

The Milky Way neutron star population viewed from afar *and the implications for fast radio bursts*

by

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Intro - the Milky Way as an FRB host



- Increasing numbers of well localised FRBs (The CHIME/FRB Collaboration 2021)
- Can begin to do host population studies (Heintz et al. 2020, Mannings et al. 2020)
- Measurements such as:



Offset
(& host-normed offset)



Enclosed Flux



F_{flight}

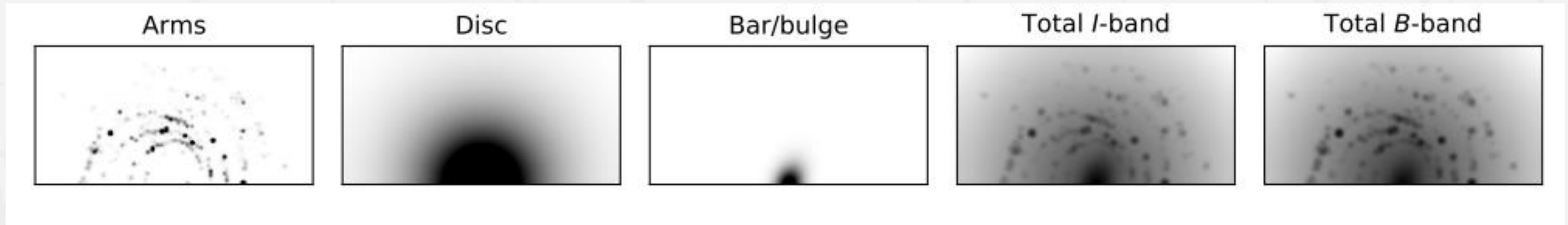
- If we assume SGR1935 is a representative FRB source (CHIME/FRB Collab et al. 2020, Bochenek et al. 2020), then the Milky Way is an FRB host galaxy
- If we further assume that all magnetars produce FRBs...
 - » Then the distribution of magnetars on the Milky Way should match the distribution of FRBs on their host!

Talk based on Chrimes et al. (2021) – see QR



- Create a synthetic face-on image of the Milky Way
- Place the Galactic magnetar population on this map, and measure the Galactocentric offsets, enclosed fluxes and F_{light} distribution
- Do the same with other Galactic neutron star systems (XRBs, pulsars) – as many FRB models also invoke neutron stars in binaries, e.g. binary comb models (Ioka et al. 2020), XRB-type systems etc (Tendulkar et al. 2021)
- Compare to FRBs (and other extragalactic transients)
 - **Which extragalactic transients do the Galactic neutron stars best match in terms of locations within their host?**

Milky Way image construction



BESSEL bayesian distance
assignment of masers,
following Reid et al. 2016, 2019

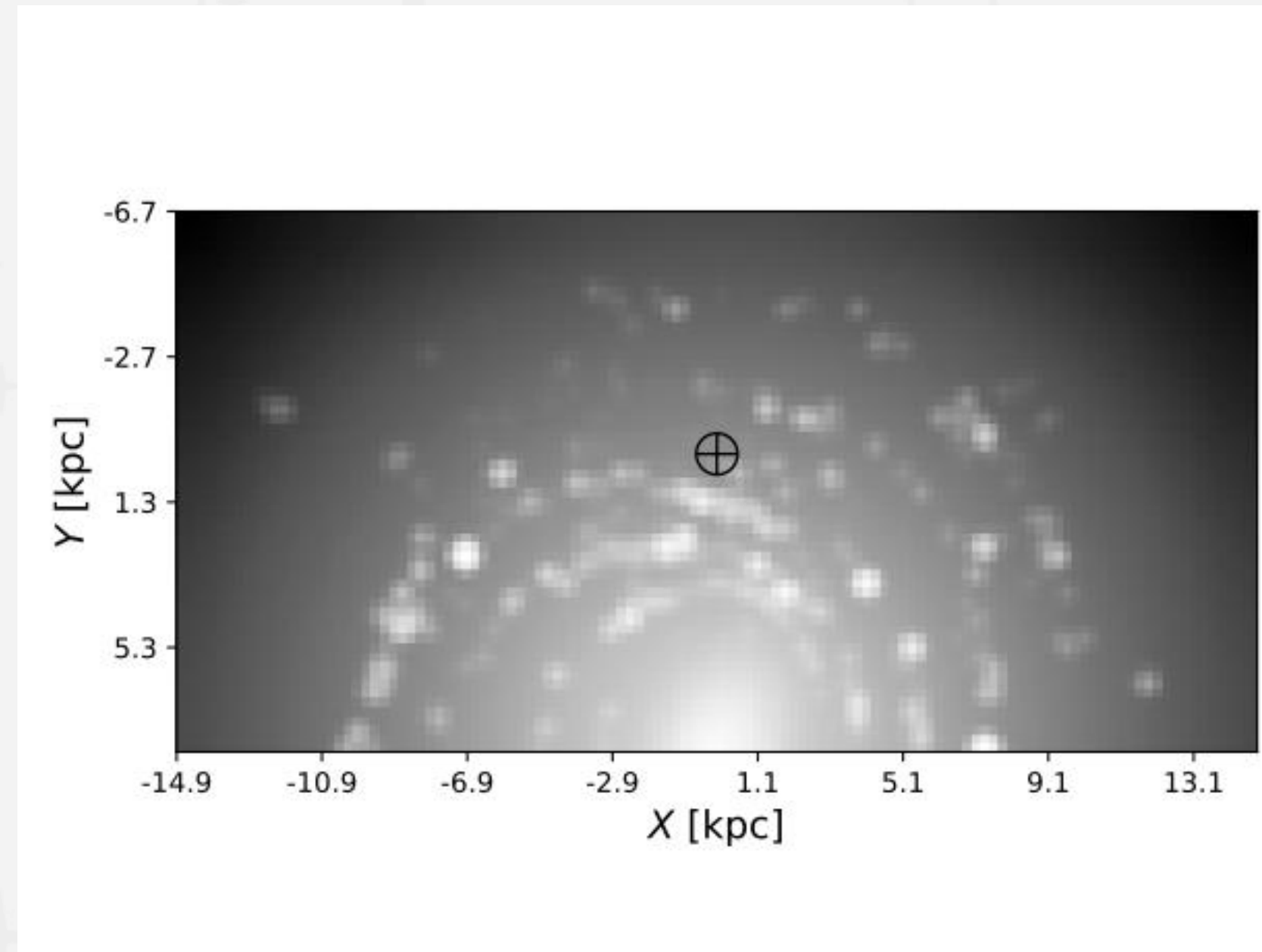
Using Urquhart et al. 2014
YSO/HII region input
catalogue.

