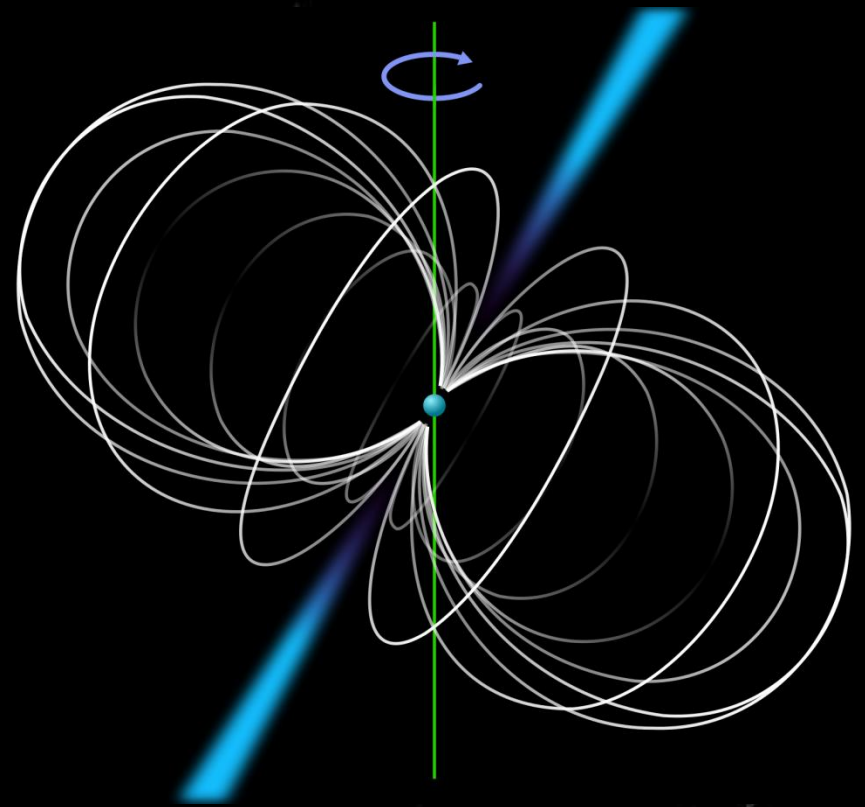


# Amateur Pulsar Detection Using EME Equipment

- 1) 7,3m Offset Dish,  
Airspy SDR, RTL-SDR
- 2) 3m (Hybrid)Dish,  
Airspy SDR, RTL-SDR
- 3) 23 element Yagi,  
RTL-SDR



# Results with 7.3m Offset Dish



Software:

IW5BHY

Murmur (I0NAA)

Presto

**54 pulsars  
detected**

47 on 70cm,

18 on 23cm,

11 both bands

Weakest:

70cm B0626+24:  
31mJy

23cm B1845-01:  
8.6mJy

# Results with 3m Hybrid Dish



4 pulsars  
detected

70cm:

B0329+54

B0950+08

B1642-03

B1929+10

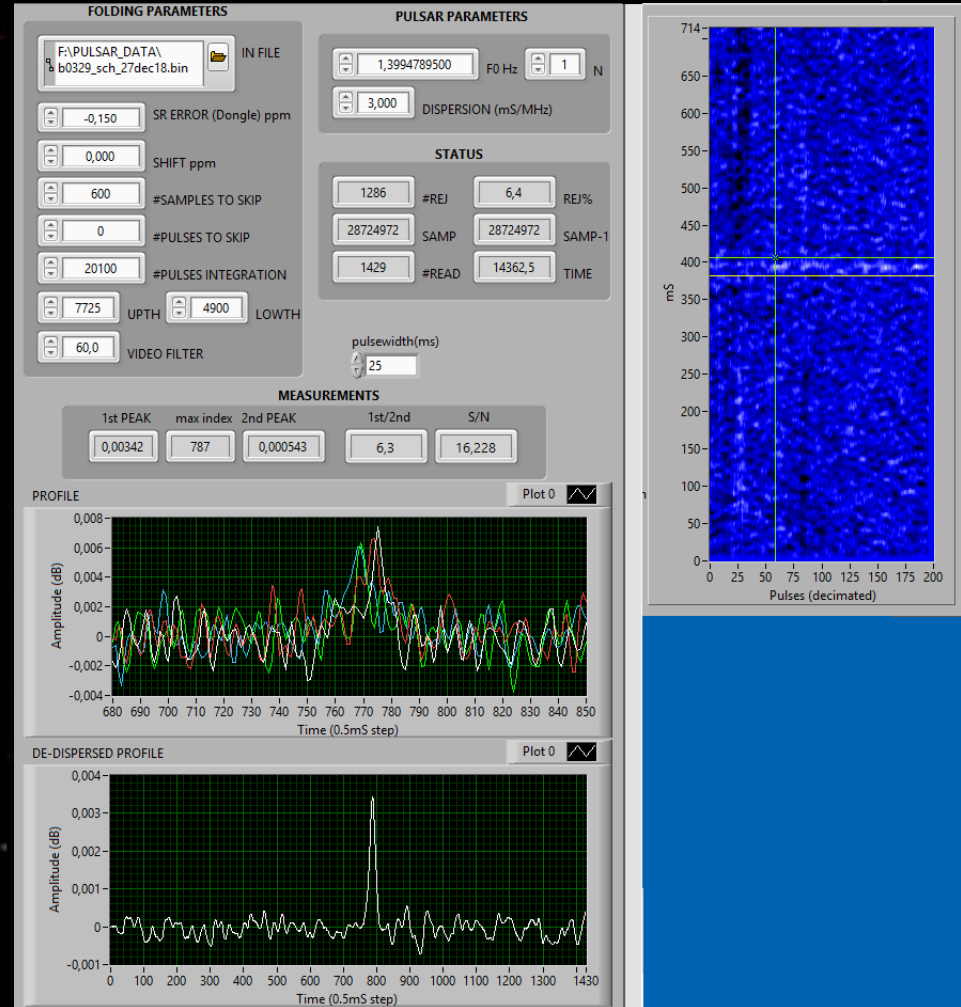
23cm:

