# The Phase-I Trigger Readout Electronics Upgrade of the ATLAS Liquid Argon Calorimeters

## INSTR20 2020

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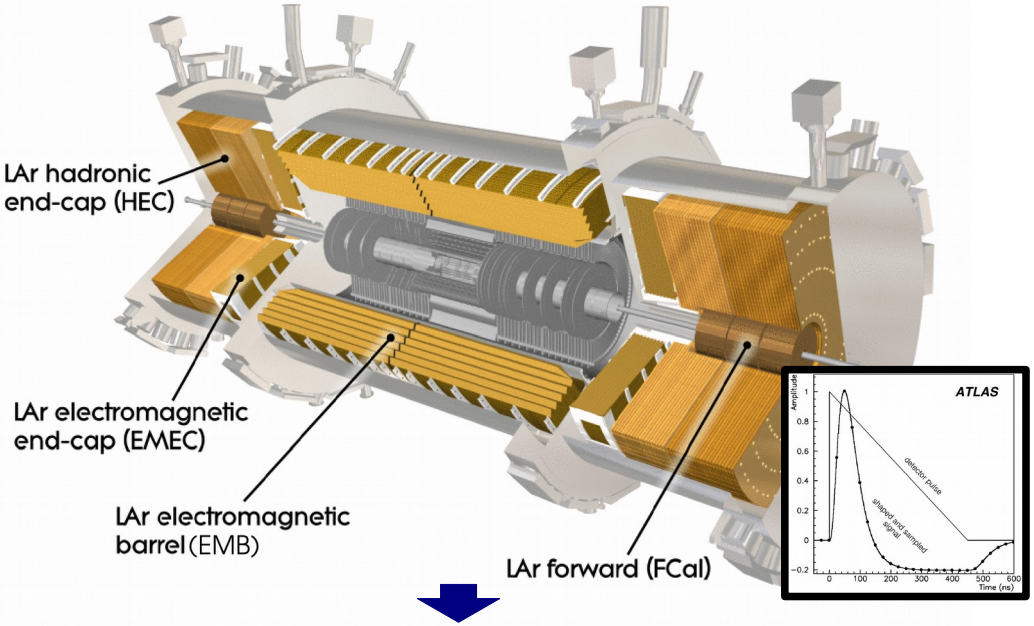
**On behalf of the ATLAS Liquid Argon calorimeters group**

# Liquid Argon Calorimeter (LAr)

**Pb(Cu,W)/LAr sampling calorimeter**

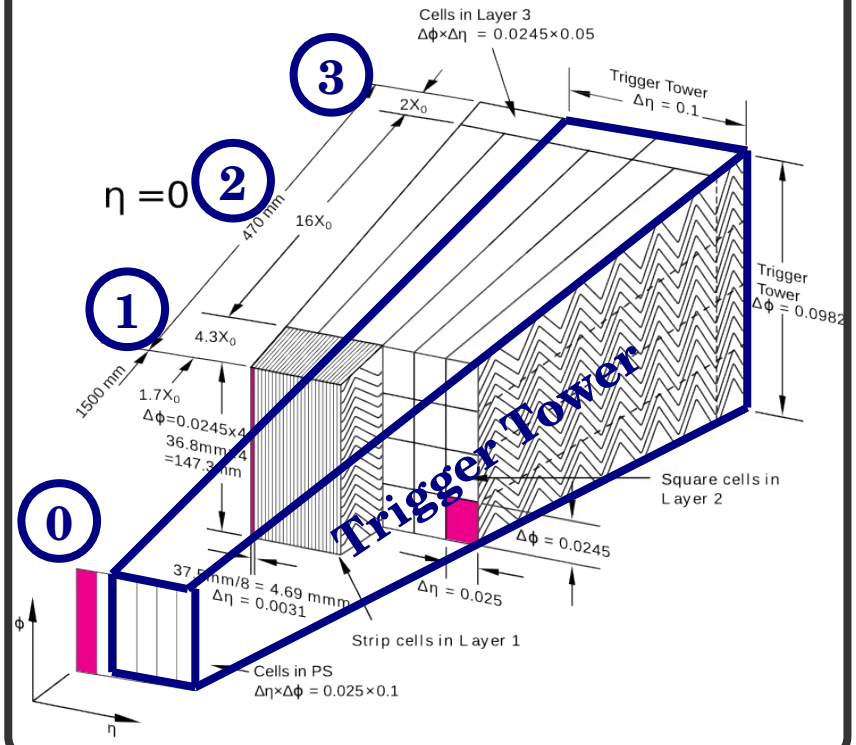
- ~180k cells → only for main readout (100 kHz max)



