



Gas studies for the Multigap Resistive Plate Chambers of the EEE project

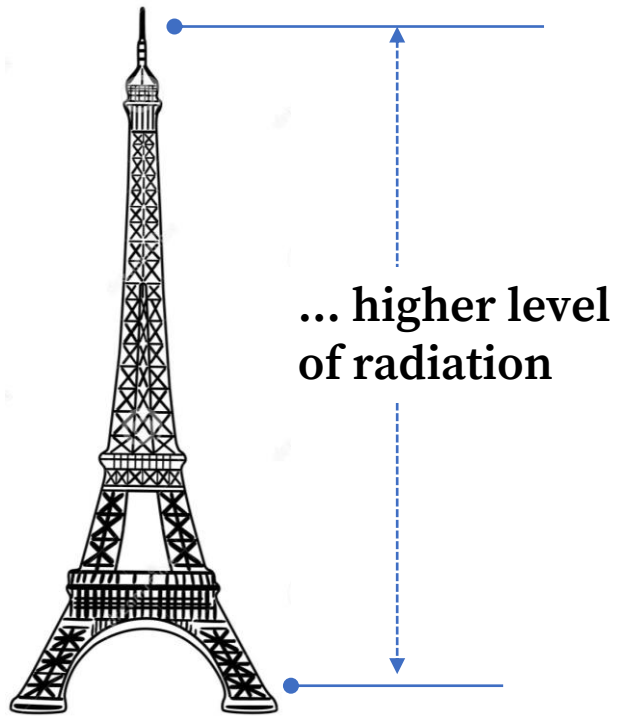
Ektoras Ioannis Vasilas

Ioannis Loumakis

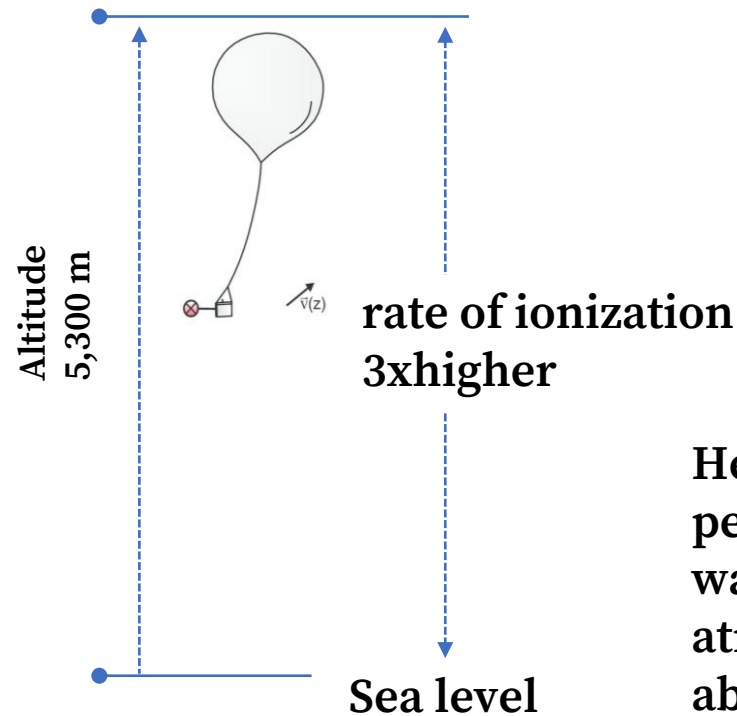


History, the first studies of cosmic rays

In 1909 Theodor Wulf measured, using an electrometer...



In 1912 Victor Hess, using balloons, measured atmospheric ionisation as a function of altitude.



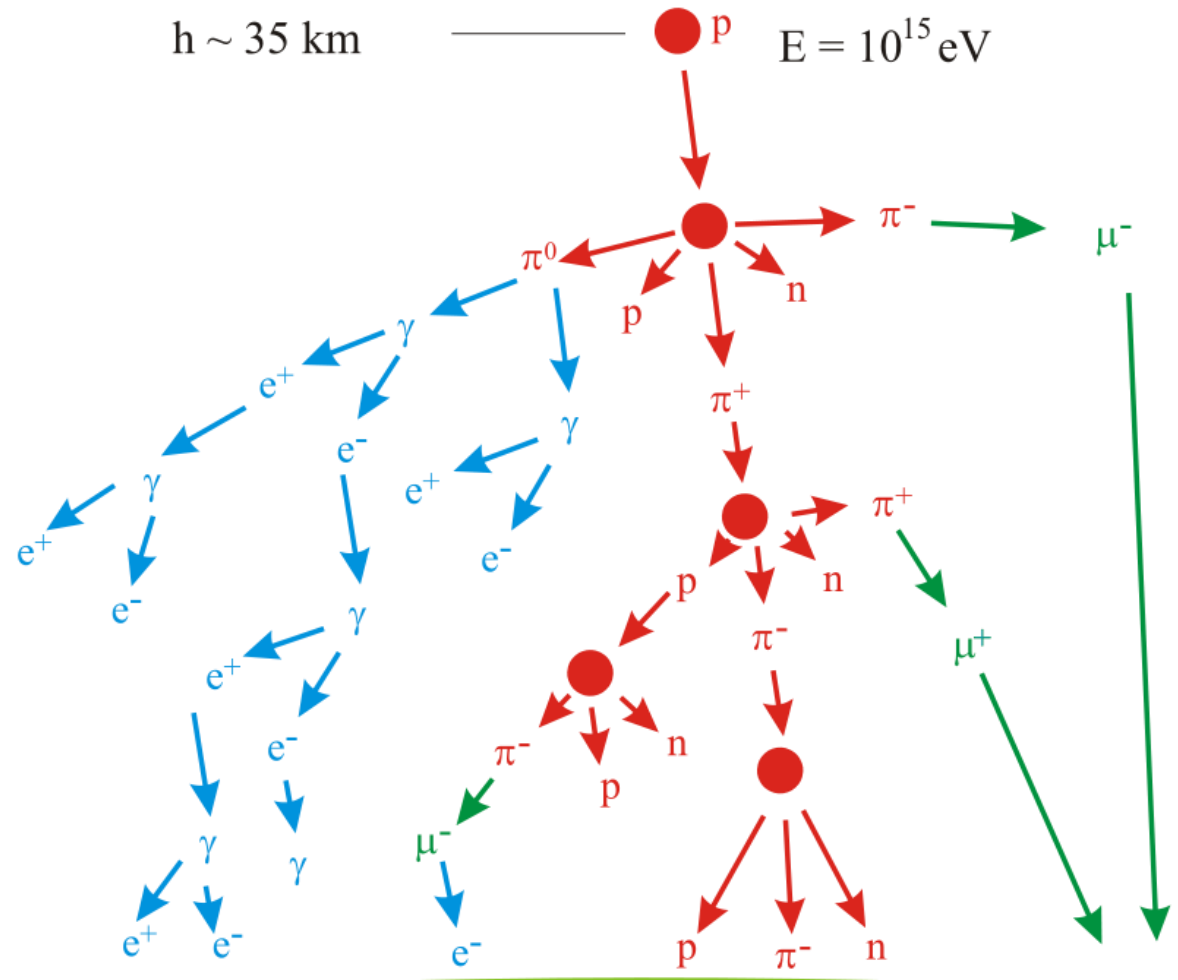
He concluded that penetrating radiation was entering the atmosphere from above. He had discovered cosmic rays.

