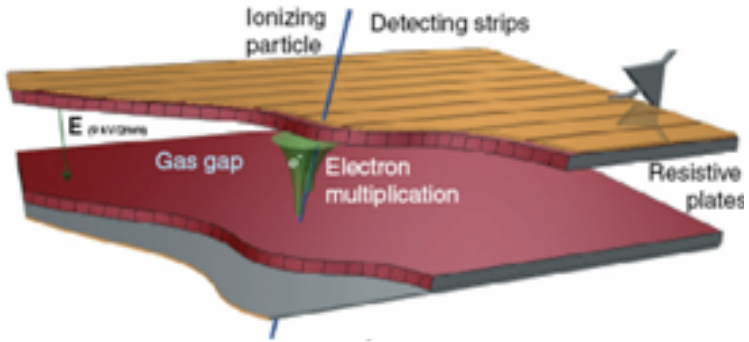
RPC Purifiers' studies
/status/

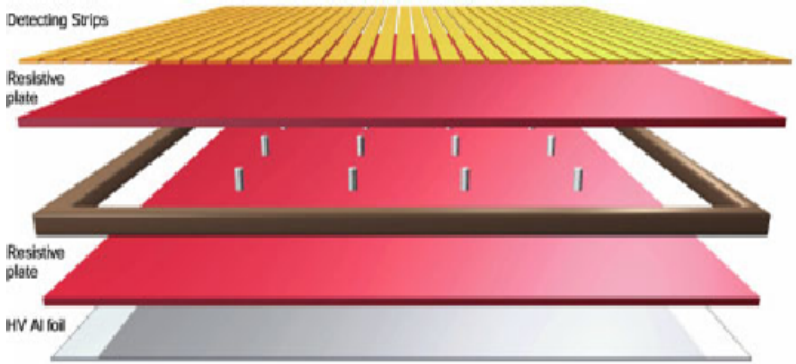
IR, RG
11.01.2010

The task

Problems

- Possible high currents on long term operation of RPCs
- Small amounts of F based impurities observed
- Under irradiation larger amounts and additional impurities observed
- Constant water levels in the gas mixture – vital for the RPC operation





The **Solution** we search is..
The optimal combination of filters:
• With the best H2O and O2 filtering capacity
• Removing maximum F-based impurities
• To keep the chamber currents stable

GIF in a nutshell

GIF gives us:

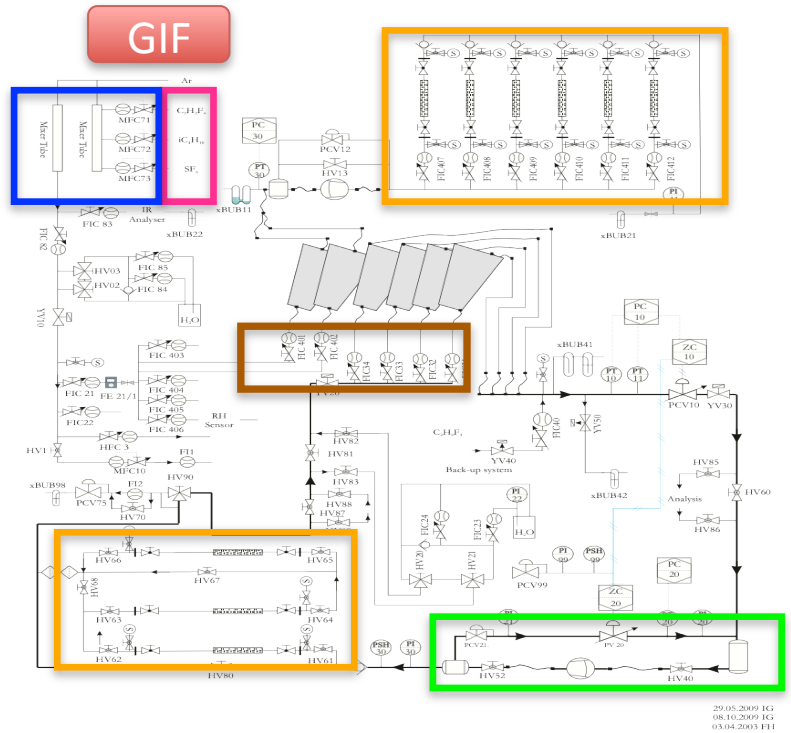
- 0.66 MeV gamma (650 GBq 137Cs)
- x30 acceleration factor in comparison to LHC
- Similar irradiation to the one expected for the RPCs in LHC

We have there:

- 6 CMS RPC double gaps (DG)
- 1 volume/hour (nominal gas mixture)
- High voltage supply
- Gaps' operation conditions and performance monitoring

