

# *Outreach activities of the Extreme Energy Events Project*

*M. Garbini on behalf of the EEE Collaboration*

*Centro Fermi, Rome & INFN Bologna*



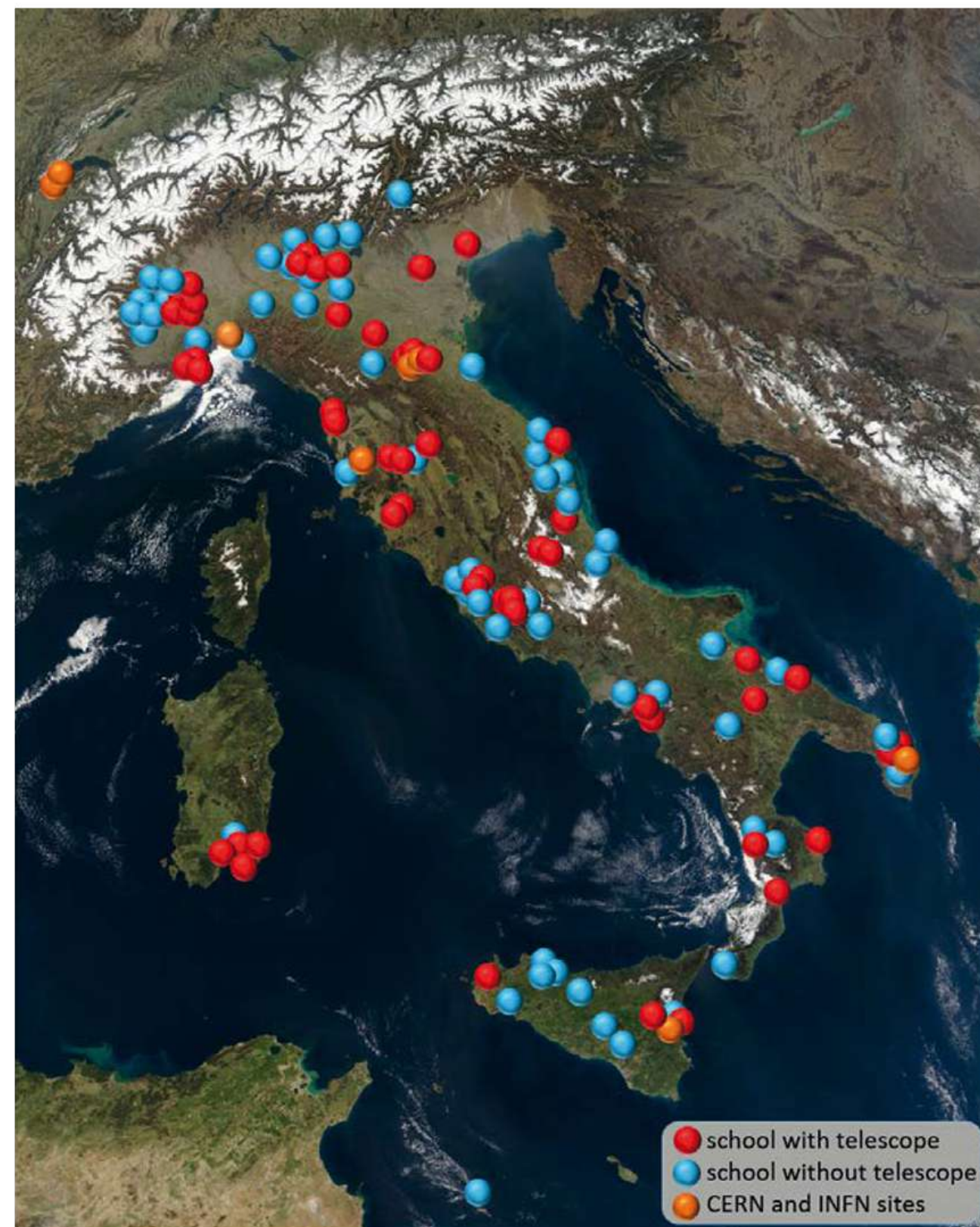
## The Extreme Energy Events Project is a Centro Fermi & INFN Experiment with dual role