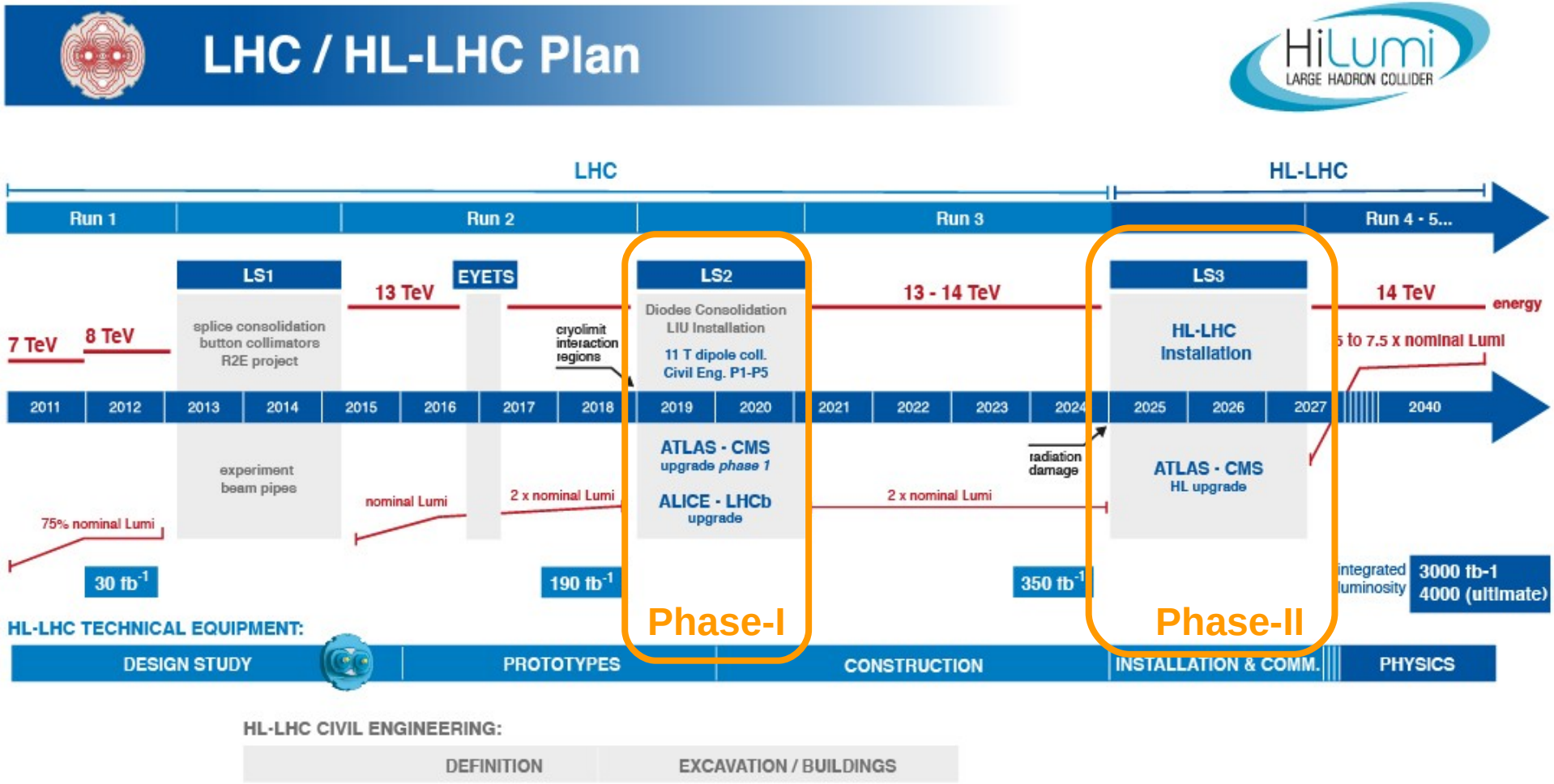

**γ, e±, jets, MET from ionisation pulse**

**Run 1 & 2 : Trigger Tower (TT) (6k)**

- Cell clusters in (η,φ) for trigger



# LHC-HL



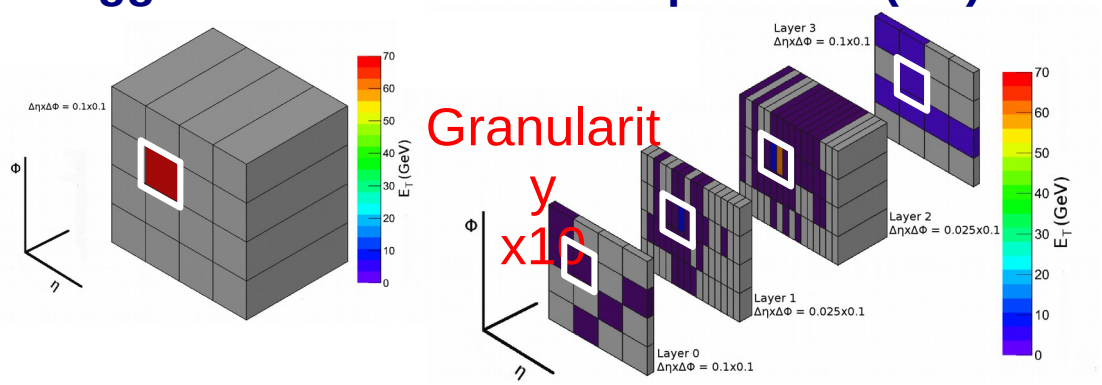

- LAr Upgrade Phase-I (Now) : trigger readout upgrade
- LAr Phase-II (2025-2027) : main readout upgrade

# LAr Phase-1 Upgrade

**LHC Run-3 :**

- - L1 trigger bandwidth stays at 100 kHz (~20kHz for $e^{\pm}$)
- - Avoid raise of $p_T$ thresholds → **improve background rejection → Upgrade trigger readout**

**Trigger Tower** → **Super Cells (SC)**



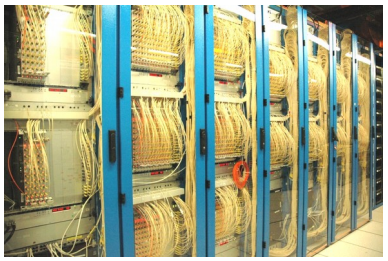

70 GeV electron simulation

- **10-fold increase in granularity**
  longitudinal +
  lateral segmentation
- **Better digitization precision**

