Modeling the nHz gravitational wave background with t-process

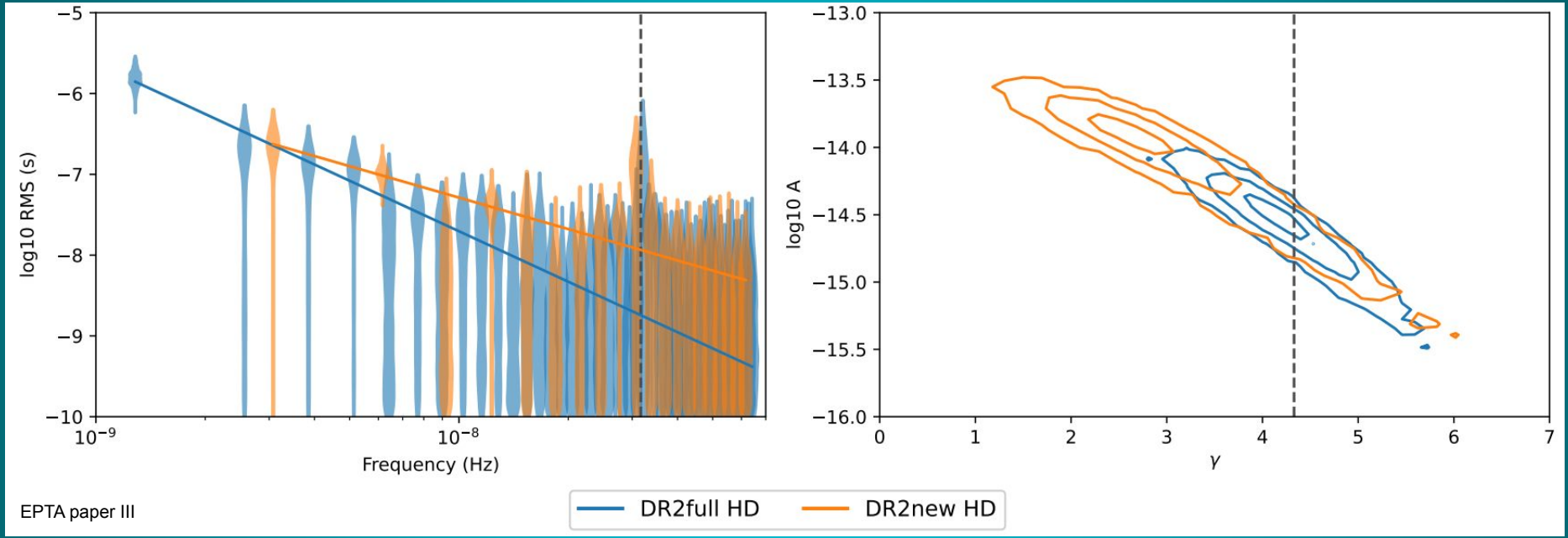
Beatrice Eleonora Moreschi

Third year PhD student

1st BiCoQ Conference: from gravity to particles

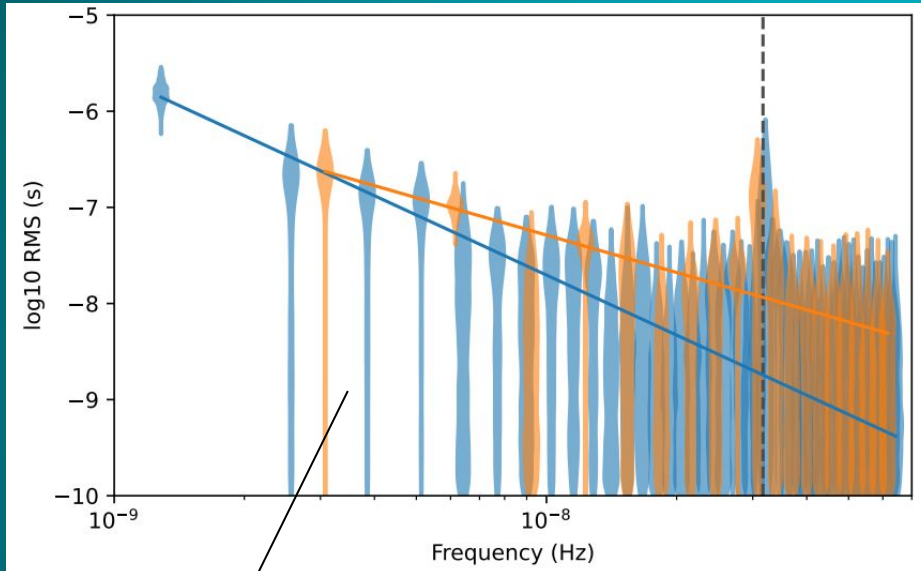
17/06/2026

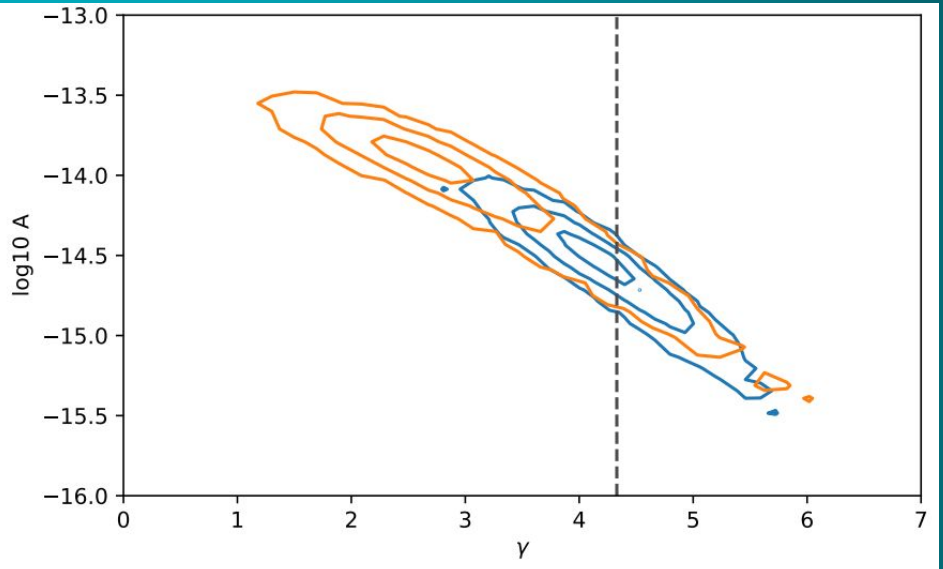
What is the t-process?



EPTA paper III

What is the t-process?





