

IFD 2022 : INFN Workshop on Future Detectors
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Green Resistive Plate Chamber detectors for HEP applications

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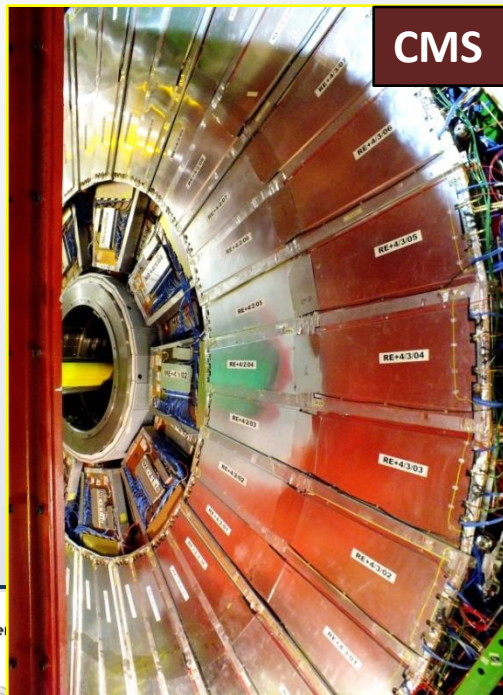
on behalf of the **RPC EcoGas@GIF++ Collaboration**,
born within the ALICE, ATLAS, CMS, LHCb/SHiP and CERN EP-DT RPC Communities

Resistive Plate Chambers in HEP

RPC technology continuously improved, aiming at more and more challenging applications



ALICE



CMS

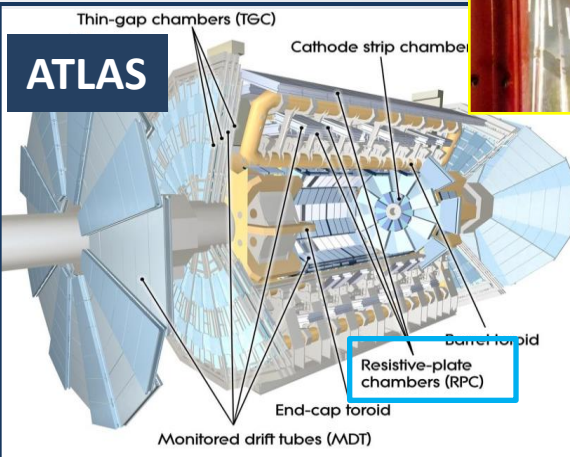
- In HEP, typically operated in avalanche mode
- “standard” gas mixture is a perfect match:

CH_2FCF_3 (> 90%) / C_4H_{10} / SF_6

BUT

Gas	GWP* values 100-year time horizon
CO_2	1
CH_2FCF_3	1300
SF_6	23500

www.ipcc.ch, AR5



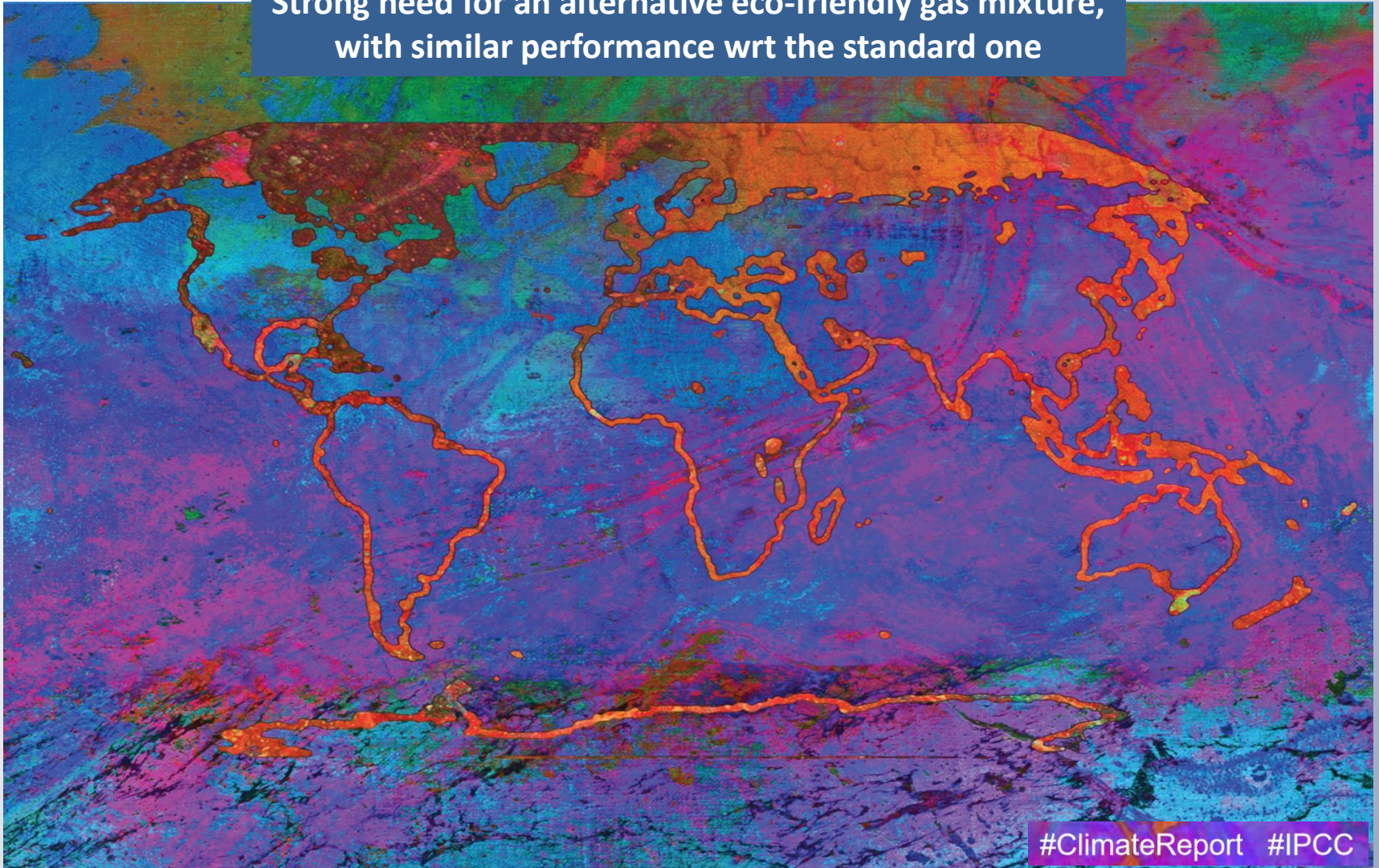
ATLAS



*Global Warming Potential = measure of the heat trapped in the atmosphere by a ton of a given gas, if compared to a ton of CO_2

Eco-compatibility of RPC detectors

**Strong need for an alternative eco-friendly gas mixture,
with similar performance wrt the standard one**

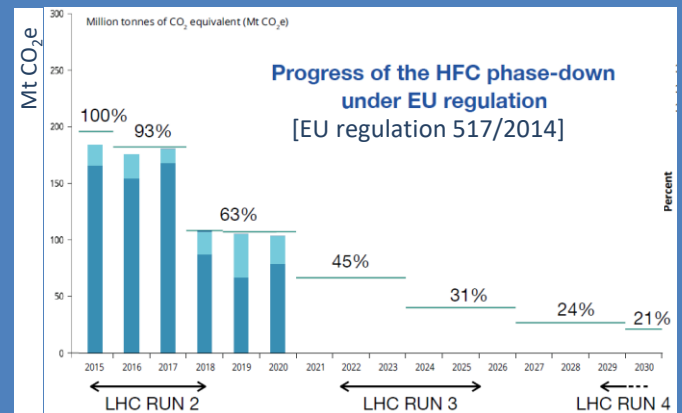


Eco-compatibility of RPC detectors

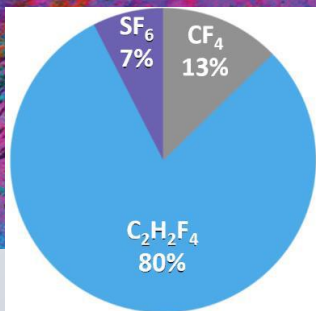
Strong need for an alternative eco-friendly gas mixture, with similar performance wrt the standard one

EU “F-gas regulation”

- Limiting the total amount of the most important F-gases that can be sold in the EU.
- Banning the use of F-gases where less harmful alternatives are widely available.
- Preventing emissions of F-gases from existing equipment.



relative contribution to GHGs emissions from particle detectors at CERN LHC experiments