Gas System

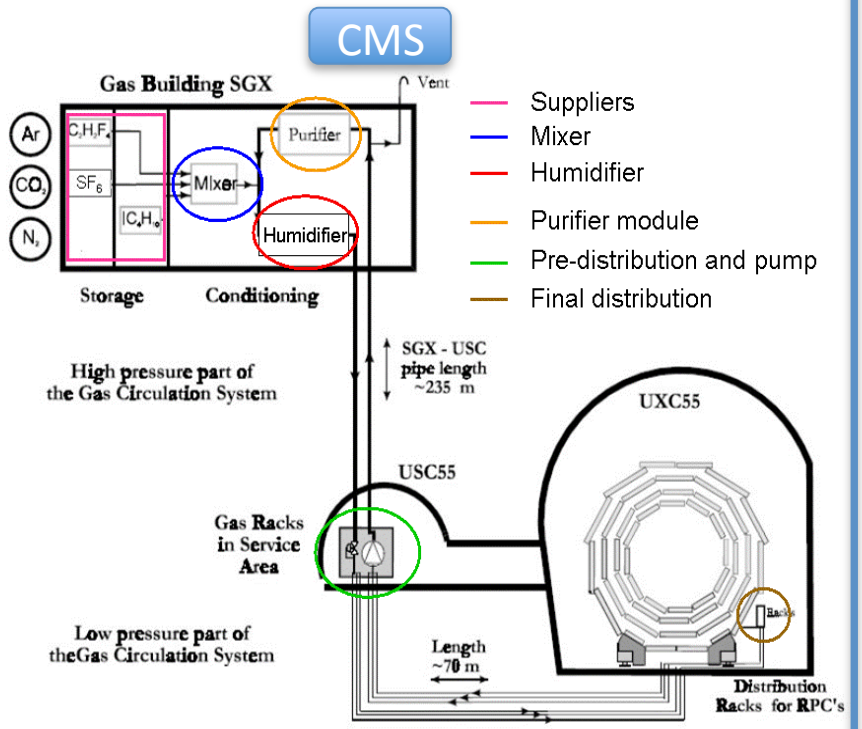
GIF



Parameters
Open Mode: 3 DG, Flow 30 l/h
Closed Loop: 3 DG, Flow 30 l/h

Purifiers
MS 3A, 4A, 5A, NiAl, NiSi, R11, R12, SiGel
2 l cartridges

CMS



Purifiers
P1: MS5A MS3A
P2: NiAl, R11, R12
P3: empty
24 l cartridges

Parameters
Total flow 1000 l/h
Closed loop, 10% recalculation
~1000 RPCs

Parameters monitoring

- Control and monitoring of Environmental RH & temperature
- Source status
- Gas mixture quality
  - Composition
  - humidity before & after the purifiers
- Chambers properties and performance
  - Currents
  - Resistivity

GC/MS & HF station

Gas Chromatography

- Allows quantifying ppm of impurities
- 3 columns – allowing separation for different type of impurities

