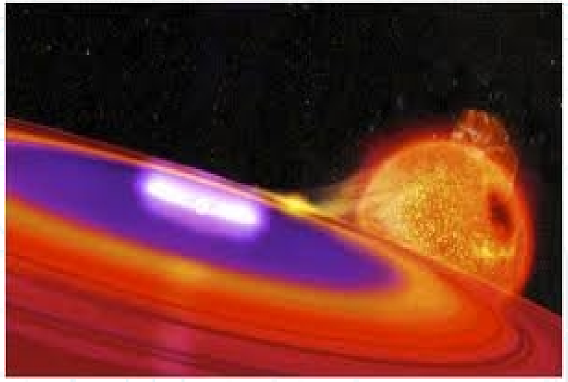
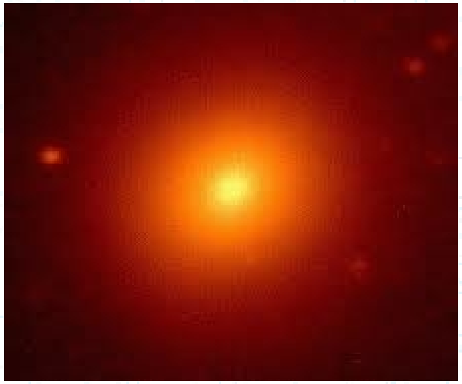
The effects of SN Ia on the chemical properties of simulated SPH galaxies

Noelia Jimenez, Francesca Matteucci
&
Patricia B.Tisssera

Observatory of Trieste
IAFE-CONICET, Buenos Aires





CONICET
MARIE CURIE ACTIONS
OSSERVATORIO ASTRONOMICO DI TRIESTE
SEVENTH FRAMEWORK PROGRAMME
INAF

Scientific motivation:

→ **The importance of a correct treatment of SNe feedback:**

- Main course of heavy elements
- Cooling rates and metal abundances
- Reduces SF
- Feeds IGM

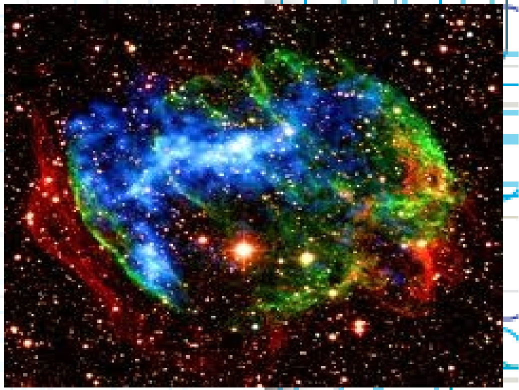
Include Francesca's models in the cosmological hydrodynamical simulations!

Outline:

- Analytical models for different SN Ia progenitors scenarios
- Implementation of the models in isolated galaxies
- Results of the chemical evolution and comparison with observable data

Trieste

SN Ia Progenitor Scenarios:



Theoretical Delay Time Distributions (DTD):

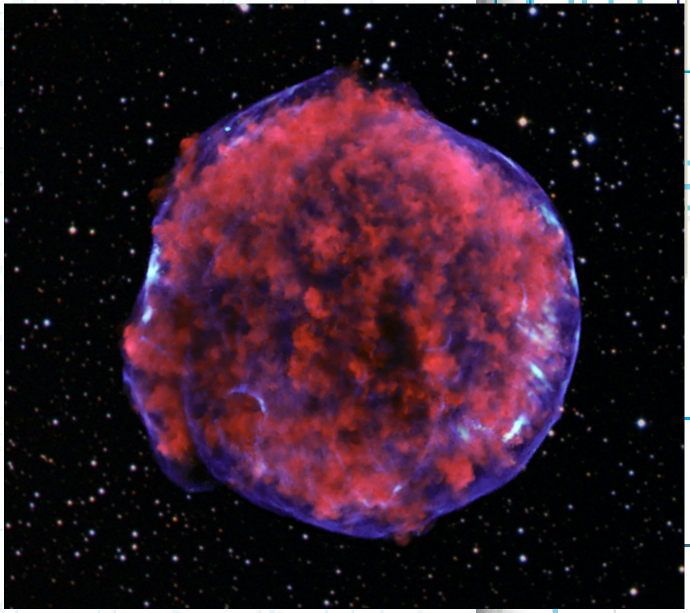
- **SD, Matteucci & Recchi (2001)**
- **Double Degenerated, Greggio (2005)** [wide]

Empirical DTDs:

- **Bimodal Scenario: Mannucci, Della Valle & Panagia (2006)** [radio gxs]

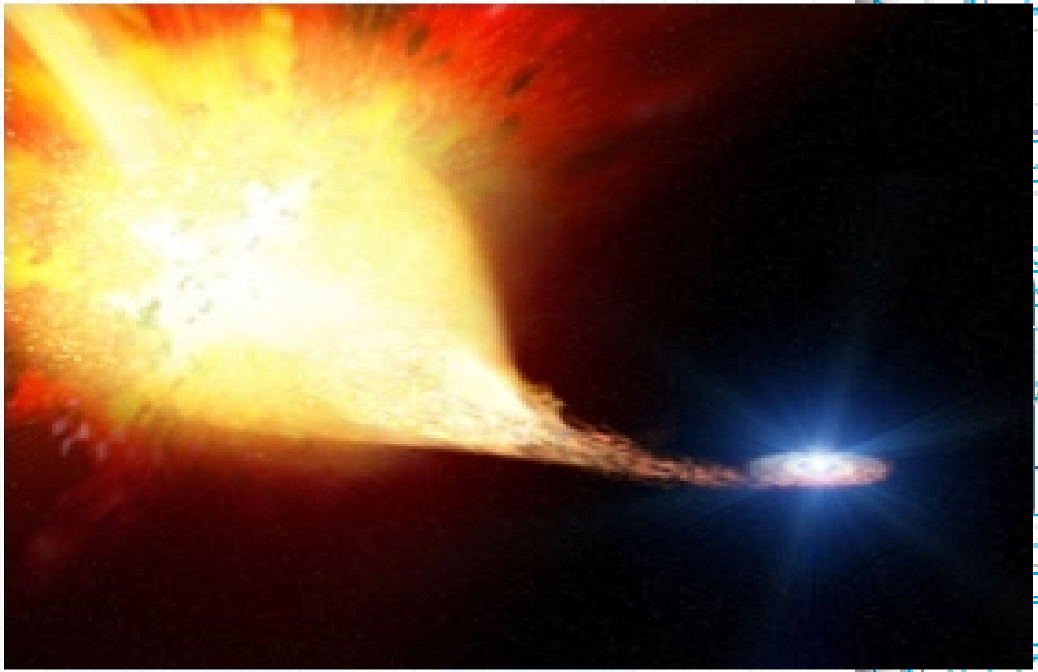
- **Pritchet et al. (2008)** [l=-0.5 SNLS]
- **Maoz et al. (2012)** [l=-1.12,SDSSII]

all equivalent to DD and to
Totani et al. (2008) (l=-1 SXDS)



The Single Degenerated Scenario

Matteucci & Recchi (2001)



- a binary system
- Red Gigant +WD.
- Chandrasekhar mass

Laura Greggio's talk

The minimum time for the first system to explode is 3e7 yrs

Analytical model of Matteuci & Recchi (2001)

Delay Time Distribution (DTD): is the rate of SN Ia produced by a instantaneous starburst

$$R_{\mathrm{Ia}}(t) = A \int_{M_{\mathrm{B,inf}}}^{M_{\mathrm{B,sup}}} \phi(M_{\mathrm{B}}) \int_{\mu_{\min}}^{\mu_{\max}} f(\mu)\psi(t-\tau_{M_2})\,d\mu\,dM_{\mathrm{B}},$$

free parameter

A: the fraction of binary systems in the IMF with the right characteristics to become a SN Ia

