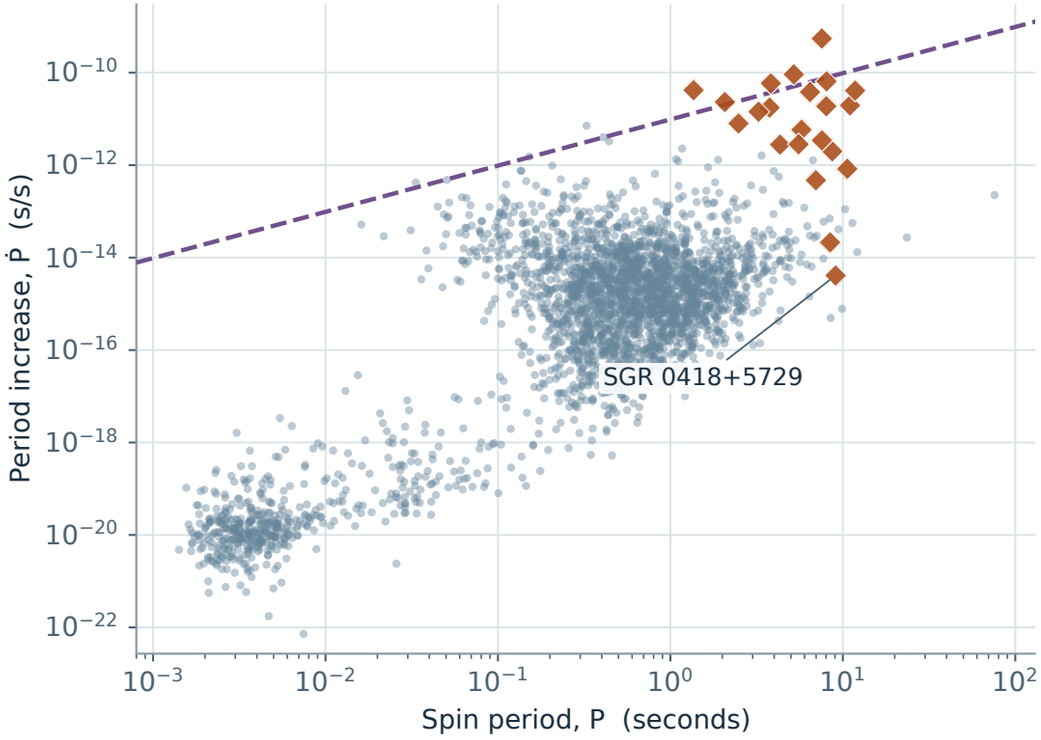
Pulsars and magnetars on the same map

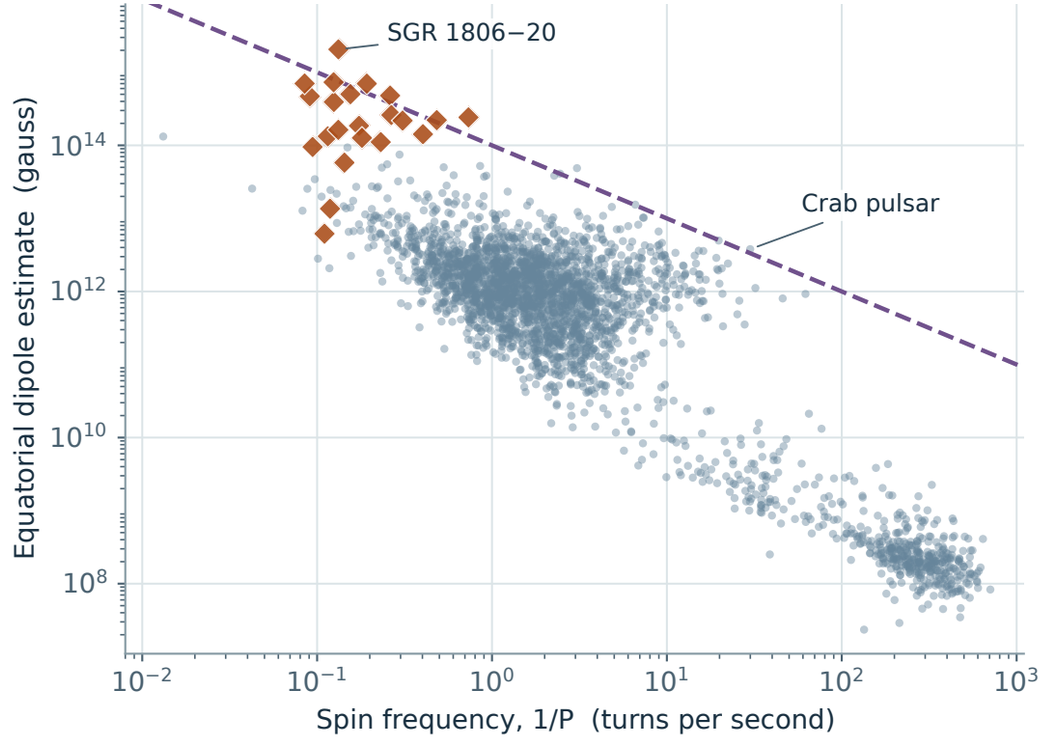
Each point is one ATNF source. The right panel converts the same timing measurements into spin frequency and estimated dipole field.