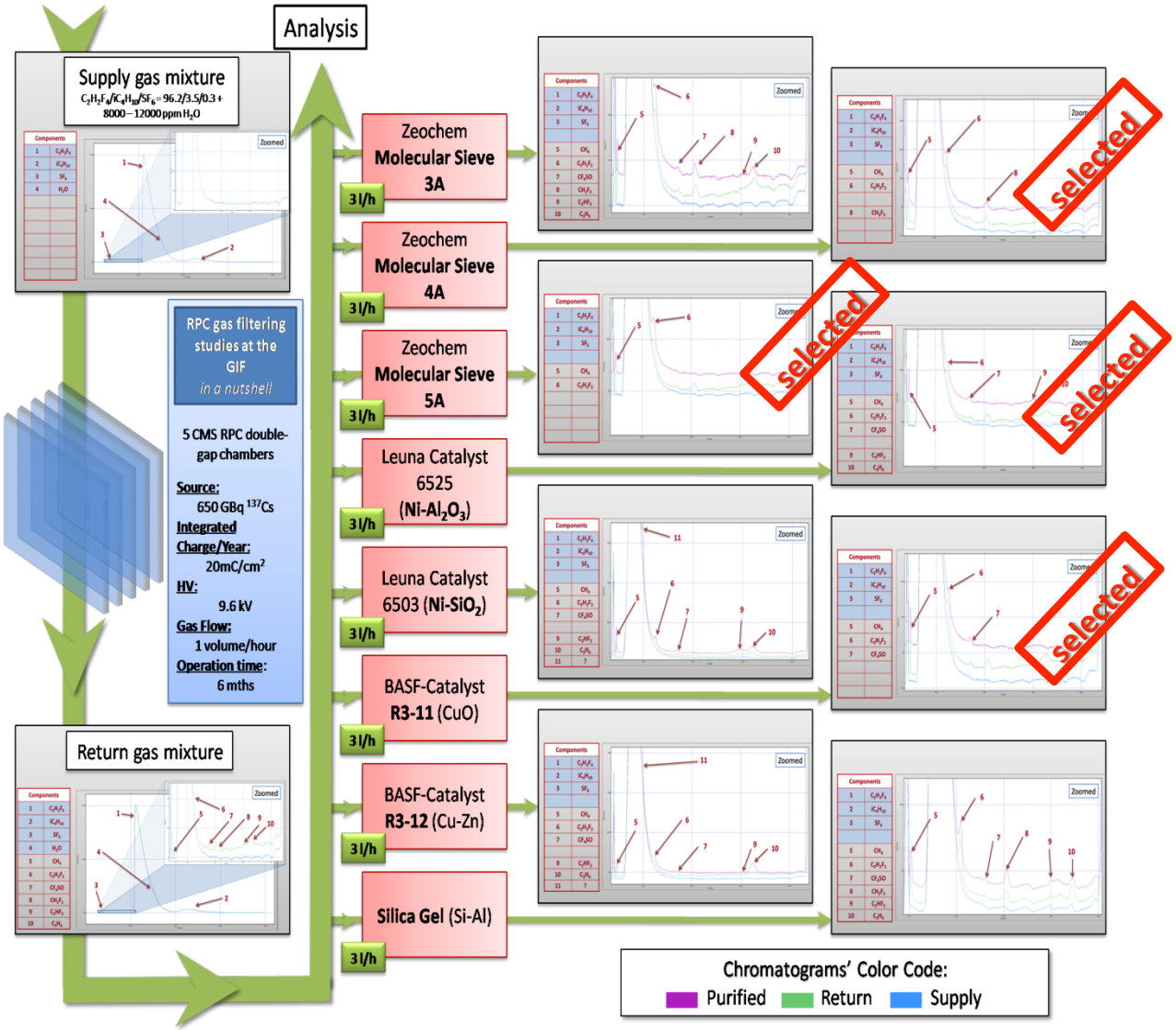
Mass Spectrometry

- Identification of the impurities

F- ions Concentration

Based on bubbling the gas mixture and measuring of the pH of the solution

Purifiers verified at GIF



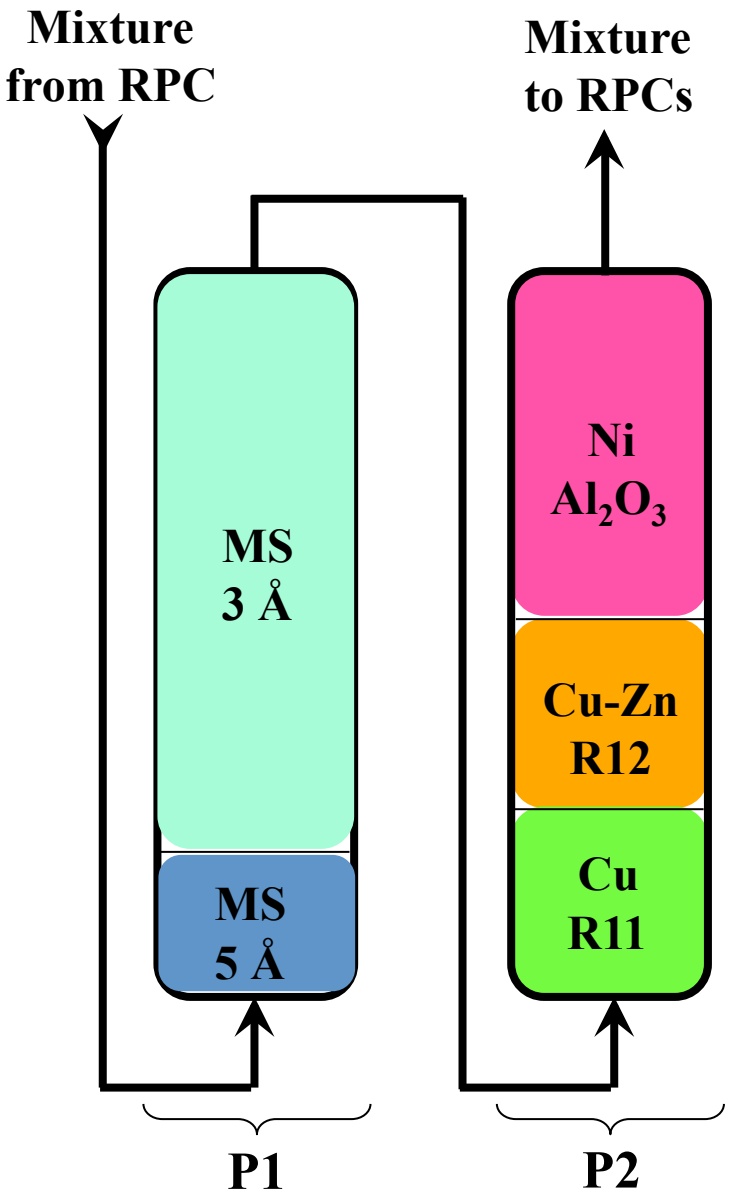
Tested:

Mol. Sieves: 3A, 4A, 5A
Leuna: NiAl2O2, NiSiO2
BASF: R3-11, R3-12
Silica Gel

Approved:

Purifier	Removes
MS4A	H2O, Impurities
MS5A	Impurities
R11	O2, impurities
NiAl	O2, impurities

Present purifiers configuration



Very short cycle:
Limiting factor if flow increase is needed

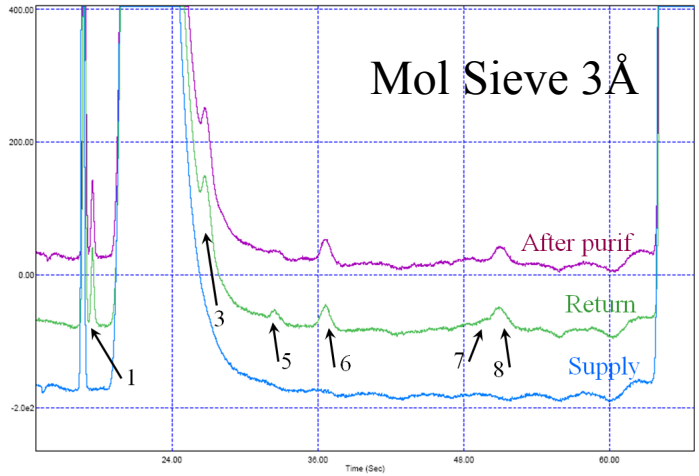
Too many regeneration cycles:
Never tested before
Possible limit for the catalyst

	Purif. 1	Purif. 2
number of regenerations	91	30
Pre-SaturationVol (m^3)	160	850
process gas flow (m^3/h)	5	5
Pre-SaturationTime (h)	33	163
Pre-SaturationTime (day)	1.4	6.8
Regeneration time (min)	480	360
Regeneration temperature (°C)	220	200
Conditioning time (min)	150	720
Conditioning flow (l/h)	*100*	*100*
Conditioning time (vol)	10	50

