EP-DT
Detector Technologies

# Task 7.2: Eco-friendly gas mixtures for RPCs

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on behalf of the AIDAinnova WP 7.2 community

CERN

AIDAinnova kick-off meeting
13 April 2021

# Institutes involved in the task

| Institute | Main contact person |
|---|---|
| CERN * | Beatrice Mandelli |
| INFN LNF * | Davide Piccolo |
| INFN Bari | Alessandra Pastore |
| INFN Bologna | Davide Boscherini |
| INFN Roma | Barbara Liberti |
| INFN Torino | Alessandro Ferretti |
| Ghent University | Michael Tytgat |

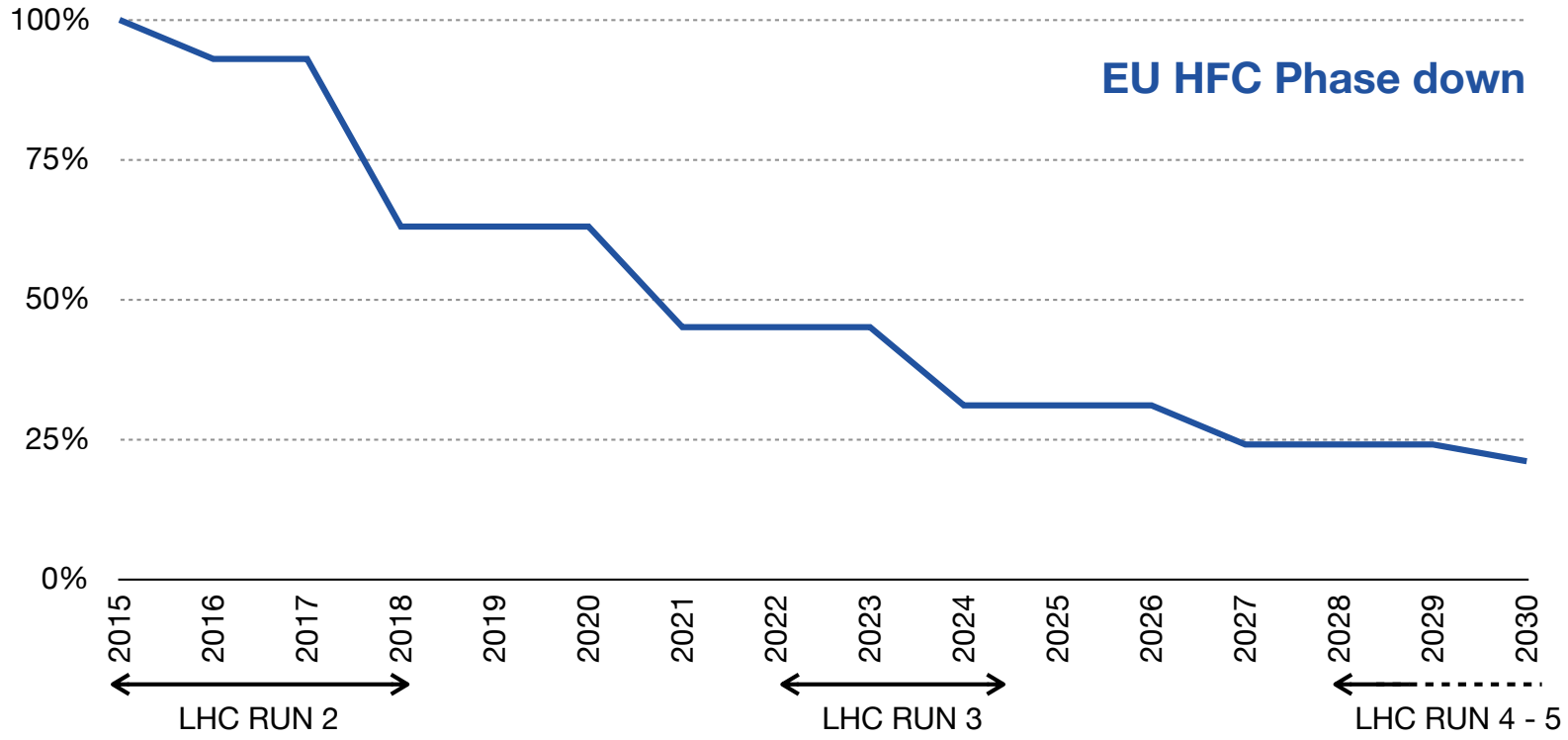
***Beneficiaries**

| Institute | EC requested funding without overheads (kEURO) | Person months |
|---|---|---|
| CERN | 40 | 13 |
| INFN LNF | 30 | 19 |

