# BNSs populations in the Milky Way

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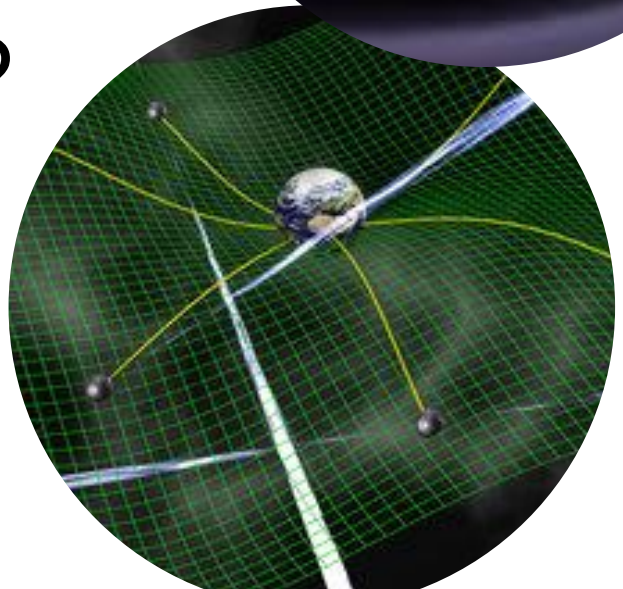
SISSA

# Why study the BNSs?



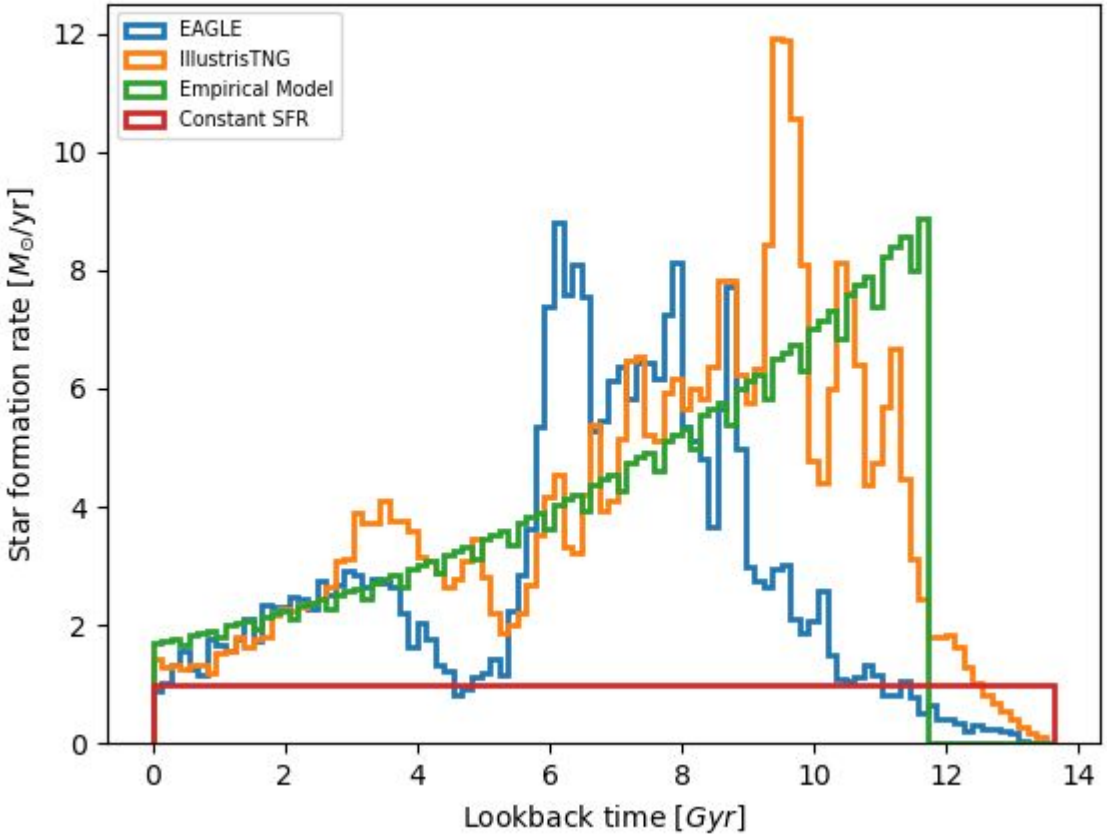
# 3 main ingredients ...

Milky-Way model

Stellar evolution

Neutron Star evolution

# Milky Way model




1. $SFR(z = 0) \sim 1.65 \mathrm{M}_\odot \mathrm{yr}^{-1}$
2. $M_* \sim 5 \times 10^{10} M_\odot$

EAGLE Schaye et al. 2015
IllustrisTNG Nelson et al. 2019


# Stellar EVolution N-body

Population synthesis code written in C++

https://gitlab.com/sevncodes/sevn

## STELLAR EVOLUTION

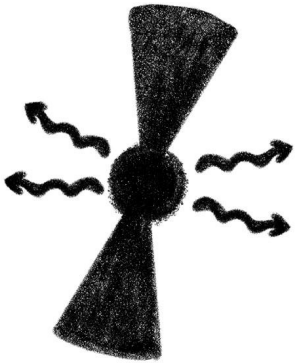
Interpolation of
precomputed stellar tracks

