



UNIVERSITÄT  
HEIDELBERG  
ZUKUNFT  
SEIT 1386

# L1Calo – Commissioning & Calibration

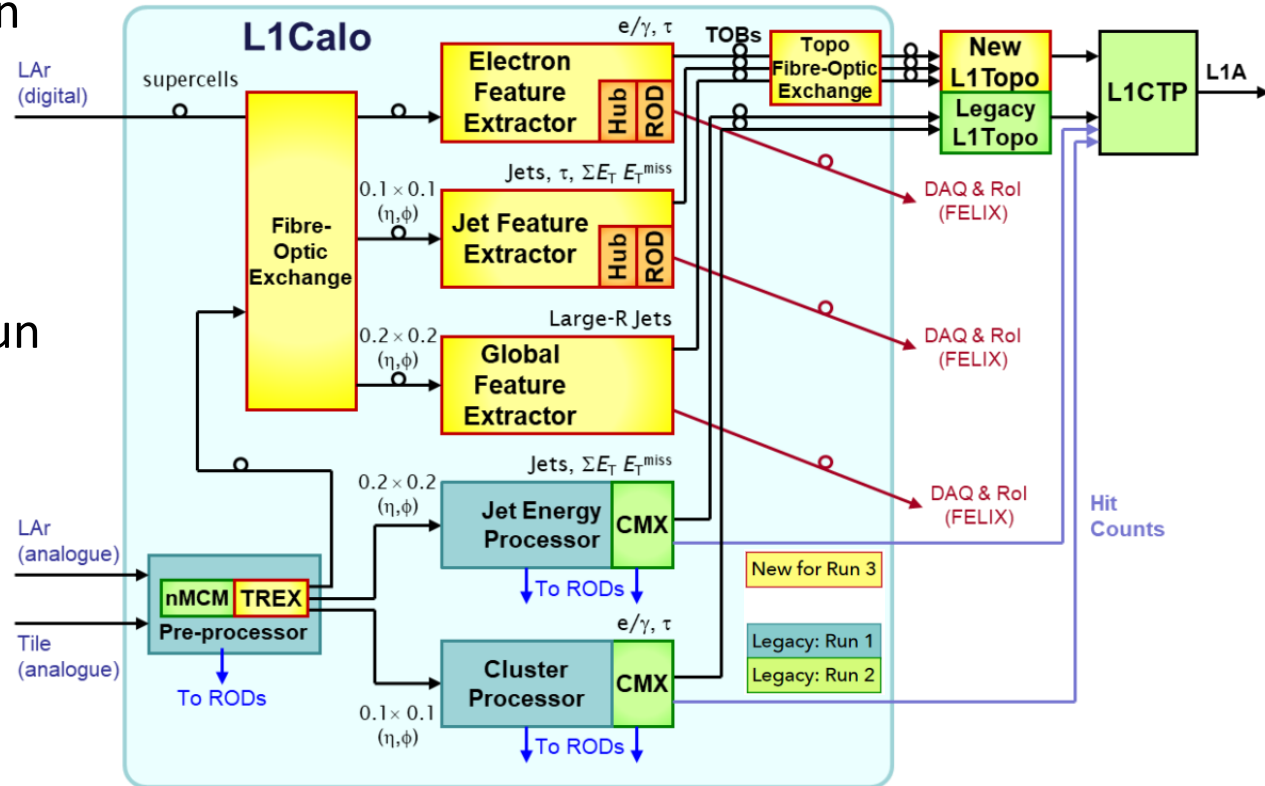
**Damir Raßloff**

Kirchhoff-Institut für Physik  
Ruprecht-Karls-Universität Heidelberg

ATLAS-Heidelberg Meeting, Trifels, 30.05.2022

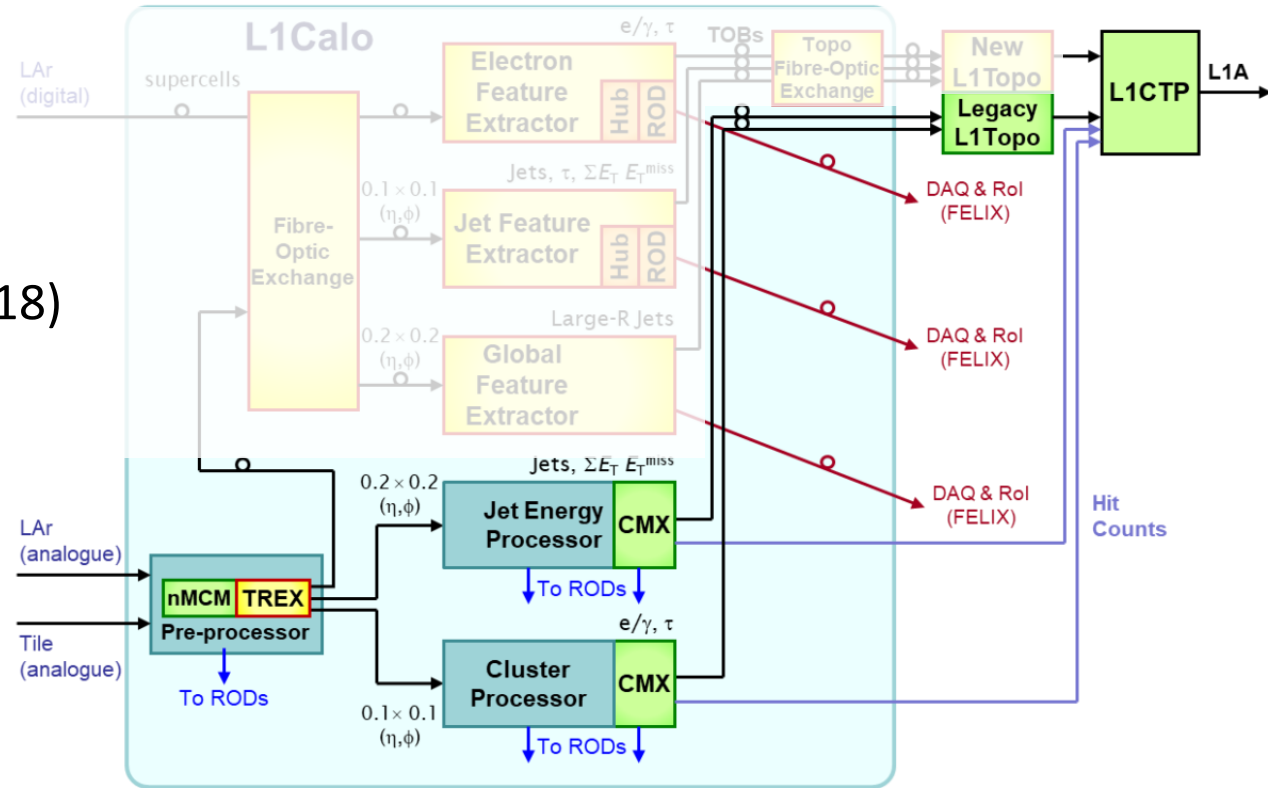
# L1Calo - Short overview

- Legacy System (Run1 & Run2):  
Re-commissioning & Re-calibration
- Phase-I System (New for Run3):  
Commissioning & Calibration
- Run 2 legacy L1Calo system will run  
in parallel with Phase-1 system at  
the beginning of Run 3



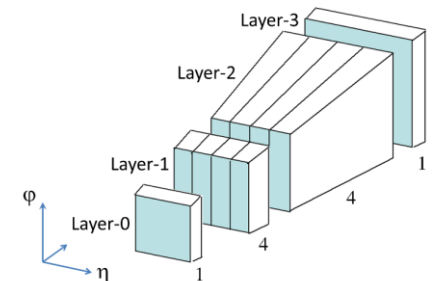
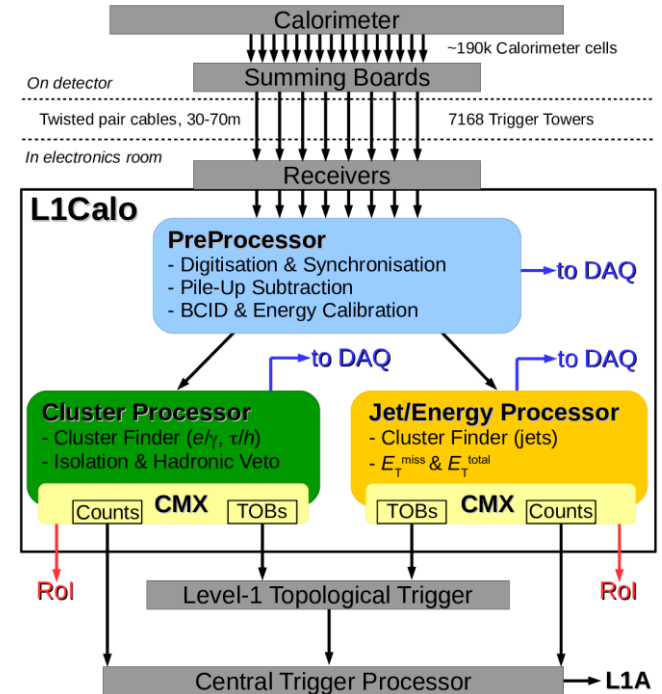
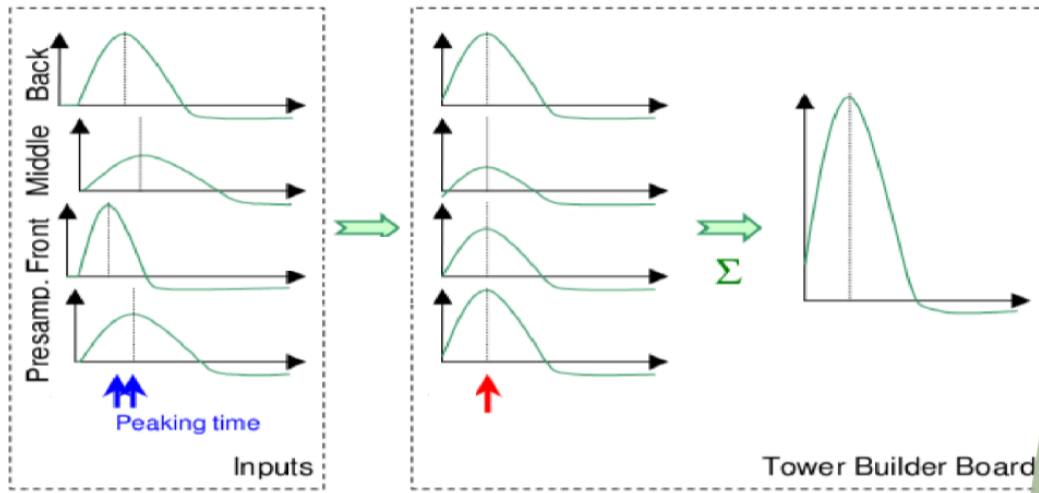
# Why to re-commission & re-calibrate the legacy system?