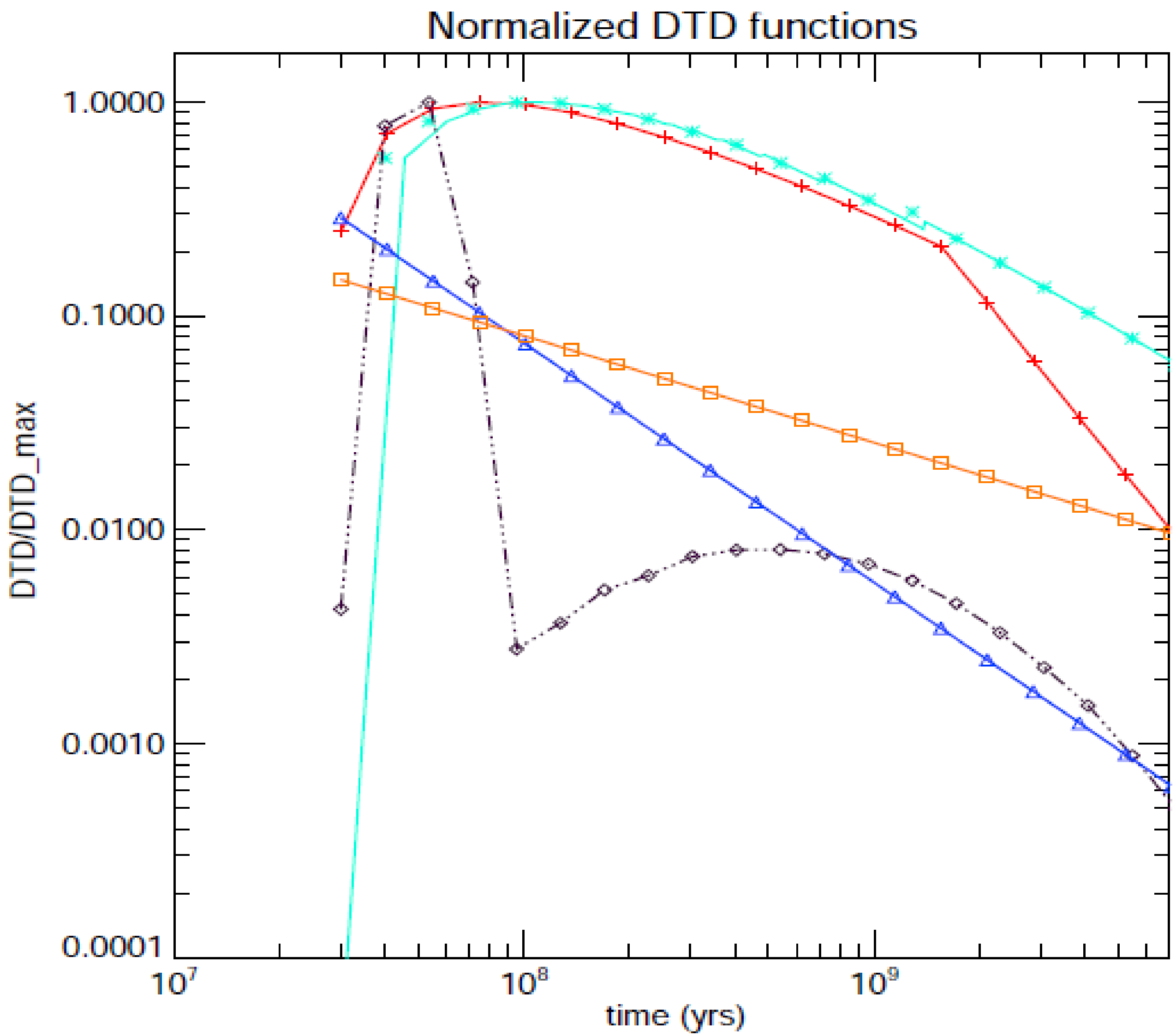
$$\phi(M_{\mathrm{B}}) = C M_{\mathrm{B}}^{-(1+x)}$$

Salpeter IMF

the mass fraction of the primary and secondary star M_2 and its distribution function

SFR

How the Delay Time Distributions (DTD) look like?



Numerical Simulations

- **Original Model:** Mosconi et al. (2001) for the metal distribution + Scannapieco et al. (2005,2006)
- TreePM/SPH–GADGET– 2
- **SNIa events randomly distributed within [0.1, 1] Gyr. NO DTD. Rates by observations of SNIa/SNCC**

All the simulations include:

- 1e5 DM particles and, initially, 8.5e4 baryonic particles
- Mass resolution: gas particles: 1e7 h^−1 Msun
- gravitanional softening for gas= 0.4 ^−1 kpc
- Chemical enrichment and feedback from SNII (dep with metallicity) and SNIa
- Multi−phase model for the gas component
- Metal−dependent cooling functions from Sutherland & Dopita (1993)

New Implementations:

- TreePM/SPH-GADGET- 3
- SFR at high redshifts is in better agreement with observations

Theoretical DTDs:

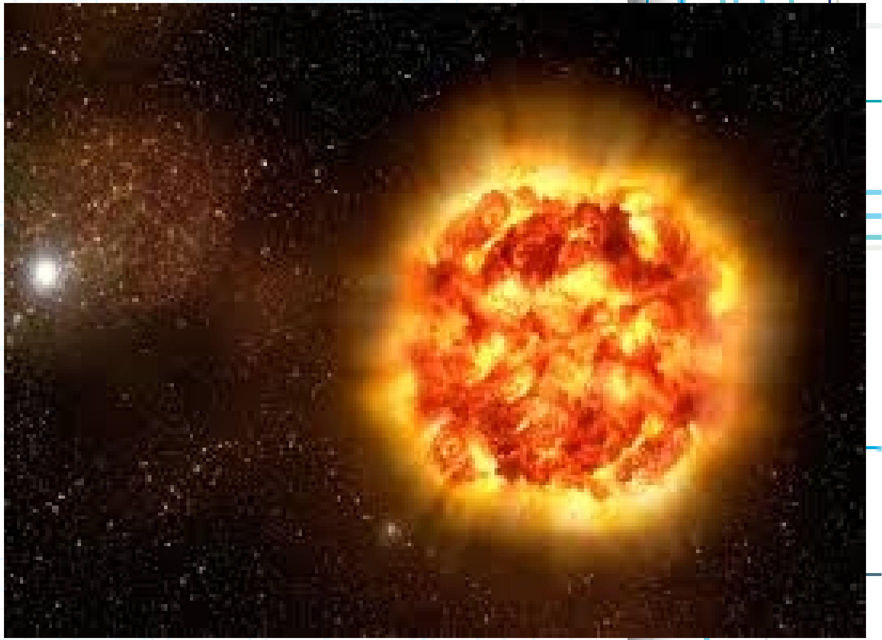
- SD, Matteucci & Recchi (2001)
- Double Degenerated, Greggio (2005)

Empirical DTDs.

- Bimodal Scenario: Mannucci, Della Valle & Panagia (2006)

Potencial laws:

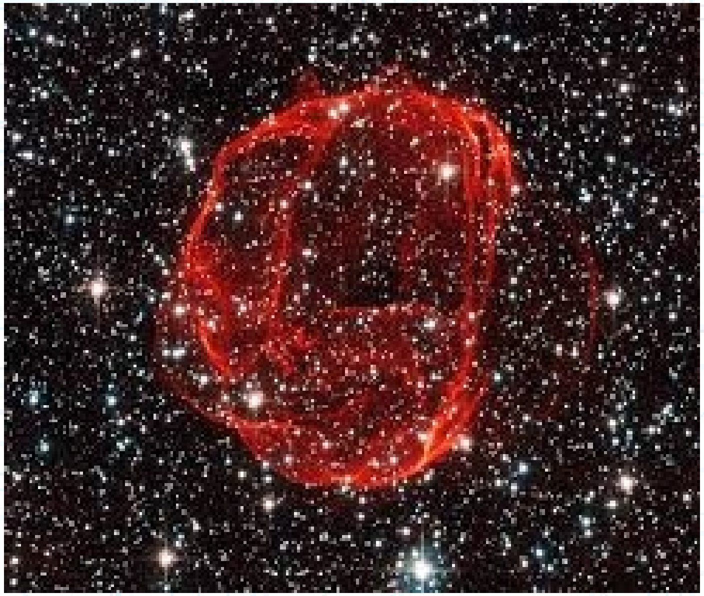
- Pritchet et al. (2008)
- Maoz et al. (2012)



<u>First Test</u>:

Fixing the DTD (MR01) and varying the A

- We ran 4 simulations of isolated galaxies with ~2.5e10 Mo.
- All the models share the same IC



disk1-first, Original model, A=0.0015

disk1-first1, DTD: MR01, A=0.0015

disk1-first2, DTD: MR01, A=0.00015

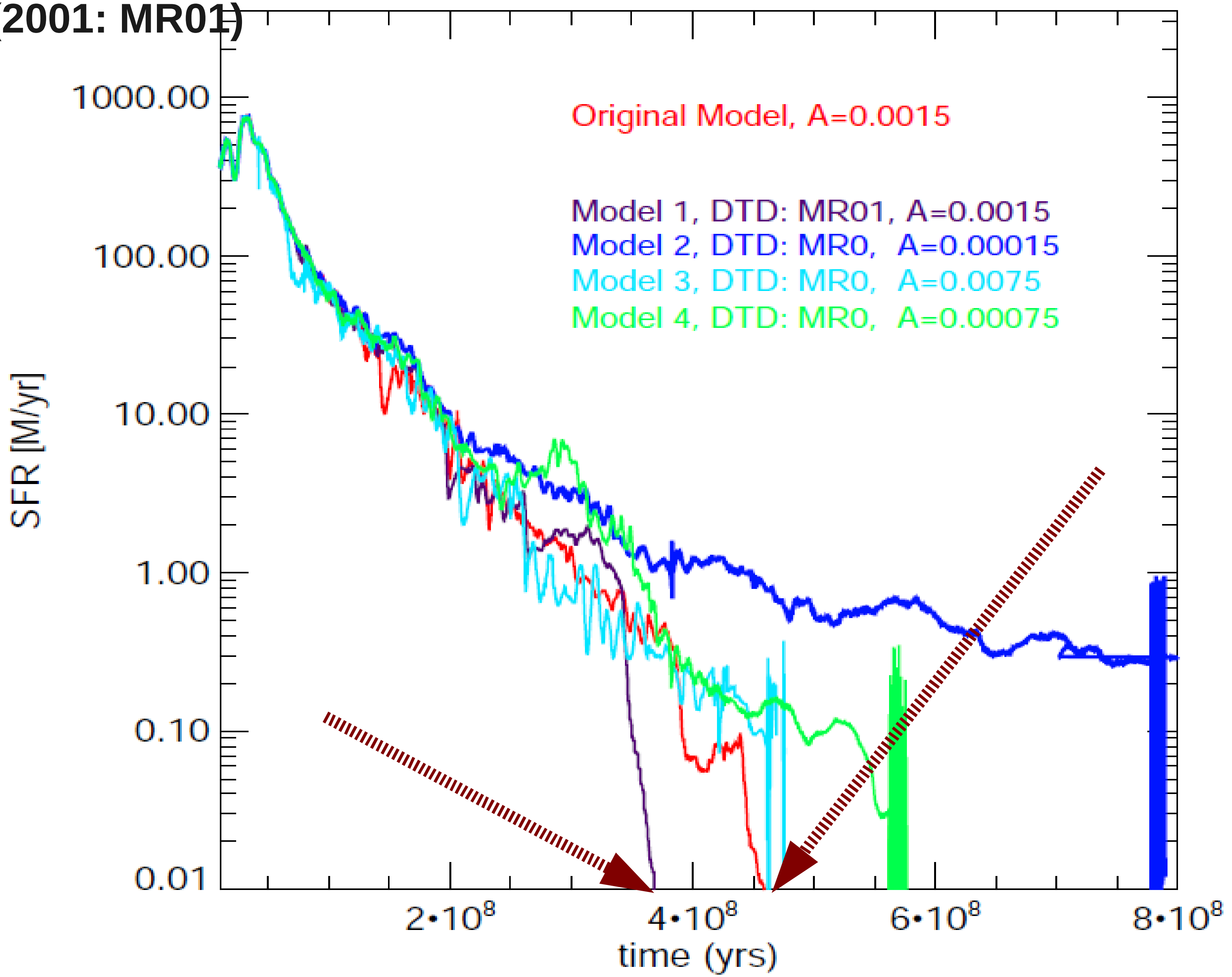
disk1-first3, DTD: MR01, A=0.0075

disk1-first4, DTD: MR01, A=0.00075

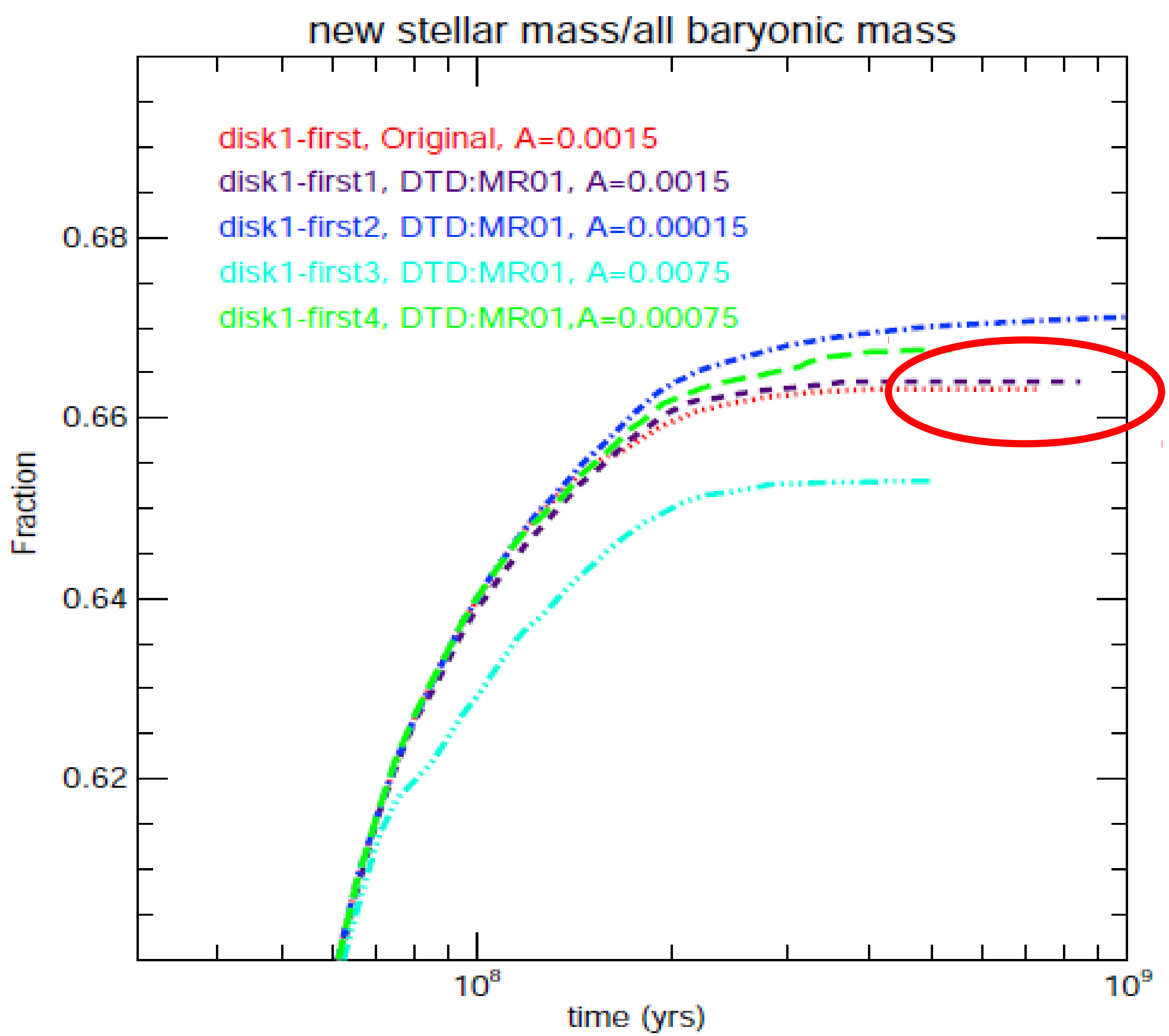
Results

Star Formation Rate

Matteucci & Recchi (2001: MR01)