Exponential with scale
length of $R_d = 4$ kpc
(Kumar et al. 2020)

Sérsic profile with index $n = 1.32$ and half-light radius $R_d = 0.64$ kpc. Convolved with the bar profile as mapped by Mira variables with *Gaia* (Grady et al. 2020).

Flynn et al. 2006, Licquia et al. 2015, Bland-Hawthorn & Gerhard 2016, Yu et al. 2018 for the colours and luminosities of the components

Galactic neutron star populations



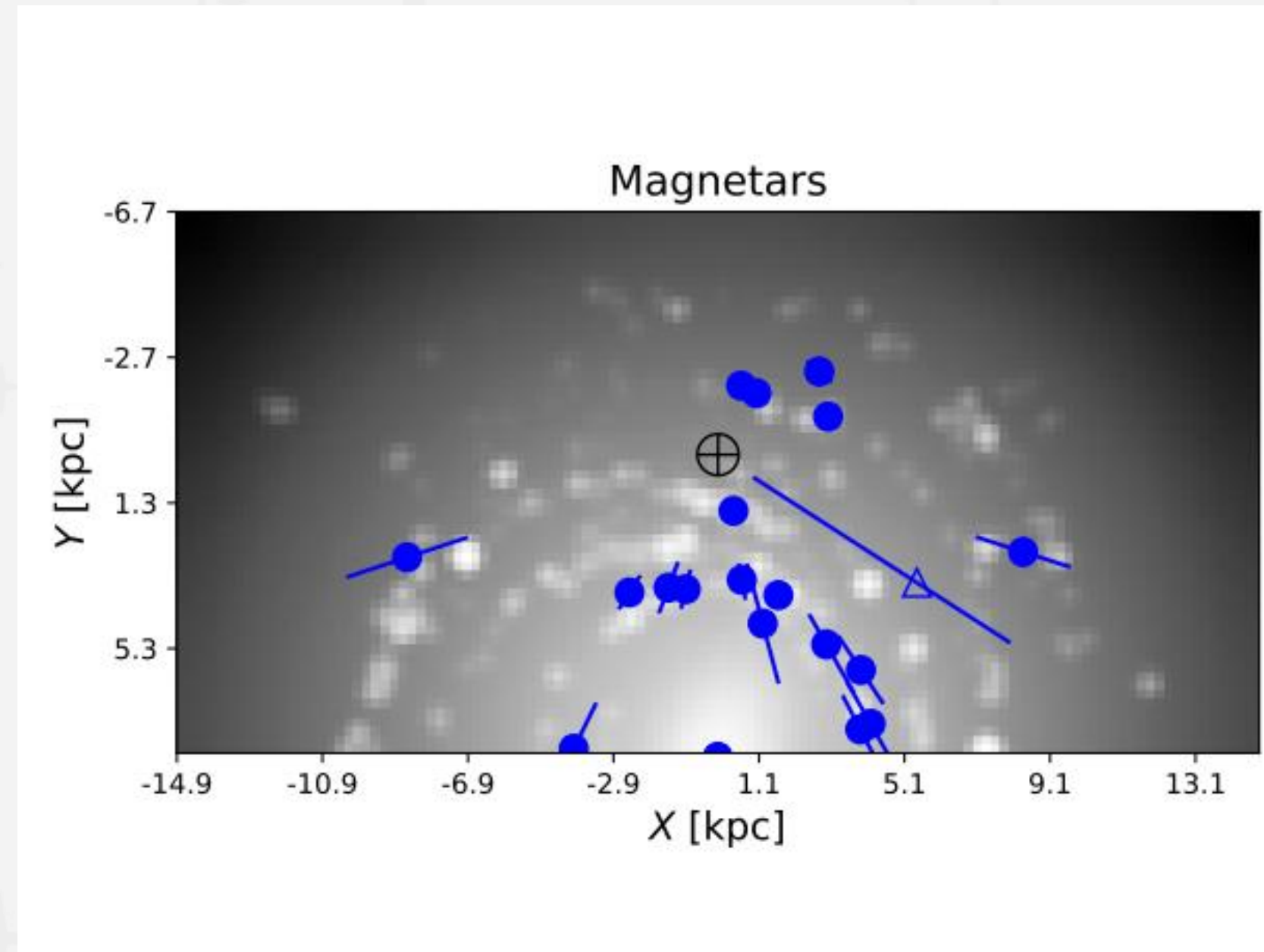
Galactic neutron star populations



Magnetars

McGill catalogue

Olausen & Kaspi (2014)