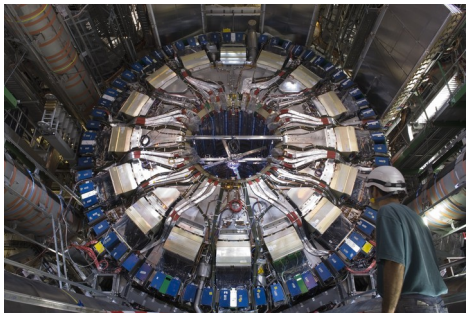
# LAr Readout Electronics

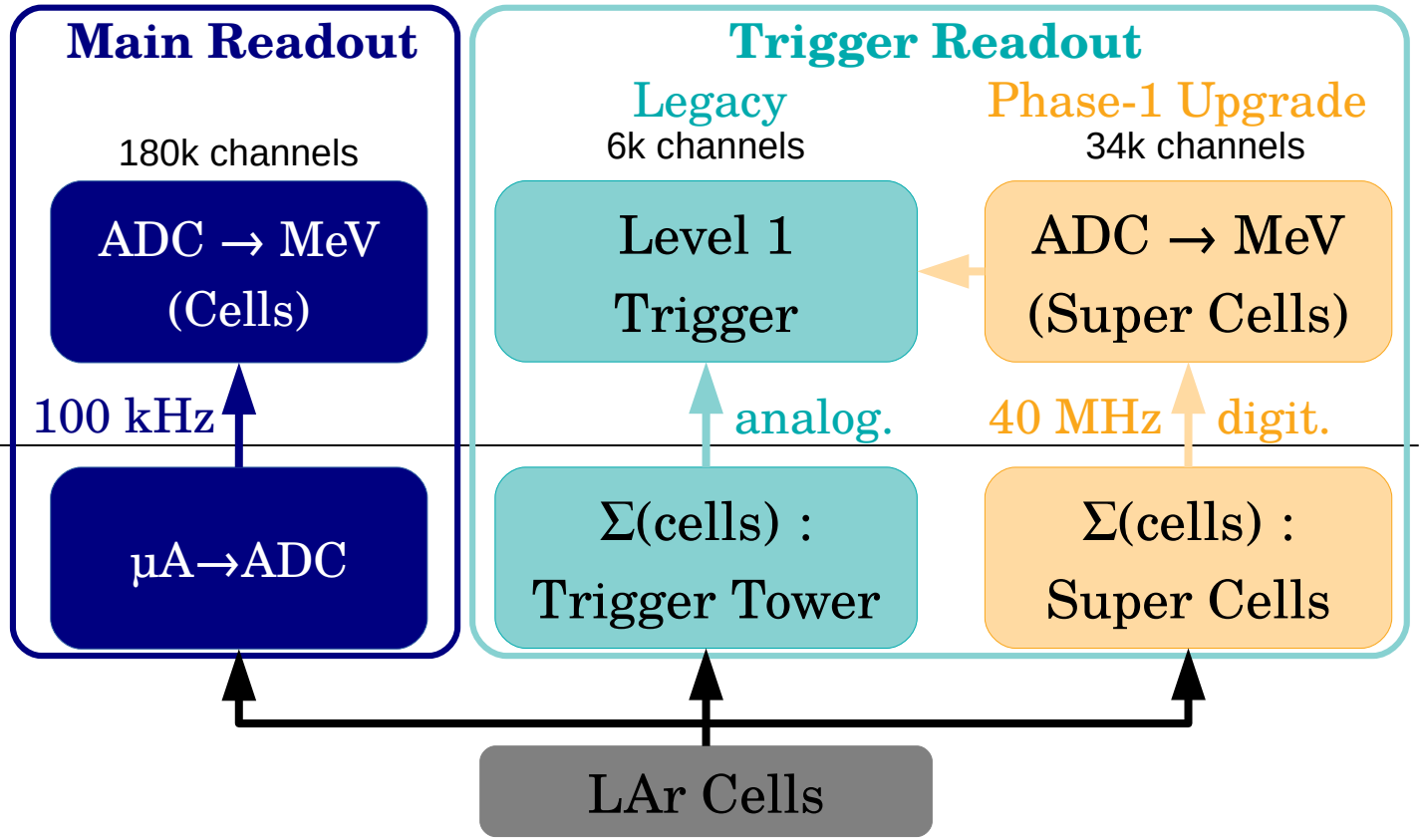
**Back-End**

(Counting room)



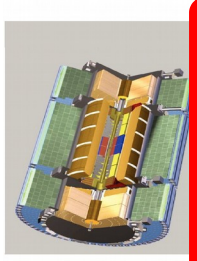
**Front-End** (On detector)



