Radio astronomy training at VATLY

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VATLY
Vietnam Auger Training LaboratorY

High Energy Cosmic Rays

collaboration with

the Pierre Auger Observatory

in Argentina

→

Radio-astronomy

- *collaboration with French institutes on the study of data collected in the Plateau de Bure, Nancay, VLA*
- *21 cm observation (SRT) at home*

The VATLY Radio Telescope

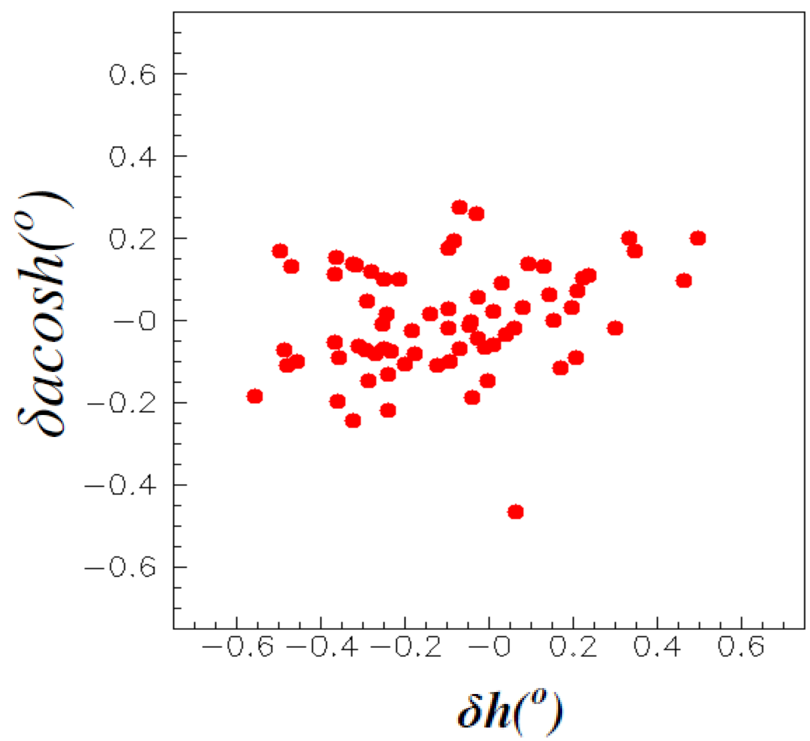
- mobile parabolic dish, 2.6 m in diameter
- observation in the region of the 21 cm hydrogen line
- pointing accuracy of ~0.3^{o} (after applying corrections of ~1^{o})
- the size of the lobe (FWHM) measured to be 5.5±0.3^{o}

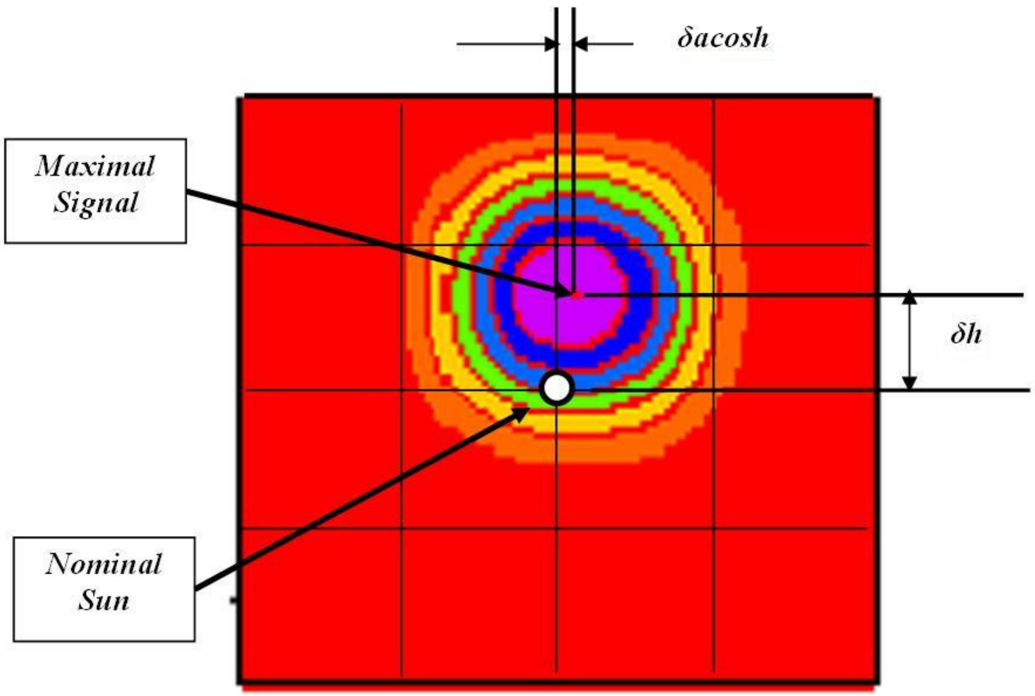
Pointing corrections

$$\delta a = \varepsilon_1 \cos a \tan h - \varepsilon_2 \sin a \tan h + \varepsilon_3$$

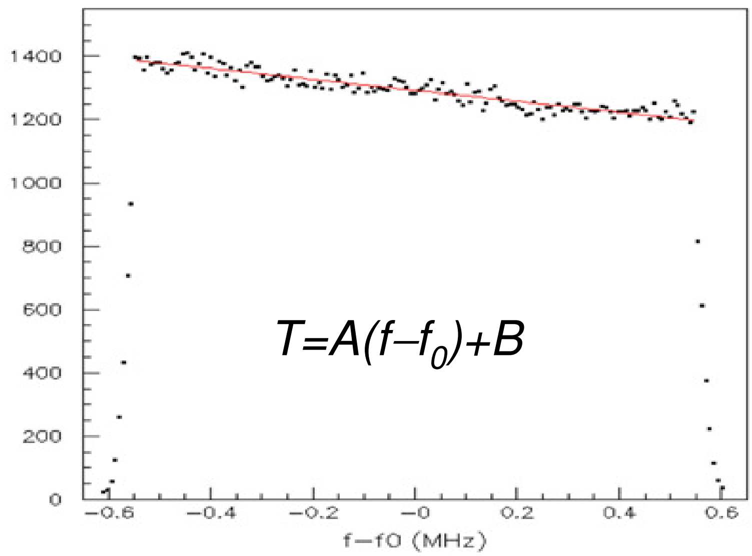
$$\delta h = -\varepsilon_1 \sin a - \varepsilon_2 \cos a + \varepsilon_4 \partial h/\partial + \varepsilon_5$$

$\varepsilon_1 = 0.89 \pm 0.03$, $\varepsilon_2 = 0.82 \pm 0.06$, $\varepsilon_3 = -0.10 \pm 0.01$, $\varepsilon_4 = 1.07 \pm 0.03$, $\varepsilon_5 = 0.68 \pm 0.01$

