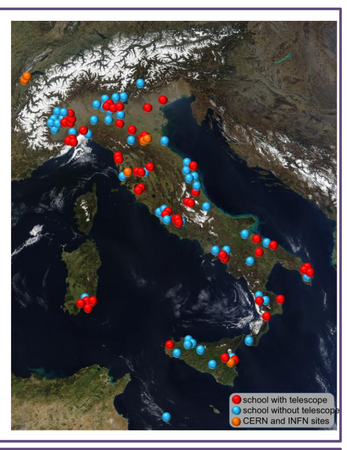
Test of new Eco-Gas mixtures for the Multigap Resistive Plate Chambers of the EEE Project

Marina Trimarchi on behalf of the EEE Collaboration

Museo Storico della Fisica, Centro Studi e Ricerche E.Fermi, Roma, Italy
Dipartimento MIFT– Università degli Studi di Messina, Italy
INFN – Sezione di Catania, Italy

The EEE Project

The Extreme Energy Events [1],[2] experiment is a project by Centro Fermi (Museo Storico della Fisica e Centro Studi e Ricerche "Enrico Fermi") in collaboration with INFN (Istituto Nazionale di Fisica Nucleare), CERN (European Organization for Nuclear Research) and MIUR (the Italian Ministry of Education, University and Research).
EEE is designed to study Cosmic Rays and related phenomena, via a synchronous sparse network of 56 tracking detectors installed in High Schools, each made of 3 MRPC detectors, deployed over an area covering more than 10° in latitude and 11° in longitude, corresponding to more than 3 x 10^5 km^2.



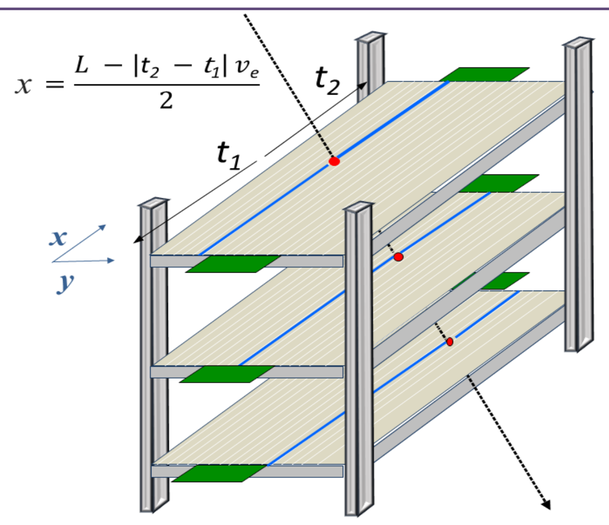
The Global Warming Potential reduction problem

MRPC chambers of the EEE telescopes have been operated since the beginning with a gas mixture of 98% of tetrafluoroethane and 2% of sulfur hexafluoride, but recent restrictions on greenhouse gases have prompted the study of the performance of these chambers with new gas mixtures.
Extensive tests of several gas mixtures with cosmic muons detected by one of the telescopes installed at CERN have been carried out.
The detection efficiency, the chamber current and the cluster size with new mixtures of tetrafluoropropene and carbon dioxide or sulfur hexafluoride have been studied under different conditions as a function of the applied high voltage.

The EEE muon telescopes

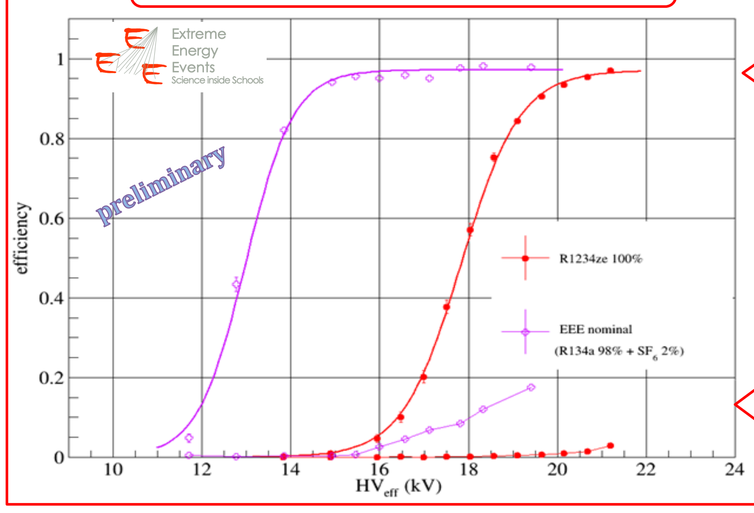
Three Multigap Resistive Plate Chambers(MRPC), providing the impact coordinates of incoming muons, hence the reconstruction of their tracks, with high efficiency and good angular resolution.

