Measurements campaign aboard the Amerigo Vespucci ship

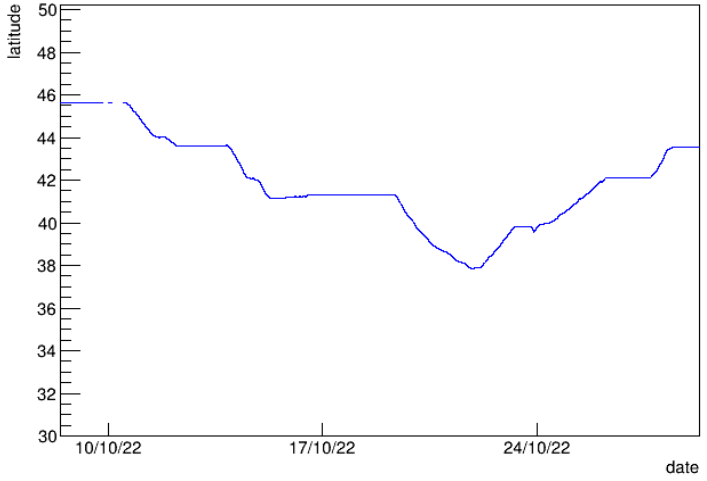
UPDATE

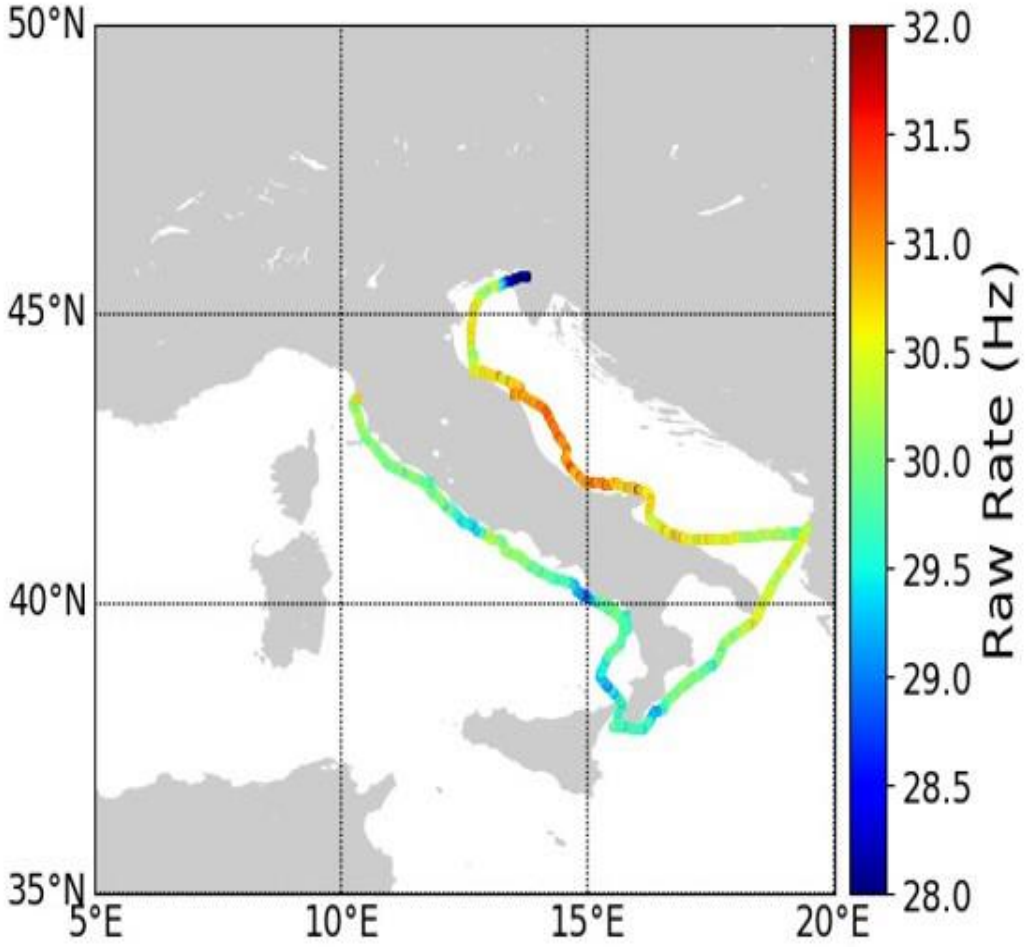
Paola La Rocca

EEE Analysis Meeting – 12/12/2024

The trip

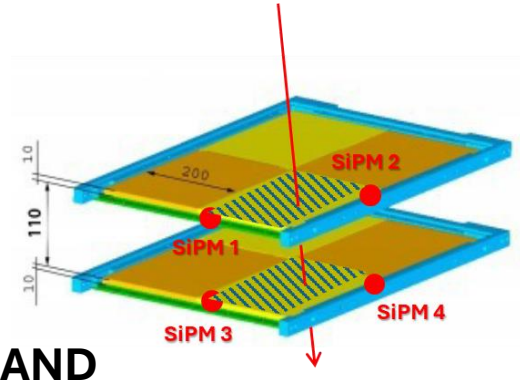
- 2022, 8 October: POLA-02 installation in Trieste
- 2022, 29 October: end of the trip in Livorno
- Latitude interval covered: 38° N-46° N
- Minor issues: direct sun light on the detector



