CENTRE NATIONAL D'ÉTUDES SPATIALES

Doris Phase Measurements – Rinex Data Format

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Jason 2 Doris Measurements

New instrument generation

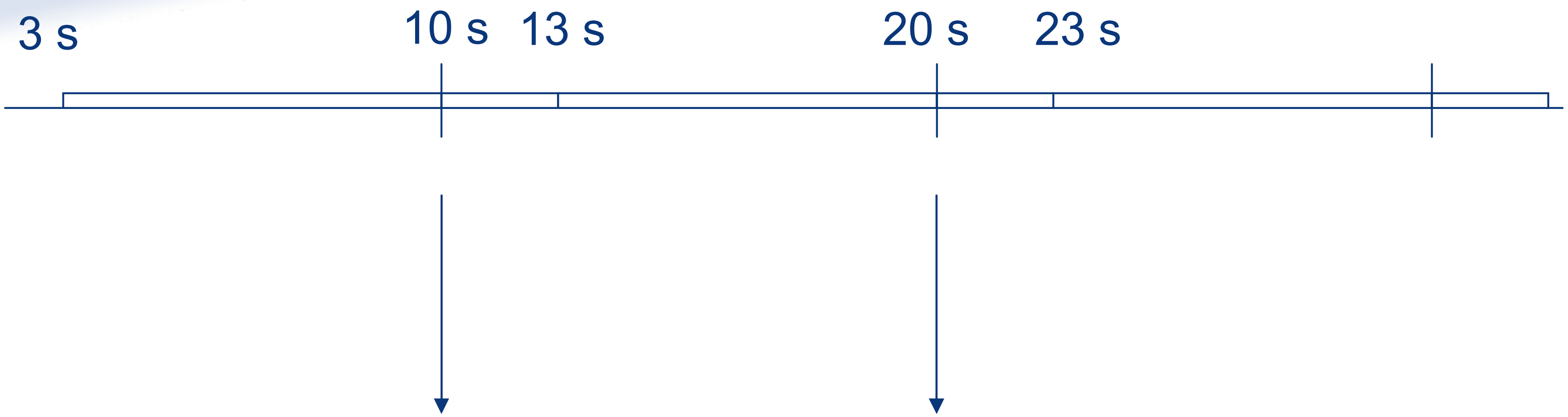
- more channels (two for Jason1, six/seven for Jason2)

- new measurement definitions
  Jason 1 : delta phase, and it3 measurement
  Jason 2 : synchroneous phase and pseudo-range

New file format

- Doris Rinex format, extension of GPS Rinex 3 format

Doris pseudo-range and phase measurements



pseudo range C1, C2
phase L1, L2
epoch t

C1, C2
L1, L2
epoch t+10 s

All epochs are present in the rinex file (0 s – 3 s – 10 s – 13 s - 20 s ….)
present study (also POD) : only 0 s - 10 s - 20 s …

Notation : frequency 1 for 2 GHz, and frequency 2 for 400 MHz

Some characteristics

Acquisition strategy :

Below 5 degrees, acquisition is performed by channel 7

Above 5 degrees, the emitter is designated by Diode (channels 1 to 6)
and removed from channel 7 → frequent interruptions around 5 degrees

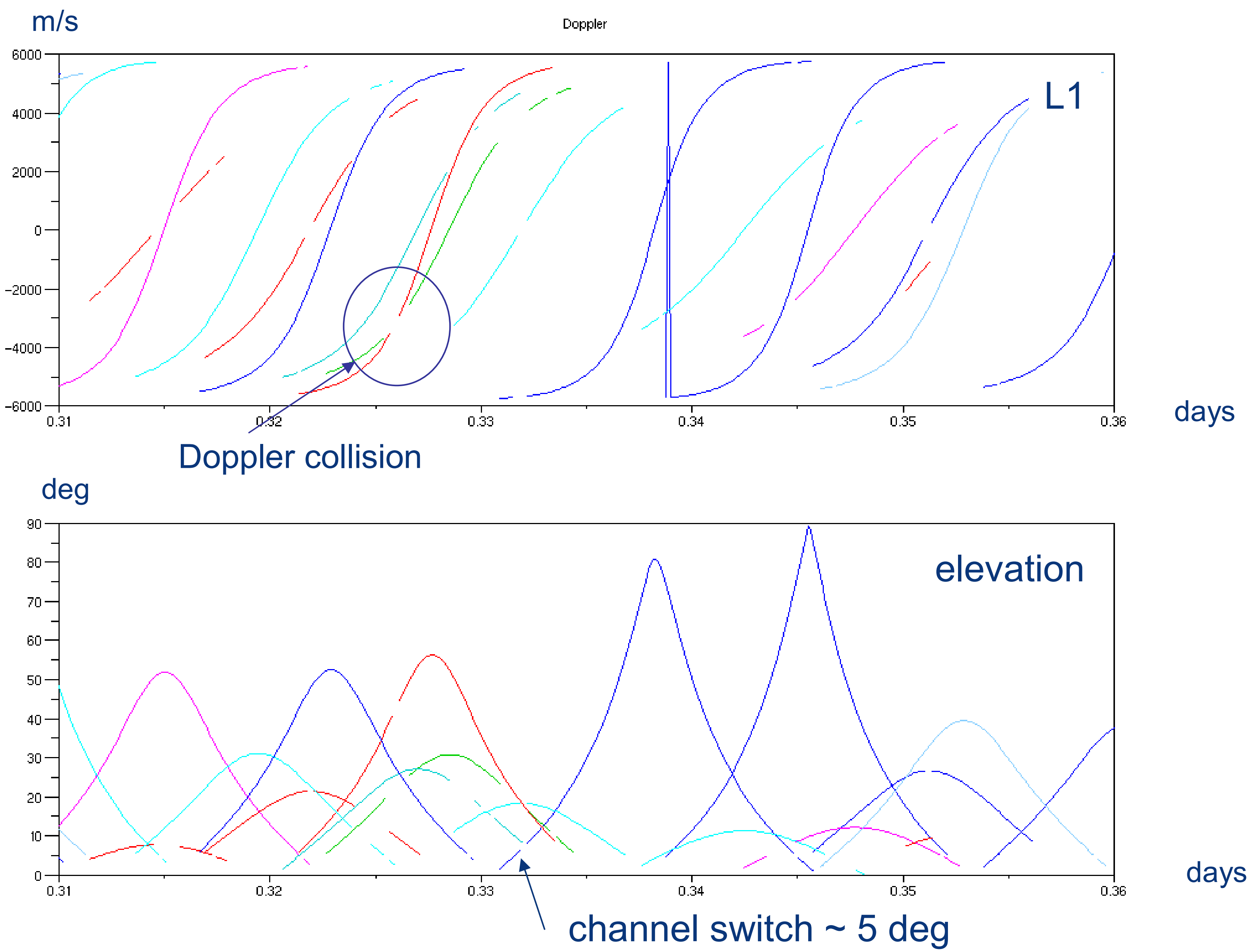
Low elevations :

New troposphere models are needed to process correctly these low elevations
current POD process > 10 degrees
< 10 degrees useful for positioning, tropospheric studies …
30 % of the measurements are below 10 degrees

