The ATLAS Run III L1 calorimeter trigger

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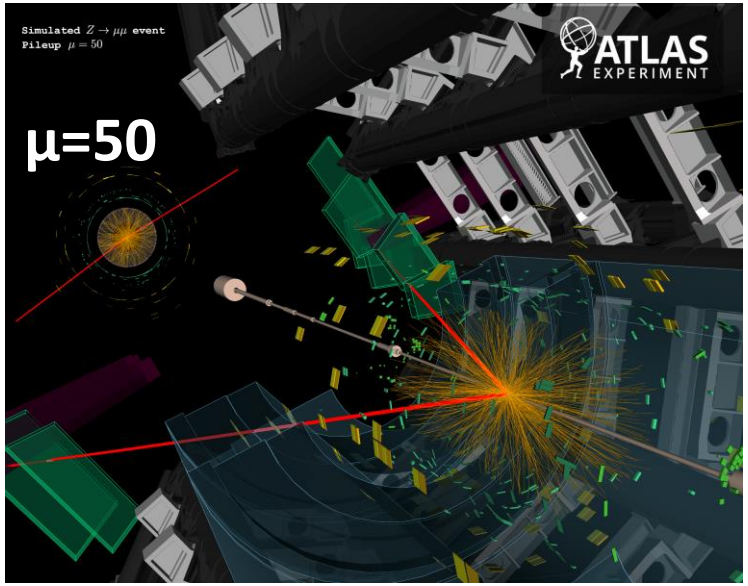
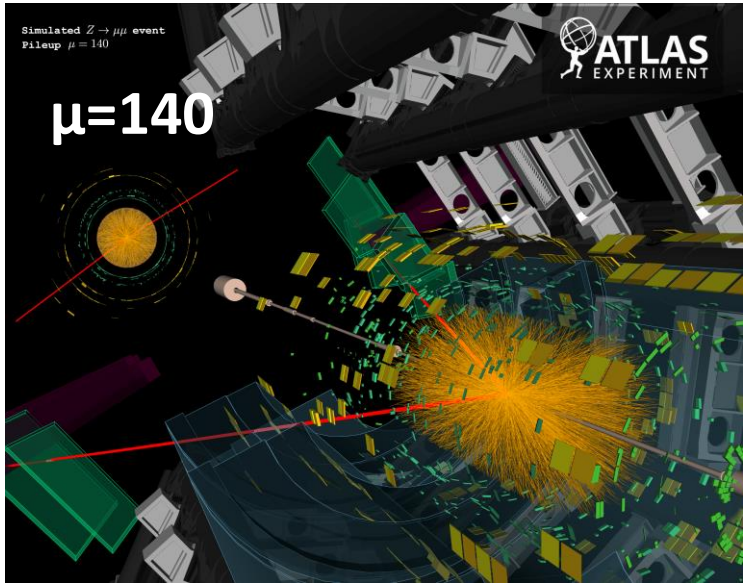
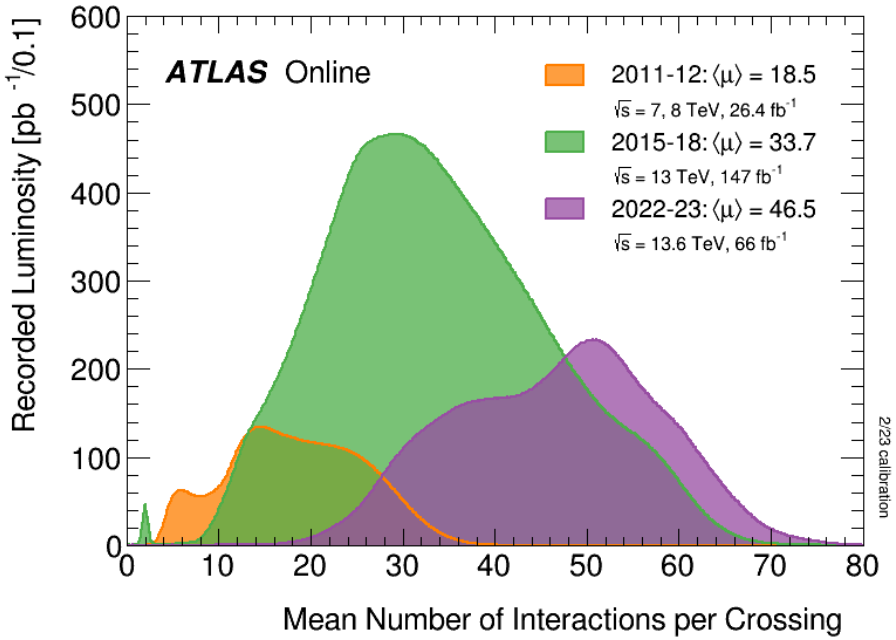
ATLAS EXPERIMENT

