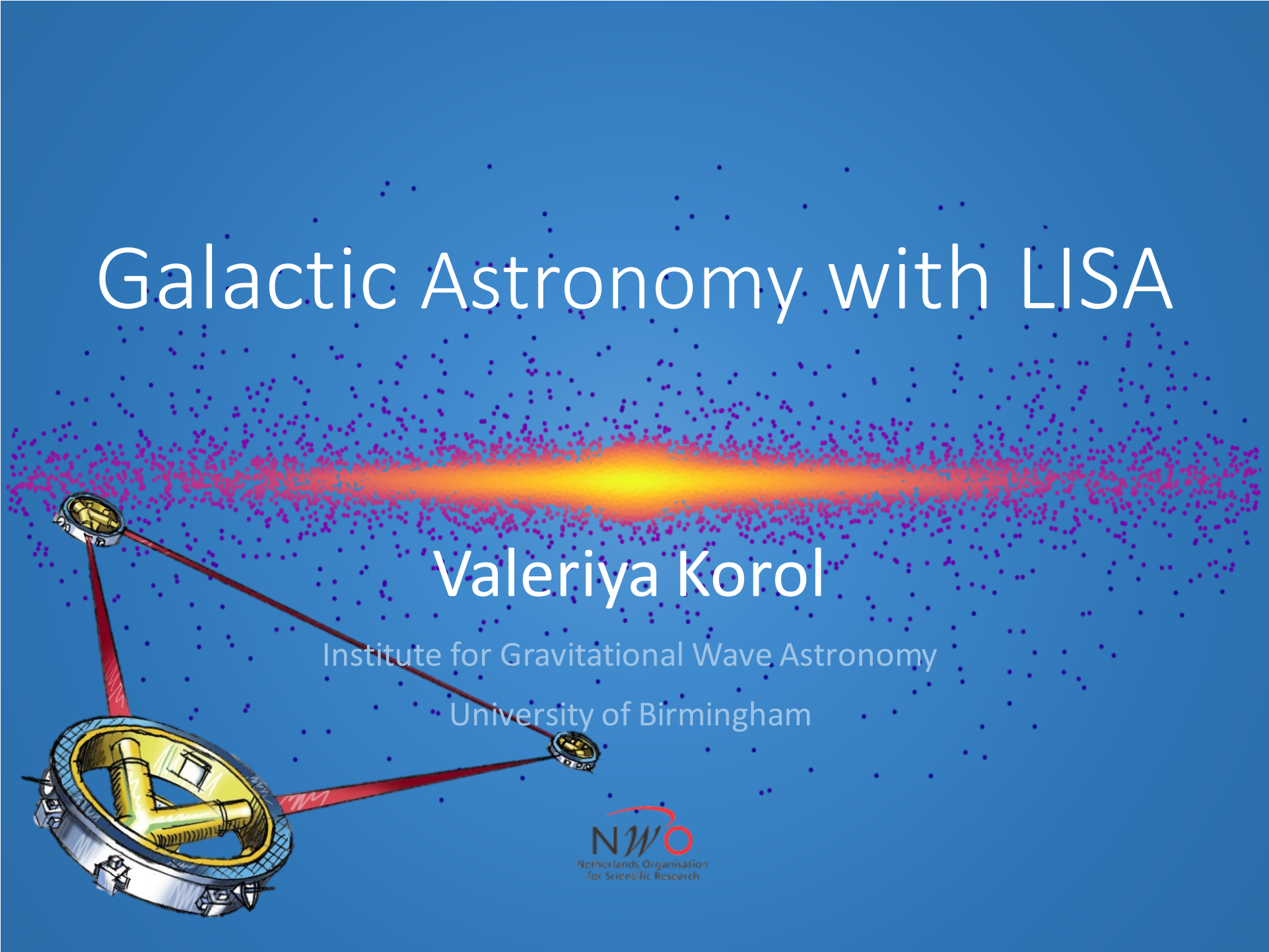
Galactic Astronomy with LISA



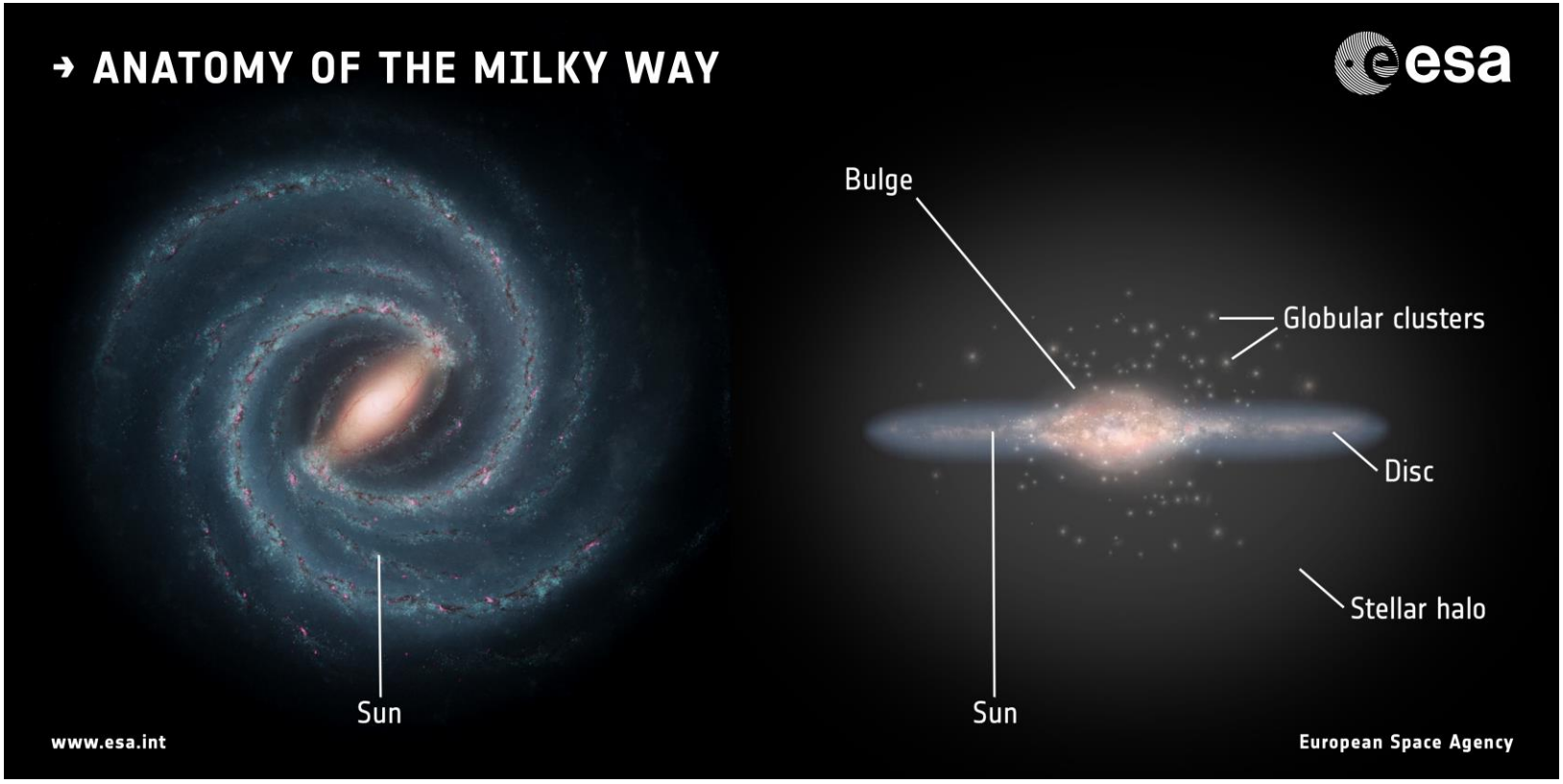
Valeriya Korol

Institute for Gravitational Wave Astronomy

University of Birmingham

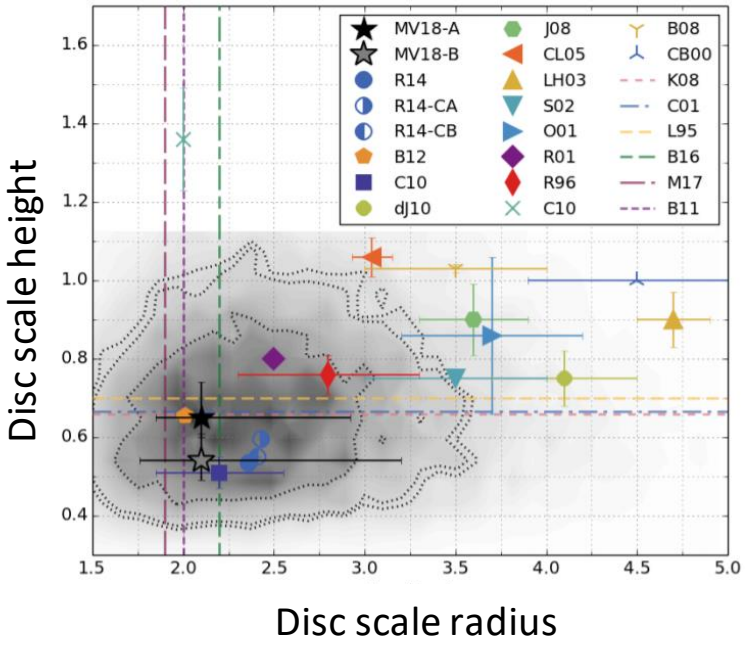
NWO
Netherlands Organisation for Scientific Research