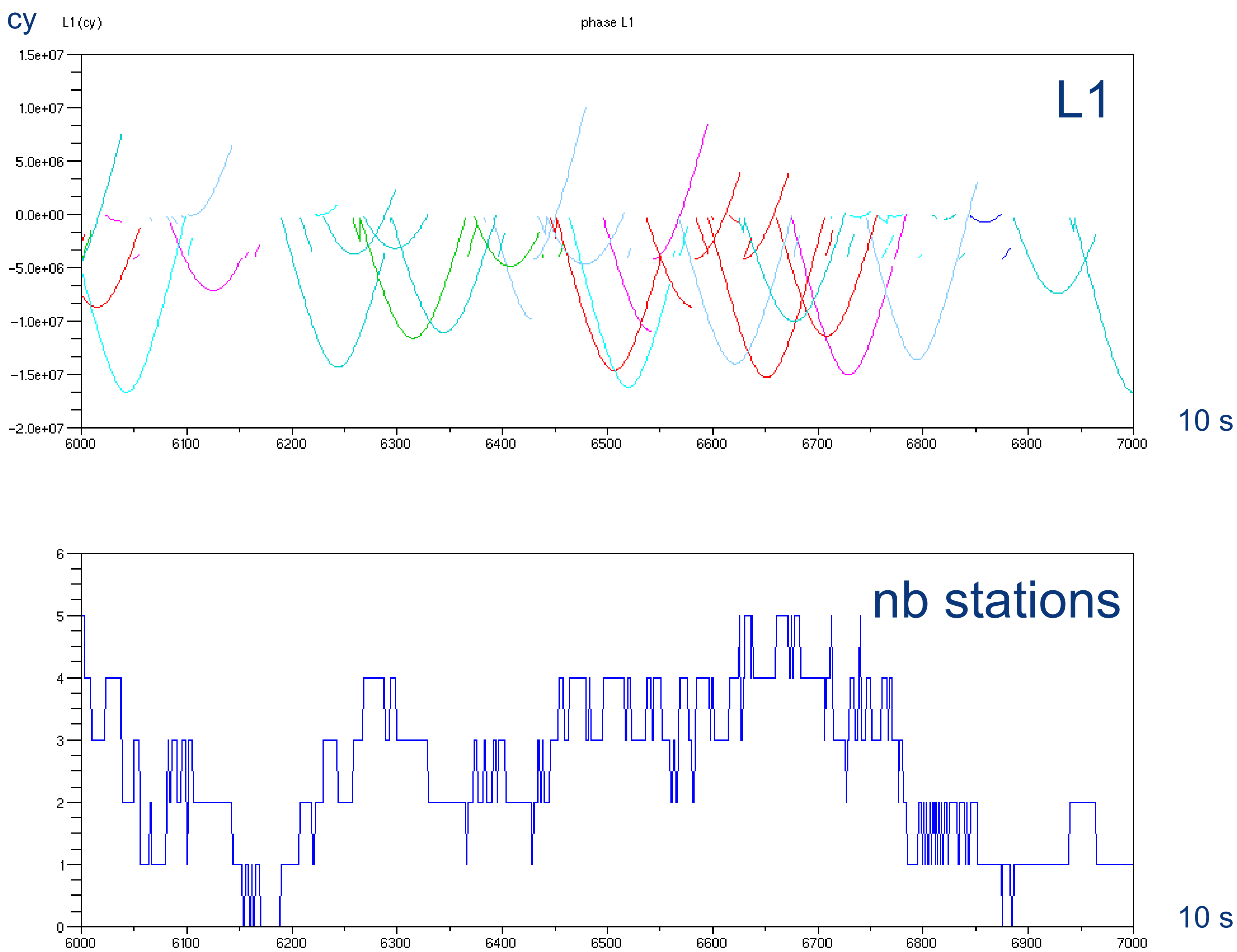
Doppler collisions :

When two signals have the same Doppler, interruption in the measurements
true for all Doris instruments, but will interrupt here the phase continuity

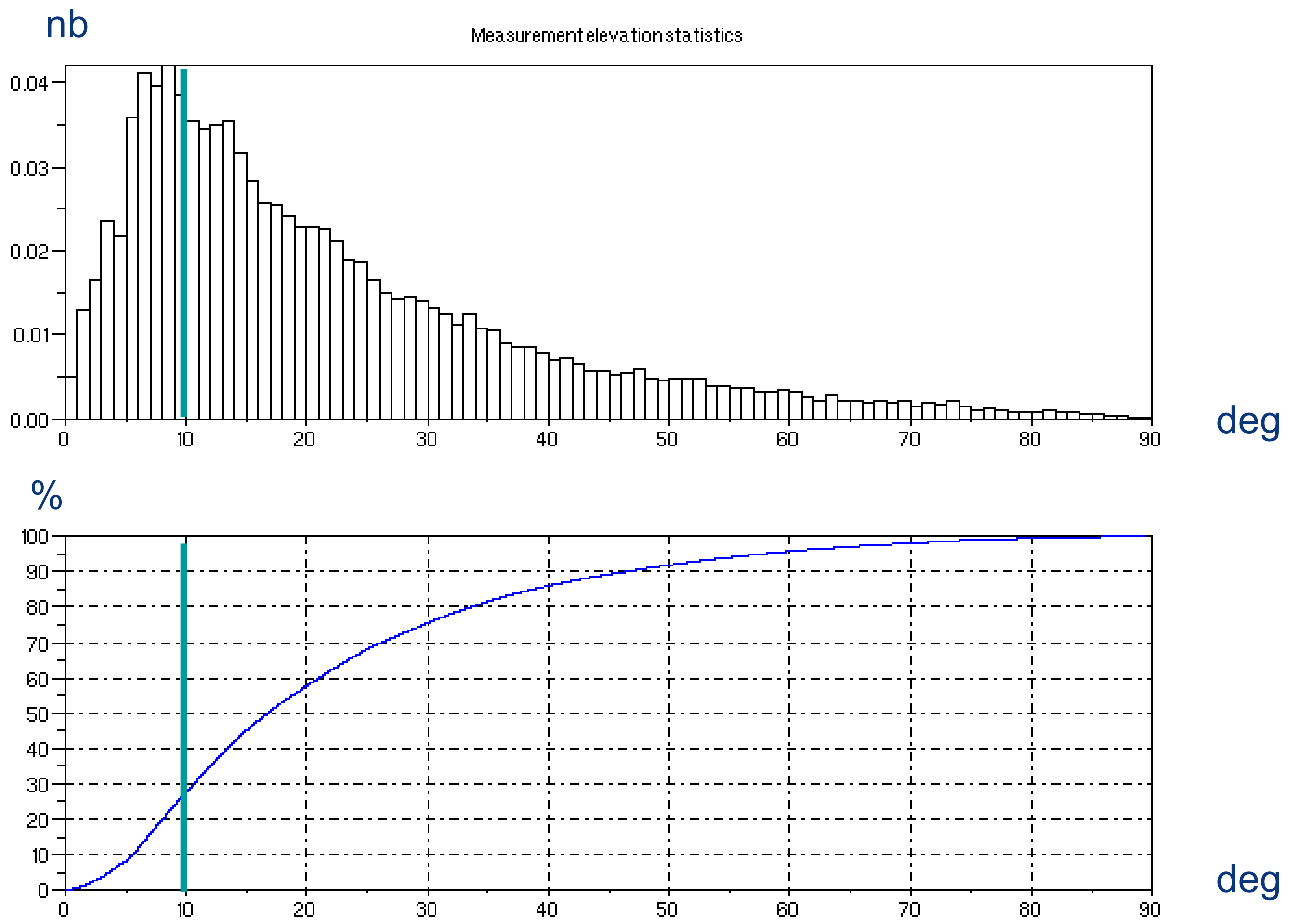
Acquisition strategy, Doppler collisions



Phase measurements



Statistics for measurement elevation



Around 30 % of the measurements are below 10 degrees

- these measurements are eliminated from the POD process

  they are probably very interesting for positioning or troposphere analysis

Doris Rinex Format

GPS like phase and pseudo-range measurements
all instrumental delays corrected
Synchroneous acquisition (on board Jason 2).

