ATLAS LIQUID ARGON CALORIMETER AT DAWN OF LHC RUN-2

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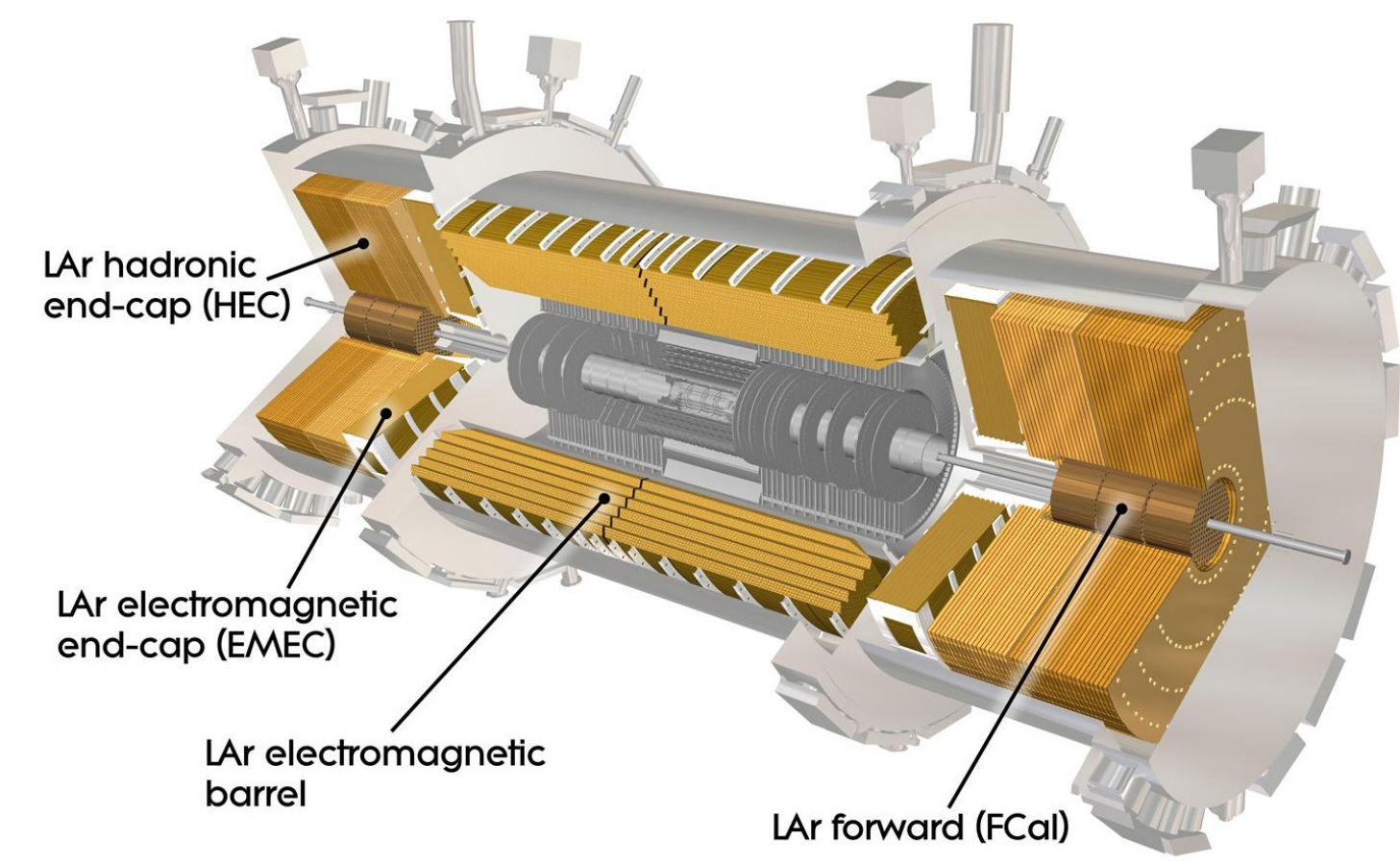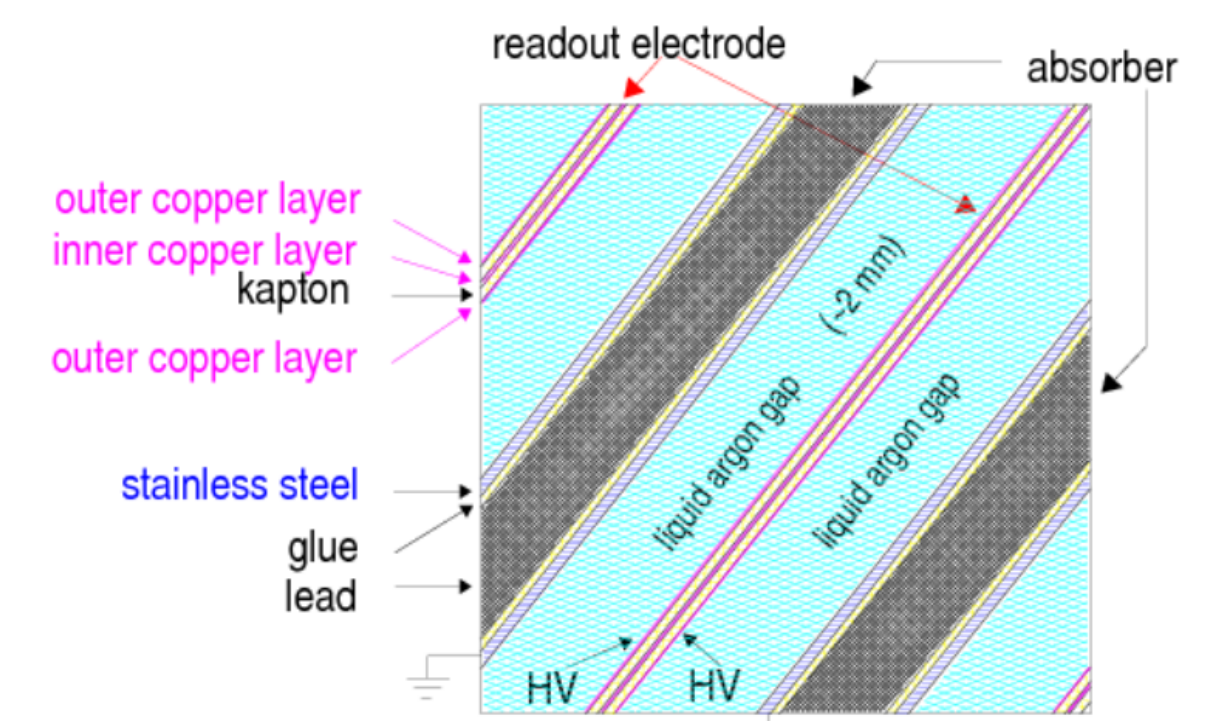
LIQUID ARGON (LAr) SAMPLING CALORIMETER [1]

