

EP-DT Eco-friendly Gas Studies for RPCs at GIF++

Annual User Meeting - the 3rd of December 2024

Ştefania A. Juks, on behalf of the CERN EP-DT-FS Gas Group

Outline

Annual GIF++ User Meeting

- Motivation
- EP-DT Set-ups & Upgrades
- Test Beams
- Long-term studies
 - Ageing Campaign
- Summary and future plans

Motivation

Objectives

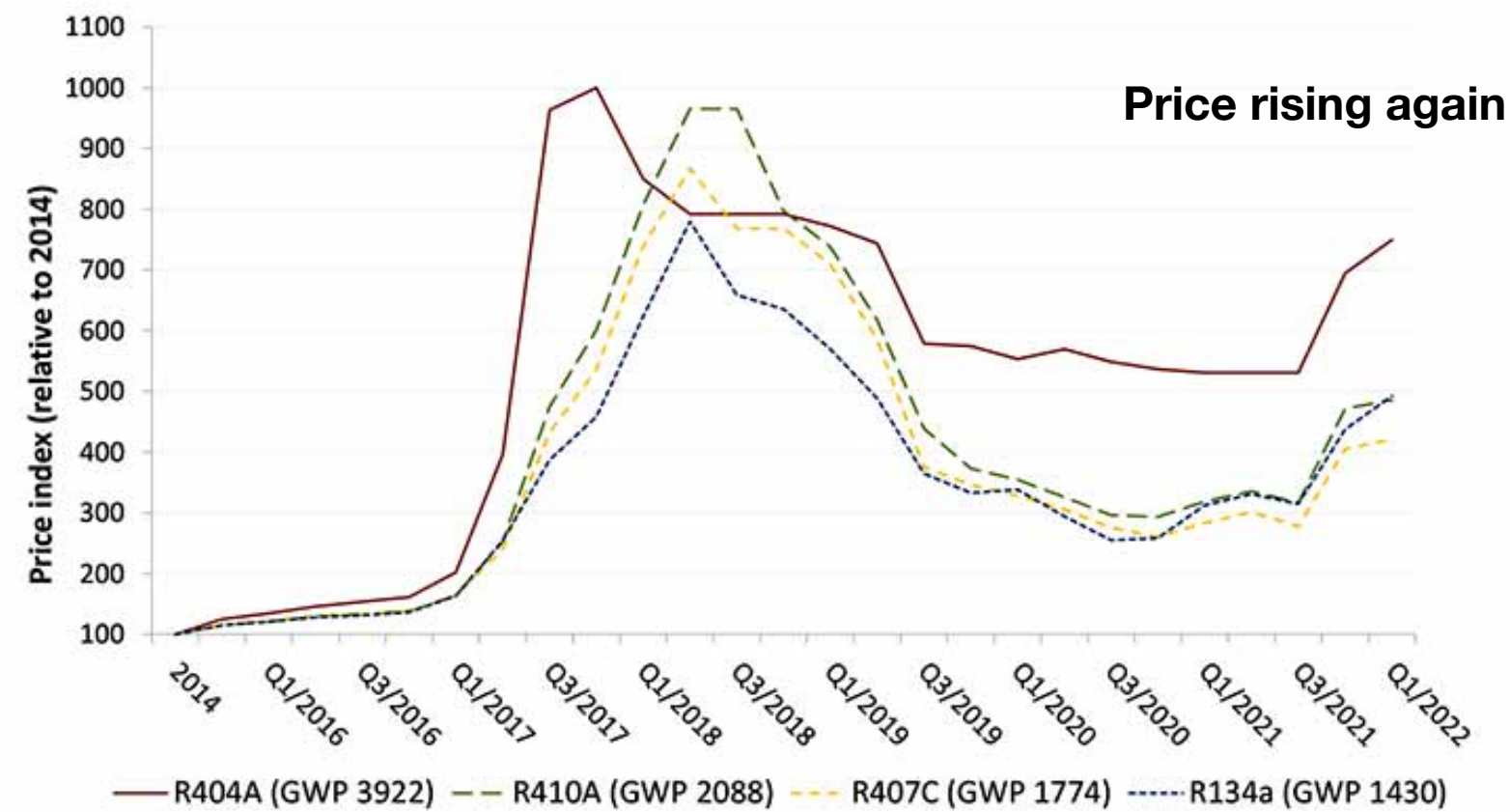
Context

78% of CERN's emissions from the use of Fluorinated gases (F-gases).
~ 180 000tCO₂e in 2022 alone

Problem

RPCs use F-gases in all major LHC experiments.

↑ Emissions ↑ Price ↓ Availability ↑ Regulations



Mitigation strategies

GHG Consumption Reduction

Alternative Gases

Recirculation

Recuperation

Short-term

Medium-term

Long-term

Research Lines

- ▶ Performance studies on CO₂-based gas mixtures.
- ▶ Testing R-134a and SF₆ replacements for GWP reduction.

- ▶ Validate the mixture for use in LHC and in the future HL-LHC.

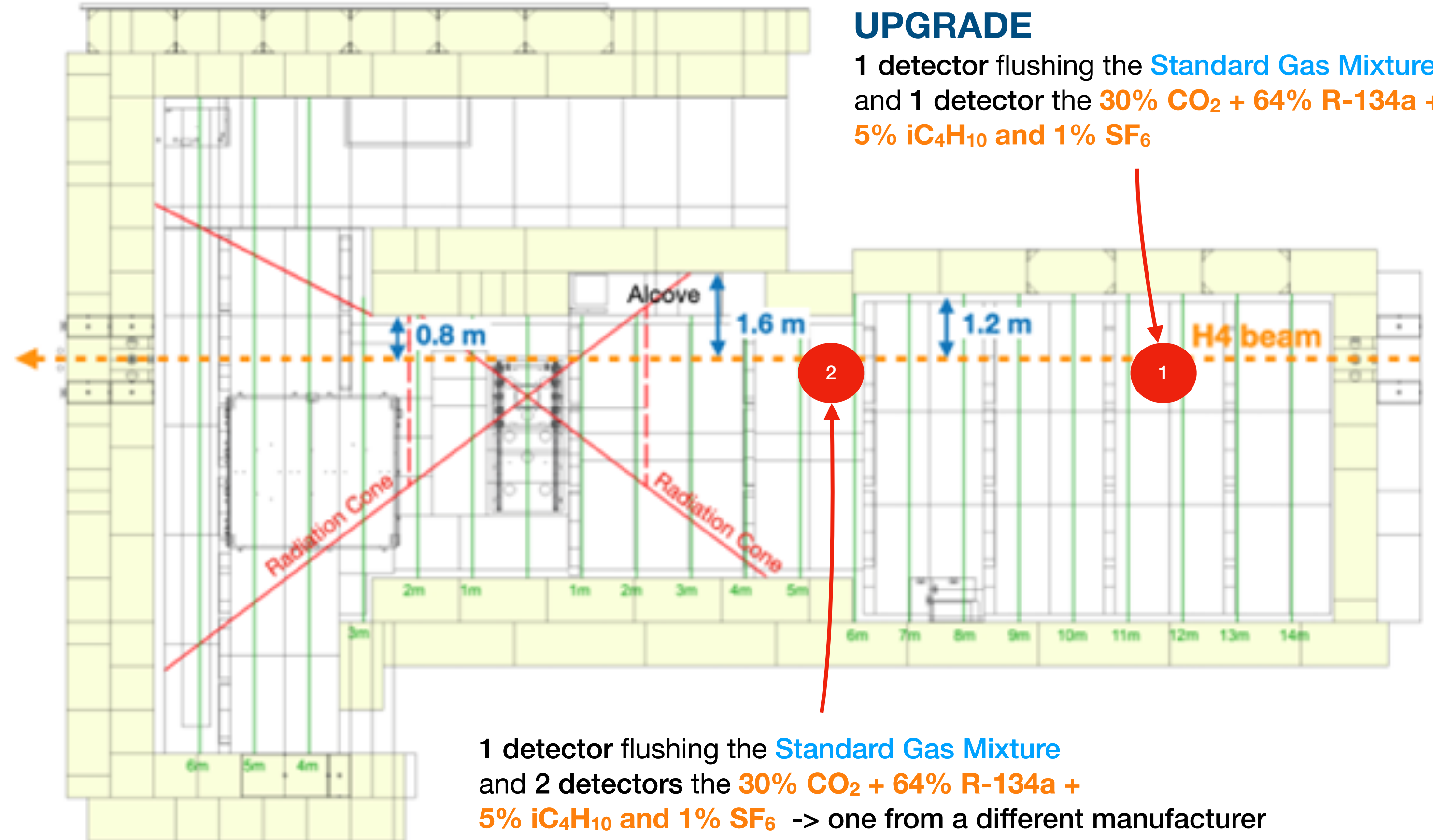
- ▶ Test the mixtures under recirculation.

