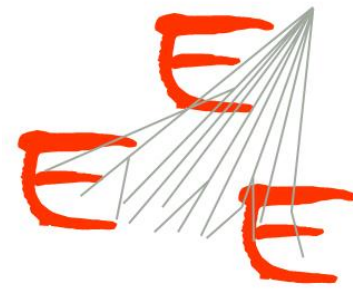




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STUDI E RICERCHE  
ENRICO FERMI



Extreme  
Energy  
Events  
Science inside Schools

# PolarQuEEEst

Extreme Energy Events

@

Extreme Weather Conditions !

## The PolarQuEEEst mission

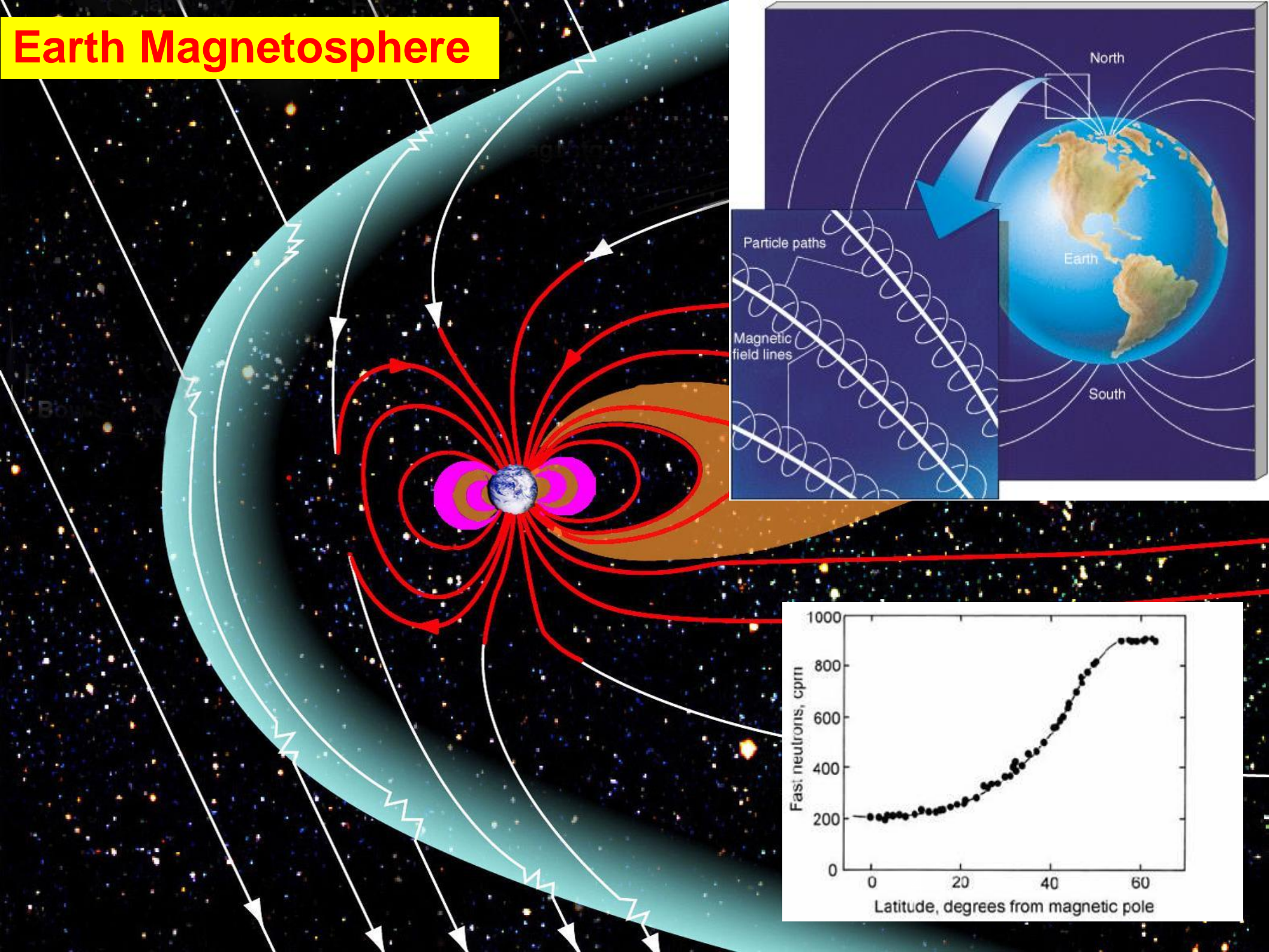
... Cosmic Rays, the Geomagnetic Field ....

... and the Earth Climate ...

