CAN THE CRAB PULSAR HELP US UNDERSTAND FAST RADIO BURSTS?

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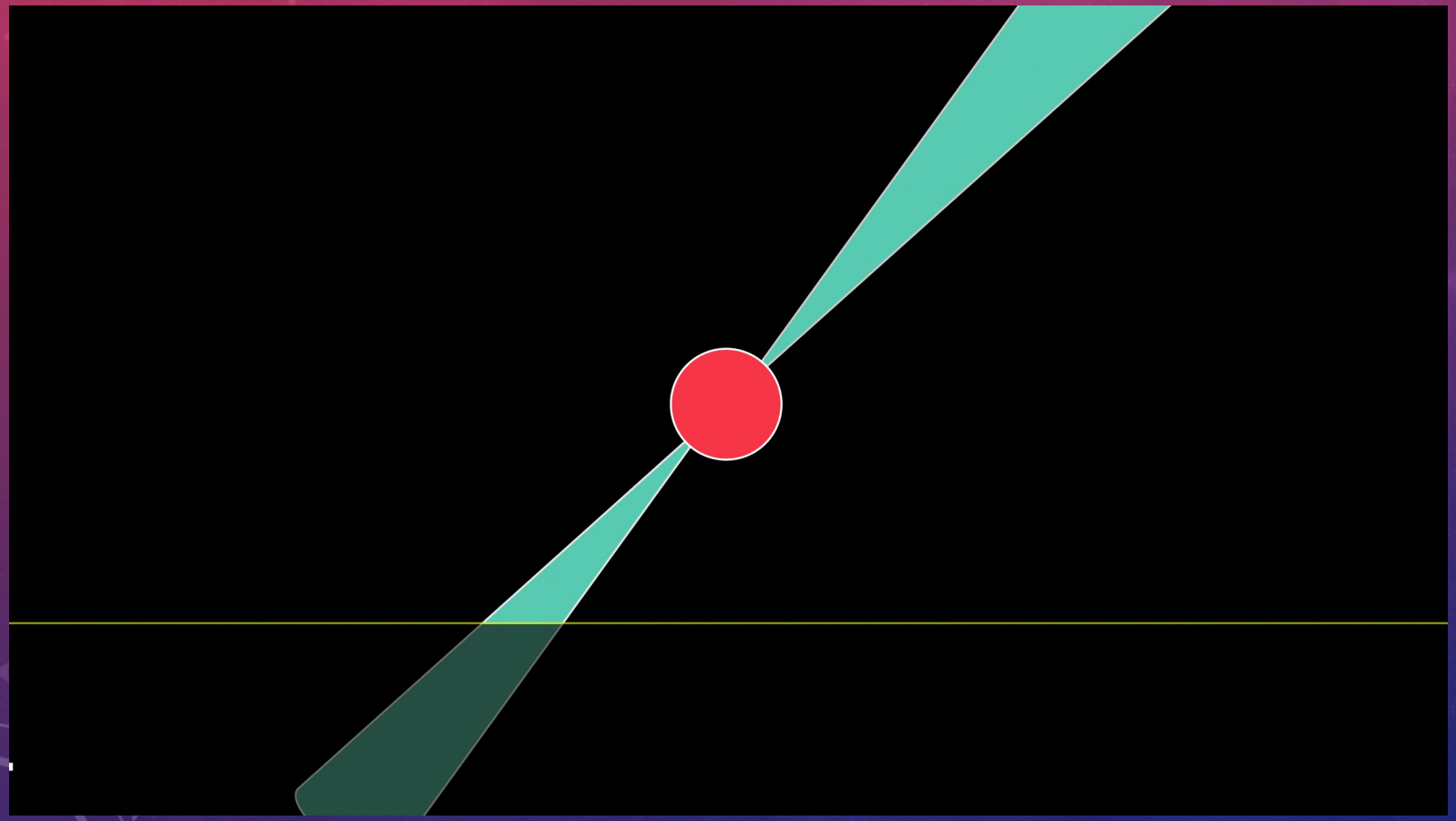
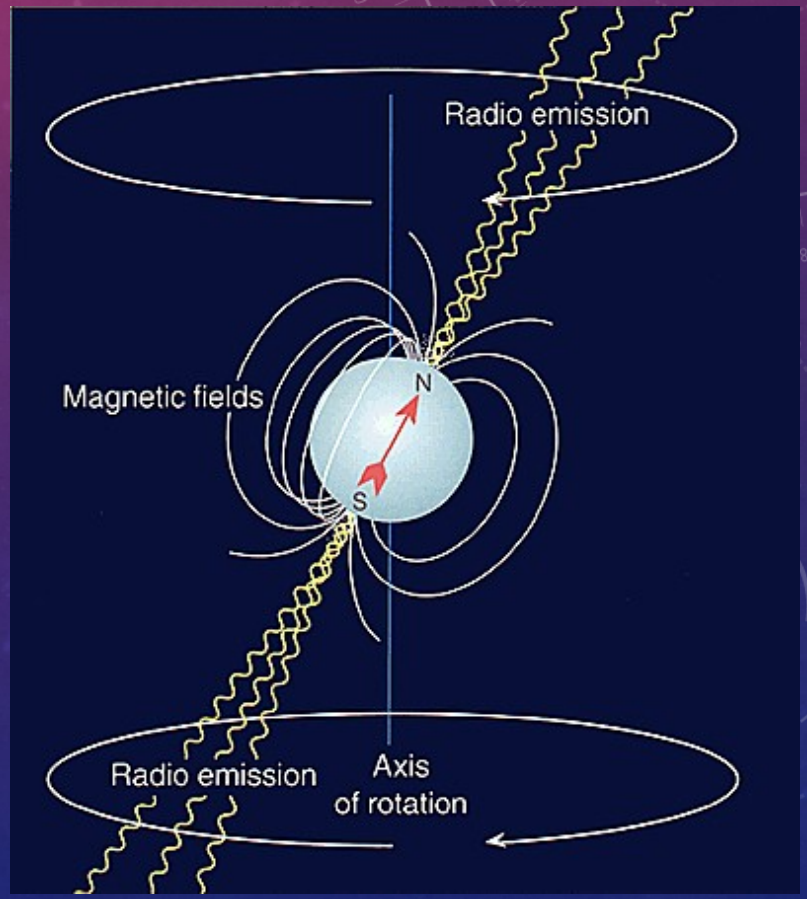
CASPER CONFERENCE 2017