Galactic neutron star populations

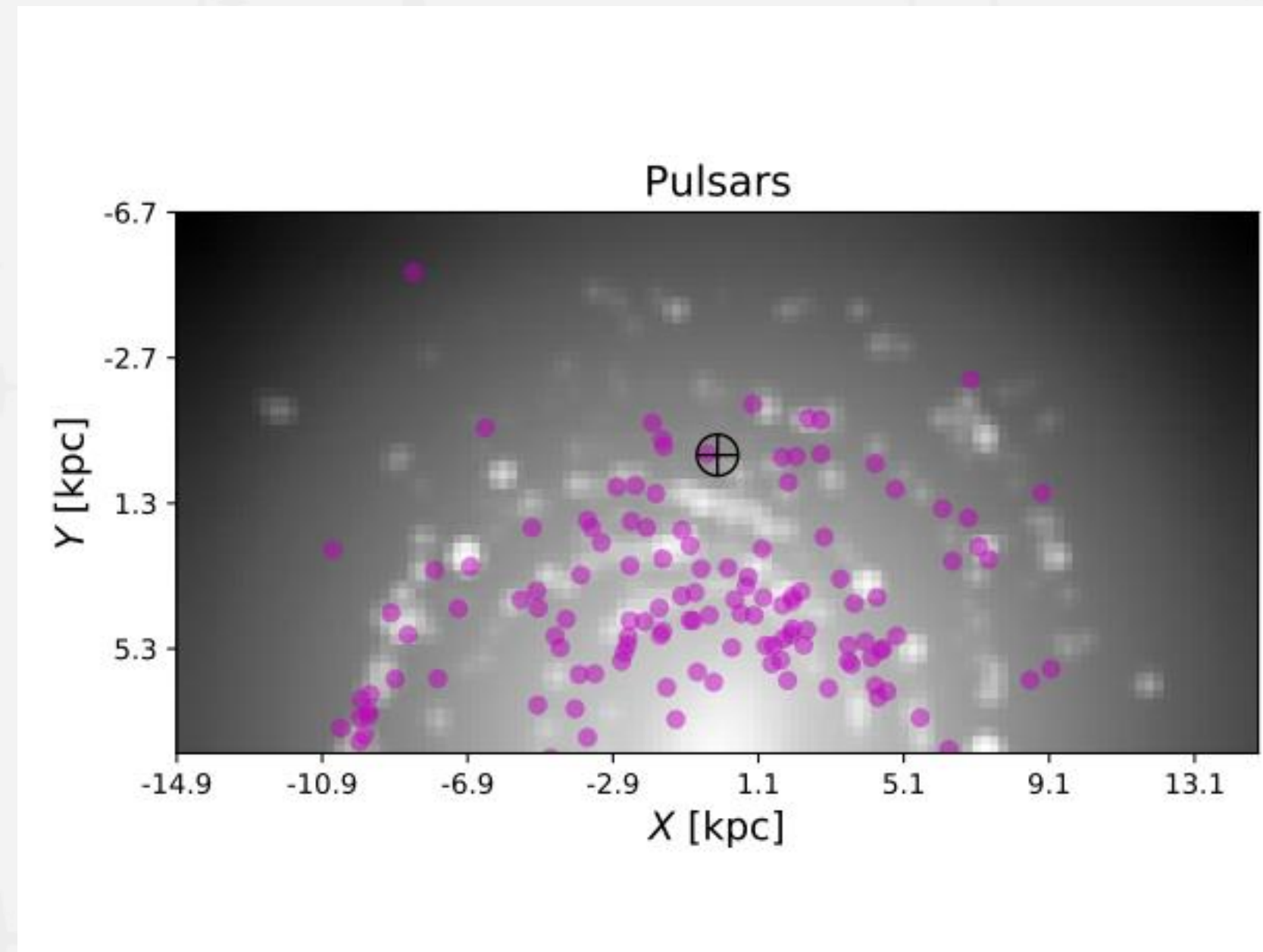


Pulsars

ANTF database

$L > 65 \text{ mJy kpc}^{-2}$

Manchester et al. (2005)

