Performance of the ATLAS RPC detector and L1 Muon Barrel trigger at 13 TeV

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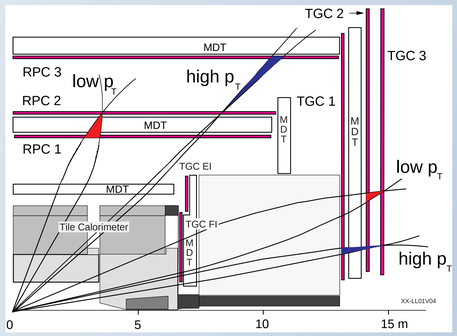
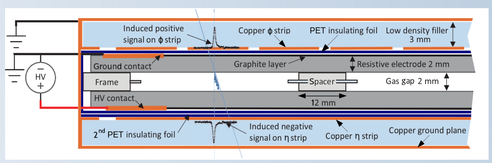
on behalf of the ATLAS Collaboration

The ATLAS RPCs and the Level-1 Muon Barrel Trigger System

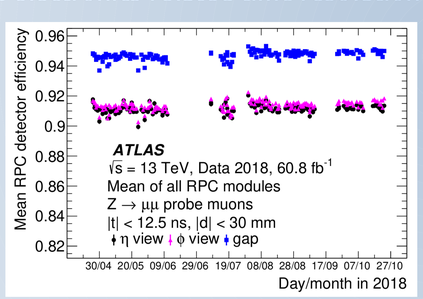


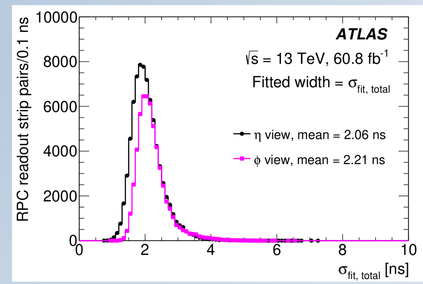


- Three concentric doublet layers of Resistive Plate Chambers (RPCs)
- Total surface of ~4000 m², pseudo-rapidity coverage $|\eta| < 1.05$
- Trigger algorithm based on hit coincidence of the RPC doublet layers: coincidence between the two innermost layer for the low-p_T triggers, a further coincidence on the outermost layer for high-p_T triggers
- ~3700 RPC gas volumes of 2 mm width
- Non-flammable $C_2H_2F_4$(94.7%)+C_4H_{10}(5%)+SF_6(0.3%) gas mixture
- Signal read-out by two orthogonal planes of strips, in η and Φ views, with a width of 23-35 mm
- Fast response and good time resolution make RPC suitable for triggering

RPC detector performance

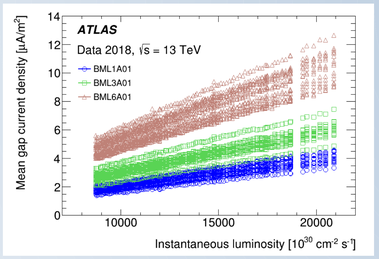
- Detector efficiency measured in each ATLAS run and found to be stable across the whole 2018
  Average single module efficiency ~ 94%
- Total time resolution measured to be 2.1/√2 ~ 1.5 ns
  Intrinsic and electronics-related time resolution measured also separately → ~1.1 ns each

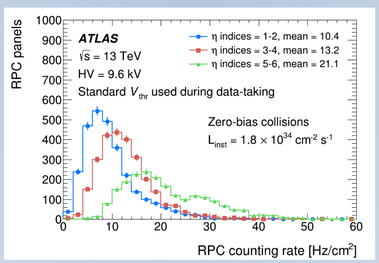


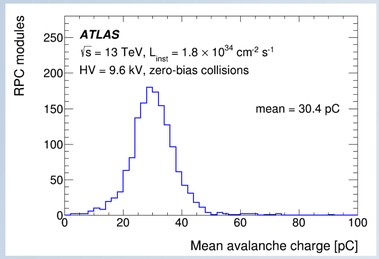


Measurements of RPC currents and counting rates

- RPC currents increase linearly with the instantaneous luminosity
- Counting rates measured using the three bunch crossings preceding the trigger signal to provide an unbiased sample of LHC collisions
- Mean avalanche charge per single hit measured for all RPC modules and found to be consistent with earlier measurements in test beams

