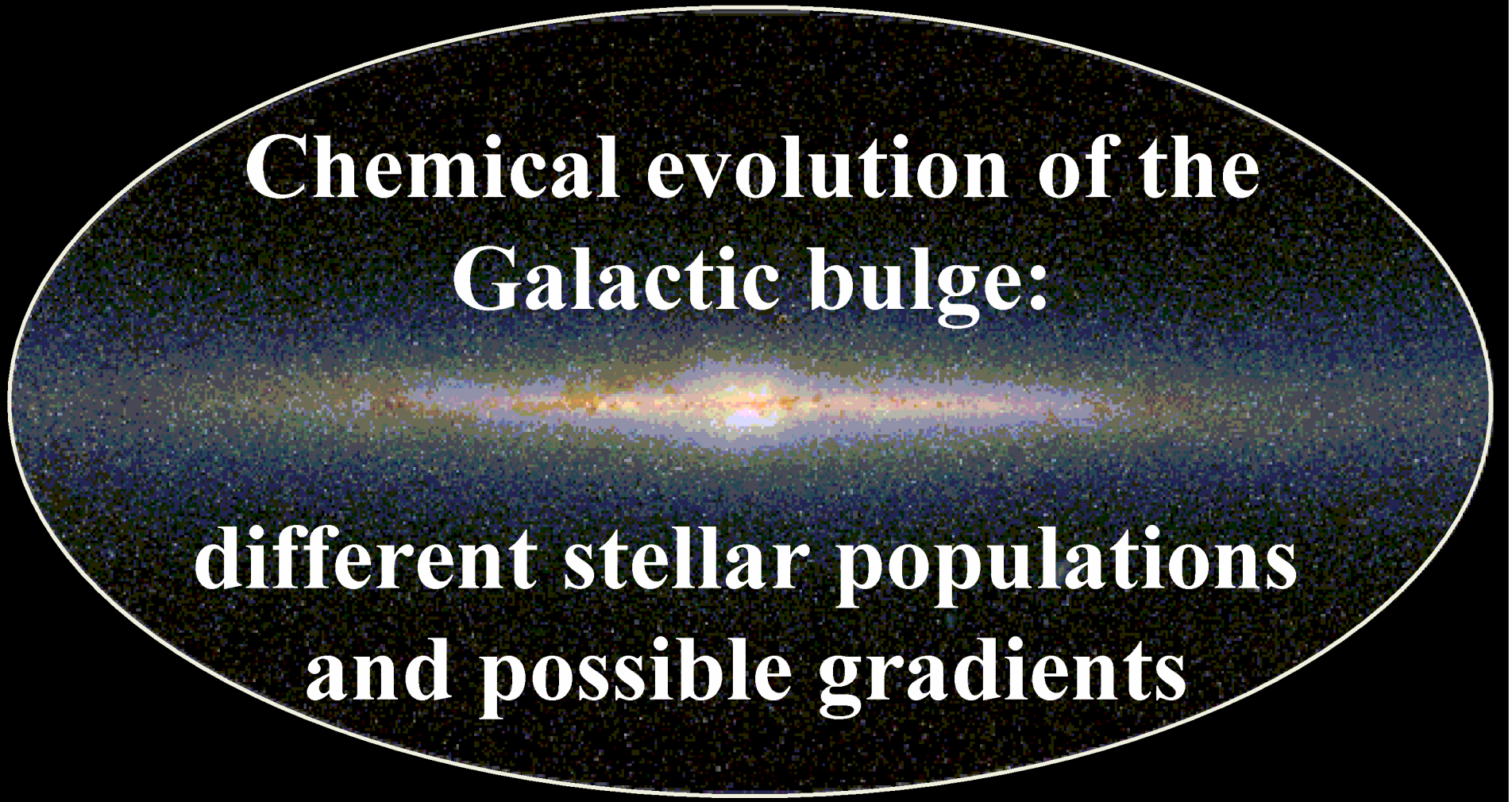
Chemical evolution of the Galactic bulge:

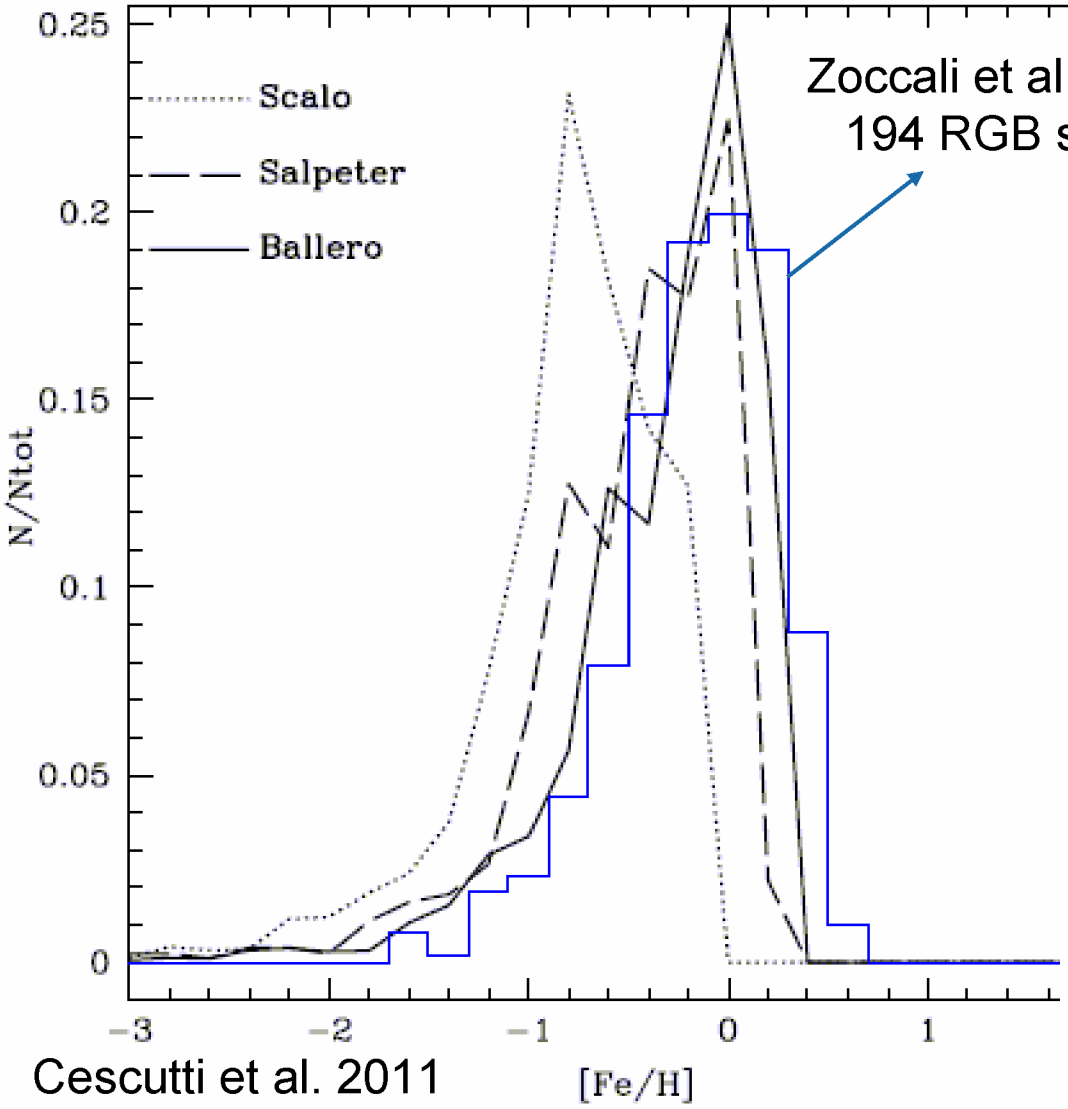


different stellar populations and possible gradients

Grieco Valentina, Matteucci F., Pipino A.

Bologna, 29 May 2012

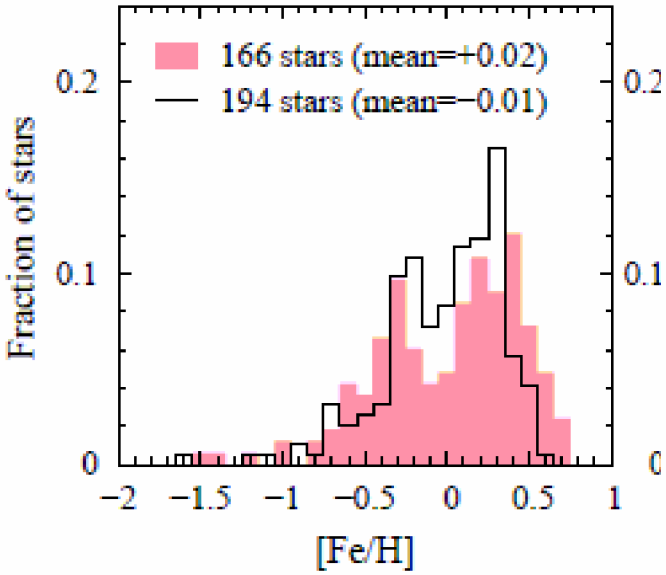
The metallicity distribution function



Zoccali et al. 2008
194 RGB stars

Cescutti et al. 2011

Hill et al. 2011: comparison between The MDFof RGB stars obtained with the automatic procedure (red histogram) and the MDF of Zoccali et al. (2008)



