

Further gas mixtures with low environnement impact

B.Liberti INFN “Tor Vergata”
On behalf of “Tor Vergata” RPC Group

Introduction

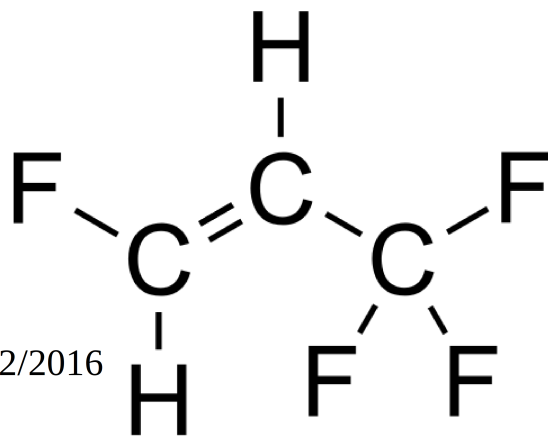
- ✓ The indication is that in near future we might be obliged to abandon the current “Standard Mixture” mainly due to the TFE and SF6 Global Warming Power, of 1430 and 22300 respectively, which raise GWP of StadMix = 1400
- ✓ The research of new eco-friendly gas has already started
- ✓ **To find a good mixture working in pure avalanche mode to be used in already built RPC systems installed in running experiments is one problem....**
- ✓ **To find a good mixture working in pure avalanche mode to be used in new RPC system is another one**

New Gas Tetrafluoropropene (CHF=CHCF₃) HFO

- It can easily replace HFC- 134a
- It is not flammable
- It has a safe use
- Environmental acceptability (low GWP)
- Compatibility with materials commonly used

Compatibility: The product does not present any particular problems of compatibility with materials (plastics and elastomers) and is similar to R134a

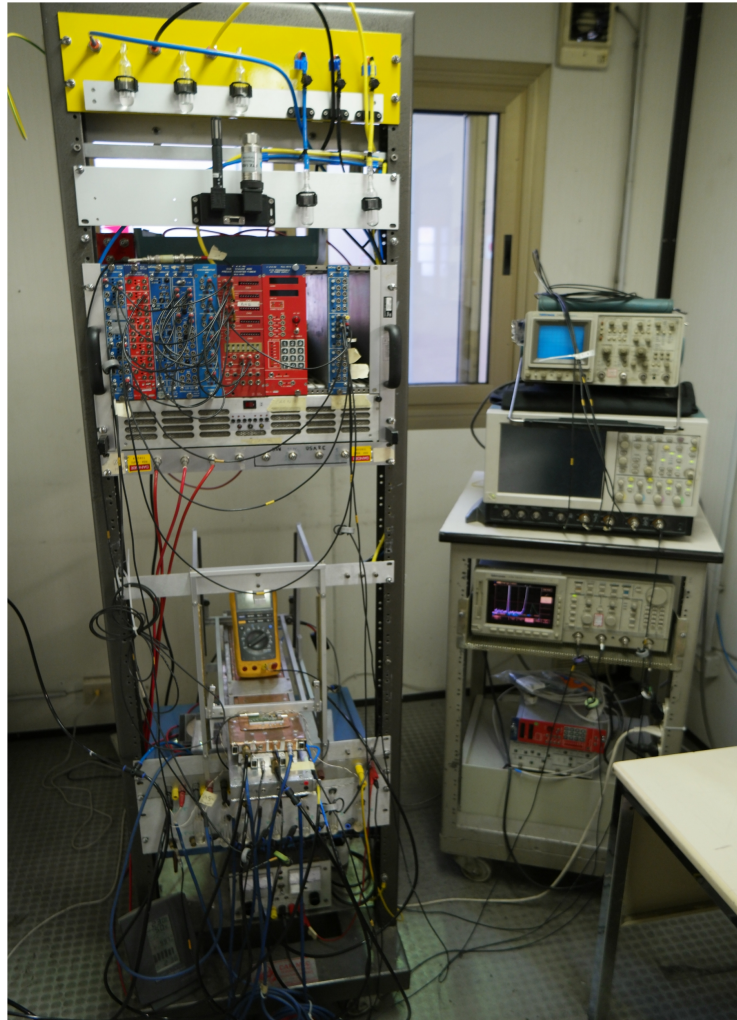
Security: HFO- 1234ze ,
At the reference ambient temperature (21 ° C)
is not flammable , according to the ASTM
Method E-681 and the EU Test A-11



GENERAL PROPERTIES

Molecule	Honeywell HFO-1234ze Blowing Agent trans - 1,3,3,3-tetrafluoropropene
CAS #	1645 - 83 - 6
ELINCS # (EU)	471 - 480 - 0
Formula	trans - CHF=CHCF ₃
Molecular Weight	114
Boiling Point	- 19° C
Vapor Pressure @ 25° C	490 kPa
Vapor Pressure @ 55° C	1080 kPa
Liquid Density @ 25° C	1.18 gm/cm ³
Vapour Thermal Conductivity	13.0 mW / m• °K (@ 25°C)
Flame Limits	None to 30° C
Ozone Depletion Potential	Zero (non-ODS)
Global Warming Potential	6 (100 yr time horizon)

Experimental Set-Up 1



Experimental Set-Up 2

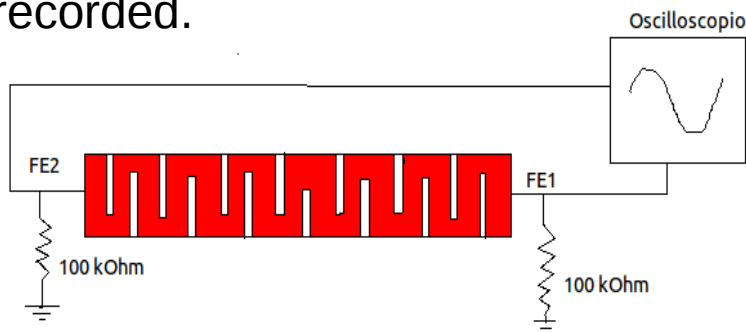


Thanks to L. Di Stante

Experimental Set-Up 3.

- The prompt fast signal induced on the read-out strip is read out at both strip ends for each event.
- The full waveforms of the signals called FE1 and FE2 are acquired at different voltage scale sensibility to read properly avalanche and if any streamer in the same event.
- Signals parameters are extracted and recorded.

All data presented here are obtained on 2 mm gas gap



3 RPCs compose the hodoscope and generate the trigger signal. The triggered area is a finger of 50 cm x 1.3 cm.

The RPC under test has 52.6 cm x 7.6 cm of active area.

The read-out strip area is 50 cm x 2.7 cm.

Pulses are acquired by means of a digital oscilloscope (5 GSample/s and 1 GHz analog bandwidth) and registered by a dedicated LabView program.

The DAQ rate is less 1 Hz.

No Full Geometrical Acceptance

Analysis Criteria

Definition of efficiency on an event defined by an amplitude waveform is not trivial.

A threshold safe from noise i.e. $v_{th} = 5 \cdot rms_bck$ could varies from run to run along the same scan because of change in vertical scale sensibility or external and temporary noise source, while a fixed threshold i.e. $v_{th} = 1.5 \text{ mV}$ could become in some conditions too low for rejecting fake counting.

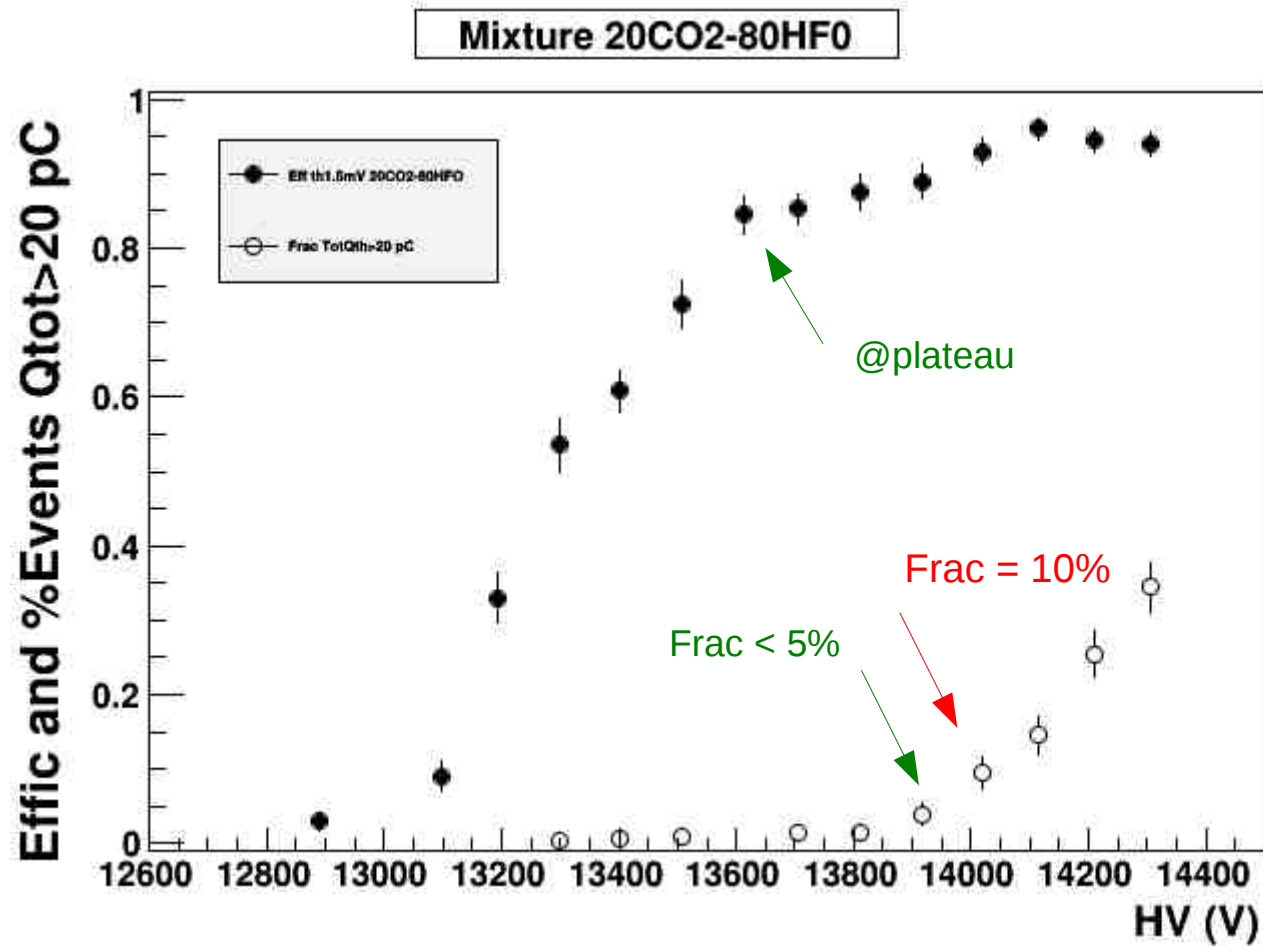
The signal dedicated to avalanche is compared to a fixed threshold of 1.5 mV similar to the ATLAS RPC and the prompt charge is integrated over a 10 ns window around the maximum.

