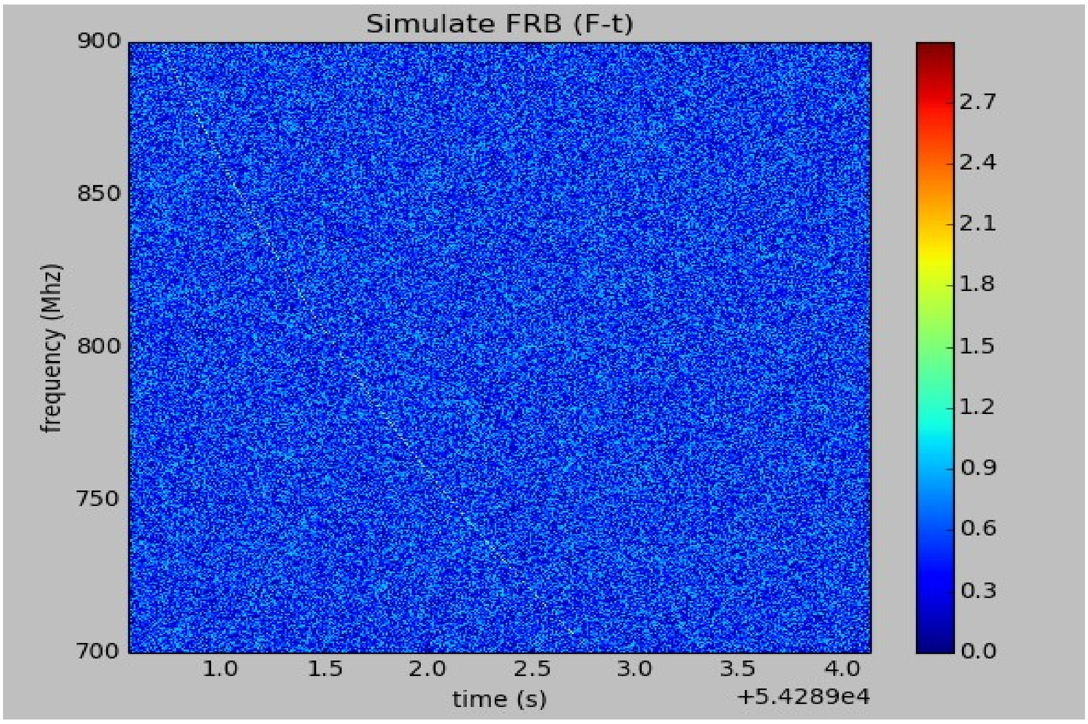
A new method to search FRB signal

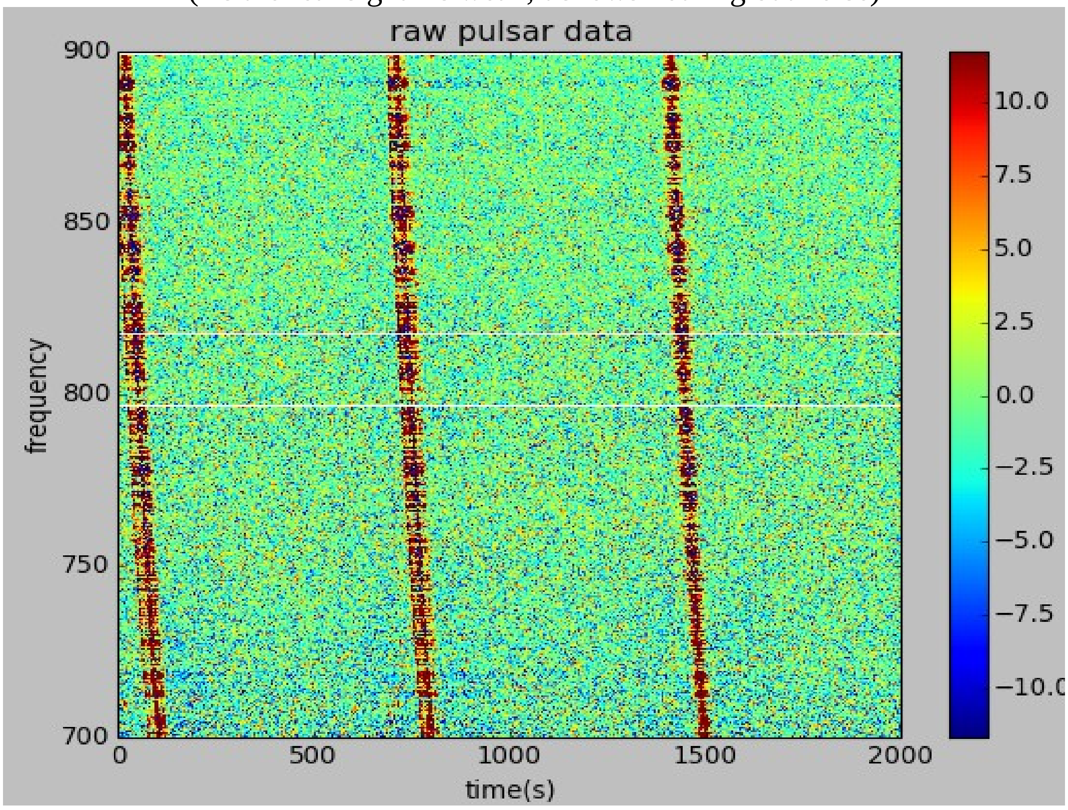
We copied the FRB 110523 data from GBT,and use the Image processing method to search the signal.

1.Load data

Choose filtered_short.npy and the “I” polar direction. The data loaded is a [4096,3500] matrix which contains 3500 time points and 4096 frequency points.



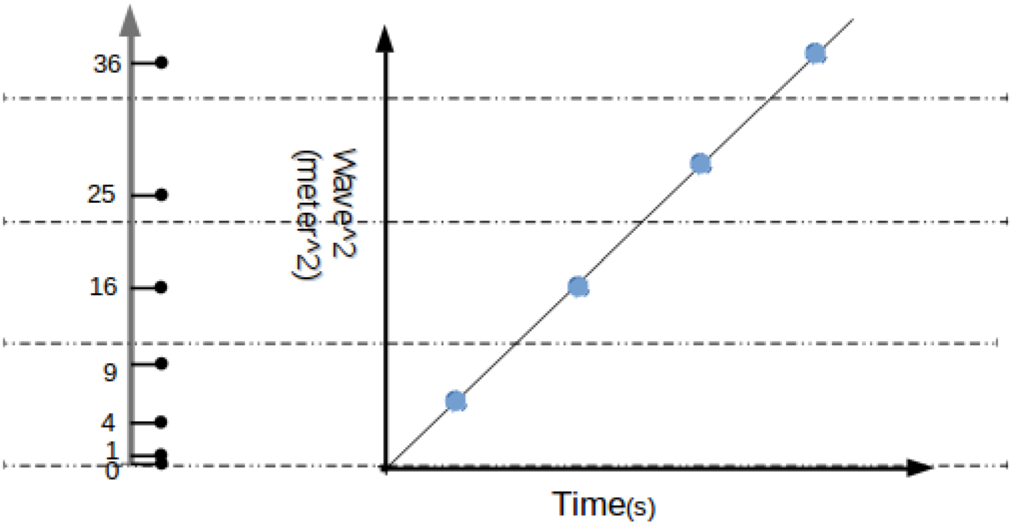
The simulate FRB signal with a high SNR :5
(As the real signal is weak,it shows nothing but noise)

