# Performance of the ATLAS RPC Detector and L1 Muon Barrel Trigger at 13 TeV

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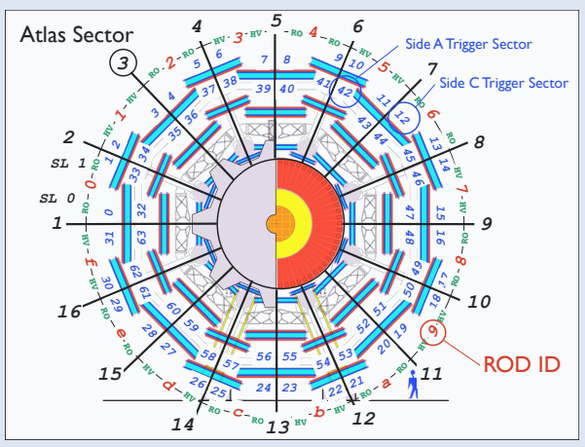
## Introduction

- Muon signatures are the key to many of the important physics results published by the ATLAS collaboration at the Large Hadron Collider (LHC).
- The ATLAS muon spectrometer employs the Resistive Plate Chambers (RPC) detector [1] for the first level hardware (L1) muon trigger system in the barrel region. Good performance of the RPC system is fundamental for the muon trigger [2], and for reconstruction and identification of muon candidates.
- In this poster, the performance is shown using proton-proton collisions at a centre-of-mass energy of 13 TeV collected in 2018 [4] [5].

## The ATLAS RPC Detector and Trigger System

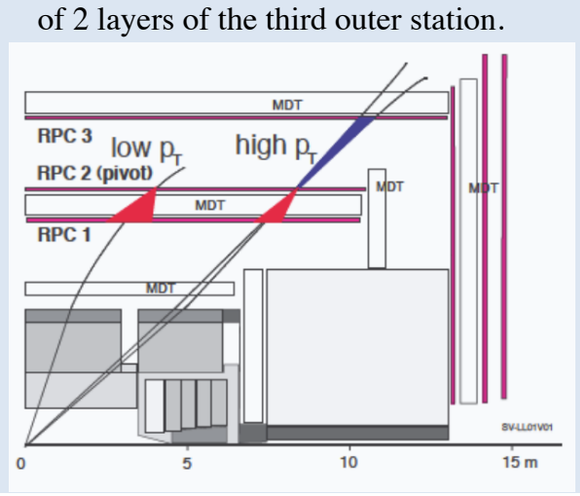
The present ATLAS RPC detector system, covering the region $|\eta| < 1.05$, is arranged in:

- 3 concentric double layers of chambers for a total ~3700 gas volumes readout by more than 380000 strips.
- 32 $\phi$ sectors for A and C sides.
- 432 trigger towers.

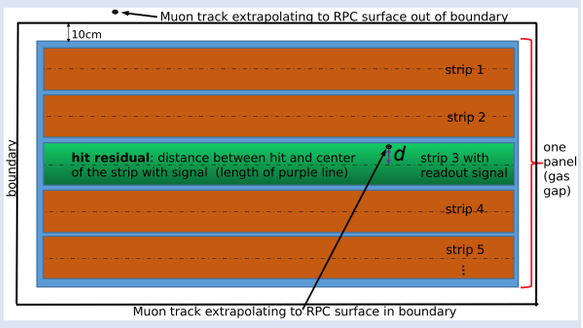



The first level trigger algorithm is based on hit coincidence among concentric RPC stations [3]:

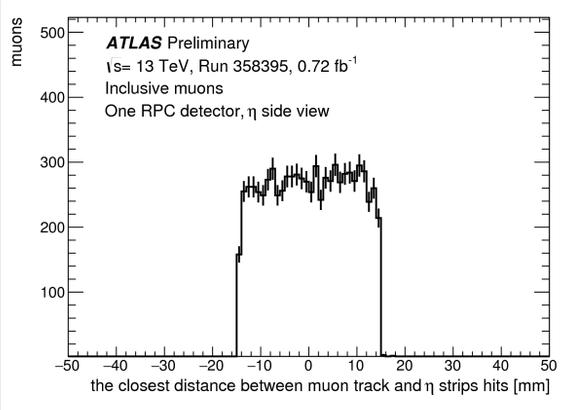
- *low $p_T$ trigger*: coincidence between the innermost two RPC stations.
- *high $p_T$ trigger*: one additional hit in one of 2 layers of the third outer station.