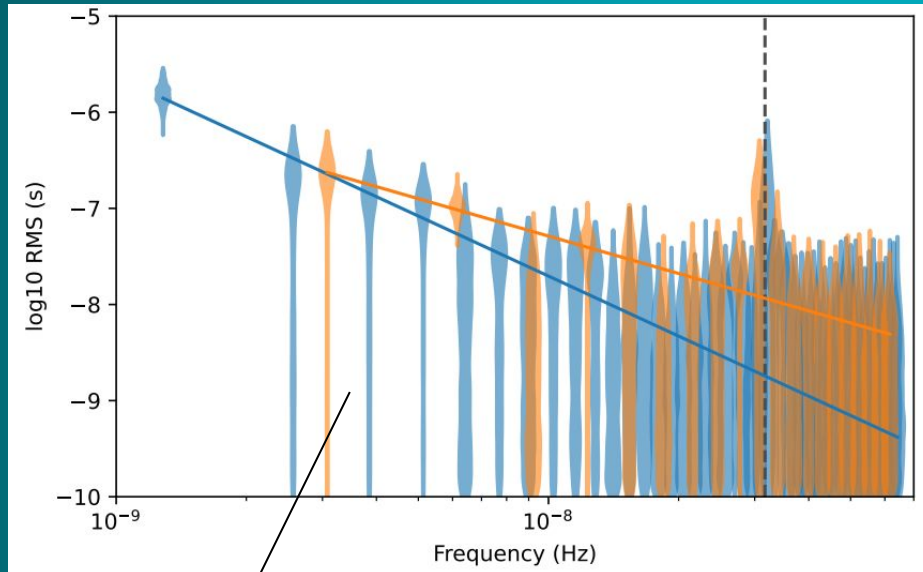
EPTA paper III

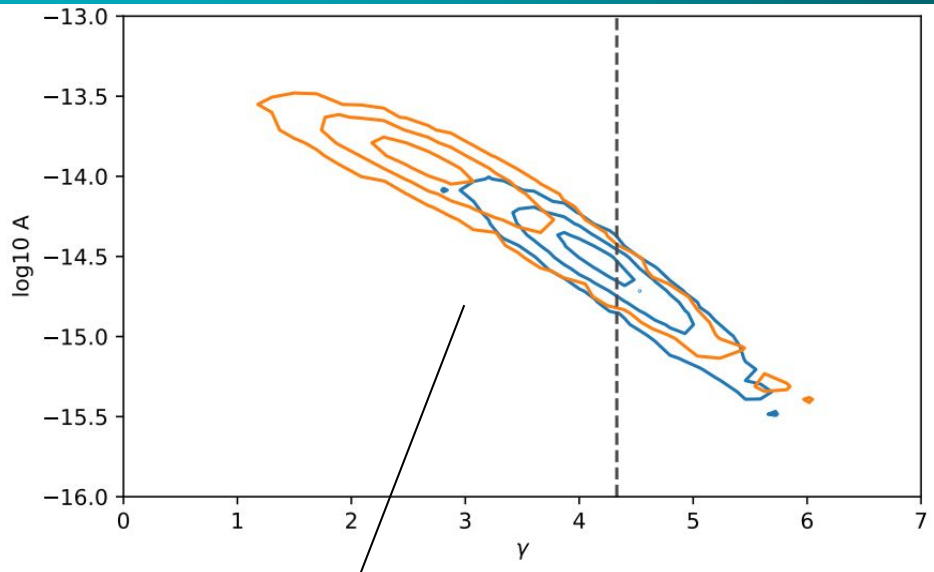
DR2new HD

$$P_{\mathrm{fs}}(f_i) = \frac{h_c^2(f_i)}{12\pi^2 f_i^3} df = \delta t^2_{\mathrm{delay}}(f_i)$$

Agnostic model, it allows for deviations in the PSD from a power law

What is the t-process?





EPTA paper III

DR2new HD

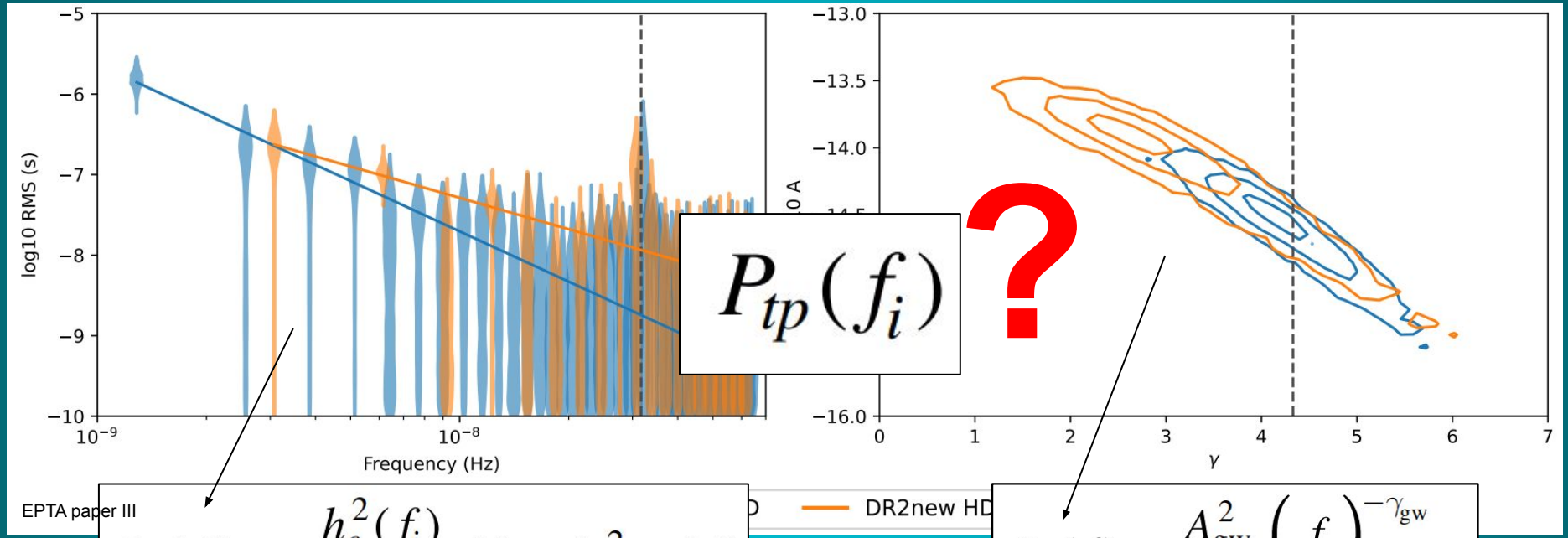
$$P_{\rm fs}(f_i) = \frac{h_c^2(f_i)}{12\pi^2 f_i^3} df = \delta t^2_{\rm delay}(f_i)$$

Agnostic model, it allows for deviations in the PSD from a power law

$$P_{\rm pl}(f) = \frac{A^2_{\rm gw}}{12\pi^2}\left(\frac{f}{f_{\rm yr}}\right)^{-\gamma_{\rm gw}} df$$

Relationship between the power at different frequencies

What is the t-process?



$$P_{tp}(f_i)$$

?

$$P_{\rm fs}(f_i) = \frac{h_c^2(f_i)}{12\pi^2 f_i^3} df = \delta t^2_{\rm delay}(f_i)$$

Agnostic model, it allows for deviations in the PSD from a power law

$$P_{\rm pl}(f) = \frac{A^2_{\rm gw}}{12\pi^2}\left(\frac{f}{f_{\rm yr}}\right)^{-\gamma_{\rm gw}} df$$

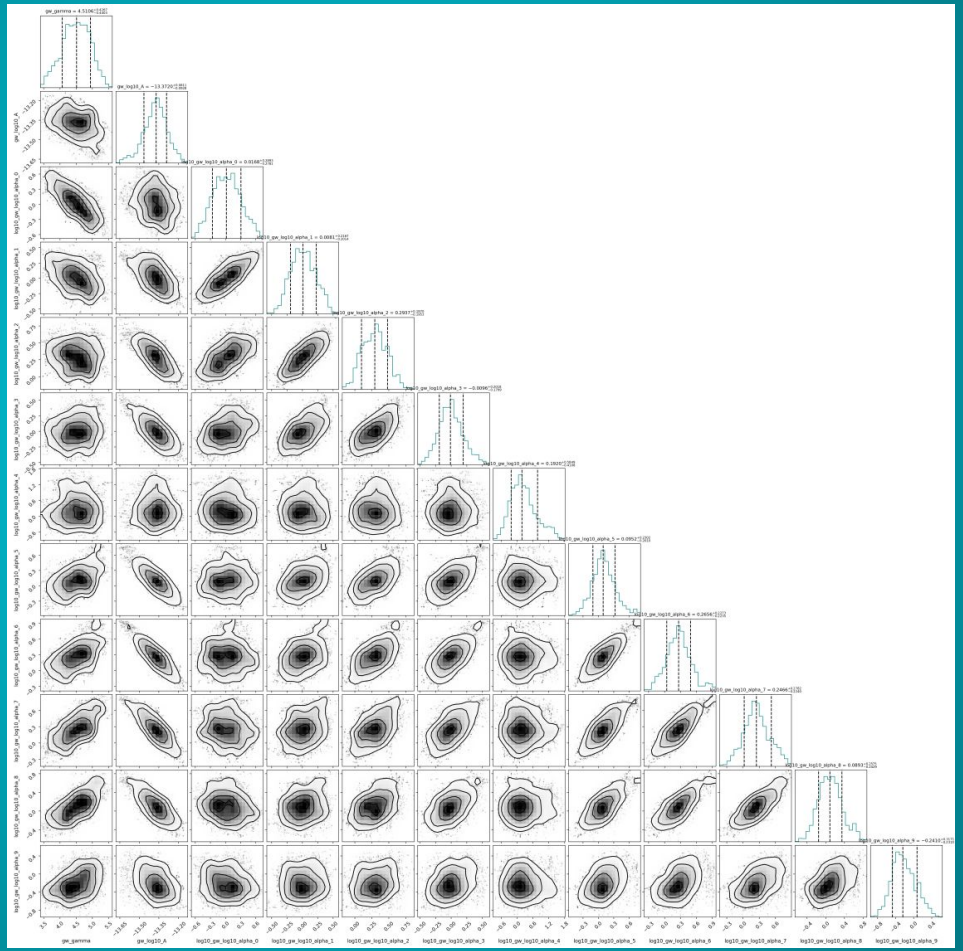
Relationship between the power at different frequencies

What is the t-process?