# Use of F-gases in Europe

## European Union “F-gas regulation”:

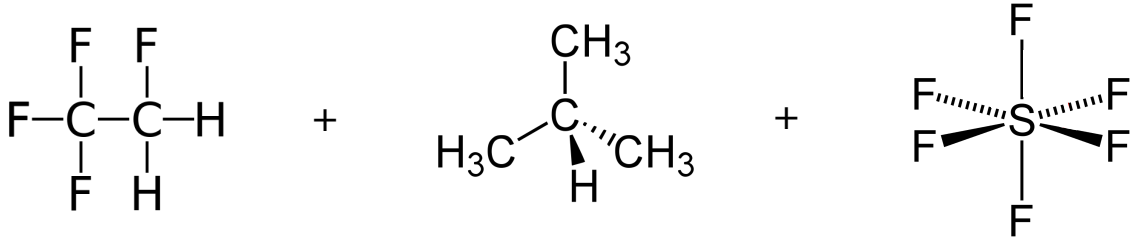
- **Limiting the total amount** of the most important F-gases that can be sold in the EU from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in 2030.
- **Banning the use** of F-gases in many new types of equipment where less harmful alternatives are widely available.
- **Preventing emissions** of F-gases from existing equipment by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life.




***Prices are increasing in EU and availability in the future is not known.***
***Reduction of use of $C_2H_2F_4$ is fundamental for next LHC Runs***

# The RPC gas mixture

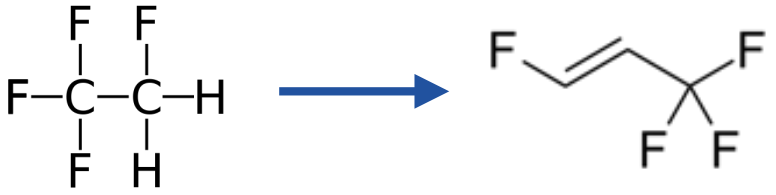
~95% + 4-5% + 0.3%



GWP 1430 | GWP 3.3 | GWP 22800

RPC gas mixture used in ATLAS and CMS experiments (very similar for ALICE)
GWP of the gas mixture: 1430

***It is fundamental to search for new eco-gases***



**R134a**
($C_2H_2F_4$)
GWP 1430

**HFO-1234ze**
($C_3H_2F_4$)
**GWP 6**

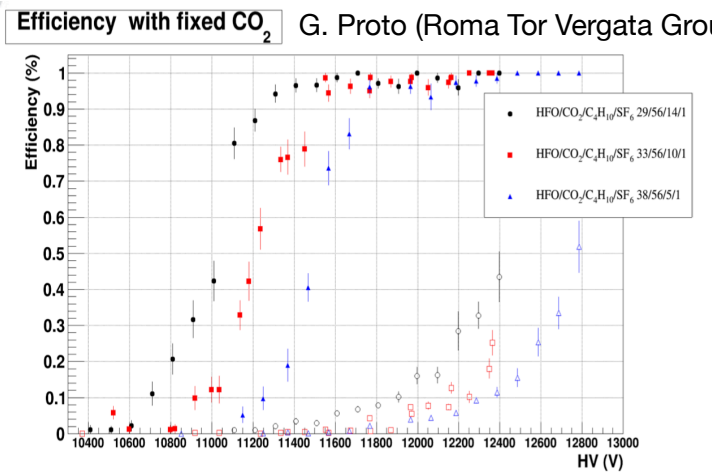
Hydro-Fluoro-Olefin (HFO)
- C=C double bond
- fluorine-containing
- hydrogen-containing

***New eco-friendly liquids/gases have been developed for industry as refrigerants and HV insulating medium… not straightforward for RPC operation***

