CMS GAS SYSTEM R&D

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EP-DT

Detector Technologies

OUTLOOK

- **Gas Recuperation Plant**
  - CF_4 Recuperation - CSC
  - R134a Recuperation - RPC
- **RPC Distribution Regulation Valves**
- **RPC Dummy Chambers**
- **RPC Ecogas**

GAS RECUPERATION

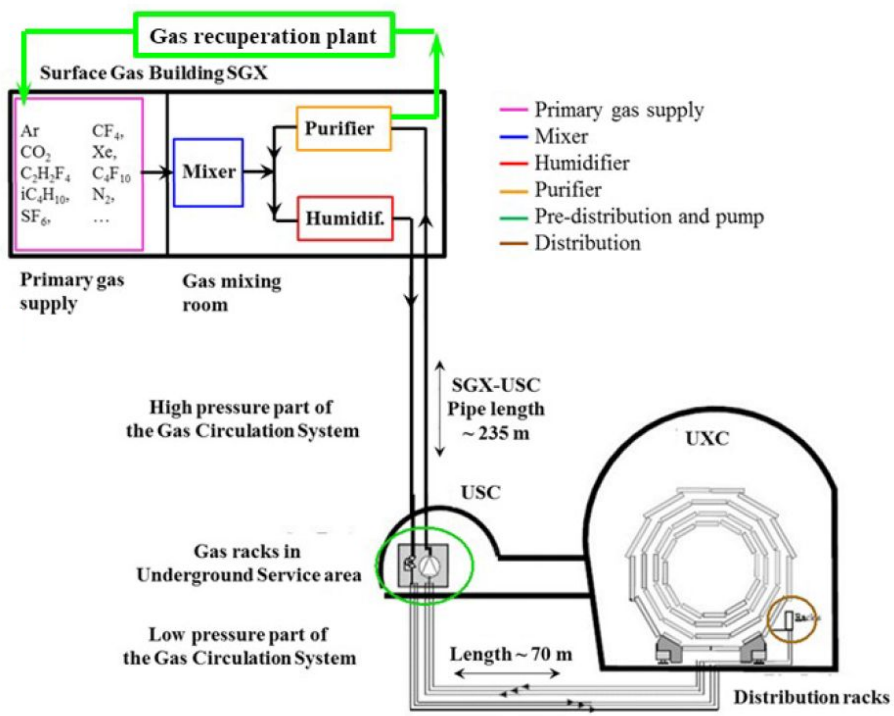
Several LHC gas system are already using recuperation plants

➔ **PROS**

- Further reduction in gas consumption
- Level of N2 impurities under control
- Operation at lower detector pressure

➔ **CONS**

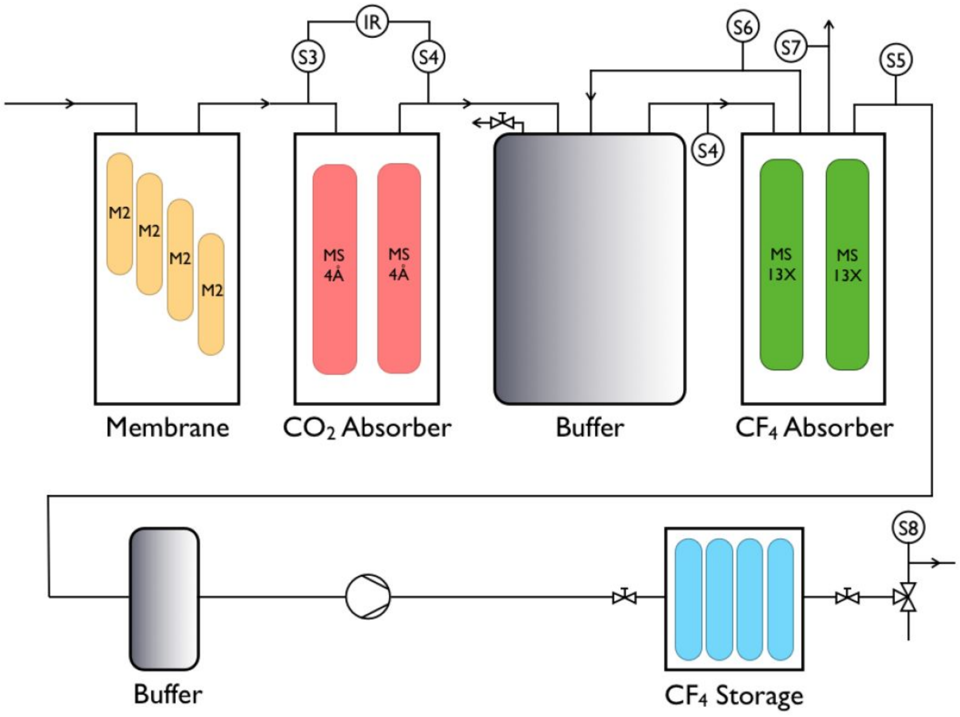
- Additional complexity of the gas system
- Dedicated R&D
- Gas mixture monitoring necessary



