Detection and removal of time events in the continuous wave search pipeline

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In the c.w. searches,

- short but huge signals in the time domain affect the data in the frequency domain producing a loss in the efficiency of detection for the signals we are looking for. For example, a delta-like spike in time will enhance the noise level in the spectrum by an amount which depends on the signal to noise ratio (SNR) of the spike.

The procedure

- **Described in CQG, Volume 26, Number 20, 21 October 2009**
  - ***As a by-product it can be used to identify events and characterize the noise of the detector***
- ***Here we have used the h-reconstructed (blue) channel and the dark fringe (red) channel***

Events detection

- Because of the non-stationary noise, the variance changes with the time and hence the sensitivity of the detector changes with the time. This implies that, to detect events, we must change the threshold with the time   (“adaptive threshold”)

We use AR procedure to identify events

Time events detection

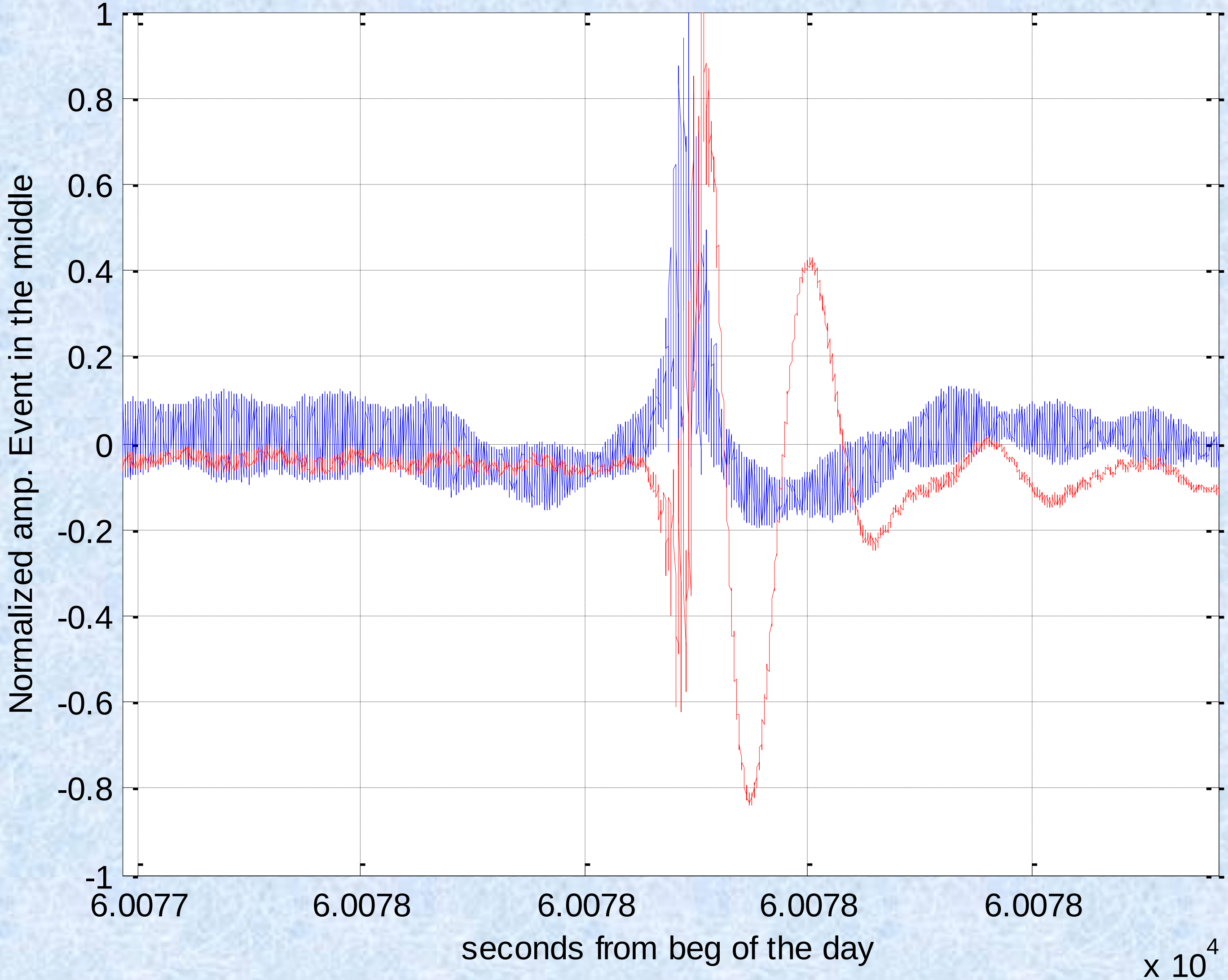
- **EVT:** events which affect the whole band, after the application of an high-pass filter
- **EVB**: events which affect sub-bands.

  It might happen that a spike releases energy only in a particular band and, when its effect is integrated over the whole detector band, the global energy release is small, so small that the event is missed during the first step of the cleaning procedure.

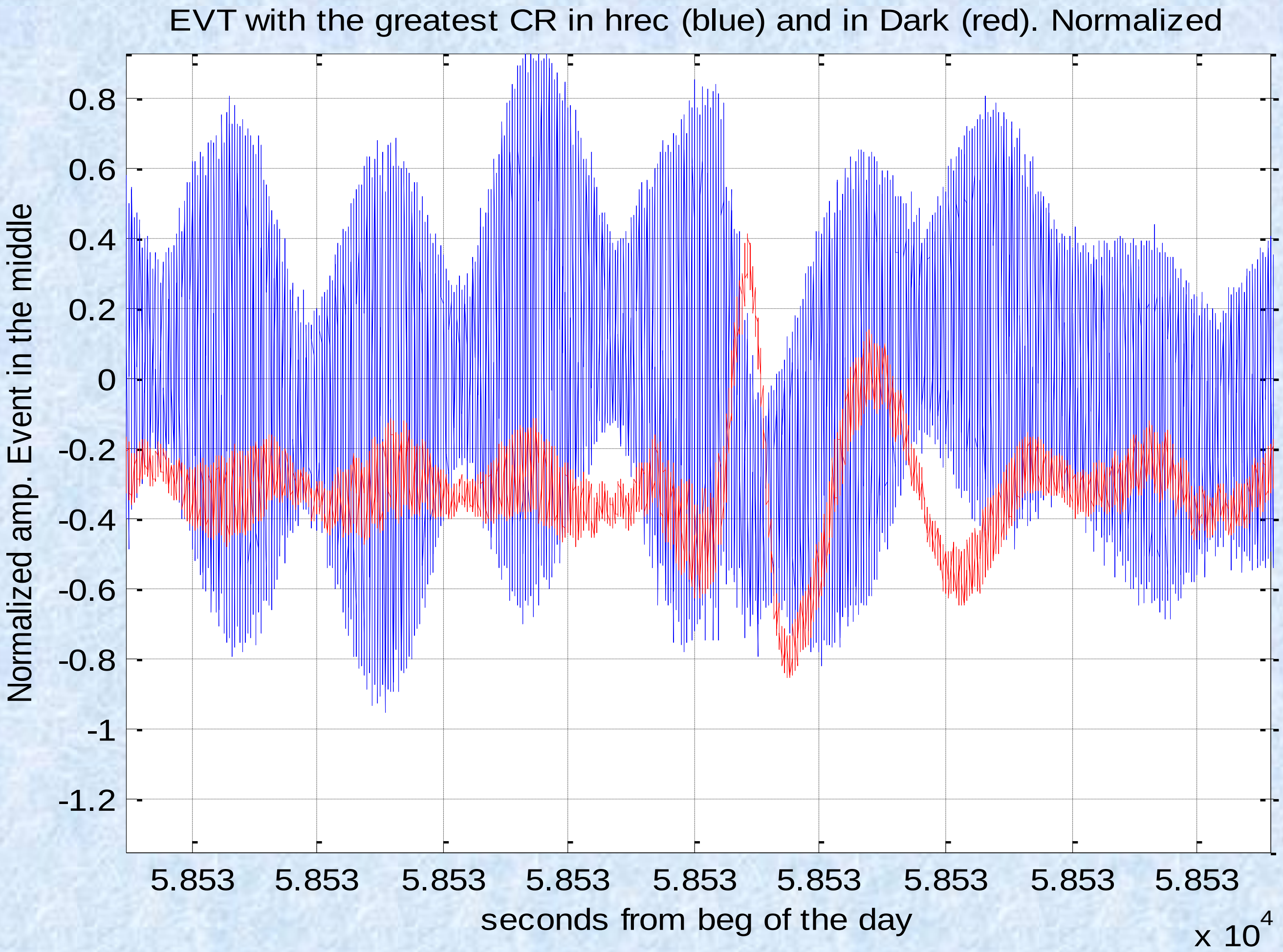
H-reconstructed and Dark fringe

- We have found a good – better than in past data- agreement among the two channels, but some events were still not coincident.
- We applied the procedure to VSR2 data taken in July.
- Here we give some examples

Example of EVT : h-rec (blue) and dark (red)