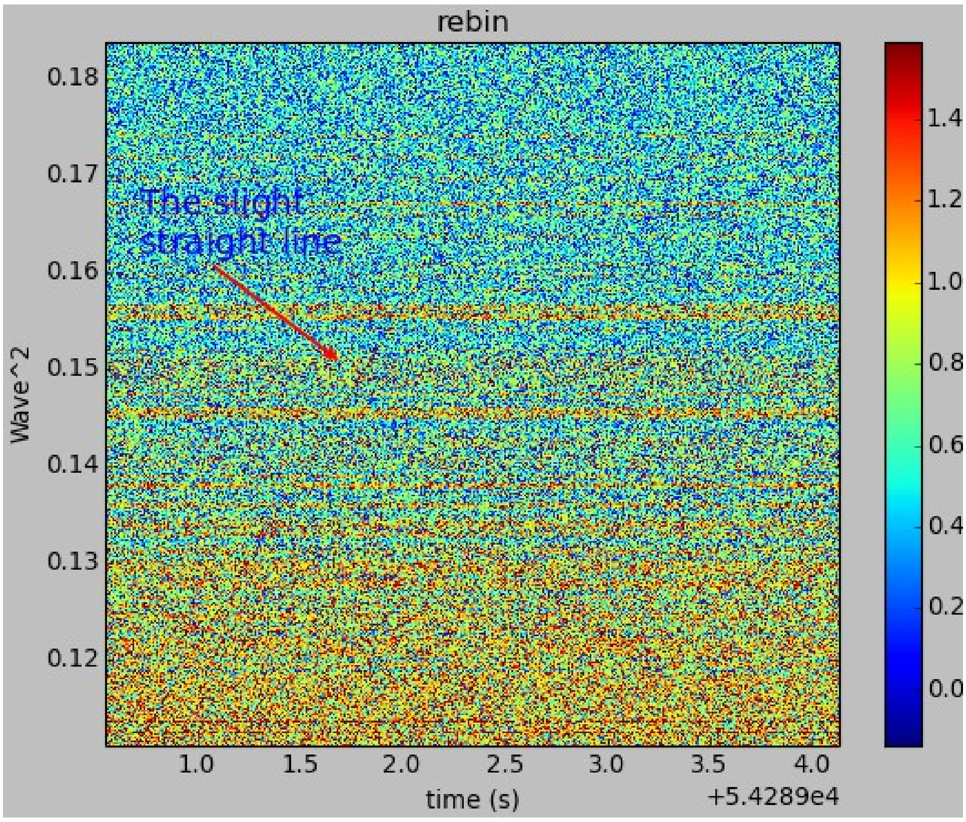


The pulsar B0329+54

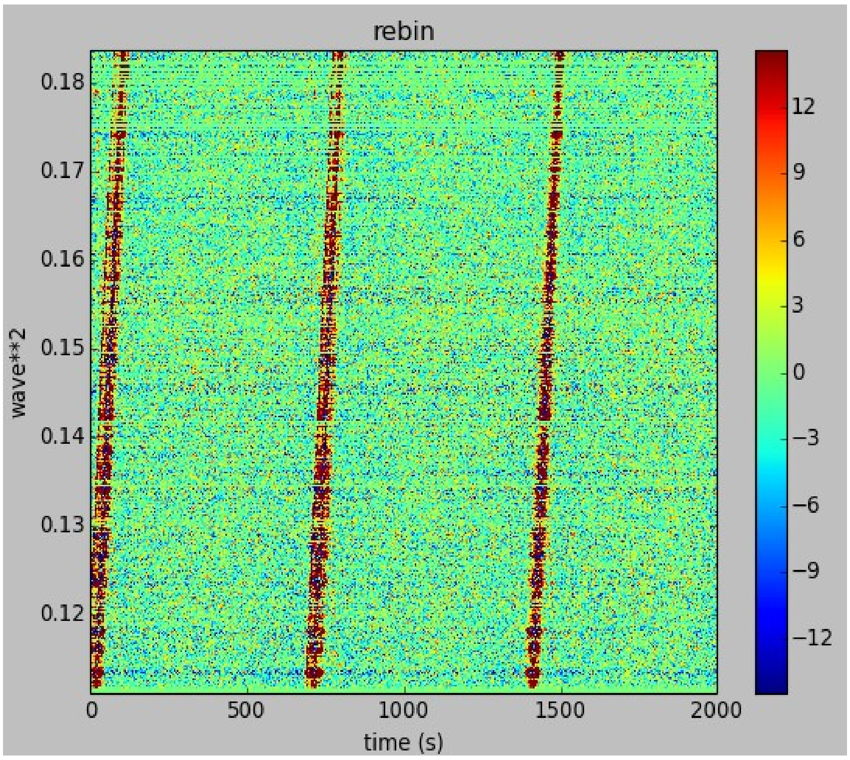
2. Re-bin data:

As the data matrix has a uniform f axis,The dispersion is a curve. We interpolate the frequency axis and change it into wave square axis. Thus the dispersion should be a line in the matrix. For calculation convenient, We re-bin the wave square axis to make the matrix smaller.





The simulate FRB signal after re-bin. When the SNR is 5,we could see a slight straight line on it.



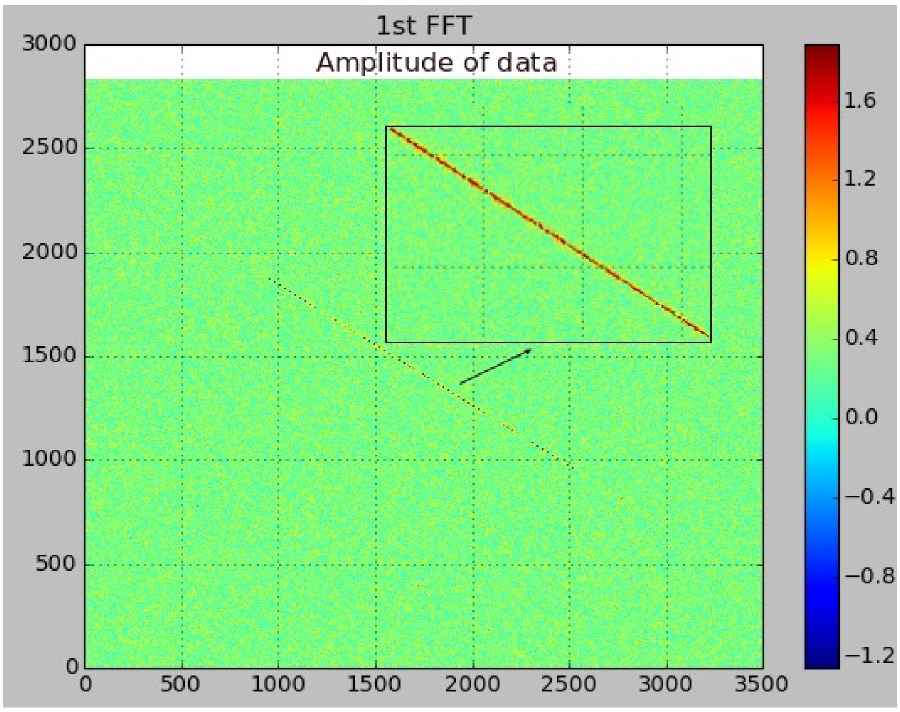
The pulsar B0329+54 after re-bin.

We could not see any signal line from the 2-D picture with naked-eyes ,no matter what process is,when we plot the FRB 110523 data (e.g. raw-data or re-bin or FFT).So we only display the simulate signal and the pulsar 2-D pictures.

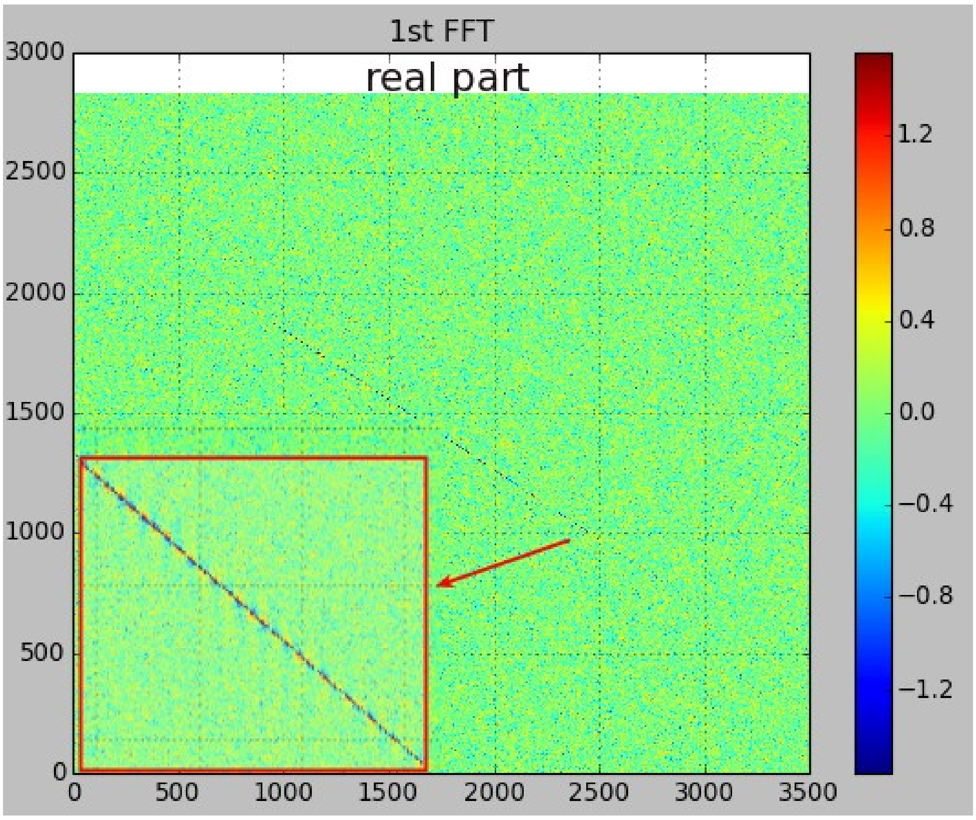
3. 2-D FFT ：

The next job is to find this line in the image. Firstly We do the 2-D FFT on the re-bin data. This helps to make the line of the image ,if it exists,pass through the center of image. After this All the lines will pass through the center.