Definition of Streamer with new gas mixture could be not trivial too.

A combination of selection criteria on maximum amplitude, time duration and charge could be necessary.

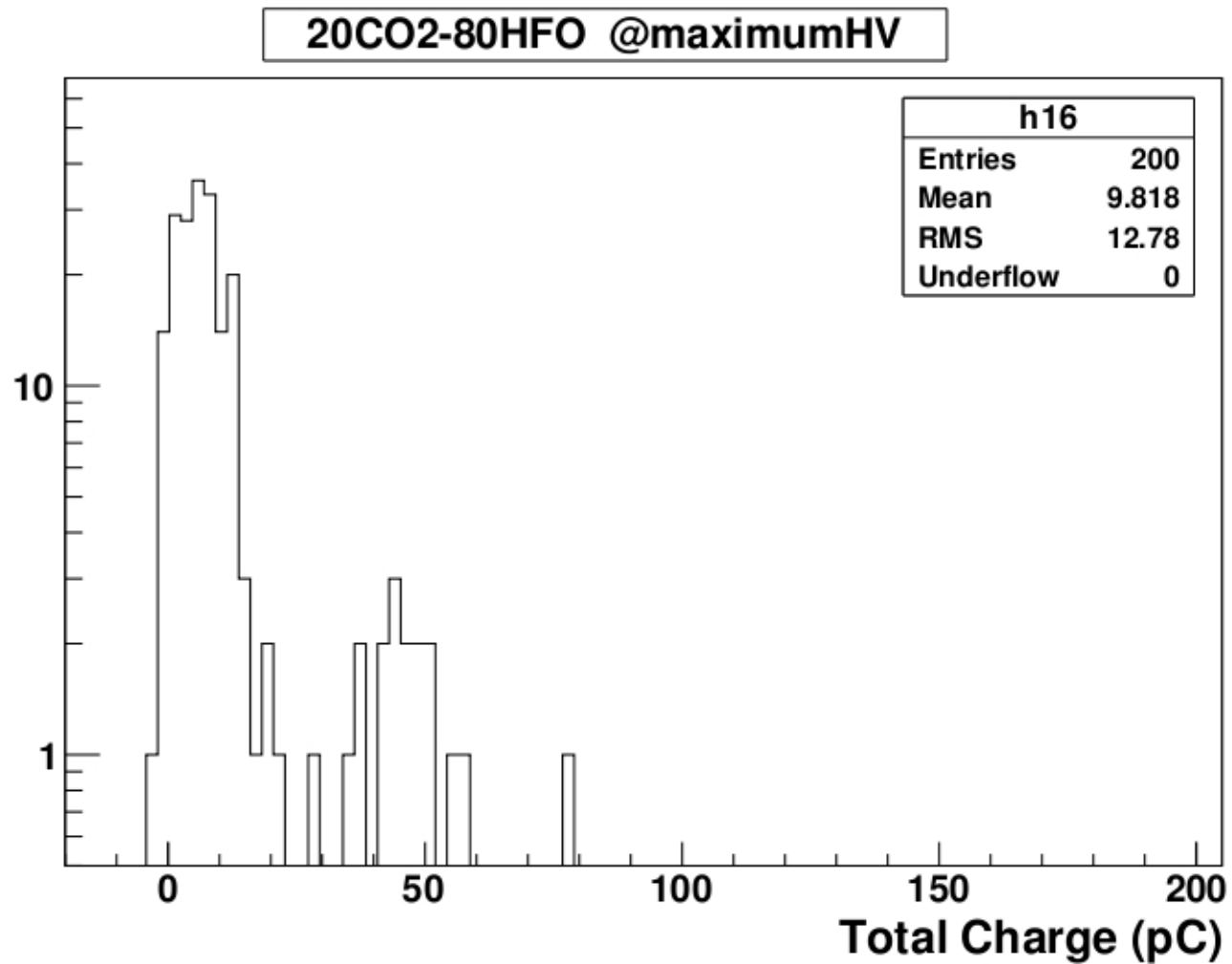
The total prompt charge is the integral over the full event time window of the signal dedicated to streamer and it is compared to a fixed threshold of 20 pC.

First Choice GWP < 6 1.

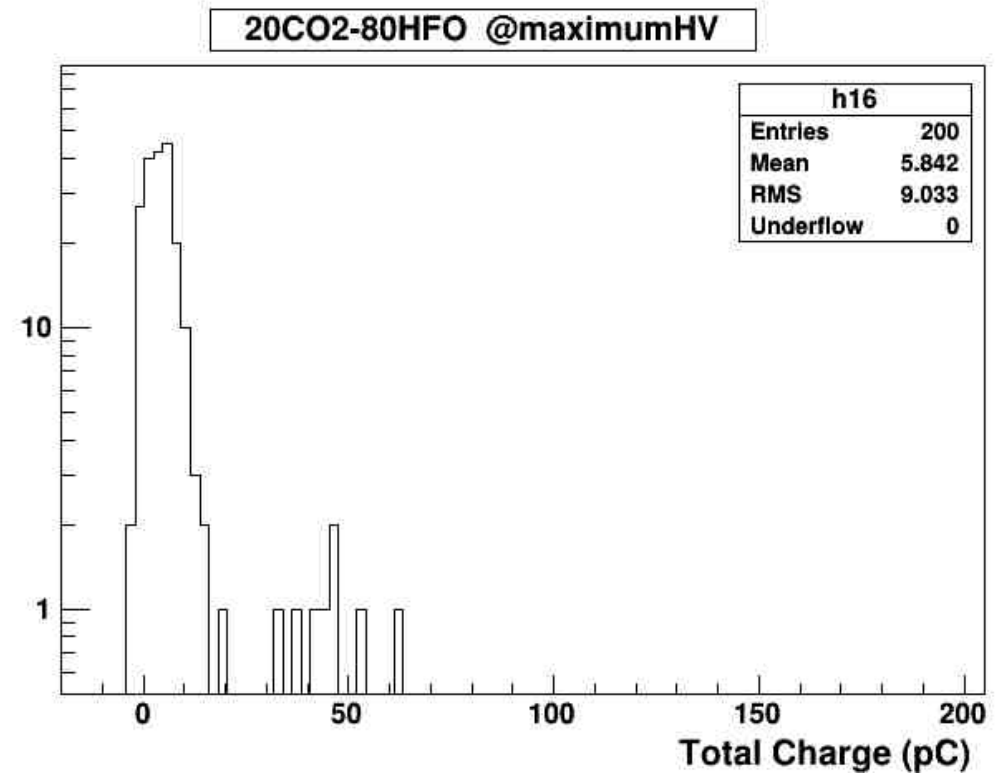
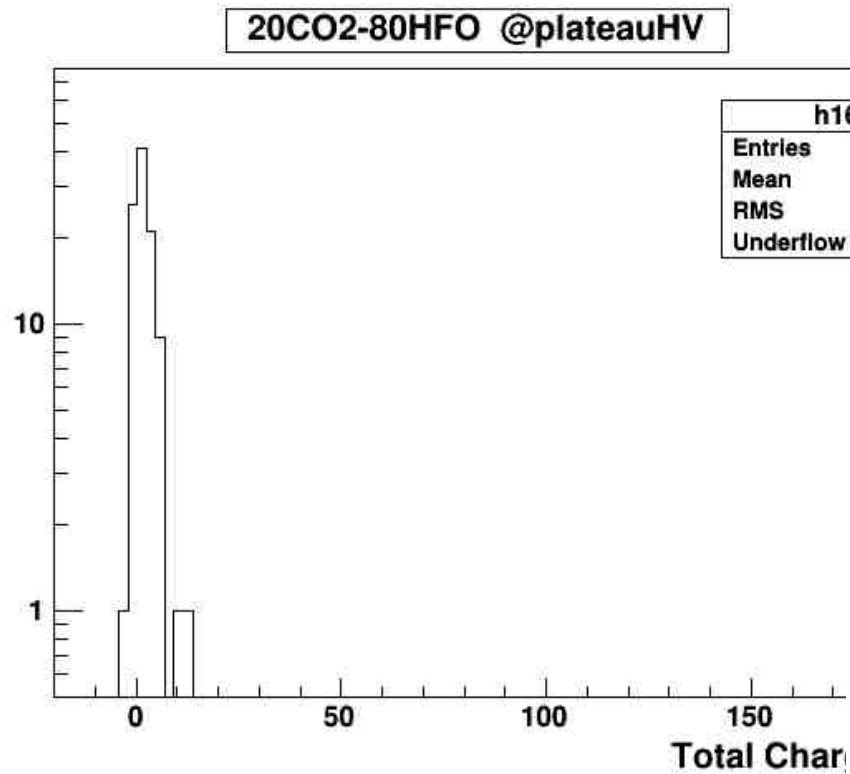


