EP-DT
Detector Technologies

Gas Systems Operation & Development

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on behalf of the Gas Team

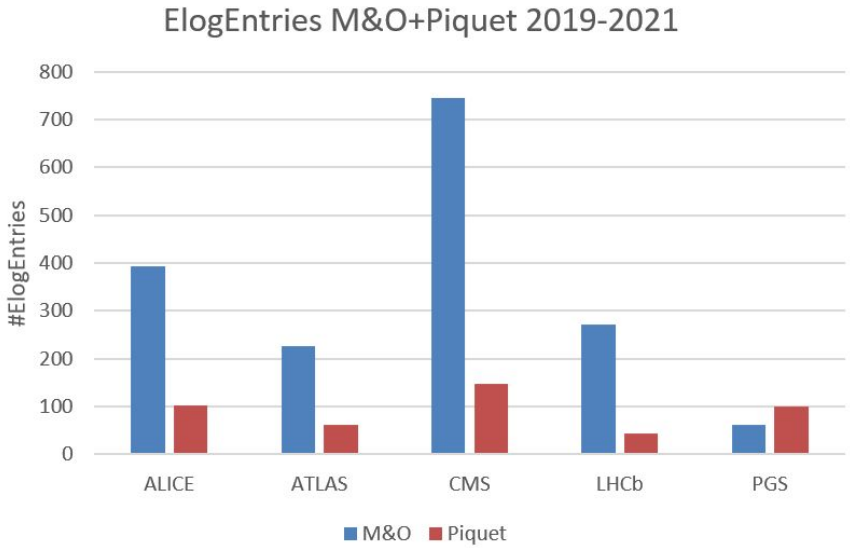
OUTLINE

- Gas System Project
- LHC Gas Systems
  - Maintenance & Operation Improvements
  - LS2 R&D and Upgrades
  - New LHC Gas Systems
- New Non-LHC Gas Systems
- Greenhouse Gases Reduction Strategies
  - Optimization of Current Technologies
  - Gas Recuperation Systems
  - Alternative Gases
- Conclusion

Gas System Project

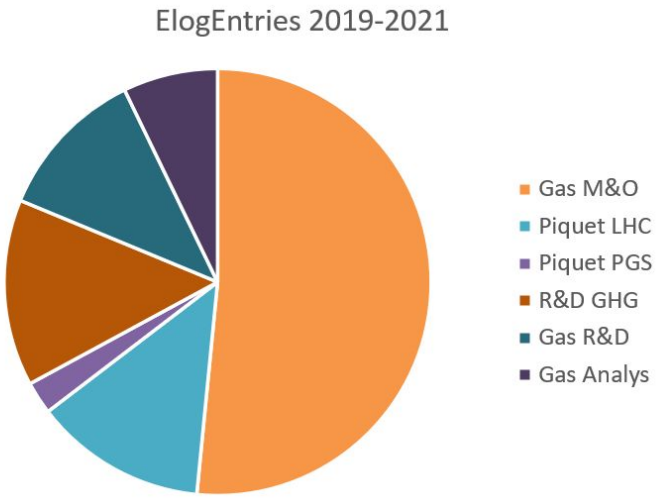
M&O of > 30 Gas Systems

- Daily operation monitoring
- Modules maintenance
- *Stand by duty (piquet)*,
  ~ 150 interventions per year in LS2
  systems in maintenance, unstable status
- Gas systems upgrades
- Gas quality monitoring
- Implementation of new Gas Systems



Gas Systems R&D

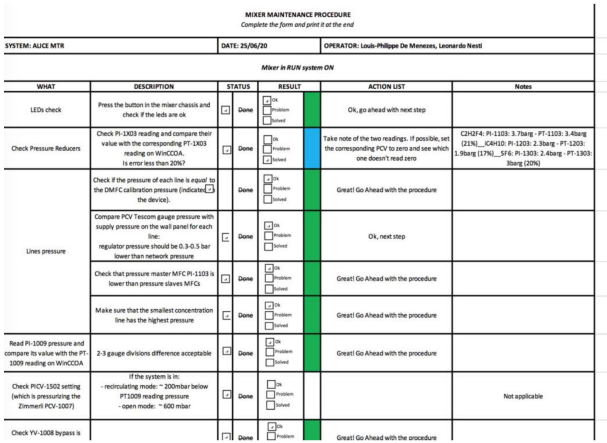
- LHC systems performance optimization
- Greenhouse gases reduction strategies
- Gas systems long term R&D (Lab/GIF++)
- Gas analysis techniques



