

Overview of the CHIME/Pulsar Project

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(On behalf of the CHIME/Pulsar collaboration)



CHIME



CHIME telescope parameters

Collecting Area	8000 m ²
Frequency Range	400-800 MHz
E-W FoV	2.5 deg - 1.3 deg
N-S FoV	~110 deg
Receiver noise Temperature	50 K

Hardware Overview



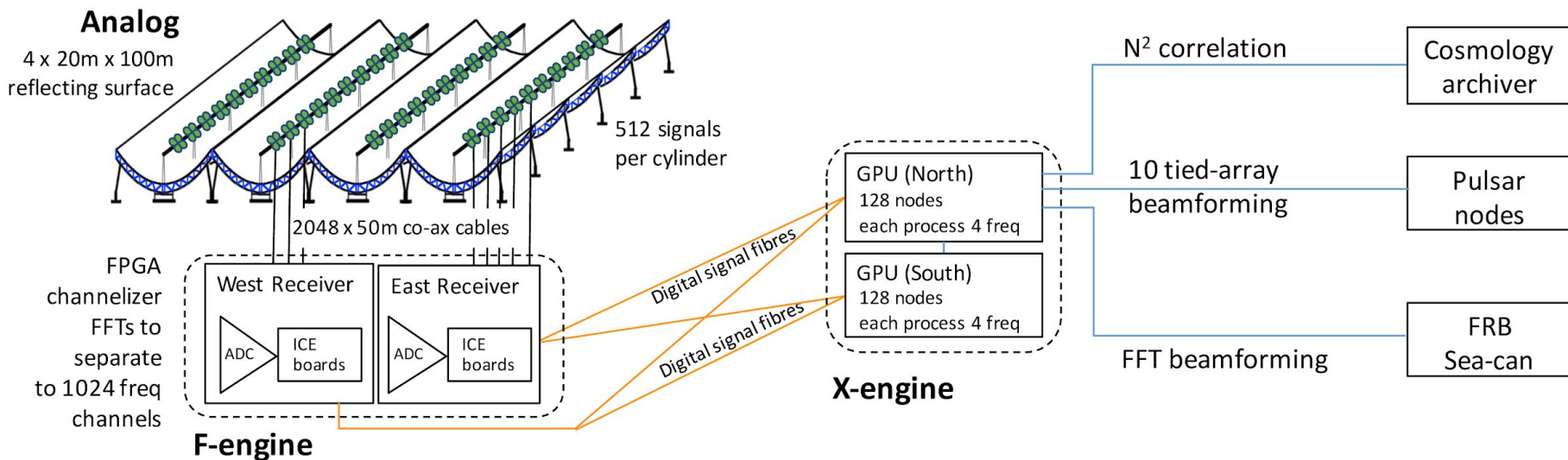
1024 Feeds

Receiver Huts

Correlator Huts

FRB sea-can

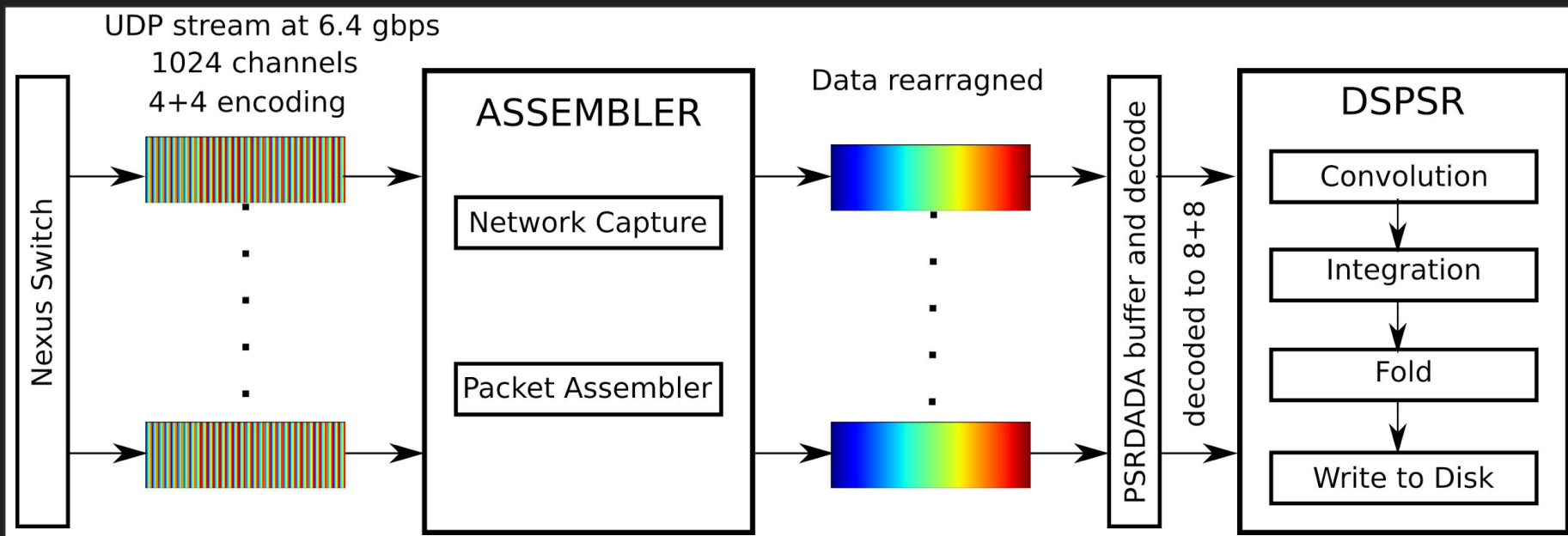
Power supply



Chime pulsar instrument: tracking known sources

- 10 independently positioned tied-array beams, with 1 GPU node processing each beam.
- Observing modes include coherent dedispersion (folded or time-series output) filterbank output and baseband mode.
- The tracking duration is declination-dependent: about 10 minutes for sources on the Celestial Equator, and 24 hours at the North Celestial Pole.
- All Northern-hemisphere pulsars can be observed with a cadence of 10 days or better.

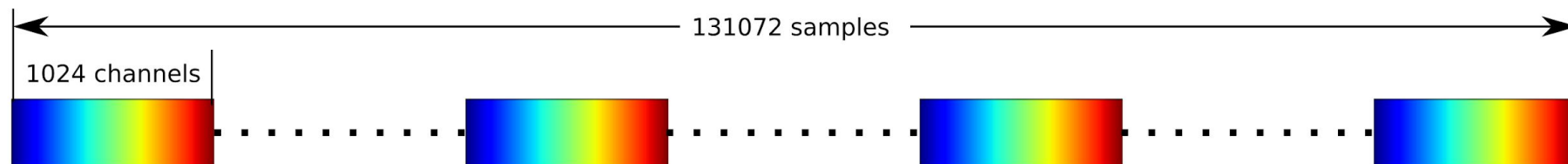
Pipeline (DSPSR)



- UDP packets are captured , assembled and passed to DSPSR process via PSRDADA buffer.
- Assembling UDP packets is a memory bound operation.
- Intel AVX2 kernels are used for assembler resulting in 15x speed up.
- DSPSR has trouble accepting 4+4 encoding so the PSRDADA software is modified to decode the data before passing it to DSPSR.
- Not efficient for DMs more than 350 pc/cm³.

Pipeline Cont.. (Data format for Filterbank mode)

