Studies of F- Impurities Formation in ALICE MID RPC Detectors: A Comparison Between RUN2 and RUN3

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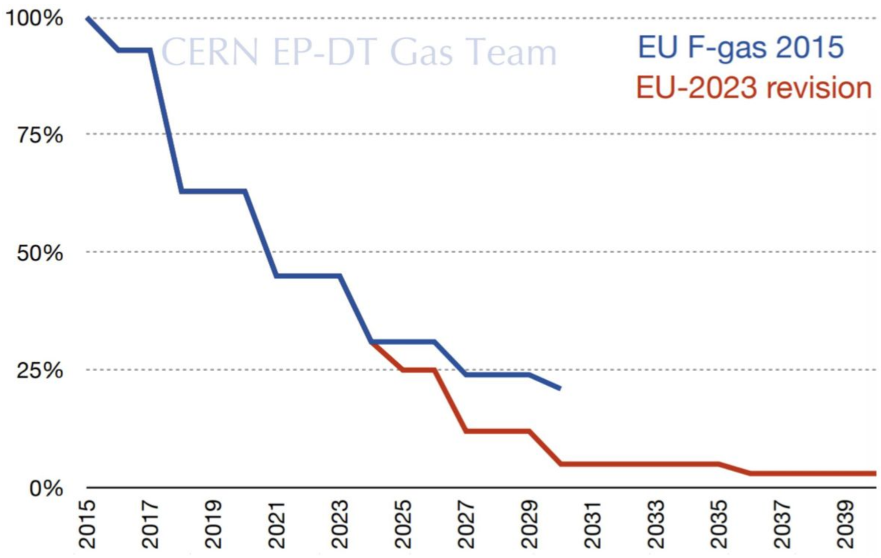
Outline

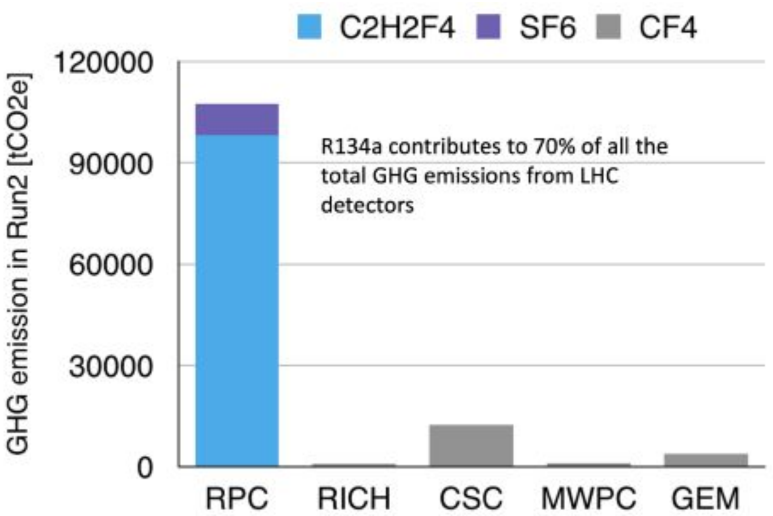
- Greenhouse gas emissions at CERN
- Gas recirculation systems: the case of ALICE MID
- Setup and Activity overview
- GC Analysis
- F^- measurements
- Conclusion

Greenhouse gas emissions at CERN

CERN Environment Report:
- Reduce GHG emissions by 28% by the end of RUN3;

EU fluorinated gases regulation (2014):
- Reducing products availability of fluorinated GHGs;
- This regulation already affected fluorinated gases prices.





CERN gas team developed different strategies to reduce GHG emissions:
- Research on alternative eco-friendly gases;
- Optimization of current gas systems technologies and gas recuperation plants;
- Development of gas recirculation systems.

