CMS GAS SYSTEM R&D
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OUTLOOK

- Gas Recuperation Plant
  - CF4 Recuperation - CSC
  - R134a Recuperation - RPC
- RPC Distribution Regulation Valves
- RPC Dummy Chambers
- RPC Ecogas
Several LHC gas systems 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 module
  - Infrared analysis module
  - SWC monitoring module
CF4 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
CF4 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
CF4 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
CF4 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
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
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
Replacement of manual valves with automatic regulation

- Manual valves present to equalize pressure between different detector zones

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)
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
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/