Input Data format for Filterbank mode

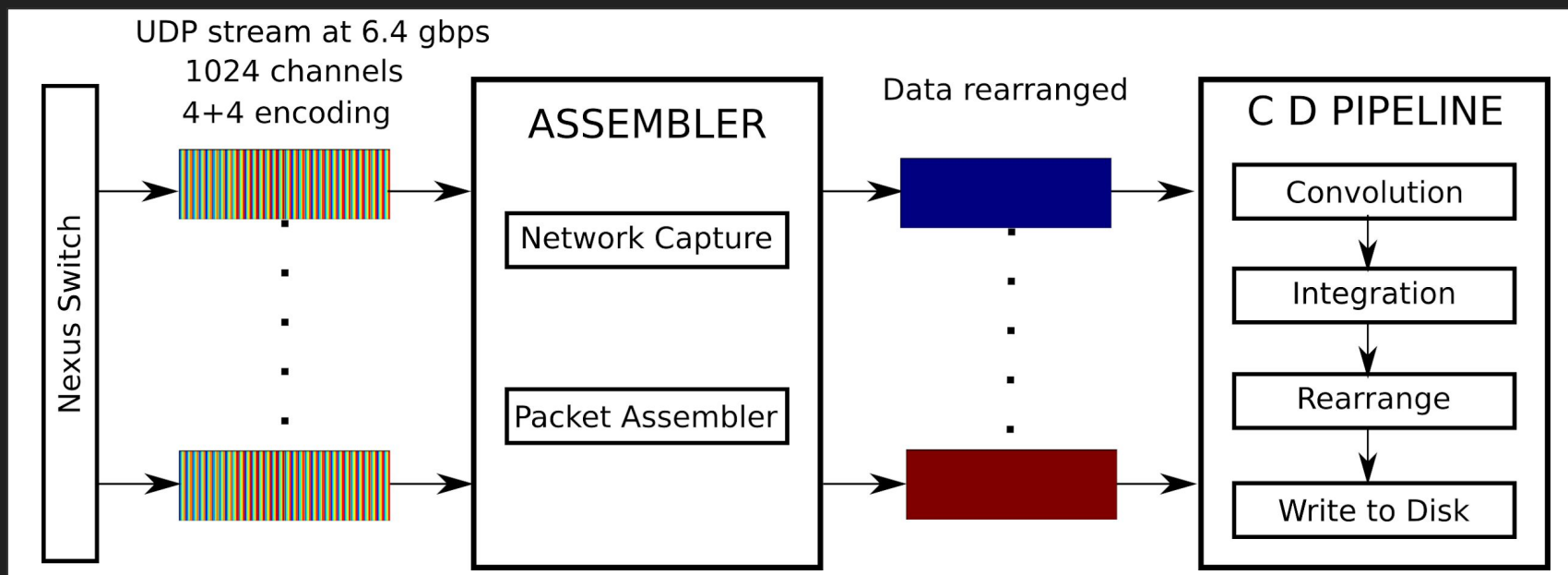


Input Data format for Filterbank mode



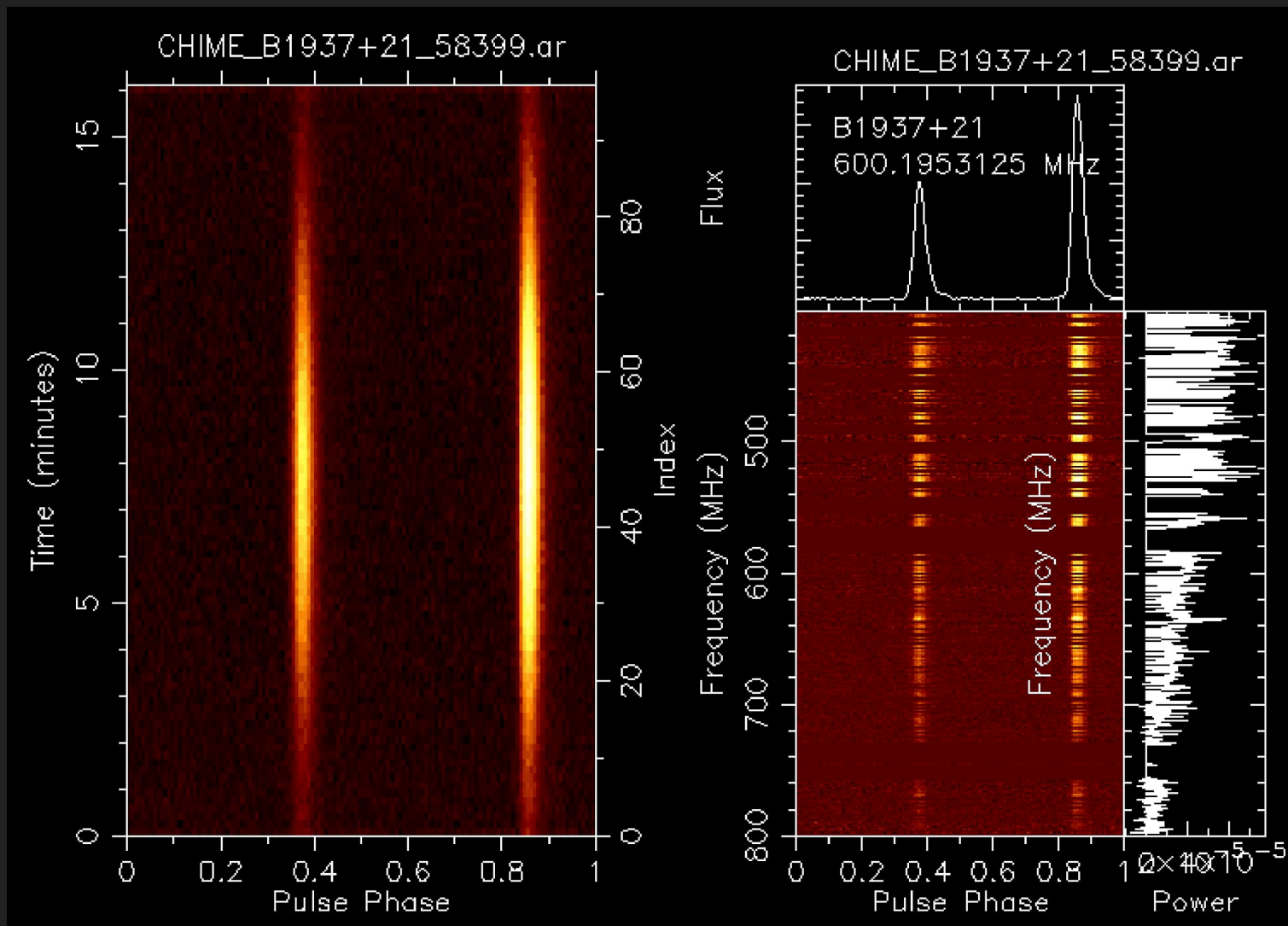
- The input data format for filterbank mode is different from that of DSPSR (essentially a transpose).
- By using the above data format we get 5x improvement in GPU performance.
- These transpose operations are performed in real time by using Intel AVX2 kernels.