- New LAr electronics
- New TREC board
- New TTC system: ALTIs
- Obvious reason: Time (Run2 in 2018)

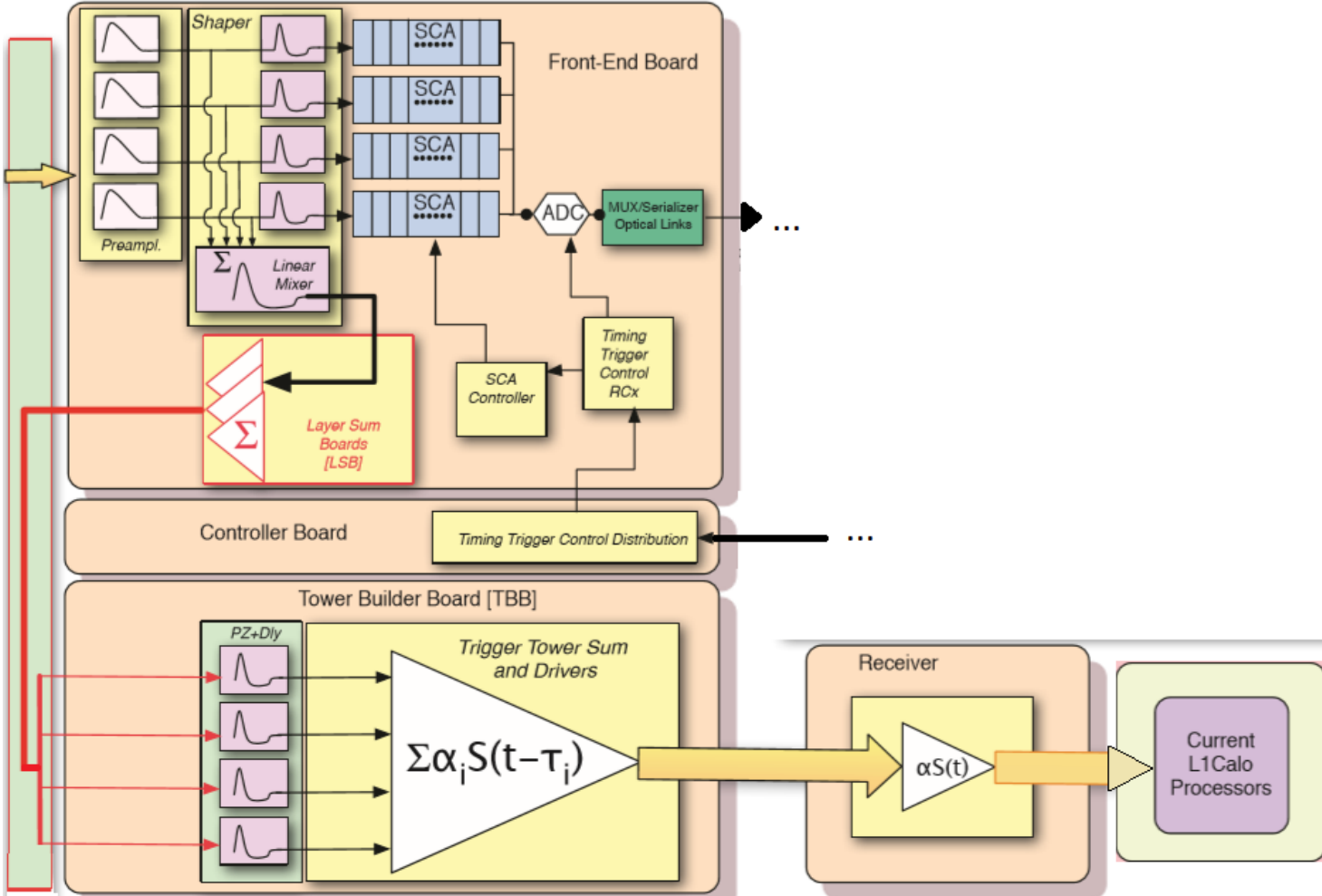


# New LAr electronics - Introduction

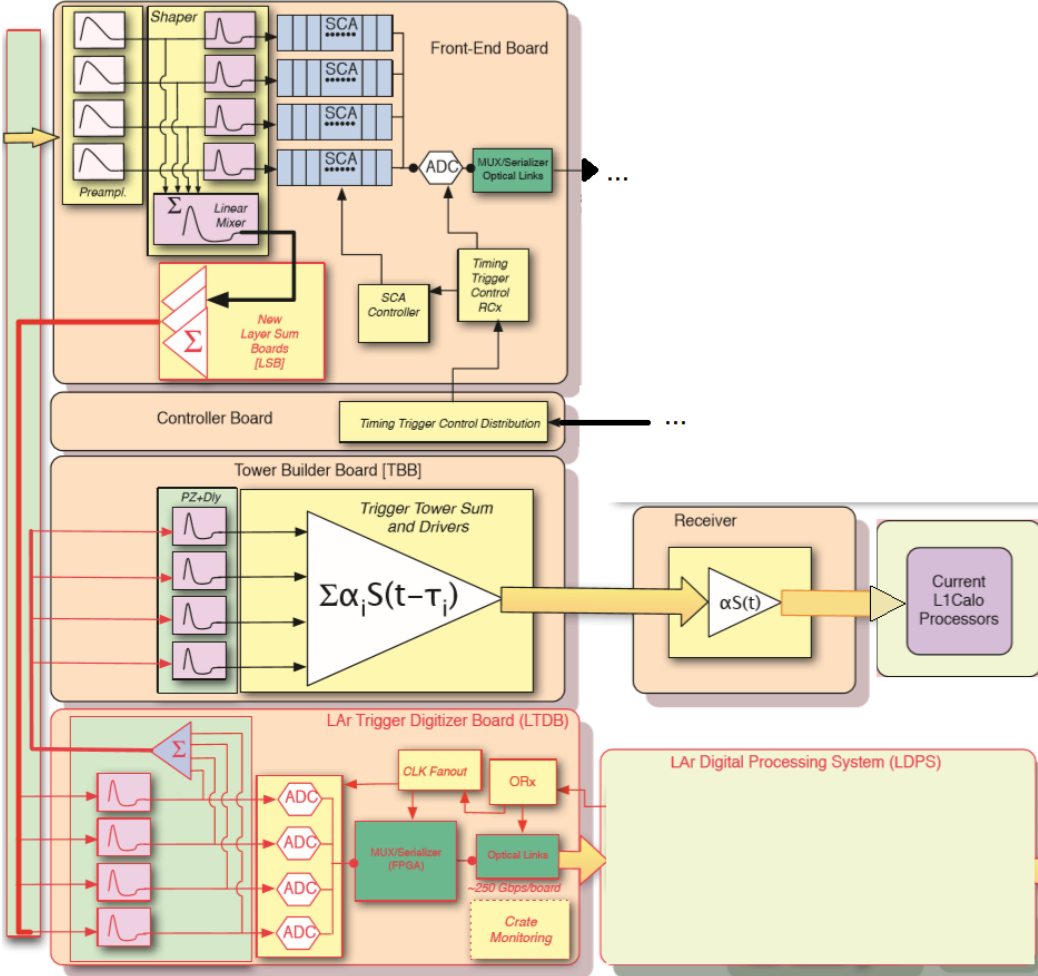
- Legacy L1Calo receives Trigger Towers (TTs) from LAr
- 1 TT = Sum of up to 60 LAr cells of four layers
- Tower Builder Boards (TBBs) should sum up analog LAr signals of the four layers at the peak position