Test Beams & Ageing Campaigns @GIF++

Experimental Set-ups

Overview

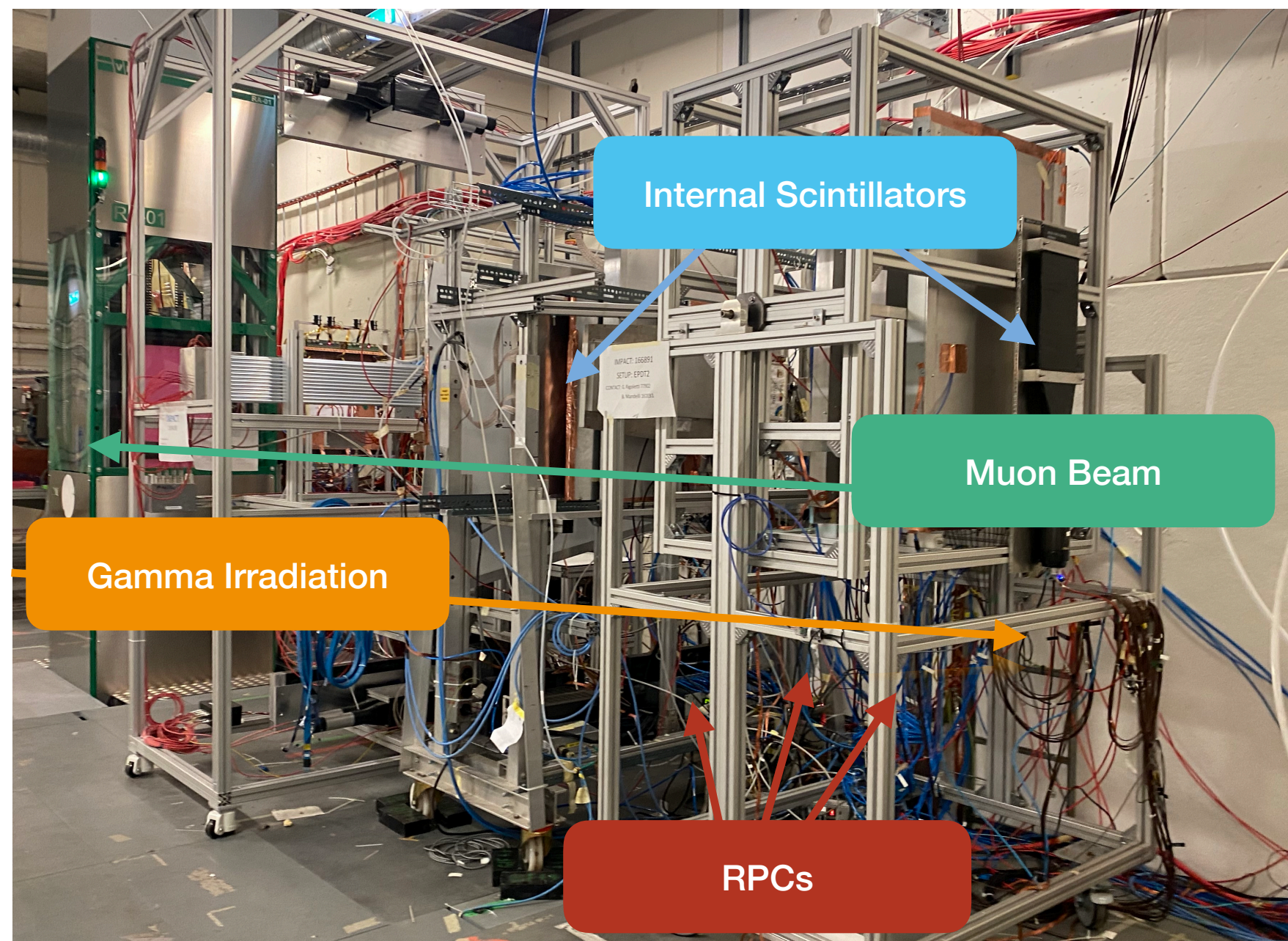
- Performance studies under LHC-like conditions with muon beam
 - ^{137}Cs , 12.5TBq irradiator
 - Pb Filters are used to regulate the gamma background intensity
- Two set-ups:
 1. LHC conditions
~100Hz/cm²
 2. HL-LHC conditions
~350Hz/cm²



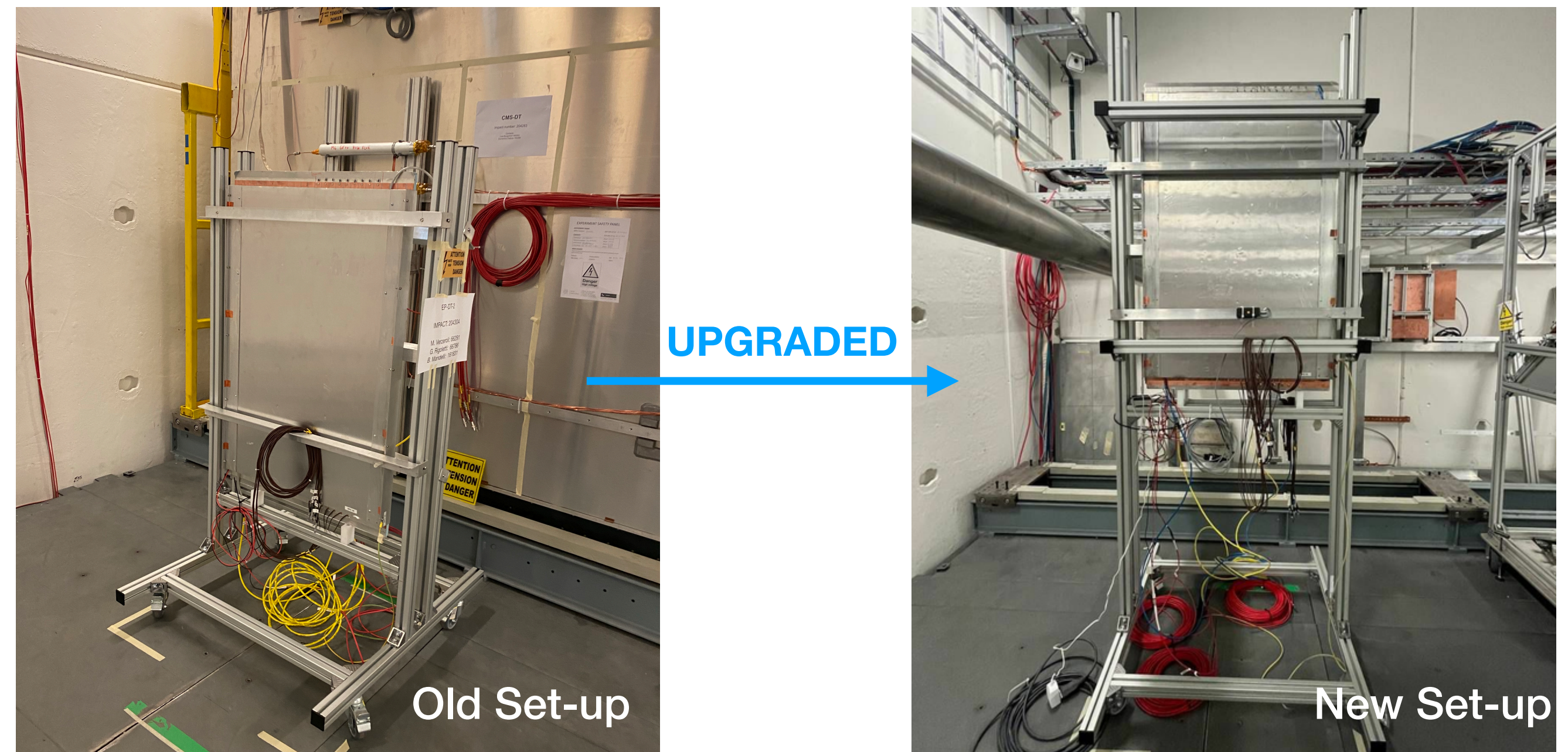
Experimental Set-ups

@GIF++

Main Trolley



Lower-Irradiation Trolley



- RPC detectors

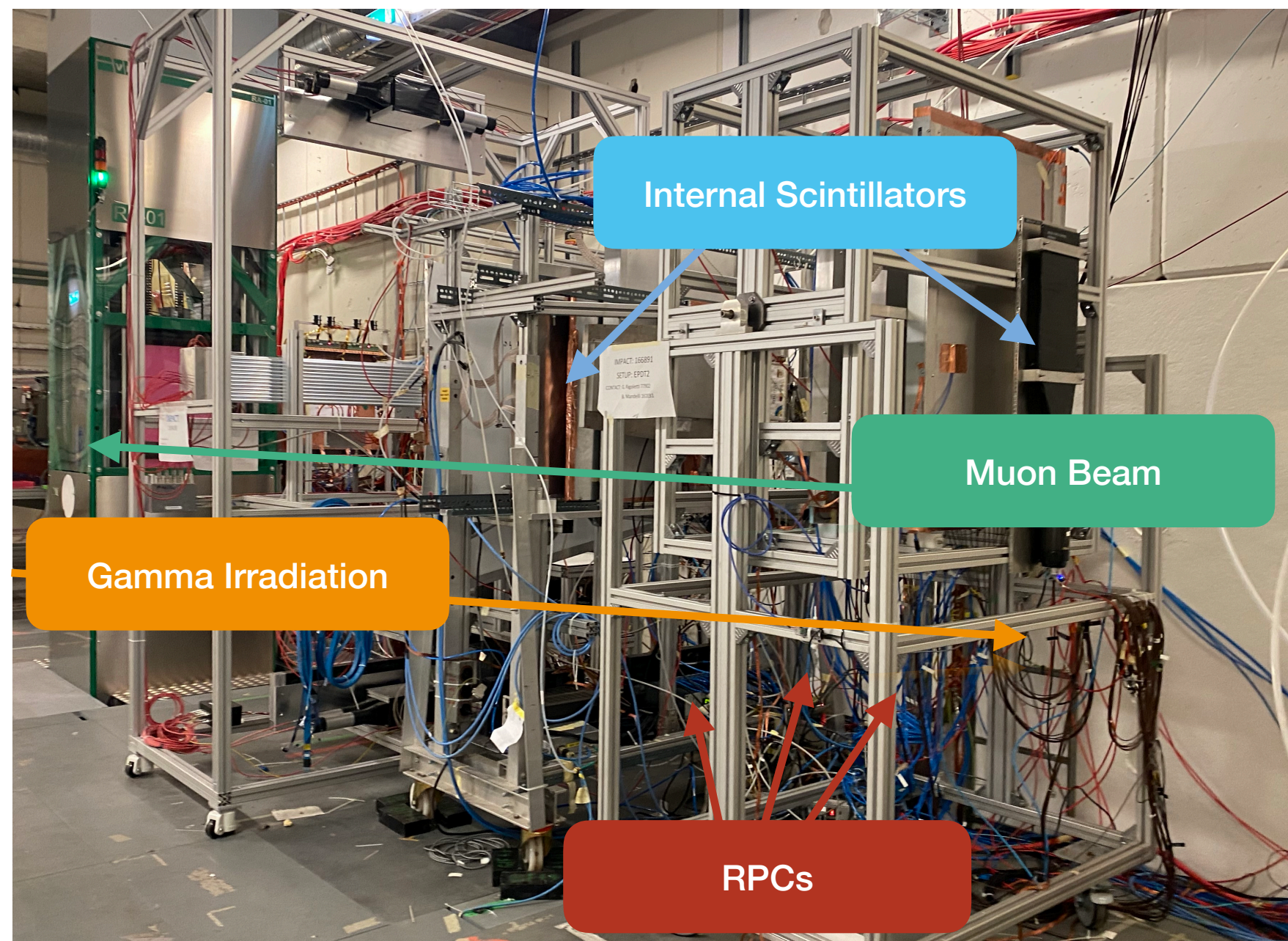
- 2mm gap, high pressure laminates (HPL), strip size between 2-2.5cm

- The old trolley was modified to accommodate two detectors so as we would have one with the Standard Gas Mixture and one with the mixture under test - 30% CO₂-based gas mixture.

