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White dwarfs in the *Gaia* era

Pier-Emmanuel Tremblay

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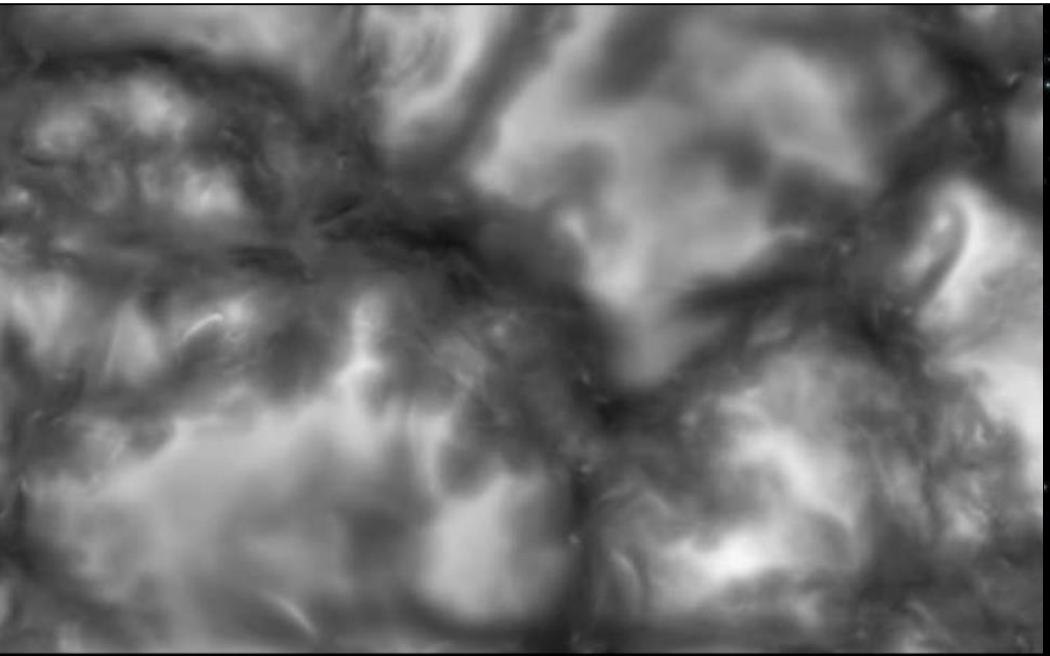
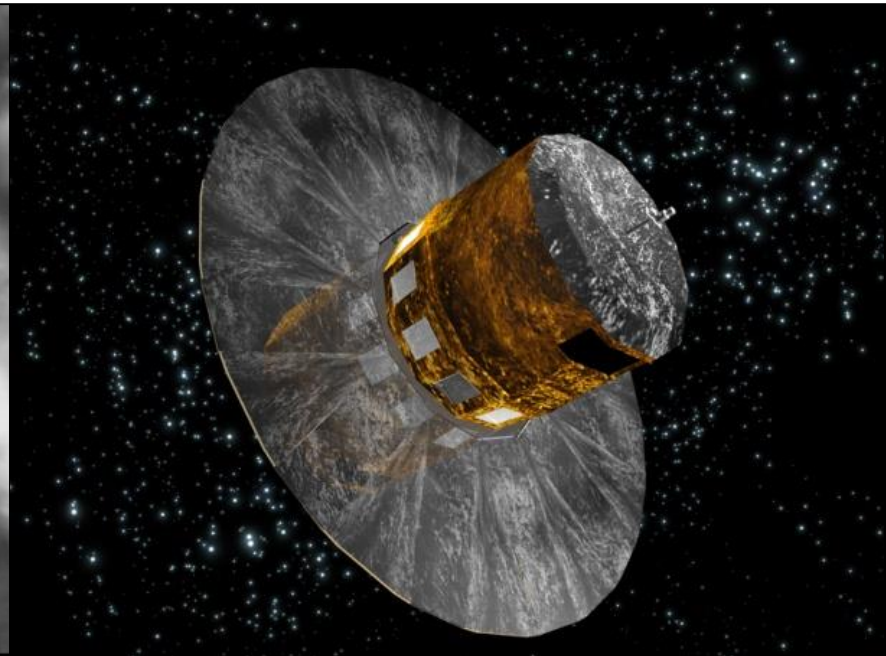
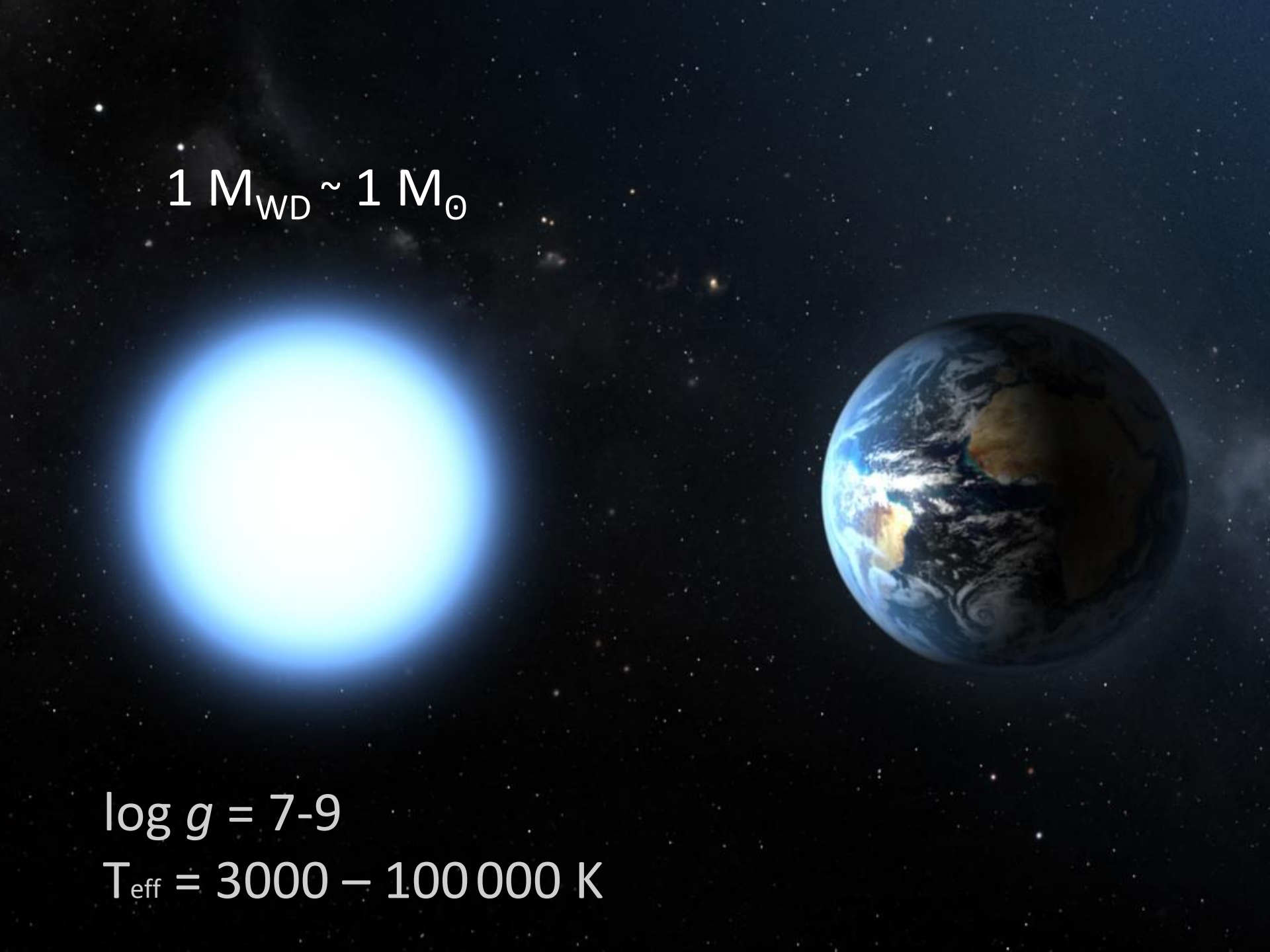
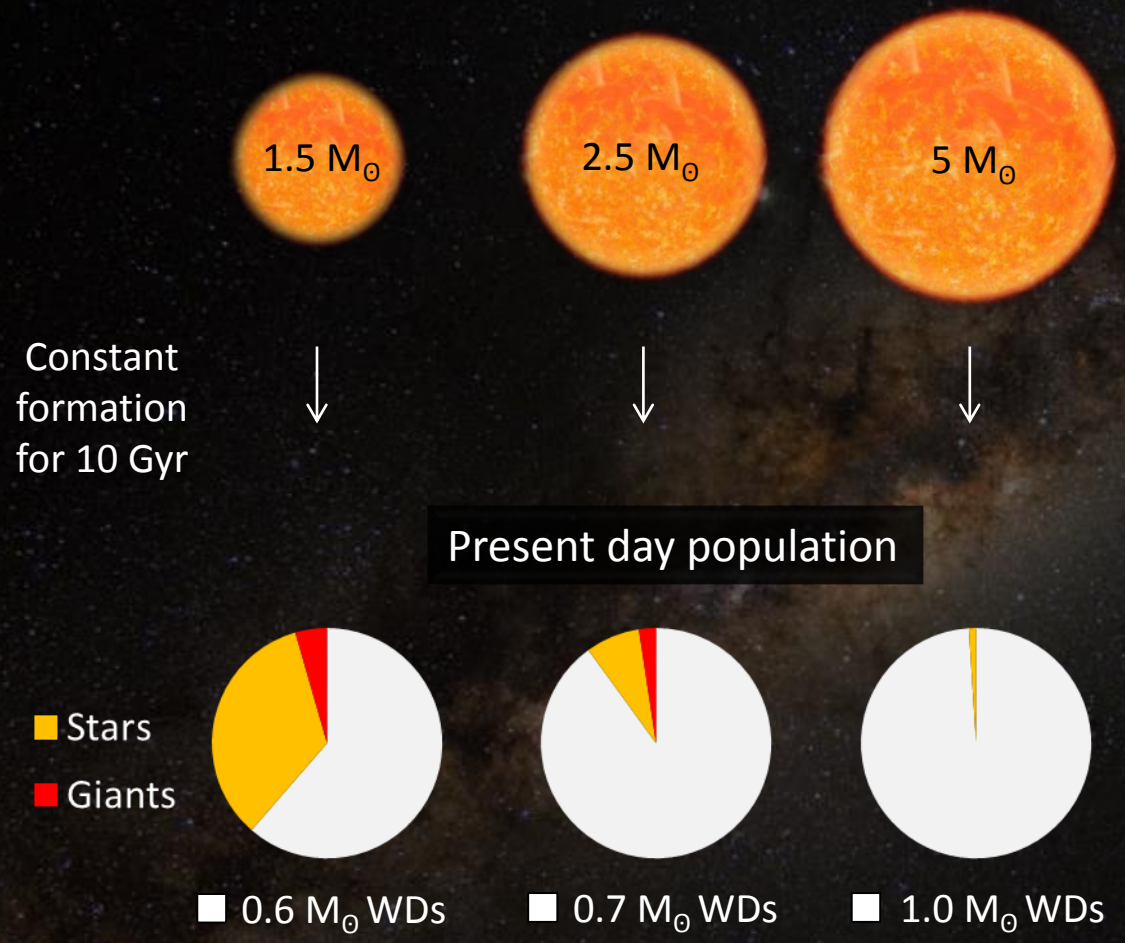