# New LAr electronics - Run2 overview

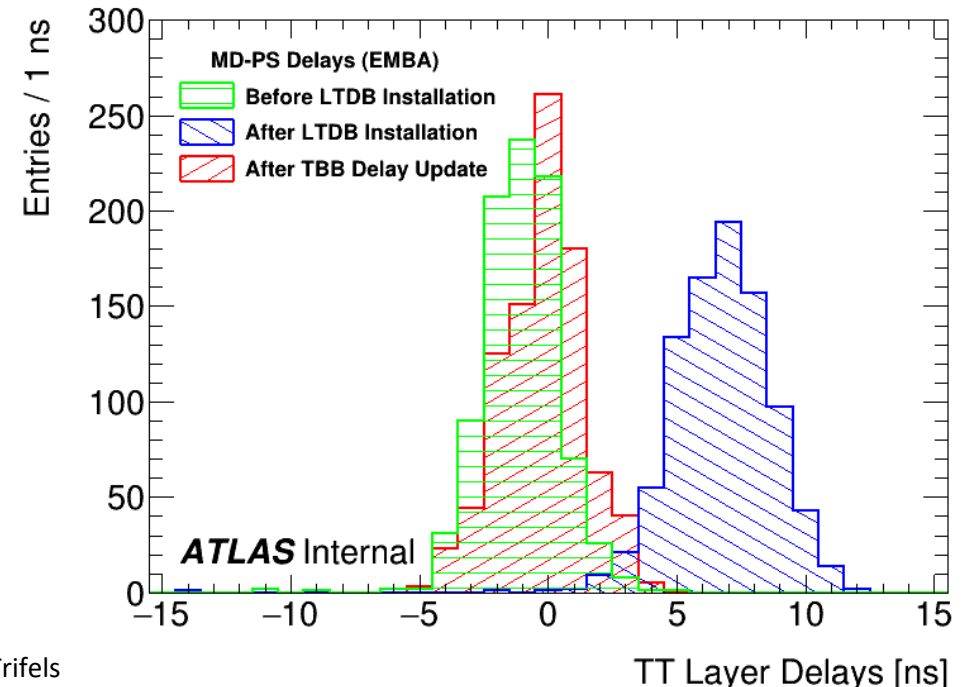


# New LAr electronics - Run3 overview



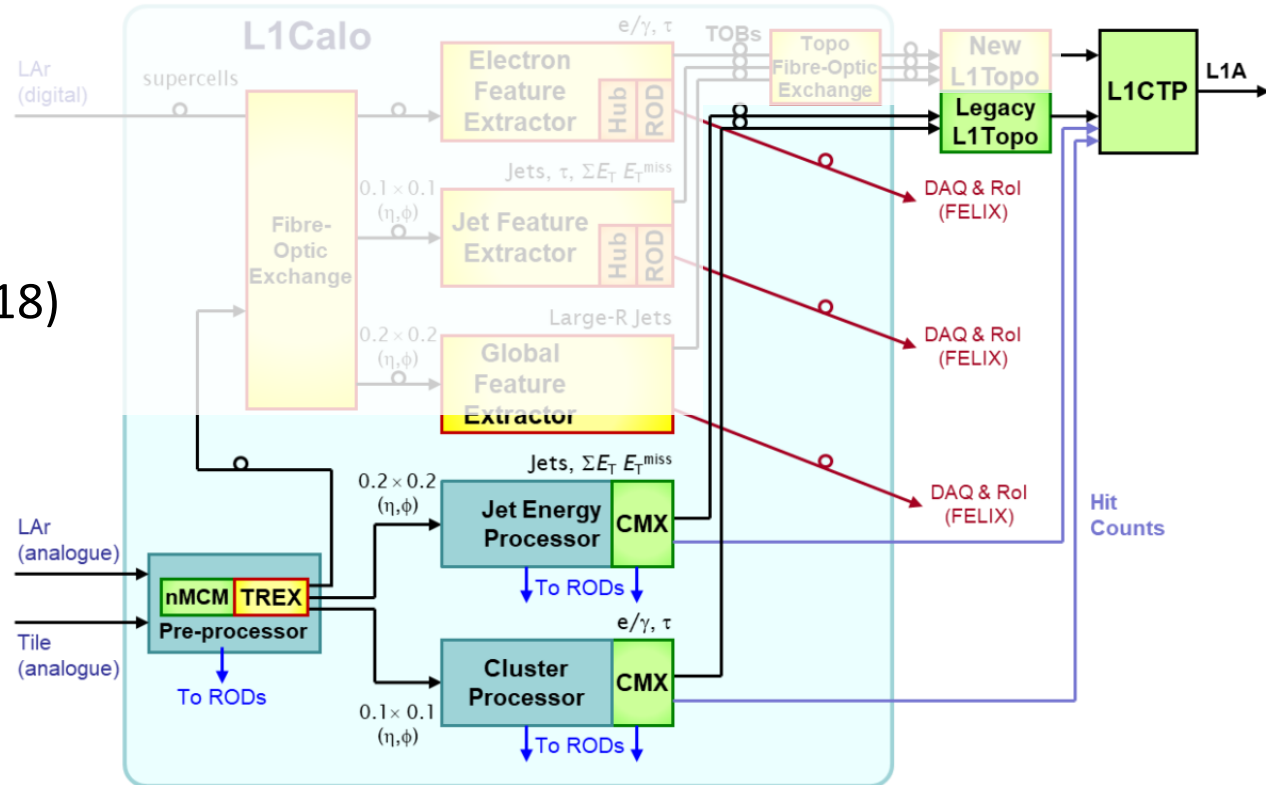
# New LAr electronics – New TBB delays

- Phase-I upgrade of LAr leads to slightly changed timing between different layers of LAr
- Calculate & apply new Tower Builder Board (TBB) delays in calibration runs
- Changed TBB delays for actual physics runs predicted & applied
- Done by Thomas (Details in [talk](#))
- Checks during Splashes & Pilot run (stay tuned)



# Why to re-commission & re-calibrate the legacy system?

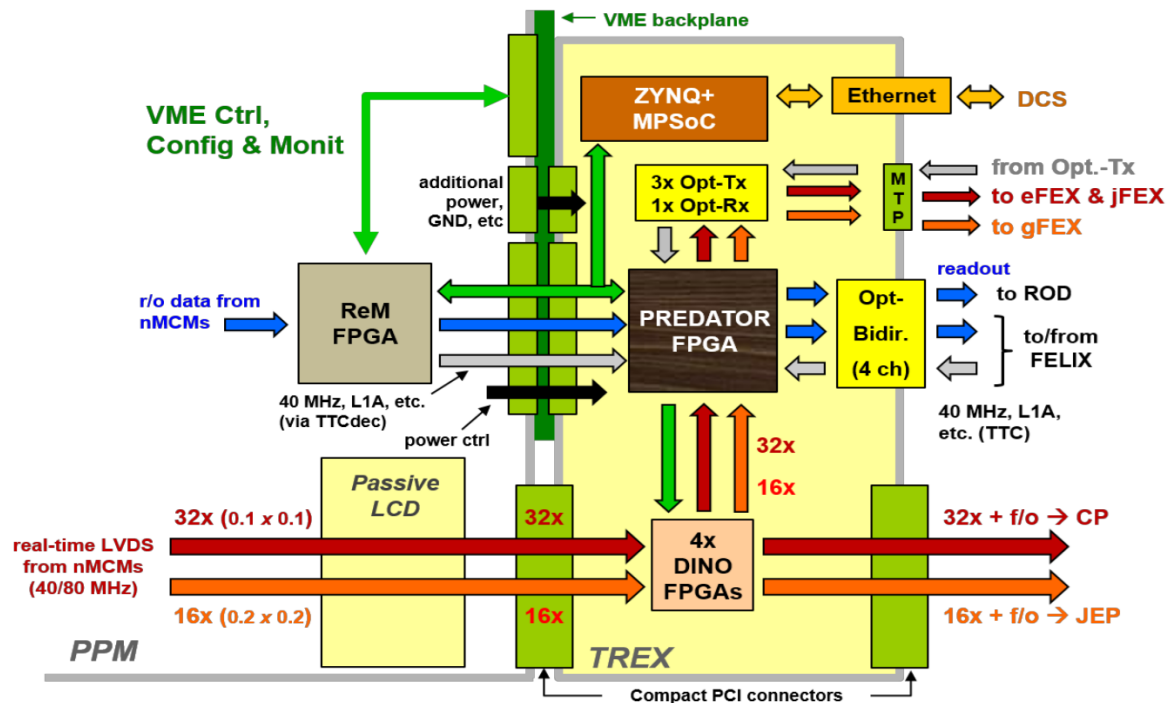
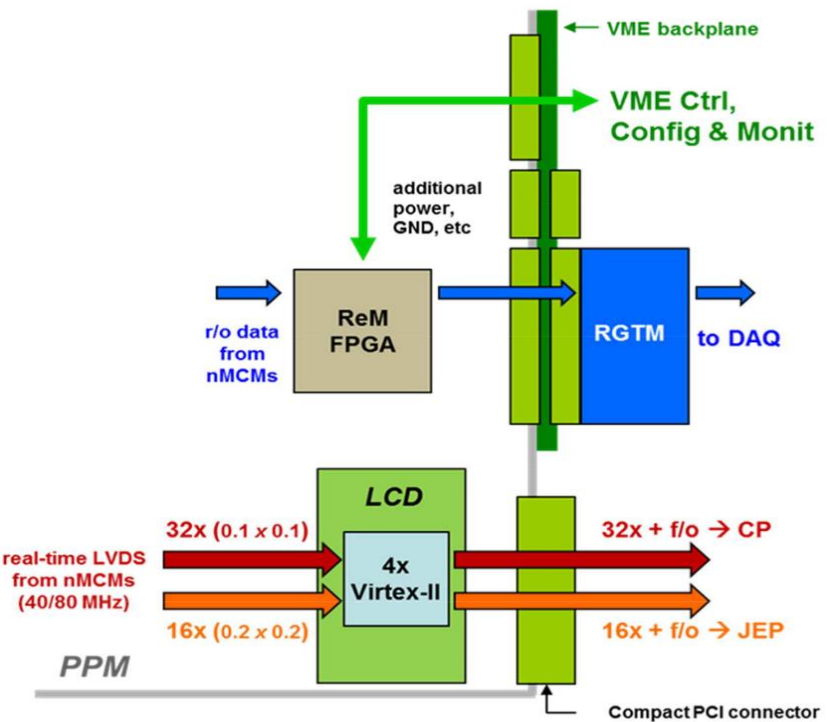
- New LAr electronics
- **New TREC board**
- New TTC system: ALTIs
- Obvious reason: Time (Run2 in 2018)





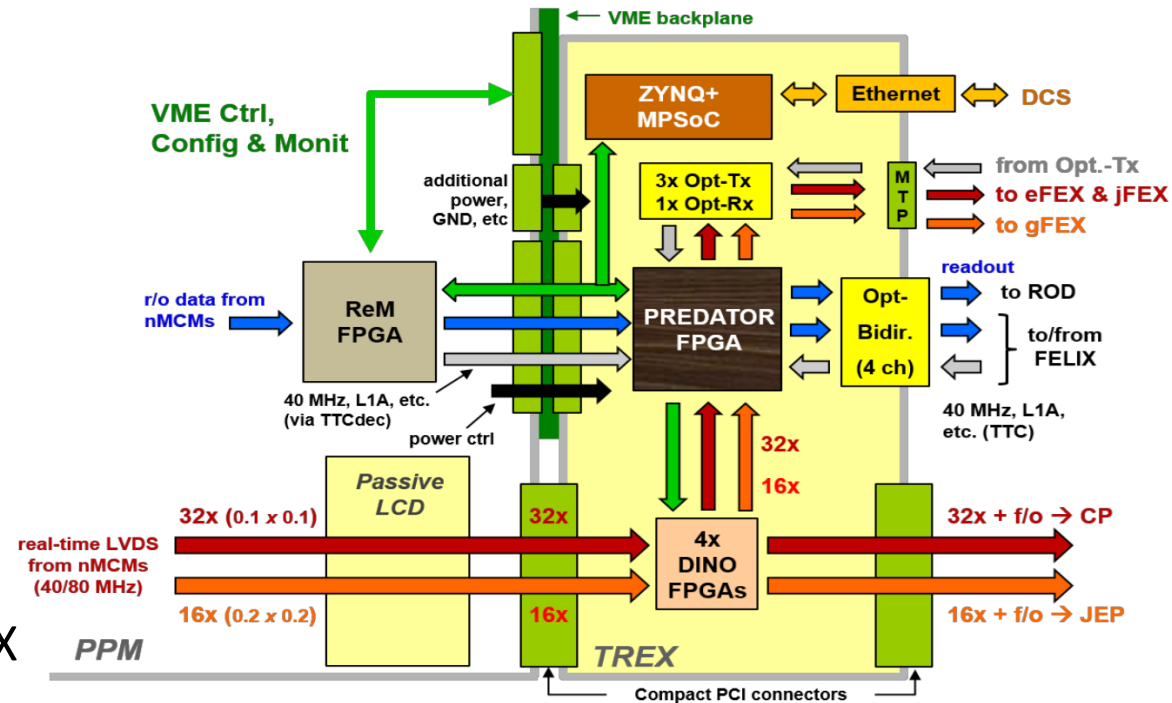
# New TREX board - Run2 & Run3 differences

