Vespucci and Norway data analyses update

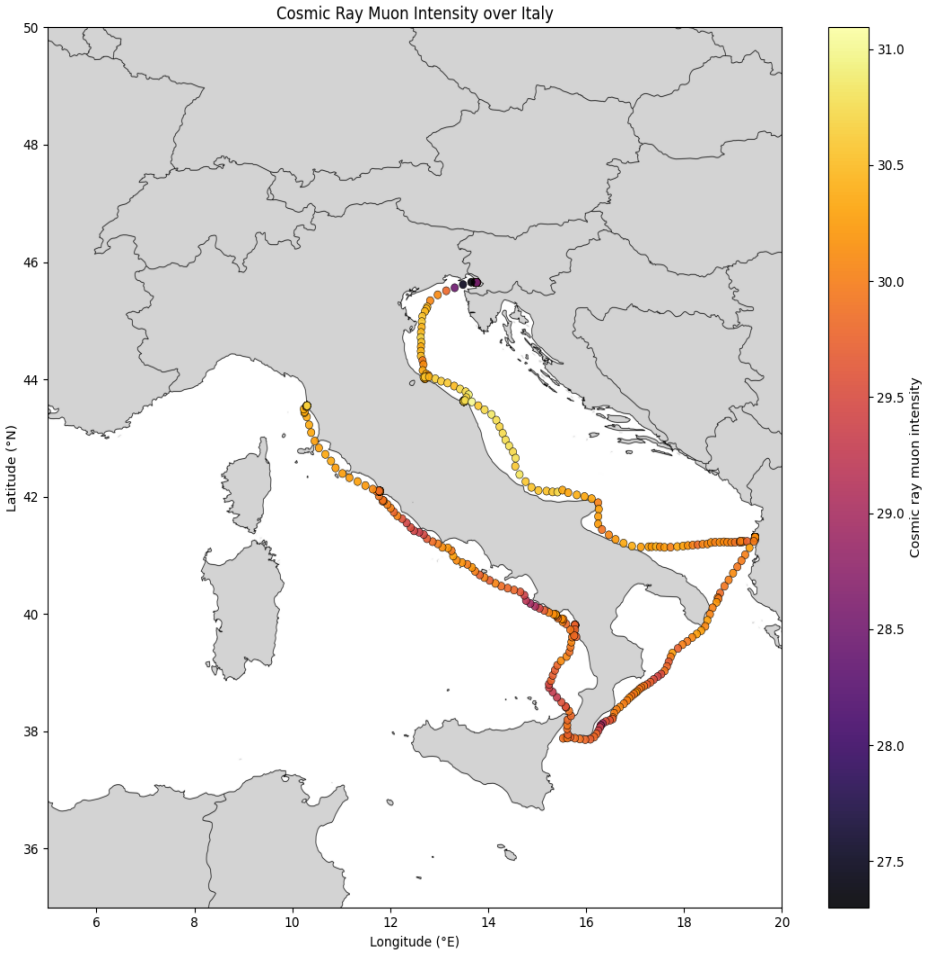
Paola La Rocca, Francesco Riggi

Meeting di Collaborazione EEE - 30 June 2026 to 1 July 2026

Finalization of the Vespucci data analysis

Recap of the Vespucci analysis

- 2022, October 8-29
- Latitude interval covered: 38° N-45° N
- Issues: temperature and direct sun light → temperature-dependent efficiency
- NEW: pseudo-efficiency correction
- NEW: quality cuts optimized
- NEW: normalization to POLA-01 data (to correct for variations that do not depend on latitude)



Full analysis procedure

1) Correction for pseudoefficiency (majority):

For a given *i-th* pair of tiles, the **efficiency** is:

$$\varepsilon[i] = \varepsilon_1[i] \times \varepsilon_2[i] \times \varepsilon_3[i] + \varepsilon_1[i] \times \varepsilon_2[i] \times \varepsilon_4[i] + \varepsilon_1[i] \times \varepsilon_3[i] \times \varepsilon_4[i] + \varepsilon_2[i] \times \varepsilon_3[i] \times \varepsilon_4[i] - 3 \times \varepsilon_1[i] \times \varepsilon_2[i] \times \varepsilon_3[i] \times \varepsilon_4[i]$$

Rate corrected for efficiency =

$$R_{eff\_corr} = \sum_{i=0}^{15} ratePair[i] / \varepsilon[i]$$

Full analysis procedure

2) Final quality cuts (similar to the POLA-01 analysis):

status==0 → 4863 rej. measures
fabs(rateRaw - parRates[0]) <= 2 → +341 rej. measures
temp>15 && temp<40 && temp2>15 && temp2<40 → +7 rej. measures
Nsat > 3 → +2 rej. measures
rate > 10 → +37 rej. measures
(rate - rate4c)/rate < 0.2 → +325 rej. measures
!isWrong* → 0 rej. measures
corrRate > 15 → +2 rej. measures
(rate/corrRate) > 0.95 → 0 rej. measures

