Rating Single Pulse Candidates on cyberSKA

Properties of an astrophysical single pulse candidate:

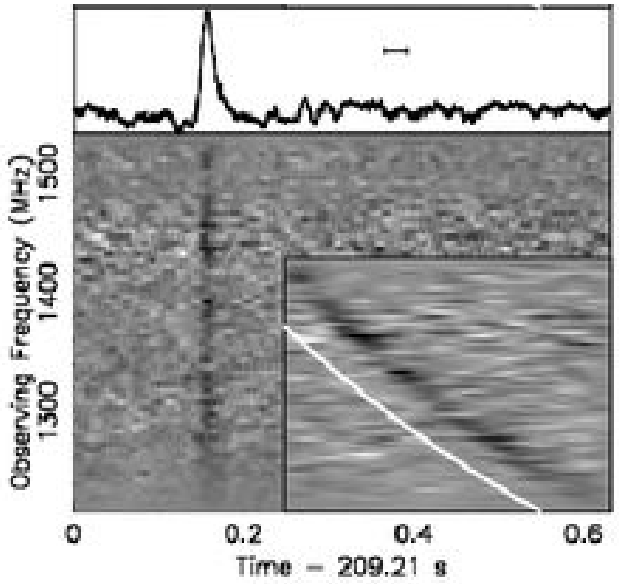
Frequency vs Time:

Radio signals get dispersed by the interstellar medium such that lower frequency signals arrive after higher frequency signals. This is what we try to look and correct for.

Look for a dispersed sweep right next to the white sweep in the inset plot.

There should be a visible de-dispersed signal across the frequency channels about a quarter of the way into the plot.

There should be a corresponding peak in the time series above due to the sum of the signal strengths below.

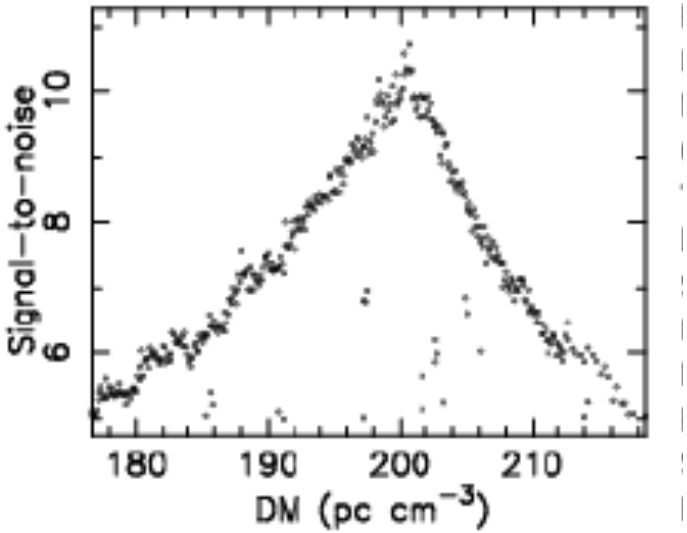


Properties of an astrophysical single pulse candidate:

Signal-to-Noise vs DM:

The signal to noise of an astrophysical pulse peaks at the optimal DM and drops smoothly on either sides.

You should see a rise in Signal-to-noise followed by a fall.



Properties of an astrophysical single pulse candidate:

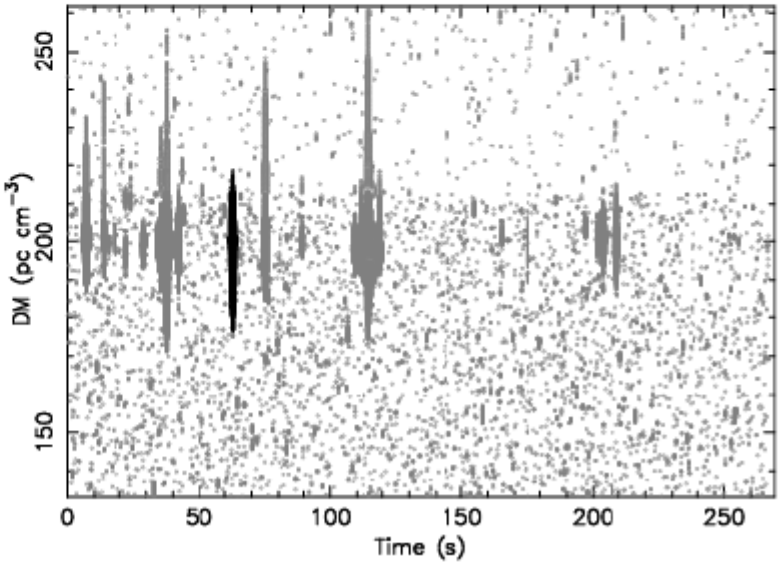
DM vs Time:

Each point on this plot is a single pulse event.

A pulse is a cluster of such events closely spaced in DM and time.

You should see a cluster of pulses around a similar DM. The pulse in the black is the pulse for which the other features shown before are plotted.

Sometimes you may only see one pulse. In this case, if the previous two features look astrophysical and the signal to noise is high (>8), then it may be a real astrophysical pulse.