Characterization of the purifiers

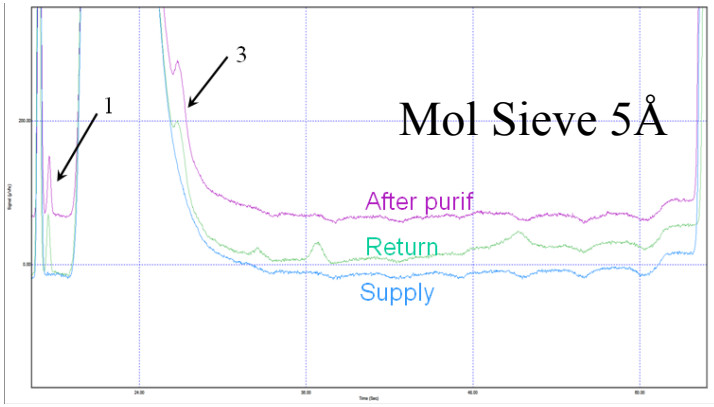
Filtering Capacity of Molecular Sieves

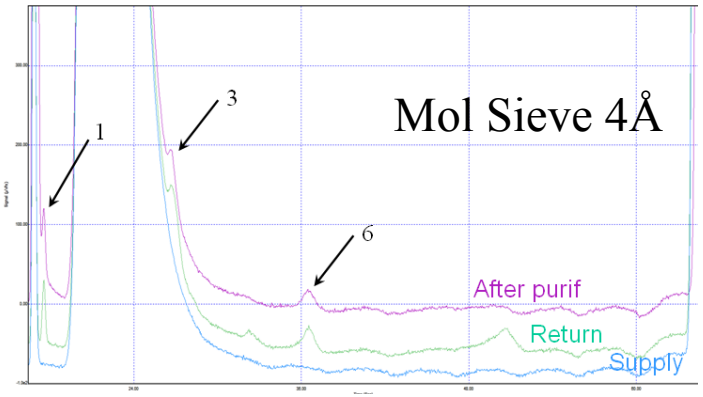
Mol Sieves: filter as they should H_2O (capacity ~ 150 g(H2O)/kg(MolSieve)) +
filter some extra impurities + Absorb part of the RPC mix (need conditioning)



Currently 90% of Purif1 is MS3Å:
- adsorbs water
- is not adsorbing $C_2H_2F_4$
- is not effective wrt other impurities

Possible alternative is MS4Å:
- Is not adsorbing a lot of $C_2H_2F_4$
- Quite effective
- Release Ar (if used during regeneration)





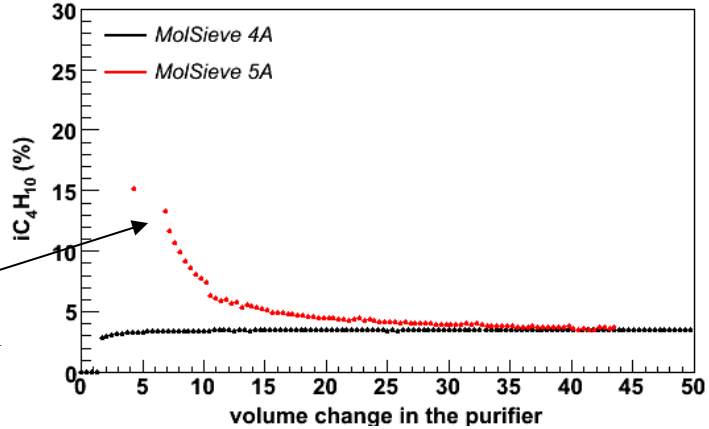
However, many other impurities are removed (for a certain time equivalent to ~2000 volume change in the purifier cartridge)

Characterization of the purifiers

Conditioning phase:

when a mixture component is also absorbed →

Some purifiers (see example of mol.sieve 5 Å) need a preparation time (conditioning phase) because at start-up they absorb a mixture component (in the example the $C_2H_2F_4$ is absorbed and as a result the iC_4H_{10} concentration increase).

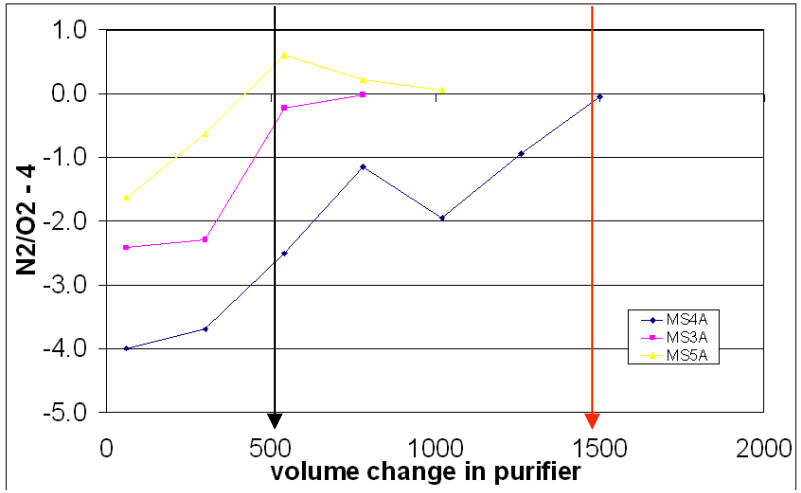


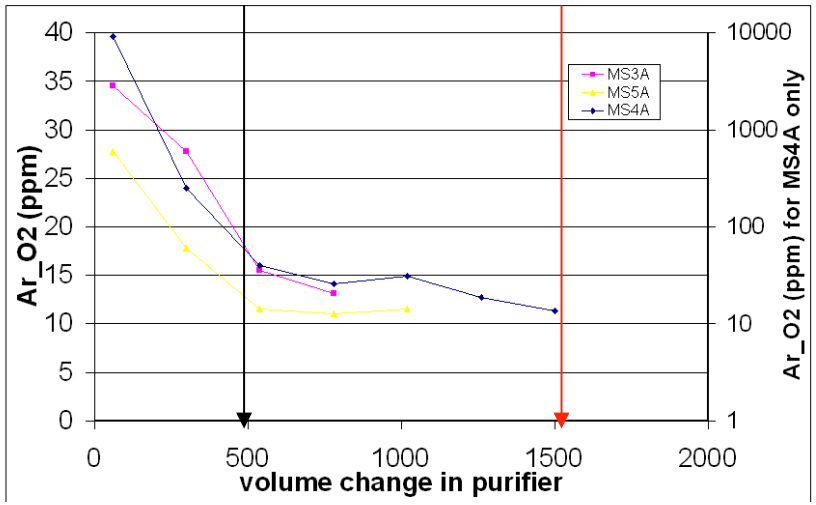
Argon desorption from Mol. Sieve 4Å

Mol. Sieve 4Å is releasing Ar for long time after regeneration:

It can be regenerated pumping down

Alternative gas for filling during Stand-by to be found (N_2, process gas, …to be tested).