$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$

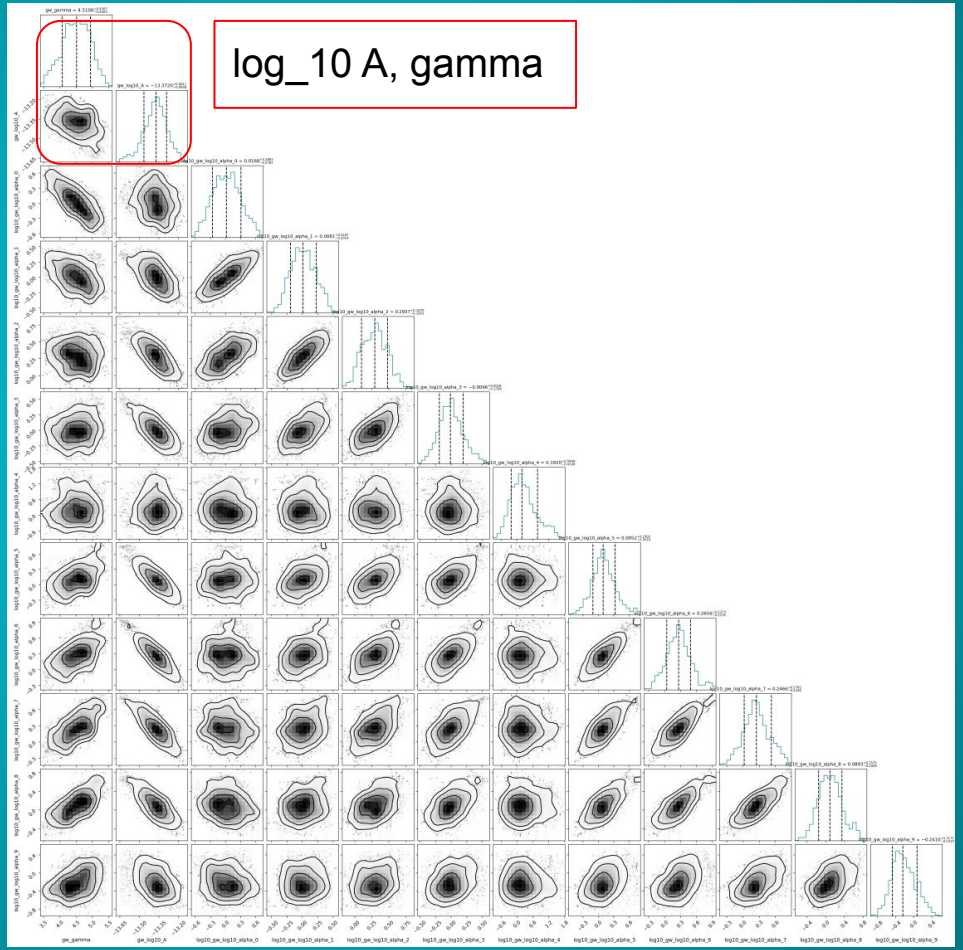
What is the t-process?

$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$



What is the t-process?

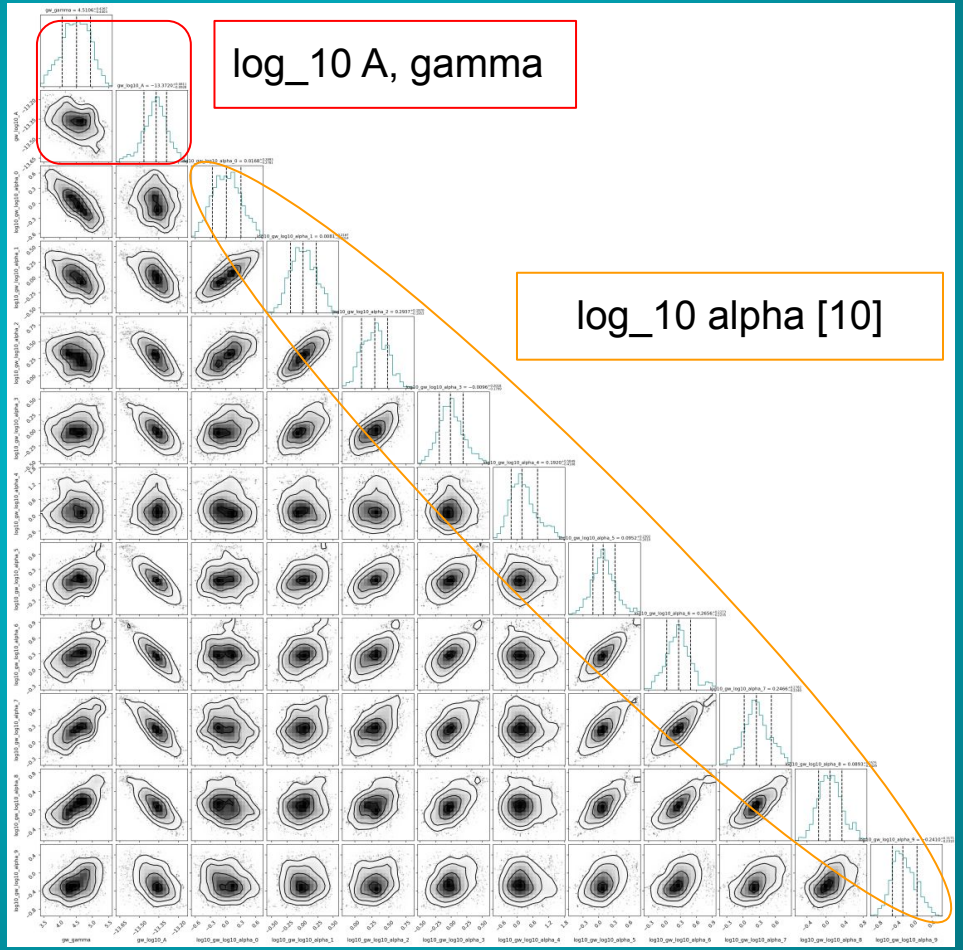
$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$



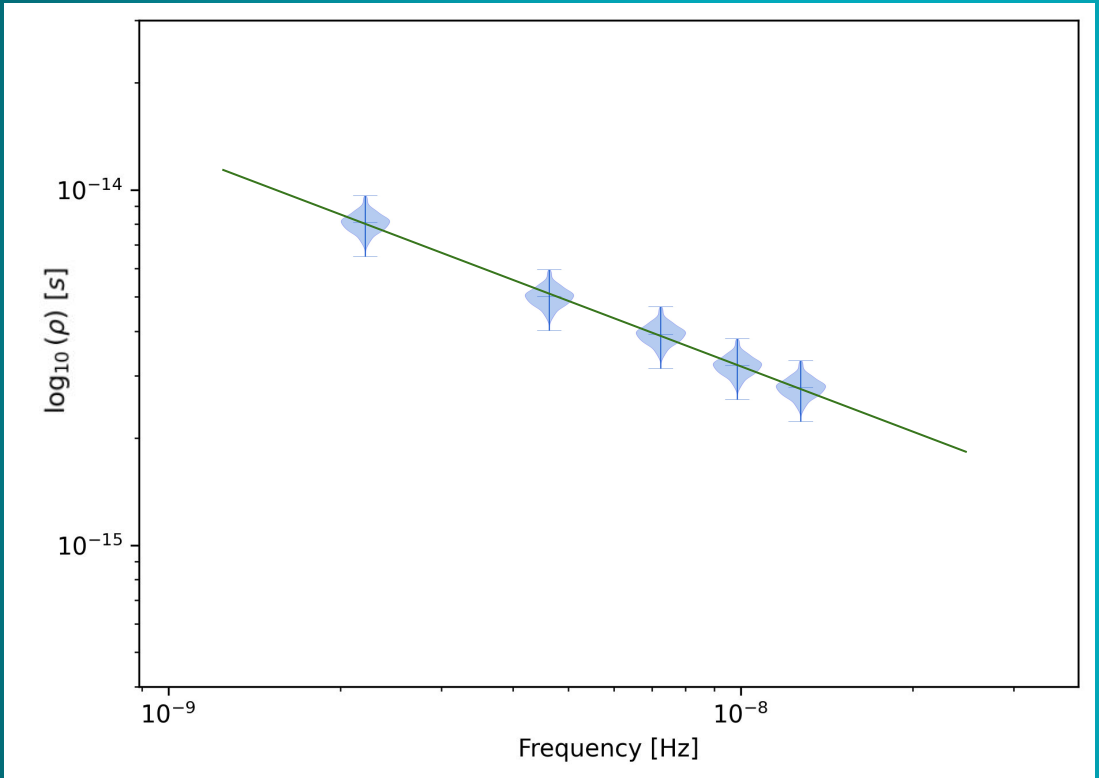
log_10 A, gamma

What is the t-process?

