM VST

- Full crate: installation with 14FEBs
- Full crate slow control test
- Full crate data readout test without signal injection
- Test all the communication lines between OCB and 14FEBs
- Housekeeping test for all FEBs

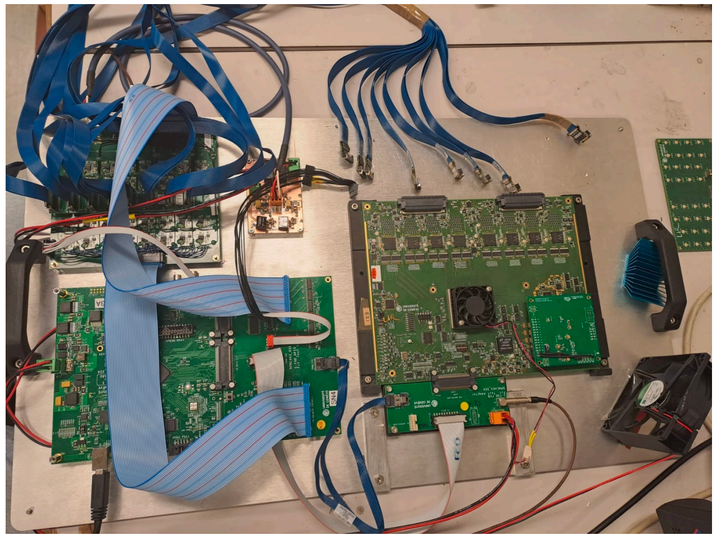
- All these tests are documented and the OCB software to test is easy to use

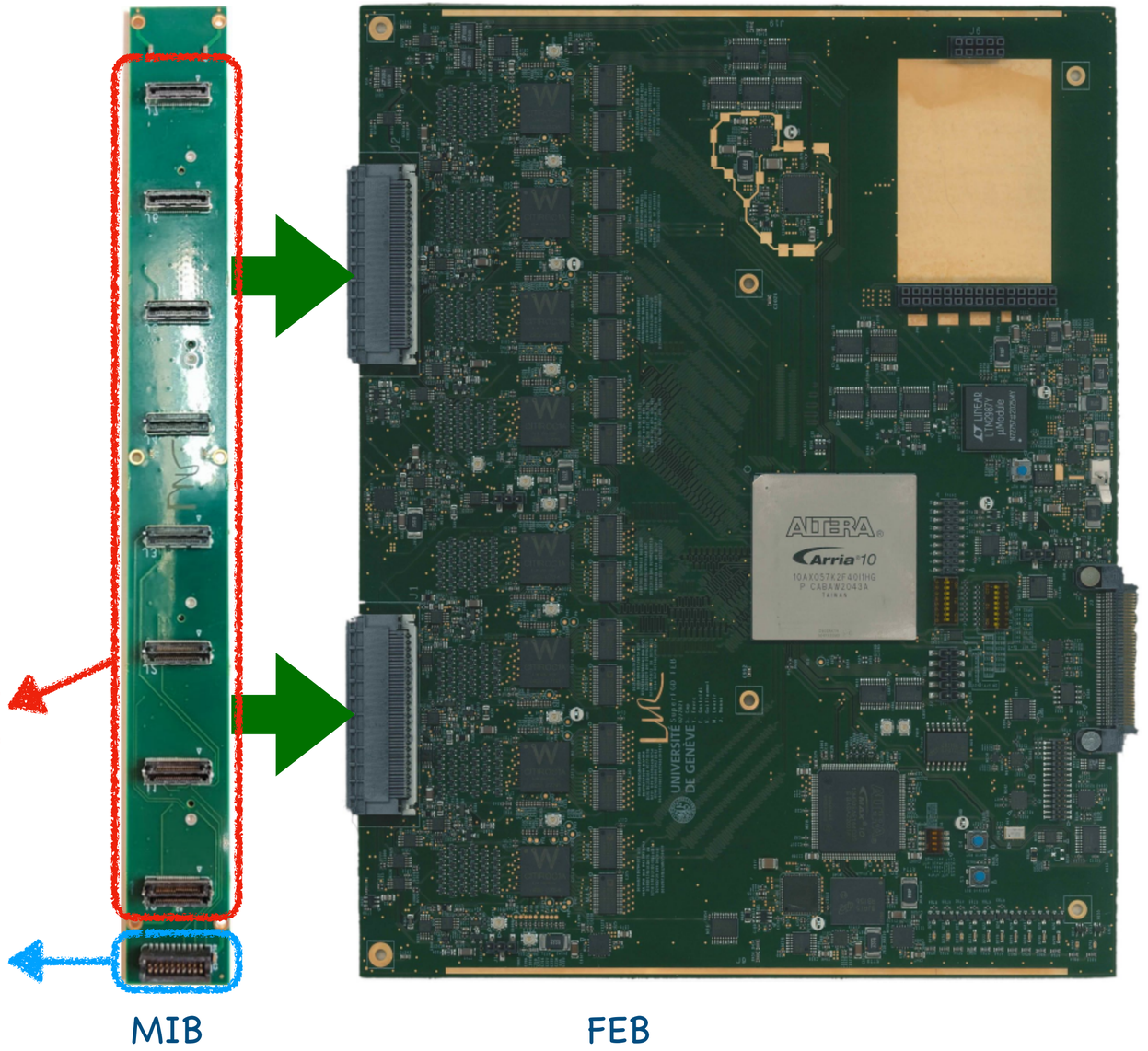
After these results, the green light for FEB v2 assembly was sent more than 1 month ago.
=> Around 230 FEBs to be tested soon  

Thank Andres and Lena in advance <3

MIB FUNCTIONAL TEST

- The MIB is used to connect the cables from MPPC board to FEB.
- The MIB test (early March at Geneva) is to test the function of all the lines that pass through the MIB
- The test includes:
  - Housekeeping test: High Voltage, temperature
  - Debug line test.
  - Analog channels test.