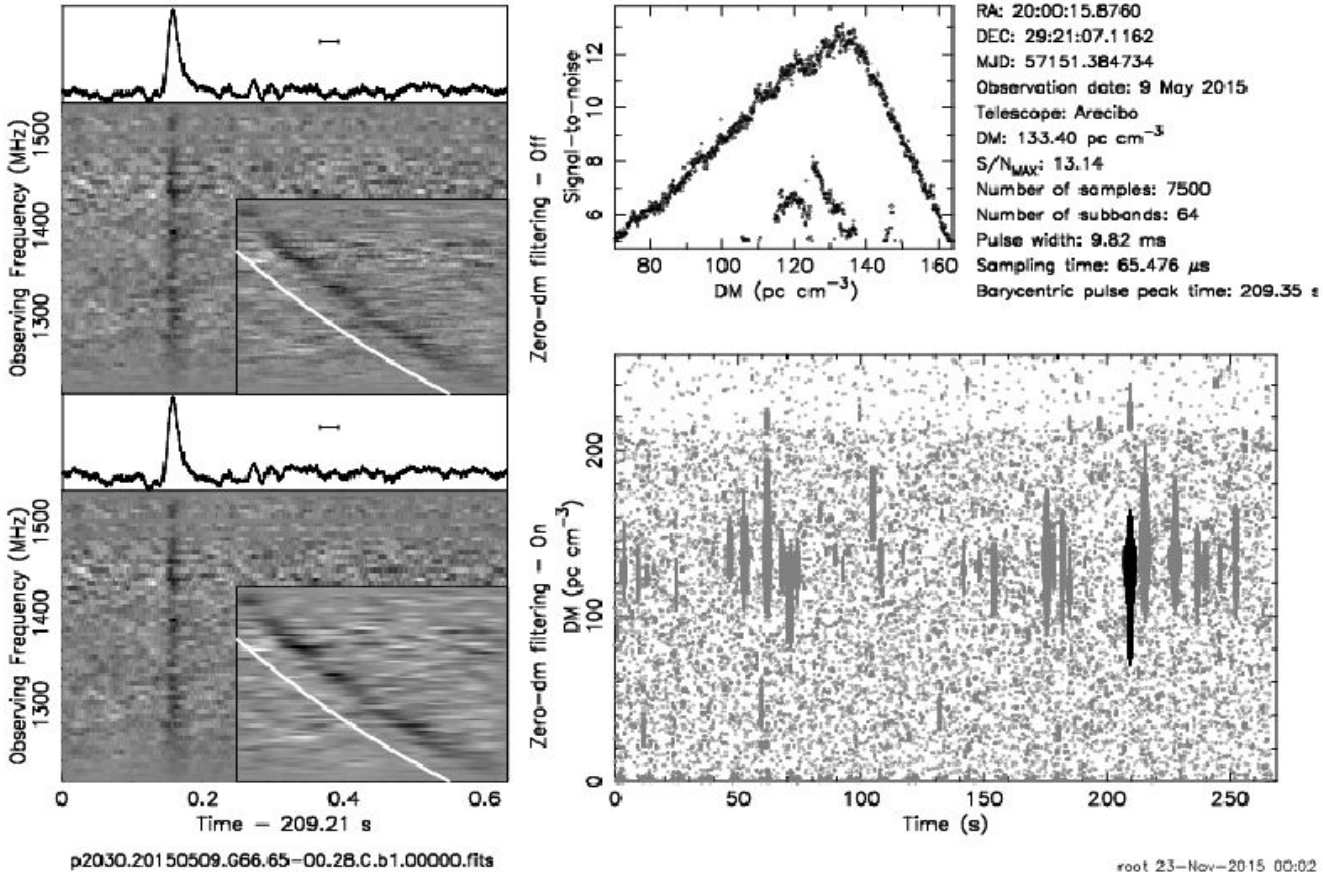
Now look at it all together

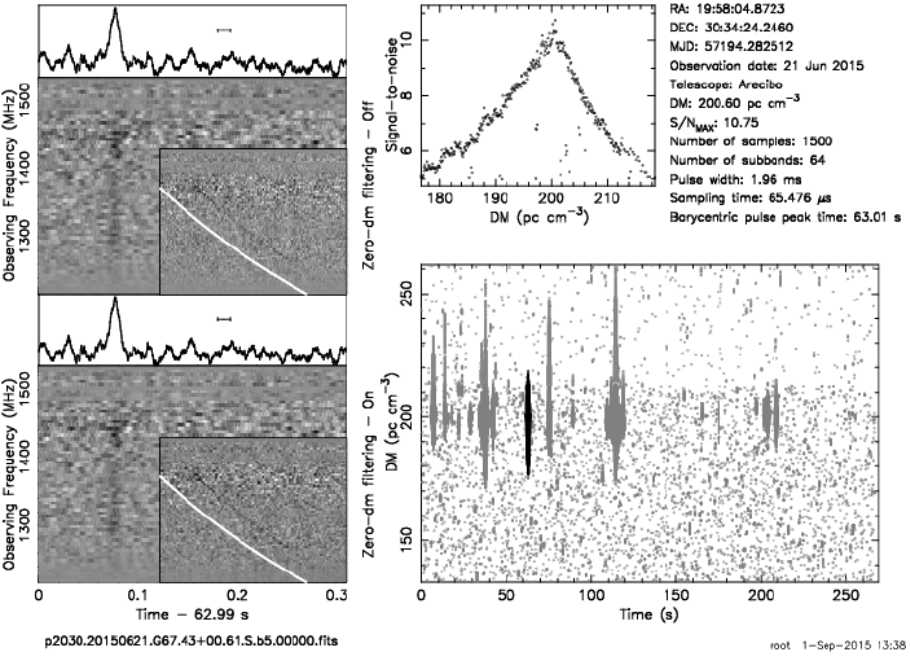
1. Look at the Frequency vs. time plot.
    a. Look for the dispersed sweep
    b. Look for a bright de-dispersed signal across the bandwidth.
    c. Look for a corresponding significant peak in the timeseries above.
2. Look at the signal-to-noise vs. DM plot.
    a. Look for a rise in signal-to-noise followed by a fall.
3. Look at the DM and Time plot.
    a. Look for clustering of pulses around a similar DM.
    b. If only one pulse, make sure that the above features look astrophysical and the signal to noise is high (>8) .

Let’s take a look at a few astrophysical single pulse candidate plots.

I would classify these type of candidates as Rank 1 unless they are known pulsars in which case Rank 6.

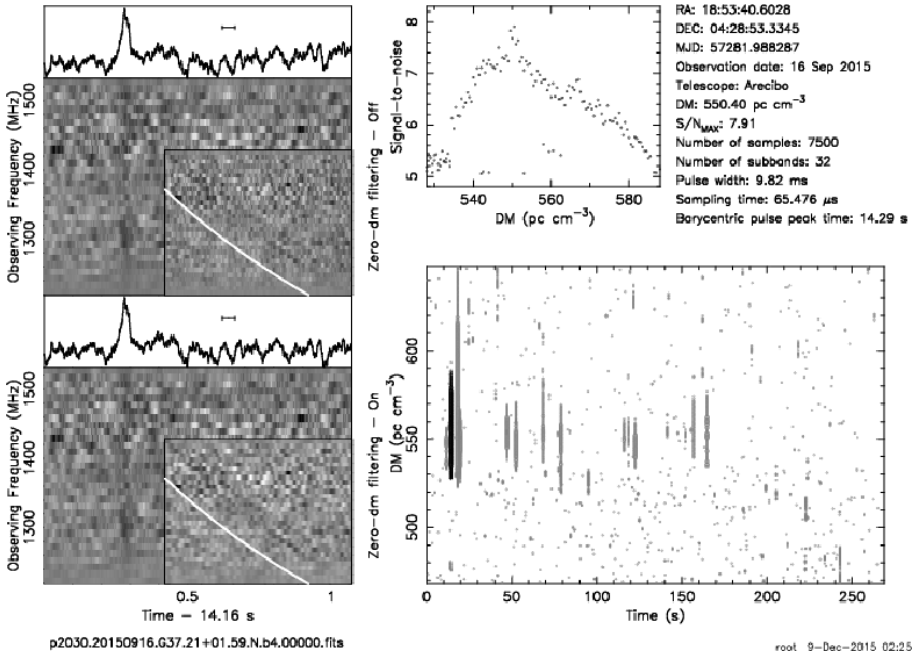
Examples of Astrophysical Singal Pulse Candidates