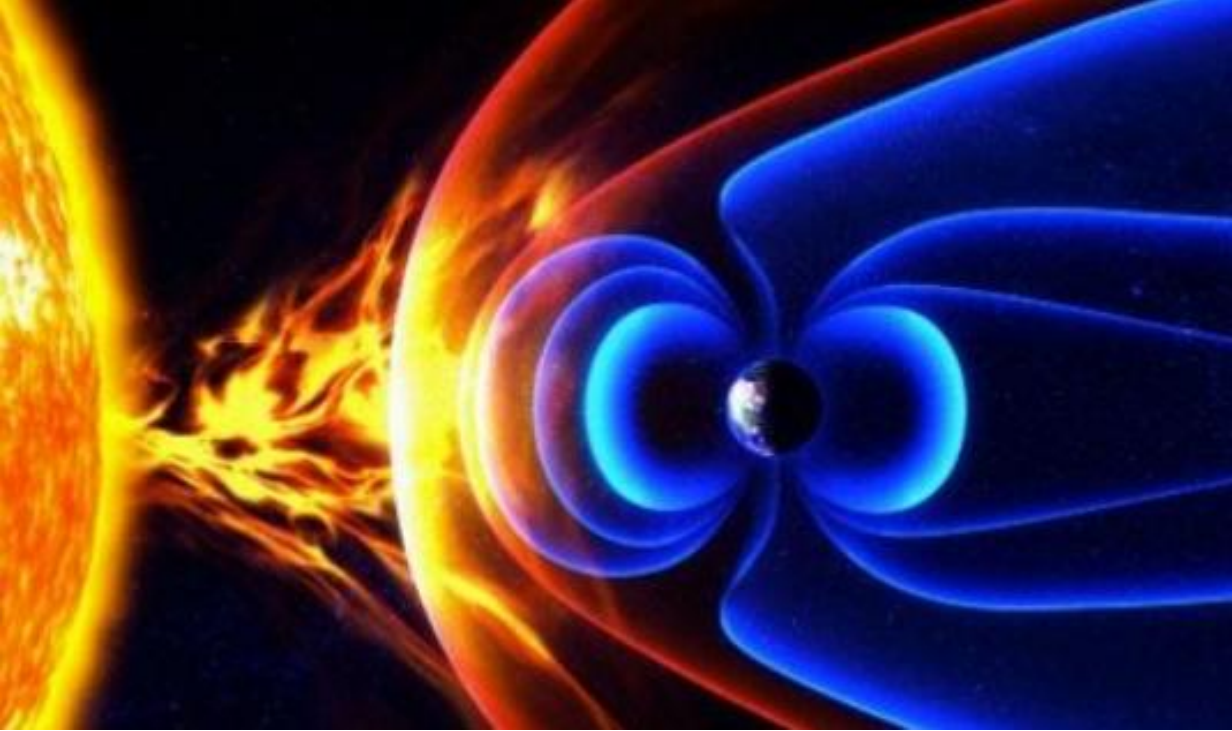




# Earth Magnetosphere



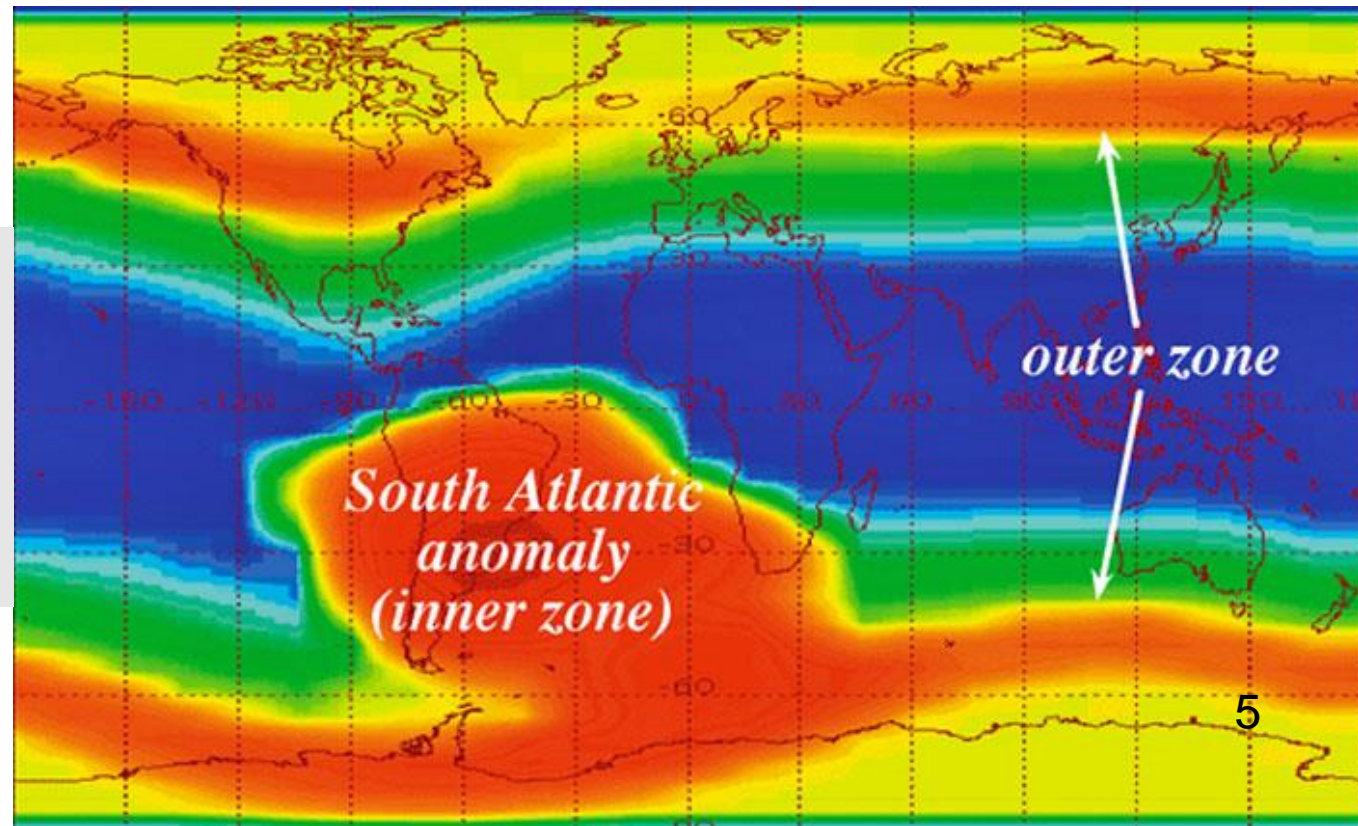




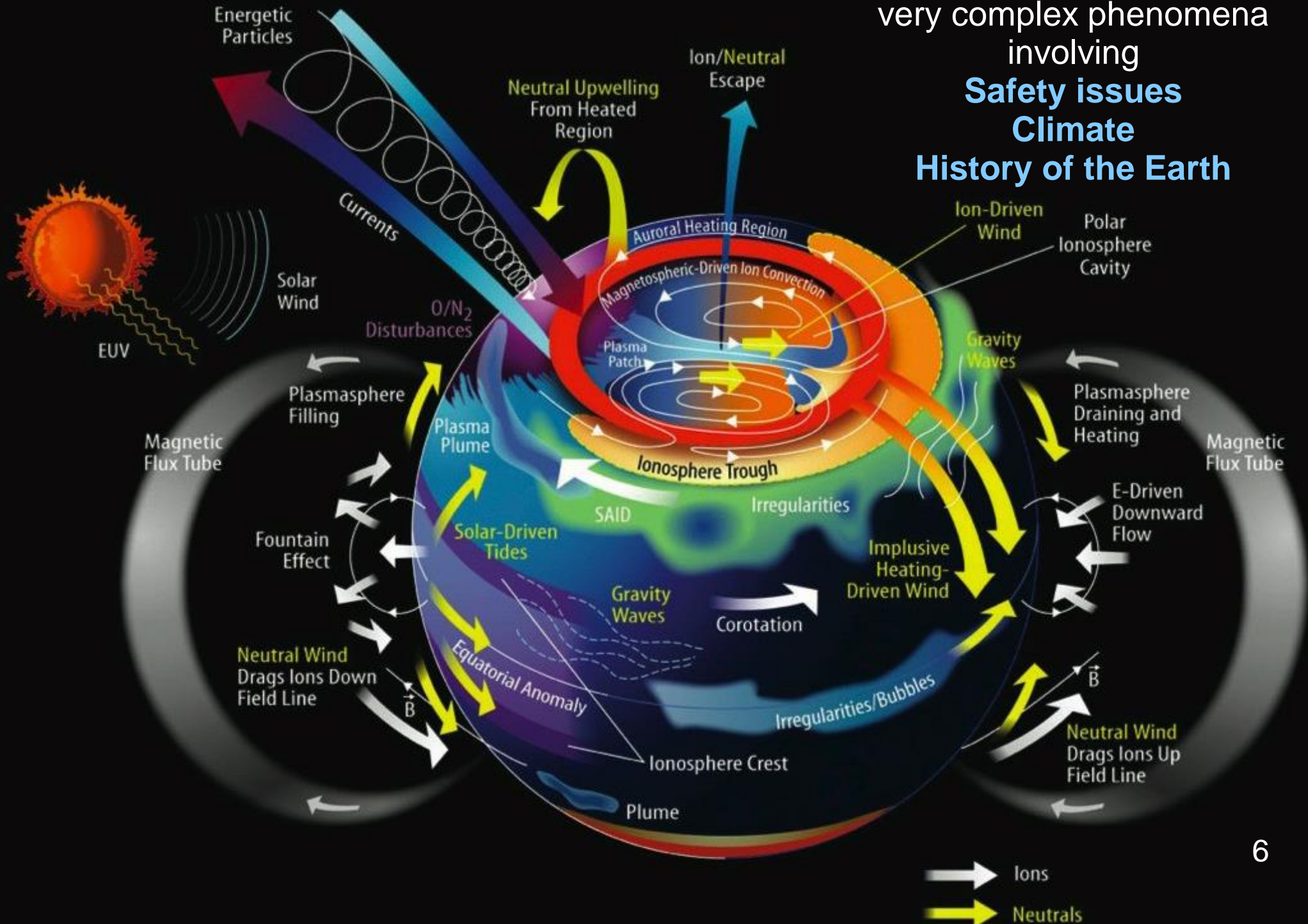
Earth Magnetosphere is modified by solar wind

