Advances Towards a Large-Area, Ultra-Low-Gas-Consumption RPC Detector

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1. INTRODUCTION

Large Resistive Plate Chamber (RPC) systems have their roots in High Energy Physics (HEP) experiments at the European Organization for Nuclear Research (CERN): ATLAS, CMS, ALICE, where hundreds of square meters of both trigger and timing RPCs, have been deployed. These devices operate with complex gas systems, equipped with re-circulation and purification units, which require a fresh gas supply of the order of 6 $cm^3/min/m^2$, creating logistical, technical and financial problems. Recently, new EU legislation [1] for the progressive phasing out of the main gas used on RPCs - the 1,1,1,2-tetrafluoroethane ($C_2H_2F_4$) or R-134a - due to its Global Warming Potential over 100 years (GWP_{100}) of 1430, has further increased constraints on these systems.

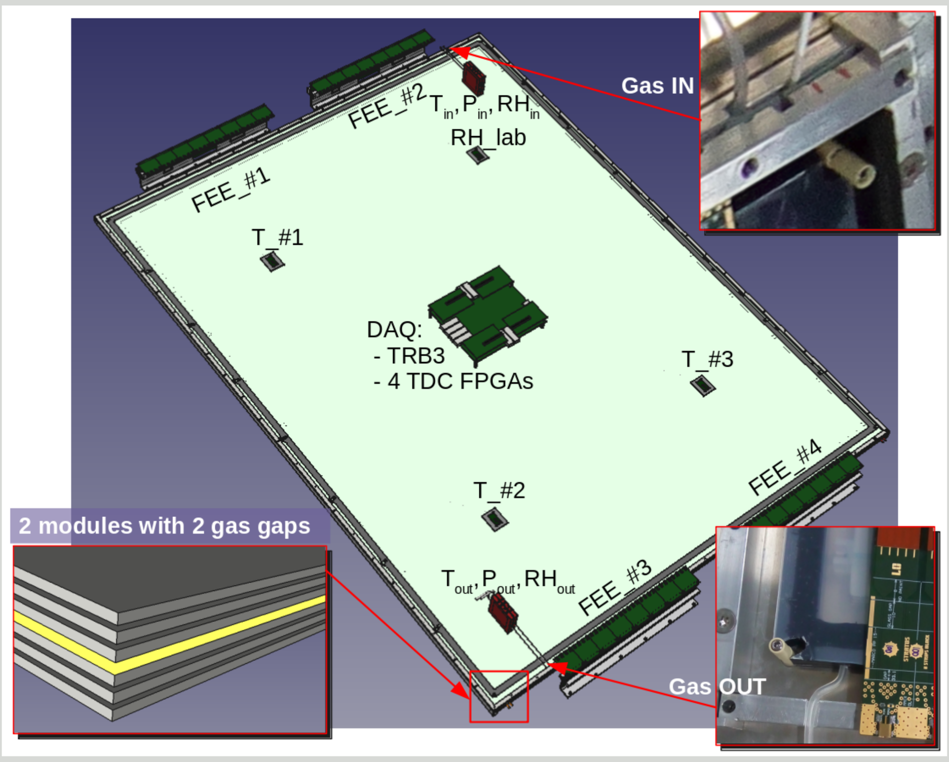
In this communication, we present a new concept in the construction of RPCs which allowed us to operate the detector in a ultra-low gas flow regime. With this new approach, the glass stack (sensitive part of the detector) is encapsulated in a tight plastic box made of polypropylene, which presents excellent water vapor blocking properties as well as a good protection against atmospheric gases.

As shown below, a detector with 2 m^2 was constructed and operated for more than one month with a gas flux of 1 $cm^3/min/m^2$ in stable conditions.