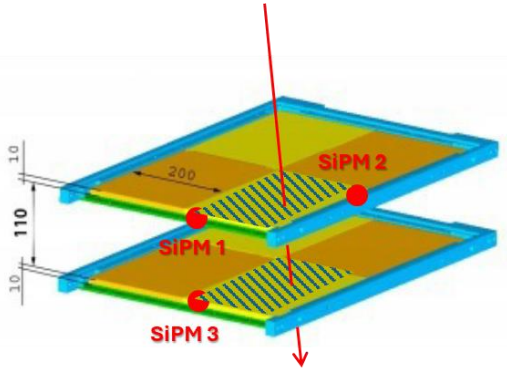


The data set

- Continuos readout (only a short interruption at the beginning)
- Data reduction → Rates evaluated in 1-minute steps (28699 values)
  - rate // rate majority condition + 1 single track
  - rate4c // rate requiring all 4 SiPMs fired + 1 single track
  - ratePair[16] // rate for each pair of plates (majority condition + 1 single track)
  - ratePair4c[16] // rate for each pair of plates (4AND condition + 1 single track)
- **4AND** condition (4 SiPMs fired + 1 single track): rate4c
  - rate4c = $\sum_{i=0}^{15}$ ratePair4c[i]
- **Majority** condition (3 out of 4 SiPMs fired + 1 single track): rate
  - rate = $\sum_{i=0}^{15}$ ratePair[i]
- Rates corrected for barometric effect and efficiency



4AND



Majority

Update of the analysis

1. Selection criteria
2. Order of corrections
   - Barometric effect, efficiency → efficiency, barometric effect
3. Results compared to POLA-01 published data
   - Eur. Phys. J. C (2023) 83:293
4. Estimation of the normalization factor

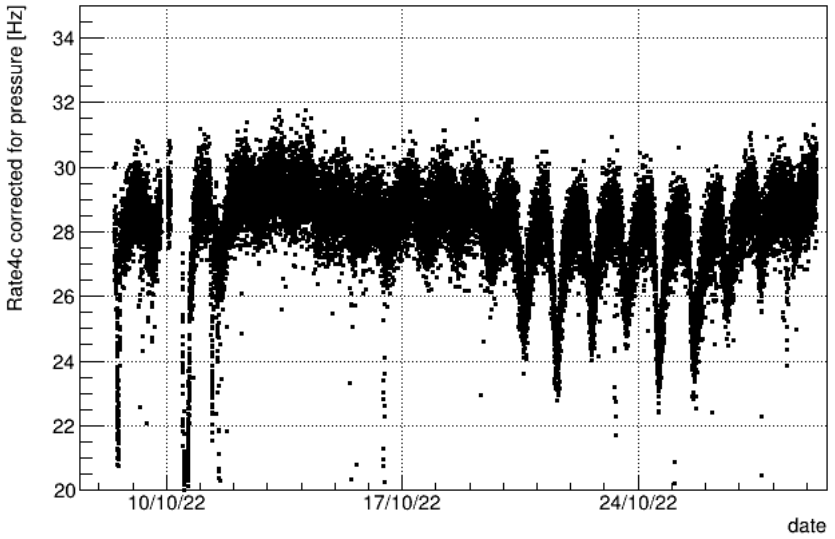
1. Selection criteria

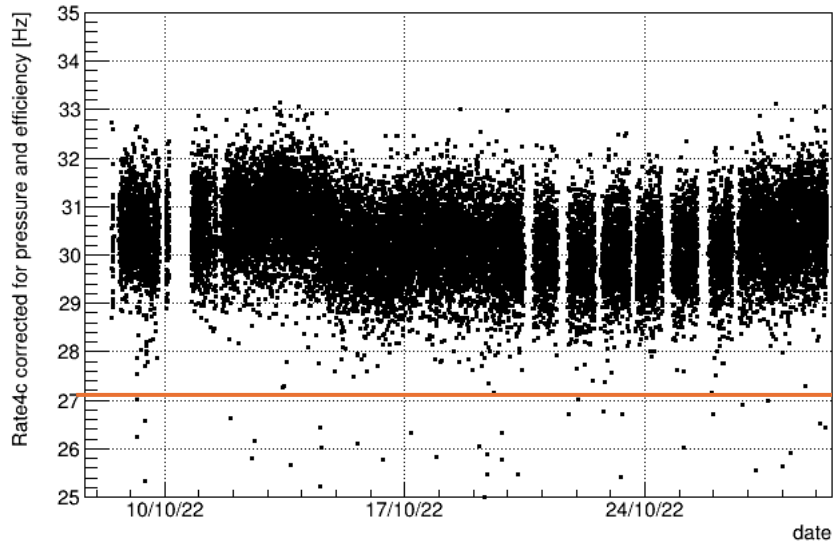
- status = 0
- pres > 800 && < 1100
- temp AND temp2 > 15 && < 40
- rate > 10
- (rate -rate4c)/rate < 0.1
- Efficiency[ipair] > 0.2
- **corrRate4c > 15 → corrRate4c > 27**
- **rate4c/corrRate4c>0.95 → removed**

Total number of rejected measures:

8048/28699 (**28%**) → 4872/28699 (**17%**)

