Has Pulsar B Appeared Again?
An Analysis of the J0737-3039A/B Double-Pulsar System

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DCC: G2401304

What is a Pulsar?

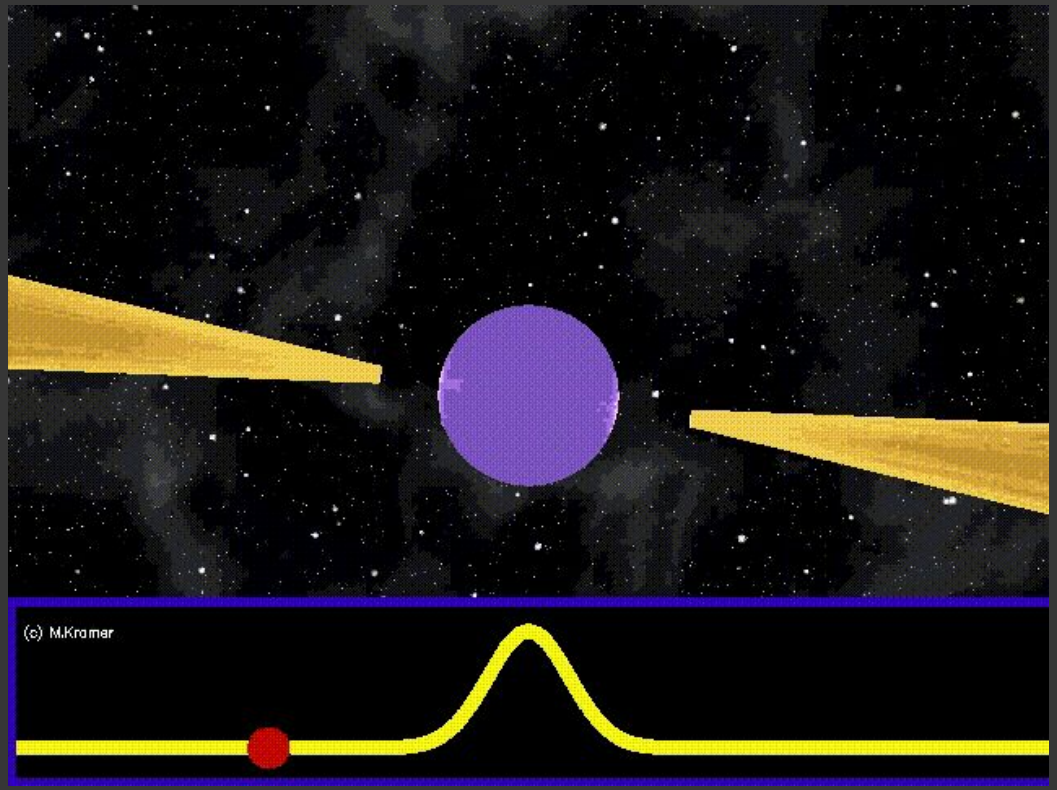


Image credit: Michael Kramer

- Bunched magnetic fields create radio beams
- Periods from milliseconds to tens of seconds
- Often found in binary systems
  - Main sequence stars and compact objects
  - Useful for tests of general relativity

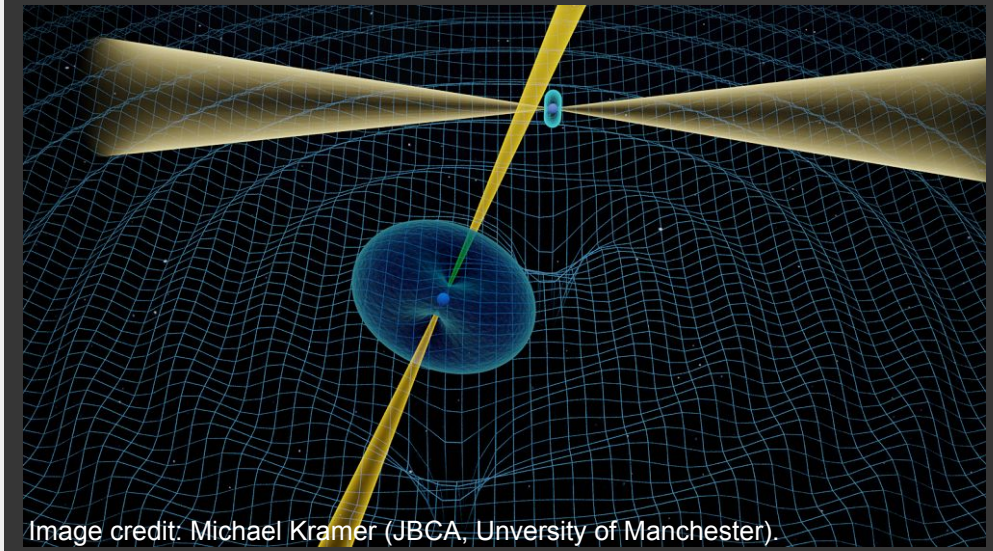


Image credit: Michael Kramer (JBCA, Unversity of Manchester).

Wind from Pulsar A shapes magnetosphere of pulsar B

- Eclipsing binary
- Shapes beam of pulsar B?
  - Horseshoe shape
  - Presession creates a sweep of the beam

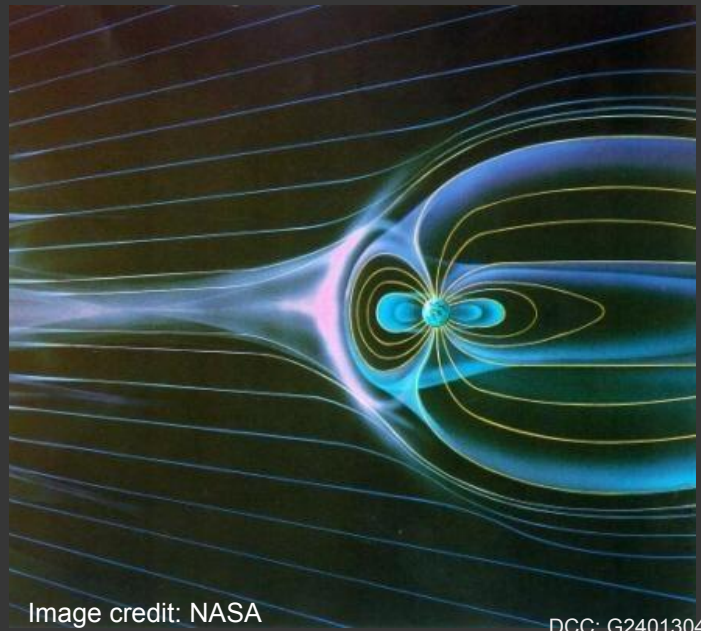


Image credit: NASA

Binary Double-Pulsar System

- Orbital plane aligned with line-of-sight
- Only double pulsar system
  - 2.7 ms Pulsar A
  - 2.8 s Pulsar B
- Geodetic precession causes B to come in and out of line-of-sight

Geodetic (relativistic) precession causes the beam of Pulsar B to appear and disappear

- Disappeared in 2008 (aligned with model)
- Thought to appear again this year
- Complete precession of rotational axis every 75 yr