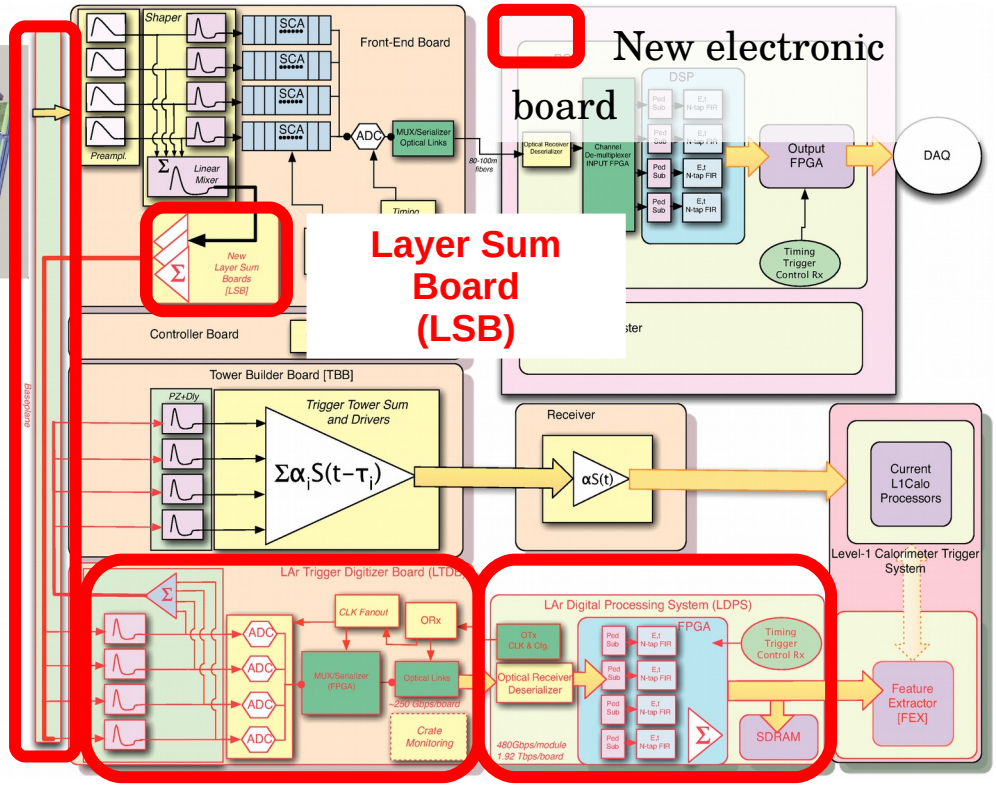


# New Electronics : Front End

- **Layer Sum Board**
  - Higher Granularity
- **Baseplane**
  - #channels x 10
- **LTDB**
  - Digitizes Super Cell Signals at 40 MHz, 12b precision
  - Send ADC to LDPS
  - 320 Channels per board
  - Send old layer sums to legacy trigger system (backup)



Baseplane

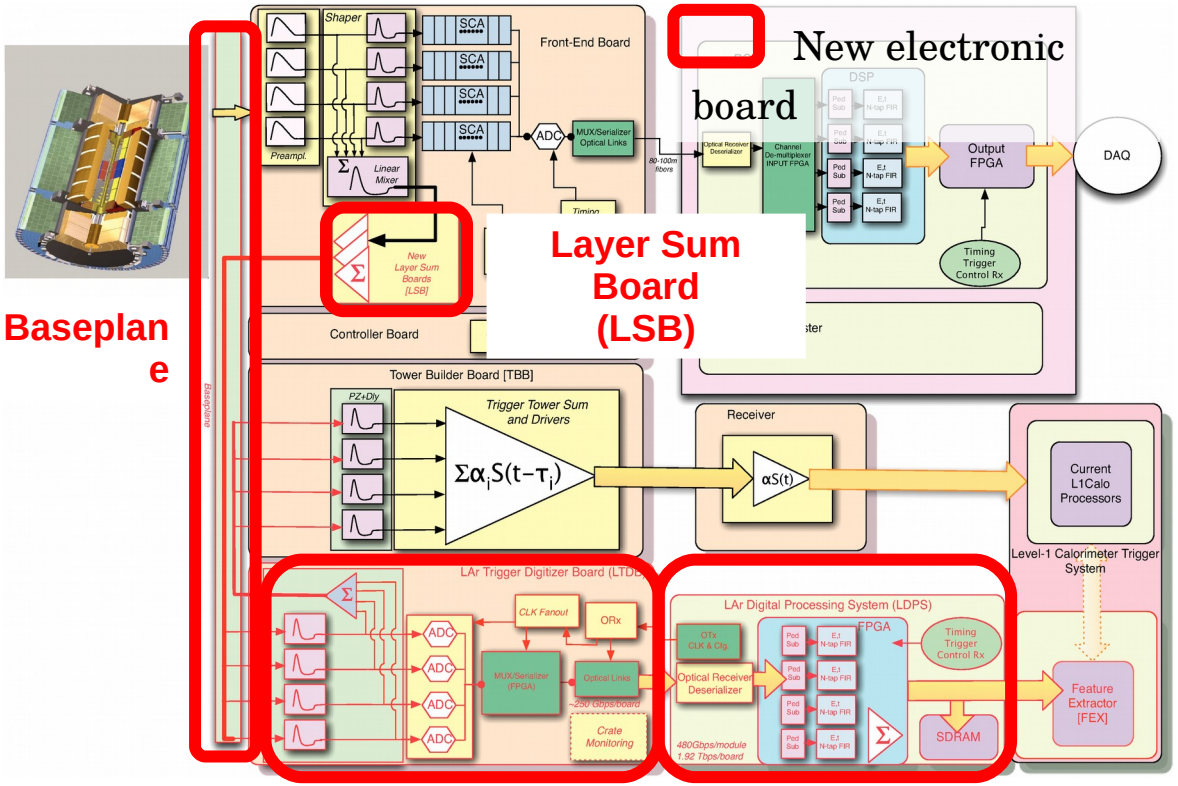



LAr Trigger Digitizer Board (LTDB)

LAr Digital Processing System (LDPS)

