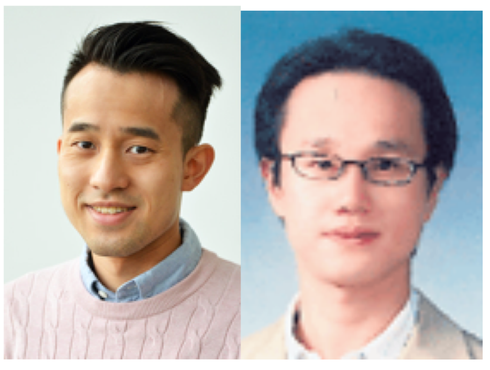
Bayesian Inference on Radio and γ-Ray Pulsars



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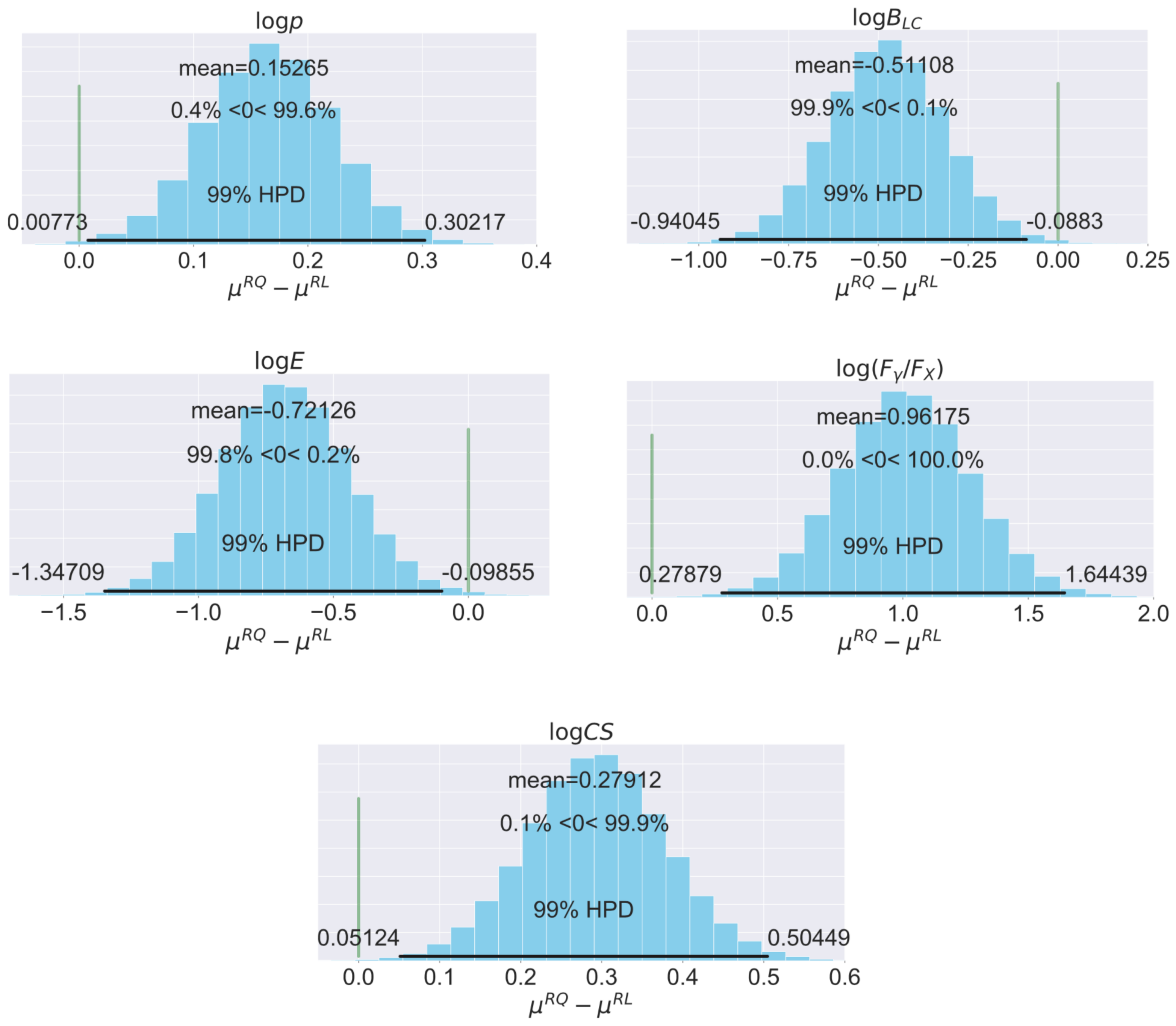
Abstract We demonstrate for the first time using a robust Bayesian approach to analyse the populations of radio-quiet (RQ) and radio-loud (RL) gamma-ray pulsars. We quantify their differences and obtain their distributions of the radio-cone opening half-angle and the magnetic inclination angle by Bayesian inference. In contrast to the conventional frequentist point estimations that might be non-representative when the distribution is highly skewed or multi-modal, which is often the case when data points are scarce, Bayesian statistics displays the complete posterior distribution that the uncertainties can be readily obtained regardless of the skewness and modality. We found that the spin period, the magnetic field strength at the light cylinder, the spin-down power, the gamma-ray-to-X-ray flux ratio, and the spectral curvature significance of the two groups of pulsars exhibit significant differences at the 99% level. Using Bayesian inference, we are able to infer the values and uncertainties of opening half-angle and magnetic inclination angle from the distribution of RQ and RL pulsars. We found that opening half-angle is between 10-35 degrees and the distribution of magnetic inclination angle is skewed towards large values.