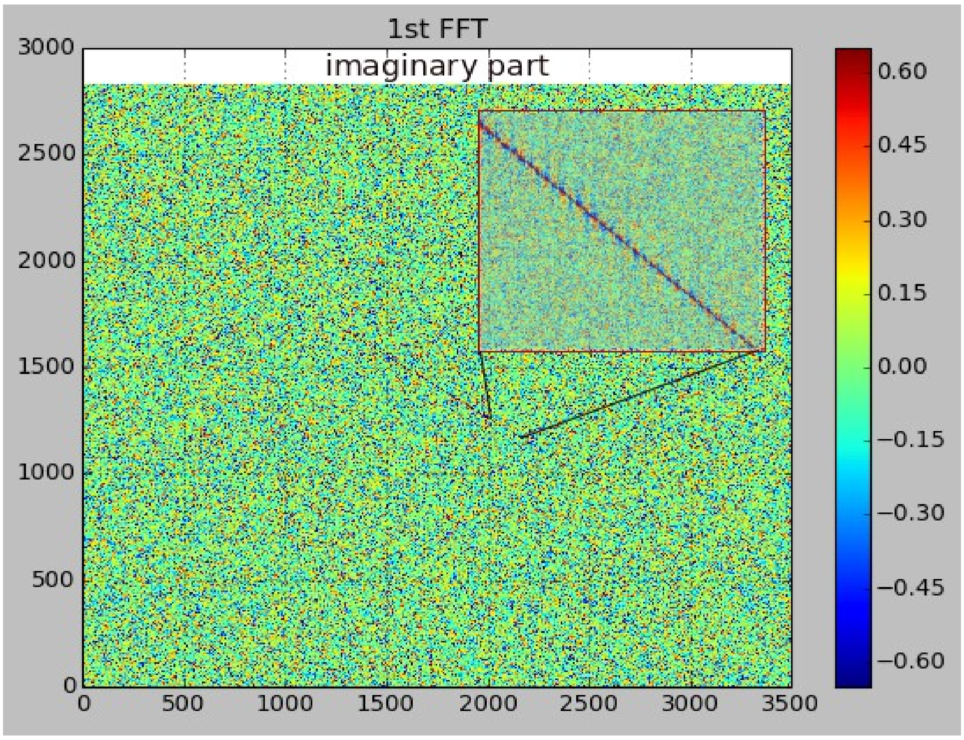
The simulate data after 2-D FFT:



(The amplitude of the complex data.)

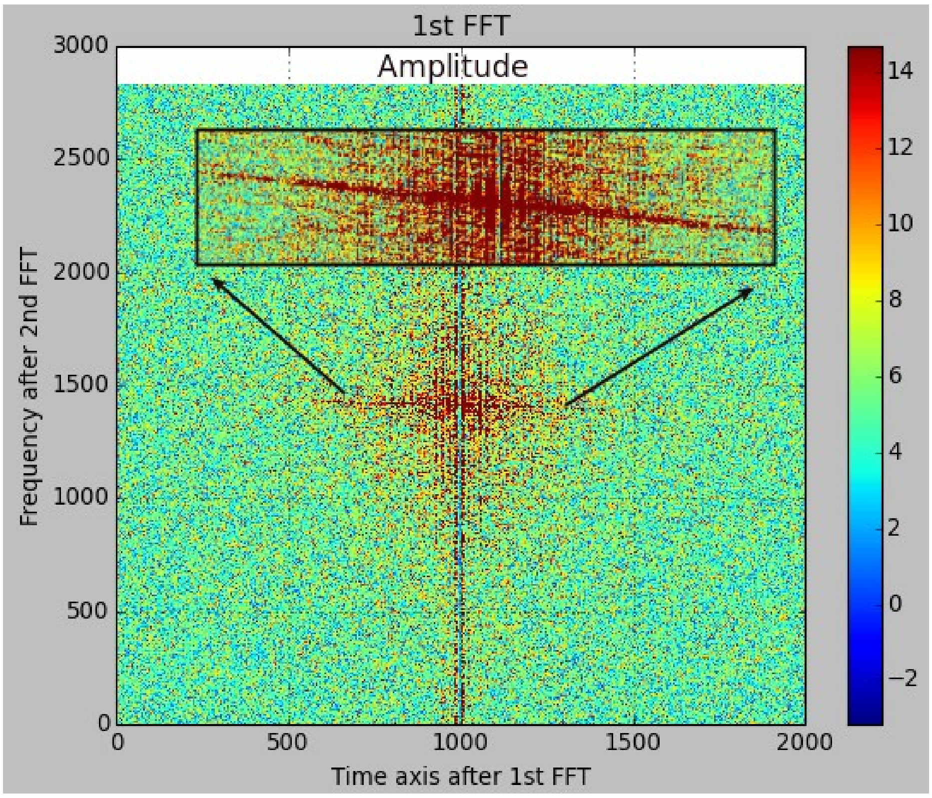


(The real part of the complex data.)

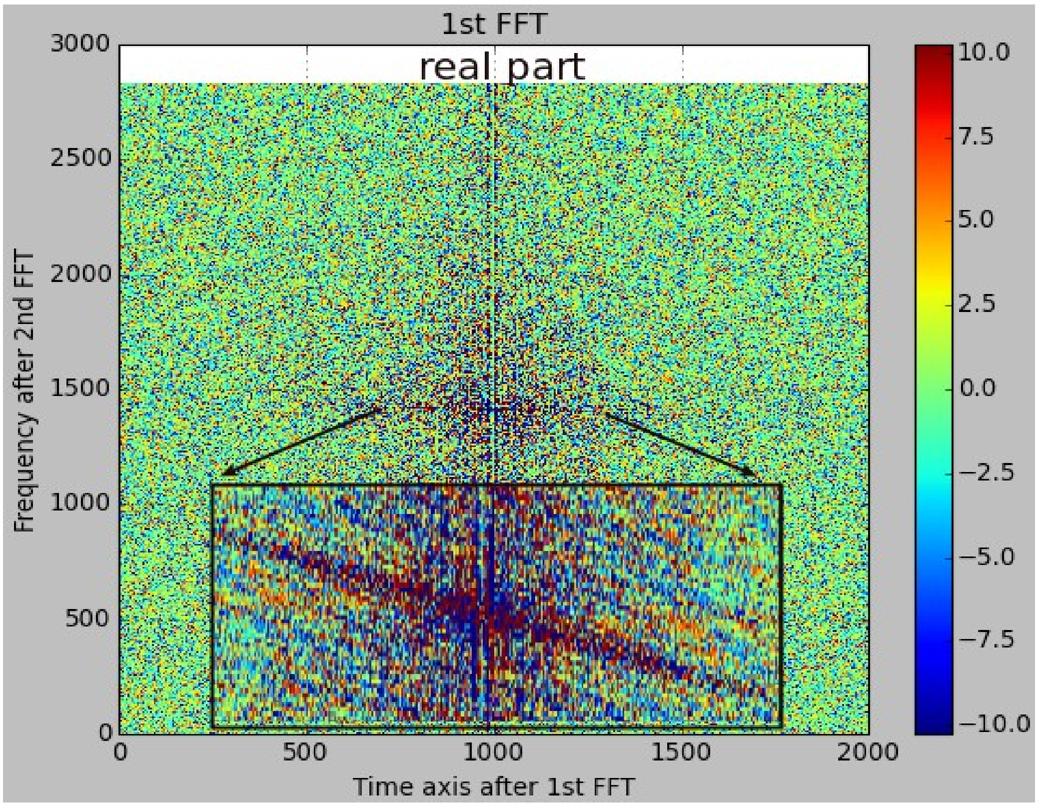


(The imaginary part of the complex data.)

The pulsar B0329+54 after 2-D FFT:

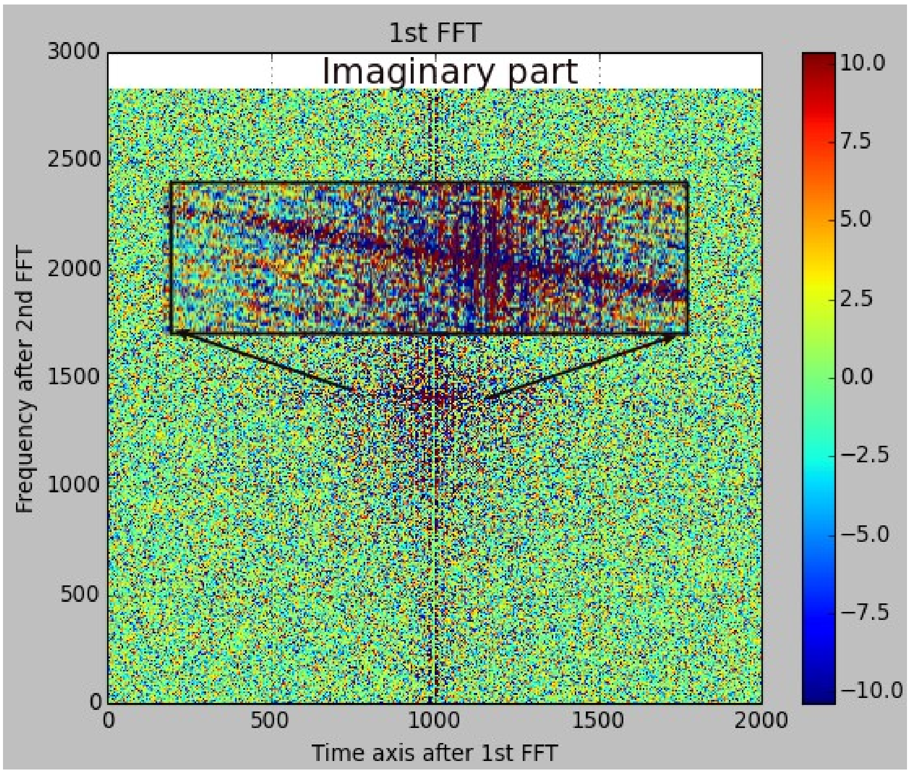


(Amplitude of the data)