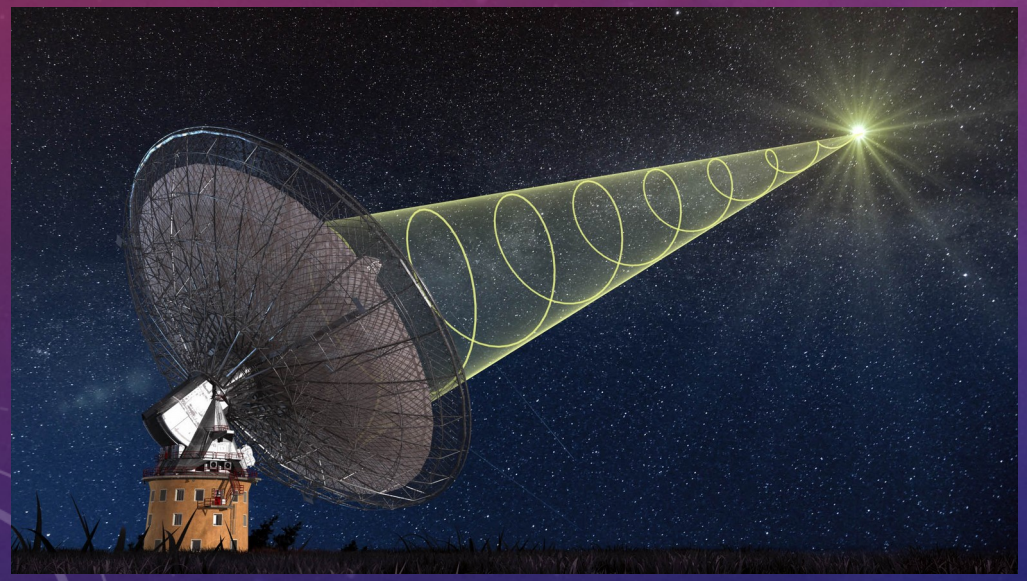
WHAT ARE PULSARS?

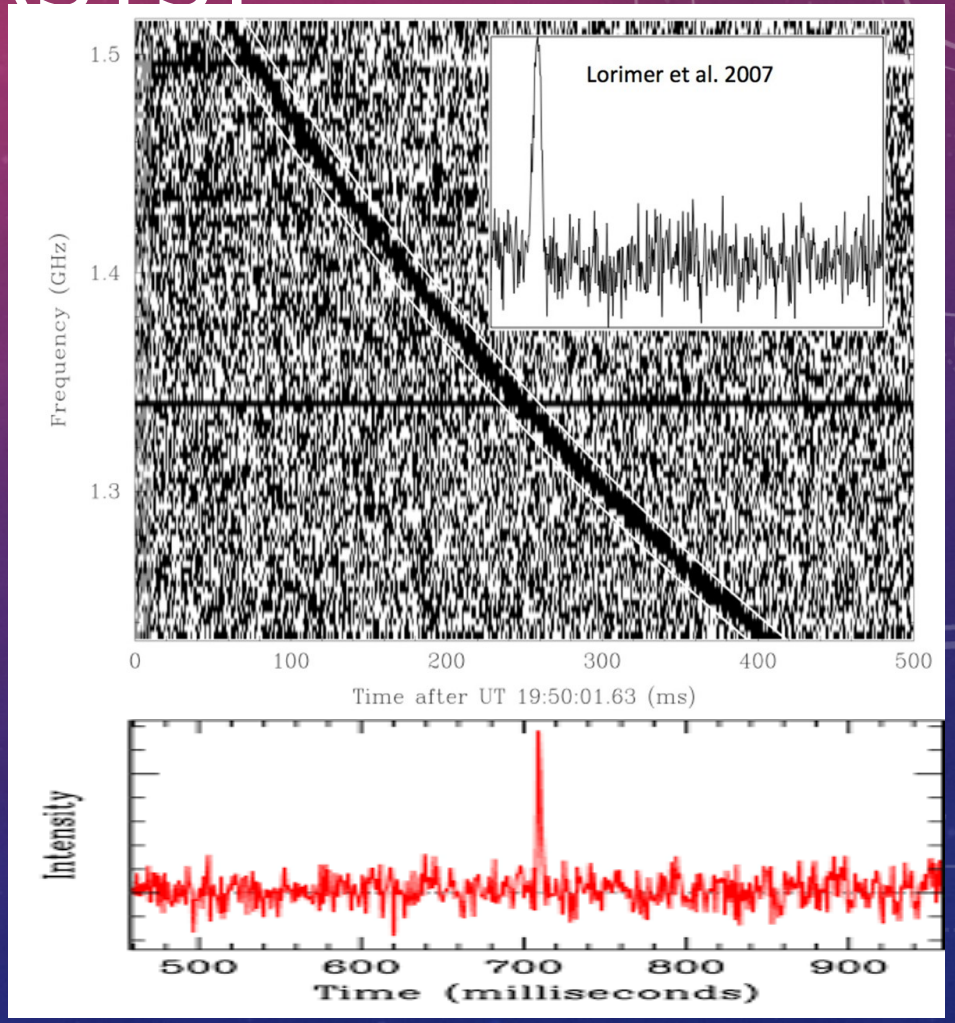




WHAT ARE FAST RADIO BURSTS?

- Discovered in past decade
- Last several milliseconds
- Extremely bright
- Various hypotheses for origin



