# HK Clocks @LPNHE
# Status of the GNSS data-taking

**Claire Dalmazzone 14th February**

# Description

# GNSS data-taking

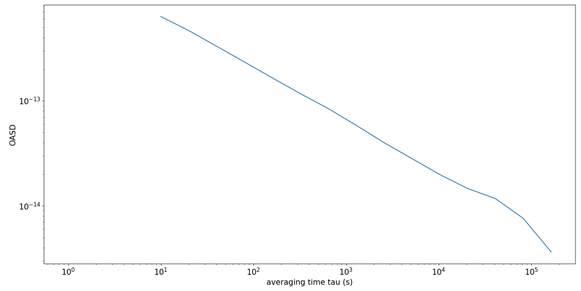
## Setup description

On the 18th of January, at ~3.30pm, started two simultaneous data-taking:

1. Pps residuals, with GNSS receiver, using Rb 10MHz as external reference

2. Frequency measurement, with frequency counter 2, of 5MHz Rb using 5MHz PHM as external reference, 0.1mHz resolution

3. (+ frequency measurement, with frequency counter 1, of 10MHz WR using 10MHz PHM as external reference, 0.01mHz resolution. Long run to look for a PHM random walk.)



# GNSS data-taking

## Motivation of RbvsPHM measurement settings

On frequency counter 2:

1. Wanted relative resolution of the order of the Rb phase WN (~1e-11)
2. Wanted 1 measurement per s

| Avalaible frequencies | Ideal minimum resolution | Meas time < 1s |
|---|---|---|
| **100MHz** | 1 mHz | No |
| **10MHz*** | 0.1 mHz | No |
| **5MHz** | 0.1 mHz | Yes |

* only frequency available on WR

# Results until last Thursday

# Preliminary results

## Correction description

The correction performance is evaluated using the ASD of the Rb frequency series measured against the PHM.

1. The frequency $y^i_{RbvsPHM}$ series is converted in time series $dt^i_{RbvsPHM}$
2. The time series is corrected:
   $dt^i_{RbvsPHM,\,corr} = dt^i_{RbvsPHM,\,corr} - a \times i^2 - b \times i - c,$ where $a$, $b$ and $c$ are extracted form the fit of the pps residuals with GNSS over a certain time window $\Delta t$
3. The ASD of the corrected time series is compared for different values of $\Delta t$

# Preliminary results

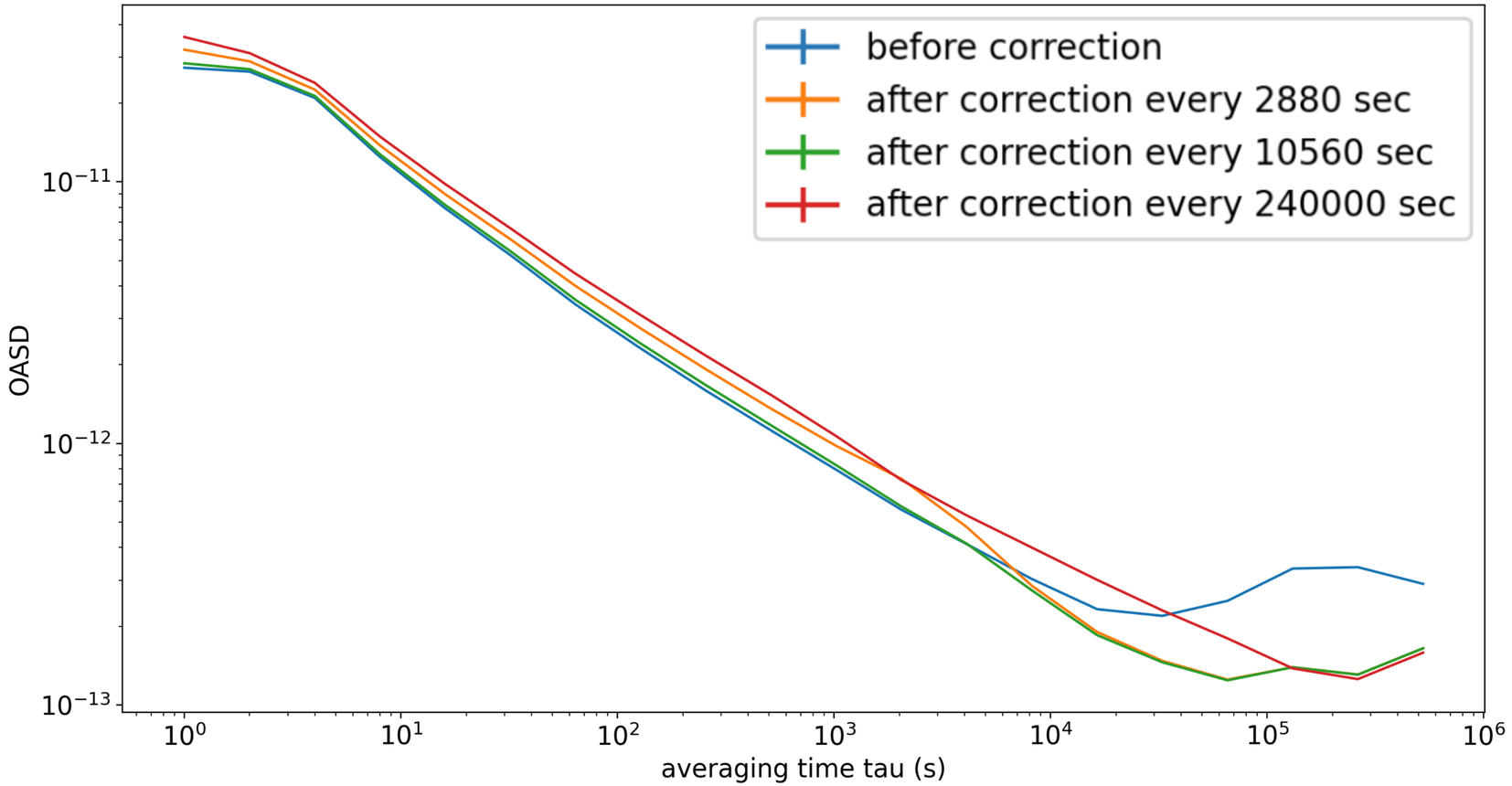
## Correction description

Two correction principle possible:

1. Offline: we fit consecutive subset of the residuals with GNSS to get $a$, $b$ and $c$; we correct the corresponding (simultaneous) subset of RbvsPHm time series. Results shown in next slides

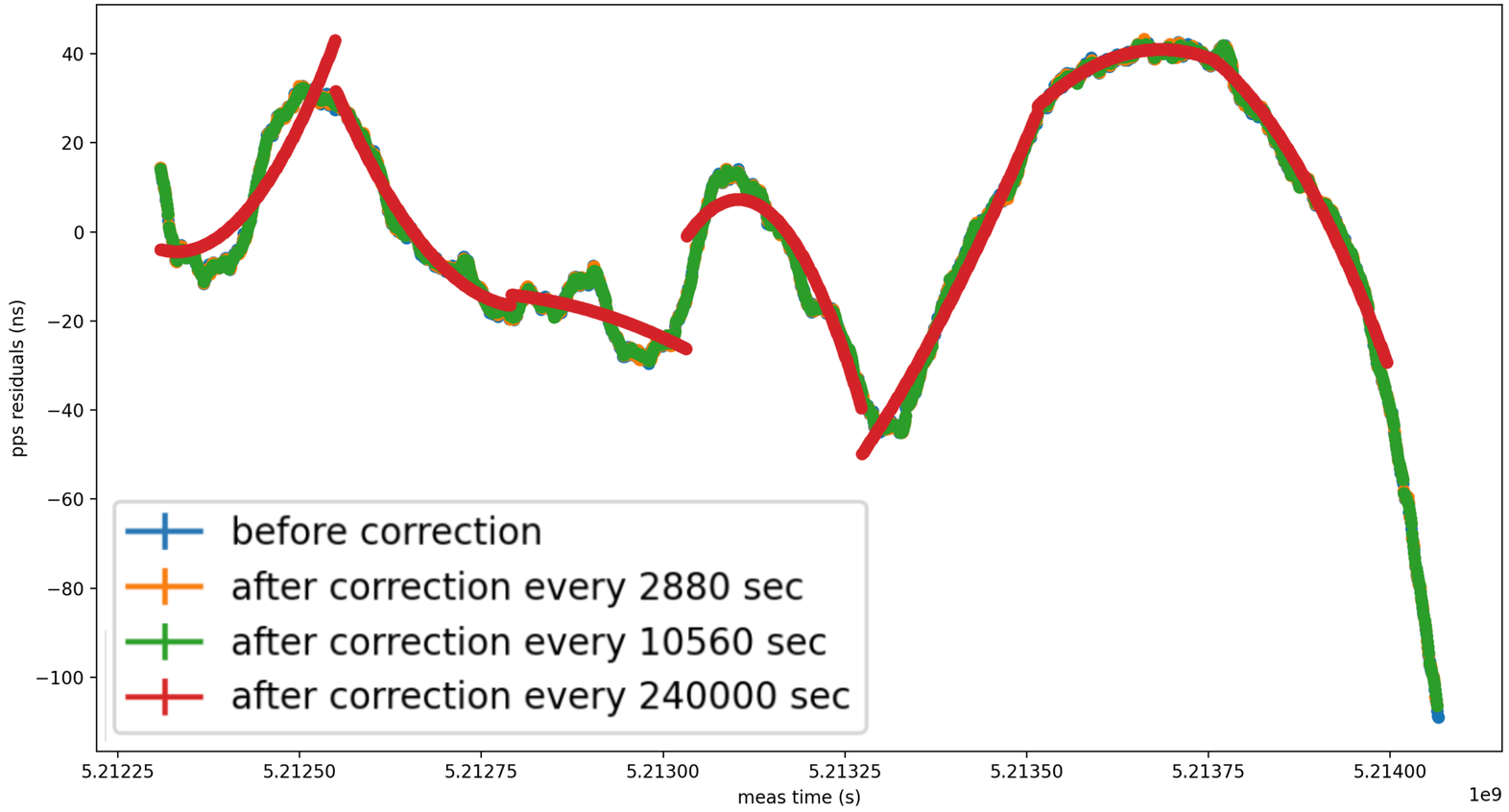
2. Online: The RbvsPHM time series is corrected with the latest values of $a$, $b$ and $c$; $a$, $b$ and $c$ are updated every time we receive a new pps residual from the GNSS receiver. Only started to implement it

