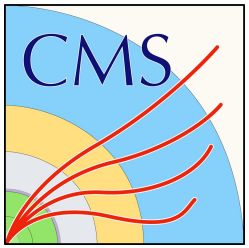


Ecogas KODEL-H
Test Beam results

Dalia Ramirez,
Karam Kaspar,
Dayron Ramos

Investigating Greenhouse Gas Emissions at CERN

CMS RPCs use a gas mixture:

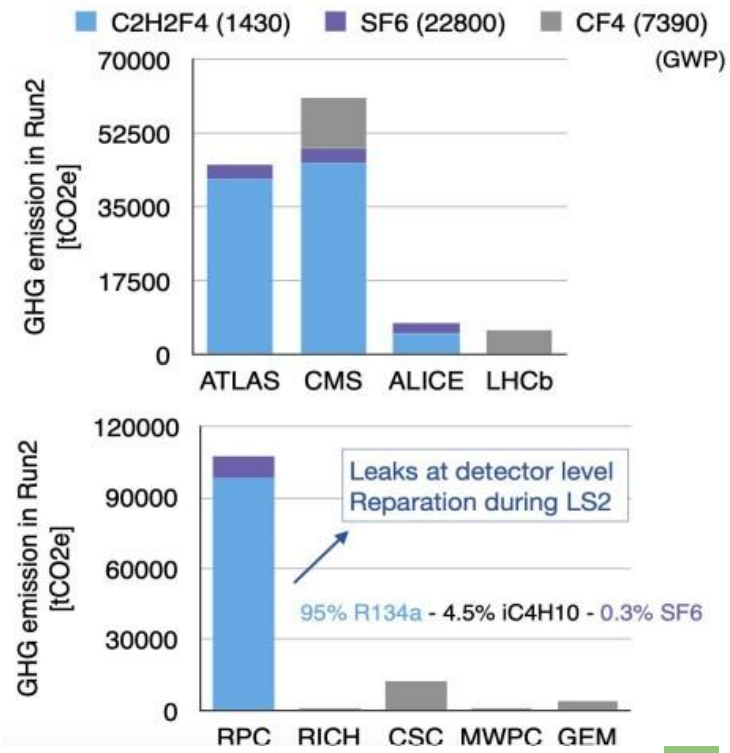
95.2% R134a + 4.5% iC_4H_{10} + 0.3% SF_6

Greenhouse Gases (GHG) with high global warming potential (GWP)

CERN strategies to reduce GHG emissions:

Experimental setup was designed to study the performance of RPCs with eco-friendly gas mixtures.

- The increase of the cost of Freon is one of the reasons to replace it from the used mixture



https://indico.cern.ch/event/1044975/contributions/4663695/attachments/2396393/4097550/BMandelli_VCI.pdf

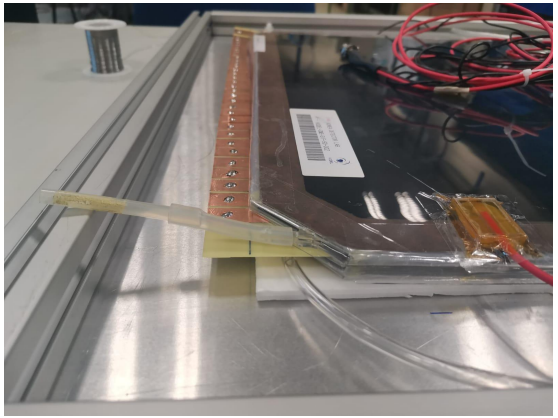
Studies of KODEL-H

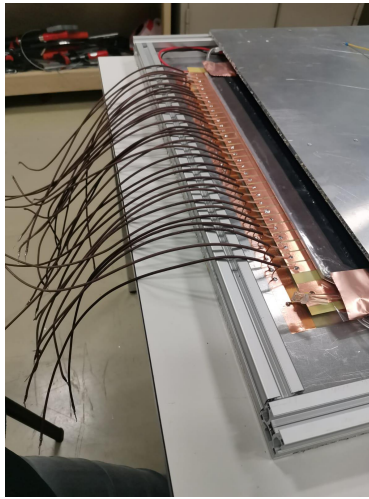
Gaps
Area: 51x51 cm^2
Active Area: 45.5x45.5 cm^2
Electrode thickness: 1.43 mm
Gap thickness: 1.4 mm

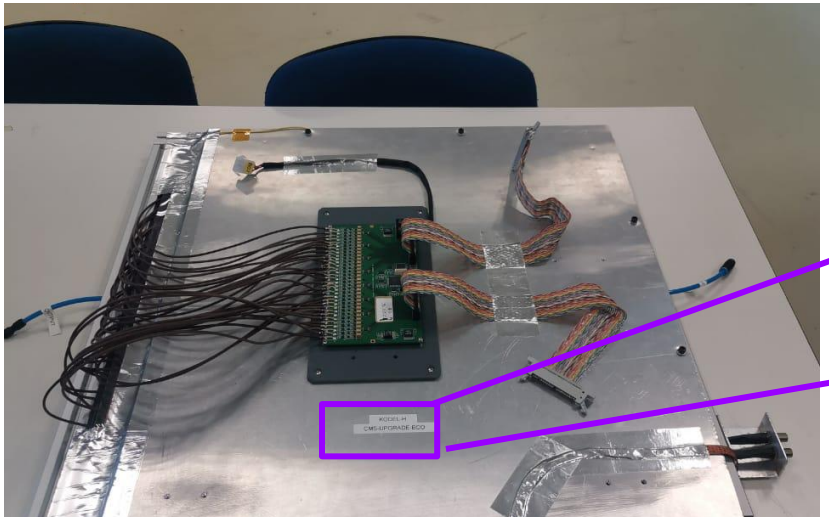
Mechanical box
- 66 cm x 58 cm

- 32 strips 1.2 cm width
- "pitch" 1.4 cm

GIF++
Trolley 3 ~ 4m from the source





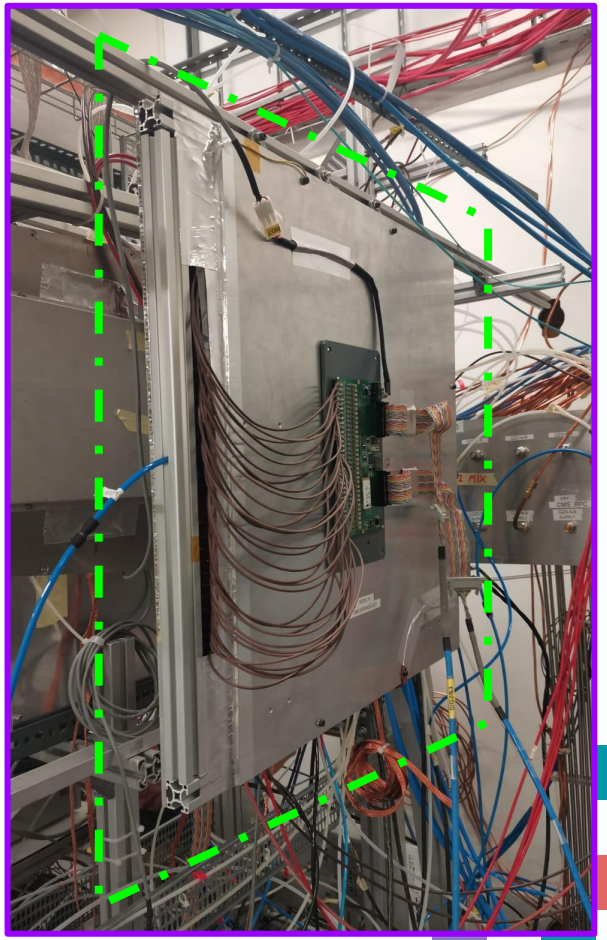


Experimental Setup & Gas mixtures

The GPW index of each mixture is obtained using the formula: $GWP_{of\ Blend} = \sum_{i=1}^{n} M_i\% \times GWP_i$

Gas	CMS STD mix	ECO2	ECO3
Freon (%)	95.2	-	-
HFO-1234ze (%)	-	35	25
CO_2 (%)	-	60	69
i-C_4H_{10} (%)	4.5	4	5
SF_6 (%)	0.3	1	1
GWP	344.12	476	527