300 V of very clean working mode

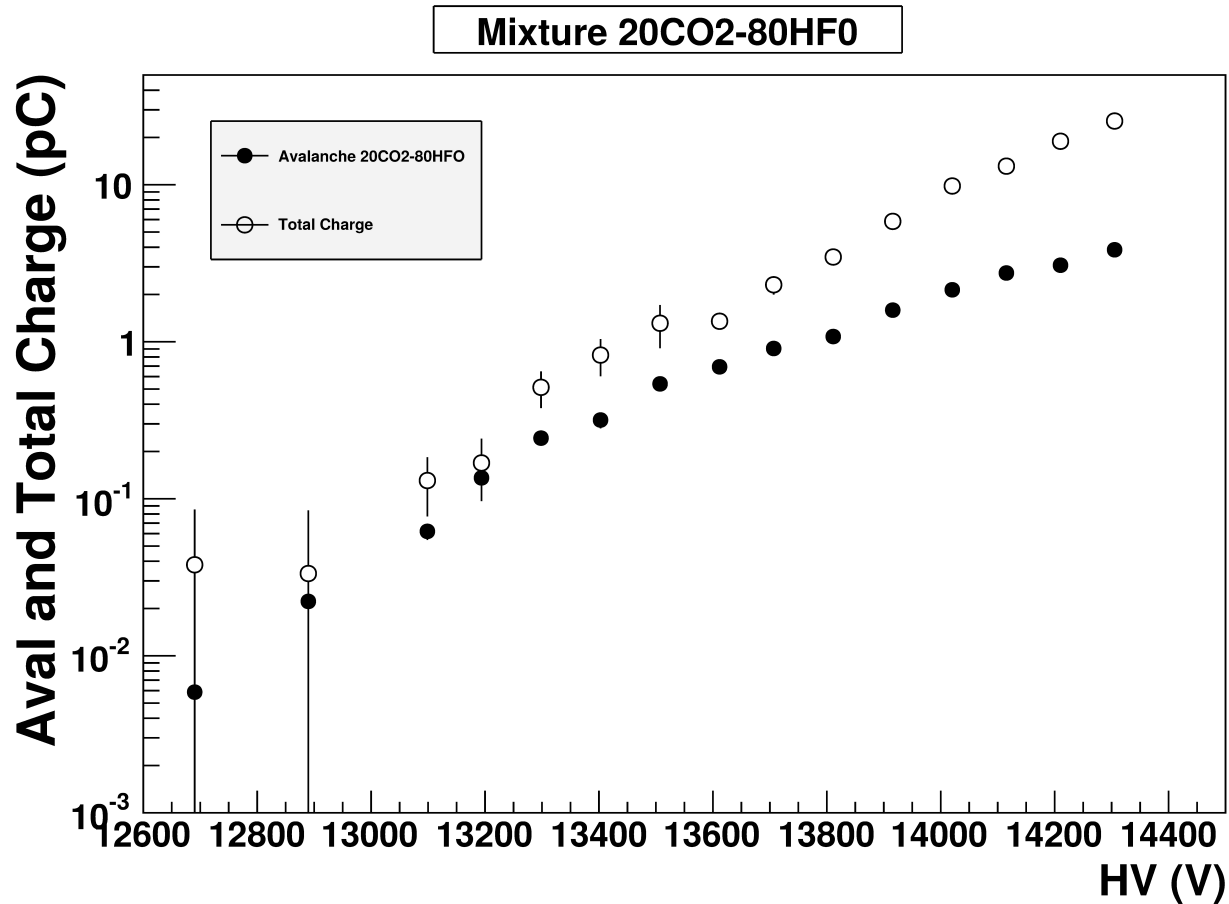
First Choice GWP < 6 2.



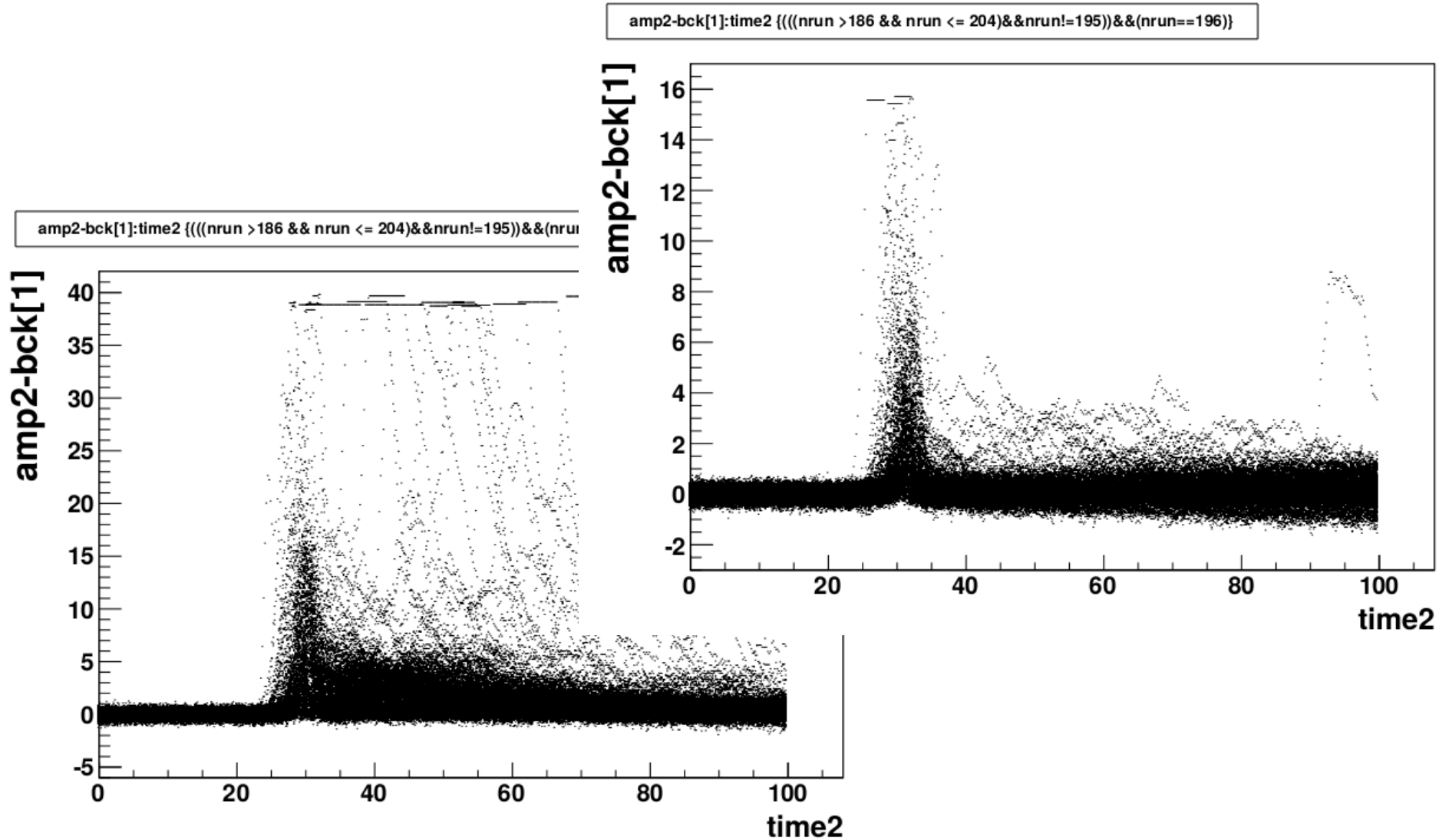
First Choice GWP < 6 3.



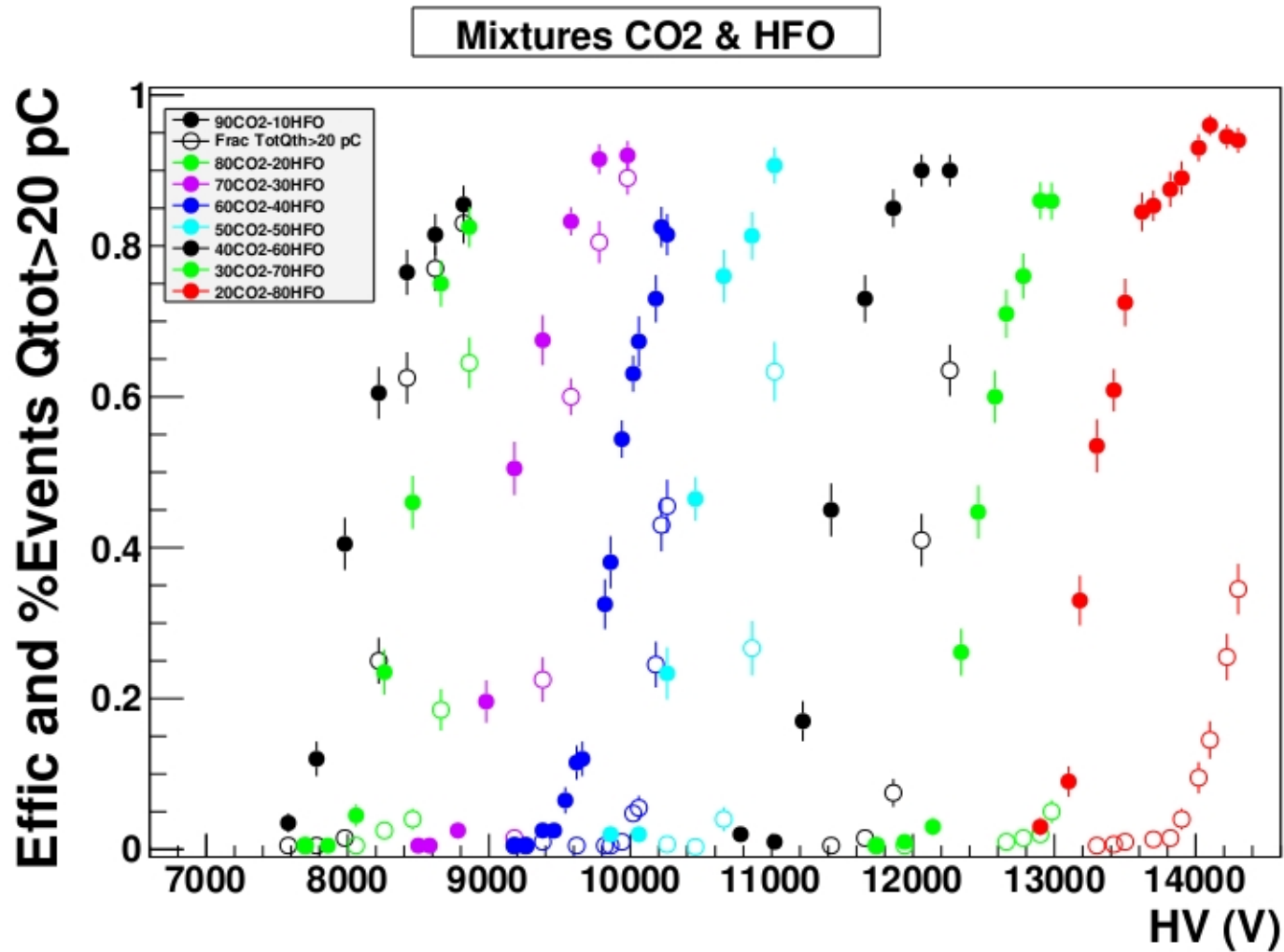
First Choice GWP < 6 4.



