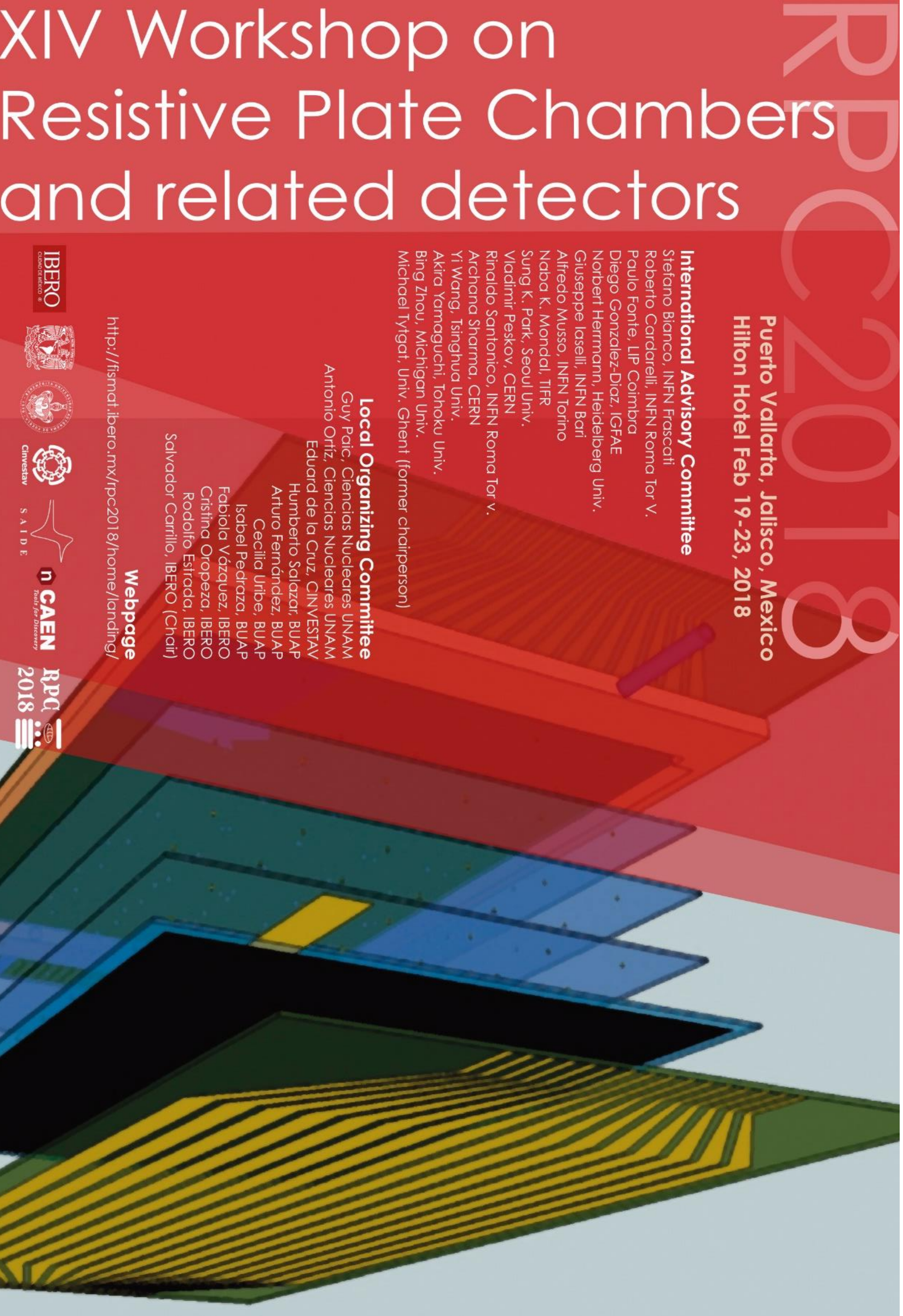

New Eco-gas mixtures for the Extreme Energy Events MRPCs: results and plans

Silvia Pisano*
for the EEE Collaboration

*Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi
and Laboratori Nazionali di Frascati - INFN

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Eco-friendly gas mixture for gaseous detectors: why?

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- **Global Warming Potential** (GWP) measures the greenhouse effect of a gas normalized to CO_2 (GWP_{CO_2}=1)
- Gas mixtures with **GWP > 150** have been banned by EU
- Present RPCs adopt mixtures with high GWP

Example (EEE nominal): 98% $C_2H_2F_4$ + 2% SF_6 ⇒ **GWP = 1889**

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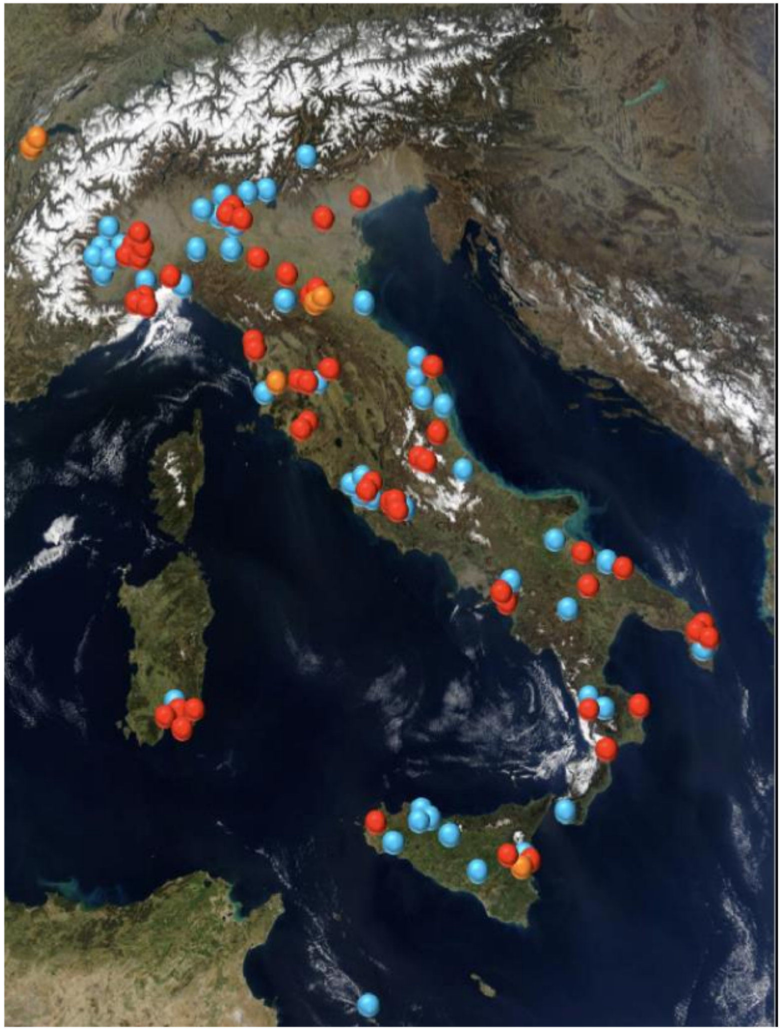
Ecogas tests within the EEE Project

EEE Project: a network of telescopes based on Multi-gap Resistive Plate Chambers for the detection of Extreme Energy Events in cosmic rays

~ 56 stations



Ecogas mixture tests:

⇒ first tests on MRPCs (together with the ongoing tests at high rate – see Yonwook Baek's talk)

⇒ first tests at low rate ($100\ Hz/m^2$)

⇒ see M. Abbrescia's talk on the project upgrade
⇒ see D. De Gruttola's talk on the performances

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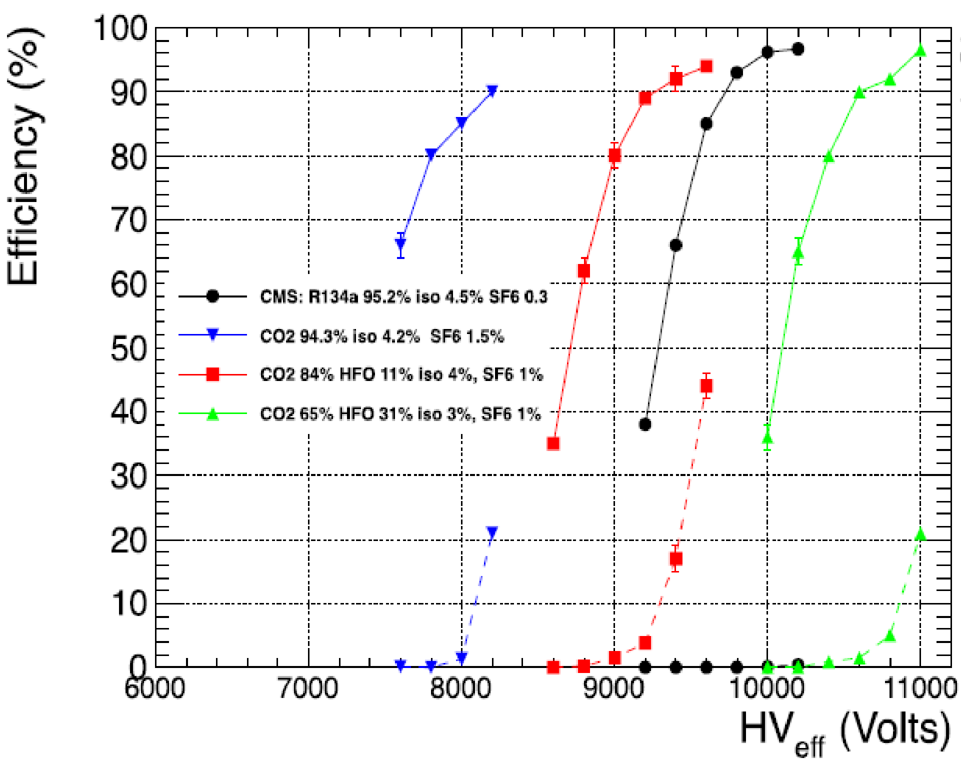
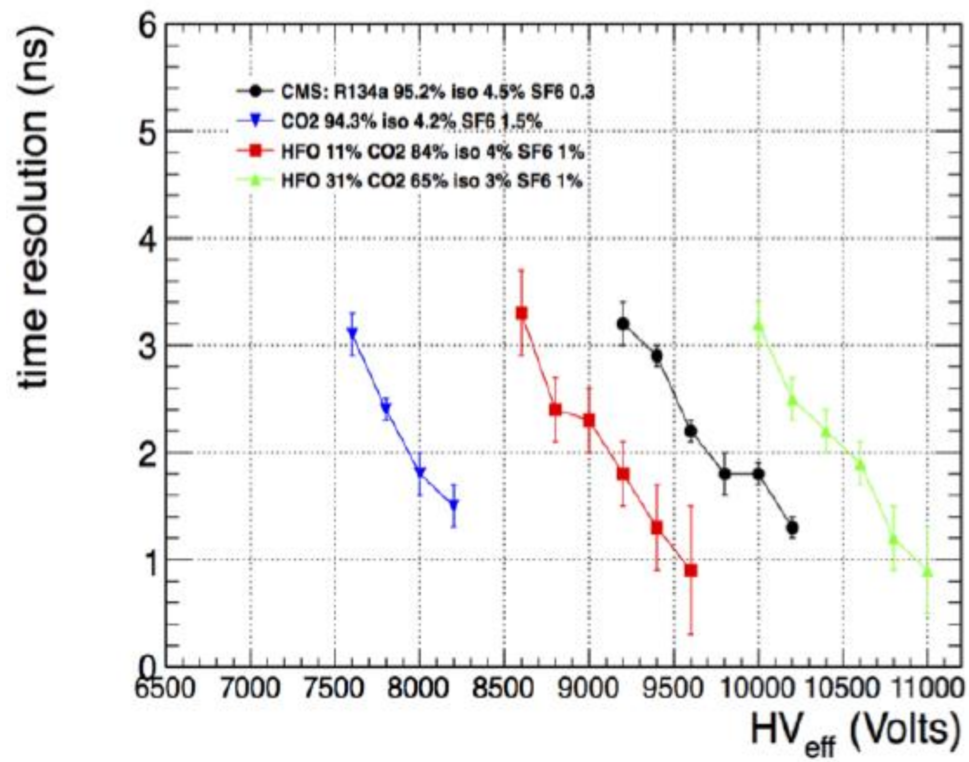
Recent tests on RPCs at high rate

