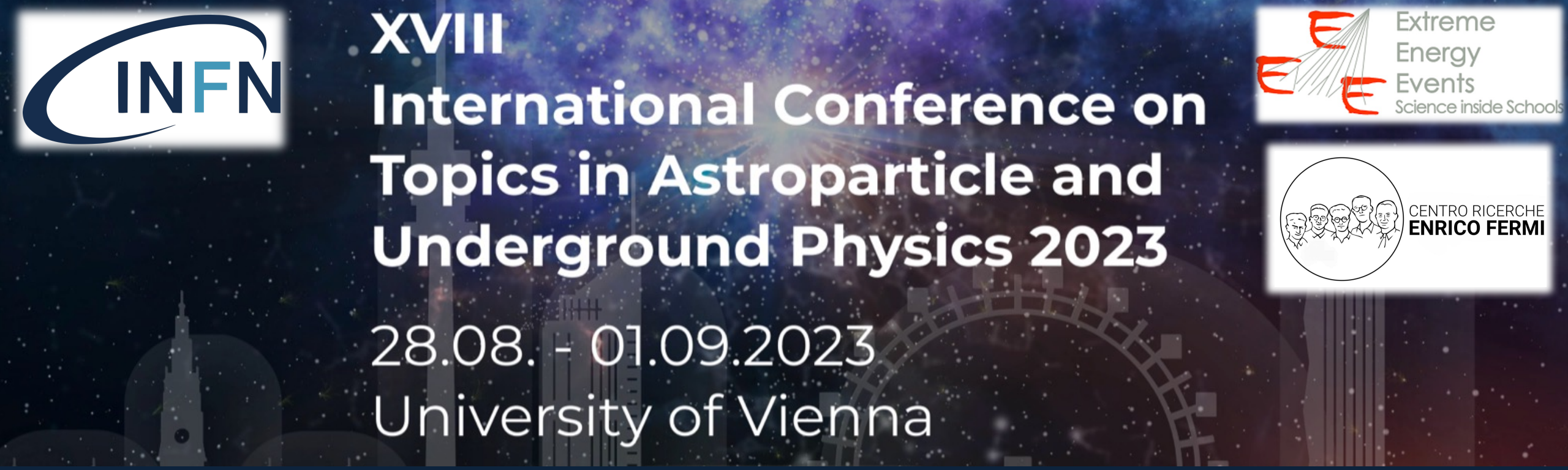


Involving high school teams in the upgrade phase of the Extreme Energy Events Project: a review of recent activities

Cristina Ripoli

University and INFN of Salerno

On behalf of EEE Collaboration

c.ripoli@unisa.it

Extreme Energy Events (EEE) Project

Extreme Energy Events
Science inside Schools

Cosmic rays experiment

The EEE Project has two main goals

The Project also born with an educational purpose!

Research

- The EEE Project aims to study **cosmic rays** by detecting secondary muons on the Earth surface generated by the primary cosmic rays interaction in atmosphere
- High performance **tracking** and **timing** system
- Scientific pubblications on **construction, performances, physics, upgrade, outreach**

A few papers signed by students too!

A. ZICHICHI, *Progetto "La Scienza nelle Scuole"*
EEE – Extreme Energy Events
Società Italiana di Fisica (SIF), Bologna
1st Ed. 2004; 2nd Ed. 2005
3rd Ed. 2012; 4th Ed. 2014
5th Ed. 2017

Collaboration project

Centro Fermi
CERN
INFN
MIUR
SIF

Launch event on 3 May 2004 at CERN

R. Aymar – CERN DG
L. Moratti – Minister of Science & Education
A. Zichichi – Centro Fermi President

Education

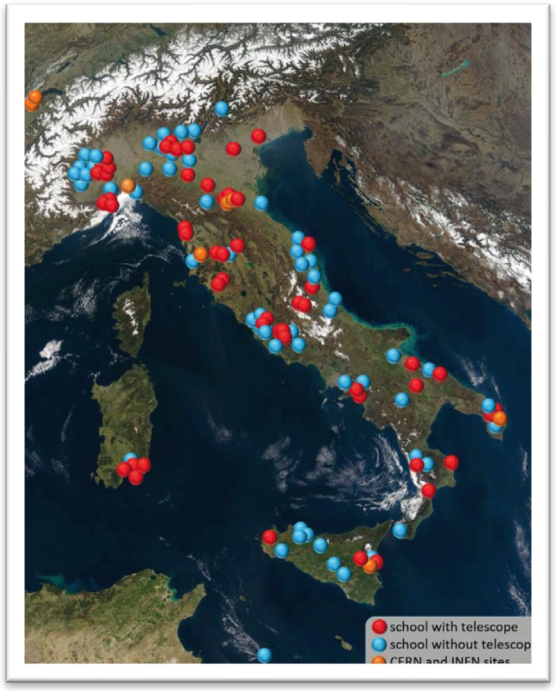
- Actively **involve high school students** and **teachers** in the experiment
- Equip high school buildings with **particle detectors**
- **Include** also schools not equipped with a detectors

