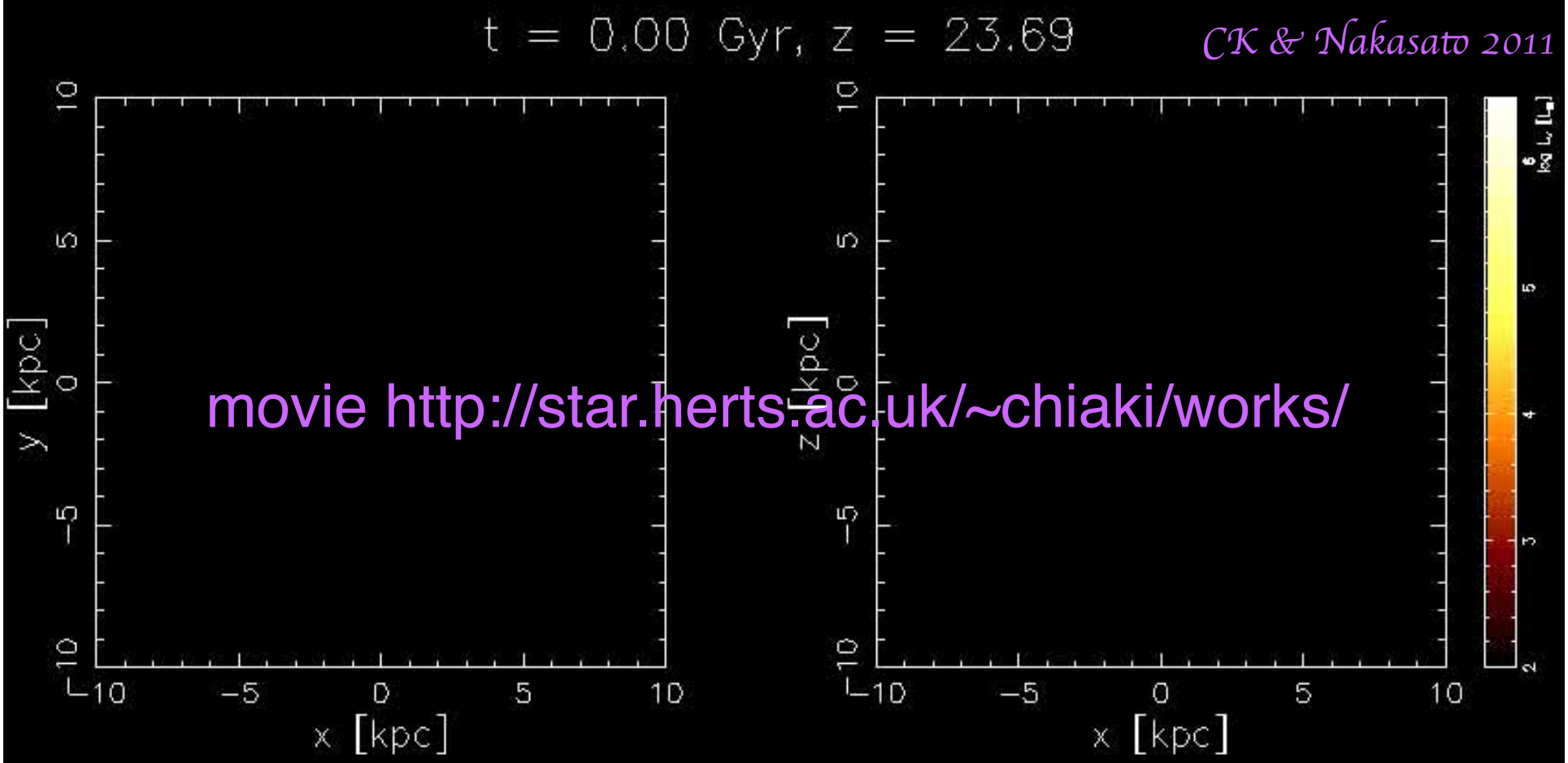
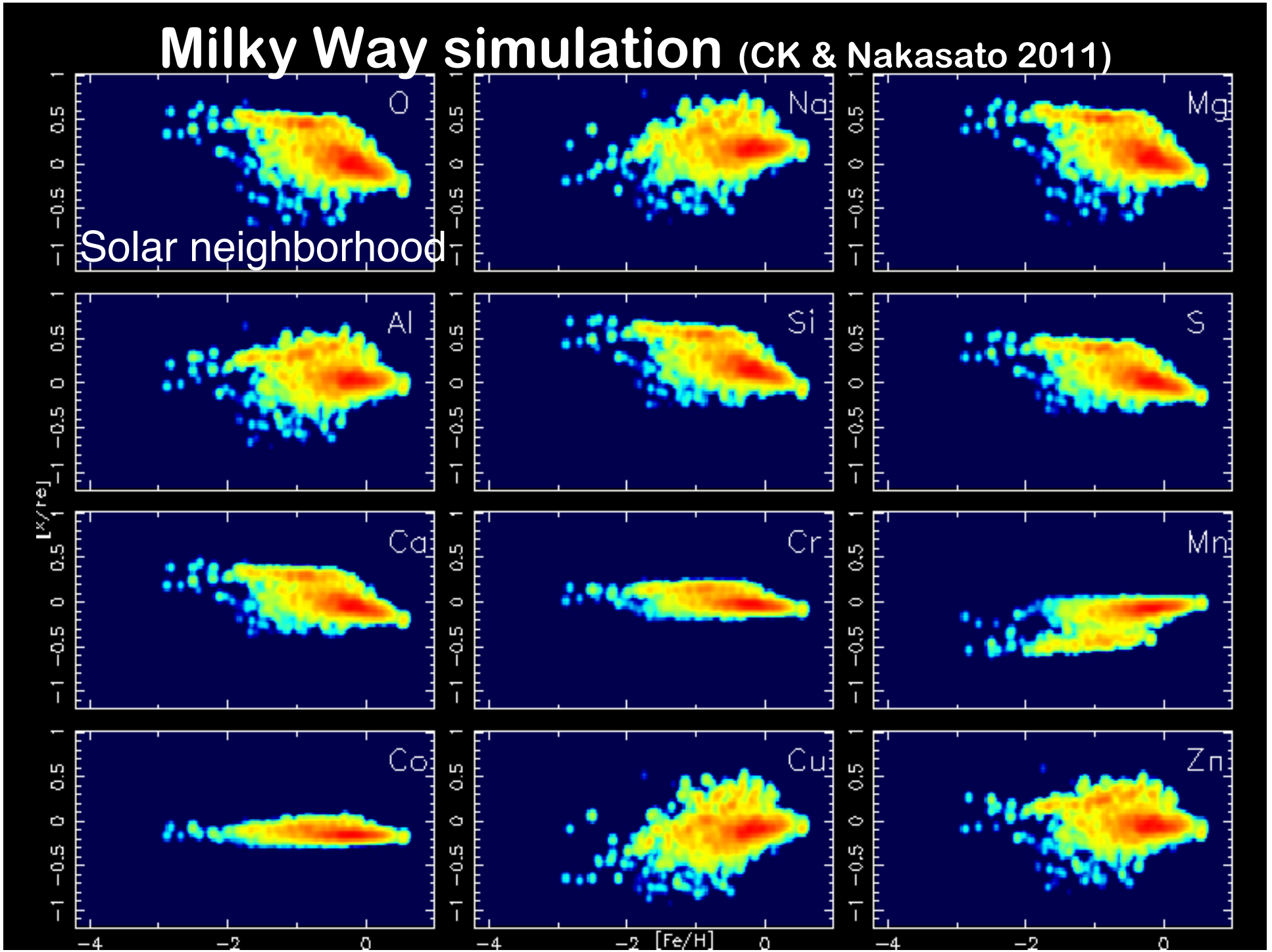
Constraints from galactic chemical evolution

& chemodynamical simulation (excl. stocastic GCE & neutron capture elements – Wehmeyer+, Cescutti+)