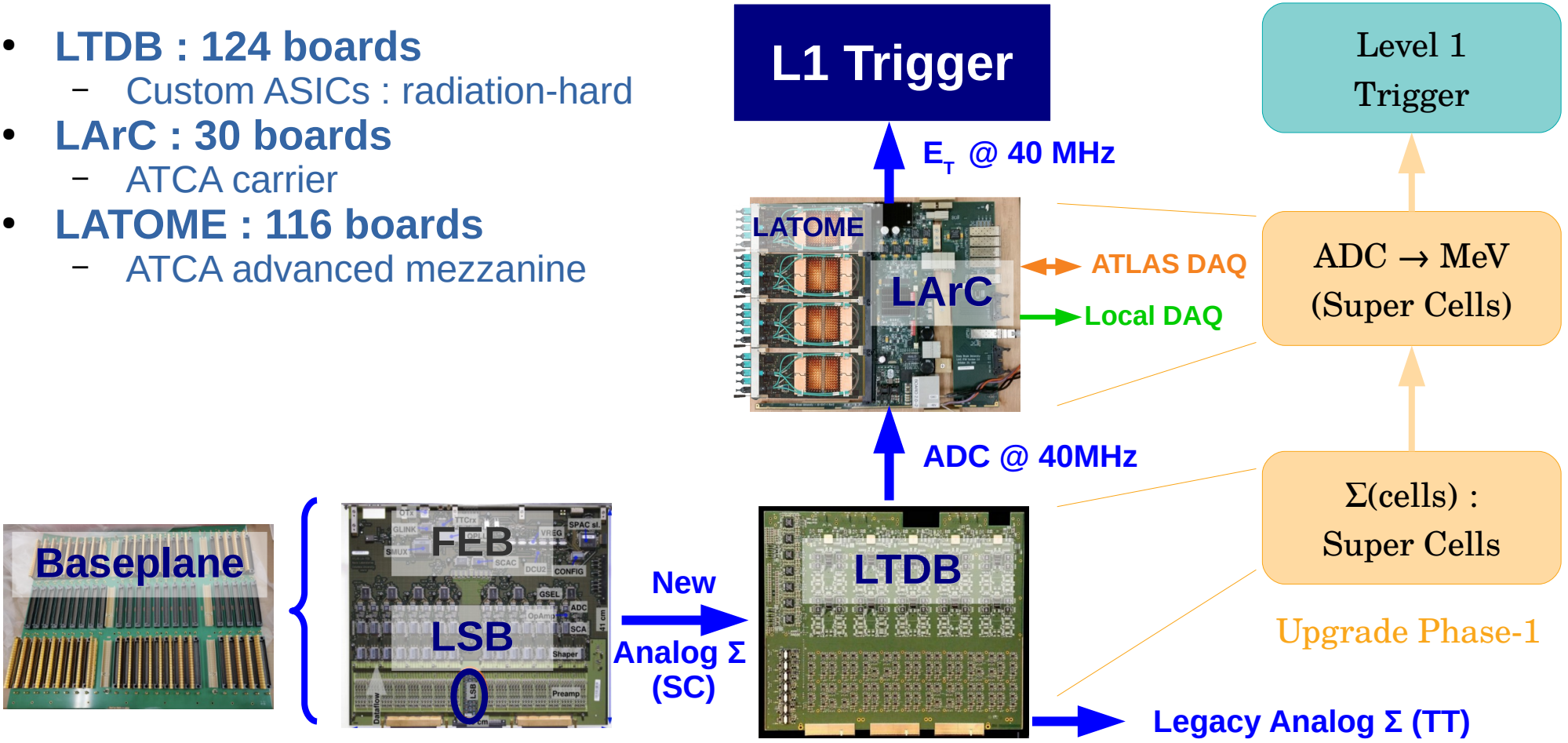
# New Electronics : Back End

- **LDPS**
  - Read Super Cell ADC @ 40 MHz
  - Compute Super Cell $E_T$
  - Identify Bunch Crossing ID of the Super Cell signal
  - Send data to L1 Trigger (41 Tbps) + Monitoring
  - Main board : Lar Digital Processing Blade LDPB=LArC (ATCA Carrier) + 4 LATOME( Advanced Mezzanine Card)
- **System with fixed latency**
  - Smaller than 1.625 µs



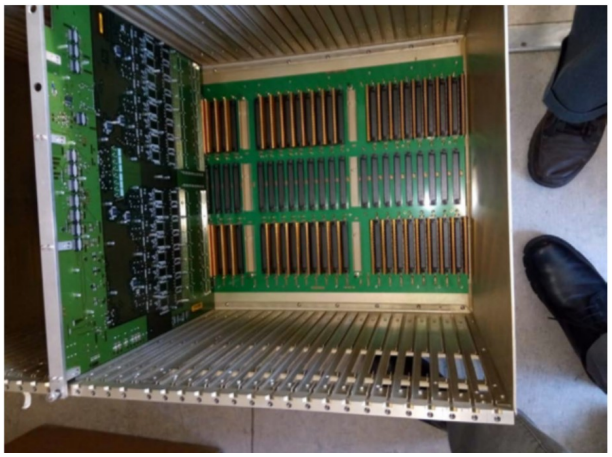
# New LAr Electronics

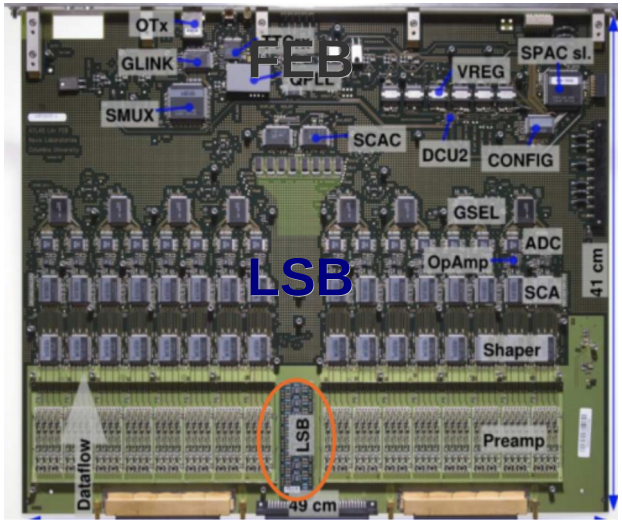
- **LTDB : 124 boards**
  - Custom ASICs : radiation-hard
- **LArC : 30 boards**
  - ATCA carrier
- **LATOME : 116 boards**
  - ATCA advanced mezzanine

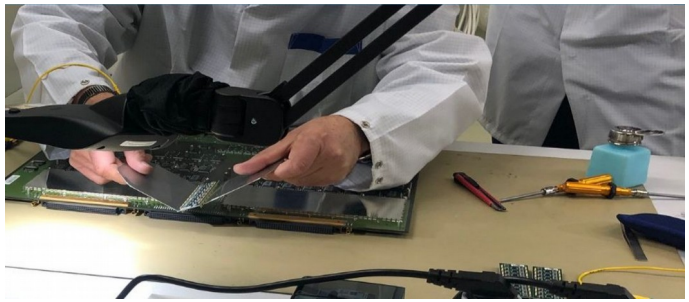


# Baseplanes & Layer Sum Boards

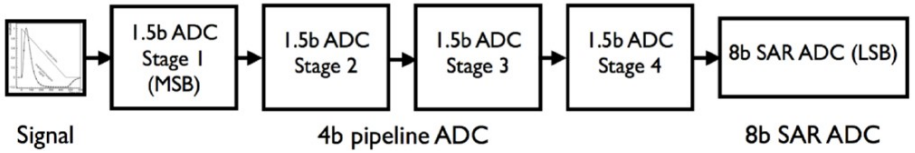
- Baseplanes : 6 different topologies (Barrel, End-Cap …)
  - Nominal production done (spares production ongoing)
  - 93 out of 114 installed (~80%)
- Layer Sum boards (LSB)
  - Production completed (2456), delivered to CERN
  - FrontEnd Boards of Barrel A/C and EMEC A re-installed , EMEC C installation just beginned