→ Statistical uncertainties reduced





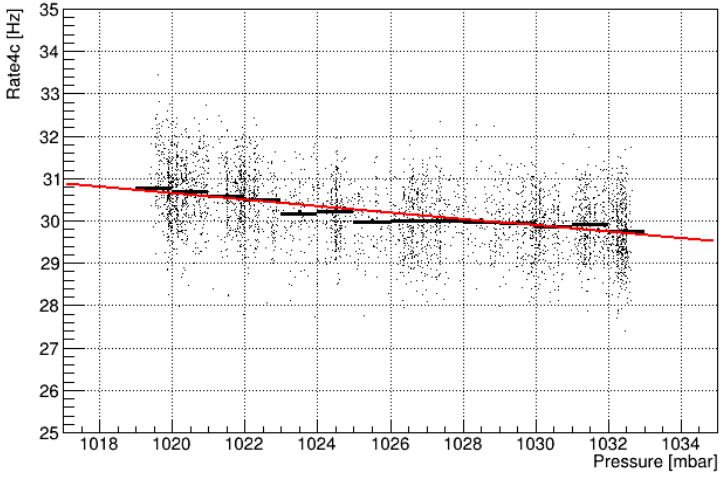
2. Order of corrections

The order of the corrections applied (for barometric effect and efficiency) was inverted

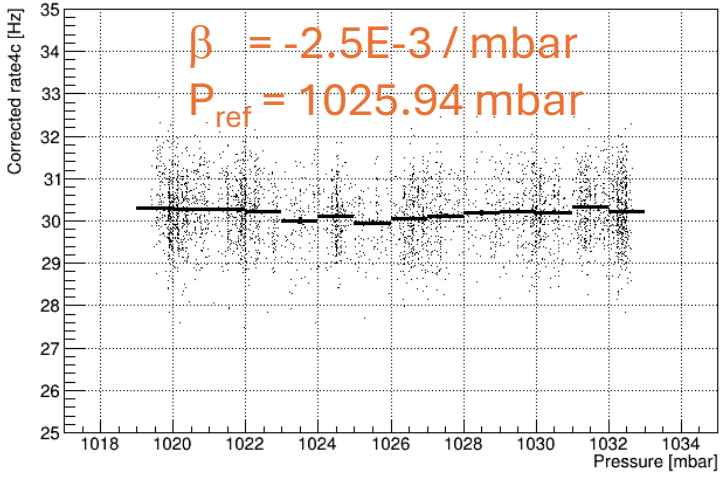
→ **now major correction first applied**

BEFORE: barometric effect, efficiency

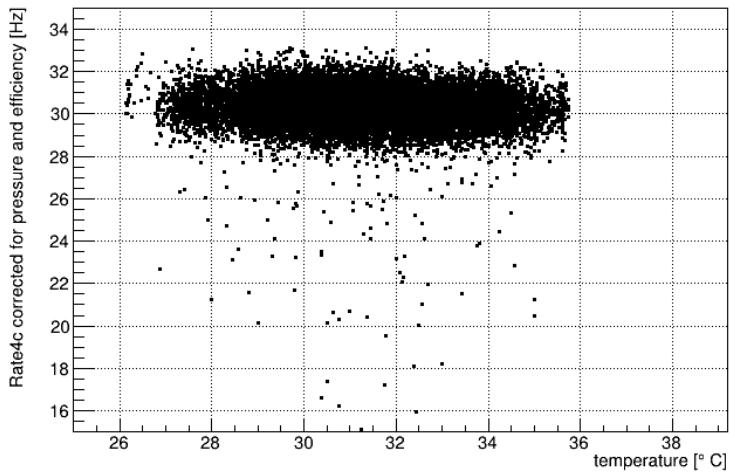
NOW: efficiency, barometric effect



Rate4c corrected for efficiency VS pressure



Rate4c corrected for efficiency and barometric effect VS pressure



Rate4c corrected for efficiency and barometric effect VS temperature

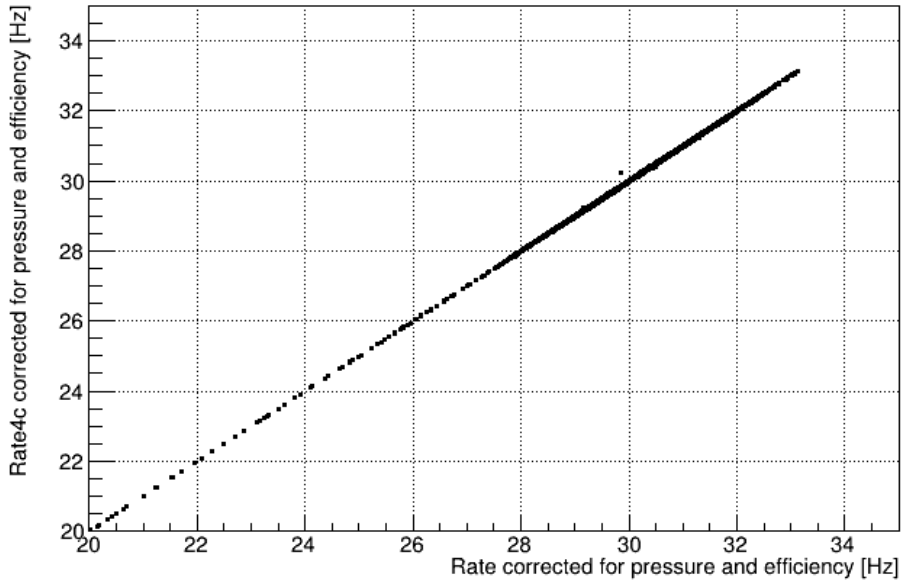
2. Order of corrections

The order of the corrections applied (for barometric effect and efficiency) was inverted