+

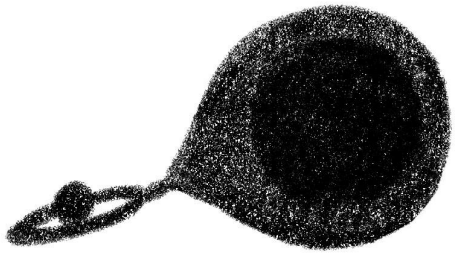
## BINARY PROCESSES

Analytical and
semi-analytical models

Spera and Mapelli 2017, Spera et al. 2015, Spera et al. 2019, Iorio et al. 2022



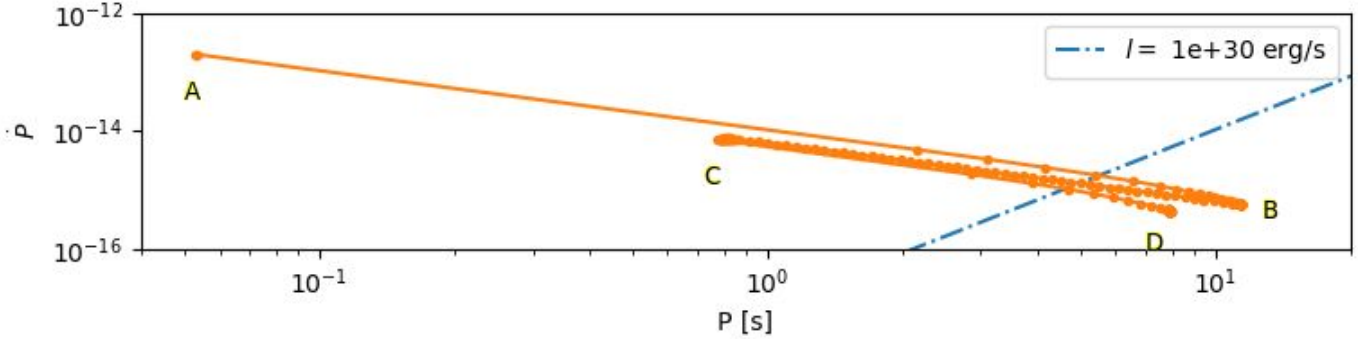
Spin-down

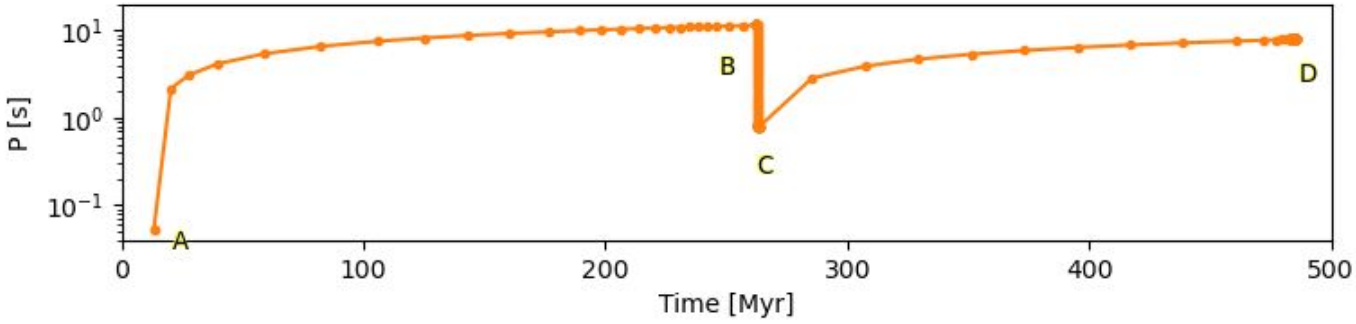


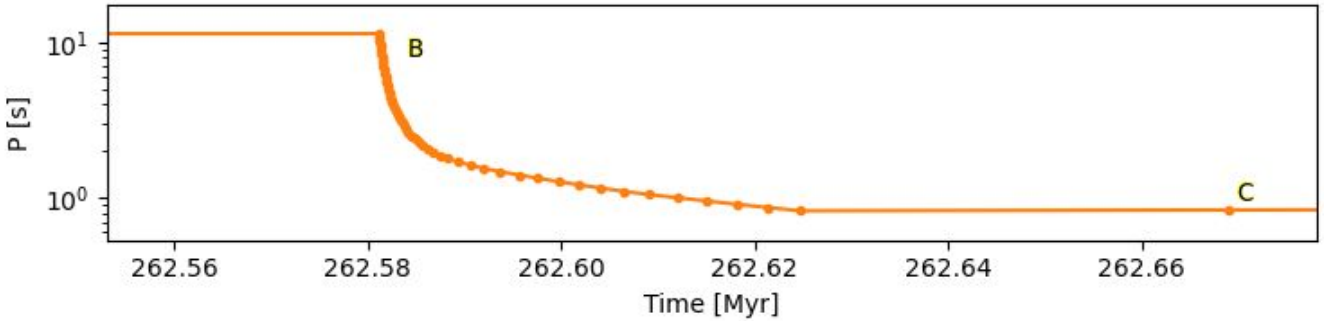
Spin-up

Radio Selection Effects

PSRPOPPY
Lorimer et al. 2011




- A. First NS
- B. Roche Lobe Overflow
- C. End of Roche Lobe Overflow
- D. Second Compact object