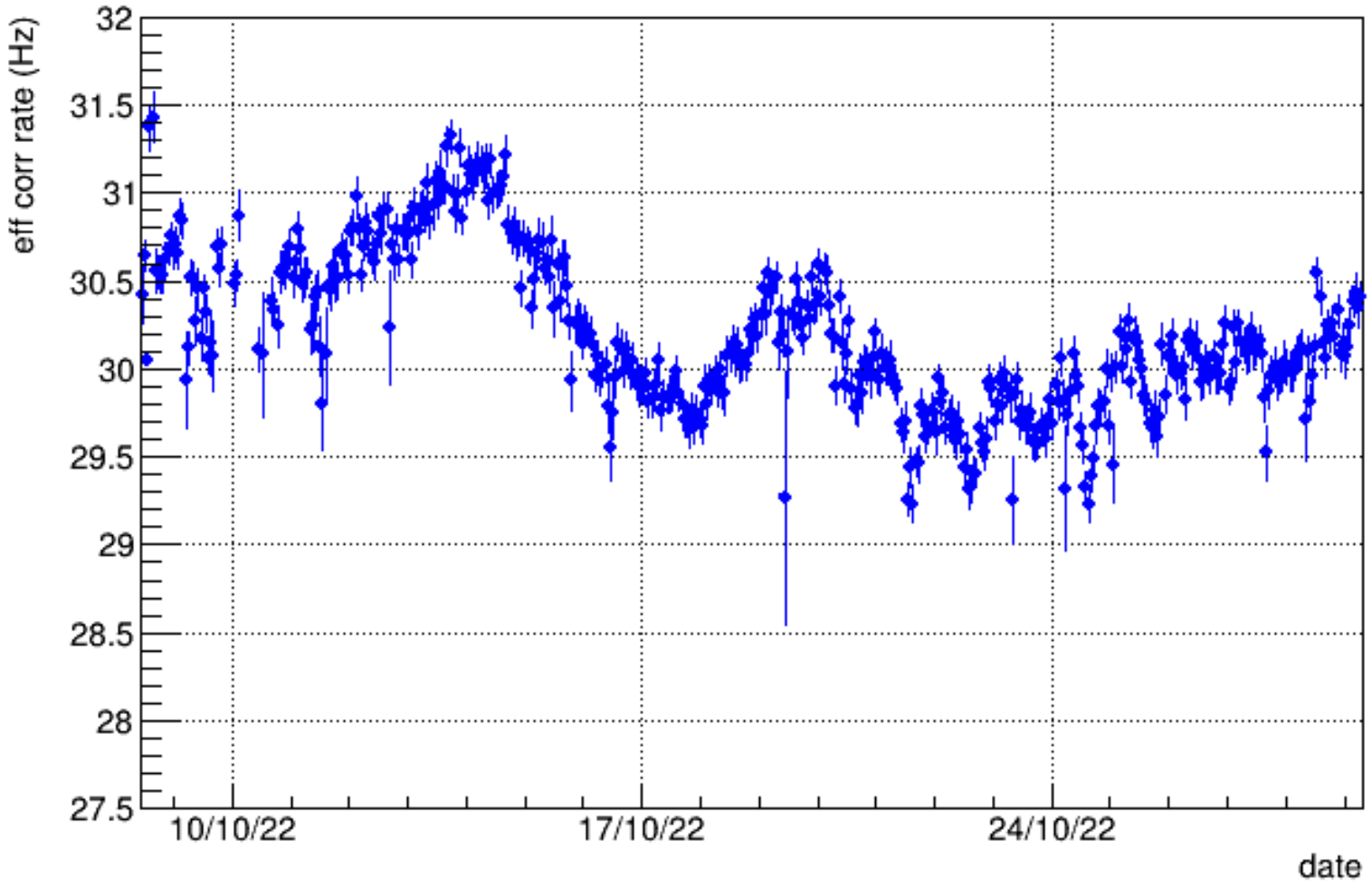
Tot. 5577 rejected measures

5577 / 28699 = 19%

*isWrong: Boolean variable indicating whether the tile pair efficiency is > 0.2

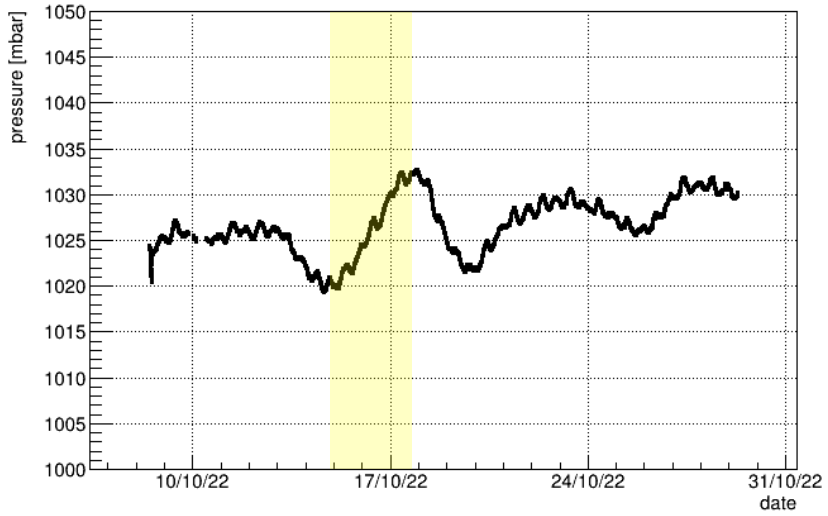
Full analysis procedure

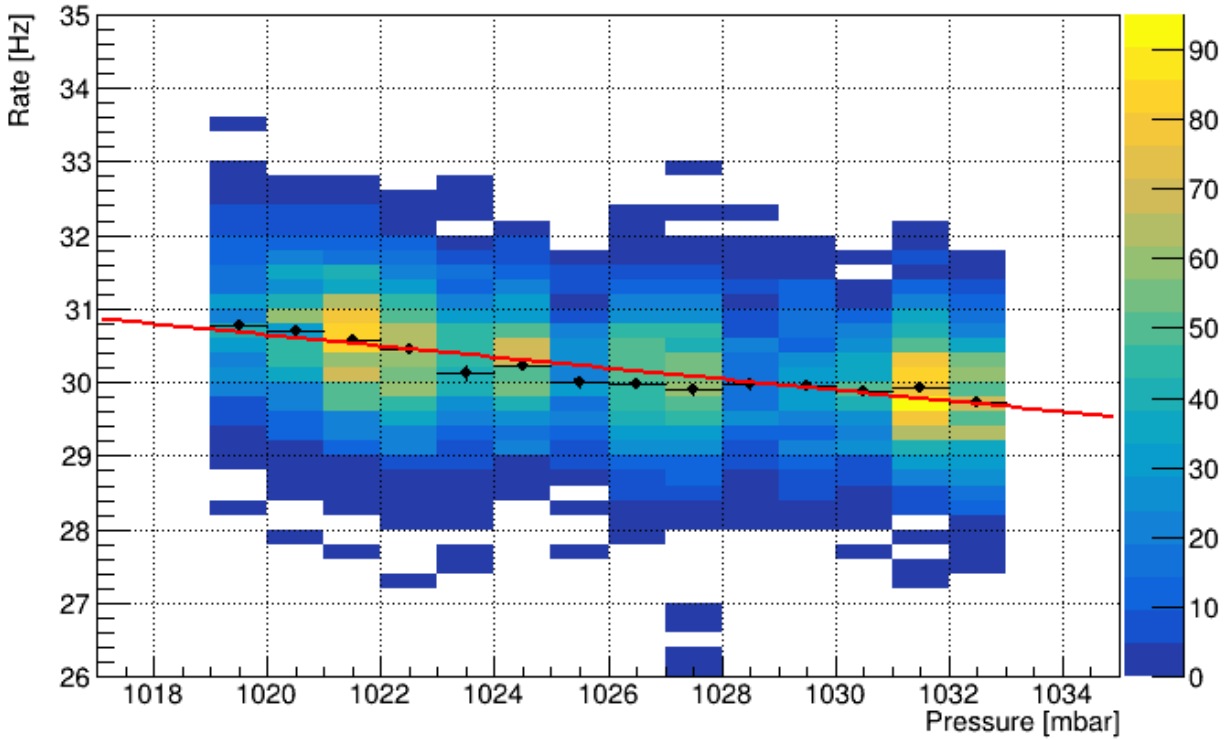
2) Final quality cuts (similar to the POLA-01 analysis):



Full analysis procedure

3) Correction for barometric effect





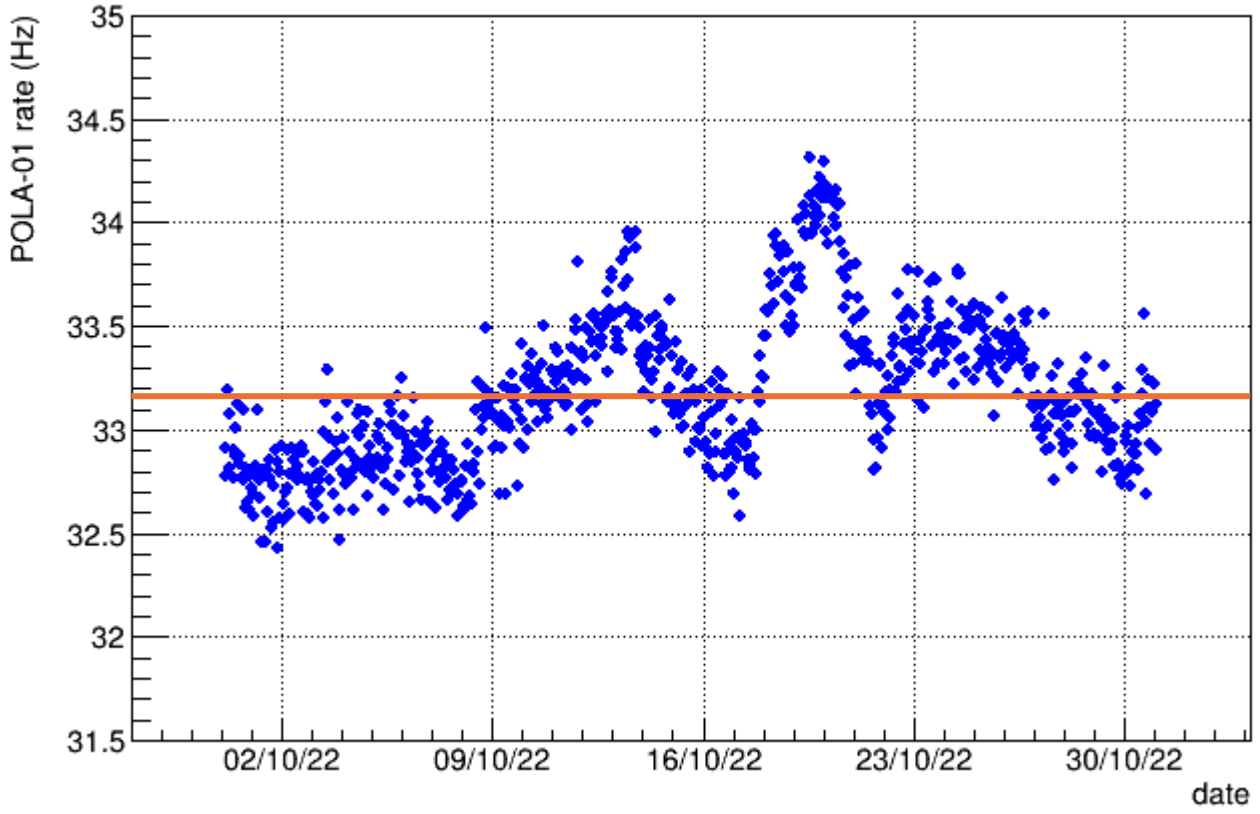
Fit function $R = \exp[\alpha + \beta(p - p_{ref}^*)]$

