The Radio Evolution of the Galactic Center Magnetar

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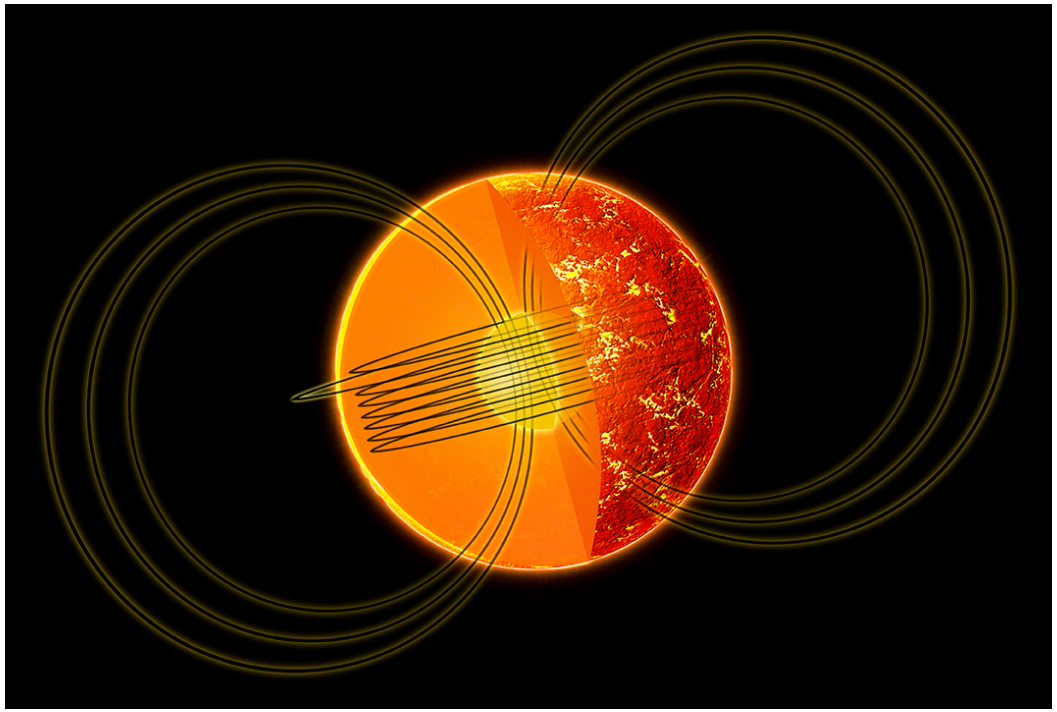
Outline

- What is a magnetar?
  - Why care about a magnetar's radio emission?
- Galactic Center Magnetar SGR J1745–29
  - Located only a few parsecs from Sgr A*
- New observations
  - 44 GHz pulsations: Predominantly bright single pulses
  - Broadband continuum radio: Possible change in radio spectrum

What is a magnetar?

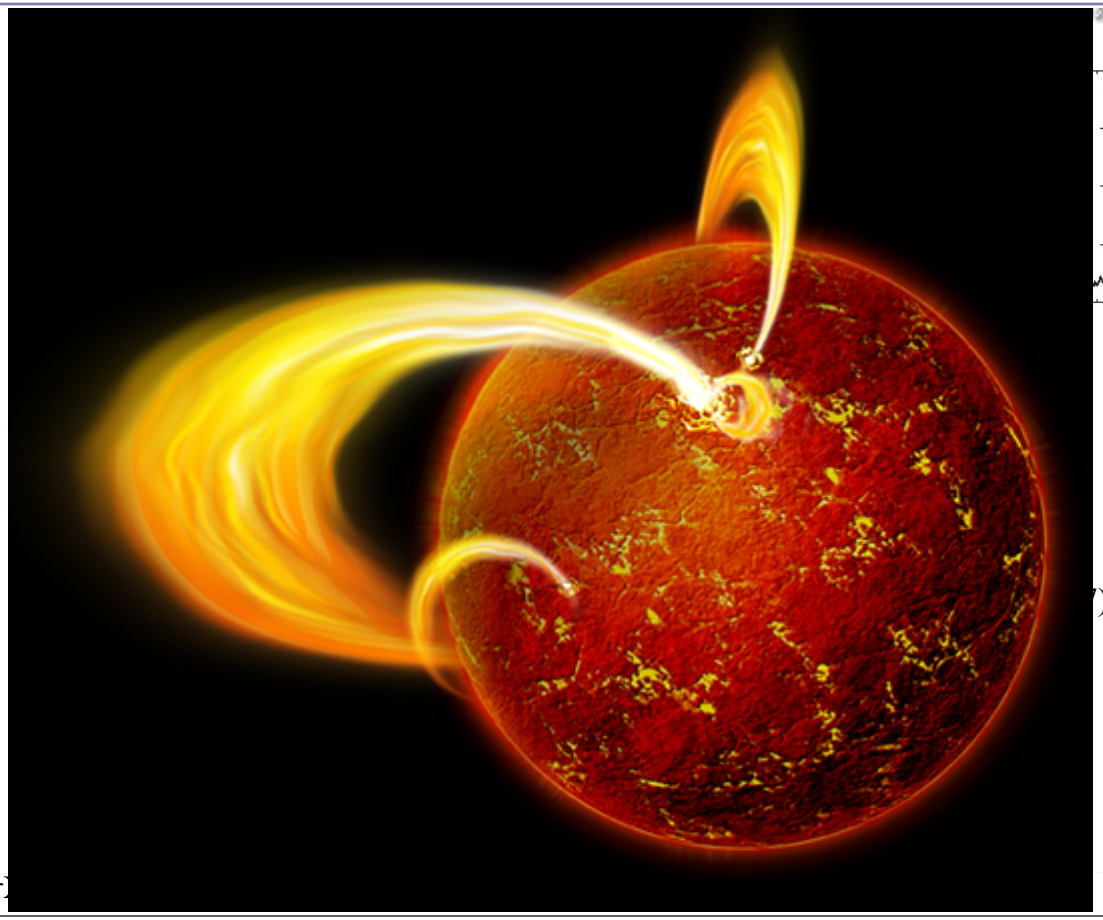
- Class of isolated neutron star
  - $\geq 10^{14}$ G external magnetic fields
  - Even stronger internal magnetic fields
  - Emission powered by magnetic field decay