BNSs
with SEVN

populate

Milky-Way

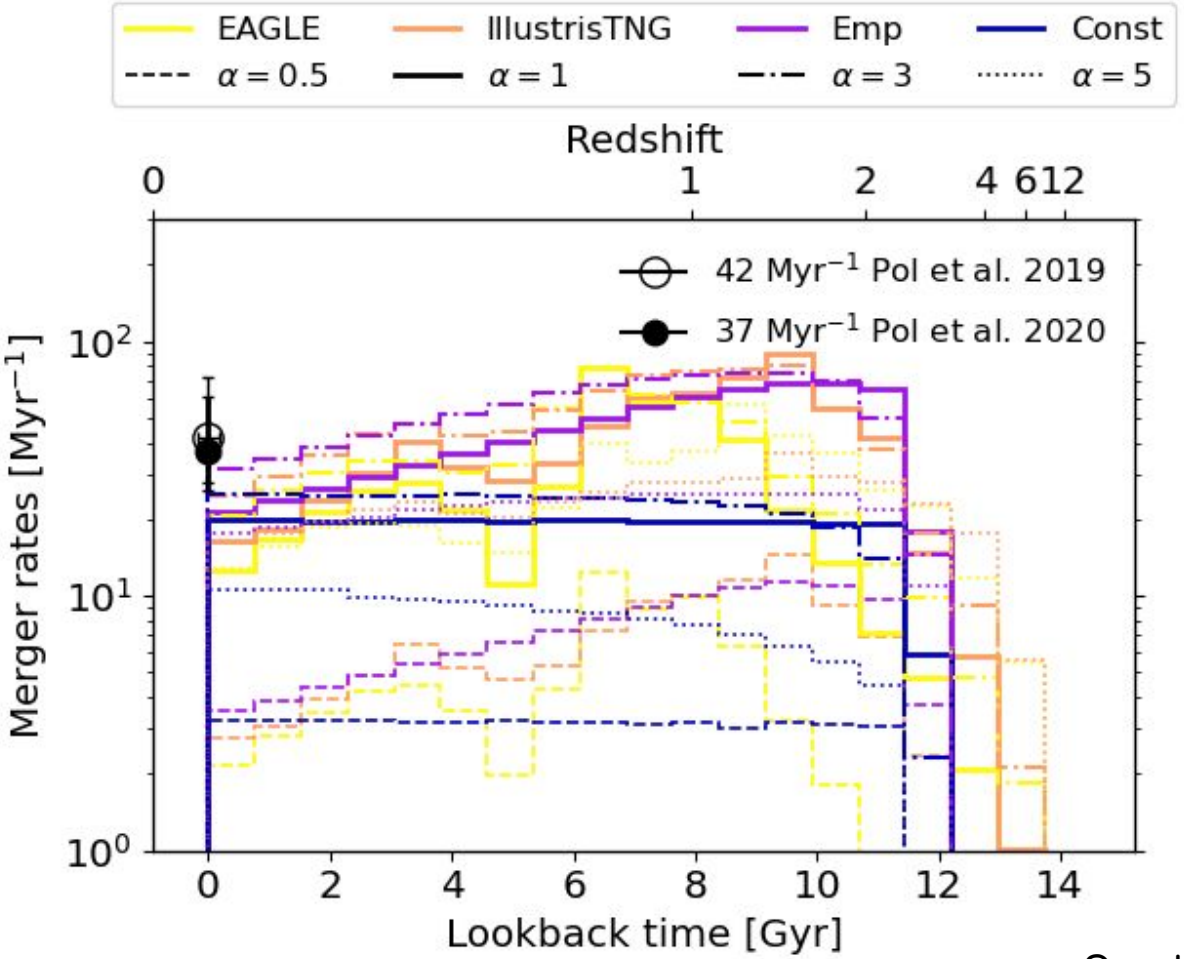
evolution
- Gravitational Waves
- NSs properties