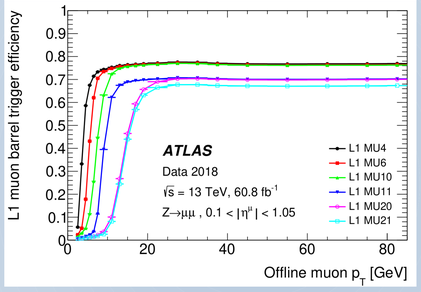


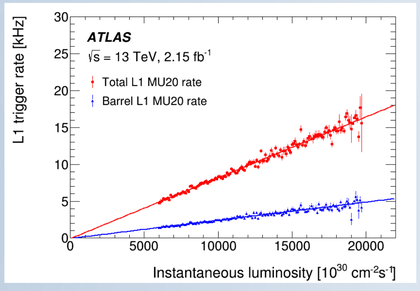




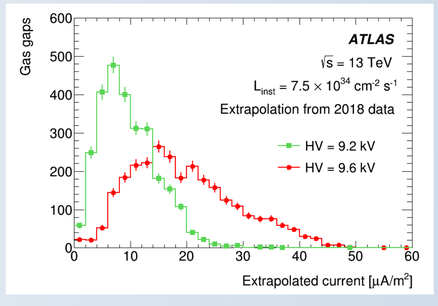
L1 muon barrel trigger performance

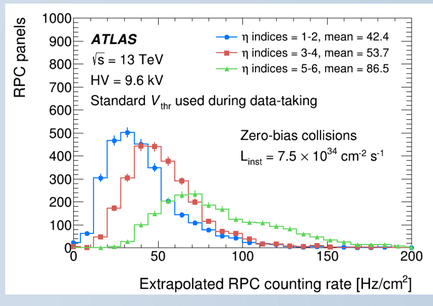
- 3 low-p_T trigger thresholds: MU4, MU6, MU10
- 3 high-p_T trigger thresholds: MU11, MU20, MU21
- L1 MU20 used as primary L1 muon trigger for data-taking in 2015–2018

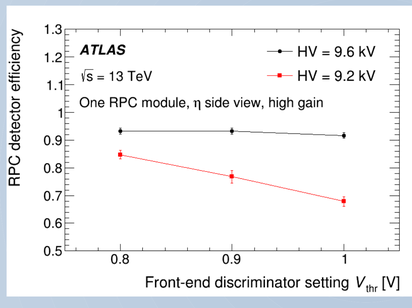




- Trigger efficiency evaluated using Z→μμ Tag&Probe method: 77% for L1 MU10 and 70% for L1 MU20
  Limited by detector services and detector support structures
- L1 MU20 trigger rate contributes with ~ 15% to the 100 kHz Level 1 trigger bandwidth at the highest luminosity value of Run 2. The trigger rate from the barrel region only is measured to be ~5 kHz







Expected performance of the existing RPCs at HL-LHC

- Operating voltage expected to be reduced to ~9.2 kV for High Luminosity LHC (HL-LHC) to limit the collected charge and the detector ageing effects
- RPC currents extrapolated to an instantaneous luminosity of 7.5×10³⁴ cm⁻²s⁻¹ under two different voltage working point hypothesis to investigate the safety limit conditions
- The lower operating voltage also leads to a decrease of the muon detection efficiency that can be partially recovered by adjusting the thresholds of the FE electronics

- Between 2025 and 2026, three new layers of RPCs will be installed in the innermost region of the barrel Muon Spectrometer to improve system redundancy, to increase the muon trigger efficiency and to reduce the trigger rates
  New trigger electronics will be also installed and more sophisticated, customisable trigger algorithms will be deployed utilising FPGAs

Main reference: ATLAS collaboration, Performance of the ATLAS RPC detector and Level-1 muon barrel trigger at √s = 13 TeV, JINST 16 (2021) P07029, DOI:10.1088/1748-0221/16/07/P07029