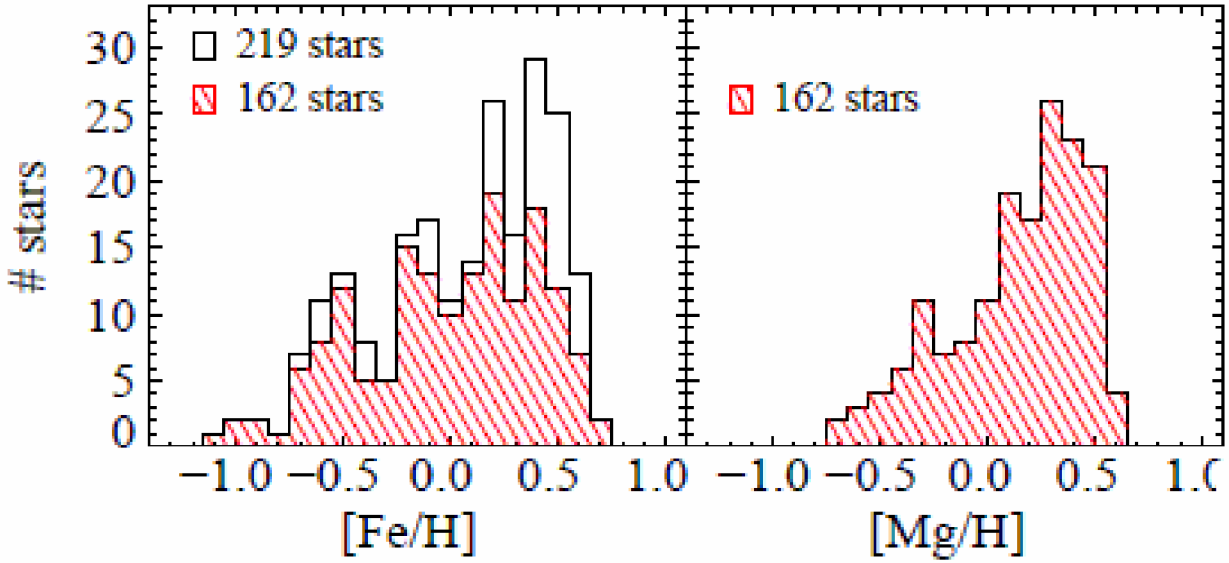
MDF bimodal

Peaks:

[Fe/H] = -0.45dex

[Fe/H] = +0.3dex

(Hill et al. 2011)

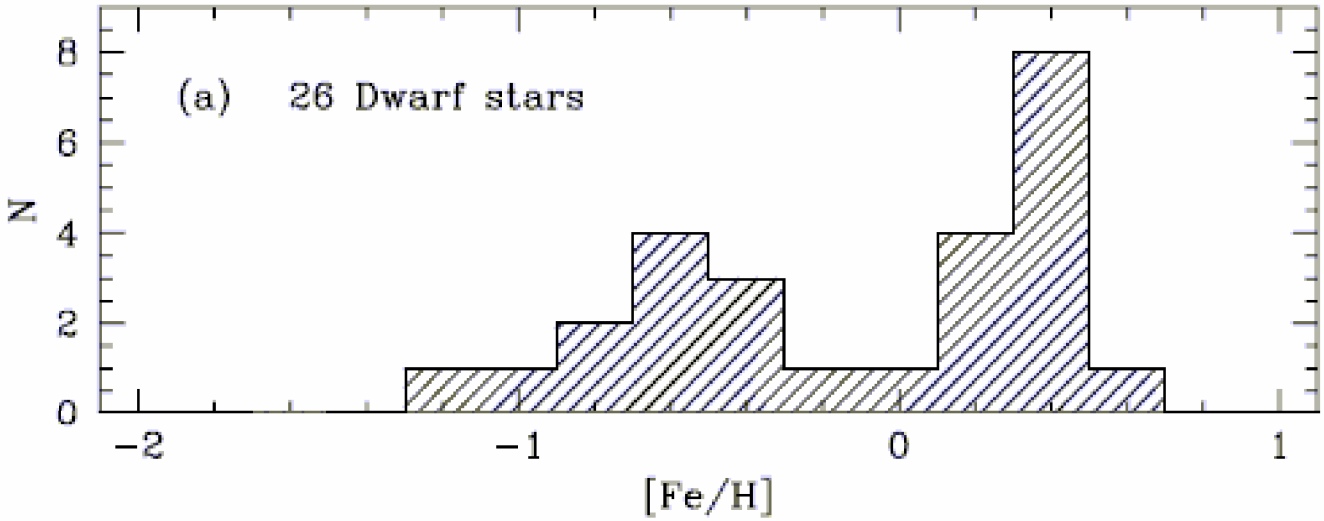


Peaks:

[Fe/H] = -0.6dex

[Fe/H] = +0.3dex

(Bensby et al. 2011)



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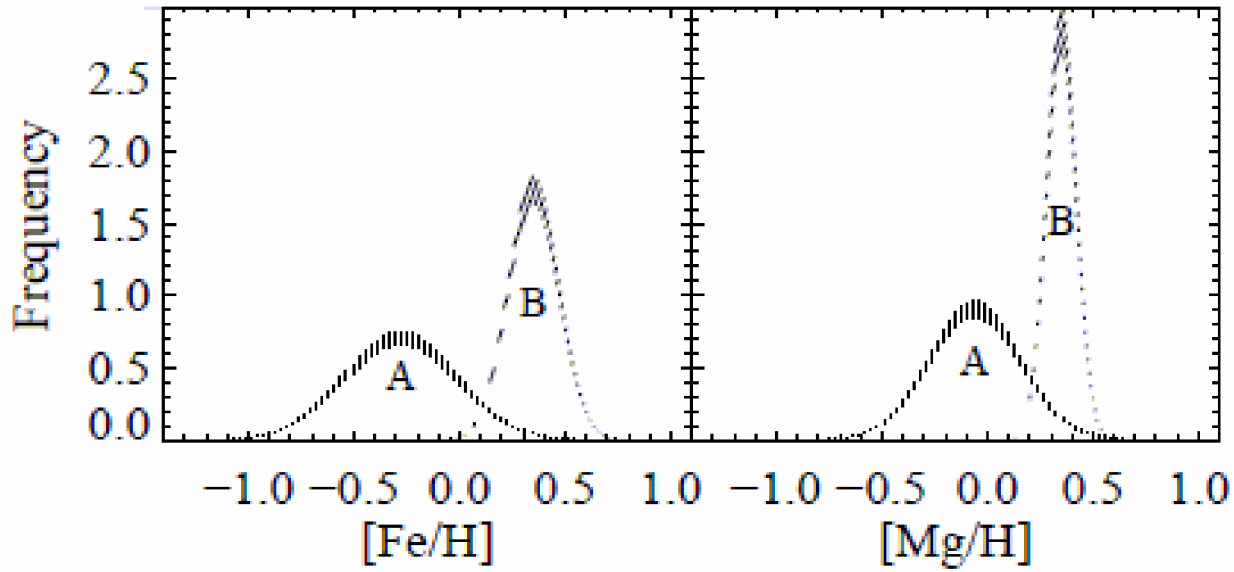