Merger

Today

Repeat
with different parameters / prescriptions

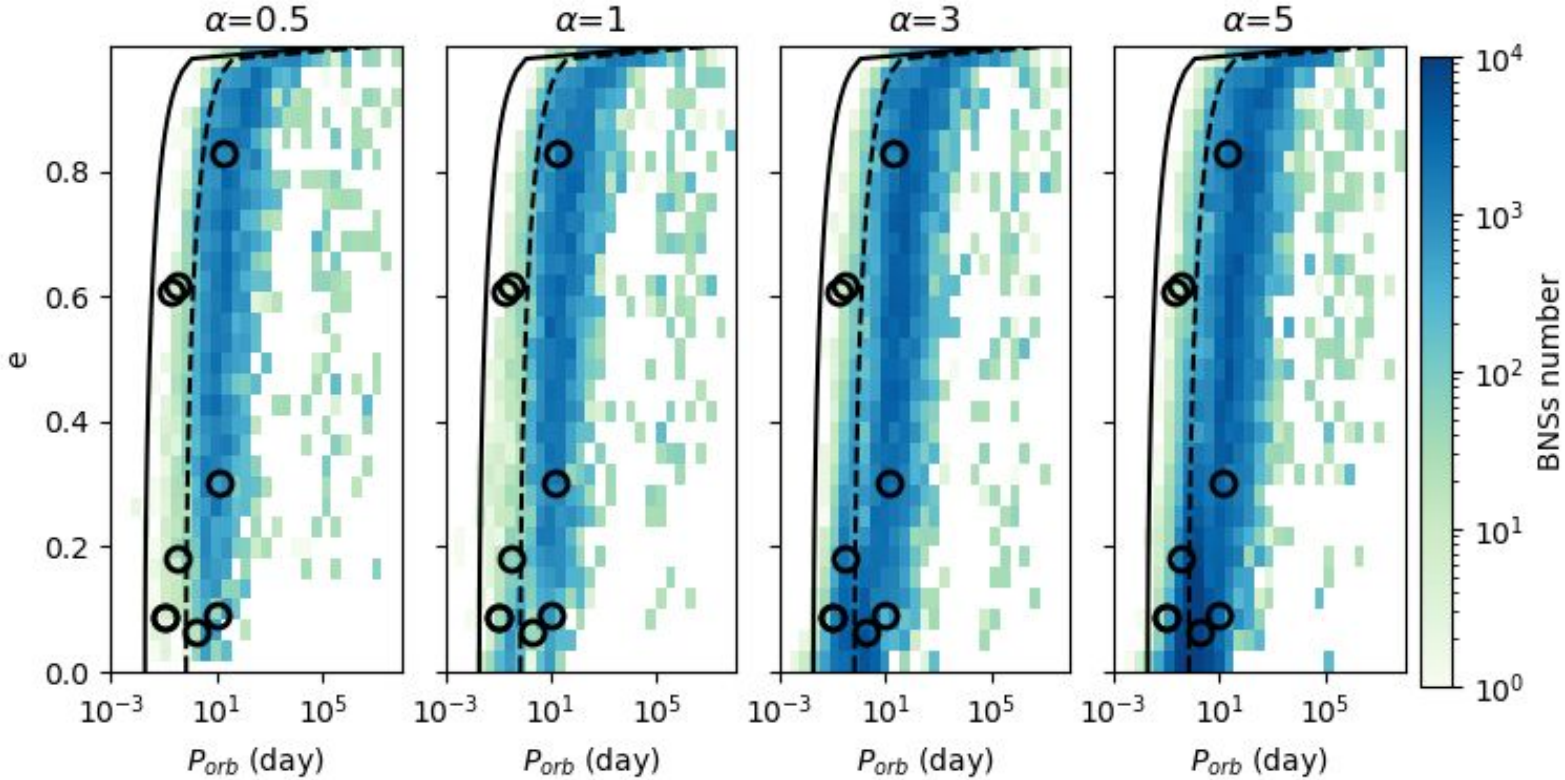
# Merger Rates




Sgalletta et al 2023:
10.1093/mnras/stad2768

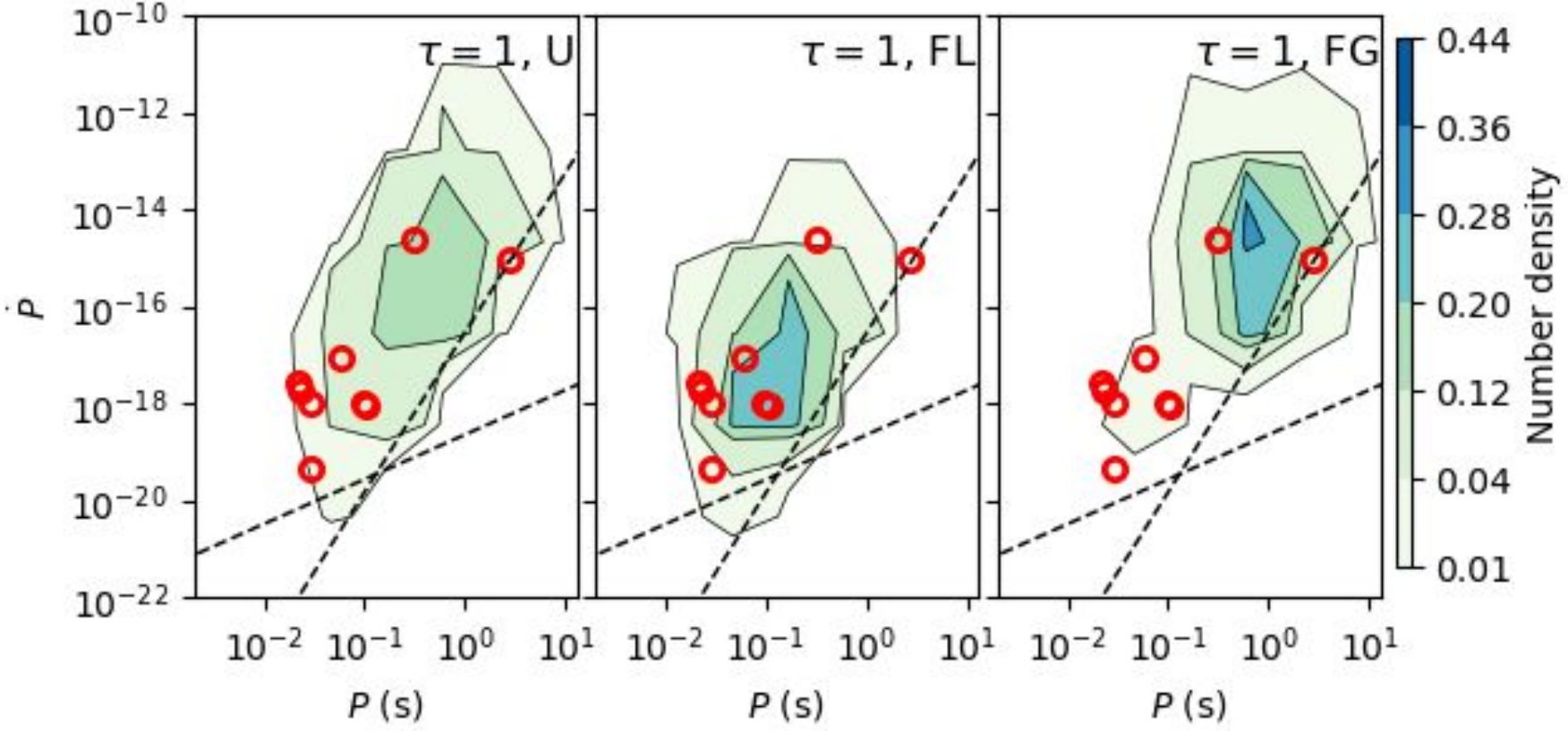
# BNSs population

Sgalletta et al 2023:
10.1093/mnras/stad2768



