Resistive Plate Chambers for the CMS upgrade

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The proposed RE4 upgrade project for CMS is currently being implemented in the Long Shutdown -1 (LS-1, 2013-2014) at CERN. It envisages another 200 RPCs to be built, tested, characterized, installed and commissioned jointly by India (BARC & Panjab University, Chandigarh), Belgium (University of Ghent) and CERN [1], which is detailed in Table 1, in terms of RPCs to be built at the three assembly sites.

Table 1
Chambers to be built at three assembly sites

SN	Chamber Type / Assembly Site	RPCs
1	RE4/2 / CERN	50
2	RE4/2 / BARC	50
3	RE4/3 / Ghent	50
4	RE4/3 / CERN	50

The bakelite gas gaps after being fabricated at Korean DEtector Lab. (KODEL), South Korea are dispatched to the respective assembly sites in a phased manner. At each assembly site, the gas gaps undergo a visual inspection on arrival, mechanical tests in terms of leak and spacer tests followed by electrical tests and after passing the required QA/QCs are integrated into an RPC with read out plane, front end electronics and Cu cooling system. After the full assembly of an RPC, it is subjected to its performance evaluation in terms of efficiency, cluster size, noise and strip profile in the cosmic hodoscope at the respective sites [2], prior to their dispatch to CERN. Standard RPC gas mixture with 40% humidity in the gases is used with hardware thresholds set at 215 mV for the front end electronics. BARC has so far built eight RE4/2-RPCs which were sent to CERN in May, apart from the Cu cooling sets for the entire 200 chambers. The Manufacturing Progress Review (MPR) was held at CERN in July where the performance of the chambers assembled at three different sites was evaluated. Each RPC has a segmented read out, sandwiched between the double layered gas-gaps. The read out is segmented in three η sections (Δη = 0.1 : A, B, C), which constitutes a roll. The performance of the eight RE4/2-RPCs, built at BARC, was quite satisfactory and at par with the performance of chambers assembled at CERN and Ghent (Fig.1), where the distribution of maximum efficiency is shown for each roll, in all the 44 chambers built, at the time of MPR.

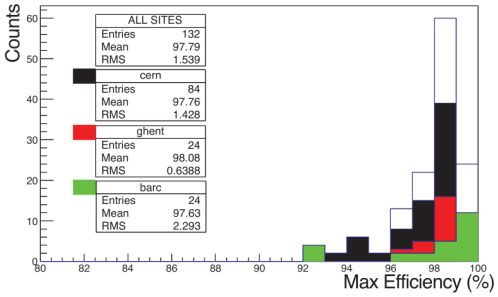

Fig.1, Distribution of the maximum efficiency (%) of the RPCs built at the three sites at the time of MPR

Subsequent to MPR, the total number of chambers built and characterized for RE4 are shown in Table 2.

Table 2
Total number of chambers built for RE4 upgrade

SN	Chamber Types	RPCs
1	RE4/2	21 of 36
2	RE4/3	32 of 36
3	Total number of chambers built	53 of 72

At CERN, each assembled chamber is subjected to QC4.2 level of tests which includes long term monitoring of leakage currents, a plot of which is shown in Fig.2, for a top layer in a typical chamber (CMS-RE4-2-BARC-019). The plot shows the $HV_{applied}$ (dashes) and the leakage current behavior (dots), which seems to steadily reduce from 0.3 µA to 0.15 µA over a period of 7 days, thereby signaling a go ahead for the RPC to be configured into a Super Module (SM) assembly .

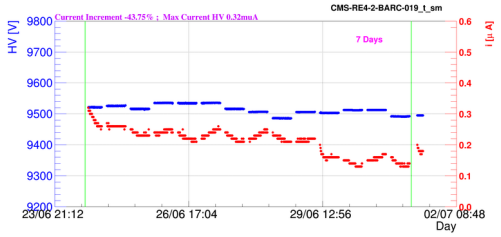

Fig.2, The long term current monitoring (QC4.2) at CERN for the top layer in one of the BARC chambers (CMS-RE4-2-BARC-019)

In an SM, an RE4/2-RPC mates with an RE4/3-RPC in terms of Cu cooling sets and the gas pipes. The SM assembly is then subjected to another leak test of the Cu cooling assembly (Fig.3). So far, 19 out of 36 Super Modules have been assembled for installation of the positive side of the end cap, scheduled in Oct/Nov this year at Point 5, in Cessy in France.

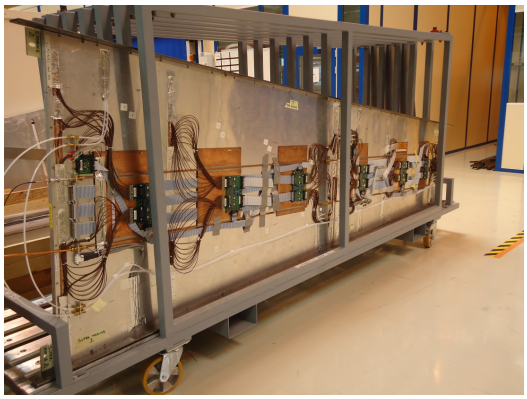

Fig.3, A Super Module Assembly under leak test for Cu cooling sets after an RE4/2 chamber is mated with an RE4/3 chamber at 904, CERN

Six out of eight RE42-RPCs sent from BARC have also been configured in a SM assembly. The remaining two shall be recovered by changing the Tripolar HV connector in one and replacing a gas-gap in the second, as they were observed to have fluctuating leakage currents at QC4.2. Similar problems were also observed in a few chambers assembled at other sites too and they are being similarly addressed to. The second end-cap (-) is scheduled for installation in Feb/Mar 2014. While the focus at CERN at the moment is the installation and commissioning of the first end-cap, the assembly sites would continue with the further production of RPCs for the second end-cap.

References :

[1] Resistive Plate Chambers for the RE4 upgrade of the CMS endcap system, L. M. Pant *et. al.*, 2012 JINST 7 P10025

[2] Development of large area scintillators for the cosmic hodoscope for characterization of RPCs, C. Yadav *et. al.,* Proceedings of the DAE Symp. on Nucl. Phys. 56 (2011) 1066

[3] Assembly, testing and production of bakelite RPCs for the end-cap region of the Compact Muon Solenoid experiment at CERN, L. M. Pant *et. al.,* NIMA 602 (2009) 817