Theoretical Delay Time Distributions

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Outline

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- Population synthesis
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  - Progenitors and progenitor progenitors
  - Comparison with observations
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Introduction

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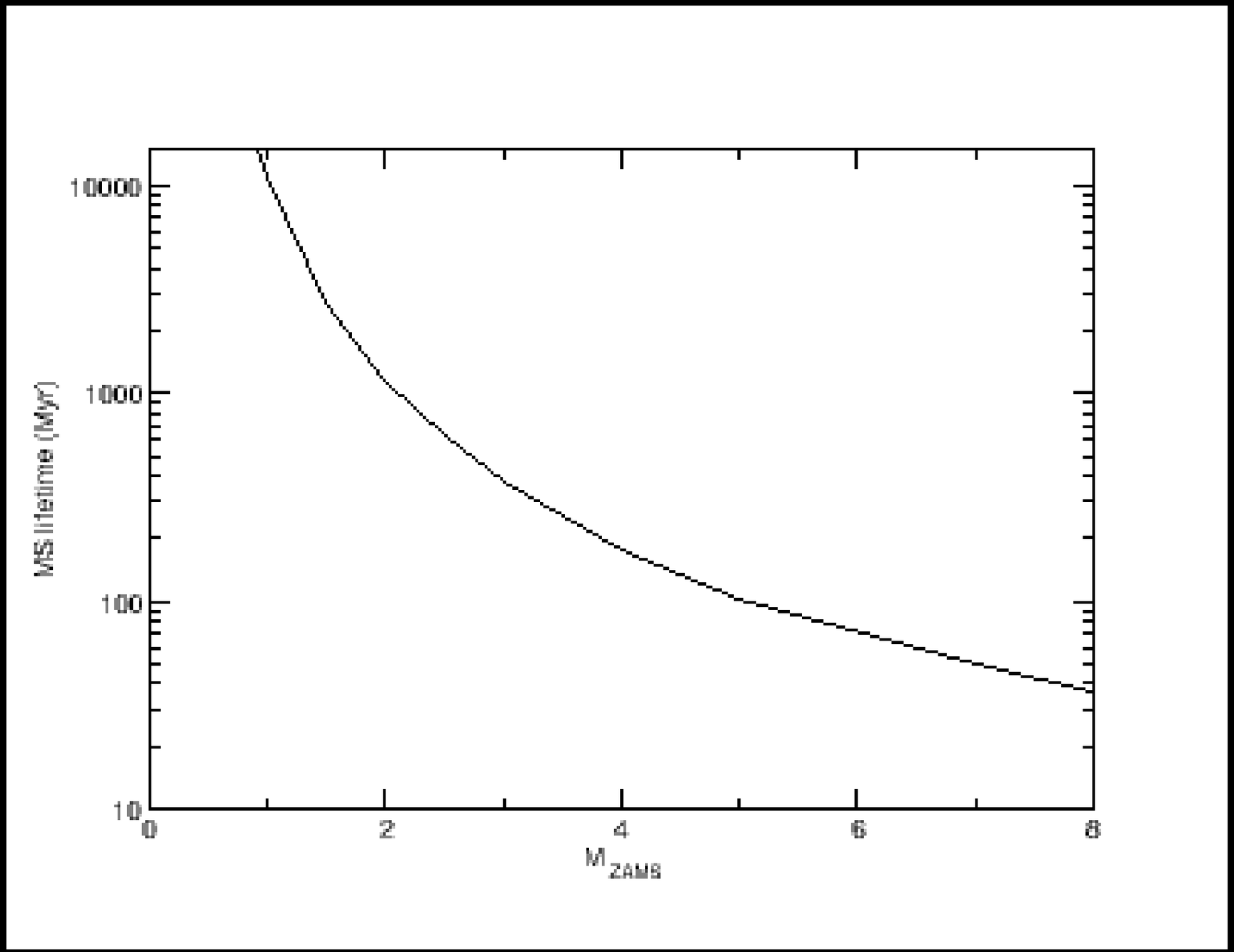
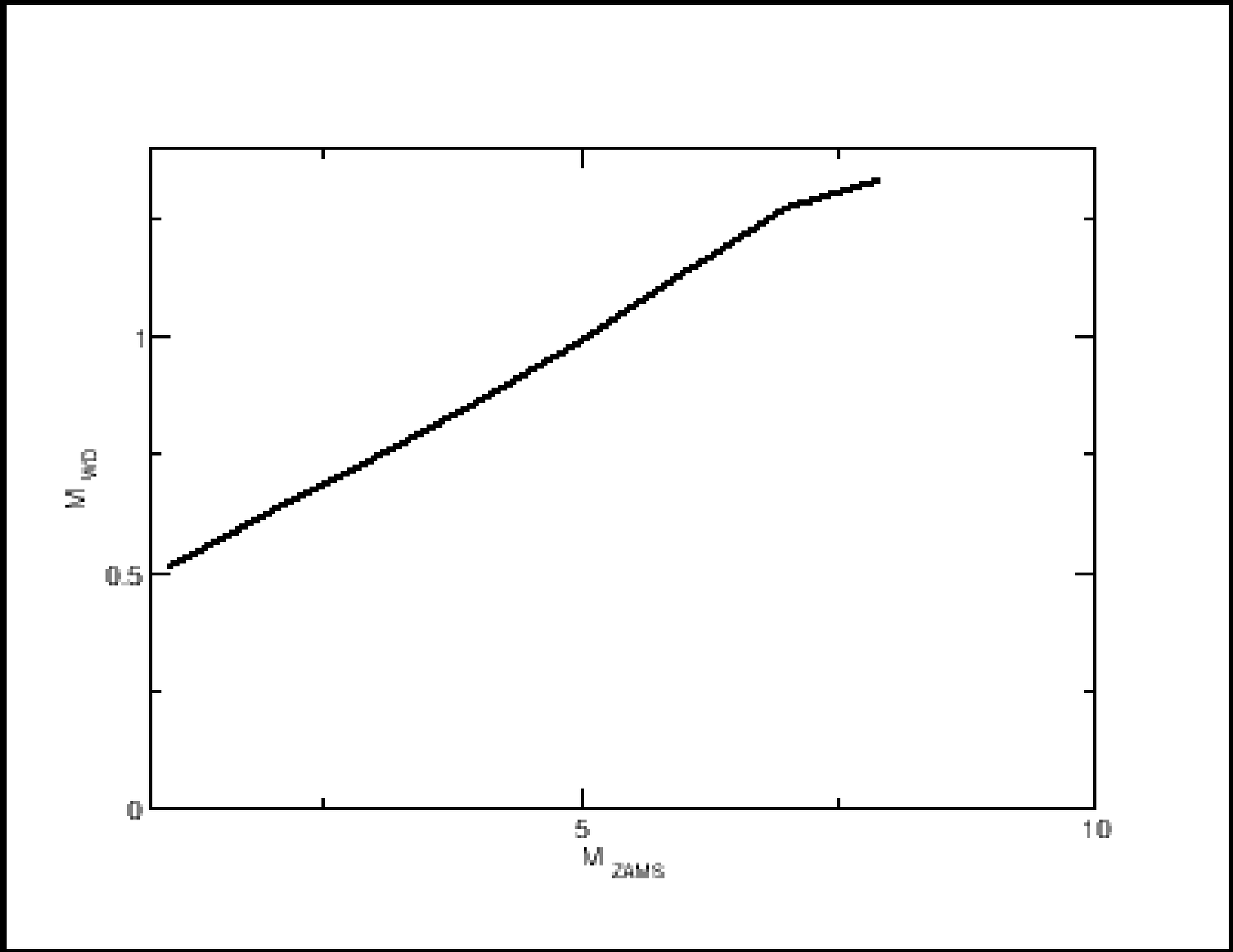
Some basics