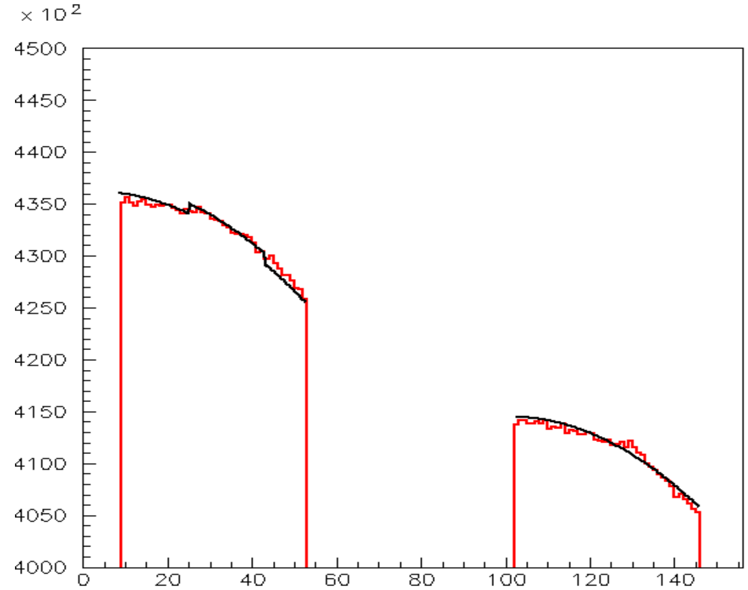




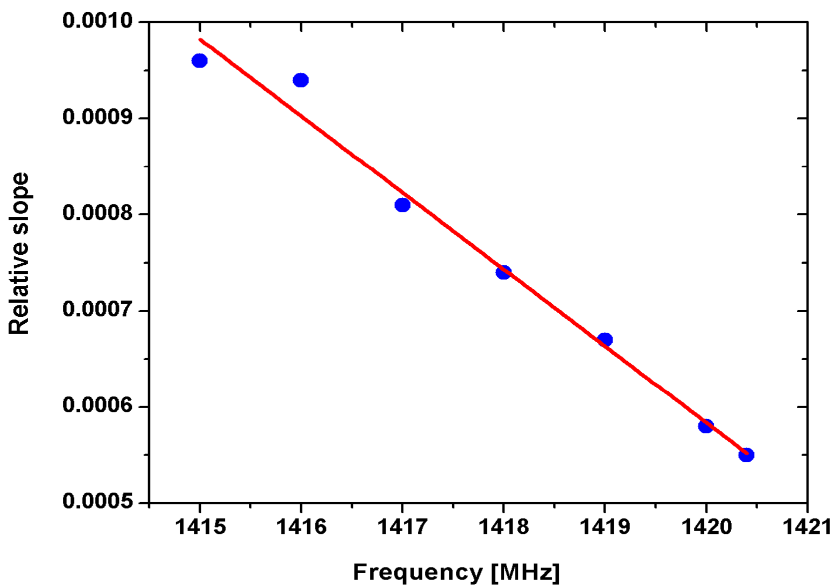
Response of the SRT

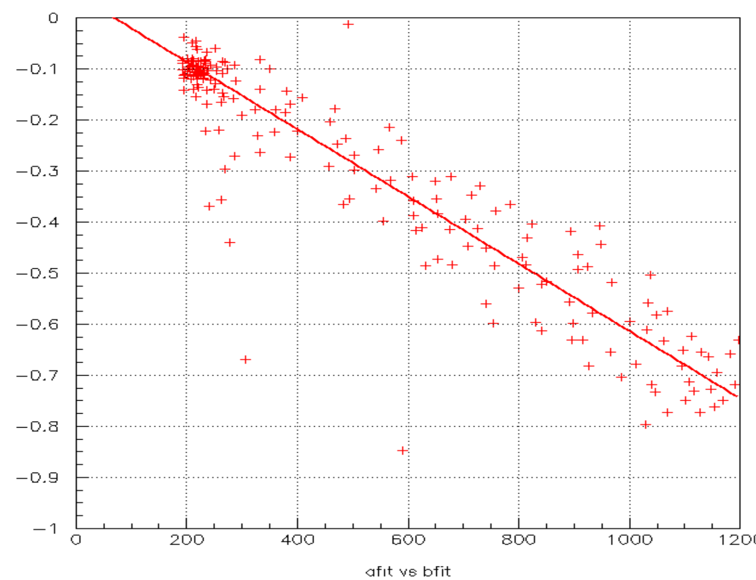


frequency spectrum



Gain is non linear

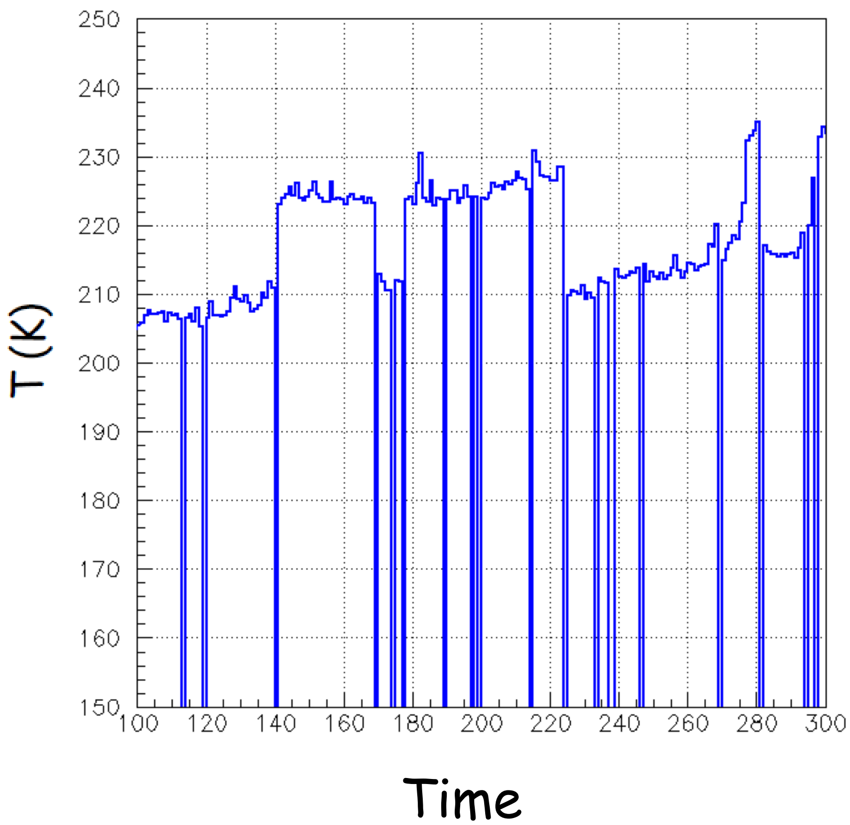




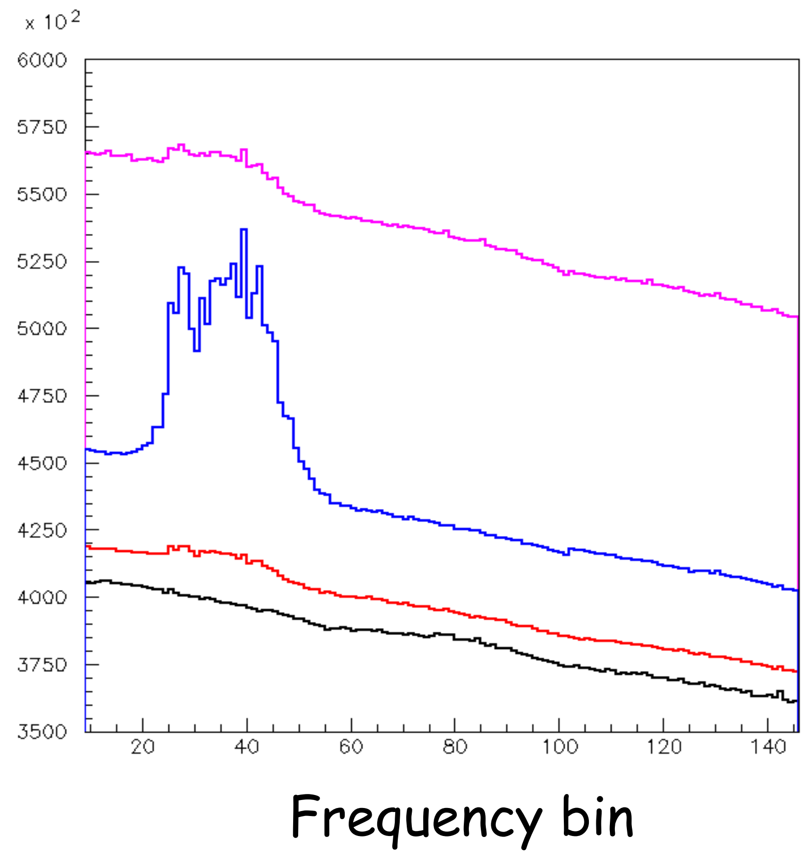
slope increases with amplitude

Response of the SRT

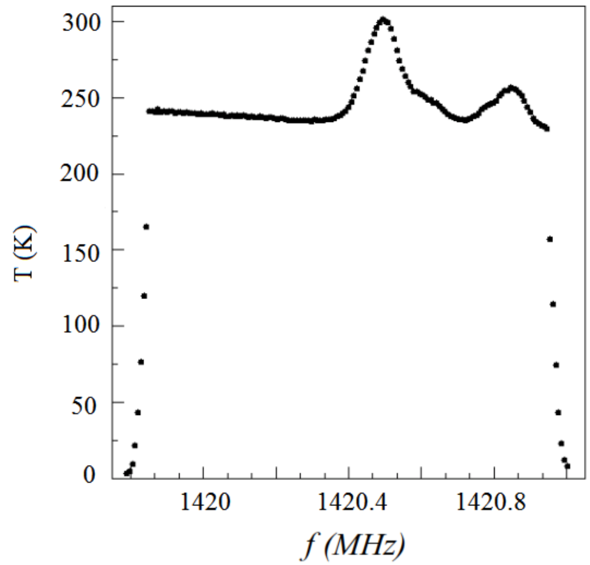