The Milky Way is a unique laboratory to test galaxy formation theory and ΛCDM



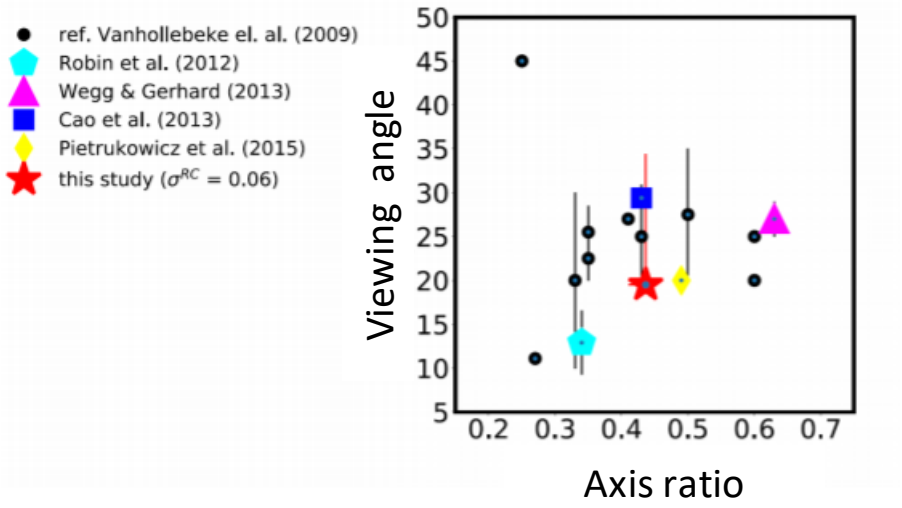
The Milky Way is a unique laboratory to test galaxy formation theory and ΛCDM:
current constraints from EM are poor

Disc scale parameters



(Mateu & Vivas 2018)