Run2 | Run3



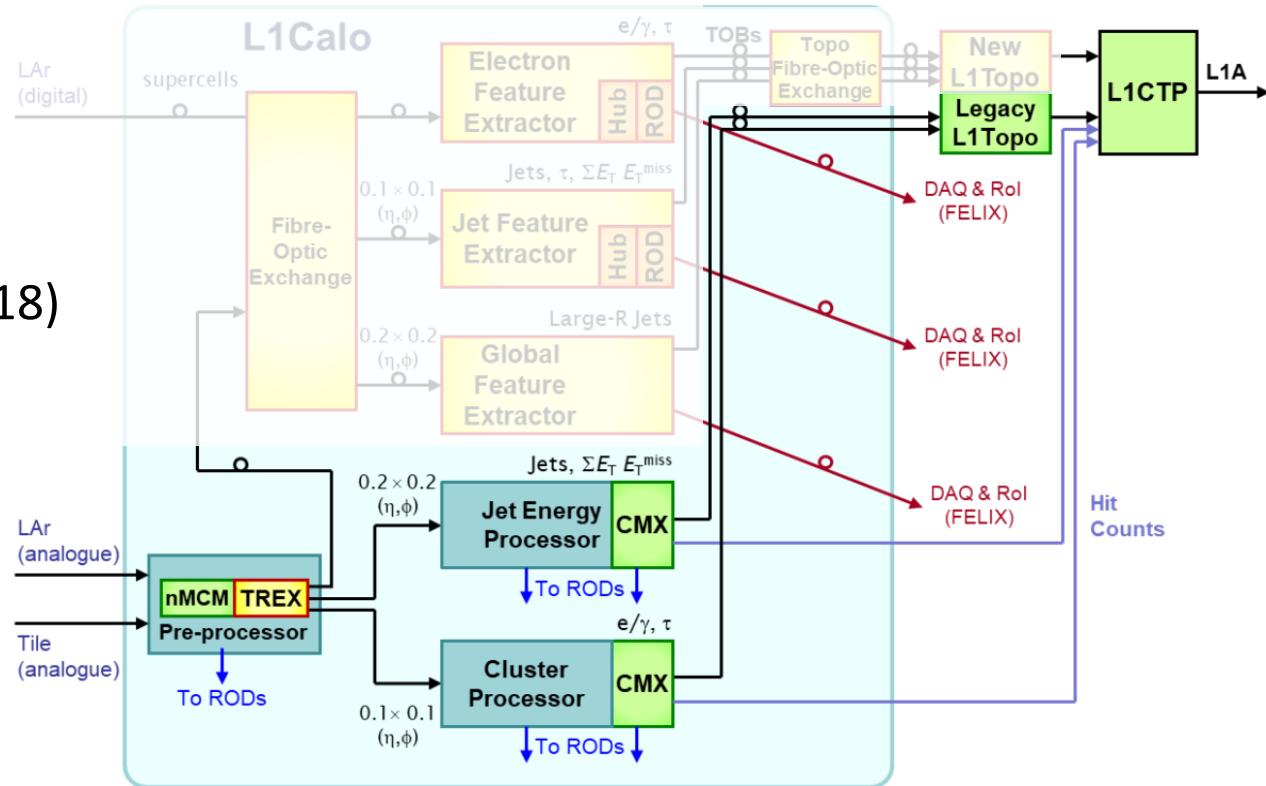
# New TREX board - Overview

- pLCD: Passive bridge replaces LCD
- DINO FPGAs: Duplication and transmission to CP, JEP & new systems
- PREDATOR:
  - Realtime: Data formatting and transmission to FEXes
  - Readout: Data formatting and transmission to legacy ROD & FELIX
- Installed only in Tile crates



# Why to re-commission & re-calibrate the legacy system?

- New LAr electronics
- New TREC board
- **New TTC system: ALTIs**
- Obvious reason: Time (Run2 in 2018)



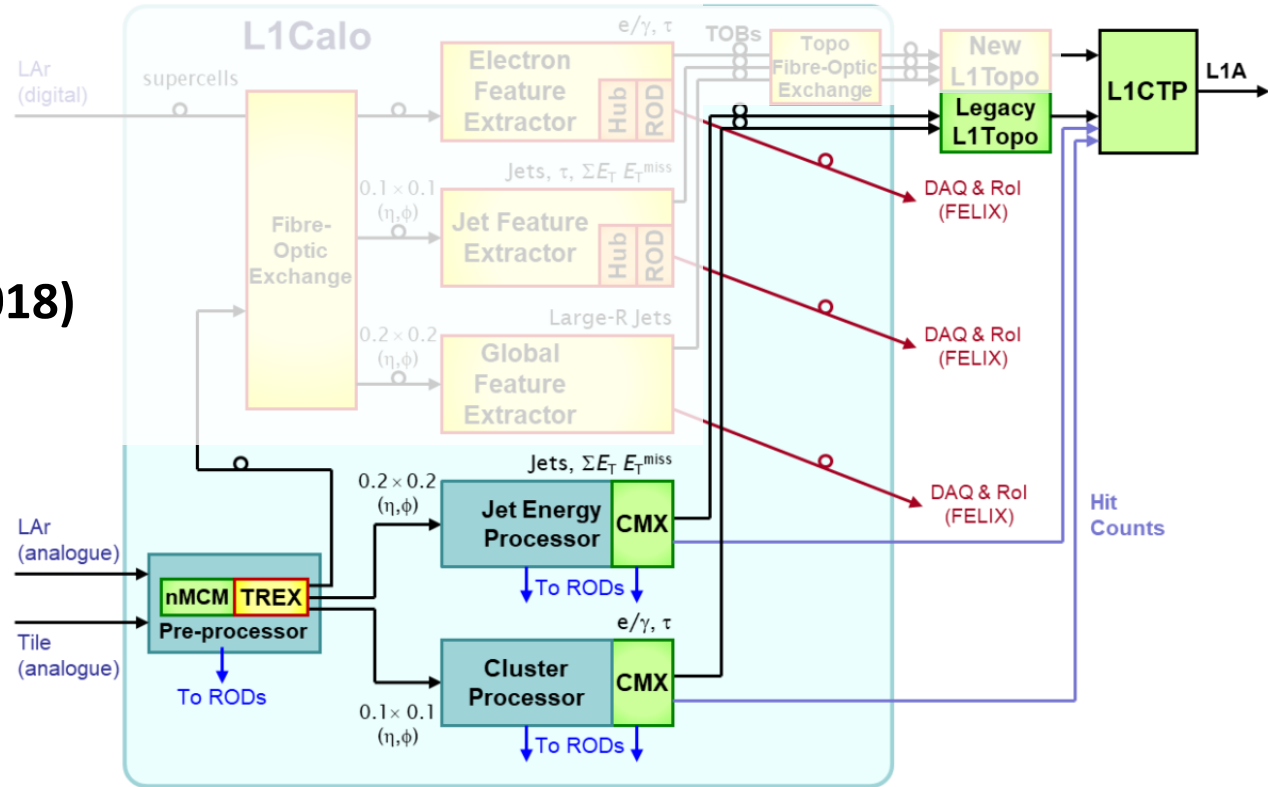
# New TTC system: ATLAS Local Trigger Interface (ALTI)

- With the upgrade: new sub-detectors which need TTC modules, but low on spares of legacy TTC modules
- Replaces the following legacy modules: the Local Trigger Processor Interface (LTPI), the Local Trigger Processor (LTP), the TTC VMEbus Interface (TTCvi), and the TTC Emitter (TTCex)
- Single VME module
- All sub-detectors moved to ALTIs
- Whole new TTC setup  
(changes in calibration & physics timing, calibration setup, clock distribution, etc.)

TTC SIGNAL	DIRECTION	DESCRIPTION
BC	forward	Bunch crossing clock: 40.079MHz, 50% duty ratio.
ORB	forward	Periodic signal representing one LHC turn. Period is 3564 bunch crossings, pulse width is 40BC.
L1A	forward	Level-1 trigger accept signal of 1BC pulse width.
TTR[3..1]	forward	Auxiliary triggers generated locally by the partition.
BGO[3..0]	forward	Signals for sending B-channel TTC commands.
TTYP[7..0]	forward	8-bit trigger type identification word associated with each L1A.
BUSY	backward	Used to inform the CTP to introduce L1A dead-time, i.e. throttle L1A generation when the readout buffers are overwhelmed.
CALREQ[2..0]	backward	3-bit word issued by the sub-detector and used by the CTP to generate calibration triggers.

# Why to re-commission & re-calibrate the legacy system?

- New LAr electronics
- New TREC board
- New TTC system: ALTIs
- **Obvious reason: Time (Run2 in 2018)**



# Time

- Broken equipment over time: Replace with spare & repairs
- Software updates: OS updates, TDAQ & Run control SW updates, L1Calo SW updates, etc.
- Calorimeter changes (re-calibration needed):
  - Repairs & replaces of broken equipment
  - Aging of calorimeters & time related effects
  - Re-configuration

# How to re-commission the L1Calo legacy system & commission the new Phase-1 system?

- Legacy system:
  - Standalone tests in P1
  - Standalone calibrations & combined calibrations with calorimeters
  - Combined runs with calorimeters
  - In ATLAS: Standalone tests & combined runs with several subsystems (e.g. during Milestone weeks (M-weeks))
- Phase-1 system:
  - Module specific hardware, firmware & software tests in Home Institutes or Surface Test Facility (STF) at CERN
  - Combined slice tests with all Phase-1 modules at STF
    - Synchronous readout & event building
    - Transmission through all modules
  - Combined runs with calorimeters in P1
  - In ATLAS: Standalone tests & combined runs with several subsystems (e.g. during Milestone weeks (M-weeks))

L1Calo in P1



STF

# Re-commissioning & commissioning in ATLAS (1)

- Many tests in Home Institutes, STF & P1
- Focus on tests in ATLAS especially during M-weeks
- M1 (May 2020):
  - First time combined running in ATLAS since 2018
  - L1Calo fully powered & included except L1Topo & Athena Monitoring
- M3 (August 2020):
  - L1Topo included
- M7 & M8 (May 2021 & June 2021)

The screenshot displays the ATLAS TDAQ SOFTWARE interface. The title bar reads "ATLAS TDAQ SOFTWARE - Partition ATLAS@pc-atlas-cr-35.cern.ch". The menu bar includes "File", "Commands", "Access Control", "Settings", "Logging Level", and "Help".