CF4 RECUPERATION - CSC

- **The technical challenge:**
  - It is the first plant built for CF4 warm adsorption
  - It is a completely non-standard gas system

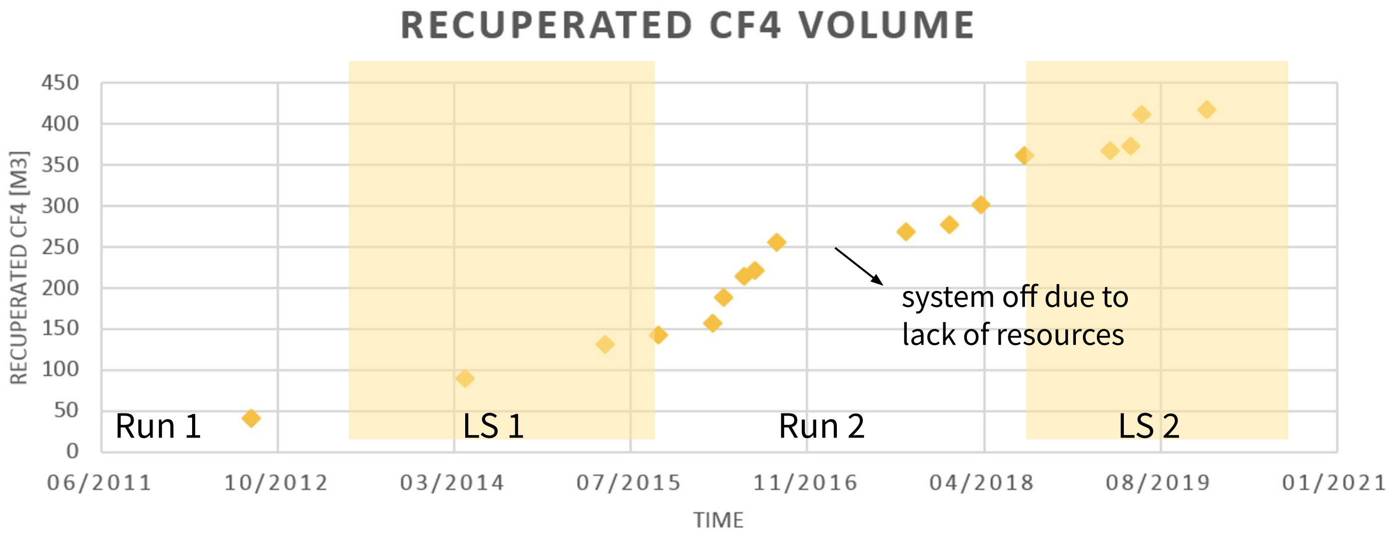
- **The modules:**
  - Input to plant
  - Membrane separation module
  - CO2 adsorption module
  - CF4 adsorption module
  - CF4 compression module
  - Recuperated CF4 injection m
  - Infrared analysis module
  - SWC monitoring module



CF_4 RECUPERATION - CSC

- **STATUS:** in operation since 2012, a lot of tuning/upgrades done
- **420 m^3** of recuperated CF4 (eq. to 1 year of operation at 10%)