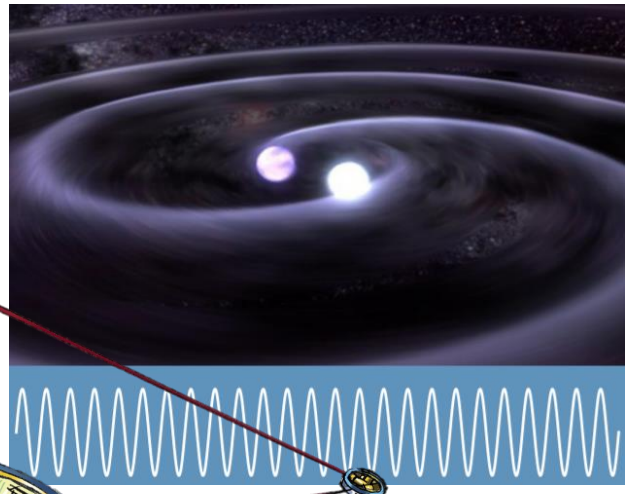
Bar scale parameters

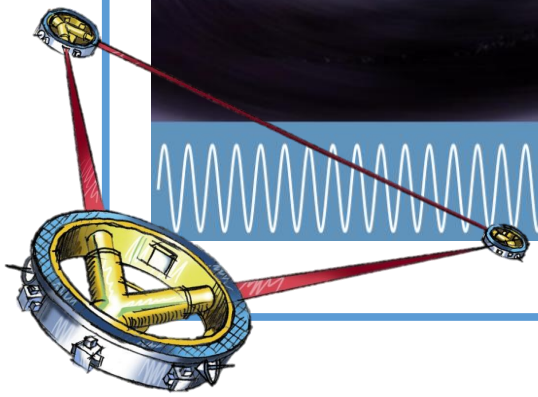


(Simon+2017)

Can GWs from DWDs be used as Galactic tracers?

Detached double white dwarfs

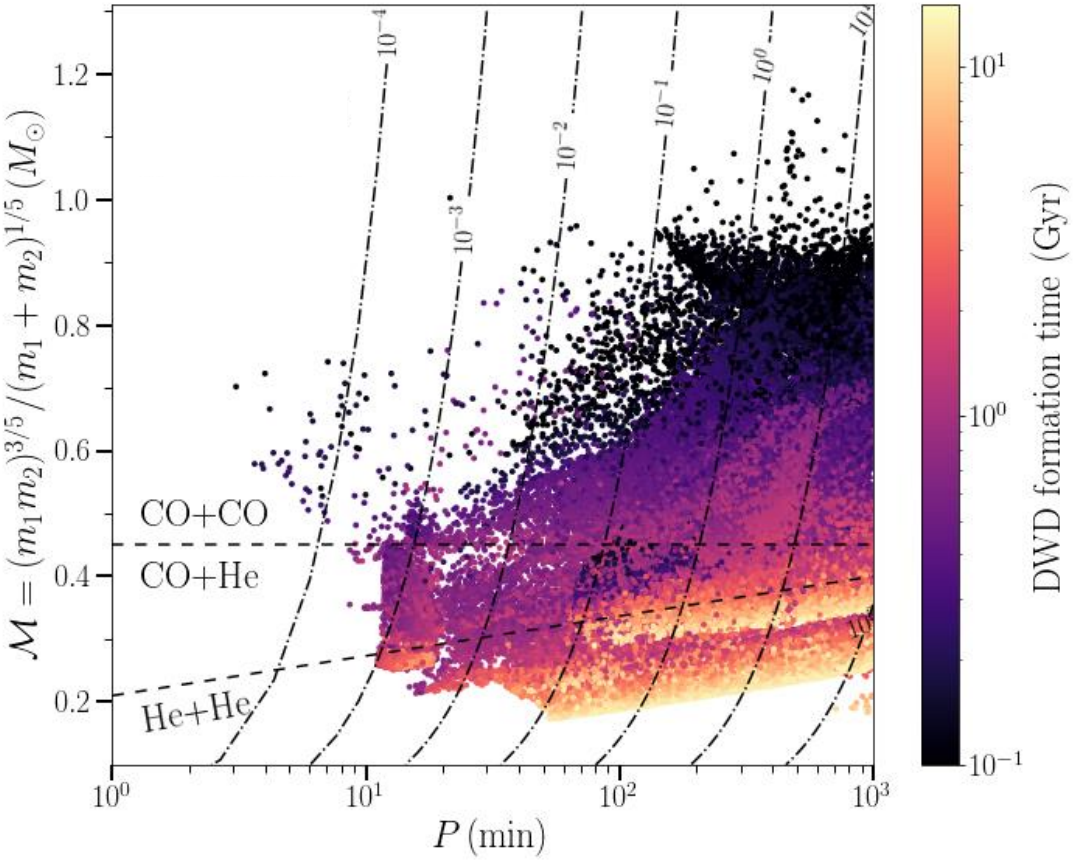




- Frequency: 10 – 40 thousand detectable by LISA in the Milky Way
- Luminosity: can be detected throughout the Galaxy
- Contamination: none
- Direct measurement of the distance

Synthetic population of DWDs

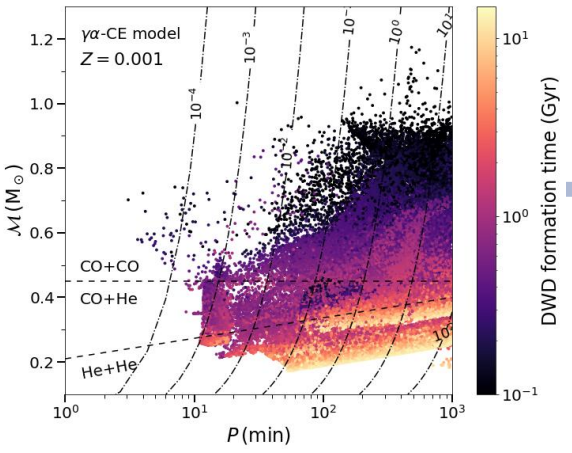
*Models are constructed using binary population synthesis code **SeBa** (Portegies Zwart+96, Nelemans+01, Toonen+12) and carefully **calibrated against state-of-the-art observations** in terms of both mass ratio distribution (Toonen+12) and number density (Toonen+17).*



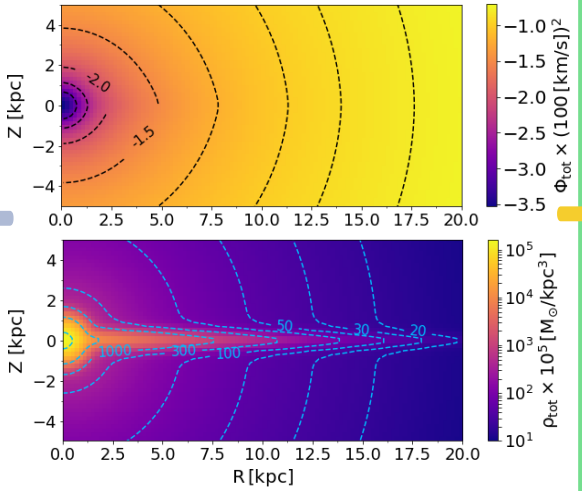
(Korol, Toonen, Klein + 2020)