Example :

reception epoch

estimated on board clock offset

```
> 2008 08 31 01 13 16.979948170  0  5         4.873984107 0
D18 -13343786.710 0  -2629434.840 0-135193433.464 1-135193362.999 1       -118.700 7
         -106.800 7       2170.119          997.259 1          19.377 1         80.328 1
D20    -86550.535 1    -17056.397 1-145734619.907 2-145735021.607 2       -133.050 7
         -121.500 7       2170.119         1000.828 1          21.500 0         73.000 0
D19   -2710106.688 0   -534036.209 0-128063516.563 3-128062854.027 3       -128.500 7
         -123.950 7       2170.119         1000.984 1           9.836 1         73.279 1
D16 -11123449.559 0  -2191909.891 0-144169109.475 4-144168971.573 4       -118.350 6
         -108.200 6       2170.119         1010.628 1          25.361 1         72.098 1
D15   -2666097.739 0  -3893168.756 0-145712808.006 7-145711965.597 7       -135.850 7
         -121.500 7       2170.119          995.344 1          25.800 0         86.000 0
```

L1 phase

Meteo

W1 S/N ratio

C1 pseudo-range

station number (krvb)

Pseudo Range measurements

Purpose : estimate the on board clock offset

For Jason 2 : use of the master beacons only
reference offsets are given in the header

```
D01   JIUB JIUFENG                           21602S005  3   0    STATION REFERENCE
...
D15   KRVB KOUROU                            97301S004  3   0    STATION REFERENCE
D20   TLSB TOULOUSE                          10003S005  3   0    STATION REFERENCE
D39   YEMB YELLOWKNIFE                       40127S009  3   0    STATION REFERENCE
D49   HBMB HARTEBEESTHOEK                    30302S008  3   0    STATION REFERENCE
...
D52   HEMB ST HELENA                         30606S004  3   0    STATION REFERENCE
      4                                                          # TIME REF STATIONS
D15          -0.495           -6.944                             TIME REF STATION
D20          29.774            5.787                             TIME REF STATION
D39         -61.692         -158.565                             TIME REF STATION
D49         -11.419          -38.194                             TIME REF STATION
```

bias (10^{-6} s)   drift (10^{-14} s/s)

Datation of measurements

from the rinex

from the header (a few μs)

$$C_1 = c\left(t_{rec}^{rec} - t_{emi}^{emi}\right)$$
$$= D\left(t_{rec}^{rec} - h_{rec}\right) + c\left(h_{rec} - h_{emi}\right)$$

model

adjusted (polynomial)

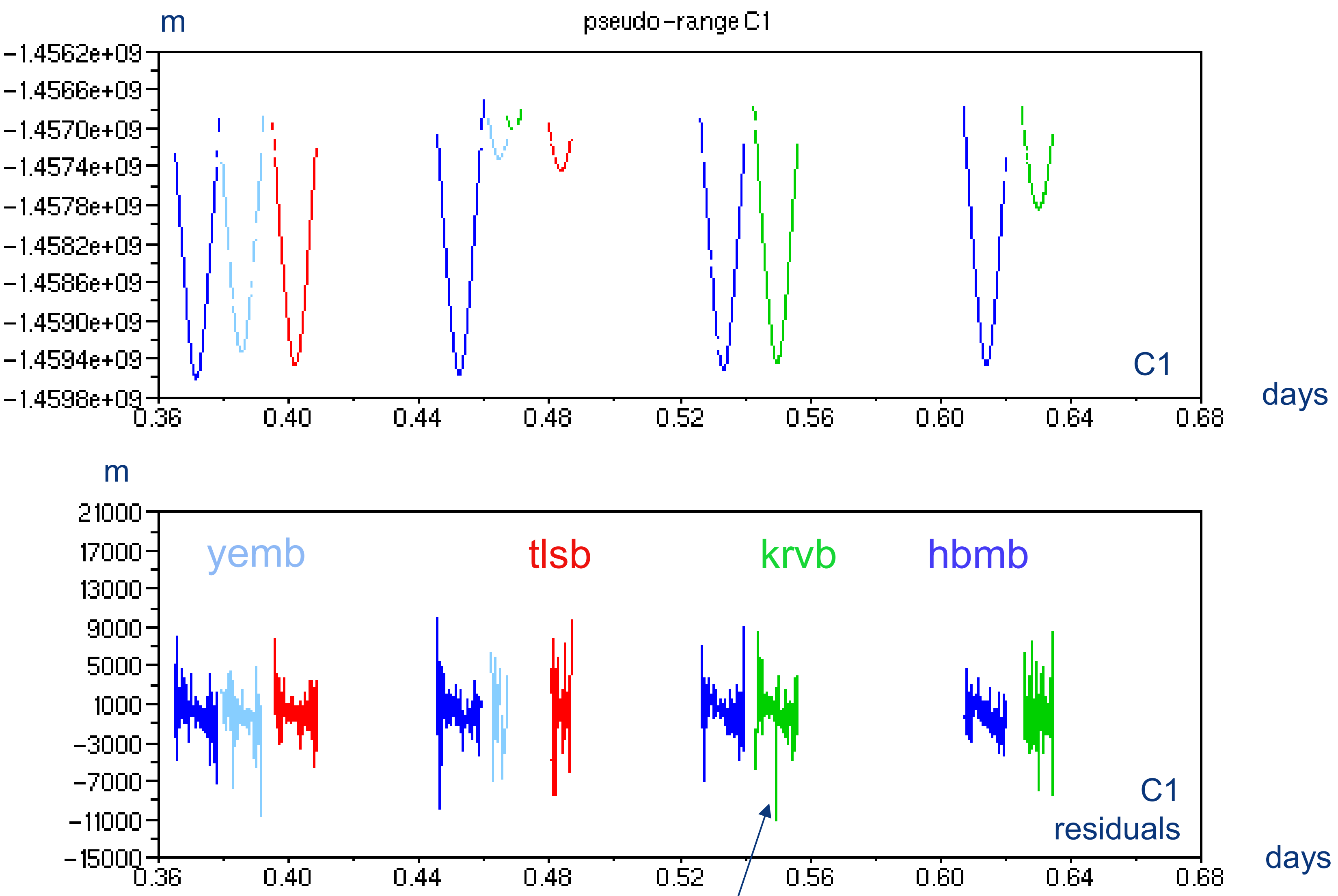
Use of the master station measurements only

h_{rec} : polynomial prepresentation for the on board clock offset (typically degree 2-3 for a 10 days arc)

Other formulation : $t_{emi} = t_{rec}^{rec} - \frac{C_1}{c} - h_{emi} \rightarrow D\left(t_{emi}\right) \rightarrow h_{rec} - h_{emi} = \frac{C_1 - D}{c}$

