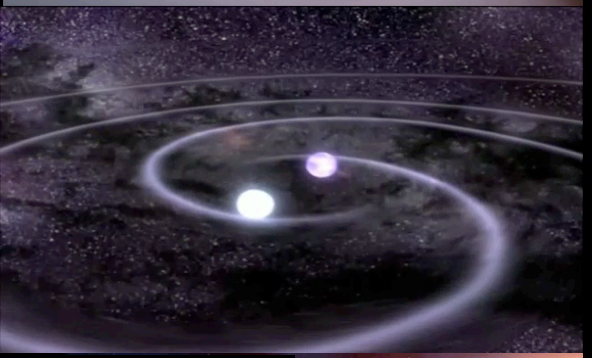
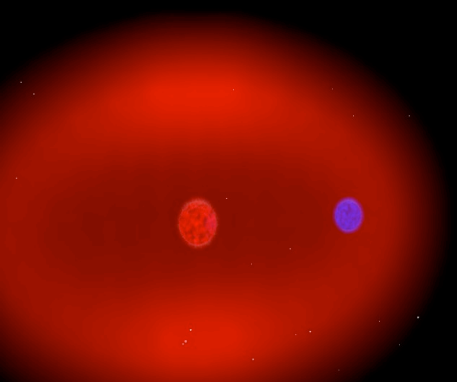




The Delay Time Distribution of Type Ia Supernovae

Chris Pritchet
U. Victoria

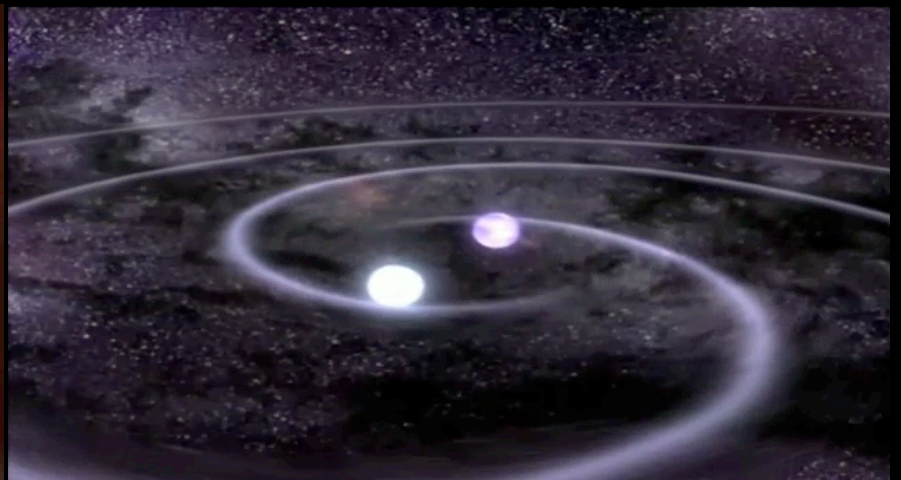
with Epson Heringer
U. Toronto

2017 ApJ 834, 15

	SNe Ia
brightness	$10^{10}\ L_{sun}$
progenitor	Binary -- 1 or 2 white dwarfs
mechanism	Mass transfer/merger
Progenitor age	10^{8}-10^{10} yr
remnant	no
Metals ejected	Fe, Ni, …

