Measurement of the performance of the ATLAS RPC detector in 2016 LHC pp run at $\sqrt{s} = 13$ TeV, preparation for the next ATLAS simulation campaign and for the 2017 data taking

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From April to October 2016 the ATLAS experiment at the LHC was running smoothly, collecting pp collision data at 13 TeV corresponding to a total integrated luminosity of about 35 fb^{-1}. Between November and early December, ATLAS collected p-Pb collision data at $\sqrt{s_{\rm NN}} = 5$ and 8.2 TeV, which amounted to an integrated luminosity of roughly 800 nb^{-1}. A relevant fraction of the recorded events was selected online by the muon trigger, which is based on the LVL1 muon trigger signals provided by the RPC system, in the region $|\eta| < 1.05$. The essential role of this detector requires a careful simulation of its performance in the MC production campaigns that are providing all physics working groups with reference samples for the estimate of background processes and sensitivity to new physics effects. Results of detailed studies performed on 2015 data are summarised in [1]. Previous studies on run 1 data (2011 and 2012 at $\sqrt{s} = 7$ and 8 TeV respectively) are presented in [2] and [3].

The detector efficiency for each RPC gas gap and the corresponding η and ϕ strip panels has been measured with a large data set recorded during the LHC pp run at $\sqrt{s} = 13$ TeV. These data allow for a careful study of the response of the system and, in addition, the strip-panel efficiencies and cluster size distributions measured with them are a valuable input for the production of a new round of the official ATLAS simulation production. The MC samples currently in preparation, conventionally referred to as MC16, are meant to be used for the interpretation of the ATLAS data at 13 TeV collected so far (i.e. during the 2015 and 2016 run) and for the interpretation of the data that will be collected this year. Since the operating conditions of several detectors are going to be different in the forthcoming data taking with respect to the past runs, ATLAS decided to produce the MC samples with mixed conditions, i.e. reproducing in a certain fraction of events the detector conditions observed from data in the past run (2015 and 2016 together) and in the rest of the events emulating the current best guess about the detector conditions in the next data taking. A condition-related run number assigned to the simulation jobs allows to apply, at the digitisation stage, selectively conditions data valid for the Interval of Validity (IoV in the ATLAS data preparation jargon) 2015-2016 or 2017.

For the RPC efficiency and cluster size, it was decided to associate to the IoV 2015-2016 the measurements on data as obtained strip-panel by strip-panel. In case the measurement of the efficiency and cluster size in a strip panel is done with a number of probe tracks (extrapolated to the measurement surface) smaller that 100, "ideal efficiency values" (corresponding to the most probable values measured in 2012 data) are used. By using the entire set of pp data in 2015 (about 3 fb^{-1}) and in 2016 the local efficiency measurements are already a luminosity weighted parameter describing the global 2015-2016 run. On the other hand, for the IoV starting in 2017 the best guess is represented by the measurements on 2016 data. These however are further manipulated before being injected in digitisation, because it is intended to prevent declaring dead in MC a detector element that is possibly going to be recovered by hardware repairs in the ATLAS cavern during the months of LHC shutdown between the 2016 and 2017 runs. Therefore, all strip-panels or gas-gaps that are unresponsive in the 2016 data or that exhibit an efficiency below 50% are represented in the IoV 2017 of the next MC production as 50% efficient.

As in the past, the measurements reported here are performed with an extended version of the software used for the Offline Data Quality Monitoring of the RPC detector, which runs in the standard reconstruction chain and fills the WEB display running for Data Quality shifters in the ATLAS Control Room and accessible through the WEB with a very short delay during data taking. The efficiency is measured using RPC tracks built with RPC hits only, excluding the unit under test from the patter recognition algorithm used to build the probe track. The entire *Physics_main* data-stream is used for the measurements. Fig. 1 allows to compare the measured efficiency of all strip-panels in the 2015 and 2016 data. After combining the measurements of 2015 and 2016 the "conditions" for a realistic emulation of the RPC response out of Geant4 hits produced in simulation have been filled in the proper folder of the Condition Database accessed by the ATLAS job running digitisation and reconstruction, as described in [4]. Fig.2 shows the “true efficiency” of all strip panels as measured by the ratio of the number of hits producing a digit ready for input to the LVL1 trigger algorithm and for the muon track reconstruction in MC16 for condition data corresponding to the 2015-2016 IoV (left) and the 2017 IoV (right). These maps are obtained by validation jobs produced specifically for testing the software and condition data to be used in the MC16 production campaign. They are based on 10^6 geantino tracks generated at an ideal point-like ATLAS interaction vertex (at the center of the global reference frame of the experiment) and propagating uniformly in all directions in $-1.05 < \eta < 1.05$ and the full range of the azimuthal angle ϕ. Geantino tracks are an artefact of GEANT4 allowing to produce hits in all the sensitive volumes crossed by a straight line, described as a particle four-momentum, and neglecting all physics interactions of a real particle with matter (like energy loss, multiple scattering, etc). The distributions of the ”true panel efficiencies” determined with this special validation sample are shown in Fig. 3 for the two IoVs. The dead strip panels and gaps, featuring null efficiency in the IoV representing the real conditions of the RPC system in the past years, correspond to the small bump around the value of 50% efficiency in the IoV corresponding to the expected conditions of the system.

