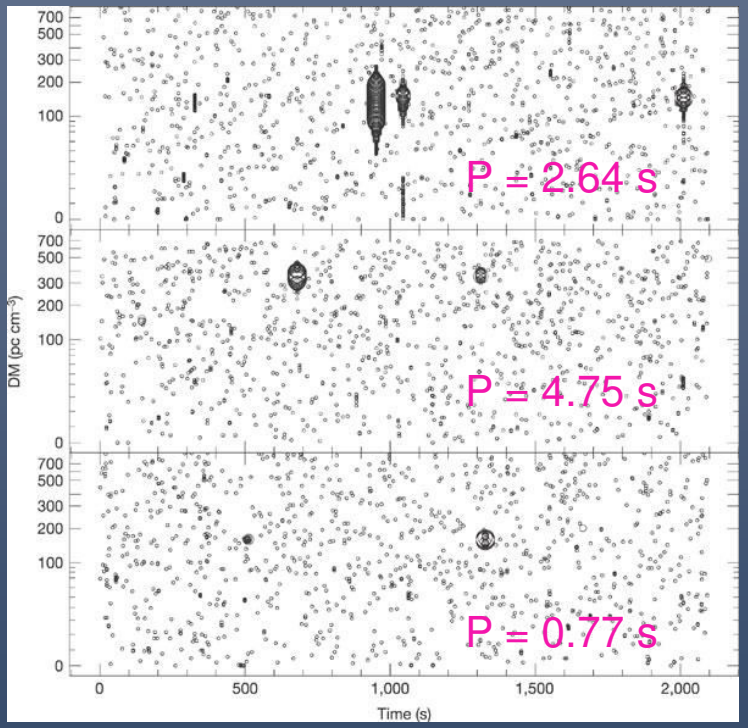
Observing Rotating Radio Transients with the LWA

Rossina Miller and Maura McLaughlin
West Virginia University

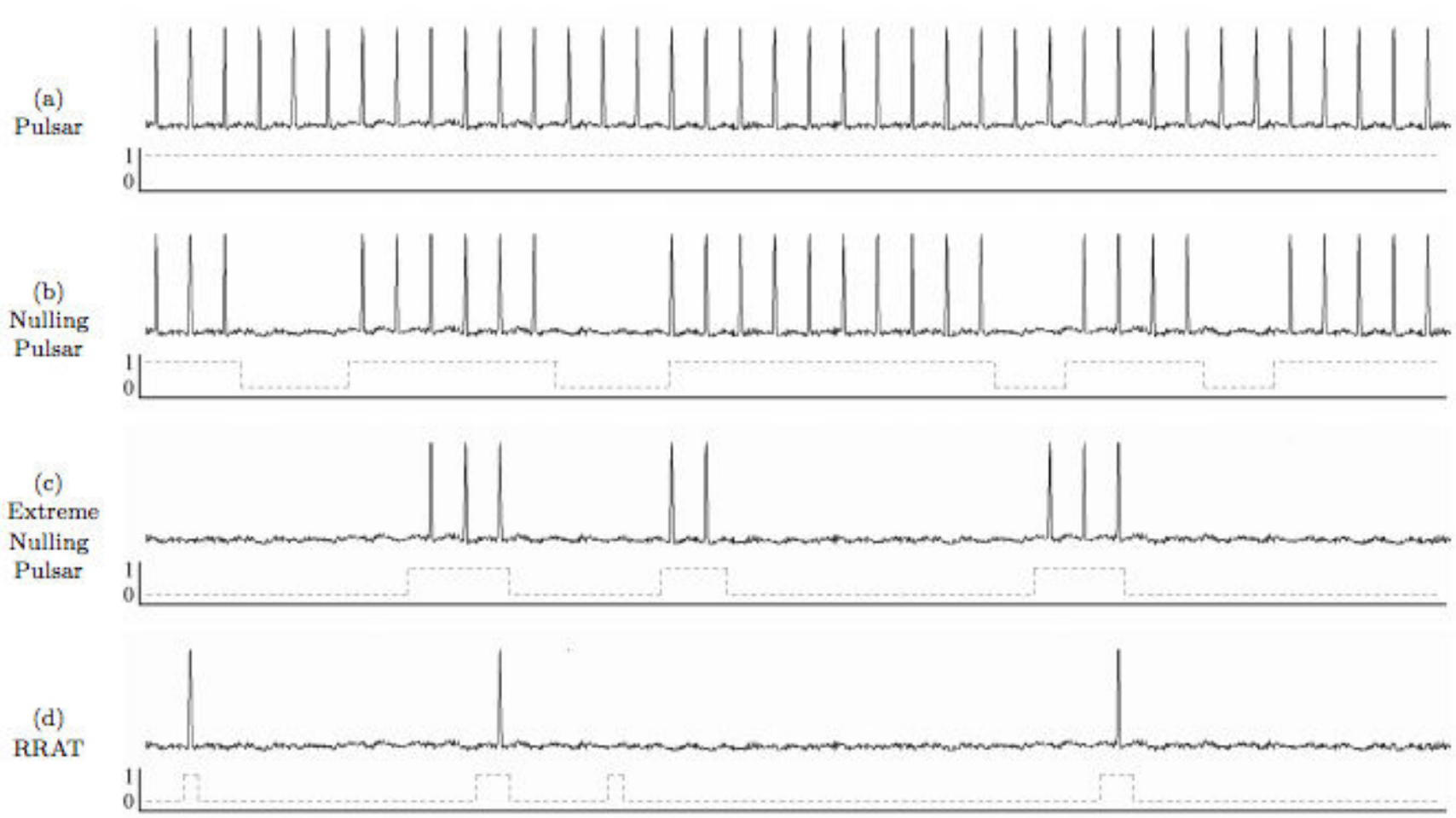
Collaborators:
Chen Karako, McGill University
Victoria Kaspi, McGill University
GBT Drift Scan & GBNCC Survey Teams
(And thank you Kevin Stovall!)