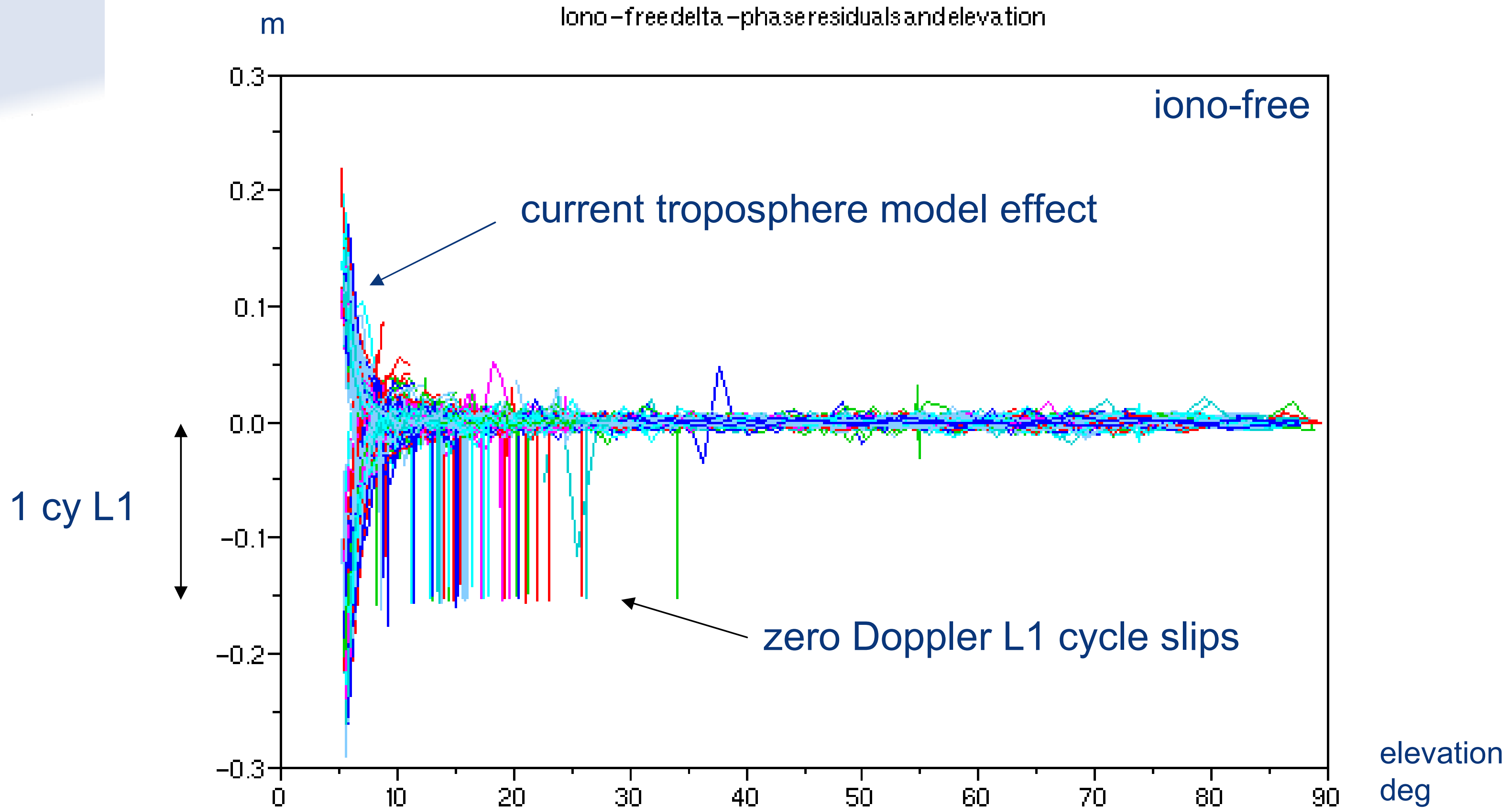
On board clock offset adjustment

offset ~ -5s



erroneous measurement close to zero Doppler

Delta-phase residuals, all measurements

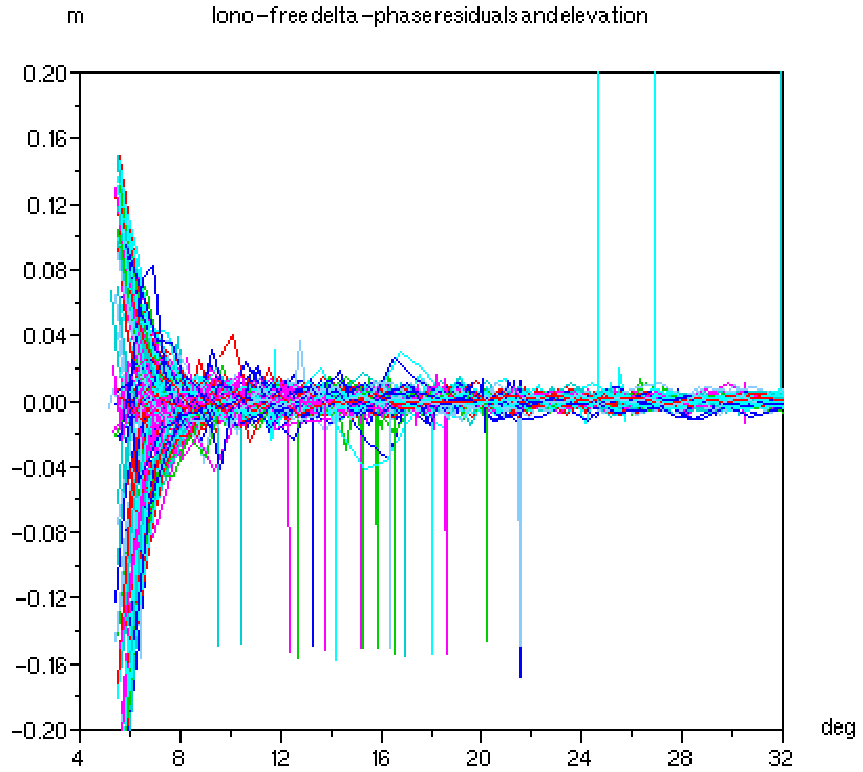


Elevation > 5 degrees only

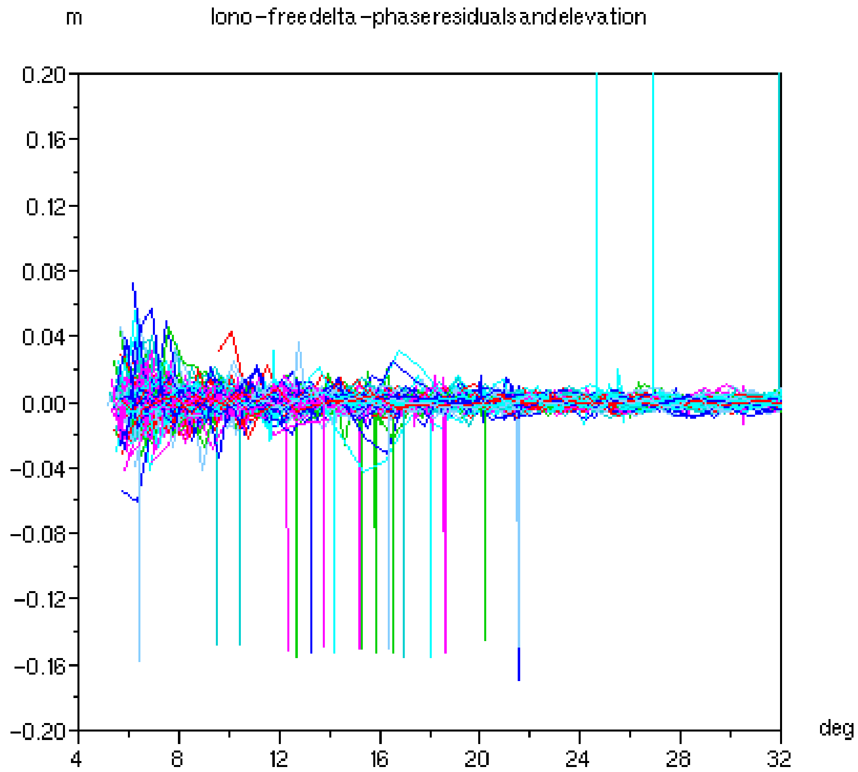
Most cycle slips occur below 30 degrees, and when Doppler is close to 0
(small Doppler measurements are flagged in the Rinex file)