The data of the last year have shown that the hardware cabling in the sectors 12 and 14 (ATLAS feet) is not optimal for the trigger acceptance of the muon LVL1 high p_T thresholds. Therefore a recabling of the corresponding RPC stations has been done on the detector at the end of the 2016 data taking. As a consequence, the cabling maps used in the offline software for data decoding (and also in the MC digitisation to encode the geometrical information of the digits into proper identifiers of electronic channels) have to be updated for the chambers affected by the hardware intervention, before the 2017 data taking. In practice the IoV mechanism of the ATLAS software has to be used in order to peak up the correct cabling maps, corresponding to the real detector, when processing data taken before of after January 2017 (and similarly for the MC samples intended to represent the data before and after this change). The RPC Lecce team has implemented in the software the new cabling maps suitable for the next data taking. Moreover the 2016 data allowed to identify a problem with the software implementation of the cabling in ϕ related to the description of the hardware/logical OR of the recently installed BME/BOE chambers and of the extra layer of RPC in the BOG and BOF chambers of the feet region. A proper fix was implemented and introduced in the production code to be used for 2015-2016 data reprocessing, for the prompt processing on 2017 data and for all the related simulations. Fig.4 shows the coincidence pattern in η between pivot and high-pt confirm plane in some trigger towers of one of the sectors affected by the optimisation of the cabling, as seen in validation simulated samples produced using the new cabling maps. For each trigger tower, the coincidence pattern obtained is compared to the corresponding coincidence pattern observed in the data collected so far, with the cabling as implemented in the hardware and software until the end of 2016. The benefit of the new cabling schema is shown by the wider overlap of the pivot and high p_T hits from muon tracks in the coincidence matrices, allowing to generate LVL1 high p_T triggers.

REFERENCES

1. G. Chiodini, M. Corradi, S. Rosati, G. Salamanna, S.Spagnolo, ”Plots on RPC / L1 Muon Barrel Trigger Performance in 2015”, ATL-COM-MUON-2016-005, https://cds.cern.ch/record/2131167, Feb. 2016.
2. G. Chiodini, D. Boscherini, ”RPC coverage, efficiency and time resolution in 2012 data”, ATL-COM-MUON-2014-009, https://cds.cern.ch/record/1648012, Feb. 2014.
3. G. Chiodini et al., ”RPC coverage, efficiency and time resolution in 2011 data”, ATLAS-PLOT-MUON-2012-001, https://cds.cern.ch/record/1421212, Mar. 2012.
4. https://twiki.cern.ch/twiki/bin/view/Atlas/LiveFractionDeadChannel