Rotating Radio Transients (RRATs)

- Discovered in 2006 (McLaughlin et al.)
- 11 objects detectable only through their single pulses. Periods of 0.9 to 6 seconds measured through single-pulse differencing.



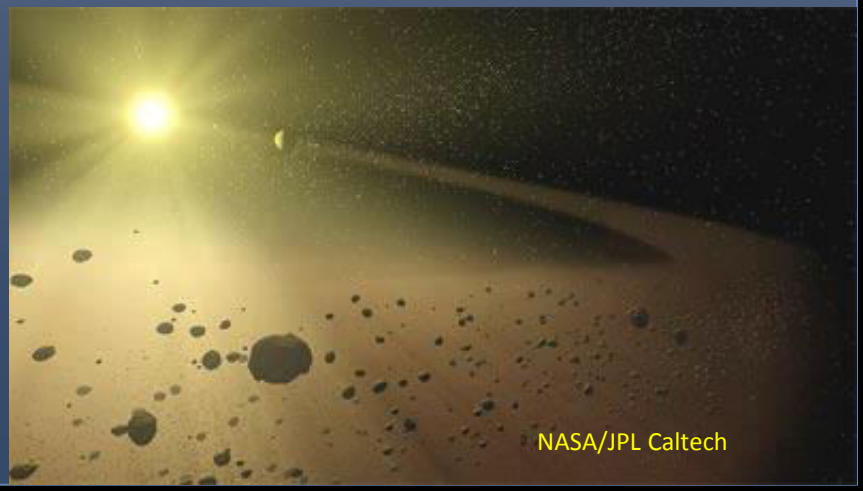
Rotating Radio Transients (RRATs)



Burke-Spolaor & Bailes, 2010, MNRAS

Rotating Radio Transients (RRATs)

- Possible Definition: A type of pulsar that was only discoverable through a search for single pulses (definition up to debate!)
- Cause of intermittency unknown (asteroid belts? Magnetars? Dying pulsars?)

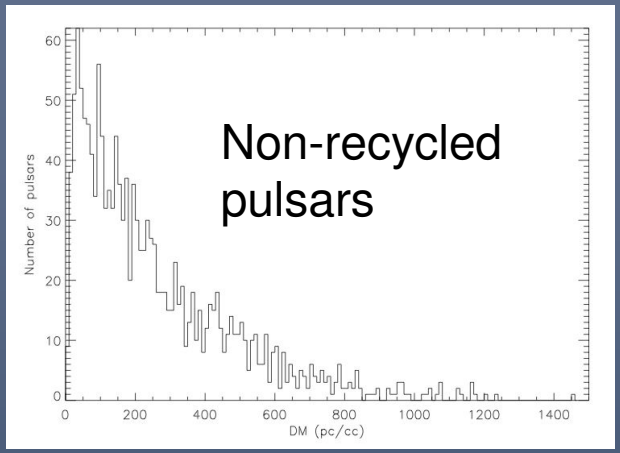


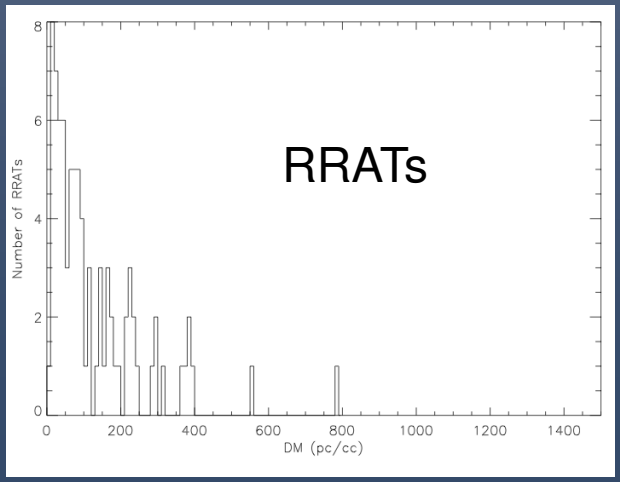
Rotating Radio Transients (RRATs)

- ~100 known RRATs today
  - http://astro.phys.wvu.edu/rratalog/
- Many from recent surveys:
- 18+ from 350-MHz GBT surveys (Chen Karako)
- 10+ from PALFA (Julia Deneva, Laura Spitler)
- 26 from HTRU (Sarah Burke-Spolaor)
- 29 from PMSURV (Evan Keane)
- Many others….long lag time to publish due to difficulty following up.

Locations

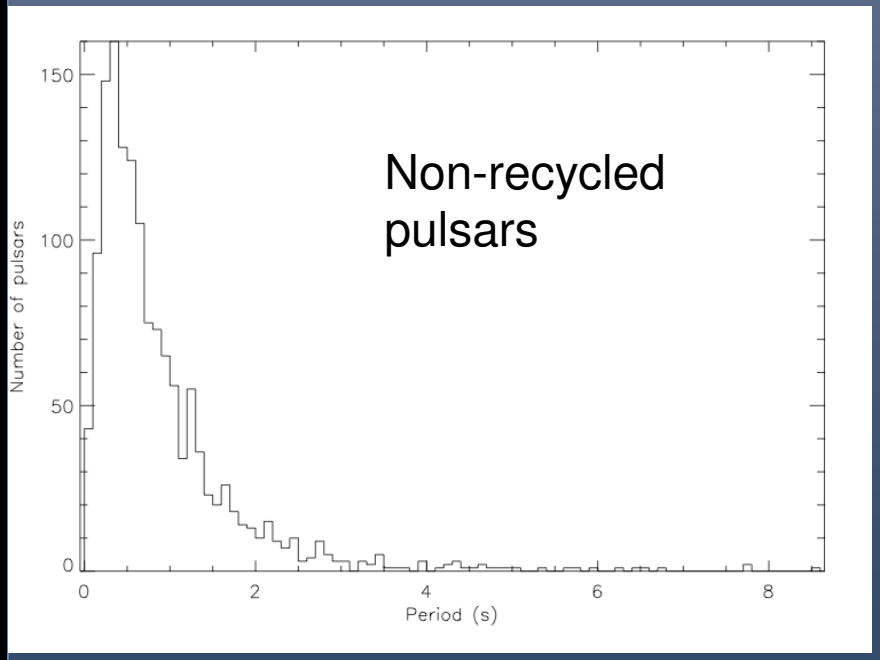
- Latitudes and longitudes are similar to other pulsars.
- DM distributions differ, presumably due to selection effects.