1% of all WD's

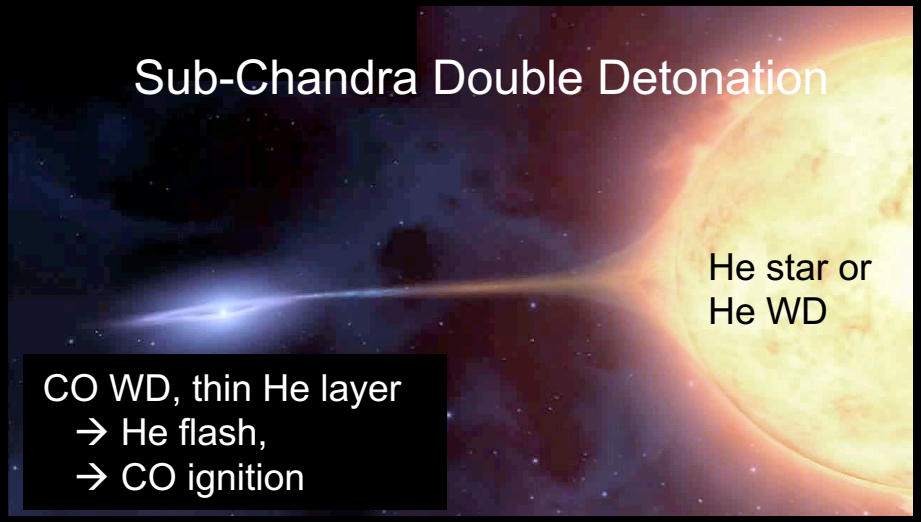
Young and old



Single Degenerate

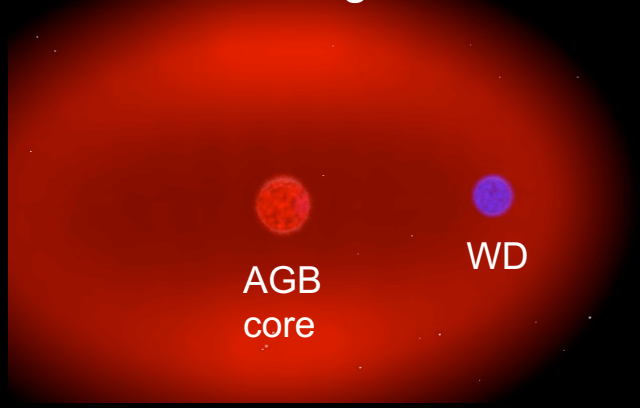
Double Degenerate

Sub-Chandra Double Detonation



Shen 2016 …

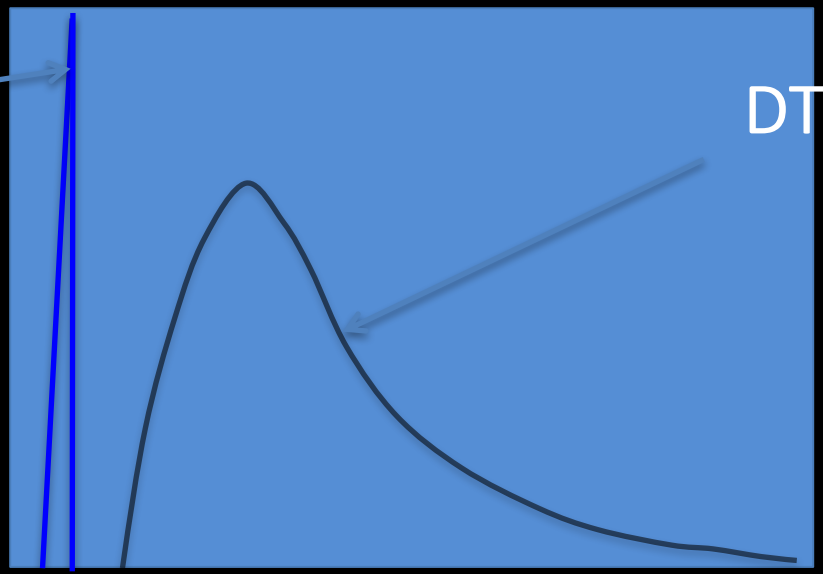
Core Degenerate



Livio and Riess 2003
Kashi and Soker 2011 …

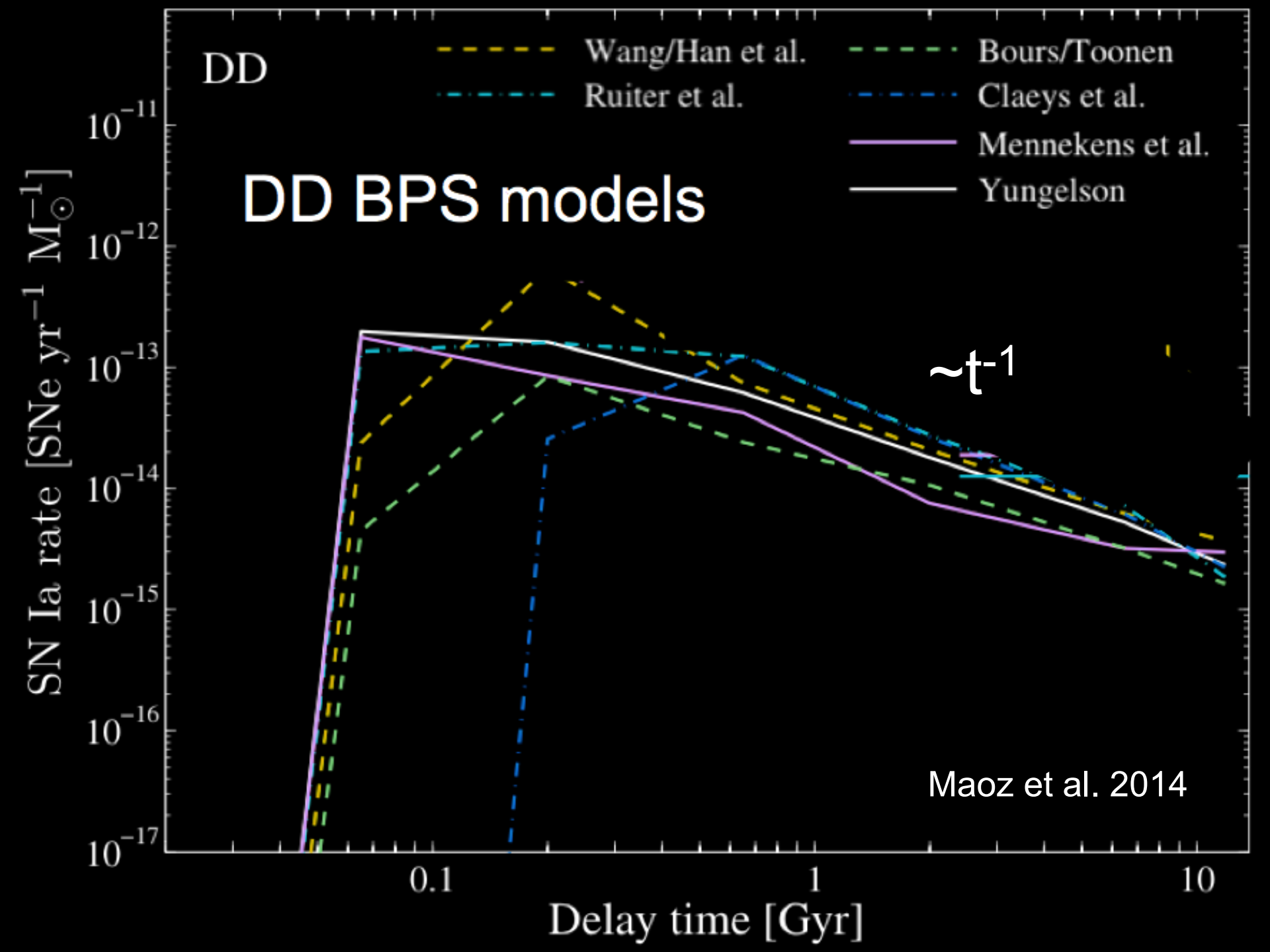
Delay time distribution

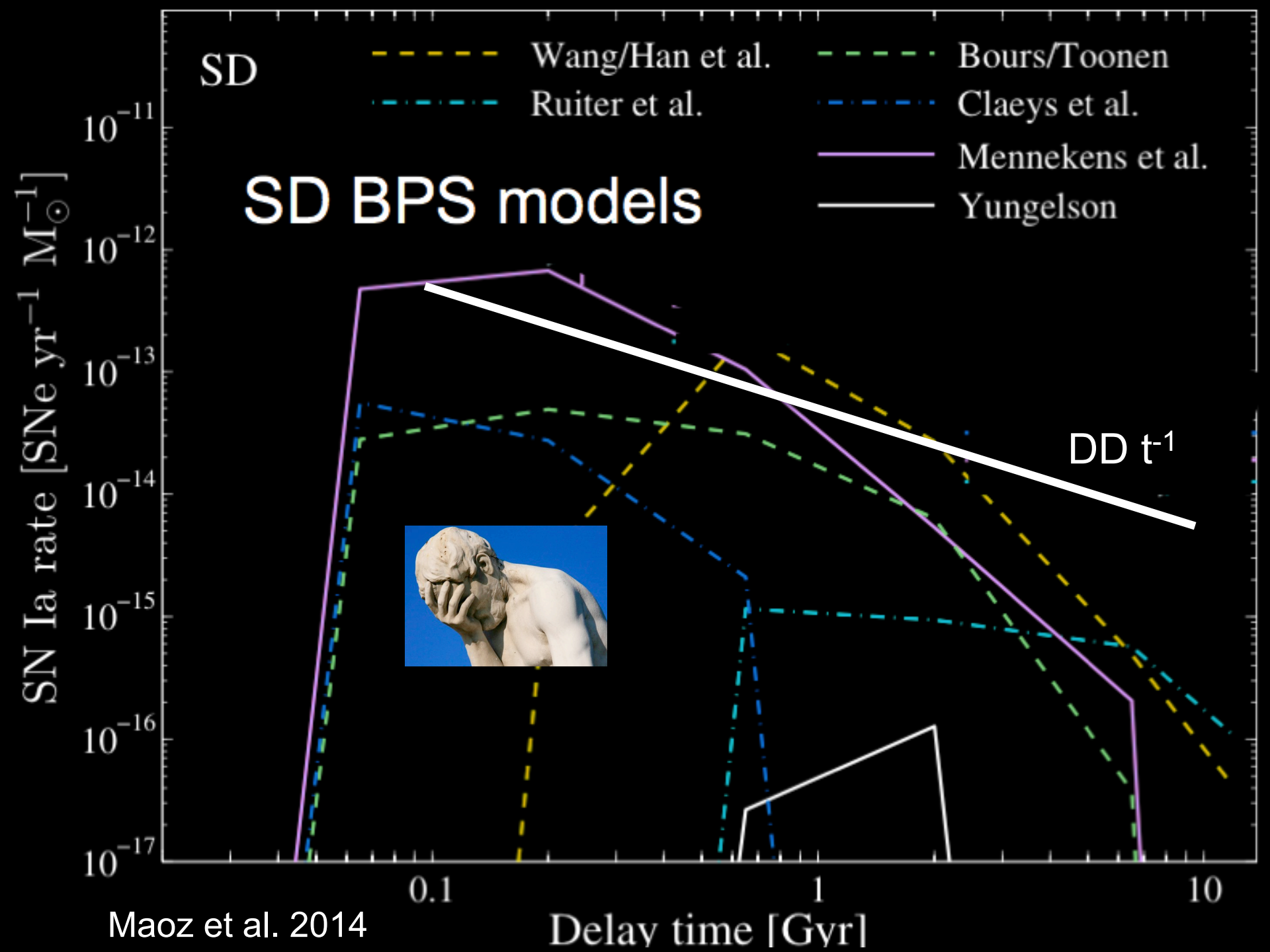
- DTD(t) = ***rate*** of supernovae as a function of time from a burst of star formation
- Sensitive to progenitor model