- Stellar evolution timescale

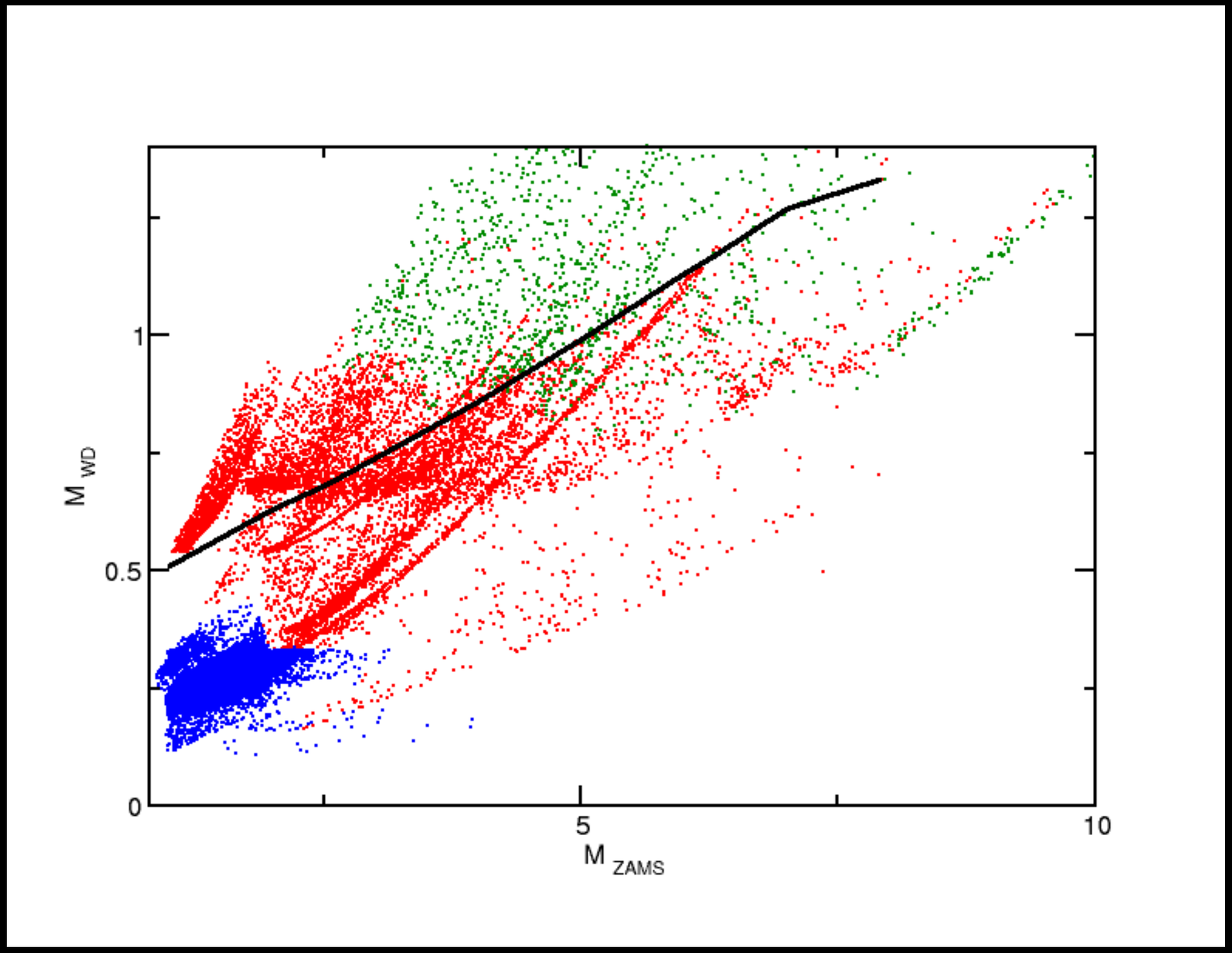


Initial mass – final mass relation



Hurley et al. 2000 tracks

Binaries mess everything up!



Binary population synthesis

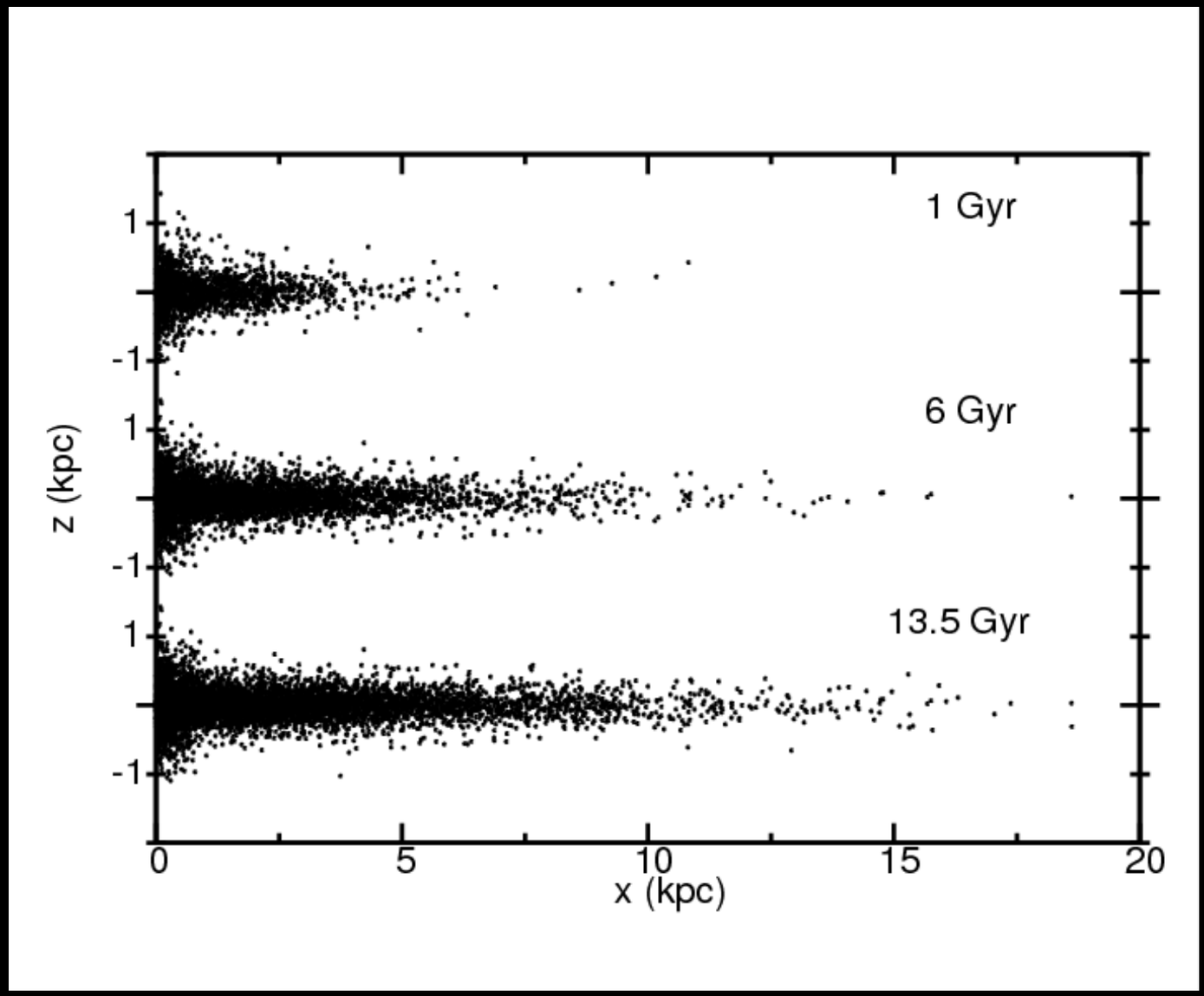
- Recipes for stellar and binary evolution (rapid)

  Portegies Zwart & Verbunt, 1996
  Nelemans et al. 2001

- Model for initial distributions (M,m/M,P)