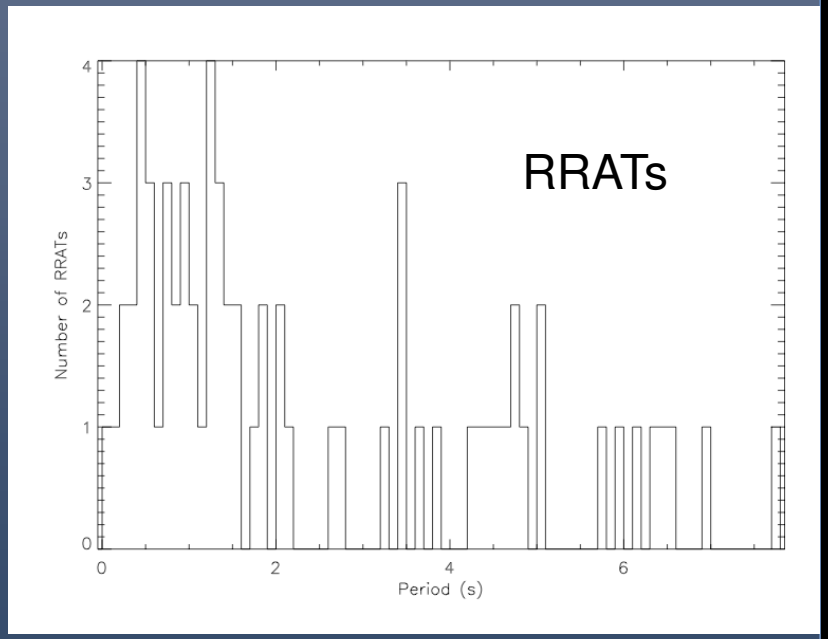




Periods

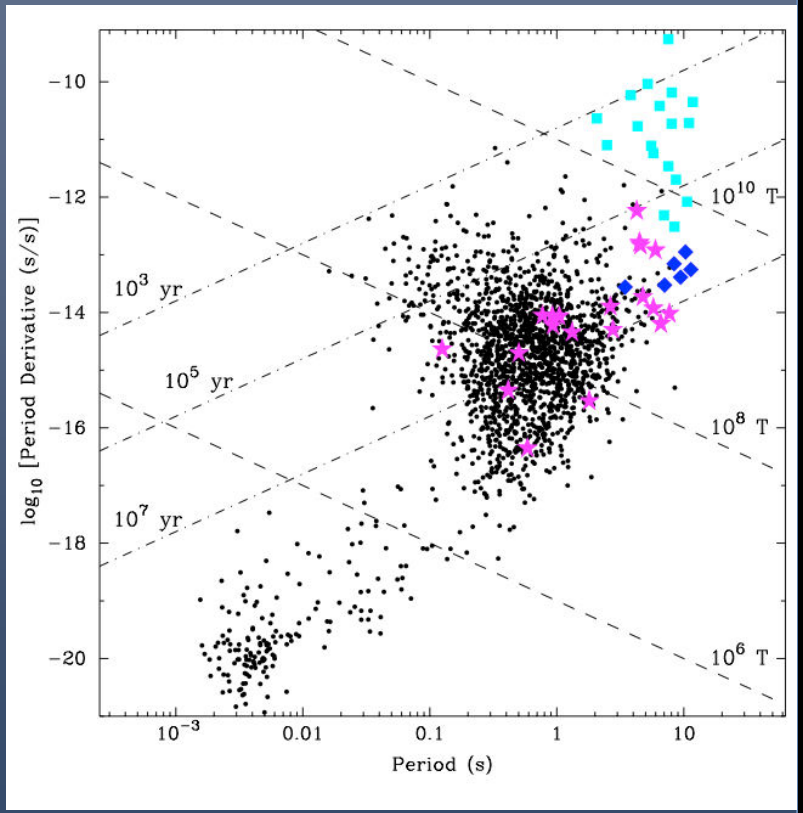
- Only 65 have measured periods.
- Periods are generally longer than for other pulsars. May be a selection effect.





Spin-Down Properties

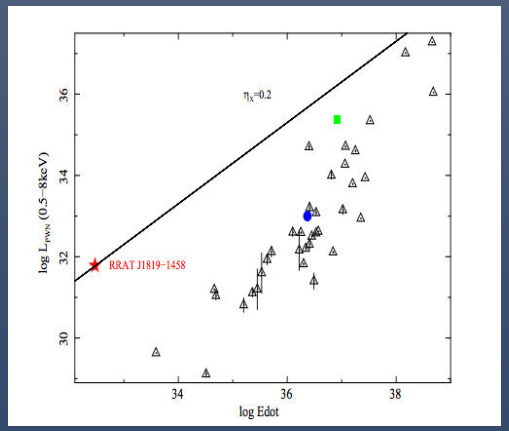
- Only ~20 have timing solutions – sporadicity makes follow-up difficult.
- Period derivatives (and hence B fields) are generally longer than for other pulsars.
- How related to other classes of neutron stars?