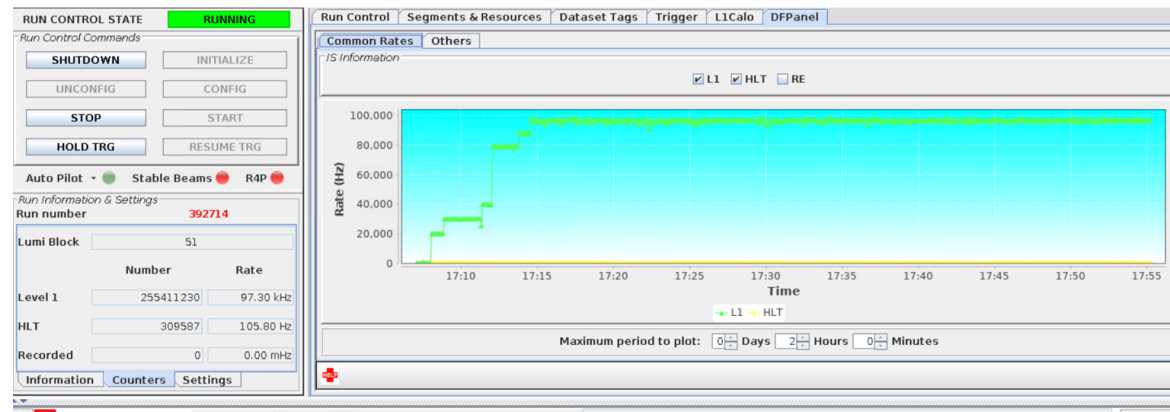
The main interface is divided into several sections:

- Commit & Reload** and **Load Panels** buttons are at the top left.
- Run Control State** shows a green "RUNNING" indicator.
- Run Control Commands** includes buttons for SHUTDOWN, INITIALIZE, UNCONFIG, CONFIG, STOP, START, HOLD TRG, and RESUME TRG.
- Auto Pilot** section shows "Stable Beams" and "R4P" as active (green circles).
- Run Information & Settings** section shows:
  - Run number: 423211
  - Lumi Block: 287
  - Level 1: 376861 (19.00 Hz)
  - HLT: 328000 (21.20 Hz)
  - Recorded: 482263 (31.19 Hz)
- Run Control** tree view on the right shows a hierarchy of components, all marked as "RUNNING":
  - RootController
  - Online Segment
  - Infrastructure
  - TDAQ
  - Infrastructure
  - UP (ddcdtATLAS\_ATLGCSDDC)
  - L1CentralTrigger
  - L1Calo
  - HLT
  - TRP\_Segment
  - TDAQ\_Monitoring
  - MUCalServerController
  - olc2hlt\_ctrl
  - InnerDetectors
  - Calorimeters
  - MuonDetectors
  - GlobalMonitoringSegment
  - BeamSpotController



# TREX & Stage 1 of ALTI: Milestone week 7 & 8

- M7 (03.05. - 07.05.2021):
  - TREX installation
- M8 (14.06. - 18.06.2021):
  - TREX legacy path integrated & validated
    - 100 kHz readout to legacy ROD
    - & error free real-time data to CP/JEP
    - First Phase-1 L1Calo system integrated in ATLAS
  - Stage 1 of L1Calo ALTI setup
    - LTP, TTCvi, TTCex replaced
    - 2x LTPi still used



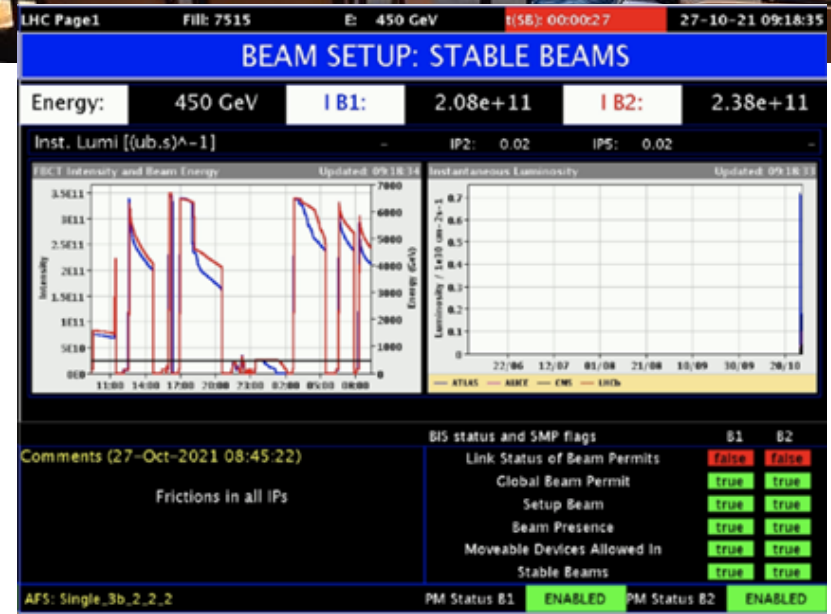
# Re-commissioning & commissioning in ATLAS (2)

- M9 (September 2021)
  - TREX Phase-1 readout tests
  - eFEX & gFEX included in ATLAS
  - Preparation for Pilot Beam
- M10 Pilot Beam (October 2021)



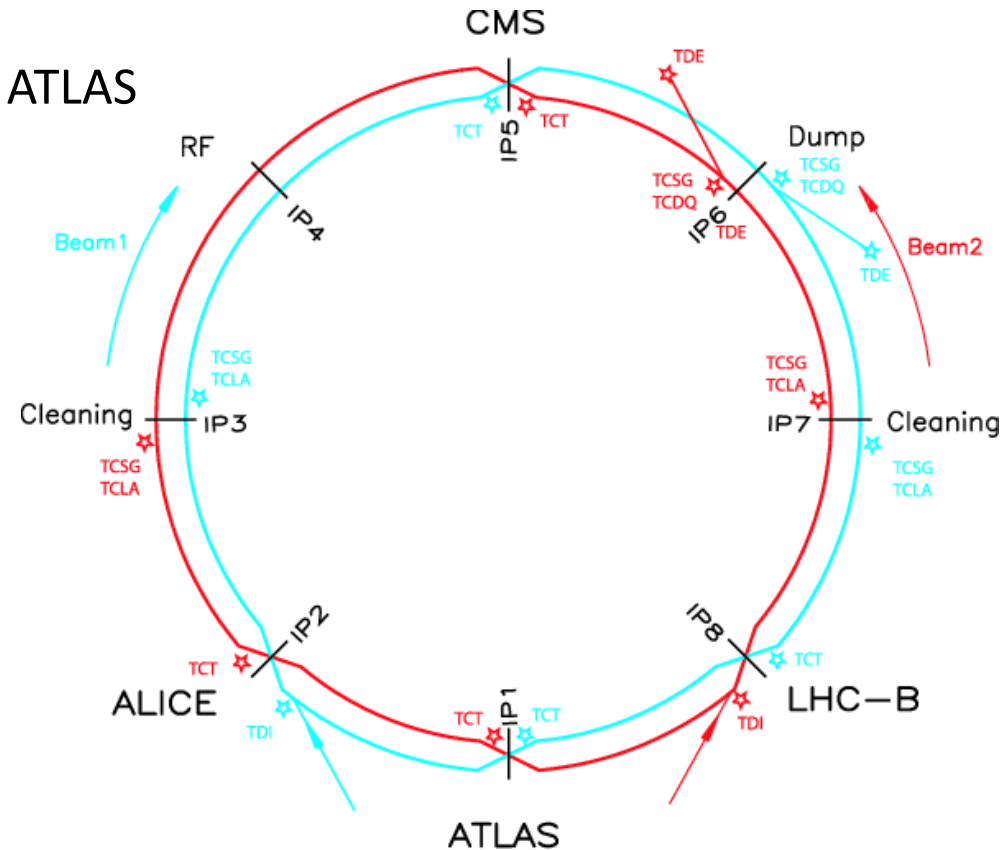
# Pilot beam 2021

- First LHC beam since 2018
- 18th October - 01st November:
  - First week: Splashes
  - Second week: Collisions
- Re-commissioning of legacy system:
  - Check Tile signals through TRES
  - New TBB delays: Check timing
- Commissioning of Phase-1 system:
  - FEXes recorded data parasitically
- Legacy Athena Monitoring integrated



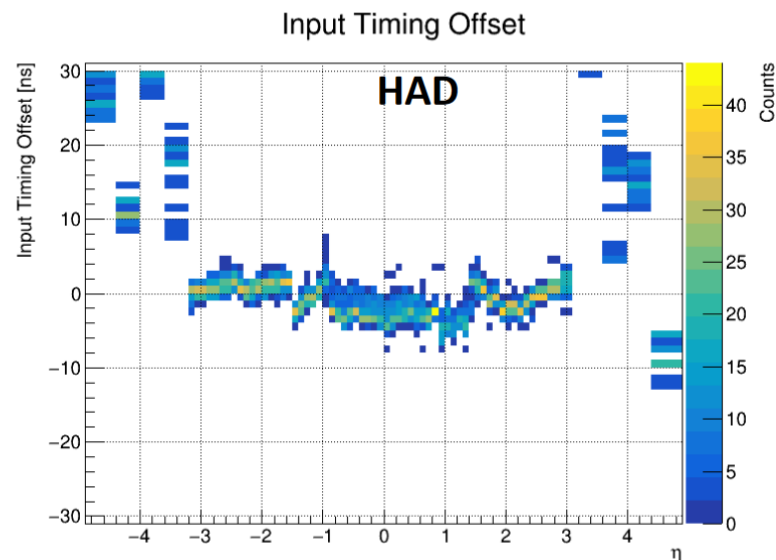
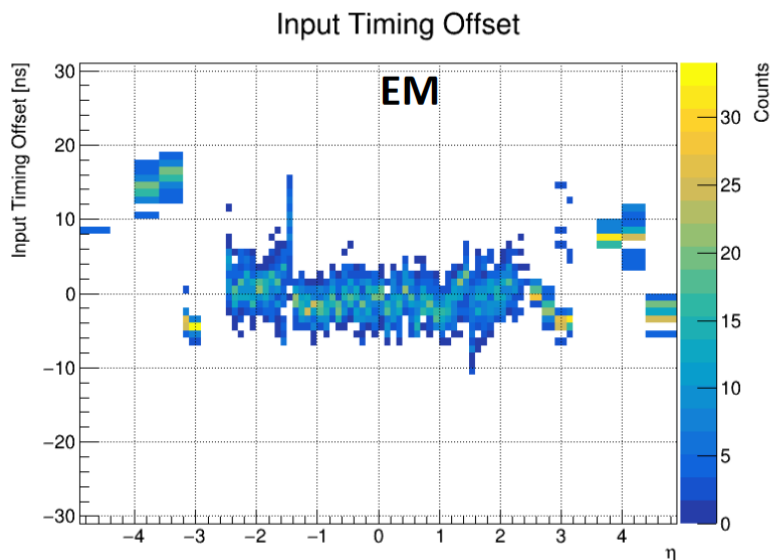
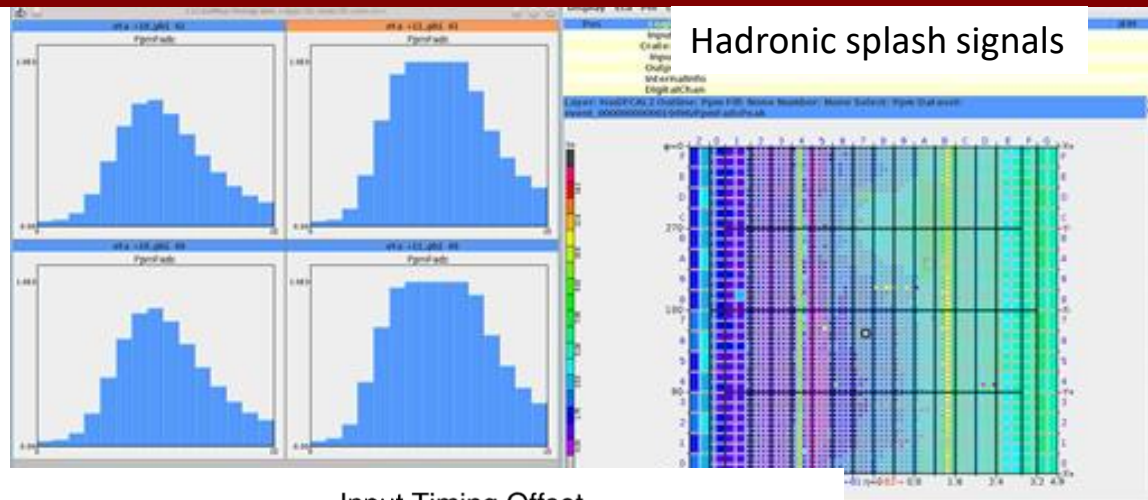
# Special runs: Splashes

