RESCEU APCosPA summer school @ Asama onsen, August 1st, 2014

# Origin of the most iron-poor stars in the Galaxy

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in collaboration with

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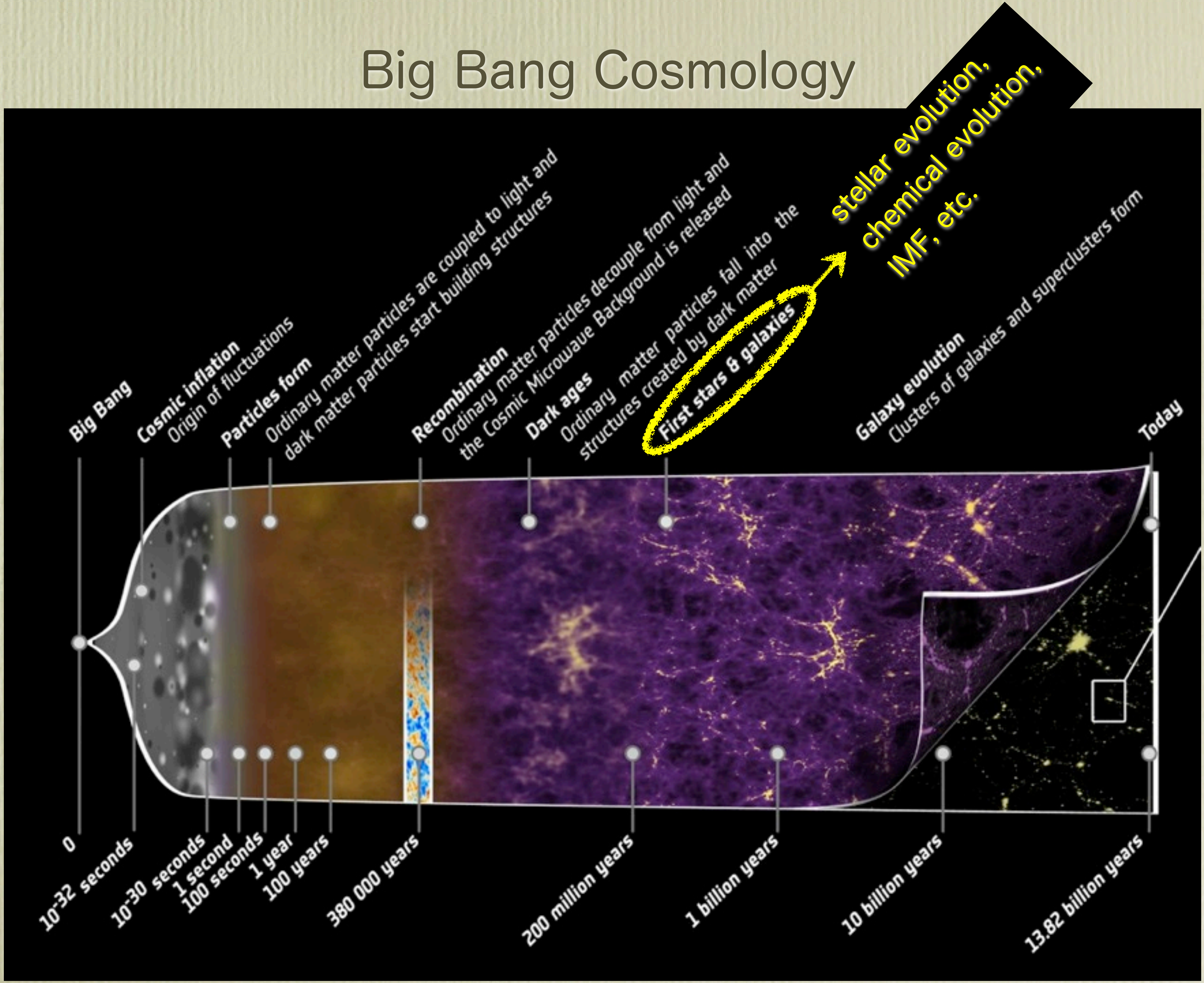
# Big Bang Cosmology

