

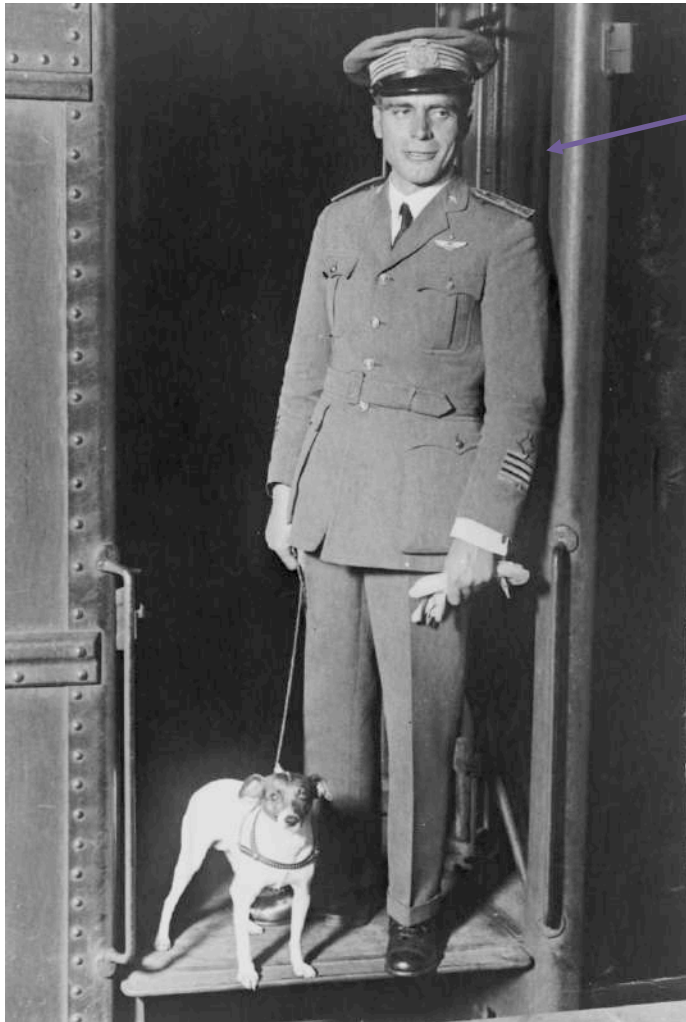
PolarQuest 2018-2019: alla ricerca di raggi cosmici, sulle tracce di Umberto Nobile

*Marco Garbini,
Francesco Noferini,
Carmelo Pellegrino,
Ombretta Pinazza*



EEE Meeting – 22 aprile 2020

Umberto Nobile



Ing. dott. prof. Generale del Genio
della Regia Aeronautica **Umberto Nobile**
progettava, costruiva e pilotava **dirigibili!**



La spedizione di Nobile

Il 19 marzo 1928 parte da Ciampino (Roma)

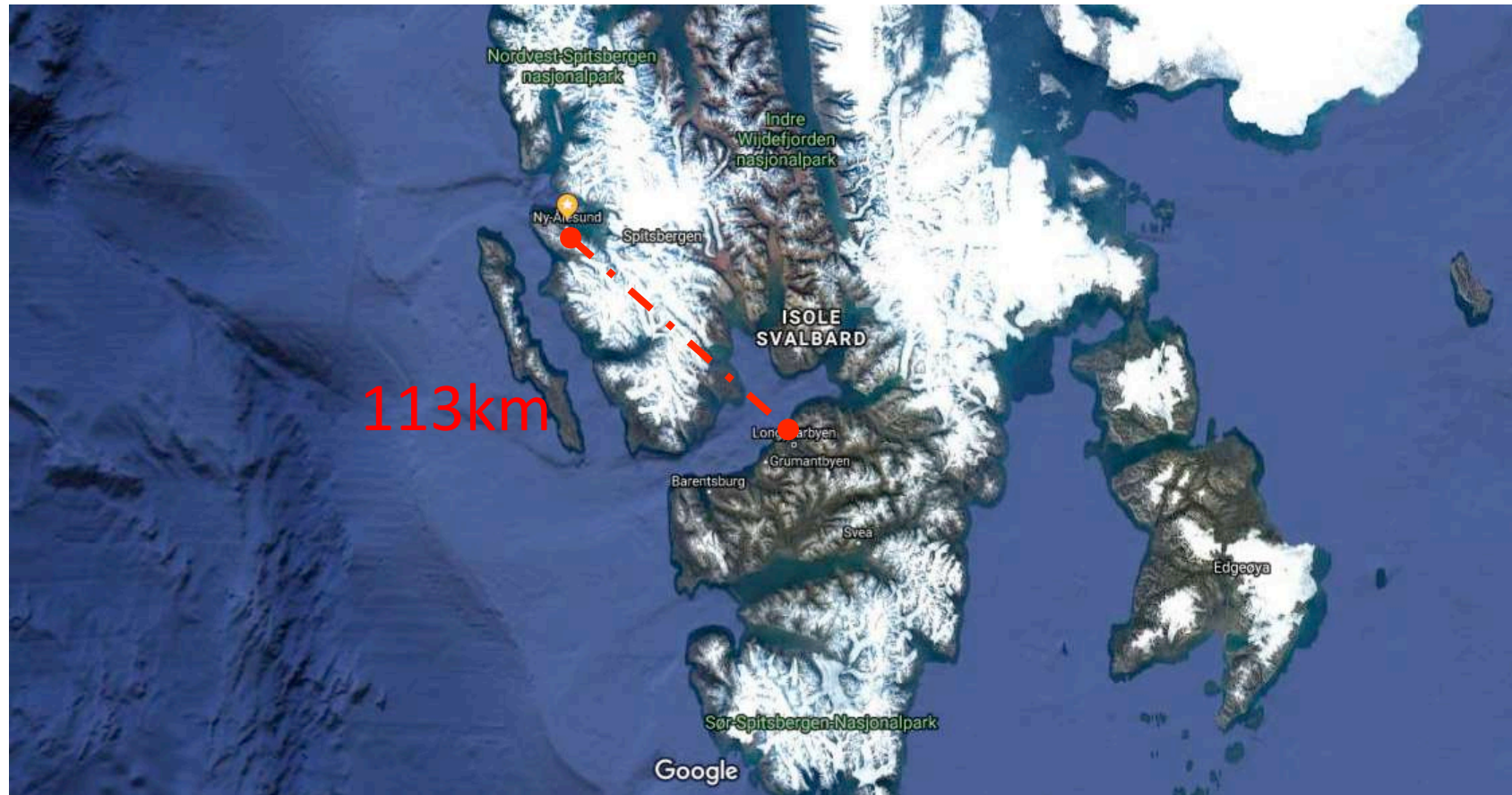
Il 15 aprile 1928 riparte da Baggio (Milano)

Alle **4:28 del 23 maggio 1928**, il Dirigibile Italia salpa dalla base artica di **Ny-Ålesund**, Svalbard, alla volta del **Polo Nord**.

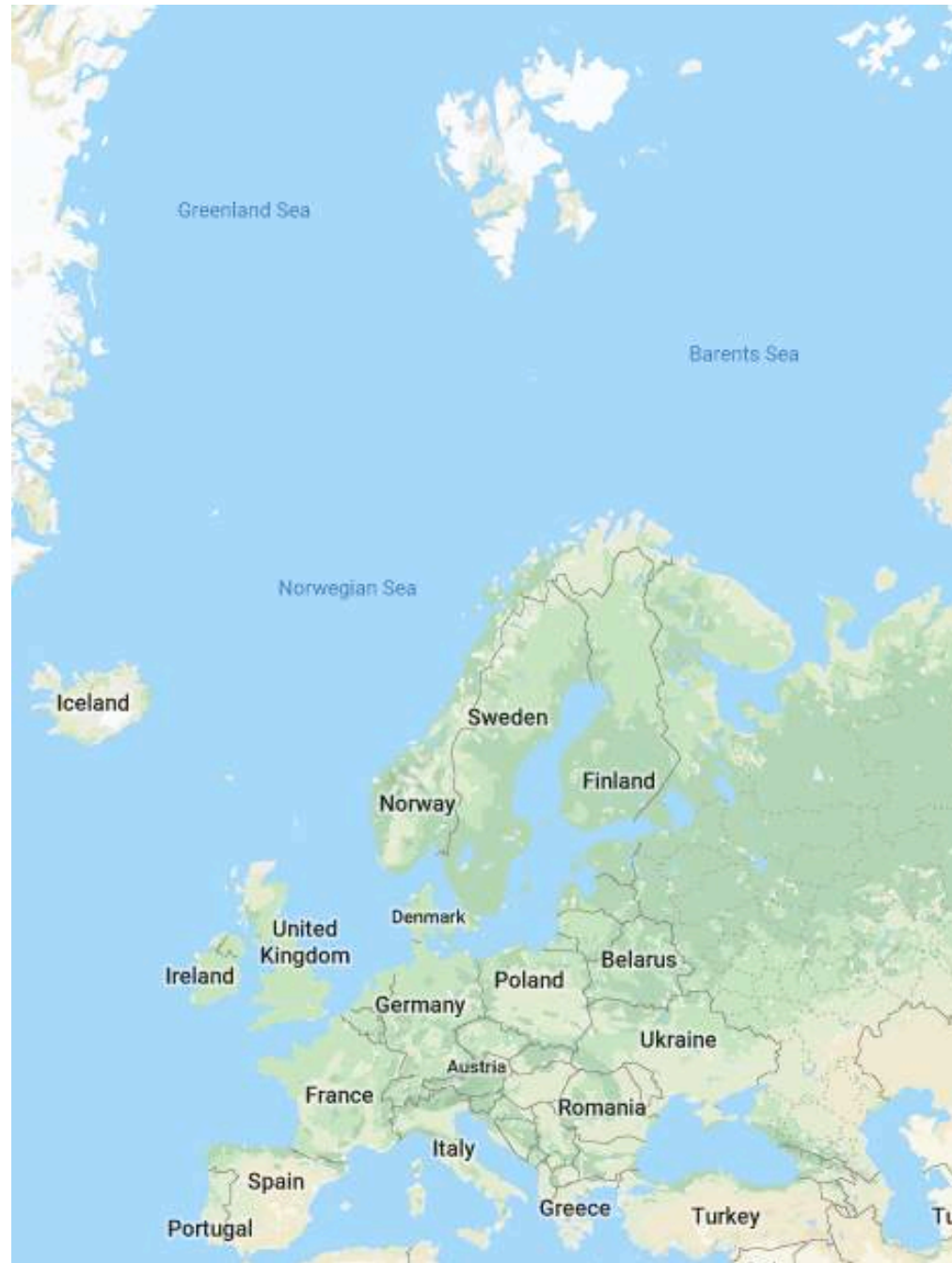
A bordo erano presenti 16 persone (aviatori, tecnici motoristi, marconisti, giornalisti, fisici e meteorologi) e la cagnolina Titina.



Dov'è Ny-Ålesund?







La tragica fine della spedizione di Nobile

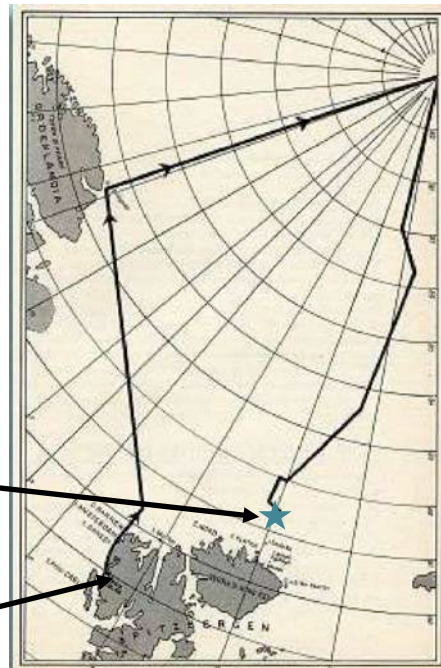
- 24 maggio 1928 - L'Italia sorvola il Polo Nord!
- 25 maggio 1928 - L'Italia si schianta sul ghiaccio

Sopravviveranno all'incidente solo 8 persone, tra cui Umberto Nobile

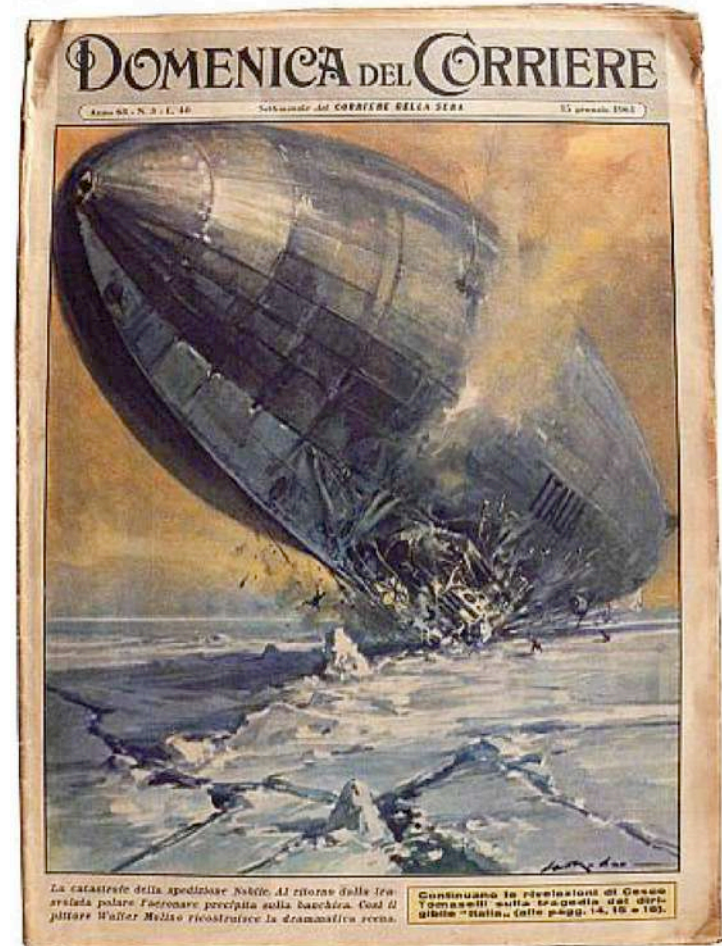
I soccorsi arriveranno a trarre in salvo i superstiti dopo ben 7 settimane

Luogo dello schianto

Ny-Ålesund



«Domenica del Corriere» - 15 gennaio 1961
L'«Italia»



La spedizione di Nobile

Obiettivi scientifici della spedizione:

- ▶ geografia
- ▶ geofisica
- ▶ gravimetria
- ▶ meteorologia
- ▶ oceanografia
- ▶ **elettromagnetismo**

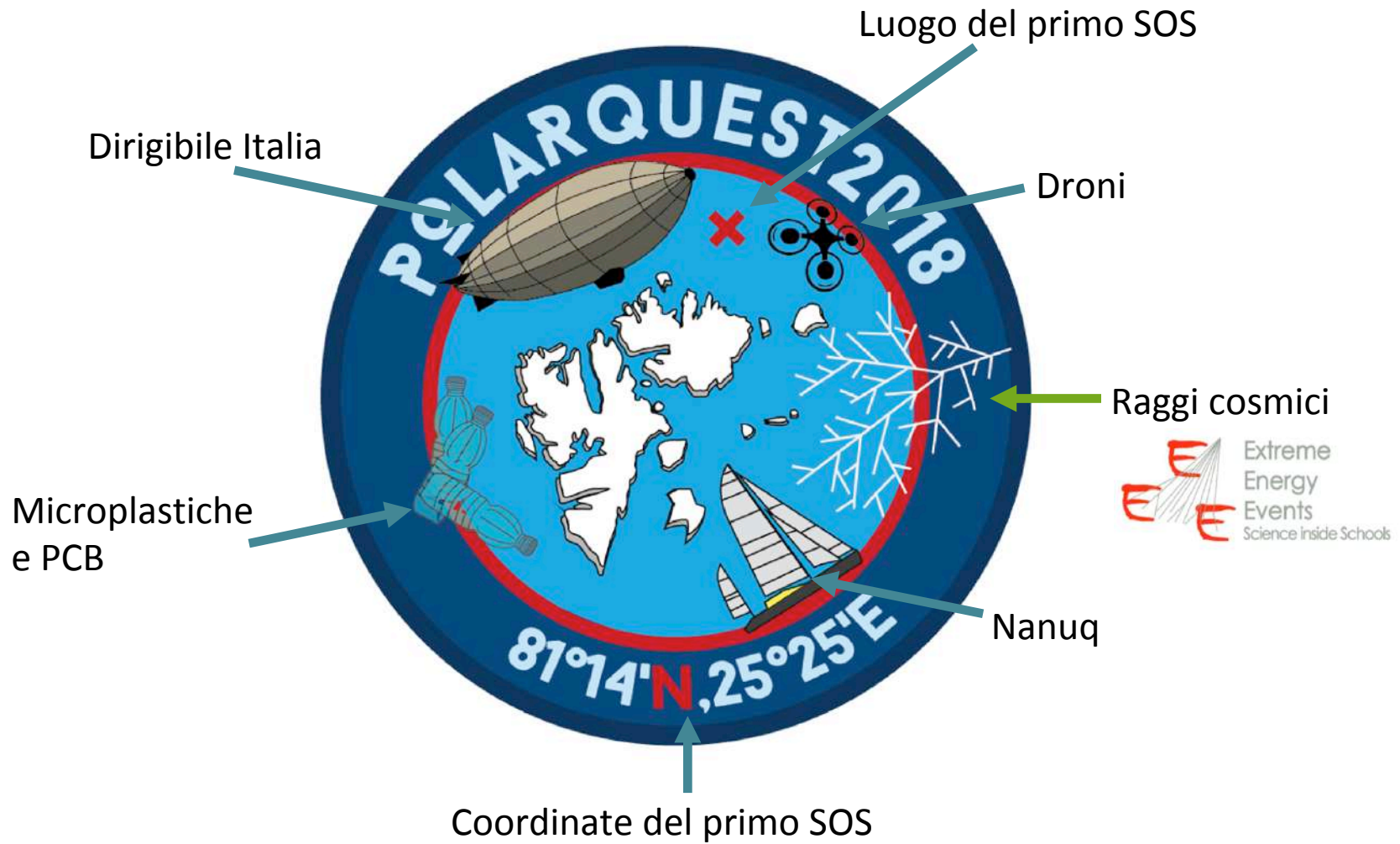
Quasi 300kg di
attrezzatura scientifica

Umberto Nobile, *La preparazione e i risultati scientifici della spedizione polare dell'Italia*, Milano, Mondadori, 1938.