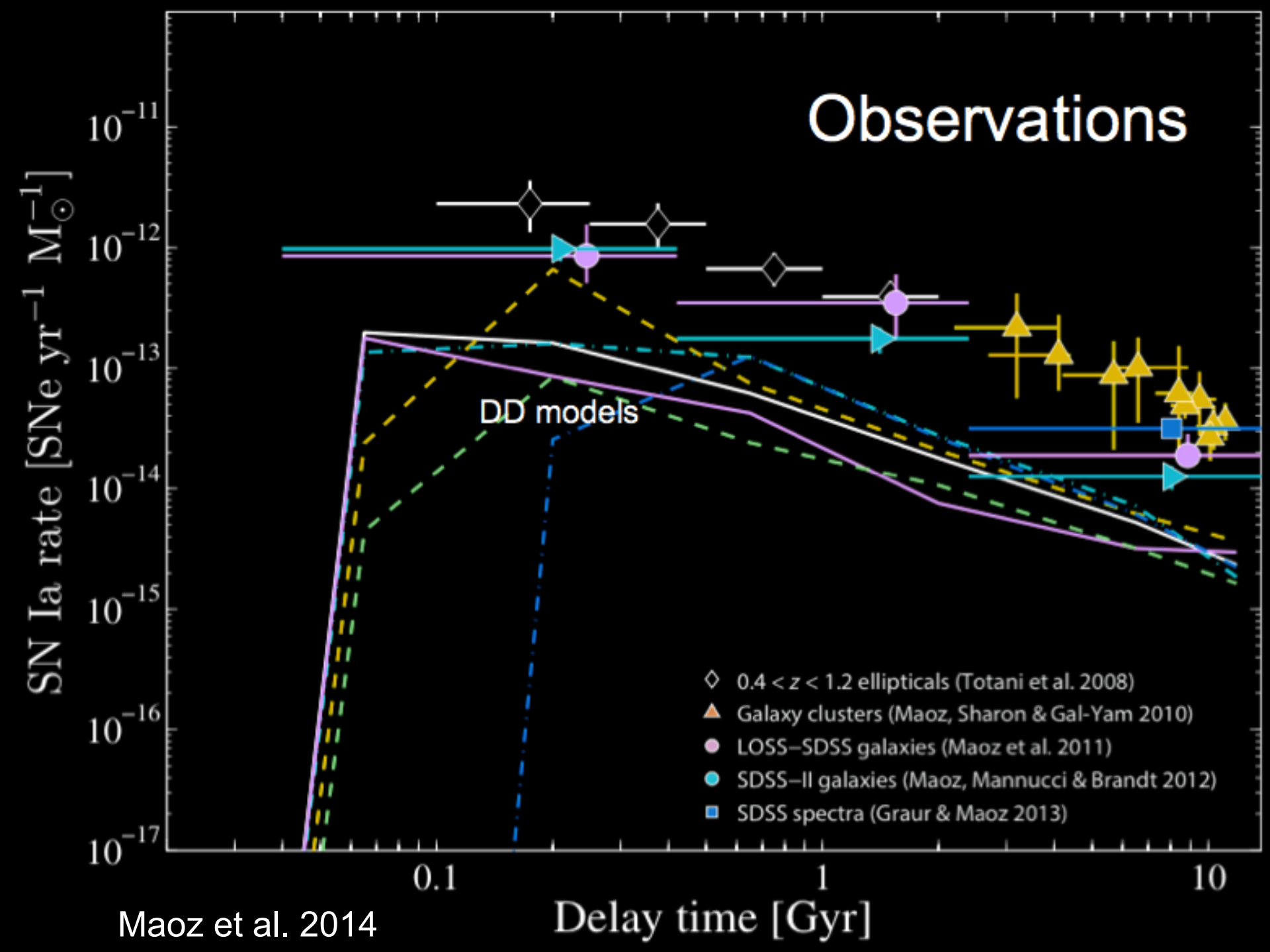
DTD(t) [SNe/yr/$M_\odot$]

SNR(t) = SFR(t)∗DTD(t)


DD
Wang/Han et al.
Ruiter et al.
Bours/Toonen
Claeys et al.
Mennekens et al.
Yungelson
DD BPS models
~t-1
Maoz et al. 2014
SN Ia rate [SNe yr−1 M⊙−1]
Delay time [Gyr]
10−11
10−12
10−13
10−14
10−15
10−16
10−17
0.1
1
10



Maoz et al. 2014



Maoz et al. 2014

This work

Determine shape of DTD of SNe Ia using host galaxy colours and luminosities.

- A new method that is insensitive to SFH

Method

Stellar population synthesis code – FSPS -- Conroy et al.

1. Choose DTD(t), SFH(t)
2. Derive SNR/L as a fcn of *t*
3. t → *g-r* host colour
4. Compare obs host colour distribution with models