  50k Chf at today price, 200 kChf at 2010 price …
- **Recuperation efficiency** improved : today **60%**
- CF4 consumption reduced by 40% starting from 2018



CF_4 RECUPERATION - CSC

➔ INPUT TO PLAN:

- Ok for operation
- **Plant input flow affects recuperation efficiency:**
  compromise between CSC Gas System operation and Exhaust flow stability

➔ MEMBRANE FOR SEPARATION MODULE:

- Working with good efficiency (~ 70%)
- Installation of new flowmeters
- Test new High Sensitivity membrane

➔ CO2 ADSORPTION MODULE:

- Ok for operation

➔ CF4 ADSORPTION MODULE:

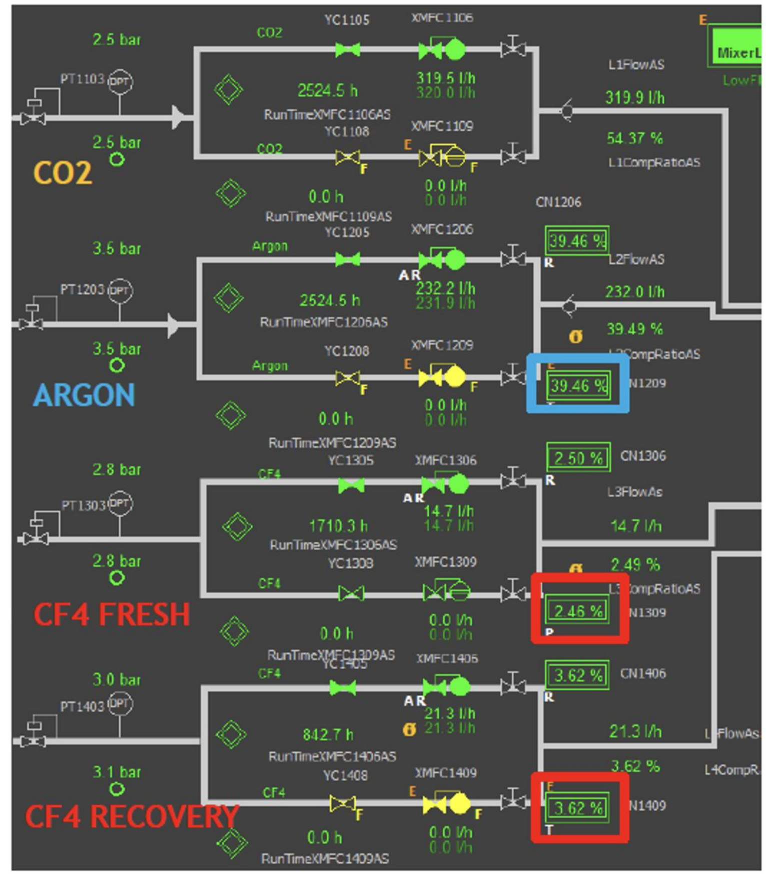
- Leak in column B, maintenance necessary > 1 week stop might be needed
- New pump test and installation
- Valves timing test to optimize recuperation cycles

CF_4 RECUPERATION - CSC

- **CF4 COMPRESSION MODULE:**
  - Test and installation of new compressor
  - New storage tank to be installed
- **CF4 INJECTION:**
  - Ok for operation, working at design condition (see next slides)
- **GC ANALYSIS:**
  - Ok for operation
- **CF4-CO2-Ar IR ANALYZER:**
  - Calibration necessary
- **CF4 SWPC MONITORING**
  - Stable operation since 2015 (see next slides)