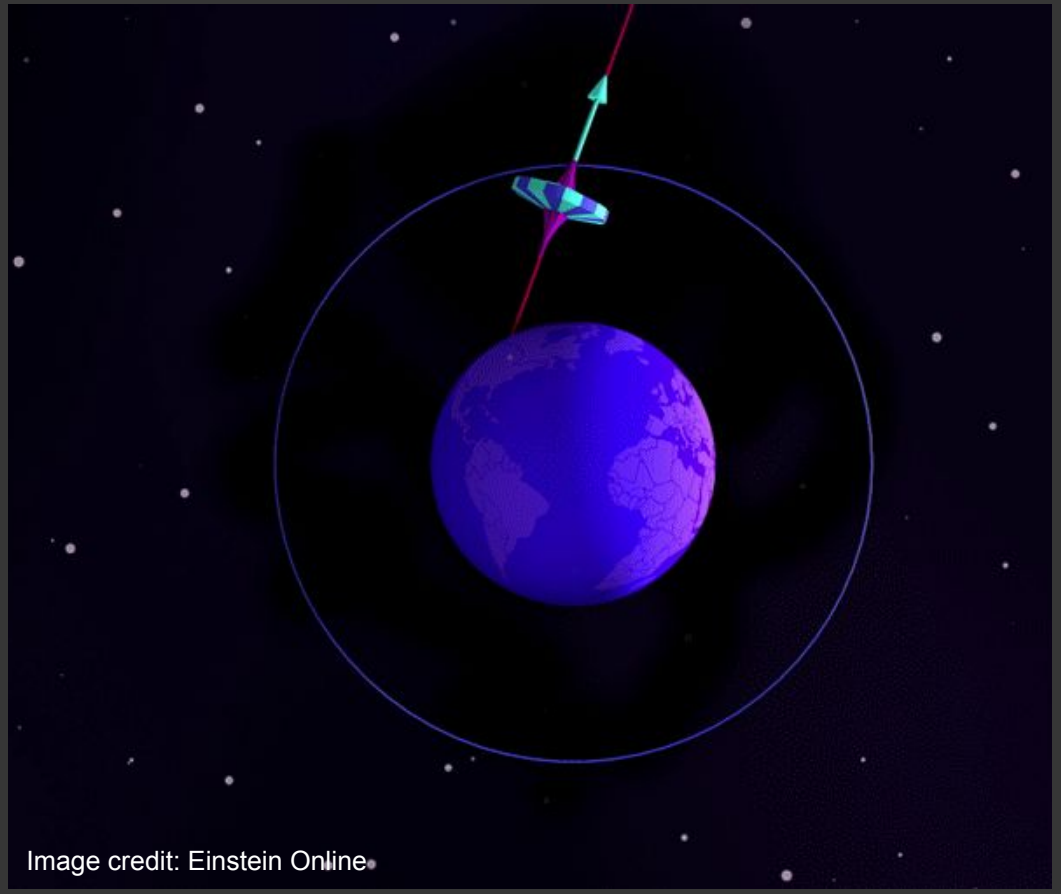
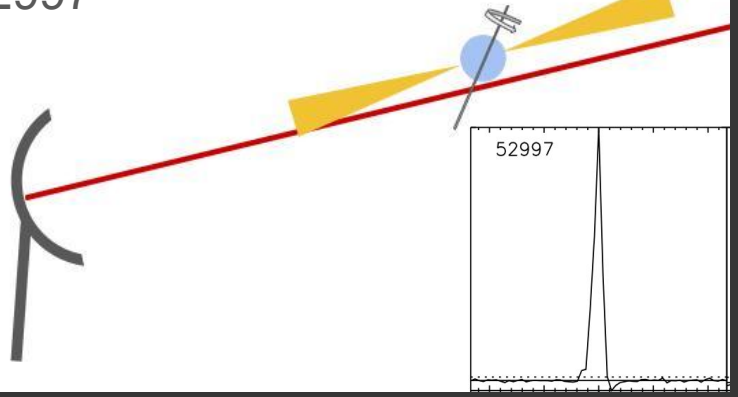


Image credit: Einstein Online

52997



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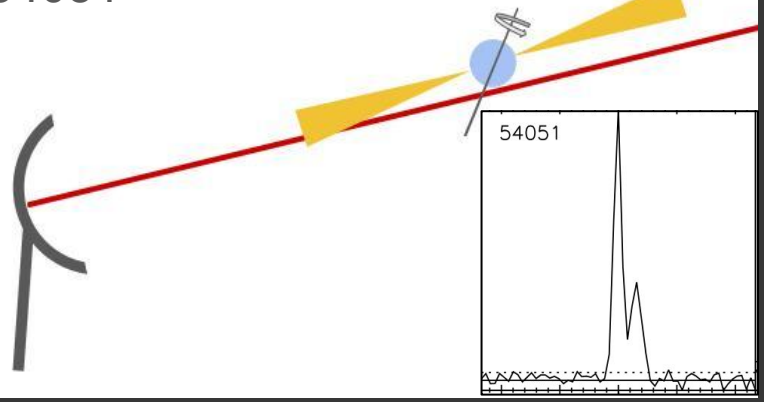
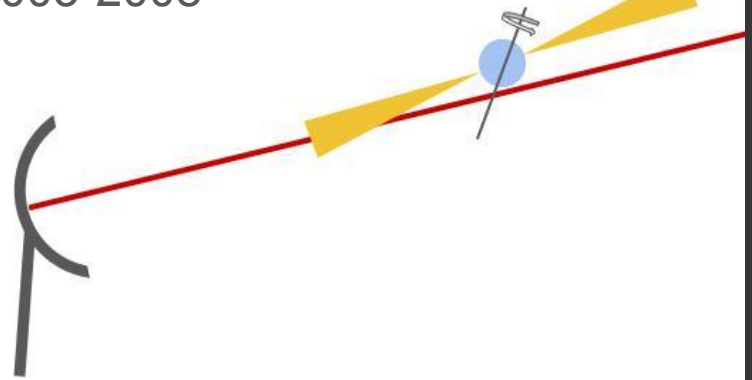
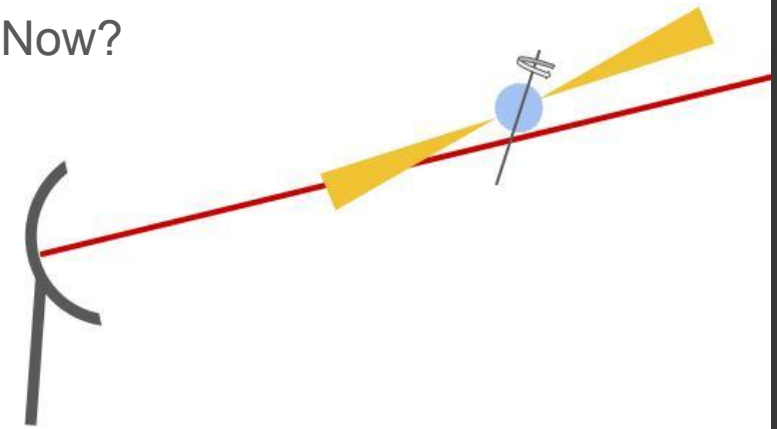


2003-2008



Now?



The most recent modeling (B. B. P. Perera et al 2012) suggests a reappearance in 2024

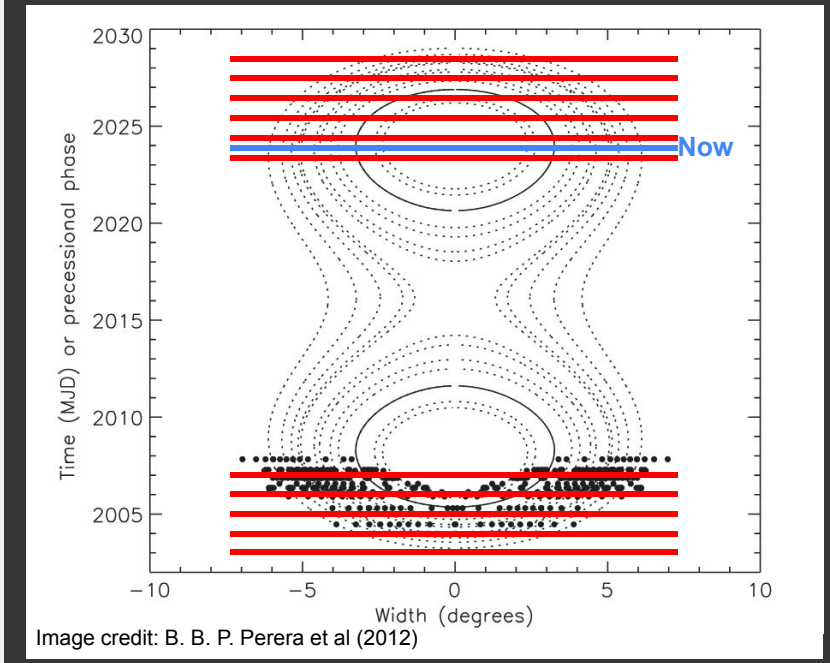


Image credit: B. B. P. Perera et al (2012)