$\beta = (-0.247 \pm 0.009)$ %/mbar

*p_{ref} = 1026.78 mbar (average pressures during the whole data taking)

Full analysis procedure

4) Normalization to POLA-01 trend (corrected for barometric effect)



norm (t) = $R_{POLA-01}(t) / \overline{R}_{POLA-01}$

$\overline{R}_{POLA-01}$ = 33.18 Hz

Full analysis procedure

5) Global normalization factor

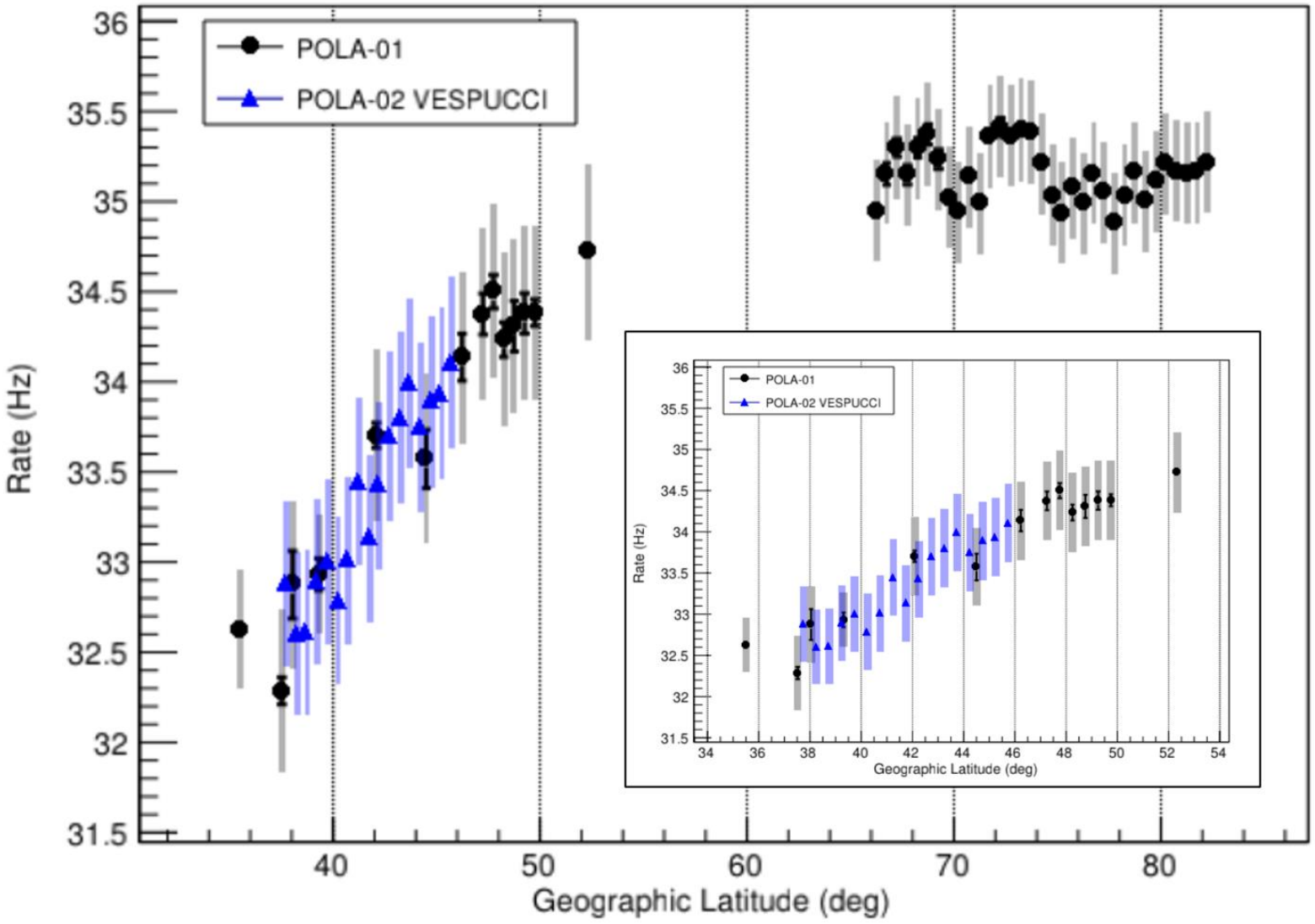
- Efficiency correction (96% for POLA-01) → ~ +4% (no pseudo-eff correction*)
- Shielding effect (measurement outside) → ~ +2.3%
- Seasonal effect
- Solar cycle effect