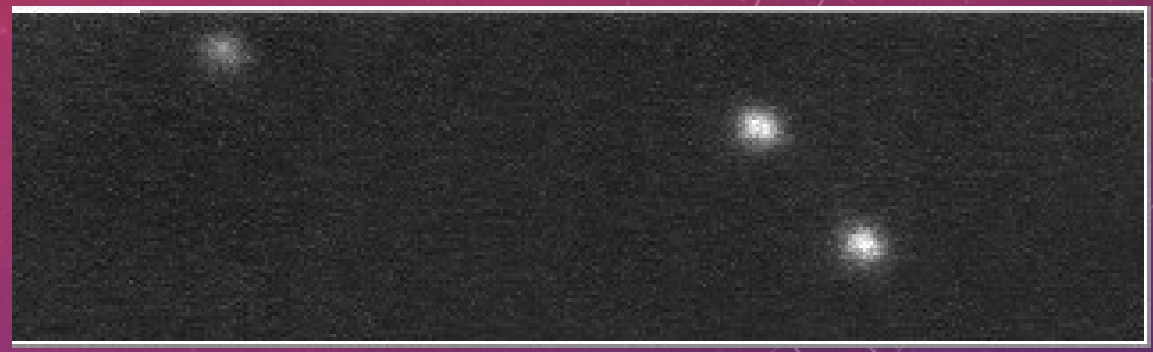


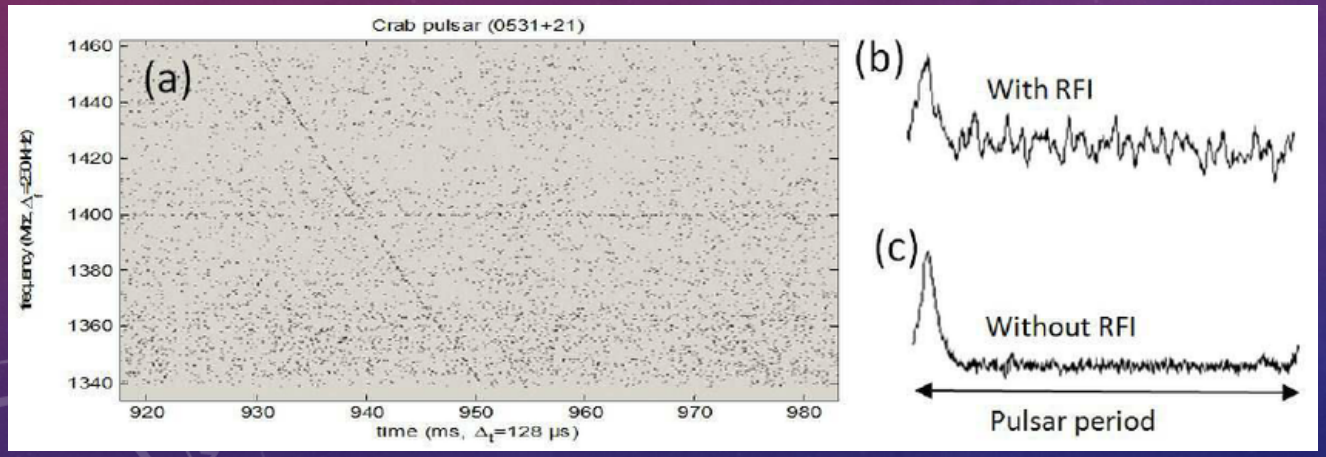
WHY THE CRAB PULSAR?

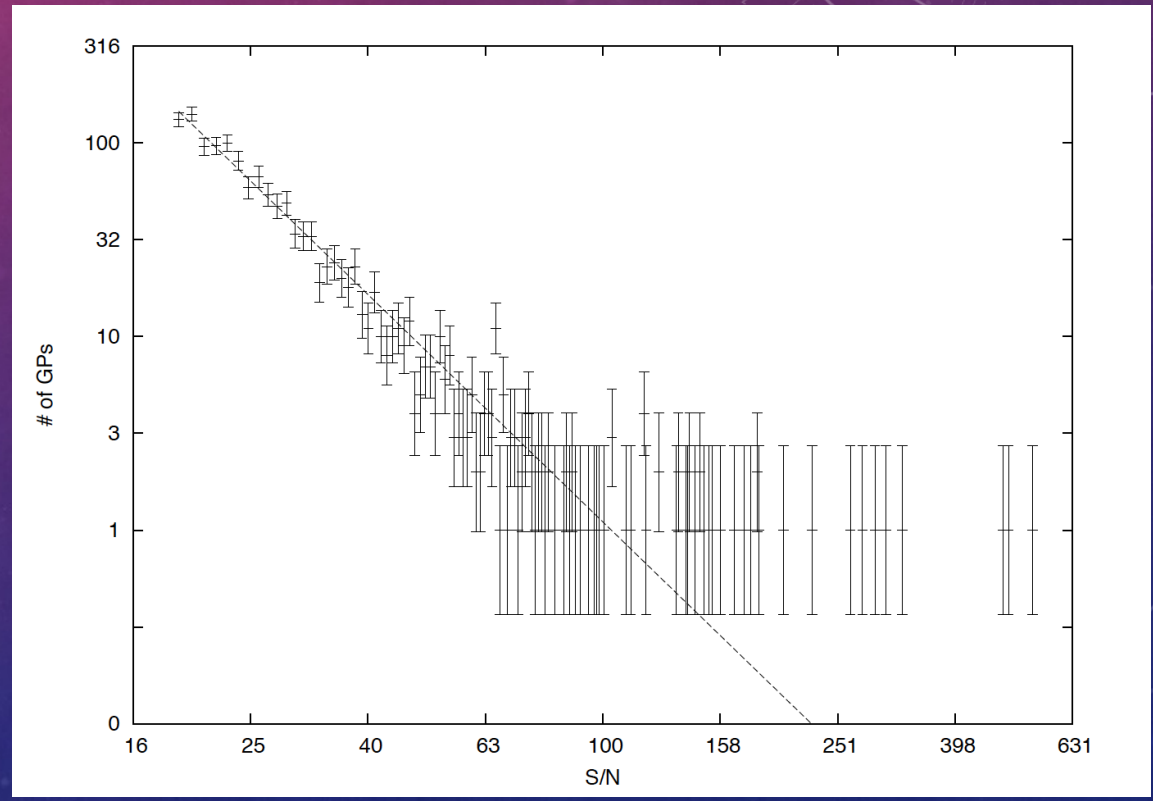
From the Supernovae explosion in 1054 AD

