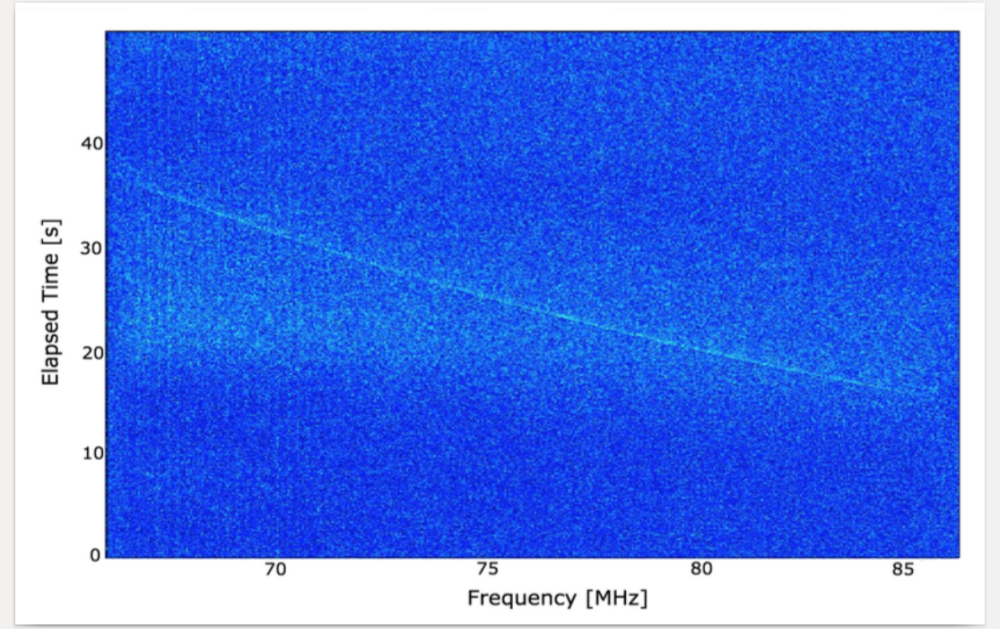
Echoes from the Crab Pulsar

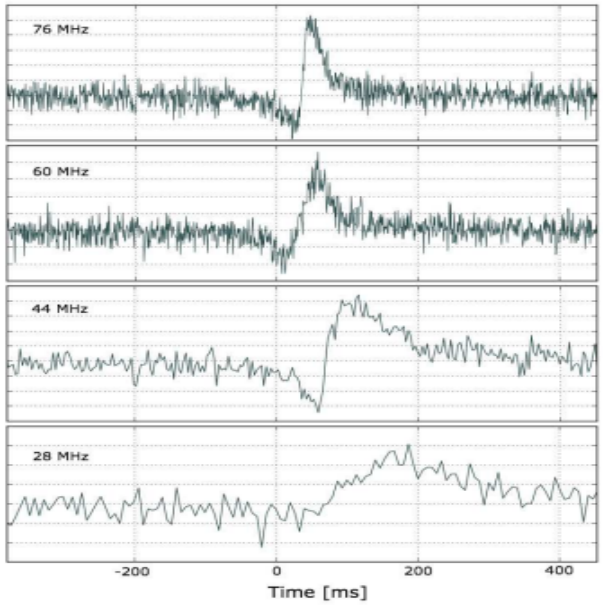
Pratik Kumar
Greg Taylor
Jayce Dowell
Kevin Stovall
Frank Schinzel

Crab Pulsar and Nebula

- Crab is one of the brightest Pulsar in the sky with the associated supernova remnant Crab Nebula
- Emits sporadic burst: Crab Giant Pulses(CGP), once in a while. Origin?
- Most of the previous studies consider a 10 times brighter than normal pulse to be a CGP.
- Considering the 10 times definition, at 76 MHz should be about >100 Jy.
- Typical scattering time at 76 MHz can vary from 48ms (Eftekhari et al. 2016) to 439ms (Ellingson et al. (2013a))
- Previous studies have inferred the presence of echoes from the Nebula, no direct detection.



Eftekhari et al. 2016



What can we do?

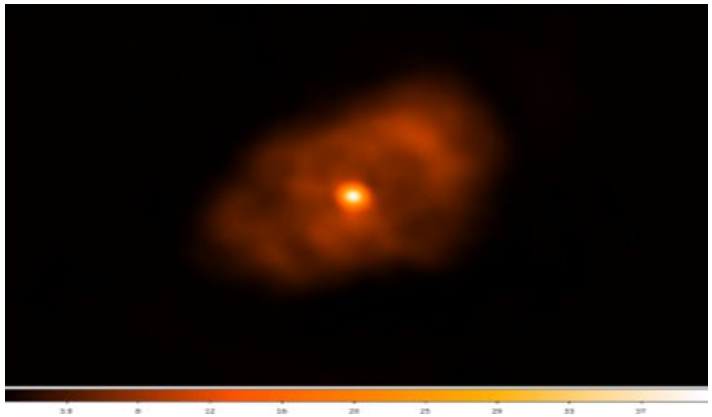
- Pulsars are brighter at low frequencies, so better chance of detection
- Still, Need to localize.
- We developed a new imaging mode to look at coherent compact sources

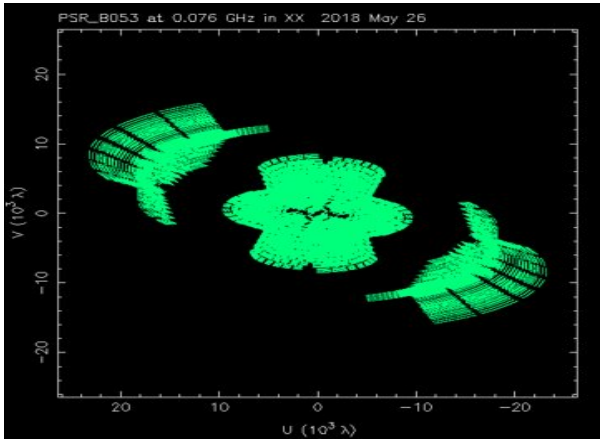
    - What's the origin of Giant Pulses? Pulsar?
    - Are there echoes? Where are they coming from?