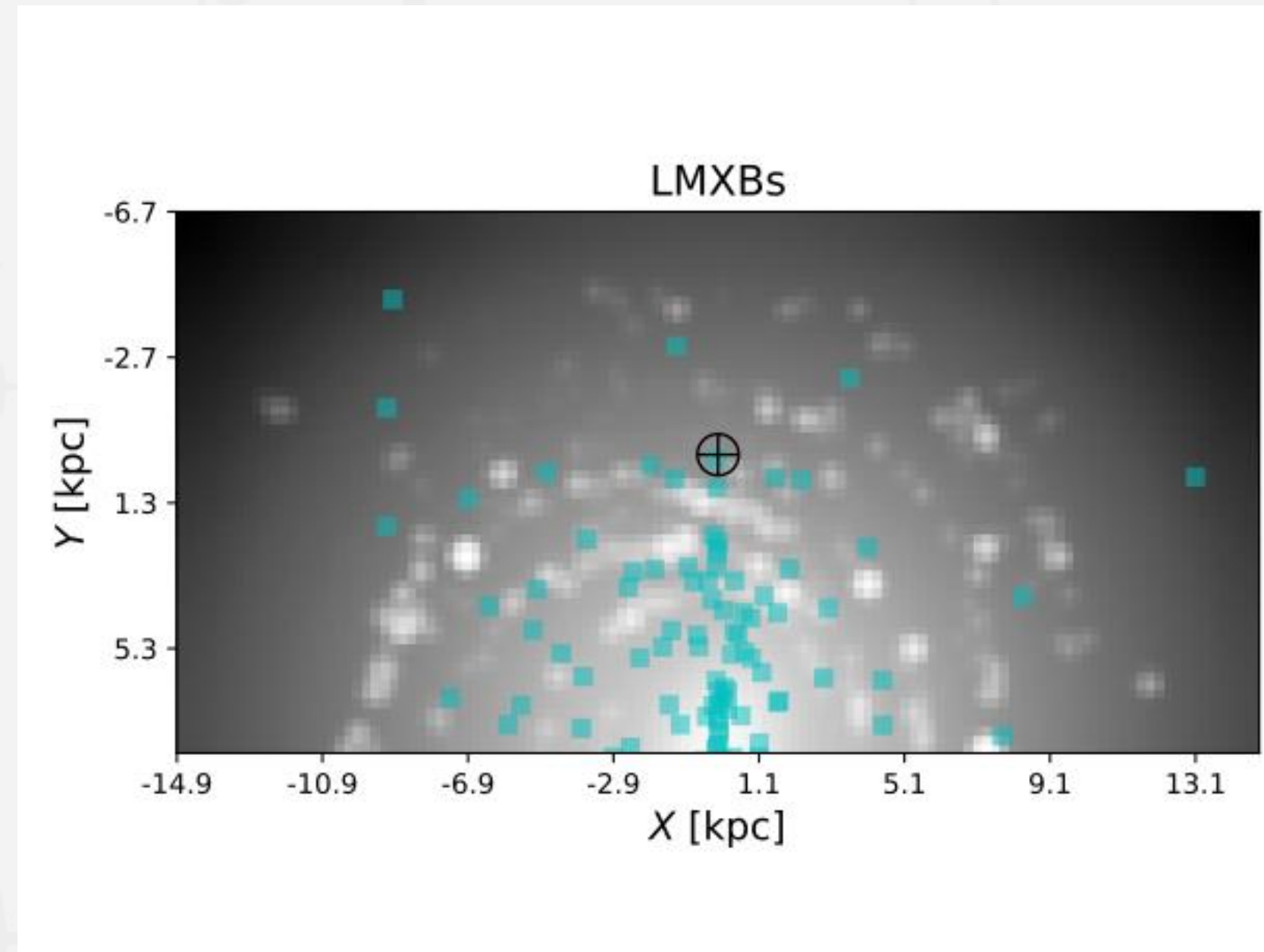


Galactic neutron star populations



LMXBs

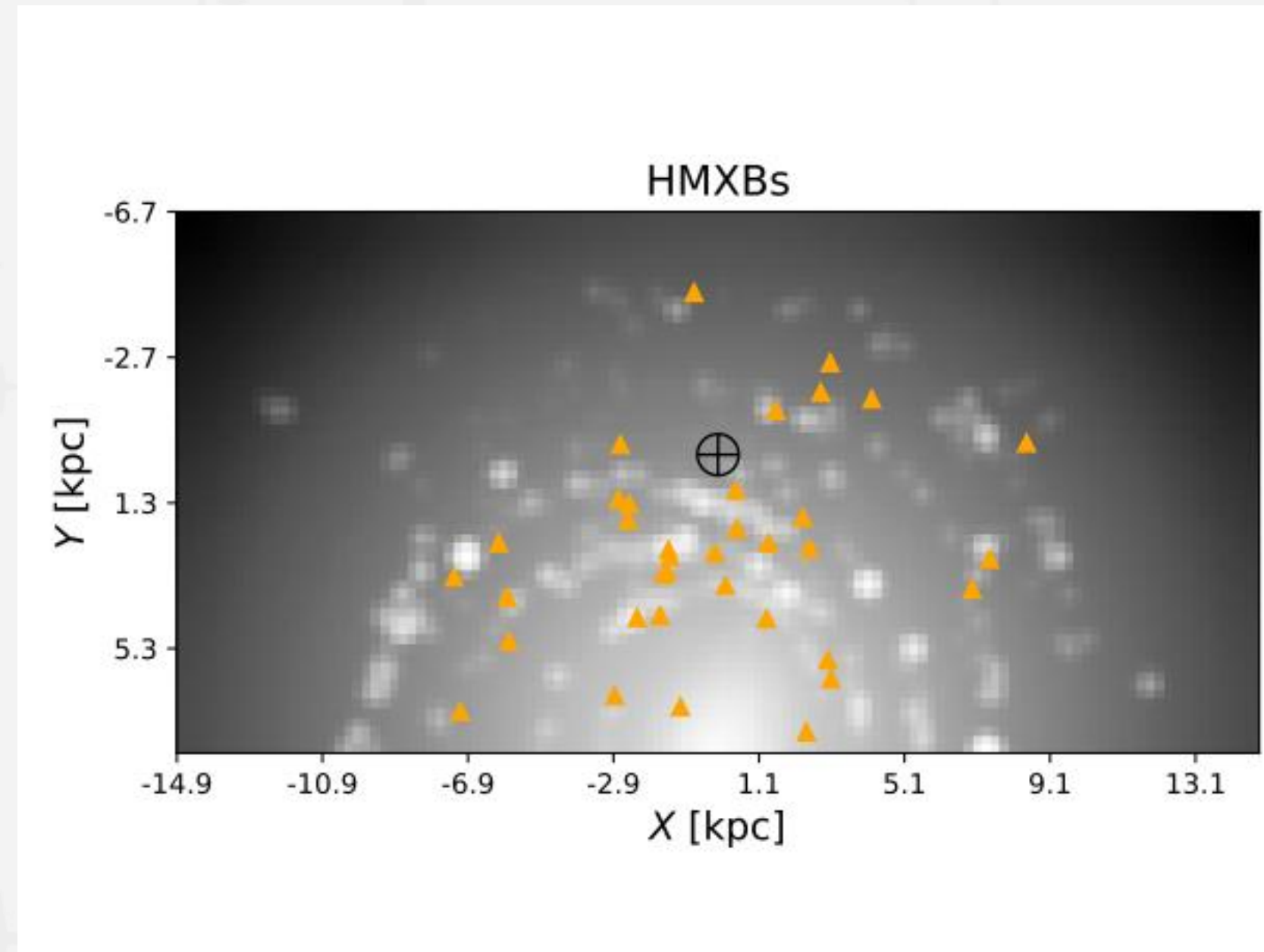
INTEGRAL catalogue
Sazonov et al. (2020)



Galactic neutron star populations



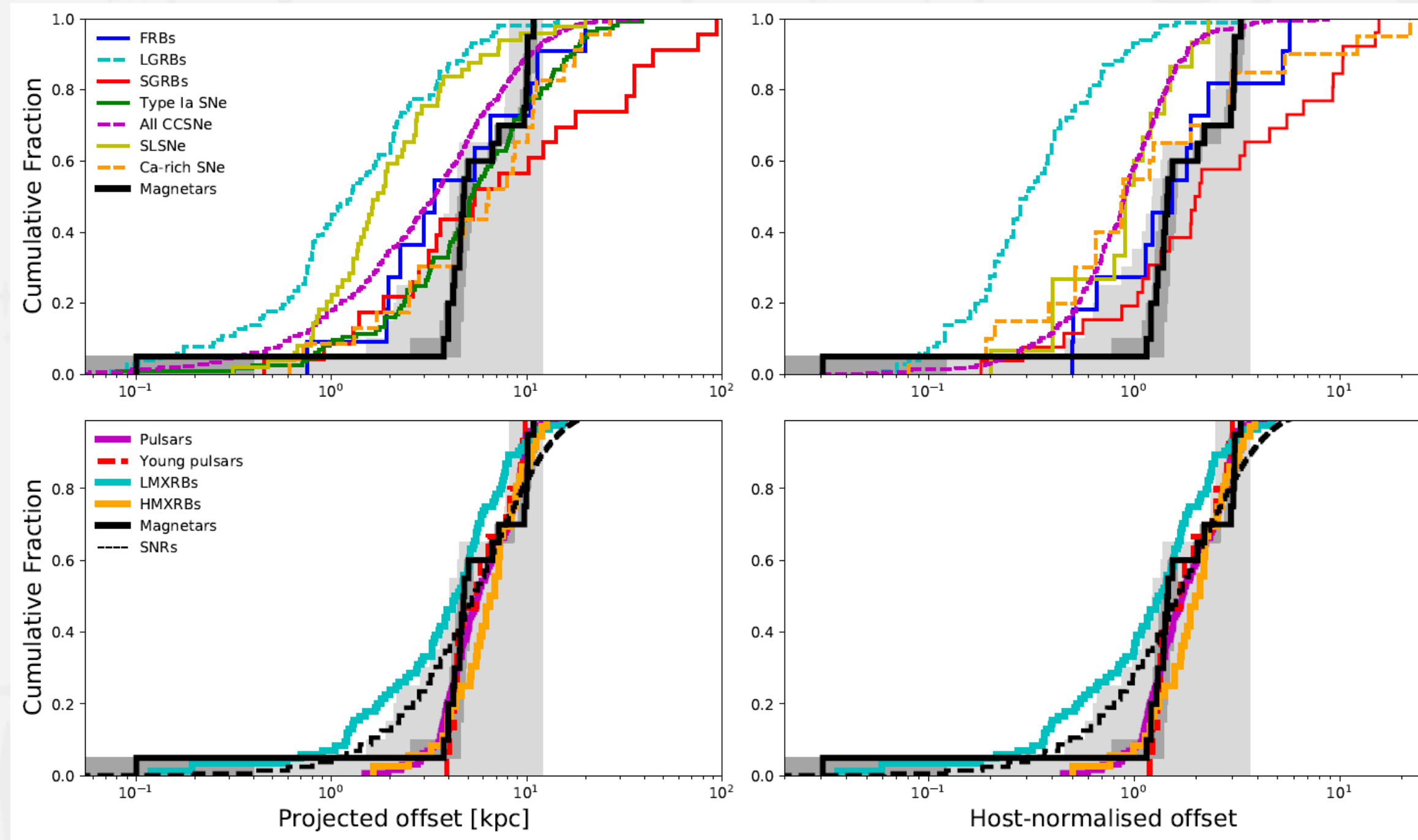
HMXBs
INTEGRAL catalogue
Kretschmar et al. (2019)