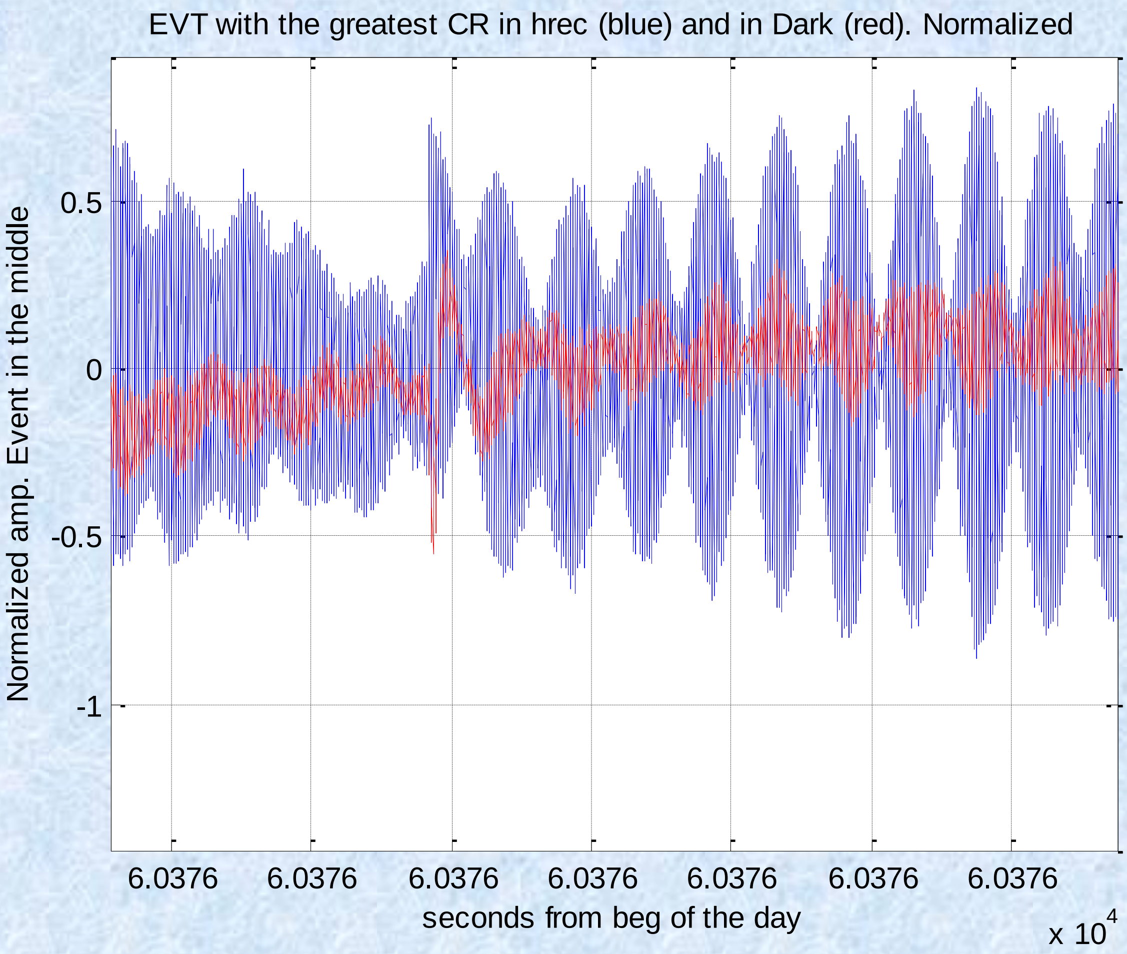


Here the burst is not visible in h-rec, hidden by a huge low frequency noise

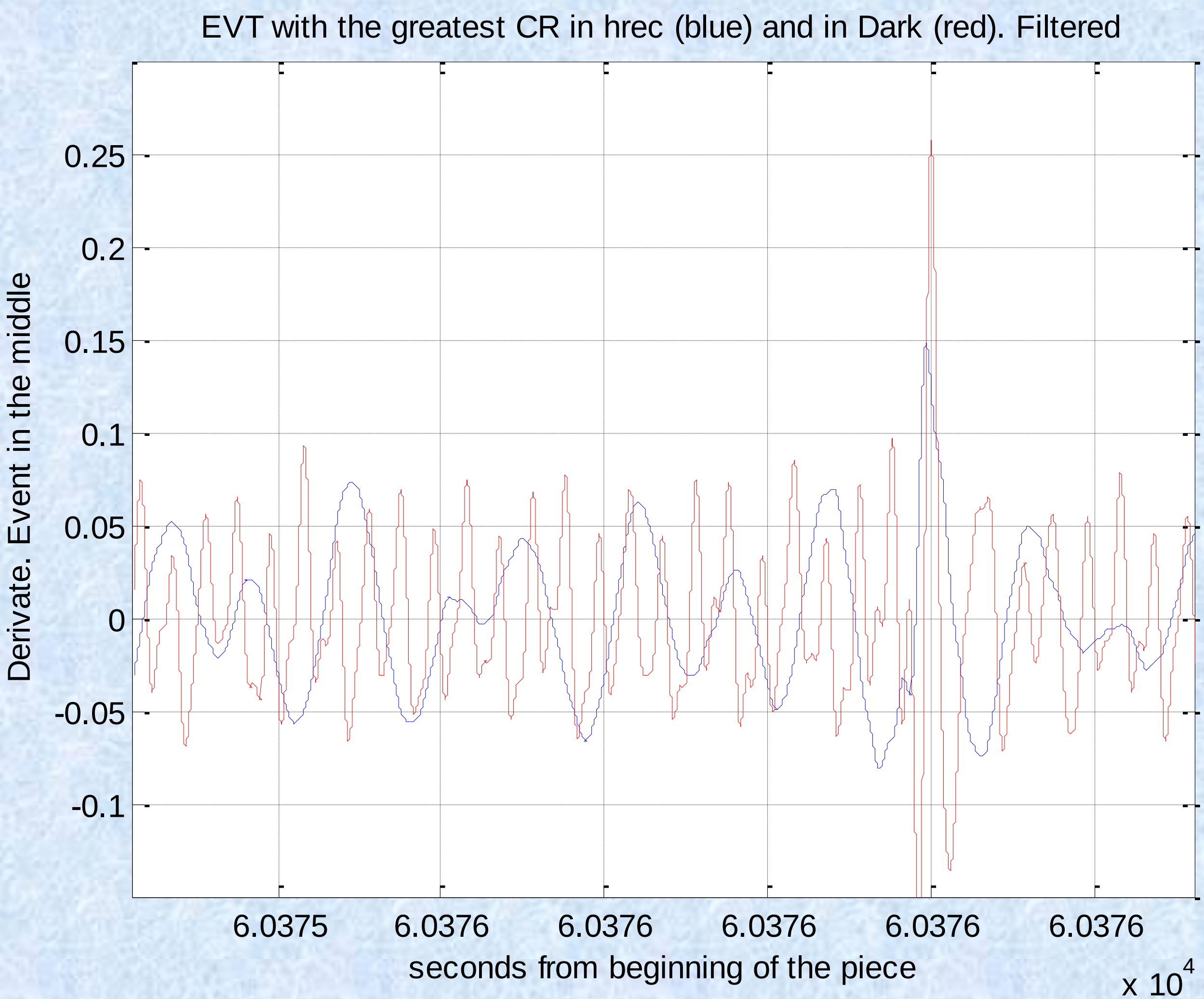


But it can be seen after a proper filtering:

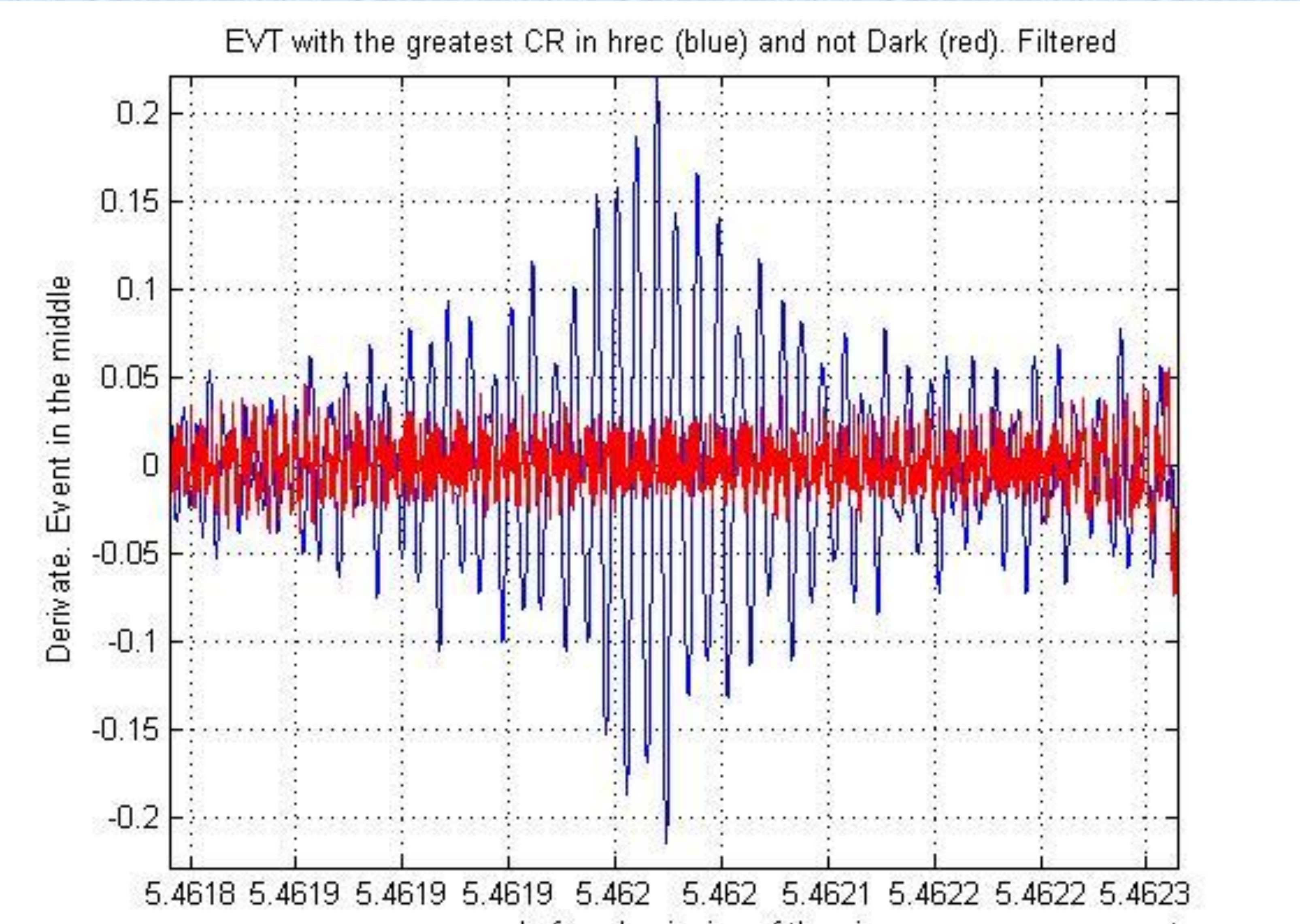
The same situation here:



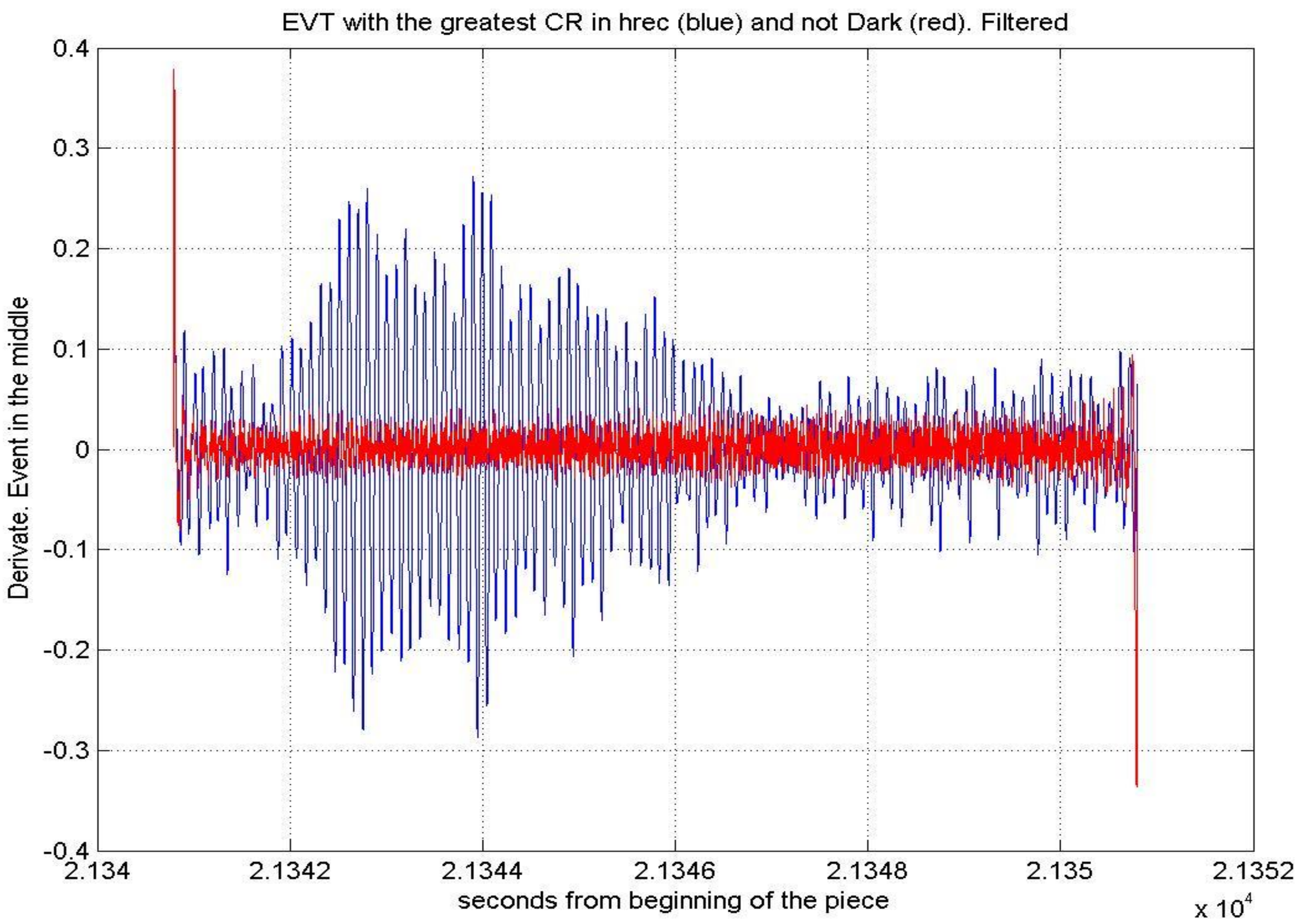
But after high-pass filter the burst is well visible in both the channels