Each detector is operating in avalanche mode, with characteristic similar to the ones built for the Time Of Flight array of ALICE at LHC.



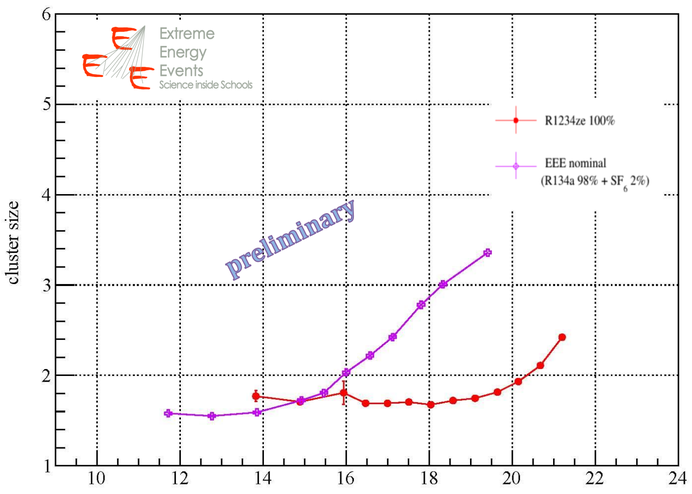
- **3 MRPCs**, size 1.58 x 0.82 m^2
- filled with a mixture of **$C_2H_2F_4$(98%)** and **SF_6 (2%)**
- **24 readout copper strips** as electrodes, pitch of 3.2 cm
- **HV** up to **20 kV** (**avalanche mode**) supplied by 2 DC/DC converters
- **GPS UNIT** provides the event time stamp (UTC time) to record and synchronize informations
- DATA are transferred and stored at **INFN computer centre (CNAF)**, where an all data reconstruction algorithm is immediately applied to all telescopes raw data [3].

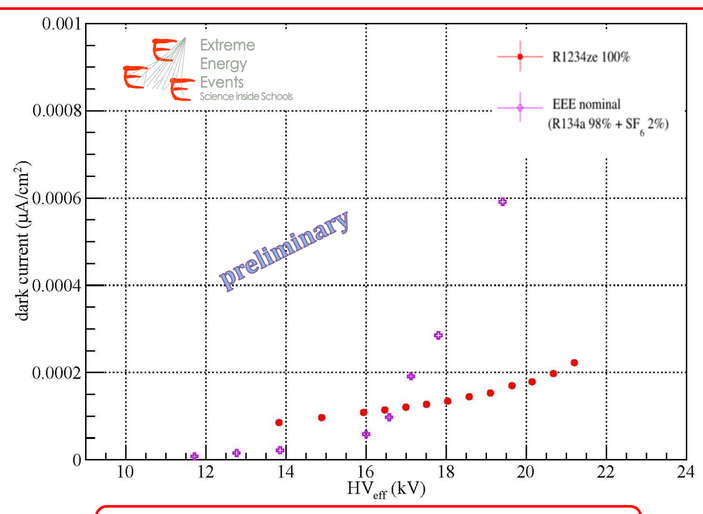
Pure tetrafluoropropene (R1234ze)