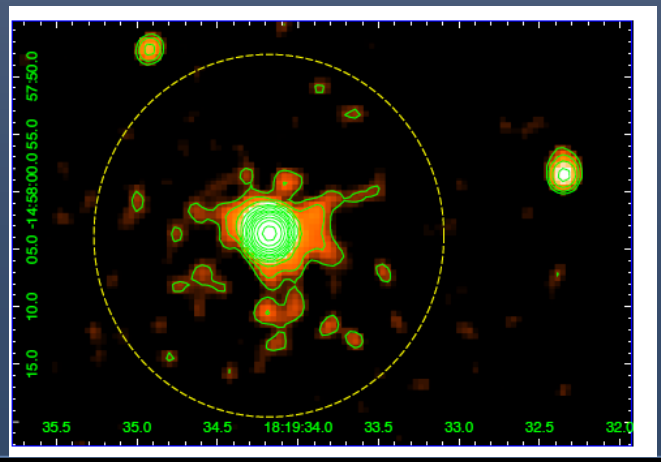


Other Properties

- X-ray emission detected around one RRAT indicates ultra-bright nebula, perhaps powered by magnetic energy (B = $5x10^{13}$ G), and unusual absorption lines. Perhaps hints at a connect with magnetars.
- X-ray observations of other RRATs will be possible with timng-derived positions.

Camero-Arranz et al. 2012





Current Observational Campaigns

- Regular 1.4 GHz timing campaign at Parkes, ongoing for seven years. Most of known RRATs found with Parkes.
- Low-frequency (350 MHz) surveys with the GBT have revealed 18 RRATs. Higher-frequency (1.4 GHz) surveys with Parkes have revealed 12 RRATs.
- Follow-up timing campaigns at the GBT (820 MHz) and Arecibo (1.4 GHz) exist. However, time available (once per month) is often not sufficient to achieve timing solutions. Also follow-up at 820 MHz requires gridding observations, and some of the GBT RRATs are steep spectrum and simply not timeable at 820 MHz (but 350 MHz receiver is not up often enough...)

LWA Campaign

- RRATs were chosen based on
  - DMs less than 50 pc cm^{-3} (pulse broadening of 10s of milliseconds)
  - Lack of timing solutions
  - Multiple pulse/confirmed in follow-up
- Initial two hour observations
  - Center Frequency of 64 MHz
  - 32 MHz Bandwidth
- 30 minute follow-ups of confirmed RRATs

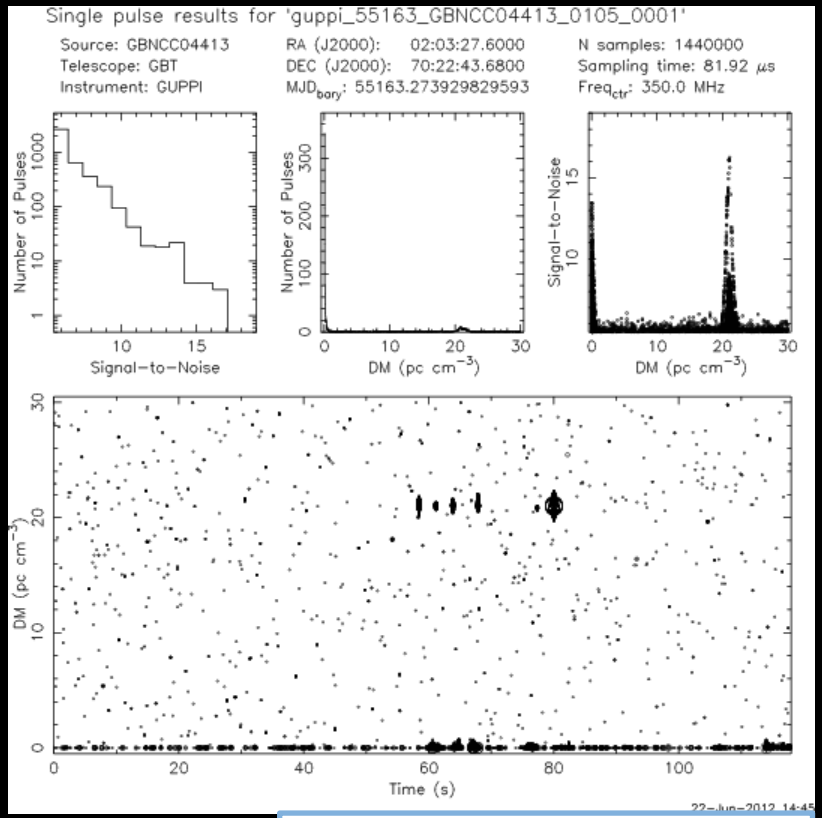
Overview of Results

- Two of the 10 RRATs detected so far, but strong RFI has prevented detection of most.
- For detections, DMs are determined far more precisely. There is a lower rate of pulse detection than with the GBT, but still enough for phase-connected timing.
- Several observations of a few RRATs, and a tentative period derivative measurement for one.