# ASD Rb vs PHM




Why the short term performance is also reduced in the “under-corrected case”

# Rb vs GNSS fitted residuals




Because the fit quality is too bad (time scale of fit >> time scale of significant variations)

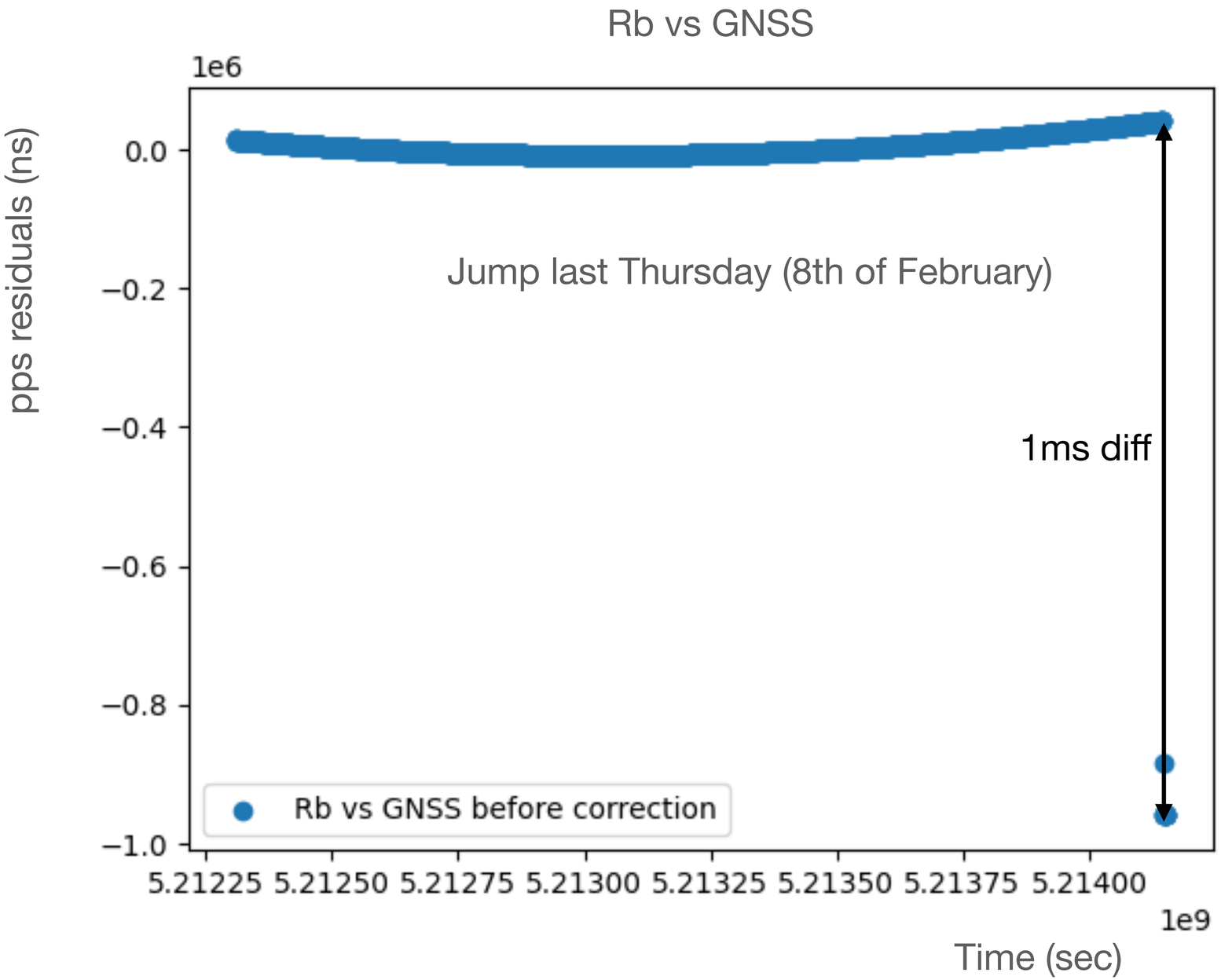
# Preliminary results

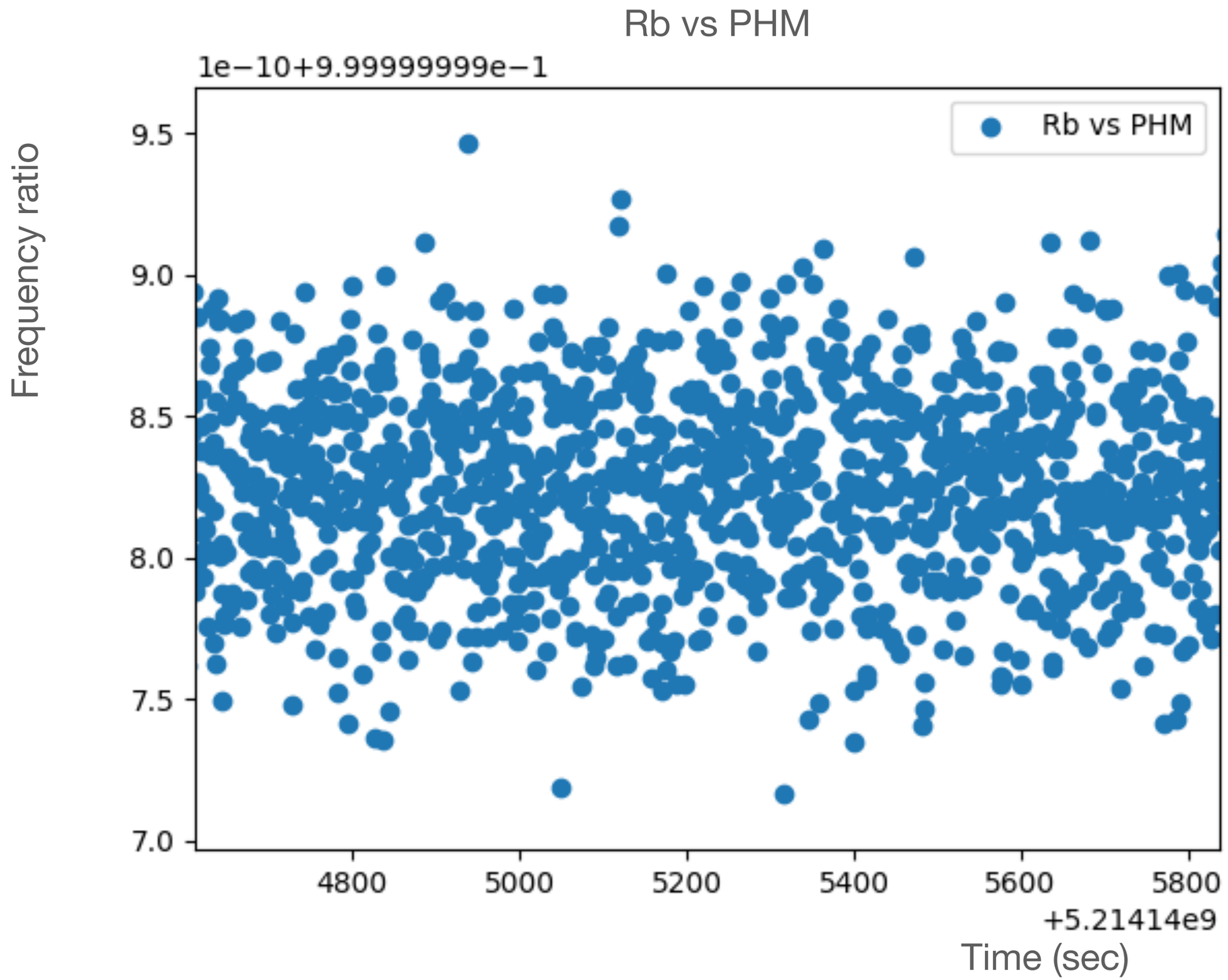
## Conclusion

The corrected ASD behaves more or less like we expected:

- For a too small time window: the short term performance is reduced because we get the GNSS phase WN (over-correction)
- The ideal time window seems to be around 1e4 s (2-3 hrs)
- For a too big time window:
    1. the short term performance is reduced because we cannot fit properly the variations of the pps residuals with GNSS (jumps are introduced
    2. Expect a reduction of the long term performance but to assess this we need more data