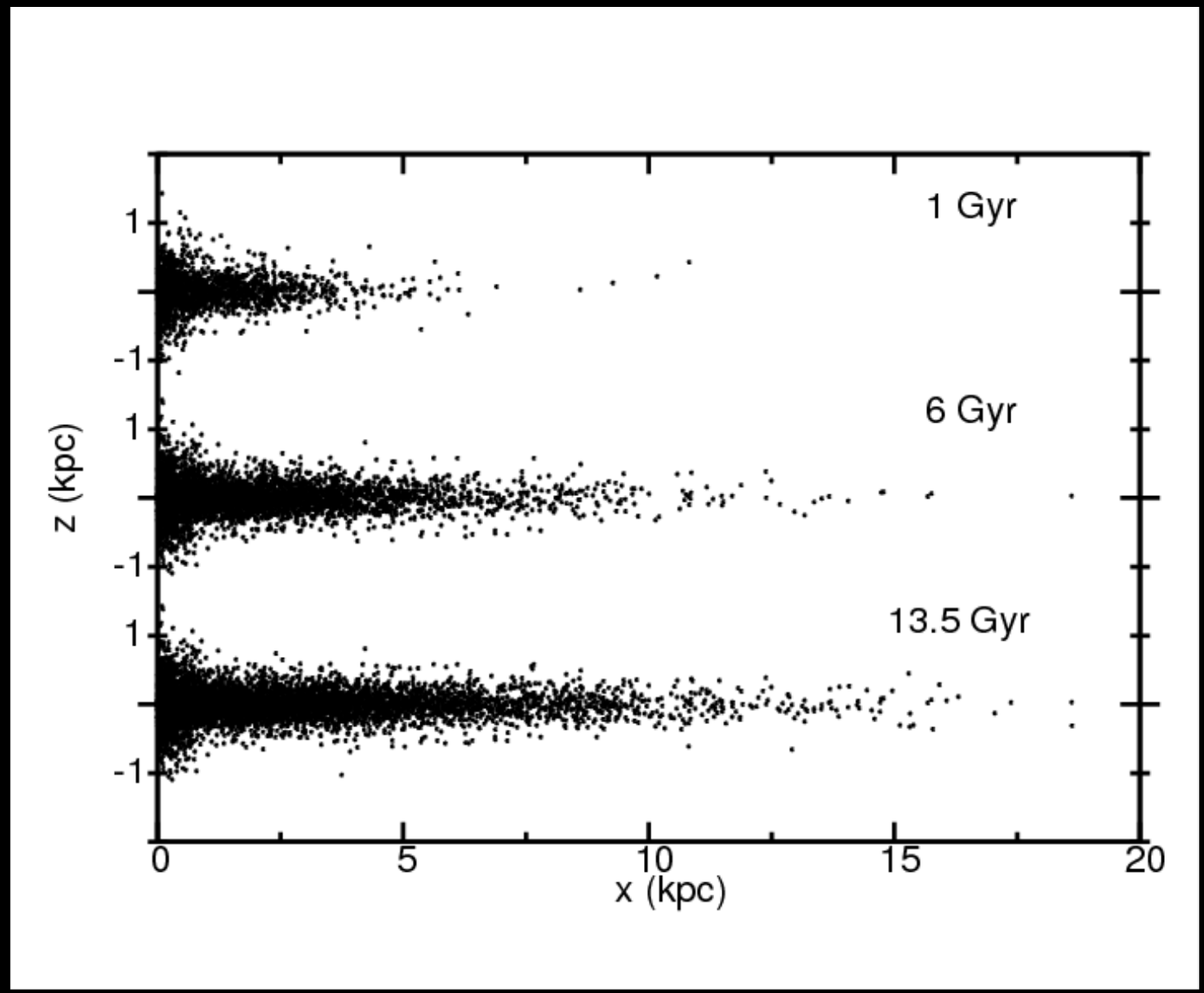
- Model for the star formation history

  Nelemans et al. 2004 based on Boissier & Prantzos 1999



Binary population synthesis

- Common envelope, stellar wind...
- Model for initial distributions?
- Galactic model and reddening
  - Schlegel et al dust map



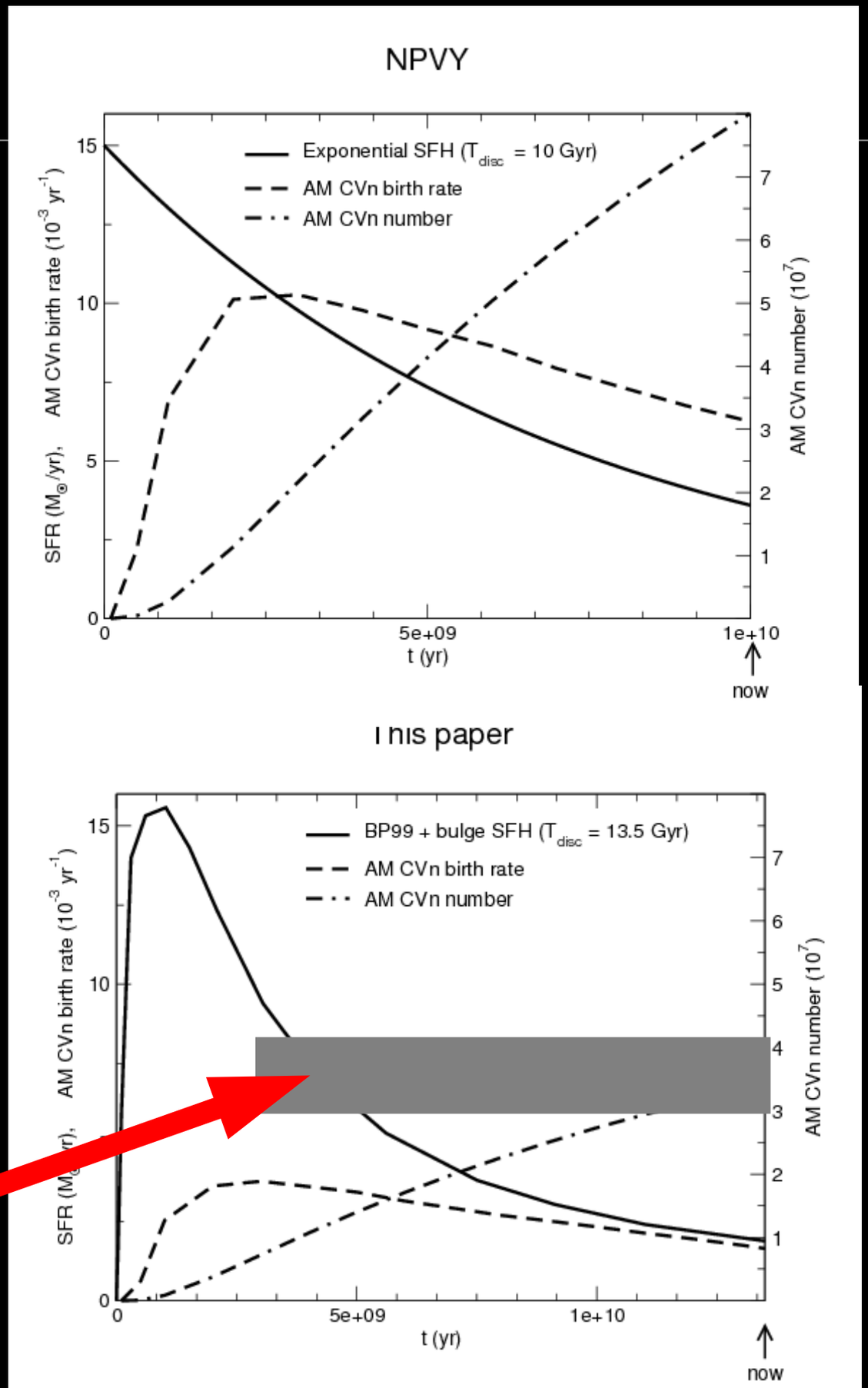
Uncertainties and assumptions

- Stability of mass transfer
  - Tricky: mass transter → change of donor radius → redistribution mass, i.e separation + mass loss from system → change separation → change in Roch lobe
  - Different approaches
    - “by hand”
    - Critical mass ratio (q)
    - Determine dR and dR_L
- Common envelope
  - When and what is outcome
  - Efficiency
- Single star models
- Models for peculiar stars
- Mass and angular momentum loss during mass transfer
  - Fixed or dependent on accretor
- White dwarfs
  - Mass accretion efficiency
  - Novae and their interaction with binary
  - He novae and their interaction...

Normalisation

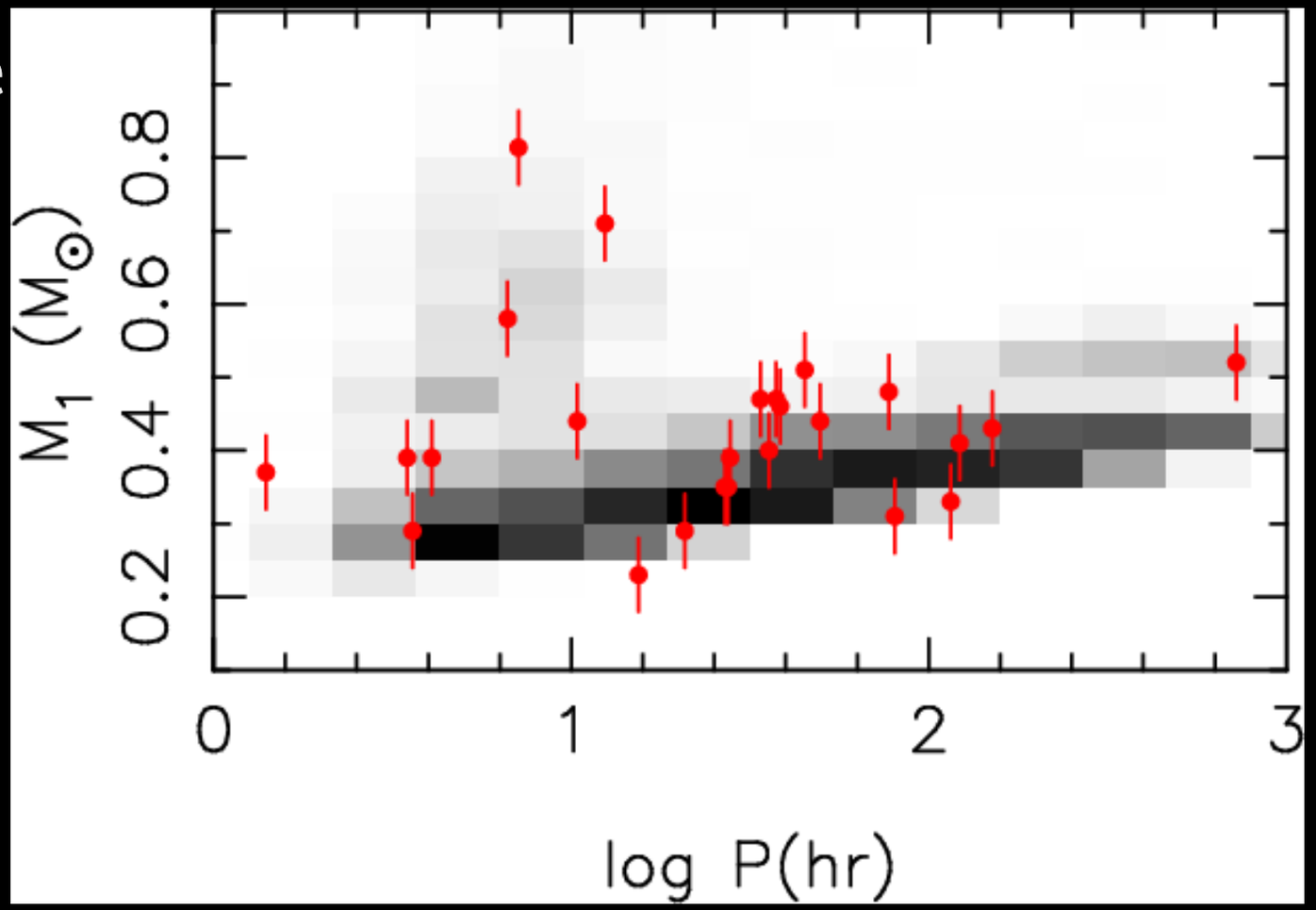
- For Ia progenitors only stars > 2 Msun important
- Mass in population in lower mass stars
- How to translate Ia rates from models to observations?
  - Often: 100% binaries
  - Different IMFs
  - Star formation history

