Noise burst mitigation measures in the ATLAS Liquid Argon calorimeter

Journées de Rencontre des Jeunes Chercheur·se·s 2024

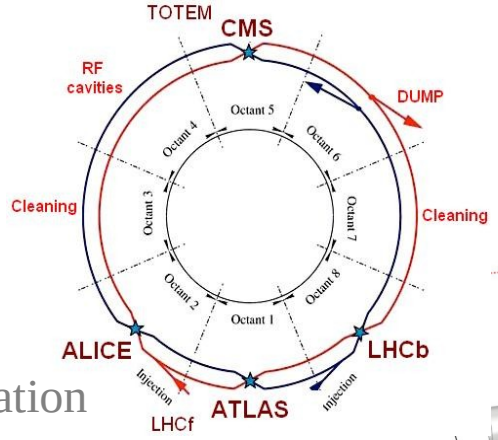
Christian Mavungu Tsava

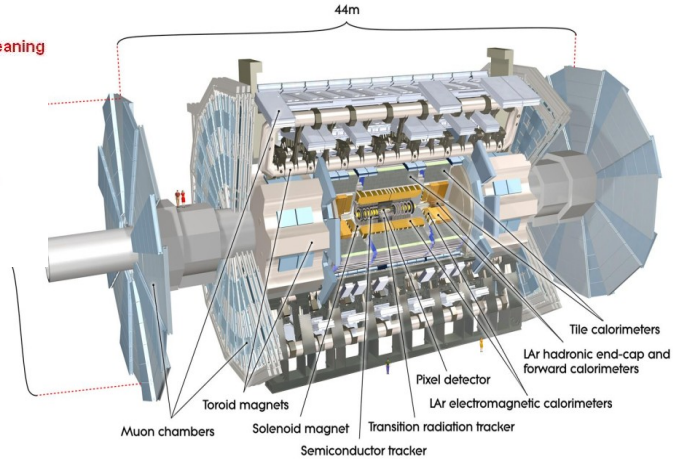
Aix-Marseille University

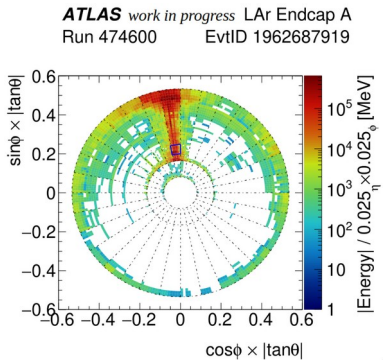
Funded by Commissariat Général à l'Énergie Atomique (CGEA/DRC

Outline

- **The LHC and the ATLAS detector**
  - Liquid Argon calorimeter
  - Readout system
- **Noise Bursts (NB) treatment**
  - Front End board (FEB) based identification
  - NB Time-Window Veto
- **High-Voltage (HV) Line system**
  - Correlation HV Line and Noise Bursts
  - HV-based NB identification
- **Conclusion**

