Creating ultra-compact binaries in globular clusters through stable mass transfer

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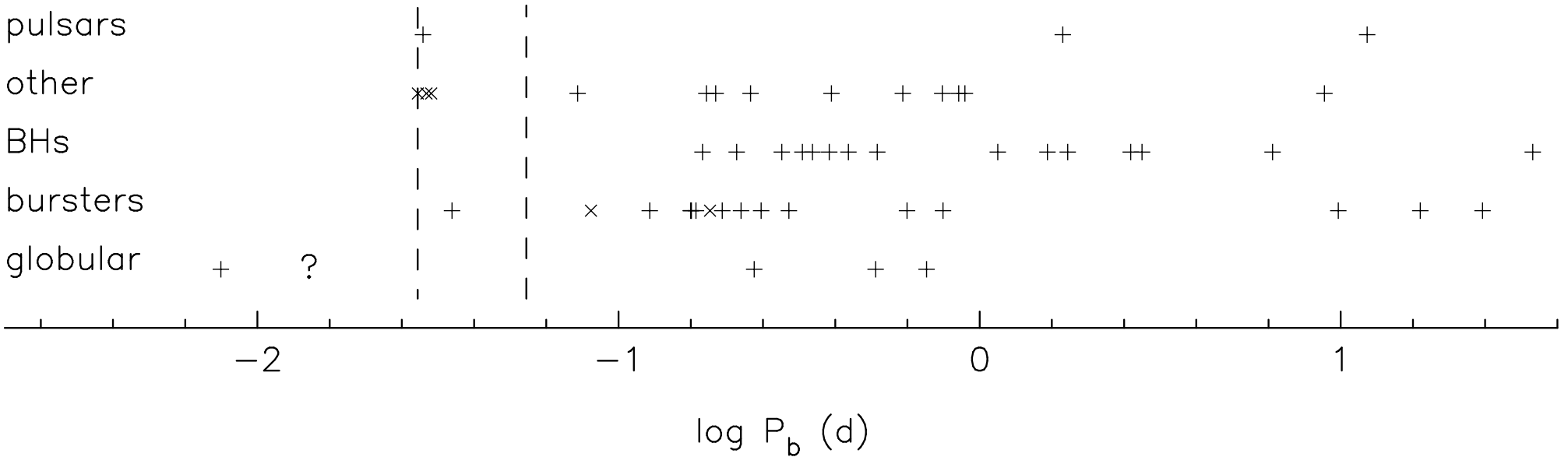
Outline

- Observed low mass X-ray binaries
- Two scenarios
- Model calculations
- Statistics
- Conclusions