Fraction of new stars

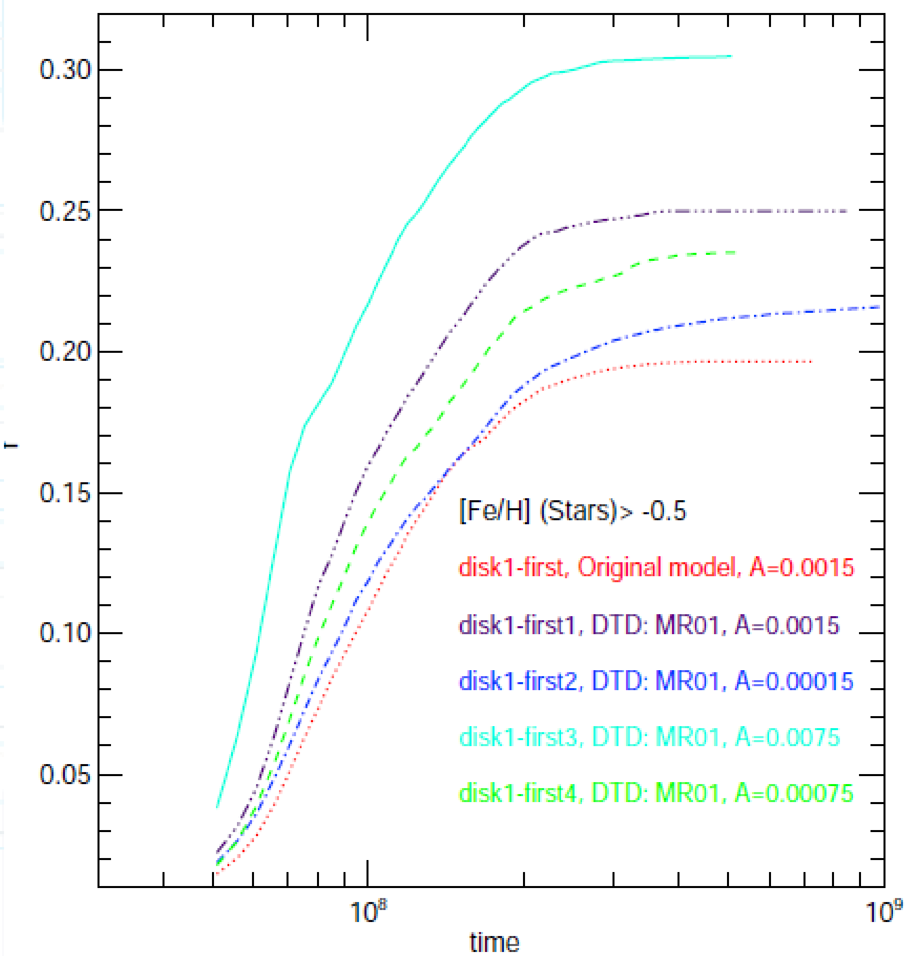


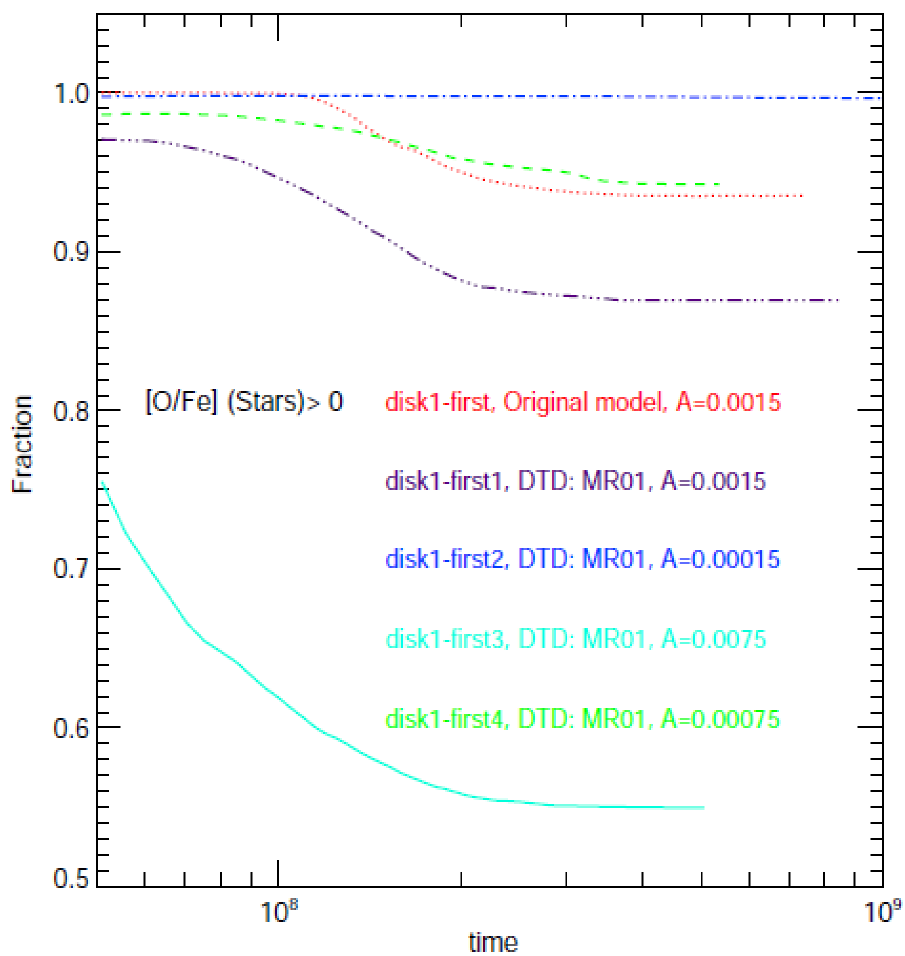
Delta-time between (Original-MR01)=7e7 yrs