One of the brightest pulsars known

Occasionally emits giant pulses





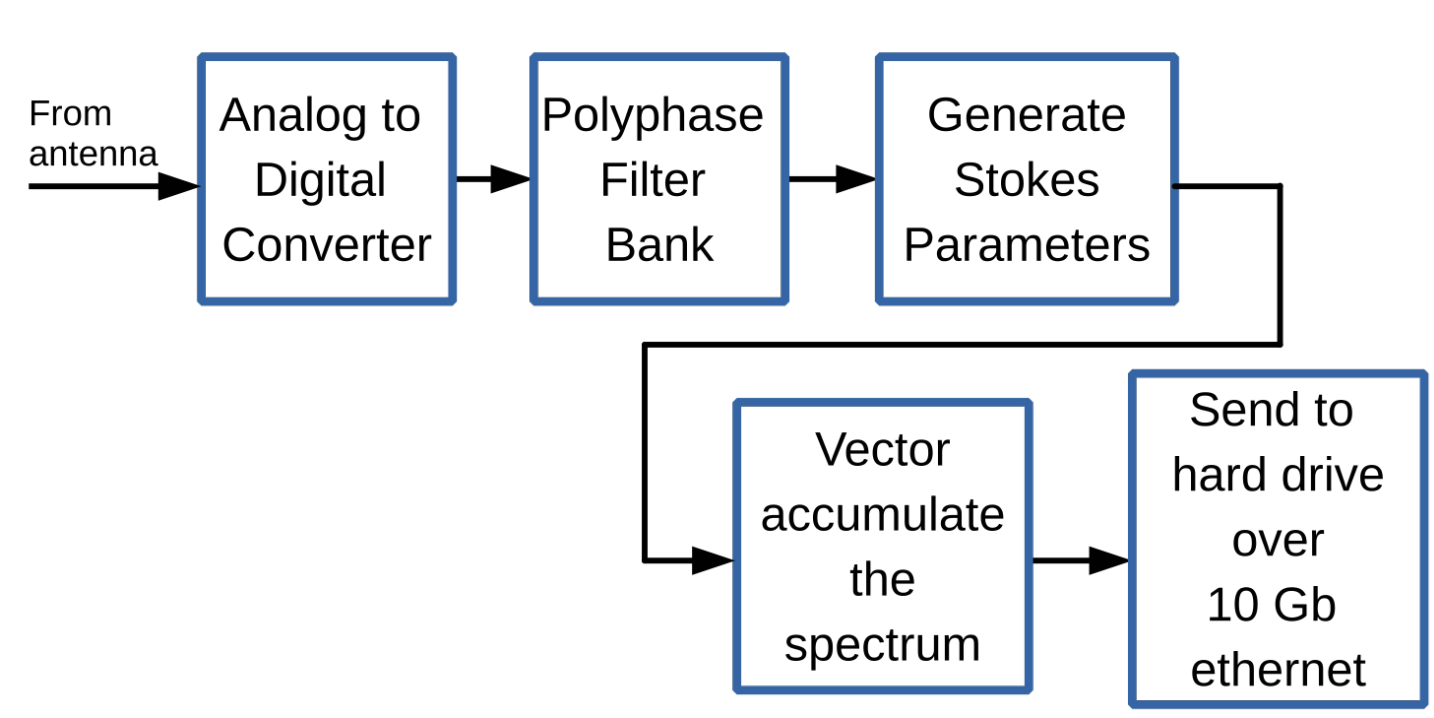


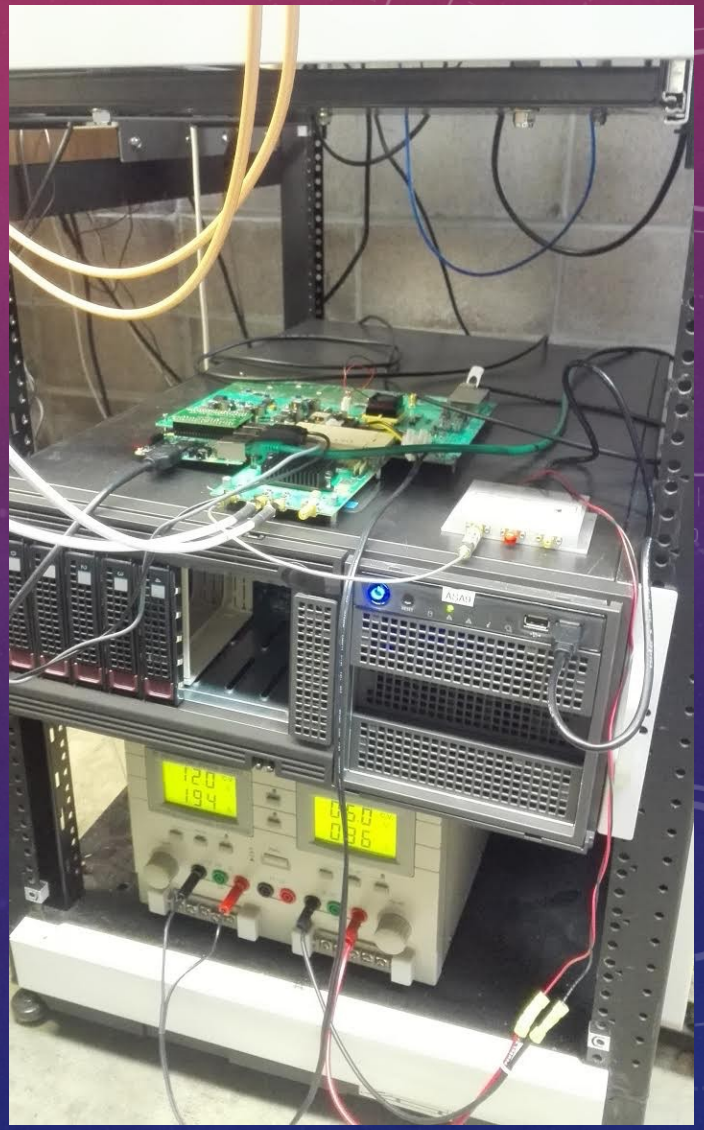
SPECS FOR OUR TELESCOPE

- **Telescope Radius:** 4.1 m
- **System Temperature:** 110K
- **System Gain:** 3mk/Jy
- **Sampling Rate:** 2.1 Gsps
- **Center Frequency:** 1515 Mhz
- **Bandwidth:** 230 Mhz (1400 to 1630 Mhz)
- **Channel Bandwidth:** .25634765 Mhz
- **Integration Time:** 249.660953us
- **Source Power:** > 2000 Jy
- **Source DM:** 56.77118
- **Pulse Width:** 20 – 40 ns
- **Expected S/N:** > 8