DD DTD

uncertain

Gravity wave energy losses

t^{-1}

log SN *rate*

0.1 Gyr

4-5 $M_\odot$

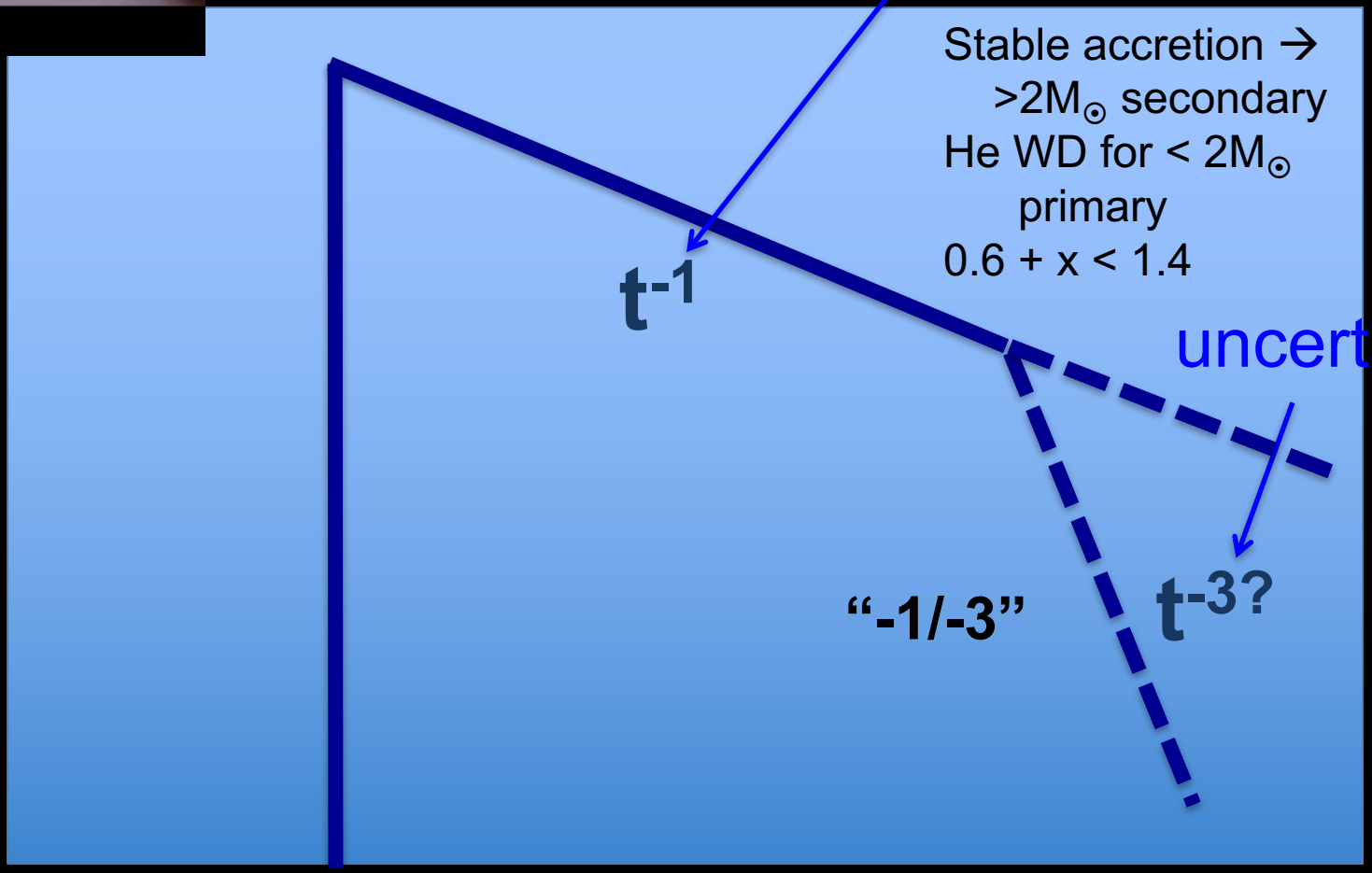
CO WD

log age

1 Gyr

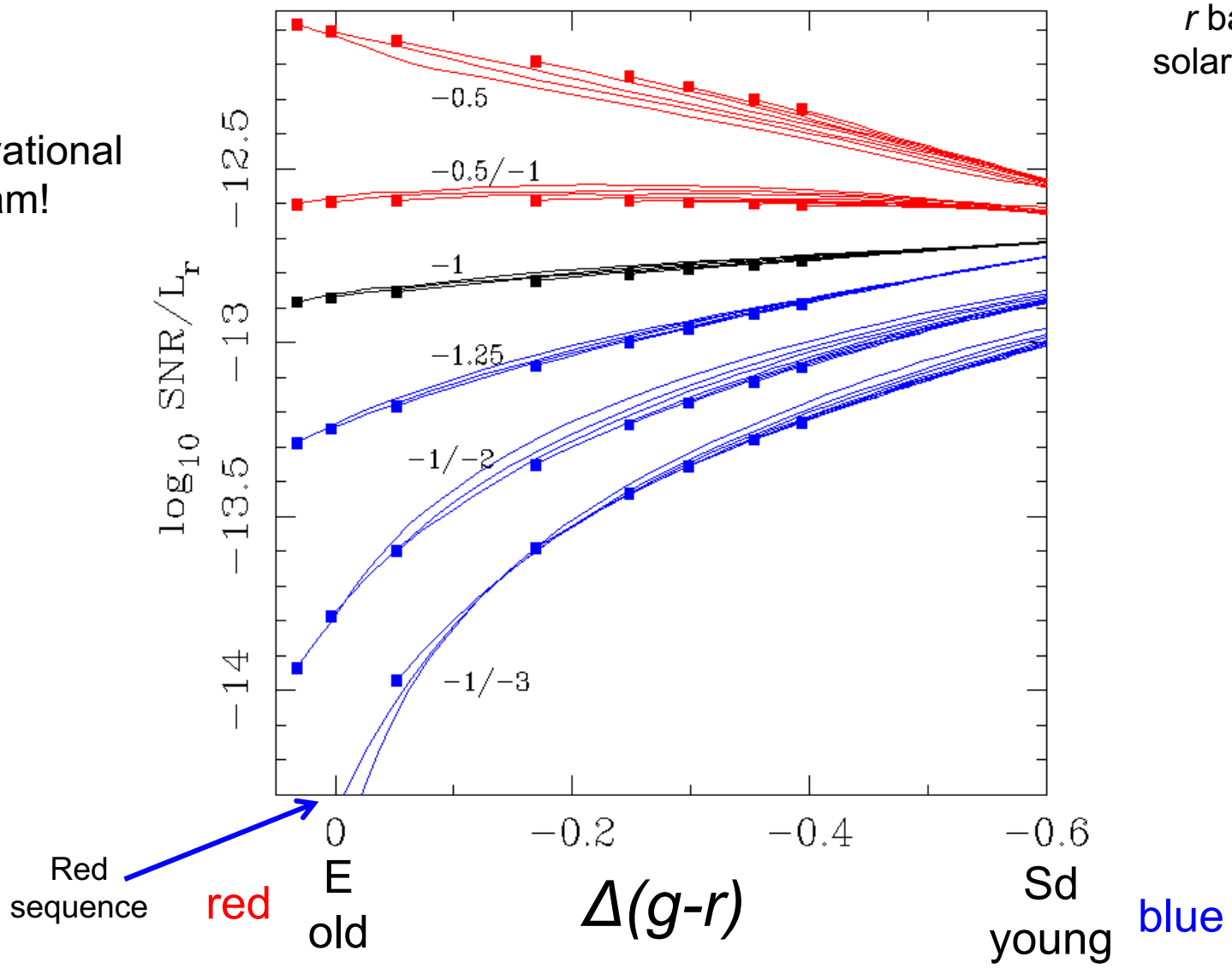
2 $M_\odot$

SD DTD

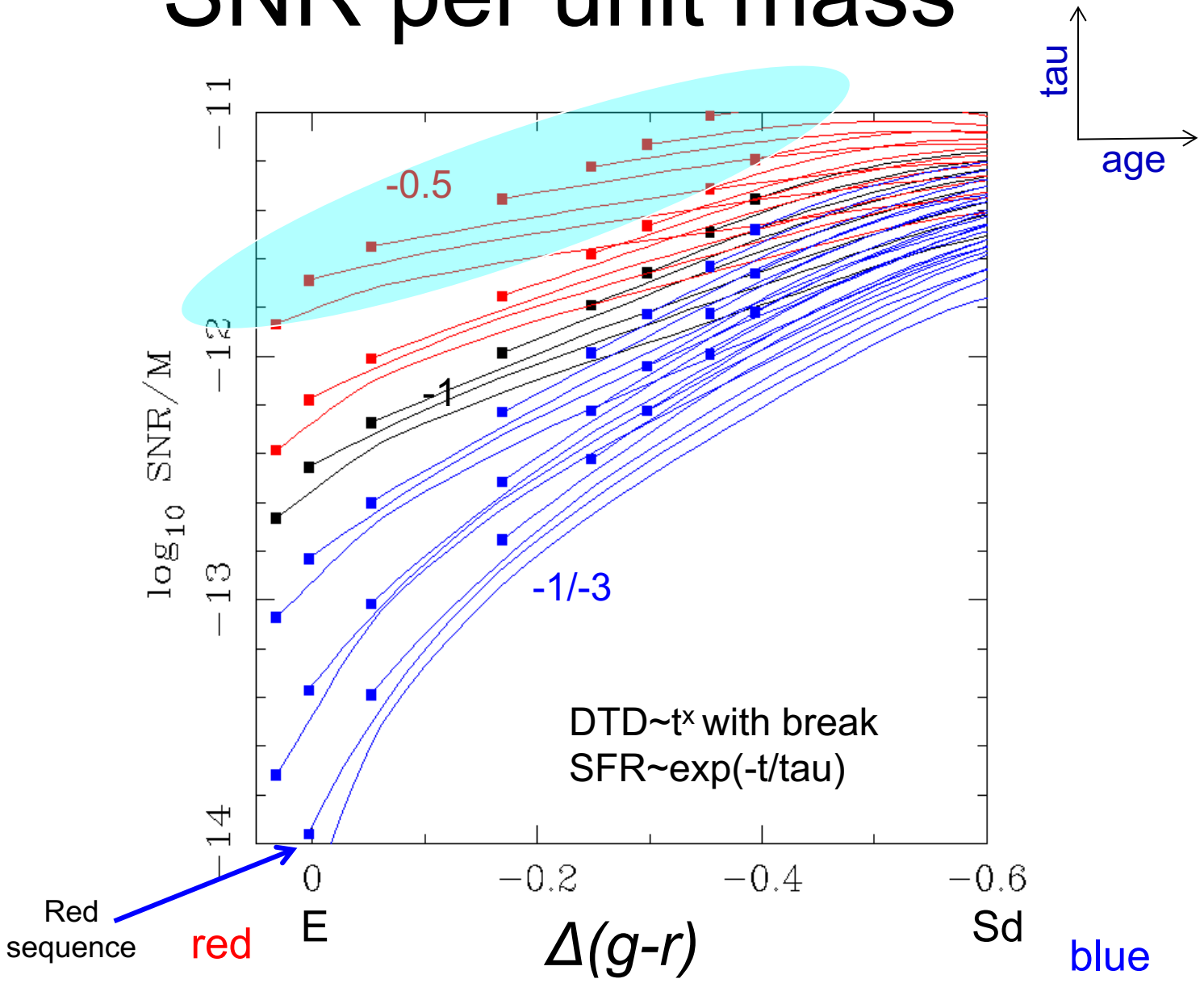

or $t^{-1/2}$?
Stable accretion →
>2M$_\odot$ secondary
He WD for < 2M$_\odot$
primary
0.6 + x < 1.4
t^{-1}
uncertain
"-1/-3"
t^{-3}?
log SN rate
0.1 Gyr
4-5 M$_\odot$
log age
1 Gyr
2 M$_\odot$