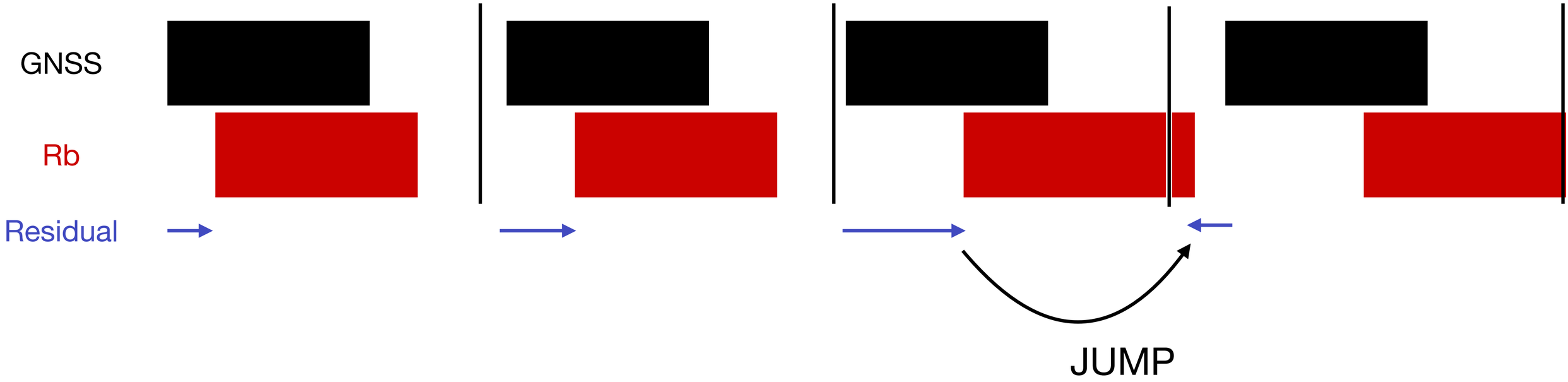
# Jumps in the receiver data


Rb vs GNSS
1e6
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
pps residuals (ns)
Jump last Thursday (8th of February)
1ms diff
Rb vs GNSS before correction
5.21225 5.21250 5.21275 5.21300 5.21325 5.21350 5.21375 5.21400
1e9
Time (sec)

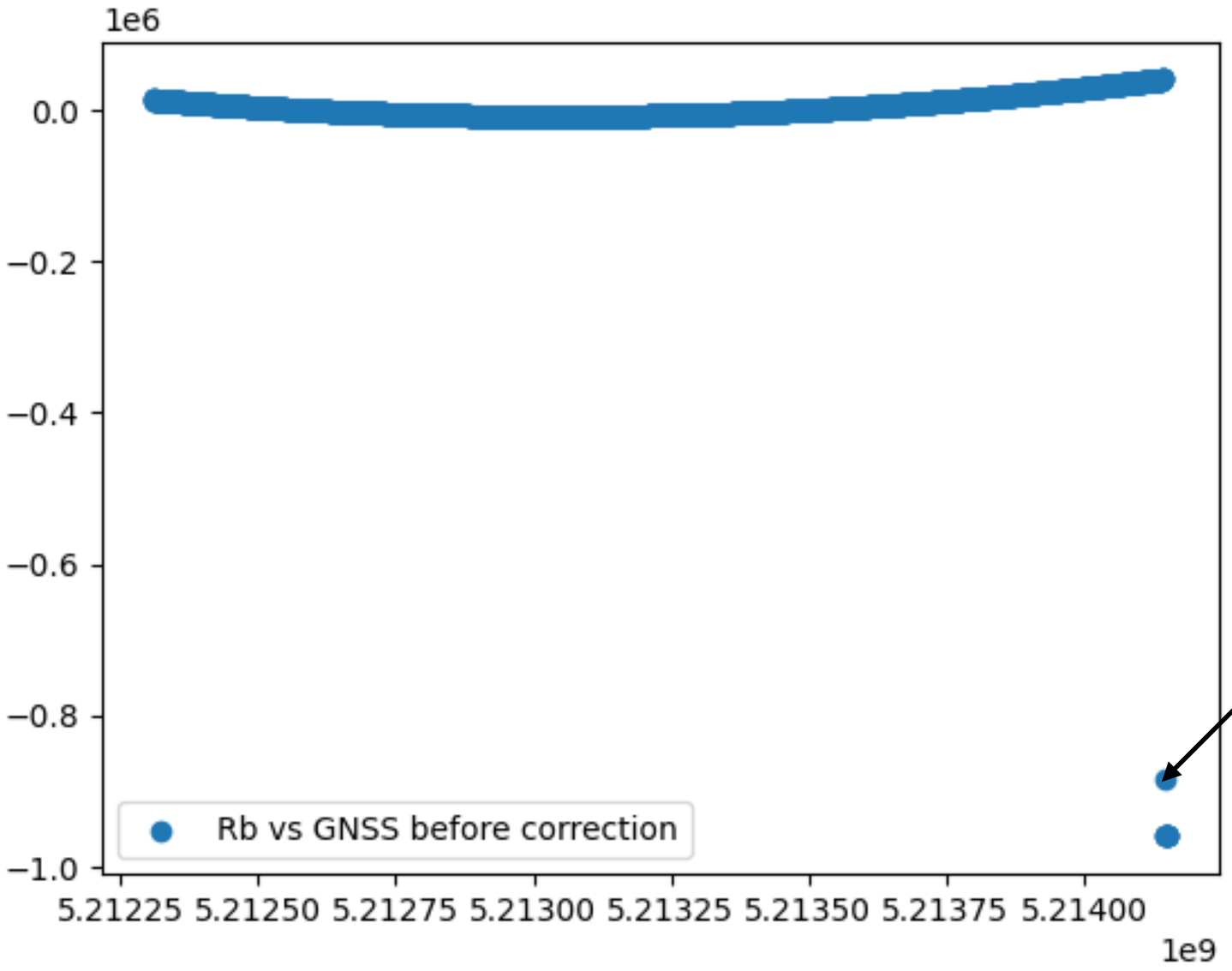



Evolution of frequency ratio with PHM around the time of jump in Rb vs GNSS data: shows nothing special

# Possible explanation




In that case wouldn’t we expect a 1s jump?



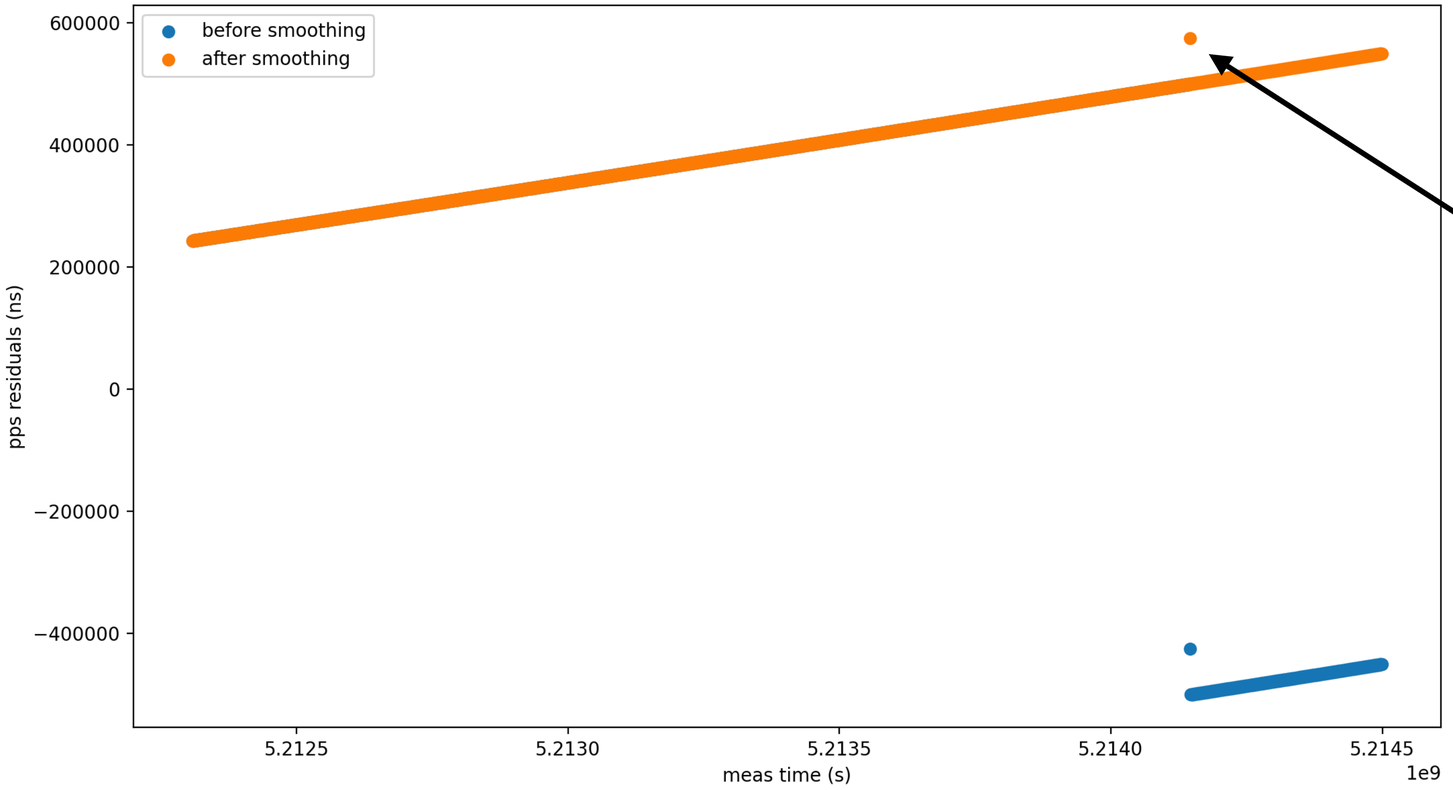

The jump happened probably towards the beginning of this 16min integration time window (small part of the residuals were still positive and the rest were negative)

# Possible solution

- These jumps need to be taken into account somehow
- If we understand them, we can correct for them (smooth the residuals' evolution with time) and correct our signal thanks to corrected residuals (without jump).
- How can we be sure this is what happens (is there any info on what pps is used in the residual in the EZL or GZL files)?

