RPC2020

XV Workshop on Resistive Plate Chambers and related detectors

Characterization of new eco friendly gas mixtures for RPCs mainly based on HFO

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on behalf of Roma Tor Vergata group
Rome 14 Febbraio 2020

Outline

- Introduction
- Strategy
- HFO1234zd measurements
- HFO-1233zd measurements
- Conclusions

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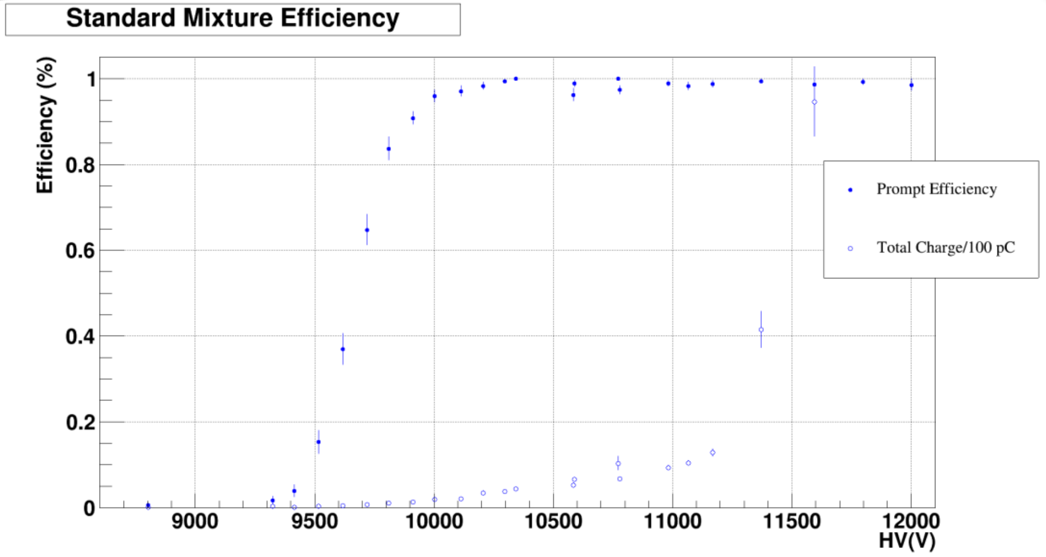
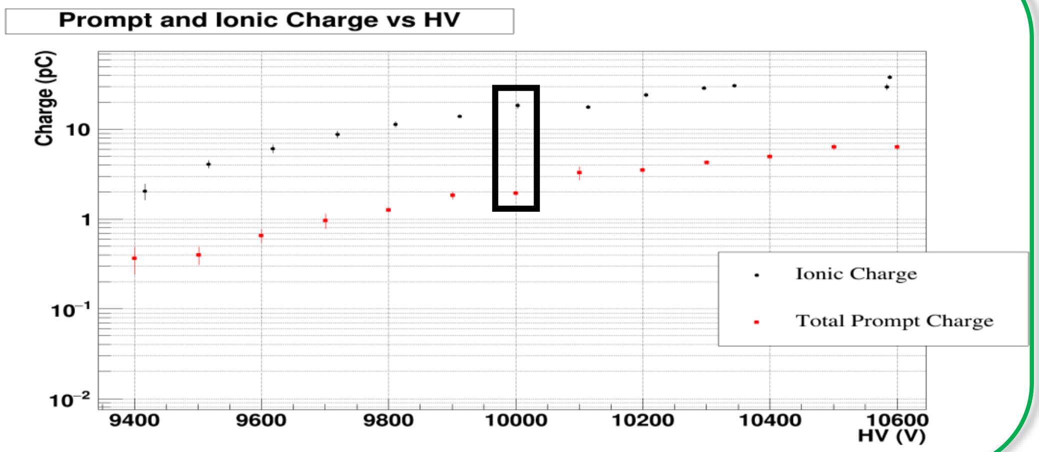
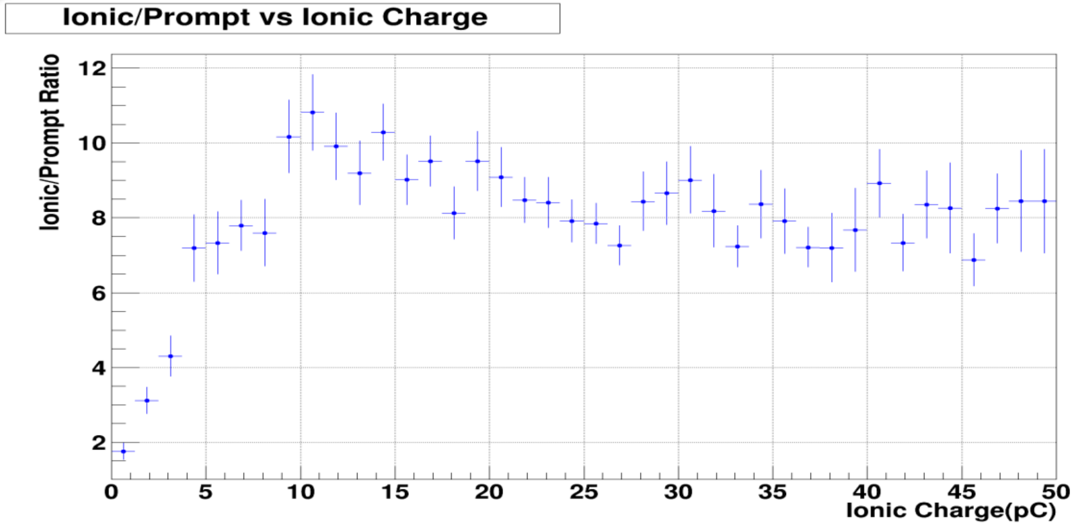
Introduction – Reference Parameters





- Net separation between pure avalanche regime and streamer mode over a large electric field interval
- 98% of Efficiency @ 10 kV
- 2 pC of prompt charge and 10 pC of Ionic charge at the working point
- High **Global Warming Power** (≈ 1430)



Parameters definition

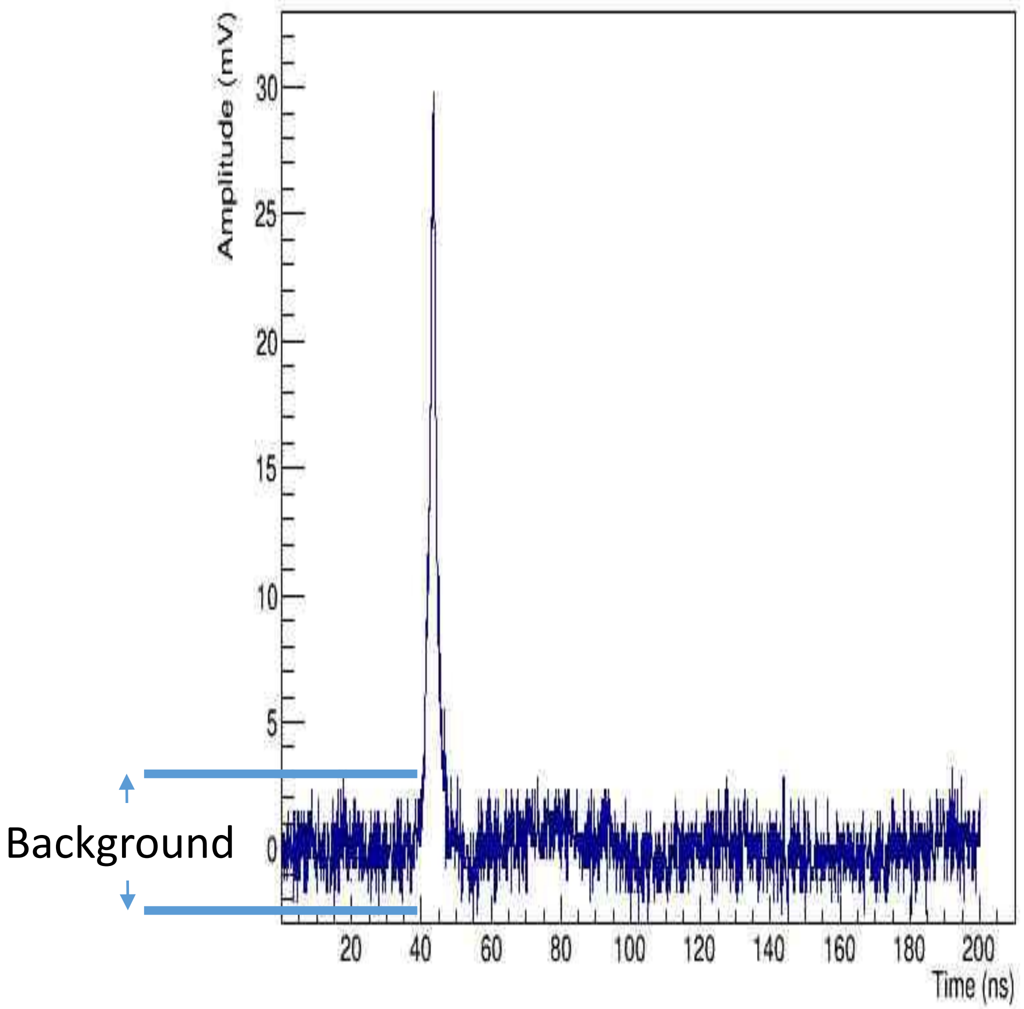
➢ Efficiency

- The threshold is fixed to the value of 5 times the RMS of the background calculated in the 20 ns time window which anticipates the signal