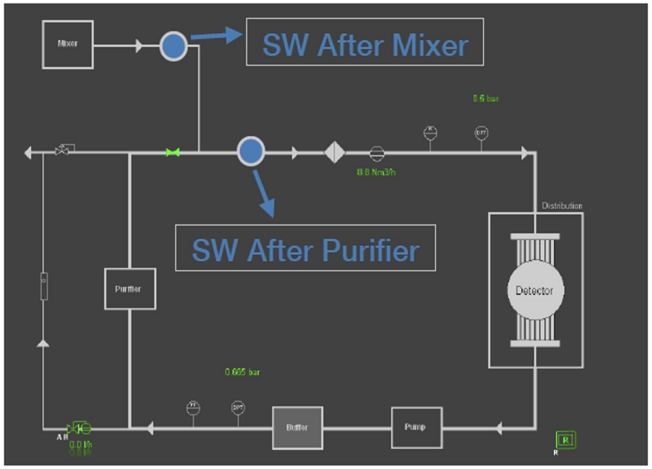
CF4 RECUPERATION - CSC

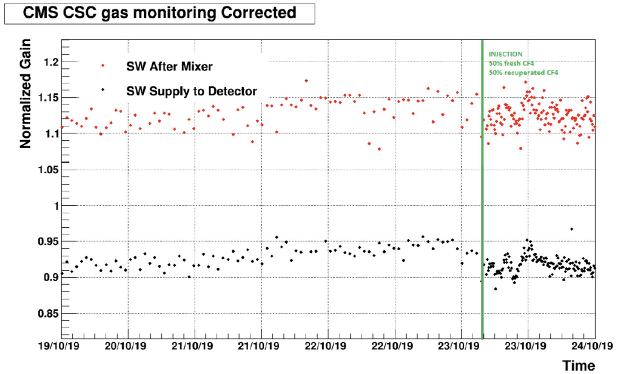
- By design, **the reinjection is half of the total CF4 of the mixture**
- MFCs have to be properly set
  to take into account CF4 pollution
- The tuning of MFCs is done
  thanks to GC analysis,
  comparing the mixture to standard
  mixer injection
- **Mixer operation with recuperated CF4 for around 20% of Gas System operation time**

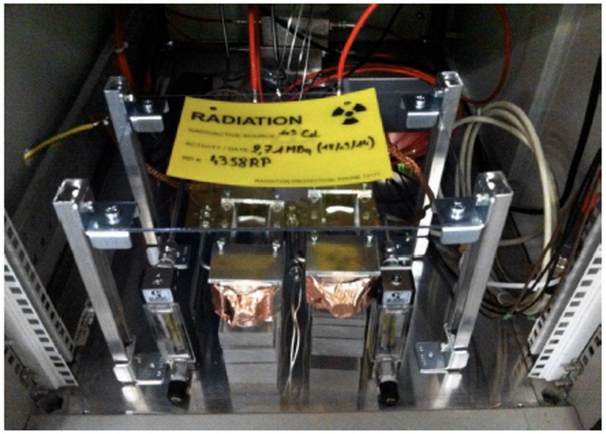


CF_4 RECUPERATION - CSC

- Single Wire Chambers are installed After Mixer and After Purifier
- Irradiated with 55Fe gamma source
  - Amplification gain monitored > peak position
  - Rate around 400 Hz
- SWPC are used to monitor ordinary operation but also to *check Mixer tuning during Recuperated CF4 Injection*







available to CSC people on DIP and on webpage
https://cms-csc-gas-monitoring.web.cern.ch/cms-csc-gas-monitoring/