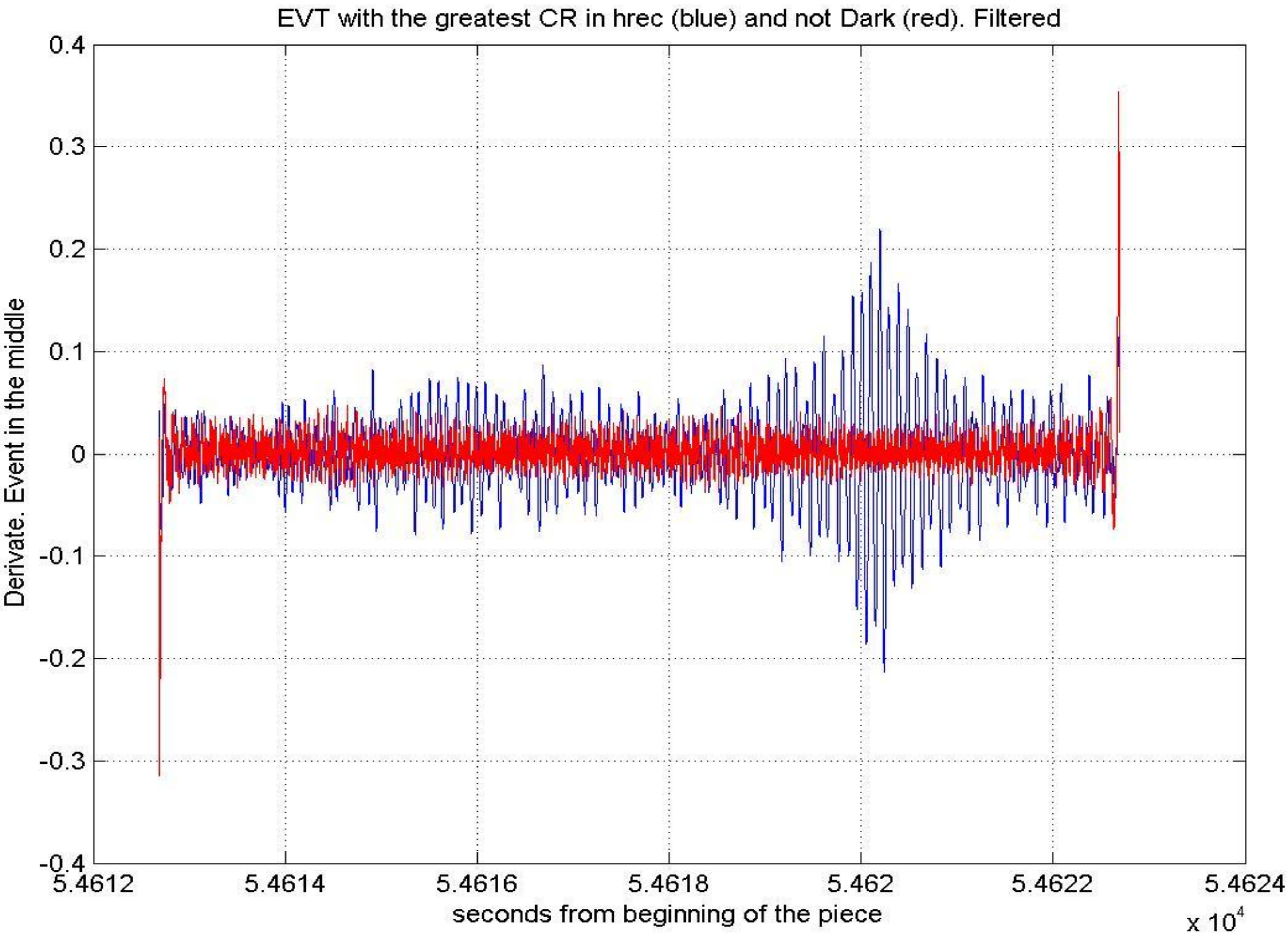


Filtered EVT present in h-rec and not in dark ?



Another example



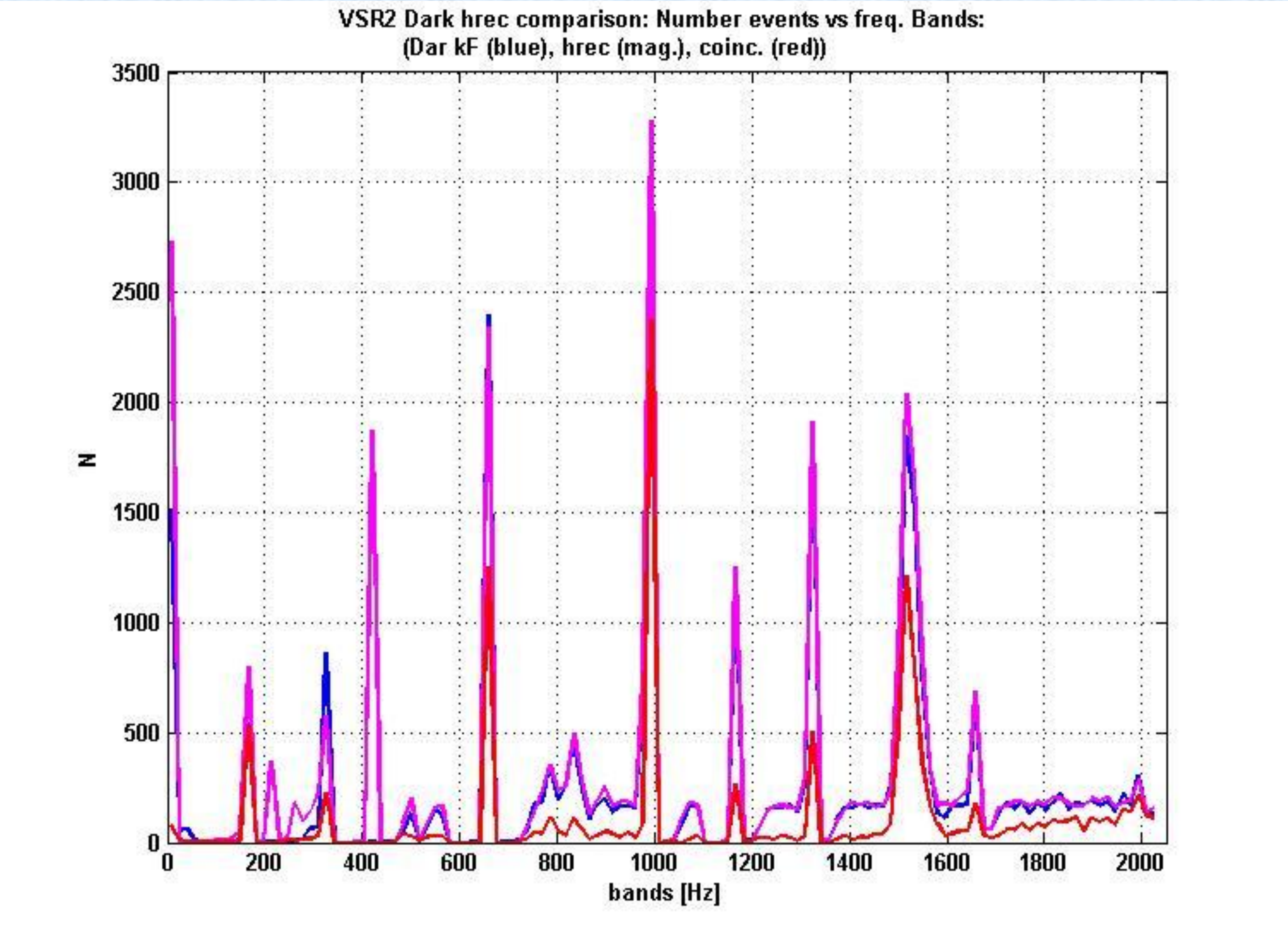


EVT with the greatest CR in hrec (blue) and not Dark (red). Filtered
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
Derivate. Event in the middle
5.4612
5.4614
5.4616
5.4618
5.462
5.4622
5.4624
seconds from beginning of the piece
x 10^4

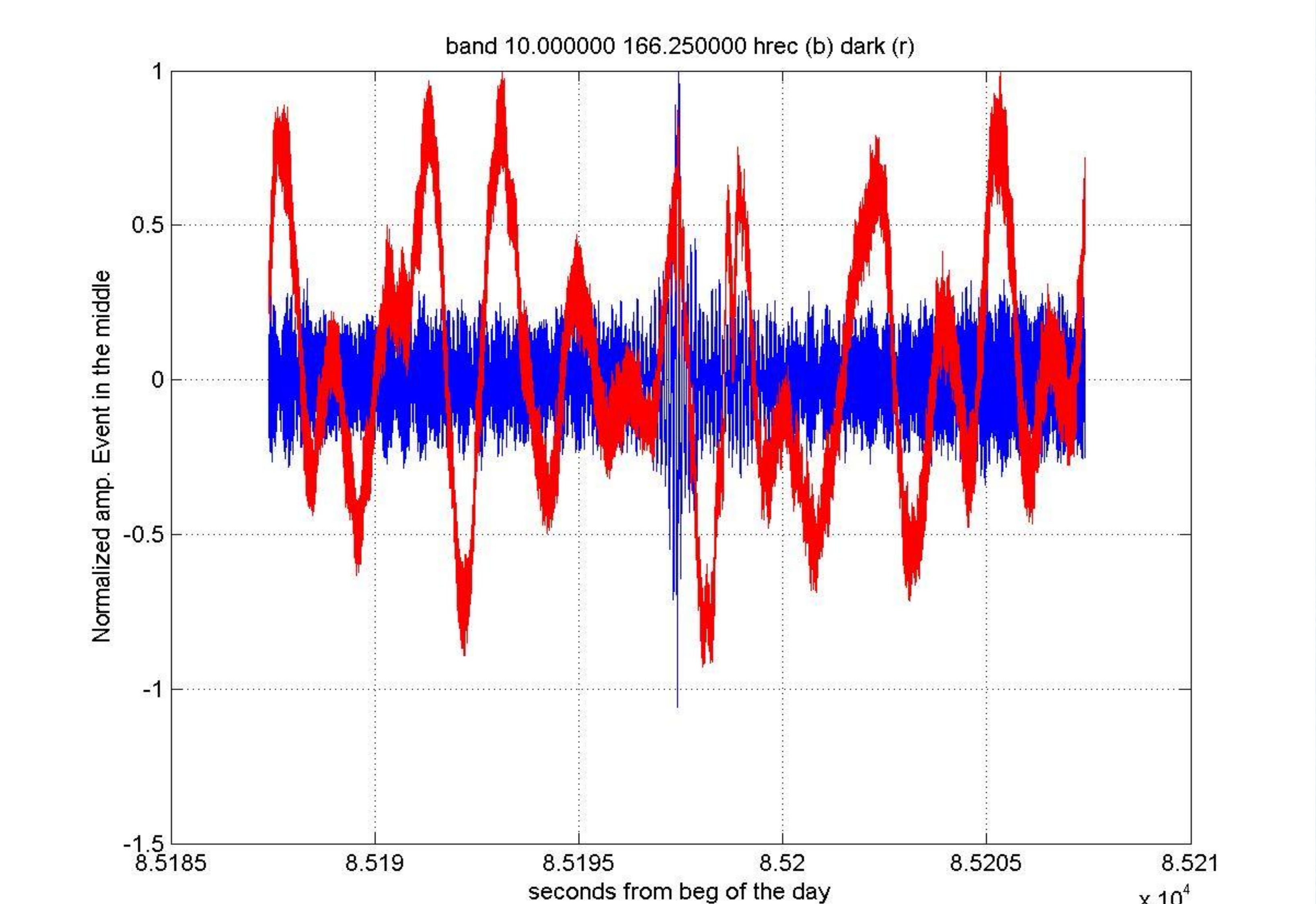
Detection of ‘EVB’

- Events detected over sub-bands
- Extension of sub-bands: the sub sampling factor we have chosen here is 256, which means bands of 16 Hz for the 4096 Hz data and of 156 Hz for the 20 kHz data