- **Cosmic ray experiment:** detection and study of cosmic rays at ground
- **Scientific Education:** involve high school students in all the phases of the experiment

It is constituted by a network of 60 muon tracking telescopes installed inside **Italian high schools, INFN laboratories, Centro Fermi and CERN.**

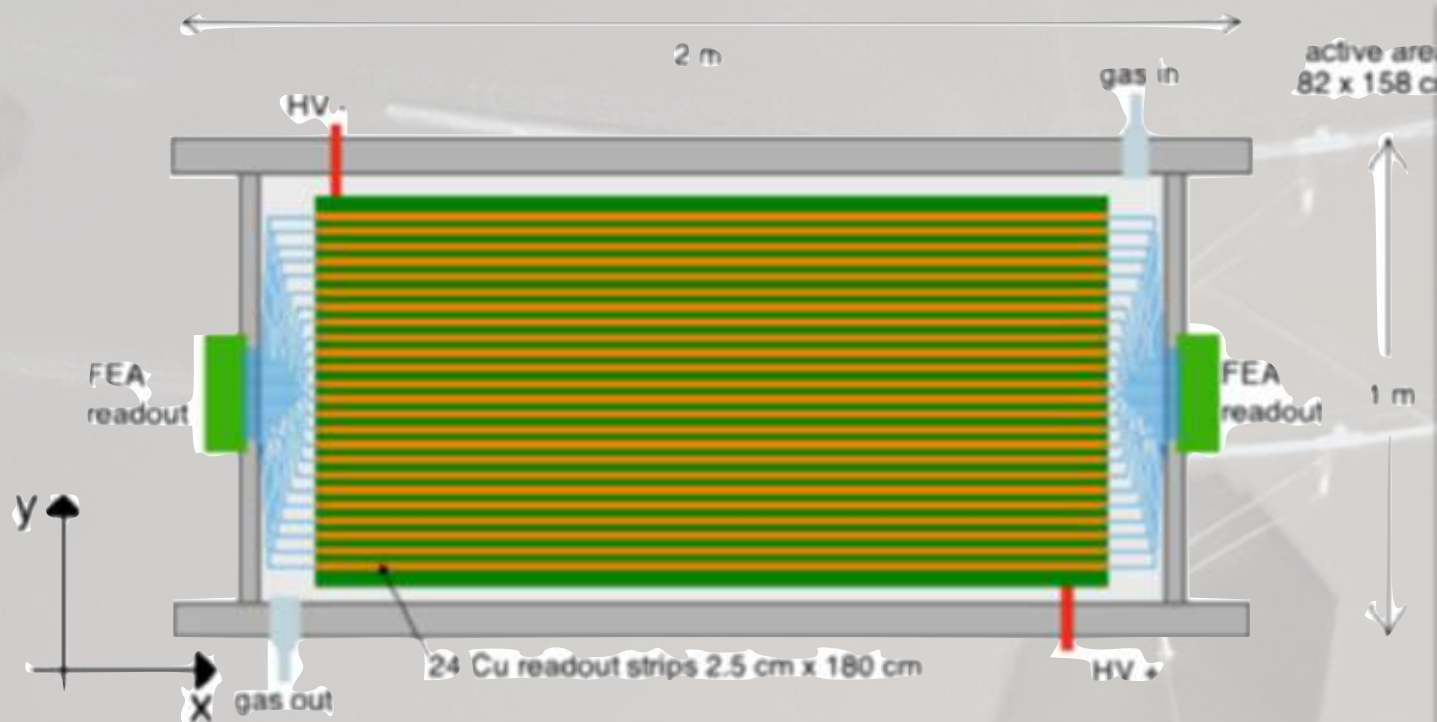
Many other High Schools participating **without telescopes**

**Hundreds of students working in the EEE experiment each year!**





The EEE telescopes are constituted by 3 Multigap Resistive Plate Chambers



- Muons are detected and reconstructed with  $\sim \text{cm}^2$  spatial resolution and hundreds of ps time resolution.
- The telescopes are GPS synchronised for offline analysis on time correlated events.
- Data from each station are sent to the Bologna INFN CNAF for the track reconstruction and storage.