Leuschner Telescop

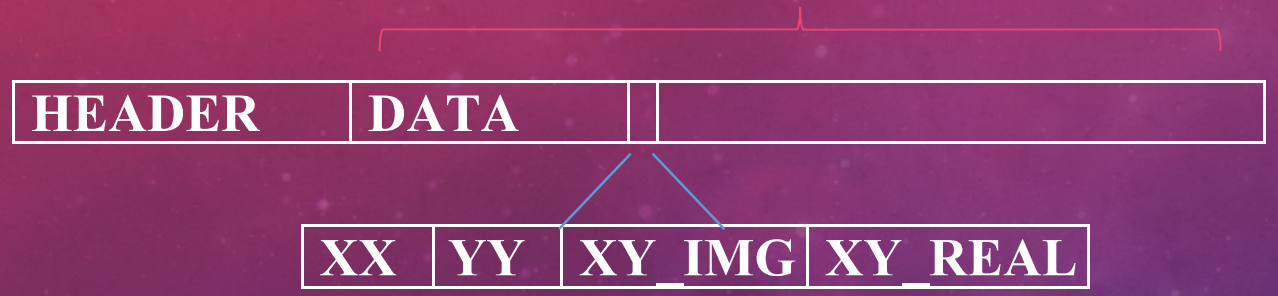
FPGA BACKEND





FROM THE FPGA

Packet Format **512 Channels** **Interpretation**

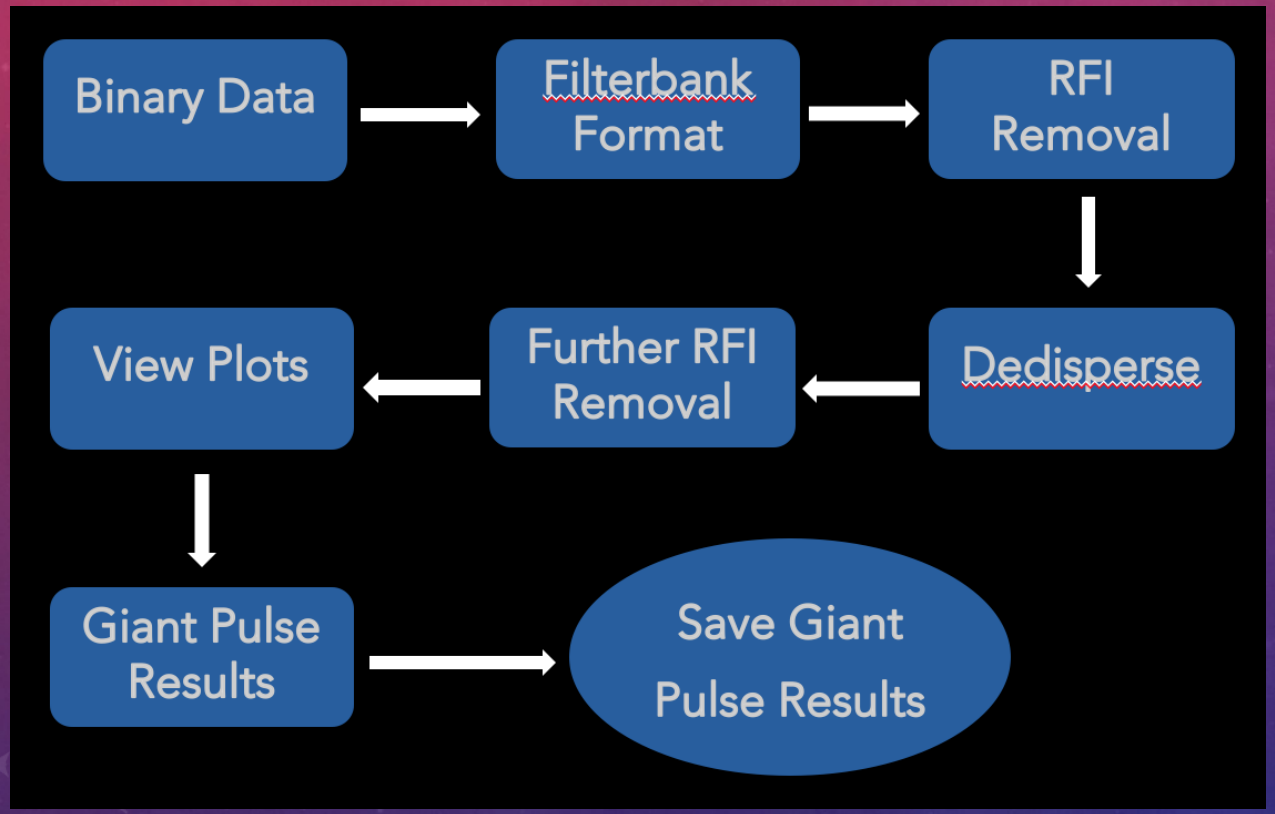


Header: 8 byte counter (starts from 0)
Data: 512 Channels per packet
4 polarization values per channel
2 bytes per polarization value

Total Size: 8 + 512*4*2 = 4104 bytes

Packet # = Header % 8		
PACKET #	**CHANNELS**	**FREQUENCY RANGE (Mhz)**
0	0-511	2100-1968.75
1	512-1023	1968.5-1837.5
2	1024-1535	1837.25-1706.25
3	1536-2047	1706-1575
4	2048-2559	1574.75-1439.75
5	2560-3071	1443.5-1312.5
6	3072-3583	1312.25-1181.25
7	3584-4095	1181-1050