M&O Improvements

LS2 Maintenance and Upgrades

- **Modules maintenance:**
  ~300 modules performed, procedures worksheets
- **Components:** ~ 100 MFC calibration,
  ~ 400 safety valves calibration,
  ~ 30 low pressure buffer re-validation,
  ~1000 flowcells installation/re-calibration..
- **New generation PLC (**with BE-ICS team**)**
  ~20 new PLC + Software new/upgraded



MIXER MAINTENANCE PROCEDURE
Complete the form and print it at the end

SYSTEM: ALICE MTR | DATE: 25/06/20 | OPERATOR: Louis-Philippe De Menezes, Leonardo Nesti

Mixer in RUN system ON

WHAT	DESCRIPTION	STATUS	RESULT	ACTION LIST	Notes
LEDs check	Press the button in the mixer chassis and check if the leds are ok	Done	Ok, Problem, Solved	Ok, go ahead with next step	
Check Pressure Reducers	Check PI-1X03 reading and compare their value with the corresponding PT-1X03 reading on WinCCOA. Is error less than 20%?	Done	Ok, Problem, Solved	Take note of the two readings. If possible, set the corresponding PCV to zero and see which one doesn't read zero	C2H2F4: PI-1103: 3.7barg - PT-1103: 3.4barg (21%)__IC4H10: PI-1203: 2.3barg - PT-1203: 1.9barg (17%)__SF6: PI-1303: 2.4barg - PT-1303: 3barg (20%)
Lines pressure	Check if the pressure of each line is equal to the DMFC calibration pressure (indicated on the device).	Done	Ok, Problem, Solved	Great! Go Ahead with the procedure	
	Compare PCV Tescom gauge pressure with supply pressure on the wall panel for each line: regulator pressure should be 0.3-0.5 bar lower than network pressure	Done	Ok, Problem, Solved	Ok, next step	
	Check that pressure master MFC PI-1103 is lower than pressure slaves MFCs	Done	Ok, Problem, Solved	Great! Go Ahead with the procedure	
	Make sure that the smallest concentration line has the highest pressure	Done	Ok, Problem, Solved	Great! Go Ahead with the procedure	
Read PI-1009 pressure and compare its value with the PT-1009 reading on WinCCOA	2-3 gauge divisions difference acceptable	Done	Ok, Problem, Solved	Great! Go Ahead with the procedure	
Check PICV-1502 setting (which is pressurizing the Zimmerli PCV-1007)	If the system is in: - recirculating mode: ~ 200mbar below PT1009 reading pressure - open mode: ~ 600 mbar	Done	Ok, Problem, Solved		Not applicable
Check YV-1008 bypass is		Done	Ok, Problem	Great! Go Ahead with the procedure	