Synthetic Milky Way

Synthetic population of DWDs

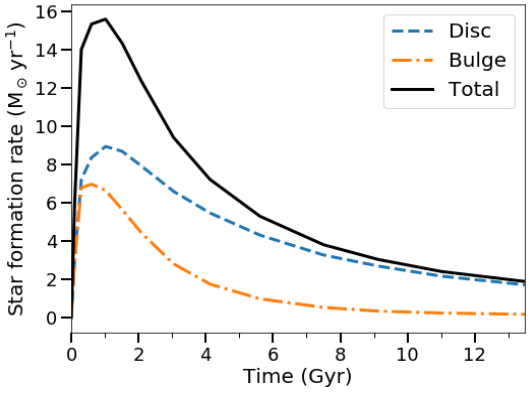


Milky Way's potential



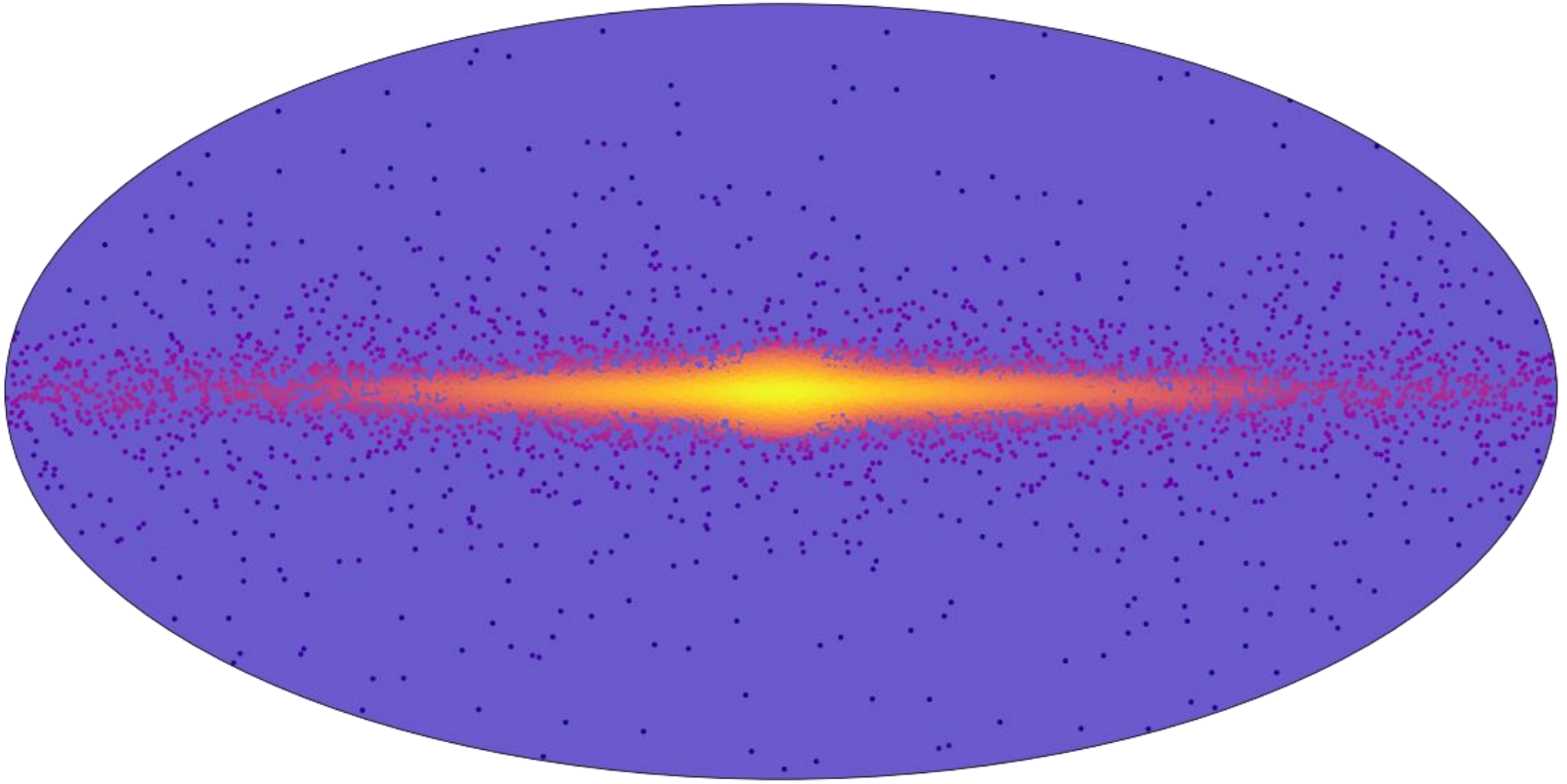
(Binney & Tremaine 08)