$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$



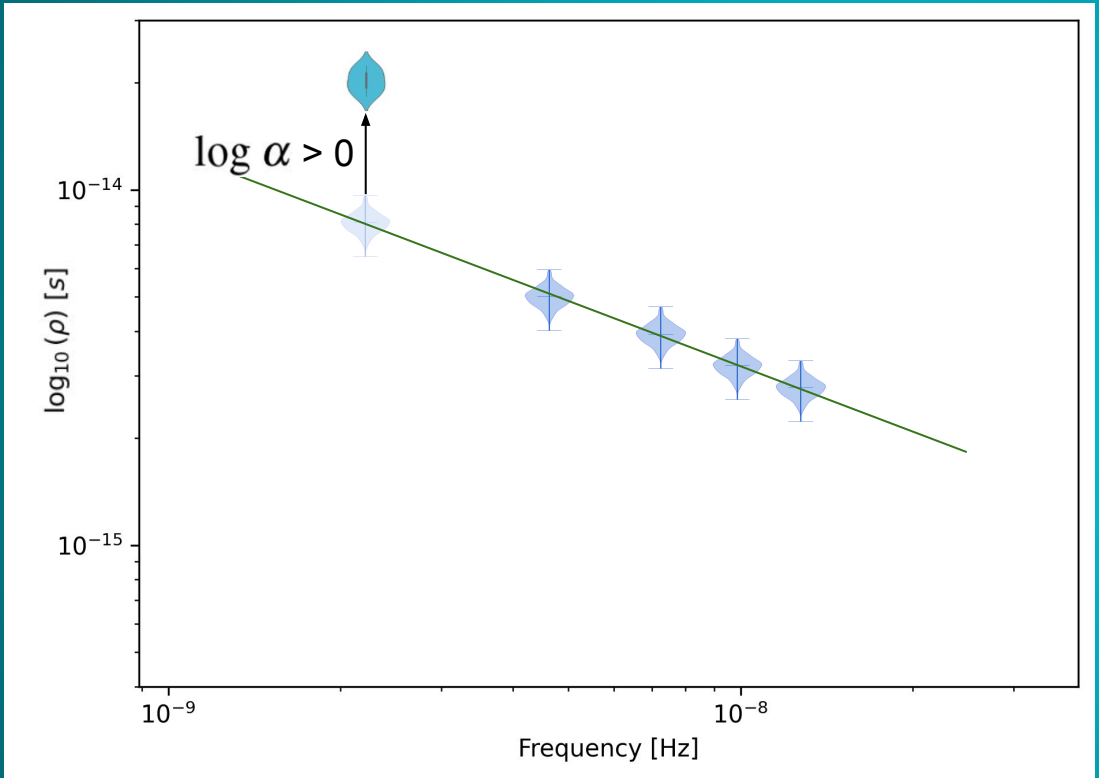
What is the t-process?



$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$

- Shashwat C. Sardesai et al. 2024
- Agazie et al. 2023 (NANOGrav 15 years, fs and pl different)
- Arzoumanian et al. 2020, used t-process on J0613−0200
- K. Aggarwal et al. 2019 (PSR J0613−0200 has unmodeled signal)

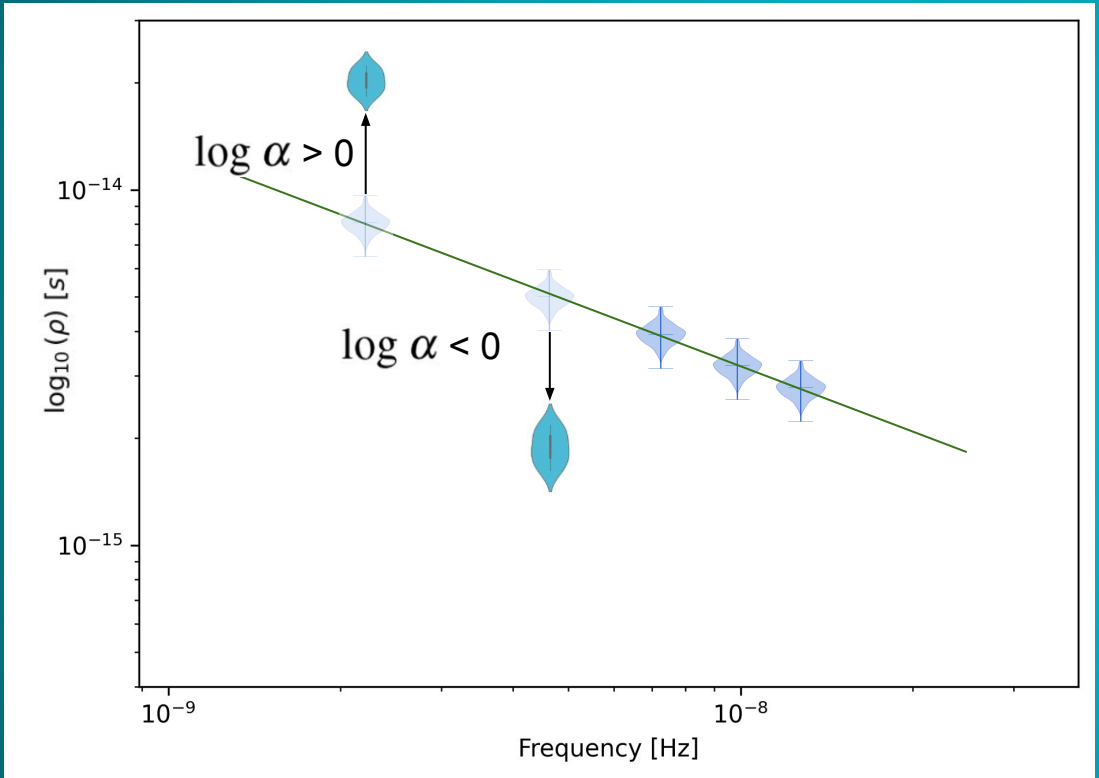
What is the t-process?



$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$

- Shashwat C. Sardesai et al. 2024
- Agazie et al. 2023 (NANOGrav 15 years, fs and pl different)
- Arzoumanian et al. 2020, used t-process on J0613−0200
- K. Aggarwal et al. 2019 (PSR J0613−0200 has unmodeled signal)

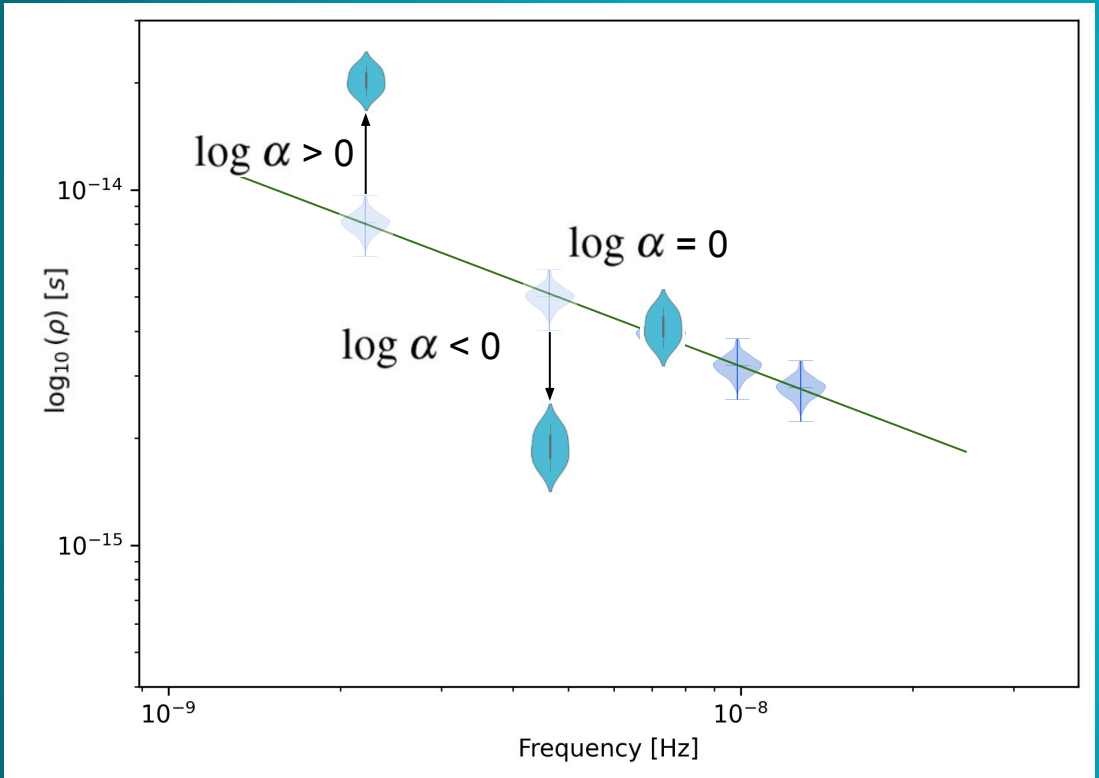
What is the t-process?