M&O Improvements

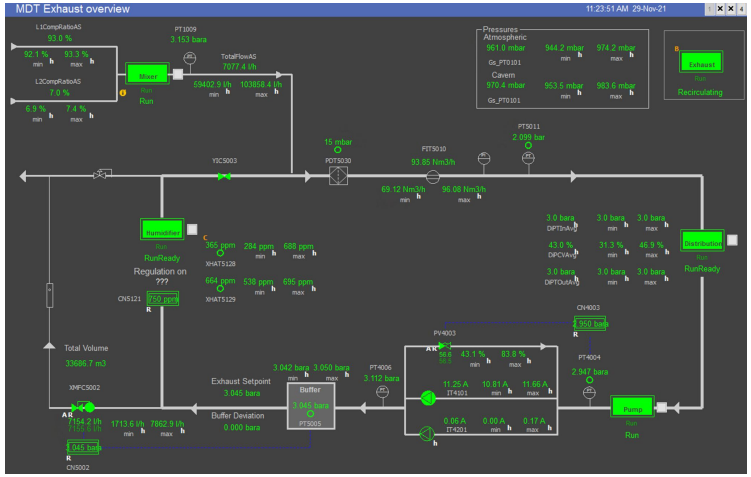
Gas Systems Monitoring

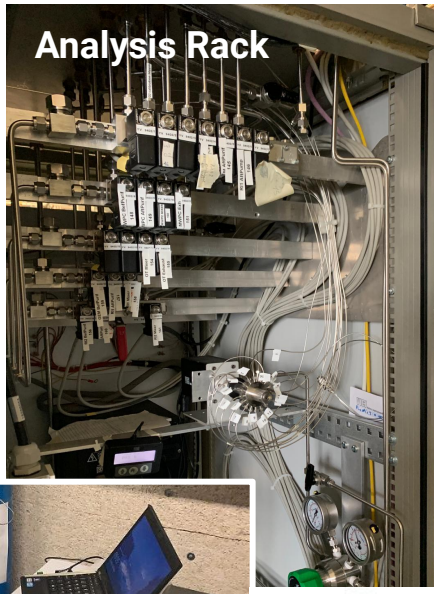
- Implemented weekly checklist to monitor most important parameters
- Gas System general **overview page** improved (operational 2022)
- Implemented **warning system**, to notify potential issues

Gas Quality Monitoring

- x8 IR modules (iC_4H_{10}, CO_2, CF_4), ~30 H_2O + O_2 analyzers
- x5 Fixed + x2 Portable micro Gas Chromatographs
- > 10 ISE Fluoride Electrode Stations

before → **after**





LS2 R&D and Upgrades

Consolidation and upgrades performed on ~15 LHC Gas Systems

CMS

- **RPC** Automatic regulation valves
- **RPC** Dummy chambers installation
- **DT** Analysis module upgrade (ongoing)

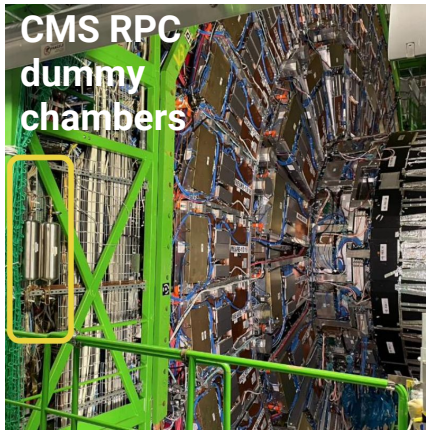
ATLAS

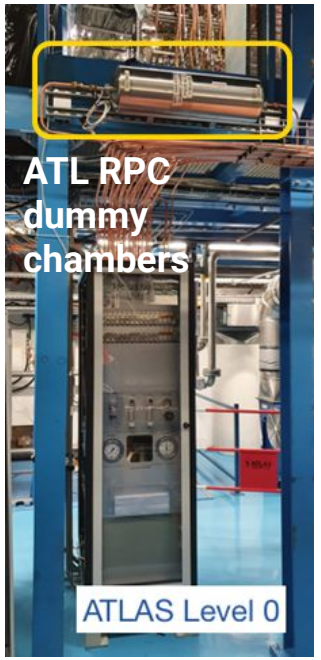
- **RPC** New distribution racks
- **RPC, MTR** Dummy chamber installation
- **MDT** Pump and Humidifier upgrade

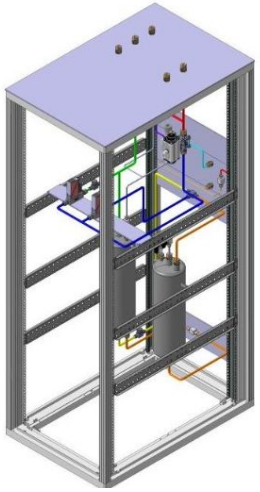
ALICE

- **CPV** New humidifier module
- **TPC** Gas system clean room
- **TRD** Software Upgrade for Xenon recuperation

