The impact of mergers in the mass distribution of white dwarfs

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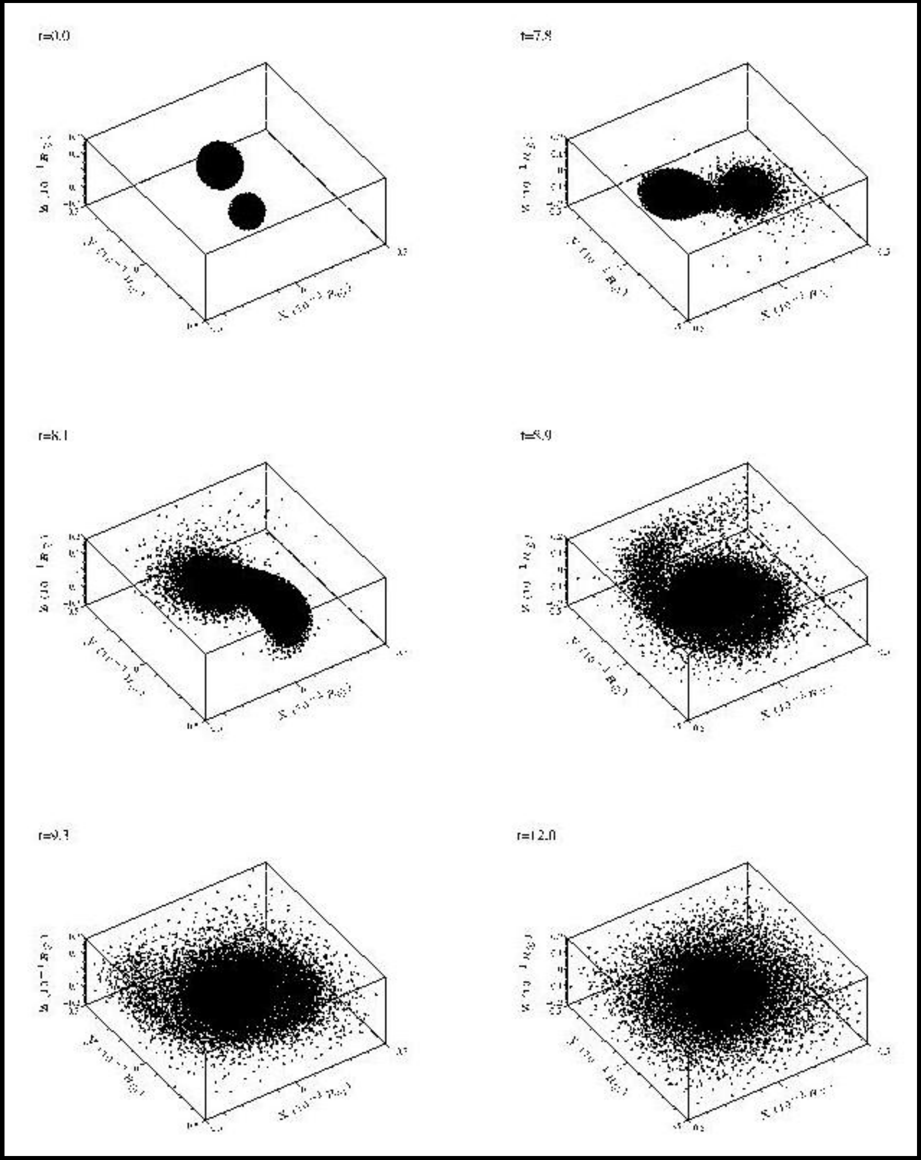
Progenitors & environments of supernova explosions

Supernova progenitors: The DD scenario

0.6+0.8 case

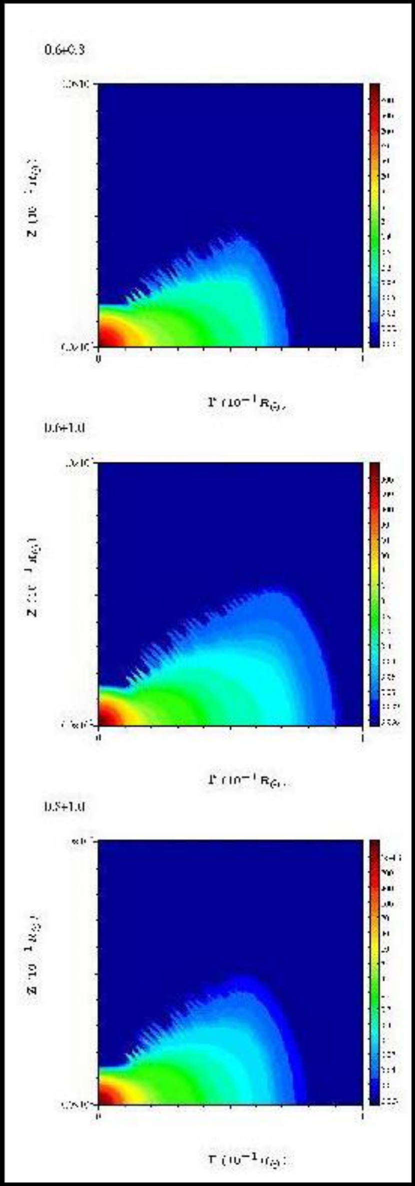
Guerrero et al 2004



Two WD merge by emission of GW
If the masses are not too different: catastrophic disruption
No prompt ignition

0.6+0.8 case

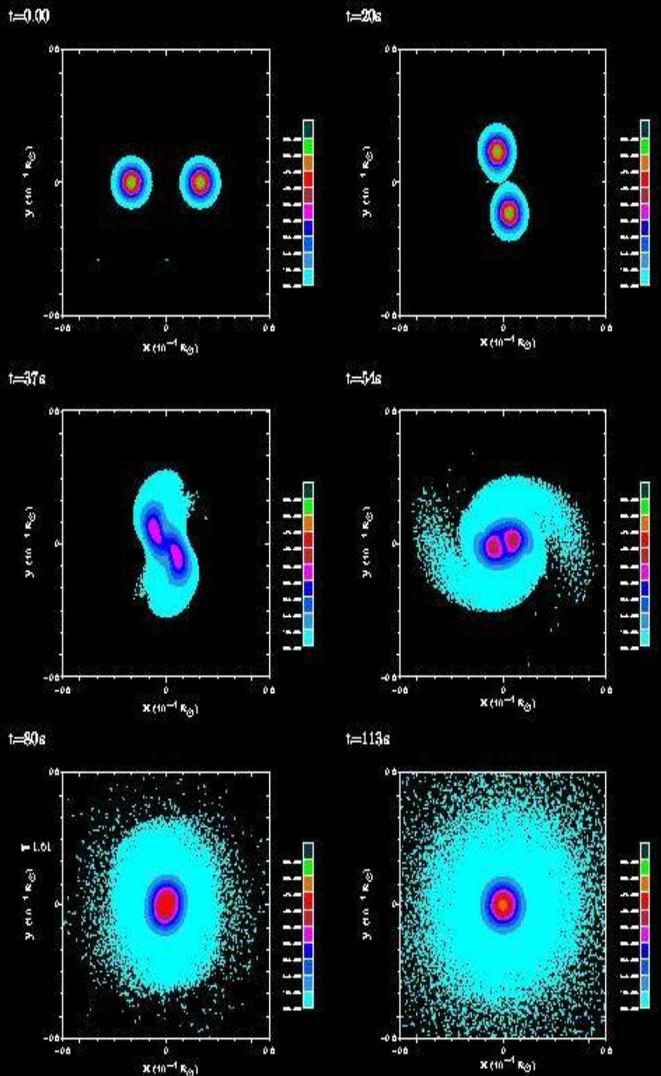
Density profiles



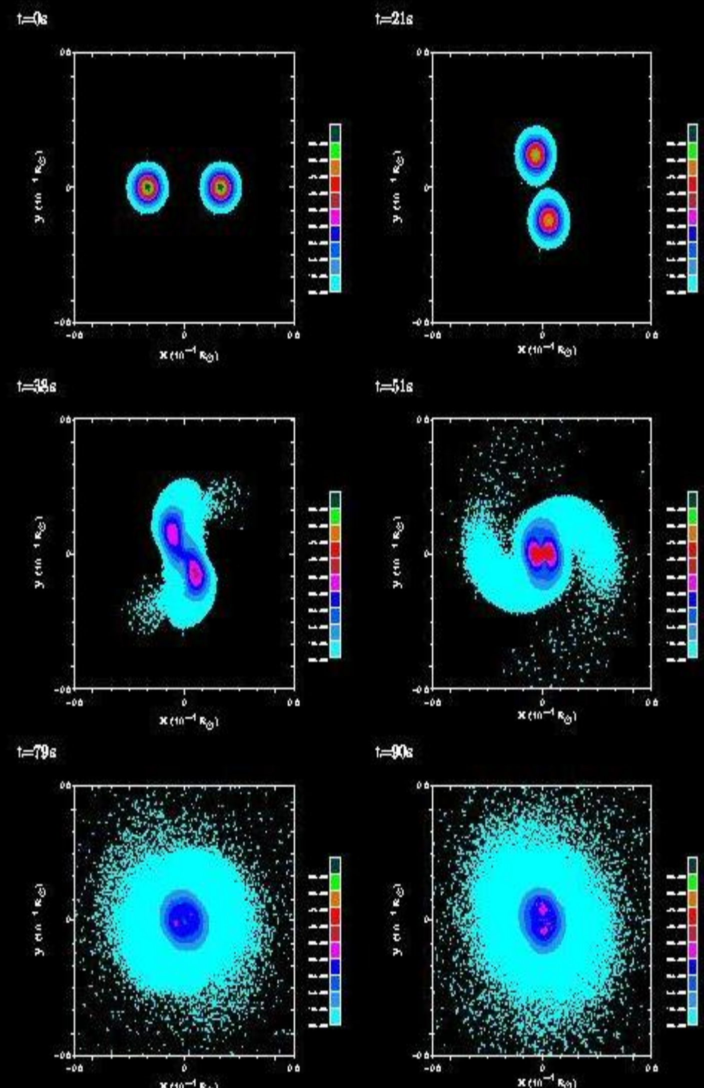
A thick disc forms.
Depending on how the mass is ransferef to the WD
AIC (Nomoto , 1980)
SNIa (Piersanti et al 2003, Yoon et al 2007)
The answer depends on:
At which rate the disc transfer matter
Which rate can be accepted by the WD
How much mass is lost by the system