Metallicity of the stars

[Fe/H]> -0.5

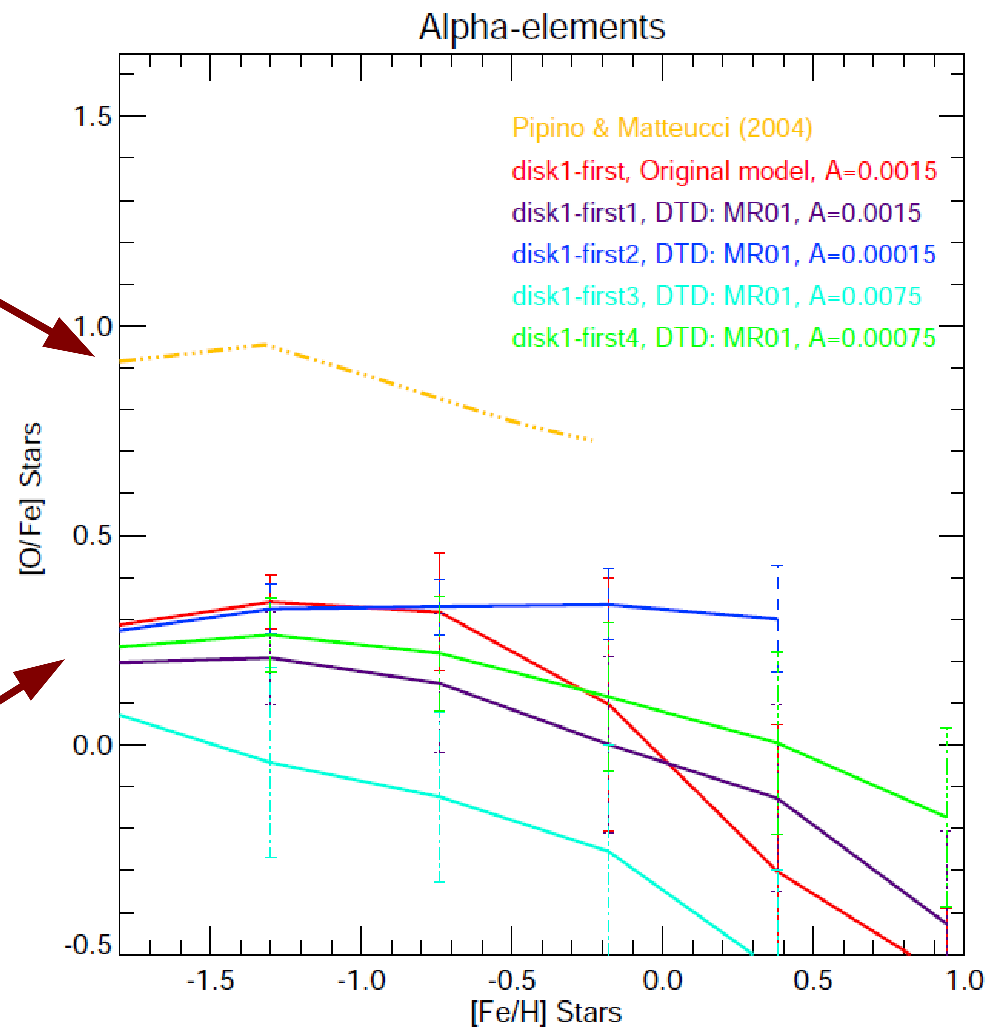
[O/Fe]> 0





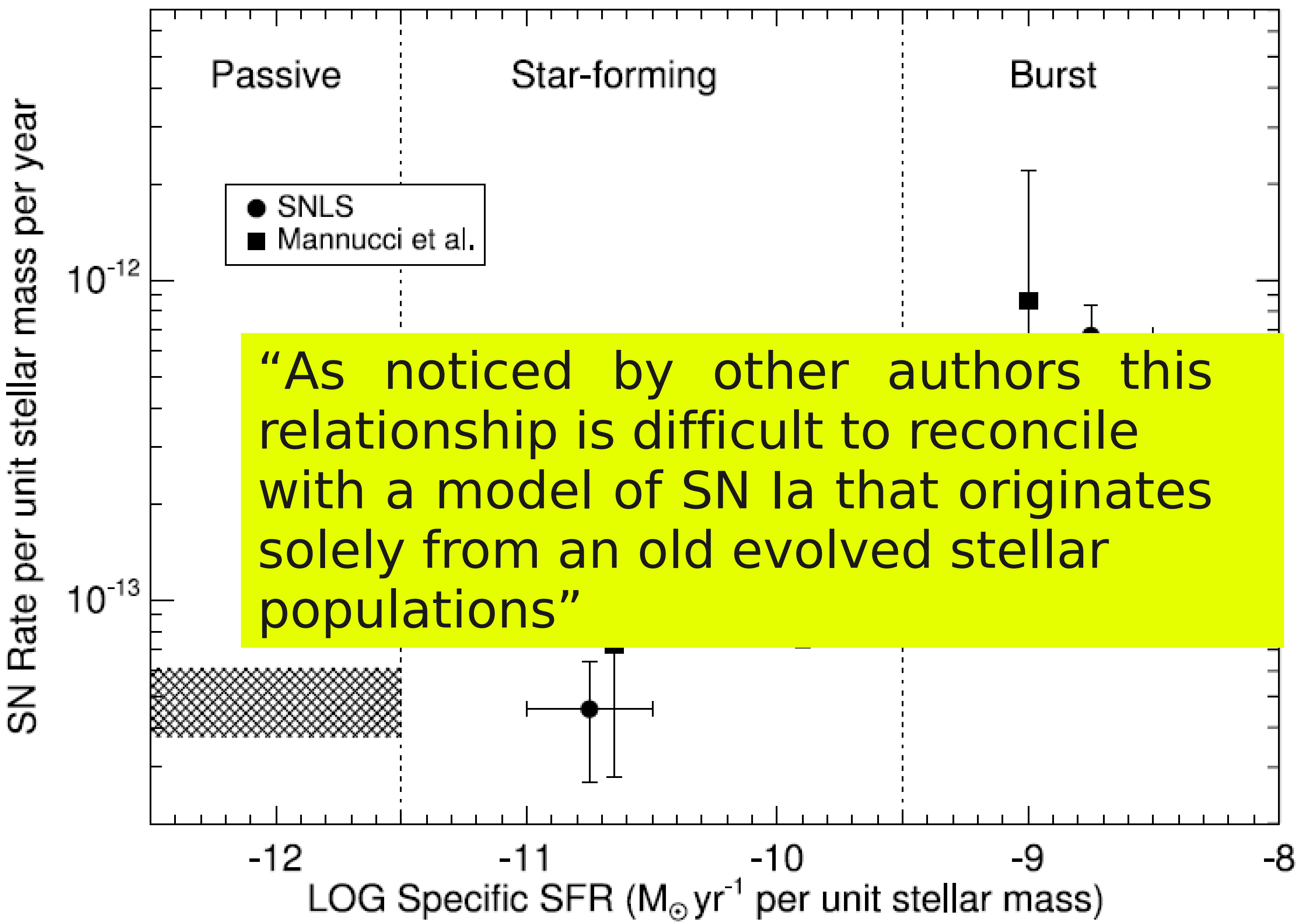
Alpha abundances in the Stars

Yields for SNII from Thielemann, Nomoto & Hashimoto (1996)



Yields for SNII from Woosley & Weaver (1995)

Sullivan et al. (2010) and Mannucci et al. (2005)



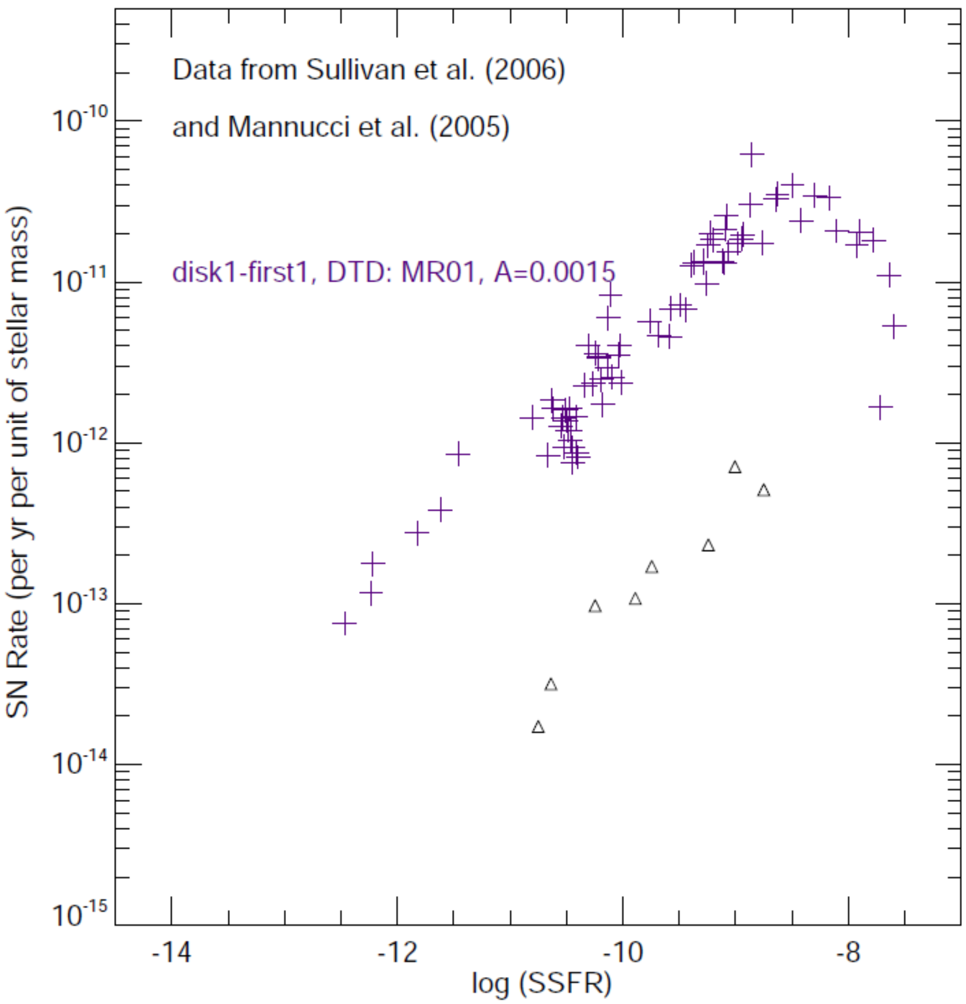
"As noticed by other authors this relationship is difficult to reconcile with a model of SN Ia that originates solely from an old evolved stellar populations"

SN Ia Rate/ (galaxy mass)