DATA ANALYSIS PIPELINE



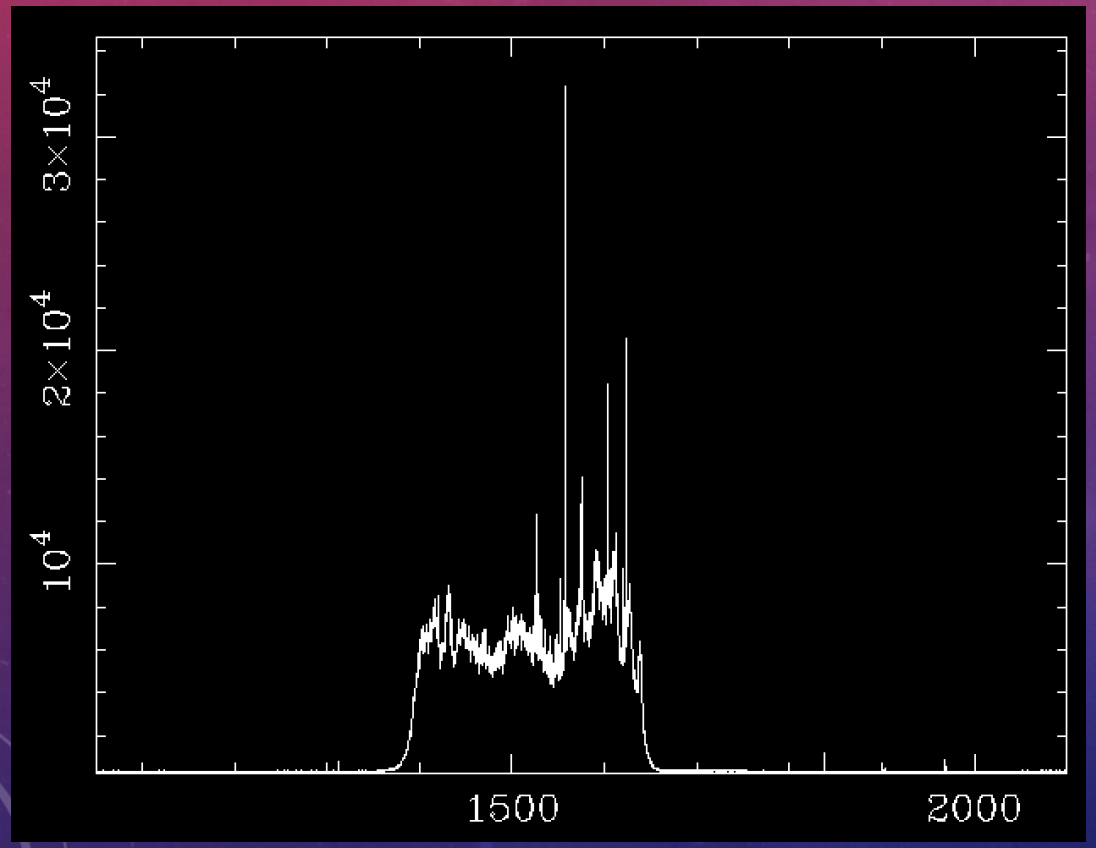
HEADER (source_RA, source_DEC, MJD time, Frequency Range)				
	Time Sample 0	**Time Sample 1**	**Time Sample 2**	**…**
Channel 0	Data	…		
Channel 1	…			
Channel 2				
…				

RFI MITIGATION ALGORITHM

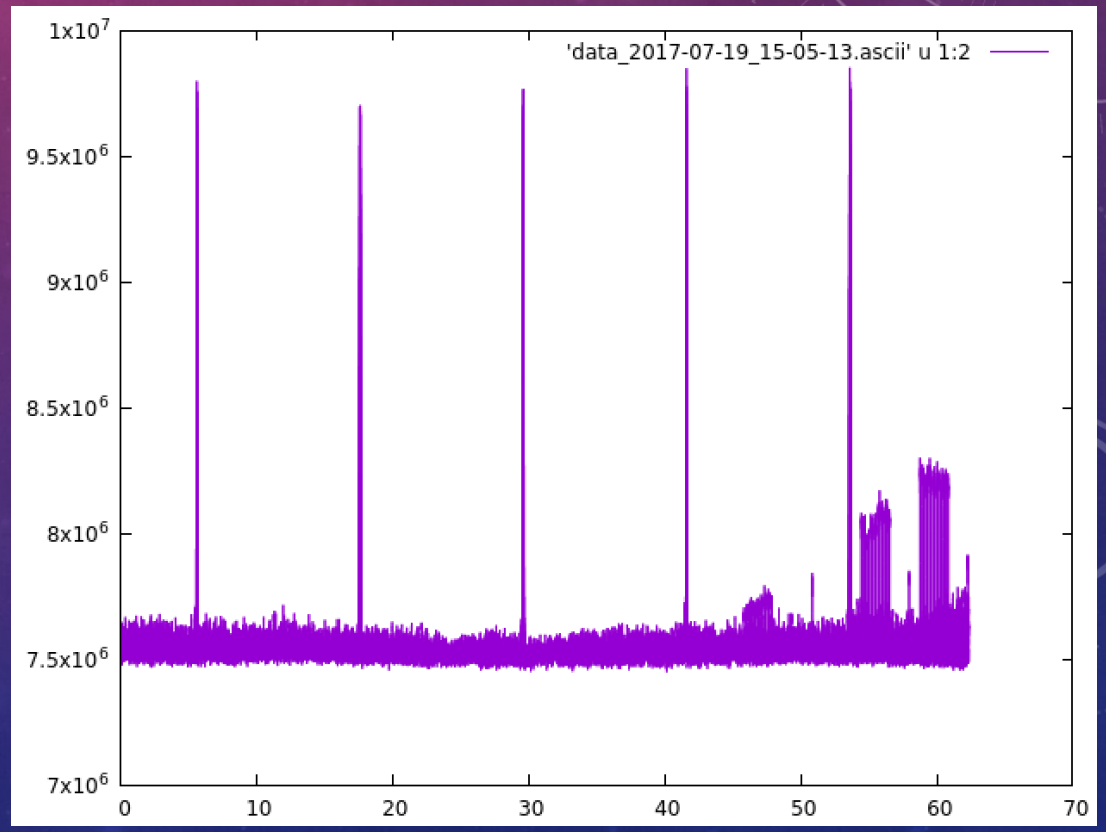
- For every time sample, set channel values outside of our bandpass equal to 0
- Calculate average power for each time sample and replace bad channels (avg +/- 3σ) with gaussian noise
- Narrowband RFI: For each channel in every time sample, calculate average and variance of channel in previous 5000 time samples. If power is outside avg +/- 3σ, replace with Gaussian noise
- Broadband RFI: For every time sample, calculate average and variance of total power of channels in previous 5000 time samples. If power is outside avg +/- 3σ, replace with Gaussian noise
- Possible to do in real time