ELWA: 4-band VLA+LWA stations

New 4 band feeds (MJP)
4 meter band: 50-86 MHz

TauA(Crab) at 72 MHz
May 26,2018
~4 hours on source
38 Jy Peak
RMS~40 mJy/beam





Dedispersion Imaging Mode

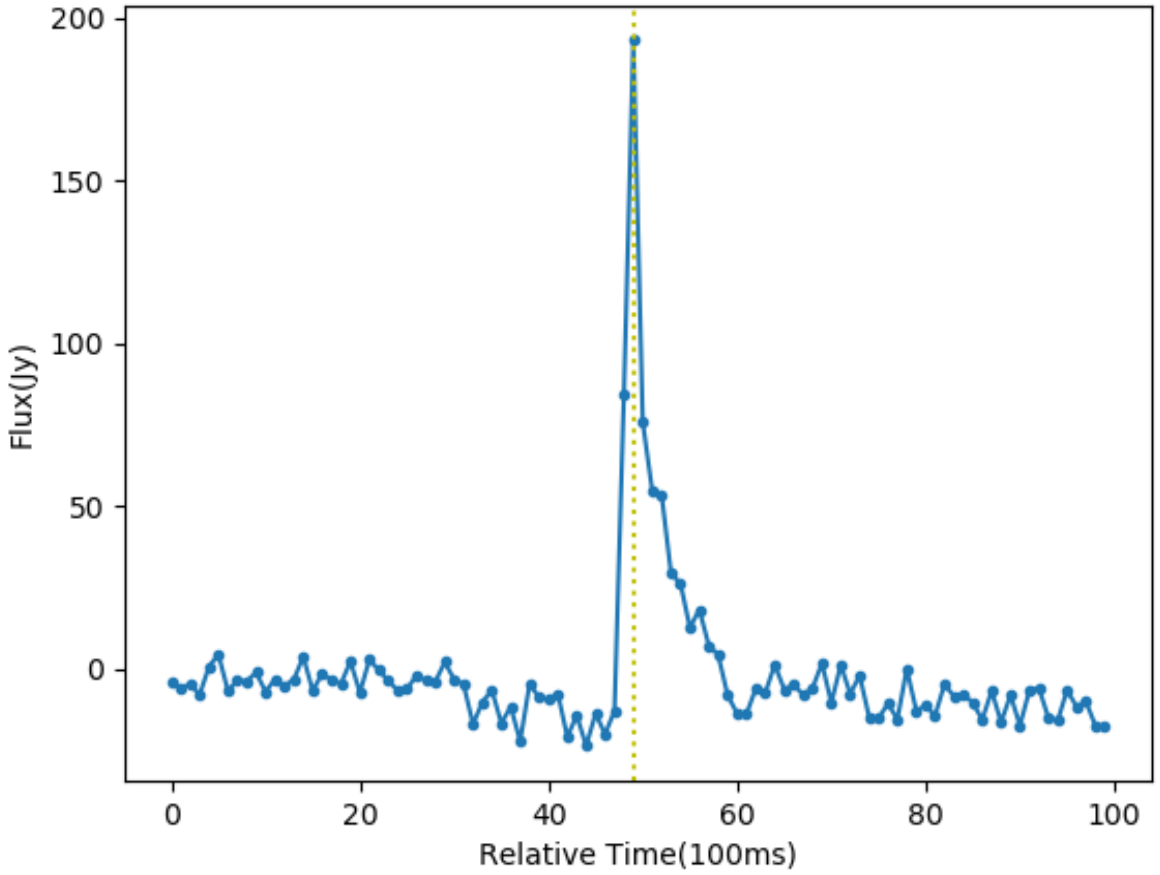
We have developed a new mode for looking at compact coherent sources

- Dedispersion Correlator : Correlation followed by Dedispersion
- Calibration and RFI removal
- Snapshot Imaging UV coverage at possible time interval
- Searching for compact and bright candidates in the data
- Analyzing the candidates

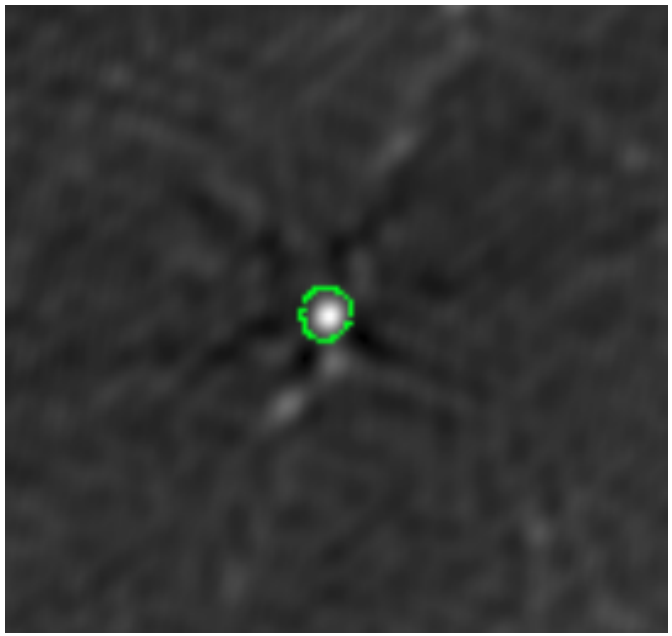
For our data

- ELWA observations at 76 MHz, at 24" resolution, BW~6MHz
- Correlate and dedisperse at 100ms time resolution
- Manual calibration and RFI removal
- Automated Imaging at 100 ms time resolution after subtracting the model of Crab nebula
- Automated Searching for Candidates: PyBDSF and generating images and light curves
- Manual Identification of good candidate from the Light curves and Image – Isolated candidates Only