What are cosmic rays?

- Very energetic charged particles coming from outer space that continually bombard the earth.
- Protons (hydrogen nuclei) 89%
- Helium nuclei 10%
- Heavier nuclei 1%
- When they collide with atoms in the earth's upper atmosphere, they create a shower of lower energy secondary particles, mainly pions.
- Pions swiftly decay emitting muons, which travel through the atmosphere and penetrate below ground.
- A hundred of these secondary particles pass through our bodies every second.
- Energies of primary cosmic rays from 1 GeV (rate : 10 000 / m²s) up to 10⁸ TeV (rate : < 1 /km²century)
- Very high energy cosmic rays generate huge showers of up to 10 billion secondaries spreading over areas of 20 km² at the surface of the earth.

$h \sim 35 \text{ km}$

$E = 10^{15} \text{ eV}$

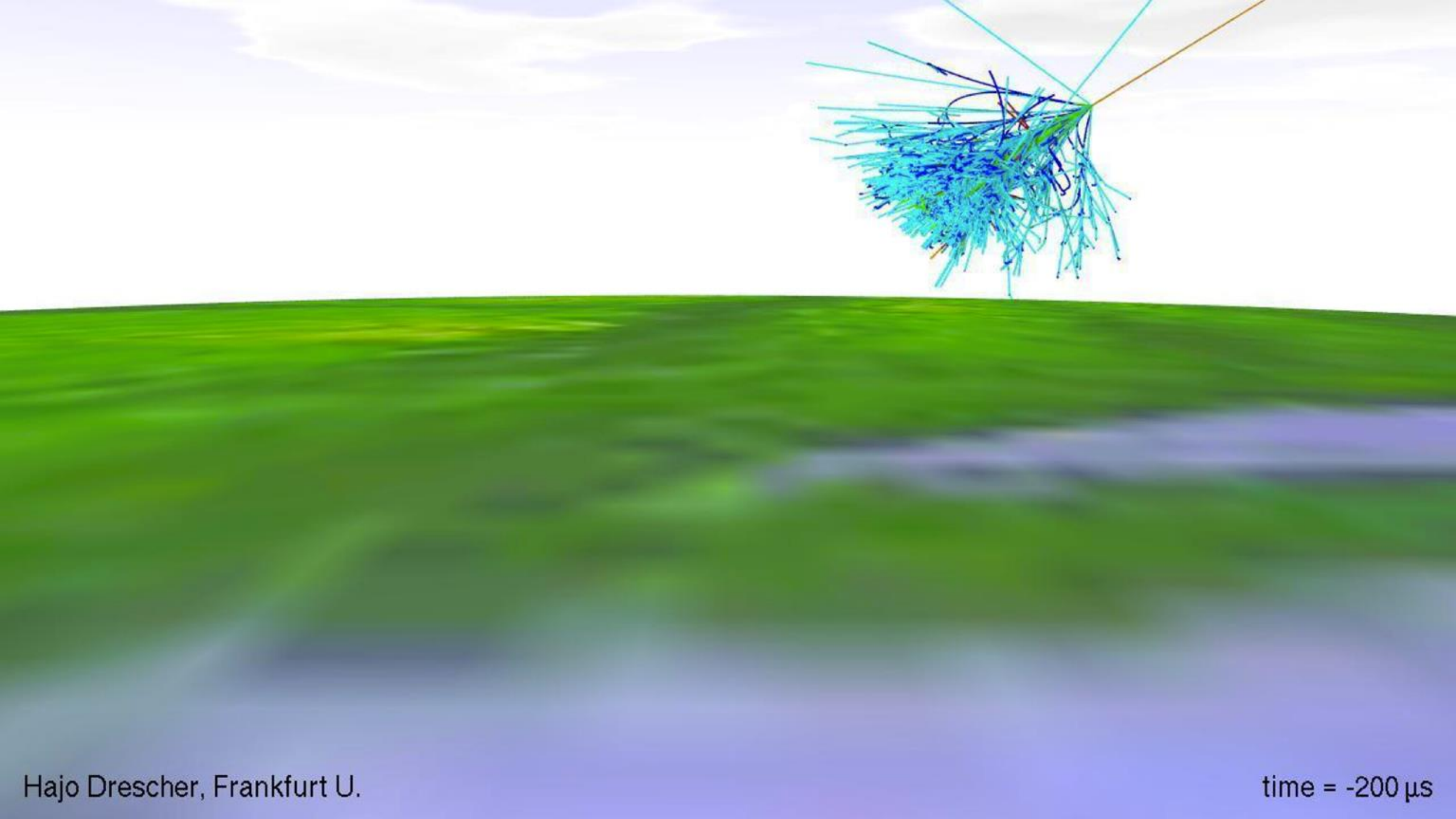


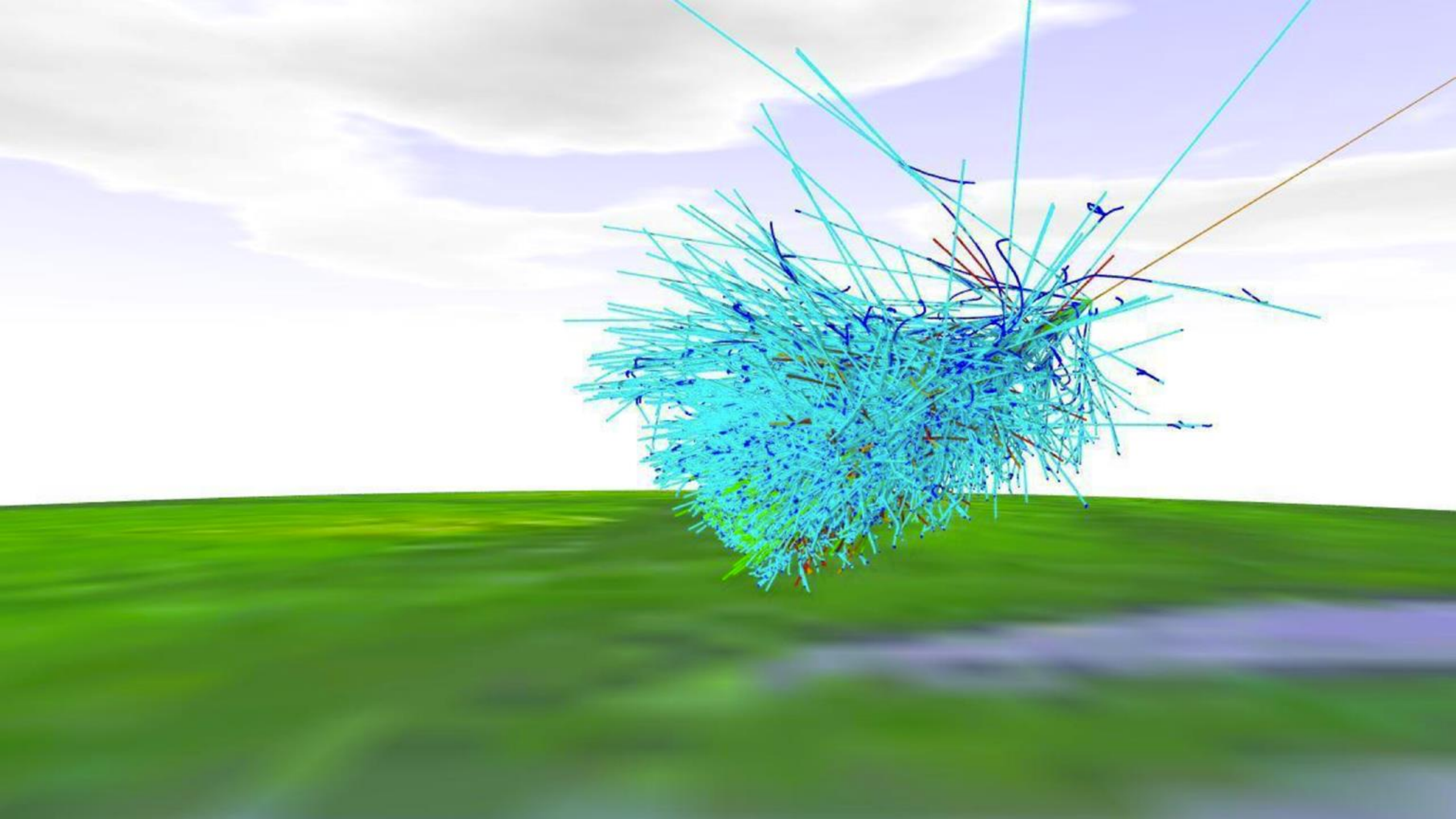
$N = 10^6$	$N(e) = 18\%$	$N(p, n, \pi) = 0,3\%$	$N(\mu) = 1,7\%$
	$N(\gamma) = 18\%$		

