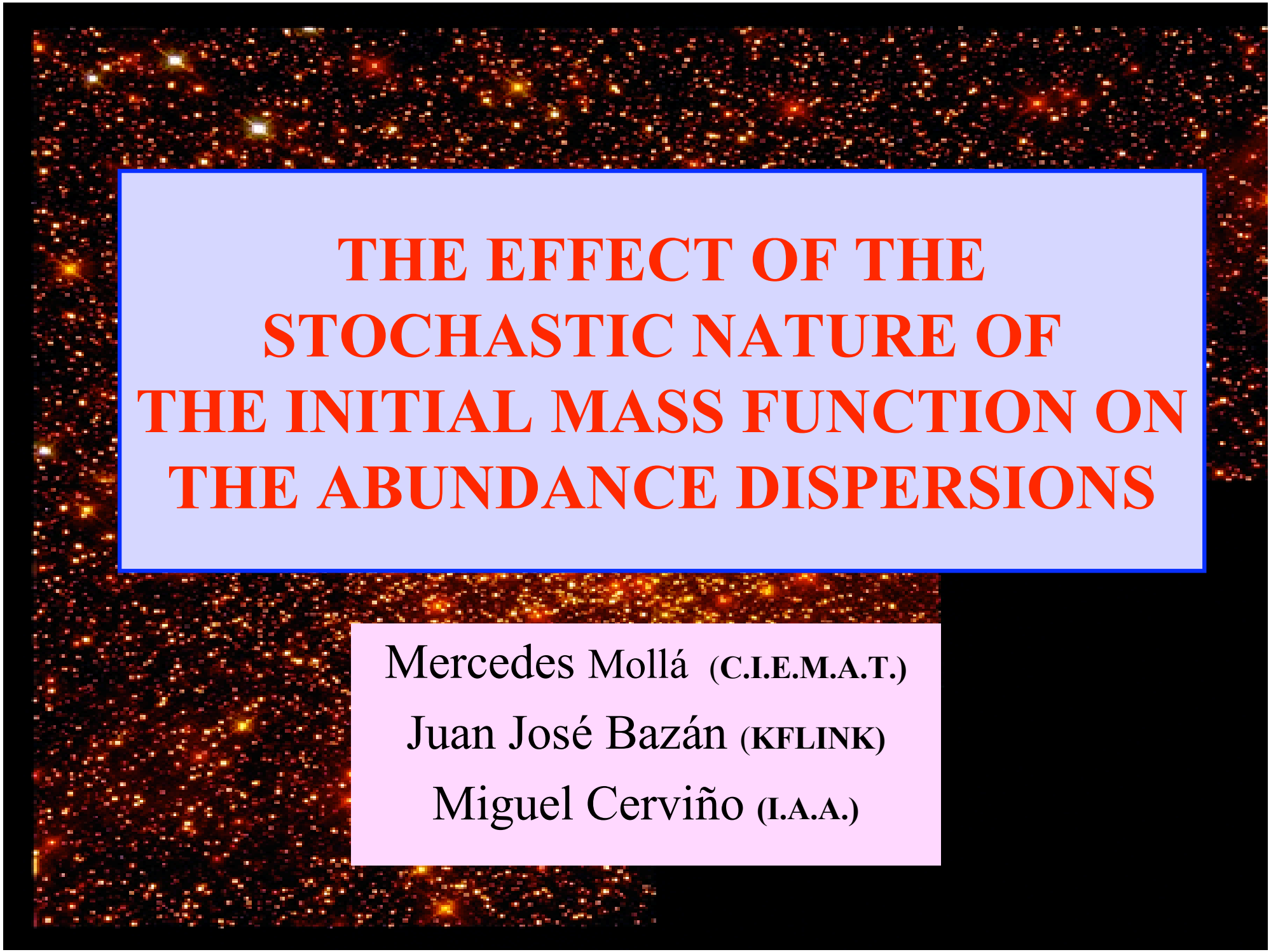


THE EFFECT OF THE STOCHASTIC NATURE OF THE INITIAL MASS FUNCTION ON THE ABUNDANCE DISPERSIONS

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Abstract

Purpose: to analyze if variations in the IMF due to its stochastic nature may have important effects on the final chemical abundances measured in the ISM.

Results:

1. A high dispersion around the expected averaged abundance appears if the stars form in clusters as small as 10^3 or 10^4 Msun.
2. The dispersion depends on mass of the stellar cluster, decreasing below the error bar when this is 10^5Msun.

The work method of chemical evolution models

- **The aim of chemical evolution is to determine with the largest precision the abundances existing in studied regions or galaxies.**
- **It also tries to undestand which mechanims (star formation, in or out gas fluxes, stellar or galactic winds...) are determining those abundances.**

Two usual tools are used:

1)The observation of a given region or galaxy for estimating the elemental abundances;

2) The calculation of expected abundances by codes or models including as ingredients the different hypothesis which will be tested.

By comparing the model results with data, the goodness of those hypotheses is determined.

THE PROBLEM

1. The numerical codes are extraordinarily improved. The actual capabilities of computers allow an unprecedent power of calculation.

2. The external errors are easily determined comparing the obtained results by different models with similar or equal input parameters (Tosi 1995).

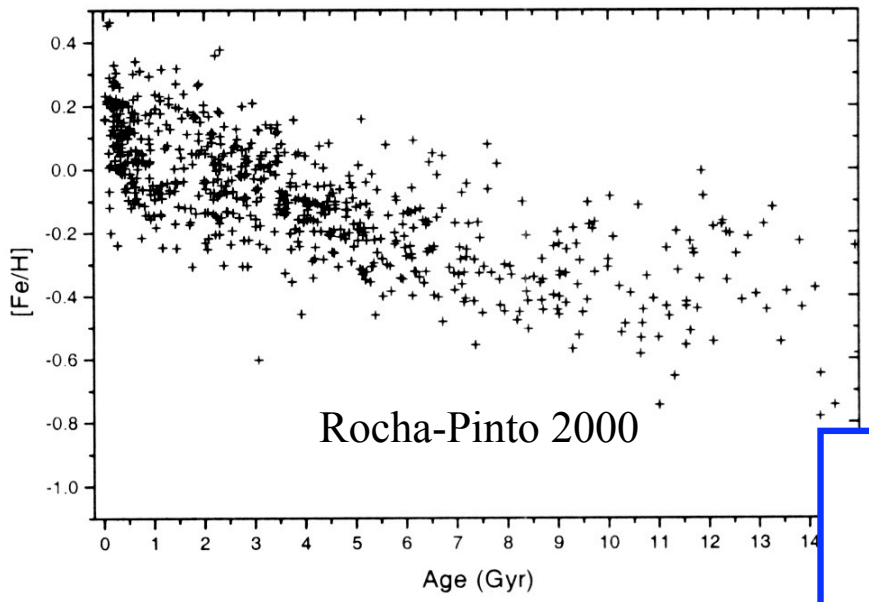
3. However, in contrast with this well established goodness of theoretical models, the study of their errors and statistical variations has not been payed attention.

On the other hand, the chemical abundance data show a very large dispersion. In particular in our Galaxy, and in the Solar Neighborhood, where the number of data is high enough to allow a statistical study, we observe abundances very different.

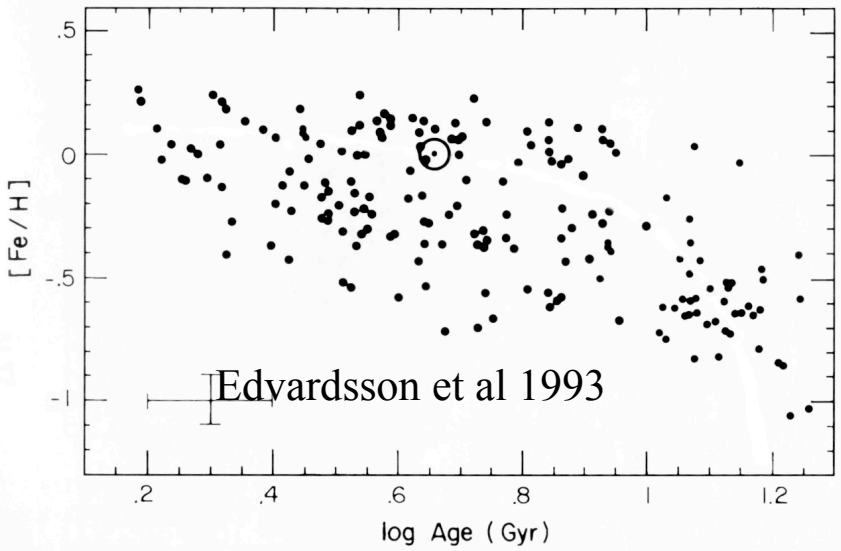
The dispersion is larger than the data error bar

Abundance Data:

Age-metallicity relation

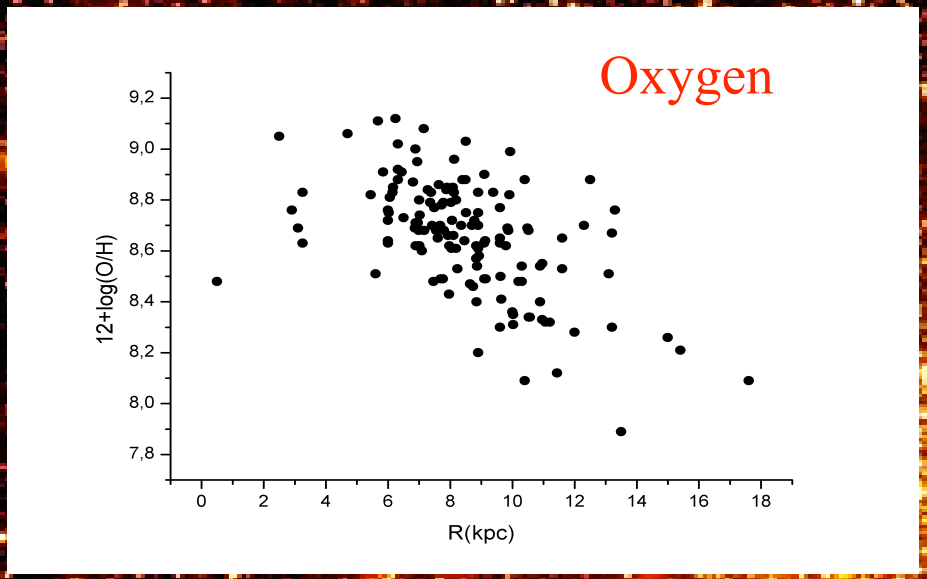


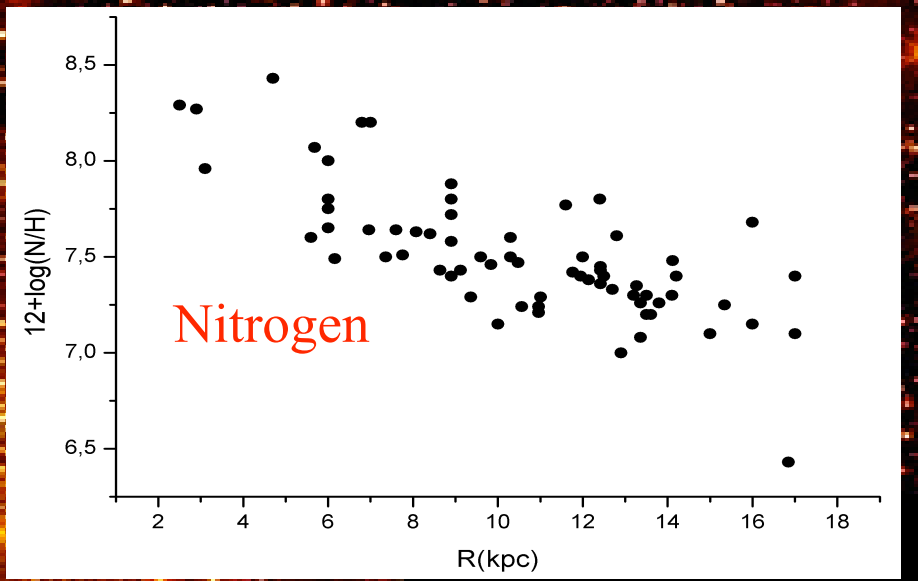
Rocha-Pinto 2000

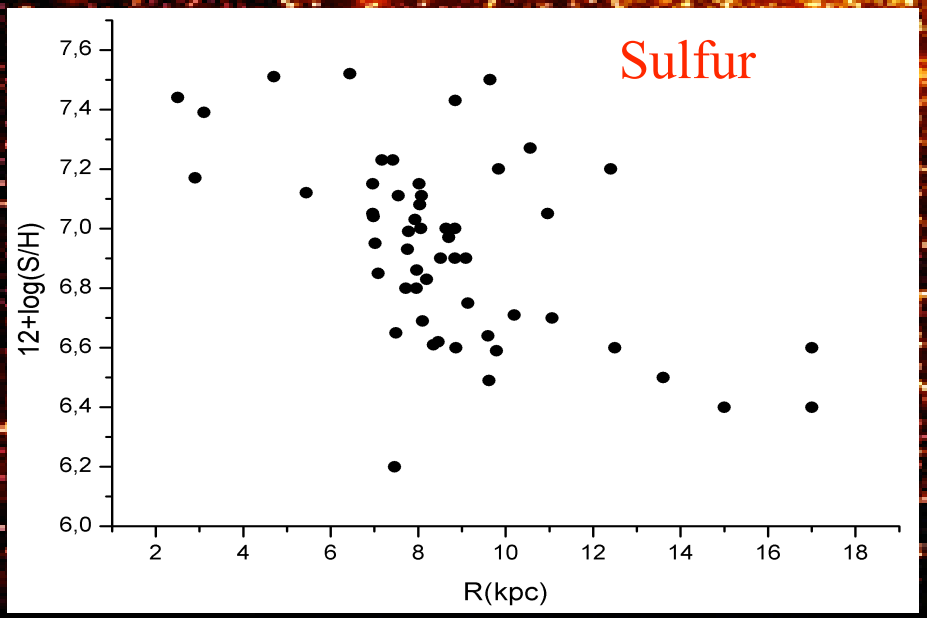


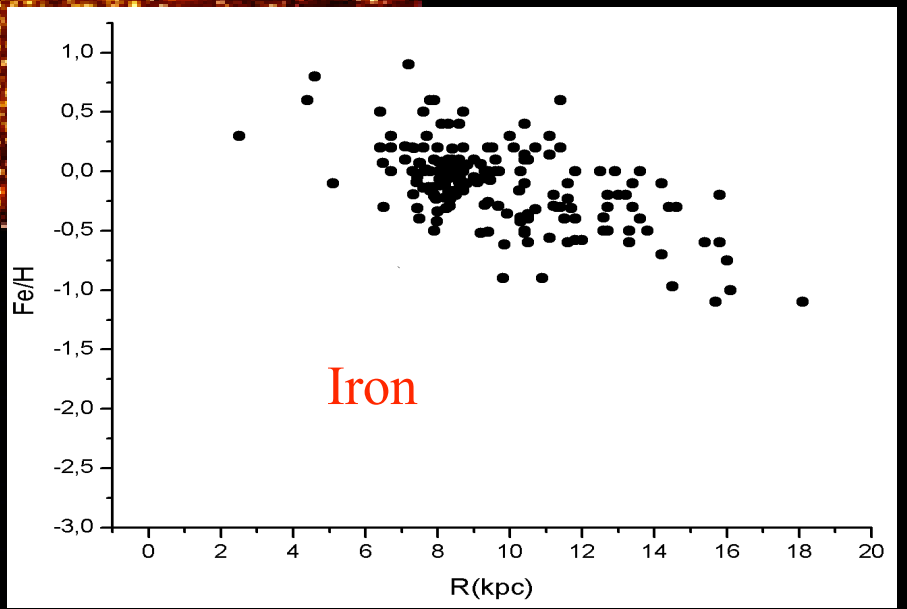
Edvardsson et al 1993

Abundance Data: Radial Gradients









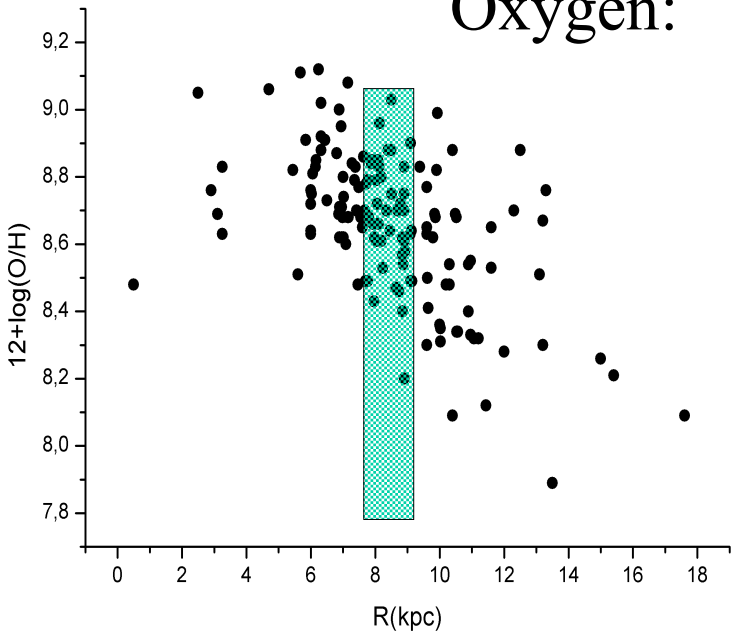
The multiphase model

Based in Ferrini et al.1992

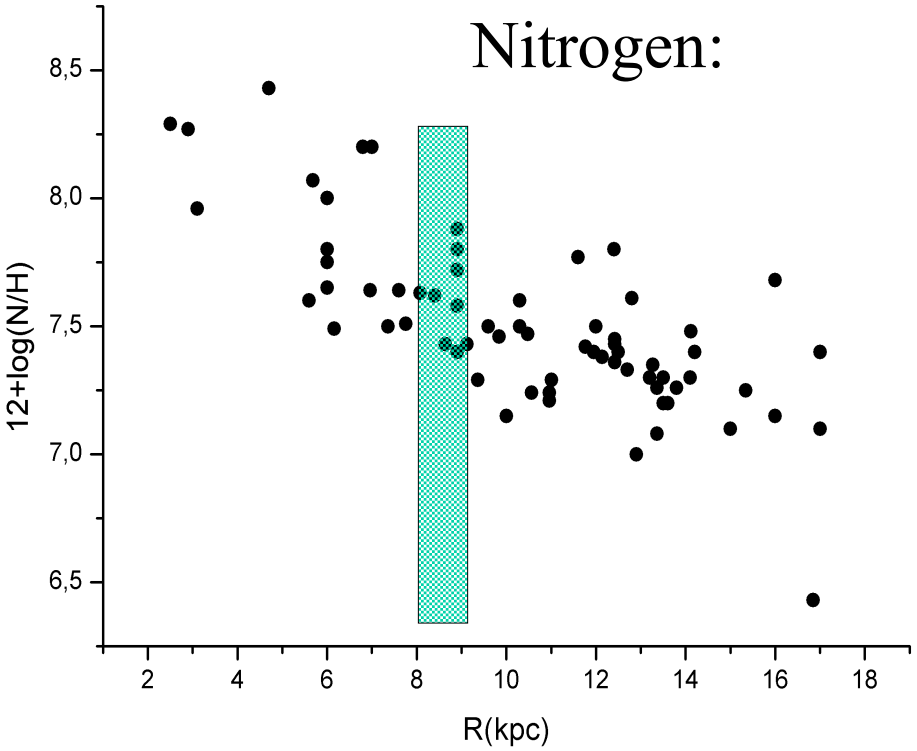
Characteristics:

- Applied to the Solar Neighbourhood
- Z = 0.02
- $$\Phi(m) = 2.0865 m^{-0.52} \, x \, 10^{-[2.07(\log m)^2 + 1.92 \log m + 0.73]^{\frac{1}{2}}}$$
- Nucleosynthesis yields for massive stars (WW) ,
  LIM stars (Buell) and SN Ia (Nomoto W7, Iwamoto)
- Evolución: 13,2 Gyrs. Tiempo de integración 0.01 Gyrs

Oxygen:



Nitrogen:



We applied this work only to the Solar Region (around 8.5 kpc)

Chemical Evolution Model

$\Phi(m)$

$q_{i,j}$ = fraction of the mass of the star initially in form of element j which is transformed in element i and then ejected

Calculation of the matrix elements

$(Q_{i,j})$

The evolutionary model

0-13. Gyr

$$Q_{ij} = \int_0^{\infty} \Phi(m) q_{ij} dm$$

Elemental Abundances:

H, C, N, O,... Fe...

THE ANALYTICAL MODEL RESULTS

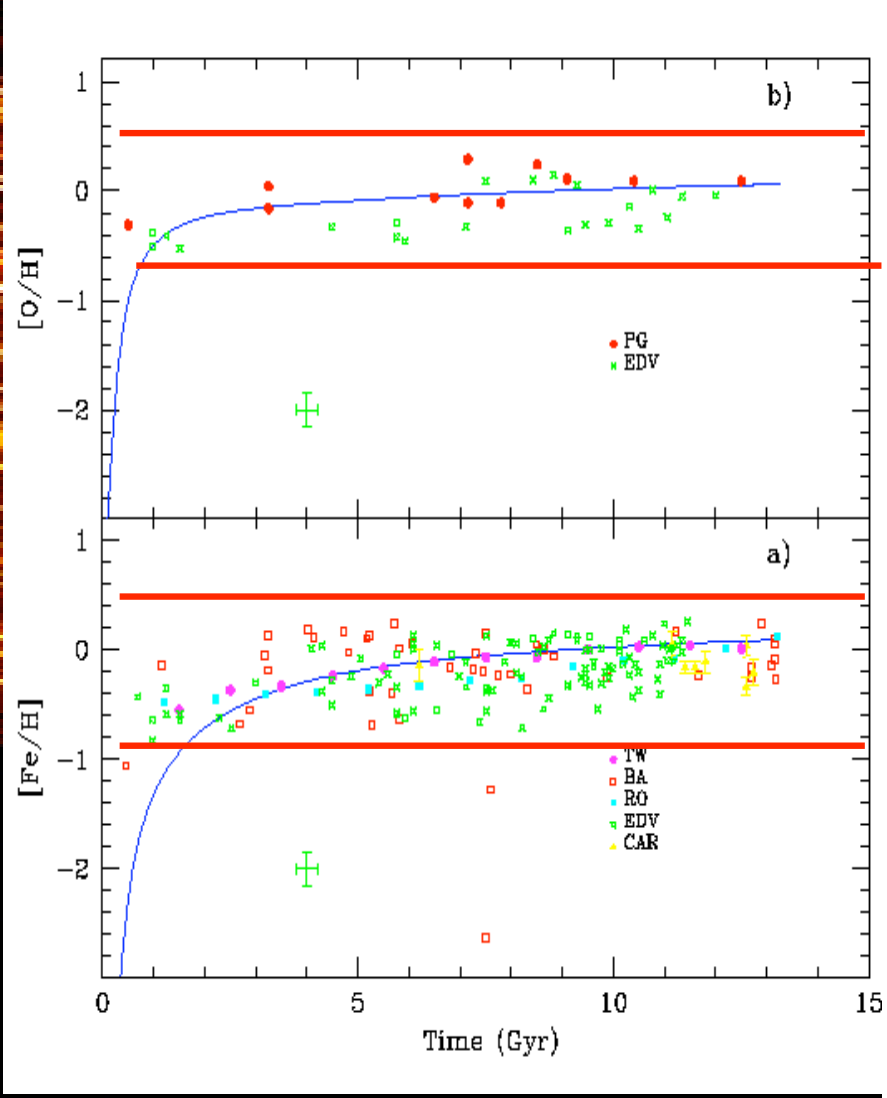
The abundances obtained with the multiphase model using an analytical IMF can not explain the observed dispersion

The initial mass function represents the quantity of stars, in each mass range, existing in the initial moment of the star formation burst.