MIB FUNCTIONAL TEST : RESULT

- Total MIB in this serie: 224 (-16 to be sent; -2 at LLR)

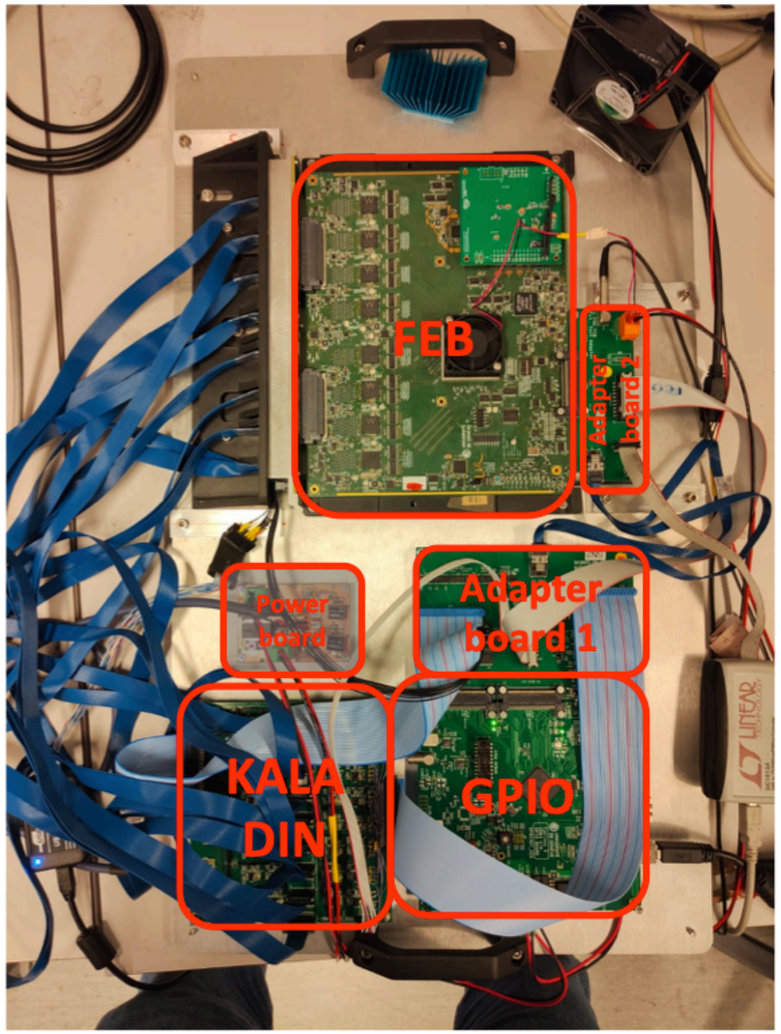
- Status of the mass test
  - Failed : 8 (preliminary result by LLR people)
    - 5 checked manually by Uni Geneva and finally OK
    - 3 failed board confirmed (short LSHM (x2), connection broken (x1))
  - All the 8 were sent back to check

- Total qualified MIB
  - Pre-serie: 15 (12 failed) => 3 qualified. High failure rate is under investigation ("aging connection", overused during vertical slide test)
  - Around 220 MIBs are ready to be sent.

LSHM connection from the back of MIB

NEXT FUNCTIONAL TEST FOR FEB

- GPIO: auxiliary board that allow us to use the FEB without a backplane. It has ADCs that provide a reference for calibration
- Kaladin (SOKENDAI): demultiplexer board that allows injecting signal in each channel individually with a single input signal. Controlled by the GPIO
- FEB: Device under test. This set up can easily remove and install a FEB.
- Functional test includes:
  - Housekeeping and loopback
    - Test all the backplane lines: SYNC, trigger, busy
    - Test debug connector lines
    - Housekeeping (HK) values (currents, temperature, voltage)
  - Calibration
    - Produce calibration parameters to be passed to DAQ
  - All 256 channel test
    - Short test of each channel
    - Check ADC distribution in each channel
    - Citiroc triggers, baseline, noise.



SUMMARY

- Need to do the timing measurement again for FEB v2
- Around 220 MIB are ready to be sent.
- First batch of FEB will arrive at GENEVA soon (1 week)
- Functional test set up and vertical slide test set up are ready at Geneva.
- This test will be more painful than previous one since the FEB has many more function than MIB.

  But we are ready

BU

MCB CLOCK DELAY TEST

Delay (ns)	OCB (UT5)	FEB 0	FEB 1	FEB 2	FEB 3	FEB 4	FEB 5	FEB 6	FEB 7	FEB 8	FEB 9	FEB 10	FEB 11	FEB 12	FEB 13
0	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
0.5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
1.5	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y
2	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	Y
2.5	Y	Y	Y	Y	N	N	N	N	N	N	N	N	Y	Y	Y
3	Y	Y	N	N	N	N	N	N	N	N	N	Y	N	Y	Y
3.5	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N
4	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N
4.5	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N
5	Y	N	N	N	N	N	N	Y	Y	N	N	Y	N	N	N
5.5	Y	N	N	N	N	N	Y	Y	N	Y	N	Y	N	N	N
6	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N
6.5	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N
7	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
7.5	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y
8	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y
8.5	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
9	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
9.5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y