Extreme Energy Events (EEE) Project

Extreme Energy Events
Science inside Schools

The EEE network consists of more than 60 **muon telescopes** installed:

- in Italian **high schools**
- in Italian laboratories
- at CERN



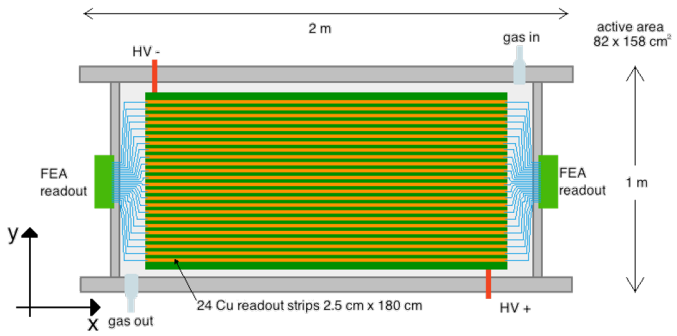
More than 100 Italian High Schools involved in the Project

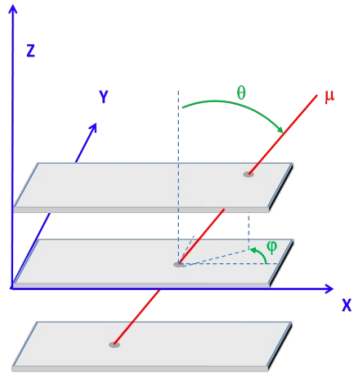
Largest area of MRPC detectors built and operating in unconventional working sites

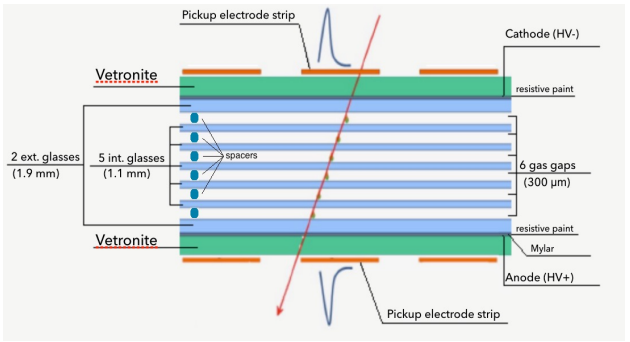
Distributed across an area of about $0.5 \times 10^6 km^2$

TELESCOPE LAYOUT:

3 **M**ultigap **R**esistive **P**late **C**hambers (**MRPC**s) (80 cm x 160 cm)







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

EEE MRPCs chambers built by students

Extreme Energy Events
Science inside Schools

The chambers are built and tested with the students playing an active role in all the relevant steps at CERN

Students built the detectors at CERN!

More than 180 MRPCs successfully built by students!

After the final performance validation, the MRPCs are sent to school institute, where they are installed and commissioned

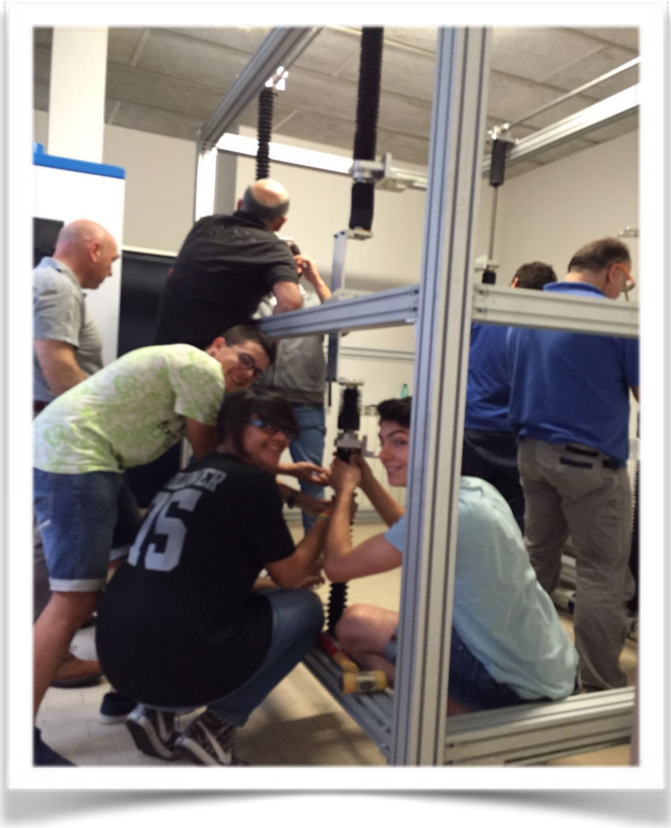
Once the station has been commissioned, data taking operations started