Young students and teachers are involved in each phase of the experiment:

- they build at CERN the detectors for the telescope.
- they are involved in the installation at school, in the operation and monitoring of the telescopes.
- they participate to monthly online and in presence (bi-annual pre COVID) meetings presenting their analysis or attending masterclasses.



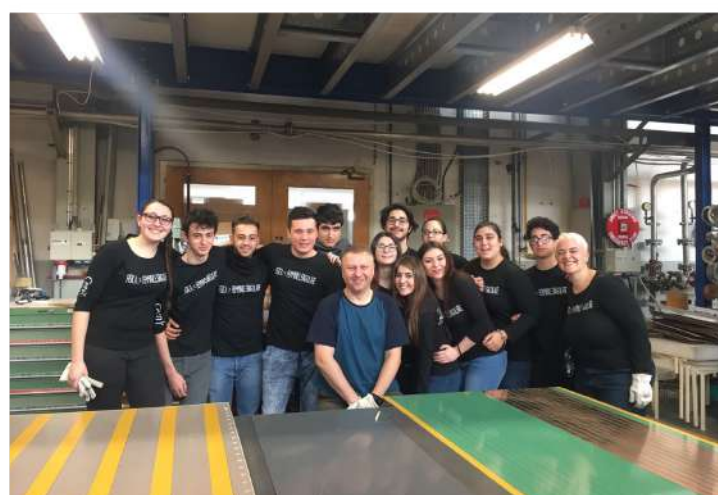


Teams of students and teachers build 3 MRPCs in a week at CERN under the supervision of EEE researchers.

This is the starting point of their path in experimental cosmic rays Physics: they learn how to build a particle detector starting from common materials (i.e. glass, fishing line, copper tape).

Together with a better understanding of the working principle of the detectors during the week they have a first idea of the researcher work and life.

**More than 180 MRPCs have been successfully built by students!**





After the construction the telescopes are installed in the schools and students are responsible for the monitoring and operation of the detector and contribute to data analysis.

Since 2014, coordinated data taking periods have been performed during each year.

Thanks to this organisation **more than 100 billions** of candidate muon tracks have been collected and used for many analyses.

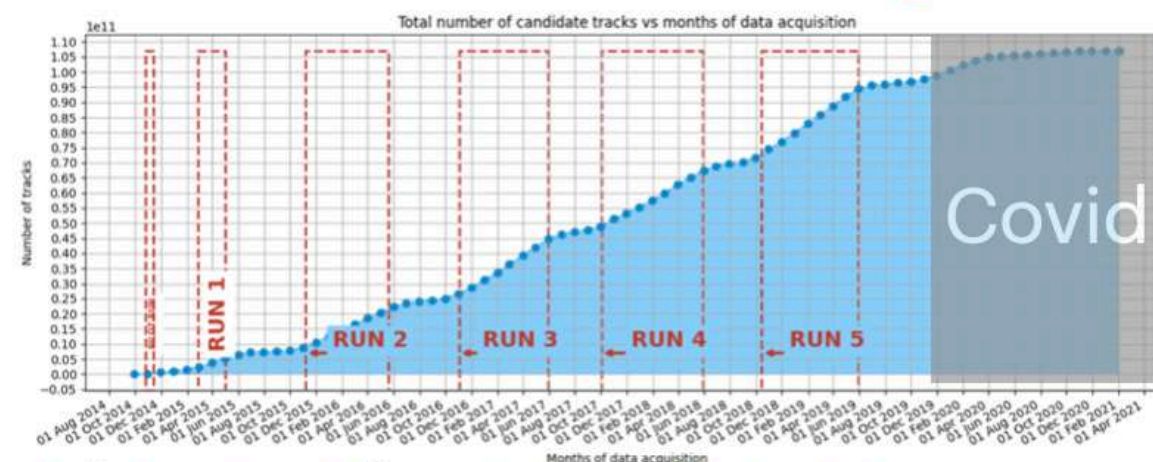
The students participate to the online monthly Run Coordination Meetings devoted to the network operation.

