

Status update on Cycle 0/1 pulsar observations

LOFAR Pulsar Working Group



Measuring the low-frequency spectral turnovers of pulsars

Hassall et al. 2014, submitted



Hassall et al. 2014

Submitted for internal refereeing

Measuring the low-frequency spectral turnover of pulsars

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ABSTRACT

The spectra of radio pulsars are fundamental observables which have a direct link to the physics of the emission mechanism and the conditions in the pulsar magnetosphere. They could be invaluable in testing emission theories, but at present very few pulsars have enough broadband flux-density measurements to do so. Here, we present flux-calibrated Stokes I measurements of 122 pulsars, including 30 millisecond pulsars (MSPs), using LOFAR in the frequency range 20–200 MHz. We compare these data to previously published data from higher frequencies to examine the broadband spectral behaviour of pulsars, with a particular focus on the low-frequency 'turnover'. For most of the pulsars in our sample, we find a spectral break at around 160 MHz, but the turnover is quite gentle and the low-frequency spectral index rarely exceeds +1 (compared with the high-frequency spectral index, which is typically between -1.4 and -2.0 , but can be as steep as -4.5). We show that poor spectral coverage is probably responsible for the fact that very few MSPs have been seen to exhibit a spectral turnover, rather than an intrinsic difference between MSPs and the rest of the population. Finally, we present evidence for spectral signatures caused by evolution of the pulse profile with frequency.

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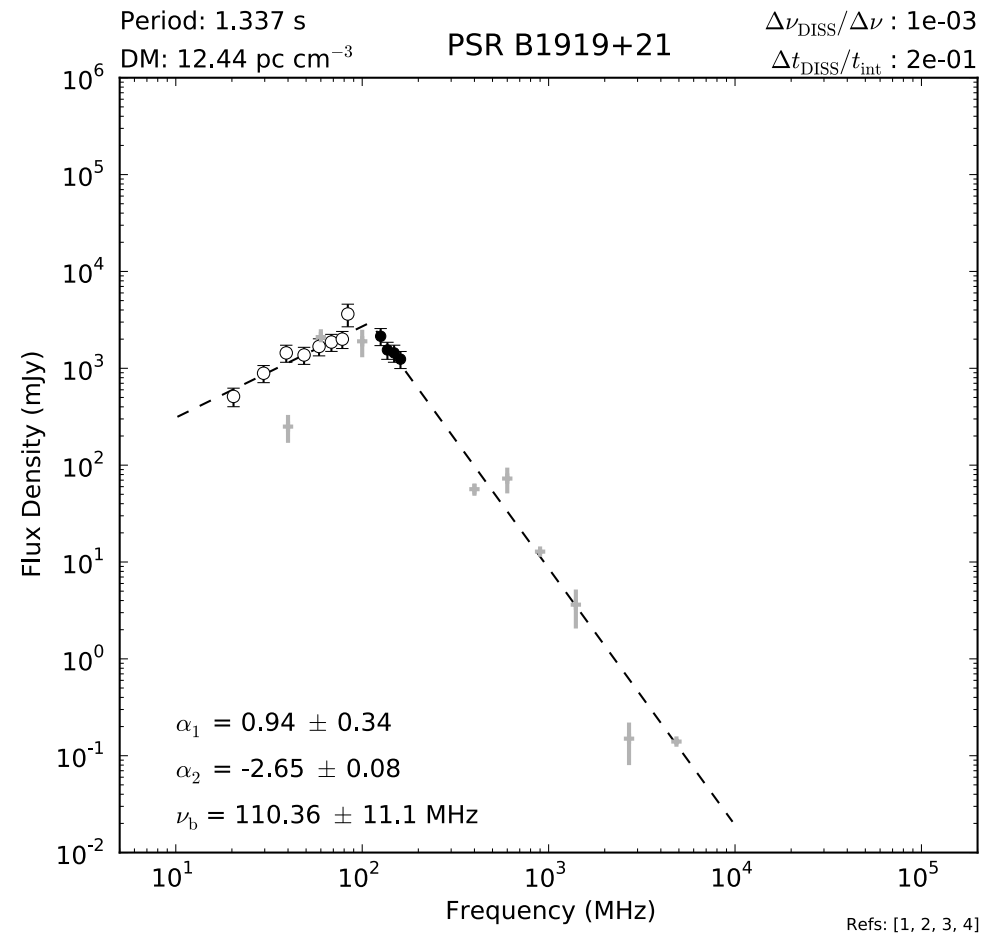
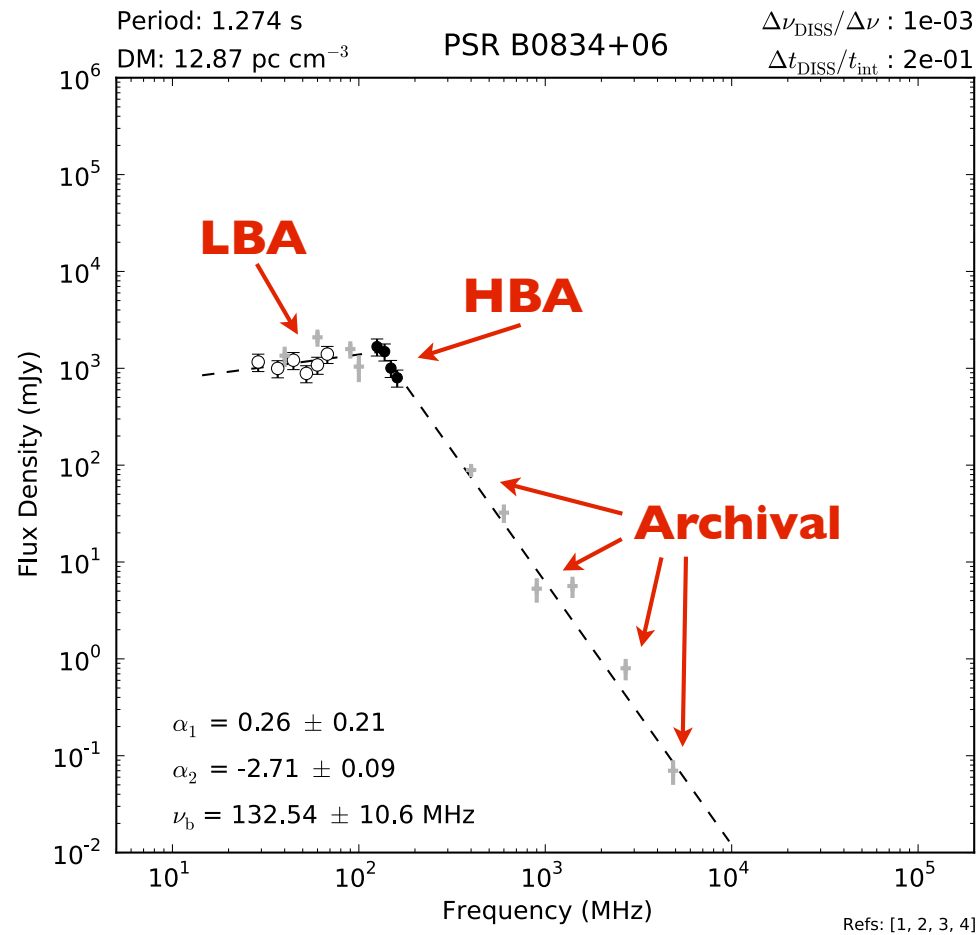
- Spectra are an important observable; link to emission mechanism and physical conditions in the magnetosphere.
- Truly broadband spectra lacking for most pulsars.
- Spectral turnover at low frequencies, typically.
- LOFAR provides the necessary sensitivity and large fractional bandwidth (good sanity check).
- Calibrated, Stokes I flux measurements for 122 pulsars, including 30 millisecond pulsars.
- All 122 in HBA, 28 pulsars also LBA.