Improvement of the troposphere models

Delta phase measurements



Current model



GPT – GMF model

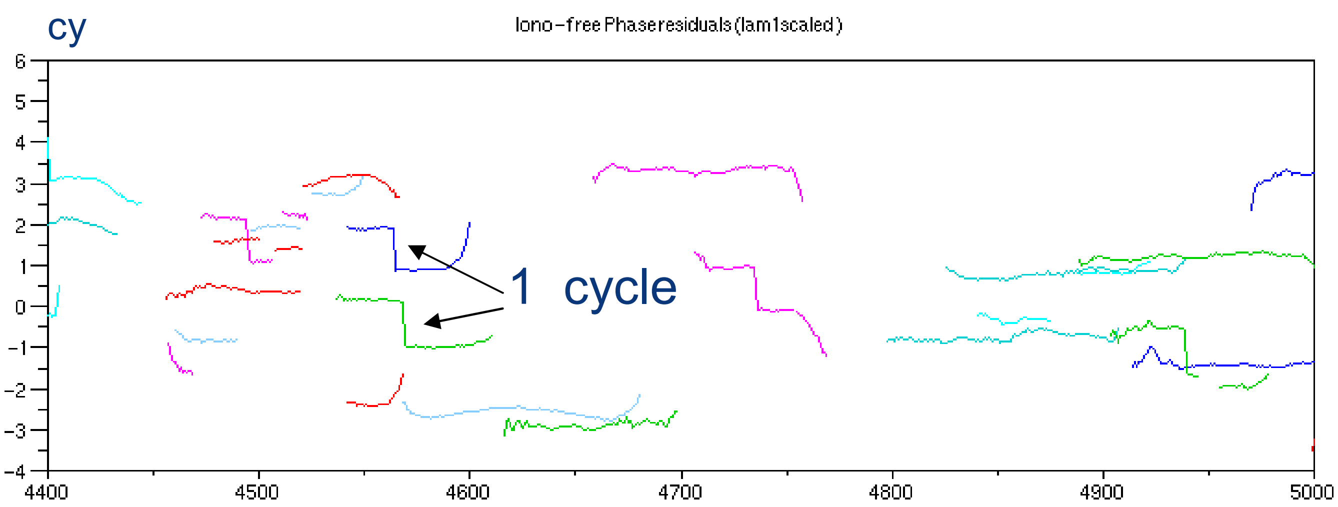
No significative troposphere effect on POD, but possible changes in station positioning

Phase residuals

$$L_1 - \frac{\lambda_2}{\gamma\lambda_1} L_2$$

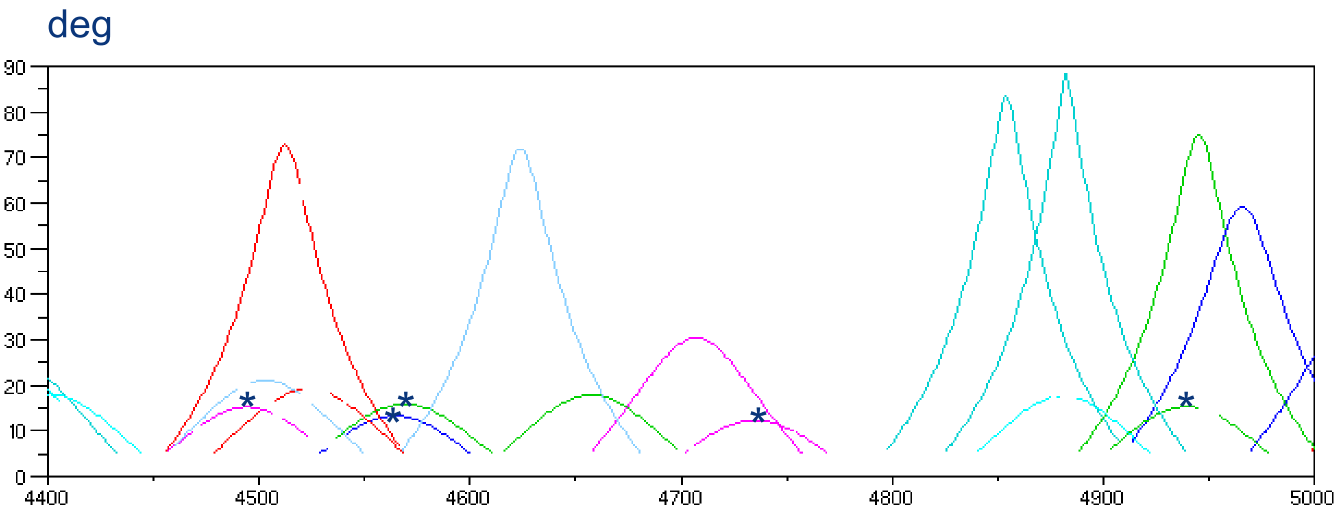
(~ iono-free)

no adjusted bias



10 s

Elevation



10 s

Study of the phase residuals

Correction of the L1 cycle slips using 5*L1-L2

Threshold for passes definition on iono-free $L_2 - \frac{\gamma\lambda_1}{\lambda_2} L_1$: 0.5 cy L2

(elimination of the remaining L2 cycle slips, assuming no L1 errors)

Phase residuals : see Spot5 SWT Venice 2006 (reconstructed measurements)
now we have directly the phase measurements

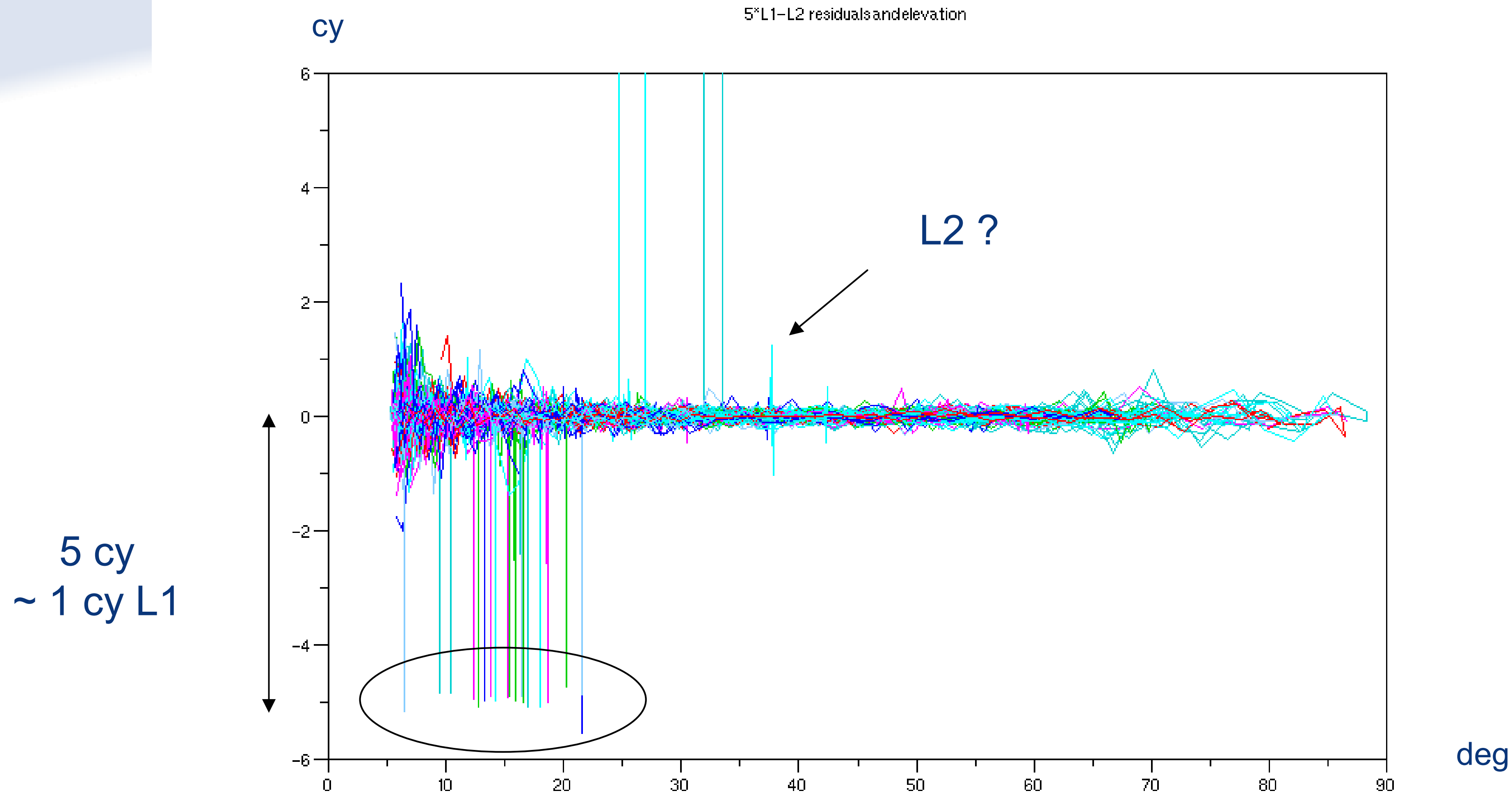
Analysis of the phase residuals for the remaining full passes
(passes with more than 500 s continuous measurements)