Due to the Pandemic the experimental operations have been interrupted but we continued the monthly meeting.

A new ELOG entry has been submitted:	
Logbook: <b>EEE e-log</b> Message ID: <b>546</b> Entry time: <b>Fri 12/12/2014 13:22:45</b>	
Scuola:	BOLO-03
Operatore:	Matteo Postacchini & Alice Dalla
MRPC1 HV_POS (V):	8490
MRPC1 HV_NEG (V):	8460
MRPC1 I_POS (microA):	8.59
MRPC1 I_NEG (microA):	8.53
MRPC1 LV (V):	4.5
MRPC2 HV_POS (V):	8070
MRPC2 HV_NEG (V):	8450
MRPC2 I_POS (microA):	8.03
MRPC2 I_NEG (microA):	8.40
MRPC2 LV (V):	4.5
MRPC3 HV_POS (V):	8470
MRPC3 HV_NEG (V):	8790
MRPC3 I_POS (microA):	8.49
MRPC3 I_NEG (microA):	8.71
MRPC3 LV (V):	4,5
Front-End LV (V):	2.7
SF6 (press):	26.8
C2H2F4 (press):	25.0
SF6 (flusso):	24.9
C2H2F4 (flusso):	25.0
Temp (C):	17.0
Press (mbar):	1010.2
Rate (Hz):	39.2

## Progetto Extreme Energy Events - La Scienza nelle Scuole

### EEE MONITOR - DQM



Total number of candidate tracks ( $X^2 < 10$ ) in the database: 112905535371



Before the pandemic the EEE Collaboration organised two in person meetings per year with the schools of the network.

During these events, students present their work, take part to masterclasses and participate to measurement campaigns.

Once per year the workshop is hosted by the Ettore Majorana Foundation and Centre for Scientific Culture@Erice.

**In November 2021 the EEE Collaboration organised the first in person meeting event after the Covid.**

**The meeting was focused on a the Ecological Transition of the EEE Project that is going to use new gases in the detectors.**

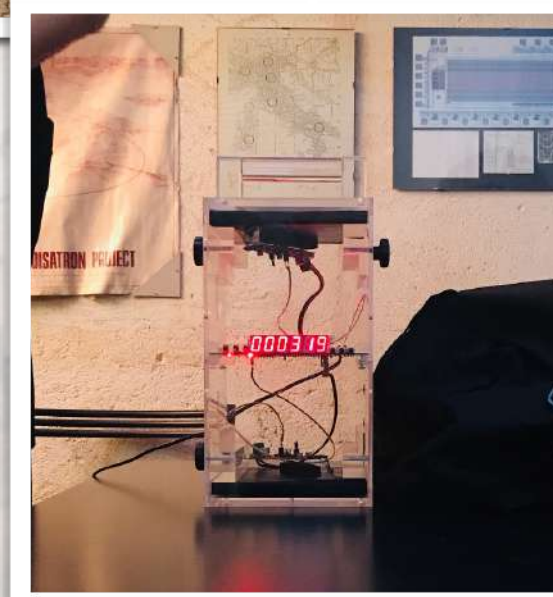
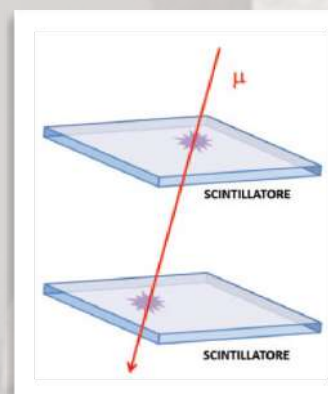