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PolarQuest 2018



Il progetto Extreme Energy Events

Il progetto **EEE** ha una doppia missione:

- ▶ Ricerca nel settore dei Raggi Cosmici
- ▶ Disseminazione scientifica

59 telescopi:

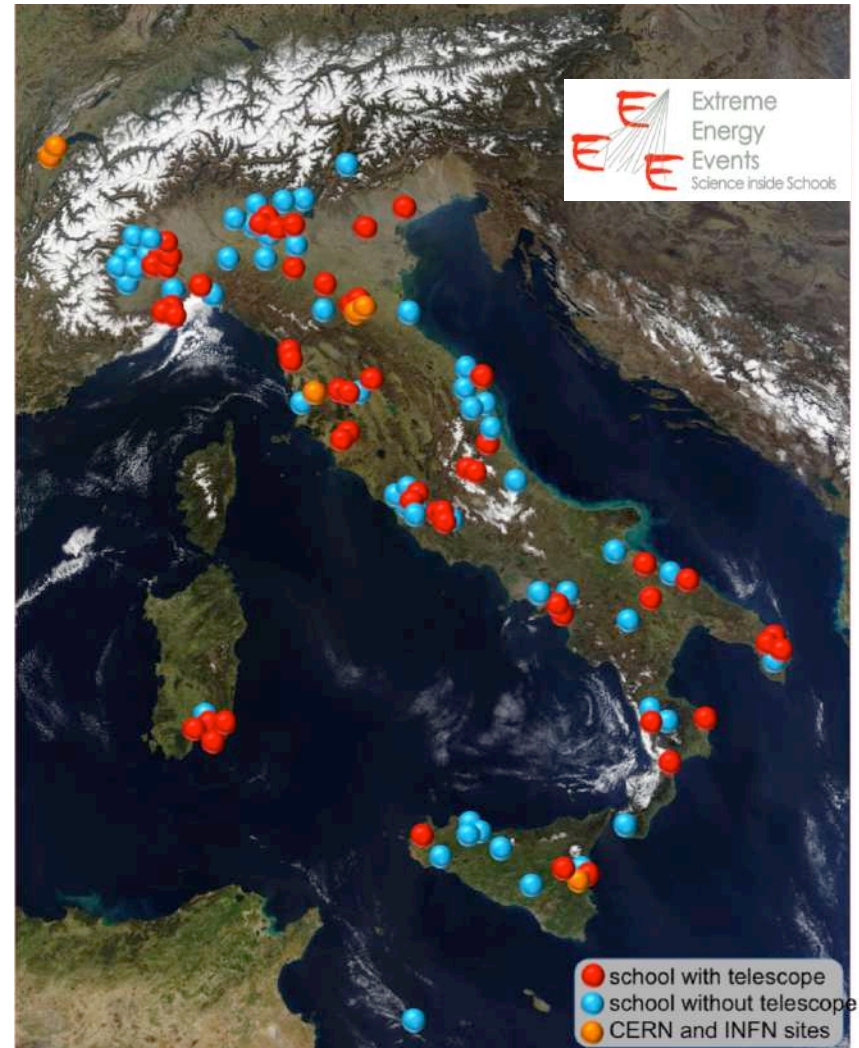
51 in Istituti di istruzione superiore

+ **2** telescopi al CERN

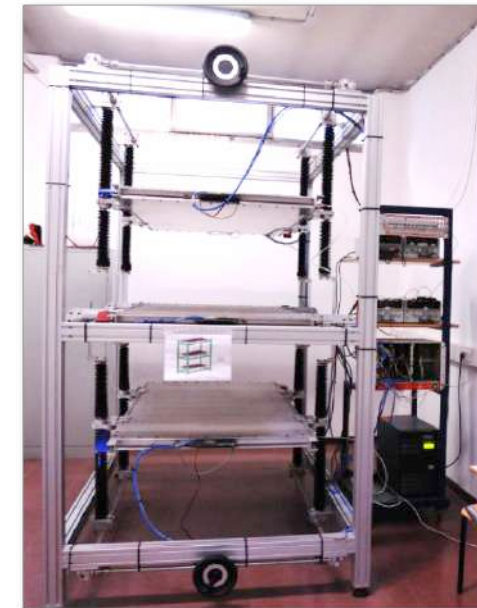
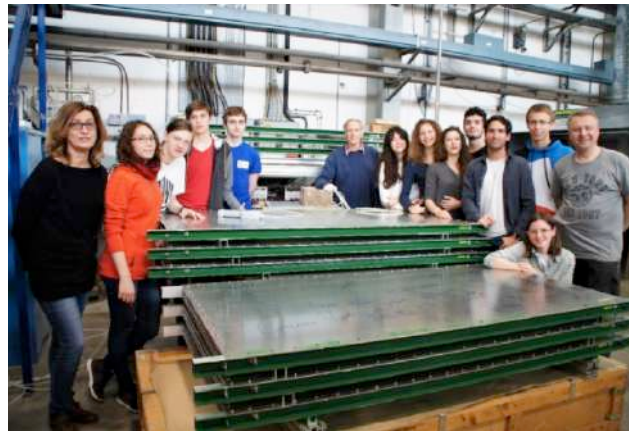
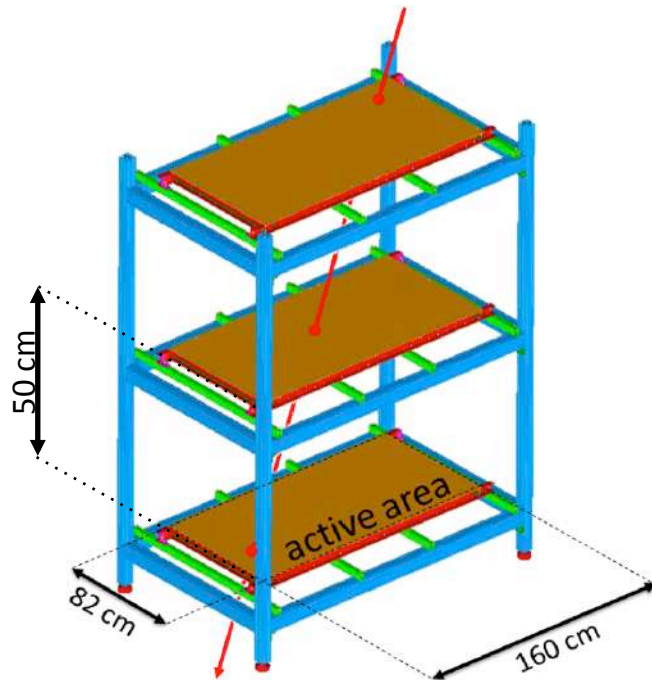
+ **6** telescopi in Sezioni INFN

54 Scuole partecipano senza ospitare un telescopio

Fortissima partecipazione di **studenti** di scuole superiori a tutte le attività dell'esperimento: dalla **costruzione** del telescopio alla **raccolta** e l'**analisi** dei **dati**.



Telescopio EEE



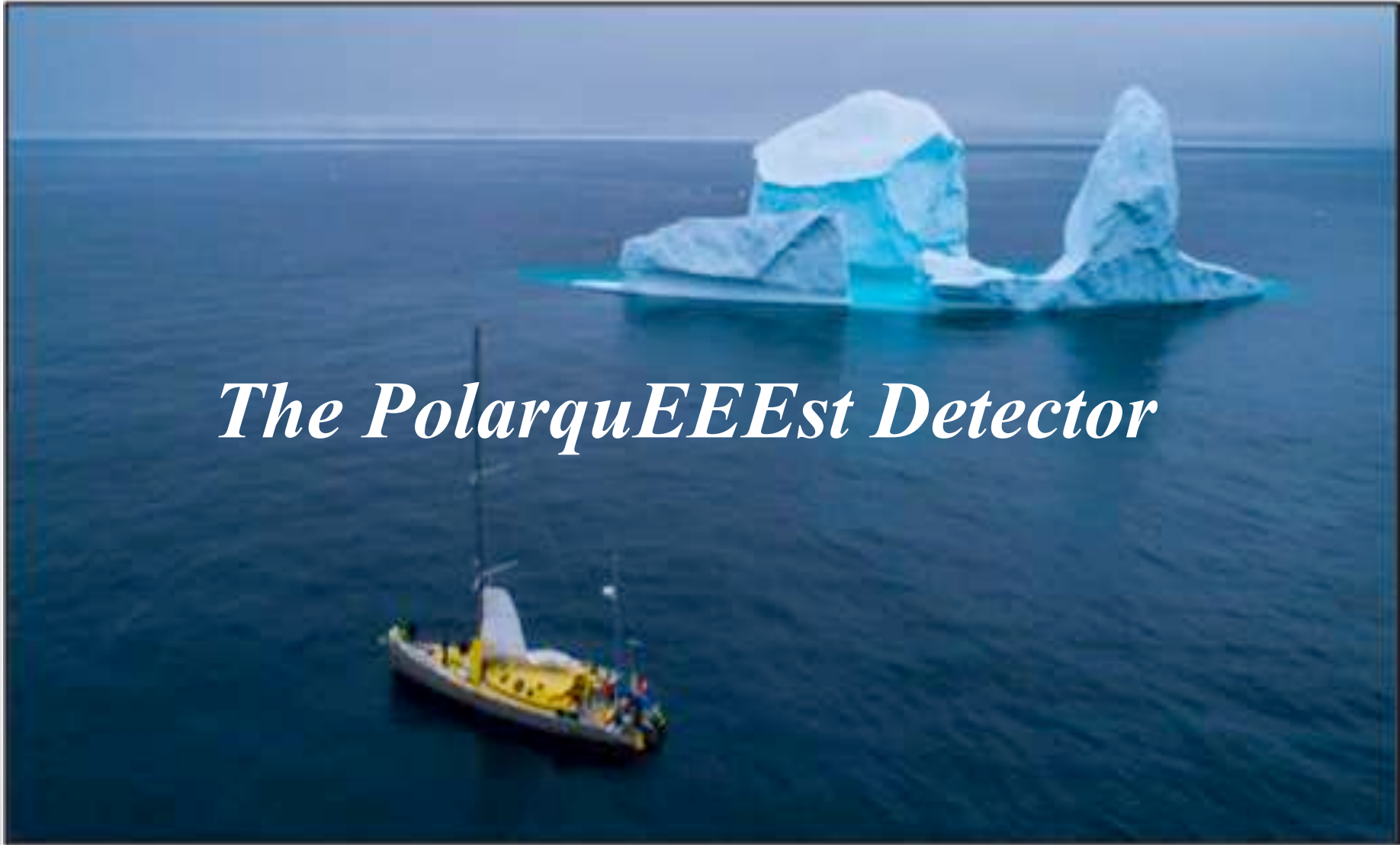
- ▶ 3 camere MRPC da 24 strip ciascuna
- ▶ Elettronica ad alta risoluzione temporale ($\sim 200\text{ps}$)
- ▶ Dati con timestamp basato su GPS
- ▶ Ricostruzione quasi on-line delle tracce
- ▶ Ricerca di coincidenze a lunga distanza ($O(1000\text{km})$)
- ▶ Ricostruzione di sciami (usando gruppi di telescopi nella stessa città)

Polar QuEEEst

Il Centro Fermi ha colto la sfida polare, cioè pensare e costruire un rivelatore di particelle cariche che:

- funziona con un bassissimo consumo energetico ($< 15\text{W}$)
- resiste alle avversità dell'ambiente polare (temperatura, umidità)
- è poco ingombrante (dimensioni fissate dal capitano della nave)
- è poco pesante ($< 50\text{kg}$)
- è dotato di una vasta gamma di sensori e di GPS

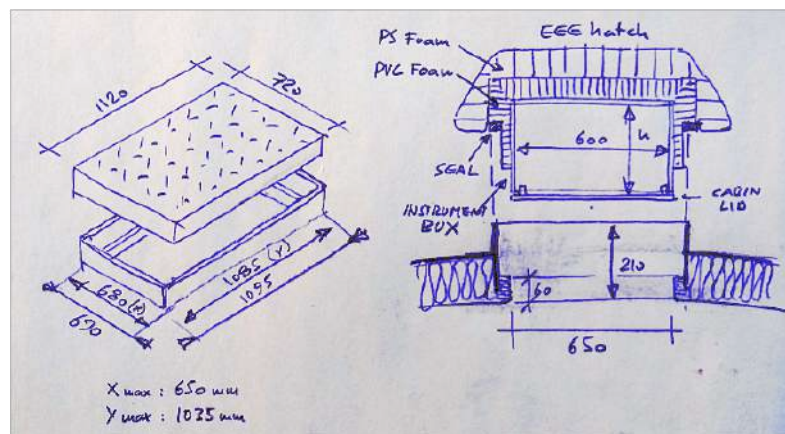
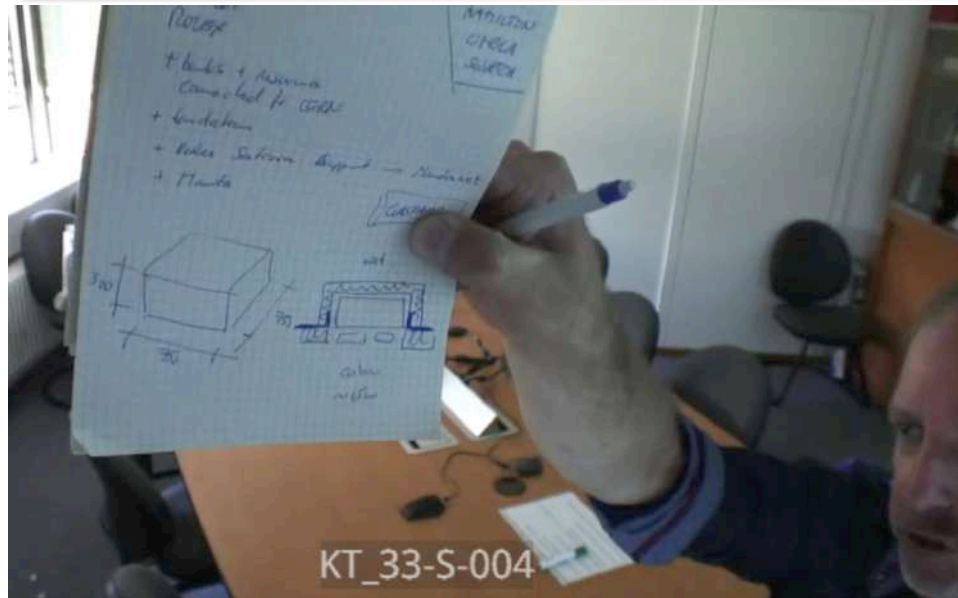
la parola al dott. Garbini
per la seconda parte



The PolarquEEEst Detector



Requirements

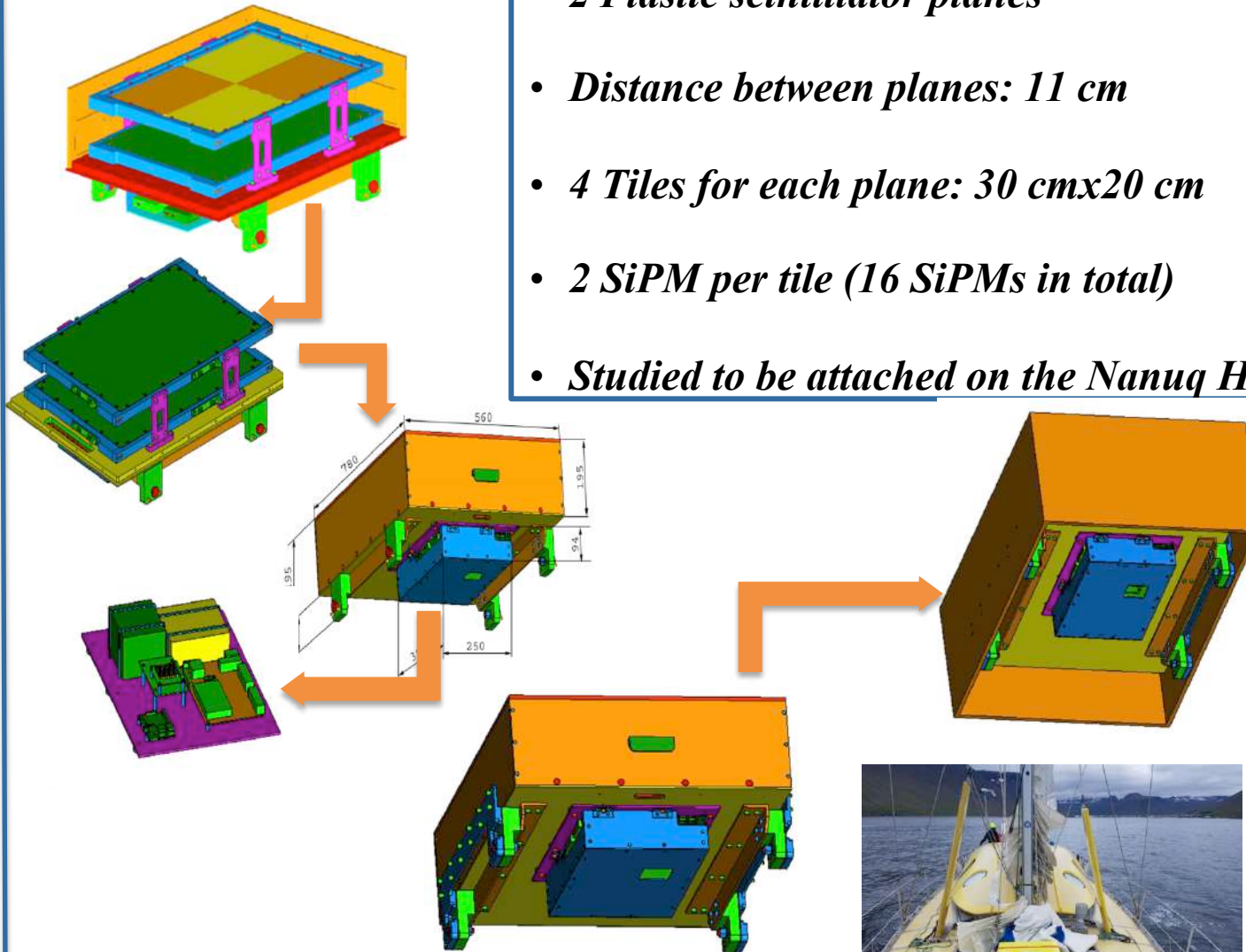


The Detector on the Polar Nanuq boat has been designed to fulfill the requests on

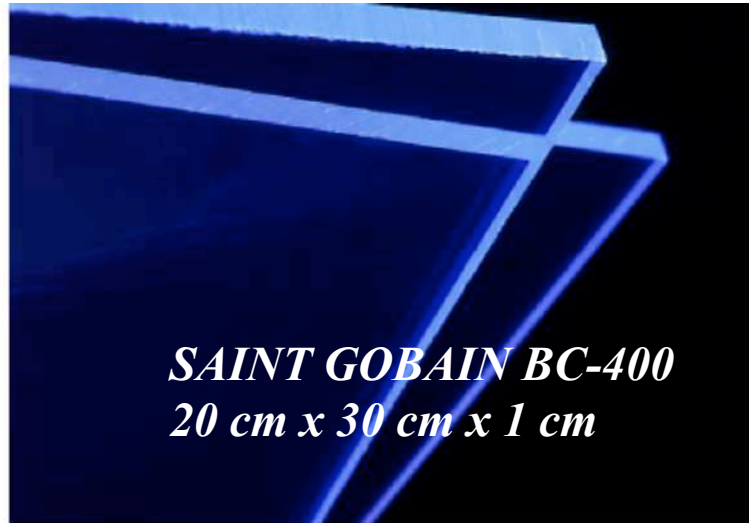
- **Dimension**
- **Weight (~ 50 kg)**
- **power consumption (< 15 W)**

The Design

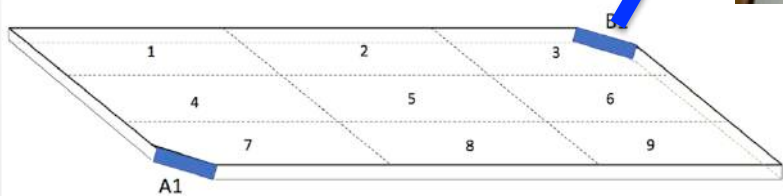
- *2 Plastic scintillator planes*
- *Distance between planes: 11 cm*
- *4 Tiles for each plane: 30 cmx20 cm*
- *2 SiPM per tile (16 SiPMs in total)*
- *Studied to be attached on the Nanuq Hatch*



The Scintillator



Two corners of each tile have been milled to house SiPMs.