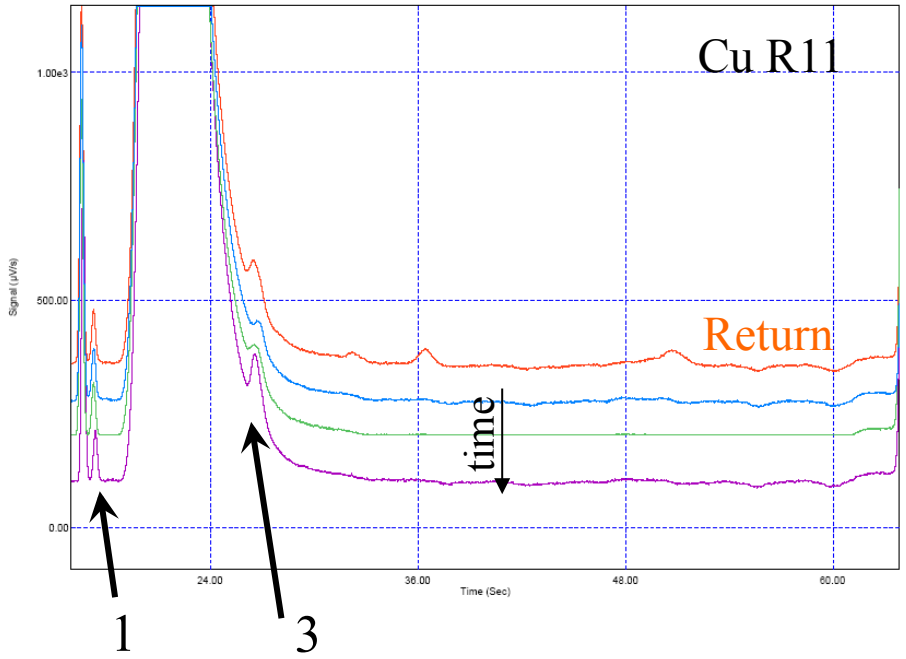




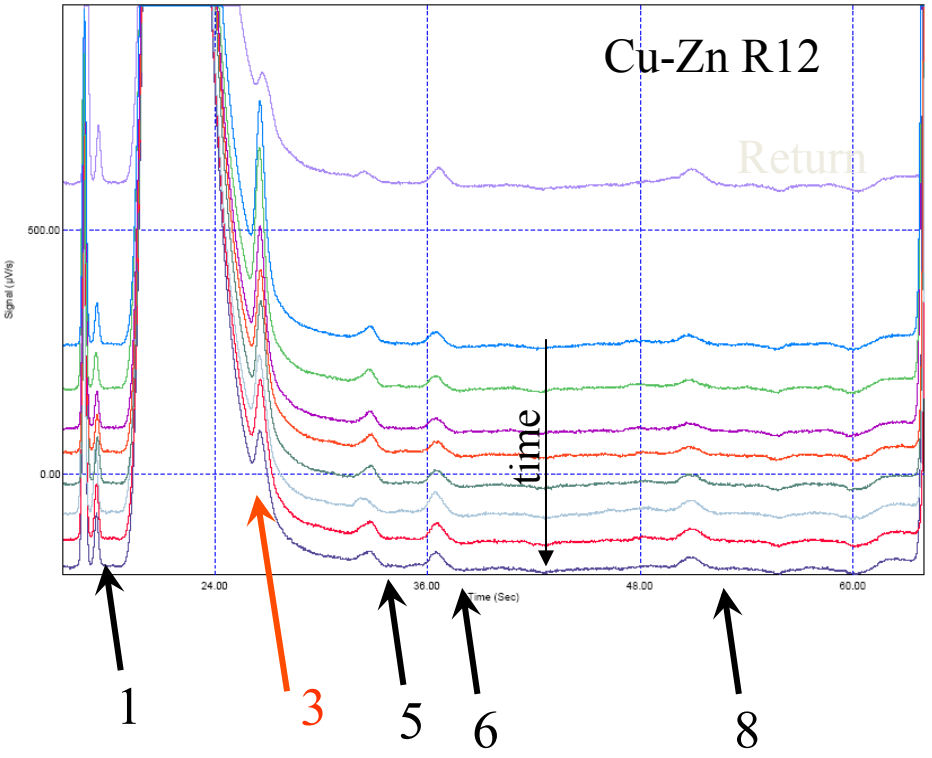
Characterization of the purifiers

Filtering Capacity of R11(Cu catalyst) and R12 (Cu-Zn catalyst)

Filter as they should O_2 (capacity ~ 5 g(O2)/kg(catalyst)) +
H_2O (capacity ~ 50 g(H_2O)/kg(catalyst)) .
R11 filters additional impurities, R12 does not and it enhance an extra component