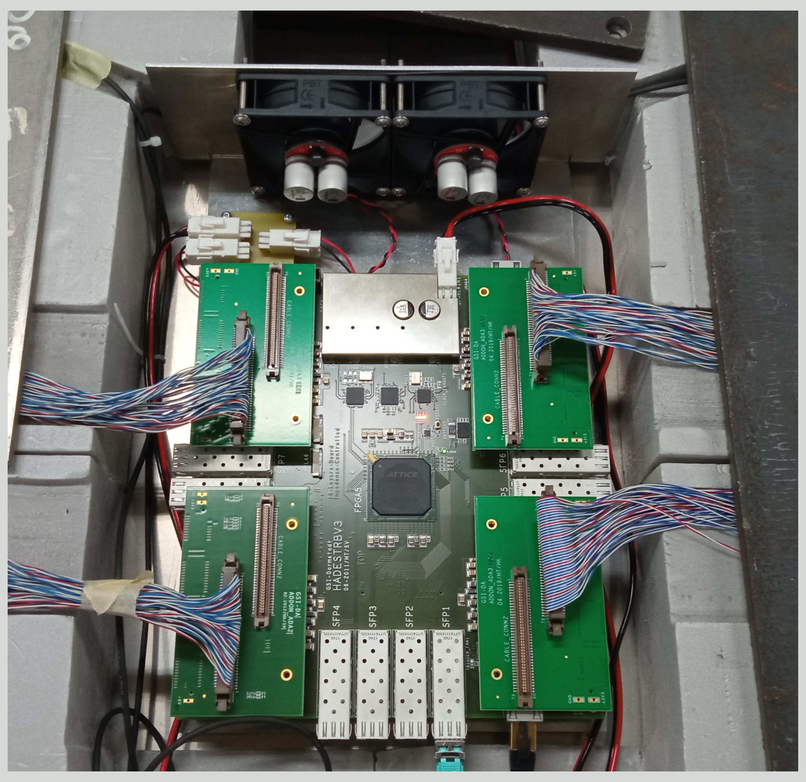
2. DETECTOR

DETECTOR:

- active area: 1.2 x 1.6 m^2
- 2 multi-gap RPC, one on each side of the pick-up strips, with two gas gaps each, 1 mm wide, and glass 2 mm thick with a bulk resistivity of $\approx 4\text{x}10^{12}$ Ωcm at **25** °C
- 64 longitudinal pick-up strips (1.55 cm wide and 1.85 cm pitch)



3. FRONT-END & DAQ



DAQ - TRB3

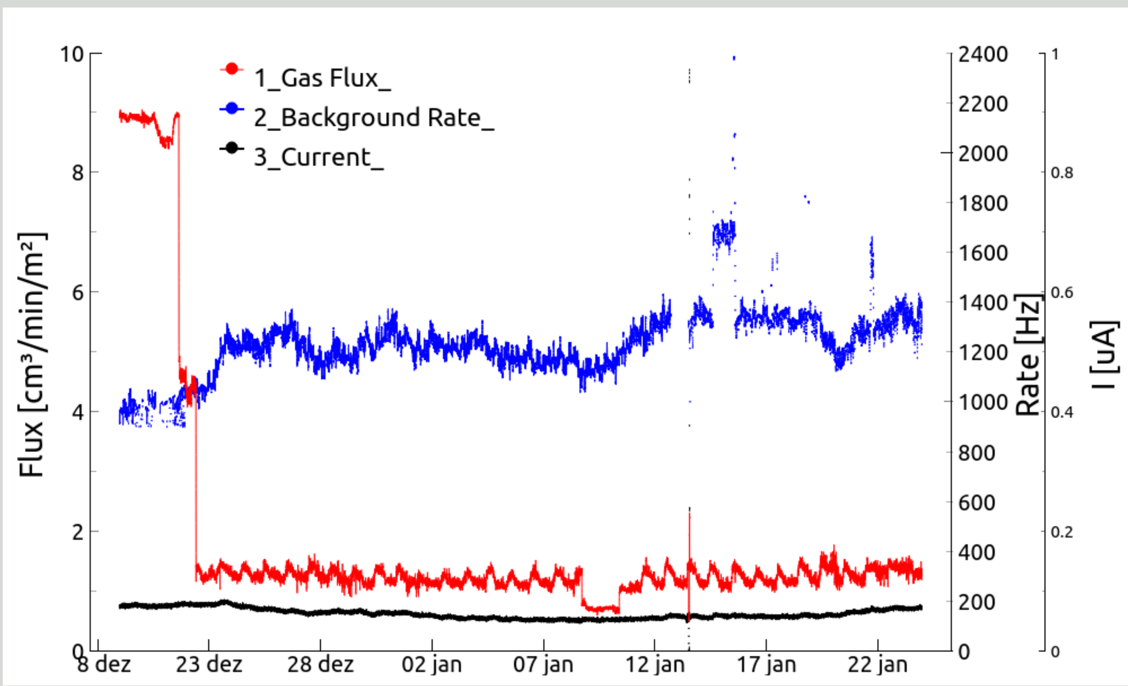
DAQ & FEE:

- multi-purpose Trigger Readout Board (TRB3) with four FPGA-based TDCs ($\sigma_t \sim 20ps$)
- FEE ($\sigma_t \sim 35ps$): time and charge encoded in the leading edge and the width of LVDS signals

PARTICLE DETECTION:

- time: $(T_F + T_B)/2$
- charge: $(Q_F + Q_B)/2$
- longitudinal position: $(T_F - T_B)/2$
- transverse position: strip of higher **Q**