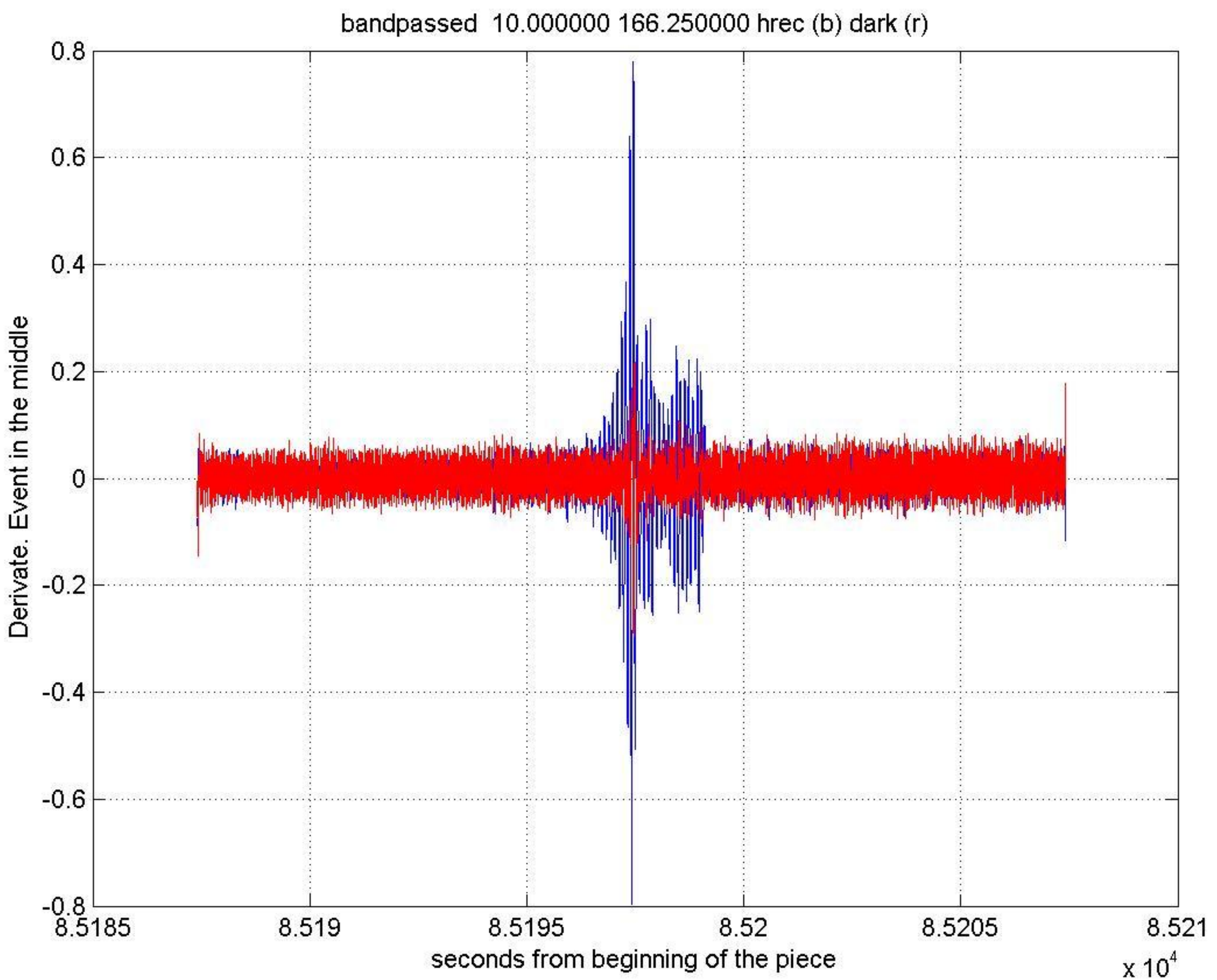
Number of events vs frequency bands



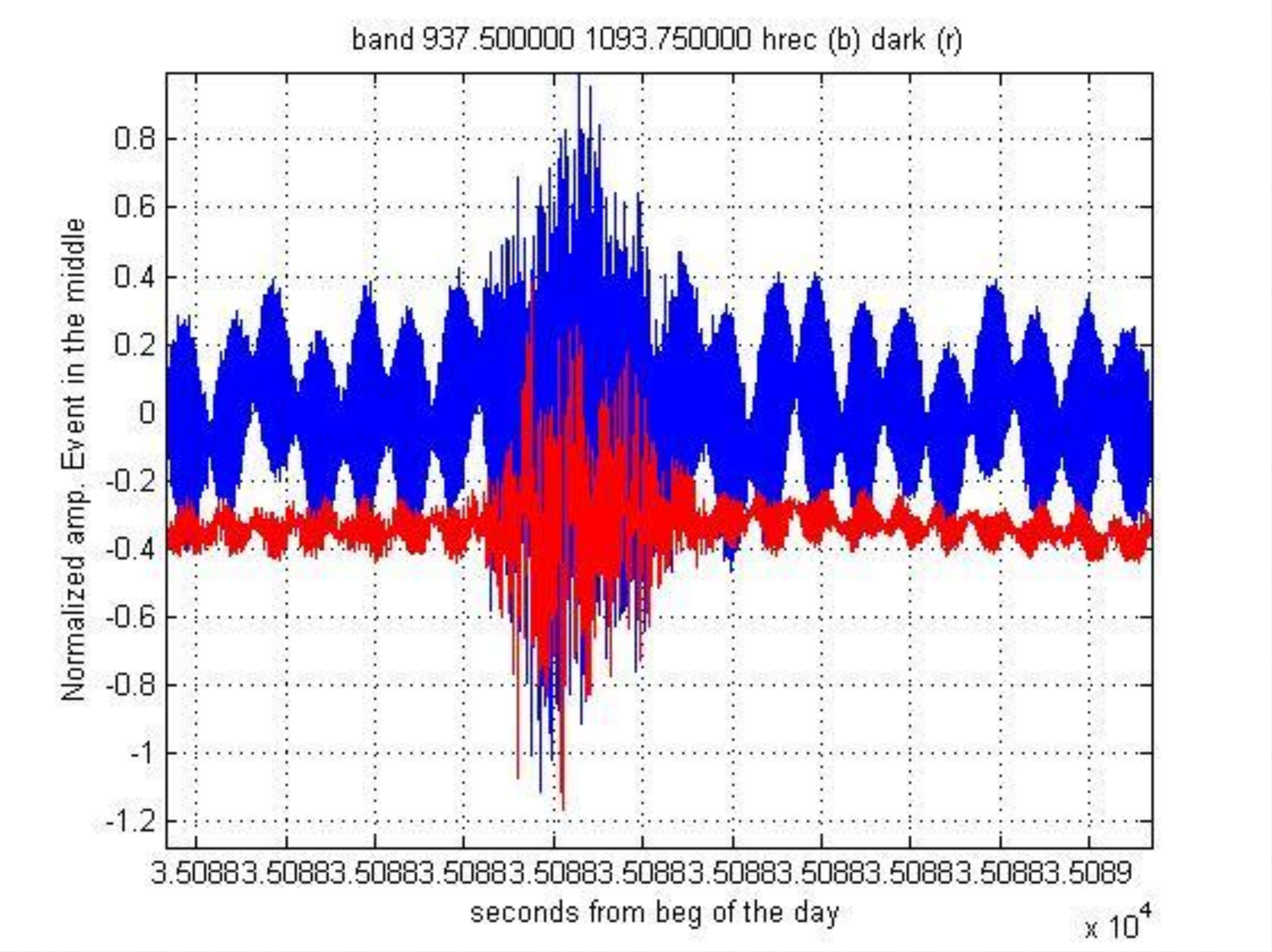
Event detected in the band (10-166.25) Hz



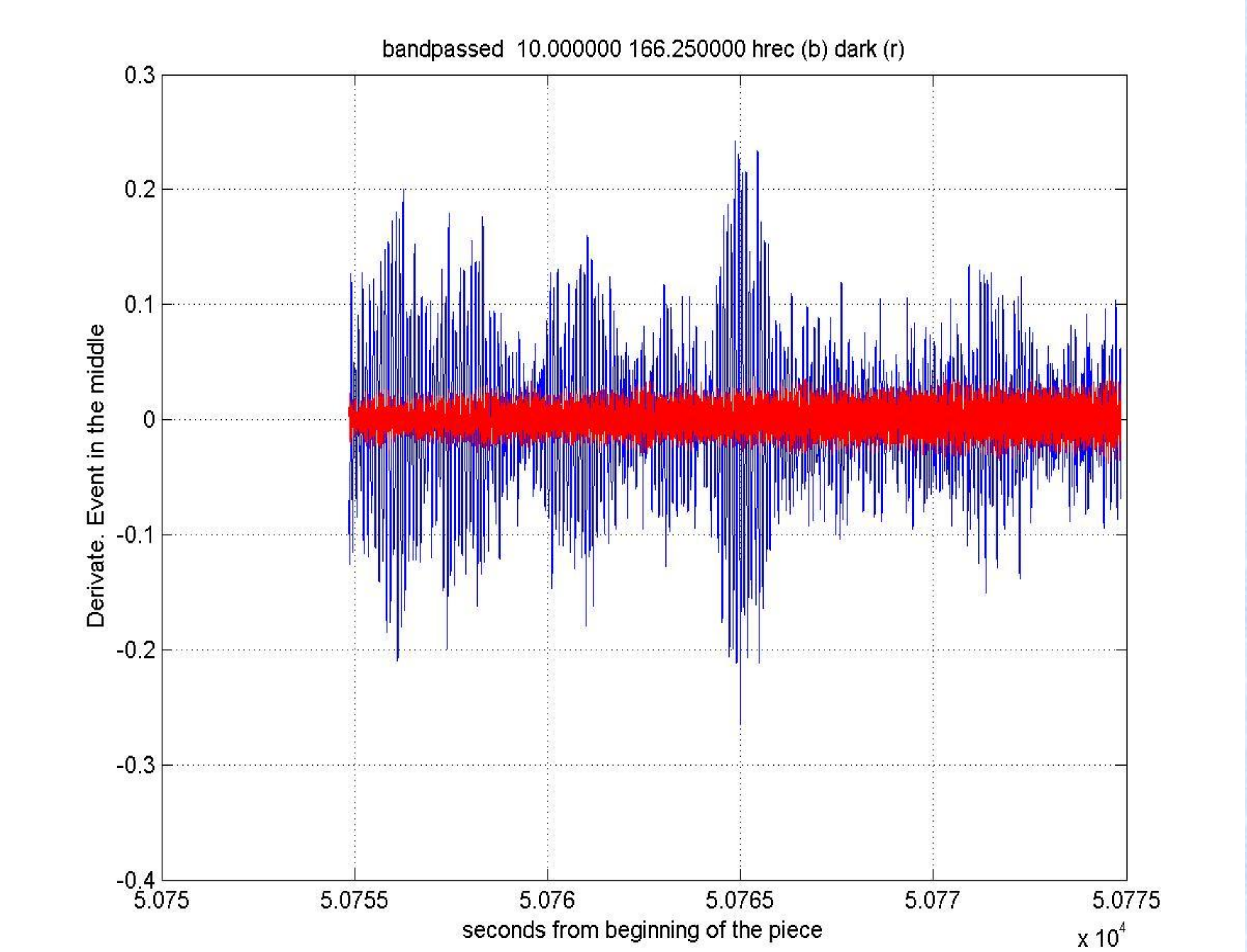
The same after band-pass filtering



Band 937.5-1093.75 Hz



Band 10-166.25 Hz, present in h-rec and not in dark ?