$C_3H_2F_4$ (tetrafluoropropene, HFO, GWP=6) emerged as a good candidate to substitute $C_2H_2F_4$ (GWP=1300) when combined to CO_2 and CF_3I or SF_6





Abbrescia et al. JINST 11 (2016) no.08, P08019

Tests with cosmics at low rates

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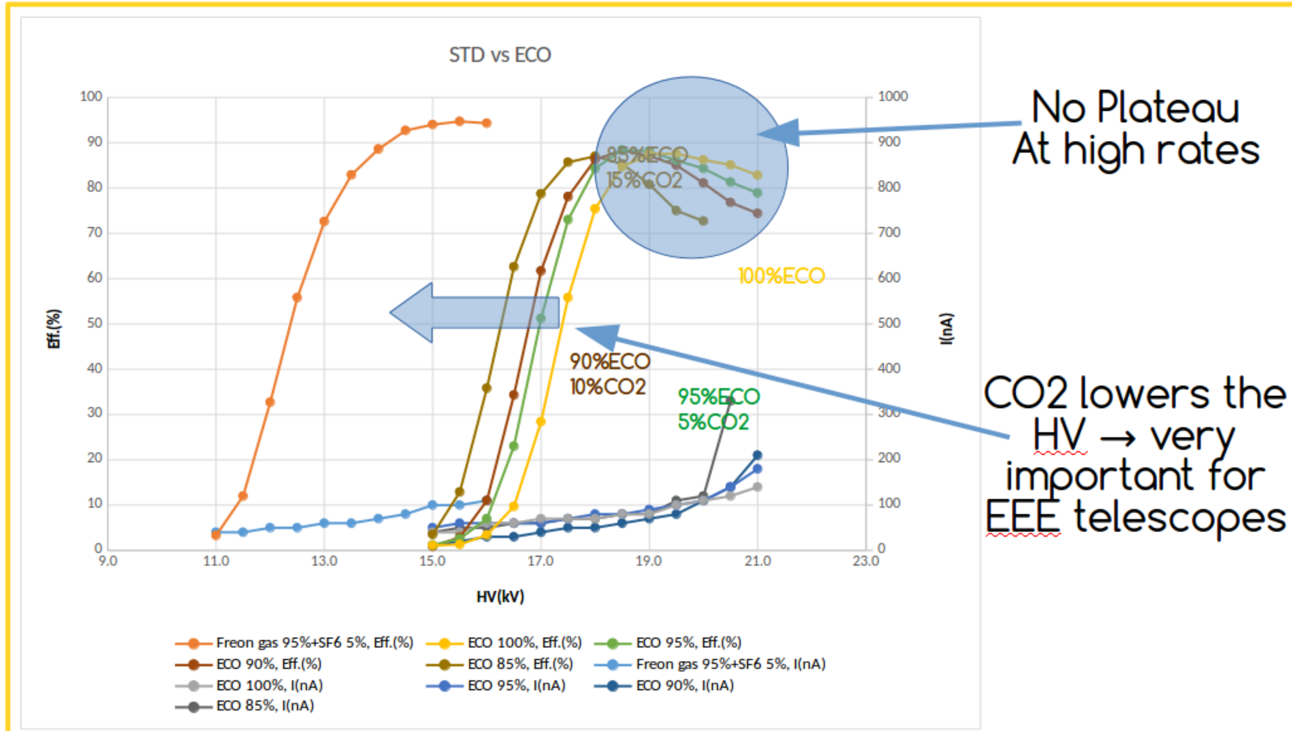
Open questions from high rate studies:

1. Is it possible to reach a stable **plateau** with eco-friendly mixtures at **low rates?**
2. Can the **streamer percentage** be kept **low** enough?
3. Can the HV-lowering by CO_2 observed at high rate be exploited in EEE MRPCs?
4. Can mixtures containing SF_6 be produced still fullfilling ECO requirements?



⇒ See Yonwook Baek talk

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Tests with cosmics at low rates

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Tested mixtures

Pure R1234ze

R1234ze + CO_2
(90/10 – 80/20 – 50/50)

R1234ze + SF_6
(98/2 – 99/1)

CO_2-based mixtures

Original mixture: R134a – tetrafluoroethane
GWP=1300

R1234ze (GWP=6) + CO_2 (GWP=1)
- No limitations on percentages
- streamer % with CO_2 at low rates?
- lower HV?

R1234ze + SF_6 (GWP=23900)
- SF_6 < 0.5%
- likely better in terms of streamer %
- HV above the DC/DC limits

Further combinations being tested:
- CO_2-based combinations
- CF3I (trifluoroiodometane, GWP<5)

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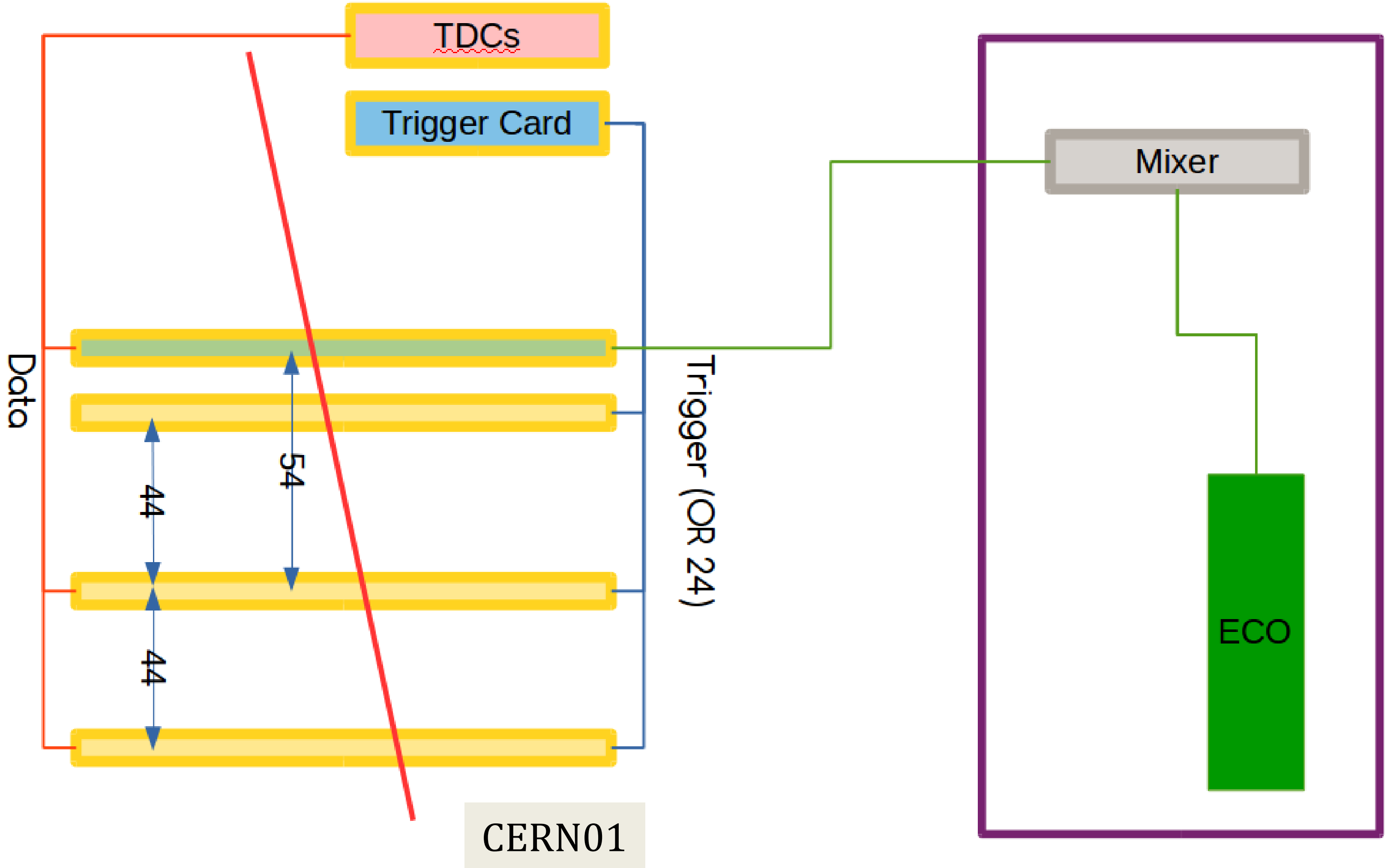
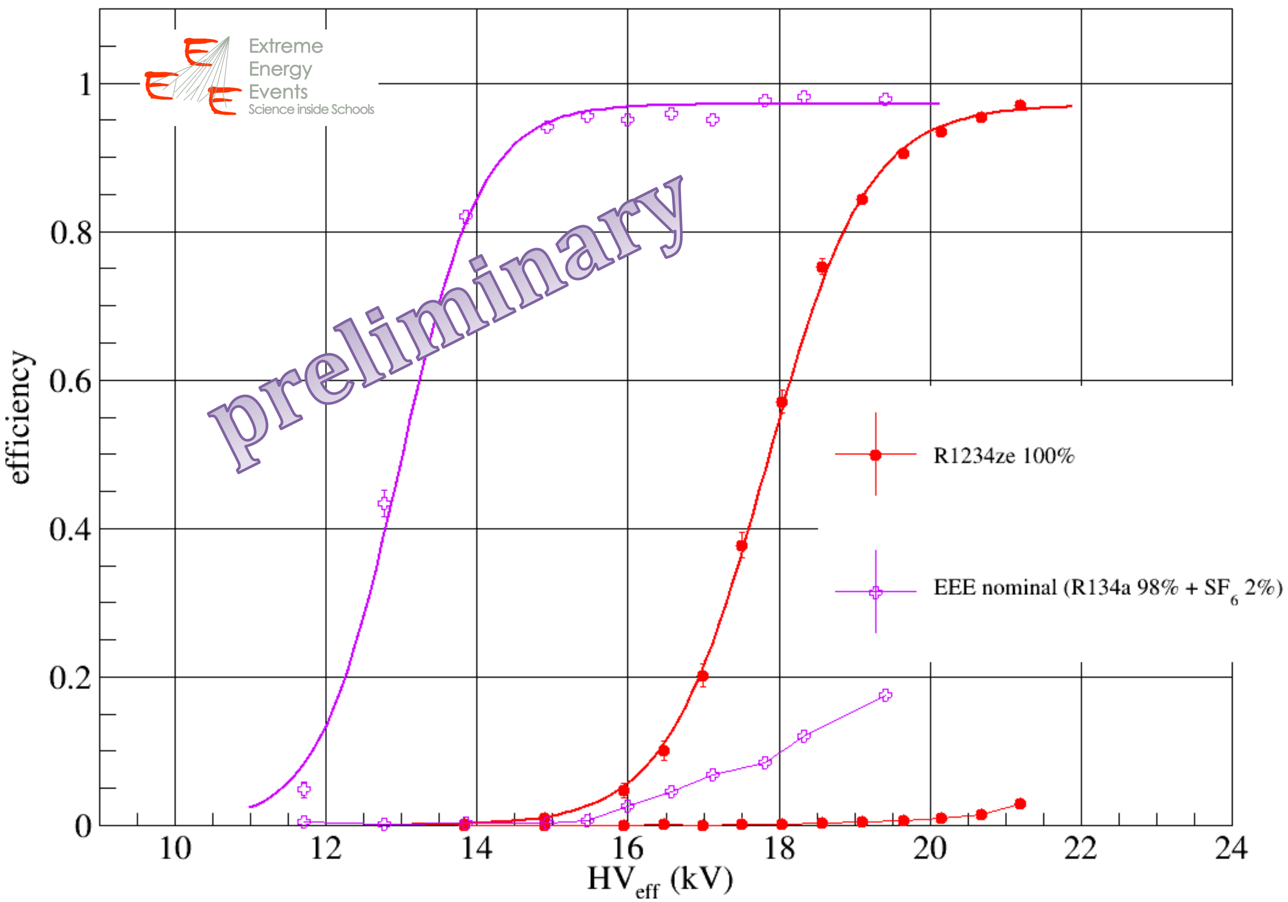
Pure R1234ze