ALICE MID ~~pipeline~~ timeline

End 2015

Start operation under gas recirculation

2016

Recirculation fraction increased by step, up to **75%**

2017

Recirculation fraction reduced up to **50%** to study of possible correlation

2018

Installation of the **new Gas Analysis Rack** in the Service Area

End 2023

Restart of operation with a recirculation fraction of **88%**

GC, MS, ISE

GC, ISE

RUN2	LS2	RUN3

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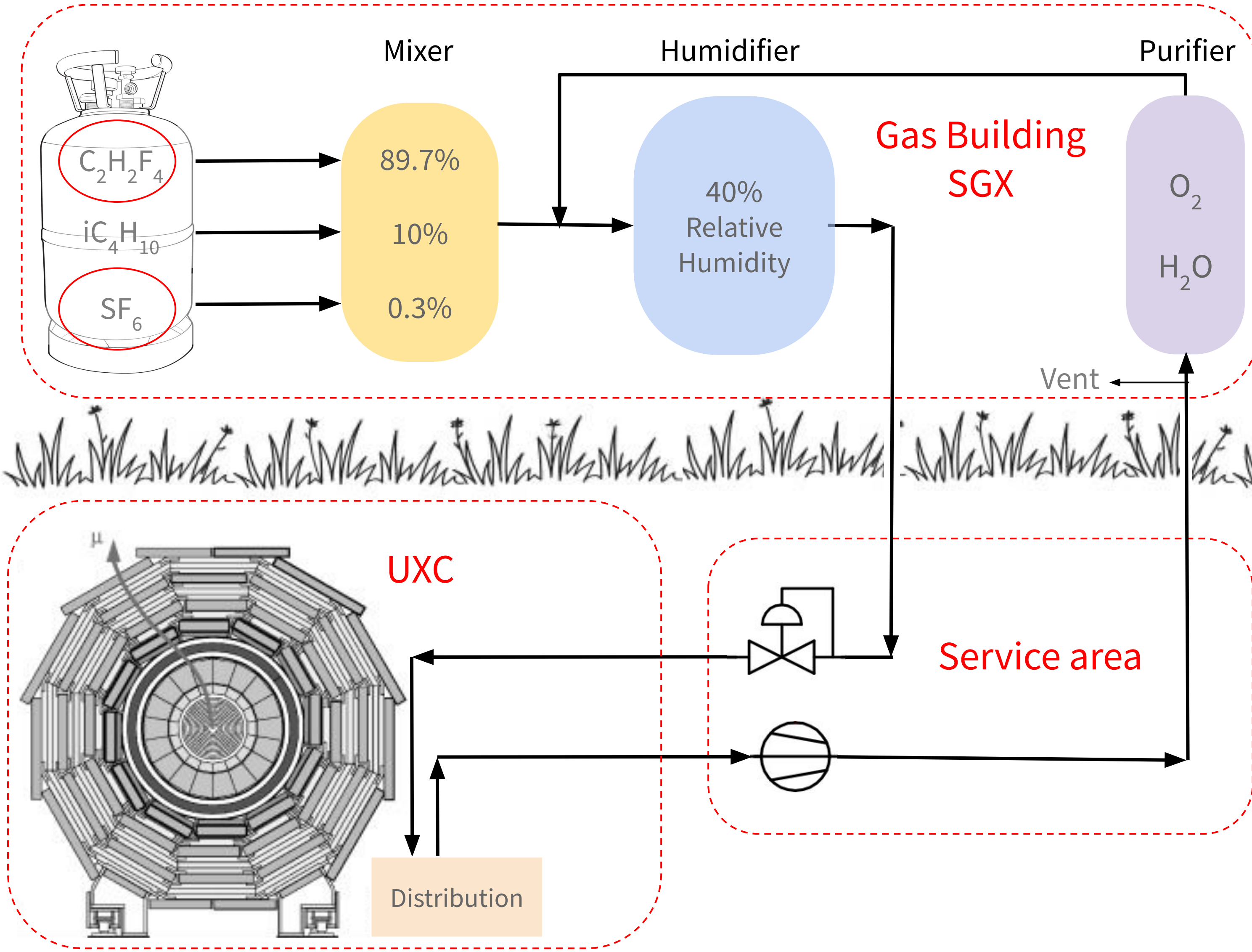
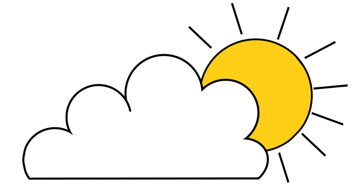
Gas Recirculation for RPC detectors





High Pressure Section of the Gas Recirculation System

Low Pressure Section of the Gas Recirculation System

Gas Recirculation for RPC detectors

Significant reduction of gas consumption

BUT

Lot of parameters to be controlled:
-> flows, pressures, % recirculations…

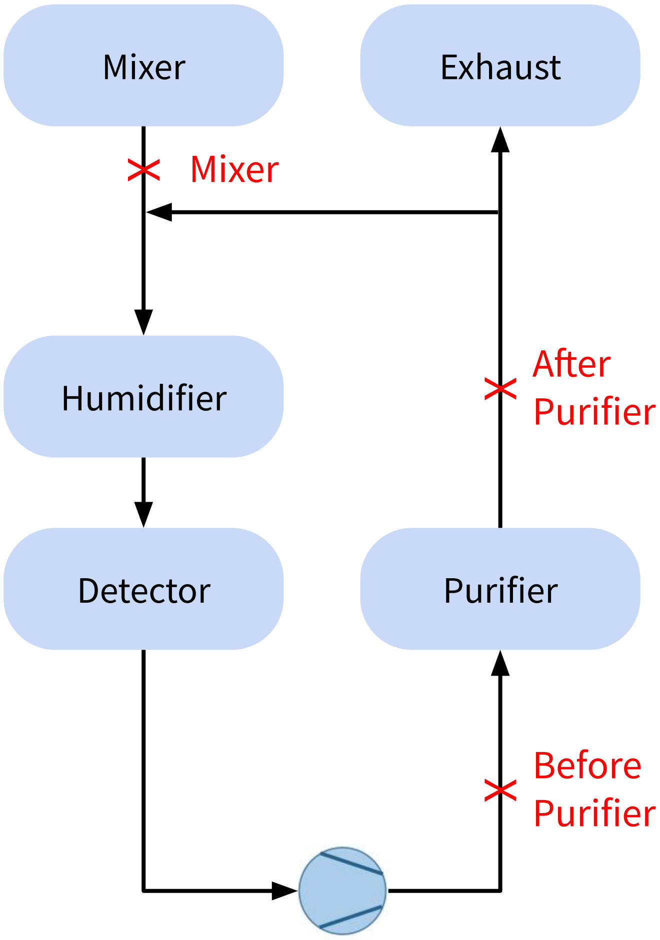
Possible impurities accumulation:
-> additional module to purify the mixture.