Density (0.6 + 0.6)

Balasara viscosity



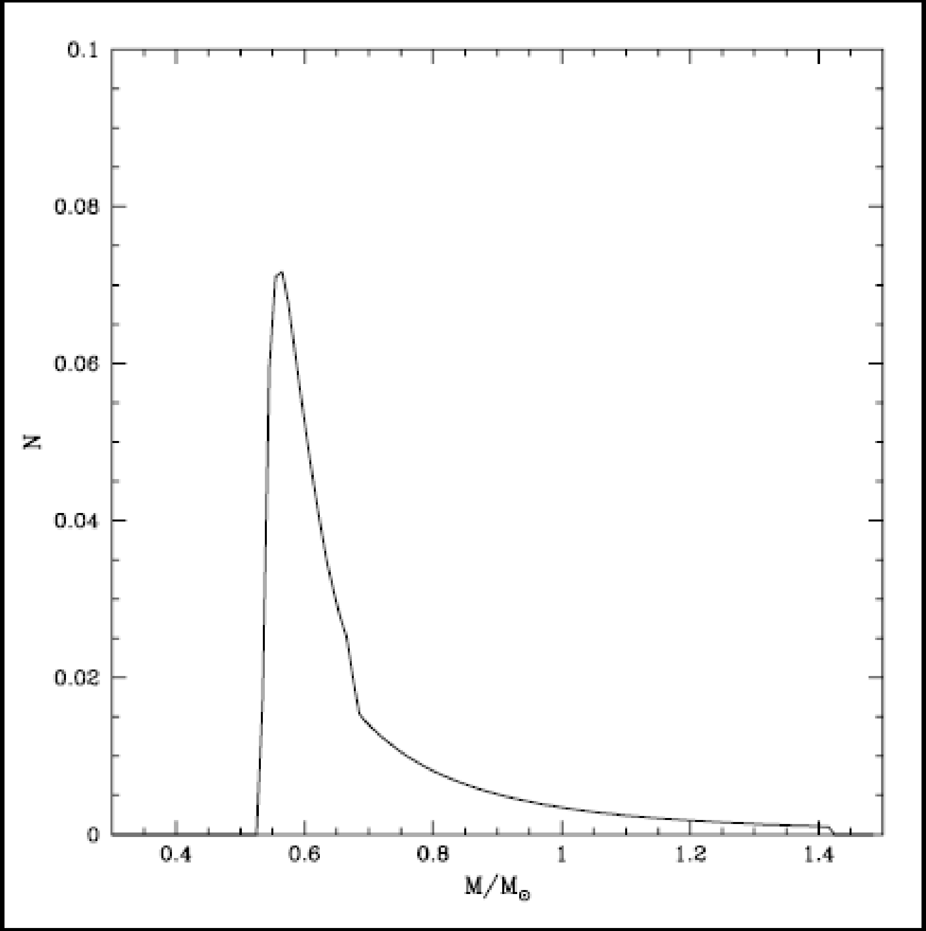
Riemann solver

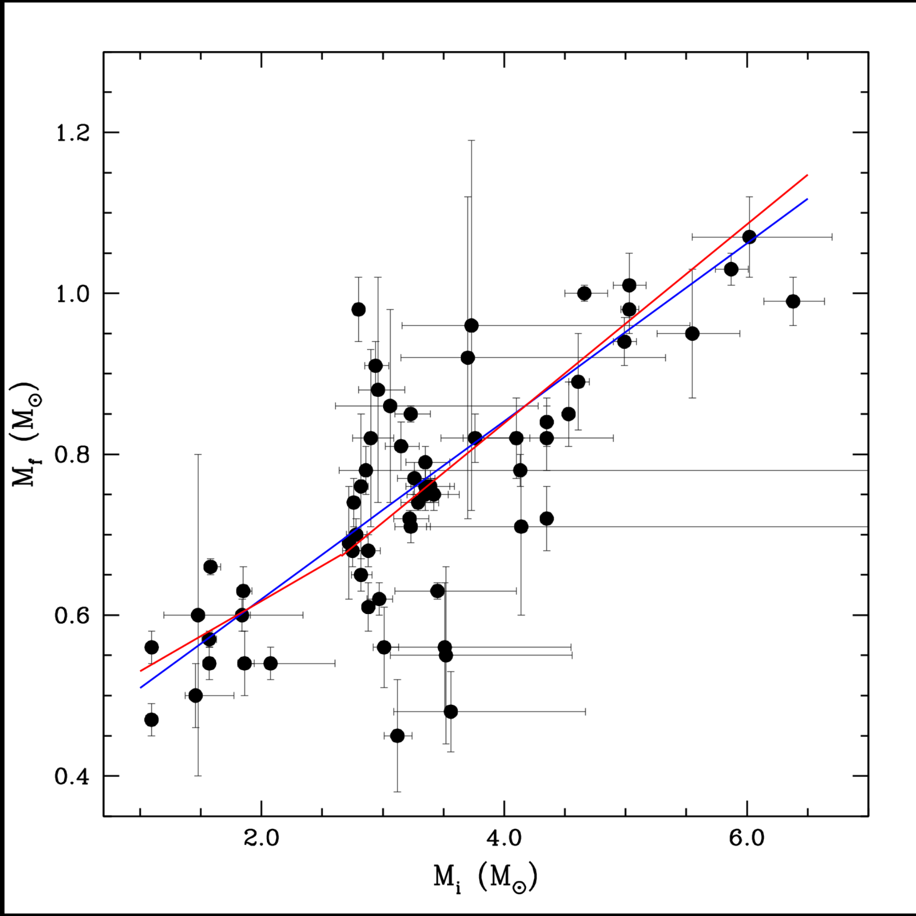


Loren et al'08

See Pakmor's talk

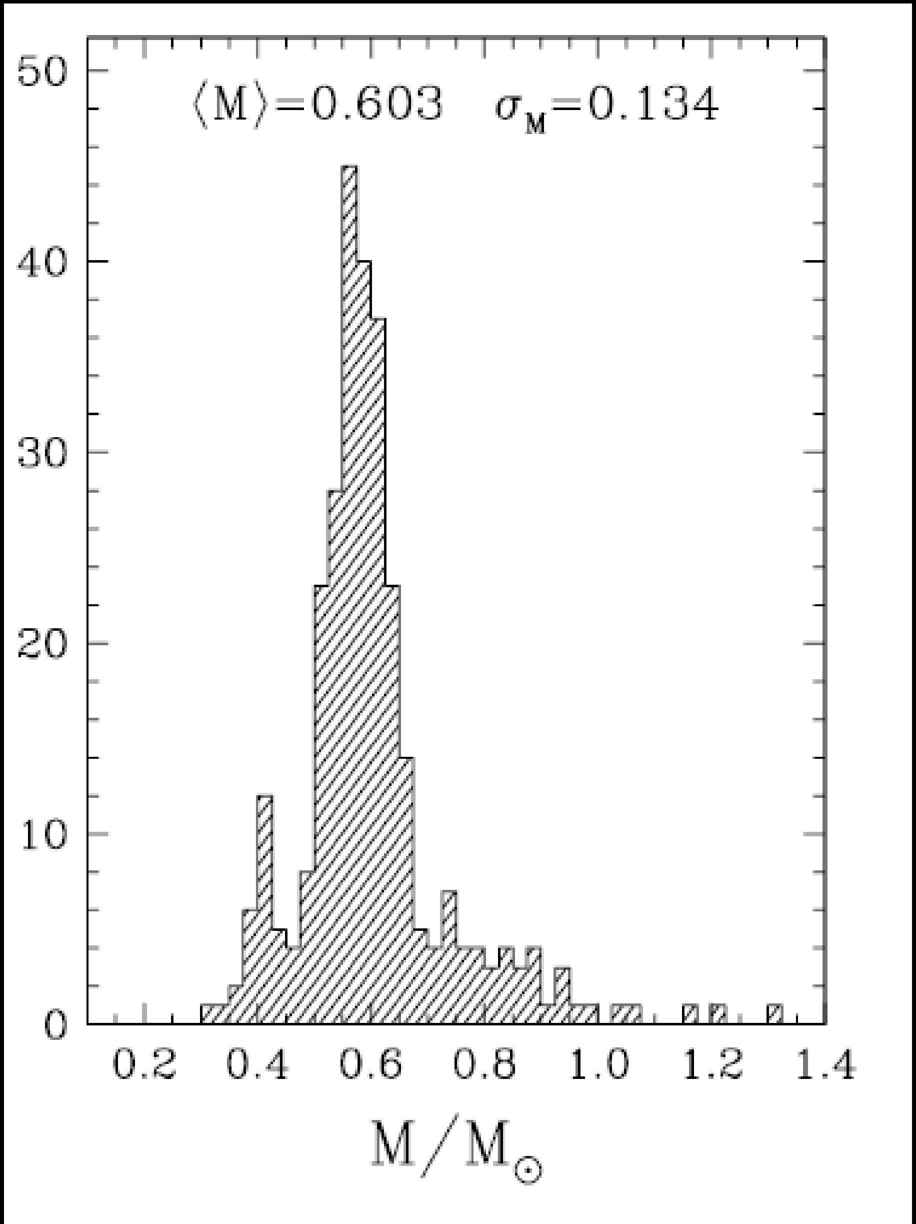
Mass distribution of single WD





IFMR from Catalan et al'08

Mass function from the Palomar – Green survey (Liebert et al'05)