$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$

- Shashwat C. Sardesai et al. 2024
- Agazie et al. 2023 (NANOGrav 15 years, fs and pl different)
- Arzoumanian et al. 2020, used t-process on J0613−0200
- K. Aggarwal et al. 2019 (PSR J0613−0200 has unmodeled signal)

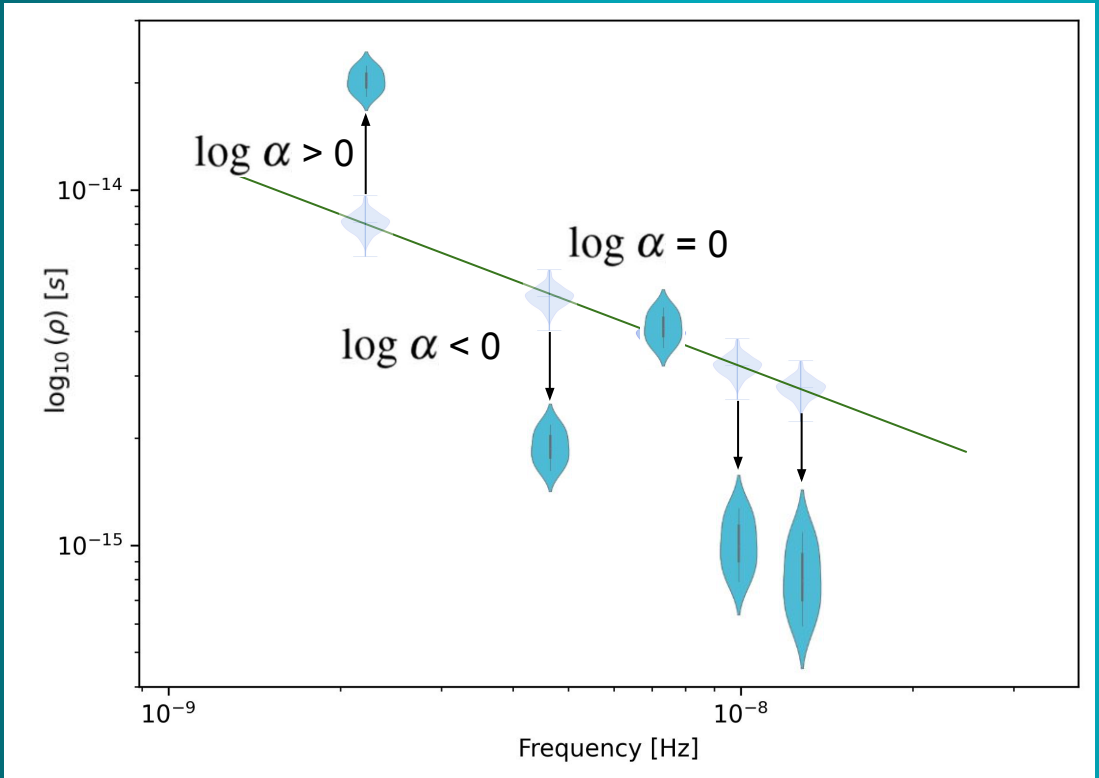
What is the t-process?



$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$

- Shashwat C. Sardesai et al. 2024
- Agazie et al. 2023 (NANOGrav 15 years, fs and pl different)
- Arzoumanian et al. 2020, used t-process on J0613−0200
- K. Aggarwal et al. 2019 (PSR J0613−0200 has unmodeled signal)

What is the t-process?



$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$

- Shashwat C. Sardesai et al. 2024
- Agazie et al. 2023 (NANOGrav 15 years, fs and pl different)
- Arzoumanian et al. 2020, used t-process on J0613−0200
- K. Aggarwal et al. 2019 (PSR J0613−0200 has unmodeled signal)

What is the t-process?

$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$

$$\alpha_i \sim \mathrm{invgam}(1, 1).$$

The inverse gamma function follows a probability of

$$invgam(\alpha_{\mathbf{i}}, 1, 1) = \frac{1}{\Gamma(1)} \alpha_{\mathbf{i}}^{-2} \exp\left(-\frac{1}{\alpha_{\mathbf{i}}}\right),$$

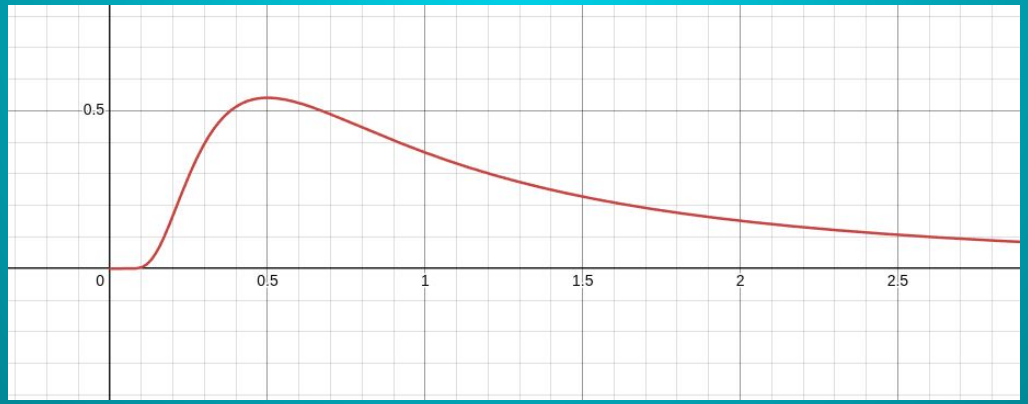
What is the t-process?

$$P_{tp}(f_i) = \alpha_i P_{\mathrm{pl}}(f_i)$$

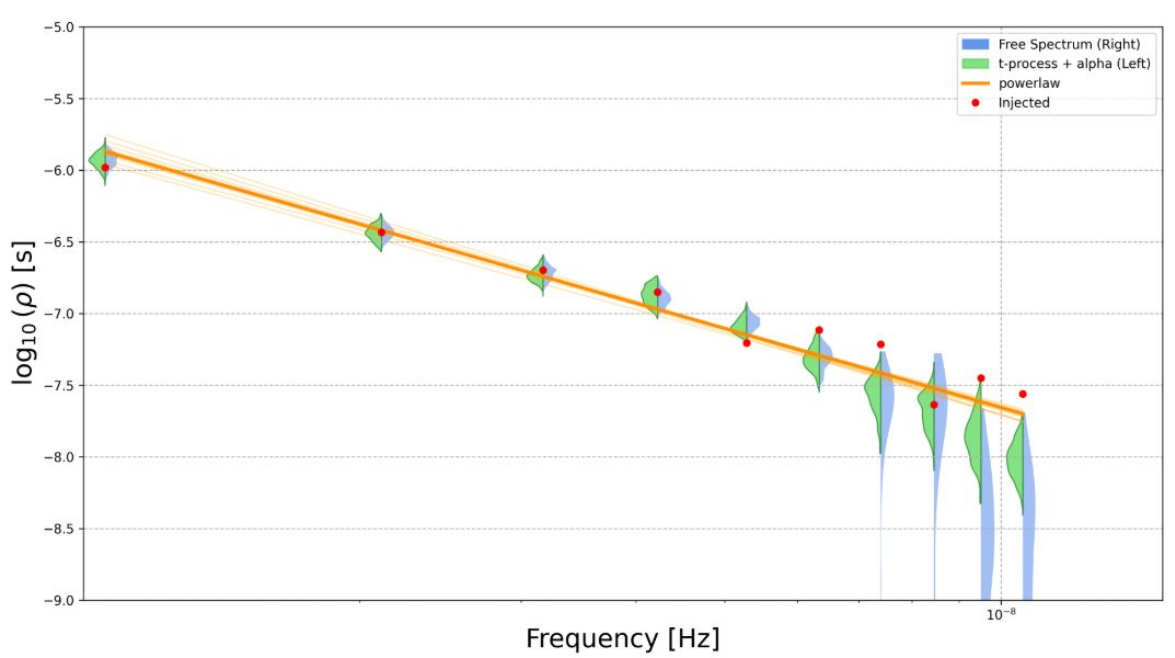
$$\alpha_i \sim \mathrm{invgam}(1, 1).$$

The inverse gamma function follows a probability of

$$invgam(\alpha_\mathbf{i}, 1, 1) = \frac{1}{\Gamma(1)} \alpha_\mathbf{i}^{-2} \exp\left(-\frac{1}{\alpha_\mathbf{i}}\right),$$