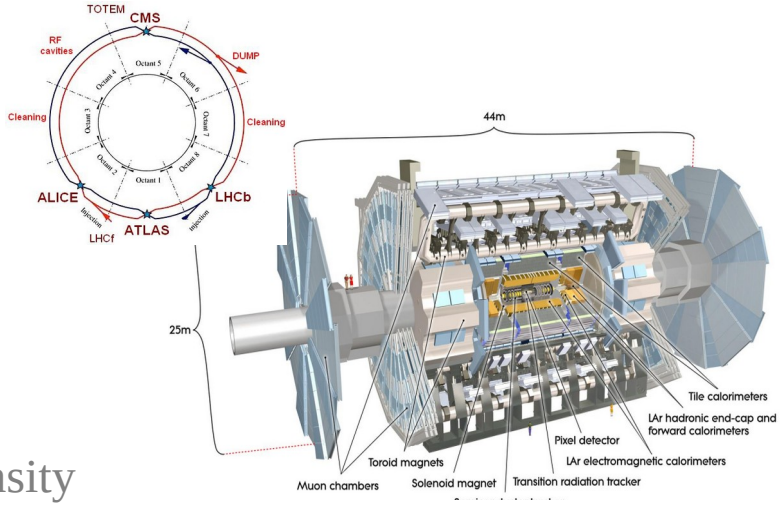


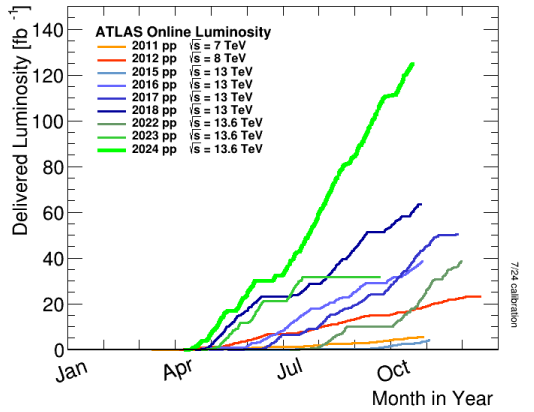




LHC and ATLAS Detector

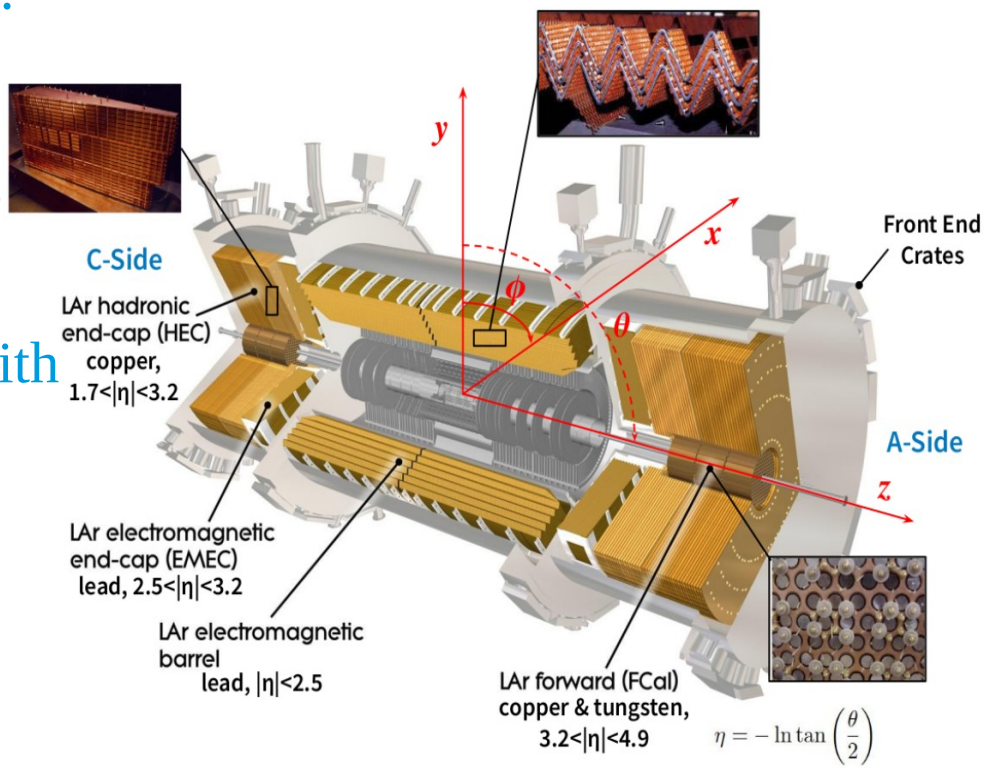
- The Large Hadron Collider at CERN was designed to provide:
  - Precise measurements of Standard Model (SM) of particle physics
  - Potential discovery new physics
  - Studying strongly interacting matter at extreme energy density
- ATLAS is the largest among the four LHC detectors, a general-purpose experiment:
  - The success of ATLAS data taking relies on its performance to record the luminosity delivered by LHC
    - Large statistics is needed to fulfil its physics potential





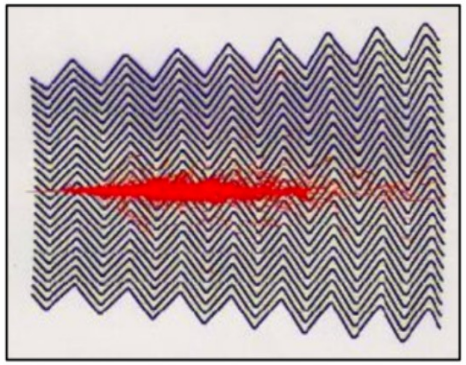
ATLAS Liquid Argon Calorimeter

- The primary purposes of LAr calorimeter are:
  - Measurements of electrons and photons
  - Provide important data for measurements of jets and missing energy
- LAr is a sampling calorimeter with consist with four main parts with different absorber geometries and materials:
  - Electromagnetic Barrel calorimeters (EMB)
  - Electromagnetic End Cap calorimeters (EMEC)
  - Hadronic End Cap calorimeter (HEC)
  - Forward Calorimeter (FCal)