$1\ M_{WD} \sim 1\ M_{\odot}$
$\log g = 7\text{-}9$
$T_{eff} = 3000 - 100\,000\ K$

Probing the history of the Milky Way

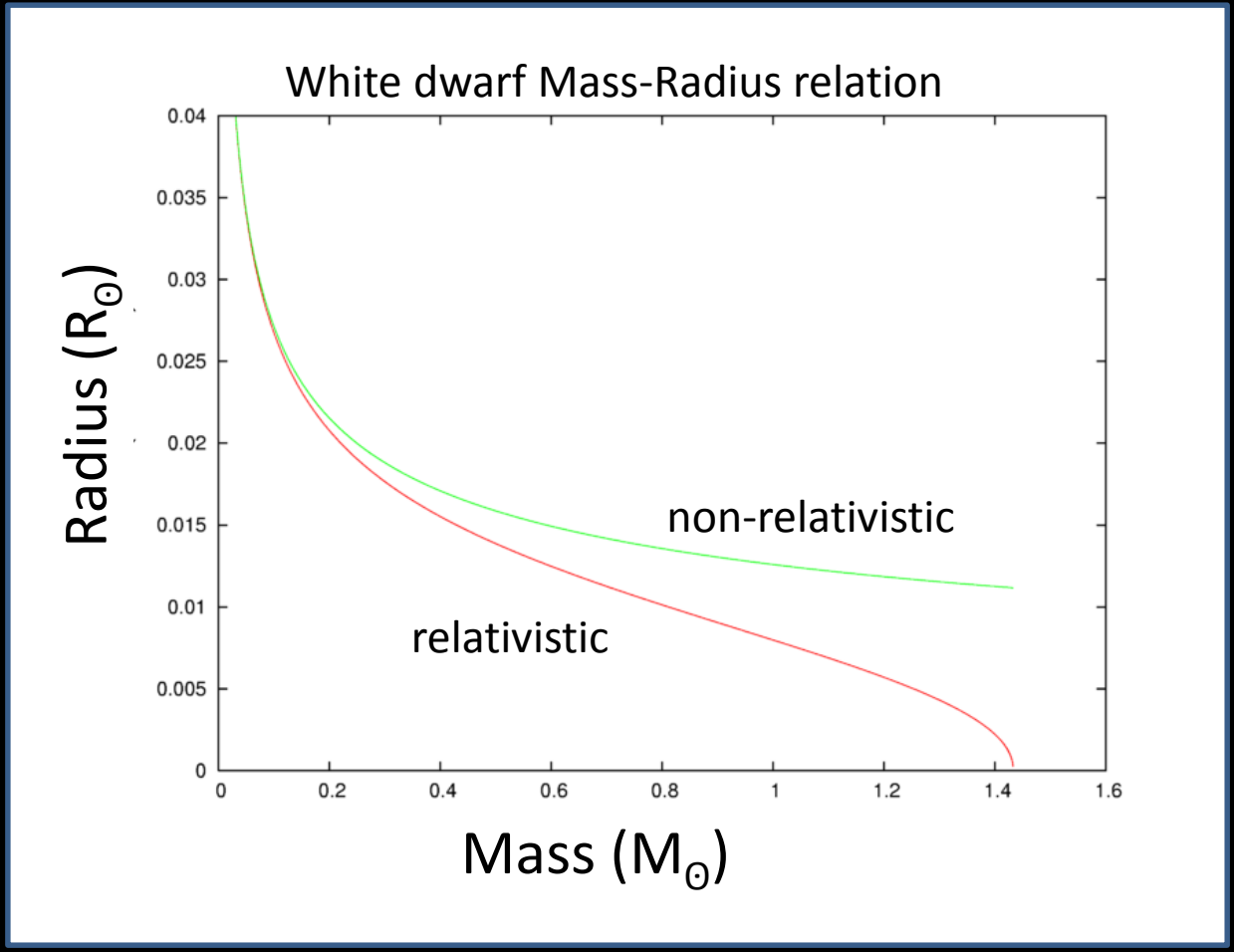


WDs provide

- Calibration of the mass loss in stellar evolution (Casewell et al. 2009, Kalirai et al. 2014)
- Precise star formation history and IMF for the disk, halo, and clusters of the Milky Way (Tremblay et al. 2014)
- History and fate of planetary systems (metal pollution, Zuckerman et al. 2007)

Gaia parallax and colours gives T_{eff} and R → mass-radius relation → total age with evolution models

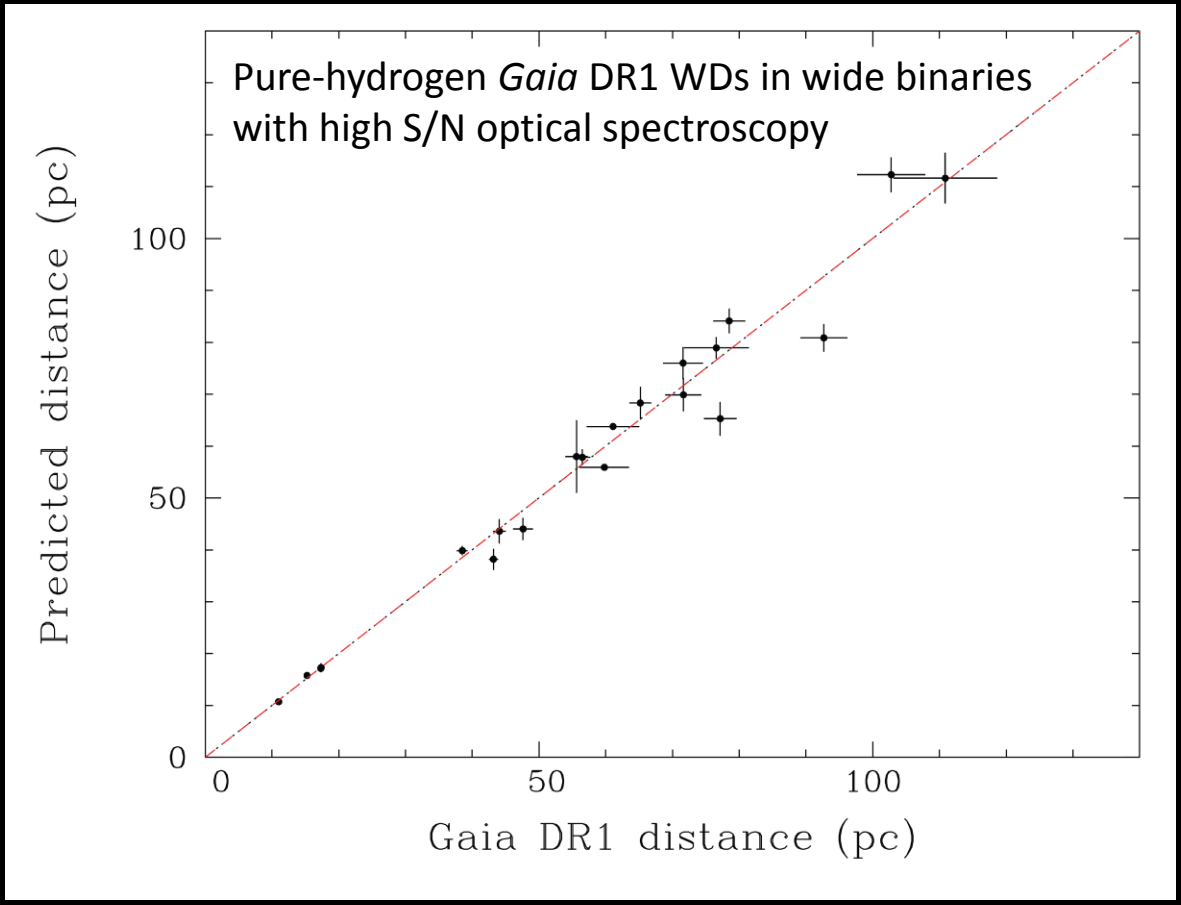
Spectroscopic follow-ups for more precision, subtypes, and internal check of models



White dwarfs in *Gaia* DR1 (Tremblay et al. 2017)