Gas quality analysis is essential:

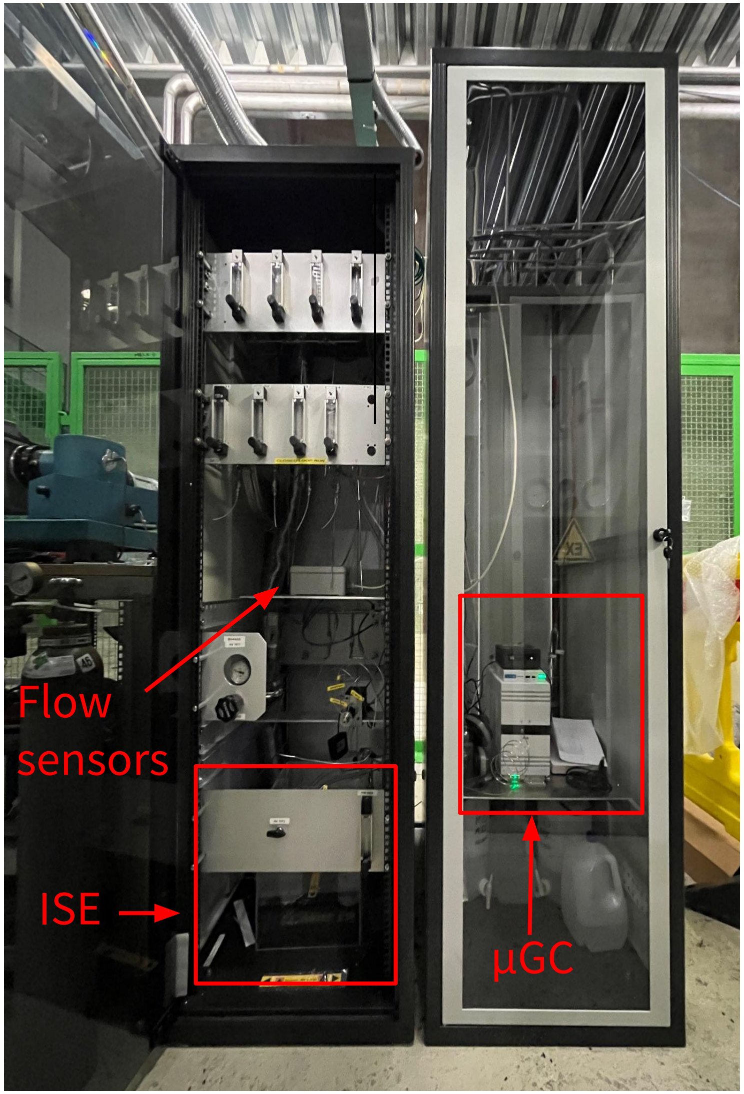
- Gas Chromatograph (GC): Gas separation and composition monitoring;
- Mass Spectrometer (MS): Impurities identification;
- Ion Selective Electrode (ISE): F^- Formations.

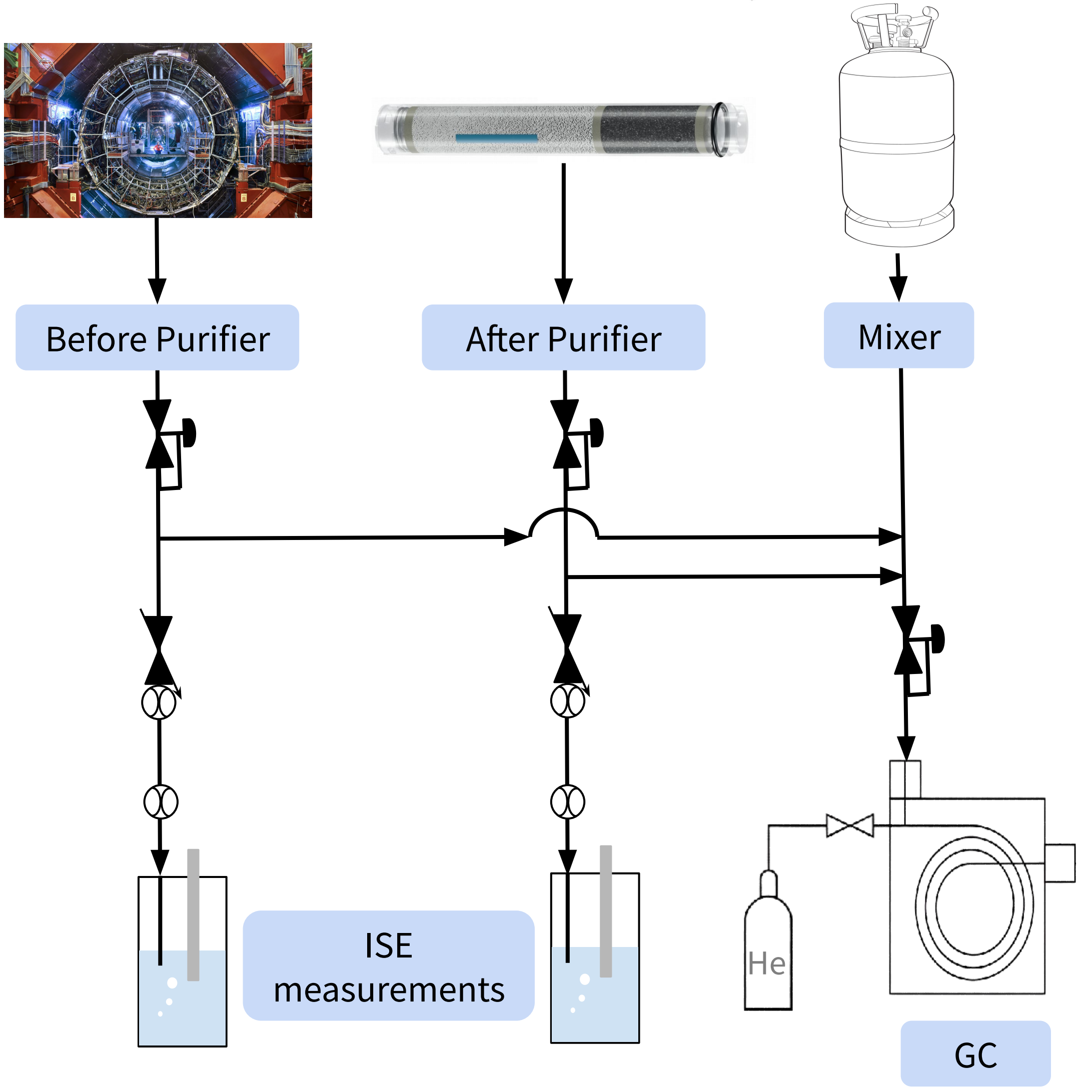
3 different sampling point:

- Mixer: fresh gas sampled after the mixer;
- Before Purifier: gas sampled at the detector's exhaust;
- After Purifier: gas sampled after the purifiers, so after the cleaning agents (Molecular Sieve + Cu/Ni catalyst).

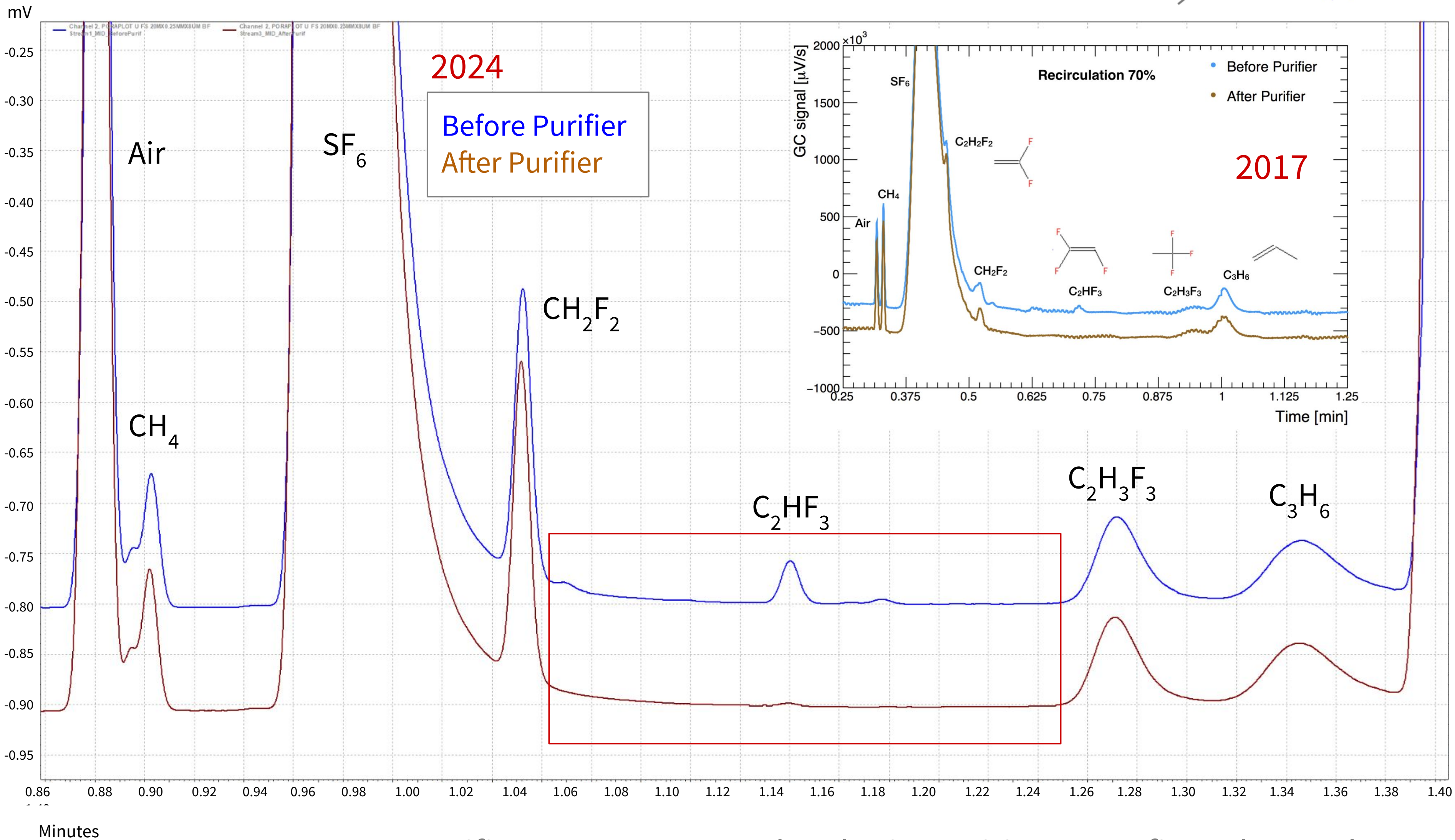


Setup: dedicated Gas Analysis Rack





GC analysis

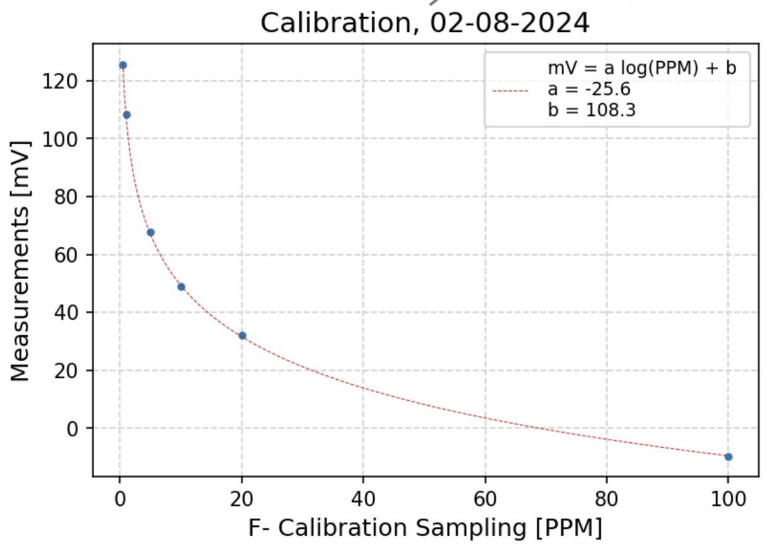


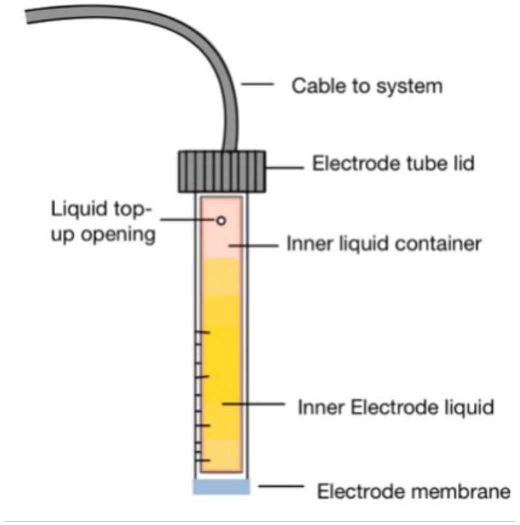
Purifiers traps some molecular impurities -> confirmed 2017 data.

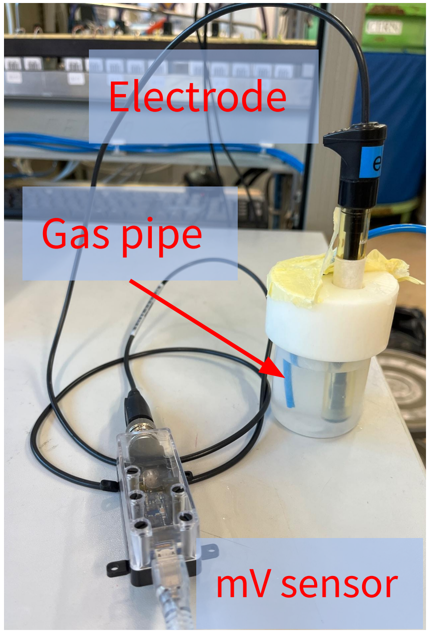
Ion Selective Electrode Measurements

Potentiometric technique that allows to <u>measure the concentration of F^- in a specified solution of water + TISAB</u> (Total Ionic Strength Adjustment Buffer)