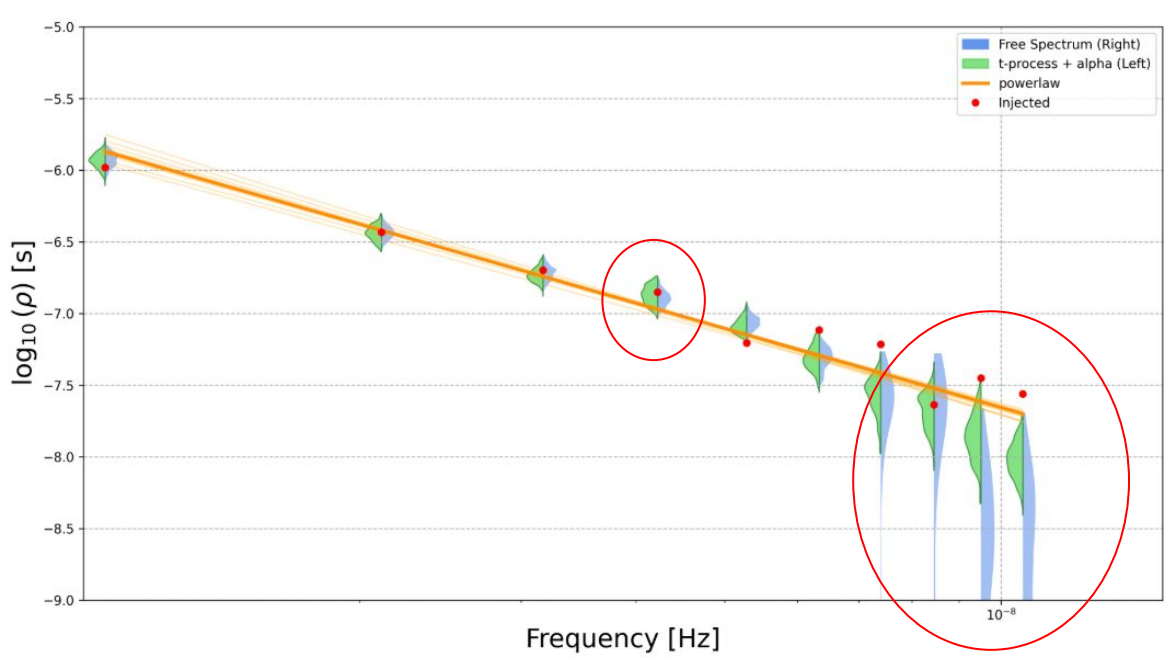
Test on simulated dataset



Real population
e = 0.9
+ strong environment effects

20 pulsars
10 bins

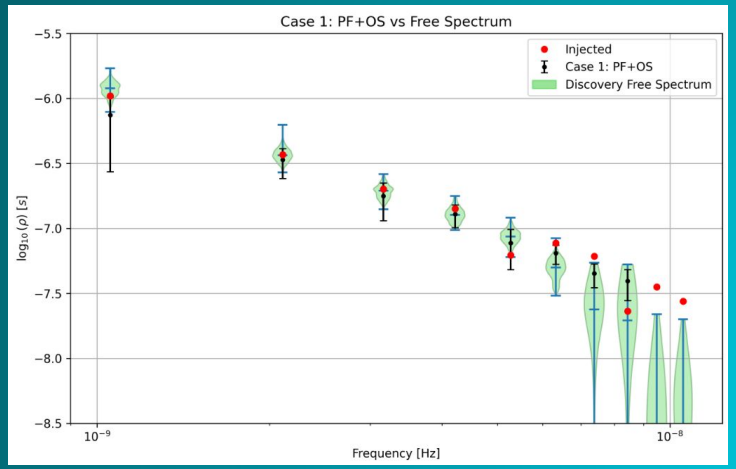
Test on simulated dataset

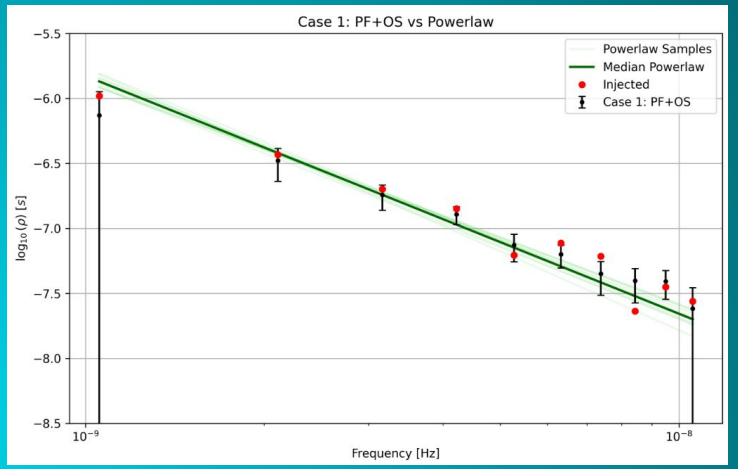


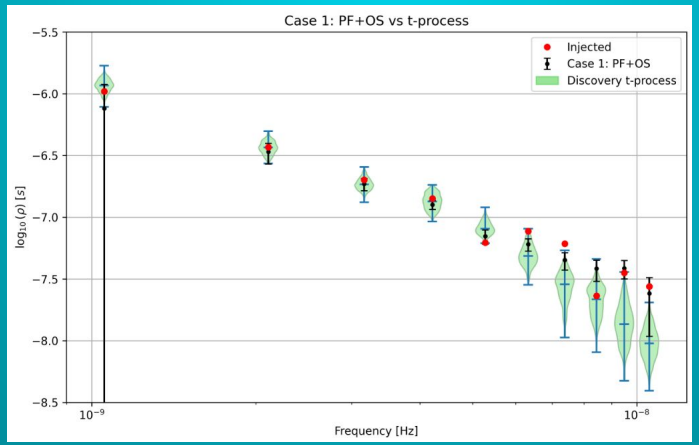
Real population
e = 0.9
+ strong environment effects