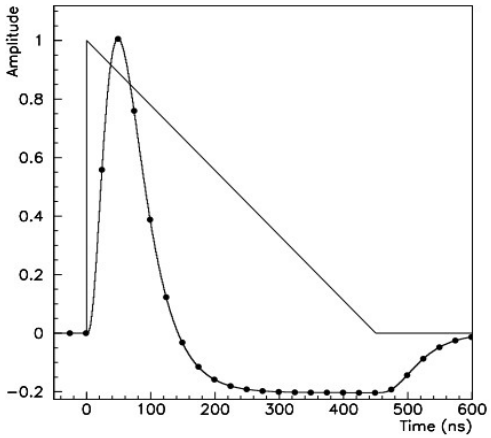


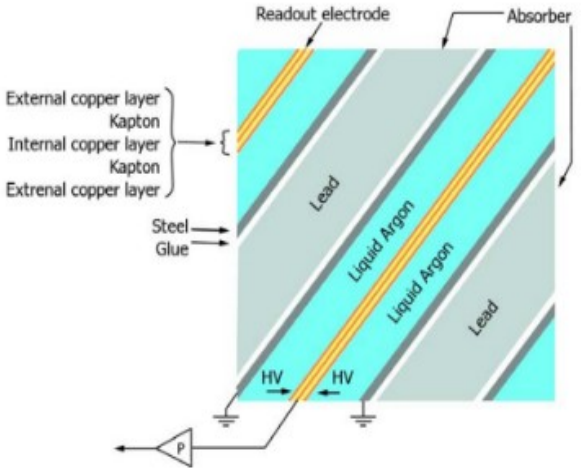
ATLAS Liquid Argon Calorimeter (LAr)

- From the the Electromagnetic shower...
  - LAr ionization from secondary particles created in collisions with the absorber
  - Drift electrons collected thanks to High Voltage (HV) applied between cell electrodes



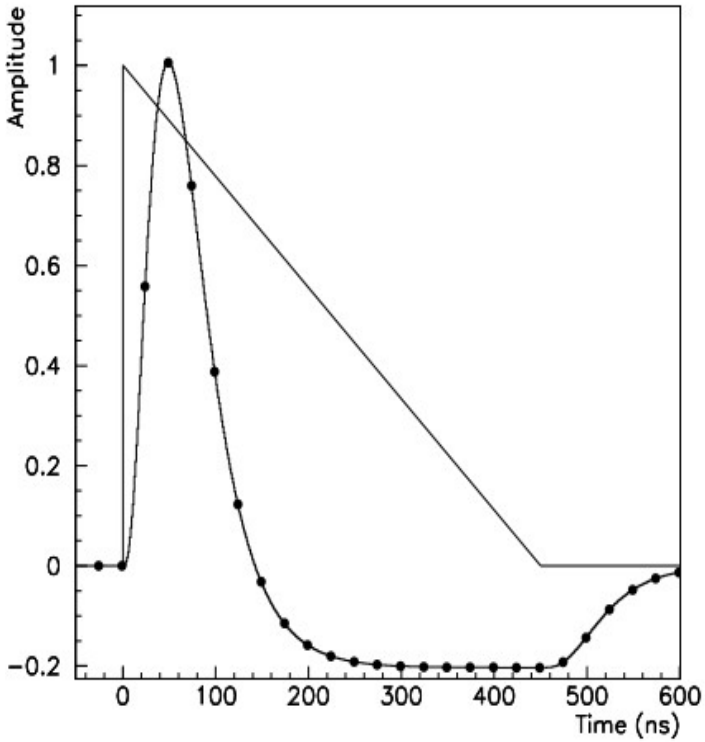
- ...to the Read out system:
  - Drift electrons induce triangular pulse in the readout electrodes
  - Bipolar pulse shaped and digitized by a Front-End Board (FEB)
  - Samples of 4 points per channel.





Readout system and Noise

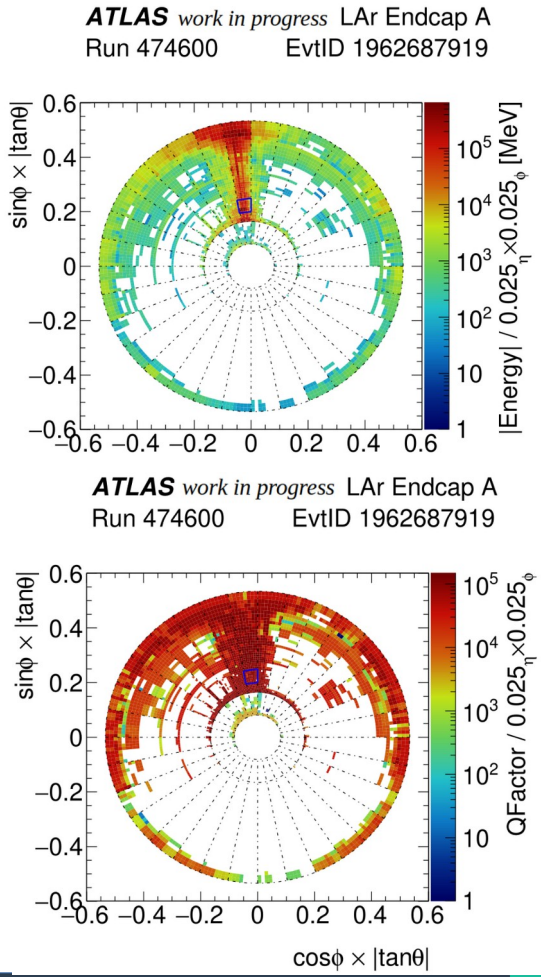
- Signals shaping by FEBs are sent to Read Out Driver boards for:
  - Estimation by optimal filtering algorithm of
    - Signal Amplitude
    - Energy time deposition
    - Quality Factor (Q)
- ATLAS data are monitored at several stages:
  - During calibration Gaussian electronic noise is measured
- Q is used for noisy cell detection:
  - Large Q → pulse not compatible with signal