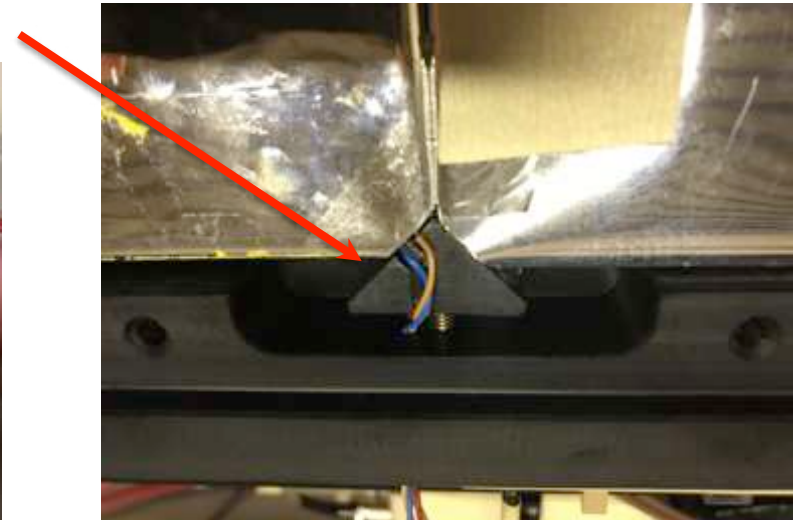
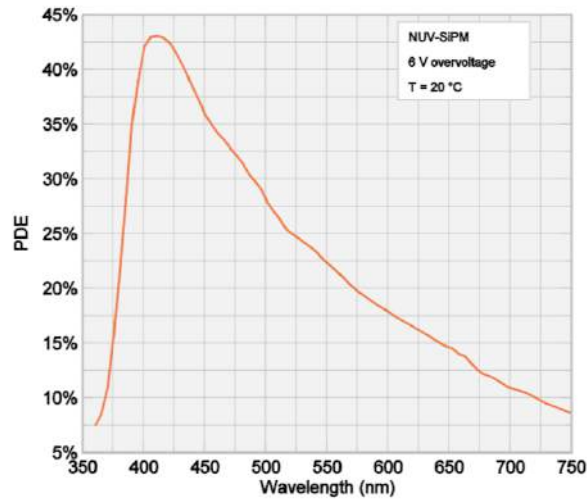
The SiPMs



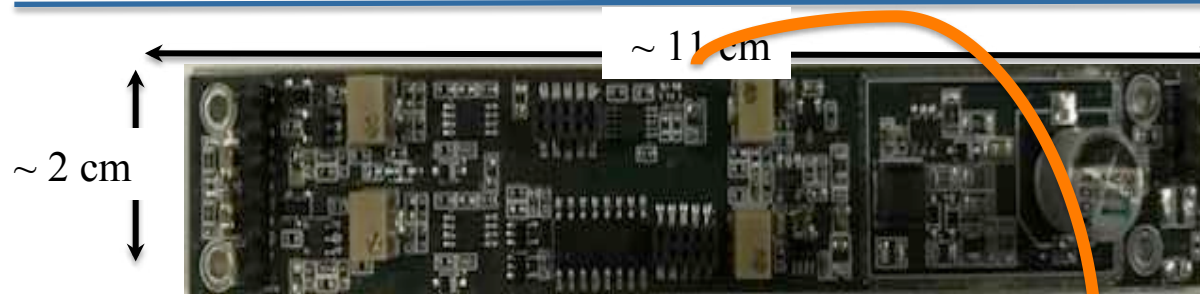
NUV SiPMs
Chip Scale Package (CSP)

Symbol	Parameter	Product			
		ASD-NUV1S-P	ASD-NUV1C-P	ASD-NUV3S-P	ASD-NUV4S-P
AA	Effective active area	1×1 mm ²	1.13 mm ²	3×3 mm ²	4×4 mm ²
N	Cell count	625	673	5520	9340
CS	Cell size (pitch)	40 μm × 40 μm			

Directly coupled to the scintillator



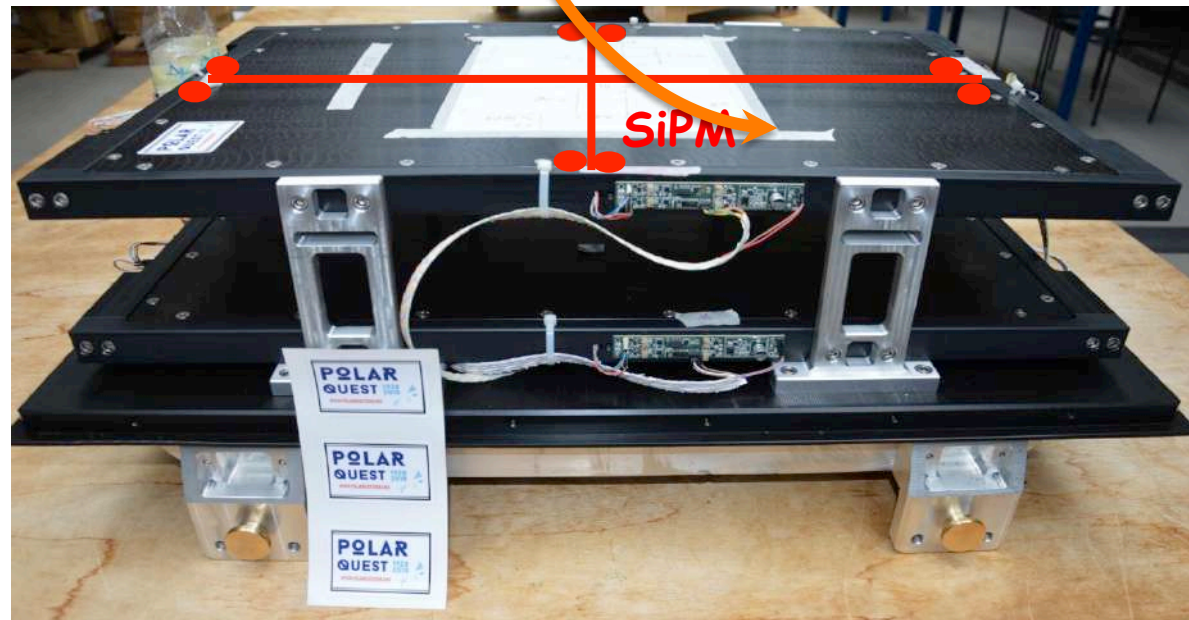
Front End Electronics



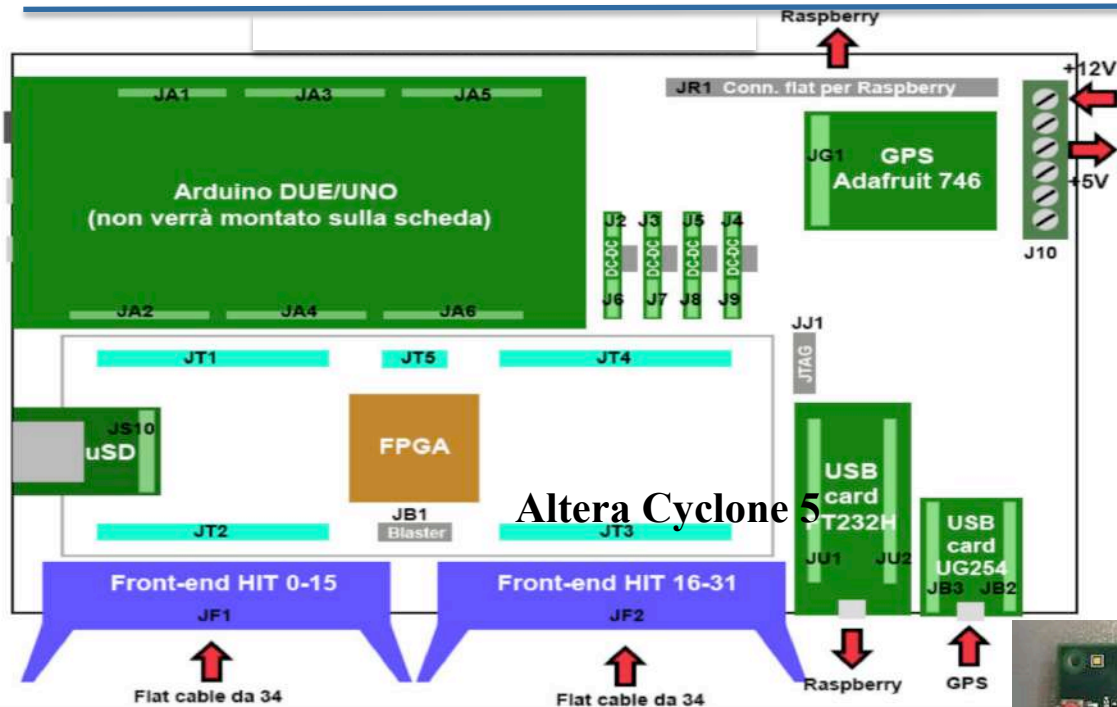
Custom Front End Card serving 2 SiPMs

- SiPMs Vbias (Temperature feedback)
- Signal Discrimination/Digitalization (LVDS standard)
- T.O.T (Charge) measurement

8 Front End cards in total
Total Power consumption ~2 W
All tested and characterized



Trigger & Read Out Board

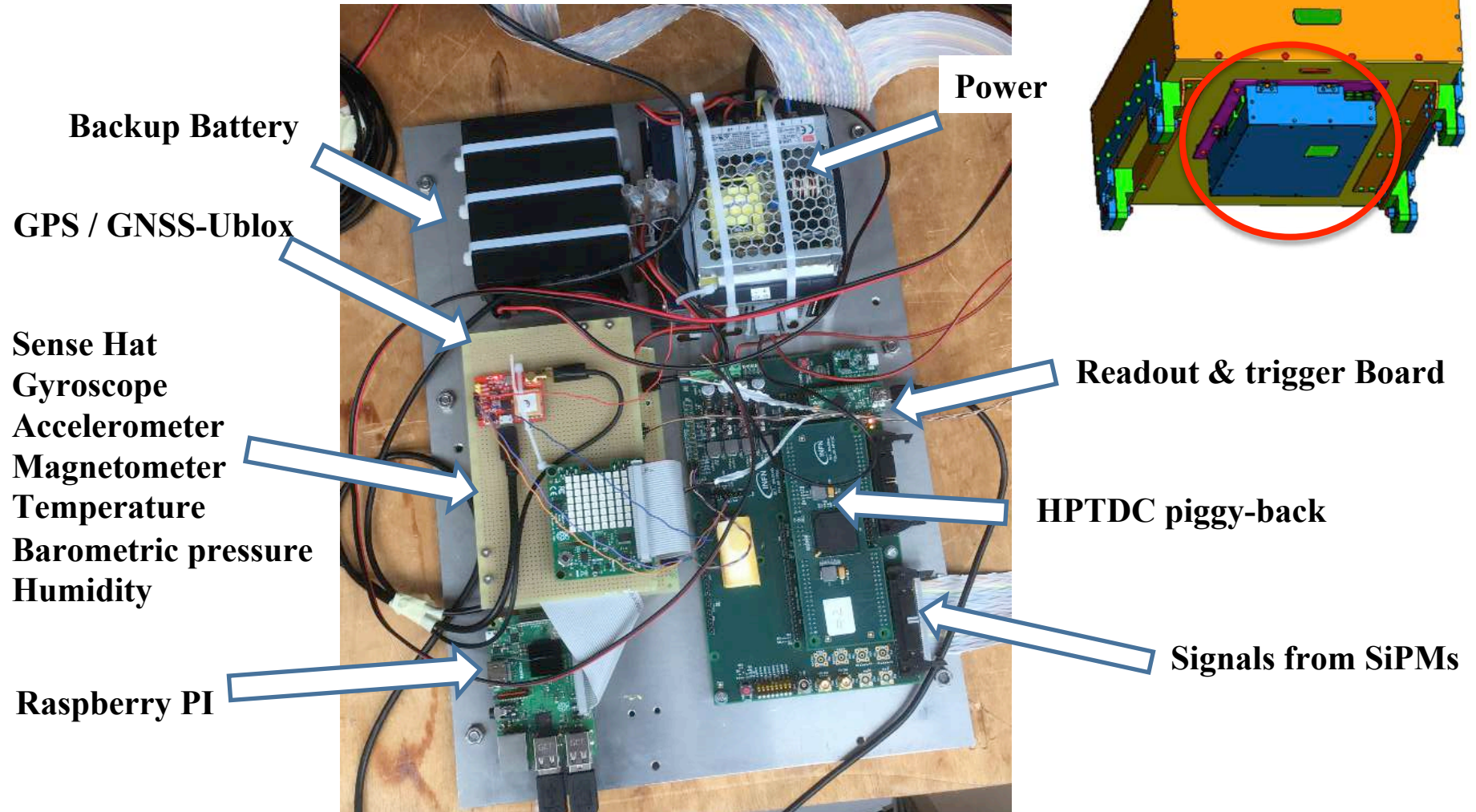


Provides:

- Trigger logic
- TDC and TOT measurements (HPTDC & Internal)
- GPS time Stamp
- Data stream to Raspberry
- Supply Voltage for Raspberry PI



The complete Electronics

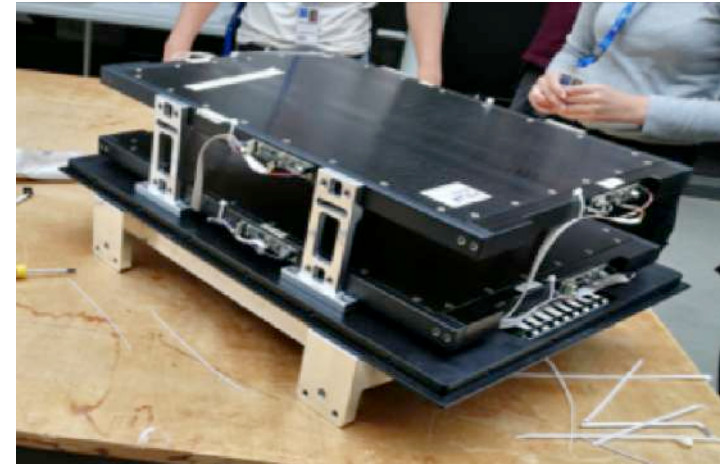
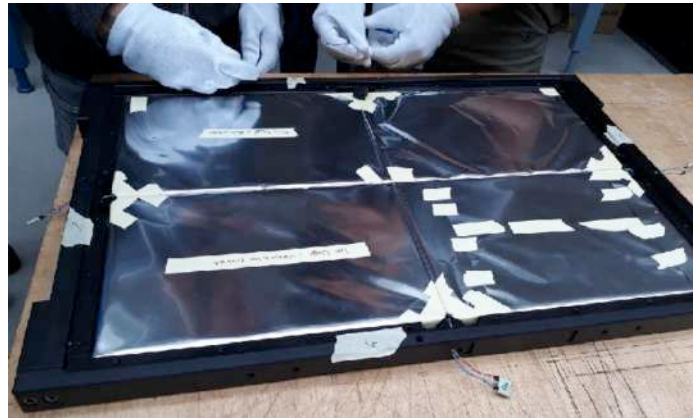


