The Extreme Energy Events experiment:

✓ The future

M. Abbrescia for the Extreme Energy Events collaboration
Present status

50 telescopes at High Schools
+ 2 telescopes at CERN
+ 4 at INFN Units
Total: 56 telescopes
+ ≈ 50 schools on the waiting list

✓ Largest (in terms of area) system using MRPCs
✓ Largest cosmic rays experiment in Europe
✓ Four new stations in the last six months!

- Stations in operation at schools
- Stations in operation at research centers
- Schools on the waiting list
Data taking

- Almost 55 billion events collected since the start of organized data taking
- More than 20 billion events collected during Run-3 only!
- Plan to take another 20 billion events during Run-4
Improvements in the data flow

- Overcome the 100 MEvents/day threshold (during March and April)
- New reconstruction algorithm: Analyzer v.2.0
- New data transfer tool: SyncThing
- New automatic elog
Incredible effort done by Francesco, Fabrizio, Carmelo and people at ReCasas

<table>
<thead>
<tr>
<th>School</th>
<th>Day</th>
<th>Time</th>
<th>Name of the last transferred File</th>
<th>Number of Files transferred today</th>
<th>Name of the last File analyzed by DQM</th>
<th>DQM daily report</th>
<th>RATE of Triggers for the last Run</th>
<th>RATE of Tracks for the last Run</th>
<th>Link DQM</th>
</tr>
</thead>
</table>

[EE Monitor] Back from the abyss of the waters...  
[EE Monitor] ... running in ReCas - Bari

[EE Monitor] Start of RUN4: October 2, 2017

Total number of candidate tracks ($X^2<10$) in this database: 4307311741
The EEE crew...
Corrado, Daniele, Edoardo, Federico, Fabrizio, Francesca, Francesco Nof., Francesco Noz., Giovanni, Ivan, Laura, Luca, Marco B., Marco G., Marco P., Marco S., Marcello, Maria Paola, Nicola, Paola, Rosario, Silvia M., Silvia P., Stefano...
EEE network upgrade

✓ Plan to build another 20 telescopes
✓ Will increase the capability of the EEE network to study the high-energy part of the cosmic rays spectrum
✓ Huge effort for 2017-18!

First bunch already almost completed

✓ 20-27 February → Lampedusa
✓ 12-18 March → Genova
✓ 23-29 April → SIEN-02
✓ 7-13 May → TORI-05 + Moscow
✓ 21-27 May → LODI-03
✓ 10-14 July → LODI + Korca (spare chambers)
✓ 25-29 September → CAGL-04
✓ 21-24 November → BOLO-05
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EEE smallest (but great) town

- Plan to build another 20 telescopes
- Will increase the capability of the EEE network to study the high-energy part of the cosmic rays spectrum
- Huge effort for 2017-18!

Liceo Scientifico “Patrizi” di Cariati
EEE arrives to Moscow

Mixed team of teachers/students from Gobetti Segrè Lyceum in Turin and the Lyceum for Chemical Physics in Moscow
Invited to go to a location close to Moscow next February (−25°C!!!)
External collaborations

- EGO-VIRGO collaboration interested in having one (or more) EEE telescopes hosted at their lab in Cascina
  - As a veto for cosmic ray showers in coincidence with possible signals coming from gravitational waves
    - There is a similar device at LIGO
    - There is some literature on that
    - Possibility to sign up an agreement

- University of Santiago de Compostela (Spain) interested in analyzing EEE data looking for correlations between the cosmic rays flux and temperature and pressure conditions in the troposphere
  - An agreement has been signed up

And, of course, Polar QuEEEst!
Extreme Energy Events

Polar Quest 1928-2018

Extreme Adventure
Complete circumnavigation of the Svalbard archipelago with a sailing boat.

Extreme Science
An international team of arctic researchers, today’s explorers of the unknown, looking for answers to some of the great enigmas of science, from climate change to measuring the impact of human pollution at extreme latitudes, from the study of paleoclimate to the origin of high energy cosmic rays.

Extreme Exploration
A quest for the wreck of the Italia airship on the 90th anniversary of the crash which made the history of polar exploration.