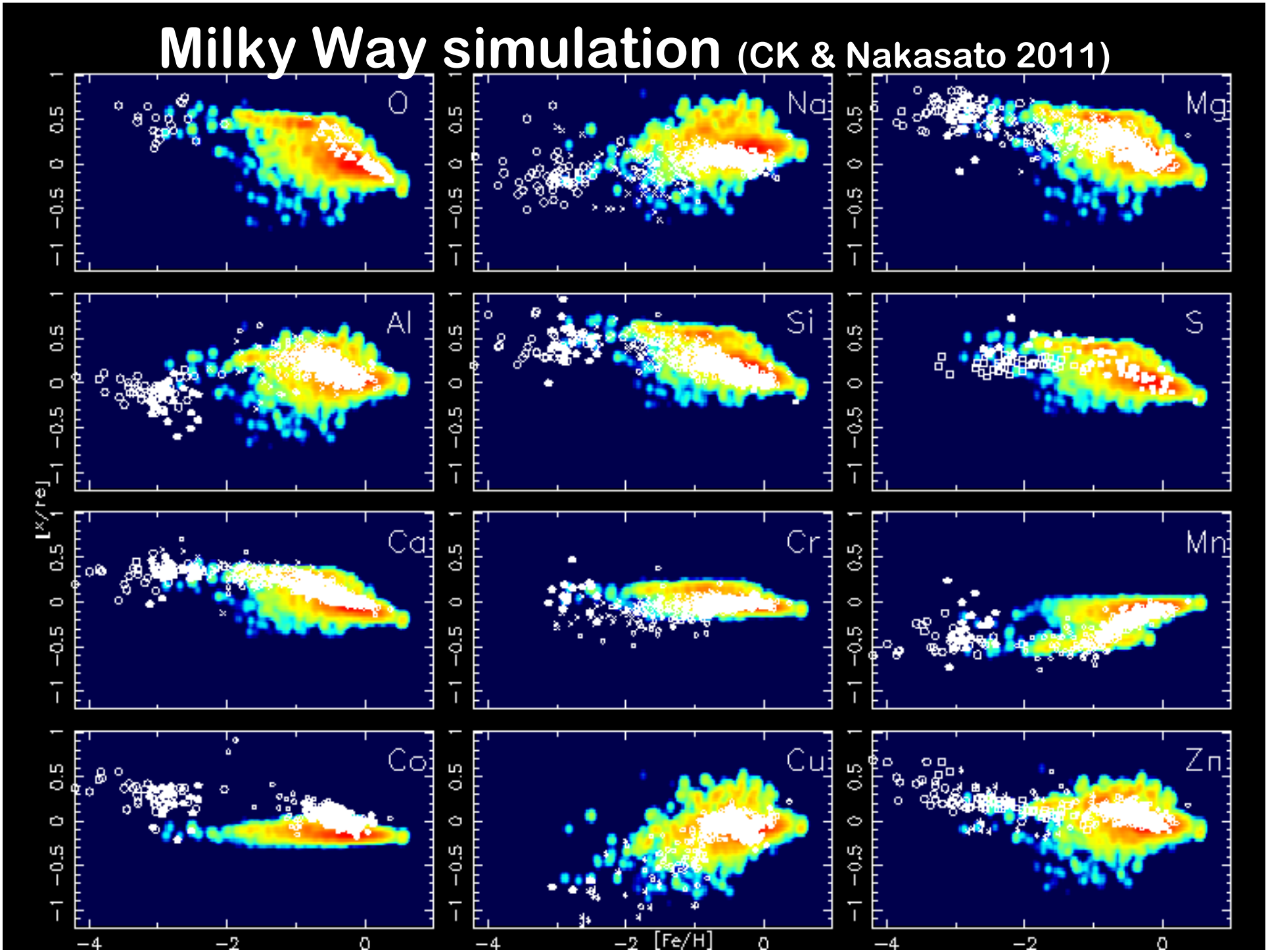


CK & Nakasato 2011

Chiaki Kobayashi (Univ. of Hertfordshire, UK)


Milky Way simulation (CK & Nakasato 2011)
Solar neighborhood
O
Na
Mg
Al
Si
S
Ca
Cr
Mn
Co
Cu
Zn
[X/Fe]
[Fe/H]

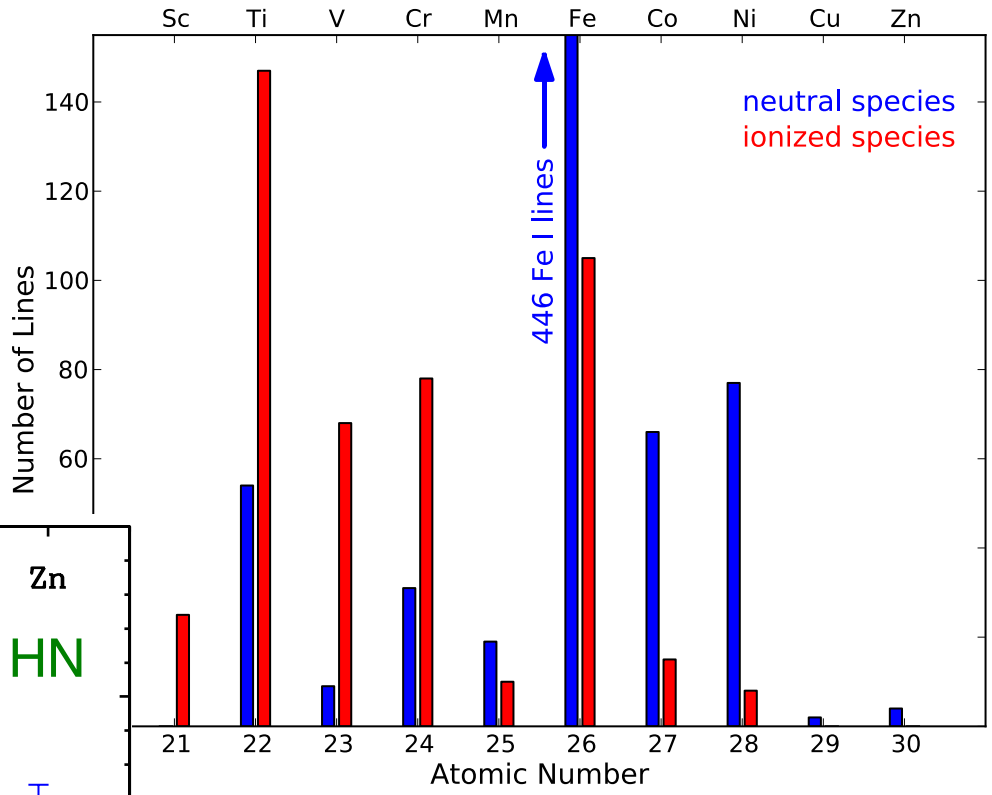
Milky Way simulation (CK & Nakasato 2011)