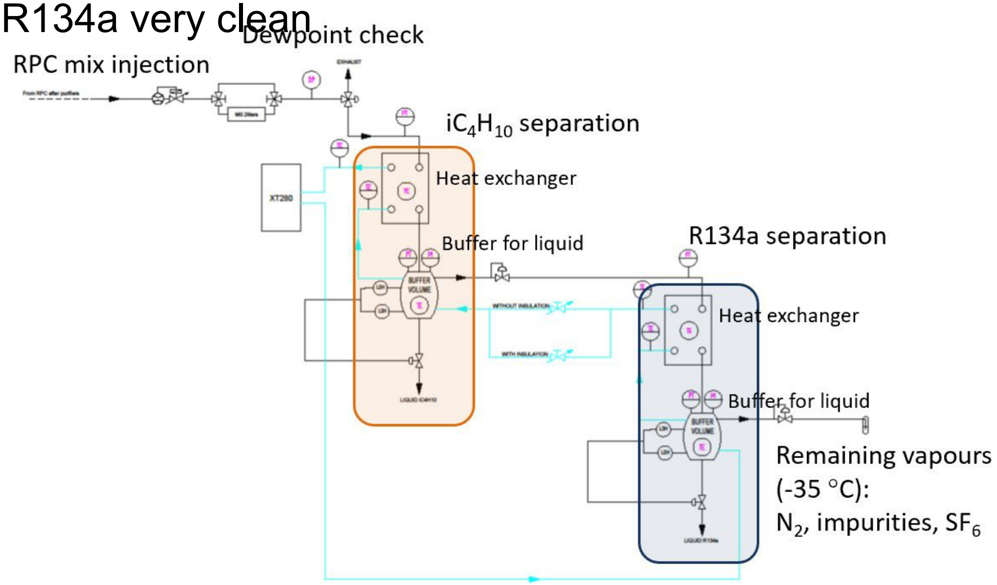
R134a RECUPERATION - RPC

Prototype 0:

built for ATLAS-RPC in December 2018 (low flow, 100 l/h)

➔ **Promising results**

- High efficiency (close to 100%)
- N2 removed to same level as in new R134a
- Recuperated R134a very clean



R134a RECUPERATION - RPC

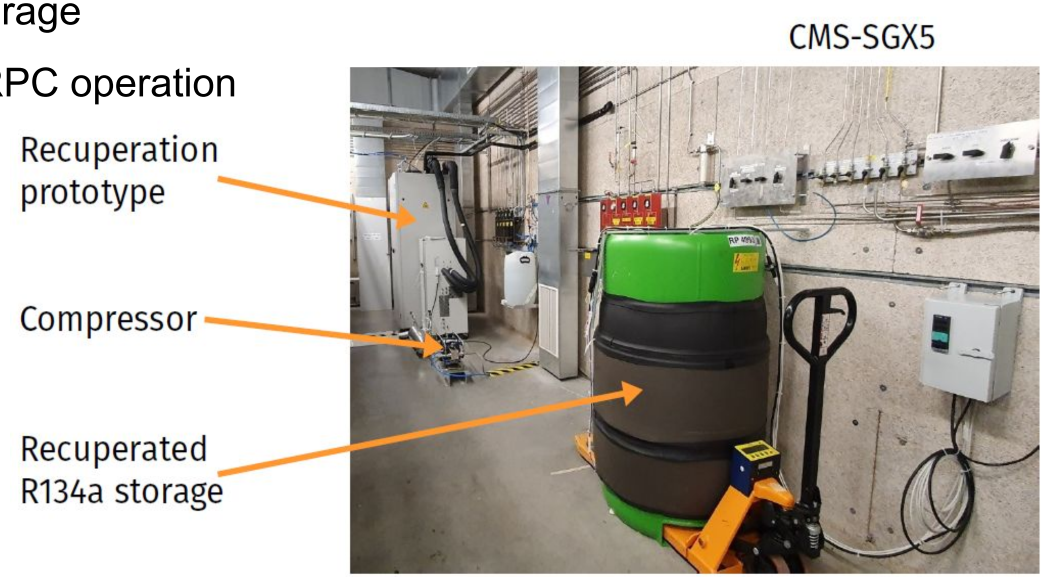
Prototype 1:

connected to CMS-RPC in December 2019,

test started around mid-January 2020

➔ **Goals:**

- Run with higher flows (500-1000 l/h)
- Test compressor and R134a storage
- Reuse recuperated R134a for RPC operation



R134a RECUPERATION - RPC

Prototype 1:

full system (cold separator, compressor, storage) started at 300 l/h

➔ **BUT:**

- Presence of iC4H1 and SF6 when system operated with compressor
- Problems due to higher flow (300l/h vs 100l/h)
- Adjust settings to integrate new components

now running at same conditions as on ATLAS (100l/h, no storage)