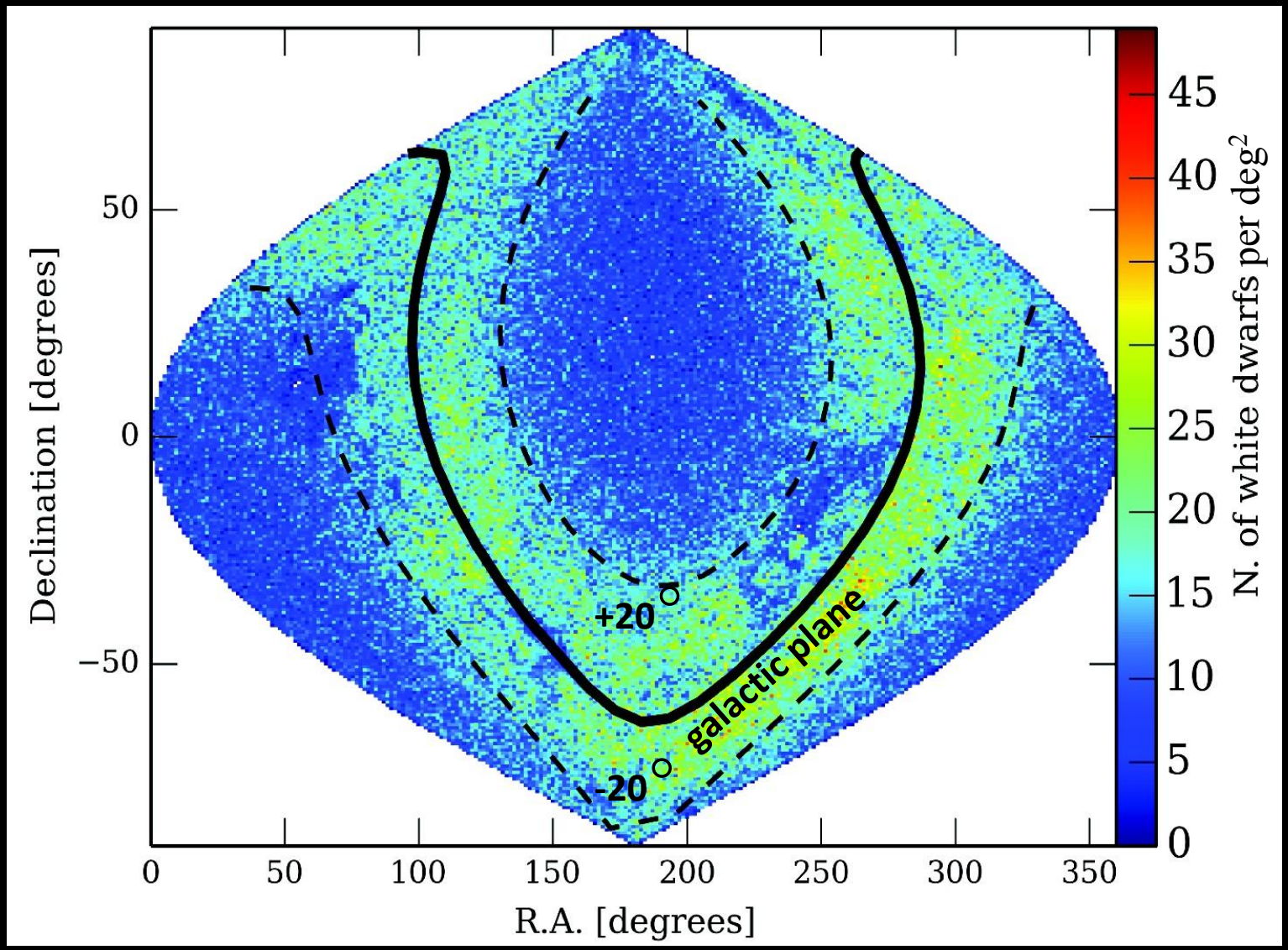
- Only 6 white dwarfs directly observed
- 46 in wide binaries, 32 in unresolved binaries (S. Joyce talk)
- *Gaia* parallaxes and *G*-band magnitudes agree with WD models at the 0.5% level!
- There are a few outliers! (e.g. 2 new suspected double degenerates)