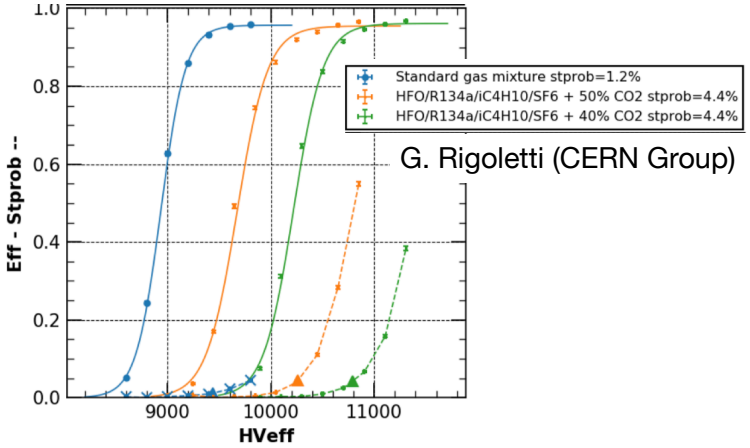
# Laboratory results from RPC community

***RPC community is testing eco-friendly gas mixtures since few years***

- Until now no eco-friendly gas mixtures have been found to fulfil the requirements for already installed RPCs at LHC experiments
  - Detector layout is fixed
  - FE electronics cannot be changed
  - Maximum achievable working voltage limited by existing cables and power supplies
- Good alternatives have been found with a HFO-$CO_2$ based gas mixture
- Studies are still on-going in the different institutes
  - Each laboratory is working independently




G. Proto (Roma Tor Vergata Group)




G. Rigoletti (CERN Group)

***RPC long-term operation with eco-friendly gas mixtures under high background radiation and possible ageing effects must be investigated***

↓

**AIDAinnova WP 7.2**

# AIDA WP 7.2: deliverables

***Deliverable:***
***Report on performance studies of several eco-friendly gas mixtures for RPCs operated at different background conditions***

1. Selection of possible eco-friendly gas mixtures
   - Each laboratory works independently in the search of new eco-friendly gas mixture and it will propose to the AIDA WP7.2 community possible eco-friendly gas mixtures
2. Long term test of RPC operated with selected eco-friendly gas mixtures at the CERN Gamma Irradiation Facility (GIF++)
   - Detector performance on long-term operation
   - Detector performance in presence of high gamma rate (test-beam)
   - Fundamental for the validation of new eco-friendly gas mixtures in presence of LHC and HL-LHC like background radiation and after accumulation of large integrated charge
3. Studies on formation of impurities and their impact on RPC operation
   - It is known that HFO breaks easier than R134a during detector operation
   - Systematic studies are needed to quantify these impurities and their effects on RPCs with respect to different operation conditions

# AIDA WP 7.2: deliverables

***Deliverable:***
***Report on performance studies of several eco-friendly gas mixtures for RPCs operated at different background conditions***


1. Selection of possible eco-friendly gas mixtures

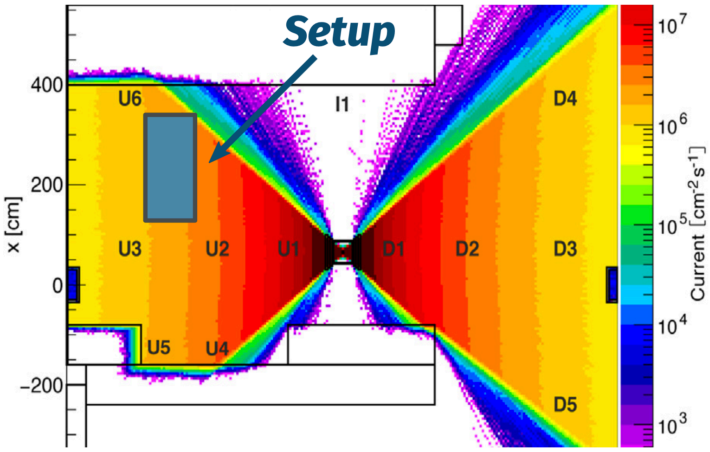
2. Long term operation at GIF++ with different eco-friendly gas mixtures