Run III







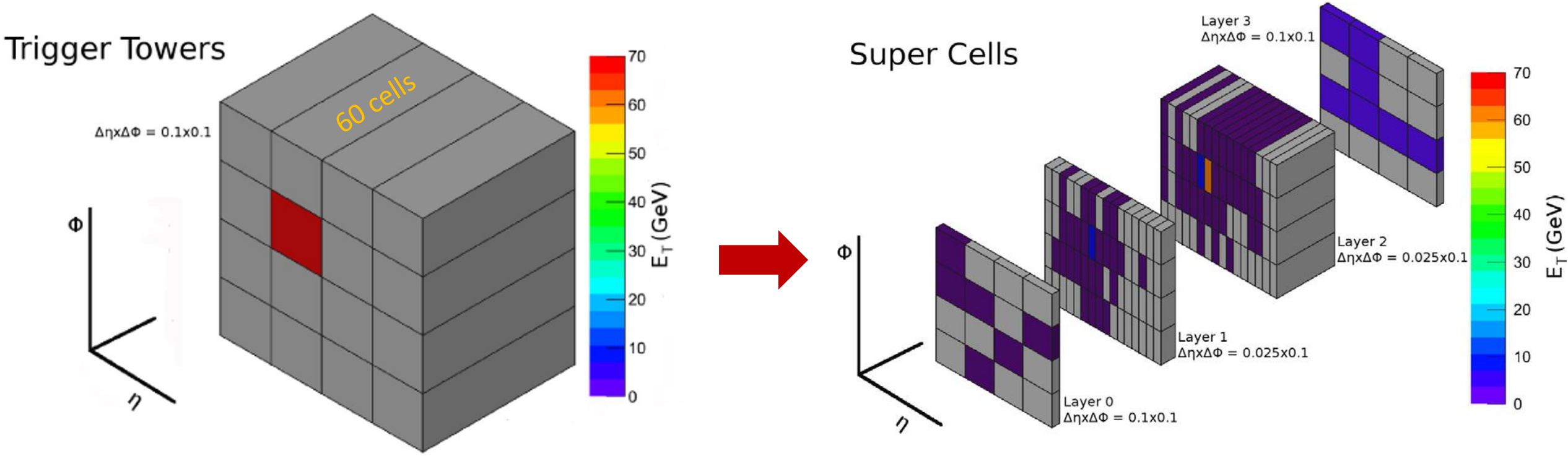
AtlasResultsRun3

- **40 MHz → 60 PetaByte/s**
  - Level-1 trigger (hardware)→ 1/400 events (100 kHz)
  - High Level Trigger (software) → 1/100 (1 kHz)

- **Run 3 - 2022-2025 x2 nominal luminosity**
  - Decreased ability to identify signals due to severe pile-up
  - Increase L1 Calo trigger rate or higher p_T thresholds

- **New L1 system needed**

L1-calo granularity

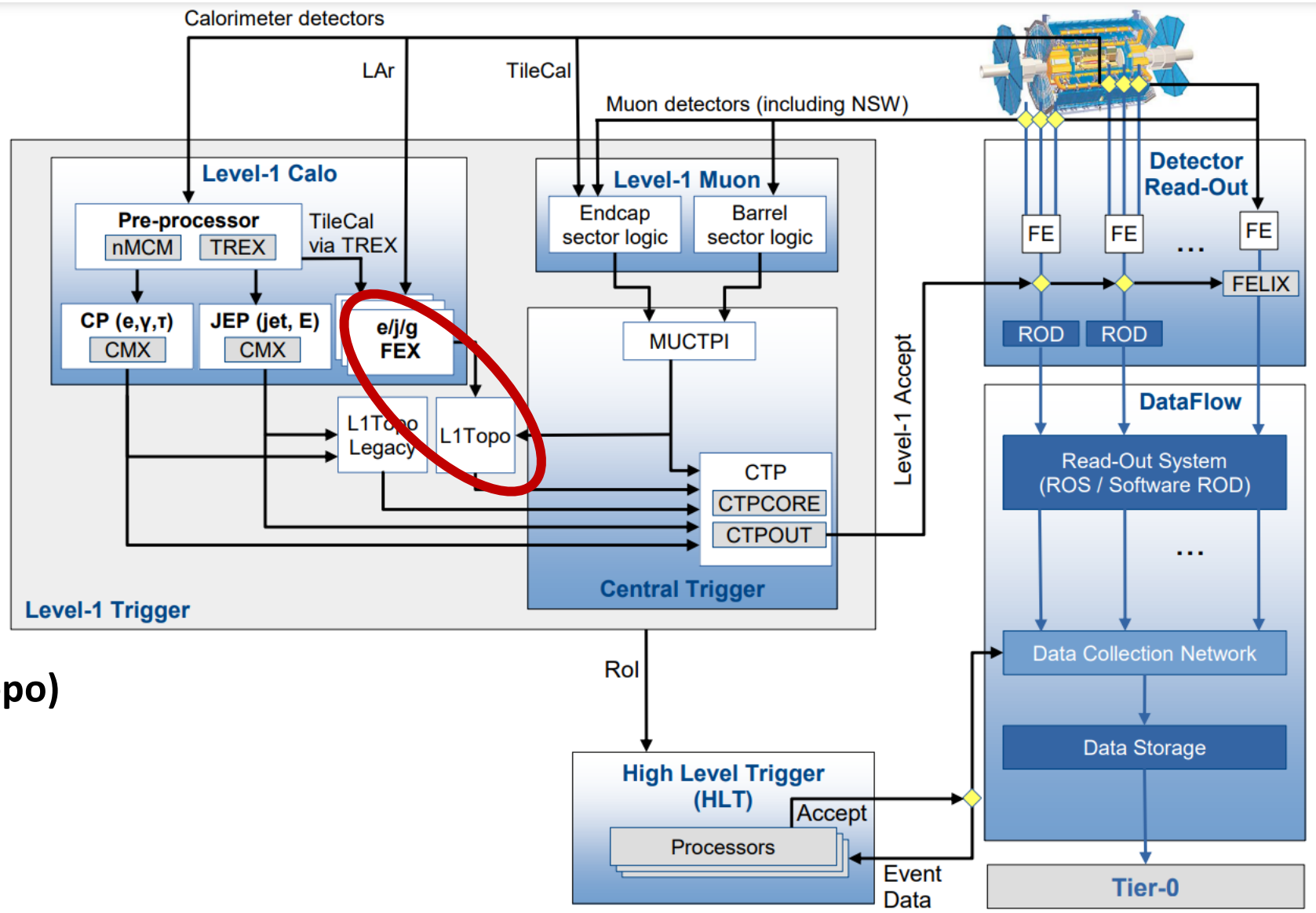


- **Trigger Tower → 10 Super Cells**
  - Shower shape algorithms
  - Better selection criteria
  - Improved resolutions