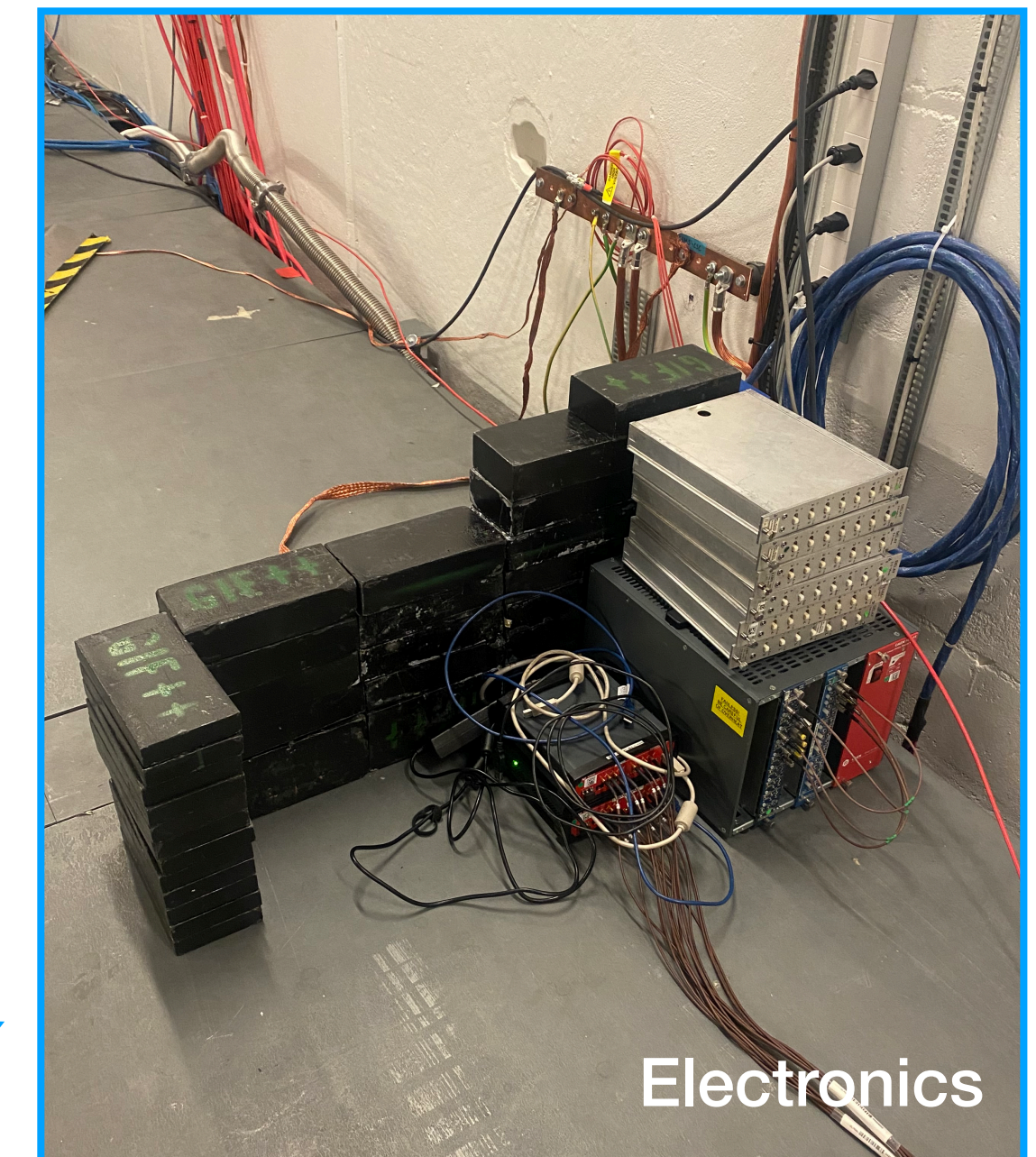
Experimental Set-ups

@GIF++

Main Trolley



Lower-Irradiation Trolley



- RPC detectors

- 2mm gap, high pressure laminates (HPL), strip size between 2-2.5cm

- A new set of electronics (NIM Crate, discriminator, delay units, CAEN Digitizers, PC) were added for data acquisition during test beam campaigns.