R11 seems to be quite effective



R12: basically no extra component filtered
comp. #3 is even enhanced

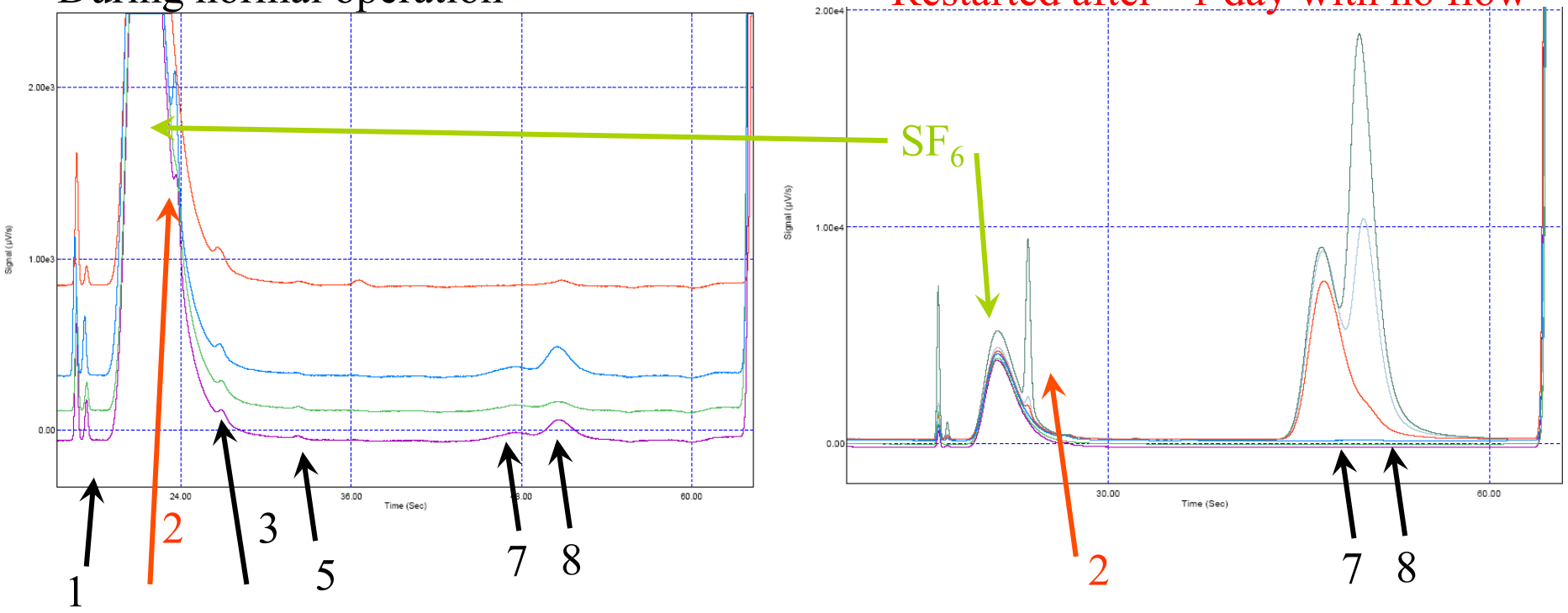
Characterization of the purifiers

Filtering Capacity of Ni-Al_2O_3 catalyst

Filter as it should O_2 (capacity ~ 15-20 g(O2)/kg(catalyst)) +
H_2O (capacity ~ 50 g(H_2O)/kg(catalyst)) .
Filters additional impurities, but it enhance also an extra component

During normal operation

Restarted after ~1 day with no flow



Component #2 (not present in return mixture) is strongly enhanced
After a short stop, the catalyst is releasing important concentration of extra-components (in the plot they can be compared with the SF_6 signal)

Characterization of the purifiers

Systematic understanding of a set of purifiers vs some impurities

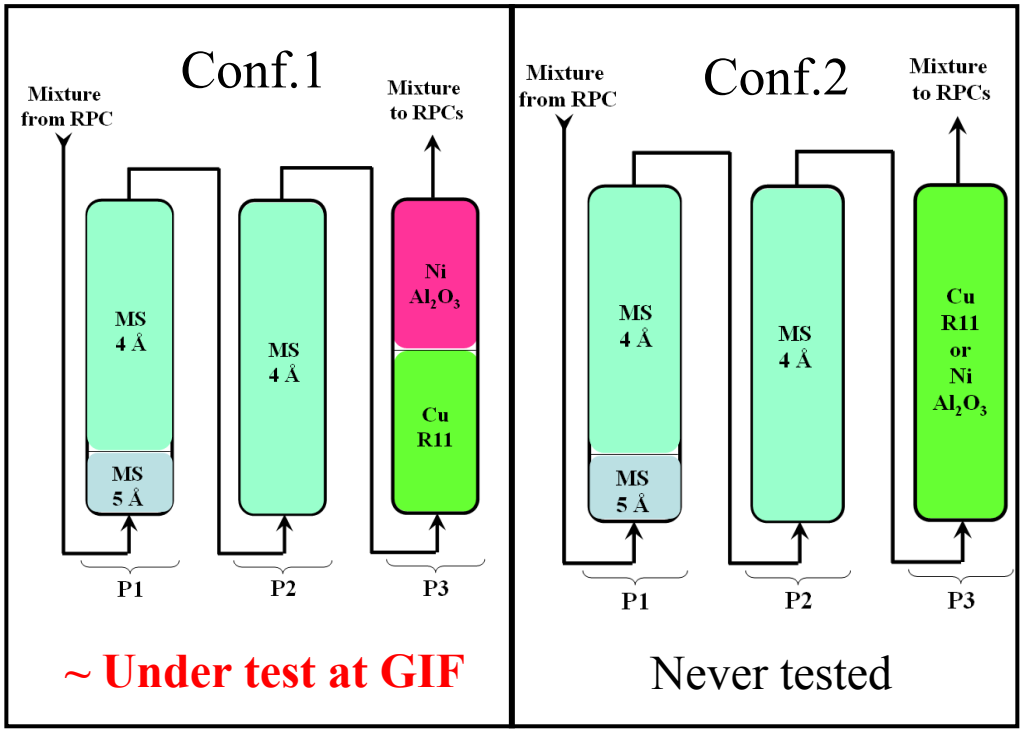
	Conditioning (volume change)	Main component filtered	Saturation for main component filtered (g (O_2/H_2O)/kg)	(1) CH_4	(3) $C_2H_2F_2$	(5) CH_2F_2	(6) C_2HF_3	(7) $C_2H_3F_3$	(8) C_3H_6
MS3A	3	H_2O	140	Unch.	Unch.	Unch.	Unch.	Unch.	Unch.
MS4A	10	H_2O	170	Unch.	Unch.	Rem.	Unch.	Rem.	Rem.
MS5A	50	H_2O	130	Unch.	Back after 1000 vol change	Rem.	Rem.	Rem.	Rem.
Cu R11	20	O_2/H_2O	5/50	Unch.	Unch.	Unch.	Rem.	Rem.	~Rem.
Cu/Zn R12	20	O_2/H_2O	5/50	Unch.	Enhanced	Unch.	Rem.	Rem.	450 vol change
Ni Al2O3	15	O_2/H_2O	15/50	Unch.	Unch.	Unch.	Rem.	150 vol change	150 vol change
Ni SiO2	15	O_2/H_2O	15/50	Unch.	Unch.	Unch.	Rem.	Unch.	Unch.