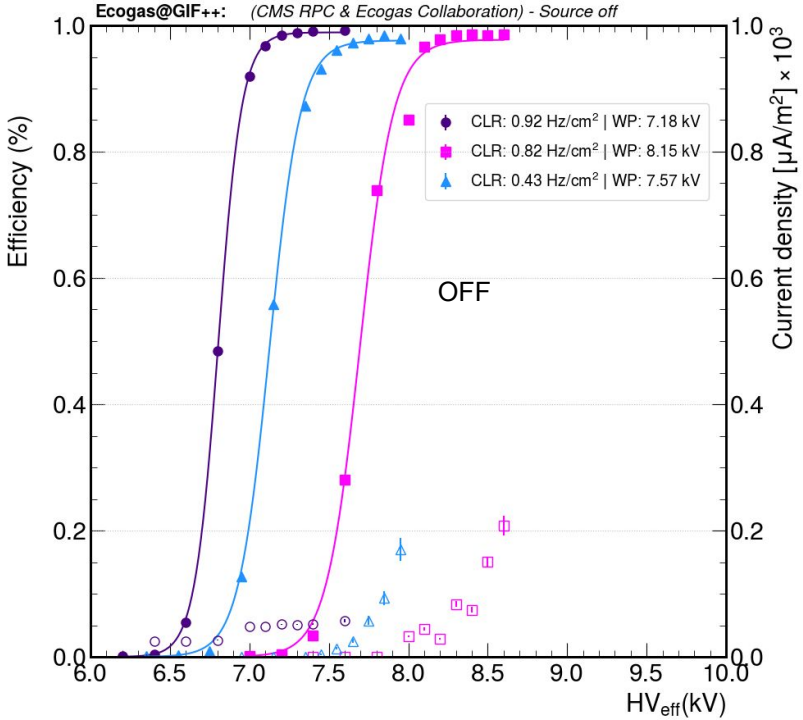
This value considers the recycling system used at CERN for the Freon, thus the GWP index of the standard mixture has decreased.

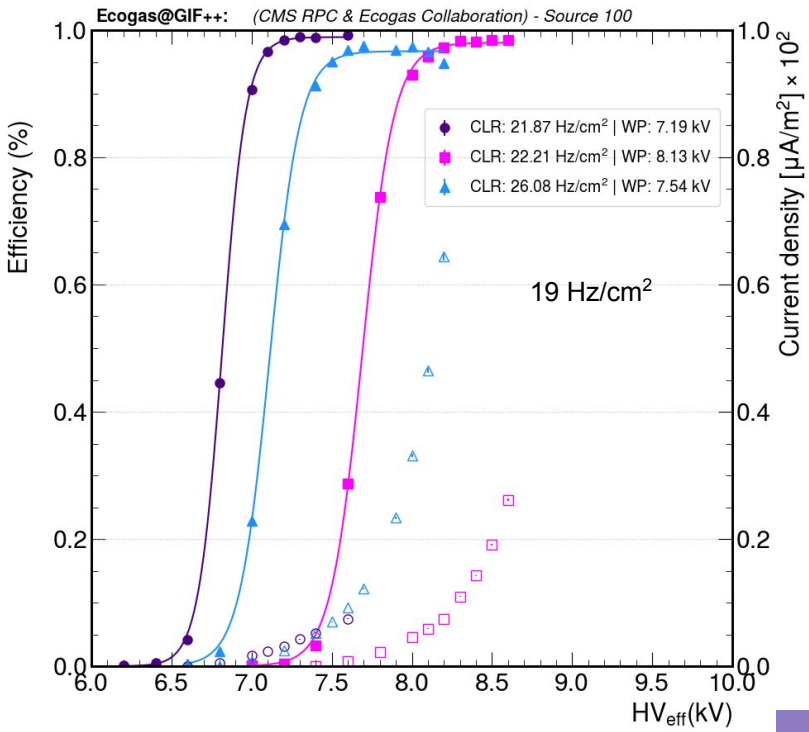


Efficiency vs HV

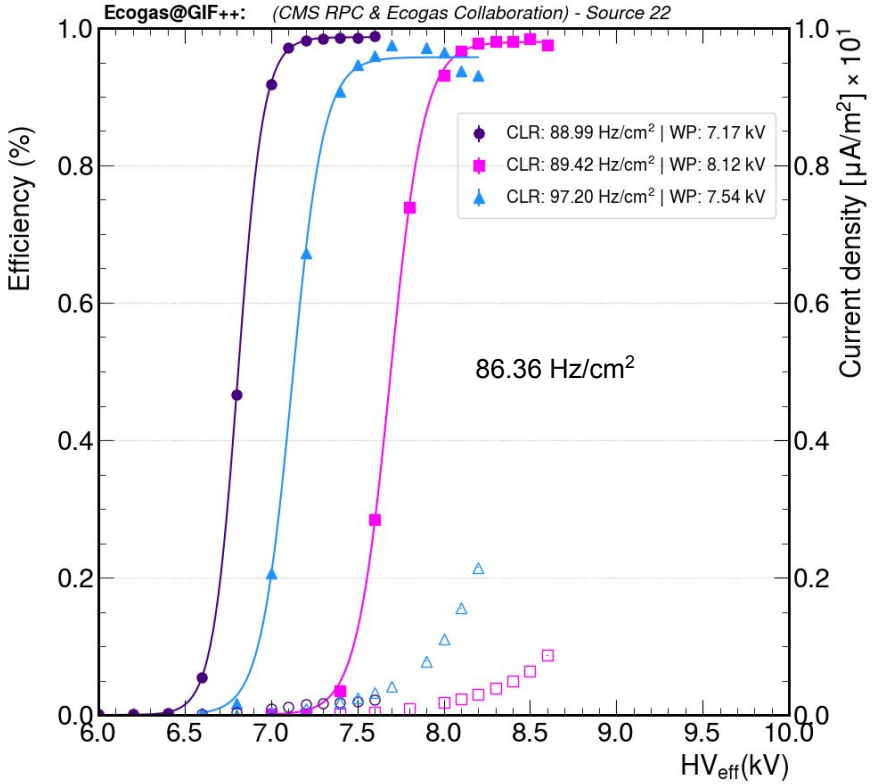
Color code	
STD mix	♦
ECO2	♦
ECO3	♦

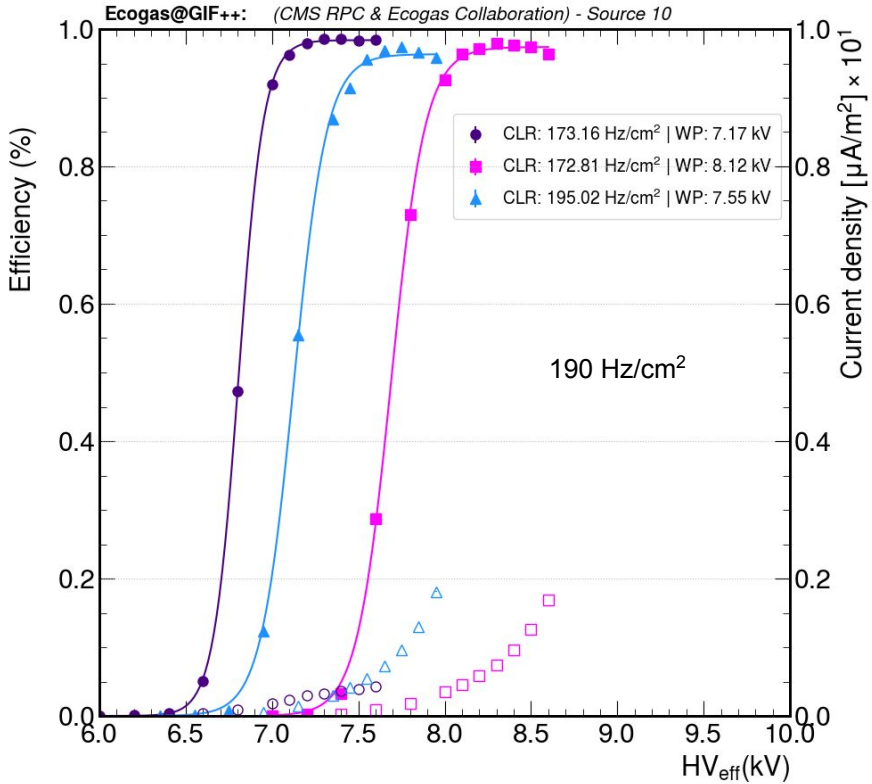
In the following plots the efficiency as a function of the high voltage is shown. The Working Point defined as $WP_{HV} = HV_{95\%Eff} + 150V$ increases when increasing the amount of HFO in the mixture. Mixture ECO2 (pink) presents a higher WP being the mixture containing 35% of HFO.