Concerns about environment, F-gases availability and costs

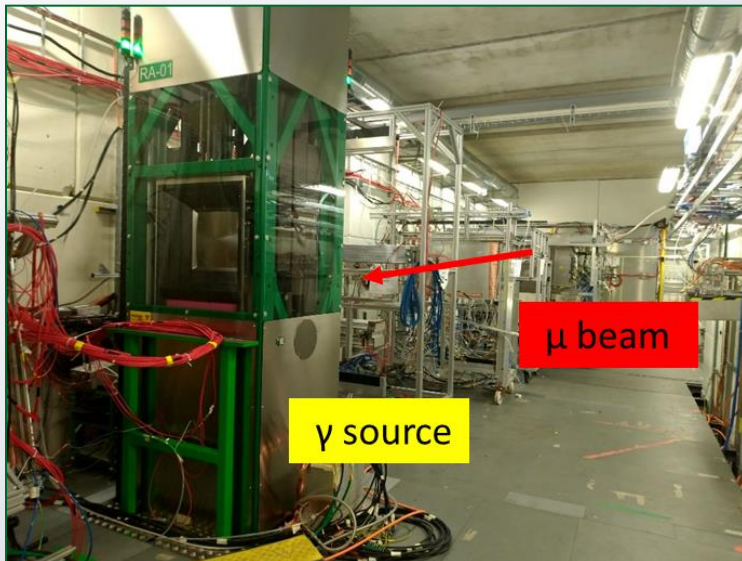
f.e. CH₂FCF₃ in early LHC Run 3 expectation:
~ 90 ktCO₂e/year emitted
price increase of ~2.5 times w.r.t to 2015

#ClimateReport #IPCC

The RPC EcoGas@GIF++ Collaboration



- recently born within the **ALICE, ATLAS, CERN EP-DT, CMS and LHCb/SHiP RPC Communities**
- shares **person-power, instrumentation, ideas** in order to search for potential **eco-friendly gas mixtures** in home-laboratories and at CERN, and **assess the performance of RPCs in different irradiation conditions** at the CERN Gamma Irradiation Facility GIF++



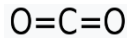
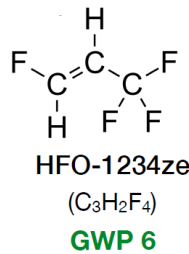
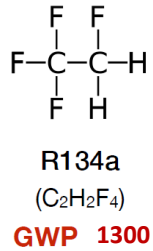
View of the setups inside the GIF++ bunker

Group	Dimension (cm ²)	# of gaps	Gap/electrodes Thickness (mm)	Readout	# of strips
ATLAS	500	1	2 / 1.8	Digitizer	1
CMS	4350	2	2 / 2	TDC	128
EP-DT	7000	1	2 / 2	Digitizer	7
ALICE	2500	1	2 / 2	TDC	32
ShiP/LHCb	7000	1	1.6 / 1.6	TDC	64

Summary table of all the RPCs of the collaboration

The 'HFO' option for avalanche RPC detectors

Several gas mixtures have been tested. Two of them have shown to be very promising:

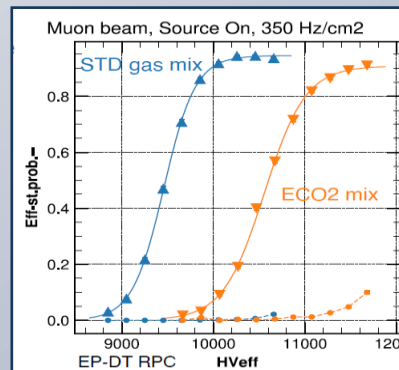
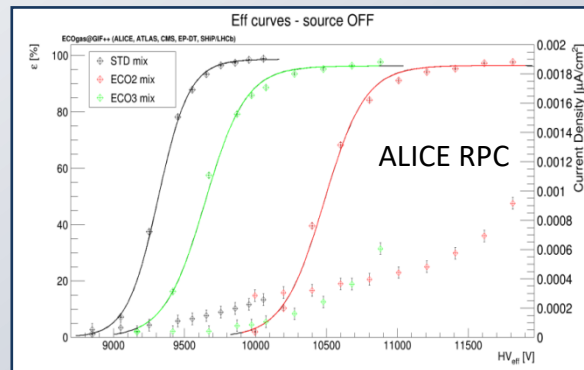
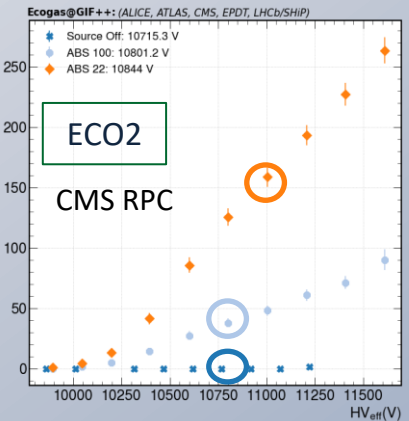
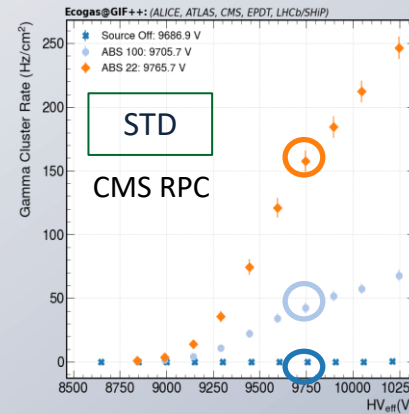
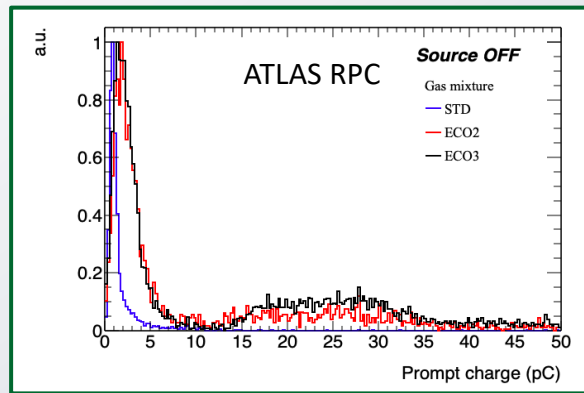