⇒ see D. De Gruttola's talk for details on performances
⇒ see M. Abbrescia's talk on efficiency calculation

Pure R1234ze



- Higher HV setting point with respect to standard mixtures
- streamer percentage under control
- Less noisy behaviour (lower dark currents)
- Stable cluster size
- HV at the limit of the DC-DC converters

Pure R1234ze

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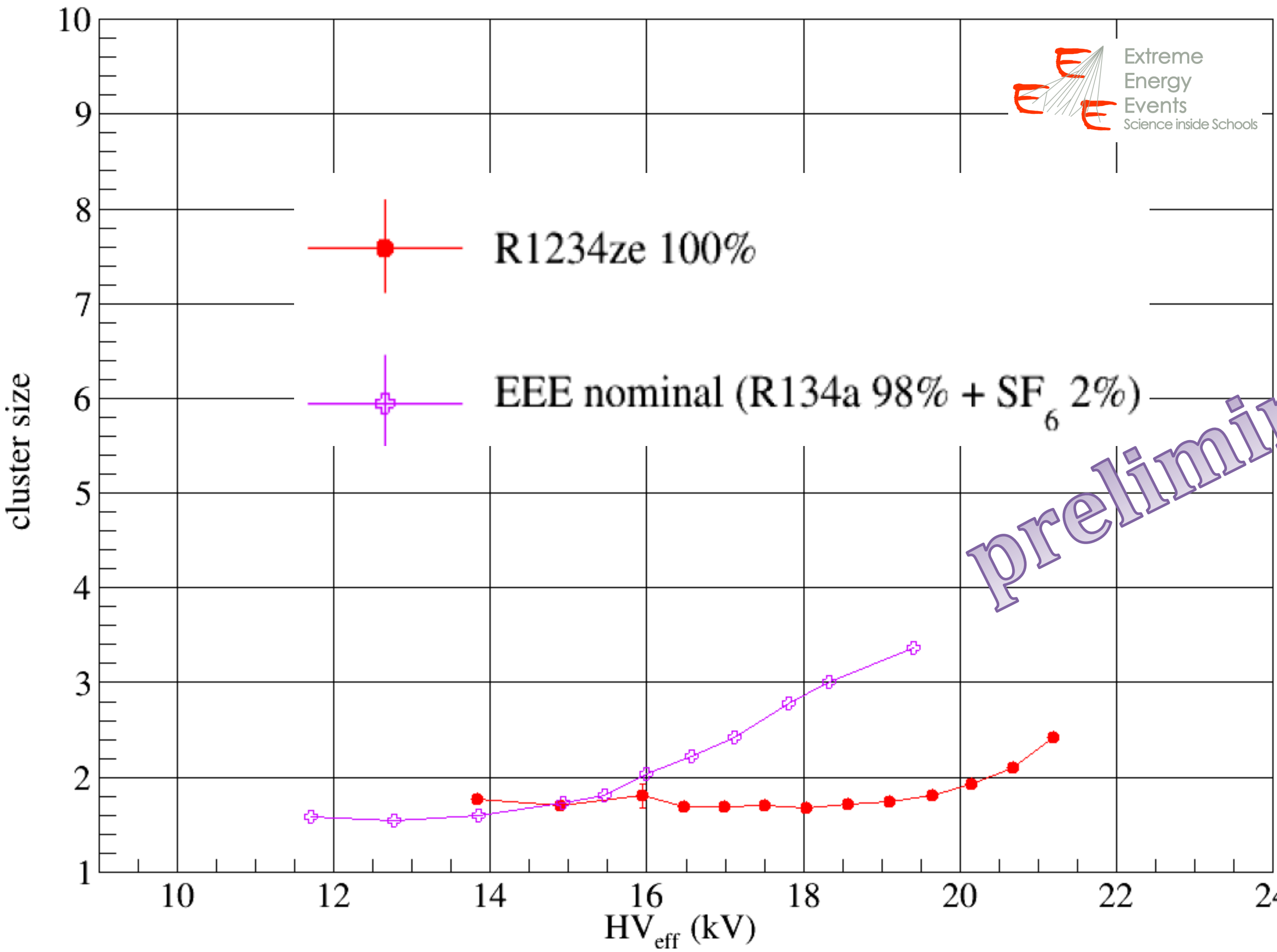

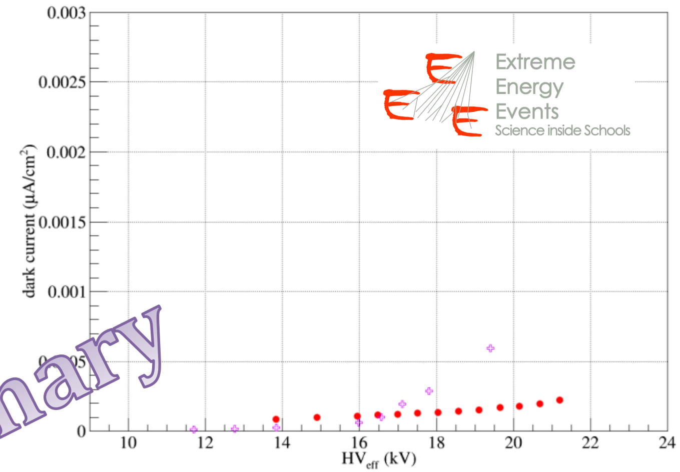

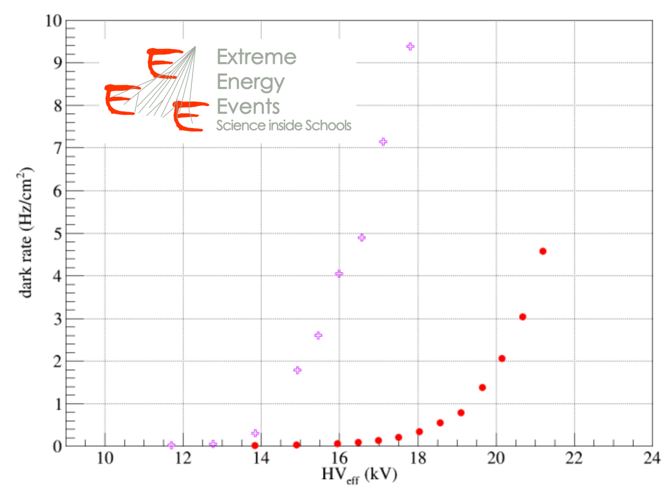

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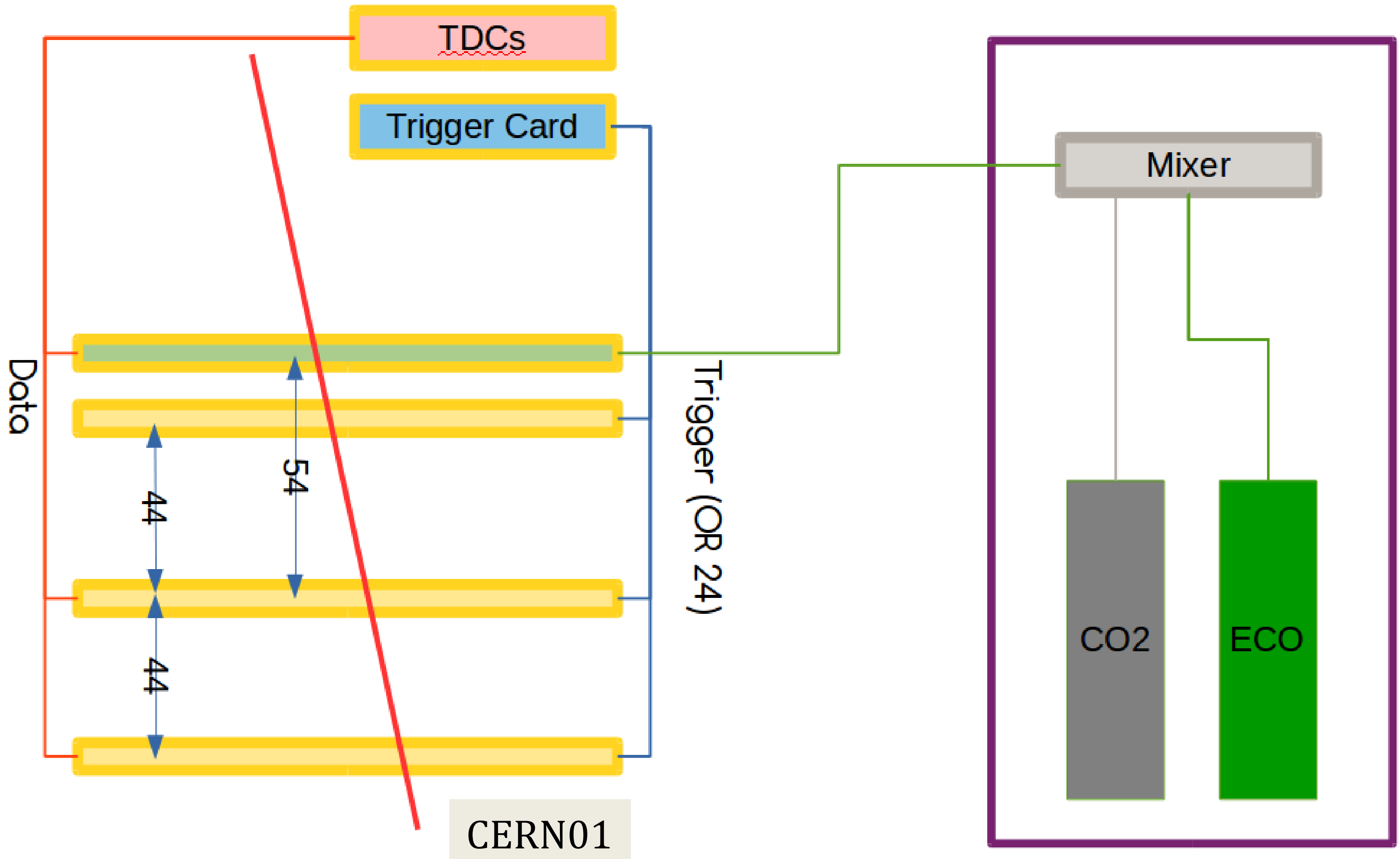
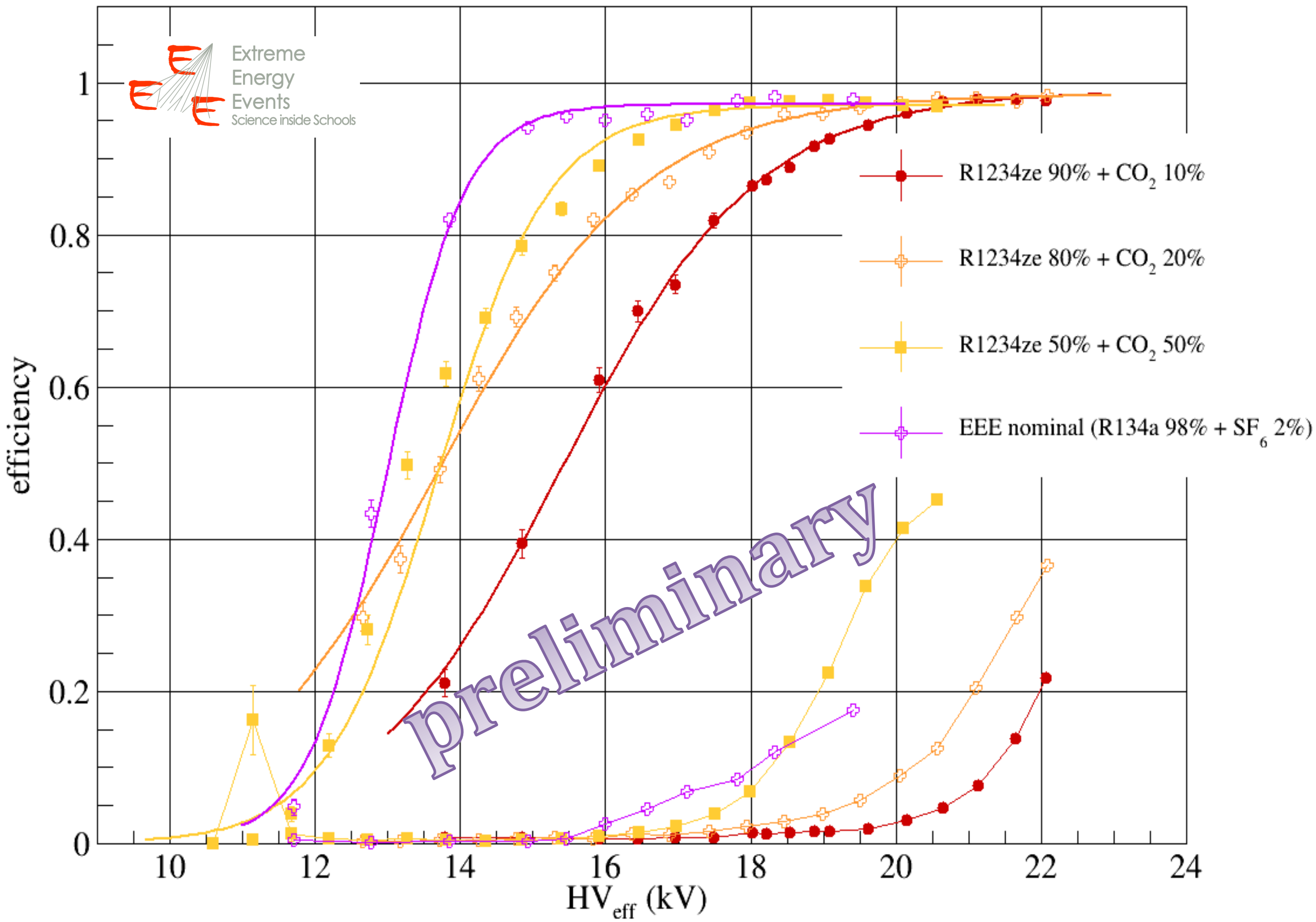
R1234ze + CO_2