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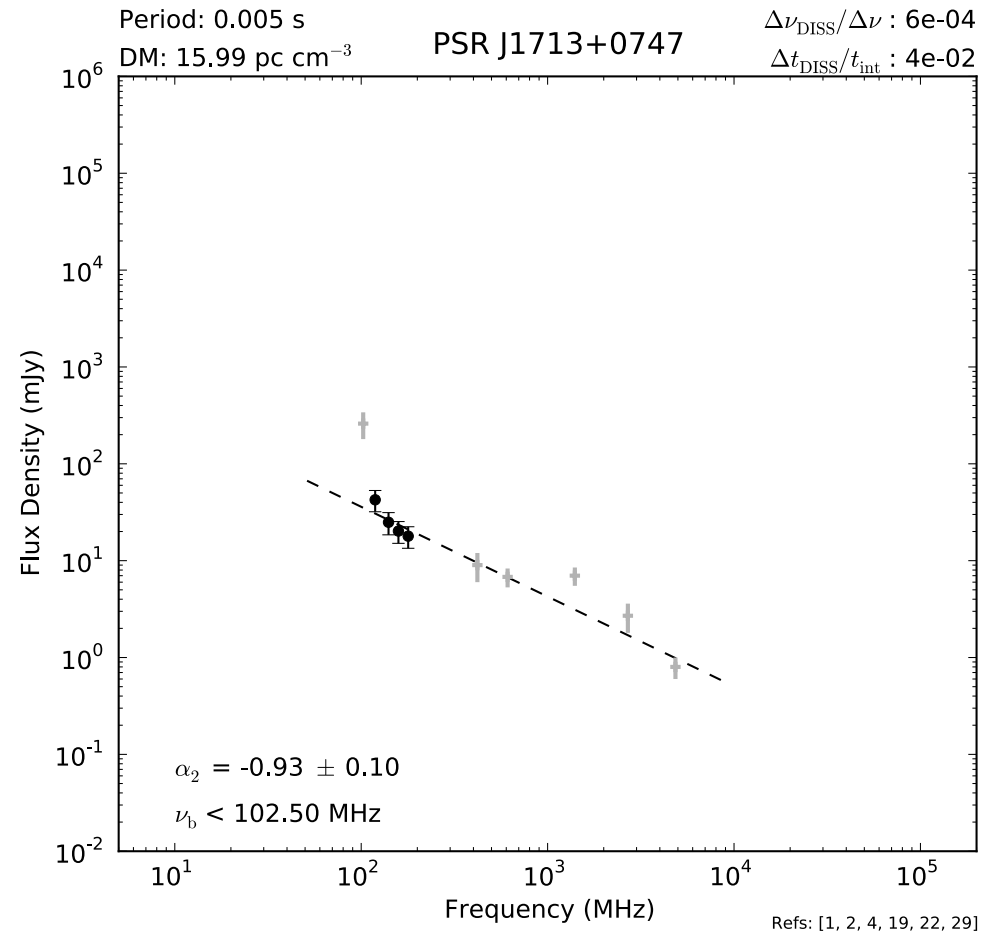
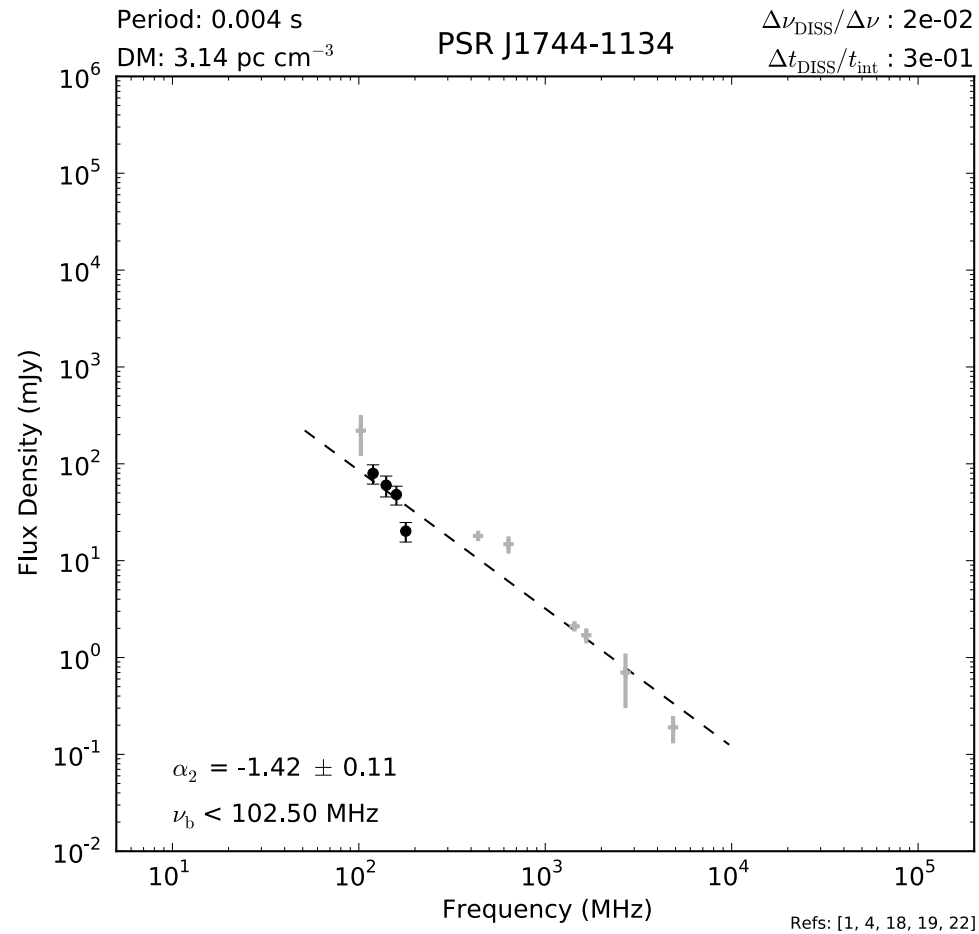
- LOFAR fluxes compared with archival high-frequency fluxes (300MHz - few GHz).
- Measure the spectral index and turnover frequency.
- Most pulsars show a spectral break around 160MHz.
- Turnover is normally quite “gentle”.
- Looks like there is no major difference in the turnover properties of slow pulsars and millisecond pulsars.
- Pulse profile evolution also effects the observed spectra.