Allan variance

Time history

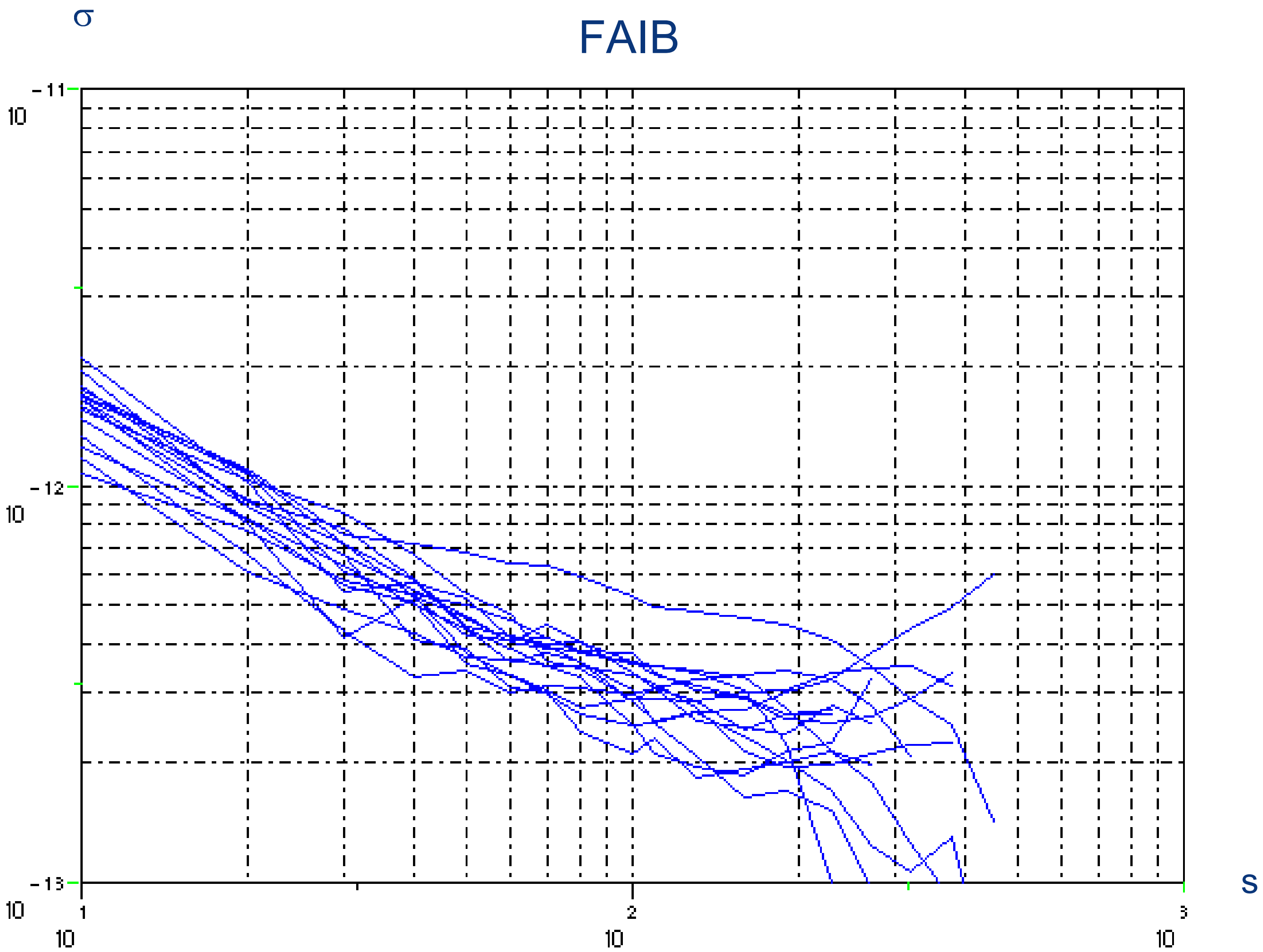
Results similar to Spot 5

Combination 5*L1-L2



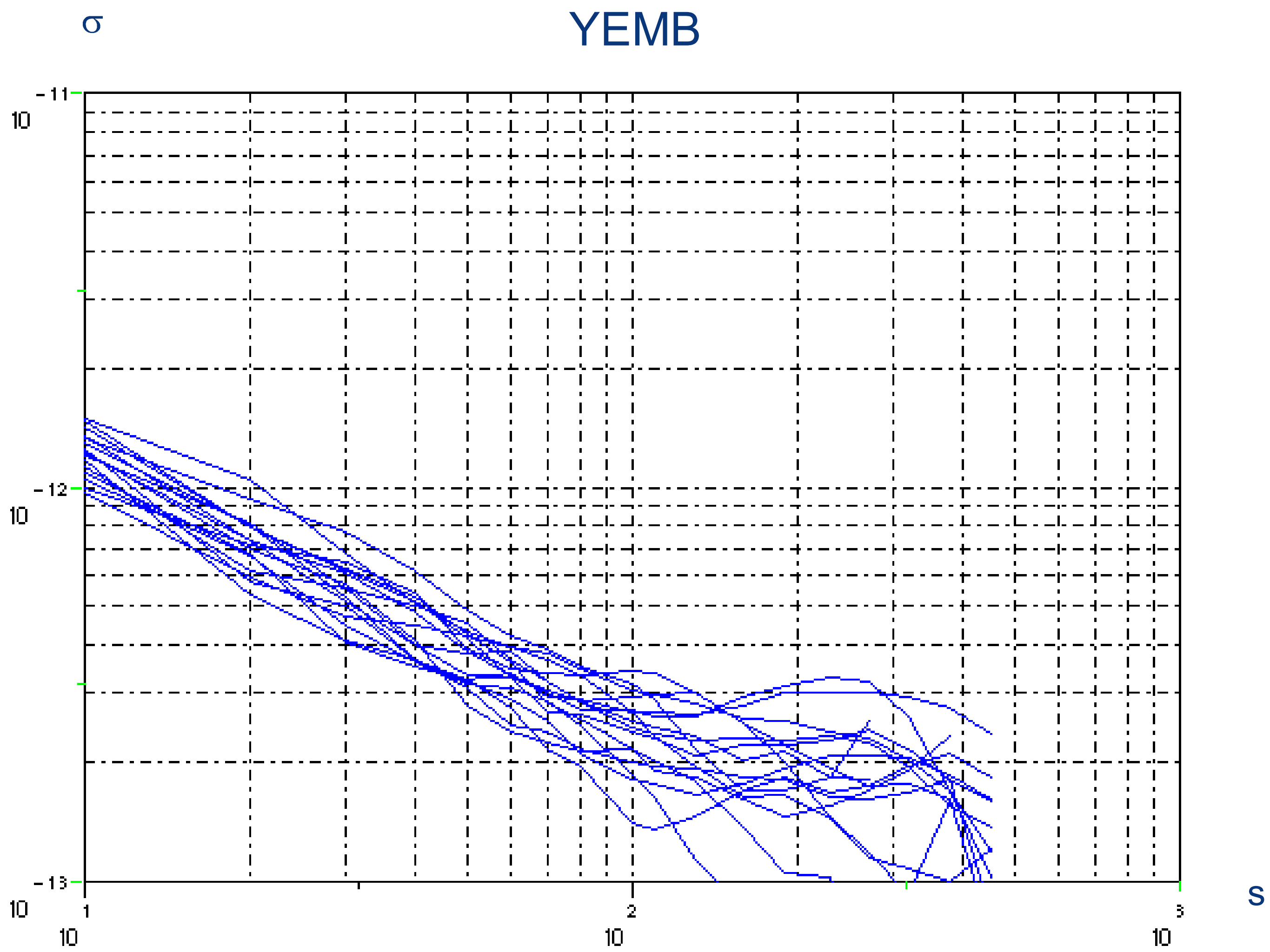
Correction of the small Doppler L1 cycle slips