Efficiency vs HV

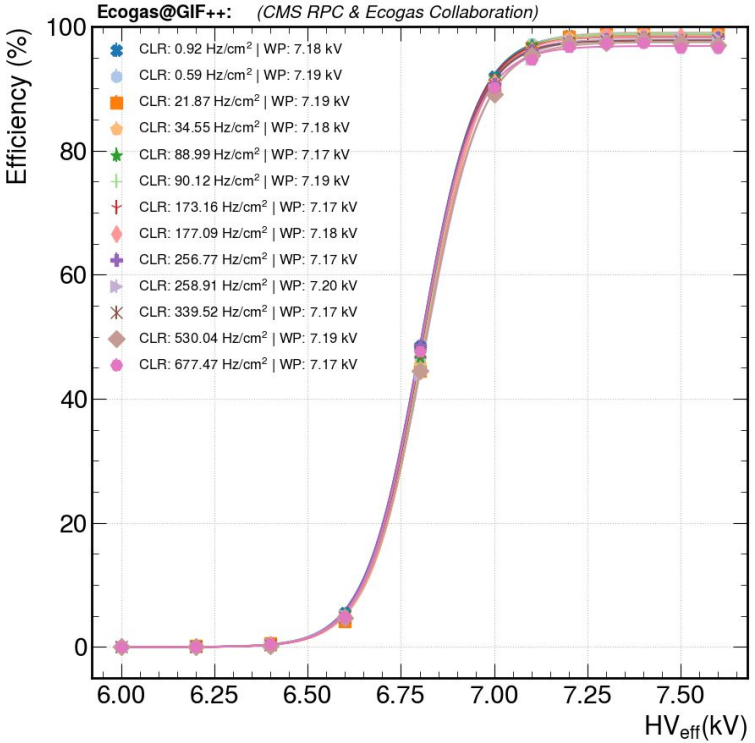


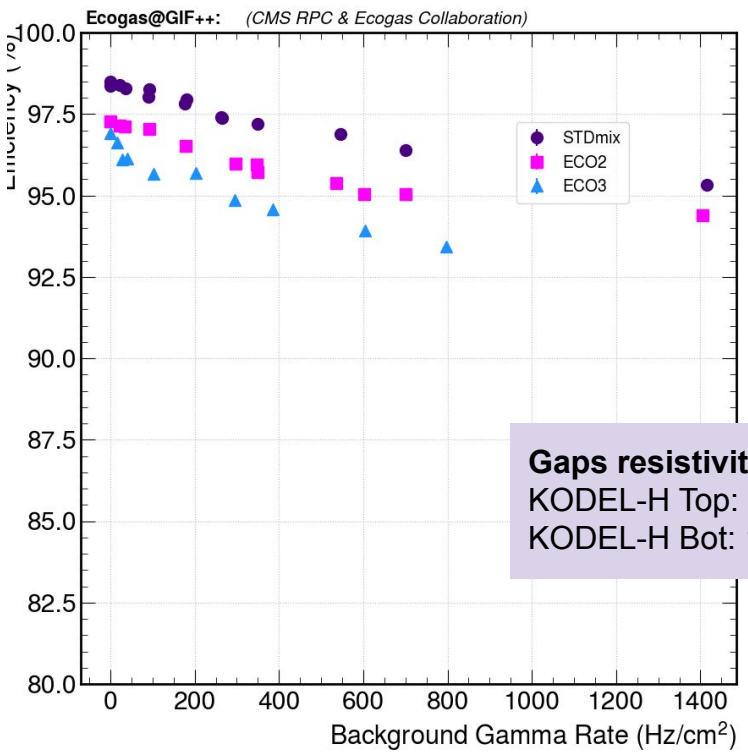


Efficiency vs HV considering all the absorbers

Standard mixture

The efficiency vs the HV is shown in the left, as we can se, given the different backgrounds we don't have a shift in the working point, this is due to the small size of the gaps and their resistivity[1]. But there is a decrease in the efficiency as we can see better in the right plot with the efficiency at the WP as a function of the background gamma rate.



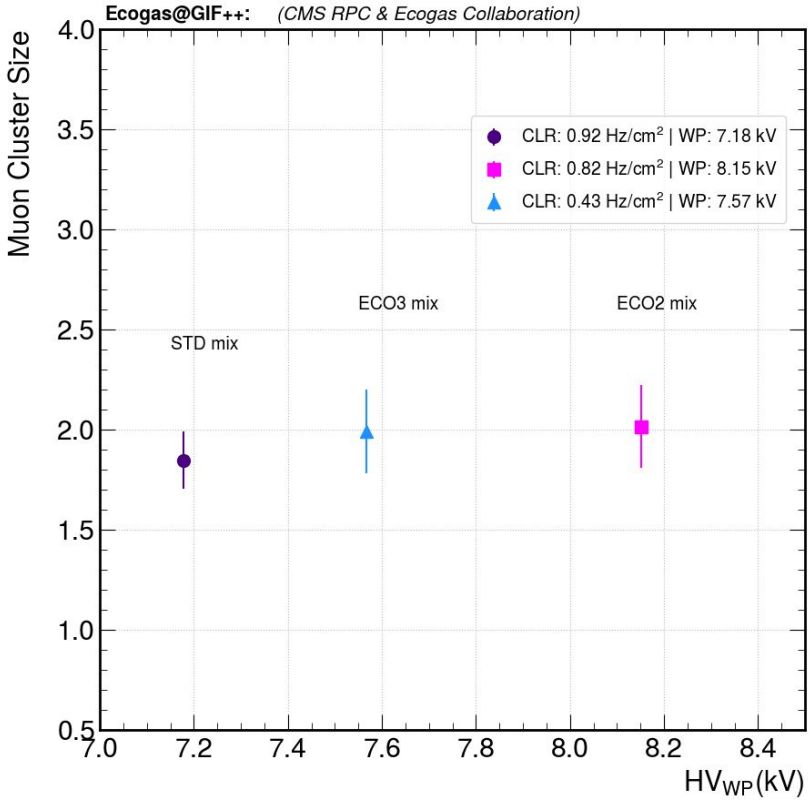


Gaps resistivity
KODEL-H Top: 1.17e+10 Ωcm
KODEL-H Bot: 1.39e+10 Ωcm

1 https://agenda.infn.it/event/37172/contributions/207735/attachments/103974/154609/KODEL-H.pdf

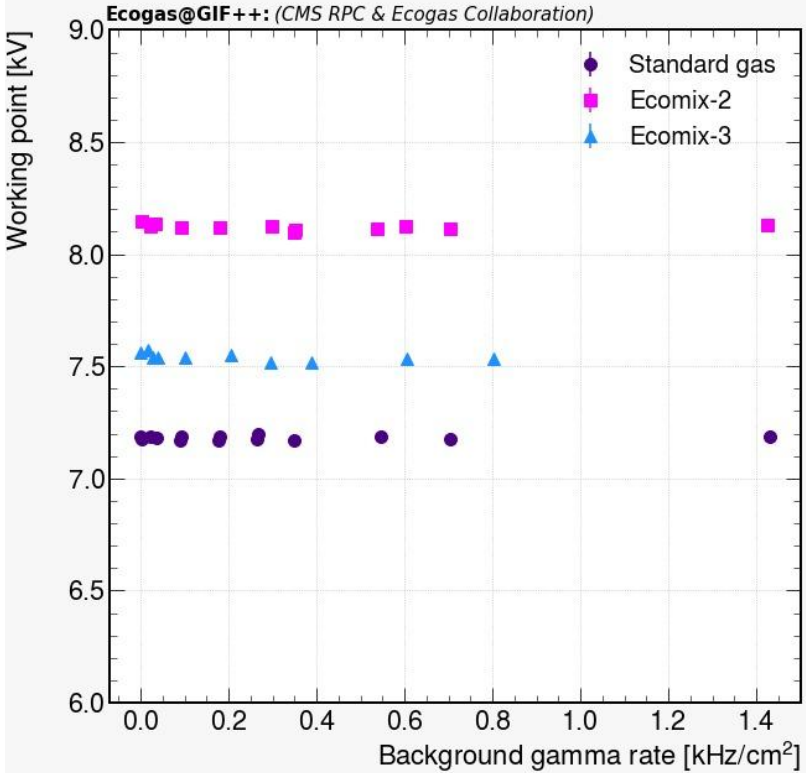
Cluster Size (CLS) vs HV

The cluster size for the different mixtures is summarized, being around 2 which is the expected value using the standard mixture