(Illustration: NASA/CXC/M.Weiss)

Why do we think "magnetars" exist?

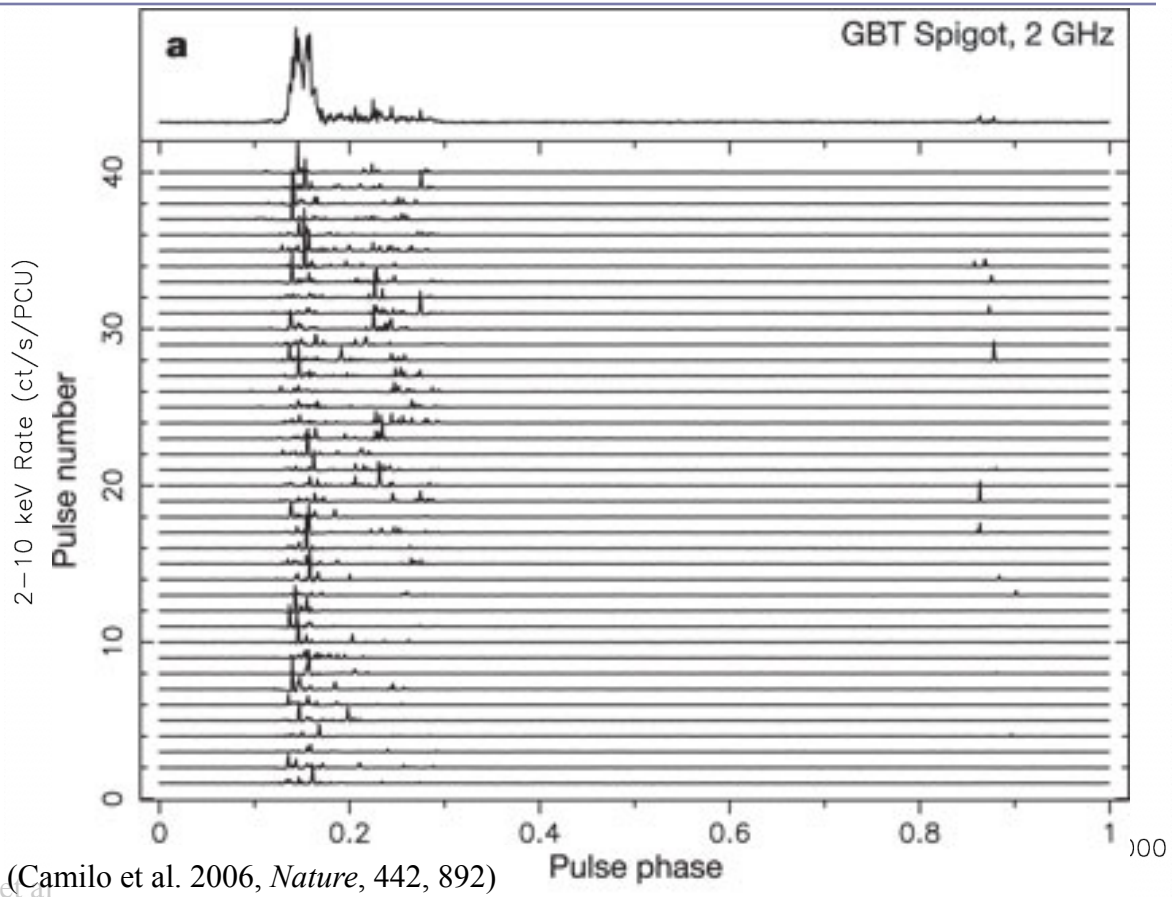
- Neutron stars with high $\dot{P}$, P
  - Dipole Surface B ≥ few×10^{13} G
- Soft Gamma Repeaters (SGRs)
  - Repeated bursts of hard X-rays
  - Giant flares
- Anomalous X-ray Pulsars
  - Blackbody X-ray spectrum
  - $L_x \geq \dot{E}$



(Younes et al. 2015, ar

Magnetar "activation"

- Rapid increase in X-ray luminosity
  - ≥1000x quiescent luminosity
  - Followed by slow exponential decay to new steady-state level
- Magnetar often produces pulsed radio emisson



(Camilo et al. 2006, *Nature*, 442, 892)

(Ibrahim et al.