SNR per unit luminosity L_r

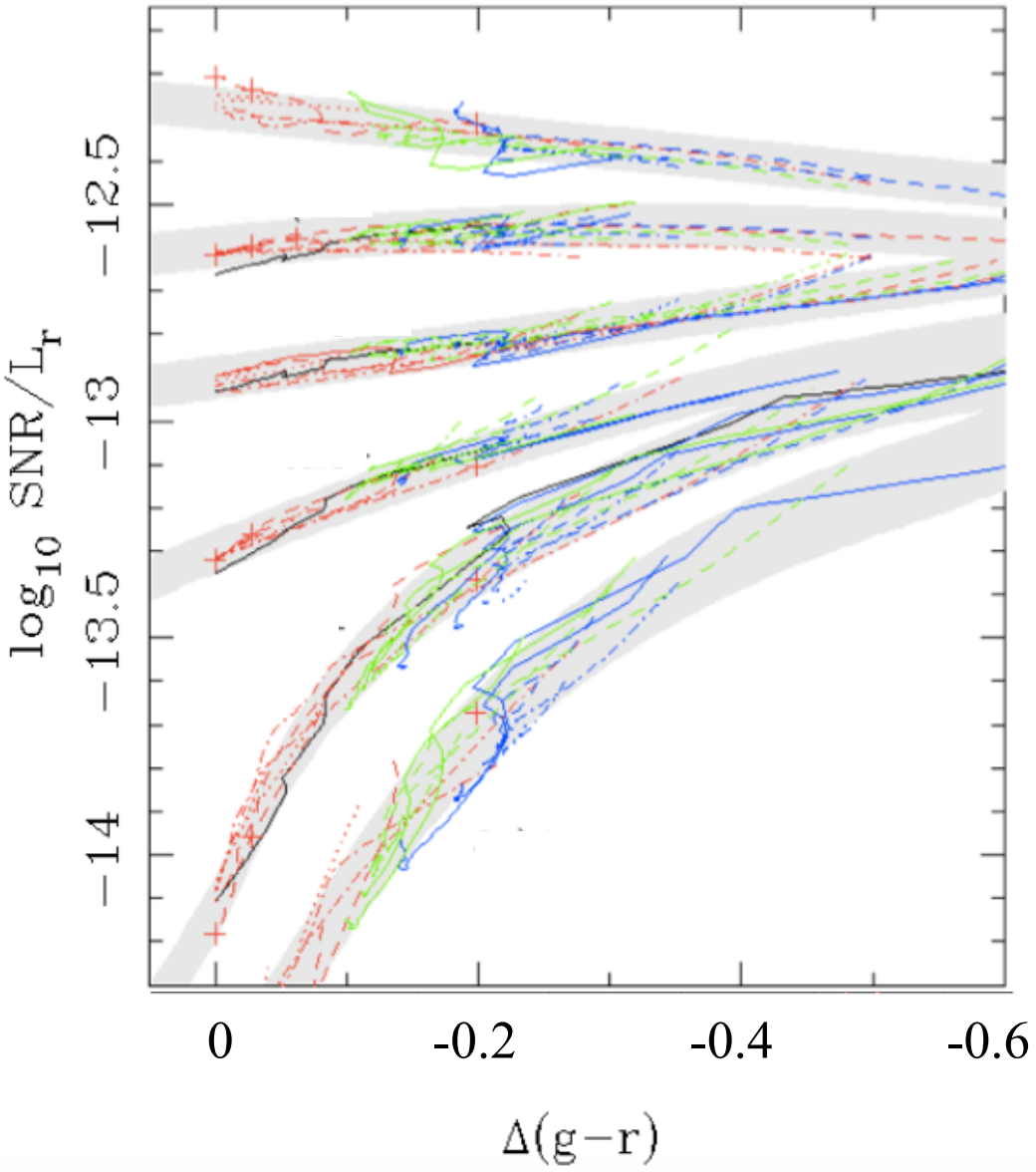
An observational diagram!



SNR per unit mass



SNR/L_r does not depend on SFH!

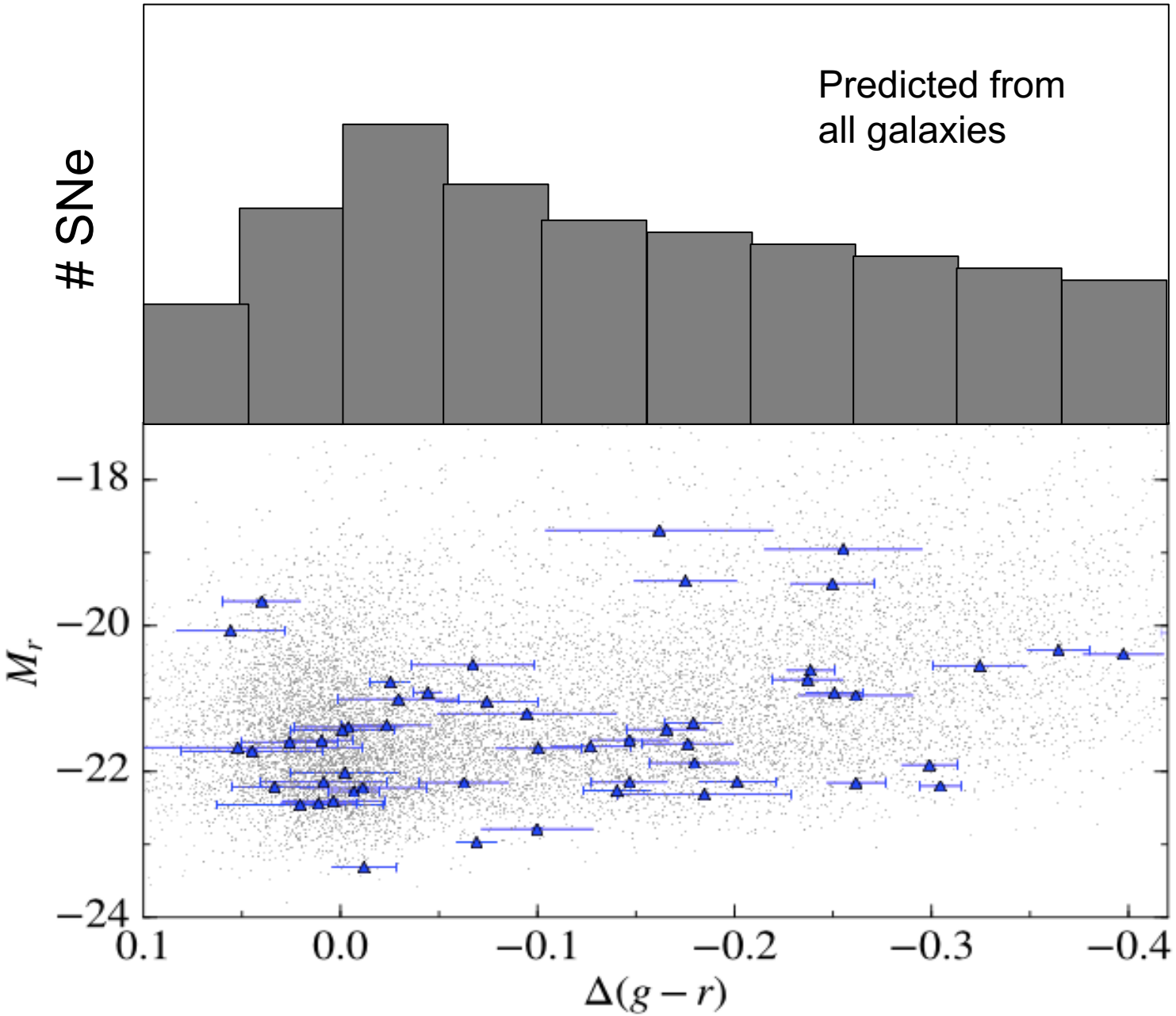


- Single burst
- 2 burst
- Exponential
- Power-law
- Infall
- Infall + burst
- Exp + burst