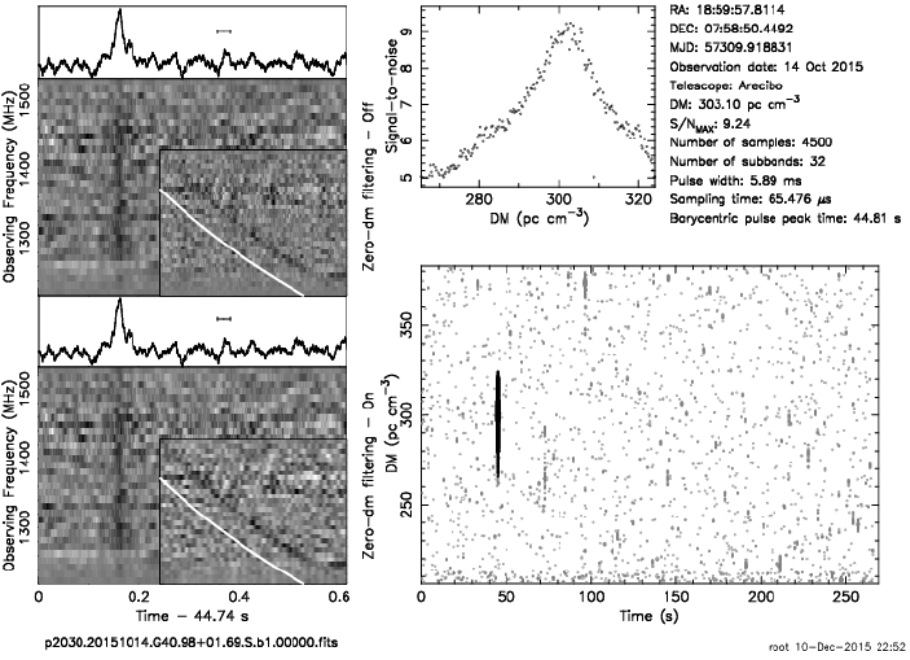
p2030.20150621.G67.43+00.61.S.b5.00000.fits

root 1-Sep-2015 13:38



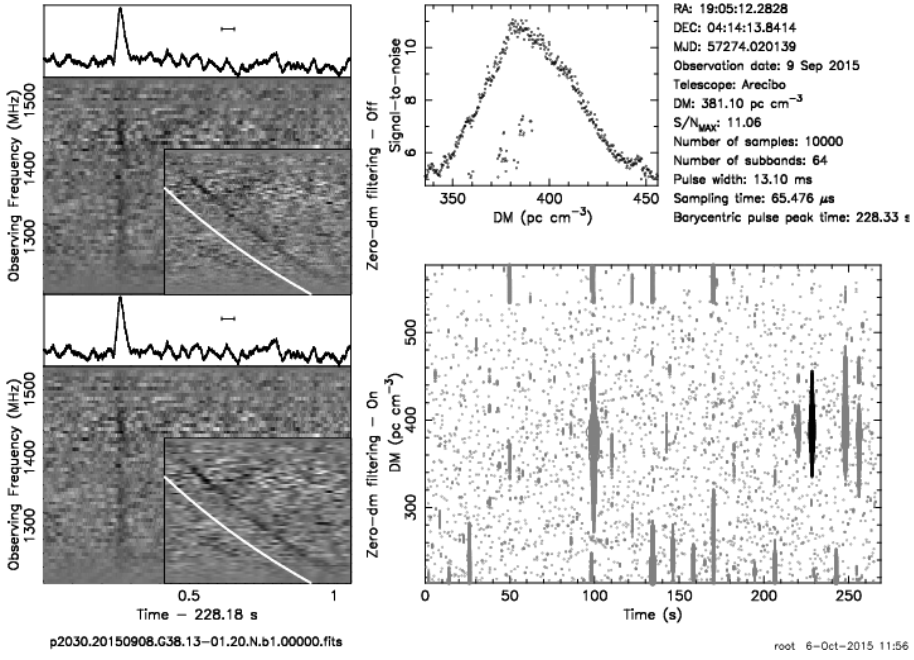
p2030.20150916.G37.21+01.59.N.b4.00000.fits