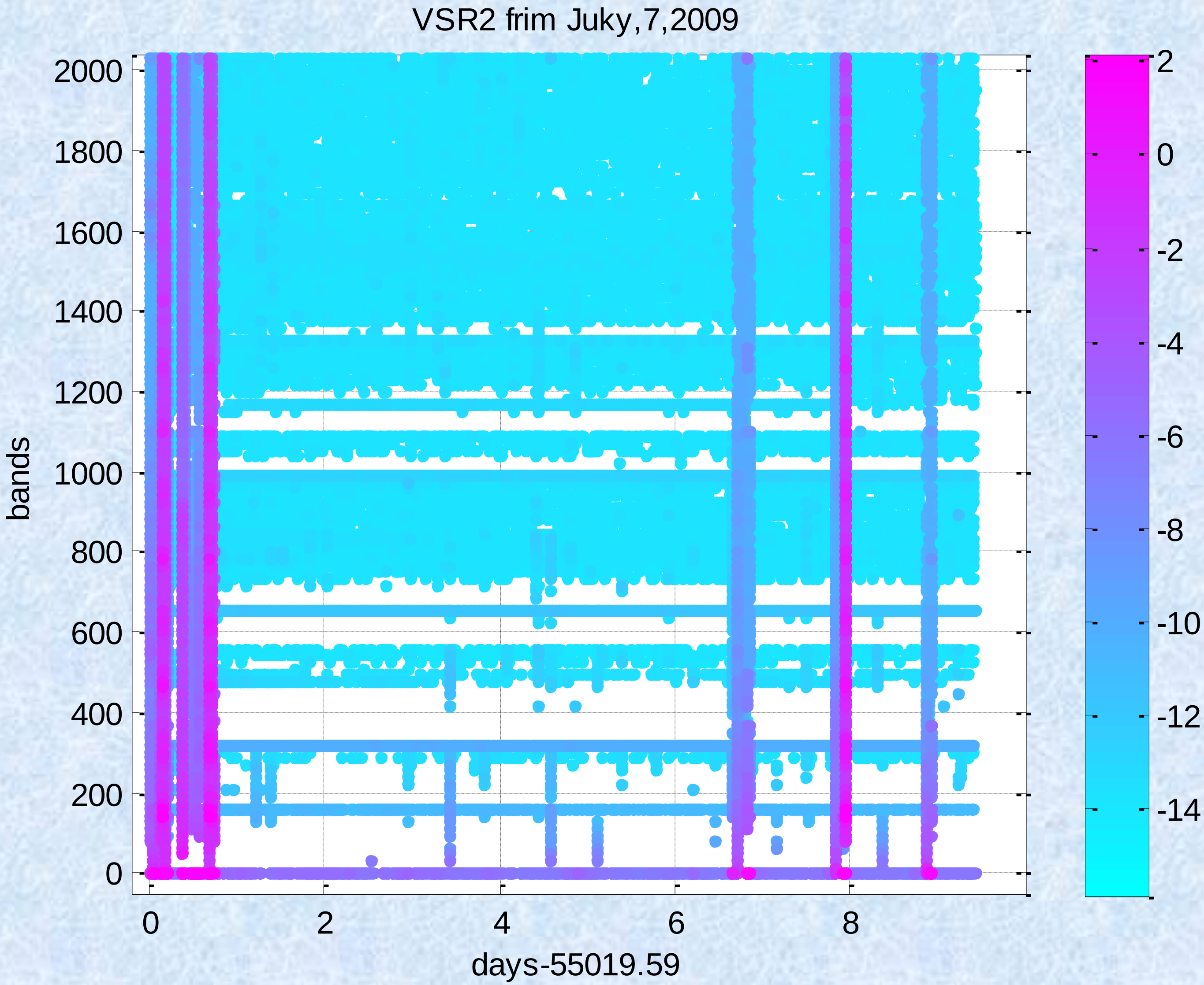


Events characterization

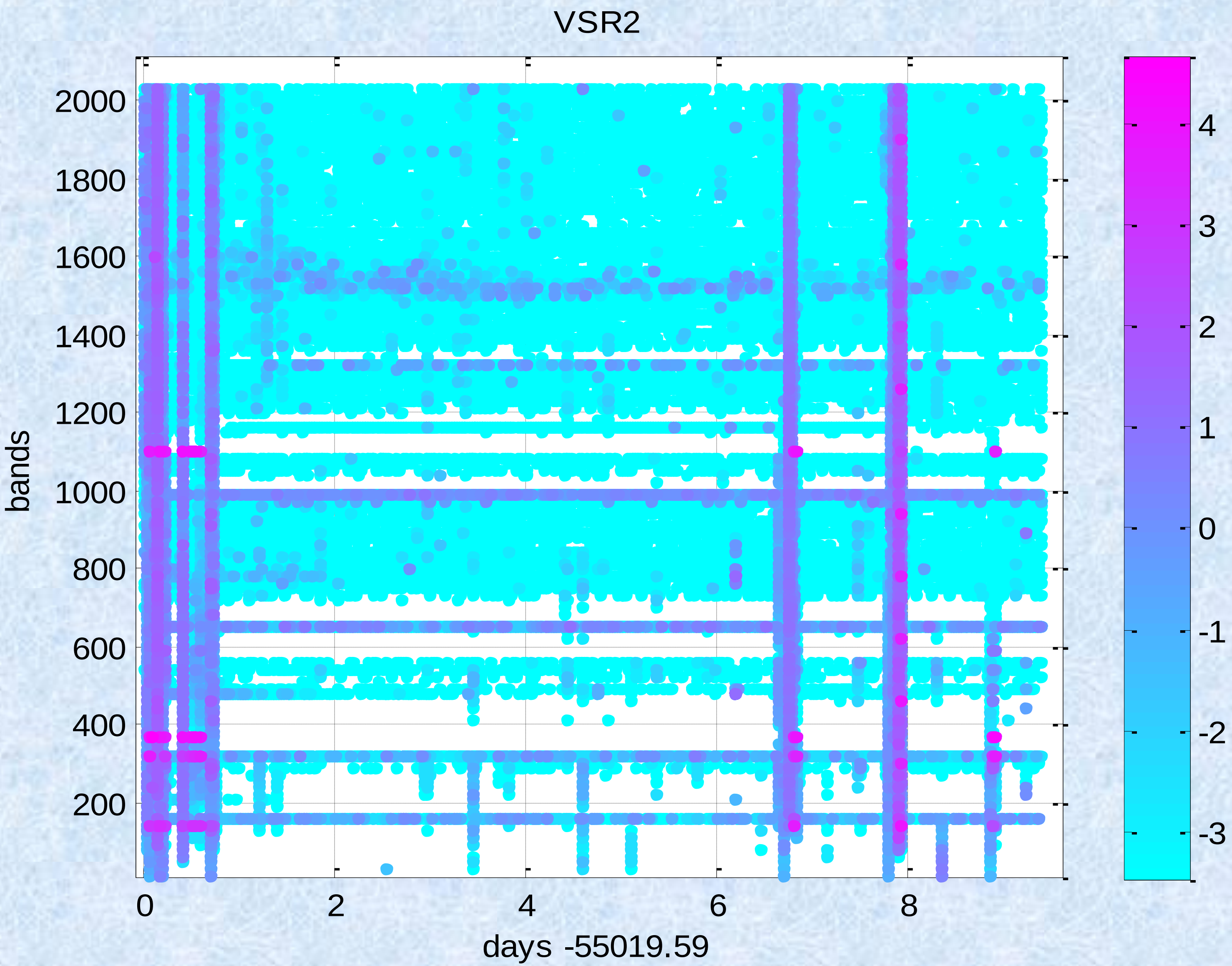
- The following is to show which kind of information we can easily give on events

- We recall that events are characterized by parameters like: ***time of the maximum, beginning time, CR, duration, amplitude and –in the case of EVB- band***

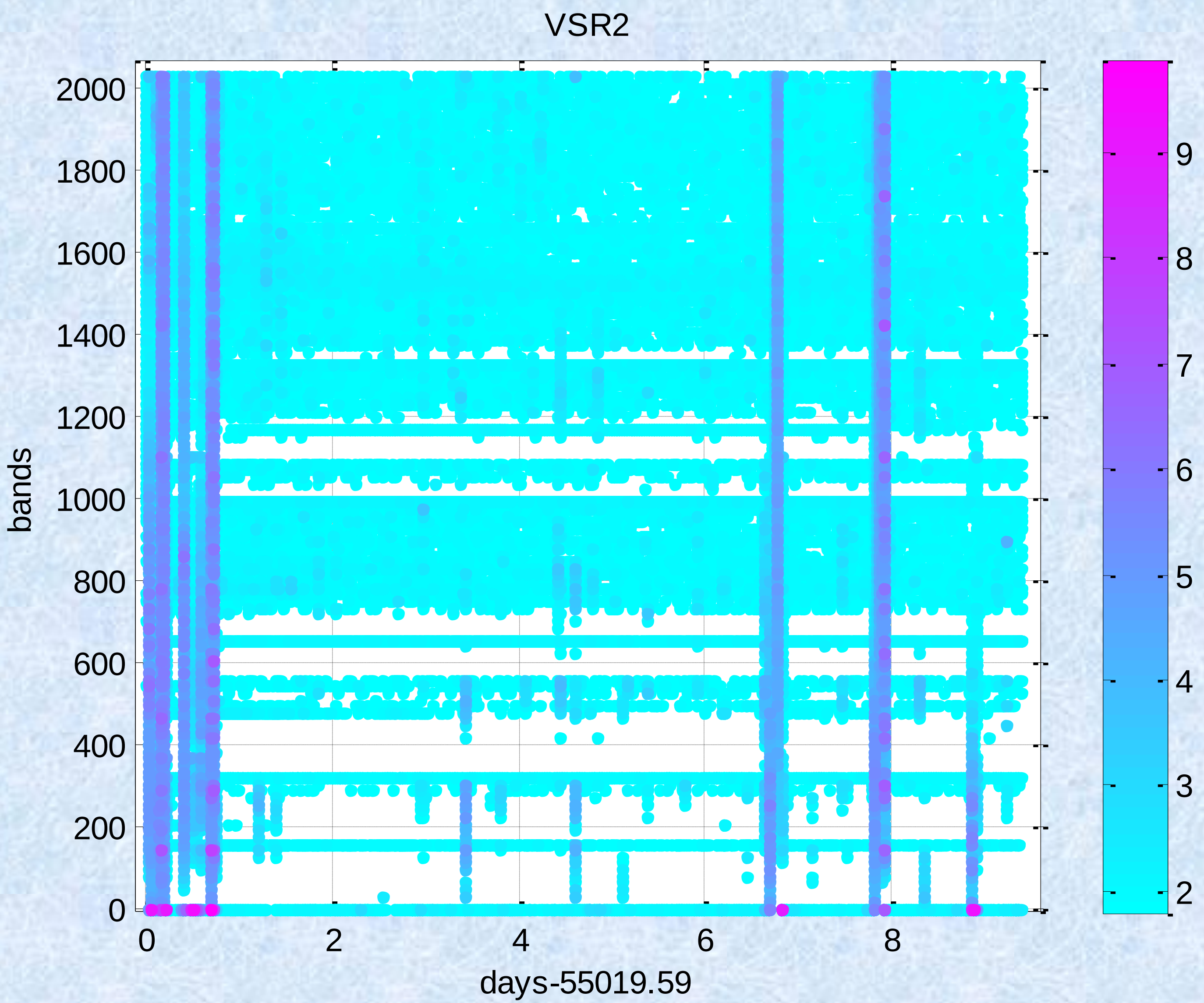
EVB in Dark: t, bands, log(|a|)



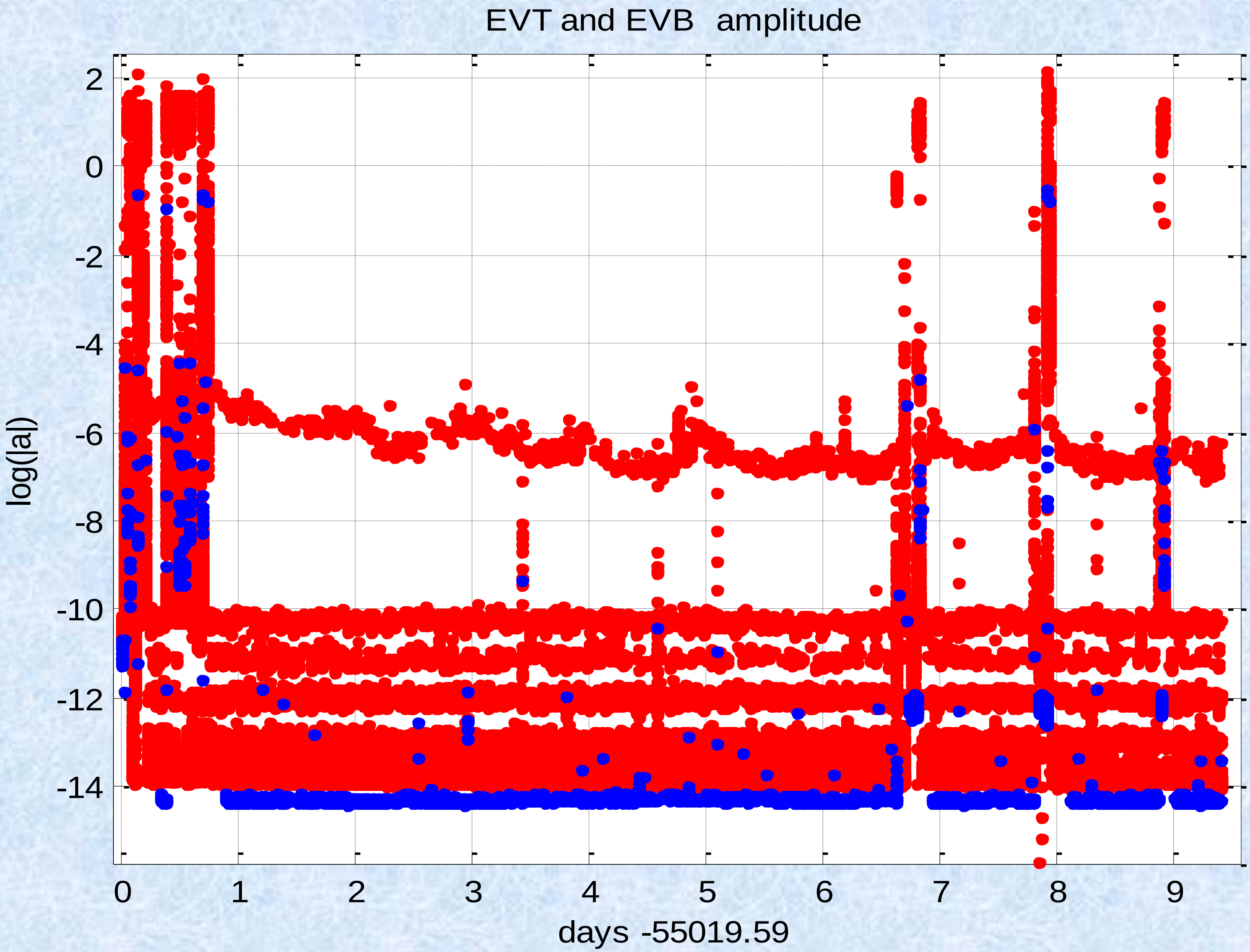
EVB in Dark: t, bands, log(dur)