The EEE students are involved in other activities:

- **International Cosmic Day:** an international event dedicated to Cosmic ray physics (organised by DESY)
- **International Muon Week:** international event devoted to the measurement of the muon speed.
- **European Researcher Night:** the Europe-wide public event, which displays the diversity of science and its impact on citizens' daily lives
- **Cosmic Box Contest:** EEE students can submit a research program to be performed with the **Cosmic Box**; the best are awarded with a detector to carry on the proposed activity

... and many other on local base!!!





The **Polar Quest 2018 mission** was a scientific multidisciplinary exploration of Svalbard archipelago.

The EEE Project and INFN contribute to the mission with a cosmic ray detector, POLA, to observe Cosmic Rays at very high latitude.

3 POLA detectors were assembled at CERN by high school students: POLA-01, installed on **Nanuq** sailboat, POLA-02 installed in a Italian high school (Bra) and POLA-03 installed in a Norwegian high school (Nesodden)

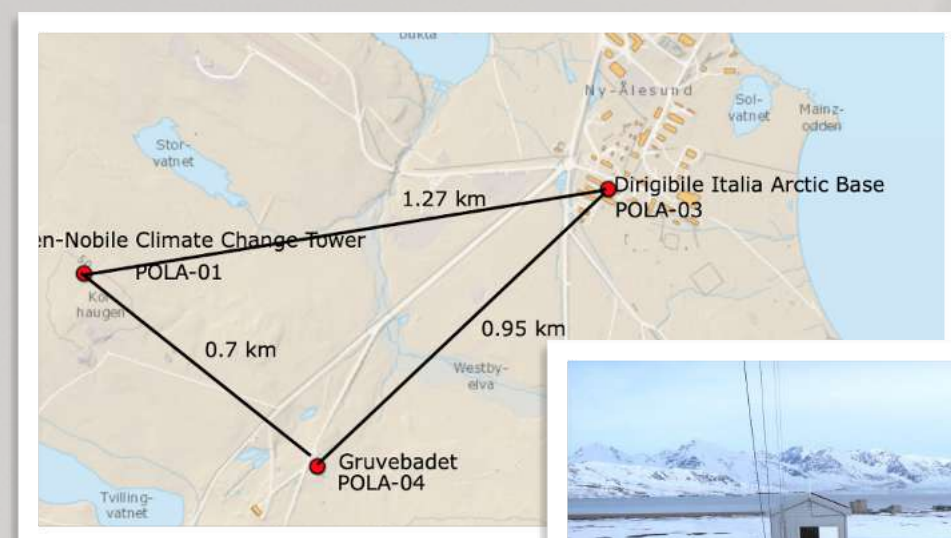




The data collected during the **Polar Quest 2018 mission** have been used to study the cosmic rays flux vs latitude.