# Radio selection effects

Sgalletta et al 2023:
10.1093/mnras/stad2768



# Radio selection effects

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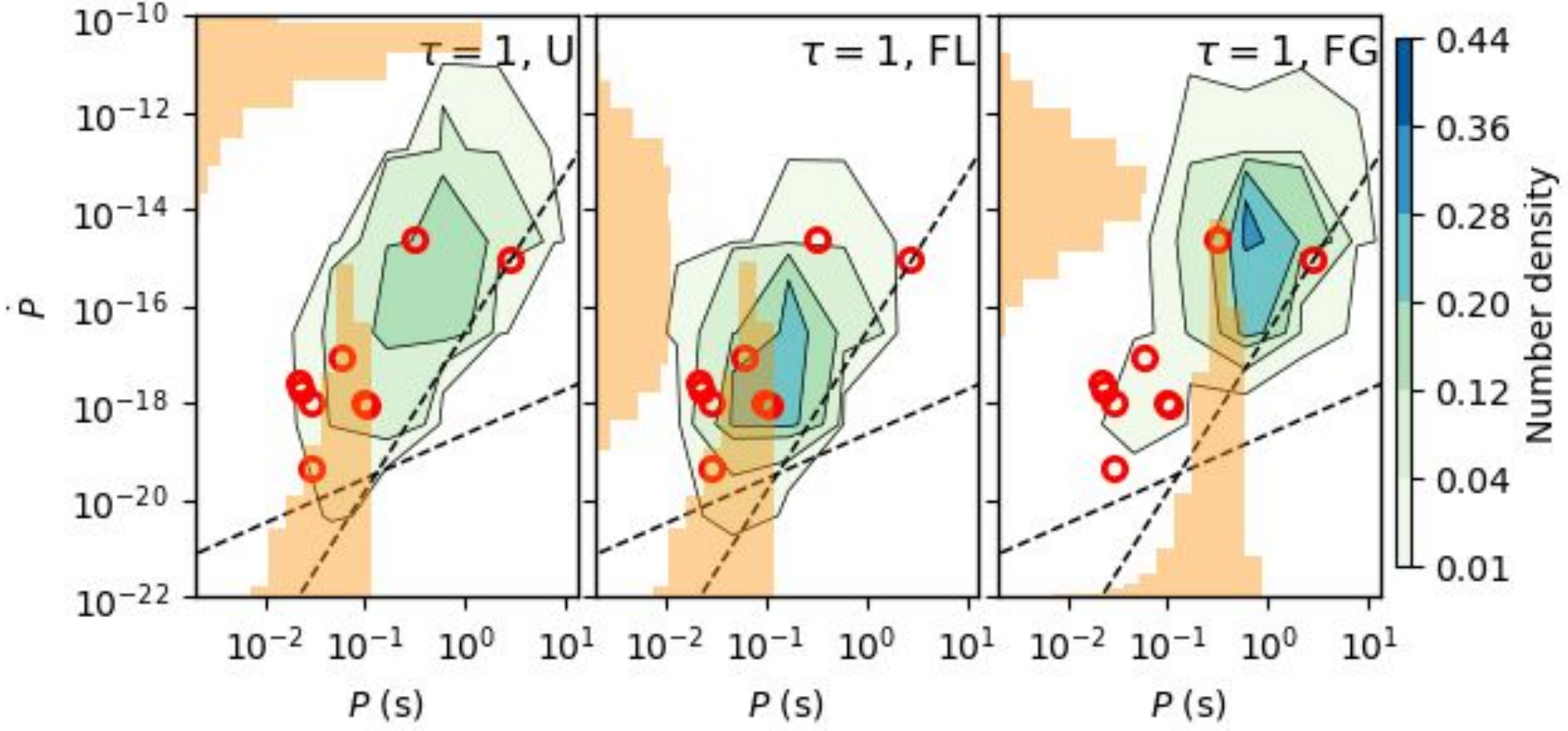
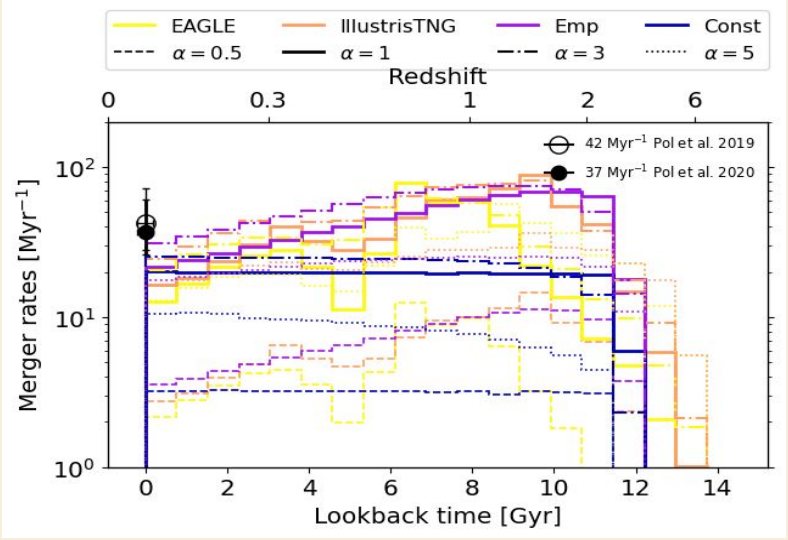
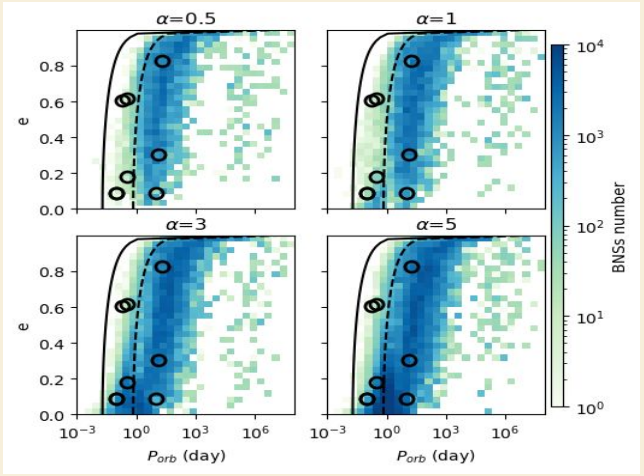