- Special runs with high statistics to check the legacy timing
- Splash: Dump beam into collimator 100m from ATLAS  
→ Shower of particles, every cell is hit
- Beam 1: Splash from right side, hits A-side first
- Beam 2: Splash from left side, hits C-side first



# Splashes: Legacy system

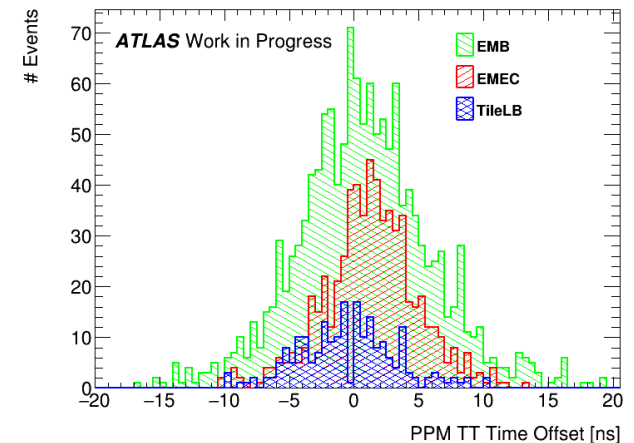
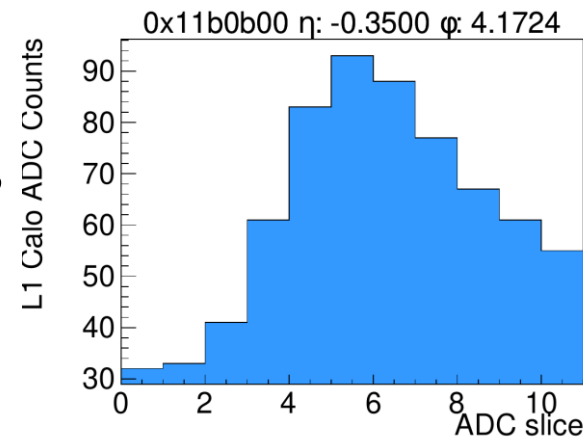
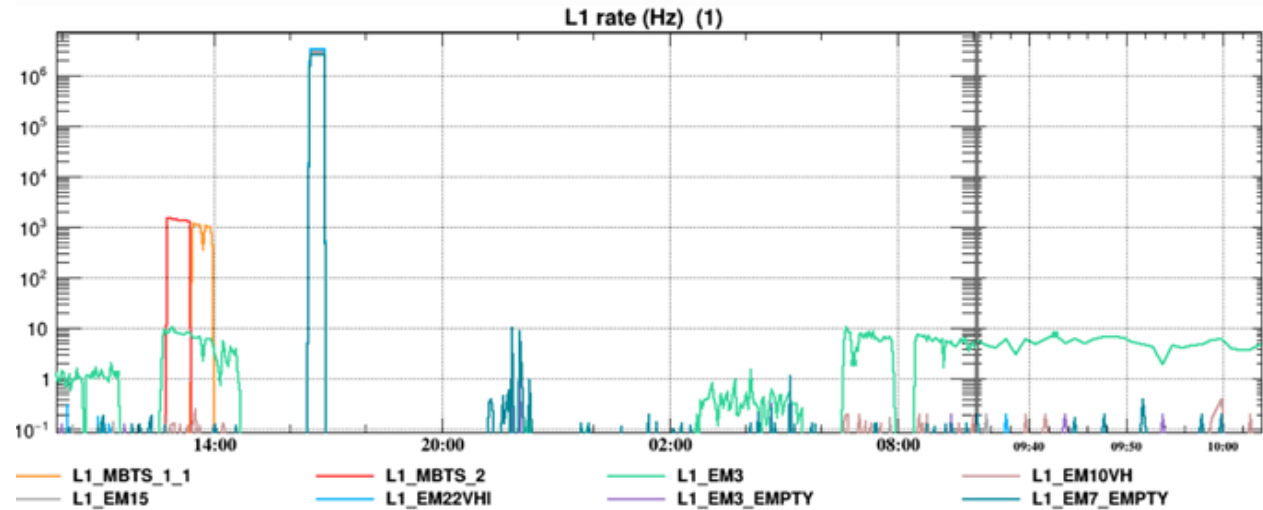
- New TREX board:
  - Tile signals were successfully provided to legacy system
- New TBB delays:
  - Legacy timing in a good shape
  - Predictions were made correct





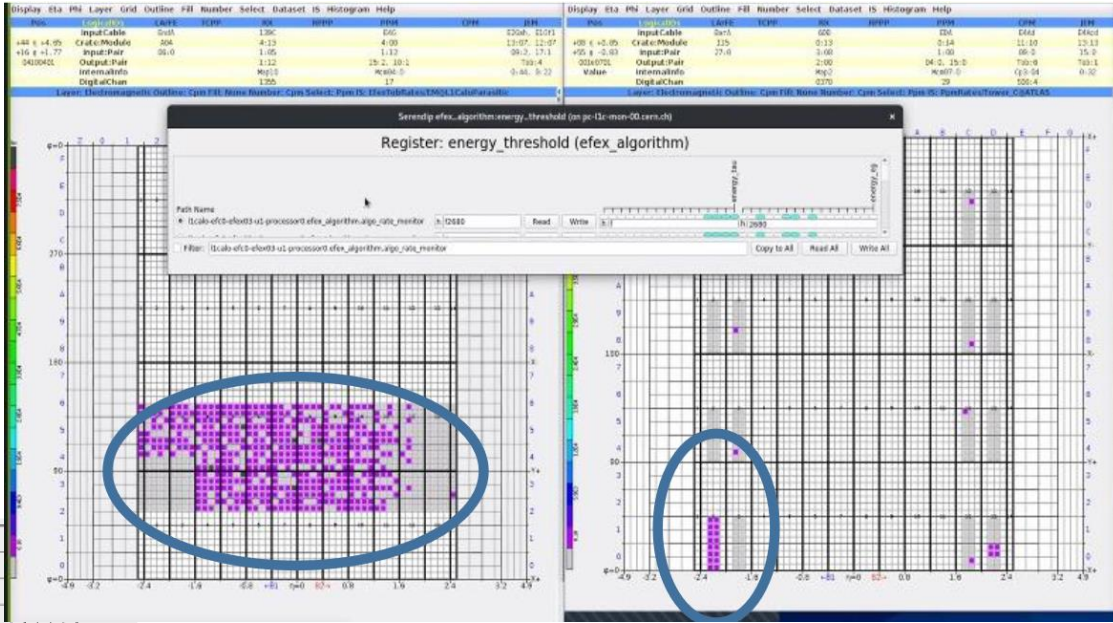
# First collisions: Legacy system

- Several collision sessions with unstable & stable beams during the 2nd week
- Low energy beam (900 GeV), L1\_EM3 trigger rates  $\sim 10\text{Hz}$  (expected)
- Reasonable timing & pulse shapes
- In summary: Good behaviour of the legacy L1Calo after a break of 3 years



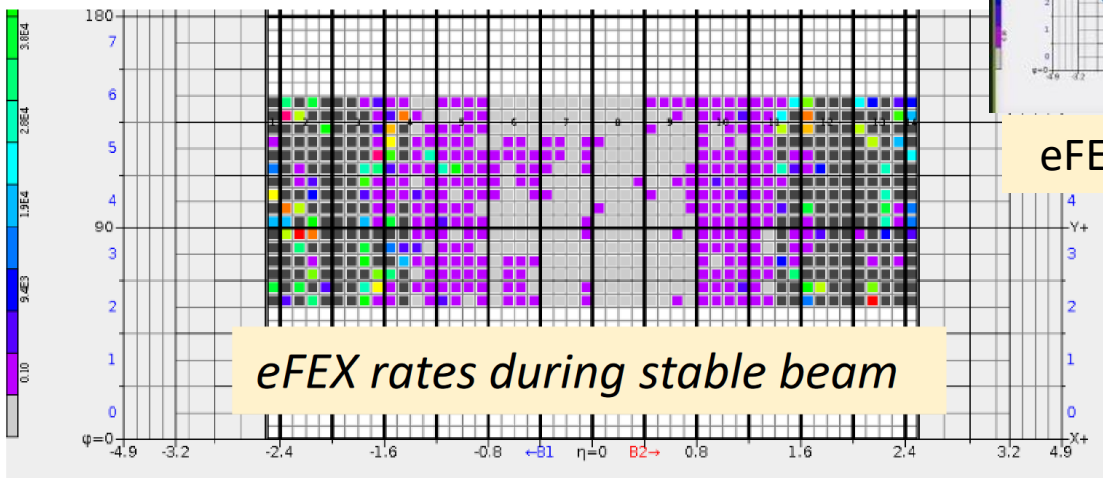
# Splashes & Colissions: Phase-1 systems