… & more



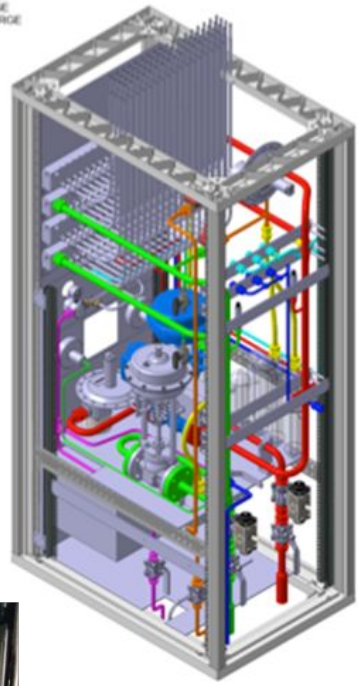


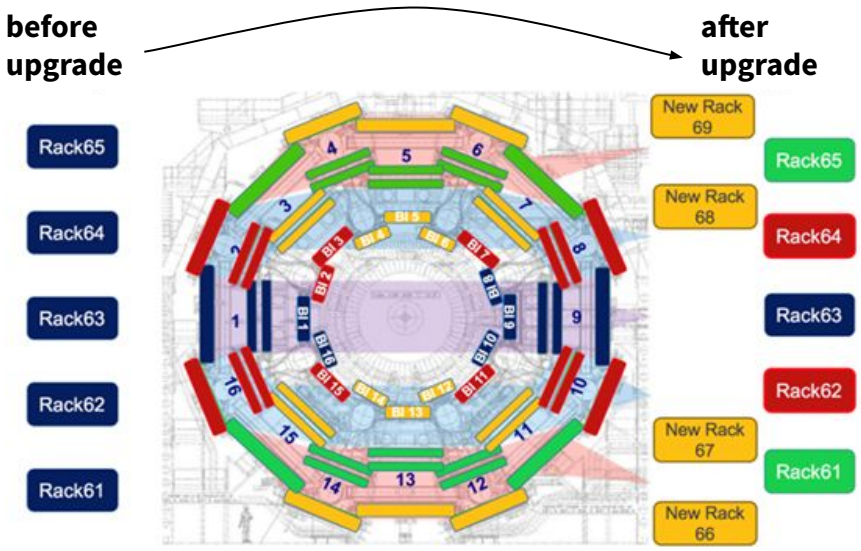


LS2 R&D and Upgrades

e.g. : ATLAS RPC New distribution racks

- x4 new additional distribution modules
  designed with 3D models before realization
- New distribution layout configuration (from 5 to 9 levels)
  to decrease hydrostatic pressure difference rack-chambers
- Additional channels needed for detector upgrade
  + support to TC team for piping installation





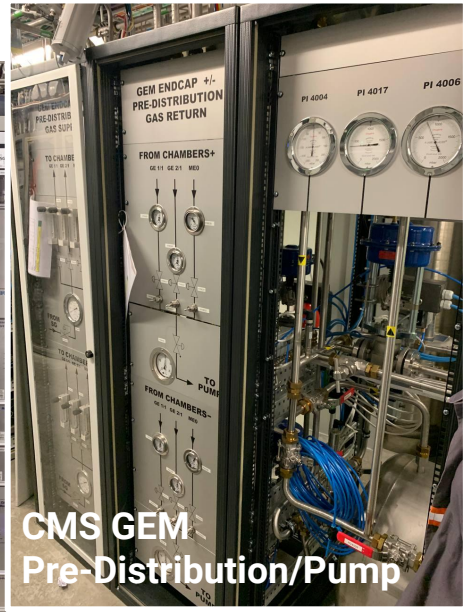
New LHC Gas Systems

CMS GEM

- New full gas system (modules/PLC/software)
- Mixer with 2/3 components (Ar, CO_2, spare)
- x6 Distribution racks in UX (4 GE + 2 ME0)
- Filters installed before distribution

ATLAS MicroMegas

- New dedicated PLC + WinCCOA software
- ATEX mixer, 3 components: Ar, CO_2, iC_4H_{10}
- Analysis module for iC_4H_{10} + H_2O monitoring
- Distribution from upgraded old CSC modules



LHCb Scintillating Fibers (SciFi) + Upstream Tracker (UT)