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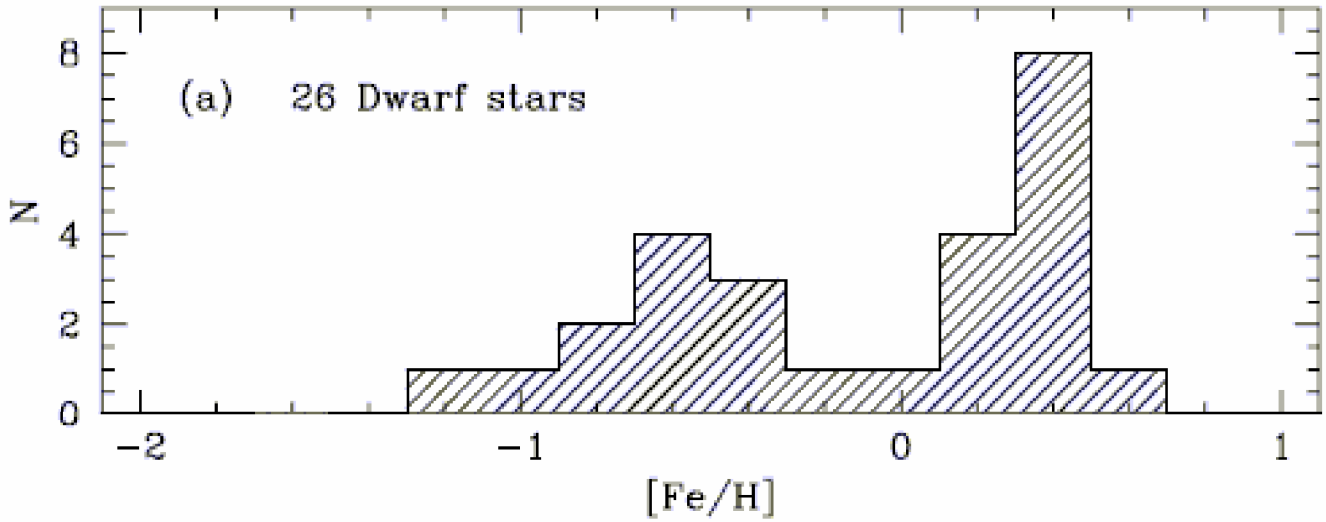


Interpretation: two populations

Metal poor stars correspond to a population (MP) that probably reflects the *classical bulge* component: the old spheroid population formed in a short timescale (high [Mg/Fe] ~ +0.3)

Metal rich population (MR) seems to have originated by a pre-enriched gas coming either from the residual gas of the MP formation or from the metal rich inner disk. These stars could have formed on a longer timescale (almost solar [Mg/Fe] ratio) driven by the evolution of the bar (*pseudo-bulge*)

Evolutionary timescales of massive stars exploding as SN II is short, therefore, the α-elements will be the first metals put back into the ISM. In a regime of a very *fast SFR*, most of the stars form with *high* [Mg/Fe] ratios due to the pollution of CCSNe while in a regime of slow SFR, [Mg/Fe] ratios tend to be lower owing to the pollution by SNe Ia intervening later than CCSNe

Basic ingredients of galaxy evolution

- Initial conditions:
  - open or closed-box
  - initial chemical composition
- The stellar yields
- The stellar birthrate function: SFR, IMF
  - Salpeter IMF:

$$\phi_{Salp}(M) = A_{Salp}\, M^{-(1+x)}$$

$A_{Salp} \approx 0.17$ x = 1.35

  - SFR:

$$\psi(t) = \nu\, M_{gas}$$

ν = star formation efficiency

- Gas flows: infall, outflow

Main assumptions of the models

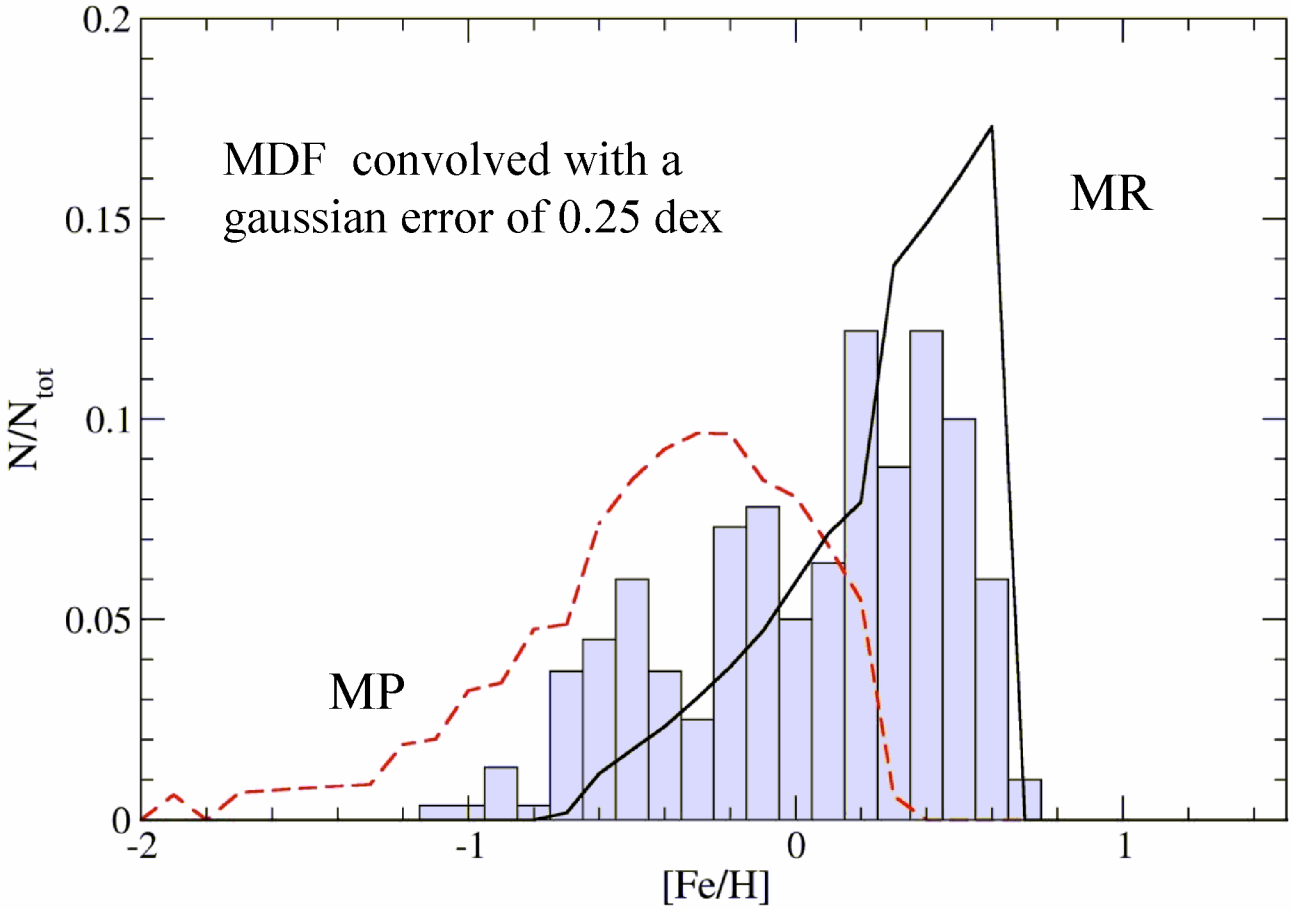
Both stellar population formed during episodes of gas accretion with the same infall law but different abundances of the infalling gas:

- The gas which formed the MP component is primordial or slightly enriched from the halo formation.

  The population is obtained by means of a very efficient SF and a short timescale for infall
- The gas which formed the MR component was substantially enriched (i.e. [Fe/H]=-0.6dex)

  The population is obtained with a less efficient SF and a longer infall timescale