Possible new purifiers configurations

A third purifier module will be soon available (originally foreseen to be used during high luminosity LHC run) → possibility to redistribute the cleaning agents on three module.

Objective:

- ➢Increase the water adsorption capacity (already at the limit, it will be a real problem if any flow increase will be needed)
- ➢Increase the adsorption capacity for extra-Freon and extra-Hydrocarbons (but, are they really dangerous? Concentration at 50 ppm level)
- ➢Increase the cycle duration for the metallic catalysts (it will avoid the necessity to substitute the material during LHC running time)



Conf.1 and 2:

+ P2 is devoted to extra-Freon adsorption

- Basically no increase of H_2O adsorption capacity

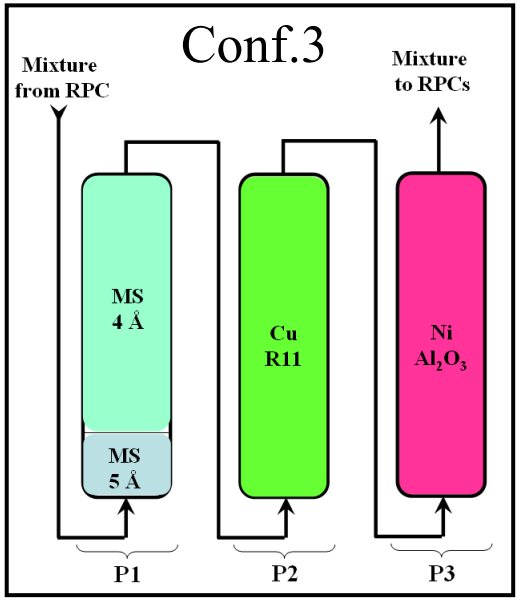
Expected run cycles:

P1: 1.4 d P2: ~1 d P3: 7 d

Conf.2 is a simplification of Conf.1 for P3: Since O_2 on return gas is generally very low (≤100 ppm) and Ni-Al_2O_3 seems to be not very effective

→ Needs to be tested

Possible new purifiers configurations

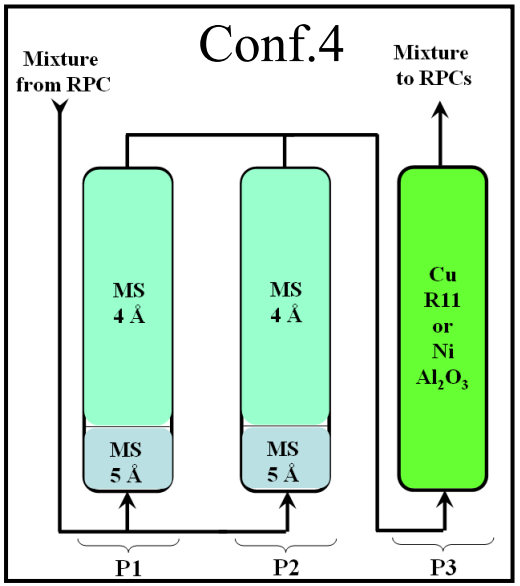


Conf.3 (~ **Under test at GIF**):

+ each metallic catalyst has one Purifier
+ double volume for Cu and Ni
- no increase of H_2O adsorption capacity
- no increase of other Freon adsorption capacity

Expected run cycles:

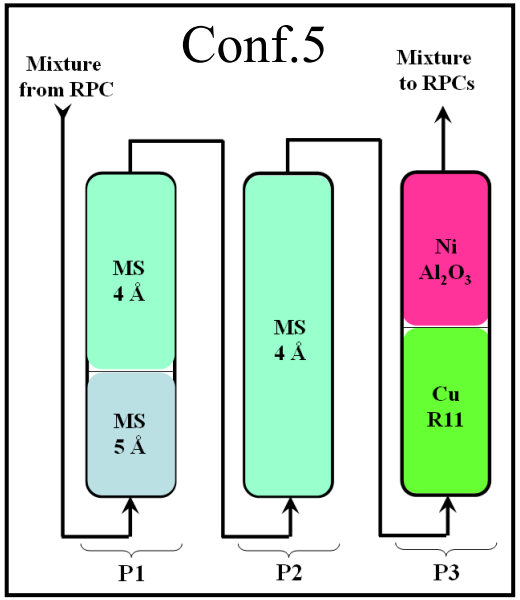
P1: 1.4 d P2: 7 d P3: ~7 d



Conf.4 (not tested) → P1 and P2 in parallel:

+Double the H_2O adsorption capacity
+Double the other Freon adsorption capacity
-P3 cycle still critical (may be necessary to change the material during LHC running time)