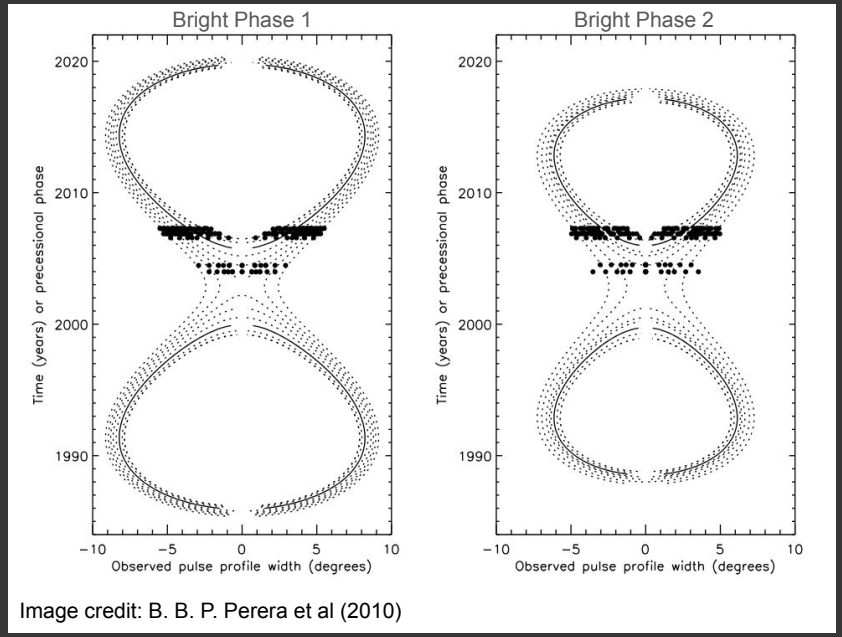
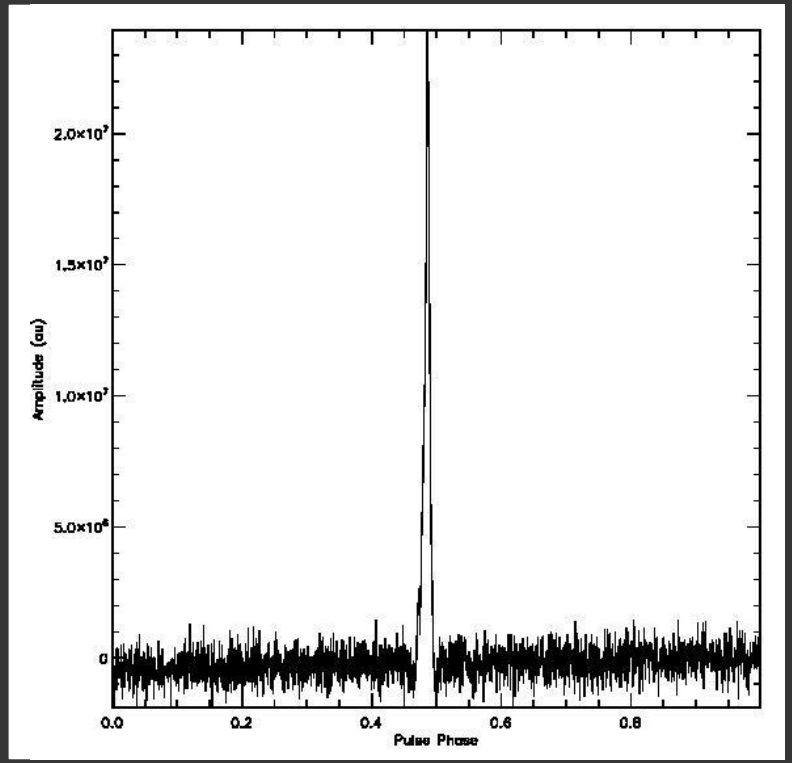
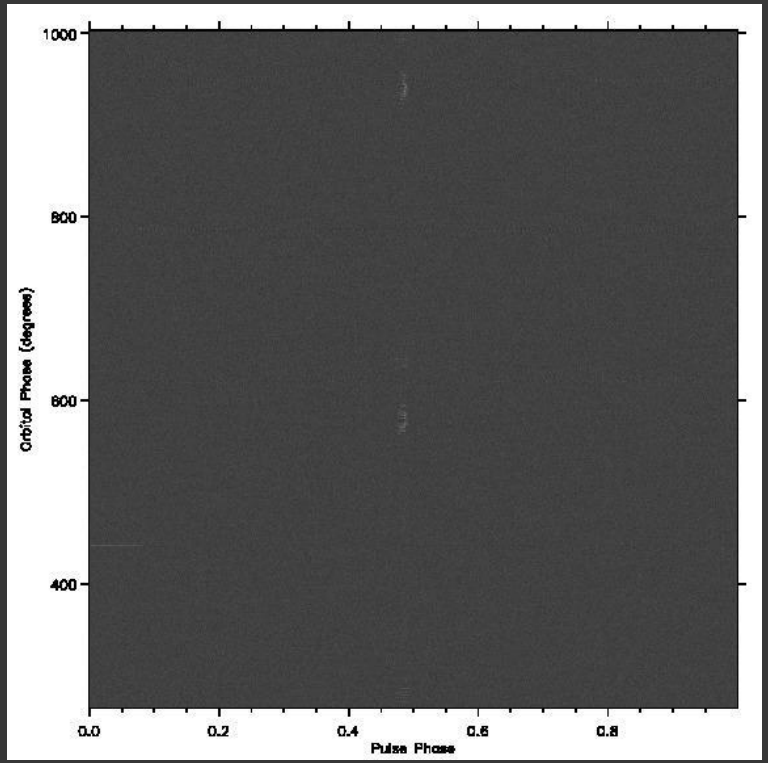


Image credit: B. B. P. Perera et al (2010)

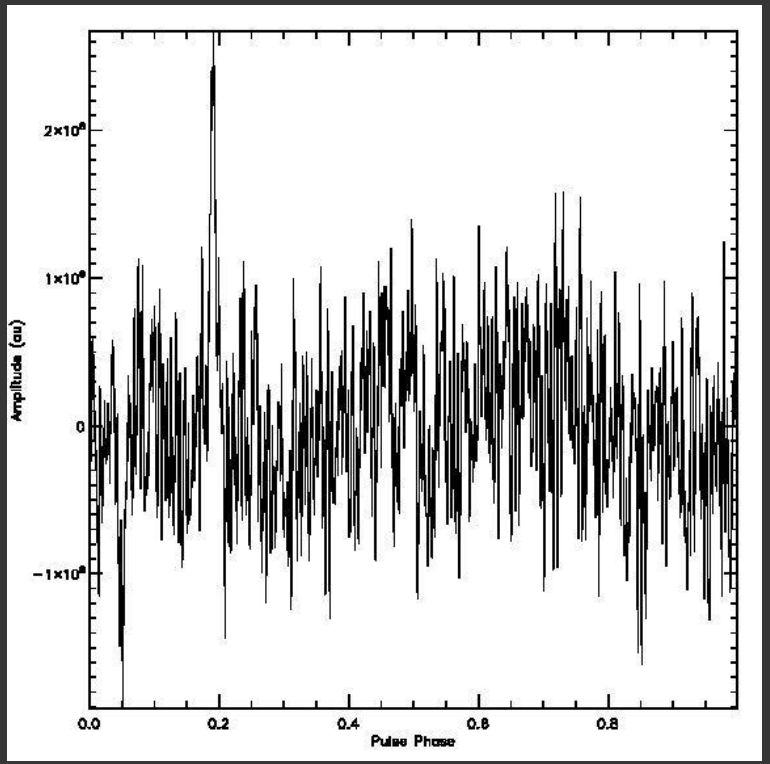
Previous modeling shows slight differences in beam detection for BP1 and BP2

