(Observations of) Double white dwarfs

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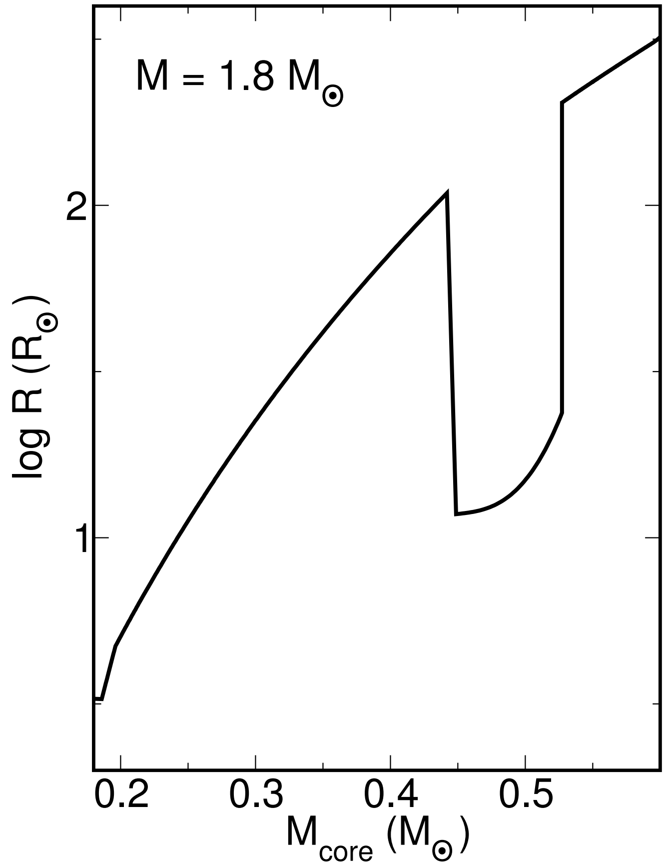
Why study double white dwarfs?

- They may be type Ia supernova progenitors
  - Do massive (wd, wd) exist? Rates?
  - Fate of massive (wd, wd) merger?
- Many possible and exciting merger outcomes
- Only known sites of possible He novae
- They can be used to test stellar and binary evolution
  - Common-envelope evolution
  - White dwarf structure and cooling
- They are strong gravitational wave sources
  - Important LISA sources
  - How many in the Galaxy
  - What can we learn? How do we remove them?

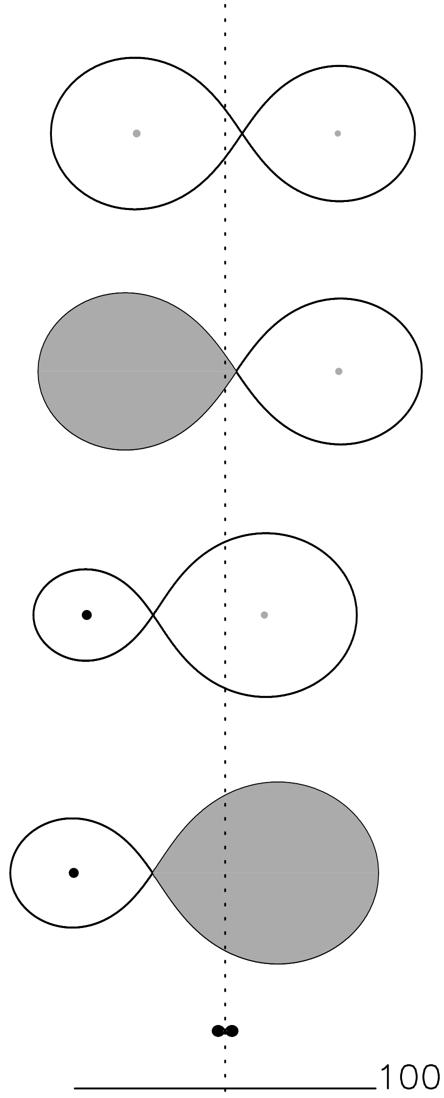
Formation of double white dwarfs

- Most stars become white dwarfs and many are part of (close) binary system
- Low and intermediate mass giants: core is white dwarf
- After two phases of mass transfer two cores in close binary



- Masses of the white dwarfs can be lower than for single stars (below 0.5 $\mathrm{M}_\odot$)

$M_1 (M_\odot)$	$M_2 (M_\odot)$	P_b(d)	t (Myr)
1.40	1.10	40.0	0.0
1.27	1.10	44.4	2943.5
0.31	1.10	44.2	2943.5
0.31	0.93	57.4	6990.8
0.31	0.32	1.4	6990.8