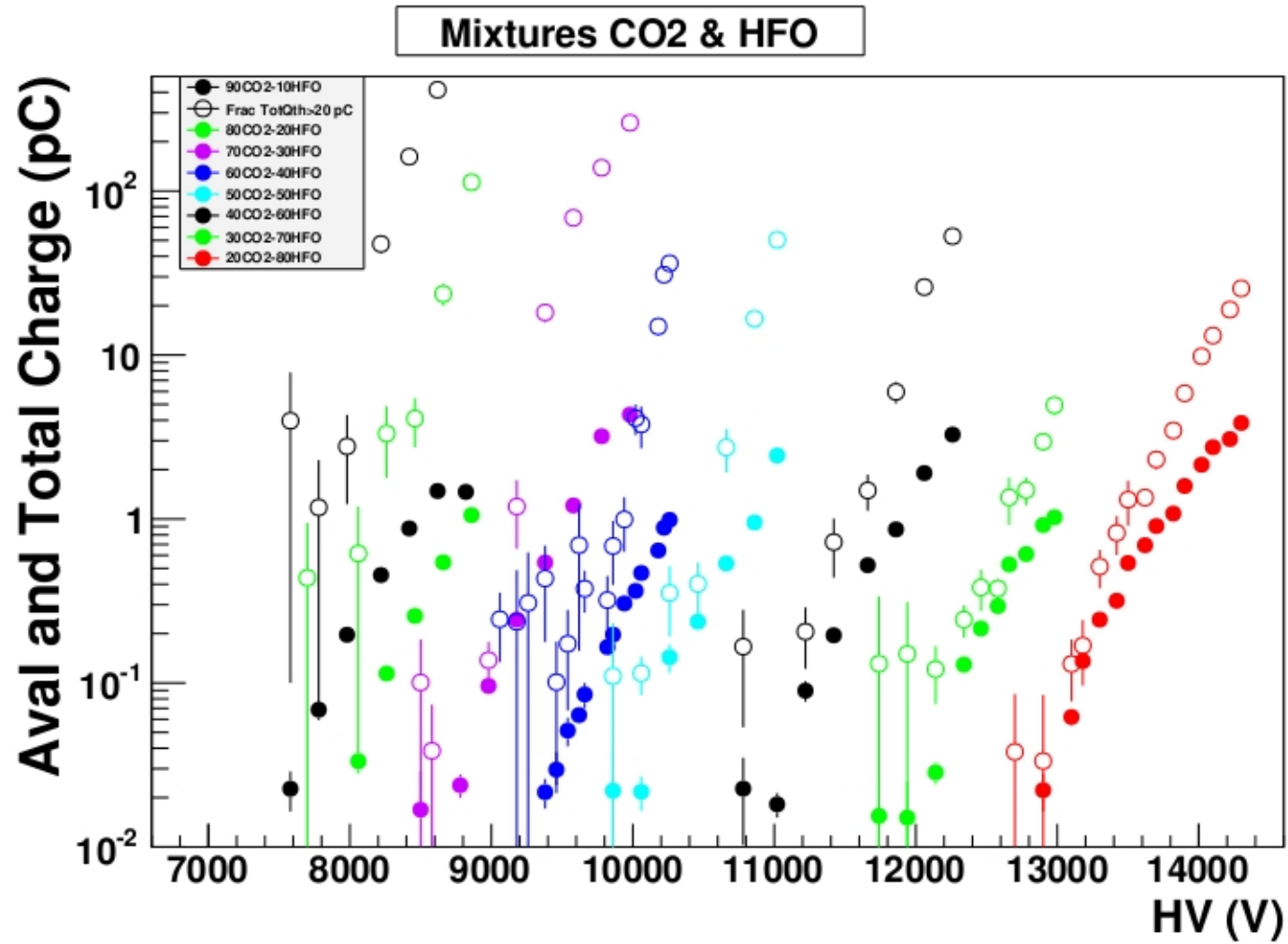
Events display @ plateau Mix20CO2-80HFO



CO2-HFO series 1.

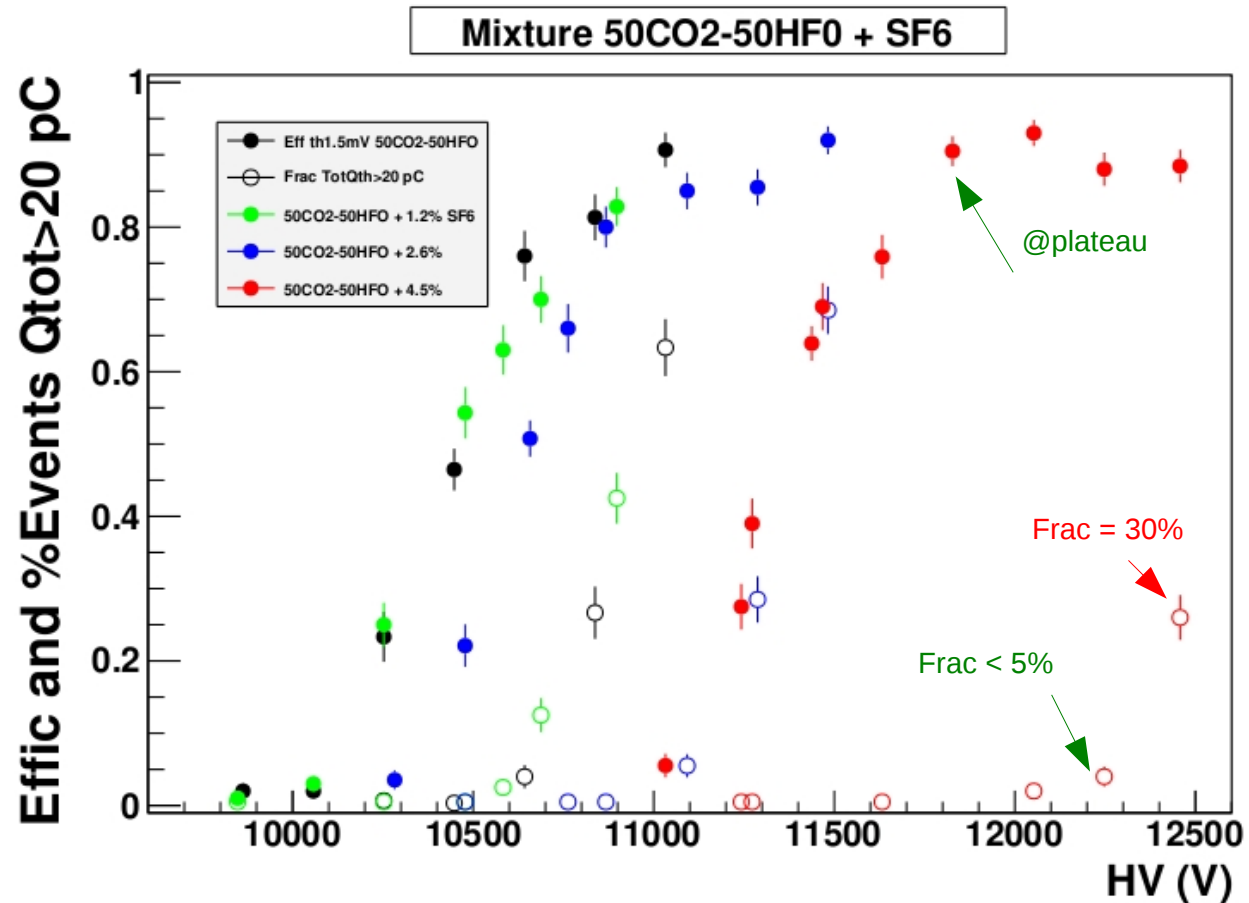


CO₂-HFO series 2.



Seconde Choice 1.