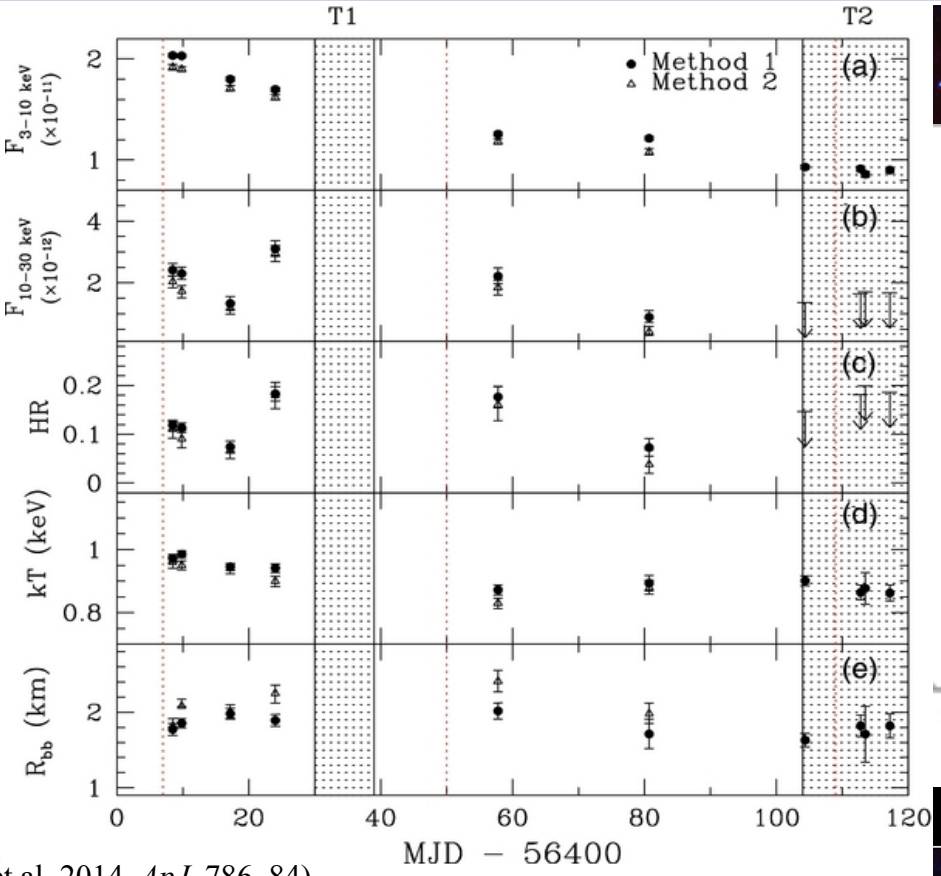
Pulsed radio emission from a magnetar

- Radio Pulsars
  - Stable pulsar shape
  - Constant flux density
  - Steep radio spectrum
  - Somewhat polarized
  - Bright single pulses rare
- Magnetars
  - Variable pulse shape
  - Variable flux density
  - Flat or gigahertz radio spectrum
  - 100% linear polarization
  - Bright single pulses common

Different emission mechanism?

Galactic Center Magnetar SGR J1745-29

- 2013 Apr 24: *Swift* XRT detects increase in X-rays from GC region
  - 2013 Apr 26: *NuSTAR* detects 3.76 s pulsations
  - Subsequent decrease in X-ray flux