Slow Pulsar Spectra



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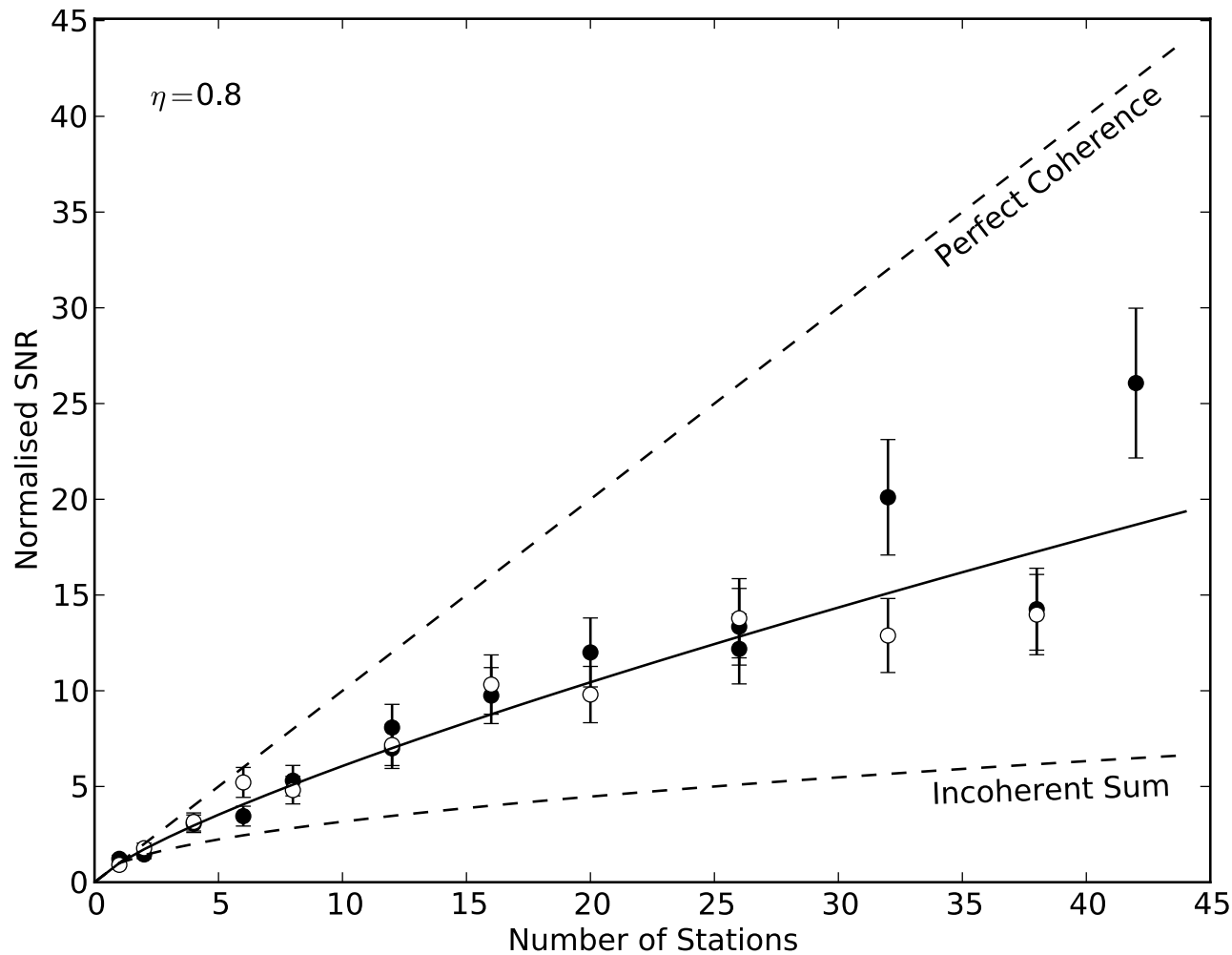
Millisecond Pulsar Spectra