Pipeline Cont.. (Filterbank mode)

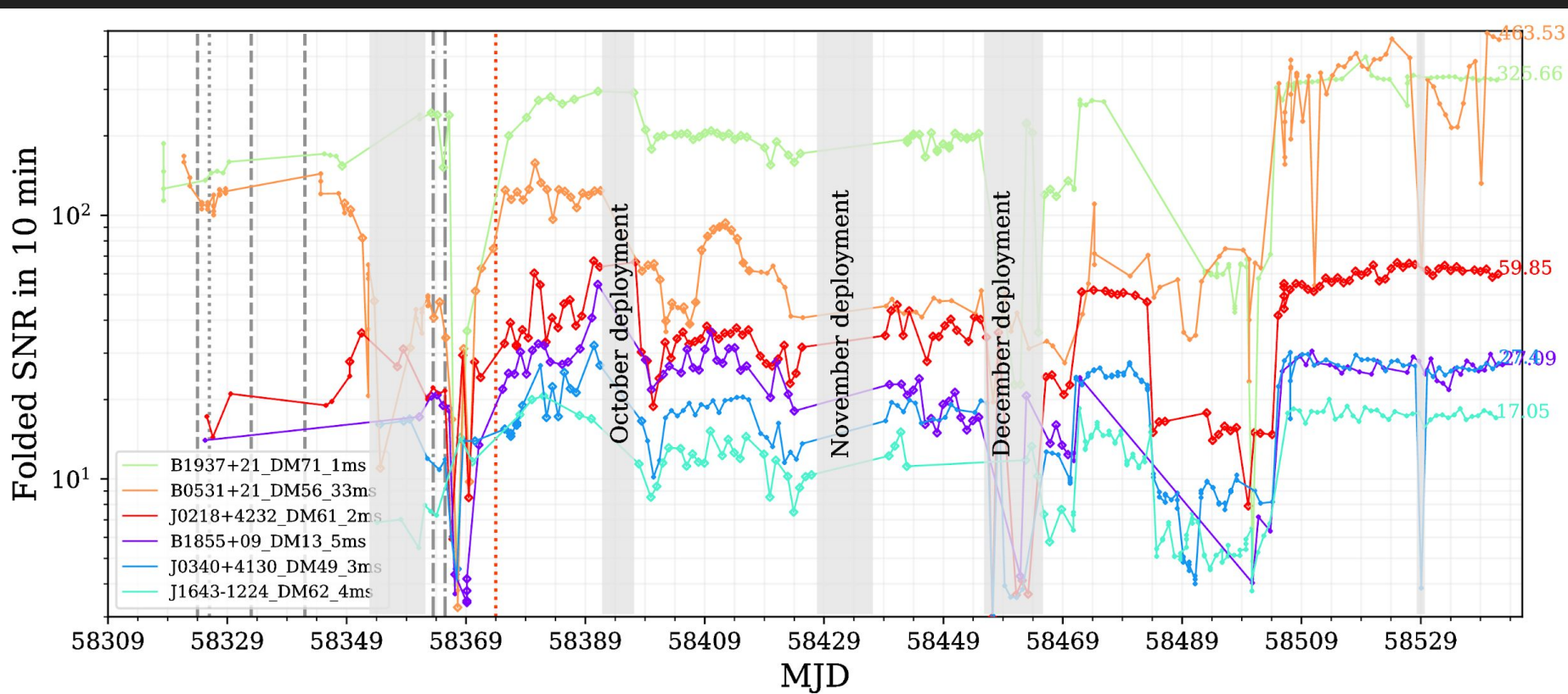


- Cut off DM is 2500 pc/cm³.
- Only convolution is performed on GPU rest of the operations are carried out on CPUs.
- Regularly used for monitoring Repeating FRBs and potential pulsar or RRats.