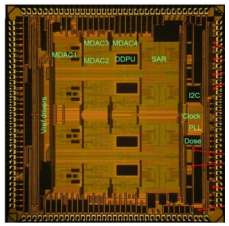


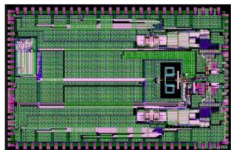


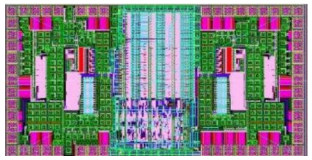



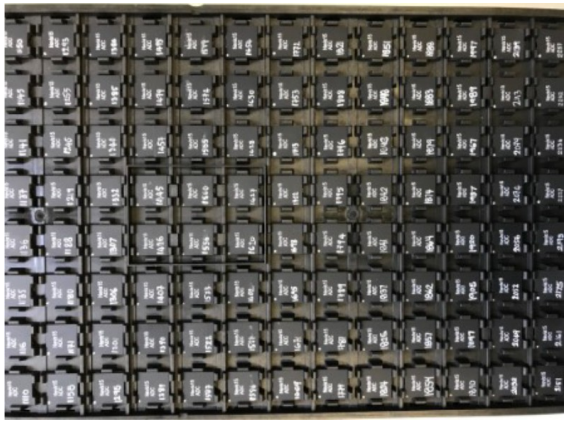
# Custom ASICs



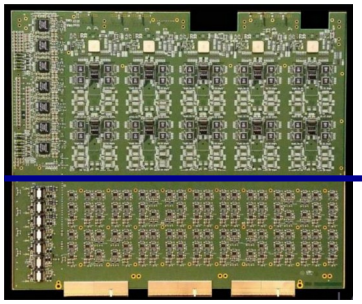






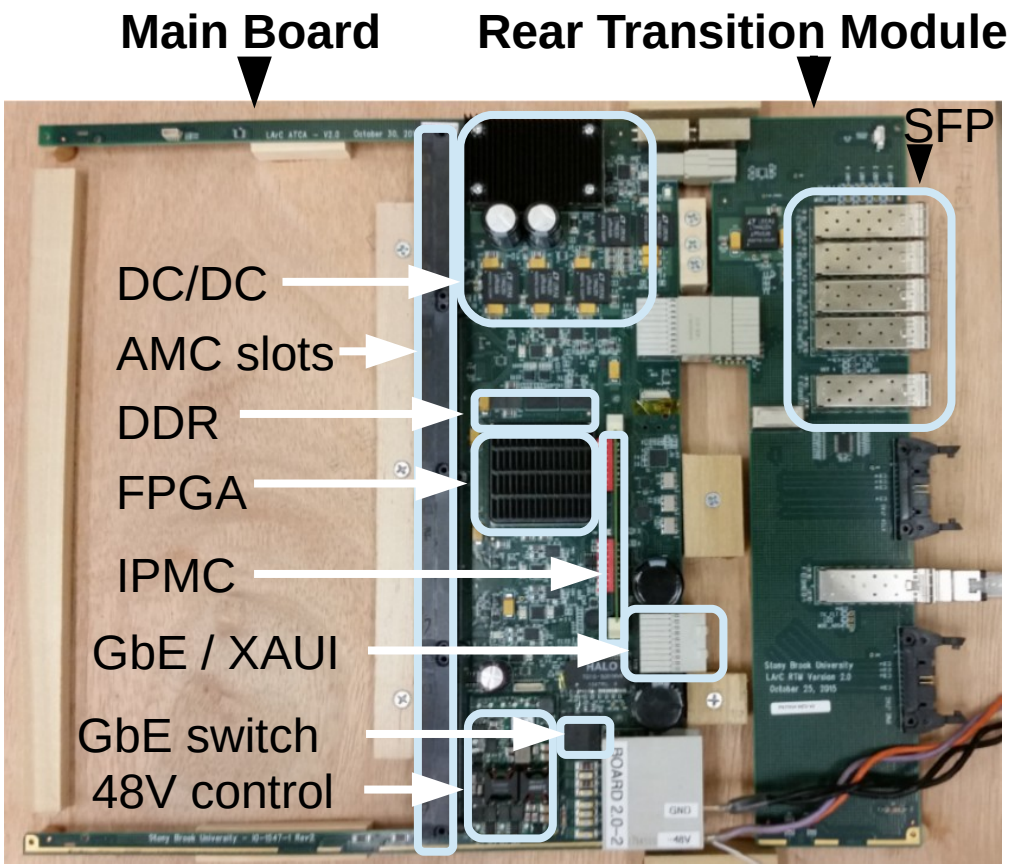
- ADC: 12b, 4 channels (80 / LTDB)
  - Tolerance established up to 10 MRad
  - 12.8k chips qualified for LTDB production
  - Tests continue to cover shelf spares
- Serializer : LOCx2 (20 / LTDB)
  - 3.2k chips qualified for LTDB production
- Optical modules: MTx/MTRx (40 / LTDB)
  - 3.2k Mtx qualified for LTDB production
  - 800 MTRx qualified for LTDB production
  - Few spares production ongoing