4. OPERATION - LOW FLUX



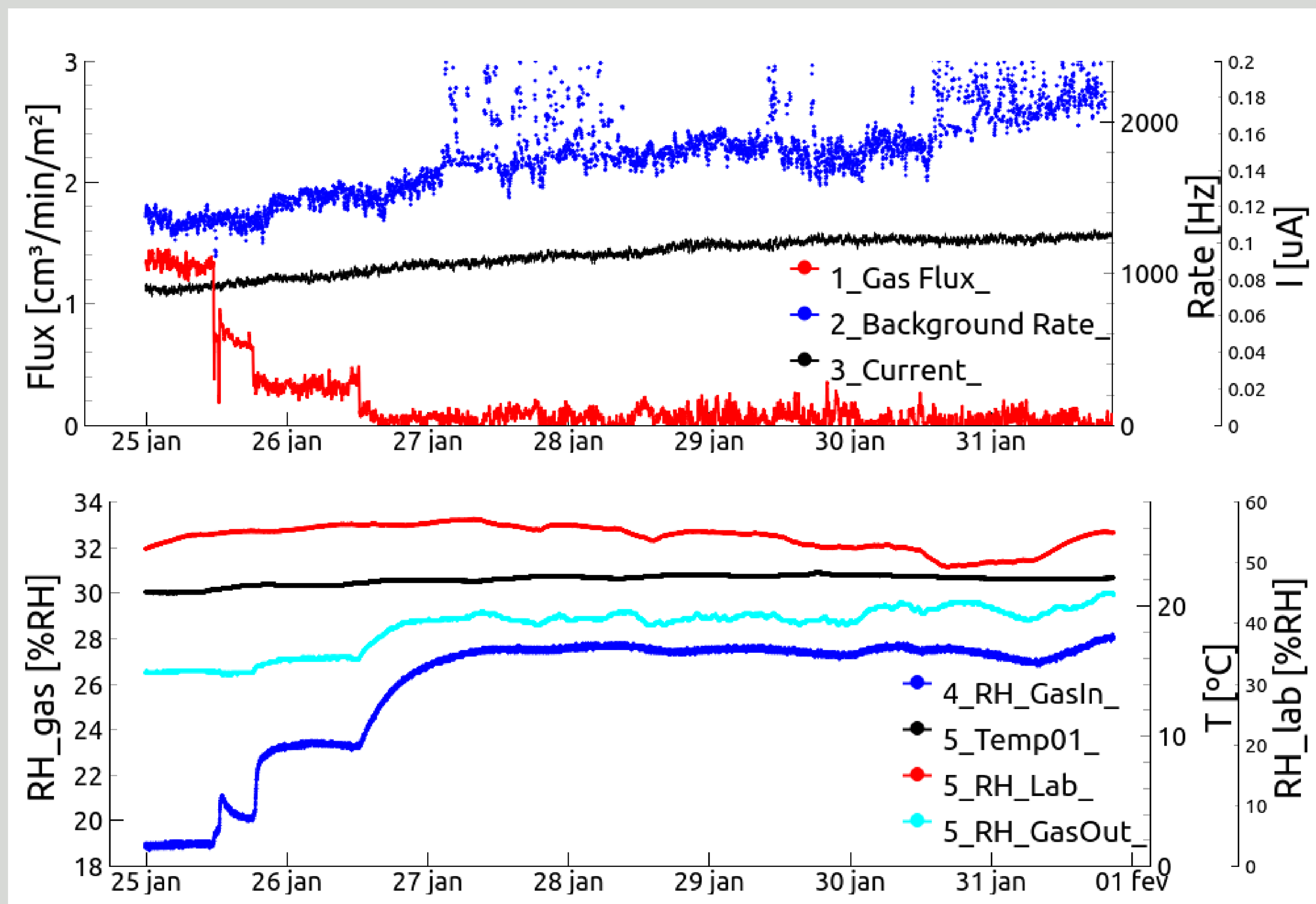
← One month-long operation at very low gas flux (slightly above 1 $cm^3/min/m^2$)

The choice of polypropylene resulted in a high sealing performance against external contaminants.