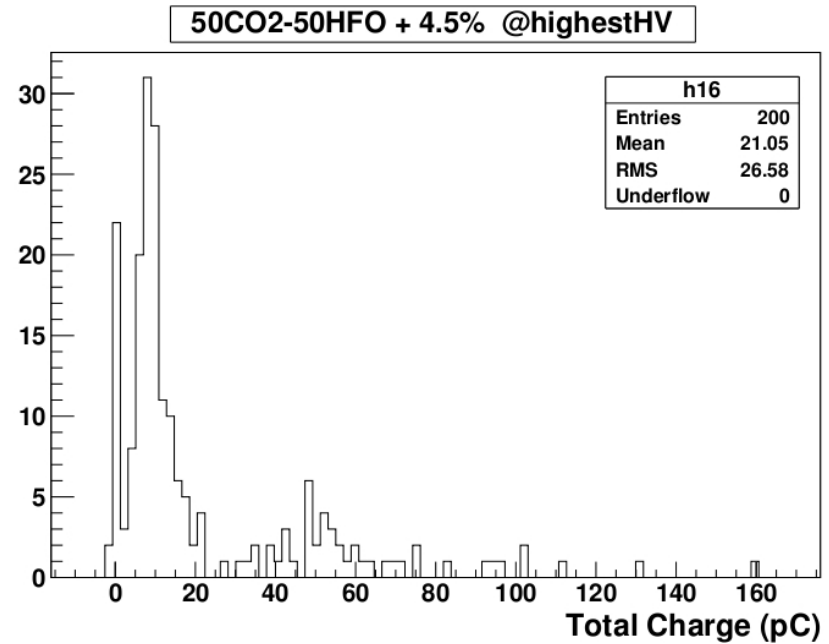
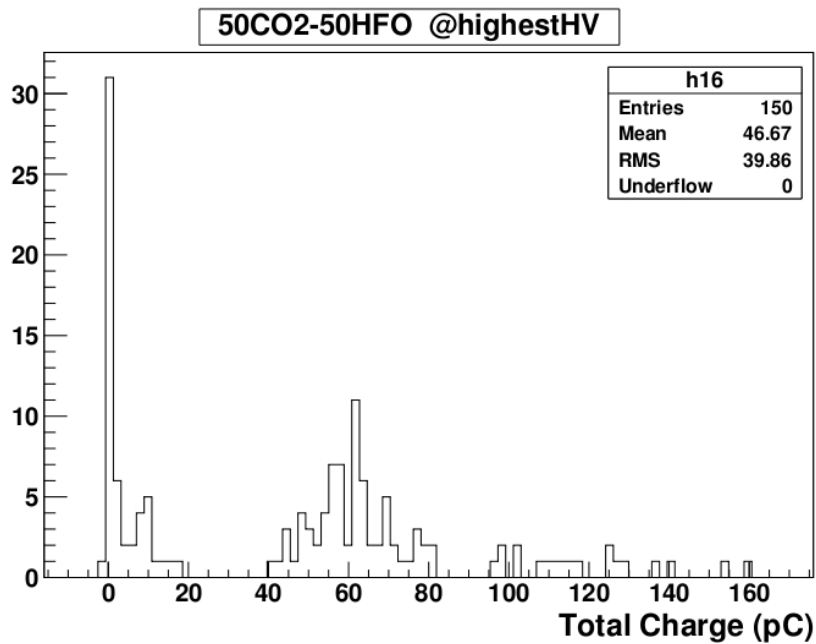
CO2-HF0 plus SF6 series GWP=700



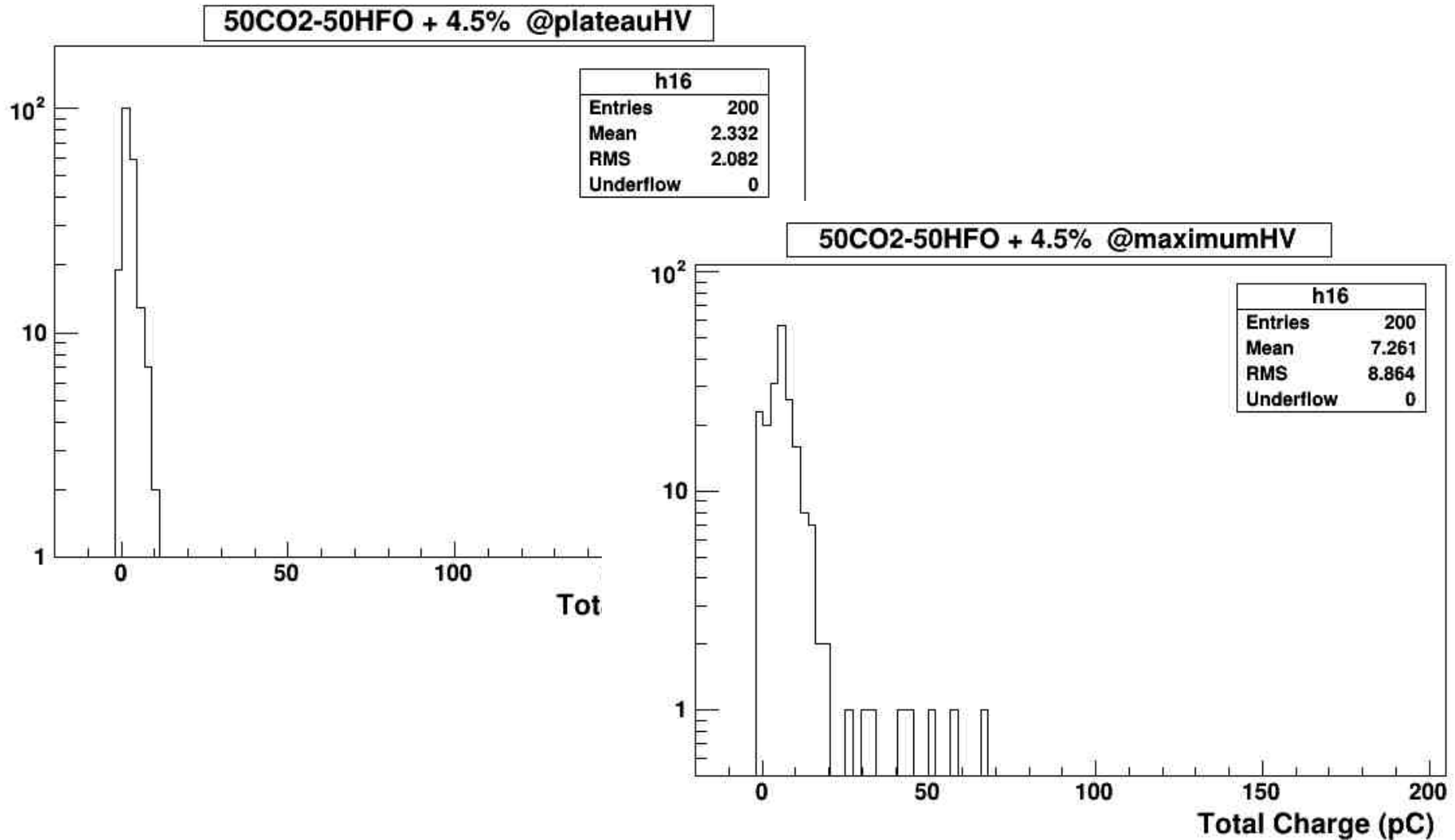
300 V of very clean working mode

Seconde Choice 2.