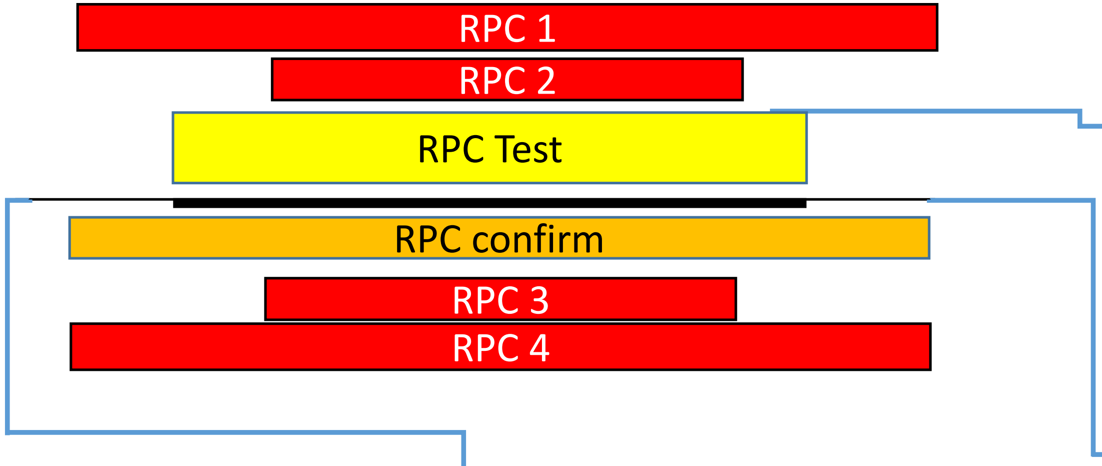
- Threshold applied directly to the naked signal (no Front-End electronics has been used)

➢ Charges definition

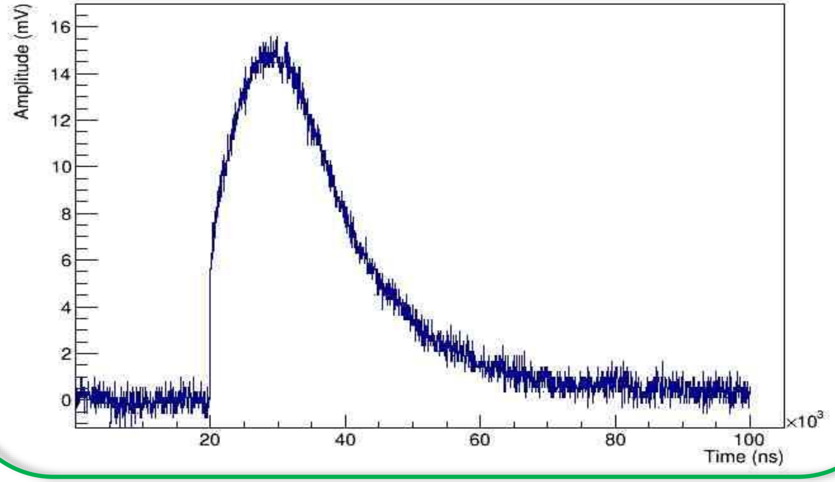
- Avalanche charge: charge integrated over a window of 20 ns
- Total charge: charge integrated over all the time window(200 ns)
- Extra Charge/ streamers: Signals which have a total charge more than **20 pC** and a width> 10 ns



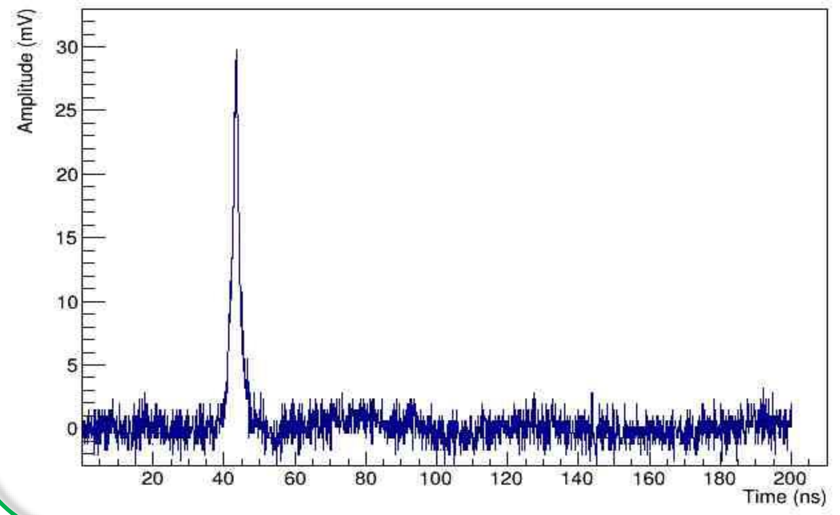
Experimental Setup



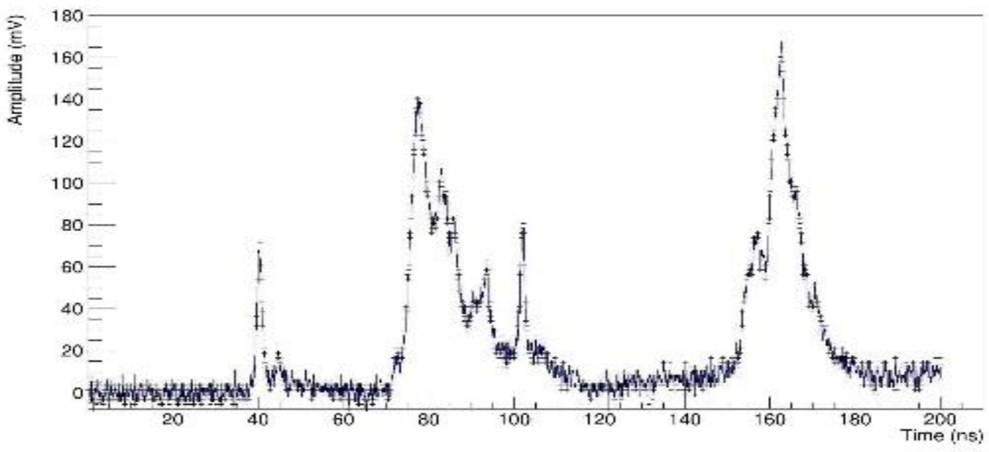
Ionic signal



Prompt Signal for the Avalanche



Prompt Signal for the Streamer



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Measurement Strategy

Starting point

$HFO/CO_2/i-C_4H_{10}/SF_6$=38%/56%/5%/1%

➢ **SET (I):Study of the quenching contribution**

- <u>CO_2 and SF_6 constant and HFO/i-Butane variable</u>

$HFO/CO_2/i-C_4H_{10}/SF_6$=33%/56%/10%/1%

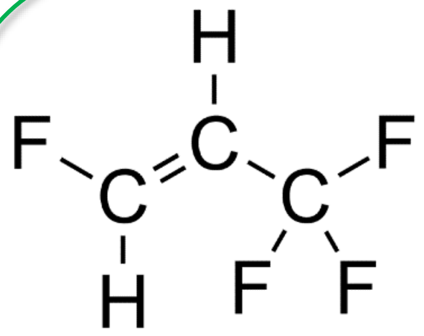
$HFO/CO_2/i-C_4H_{10}/SF_6$=29%/56%/14%/1%

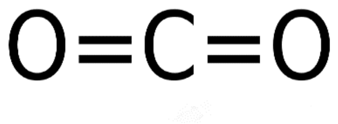
➢ **SET (II): Study of the HFO/CO_2 contribution**

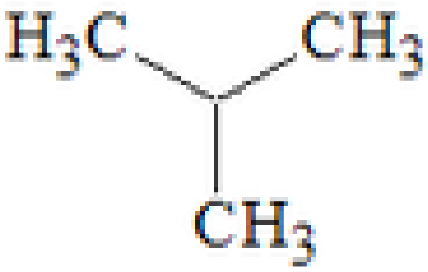
- <u>$i-C_4H_{10}$ and SF_6 constant</u>

