Type Ia Supernovae:

Distribution of event times

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Distribution of event times

- RD
- Andy Howell
- Chris Pritchet

Connection to the models:

Can the models inform the predicted distribution of delay times?

Can delay times inferred from data test the models?

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Only if the models are predictive.

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Several good attempts.

Connection to the models:
can delay times test the models?

Only if the models are predictive.

Several good attempts.

But there are many uncertainties.

Uncertainties

- Starting binary parameters
- Region in m-mdot space in which WD can gain mass.
- Role of winds
- Photospheric radius
- Common envelope
- Single degenerate? Double degenerate?

Certainties

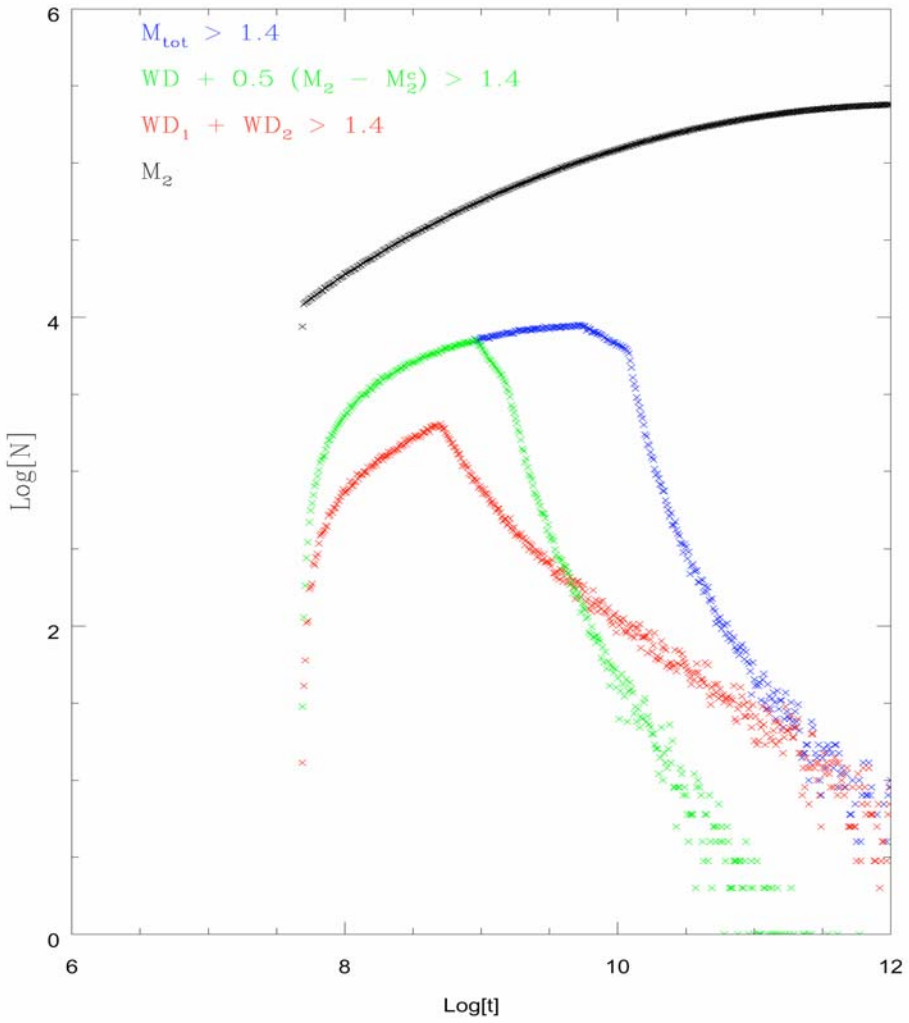
- Type la supernovae occur!

Certainties

- Type Ia supernovae occur!
- WD progenitor
- WD must gain mass
- Binary companion required

Build predictions starting from the certainties

- Progenitor of the WD starts with mass, m_1.
- Starting WD mass is M_{WD}.
- M_{WD} increases.
  Here we assume it must achieve a specific value, $M_{Ch.}$
- Binary companion required.
- Companion starts with mass m_2..
- Companion begins interacting with WD when its core mass is m_c.