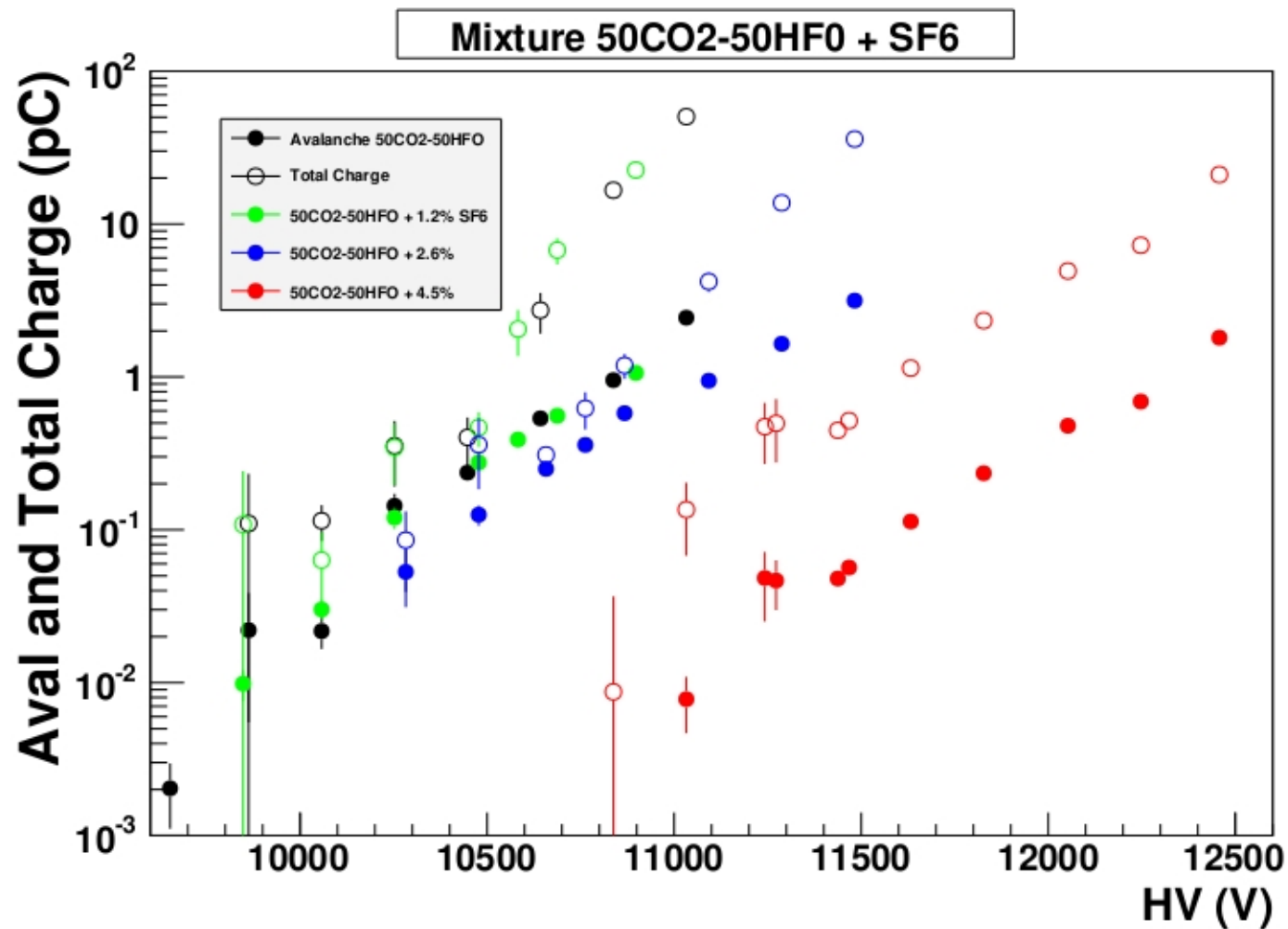
CO2-HF0 plus SF6 series GWP=700



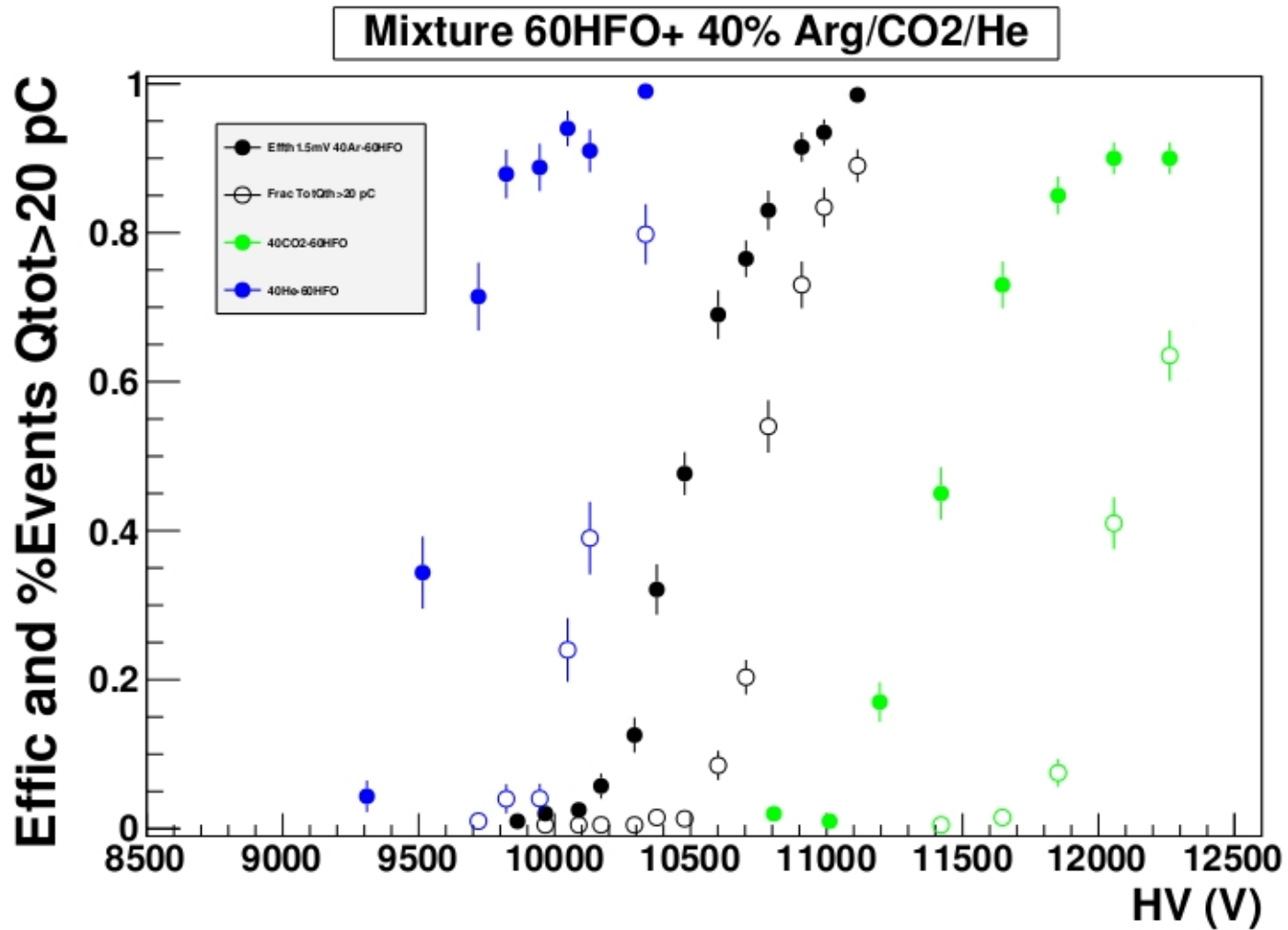
Seconde Choice 3. CO2-HF0 plus SF6 series GWP=700



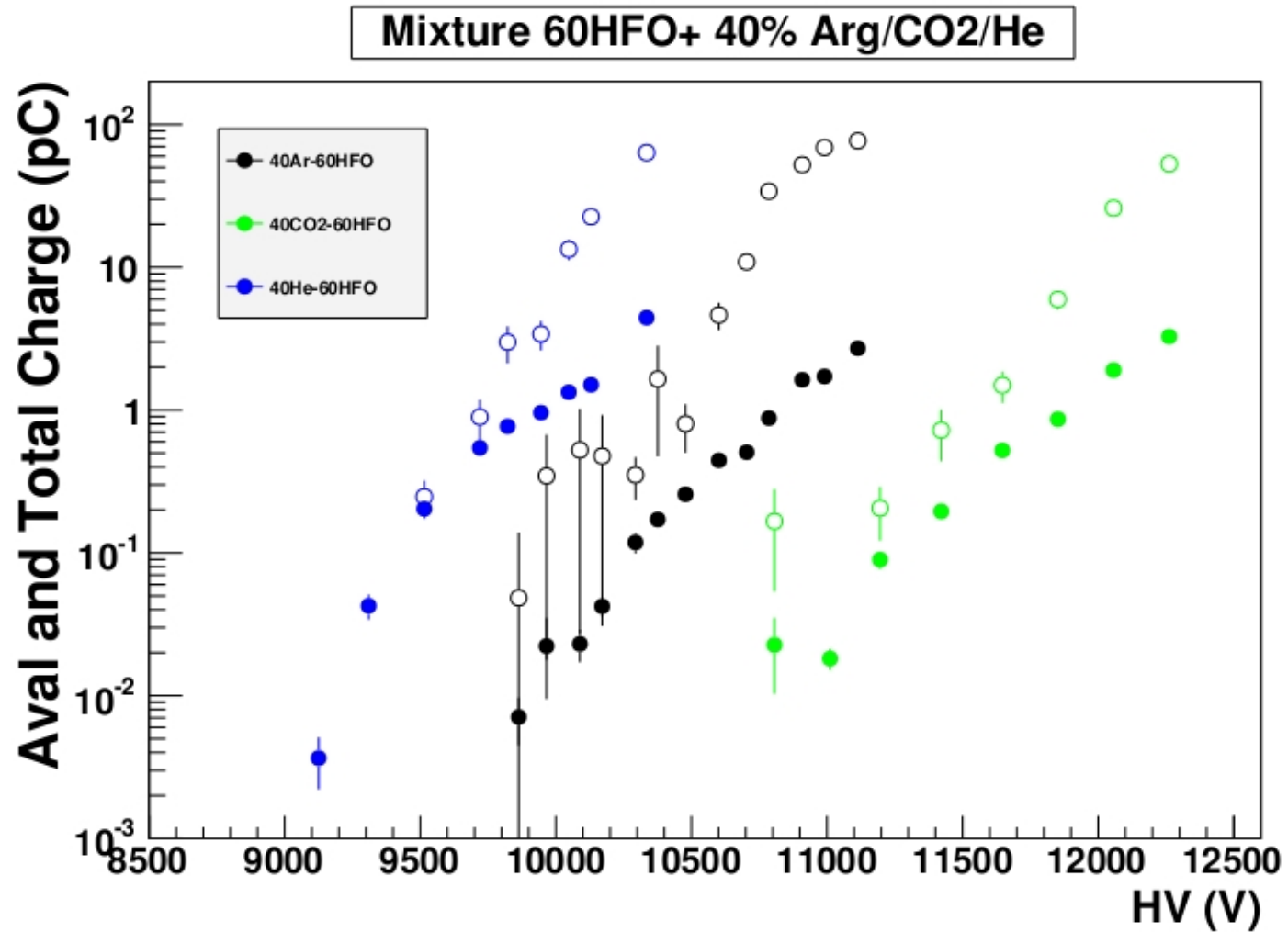
Seconde Choice 4. CO2-HFO plus SF6 series GWP=700



HFO with He 1.

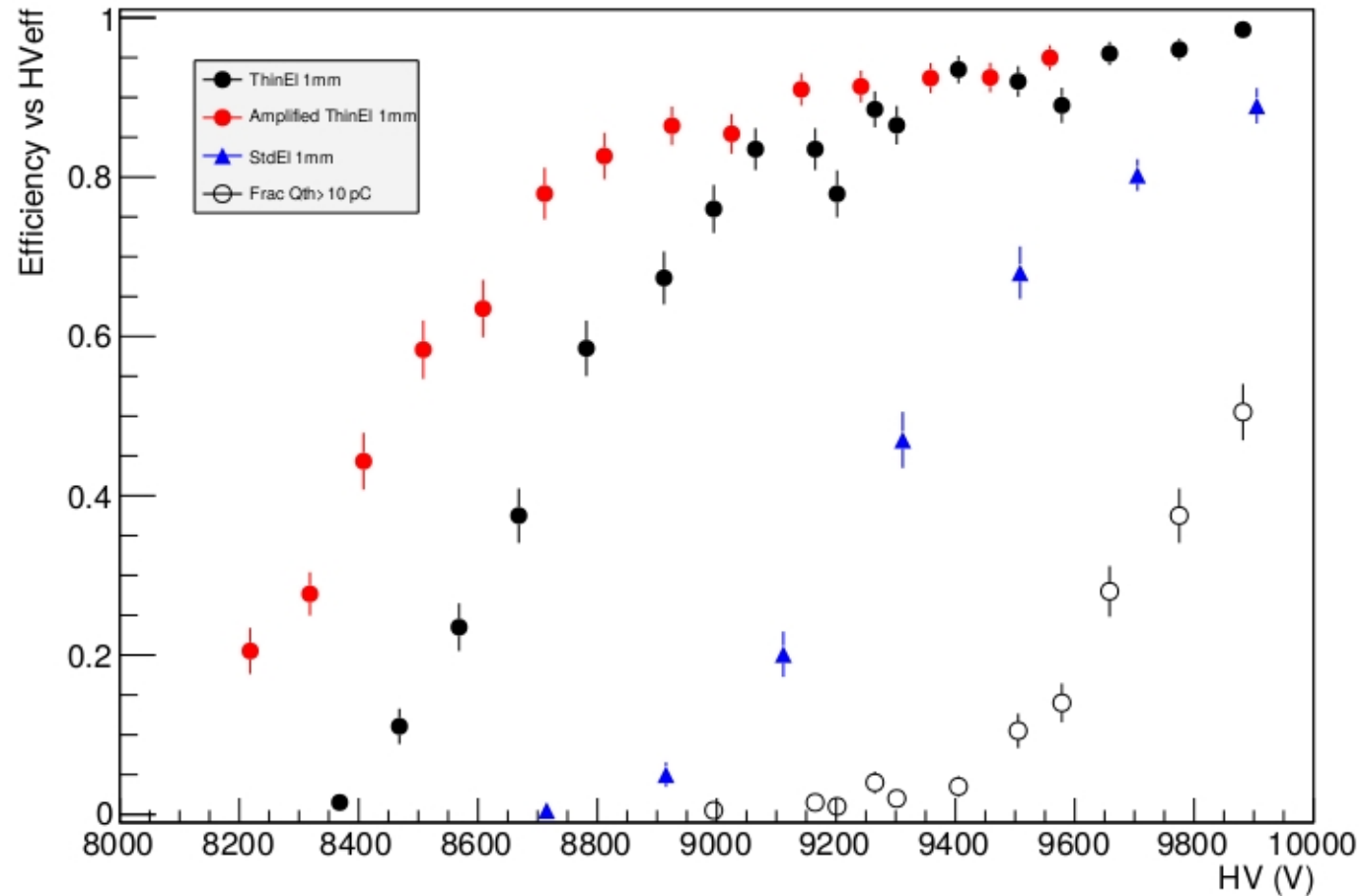


HFO with He 2.