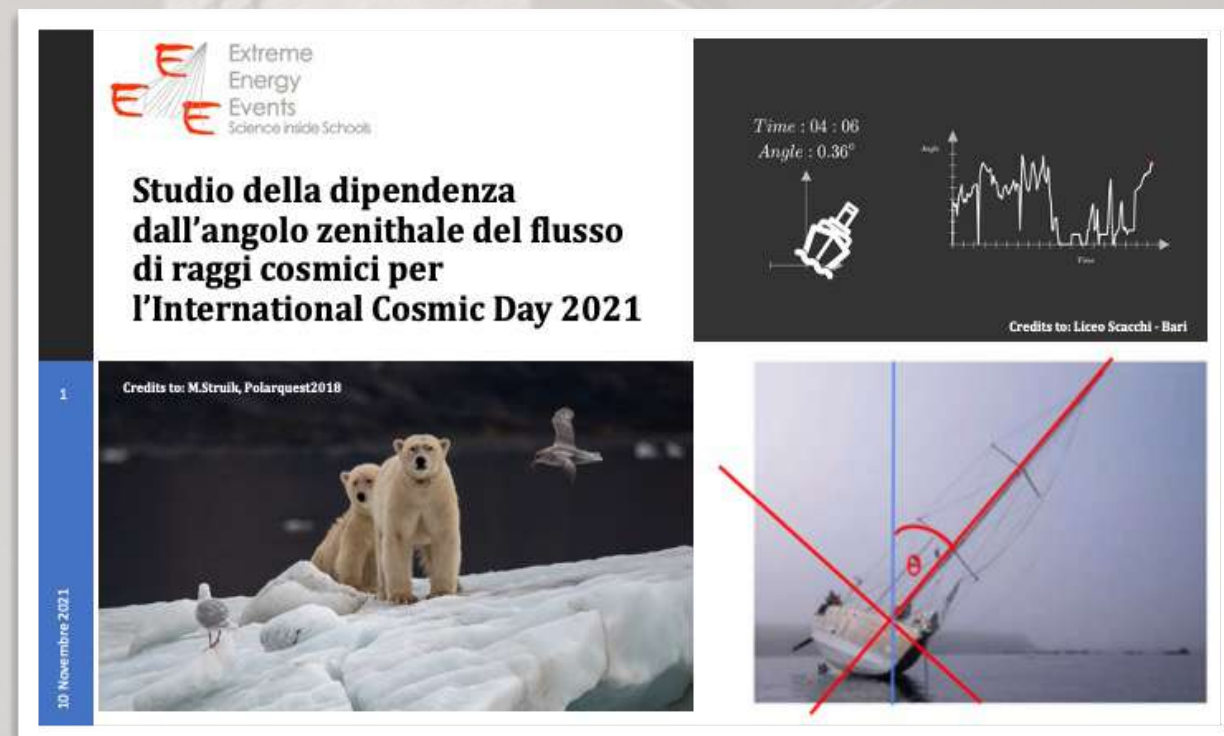
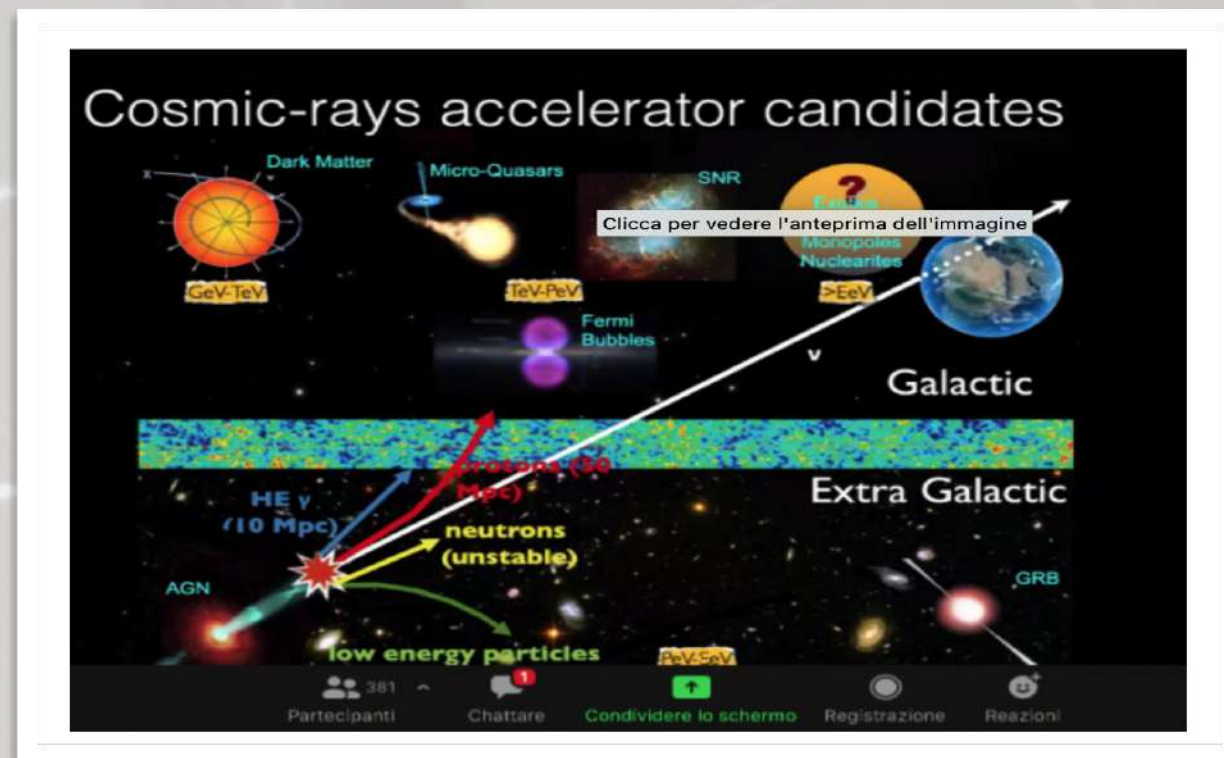
Thanks to the collaboration with CNR in 2019 we installed three detectors in the CNR arctic base at NyÅlesund (Svalbard) to study extended air showers at the extreme latitudes.