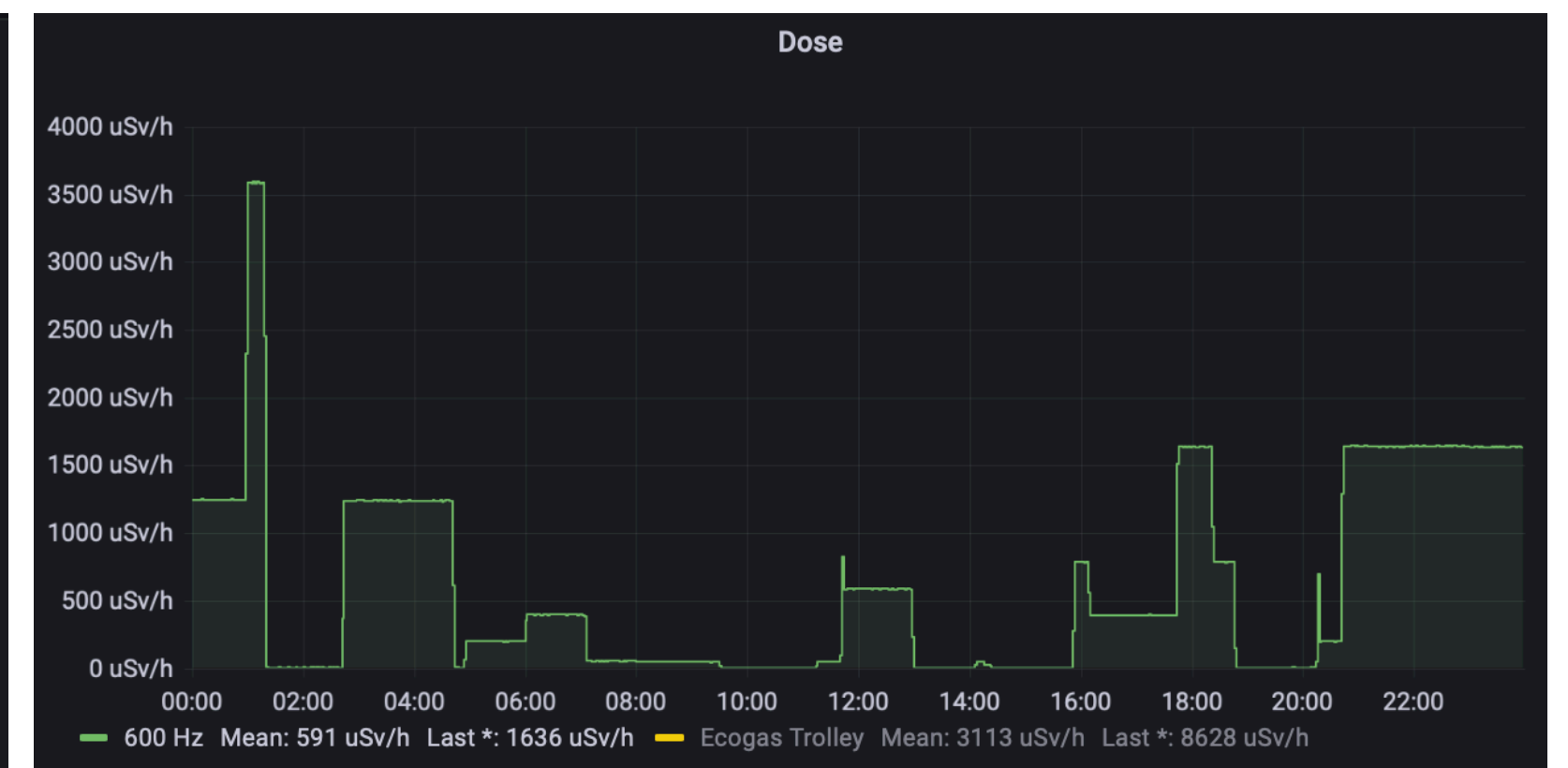
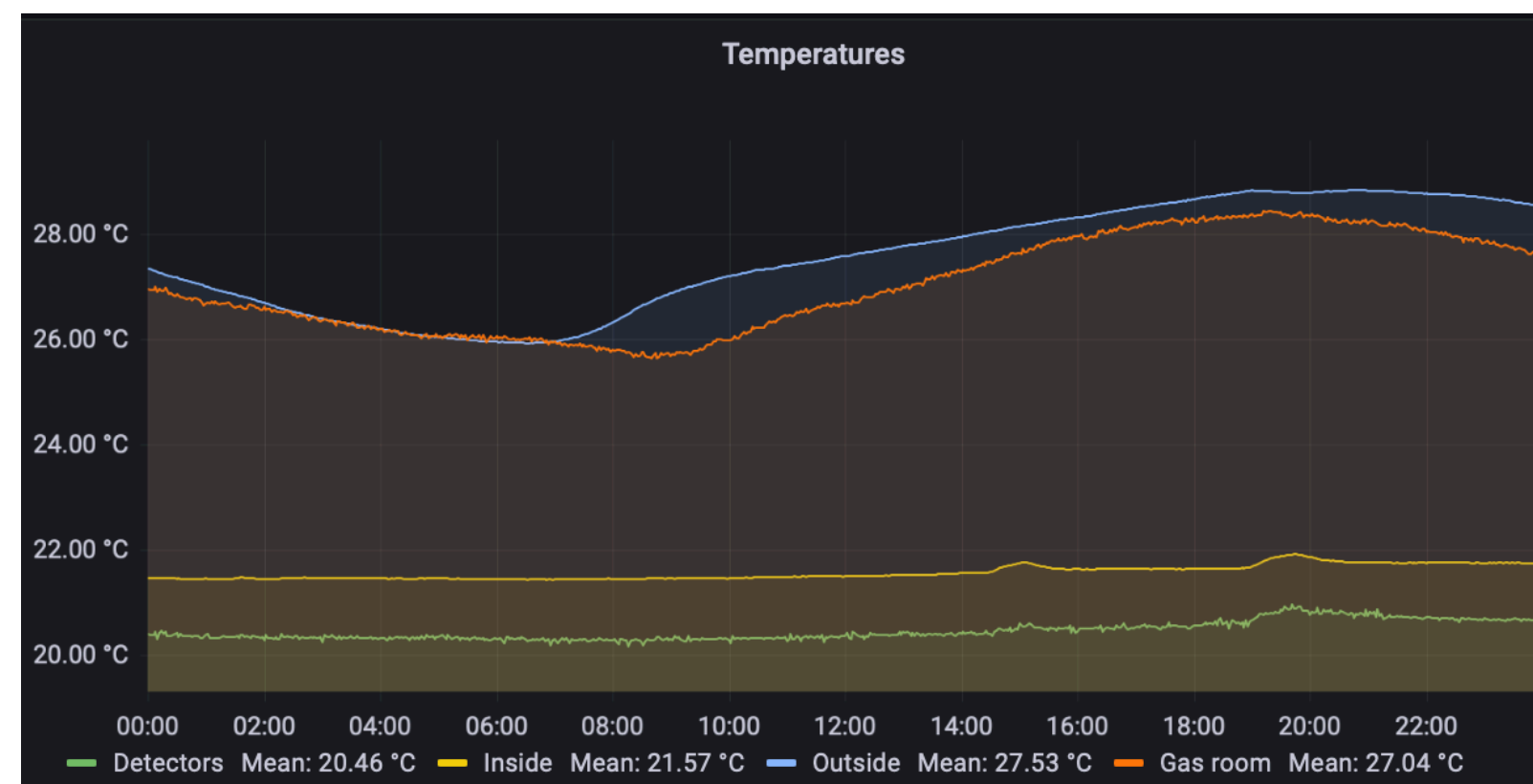
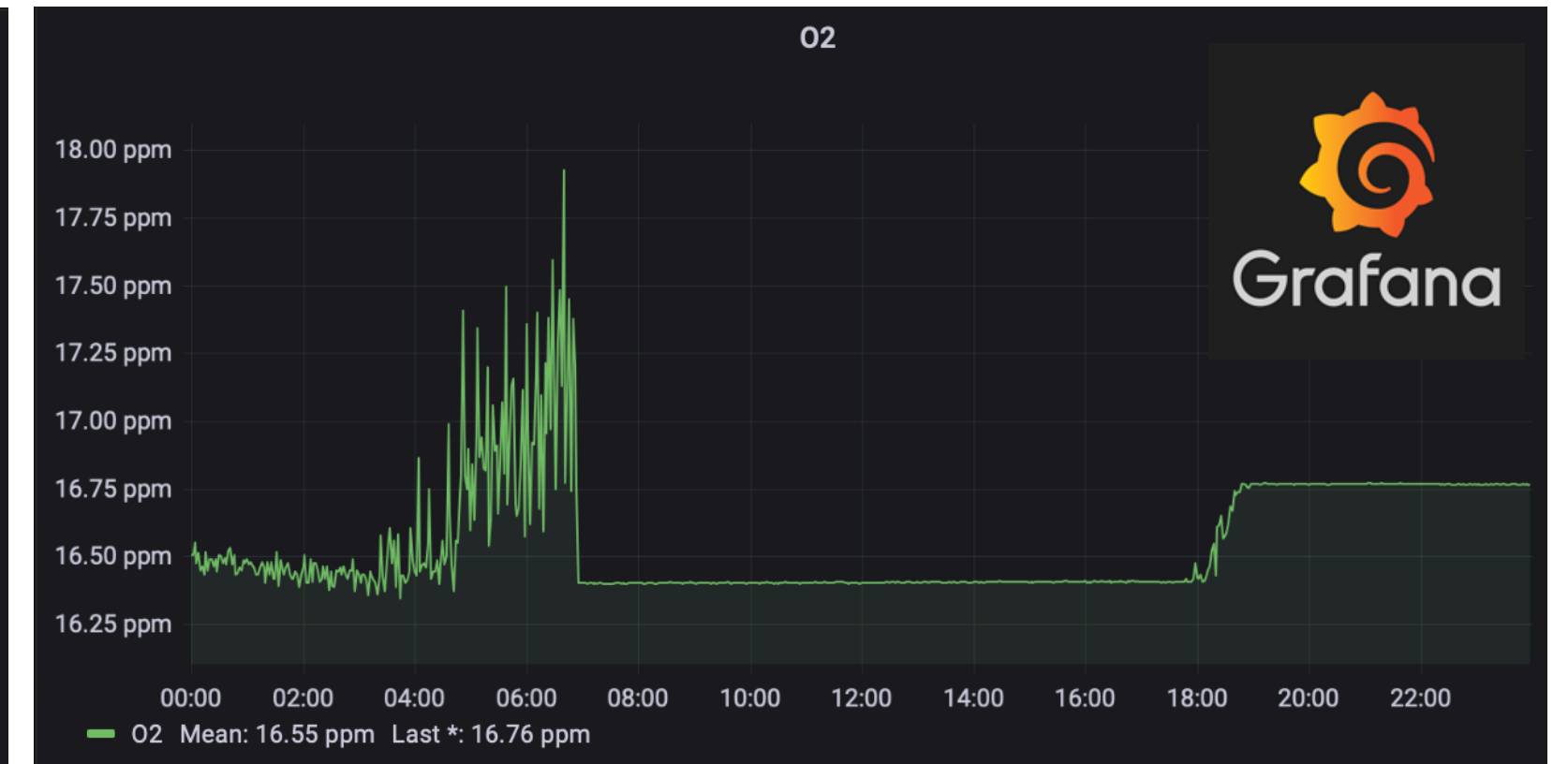
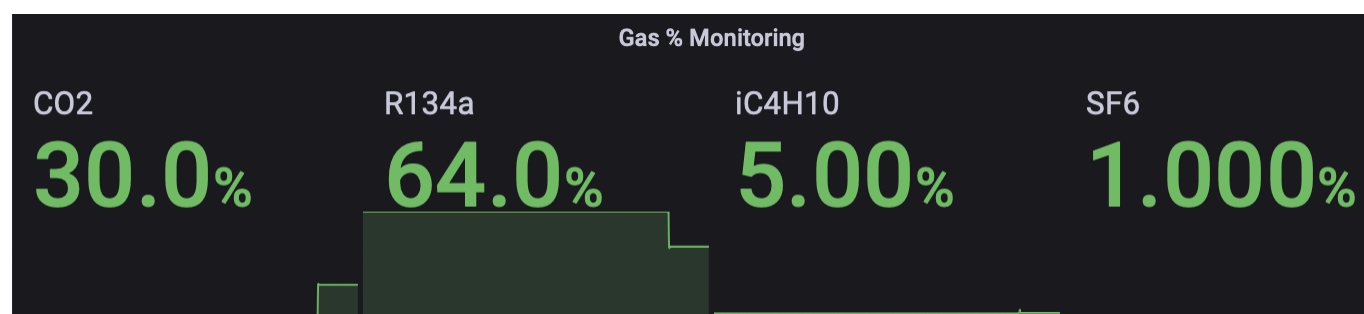
Set-up and Methodology

Dedicated Gas Monitoring System

Monitoring includes various metrics:

- oxygen,
- humidity,
- dose
- environmental parameters
 - temperature
 - pressure,
- gas flow measurements.

Data is continuously recorded.