$M_1 < 1.4$

$M_{WD} > 0.5$

$T = t(2)$

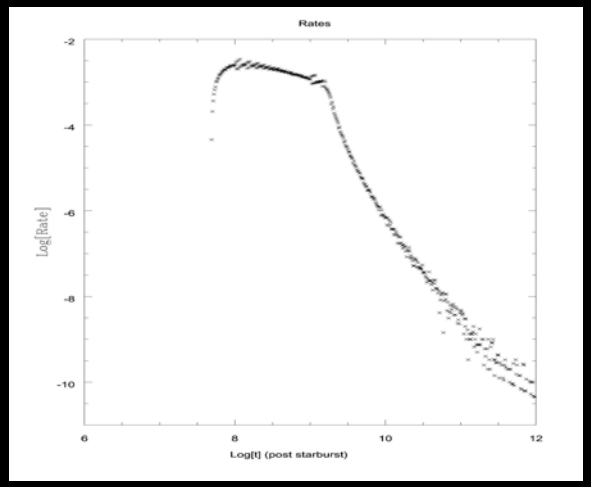
$M_{total} > 1.4$

$M_{WD}+0.5(m_2 - m_c) > 1.4$

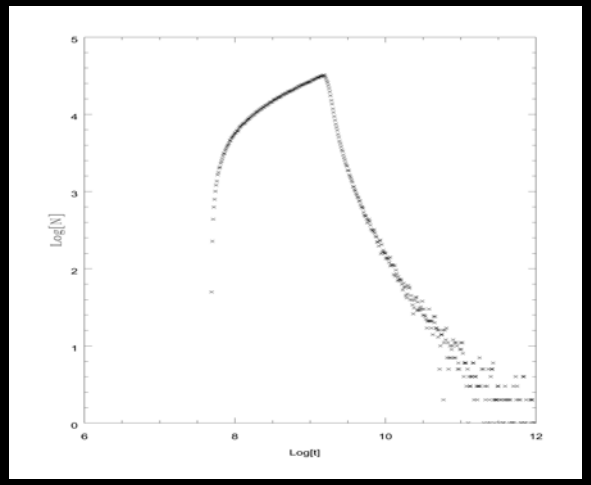
$M_{WD} + m_c > 1.4$

t is the time at which interaction starts: the approximate explosion time for all but DDs