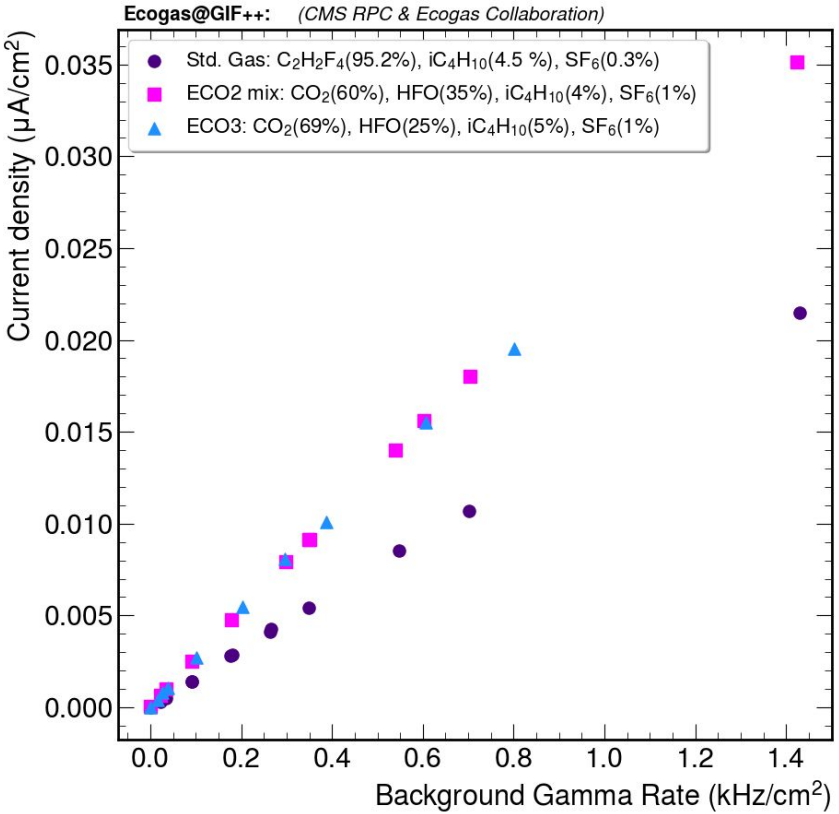


WP vs Gamma Rate

WP as a function of the background gamma rate. The WP remains constant for the 3 gas mixtures.

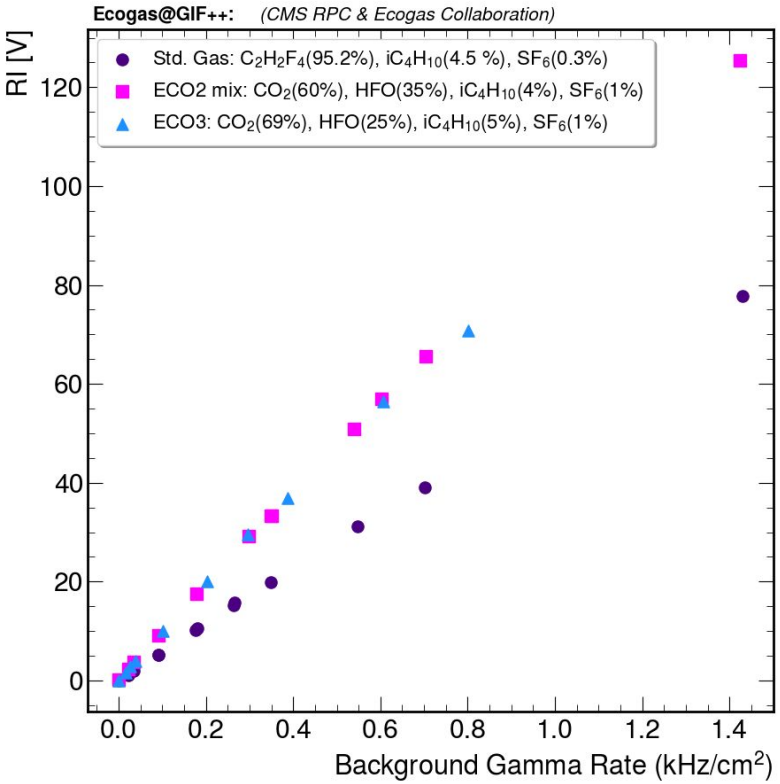


Current Density



Current density as a function of the background gamma rate shows a linear behaviour for the three mixtures. The slope increases for the ECO gas mixtures

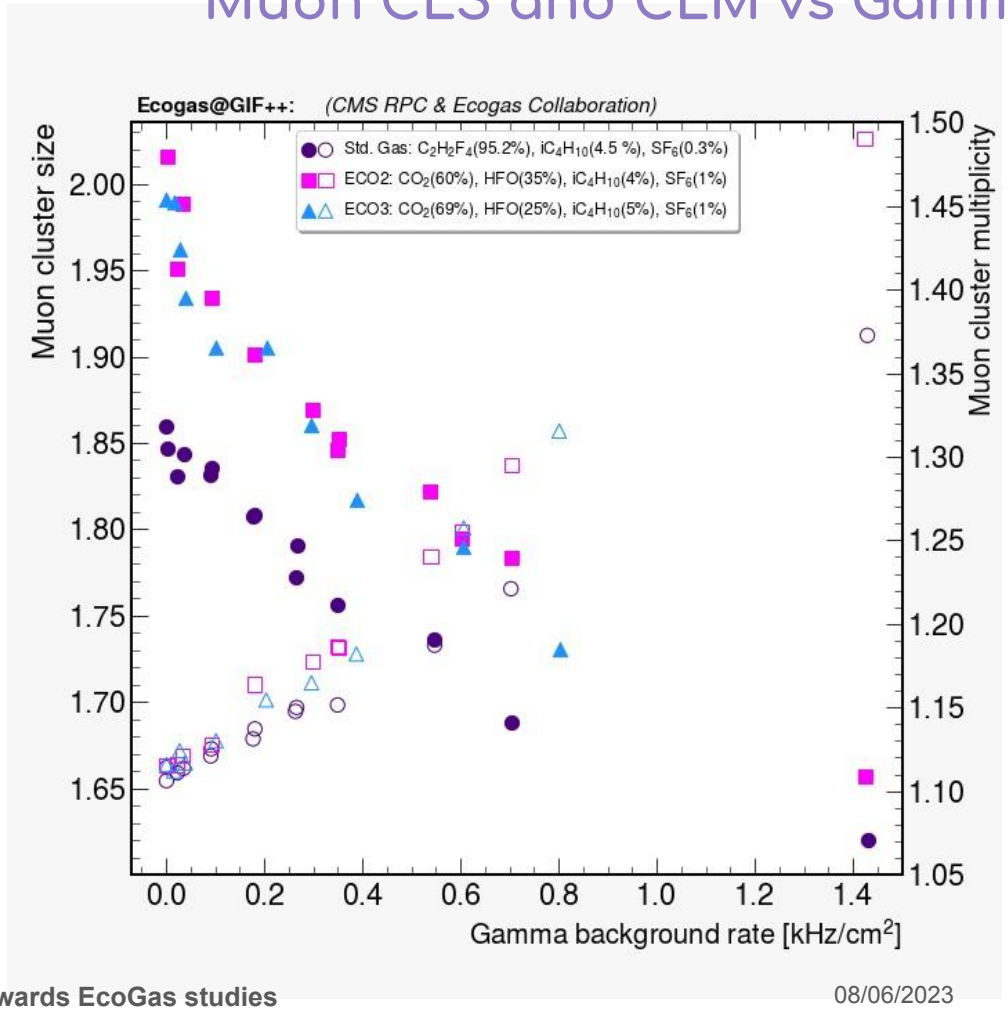
RI correction



A linear behaviour is shown having the voltage value of the ohmic correction as a function of the background gamma rate.

The slope for ECO2 and ECO3 mixtures is higher than for the STD mixture, due to their different composition. The maximal value of the voltage is around 1% of the high voltage applied during the test beam, then no shift in the WP is expected.