- **Preserve low-p_T thresholds at Level-1 and improve triggering performance**

Run III L1 overview

- **FEX (Feature EXtractors) + L1Topo**
  - Reprogrammable circuits (FPGA)
- **eFEX**
  - e/γ , τ
- **jFEX**
  - Small-R jets , τ , E_{Tmiss} , fwd e
- **gFEX**
  - Large-R jets , E_{Tmiss}
- **Level-1 Topological Processor (L1Topo)**
  - Combined triggers



L1calo UK

- **UK institutes are heavily involved**
  - Birmingham, Cambridge, QMUL, and RAL

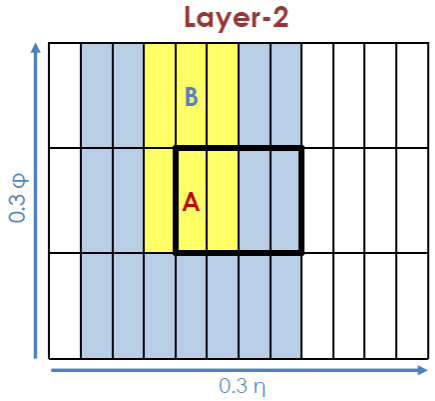
- **Responsibilities**
  - eFEX
  - FEX Test Module (FTM) : Test module used before final commissioning
  - ReadOut Drivers (ROD) : Collect and buffer data and transmits them to the DAQ system

- **Several management positions**

Activity	Contact person
Coordinator	Martin Wessels
Deputy coordinator	Paul Thompson
L0Calo Coordinator	Ian Brawn
Run Coordination	Silvia Franchino, Rhys Owen, Simone Sottocornola
Offline software	Will Buttinger
Online software	
DCS & monitoring	
Performance & Tuning	Panagiotis Bellos, Silvia Franchino
Menu coordination group contact	Cecilia Tosciri
L1Topo algorithm commissioning	Ralf Gugel, Javier Jimenez Pena

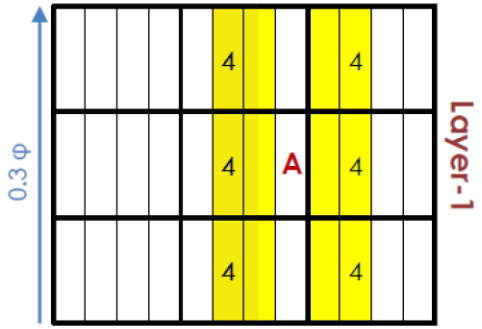
Electron Algorithms

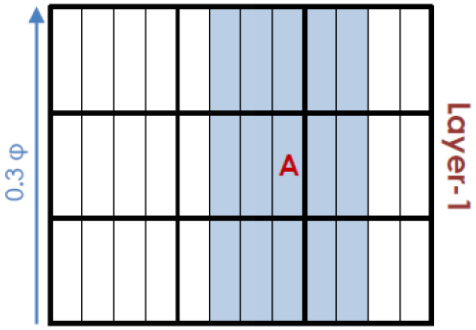
- **Seed Finder looks for local maxima on Layer 2**
  - Clusters are built around the seed – 99 SuperCells



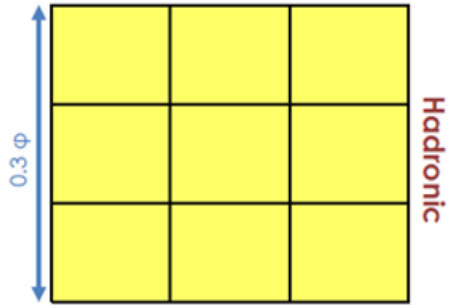
- **The isolation condition :** $\mathbf{R_\eta = \frac{E_{clu}}{E_{clu}+E_{env}}}$
  - e/γ are isolated

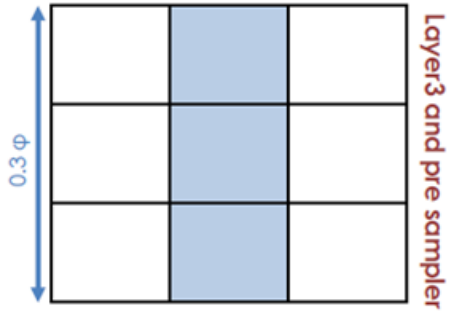
- **The Cluster width condition :** $\mathbf{w_s^2 = \frac{\sum E_i \cdot (i - i_{max})^2}{\sum E_i}}$
  - e/γ are more narrow than jets