Often assumed constant SFR for 10 Gyr



Compare with observations: double white dwarfs

- Mostly “CE”+ CE
- First CE different → picture even more complicated
- Total number: 100 million
- Birth rate: 1/50 years
- Merger rate: 1/125 years
- Including selection effects
- Compare to observations
- Reasonable agreement (SWARMS, NLTT object not yet in picture)



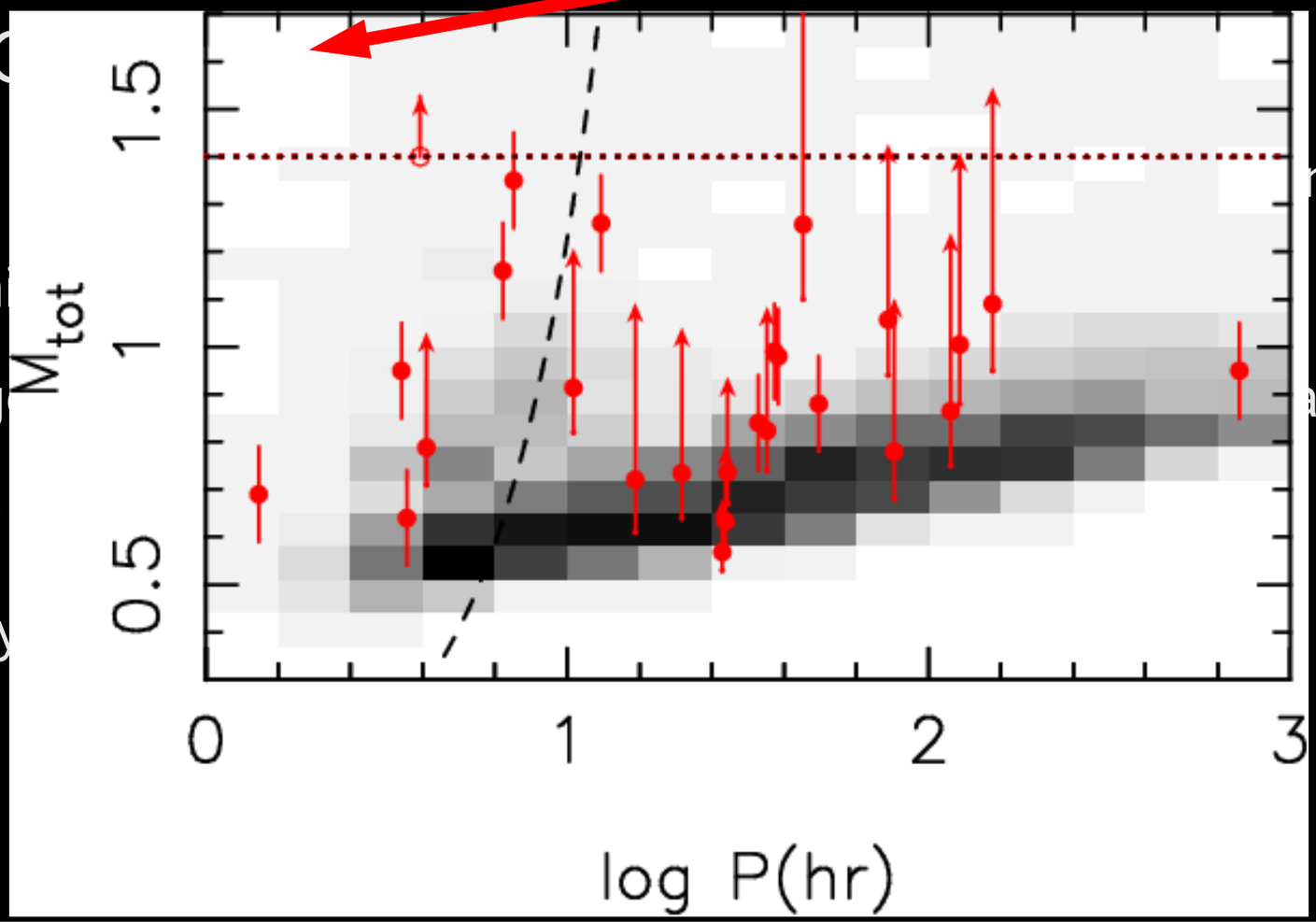
Nelemans et al. 2001a,b, 2005

Double white dwarf progenitors, where are they?

- Type Ia supernova progenitors?
  - Rates promising (but maybe too few [Maoz])
  - Short as well as long delays
  - Rapid accretion more likely to produce AIC and NS?
  - No real convicing case seen yet (V458 Vul?), few “close” ones
- WARNING
  - Should be
  - Double wh
  - Single deg
  - (recurrent)
  - Possible sy
    M_{WD} from

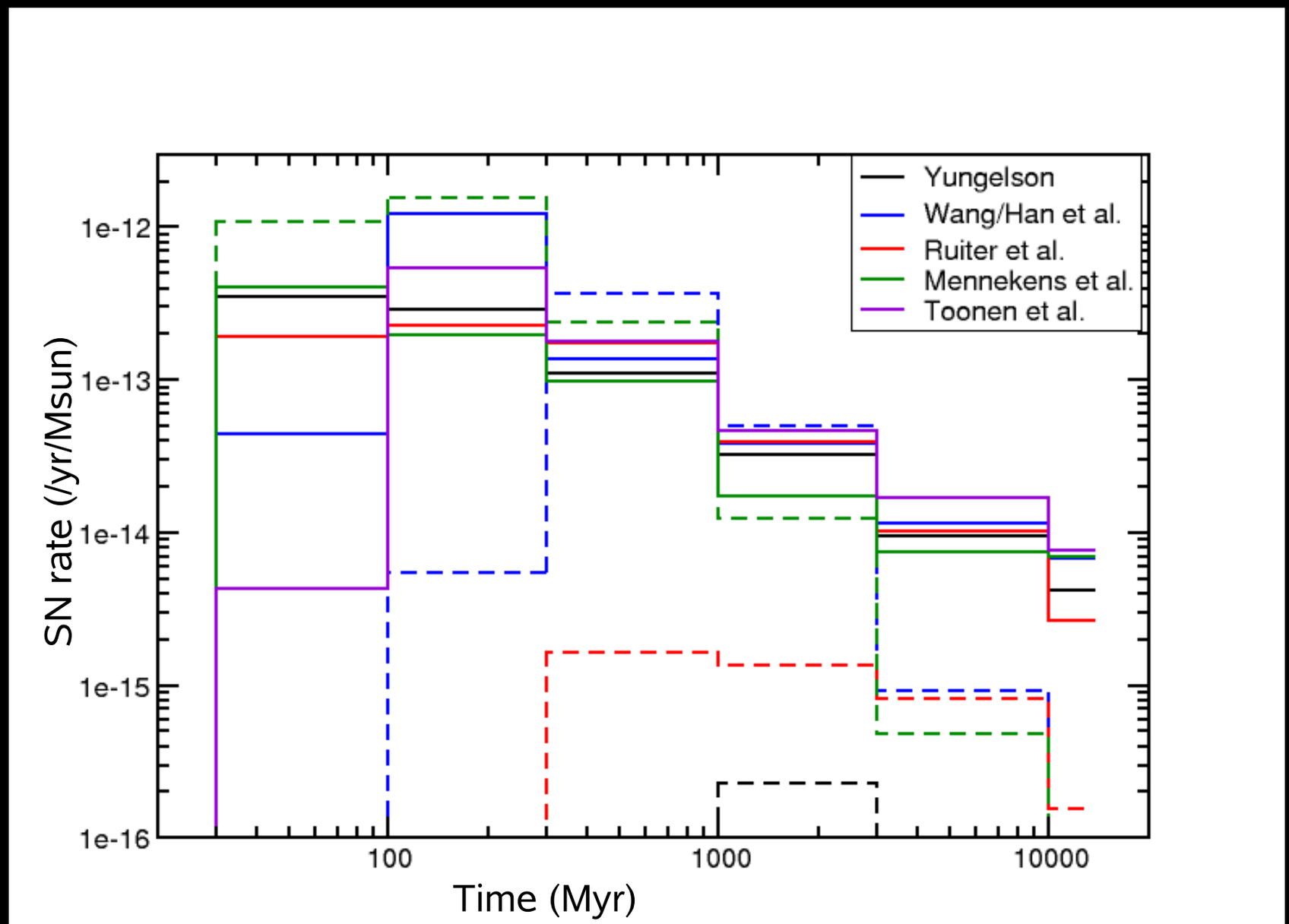
nitors

ax > 1 Mpc!