Galactocentric offsets & enclosed flux



*Magnetars versus
extragalactic transients*



*Magnetars versus
other Galactic neutron stars*

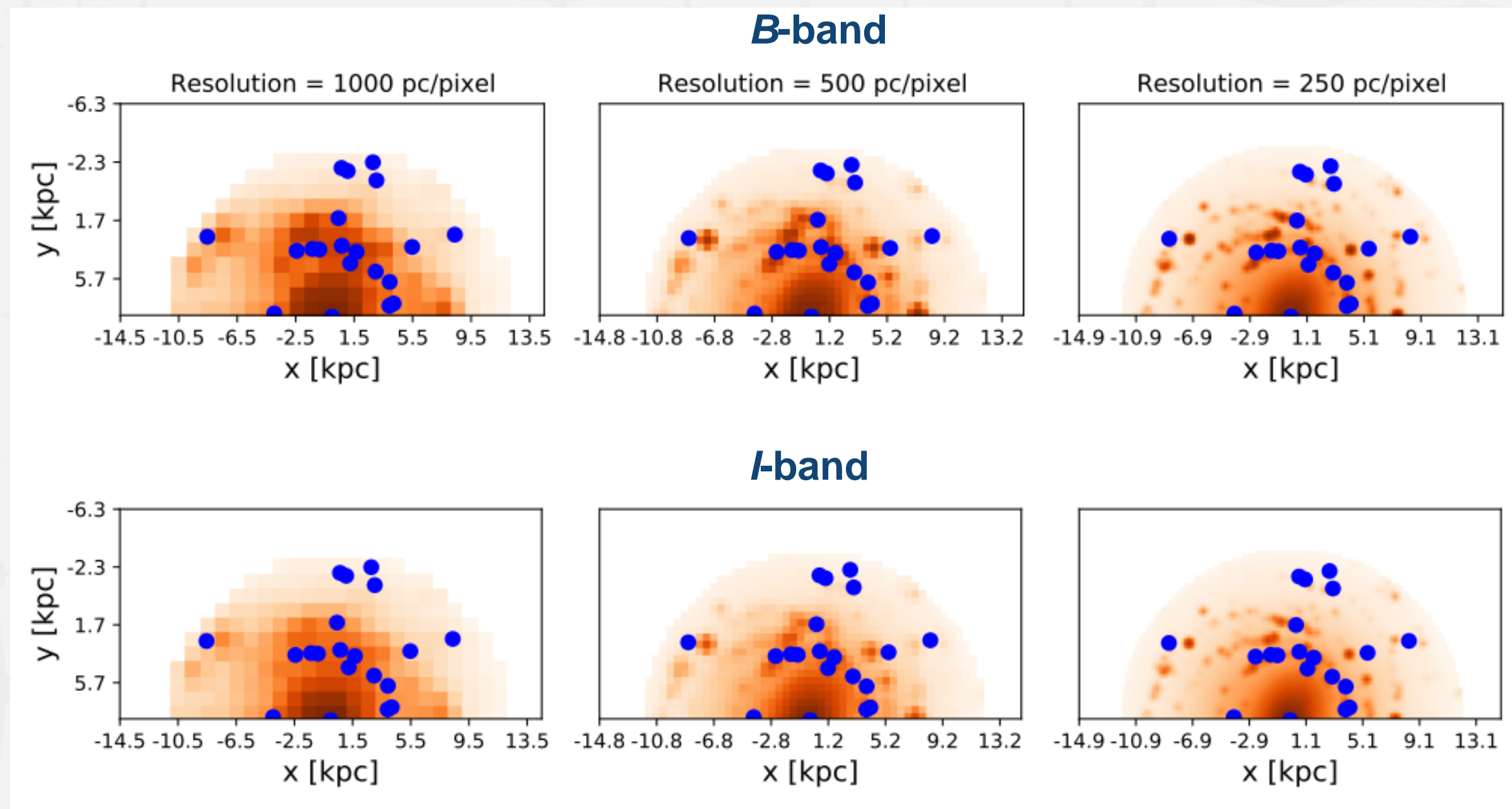
Fraction of light



To generate F_{light} value for each pixel (Fruchter et al. 2006):

1. Decide on which pixels will be 'associated' with the Galaxy (12kpc in this case)
1. Rank the associated pixels by value in a cumulative sum
1. Normalise by the total cumulative flux such that the brightest pixel takes the value 1. Unassociated pixels are assigned 0.

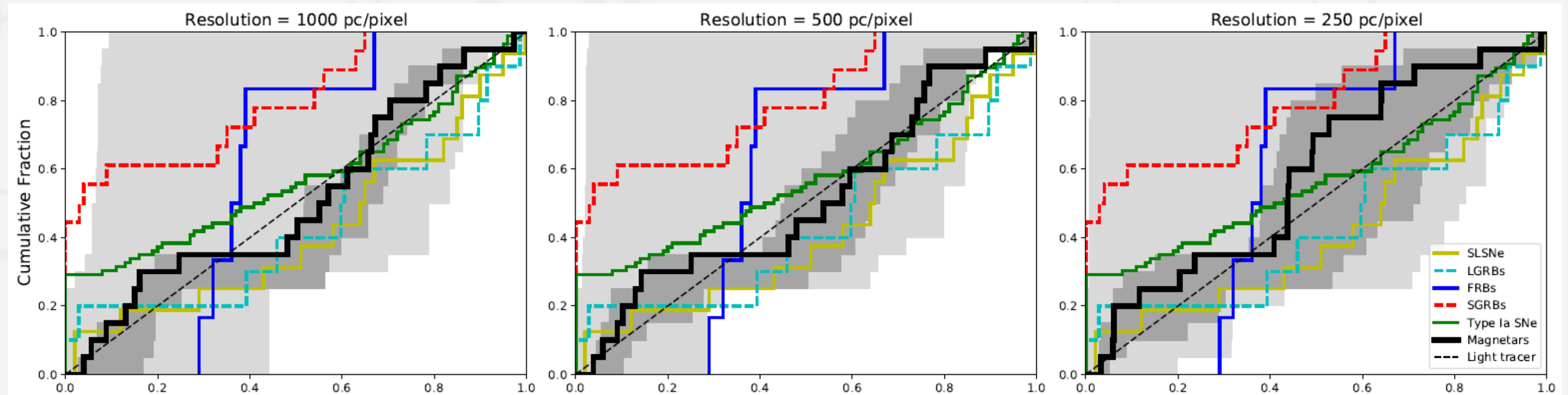
A cumulative distribution of F_{light} values for a transient that is uniformly sampled from the light is a 1:1 line.