What we know: observations

Double white dwarfs

- In 1990's: 15 (low-mass) double white dwarfs

  Marsh, 2000, NewAR, 44, 119

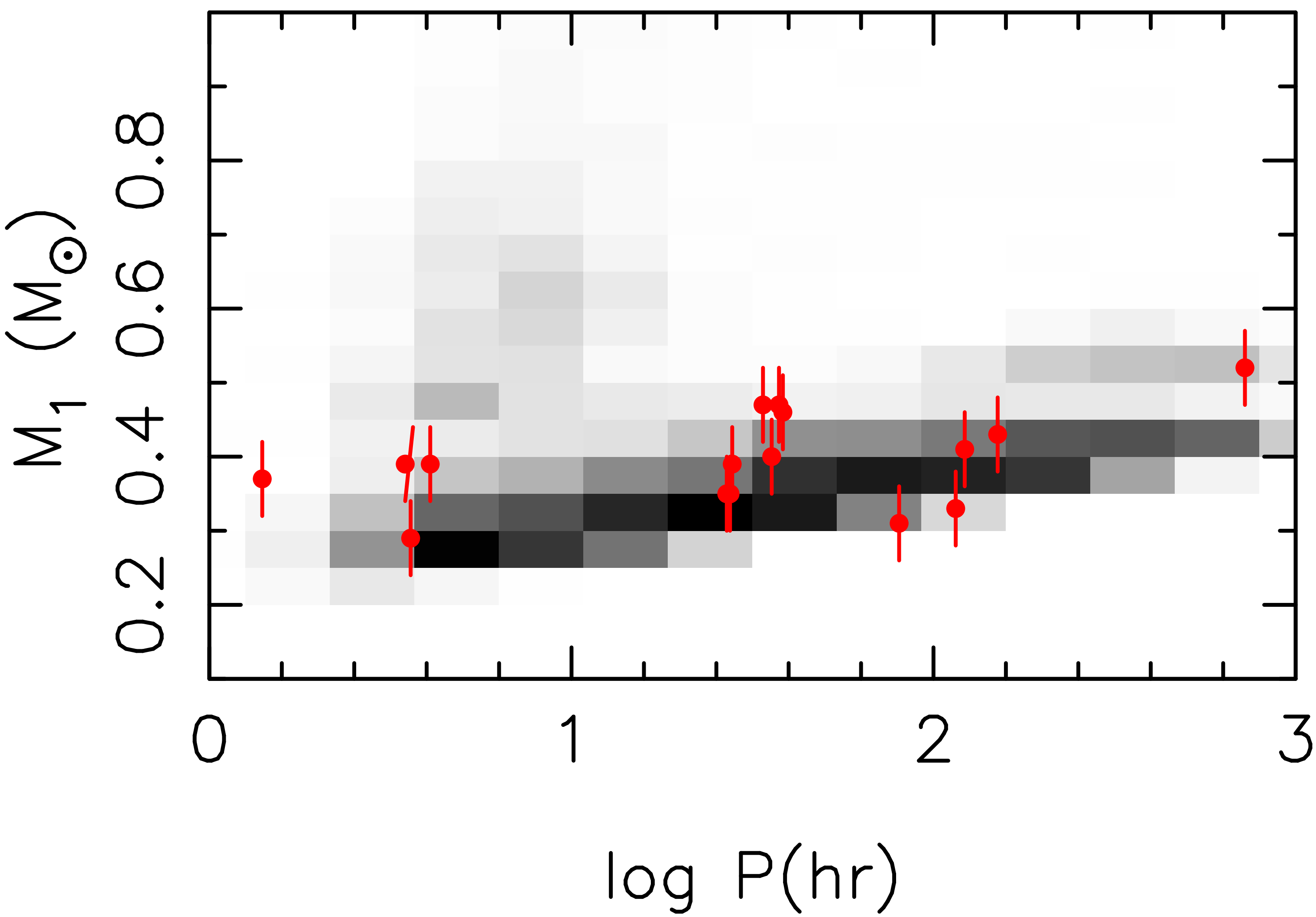
- Periods: 1.5 hr - 30 days

- New double white dwarf observations, the SPY project
  ESO VLT survey of $\sim$1000 white dwarfs for radial velocity variations *(PI Napiwotzki)*

- Current status:
  - 178 with radial velocity variations (156 double white dwarfs)
  - $\sim$15 period determinations (between 0.3 and 5 d)