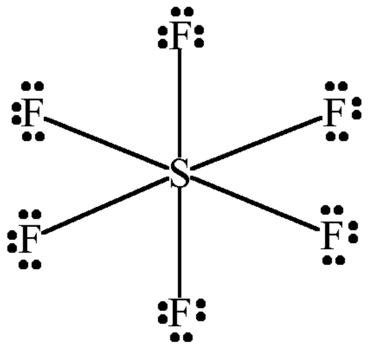
$HFO/CO_2/i-C_4H_{10}/SF_6$=33%/61%/5%/1%

$HFO/CO_2/i-C_4H_{10}/SF_6$=28%/66%/5%/1%

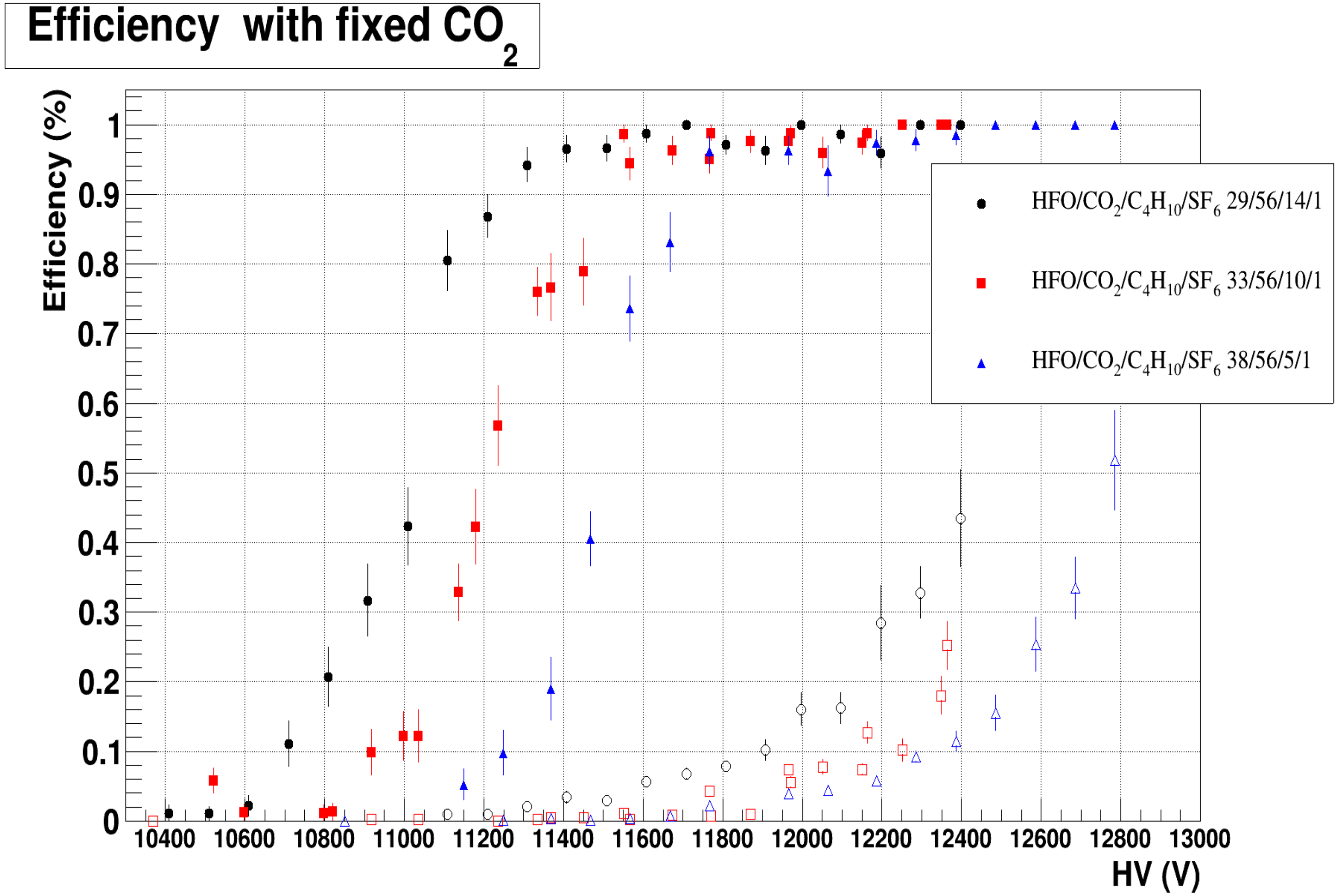








$SET\ I$: $Efficiency$ – HFO/i–Butane variable ratio (CO_2 and SF_6 constant)



HV Working Point

- HFO/i-Butane 38%/5% : 96% at 11.4 kV
- HFO/i-Butane 33%/10% : 96% at 11.6 kV
- HFO/i-Butane 29%/14% : 96% at 12 kV

➢ The empty markers represent the average prompt charge integrated over the whole time window (200 ns) divided for 100

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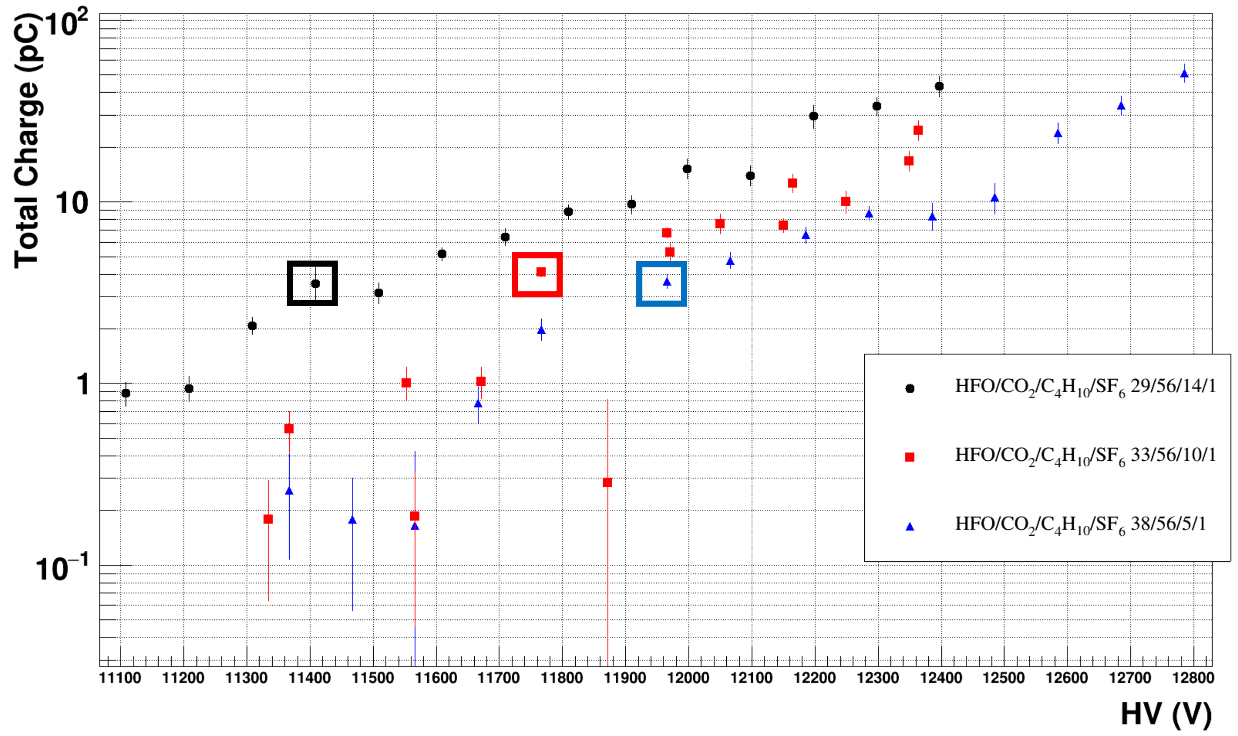
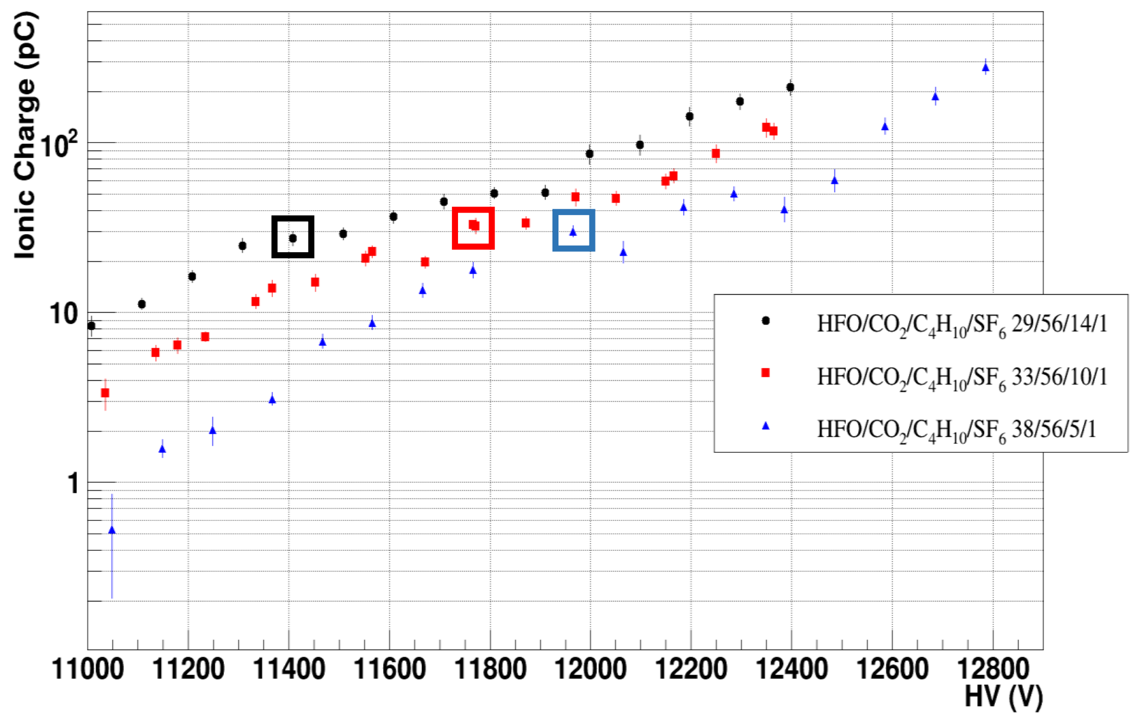
SET I : Total and Ionic charge – CO_2/SF_6 constant