Occasional jumps

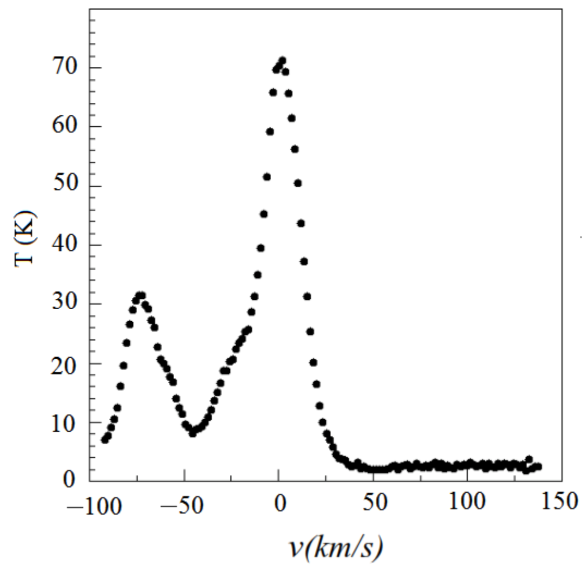


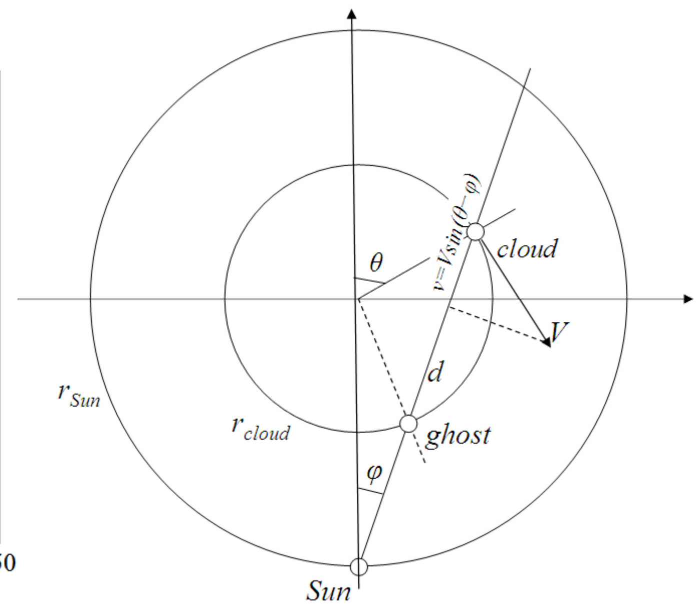
Interferences

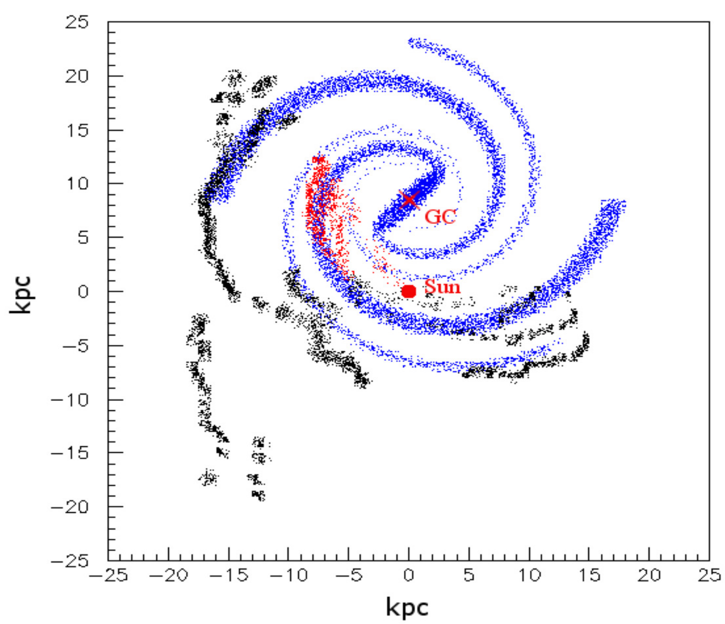


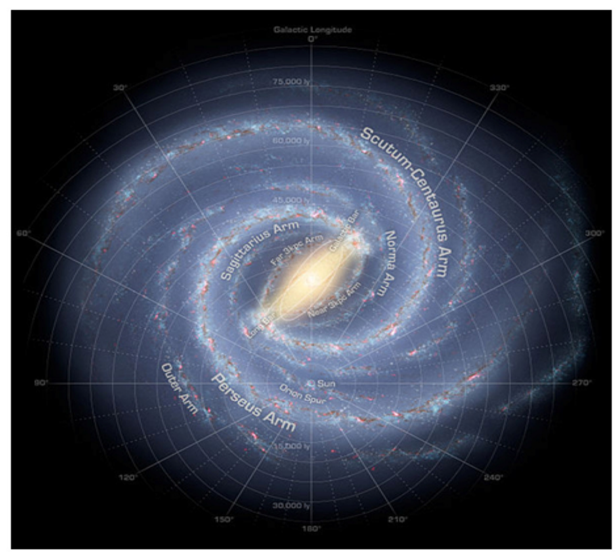
Mapping HI in the Milky way











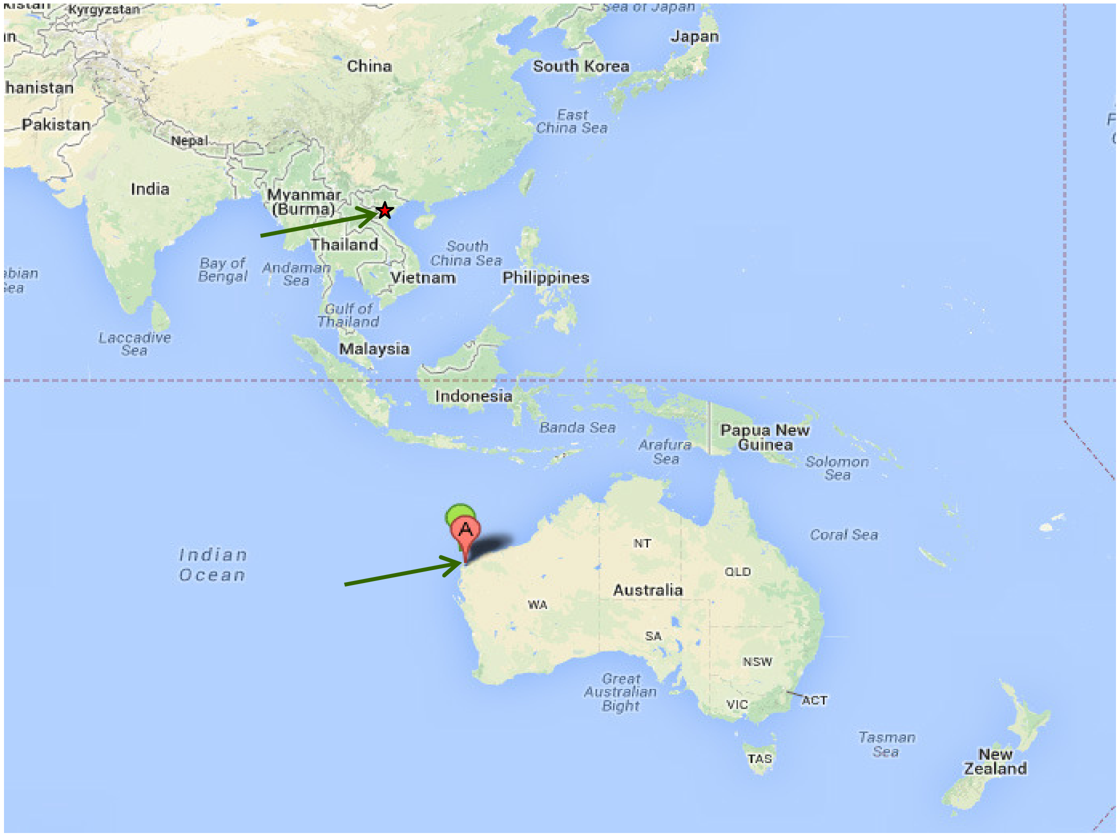
General features

The Sun was observed nearly continuously in the period between mid April and early September 2012.