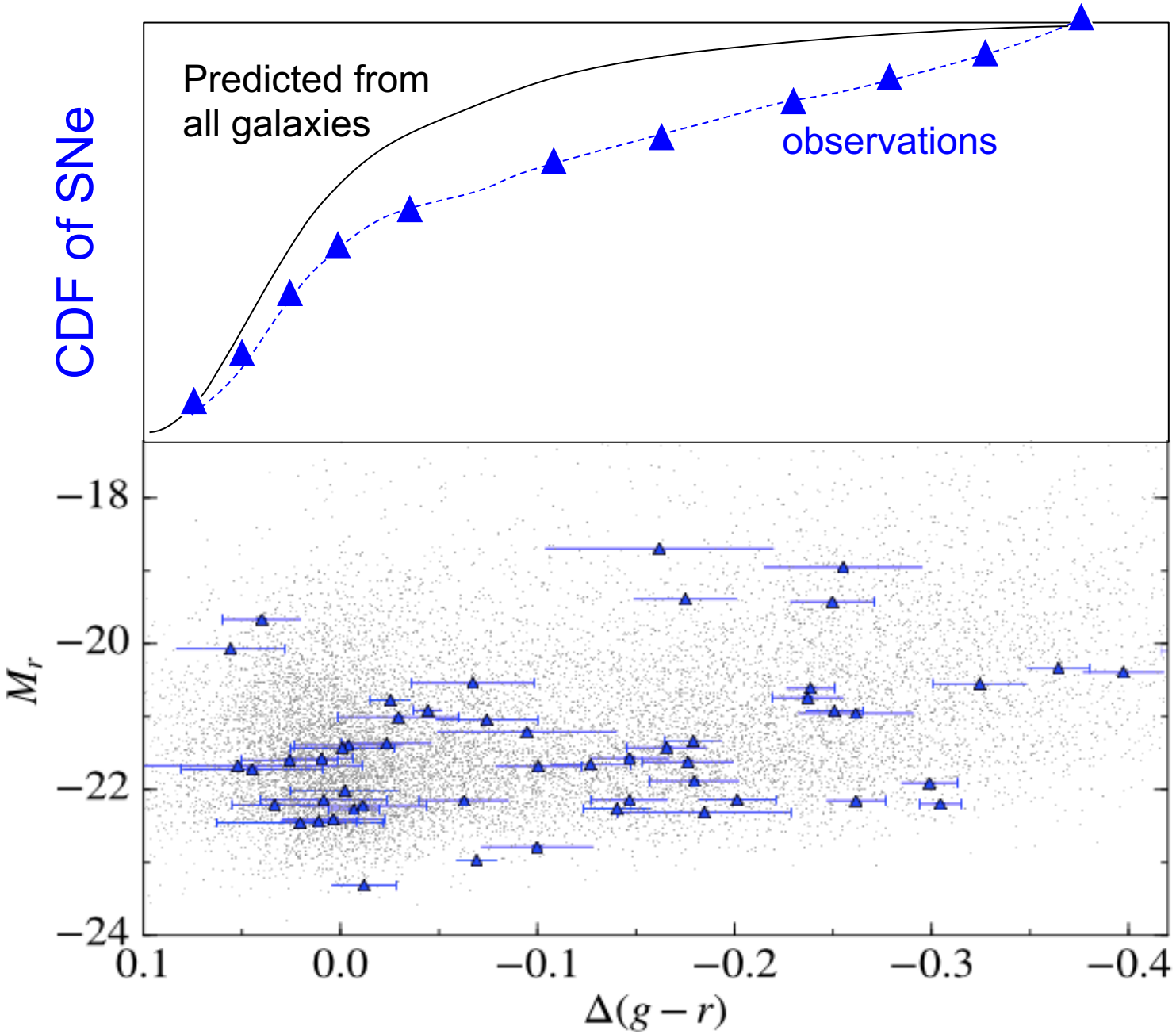
Observations

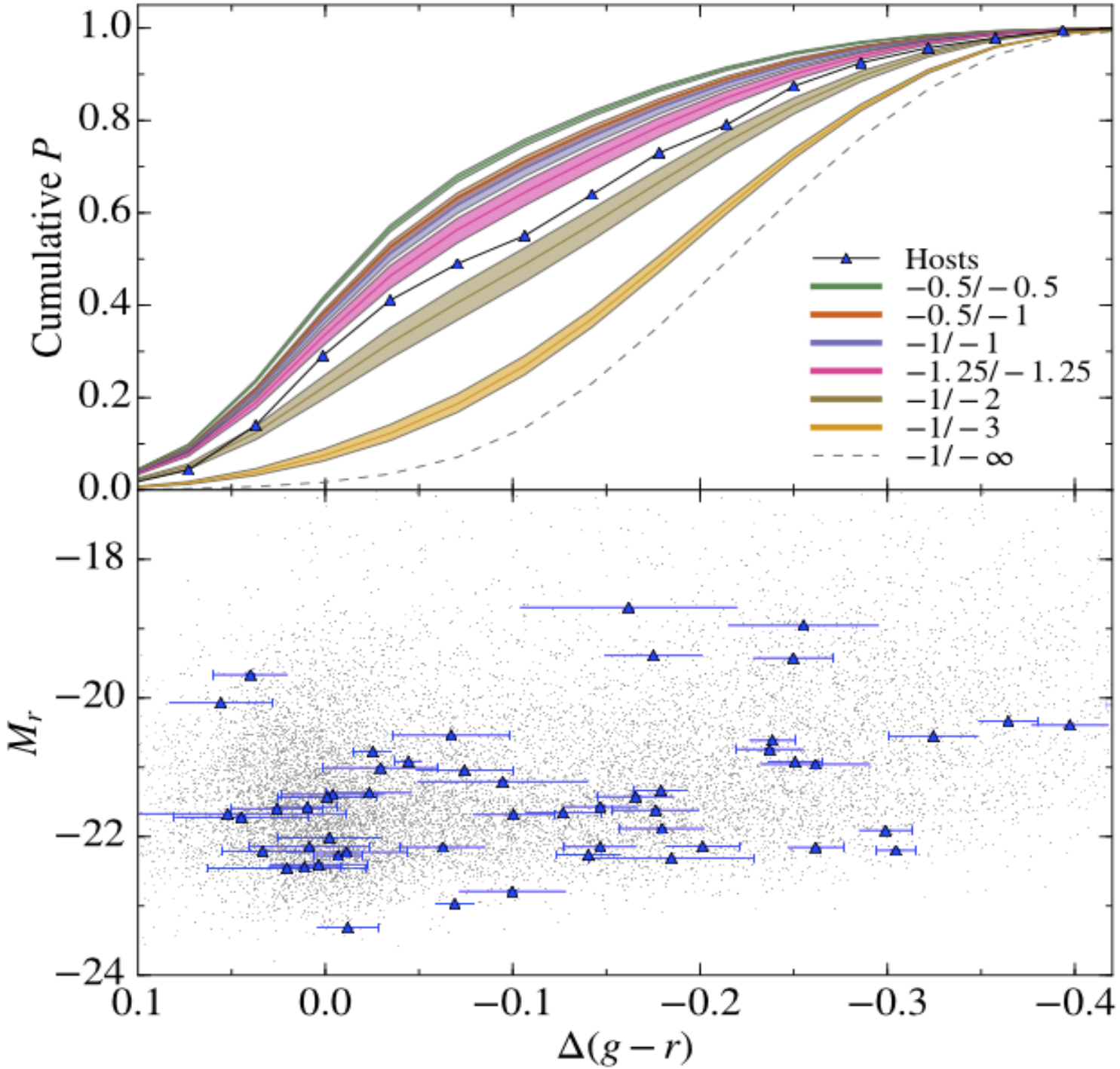
- MENeaCS cluster SN survey *g-r*
- SDSS SN survey *u-r*
- SDSS SN survey *g-r*