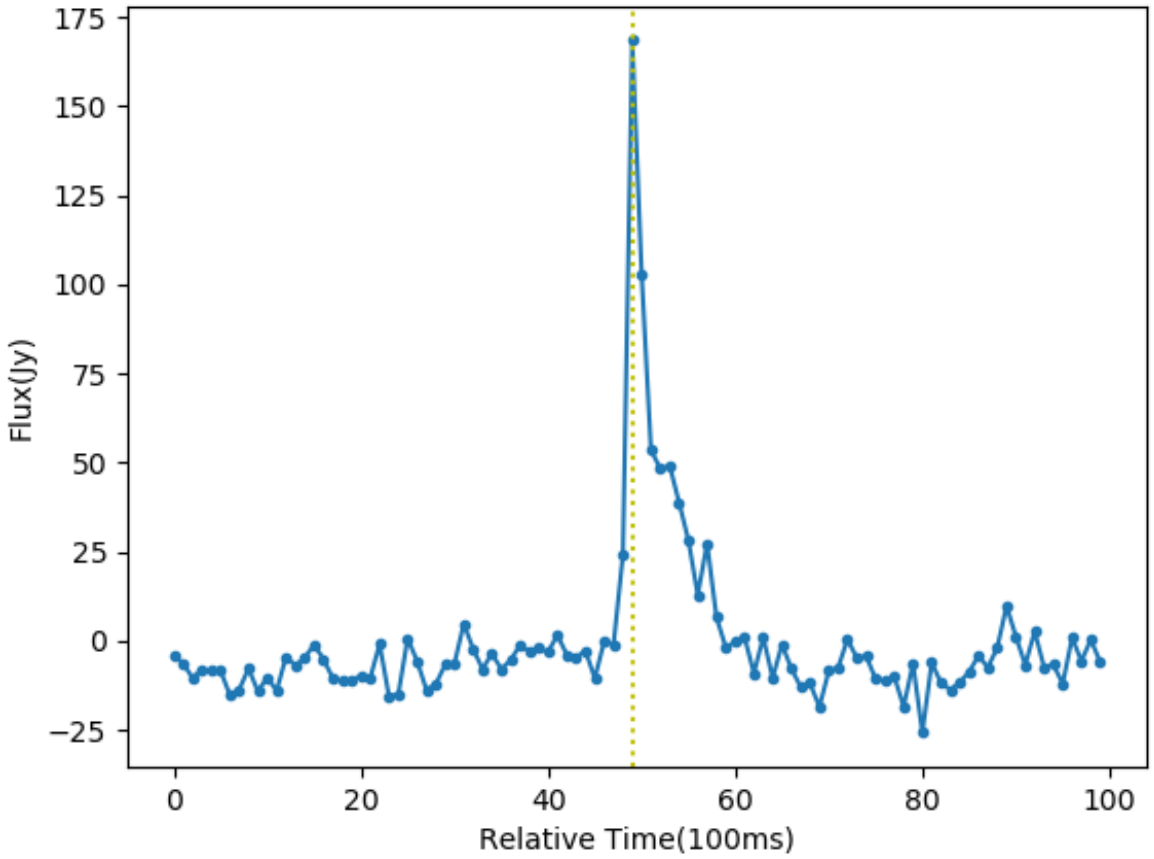
CGP light curve

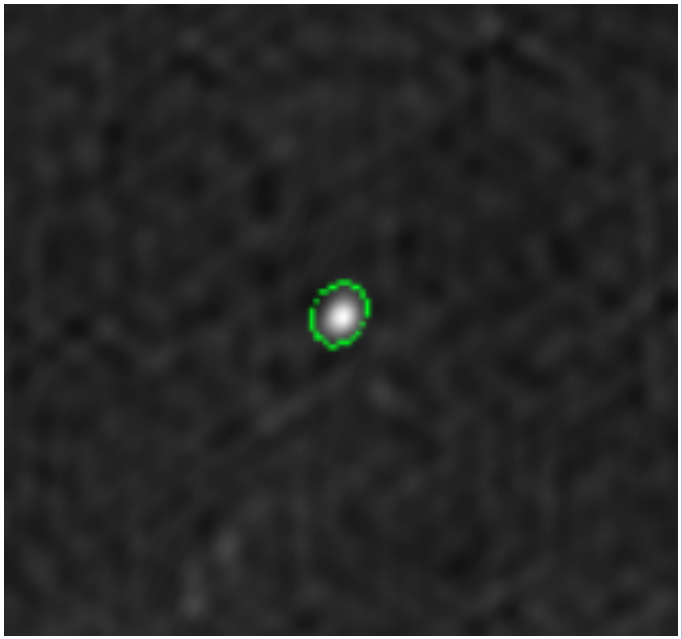


RMS~3.5 Jy/beam, in each snapshot image

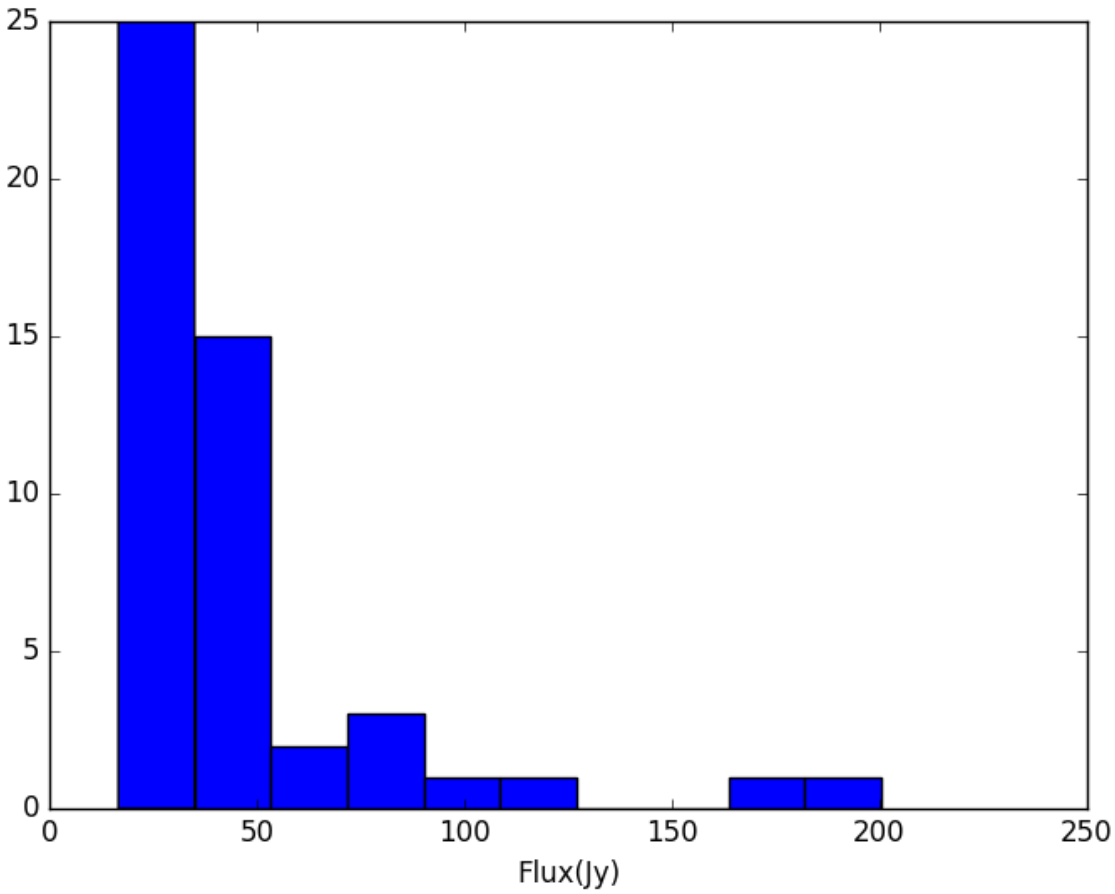


CGP light curve





CGP Flux distribution