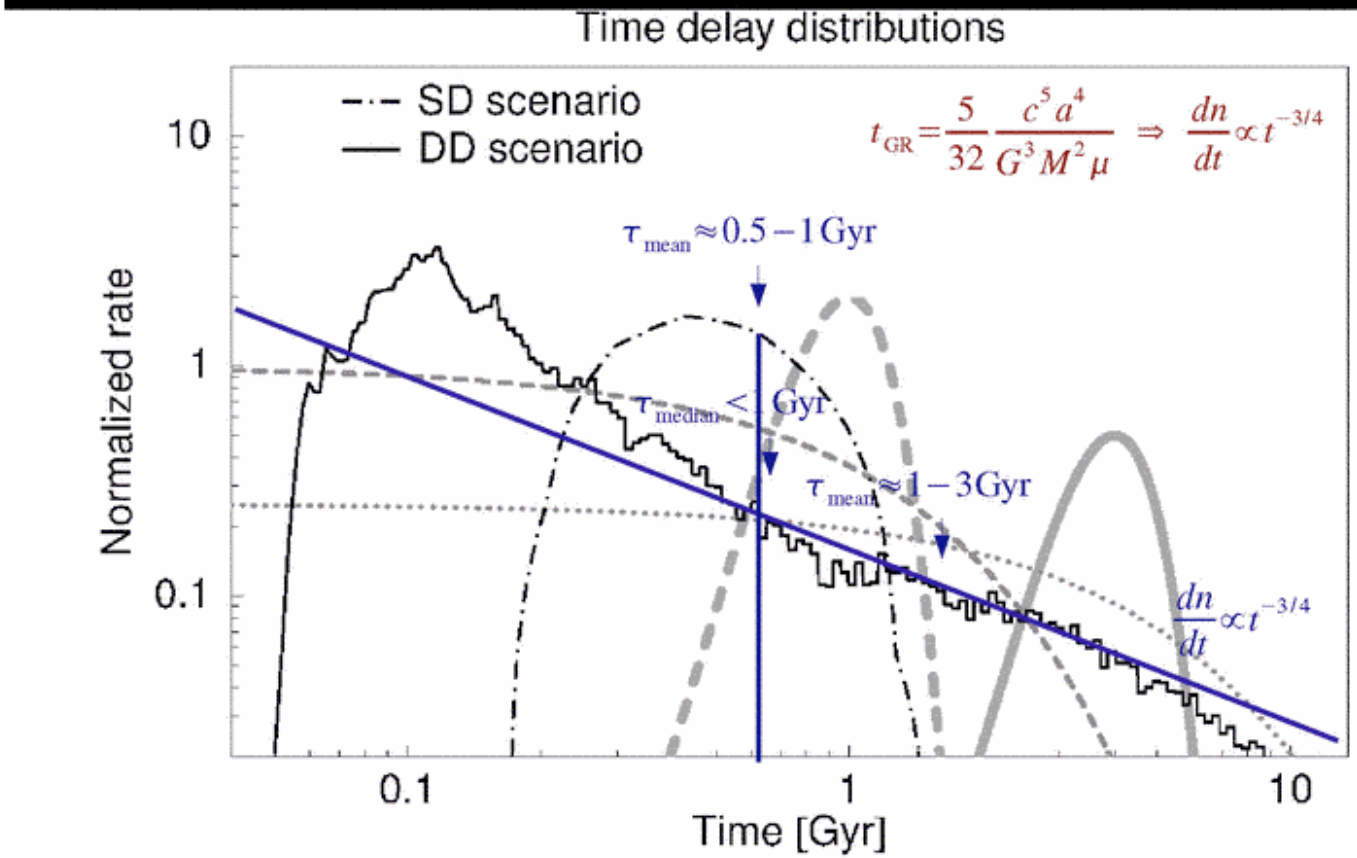
Rate



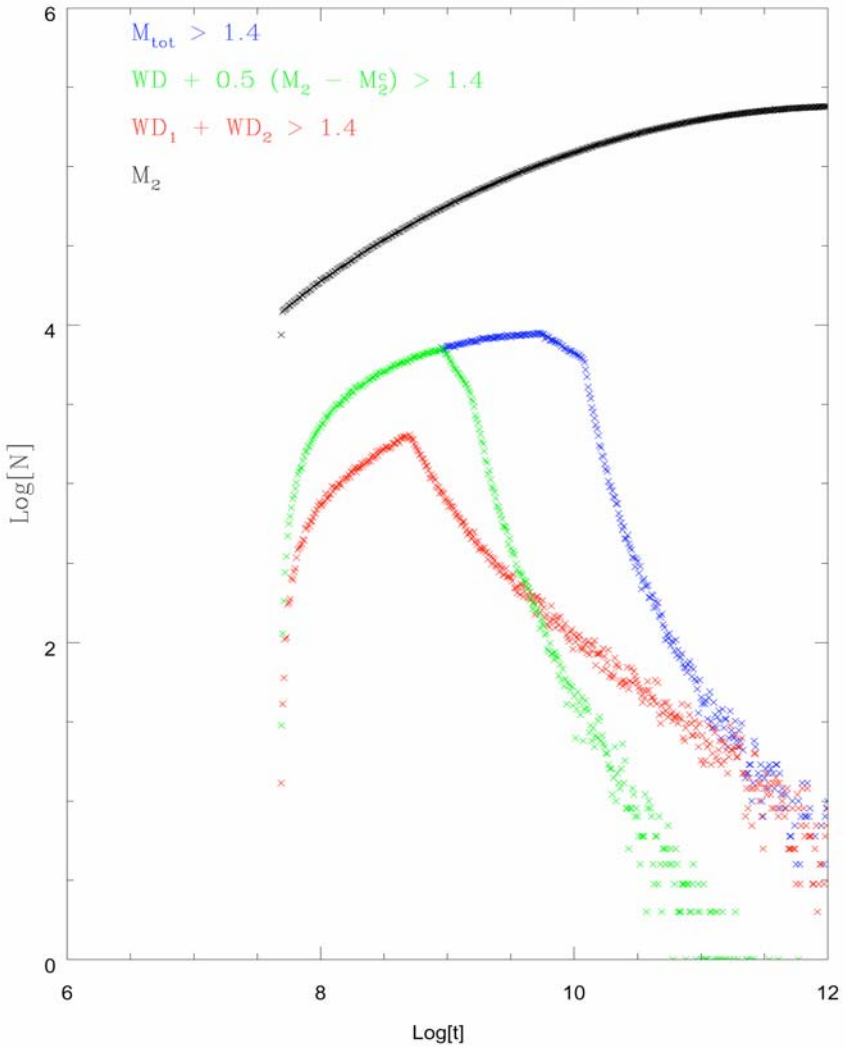
Distribution of delay times



Time delay distributions



Core Collapse SNe	1.0
Total mass > 1.4	2.8
$M_{WD} + M_c > 1.4$	0.3
$M_{WD}+0.5(m_2 - m_c) > 1.4$	1.3



Both single and double degenerate models can have prompt components.

Both can have components erupting at several Gyr.

Which subset are true Type Ia progenitors?

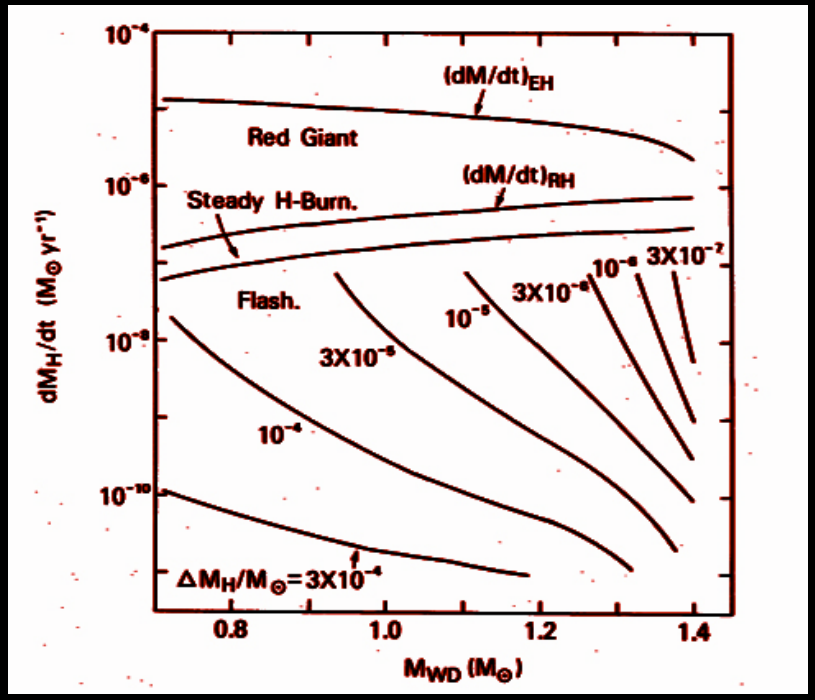
- Use the secondary's core mass at the time it starts to interact with the WD as a guide.

- We generate a distribution of core masses that is logarithmically uniform-- this corresponds to a logarithmically uniform distribution of orbital separations at the time the interaction starts.