Muon CLS and CLM vs Gamma Background Rate

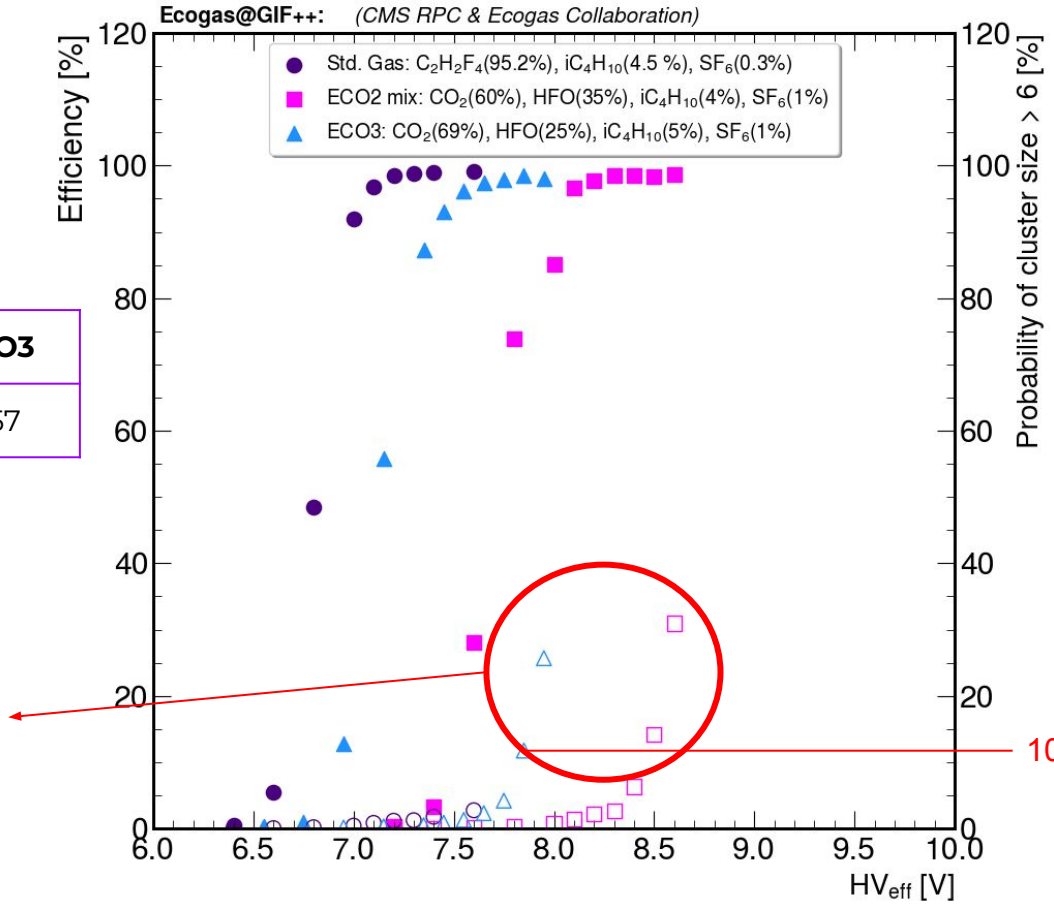


The muon cluster size (filled markers) and the muon cluster multiplicity (empty markers) is shown as a function of the gamma background rate.

- For Eco2 and Eco3 the muon cluster size, and multiplicity are higher than for the standard gas mixture.
- Muon Cluster Size: decreases for higher gamma background rates
- Muon Cluster Multiplicity: increases for higher gamma background rates.

Streamer Probability vs the HV (Source OFF)

Mixture	STD mix	ECO2	ECO3
WP [kV]	7.18	8.15	7.57



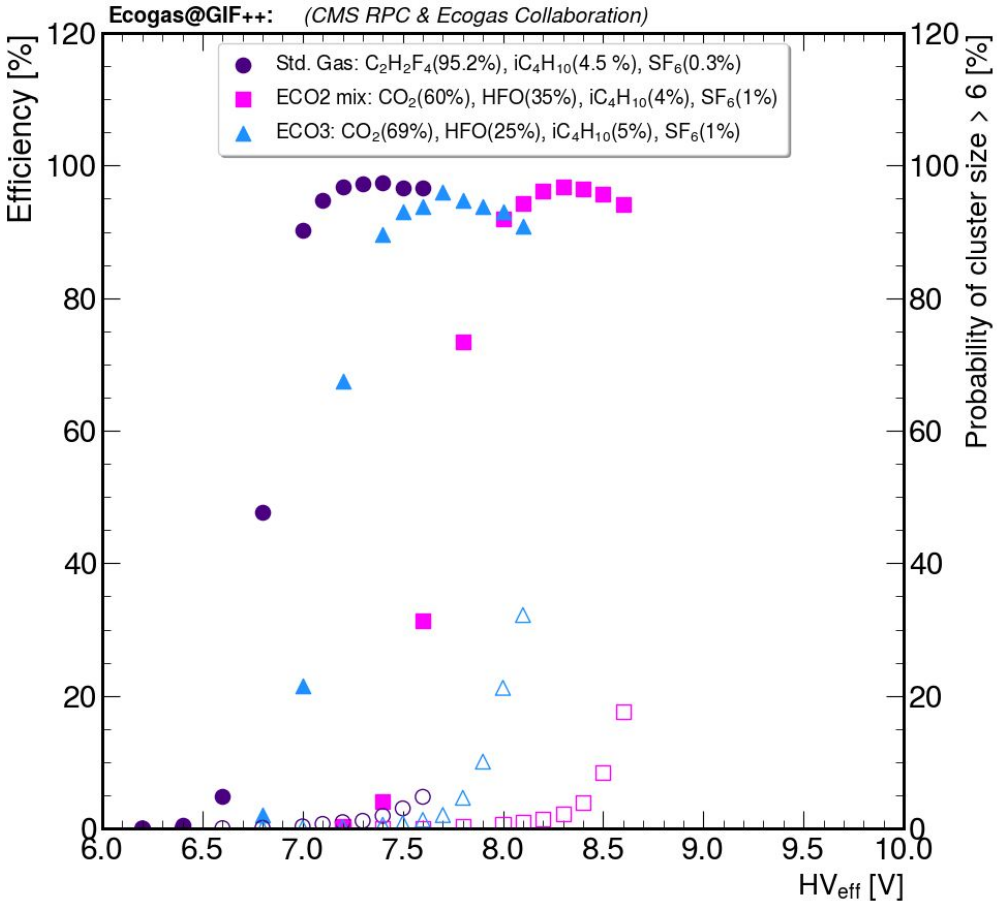
Using the ECO mixtures there is an increase of the probability of having cluster size greater than 6. However, this probability is less than 10% at their WP, respectively

Conclusions

- KODELH was built for ecogas studies during July 2023 Test Beam
- Characterization of KODELH:
  - WP increases when using eco gas mixtures: ECO2 shows a higher increase of the WP which corresponds to 35% of HFO.
  - No shift in the WP considering different gamma rates.
  - Efficiency decreases as a function of the gamma background rate.
    - For ECO3 the efficiency is less than 95% for background gamma rates greater than 200 Hz/cm^2
  - Cluster size for ECO 2 and ECO3 is around 2, matching with standard mixture.
  - Streamer probability for the ECO mixtures is less than 10% at their WP, respectively.