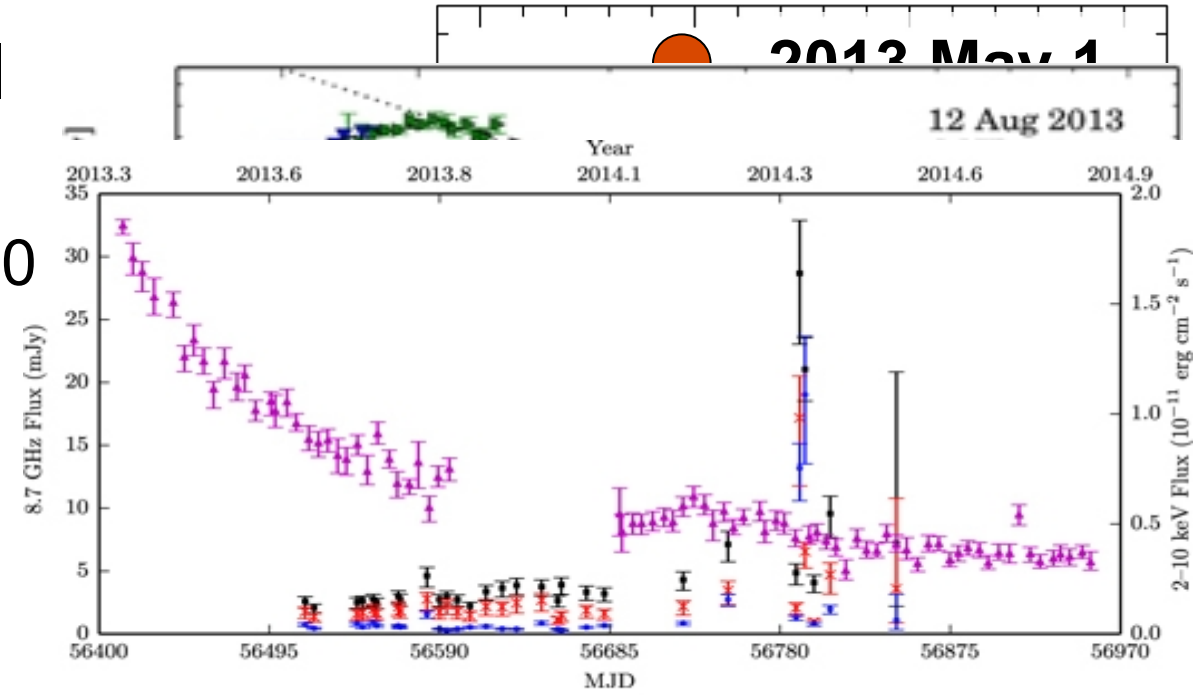


(Credit: NASA/CXC/INAF/F.C. Gu, G.L. Israel)

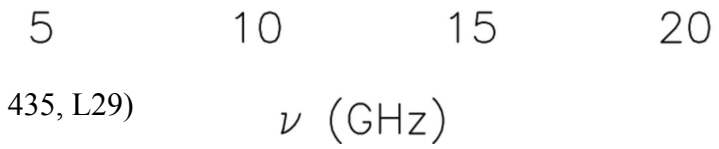
(Kaspi et al. 2014, *ApJ*, 786, 84)

Early Radio Observations

- Radio spectral variability
  - Particularly ≤10 GHz
  - Flattening of spectrum
- Constant flux density
  - Until 2014 Mar



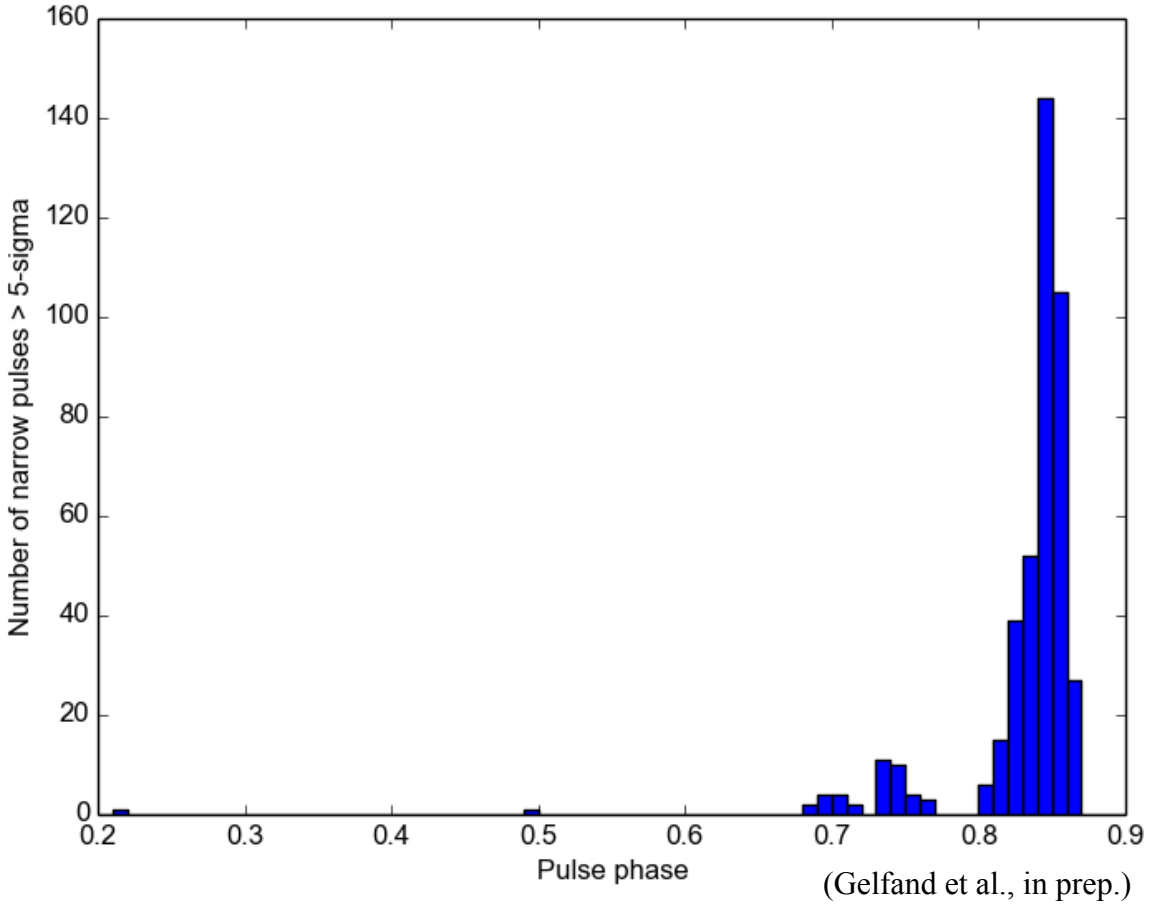
(Lynch et al. 2015, *ApJ* , 806, 266)