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

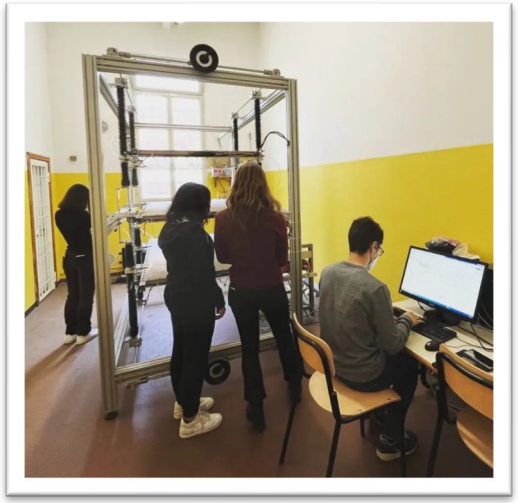
Students involvment

Extreme Energy Events
Science inside Schools

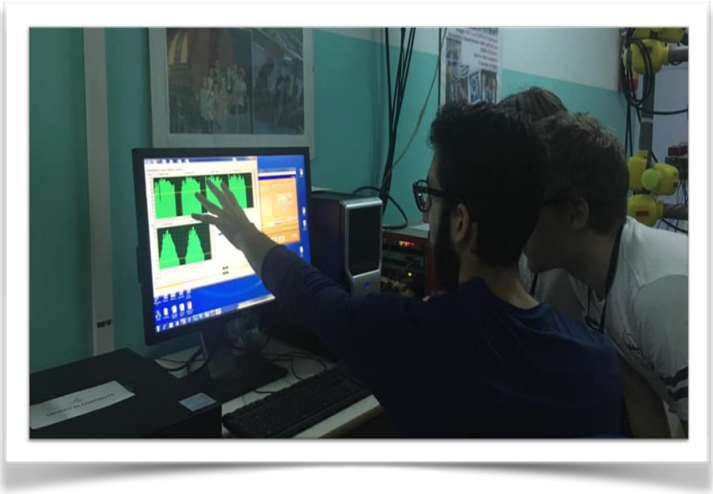
Students are involved in the **installation** at school



..in the operation and **daily monitoring** of the telescopes..