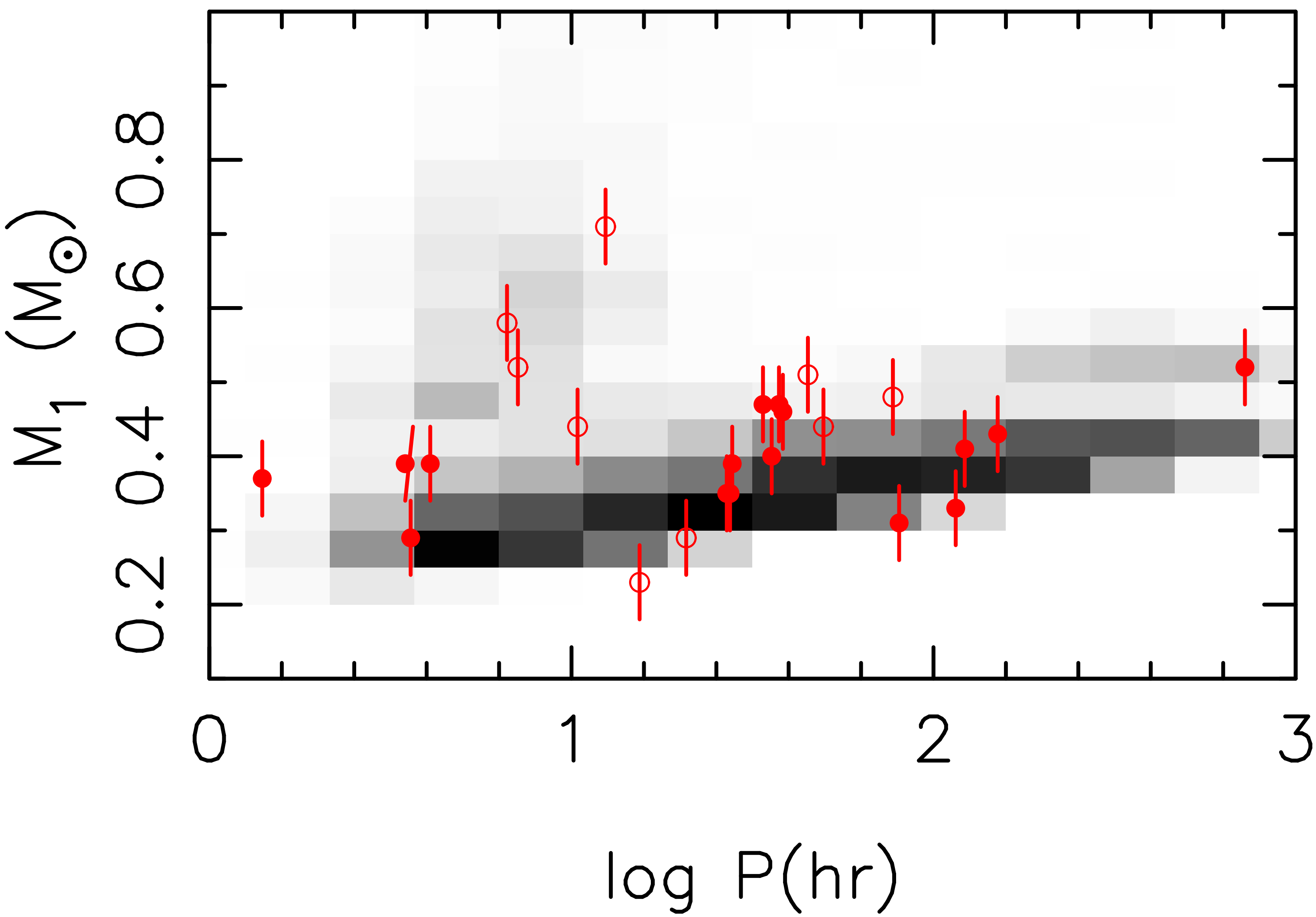
  Napiwotzki et al., 2002,2004; Nelemans et al., submitted

Pre-SPY



Nelemans, Yungelson, Portegies Zwart & Verbunt, 2001, A&A, 365, 491, with updates