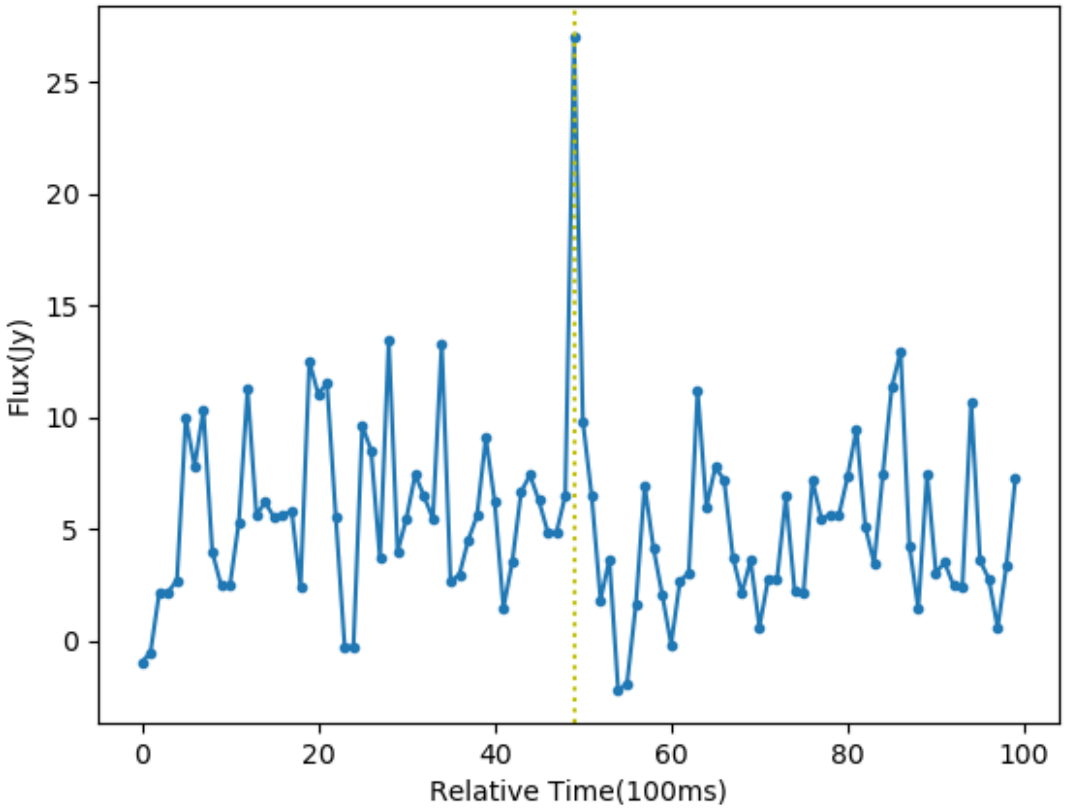


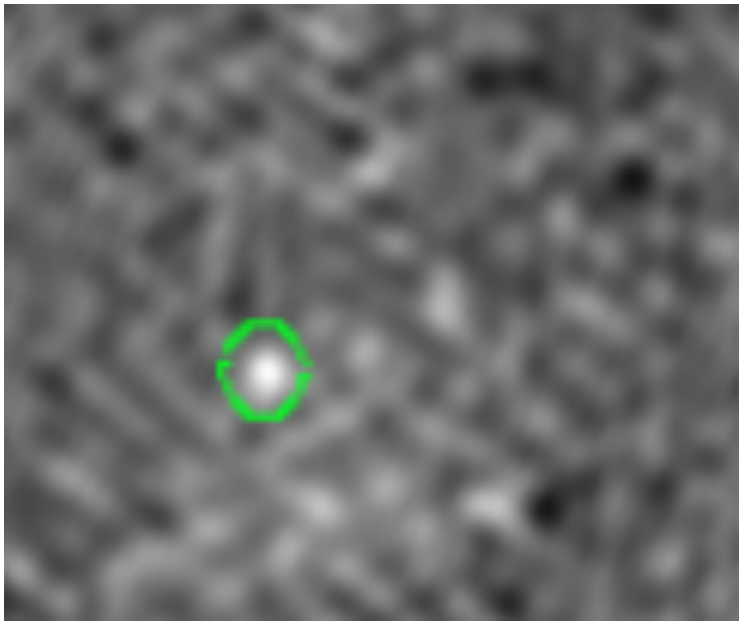
49 detections

Rate ~ 10/hr >> previous reported value of few/hr (Eftekhari et al. 2016)

Better Sensitivity!

Point source away from the pulsar?