PSR B1937+21



Backend Stability

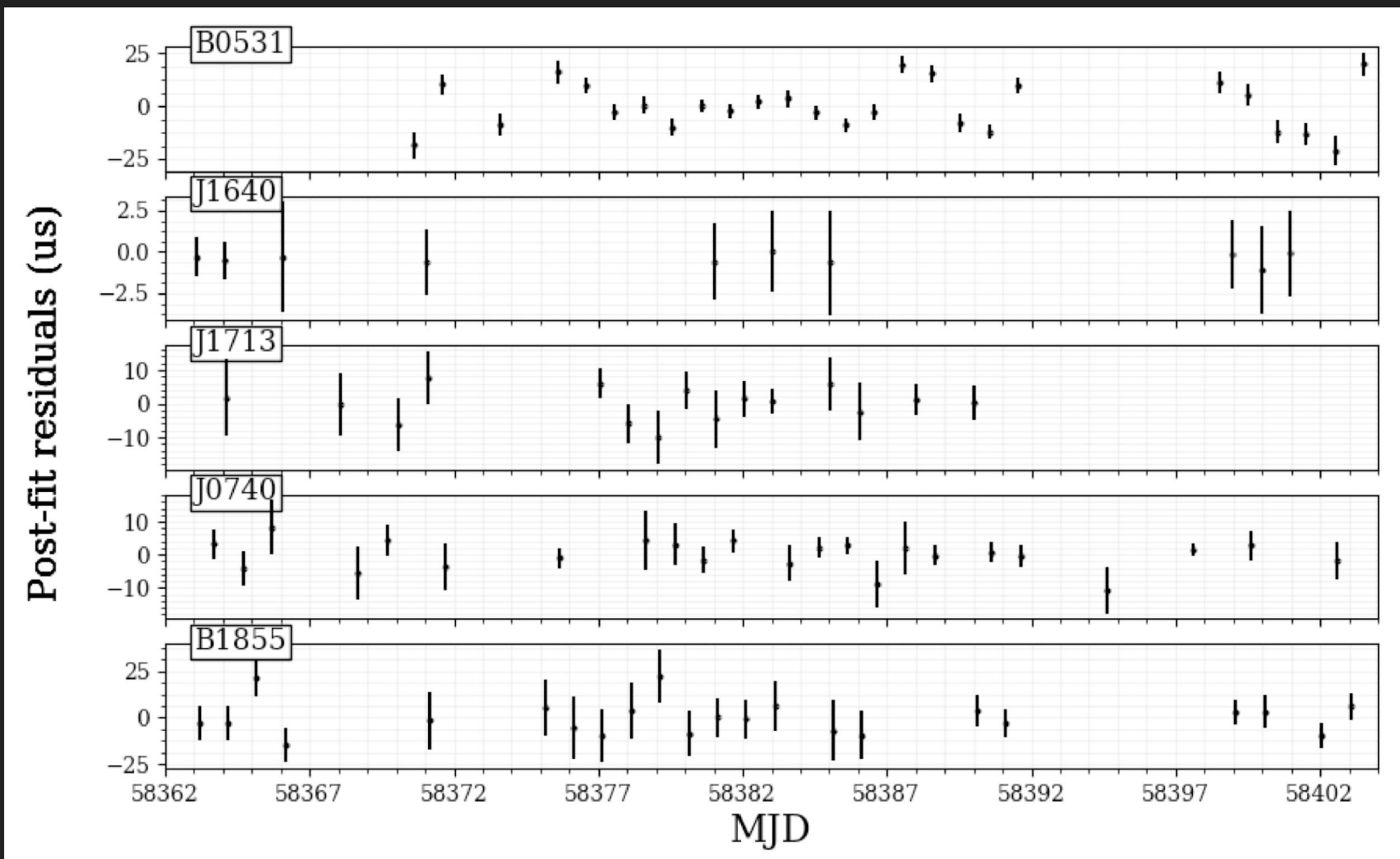