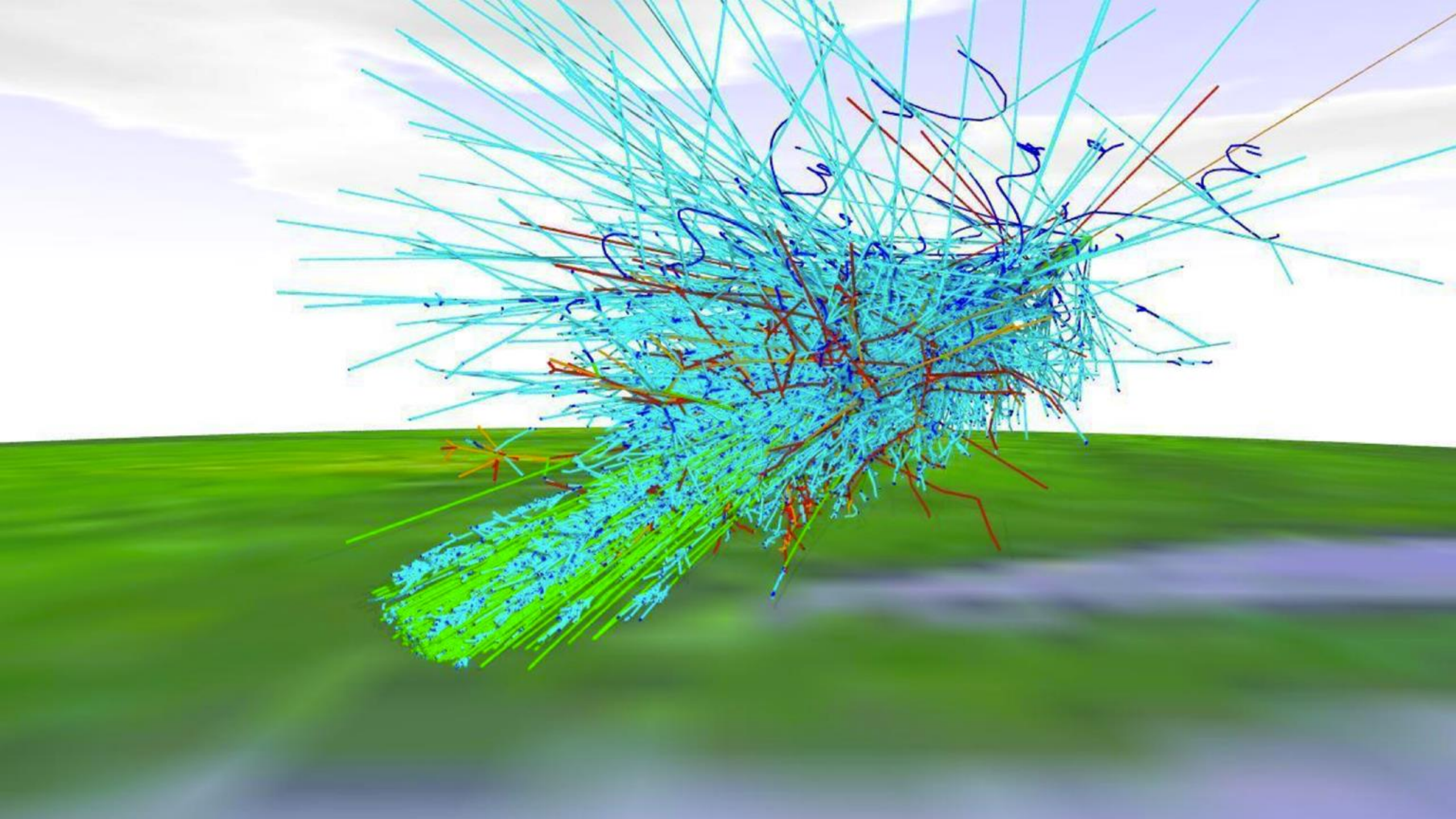












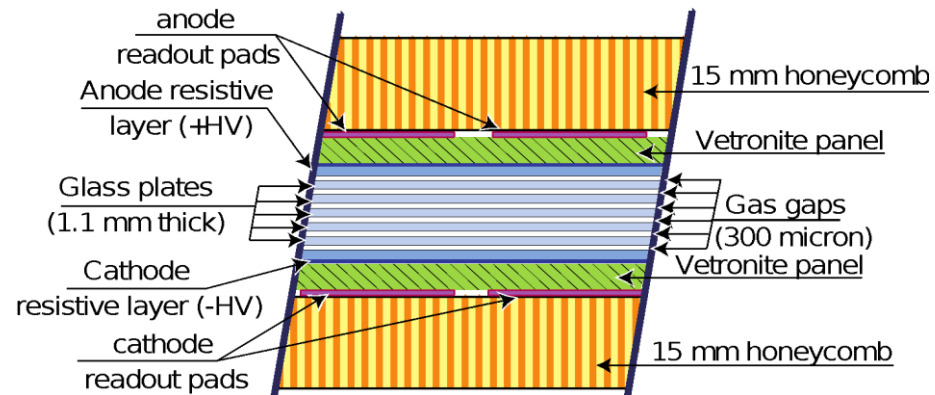
What is the EEE project?

The EEE project is looking for extended air showers and extreme energy events by detecting the presence of muons in the shower.

