Extreme Energy Events
Science inside Schools

Update on the PolarquEEEst 2 analysis and publication

Analysis people: Francesco N., Marco G., Nicola M., Carmelo P., Daniele D.

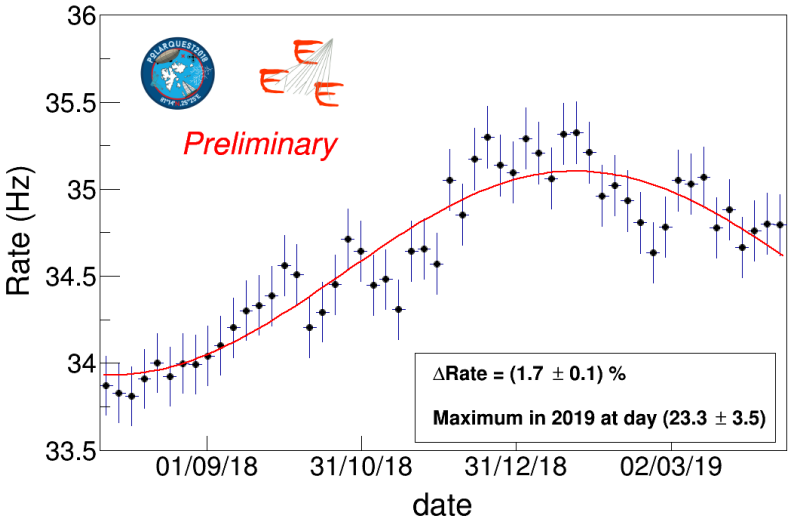
Paper: Rosario N., Marcello A.

INFN

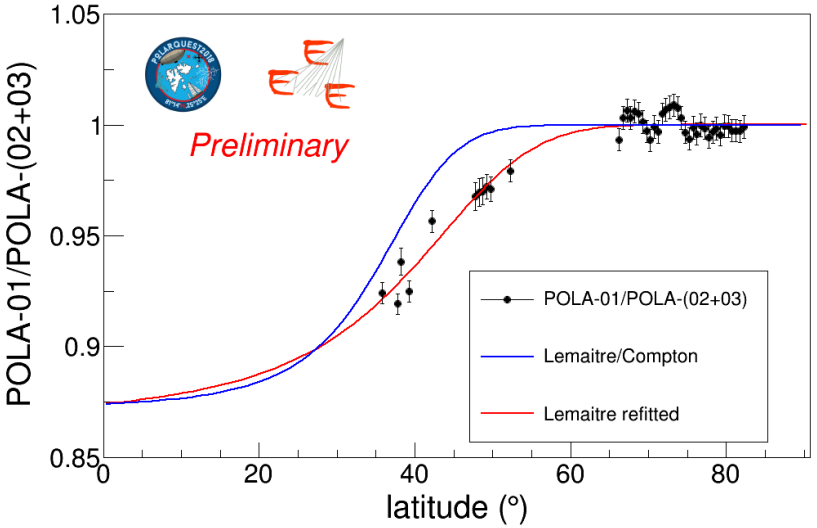
Summary

- Preliminary results
  - Seasonal effect
  - Rate vs latitude
- Expected rate as function of latitude
- Available measurements and Quality Checks
  - ELOG
  - Extra info
- Open issues and plans

Preliminary results



POLA-02 + POLA-03



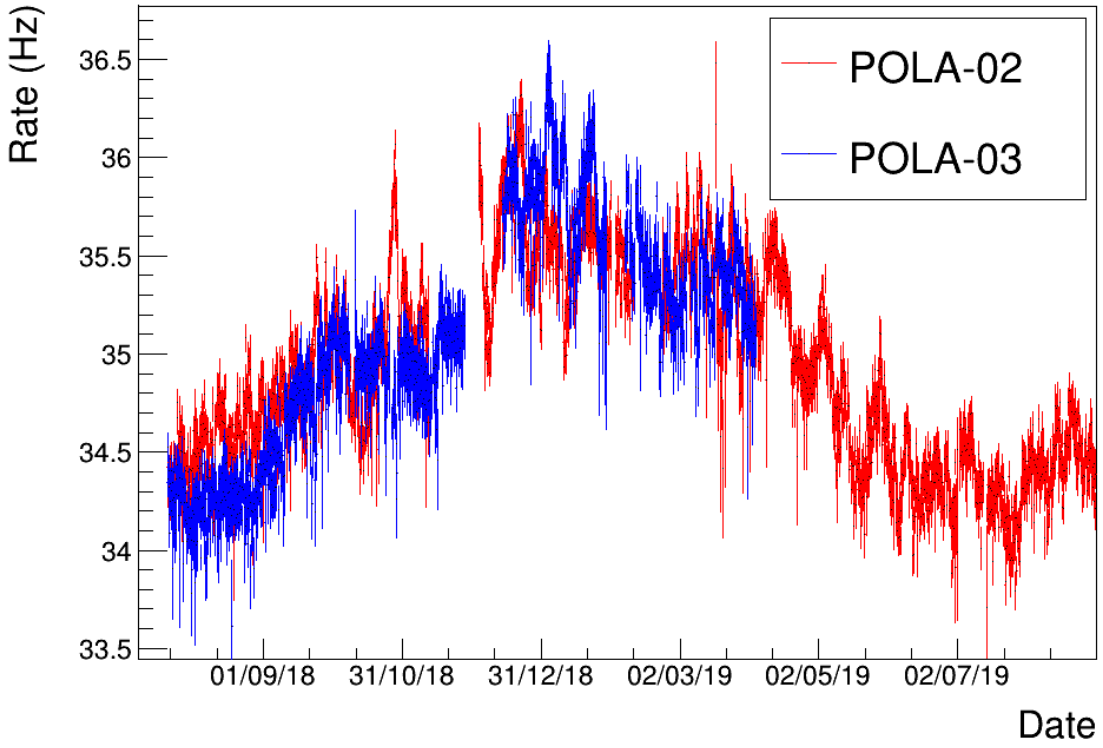
Include:

- Svalbard
- Germania
- Vigna di Valle
- Cosenza
- Cefalù
- Catania
- Lampedusa

Presented at several conferences

Potential issues

Seasonal effect



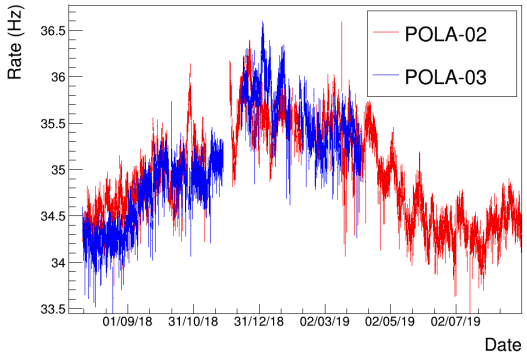
Updated with data up to September 2019

Rate correected for material effect and efficiencies (see later).

Reference pressure of 1000 mbar here and in next plots (easy to change).