When these distributions are included in a theoretical model, they are implemented as analytical laws,

only valid on ideal conditions, when an infinite number of stars are created in a burst and when no fluctuations are assumed.

The model only represent sthe generic trends of the evolution, and, obviously, no dispersion is associated to its results.



THE POSSIBLE SOLUTION

- **We will analyze the posibility that the dispersion be due to the the stocastic nature of this IMF**
- **In that case it will show variations when stars are created in very massive clusters or when they refer to regions with a small number of stars .**
- **We use a chemical evolution model which assume a instantaneous mixig of elements**

We take into account the real conditions imply that the number of stars involved in a given burst is an integer and finite quantity.

OTHER WORKS

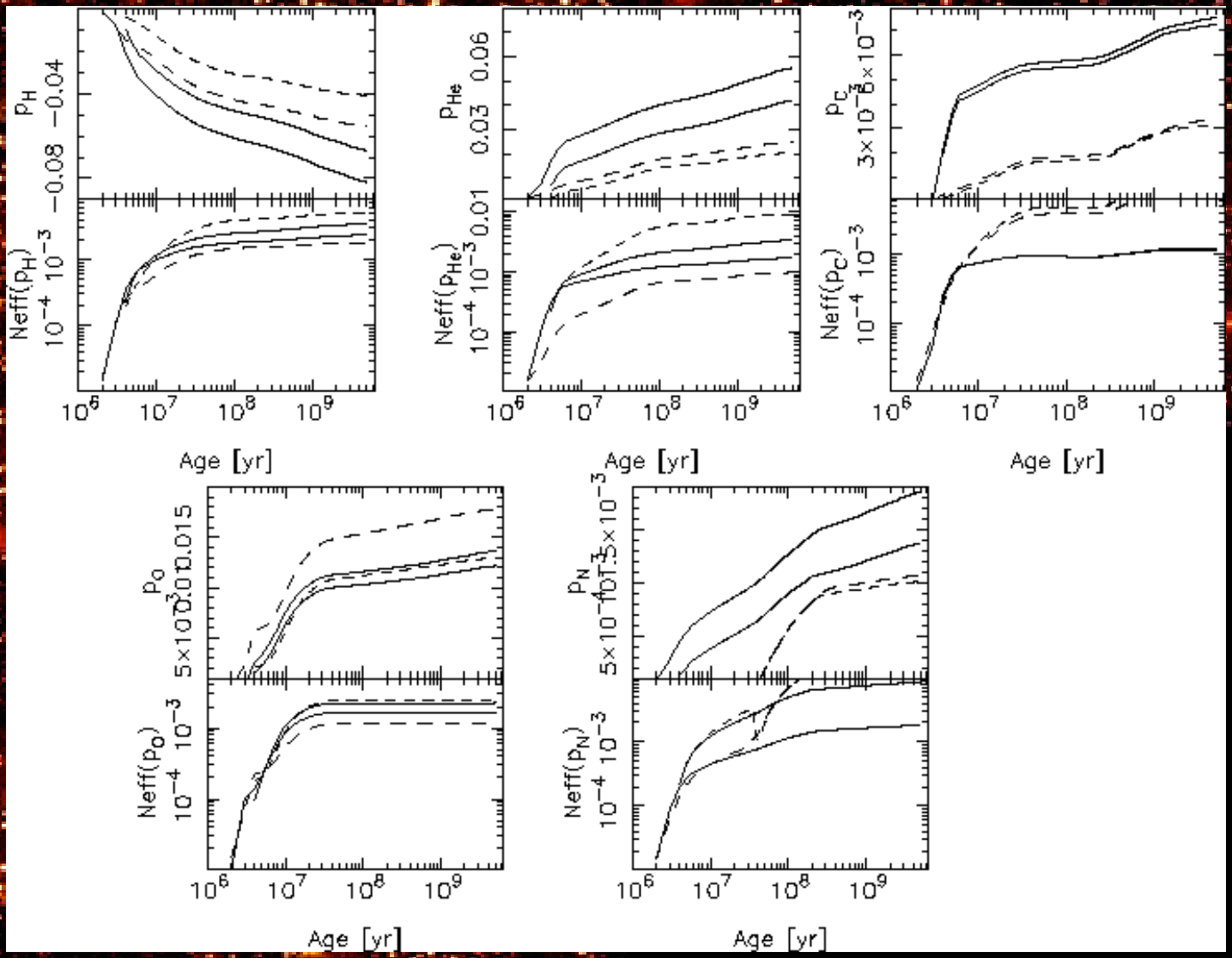
Some recent works by Cerviño et al. (2000,2001) face this problem in the evolutionary synthesis models.

In those works the expected dispersion on these codes results, calculated as a consequence of a poissonian behavior of the IMF, is shown.

They also computed some models based in MonteCarlo simulations for different total mass of the clusters.

The most important result is that a cluster of 10^6 M_0 will show a very small dispersion, while other with 10^4 M_0 may show a dispersion as large as 10% in the data.

RESULTS USING A CLOSED BOX MODEL



Cerviño & Mollá (2002)

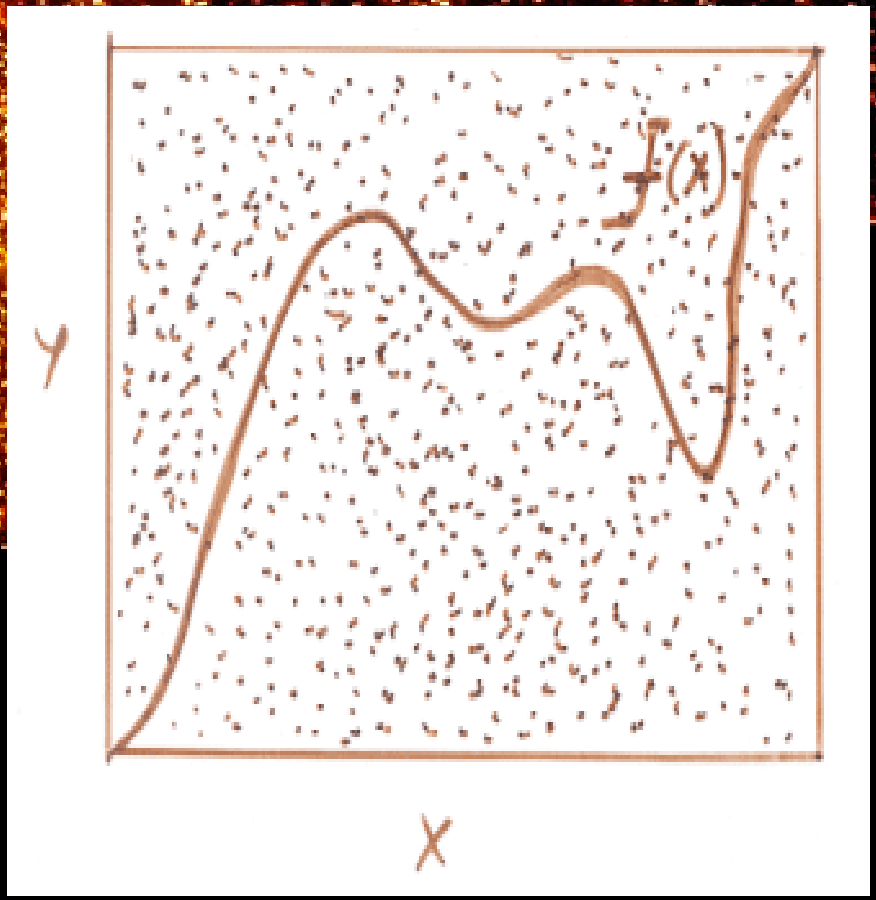
Method: Montecarlo Simulations

We will run some calculations where the IMF is computed from MonteCarlo simulations, in order to see if abundances actually show a dispersion similar to this one observed.

We use a generator of random numbers with a uniform distributions (randgen from Richard Chandler and Paul Northrop).

We transform the generated points to the desired probability: the IMF. For that we only accept the x number as a valid mass if