root 9-Dec-2015 02:25



p2030.20151014.G40.98+01.69.S.b1.00000.fits

root 10−Dec−2015 22:52



p2030.20150908.G38.13−01.20.N.b1.00000.fits

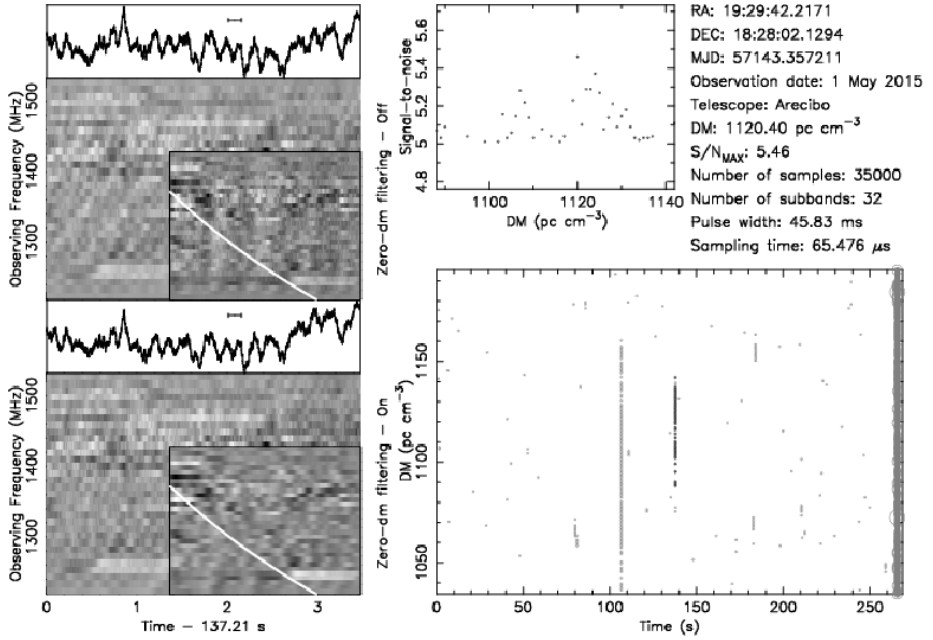
root 6−Oct−2015 11:56

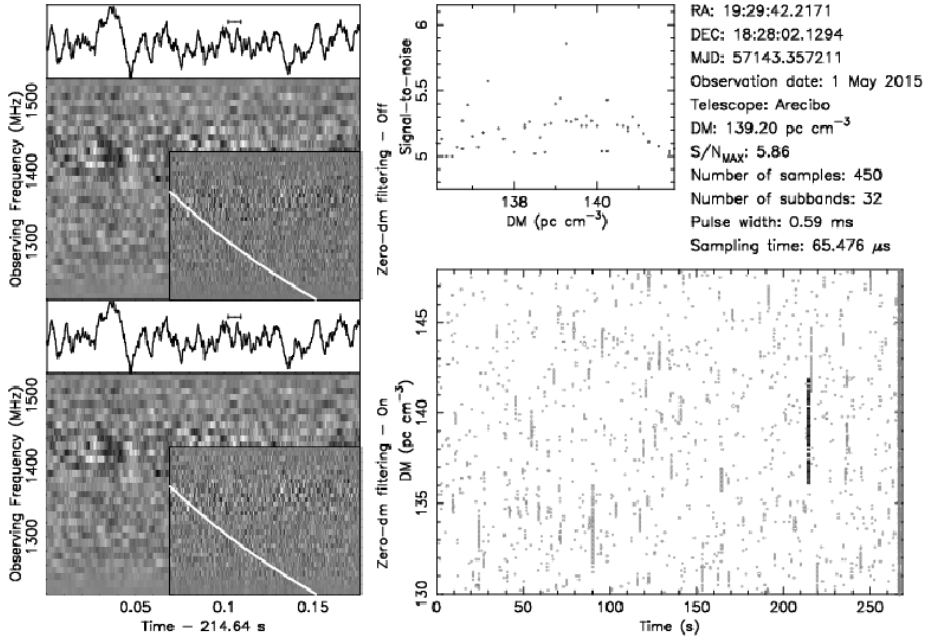
Examples of non-astrophysical Singal Pulse Candidates

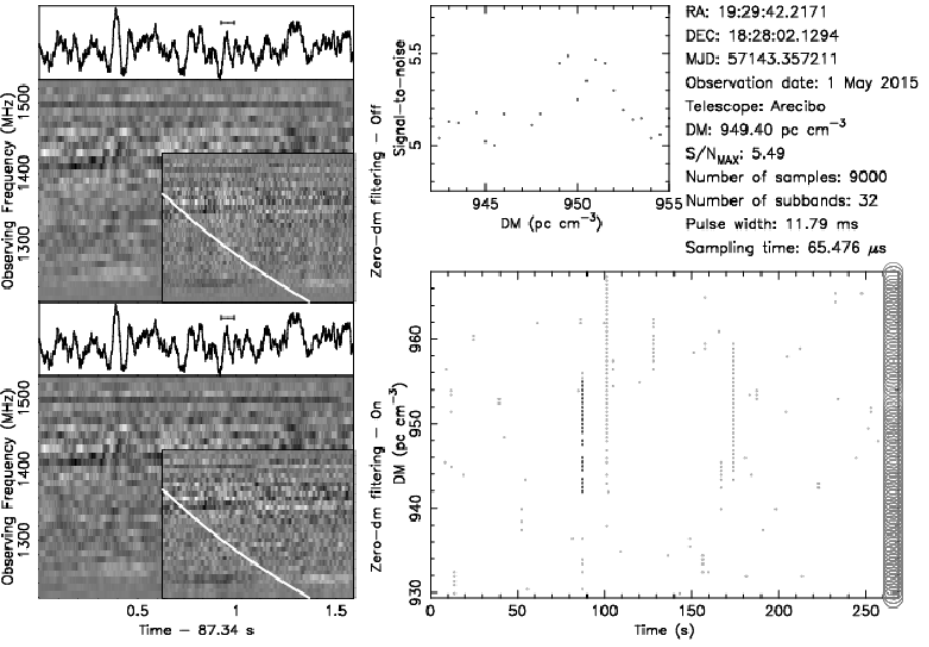
Could be RFI, or other false positives.

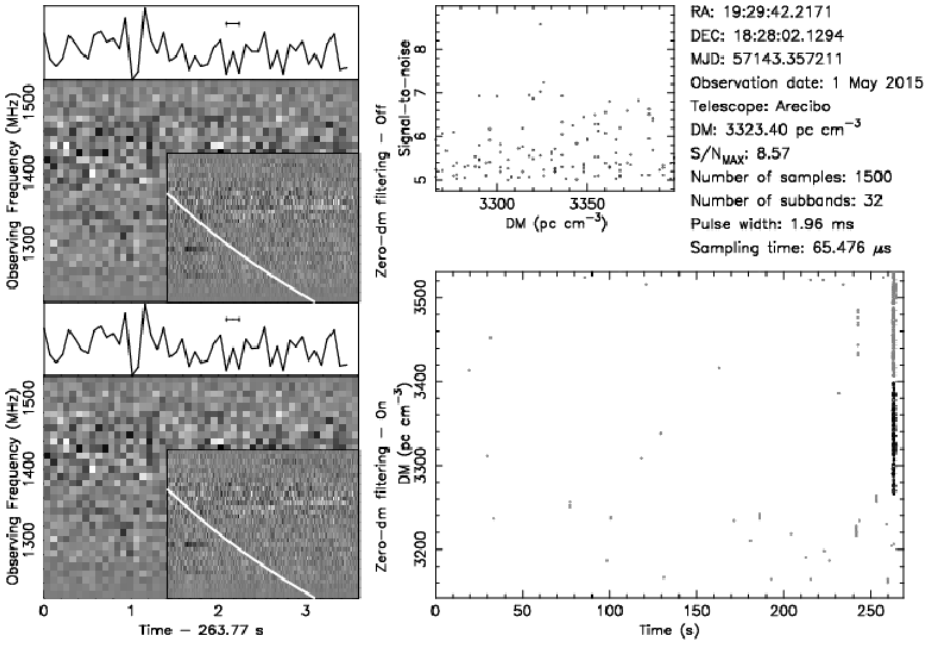
They do not follow all the features discussed above.