distance modulus from spectroscopic parameters and *Gaia G*-band



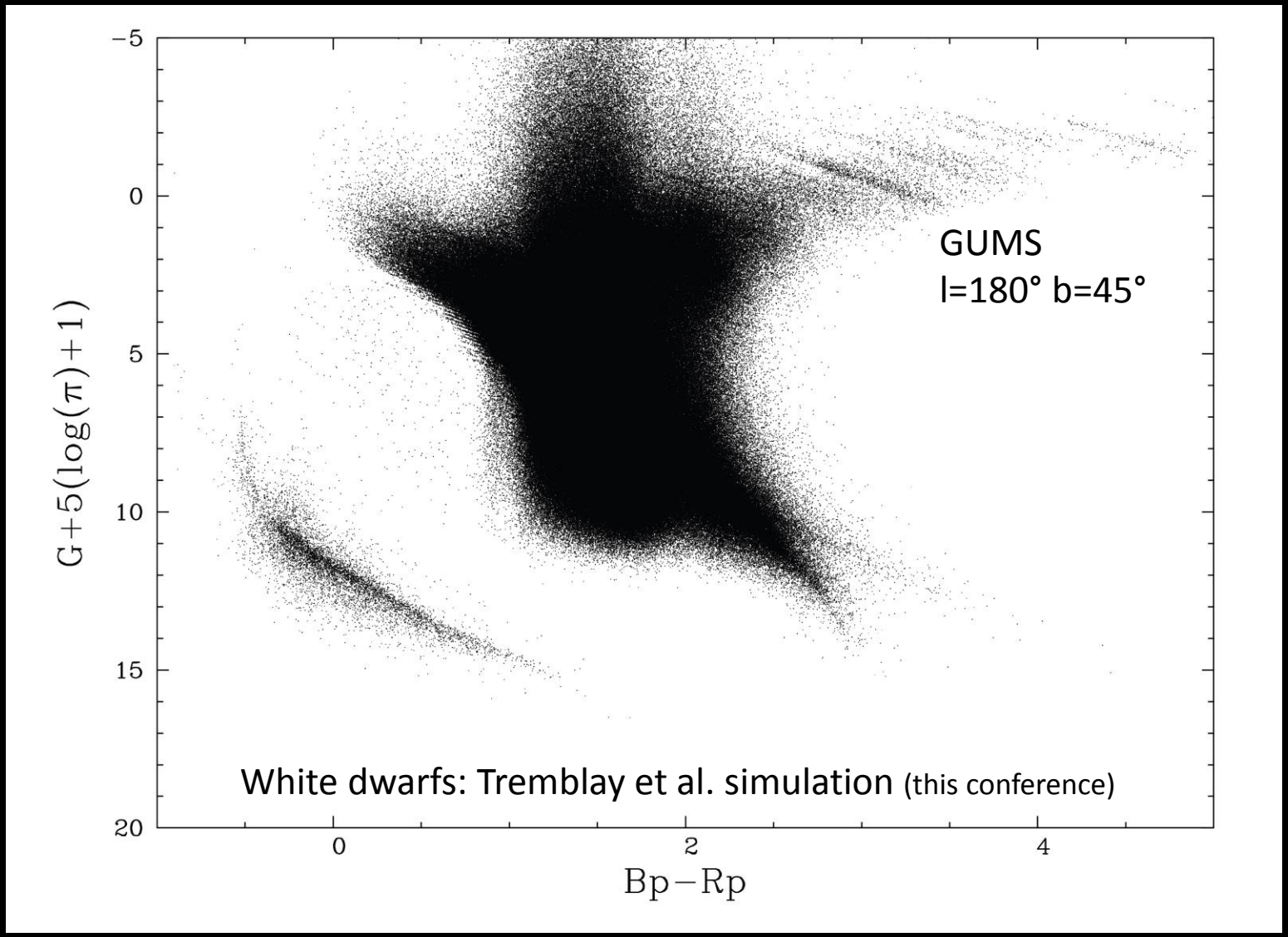
Gaia DR2 white dwarf population

About 300000 WDs / ~10-25 white dwarfs per deg^2



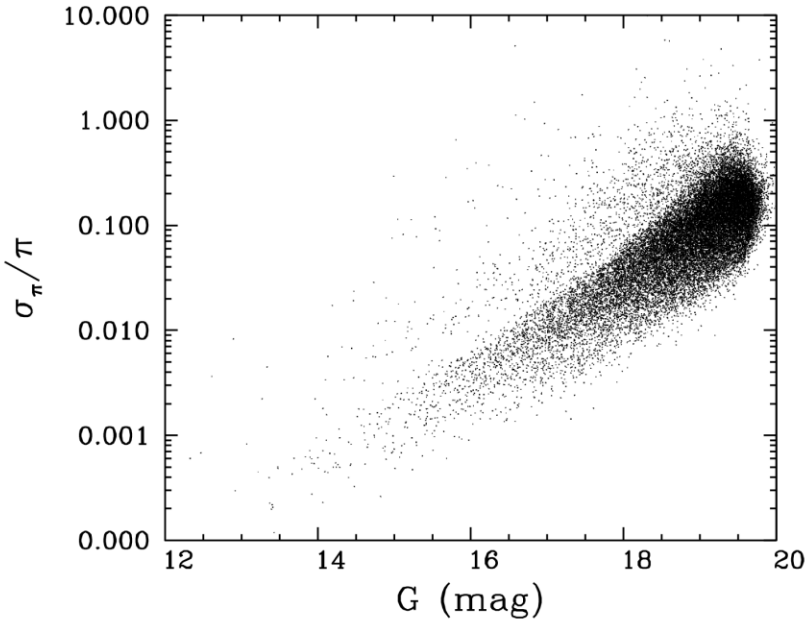
300000 white dwarfs *Gaia* DR2

predicted HR diagram with *Gaia* errors

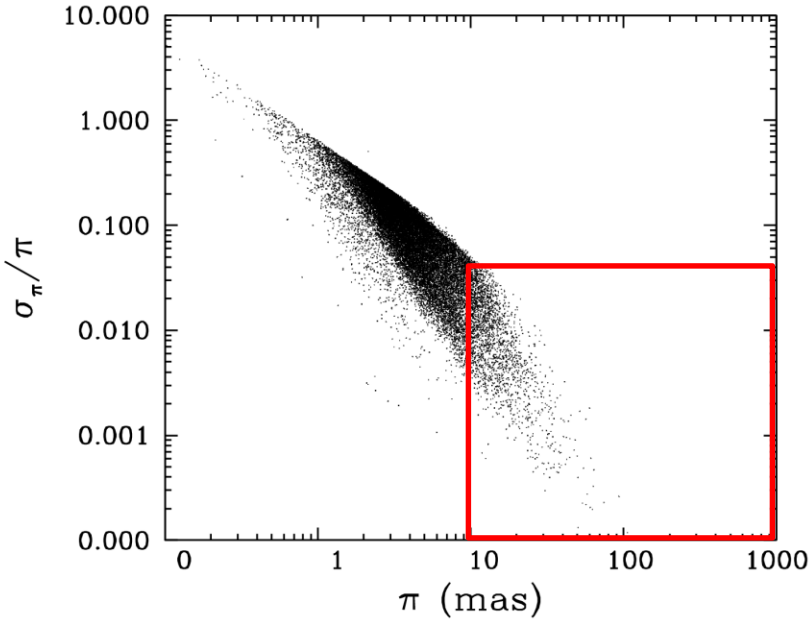


WDs in *Gaia* DR2