# Possible solution

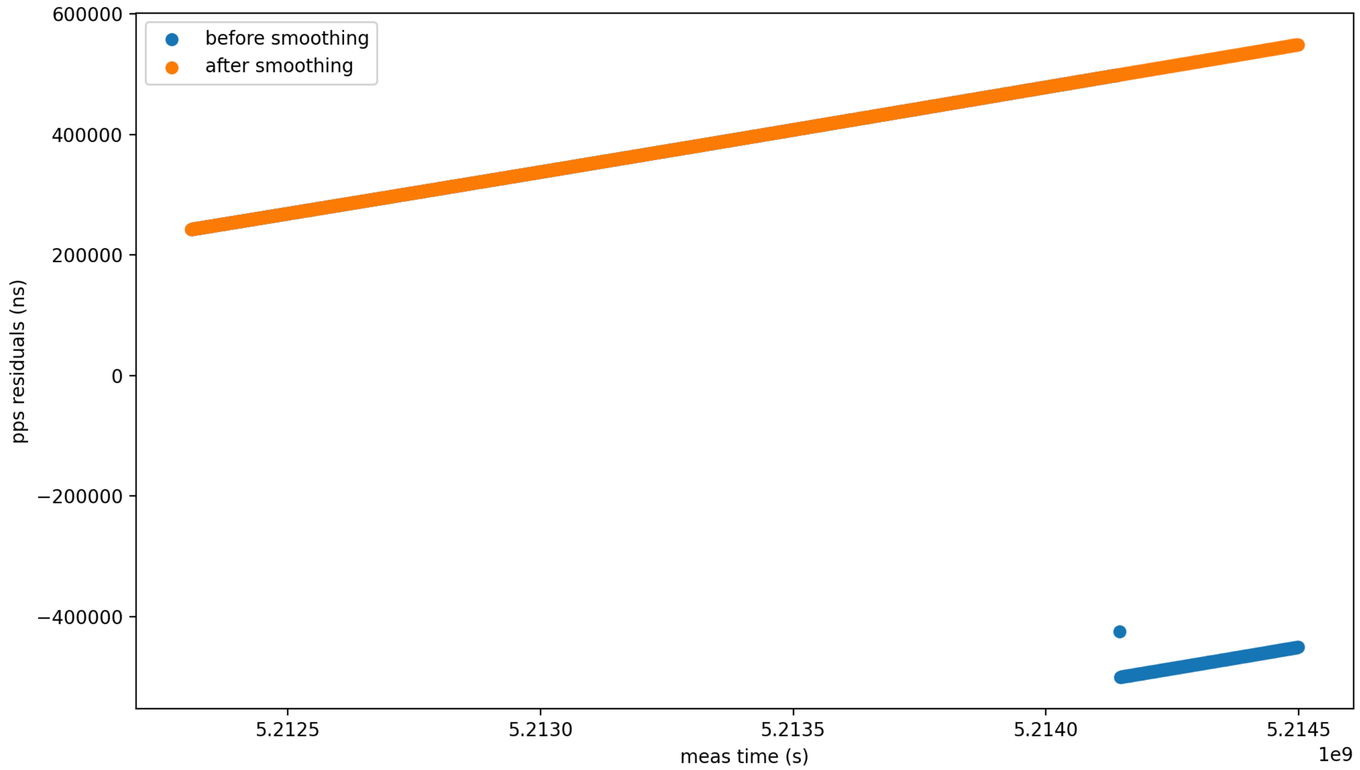
Applied a 1ms offset after jump




What to do with this point?
Don’t use it?
Replace it by an interpolated point?