$$Q = \sum_{i}^{4} \left(s_i - ped - A(g_i - \tau g_i') \right)^2$$

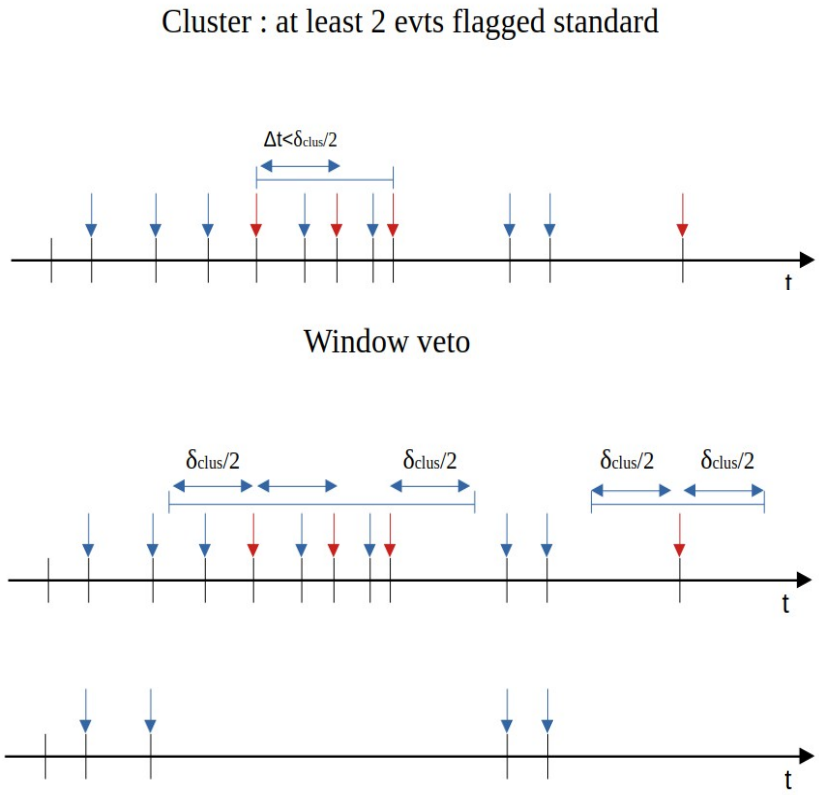
Noise Burst Events

- Since Run 1 coherent noise was observed, very short in time called Noise Bursts:
  - Large energies deposits and Q (>4000)
  - Correlated Spatially and in time
- NB candidate events are identified by noisy cells per FEB in “cosmic calo” streams:
  - Record event only when LHC bunch-crossings are empty
- The objectives of my study are:
  - Improve these noise bursts mitigation measures
  - Find an optimal NB flag definition minimizing the loss of physics data