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Pulsar Spectra Calibration

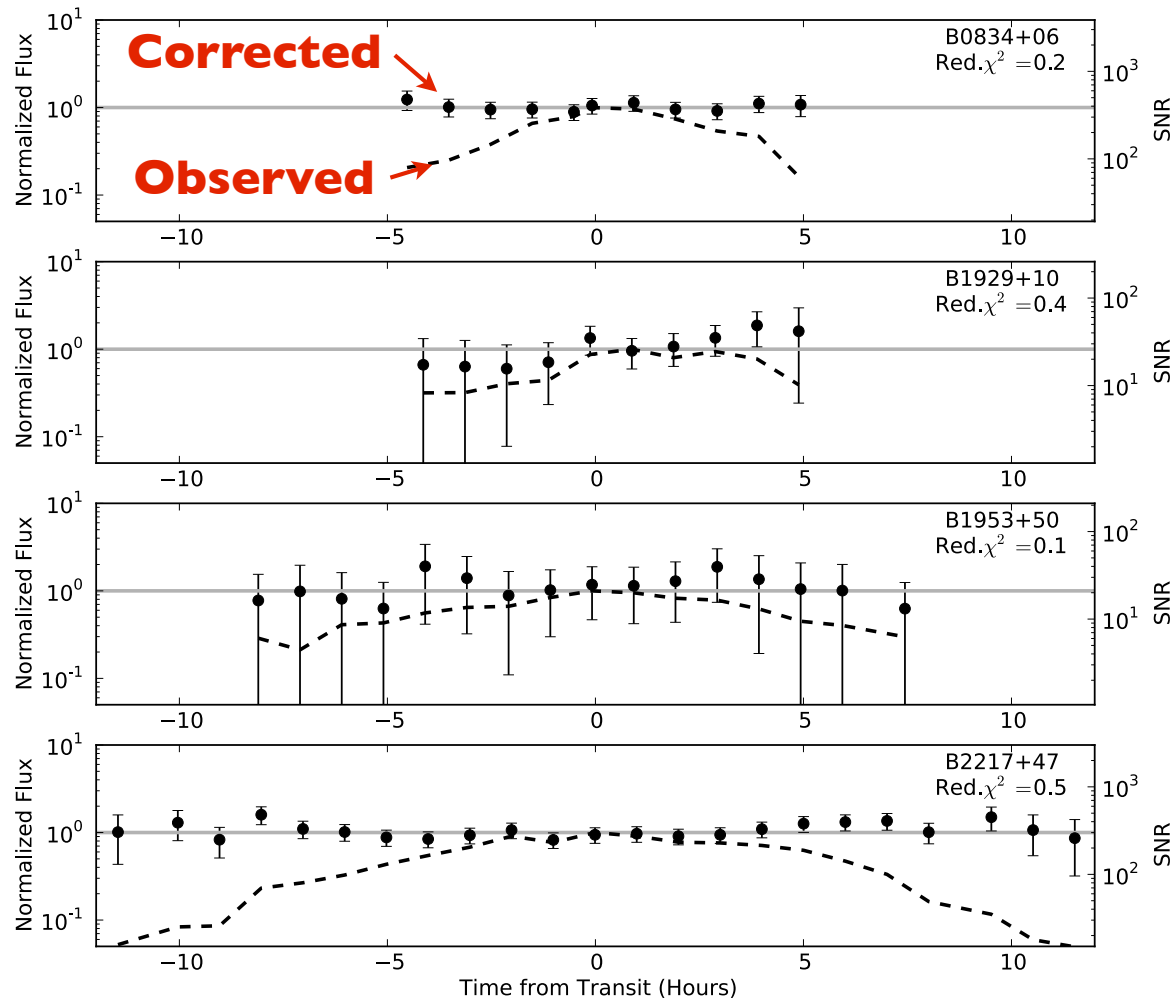
Account for imperfect coherency of the tied-array beams