New



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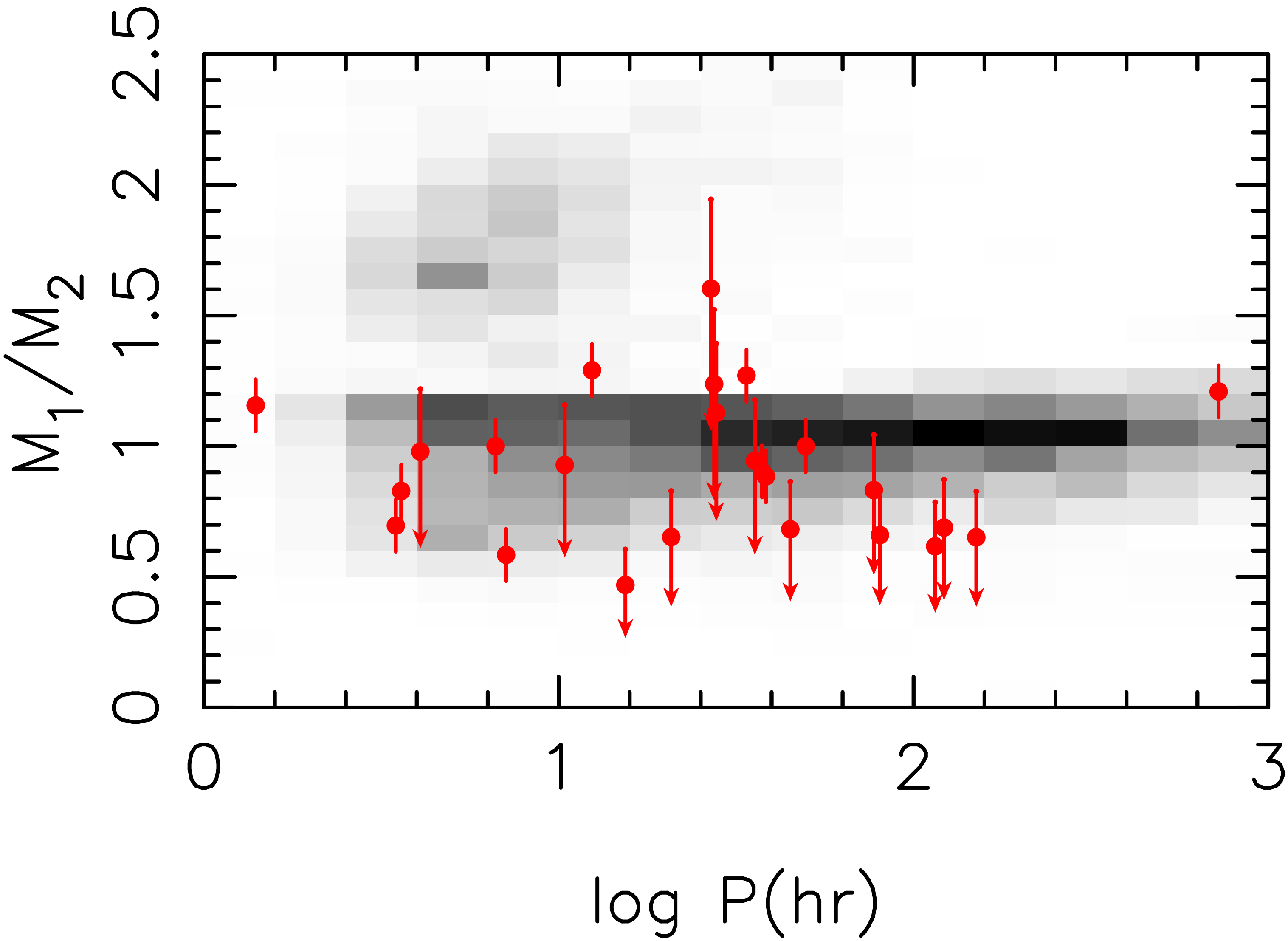
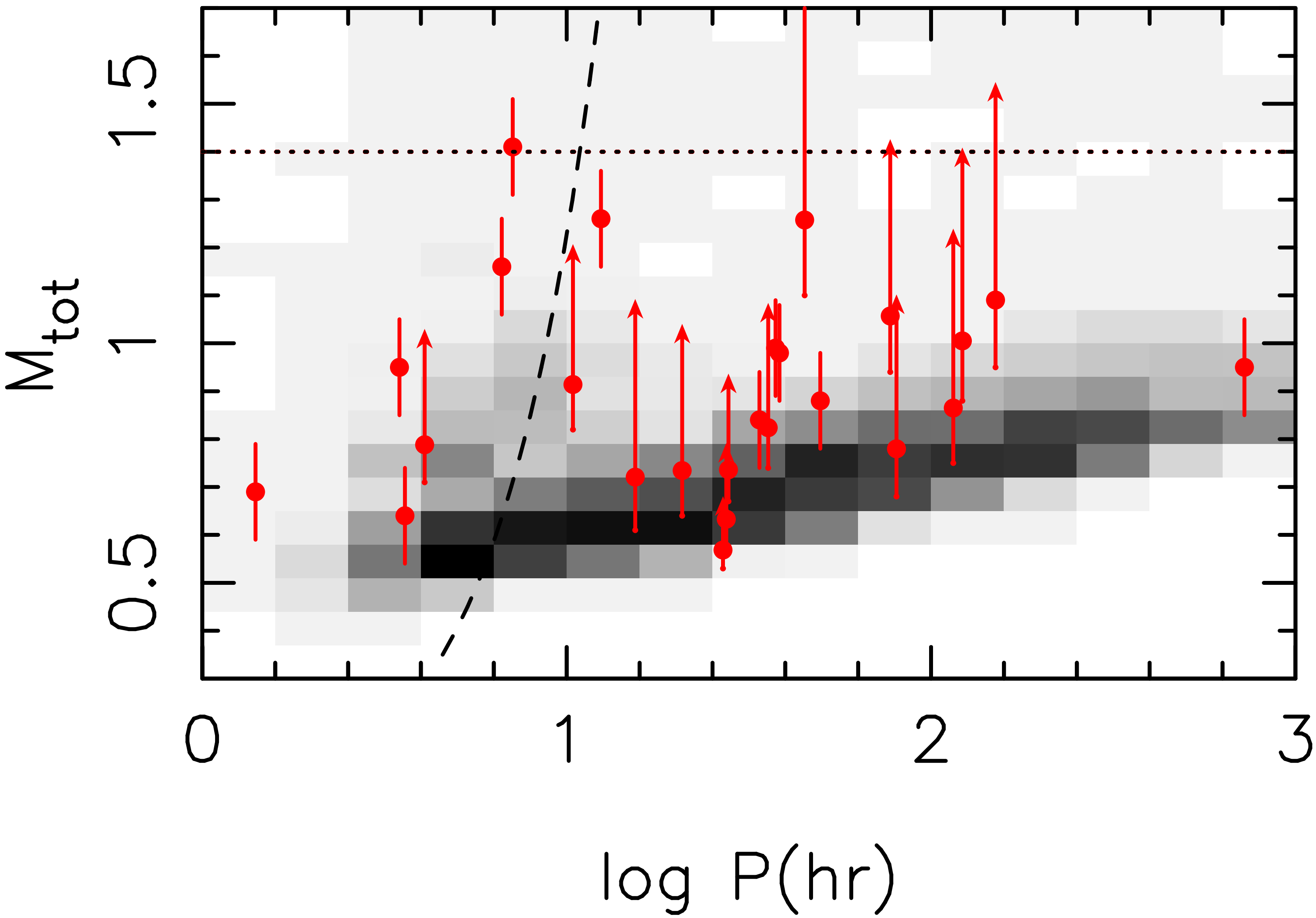