B0329+54

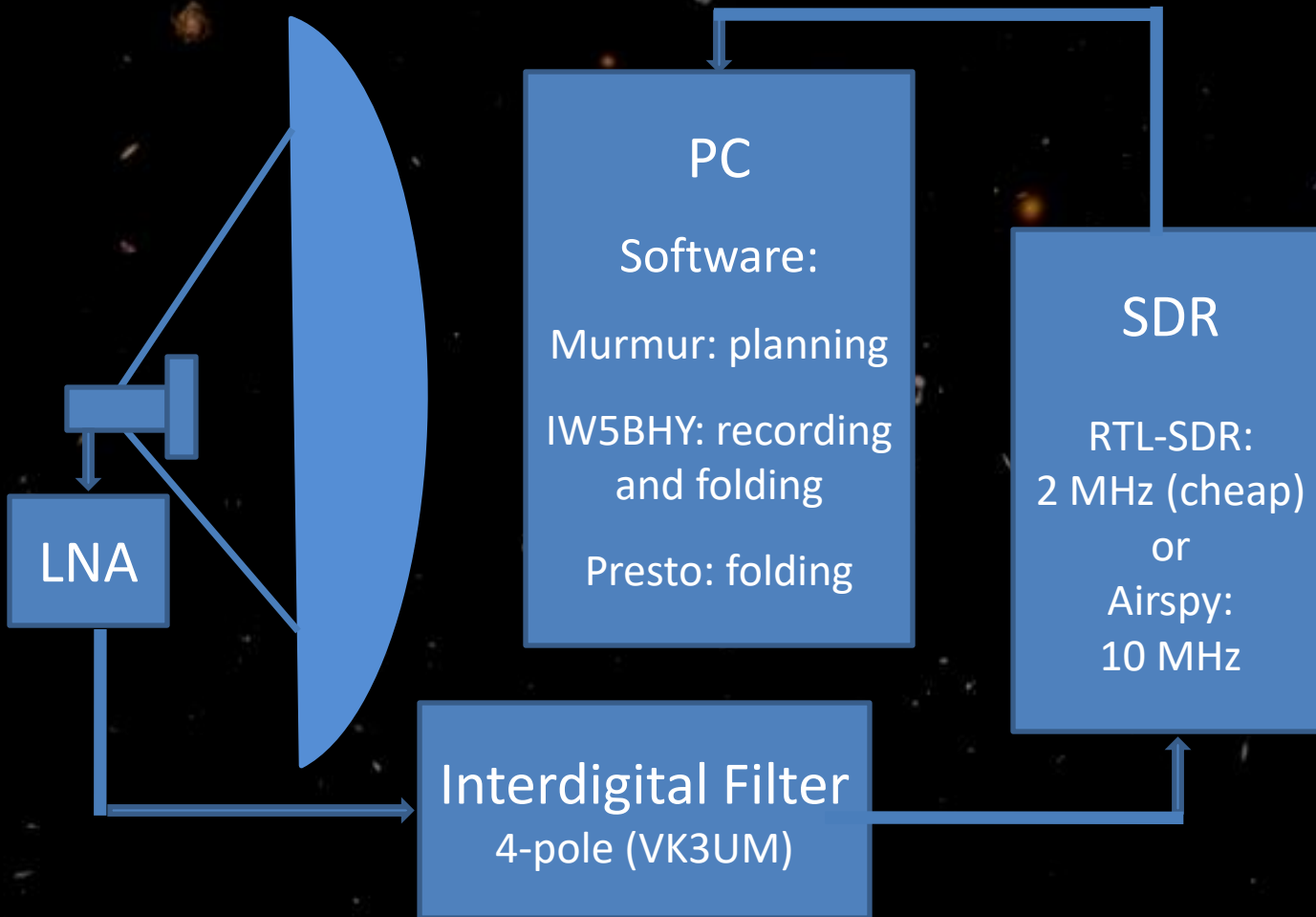


# Result with 23 Element Yagi

## B0329+54 detected



# Setup Block Diagram



# How to achieve success the easiest way:

Choose 70cm band:

Pulsars have in general best S/N around 400MHz

RX with RTL-SDR:

Cheap, limited to 2 MHz bandwidth,  
choose a high quality device! (accuracy < 1 ppm)

Use IW5BHY software:

For Windows, easy to learn, limited to 2 MHz

(Professional Presto Software needs Linux OS, offers more possibilities,  
but is more difficult to learn, not well documented)

# Installing and testing the RTL-SDR:

First install USB drivers and SDR# software, following these instructions:

<http://www.rtl-sdr.com/rtl-sdr<>-quick-start-guide/>

Next step is to test the hardware, running SDR# software:

Adjust RF-gain:

noise difference minimum 15dB switching ON/OFF the preamplifier

Check sun noise:

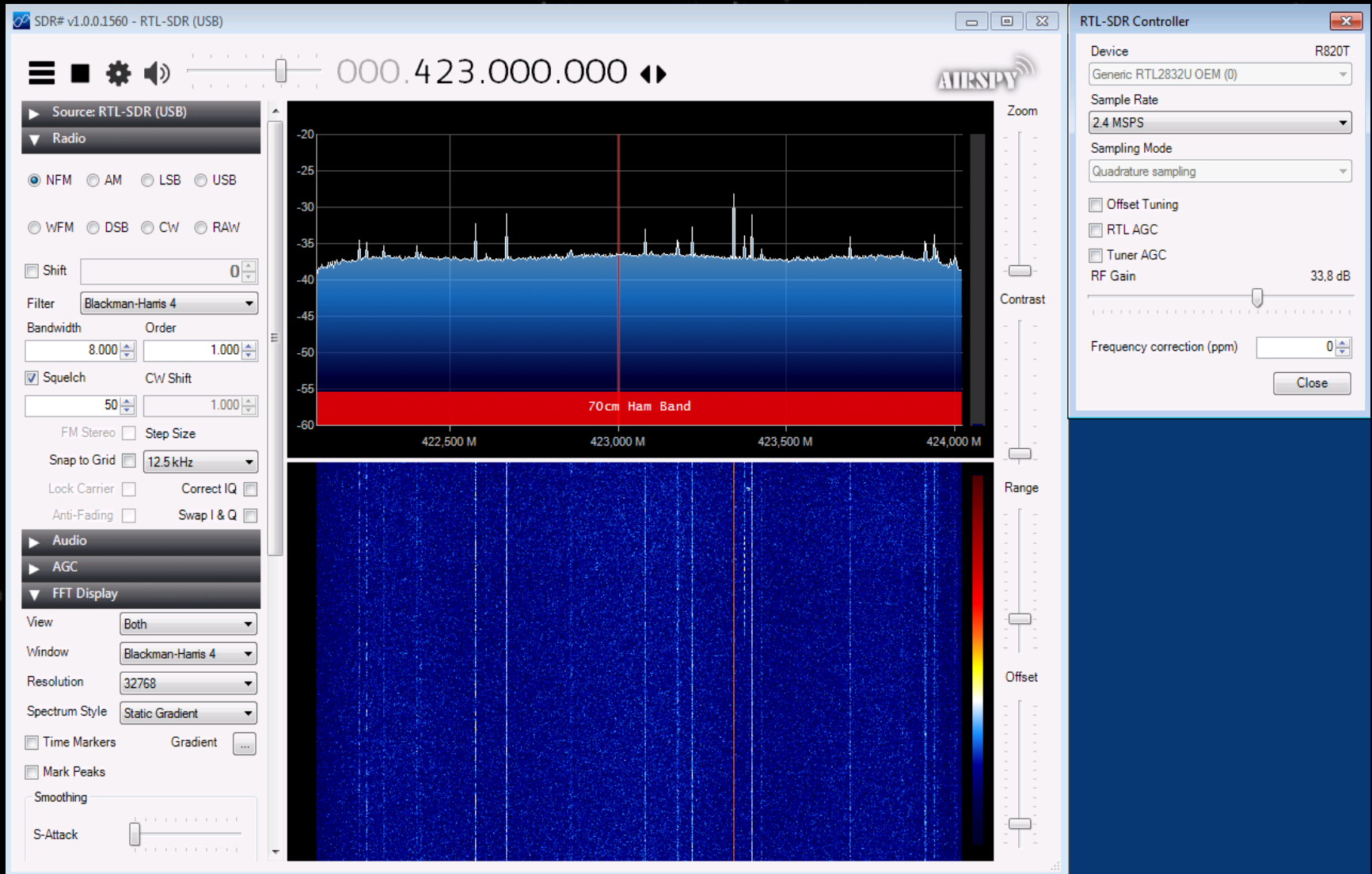
should be minimum 6dB at SFI=70

Look for the best 2MHz with low RFI:

constant carriers are less a problem compared to (for example) intermittent broadband noise.

If necessary and possible readjust the filter for a flat noise floor within the 2 MHz passband

# Example for the settings and how the waterfall looks like:





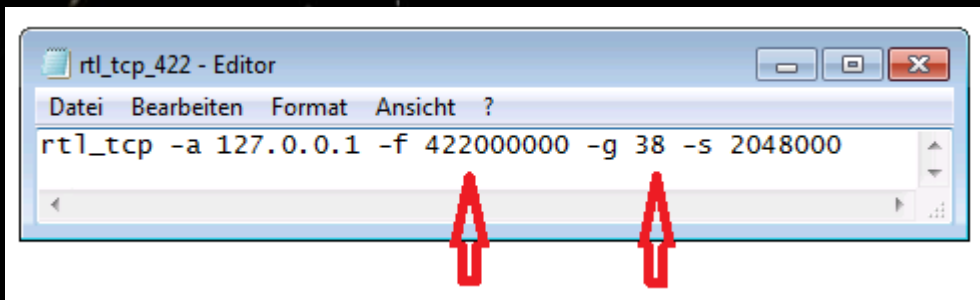
# Pulsar Software:

1. recording and storing data to HD
2. calculating pulsar frequency
3. analyzing the stored data

First install Labview Runtime Engine

<http://www.ni.com/download/labview-run-time-engine-2012-sp1/3710/en/>

## 1. Recording



```
rtl_tcp_422 - Editor
Datei Bearbeiten Format Ansicht ?
rtl_tcp -a 127.0.0.1 -f 422000000 -g 38 -s 2048000
```