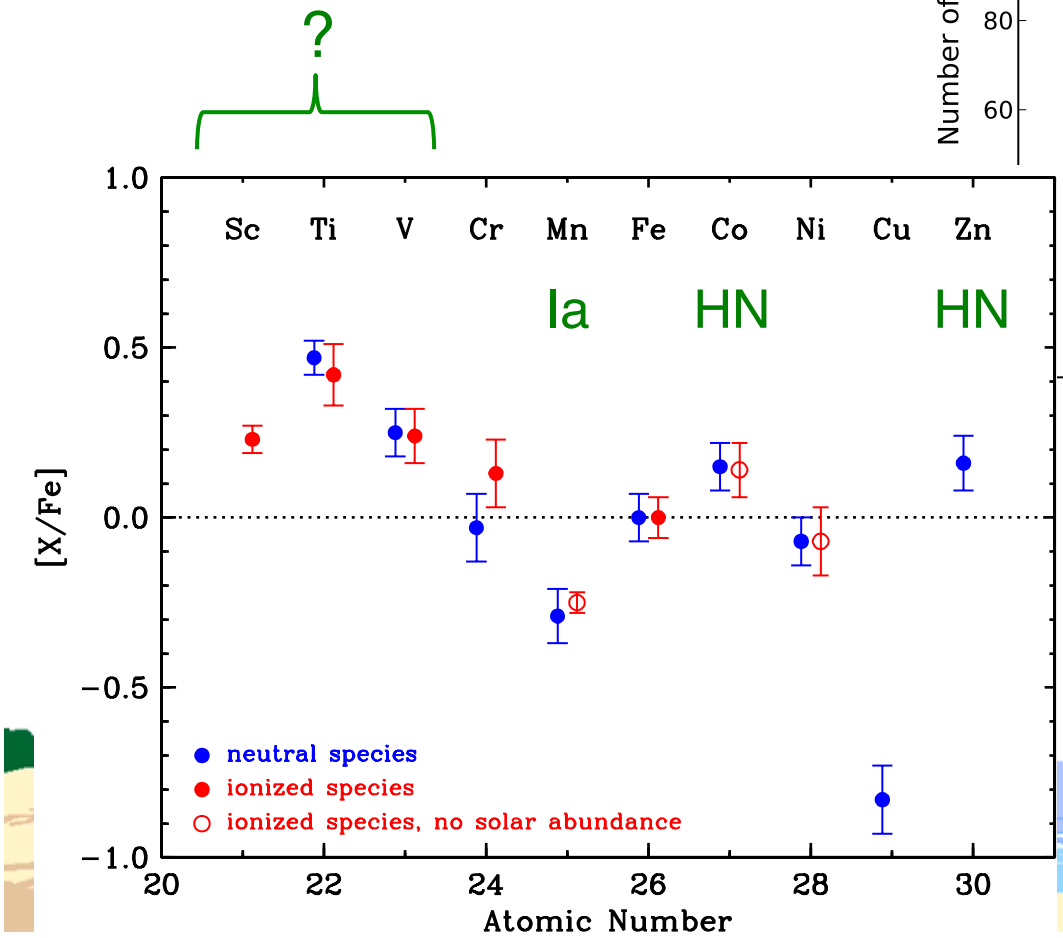


New atomic data

Sneden, Cowan, CK, et al 2015

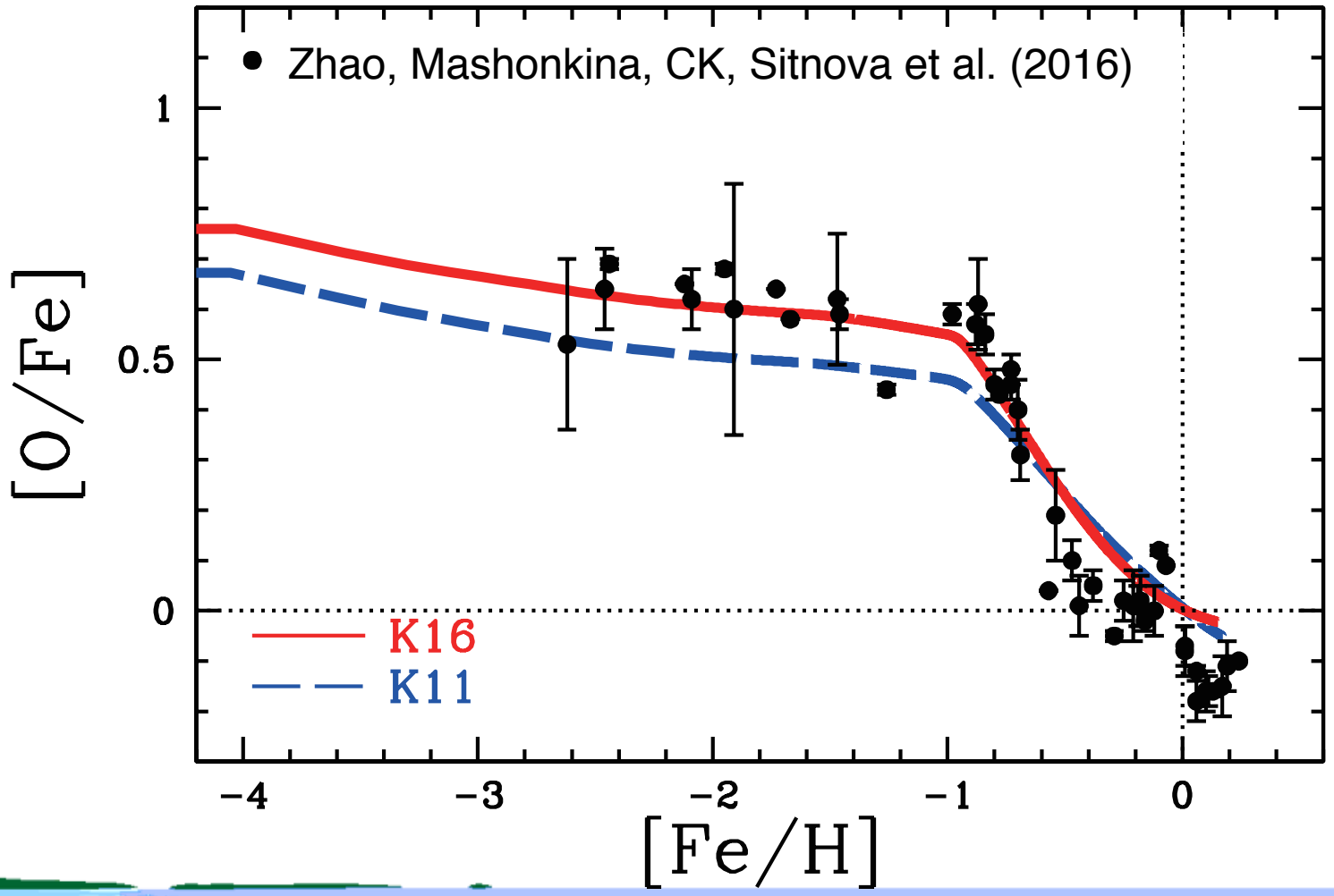
- HD 84937, [Fe/H]=-2.32
- LTE analysis not bad fro iron-peak elements





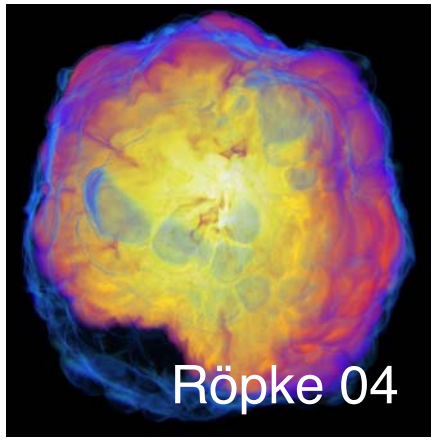
NLTE abundances

obs: 51 stars, 48 from Shane/Hamilton R~60000

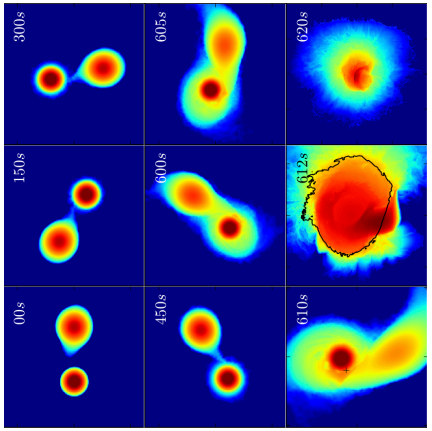


※Asplund+09 solar abundance applied in K16

SN Ia progenitors / explosions



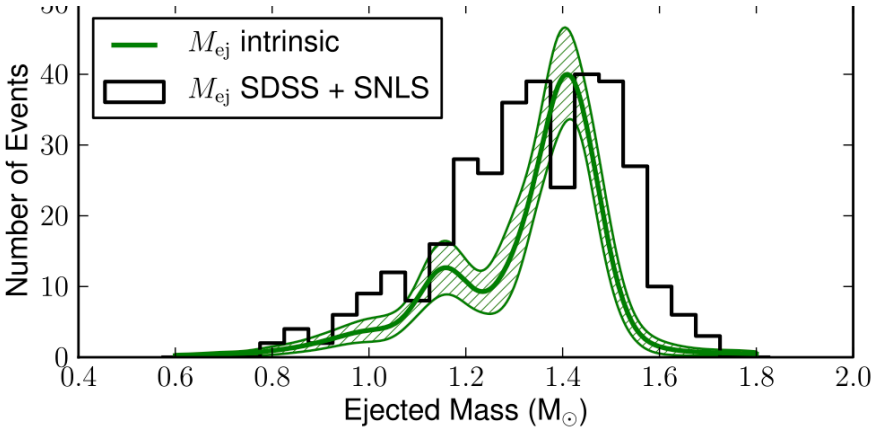
- Ch-mass deflagration or delayed detonation
  higher rate in binary pop. synthesis (Nelemans+13)
- sub-Ch double detonation from He-star (Ruiter+14)
- sub-Ch double detonation from H accretion (Yungelson+95, CK+15)
- Ch-mass deflagration of CONe WD (Meng & Podsiadlowski 14, CK+15, Kromer+15)