MonoGas HFO 100% 1.

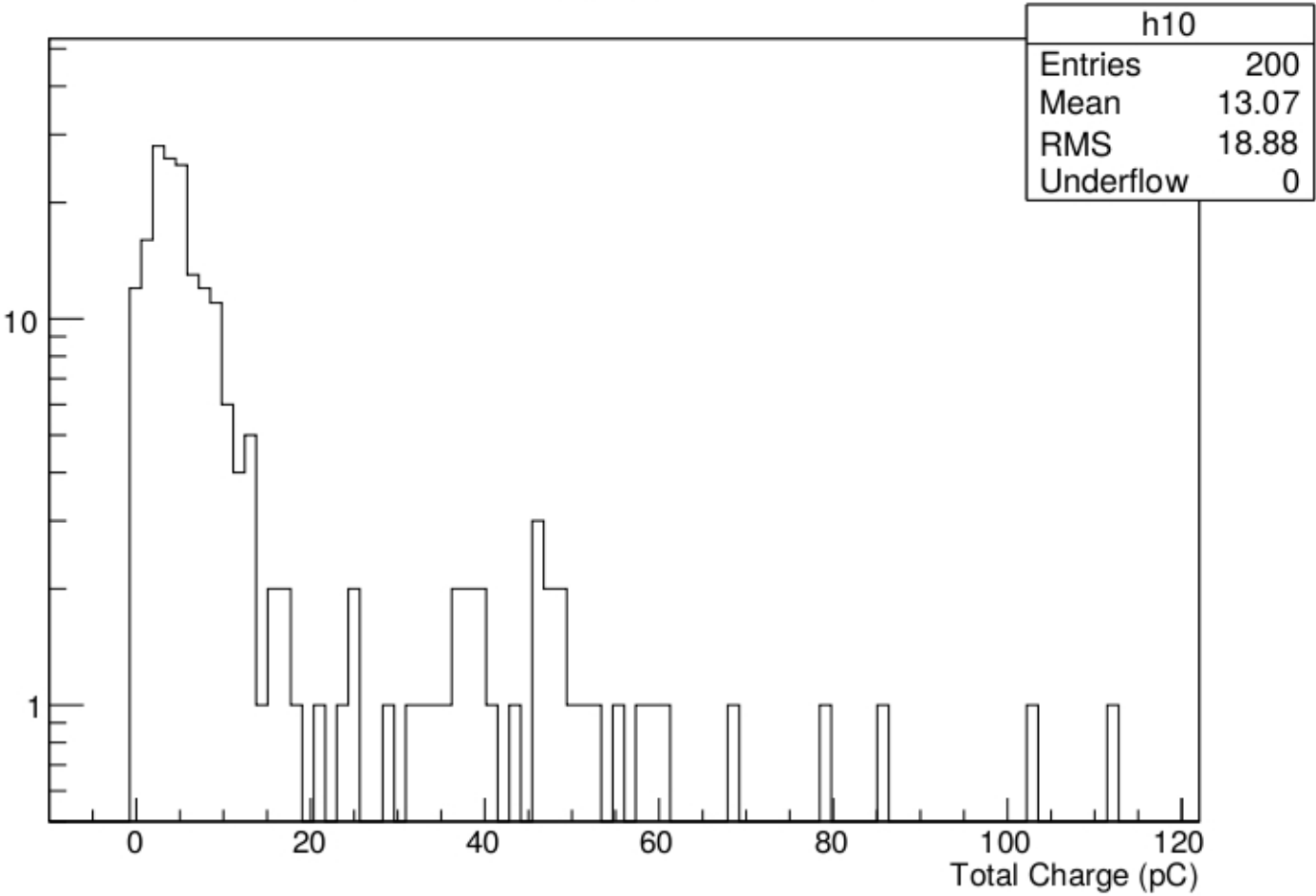
1 mm Gas Gaps ThinElectrodes - Gas 100% HFO



NewFE Electronics of Cardarelli over New RPC 1mm gas gap and thin electrodes 0.8mm
500 V of very clean working mode over 1mm

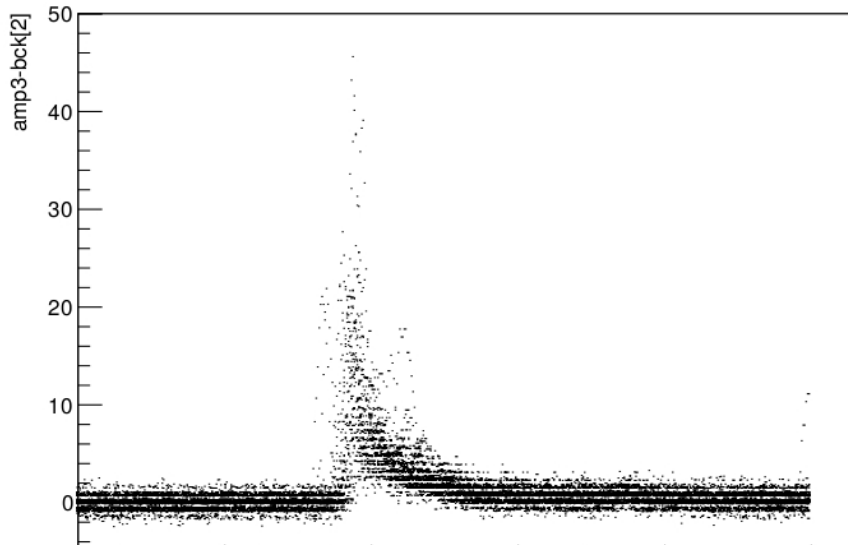
Monogas HFO 100% 2.

HFO 100% @highestHV

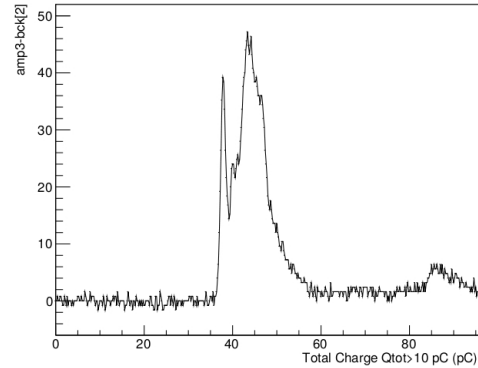


Monogas HFO 100% 3.