- **LAr Calorimeters are composed of 3 main parts** using liquid argon as active medium:
  → The Electromagnetic Calorimeter (barrel and end-cap) is characterized by an homogeneous **accordion shape** enabling a full azimutal coverage and a fast readout.
  → The hadronic end-cap makes use of **copper plates as passive material**.
  → The Forward calorimeter has a copper/tungsten matrix with a **specific honeycomb design and thin argon gap** to sustain high irradiation in regions close to the beam pipe.
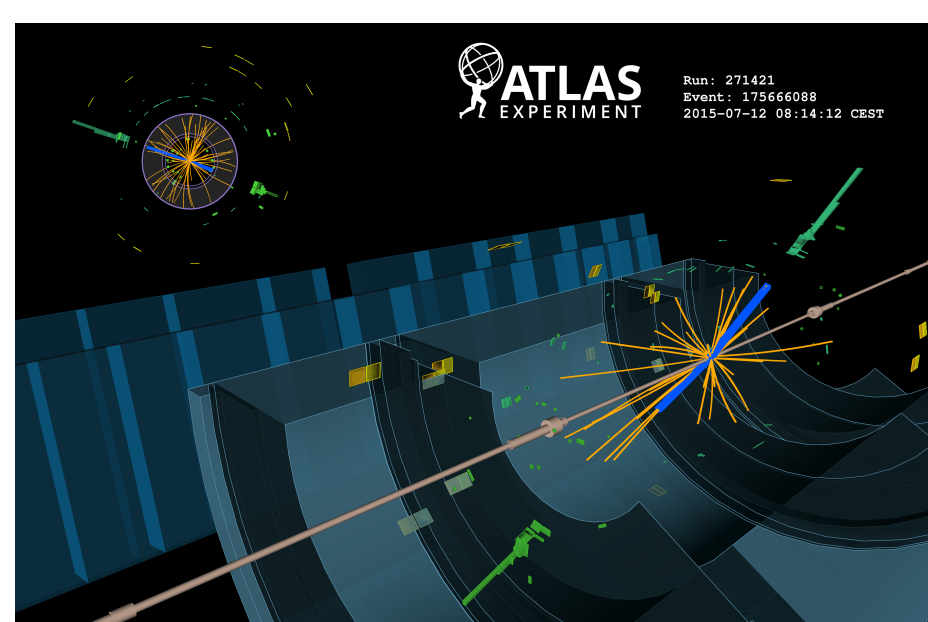- Between 3 and 4 layers enable to determine the shower shape development.