Highlight of Results – (1)

Some RQ & RL parameters distribute differently



http://adsabs.harvard.edu/abs/2018ApJ...857..120Y

Scan QR code to get the paper!

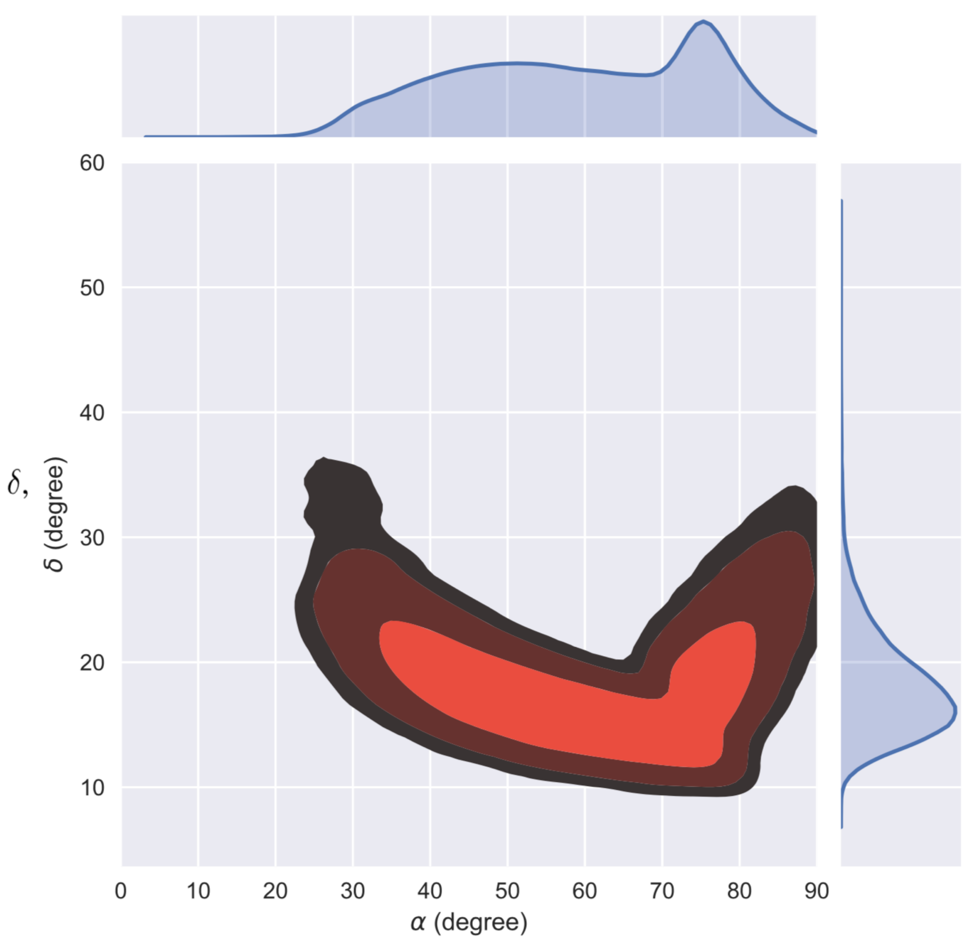
Highlight of Results – (2)