- **SciFi** read out by SiPM detectors, at low temperature
- Dry air (dew point -70° C) flushing to keep low humidity
- SGX+UX PLC and gas supply + 2 distribution racks
- **UT** flushing system construction ongoing

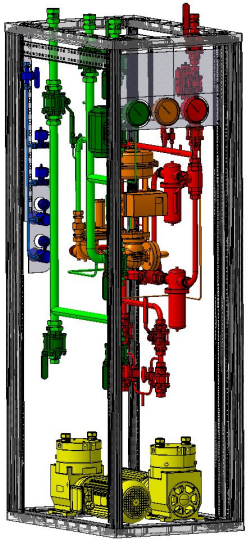
New Non-LHC Gas Systems

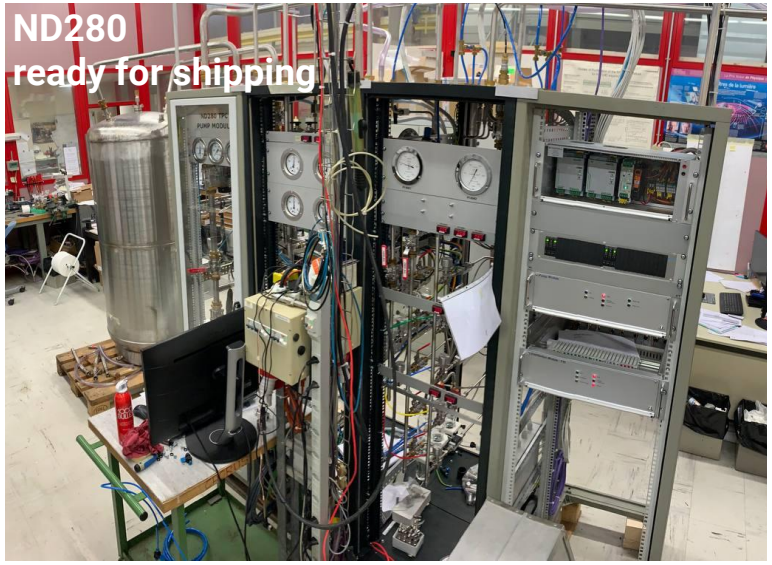
CLOUD

- Full design and construction of new modules
- Removal and recuperation of old modules
- Large need of resources, delivery March 2022

T2K-ND280 neutrino TPC:

- 3D design of modules before construction
- Commissioning @CERN completed by 2021
- Will be shipped in Japan, operational at J-parc in 2022





NA61/SHINE TOF-RPC

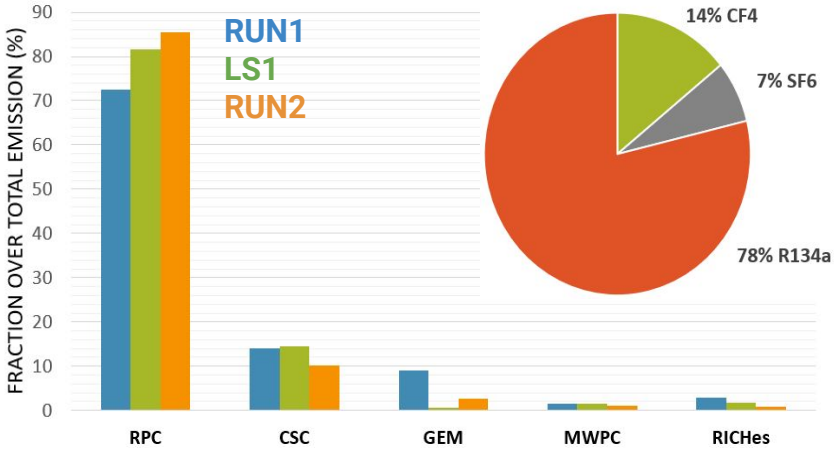
- 3D design of modules before construction
- Gas System running since Sept 2021

GHG Reduction Strategies

CERN is taking steps to lower consumption of GHG gases used in LHC Experiments
GHG = high Global Warming Potential
(in gas detectors: R134a, CF_4, SF_6,..)