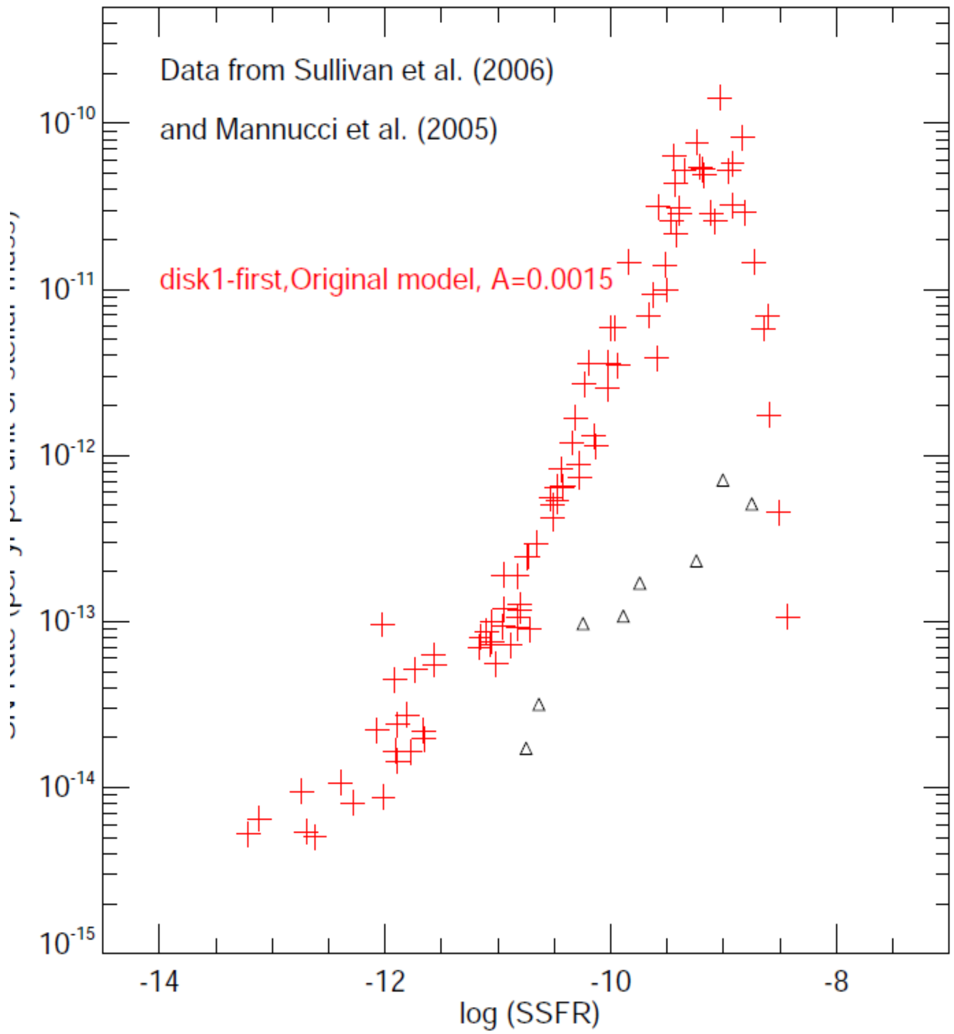
SSFR=SFR/(galaxy mass)

Comparision with data from Sullivan et al.(2010) and Mannucci et al.(2005)

Single Degenerated, MR01



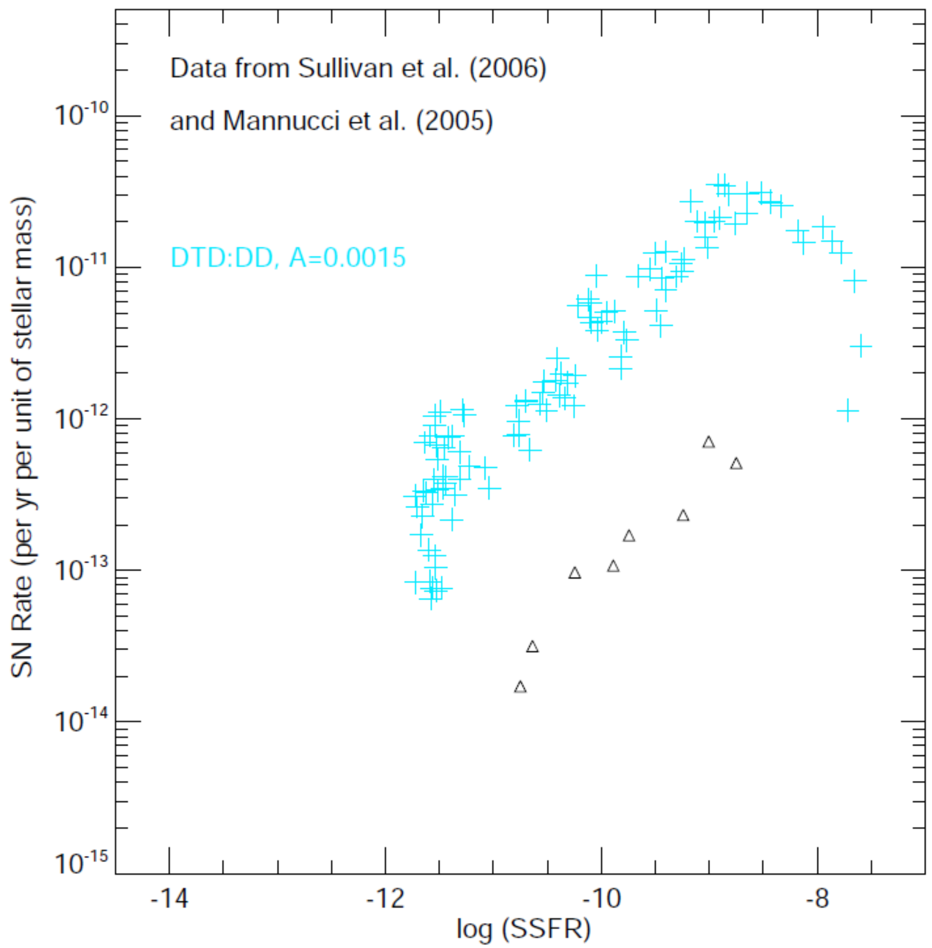
Original Model

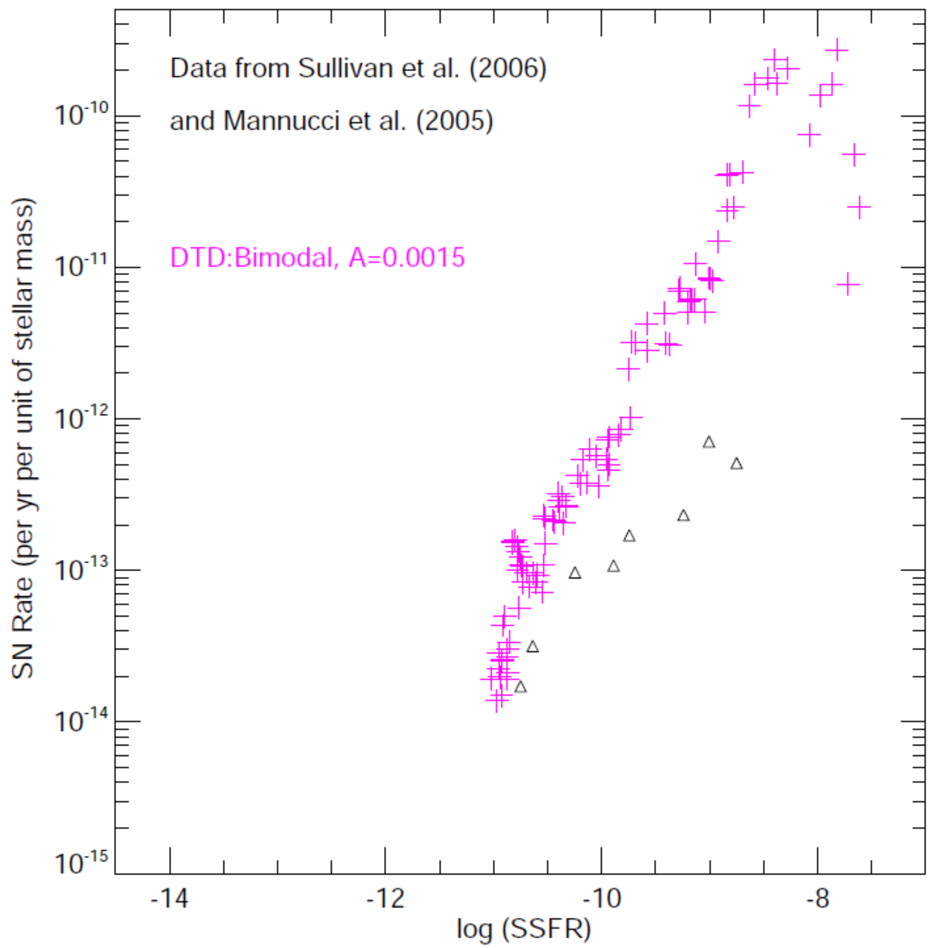


Comparision with data from Sullivan et al.(2010) and Mannucci et al.(2005)

