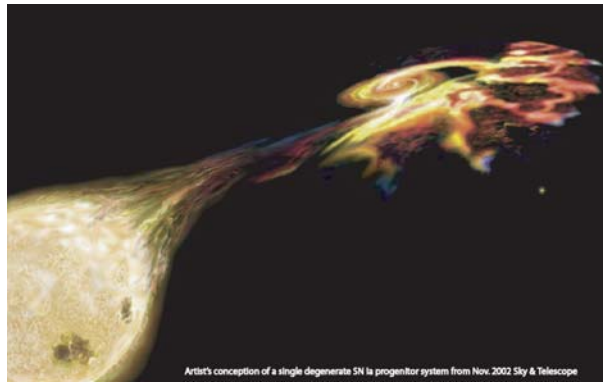
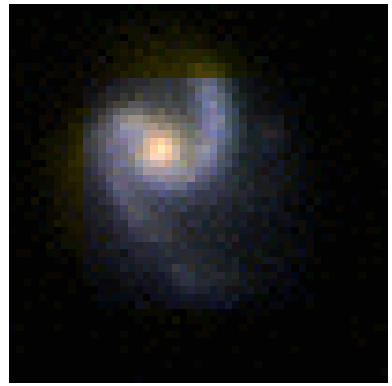
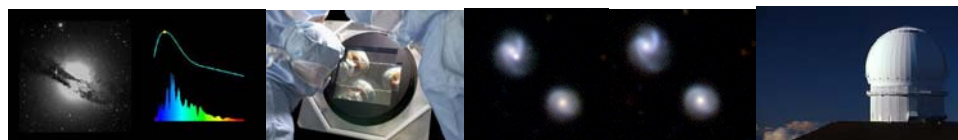




Rates, Delay Times

Chris Pritchet, U. Victoria

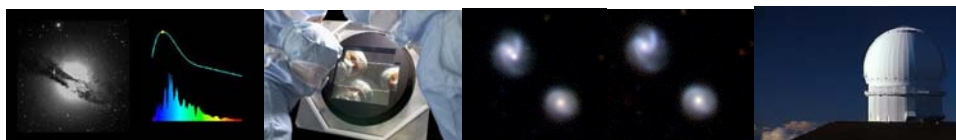
KITP Apr 13 2007



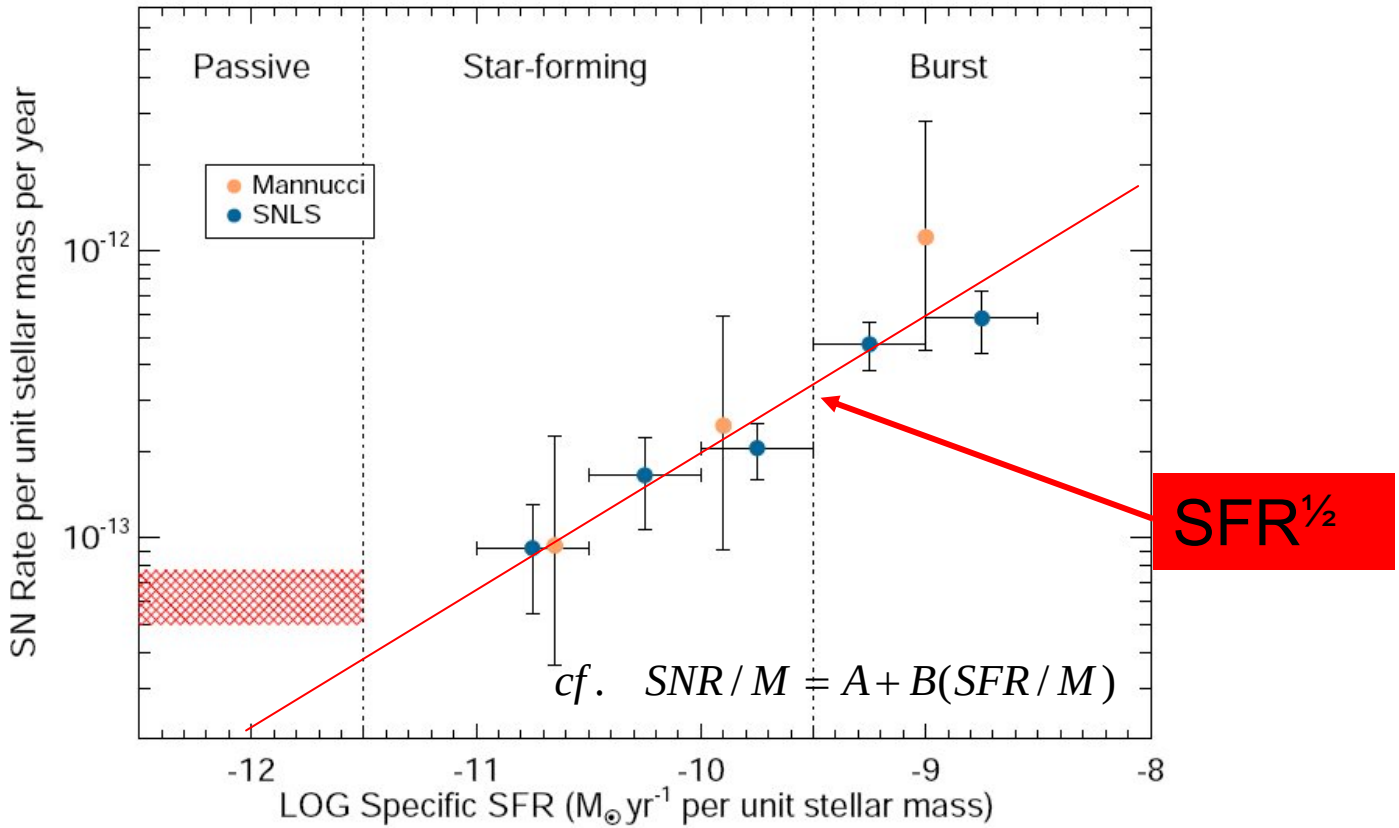
Mark Twain's view

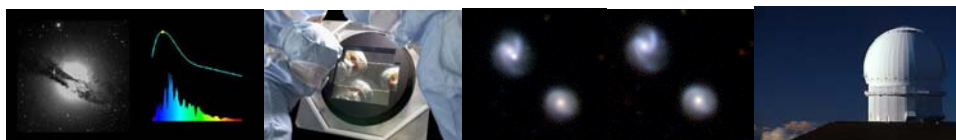
In the space of one hundred and seventy six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over a mile and a third per year. Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oölitic Silurian Period, just a million years ago next November, the Lower Mississippi was upwards of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing-pole. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo [Illinois] and New Orleans will have joined their streets together and be plodding comfortably along under a single mayor and a mutual board of aldermen.

There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.



SN Ia rate depends on SFR

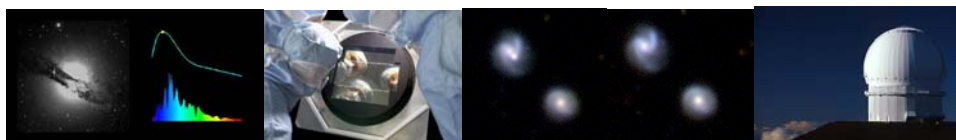


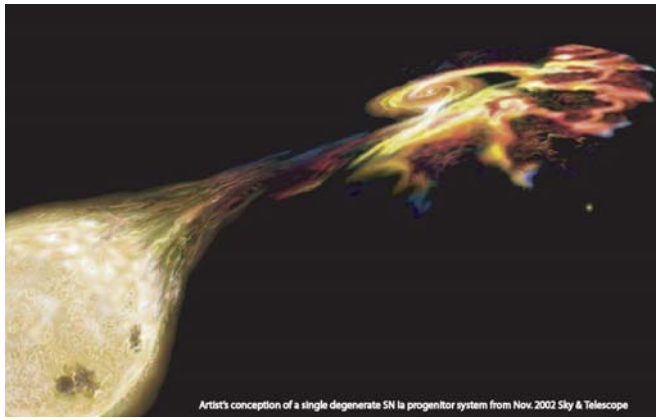


Meaning of A·M + B·SFR

$$SNR/M = A + B(SFR/M)$$

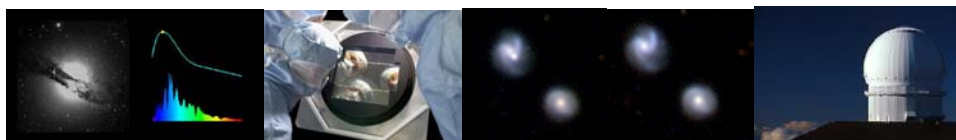
- Does this imply two paths to SNeIa? …
- … or is there a simple unifying picture that can be used to understand the A+B prescription for the SNIa rate?
- Why do the A and B values have the values that are observed?
- Continuum of delay times – more natural?
- Why ~√SFR dependence?