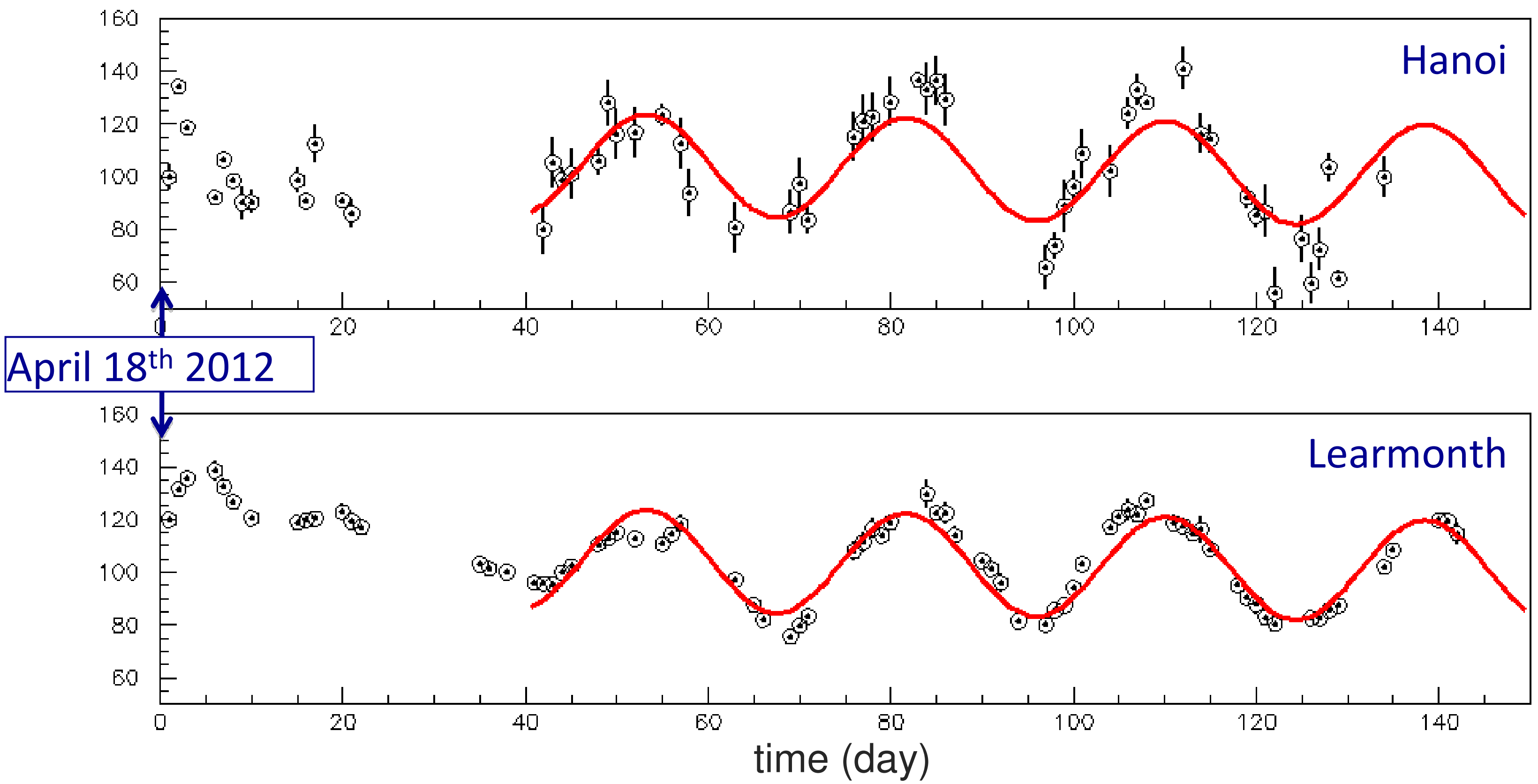
SRT was operated at a frequency of 1.415 GHz

The data are compared with data from the Learmonth Observatory taken at the same frequency during the same period.

Hanoi and Learmonth are located at nearby longitudes (105.8° E/114.1° E) and at nearly opposite latitudes (21.0° N/22.2° S).