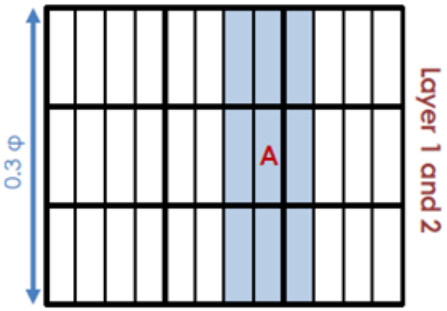




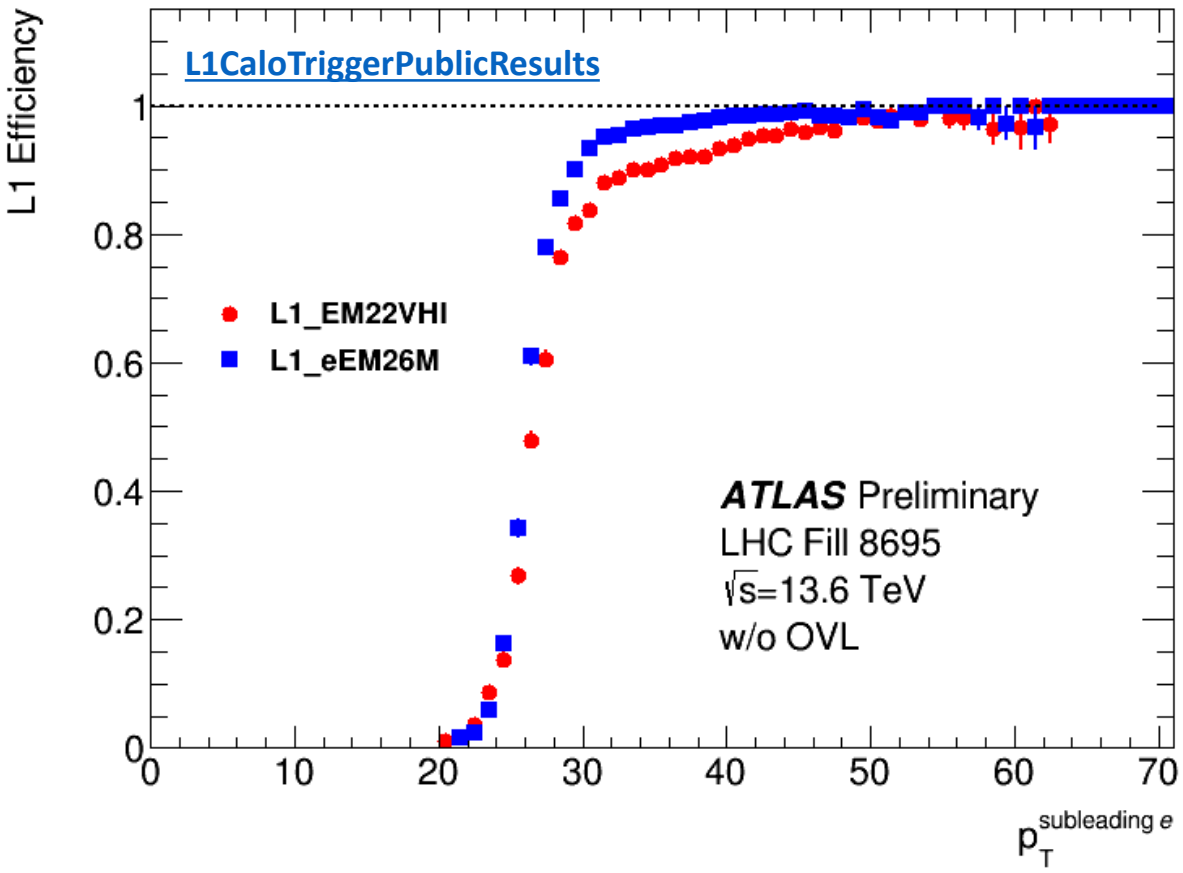
- **The hadronic condition :** $\mathbf{R_h = \frac{E_{had}}{E_{EM}+E_{had}}}$
  - Jets deposit more energy in hadronic than e/γ