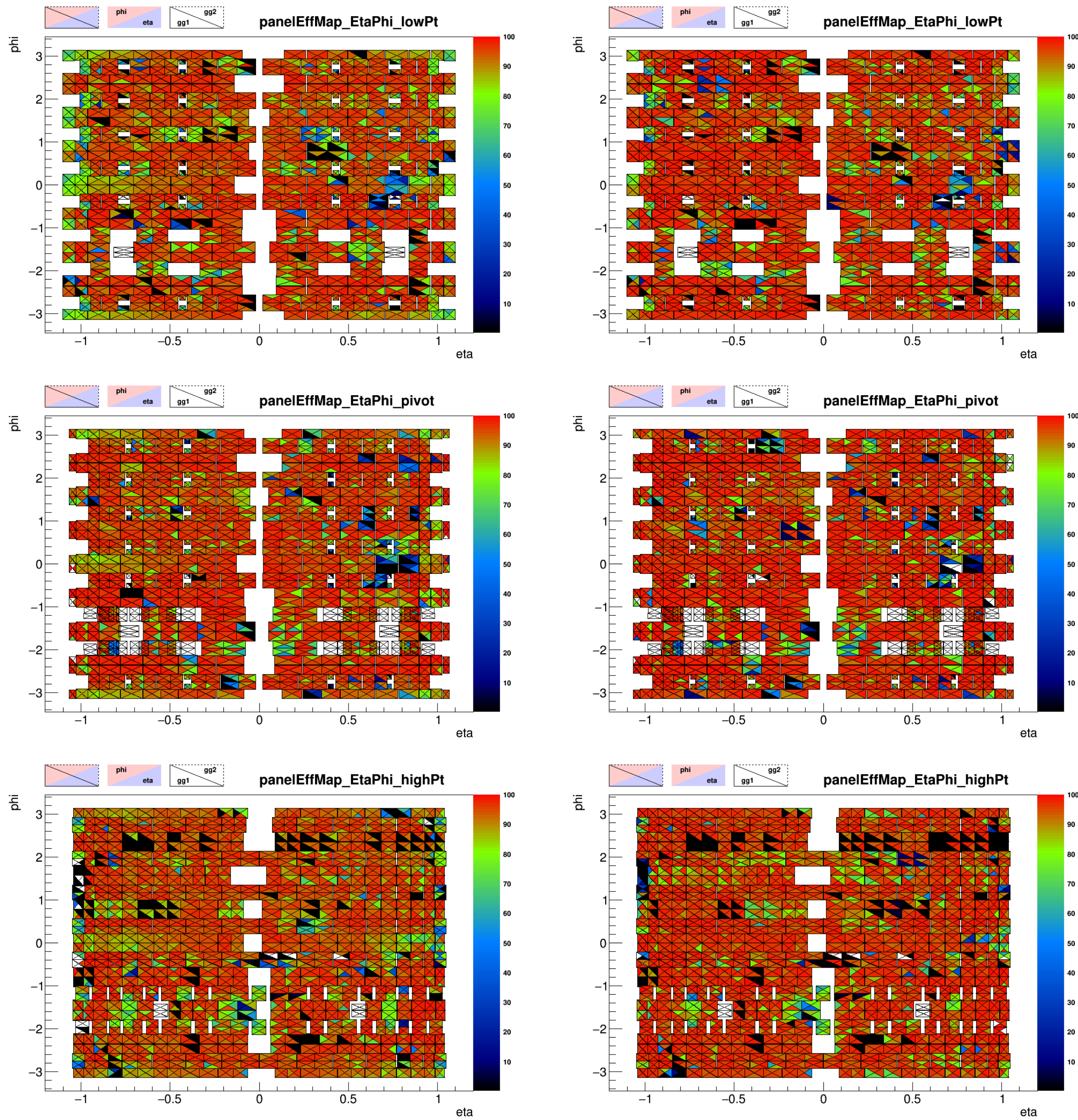

Figure 1. Color-coded map of strip-panel efficiency (ϕ and η) for the two gas gaps of all RPC in the pivot plane, as measured in 2015 data (25ns bunch crossing sample) -on the left- and in 2016 pp data (period A to L) -on the right. The rectangular areas in the plots correspond to the $\eta \times \phi$ extension of each strip panel (equal for η and ϕ strip panels and for the two gas gaps in the doublet); the segmentation in triangles allows to display the efficiency of each of the 4 individual panels at the same time. White areas are “unmeasured”, i.e. no tracks are extrapolated to test the efficiency of the relevant strip panels.