Direct inference of radio cone opening angle, δ, & magnetic inclination angle, α

Likelihood function :

$$f_{\mathrm{RQ}}(\alpha,\delta)=\begin{cases}\cos(\alpha+\delta) & \text{for } \alpha<\delta,\\ 1-2\sin\alpha\sin\delta & \text{for } \delta\leqslant\alpha\leqslant\frac{\pi}{2}-\delta,\\ 1-\cos(\alpha-\delta) & \text{for } \alpha\geqslant\frac{\pi}{2}-\delta,\end{cases}$$

$$\mathbb{P}(N,R|\alpha,\delta)\propto[f_{\mathrm{RQ}}(\alpha,\delta)]^R \times[1-f_{\mathrm{RQ}}(\alpha,\delta)]^{N-R}.$$

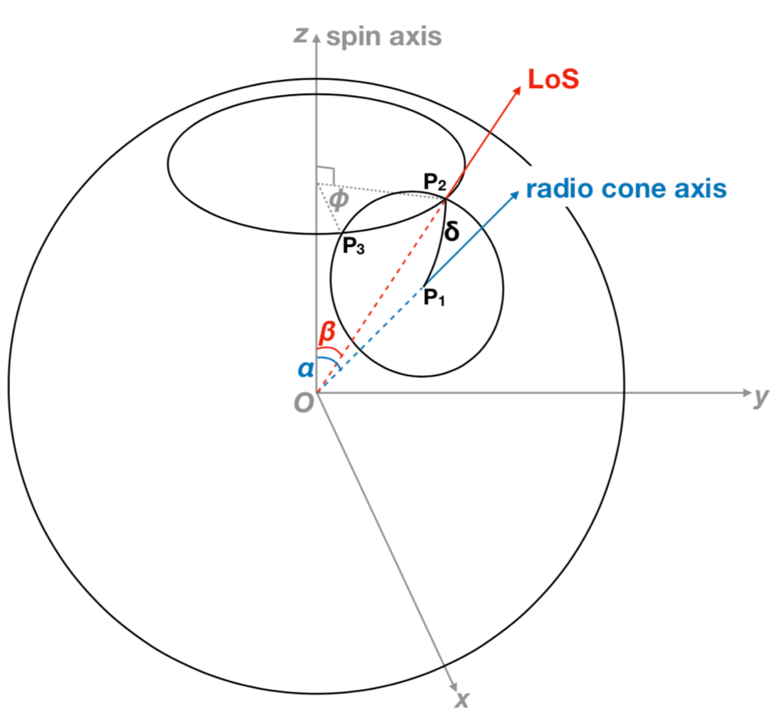


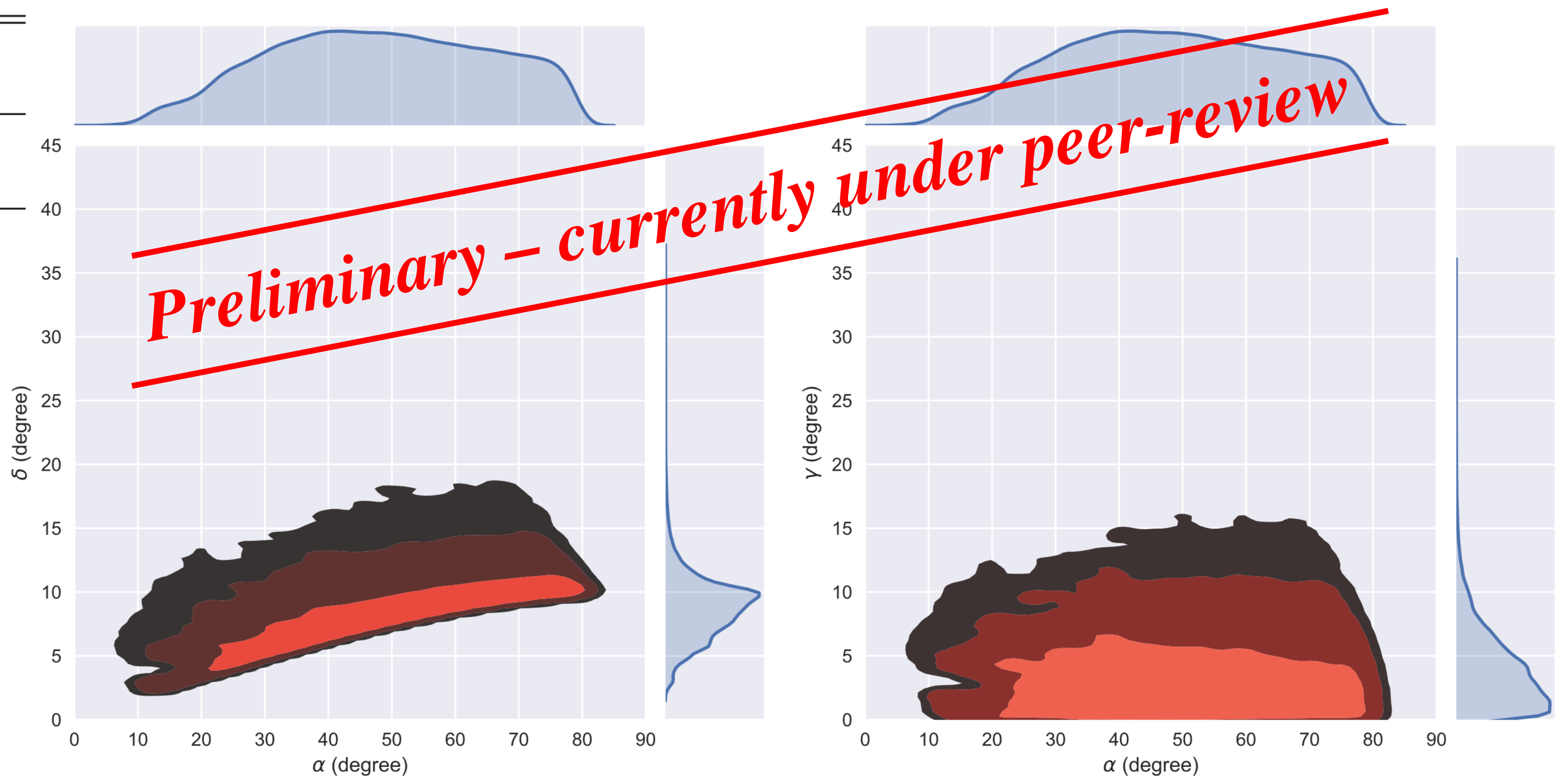
Follow-up work –

How about line-of-sight orientation?

Direct inference δ, α, and impact angle γ, using the information of <u>radio pulse width</u>!

Pulsars	α (°)	δ (°)	β (°)	γ (°)
Radio selected	$48.25^{+31.33}_{-31.42}$	$8.78^{+7.93}_{-6.35}$	$48.48^{+33.79}_{-35.19}$	$3.99^{+10.41}_{-3.99}$
γ-ray selected	$62.74^{+27.26}_{-35.16}$	$18.73^{+12.18}_{-7.38}$	...	...





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