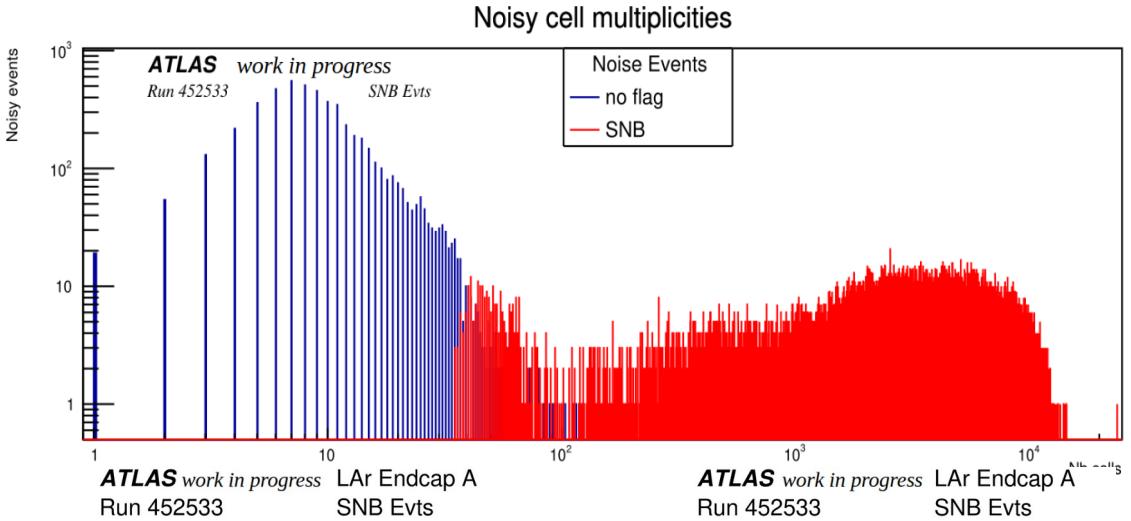
Noise Bursts Treatment

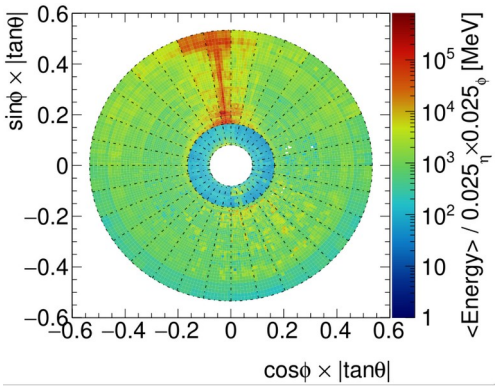
- Standard NB event (NB flag):
  - ≥ 30 noisy cells with Q-Factor>4000 in ≥ 5 FEBs
- Events originating from same Noise Burst Cluster:
  - Flagged Events separated by half of δ_{clus} ≤ 200ms
- NB final Time-Window Veto:
  - Events from the same cluster are vetoed
    - Adding $\delta_{veto}=\delta_{clus}$ /2 before and after the first and the last flagged events

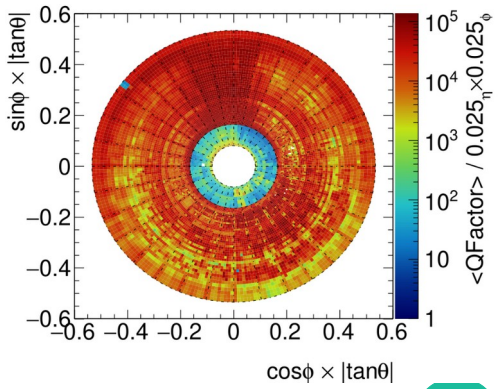


Properties of NB events

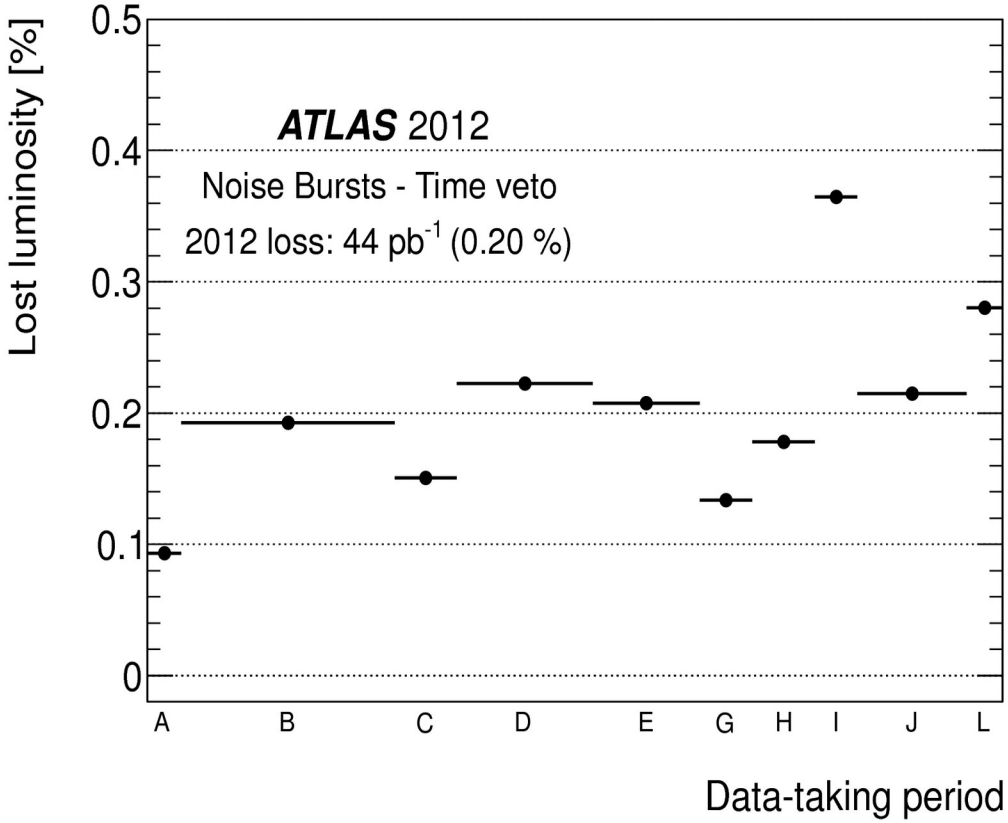
- Large multiplicities of noisy cells:
  - $(E_{cell} - E_{ped}) > 3\sigma_{Eped}$
- Spatial Correlation of large energy deposit and large Q value