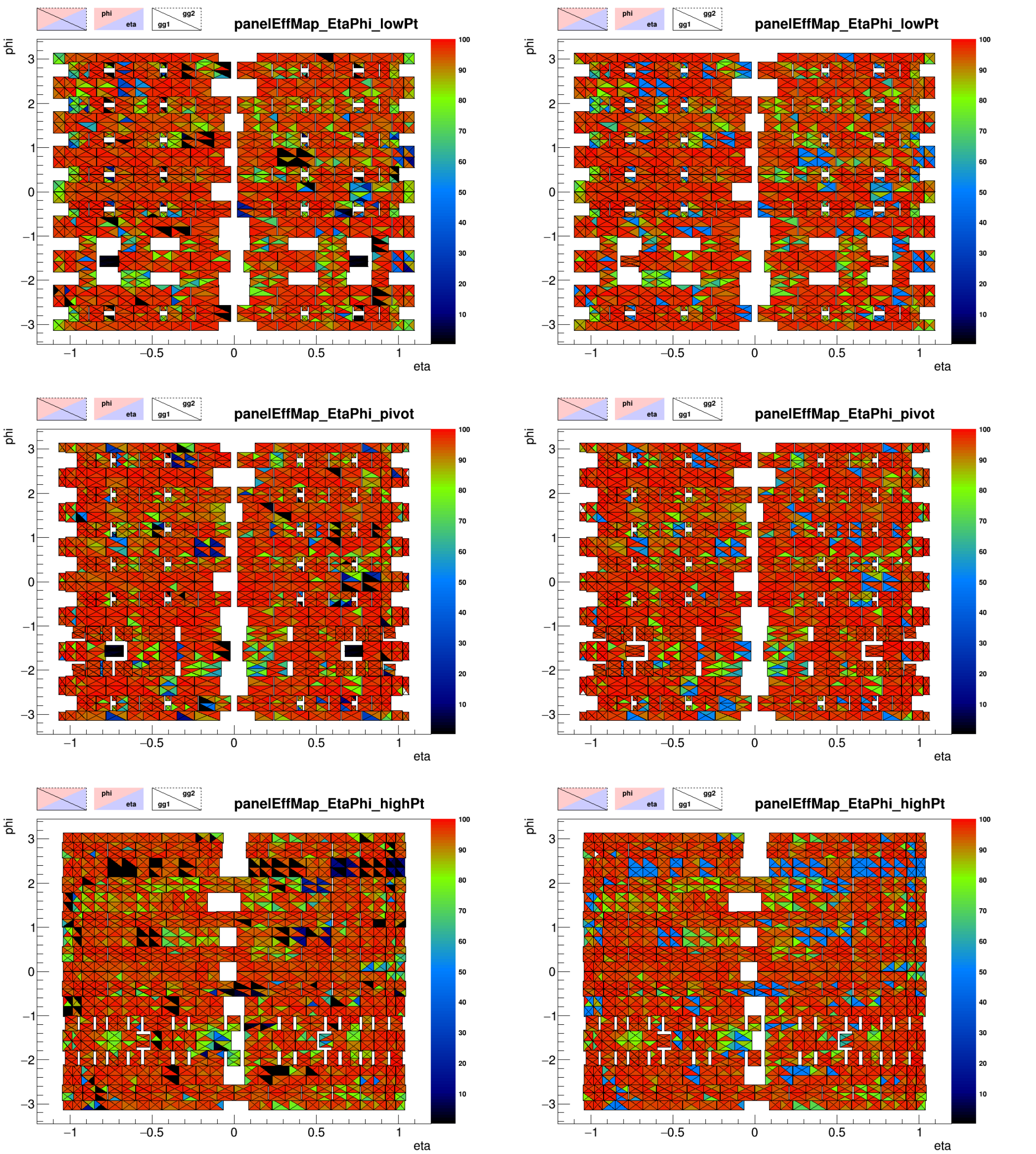

Figure 2. Color-coded map of strip-panel efficiency (ϕ and η) for the two gas gaps of all RPC in the pivot plane, as measured from the ratio of hits giving digits to hits for each strip panel in a validation MC sample produced with the same conditions injected in MC16 for the IoV 2015-2016 (left) and 2017 (right).

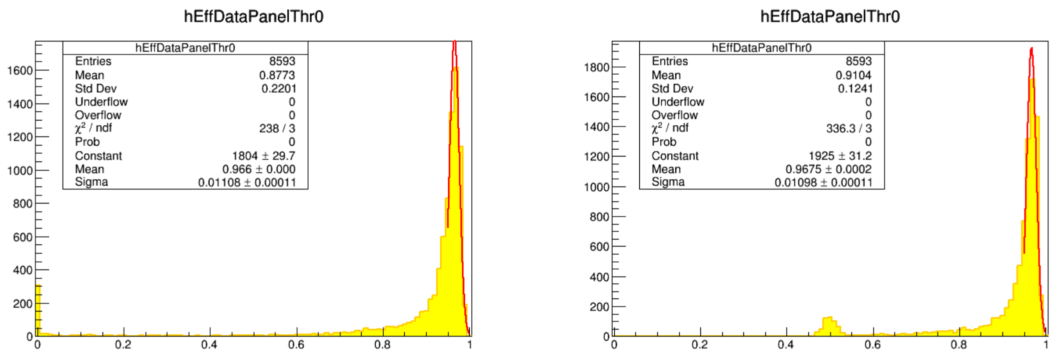

Figure 3. Distribution of the true panel efficiency measured in a validation sample with RPC conditions prepared for MC16 IoV 2015-2016 (left) and IoV 2017 (right).