Comparison with previous measurements

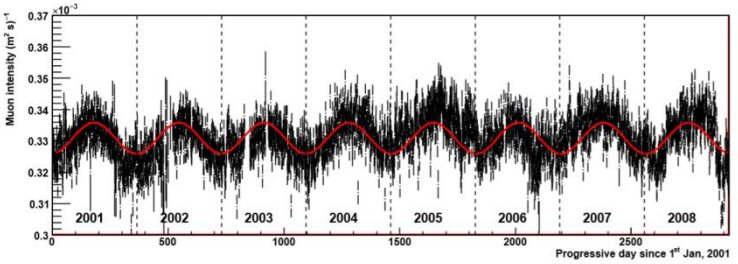
Our measurement



$E_\mu \sim 1$ GeV
Maximum → ~ 20 days

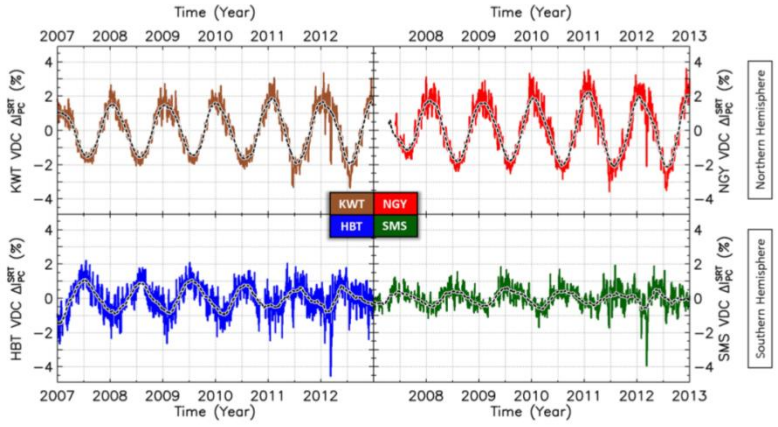
LVD

http://www.bo.infn.it/lvd/pubdocs/icrc0766.pdf



$E_\mu > 1.3$ TeV
Maximum → (185 +/- 15) days

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



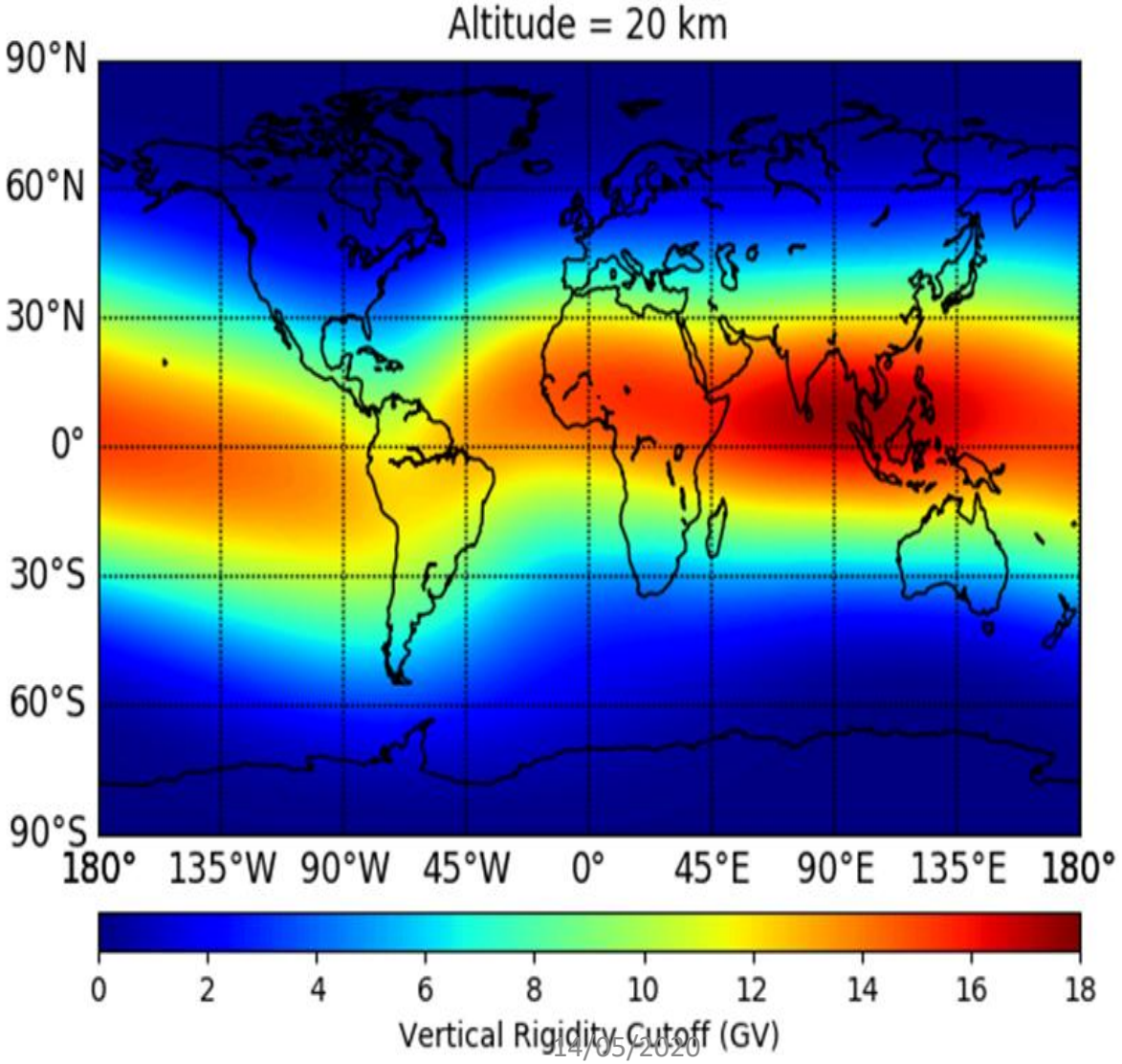
Similar modulation intensity both for low and high energy muons (1.5-2%)

Low and High energy muons with opposite phase!
Low energy → max in Winter
High energy → max in Summer