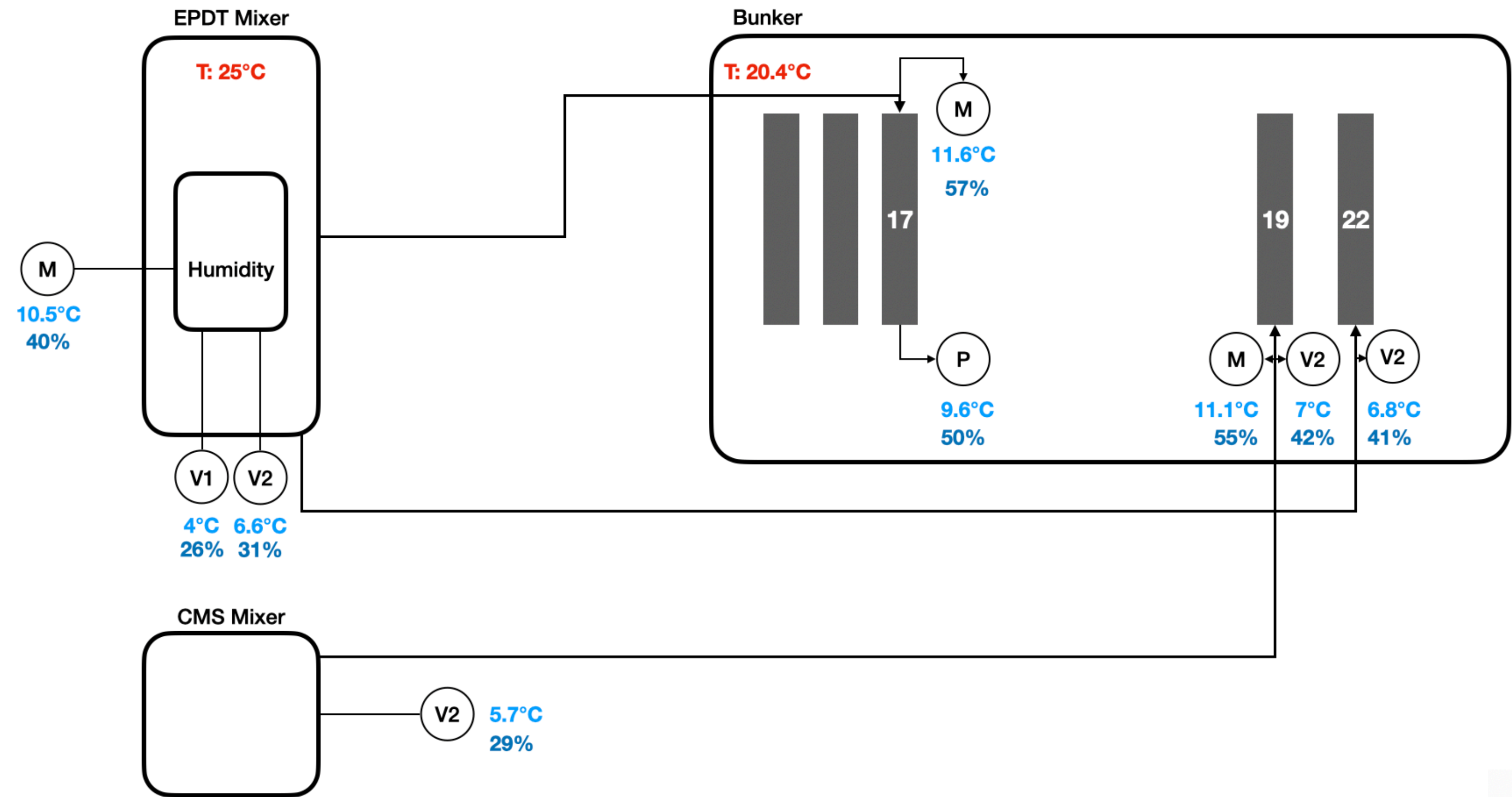
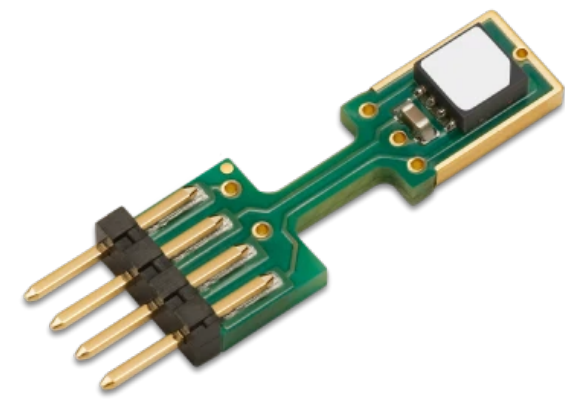


Experimental Set-ups - Upgrades

@GIF++

[Dew Point/RH Calculator](#)

- New humidity sensors under check (SHT85)
- Test performed with:
 - 2 Vaisalas (V1 & V2)
 - 2 SHT85 sensors (M, P)
- Higher humidity in the bunker



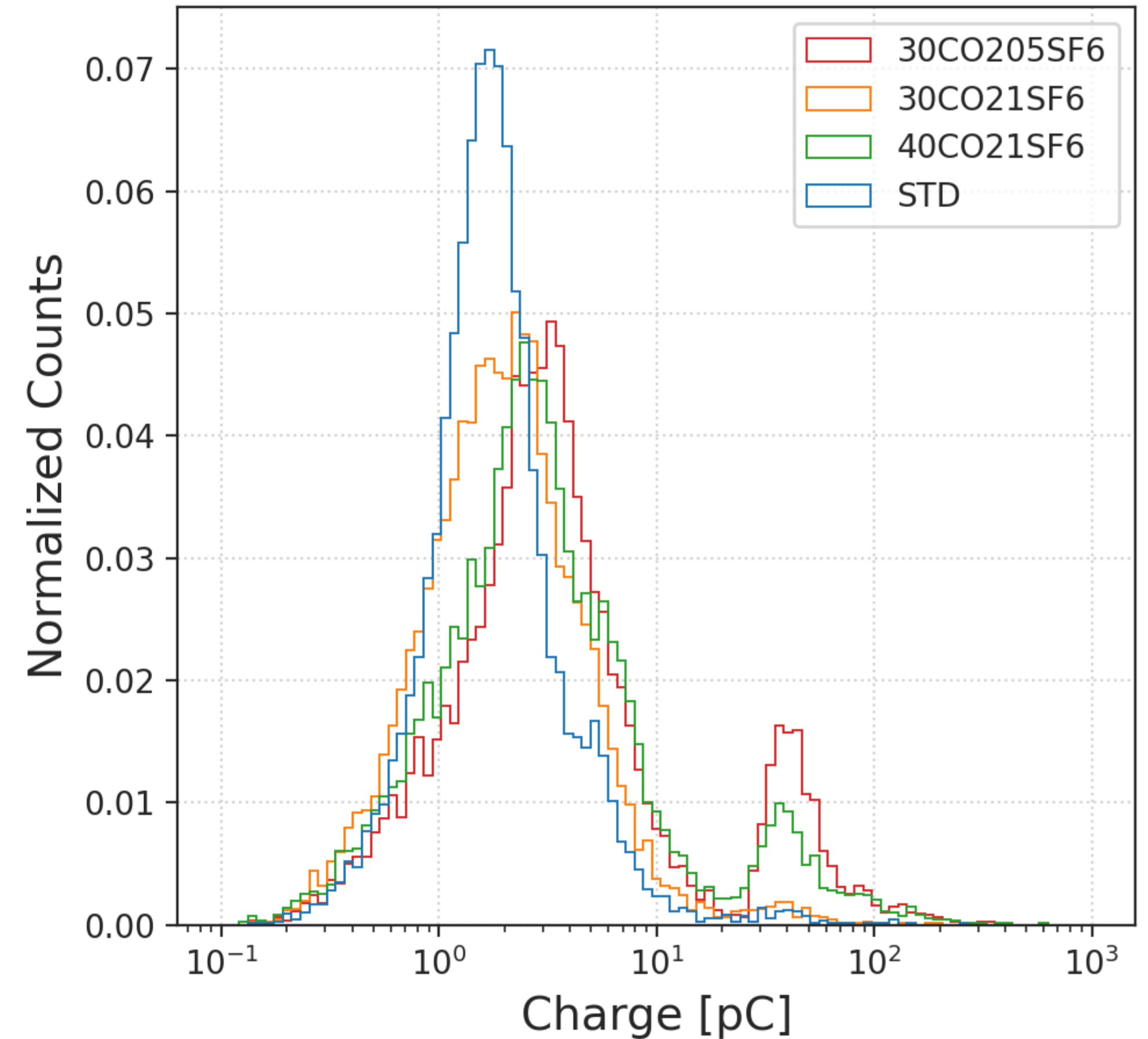
Test Beam Campaigns

@GIF++

- Participated in the June and September test beam campaigns:
 - June Test Beam: check performance after irradiation.
 - September Test Beam: **New set-up** (two 2mm chambers installed in the beam line) at LHC-like conditions $\sim 100\text{Hz}/\text{cm}^2$ characterisation.
 - All experimental parameters were gathered for the Standard Gas Mixture and the STD + 30% CO_2 added.

S.Off	WP [V]		Eff [%]		St.Prob [%]	
	STD	30CO ₂	STD	30CO ₂	STD	30CO ₂
19	9492	9340	95.64	96.71	0.26	0.57
22	9941	9795	91.17	92.17	1.71	5.87

Charge Distribution, RPC 22



Ageing studies for 30% CO₂ Added

@GIF++

- Detectors are continuously irradiated ~working point.
- The detectors are checked with weekly high voltage scans with the irradiation source off and on
 - Current behaviour observed.