Higher HV setting point

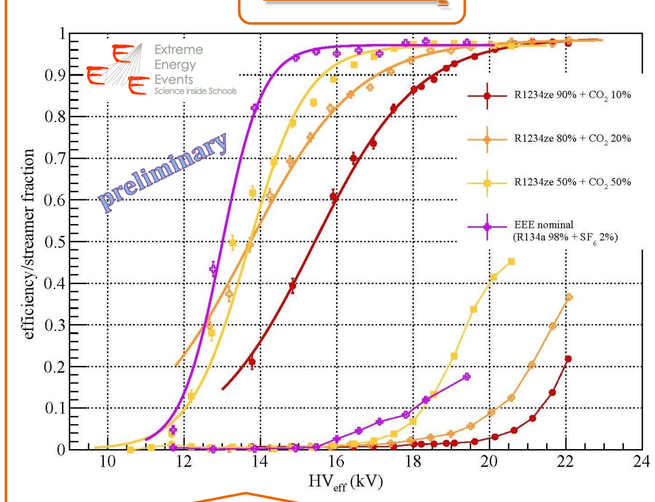
Streamer percentage under control

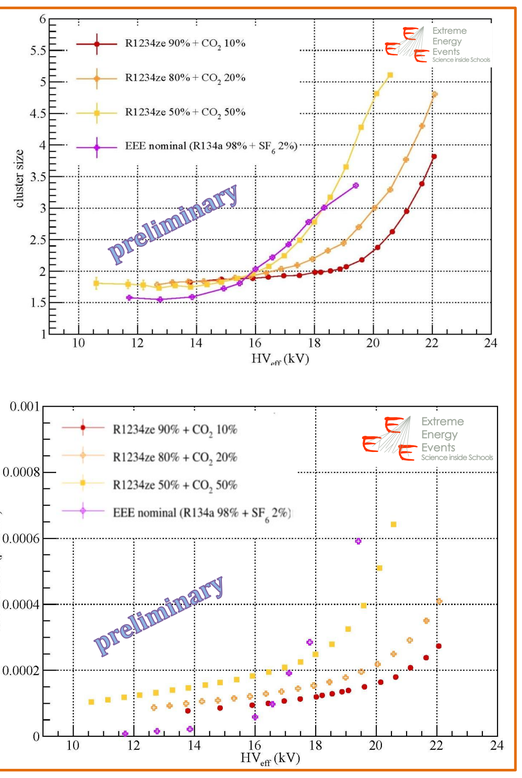




Low dark current & Stable cluster size

R1234ze + CO_2

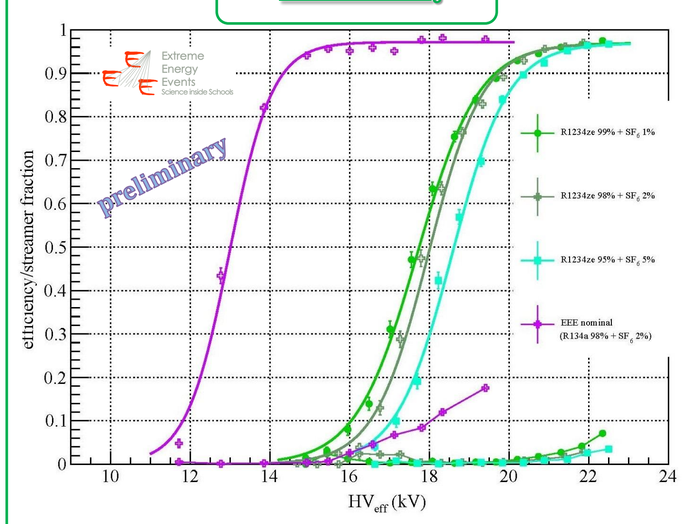


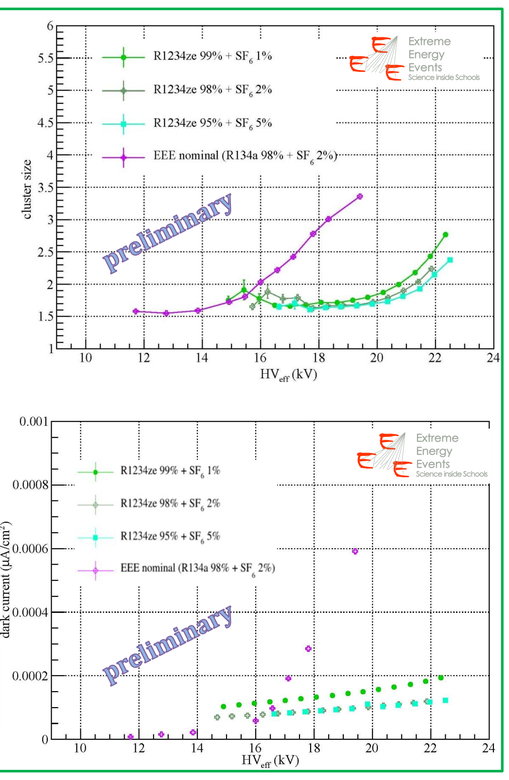


Lower HV setting point
Streamer percentage increases

High dark current & High cluster size

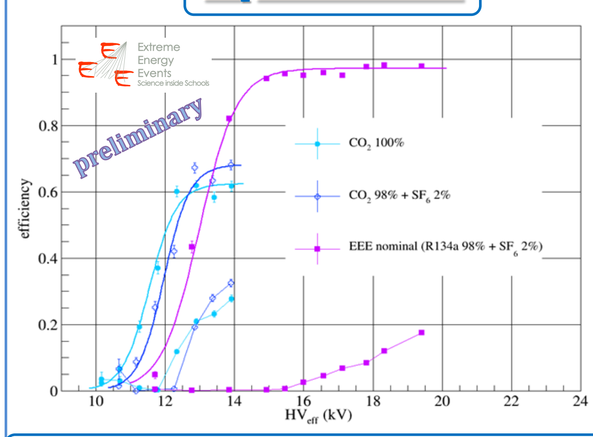
R1234ze+SF_6

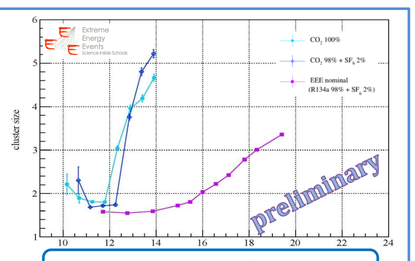




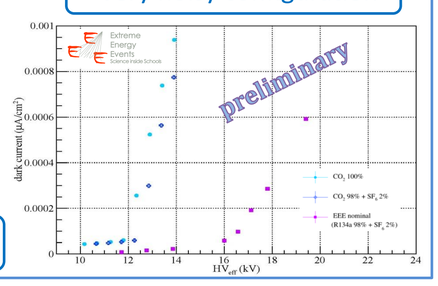
High HV setting point
Noise highly suppressed by SF_6
SF_6 percentage still too high for GWP requirements