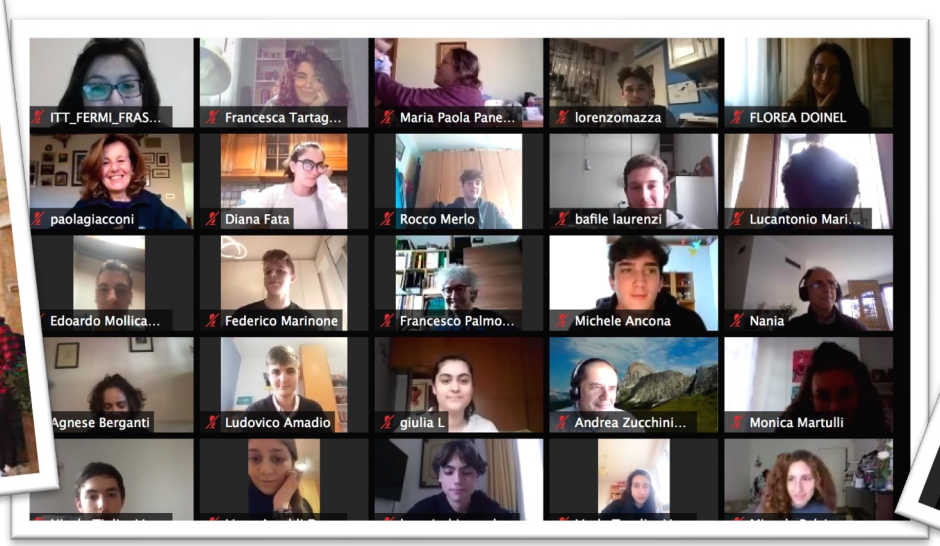


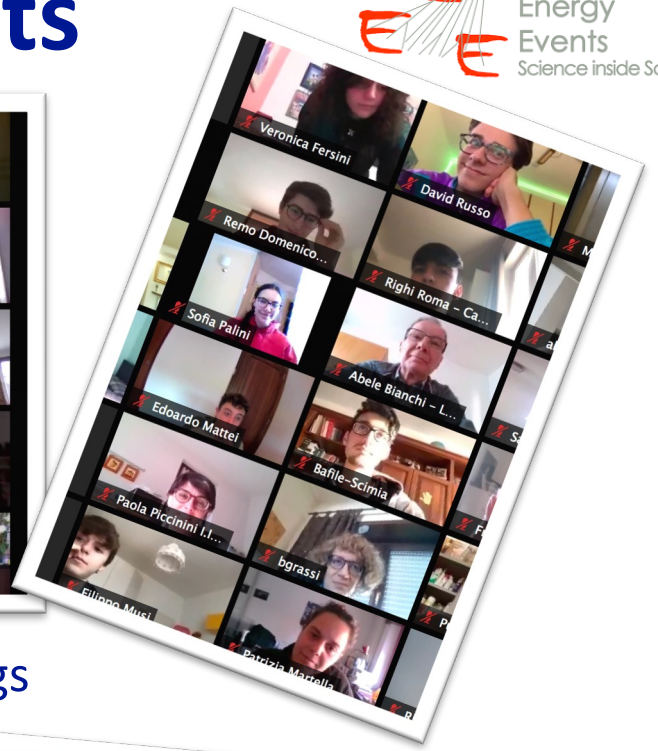
..in **data analysis**



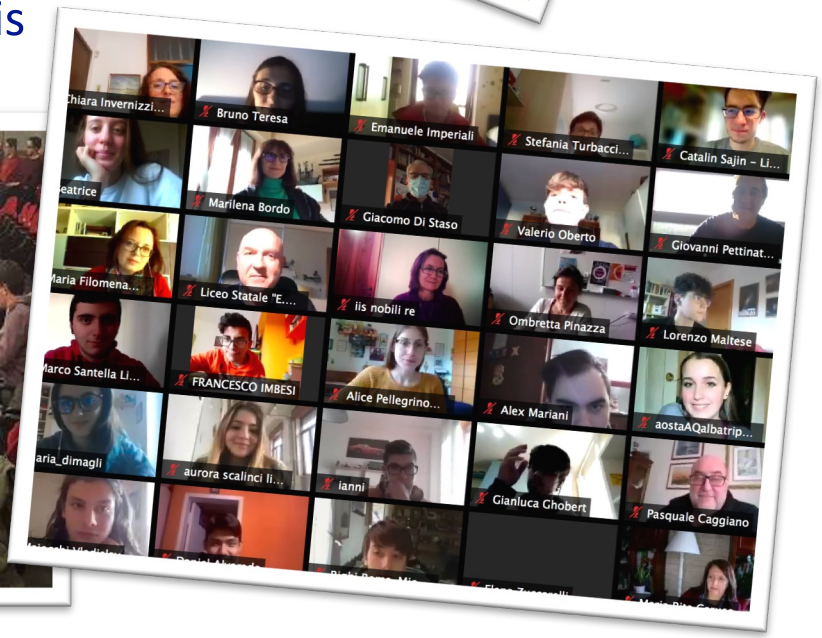
Keeping in touch with students

Extreme Energy Events
Science inside Schools





Students take part in presence (bi-annual) and online meetings attending masterclasses or presenting their analysis



Students analysis

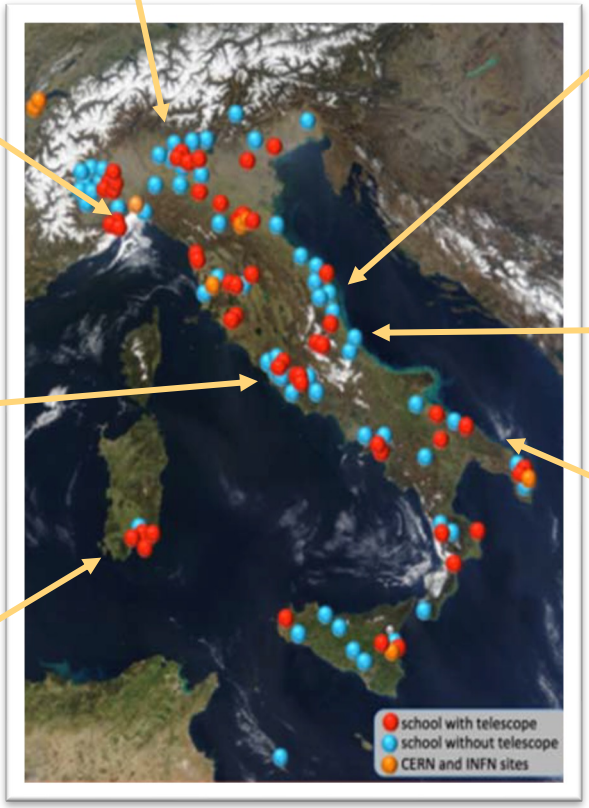
Extreme Energy Events
Science inside Schools

Students present their work and report results and issues in a dedicated monthly online meeting

Liceo Vittorio Veneto – Milano
"Cosmic ray flux and air pollution"

Liceo Calasanzio , Liceo Chiabrera – Savona
"Measurements of the flux of muons as a function of the height "

IIS Amedeo D'Aosta - L'Aquila
"Cosmic box measurements"



Liceo Blaise Pascal – Pomezia
"CATACOSMIC-BOX: Possible correlation between cosmic ray and radon"