Pakmor+ 11,12

- CO WD+CO WD merger, likely to be sub-Ch
- sub-Ch double detonation from He-WD (Ruiter+14)
- triple merger

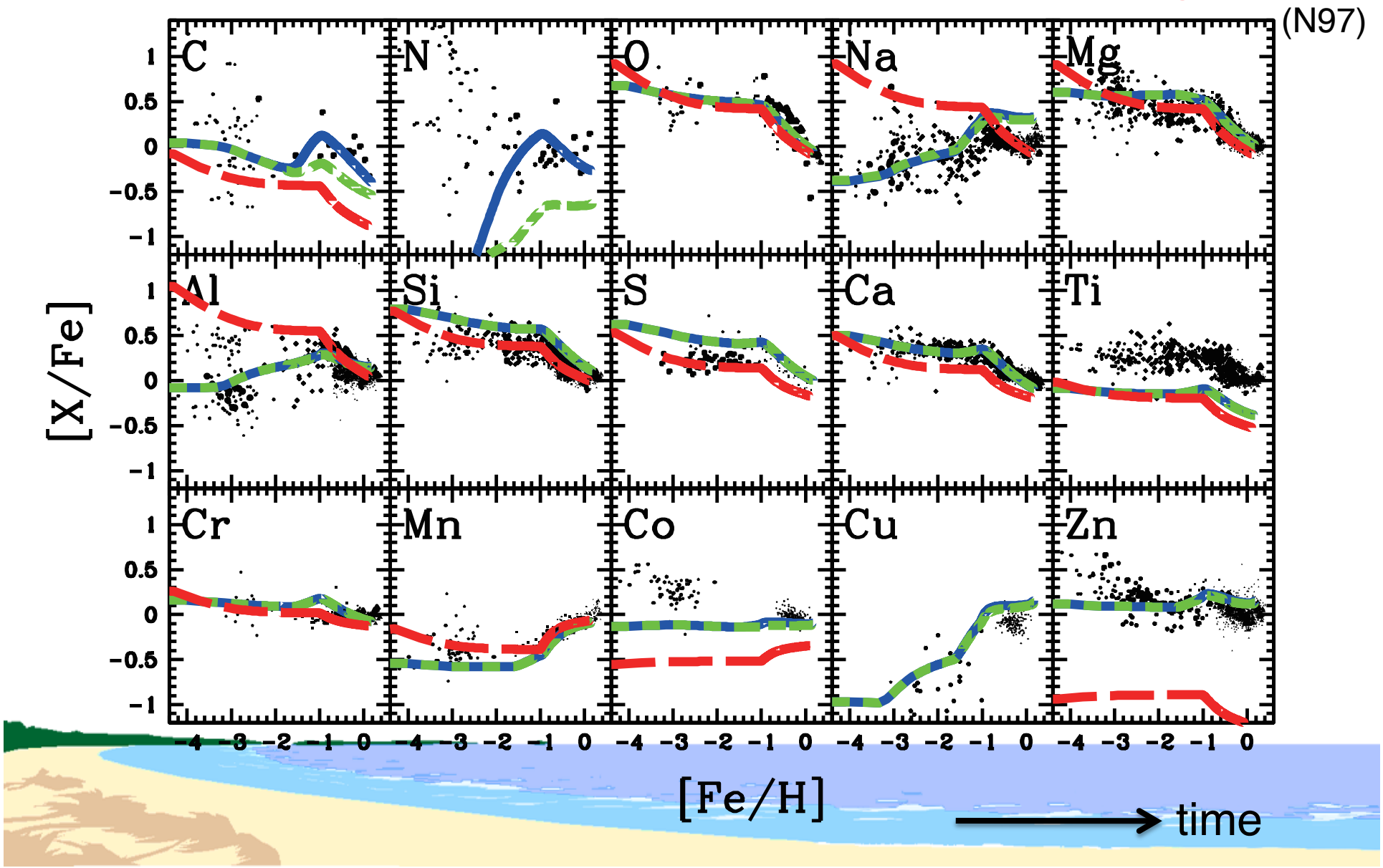
Scalzo et al. 2014



Observations→
The majority of SNe Ia have ~1.4$M_\odot$.