Dependence on calendar time of the daily average signals

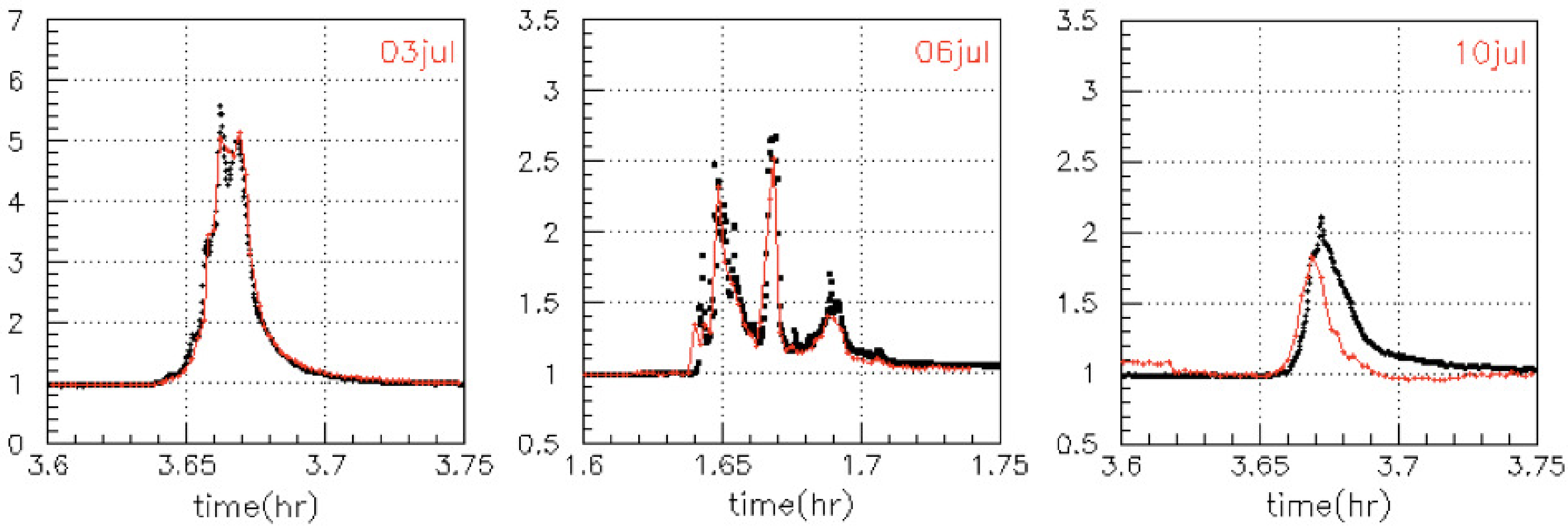


Learmonth and Hanoi data are consistent, the noise in the Learmonth data is typically 1.7 times lower.

28 day rotation period of the Sun has a strong effect on the measured signal: increases ~ 50% between minima and maxima.

Comparing Hanoi data with Learmonth data:

30 flares common to both sets (½ are single flares);
an increase of ~ 15% with respect to the quiet Sun level;
3 flares exceed 40% (on July 3rd, 6th and 10th).

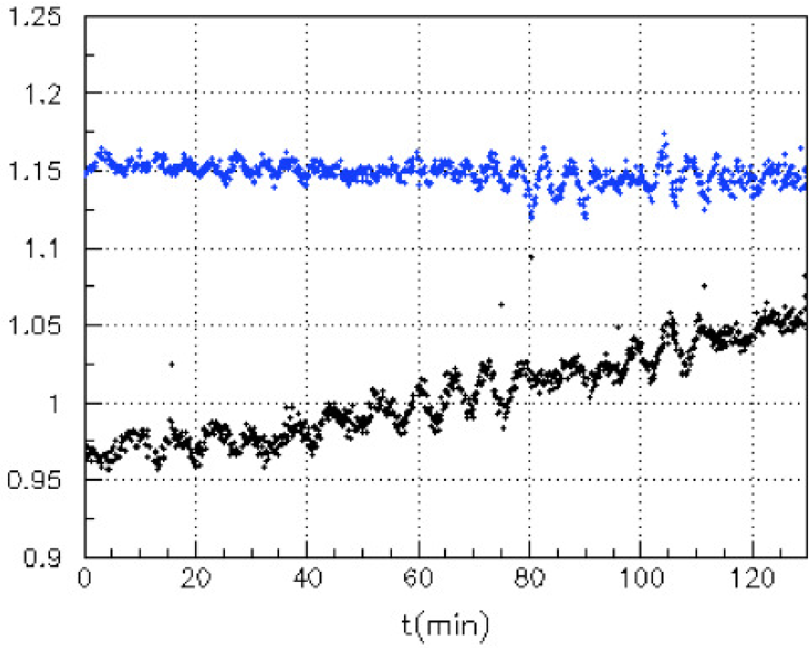


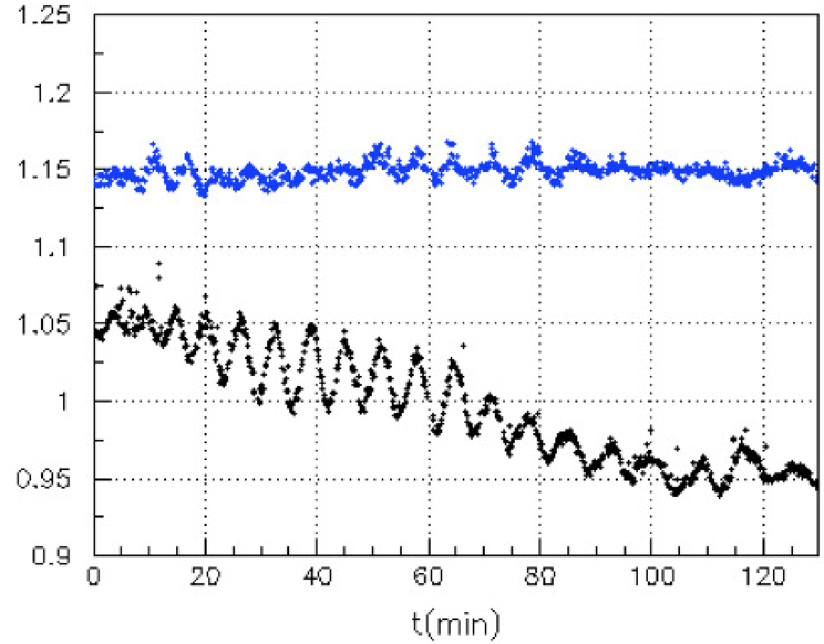
Hanoi

Learmonth

Oscillations: observations

Oscillations at the percent level present in both the Learmonth and Hanoi data, with typical periods of five to seven minutes.