TDCs
Trigger Card
Data
Trigger (OR 24)
44
54
44
CERN01
Mixer
CO2
ECO

R1234ze + CO_2



- **Lower HV** setting point with respect to standard mixtures
- However, noisy behaviour observed
- Possible working point under identification (17÷18 kV?) for **R1234ze 50% + CO_2 50%** (but streamer component close to diverge)

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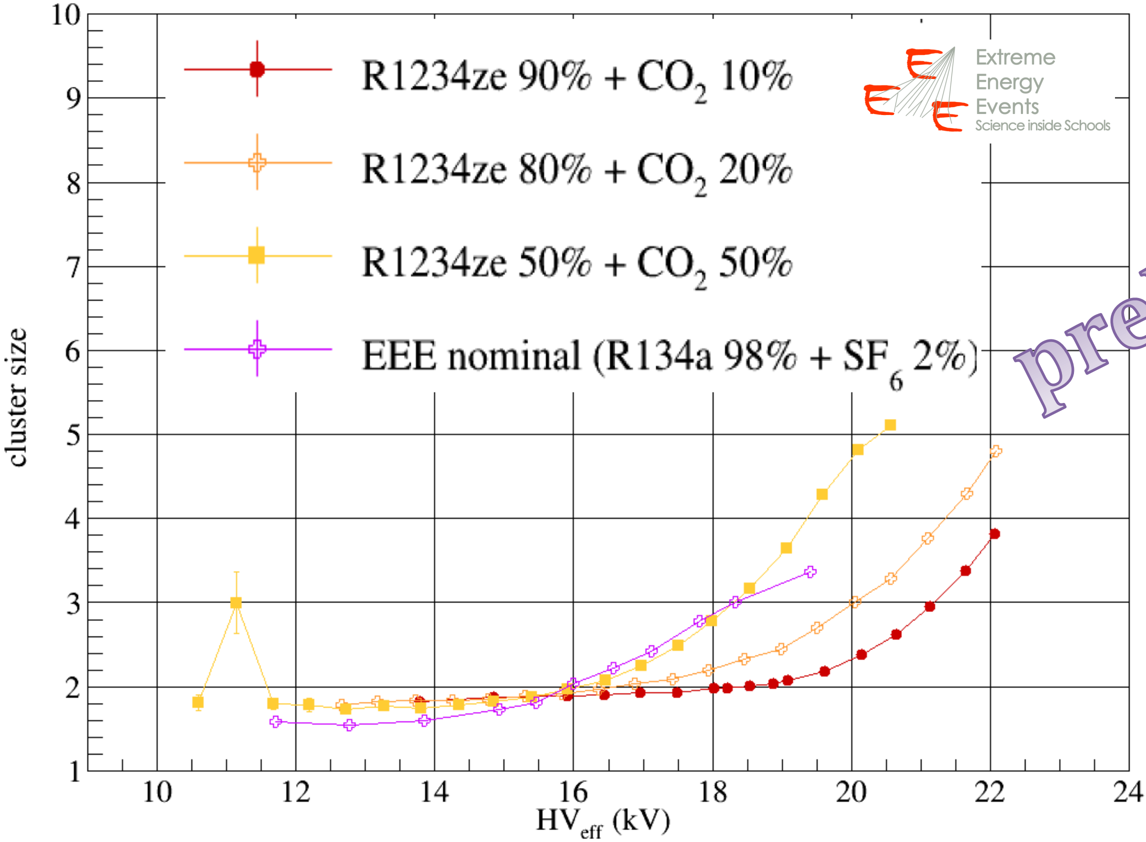
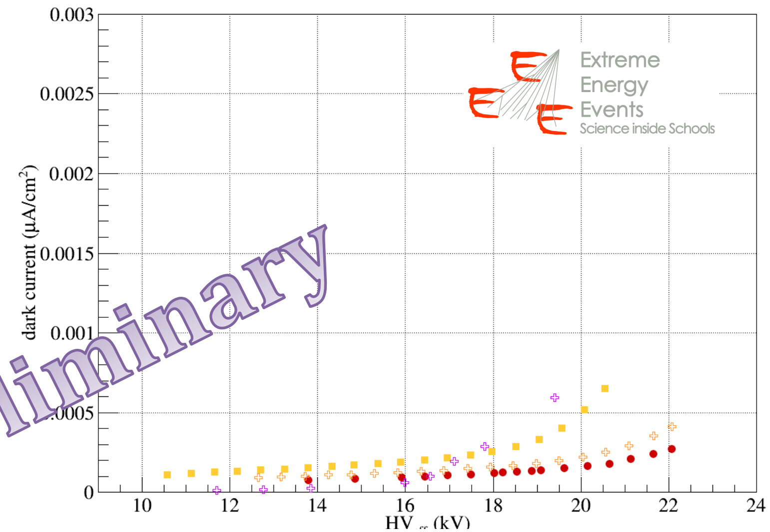
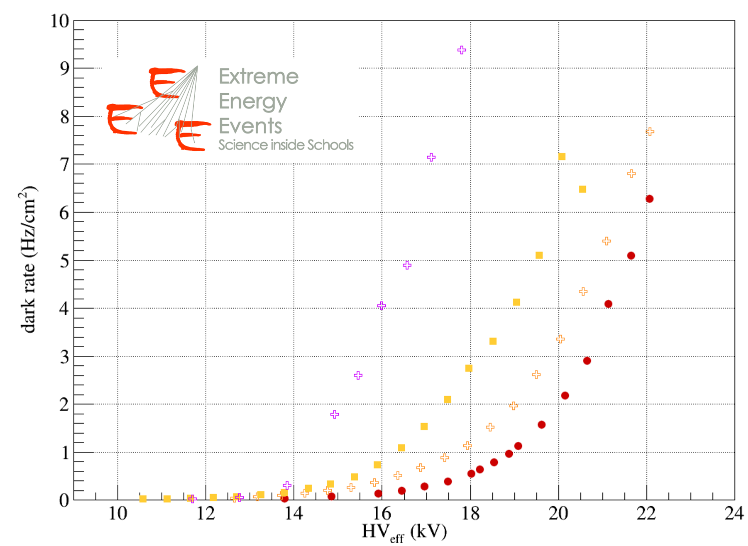
R1234ze + CO_2







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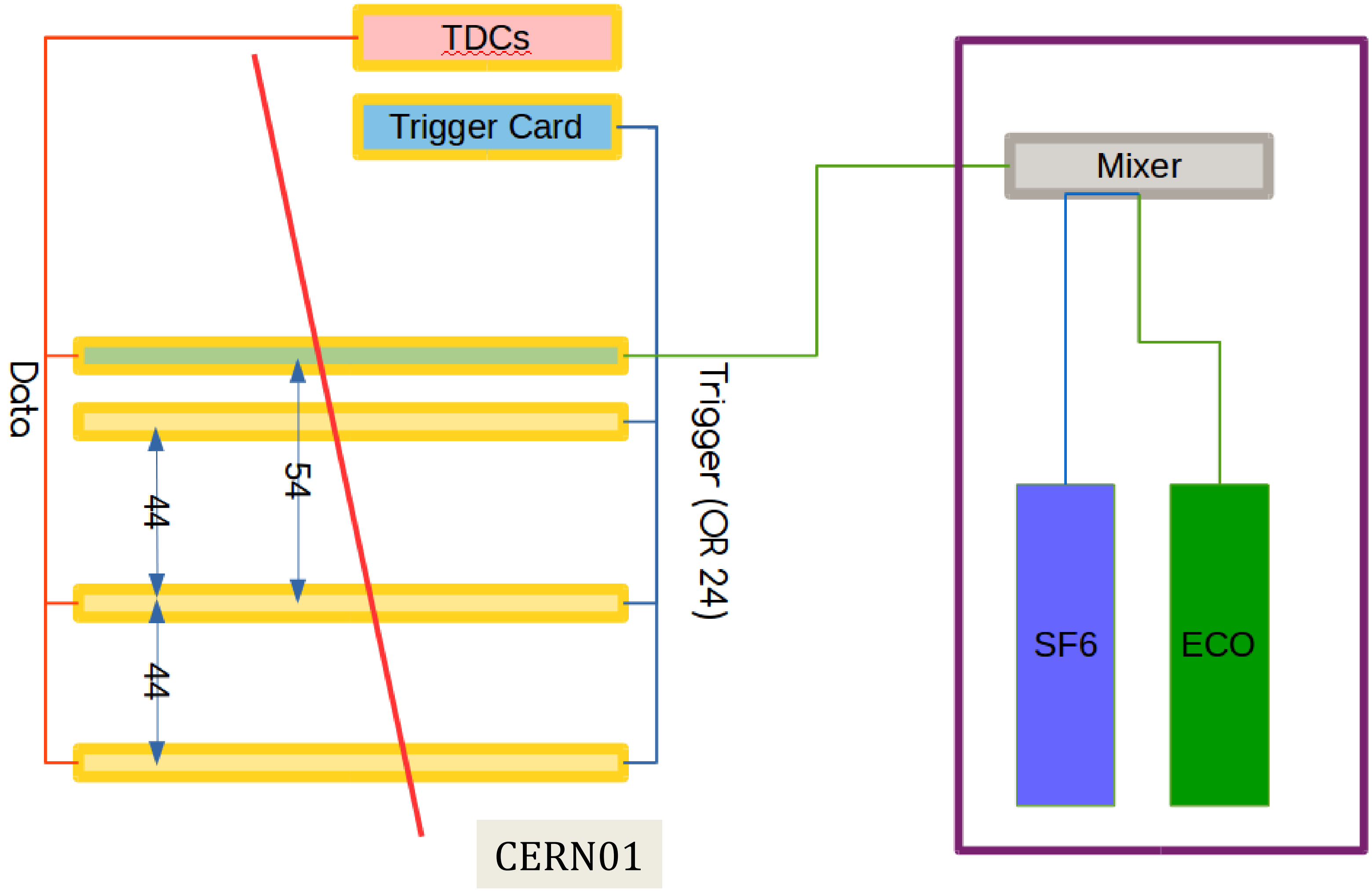
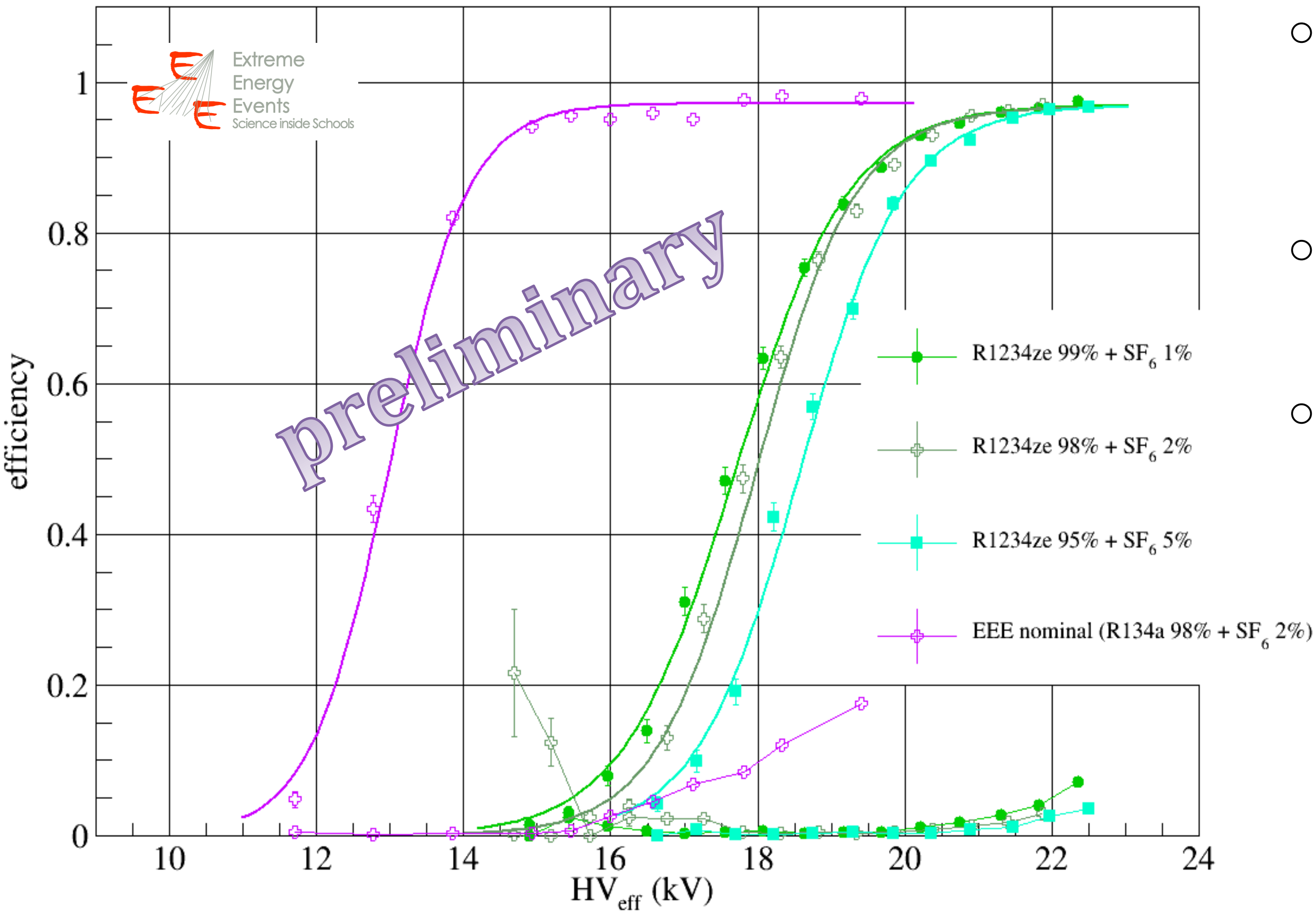
R1234ze + SF_6