- **LAr Calorimeter signals serve as input to the level-1 trigger** (L1Calo).
  → Cell energies are summed over the layers and on $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ regions to form trigger towers (TT).

AT HEART OF DISCOVERIES

- **LAr Calorimeters are essential for photon and electron identification and precise energy measurement.**
$$\frac{\sigma_E}{E} = \frac{10\%}{\sqrt{E}} \oplus \frac{250 MeV}{E} \oplus 1\% \text{ (barrel)}$$
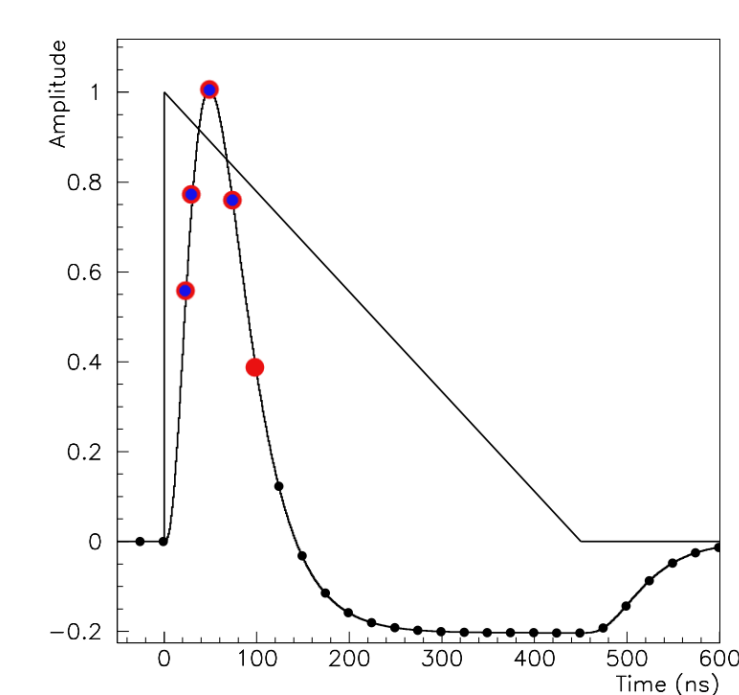- LAr Calorimetry had a key role in the **Higgs boson discovery**, in New Physics searches.

  Di-electron event recorded at $\sqrt{s} = 13$ TeV with invariant mass of $m_{e^+e^-} = 739$ GeV. The green bars represent the energy deposed in LAr .

- It also contributes to **Jet reconstruction** and **missing transverse energy** computation.

WHAT IS NEW FOR RUN-2 ?