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Pulsar Spectra Calibration

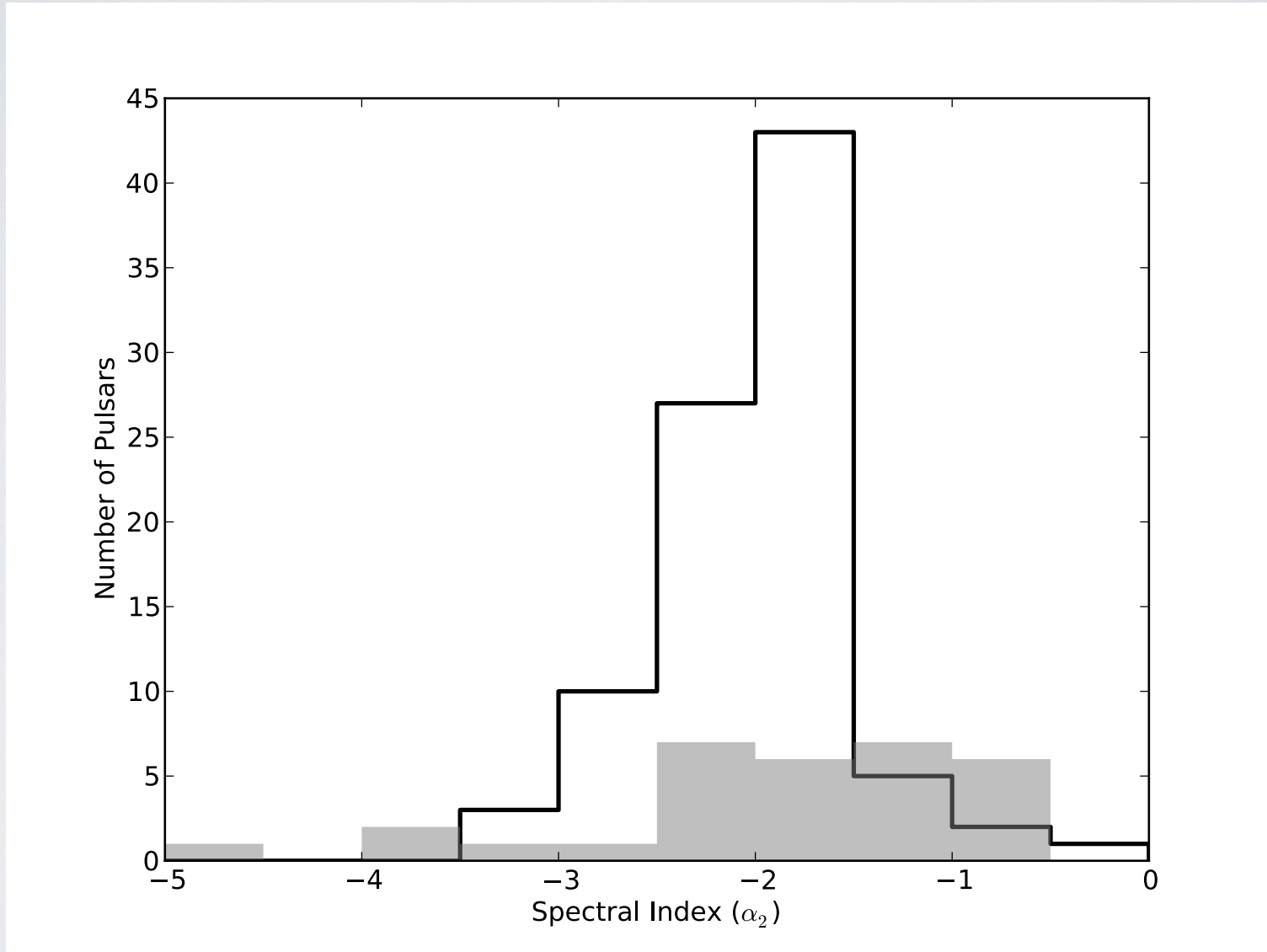
Account for beam (hour angle)