Total power consumption ~ 12.5 W



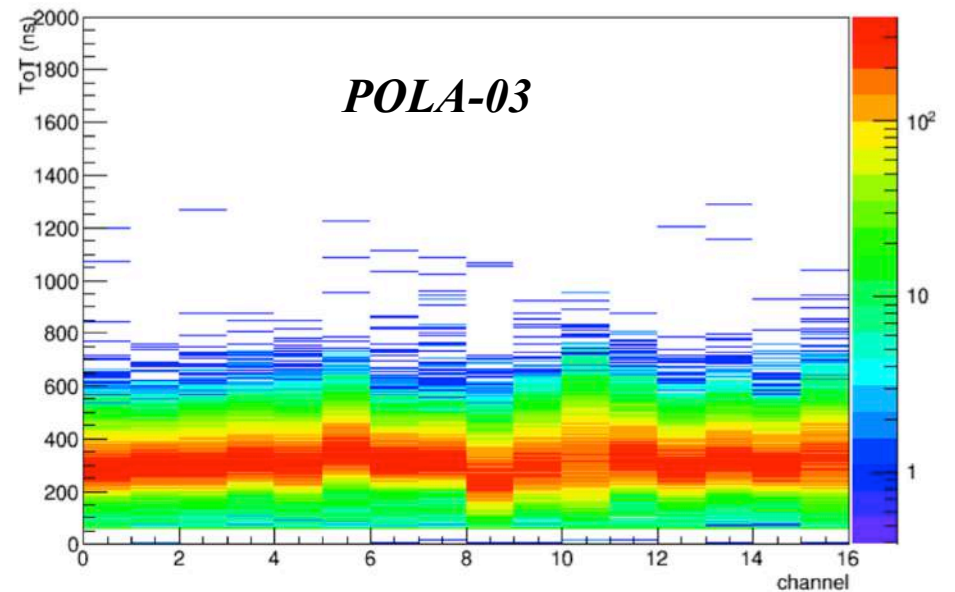
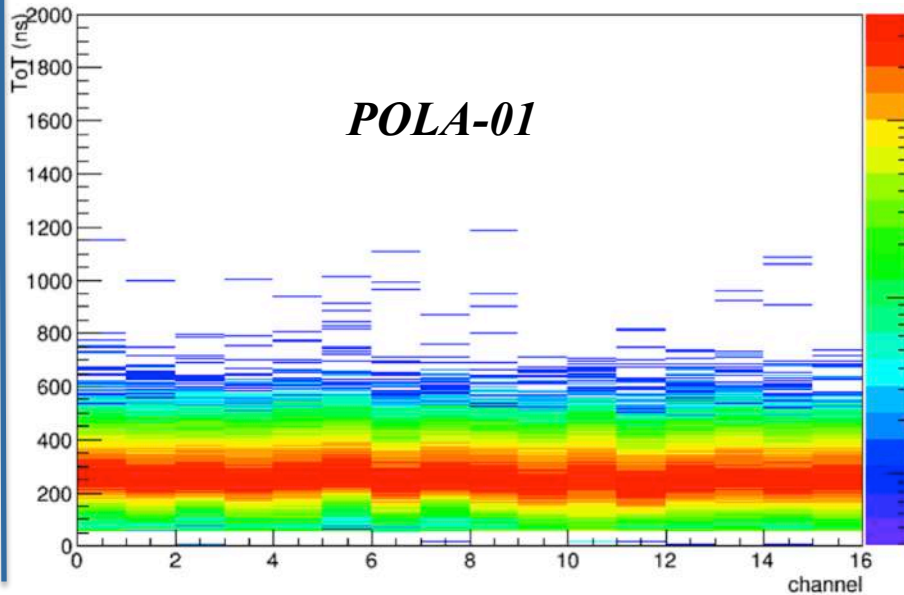
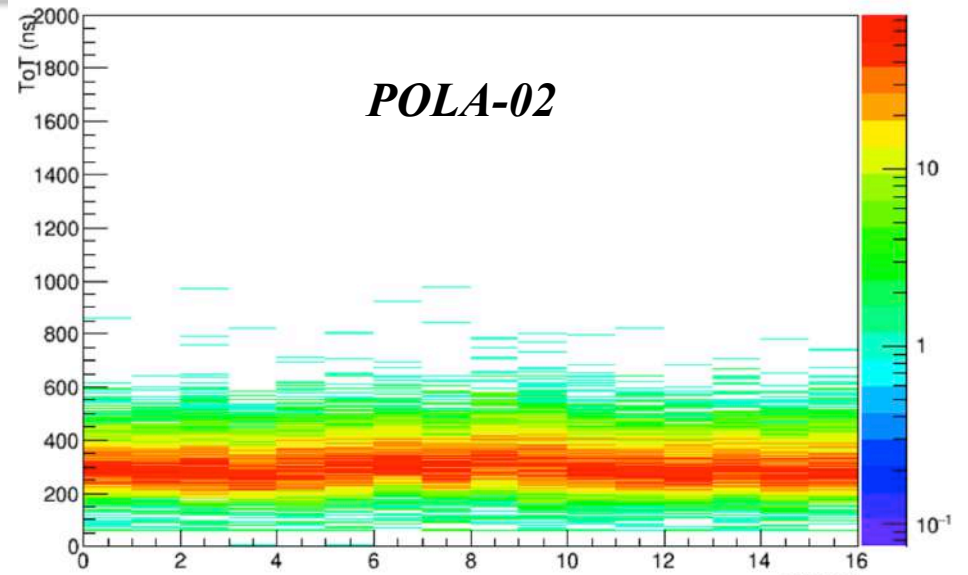
Assembling

*Performed at CERN by high schools students from
Italy Switzerland and Norway*



Calibration and Final tuning

Final calibration of the detectors at CERN using cosmic rays



Installation

All the detectors installed by the end of July 2018



POLA-01 @ Isaffjordur



POLA-01 on board



POLA-02 @ Oslo



POLA-03 @ Bra



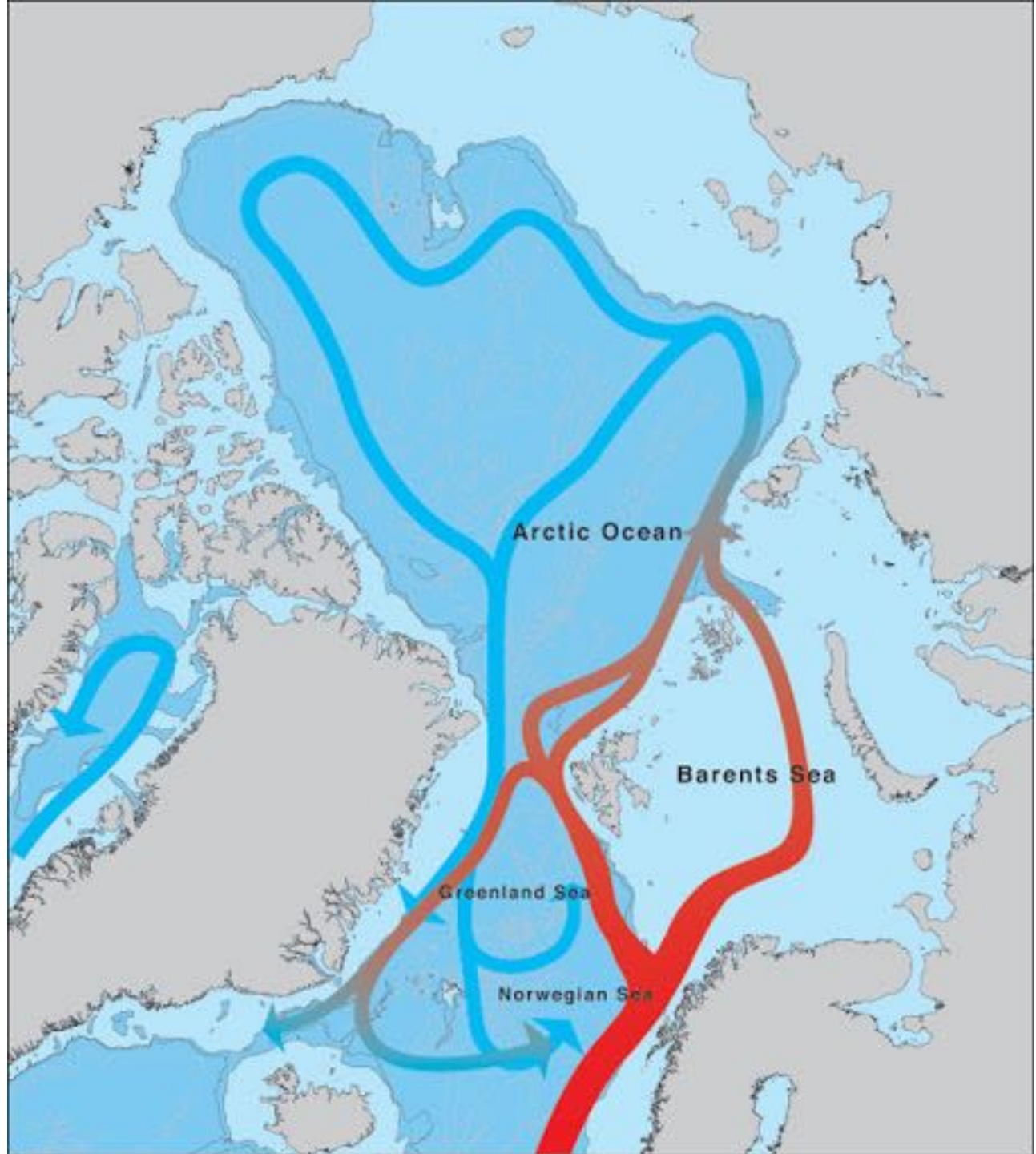
Il Racconto fotografico di Ombretta Pinazza



PolarQuest2018

in barca con il detector PolarquEEEst

Ombretta Pinazza, EEE Collaboration

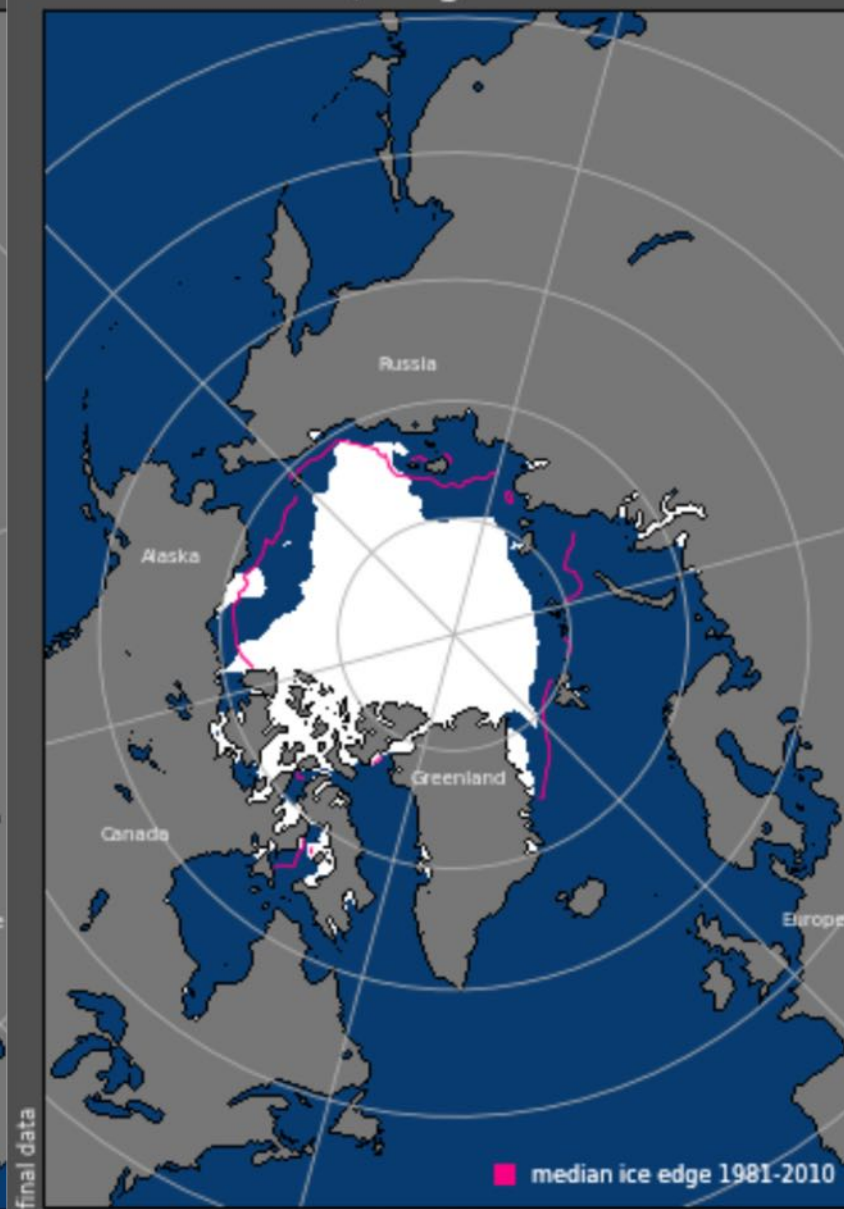


Sea Ice Extent, Aug 2017



Total extent = 5.5 million sq km

Sea Ice Extent, Aug 2018



Total extent = 5.6 million sq km

Sea Ice Extent, Aug 2019



Total extent = 5.0 million sq km



Ísafjörður, Islanda, 19 luglio 2018















































































Longyearbyen, 24 Agosto 2018

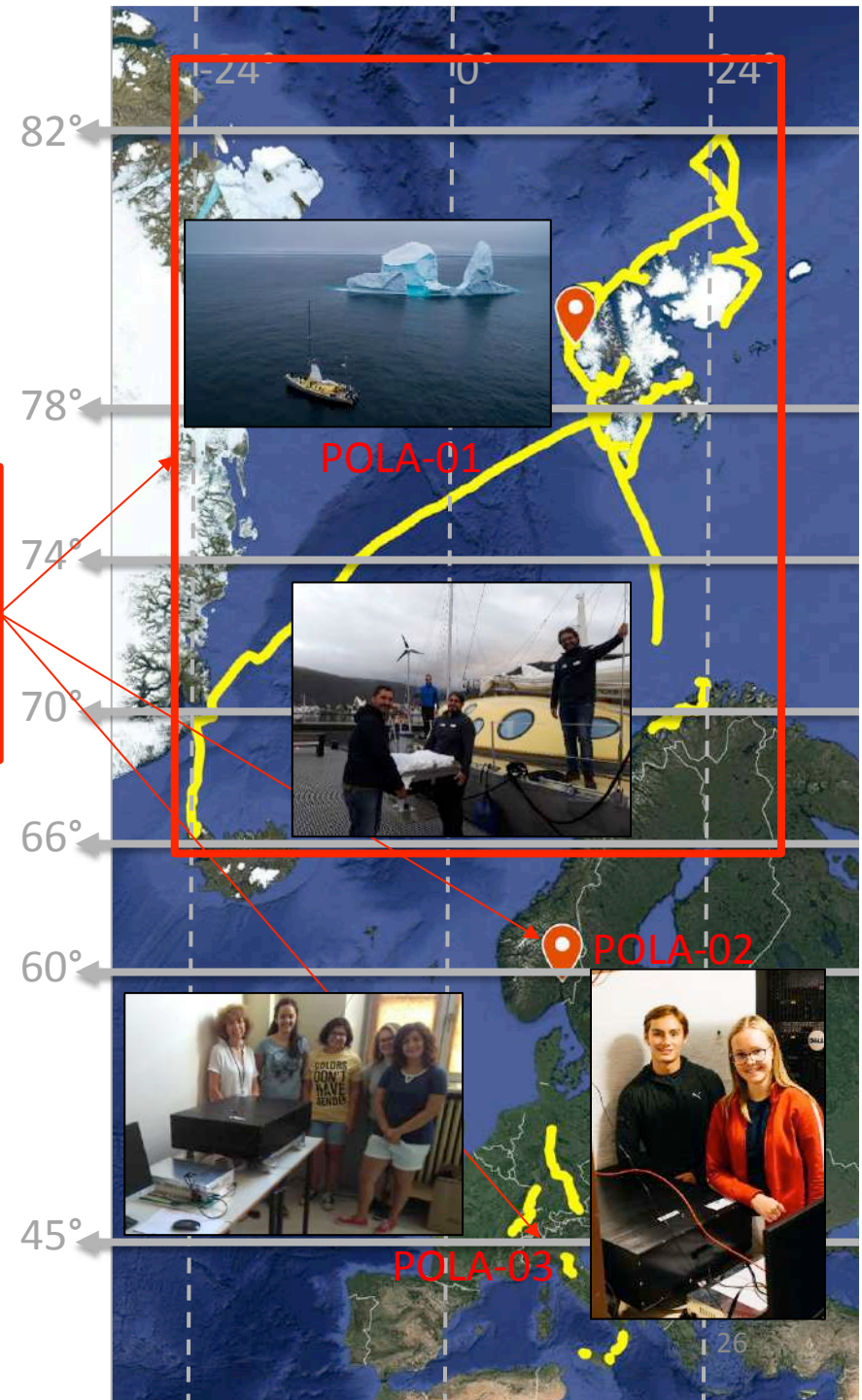


GRAZIE

The polarquEEEst schedule

GOAL: Cosmic ray at extreme latitudes

- 2018 **PolarquEEEst2018**
 - 3 detectors (POLA-01, POLA-02, POLA-03)
 - PolarquEEEst2018 → one on board of Nanuq (July-September) + 2 telescopes at fixed locations (Bra(TO), Nessoden(Norway))



Stats



Trip length

Nanuq sailed for 45 days covering about **3500 NM**

Duty cycle

The POLA-01 cosmic ray detector has taken data almost continuously for about **984 hours**

Detector efficiency

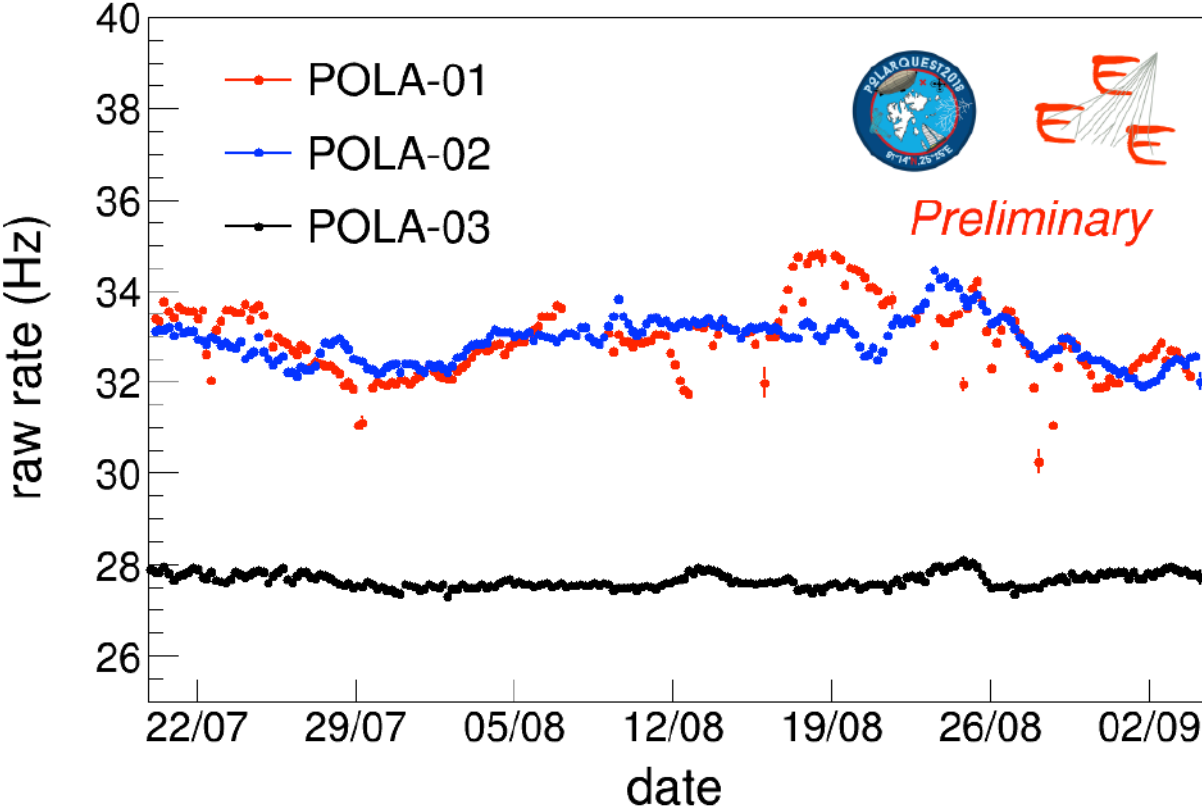
With a global efficiency for **POLA-01 of about 91%**, due to various reasons (main power down, difficult weather conditions, detector reset)

