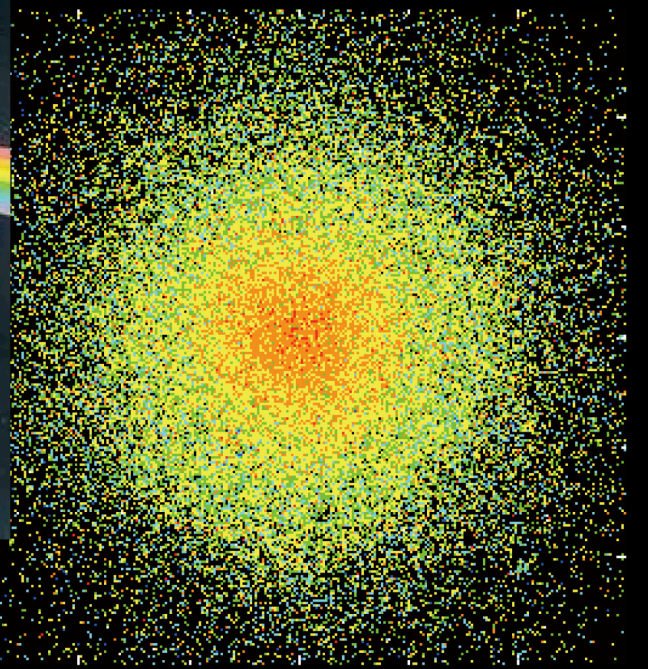
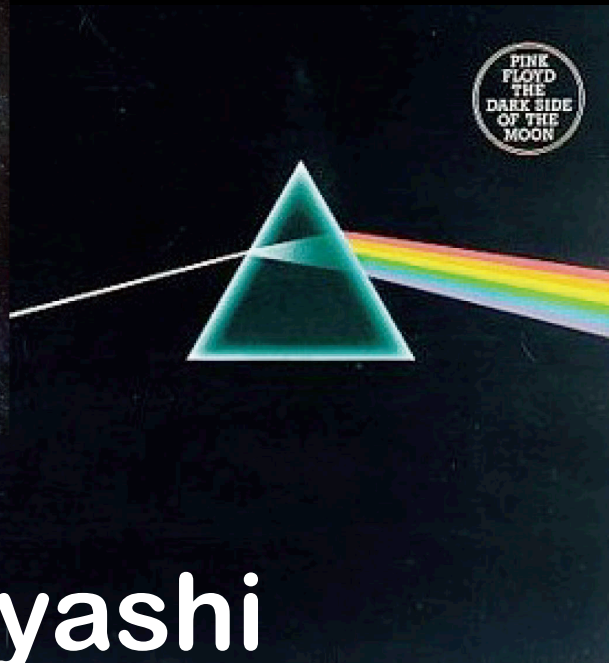
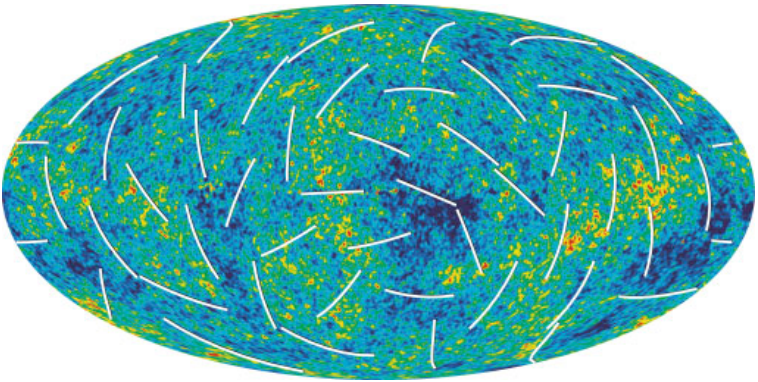


# Galactic Archaeology with ~~WFOS~~ and Chemodynamical simulations



**Chiaki Kobayashi**  
(Australian National University)

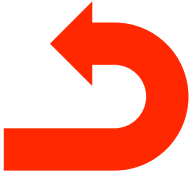
# Chemodynamical Simulation



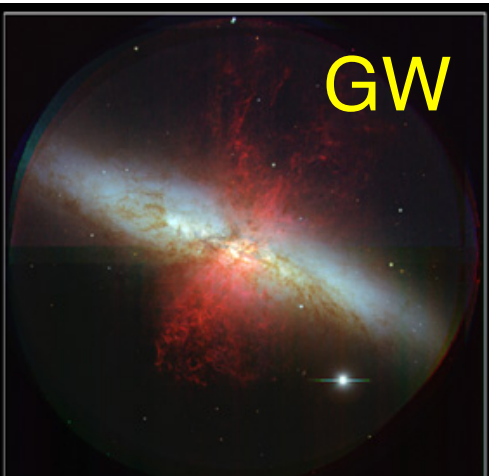
Evolution  
of Baryon?