- good quality of recuperated R134a
- study impact of flow and new components

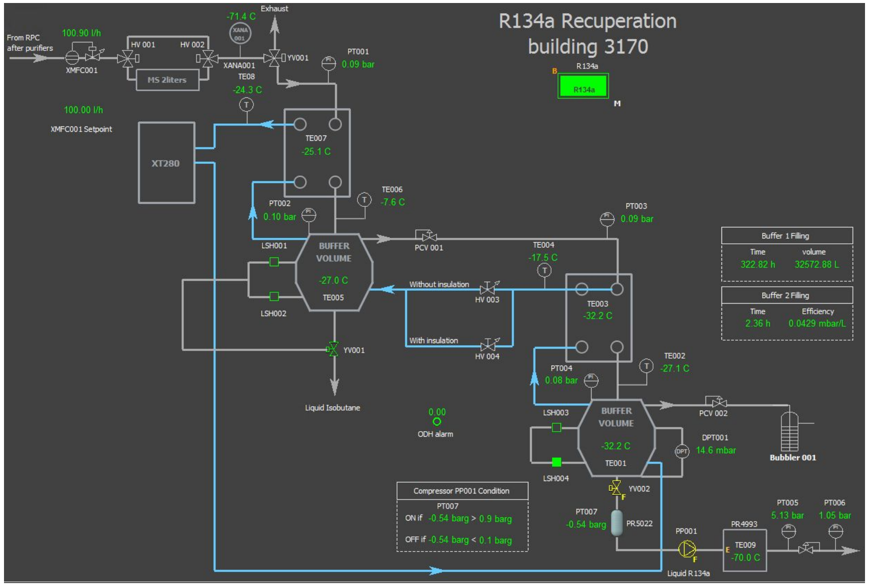
➔ **Next:**

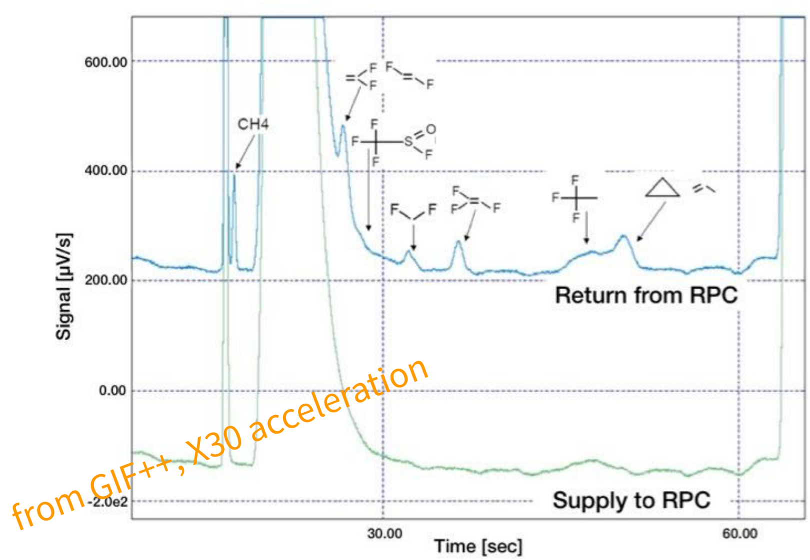
- Operation with higher flow > additional heat-exchanger ordered > 1 week test
- Compressor + Storage > 2 weeks test after addition of a new component
- Mixer Re-Injection > 2 weeks test

R134a RECUPERATION - RPC

➔ **Next Steps:**

- Optimize new configuration settings
- Studies on HFCs impurities separation, to be evaluated before Run3
- Possible SF6 recuperation





Molecule	Boiling point (°C)	Molecule	Boiling point (°C)
C2H2F4	-26	C2H2F2(e)	-42
iC4H10	-12	CH2F2	-51
SF6	-64	CHF3	-84
		C2HF3	-51
CH4	-161	C2H3F3	-47
C2H4F2	-117	C3H6 (propene)	-33
CF4SO	110	C3H6 (cyclopropane)	-47
C2H2F2(z)	-20		