  ] → ~ -0.2%
- Average pressure → ~ +3.7%

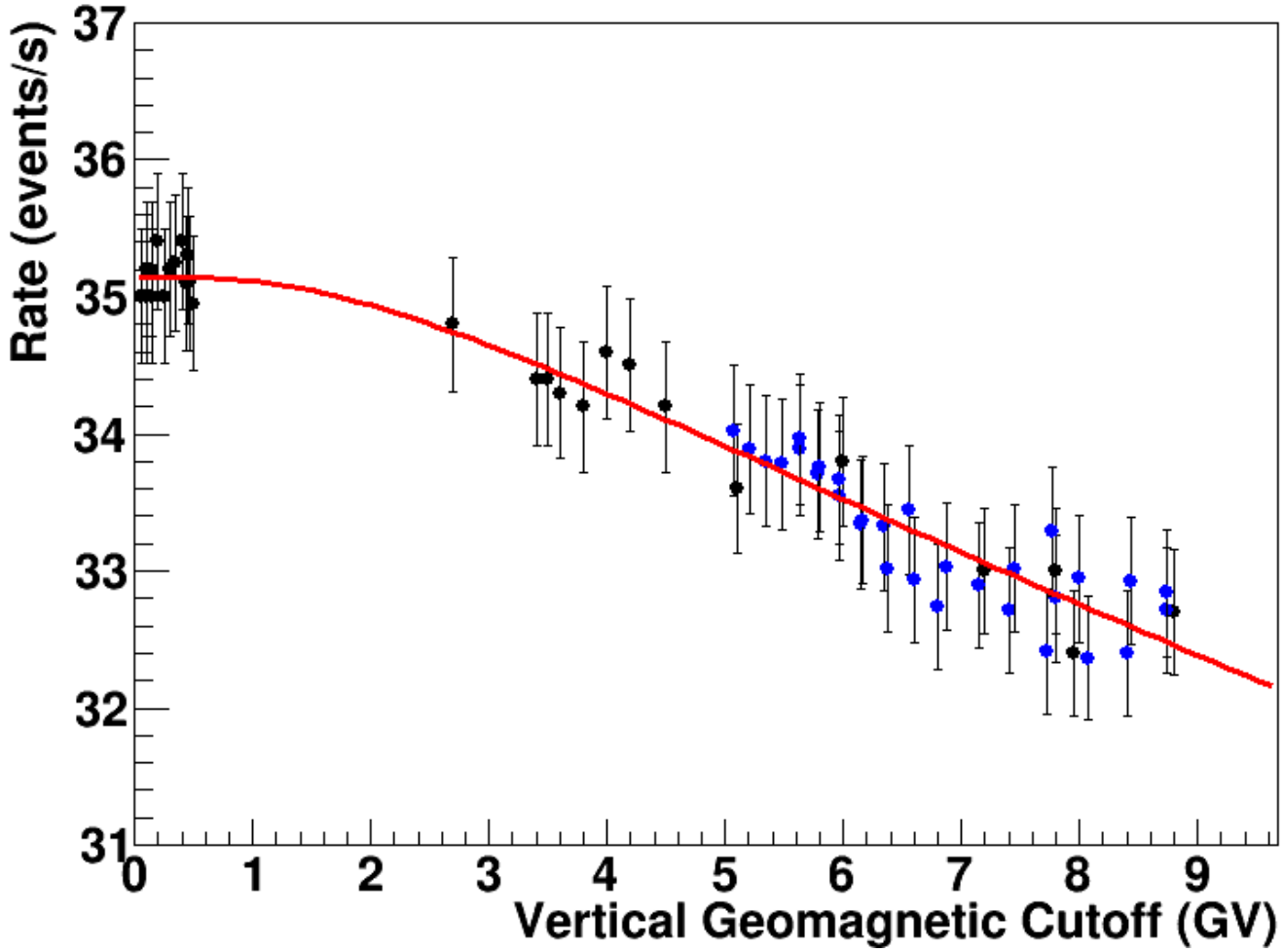
TOT. +10.1 %

6) Additional +1% to fit POLA-01 data (efficiency?)

Comparison POLA-01 – Vespucci



Comparison POLA-01 – Vespucci



Paper draft

Eur. Phys. J. Plus manuscript No.
(will be inserted by the editor)

Latitude dependence of the cosmic ray rate from an Italian circumnavigation campaign within the EEE Project

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

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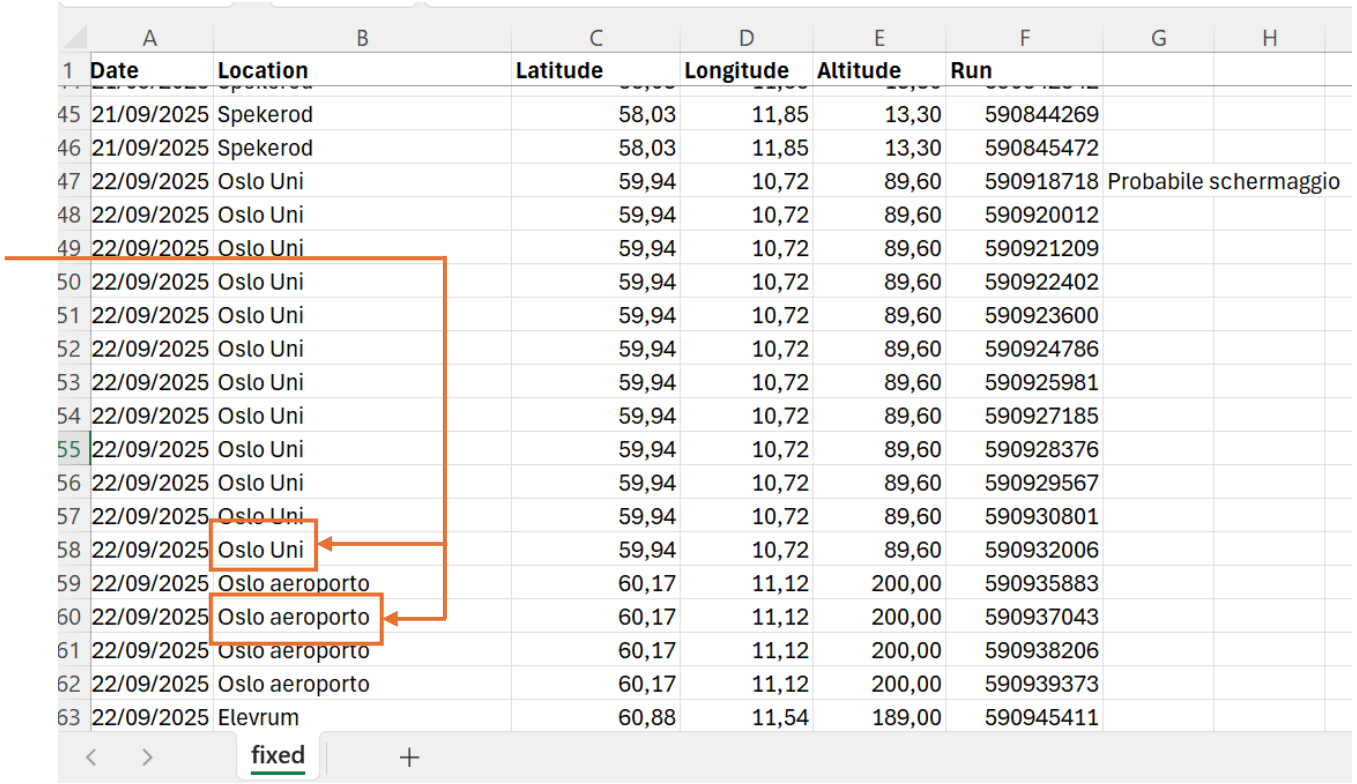
Norway data analysis

Measurements @ fixed positions

- Total number of runs: 452 (moving) + **270** (**fixed**)
- Excel with info about fixed locations (52 in total, some of them repeated)
- Excluded from the anaysis: measurements of the shielding effects in Bologna (08/10/2025)
  - 592326198 (IN)
  - 592327647 (IN)
  - 592329431 (OUT)
  - 592330879 (OUT)
- Rates evaluated in 1-minute steps (5281 measures)



	A	B	C	D	E	F	G	H
1	Date	Location	Latitude	Longitude	Altitude	Run		
45	21/09/2025	Spekerod	58,03	11,85	13,30	590844269		
46	21/09/2025	Spekerod	58,03	11,85	13,30	590845472		
47	22/09/2025	Oslo Uni	59,94	10,72	89,60	590918718	Probabile schermaggio	
48	22/09/2025	Oslo Uni	59,94	10,72	89,60	590920012		
49	22/09/2025	Oslo Uni	59,94	10,72	89,60	590921209		
50	22/09/2025	Oslo Uni	59,94	10,72	89,60	590922402		
51	22/09/2025	Oslo Uni	59,94	10,72	89,60	590923600		
52	22/09/2025	Oslo Uni	59,94	10,72	89,60	590924786		
53	22/09/2025	Oslo Uni	59,94	10,72	89,60	590925981		
54	22/09/2025	Oslo Uni	59,94	10,72	89,60	590927185		
55	22/09/2025	Oslo Uni	59,94	10,72	89,60	590928376		
56	22/09/2025	Oslo Uni	59,94	10,72	89,60	590929567		
57	22/09/2025	Oslo Uni	59,94	10,72	89,60	590930801		
58	22/09/2025	Oslo Uni	59,94	10,72	89,60	590932006		
59	22/09/2025	Oslo aeroporto	60,17	11,12	200,00	590935883		
60	22/09/2025	Oslo aeroporto	60,17	11,12	200,00	590937043		
61	22/09/2025	Oslo aeroporto	60,17	11,12	200,00	590938206		
62	22/09/2025	Oslo aeroporto	60,17	11,12	200,00	590939373		
63	22/09/2025	Elevrum	60,88	11,54	189,00	590945411		

fixed

https://agenda.centrofermi.it/event/332/#3-oveeerland-data-analysis

Full analysis procedure (same as in the Vespucci data analysis)

1) **Correction for pseudoefficiency (majority)**

Full analysis procedure (same as in the Vespucci data analysis)

1) Correction for pseudoefficiency (majority)
2) **Quality cuts**

status==0 → 1032 rej. measures
fabs(rateRaw - parRates[0]) <= 2 → +81 rej. measures
temp>15 && temp<40 && temp2>15 && temp2<40 → +27 rej. measures
Nsat > 3 → +3 rej. measures
rate > 10 → 0 rej. measures
(rate - rate4c)/rate < 0.15 → +214 rej. measures
!isWrong* → 0 rej. measures
corrRate > 15 → 0 rej. measures
(rate/corrRate) > 0.95 → 0 rej. measures