CO₂

GWP 1

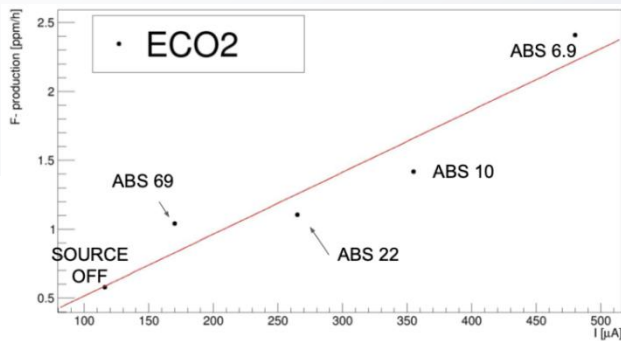
ECO2 = CO₂/C₃H₂F₄/i-C₄H₁₀/SF₆=(60/35/4/1)%
 ECO3 = CO₂/C₃H₂F₄/i-C₄H₁₀/SF₆=(69/25/5/1)%

impact on the environment reduced of ~ 80% wrt STD mix



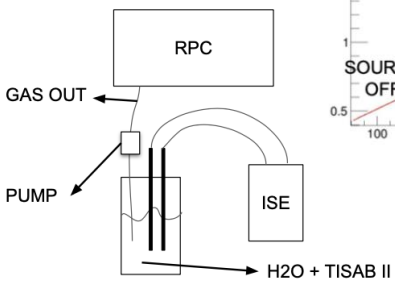
*comparable performance
at working point*

Long term performance studies



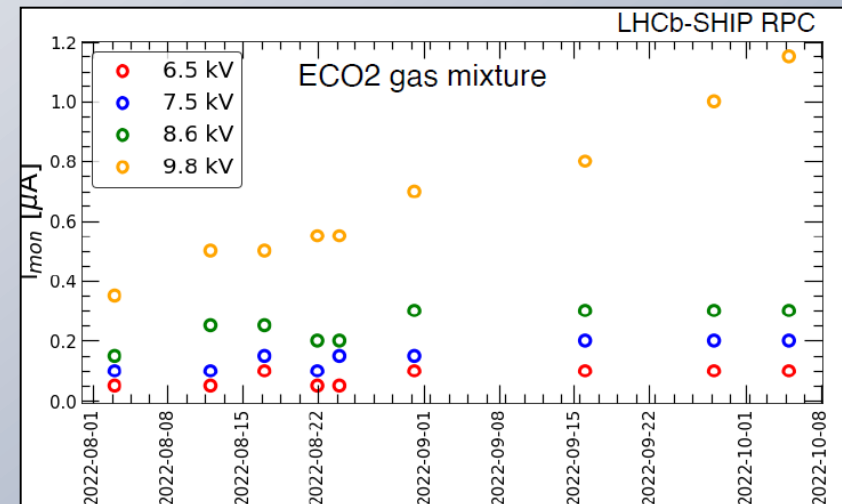
F⁻ produced from the C₂H₂F₄ and C₃H₂F₄ molecules, especially in high irradiation conditions and high electric fields, combines with H₂O, producing HF acid

→ Ion Selective Electrodes (ISE) at CERN



Irradiation campaign of RPCs to accumulate an equivalent charge of the HL-LHC Phase

Fundamental for the validation of new eco-friendly gas mixtures



towards future ...