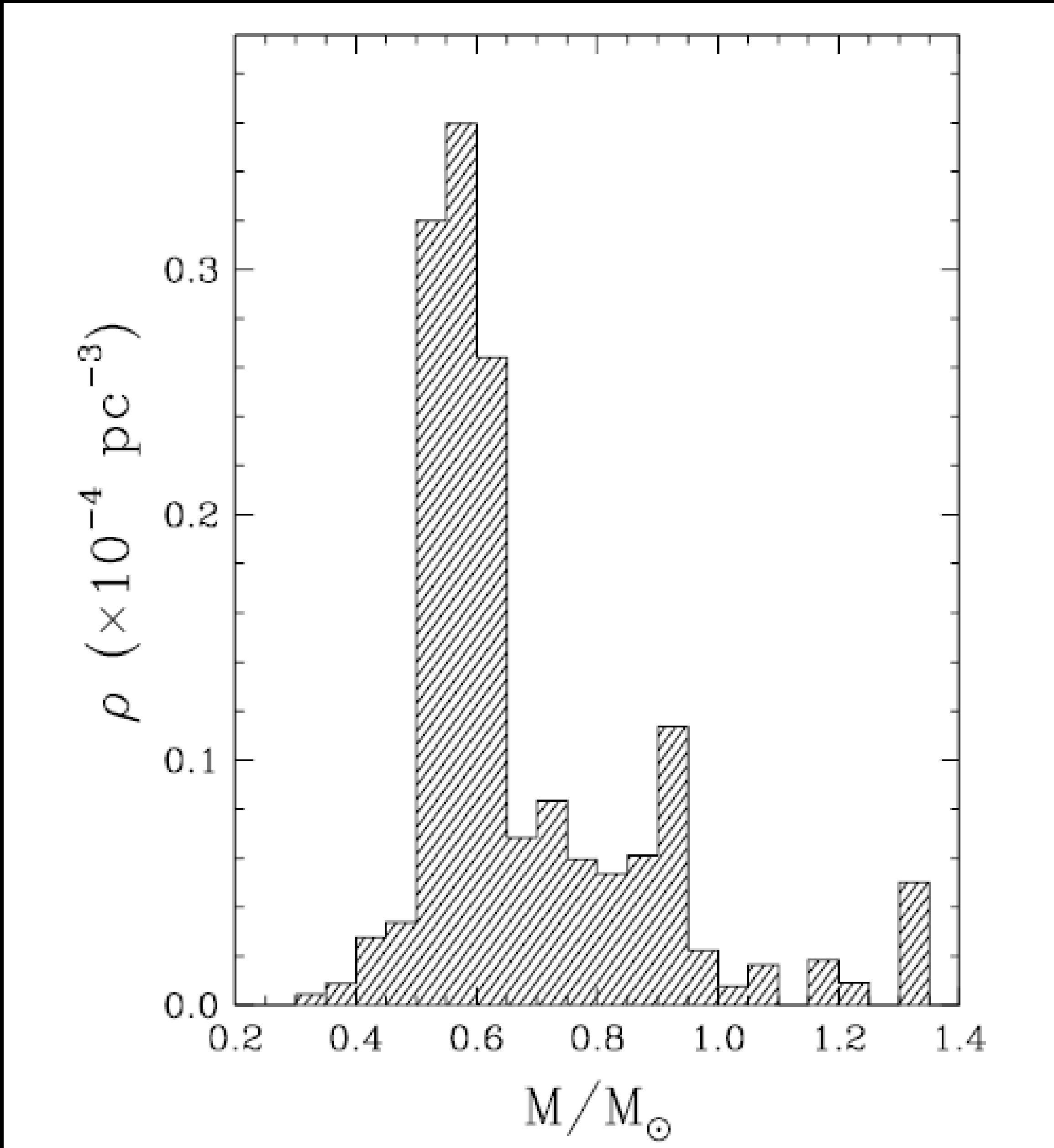


The sample is composed by 298 DA-WD with $T_e >$ 13,000 K

Bins of 0.025 M_o

Presence of structure:

$M_C \sim 0.40\ M_o$	8%	$4.52 \times 10^{-6}\ pc^{-3}$
$M_c \sim 0.57\ M_o$	76%	$1.58 \times 10^{-4}\ pc^{-3}$
$M > 0.78$	16%	$5.33 \times 10^{-6}\ pc^{-3}$



PG-survel is magnitude limited
Sample weighted by $1/V_{max}$

Influence of the binary population

Number of degenerate systems born per unit time and volume with a $\frac{1}{2}$ separation a at the instant t is:

$$b(a,t)=\int_{M_1}\int_{M_2}\Phi(M_1,M_2)H_0(A_0)\frac{dA_0}{da}\Psi(t-\tau_b)dM_1dM_2$$

M_1, M_2 and A_0 are the masses and the inital separation at the ZMS

$\tau_b(M_1,M_2,A_0)$ is the time to form a binary degenerate (single or double), $\Phi(M_1,M_2)$ is the initial mass function of the binary, $H_0(A_0)$ is the distribution of initial separations

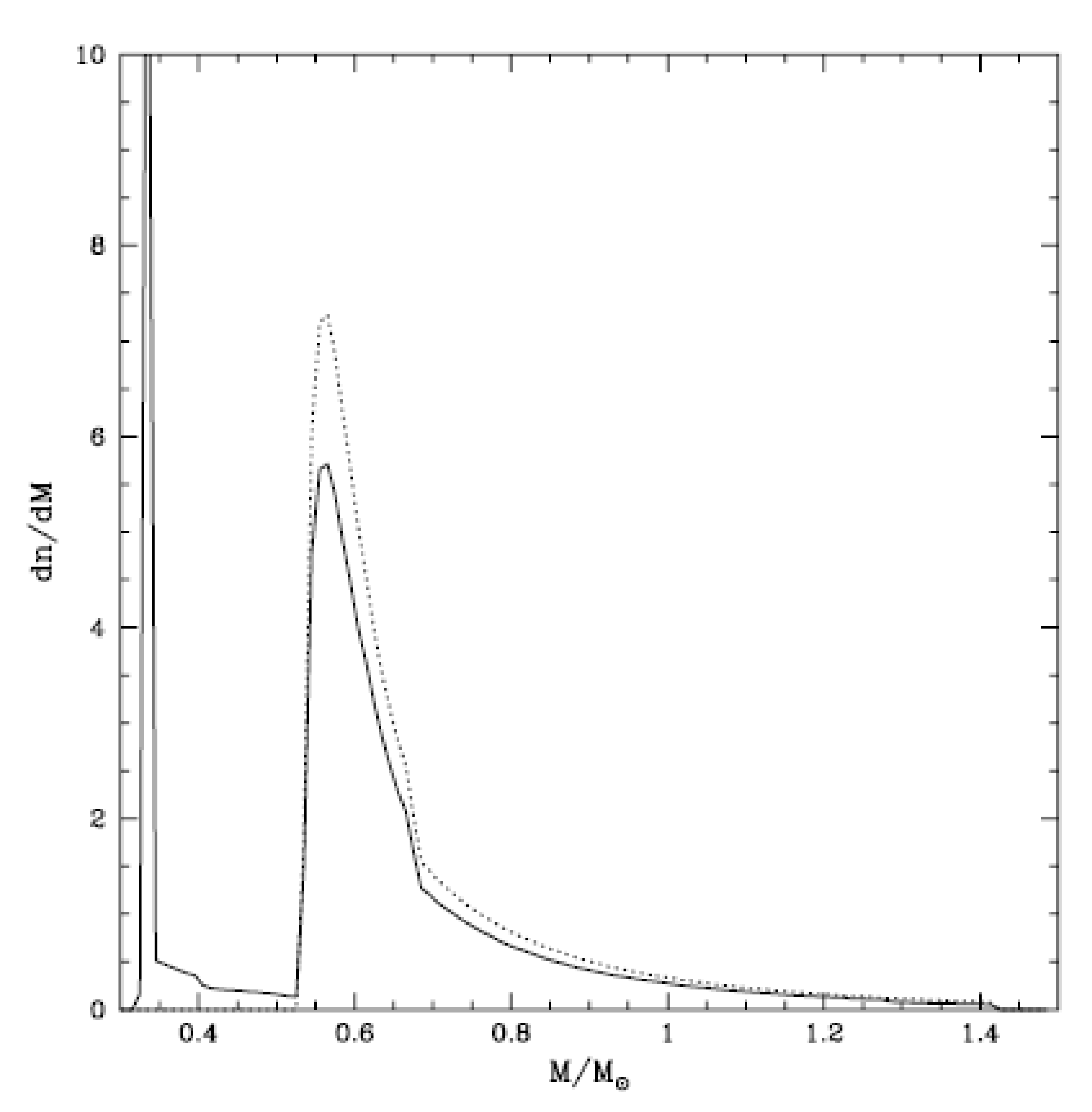
The DD formed at the instant t will merge after a time:

$\Delta t_m=\frac{a^4}{4K}$ where $K=m_1m_2(m_1+m_2)/0.6$ where masses are in solar units separations in solar radii and time in Gyr.