Geomagnetic field anomalies play fundamental role in cosmic rays flux on Earth

ISS, satellites and expeditions have to take it into account



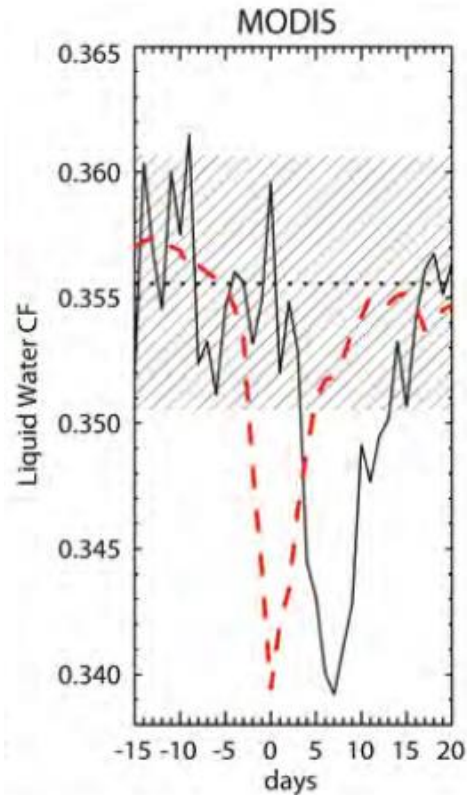
Magnetosphere and Cosmic ray  
interplay is a  
very complex phenomena  
involving  
**Safety issues**  
**Climate**  
**History of the Earth**





# Cosmic Rays, Life and Paleoclimate

<https://www.europhysicsnews.org/articles/e pn/pdf/2015/02/e pn2015462p26.pdf>

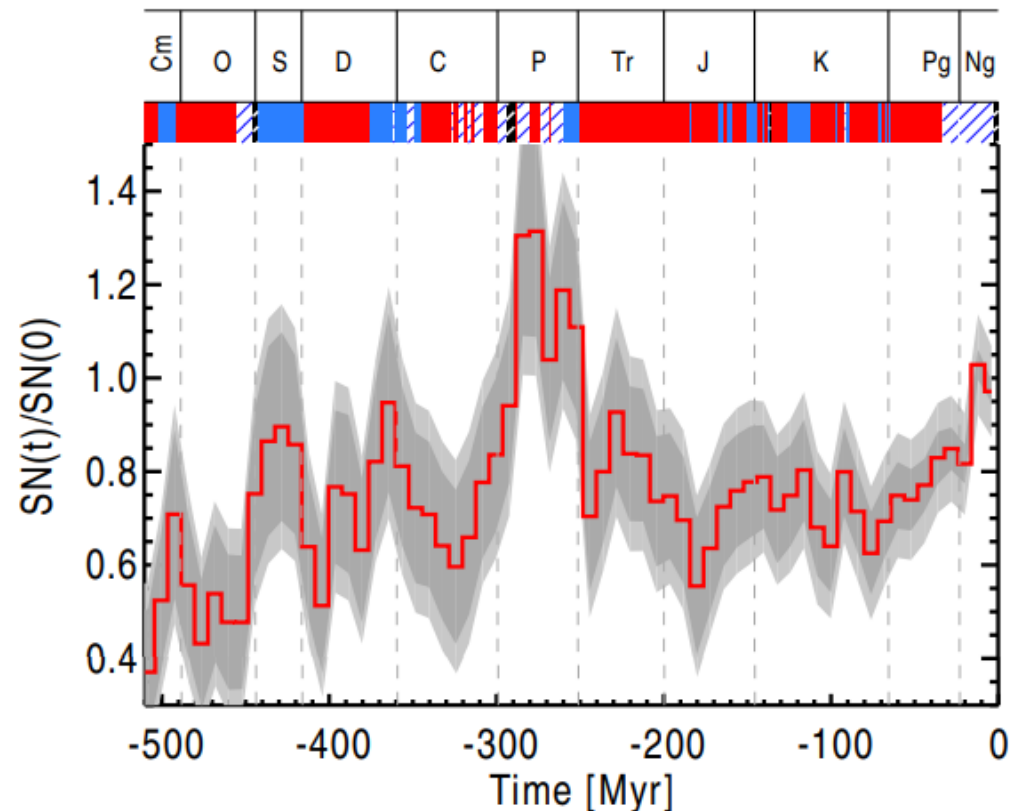


## Forbush events

Correlation of neutron measurements (red) and liquid water cloud fraction (black)