<sup>SPH</sup>  
**Hydrodynamics,  
Radiative Cooling,  
Star Formation**

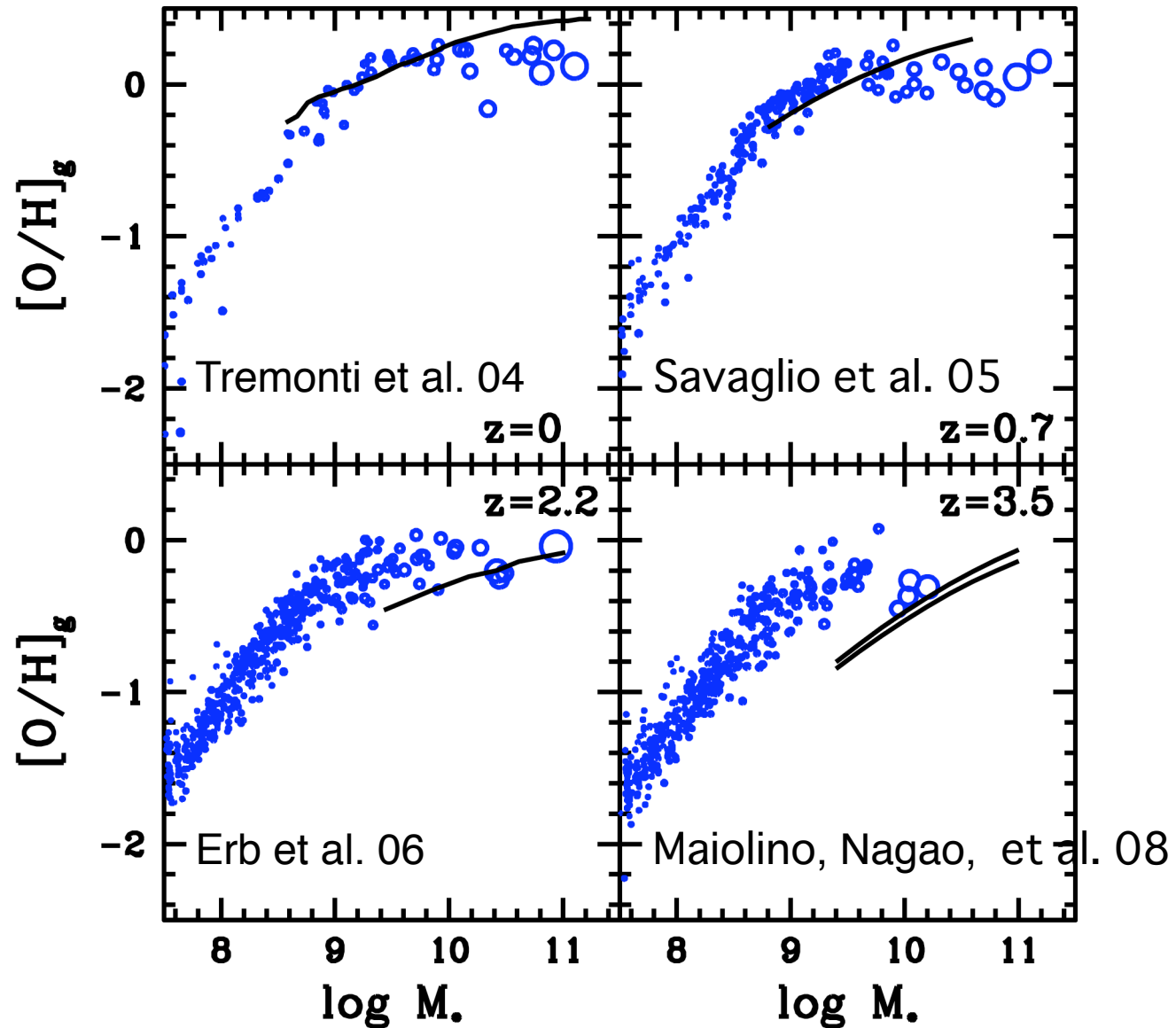


**+ Supernova  
(SN&HN)  
+ Chemical  
Enrichment**



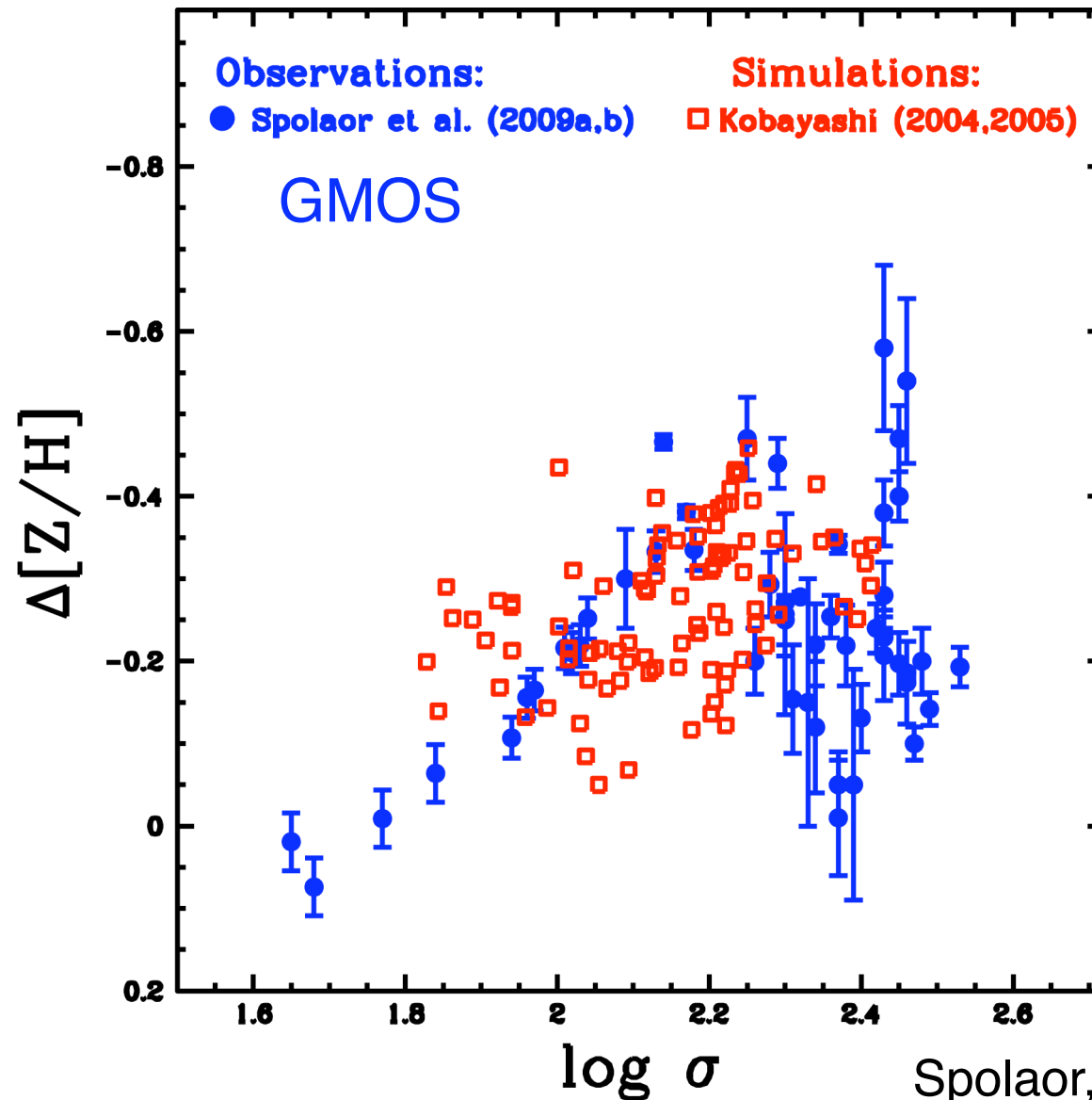
# Mass-Metallicity Relation

○ Cosmological Simulation (CK, Springel, White 2007)