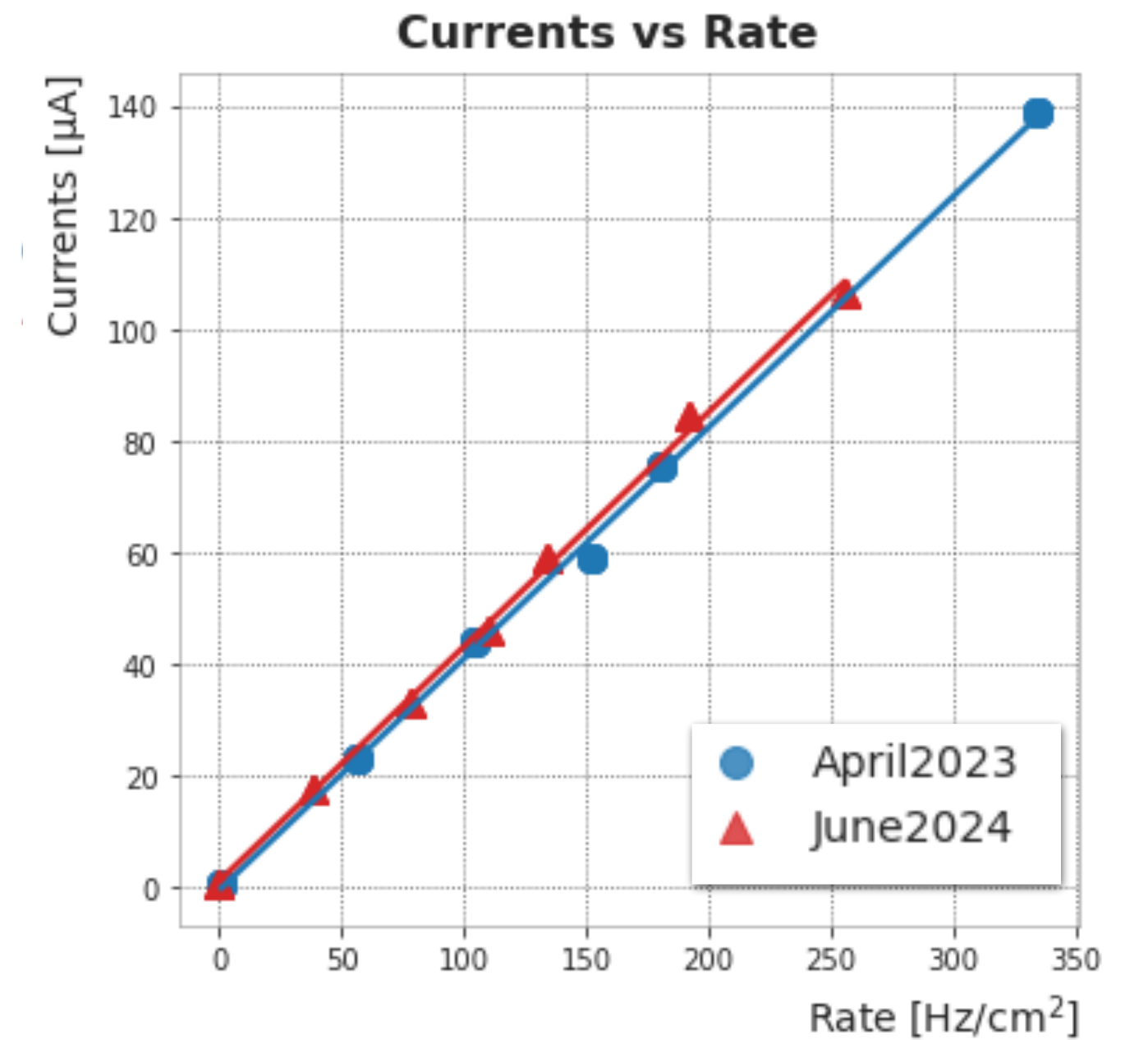
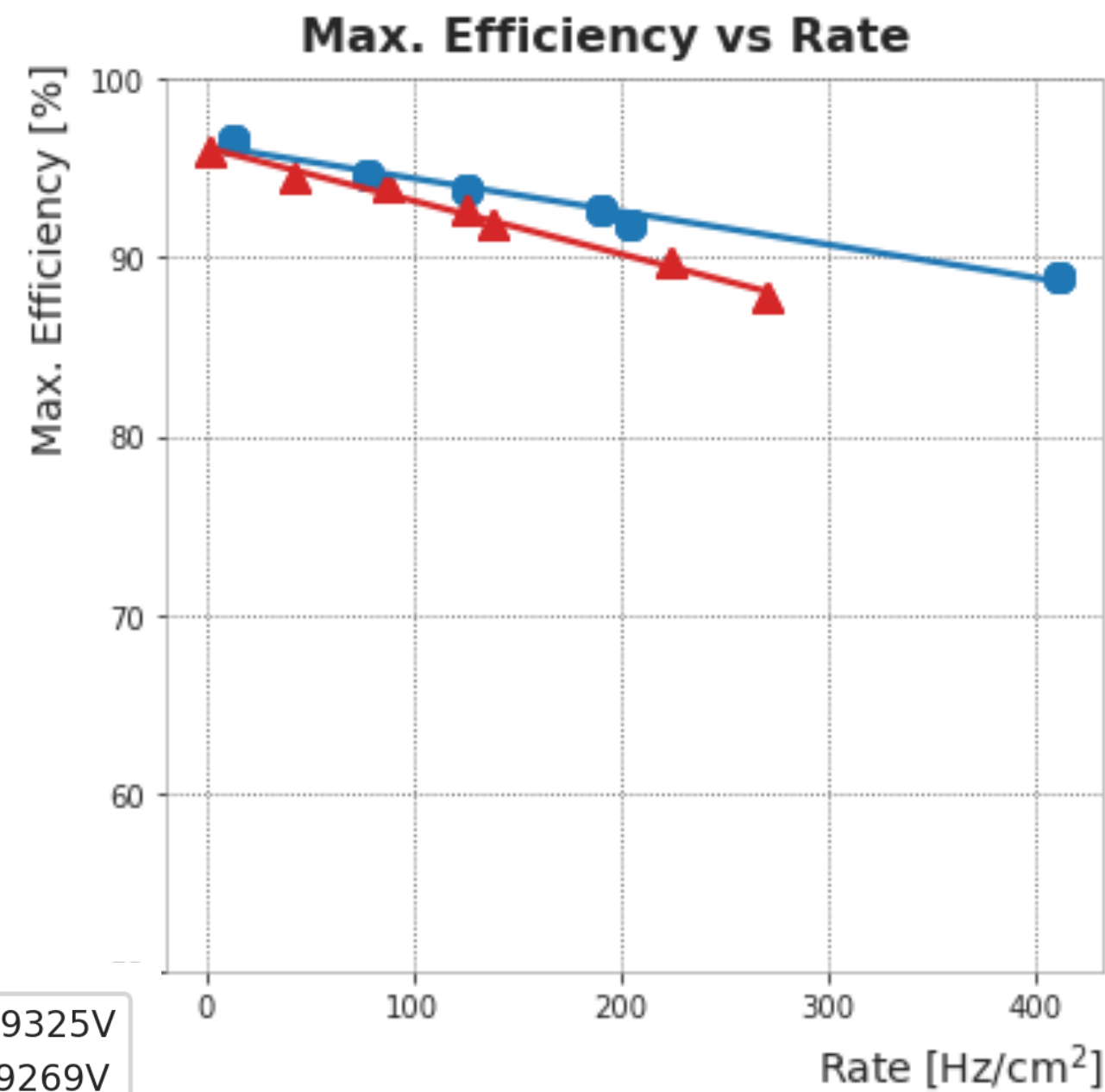
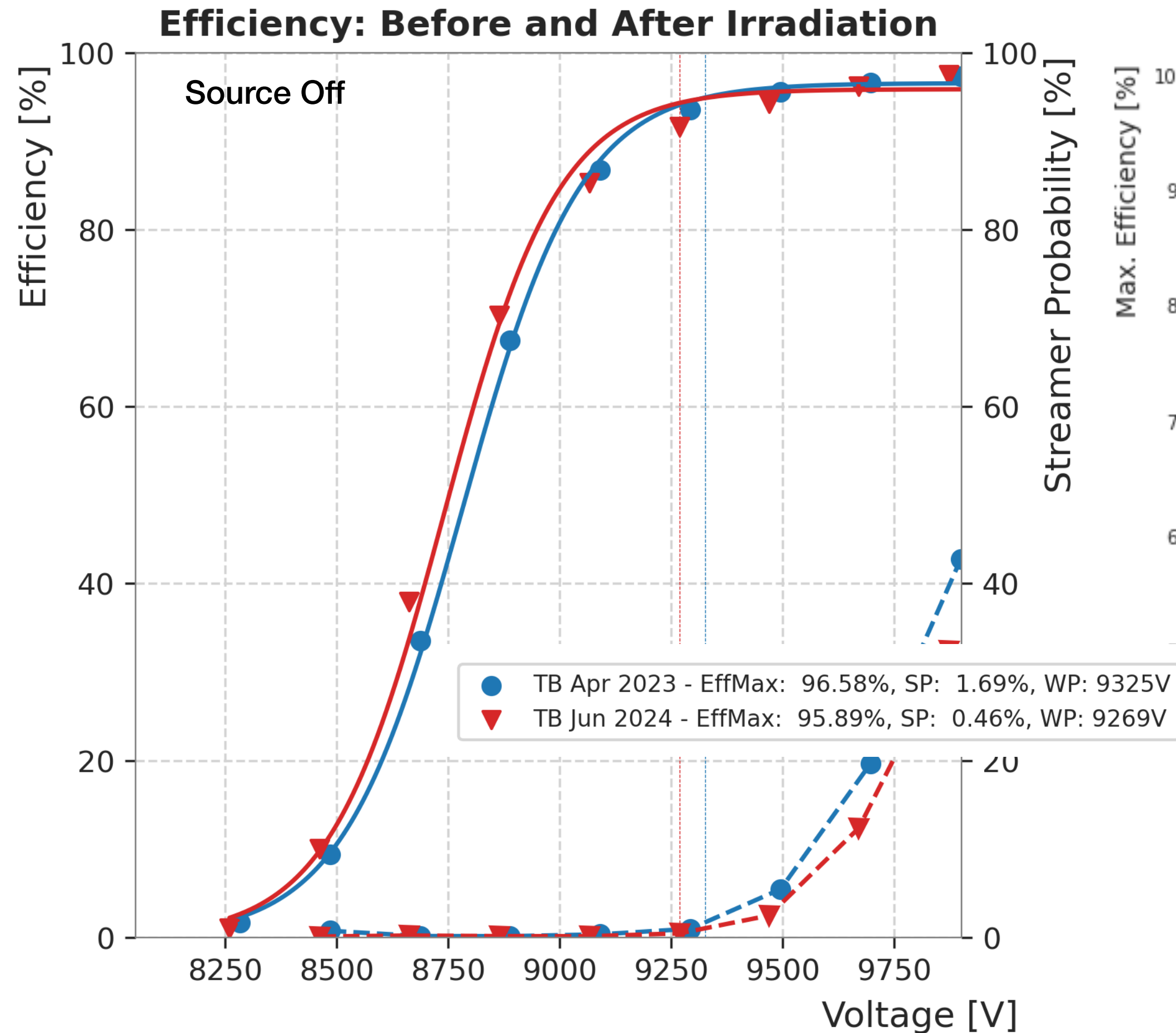
July 2022
Mixture proposed



- The ageing campaign was re-started later this year with the Standard Gas Mixture.
- The system was monitored first to ensure the proper functioning.
- After the end-of-the-year stop, we will re-start the ageing campaign.

