Test Beam April 2024 results: CMS RE1_1 Chamber

- CMS RE1_1 is a Double gap chamber prepared using three single gaps, namely one larger Bottom and two smaller(TOP Wide and Top Narrow) as shown in the figure 1.
- Data acquisition carried out using two of the four partitions namely A,B were used C and D not active.
- The approximate position of the beam in 2024 is shown in figure 1.
- In April 2024, most test beam data stored in partition A and a small portion of data stored in partition B.
- For the efficiency analysis Partitions A and B are combined together in order to get the full efficiency.
- In 2023, the CMS RPC chamber test beam data were from one partition (B) only for the majority of the scans. There are very few scans with two partitions (A and B).
- Which indicates that the position of the RPC or trigger Scintillators were moved from 2023 to 2024.



Fig 1: Top view of the RE1_1 Chamber



- Combined RPC (BOT+TW): Efficiency for the STD, ECO2 and ECO3 is approximately 98%, 96% and 97% respectively.
- Bottom RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 77%, 77% and 67% respectively. Even when operating at 1000 to 1500 V higher than the voltages in combined mode, the bottom RPC's efficiency does not exceed 78%.
- Top Wide RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 98%, 96% and 97% respectively.

ABS_100

Efficiency vs HV_eff



ABS_100:

- Combined RPC (BOT+TW): Efficiency for the STD, ECO2 and ECO3 is approximately 98%, 96% and 96% respectively.
- Bottom RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 78%, 77% and 67% respectively.
- Top Wide RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 97%, 95% and 96% respectively.
- Efficiencies at source off and ABS_100 conditions are quite similar for all the gas mixtures

ABS_3.3

Efficiency vs HV_eff



- Combined RPC (BOT+W): Efficiency for the STD, ECO2 and ECO3 is approximately 96%, 96% and 96% respectively.
- Bottom RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 78%, 78% and 64% respectively.
- Bottom RPC efficiency with ECO3 is roughly 10% lower than that with STD and ECO2 for all ABS.
- Top Wide RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 96%, 90% and 88% respectively.
- The steepness of the efficiency curves is lower for ABS_3.3 than the Source_off and ABS_100

Source_off

Current density vs HV_eff



Source off:

- Combined RPC (BOT+TW): the current densities for STD, ECO2, and ECO3 gas mixtures is approximately 8-10 nA/cm² respectively, at their WP.
- Bottom RPC: the current densities for STD , ECO2, and ECO3 gas mixtures is approximately 20-25 nA/cm² at their WP.
- Top Wide RPC: current densities for the STD, ECO2 and ECO3 is around 4-5 nA/cm² respectively at their WP.



Current density vs HV_eff

ABS_100:

- Combined RPC (BOT+TW): the current densities for STD, ECO2, and ECO3 gas mixtures is approximately 8-10 nA/cm² respectively, at their WP.
- Bottom RPC: the current densities for STD, ECO2, and ECO3 gas mixtures is approximately 22,35 and 28 nA/cm² respectively at their WP.
- Top Wide RPC: current densities for the STD, ECO2 and ECO3 is approximately 4-5 nA/cm² respectively at their WP.



Current density vs HV_eff

- Combined RPC (BOT+TW): the current densities for STD, ECO2, and ECO3 gas mixtures is approximately 28, 32 and 24 nA/cm² respectively, at their WP.
- Bottom RPC: the current densities for STD, ECO2, and ECO3 gas mixtures is approximately 46, 56 and 64 nA/cm² respectively, at their WP.
- Top Wide RPC: current densities for the STD, ECO2 and ECO3 is approximately 22, 22and 28 nA/cm² respectively, at their WP.



Muon cluster size vs HV_eff

Source off:

- Combined RPC (BOT+TW): muon cluster size for STD, ECO2, and ECO3 gas mixtures is approximately 2.2 -3.2 (# strip units) respectively, at their WP.
- Bottom RPC: muon cluster size for STD, ECO2, and ECO3 gas mixtures is approximately 2.5-3.2 (#strip units) respectively at their WP.
- Top Wide RPC: muon cluster size for the STD, ECO2 and ECO3 is approximately around 2.2 to 3.1 (#strip units) at their WP.



Muon cluster size vs HV_eff

ABS_100:

- Combined RPC (BOT+TW): muon cluster size for STD, ECO2, and ECO3 gas mixtures is approximately 2.5-2.8 (# strip units) respectively, at their WP.
- Bottom RPC: muon cluster size for STD , ECO2, and ECO3 gas mixtures is around 2.5-3 (#strip units) at their WP.
- Top Wide RPC: muon cluster size for STD, ECO2 and ECO3 is around 2.2 to 2.4 (#strip units) respectively, at their WP.



Muon cluster size vs HV_eff

- The data showed that the muon cluster size decreased as the irradiation cluster rate increased.
- Combined RPC (BOT+TW): muon cluster size for STD, ECO2, and ECO3 gas mixtures is approximately 1.8-2.2 (# strip units) • respectively, at their WP.
- Bottom RPC: muon cluster size for STD, ECO2, and ECO3 gas mixtures is around 2.2-2.4 (#strip units) at their WP. •
- Top Wide RPC: muon cluster size for the STD, ECO2 and ECO3 gas mixtures is around 2 to 2.2 (# strip units) respectively, at their WP.