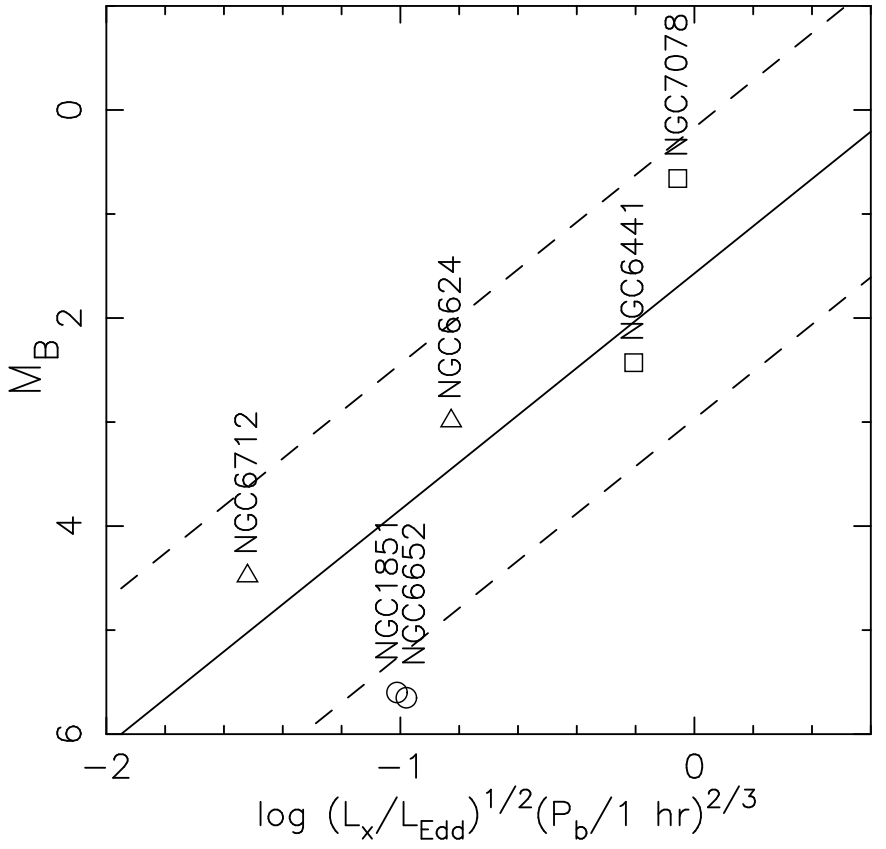
Low mass X-ray binaries

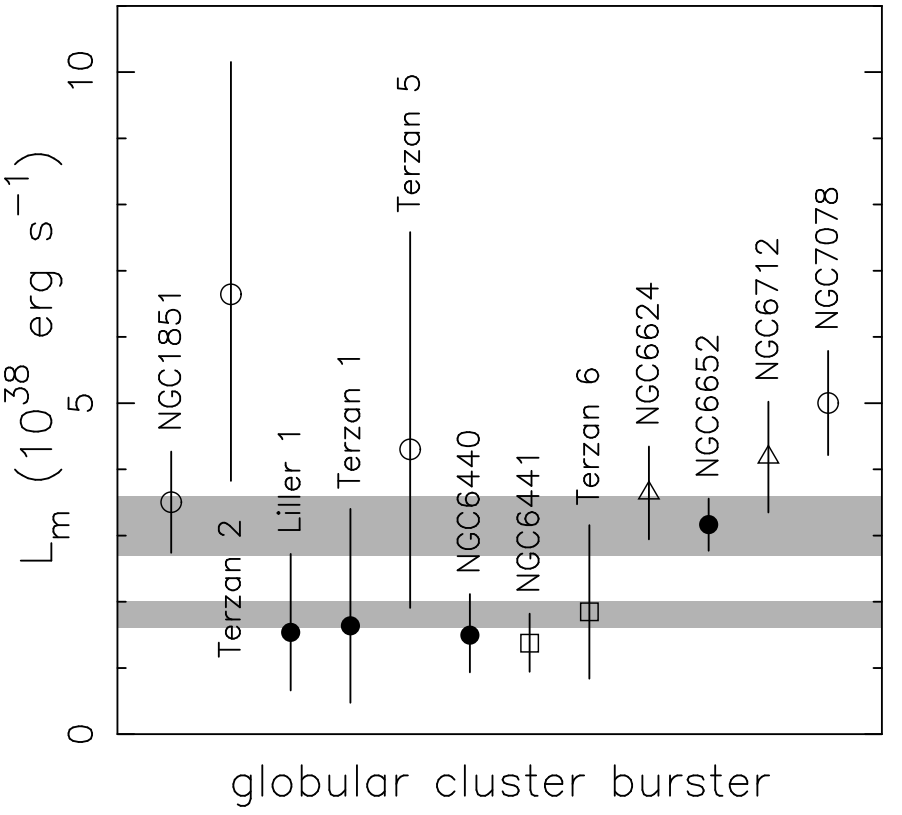


Data from:

- Liu et al., 2001
- Charles & Coe, 2003
- Wijnands, 2004

Indirect period indication

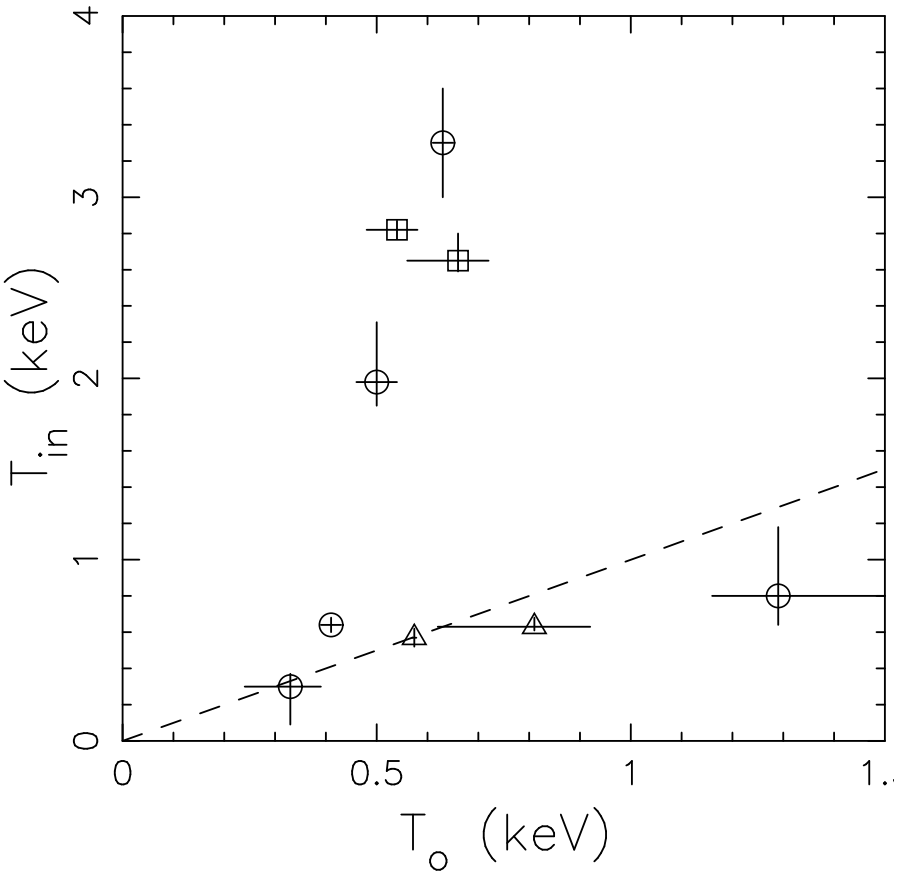




□ normal P △ ultra-short P O unknown P

Verbunt 2004

Indirect period indication



□ normal P △ ultra-short P O unknown P

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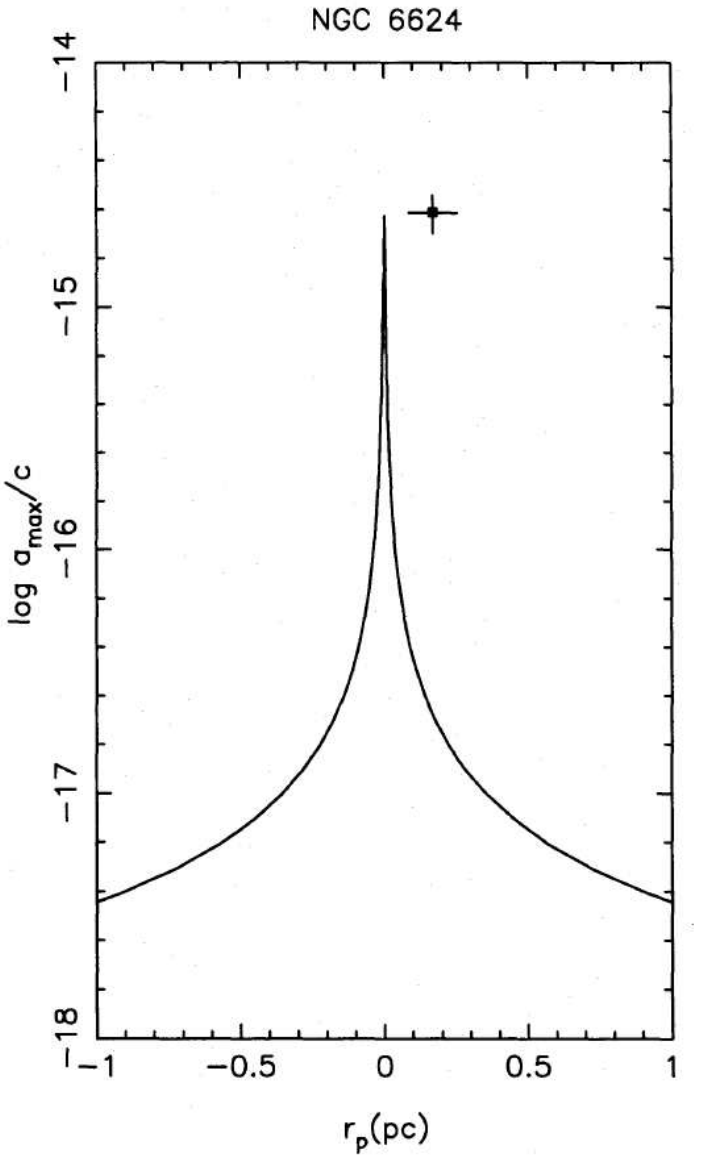
Observed X-ray sources in GCs

Cluster	Position	P_{orb}	Indirect indication		
			low f_{opt}/f_x	burst max.	X-spect.
NGC 1851	0512–40	?	U	U	U
NGC 6440	1745–20	?	—	—	N
NGC 6441	1746–37	5.7 h	—	N	N
NGC 6624	1820–30	11.4 m	U	U	U
NGC 6652	1836–33	?	U	U	U
NGC 6712	1850–09	21/13 m	U	U	U
NGC 7078	2127+12a	?	—	U	—
Terzan 2	1724–31	?	—	U	N
Terzan 5	1745–25	?	—	—	U
Terzan 6	1751–31	12.4 h	—	—	N
NGC 7078	2127+12b	17.1 h	—	—	—
Terzan 1	1732–30	?	—	—	—
Liller 1	1730–33	?	—	—	—

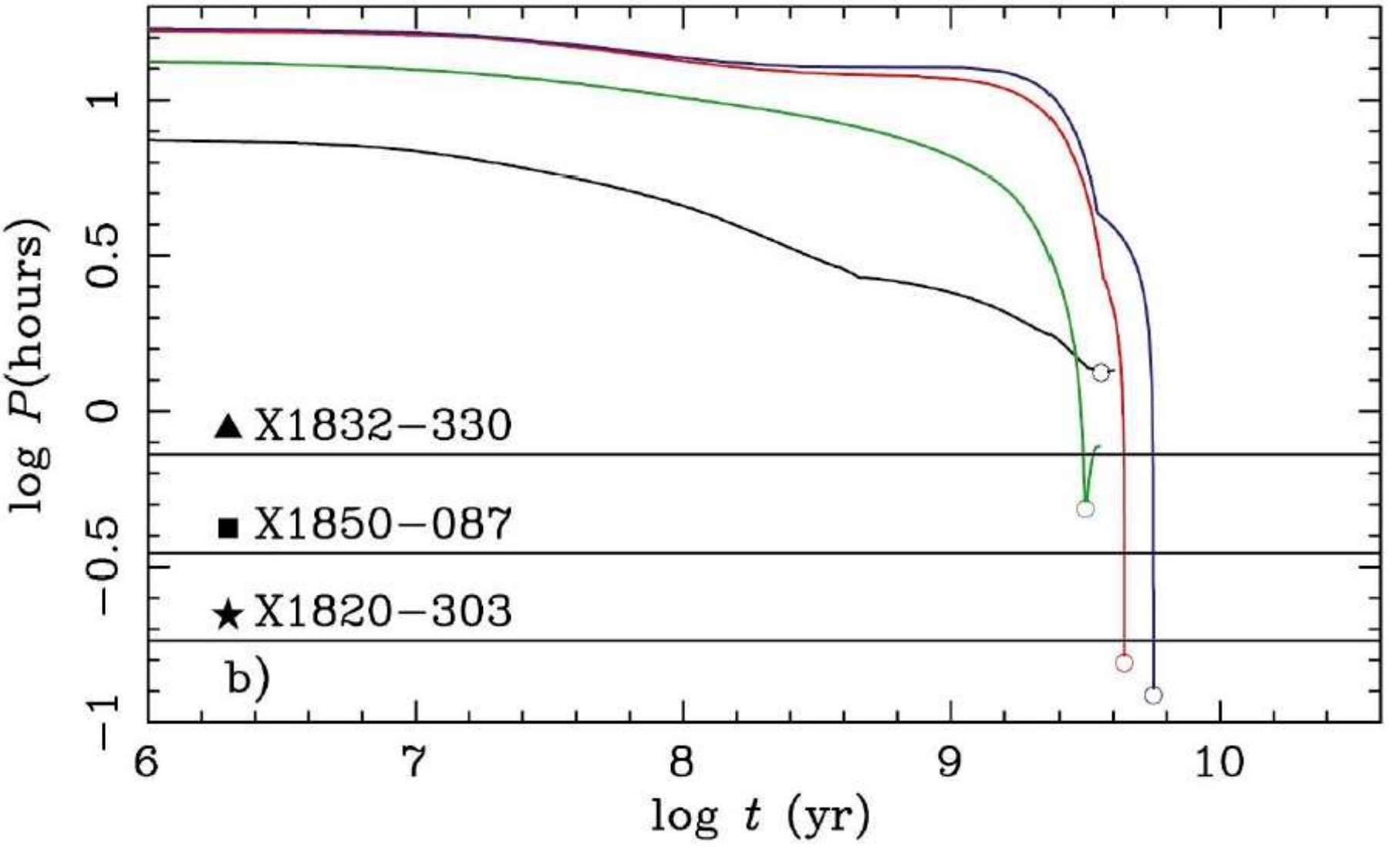
Scenario 1: NS-WD binary

- A NS-WD binary is created
- Gravitational radiation shrinks the orbit
- The orbit expands after mass transfer started
- The 11 m system has a measured $\dot{P}/P = -1.8 \pm 0.3 \times 10^{-15}\,\mathrm{s}^{-1}$