I would rank these candidates 4 (clearly RFI narrow band or bright and low DM signals) or 5 (“not a signal”)

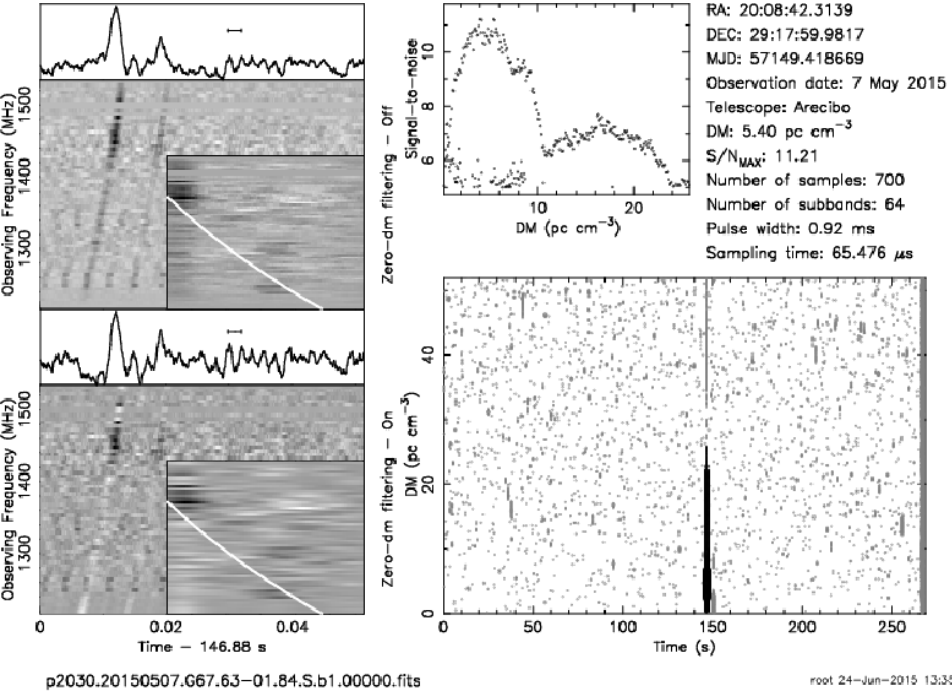

Observing Frequency (MHz)
1500
1400
1300
Time − 137.21 s
0
1
2
3
Zero−dm filtering − Off
Signal−to−noise
5.6
5.4
5.2
5
4.8
DM (pc cm^{-3})
1100
1120
1140
Zero−dm filtering − On
DM (pc cm^{-3})
1150
1100
1050
Time (s)
0
50
100
150
200
250
RA: 19:29:42.2171
DEC: 18:28:02.1294
MJD: 57143.357211
Observation date: 1 May 2015
Telescope: Arecibo
DM: 1120.40 pc cm^{-3}
S/N$_{MAX}$: 5.46
Number of samples: 35000
Number of subbands: 32
Pulse width: 45.83 ms
Sampling time: 65.476 μs
p2030.20150501.G53.51+00.26.N.b3.00000.fits
root 16−Jun−2015 10:34


Observing Frequency (MHz)
1500
1400
1300
Time − 214.64 s
0.05
0.1
0.15
Zero−dm filtering − Off
Signal−to−noise
6
5.5
5
DM (pc cm^{-3})
138
140
Zero−dm filtering − On
DM (pc cm^{-3})
145
140
135
130
Time (s)
0
50
100
150
200
250
RA: 19:29:42.2171
DEC: 18:28:02.1294
MJD: 57143.357211
Observation date: 1 May 2015
Telescope: Arecibo
DM: 139.20 pc cm^{-3}
S/N$_{MAX}$: 5.86
Number of samples: 450
Number of subbands: 32
Pulse width: 0.59 ms
Sampling time: 65.476 μs
p2030.20150501.G53.51+00.26.N.b3.00000.fits
root 16−Jun−2015 10:35


Observing Frequency (MHz)
1500
1400
1300
Time − 87.34 s
0.5
1
1.5
Zero−dm filtering − Off
Signal−to−noise
5.5
5
945
950
955
DM (pc cm^{-3})
Zero−dm filtering − On
DM (pc cm^{-3})
960
950
940
930
0
50
100
150
200
250
Time (s)
RA: 19:29:42.2171
DEC: 18:28:02.1294
MJD: 57143.357211
Observation date: 1 May 2015
Telescope: Arecibo
DM: 949.40 pc cm^{-3}
S/N$_{MAX}$: 5.49
Number of samples: 9000
Number of subbands: 32
Pulse width: 11.79 ms
Sampling time: 65.476 μs
p2030.20150501.G53.51+00.26.N.b3.00000.fits
root 16−Jun−2015 10:37