Plot by Cherry Ng

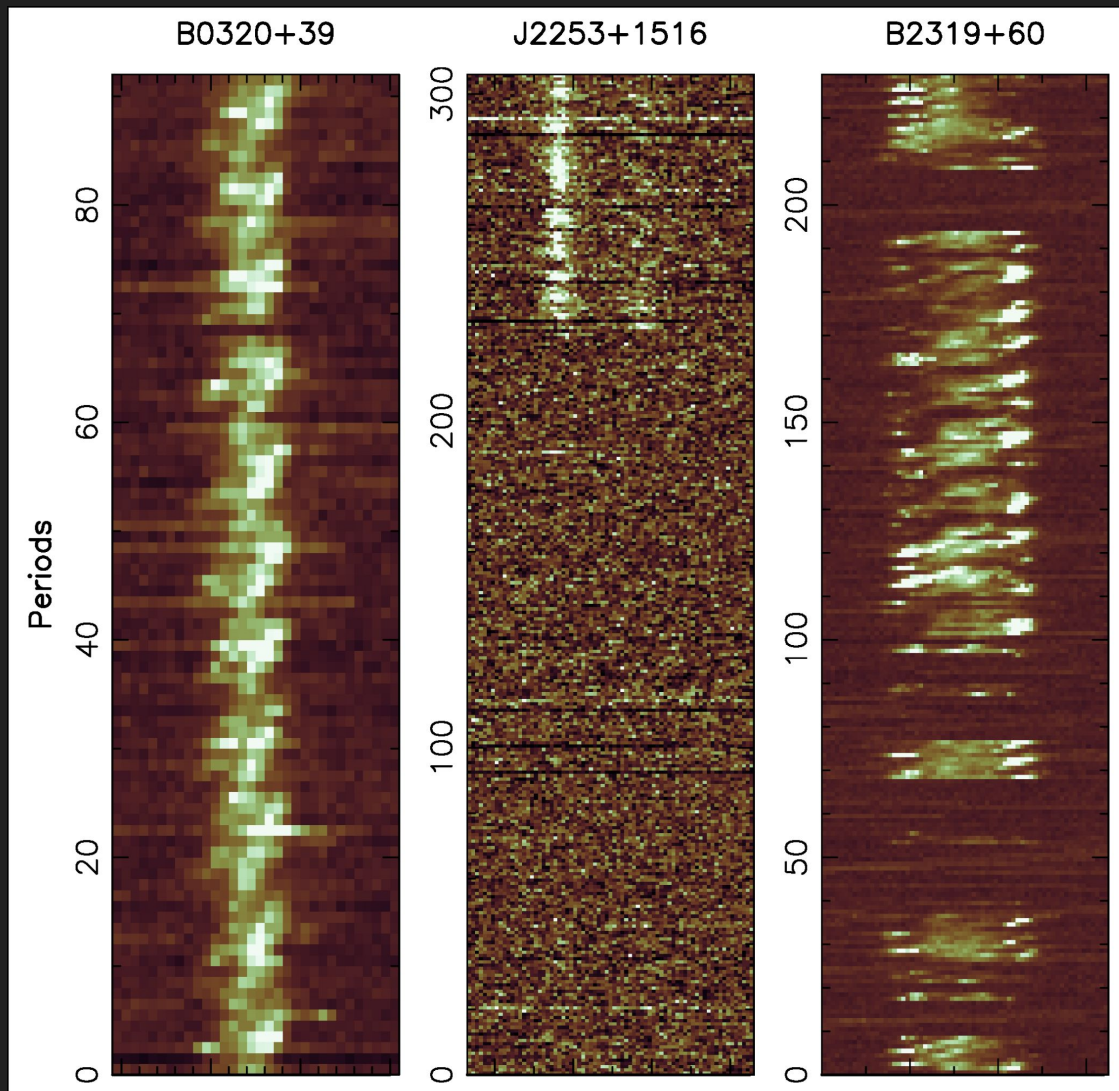
Science case.