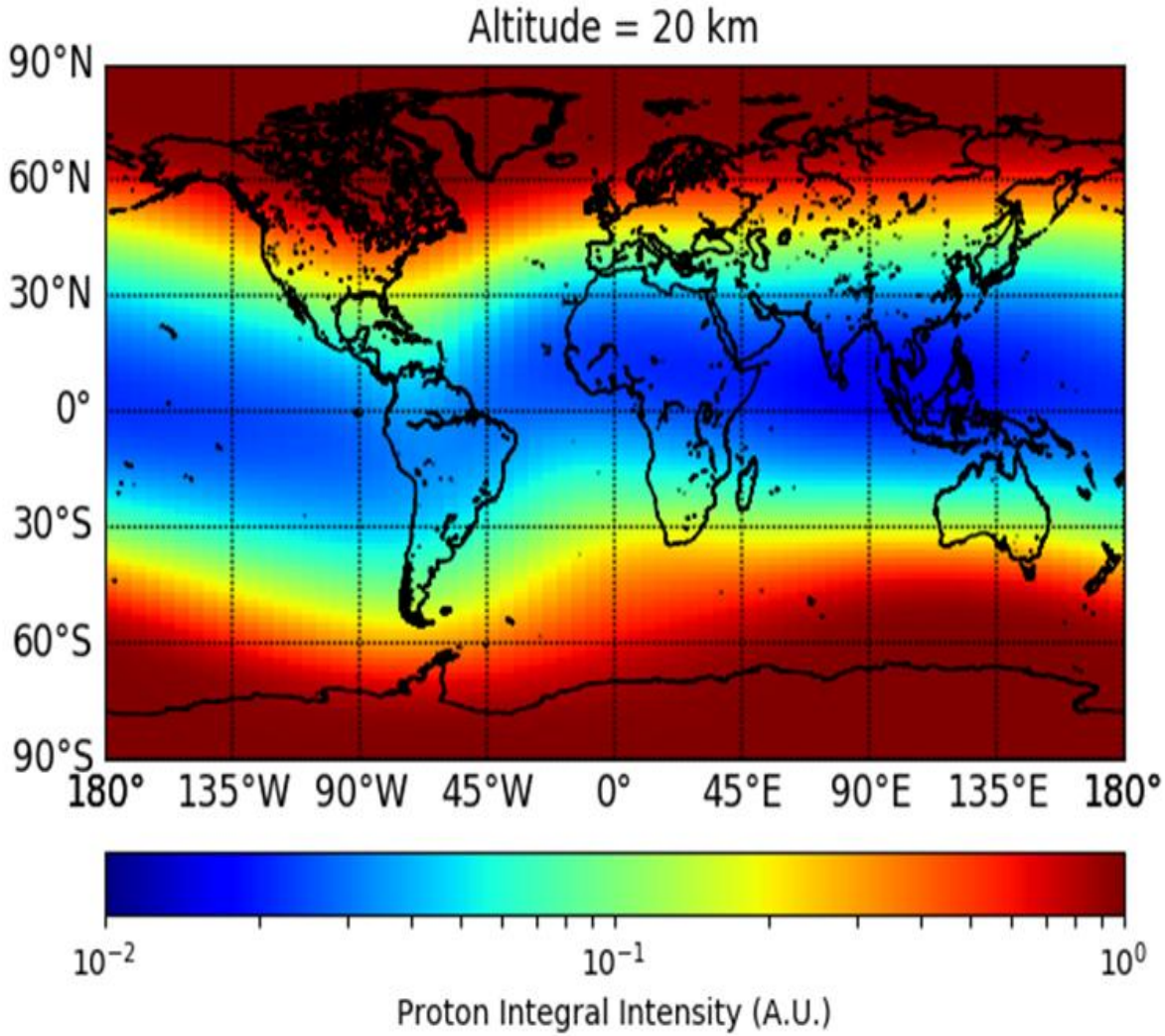
Secondary cosmic ray (CR) intensity at sea level

- The secondary cosmic rays (i.e. muons, electrons, positrons, protons, neutrons) at sea level for a given (longitude, latitude) position depends on the CR intensity at the top of the atmosphere, the geomagnetic cut-off and the yield of secondary at the
- At the first glance the vertical geomagnetic cut-off could be used at 20 km of altitude (assumed as the average primary interaction point)
- For more details see https://agenda.centrofermi.it/event/136/contributions/1130/attachments/561/851/NicolaM_08May19.pdf

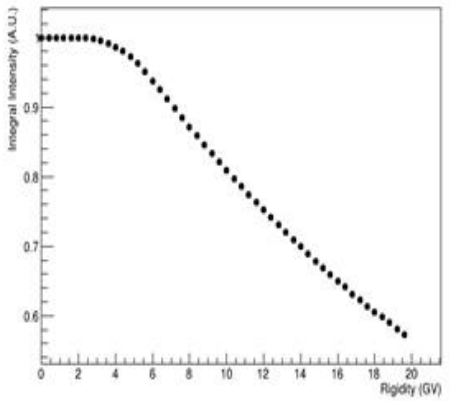
Vertical geomagnetic rigidity cut-off: IGR

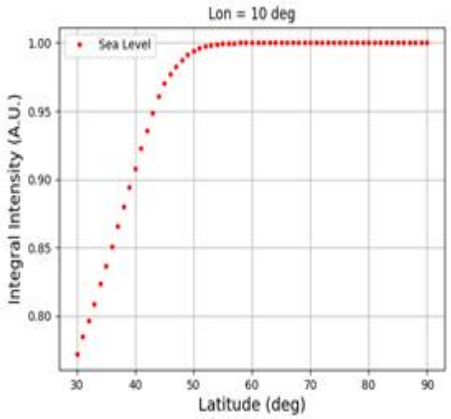


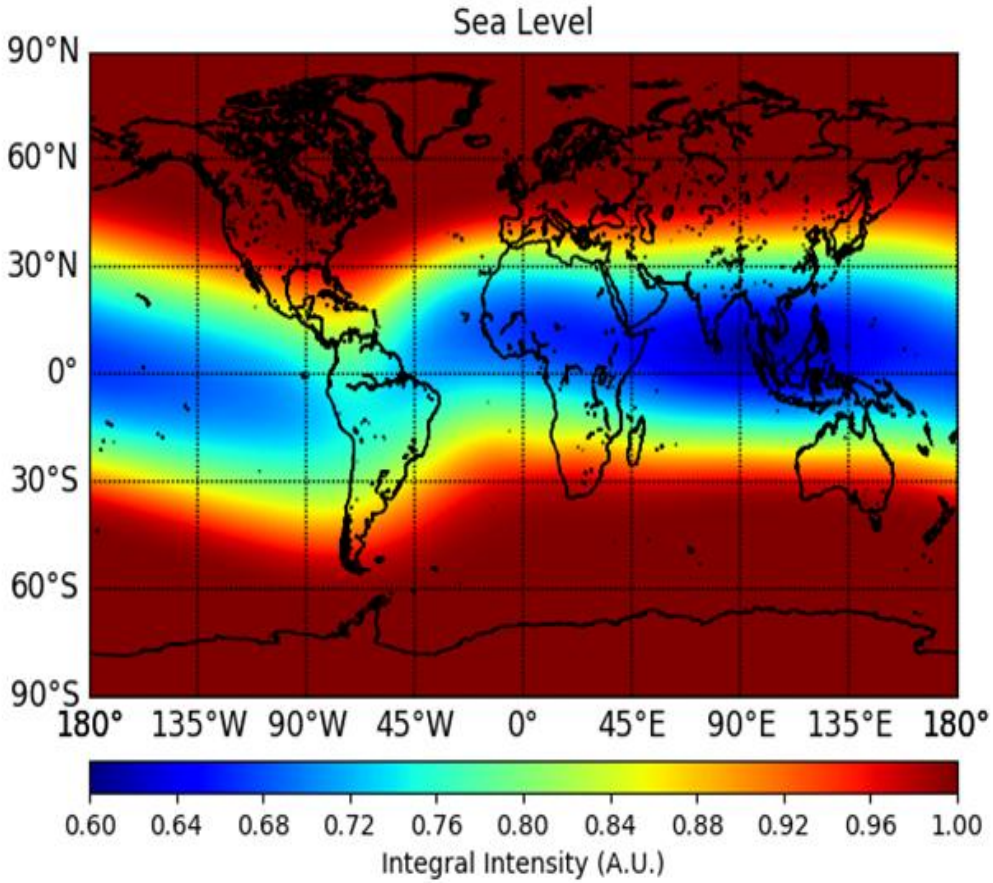
AMS02 proton intensity map with geomagnetic cut-off