TDCs
Trigger Card
Data
54
44
44
Trigger (OR 24)
CERN01
Mixer
SF6
ECO

R1234ze + SF_6



- **Higher** HV setting point with respect to standard mixtures
- However, noise is highly suppressed by SF_6
- **R1234ze 99% + SF_6 1%** ⇒ most promising configuration
  - However, **SF_6 0.5% max percentage to fullfill UE requirements**
  - Future tests on **R1234ze 99.5% + SF_6 0.5%**

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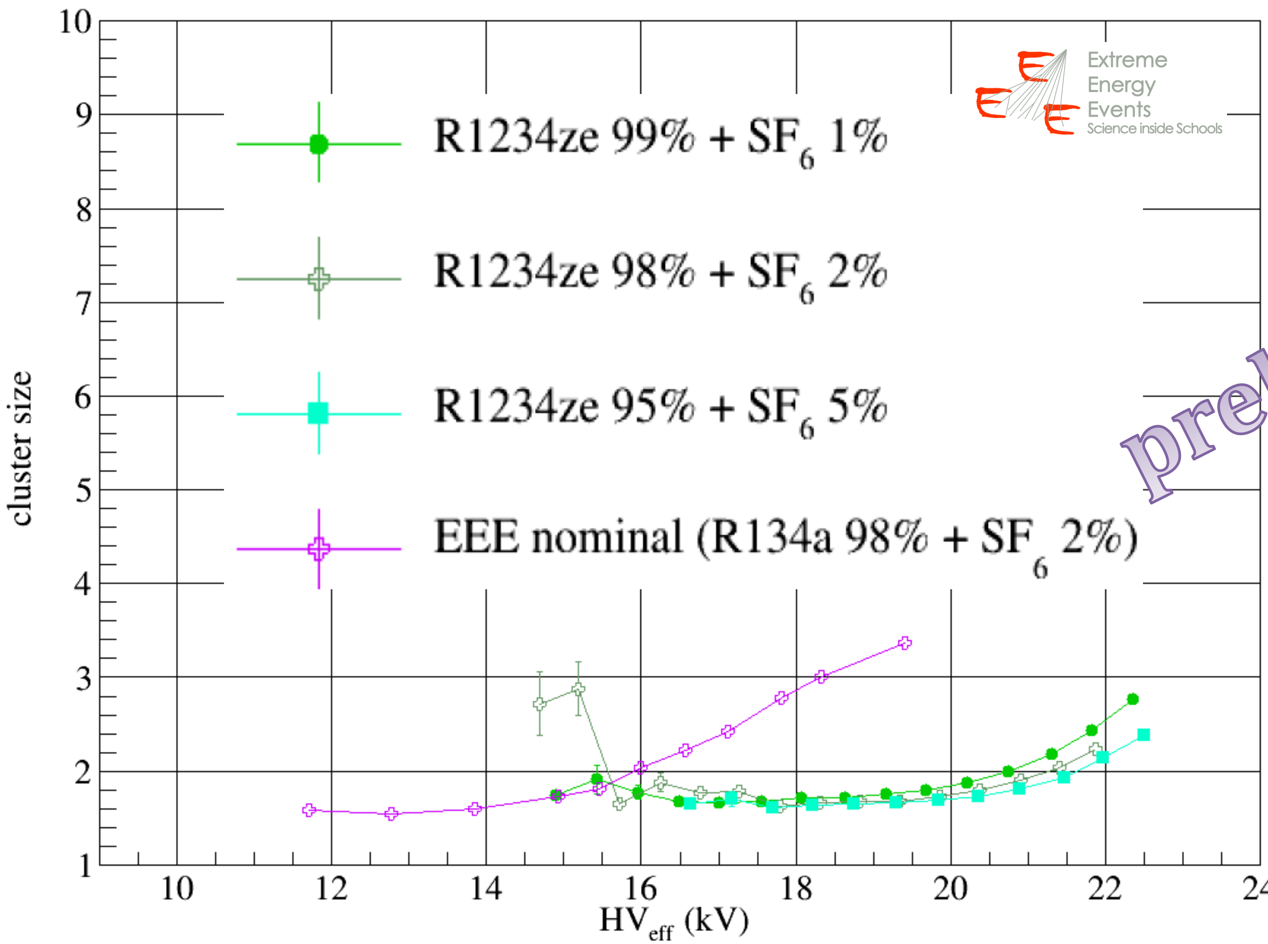
R1234ze + SF_6



cluster size
HV$_{eff}$ (kV)
R1234ze 99% + SF$_6$ 1%
R1234ze 98% + SF$_6$ 2%
R1234ze 95% + SF$_6$ 5%
EEE nominal (R134a 98% + SF$_6$ 2%)
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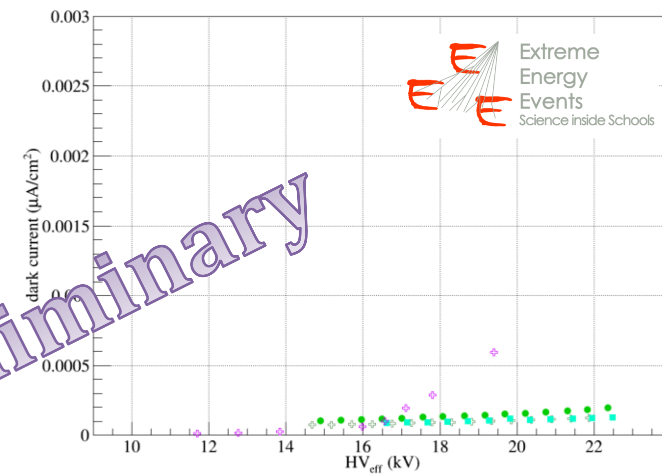
preliminary



dark current (μA/cm^2)
HV$_{eff}$ (kV)
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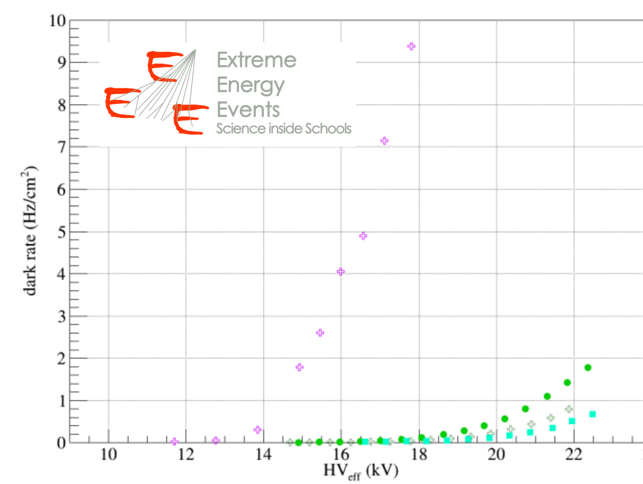

dark rate (Hz/cm^2)
HV$_{eff}$ (kV)
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CO_2-based mixtures

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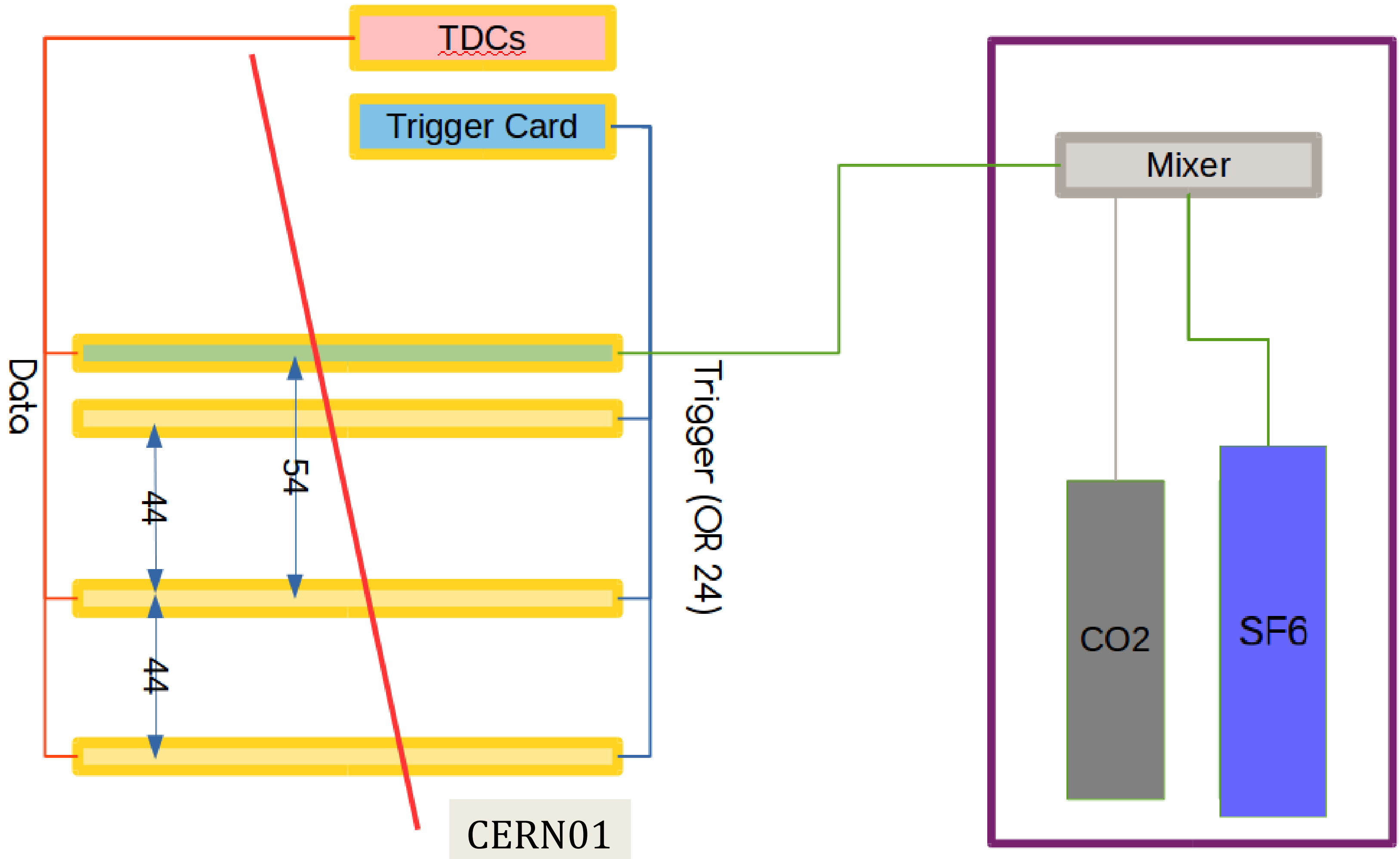