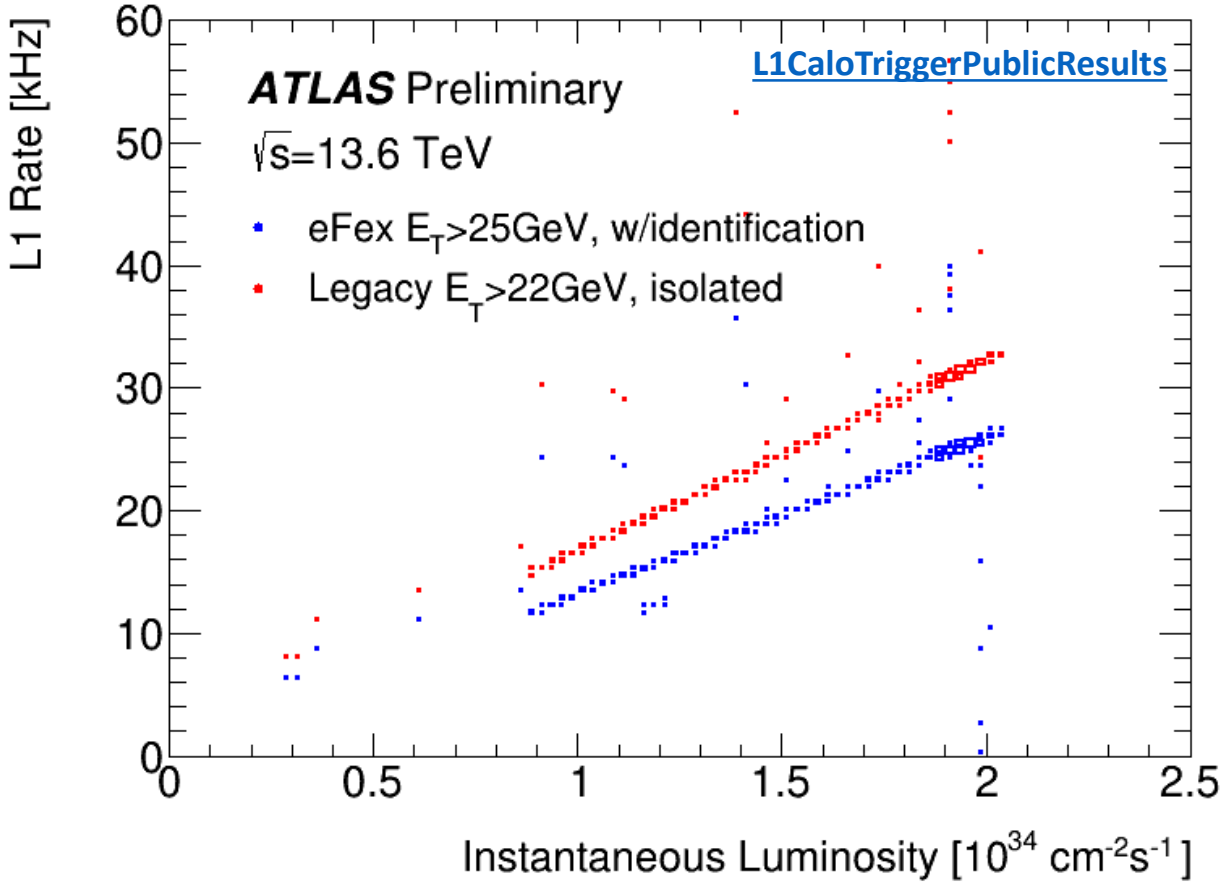






Electron performance

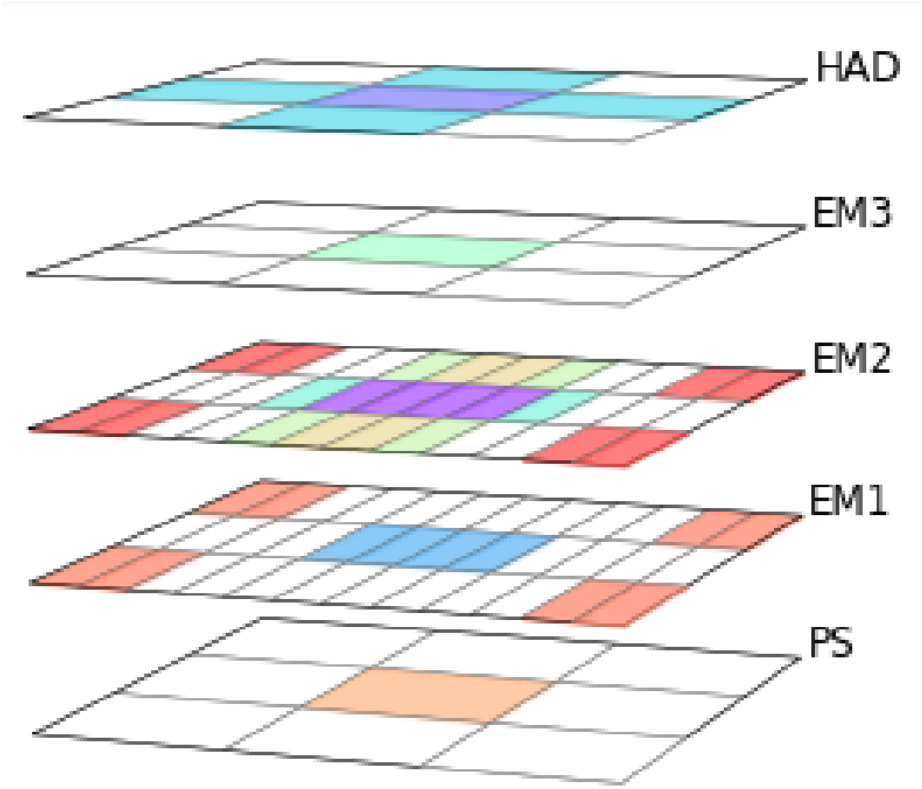


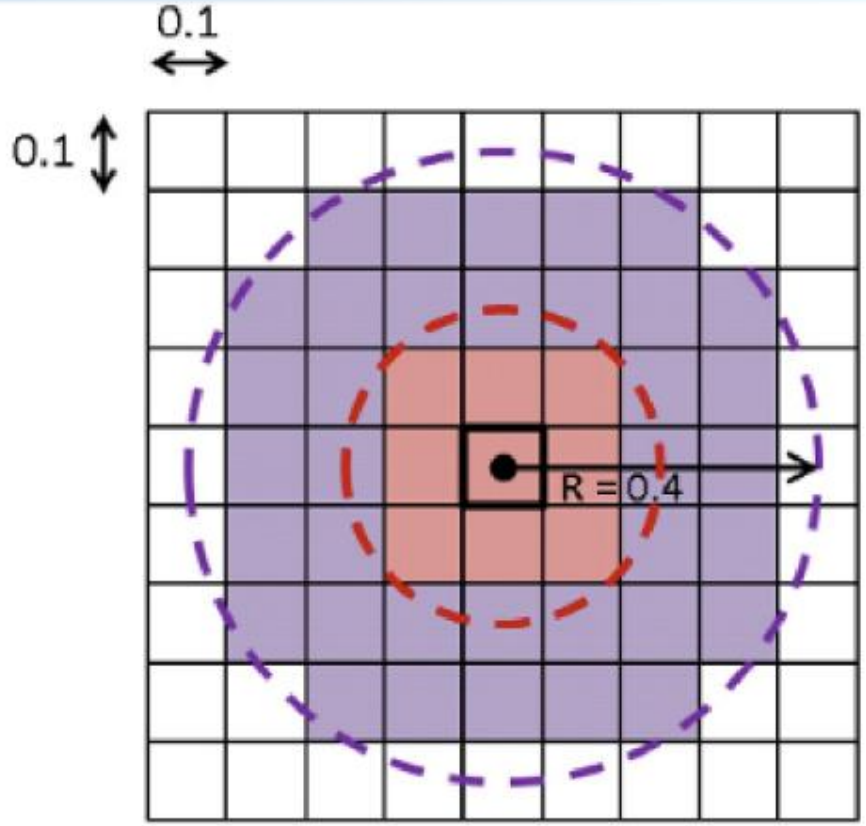


- **eFEX used for electron trigger in 2023!**

- **Switching from Legacy to eFEX**
  - Single-e saves ~ 5 kHz
  - Smaller saving from multi-e