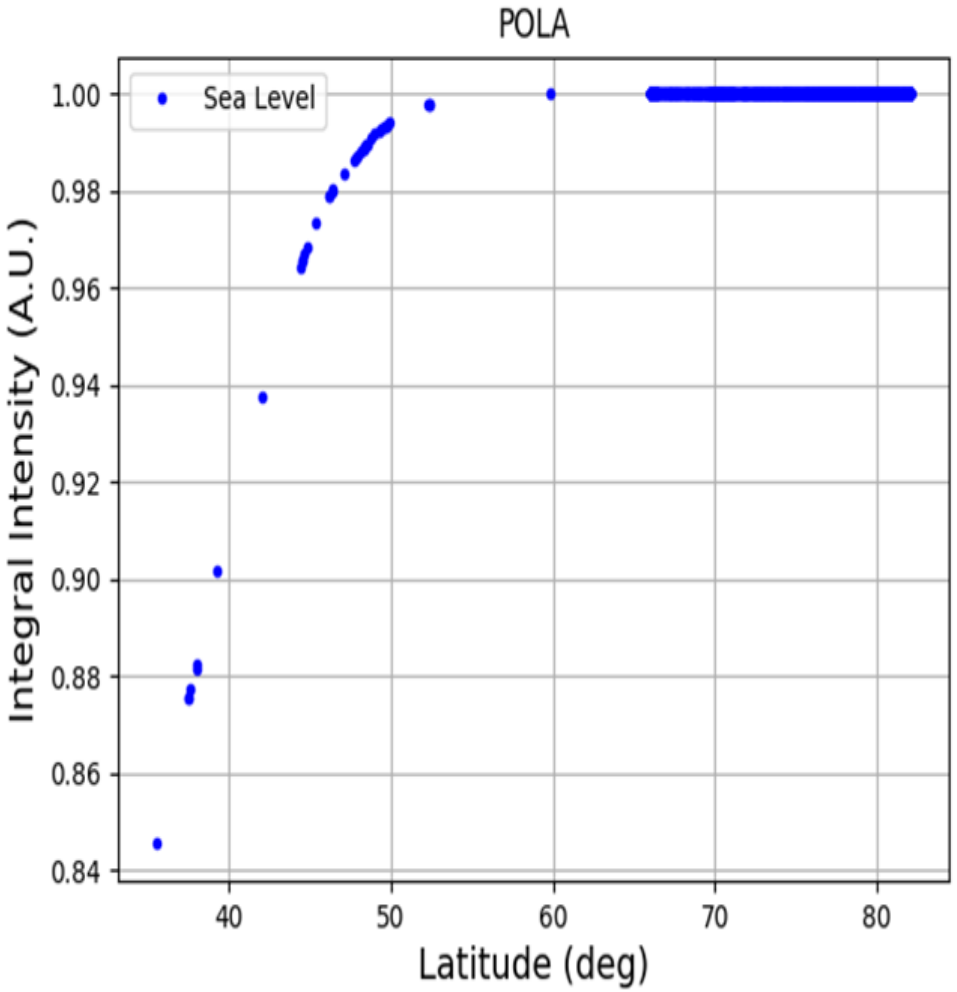
Integral intensity at sea level: $\mu^{\pm}$, $e^{\pm}$, p (E>10 MeV)



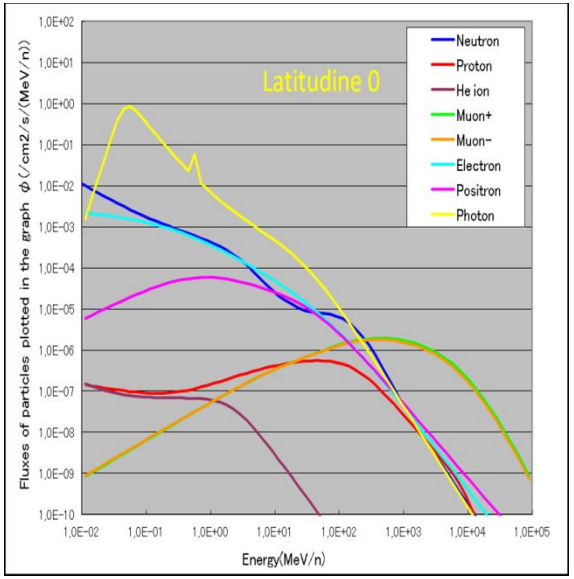


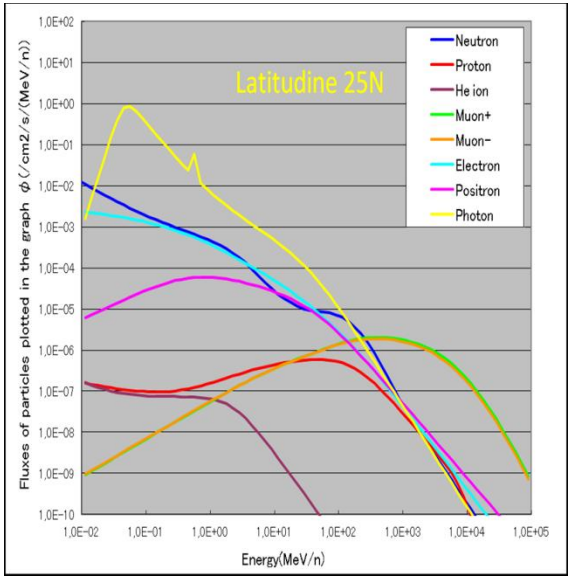


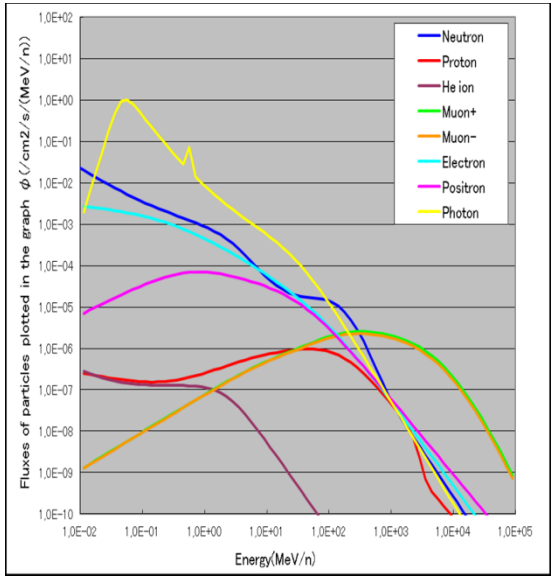
Expected rate at Polar positions ($\mu^{\pm}$, $e^{\pm}$, p E>10 MeV)



Parametrization available in literature







To be folded with the detectors response → cut in energy and acceptance

Rate vs latitude

Available measurements from POLA-01:

Svalbard, Hannover, Franckfurt, Germany travel, CERN, Bologna, Vigna di Valle, Cosenza, Cefalà, Catania, Lampedusa

Material effect measured for POLA-02, POLA-03

Potential iussues for Bologna, Cosenza, Catania (see later)

Missing info: material effect for POLA-01 (see later)

To be checked: building shadowing?