- Real-time measurements;
- Wide concentration measurements range;
- Inexpensive and easy to operate.







- Gas bubbled continuously in 330 ml sampling solution;
- Measured the <u>integrated accumulation</u> -> no change of the sampling solution;
- 1 ln/h gas flow;
- 2 measurements / week;
- 1 calibration / 2 weeks.

Example of ISE setup

Ion Selective Electrode Measurements

This measurements are not trivial, several parameters need to be fixed:

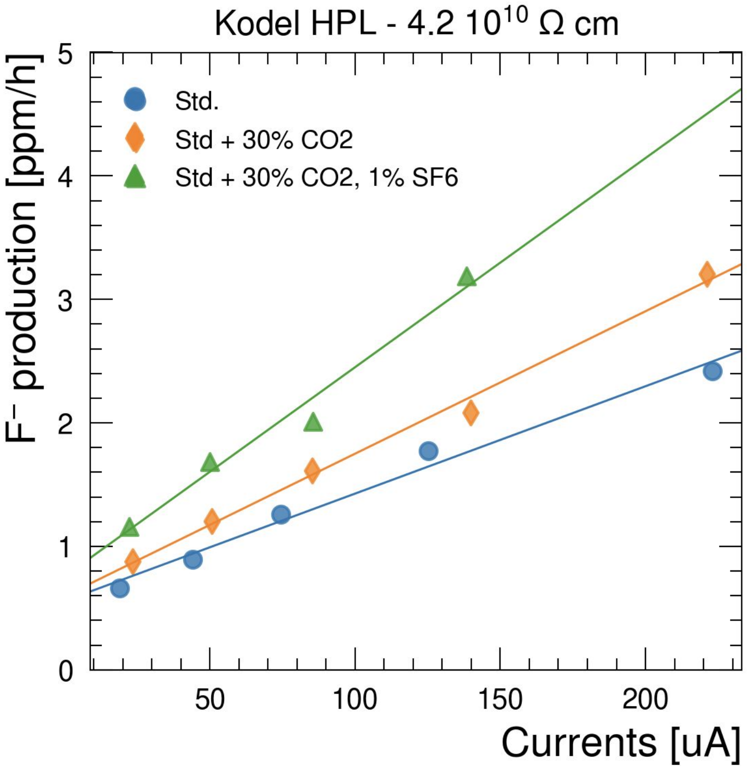
- Gas flow to the sampling bottle;
- Gas pressure;
- Temperature;
- Volume of the sampling solution;

