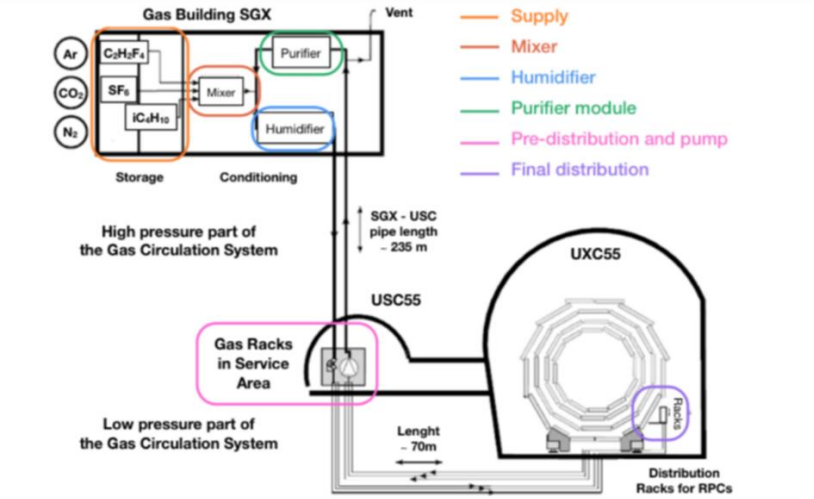
Monitoring the Concentration of Fluoride and Other Impurities Across a Purification System

Naomi Mburu
University of Maryland, Baltimore County
Supervisors: Beatrice Mandelli and Roberto Guida
R&D for LHC Experiments

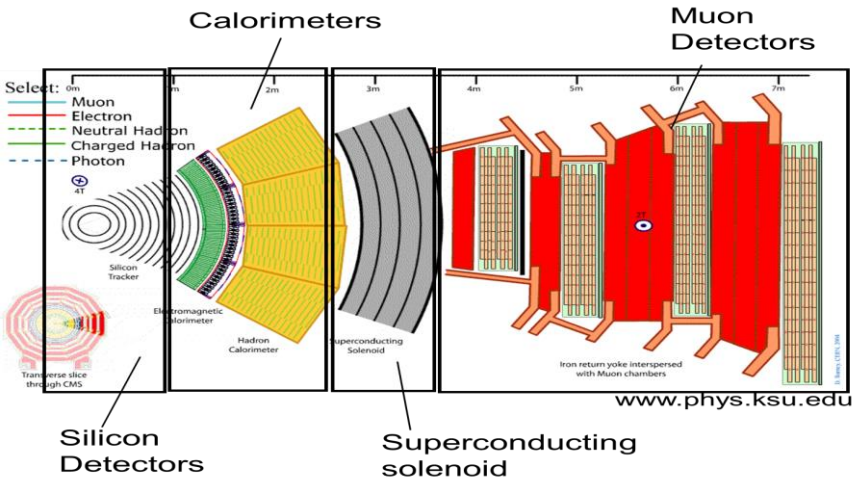
Background

- Resistive Plate Chambers(RPCs) are a type of muon detector that utilizes gas mixtures to induce avalanche ionization reactions
- Harmful impurities can damage the inside of the detector if they are not properly filtered



Schematic of gas recirculation system at CMS

- Gas mixtures must be recycled because they are expensive and may produce greenhouse effects
- Typical gas composition for RPC detectors:
  - 94.7% Freon ($C_2H_2F_4$) to induce avalanche ionization
  - 5.0% Isobutane (i-C_4H_{10}) for quenching
  - 0.3% Sulfur Hexafluoride (SF_6) as a source of electronegativity



Cross-section illustration of the components of the CMS detector

How do we monitor purification systems?

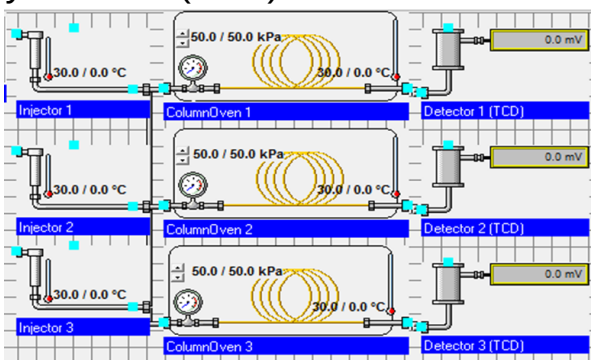
Ion Selective Electrodes (ISE)