Ageing studies for 30% CO₂ Added

Before & After Irradiation

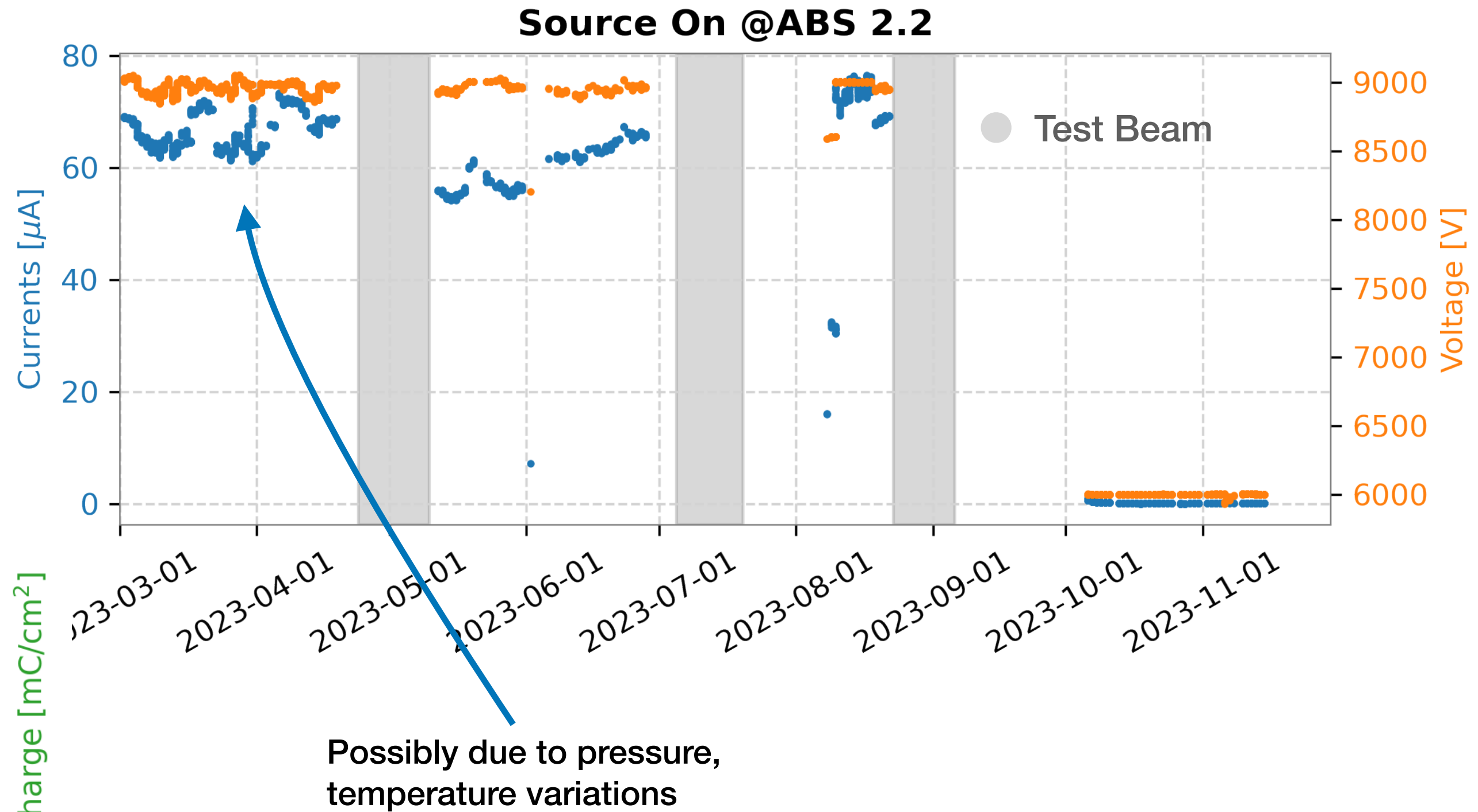
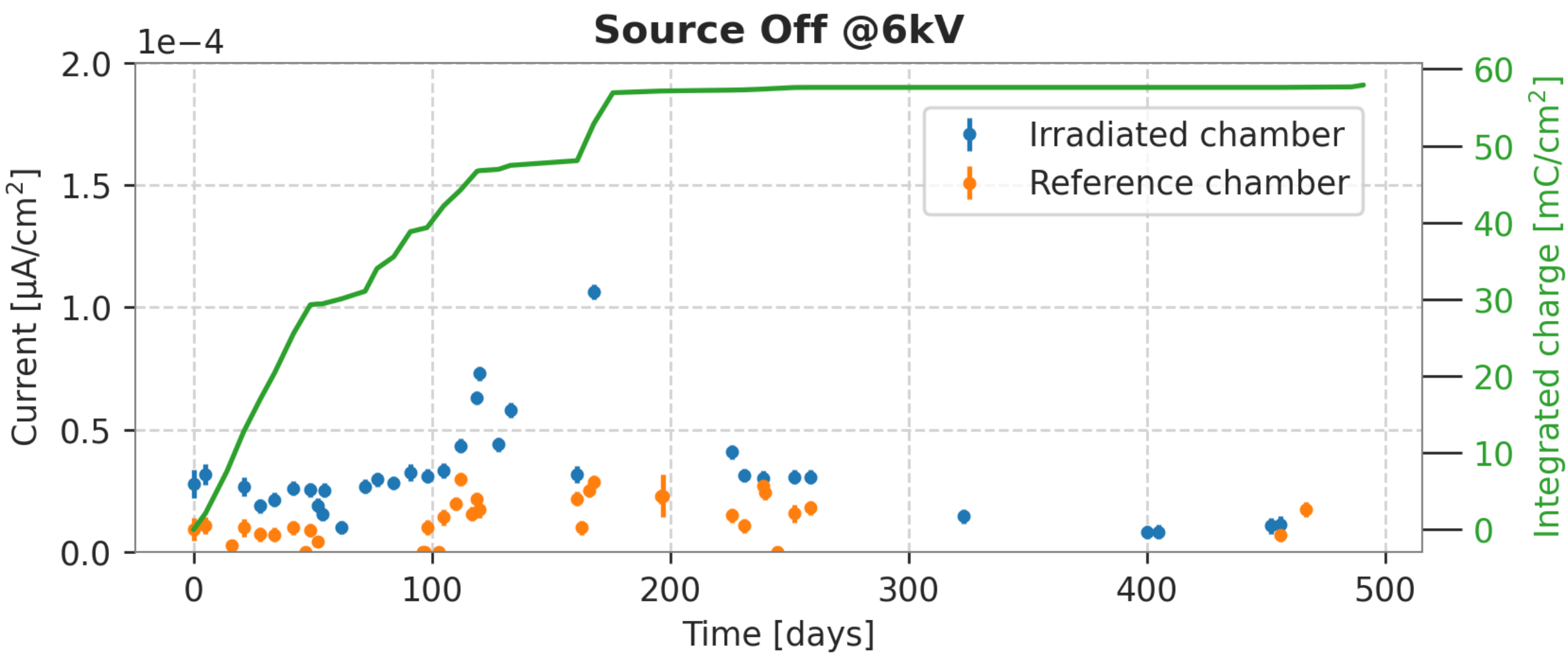


30% CO₂ + 64% R-134a + 5% iC₄H₁₀ and 1% SF₆ was validated for the ATLAS experiment, being now in use for a year.

Ageing studies for 30% CO₂ Added

Before & After Irradiation

- ~60mC/cm² of charge were up to now integrated
 -> validated the mixture for RUN3
- No significant signs of deterioration in the performance were observed, when checking between test beam campaigns.