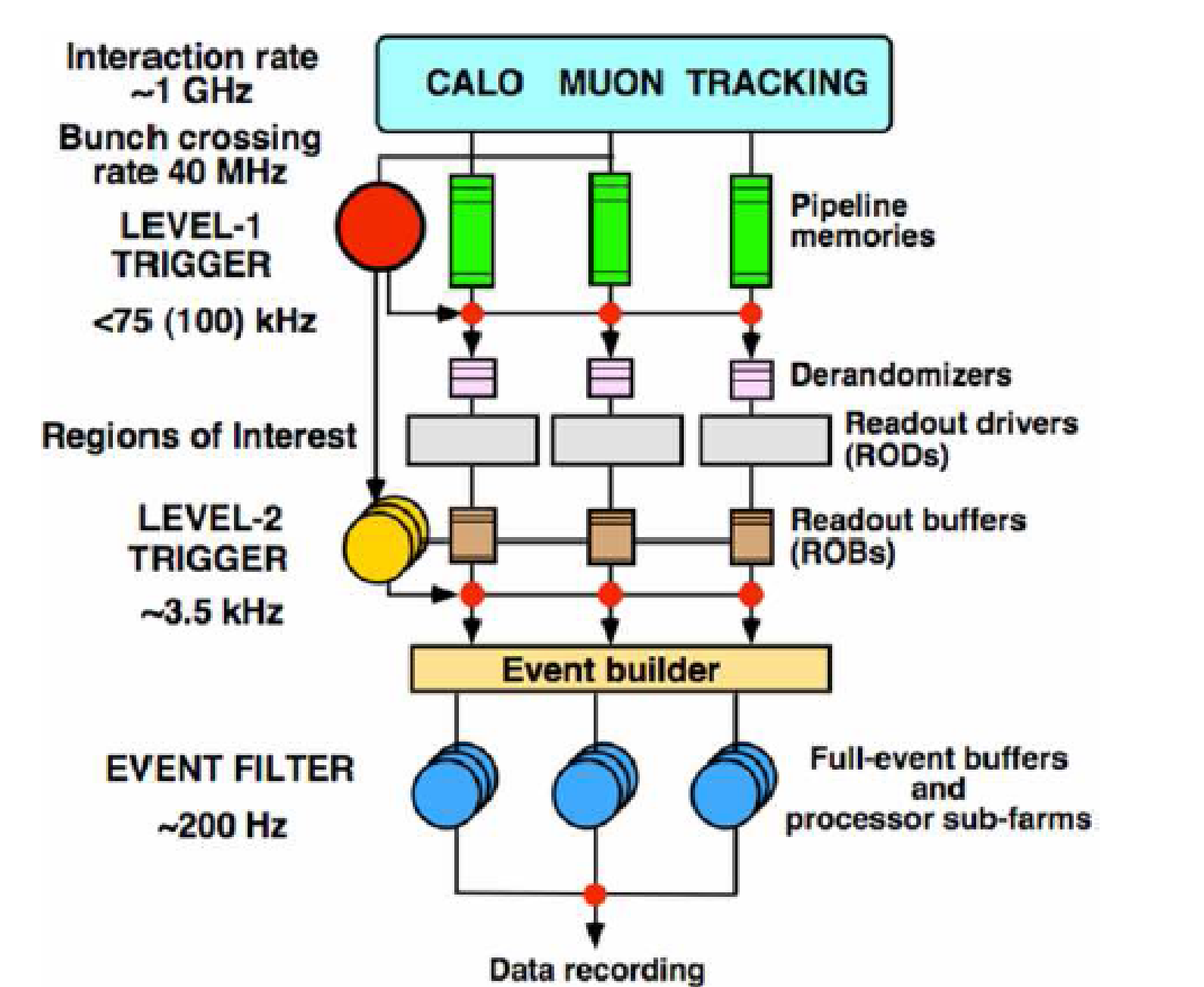- **Four digitized samples are now used to reconstruct the signal.** (5 during Run-1)

  → A negligible degradation is expected on energy/peak-timing resolution.
  → It reduced the readout latency and the event size and permits to enhance the L1 trigger rate to 100kHz (75kHz during Run-1).

- **Several high voltage (HV) power supplies were replaced.**
  → HV trips (due to intensity spikes) were the main source of LAr data losses: 0.46% out of a total of 0.88% in 2012 [2].
  → A new generation of power supplies has been successfully tested during Run-1 and proved **their robustness to intensity spikes.**
  → They have been **largely deployed during the 2013-2015 shutdown.**
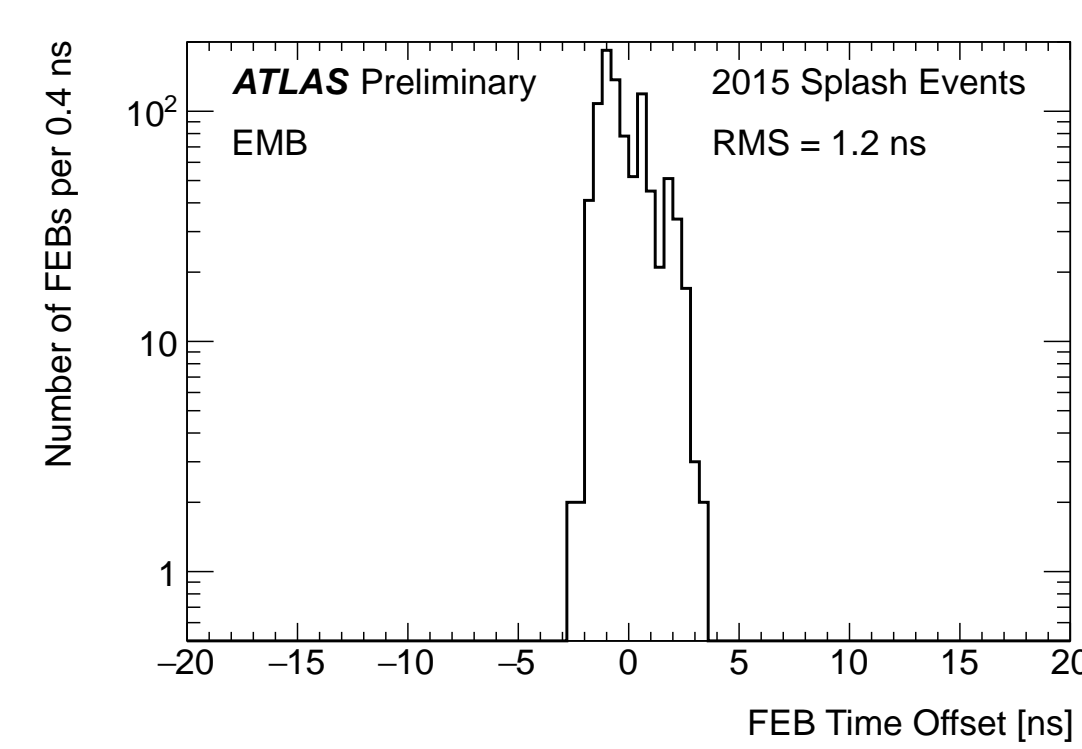
GLOBAL SYNCHRONIZATION