Use of GHG is discouraged by European Union

- GHG cost already started to increase
- some will be phased out by 2030, lower availability on the market



Strategies to reduce GHG usage

- **Optimization of Gas Recirculation**
- **Gas Recuperation**
- **Alternative Gases**
- ~~**Gas Disposal**~~

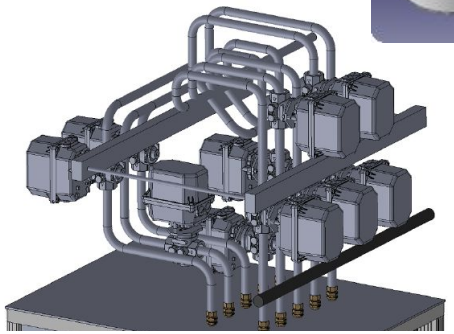
GHG Reduction Strategies

Optimization of Current Technologies

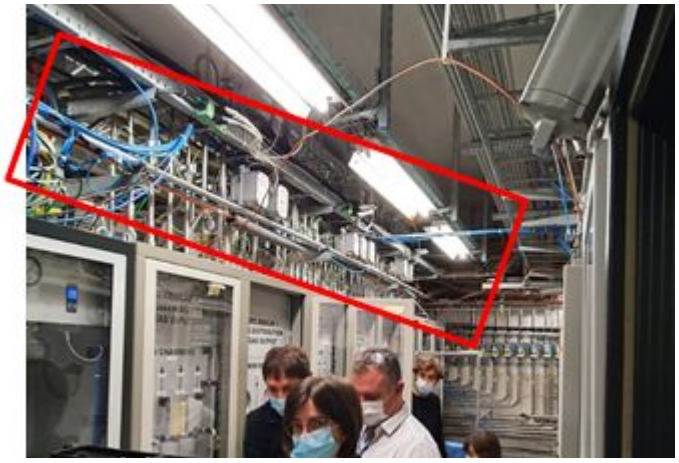
Example

CMS RPC automatic regulation valves *to improve operation with gas recirculation by minimizing changes in chamber pressure (lower risk of new leaks)*

- More than 20 valves tested: selected ECONEX
- Tests + simulation performed for valve configuration
  → custom 3D printed valve seat to adapt to flow
- **x30 valves installed on the return of each distribution rack**
- Operational since mid-November, very good performance in keeping Chamber Pressure stable



without Econex ← RPC Chamber Pressure → with Econex

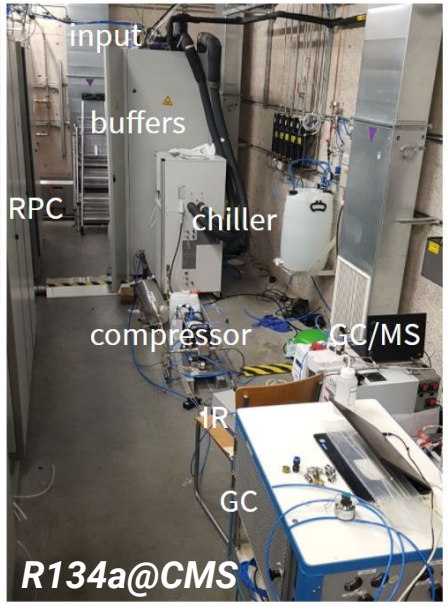


GHG Reduction Strategies
Gas Recuperation Systems

Gas recuperation plants operational on LHC Gas Systems:
6 in stable operation + 1 prototype

LHCb RICH2 CF_4 Recuperation (CO_2/CF_4)
- New system commissioned
- Efficiency 60%, 30 m^3 recuperated

CMS CSC CF_4 Recuperation ($Ar/CO_2/CF_4$)
- Average efficiency > 60%
- -45% GHG emission & gas cost (Run2)
- CF_4 re-injected into system by mixer