- Measures potential difference between sample and a standard, then utilizes Nernst Equation to solve for ion concentration
- Used to determine the accumulation of Fluoride ions over time before and after purifier

ISE Fluorine Monitor

Gas Chromatography (GC)/ Mass Spectrophotometry (MS)

- GC separates gas components in time and quantifies them using chemically treated columns and a thermal conductivity detector (TCD)



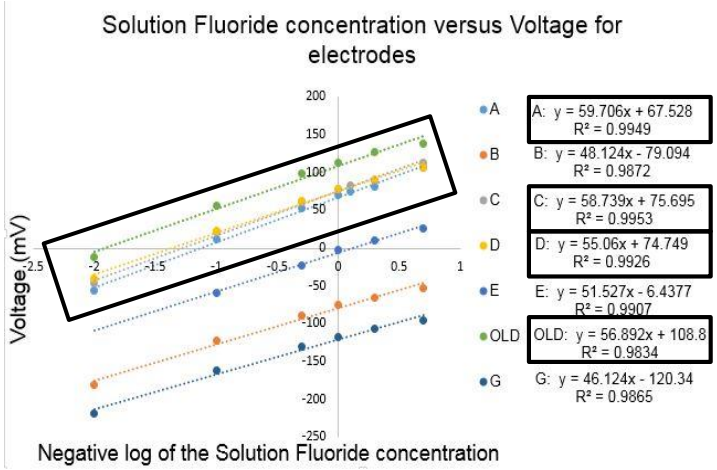
Schematic of the GC internal set-up

- MS identifies components by ionizing and accelerating the sample in a magnetic field. Mass/charge ratios are then determined.
- Coupled together to allow for separation, quantification and identification of gas components

ISE Set-Up

Goal: Monitor the levels of Fluoride build-up over time before and after the purifier

Step 1: Calibrate Electrodes



Ideal Slope:
56+/-4

Step 2: Troubleshooting

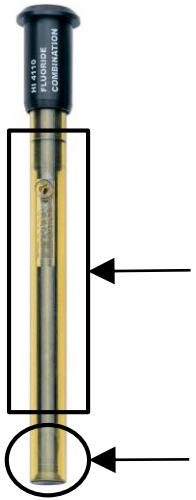
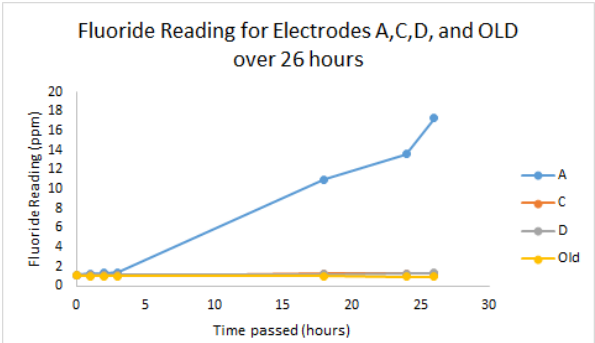
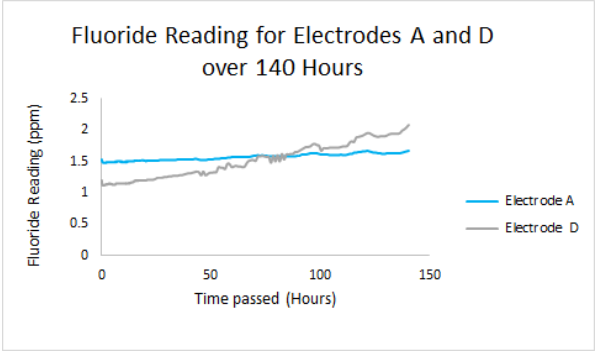