2.5
2
1.5
1
0.5
0
M_1/M_2
0
1
2
3
log P(hr)

1 “SN Ia progenitor”



Double white dwarfs: numbers and rates

- Rates from theoretical model

  Birth rate: 0.02 yr^{-1}, one every 50 years

  'Merger rate': 0.008 yr^{-1}, one every 125 years

  "SN Ia rate" : 0.0011 yr^{-1}, one every 900 years

- Numbers

  About 200 million double white dwarfs in the Galaxy

- Expected visible systems:

$V_{\rm lim}$	N wd	N (wd,wd)	N SNIa
15	$\sim$500	56	1
17	$\sim$7000	758	17
20	$\sim$200000	17033	316

- Rough agreement theory and obs

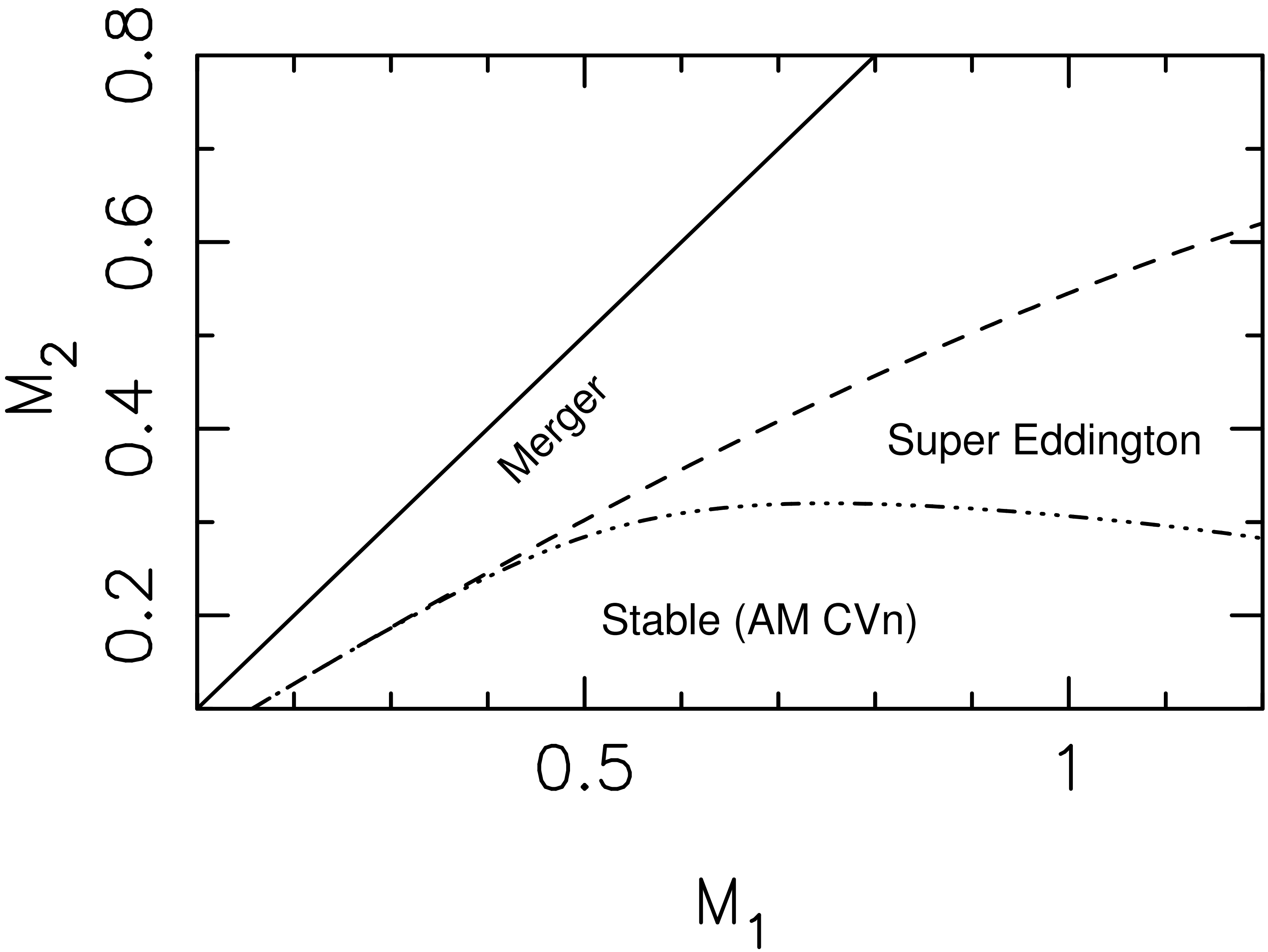
Complications

- WDs are faint! (N_{tot} = $N_{obs} \times$ large number)
- White dwarf cooling: systematics between (wd, wd) binaries (He-core WD) and single WD (CO-core WD)

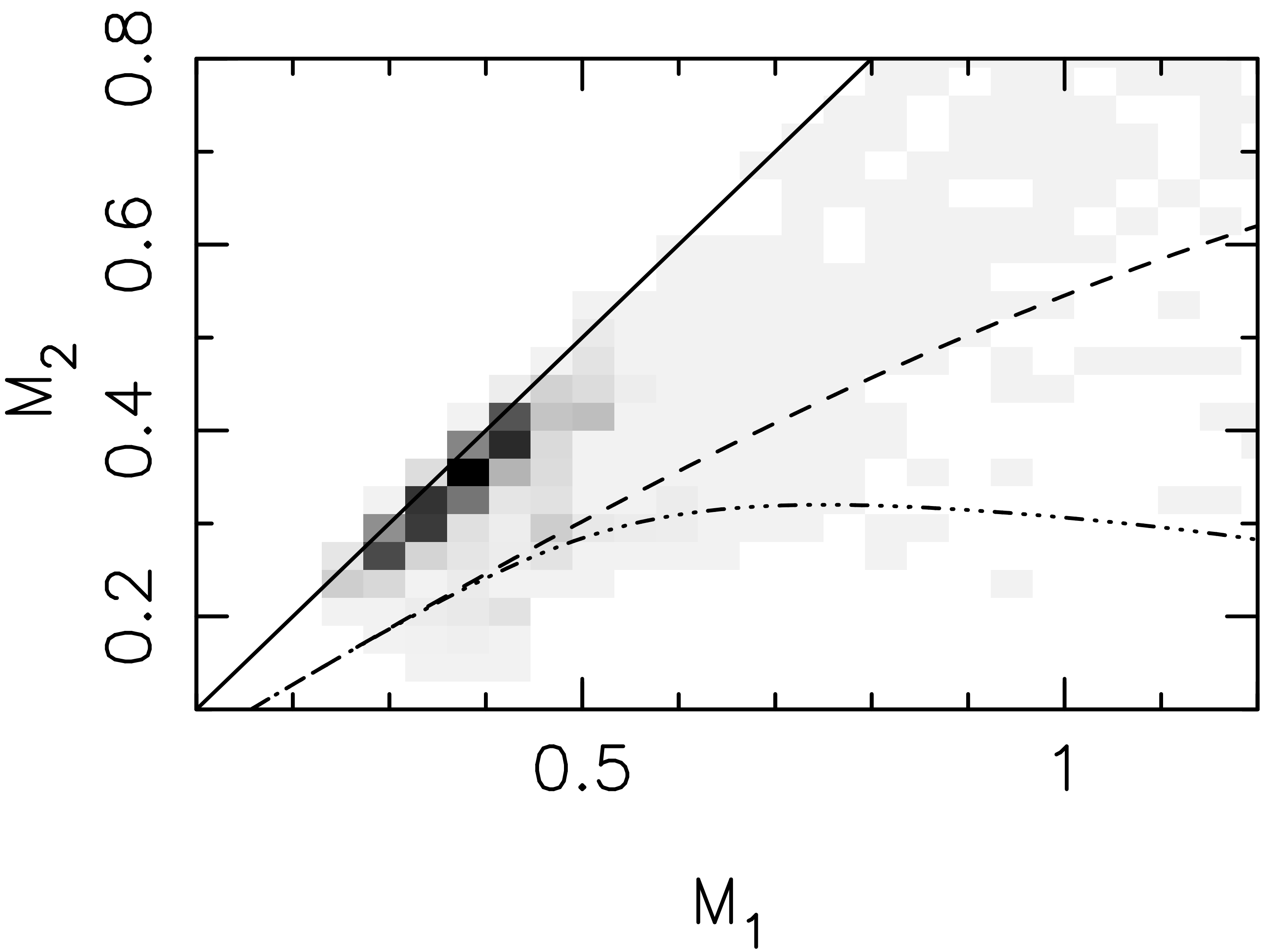
V_{lim}	N wd	N (wd,wd)	N SNIa
17	$\sim$7000	758	17
17.0	12155	2551	11.2

- Short period systems: badly constrained!