Van der Klis et al., 1993

Scenario 2: NS-MS binary



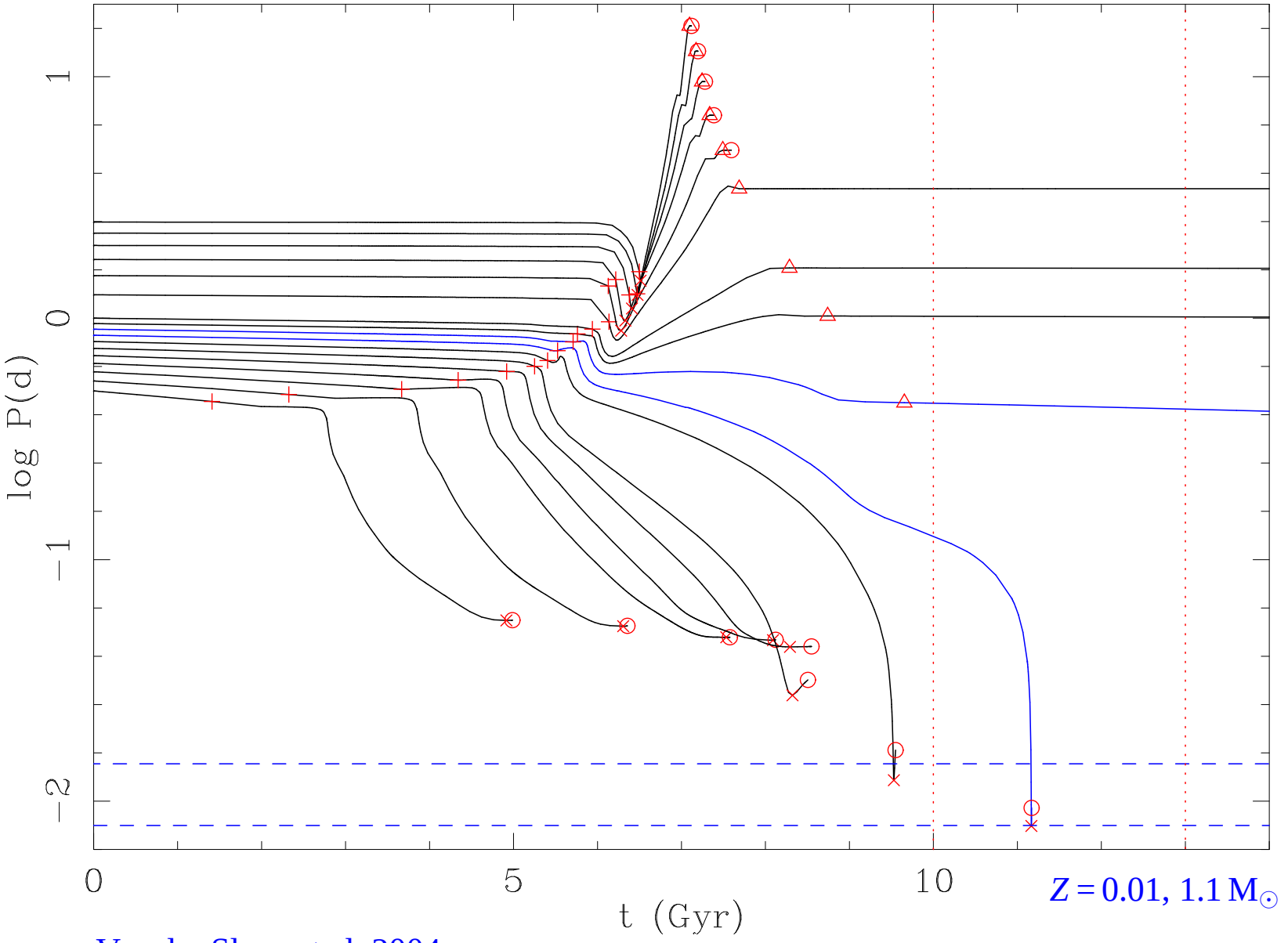
Podsiadlowski et al., 2002

Binary models

We calculated models with a point mass of 1.4 $M_\odot$ and a donor, with initial parameters:

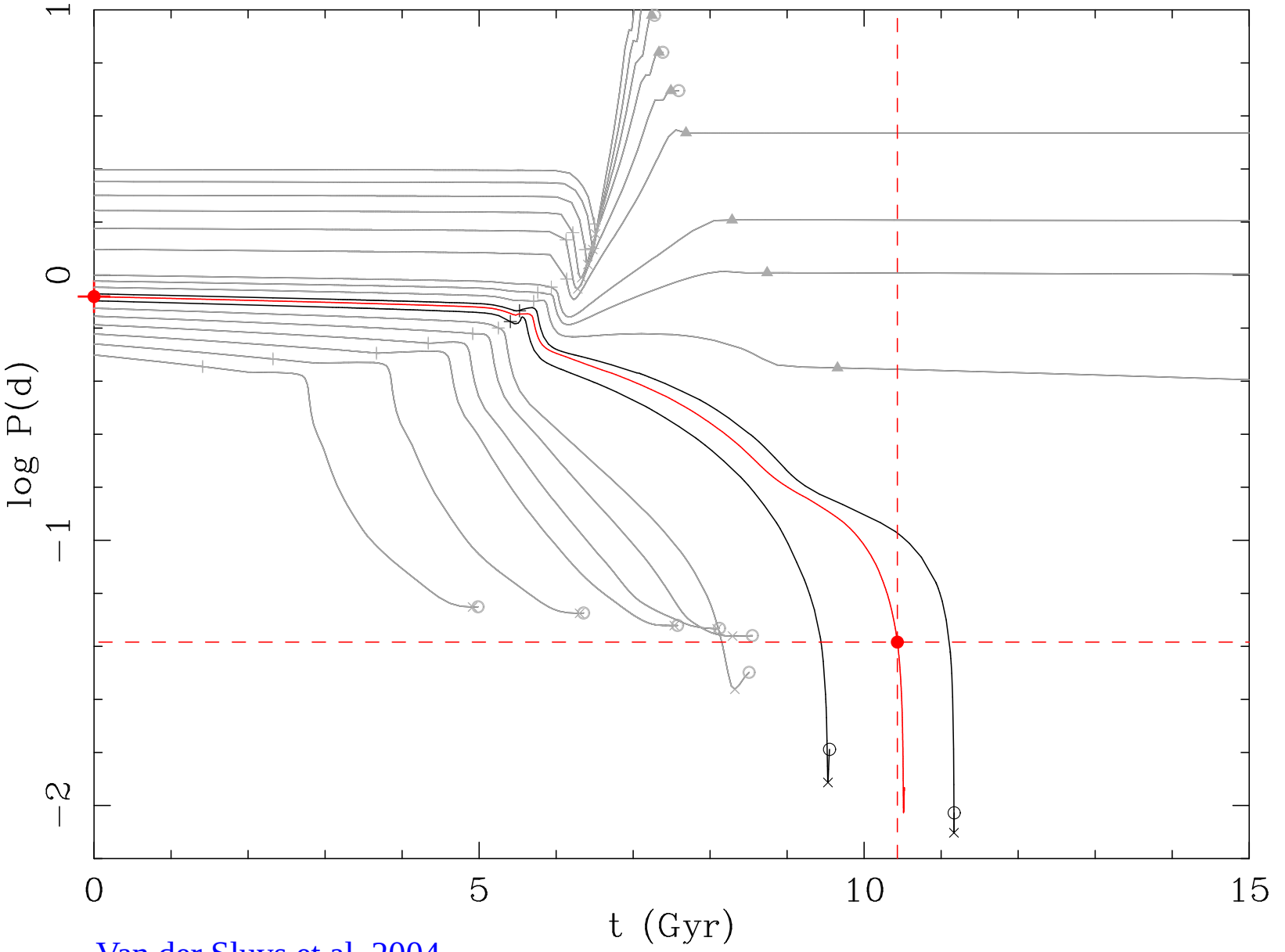
- M_i: 0.7 – 1.5 $M_\odot$ with ΔM_i = 0.1 $M_\odot$
- P_i: 0.35 – 2.5 d with ΔP_i = 0.25, 0.05 or 0.01 d
- Z: 0.0001, 0.002, 0.01 and 0.02
- Magnetic braking:
  - * Verbunt & Zwaan, 1981
  - * VZ81 with reduced strength
  - * Sills et al., 2000 (saturating)