2,876 other ATNF sources 22 with the anomalous X-ray pulsar (AXP) tag Proposed ESFD threshold $\chi = 1$

Measured spin timing



Field strength inferred from timing

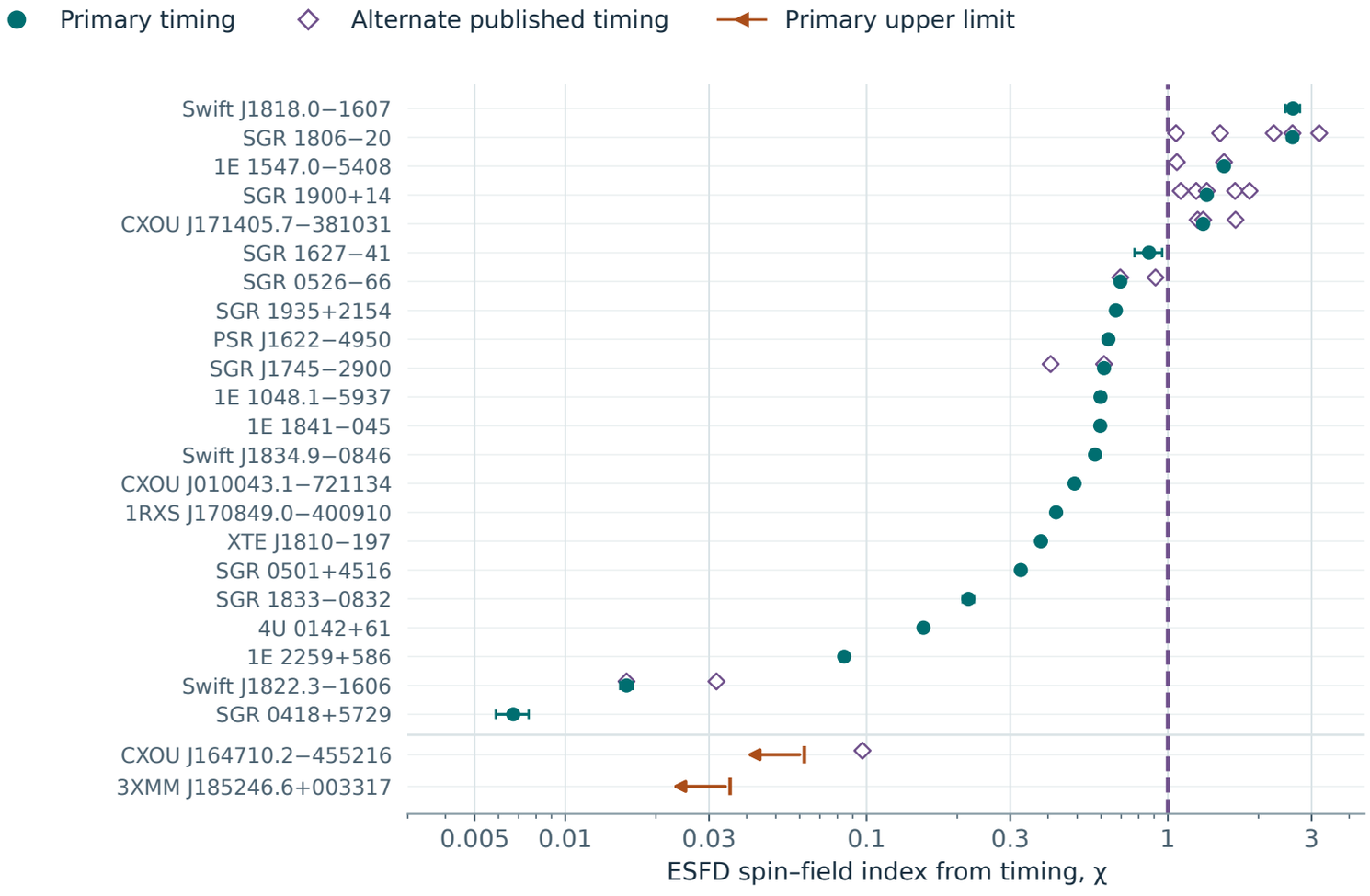


Nine sources lie above the line. Five carry the AXP tag. The Crab pulsar is one of the four others.

With a timing-derived field, $\chi = 1$ is exactly a characteristic spin-down age of 1,624 years. This age is an estimate from the present spin.

Where each confirmed magnetar falls