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Pulsar Spectra

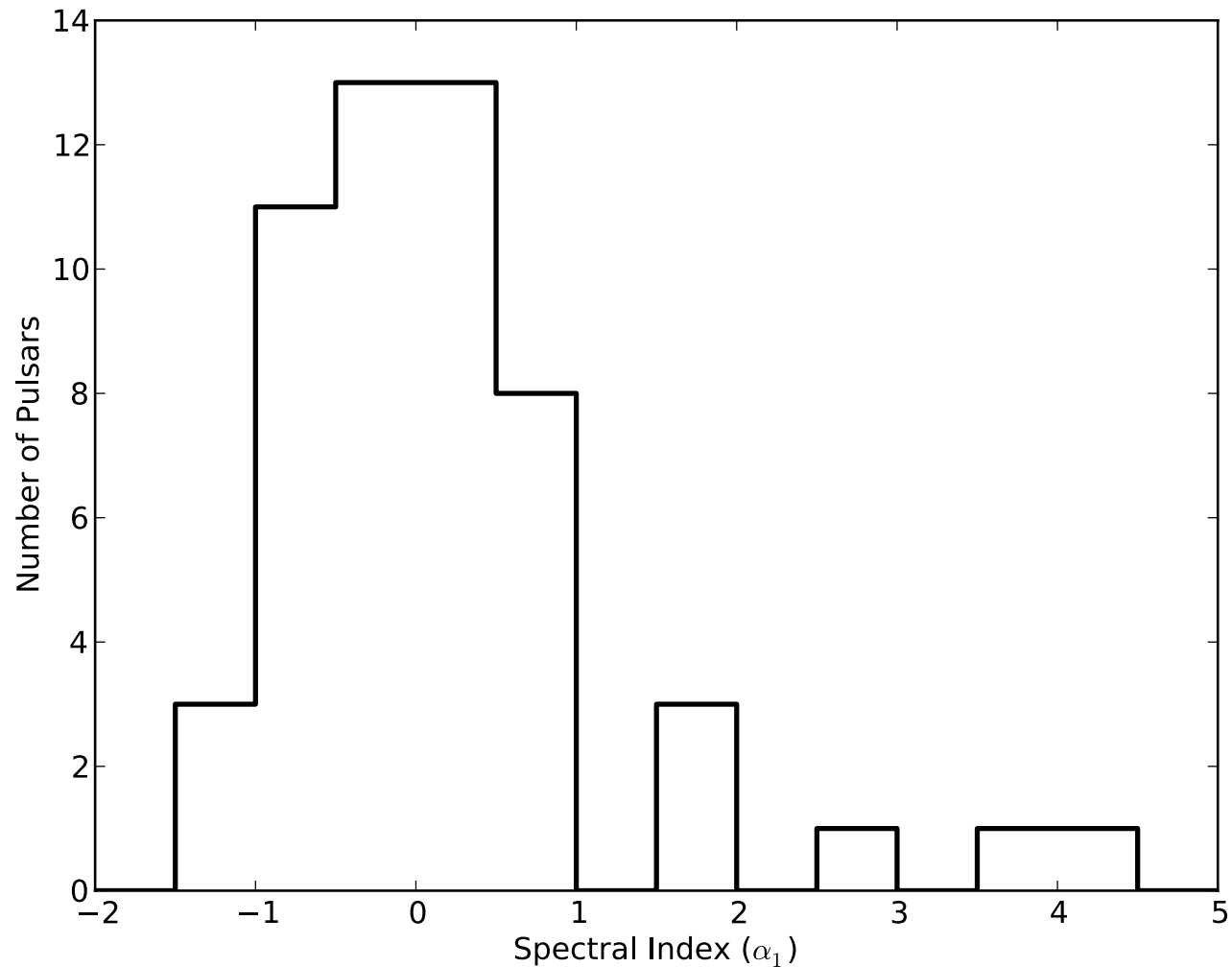
High-frequency spectral index (above the turnover)