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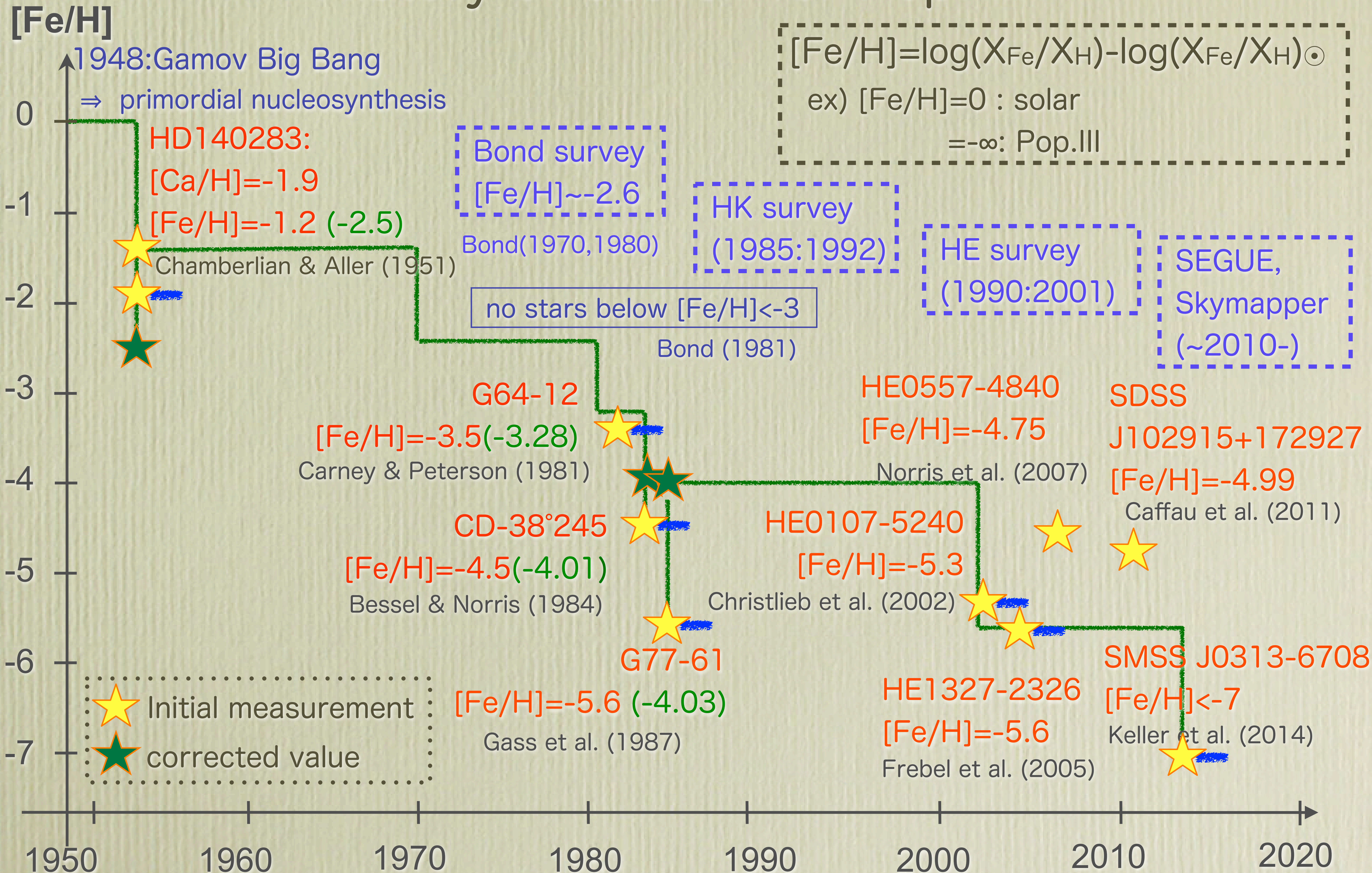
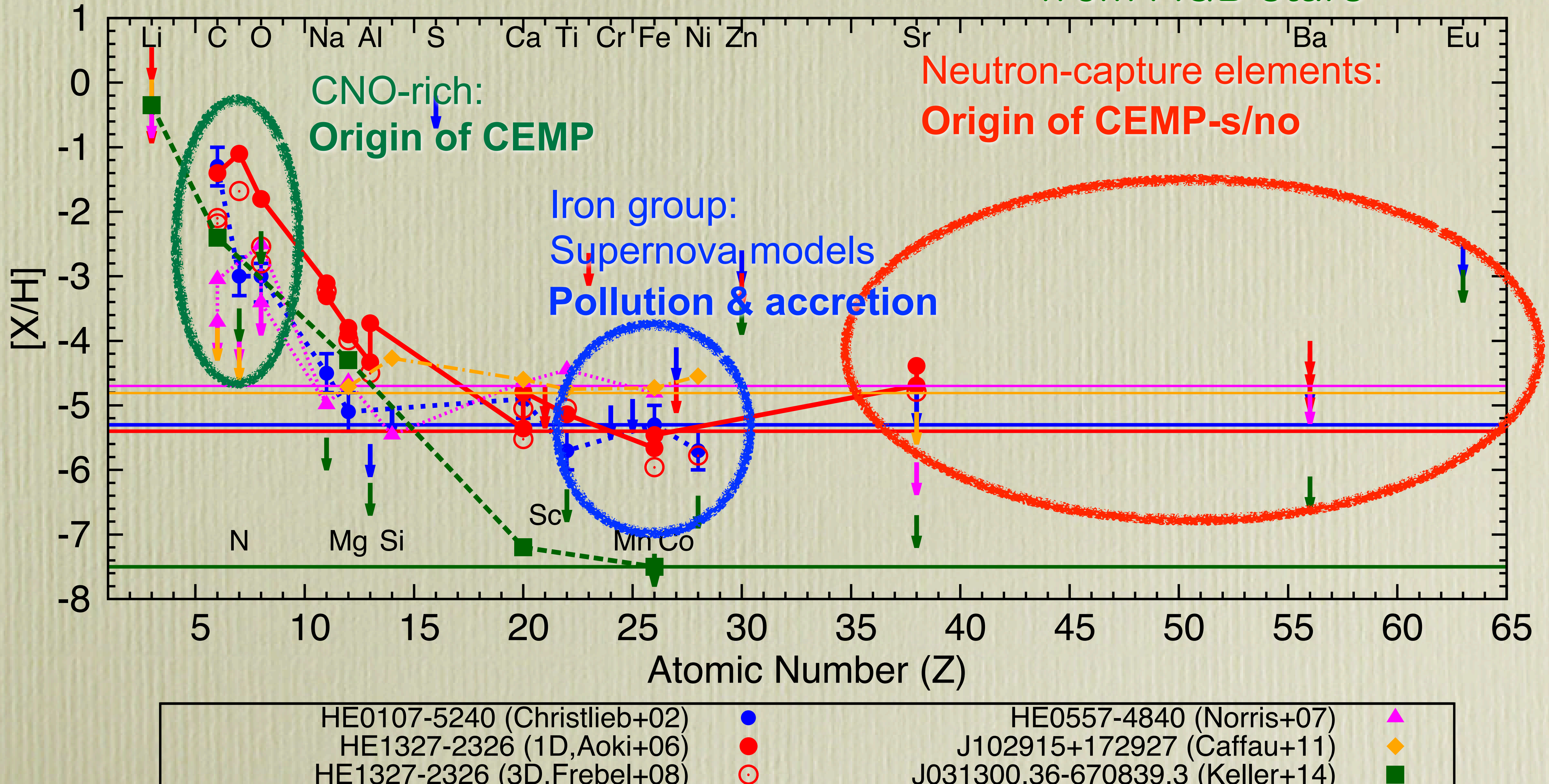
# History of Search for Pop. III