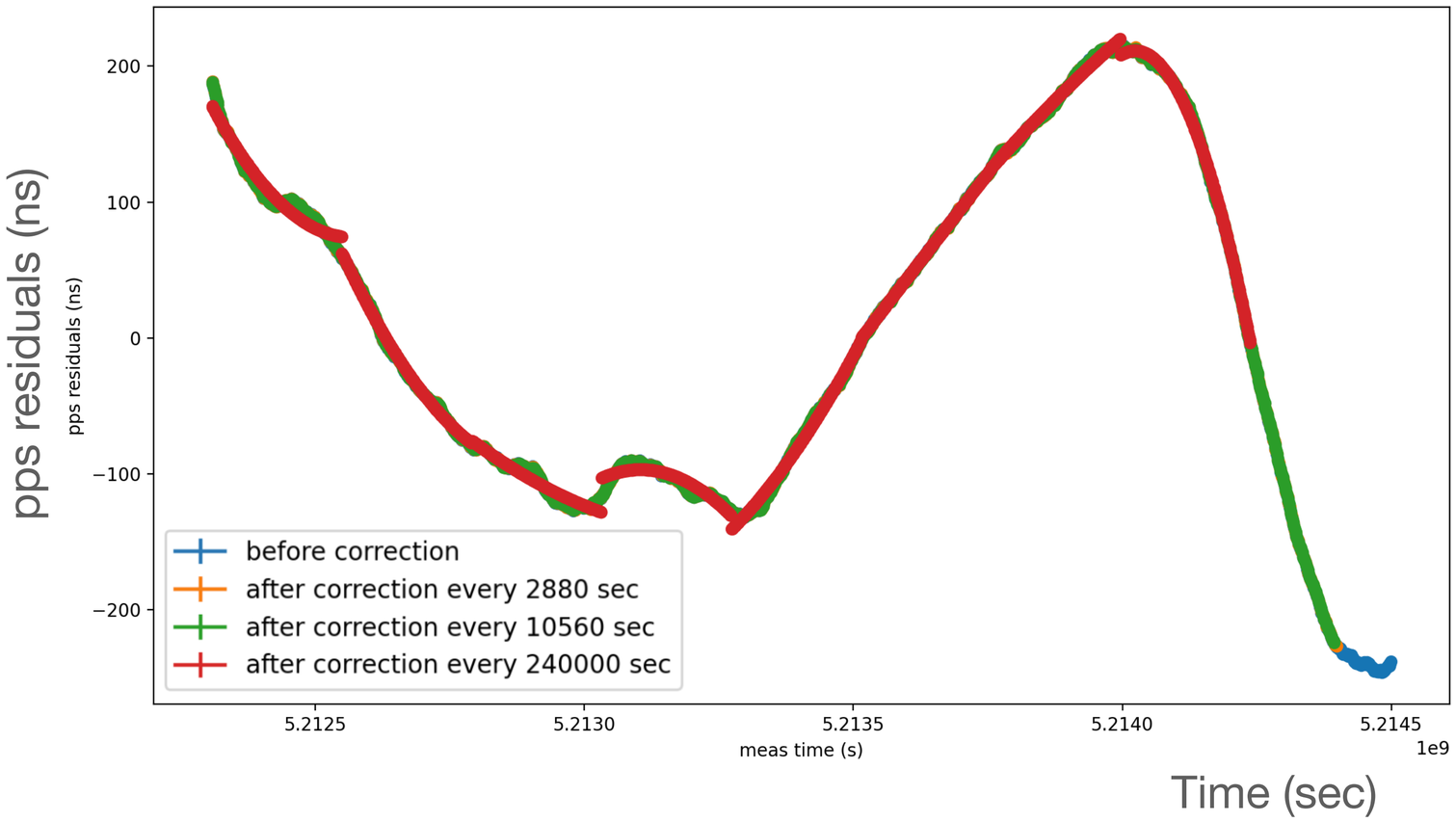
# Possible solution

Interpolated the last unsmoothed point

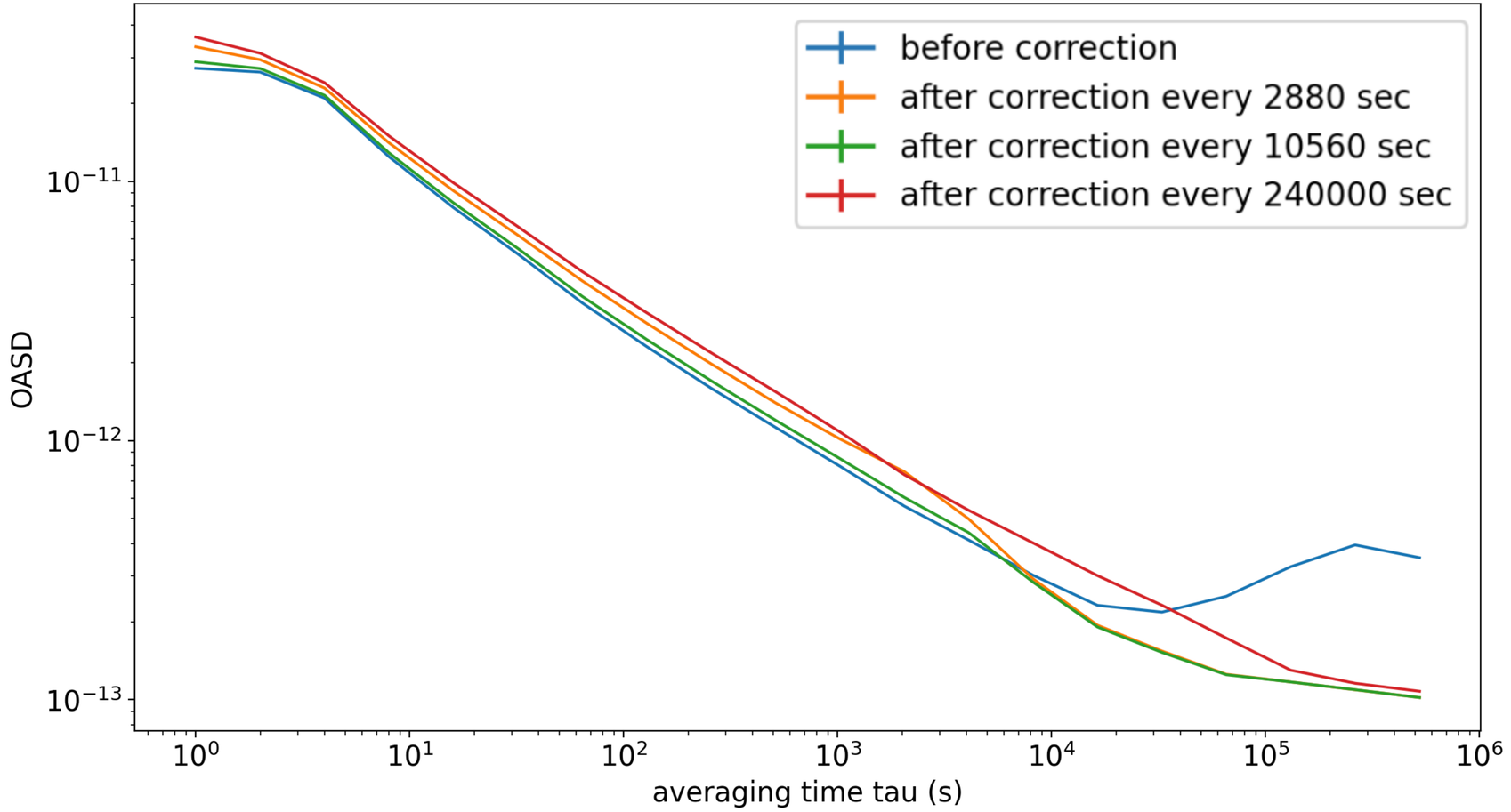


# Possible solution

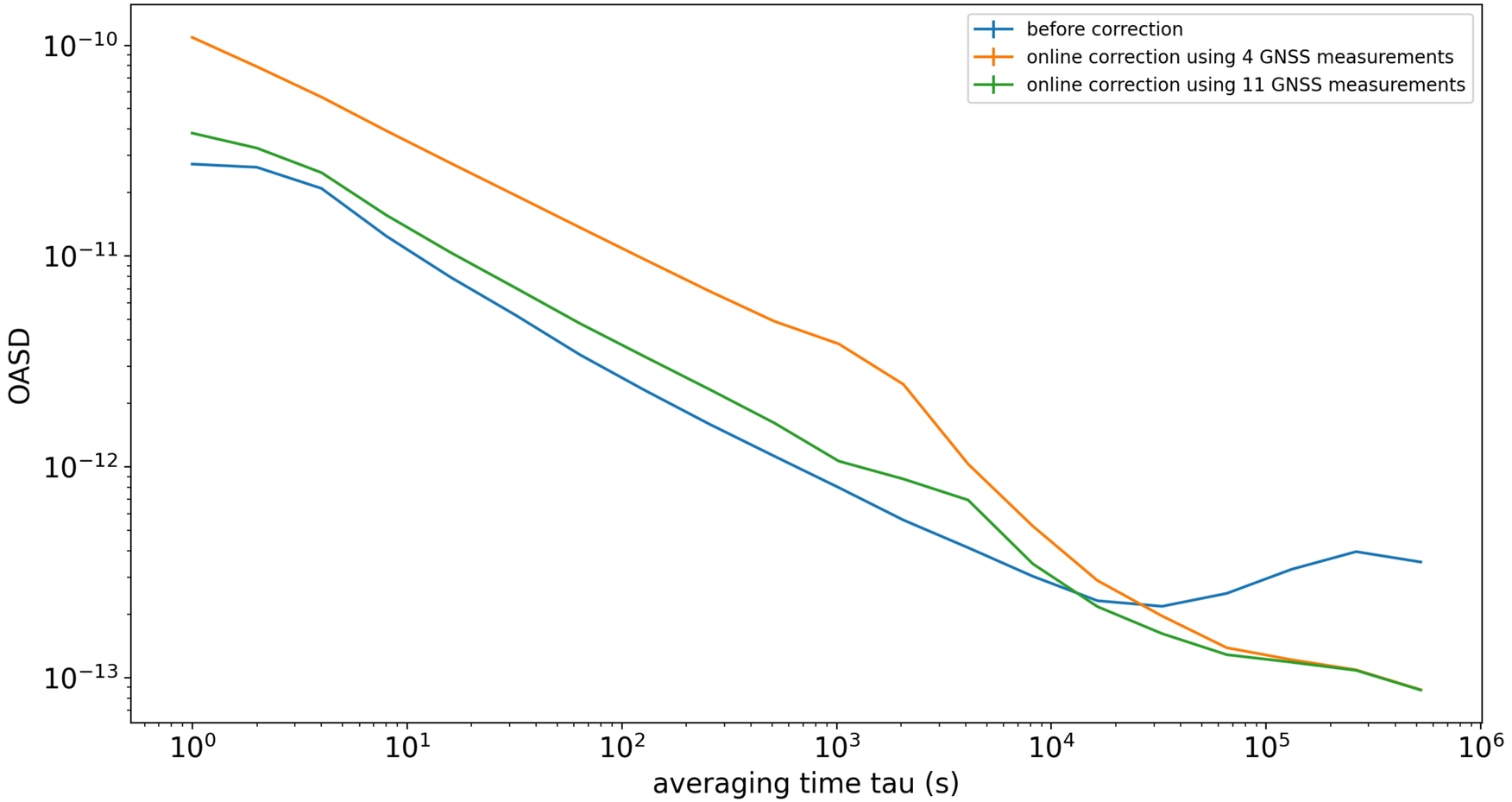
After removal of deterministic drift



# Possible solution



# Test of online corrections

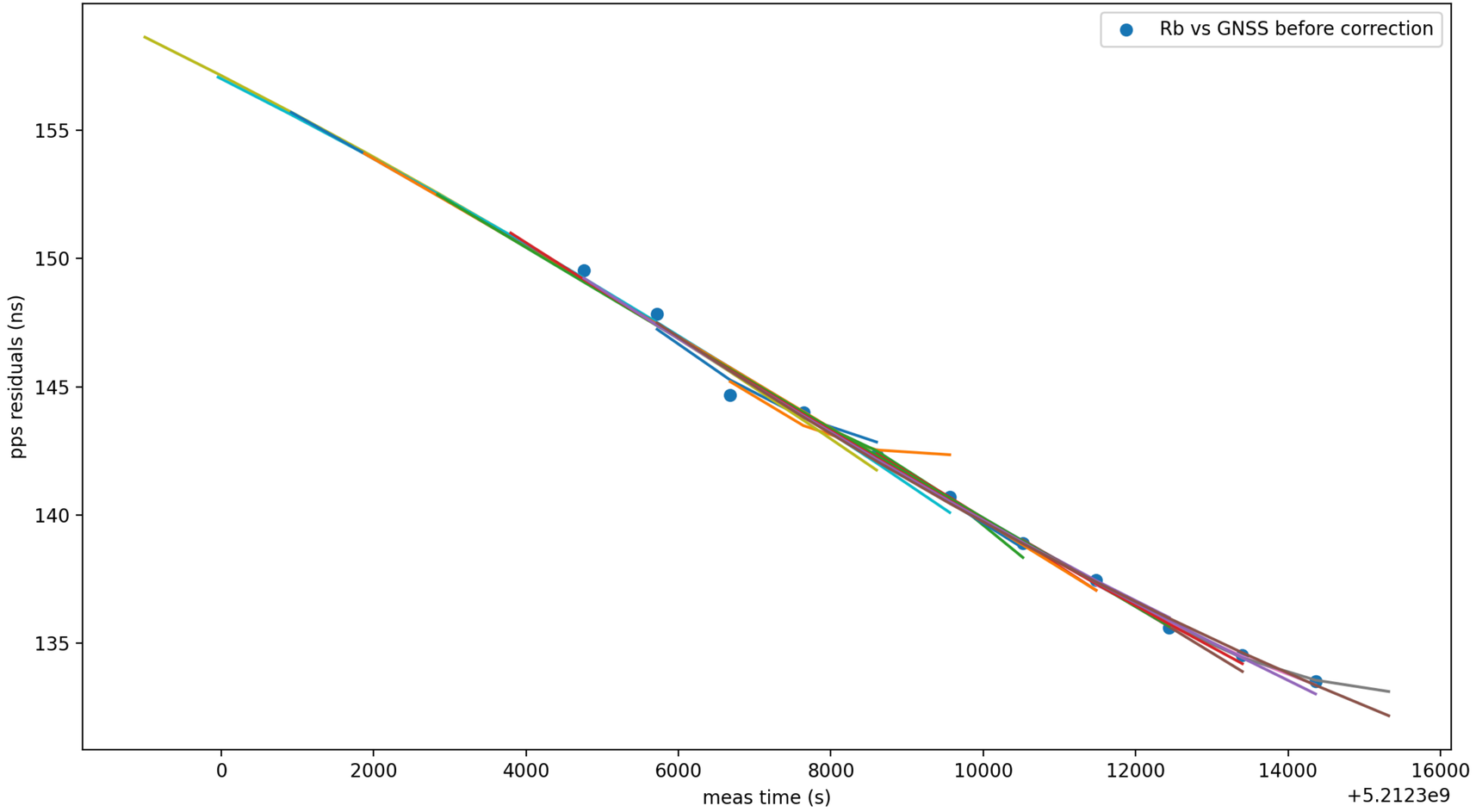