Tot. 1357 rejected measures

1357 / 5281 = 26%

*isWrong: Boolean variable indicating whether the tile pair efficiency is > 0.2

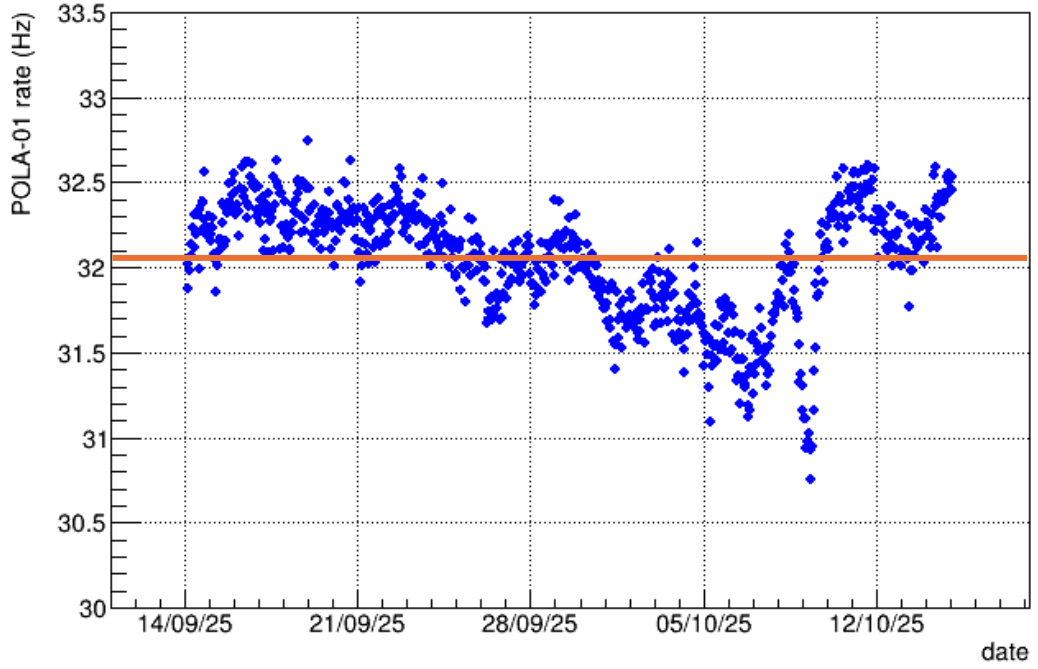
Full analysis procedure (same as in the Vespucci data analysis)

1) Correction for pseudoefficiency (majority)
2) Quality cuts
3) **Correction for barometric effect**

β = (-0.247 $\pm$ 0.009) %/mbar (from the Vespucci data analysis)
p_{ref} = 998.64 mbar (average pressures during the whole data taking)

Full analysis procedure (same as in the Vespucci data analysis)

1) Correction for pseudoefficiency (majority)
2) Quality cuts
3) Correction for barometric effect
4) **Normalization to POLA-01 trend (corrected for barometric effect)**



norm (t) = $R_{POLA-01}(t) / \overline{R}_{POLA-01}$

$\overline{R}_{POLA-01}$ = 32.05 Hz

Full analysis procedure (same as in the Vespucci data analysis)

1) Correction for pseudoefficiency (majority)
2) Quality cuts
3) Correction for barometric effect
4) Normalization to POLA-01 trend (corrected for barometric effect)
5) **Global normalization factor**

- Efficiency correction (96% for POLA-01) → ~ +4% (no pseudo-eff correction*)
- Shielding effect (measurement outside) → ~ +1%
- Seasonal effect
- Solar cycle effect

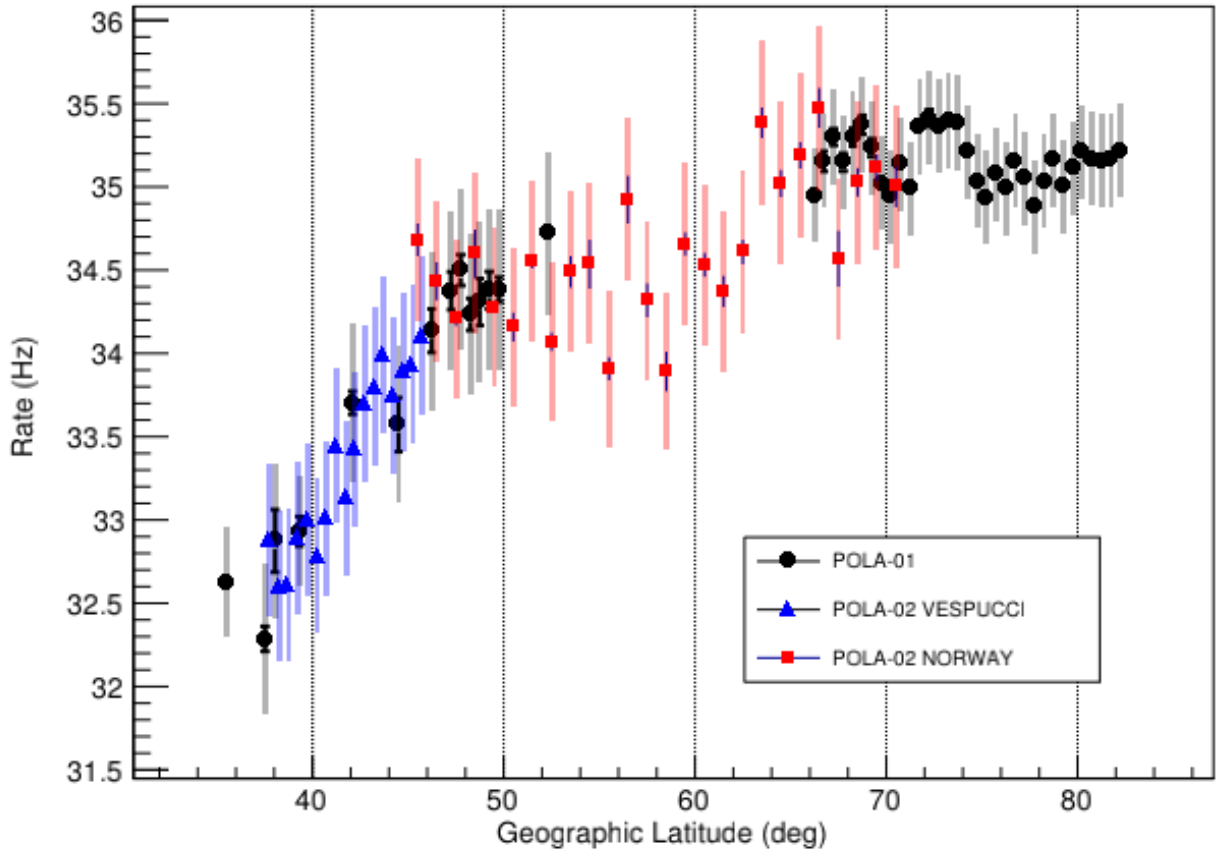
  ] → ~ +3.2%
- Average pressure → ~ -3.3%