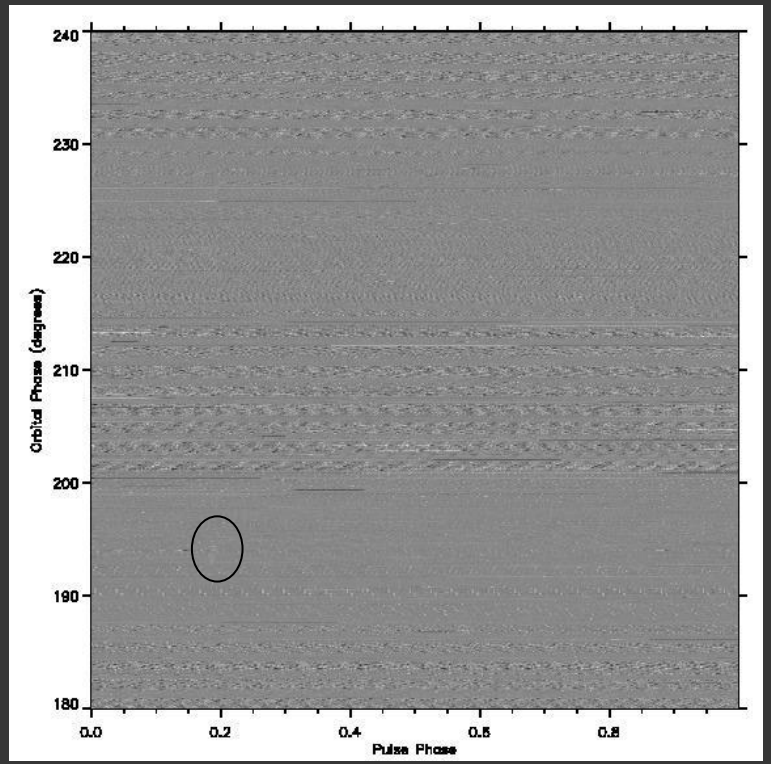
First Green Bank Telescope Observation (52997)



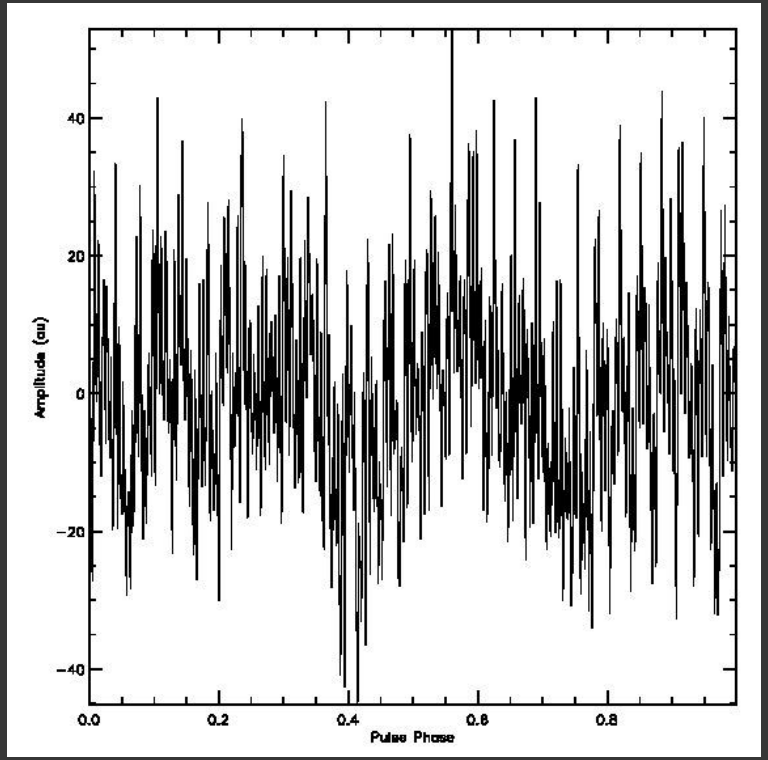


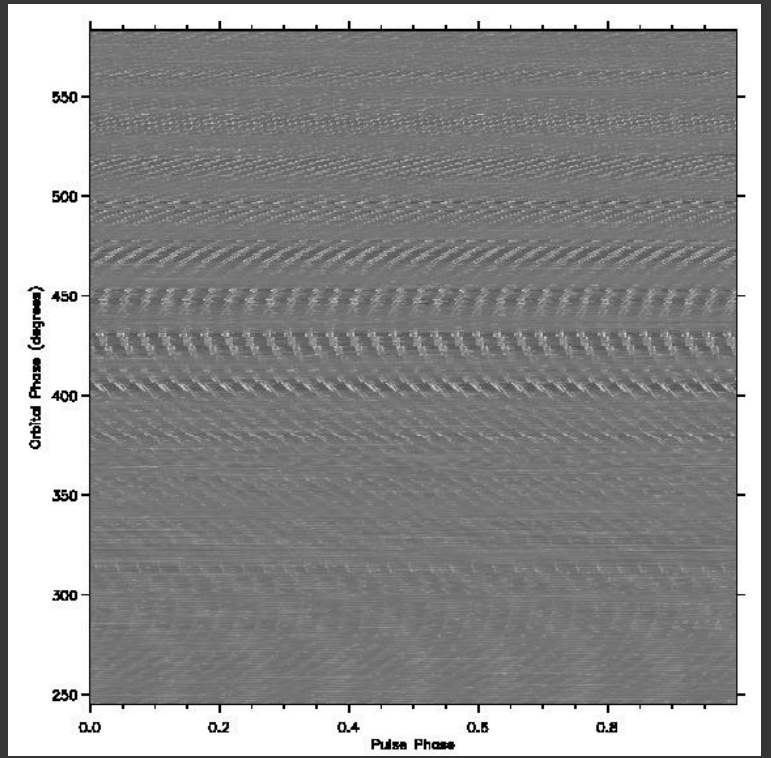
More typical observation (53175)





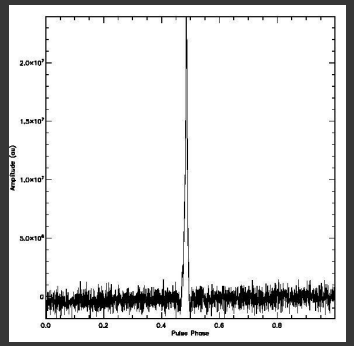
Recent Observation (no evidence of B) (59274)

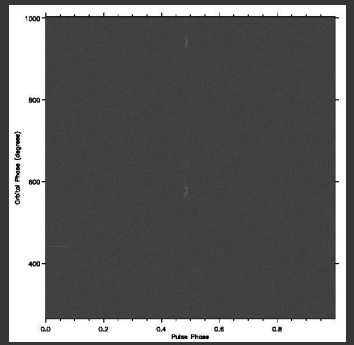




Detection Methods

Visual Analysis
- Dynamic pulse vs orbital phase plots
- Pulse profiles





Single pulse
- S/N vs orbital phase
- S/N vs rotational phase

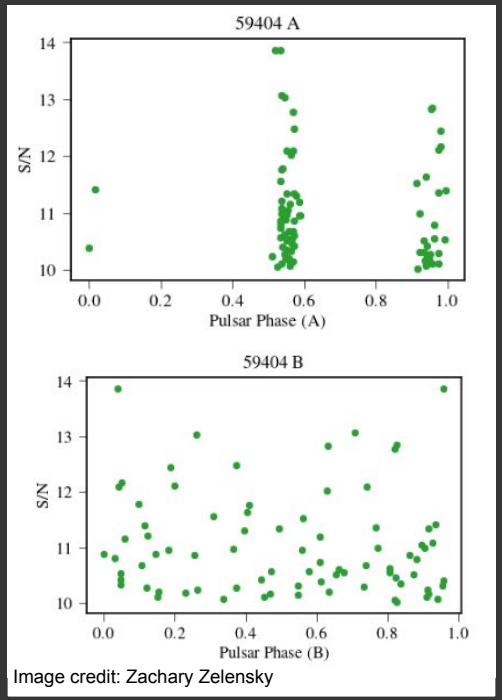


Image credit: Zachary Zelensky

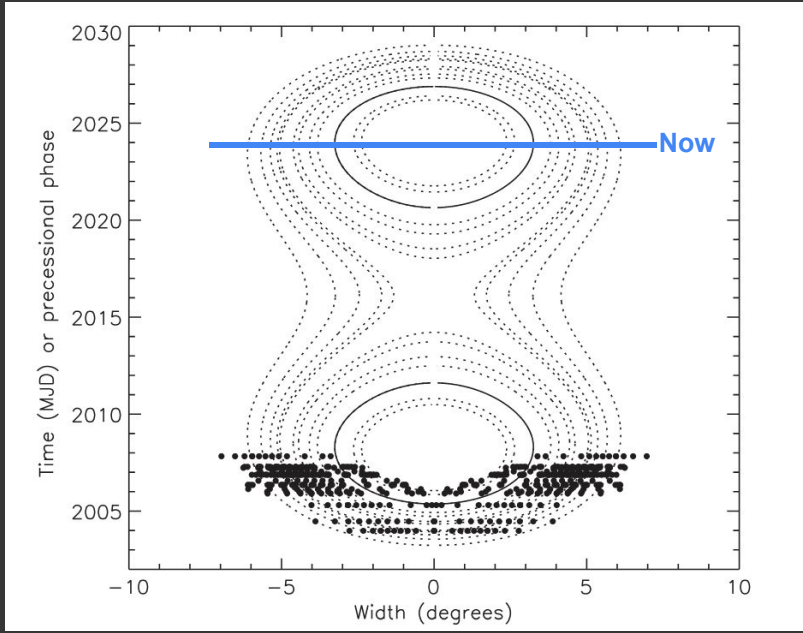
Fast Fourier Transform (FFT)
- Can detect regular bright pulses from both pulsars

No pretty pictures - sorry!