More phase WN for same time windows as offline correction.

Rb vs GNNS pps residuals

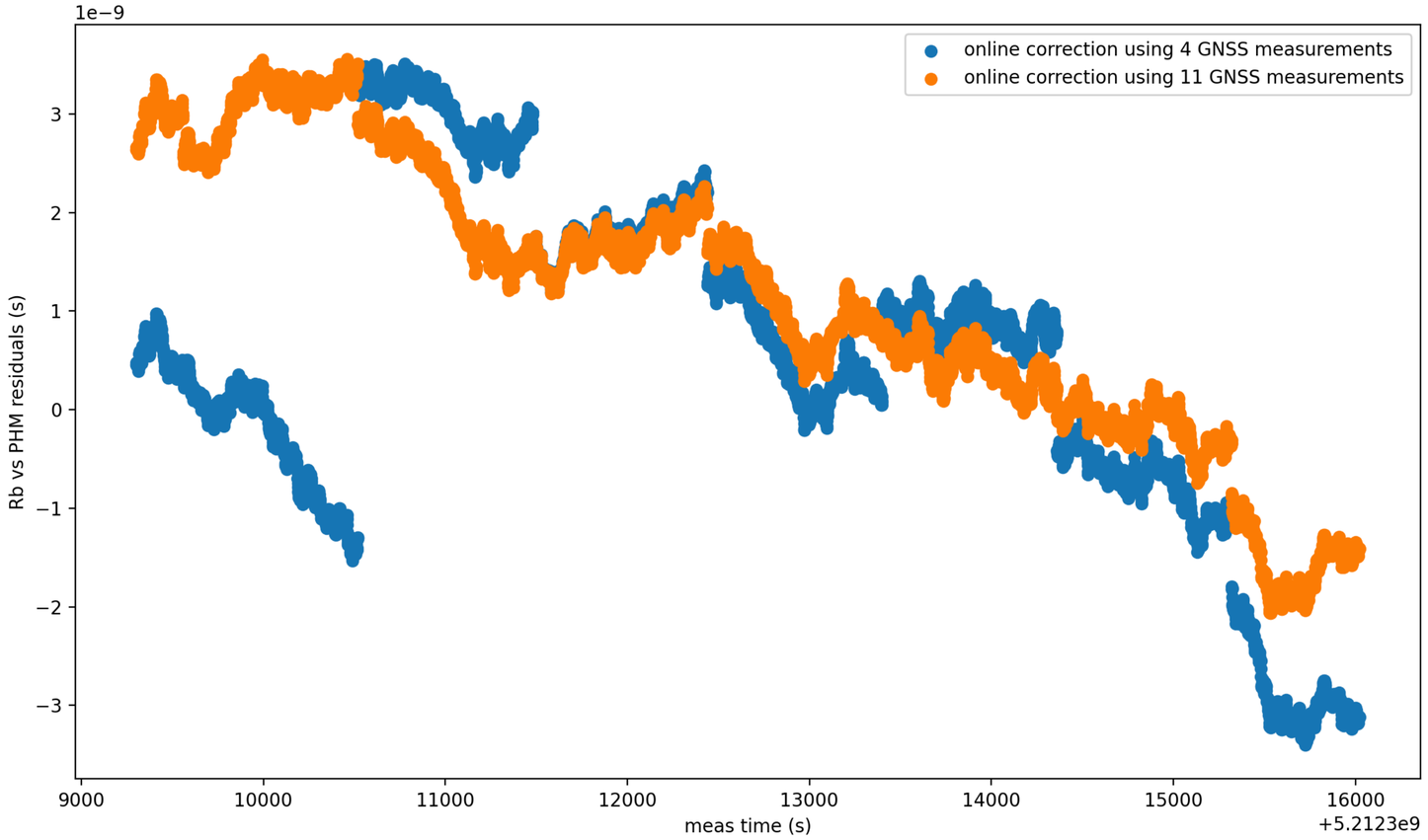
Data points in blue

Fitted distributions used for correction in coloured lines

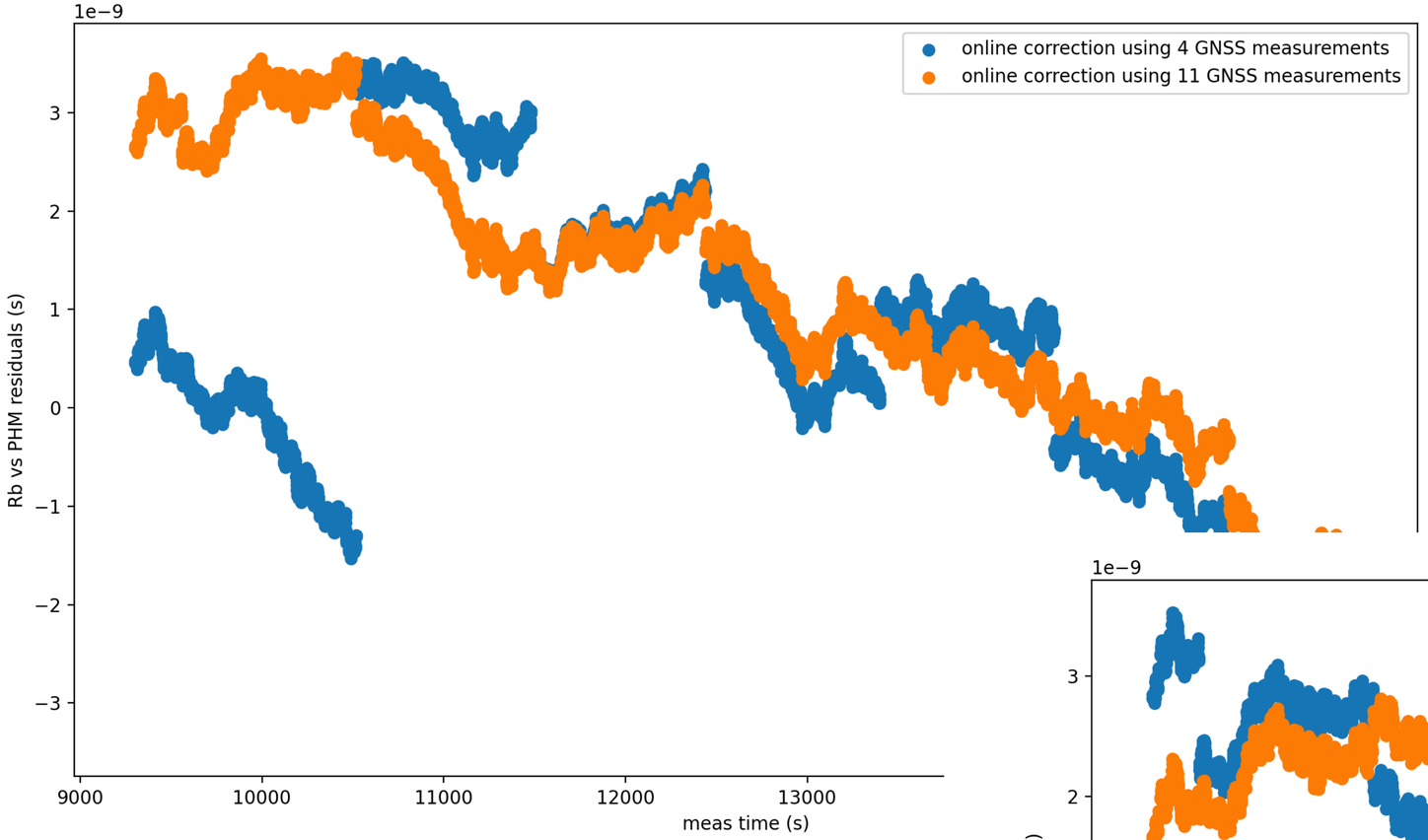



We can expect som jumps in the corrected RbvsPHM time series looking at the “coloured lines” distributions