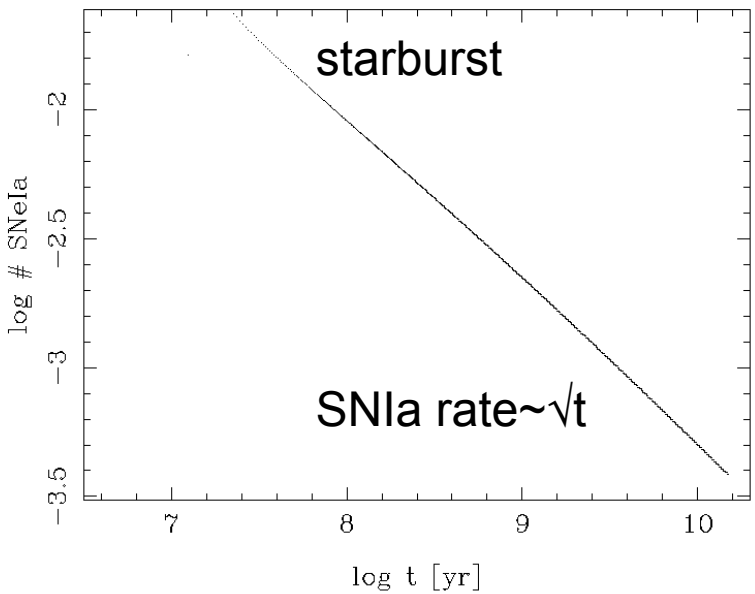
Toy Model

- Single degenerate scenario
- Delay time depends on evolutionary timescale of secondary - T(evol) ≈ T(ms)
- Simple SFR(t) ~ $t^{-\eta}$ to allow for range of ages

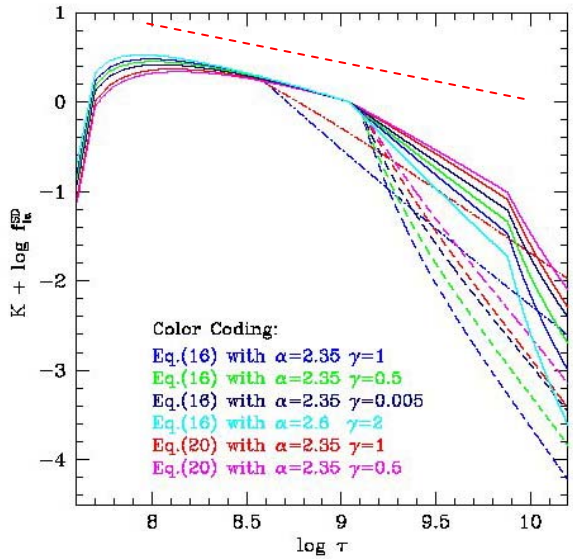


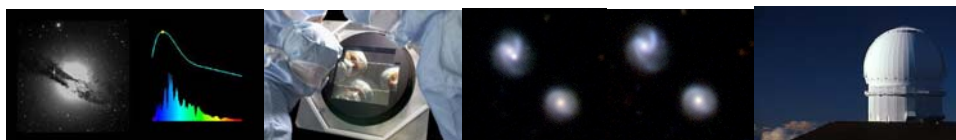
Rate vs time

- Rate at which stars leave main sequence
- This is the distribution of delay times for a burst