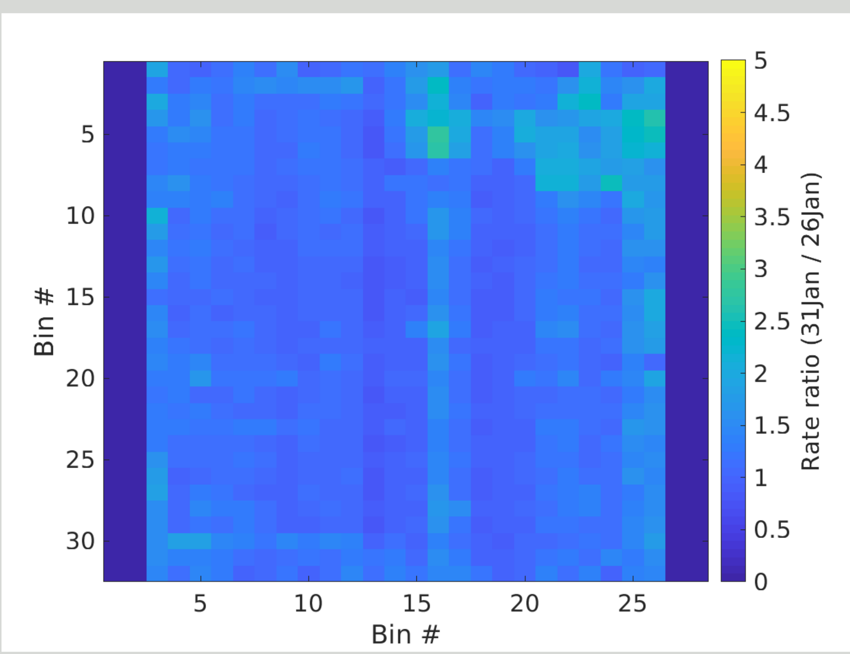
5. OPERATION - RESIDUAL FLUX

Background → rate at residual flux

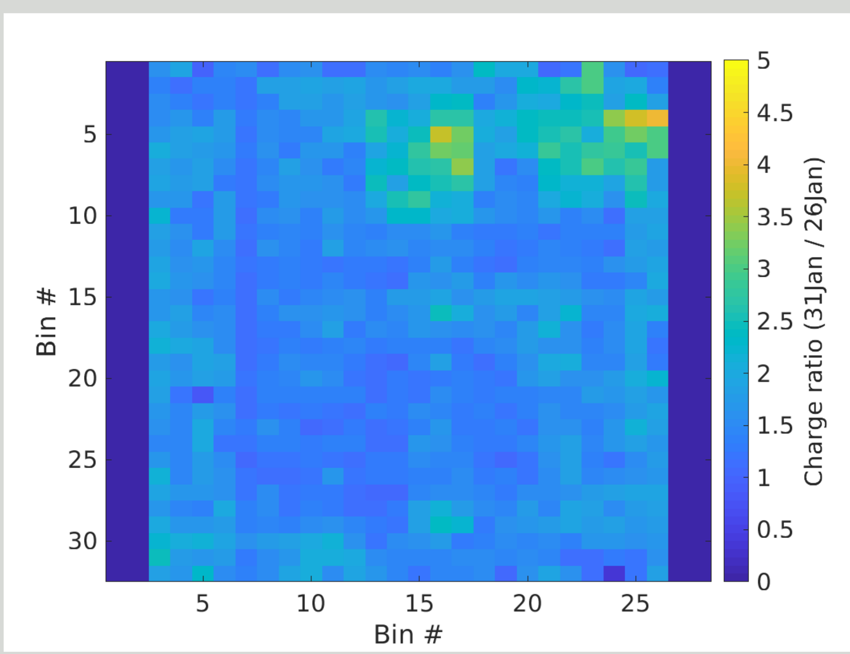
50% increase of the background rate in five days. RH of the gas: increase of 40% in one day at inlet side (< 10% at outlet side).



6. ANALYSIS - RESIDUAL FLUX



Background rate ratio (31Jan-26-Jan)



Charge ratio (31Jan-26-Jan)

The observed increase of the background rate occurred mainly in a circumscribed region close to the gas inlet of the RPC.

The quick rise of both RH of the gas entering and exiting the RPC might be due to water vapor contamination near both sensors simultaneously, probably due to a lack of sealing in these measurement points.

7. CONCLUSION

A new concept in the construction of RPCs was presented, enabling operation at ultra-low gas flow regime. The encapsulation of the sensitive volume within a tight plastic box made of polypropylene, which presents excellent water vapor blocking properties as well as a good blocking to atmospheric gases, allowed us to operate an RPC of 2 m^2 for more than one month with a gas flux around 1 $cm^3/min/m^2$. Decreasing even more the gas flux to a residual value, the sealing of the polypropylene box to contaminants was still effective, however, contamination arose upstream of the RPC.

One month later, re-establishing the gas flux, the RPC was able to recover its normal operation.

8. ACKNOWLEDGEMENTS

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9. REFERENCES

Regulation (EU) No 517/2014
http://data.europa.eu/eli/reg/2014/517/oj