Double Degenerated

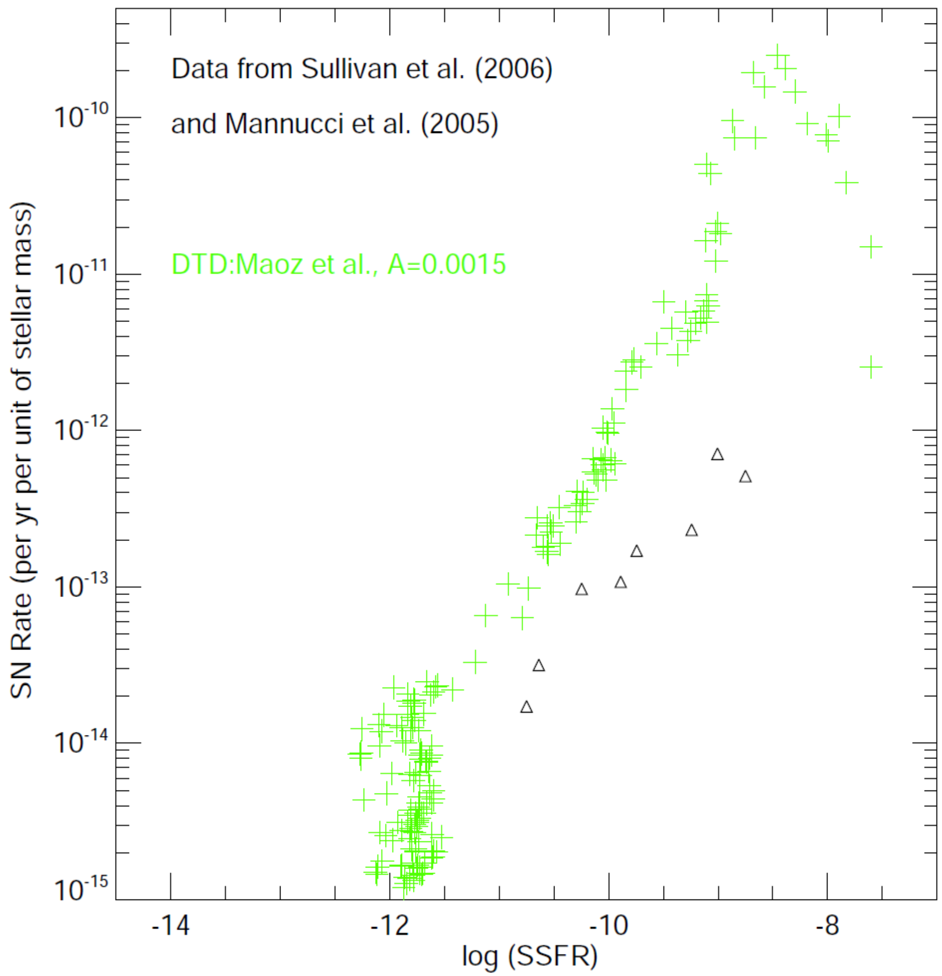
Bimodal



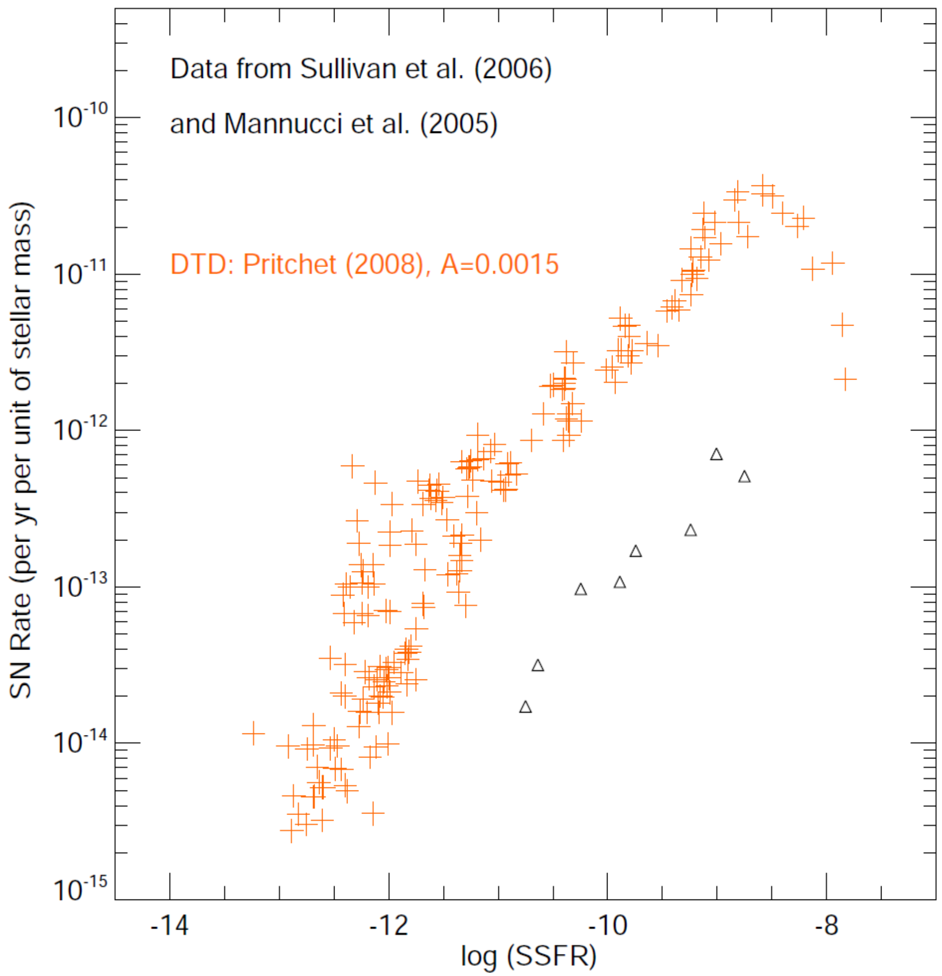


Empirical DTDs: potencial laws

Maoz et al. 2012



Pritchet et al. (2008)

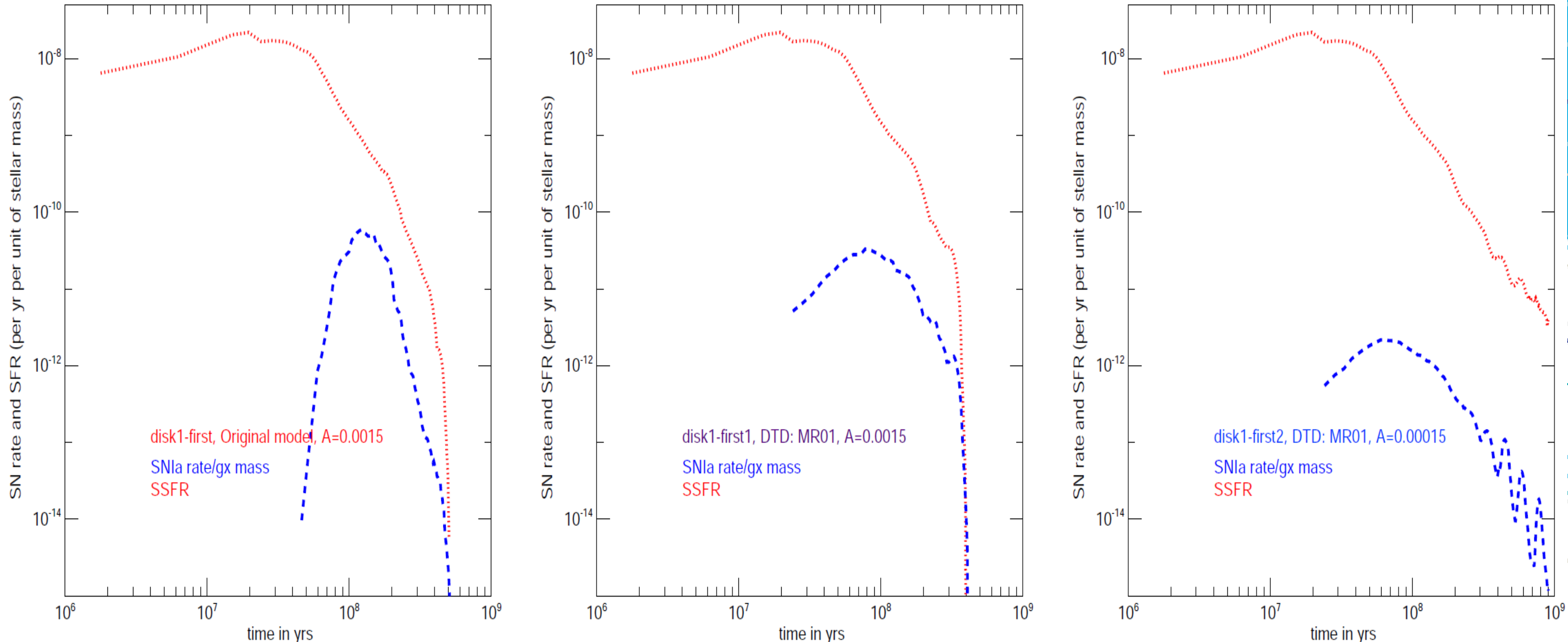


How can we explain these correlations?