Observed RRATS

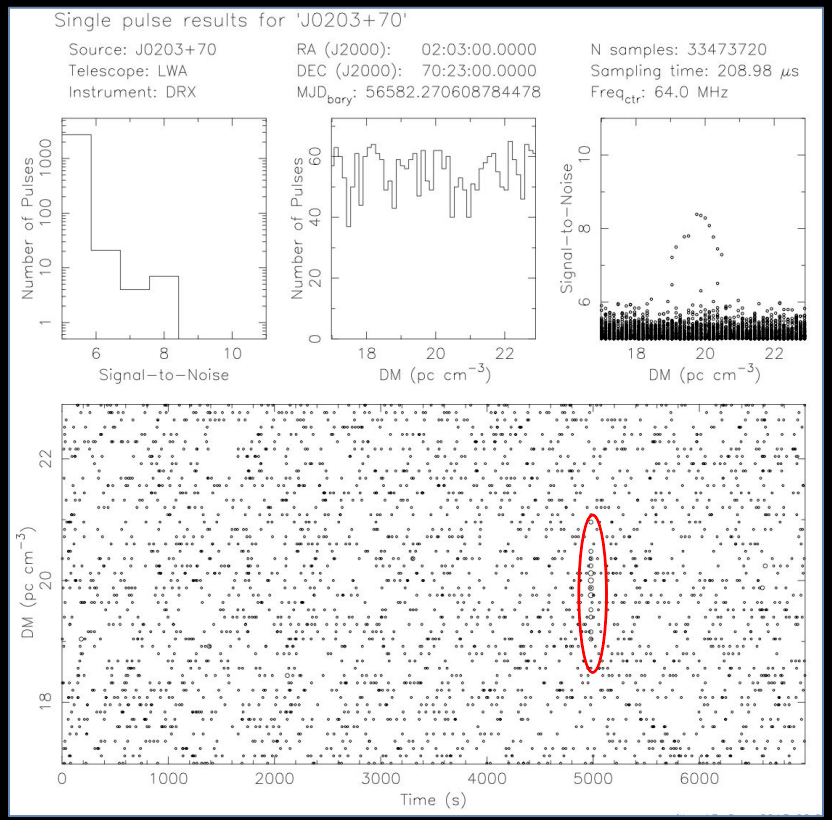
RRAT	Survey	Discovery Max SNR	Discovery DM (pc cm^{-3})	Discovery Burst/Hour	LWA Max SNR	LWA DM (pc cm^{-3})	LWA Burst/Hour
J0203+70	**GBNCC**	**16**	**21**	**150**	**8**	**19.98**	**4**
J0337+79	GBNCC	10	17	30	-	-	0
J0447-04	GBTD	13	30	120	-	-	0
J0957-06	***GBTD***	***10***	***27***	***210***	***7***	***27.01***	***1?***
J1439+76	GBNCC	19	22	360	-	-	0
J1537+23	GBTD	21	15	150	-	-	0
J1610-01	GBTD	9	27	60	-	-	0
J1704-04	GBTD	10	43	30	-	-	0
J1944-10	GBTD	24	31	180	-	-	0
J2324-05	**GBTD**	**40**	**15**	**120**	**7**	**14.96**	**12**