The underlined points are evaluated at the first point after the knee of the plateau

Total Charge vs HV



Ionic Charge vs HV



The addition of the i-butane gives no benefit to the total charge delivered in the gas

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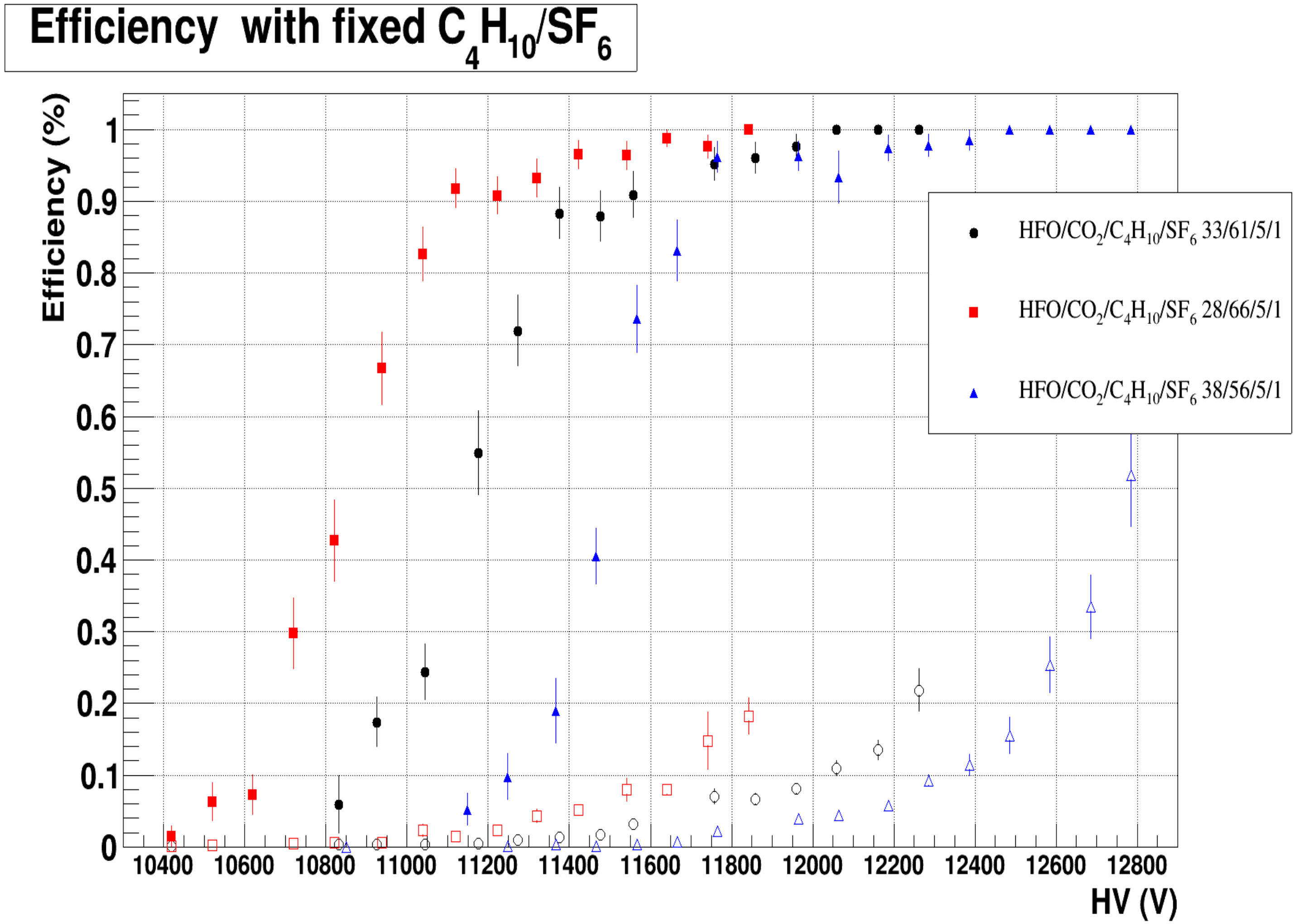
Set II: Efficiency- i-Butane $/SF_6$ constant (5%/1%)