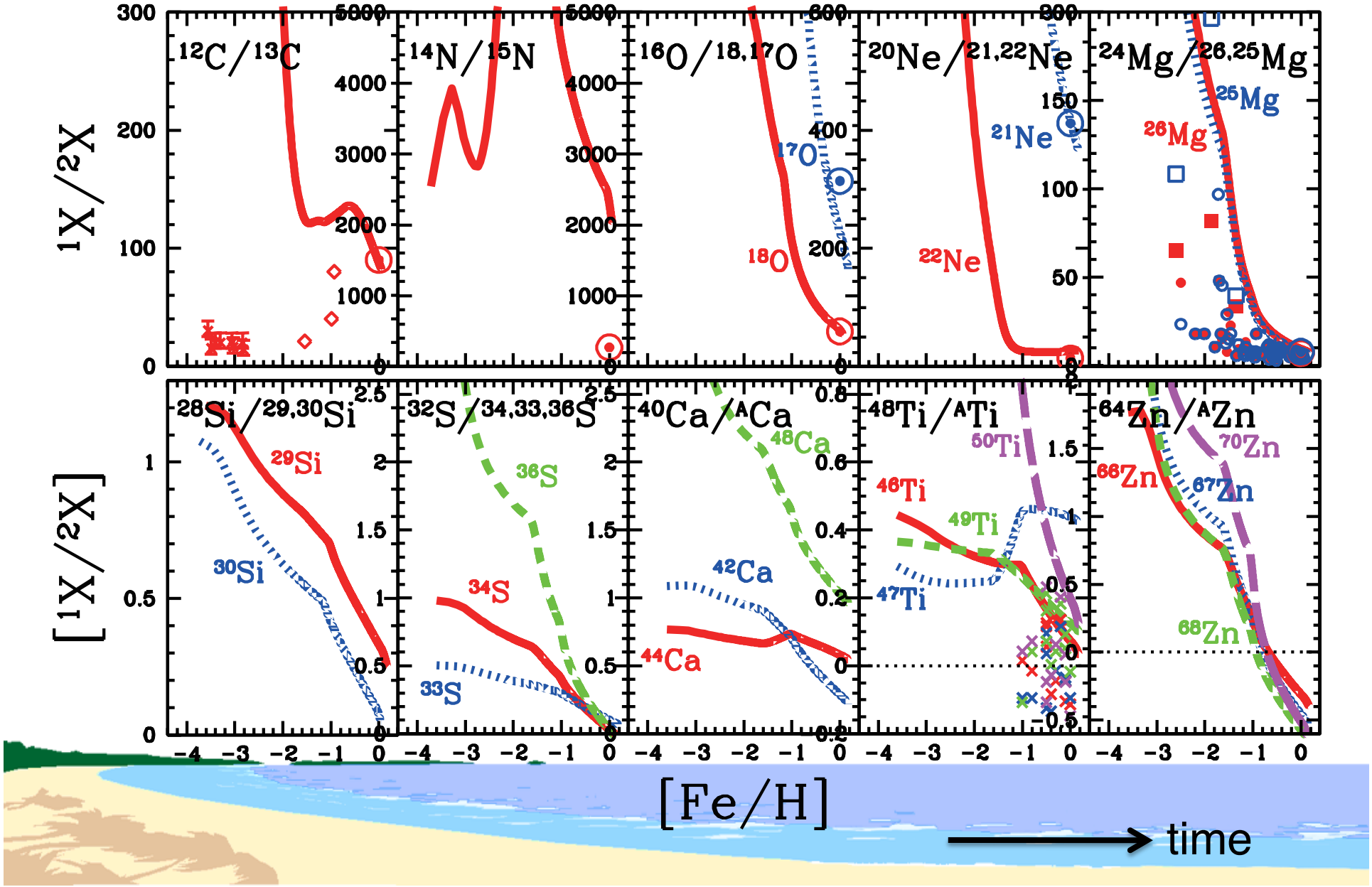
1D yields need Mixing-Fallback

SN+HN+AGB (CK+11), SN+HN (CK+06), SN only, no mixing-fallback



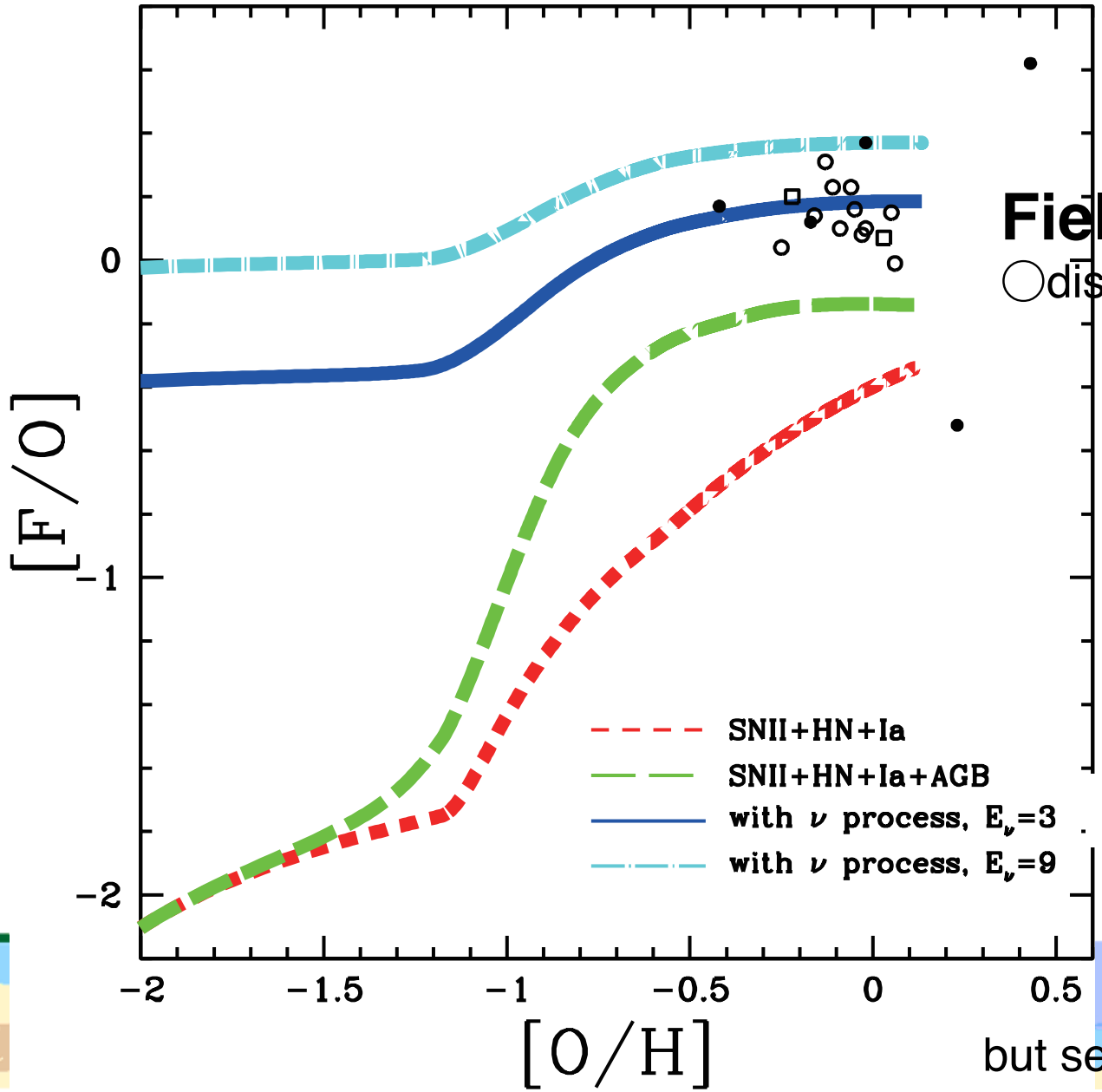
Isotope Ratios

CK, Karakas, Umeda (2011)



Fluorine Problem

CK, Izutani, Karakas, T.Yoshida, Yong, Umeda 2011



Field stars

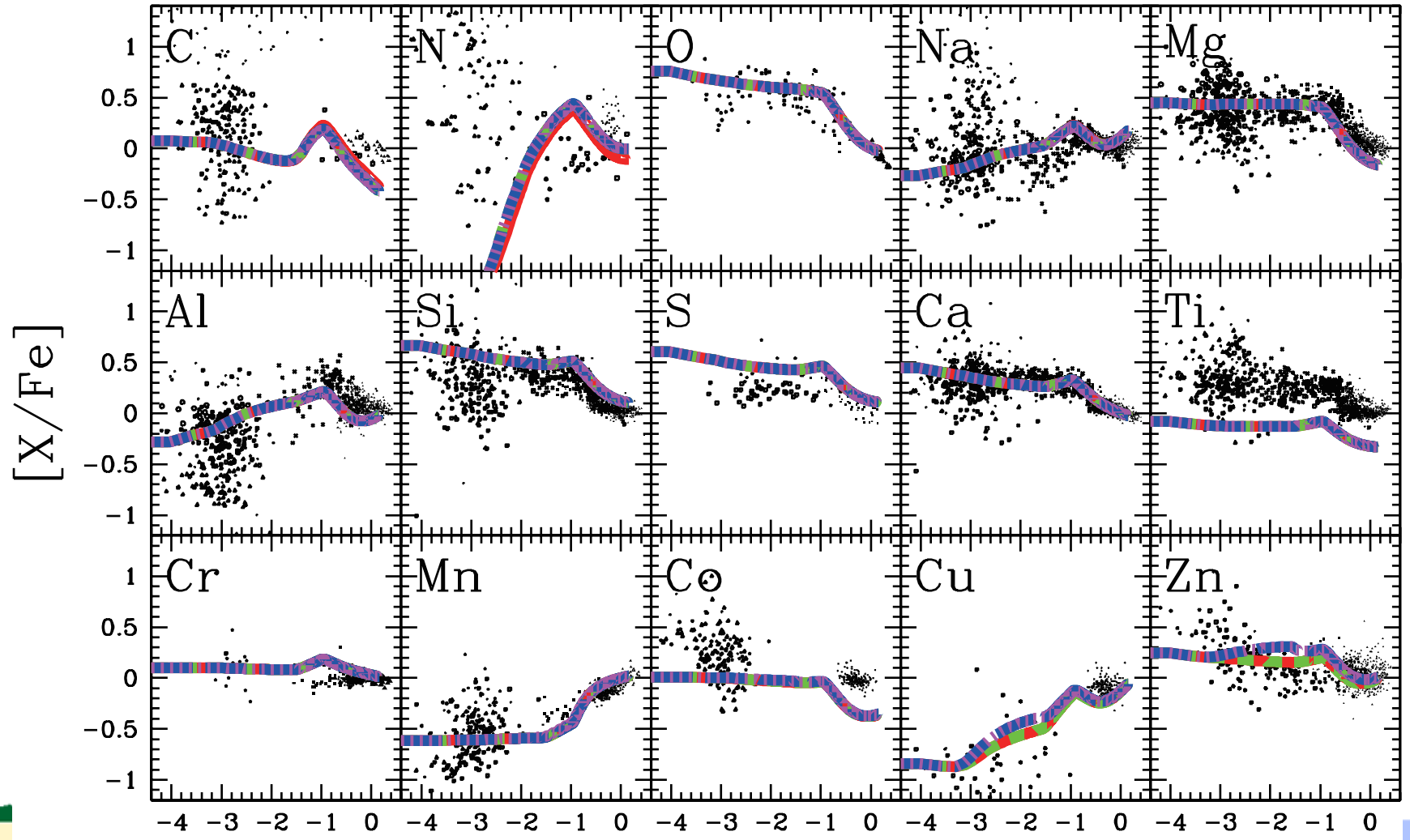
○disk, ●bulge

(Standard)