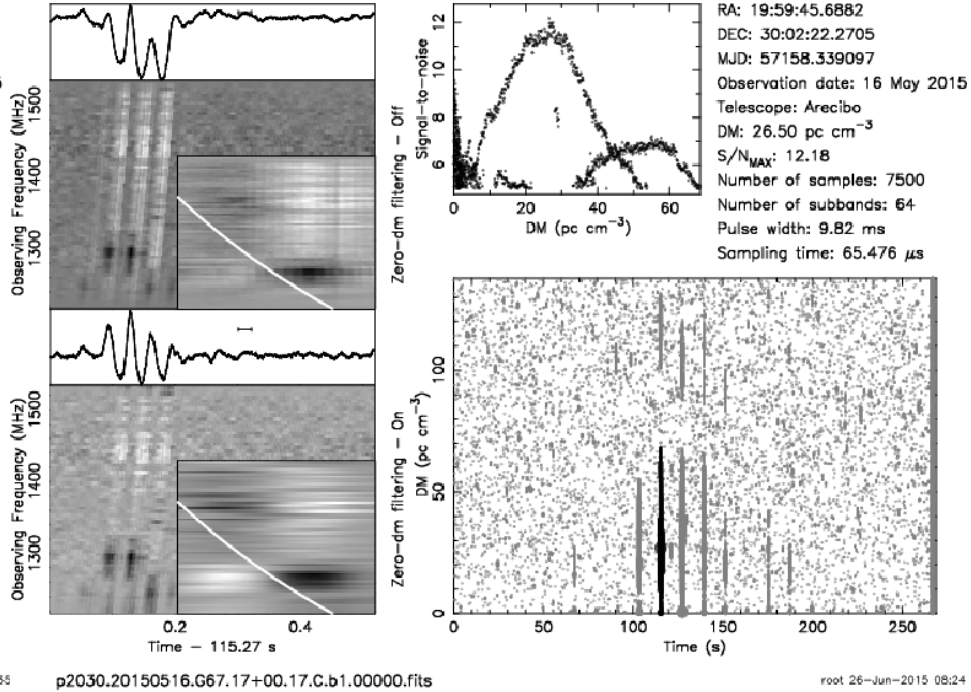

Observing Frequency (MHz)
1500
1400
1300
Time − 263.77 s
0
1
2
3
Zero−dm filtering − Off
Signal−to−noise
8
7
6
5
3300
3350
DM (pc cm^{-3})
Zero−dm filtering − On
DM (pc cm^{-3})
3500
3400
3300
3200
0
50
100
150
200
250
Time (s)
RA: 19:29:42.2171
DEC: 18:28:02.1294
MJD: 57143.357211
Observation date: 1 May 2015
Telescope: Arecibo
DM: 3323.40 pc cm^{-3}
S/N$_{MAX}$: 8.57
Number of samples: 1500
Number of subbands: 32
Pulse width: 1.96 ms
Sampling time: 65.476 μs
p2030.20150501.G53.51+00.26.N.b3.00000.fits
root 16−Jun−2015 10:39

RFI



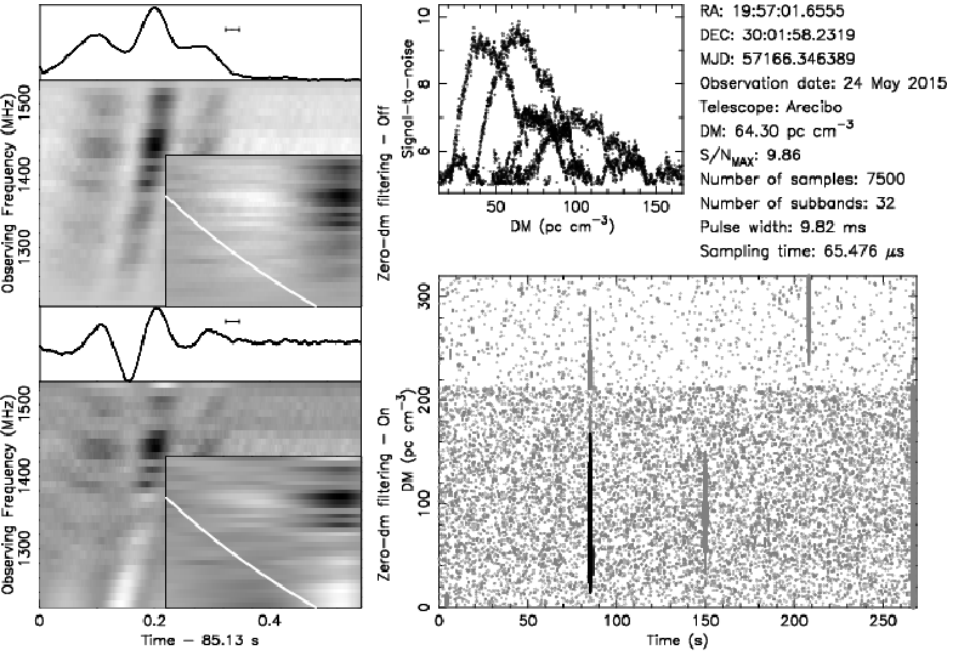
p2030.20150507.G67.63−01.84.S.b1.00000.fits

root 24−Jun−2015 13:38



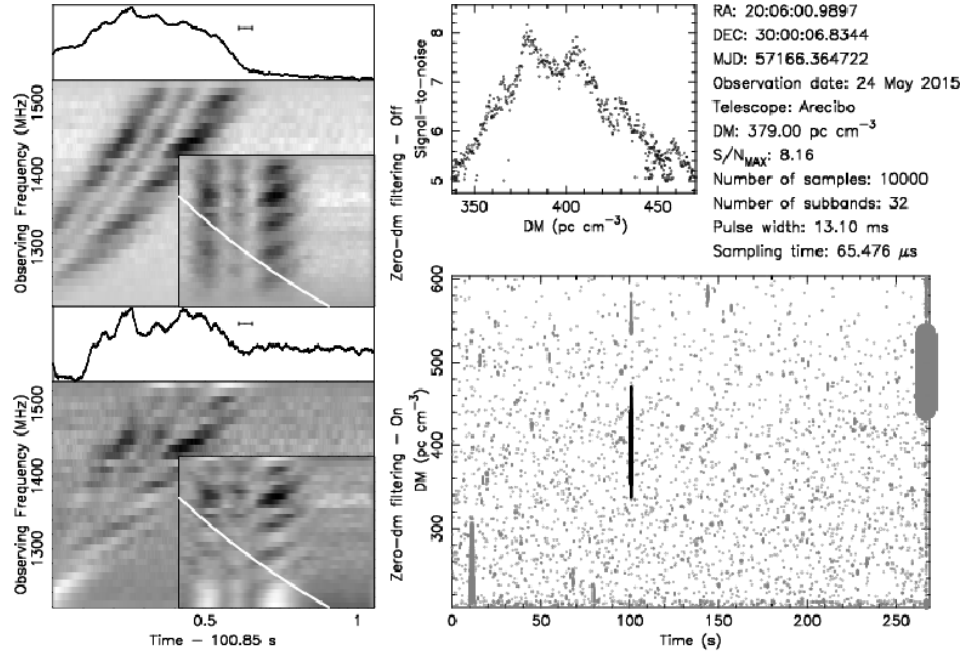
p2030.20150516.G67.17+00.17.C.b1.00000.fits