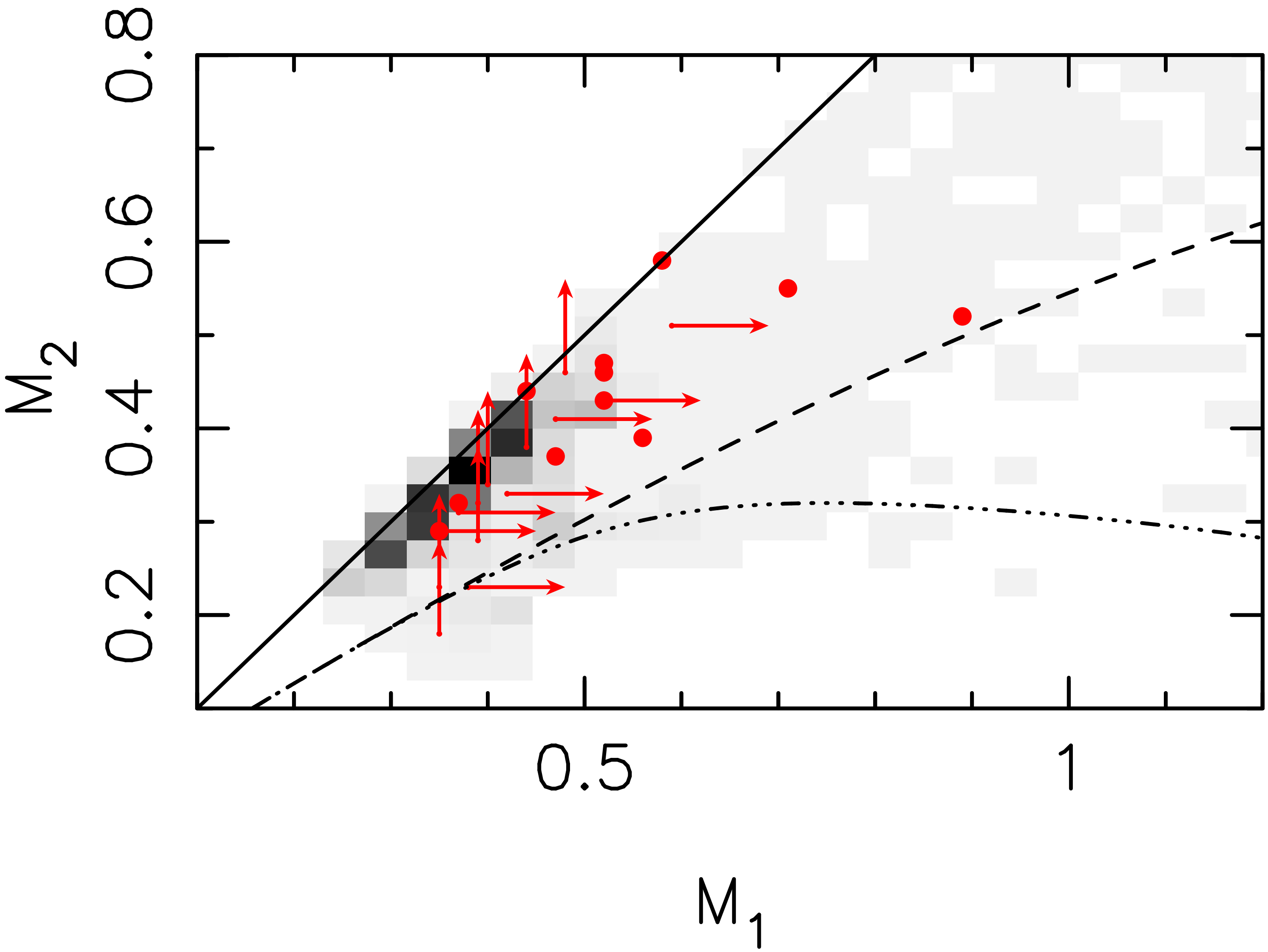
‘Merger outcomes’