Star Formation History



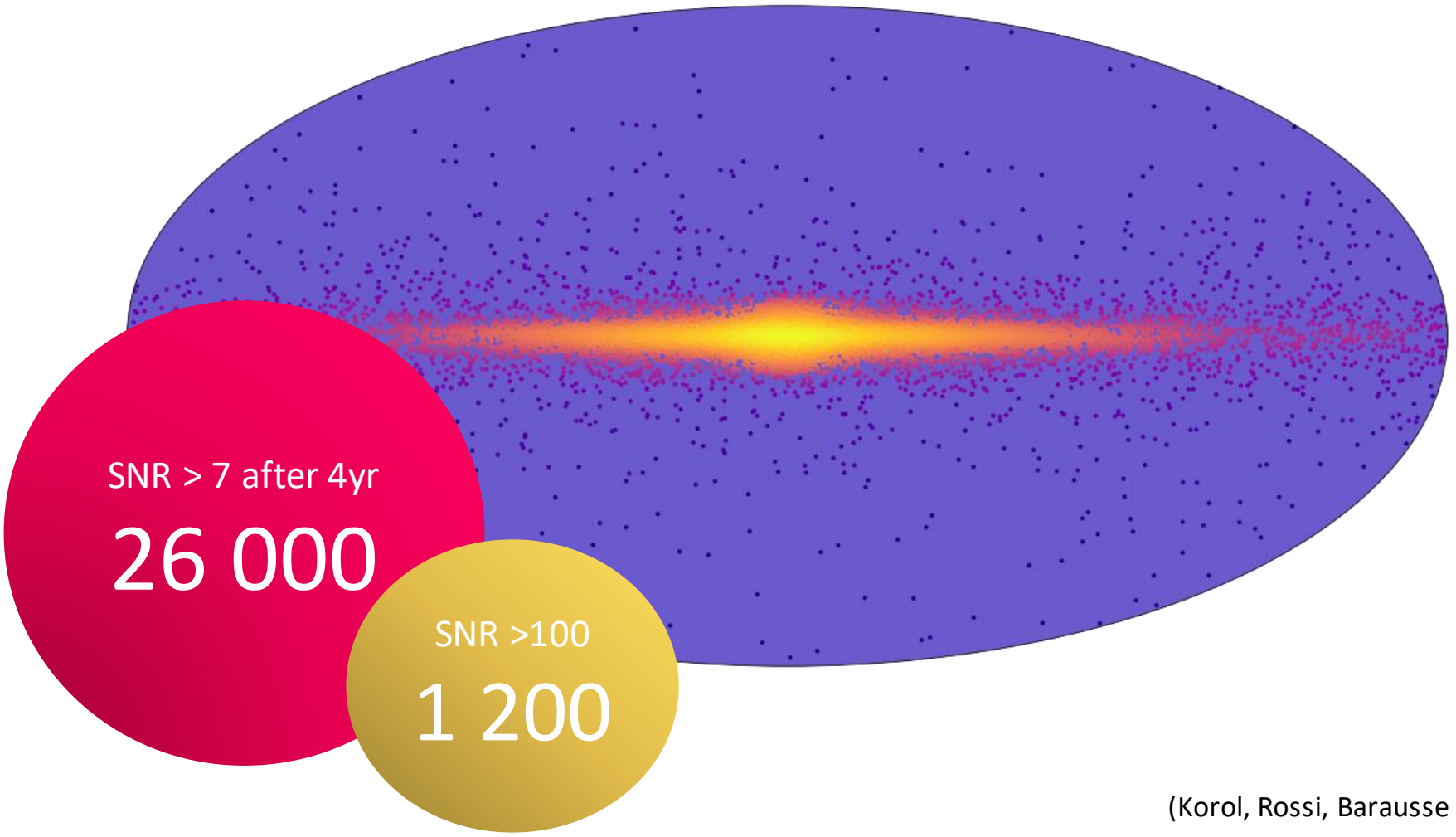
(Boissier & Pranzos 99)

Synthetic Milky Way



(Korol, Rossi, Barausse 2019)

Synthetic Milky Way



(Korol, Rossi, Barausse 2019)

Synthetic Milky Way

$\frac{\sigma_d}{d} < 30\%$

8 000

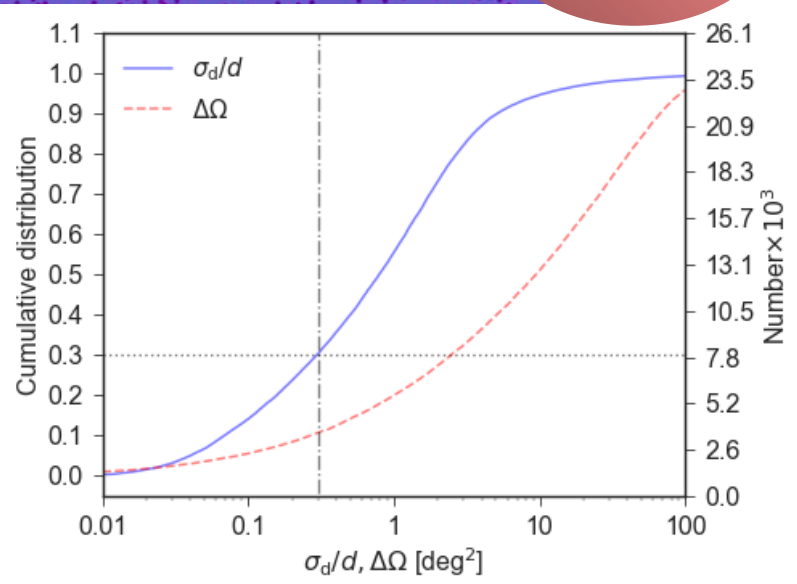
$\Delta\Omega$
<10 deg²

SNR > 7 after 4yr

26 000

SNR >100

1 200

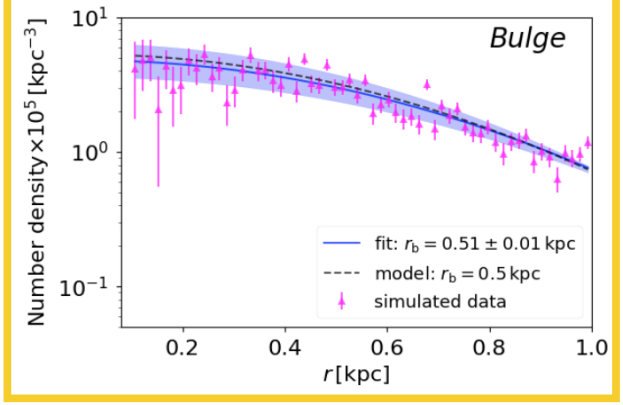


(Korol, Rossi, Barausse 2019)

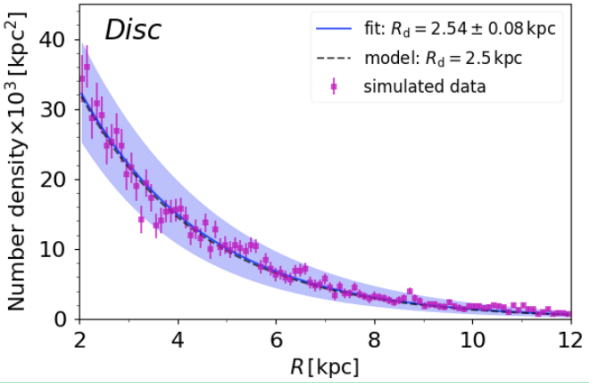
Characterising the Milky Way's structural properties with LISA