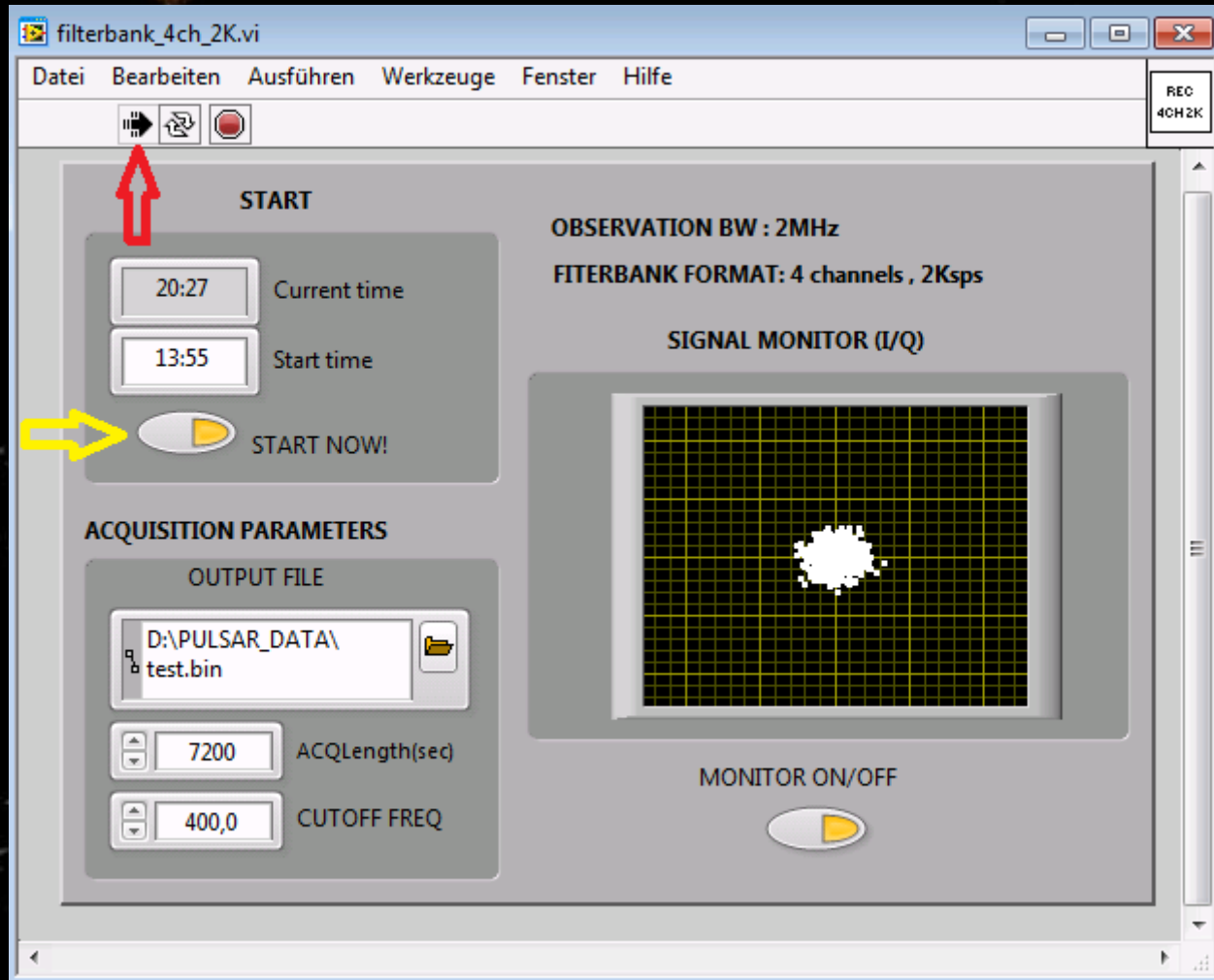
Edit **rtl\_tcp.bat** and run it

The SDR will wait now for the Labview program **filterbank\_4ch\_2k.exe** to read data from it

For tracking the pulsar you can use a nice piece of software written by I0NAA:

<http://i0naa.altervista.org/index.php/downloads/summary/2-downloads/9-murmur-7-1-0>

**Open filterbank\_4ch\_2k.exe now,**  
modify recording length (example 7200 seconds), choose a bin data  
filename in an existing folder and if you like the start time.



Start the Labview recording software (red arrow), and if you want to start the recording immediately click at START NOW (yellow arrow).

You should see the 'cloud' now, file length of the \*.bin will be 57,6 MByte per hour of recording

## 2. Calculating pulsar frequency

place folder tempo directly to drive C:\

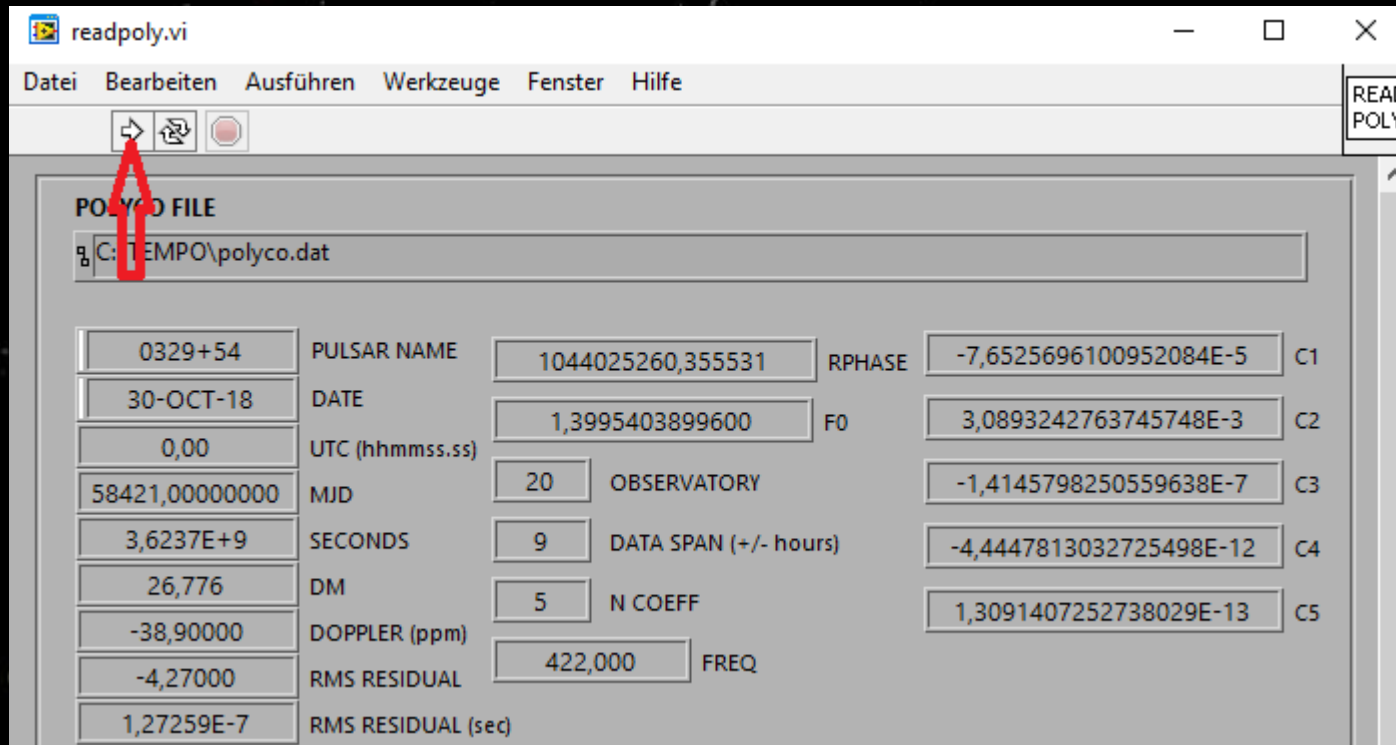
Edit obsys.dat (once) for your QTH

Edit tz.in and run tz.bat, the file polyco.dat will be updated

A more detailed description you find at:

[https://www.gsl.net/oe5jfl/pulsar/detecting\\_pulsars.pdf](https://www.gsl.net/oe5jfl/pulsar/detecting_pulsars.pdf)