Cosenza

- People: Carmelo, Marco, Francesco
- When: 04-05/12/2018
- ELOG: n. 24, 35
- Altitude = 222 m
- POLA-02: OK
- POLA-03: n.a

Message ID: **35**	Entry time: **Wed Dec 12 12:30:30 2018** In reply to: **24**
Author:	COSE-01
Telescope ID:	POLA-01
Operatore:	Francesco Noferini
Time:	05 December 2018
Place:	Cosenza (riepilogo misure)

COSE-01 wrote:

3/12/2018 -> misure nella stanza telescopio -> 24 Hz

4/12/2018 -> misure in esterno dal run 376312736 al run 376327252 (pos1,pos2,pos3)-> 33 Hz

5/12/2018 -> misura al 2 piano dal run 376392990 al run 376395351 -> 28 Hz

-> misura in esterno (pos1) dal run 376397919 fino a partenza con la macchina alla volta di Messina -> 33 Hz

Pos0 -> dati presi dentro la stanza vicino al telescopio EEE (64700 s)

Pos1 -> dati presi all'esterno a circa 10 m dal telescopio di EEE (6264 s)

Pos2 -> dati presi all'esterno a circa 15 m dal telescopio di EEE (4100 s)

Pos3 -> dati presi all'esterno a circa 20 m dal telescopio di EEE (5802 s)

Pos4 -> dati presi al 2 piano (3810 s)

Le colonne rappresentano:

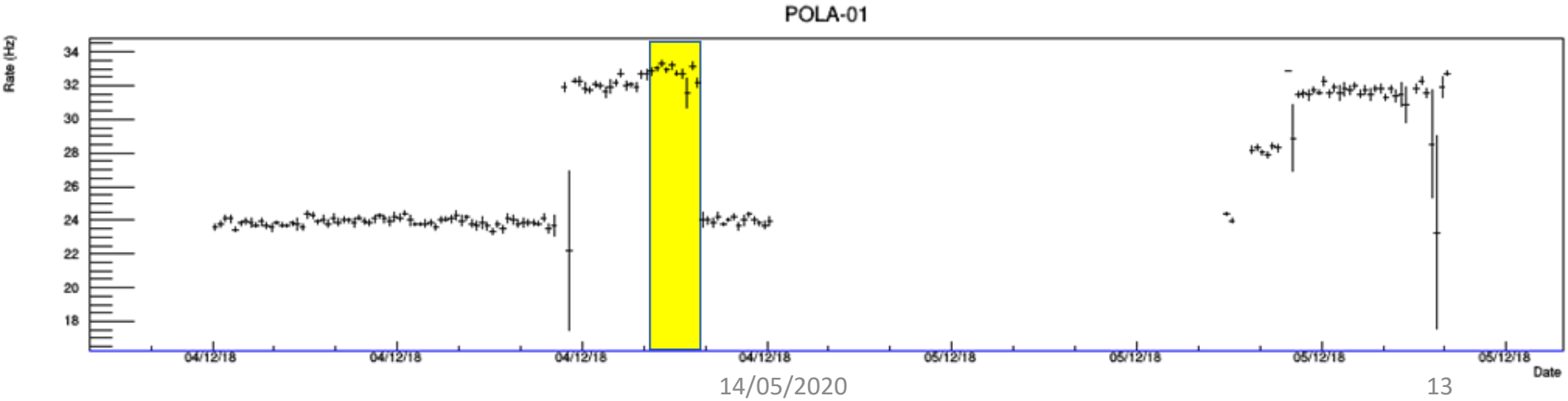
secondi trascorsi dal 1 gennaio 2009

nanosecondi

differenza in tempo tra gli eventi di COSE-01 e POLA-01

angolo theta misurato dal telescopio di EEE

angolo phi misurato dal telescopio di EEE



To be checked: building shadowing?

Catania

Message ID: **43**	Entry time: **Fri Feb 8 12:21:31 2019**
Author:	CATA-01
Telescope ID:	POLA-01
Operatore:	Paola la Rocca
Time:	31 January 2019
Place:	Catania - misura all'aperto

31 GENNAIO 2019

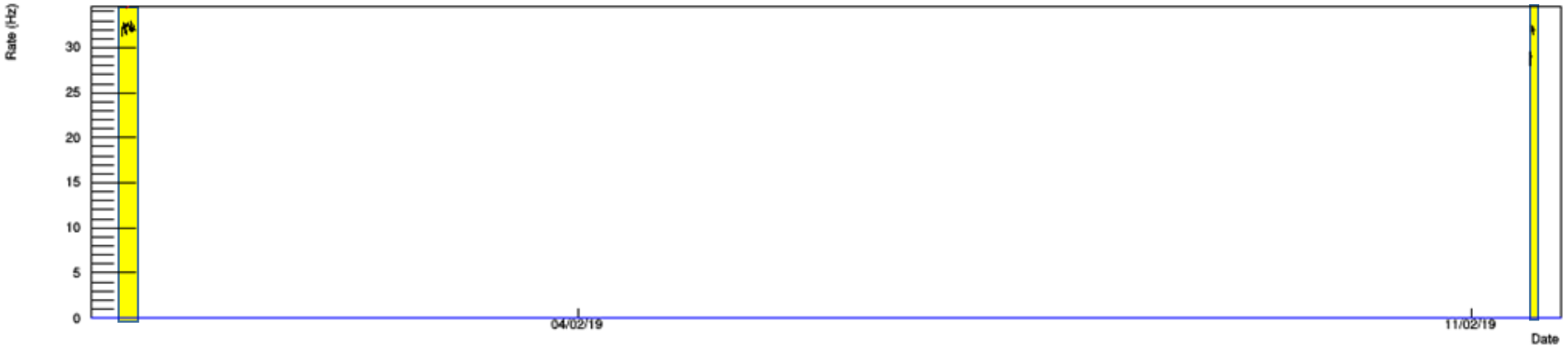
10:00 POLA-01 è stato spostato all'esterno

11:00 POLA-01 è stato spostato sempre all'esterno, ma lontano dalla parete dell'edificio vicino alla quale si trovava

13:30 POLA-01 rientrato nell'edificio a causa del maltempo

- People: Paola, Franco
- When: 31/01/2019, 11/02/2019
- ELOG: n. 43, 45
- Altitude = 158 m
- POLA-02: OK
- POLA-03: n.a

POLA-01

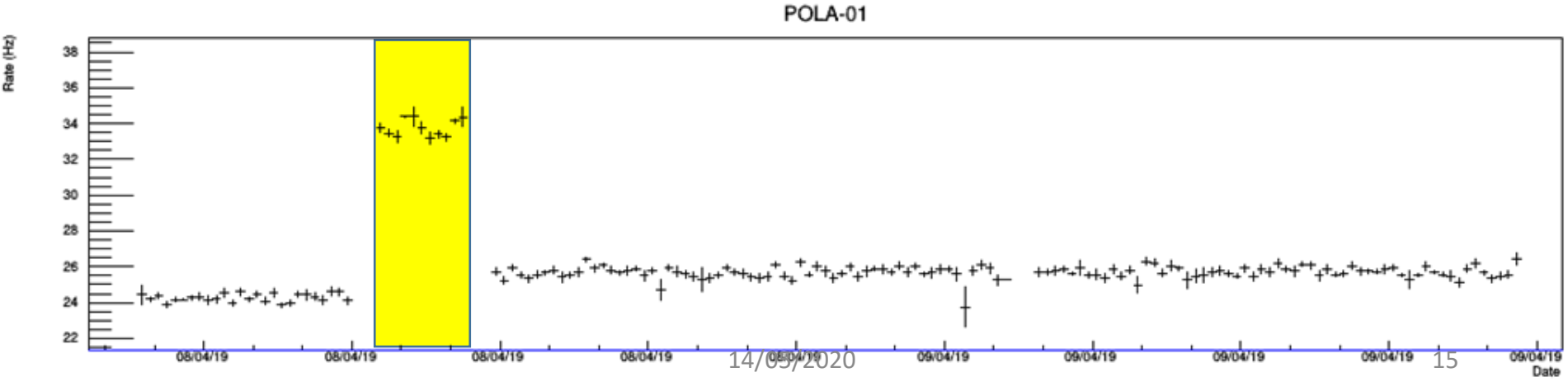


To be checked: building shadowing?