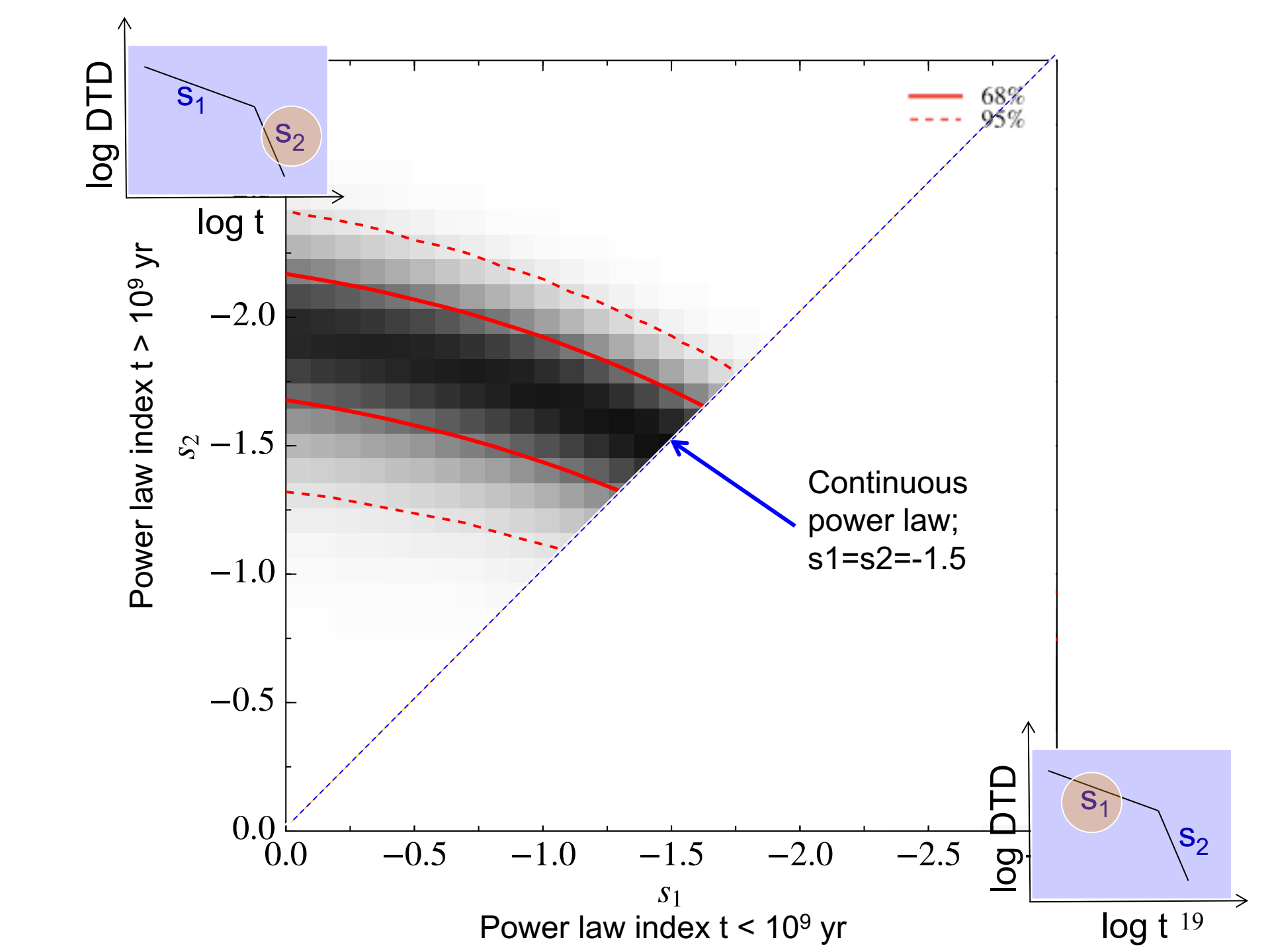
Assuming a DTD …

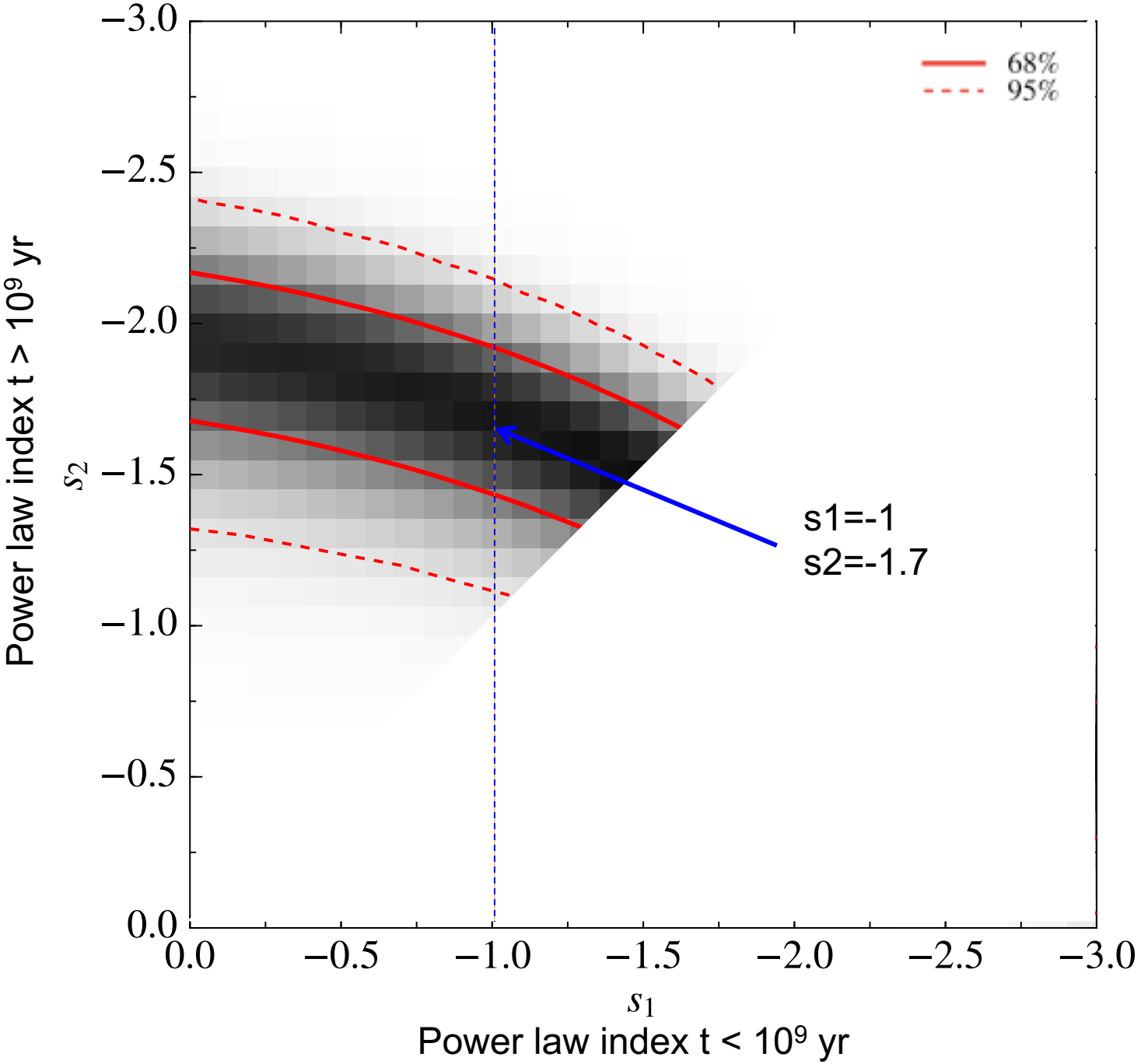


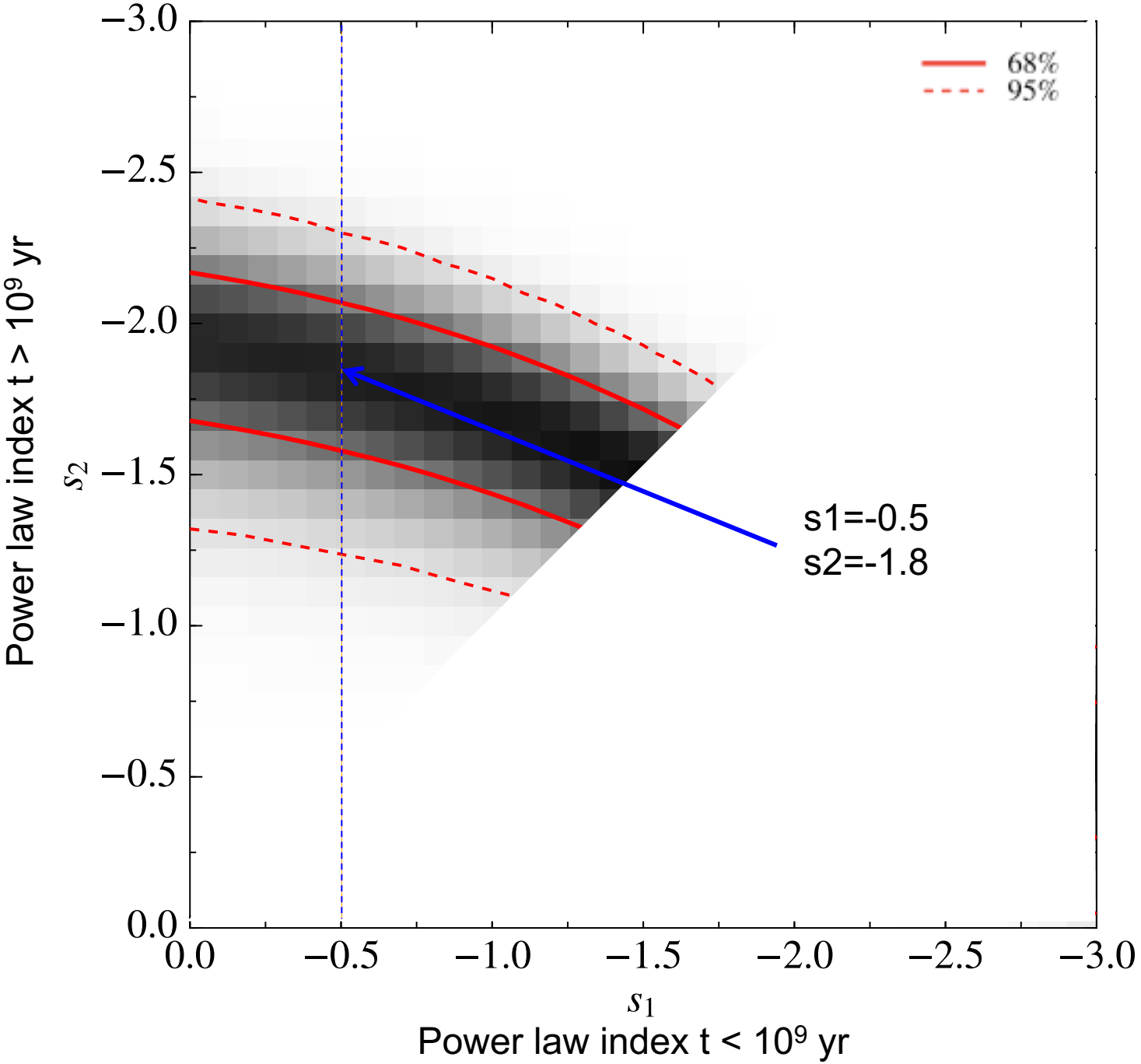
Assuming a DTD …




Cumulative P
1.0
0.8
0.6
0.4
0.2
0.0
Hosts
$-0.5/-0.5$
$-0.5/-1$
$-1/-1$
$-1.25/-1.25$
$-1/-2$
$-1/-3$
$-1/-\infty$
M_r
−18
−20
−22
−24
0.1
0.0
−0.1
−0.2
−0.3
−0.4
$\Delta(g-r)$

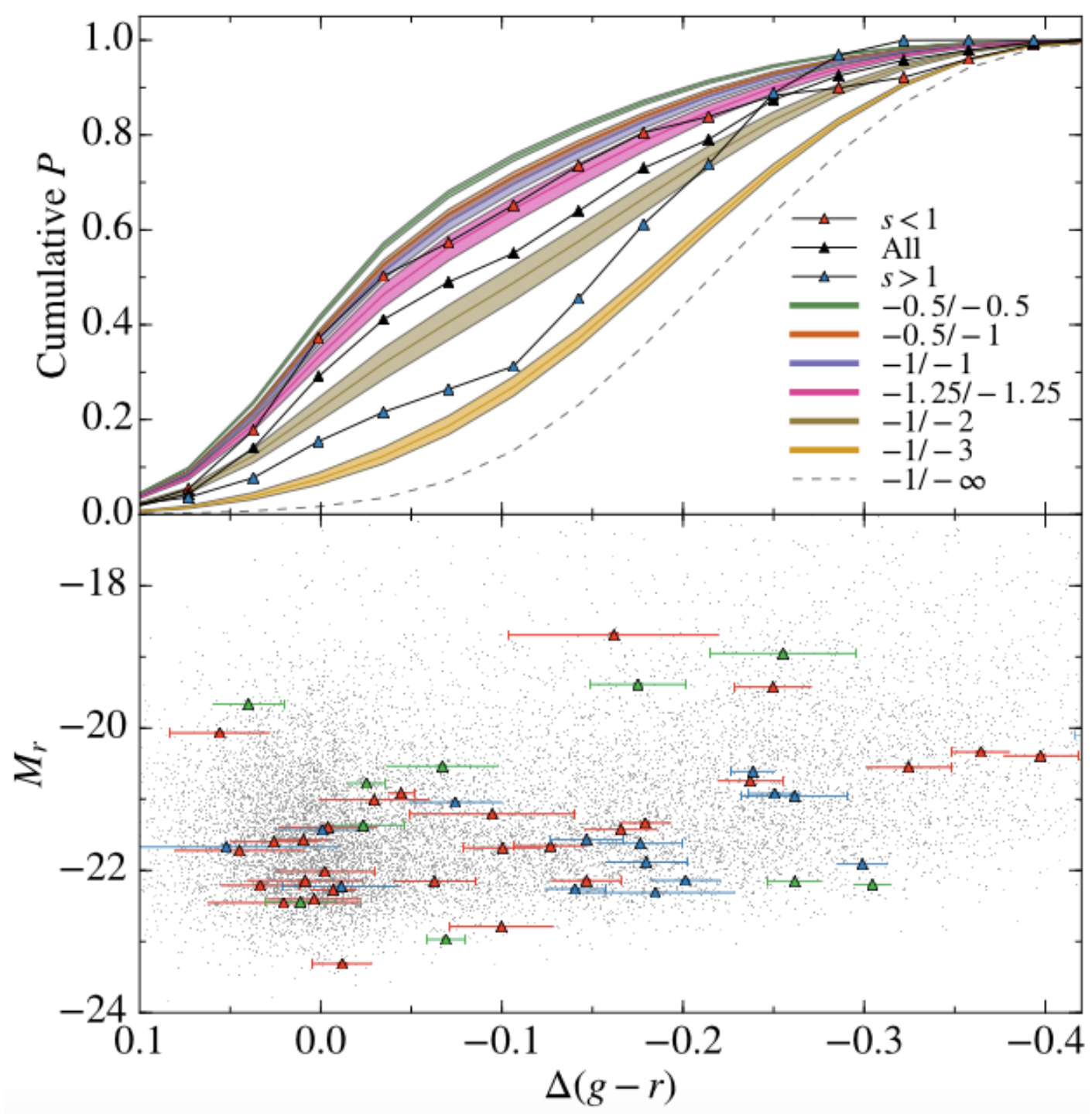

log DTD
s1
s2
log t
68%
95%
Power law index t > 10^9 yr
s2
−2.0
−1.5
−1.0
−0.5
0.0
Continuous
power law;
s1=s2=-1.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
s1
Power law index t < 10^9 yr
log DTD
s1
s2
log t


68%
95%
s1=-1
s2=-1.7
−3.0
−2.5
−2.0
−1.5
−1.0
−0.5
0.0
s_2
Power law index t > 10^9 yr
s_1
Power law index t < 10^9 yr


68%
95%
s1=-0.5
s2=-1.8
Power law index t > 10^9 yr
s_2
s_1
Power law index t < 10^9 yr
−3.0
−2.5
−2.0
−1.5
−1.0
−0.5
0.0

Effects of "stretch"

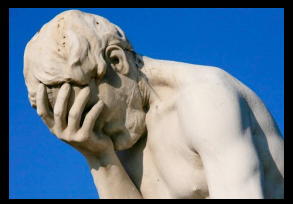
[Light curve width]



- 2 progenitor scenarios?
- There are other inter-pretations!

Summary of Results

- Host galaxy colour+DTD determine SNR/L with little sensitivity to SFH
- Host colour results suggest DTD ~ $t^{-1.5}$ and rules out t^{-1}
  - Cutoff is weak
  - DD scenario more likely [?]
- Stretch data “suggestive” of 2 populations of SNeIa, but other explanations possible
- Need more supernovae, better BPS models, predictions for double detonations and other models



- See poster 66 -***"The Spatial Distribution of Type Ia Supernovae in their Host Galaxies"***
- Host galaxy observations, bulge/disk decomposition with GIM2D
- SNeIa follow disk light, DD progenitors preferred?