Results: DTDs and integrated rates

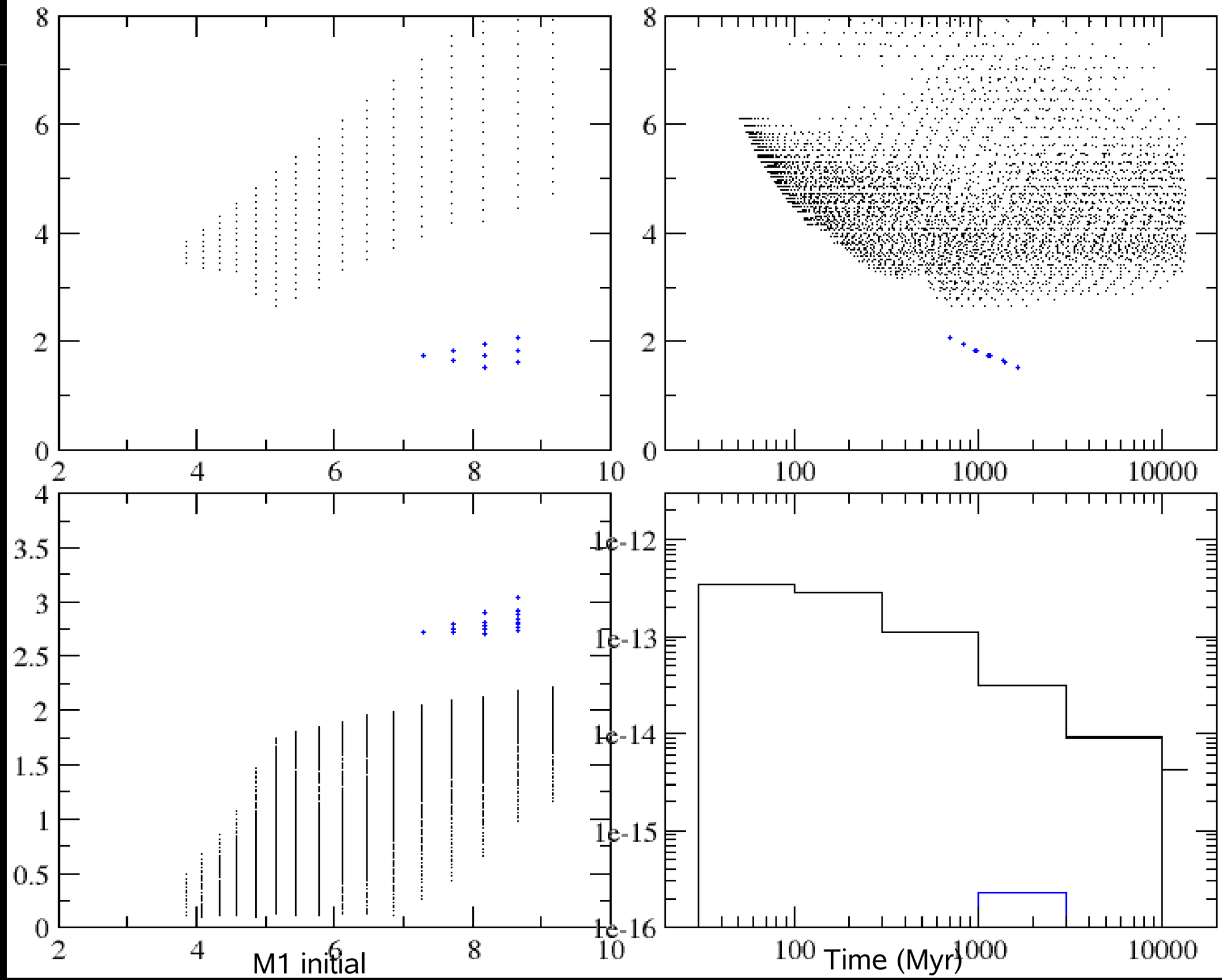
- Data from many groups: Yungelson, Wang/Han et al., Ruiter/Belczynski, Mennekens/Vanbeveren, Toonen/Nelemans
- DTDs and integrated rates