POLA-02 and POLA-03 were functioning during the whole period, with essentially 100% efficiency

Collected muons

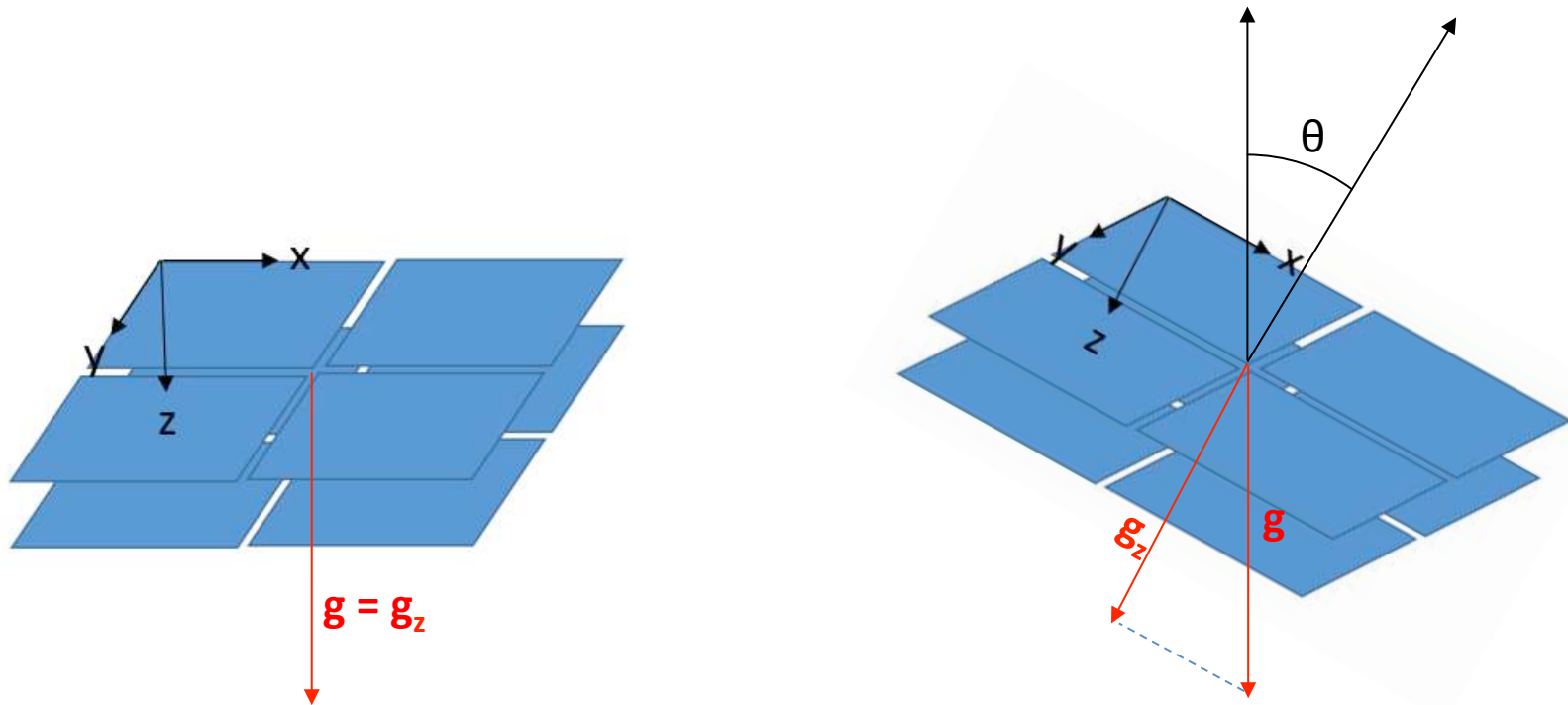
In total, more than **100.000.000 tracks per detector** were collected

Measured raw rates



Some corrections needed to take into account different data taking conditions

Orientation of the telescope



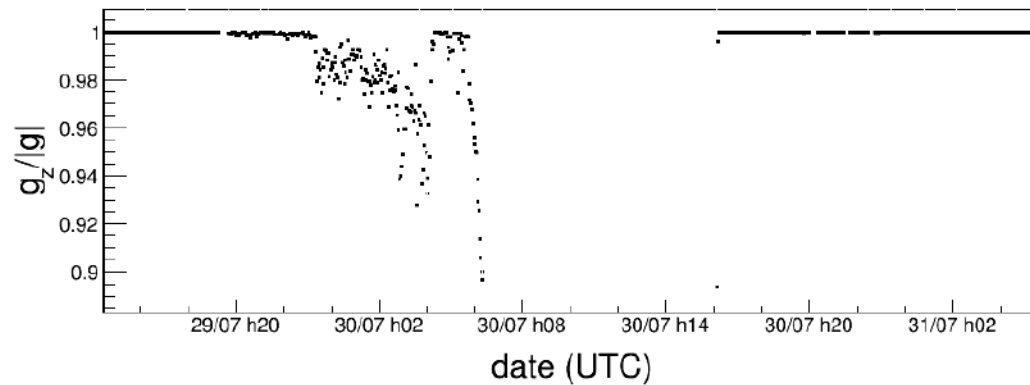
The acceptance depends on the zenithal orientation of the detector.

When sailing this orientation may change but it can be measured using the accelerometer on board and looking at the direction of the gravity acceleration in the local system $\rightarrow \cos\theta = |g_z|/g$

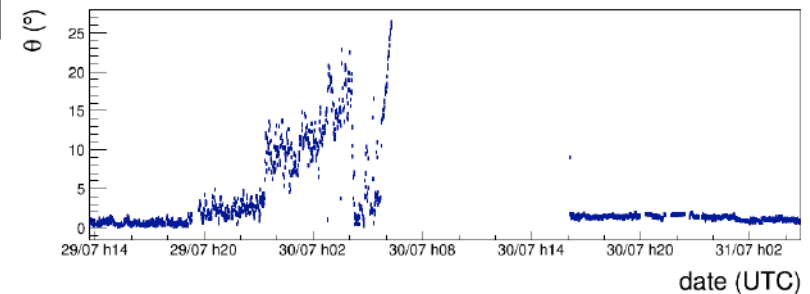
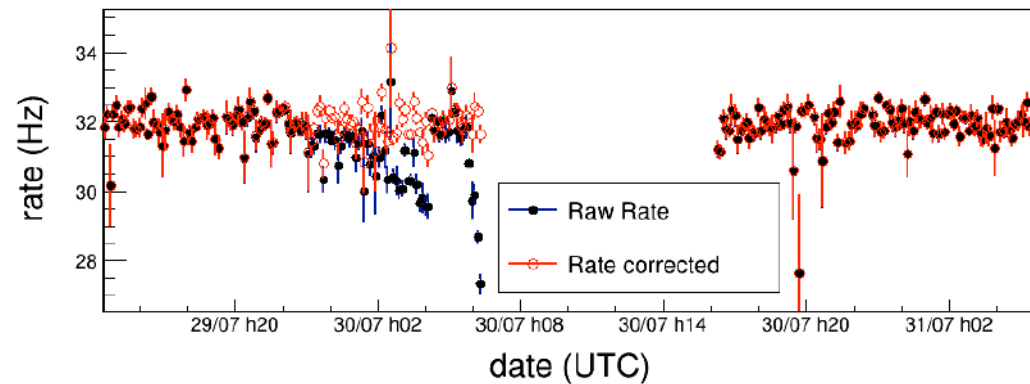
The max acceptance is expected to be at $\cos\theta=1$ ($\theta=0$) since the flux of secondaries has a maximum in the vertical direction.

Orientation correction

On 30 July a problem occurred for Nanuq (during low tide) ... Data were nevertheless collected before reaching this “exotic” position



This special event allowed to verify the proper calibration of the orientation correction.



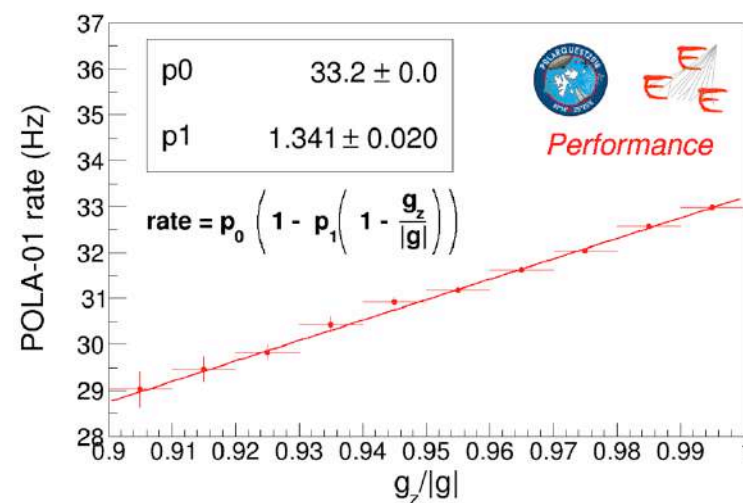
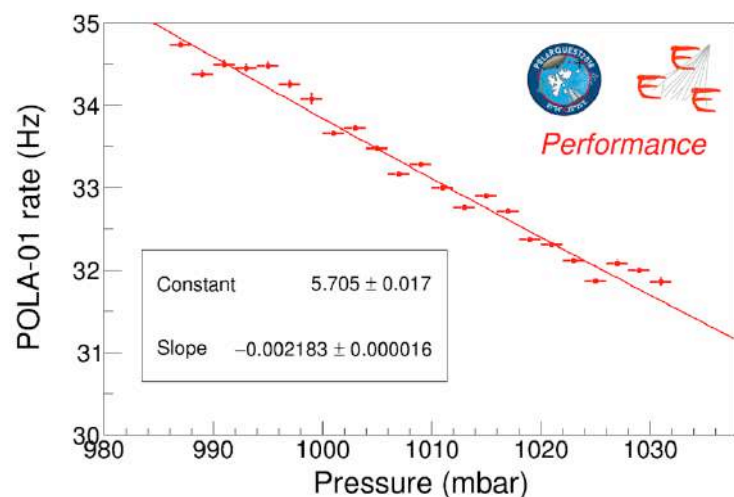
Corrections

1. Rates have to be corrected for the barometric effect since the absorption of secondaries (muons) increases with the amount of matter in the atmosphere, to which the pressure is proportional

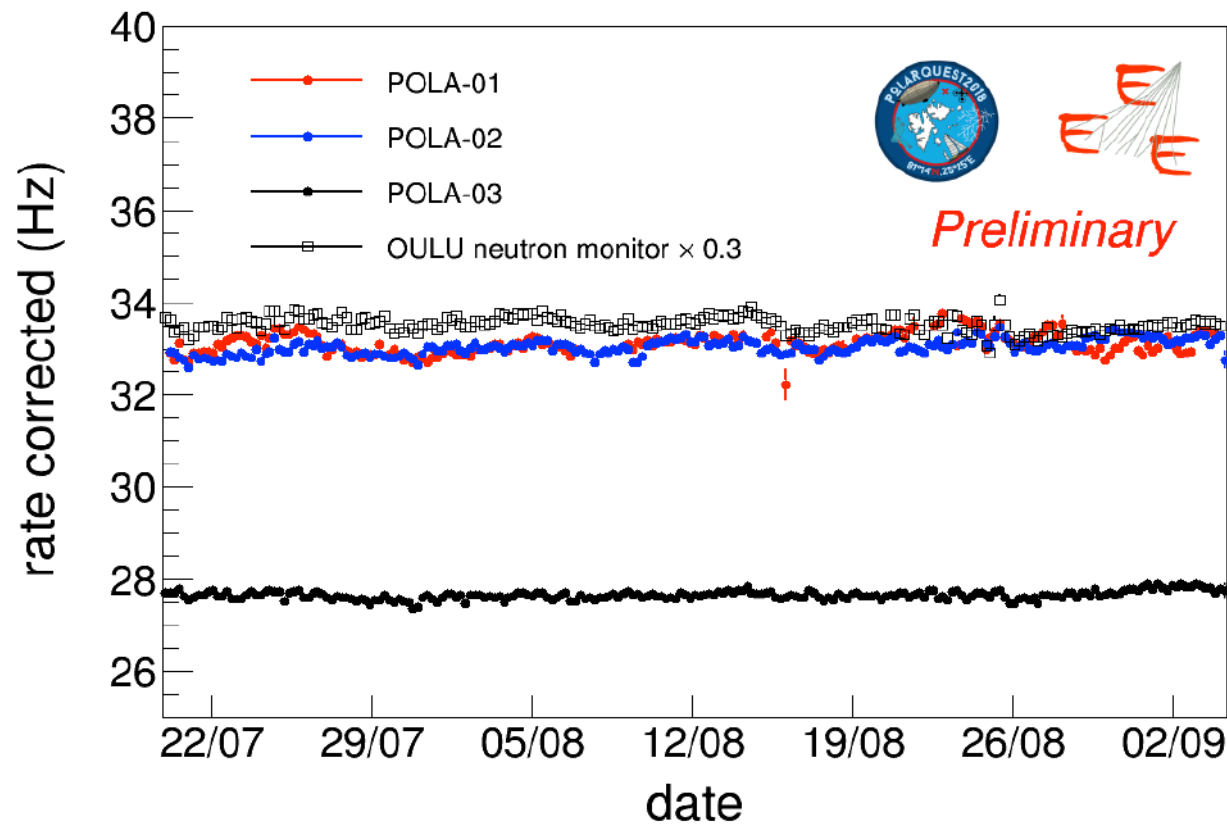
→ **corrections obtained by fitting the rate dependence on the pressure for each detector separately during the full period**

2. For POLA-01 also correction due to the detector orientation which may change when sailing (less relevant than pressure correction)

→ **corrections obtained by correlating the rate with the azimuthal angle using the accelerometer installed in the station (z-projection of the acceleration, 1 means vertical direction, i.e. gravity)**



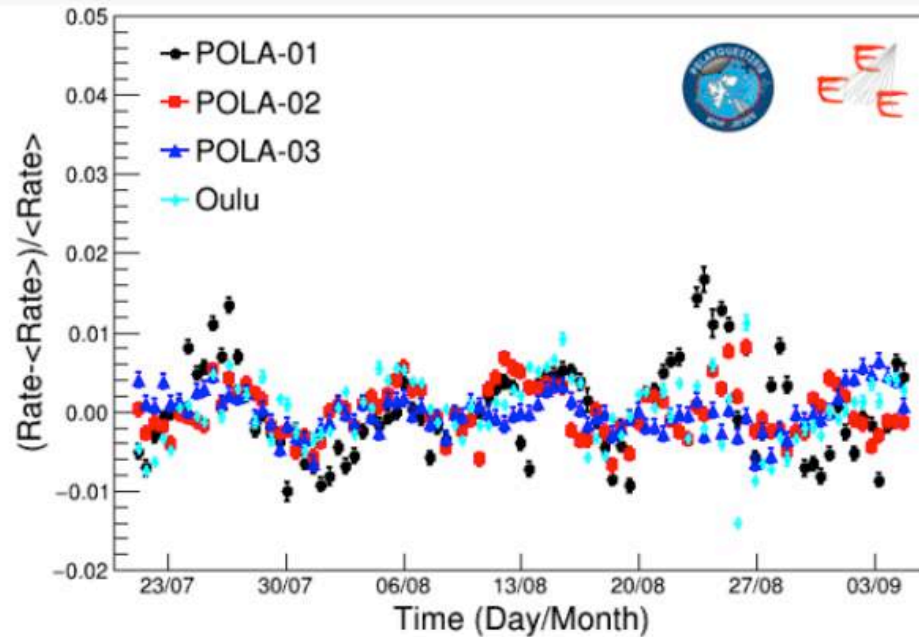
Corrected flux



Three POLA detectors, corrected for pressure and rolling of the boat, compared with the OULU neutron monitor rate in the same period → similar fluctuations related to primary cosmic rays flux variation

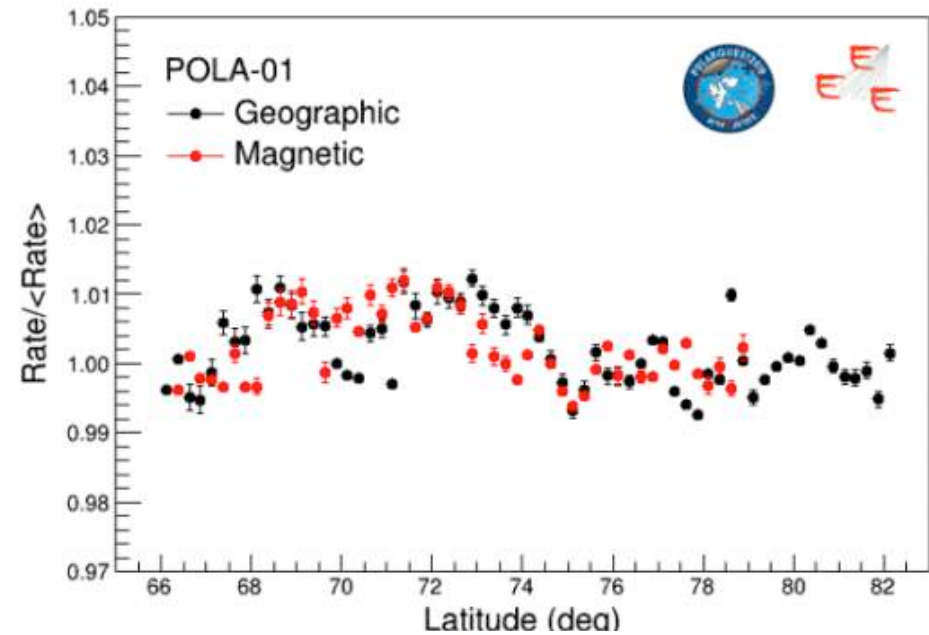
New high precision measurements of the cosmic charged particle rate beyond the Arctic Circle with the PolarquEEEst experiment

Submitted to EPJ C



July-September 2018

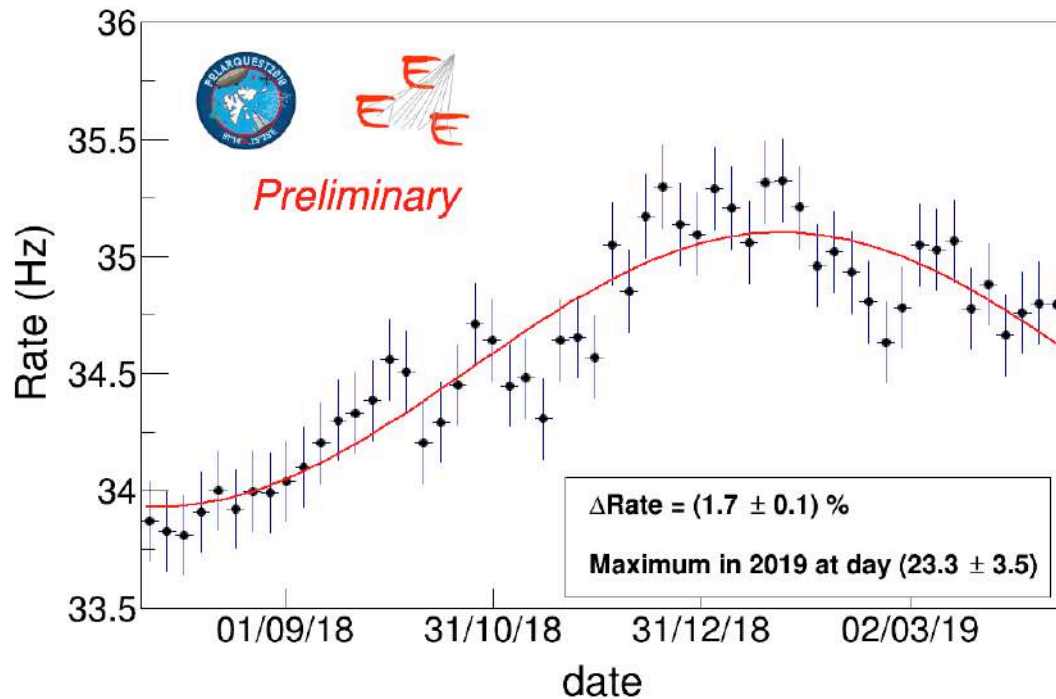
Constant flux (within 1%) for latitudes in the range $66^\circ - 82^\circ$ N.