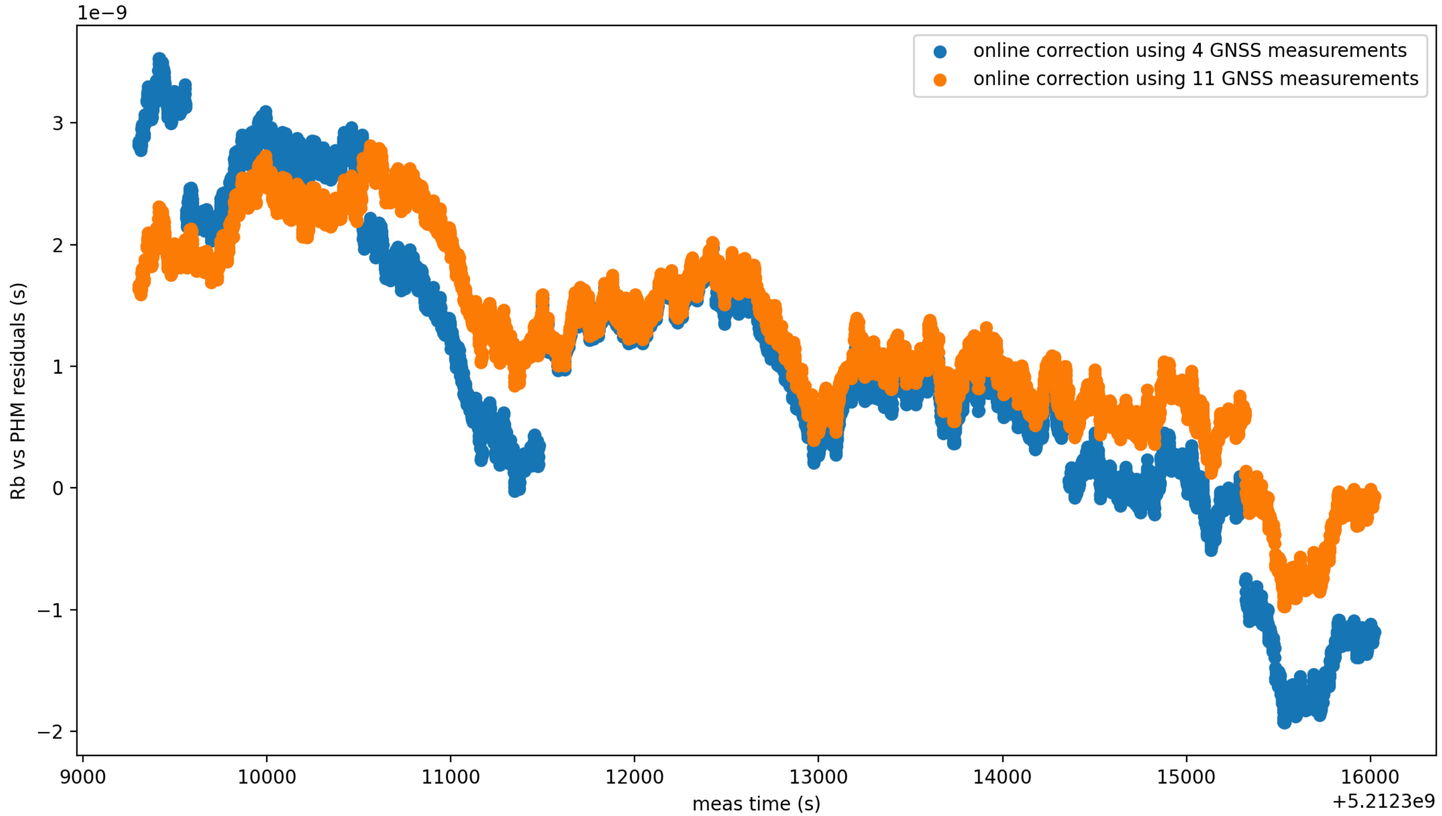
# Rb vs PHM pps residuals after correction