Results (so far)

We have not seen anything

- To be expected because B. B. P. Perera et al predicts that B will not be visible until this year and all data was collected before December 2023



References

A. G. Lyne, *A Review of the Double Pulsar - PSR J0737-3039* (Chinese Journal of Astronomy and Astrophysics, 2006)

B. B. P. Perera, et al., *PSR J0737-3039B: A Probe of Radio Pulsar Emission Heights* (The Astrophysical Journal, 2012)

B. B. P. Perera, et al., The evolution of PSR J0737-3039B and a model for relativistic spin precession (The Astrophysical Journal, 2010)

M. A. McLaughlin et al., *The Double Pulsar System J0737-3039: Modulation of the Radio Emission From B by Radiation From A* (The Astrophysical Journal, 2004)

Acknowledgements

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Collaborators and Mentors:

- Dr. Maura McLaughlin
- Dr. Joey Key
- Victoria Blackmon
- Zachary Zelensky
- Pablo Velt

Thank you!
Questions?

Up Next: Updated Monitor for Narrow Spectral Artifacts Here at Hanford

Updated Monitor for Narrow Spectral Artifacts at the LIGO Hanford Observatory

Taylor Starkman

Continuous Waves

- Near single frequency
  - Earth's motion causes doppler shift
- Likely produced by pulsars which are non-axisymmetric
- Neutron stars visible as pulsars in EM, CW in GW

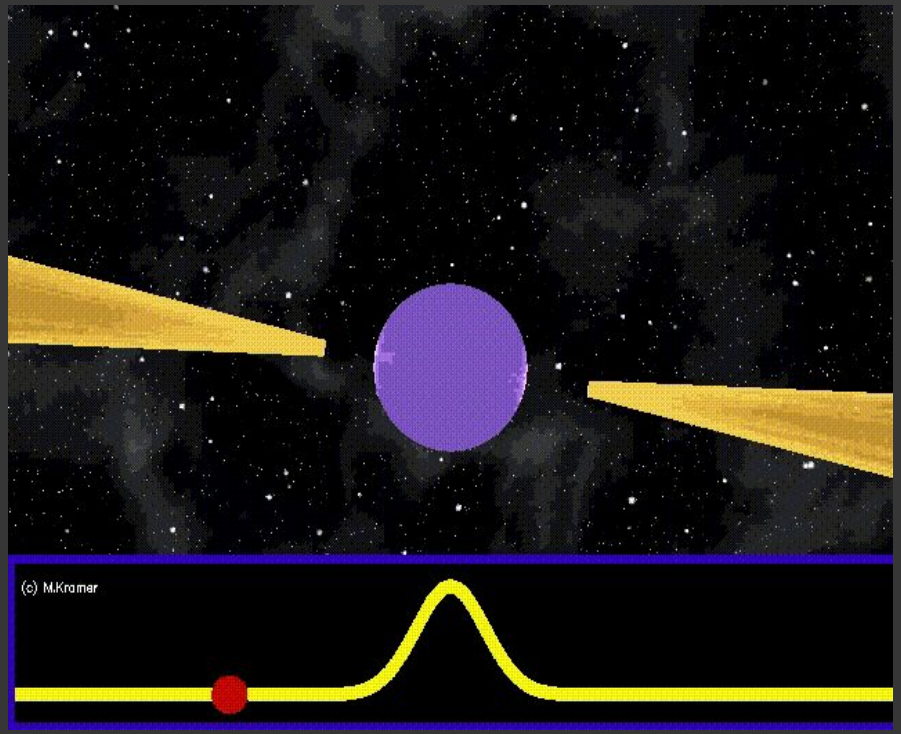


Image credit: Michael Kramer

Lines

- Near single frequency artifacts
- Mainly electronic and instrumental sources
- Cannot always be removed, so we track them

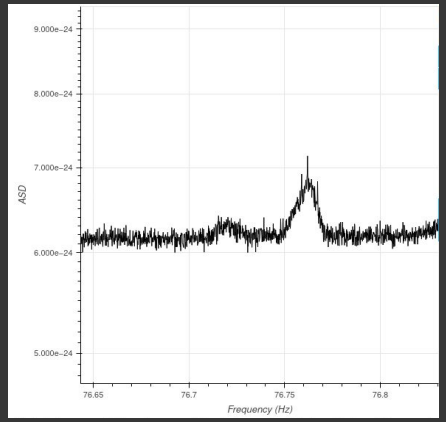


Image credit: Ansel Neunzert
Example of wide (for CW) feature (~0.026Hz wide)

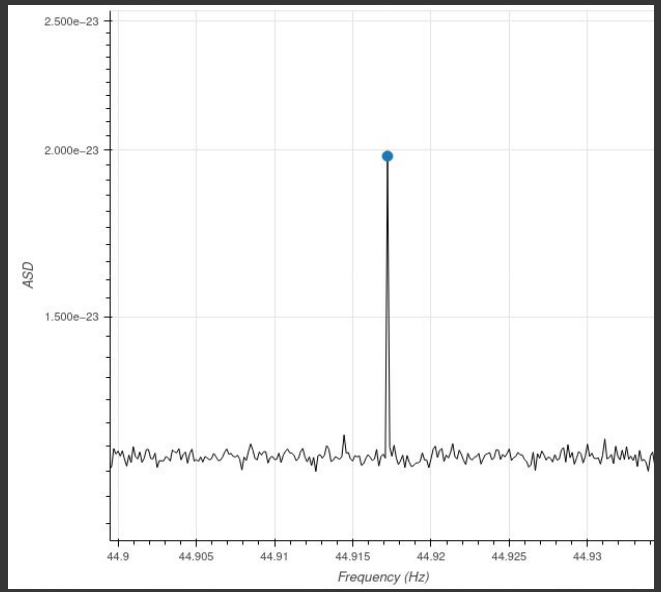
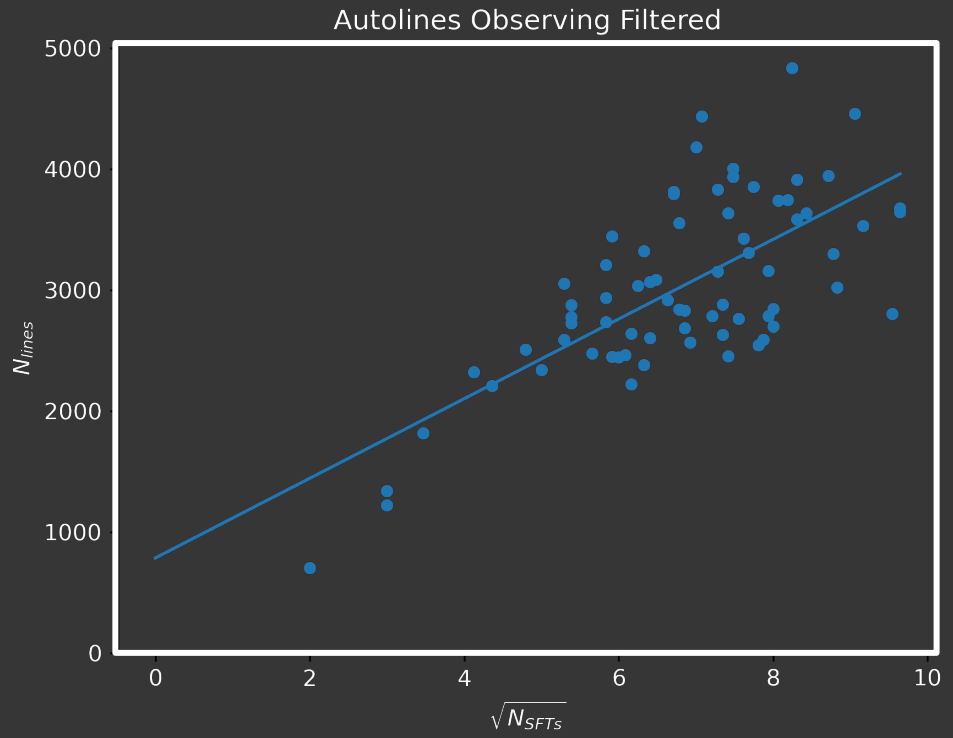