but see Jonsson+ 14

Super AGB & ECSN

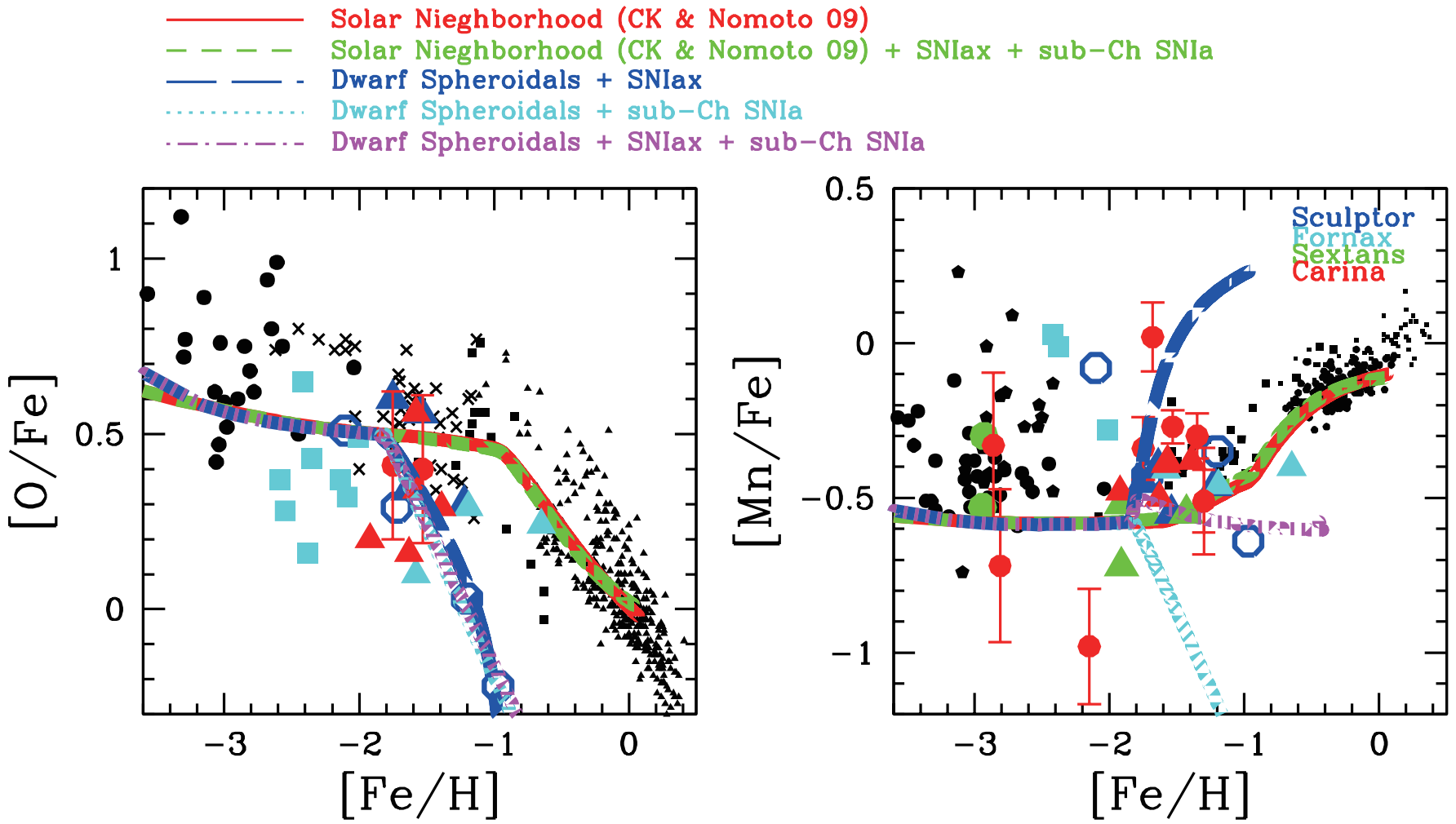
SN+HN+AGB+SNIa(Z), SAGB, ECSN, Iax



CK, Karakas, Lugaro+16, in prep.

SNIax in dSphs?

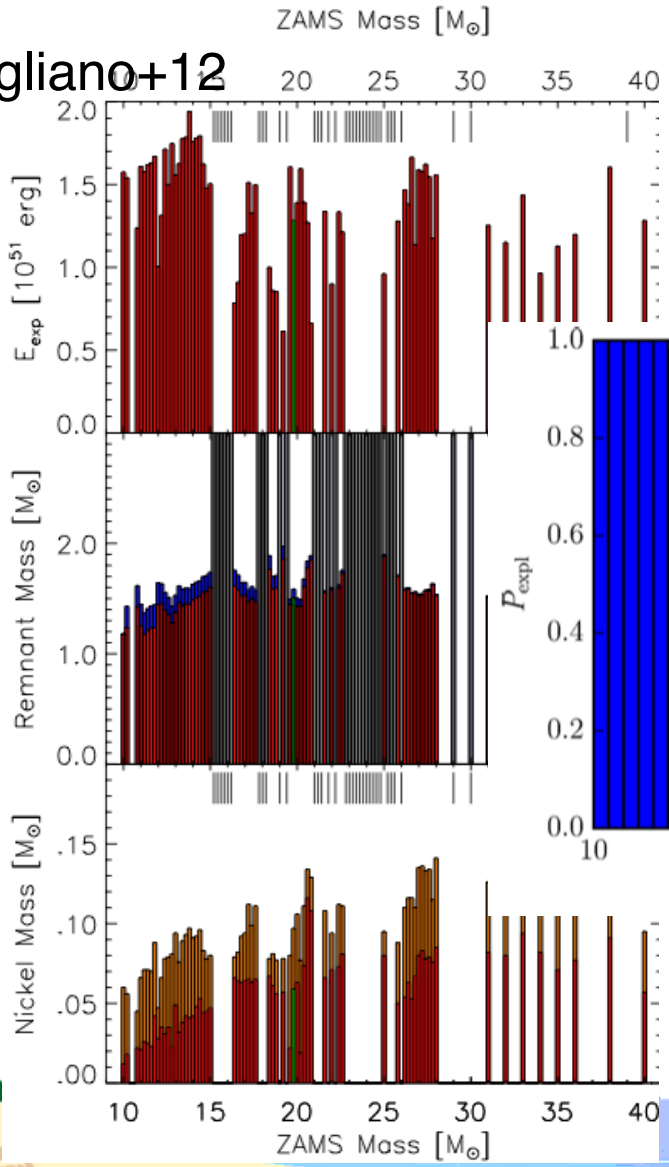
CK, Nomoto, Hachisu 2015, ApJL, 804, 24



- In deflagrations, Mn is mostly synthesized in NSE, while in sub-Ch SNeIa, mostly in incomplete-Si burning, which depends on Z.
- A mix of sub-Ch SNIa & SNIax can reproduce [Mn/Fe]~ -0.5.

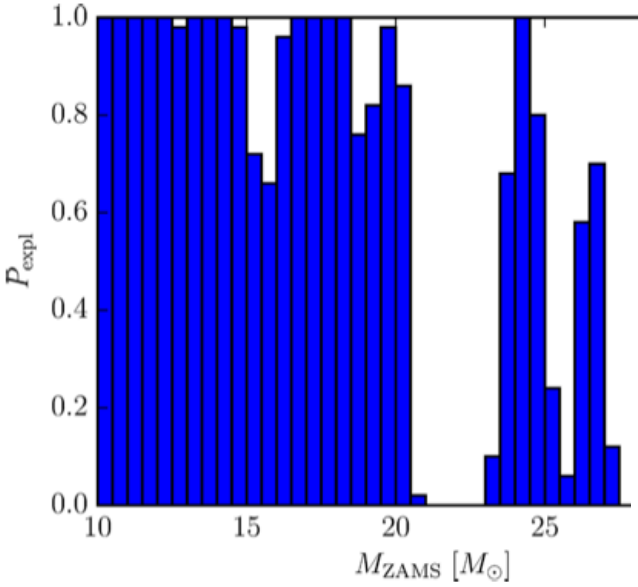
Failed Supernovae >20$M_\odot$?