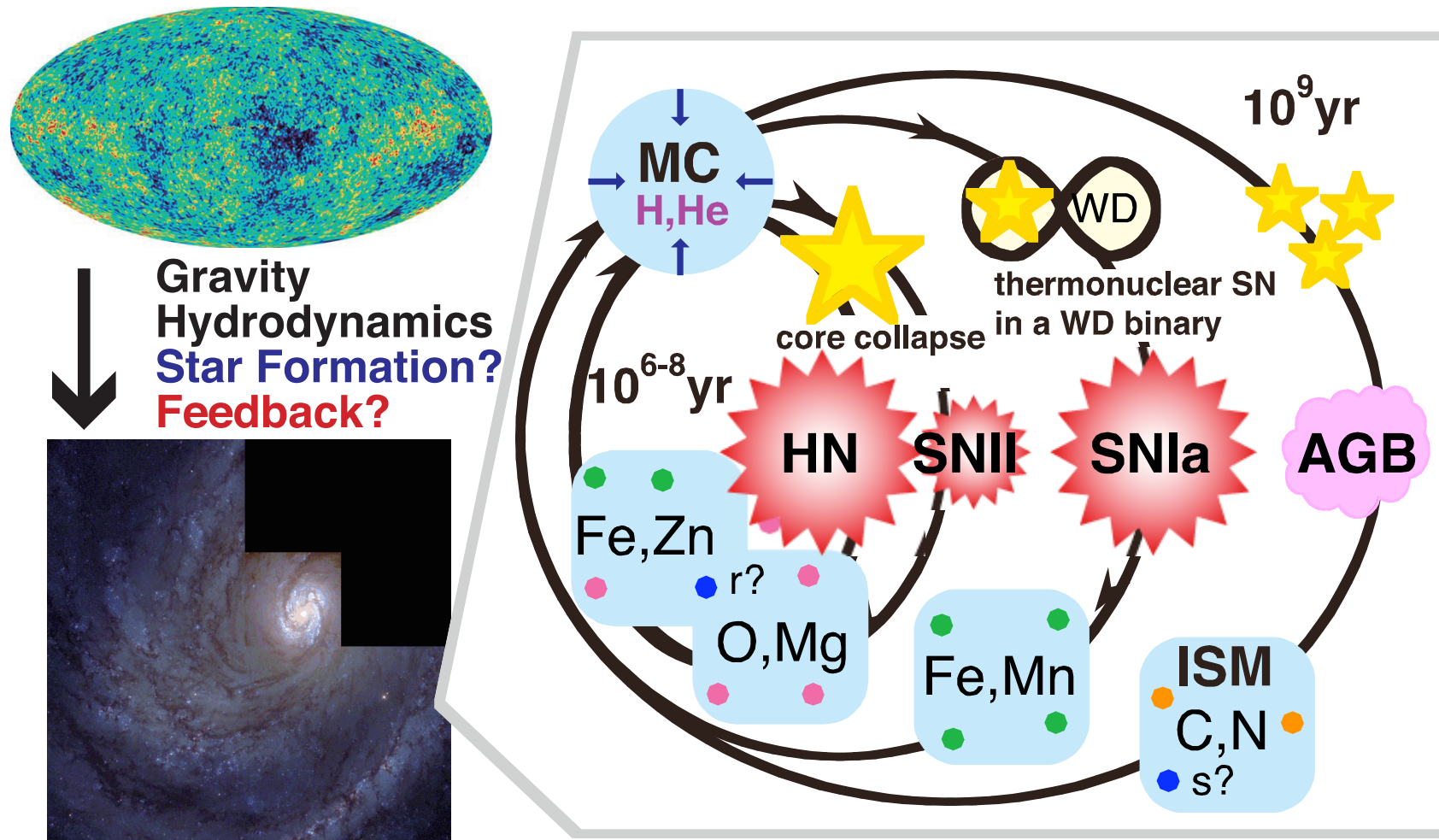


# Metallicity Gradients of Ellipticals

□ **GRAPE Simulations** of 120 Es (CK 2004, 2005)

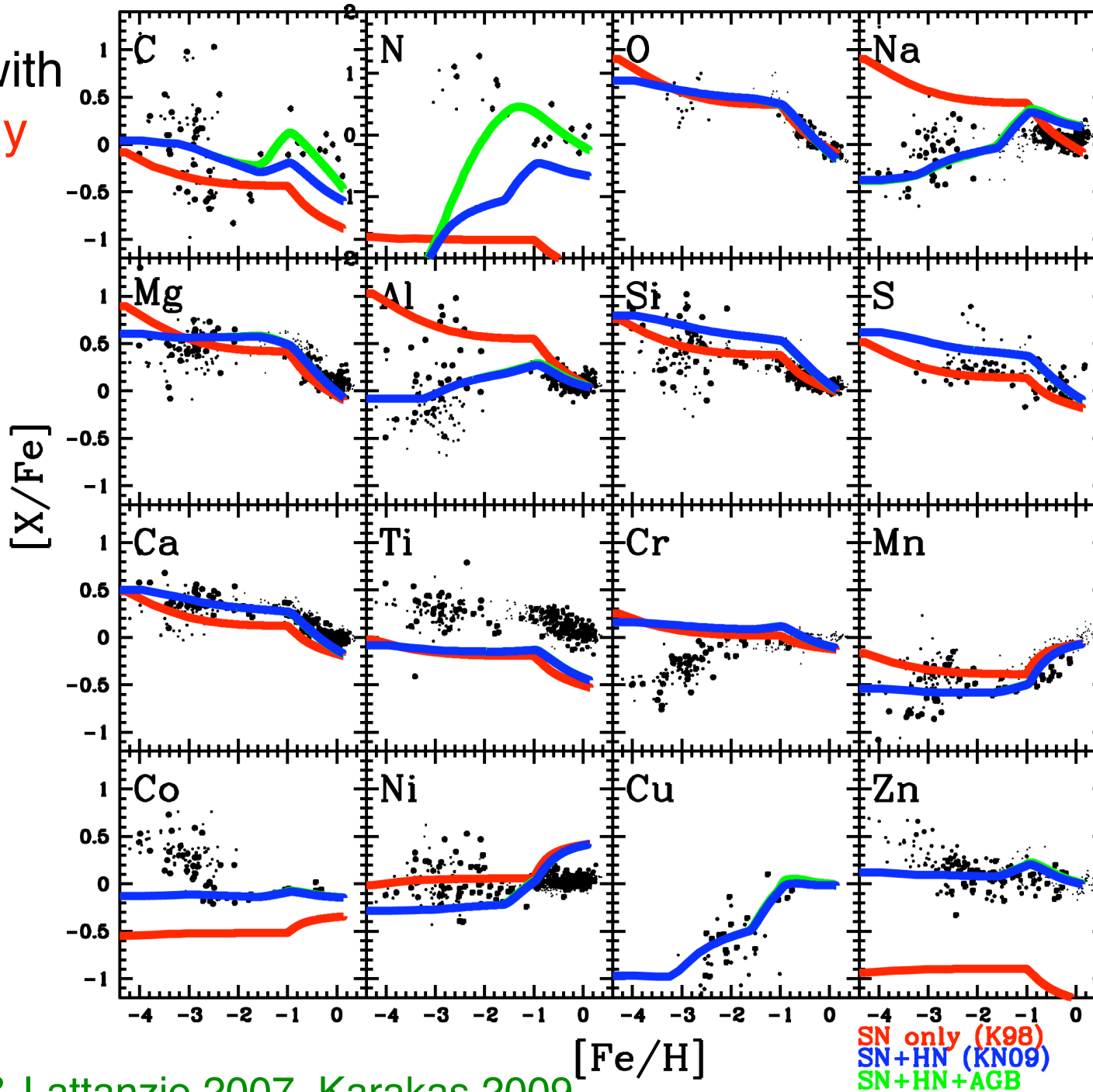


# Chemical Enrichment



- [Fe/H] and [X/Fe] evolve in a galaxy: fossils to tell the evolution history of the galaxy → **Galactic Archaeology**