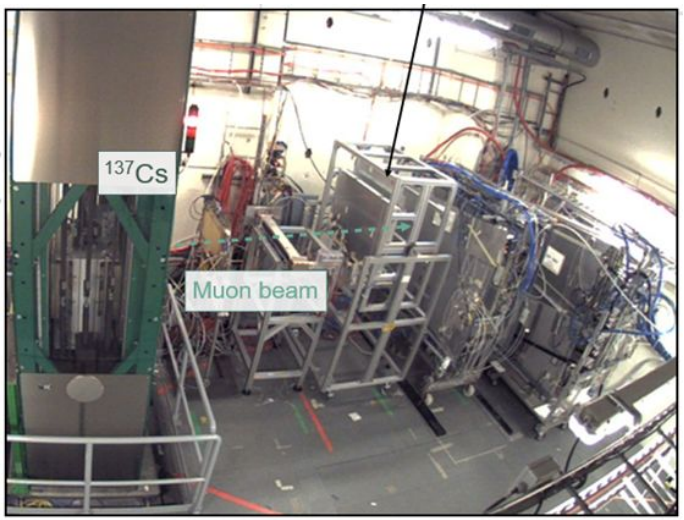
RPC R134a Prototype ($R134a/iC_4H_{10}/SF_6$)
- Prototype operational since 2018
- High separation efficiency (80-90%)
- Good quality R134a recuperated (~ 100 ppm Air)
- Further tests needed to be ready for usage on experiments

GHG Reduction Strategies

Alternative Gases

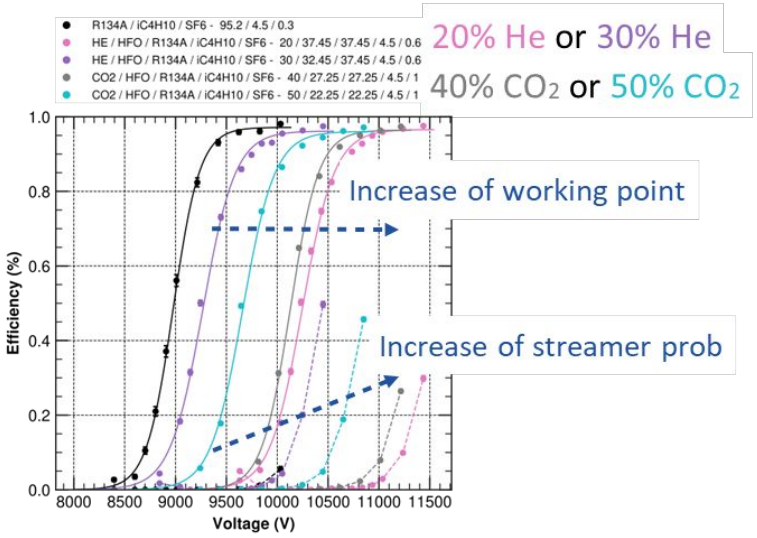
RPCs detector characterization:

- *R-134a alternative gases*:
  HFO-1234ze, R-1224yd
- *SF_6 alternative gases*:
  Novec 5110™, Novec 4710™, C_4F_8O, CF_3I
- *Characterization of additional gases*: CO_2, He
- Studies in laboratory and GIF++



HFO as substitute of R134a

- More than 50 eco-friendly gas mixtures tested
- HFO cannot directly replace R134a
- Compromise: use both HFO and R134a
  HFO reduces GWP, R134a reduces charge



+ *Participation in Eco-Gas Collaboration*
funded by AIDA innova

Conclusions

LHC Gas Systems M&O

- > 2000 intervention LS2 for maintenance, operation, stand-by duty, r&d..
- Maintenance of Gas Modules, PLC + Software, gas monitoring
- Gas Systems upgrades (*e.g. ATL RPC*)

New Gas systems

- **LHC**
  CMS GEM (2019), ATLAS MM (Nov 2021), LHCb SciFi (2020), LHCb UT (ongoing)
- **non-LHC**
  CLOUD (2022), NA61 (2021), T2k-ND280 (delivery Japan 2022)

GHG Reduction Strategies

- Optimization of current technologies for gas recirculation (*e.g. CMS RPC*)
- Improvement of existing Gas Recuperation systems (*e.g. CMS CSC, LHCb RI2*) and development of new plants (*RPC mixture prototype*)
- R&D on Eco-Friendly gas mixtures (*>50 mix tested*)

Big thanks to all Trainee, Students, Doct, FSU, Fellow, Staff!!

Thank you for your attention