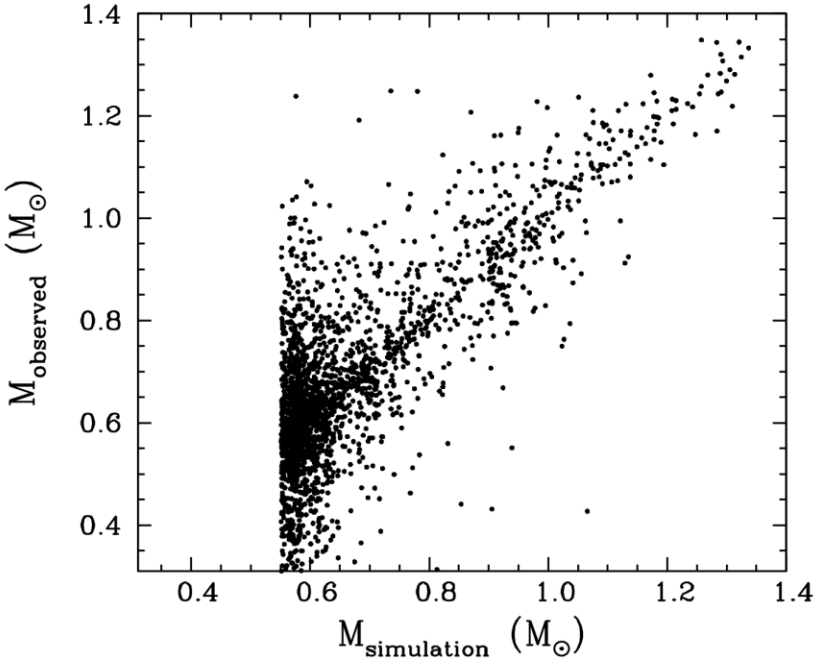
parallax accuracy

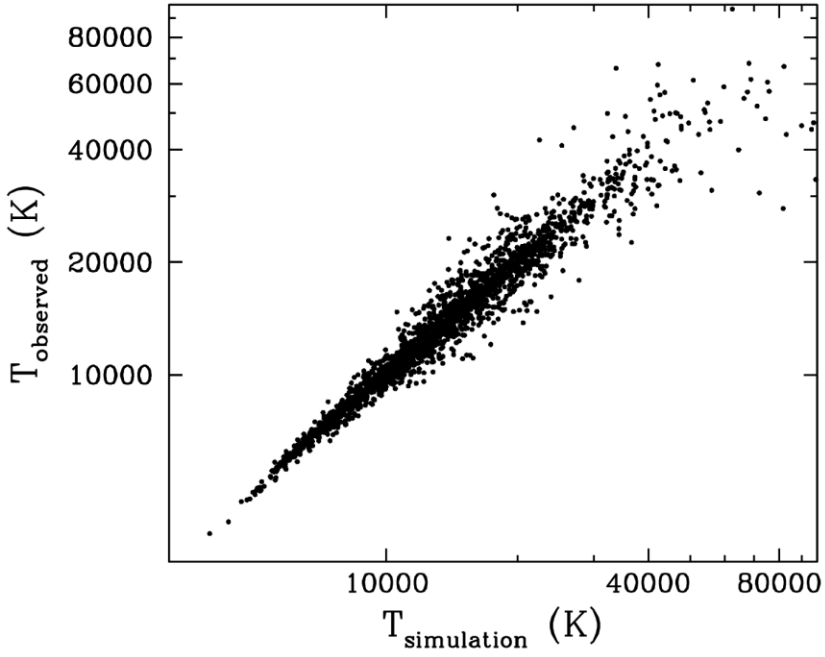


final DR will improve by ~$\sqrt{2}$



100 pc sample
(10 000 white dwarfs)





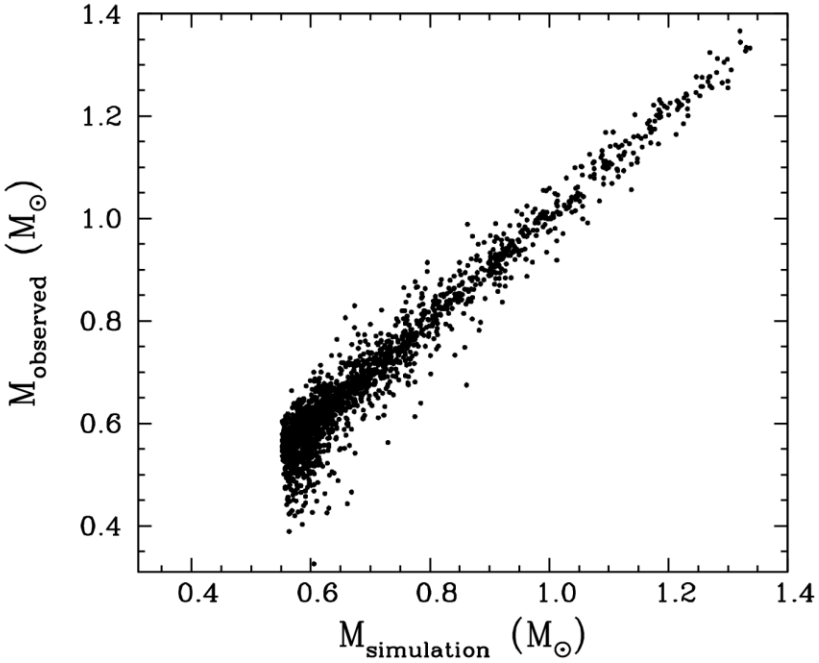
WDs in *Gaia* DR2

stellar parameters

Stellar parameters from Gaia only data (parallax, G, G_p, R_p)

does not include double white dwarfs!