Model with  
SN only  
HN  
AGB



Karakas & Lattanzio 2007, Karakas 2009

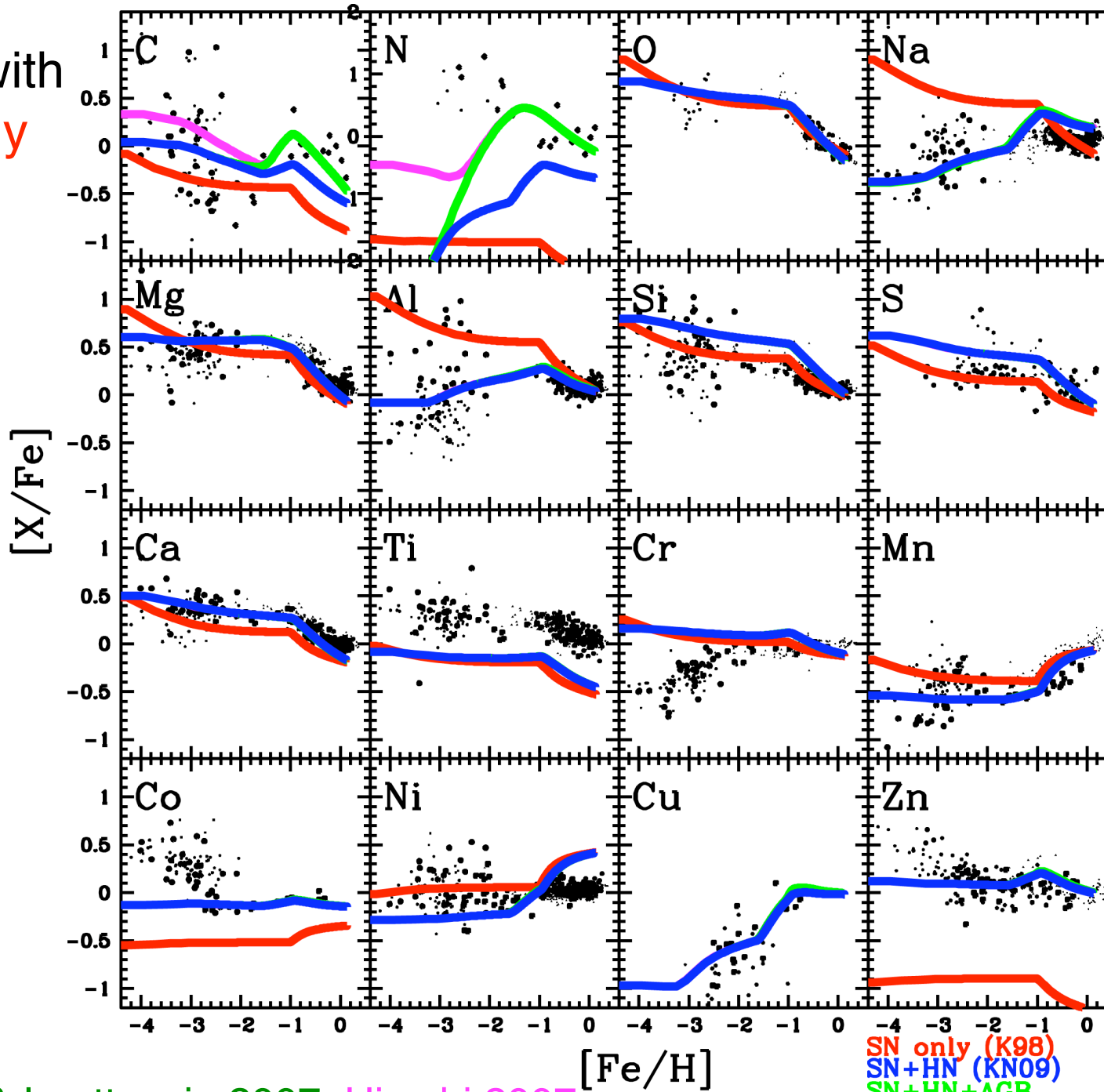
SN only (K98)  
SN+HN (KN09)  
SN+HN+AGB

Model with

SN only

HN

AGB



SN only (K98)  
SN+HN (KN09)  
SN+HN+AGB  
SN+HN+AGB+rotation

Karakas & Lanttanzio 2007, Hirschi 2007

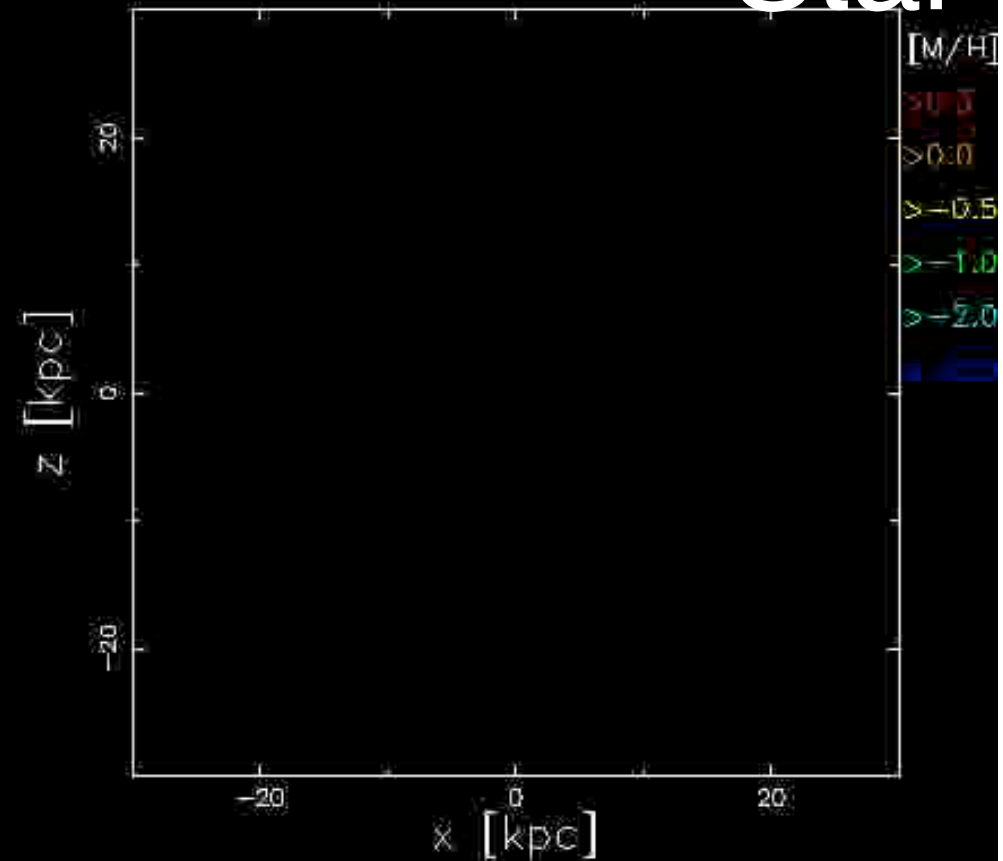
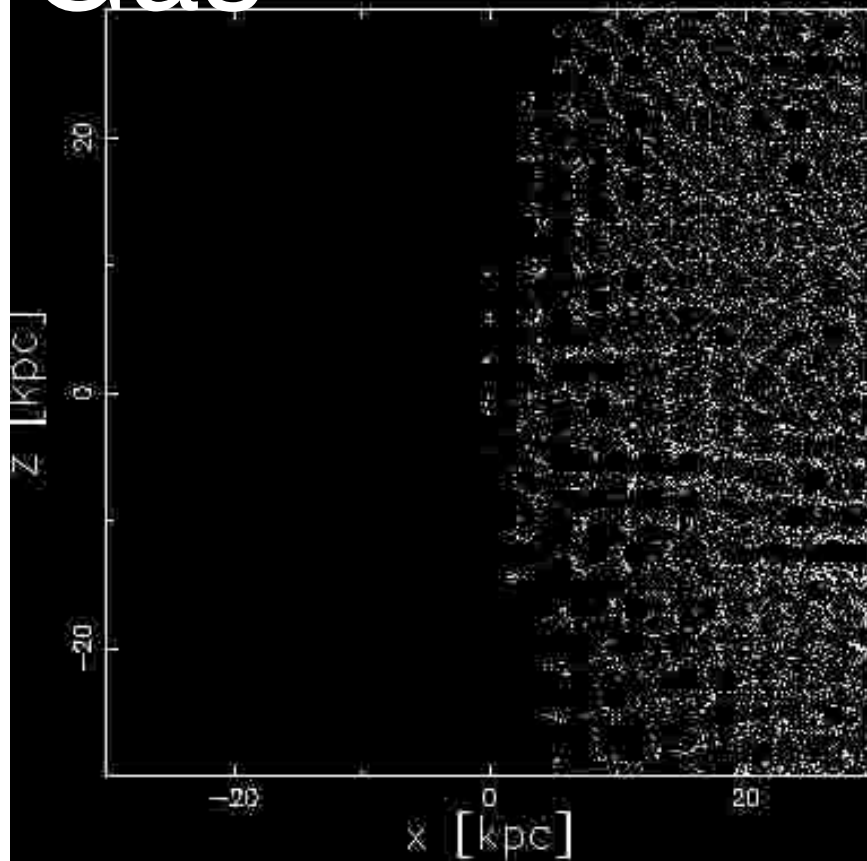
# The Milky Way Galaxy