Learmonth and **Hanoi** data

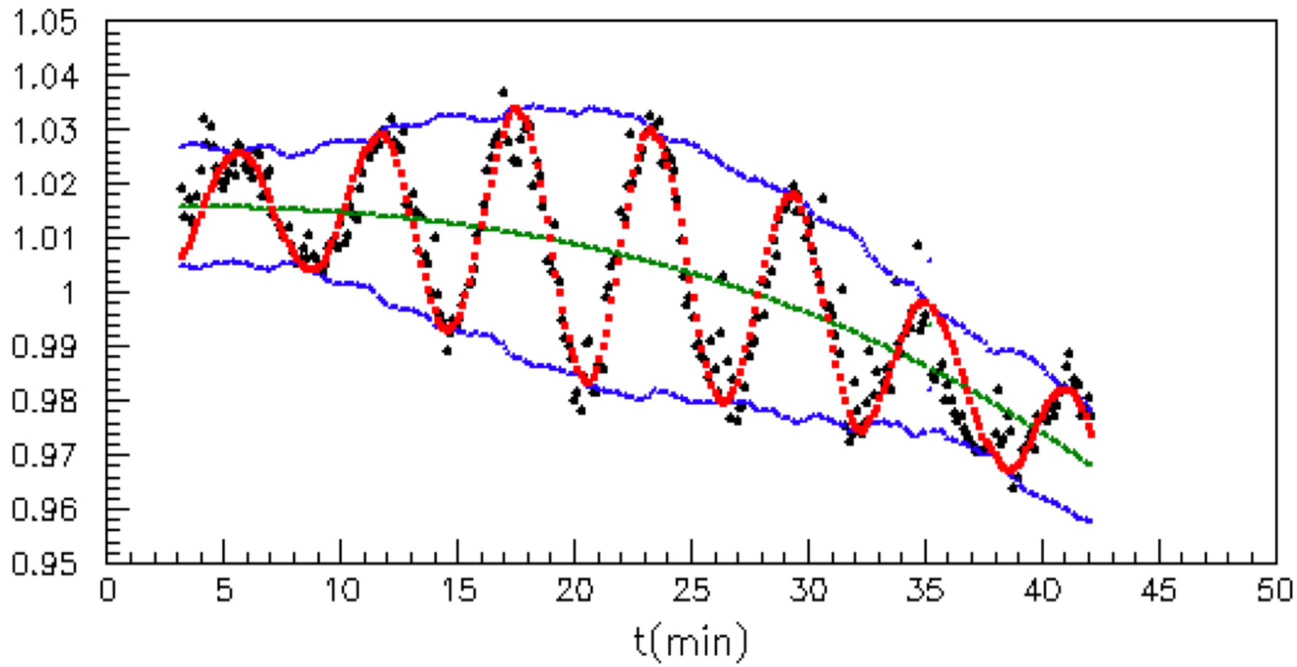
Intervals defined as data taking periods lasting more than 25 mn and including no interruption longer than 5 mn. The average duration of an interval is 40 mn.

In each interval, the Hanoi and Learmonth data are analysed separately.

Data sets are first fit to a third degree polynomial ***P(t).***

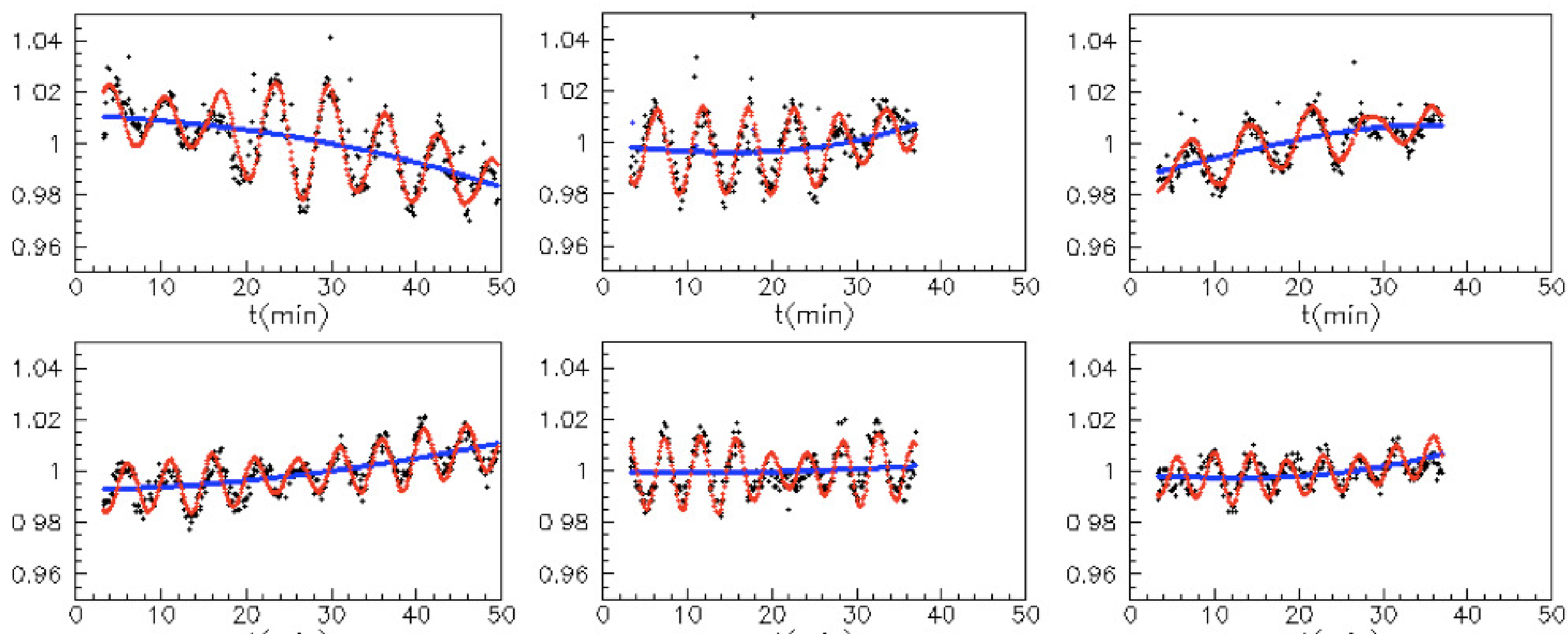
The amplitude ***A(t)*** of the oscillations is evaluated at each point from the deviation of the detected signal, ***S(t)***, with respect to ***P(t)*** in a 6 mn interval centred on the point.

Finally, the data are fit to a form: $S(t)=P(t)+A(t)\sin(2\pi t/T+\varphi)$



In 124 out of 304 time intervals both Hanoi and Learmonth data are properly described by such a form.