# Front End – Lar Trigger Digitizer Board



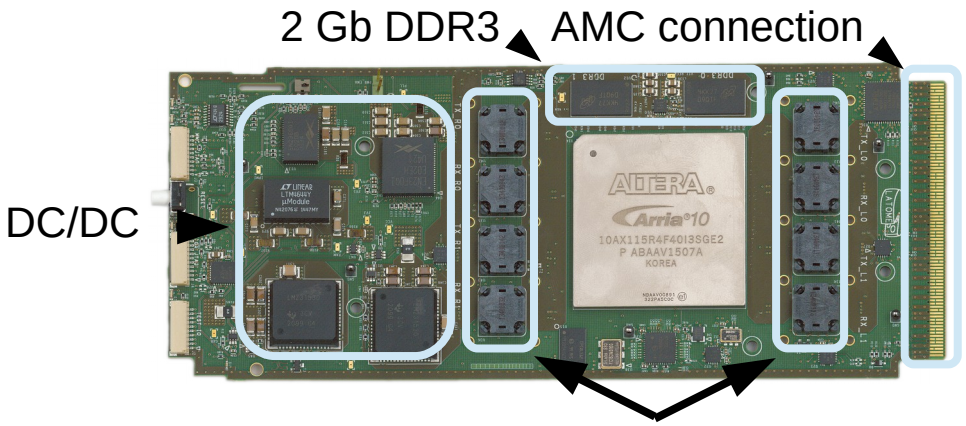

- A total of 124 LTDB to be installed
  - 150 PCB produced
  - 70 Barrel LTDB produced and tested
  - 12 End Cap LTDB produced and 2 tested
  - Production & Test of remaining LTDB ongoing
  - **33 LTDB already installed, commissioning ongoing**
  - Totality expected at CERN in Spring 2020

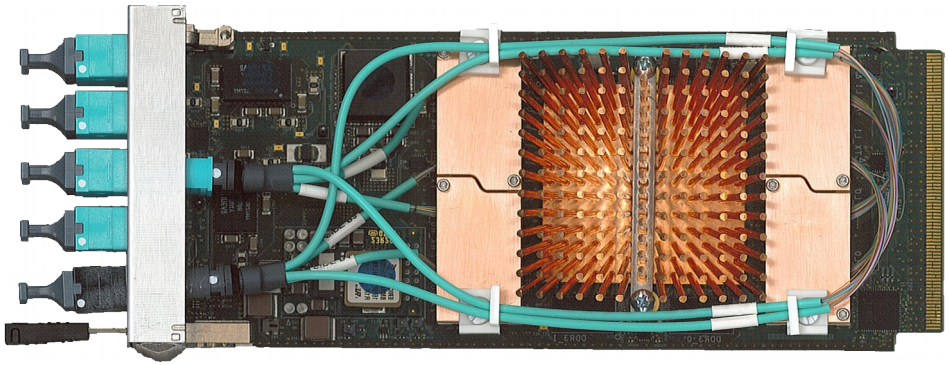
# Back End – LAr Carrier




- Carrier : ATCA back end motherboard
  - Hosts 4 Advanced Mezzanine Card (AMC) : LATOME
  - Drives Control and Monitoring Data communications
- 34 boards produced and tested (4 spares)
- Power management with dedicated card & firmware: IPMC