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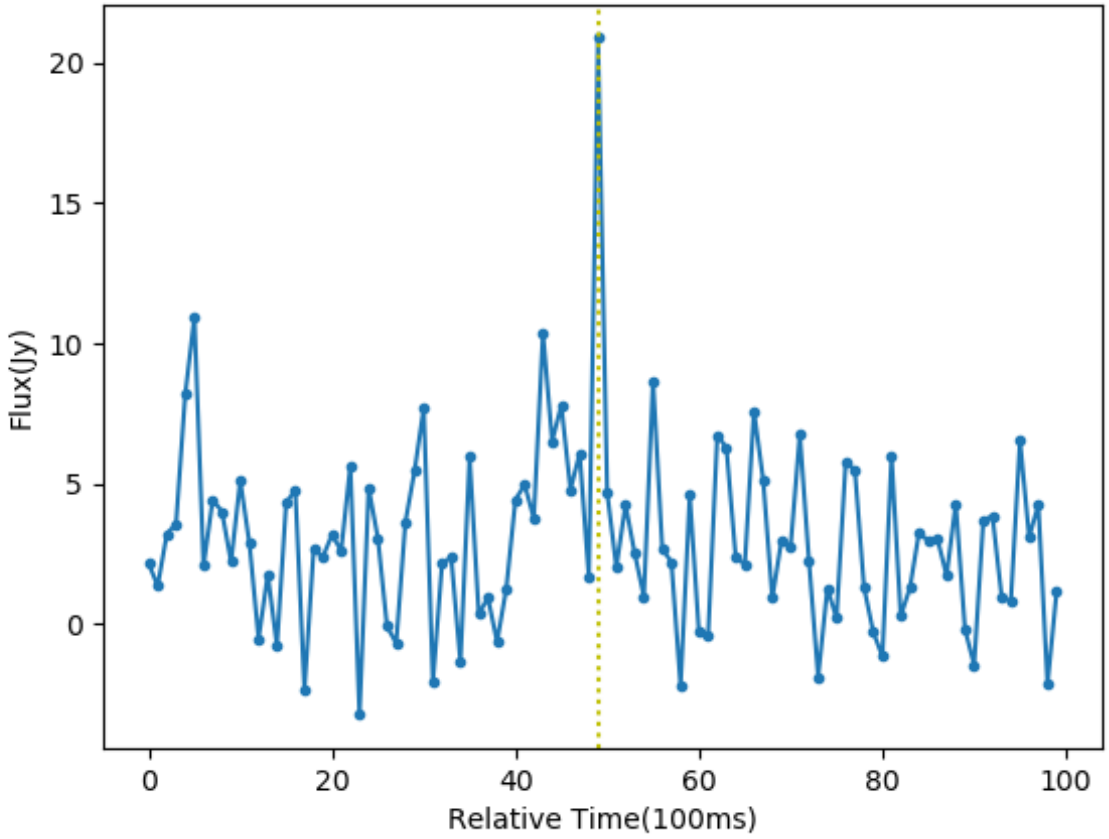
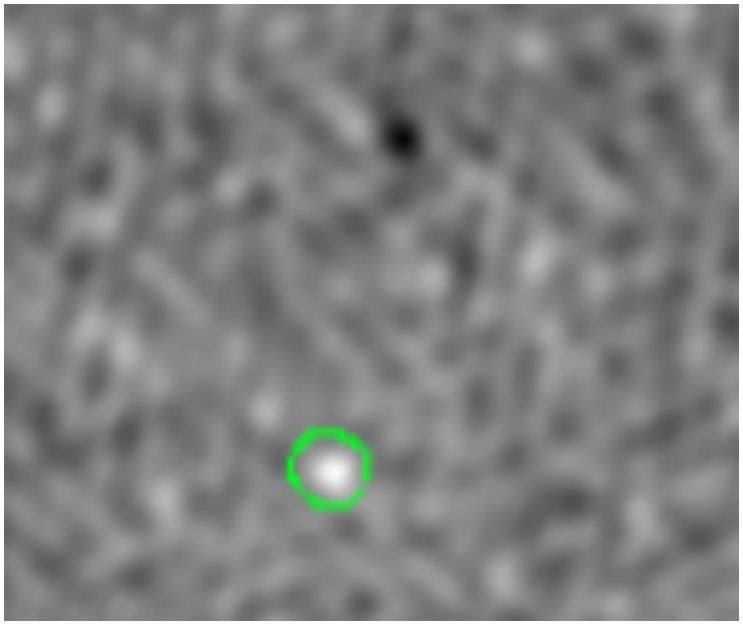
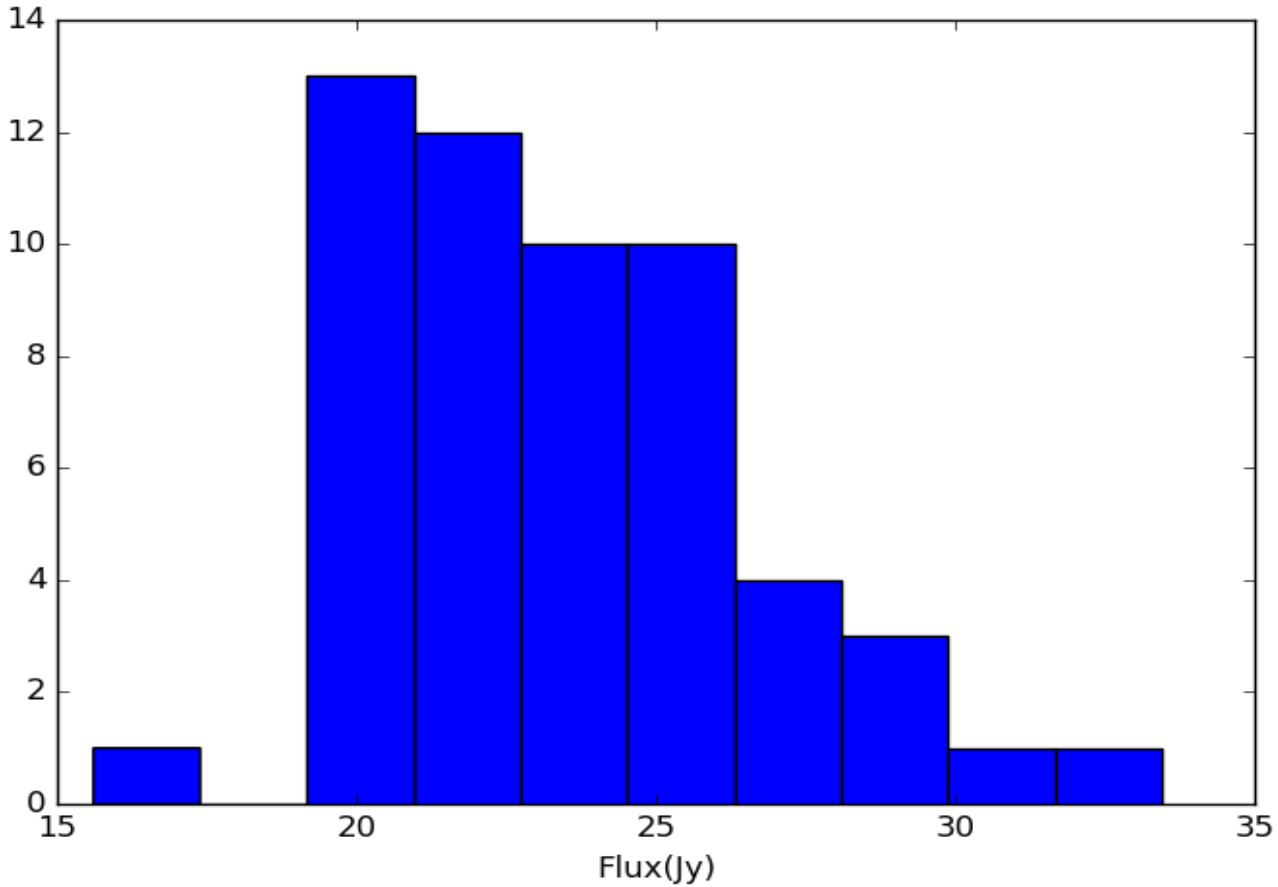




What's the flux distribution

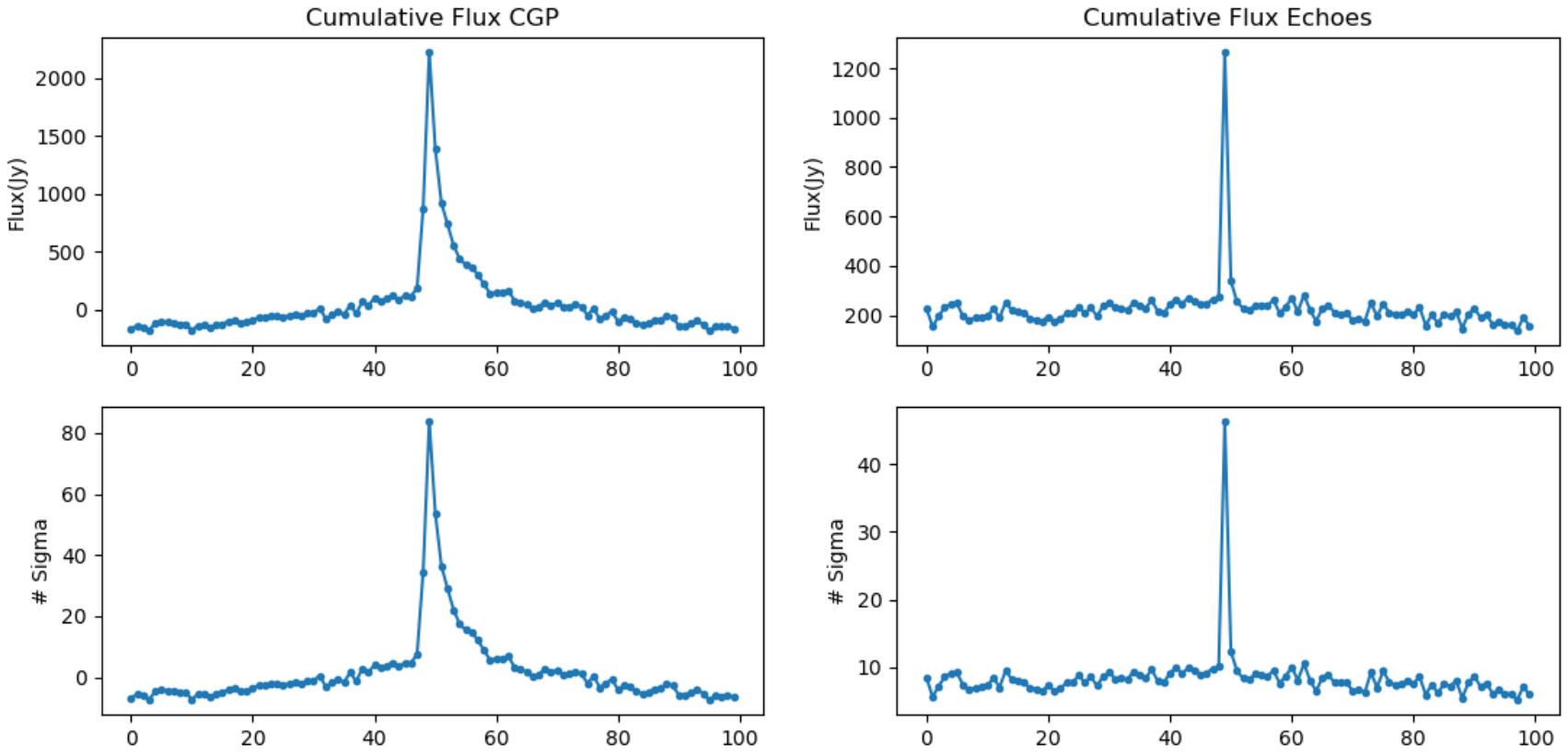


Power law

55 detections

Rate ~12/hr

Is the scattering similar?