→ **now major correction first applied**

BEFORE: barometric effect, efficiency

NOW: efficiency, barometric effect

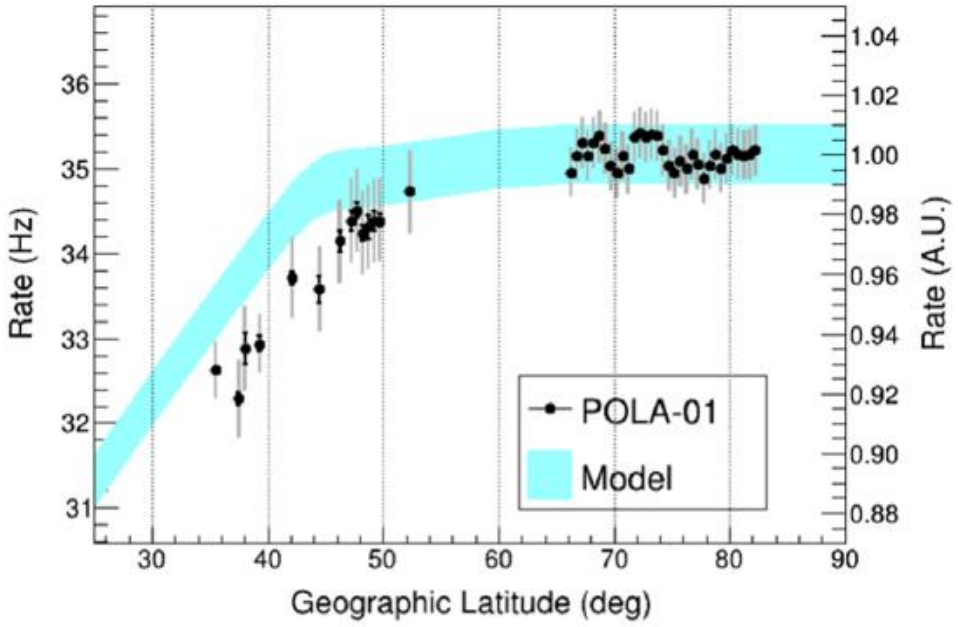


Rate4c VS Rate (both corrected for efficiency and barometric effect)

→ **No difference between Rate and Rate4c**

3. Results compared to POLA-01 published data

Eur. Phys. J. C (2023) 83:293



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THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Experimental Physics

Measurement of the cosmic charged particle rate at sea level in the latitude range 35° ÷ 82° N with the PolarquEEEst experiment

M. Abbrescia[1,2], C. Avanzini[3,4], L. Baldini[3,4], R. Baldini Ferroli[5], G. Batignani[3,4], M. Battaglieri[6], S. Boi[7,8], E. Bossini[3,4], F. Carnesecchi[9], D. Cavazza[10], C. Cicalò[8], L. Cifarelli[10,11], F. Coccetti[12], E. Coccia[13], A. Corvaglia[14], D. De Gruttola[15,16], S. De Pasquale[15,16], L. Galante[17], M. Garbini[10,12], G. Gemme[6,12], I. Gnesi[12,18], E. Gramstad[19], S. Grazzi[6,20], E. S. Håland[19], D. Hatzifotiadou[9,10], P. La Rocca[21,22], Z. Liu[23], L. Lombardo[24], G. Mandaglio[20,22], A. Margotti[10], G. Maron[25], M. N. Mazziotta[2,a], A. Mulliri[7,8], R. Nania[10], F. Noferini[10,b], F. Nozzoli[26], F. Ould-Saada[19], F. Palmonari[10,11], M. Panareo[14,27], M. P. Panetta[14], R. Paoletti[3,28], M. Parvis[24], C. Pellegrino[29], L. Perasso[6], O. Pinazza[10], C. Pinto[30], S. Pisano[5,12], F. Riggi[21,22], G. Righini[31], C. Ripoli[15,16], M. Rizzi[2], G. Sartorelli[10,11], E. Scapparone[10], M. Schioppa[18,32], G. Scioli[10,11], A. Scribano[3,28], M. Selvi[10], M. Taiuti[6,33], G. Terreni[3], A. Trifirò[20,22], M. Trimarchi[20,22], C. Vistoli[29], L. Votano[34], M. C. S. Williams[9,23], A. Zichichi[9,10,11,12,23], R. Zuyeuski[9,23]