Now run the first  
Labview program  
readpoly.vi



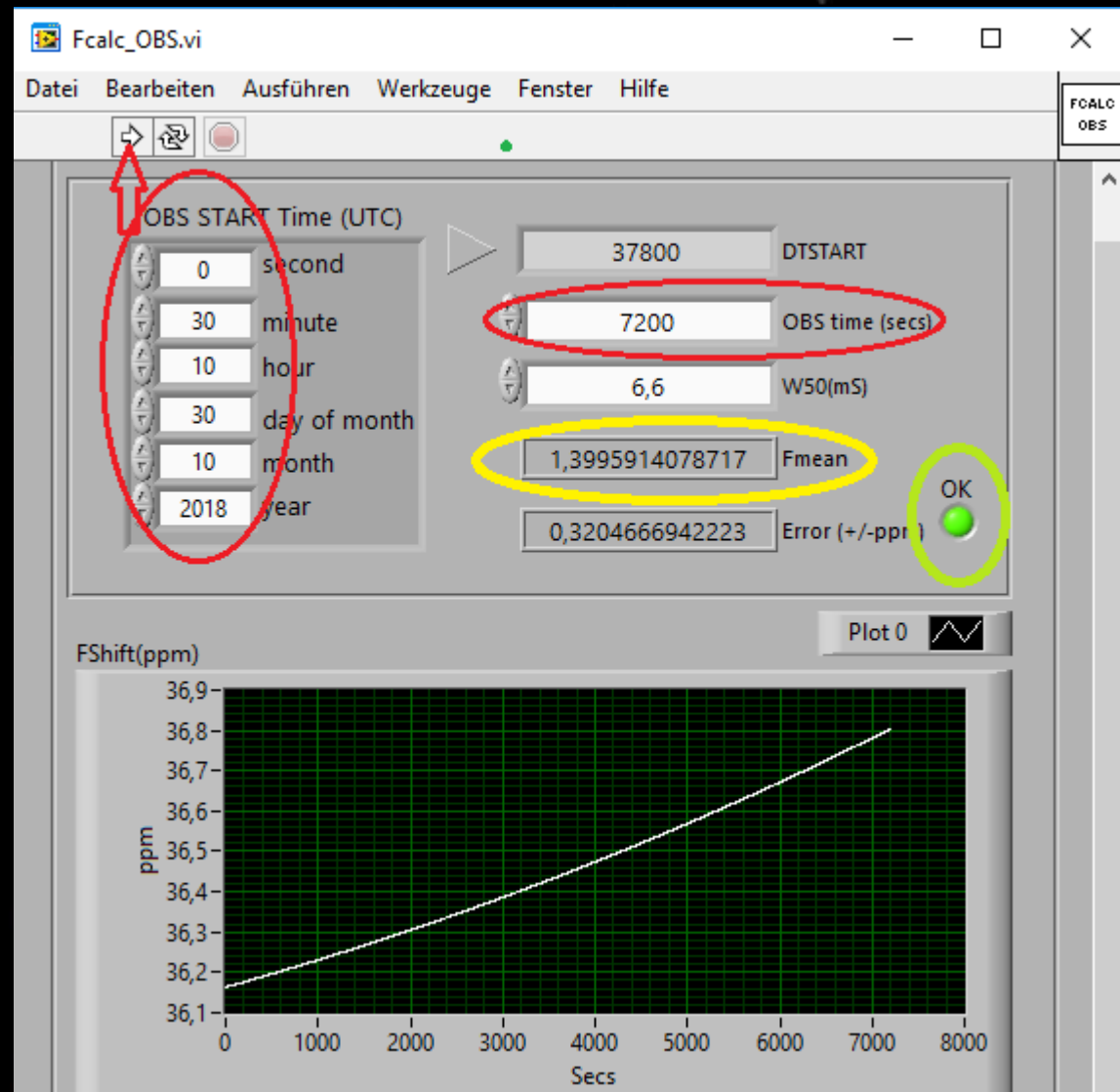
The screenshot shows the LabVIEW interface for the 'readpoly.vi' program. The window title is 'readpoly.vi'. The menu bar includes 'Datei', 'Bearbeiten', 'Ausführen', 'Werkzeuge', 'Fenster', and 'Hilfe'. Below the menu bar are three icons: a red arrow pointing to the first icon (a square with a right-pointing arrow), a second icon (a square with a right-pointing arrow and a refresh symbol), and a third icon (a red circle with a white center). The main panel is titled 'POLYCO FILE' and contains a text box with the path 'C:\TEMPO\polyco.dat'. Below this are several input fields for pulsar data, arranged in a grid-like format. A red arrow points to the first input field, which contains '0329+54'. The data is as follows:

Field	Value	Field	Value	Field	Value
0329+54	PULSAR NAME	1044025260,355531	RPHASE	-7,6525696100952084E-5	C1
30-OCT-18	DATE	1,3995403899600	F0	3,0893242763745748E-3	C2
0,00	UTC (hhmmss.ss)	20	OBSERVATORY	-1,4145798250559638E-7	C3
58421,00000000	MJD	9	DATA SPAN (+/- hours)	-4,4447813032725498E-12	C4
3,6237E+9	SECONDS	5	N COEFF	1,3091407252738029E-13	C5
26,776	DM	422,000	FREQ		
-38,90000	DOPPLER (ppm)				
-4,27000	RMS RESIDUAL				
1,27259E-7	RMS RESIDUAL (sec)				

Running the second Labview program Fcalc\_OBS.vi will provide the result **Fmean**, the value to use for analyzing.

Set date, time and duration of the observation, then run the program

If the little OK lamp will not be coloured green but black instead, the observation time might be too long or some mistake was made doing the previous steps