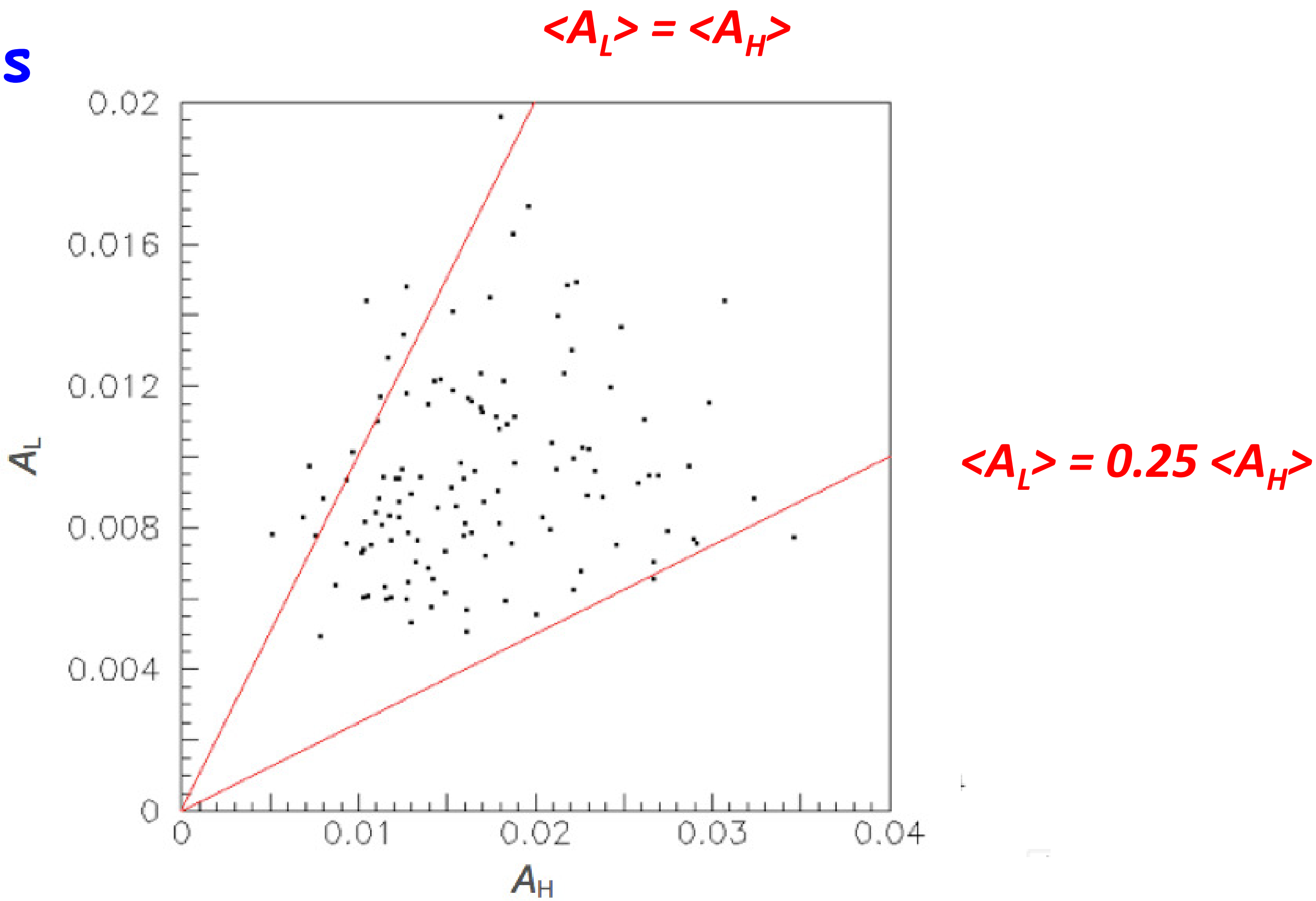
Hanoi



Learmonth

Oscillations are usually clear sine waves, however with amplitudes and, to a lesser extent, frequencies that may vary over the interval.

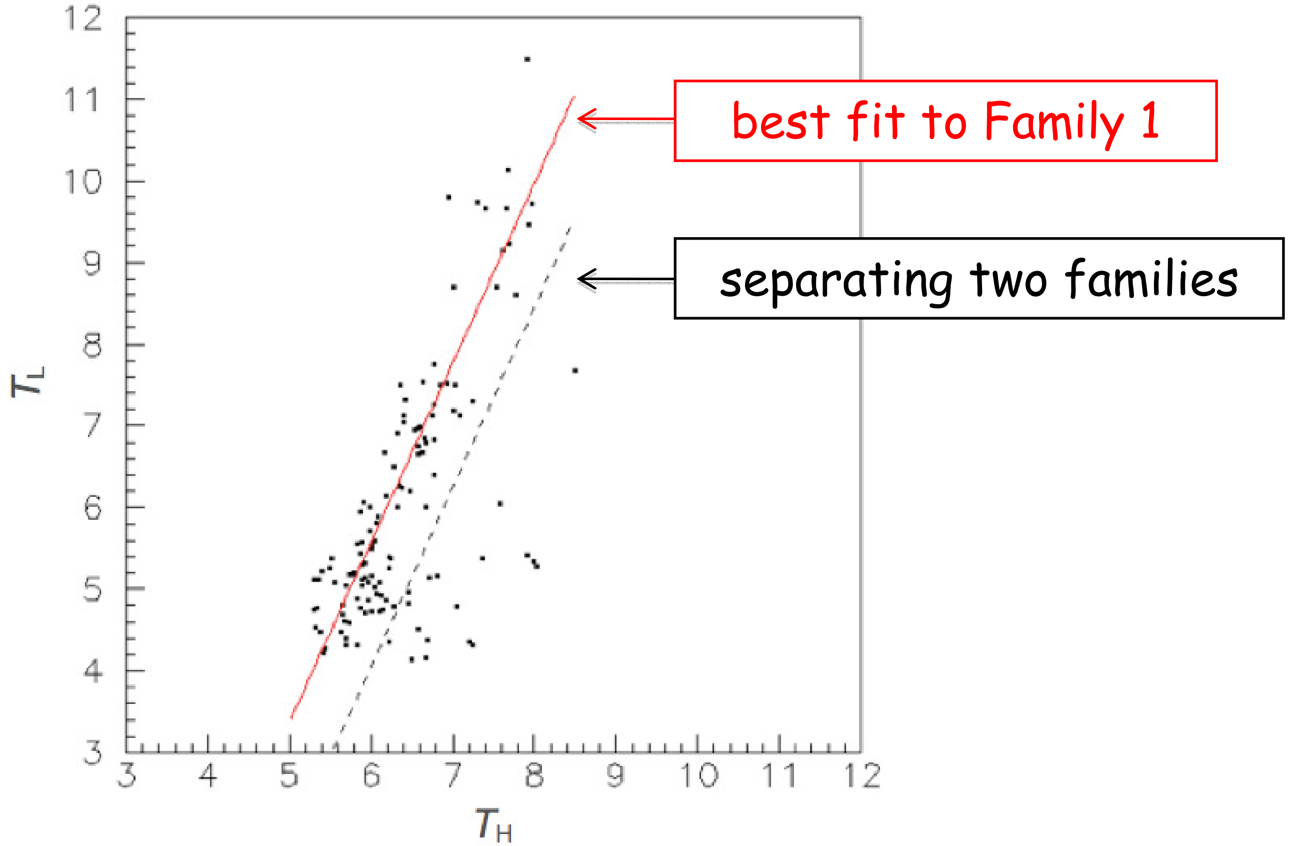
amplitudes



The mean values of $\langle A_H \rangle$ and $\langle A_L \rangle$ for intervals are 1.68 % and 0.96 % respectively,

→ a factor 1.75 higher in Hanoi than at Learmonth.

periods



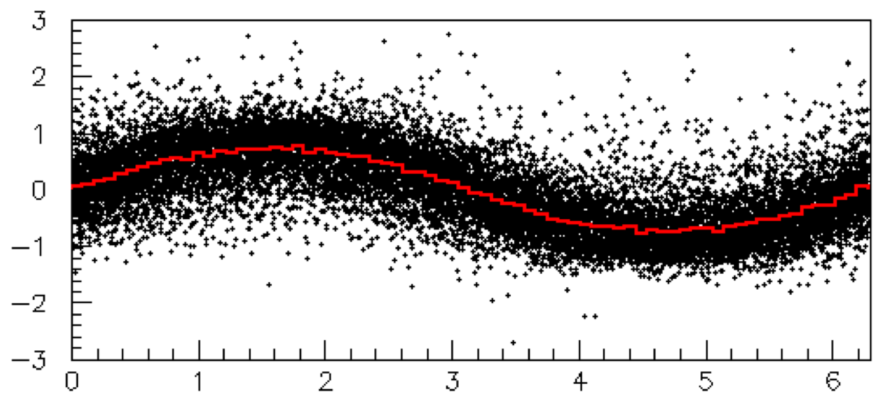
At variance with amplitudes we observe a strong correlation between Hanoi and Learmonth periods.