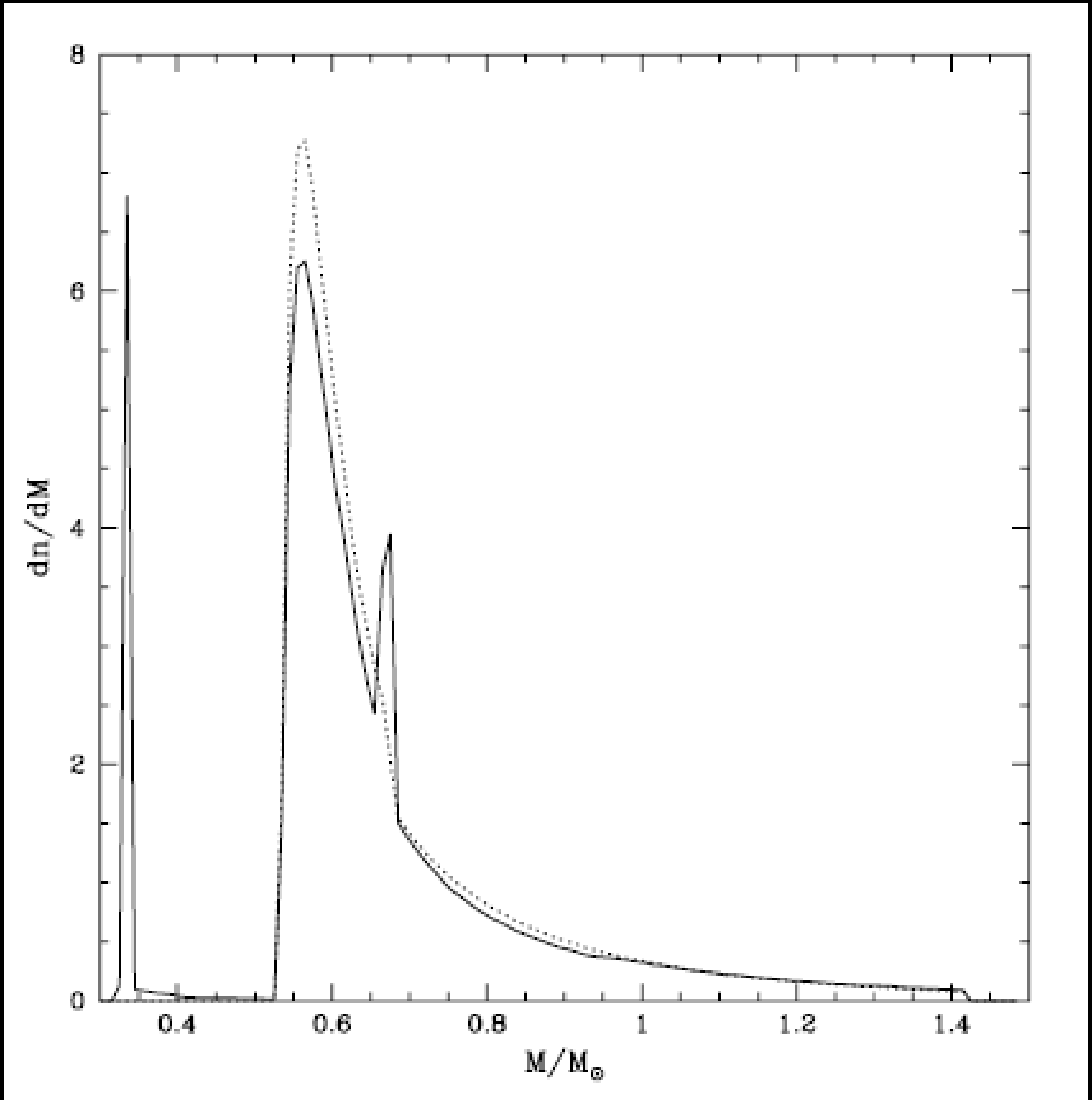
Birthrate calculation

Isern et al,
Thermonuclear Supernovae,
Ed. Ruiz-Lapuente, Canal, Isern,
Kluwer p. 127 (1997)

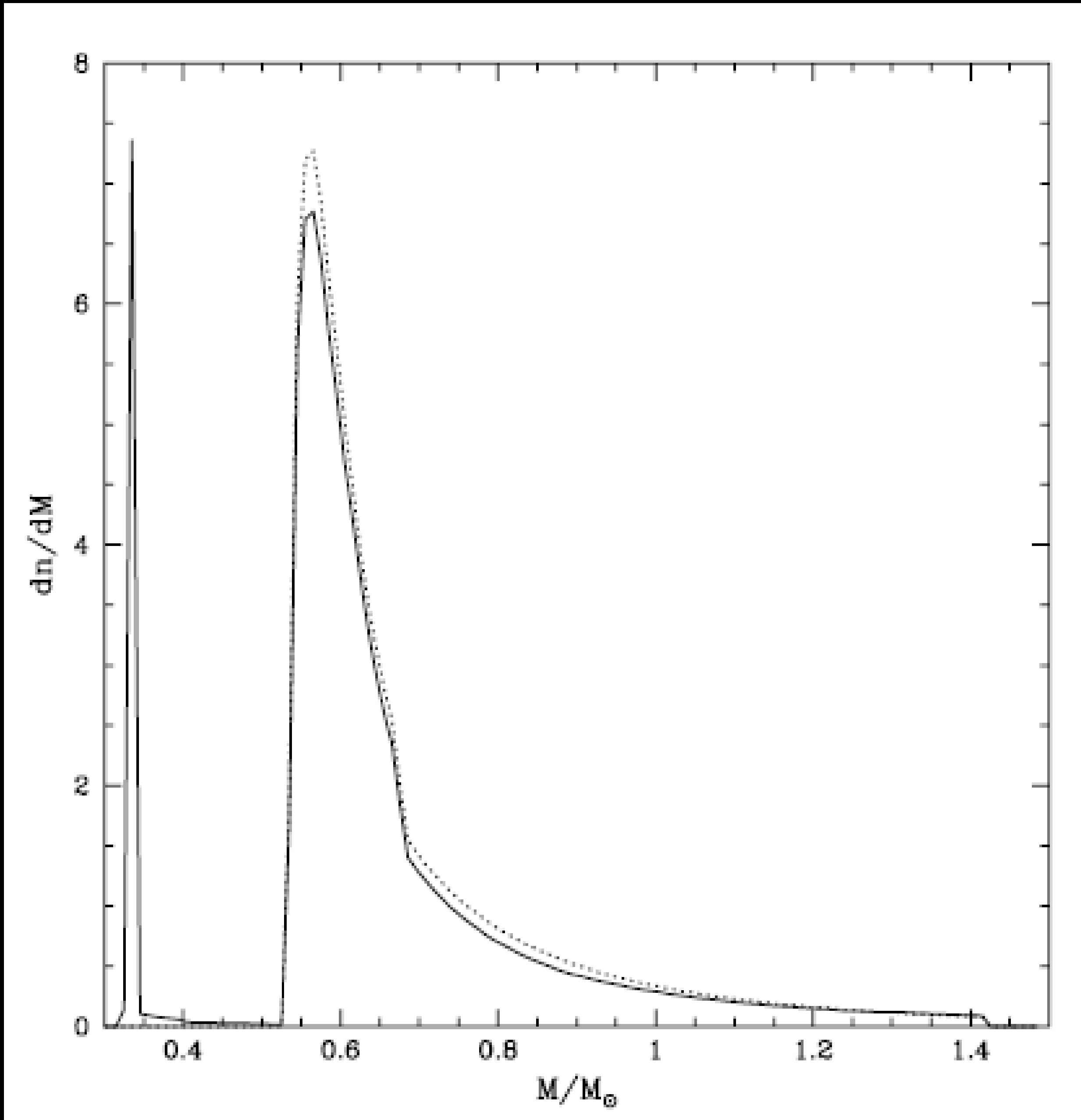
- Only evolutionary channels in which RLOF occurs when the envelope is convective
- Models obtained with FRANEC. Solar metallicity
- WD cooling models from Salaris et al 2000
- Catalán et al (2008) IFMR
- Common envelope treatment: Iben & Tutukov (1984)
- Magnetic breaking
- Salpeter's IMF for the primary,
- $F(q) \propto q$; $q = M_2/M_1$
- Distribution of initial separations: $H(A_0) \propto 1/A_0$
- During the merging ALL the mass of the secondary is transfered to the primary



Dotted line: single
Continuous line:
Binaries but no merging
SFR const, T_G = 10.5 Gyr

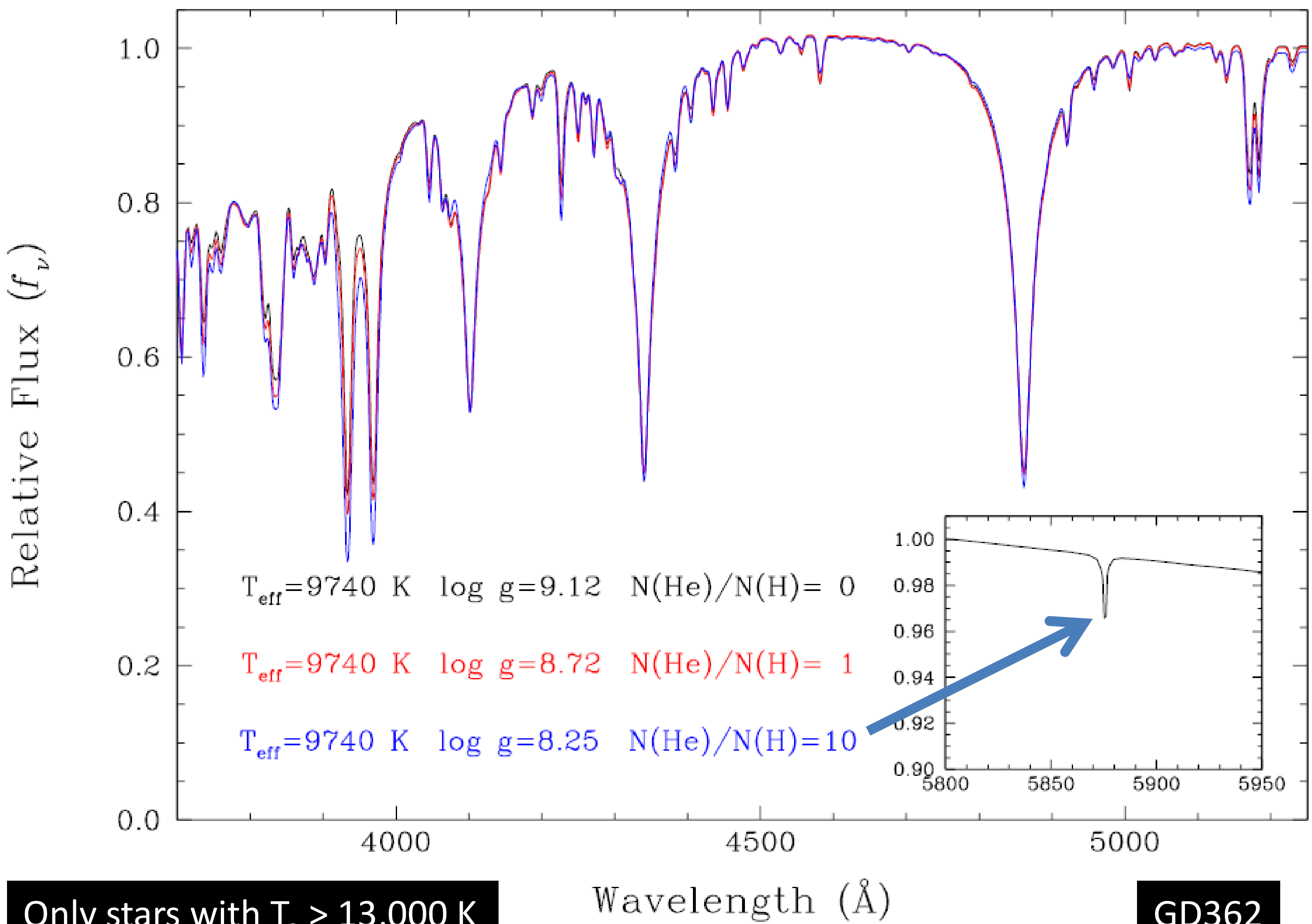


Dotted line: single
Continuous line:
Binaries after merging.
He detonation suppresed.
No mass losses
SFR const, T_G = 10.5 Gyr