Considering DWDs with relative error on the distance < 30%
and any error on sky position

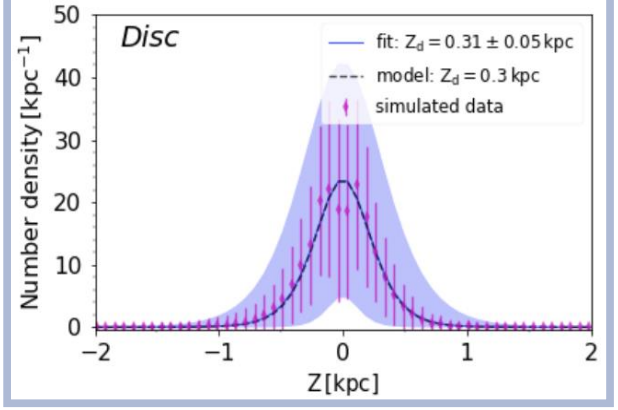
Constraint on the bulge scale radius to 2%



Constraint on the disc scale radius to 3%



Constraint on the disc scale height to 15%

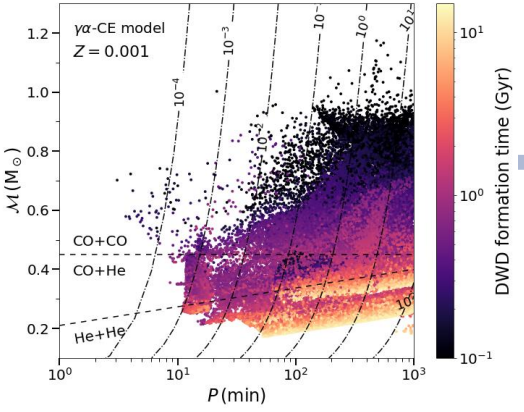


See also:
Benacquista+06, Adams+12, Breivik+19

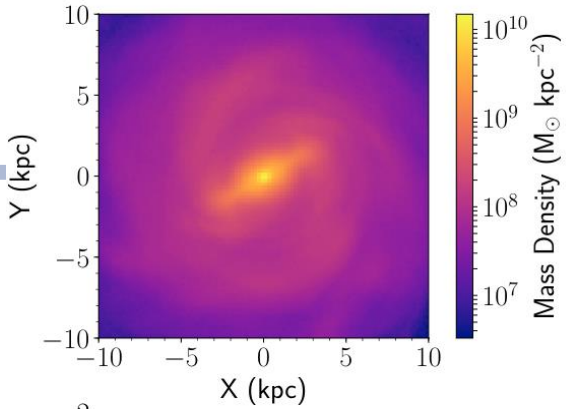
(Korol, Rossi, Barausse 2019)

Synthetic Milky Way

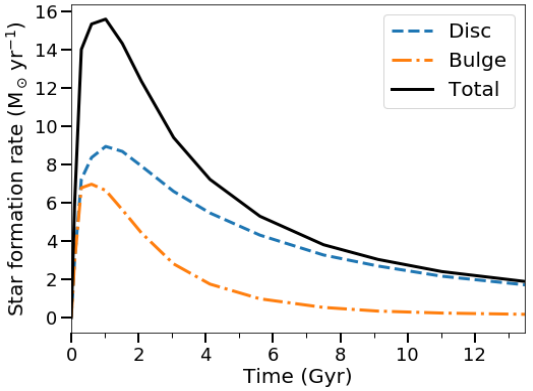
Synthetic population of DWDs



MW potential



Star Formation History

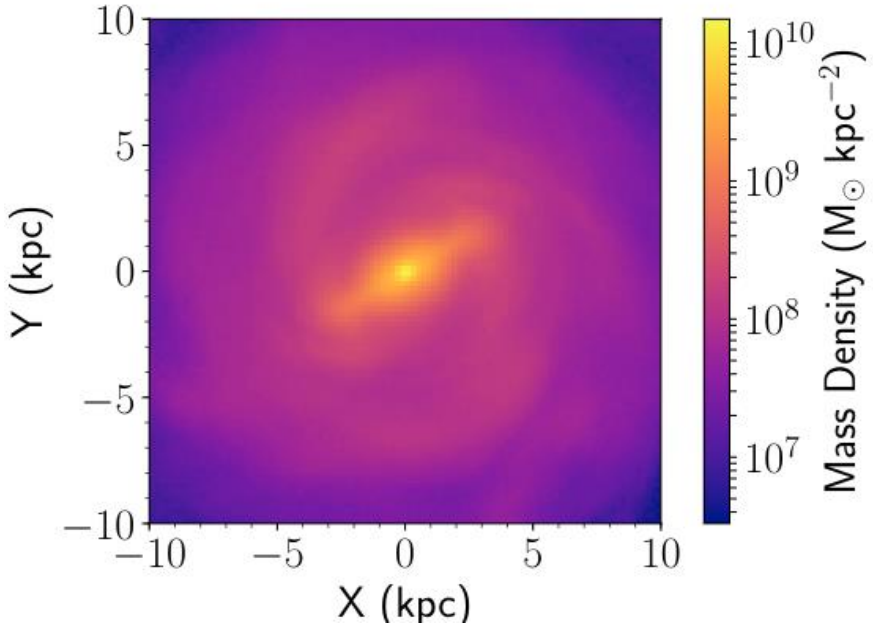


(D'Onghia & Alghieri 2019)

(Boissier & Pranzos 99)