t-P tracks



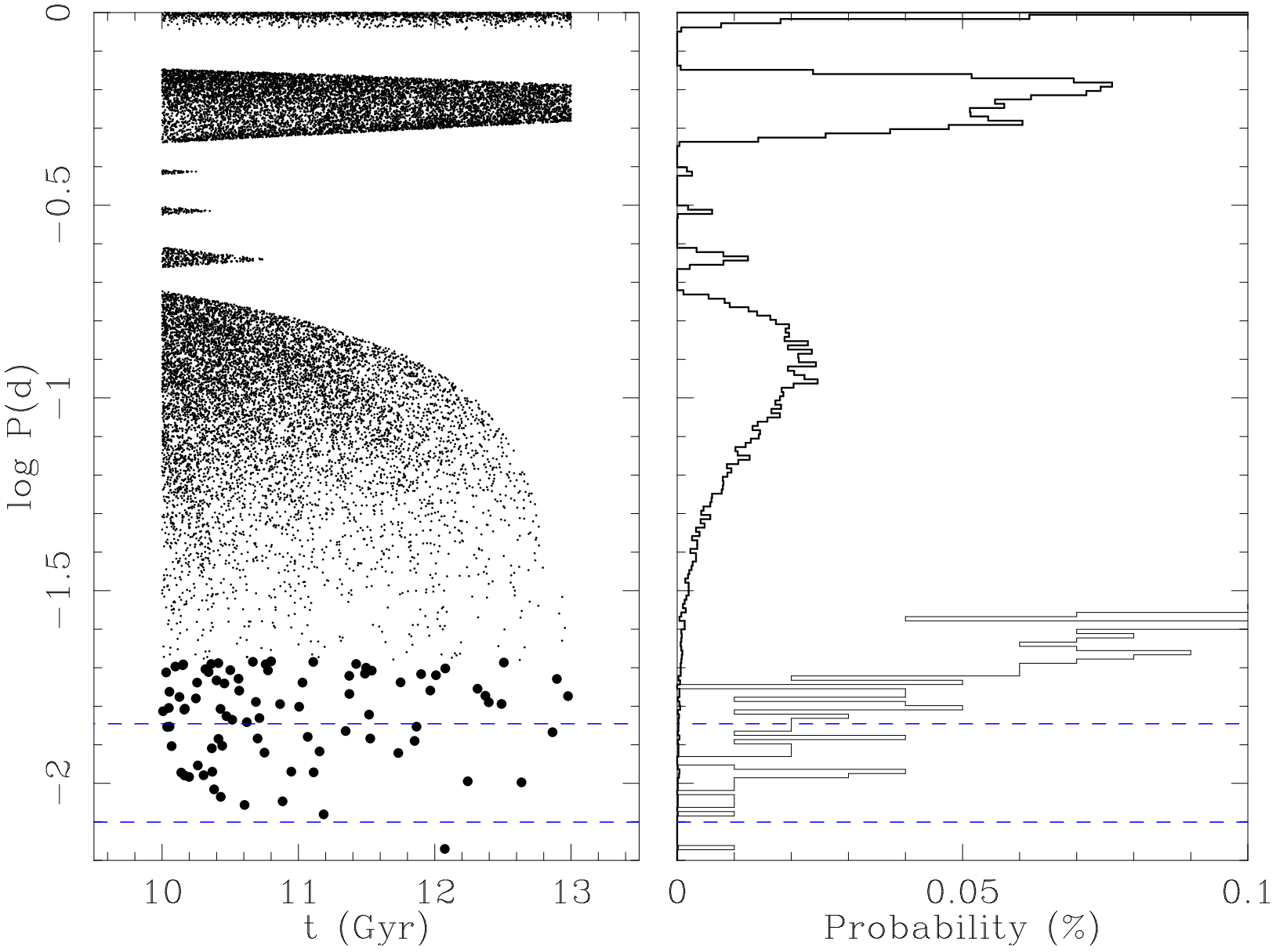
Van der Sluys et al, 2004

Interpolation



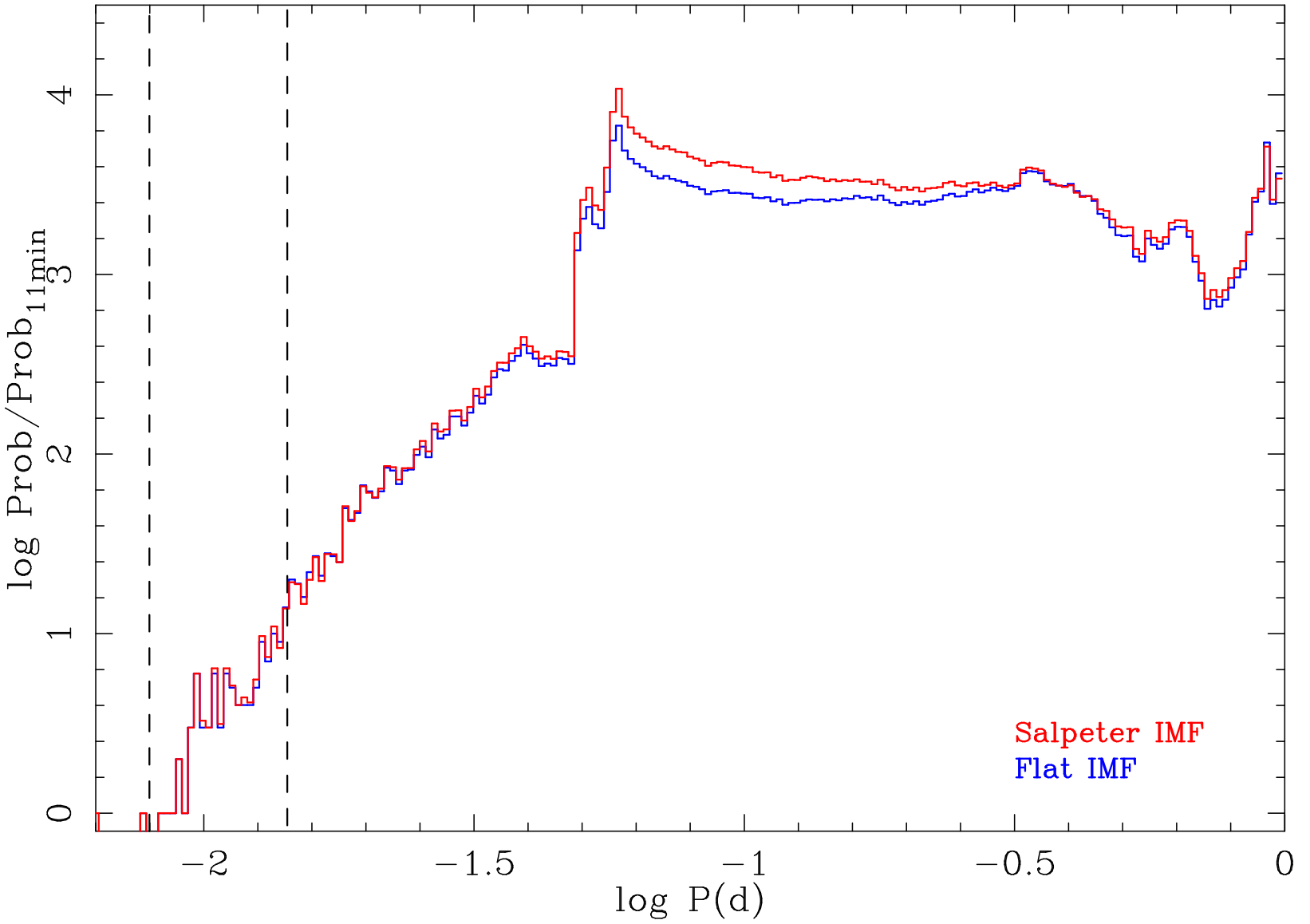
Van der Sluys et al, 2004

Statistics



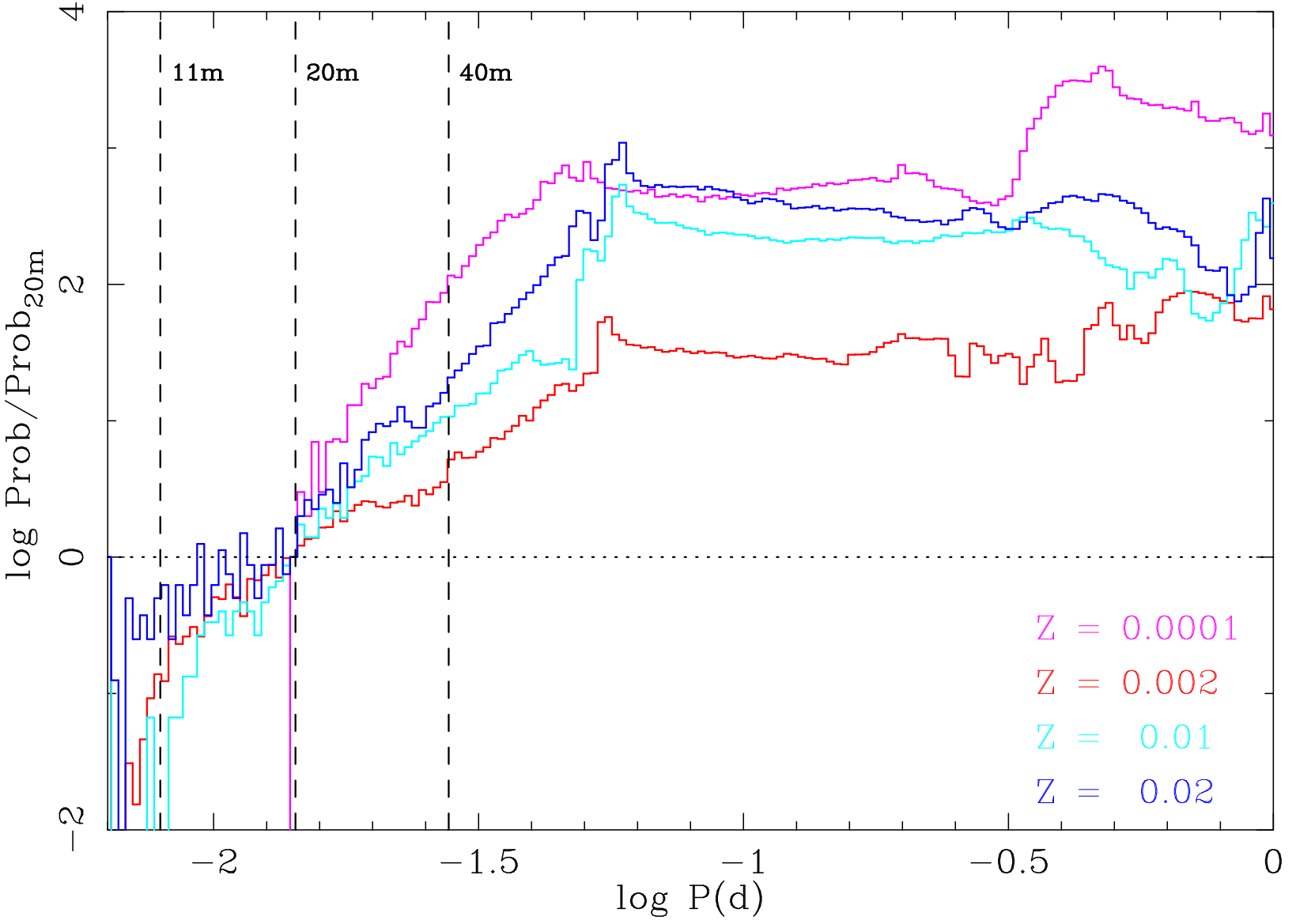
Van der Sluys et al, 2004

Statistics



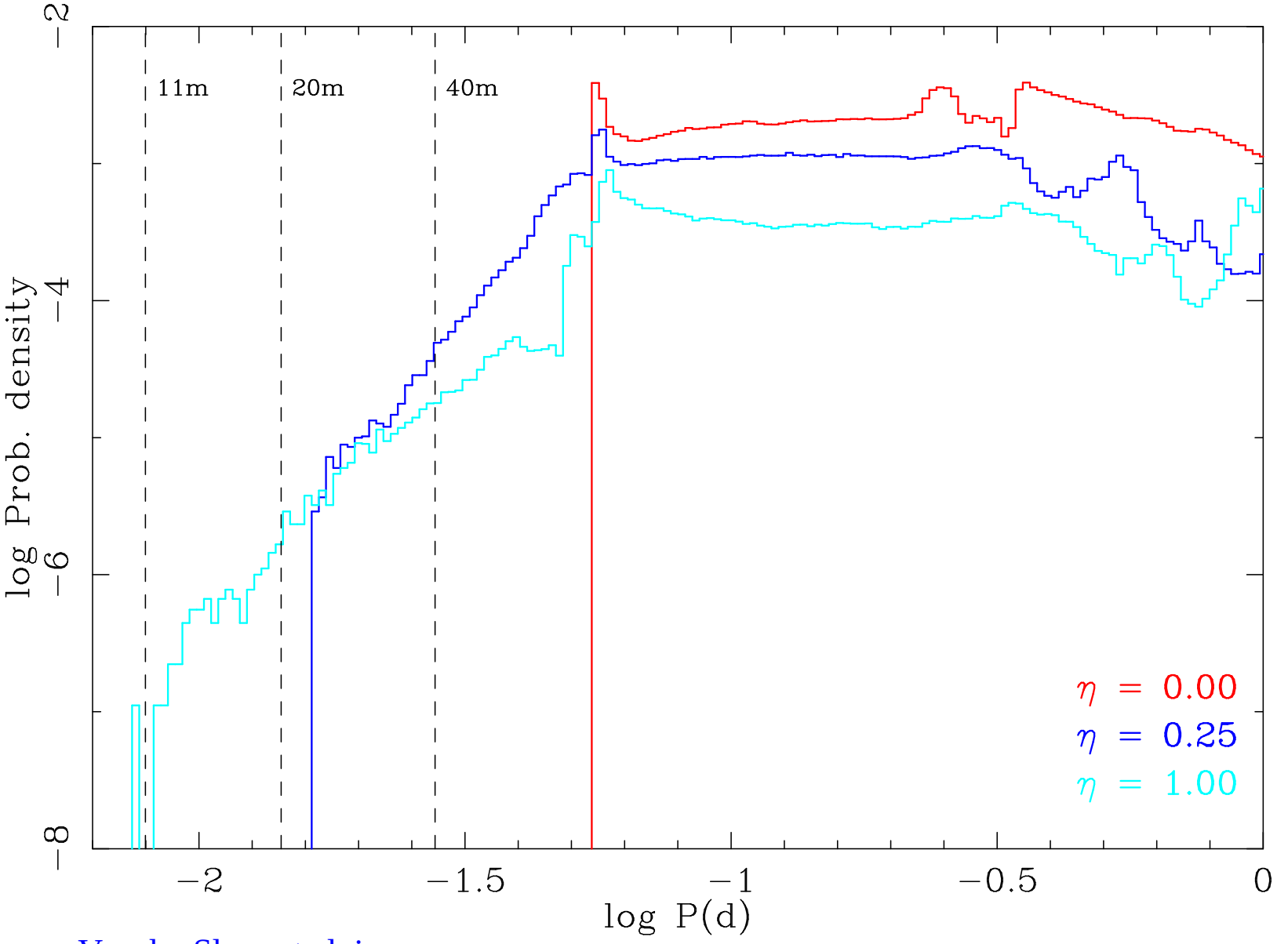