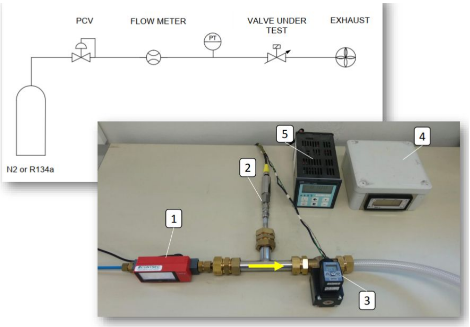
DISTRIBUTION OPTIMIZATION - RPC

Replacement of manual valves with automatic regulation

➔ Manual valves present to equalize pressure between different detector zones

LAB Test Setup

1. Flowmeter
2. Pressure sensor
3. Tested Valve
4. Pressure reading
5. Controller

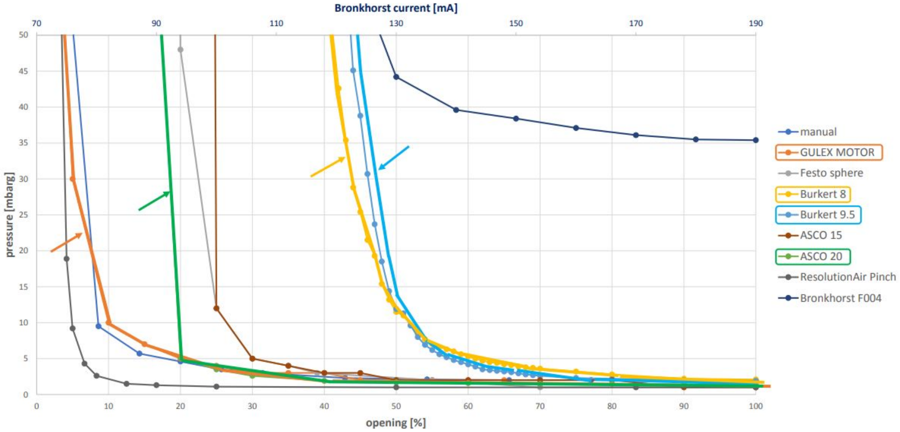


About 16 different models tested

Challenging requirements:

- **Low cost** (28 will be installed)
- **Small dimension**,
  limited space available in distribution racks
- Designed for **low pressure** (~100 mbar)