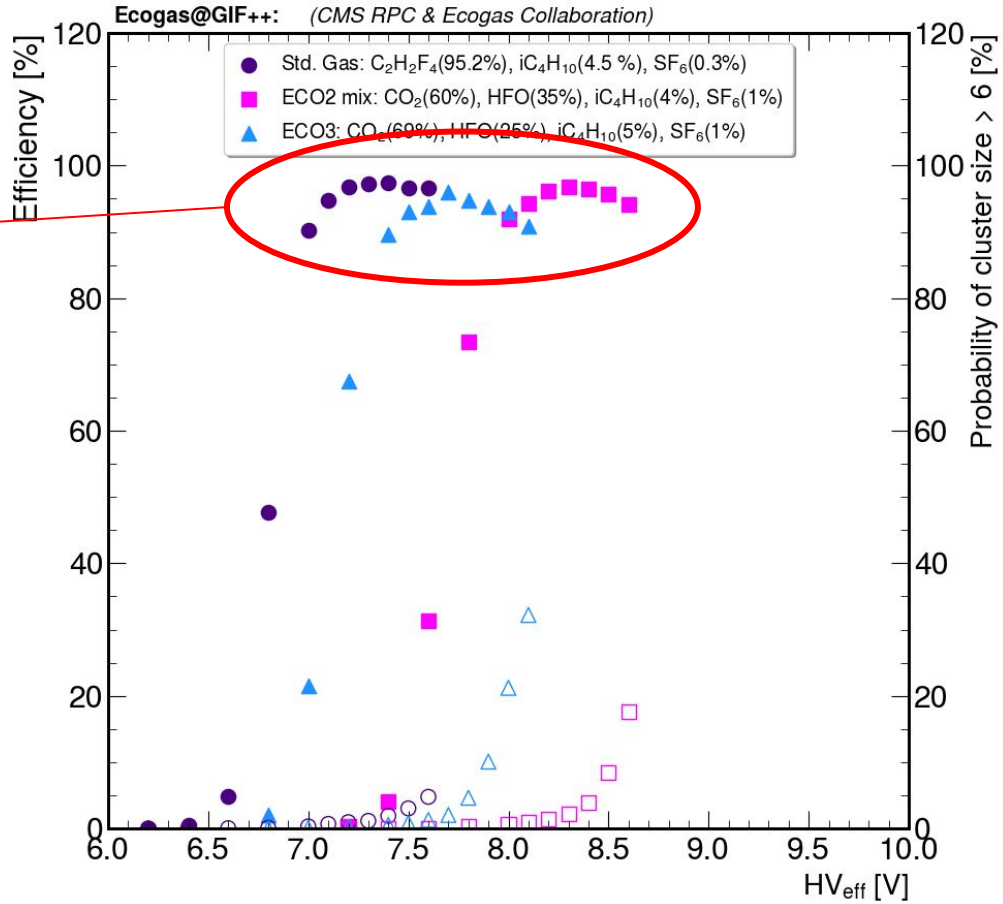

thank
you

Streamer Probability vs the HV ABS22



Streamer Probability vs HV

For ECO2 and ECO3 mixtures there is a drop in the efficiency curve in the plateau region.



Streamer Probability vs HV

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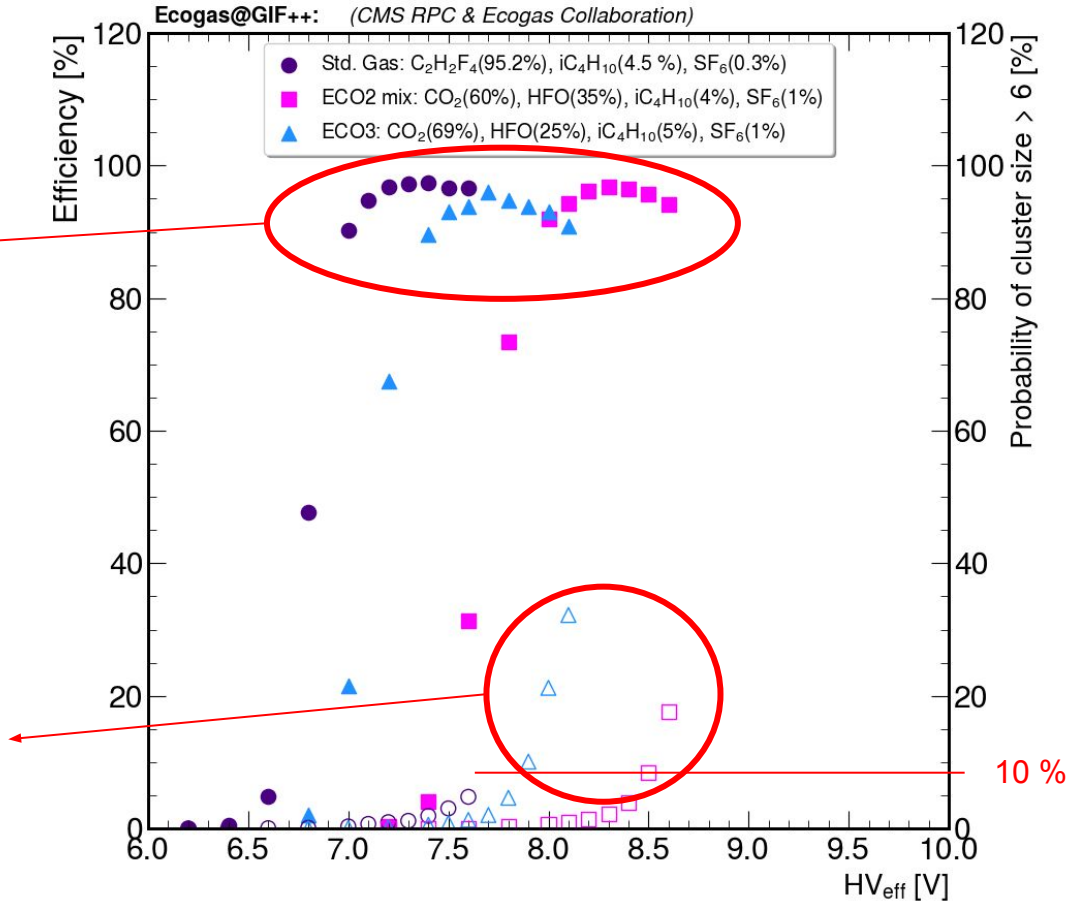
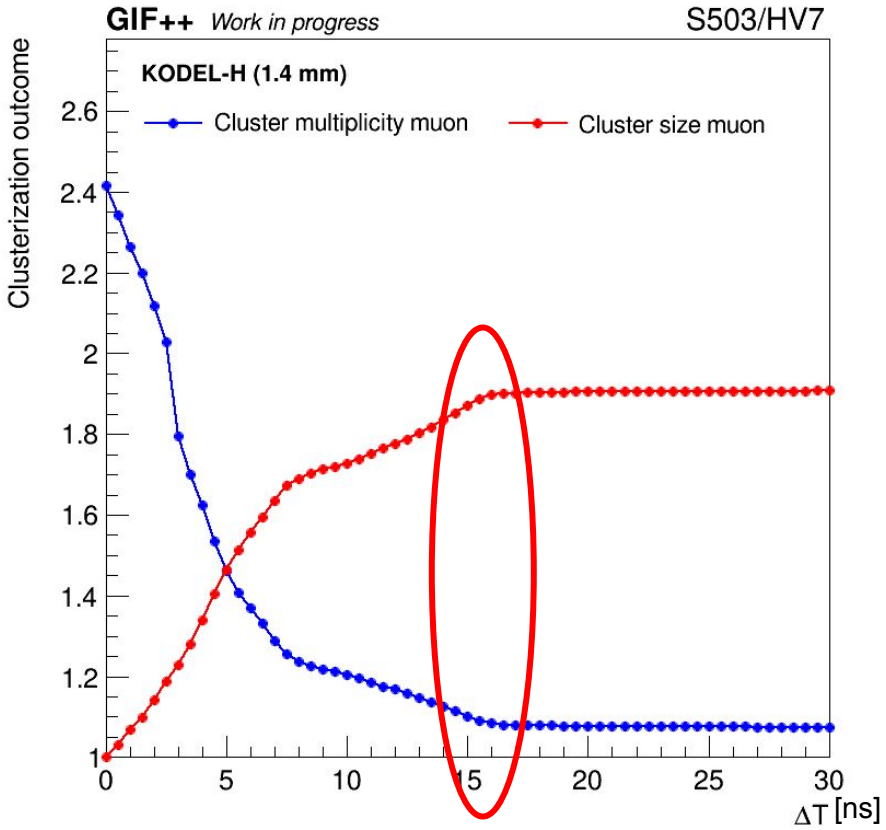
Using the ECO mixtures there is an increase of the probability of having cluster size greater than 6. However, this probability is less than 10% at their WP, respectively