CO_2 -based mixtures

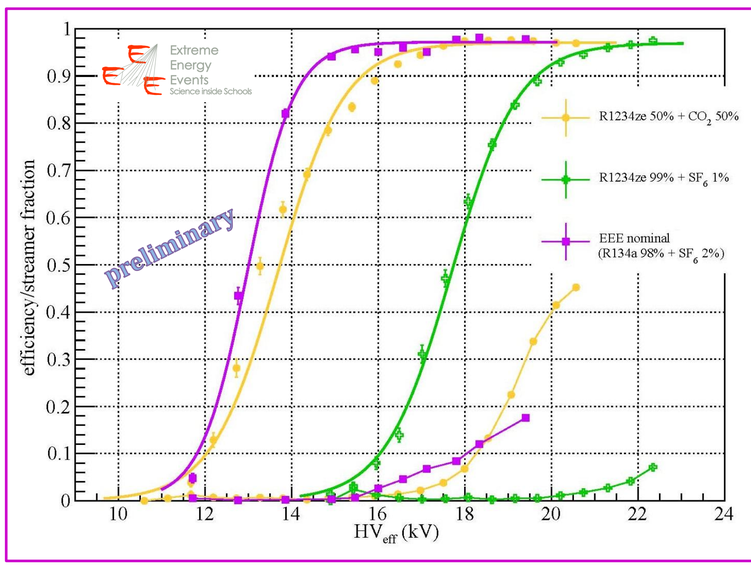




Very noisy configuration



Very low HV setting point→efficiency too low



Conclusions

Most promising configurations:

- **R1234ze(50%) + CO_2 (50%)**
- **R1234ze(99%) + SF_6(1%)**

Future Plans

- CF_3I
- R1234ze(99,5%) + SF_6(0,5%)
- R1234ze + He

References

[1]Centro Fermi web site: http://www.centrofermi.it/eee
[2] M.Abbrescia et al. Eur.Phys.J.Plus (2013) 128: 63
[3]F.Noferini et al.(EEE Coll.), Nucl. Instr. Meth. A824 (2016) 329
[4] S.Pisano et al.(EEE Coll.), *to be published in RPC18 Proceedings*