GBT Discovery Plot of J0203+70



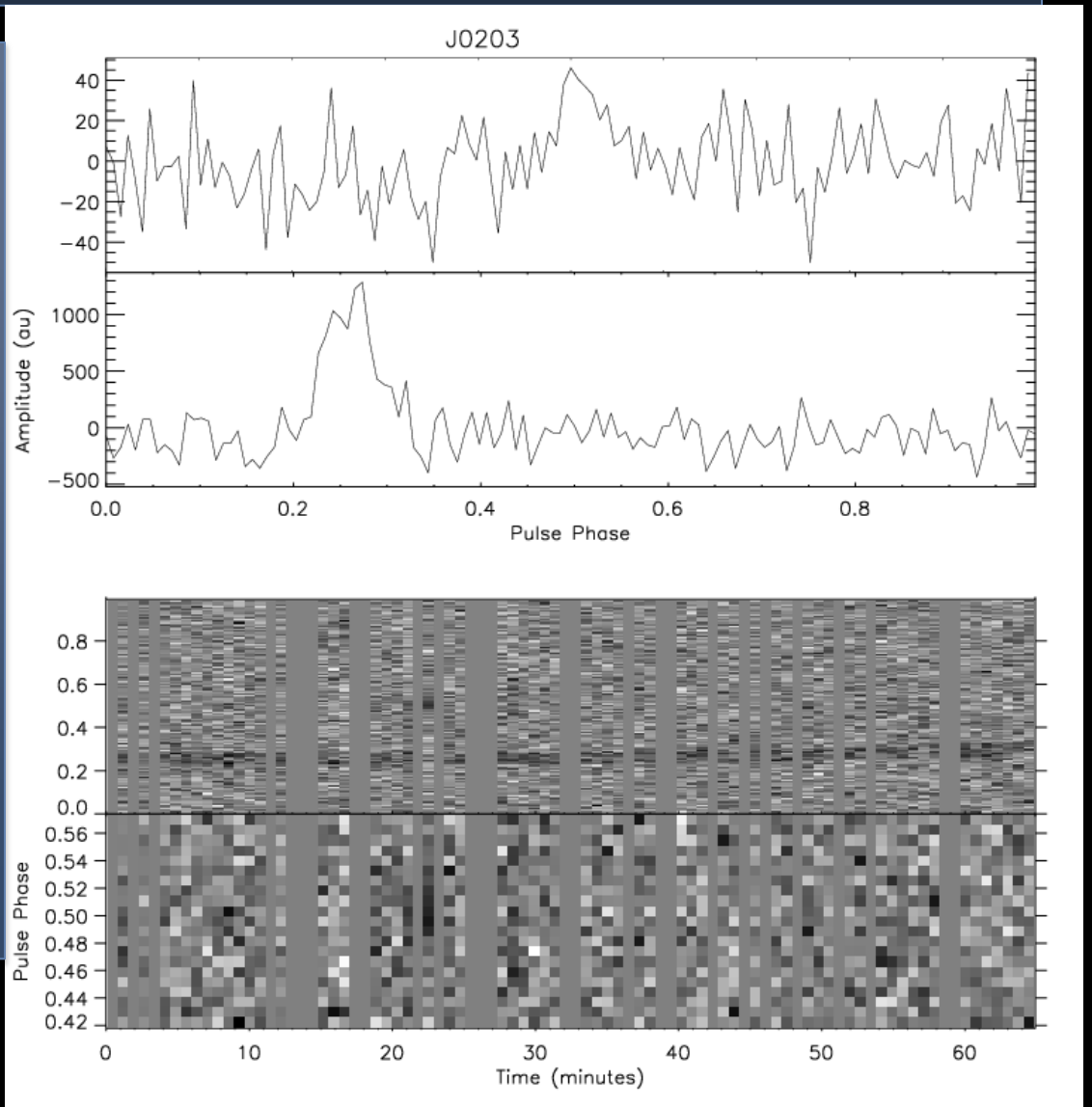
Karako et al. in preparation

LWA Detection Plot of J0203+70

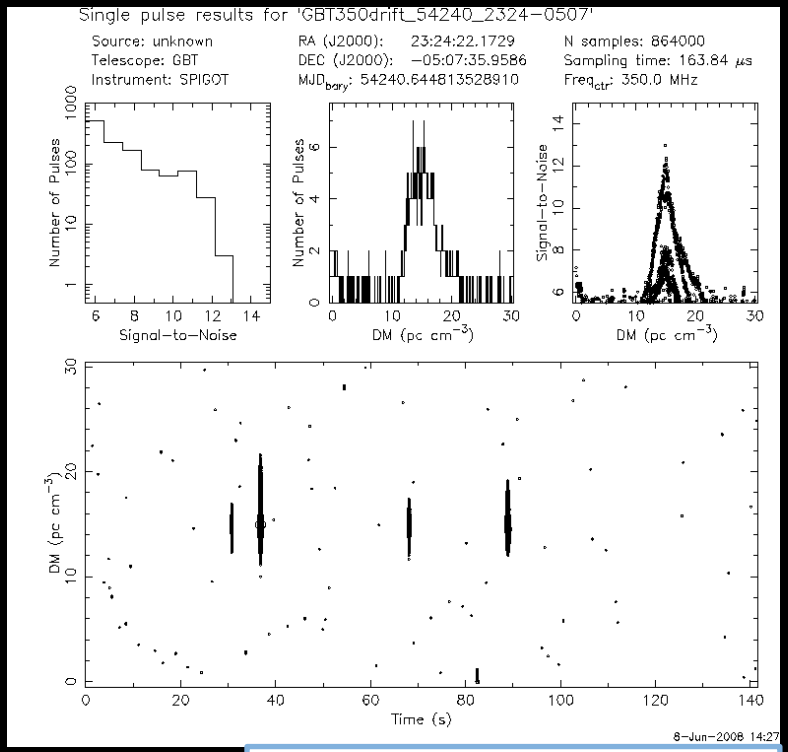


Surprise!

- RRAT J0203 detectable as a normal pulsar with period of 746 ms with the LWA (despite only one detectable single pulse!)