TOT. +4.8 %

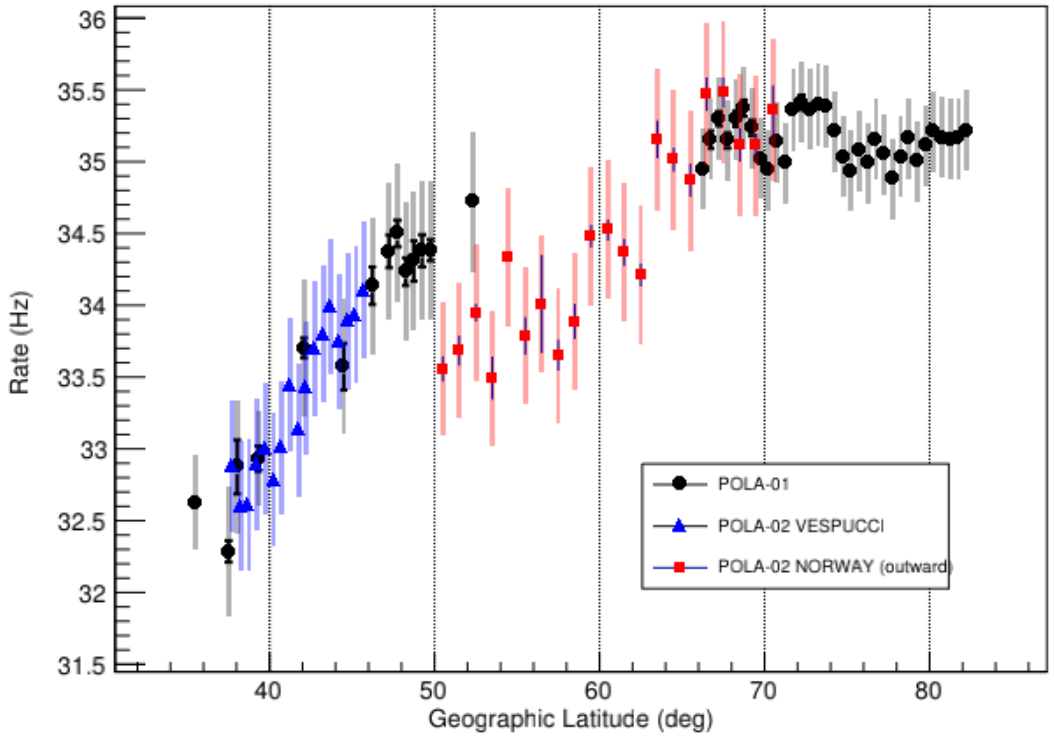
Full analysis procedure (same as in the Vespucci data analysis)

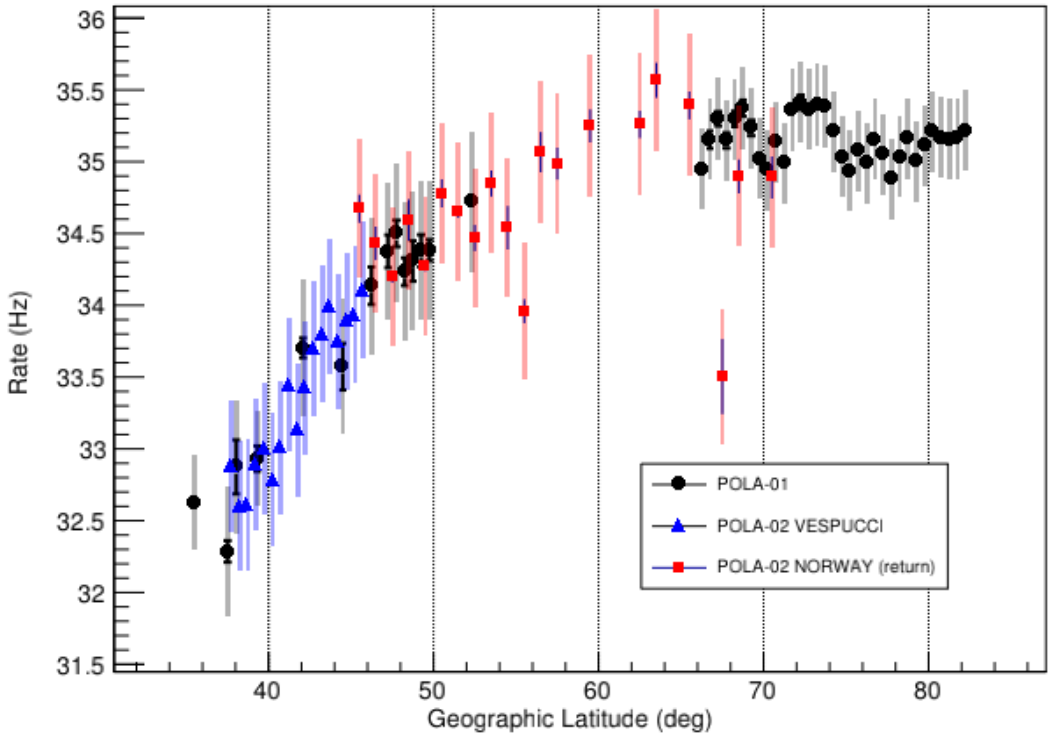
1) Correction for pseudoefficiency (majority)
2) Quality cuts
3) Correction for barometric effect
4) Normalization to POLA-01 trend (corrected for barometric effect)
5) Global normalization factor
6) **Additional +1% to fit POLA-01 data (efficiency?)**