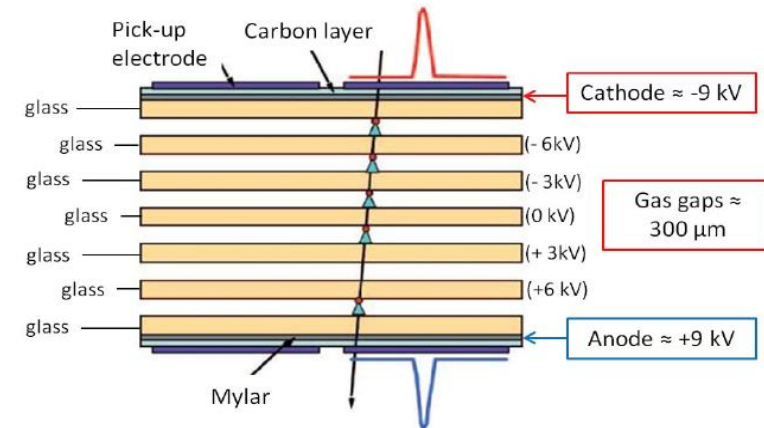


Detector

- 6 gas gaps of 300 microns each
- dimensions : 82 cm x 180 cm



Operated with a mixture of 98 % $C_2H_2F_4$ - 2% SF_6

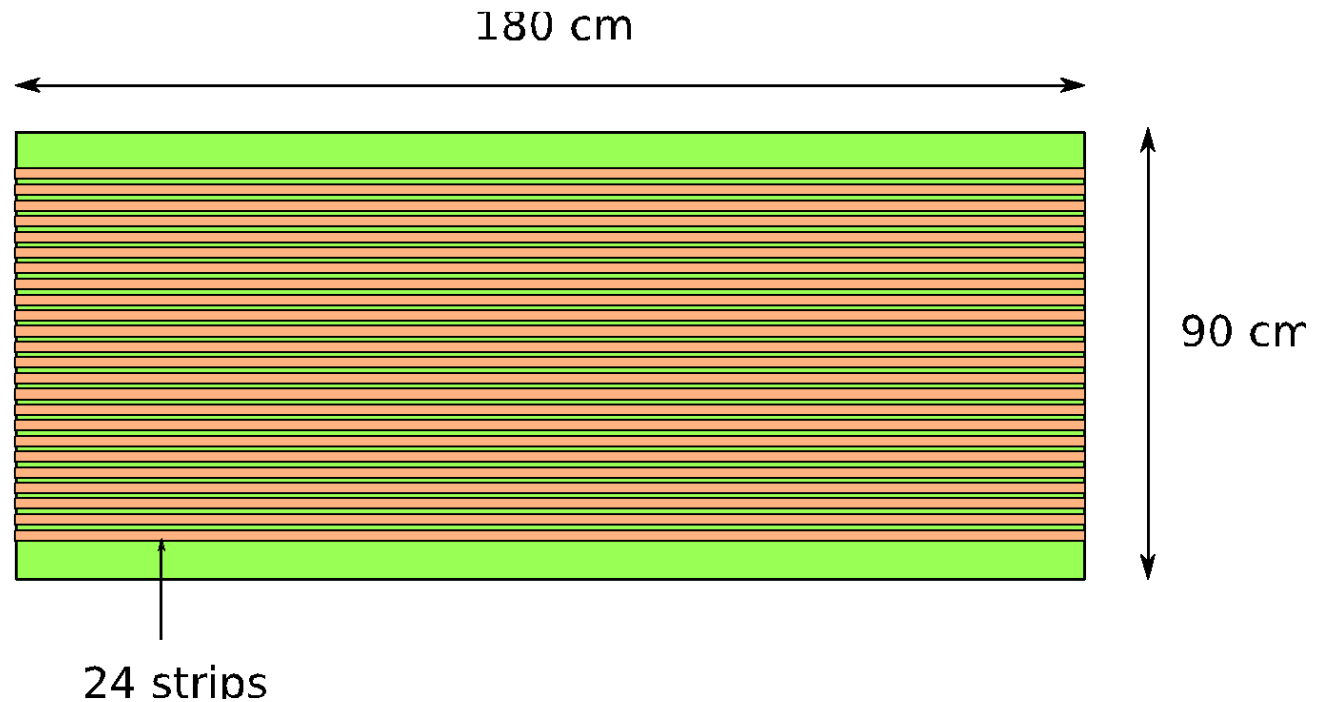


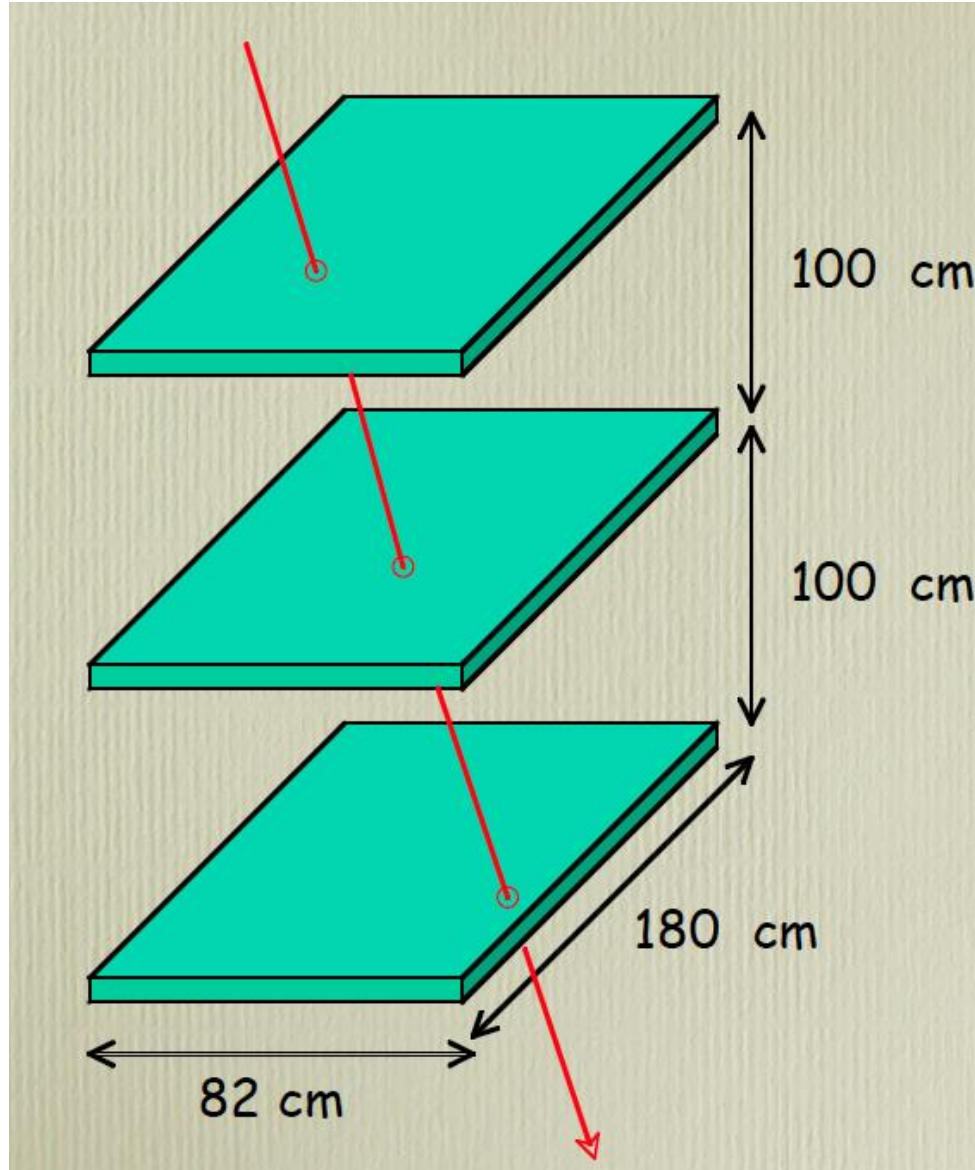
Requirements

- 1) reliable (long-term)
- 2) easy to use
- 3) not expensive

Detector

- 24 strips read out at both ends
- Time difference : position of hit along the strip
- Anode & cathode readout plane : differential signal
- Adhesive copper tape on vetronite sheet
- Strip width : 2.5 cm; distance between strips : 0.7 cm
- Pitch : 3.2 cm





WHAT IS THE MAIN PROBLEM?