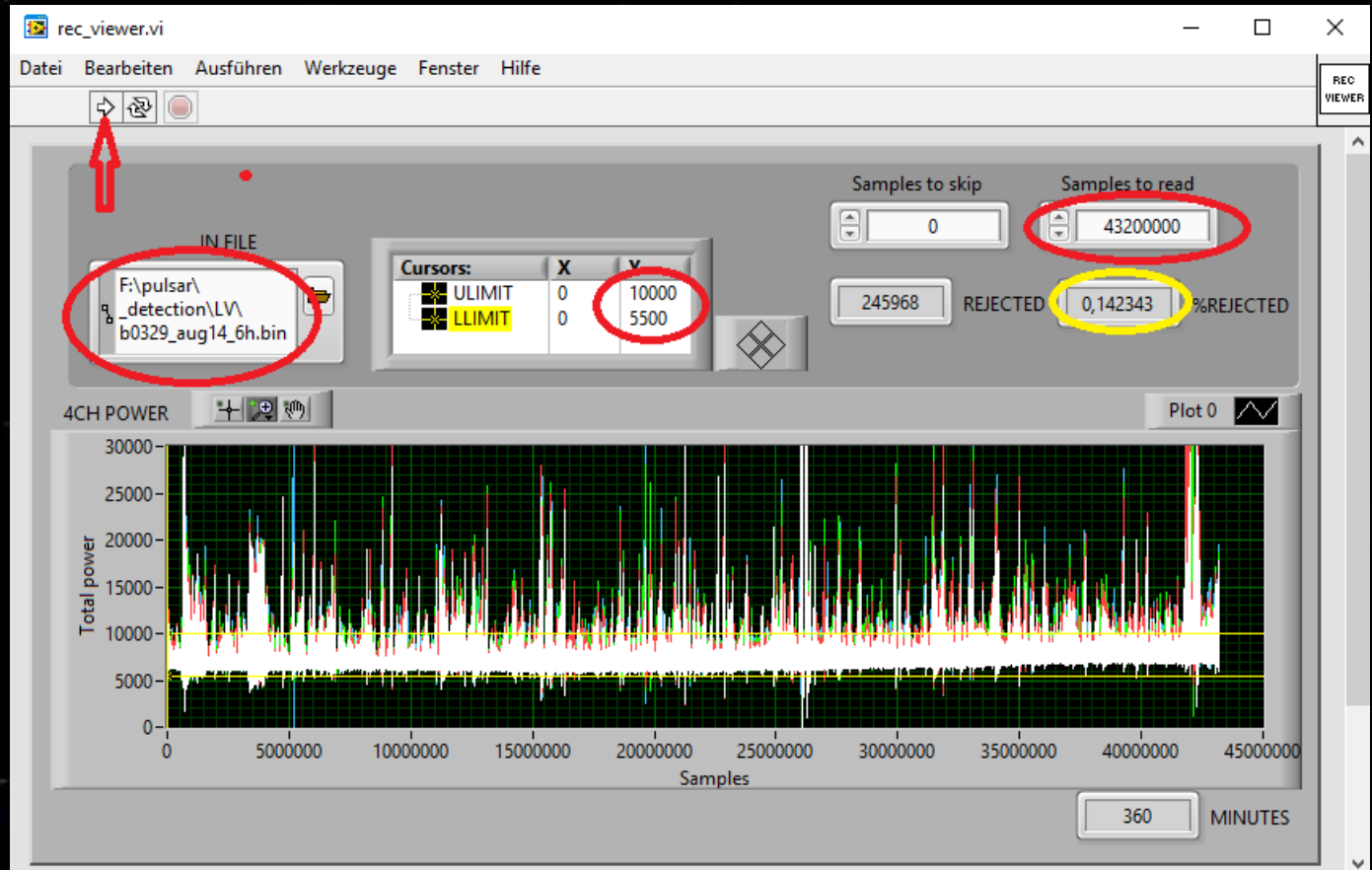




# 3. Analyzing the recorded file

For analyzing the recorded \*.BIN file I recommend to check it first with **recviewer**, to see how to set upper and lower limits for the folding process. This is important for example to suppress pulses caused by RFI, and to avoid indication of fake pulses.

As an example I took a 6 hours observation of B0329+54 (Aug 14<sup>th</sup> 2018)



Now all is prepared to try to find a pulse in the observation \*.BIN file!

### Open simple\_folding

For some values you can use default numbers. Insert the value for #PULSES INTEGRATION, for the B0329+54 this is 5000 per hour. Then set upper and lower limit from reviewer, in the example 10000 and 5000.

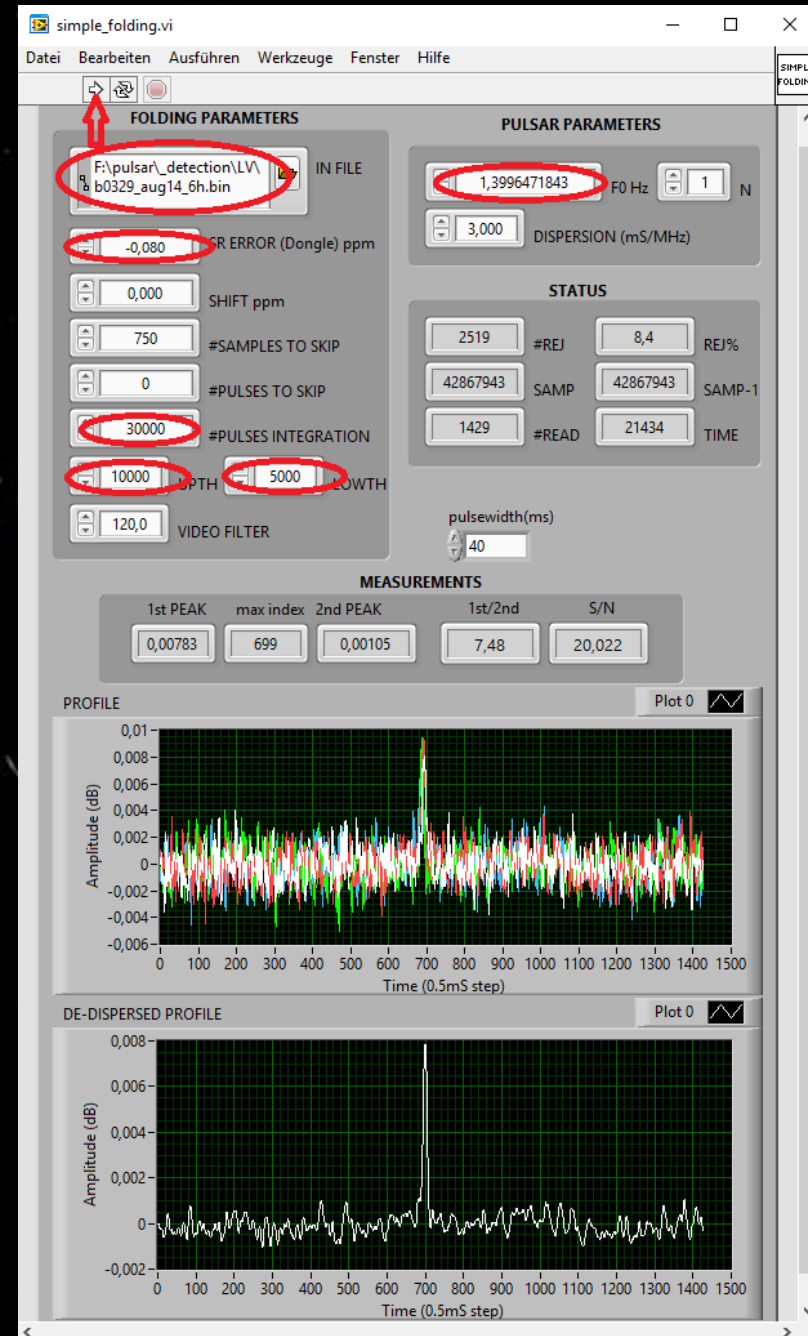
For F0 take Fmean from calculation by tempo (note the difference between the values of Aug.14th to Oct.30th).

**Running the program now, we see the pulse!**

#SAMPLES TO SKIP is for centering the pulse in the display.

Especially for long observations the frequency error off the RTL-SDR can be an issue.

In the example the value for compensation is -0,08 ppm.



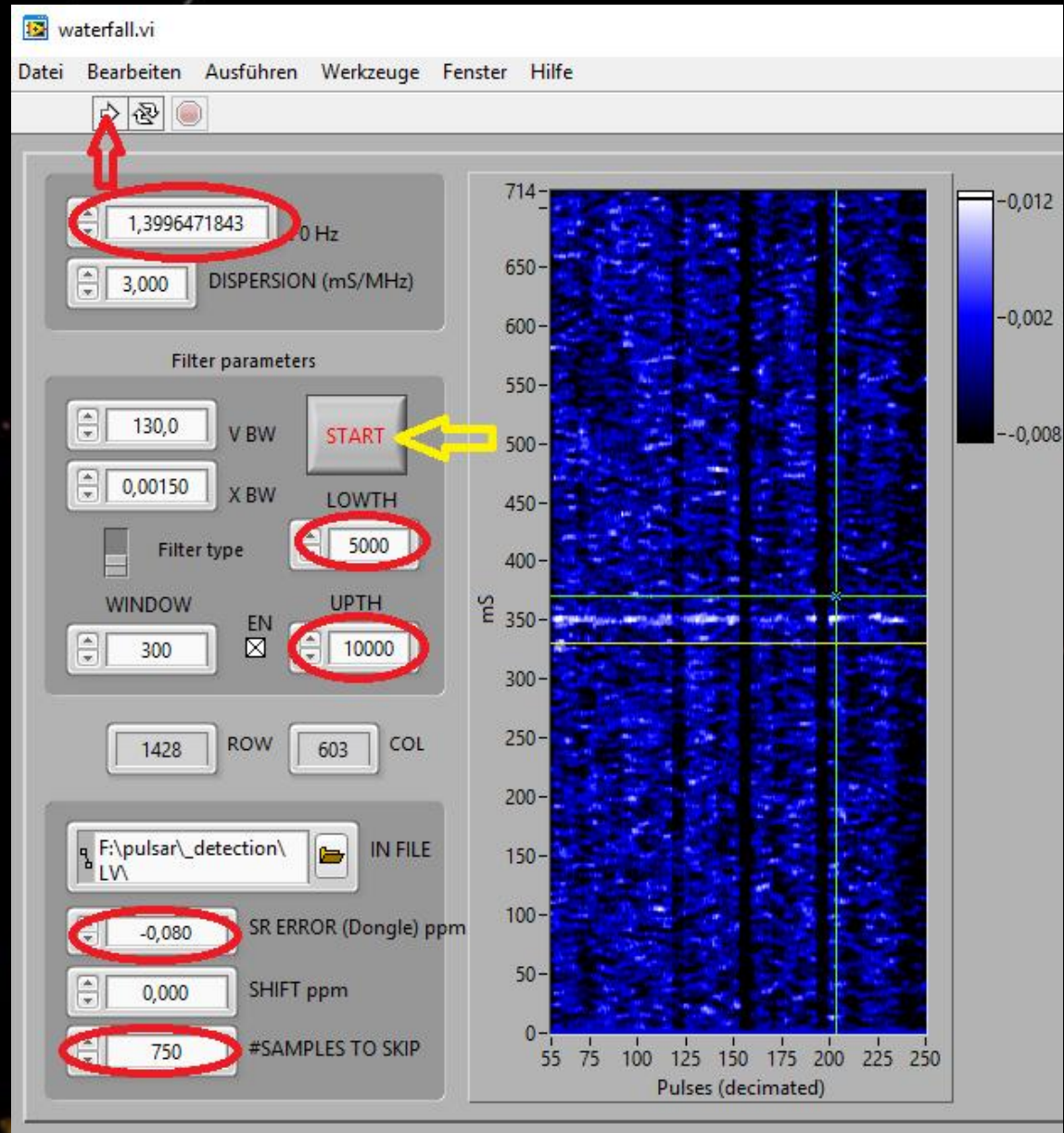
# The program waterfall is also a nice tool

In this example you see that during the observation there was strong RFI several times.