Image from Hannainst.com

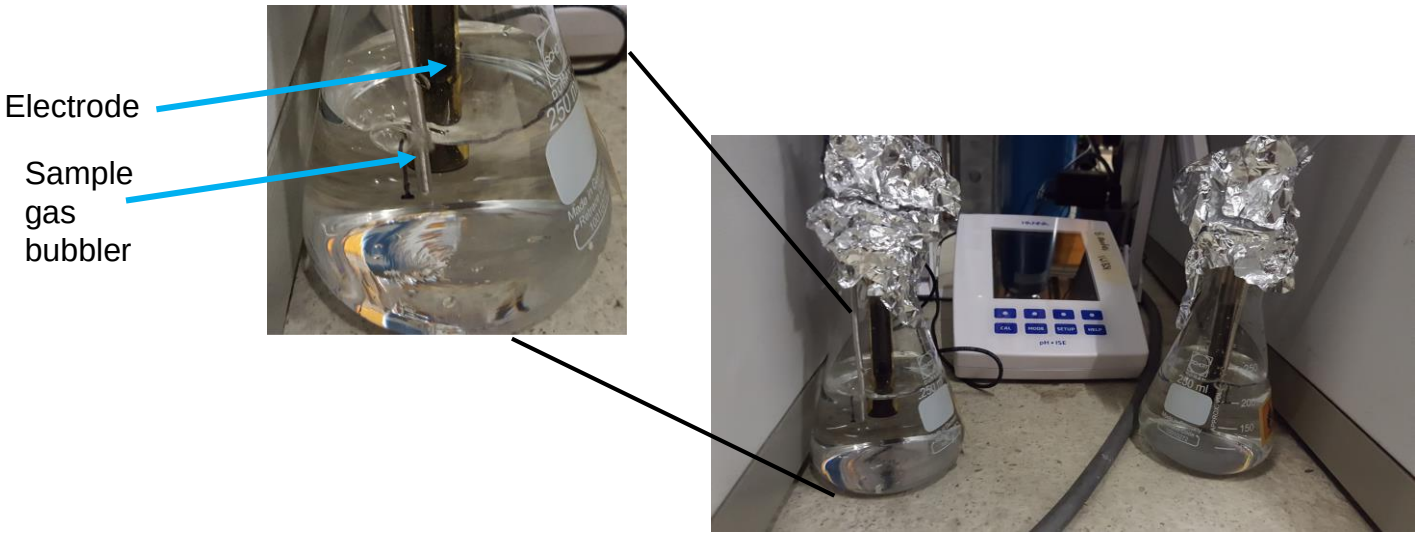
Step 3: Stability Tests





Installing ISE Station

The ISE station is now installed and recording Fluoride concentration data



ISE installed at gas distribution racks

GC/MS Set Up

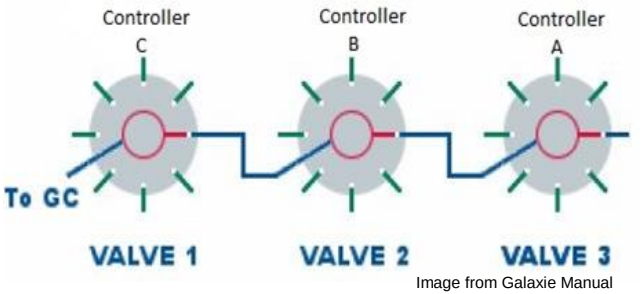


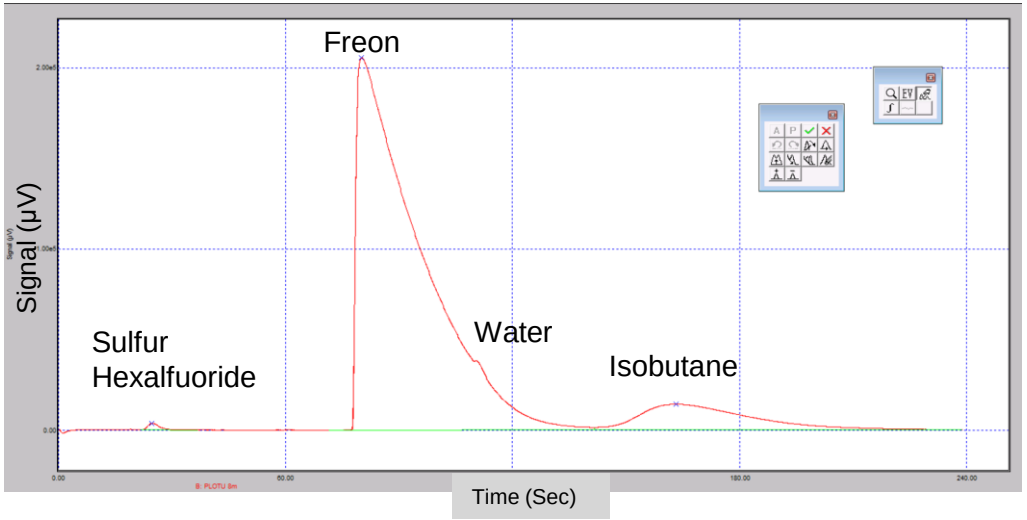
Image from Galaxie Manual

Schematic of valve controller set-up

Micro gas chromatography machine

Goals:

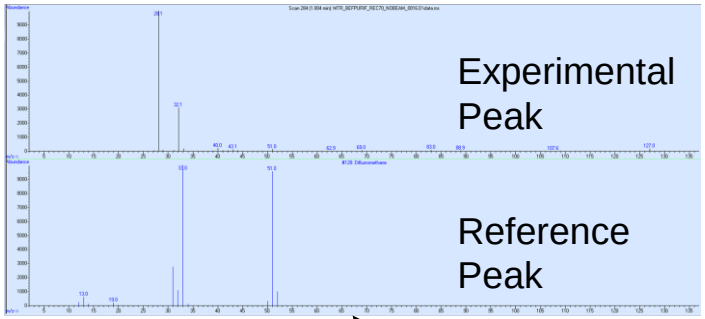
1. Troubleshoot Systems and couple GC with MS
2. Set up remote valve control
3. Identify new gas impurities before and after the purifier



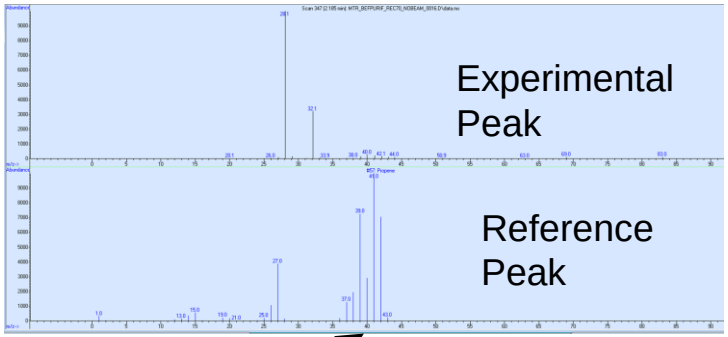
Chromatograph

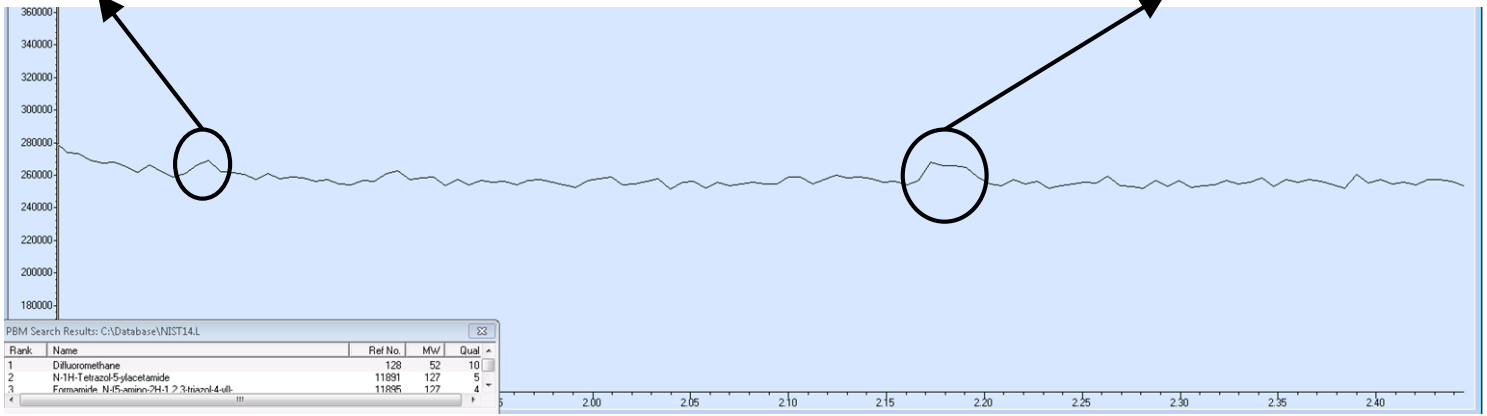
GC/MS Analysis

Difluoromethane



Propane





GC/MS chromatograph

Conclusion

- Gas mixture analysis is used to prevent aging of detector
- ISE, GC, and MS can used to determine the amount, identity, and accumulation of gas system components.

Acknowledgements

- I would like to thank the NSF for funding my summer at CERN
- I would also like to thank my supervisors, Beatrice Mandelli and Roberto Guida