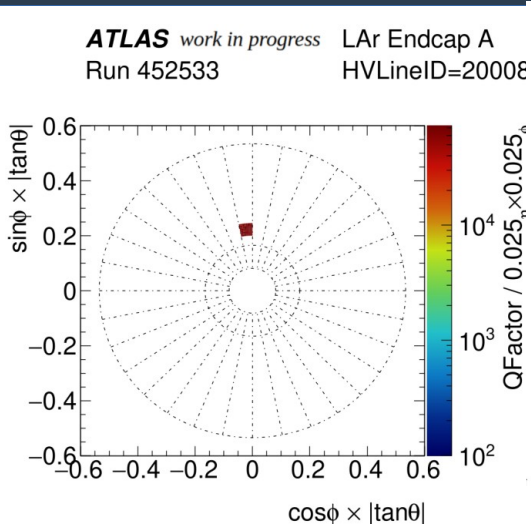
Performance of NB veto on lumi loss

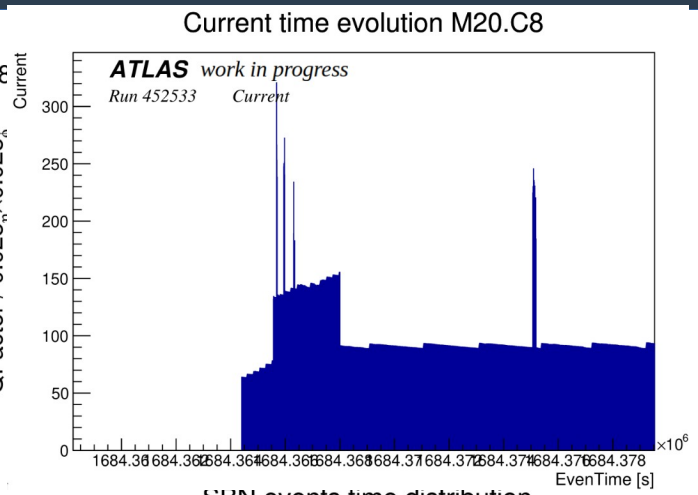


- Noise bursts are one of the main contributors to the LAr data-taking inefficiency

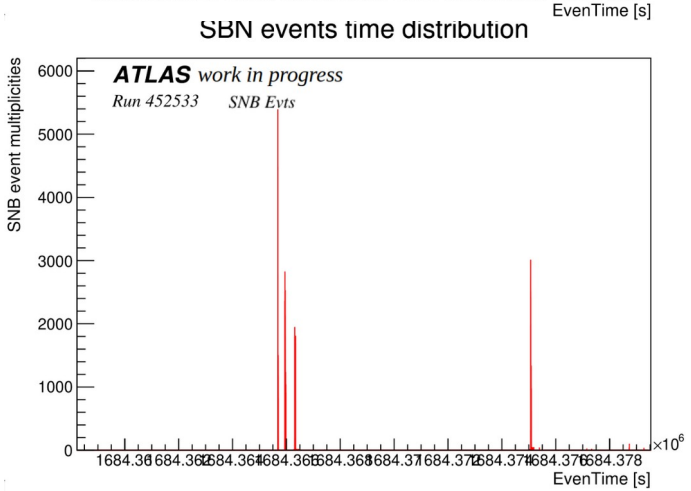
Correlation with HV Line trips

- During data-taking it was noticed a correlation between HV current spikes and Starting of NB