# Conclusions

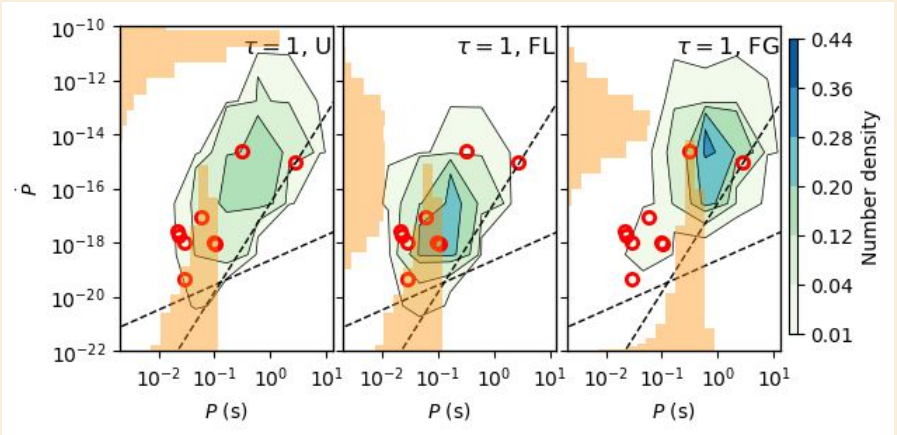



MERGER RATES

PULSAR POPULATION




ORBITAL PROPERTIES




Sgalletta et al 2023:
10.1093/mnras/stad2768


SISSA

# Future prospects

- New common envelope binding energies in SEVN
- Study and characterization of BNS systems with up-to-date prescriptions

## SISSA Research Unit

- Mario Spera (RU leader)
- Francesco Addari
- Lumen Boco
- Alessandro Bressan
- Giulia Capurri
- Francesco Gabrielli
- Andrea Lapi
- Francesco Longo
- Mattia Mencagli
- Cecilia Sgalletta
- Cristiano Ugolini