Main sequence donor	$m_c < 0.1$
Slightly evolved donor	$0.1 < m_c < 0.2$
Giant donor	$m_c > 0.2$
Double degenerate	Giant donor “doesn’t make it”
Winds only	Neither star fills its Roche lobe

Main sequence donor	1 < q < 4; beta=0.5 Masses equalize
Slightly evolved donor	1 < q < 3; beta=0.5 Masses equalize
Giant donor	q< q_max 0.5 < beta < 0.8
Double degenerate	q > q_max
Winds only	beta

Improvements: q_max and beta should be chosen self-consistently

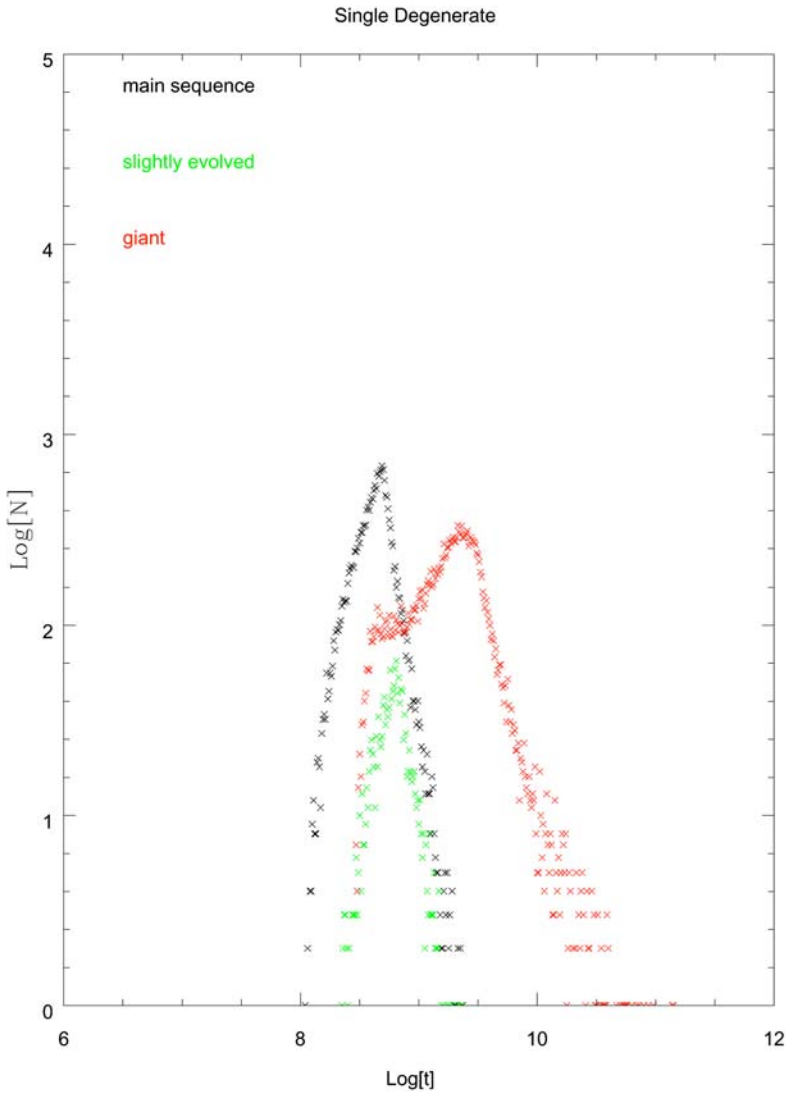


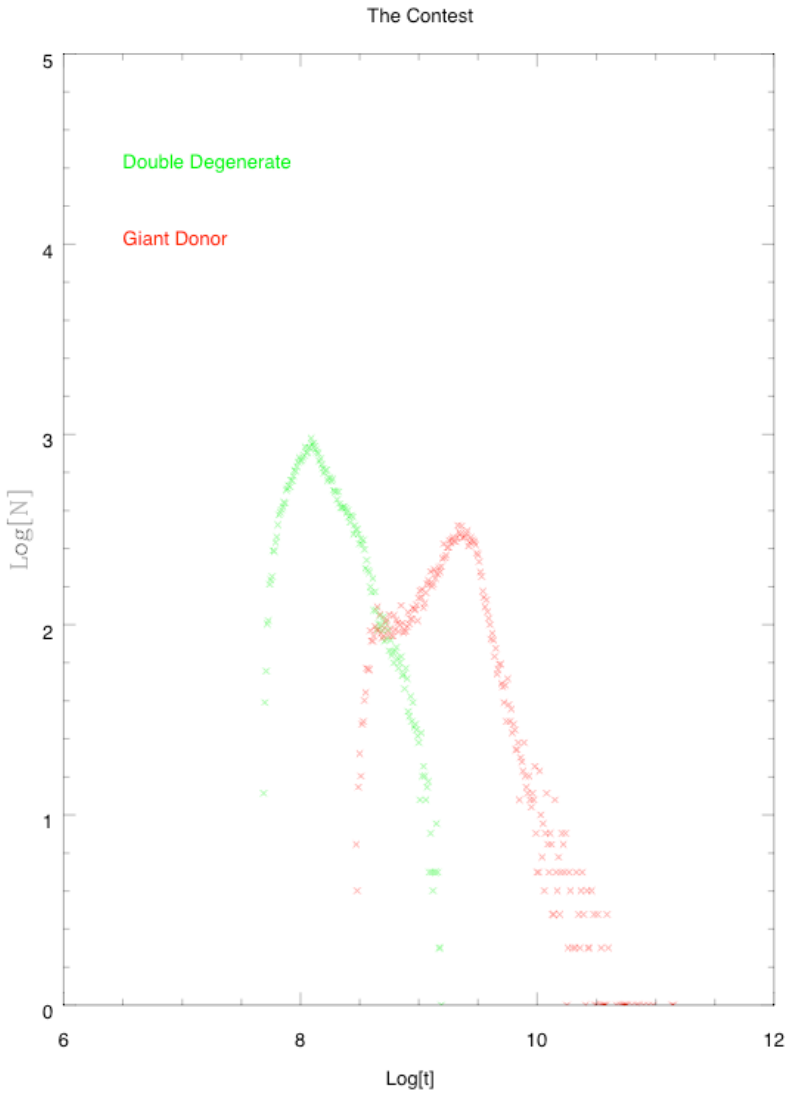
- q and beta determine mdot.
- mdot determine how WD processes material.
- Nuclear processing can drive winds, affecting beta.