Allan variance FAIB



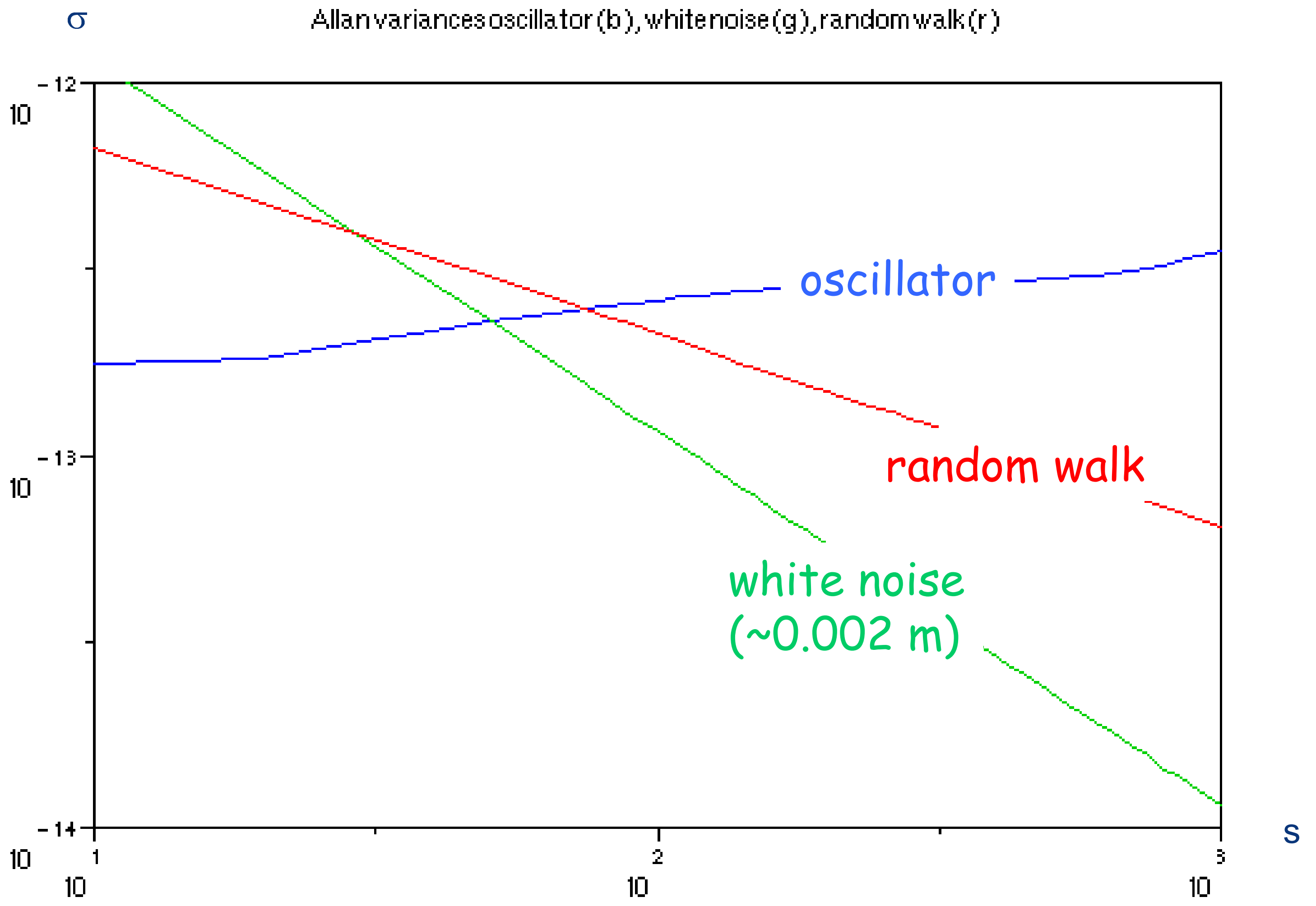
Slope between -½ and -1 : effect of the oscillator combined with phase measurement noise

Allan variance YEMB



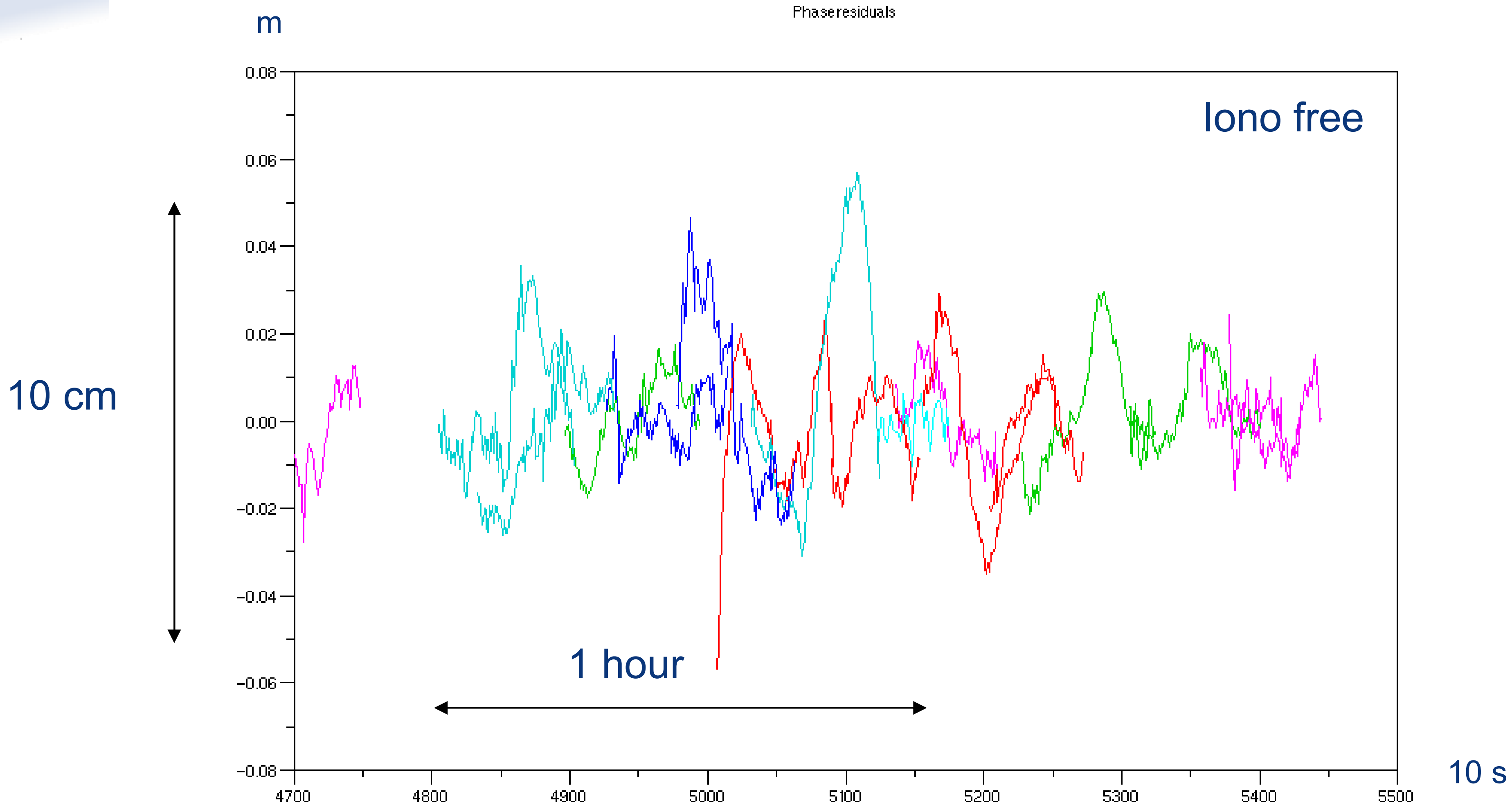
Slope between -½ and -1 : effect of the oscillators combined with phase measurement noise ?