Tau and jet algorithms





- **eFEX tau**
  - Search for local maximum on layer 2
  - 11 SC sums in a BDT
  - Identifies tau TOBs
  - Calculates TOB energy
  - Combined with jFEX info in L1Topo

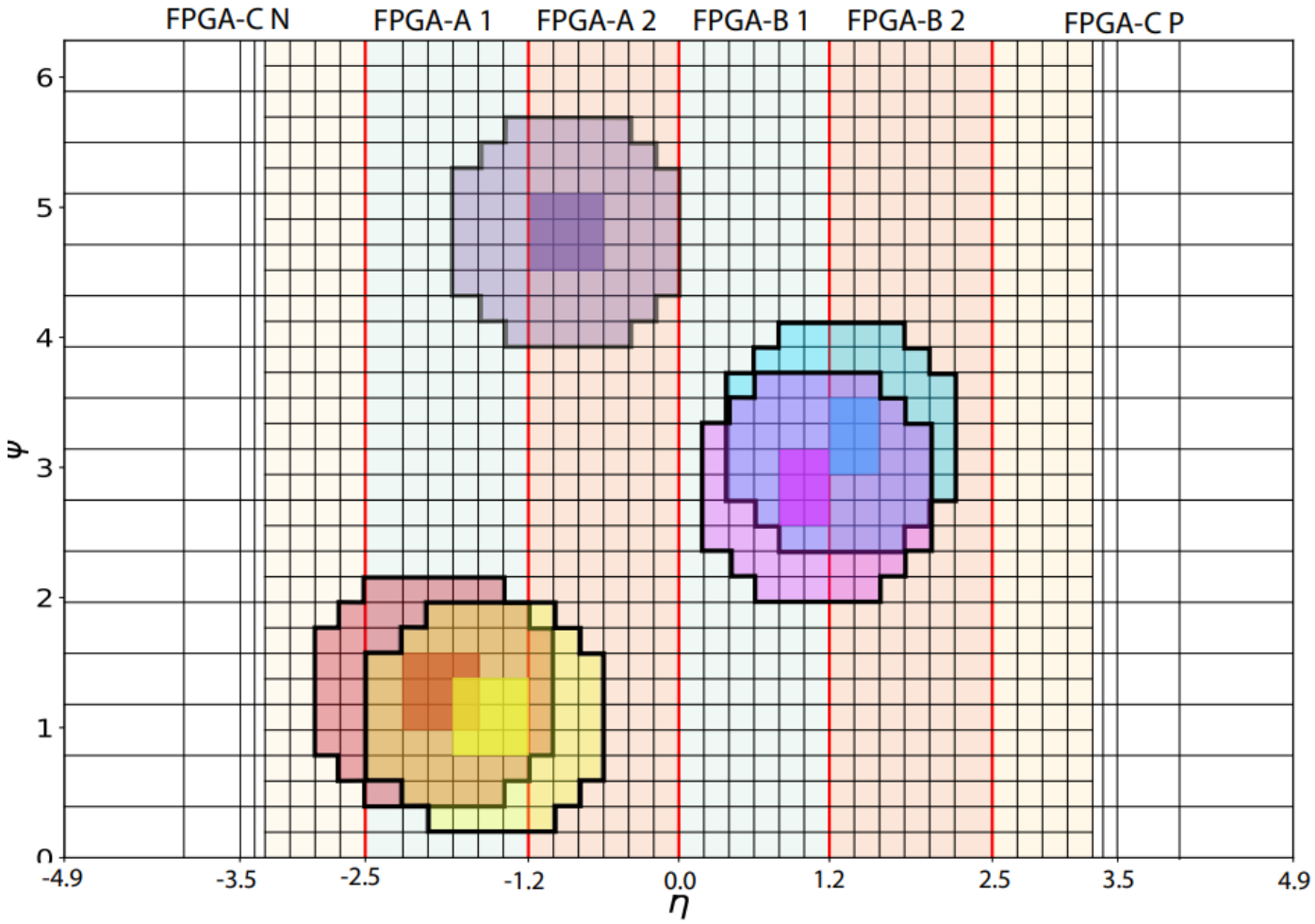
- **jFEX jets**
  - Seed if local maximum in 0.3 x 0.3
  - 0.9 x 0.9 is summed to reconstruct jet

- **jFEX MET**
  - Sum over all towers above threshold (pile-up & noise)