McGill primary timing solutions for 24 confirmed objects. The fixed threshold was specified in the ESFD manuscript.



5 of 22

timing detections reach χ = 1.

Known giant-flare hosts

SGR 1806−20	**2.59**
SGR 1900+14	**1.35**
SGR 0526−66	**0.70**

These are catalog epochs.
A flare can occur at a different spin-down rate.

SGR 0526−66 produced a giant flare and falls below the line at its catalog timing epoch.

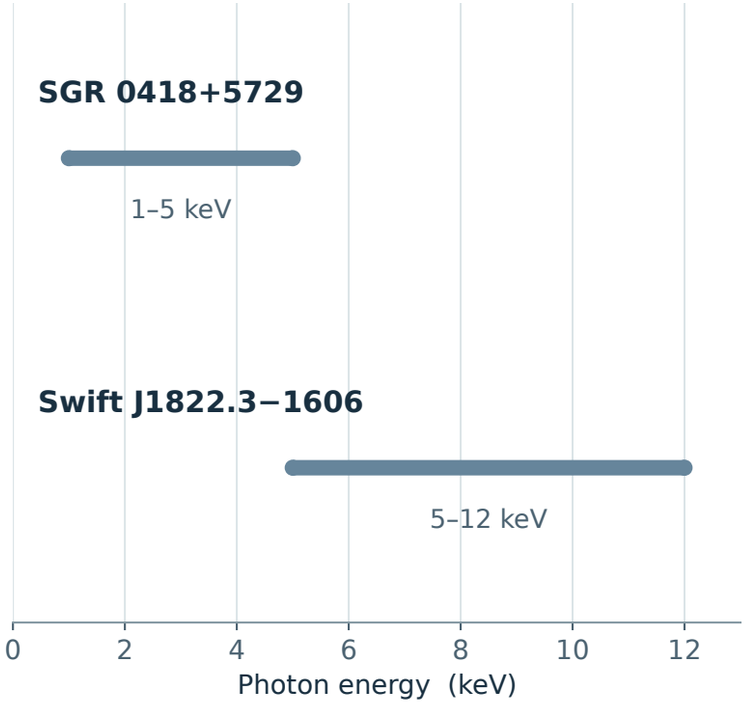
The two arrows show limits and are excluded from 5/22. Whiskers show propagated formal 1σ timing errors where supplied.