root 26−Jun−2015 08:24



p2030.20150524.G66.63+00.62.N.b3.00000.fits

root 3−Jul−2015 08:43



p2030.20150524.G67.74−01.17.N.b5.00000.fits

root 3−Jul−2015 06:50

Examples of Weak but potential astrophysical Candidates

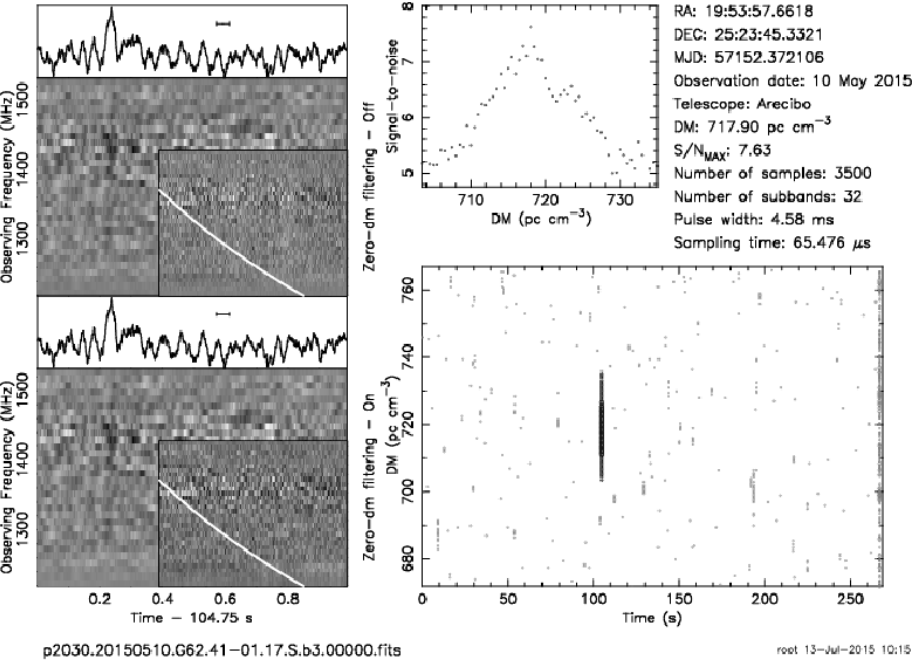
These ones show represent all the features of an astrophysical pulse, ie. good frequency vs time and signal-to noise vs DM plots but generally have only one pulse in the DM vs time window.

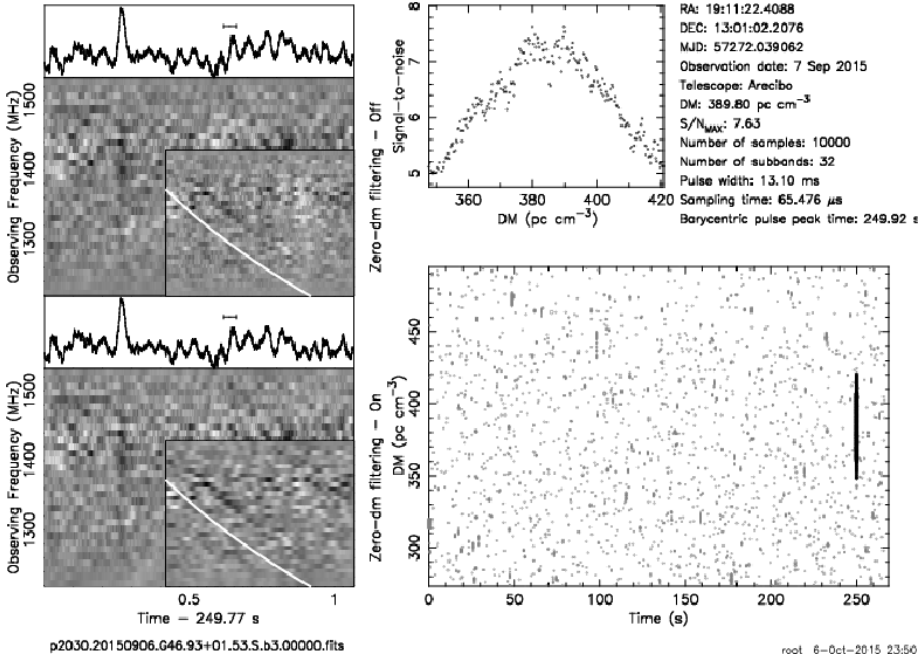
Their signal-to-noise is low (<8). A lot of these could be false positives which is why we have less confidence on these types of candidates.

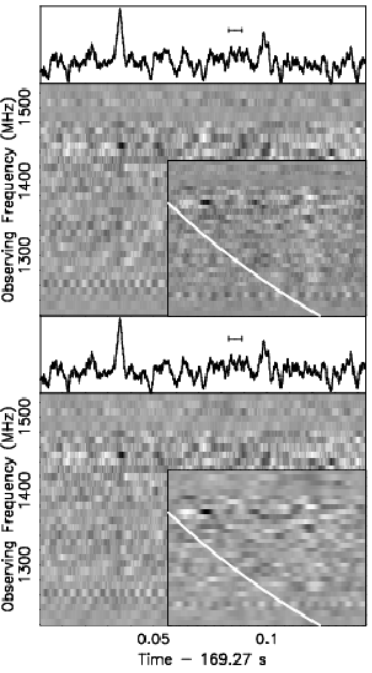
These candidates should be ranked 2 or 3.

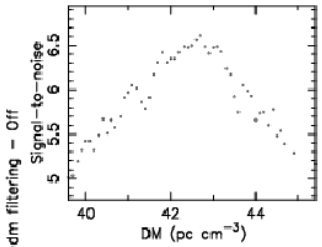
All the candidates ranked 1 and 2 should be added to the top candidates for further follow up.

Rank 2 candidates (should be added to the top candidates table)

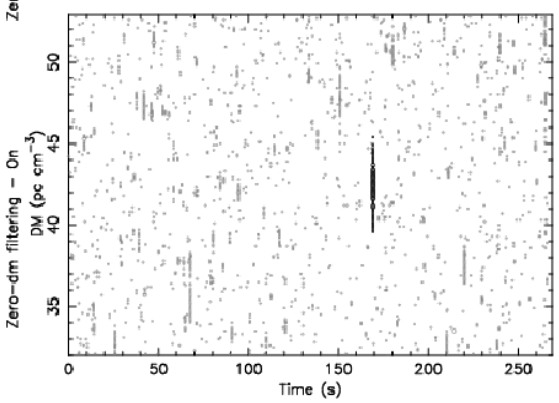






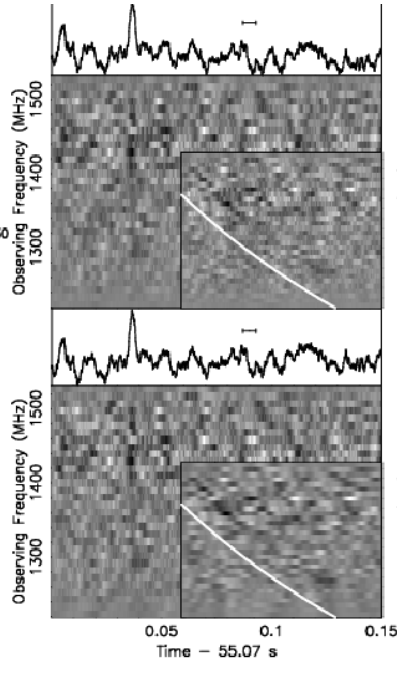


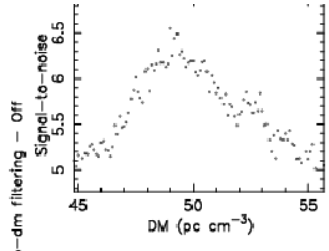
RA: 19:58:54.6919
DEC: 30:29:46.5605
MJD: 57194.282512
Observation date: 21 Jun 2015
Telescope: Arecibo
DM: 42.70 pc cm^{-3}
S/N$_{MAX}$: 6.61
Number of samples: 1500
Number of subbands: 32
Pulse width: 1.96 ms
Sampling time: 65.476 μs
Barycentric pulse peak time: 169.30