(Shannon and Johnston 2013, *MNRAS,* 435, L29)

44 GHz GBT Observation

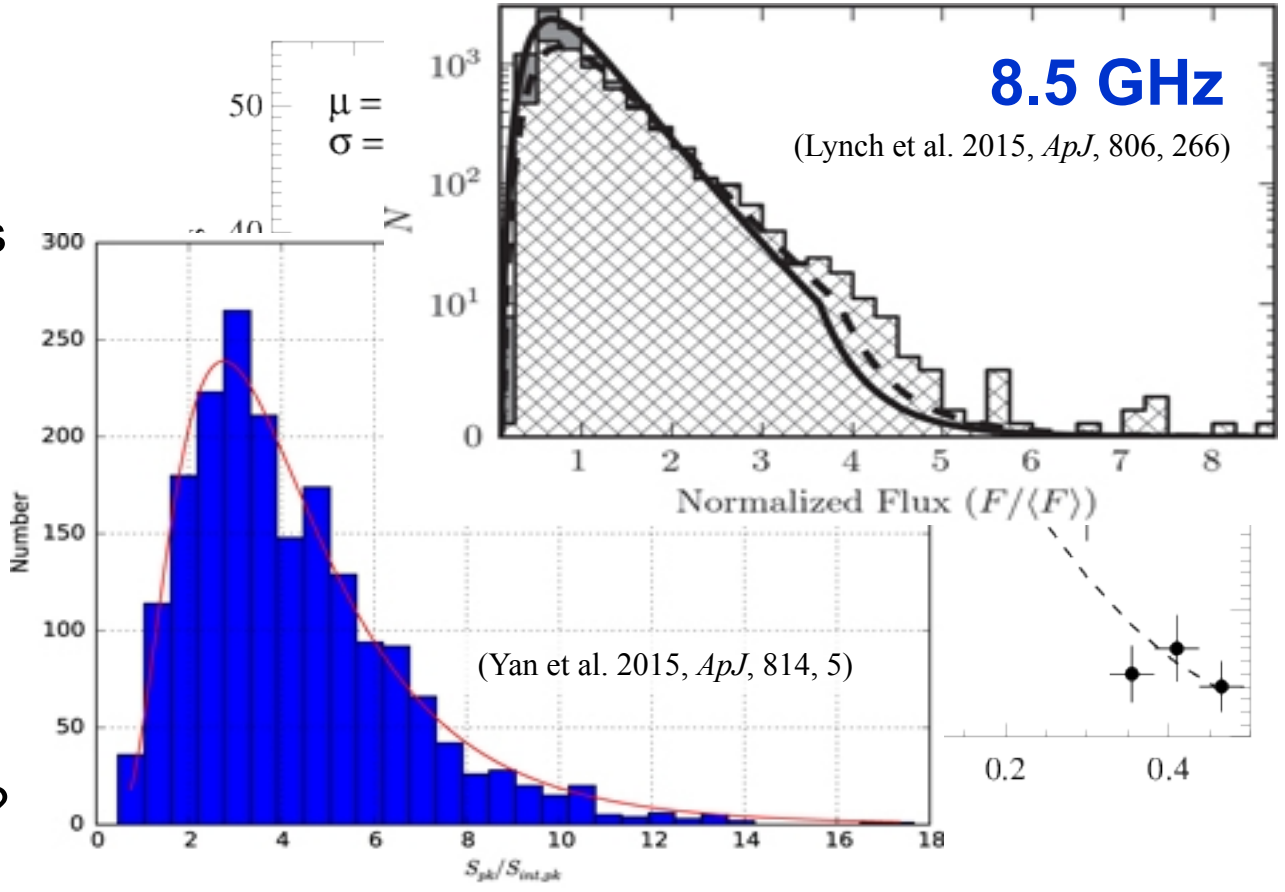
- 2014 April 10 (MJD 53105)
  - 35 minutes: GUPPI
  - 30 minutes: VEGAS
- Clear detection
  - Bright single pulses from ~70% of rotations
  - Narrow phase distribution



(Gelfand et al., in prep.)