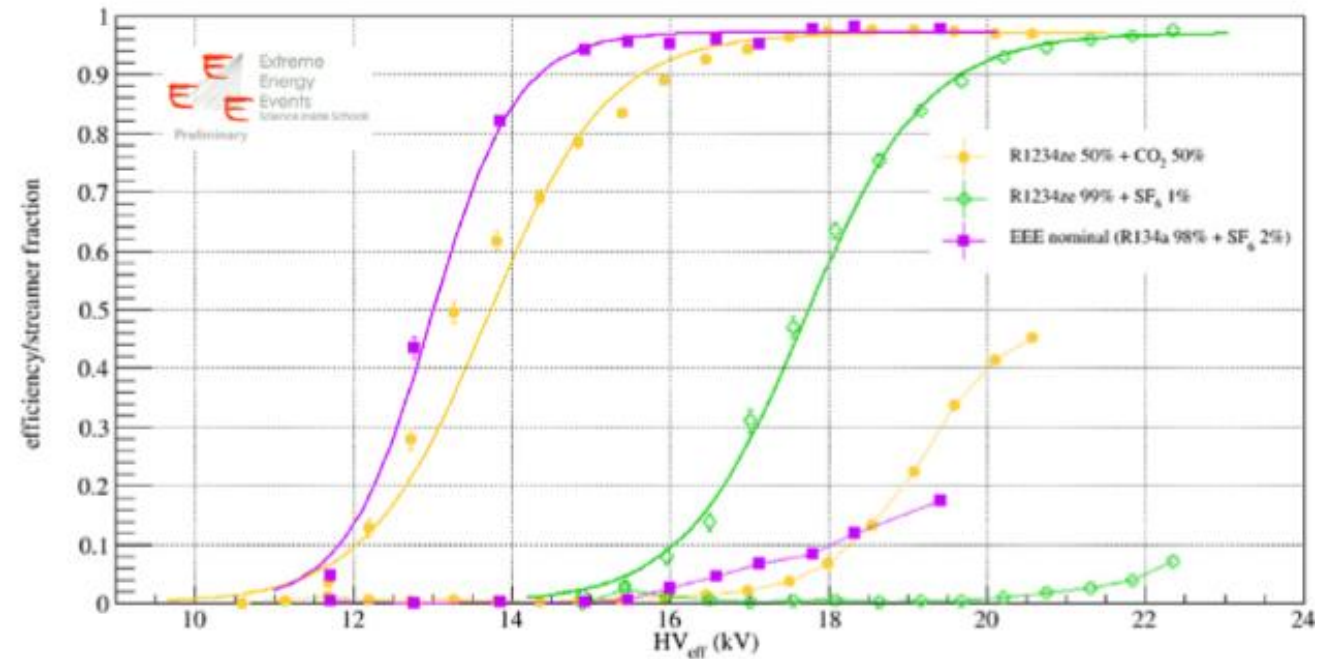
GLOBAL WARMING - EFFICIENCY

- Recently EU has imposed restrictions on green-house effects, setting up a maximum limit of 150 on Global Warming Potential (*GW P*) of gas mixtures.
- The present gas mixture (98 % $C_2H_2F_4$ – 2% SF_6) has *GW P* 1900.
- We need a gas mixture with high efficiency (90%-95%) and *GW P* below 150.

GLOBAL WARMING - EFFICIENCY

Published measurements with different gas mixtures

- 1) $R1234ze(100\%)$
- 2) $R1234ze(50\%) - CO_2(50\%)$
- 3) $R1234ze(99\%) - SF_6(1\%)$
- 4) $R1234ze(98\%) - SF_6(2\%)$