## Paleoclimate

Correlation of Supernovae rate (i.e. CR) and climatic

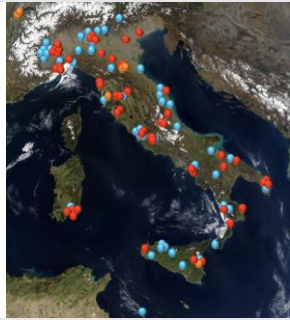


## Cosmic Rays and Clouds (CLOUD experiment at CERN)

Condensation Nuclei density is influenced by CR flux

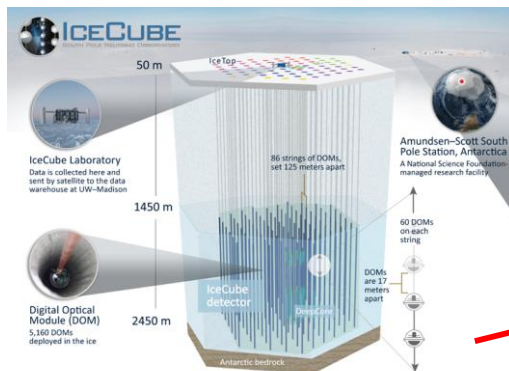
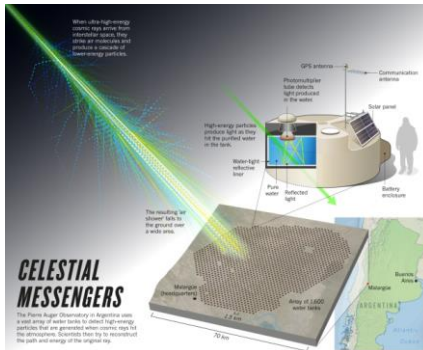
<https://home.cern/about/experiments/cloud>  
<http://cerncourier.com/cws/article/cern/41723>

## Large Area Cosmic rays experiments



EEE (Italy)