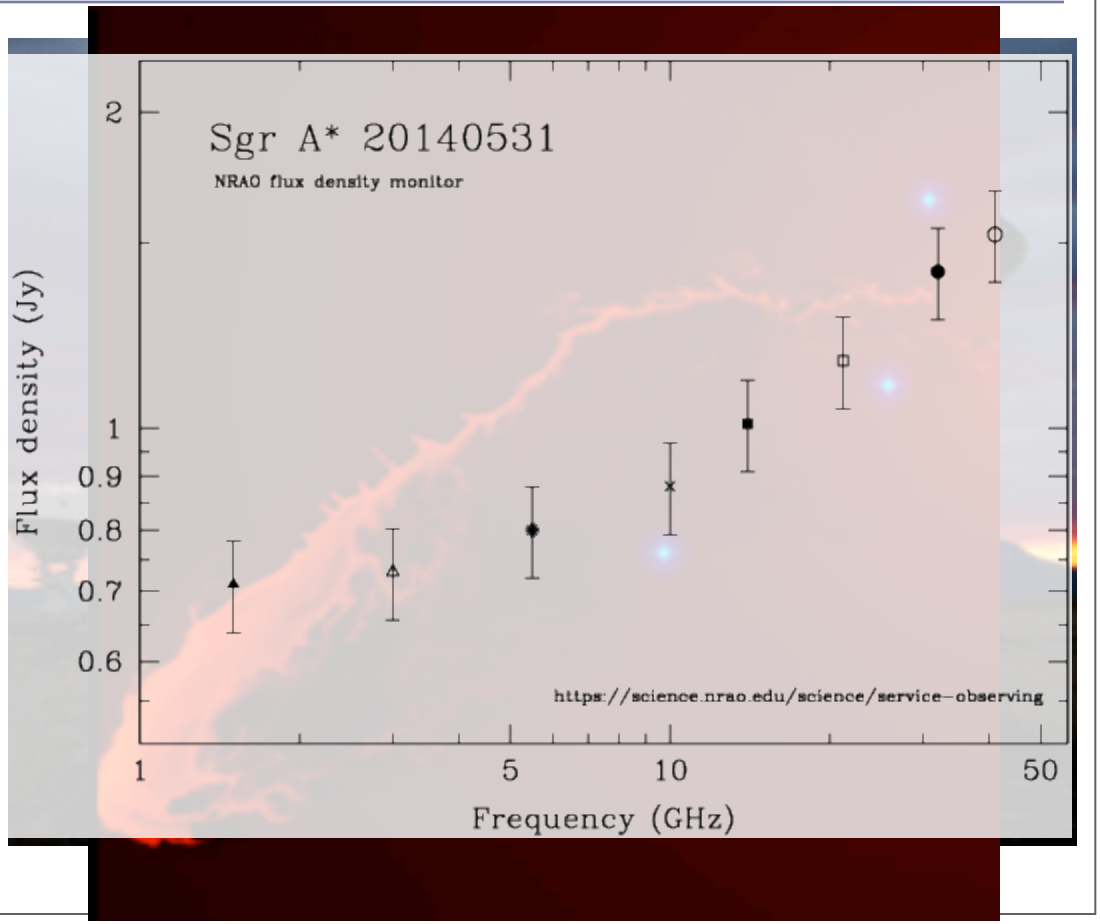
Flux distribution of single pulses

- Log-normal distribution
  - Similar distribution as 8.5 GHz
- Possible explanations
  - Same physical generating mechanism
  - Constant across observations?