OUR WORK



**UNDERSTANDIN
G**



**DATA
COLLECTION**



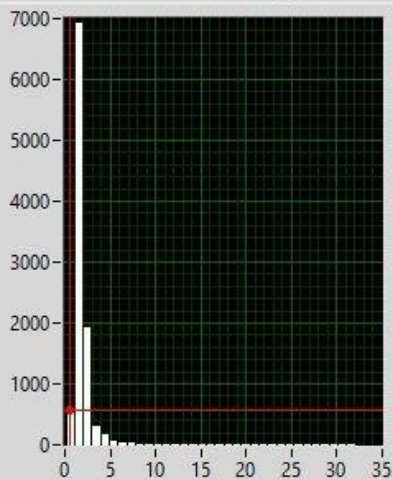
**DATA
ANALYSIS**



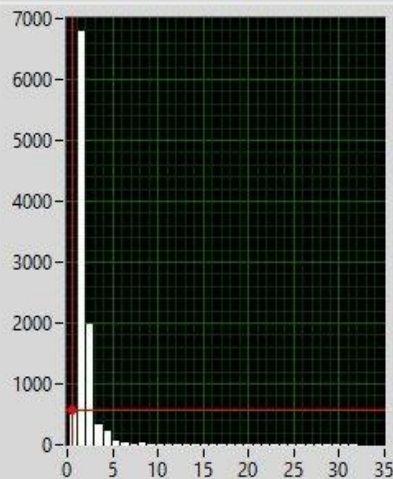
CONCLUSIONS

Channel Distribution Timing Multiplicity Parameters

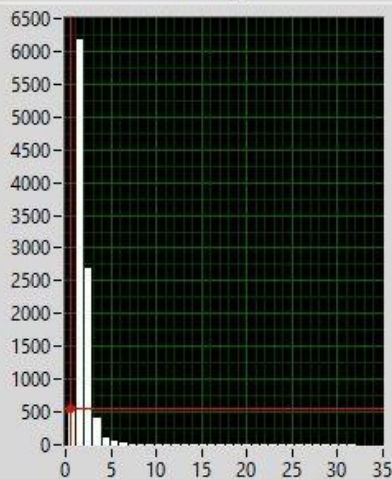
TDC 1 A - BOTTOM Chamber 1 Right



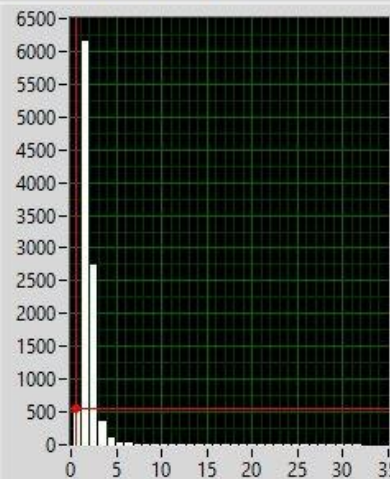
TDC 1 B - BOTTOM Chamber 1 Left



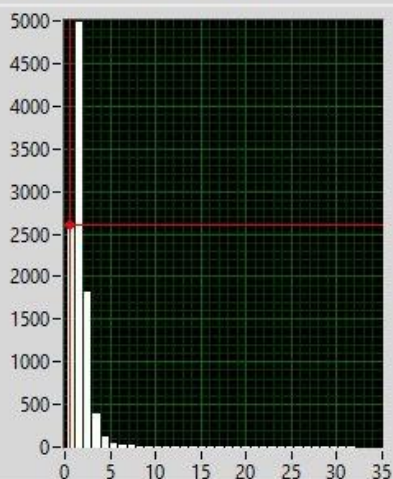
TDC 1 C - TOP Chamber 3 Right



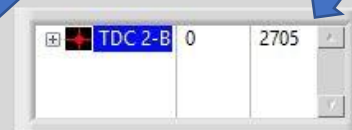
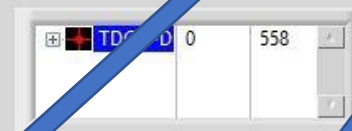
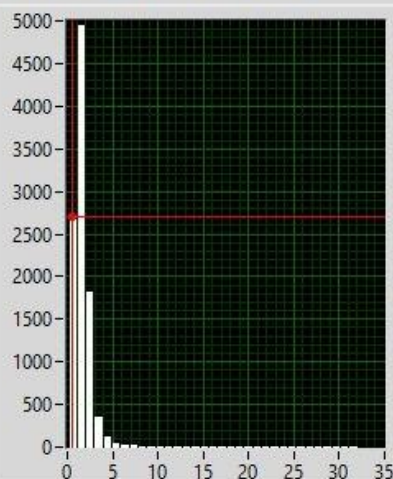
TDC 1 D - TOP Chamber 3 Left



TDC 2 A - MIDDLE Chamber 2 Right



TDC 2 B - MIDDLE Chamber 2 Left



Binary File

D:\CERN-01 Data\ChamberTest\300mkm-GasTests\R1234ze-CO2\2021-09-21\CERN-01-2021-09-21-00013.bin