Two magnetars with an X-ray field test

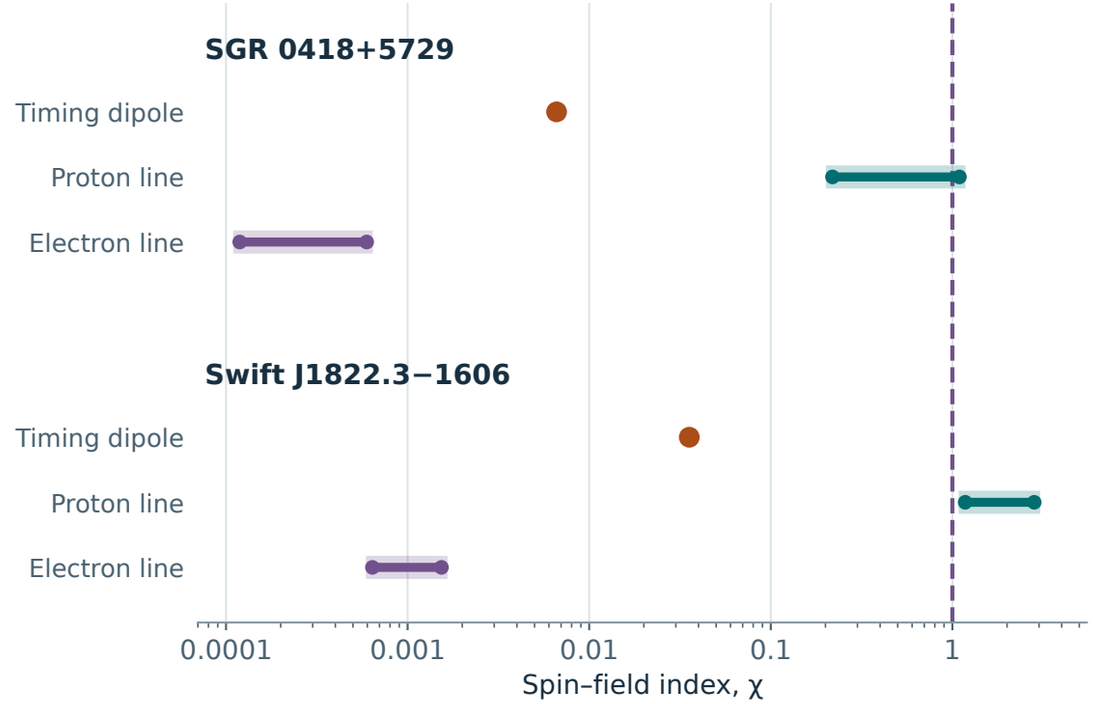
The reported features vary with rotational phase. Swift’s feature is tentative. Field estimates depend on how each line is identified.

Study’s timing dipole · Proton interpretation · Electron interpretation · Proposed χ = 1

Observed feature energies



ESFD index under each field estimate



Dark bars use an assumed gravitational redshift of 0.25. Pale ends extend the calculation across redshifts 0.15–0.35.

With a proton line, SGR 0418+5729 spans χ = 0.22–1.09 and Swift J1822.3−1606 spans 1.18–2.82 at redshift 0.25.

Both timing dipoles and both electron-line alternatives give χ below one. The energy spans trace viewing phase during the observations.

