Optimization of the Resistive Plate Chamber operation with a closed loop gas system at the Large Hadron Collider experiments

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Resistive Plate Chambers (RPCs):
- Relatively low production cost
- High time resolution (~1 ns)
- Suitable spatial resolution (~1 cm)

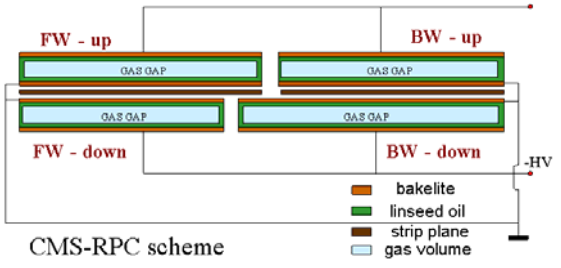
Gas mixture:

$C_2H_2F_4$ - iC_4H_{10} - SF_6 [95-5-0.3 %]
+0.1% water vapour (to control the bakelite resistivity)

Extensively employed at LHC:

The large detector volume (~16 m^3 in ATLAS and CMS) and the use of a relatively expensive gas mixture make a closed-loop circulation system unavoidable.

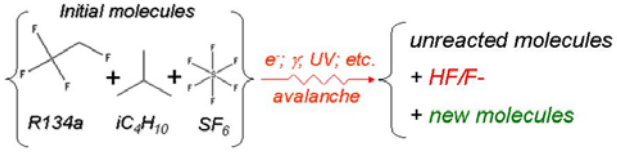
Nowadays with only 5 % of fresh gas replenishing rate, the cost is about 500 €/day

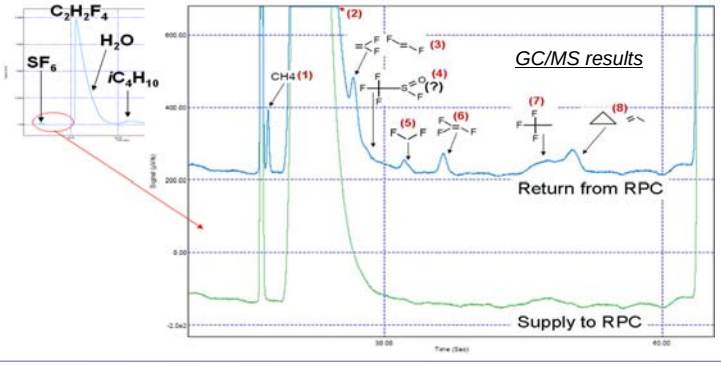


CMS-RPC scheme

Degradation of the RPC Gas Mixture under Irradiation

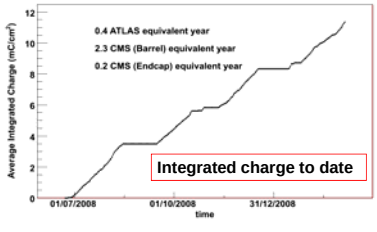
Previous long-term tests have shown that:
- Several extra-components appear in the return gas of irradiated RPCs
- Detector performances can be affected if impurities are not properly removed

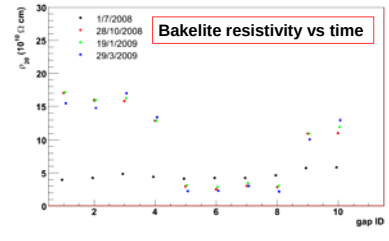




Experimental set-up and RPCs performance checks

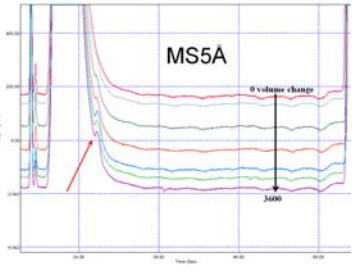
- **Six CMS double gap RPC**
- **High gamma radiation flux** (~cGy/h) over large area at the CERN GIF (^{137}Cs source)
- Small **closed-loop gas system**, with same functionalities as the LHC gas systems
- Parallel **characterization of different impurity absorbers**
- **RPC performance monitored** in terms of current, HV stability, bakelite resistivity