20 pulsars
10 bins

PFOS on simulated dataset





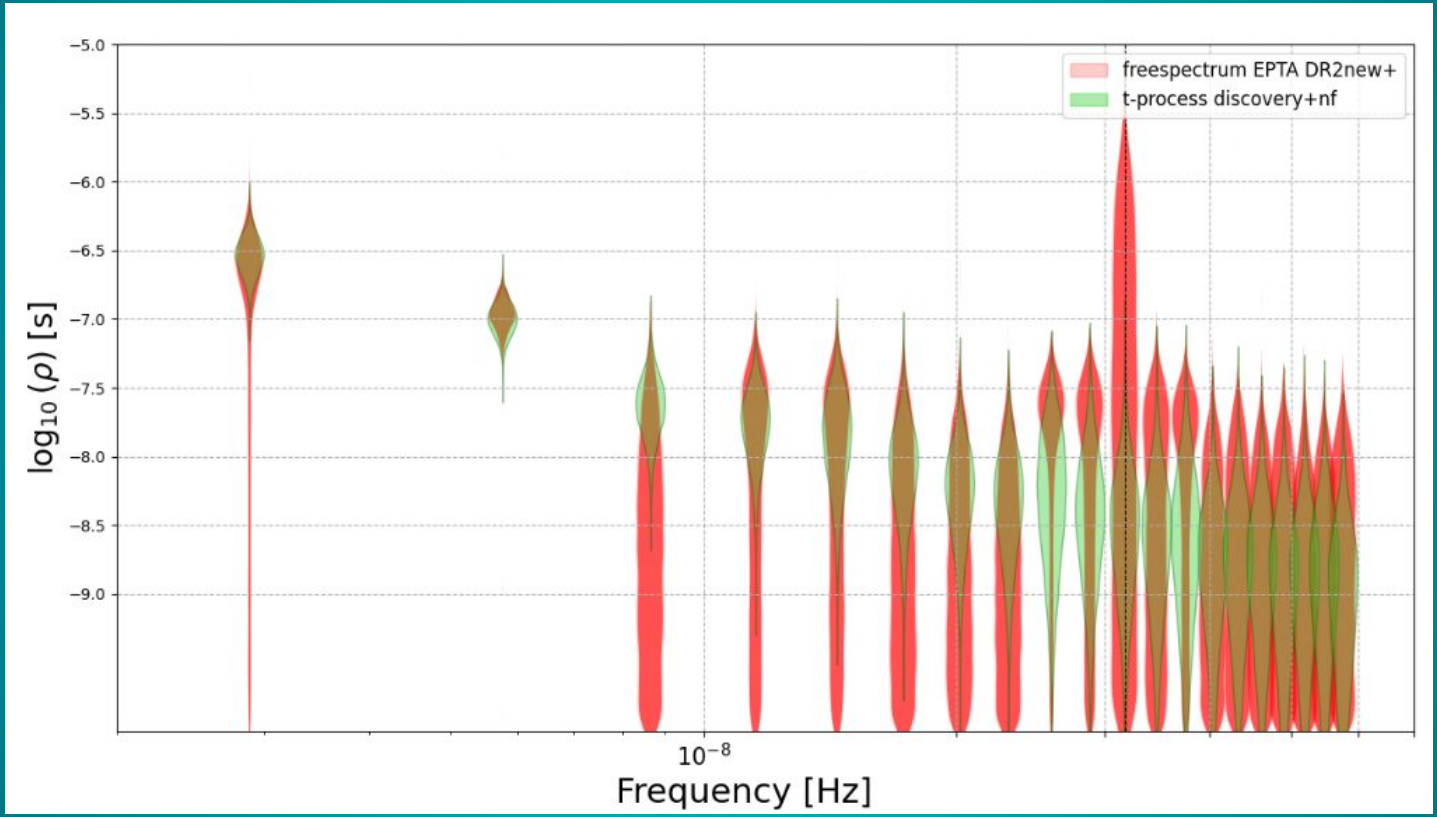


T-process and freespectrum are able to model better CGW

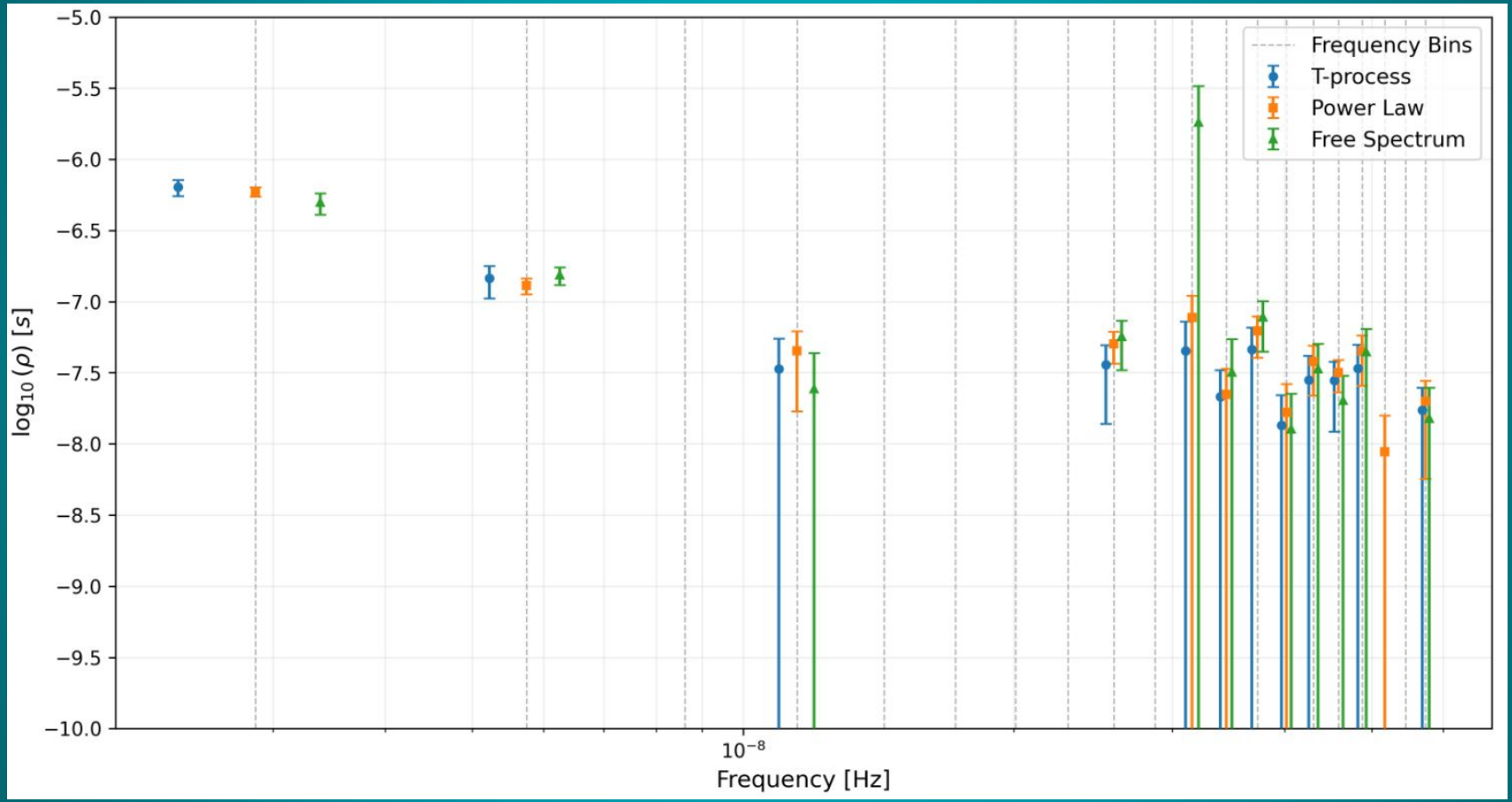
Freespectrum -> worse performance in the PFOS