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Pulsar Spectra

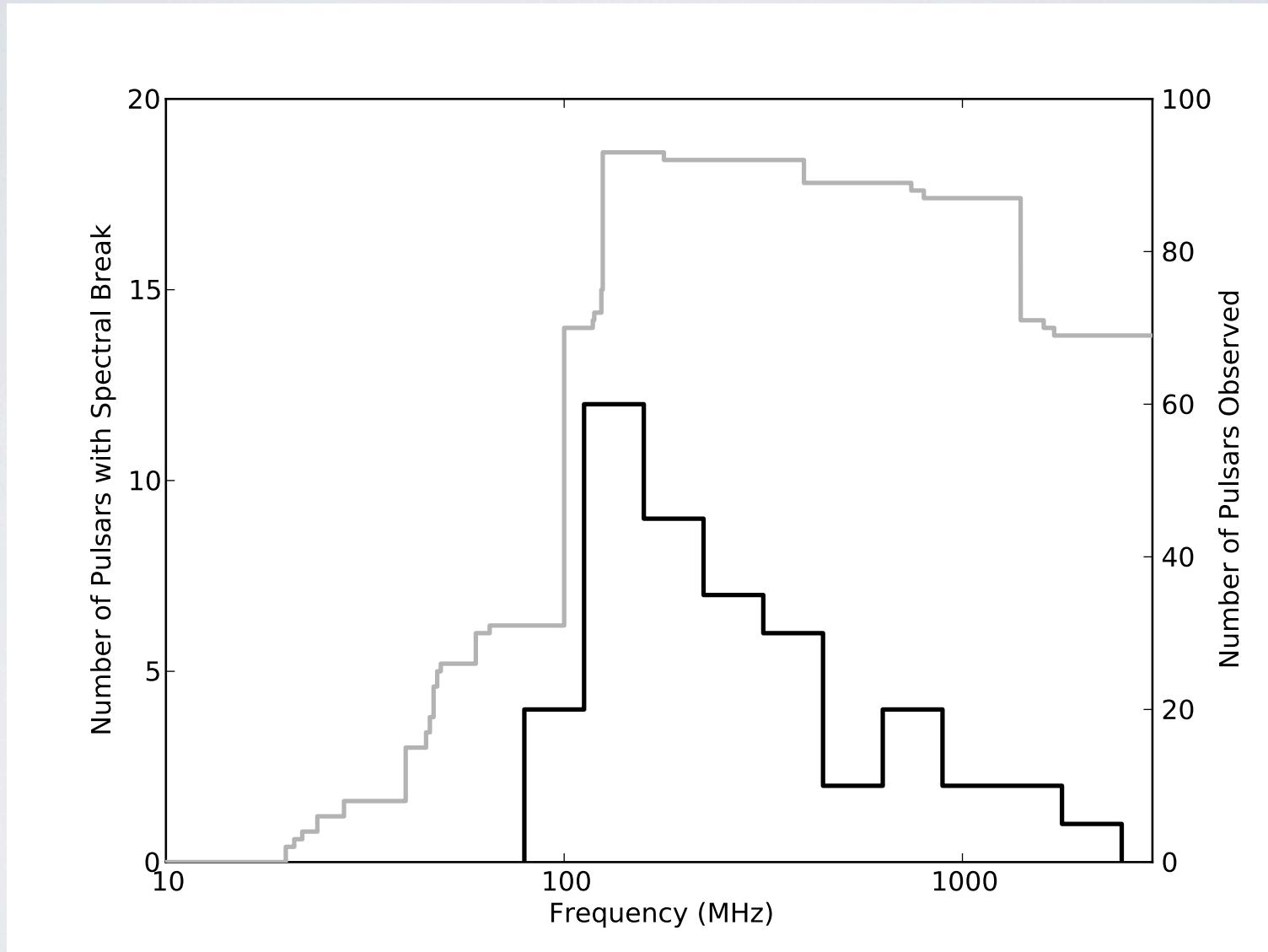
Low-frequency spectral index
(below the turnover... if one is observed)