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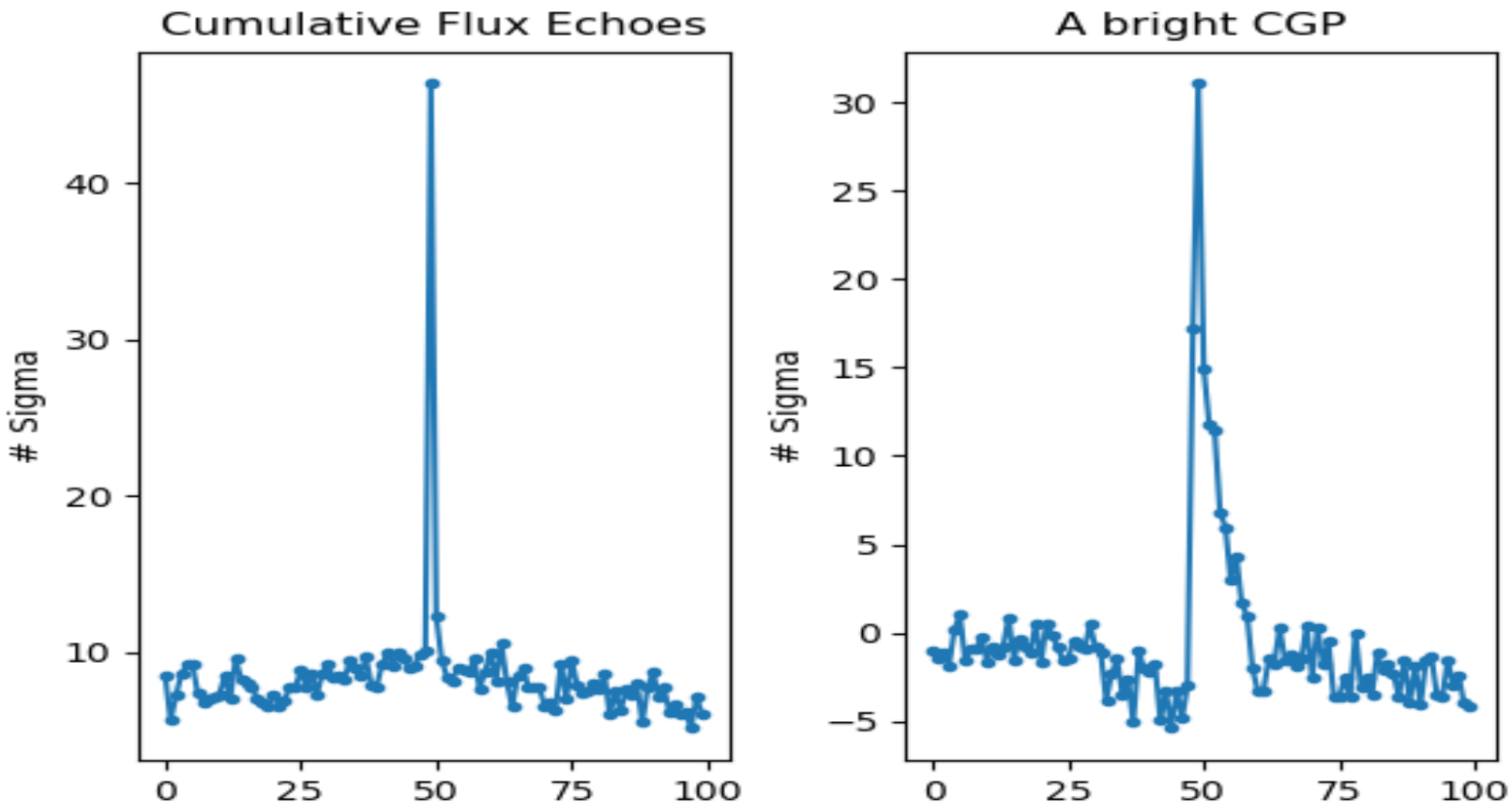
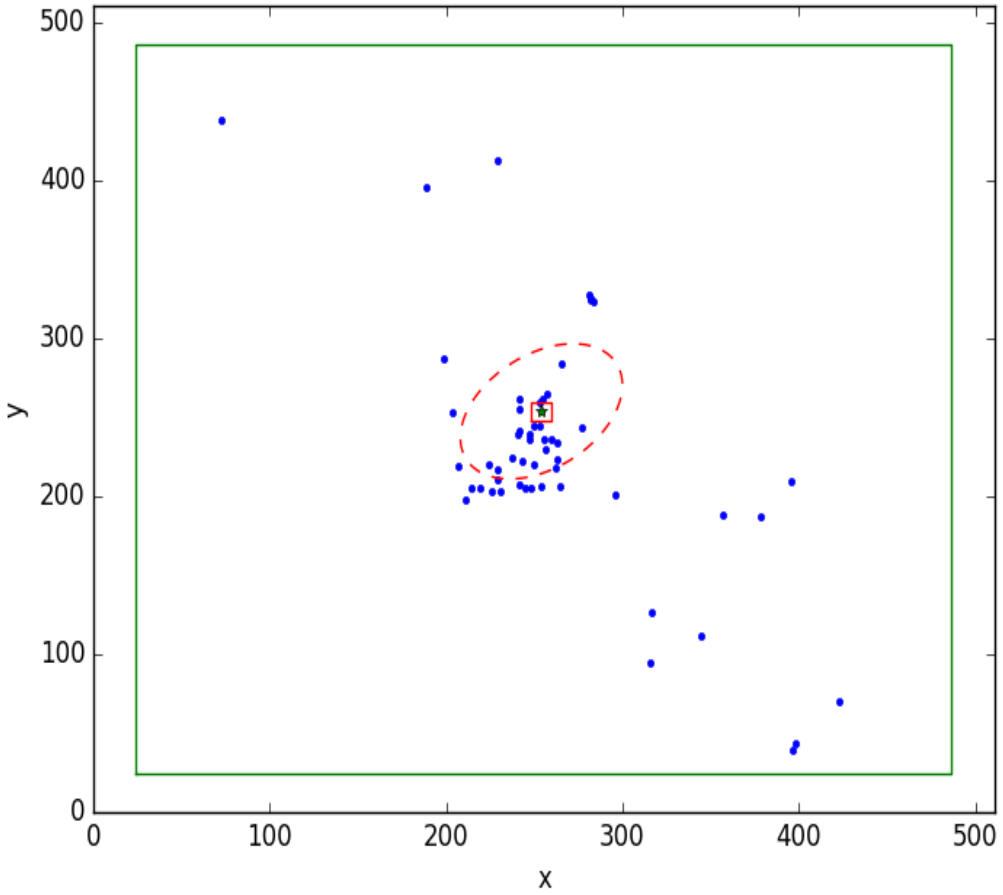
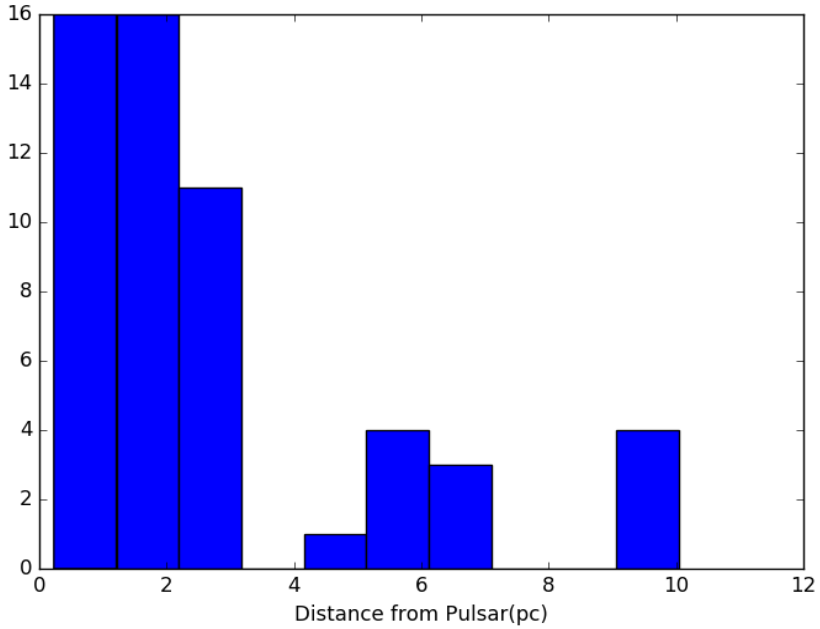