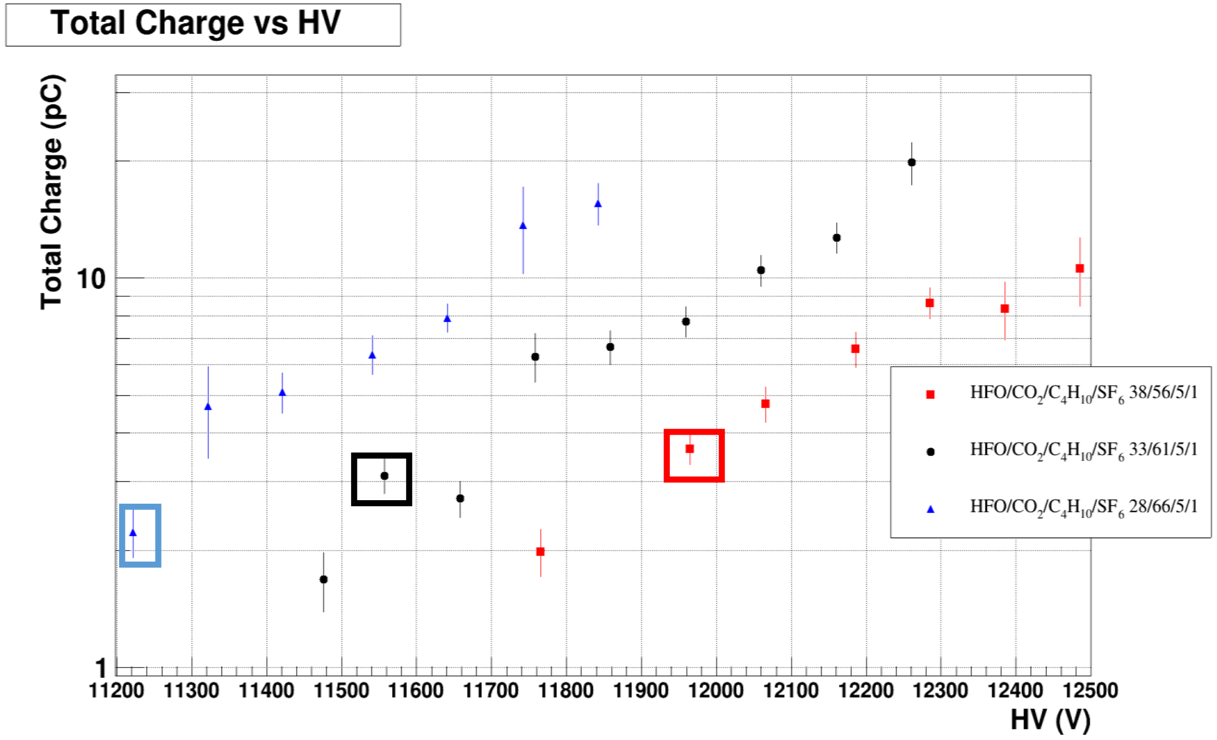


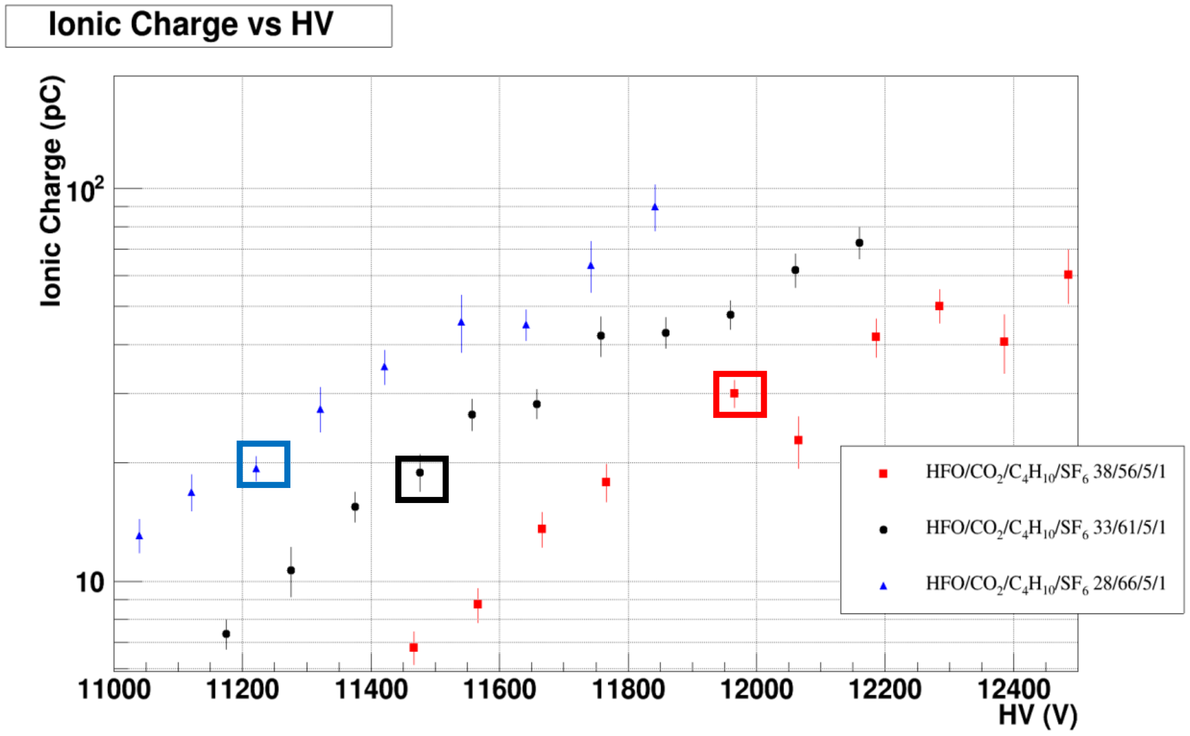
HV Working Point

- HFO/ CO_2 28%/66% : 92% at 11.3 kV
- HFO/ CO_2 33%/61% : 92% at 11.5 kV
- HFO/ CO_2 38%/56% : 96% at 12 kV

Set II: Total and Ionic Charge- i-Butane and SF_6 constant

The underlined points are evaluated at the first point after the knee of the plateau

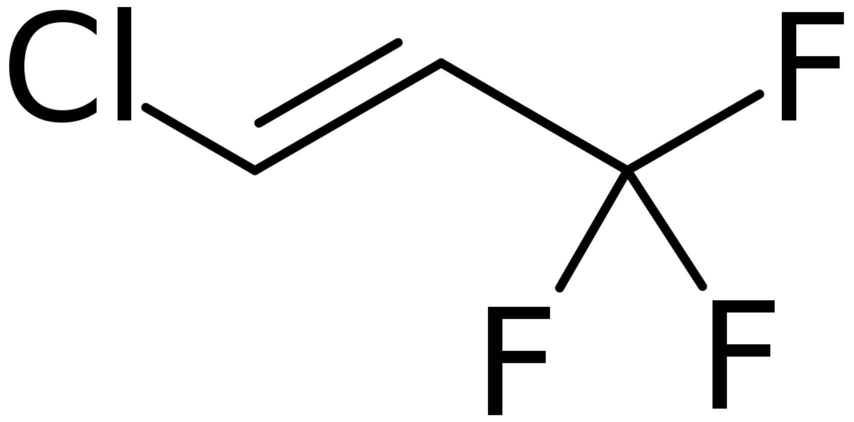




The addition of the HFO moves the working point to higher voltages, increases the average charge per count but extends the streamer-avalanches separation

New HFO-1233zd – Molecular description and measurement strategy

- More electronegative than HFO-1234zd
- Heavier than HFO-1234zd



- $HFO-1233zd/CO_2/i-C_4H_{10}/SF_6$=28%/66%/5%/1%

the first signal was at **14 kV**!!!