Fraction of light



B-band



Summary of comparisons



B-band F_{light} AD-test results

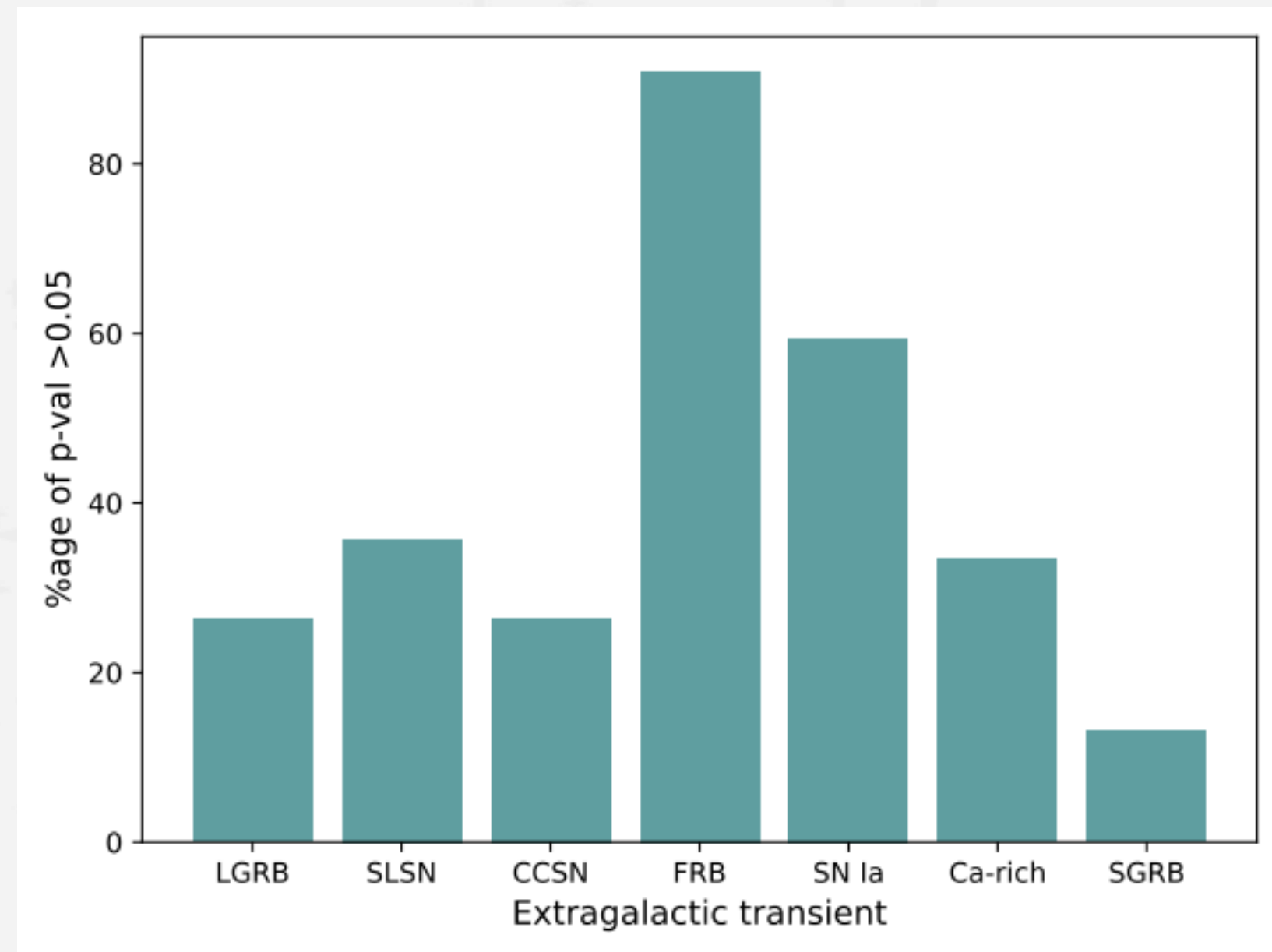
	LGRB	SLSN	FRB	SN Ia	SGRB
Magnetars	0.18	0.09	0.25	0.04	0.00
HMXRBs	0.03	0.01	0.25	0.01	0.00
Y. Pulsars	0.10	0.07	0.25	0.05	0.00
Pulsars	0.01	0.00	0.25	0.00	0.00
LMXRBs	0.25	0.25	0.22	0.00	0.00

Also:

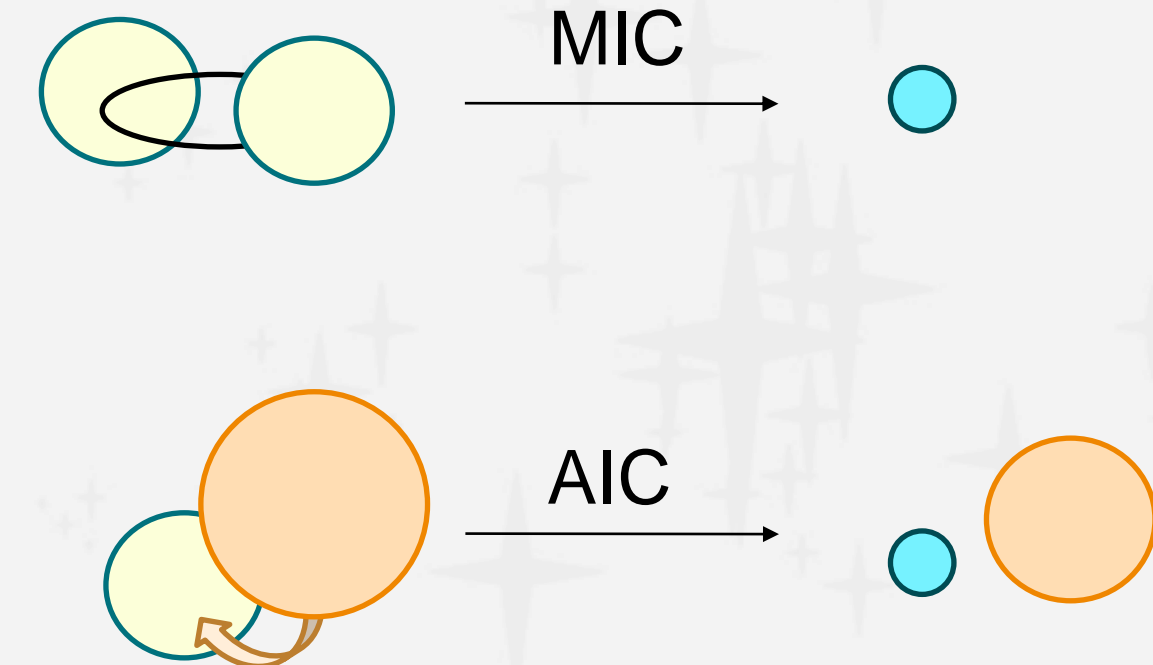
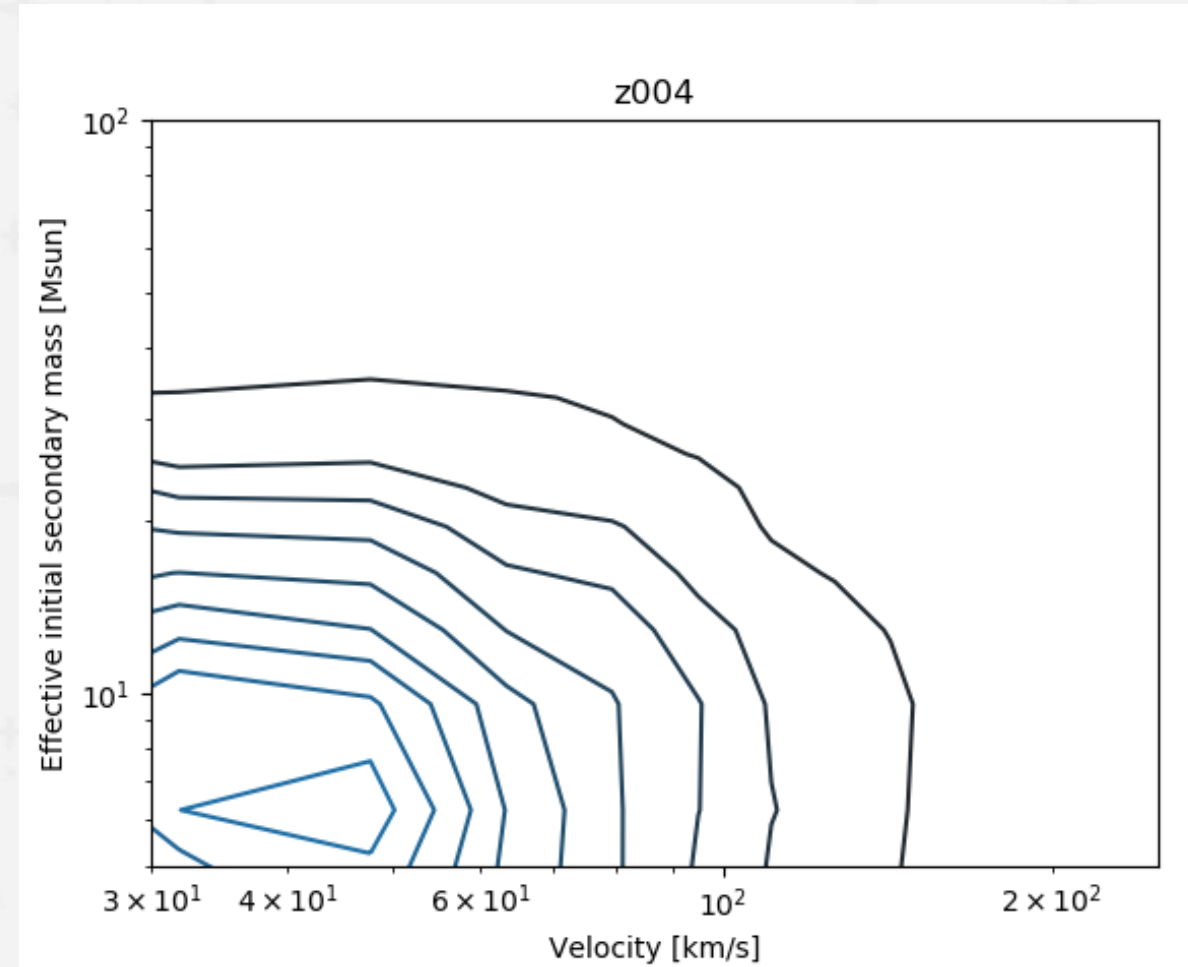
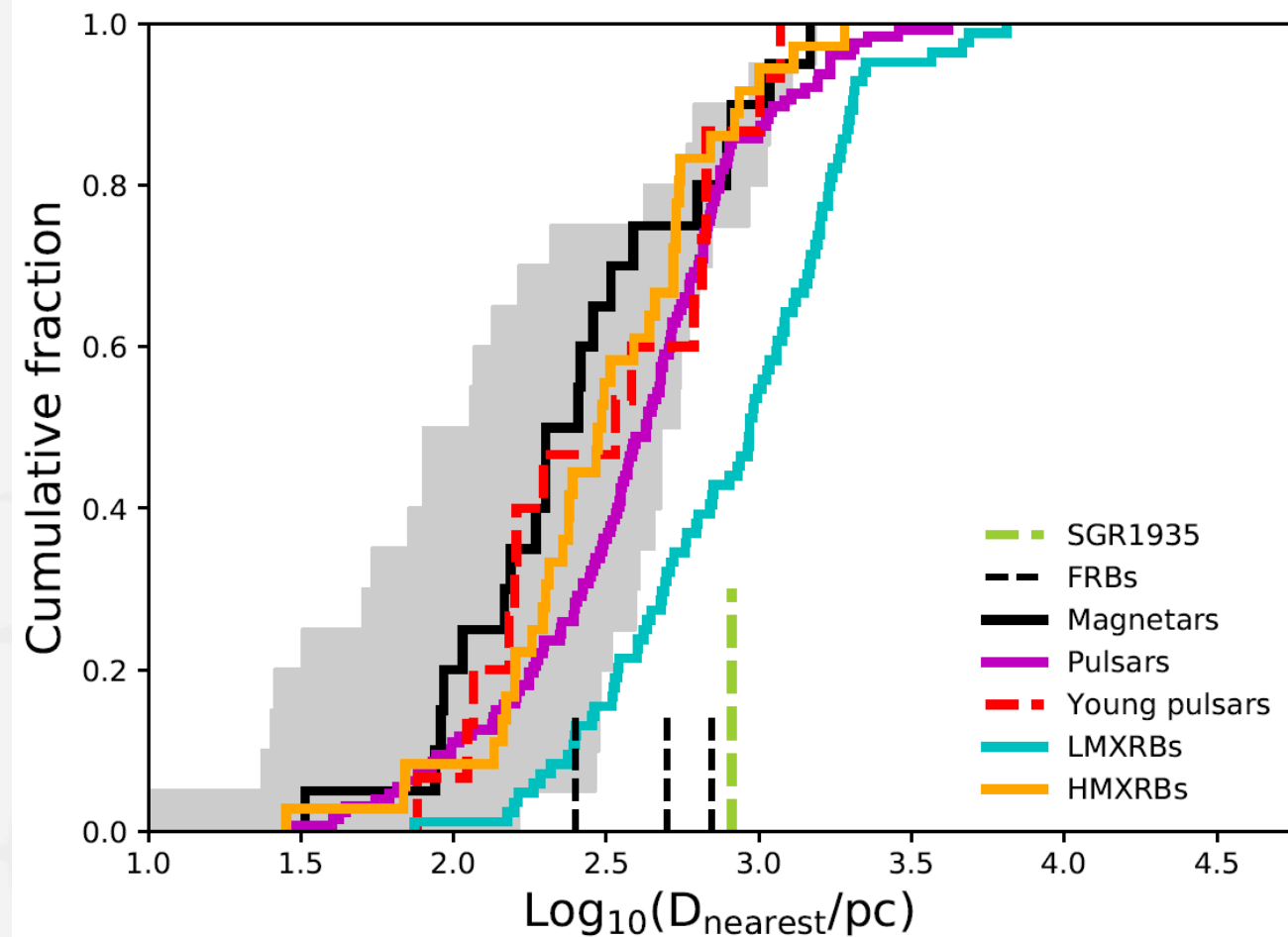
- *I*-band F_{light}
- *<5kpc B*-band Flight
- *<5kpc I*-band Flight