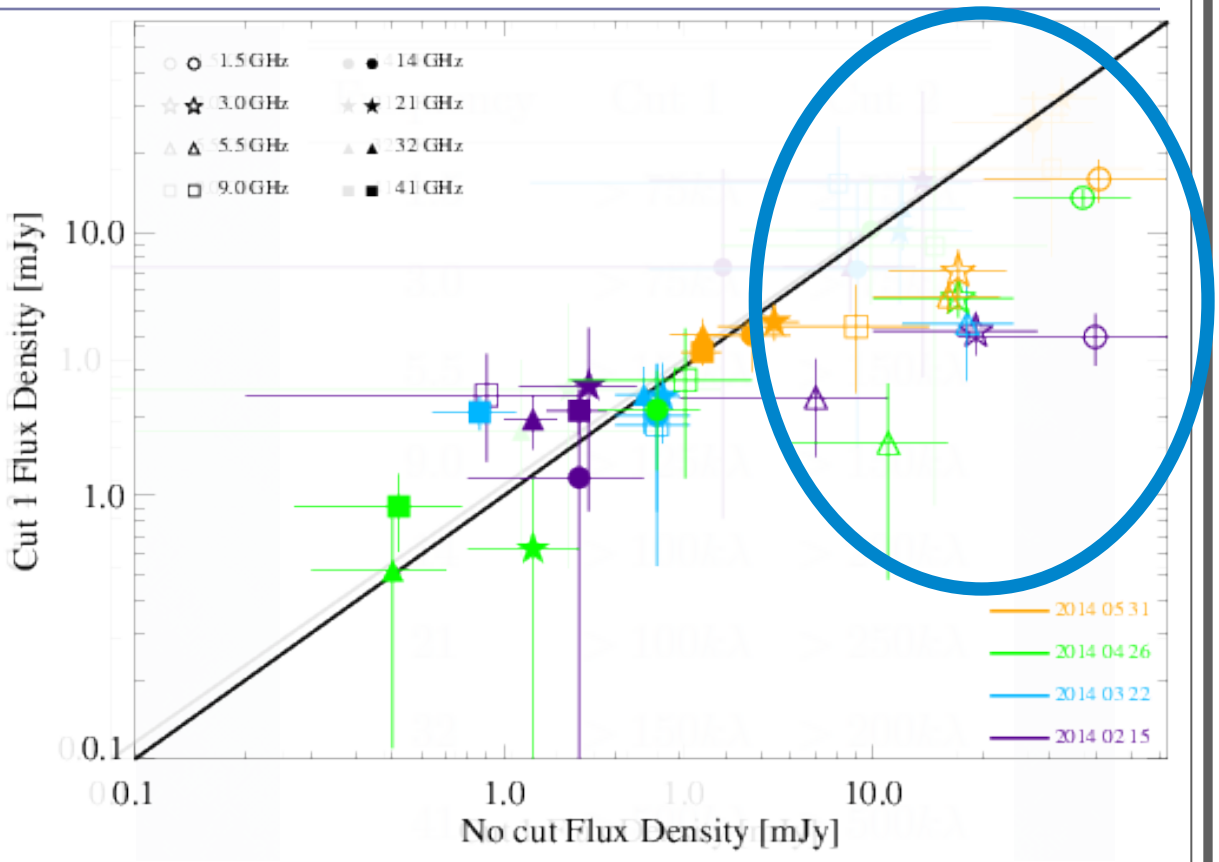
Broadband radio spectrum

- JVLA Project Code TOBS0006
  - In expectation of G2 encounter with Sgr A*
  - 1.5 – 41 GHz in 8 bands
  - A configuration: 2014 Feb 15 – 2014 May 31



GC Magnetar Flux Density

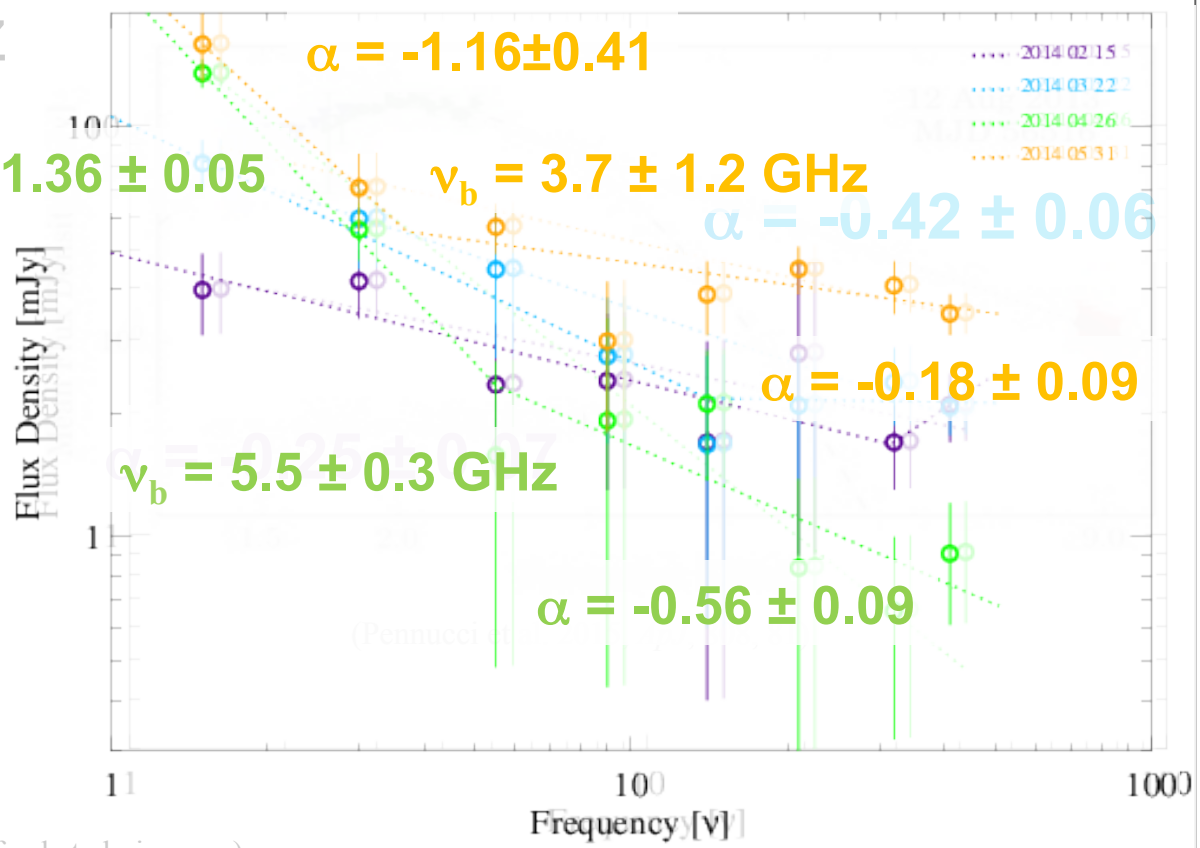
- Very crowded region
  - Significantly contaminates magnetar flux
- u,v filtering
  - 2013-10-26 B-configuration
  - 2014-05-31 A-configuration
  - Removes diffuse emission
  - Give consistent results