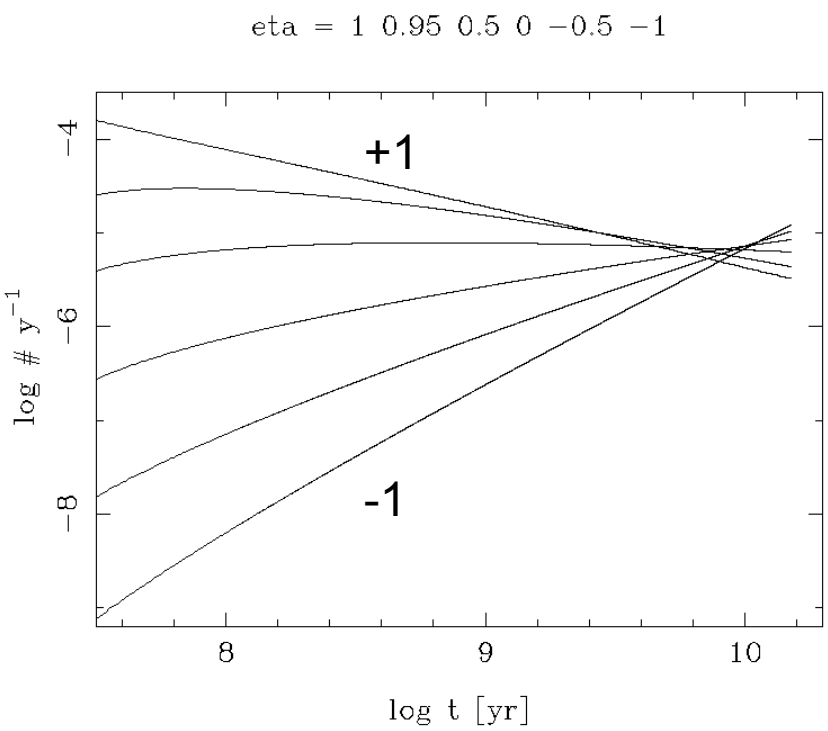


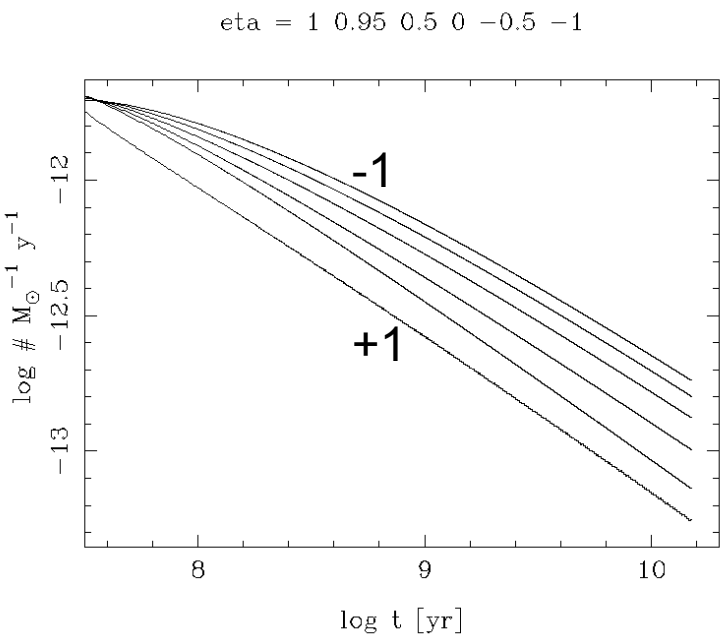
Greggio 2005

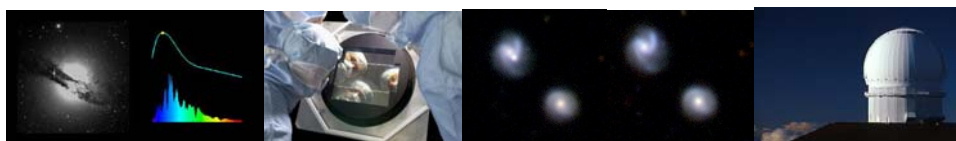




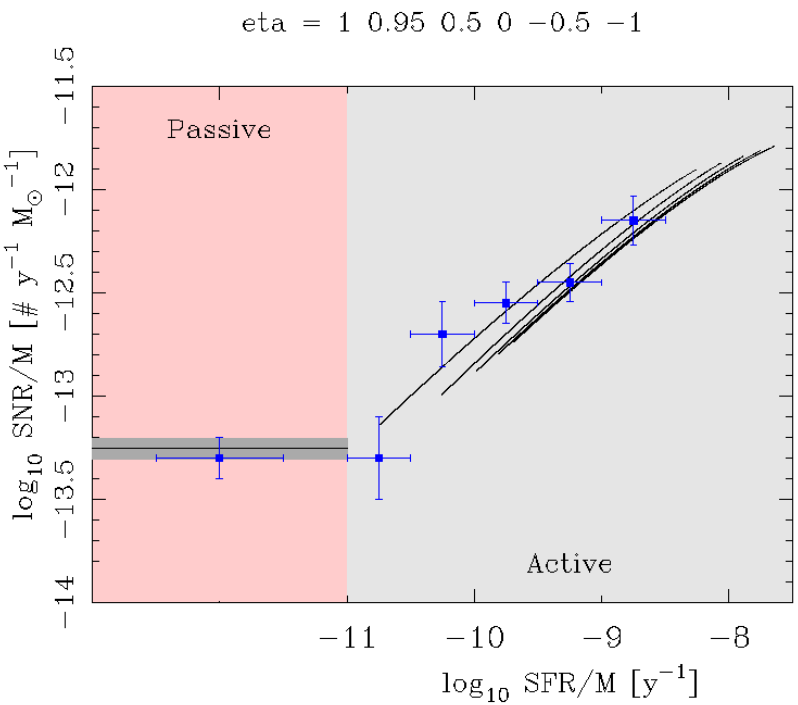
Rate vs time


eta = 1 0.95 0.5 0 −0.5 −1
+1
-1
log # y^{-1}
−4
−6
−8
8
9
10
log t [yr]

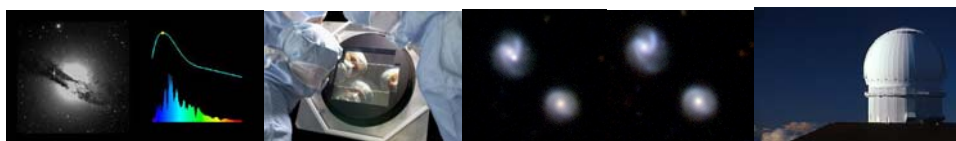

eta = 1 0.95 0.5 0 −0.5 −1
-1
+1
log # M$_\odot^{-1}$ y^{-1}
−12
−12.5
−13
8
9
10
log t [yr]



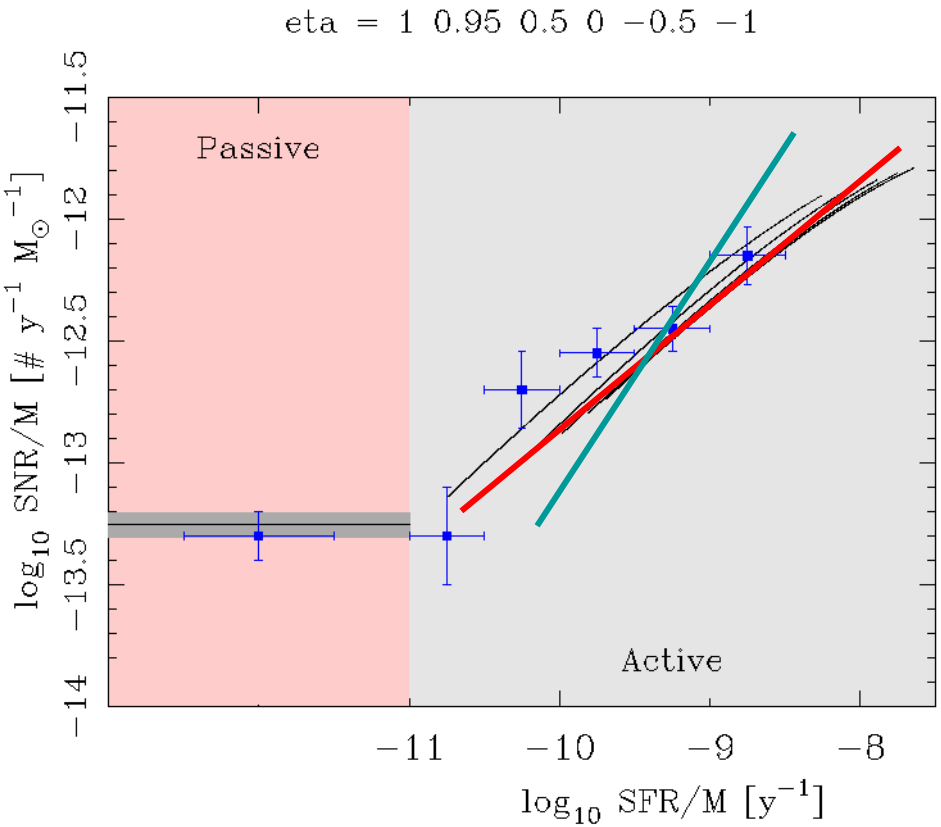
Results



- Single component model – not A+B
- Continuous distribution of delay times
- Fits data better!
- Rate in active and passive galaxies both explained
- Only physics is evol timescales
- Single free parameter normalization - f_{SNIa}



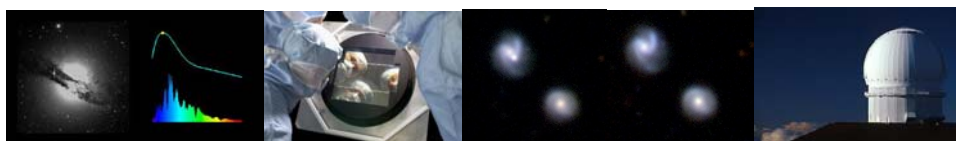
Results



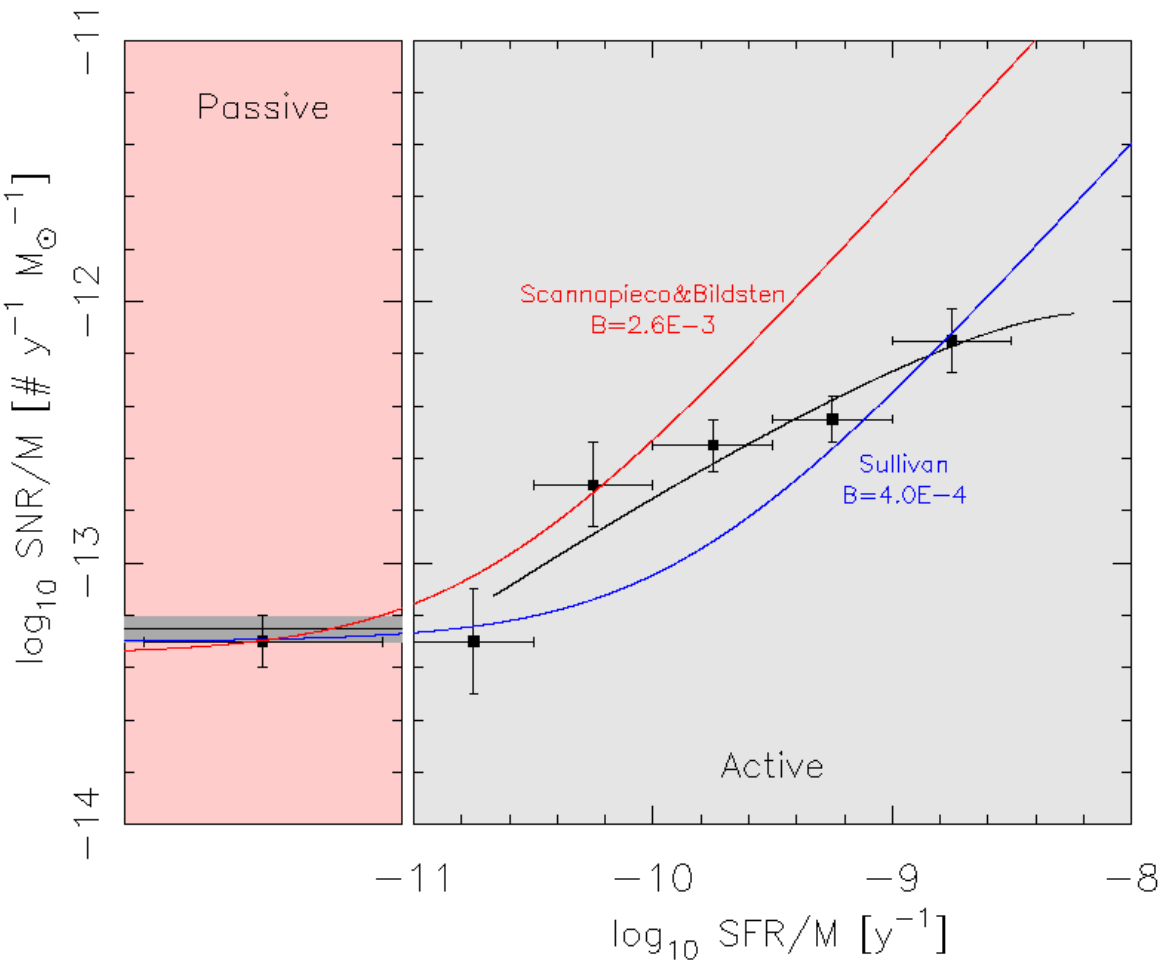
For a burst:

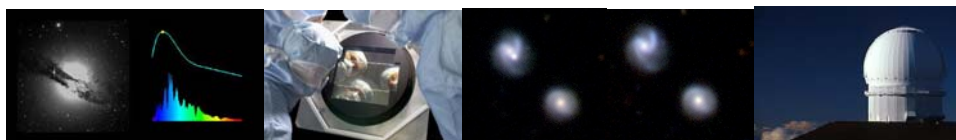
- red: $N \sim t^{1/2}$
- Blue $N \sim t$

Data constrains



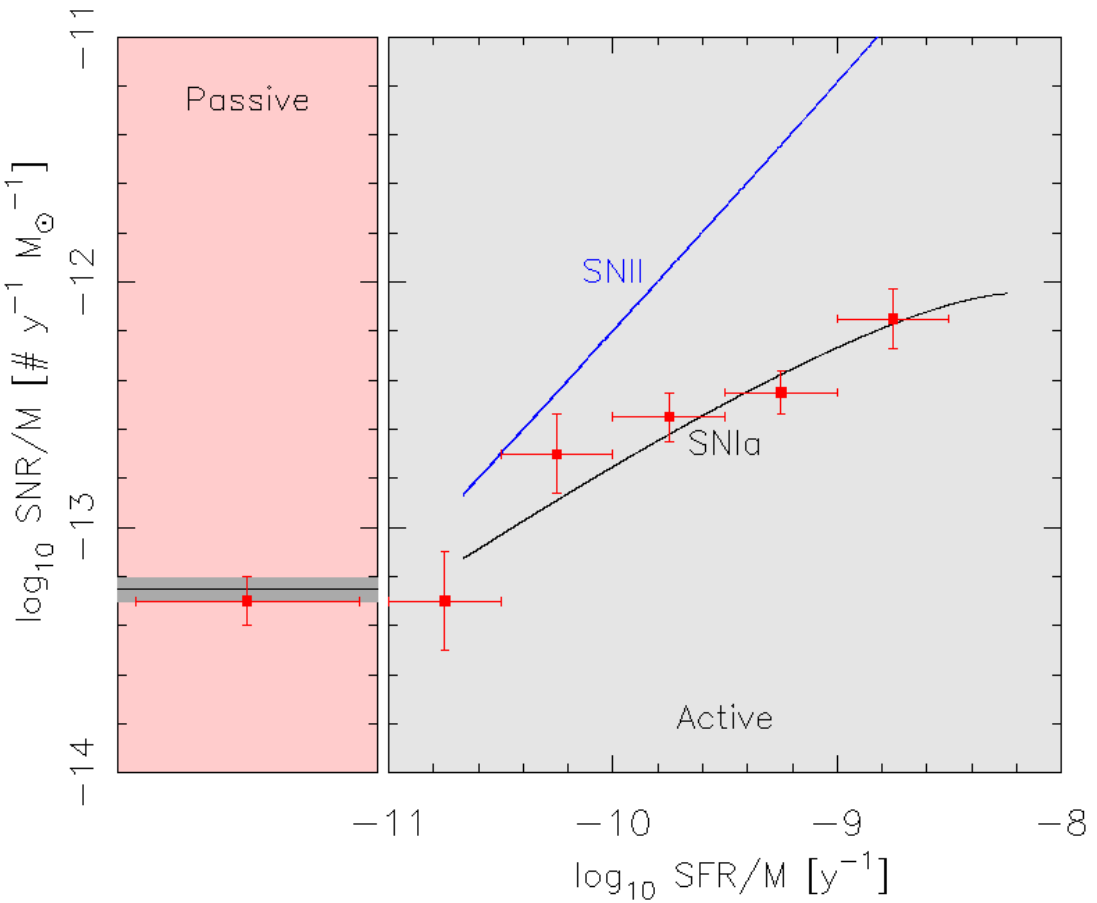
2 different B values

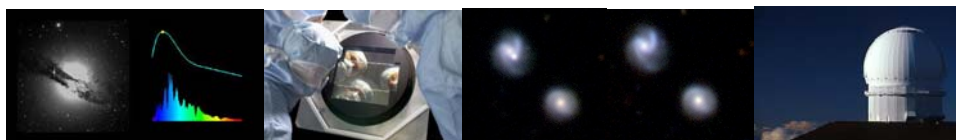




Type II vs Ia rates

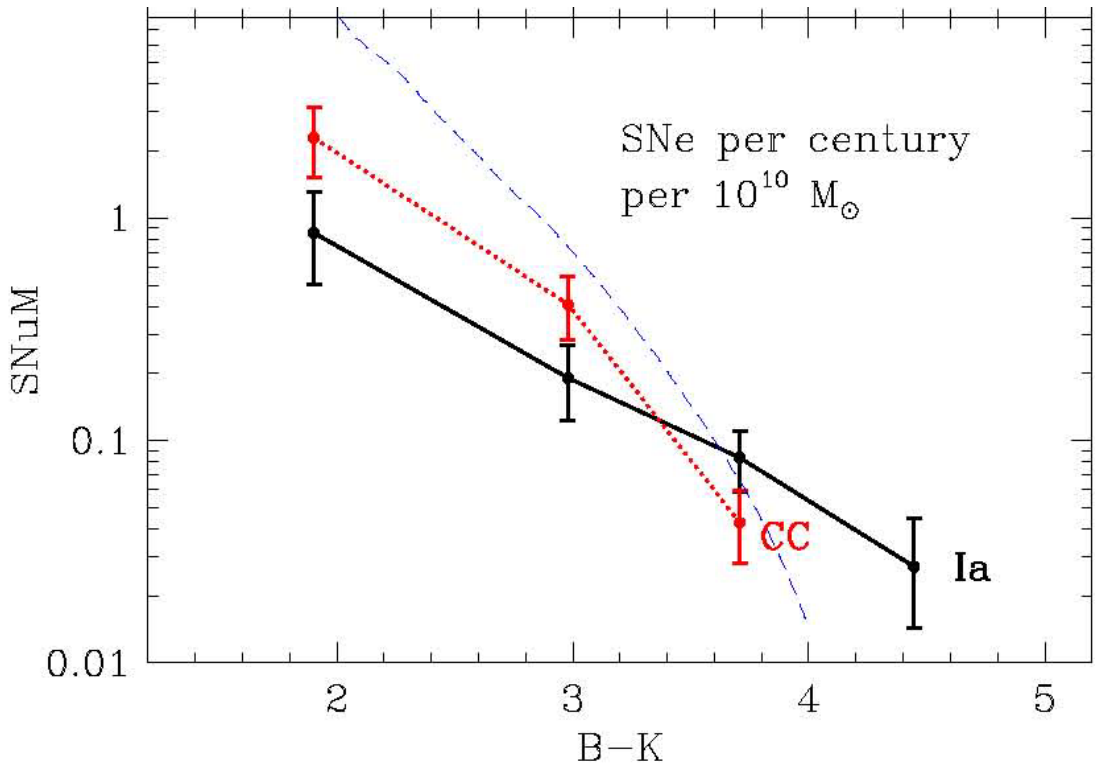
- Prediction: strong variation of SNII/SNIa rate ratio with SFR/M