Gamma rate vs HV_{eff}



- Combined RPC (BOT+TW): gamma rate for STD, ECO2, and ECO3 gas mixtures is approximately 90-100 Hz/cm² at their WP.
- Bottom RPC: gamma rate for STD , ECO2, and ECO3 gas mixtures is approximately 440, 345 and 810 Hz/cm² respectively at their WP.
- Top Wide RPC: gamma rate for the STD, ECO2 and ECO3 is approximately 18- 27 Hz/cm² respectively at their WP.

Gamma rate vs HV_{eff}



ABS_100:

- Combined RPC (BOT+TW): gamma rate for STD, ECO2, and ECO3 gas mixtures is around 130-170 Hz/cm² at their WP.
- Bottom RPC: gamma rates for STD, ECO2, and ECO3 gas mixtures is approximately 560, 846 and 907 Hz/cm² respectively at their WP.
- Top Wide RPC: gamma for the STD, ECO2 and ECO3 is approximately 60-80 Hz/cm² respectively at their WP.

ABS_100

ABS_3.3

Gamma rate vs HV_{eff}



- Combined RPC (BOT+TW): gamma rate for STD, ECO2, and ECO3 gas mixtures is approximately 2586, 2902 and 1766 Hz/cm² respectively at their WP.
- Bottom RPC: gamma rates for STD , ECO2, and ECO3 gas mixtures is approximately 3400, 2489 and 3408 Hz/cm² respectively at their WP.
- Top Wide RPC: gamma for the STD, ECO2 and ECO3 is around 1880, 1111 and 1175 Hz/cm² respectively at their WP.

HV_{gas} Study

 HV_{gas} parameters are studied for the BOT and TW RPC separately.

HV gas formula: $HV_{gas} = Hv_{eff} - RI$

Modified the HV gas formula as:

- HVgas (BOT) = HV_{eff} -R (BOT) * I_{BOT}
- HVgas (TW) = HV_{eff} –R (TW) * I_{TW}
- Computed the ΔV as follows

$$\Delta V_{BOT} = R_{BOT} \times I_{BOT} = \rho \frac{0.4}{Area_BOT} \times I_{BOT} \qquad [Area_BOT = 3824.11 \text{ cm}^2]$$

$$\Delta V_{TW} = R_{TW} \times I_{TW} = \rho \frac{0.4}{Area_TW} \times I_{TW} \qquad [Area_TW = 2299.08 \text{ cm}^2]$$

Estimated resistivity (ρ) value for Bottom RPC: 76 x 10⁹ Ω cm and resistance R_{BOT} = 8 M Ω , Estimated resistivity (ρ) value for TW RPC: 68.9 x 10⁹ Ω cm and resistance R_{TW} = 12 M Ω

Source_off



оттом	HV_50 (chamber efficiency reaches 50%)		
	Eff vs HV_eff (kV)	Effi vs HV_gas (kV)	Voltage drop (V)
STD_gas	10.02	9.62	400
ECO2	11.13	10.77	360
ECO3	10.43	10.08	350
ТОР	HV_50 (chamber efficiency reaches 50%)		
	Eff vs HV_eff (kV)	Effi vs HV_gas (kV)	Voltage drop (V)
STD_gas	9.3	9.23	70
ECO2	10.47	10.42	50
ECO3	9.63	9.59	40

HV_{gas} efficiency for:

- Bottom RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 77%, 78% and 68% respectively.
- Top Wide RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 97%, 96% and 96% respectively.





HV_{gas} efficiency for:

- Bottom RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 78%, 78% and 68% respectively.
- Top Wide RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 97%, 95% and 96% respectively.

ABS_3.3



HV_{gas} efficiency for:

- Bottom RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 78%, 79% and 64% respectively.
- Top Wide RPC: Efficiency for the STD, ECO2 and ECO3 is approximately 96%, 91% and 89% respectively.

Conclusions:

- Efficiency of the combined RPC is mainly from the efficiency of the TW RPC.
- Bottom RPC efficiency is less than 80%.
- Current densities for BOT RPC for all gas mixtures at Source off and ABS_100 are five times higher than the TW RPC and at ABS_3.3 they are around 2-3 times higher.
- Muon cluster size for all the ABS and for all the gas mixtures is around 2-3 strip units.
- Gamma rates for the BOT RPC in the source off condition for the STD , ECO2, and ECO3 are approximately 440, 345 and 810 Hz/cm², respectively, at their WP.
- In 2023 OCT data, gamma rates for combined RPC were 10 to 13 Hz/cm² at their WP, which indicates that the bottom RPC has deteriorated.
- HV gas efficiency for TW RPC is 96-97% for S_off and ABS_100 and 90-96% for ABS_3.3.
- Voltage drop at electrodes for all the gas mixtures for S_off and ABS_100 is 40 70 V and for ABS_3.3, the voltage drop is 100-140 V.