$$\Phi(x) \leq y$$

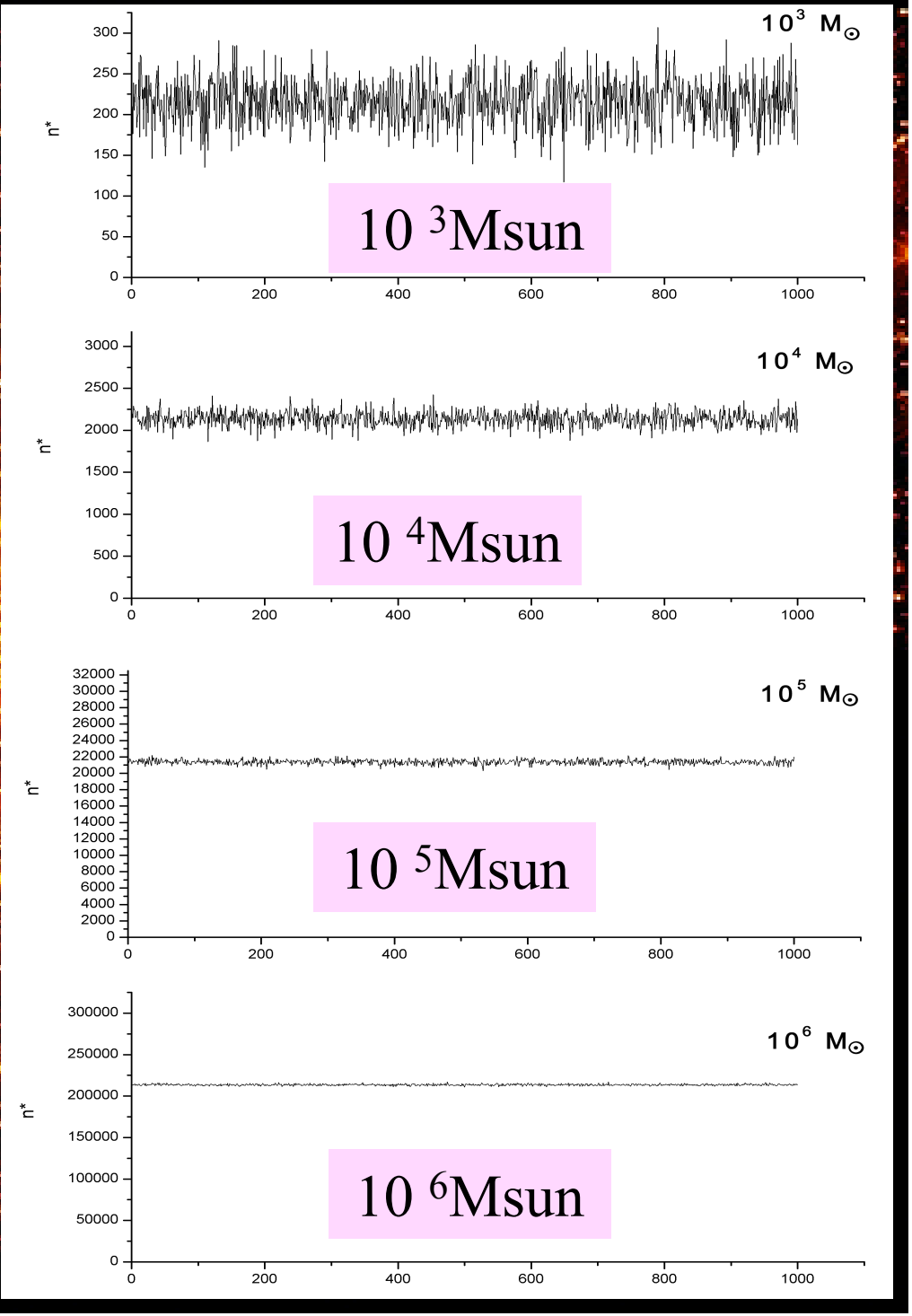


Calculated Models

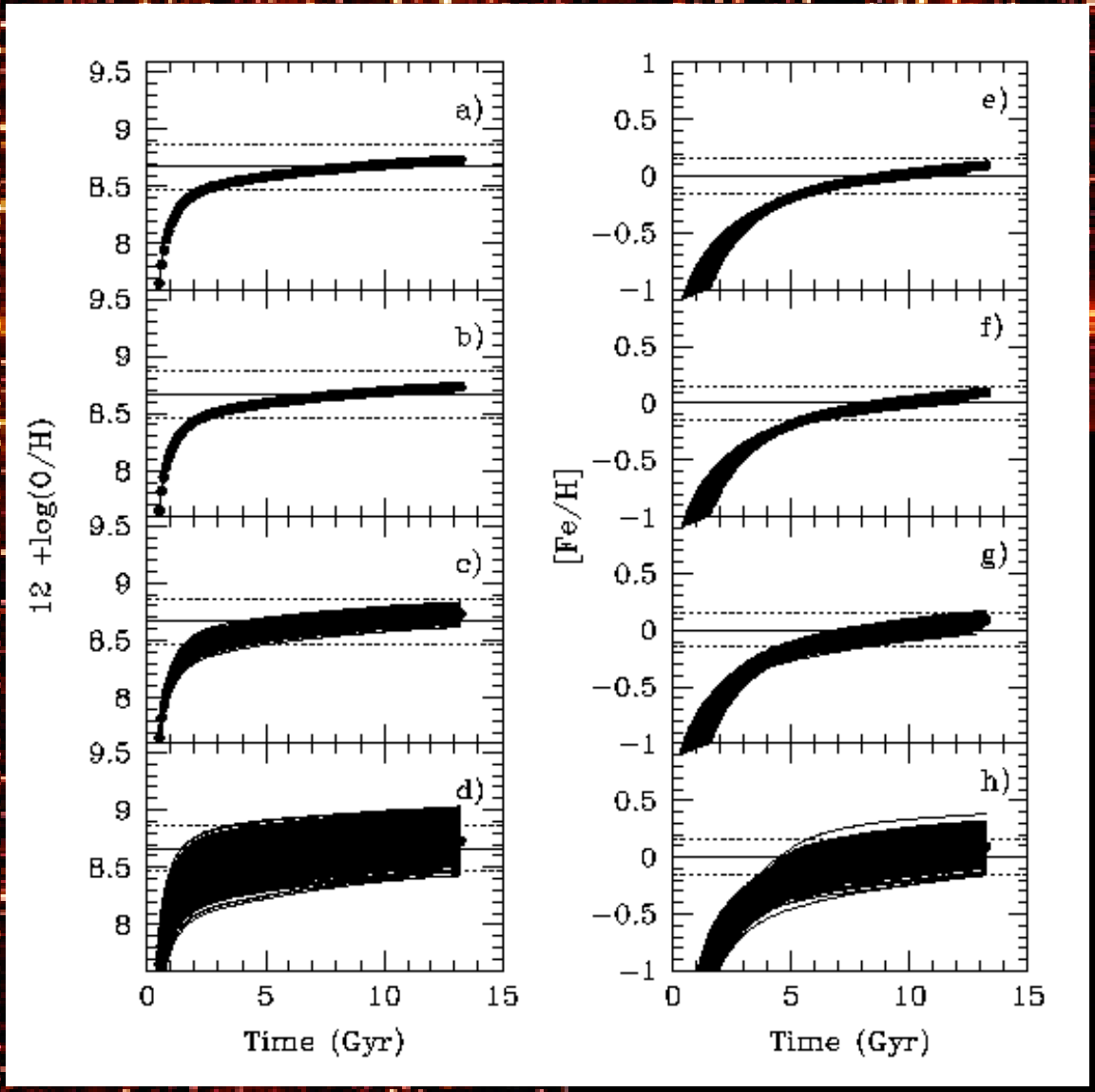
- **We perform 1000 simulations of IMF for 4 sets of models.**
- **For each one of this set we take a different total mass in the stellar clusters:**
  - **A) 10^6 (similar to the analytical model)**
  - **B) 10^5**
  - **C) 10^4**
  - **D) 10^3**
- **The total star formation history is always the same, it is not stochastic.**

RESULTS

- Number of stars for 4 sets Each one of them with a different total mass formed in a stellar cluster
- A matrix Qij for each model: 1000 matrix in each set
- We run our chemical evolution model using these matrices, one for each realization

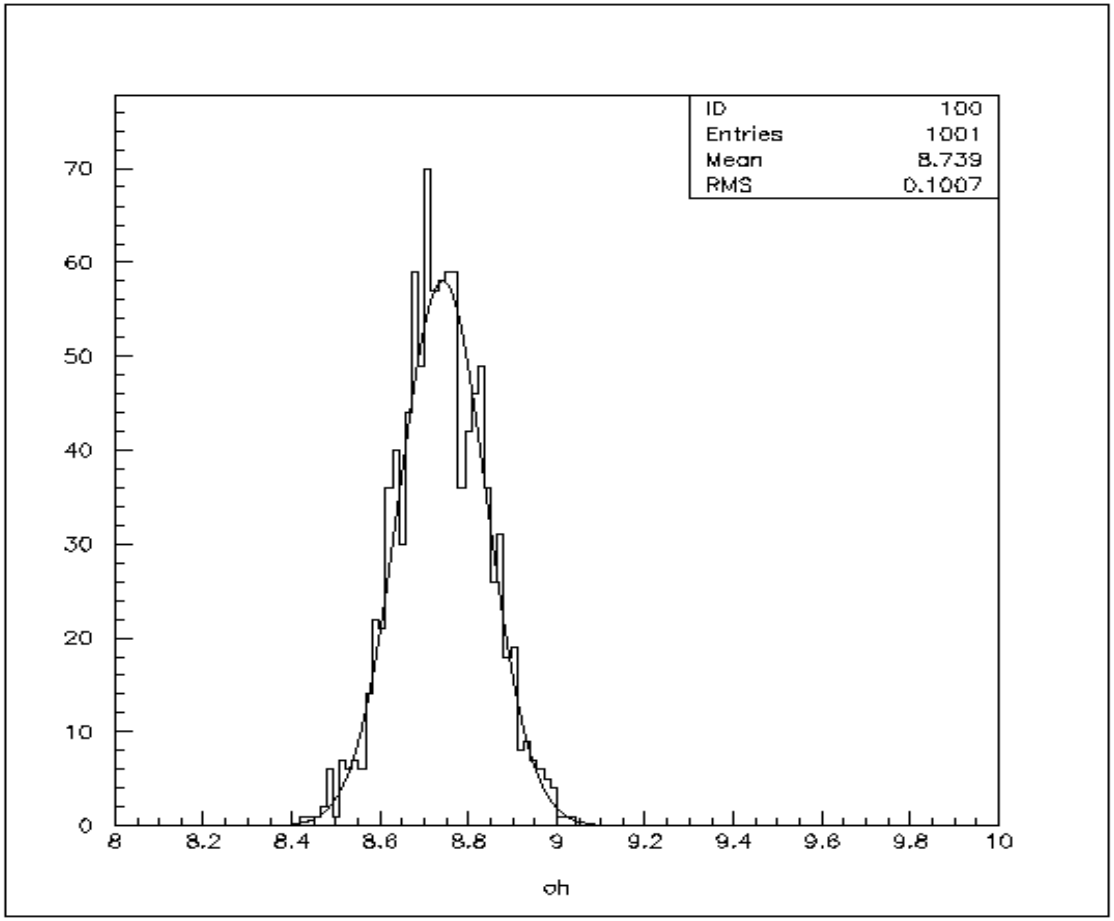


RESULTS: OXYGEN AND IRON ABUNDANCES

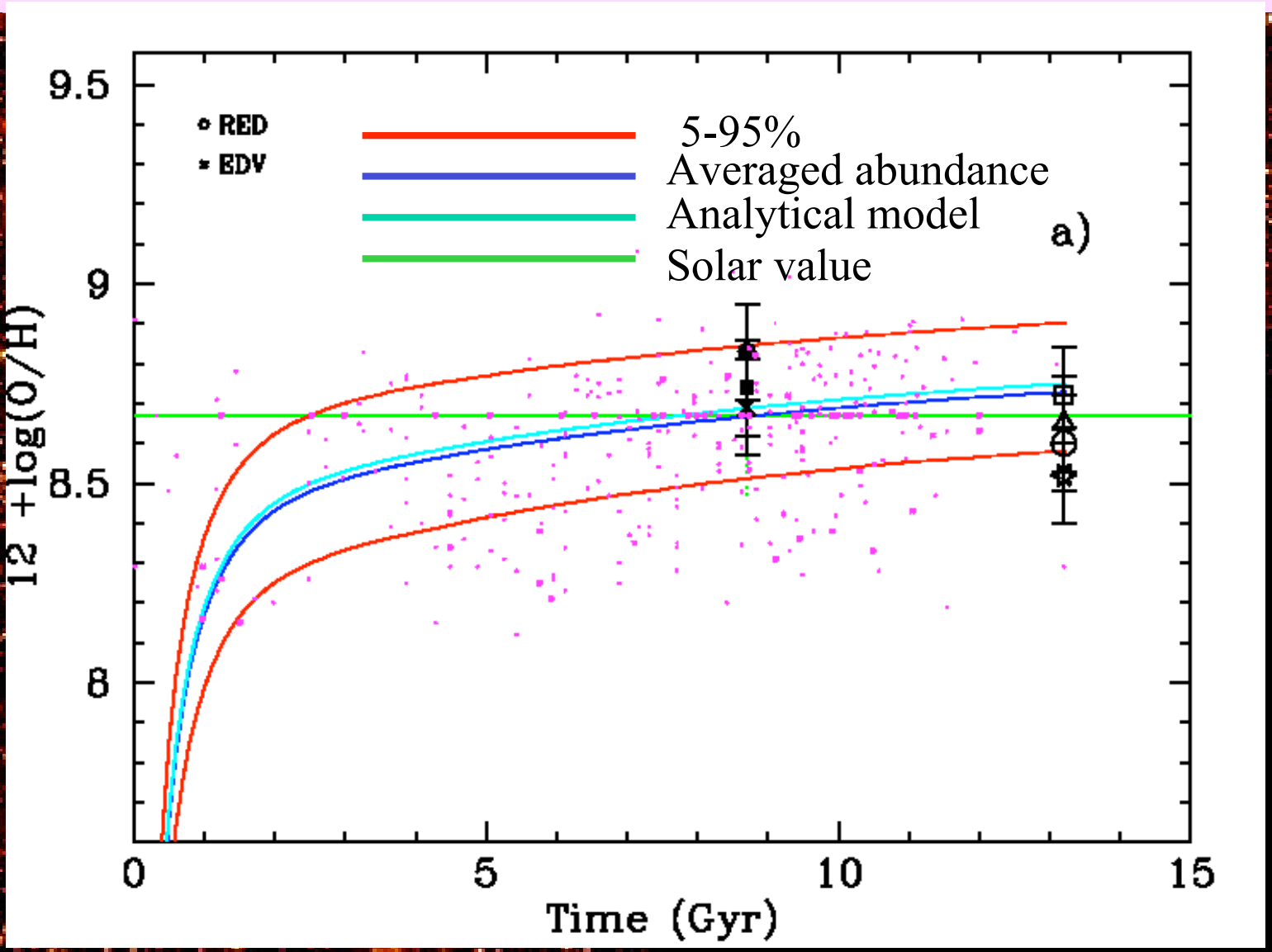


Abundances in a given time may be represented by a gaussian curve:

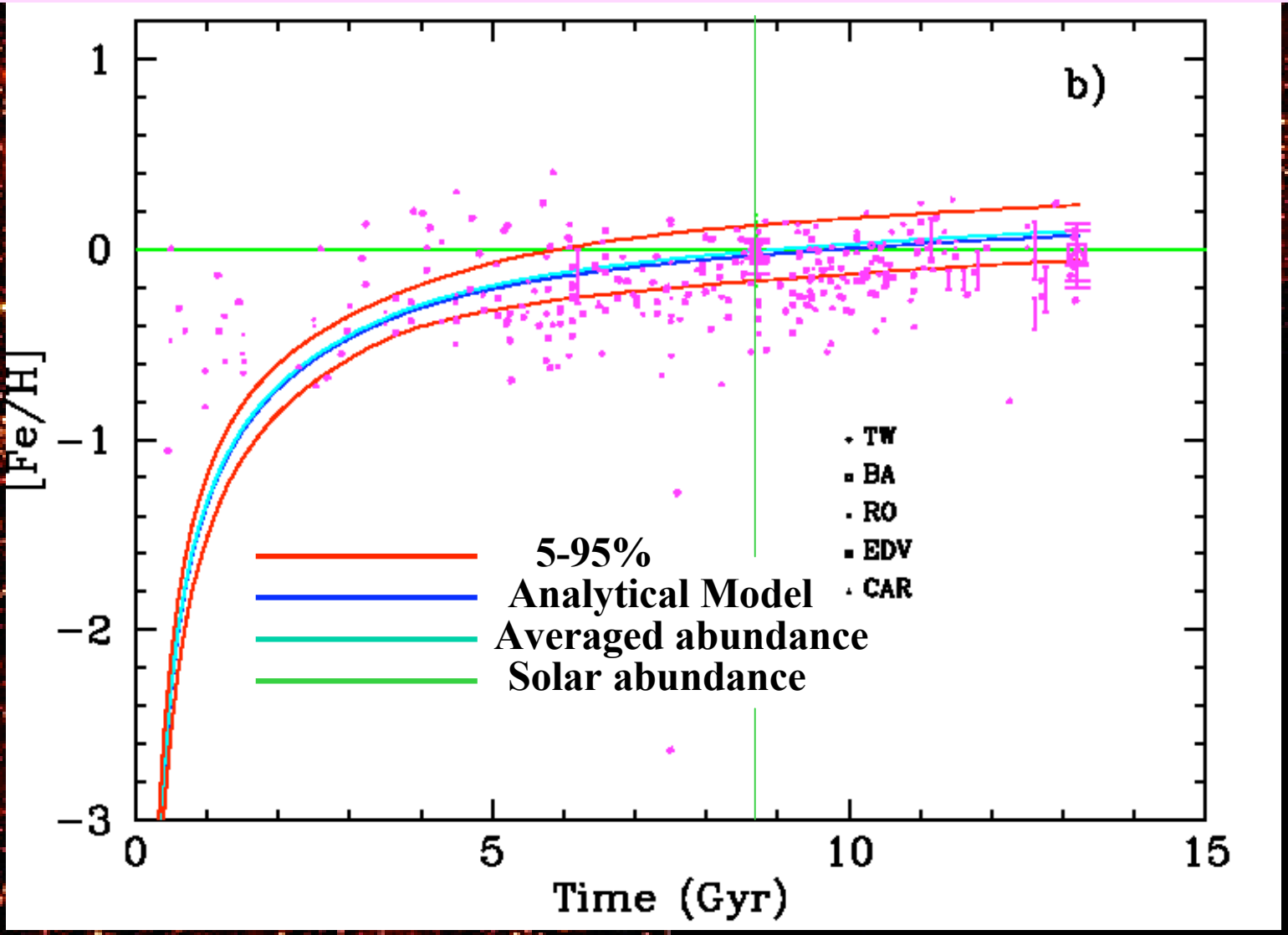
The averaged value and dispersions may be computed