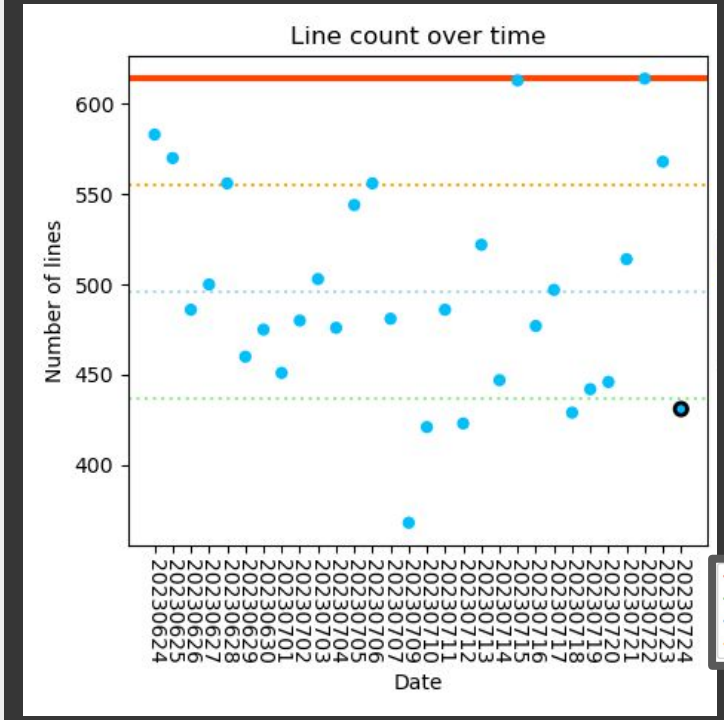
Image credit: Ansel Neunzert
Example of a narrow spectral artifact (0.00028Hz wide)

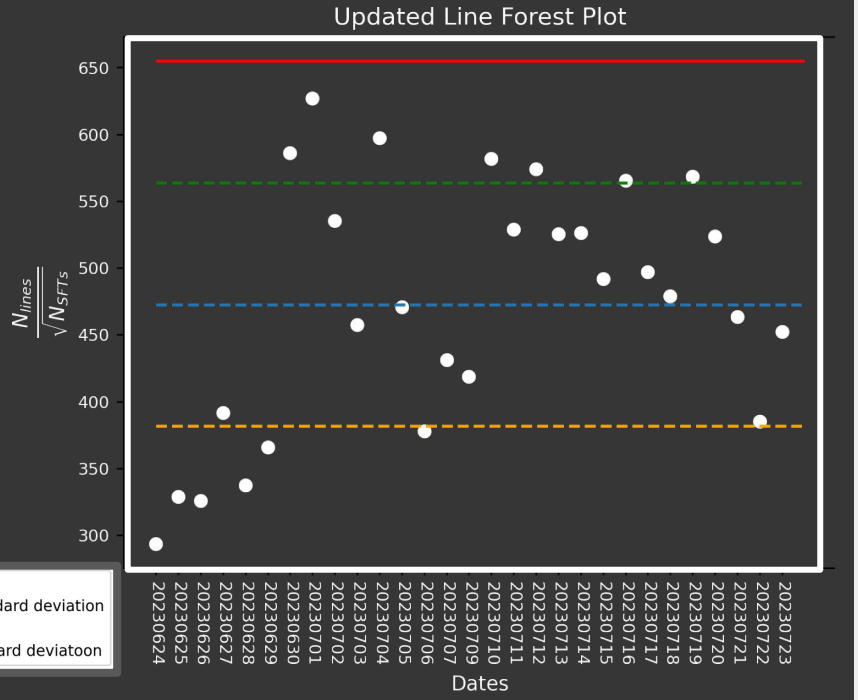
Effect of Observing Time

- Signal-to-noise ratio scales with square root of observing time
- Improved metric
- Improving LineForest monitor