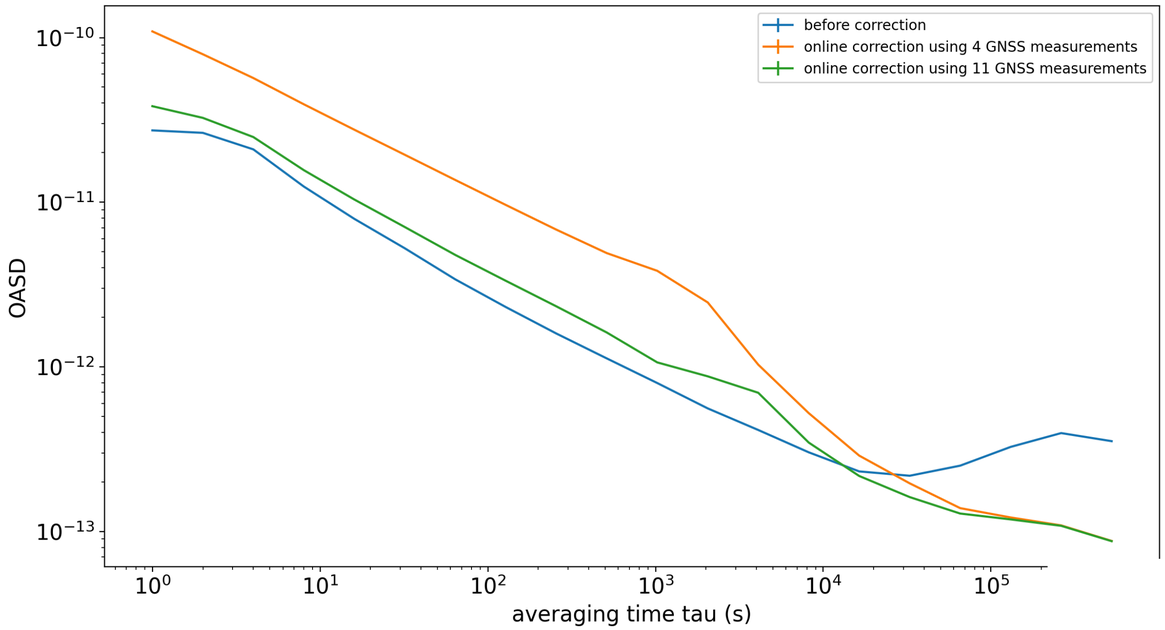


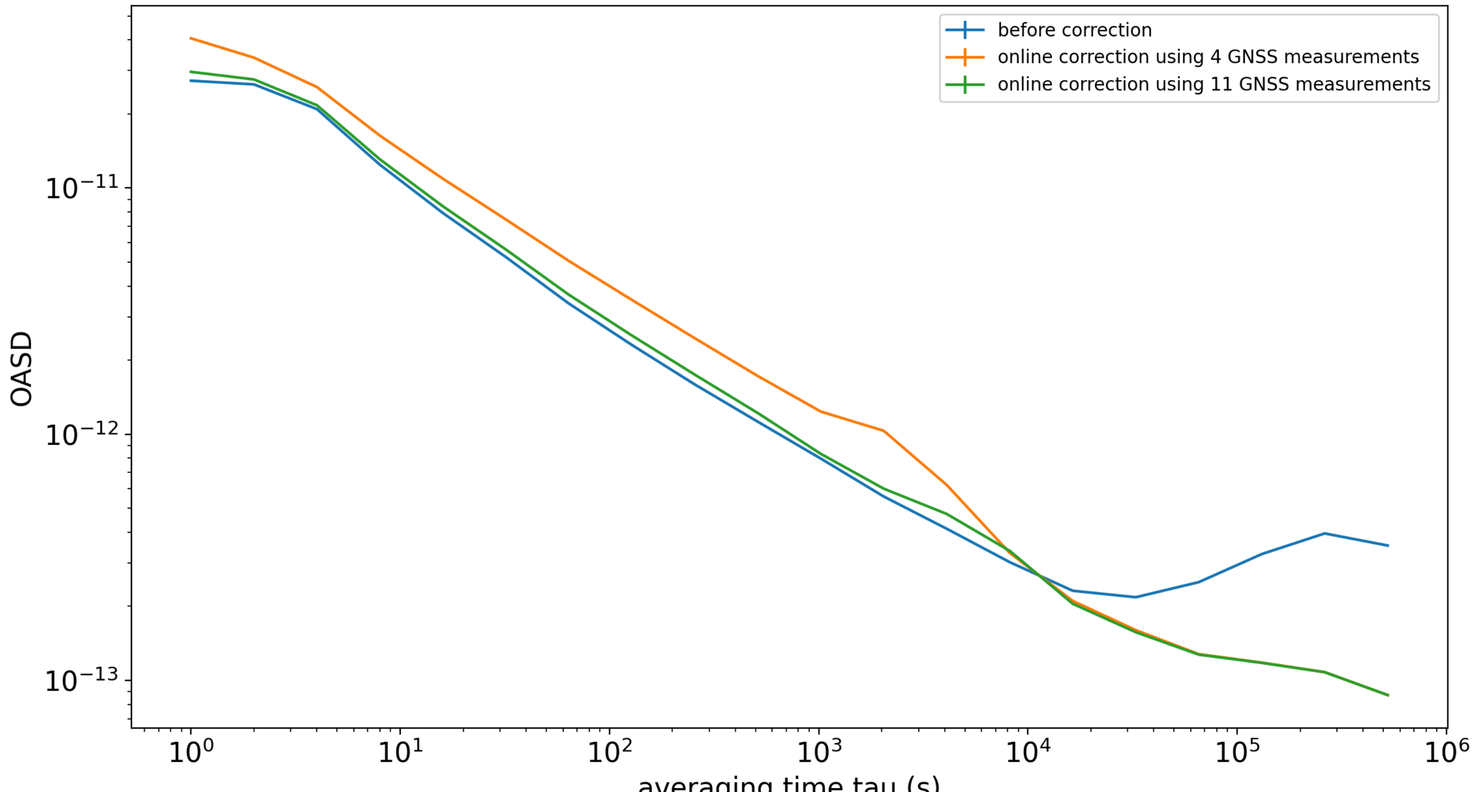
Using 2nd degree polynomial fit




Using linear fit

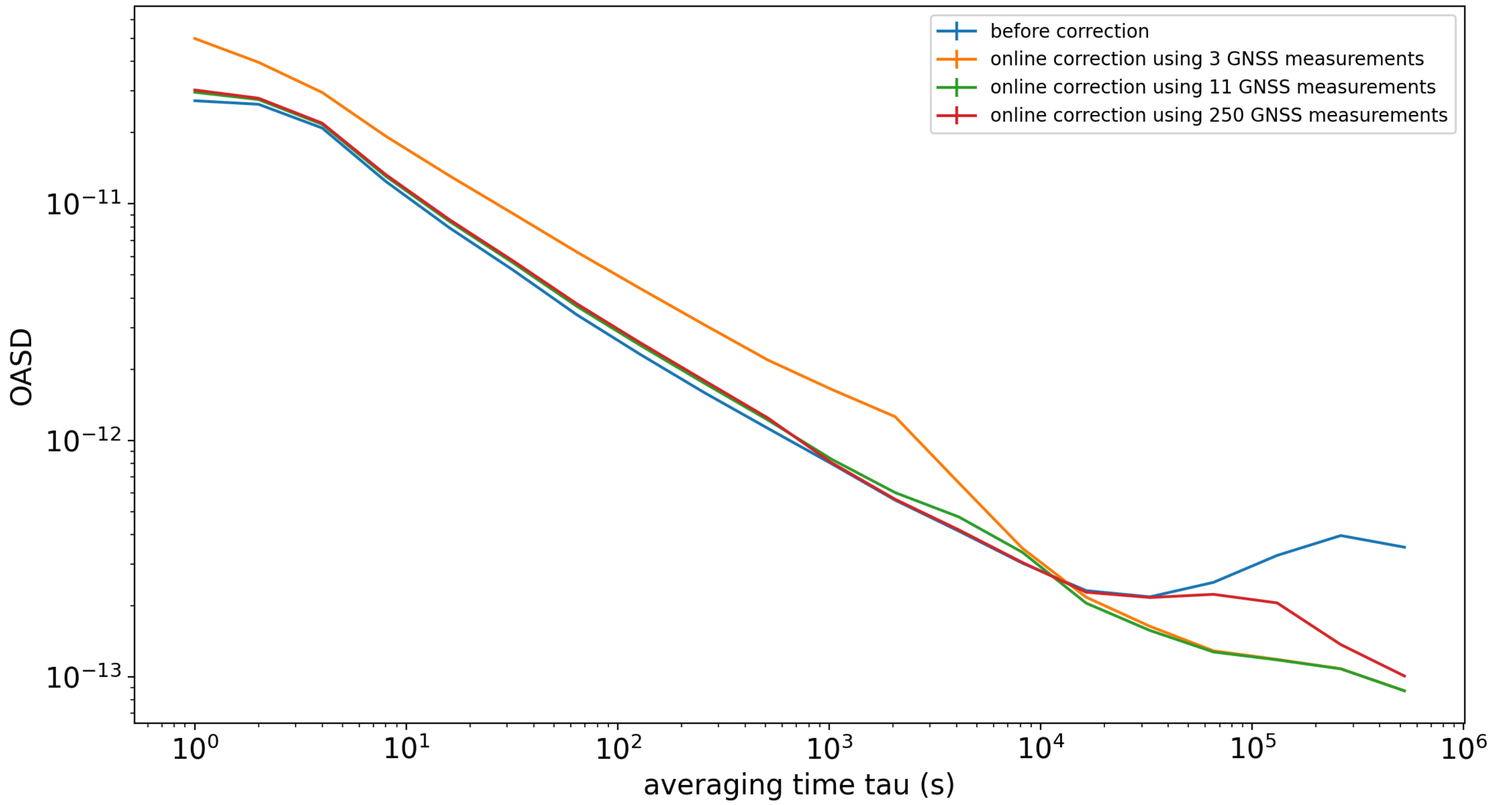





Better performance if we correct with linear fit of the RbvsGNSS pps residuals

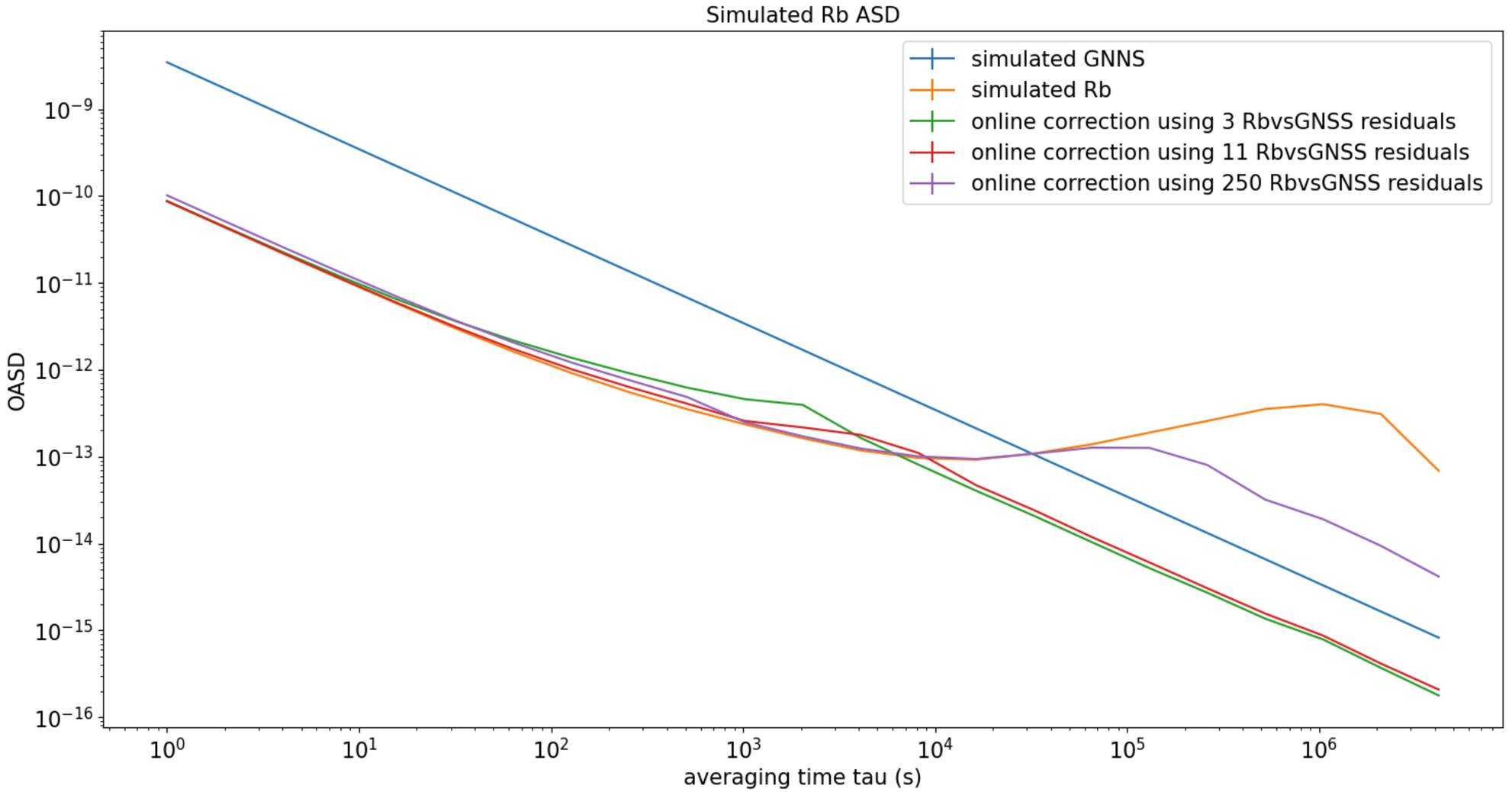
# Online correction with linear fit of GNSSvsRb pps residuals




With online correction, thanks to overlapping fit time windows, we don’t introduce jumps in the “under-corrected case” (red short-term performance is same as green).

We start to see the degradation of long term performance in the under-corrected case.

# Comparison with what was expected from simulations



# Future plans

# Future plans

- Continue this data-taking as long as possible (at least another month, would allow to see the ASD until tau ~2e6)
- Finish implementing online correction
- Far future plan: another run with frequency counter 2 for pps residual measurement between SYRTE and Rb. For that need to prepare the WR switch pps connector.
- What about the paper?