Bologna

- People: Marco, Francesco
- When: 08/04/2019, few hours of data taking
- ELOG: n. 65
- Altitude = 80 m
- POLA-02: OK
- POLA-03: n.a.

Message ID: **65**	Entry time: **Mon Apr 8 17:23:36 2019**
Author:	BOLO-01
Telescope ID:	POLA-01
Operatore:	Francesco Noferini
Time:	08 April 2019
Place:	Bologna in esterno
Acquisiti in esterno i seguenti run	
387116897	
387119596	
387121603	
Nella seconda parte prese misure per orientazioni diverse (5 minuti per posizione) per provare a calibrare il magnetometro.	



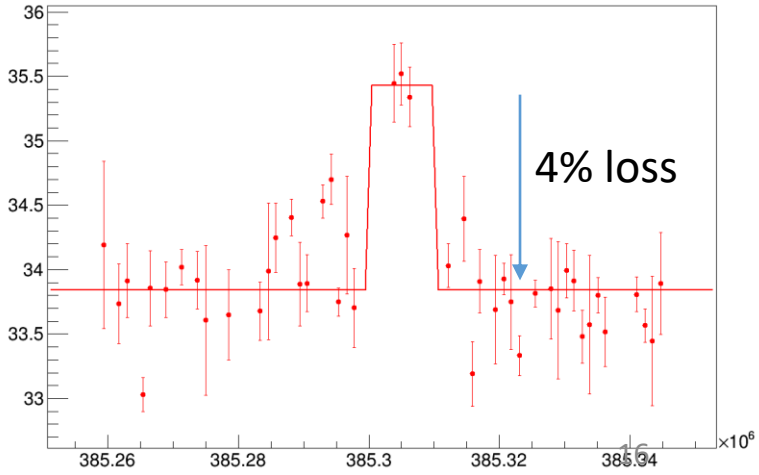
POLA-02 material

- People: Oslo staff
- When: 18/03/2019
- ELOG: n. 101
- Altitude = 70 m
- Latitude = 59.8

Message ID: **101**	Entry time: **Wed Jul 3 13:32:50 2019**
Author:	BOLO-01
Telescope ID:	POLA-02
Operatore:	Francesco Noferini
Time:	18 March 2019
Place:	OSLO (outside)

I would like to thank Randi for the work done in order to make the outside measurement possible. Data was taken outside for roughly 2 hours. The run span is the following:

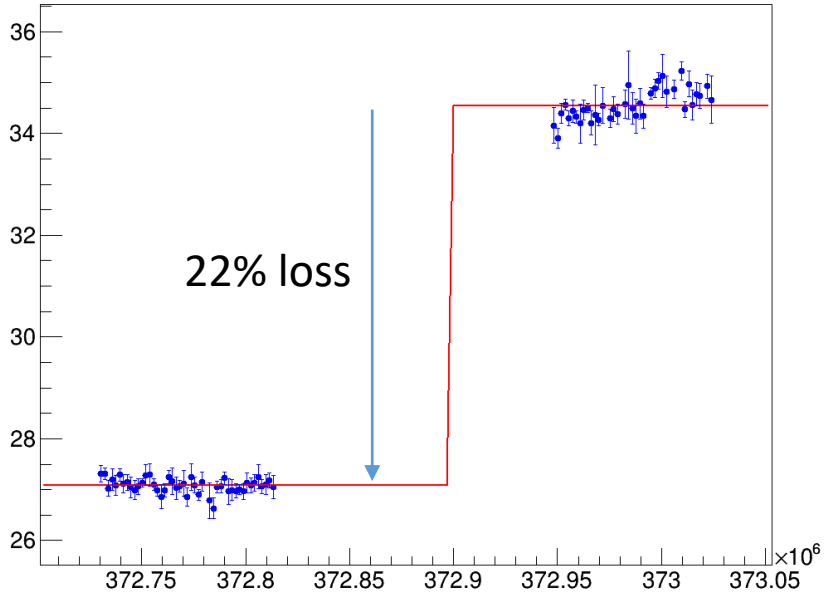
POLA-02-2019-03-18-385298567 last inside
POLA-02-2019-03-18-385309496 last outside



POLA-03 material

- People: Oslo staff
- When: 24-27/10/2018
- ELOG: n. 20
- Altitude = 45 m
- Latitude = 44.7

Message ID: **20**	Entry time: **Mon Oct 29 12:59:43 2018**
Author:	BOLO-01
Telescope ID:	POLA-03
Operatore:	Francesco Noferini
Time:	26 October 2018
Place:	Bra (all'aperto)
Misura di POLA-03 all'aperto dalle 15 (13 UTC) del 26/10 alle 12 (10 UTC) del 27/10	



Efficiency study at CERN POLA-01/03/04

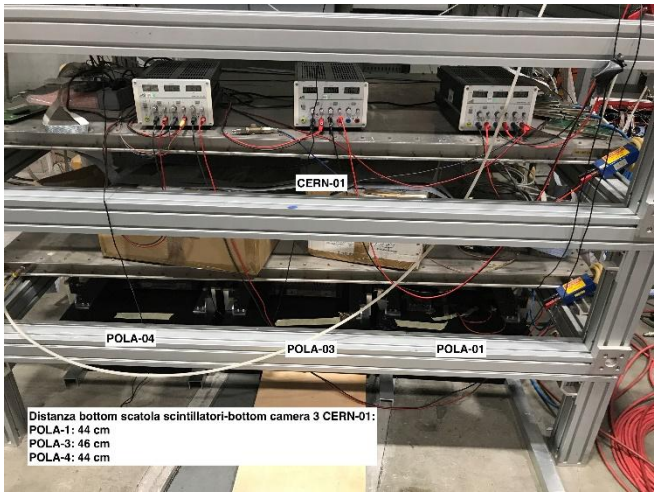
27/04/2019

POLA-01
effective time = 56529 s
Trg. Eff = 0.9578 +/- 0.0006

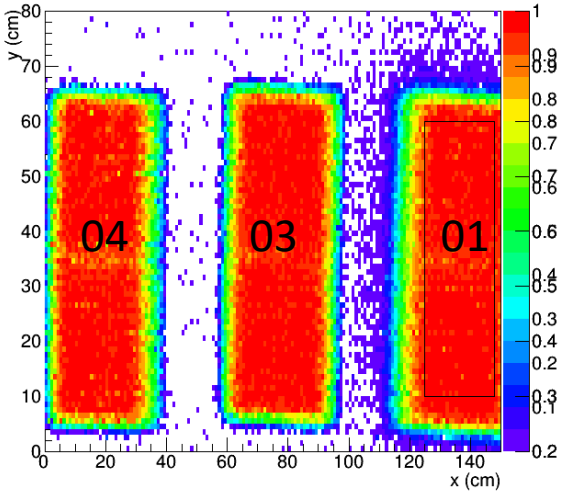
POLA-03
effective time = 45251 s
Trg. Eff = 0.9616 +/- 0.0006

POLA-04
effective time = 62730 s
Trg. Eff = 0.9567 +/- 0.0006

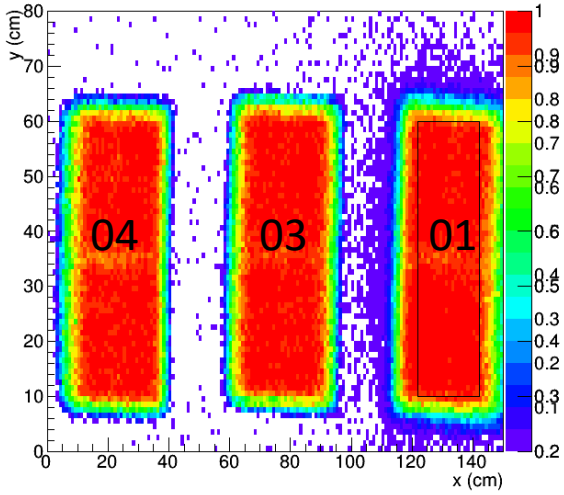
- People: Marco, Carmelo, Ivan
- When: 25-26/04/2019
- ELOG: n. 70, 71, 74