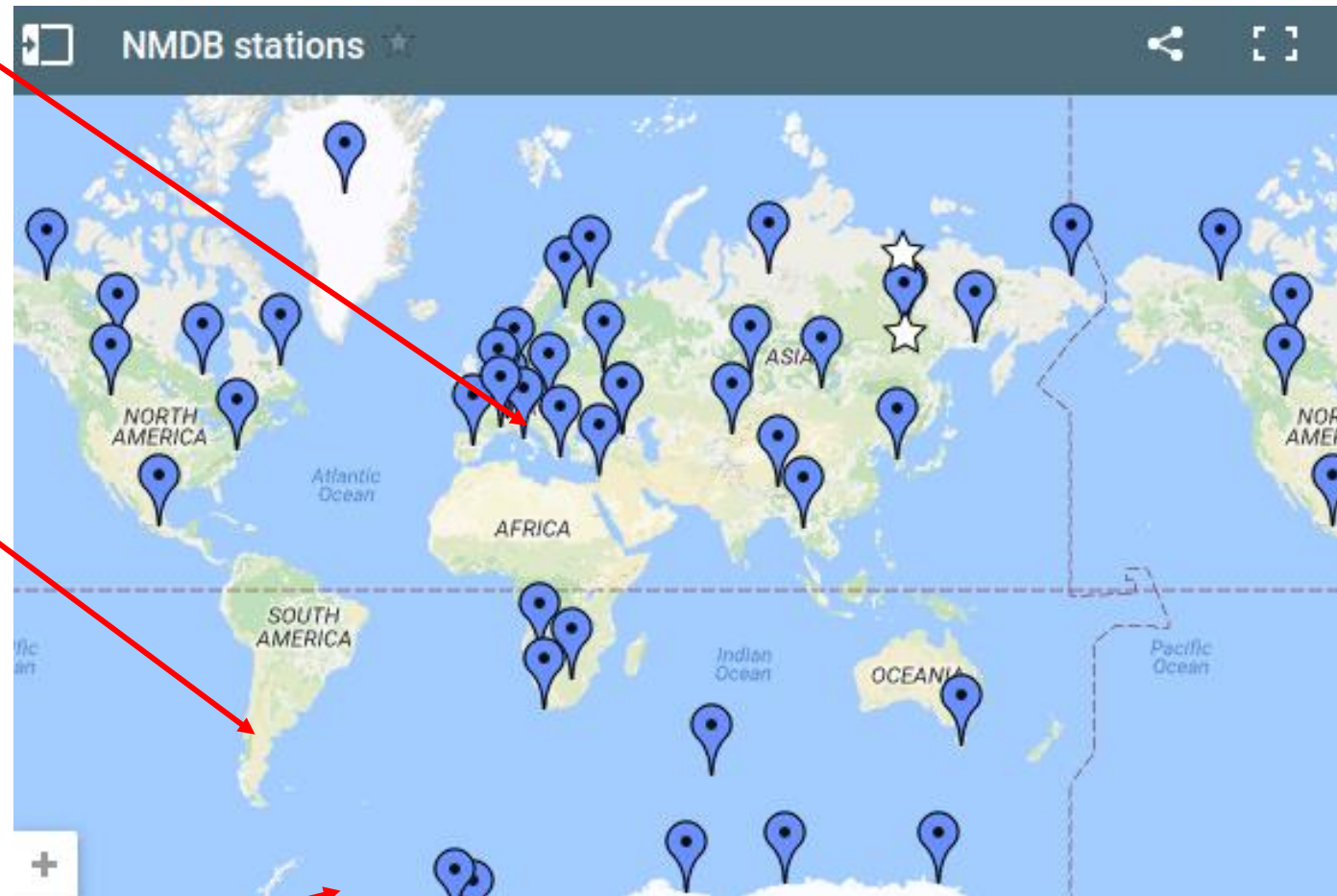
## Pierre Auger Observatory Argentina



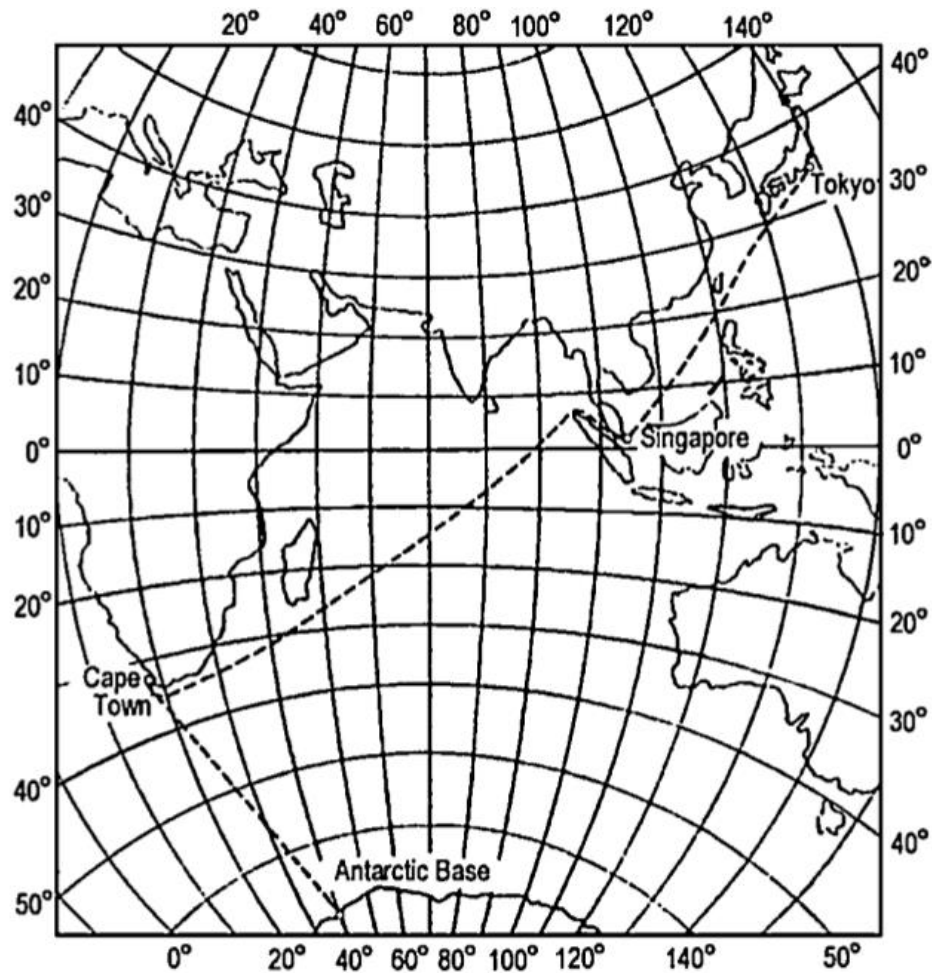
## Ice Cube Observatory South Pole Antarctica



**Cosmic rays Neutron  
Monitor Network**  
is the widest network  
for monitoring neutrons



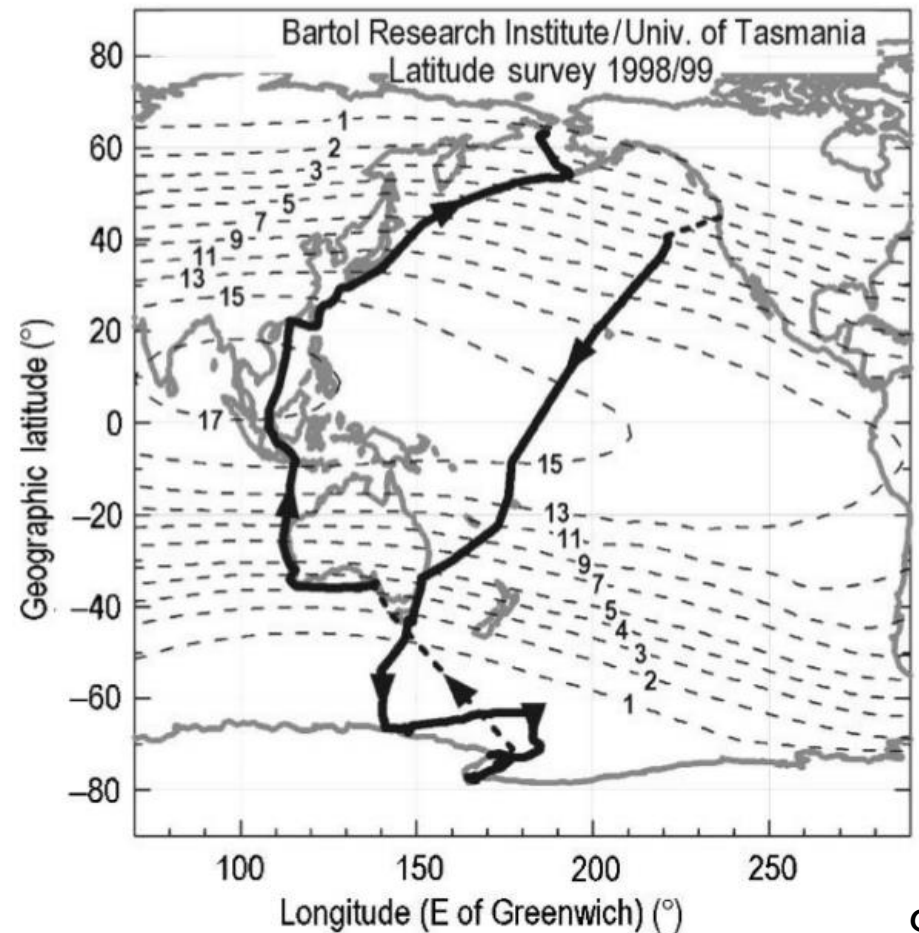




Soya Ship route, 1960

## Previous measurements on boats

### Polar Ship Survey, 1999



PolarQuEEEst and schools

... involving students

in a real scientific measurement ...

at the edges of knowledge



## Measurement of cosmic rays with detectors spread all over Italy



Students at CERN  
building detectors

One telescope  
installed in a  
Institute



Example of masterclass  
with 140 students in  
Centro Majorana (Erice)

Map of the high schools involved  
56 with a Telescope (red)  
52 participating to analysis (blue)





# Polar QuEEEest 1928 – 2018

## Purpose:

- measurement of absolute Cosmic Ray fluxes at different latitudes
- sensitivity to low energy Cosmic Rays ("trapped" at Poles by Earth magnetic field)

Telescope with Two-Planes of scintillators

SiPM readout

50x50x30 cm<sup>3</sup> total volume

Low consumption electronics

Three telescopes built by high school students at CERN

- same type detectors
- synchronous (GPS)
- installed on Nanuq sailboat and schools in Norway and Italy



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# The PolarQuEEEst Network

## 3 PolarQuEEEst detector

Onboard on Polar Nanuq

Installed in a Norwegian High School

Installed in an Italian High School

As usual in EEE tradition all detectors will be mounted by students

≈ 45° in latitude, span 5000 km



The PolarQuEEEst detector

... an Extremely Compact Telescope ....