Modelling the two populations



Metal Poor

SFE $\nu = 25$

$\tau_{infall} = 0.1$

Salpeter IMF

Metal Rich

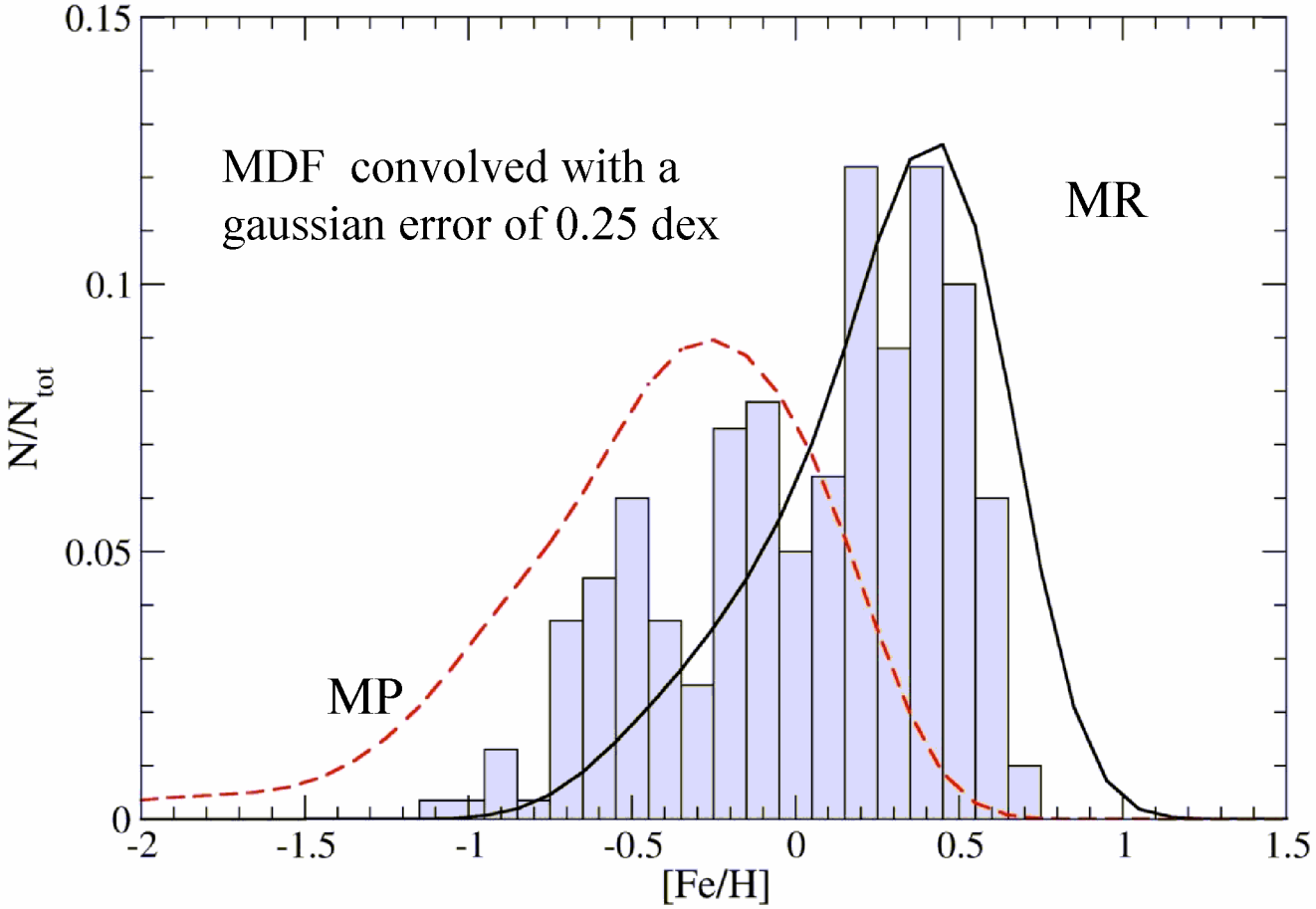
SFE $\nu = 2$

$\tau_{infall} = 3.0$

Salpeter IMF

Model	Δ<[Fe/H]>	Δ<[Mg/H]>	Δ<[O/H]>	Δ<[S/H]>	Δ<[Si/H]>	Δ<[Ba/H]>
MP-MR	-0.7 dex	-0.3 dex	-0.28 dex	-0.45 dex	-0.36 dex	-0.34 dex

Modelling the two populations



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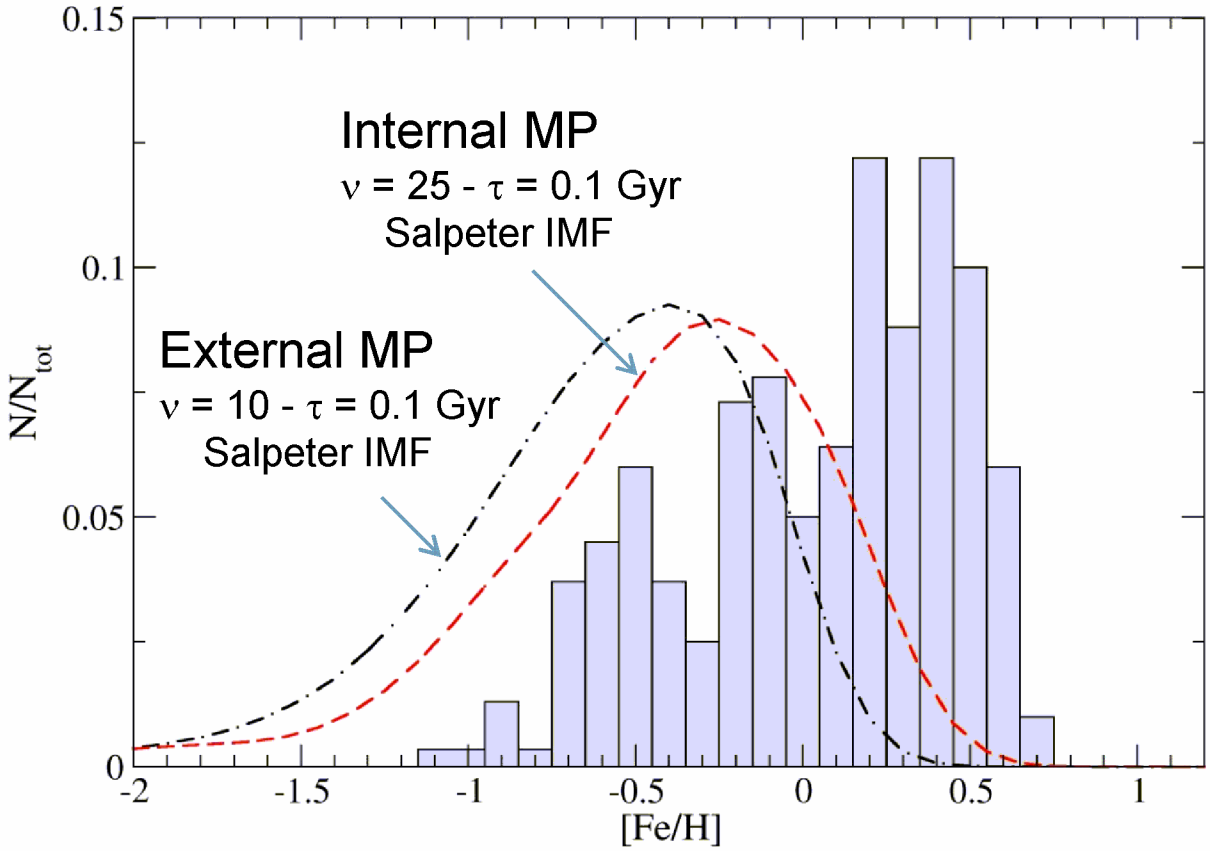
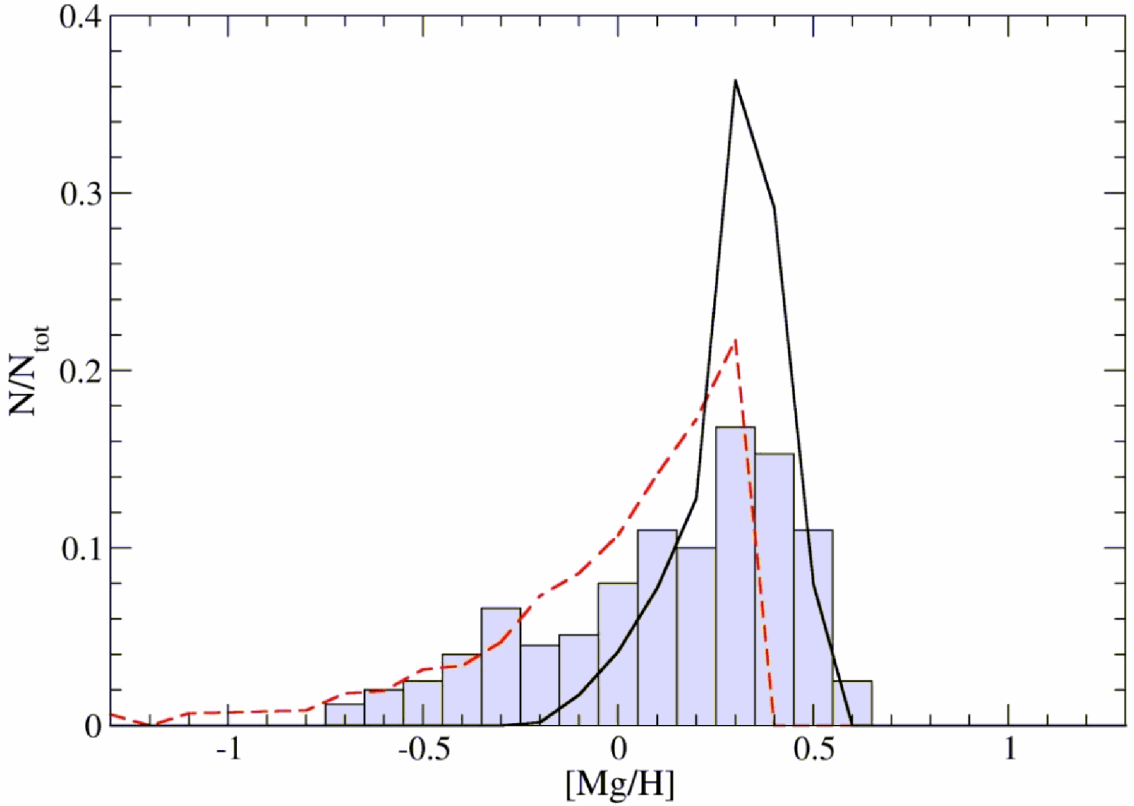
Possible abundance gradient in the MP pop.?