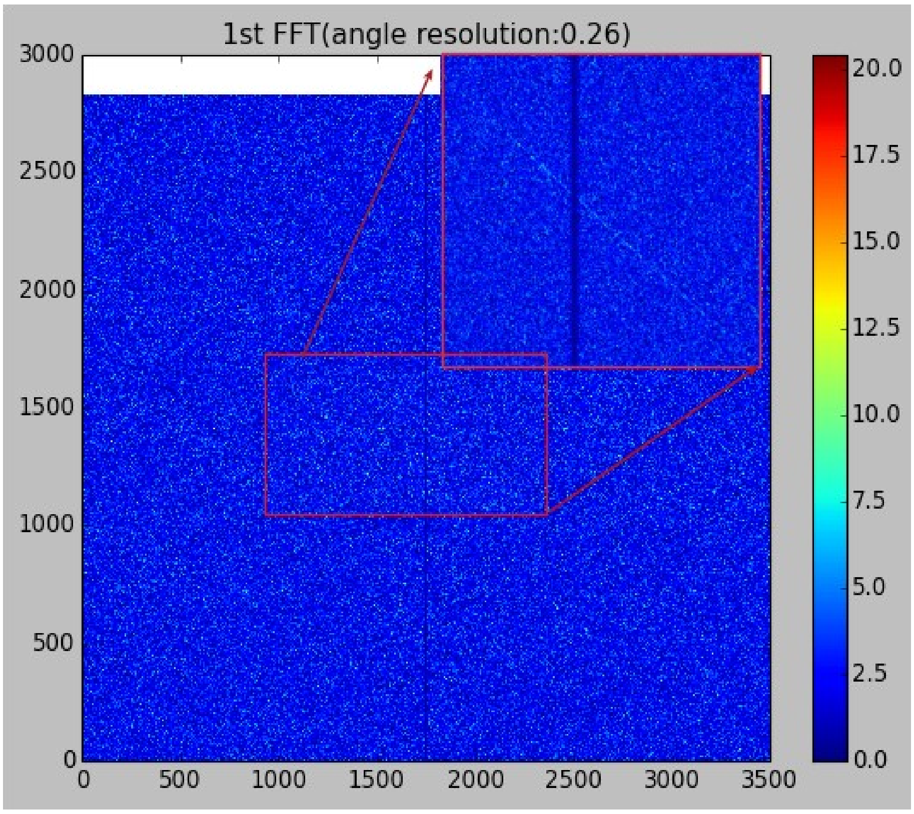
(Real part of the data)

We could see a slight line in the large scale from FRB data,but found nothing but noise from real and imaginary part .



(Imaginary part of the data)

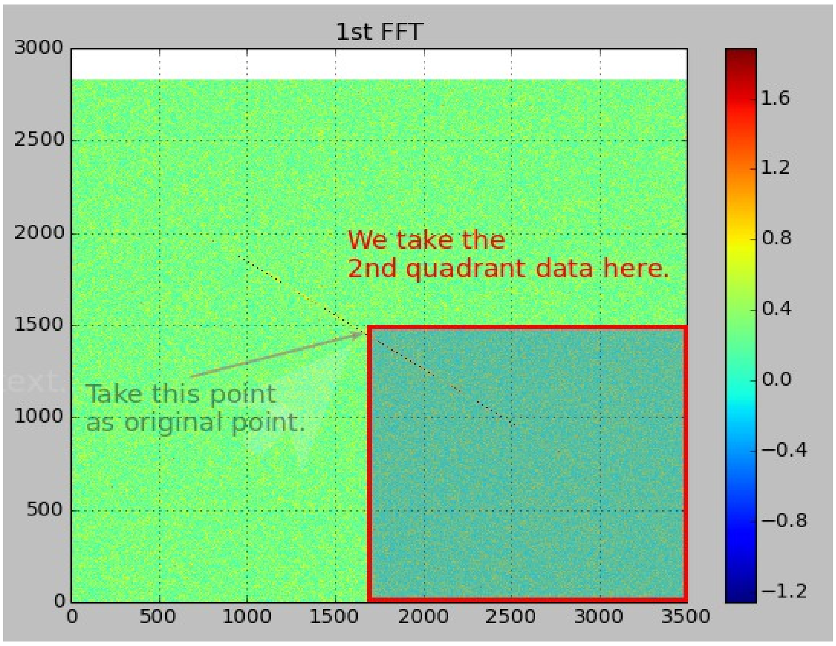
FRB 110523:



We could see a slight line in the large scale from FRB data,but found nothing but noise from real and imaginary part .

4. Polar coordinates convert.

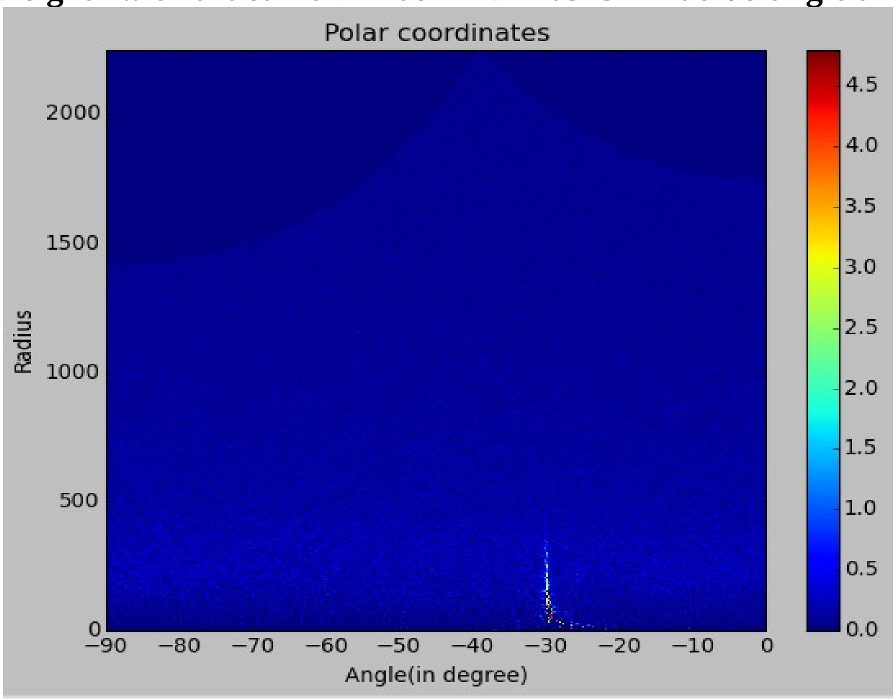
We could see the line with particular angle apparently. Each angle present a special DM signal line.And it's easier to locate a line only with angle and radius. So we convert the data to polar coordinates. As the DM always bigger than 0,the signal line after FFT should not appear in First and third quadrant. So we only need the 2nd or 4th quadrant data. (it's conjugate to each other.)



We only need the 2nd quadrant data after FFT. The part in red frame in this image.

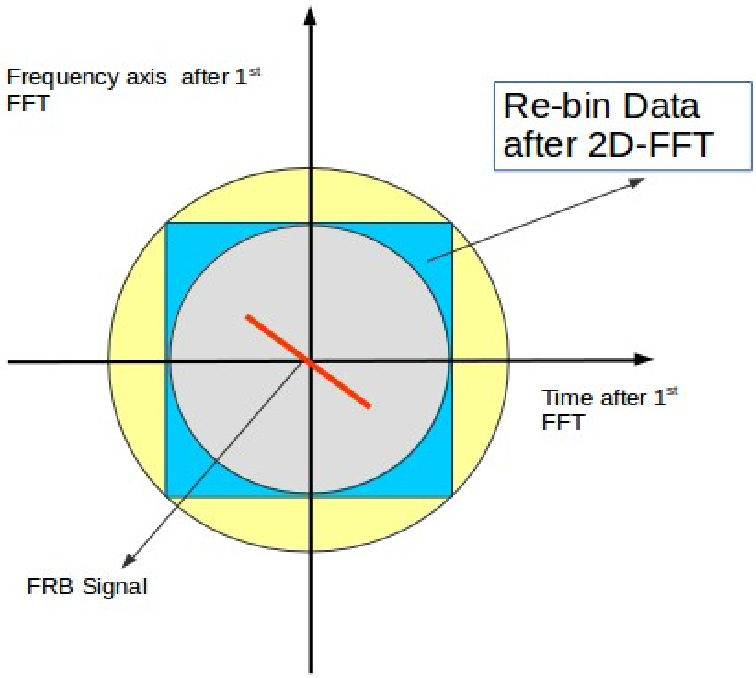
Take the center of map as original point, and calculate angle and radius length from center point for each point. Then create a zeros matrix with the shape of [max_radius,max_angle],then we can put the corresponding value to the zeros matrix with corresponding index[radius,angle]. Finally we could get the polar coordinates matrix,and could plot it with angle and radius axis.