Bottom



Top



https://amslaurea.unibo.it/18725/1/TESI_SARA_RABAGLIA.pdf

Open issues and plan

- Material effect for POLA-01
  - Svalbard: external measurement in Isafjordur (close to the Hangar, shadowing!) before to put POLA-01 inside the hatch. Shadowing inside the car to be checked with POLA-02 now in Bologna.
- Measurements to be checked: Bologna, Catania and Cosenza. The most important for us is Catania: can we do something?
- The plans with POLA-02 in Bologna:
  - Redo Bologna measurement
  - **Shadowing effect when inside the car: we can mesasure it**
  - Efficiency measurement for POLA-02 (if possible since POLA-02 has to be reworked also for other future initiatives)

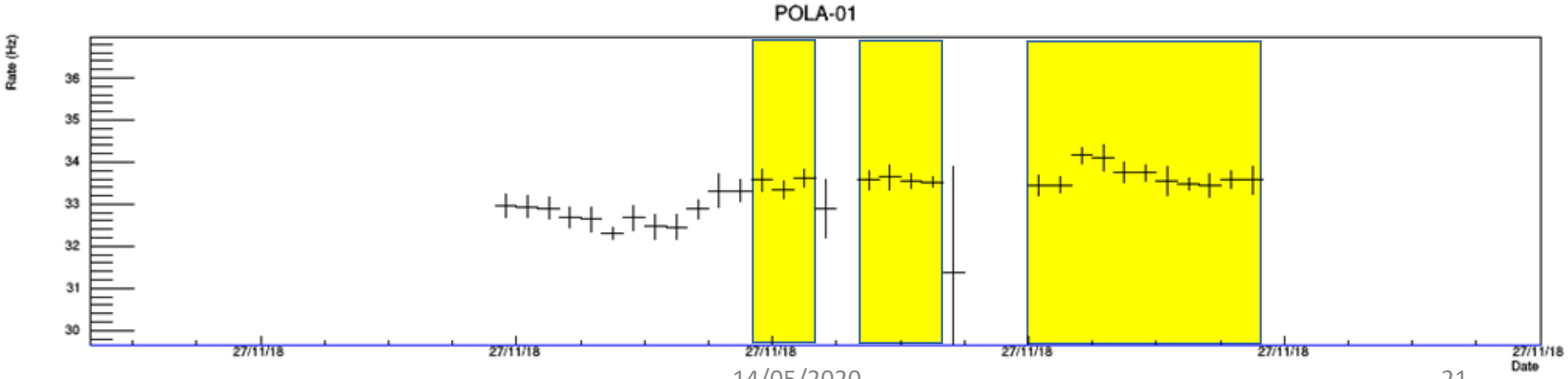
backup

To be checked: material effects?

Vigna di Valle

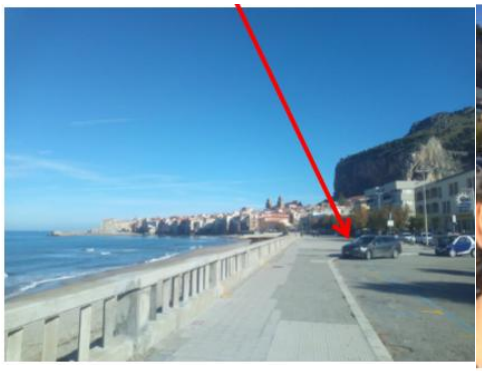
- People: Carmelo, Marco
- When: 27/11/2018, few hours of good data taking
- ELOG: n. 44
- Altitude = 150 m
- POLA-02: n.a.
- POLA-03: OK

Message ID: **44**	Entry time: **Fri Feb 8 15:15:34 2019**
Author:	BOLO-01
Telescope ID:	POLA-01
Operatore:	Francesco Noferini
Time:	27 November 2018
Place:	Vigna di Valle
Presa dati buona di 3.5 ore EEE Timestamp: 375717000 - 375730800 altitudine 150 m range pressione 987 - 990 mbar	



Cefalù

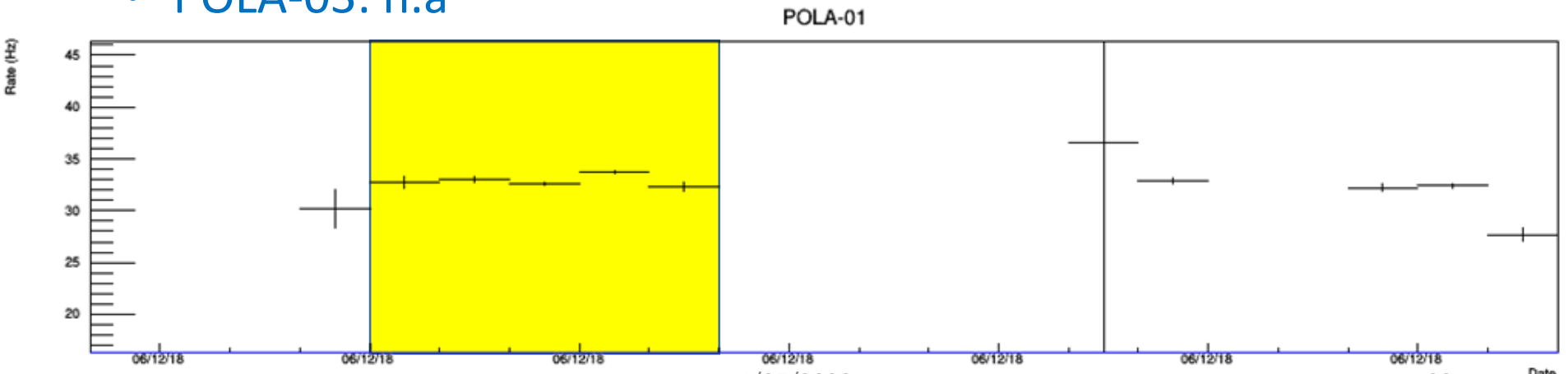
Da verificare: effetto materiale (auto)



- People: Carmelo, Marco, Francesco
- When: 06/12/2018
- ELOG: n. 29
- Altitude = 0 m
- POLA-02: OK
- POLA-03: n.a

Message ID: **29**	Entry time: **Mon Dec 10 11:00:25 2018**	Reply to this: **30** **33**
Author:	BOLO-01	
Telescope ID:	POLA-01	
Operatore:	Francesco Noferini	
Time:	06 December 2018	
Place:	presa dati a Cefalù	
Alle 11.42 presa dati a Cefalù per 1 ora circa		
Attachment 1:	datiCefalu.jpeg 48 kB | Hide | Hide all	

TIM 4G 11:41 83%



Lampedusa

- People: Carmelo
- When: 07-08/03/2019
- ELOG: n. 49, 50
- Altitude = 10 m
- POLA-02: OK
- POLA-03: OK(7/3)

Message ID: **49**	Entry time: **Thu Mar 7 17:07:57 2019**
Author:	Budda
Telescope ID:	POLA-01
Operatore:	Carmelo Pellegrino
Time:	07 March 2019
Place:	Lampedusa

Oggi è stata effettuata una prima misura in esterna, sul tetto della scuola e il più lontano possibile da ogni struttura muraria, tra le 12:25 e le 14:10 ora locale.