beta is determined by a complex "pas de deux" between the donor and WD.

- Range of event times are not much affected by these considerations. (Relative rates are.)

- Evolution times to CE are shown.
  GR times will be longer by a factor ranging from unity to 10^8.


Single Degenerate
main sequence
slightly evolved
giant
Log[N]
Log[t]
0
1
2
3
4
5
6
8
10
12


The Contest
Double Degenerate
Giant Donor
Log[N]
Log[t]
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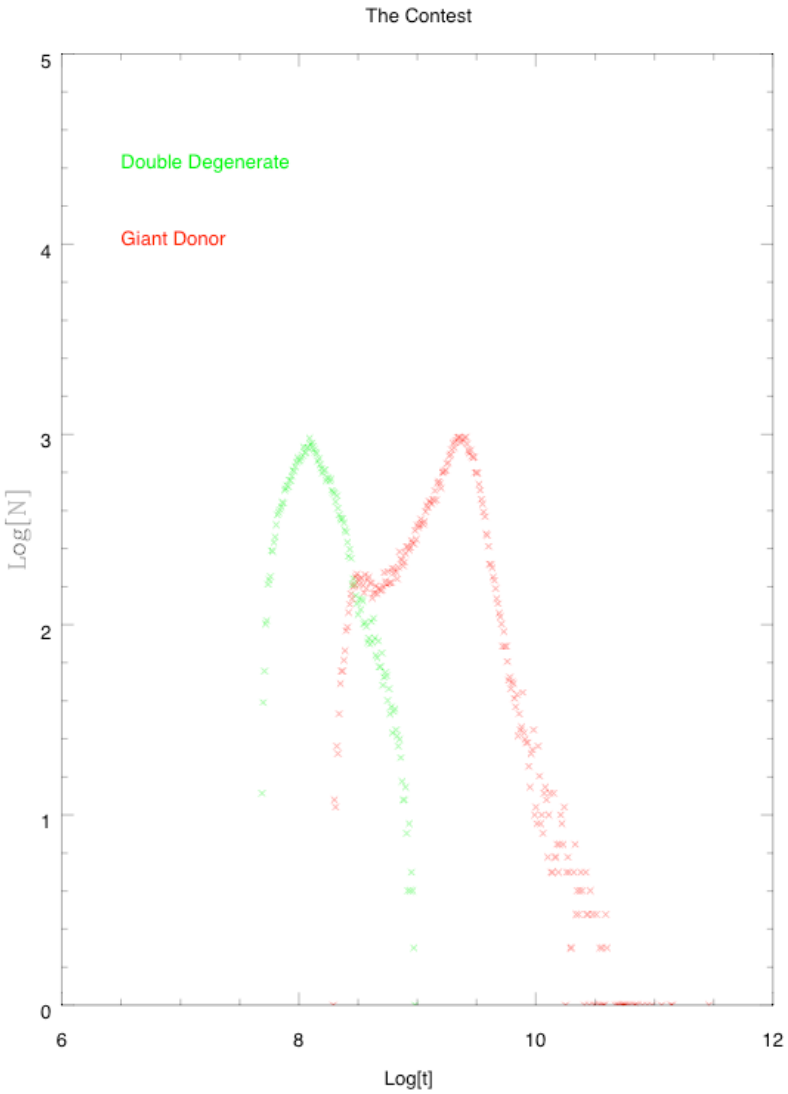
10
12