Simulate FRB signal with the same DM as FRB 110523 in radius-angle axis:

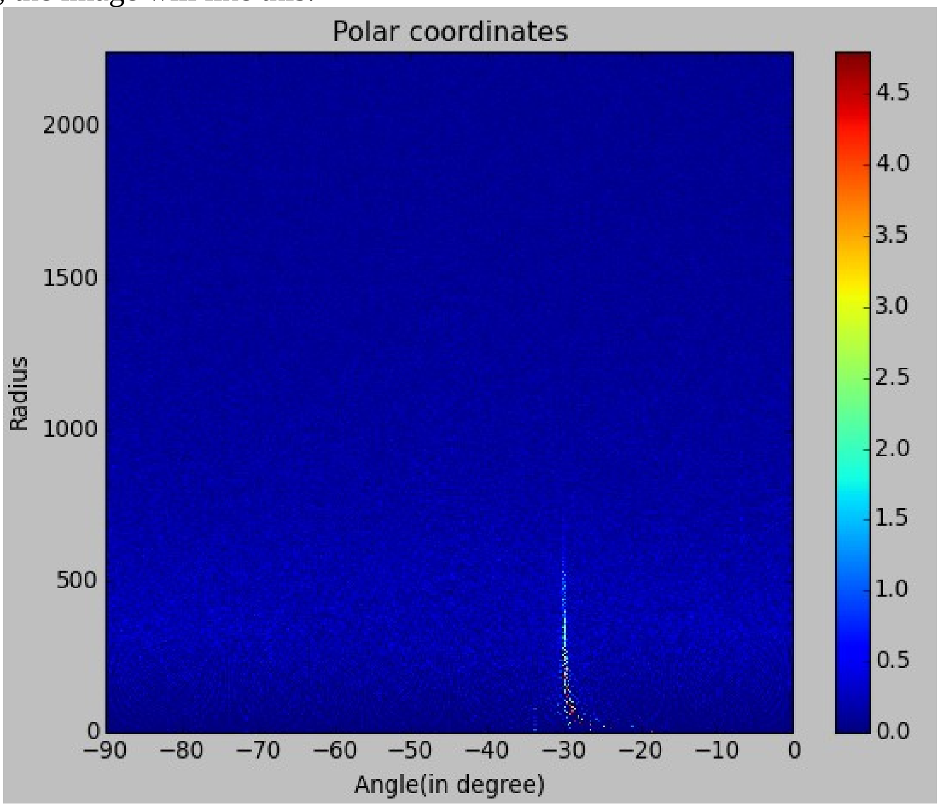


(Amplitude of data)

The length of the signal is not so long ,for calculate convenient,We can only take some part of the Data to exclude the zeros of polar_matrix. Like the following sketch map,We only take the gray part of the 3rd quadrant.

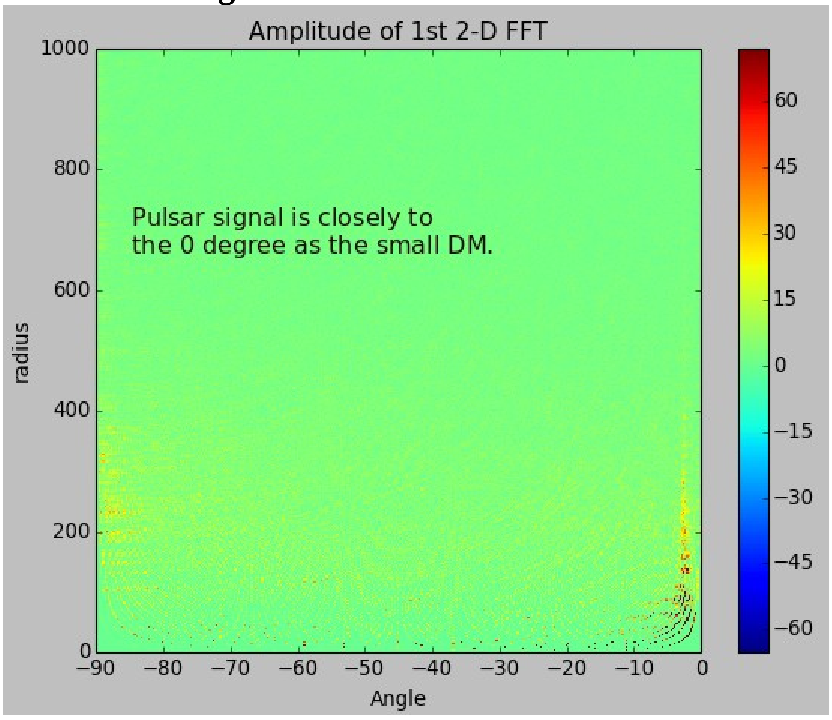


After the cut , the image will like this:



We could see the signal is obviously in about -30 degree.

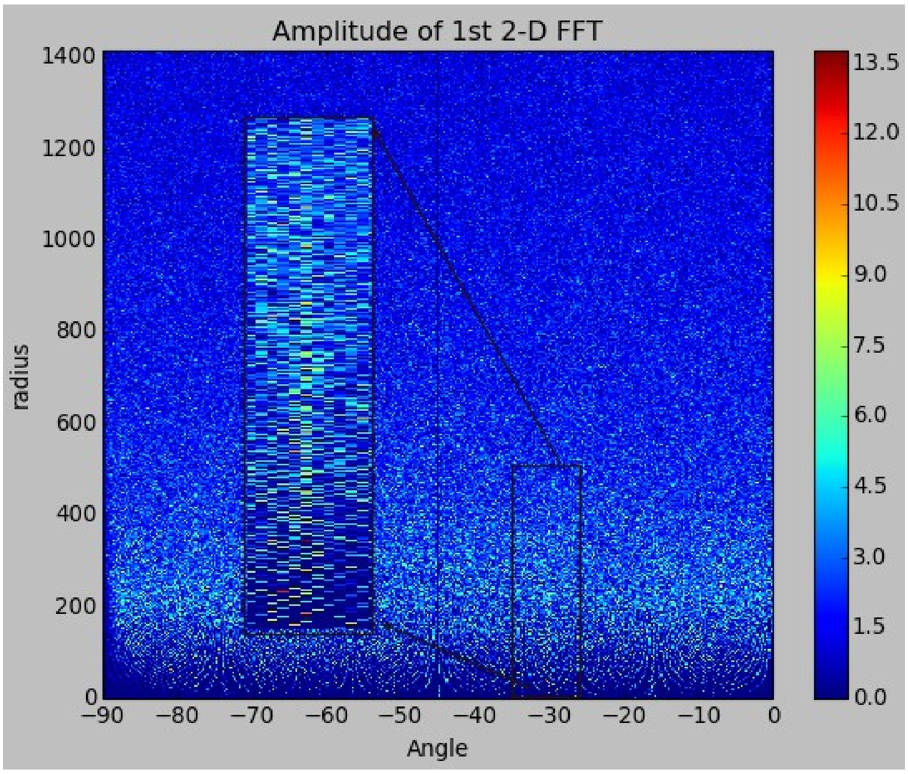
The pulsar signal in radius-angle axis:



(Amplitude of data)

As the pulsar has a small DM , so it is closely to the 0 degree.

The FRB 110523:

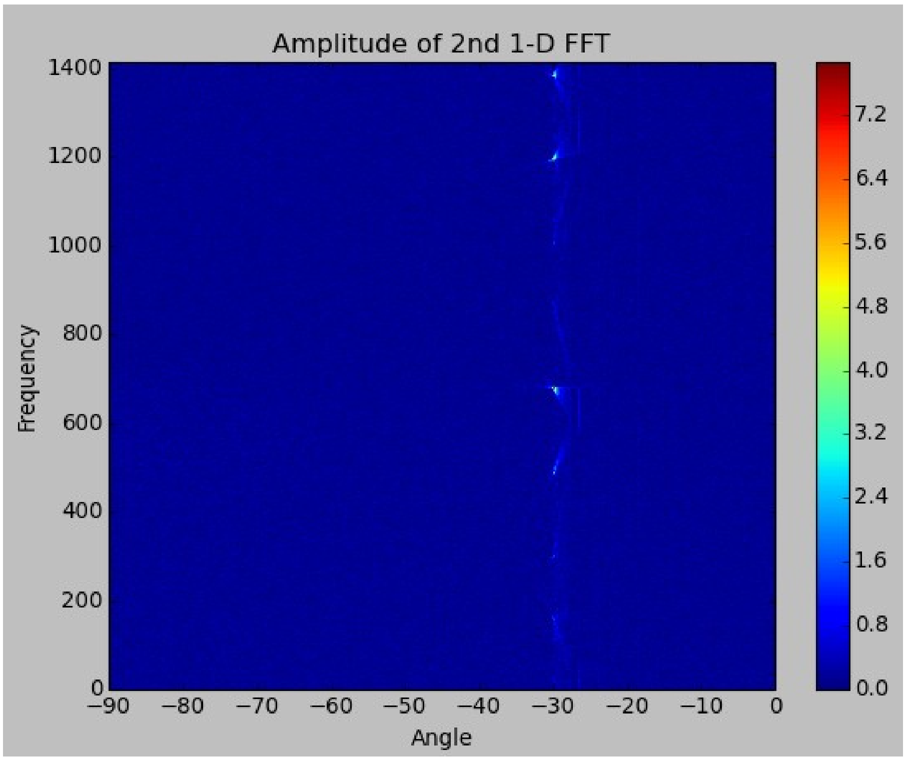


5 sum it up

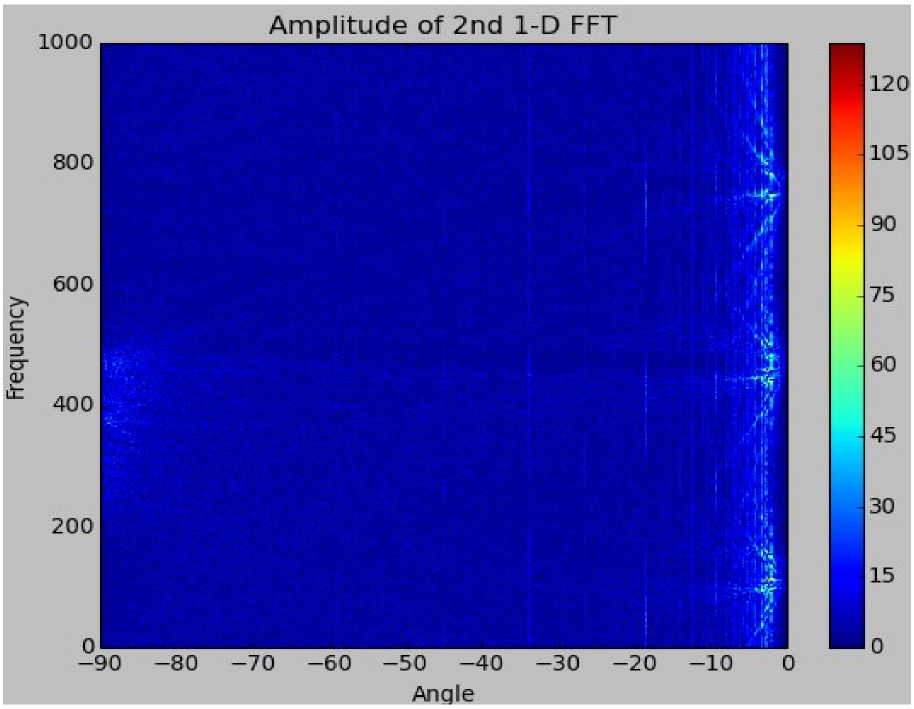
Now we need sum it up along the radius axis from -90~0 degree to find a strong signal. A 2nd FFT may help to increase the SNR as Peng sugges.

5.1 2nd FFT along the radius axis

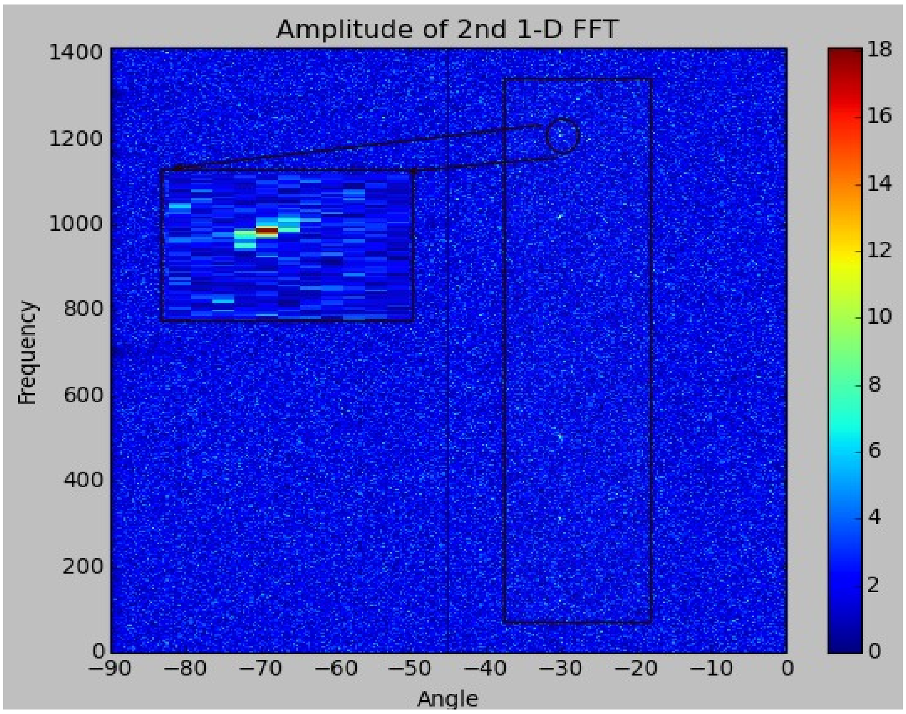
Simulate signal :



Pulsar B0329+54:

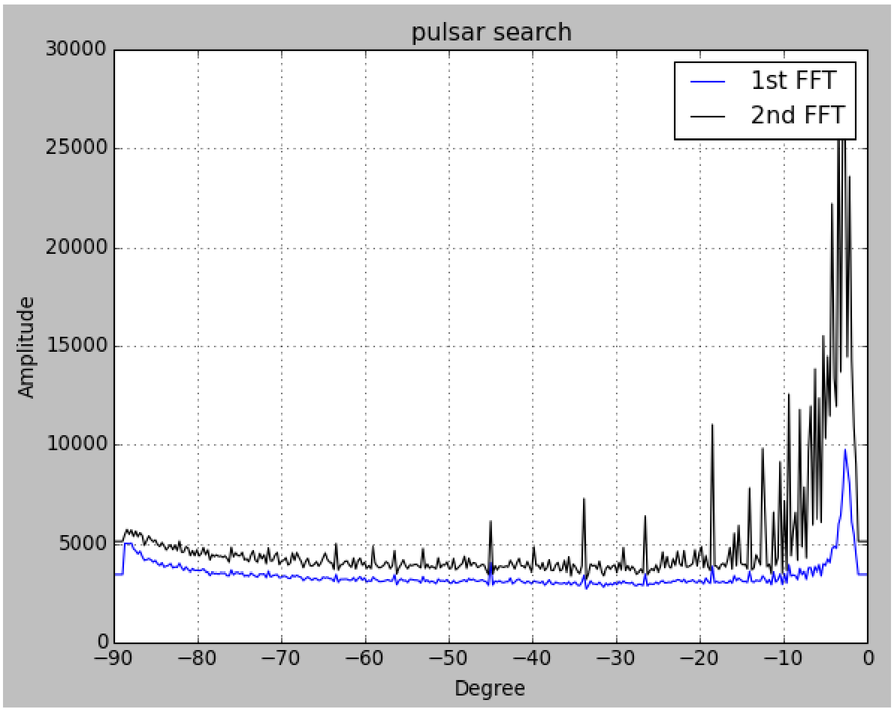


FRB 110523:



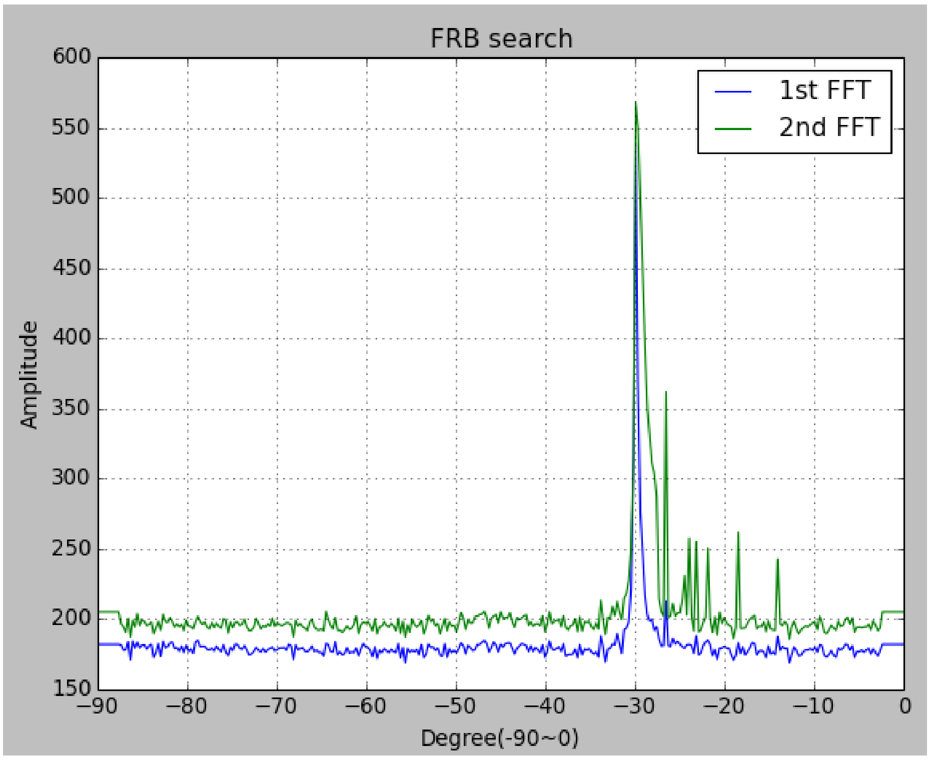
5.2 Sum it up along the radius axis.