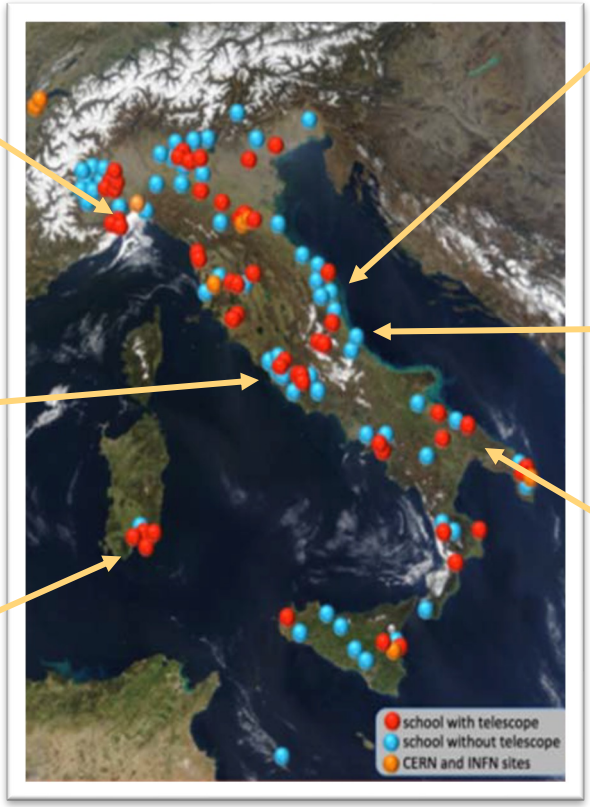
Liceo Galilei – Lanciano
"Cosmic box measurements"

Liceo Pacinotti – Cagliari
"Efficiency measurements of CAGL-01 telescope"

Liceo Scacchi – Bari
"Cosmic ray rate @ different altitude values – a preliminary report"

Some students of EEE Project

Extreme Energy Events
Science inside Schools

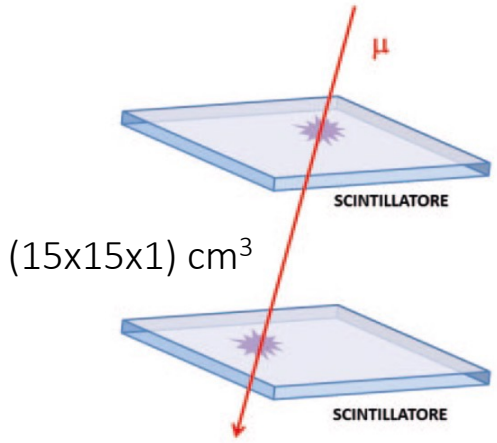


Students presentations

Extreme Energy Events
Science inside Schools

Cosmic Box

Portable detector based
on two parallel scintillator planes

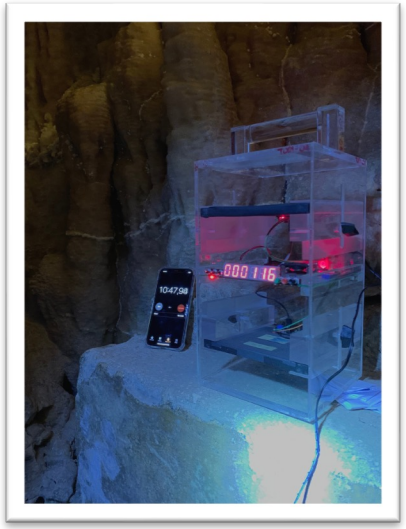


User friendly device

The light signals are read by SiPM
Provided with a display to monitor the acquisition rate, it can be operated with a single and double coincidence trigger

They studied muons rate as a function of the altitude

Liceo Scacchi – Bari
"Cosmic ray rate @ different altitude values - a preliminary report"



IIS Amedeo D'Aosta - L' Aquila
"Cosmic box measurements"

Liceo Calasanzio , Liceo Chiabrera – Savona
"Measurements of the flux of muons as a function of the height "

International Meeting

HUNDREDS OF STUDENTS AND TEACHERS

Next ICD
November 21-2023

Seminars
Masterclass
4 best students presentations:
Liceo Scacchi (Bari) - Liceo Righi (Roma)
IIS Staffa (Trinitapoli) - Liceo Pascal (Pomezia)

Students calculated the muon speed

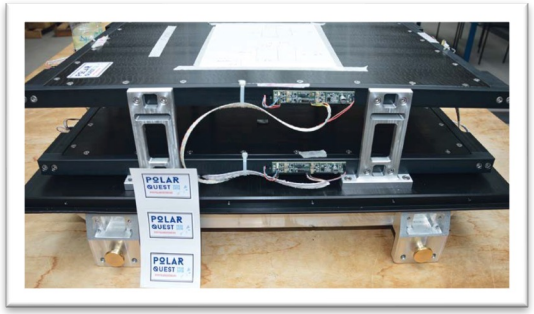
- using a recent data sample acquired by the telescope placed in their school from 13/03/2023 to 24/03/2023
- preparing a report to present their results