- Daily observations of the Northern-hemisphere millisecond pulsars (MSPs) timed by the NANOGrav collaboration (~40 sources): this will provide detailed DM and scattering variations and allow timing improvement by up to a factor of 2.
- Binary-pulsar mass measurements
- Pulsars that undergo glitches, timing noise, magnetospheric switching, mode-changing, subpulse drifting, nulling...
- Monitoring RRATs, magnetars and transitional MSPs
- Following up new and unexpected sources.
- Following FRB candidates.

Preliminary timing of few MSPs

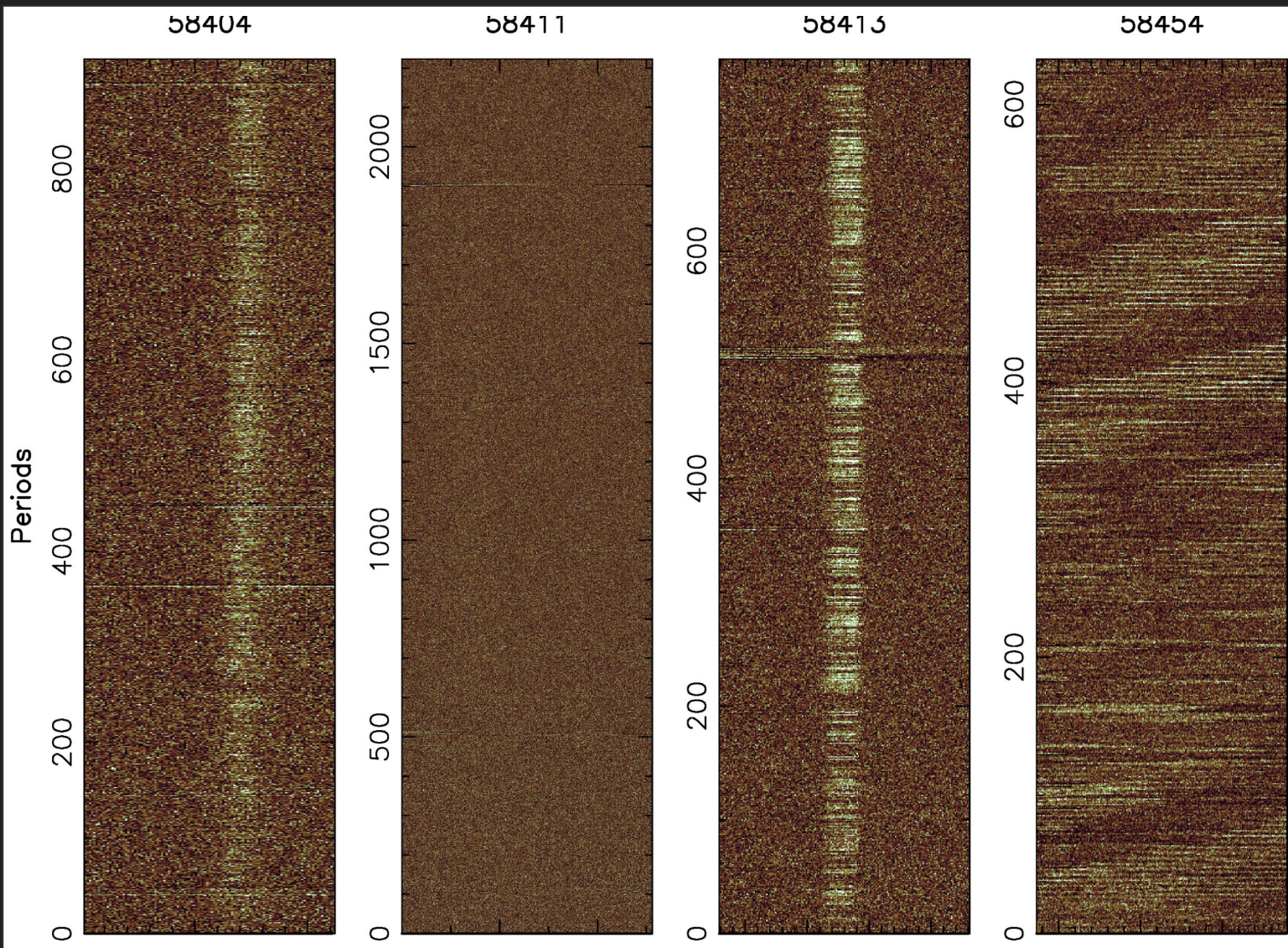


Single Pulse studies



- 400+ hours of useful single pulse data on 156 pulsars.
- ~60 of them show subpulse drifting.
- ~86 of them have some evidence of nulling.

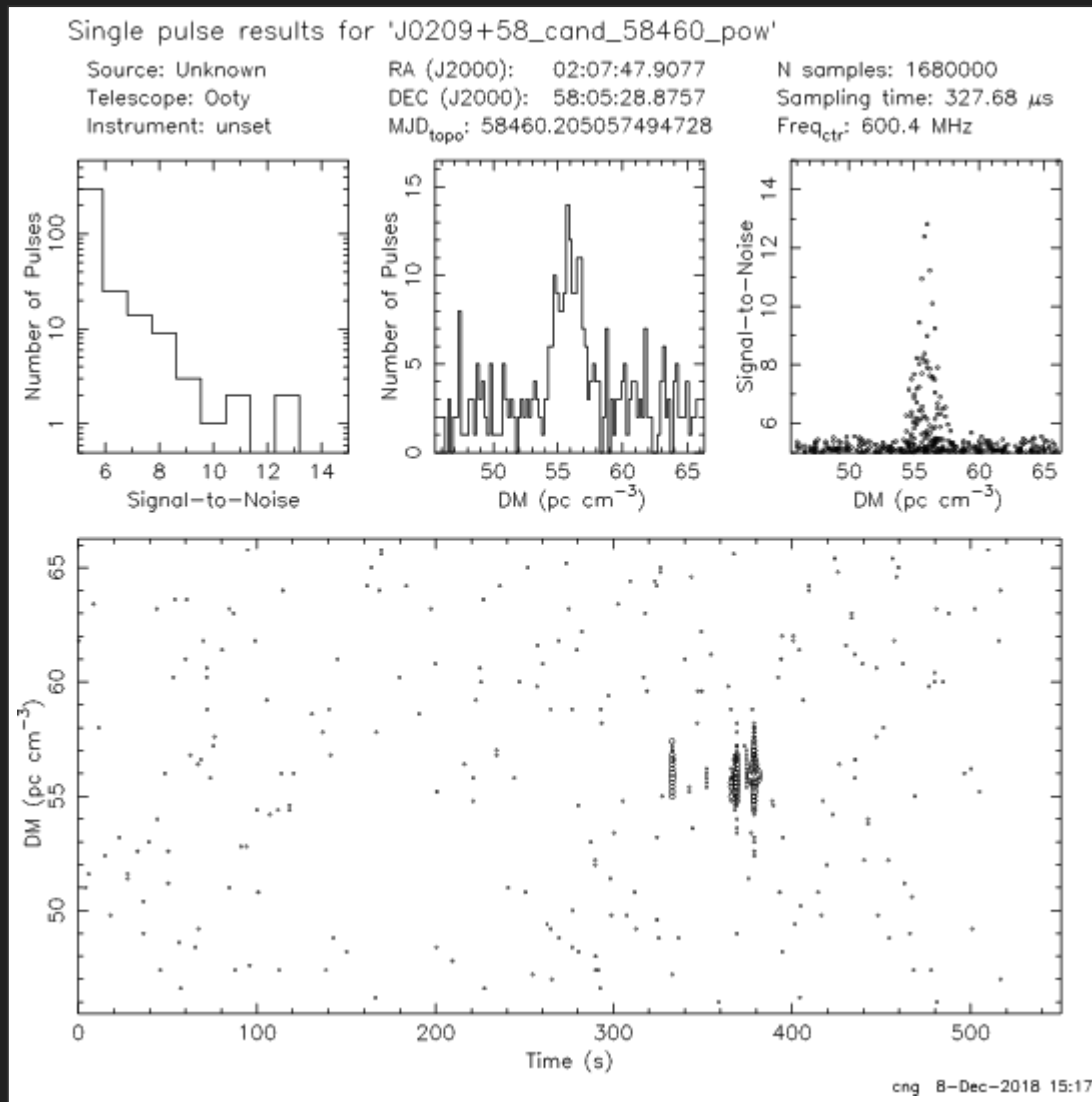
Monitoring Galactic Candidates (Extreme Nullers)



One of the first candidate confirmed by the CHIME/Pulsar backend. Shows strong evidence of Extreme nulling.