OULU neutron monitor web site, <http://cosmicrays oulu.fi/>



Seasonal effects



Secondaries flux at ground measured by POLA-02 and POLA-03 (combined) as a function of time

About 2% variation during one year [?] as expected from previous measurements [*].

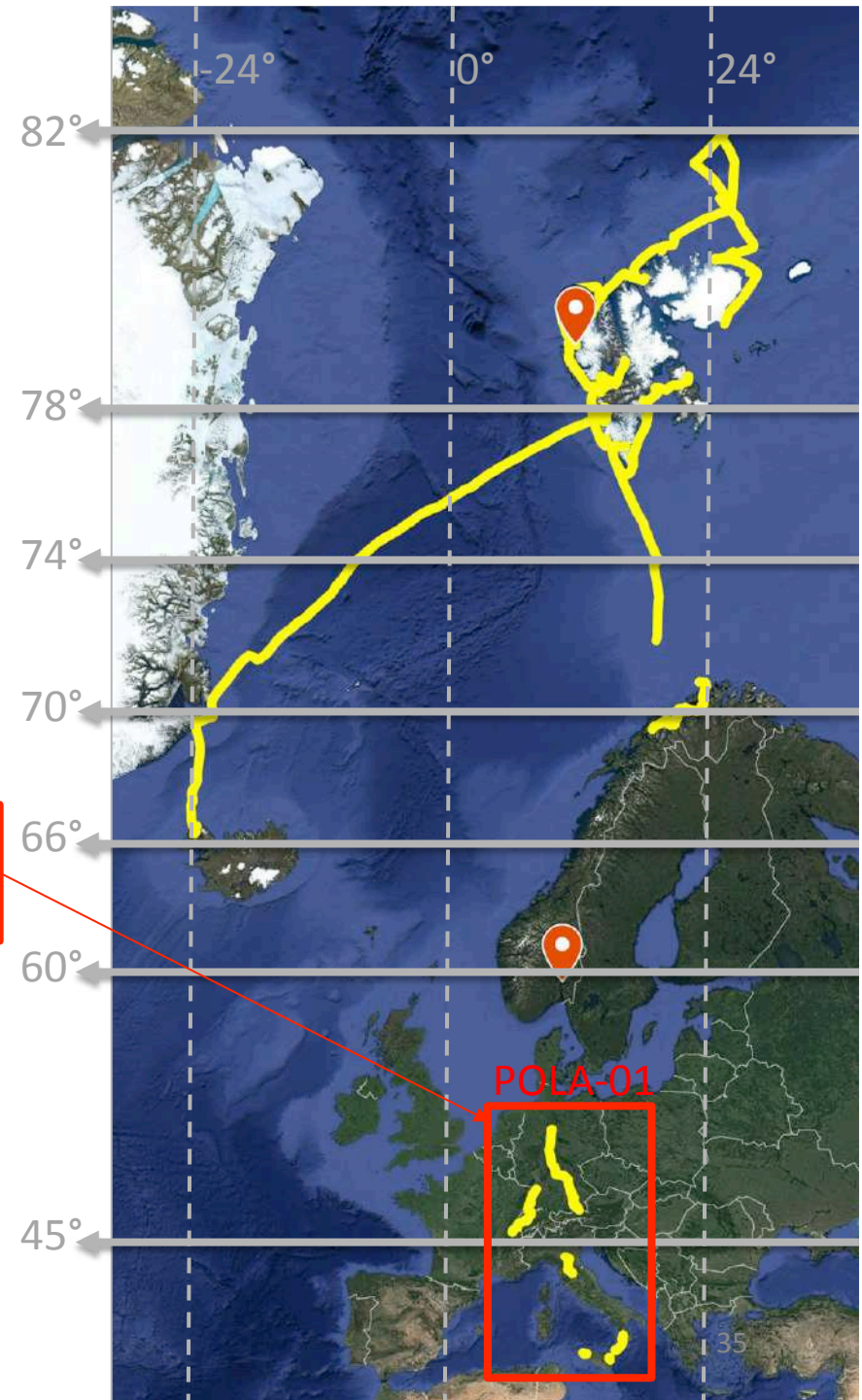
Minimum in Summer due to an increase of atmosphere temperature [?] air volume increases [?] secondaries produced at higher altitudes [?] more space for muon to decay (no effect for *neutron monitor*).

[*] R. R. S. de Mendonca, The Astrophysical Journal, 830:88

The polarquEEEst schedule

GOAL: Cosmic ray at extreme latitudes

- 2018
 - 3 detectors (POLA-01, POLA-02, POLA-03)
 - PolarquEEEst2018 → one on board of Nanuq (July-September) + 2 telescopes at fixed locations (Bra(TO), Nessoden(Norway))
- 2019 **Verso PolarquEEEst2019**
 - (Dic 18 – Apr 19) → travelling at different latitudes (Italy, Germany, CERN)



POLA-01 trip in Italy/Germany



POLA-01 at Cosenza



Our trip:

- Bologna
- Vigna di Valle
- Erice
- Catania

POLA-01 sull'Etna



POLA-01 at Lampedusa

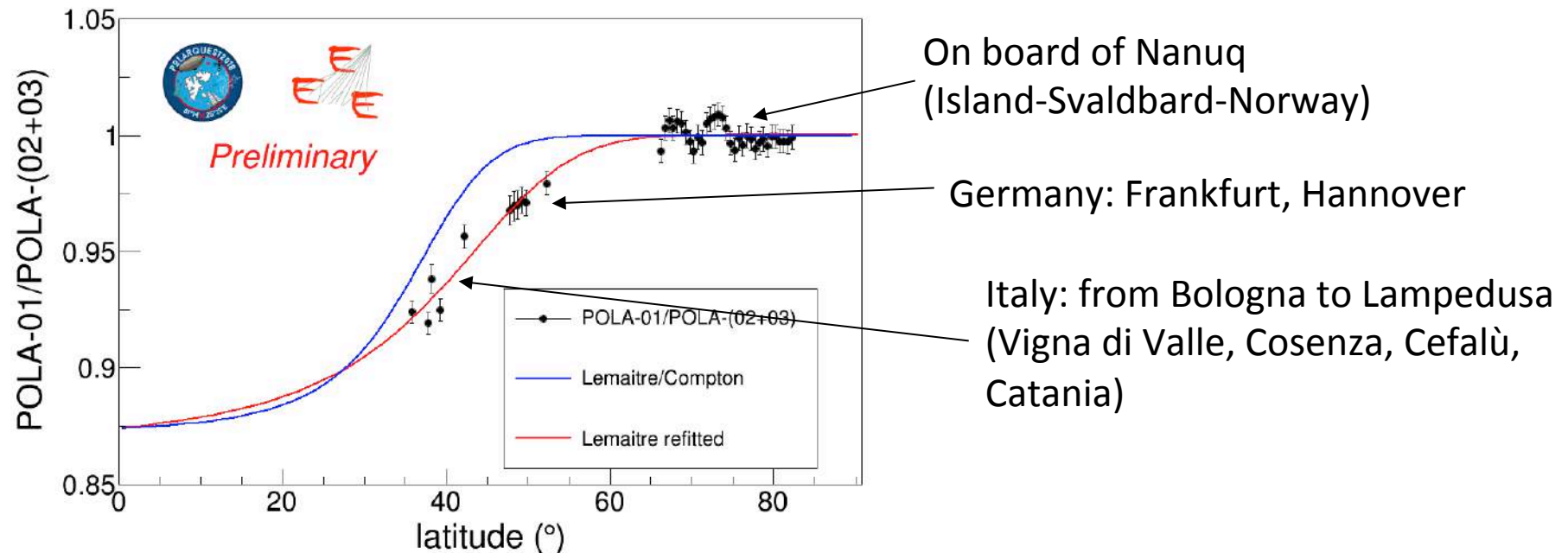
POLA-01 at Cefalù



Germany: Frankfurt, Hannover



Latitude dependence of the flux



Flux vs latitude.

Normalized to POLA-02 and POLA-03 to
remove seasonal effects

The polarquEEEst schedule

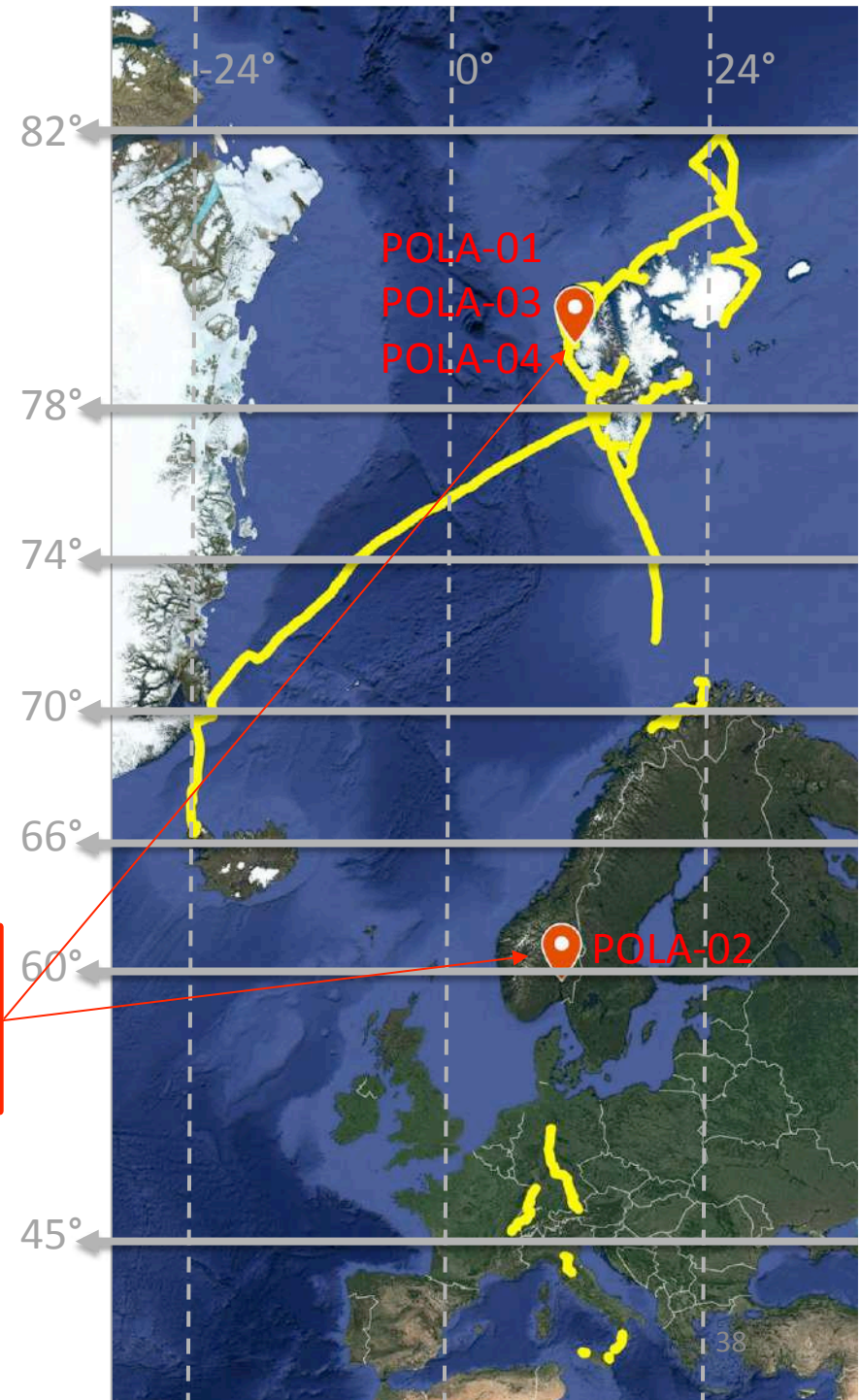
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- 2018
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- 2019
 - (Dic 18 – Apr 19) → travelling at different latitudes (Italy, Germany, CERN)



• Construction of the 4th detector (POLA-04) (PolarquEEEst2019) → 3 detectors moved to Ny Ålesund (Svaldbard)

PolarquEEEst2019



Il Racconto fotografico di Ombretta Pinazza

An aerial photograph taken from an airplane window, showing a vast, snow-covered mountain range. The mountains are rugged and covered in thick snow, with some peaks appearing sharp against the clear blue sky. The foreground shows a wide, flat expanse of snow, possibly a tundra or a large field. The overall scene is bright and clear, suggesting a sunny day in a high-altitude, cold environment.