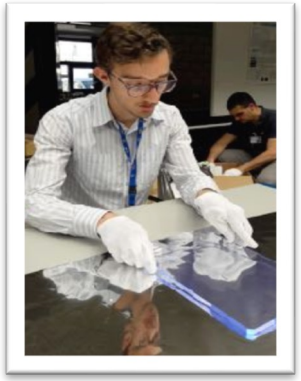
PolarquEEEst

The PolarQuest **2018** mission was a scientific multidisciplinary exploration in the Svalbard archipelago

In order to contribute to the PolarQuest scientific mission, the EEE Collaboration designed and developed portables cosmic ray detector: **POLA**

As per EEE Project tradition POLA detectors were assembled at CERN by high school Italian, Norvegian and Swiss students!

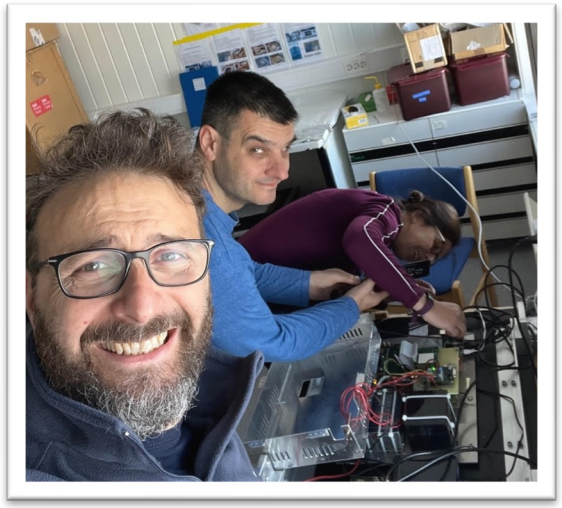




PolarquEEEst

2019
3 POLA detectors permanently installed at Ny Alesund – Svalbard

2023 Maintenance work



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

Ecological transition of the EEE Project

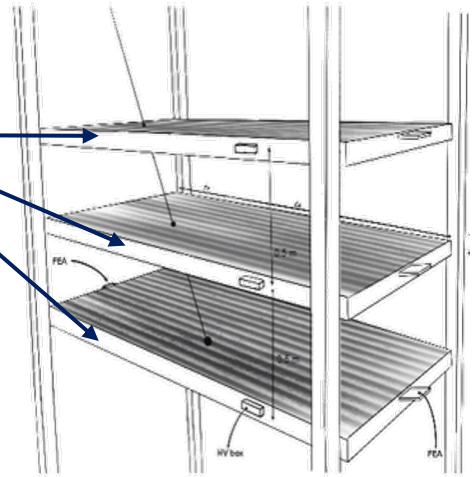
Extreme Energy Events
Science inside Schools

In the past few years students have been involved in the upgrade phase of the Project regarding the choice of an ecological gas mixture for the MRPCs gas detectors

$C_2H_2F_4$ (98%) + SF_6 (2%)

Green House Gas (GHG)

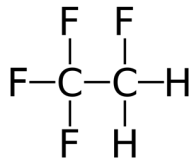
GWP* of ~ **1880**



EU regulations set an upper limit to GWP allowed in gas-operated devices
GWP > 150 banned

Still suitable for scientific purposes

EEE Collaboration decided to reduce the GHG emissions from EEE telescopes
New gas mixture with a lower GWP needed!



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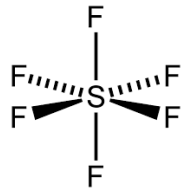
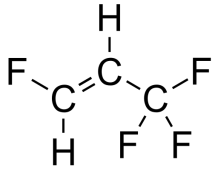


$C_2H_2F_4$
Tetrafluoroethane
GWP = 1430

SF_6
Sulfur hexafluoride
GWP = 23900



+

$C_3H_2F_4$
Tetrafluoropropene
GWP = 6

He
GWP < 1

Multidisciplinary approach students study physics and chemistry!

Standard mixture replaced with the eco - friendly mixture made of
50% $C_3H_2F_4$ + 50% He have a GWP ~ 3.5

The EEE Collaboration has restarted the experimental activities in several schools with the new eco-friendly gas mixture

* **G**lobal **W**arming **P**otential (**GWP**) measures the greenhouse effect of gas normalized to CO_2 ($GWP\ CO_2$=1)

EEE in *presence* meeting

The meeting was focused on a the Ecological Transition of the EEE Project

Masterclass:

"Ecogas for EEE stations
Data analysis on ecological mixtures"

The students had the opportunity to:
- analyze long term data acquired by telescopes fluxed with the new gas mixture
- discuss the results of the tests
- presenting their original contribution

Best works → awarded!