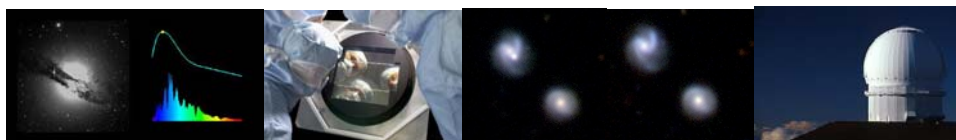




II vs Ia Observations

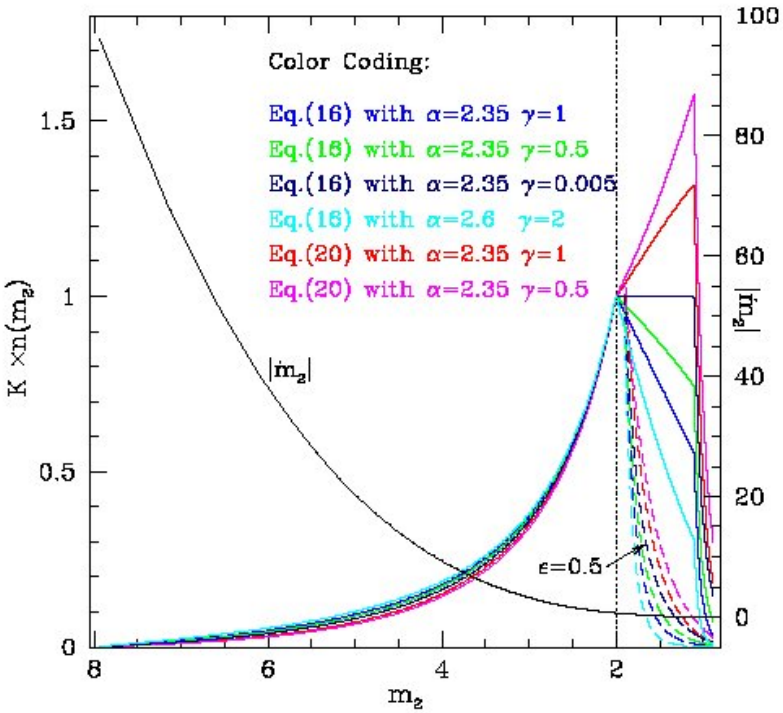
- Mannucci 2005

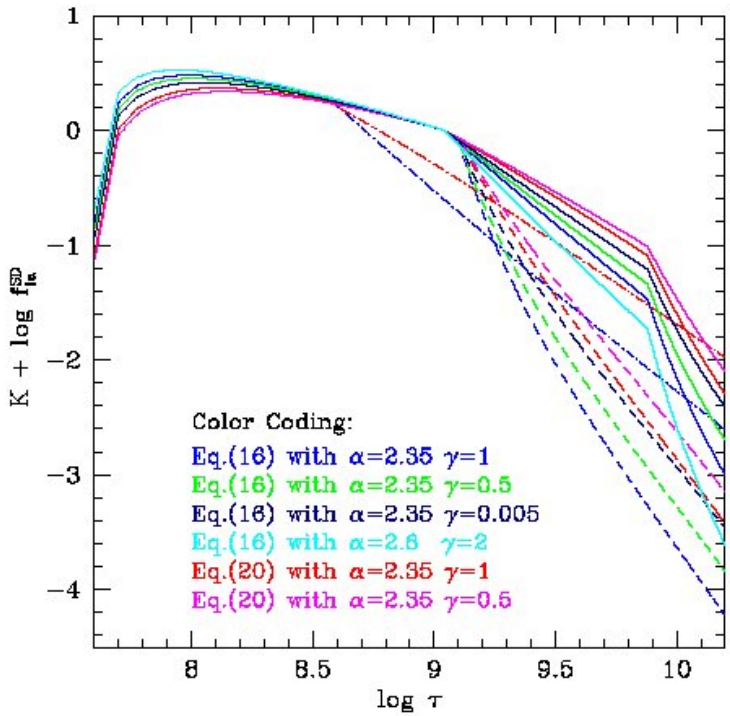


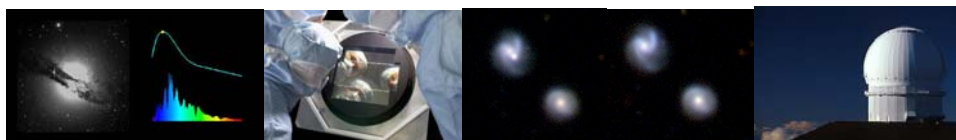


Efficiency - Greggio 2005

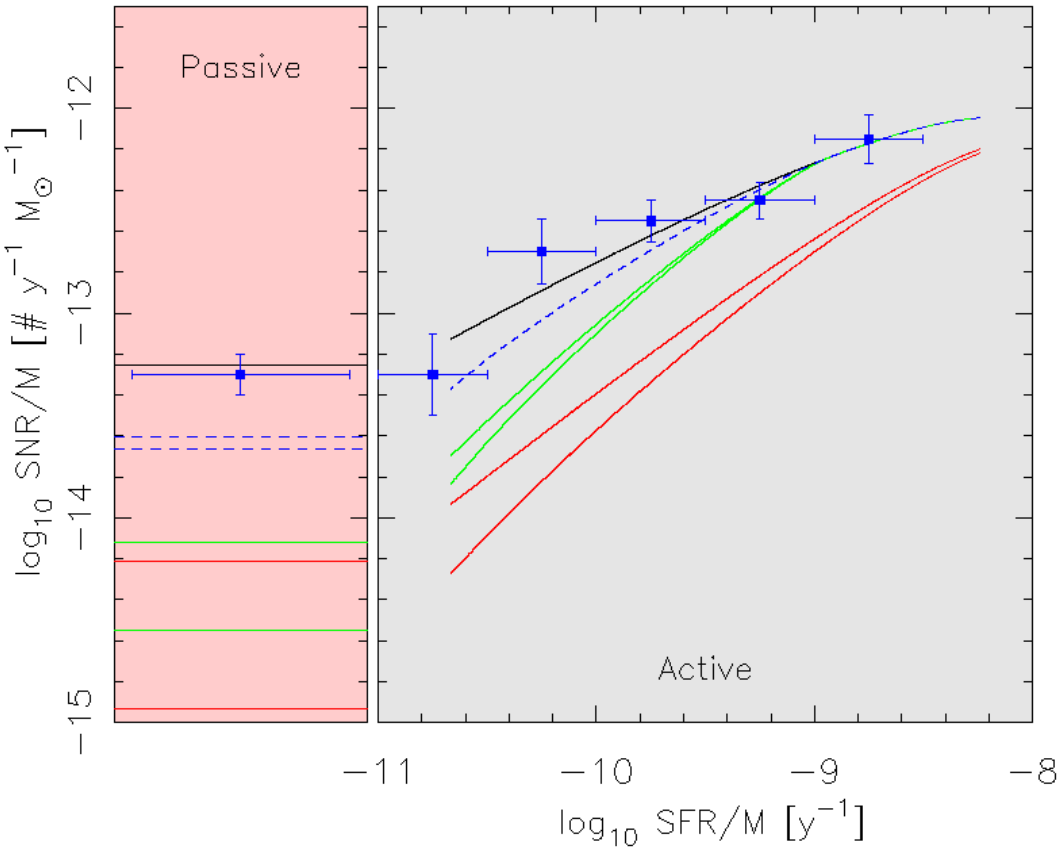
- q=m2/m1, f(q)~q$^{\gamma}$
- ε=frac of secondary envelope transferred