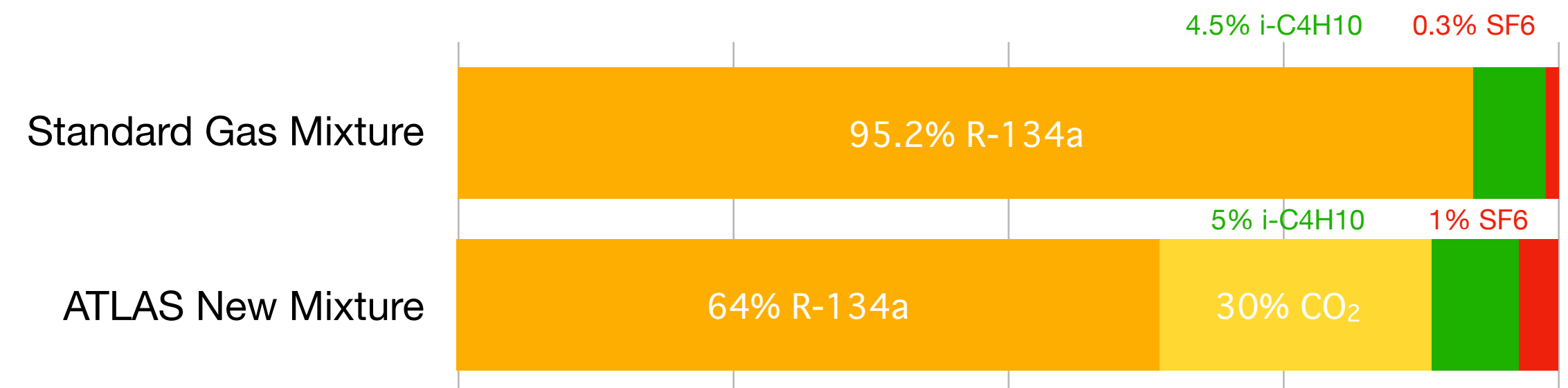


The mixture is continuing ageing tests at the moment at the Gamma Irradiation Facility (GIF++).

Summary

GIF++

- This year, we participated in two test beams: June and September:
 - 5 different gas mixtures, each tested several times
 - 6 detectors used



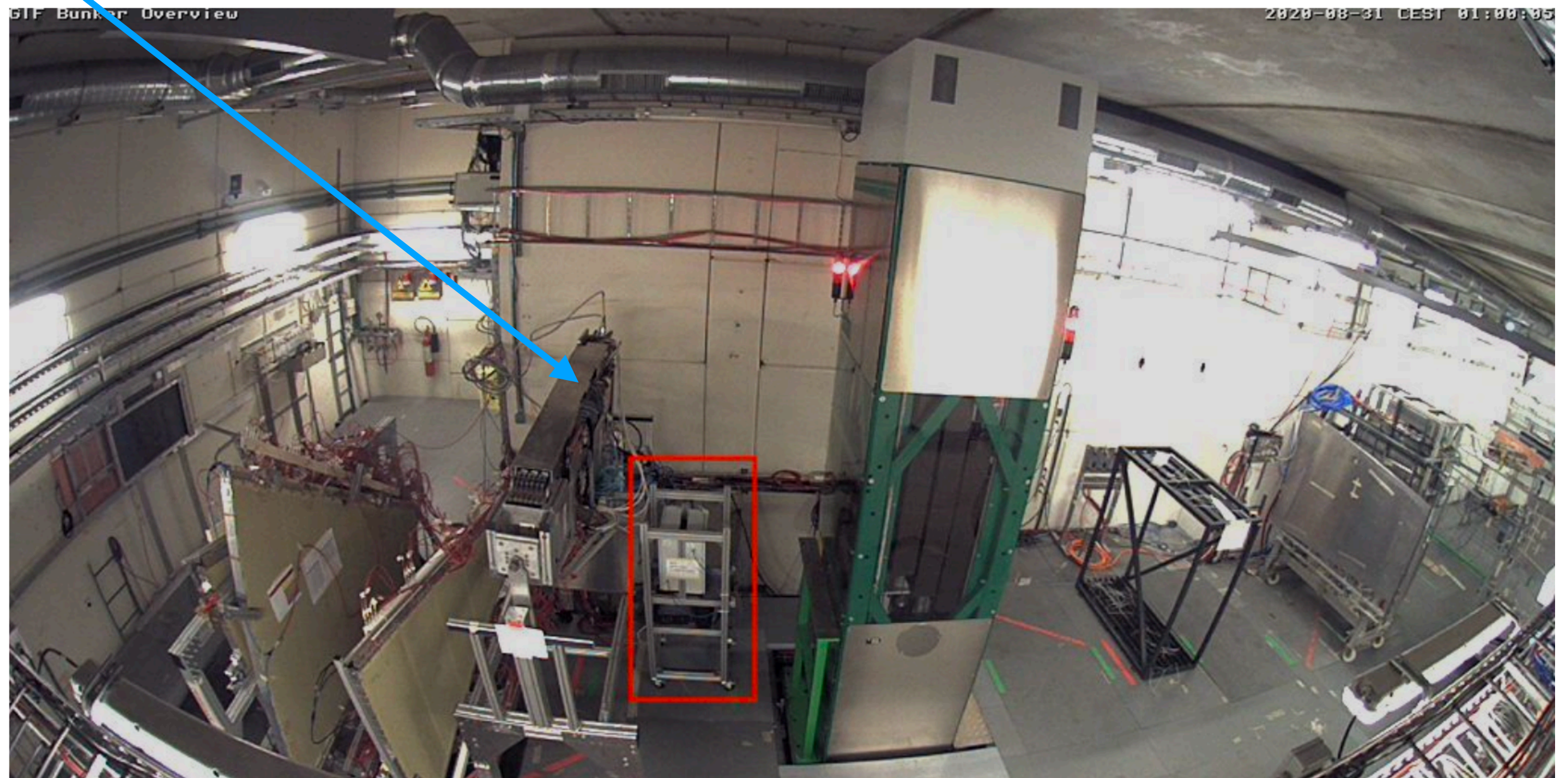
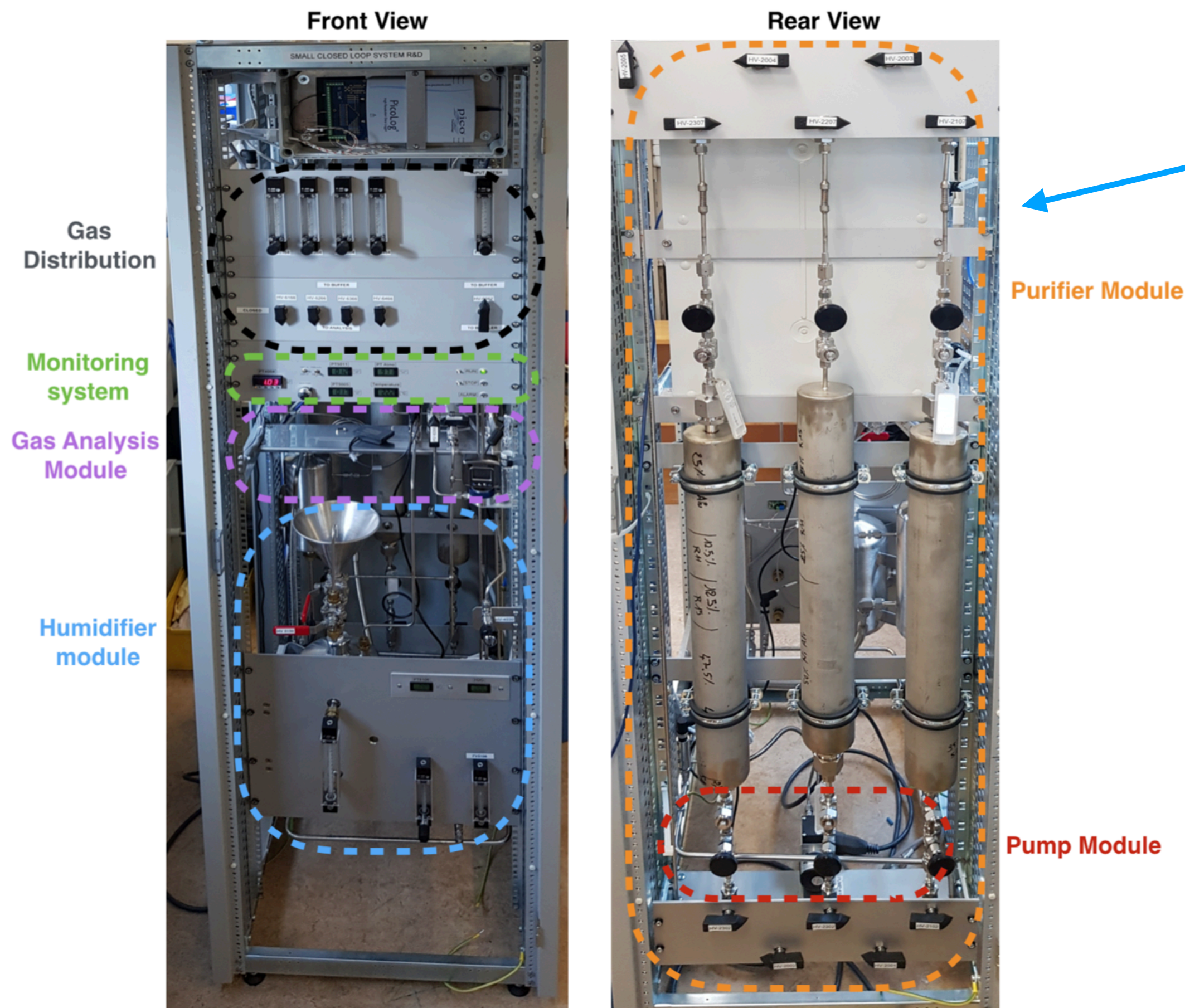
In ATLAS, for one year, reducing the R-134a consumption saved ~100kCHF

- The 30% CO₂ + 1% SF₆ was selected for ageing studies based on its experimental performance, while the 40% CO₂ or the lowering of the SF₆ concentration would need further investigation.
 - The 30% CO₂ + 1% SF₆ mixture was implemented in ATLAS this year, for RUN3.

Further Updates

Requests

- We will need the next test beams to understand the performance of the detectors after being exposed to radiation.
- Further ISE Measurements are planned to understand the production of F- radicals.
- Soon, we plan on restarting the recirculation system.
- We will also look into the gas compatibility with the materials used in LHC systems.
- Adding another detector - uRWELL in the old position of our old GEM Set-up downstream



The front and rear views of the gas recirculation unit installed at the Gamma Irradiation Facility (GIF++), showing the various logic modules (Guida & Mandelli, 2017).

Thank you :)