Pulsar B0329+54:

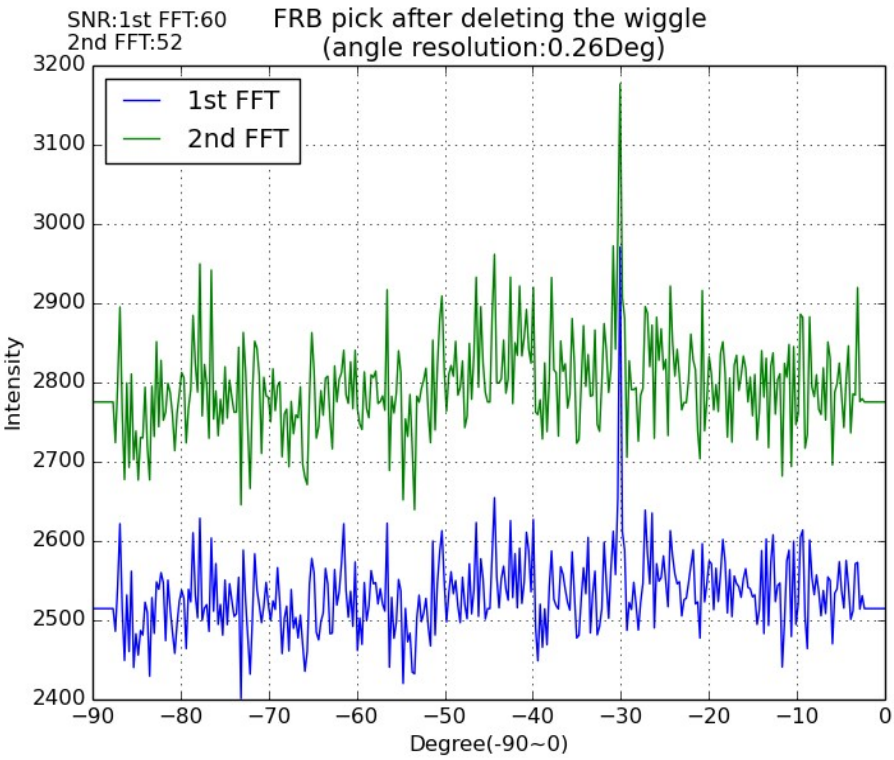


The pulsar signal

Simulate FRB with SNR=5:



FRB 110523:

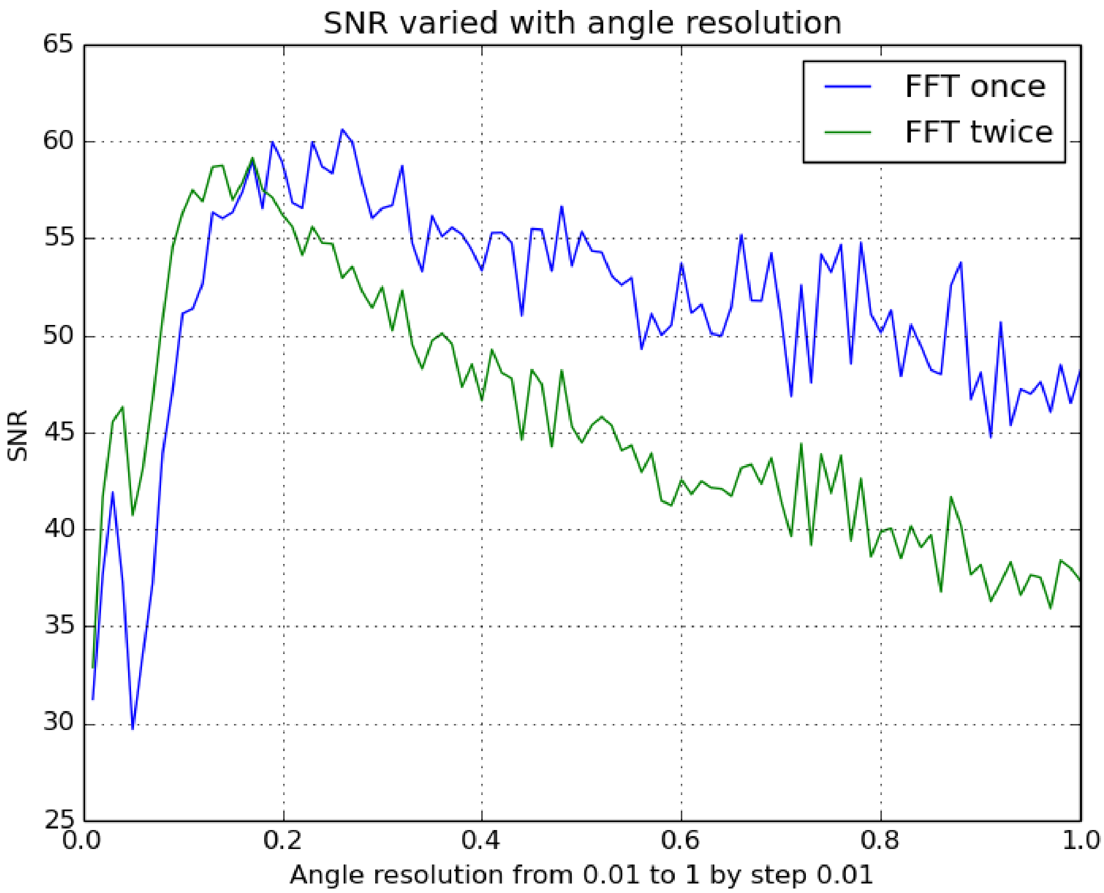


Here we do the 2nd 1-D FFT along the radius axis. And all the SNRs are calculated with the amplitude of the data. The SNR may have a decrease after the 2nd 1-D FFT. It indeed amplified the signal, However, It also amplified some false peak like the picture above.

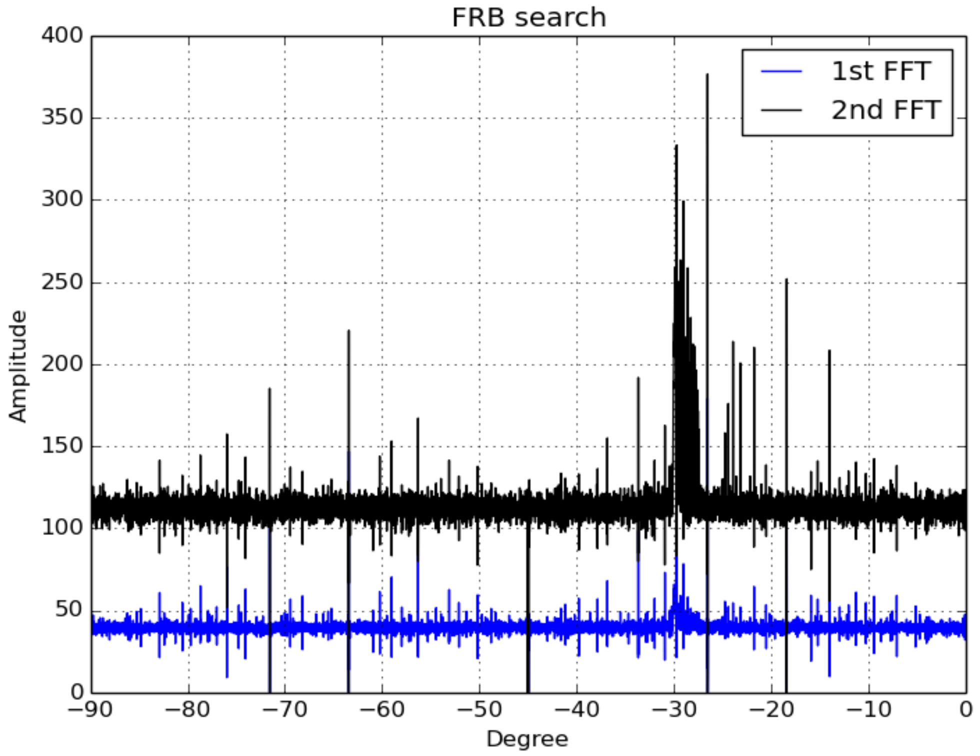
Issues to discuss:

1. Angle resolution problem:

We notice that ,the SNR is relatively depend on the resolution of angle when we change the coordinates into polar coordinates. In other words, if we separate the -90-0 degree into different interval, the SNR will change obviously. We have do a experiment that make the angle resolution change from 0.01 to 1 by step 0.01 ,when keep the radius resolution value stay in 1.Because we thought the radius resolution does not influence the SNR. We found the 0.26 degree resolution may keep the highest SNR.