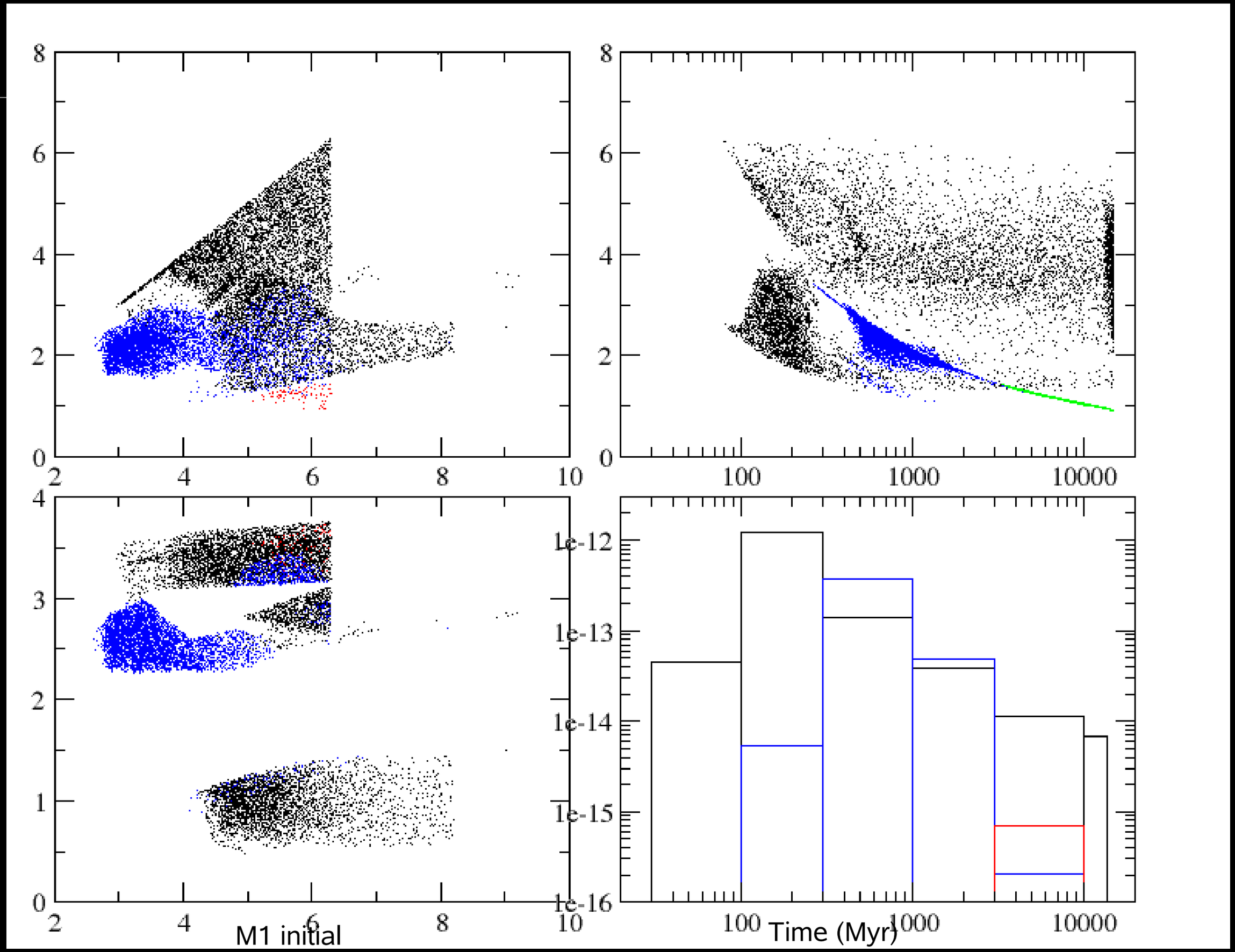
Results: progenitors of progenitors

- Initial parameters: M_1, M_2, P

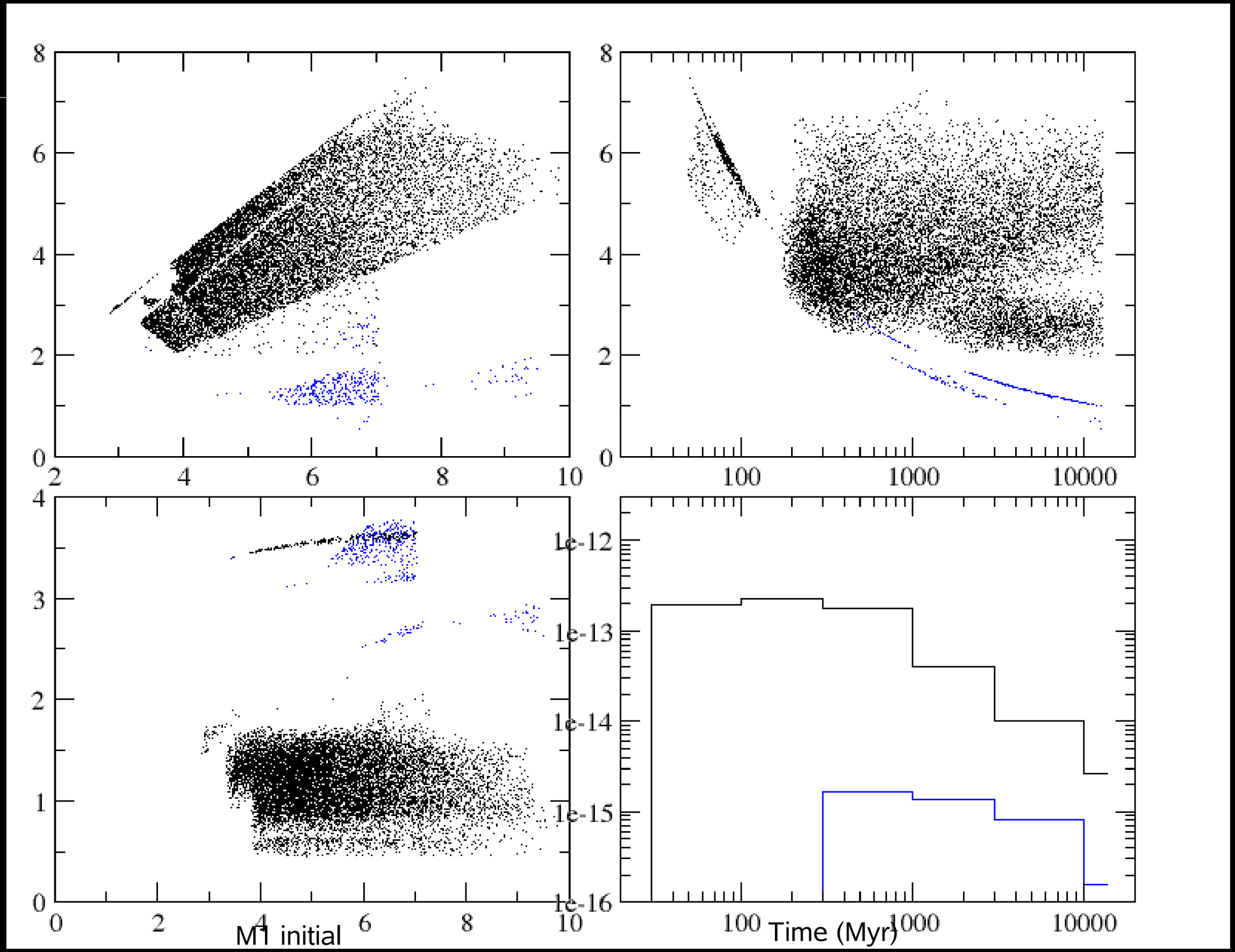
Yungelson



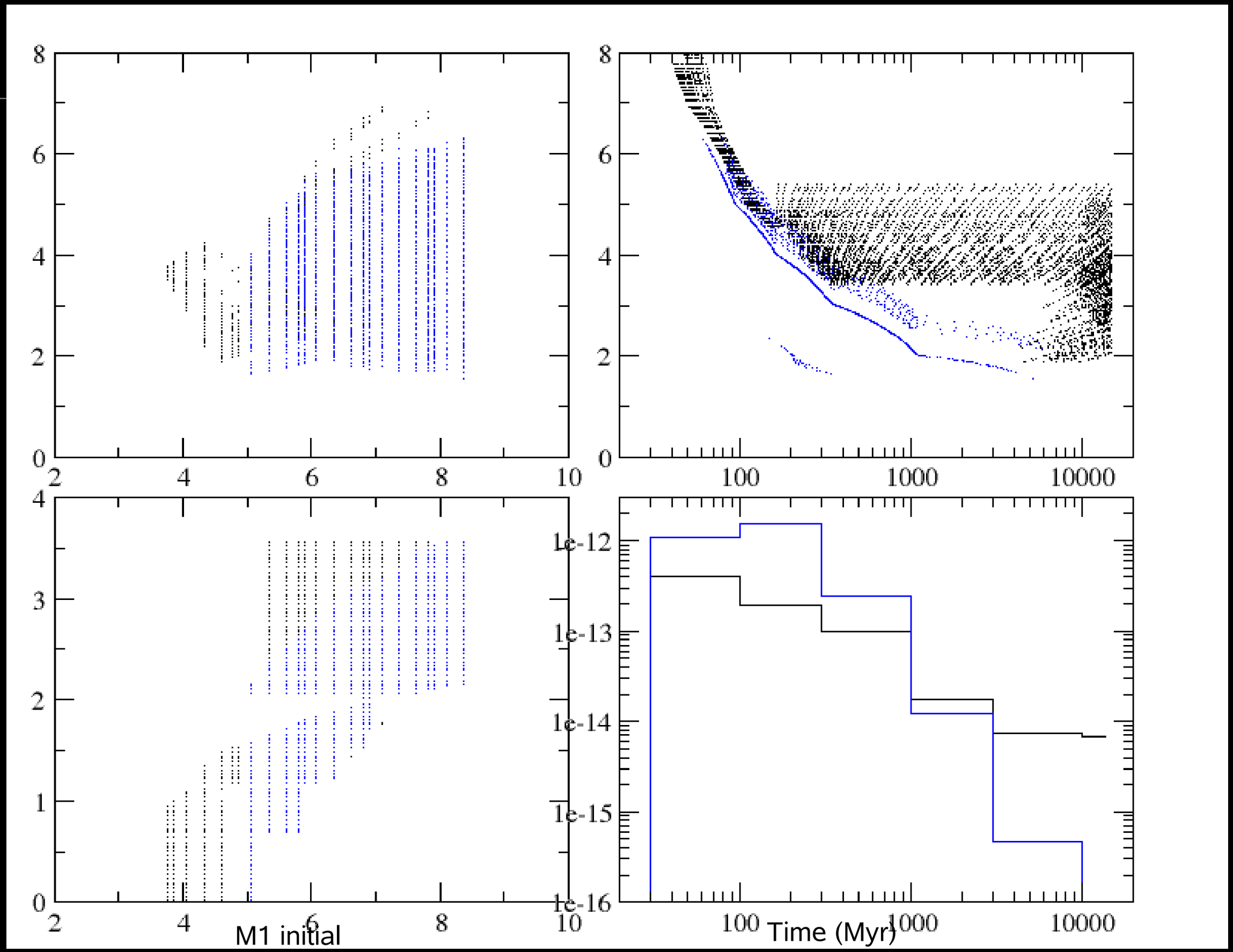
Wang/Han et al.



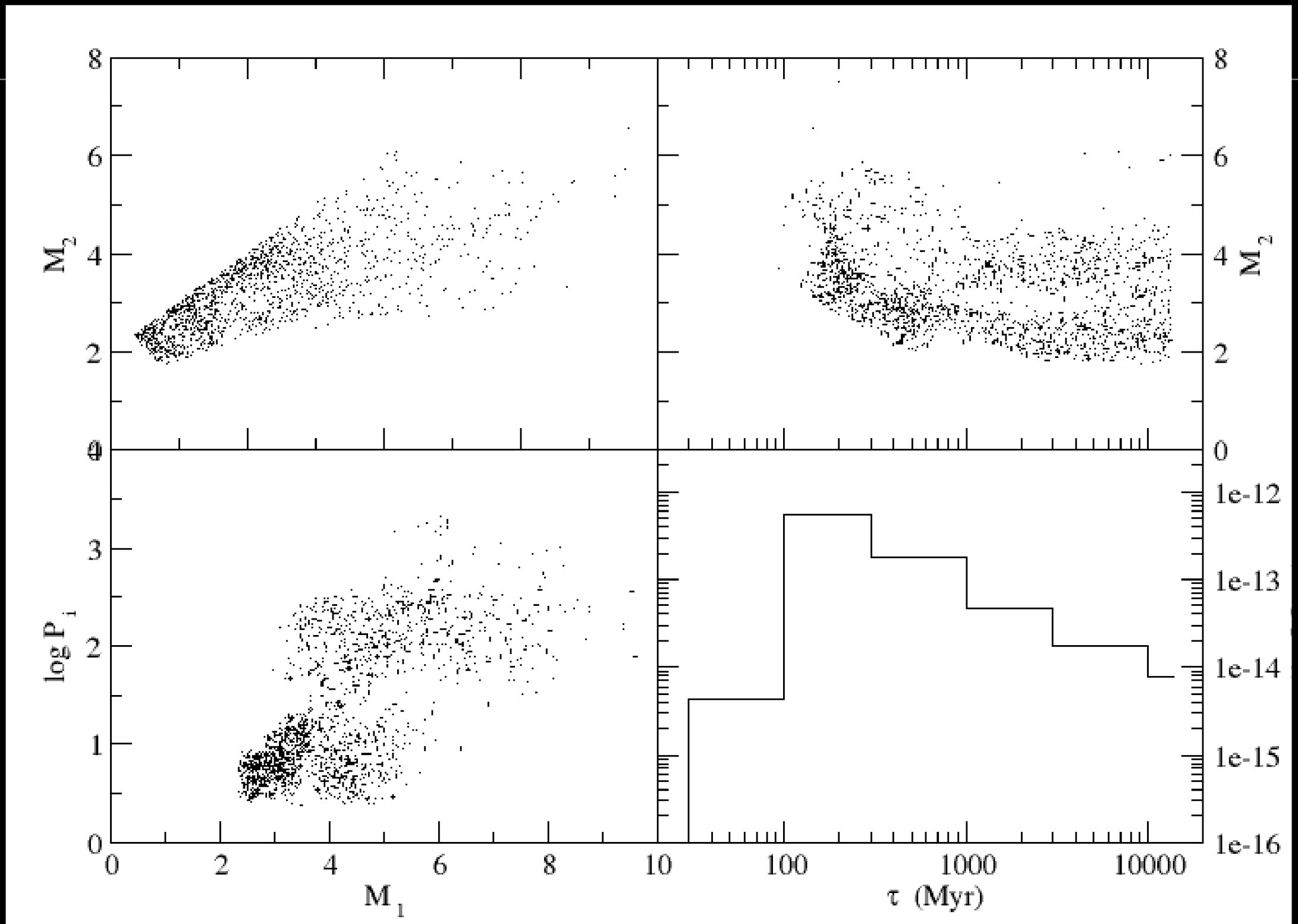
Ruiter et al.