RFI MITIGATION - BEFORE

Bandpass Plot

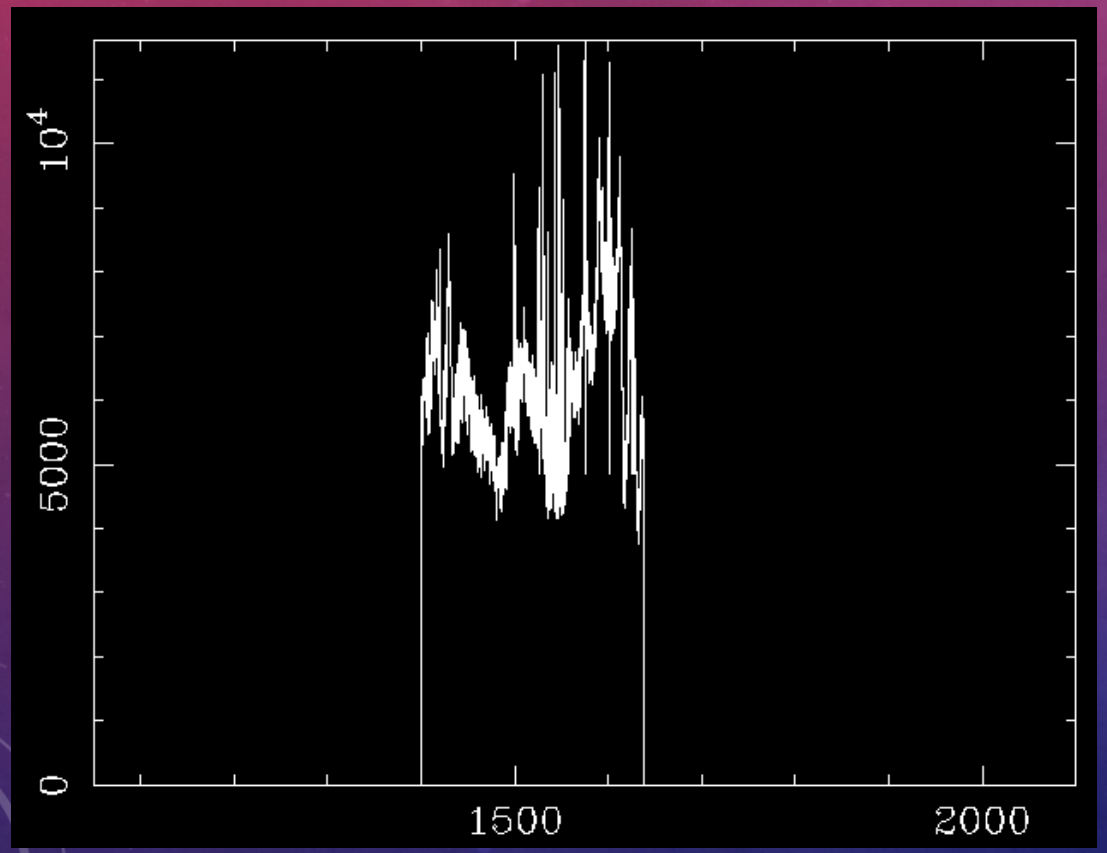


Time Series Plot

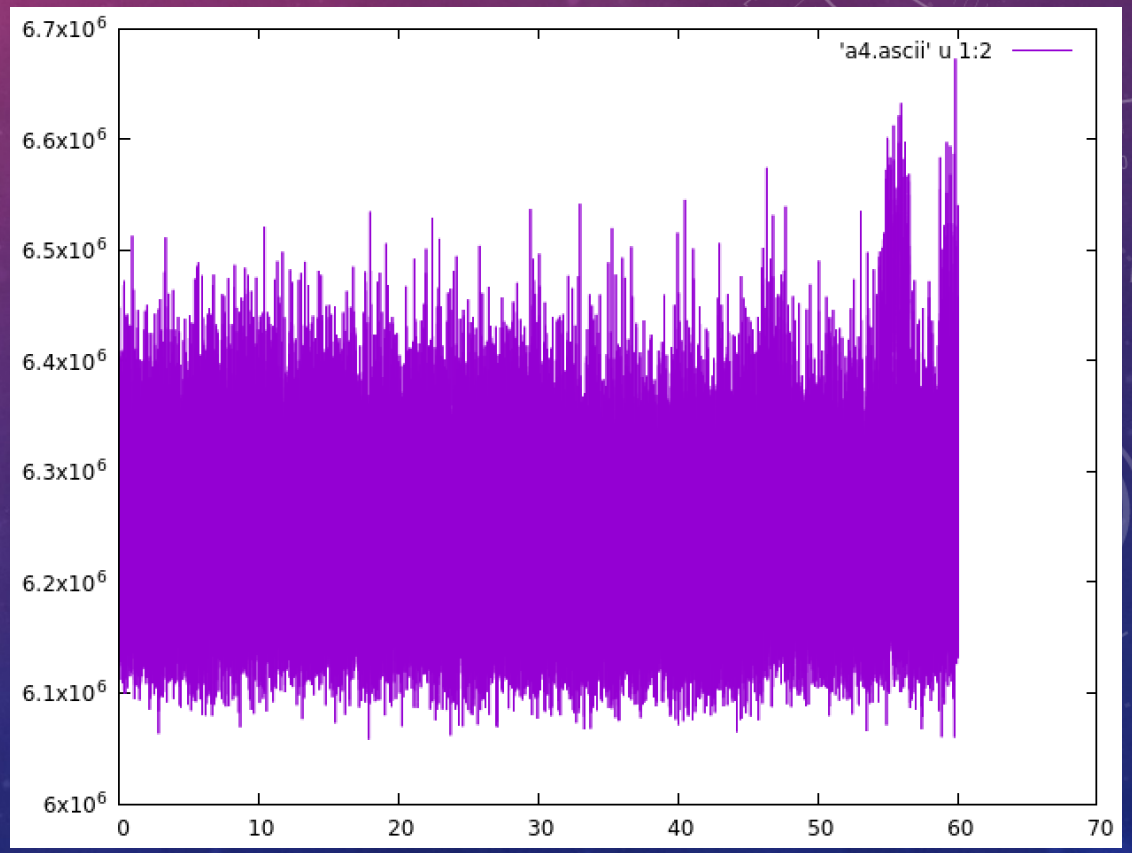


RFI MITIGATION - AFTER

Bandpass Plot



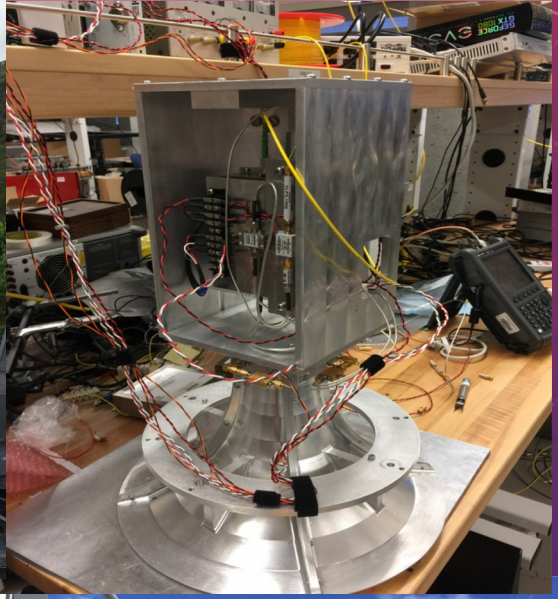
Time Series Plot

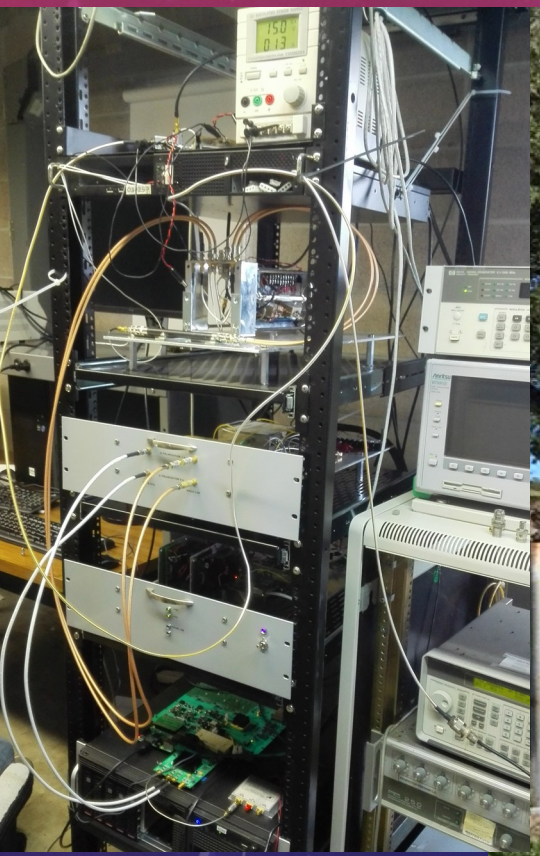


CURRENT STATUS

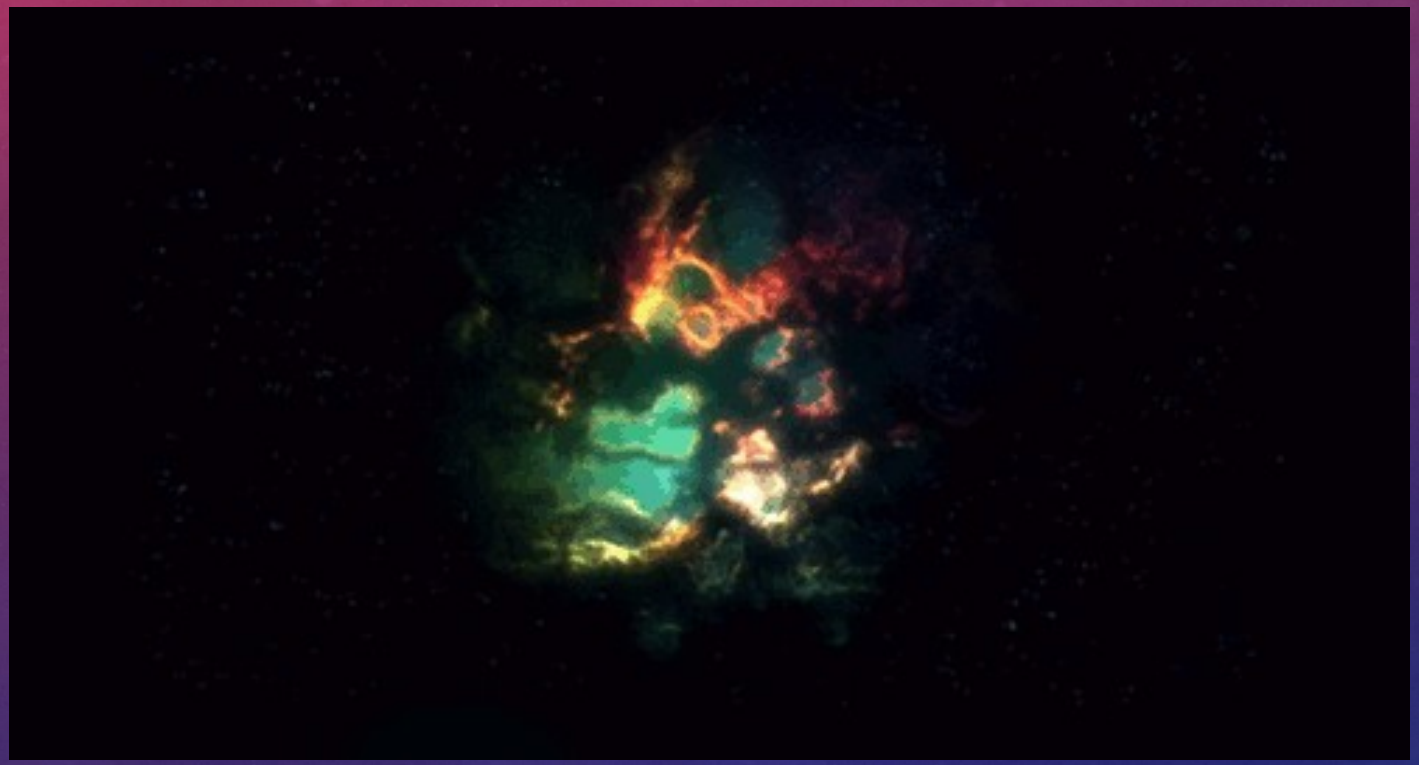
- We successfully built a pipeline that receives data packets over the network from the SNAP board. It also converts that data from binary format to filterbank format,. And finally, it successfully removes and replaces RFI with Guassian noise.

FUTURE WORK





- Collaborators: Jim Cordes, David DeBoer, Vishalkumar Gajjar, Deepthi Gorthi, Carl Heiles, Jack Hickish, Frank Latora, Casey Law, ChenHui Niu, Daniel Price, Dan Werthimer, Robert Wharton, Pei Xin



THANK YOU!

- - known dm of crab
- -50 years anniversary next year of discovering crab (through giant pulses 100,000 times larger)
- 1968, David H. Staelin and Edward C. Reifenstein III, Joceyln Bell
- -giant pulse nature of crab (unknown why), power law distribution--- fill in the gaps (possibly also detect fast radio bursts)
- -spurious nature of normal pulse
- -connection to FRBs and calculations of parameters
- -fpga backend, udp transfer protocal, diagrams of data flow, rfi removal
- -current status

- Sampling, polyphase filterbank and fft, correlation for stokes calculation,