The Contest
Double Degenerate
Giant Donor
Log[N]
Log[t]
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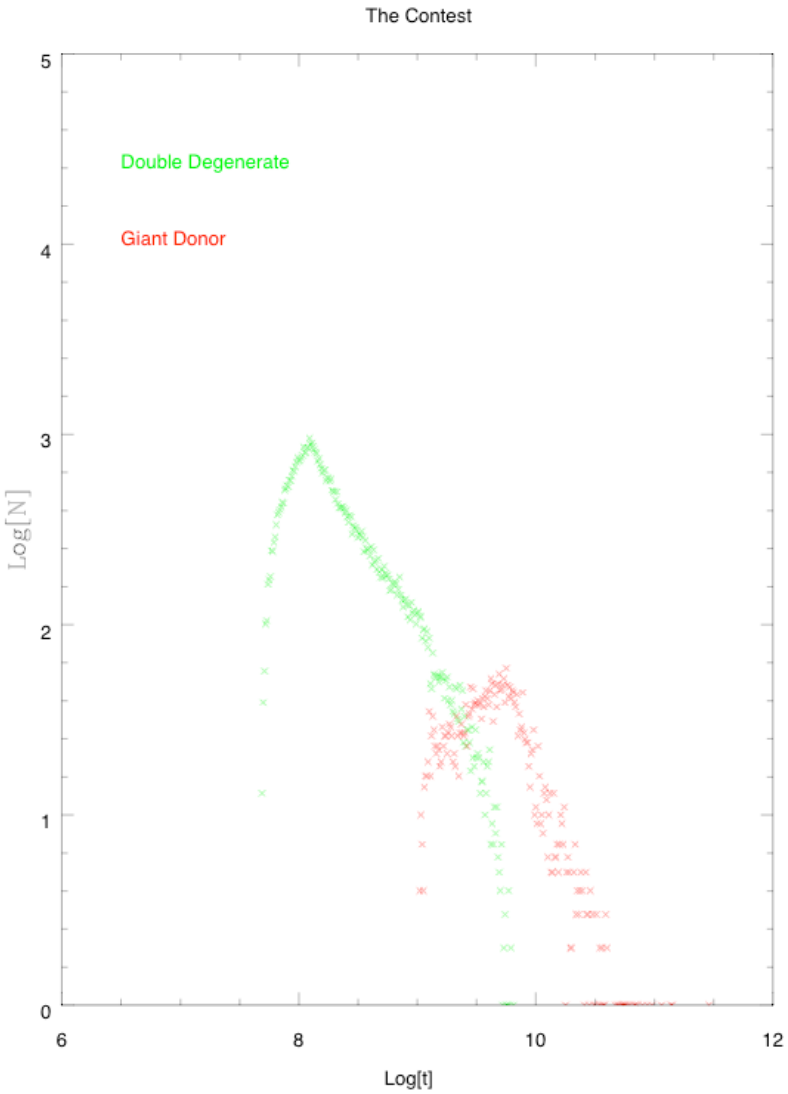
10
12


The Contest
Double Degenerate
Giant Donor
Log[N]
Log[t]
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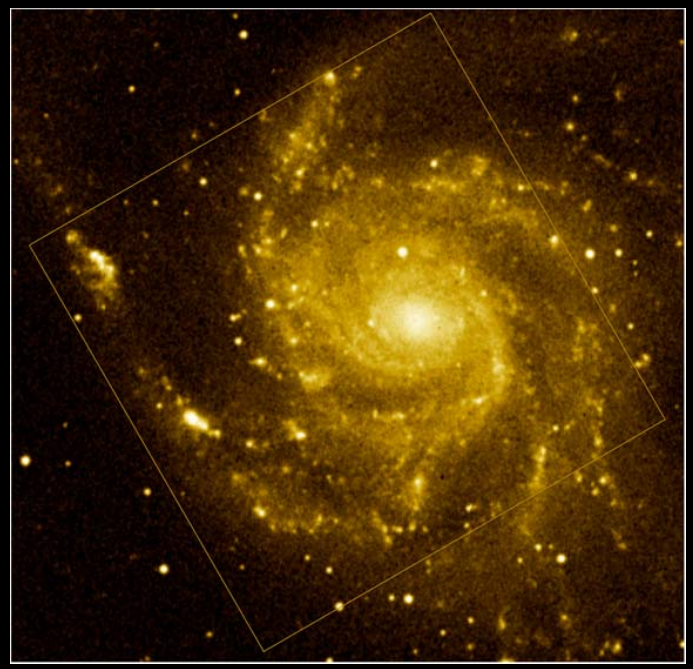
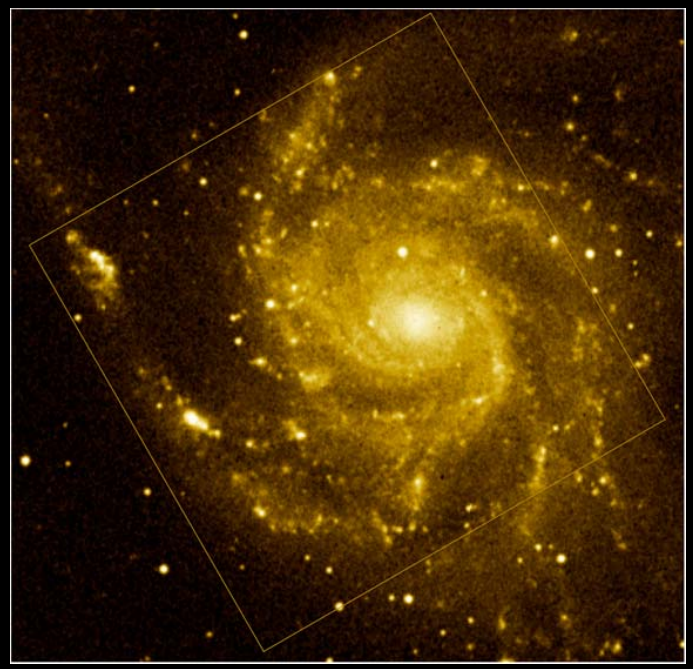
8
10
12