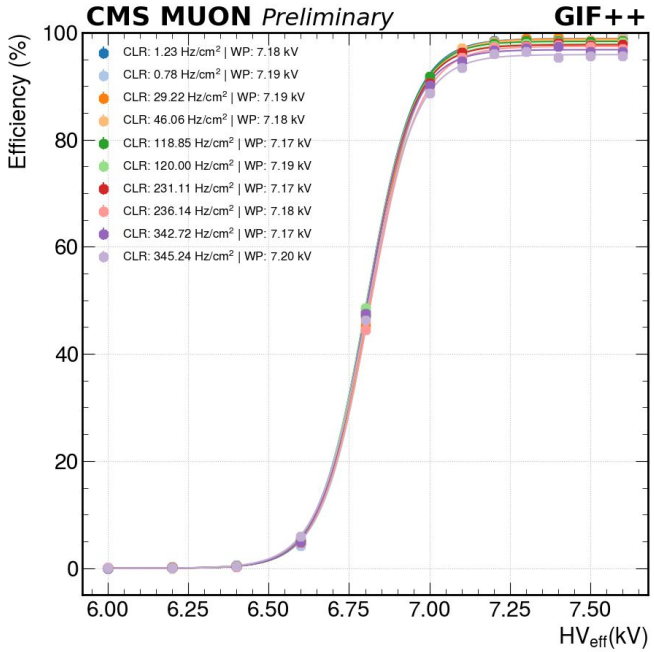
Clusterization



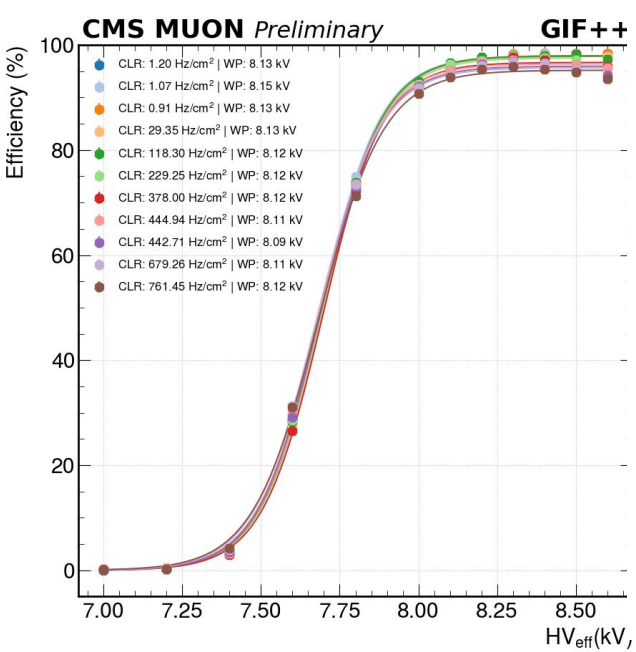
The cluster multiplicity and the cluster size reach a plateau around $\Delta T \sim 15 \pm 5$ ns which is the used value for our studies