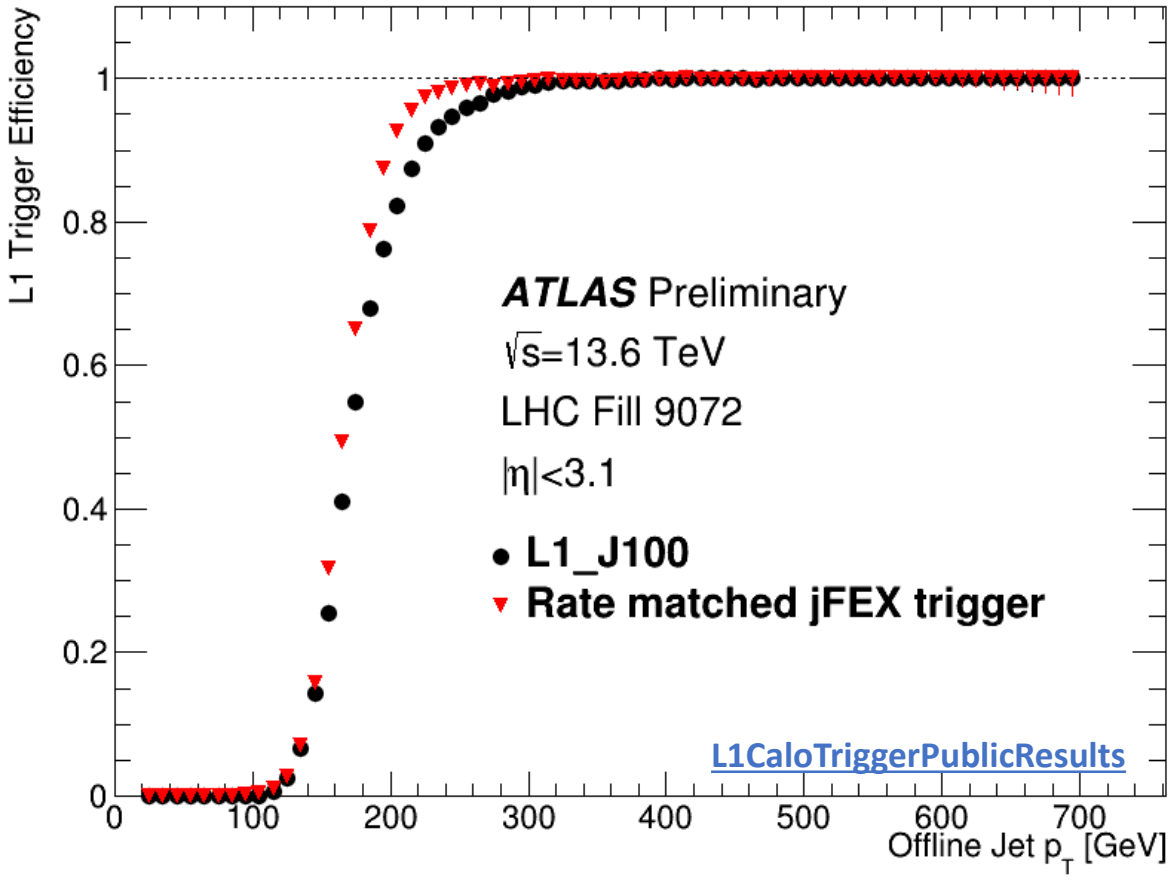
Large jets and Missing E_T

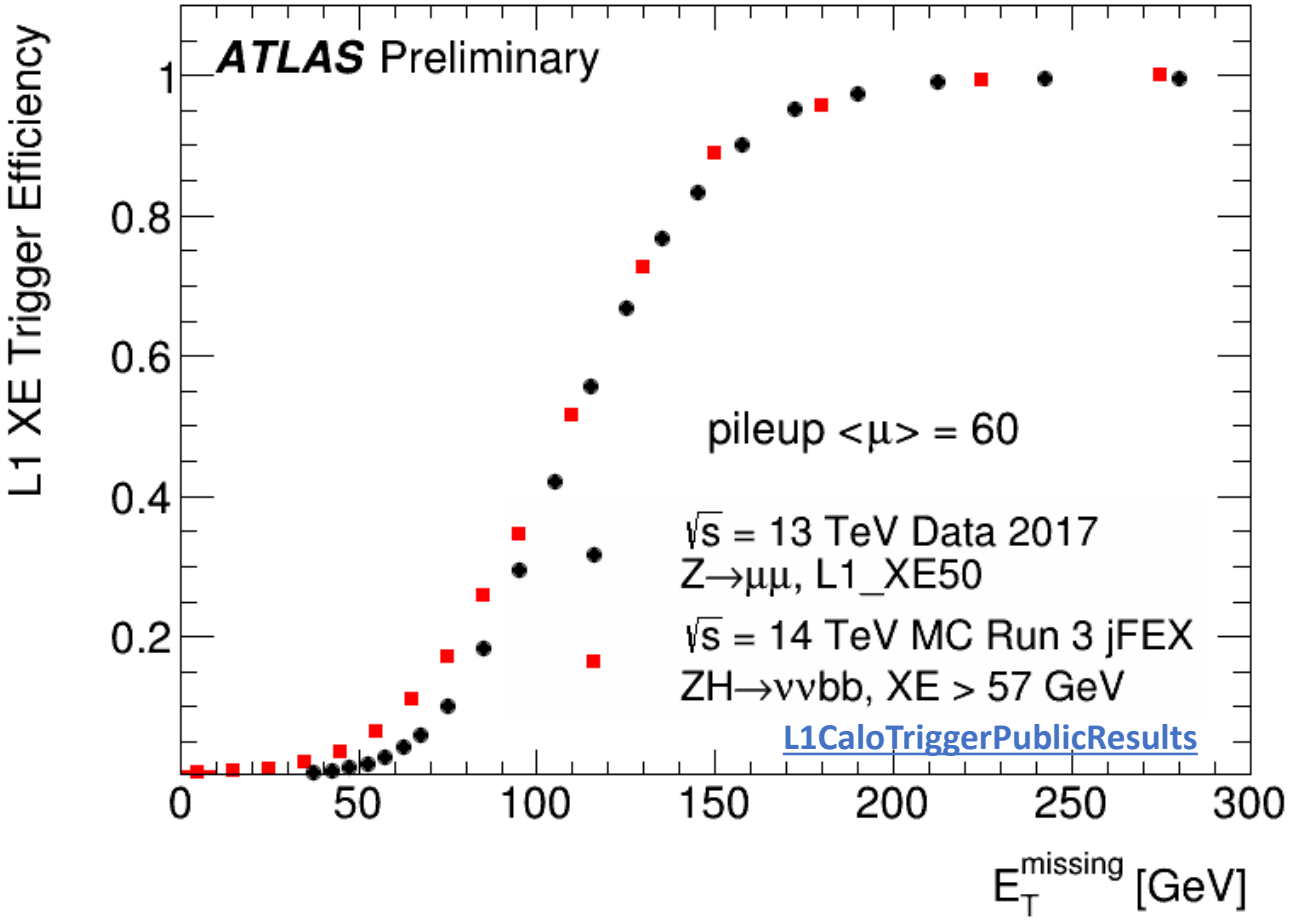
- **gFEX Large jets**
  - Inputs from entire EM and Had calorimeters
  - Seeds are defined by Towers (0.2x0.2) over a configurable E_T threshold
  - Transfer of seed information between FPGA to reconstruct large jets
  - 69 gTowers, large-radius jets built around the seed