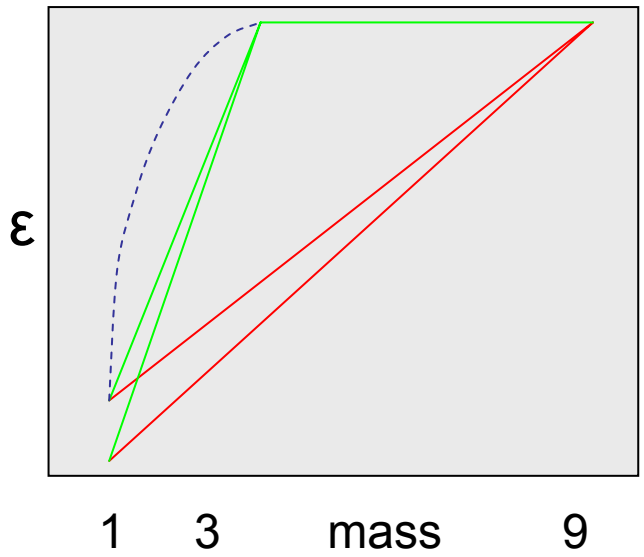


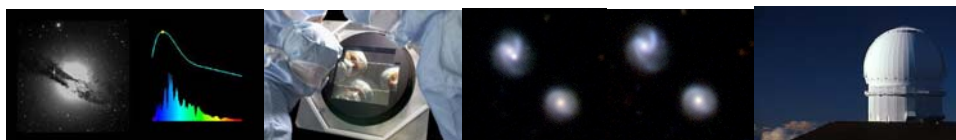




Effects of efficiency

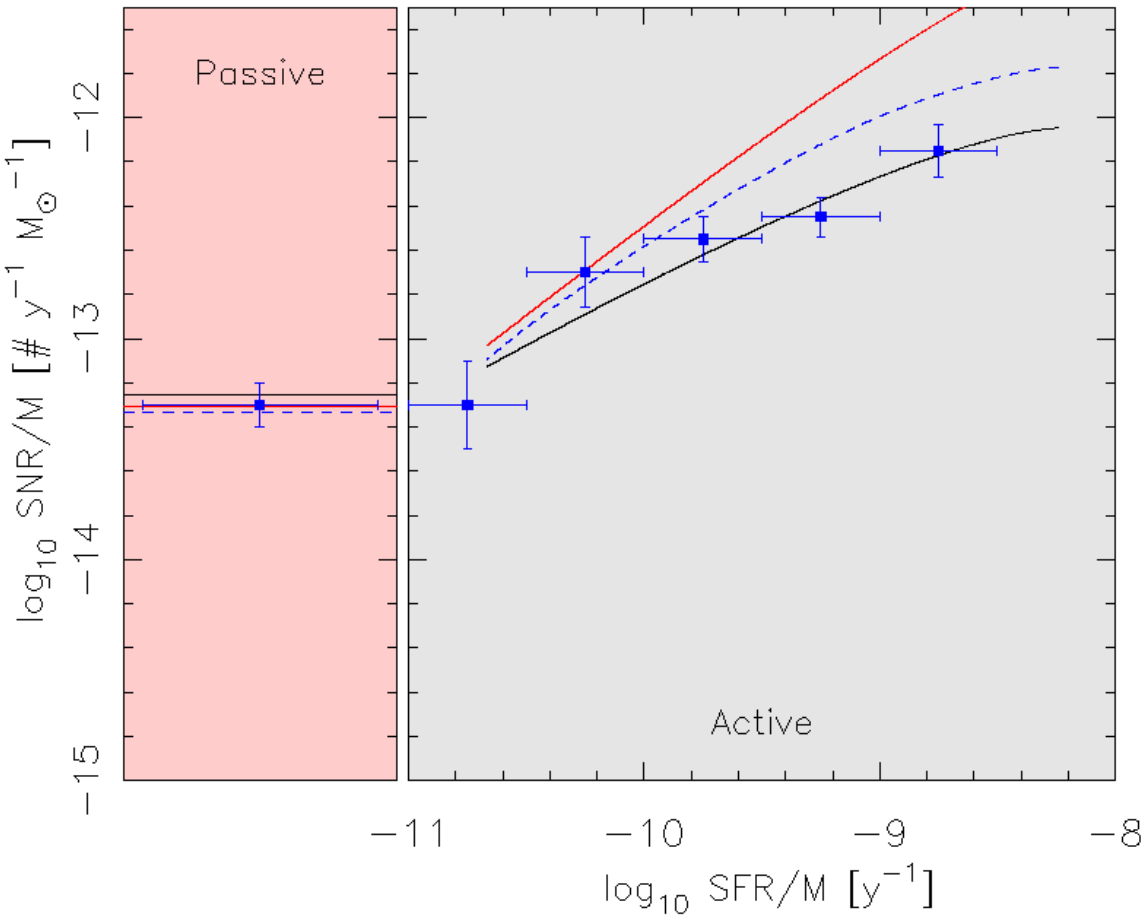


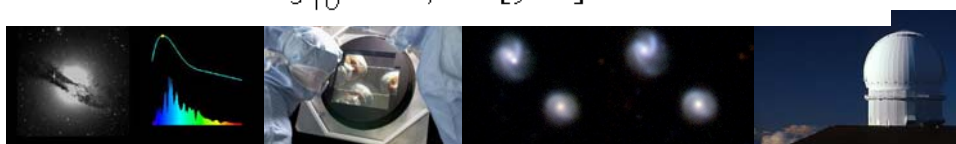




Efficiency

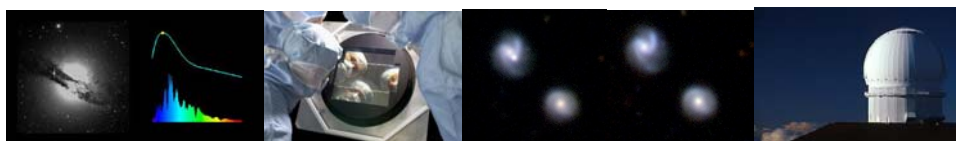
- Similar for low and high mass
- Different progenitor at low mass?