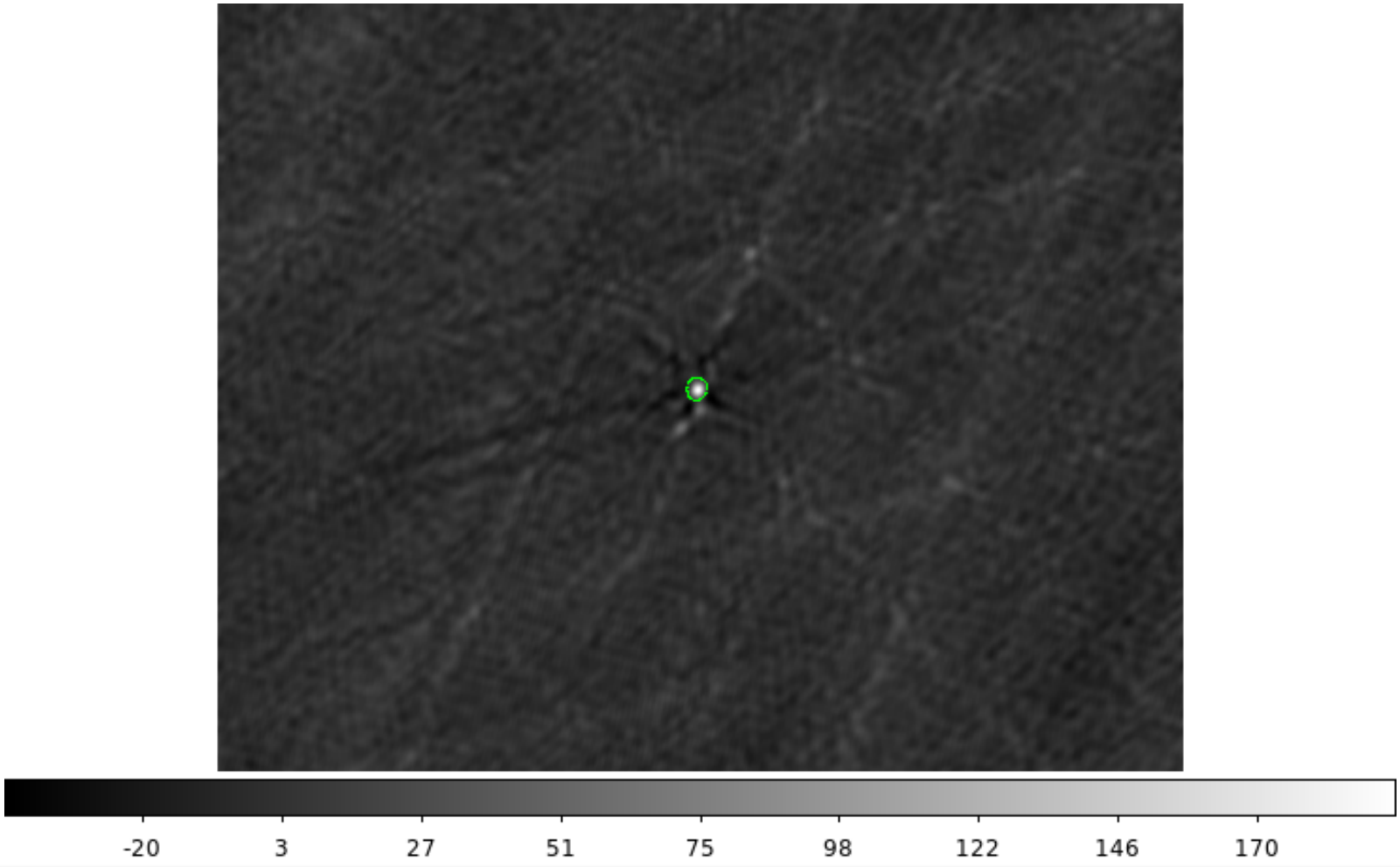
Where are echoes coming from?