- In April 2015 the beam in the LHC was dumped in collimators 175m away from interaction point: beams splash
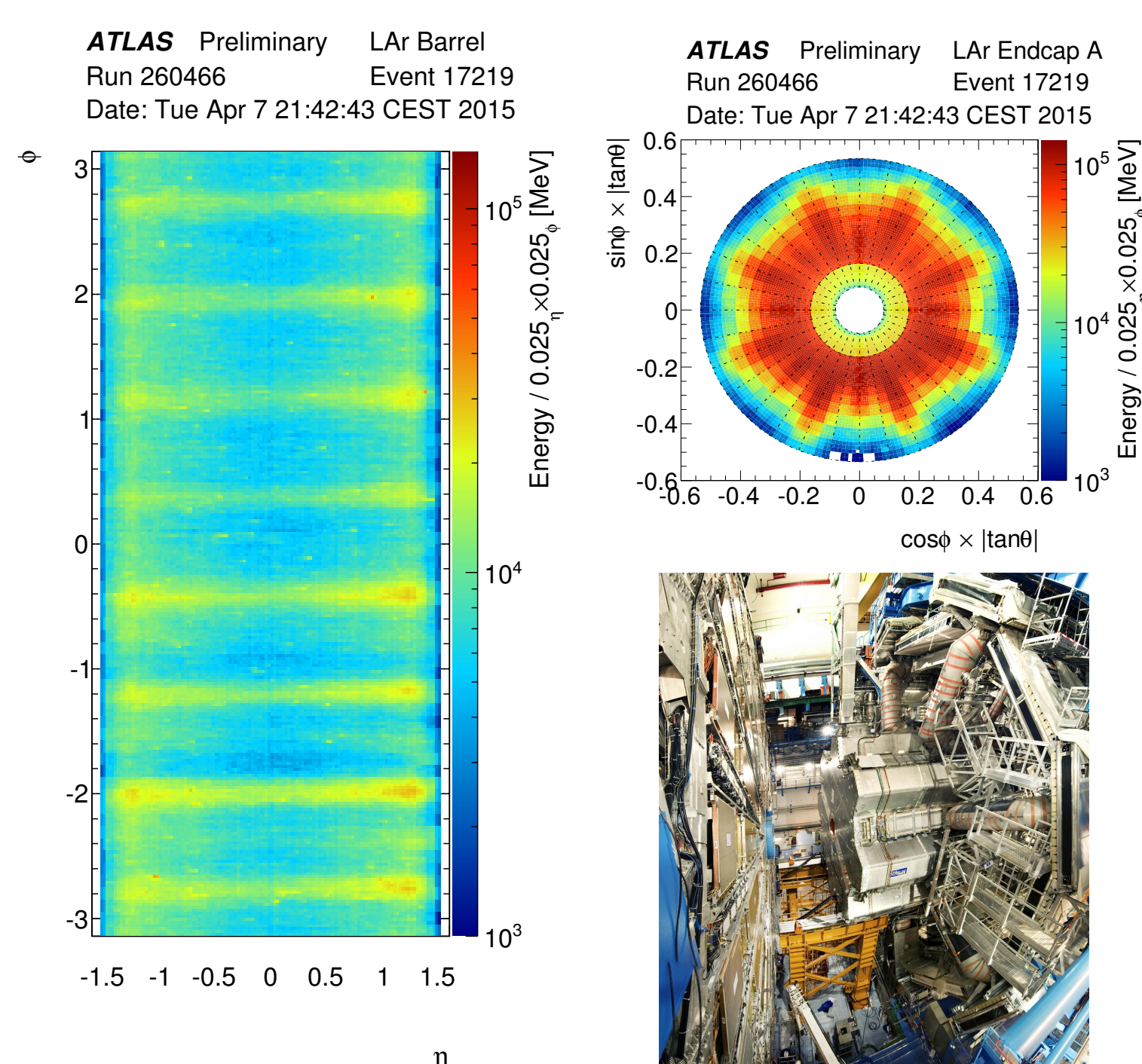 → It **lighted up the whole detector** with up to 8 PeV deposed per event.