- FEXes recorded data parasitically during the week (not affecting the ATLAS partition and the legacy system)
- TRES providing TILE signals to both Legacy and Phase-1 systems



eFEX rates during splash

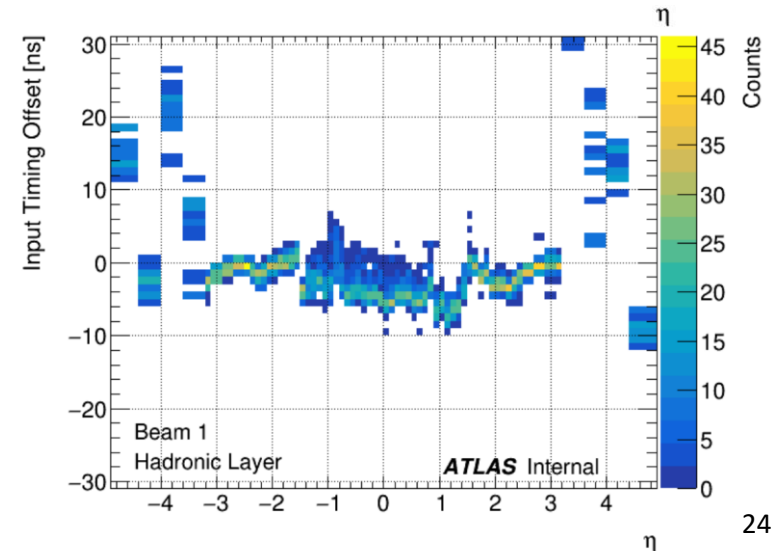
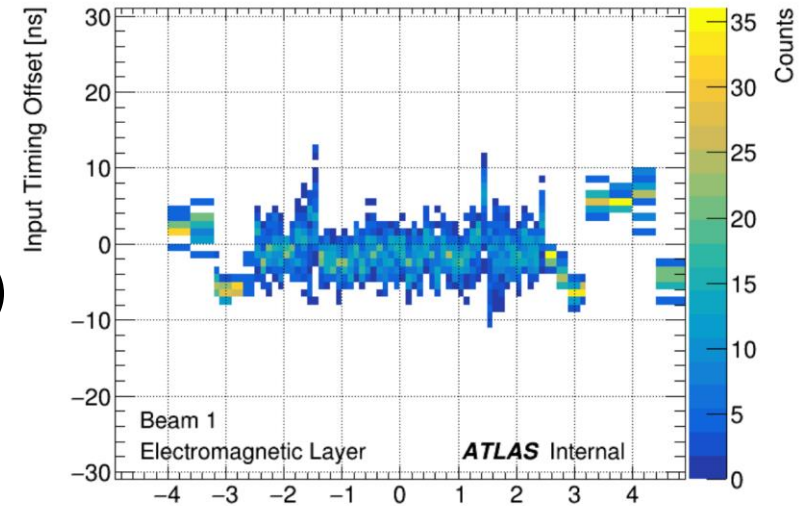
Legacy splash



*eFEX rates during stable beam*

# Re-commissioning & commissioning in ATLAS (3)

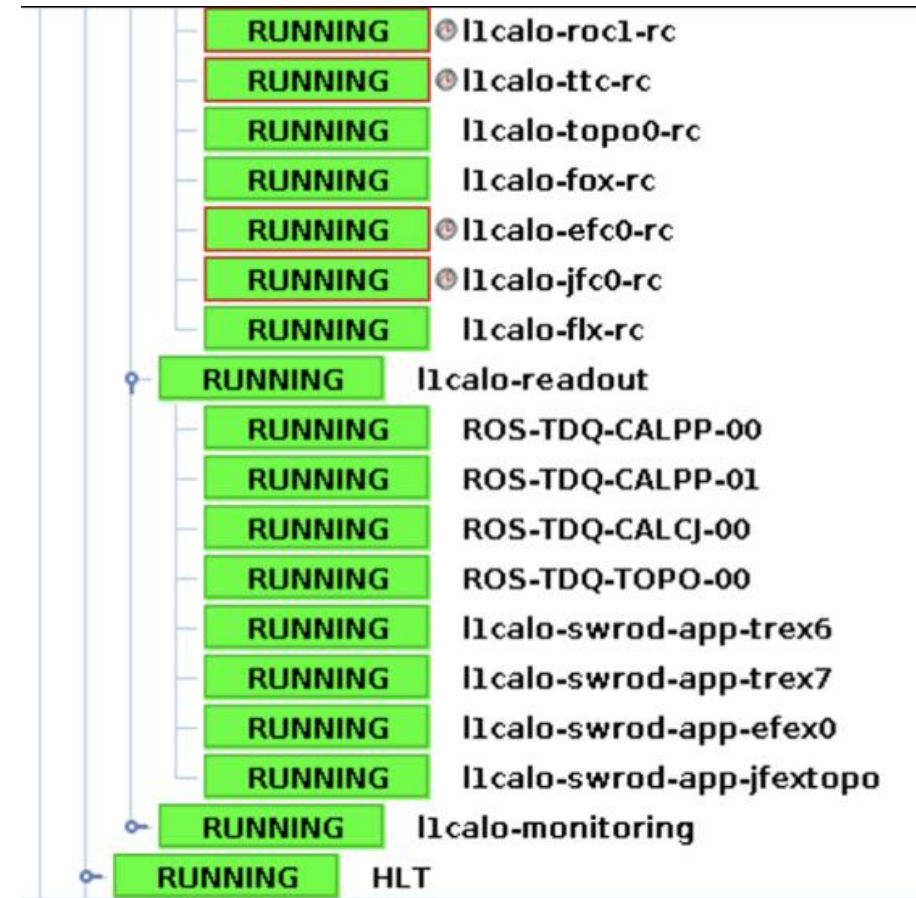
- M12 (March 2022)
  - Last Milestone week
  - After: Continuous data taking with 24h shift coverage
  - Final ALTI setup (last legacy TTC modules replaced)
- Another splash session (Start of May 2022)
  - Legacy timing still in a good shape after ALTI changes
  - eFEX readout in ATLAS data stream
- Collisions (Last week)
- Currently fast moving & interesting Phase-1 commissioning work ongoing





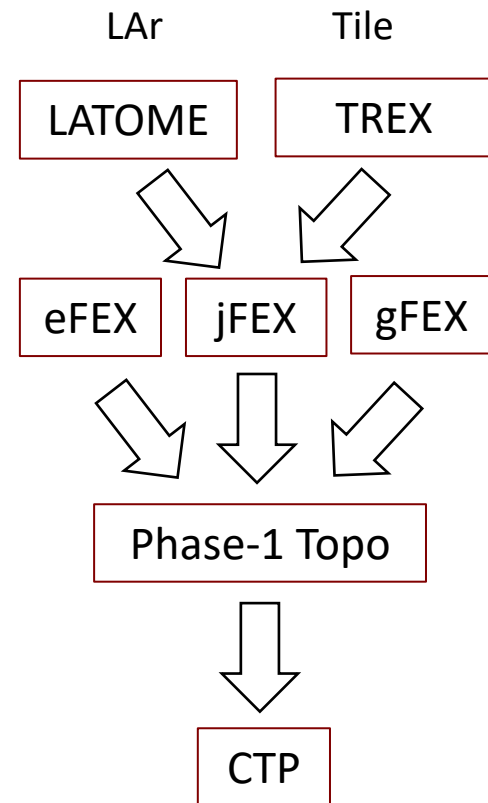
# Summary commissioning status Phase-1 systems

- TREX:
  - 100 kHz Phase-1 readout to FELIX with some issues
  - Real-time path to FEXes validated
- eFEX included in ATLAS during splashes, jFEX, gFEX & Phase-1 Topo parasitically
- All Phase-1 systems were able to be included recently into overnight ATLAS low-rate runs (stopless removal implemented)
- Issues seen with readout especially at high-rates for all the systems



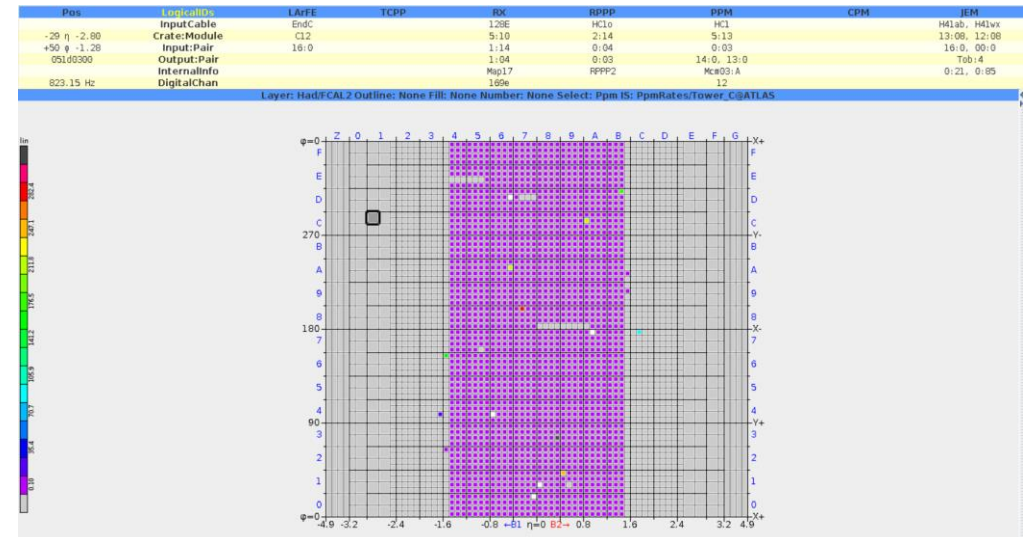
# Next Phase-1 commissioning steps

- Every Phase-1 system is heavily pushing to get the readout stable & functional
  - Readout is not stable enough yet: A lot of corrupt & dropped readout packages from all systems
  - Issues with new readout interface FELIX
  - Stable readout needed for validating algorithms & compare to simulation
- Validate the full real-time path
  - LATOME/TREX input mapping verified
  - FEX to Phase-1 Topo links tested: FW work ongoing
  - Phase-1 Topo to CTP links to be re-tested
  - Latency measurements



# Summary re-commissioning status legacy system

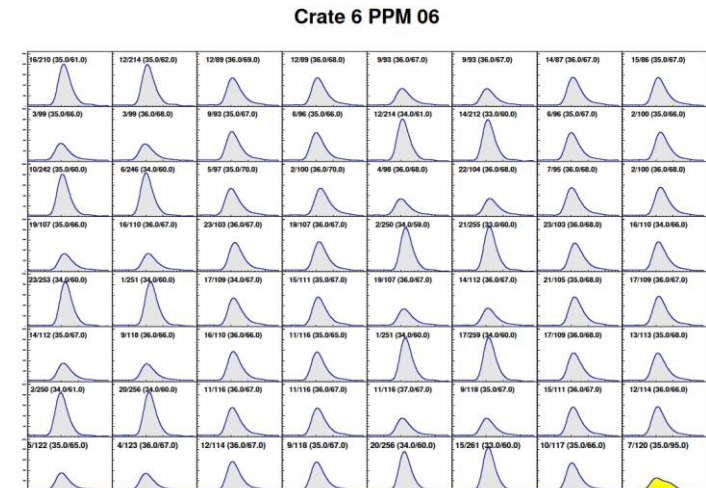
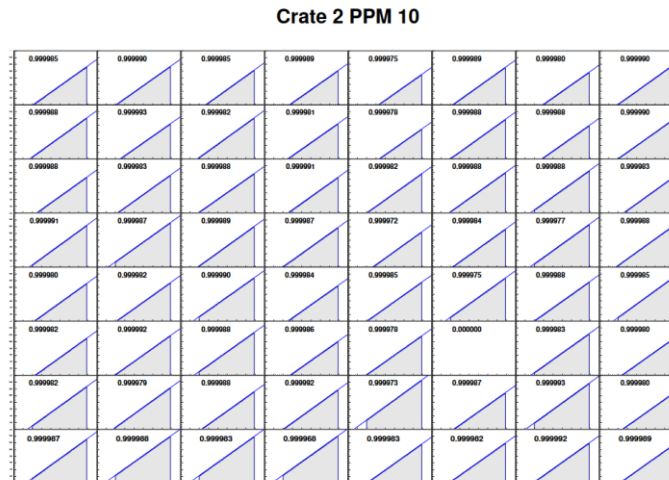
- Legacy system overall in a good state, running stably in several combined runs, splashes & collisions
- Some smaller issues most probably due to new ALTI setup (Topo busy, CPM errors, etc.) → Mostly fixable with FW reload
- Legacy physics timing in a good state, detailed analysis with more collision data
- Noisy/problematic tower hunting with LAr & Tile ongoing, already several tower fixed
- Re-calibration of the legacy system ongoing