We select family 1 (105 intervals) where the correlation reads:

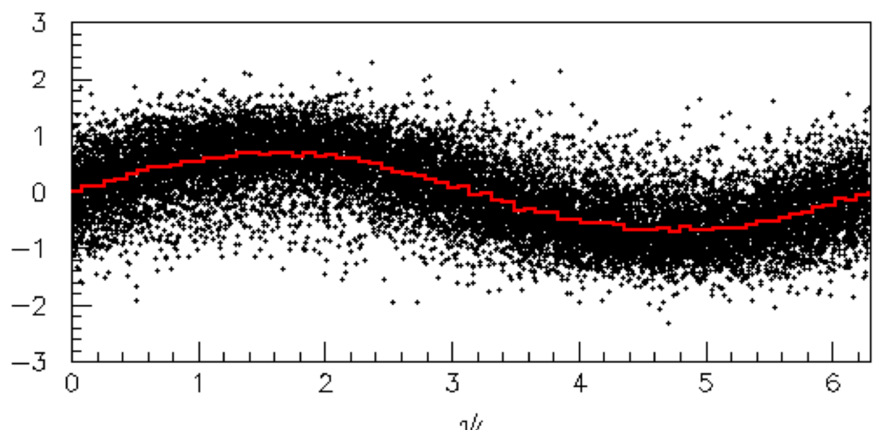
$$T_L = 2.2T_H - 7.6 \text{ mn}$$

Shapes of the observed oscillations

Hanoi



Learmonth



Distribution of ***[S(t)−P(t)]/A(t)*** vs ***[(2πt/T+φ) mod (2π)]***

Both show, on average, a clear sine wave.

S(t)=P(t)+A(t)sin(2πt/T+φ)

$$S(t)=P(t)+A(t)\sin(2\pi t/T+\varphi)$$

Oscillations: possible instrumental effects

As a check of the **solar origin of the observed oscillations**, we took data by pointing the telescope **15° off the Sun**; the absence of observed oscillations allows for placing an upper limit of 0.3% on their possible amplitudes.

The evidence for correlations between the oscillations observed in Hanoi and at Learmonth **excludes an interpretation in terms of simple instrumental effects**.

However, the similarity between the two instruments implies that they suffer from similar biases or weaknesses.

Oscillations: possible physics interpretations

The differences between the precise values of the periods of observed signals (and the weakness of amplitude correlations) is intriguing and calls for an explanation.

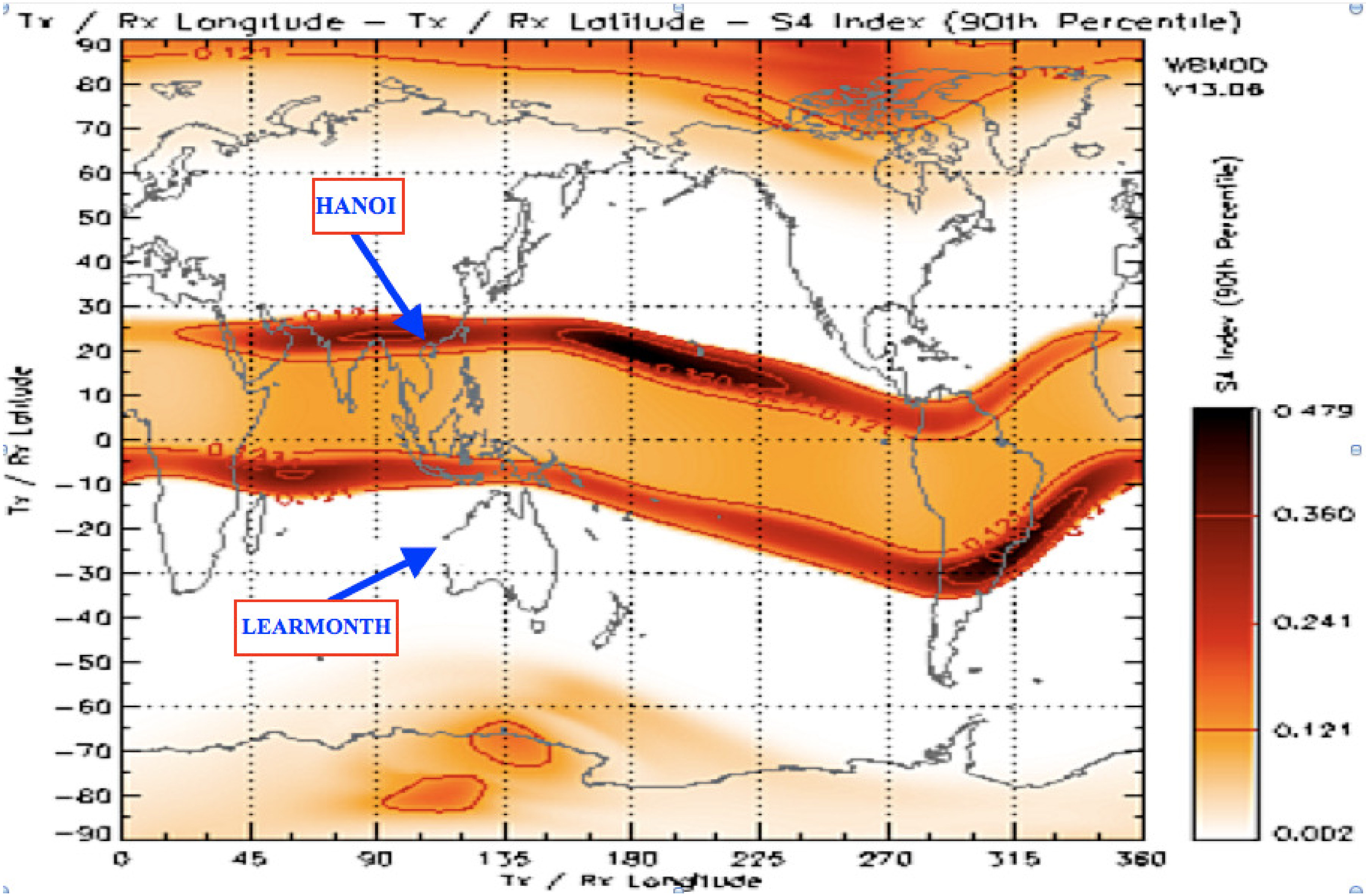
Two natural candidates:

– *the effect of the different polarization states detected in Hanoi (circular) and at Learmonth (linear) and*

– *the effect of different distortions caused by the traversal of the local ionosphere by the solar signal.*

The particular position of Hanoi with respect to the geomagnetic equator implies for it a maximal ionospheric scintillation index S4.

Ionospheric scintillation index S4



For now three weeks, we have started a **new campaign** of observations. We will pursue it for a few months. We have set the central **frequency at 1417.6 MHz (far away from human interferences)** and obtain **data of a significantly better quality** than before.

Lately, the Sun has been extremely active, with many large flares.

As earlier, **important mHz oscillations are observed at both Ha Noi and Learmonth**. The improved quality of our data will allow for a detailed study of the oscillations hopefully leading to a better understanding of what is causing them.

Summary

The Sun has been observed using the VATLY radio telescope at 1415 MHz between mid April and early September, 2012.

The data have been analysed jointly with Learmonth data. Both sets of data see the same general features. They display frequent oscillations at the percent level and with periods around 6 mn.

On average, the Hanoi and Learmonth oscillations display similar behaviours. However, when looked at interval by interval, they differ significantly, displaying important smearing.

The possible effects that might cause such differences are different polarization states or effects of ionospheric transmission.

The study was published in Solar Physics (2013), 10. 1007/s11207-013-0356-y

We are deeply indebted to the Learmonth Solar Observatory staff, who are making their data available to the public, and particularly to Dr. Owen Giersch for kindly answering many of our questions related to these data.

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Thank you for your attention!