SN Ia Rate/(galaxy mass)

SSFR=SFR/(galaxy mass)

evolving in time

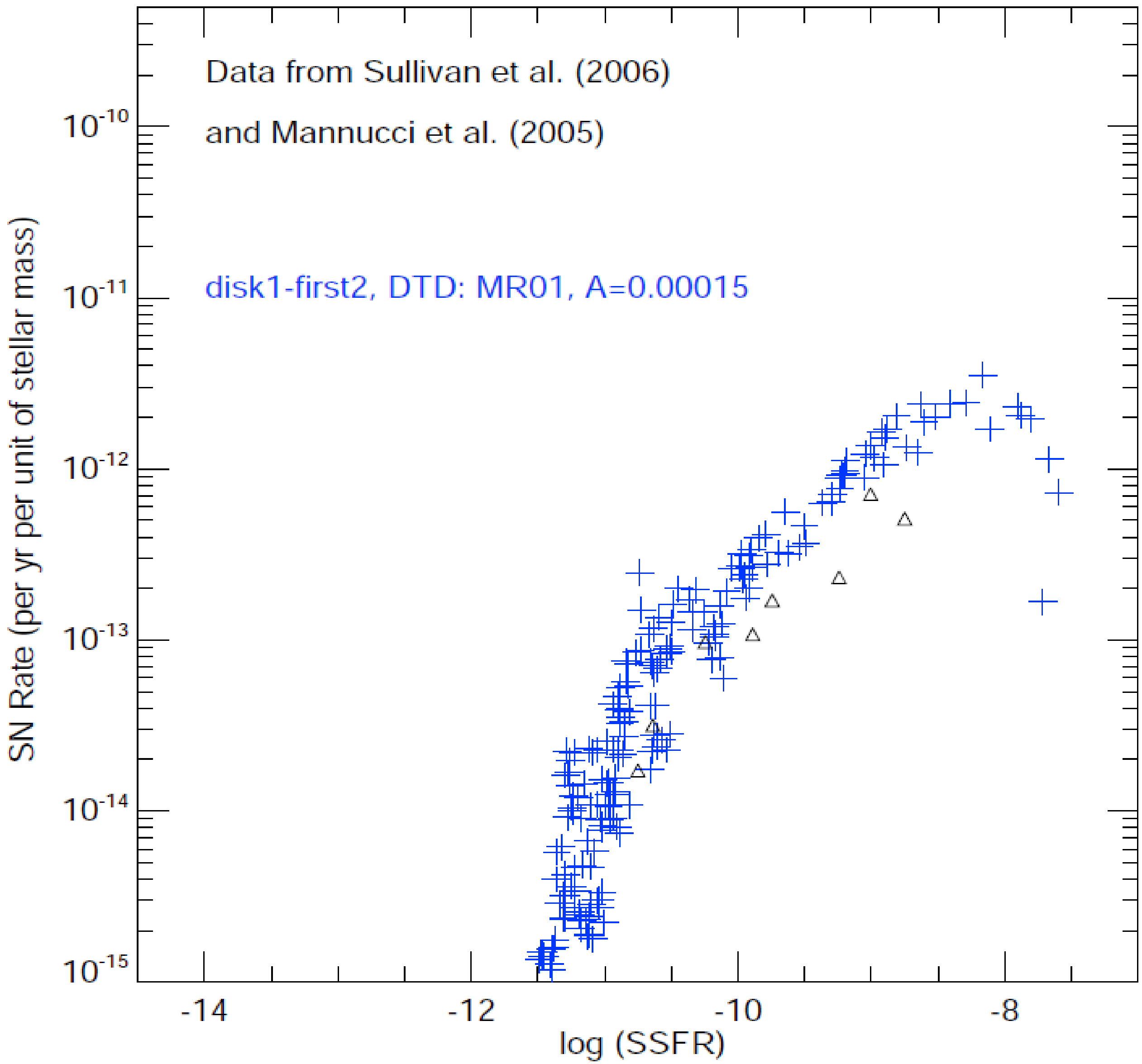


Original model, A=0.0015

MR01 with A=0.0015

MR01 with A=0.00015

Our Best model is MR01 with A=0.00015



Main Conclusions

We model galaxies with SPH-simulations including different DTDs

- In the SD scenario, varying the A parameter induces changes with respect to a original model (without DTD).
- **The chemical enrichment is more efficient with MR01, using the same A.** We obtain a fraction of 25% of the stars with with [Fe/H]>-0.5, compared to 20% in the original model.
- This also can be seen in the alpha-element of the stars
- **We reproduce the observed trends between the SSFR and SNIa rates per unit mass, given by Sullivan et al. (2010) and Mannucci et al. (2005), only when the DTD is present** and our **best scenario is the SD**. The correct normalization in our model is only obtained for **lowest A value**.

Thanks for your attention!

Observed and theoretical SNIa rates for elliptical galaxies

Simulation Name	A	SNIa rates (N/yrs). Observed value (Li et al. 2011)= 0.0011
disk1-first (original)	0.0015	0.0001
disk1-first1(DTD og MR01)	0.0015	0.0028
disk1-first2 (DTD of MR01)	0.00015	0.0005
disk1-first3 (DTD of MR01)	0.0075	0.047
disk1-first4 (DTD of MR01)	0.00075	0.0012

Data: Li et al. (2001)

Number of particles: initially con 9000 particles of gas and 9000 particles of DM
Resolution: this yileds to particles of masses of 1e8 Msun and gas particles of 1e7 Msun h-1

- **The IC are generated by radially perturbing the spheriod of superposed DM and gas particles to reproduce a cloud with a density profile of r^-1 and a radio of 100 kpc h^-1**

Threshold of critical density is 7e-26 grm cm^-3

Initial Conditions of the simulations

FactorSFR	0.1
CritOverDensity	57.7
CritPhysDensity	0.0318

en kpc

SofteningGas	0.225
SofteningHalo	0.45
SofteningDisk	0.3
SofteningBulge	0.3
SofteningStars	0.3375

CC	9.0	% halo concentration
V200	160.0	% circular velocity v_200 (in km/sec)
LAMBDA	0.044	% spin parameter

SN II

Salpeter IMF, with lower and upper mass cut-offs of 0.1 and 100 M , respectively, and assume that stars more massive than 8M end their lives as SNII

For the chemical production, we adopt metal-dependent yields of Woosley & Weaver (1995).

SN Ia

As a progenitor model, we adopt the model of I Iwomoto(1999)

The lifetime of the binary system is in the range τSNIa =[0.1, 1] Gyr, depending on the age of the secondary star!!

To estimate the number of SNIa, **we adopt an observationally motivated range for the relative ratio of SNIIand SNIa rates (van den Bergh 1991).**

Feedback and metal enrichment in cosmological smoothed particle hydrodynamics simulations - I. A model for chemical enrichment

C. Scannapieco, [1,2]⋆ P.B. Tissera,[1,2]⋆ S.D.M. White,[3]⋆ and V. Springel[3]⋆
[1] Instituto de Astronomía y Física del Espacio, Casilla de Correos 67, Suc. 28, 1428, Buenos Aires, Argentina
[2] Consejo Nacional de Investigaciones Científicas y Técnicas, CONICET, Argentina
[3] Max-Planck Institute for Astrophysics, Karl-Schwarzchild Str. 1, D85748, Garching, Germany

Feedback and metal enrichment in cosmological SPH simulations – II. A multiphase model with supernova energy feedback

C. Scannapieco [1,2]⋆, P.B. Tissera[1,2]⋆, S.D.M. White[3]⋆ and V. Springel[3]⋆
[1] Instituto de Astronomía y Física del Espacio, Casilla de Correos 67, Suc. 28, 1428, Buenos Aires, Argentina.
[2] Consejo Nacional de Investigaciones Científicas y Técnicas, CONICET, Argentina.
[3] Max-Planck Institute for Astrophysics, Karl-Schwarzchild Str. 1, D85748, Garching, Germany.