# Hyper Metal-Poor Stars

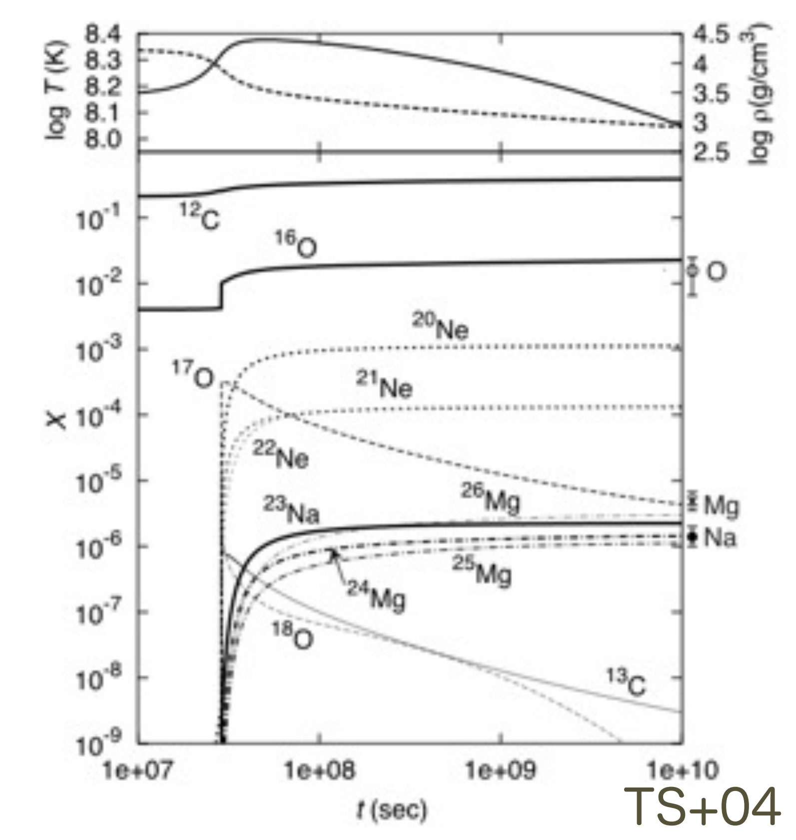
- Most of HMP stars are carbon-enhanced stars!
  - Carbon-Enhanced Metal-Poor (CEMP) stars are very common among metal-poor stars. ➡ mass transfer from AGB stars