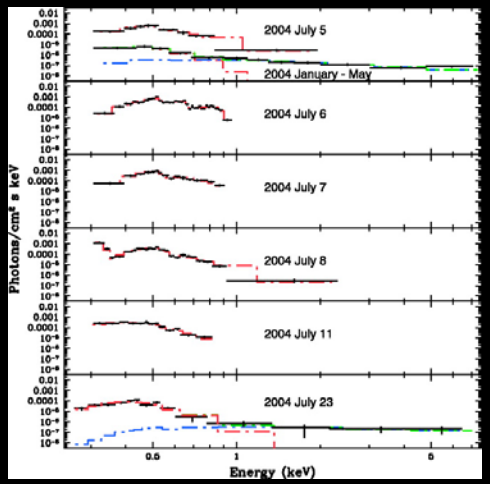
X-ray astronomy provides a useful analogy in high-mass and low-mass X-ray binaries--different descendants of a binary population.

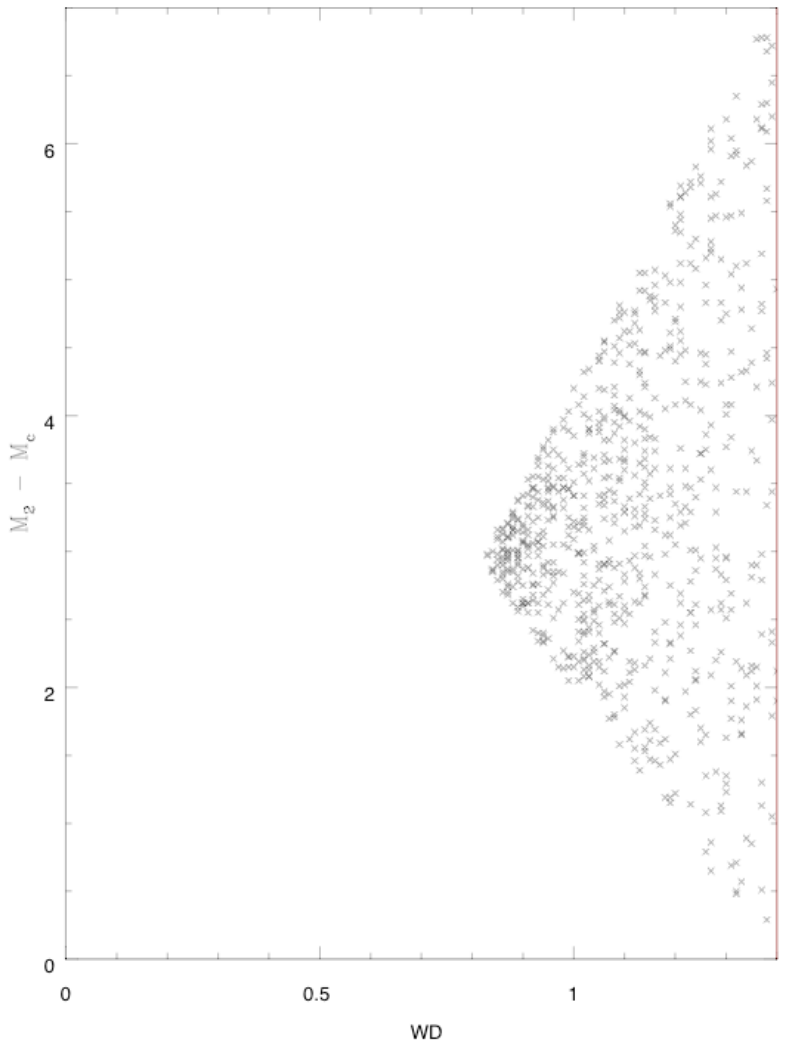


X-ray astronomy also suggests that some SSS progenitors may be *young* accreting WDs.