Ugliano+12

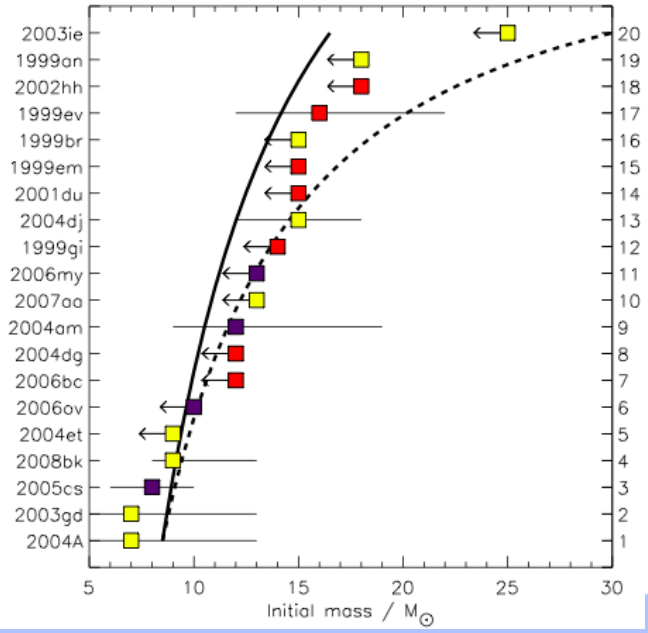


- But, convection (Hirschi)
- binary (Langer)

Mu¨ller+16

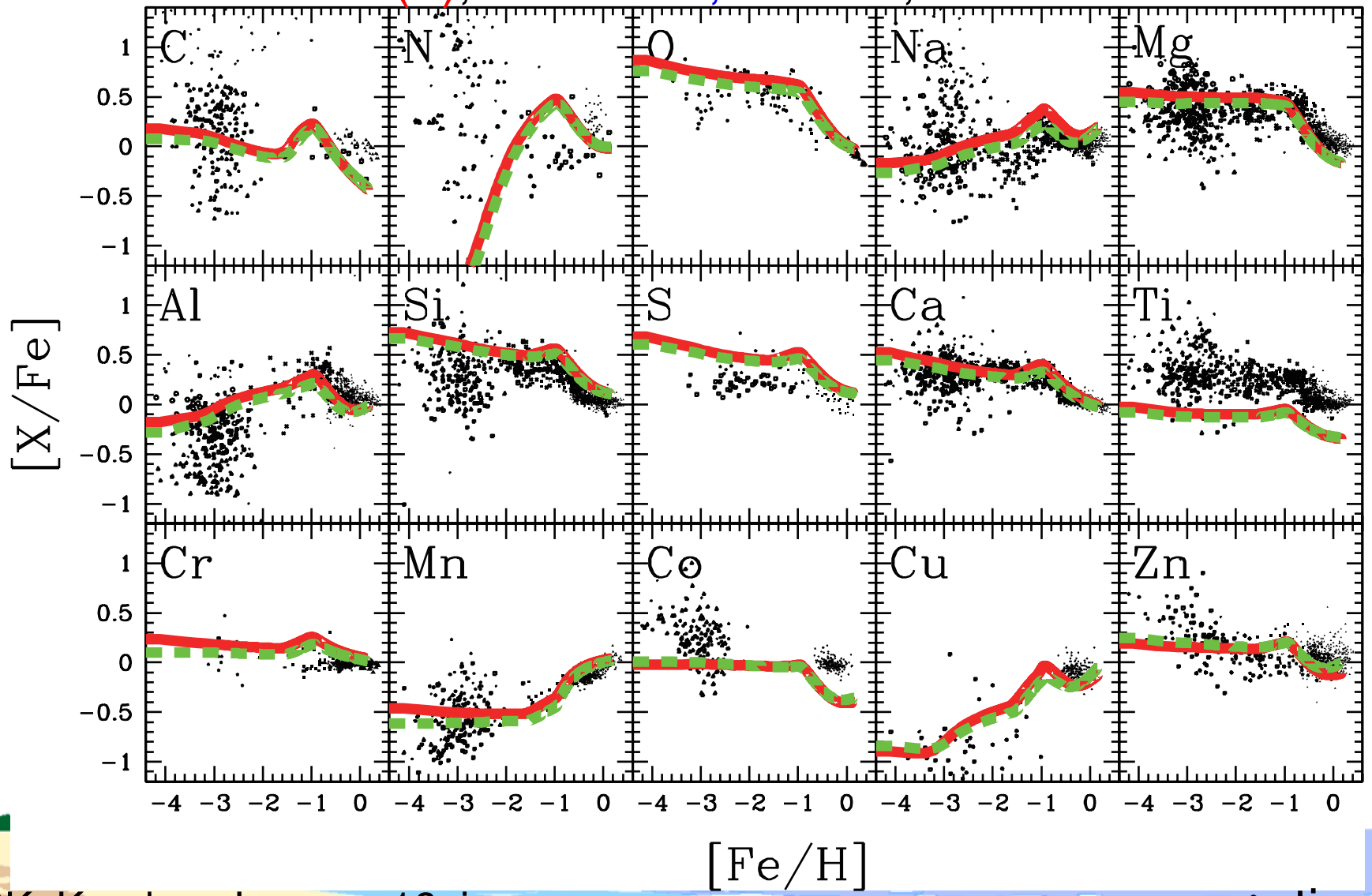


Smartt (2099), ARAA



Failed SNII (>25$M_\odot$) with HN✔

SN+HN+AGB+SNIa(Z), Failed SN, w/o HN, Failed SN w HN

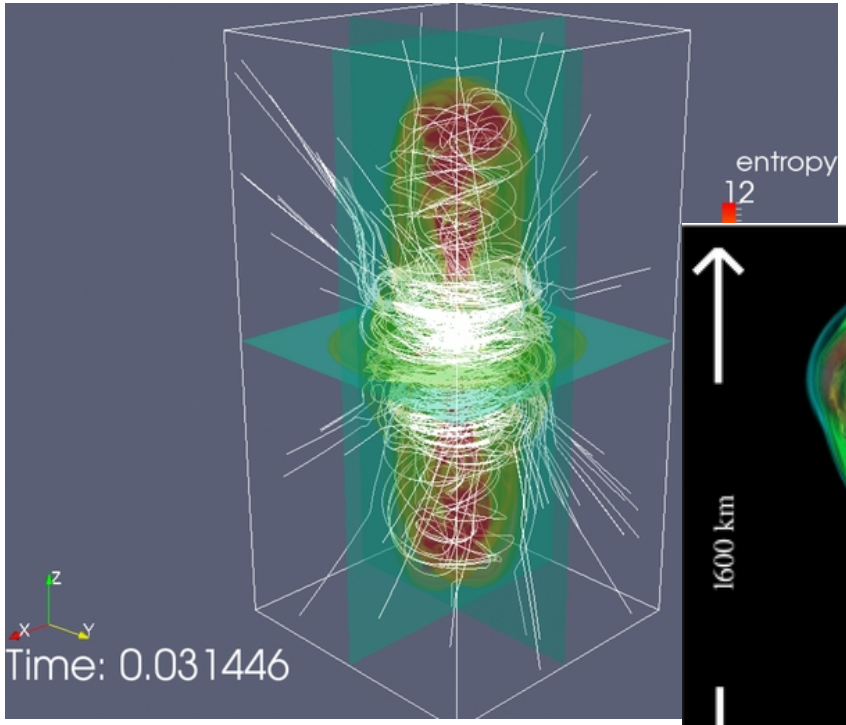


CK, Karakas, Lugaro+16, in prep.