M2 initial
Log initial Period (d)
M1 initial
Time (Myr)
1e-12
1e-13
1e-14
1e-15
1e-16

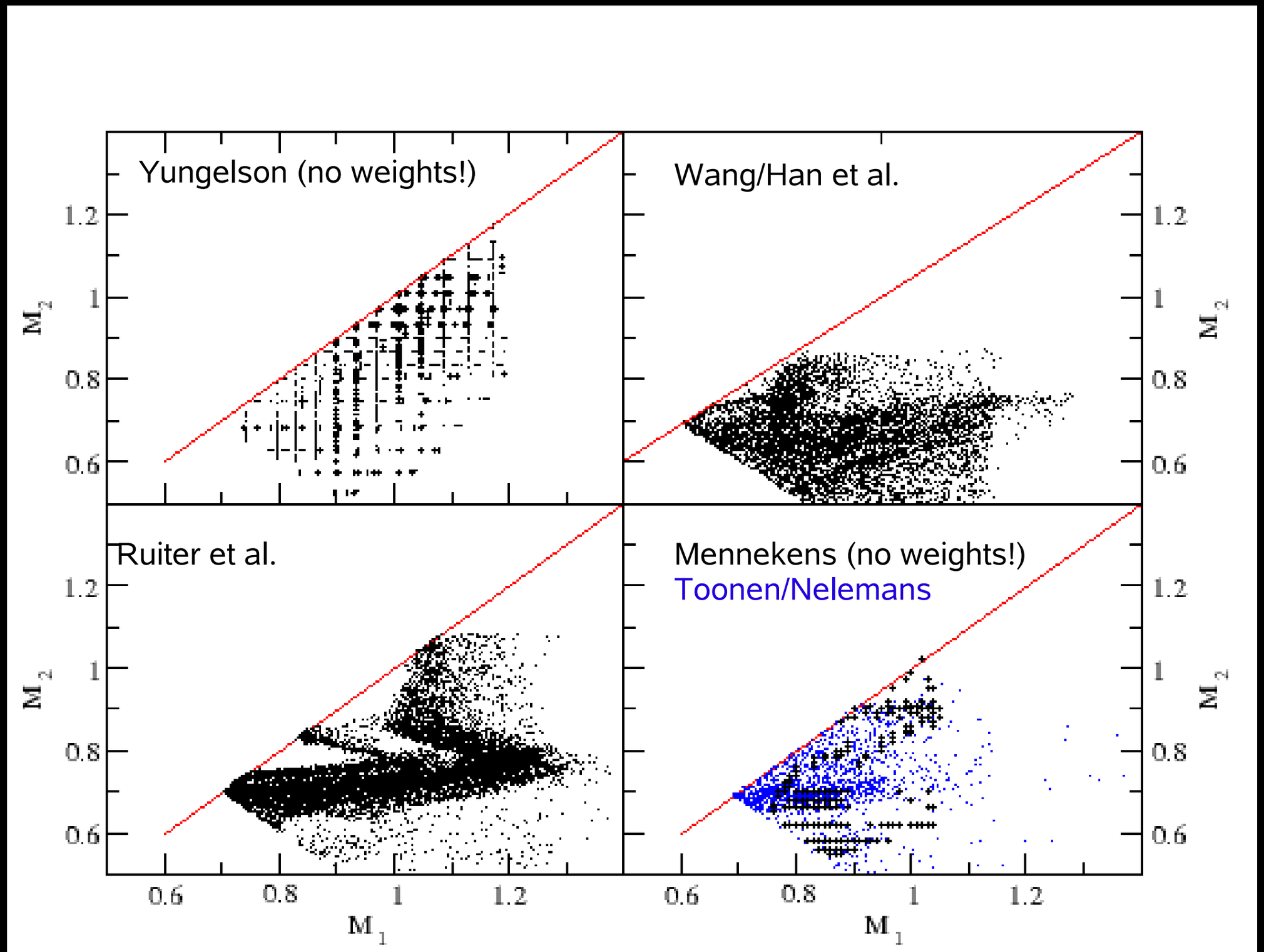
Mennekens et al.