Dotted line: single
Continuous line:
Binaries after gravitational merging. He detnation allowed. No mass losses
SFR const, T_G = 10.5 Gyr

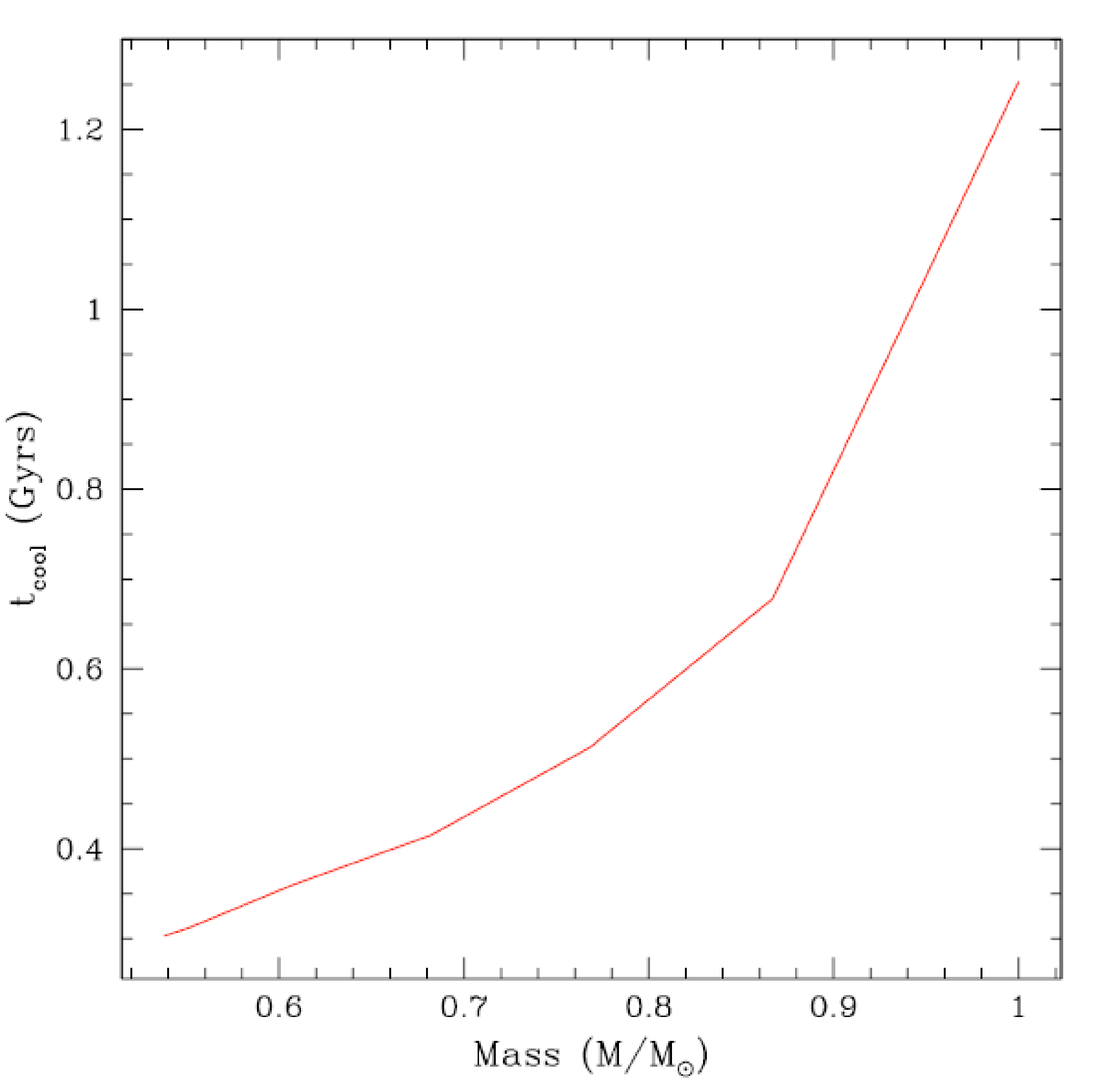
Comparison with observations



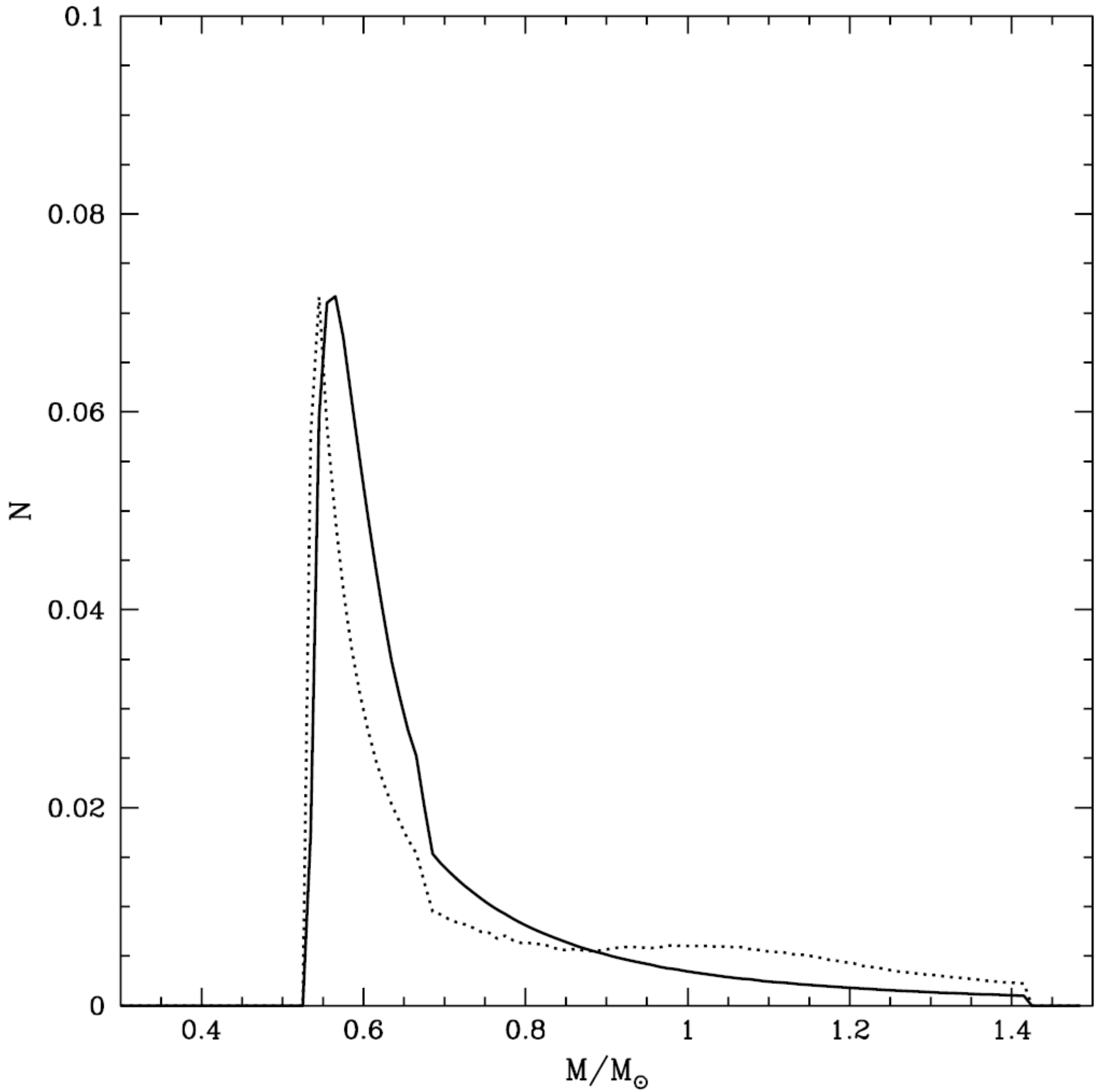
Only stars with T_e > 13,000 K

GD362

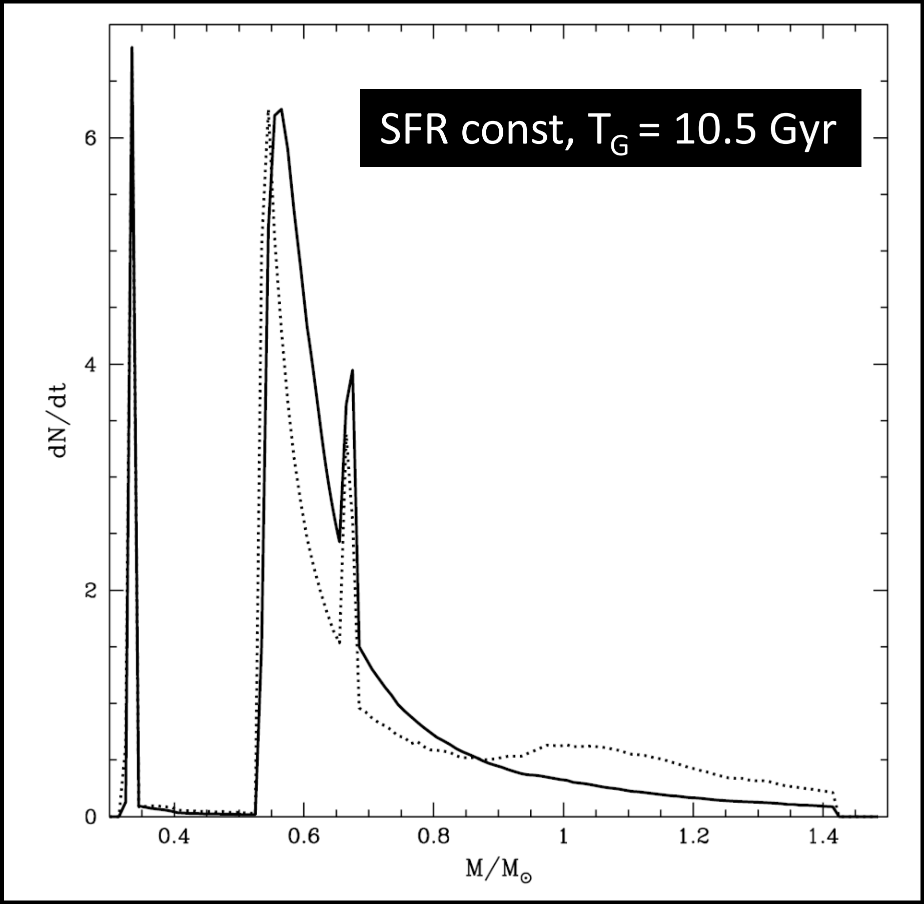
Time to reach T_e = 13,000 K

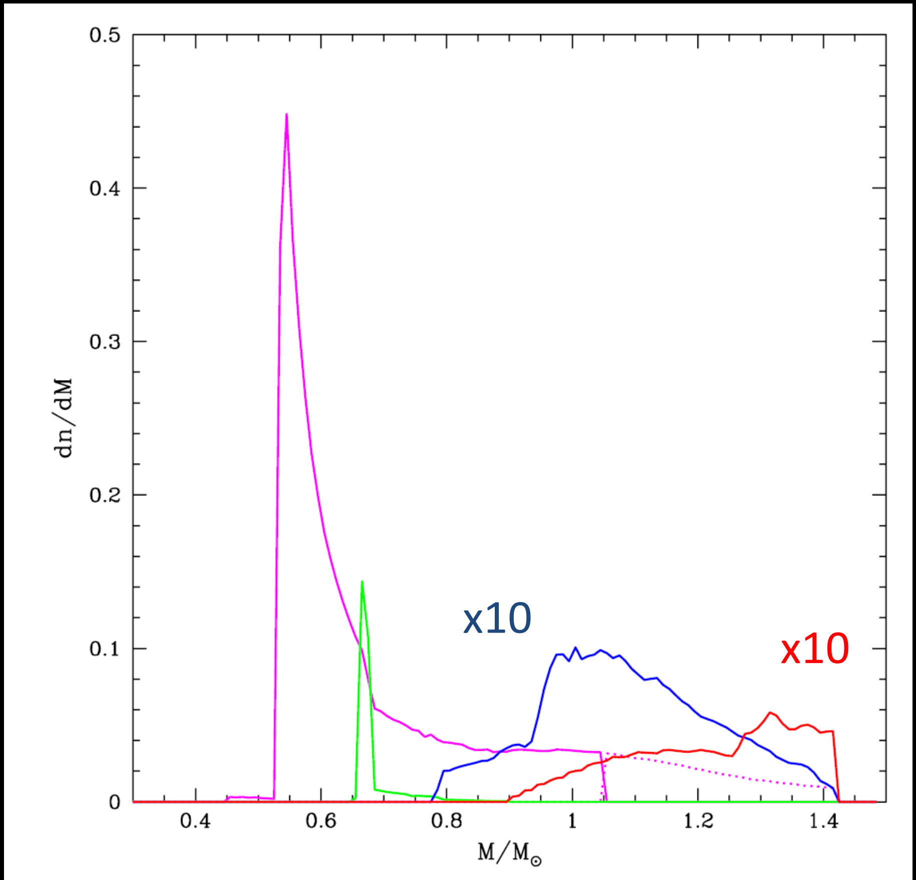