General Comparison – 16 l/min N_2

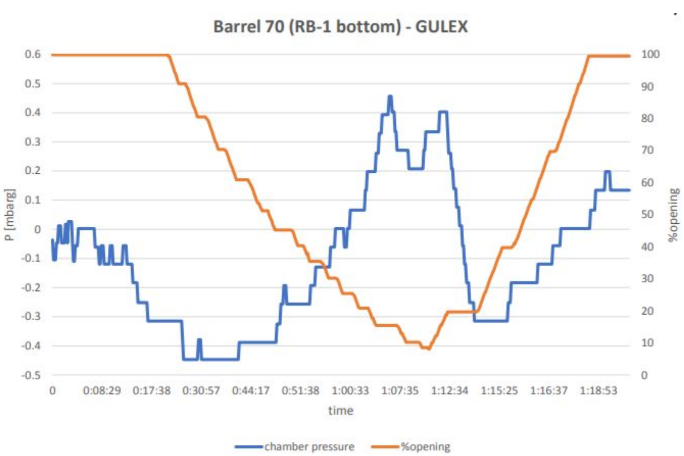


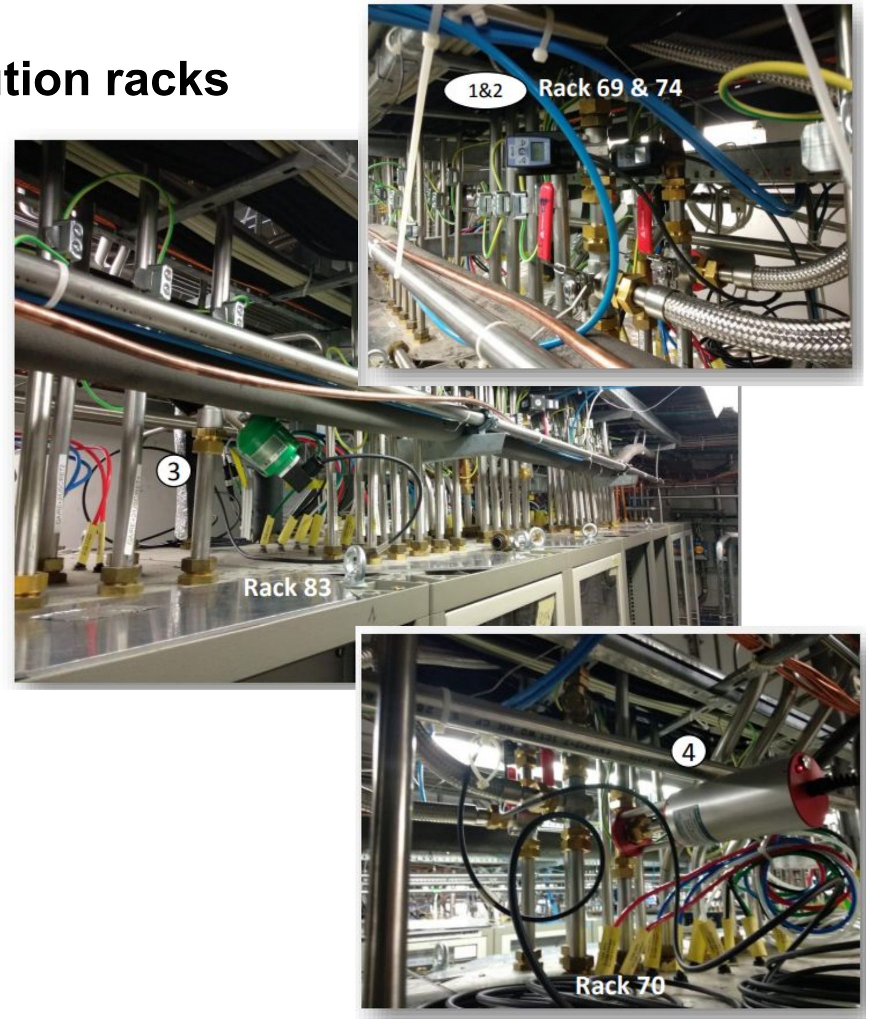
DISTRIBUTION OPTIMIZATION - RPC

4 valves installed on CMS-RPC distribution racks

for testing on real system

- ➔ Detector pressure regulation is done by sensors at rack level
- ➔ Particularly critical during filling and emptying phases

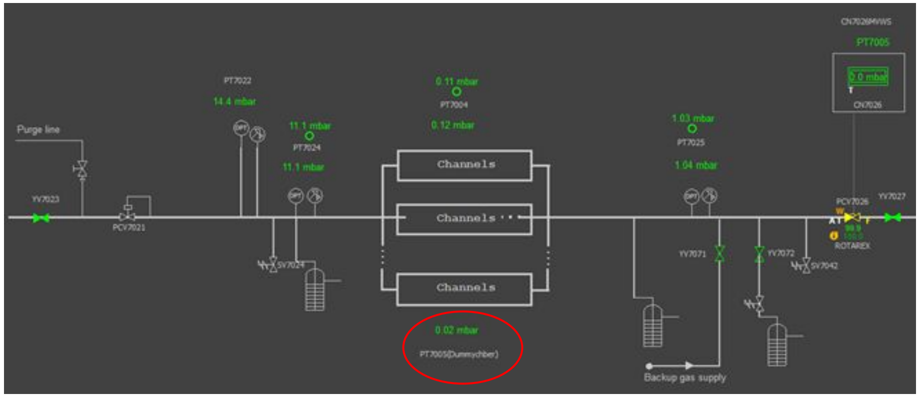




DUMMY CHAMBERS - RPC

Automatic regulation of distribution rack will be done by Dummy Chambers

- ➔ pressure sensors already present at detector level cannot be used due to risk of leak development
- ➔ “dummy chambers” are volumes that simulates real chambers
- ➔ 28 chambers to be installed (one per distribution rack)
- ➔ 4 dummy chambers already installed, under test



ECOGAS COLLABORATION - RPC

Common working group for the RPC community

➔ ATLAS, ALICE, CMS and Gas Group participating

➔ Common setup at GIF++

➔ Results presented at EPS2019 conference

https://indico.cern.ch/event/577856/contributions/3420164/