T-process -> higher freq bin are more constrained

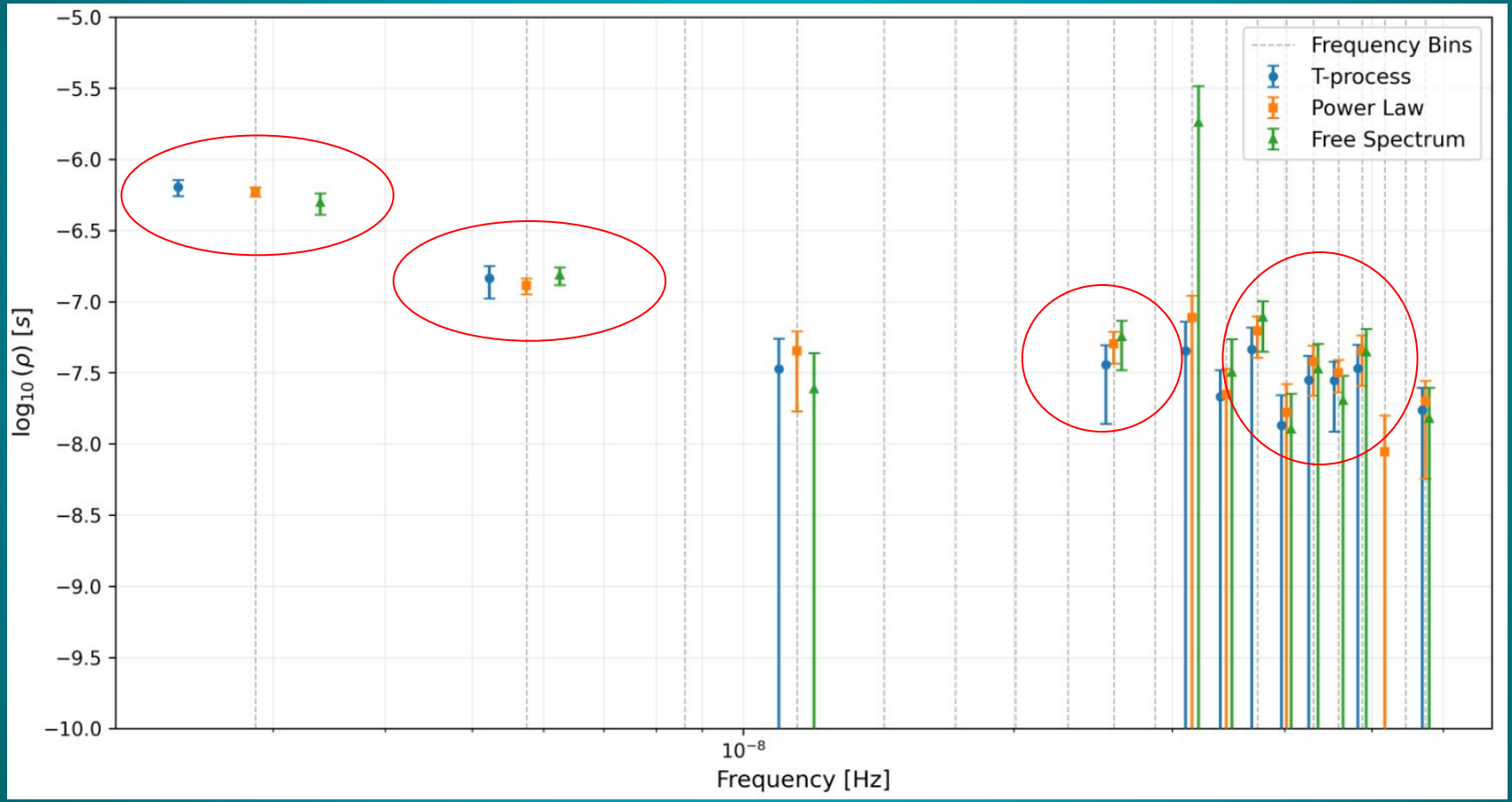
Test on EPTA DR2new+



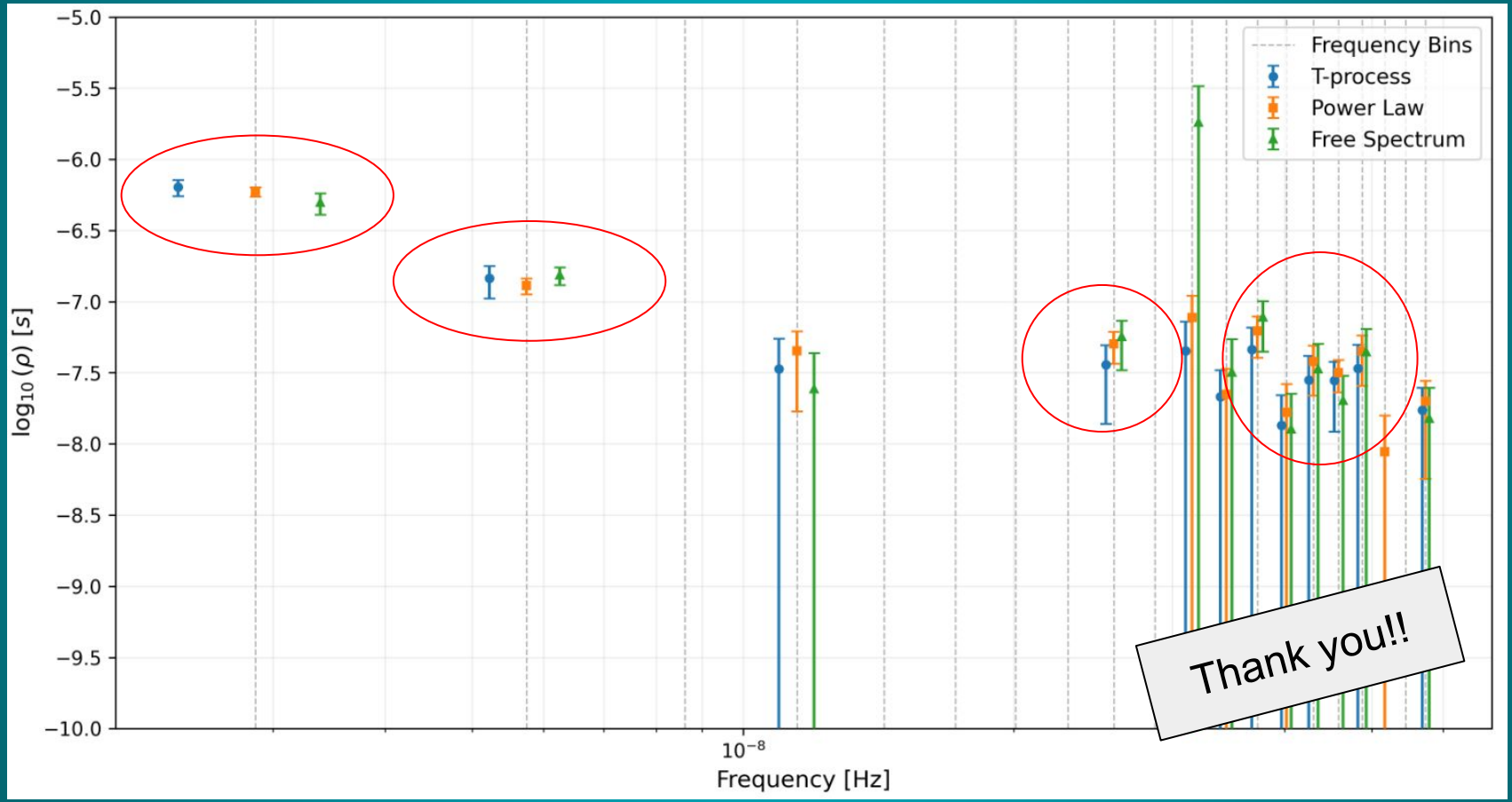
PFOS on EPTA DR2new+



PFOS on EPTA DR2new+

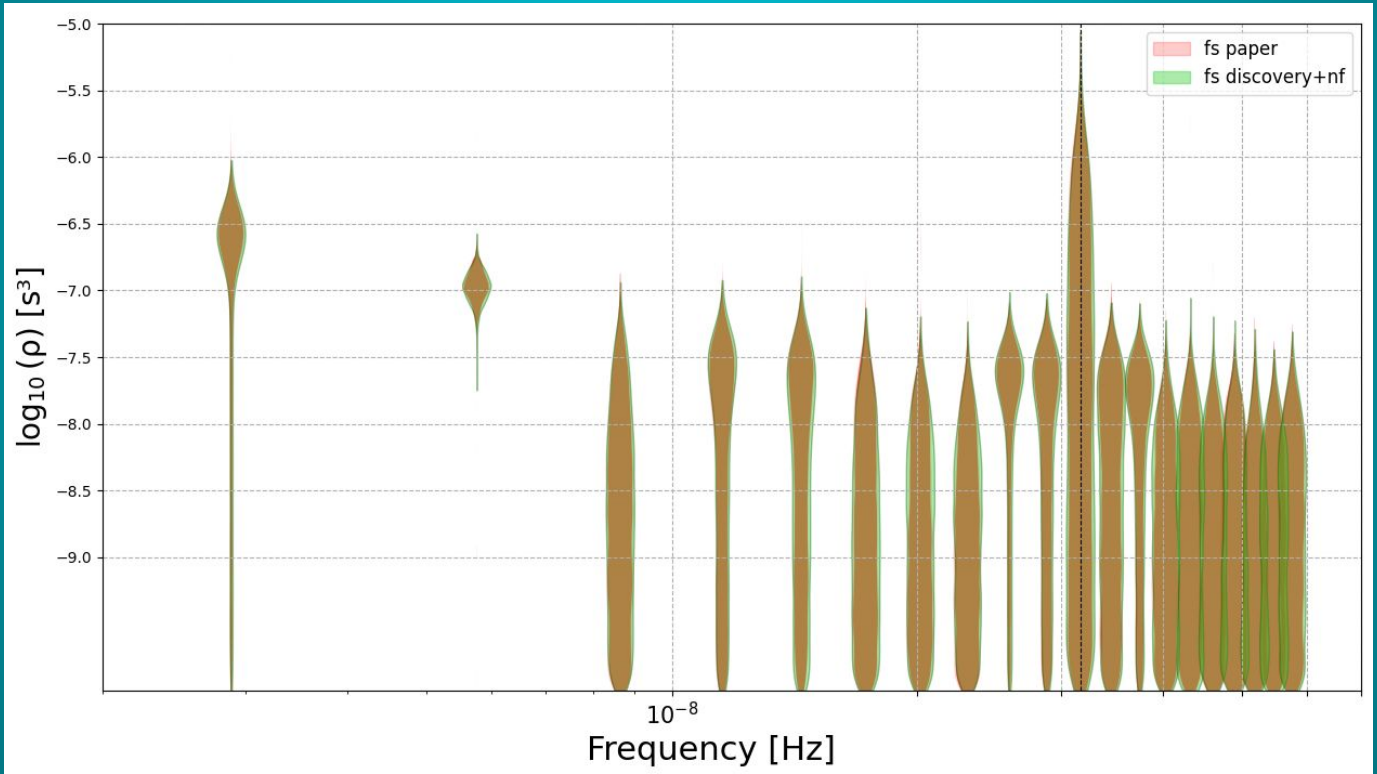


PFOS on EPTA DR2new+

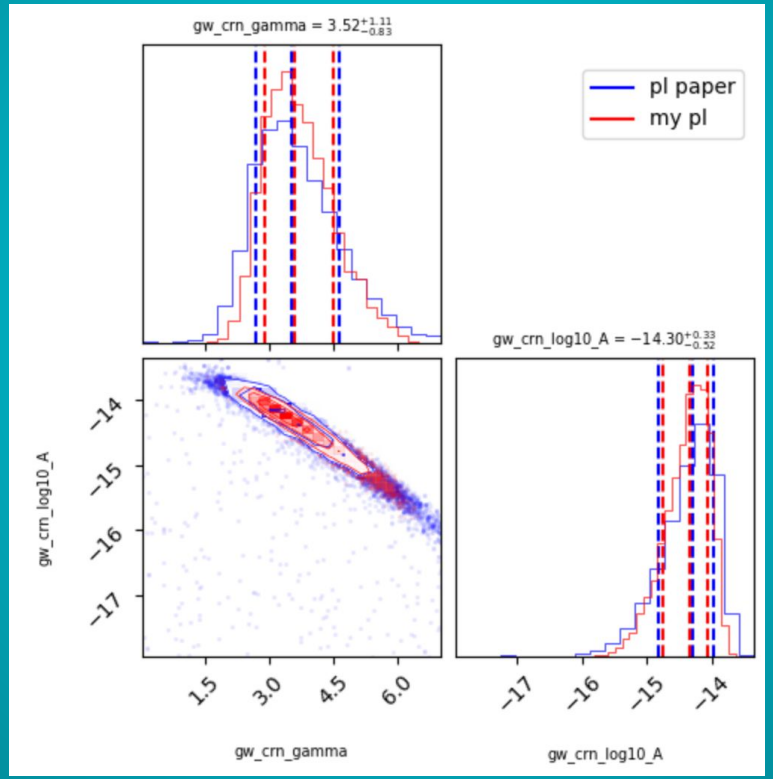


bk

Comparison enterprise vs discovery with EPTA DR2 new+



Comparison enterprise vs discovery with EPTA DR2 new+



Test on t-process model