Van der Sluys et al, 2004

Statistics: different Zs



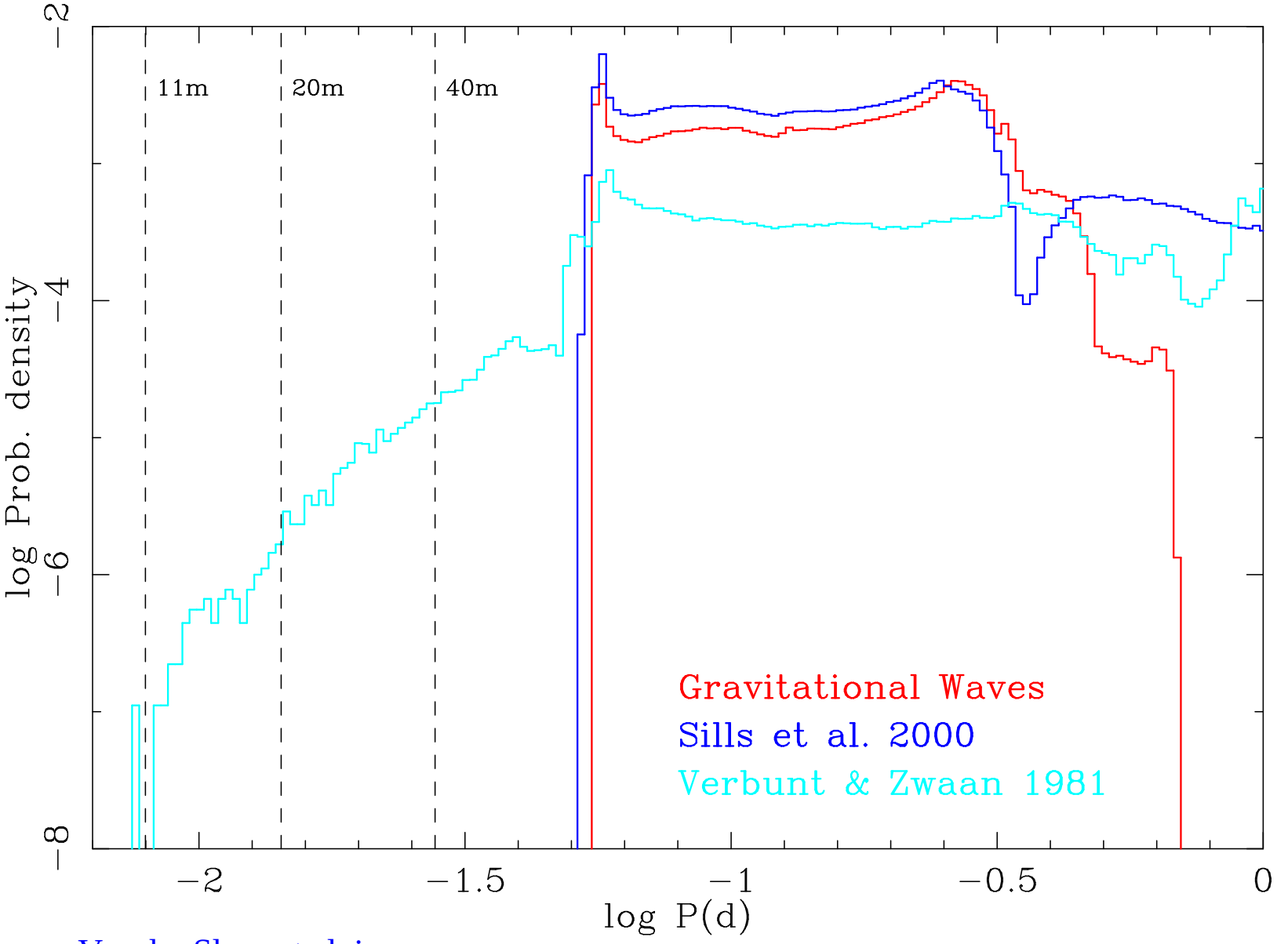
Van der Sluys et al, 2004

Statistics: different MB strengths



Van der Sluys et al, in prep.

Statistics: saturating MB law



Van der Sluys et al, in prep.

Conclusions

- A sizable fraction of X-ray binaries has an ultra-short period
- Magnetic capture cannot explain this
- If the negative $\dot{P}$ of the 11 m system is intrinsic, then:
  - a WD donor is not possible
  - we do not have a plausible scenario to create this system

References

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