I file di dati presi in esterna sono:

- POLA-01-2019-03-07-384348184.bin
- POLA-01-2019-03-07-384350280.bin
- POLA-01-2019-03-07-384352379.bin

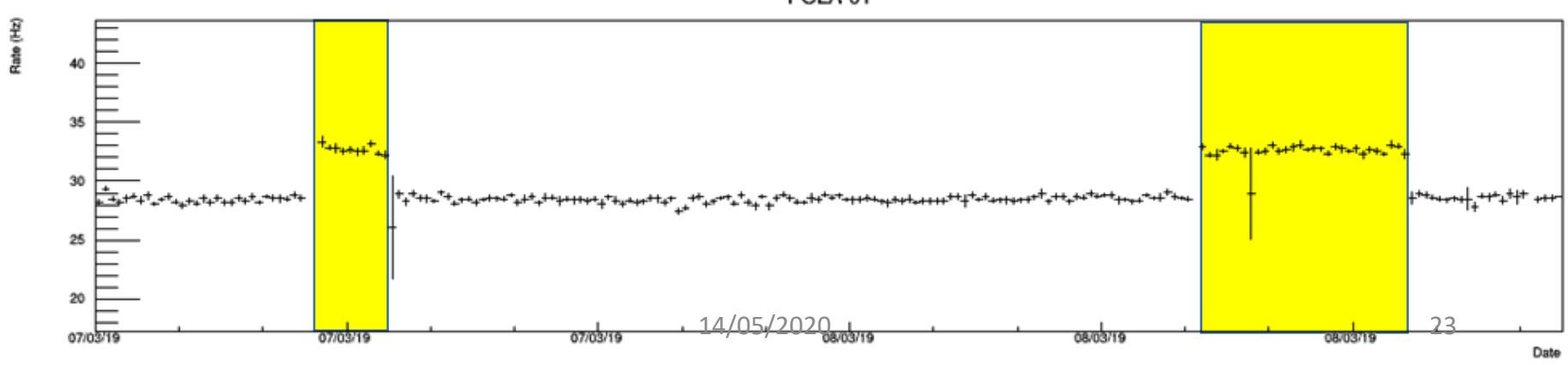
Carmelo

Message ID: **50**	Entry time: **Sun Mar 10 10:44:39 2019**
Author:	Budda
Telescope ID:	POLA-01
Operatore:	Carmelo Pellegrino
Time:	08 March 2019
Place:	Lampedusa (misure su terrazzo esterno)

Durante la mattina dell'8 marzo sono state effettuate 4 misure di un'ora circa ciascuna, corrispondenti a 4 diverse orientazioni del telescopio.

In allegato una tabella con la corrispondenza tra orientazione del telescopio e nomi dei file di dati.

Carmelo



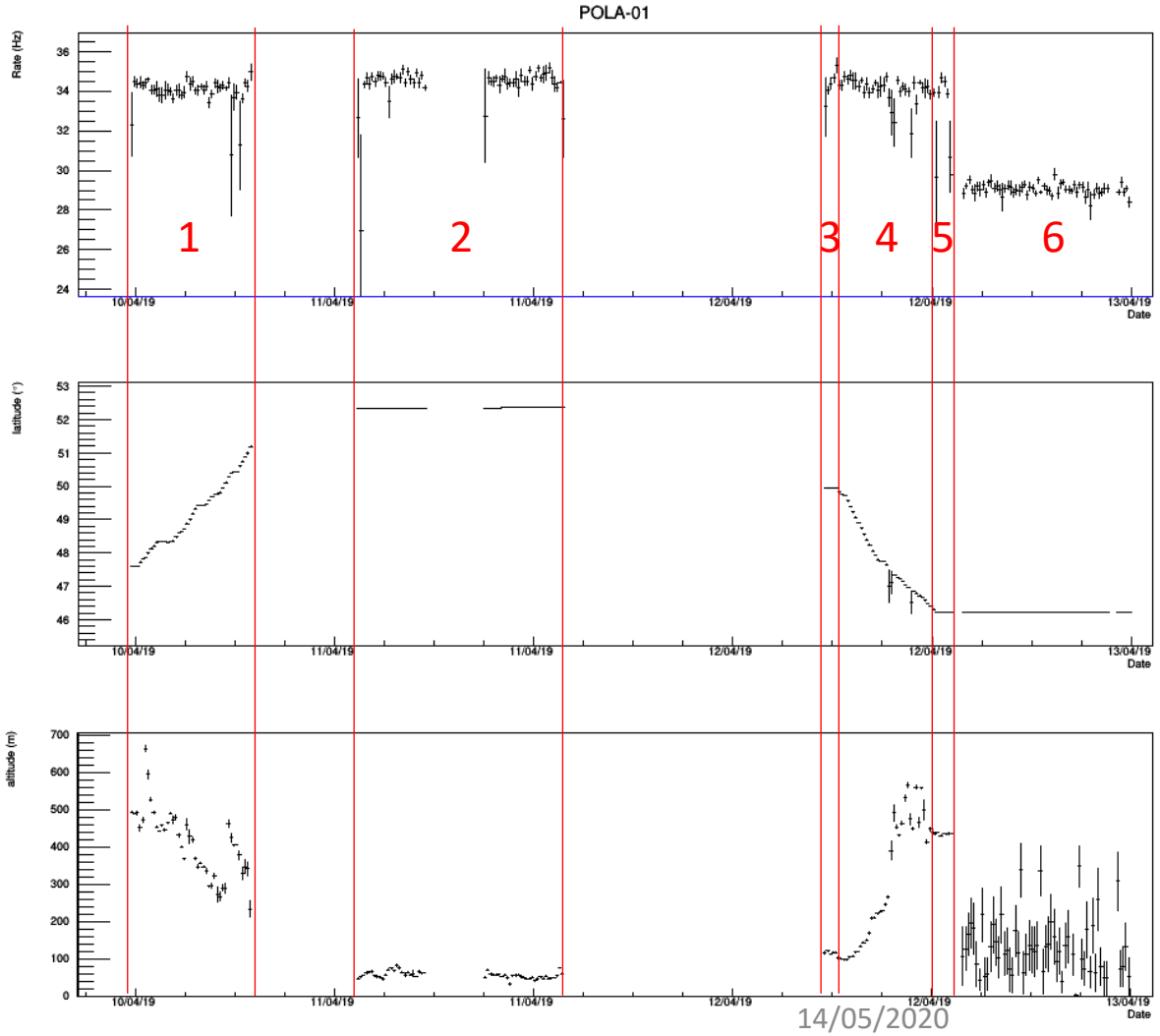
Da verificare: effetto materiale (auto)

Germania (Bologna-Hannover-CERN)

- People: Carmelo, Francesco, Daniele
- When: 10-12/04/2019
- ELOG: n. 67 (missing, only on whatsapp)
- Altitude = 60 - 700 m

- POLA-02: OK
- POLA-03: n.a.

Germania (Bologna-Hannover-CERN)



1. **Innsbruck - Gottinga**
2. **Hannover**
3. **Frankfurt**
4. **Frankfurt - CERN**
5. **CERN outdoor**
6. CERN indoor