Those parts of the observation are eliminated in the waterfall (black parts), and also for folding.

Without suppressing the parts with RFI the result would be lower S/N.

Try it and have fun!



**Special thanks go to Andrea, IW5BHY and his son Giorgio for making the software available!!**

**Now a few more interesting results I obtained over the last two years:**

**Crab pulsar including giant pulses**

**Example for the influence by dispersion**

**Parallel observation with different bandwidth and software**



# Crab-pulsar B0531+21

Young pulsar, exists since a supernova explosion in 1054  
(observed on earth as a star even visible at daylight for about two years)

Rotates 30 times per second

Fast speed slowdown: 1% in 25 years, 1ppm in less than one day!

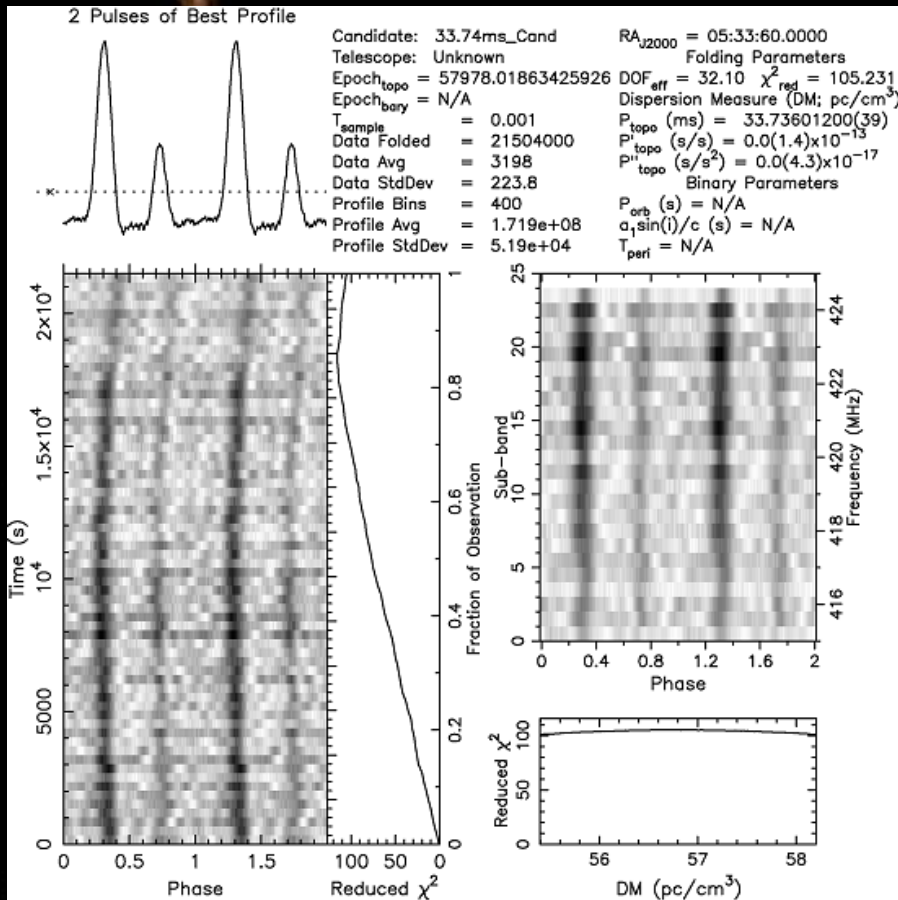
Highly dispersed : 6,4 ms per MHz is more than the pulse width,  
at 10 MHz bandwidth dispersion is 2 periods!

produces “giant pulses”

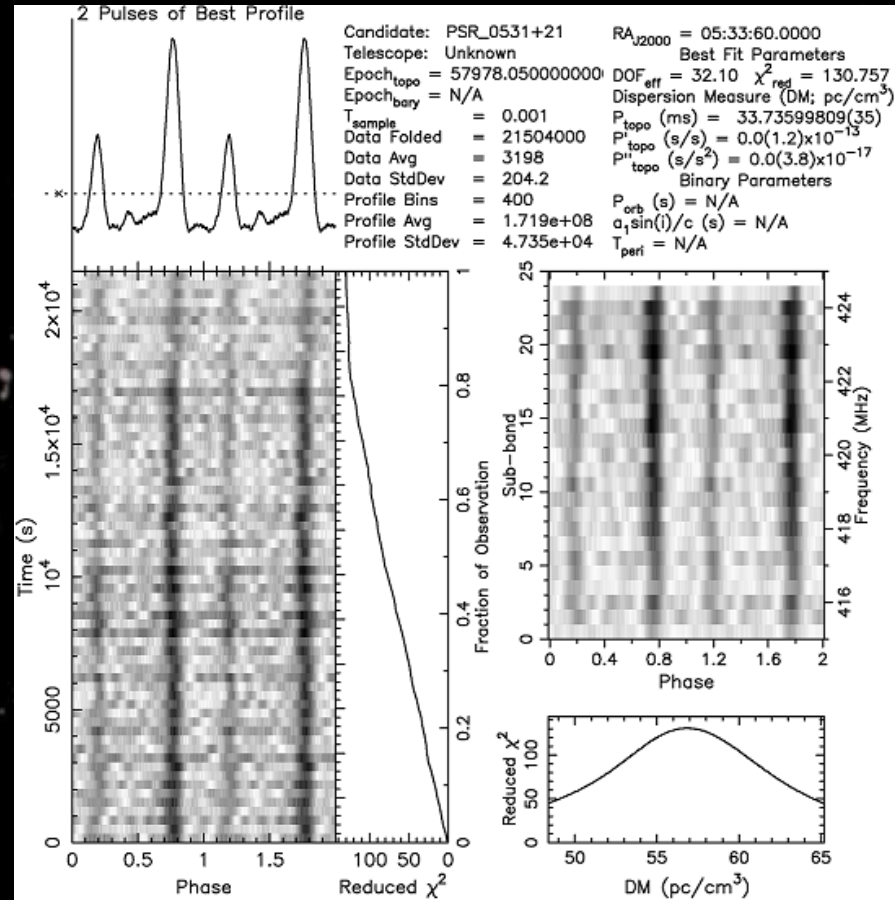
In an observation file of B0525+21 the Crab signal was  
found as well with good S/N, including giant pulses