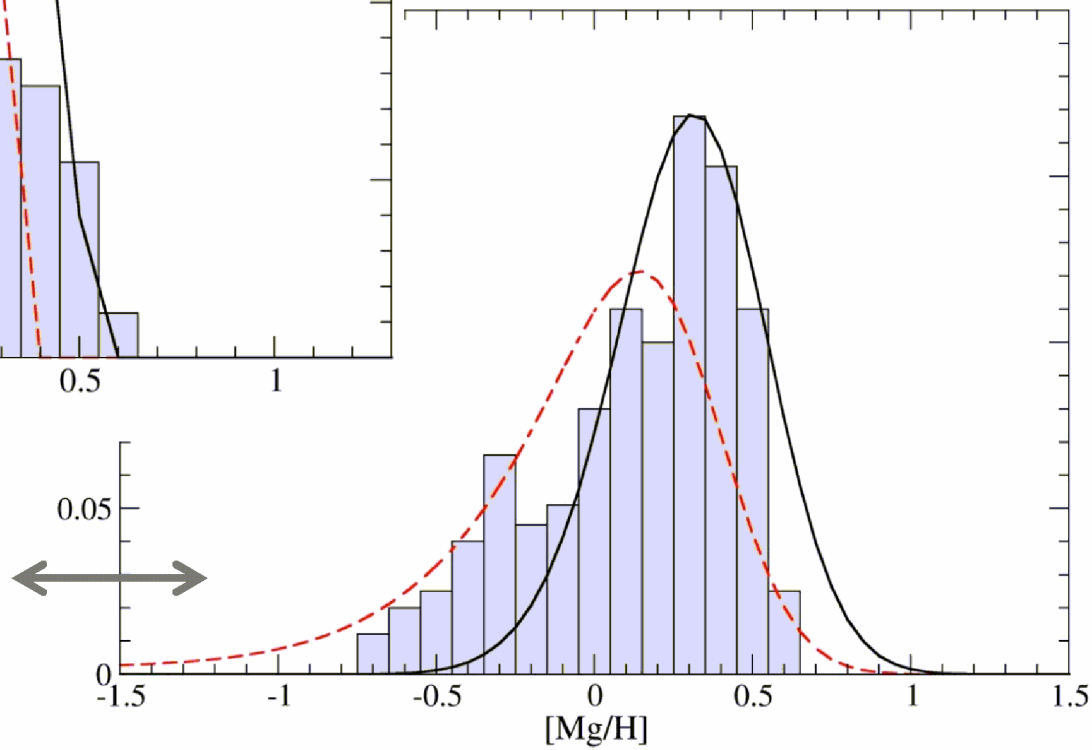
The observations tell us that the gradient produced by the MR population disappearing when going further away from the plane BUT
it could be a residual gradient *only* produced by the MP component *if* it actually corrispond to a spheroidal component formed via dissipative collapse (pure internal gradient)