Expected to detect many such pulsars.

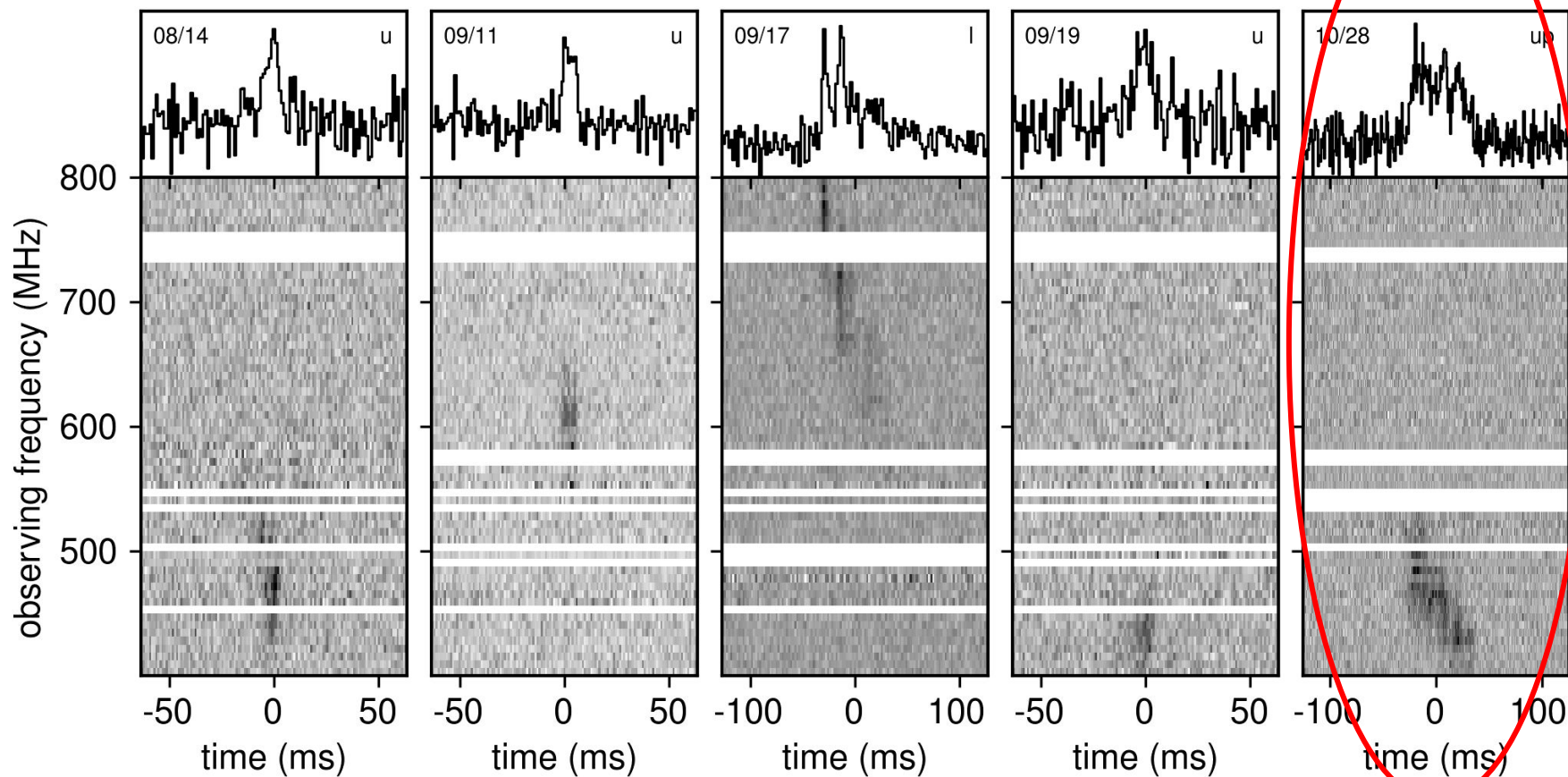
Monitoring Galactic Candidates (RRATS)



- Pulsar Backend is extensively used for following the galactic candidates from the FRB backend.

Plot by Cherry Ng

Monitoring Repeating FRBs (R2)



Summary and Future

- The CHIME/Pulsar backend is stable and observing over 350 pulsars everyday.
- Extensively used for monitoring the Repeating FRBs and new potential galactics sources. Already confirmed 10 Pulsar and RRATs.
- Better data reduction pipeline is under development.
- Lots of science.