# Backup

## Spin-down

$$\dot{\Omega} = \frac{8\pi B^2 R^6 \sin^2(\alpha)\Omega^3}{3\mu_0 c^3 I}$$

$$B = (B_0 - B_{min})e^{-\Delta t/\tau} + B_{min}$$

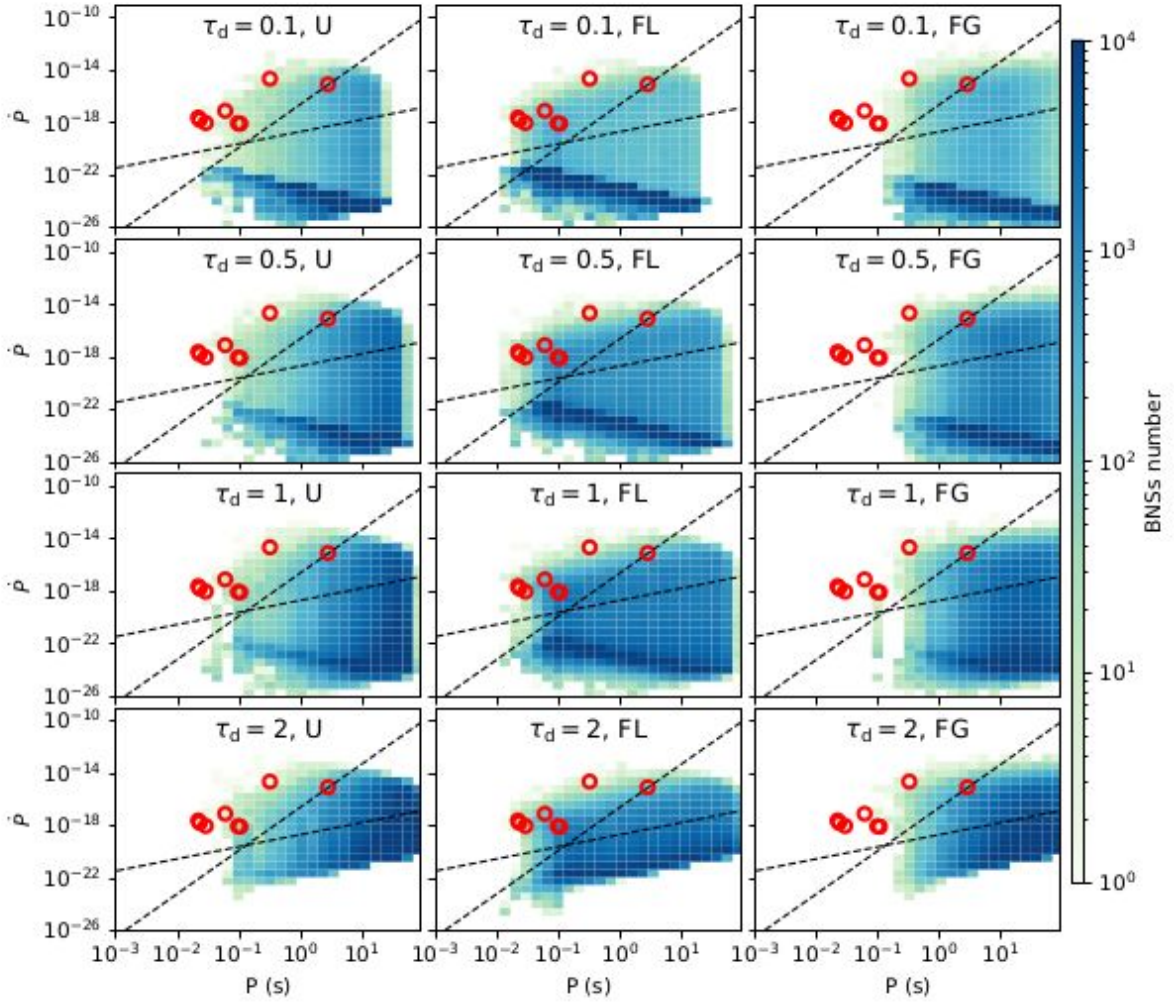
## Spin-up

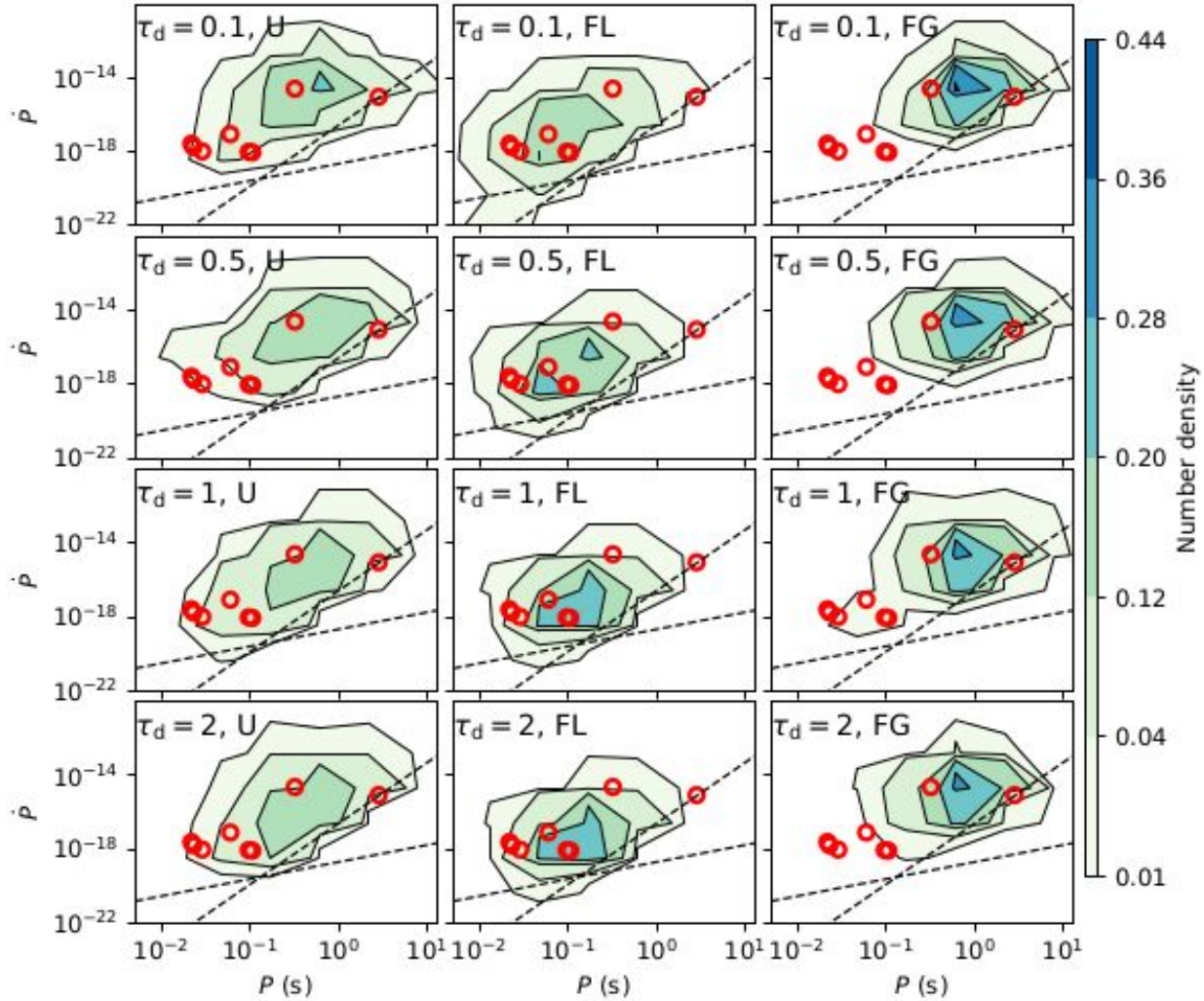
$$\dot{J} = V_{diff} R_A^2 \dot{M}_{NS}$$