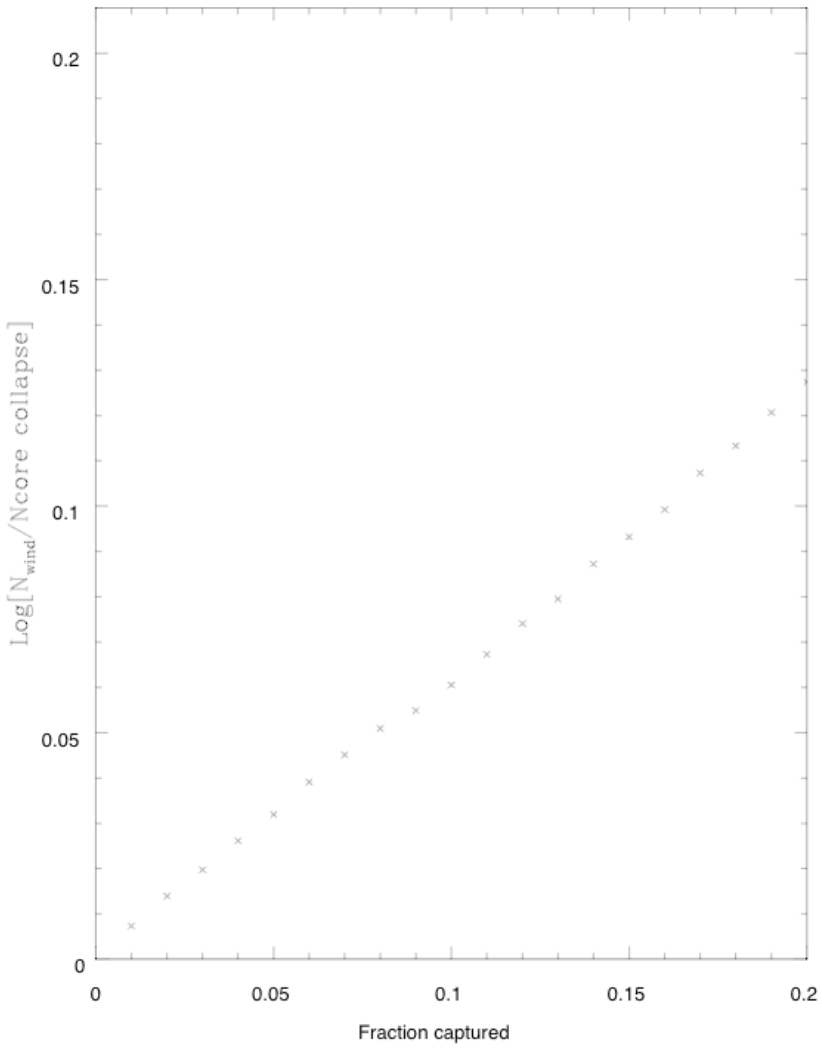


A variety of models may apply.

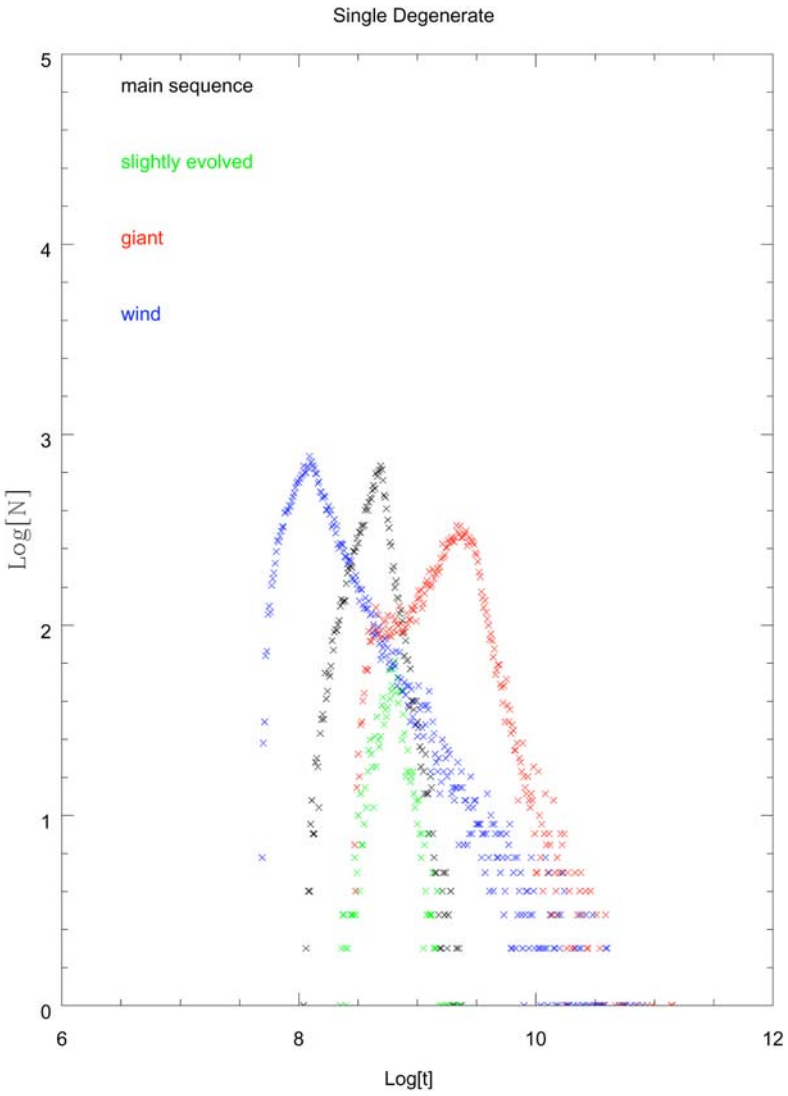




Winds From massive stars onto massive WDs



Rate of wind-generated Ia's can be a few percent of the core-collapse rate.


Single Degenerate
main sequence
slightly evolved
giant
wind
Log[N]
Log[t]
0
1
2
3
4
5
6
8
10
12

20 %
capture

Summary

- Single and double degenerate models can both produce prompt and "delayed" Type Ia supernovae.
- DDs and giant-donor models have a see-saw relationship. These competing sectors produce long term behavior, which may provide the basis to determine which is correct
- Wind models may produce a small but significant fraction of Type Ia supernovae.
- Prompt behavior is a competition between main-sequence donors, DDs, and wind models.

These distributions,

model-dependent and -independent,

can be used as input to the data analysis.