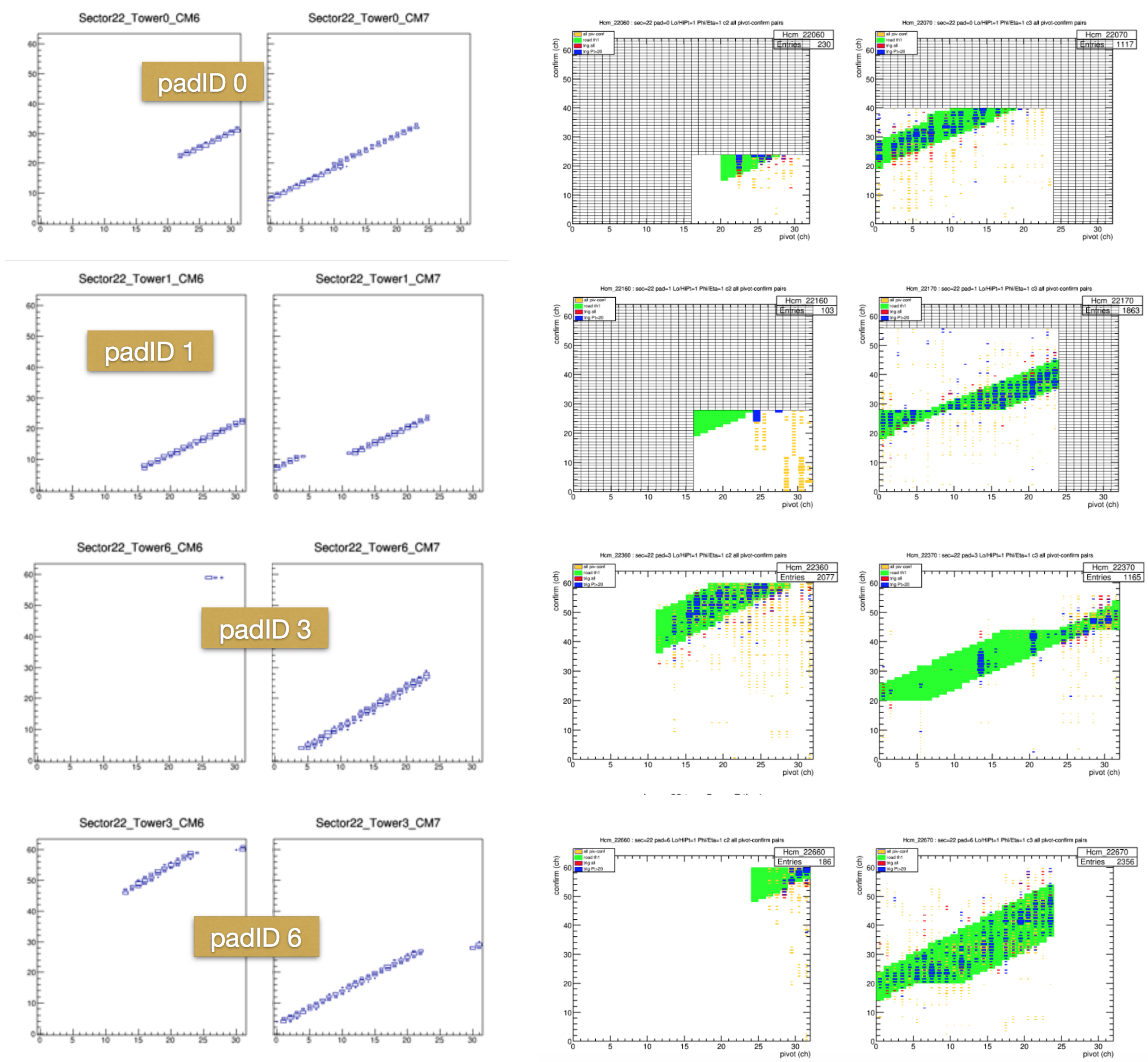

Figure 4. Coincidence patterns in η for infinite momentum tracks in the pair of confidence matrices (cmId=6 and 7) of the trigger towers 0,1,3 and 6 in the second half of sector 12 (C side). On the left the pattern is obtained with a simulation of geantinos using the new cabling schema prepared for data taking in 2017, on the right the pattern comes from 2016 data.