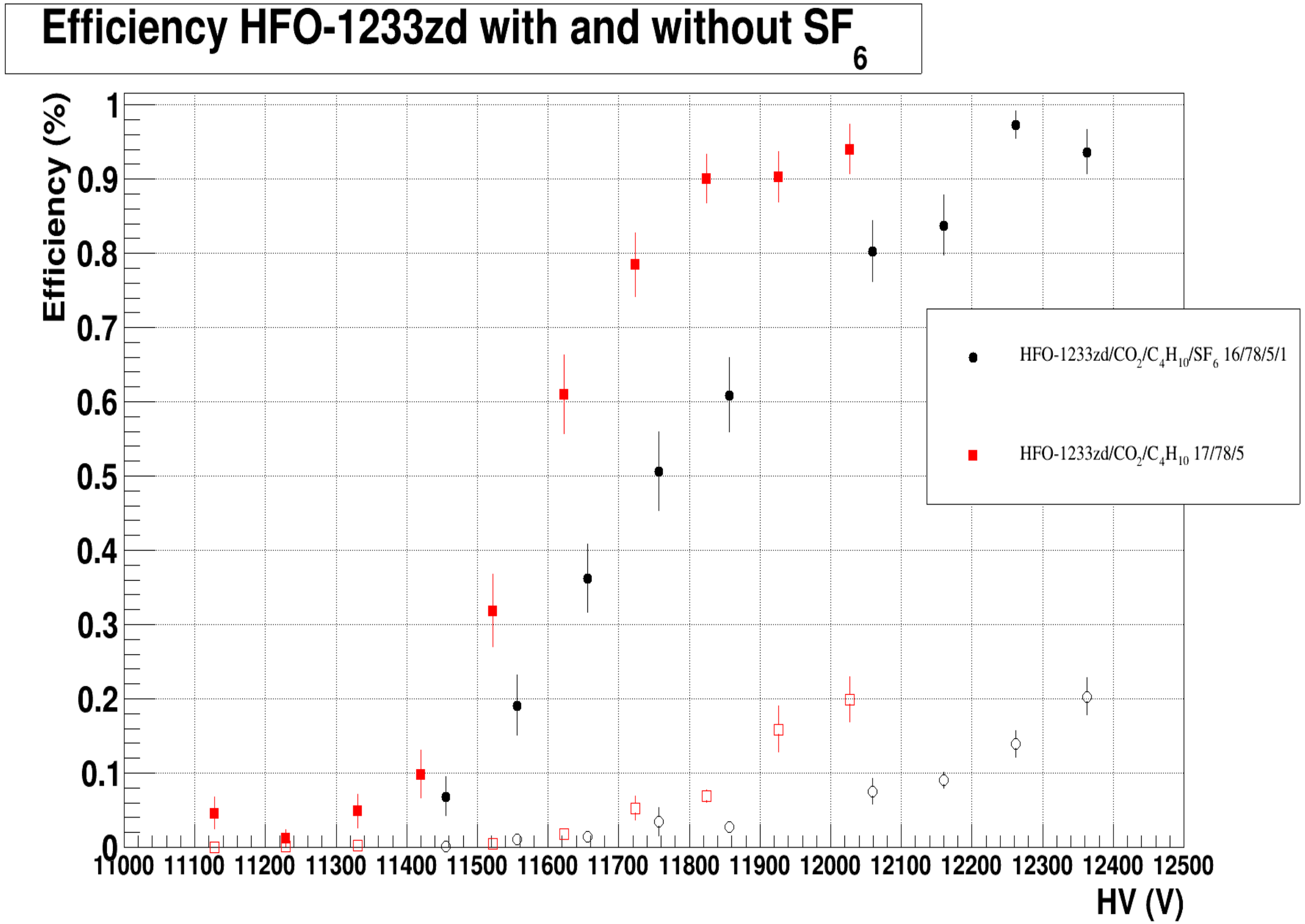
- Starting point

$HFO-1233zd/CO_2/i-C_4H_{10}/SF_6$ = 16%/78%/5%/1

Removing SF_6

Adding i-Butane

Set (I) – Efficiency with and without SF6



HV Working Point

- Mixture with SF_6 90% at 12.3 kV
- Mixture without SF_6 90% at 11.8 kV

The slope of the efficiency curve without SF_6 is steeper than that with SF_6

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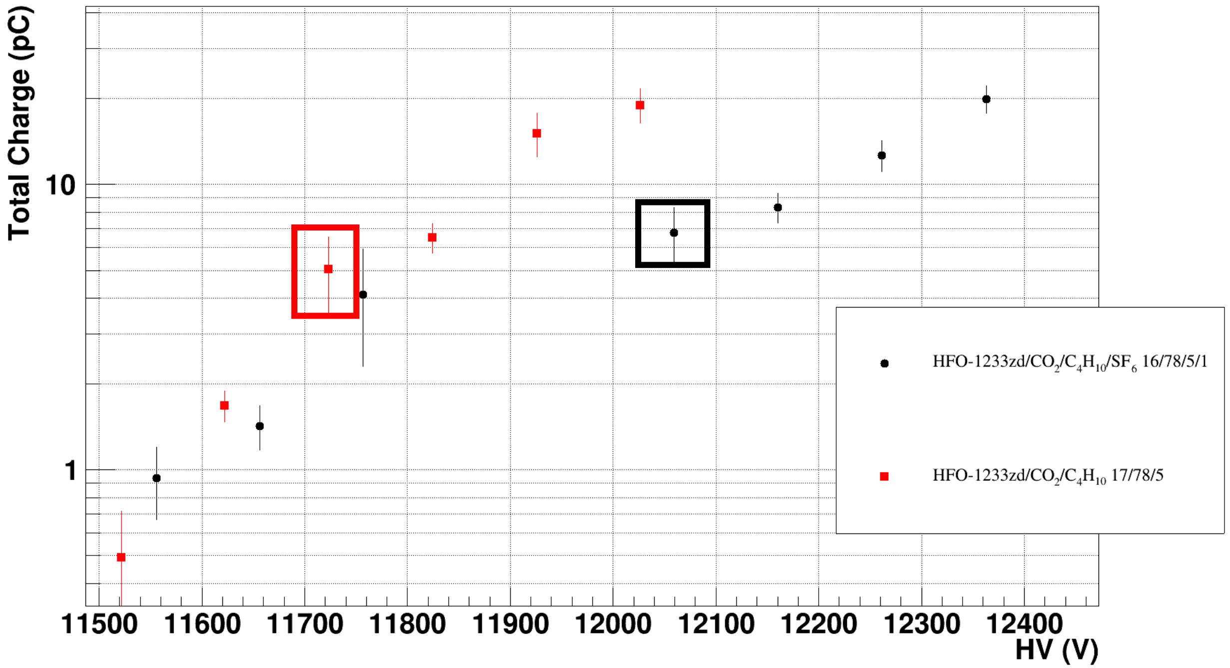
Set (I) – Charge with and without SF6

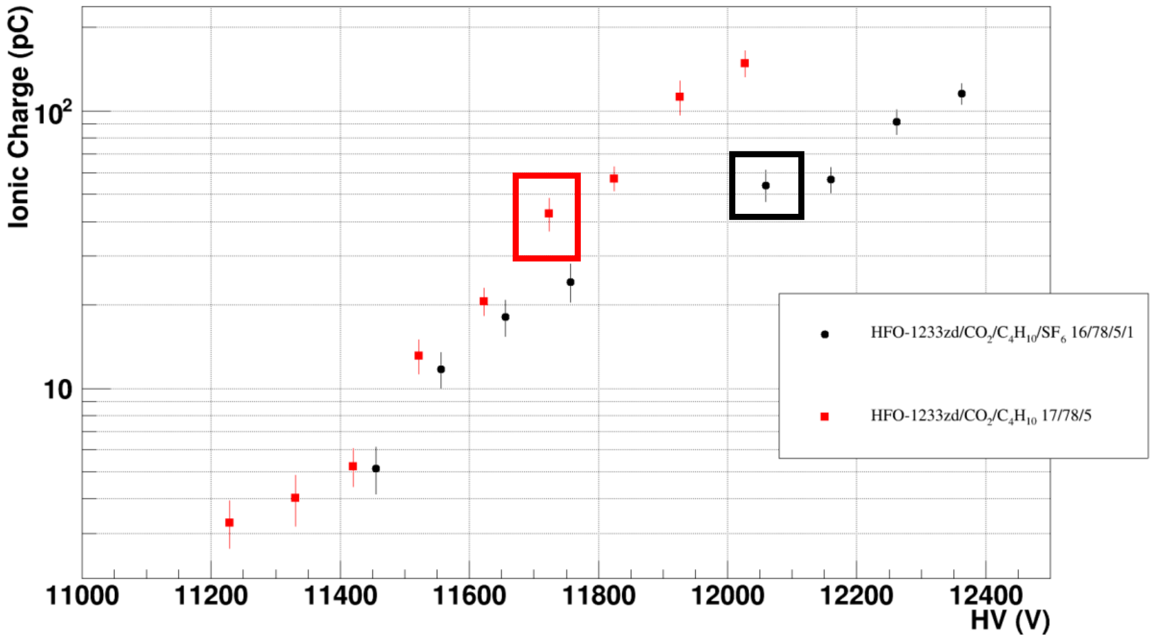
Total Charge vs HV



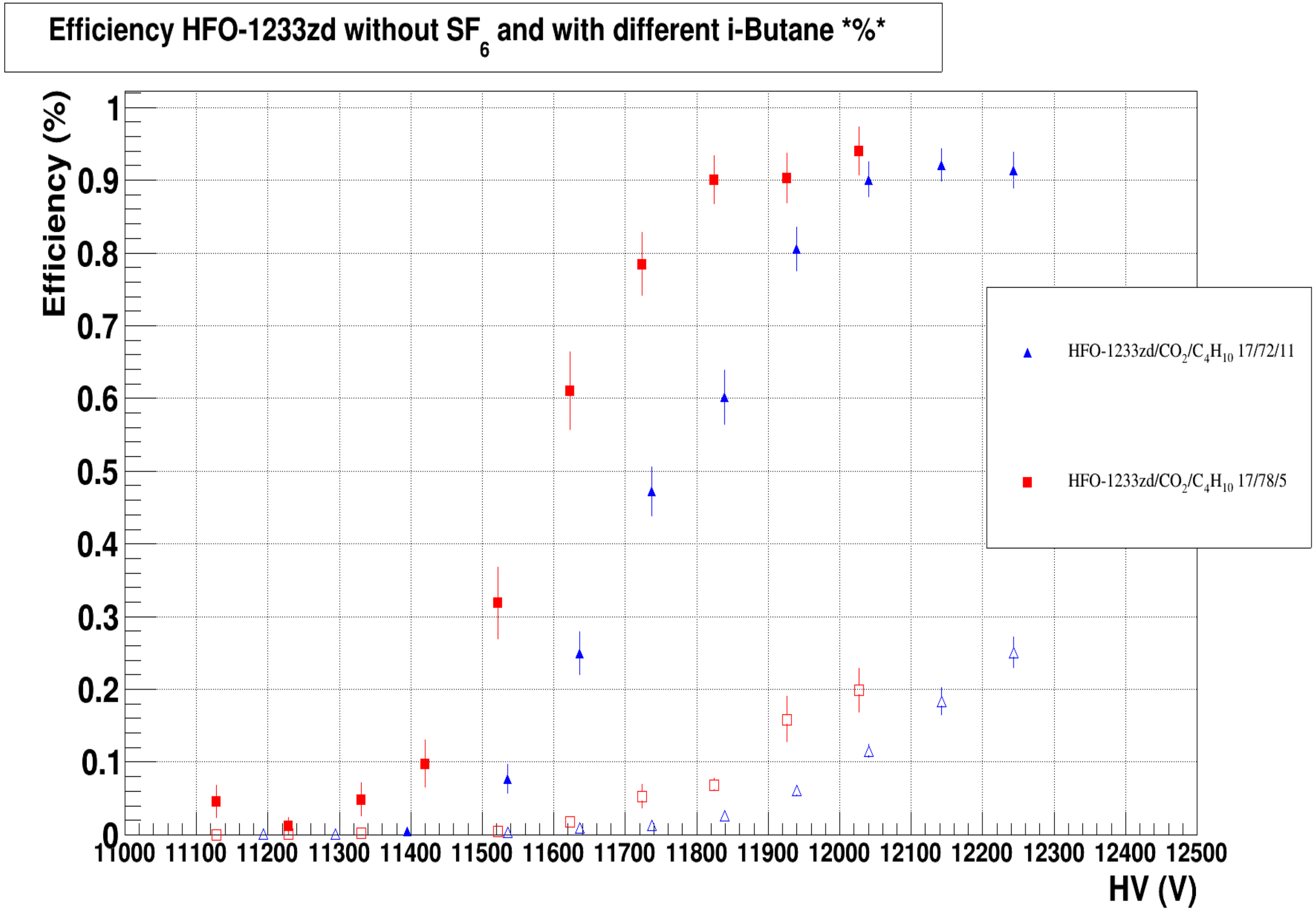
At the Working Point the average prompt charge is **9 pC** for the mixture with SF_6 and **6 pC** for the mixture without SF_6