Possible new purifiers configurations



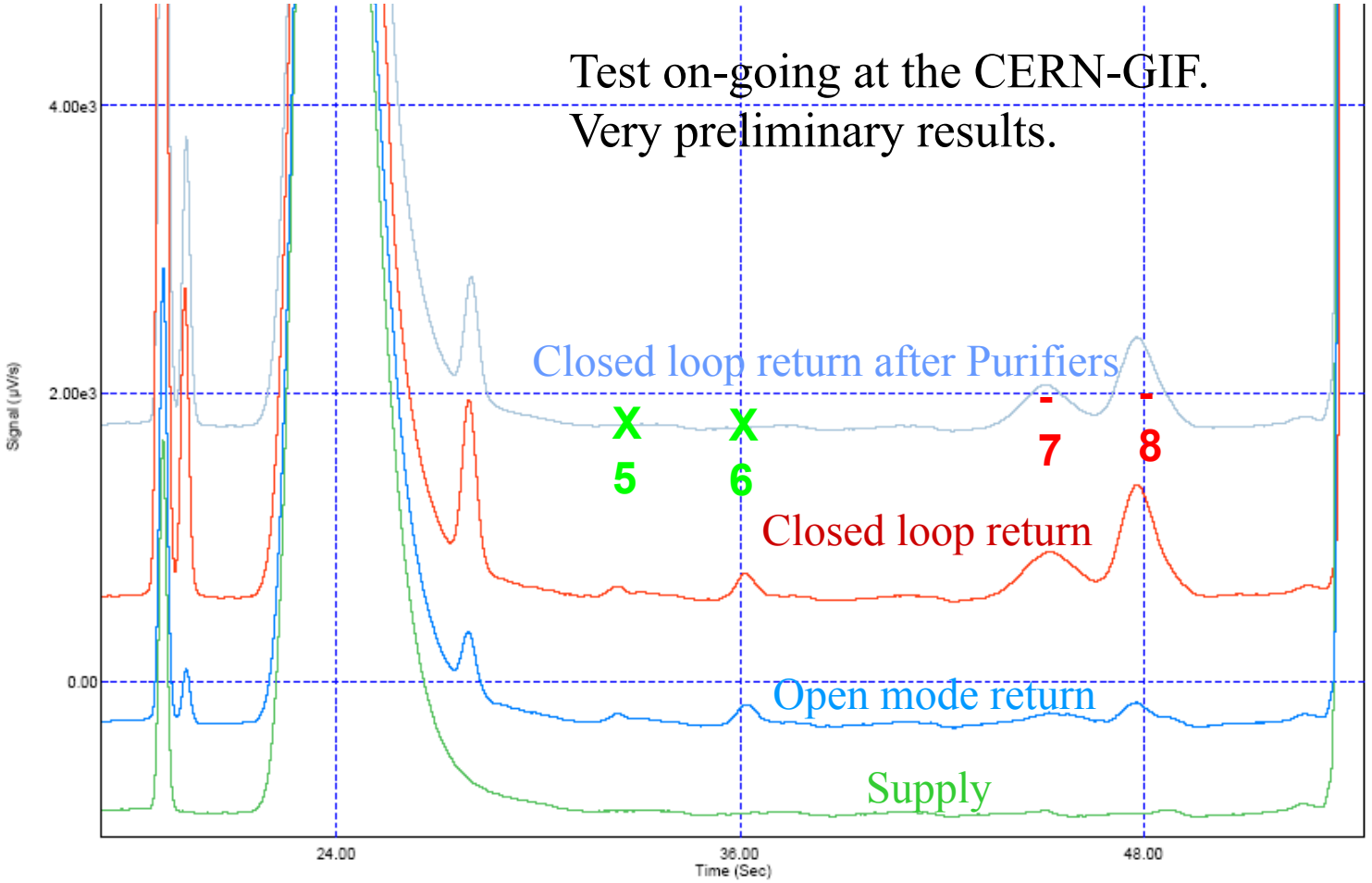
Conf.5 (not tested) x 2.5 the quantity of MS5Å in P1:

+ Double the H_2O adsorption capacity
+ double the adsorption capacity for other Freons
- no change for Cu and Ni catalysts

Expected run cycles:

P1: 3.5 d P2: 3.5 d P3: ~7 d

Closed loop operation



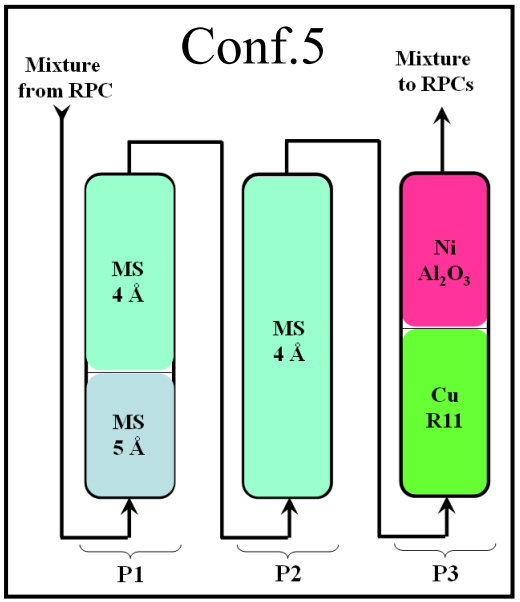
- After few days of operation, only impurities 5 and 6 are still removed.
- Some extra-components show higher concentration in closed loop return wrt open mode return (as expected if not completely filtered)
- RPC performances do not show any degradation

Conclusions

Few critical points in the present RPC purifiers configuration

- Very short cycle for P1 (Mol. Sieves) → no margin if a flow increase will be needed
- Is there a limit for the maximum number of regeneration for the metallic catalysts? The present used limits comes from max number of tested cycles during previous test at GIF (and recommendations from producer)
- Very limited action on extra-Freon/Hydrocarbons, but are they really dangerous?

- Possible improvement from new purifier configuration:



- but MS4Å desorbs Argon (if used during regeneration). Alternative candidate for fill during Stand-by phase to be found (N_2 or process gas) or no Stand-by (i.e. directly to Preparation for Run after Cool down) or ….