In parallel, Improving the setup stability

Several tests performed at the **Gamma Irradiation Facility** (GIF++):

- Fixed gas flow;
- Fixed gas pressure;
- Fixed temperature;
- Fixed volume of the sampling bottle

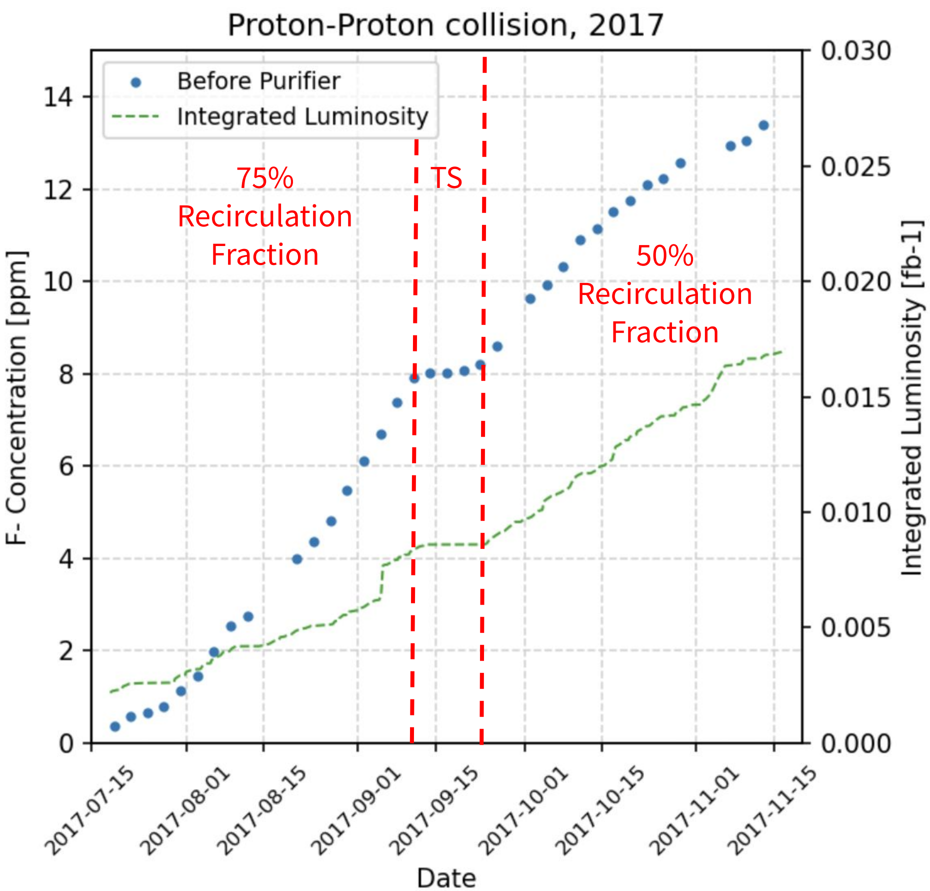
Indagated the production for different gas mixtures under different background irradiation