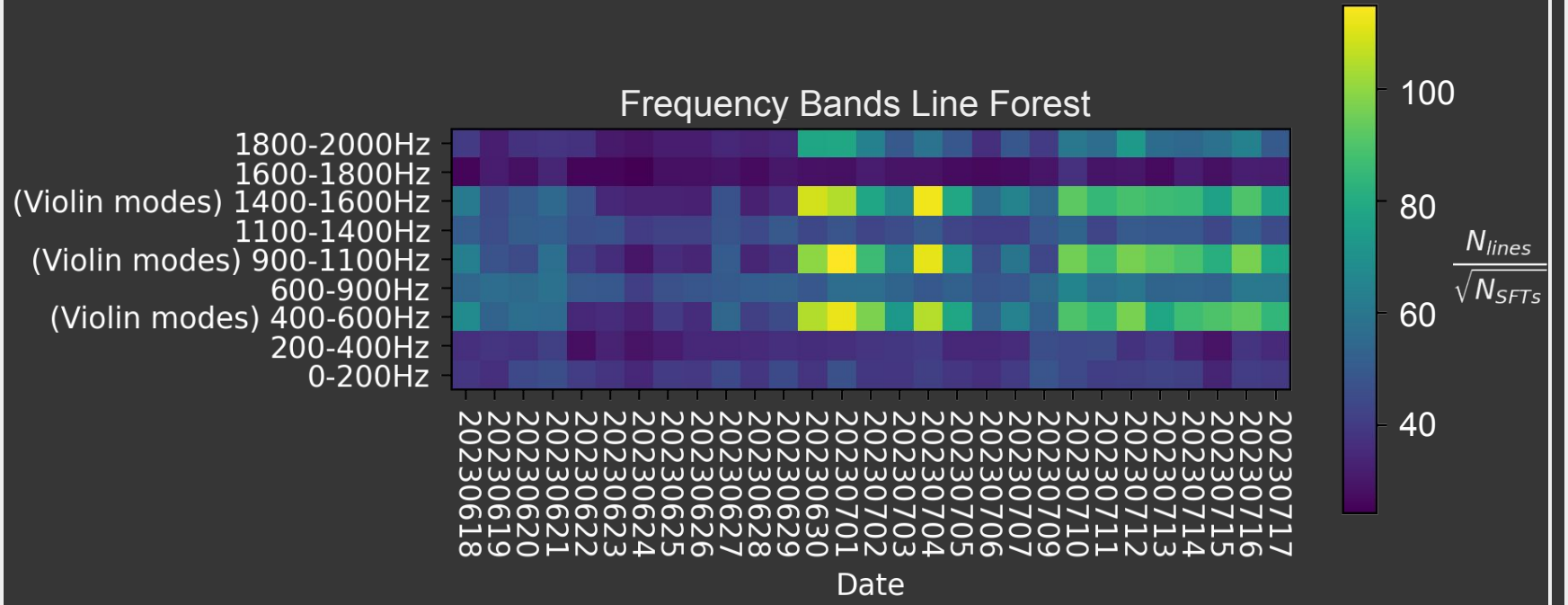


Update LineForest Monitor





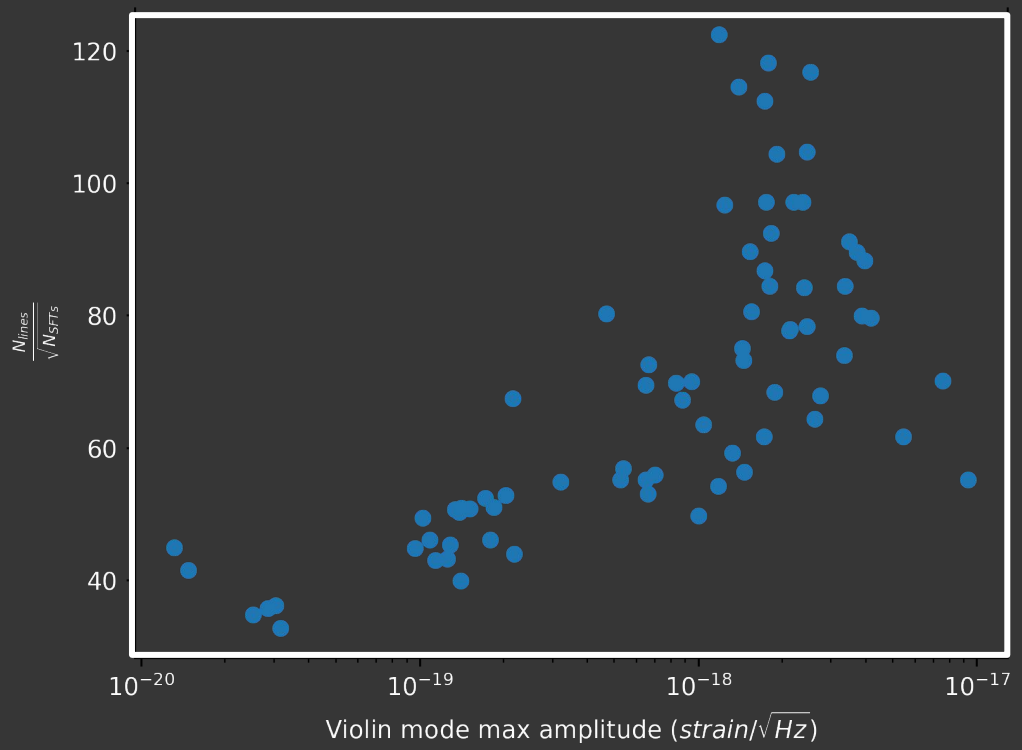
Update Line Count (All Lines)



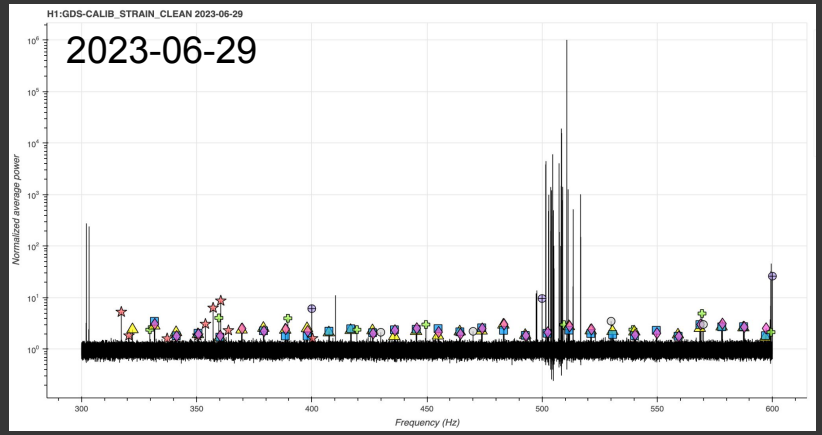
Line Contamination Around Violin Modes

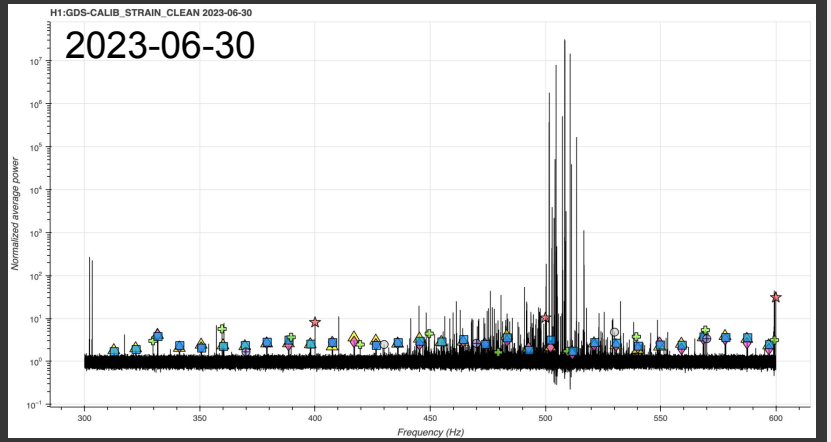
Glass fibers suspending test masses resonate at 500Hz

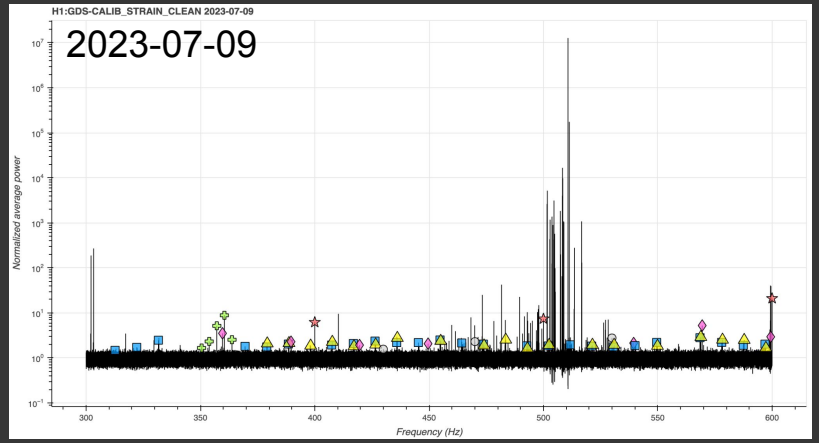
- Harmonics at 1000Hz, 1500Hz, and 2000Hz
- Ring up when string is “plucked”
  - Increased amplitude