‘Merger outcomes’ ...... + theory

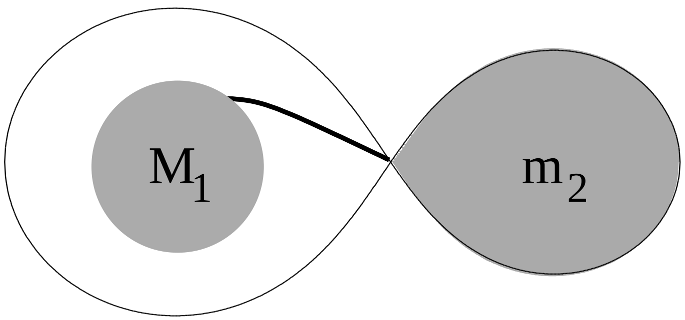


‘Merger outcomes’ ...... + observations



Direct impact accretion

- At onset of mass transfer between WD and WD not enough space for a disc



Nelemans et al 2001, Webbink 1984

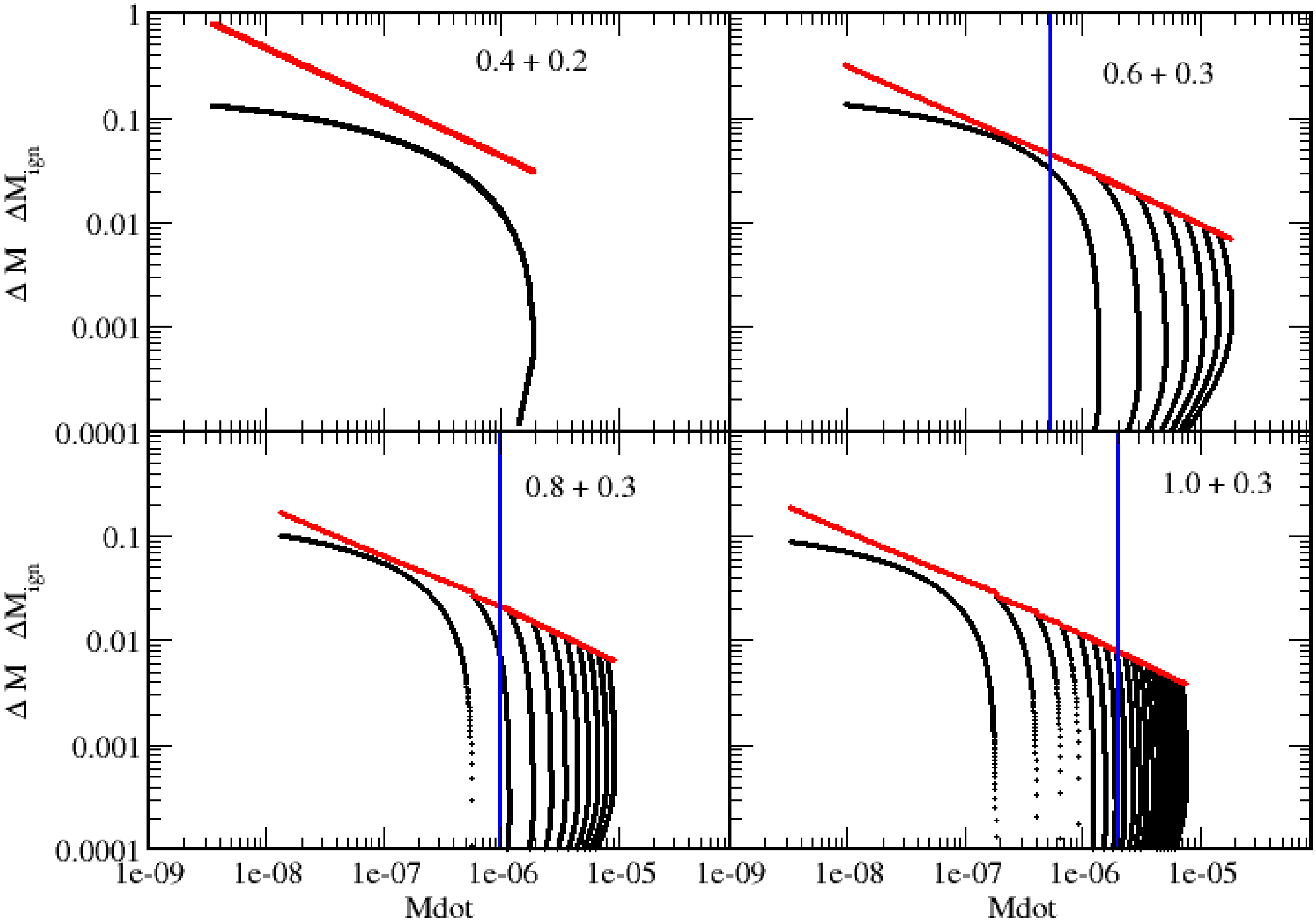
- Can influence stability of mass transfer

  Marsh, Nelemans & Steeghs, MNRAS, in press

- Affects large part of population (factor 100)

  Nelemans et al 2001, A&A, 368,939

He Novae in AM CVn stars



Netherlands Organisation for Scientific Research

Conclusions

- Double white dwarfs should be common
- Theory matches observations (numbers and distributions)
- "SN Ia rate" is about 1 in 1000 years
- Many "mergers" with many outcomes
- Direct impact accretion expected
- AM CVn stars are possible sites of He novae

- (Double white dwarfs can be used to test binary evolution)
- (Double white dwarfs are strong gravitational wave sources)