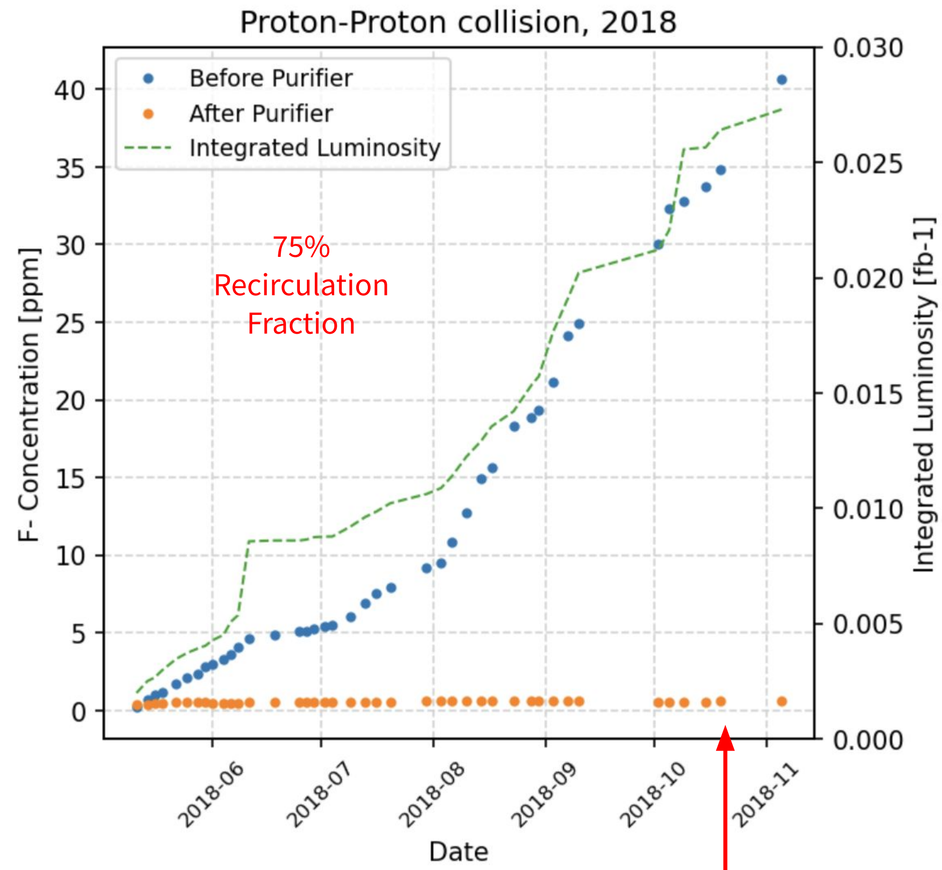


These studies allow one to understand and mitigate the criticalities of these measurements

R. Guida et al. 2023 nima.2023.168393

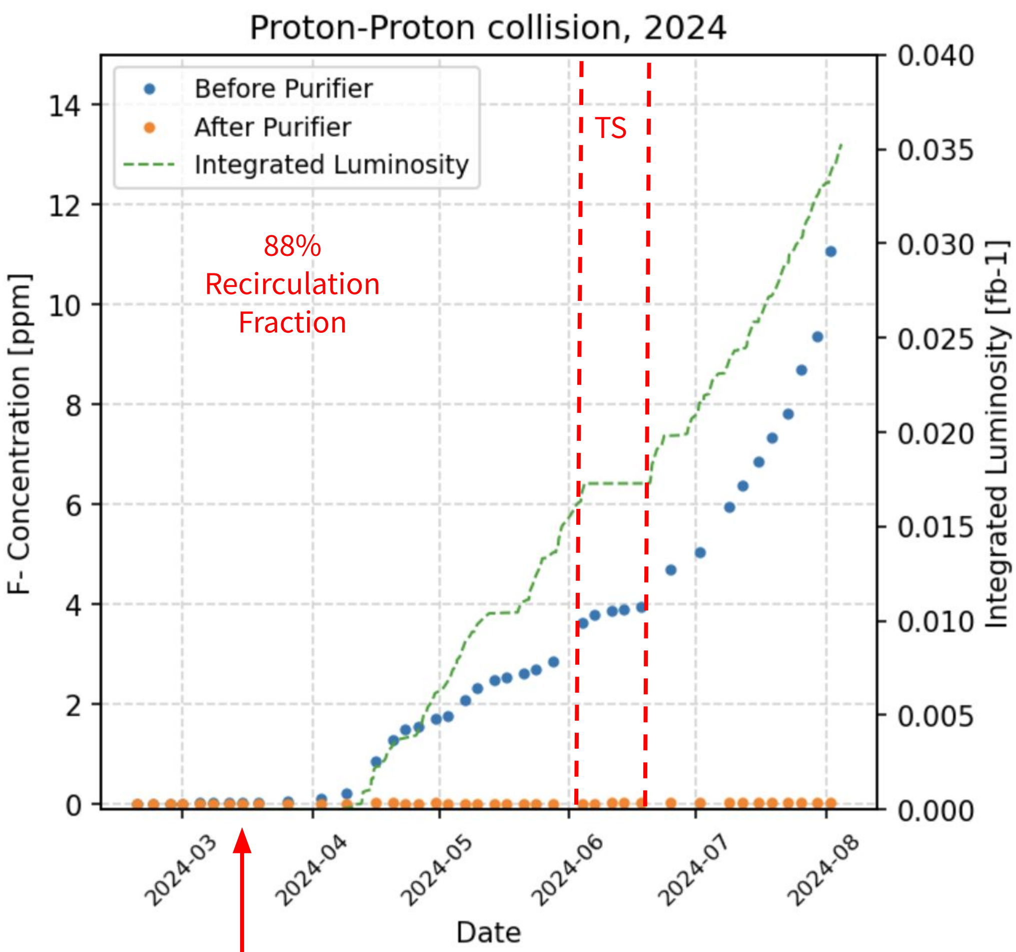
RUN2 Measurements





- PPM production increases as the Integrated Luminosity increases;
- Purifier absorbs the F^- produced.