Data from the PolarquEEEst mission are available for students analyses and are used also in EEE masterclasses.





- ★ In person activities interrupted during Pandemic 2020-2021.
- ★ A strong program of online activities has been carried on since March 2020. Online meeting on EEE Project but not only (see the list on next slide)
- ★ In November 2021 we organised the first in person meeting event after the Covid, in Erice. The meeting was focused on the Masterclass: “Ecogas for EEE stations - Data analysis on ecological mixtures”. The students of the Project analysed data acquired by some EEE telescopes, in which the standard gas mixture was replaced by different mixtures with low Global Warming Power (GWP).
- ★ We are restarting the experimental activities in some schools with a new eco friendly gas mixture





Event	Date	How	Participants	Main Focus
Run Coordination Meeting	16/03/2022	Online	350	Material Science
Run Coordination Meeting	16/02/2022	Online	350	Physics with Arduino
Run Coordination Meeting	26/01/2022	Online	380	Detection of Hunga-Tonga volcanic eruption with the POLA detectors at
Run Coordination Meeting	15/12/21	Online	220	rEEESStarting
Meeting EEE Project at Erice	17-19/11/21	In Person/Online	50/250	Masterclass on gas mixtures
International Cosmic Day	10/11/21	Online	300	PolarquEEEst Data Analysis
Run Coordination Meeting	13/10/21	Online	350	Program of activities for year 2020-2021
European Researcher night	24/09/21	Online	100	PolarquEEEst live form Svalbard
Run Coordination Meeting	26/05/21	Online	170	Physics and physical technologies for cultural heritage
Run Coordination Meeting	14/04/21	Online	500	Masterclass on Data Quality Monitor of EEE
Run Coordination Meeting	10/03/21	Online	500	Women in Science
Run Coordination Meeting	03/02/21	Online	475	Quantum Mechanics



- ★ The EEE Project has a strong and innovative outreach program based on the direct involvement of young students in all the phases of a cosmic rays experiment.
- ★ The students can experience all the steps of the research, from the construction and commissioning of a detector to the data analysis and results report.
- ★ Every year hundreds of students are involved in the experiment also thanks to a continuously enriched program.
- ★ Despite the Pandemic the EEE experimental activities are now ready to restart with the new challenge of the green transition of the EEE telescopes.
- ★ The EEE Project has also established collaborations with other outreach programs as the INFN Outreach Cosmic Ray Activities (OCRA, <https://web.infn.it/OCRA/>) and with the International Particle Physics Outreach Group (IPPOG, <https://ippog.org/>).
- ★ Other collaborations with Istituto Nazionale di Ricerca Metrologica (INRIM) and CNR have been established since 2019.