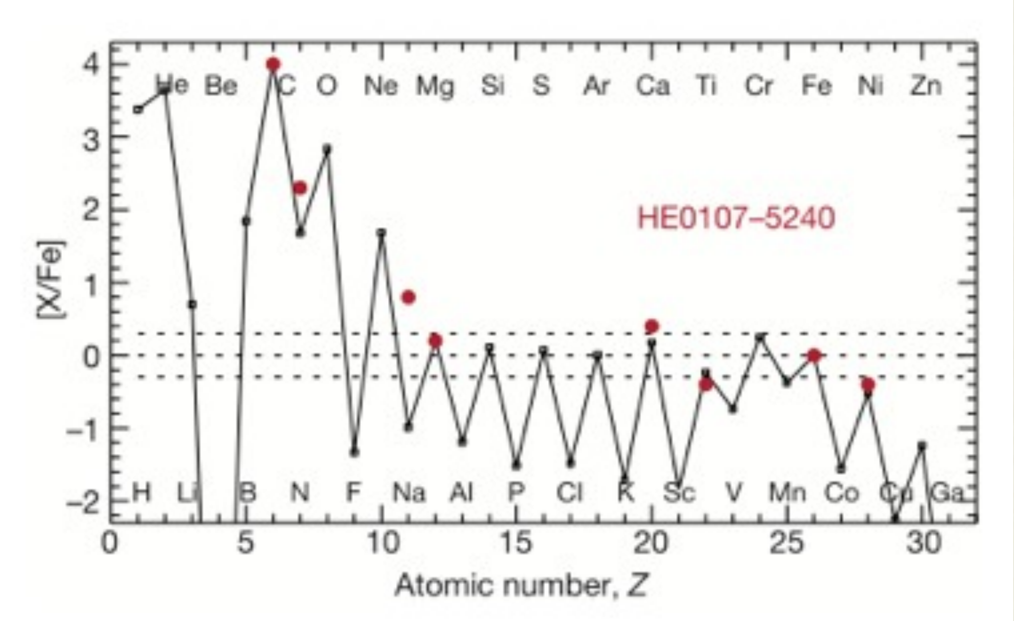

SAGA viewer

# Proposed Scenarios for the Origins of CEMP Stars

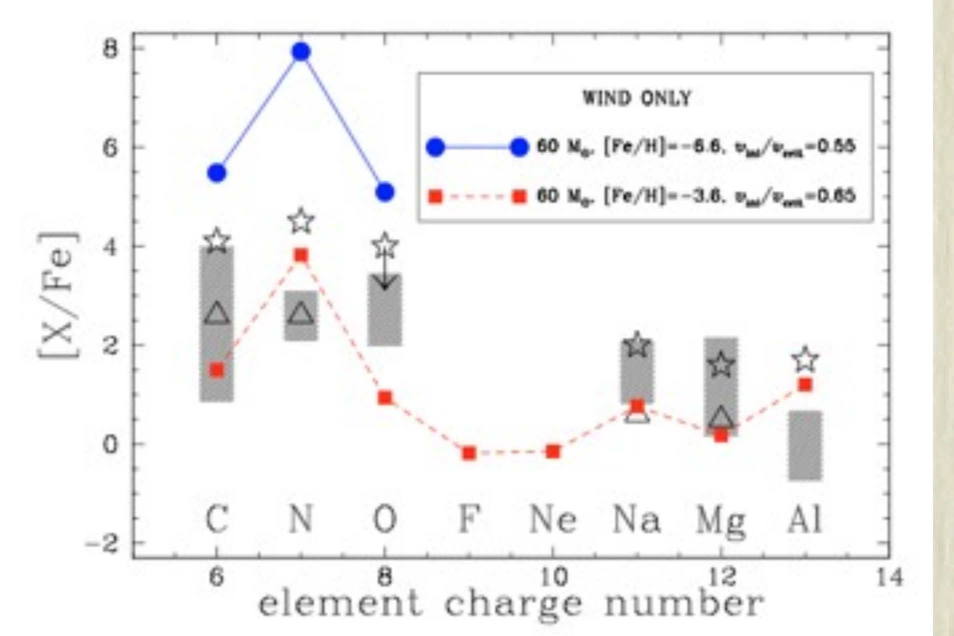
- Origin of EMP stars
  - Star formation from the gas influenced by SNe in the very early universe.
- Origin of CEMP stars
  - Mass transfer from AGB stars in binary systems (TS+04)
    - CEMP-s stars are thought to belong to binary systems (Lucatello+05), but not for CEMP-no.
  - Star formation from gas affected by peculiar supernovae in the earliest generation of massive stars (Umeda+03, Limongi+04)
    - Abundance patterns are well reproduced by mixing and fallback models.
  - Star formation affected by massive fast-rotating stars (Meynet +06)
    - Abundance patterns are well reproduced by rotational mixing.