# Crab pulsar 6 hours observation

software: Presto



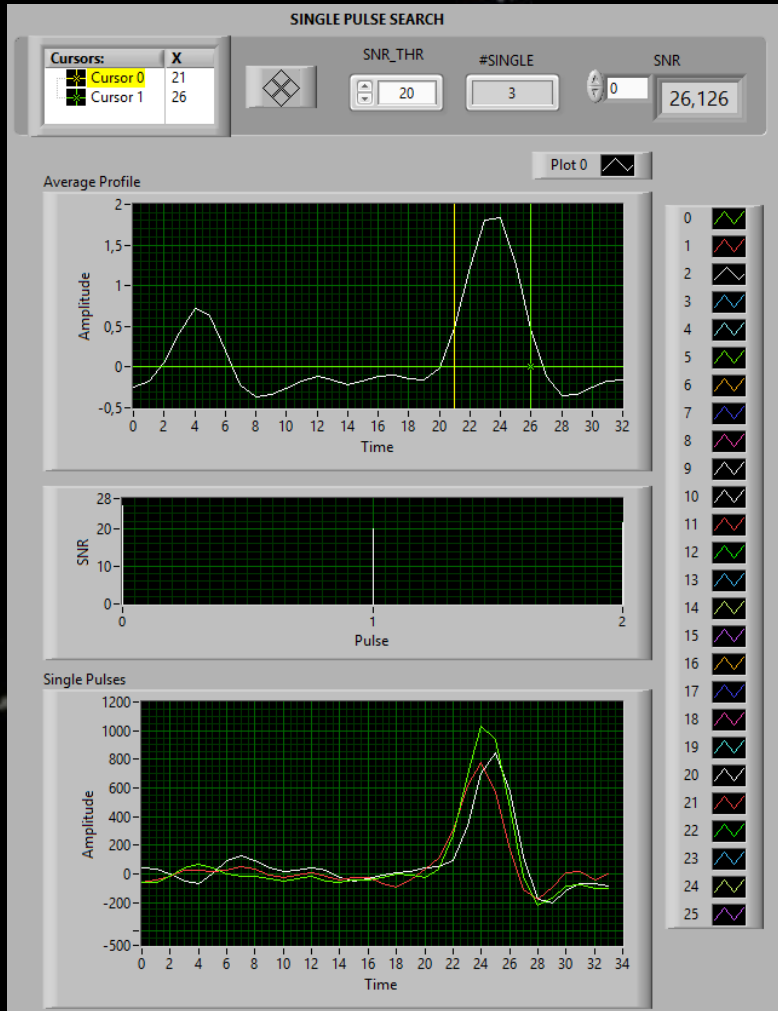
folding without frequency tracking



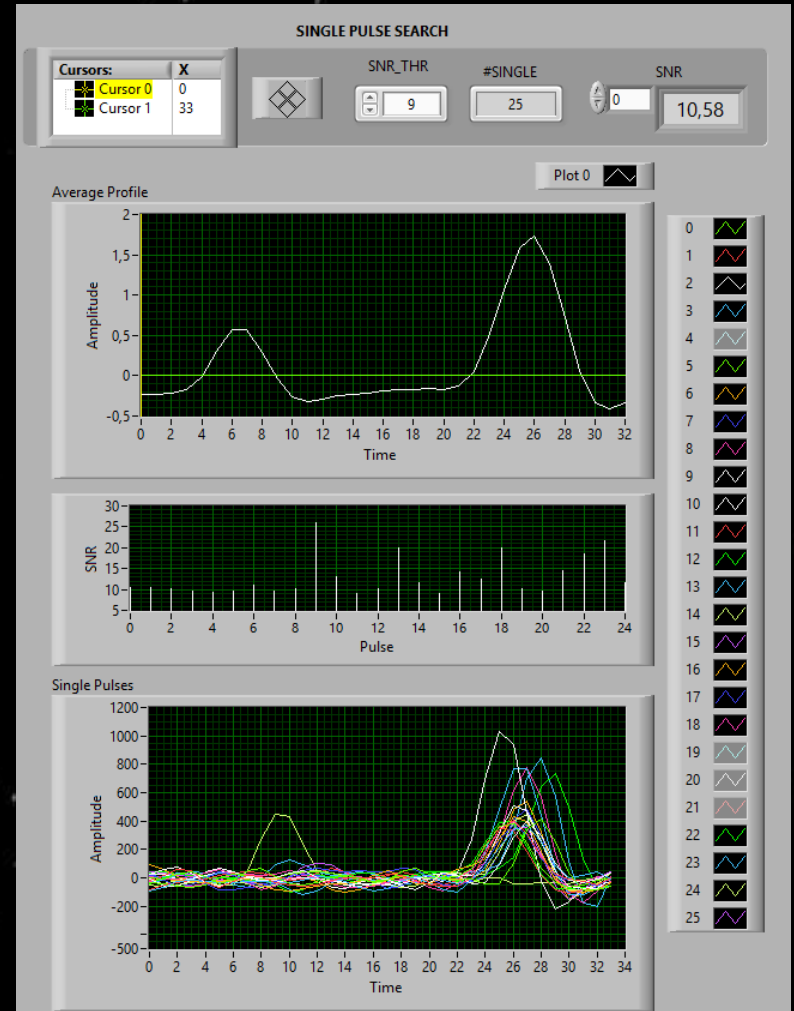
folding with frequency tracking

# Crab Pulsar: Giant Pulses

software: IW5BHY



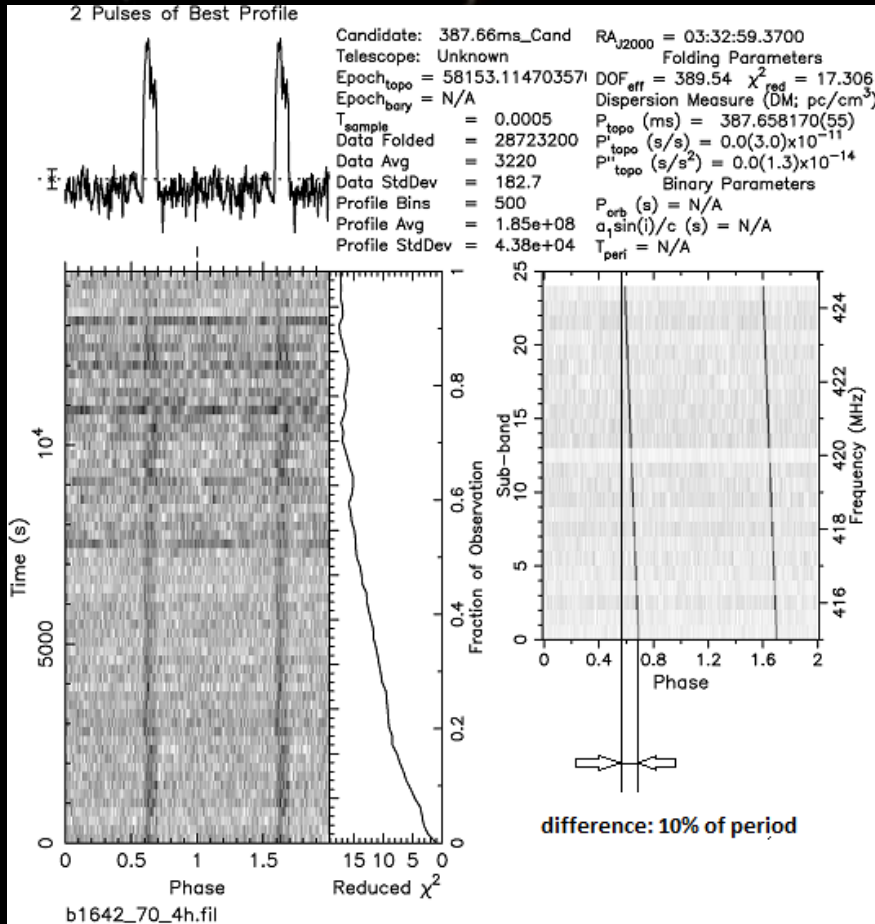
3 best giant pulses (high limit)