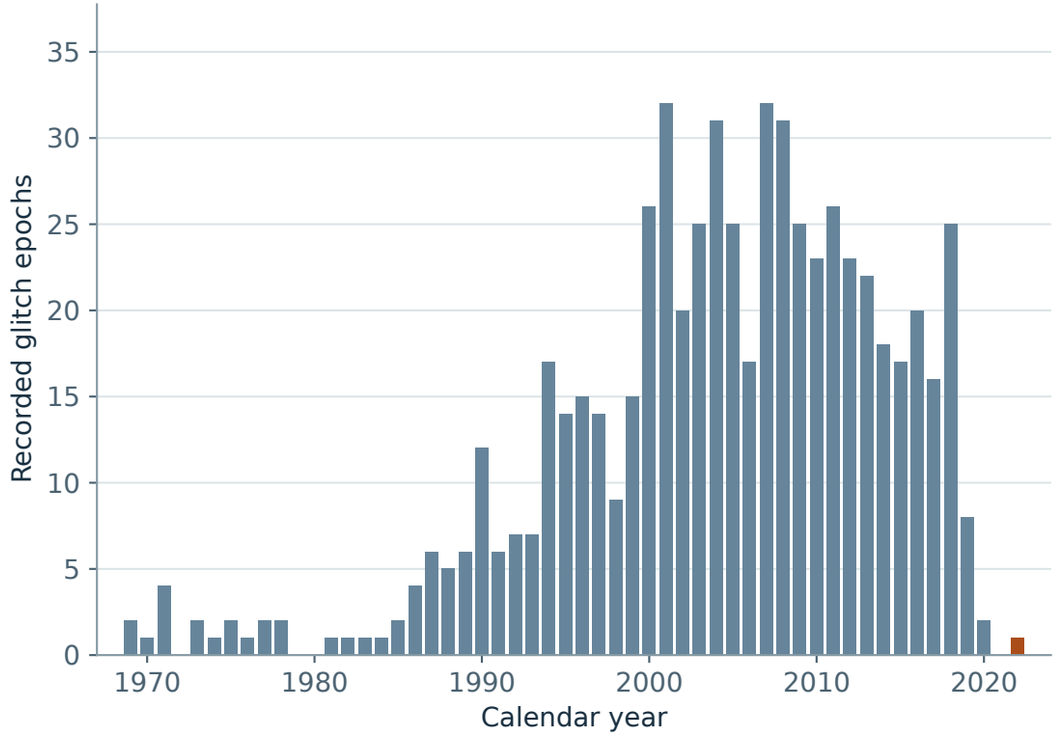
Tiengo et al. (2013), Nature 500, 312 · Rodríguez Castillo et al. (2016), MNRAS 456, 4145 · Timing values adopted by the spectral studies.

Recorded pulsar glitches across five decades

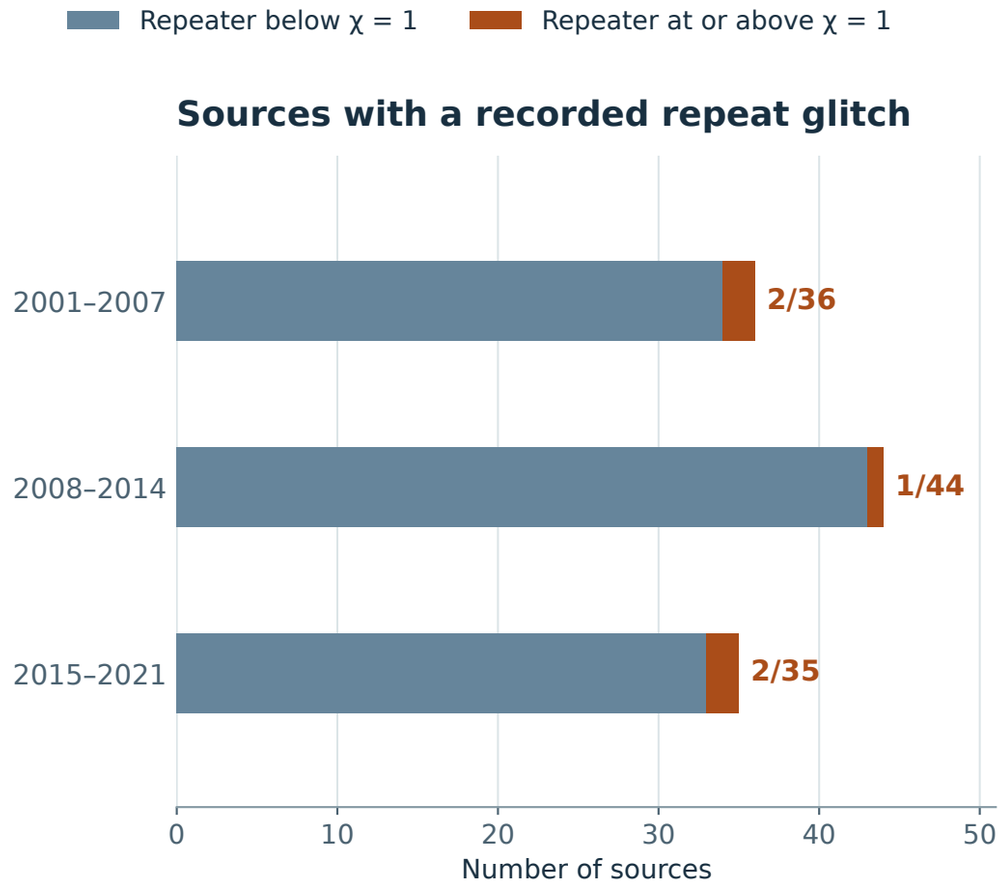
A glitch is a sudden change in a star’s spin. Each event in the archive has a source name and an epoch.