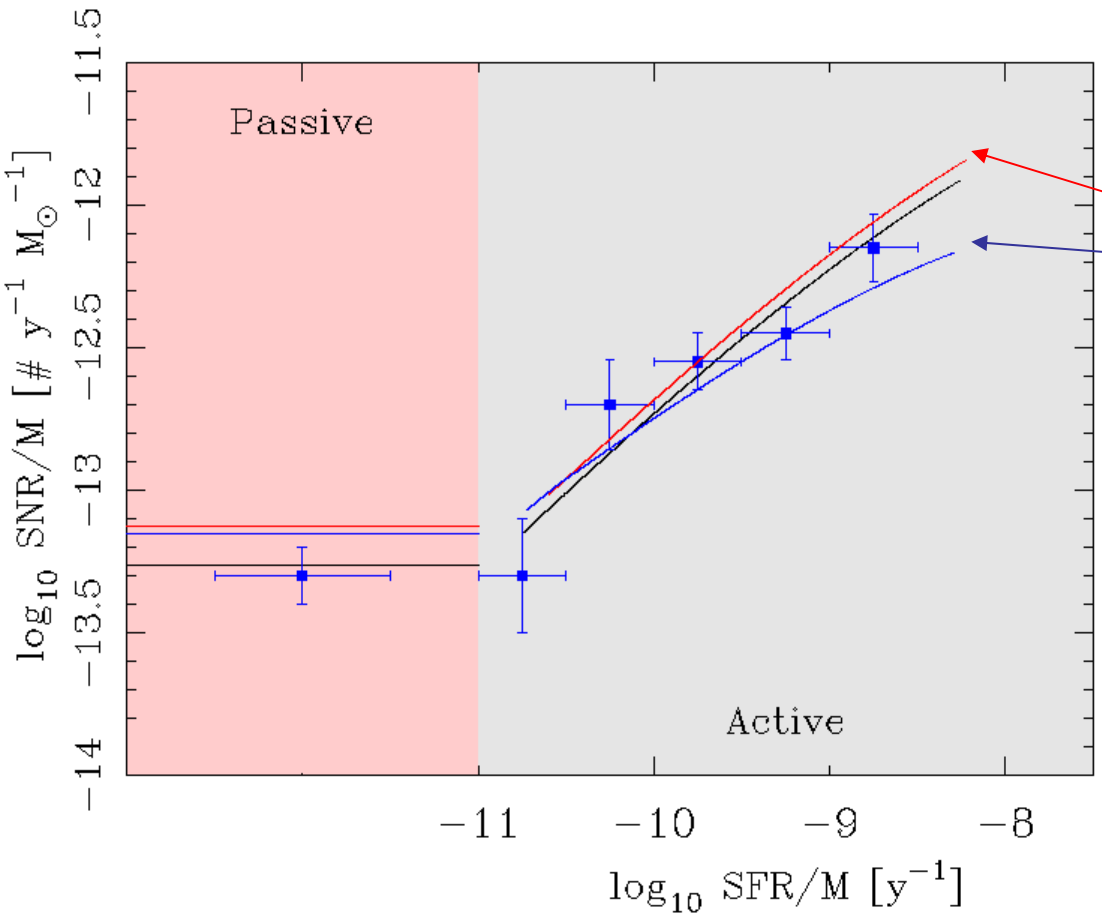


More on efficiency

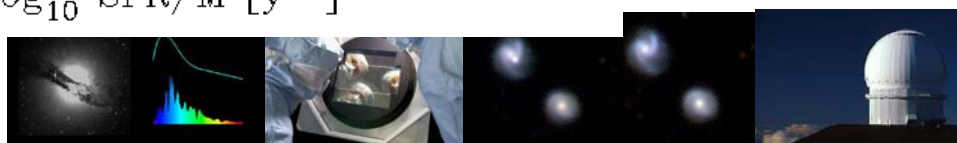
- F(SNIa)=0.0085 – fraction of stars that become SNeIa in relevant mass range
  - Reasonable??
- Need 10x larger to explain cluster [Fe/H]



IMF effects

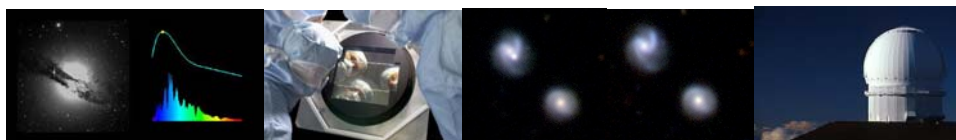


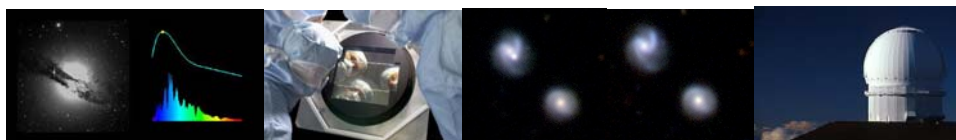
Kroupa 2006

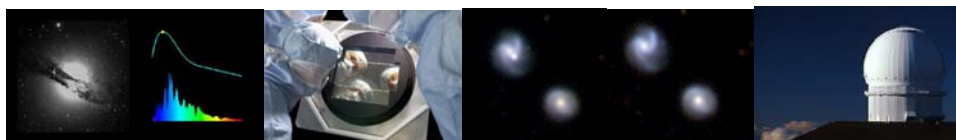


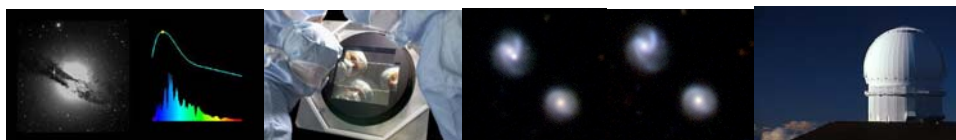
Conclusions

- one parameter model fits active and passive
  - Based on stellar evolutionary timescales
  - Continuous delay time distribution
- excellent fit to data – better than A + B SFR/M
- Consistent with SNII/SNIa rate ratio, but …
- Predictions:
  - SNIa rate will correlate with mean age from population models
  - SNII/SNIa rate ratio will show strong variation with SFR
  - Either (i) efficiency independent of mass or (ii) different progenitor for low mass
- Problems:
  - F(SNIa) doesn't work in clusters