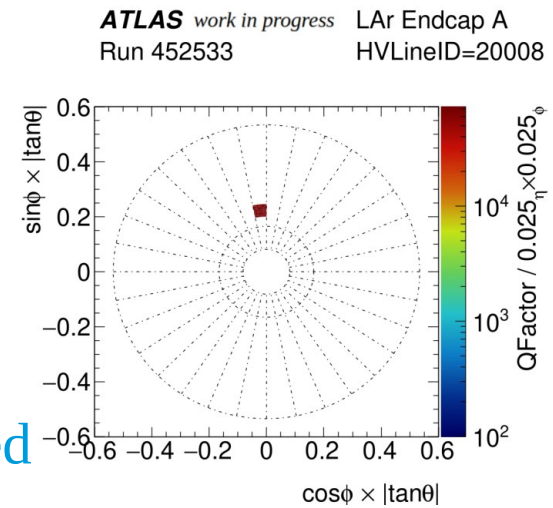


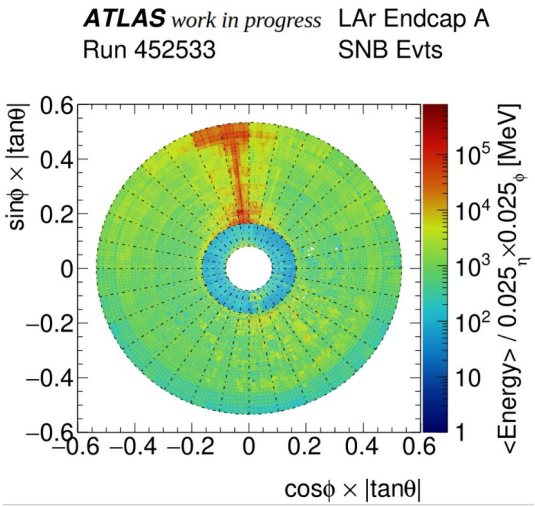
- Shown in the right the correlation between a current trip in the M20.C8 HV line and the beginning of a NB in Run 452533

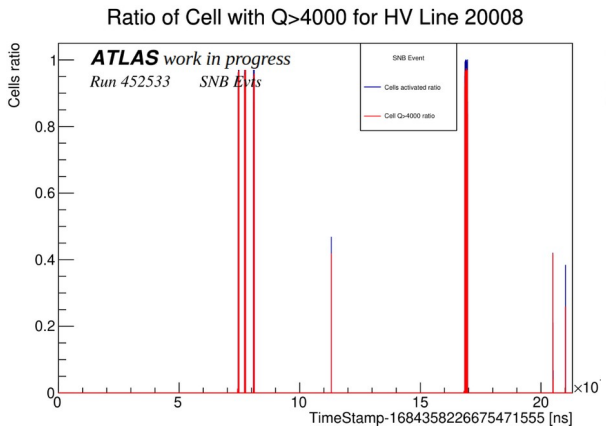


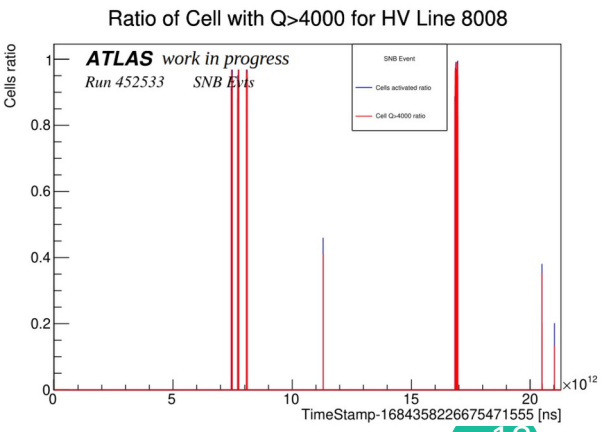
A closer look to one HV line

- Observing the cells associated with the tripping HV M20.C8:
  - Large presence of associated noisy cells with high Energy and Q-Factor
- Coherent behaviour of Cells supplied by the same HV line and neighbouring channels
- These led to the development of a HV-based NB flag







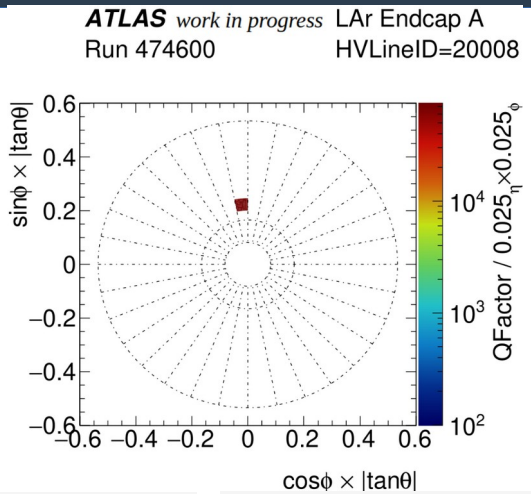


HV-Based Flag

- New definition based on the presence of noisy cells associated with the same HV lines
- HV-based flag definition:
  - Mean group ratio (Mr):

$$Mr = \frac{1}{m}\sum_{i=1}^{m}\frac{Nb_{HVcel_i}}{Nb_{HV_i}}$$

    - m: number of HV lines in the group
    - Nb_{HVceli}: for HV_i number of cells with Q-Factor>4000
    - Nb_{HVi}: for HV_i total number of cells
  - Flag require >=3 groups with Nb_{HVi}>10 and Mr > 25% in one partition