625 unique source–epoch pairs / 211 sources

Events recorded by year



Sources with a recorded repeat glitch



The file’s last recorded event is April 3, 2022. Survey coverage varies with source and year.

In 2015–2021, 2 of 35 repeaters reached the ESFD line using their catalog timing. The other 33 fell below it.

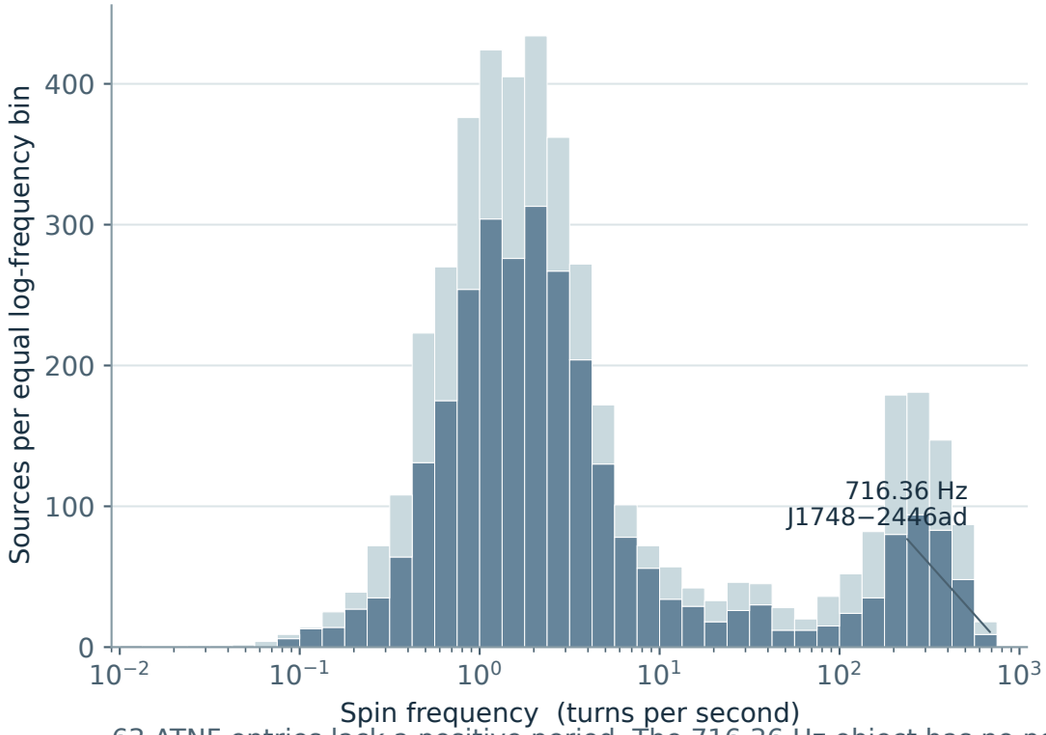
Each window includes sources with an earlier recorded glitch and usable timing. Catalog timing can postdate the window, so this is retrospective.