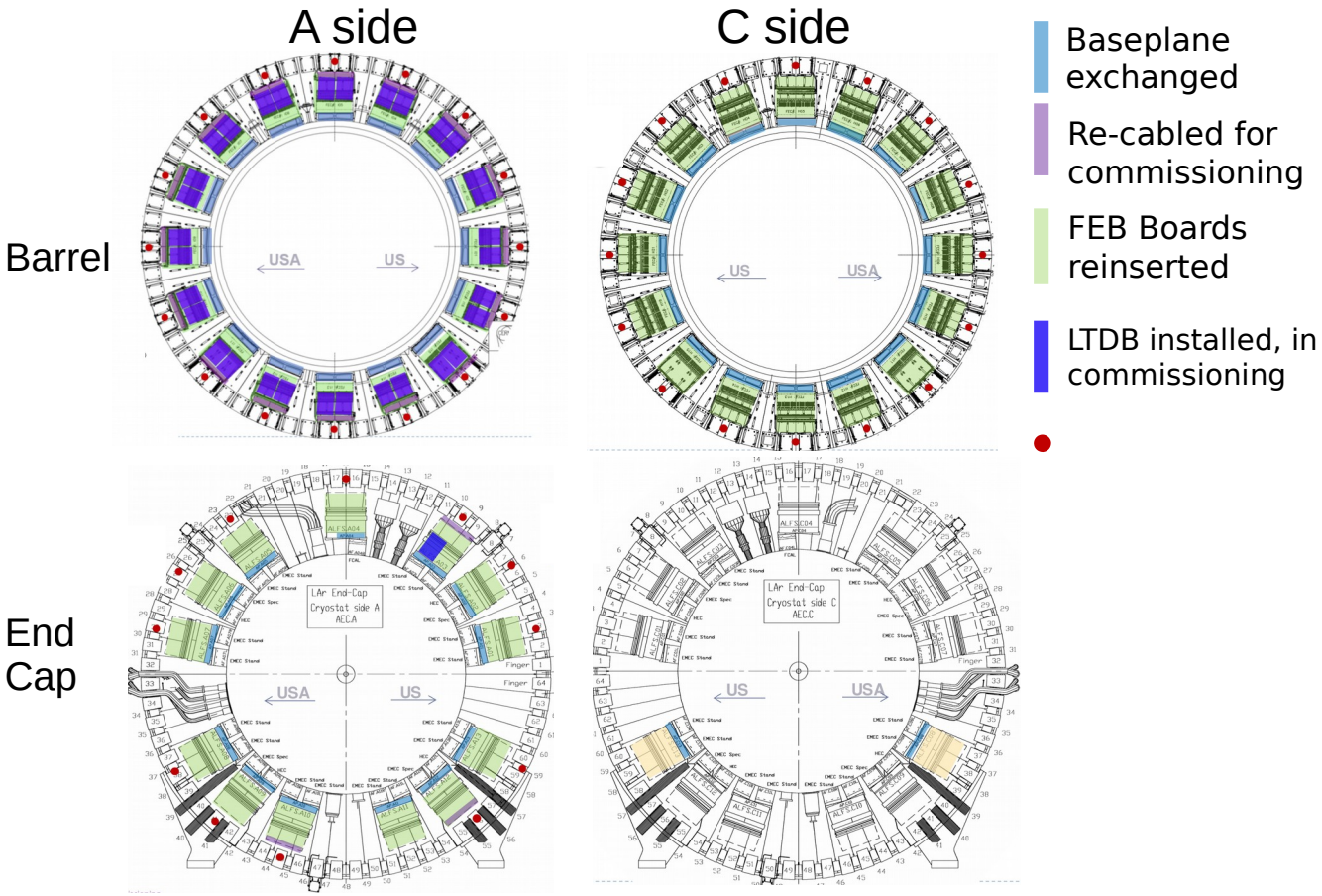
# Back End – LATOME



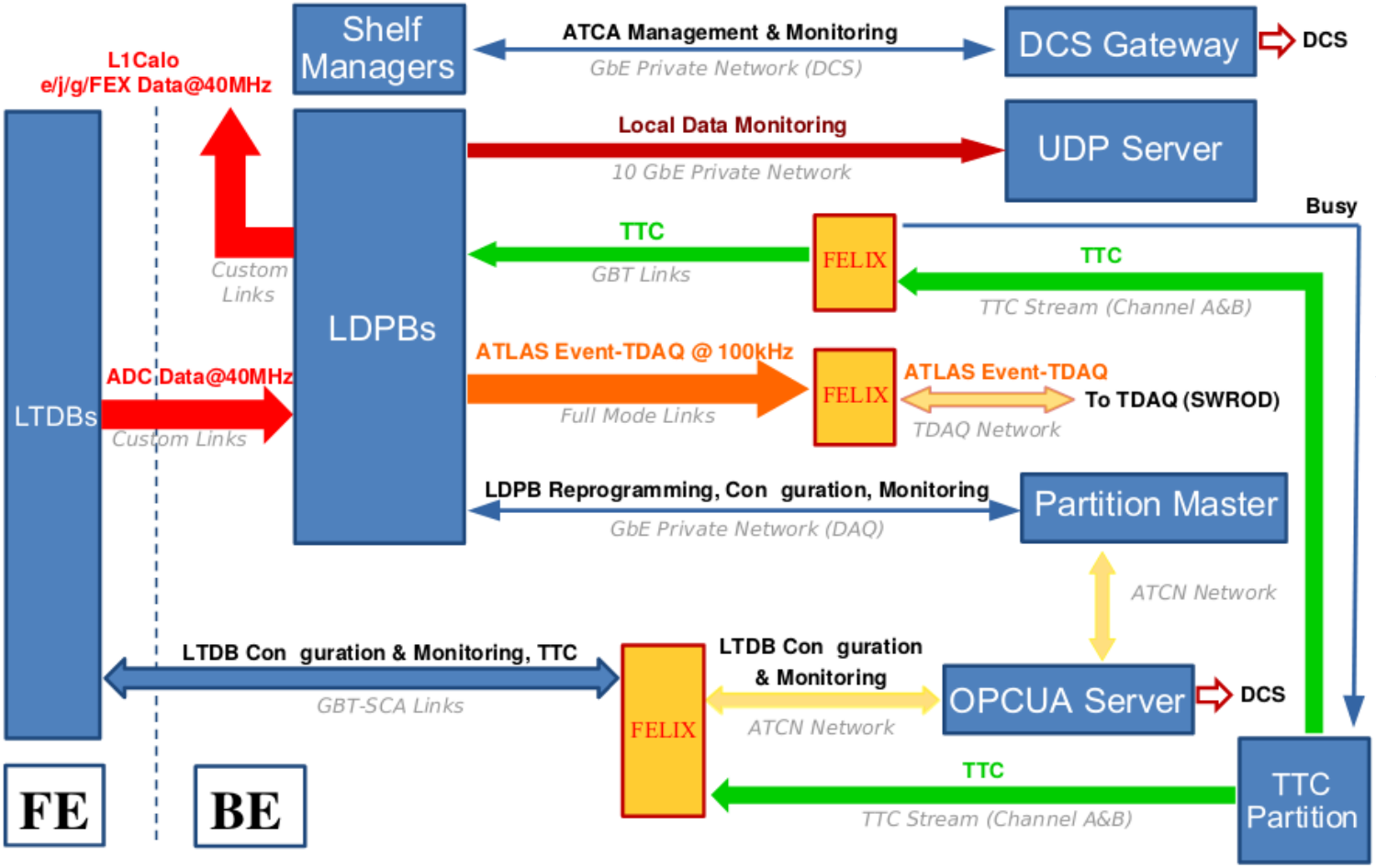
- LATOME : computes Super Cells $E_T$ and Bunch Crossing ID from ADC, corrects baseline
  - All 150 boards produced (34 spares), 145 already qualified
  - Blades validation tests LArC+LATOME ongoing
  - Firmware under validation
  - Integration tests and commissioning on the real system has started

# Installation Status




- Installation started in winter 2019
- End : 2nd half of 2020
- Access depending on the detector opening

# Felix ( control / monitoring /DAQ )




Different fonctions :
- DAQ
- DCS/ Run control
- TTC transmission

Will be delivered soon

# Conclusion

- In 2021, the Run-3 of LHC will start with an increase instantaneous luminosity
- The calorimeters are not changed, only the electronics
  - keep providing excellent performances if readout is sufficient
  - True also for the HL-LHC !
- Phase-I (now) : electronics is upgraded for the trigger readout
  - Improve background rejection capabilites + Energy resolution at first level of trigger
- Production of all the boards has started and will complete in Spring 2020
- Installation & Commissioning is ongoing