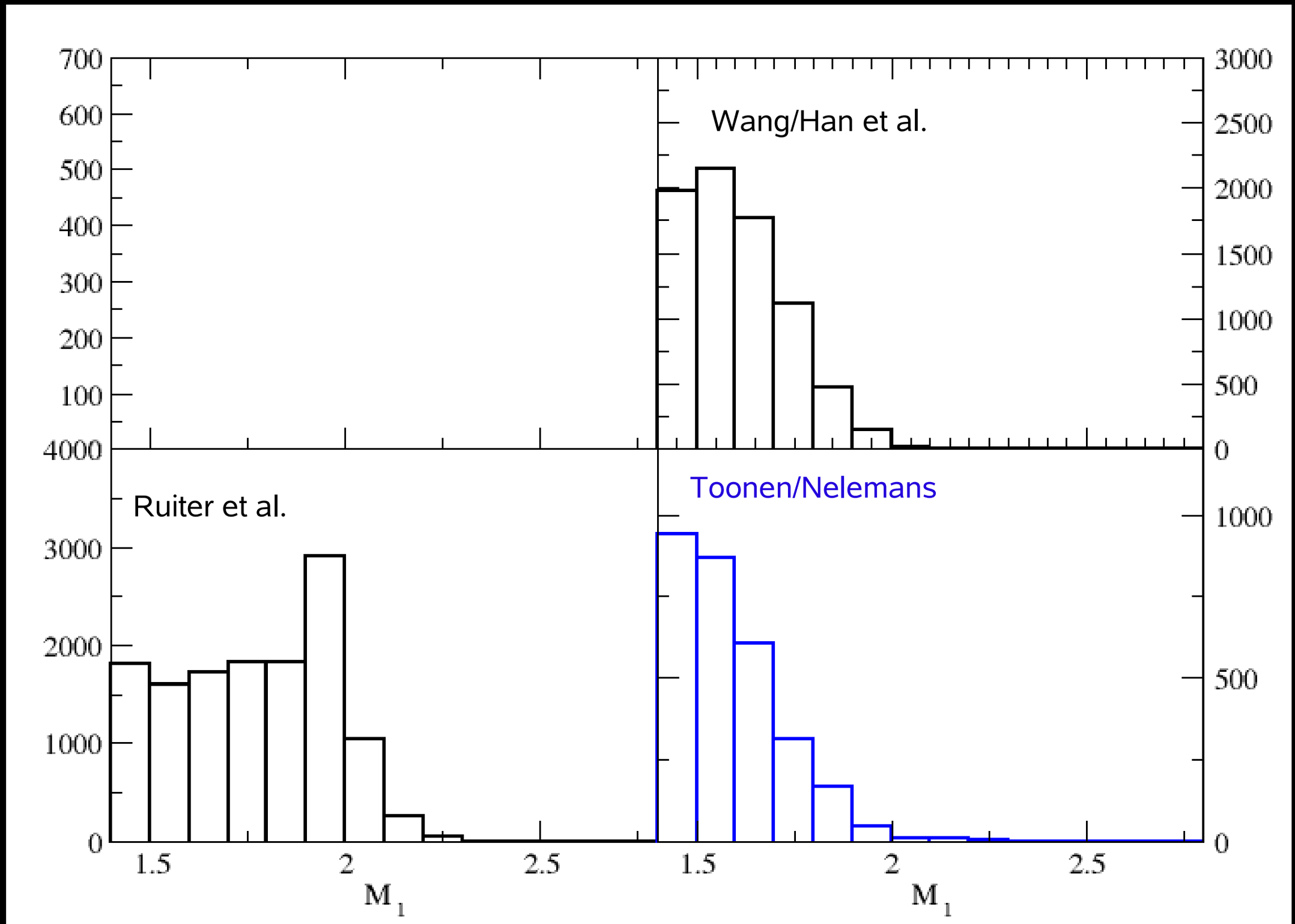
Toonen/Nelemans



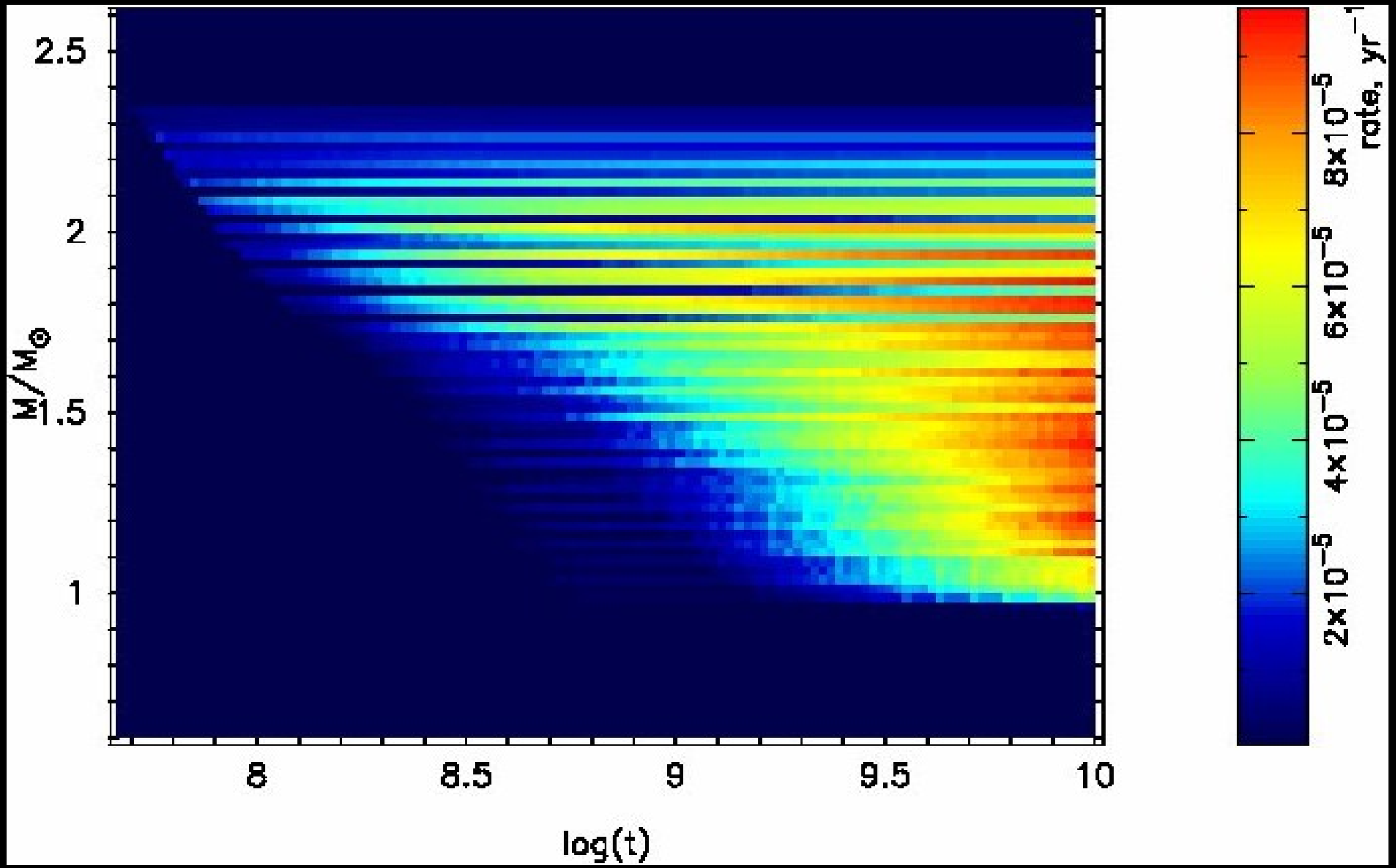
Results: DD merger masses of systems



Combined masses of CO CO megers

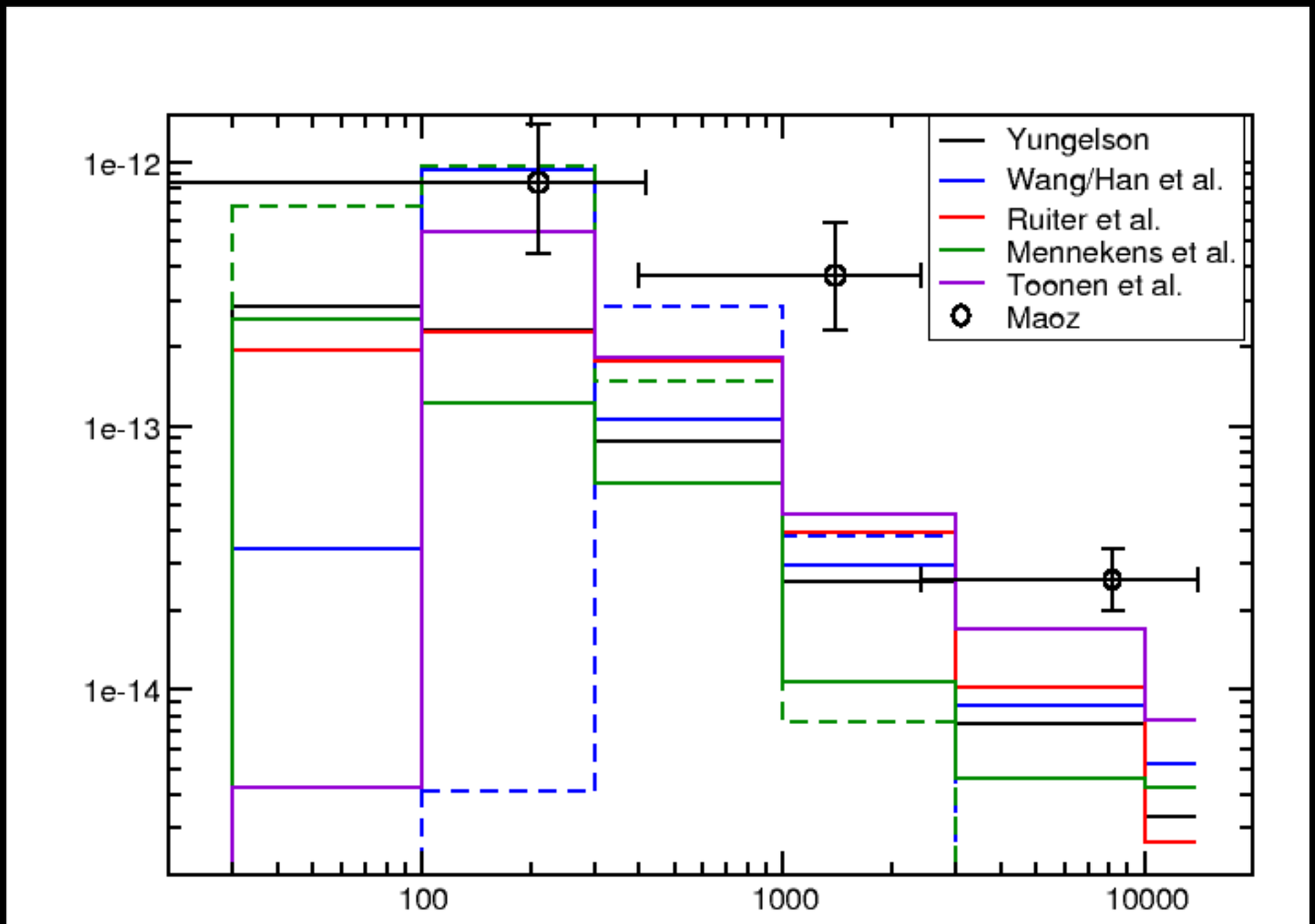


Total mass as function of age (Yungelson)



Comparison with observed rates

- Rescaled normalisation tot Kroupa IMF and 50% binaries



Integrated rates:
(10^{-4} /Msun)

DD	SD
2.4	0.006
4.4	2.8
5.7	0.17
2.2	3.7
7.5	

Maoz:
23 observed

How to proceed

- Lot of confusion in units, normalisation etc.
- Need: common way of presenting results
- Need to sort out “single degenerate” progenitor parameter space before we can give a prediction of the rate
- Need to think of a way to get enough progenitors
- Calibrate population synthesis with other populations
- Do more comparisons (like this one)

Conclusions

- Be careful with taking single star properties (in particular initial mass – final mass relations) for binary components!
- Main seq lifetime very steep function → look at extremes (t < 100 Myr, t > 1 Gyr)
- Population synthesis fairly uncertain
- Quite good agreement on DD mergers
- Single degenerate progenitors are a mess in population synthesis
- This is not a population synthesis problem!
- We don't get enough SNIa's if latest observed rates are correct
- Need calibration from other populations