How spin and field compare with stellar binding

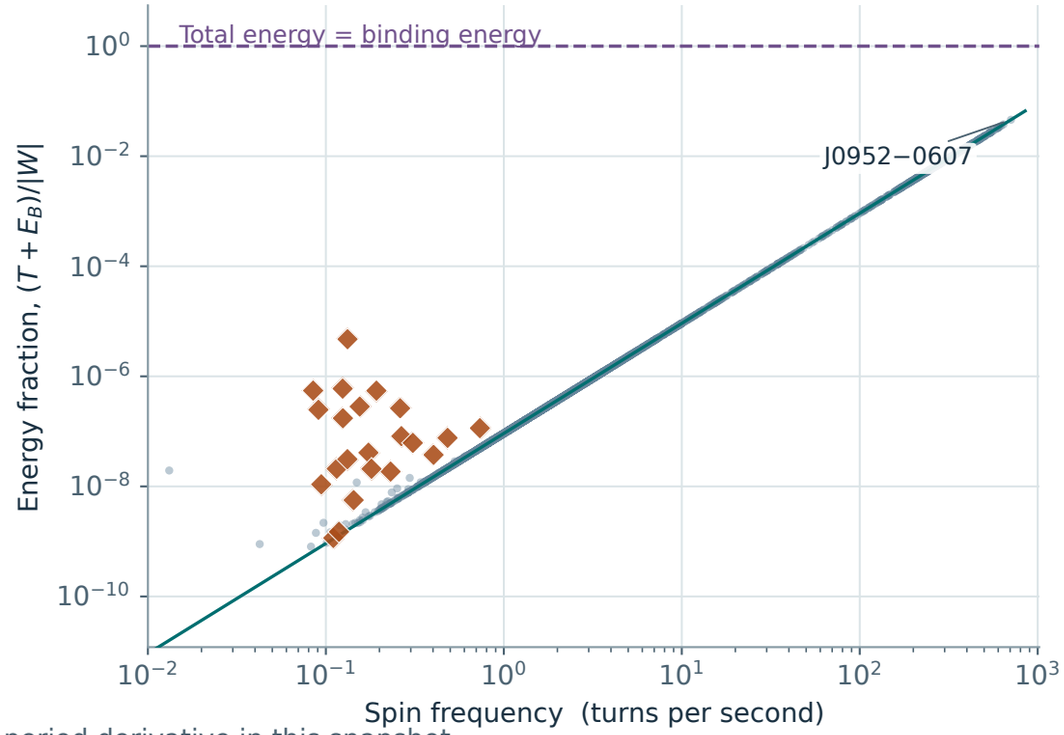
The bulk-energy calculation uses the observed spin and assumes a uniform interior field equal to the timing dipole.

2,898 positive timing pairs · 1,542 other known periods · Rotation alone · ATNF AXP tag

Spin frequencies with and without a timing pair



Energy fraction under the paper's assumptions



63 ATNF entries lack a positive period. The 716.36 Hz object has no positive period derivative in this snapshot.

The largest modeled total in the paired sample is 4.59% of the binding energy, for PSR J0952−0607.

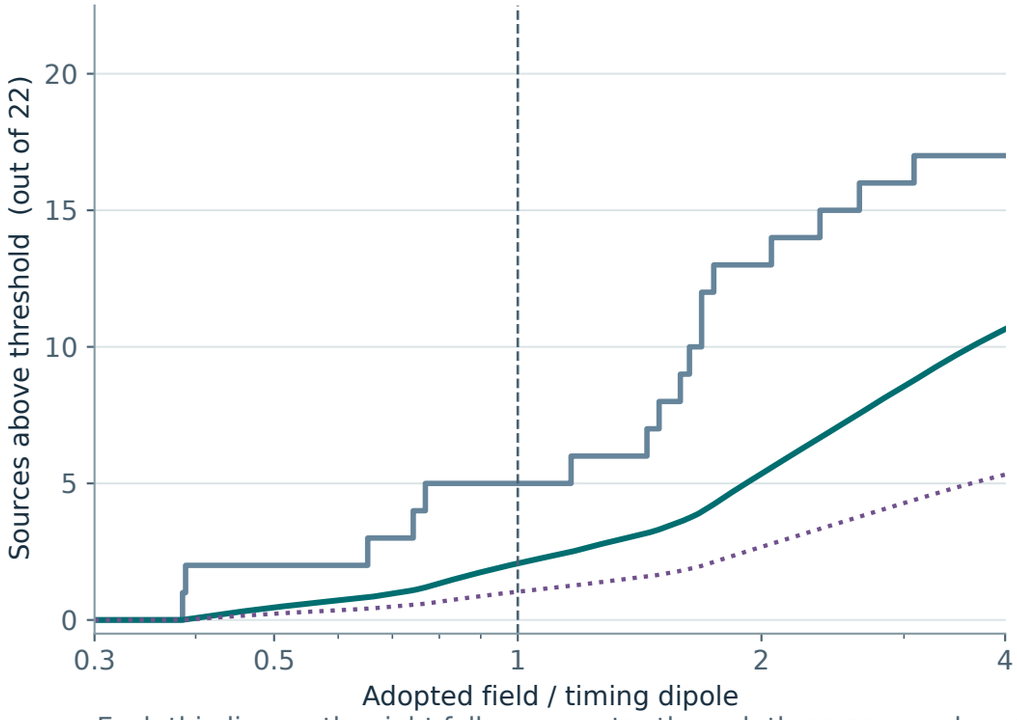
Assumptions are 1.4 solar masses, a 12 km radius and a uniform interior field. Mass, radius and the internal field can differ for each star.