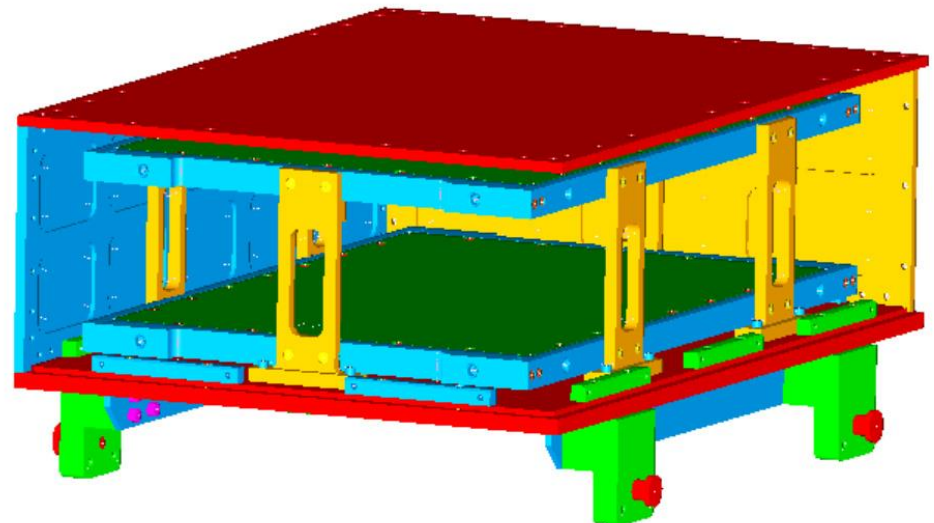
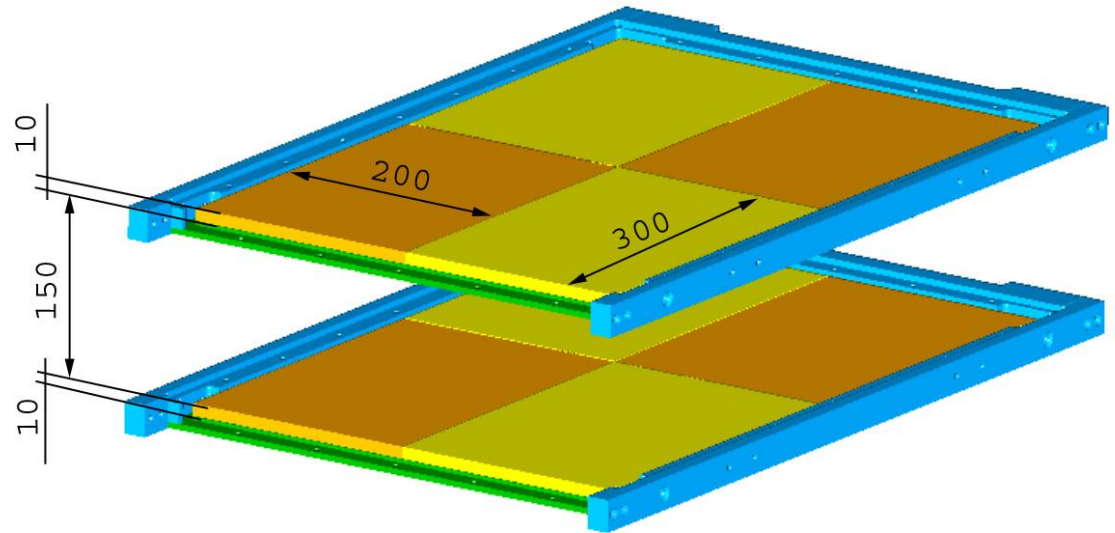
...full optional, anyway...



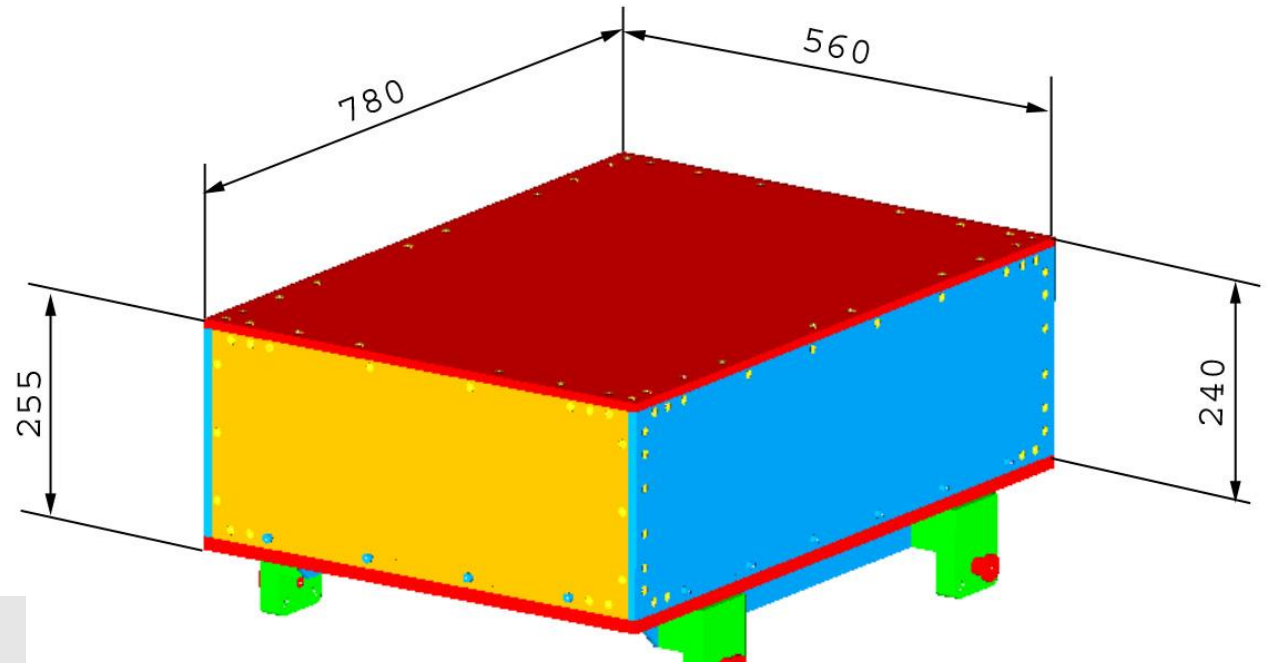
# The PolarQuEEEst Detector

## The detector

- 2 scintillator planes
- Distance between planes: 15 cm
- 4 tiles per plane 30 cm x 20 cm
- Each tile 2 SiPM
- Efficiency > 96% (overall)
- Trigger: AND among 2 planes
- Each plane: OR among 4 tiles
- Muon rate: 10-15 Hz
- Dark rate per 2 plane (4 tiles):  $3 \cdot 10^{-4}$  Hz
- S/N  $\sim 5 \cdot 10^4$