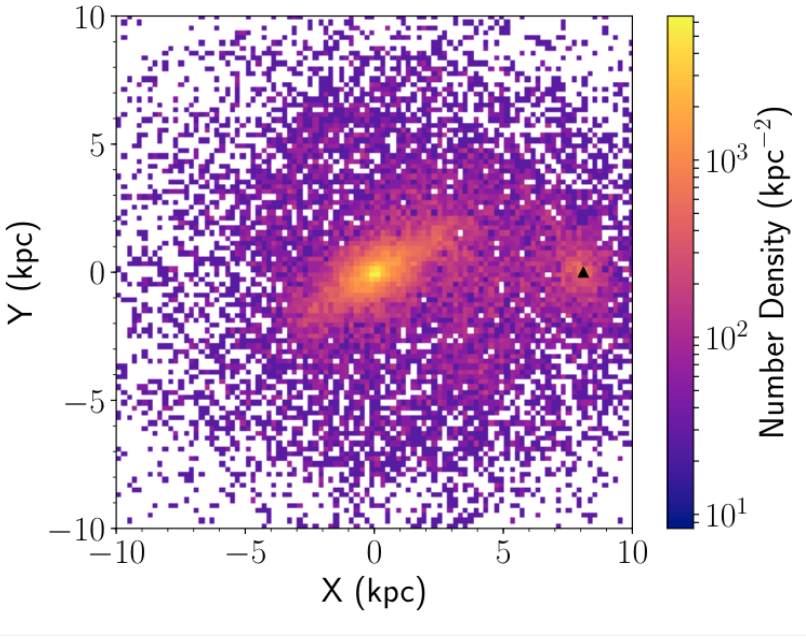
Characterising the Milky Way's structural properties with LISA

Numerical simulation



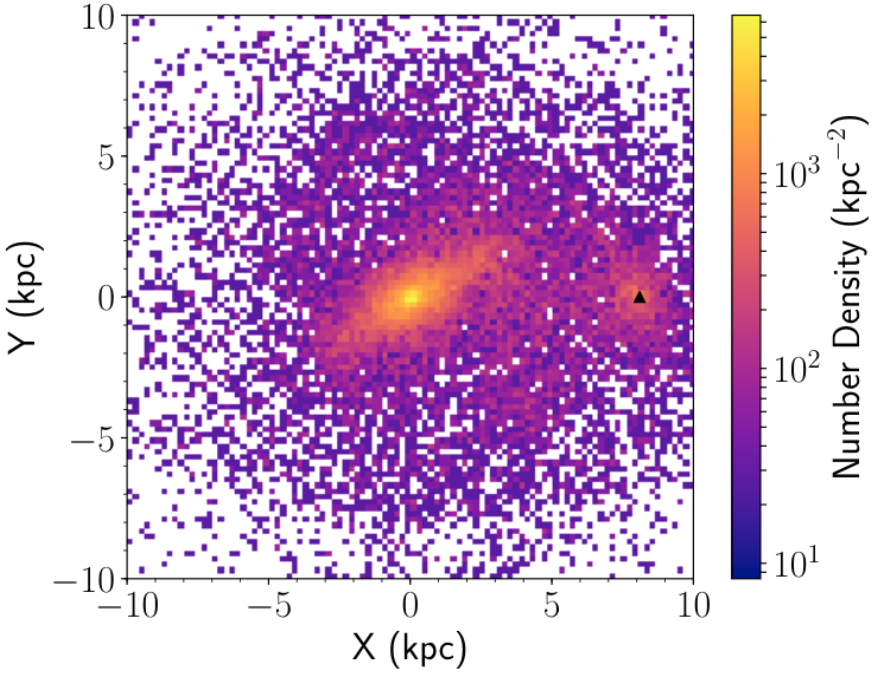
(D'Onghia & Alghieri 2019)

DWDs with SNR > 7



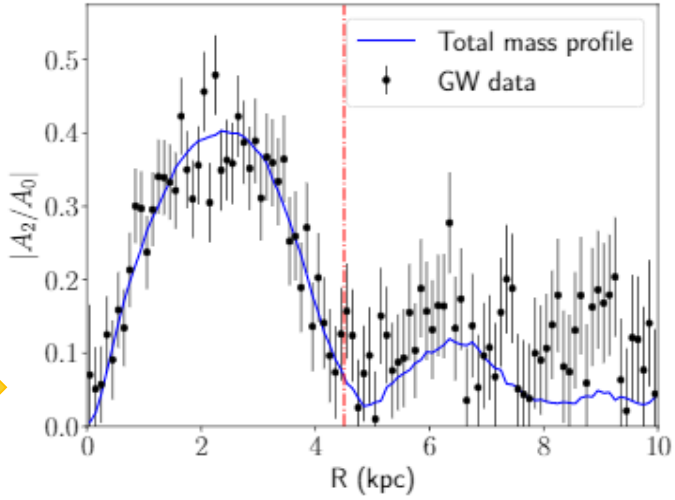
(Wilhelm, Korol, Rossi in prep.)

Characterising the Milky Way's structural properties with LISA



(Wilhelm, Korol, Rossi in prep.)