Field alignment and a superconducting core

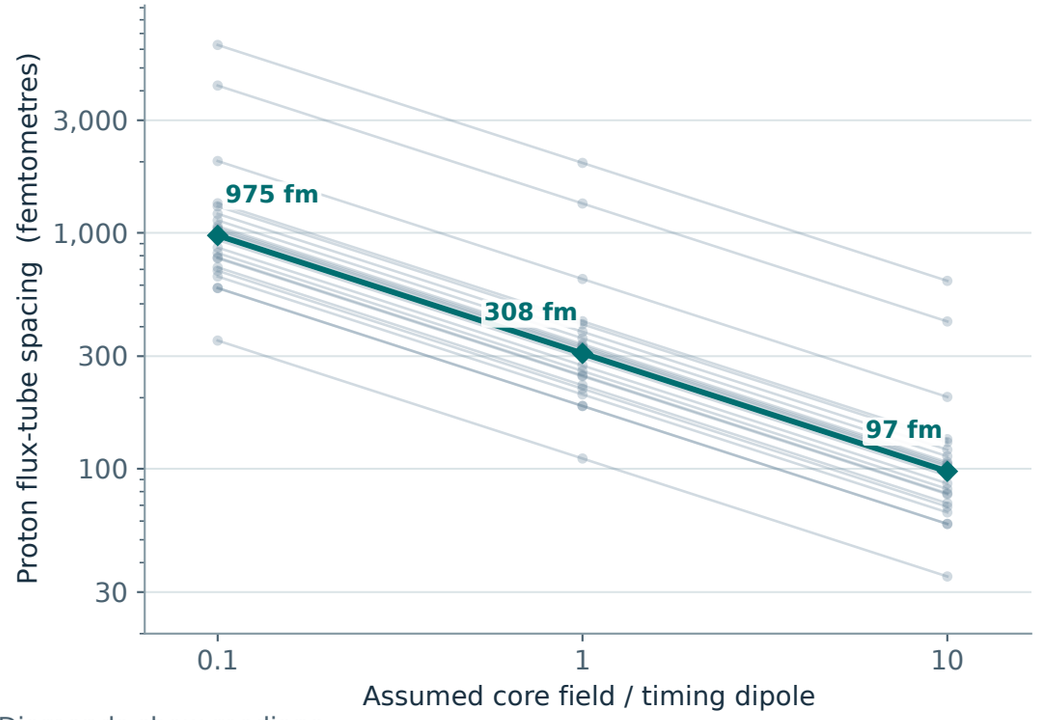
The revised stellar model can be evaluated conditionally for 22 magnetars. Their field angles and internal field strengths are unknown.

Aligned Random angles, absolute projection Random angles, positive signed projection

How many sources would reach χ = 1?



Flux-tube spacing in a type-II proton core



Each thin line on the right follows one star through three assumed core fields. Diamonds show medians.

At the timing field strength, 5 aligned sources reach the line. Random angles give an average of 2.07 using |cos θ|.

If the core field equals the timing dipole, the median tube spacing is 308 femtometres. This estimate assumes a triangular flux-tube array.