Comparison POLA-01 – Vespucci - Norway

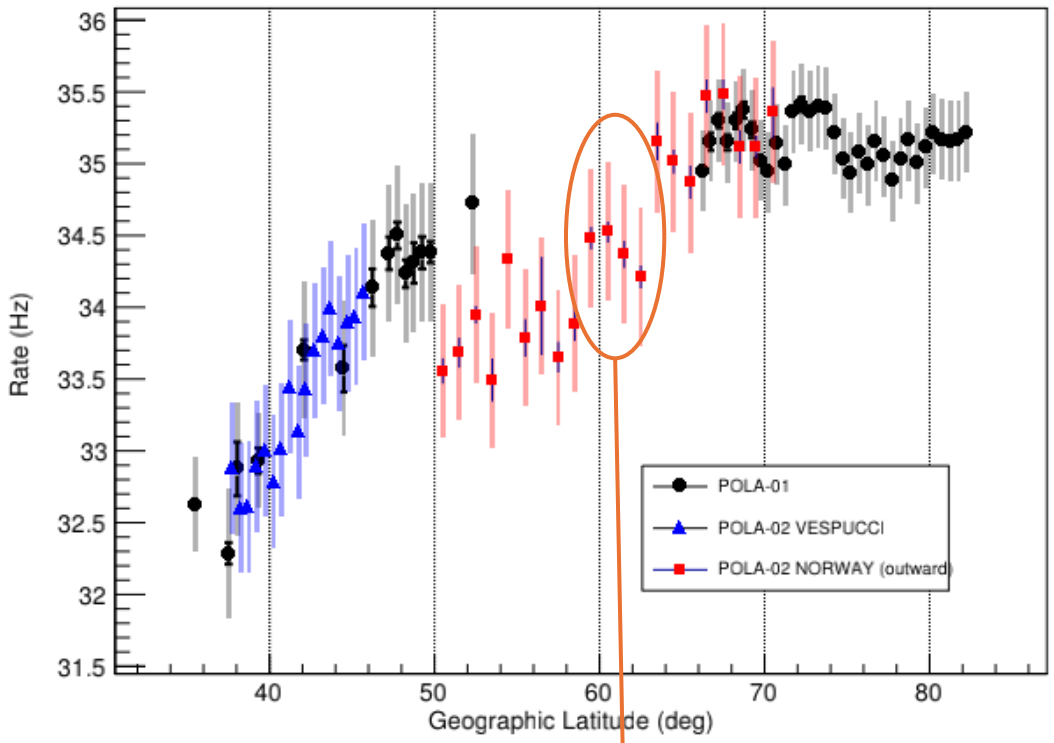


Comparison POLA-01 – Vespucci - Norway

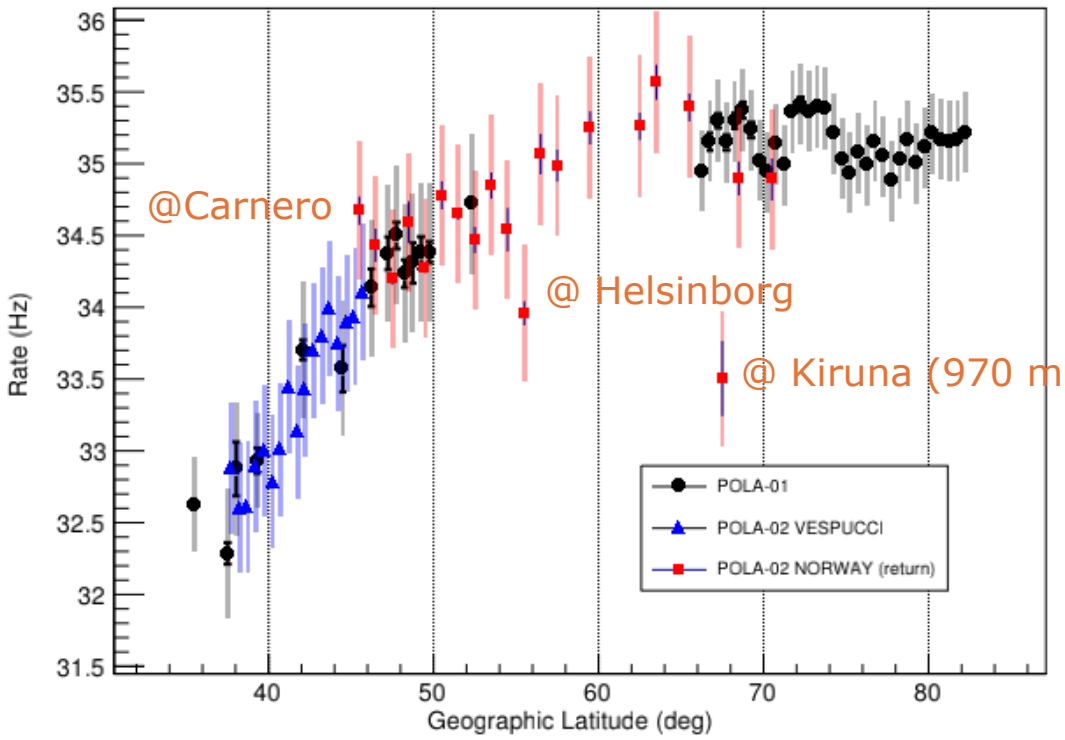




Comparison POLA-01 – Vespucci - Norway



Altitude 200-400 m
From Oslo to Ulsberg

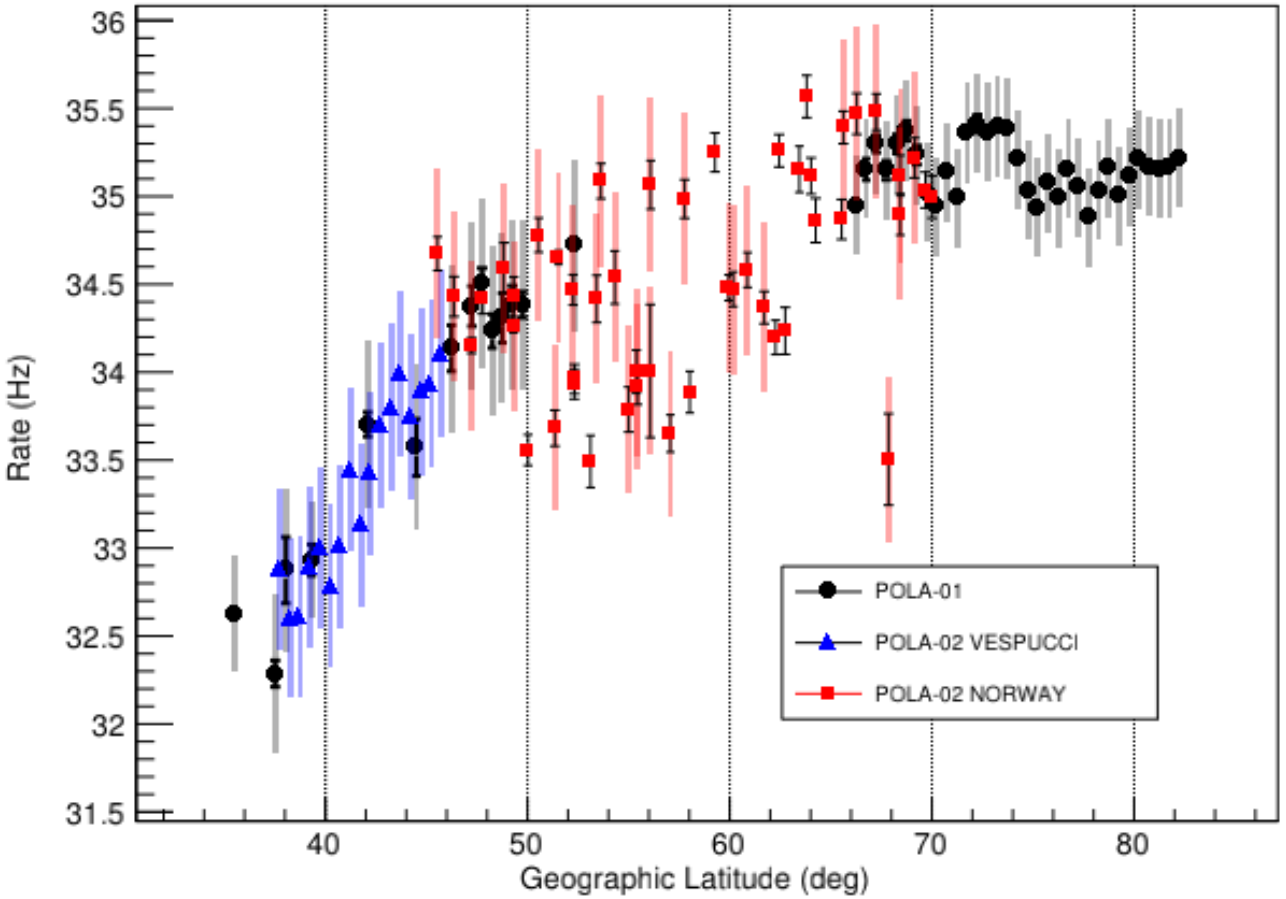


@Carnero

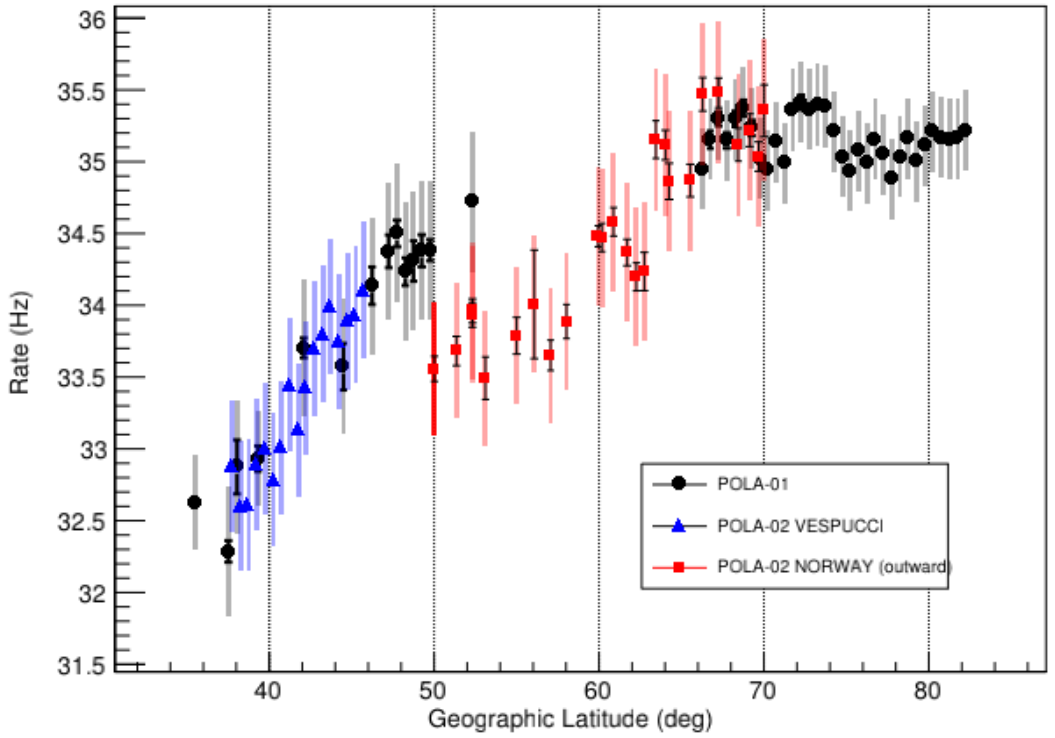
@ Helsinborg

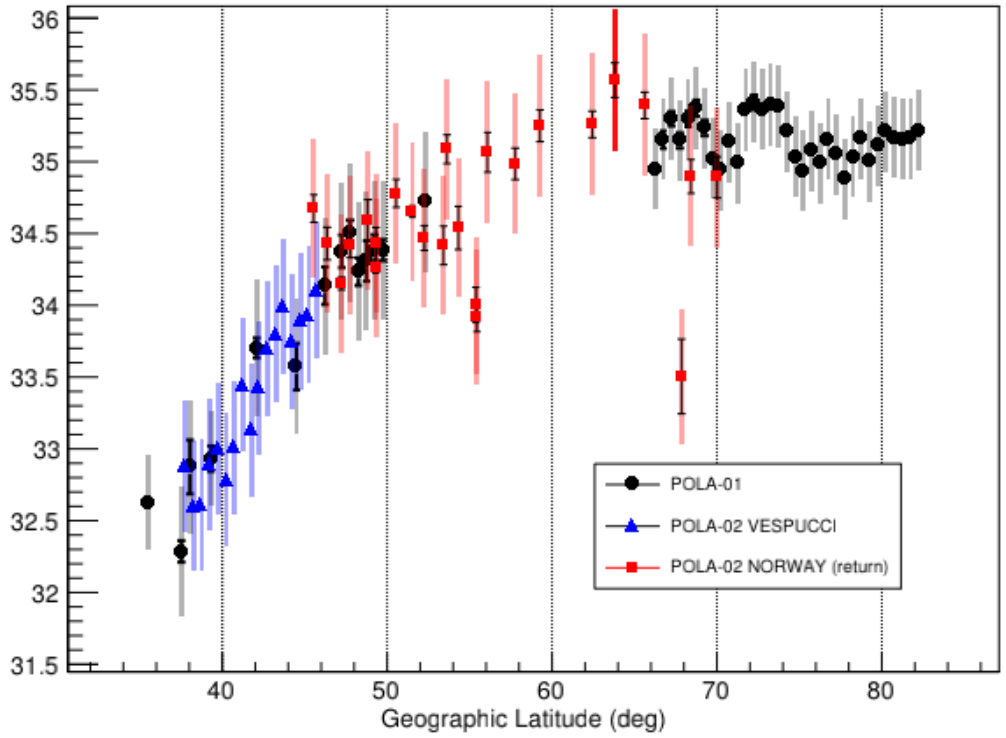
@ Kiruna (970 mbar)

Comparison POLA-01 – Vespucci – Norway (individual locations)



Comparison POLA-01 – Vespucci – Norway (individual locations)