Initial Condition:  $\lambda$ CDM fluctuated sphere with  $\lambda \sim 0.1$ ,  $r \sim 3$  Mpc,  
 $M_{\text{tot}} \sim 10^{12} M_{\odot}$ ,  $N_{\text{tot}} \sim 120,000$ ,  $M_{\text{gas}} \sim 10^6 M_{\odot}$ ,  $M_{\text{DM}} \sim 10^7 M_{\odot}$

Gas

$t = 0.00$  Gyr,  $z = 23.69$

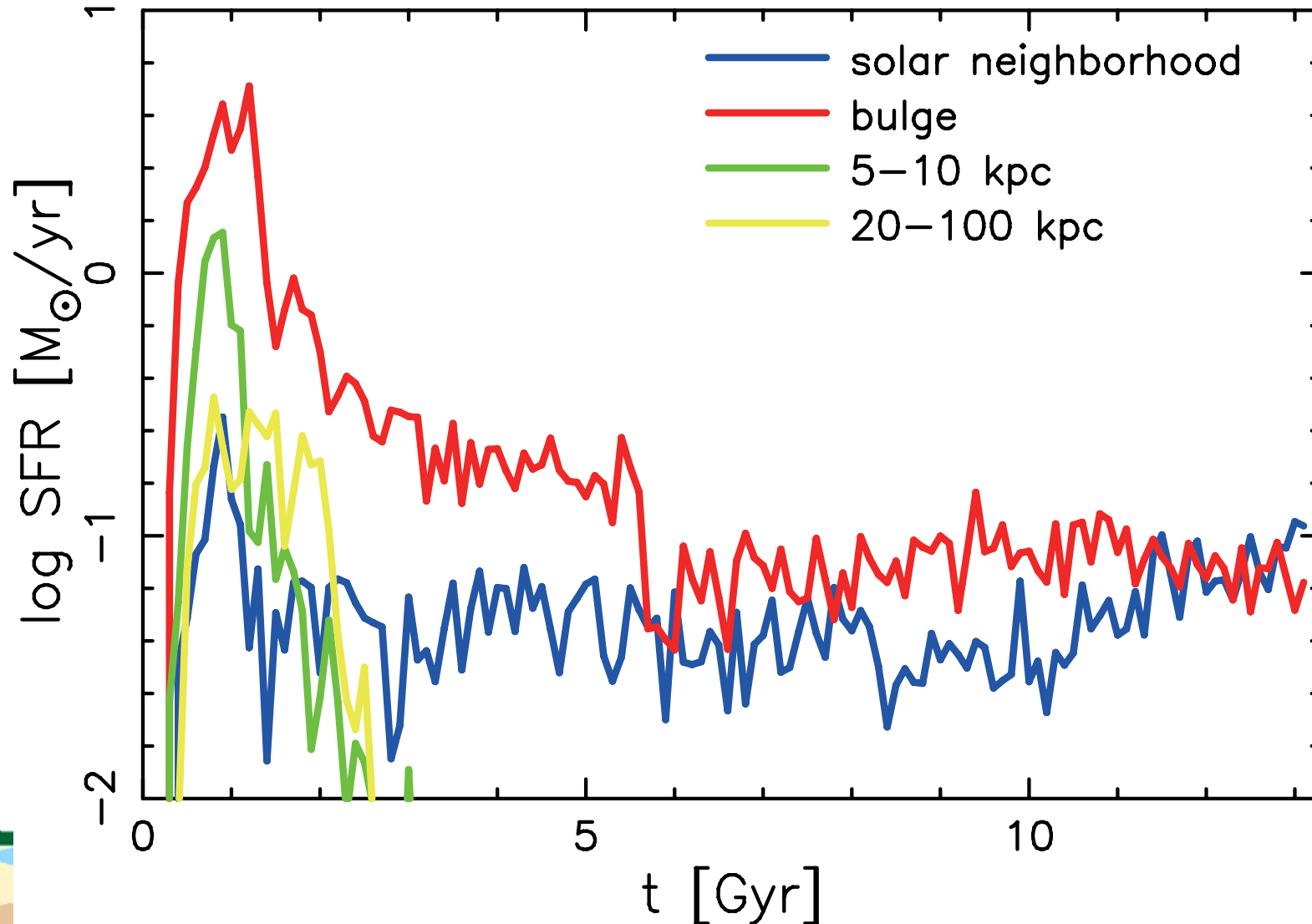
Star



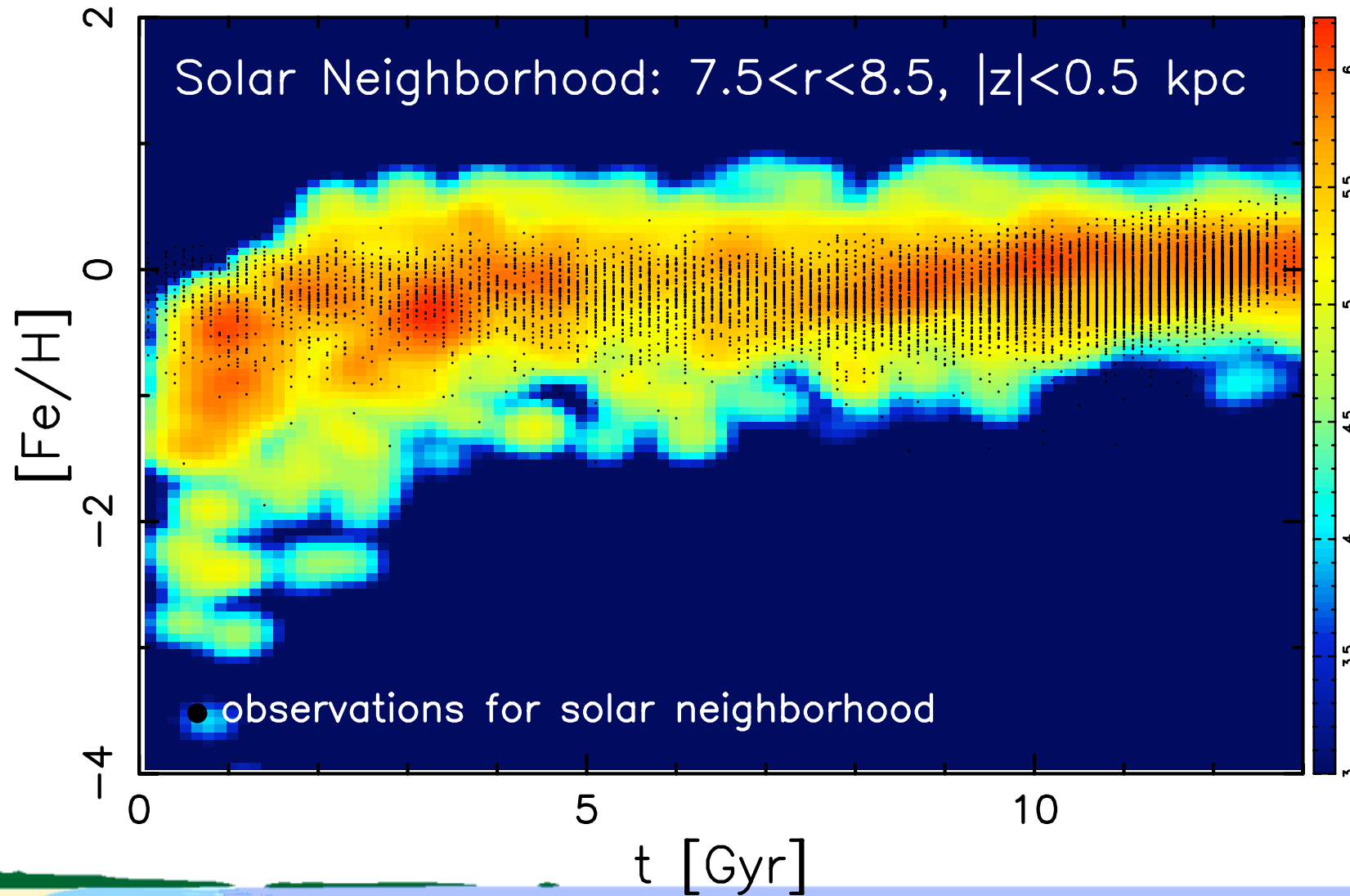


# Star Formation Rate

Bulge  $r < 1$ , Solar Neighborhood:  $7.5 < r < 8.5, |z| < 0.5$  kpc



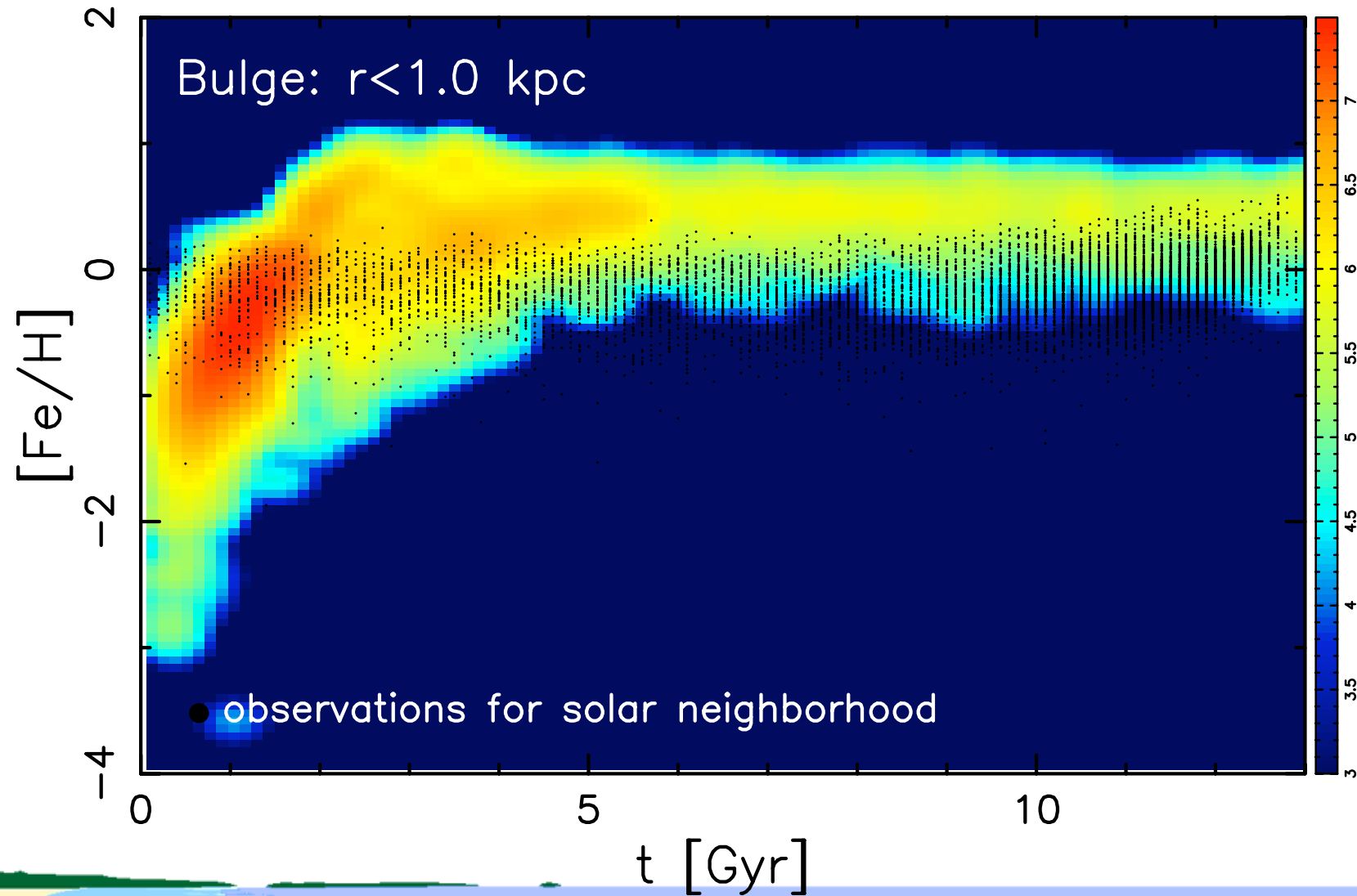
# Age Metallicity Relation



Observational Data:

- Nordstrom et al. (2004) for the solar neighborhood

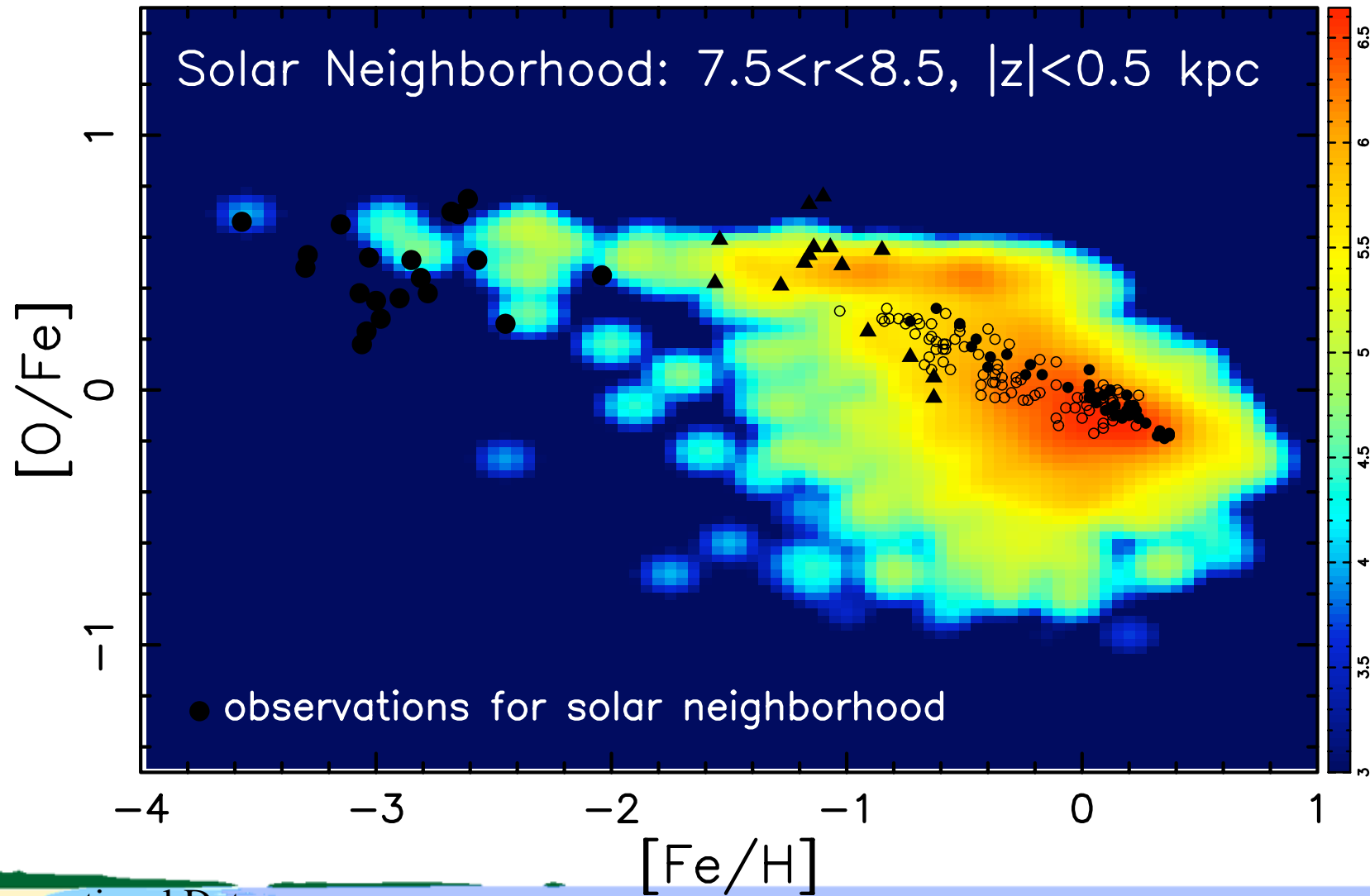
# Age Metallicity Relation



Observational Data:

- Nordstrom et al. (2004) for the solar neighborhood

# [O/Fe]-[Fe/H] Relation



Observational Data:

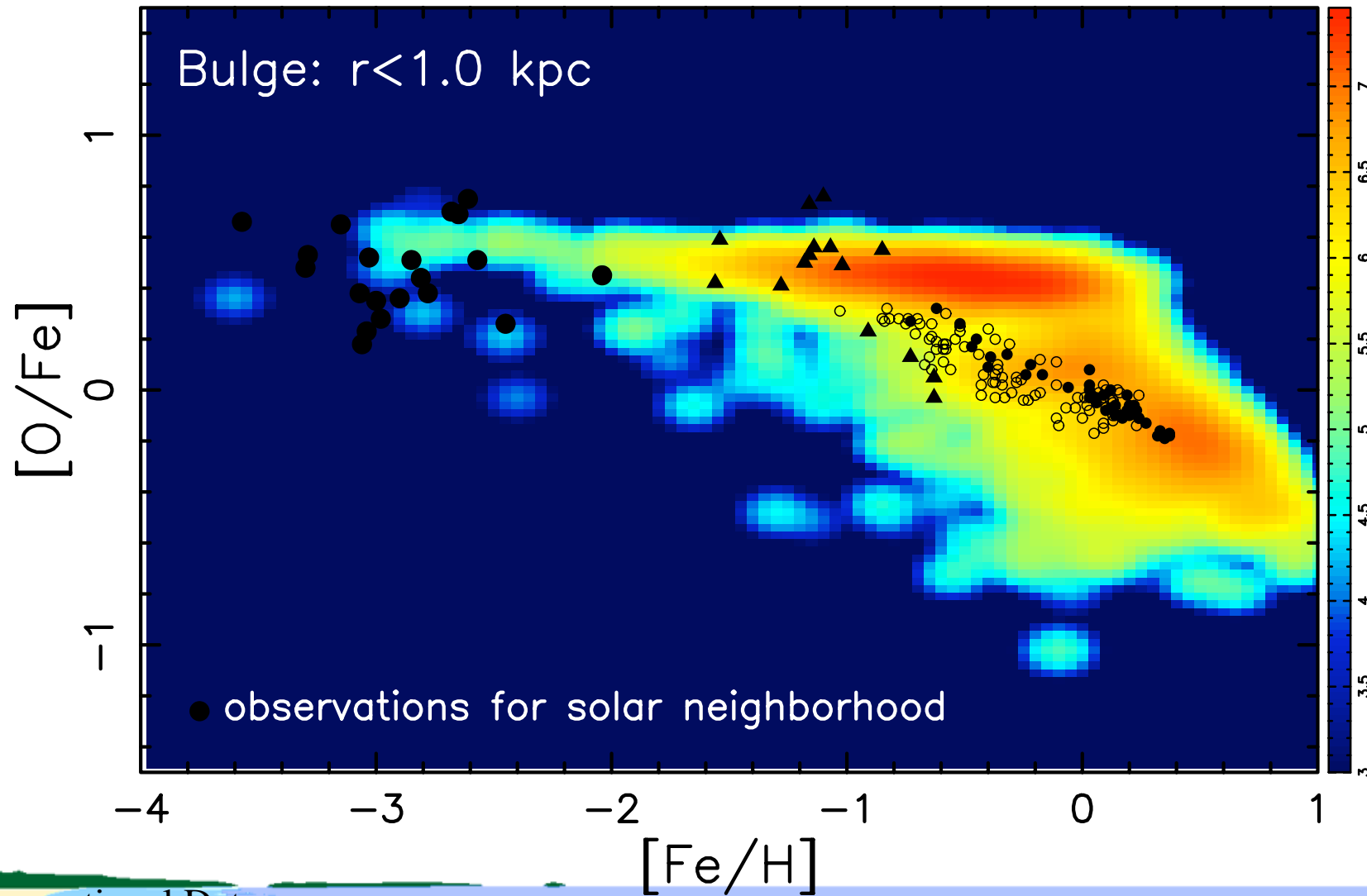
Edvardsson et al. (1993), Bensby et al. (2003),

Gratton et al. (2003), Cayrel et al. (2004) for the solar neighborhood

Not only O,

But also Mg, Si, S, Ca

# [O/Fe]-[Fe/H] Relation



Observational Data:

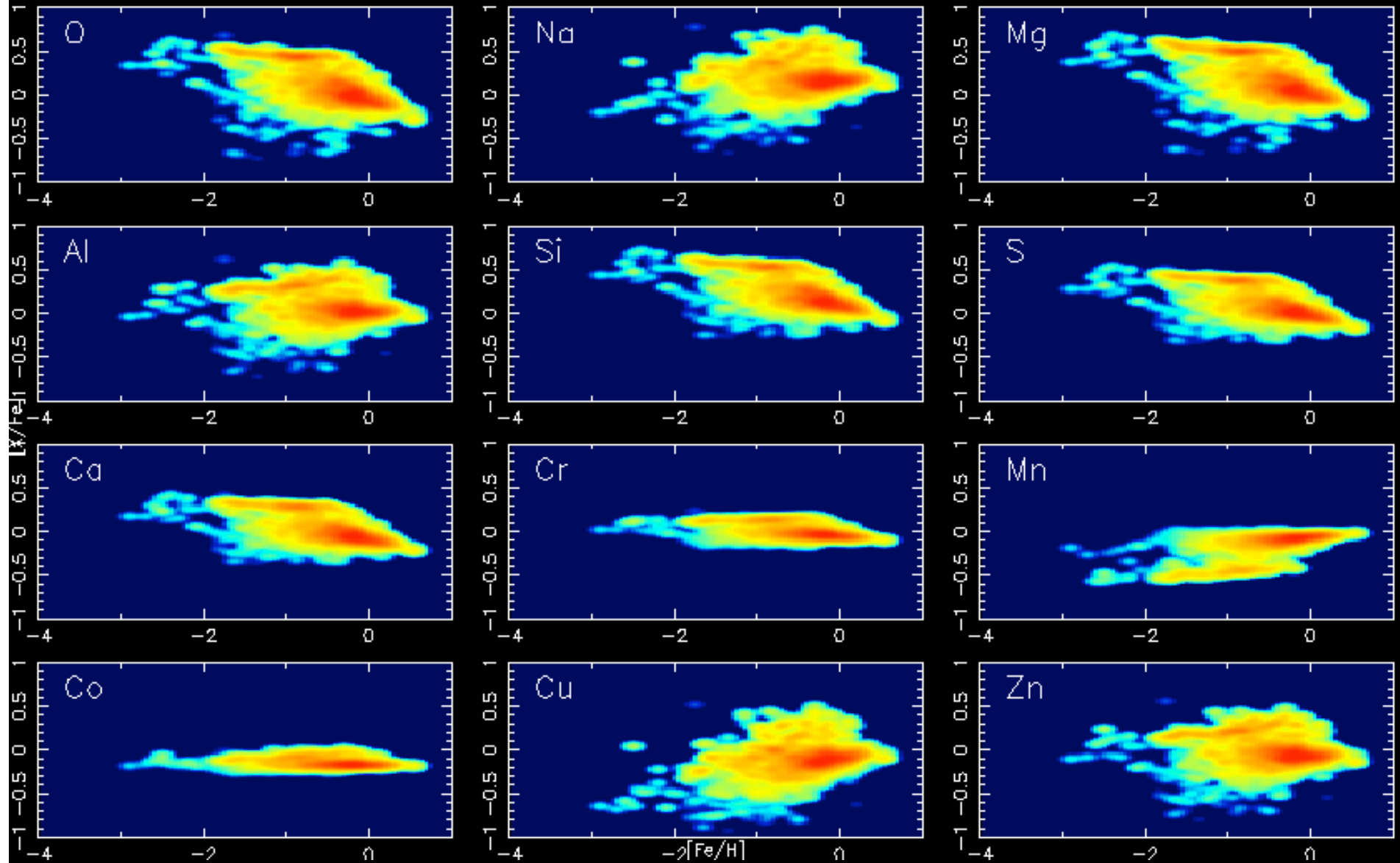
Edvardsson et al. (1993), Bensby et al. (2003),

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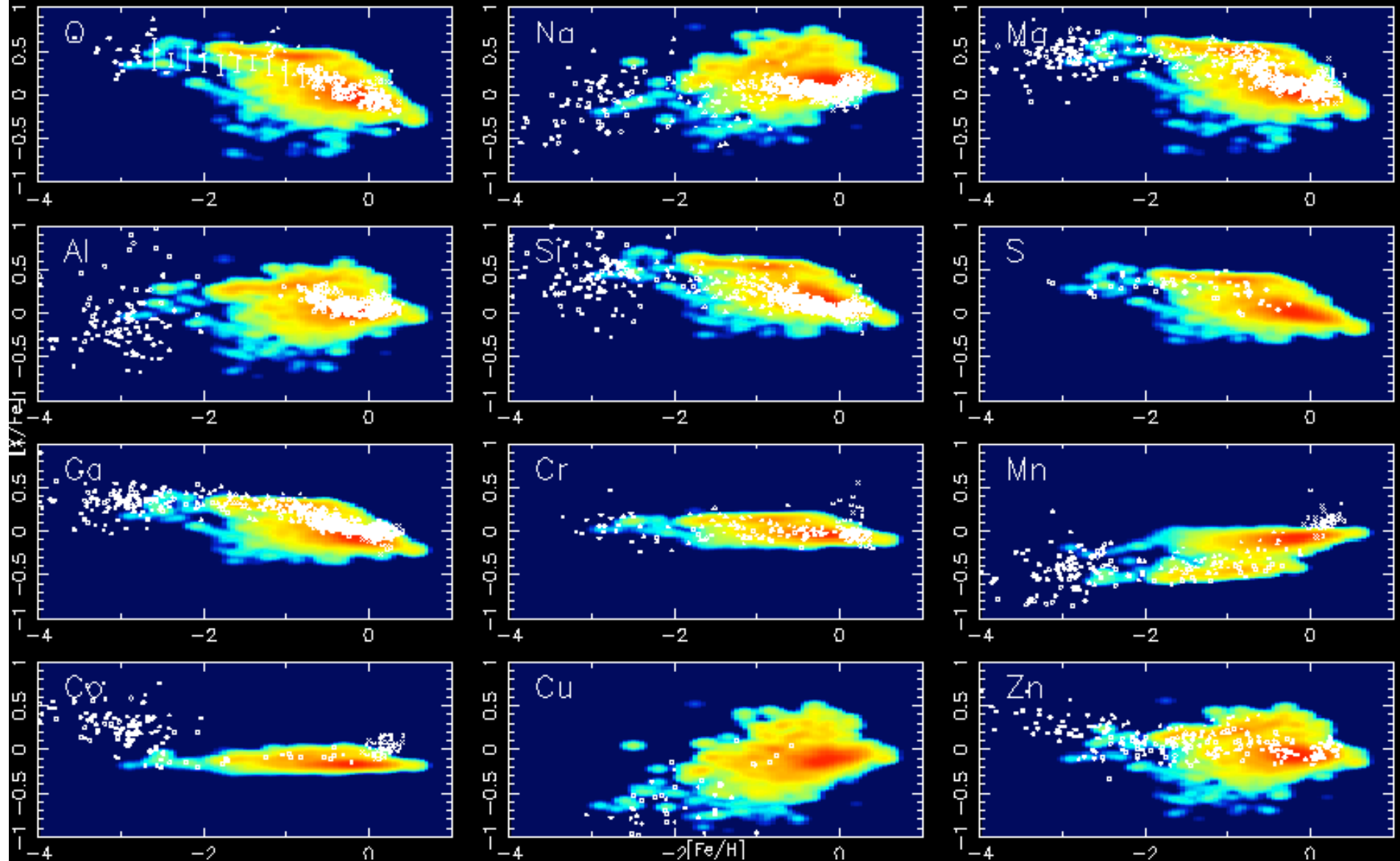
# [X/Fe]-[Fe/H] relations

Solar Neighborhood



# [X/Fe]-[Fe/H] relations

Solar Neighborhood



# Summary

- ★ **Chemodynamical Simulation of the Galaxy**
  - ★ reproduce the difference of stellar population in bulge/disk
  - ★ predict the **Frequency Distribution of Elemental Abundances** as a function of time and location
- ★ To be compared with...
  - ★ Homogeneous Dataset of **a million stars**, ~100 EMP stars
  - ★ **High-resolution** ( $R > 20,000$ ) → from Li to Eu
- ★ **Chemical Enrichment Sources**

HN	1-10 Myr	low Z	Fe, Zn, $\alpha$
SN II	1?-100 Myr		O, Mg, $\alpha$ , r?
SN Ia	0.1-20 Gyr	high Z	Fe, Mn
AGB	0.1-20 Gyr		C, N, Li, s?



# Summary

- ★ **Chemodynamical Simulation of the Galaxy**
  - ★ reproduce the difference of stellar population in bulge/disk
  - ★ predict the **Frequency Distribution of Elemental Abundances** as a function of time and location
- ★ To be compared with...
  - ★ Homogeneous Dataset of **a million stars**, ~100 EMP stars
  - ★ **High-resolution** ( $R > 20,000$ ) → from Li to Eu
- ★ Also for many studies...
  - ★ **Chemical Tagging** (Freeman & Bland-Hawthorn 04)
  - ★ **Supernova Physics, Connection with GRB**
  - ★ **O-Na/Mg-Al anti-correlation** (Stellar Astrophysics)
  - ★ **Li problem** (Nuclear Astrophysics? Cosmology??)