At the Working Point the average total charge is **70 pC** for the mixture with SF_6 and **57 pC** for the mixture without SF_6

Ionic Charge vs HV



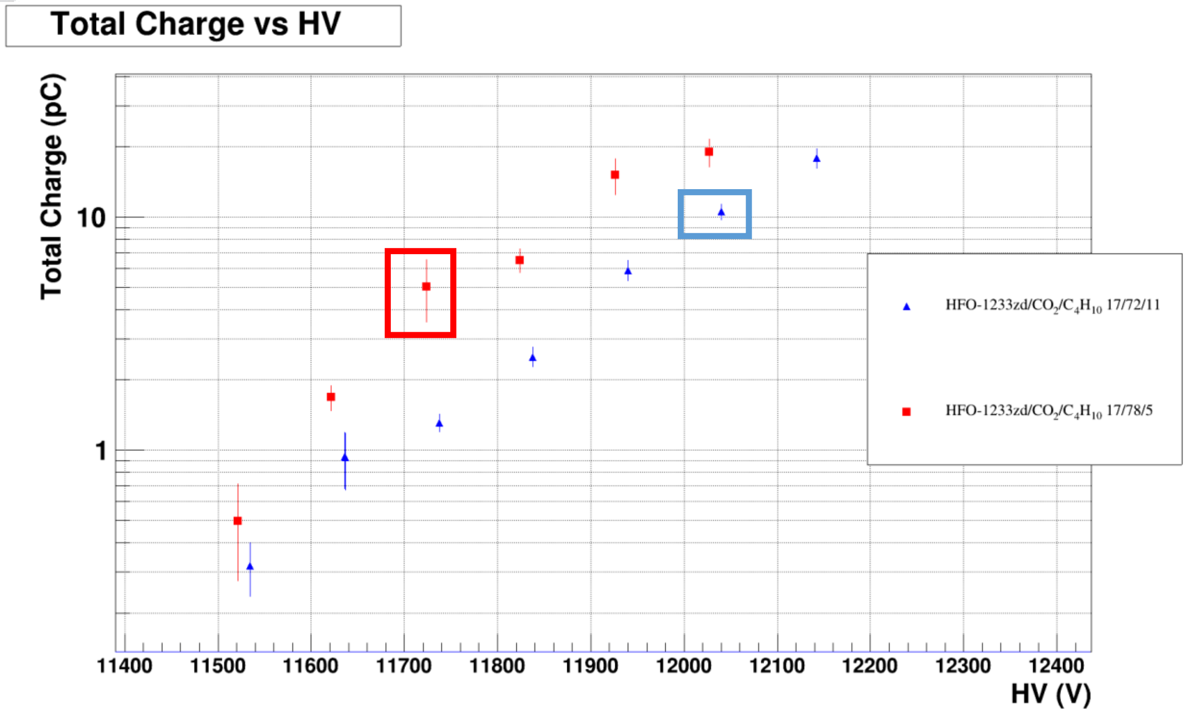
Set (II) – Efficiency with different i-butane percentage



<u>HV Working Point</u>

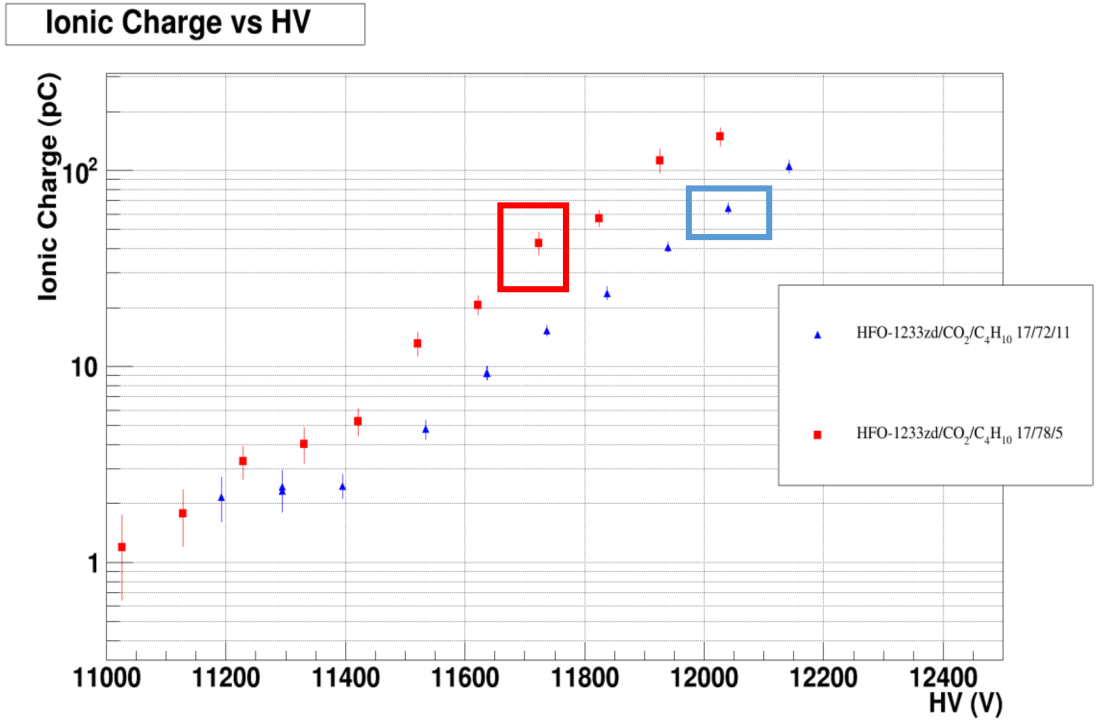
- Mixture with 5% of i-Butane : 90% at 12.3 kV
- Mixture with 11% of i-Butane : 90% at 12 kV

Set (II) – Charge with different i-butane percentage

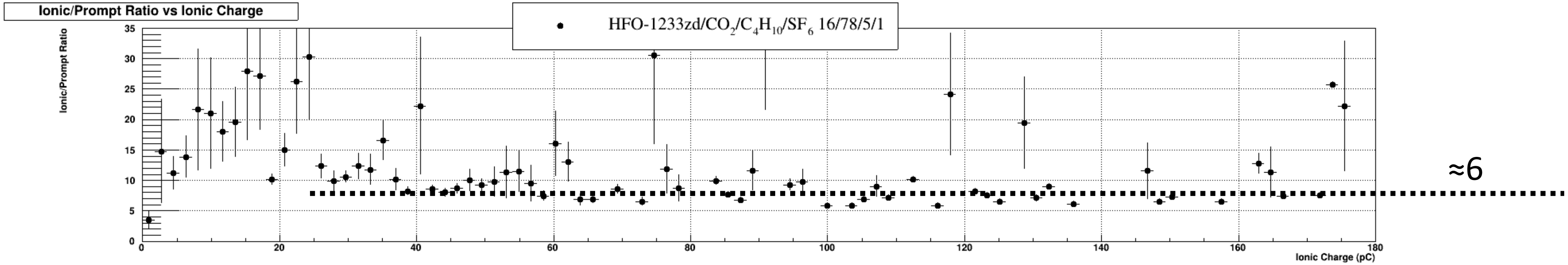


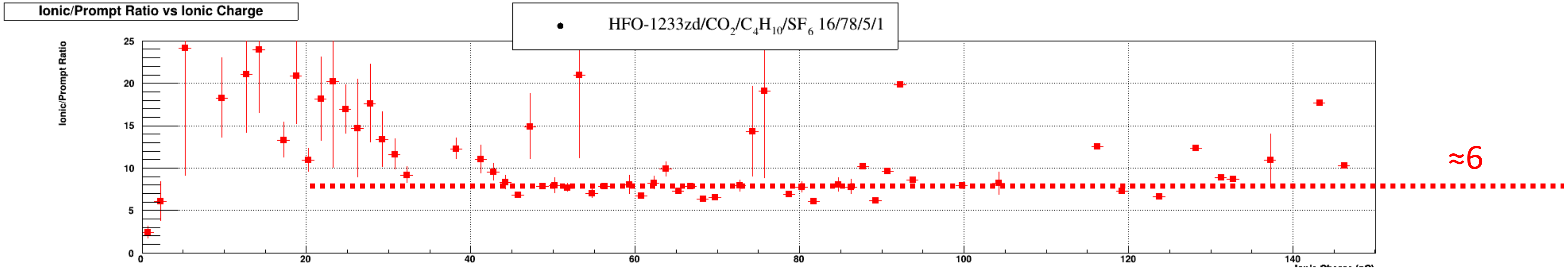
At the Working Point the average total prompt charge is **12 pC** for the mixture with 11 % of i-Butane and **5 pC** for the mixture with 5 % of i-Butane