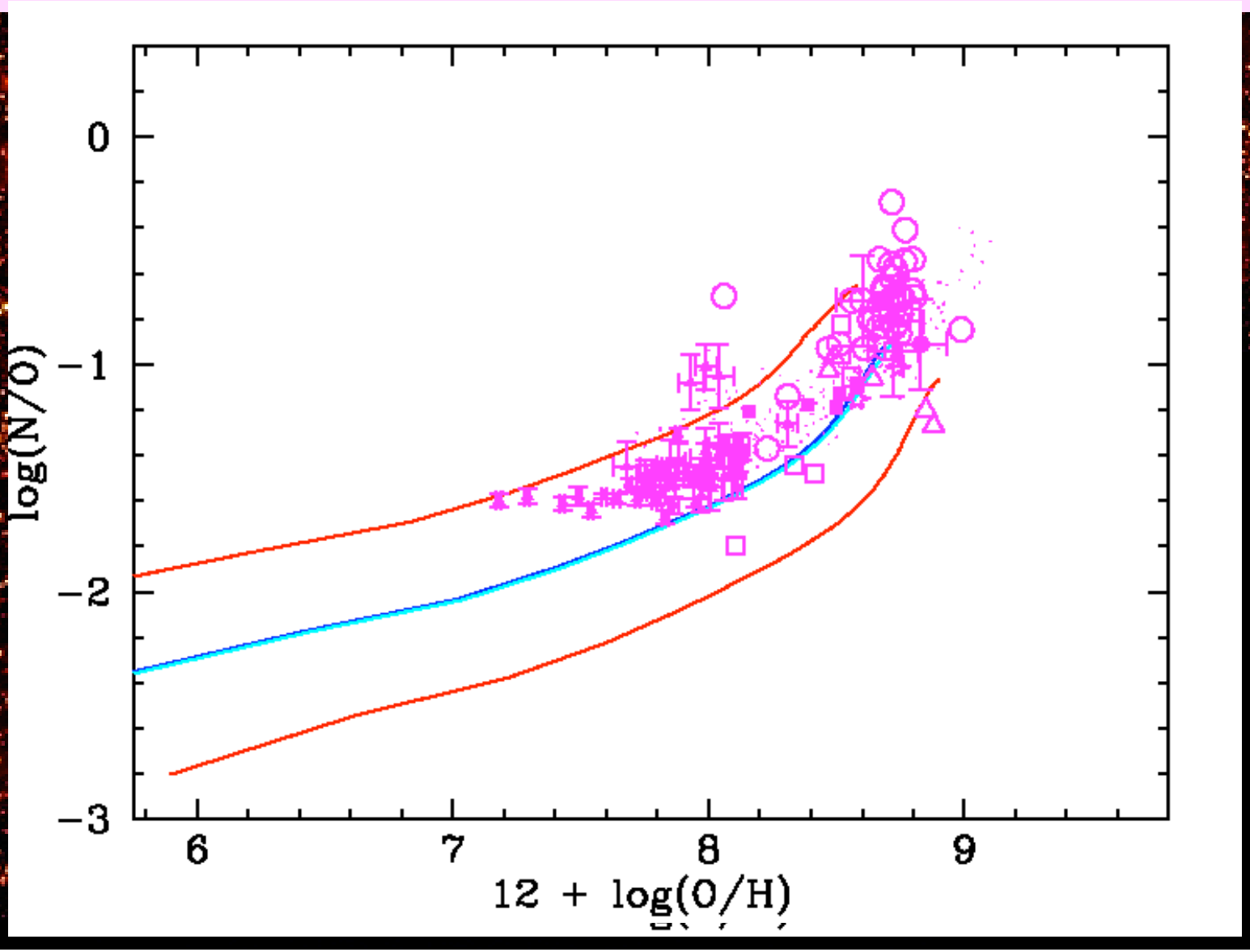
RESULTS FOR DIFFERENT TOTAL MASS OF THE STELLAR CLUSTER :OXYGEN



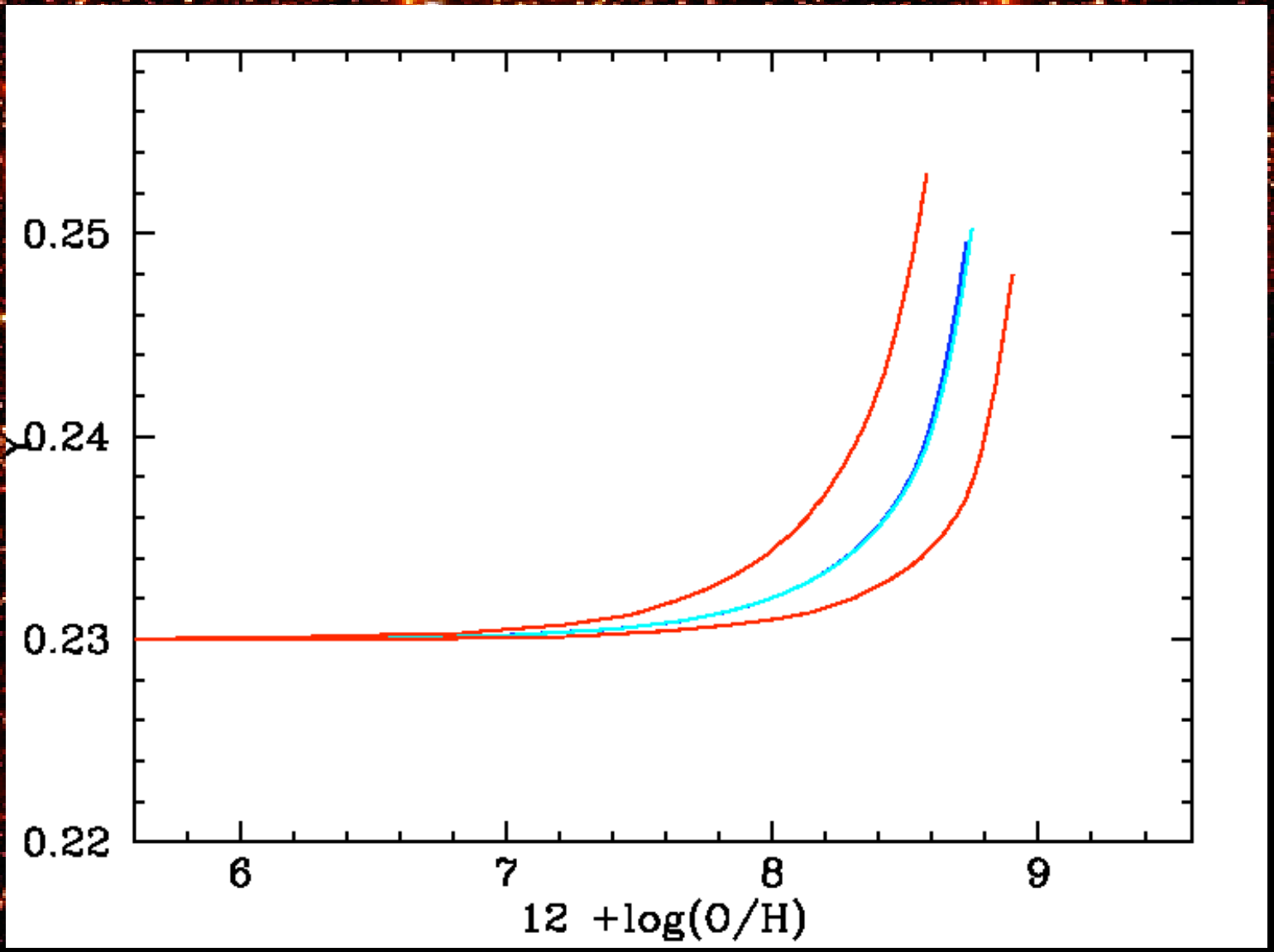
RESULTS FOR DIFFERENT TOTAL MASS OF THE STELLAR CLUSTER : IRON



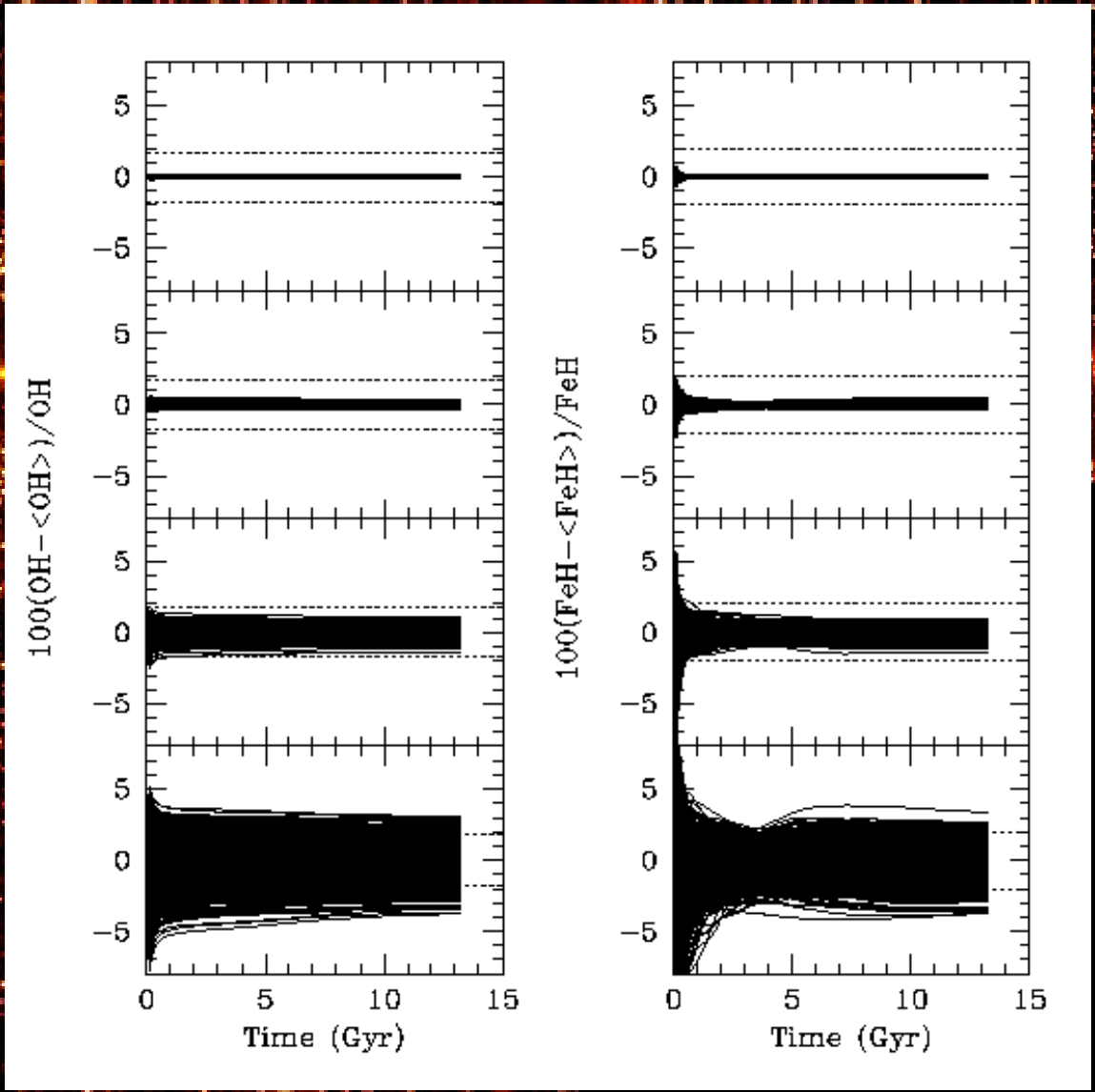
RESULTS FOR DIFFERENT TOTAL MASS OF THE STELLAR CLUSTER : N/O