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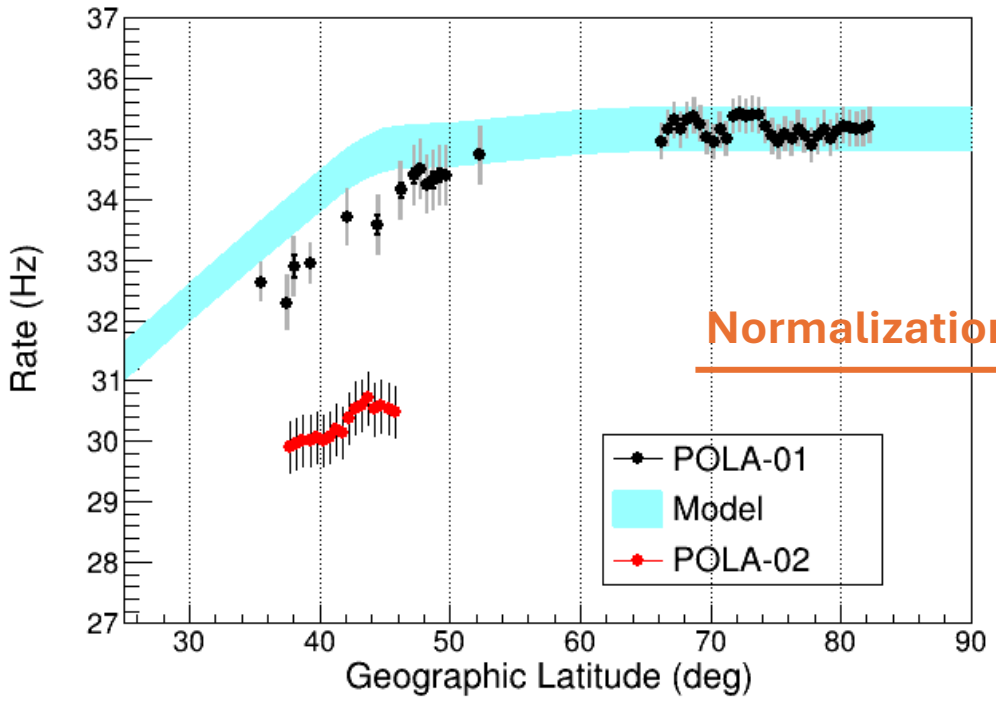
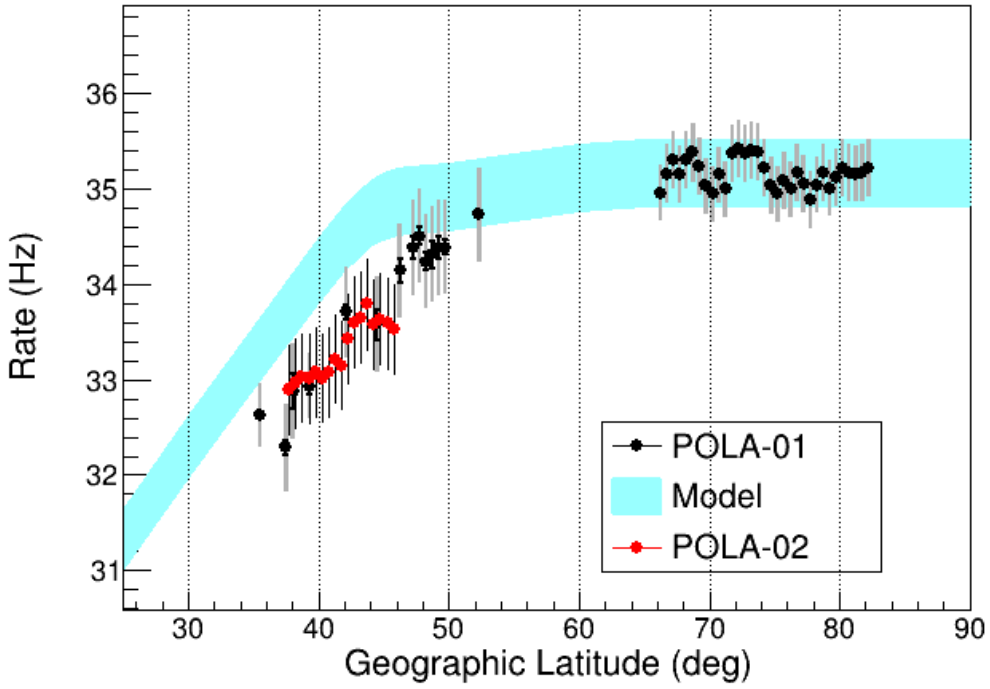
3. Results compared to POLA-01 published data

Eur. Phys. J. C (2023) 83:293

Systematic error = 1.4% (to be checked)



Normalization factor = 1.1



Thanks to Nicola for the macros

4. Estimation of the normalization factor

Possible contributions to the normalization factor:

- Efficiency correction
- Shielding effect
- Seasonal effect
- Solar cycle effect
- Average pressure

4. Estimation of the normalization factor

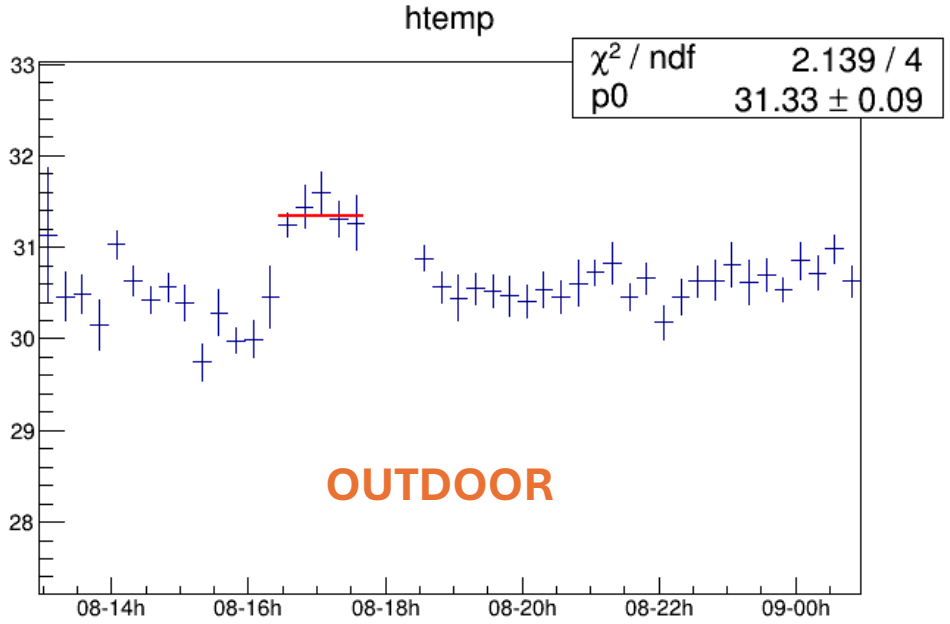
Possible contribution to the normalization factor:

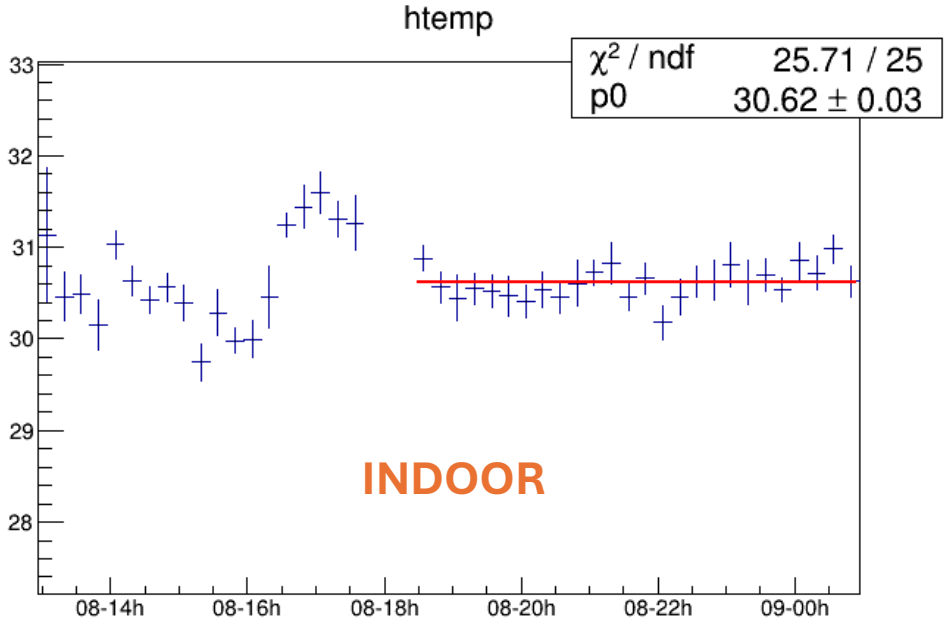
- **Efficiency correction** (96% for POLA-01) → ~ 4%
- Shielding effect
- Seasonal effect
- Solar cycle effect
- Average pressure

4. Estimation of the normalization factor

Possible contribution to the normalization factor:

- Efficiency correction (96% for POLA-01) → ~ +4%
- **Shielding effect** (measurement outside) → ~ +2%
- Seasonal effect
- Solar cycle effect
- Average pressure





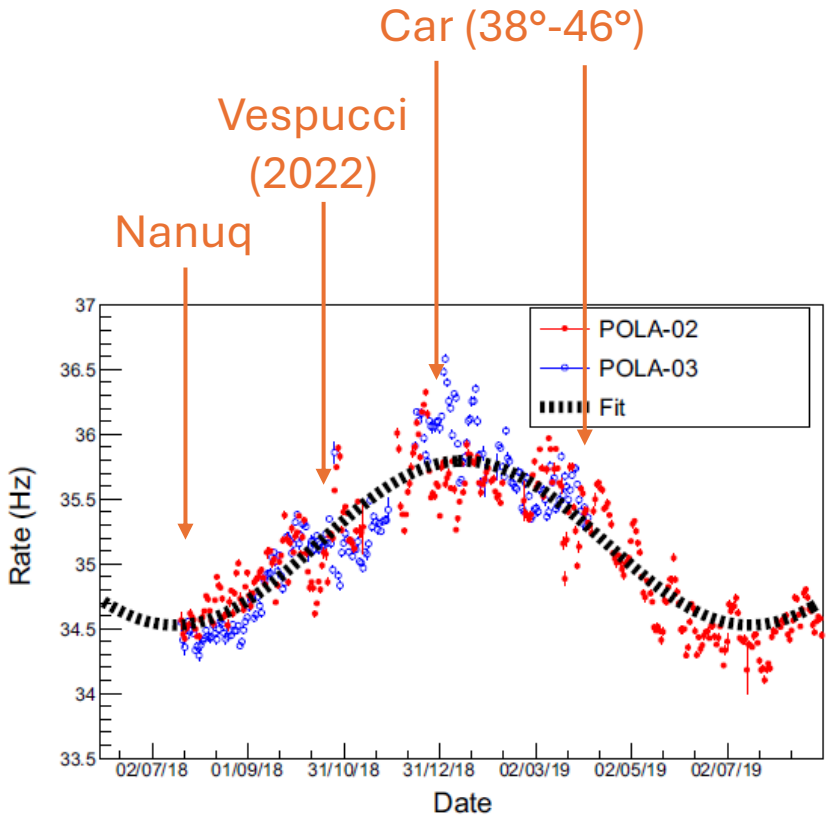
4. Estimation of the normalization factor

Possible contribution to the normalization factor:

- Efficiency correction (96% for POLA-01) → ~ +4%
- Shielding effect (measurement outside) → ~ +2%
- **Seasonal effect** → no correction if Nanuq is reference
- Solar cycle effect
- Average pressure

Table 1 List of the locations where POLA-01 took data

Location	Period (day/month/year)	Latitude (°)	Altitude (m)
CERN (Geneva)	26/06/18–28/06/18	46.23	441
Nanuq	21/07/18–05/09/18	66.82	0
Vigna di Valle	27/11/18	42.1	153
Cosenza	04/12/18–05/12/18	39.3	222
Cefalù	06/12/18	38.0	0
Catania	31/01/19	37.5	158
*Lampedusa**	07/03/19–08/03/19	35.5	10
Bologna	08/04/19	44.5	81
Bologna-Hannover	10/04/19	44.6–51.0	200–700
Hannover-Frankfurt	11/04/19	52.3	60
Frankfurt-Geneva	12/04/19	50.0–46.0	100–500



4. Estimation of the normalization factor

Possible contribution to the normalization factor:

- Efficiency correction (96% for POLA-01) → ~ +4%
- Shielding effect (measurement outside) → ~ +2%
- Seasonal effect → no correction if Nanuq is reference
- **Solar cycle effect** (4 years 2018-2022)
- Average pressure

4. Estimation of the normalization factor

Possible contribution to the normalizatio

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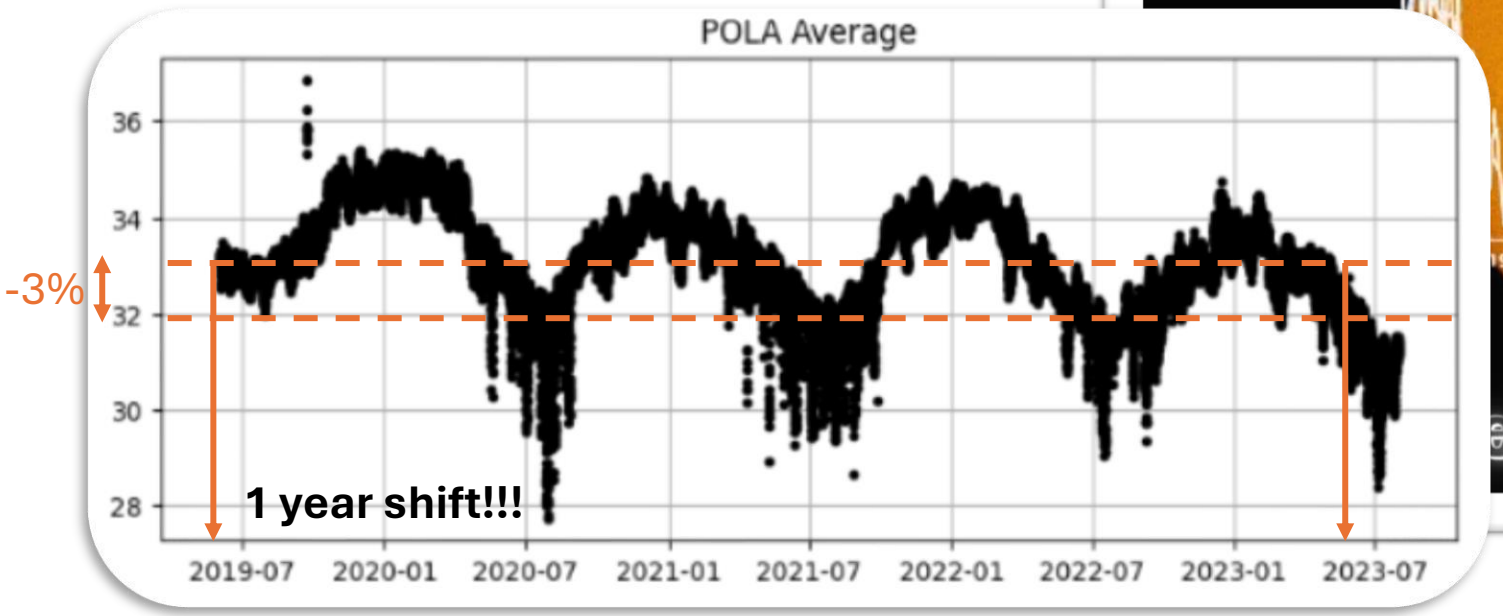
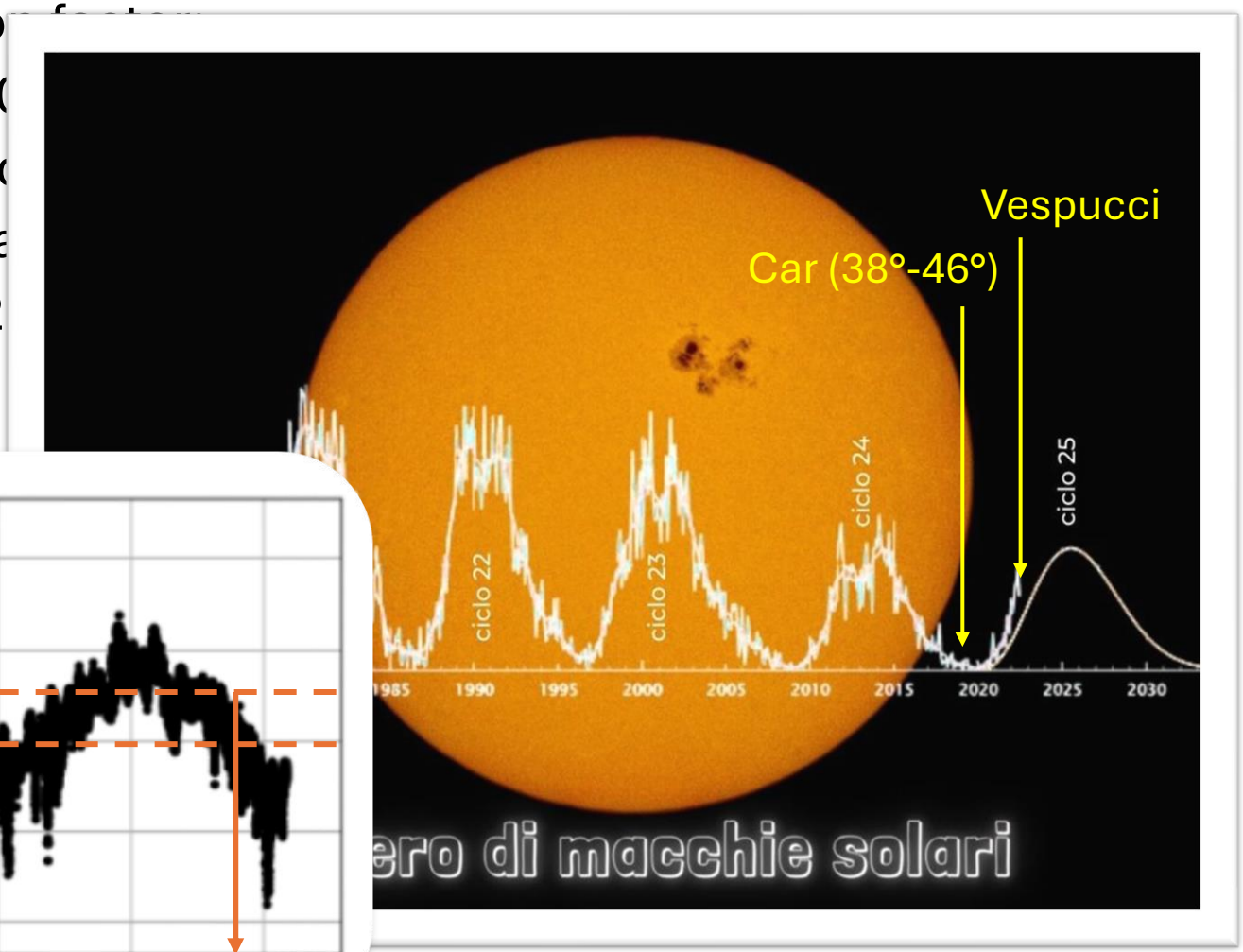
- Seasonal effect → no correction if Na
- **Solar cycle effect** (4 years 2018-202
- Average pressure