TS+04



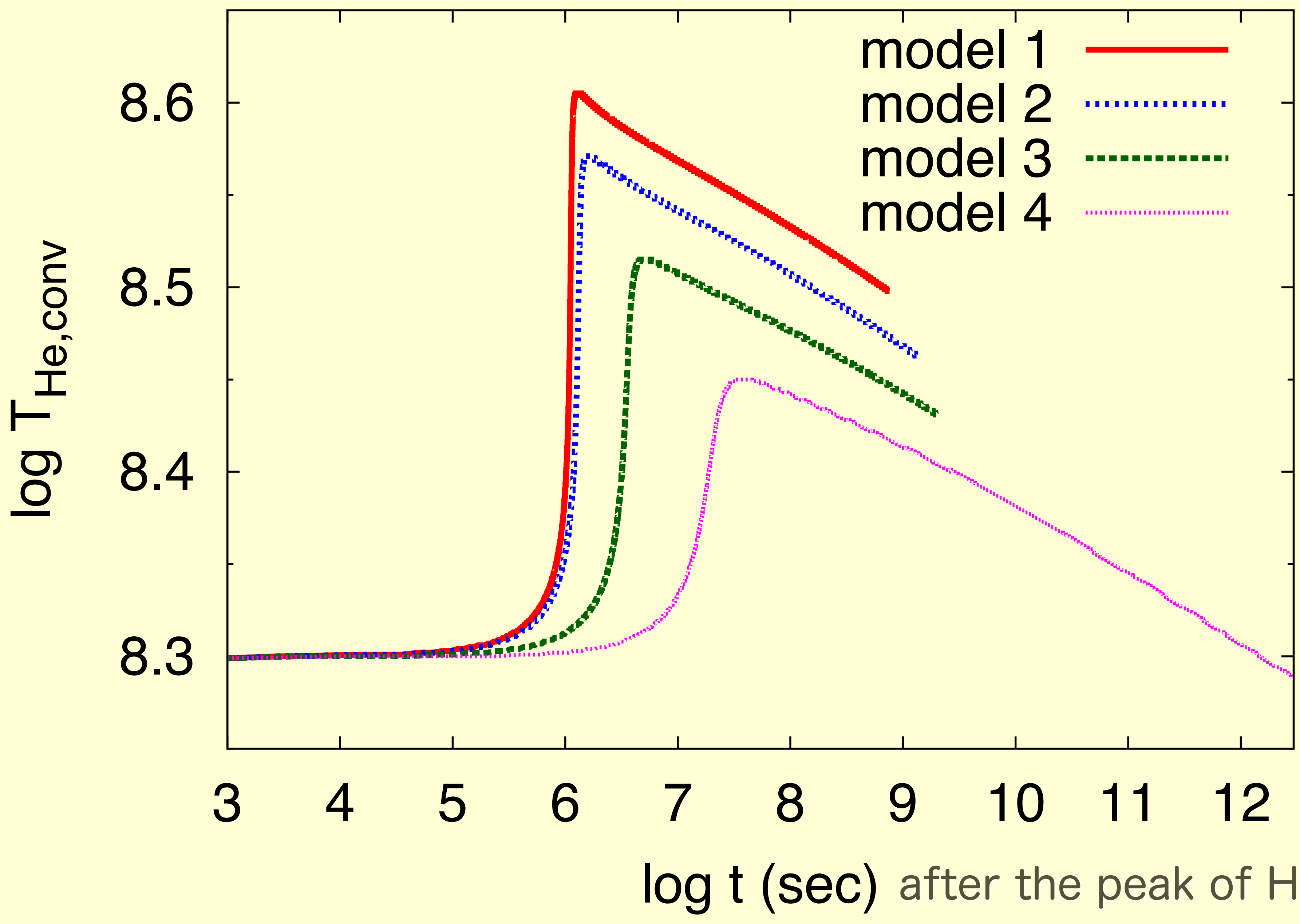

Umeda+Nomoto03




Meynet+06

# Nucleosynthesis models

- One zone approximation during the He shell flashes (Fujimoto+99, Aikawa+01)
- p-, α-, β-, n-reactions up to Bi are included in nuclear network (Aikawa+01, Nishimura+08, Yamada+, in prep.).