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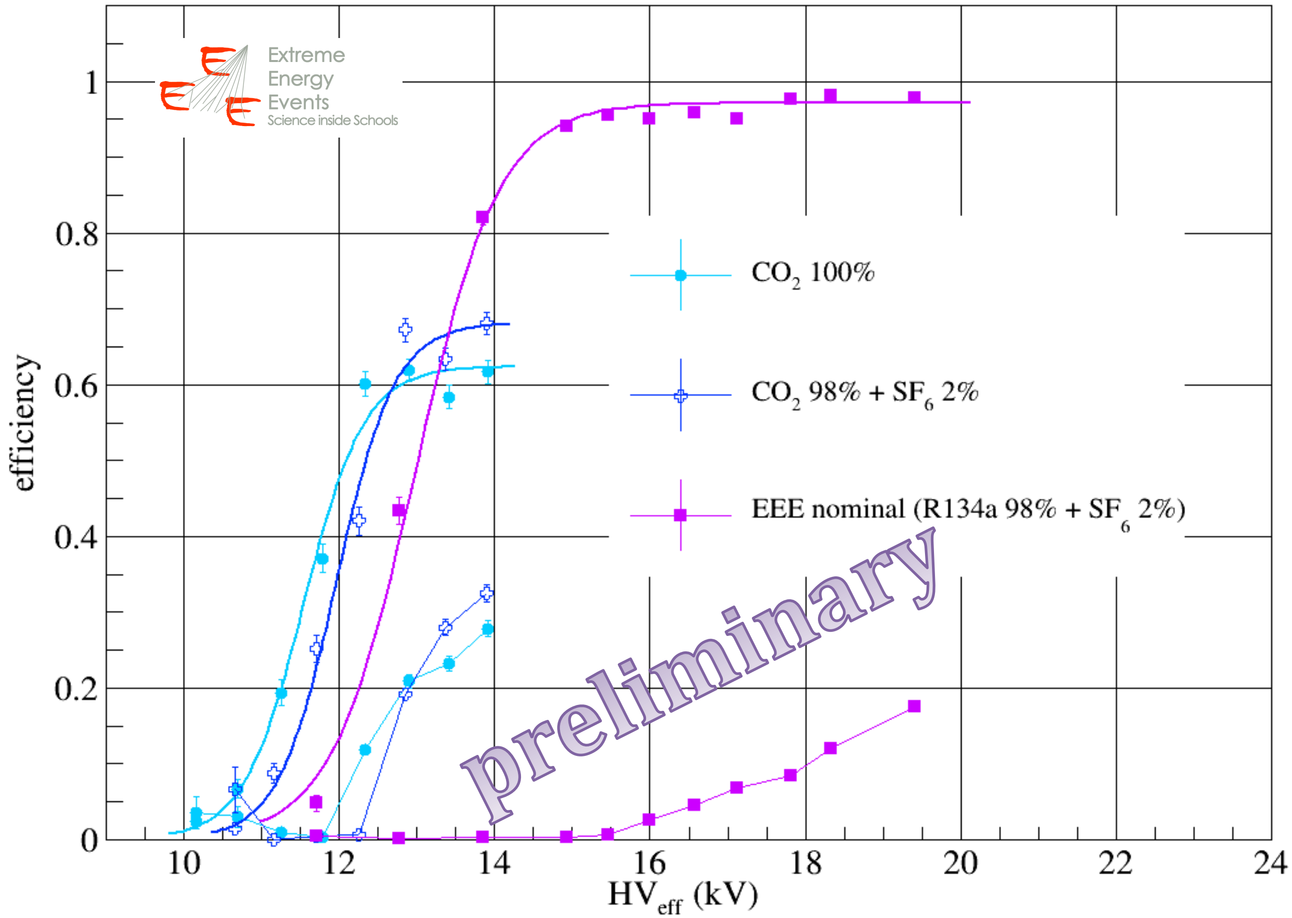
CO_2-based mixtures



- **Very low** HV setting point with respect to standard mixtures
- However, very noisy configuration
- Efficiency too low (~0.6)

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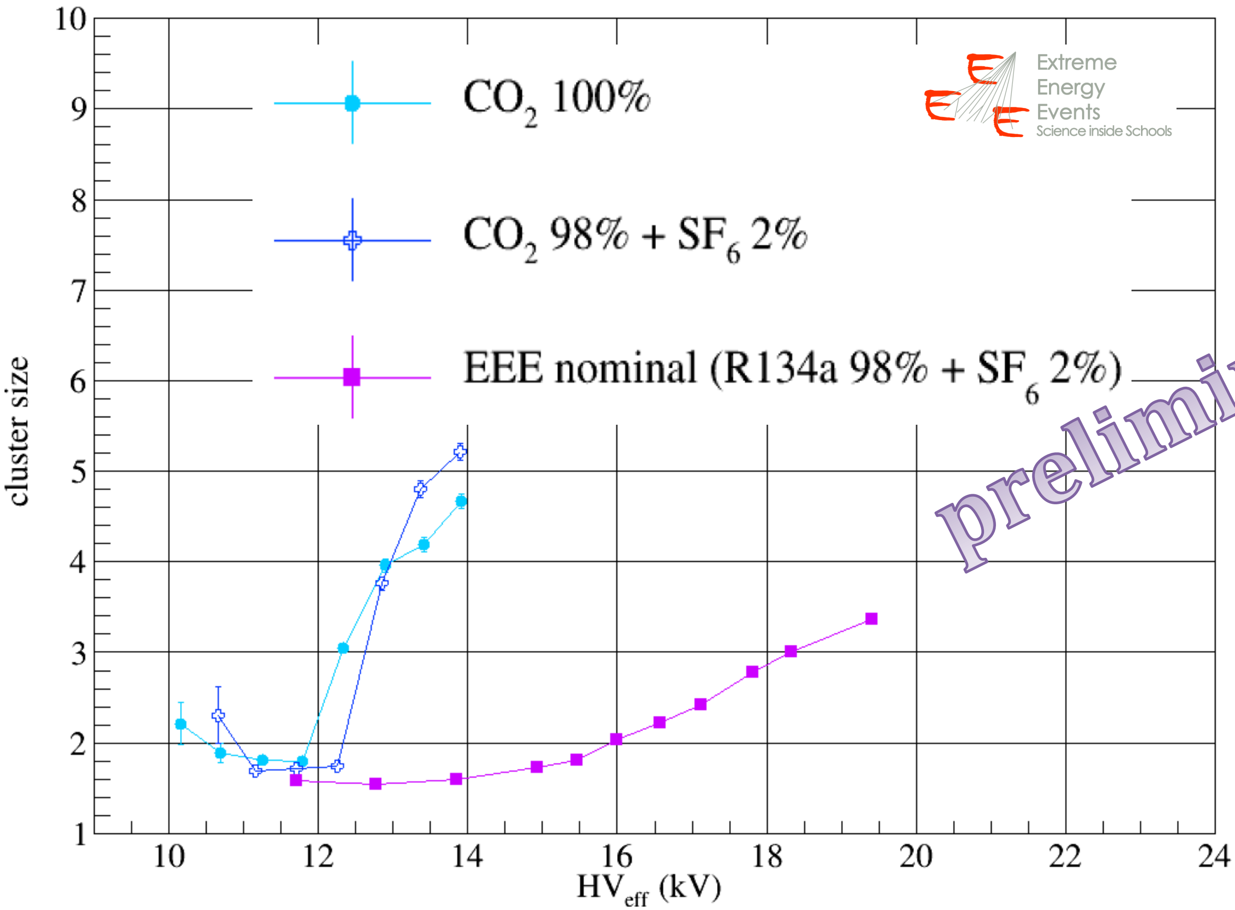
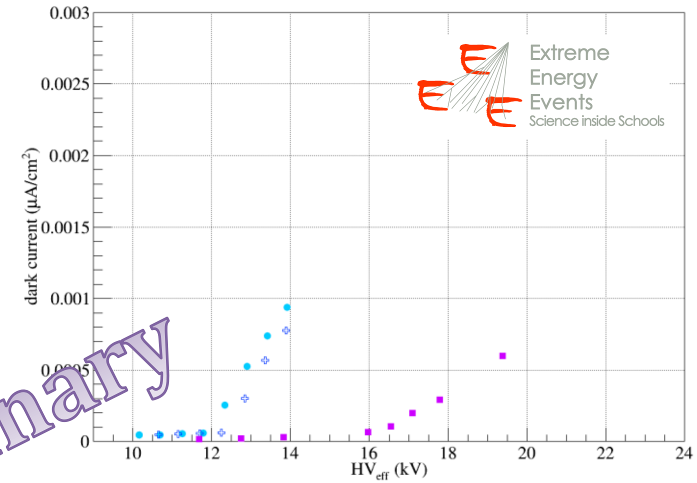
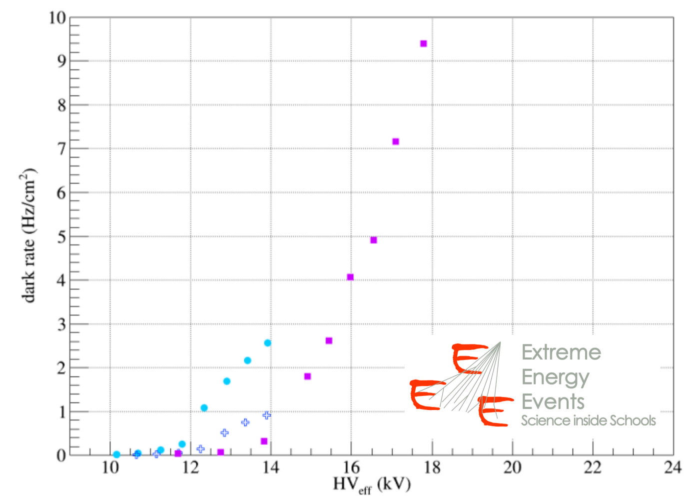
CO_2-based mixtures