Ny Ålesund

Ritorno alle Svalbard – Maggio 2019

Ombretta Pinazza, EEE Collaboration



















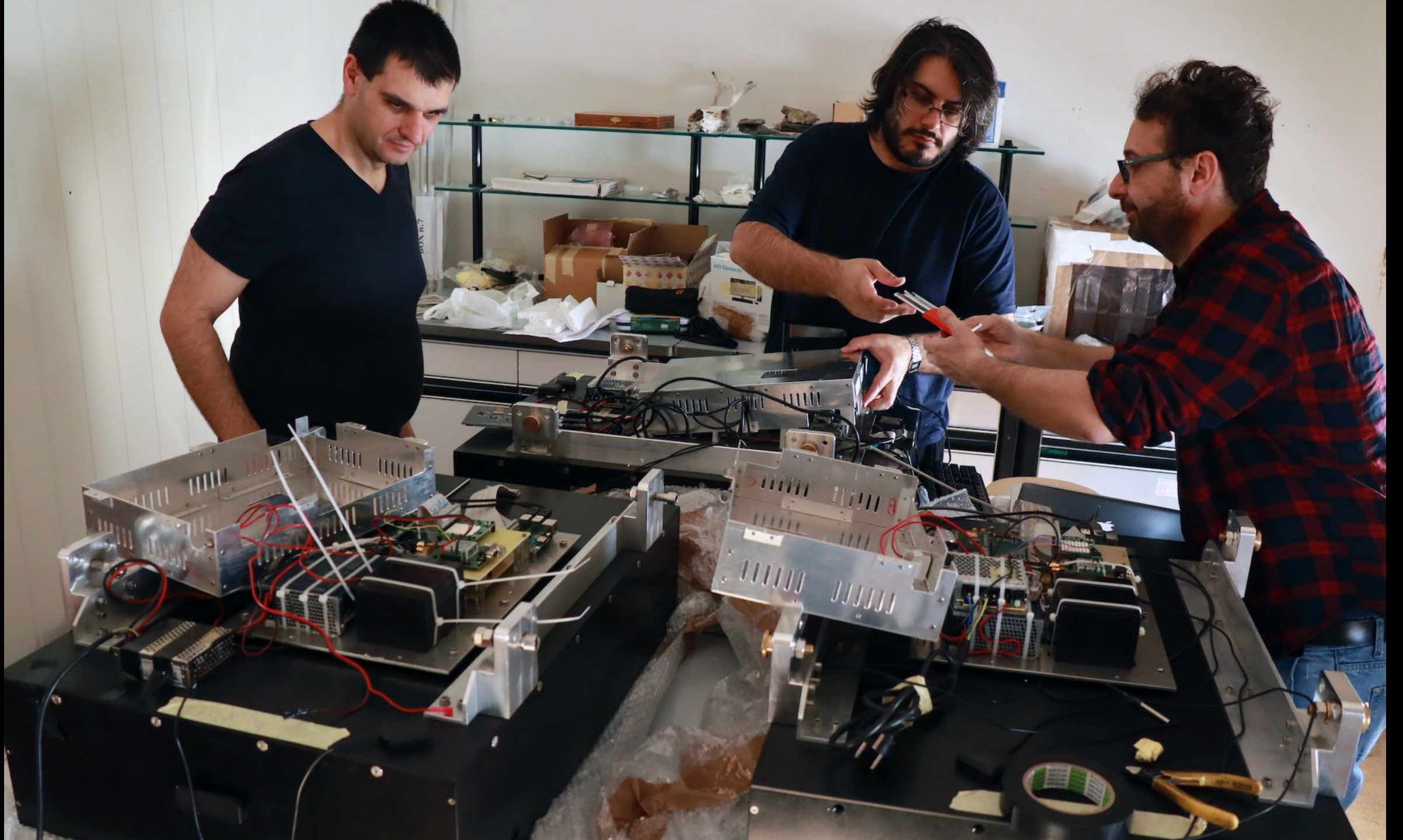
















Map



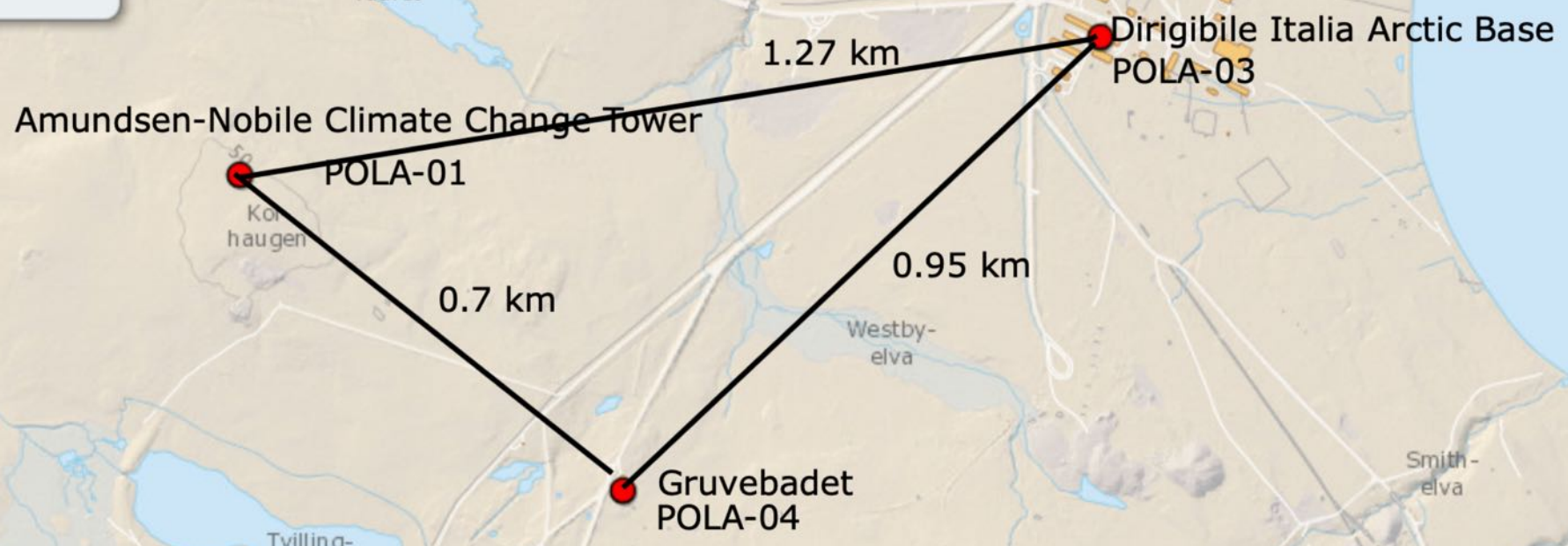
TopoSvalbard

Zoom to place name

945 m / 0.510 nm

0.95 km

North/Lat. East/Long.



















Consiglio Nazionale delle Ricerche
DIRIGIBILE ITALIA
ARCTIC STATION
NY - ÅLESUND





La squadra PolarquEEEst festeggia l'installazione di POLA-01 nel laboratorio della torre per gli studi climatici Amundsen-Nobile, il 30 Maggio 2019



GRAZIE

The PolarquEEEst2019: EEE@Ny Alesund mission

An overview of the work done
27- 30 May 2019

The Team



From Left: Carmelo Pellegrino, Daniele Cavazza, Marcello Abbrescia, Bear Polar, Ombretta Pinazza, Marco Garbini, Francesco Noferini, Mario Nicola Mazziotta,



+ The local CNR Team

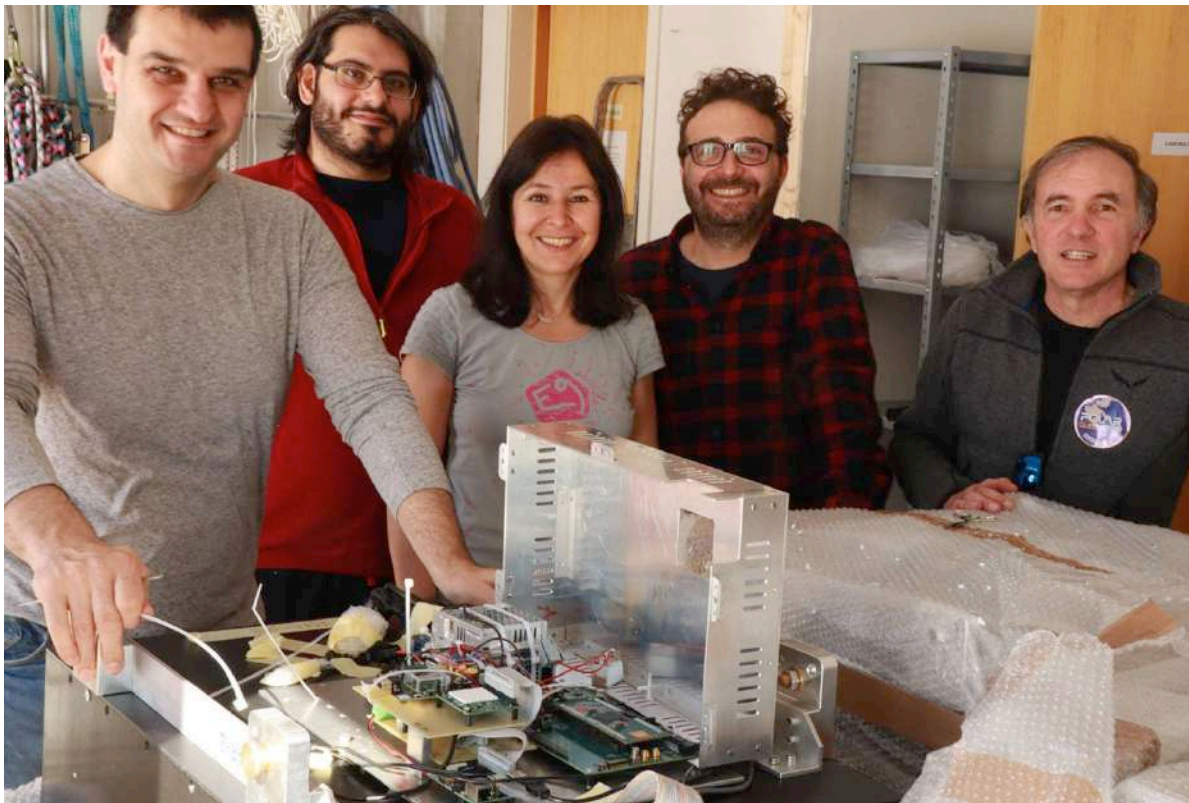


From Top-Left: Daniele Cavazza, Carmelo Pellegrino, Francesco Noferini
(Second row): Fabio Di Bona, Mario Nicola Mazziotta, Marco Garbini
(Third row): Ombretta Pinazza, Marcello Abbrescia, Mauro Mazzola,
Angelo Pietro Viola

The activity

May 27 Lunch time

After arrival we started to put the all the detectors in operation in a room at Dirigibile Italia. We needed to open the electronic box to re install the batteries. We checked that everything was fine.



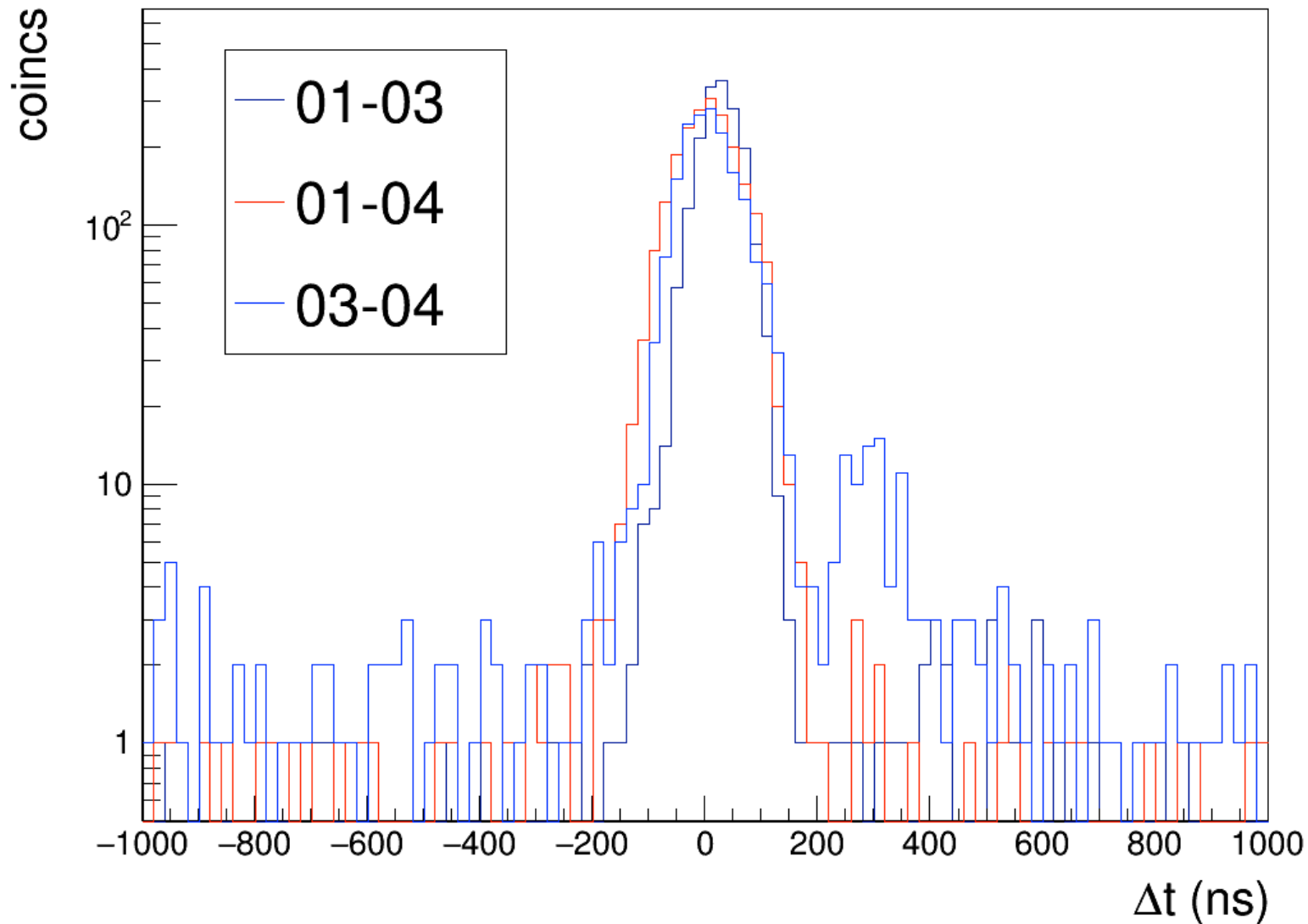
The 3 detectors remained in this site until Tuesday 28th at lunch time.

We checked the main things:

- rate
- TOT distributions
- coincidences

Check coincidences

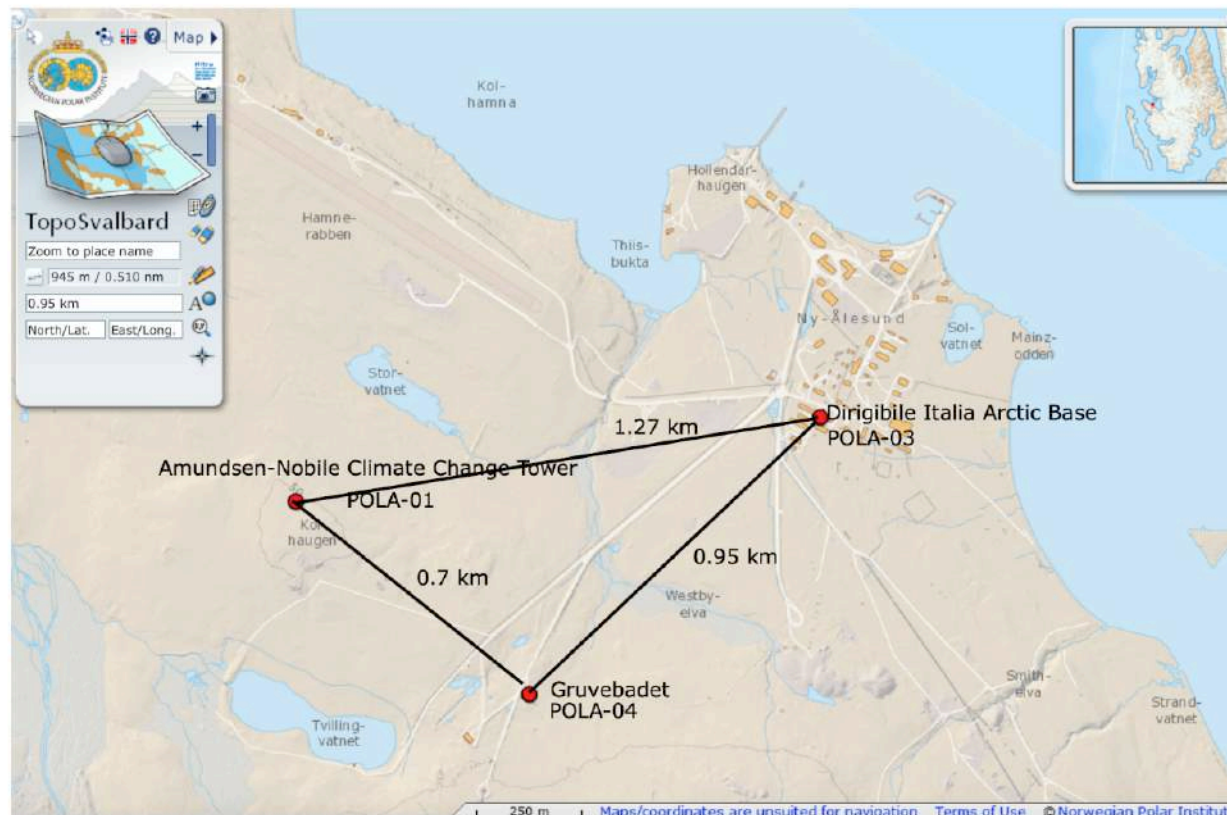
28/05/2019 @ Ny Alesund



The Sites

After a briefing with the CNR team and an inspection we decided the sites for the installations.

- POLA-01 in the Amundsen-Nobile CCT (Climate Change Tower)
- POLA-03 in the Dirigibile Italia station
- POLA-04 in the Gruvebadet laboratory



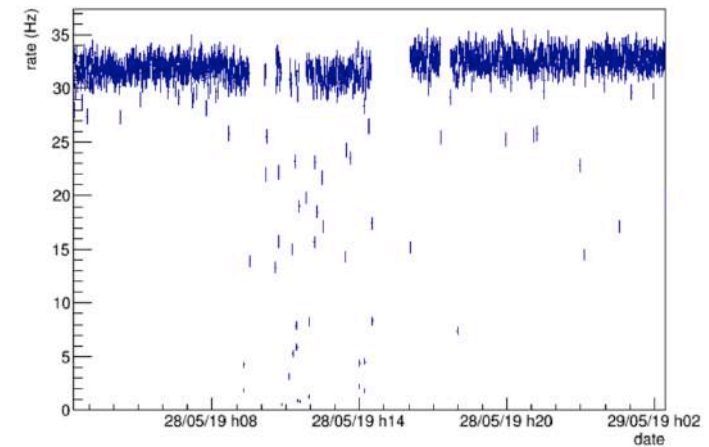
POLA-04 @ Gruvebadet

May 28 Afternoon

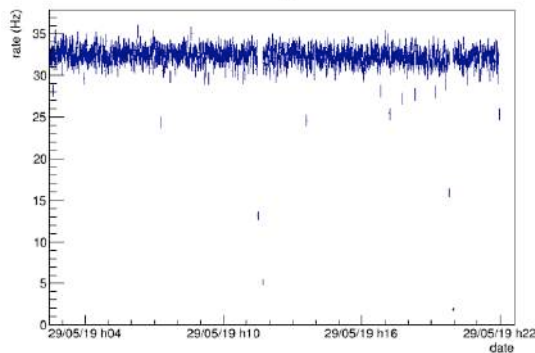


Smooth installation, just some time to acquire GPS signal.

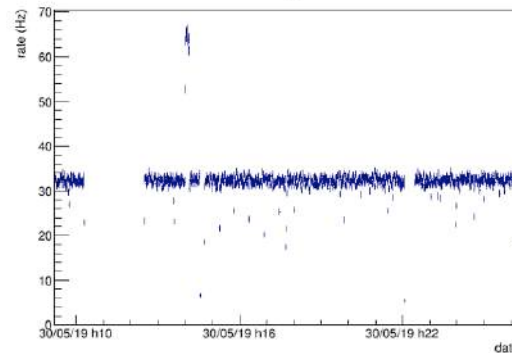
Trending Rate



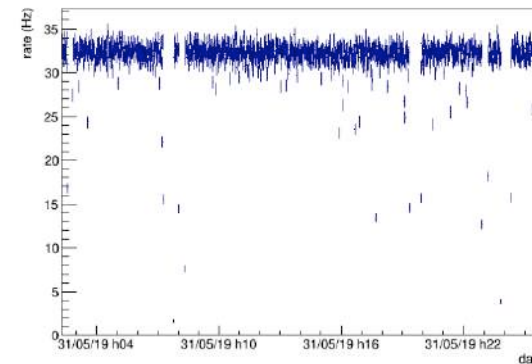
Trending Rate



Trending Rate



Trending Rate



POLA-01 @ CCT

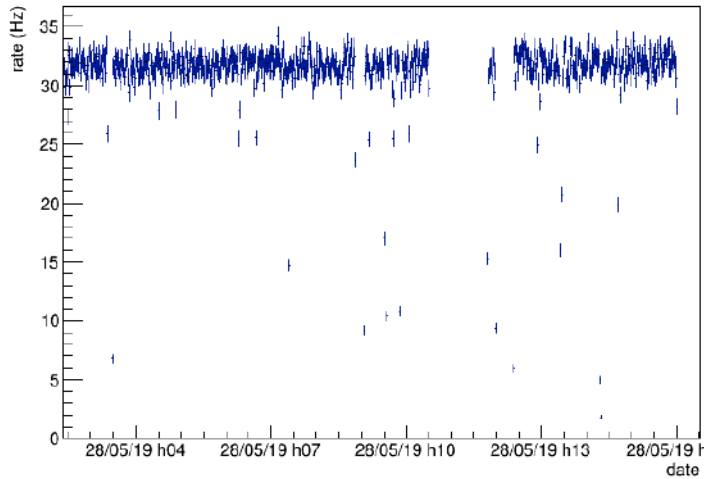
May 28 later

More complex installation.