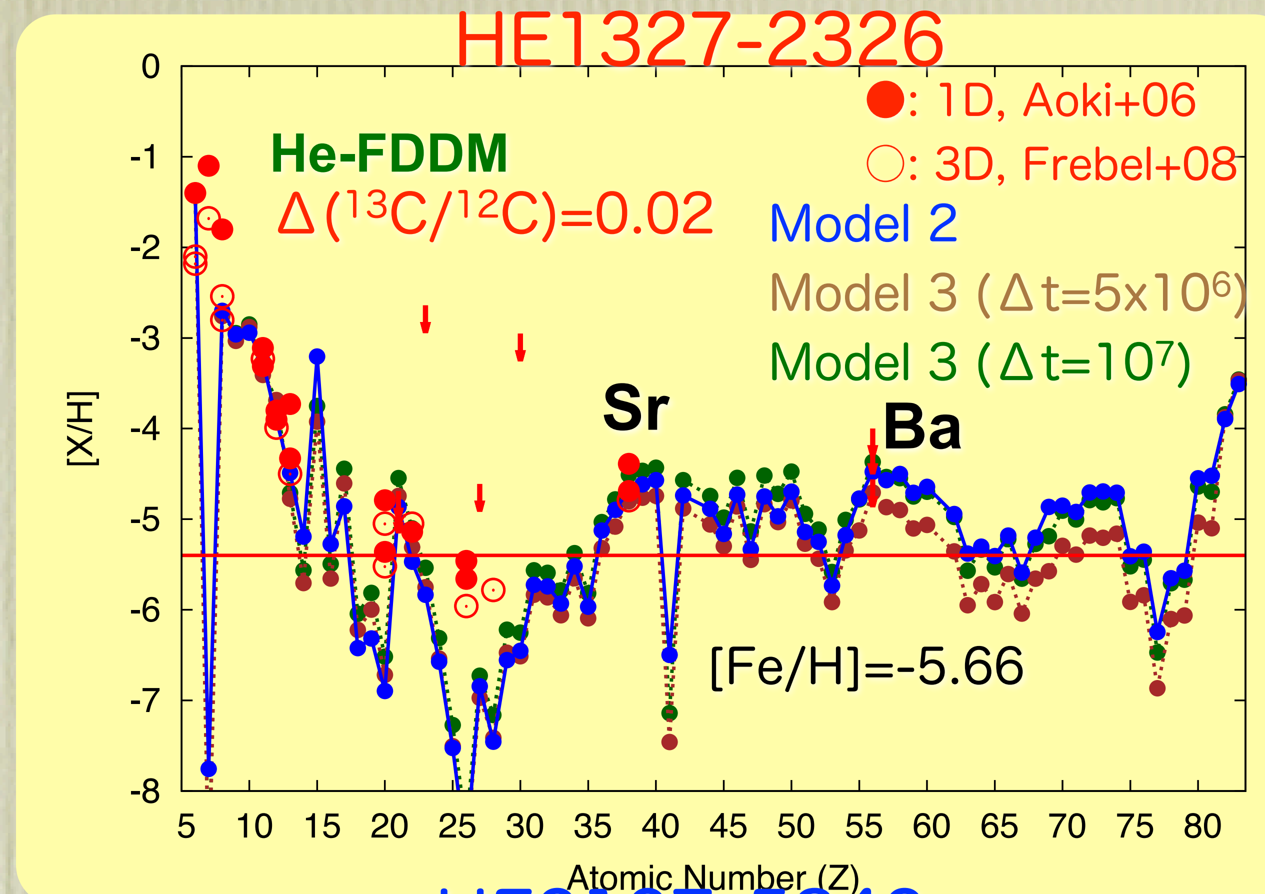


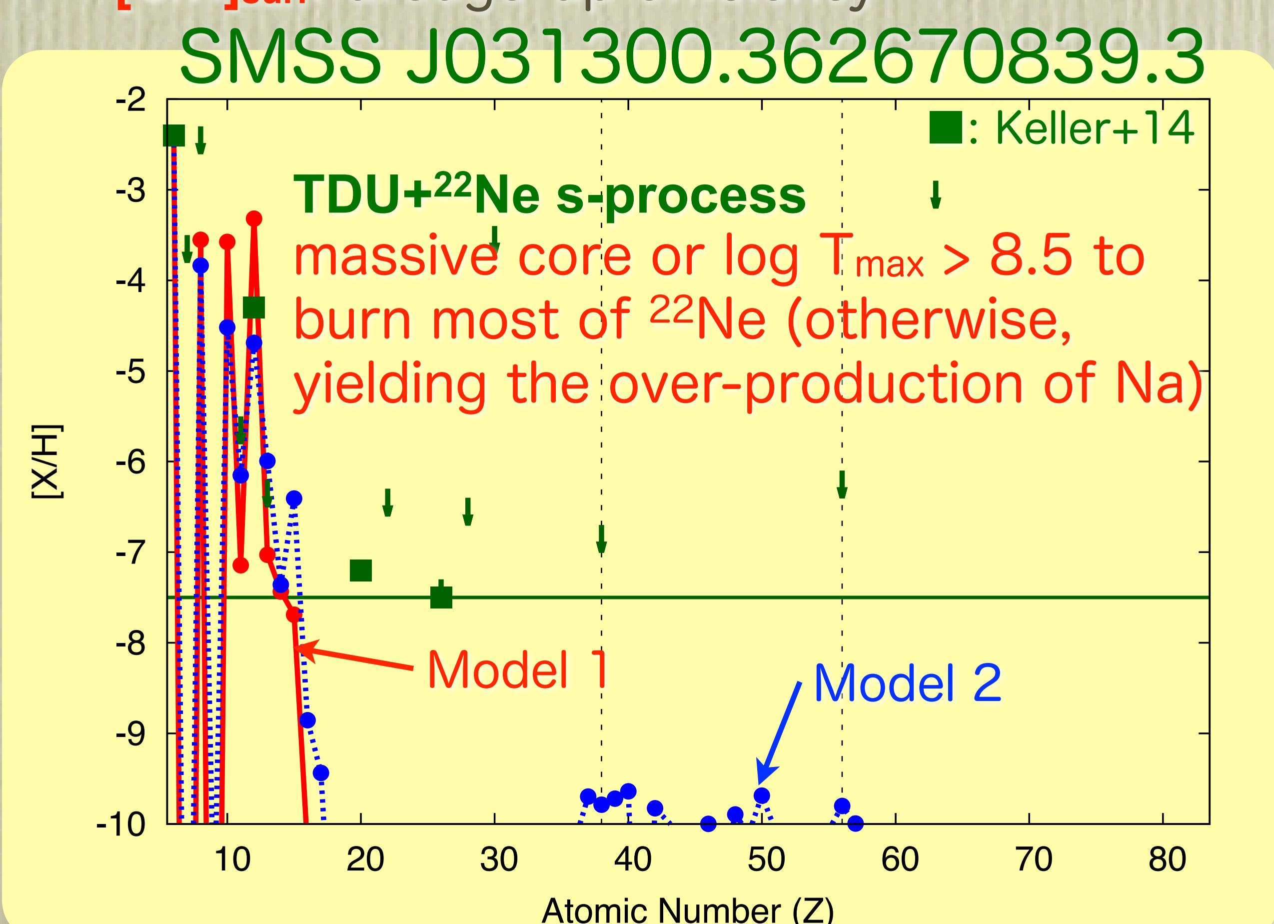

after the peak of He-burning

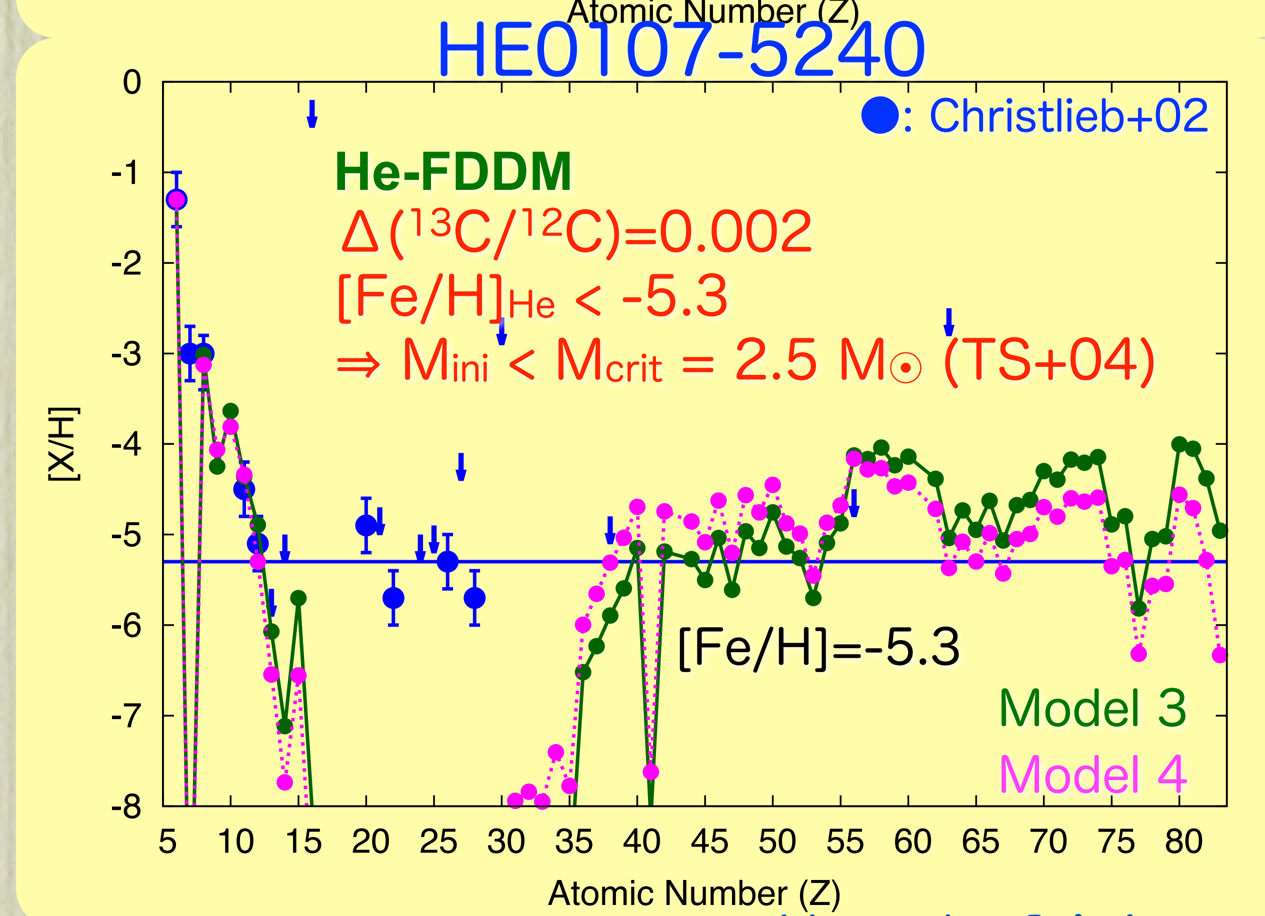
# n-capture nucleosynthesis in HMP stars

Nucleosynthesis of H-mixing into He-flash convective zones (He-FDDM) depends on:

- **$M_{init}$, $M_c$**: stellar total/core mass
- **$T_{max}$**: strength of shell flashes
- **$[Fe/H]_{He}$**: iron supply from the envelope to He-flash convective zones
- **$\Delta(^{13}C/^{12}C)$**: amount of H-mixing
- **$\Delta t$**: duration of H-mixing
- **$[C/H]_{surf}$**: dredge-up efficiency




Yamada+14, in prep.