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Pulsar Spectra

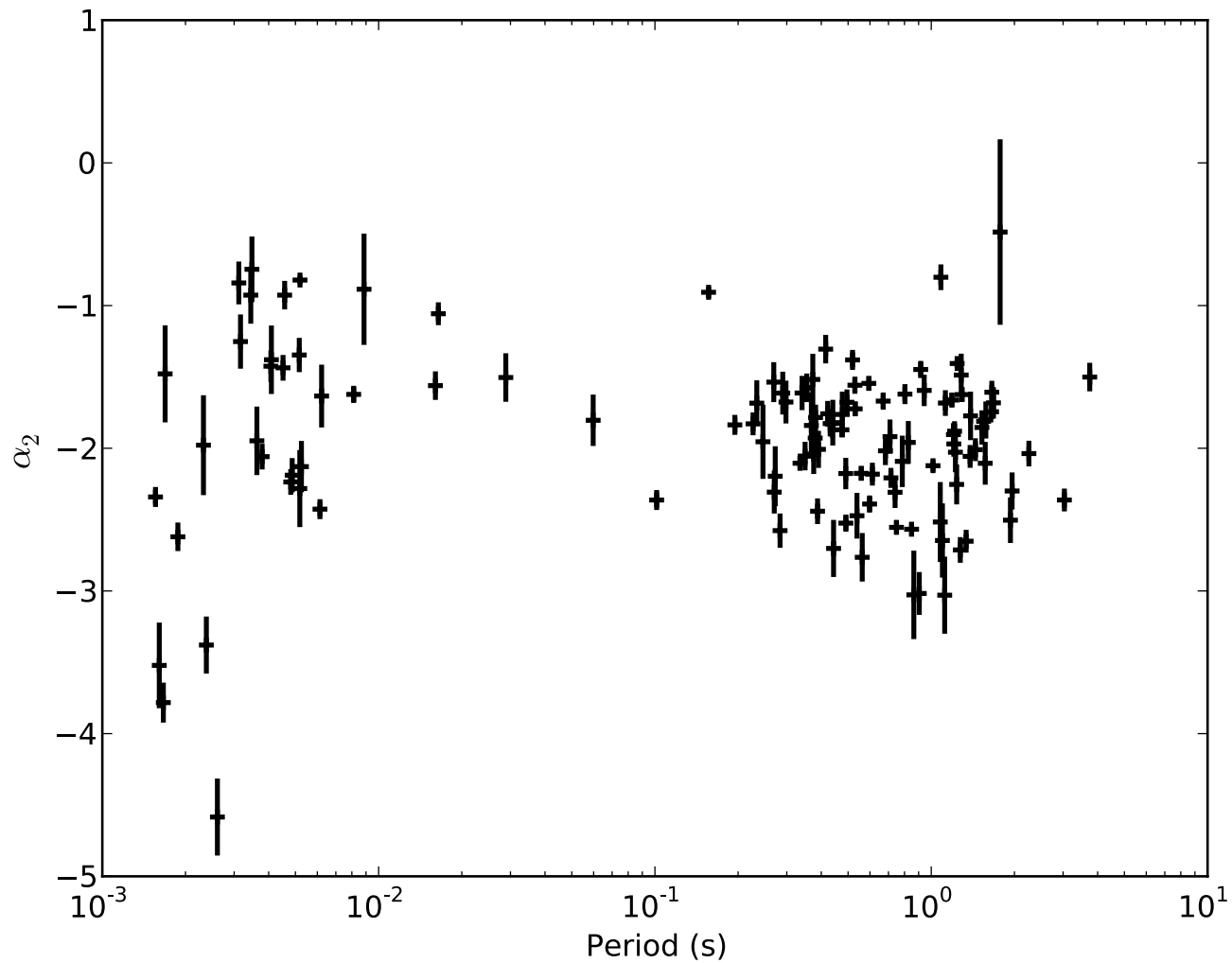
Break frequencies for slow pulsars



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Pulsar Spectra

High-freq. spectral index versus rotational period



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Summary

- Best-ever low-frequency sample of pulsar fluxes.
- Map the distribution of low-frequency spectral turnovers.
- Valuable input for testing emission models.
- No obvious difference between slow and millisecond pulsars.
- However, some very steep spectrum millisecond pulsars identified.