4. Estimation of the normalization factor

Possible contribution to the normalization factor:

- Efficiency correction (96% for POLA-01) → ~ +4%
- Shielding effect (measurement outside) → ~ +2%
- Seasonal effect → no correction if Nanuq is reference
- **Solar cycle effect** (4 years 2018-2022) → ~ +3%
- Average pressure

4. Estimation of the normalization factor

Possible contribution to the normalization factor:

- Efficiency correction (96% for POLA-01) → ~ +4%
- Shielding effect (measurement outside) → ~ +2%
- Seasonal effect → no correction if Nanuq is reference
- Solar cycle effect (4 years 2018-2022) → ~+3%
- **Average pressure**

POLA-01: 1011.88 mbar
POLA-02: 1025.94 mbar
β = -2.5E-3 /mbar

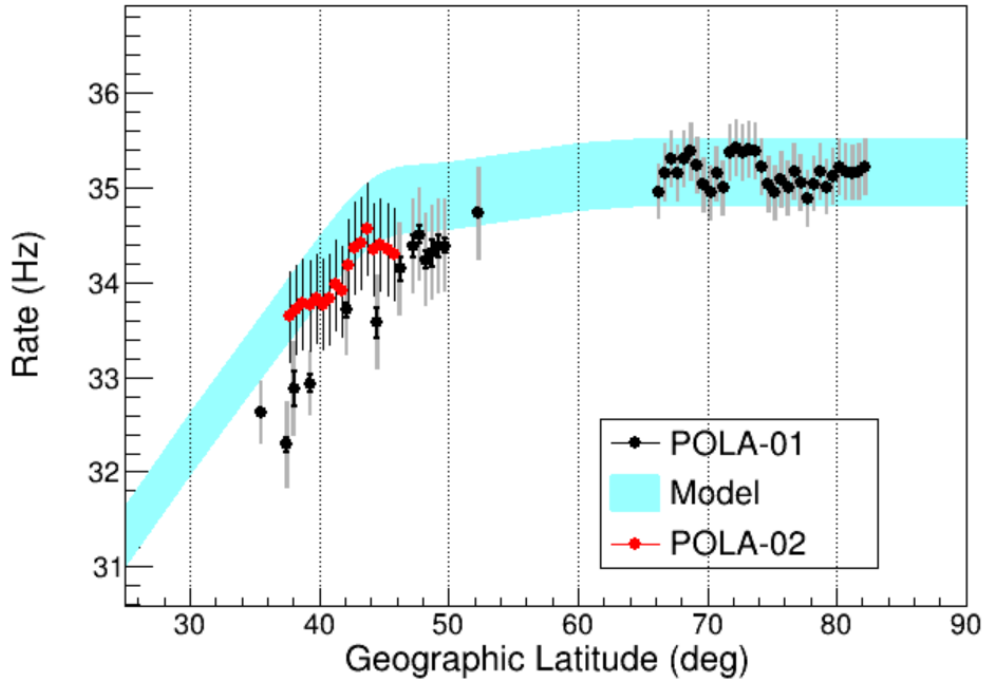
→ β x ΔP = + 3.5%

4. Estimation of the normalization factor

Possible contribution to the normalization factor:

- Efficiency correction (96% for POLA-01) → ~ +4%
- Shielding effect (measurement outside) → ~ +2%
- Seasonal effect → no correction if Nanuq is reference
- Solar cycle effect (4 years 2018-2022) → ~+3%
- Average pressure→ ~+3.5%

Tot. 12.5%



Conclusions

- POLA-02 data in agreement (if normalization factor = 1.1), within uncertainties, with POLA-01 published results
- Almost all contributions to the normalization factor can be estimated

Next steps:

- Investigate POLA-02 rate at highest latitudes (plateau)
- Evaluate systematic uncertainties for POLA-02 data
- Plot rate VS vertical geomagnetic cutoff (Fig. 9 in Eur. Phys. J. C (2023) 83:293)