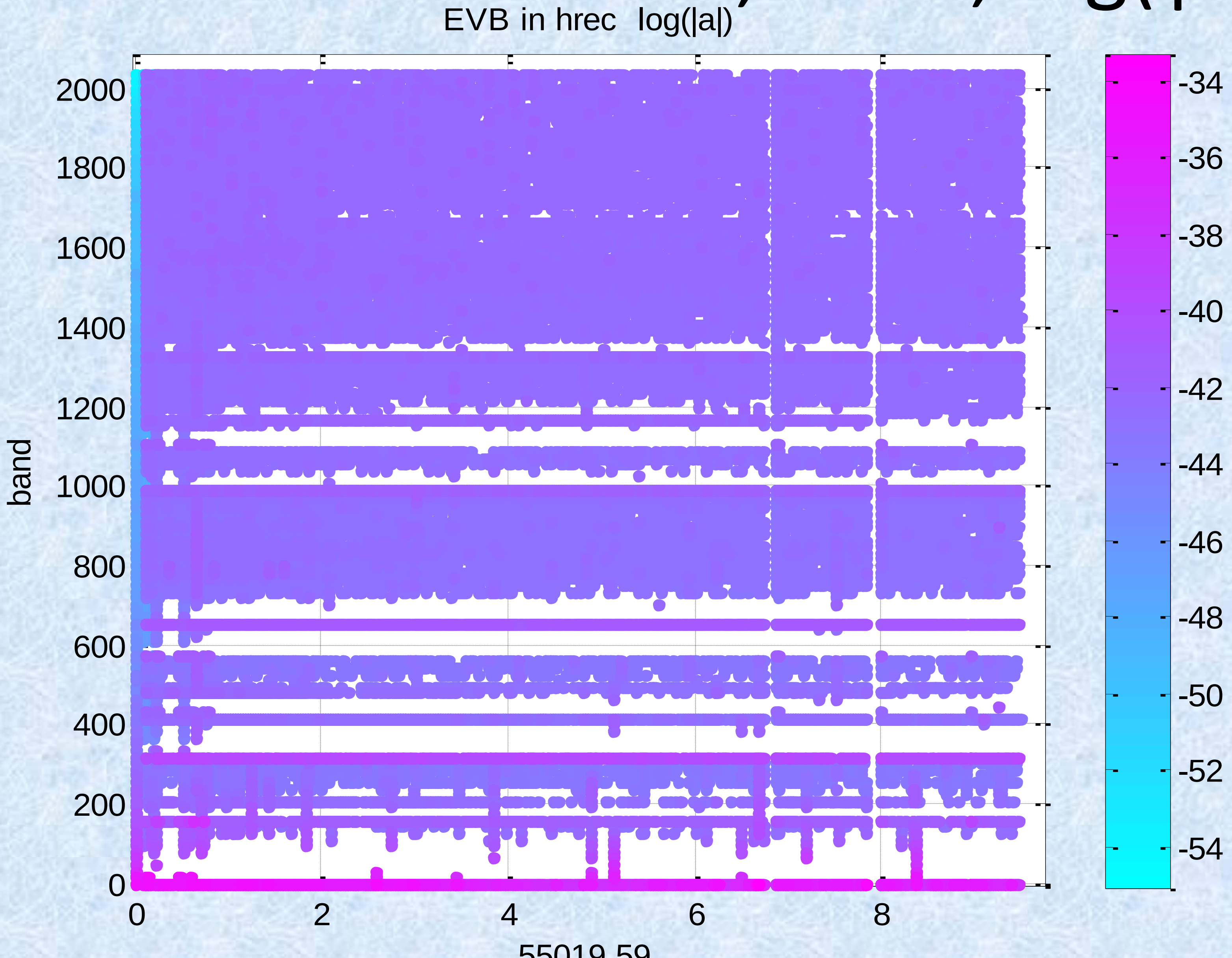
EVB in Dark: t, bands, log(cr)



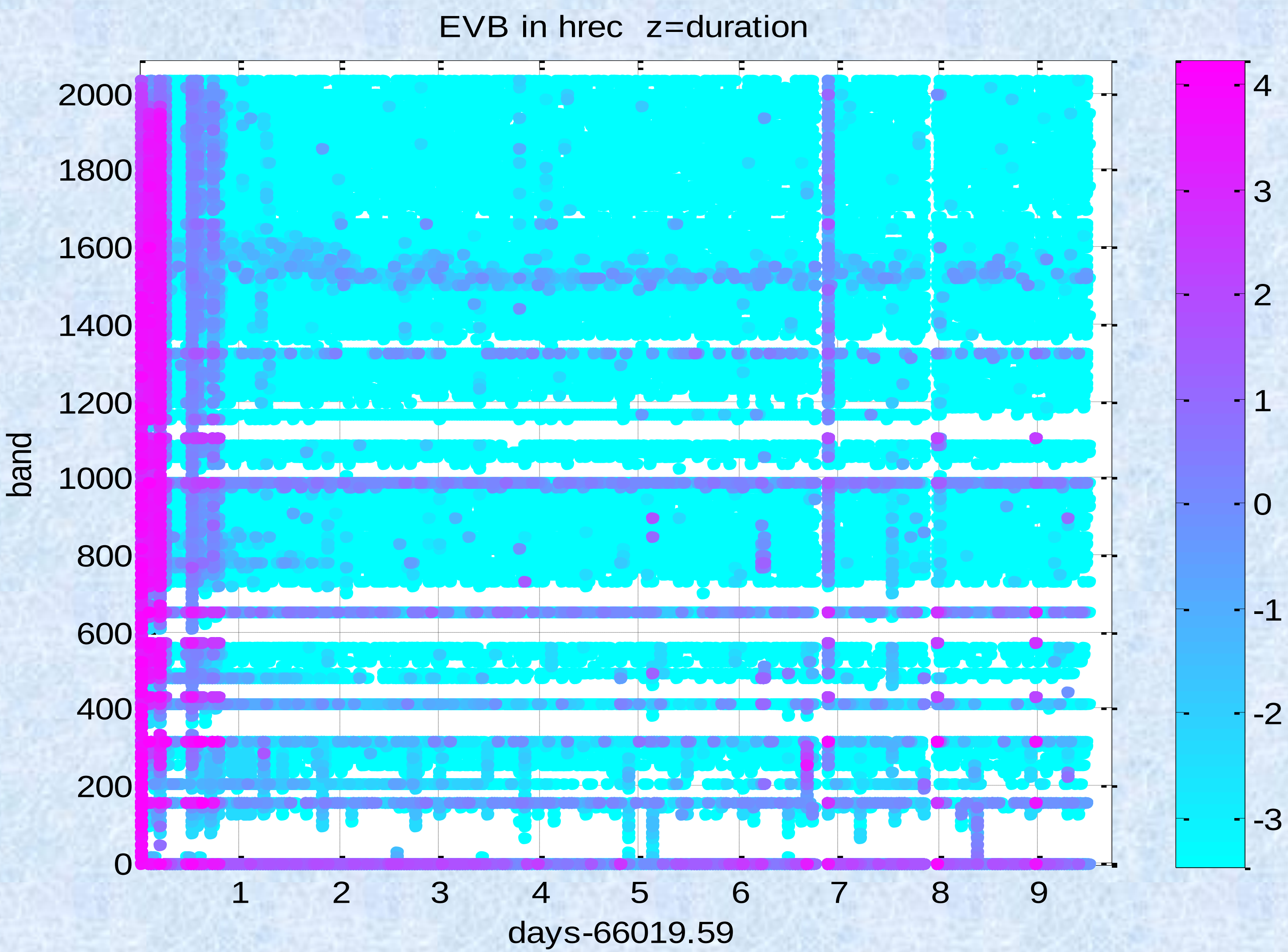
EVT (b) and EVB (r) in the dark channel: log |a| vs. time



EVB in h-rec: t, band, log(|a|)



EVB in h-rec: t, band, log(dur)



Characterization in the frequency domain

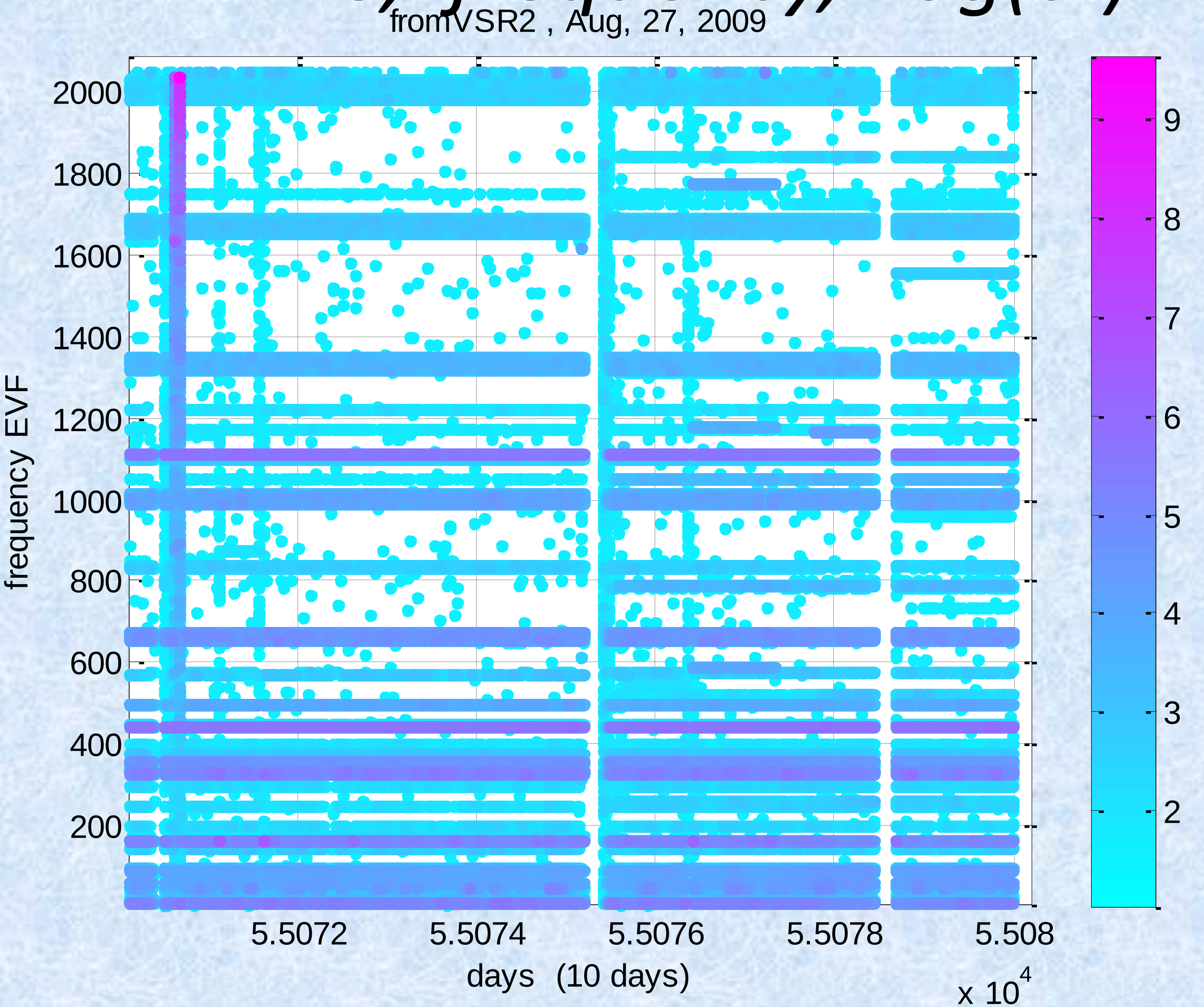
- As shown by Cristiano, this is very important for our search
- Using the peak-maps, constructed from our FFTs data base, we can identify and possibly remove, spurious lines
- In this case we have to be sure they are artifacts: the interaction with people who work on the detector and in the noise characterization is particularly important

How can we contribute ?