$$V_{diff} = \Omega_K - \Omega_{NS}$$

$$B = (B_0 - B_{min})e^{-\Delta M_{NS}/\Delta M_d} + B_{min}$$

$$R_{Alfven} = \left(\frac{2\pi^2}{G\mu_0^2}\right)^{1/7} \left(\frac{R^6}{\dot{M}_{NS} M_{NS}^{1/2}}\right)^{1/7} B^{4/7}$$


τd = 0.1, U
τd = 0.1, FL
τd = 0.1, FG
τd = 0.5, U
τd = 0.5, FL
τd = 0.5, FG
τd = 1, U
τd = 1, FL
τd = 1, FG
τd = 2, U
τd = 2, FL
τd = 2, FG
Ṗ
P (s)
BNSs number


$\tau_d = 0.1$, U
$\tau_d = 0.1$, FL
$\tau_d = 0.1$, FG
$\tau_d = 0.5$, U
$\tau_d = 0.5$, FL
$\tau_d = 0.5$, FG
$\tau_d = 1$, U
$\tau_d = 1$, FL
$\tau_d = 1$, FG
$\tau_d = 2$, U
$\tau_d = 2$, FL
$\tau_d = 2$, FG
$\dot{P}$
$10^{-14}$
$10^{-18}$
$10^{-22}$
$10^{-2}$
$10^{-1}$
$10^{0}$
$10^{1}$
$P$ (s)
Number density
0.44
0.36
0.28
0.20
0.12
0.04
0.01

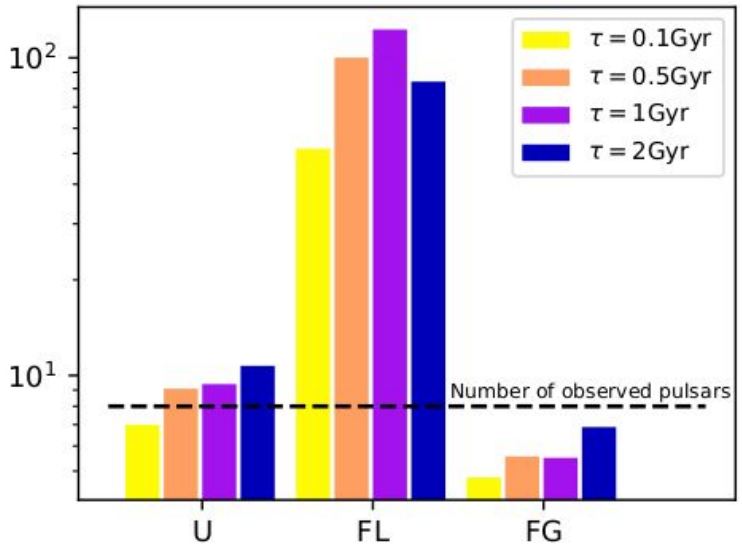



**Figure 5.** Mean number of radio selected pulsars predicted by our models after averaging over the $N = 100$ realizations of the selection effects, assuming the fiducial $\alpha = 3$ and the Emp MW model. Each bar is a different model: the $x$-axis shows the spin and magnetic field initial distributions (U, FL, and FG). Each colour is associated to a different $\tau_d$ value: yellow, pink, purple, and blue for $\tau_d = 0.1$, 0.5, 1, and 2 Gyr, respectively. The black horizontal dashed line shows the number of observed Galactic BNSs in the considered surveys, $N_{obs} = 8$.