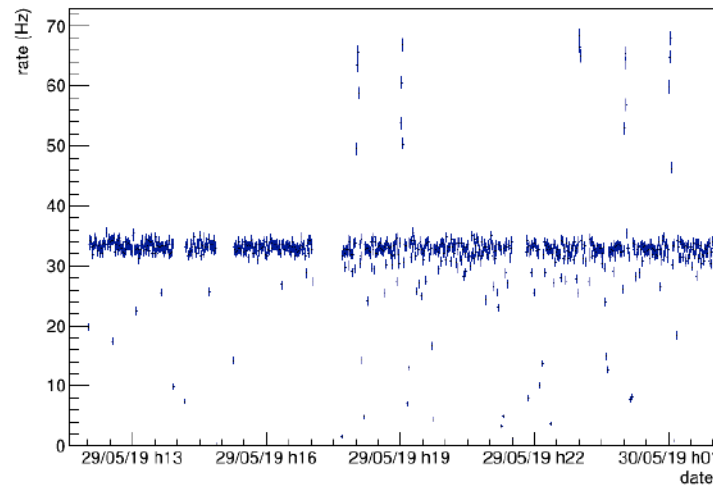


POLA-01 @ CCT

Trending Rate



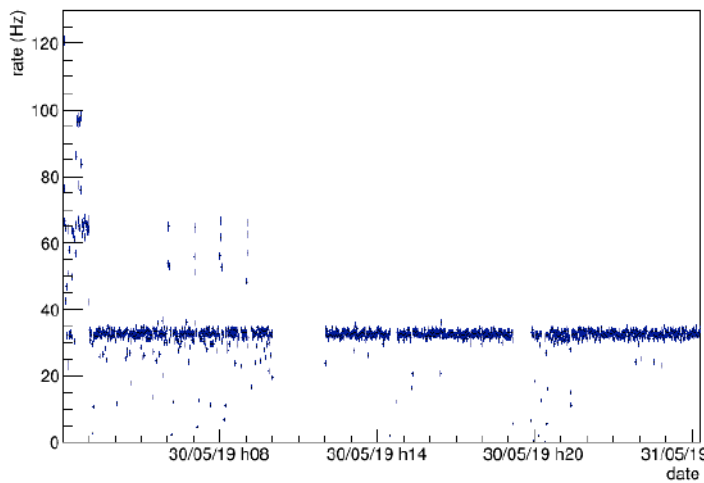
Trending Rate



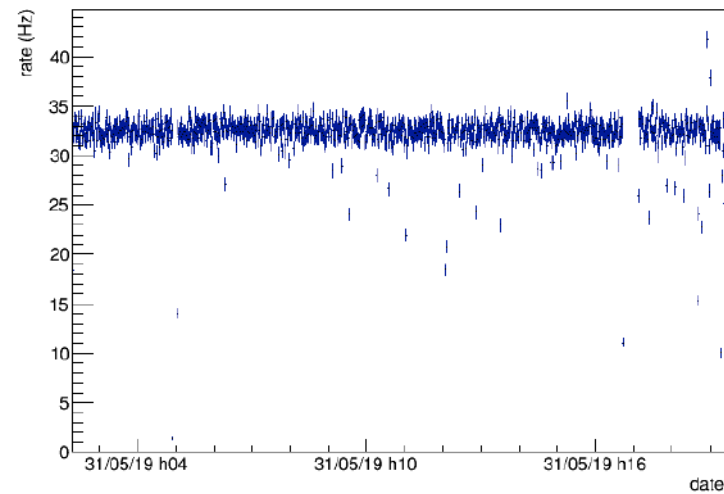
POLA-01 started operations smoothly. We had a power failure due to a loose plug. 😬

Everything fixed. 😊

Trending Rate



Trending Rate



POLA-03 @ Dirigibile Italia

May 29

Easy installation, just change the room.



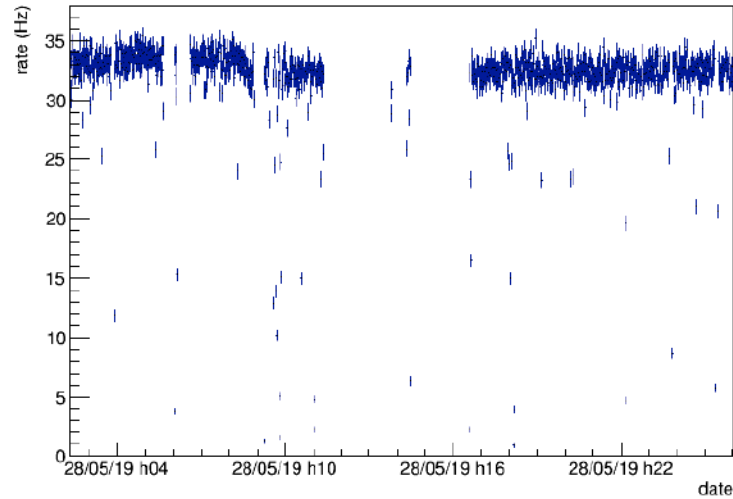
The detector has a hardware problem at the level of the Trigger and Readout Board.

The good news is that it has been “solved” via software.

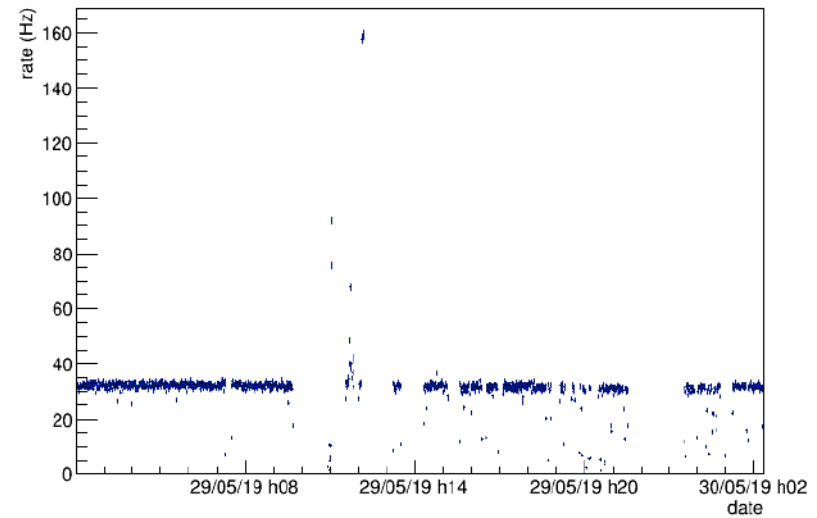


POLA-03 @ Dirigibile Italia

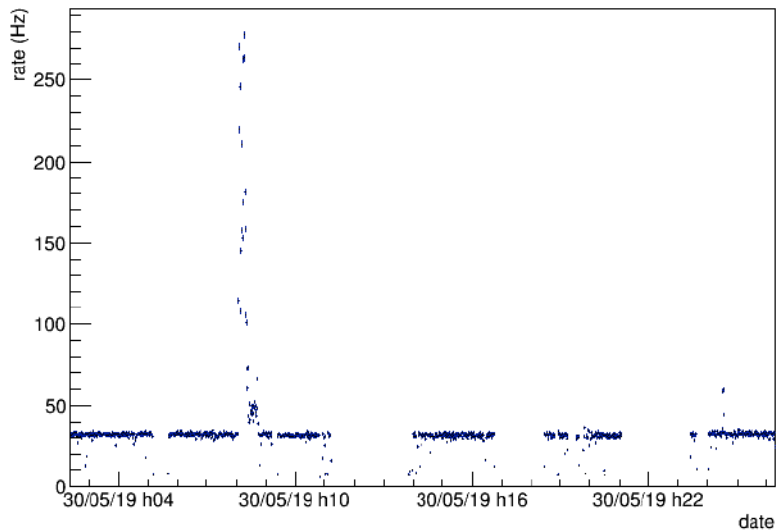
Trending Rate



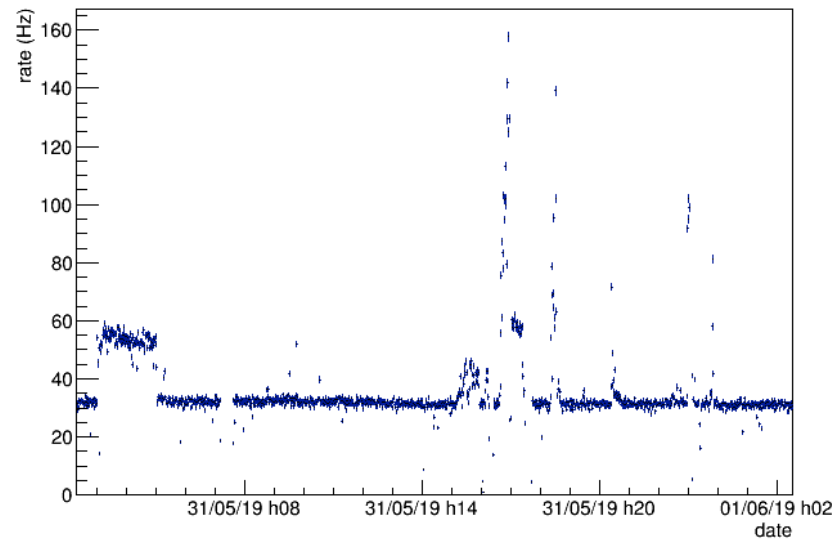
Trending Rate



Trending Rate



Trending Rate



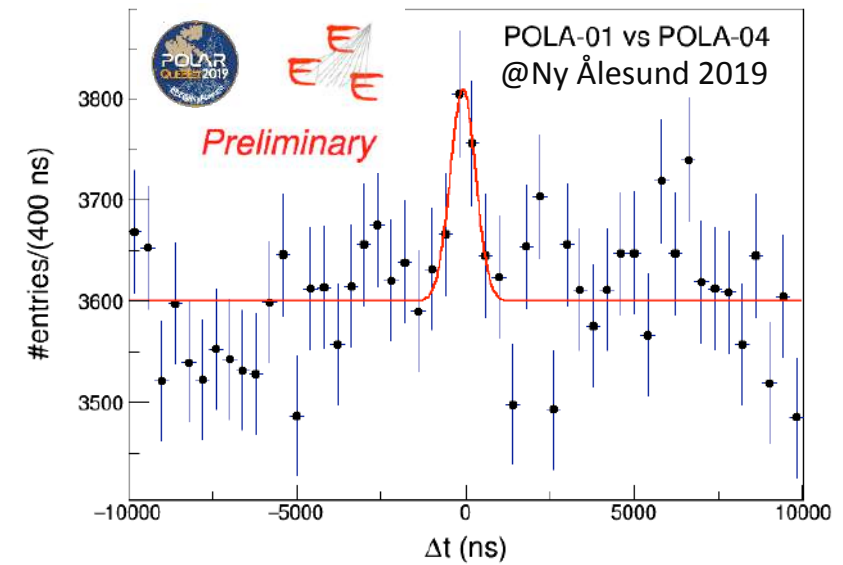
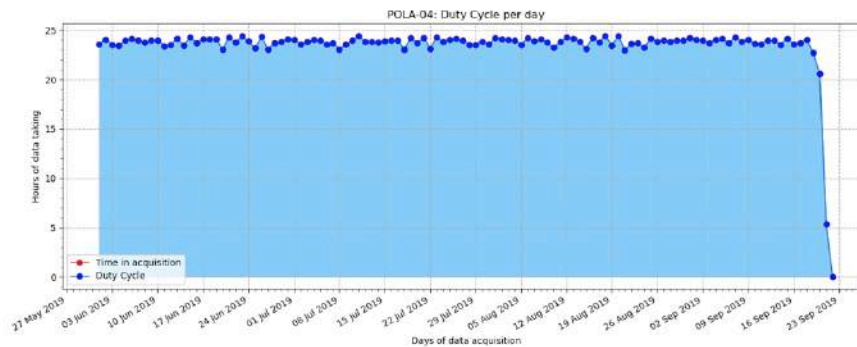
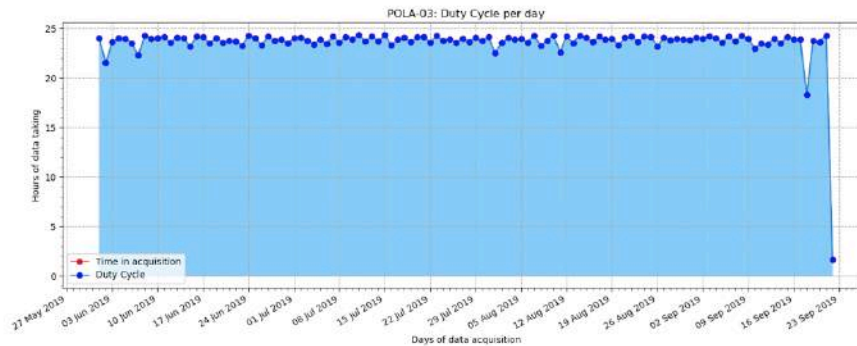
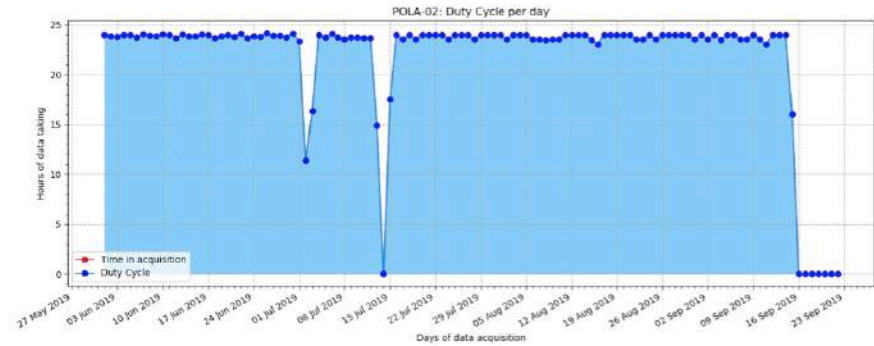
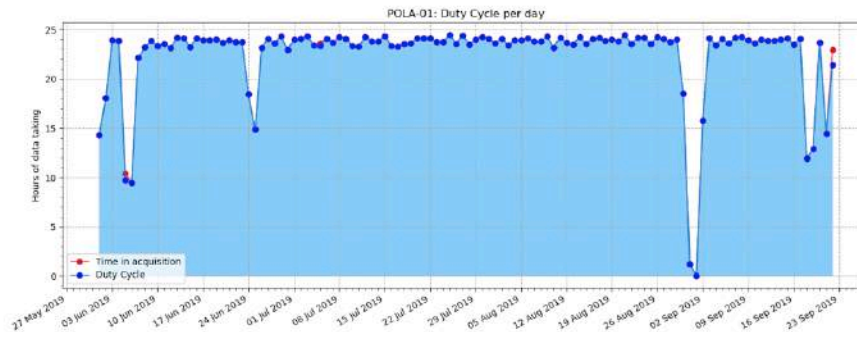
A lot of work done by all



And first of all thanks to everybody

Since then?

First 3 months of data taking

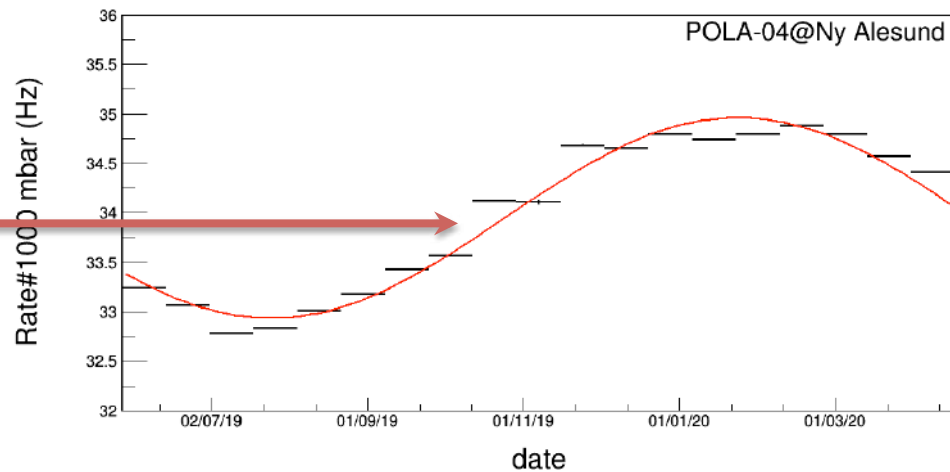
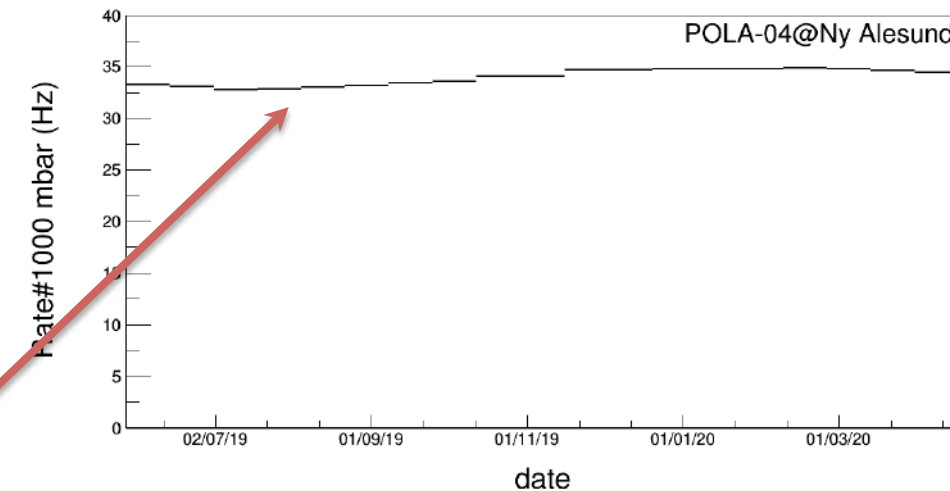


1 year of data taking@Ny Alesund

POLA-01, POLA-03,
POLA-04 acquired data
for almost 1 year.

Very stable behavior
during last year.

Clear seasonal effect



Many thanks to ...



... to many people



Grazie dell'attenzione!