In addition!
Seminars dedicated to:
- coincidences between distant detectors
- PolarquEEEst mission
- Physics applied to the archaeological sector
- a contribution that prepared the students for the visit to the Lilibeo Museum in Marsala

50 students and **teachers in person**
more than 250 participants remotely connected

Students involved in the first Meeting
in person after COVID shutdown

17-19 November 2021 Erice (Sicily)

Run Coordination meeting

EEE *online* meeting

Monthly online meeting with students and teachers

Extreme Energy Events
Science inside Schools

28 September → Introduction to the activities for 2022/2023

26 October → PolarquEEEst – Cosmic rays from Italy to North Pole

21 November → International Cosmic Day (ICD)

14 December → Restarting with eco gas

25 January → New ecogas mixtures for the EEE Project

22 February → Live broadcast from the Alice Run Control Center at CERN

15 March → Artificial Intelligence: promises, risks and opportunities for the future

26 Aprile → Nuclear physics in everyday life

24 May → Students Presentation

Several topics
always Q&A session

7 selected presentations by students

Timetable

15:30 → 15:35 **Introduction**
Speaker: Cristina Ripoli (Università di Salerno)

15:35 → 15:40 **EEE - News**
Speaker: Marco Garbini (Centro Fermi)

15:40 → 15:50 **Flusso di raggi cosmici ed inquinamento atmosferico**
Speaker: Liceo Vittorio Veneto - Milano
progetto RC-inquin...

15:50 → 16:00 **Cosmic box measurements**
Speaker: IIS Amedeo D'Aosta - L'Aquila
PRESENTAZIONE II...

16:00 → 16:10 **CATACOSMIC-BOX: Ricerca di un'eventuale correlazione tra muoni e radon**
Speaker: Liceo Blaise Pascal - Pomezia
Measurements CB ...

16:10 → 16:20 **Measurement of the flux of muons as a function of the height**
Speaker: Liceo Calasanzio (Carcare, SV) - Liceo Chiabrera - Martini (Savona)
Attività Calasanzio-...

16:20 → 16:30 **Cosmic box measurements**
Speaker: Liceo Galilei - Lanciano
COSMIC BOX 2023...

16:30 → 16:40 **Cosmic rays rate @ different altitude values- a preliminary report**
Speaker: Liceo Scacchi - Bari
Liceo Scacchi 24 m...

16:40 → 16:50 **Misure Di Efficienza del Telescopio CAGL-01**
Speaker: Liceo Pacinotti - Cagliari
4_6008358917220...

16:50 → 17:00 **Question time**

Last meeting for the school year

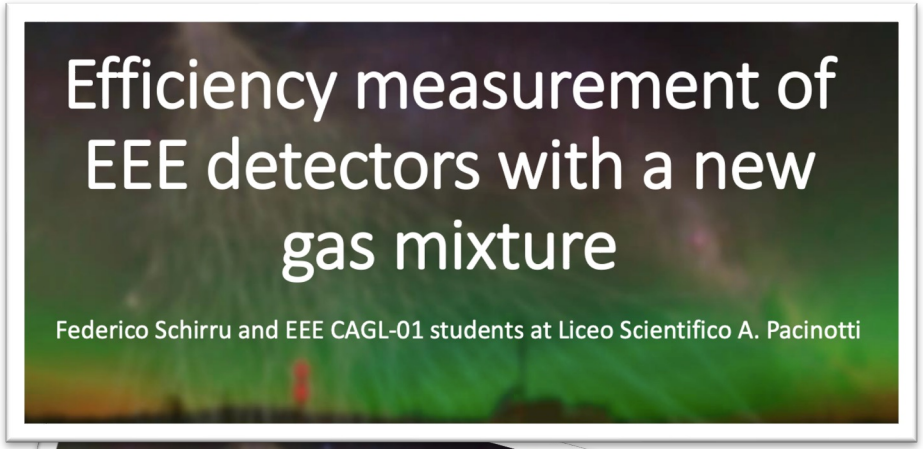
Events always posted on social

Others planned on September 2023!