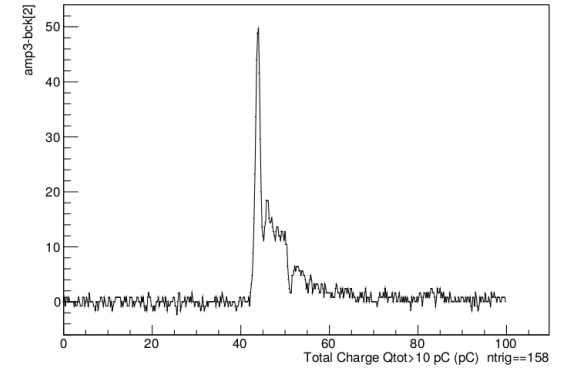
HFO 100% @maximumHV



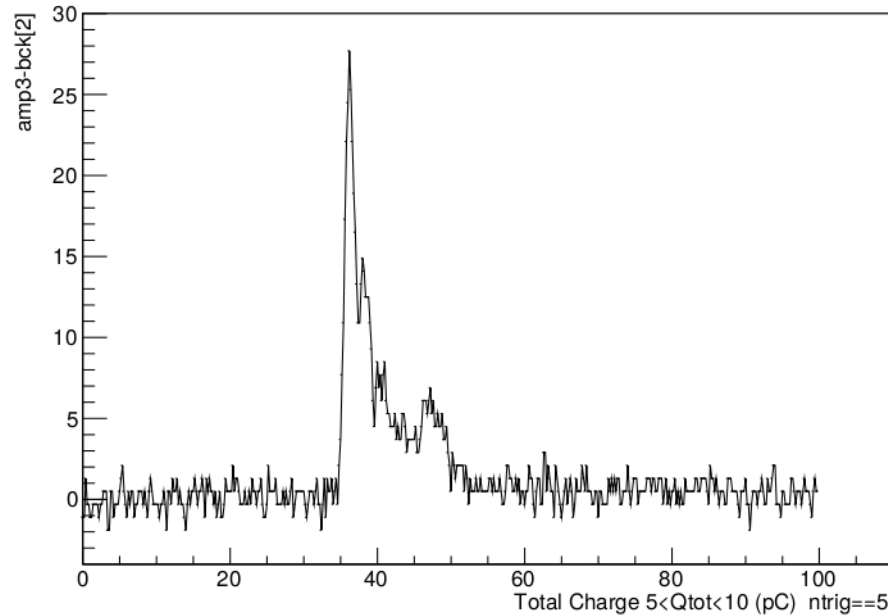
HFO 100% @maximumHV



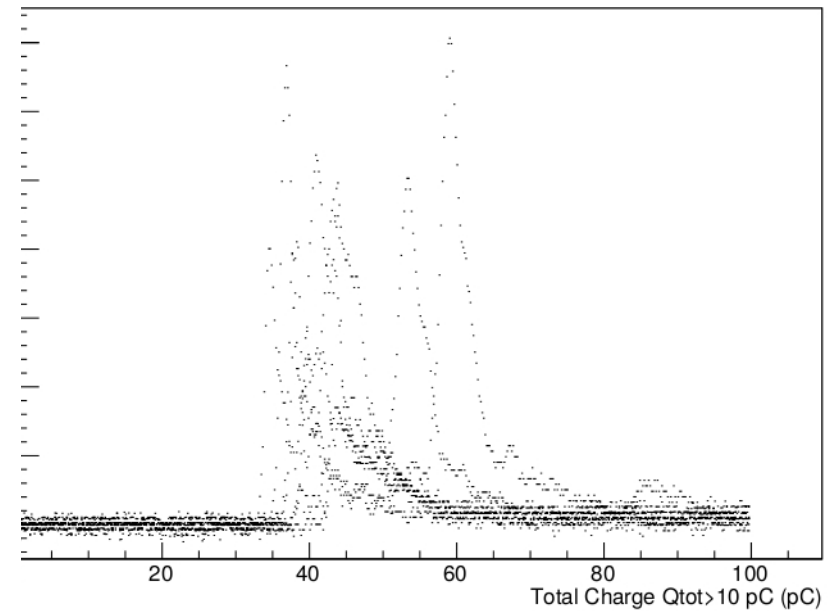
HFO 100% @maximumHV



HFO 100% @maximumHV



HFO 100% @maximumHV



RPC2

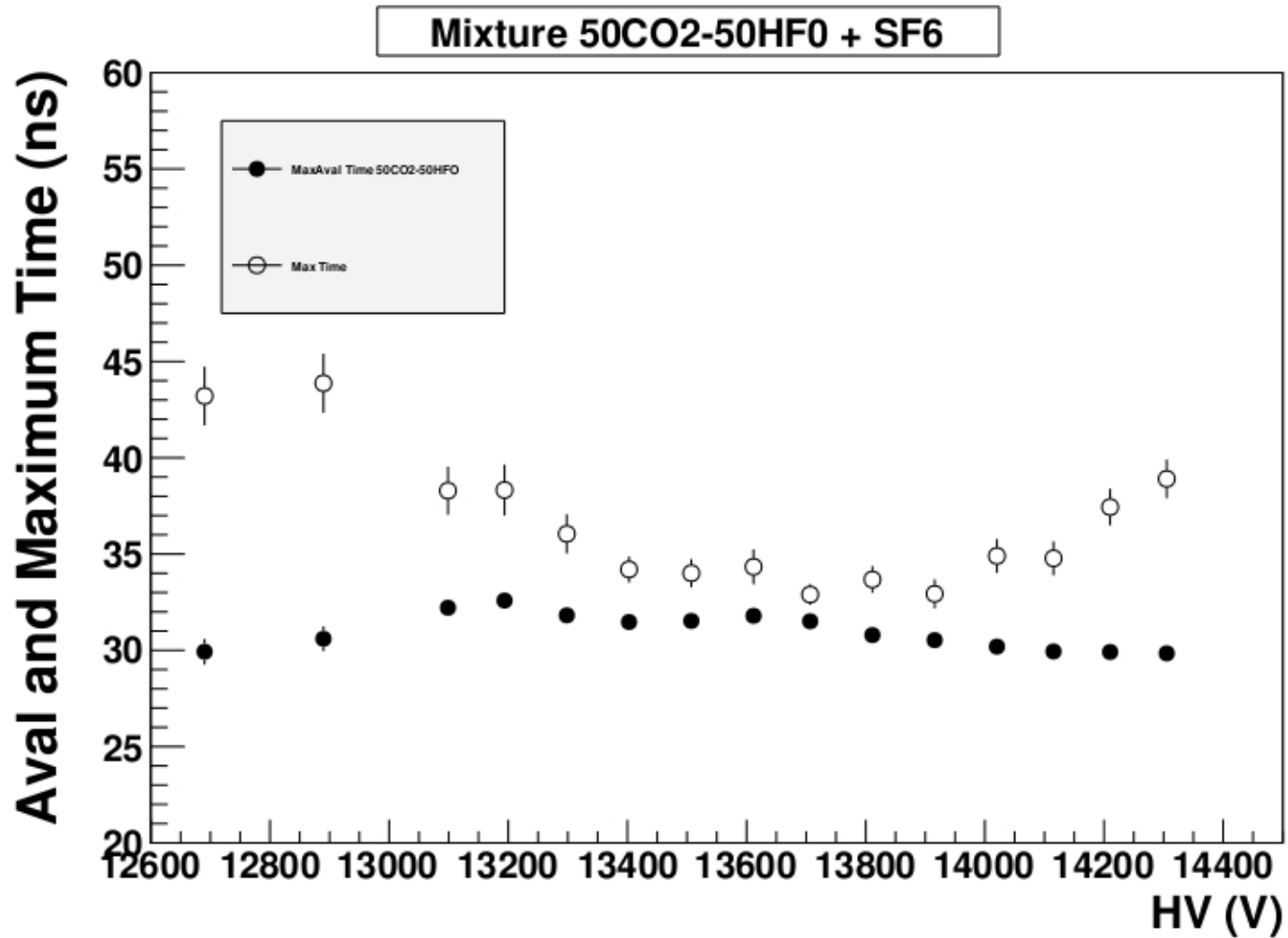
Conclusions

- Standard Mixture is a very special one for the avalanche streamer separation and for saturated avalanche charge distribution.
- For future RPC generation HFO, alone or associated with other gases, offers full opportunity to obtain a full avalanche working mode.
- **For RPC already installed, in principle, only if forced, we could consider both 20%CO₂-80%HFO with GWP=6 or in alternative, with less severe constraints, binary mixture of CO₂ and HFO with addition of SF₆ i.e. 50%CO₂-50%HFO + 5%SF₆.**

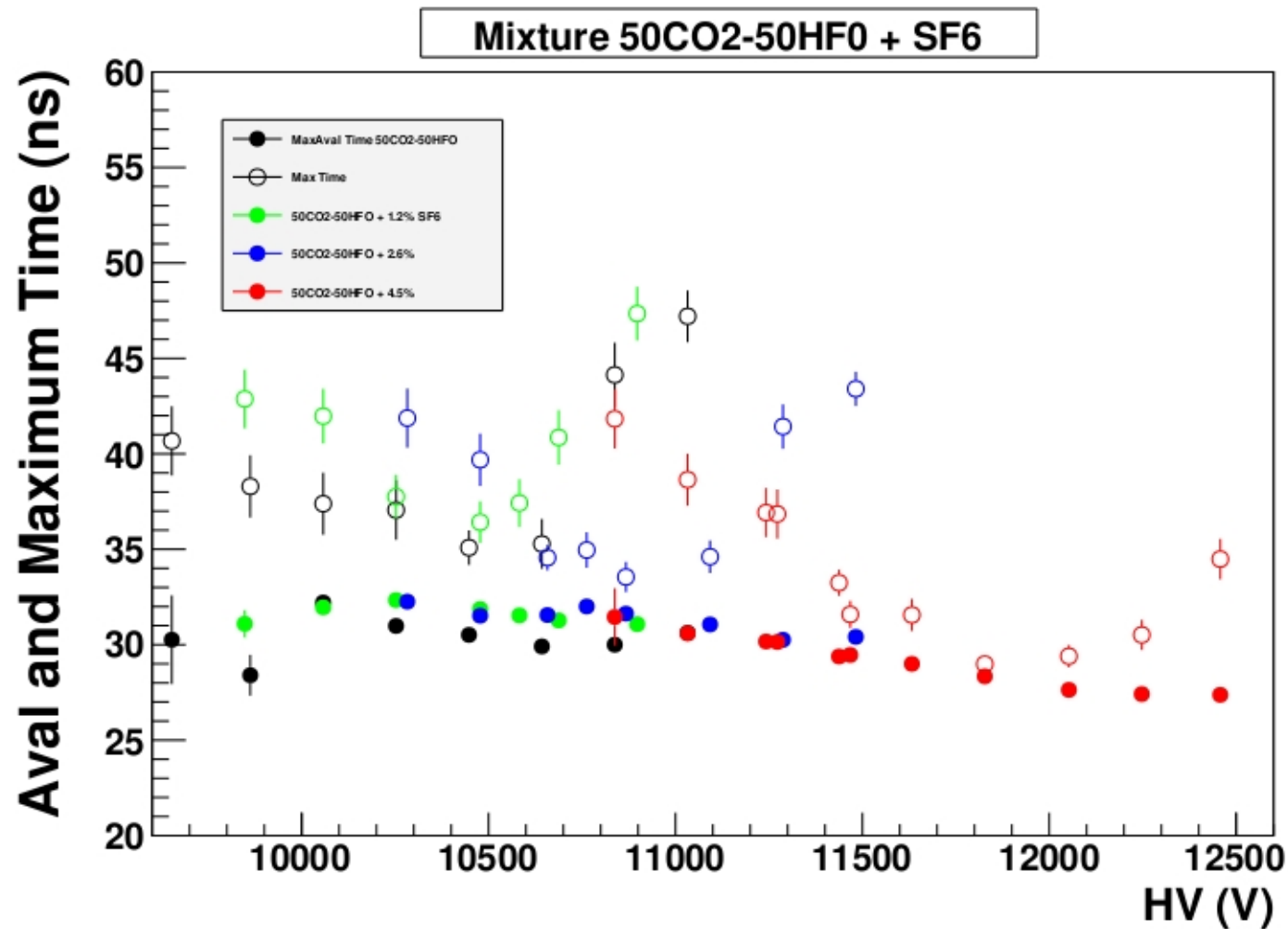
Both these mixtures have shown 300 V of Avalanche-Streamer separation and, in case of low percentage streamer contamination, they have a small average delivered charge per count.

- This is only a preliminary indication which have to be explored in detail but lots of work must be done in particular to see the behavior of this gas with respect to ageing and pollution effects.

Time Distribution Mix20CO2-80HFO



Seconde Choice 4. CO2-HF0 plus SF6 series GWP=700



HFO with He 3.