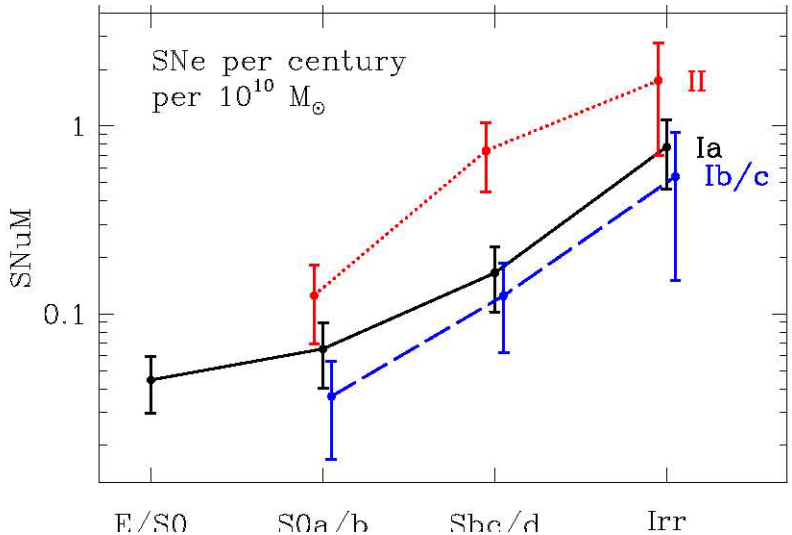








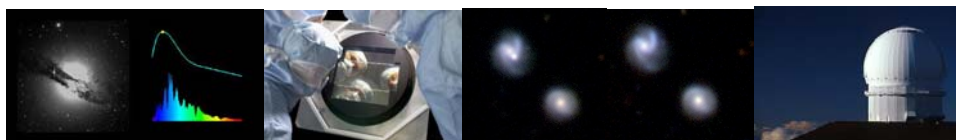
SNeIa in Star-Forming Galaxies



Mannucci et al 2006

$$\text{SN rate} = A \cdot M + B \cdot SFR$$

Scannapieco and Bildsten 2006

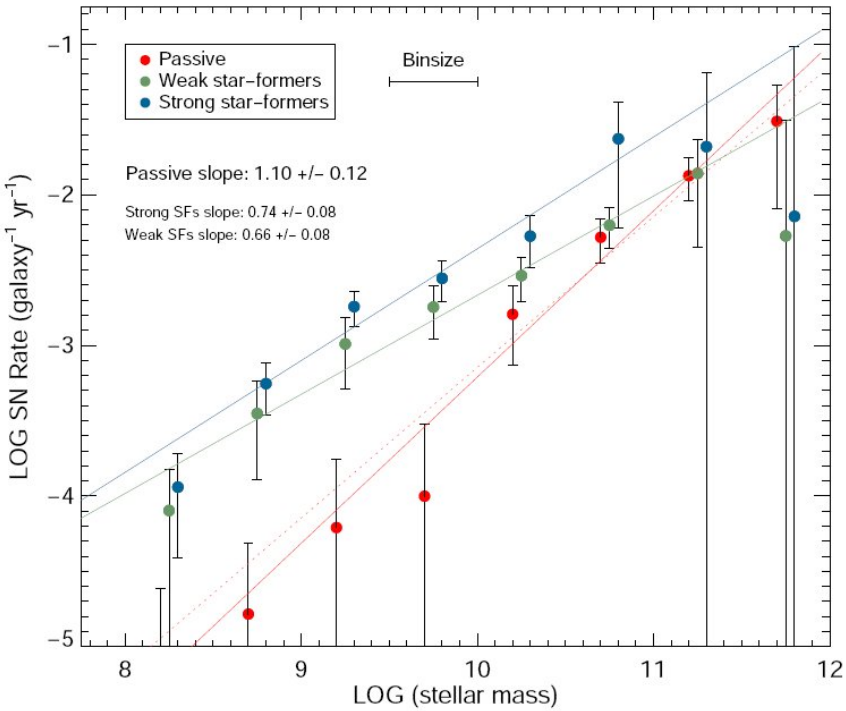


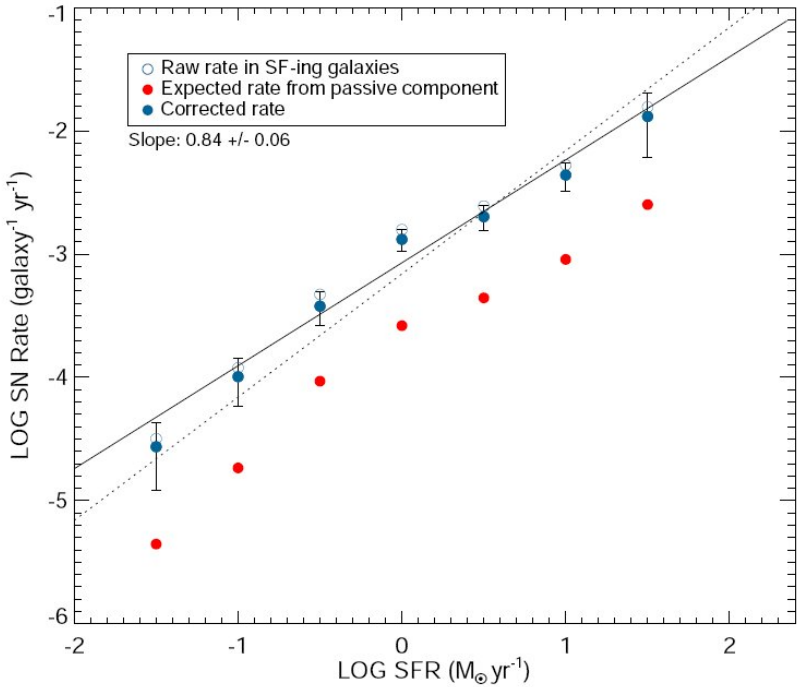
$$\text{SN rate} = A \cdot M^{m} + B \cdot SFR^{n}$$

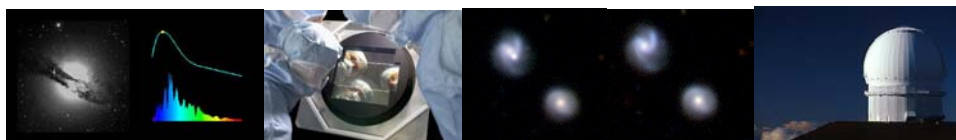
m = 1.10+-0.12, n = 0.84+-0.09
A=5.1E-14 SNe/yr/Msun
B=4.1E-4 SNe/yr/(Msun/yr)
B needed at 99.99% confidence

cf. Scannapieco and Bildsten 2005 (m=1, n=1)

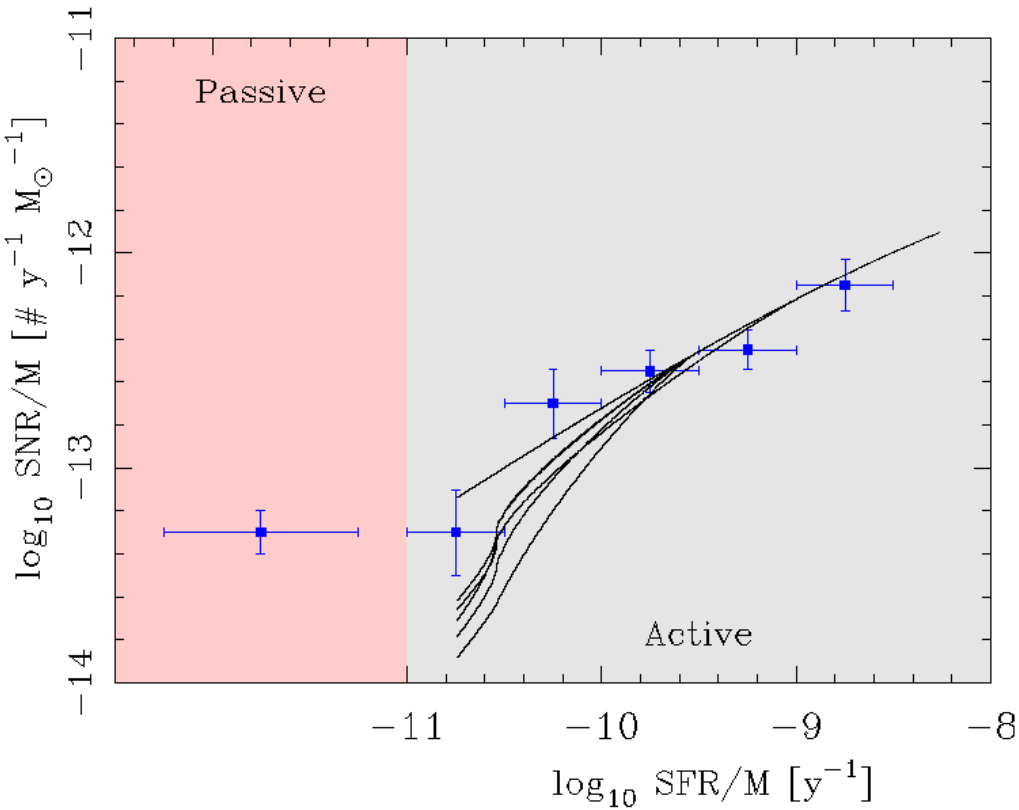
Bivariate fits give m,n close to 1

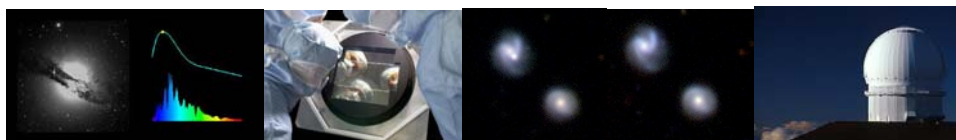






Decreasing efficiency at low mass





DD Scenario

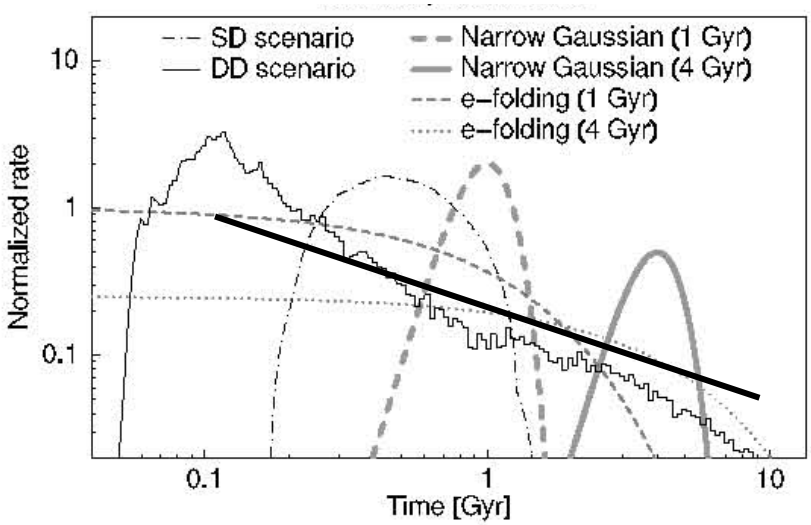


Figure 1. Theoretical time delay distributions (Han & Podsiadlowski 2004) compared to parametrized time delay distributions used in the analysis. The best-fitting model in S04 corresponds to the 'narrow Gaussian' distribution with a mean time delay of 4 Gyr

Han & Podsiadlowski 2004