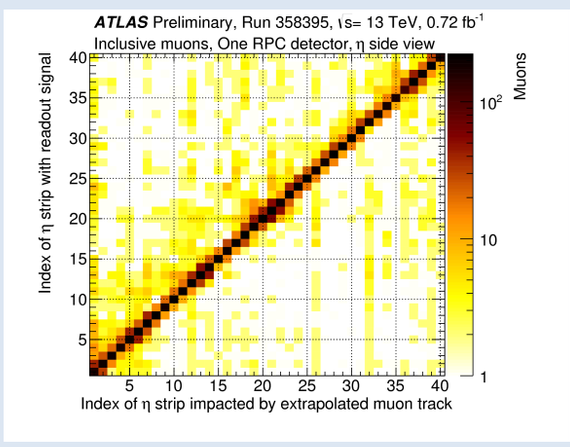

## Detector Alignment




The closest distance, ***d***, between the muon track position, extrapolated to the RPC surface from other tracking detectors, and hits readout from RPC strips is used to check the alignment and the cabling maps.



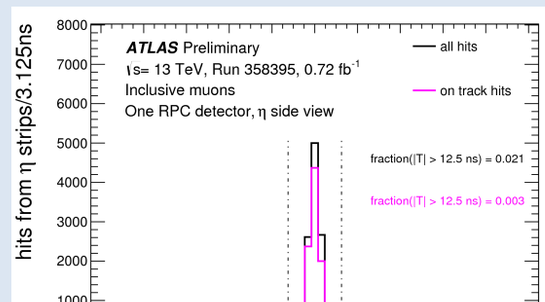

Correlations between expected and measured muon positions were used to verify the detector alignment and cabling map for all read-out panels.




## Detector Timing

Reconstructed readout hit time, based on the online calibration, shows a good resolution. It is plotted for two selections of hits:

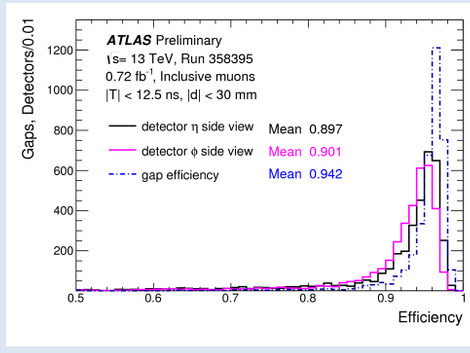
- **all hits**: all recorded RPC readout hits.
- **on track hits**: hits with |dl| < 30 mm.



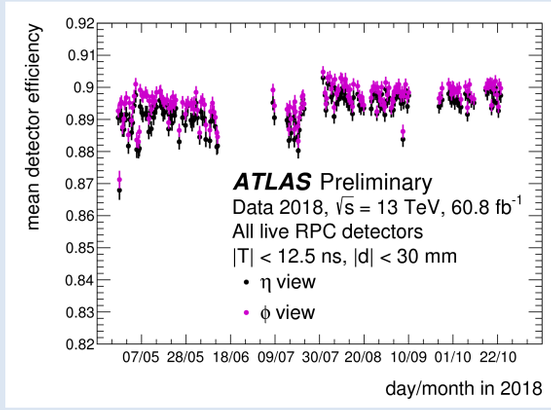

A better resolution is obtained with offline calibration.

## Detector Efficiency

The majority of gas volumes have an efficiency above 90%.



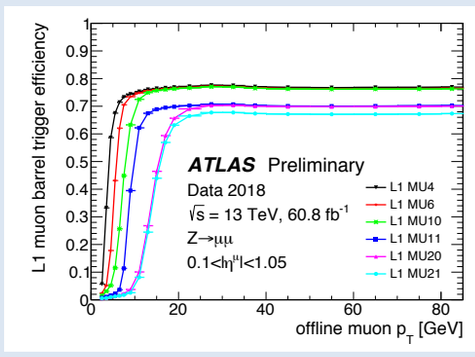

- **gap efficiency**: the presence of hits on at least one $\eta$ or $\phi$ strip through which the muon trajectory has passed.
- **detector efficiency**: the presence of hits in the corresponding strip panel.



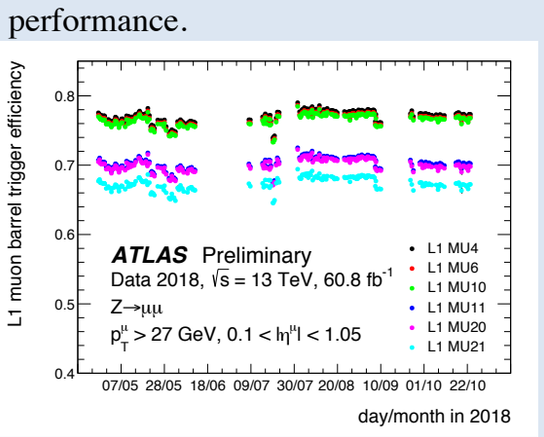

The time evolution of the detector efficiency for each detector element shows a good stability of the RPC system during data taking.

## Trigger Efficiency

Efficiencies are measured using a tag-and-probe method with $Z \to \mu\mu$ candidates as a functional of $p_T$ of the muons.