Allan variance characteristics



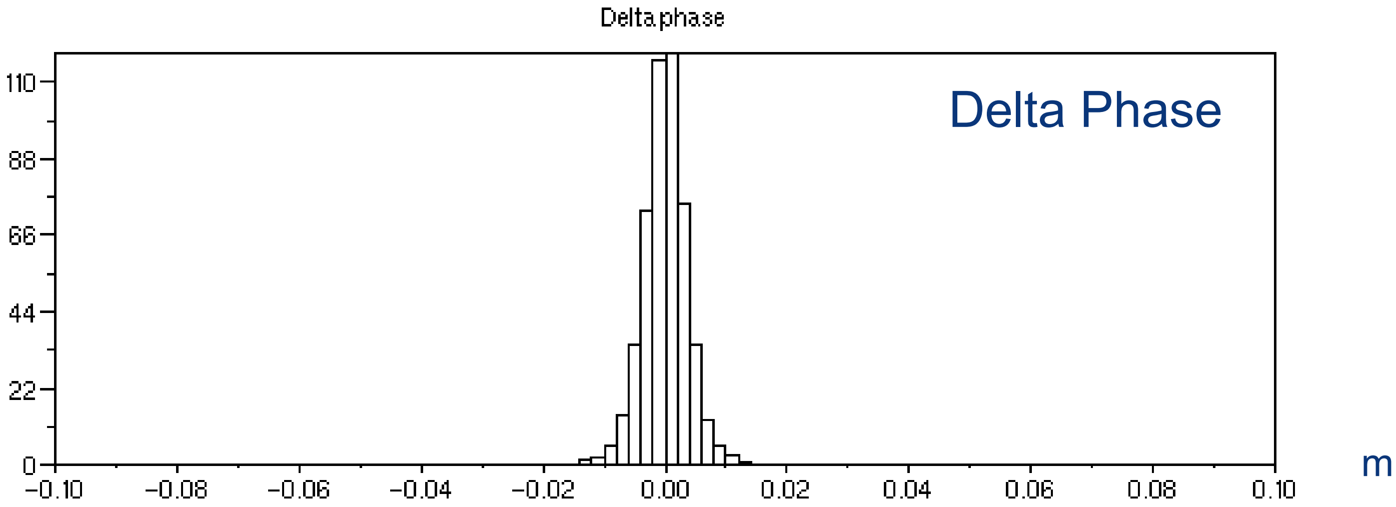
See SWT 2006 presentation (Venice)

Phase residuals time history



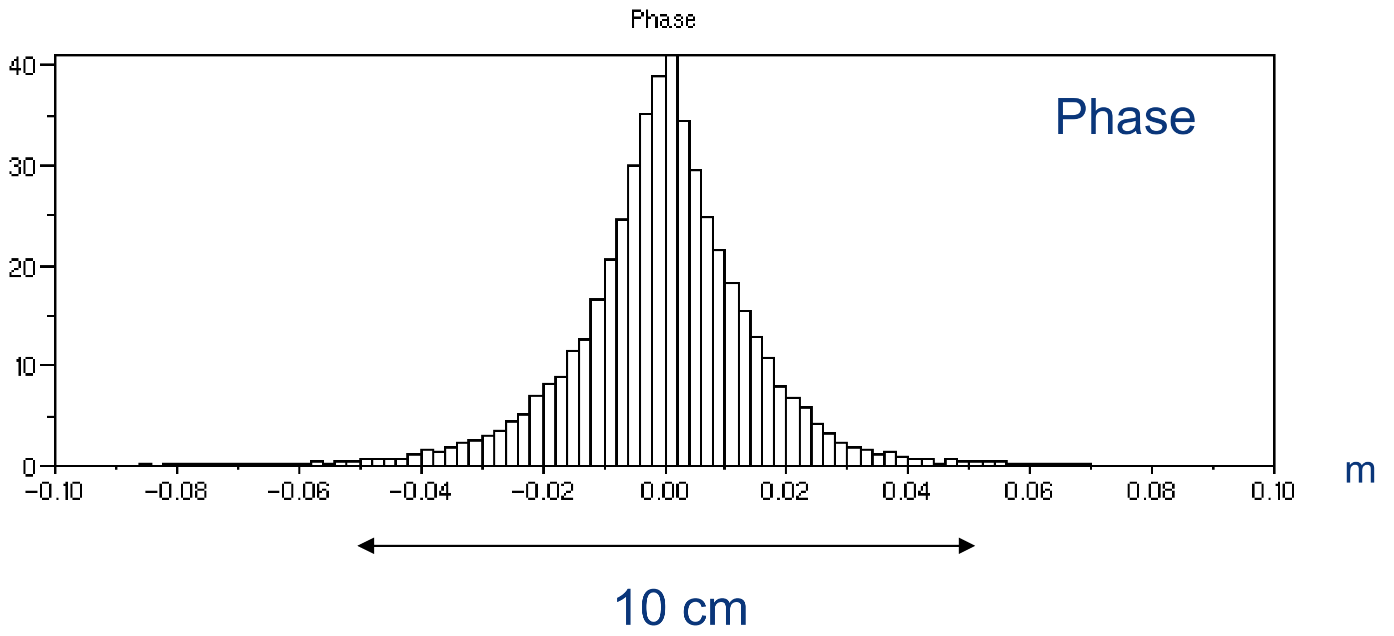
(bias and drift adjusted for each pass)

Phase and Doppler residuals statictics



rms is important due to the low frequency content

does not reflect the true measurement noise



Conclusions

Rinex format : very easy to use

no specific satellite/receiver correction to apply

the observables are very similar to GPS (pseudo-range and phase)

currently used in the POD Jason2 process

Phase measurements :

Investigation of the small cycle slips occurrence

L1 jumps possible at low Doppler, low elevation

- all these jumps can be reconstructed

L2 jumps not so frequent

- not easy to detect and reconstruct

Allan variance analysis

- confirmation of the 2006 Spot5 studies
  similar noise and oscillator effects
- it is necessary to take into account the oscillator behaviour
  the best way (up to now) : Doppler by differentiating the phase

Doris solutions using phase : improve the paramerisation for the oscillators behaviour