# Legacy calibrations

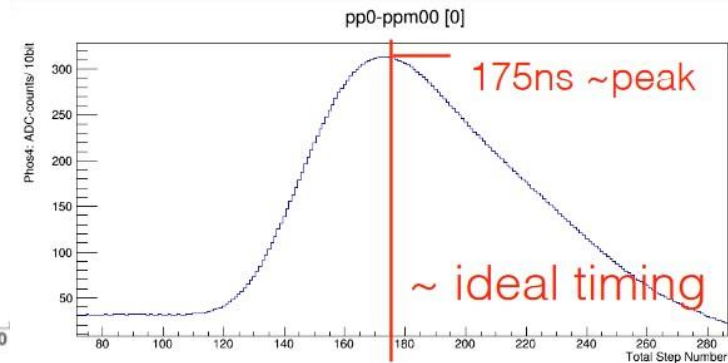
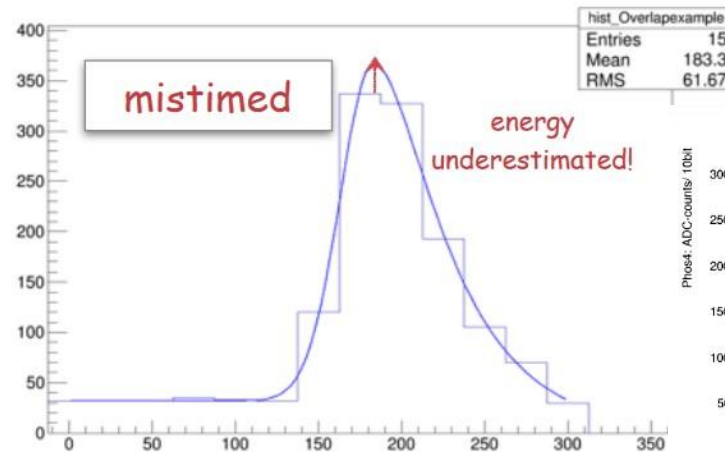
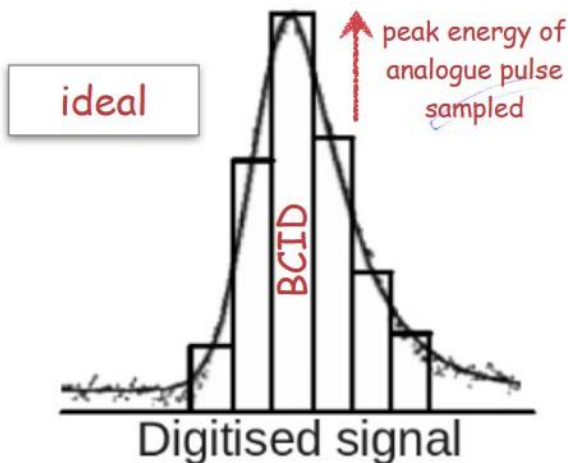
- Standalone calibrations:
  - DAC scan:
    - Set the signal pedestal (zero voltage level) to the same value for all channels
    - Scan through different DAC offset values to check linear dependence to digitized ADC values
  - PED scan:
    - Measure the mean value and width of the signal pedestal distribution for each TT

- Combined calibrations:
  - PHOS4 scan (timing)
  - Energy scan



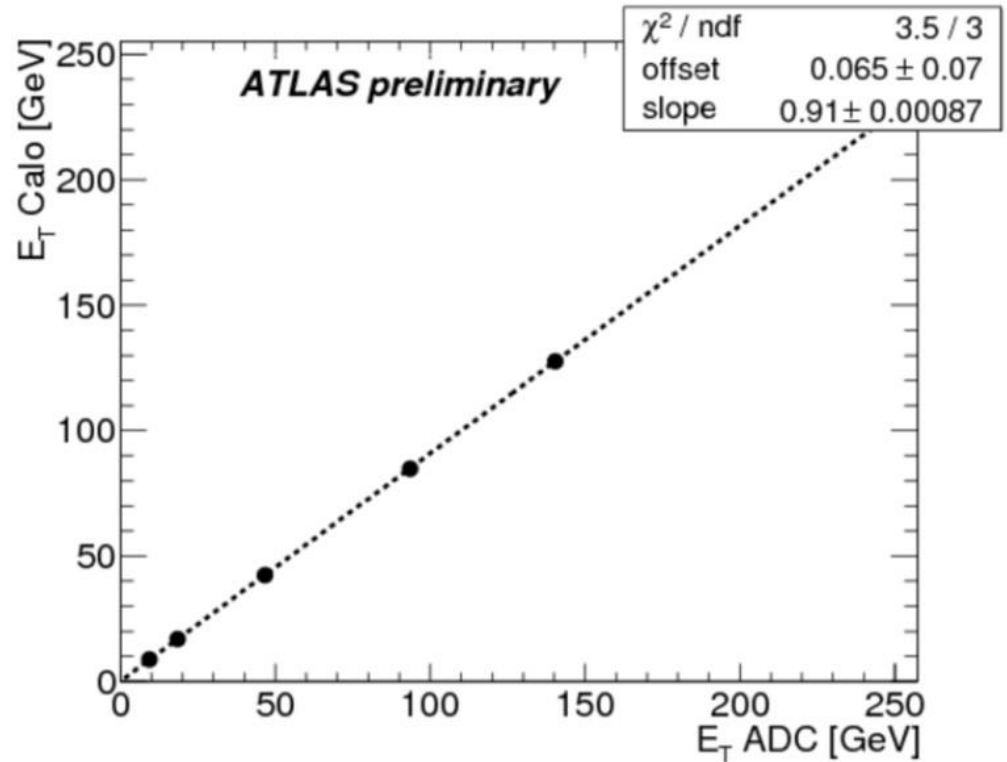
# PHOS4 scan (Timing)

- Need to adjust input timing delays per trigger tower with a precision of  $\sim 1\text{ns}$
- Calorimeter charge injection pulses as input
- Scan pulse by stepwise moving the input timing (1 step =  $1.04\text{ns}$ )
- Compare measured peak position to ideal position for 15 ADC slice readout ( $175\text{ns}$ )



# Energy scan

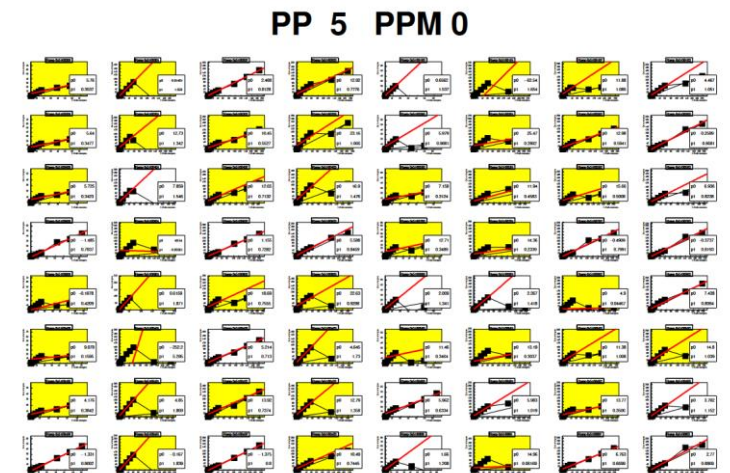
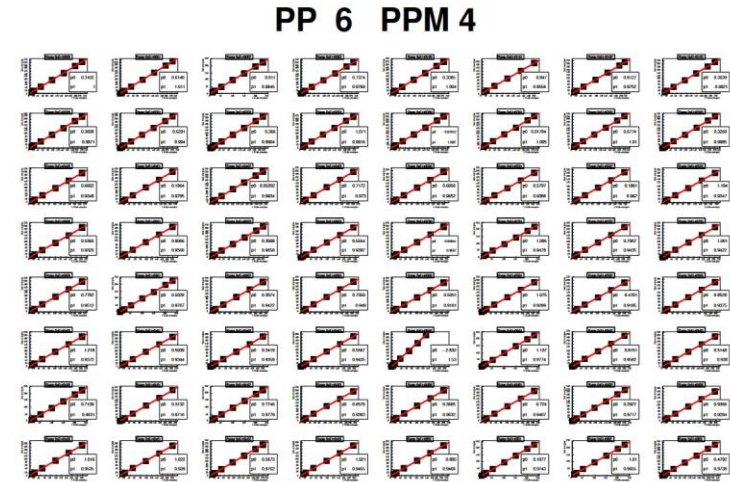
- Energy calibration per trigger tower implemented in analogue receiver gains
- Calorimeter charge injection pulses as input, increase energy every 200 events
- Calibrate with respect to the (more precise) energy as measured by the calorimeter
- In offline analysis derive receiver gains





# Legacy calibrations - Status

- After a long debugging phase after ALTI upgrade LAr & Tile calibrations finally working
- Tile calorimeter:
  - Timing calibration with final ALTI setup done → Calibration partition timed in
  - Energy scans taken, validation ongoing
  - Tile gains seem to be lower, Tile workshop 2<sup>nd</sup> of June
- LAr calorimeter:
  - Timing calibration with “almost” final ALTI setup done → Calibration partition timed in
  - Energy scans taken, validation ongoing
  - Issues seen in FCAL-C, debugging ongoing
  - Changes in LAr ALTI setup → Timing calibration re-taken
- Noisy/problematic tower hunting ongoing



# Phase-1 calibrations

- First thoughts about FEX calibration done
- Store parameter in Trigger Menu (stable) & COOL database (changes more often)
- Preliminary parameter calculated with MC studies & simulation
- eFEX (COOL parameter):
  - Noise cuts (depend on several factors)
  - Electron cluster calibration (dead material corrections)
- jFEX (COOL parameter):
  - Noise cuts
  - Small-R jet  $E_T$  calibration
  - Tower masks
  - Pile-up parameters
- gFEX (COOL parameter):
  - Noise cuts
  - Pile-up parameters
  - gTower calibration LUT



## Back-up Slides

# Timing Adjustment – Pilot Run

Idea:

1. Fit calorimeter signal to data
2. Compare to read out ADC values
3. Difference in time  
between max. amplitudes = correction

Adjustment:

- Correct the input timing by time difference