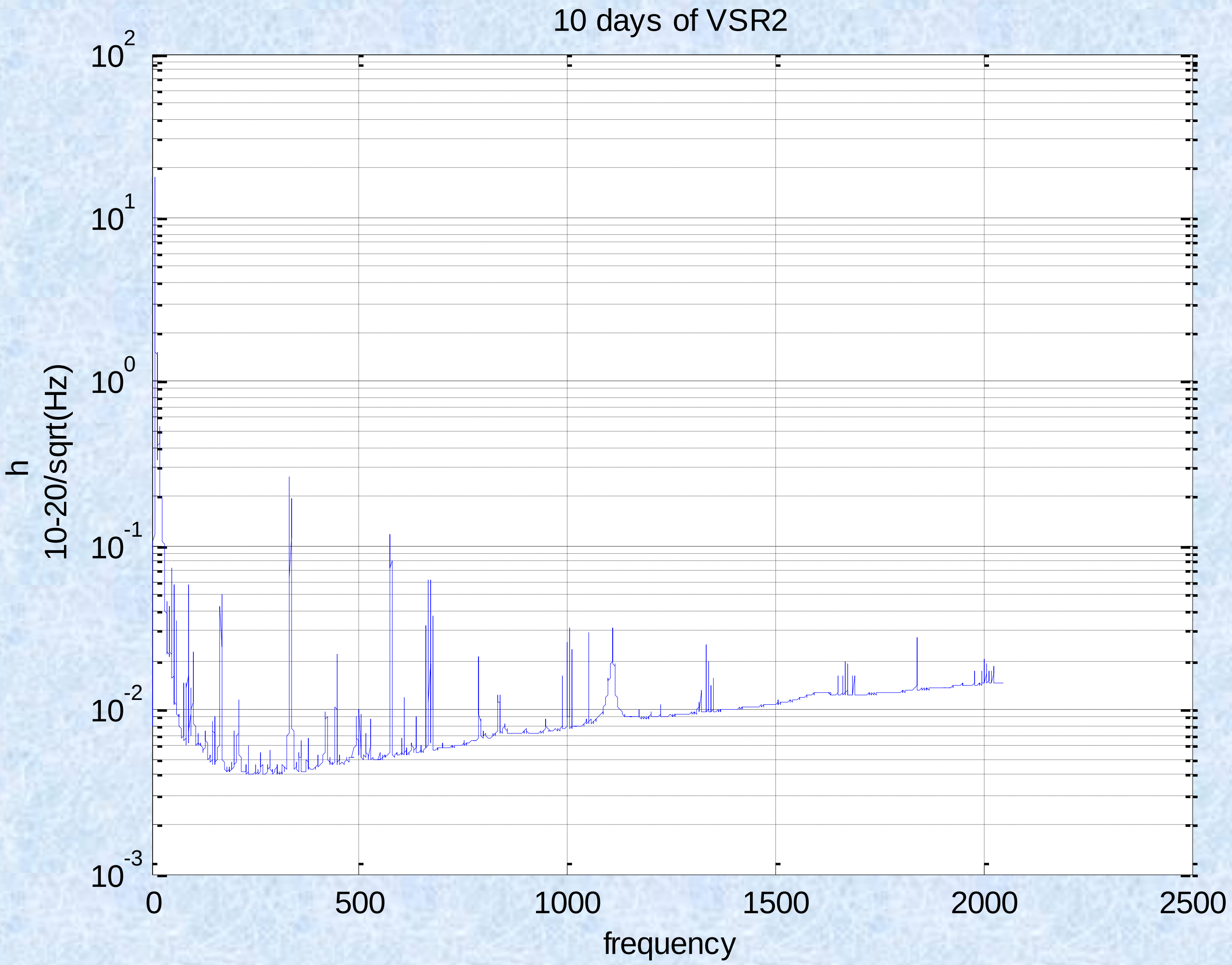
- When we construct the peak maps we estimate an AR robust estimation of the spectrum: the procedure has to detect lines, but not include them in the average estimation, and it has to be able to follow slow or rapid variations of the noise level.
- Detected lines and their parameters are stored in **EVF** events

EVF

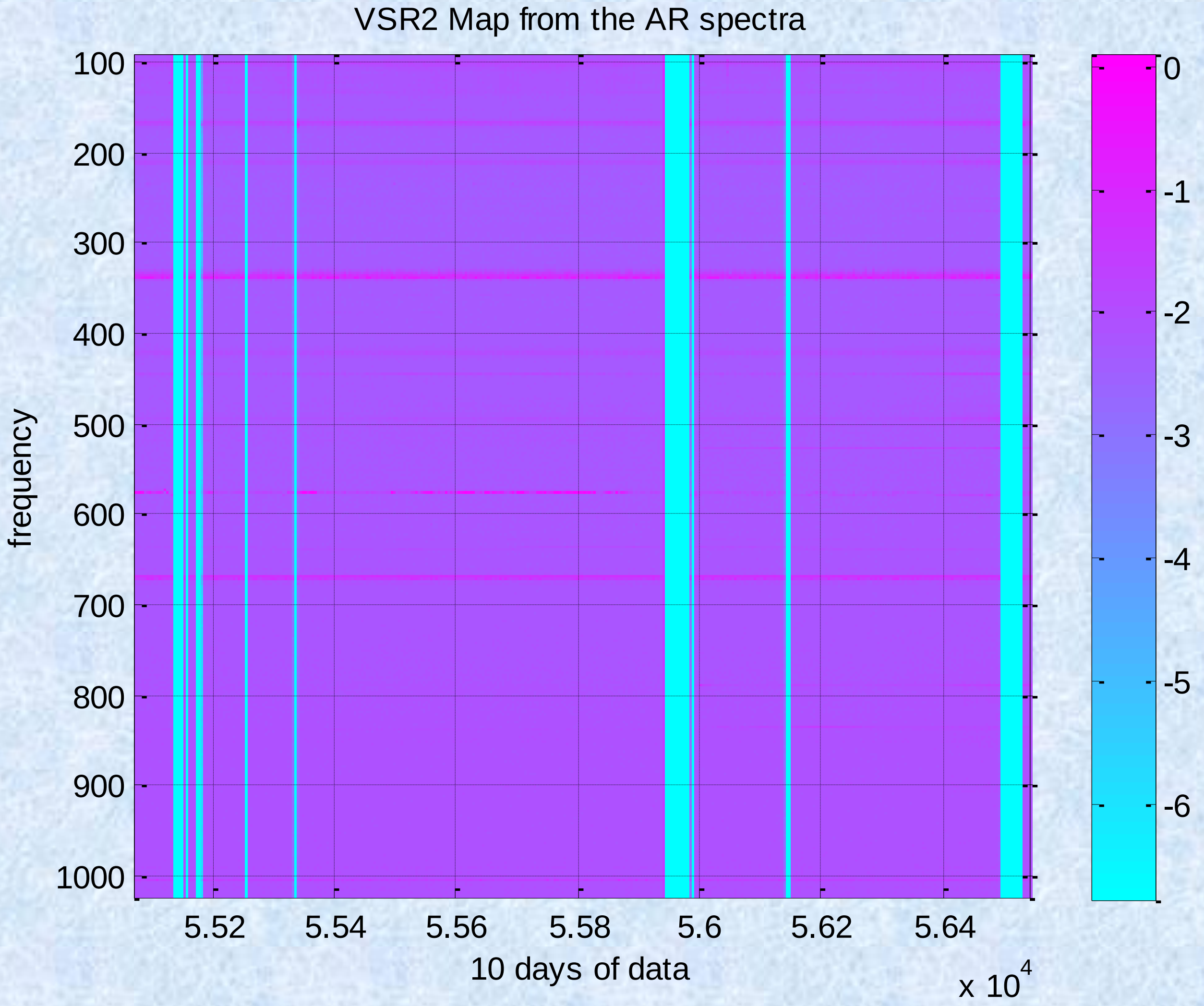
Time, frequency, log(cr)



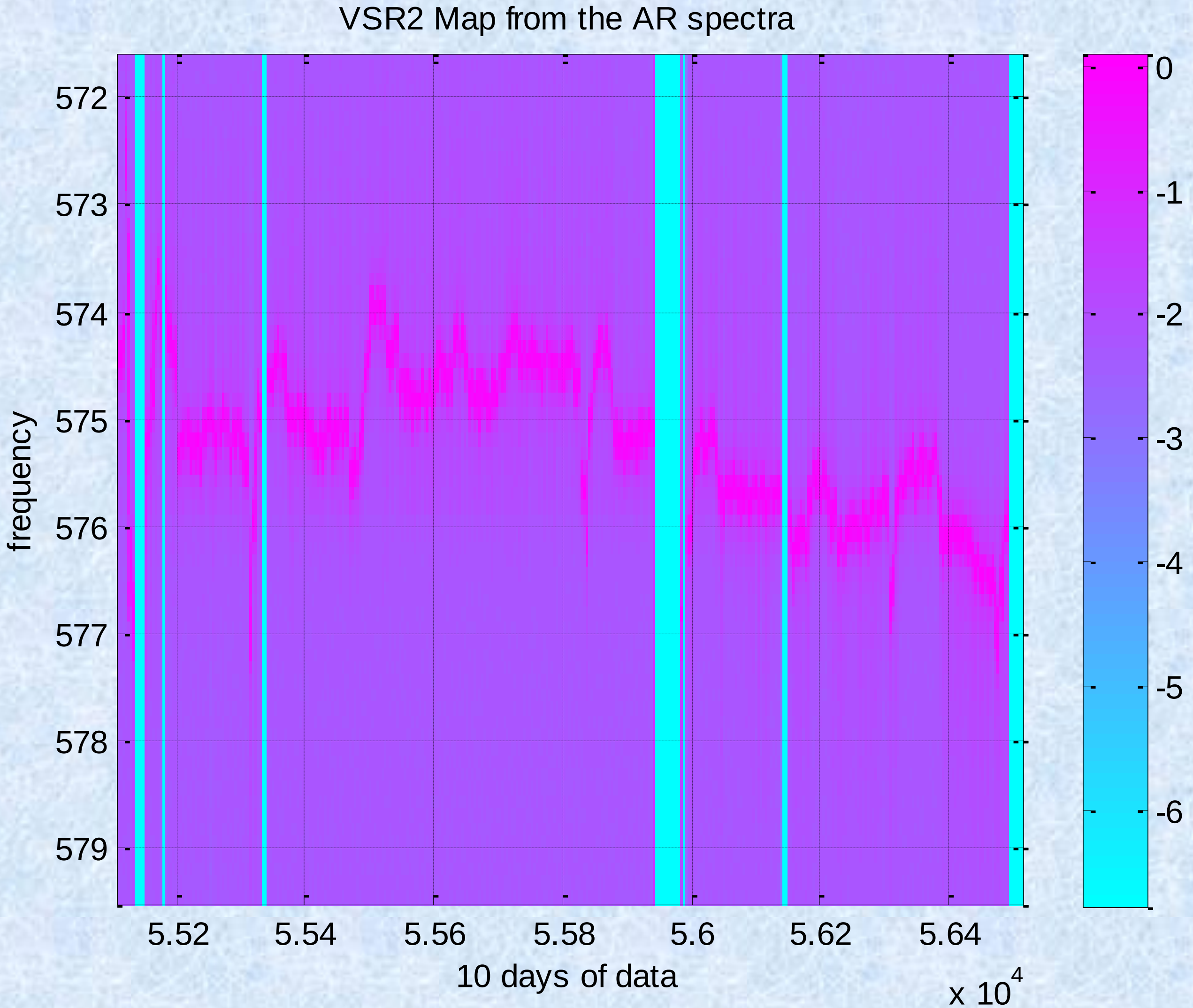
AR average spectrum from 10 days, from Aug., 31,2009