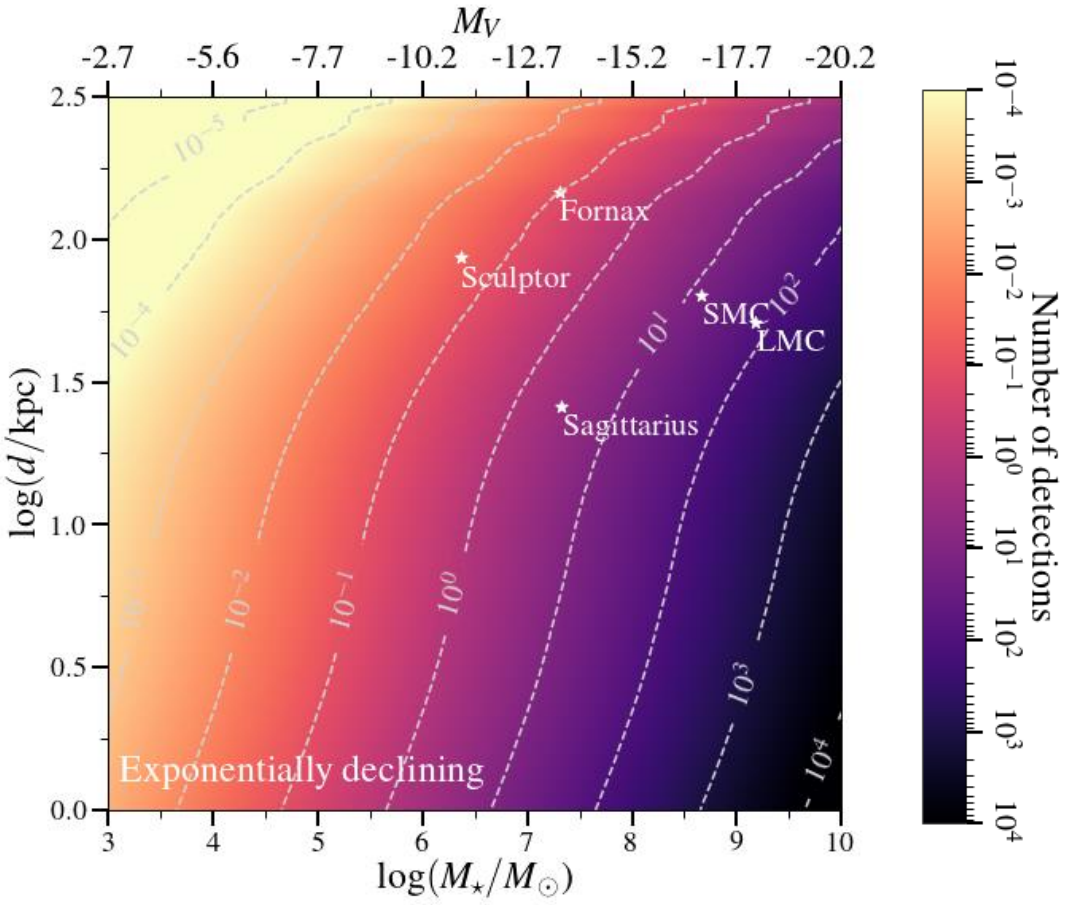
F



Constraints on

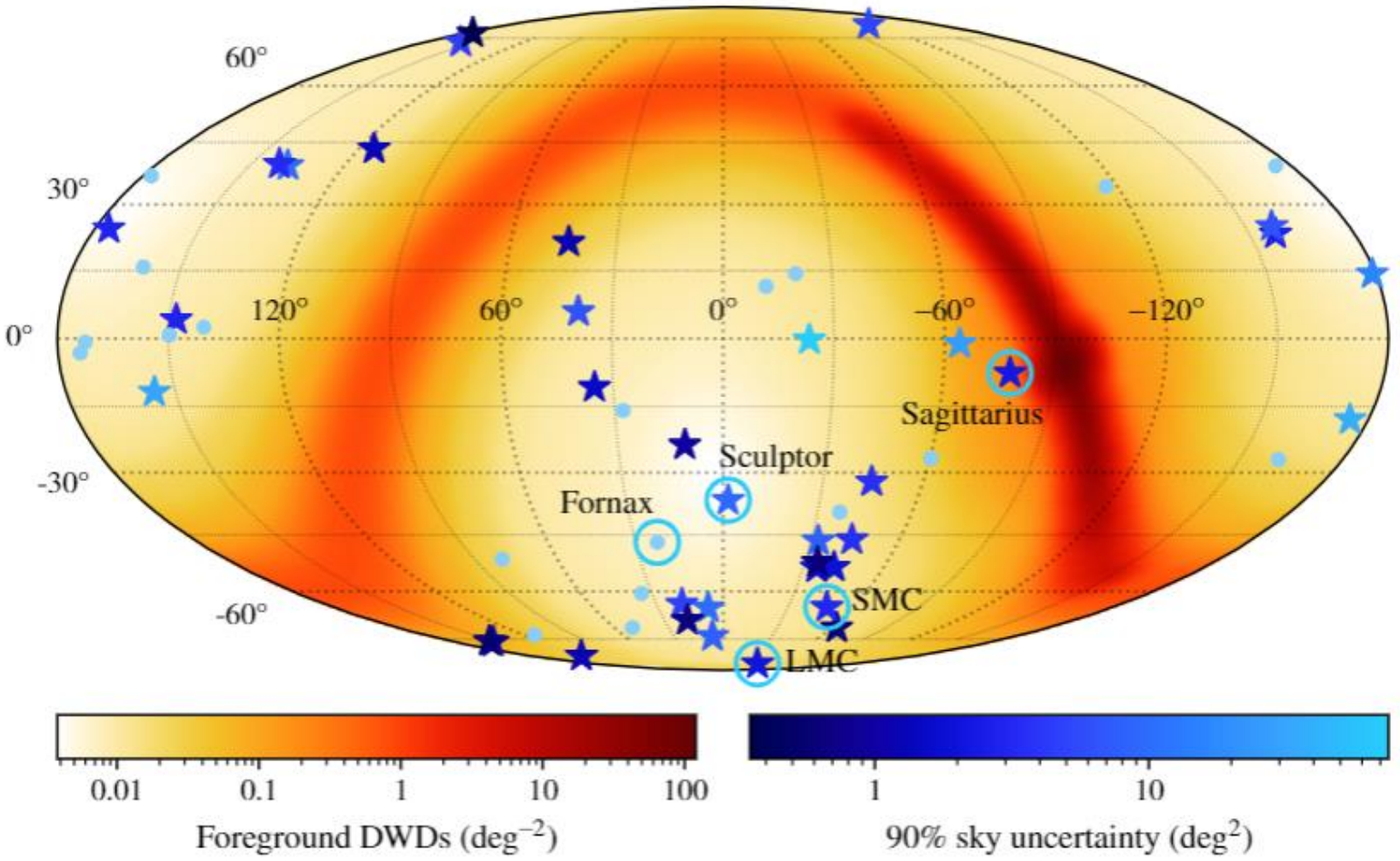
- **bar length to 10%**
- **bar width to 4%**
- **viewing angle to 3%**

Populations of DWD in Milky Way satellites



(Korol, Toonen, Klein + 2020)
https://arxiv.org/abs/2002.10462

Populations of DWD in Milky Way satellites



(Roebber, Buchicchio, Vecchio + 2020)
https://arxiv.org/abs/2002.10465

Summary

1. As an all-sky survey that does not suffer from contamination and dust extinction, LISA can map the Milky Way and environs.

2. The density distribution of LISA detections can be used to constrain scale parameters of the Milky Way's bulge, disc and bar.

3. LISA can detect known Milky Way dwarf satellites and potentially discover new ones through populations invisible to EM instruments.