- **Beam splashes are useful for an early cell by cell LAr synchronization**.

  → The **energy resolution strongly depends on the good timing** of the pulse peak.
  → The nearby figure shows an example of **cells synchronized within 1ns**. Each Front End acquisition Boards (FEB) reading out 128 of them.

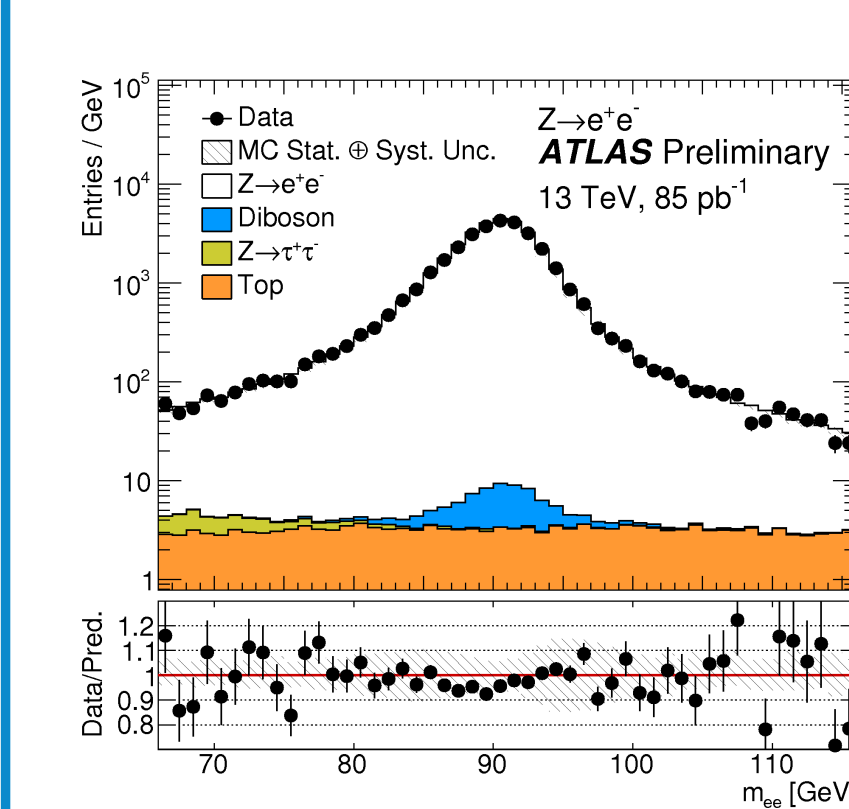- **They are also used to spot the inefficient areas**.

  → The figures on the left show the energy measured in the barrel and in one end-cap for such events.
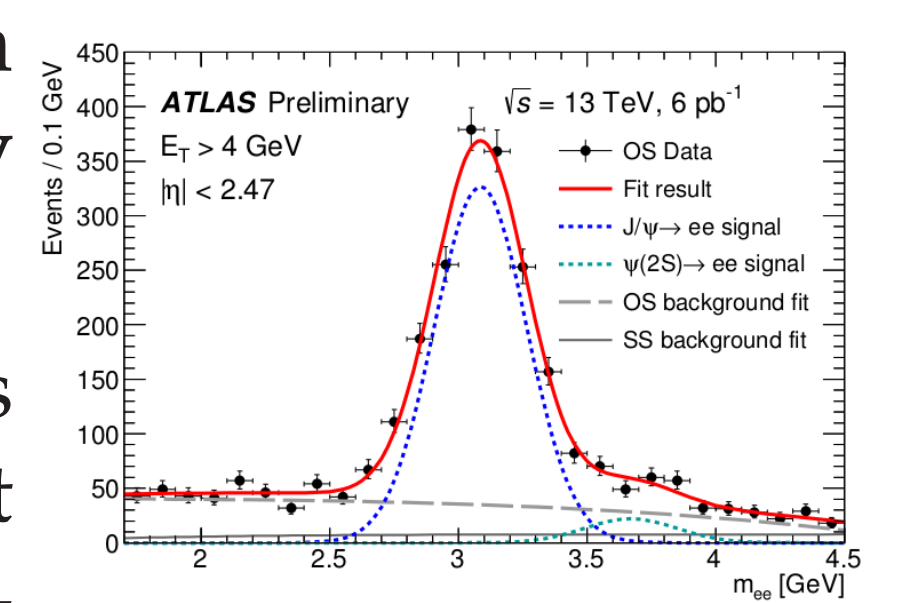 → No significant dead region appears.
  → **8 horizontal structures** in ϕ come from the **toroidal magnet end-cap**, which absorbs particles of the beam splashes events before they can reach the LAr Calorimeters.