Log map from AR estimation of average spectrum over 10 days of VSR2 data



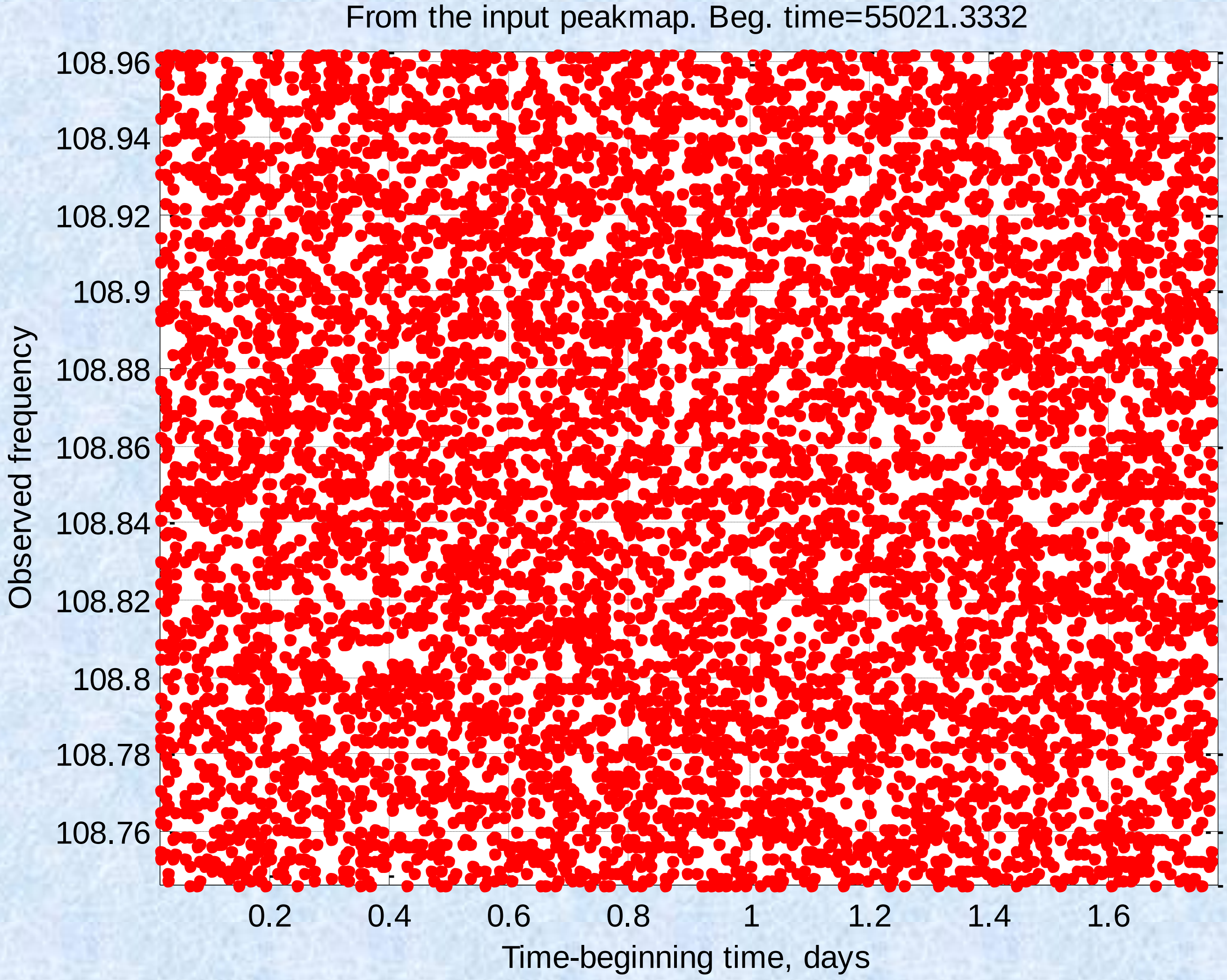
Log map from VSR2 data



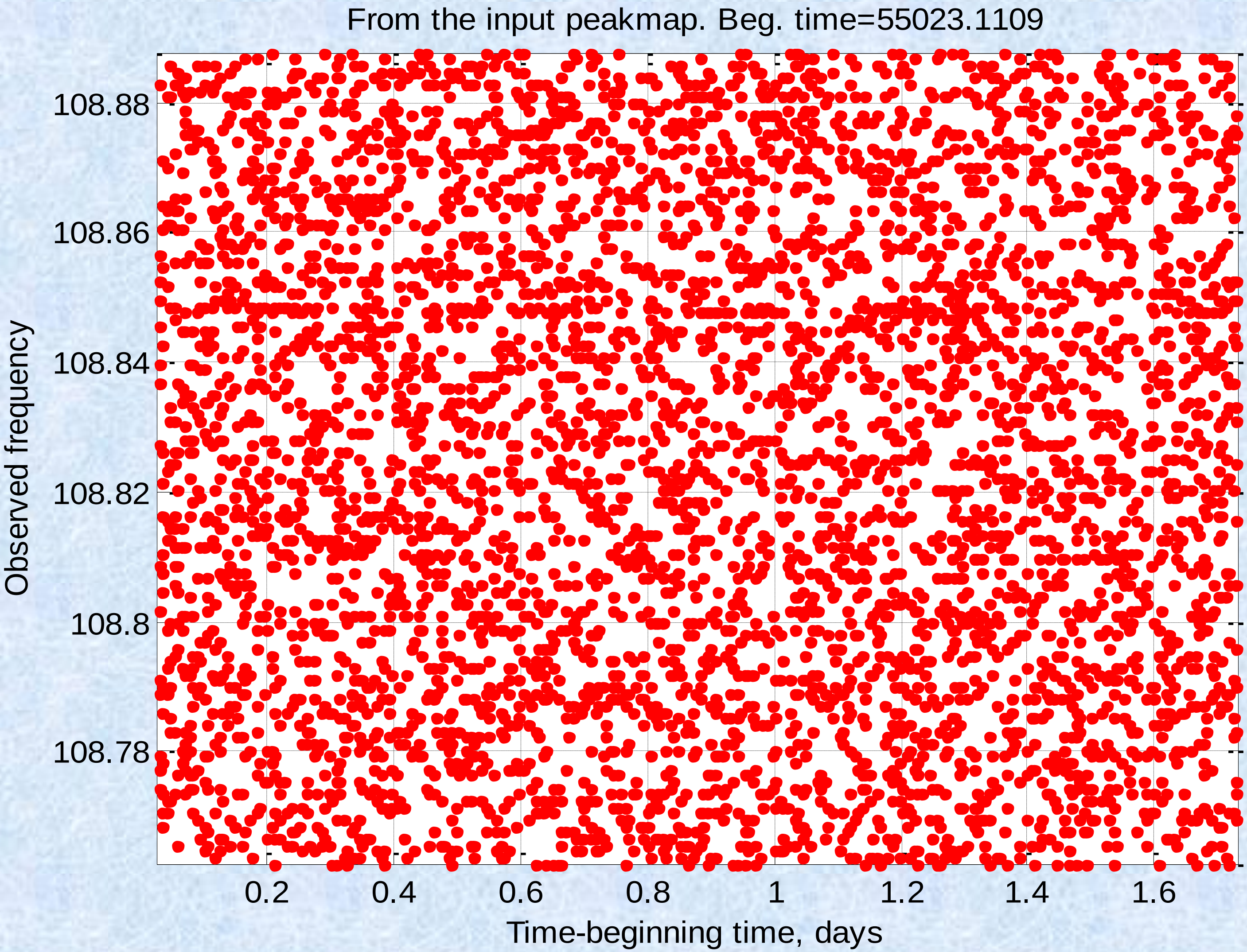
Peak-maps

- As Cristiano said, the cleaning of peak-maps is very important to our search and we do a deep study of spurious lines to remove them before the next stage of the c.w. search procedure
- New idea, on which we are actually working, is to use the ***frequency Hough map*** to detect and subtract these spurious lines

Peak map from 09-Jul-2009 07:59:48.480



Peak map from 011-Jul-2009 02:39:41.7600



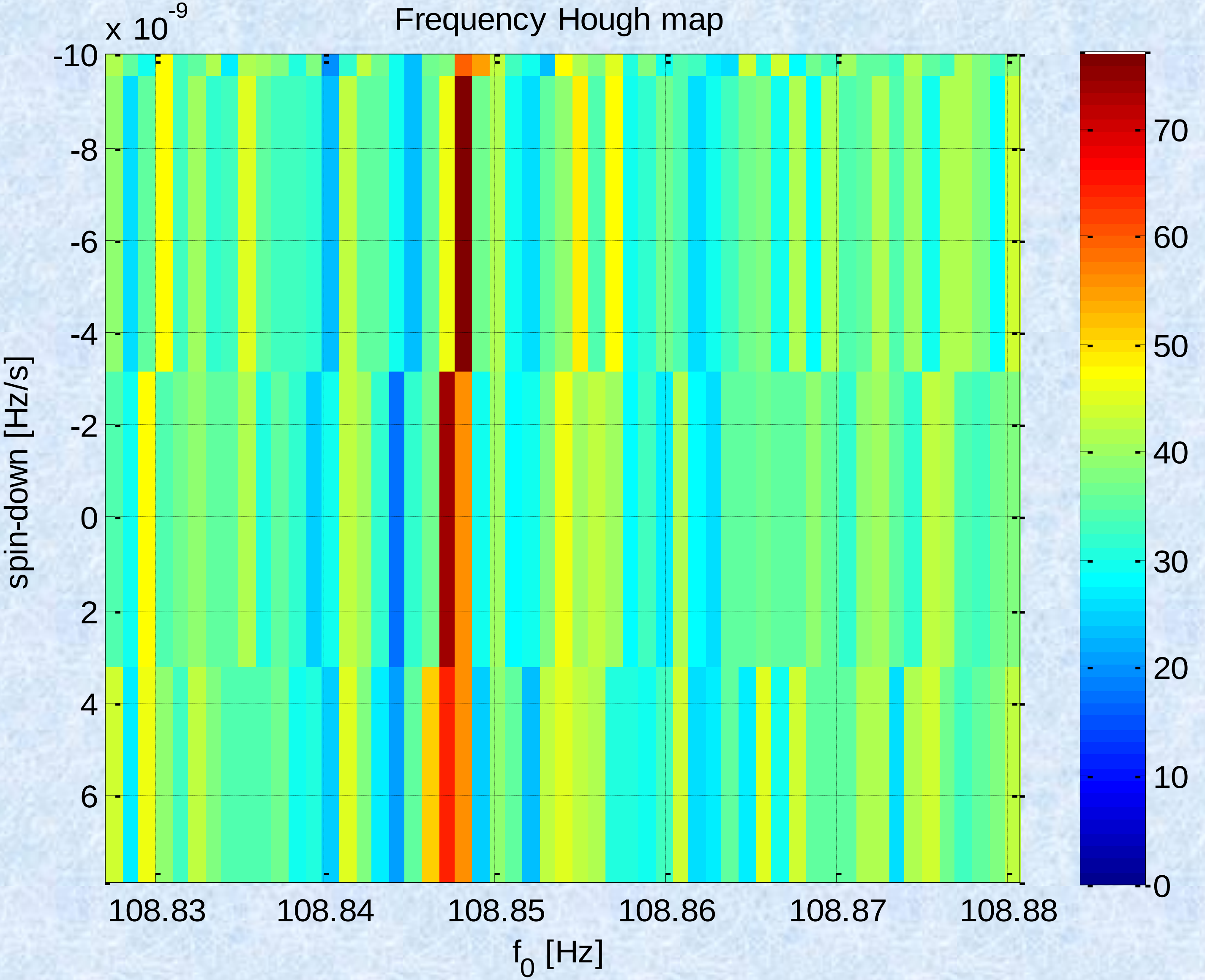
Transformation from the *time /observed frequency* plane to the *frequency /spin-down* plane

Hough plane: frequency, corrected for the Doppler from a given source location , and first spin-down parameter.
For a given source location, and for source frequency f_0 at the time t, the observed frequency is:

$$f = f_0 + d * t$$

that is, a straight line in the plane f_0, d *(the spin-down)*

Frequency Hough map: max f=108.849023 Hz (77.000000)



Frequency Hough map: max f=108.849121 Hz (81.000000)