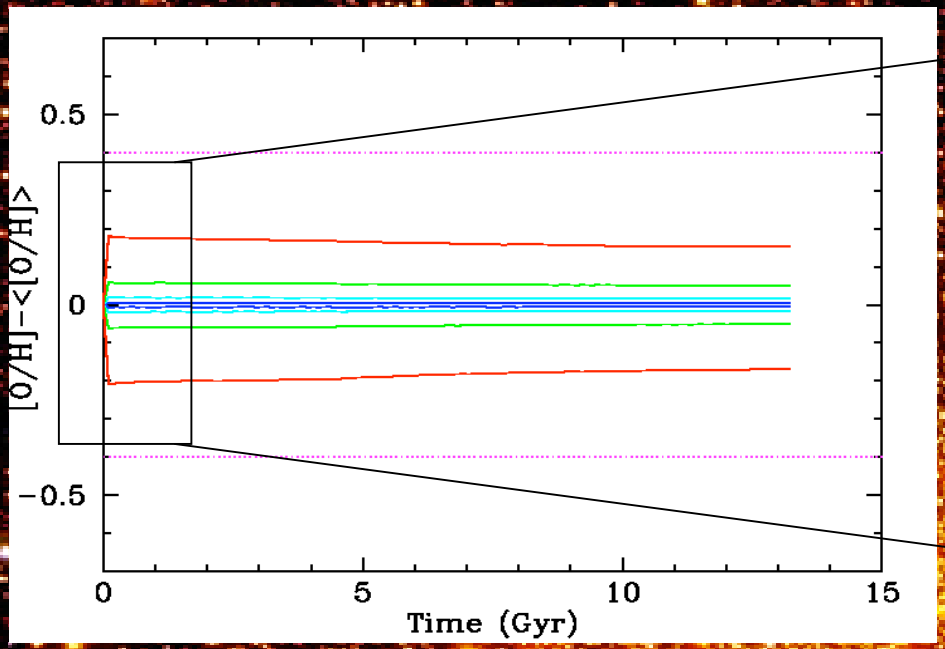
RESULTS FOR DIFFERENT TOTAL MASS OF THE STELLAR CLUSTER : HELIUM

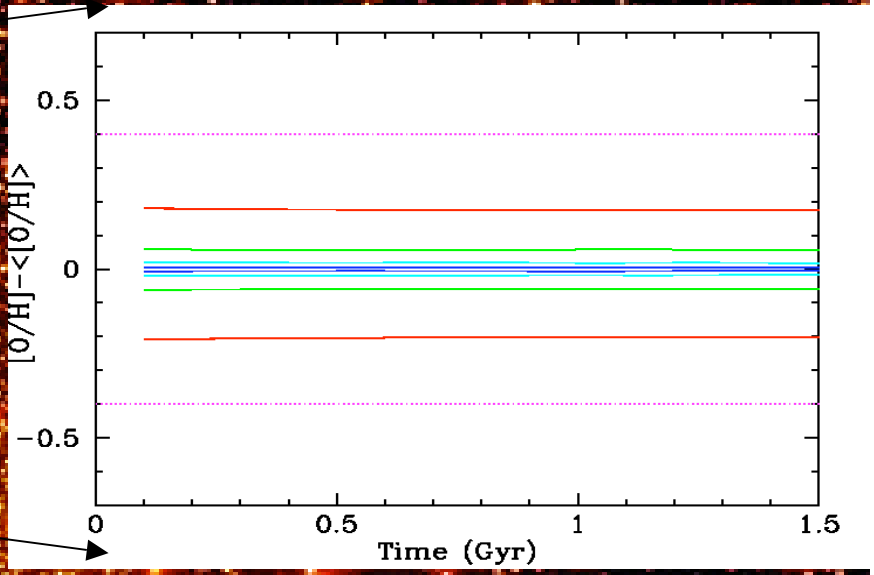


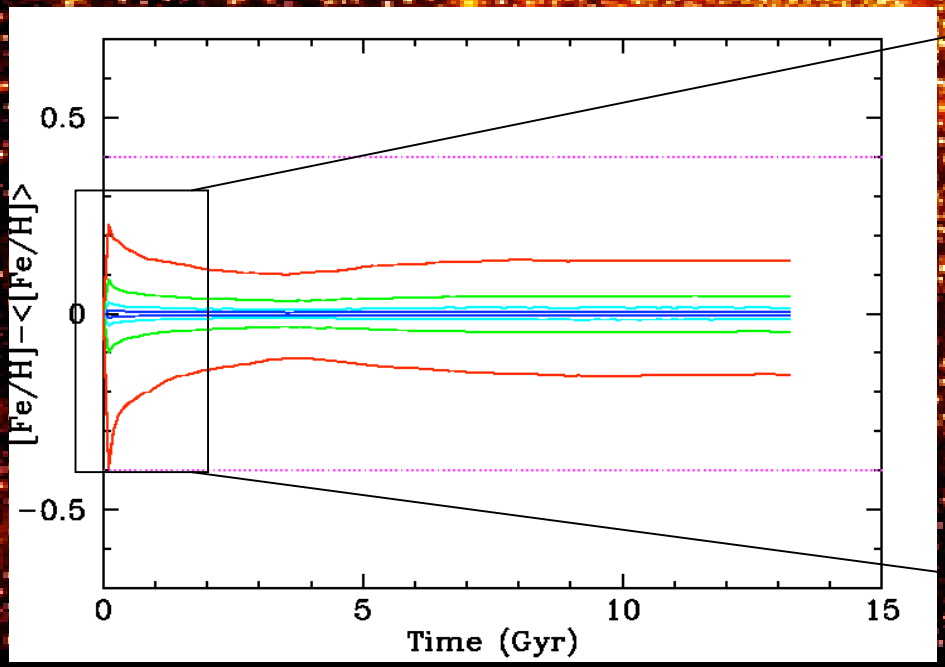
RESULTS FOR DIFFERENT TOTAL MASS OF THE STELLAR CLUSTER : DISPERSIONS

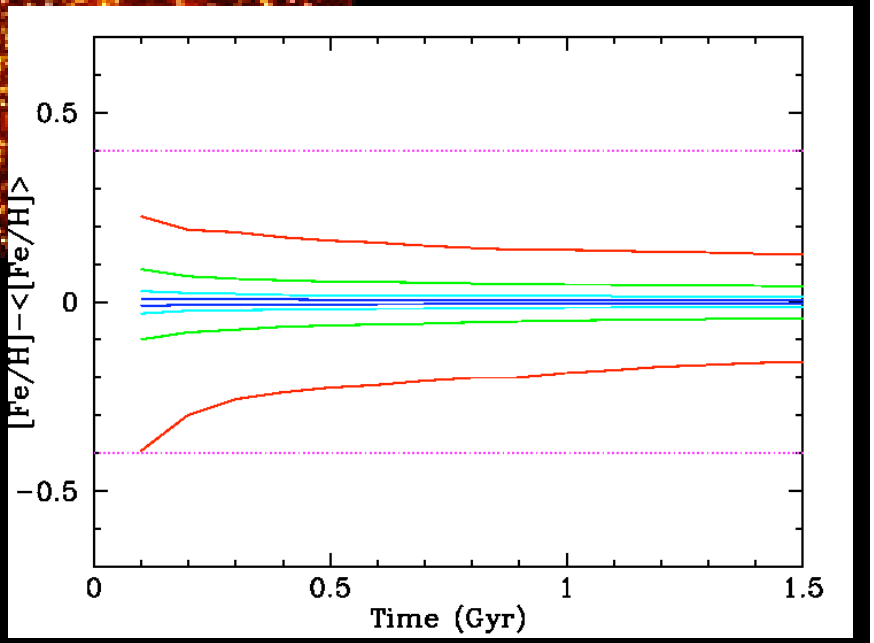


DISPERSIONS: [O/H] and [Fe/H]







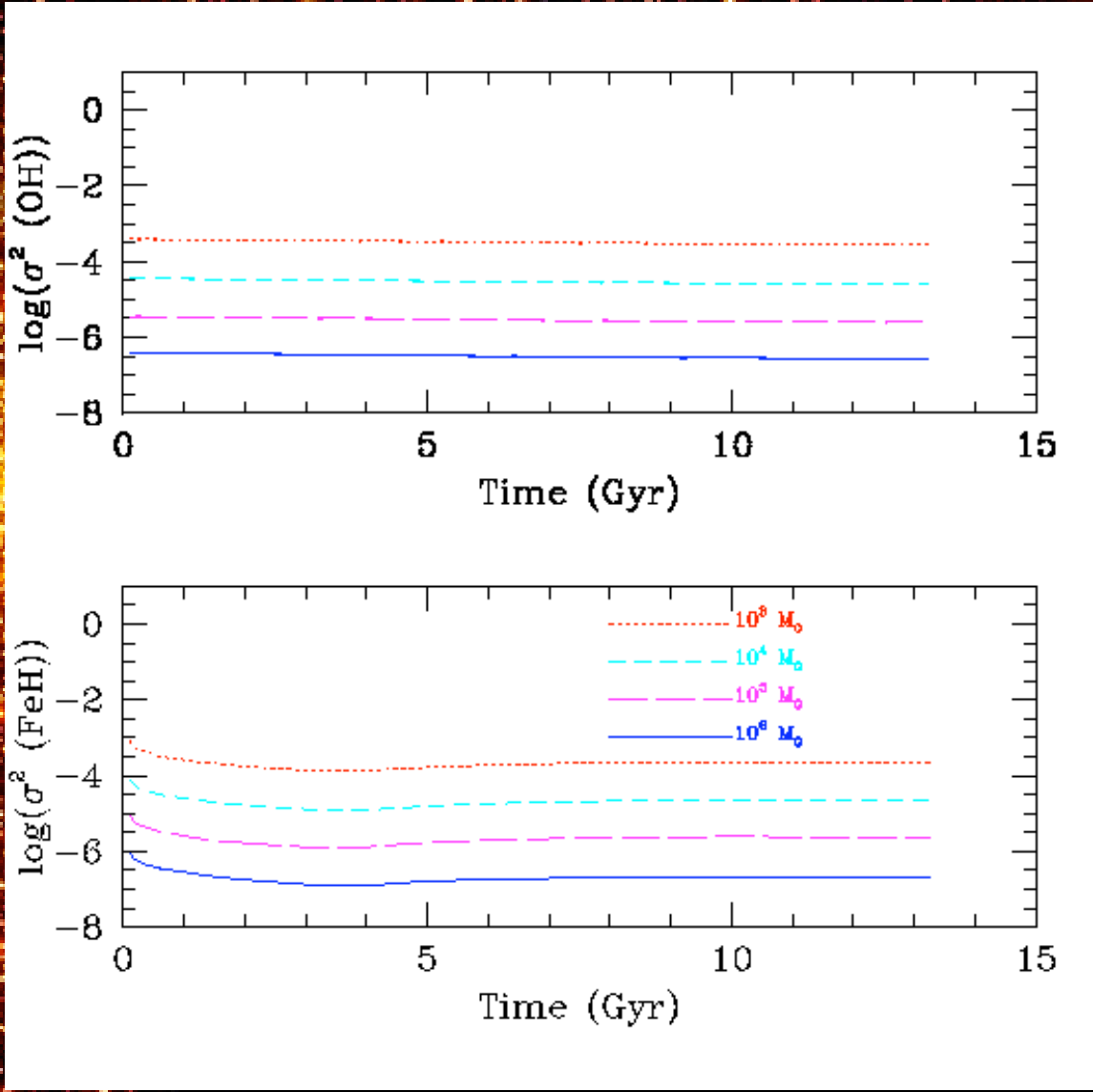


RESULTS: VARIANCE DEPENDENCE ON MASS

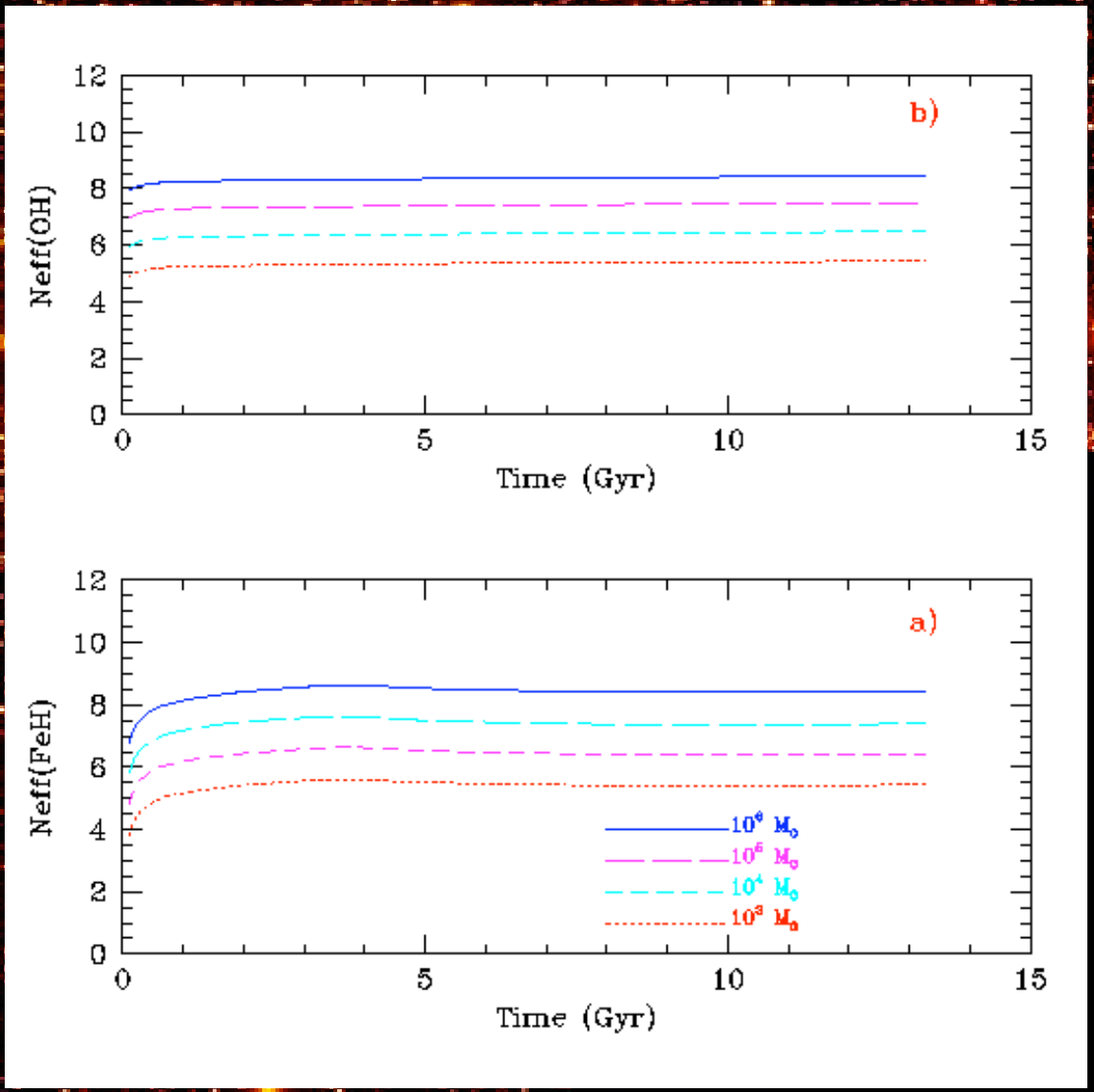
The variance is related on stellar cluster total mass

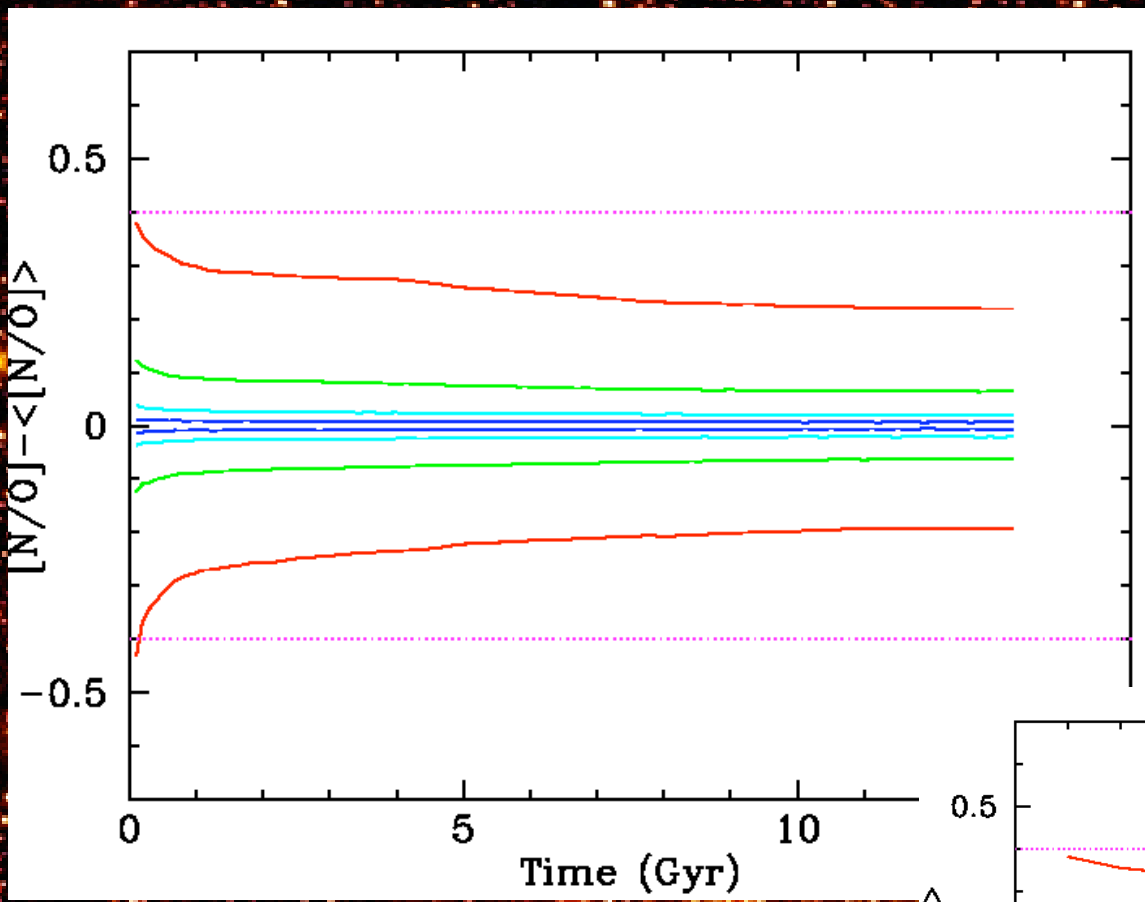
For oxygen, it does not change along the time