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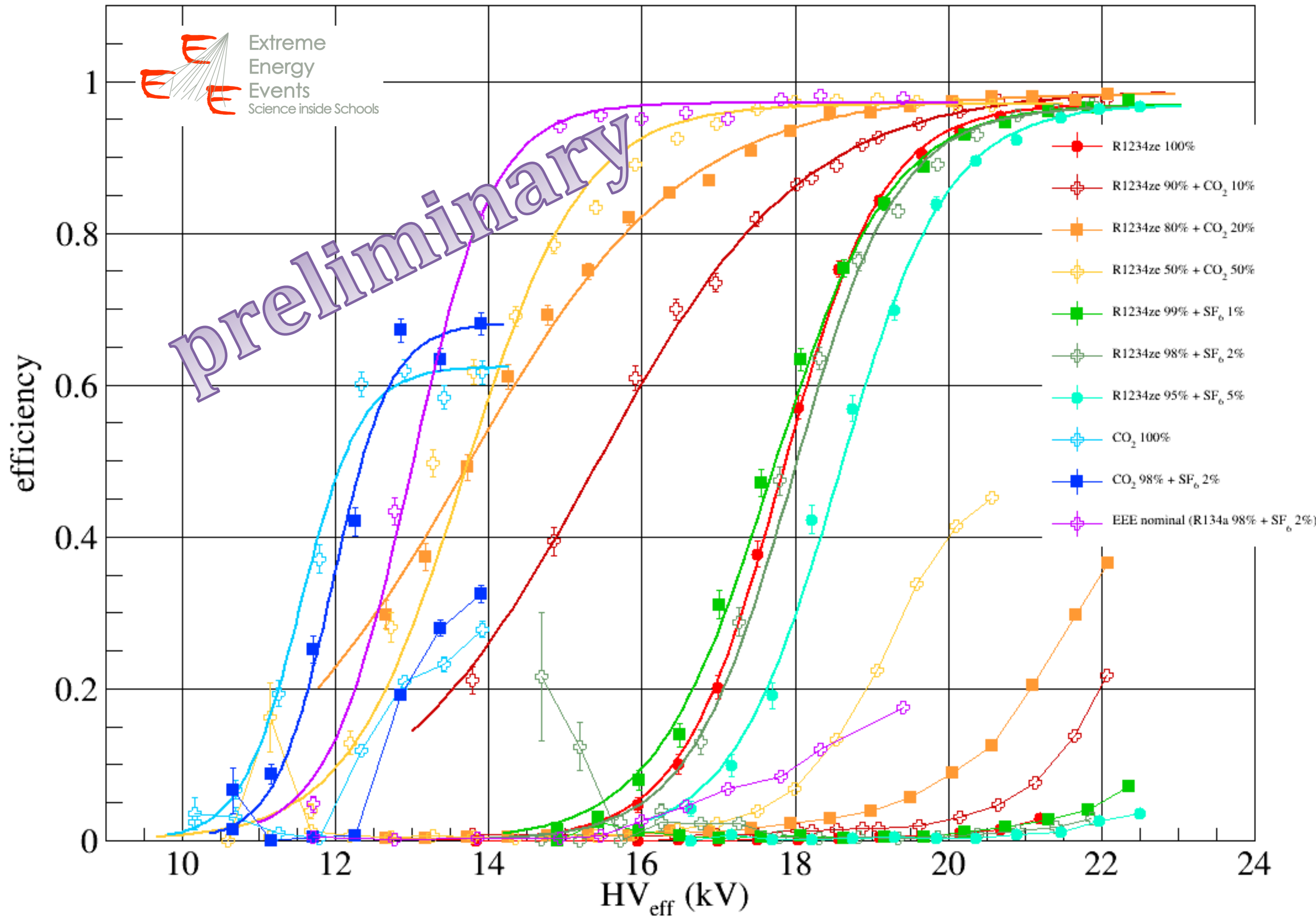
Conclusions

A **stable plateau** can be reached in the low rate configuration

CO_2 significantly lowers the working point for HV, but is very noisy

CO_2-based mixtures not efficient

SF_6 is the best candidate as a quencher, but only a very small component is allowed by UE requirements (0.5% max)



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Conclusions

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- First tests on MRPCs at low rate

- Stable plateau observed ⇒ possible HV working points can be identified

- **R1234ze 99% + SF_6 1%, R1234ze 50% + CO_2 50%** most promising configurations ⇒ under balancing now

- In few months, some stations will be equipped with the best eco-friendly mixtures for testing in full operational mode on a longer time scale

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backup

Tests with MRPCs at high rate at CERN

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⇒ See Yonwook Baek talk

Experimental setup

- T10 East Area
- 7 GeV, 60 mrad, Spill: 0.3 s, max intensity 10^6 N/s
- Pions (protons and muons also available)
- Nominal 10^3N/s-10^4N/s, 400 events per spill acquired (sw limit)

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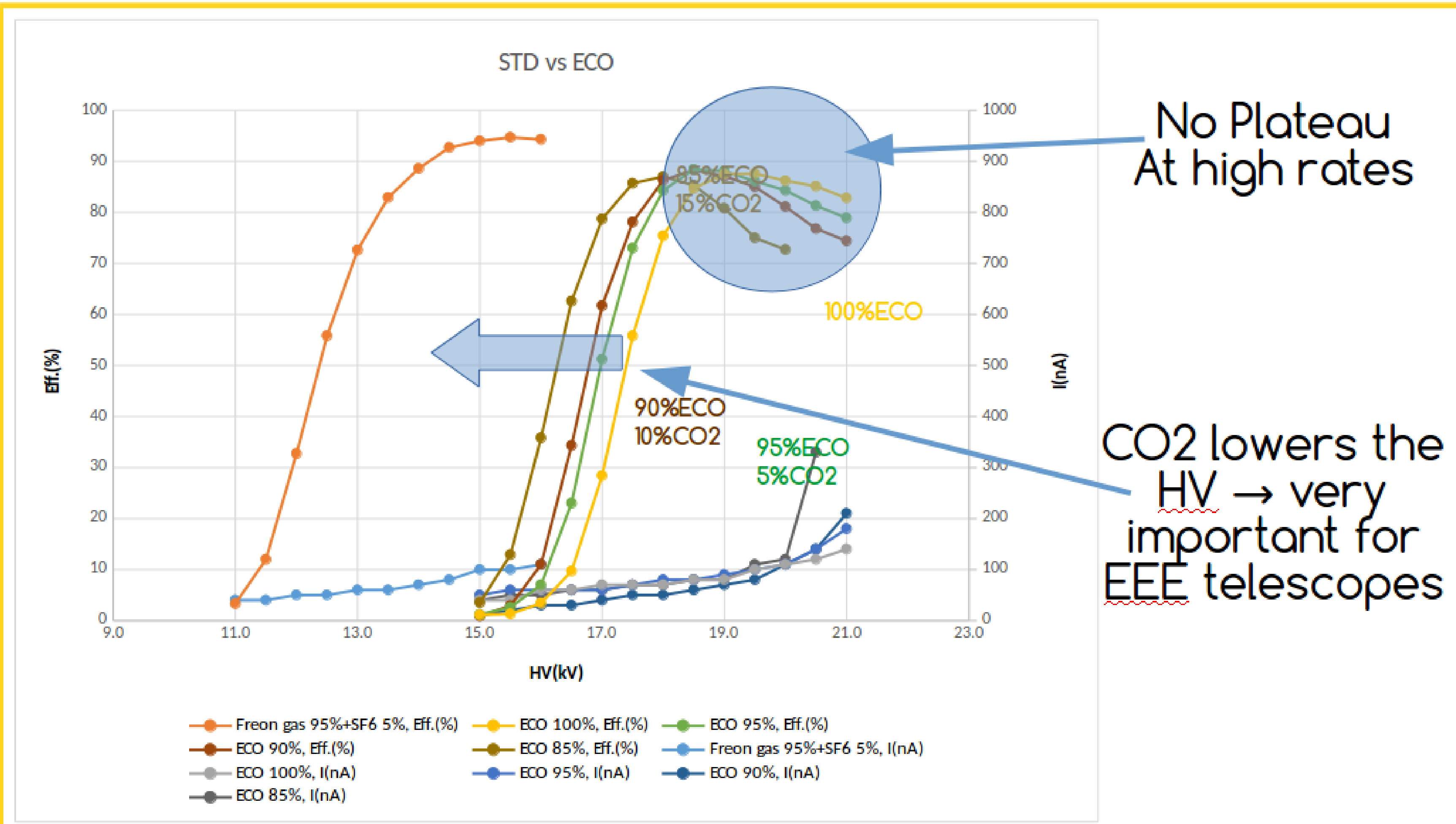
Tests with MRPCs at high rate at CERN

95% R124a + 5% SF_6
vs. R1234ze + CO_2 mixture

⇒ See Yonwook Baek talk



Tests with MRPCs at high rate at CERN

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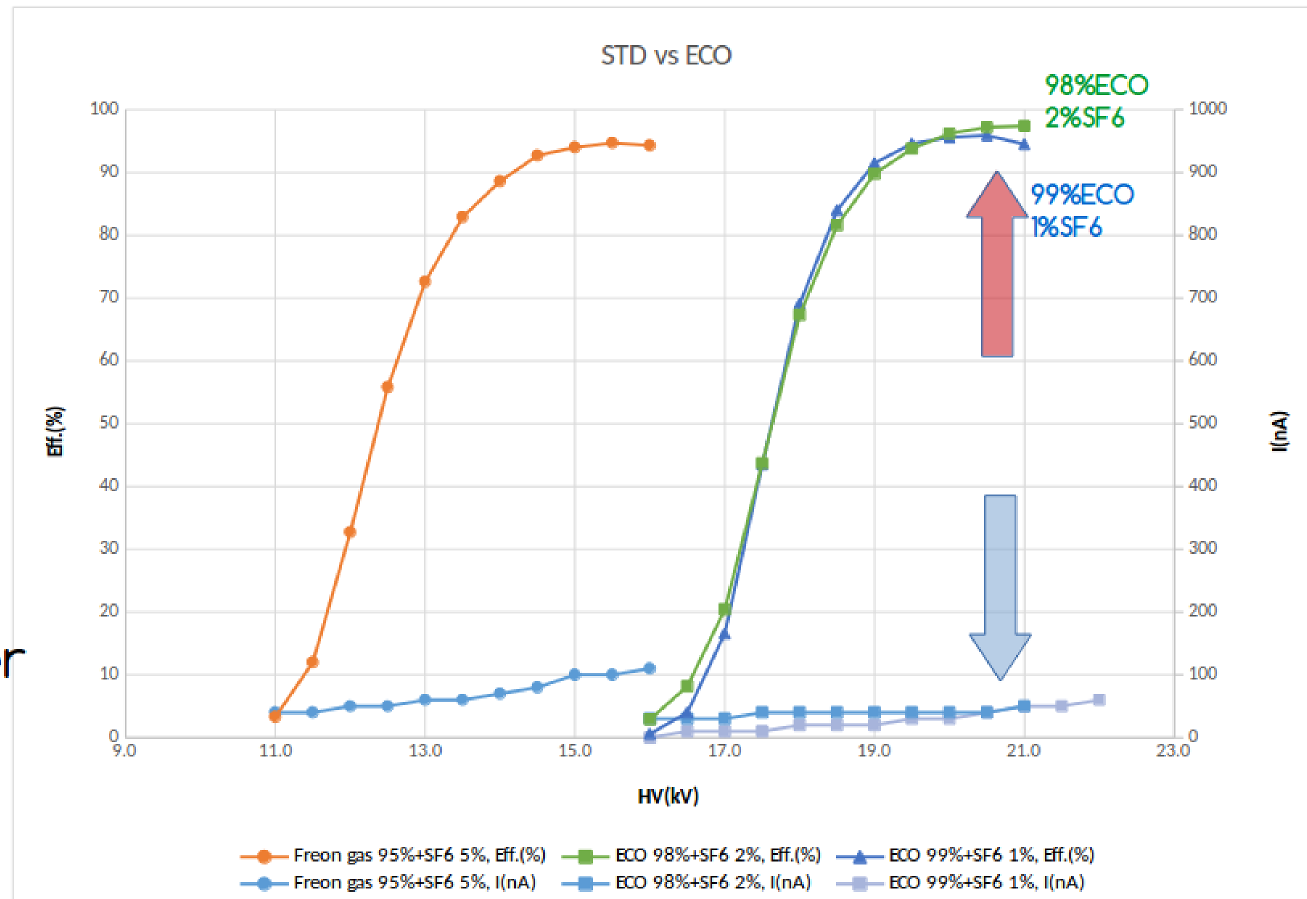
95% R134a + 5% SF_6
_vs._ R1234ze + SF_6 mixture