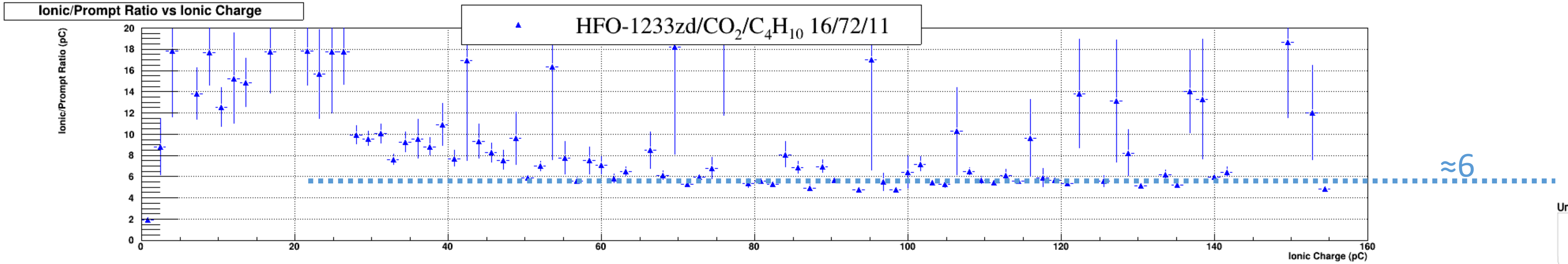
At the Working Point the average ionic charge is **40 pC** for the mixture with 5% of i-Butane and **60 pC** for the mixture with 11% of i-Butane



All HFO-1233zd Mixtures- Ionic/Prompt Ratio







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Conclusions

- SET (I) shows that the quenching effect is mainly due to HFO
- SET(II) shows that the enhancement of the HFO percentage moves the working point to higher voltages and extends the avalanche-streamer separation
- HFO-1233zd
  - Possibility to work without SF6
  - The quenching power is always dominated by the HFO presence
- Next
  - Measurements reducing the HFO fraction

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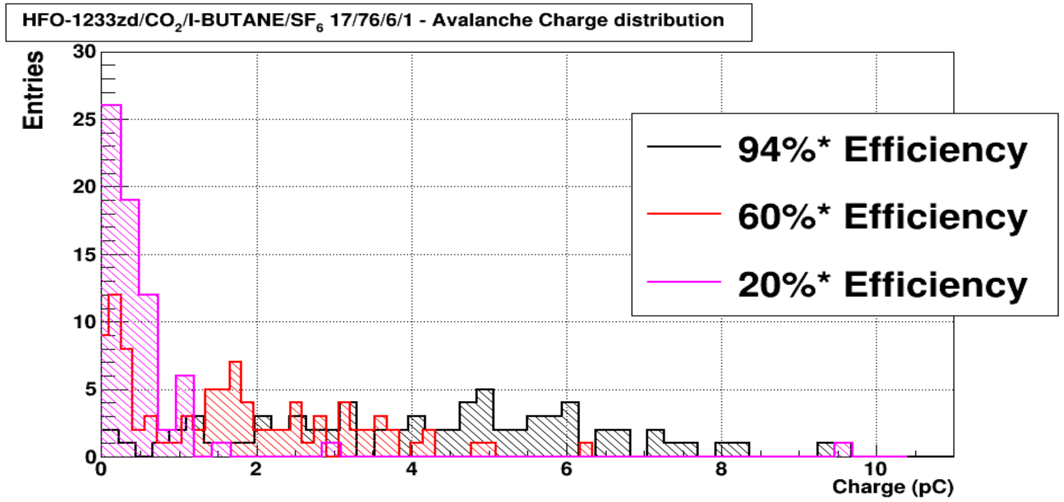
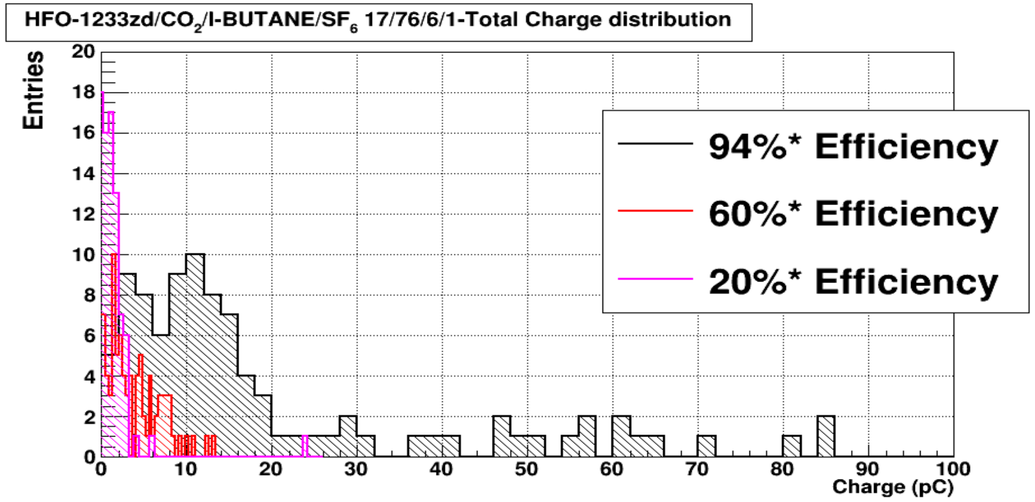
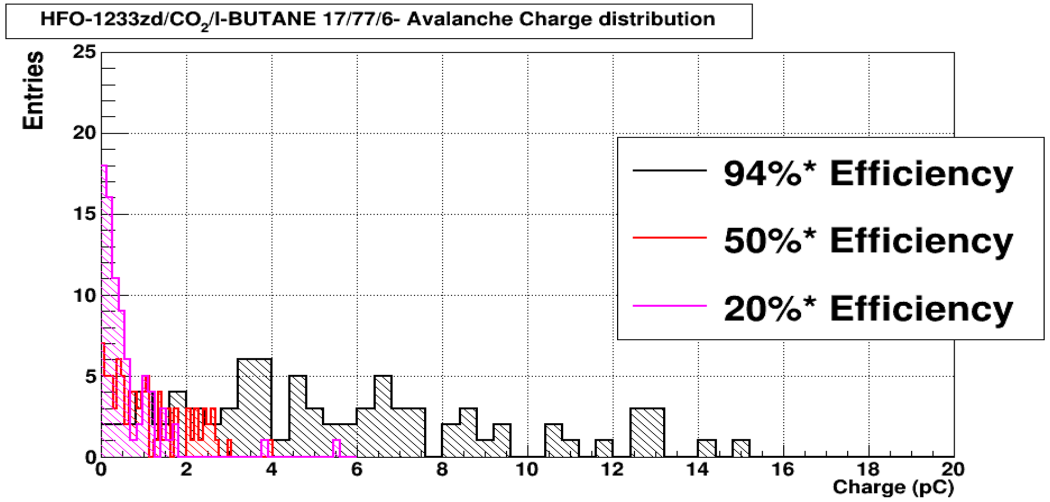
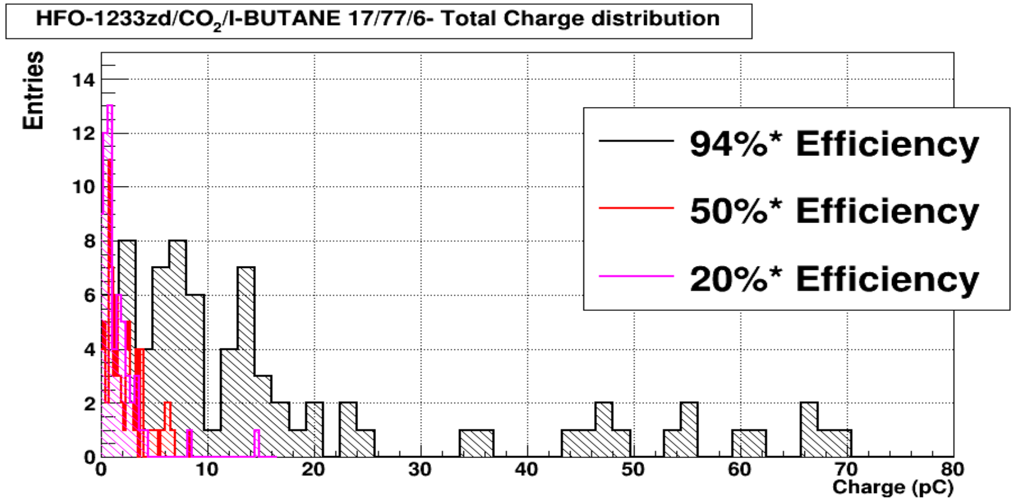
Thank You!

Set (I) – Charge Distribution with and without SF6









Charge integrated over a 10 ns window

Charge integrated over a 200 ns window

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