Efficiency vs HV considering all the absorbers

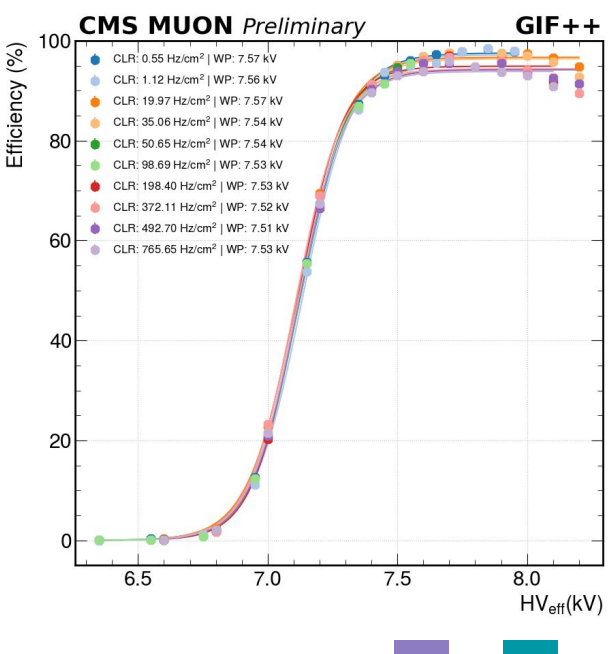
Standard mixture



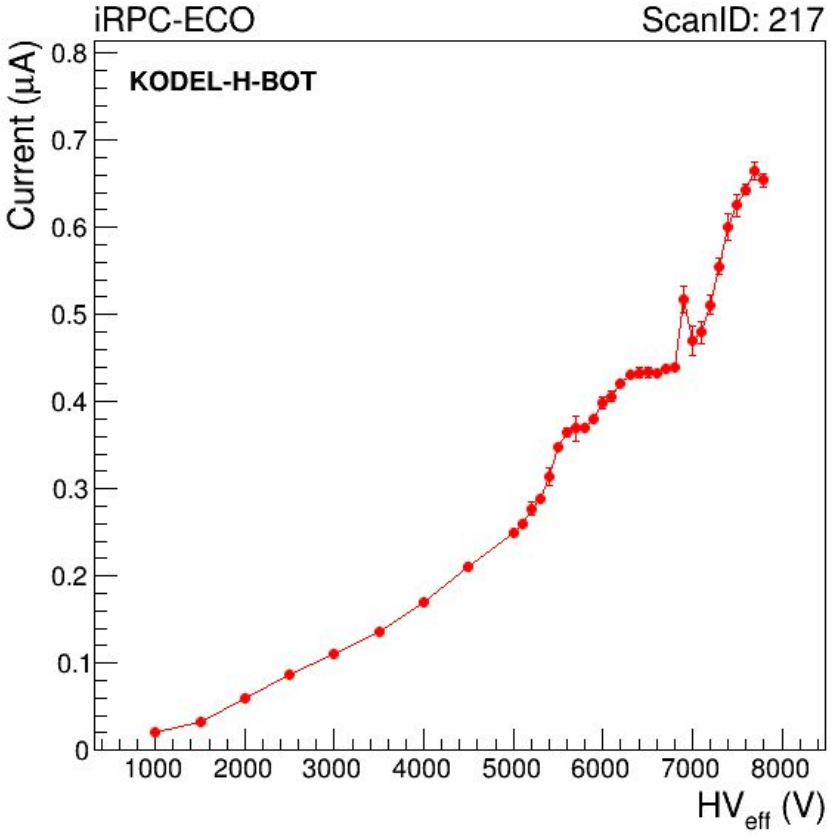
ECO2 mixture

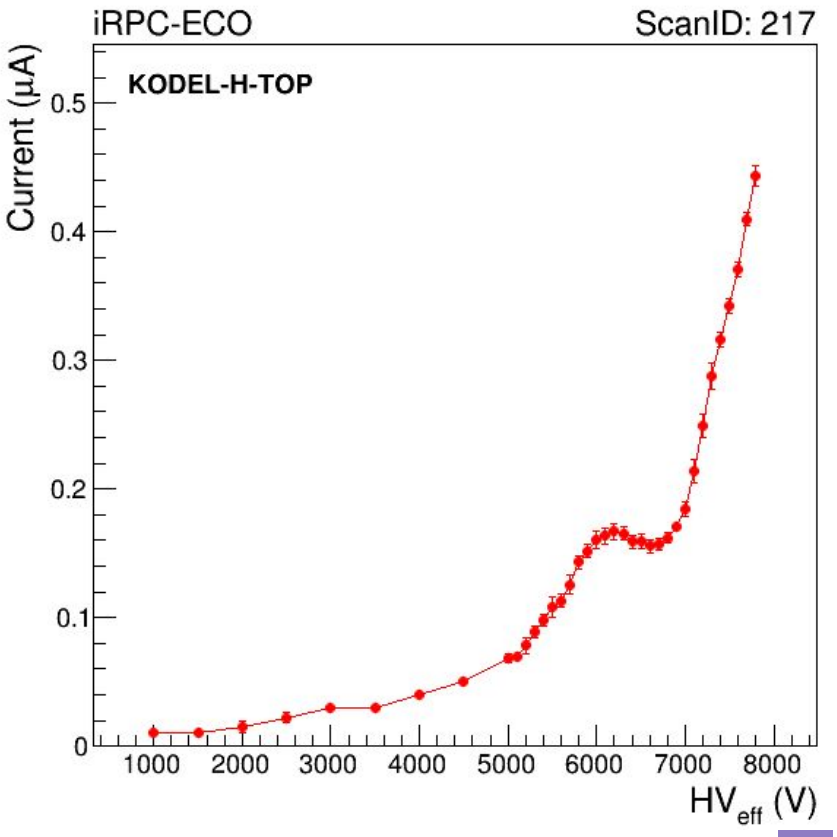


ECO3 mixture

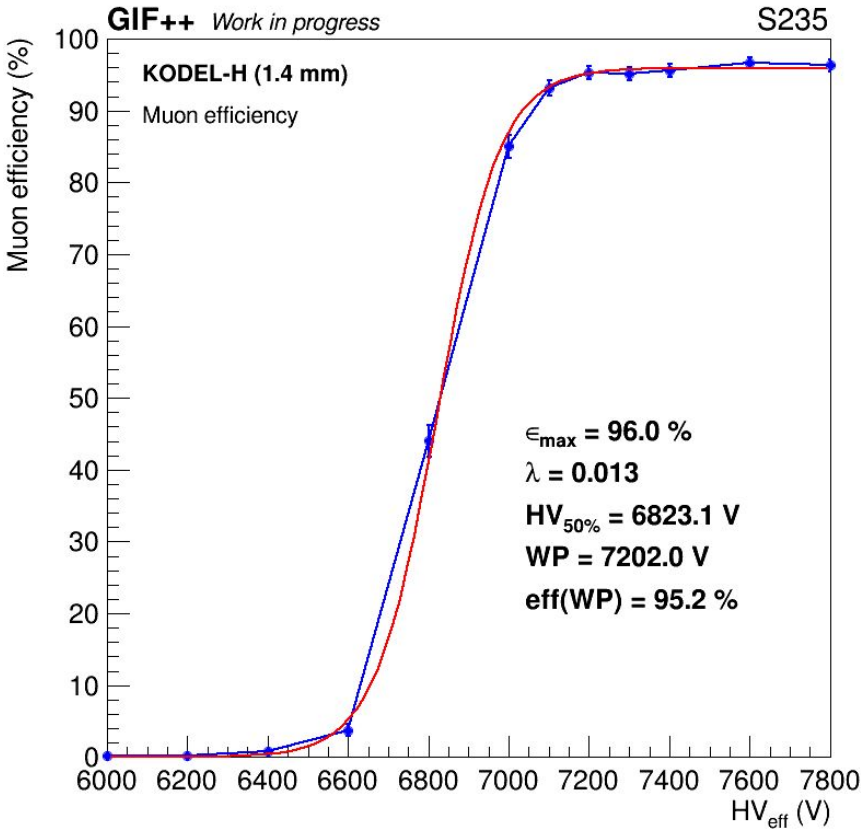


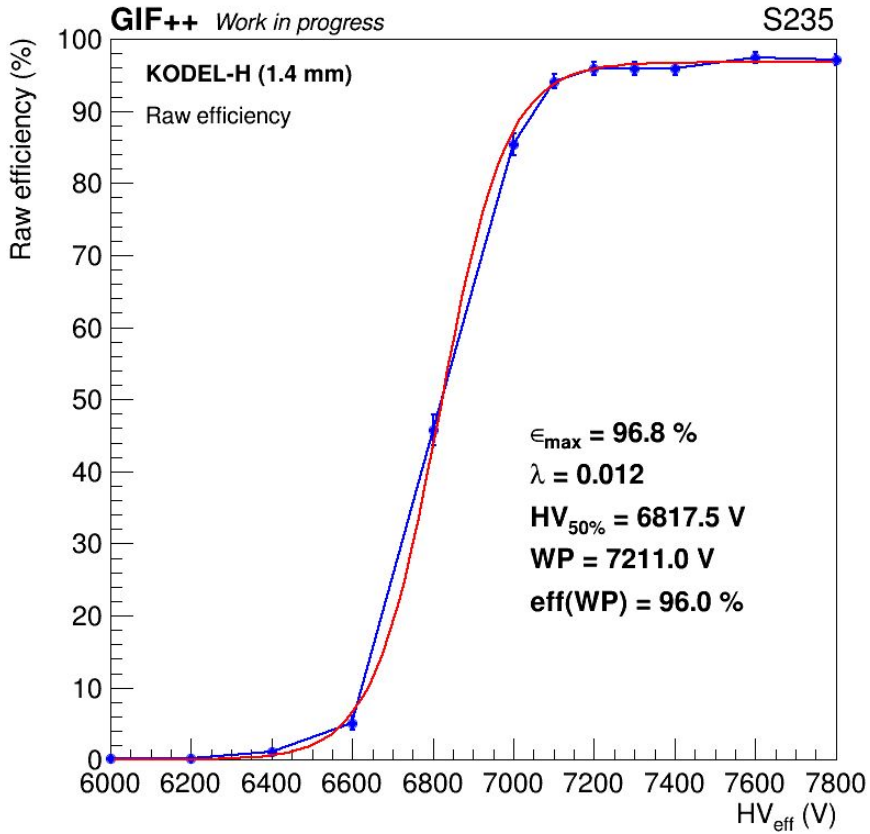
Current Scan: run 217 :: KODEL-H

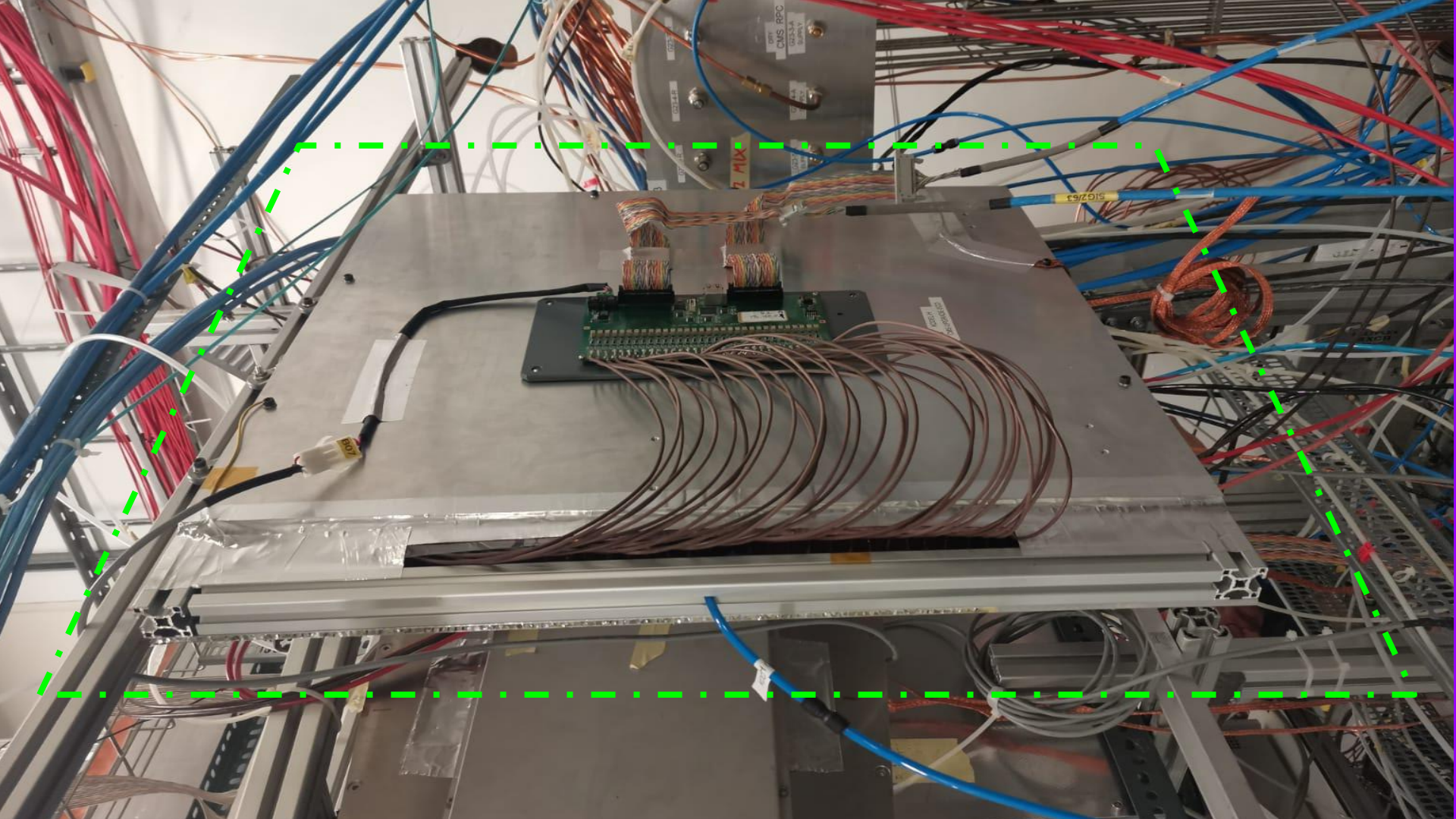




Efficiency Scan: run 235 :: KODEL-H






CMS RPC