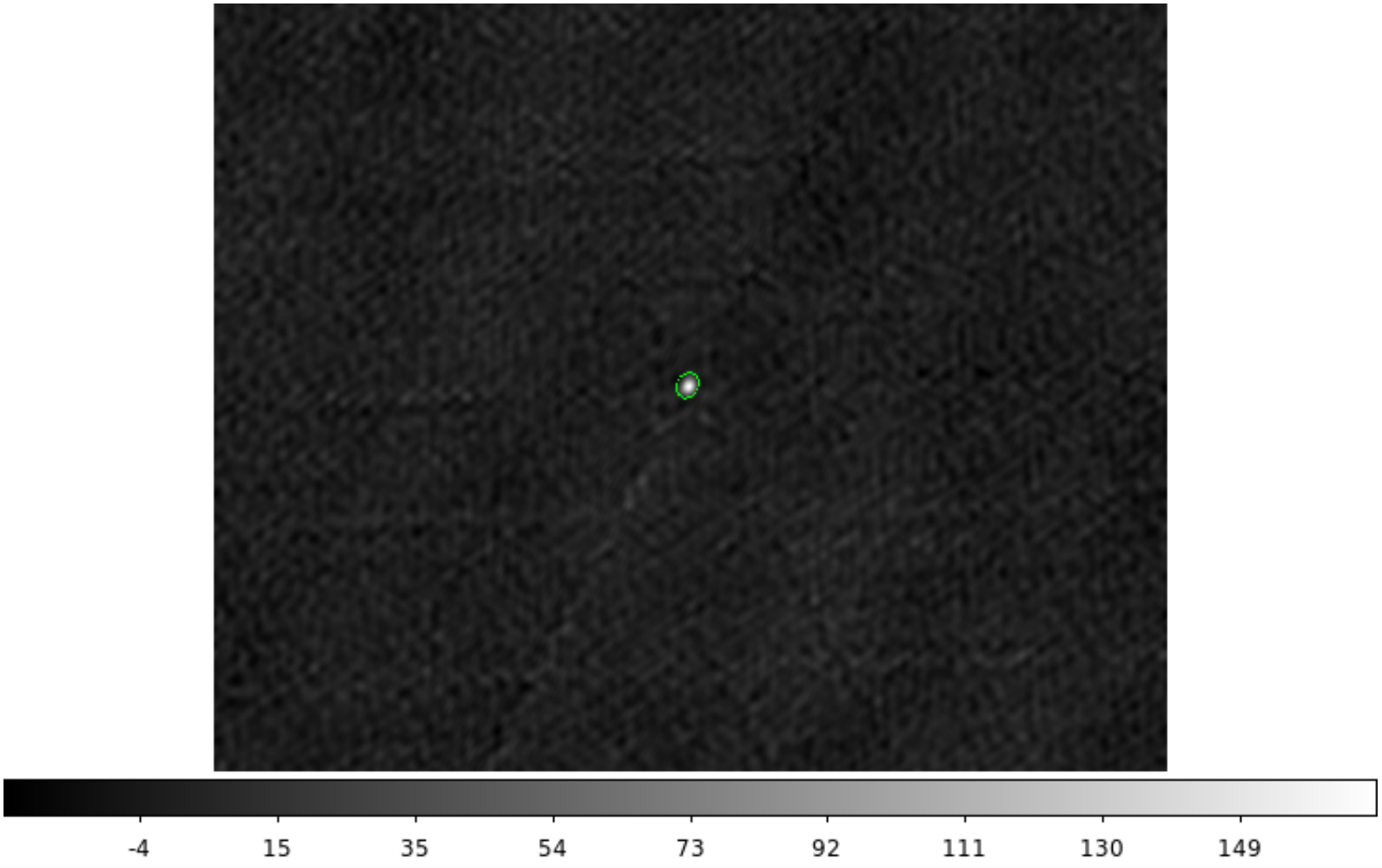


Questions?

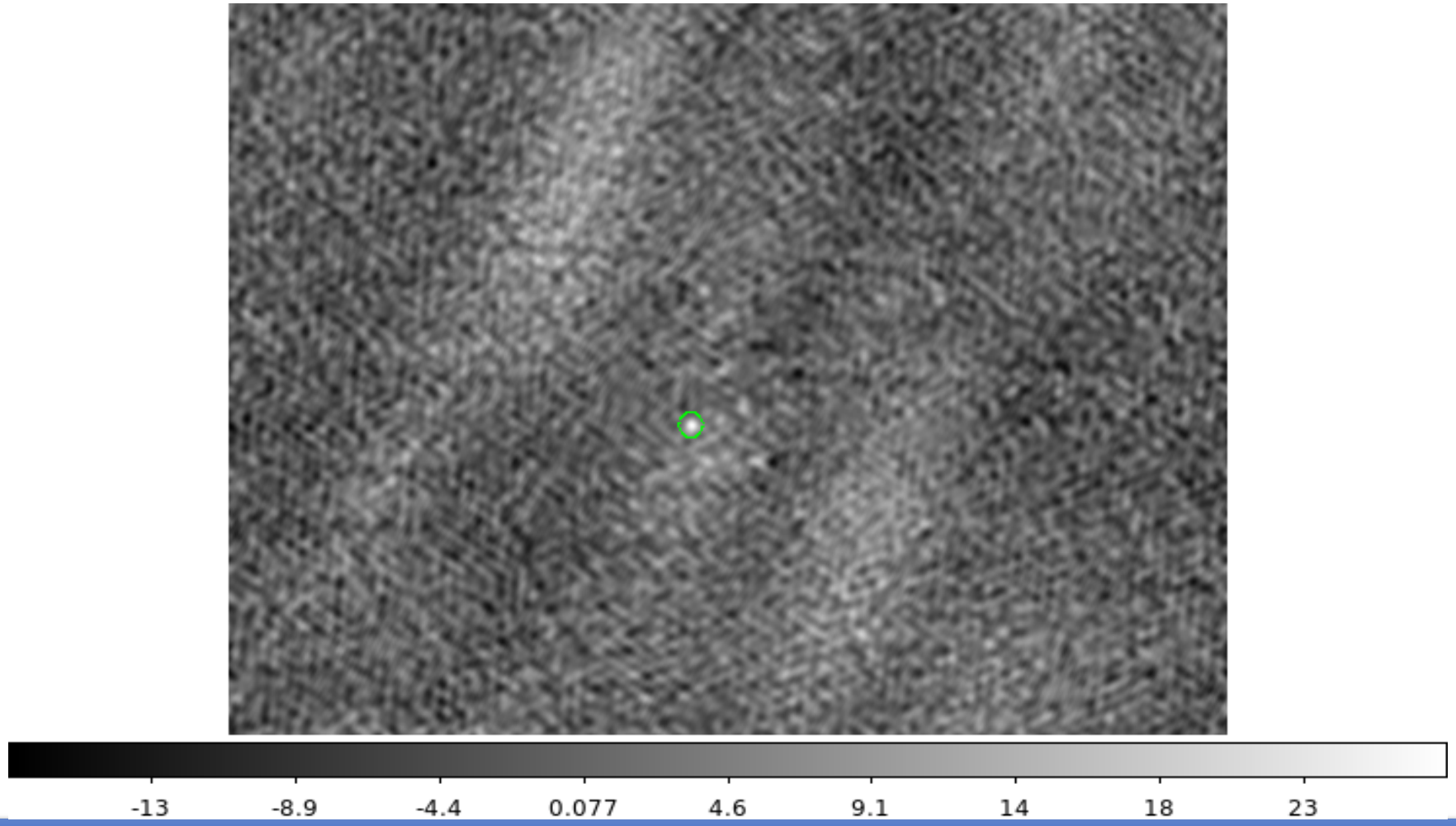
Extra Slides: CGP1



Extra Slides: CGP2



Extra Slides: Echo1



Extra Slides: Echo2