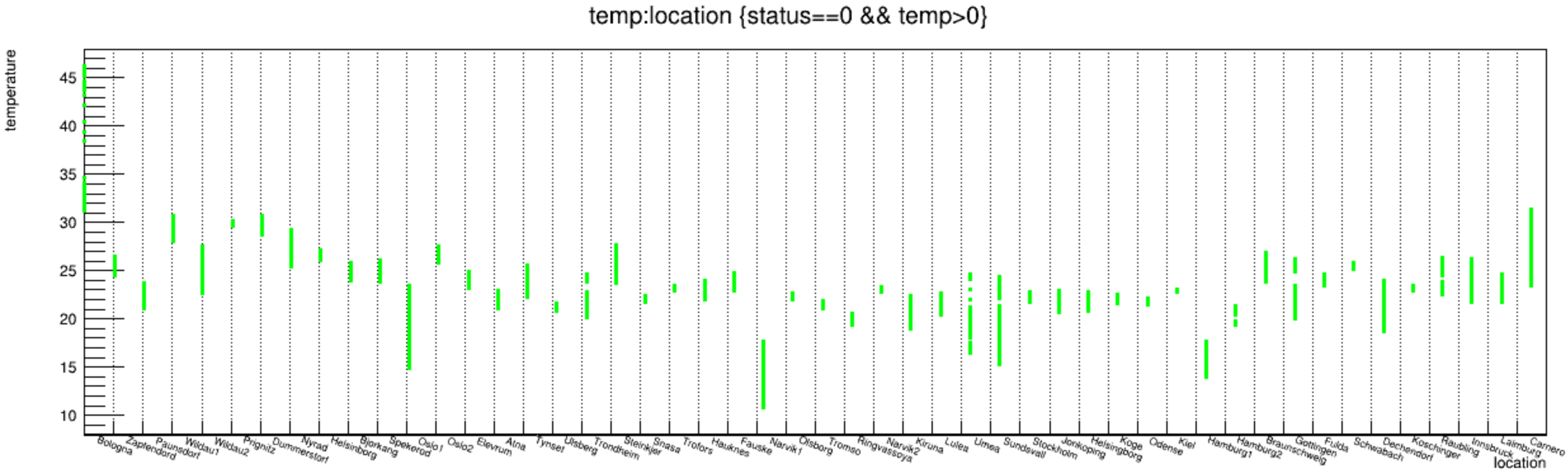


Conclusions and outlook

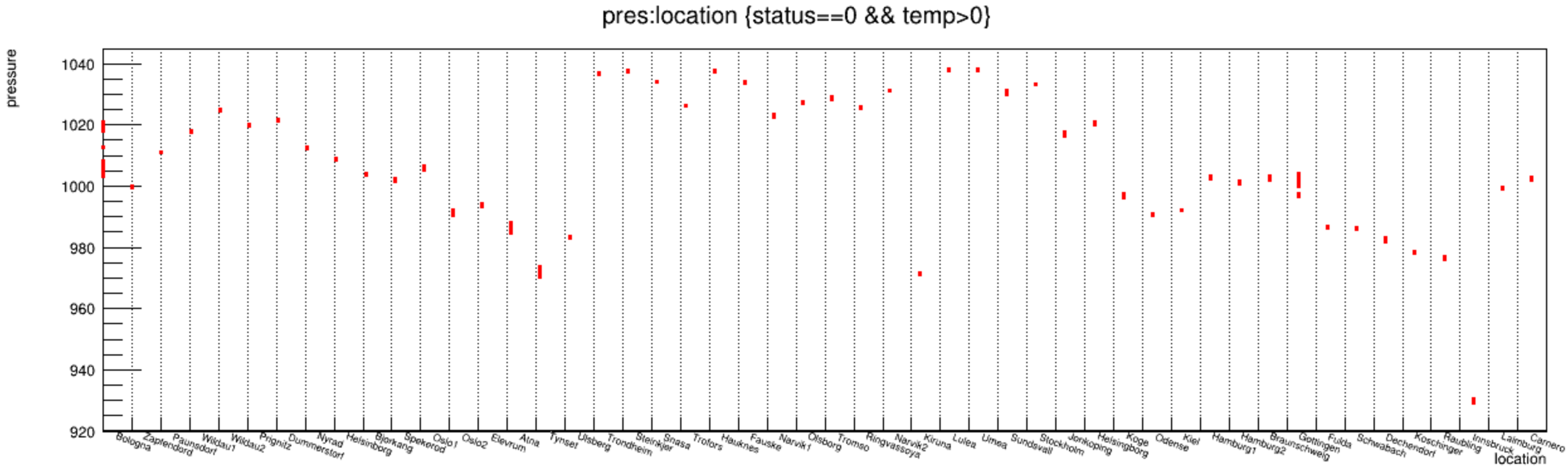
- Vespucci data analysis completed and paper draft ready
- Norway data analysis:
  - Data quality cuts optimized
  - Analysis procedure defined
  - Results reasonably consistent with those from Vespucci and POLA-01
  - Systematic difference between the outward and return trips
  - Few outliers
  - Additional corrections needed? For altitude…

Additional material

Temperature VS location



Atmospheric Pressure VS location



Altitude VS location