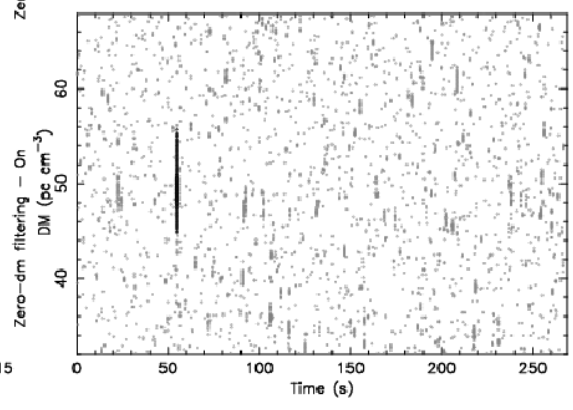
p2030.20150621.G67.43+00.61.S.b2.00000.fits

root 31−Aug−2015 18:3○





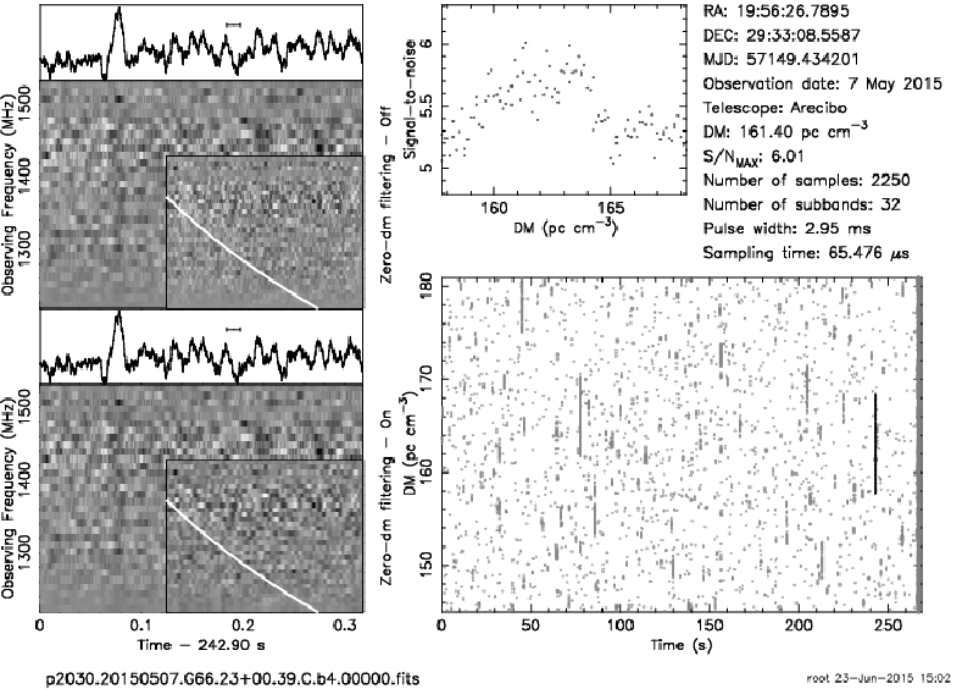
DEC: 31:12:05.6955
MJD: 57180.321030
Observation date: 7 Jun 2015
Telescope: Arecibo
DM: 49.00 pc cm^{-3}
S/N$_{MAX}$: 6.55
Number of samples: 1500
Number of subbands: 32
Pulse width: 1.96 ms
Sampling time: 65.476 μs
Barycentric pulse peak time: 55.09 s



p2030.20150607.G68.64−00.06.C.b6.00000.fits

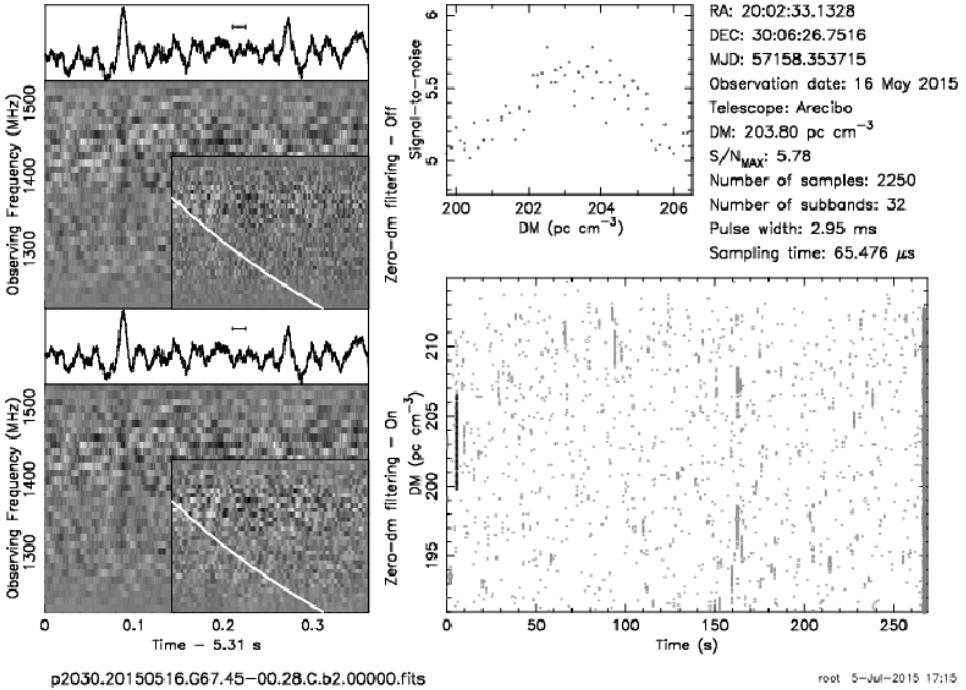
root 1−Sep−2015 11:09

Rank 3 candidates (should not be added to top candidates)



p2030.20150507.G66.23+00.39.C.b4.00000.fits

root 23−Jun−2015 15:02



p2030.20150516.G67.45−00.28.C.b2.00000.fits

root 5−Jul−2015 17:15