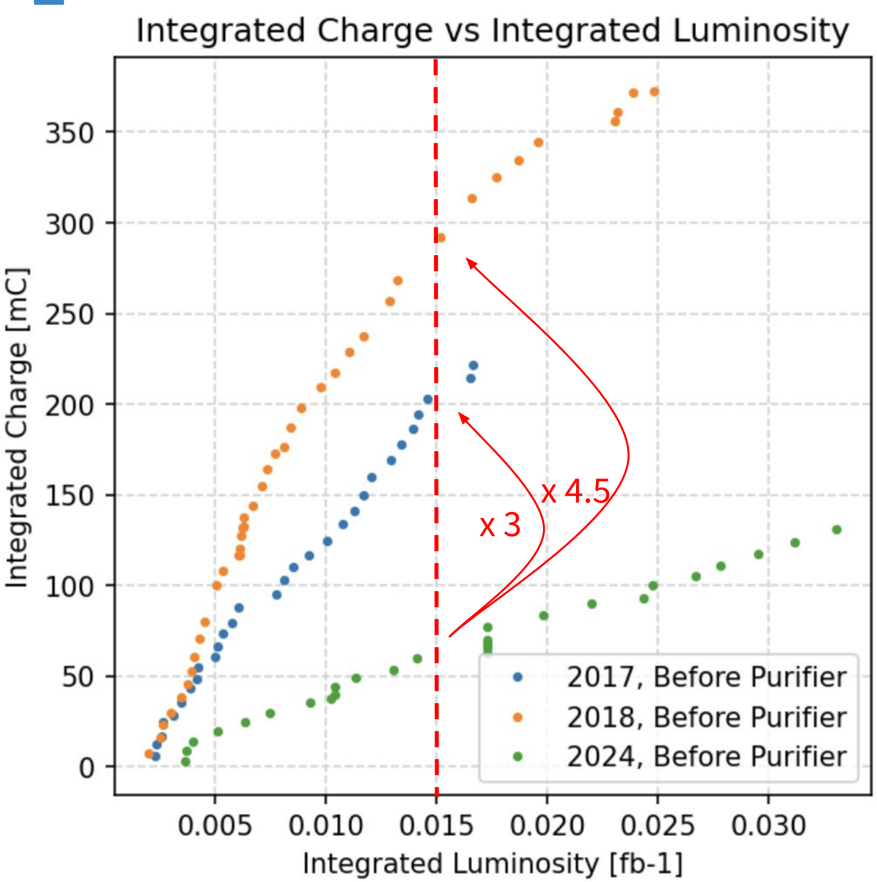
RUN3 Measurements

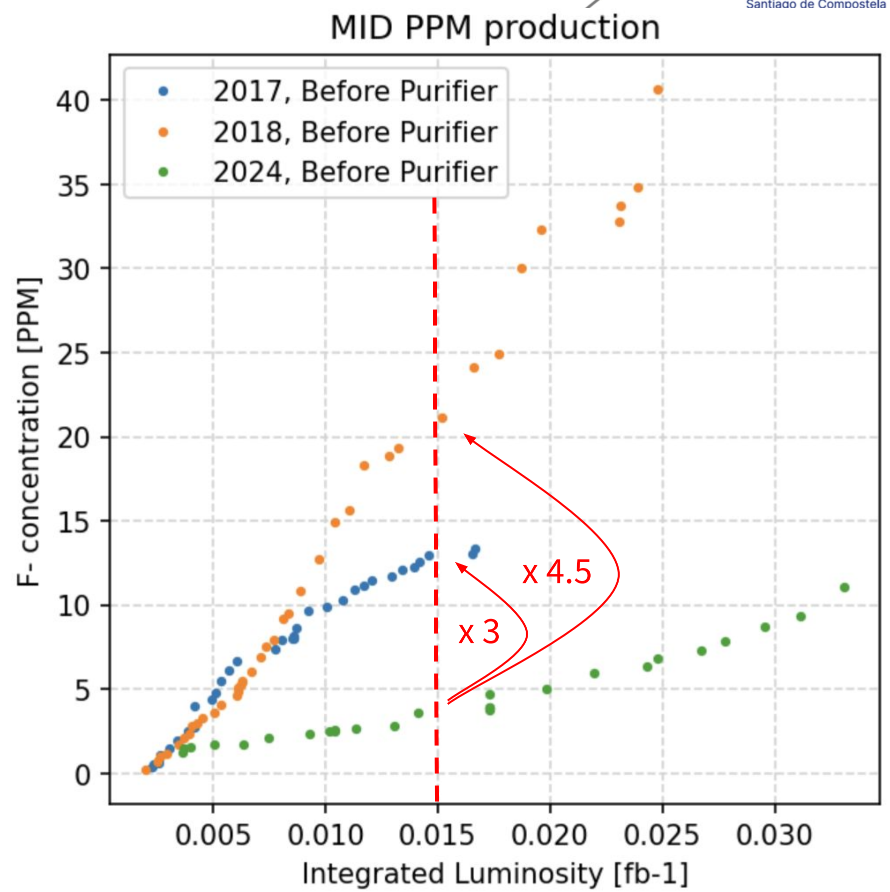


Measurements stability before the restart of LHC

- PPM production increases as the Integrated Luminosity increases;
- Purifier absorbs the F^- produced
  -> Trap efficiency constant over purifier timelife;
- The production seems lower than RUN2: changed detector WP
  -> New FEE, lower voltage required.

Comparison between RUN2 and RUN3





- Detector's integrated charge higher in 2018, lower in 2024;
- Similar trend of the integrated charge and F^- as a function of the integrated luminosity: 2024 F^- production 3 times lower than 2017 and 4.5 times lower than 2018 for fixed integrated luminosity.
- F^- production is proportional to the accumulated charge and to the integrated luminosity.

Conclusion

- The new Gas Analysis Rack is a fundamental improvement for ALICE MID gas system: -> After RUN2 experience, this system allows to reach 88% of recirculation fraction during RUN3;

- The study confirms purifier's effectiveness to trap part of impurities created and almost the totality of F^- Ions;

- The ISE campaign shows a F^- production from the detector proportional to the accumulated charge and to the integrated luminosity;

- Due to the lower operative voltage, following the change of the FEE, the F^- production is 3 times lower than 2017 and 4.5 times lower than 2018.