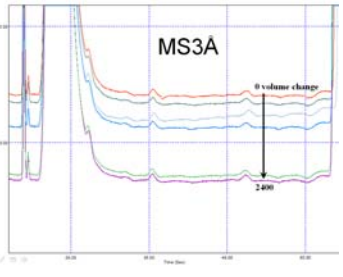


Optimization of the Closed-loop Gas System Operation

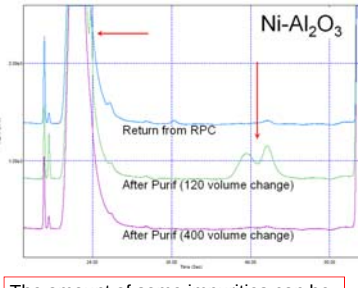
Filtering Capacity of 3 tested Absorbers



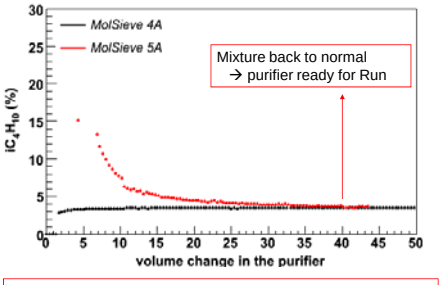
All impurities are removed (for a certain time)



No effect: impurities are not filtered



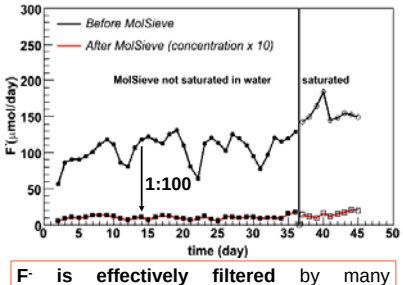
The amount of some impurities can be enhanced after a period of operation and then disappear.



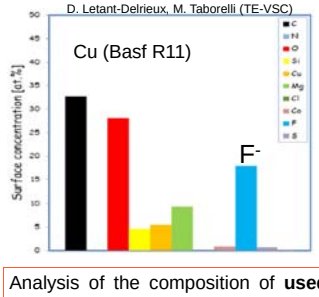
In the first hours of operation purifiers can also absorb some components of the main mixture or enhance other impurities (ex Ni-Al_2O_3) changing the mixture.
Solved with an optimized **conditioning phase**.

Fluoride Electrode Results – Monitoring F^- creation

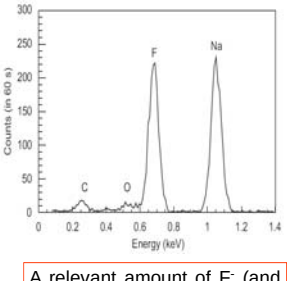
F^- is created and it is very reactive. Effects on the material already seen (bakelite surface etching, NaF deposits, material corrosion). Important to be filtered.



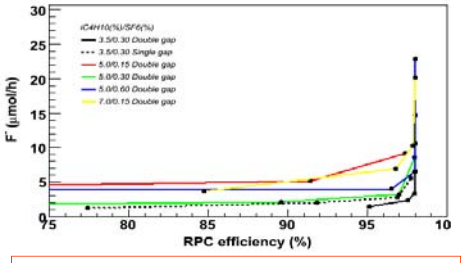
F^- is effectively filtered by many Absorbers. The MolSieve Absorber reduces F^- by a factor ~100.



Analysis of the composition of **used absorbers** show the presence of F^-. To verify if this affects the purification effectiveness at long-term.



A relevant amount of F^- (and Na) has also been observed on the internal electrode surface



Gas mixtures with other concentrations of iC_4H_{10} and SF_6 have been tested to try reducing F- production. **No clear benefits are observed. Only a lower working point (i.e. high voltage) reduces effectively the amount of impurities.**

A systematic study of the RPC gas mixture has been performed. Extra components created in the irradiated gas are identified and a strategy to filter them efficiently in being investigated. Tests continue to find the conditions to reliably operate RPC at the LHC in optimized cost-effective, closed-loop, gas systems.