$\Rightarrow$ See Yonwook Baek talk

R1234ze raises the HV

SF6 works fine as a quencher



Mean multiplicity

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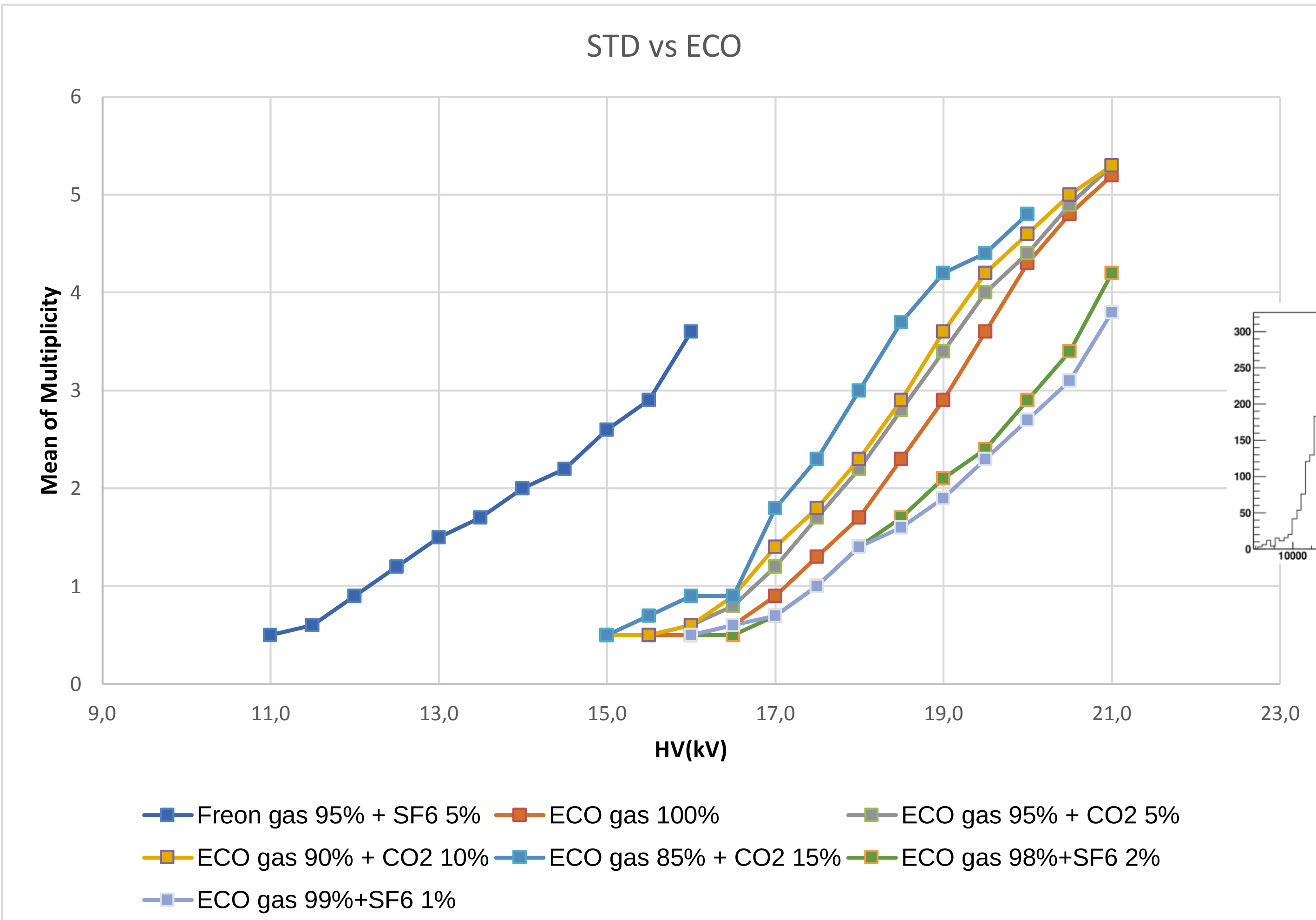

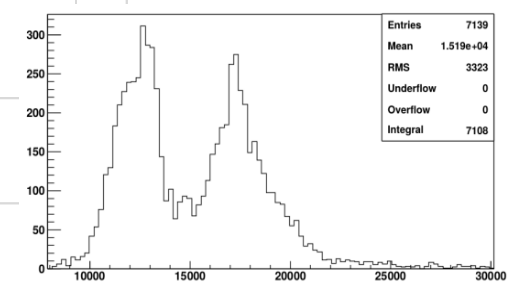

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Tests with MRPCs at high rate at CERN

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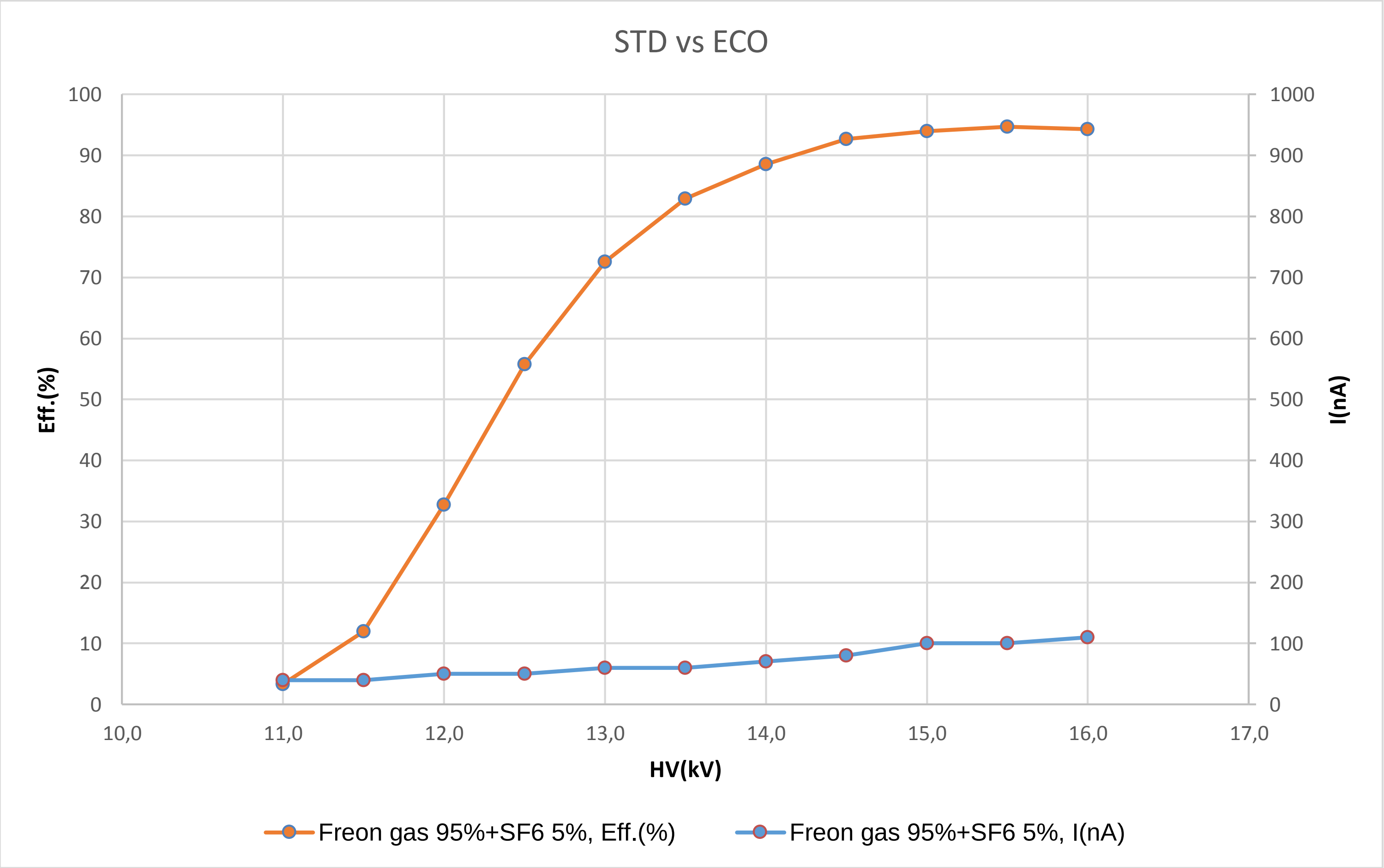
⇒ See Yonwook Baek talk

95% R124a + 5% SF_6 (EEE nominal)

Good plateau stability

Low dark currents and rates



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Tests with MRPCs at high rate at CERN: streamer %

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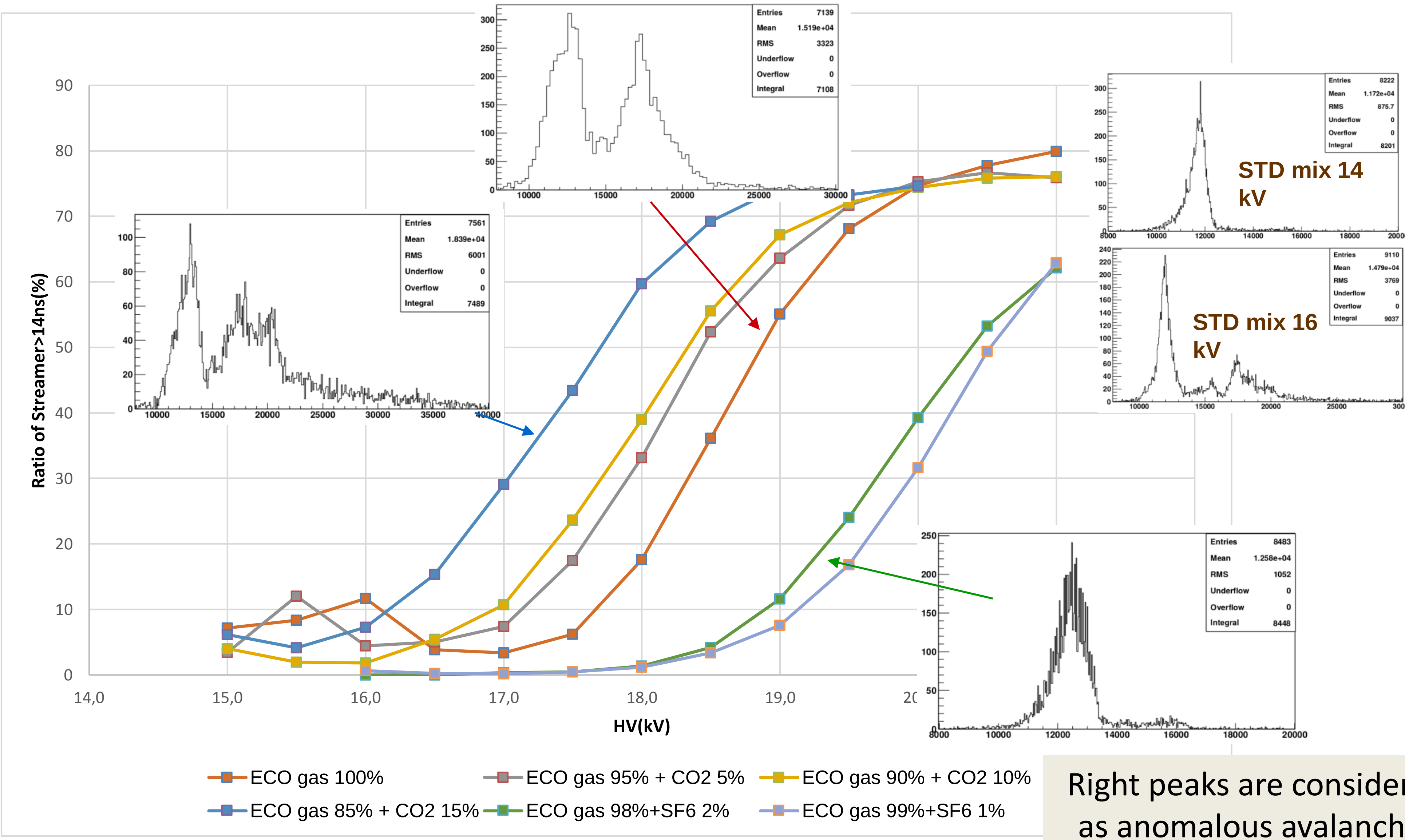

Right peaks are considered as anomalous avalanches (streamers?)