2. Detector performance at GIF++ (test-beam)

3. Studies on formation of impurities at GIF++ and impact on RPC operation

# Set-up at GIF++

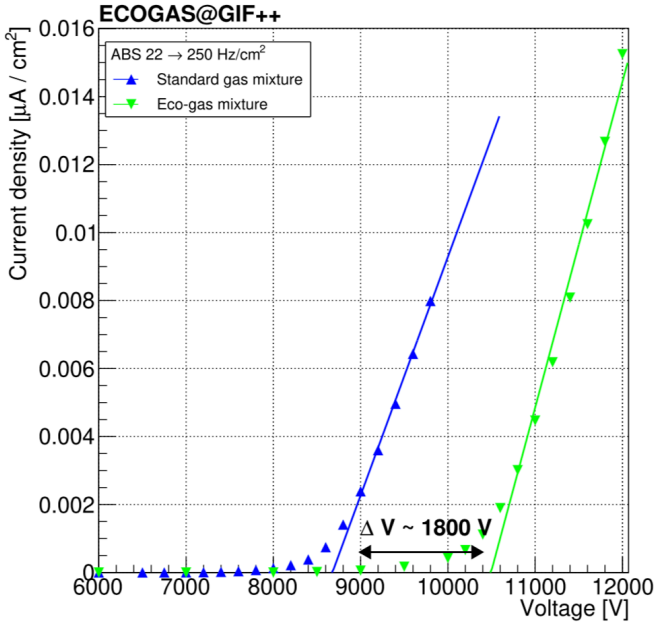
- Set-up installed in GIF++ in 2019
  - 12.2 TBq $^{137}$Cs + H4 SPS beam line
- Idea is to operate RPC chambers belonging to different experimental groups
  - Now under irradiation RPC detectors of CMS and CERN EP-DT Gas Team
- Several improvements of the set-up foreseen thanks to AIDAinnova fundings
  - New gas mixing unit
  - Improvement of DCS system
  - New DAQ system
  - Material for studying HFO impurities formation
- Gas (also HFO) provided by BE/EA team

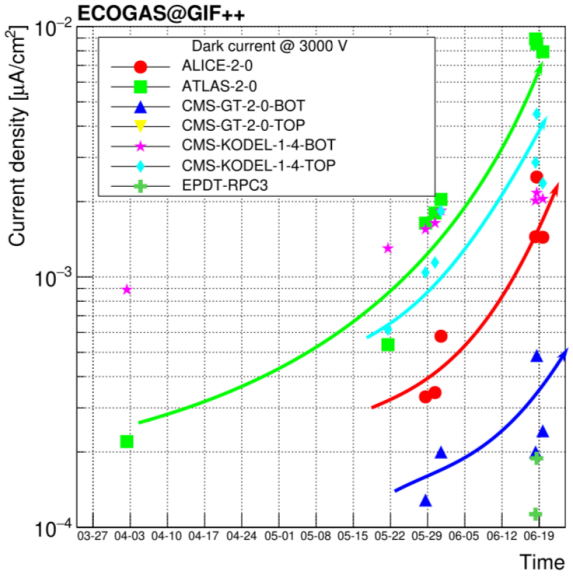


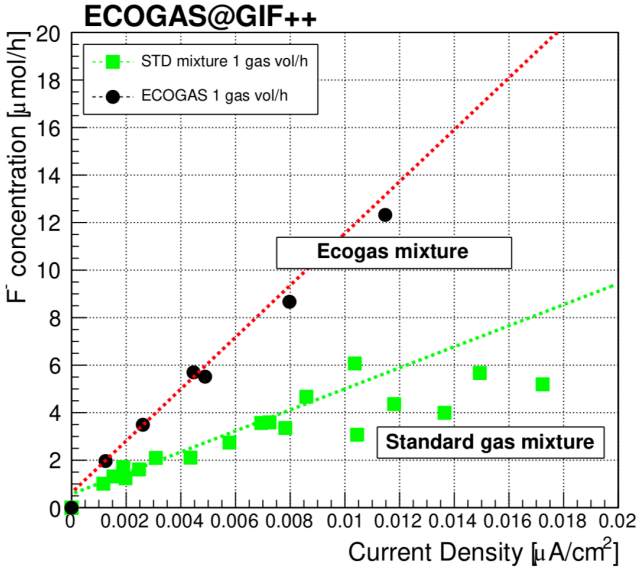

# Examples of studies and workflow

**Studies for the gas mixture:**
**HFO/$CO_2$/$iC_4H_{10}$/$SF_6$ 45/50/4/1 (GWP 250)**

- Selection of the gas mixture by the community
  - Based on performance wrt standard gas mixture
- Characterisation of the gas mixture at GIF++
  - Shift of working point with respect to the standard gas mixture
- Measurements of F- production at GIF++
  - For different operation conditions
- Long-term detector performance (ageing test)
  - Monitoring of physics currents, dark currents, ohmic currents, etc.

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