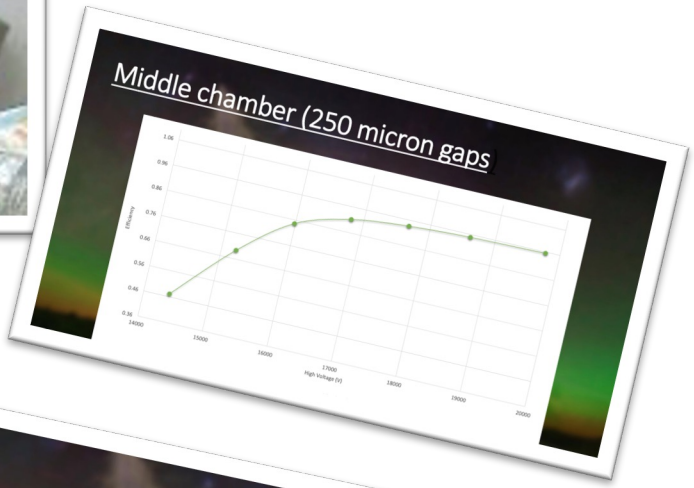
Students involved in the upgrade phase

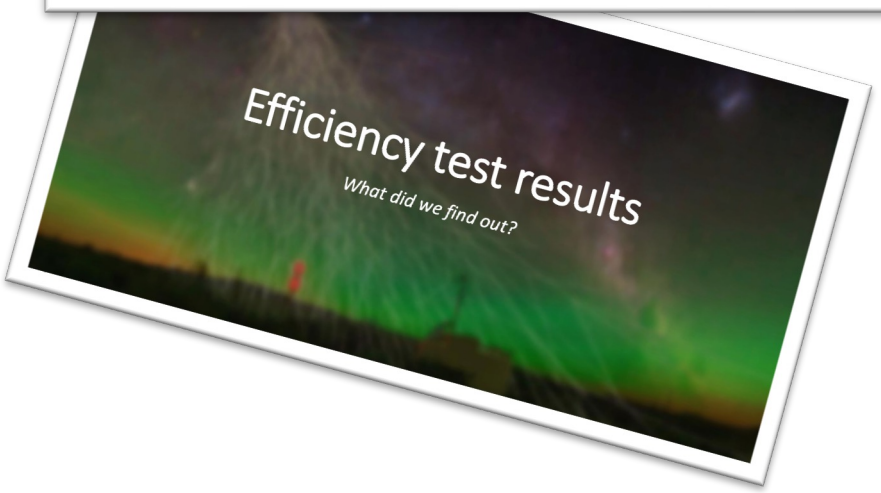
Extreme Energy Events
Science inside Schools

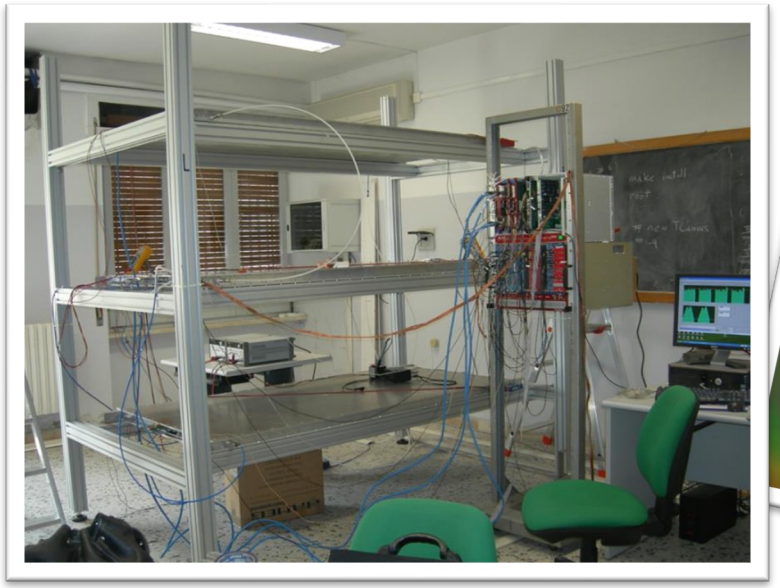
Liceo Pacinotti – Cagliari
"Efficiency measurements of CAGL-01 telescope"



Students tested the efficiency of each chamber (TOP - MIDDLE - BOTTOM) filled with new mixture and compared the results







The Project is a great opportunity for young students to:

- ✓ join EEE meeting, feeling themselves as part of a scientific Collaboration
- ✓ experience all the steps of the research from data analysis to results report
- ✓ get confidence in public speaking
- ✓ familiarize with presentation tools
- ✓ carry out independent analysis
- ✓ interact with other students, teachers and researchers

Conclusions

Extreme Energy Events
Science inside Schools

- ✓ The EEE Project has a **intense outreach programme** based on the direct involvement of students during school year
- ✓ Students get involved **for a full school year or more**. it is a long term commitment that comes with tangible opportunities to acquire new skills.
- ✓ A **strong online programme** that keeps the students engaged
- ✓ Increasing in **presence activities** ongoing


thank you
danke
gracias
merci
obrigado
bedankt
dziękuję
teşekkür ederim
go raibh maith agat
ngiyabonga
謝謝
mochchakkeram
sukriya
kop khun krap
terima kasih
dank je
tapadh leat
arigatô
dakujem
grazie
takk
taiku
спасибо
рахмат
Баярлалаа
감사합니다
ありがとう
ευχαριστώ
мерси
хвала
дякую
спасибі
mersi
barka
welalin
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spas
kia ora
vinaka
blagodaram
misaotra
matondo
paldies
grazzi
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faafetai lava
kiitos
dankie
dhanyavad
nandri
nanni
mauruuru
hvala
köszönöm
gràcie
bayarlalaa
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ačiū
asante
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gratias ago
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