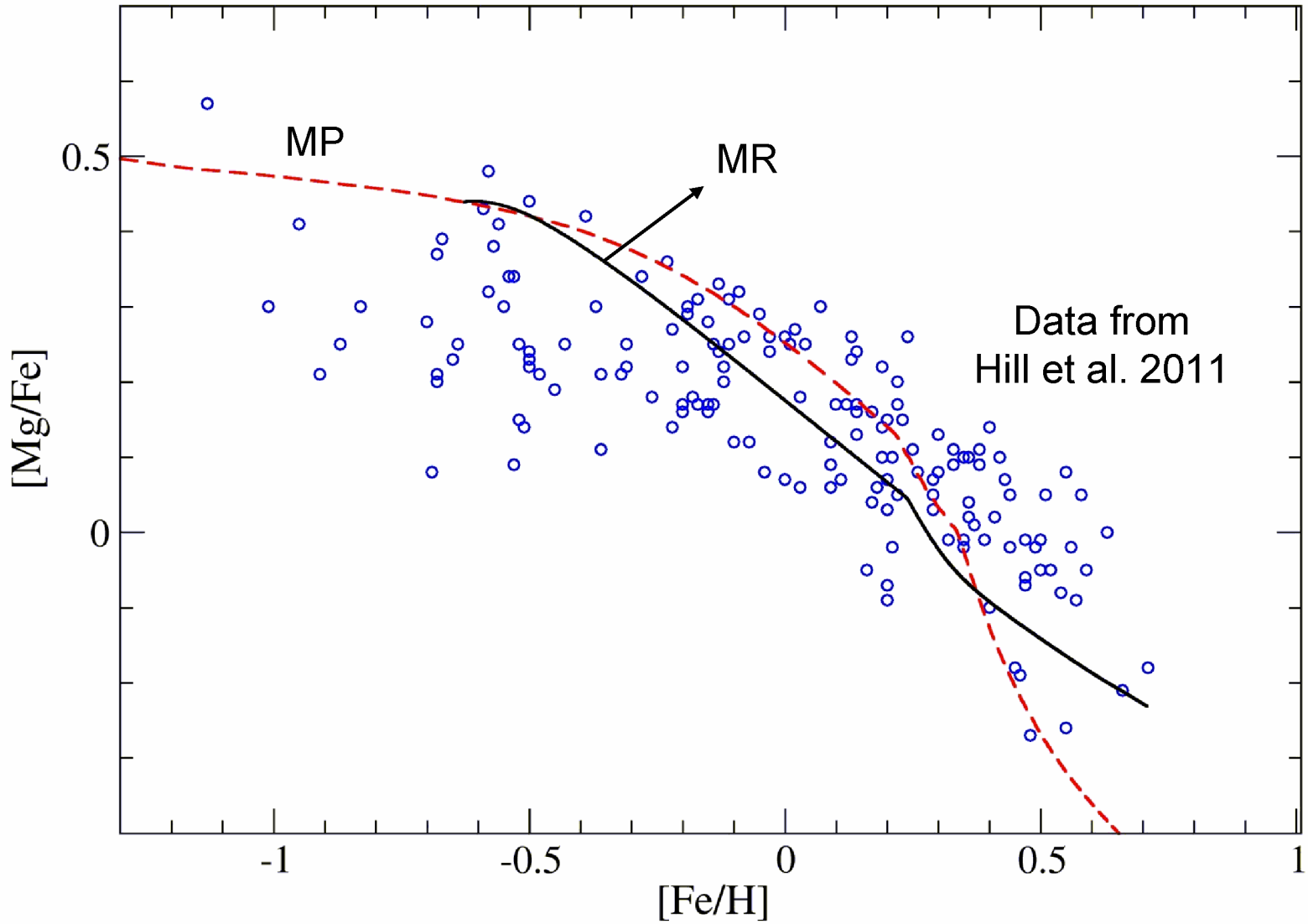
Model	Δ<[Fe/H]>	Δ<[Mg/H]>	Δ<[O/H]>	Δ<[S/H]>	Δ<[Si/H]>	Δ<[Ba/H]>
EMP-IMP	-0.18 dex	-0.21 dex	-0.12 dex	-0.17 dex	-0.24 dex	-0.23 dex

Modelling the two populations



MDF – mg convolved with a gaussian error of 0.2 dex




MP
MR
Data from
Hill et al. 2011
0.5
0
[Mg/Fe]
-1
-0.5
0
0.5
1
[Fe/H]

Conclusions

- Both the MDF and the abundance ratios of the MP population can be reproduced by a classical chemical evolution model for the bulge; this model suggests a formation timescale of 0.1 - 0.3 Gyr, high SFE and an IMF flatter than in the solar vicinity (Salpeter IMF).
- Both the MDF and the abundance ratios of the MR population can be reproduced by assuming that it formed out of pre-enriched gas residual from the formation of the MP population and/or coming from the inner disk. This population formed on a longer timescale of 3 Gyr and lower SFE and a Salpeter IMF
- The differences between the mean abundances in MP and MR are of the order of -0.7dex
- We also predict a possible gradient inside the MP population due to a dissipative gravitational collapse of the order of -0.18 dex