1) All 300 000 WDs



WDs in *Gaia* DR2

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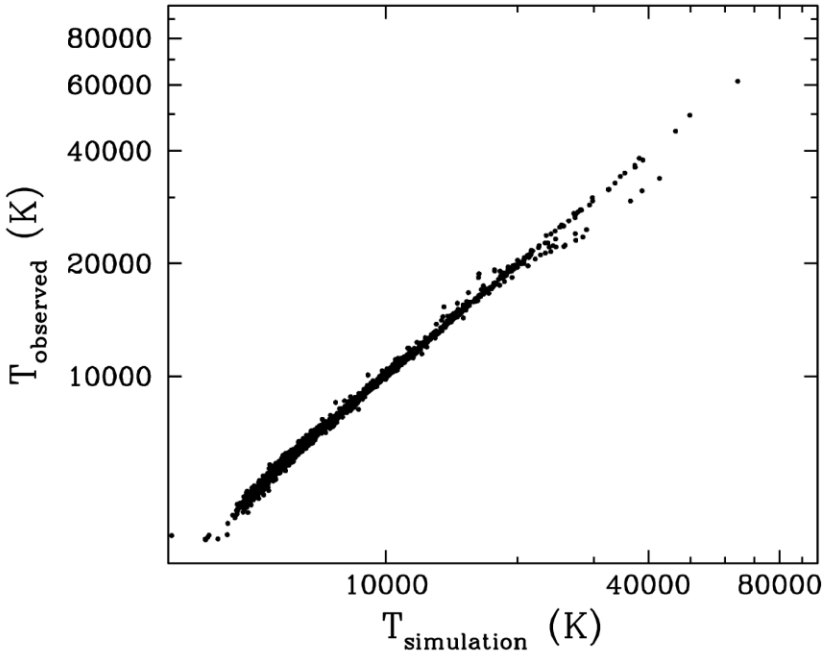
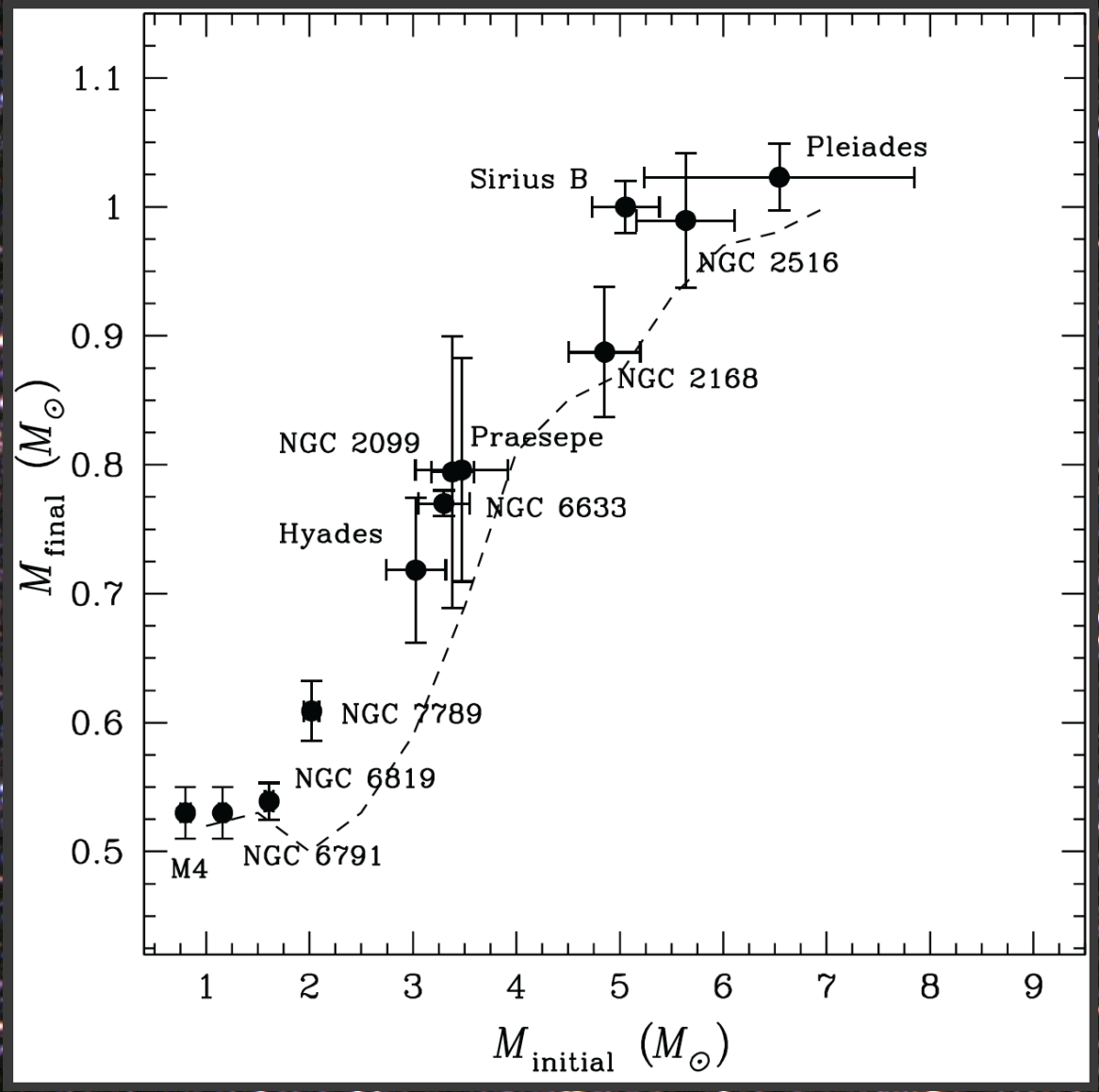


2) 100 pc sample

$\sigma_\pi/\pi < 0.01$

(same number of WDs on plot)