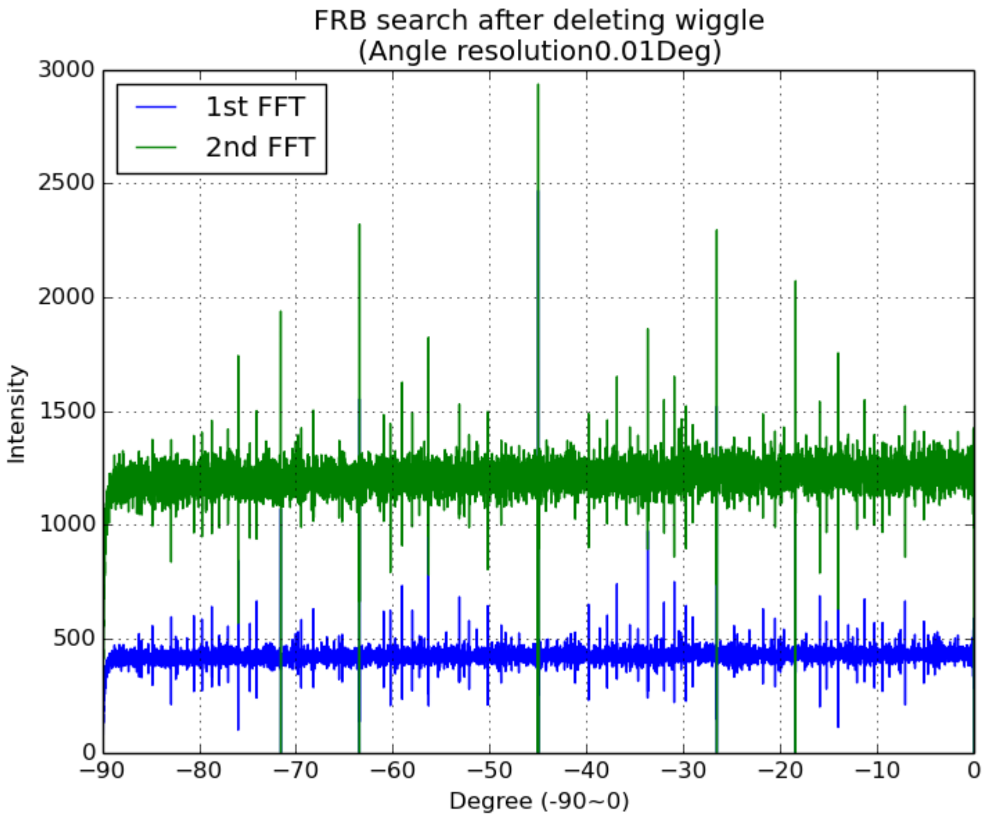


2. The different angle resolution may caused some big wiggle in the Intensity – angle map:
Simulate FRB signal with 0.01 degree angle resolution:

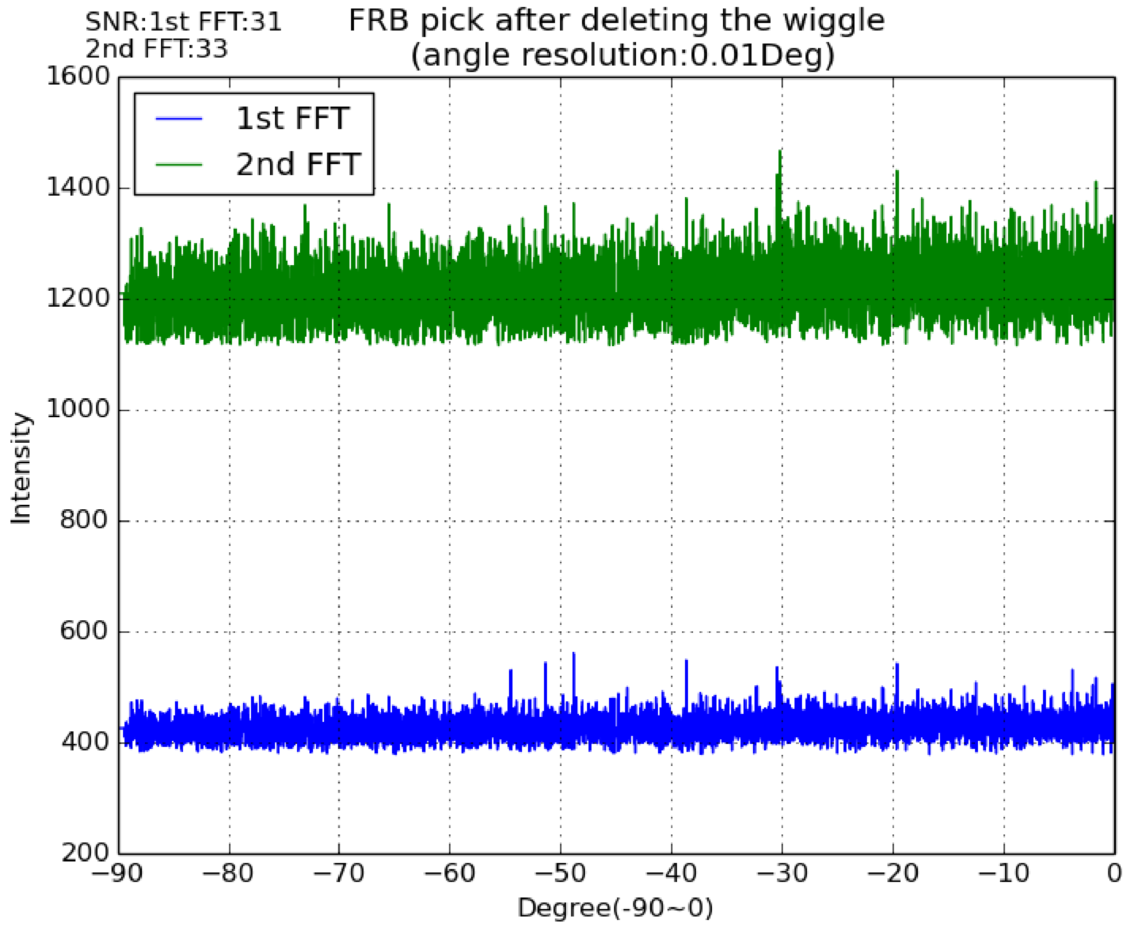


For the strong simulate signal,the wiggles do not influence the SNR so much, the signal could see from the wiggles.

FRB 110523 with 0.01 degree angle resolution:



The FRB have already smeared in the sharp wiggle. After I delete the wiggle

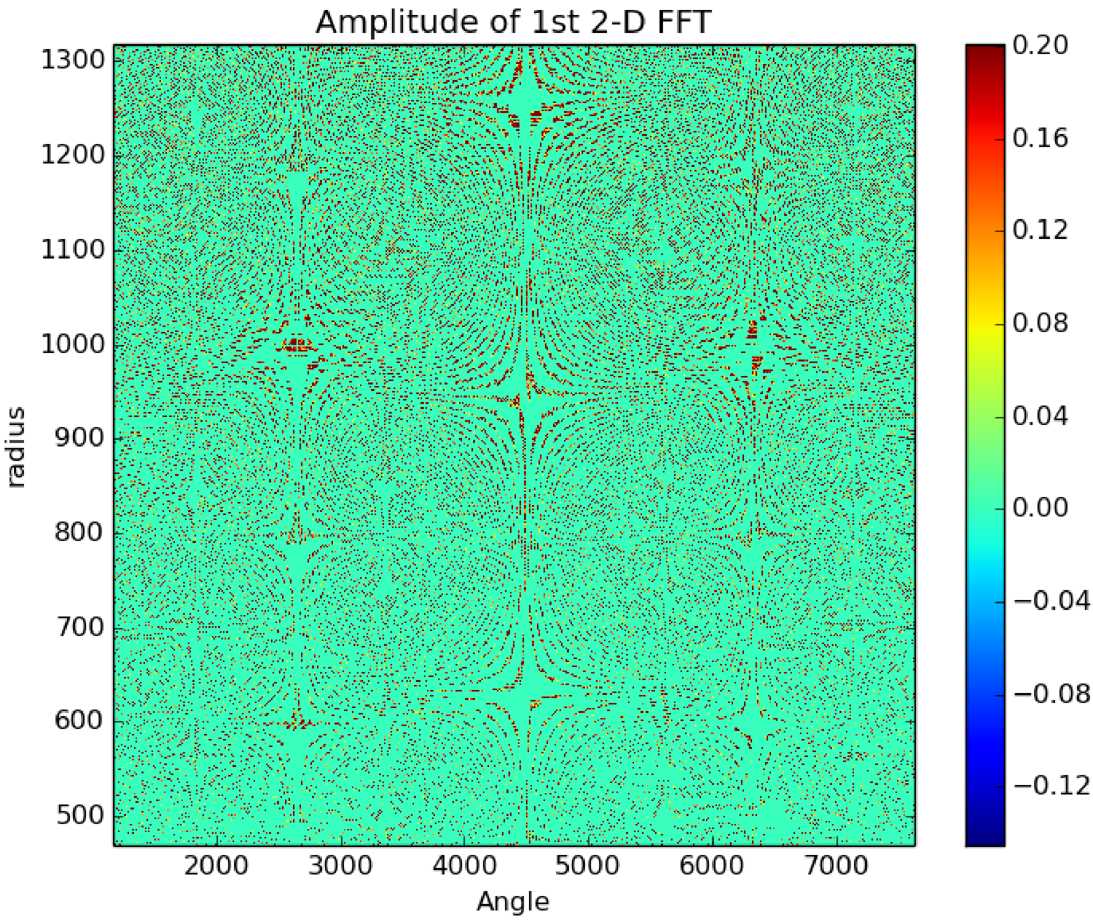


The signal show up in a shy way. This is fine with the low angle resolution ,like the 0.26 degree show above,the wiggle is not obviously. When the resolution increase ,the wiggle is more sharp. We guess it may caused by the round index when do the polar matrix change.

3. the strange pattern in the radius-angle image:

When we amplified the picture, and adjust the vmax,vmin,we found some strange wiggle like the followings:

It may caused when change to the polar_matrix, However we do not quite understand.



Conclude:

This method may be good at pick the FRB signal,and give a relatively small range of DM as the problem of resolution. I have simulate some DMs to roughly calculate angle, the result may have 10-100 deference in DM . It may be able to calculate the DM directly in the future improvement, but now it is foucused on the FRB signal alarm.