A Message for the Planet
A voyage to the last untouched wilderneses on earth, to convey the importance of the Arctic for our sustainable future.

http://www.polarquest2018.org/
Polar QuEEEst

3 PolarQuEEEst detectors
✓ onboard on Polar Nanuq
✓ installed in a Norwegian High School
✓ installed in an Italian High School

Mounted by students as EEE tradition

45° in latitude - 5000 km

Interesting technical problems
250 µm gap chambers

- Conceived for new eco-friendly gases
- Reduce operating voltage

Improved front-end boards

- Amphenol cables and connectors replaced by Nugent ones
- Pre-production boards under test

New test protocol at CERN

- Tests on electrical (strip) connectivity
- Tests on gas tightness
- Tests on current, rate and efficiency
- Everything stored in a dedicated DB
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EEC clock distribution card

- Designed at INFN Torino
- Distributed the same clock to the two TDCs of the EEE readout
- Essential to exploit time info from the middle chamber
- Built and installed in all EEE telescopes

\[ \sigma_t \approx 8 \text{ ns} \]

\[ \sigma_t \approx 0.25 \text{ ns} \]
New trigger/GPS cards

✔ Developed between Bari and Lecce INFN sections
✔ Joins the functionalities of the present trigger and GPS boards (+ GPS interface)
✔ Additional functionalities:
  - clock distribution
  - counters accessible via VME
  - trigger logic programmable via VME

✔ Already installed at:
  LODI-02, VICE-01, TORI-01…
✔ Going into production now
EEE: the taskforce

- A task force of hardware experts, to intervene where setting up/commissioning/reparation of an EEE telescope is needed
- Started activity at beginning of 2017

Already interventions at:
- TREV-01 (commissioning, now telescope taking part to the data taking)
- VICE-01 (telescope set-up, now taking part to Run-4)
- ROMA-01, ROMA-02 (testing and repairs)
- VICE-01 (telescope set-up, now taking part to Run-4)
- FRAS-02, FRAS-03 (some repairs)
- Programming interventions at LECCE, ROME, etc.
EEE meetings with schools

- Since end of 2016 monthly EEE run coordination meetings open to schools
- Using dedicated Vidyo virtual rooms
- Around 100 schools connected → hundreds of participants!
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EEE plenary meetings

✓ Bologna, November 6-7
  North Italy schools
✓ Grosseto, April 15-16
  Center Italy schools
✓ Bari, October 13-14
  South Italy schools

Erice 2017:
✓ May, 29, 30 and 31
✓ December, 6, 7 and 8
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EEE: goal of the project

Aims at covering the most interesting, and still unexplored, region of the cosmic ray spectrum:

- $E > 10^{18}$ eV
- Extragalactic sources
- GZK cutoff

(Greisen, Zatspein and Kuz’min)
Detected coincidences at 1.5 km

Higher distance → higher energy

Coincidence rate vs. distance

Each cluster is sensitive to showers of Energy high enough to involve both stations

Need an accurate Monte Carlo

Simulate shower development

Simulate environmental effects
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EEE: long distance correlations

- Strategy: correlations between individual showers in telescopes clusters
- Shower rate: 0.001 - 0.04 Hz (depending on cluster and S/N ratio)
- Spurious rate in 1 ms: $10^{-8} - 10^{-7}$ Hz (0.001 - 0.01/day)

Number of events $dN/d(\Delta t)$ for decreasing time window

Cut on the relative angle

10 ms

Not the same results for all pairs of clusters: studies ongoing!
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**EEE chamber performance**

- Efficiency measurements
  - …and counting rate

- Efficiency HV scan performed last year (middle chamber)
  - To be repeated for all chambers

- Time resolution measurements
  - With time slewing corrections, improving time resolution about 20%
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Backscattered events

Backscattered events:
$\beta_0 > 0$ && $\beta_1 < 0$

Large time difference due to Time Of Flight

Inferred distance to the ground:
46 cm below the telescope
Being up h24...

The 2016 new year Forbush: at 24.00 of 31/12/2015 our telescopes -in schools- were up and running!

GCRD 2015-12-31: EEE-OULU fluxs

New year!

preliminary

2h bins

EEE: ALTA-01 + SAVO-01 + TORI-04

OULU neutron mon.

All EEE papers: http://eee.centrofermi.it/collaboration/pubblicazioni
The future is now: Run-4

- Start: 2 October 2017 – End: 31 May 2018
  - Commissioning week: 25 September 2017 – 1 October 2017

Schools are called to:
- fix all issues in their telescopes
  - 50 cm distance between chambers
  - 2 l/h gas flow
- Complete the measure of the telescope angle wrt. North
- Start measures of the gas consumption
- Telescope startup and shutdown responsibility of the schools

Read emails, diffuse them and react
Take part and present to the EEE Run meetings open to schools
Keep the telescope in operation
Monitor the telescopes (ALL)
Conclusions

- The EEE experiment is an innovative approach to:
  - scientific research + scientific communication

- Its stations, located in high schools, take data almost continuously
  - incredible enthusiasm by students and teachers

- EEE produces *a lot of* physics!
  - detectors performance similar to LHC
  - very interesting observations of cosmics phenomena

But, above all...
... it is a lot of fun!
... it is a lot of fun!
The End:
✓ Thanks for the attention
✓ Questions?