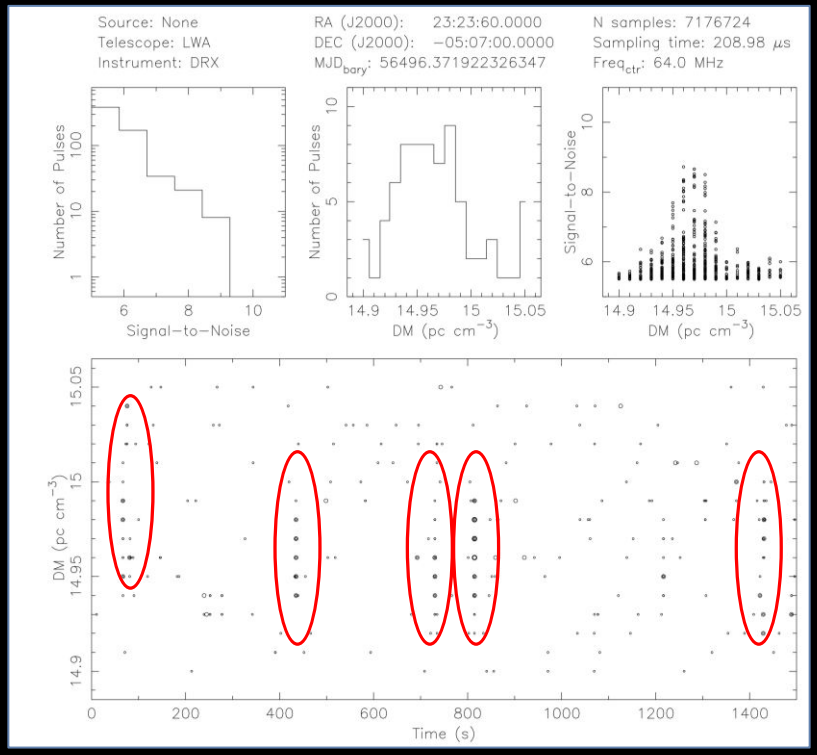


GBT Discovery Plot of J2324-05



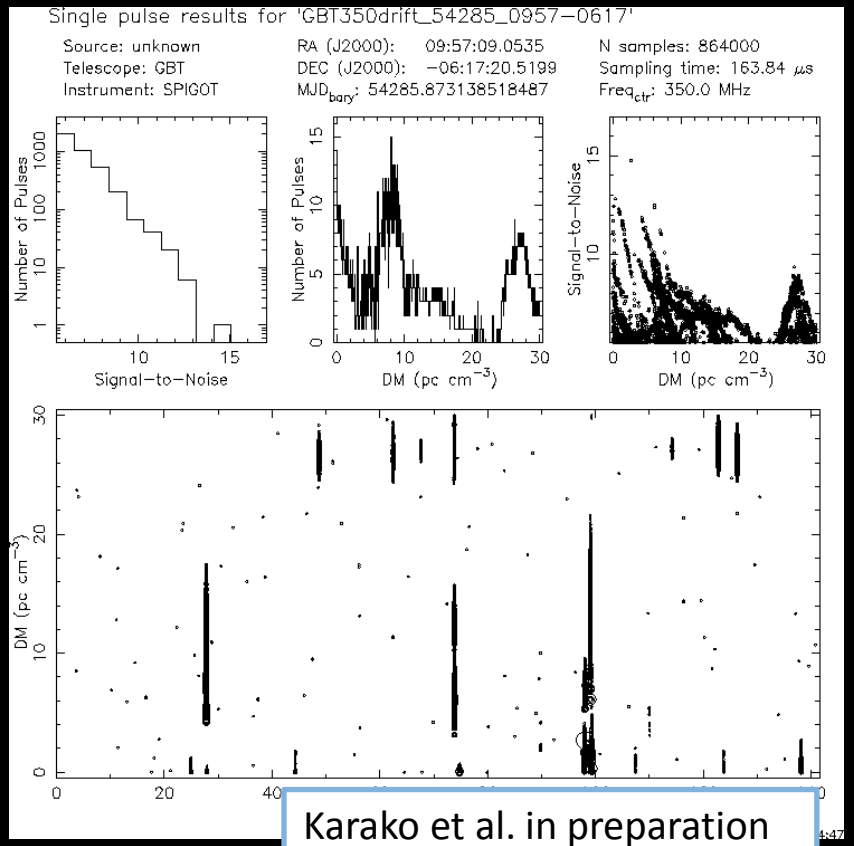
Karako et al. in preparation

LWA Detection Plot of J2324-05



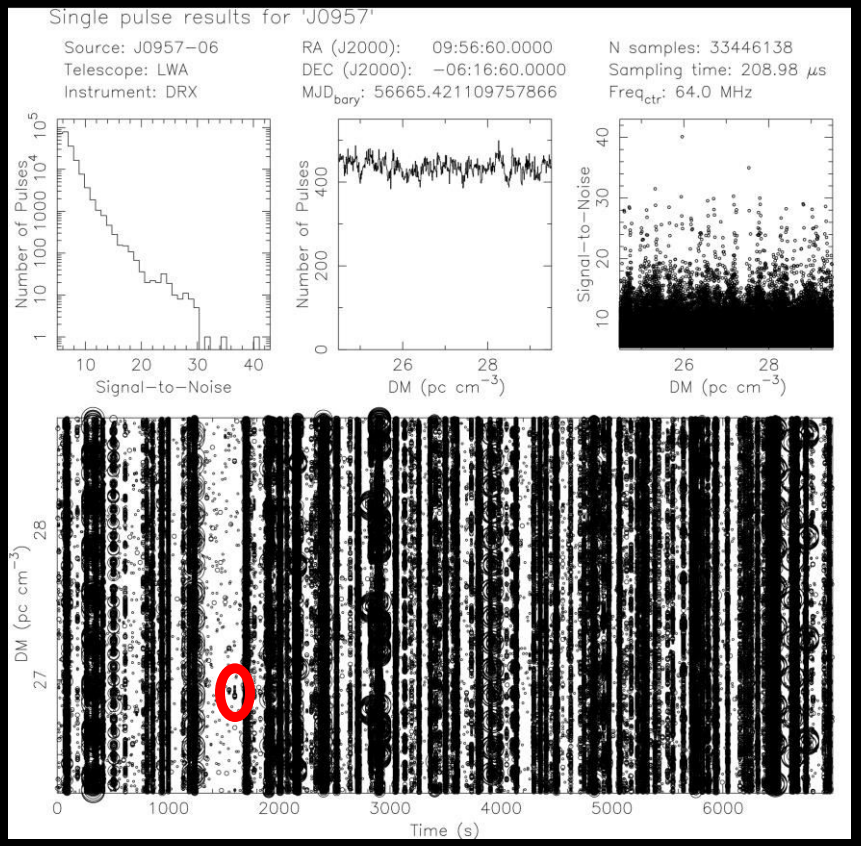
- We search over a narrow range of DM, as the low frequency necessitates very narrow DM spacing to preserve sensitivity to narrow pulses.