Log g	M_{bol}	Mass
7.0	9.19	0.24
7.5	9.96	0.37
8.0	10.67	0.61
8.5	11.46	0.93
9.0	12.43	1.20



Single WD
Continuous line:
Cold WD
Dotted line:
Hot WD. For comparison
the maximum was set
equal to the cold one
SFR const, T_G = 10.5 Gyr



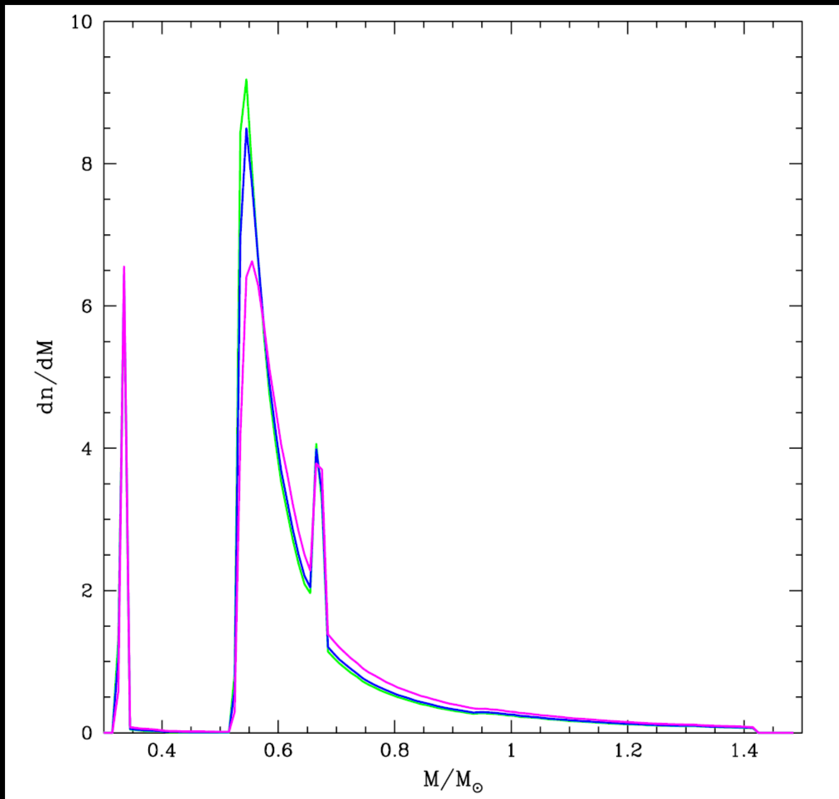


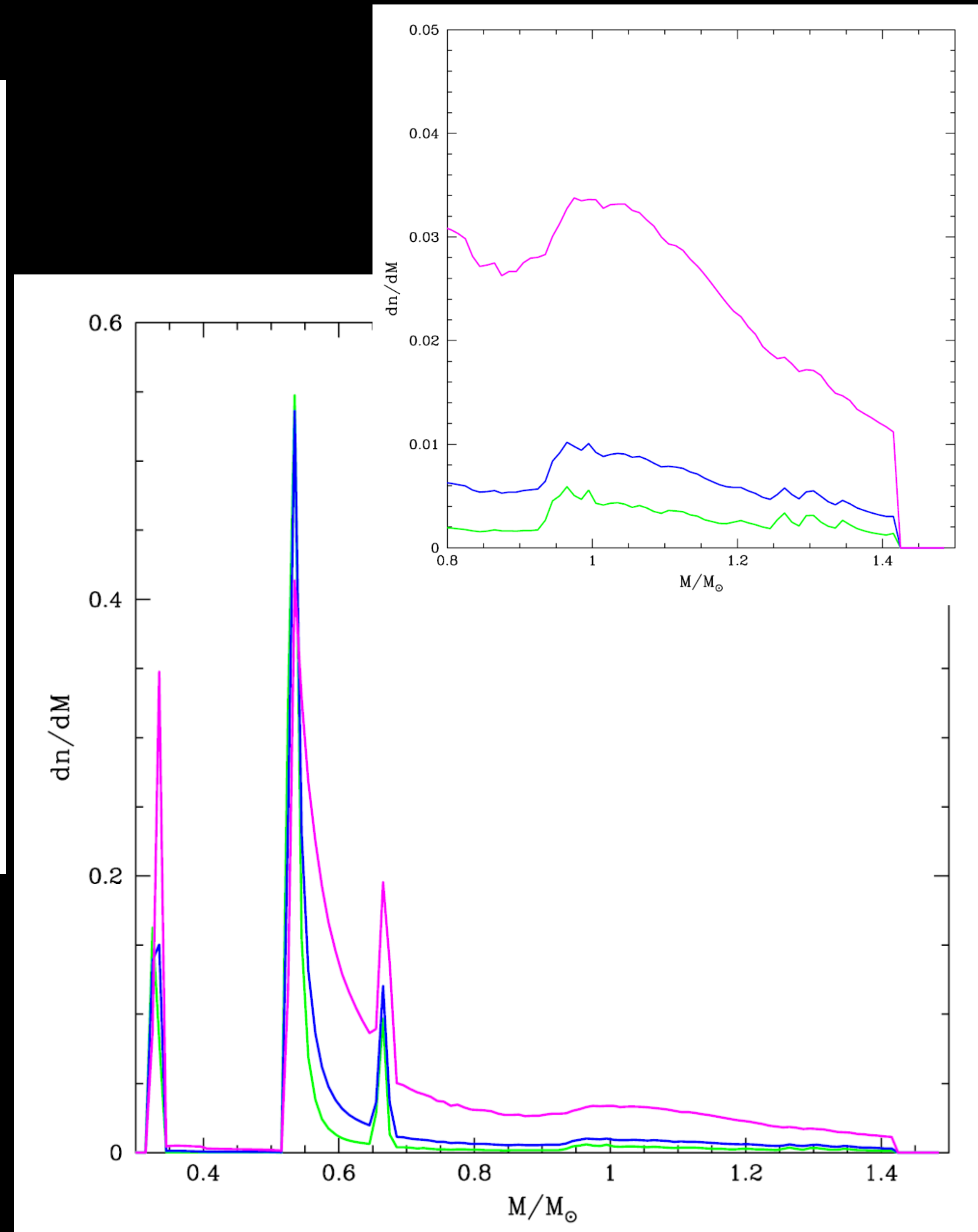
Single:
M=1.05
n_{CO} = 3.2E-4
n_{ONe} =3.2E-4