(Gelfand et al., in prep.) shtml)

Continuum radio spectrum

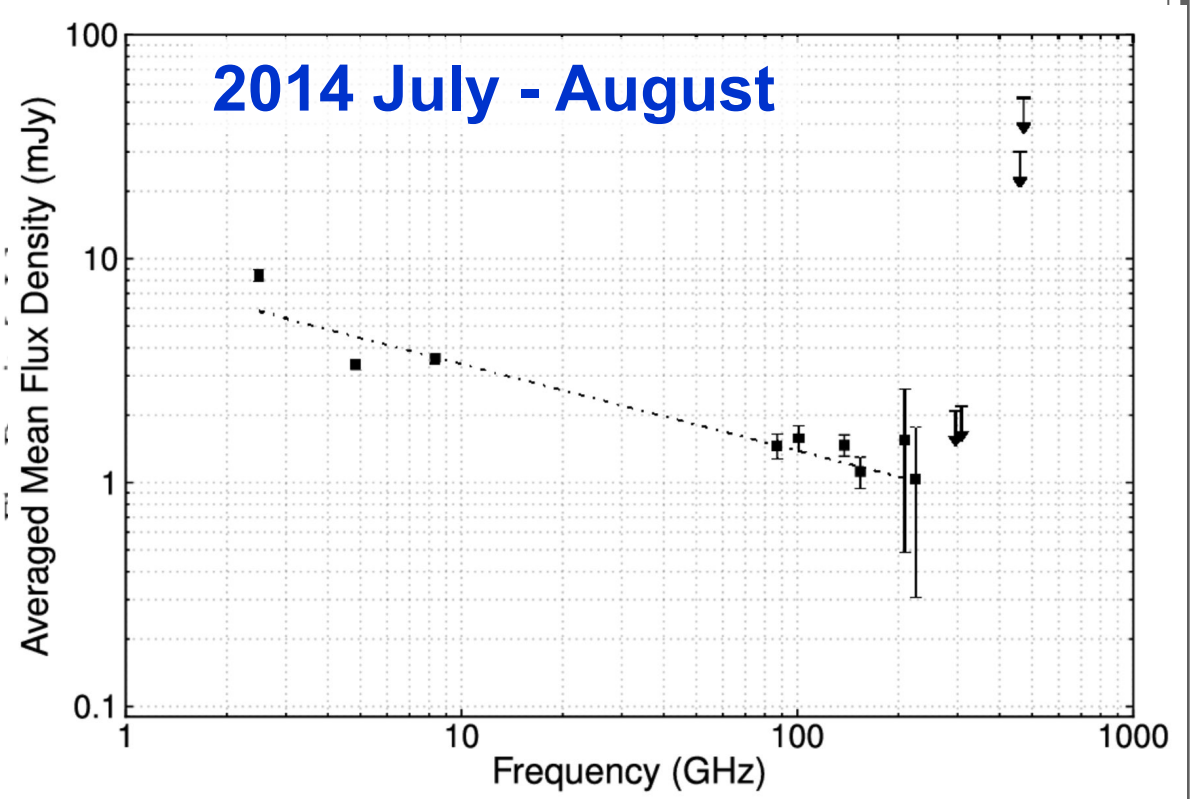
- **Not** Giga-hertz peaked
- Power law
  - Very good fit for first two epochs
- Broken power law
  - Works better for last two epochs



(Gelfand et al., in prep.)

POSSIBLE interpretation

- Flux increase at low frequencies
  - New emission component?
  - If so, likely has a steep spectrum
  - (Re-) appearance of “normal” radio pulsar emission?
- Possibly seen at later epochs



(Torne et al. 2015, *MNRAS,* 451, L50)

Summary

- 44 GHz Pulsed Emission
  - ~70% of rotations produce a bright radio pulses
  - Log-Normal Flux distribution
  - Same parameters as composite 8.5 GHz observations
- 1.4 – 44 GHz Radio Continuum Emission
  - First two epochs single power-law
  - Later two epochs broken power-law (?)
  - Increase in low-frequency flux → “normal” pulsar emission mechanism?

Thank you!