Events

10000

100.0%

Read Events

 All First

1000

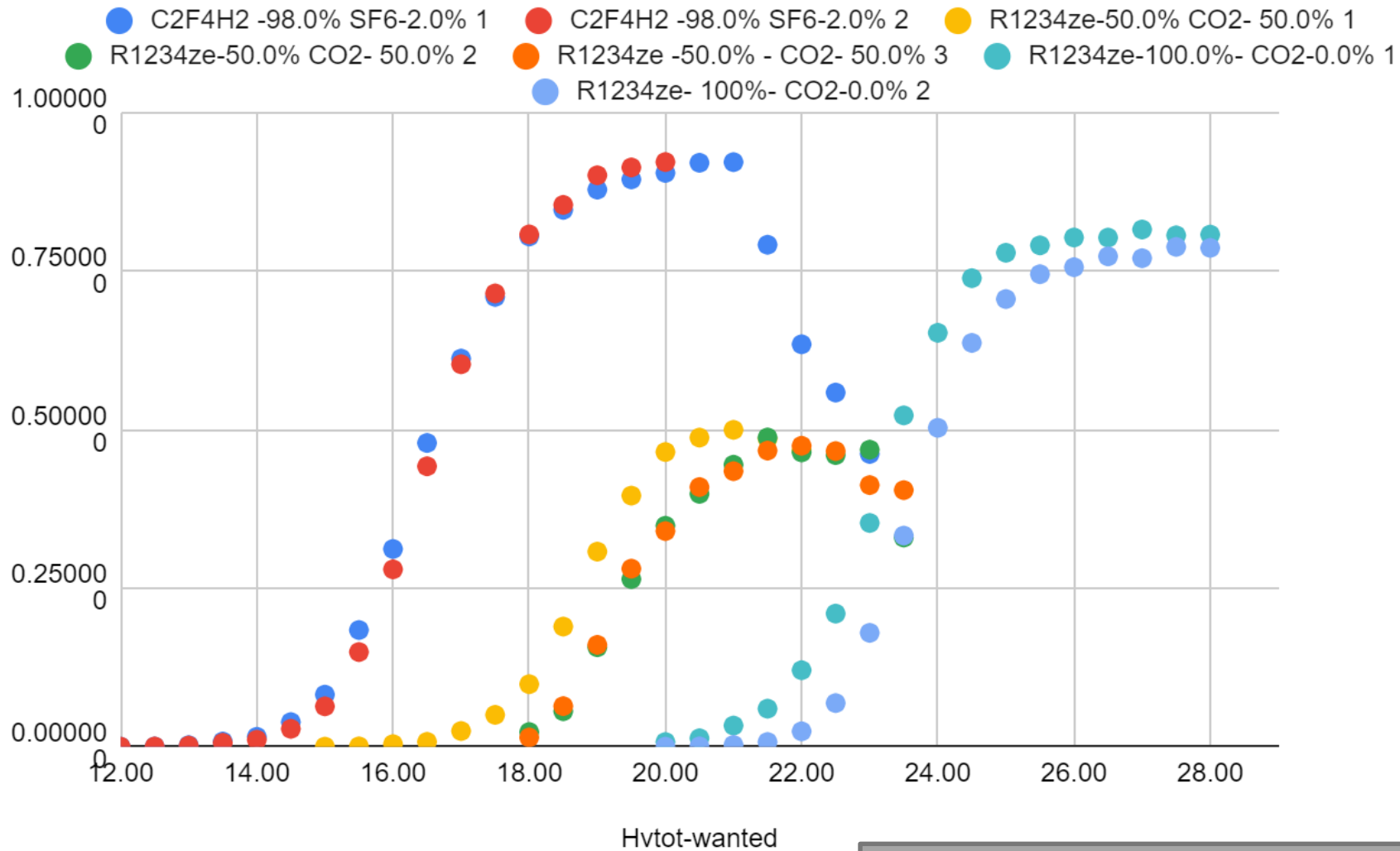
 Animate

RUN...

EXIT

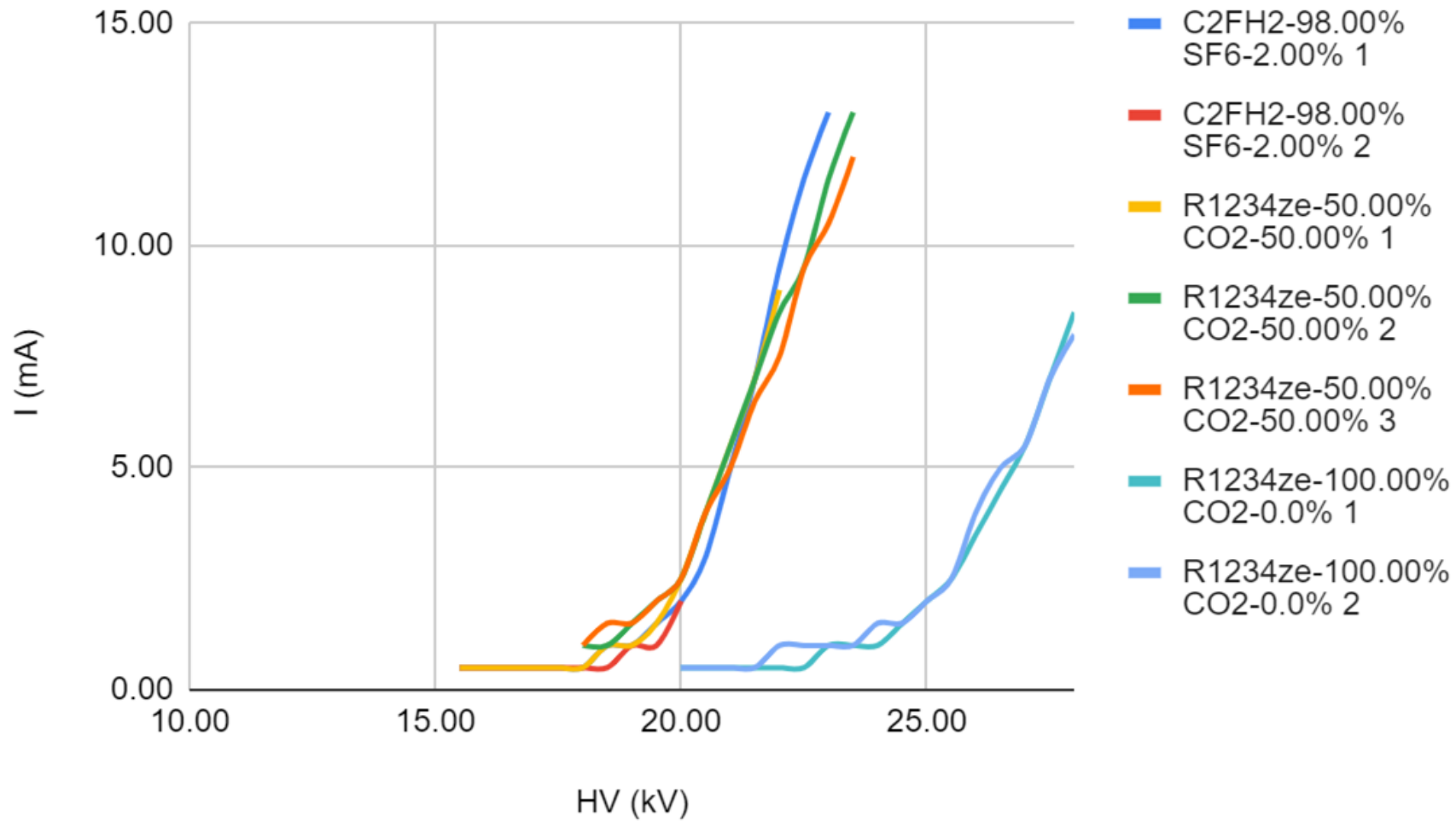
$$E = \frac{x-y}{x}$$

EFFICIENCY VS HIGH VOLTAGE



We have tested 2 new different gas mixtures that do not cover the requirements of efficiency.

INTENSITY/CURRENT VS HIGH VOLTAGE



CONCLUSIONS

1. **The 2 different gas mixtures we examined didn't reach the requirements on efficiency.**
2. **Further research is needed to find the right gas mixture.**
3. **More data collection and detailed analysis is crucial for the decision making.**
4. **This experiment (EEE) will contribute to attracting students to the field of science, as they experience the beauty of research.**

BIBLIOGRAPHY

- [Elsevier Enhanced Reader](#)
- [The multigap resistive plate chamber as a time-of-flight detector – ScienceDirect](#)
- [A new type of resistive plate chamber: The multigap RPC – ScienceDirect](#)
- [New Eco-gas mixtures for the Extreme Energy Events MRPCs: results and plans - CERN Document Server](#)
- **Discussions with Dr. Despina Hatzifotiadou**

THANK YOU FOR YOUR ATTENTION

QUESTIONS?