time

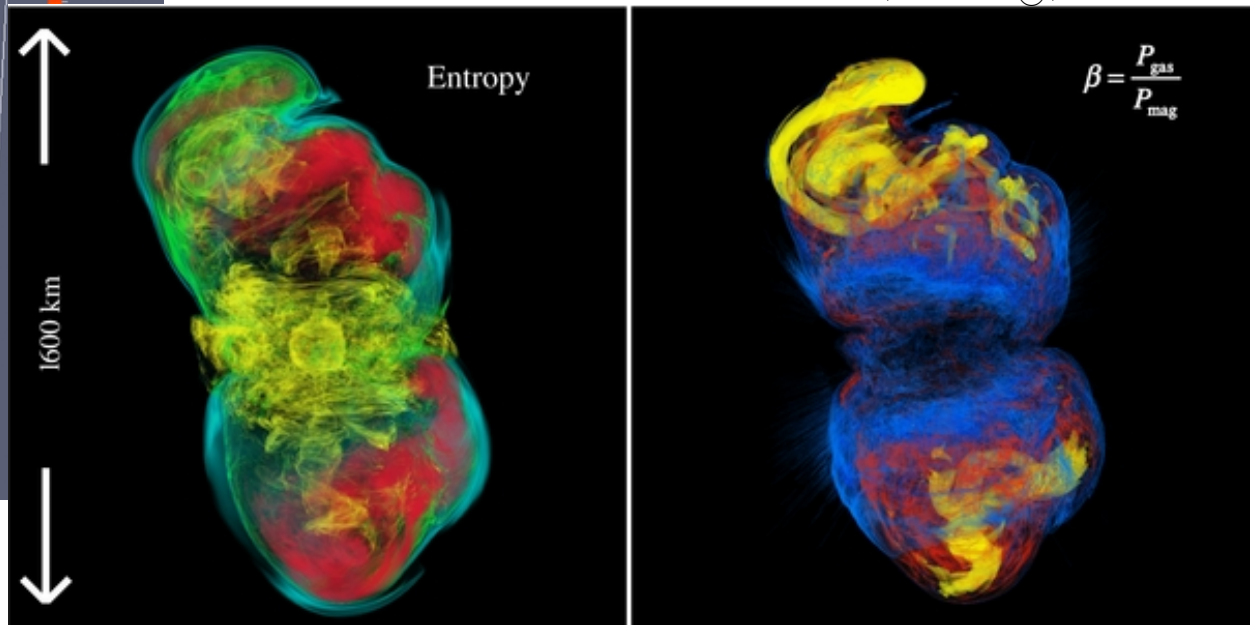
Hypernovae

- Hypernova (>20$M_\odot$, >10^{51} erg) is evidenced from observed nearby SNe. The mechanism is not known.
- Nucleosynthesis of (artificial) jet +2D hydro give higher Zn,Ti,Sc,V (Maeda & Nomoto 03; Tominaga 09)



←Winteler+12, 15$M_\odot$, 5x10^{12} G
r-process with tracer particles

↓ GRMHD: Mösta+14, 25$M_\odot$, 10^{12} G



Also, Nishimura+ 15

Sneden, Cowan, CK, et al 2016

K06: GCE model w Salpeter IMF

K11: GCE model w Kroupa IMF

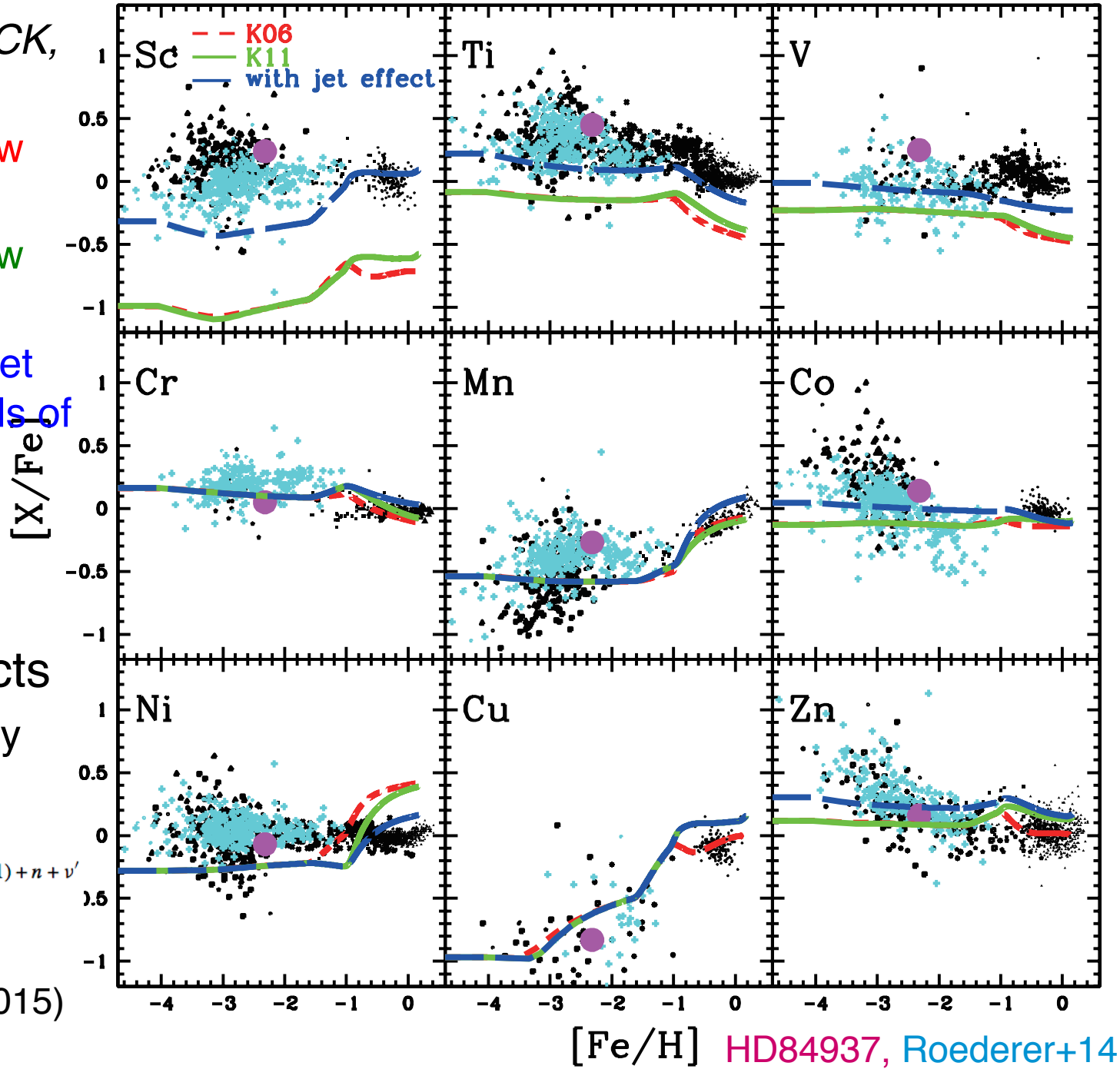
K15: HN with 2D jet effects, SNIa yields of delay.det.

Importance of

- ✷ 2D (jet) effects
  - ★ high entropy
- ✷ ν-process

$$(Z,A)+\nu \rightarrow (Z,A)^{*}+\nu' \rightarrow (Z,A-1)+n+\nu'$$
$$\rightarrow (Z-1,A-1)+p+\nu'$$
$$\rightarrow (Z-2,A-4)+\alpha+\nu'.$$

(CK, Izutani, et a. 2015)



Summary

- **SNIa/Iax**: α-Mn-Ni problem
  - Ch-mass, delayed detonation ✔
  - sub-Ch/Iax contribution: not MW but possibly dSphs
- **AGB** contribution: half of C, N, F, s
  - can appear at low [Fe/H] with inhomogeneous enrichment
  - depends on rotation & binary
- **SAGB/ECSN** contribution: ~0 for <=Zn
  - may appear in the scatter of [X/Fe] though…
- **Core-collapse SN**: Mn-Zn/Co/Cu/Ti problem
  - Mixing-fallback is necessary for 1D yields, and is proved in multi-D simulations
  - Failed SNe >25$M_\odot$ ok if HNe exit

Topics I did not cover:

- no PISN enrichment at all Z in stars/DLA
- faint SNe from CEMP