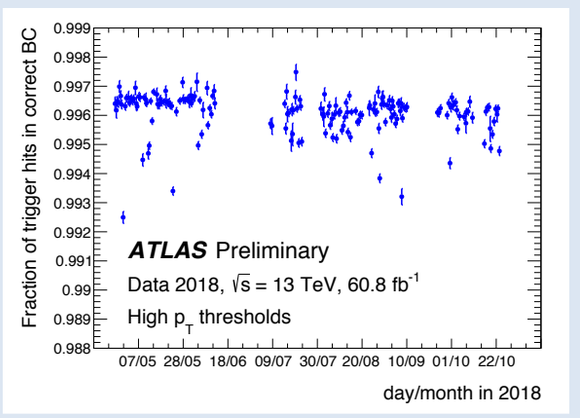

- The efficiency for low $p_T$ trigger thresholds (MU4, MU6, MU10) reaches a plateau of about 78%.
- The efficiency for high $p_T$ trigger thresholds (MU11, MU20, MU21) is around 68%.
- Efficiencies for all thresholds are very close to the geometrical acceptance values, confirming the good detector performance.




The plateau value of the L1 muon barrel trigger efficiency is stable as a function of time.

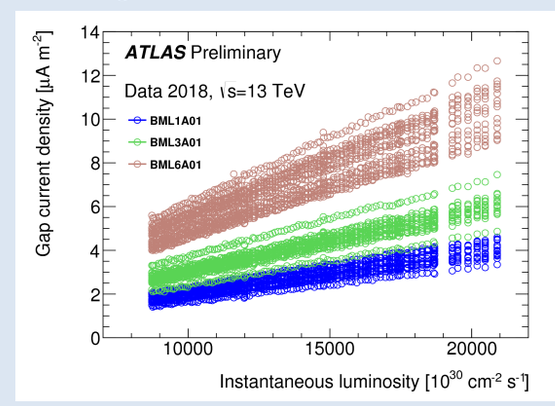
## Trigger Timing

The fraction of RPC high-$p_T$ trigger hits correctly associated to the collision Bunch Crossing (BC) for the whole RPC trigger system was 99.6% and stable during data taking [5].

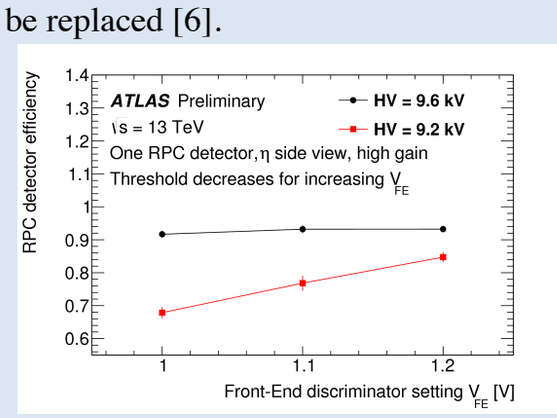



## High Luminosity LHC Prospects

- A linear increase of gas gaps current densities is observed up to $L_{inst} = 2.1 \times 10^{34}$ cm$^{-2}$ s$^{-1}$ while maintaining stable working conditions.




For the High Luminosity LHC (HL-LHC) program, the instantaneous luminosity will increase up to $7.5 \times 10^{34}$ cm$^{-2}$ s$^{-1}$ and it will be necessary to lower the RPC gas-gap high voltage (HV) from the present nominal value of 9.6 kV down to 9.2 kV to insure a safe detector operation. An additional layer will be inserted in the barrel trigger detector and the trigger electronics will be replaced [6].




Approximately 10% of efficiency loss can be recovered by lowering the Front-End discriminator thresholds.

## Conclusion

Many measurements have been carried out to study the performance of the RPC detector and L1 muon barrel trigger using muons selected in LHC collisions. These measurements indicate stable performance and efficient triggering of muons.


[1] Santonico, R., and R. Cardarelli, "Development of resistive plate counters", Nuclear Instruments and Methods in physics research 187.2-3 (1981): 377-380.
[2] M. Corradi, Performance of ATLAS RPC Level-1 muon trigger during the 2015 data taking, 6032 Journal of Instrumentation 11 (2016) C09003
[3] C. Luci, The Level-1 Trigger Muon Barrel System of the ATLAS experiment at CERN, 2009 JINST 4 P04010 [4] ATLAS Collaboration, ATL-COM-DAQ-2018-181
[4] ATLAS Collaboration, ATL-COM-MUON-2018-065
[5] ATLAS Collaboration, ATL-COM-DAQ-2018-181.
[6] ATLAScollaboration,"TechnicalDesignReportforthePhase-IIUpgrade of the ATLAS Muon Spectrometer". No. CERN-LHCC-2017-017. 2017.



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