EARLY ENERGY MEASUREMENT

- **The first $Z \to ee$ and $J/\Psi \to ee$ events have already been reconstructed from the early data** [3].
- The Monte-Carlo describes well the data, showing that the LAr Calorimeters behaviour is well understood.

LAr CALORIMETERS ARE READY TO TAKE MORE DATA!

TRIGGER UPGRADE FOR HIGHER LUMINOSITY

- **In 2018, the instantaneous luminosity is foreseen to be increased up to three times the design value** $(3 \times 10^{34} cm^{-2} s^{-1})$ equivalent to a number of collision per bunch crossing (μ) of around 80.
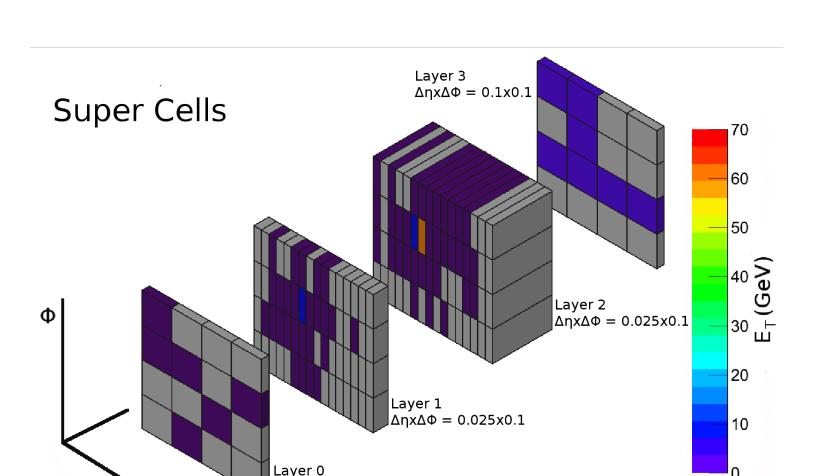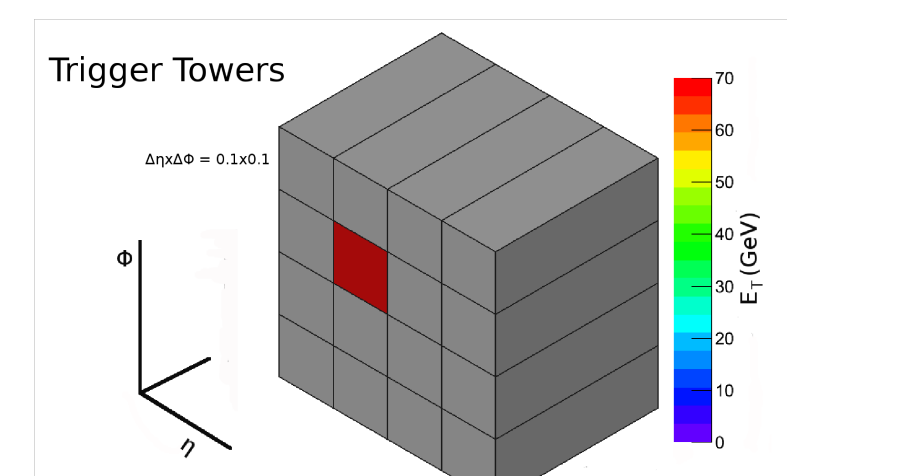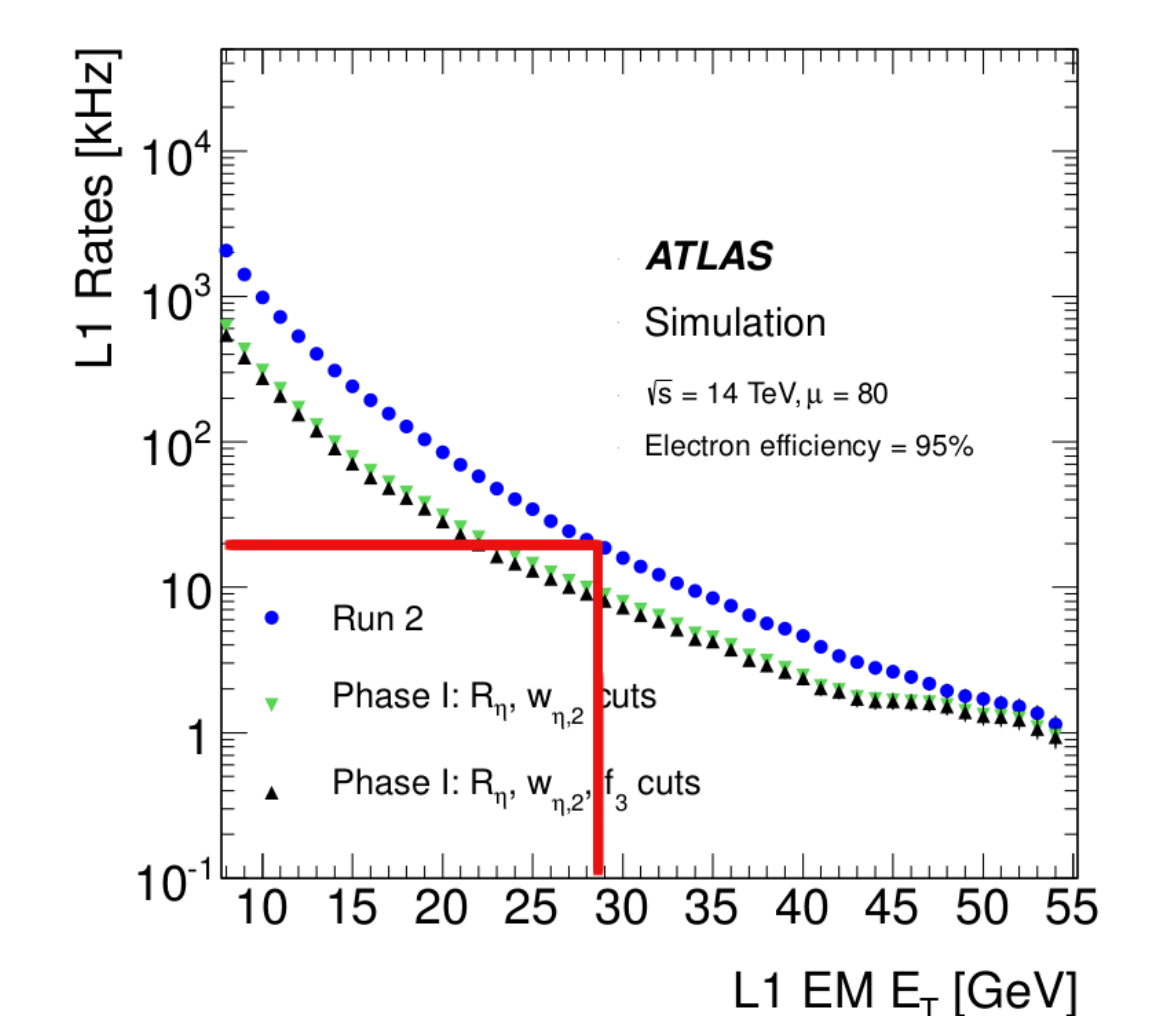
  → But the data acquisition assigns **a 20kHz bandwidth** for single electromagnetic object.
  → At $\mu = 80$ it correspond to a $E_T \approx 30$ GeV threshold limiting the ATLAS physics potential (blue dots).
  → It is planned to replace the TT by Super Cells [4] with finer granularity and the layer information.
  → The ability to reconstruct shower shapes will improve the jet background rejection for electron/photon trigger signatures. (green dots).
  → The simulation shows that a 20 GeV threshold could be restored.

- In 2015, 0.8% of the LAr readout is equipped with a parasitic upgraded trigger for hardware validation.
- Full installation is foreseen for 2018 during the Long Shutdown 2.

REFERENCES

[1] ATLAS Collaboration. The ATLAS experiment at the CERN Large Hadron Collider, JINST 3 (2008) S08003.
[2] ATLAS Collaboration. Monitoring and data quality assessment of the ATLAS liquid argon calorimeter, JINST 9 (2014) P07024.
[3] ATLAS Collaboration Measurement of W and Z Boson Production Cross Sections in pp Collisions at root s = 13 TeV in the ATLAS Detector, ATLAS-CONF-2015-039
[4] M. Aleksa et al. ATLAS Liquid Argon Calorimeter Phase-I Upgrade Technical Design Report,CERN-LHCC-2013-017, ATLAS-TDR-022.