Initial-final mass relation

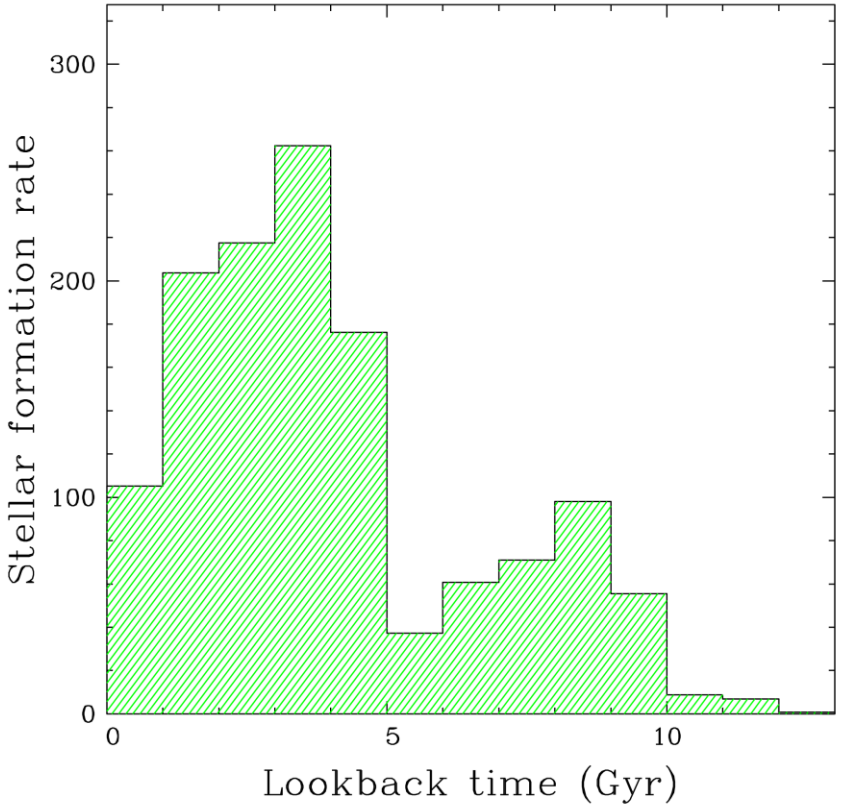


Weideman 1980, Kalirai et al. 2009, Williams et al. 2009, Dobbie et al. 2012

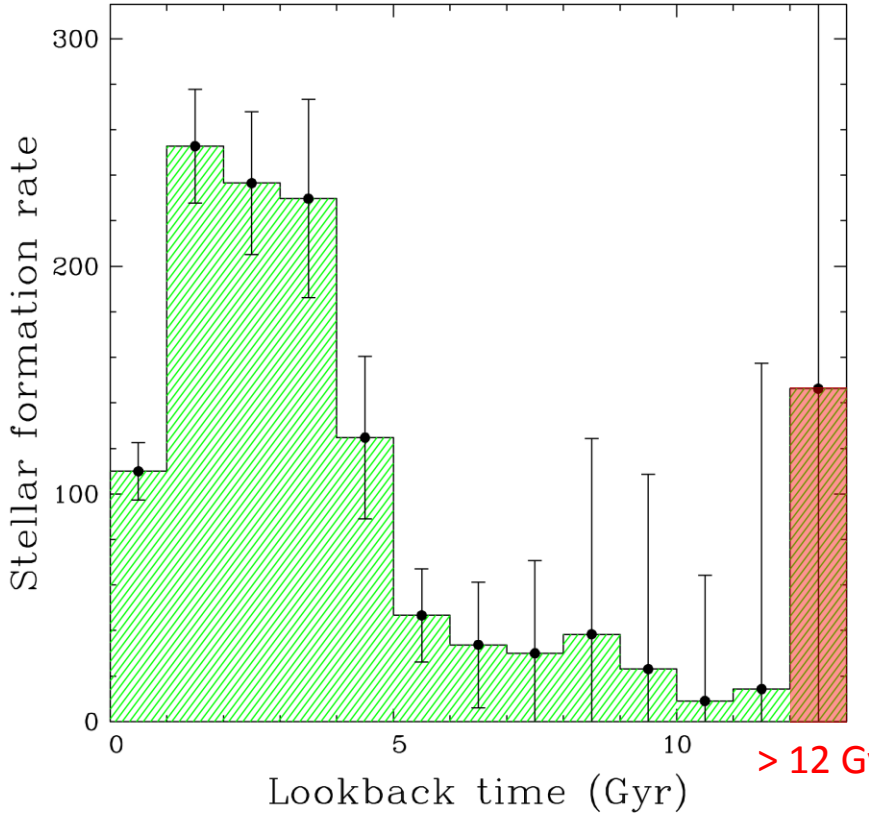
Galactic archeology with white dwarfs

1) *Gaia* parameters only

Input SFH (20 pc sample; Tremblay et al. 2014)



Gaia 40 pc (1000 white dwarfs) – G, Bp, Rp only

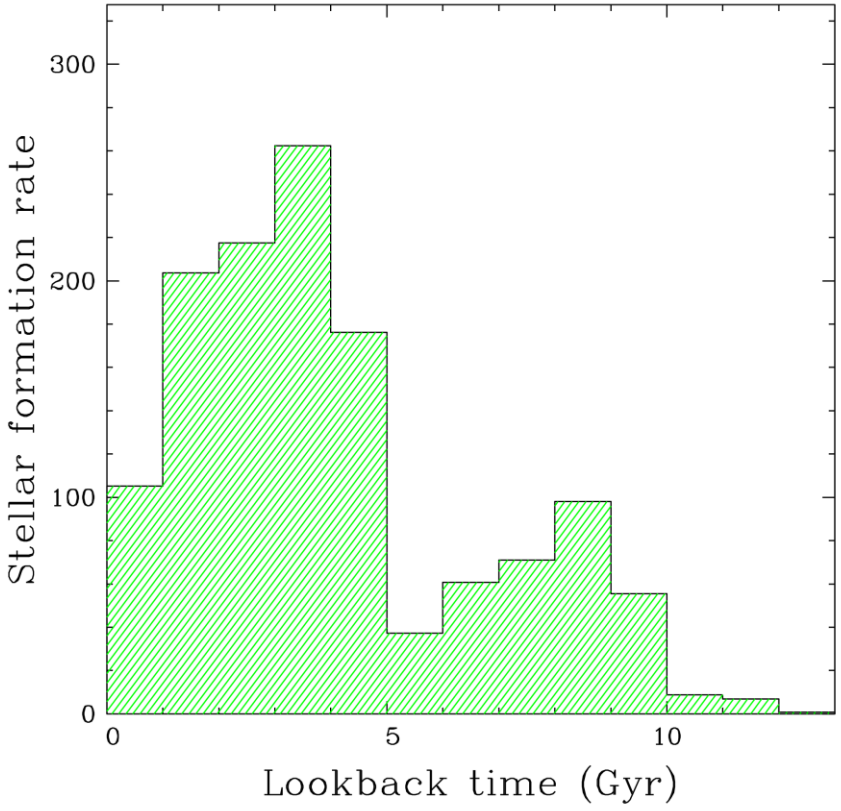


Minimum we can do (direct method)

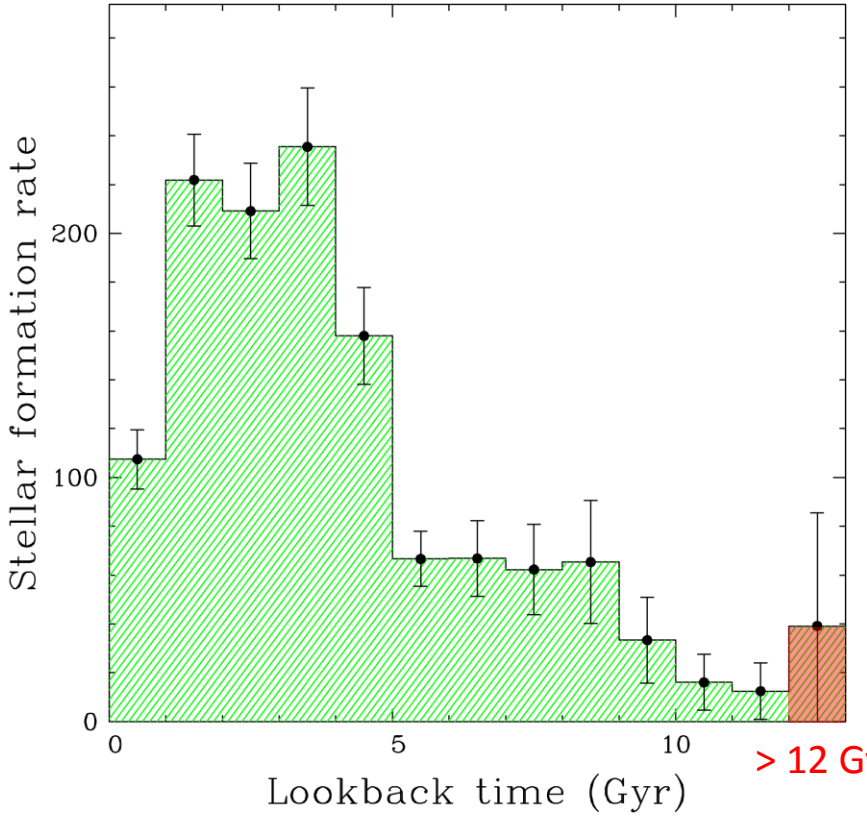
Galactic archeology with white dwarfs

2) *Gaia* + follow-up spectroscopy

Input SFH (Tremblay et al. 2014)



Gaia 40 pc – S/N > 30 spectro



Conclusion: White dwarfs in *Gaia*/WEAVE/4MOST

- Up to 3×10^5 new white dwarfs
- Spectroscopic follow-ups necessary for precise stellar parameters
- medium-resolution (380-520 nm) -> relatively small cost to include WDs!
- White dwarfs are excellent flux / telluric calibrators

Outcomes

- Stellar formation history in the disk / initial mass function
- Ages in wide binaries, clusters / mass loss in AGB
- 6D phase-space: up to 3000 halo white dwarfs, streams
- Chemical abundances: Galactic evolution of planetary systems

Long term: halo stellar formation history with *Euclid+LSST*