GBT Discovery Plot of J0957-06



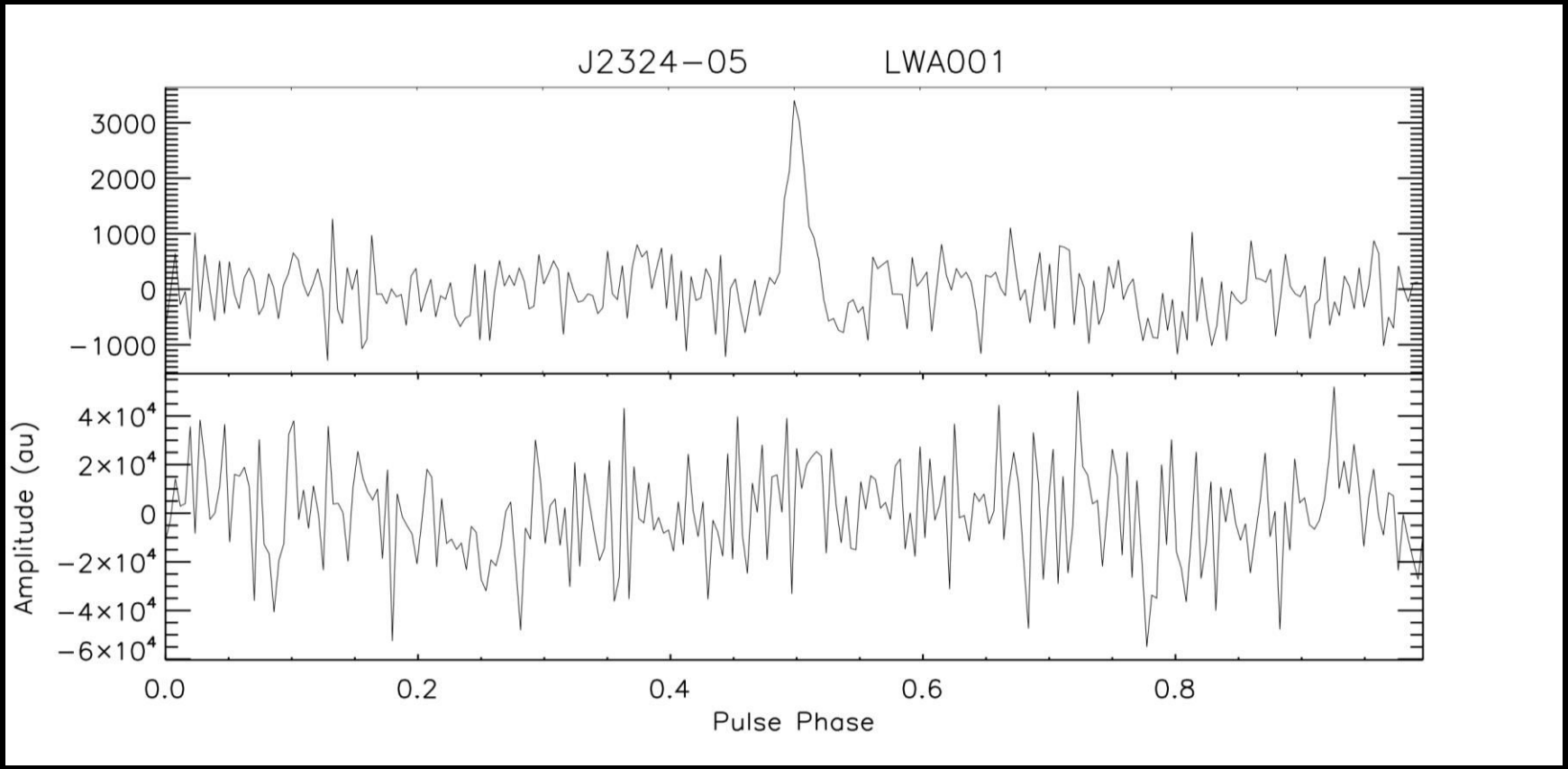
Karako et al. in preparation

Possible LWA Detection Plot of J0957-06



- We are developing RFI removal techniques but these data are very difficult to salvage. The data for most of the other RRATs are similar.

Pulse Profile for J2324-05

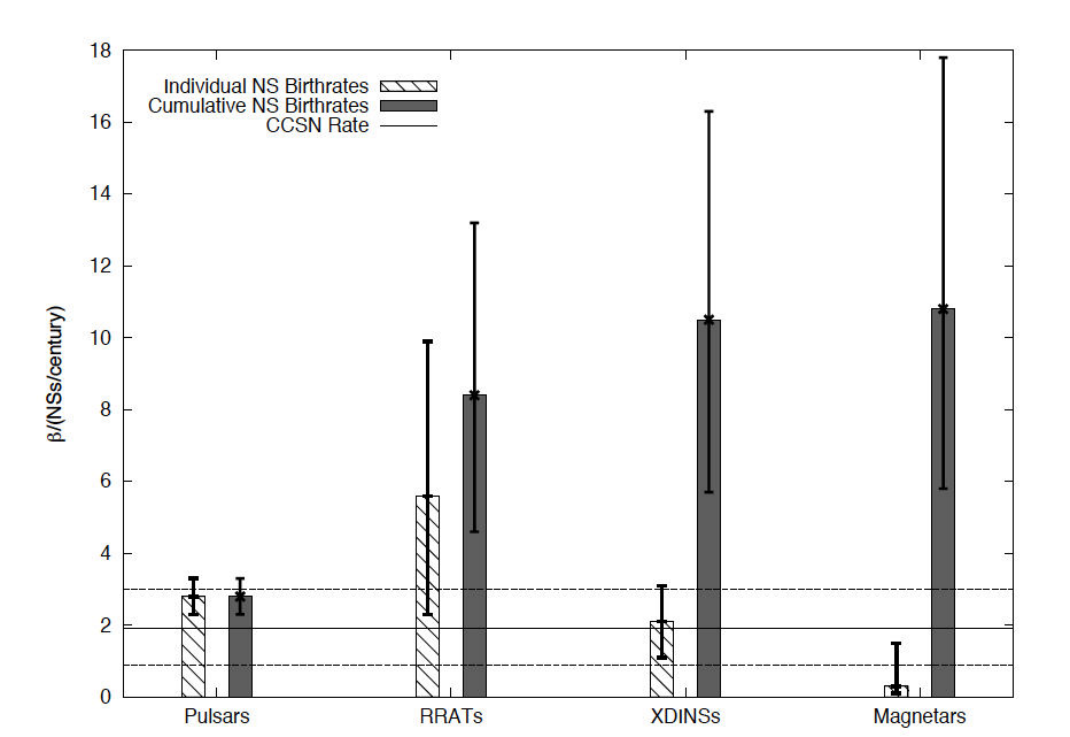


Take Away Points

- We can detect transients with LWA, but sophisticated RFI excision may be necessary
- Sensitivity is sufficient to detect FRBs if they show anomalously low scattering
- More available time than some other instruments could allow a dramatic increase in the number of RRATs with timing solutions, which will enable us to determine how they relate to other pulsars.

Neutron star populations

- If RRATs are a separate population, SN rate estimates are challenged.



Keane & Kramer, 2008, MNRAS, 391, 2009

Future Goals

- Phase connected timing solutions should be possible with six months of LWA data, if we can get slightly higher cadence (twice per month).
- Some other RRATs may be pulsarlike at low frequencies, greatly simplifying timing.
- Comparison of properties between low and high frequencies will inform emission mechanism.
- Measuring scattering tails and monitoring dispersion measure changes will constrain interstellar medium properties.
- Better RFI environment (or better excision!) necessary.
- Measuring spectra will help determine the population that ultimately will be detectable with the LWA.