HVLINES

Contains 20008

120008 122008
120008 122008
120008 122008
120008 122008
120008 122008
120008 122008
120008 122008

HVLINES

Contains 171008

171008 171009 171010 171011
171008 171009 171010 171011
171008 171009 171010 171011
171008 171009 171010 171011
171008 171009 171010 171011
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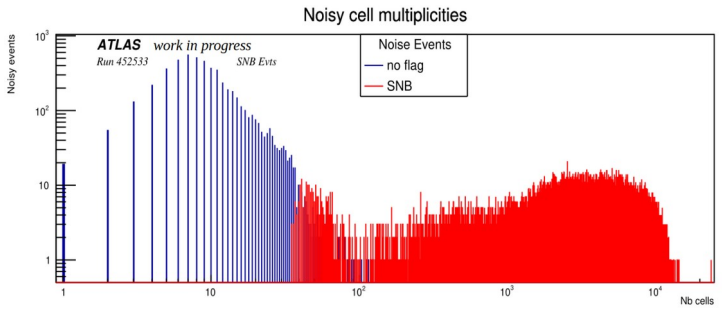
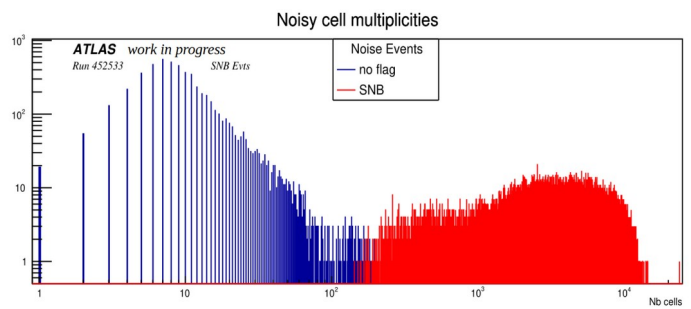
HV-based flag vs FEB-based flag

- HV-based flag
  - Remove leakage events from normal noise distribution
  - Catch NB events no flagged by FEB based

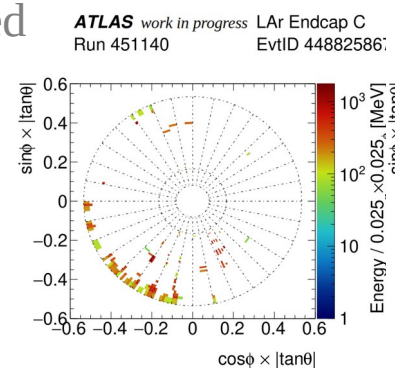
FEB-based flag



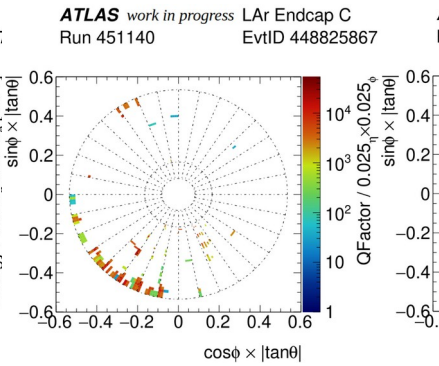
HV-based flag



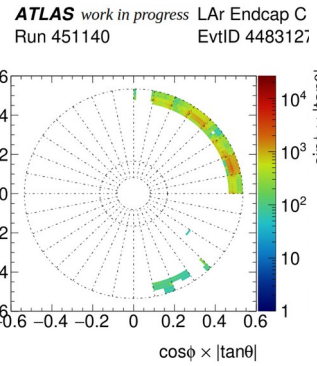
Energy



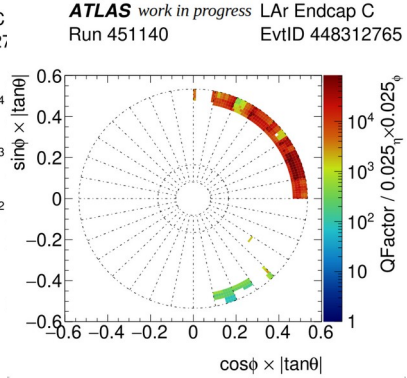
Q-Factor



Energy



Q-Factor



Conclusion

- The LAr calorimeter is essential key for ATLAS
- Noise Bursts affect data taking efficiency, therefore it is necessary to:
  - Improve NB mitigation measures
  - Find a optimal NB flag which minimize the loss of data
- Found in that Noise Bursts are Correlated with HV trips
  - Presence of current peaks occurring at the beginning of the NB
- New SN flag based on the same behavior of cells supplied by the same HV lines
  - Comparison FEB and HV line flags
    - Event based analysis shows that HV line remove flags of no NB events
- On going work:
  - Implement the HV-based flag on official ATLAS reconstruction software