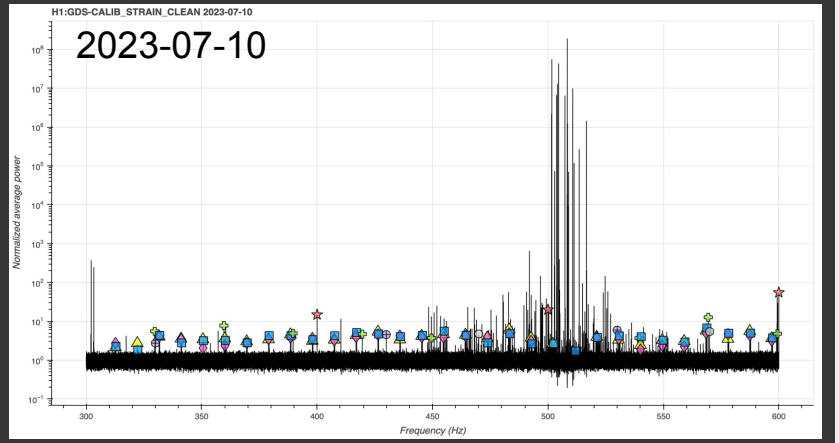


Violin Mode Line Contamination









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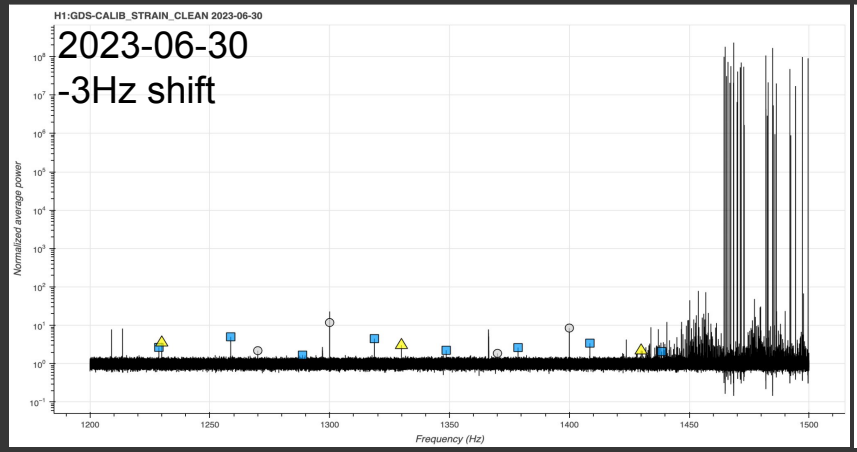
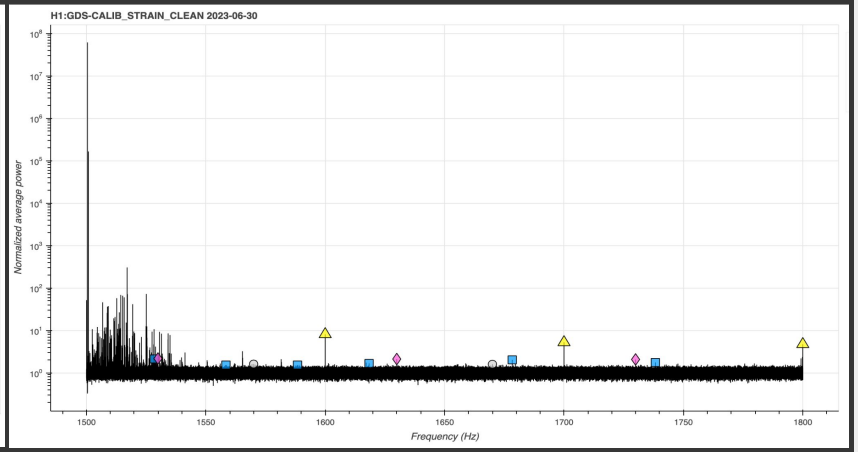
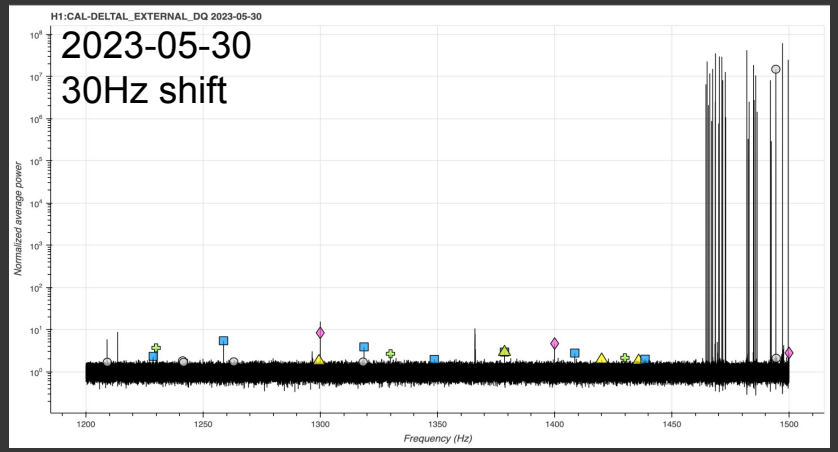
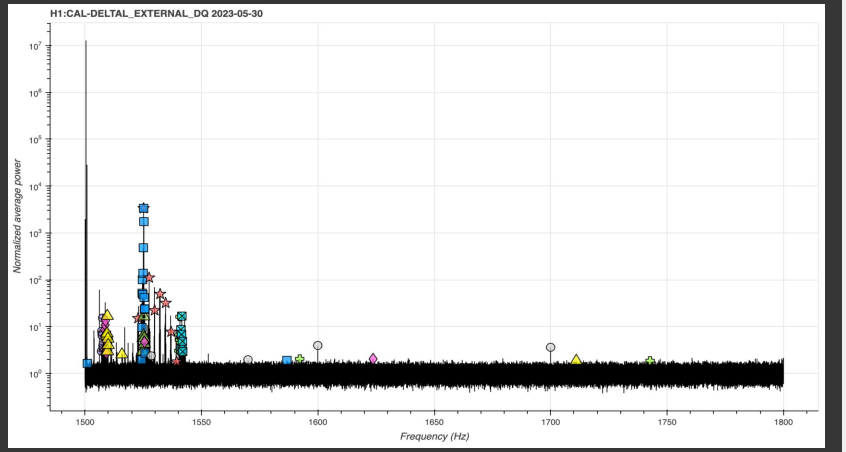
Asymmetrical Violin Mode Line Contamination









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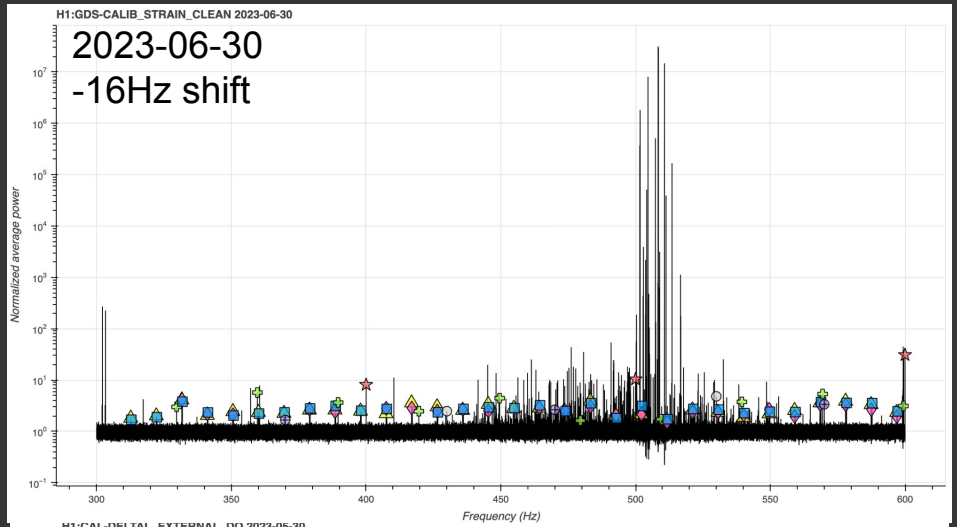
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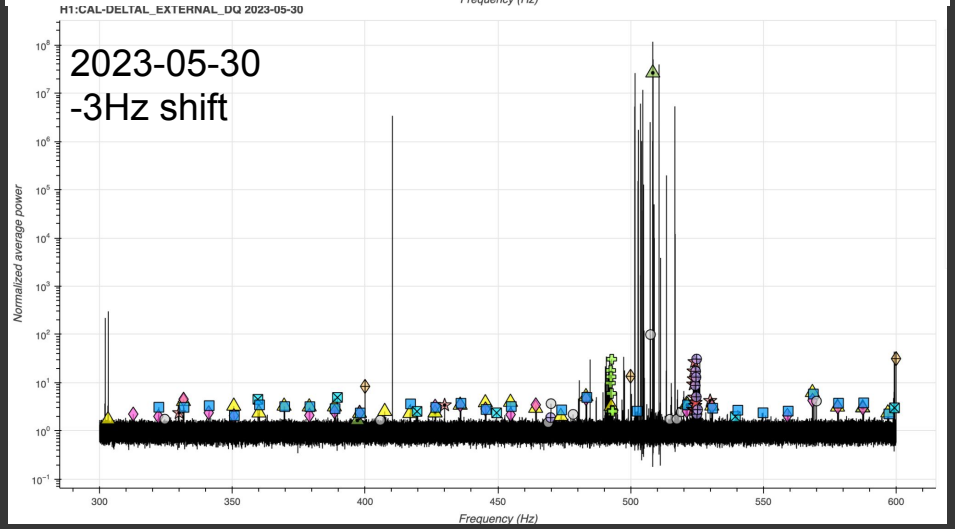
2023-06-30
-16Hz shift
Normalized average power
Frequency (Hz)


H1:CAL-DELTAL_EXTERNAL_DQ 2023-05-30
2023-05-30
-3Hz shift
Normalized average power
Frequency (Hz)

alog 71800

Future Investigations

- Confirmed mixing with calibration lines
  - All or subset?
- Impact of change of ADC between O3 and O4a
  - Investigation led by on site commissions due to lack of visibility in data
- Lack of contamination in LLO - why?
  - Difference in amplitude of violin modes between sites?

Acknowledgements

This research was funded by NSF Award PHY-1944412 and NSF REU Award 2050928

References

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K. Riles, *Searches for Continuous-Wave Gravitational Radiation* (Living Reviews in Relativity, 2023), p. 3-5

Thank you!
Questions?