He + He
M=0.65
n_{tot} = 2.4E-3
n_{HeHe} = 1.4E-3
n_{CO}= 9.8E-4

CO+He: ~ 20%
CO+Co: ~ 15%

$\Psi \sim \exp(-t/\tau)$; 3, 5, ∞ Gyr

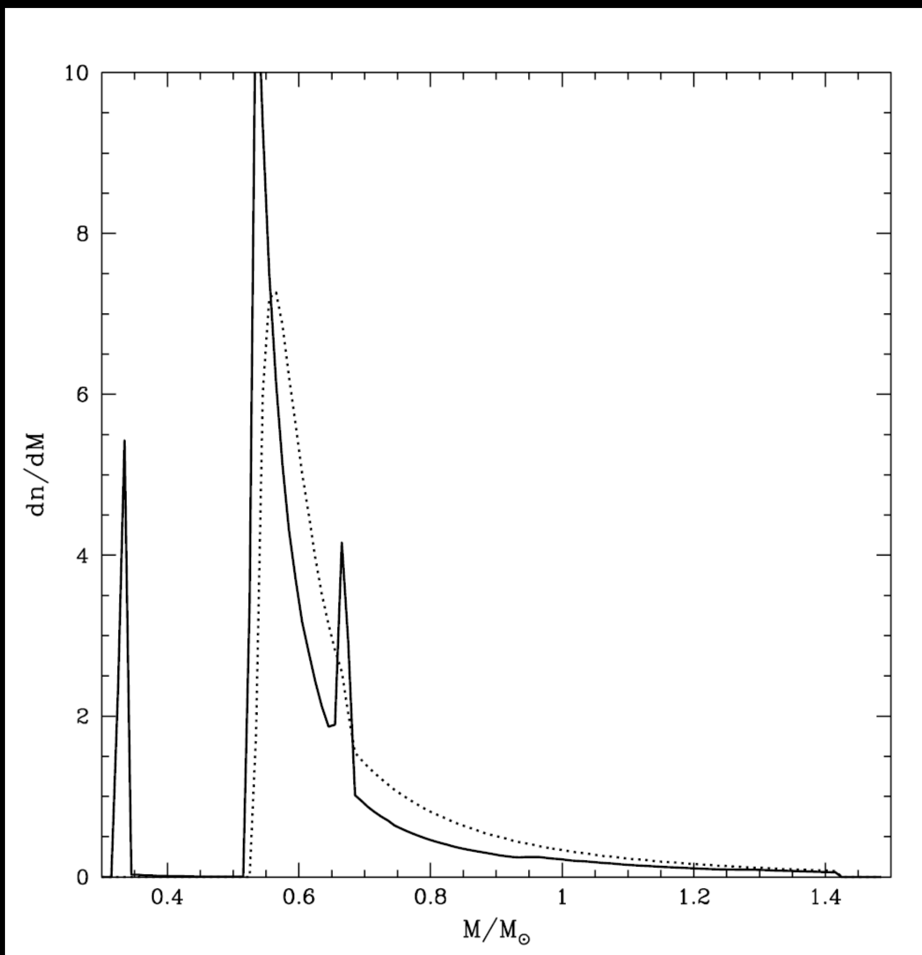


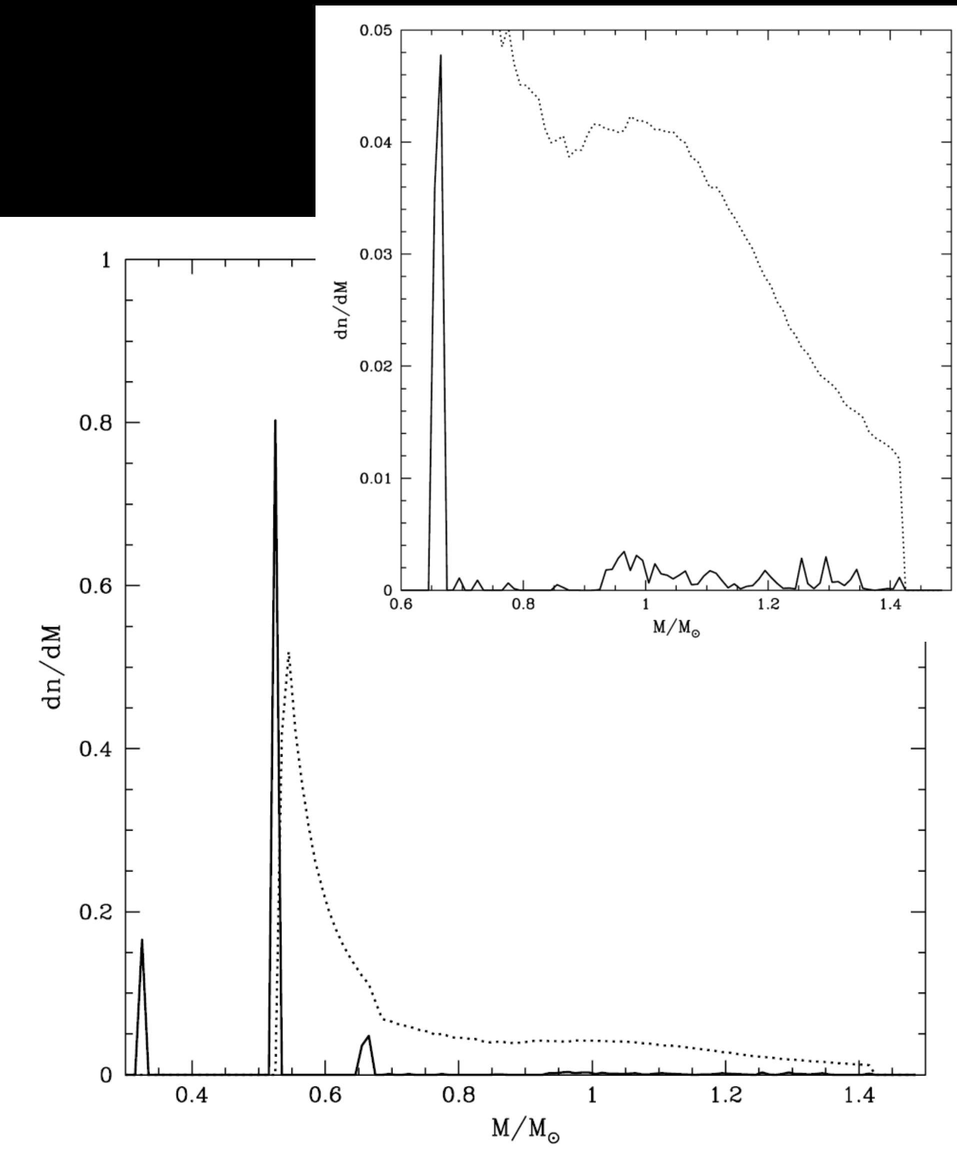


Cold

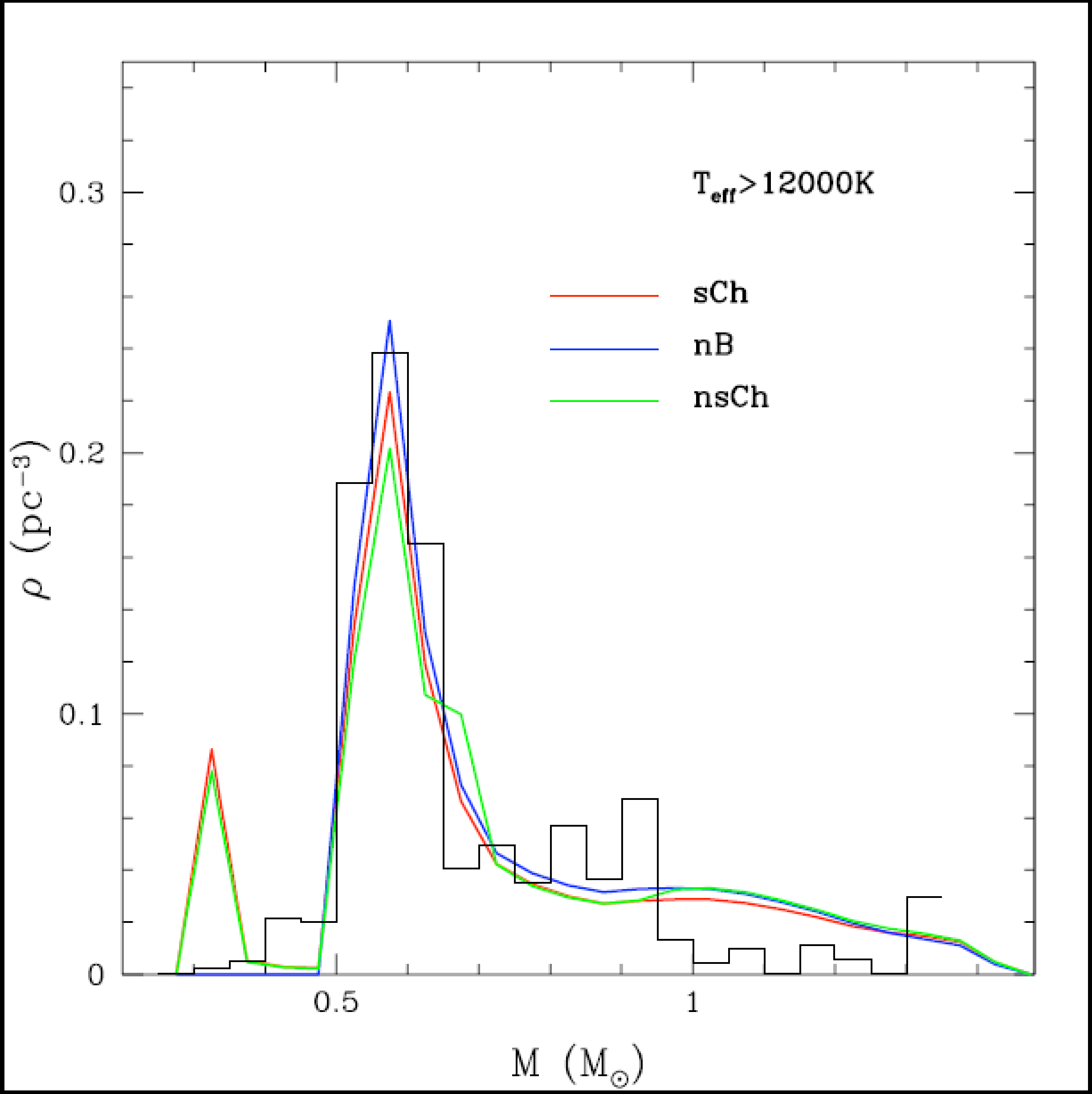
Hot

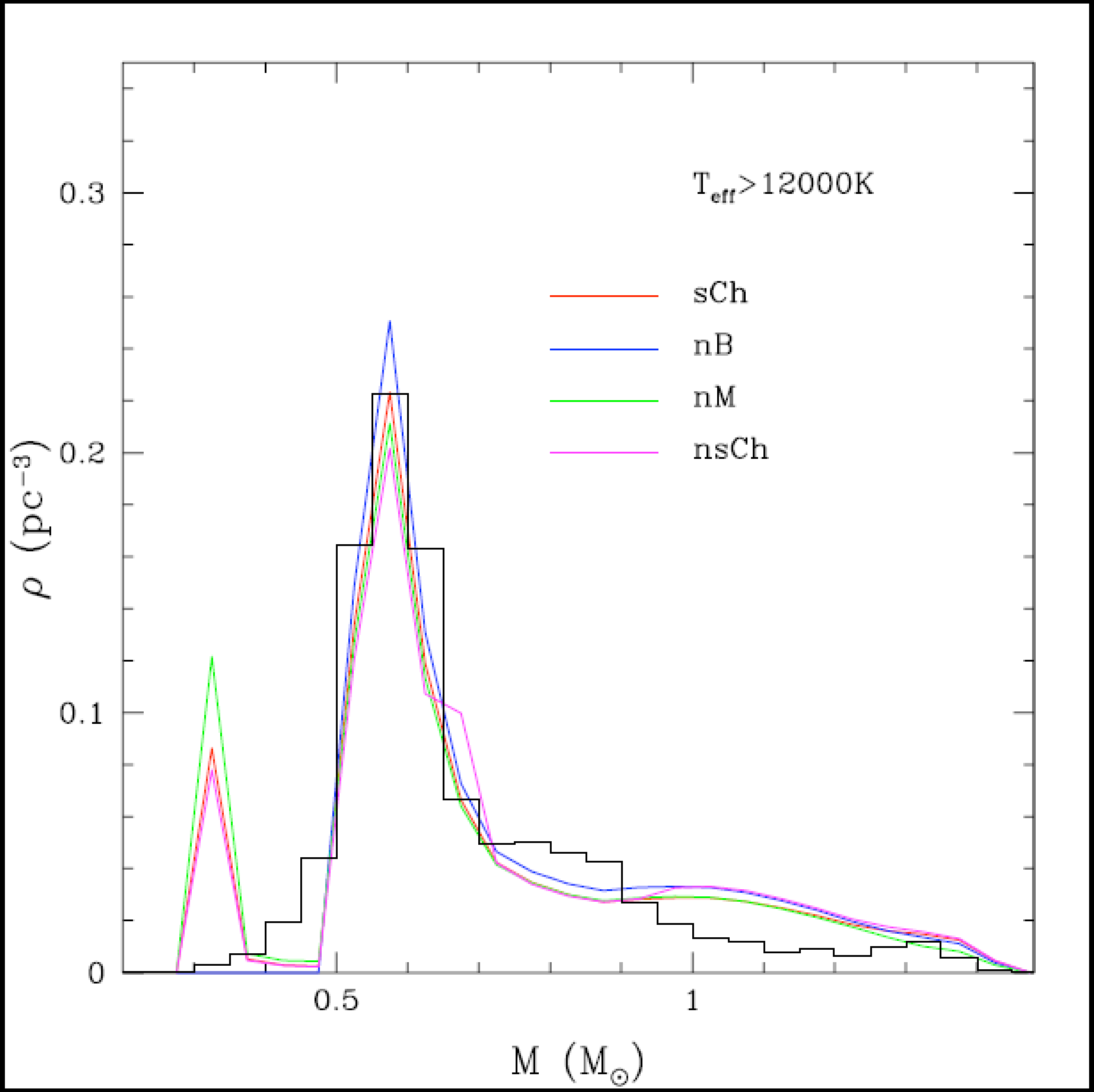
Halo: 13.5 Gyr Dt = 0.1 Gyr





Liebert et al'05
Bin average 0.05 M_o

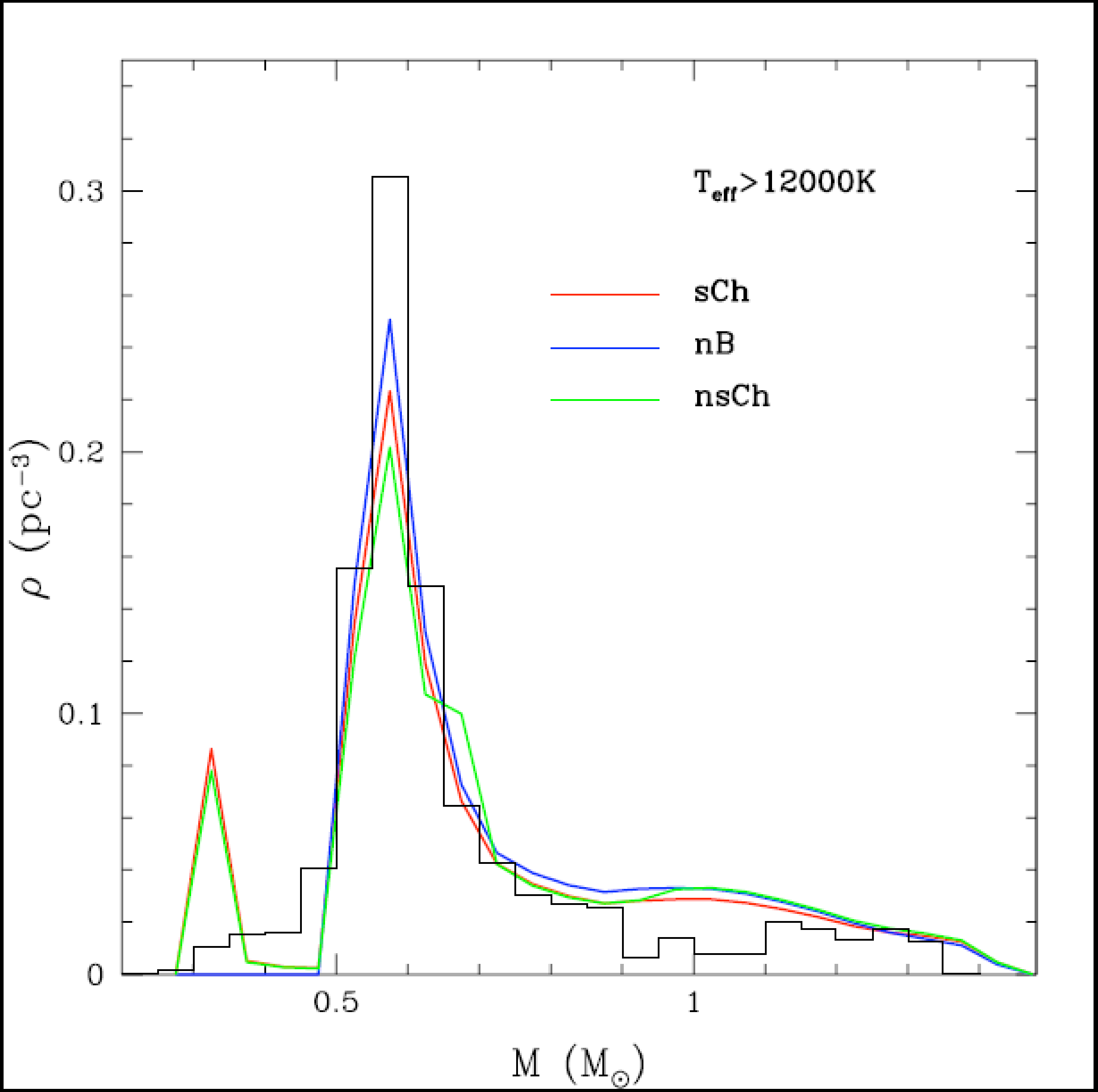




Liebert et al'05
Gaussian errors included

Conclusions

- Mergers introduce small modifications in the mass distribution of WD.
- If we restrict to “hot” WD this contribution is more prominent (the only source in some cases). Strongly dependent on the SFR adopted
- More detailed empirical mass functions are needed to :
  - Determine if the low mass peak exists
  - Decide if the 0.8 M_0 is real
  - Confirm the lack of WD ~ 1 M_o
- Improve the theoretical models



DeGenaro et al'08