For Iron, it is larger at early times, then it decreases and finally it increases again

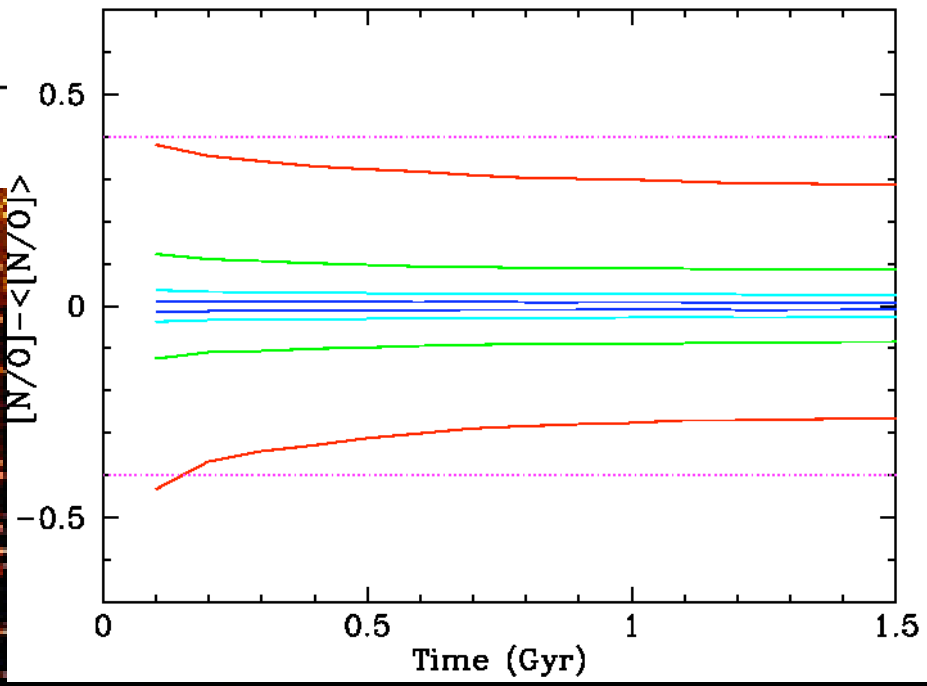


Neff is slightly small for [Fe/H] than for oxygen at early times.
For Oxygen this number is very constant along the time.

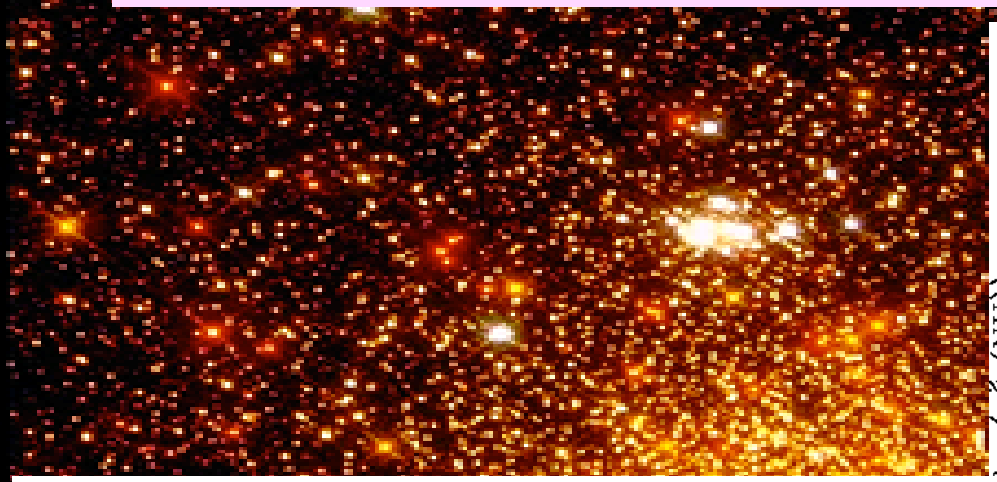


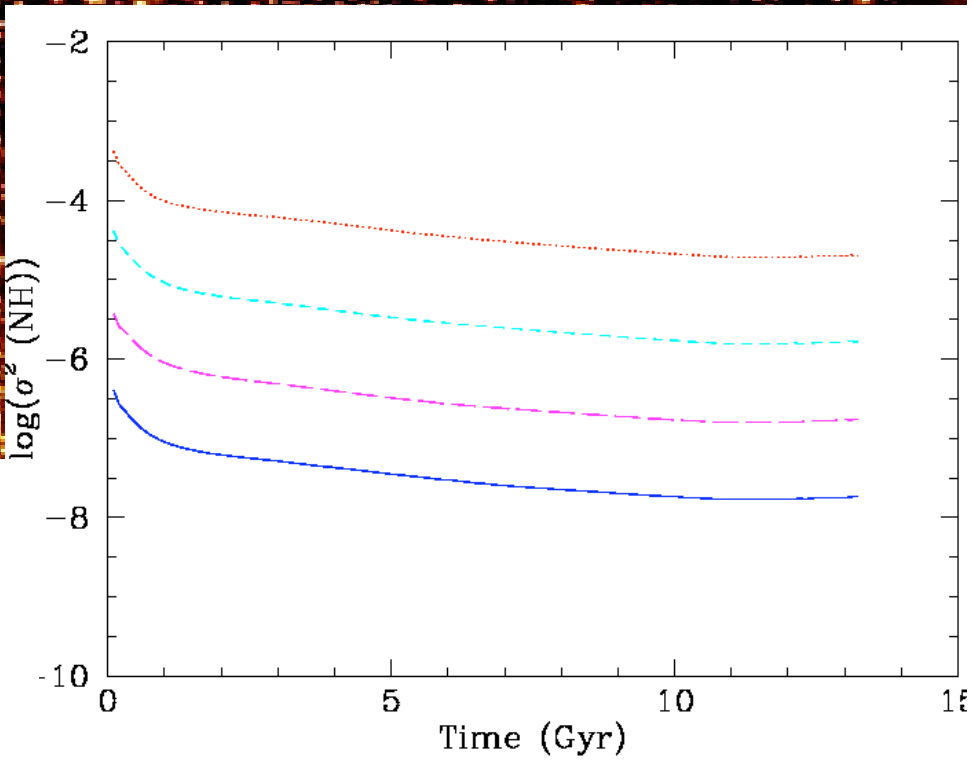


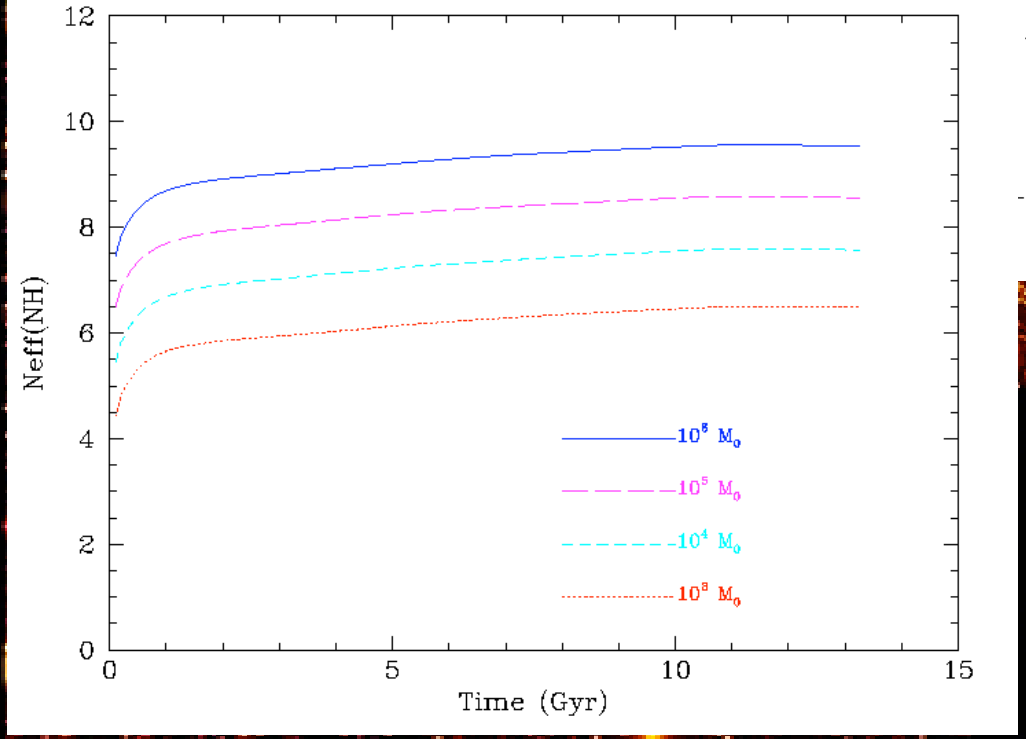
The dispersion of N/O is the largest of them for early times. Then it decreases, as it corresponds to an element proceeding from low or intermediate stars

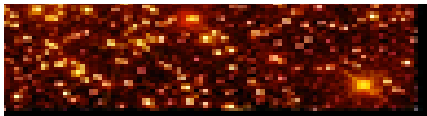


RESULTS: VARIANCE DEPENDENCE ON MASS, N









The variance of N is high only when it proceeds from massive stars

CONCLUSIONS

- The stochastic nature of the IMF has an effect when the stellar cluster is less massive than 10^4 Msun
- The dispersion obtained in chemical evolution model results when MonteCarlo simulations are used for IMF is larger than the error bar for 10^3 Msun, and similar to it for10^4 Msun
- A strong correlation between the variance of the elemental abundance and the total mass of the stellar clusters involved in the process of polluting the ISM there exists: Neff (M_*)
- The dispersion changes with time for N and Fe, decreasing with time, while it maintains constant for O.
- These variations imply that observations for early times (high redshift objects, DLA..) may show higher differences with the expected values following a chemical evolution model using an analytical IMF