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BIS78, a pilot project for Phase-2 ATLAS RPC and beyond

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Summary. — The architecture of the present trigger system in the ATLAS muon barrel was designed according to a reference luminosity of 10^{34} cm^{-2}s^{-1} with a safety factor of 5, with respect to the simulated background rates, now confirmed by LHC Run 1 data. HL-LHC will provide a luminosity 5 times higher and an order of magnitude higher background. As a result, the performance demand increases, the detector being operated under a much harsher condition than the design scenario. The ATLAS Muon Collaboration approved an appropriate upgrade plan, to guarantee the performance required by the physics program for the 20 years scheduled, consisting in installing a layer of new generation Resistive Plate Chambers (RPC) in the inner barrel, to increase the redundancy, the selectivity, and provide almost full acceptance. The BIS78 project aims to install the first 10% of the system already in LS2, at the edges of the inner barrel even sectors (BIS7 and 8). This is the barrel region with the highest background so it is an excellent pilot project for the Phase-2 full coverage. The BIS78 RPCs represent a new generation of the RPC detectors, based on a new and advanced FE electronics capable to exploit 10 times smaller signals, correspondingly increasing the rate capability. The gas gap has been halved, along with electrodes thickness and weight reduction, improving by a factor of two the time resolution. The performance of the new detectors and the project status are discussed in this document.

1. – The ATLAS RPC BIS78 project and performance

The BIS78 project will provide a new system, integrating sMDT + RPC chambers to be installed in the barrel-endcap transition region at $1.0 < |\eta| < 1.3$, which is the region characterized by the highest background rates in the barrel, as shown in fig. 1. The Phase-2 BI system could inherit most of the BIS78 design. Installing the chambers in this position allows a reduction of the fake muons downstream with respect to cryostat, increases the trigger robustness with respect to the pileup and improves the momentum selectivity. Moreover, the problem of the excessive rate on the MDT will be solved through the new sMDT installation.

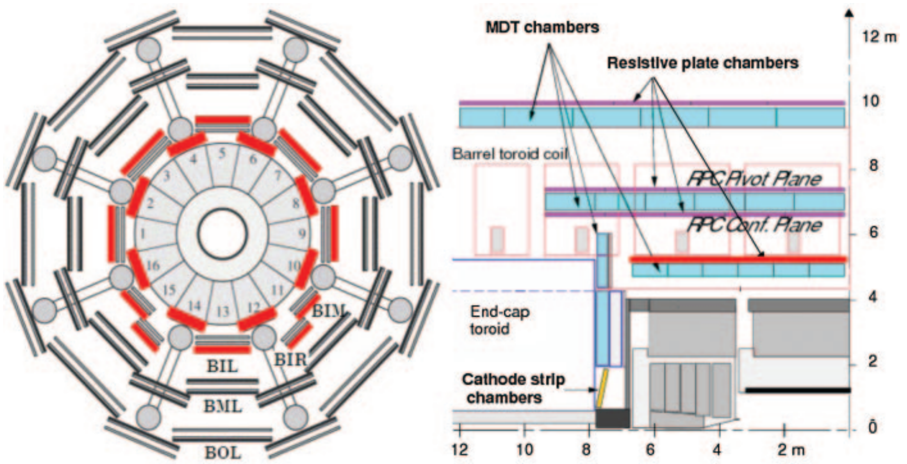

Fig. 1. – Layout of the BI layer in the X-Y (left) and Y-Z (right) projections respectively, with the new RPC and sMDT chamber positions indicated in red.

The BIS78 RPC detector is composed by 3 independent singlets of $2\,\mathrm{m}^2$, each providing a 2D orthogonal readout. The reduction of the gas gain, along with the capability to discriminate very small avalanche signals, allow an efficient and long-term RPC detector operation in high radiation background environment. The BIS78 RPC detector integrates a fast (100 ps peaking time) and sensitive (as small as $100\,\mu$V threshold) Front-End electronics (FE) with a very large size detector structure. This innovative RPC integrates a newly conceived Faraday cage, embedding the readout strips and the FE, tightly wrapped around a 1 mm gas gap RPC with 1.2 mm thick electrodes. These chambers grant a record combined performance of better than 95% single gap efficiency with a time resolution of 350 ps, as shown in fig. 2.

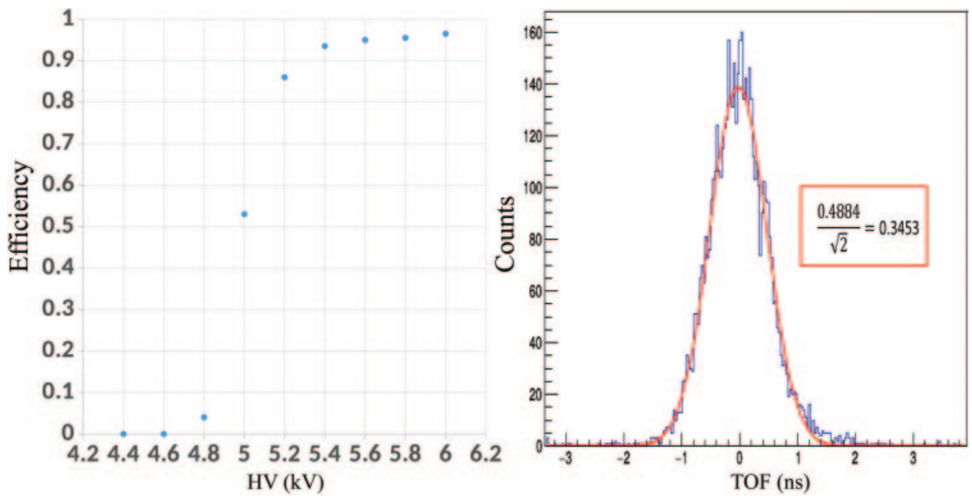

Fig. 2. – On the left the BIS78 RPC efficiency curve; on the right the time resolution achieved with this system by applying the time walk correction.