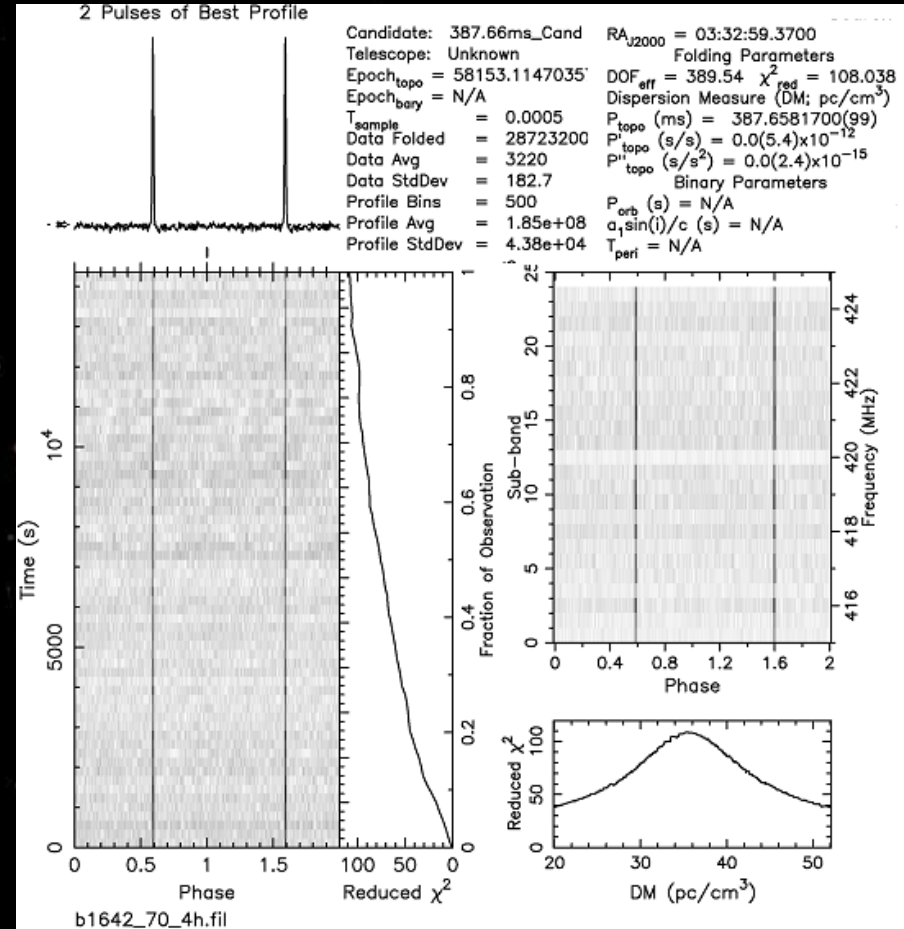
21 best giant pulses, one interpulse

# B1642-03: period 388ms, pulse width 4ms

## dispersion DM=35,76 $\rightarrow$ 4ms/MHz (40ms/10MHz)



folding without de-dispersion:  
pulse smeared, low S/N

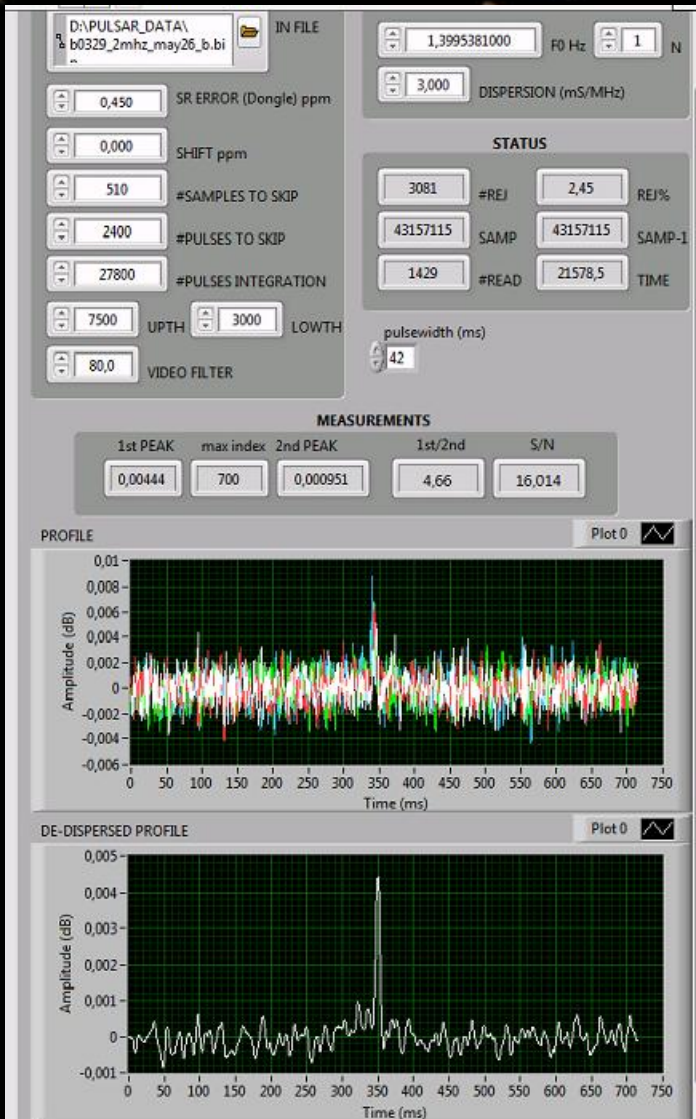


folding with de-dispersion:  
pulse very sharp, high S/N



# 70 cm Observation B0329+54 With 3m Dish

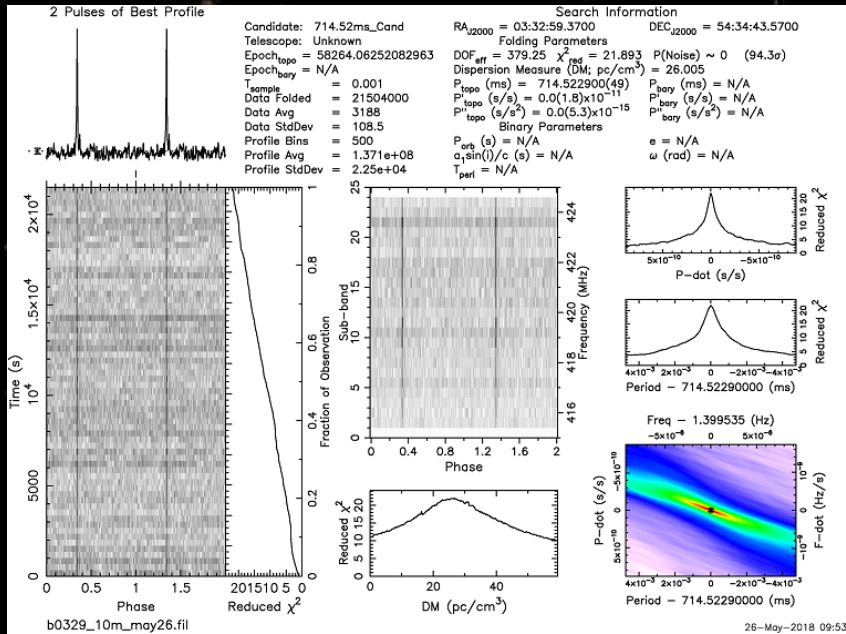
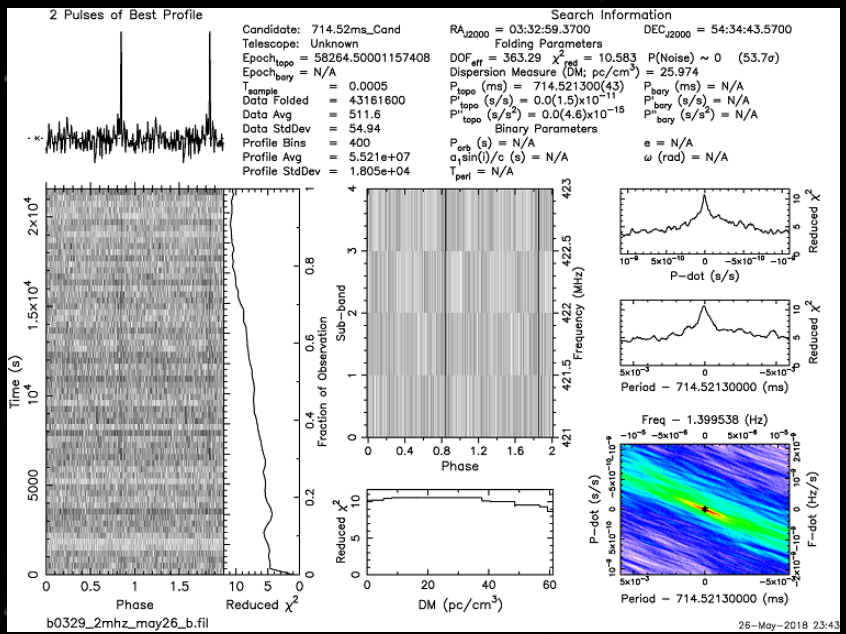
6 hours, parallel 2 MHz and 10 MHz



2 MHz  
Presto →

←  
2 MHz  
IW5BHY

→  
10 MHz  
Presto





**thank you  
for  
your attention**