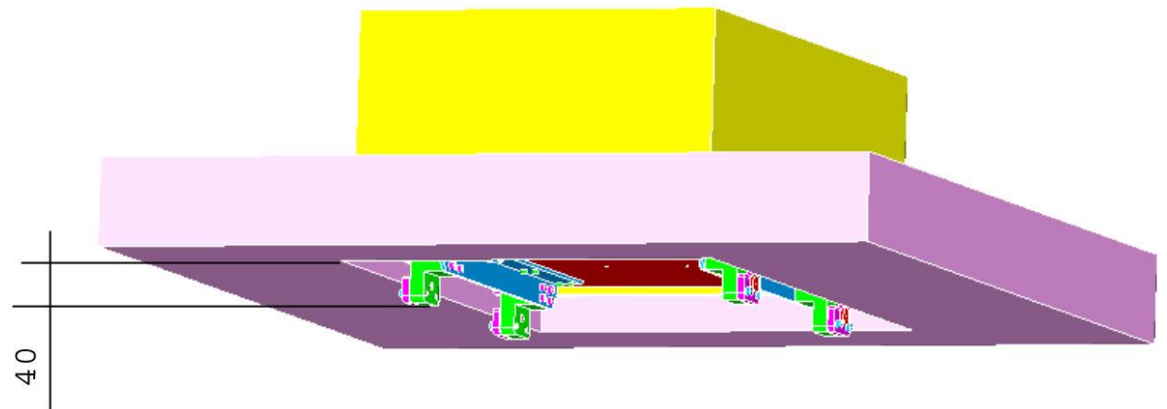
# The PolarQuEEEst Detector

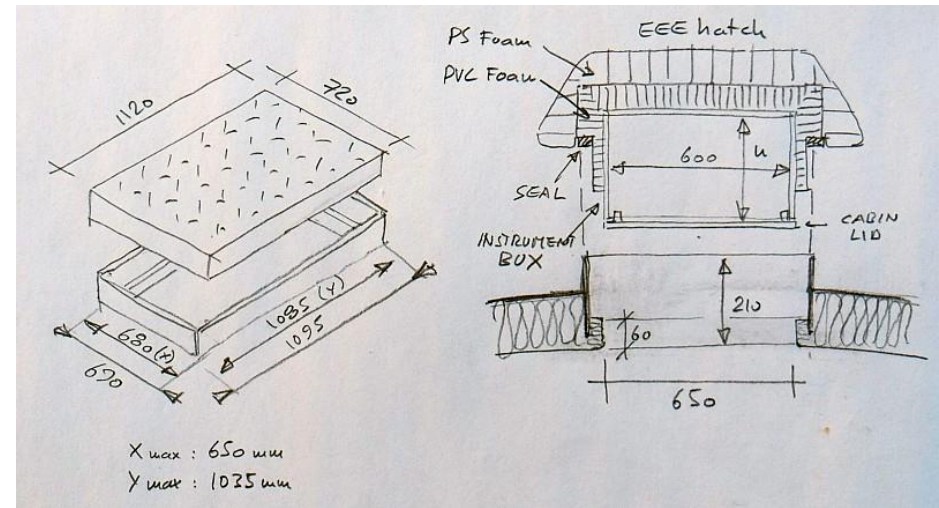


The detector case:

Shielding container:

- Light tight (black)
- Directly hooked to the boat hatch





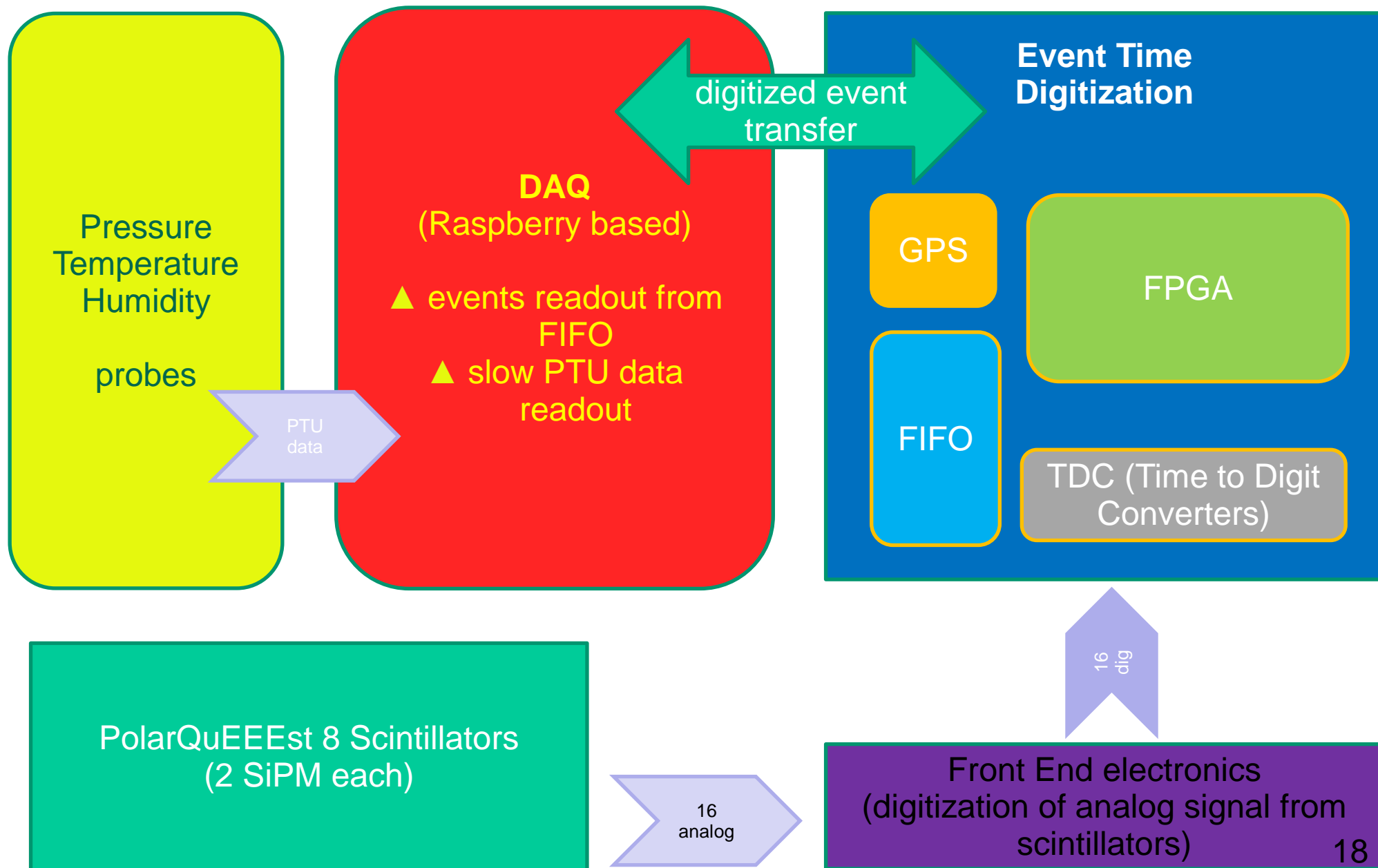
The  
**COSMIC  
HATCH**



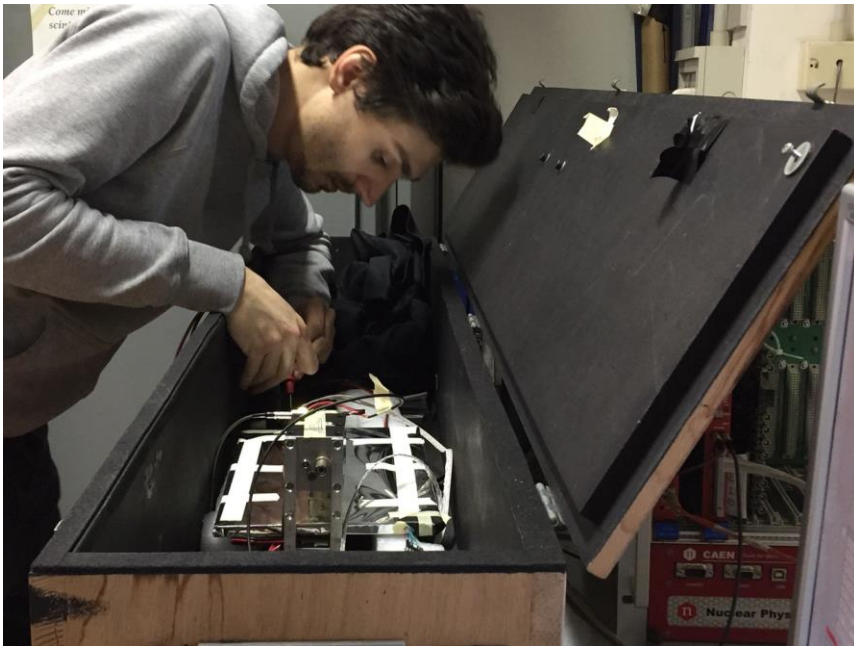


# The PolarQuEEEst Data Acquisition System

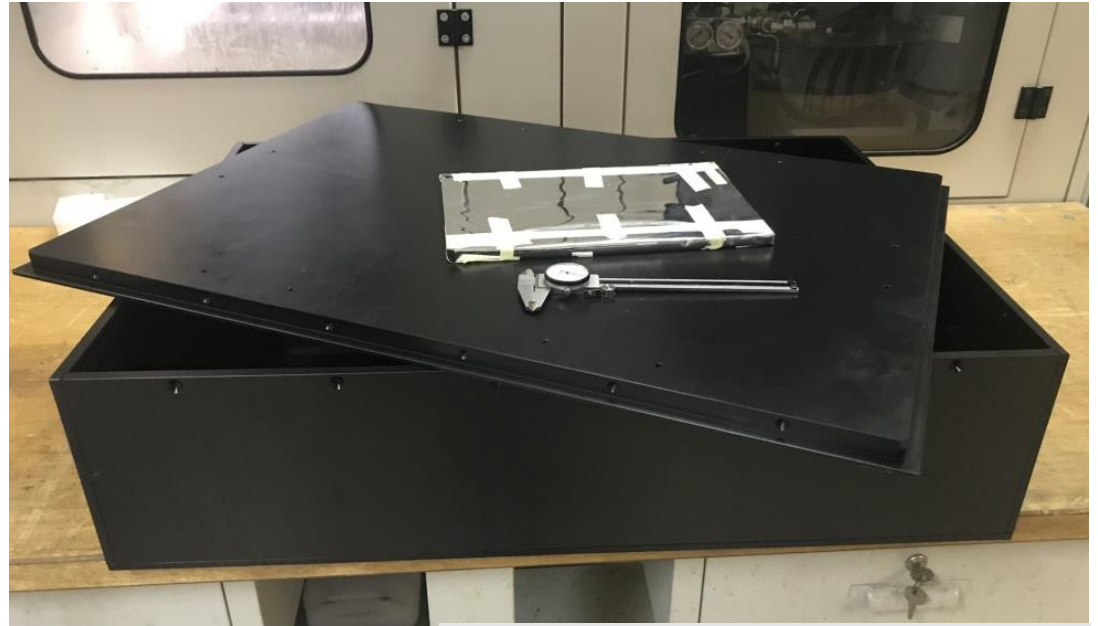
Total power < 16 W



# The PolarQuEEEst Detector tests

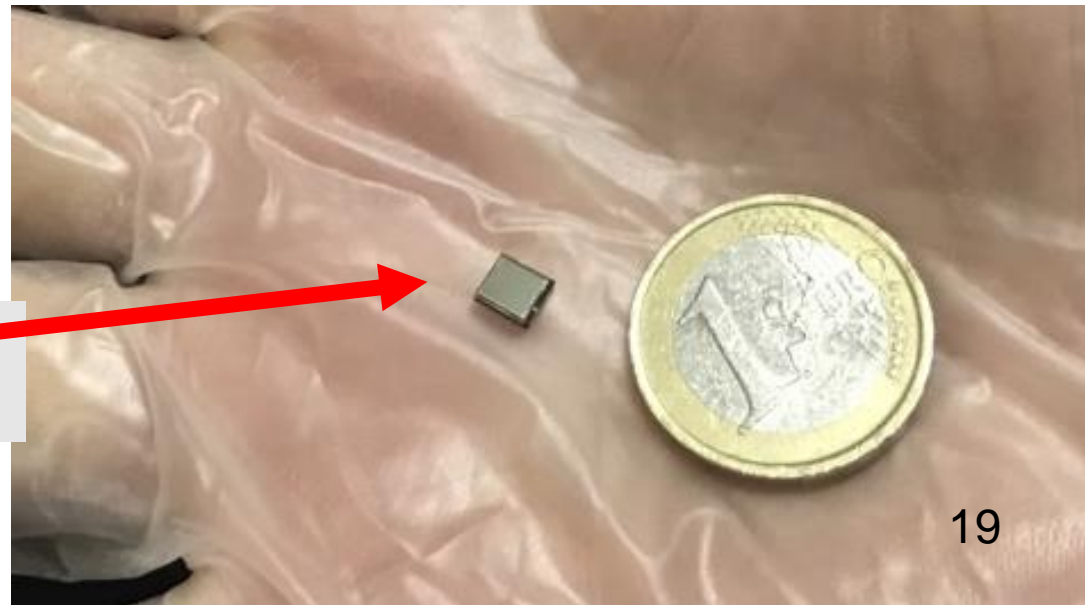


Bachelor student during  
scintillator tests



Prototypes box and  
scintillators

4x4 mm<sup>2</sup> Silicon  
Photomultiplier



...ready for the UnexpectEEEd?