- Enclosed fluxes
- Galactocentric offsets
- *I*-band host-normed offsets
- *B*-band host-normed offsets

$$\% \text{ p-val} > 0.05 = \frac{N(\text{AD-tests for all NS, both bands}) > 0.05}{N(\text{AD-tests for all NS, both bands})} \times 100$$



Further work – magnetar pop synth

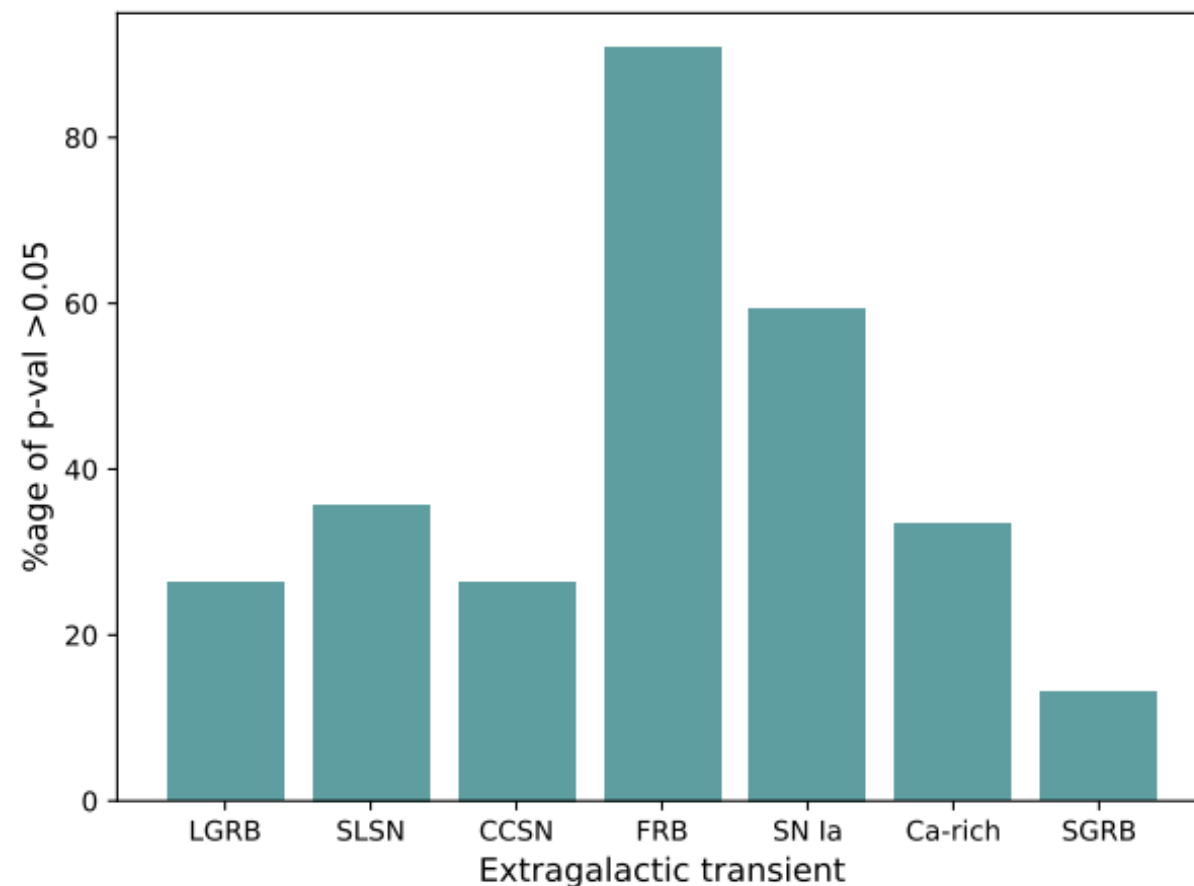


- Nearest maser - proxy for nearest spiral arm

- Updating BPASS (Binary Population and Spectral Synthesis, Eldridge et al. 2017, Stanway et al. 2018) secondary kick distributions (Eldridge et al. 2011), are kicked progenitors plausible?

- Other magnetar pathways: white dwarf MIC or AIC - see repeating FRB in an M81 globular cluster (Kirsten et al. 2021)

Conclusions



- We have created a synthetic face-on view of the Milky Way, and place Galactic neutron stars populations on it, based on their heliocentric distance estimates
- The Galactic neutron star population, when measured ‘from afar’, appears more comparable to FRBs than other extragalactic transients
- However, we cannot discern which population (e.g. magnetars, HMXBs) are the best match
- Nevertheless, further evidence that FRBs have their origin in neutron star systems

Thanks for listening!