- **gFEX MET**
  - Separates gTowers into Hard and Soft term based on E_T
  - MET is a linear combination of the 2 terms
  - Calculated in each pFPGA and summed up



Jets and MET performance





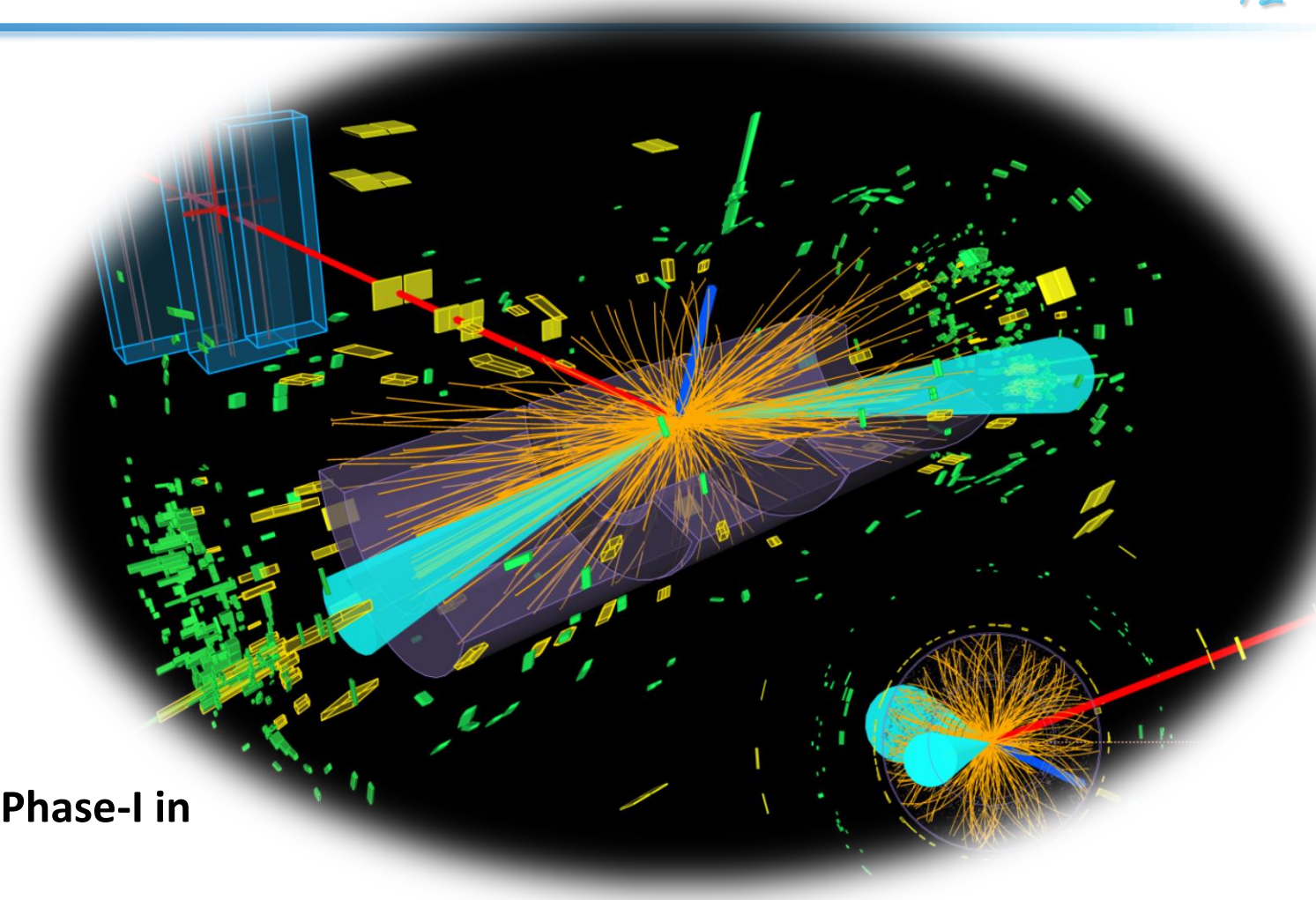
Run 3 trigger menu overview

Trigger type	System	Status
Single/multi e	eFEX	Excellent improvement - Used throughout in 2023
Single/multi τ	eFEX	In operation – better performance for high p_T
Combined τ	eFEX, jFEX, L1 Topo	In operation - better performance for high p_T
Small jet	jFEX	In operation – good performance
Large Jet	gFEX	Ready in 2024
Multi jet	jFEX	Ready in 2024
MET	jFEX	Ready in 2024
MET	gFEX	Ready in 2024
Topological	L1 Topo	Muon used in 2023, others in 2024

- **Legacy system will be disabled in 2024**
  - Trigger completed dependent on Phase I
  - e and non-isolated taus fully commissioned in 2023
  - Most of the trigger items in good shape

Summary

- L1calo is crucial for ATLAS performance
- All the phase 1 hardware is installed and functioning
- Firmware and software ready
- Performance is good after extensive tuning, fixing remaining issues
- Most of the trigger menu items work well
- Getting ready to switch remaining items to Phase-I in 2024



Thank you!