# Key ingredients: Origin of CEMP stars

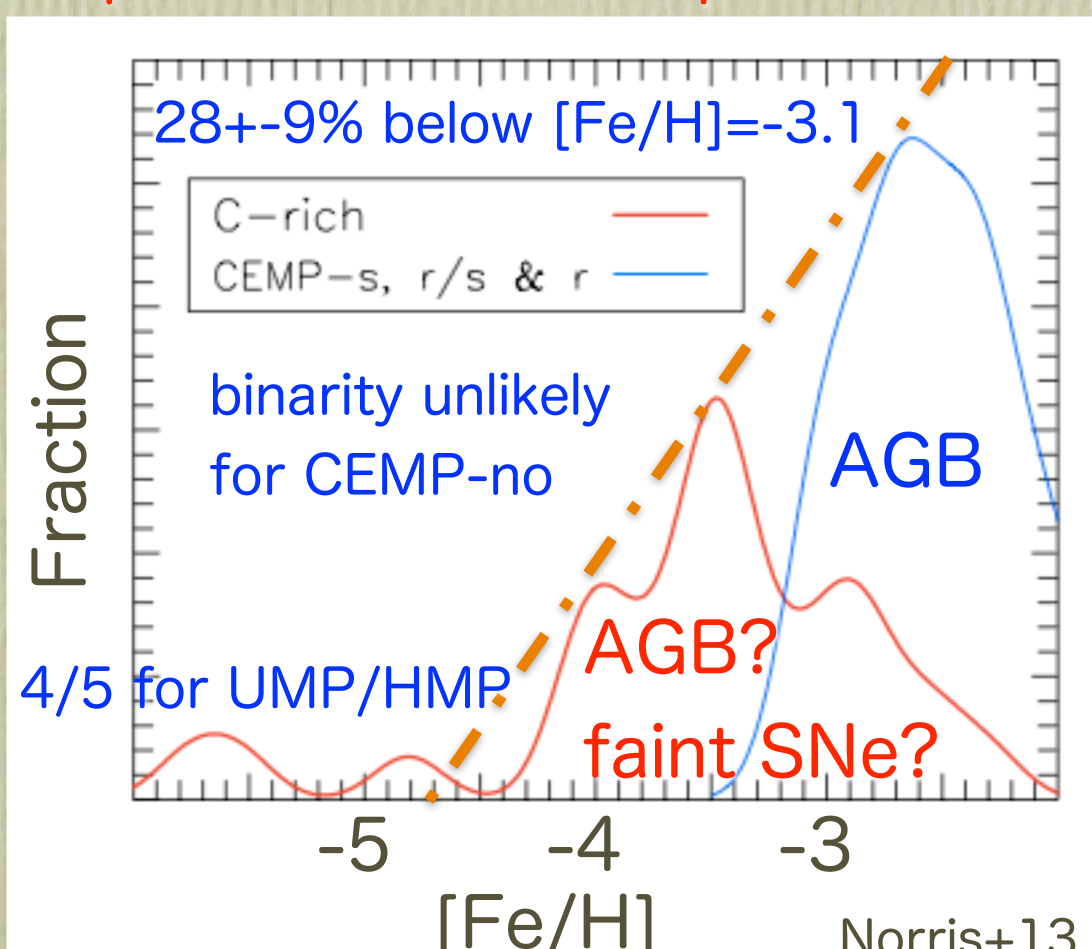
**Observed characteristics of CEMP:**

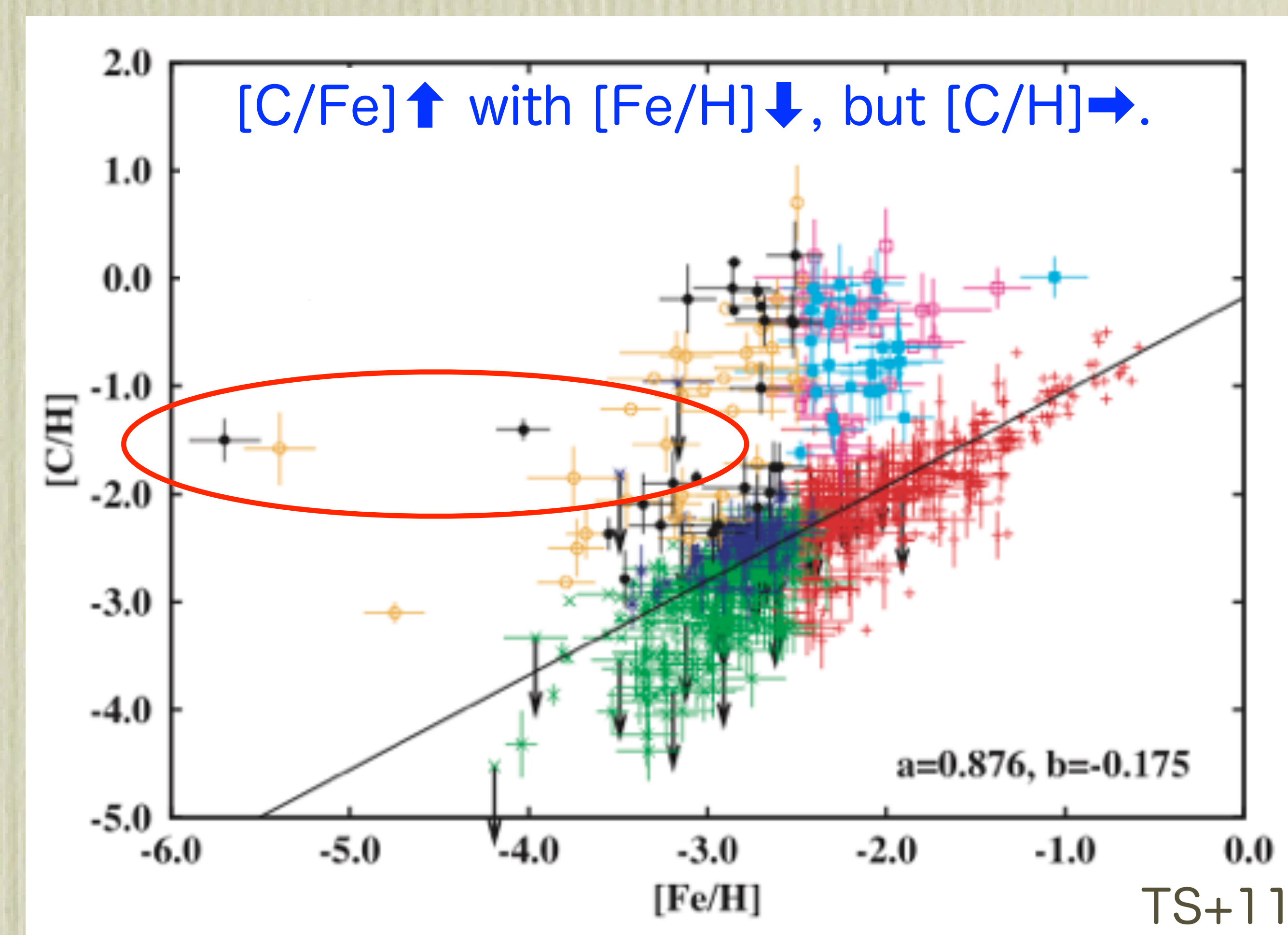
- CEMP-s disappears at [Fe/H] < -3.
- CEMP-no peaks at [Fe/H] = -3.5.
- CEMP-s + CEMP-no is more or less continuous.

should be understood as the [Fe/H] dependence of the s-process

**Possible solution by binary scenario:**

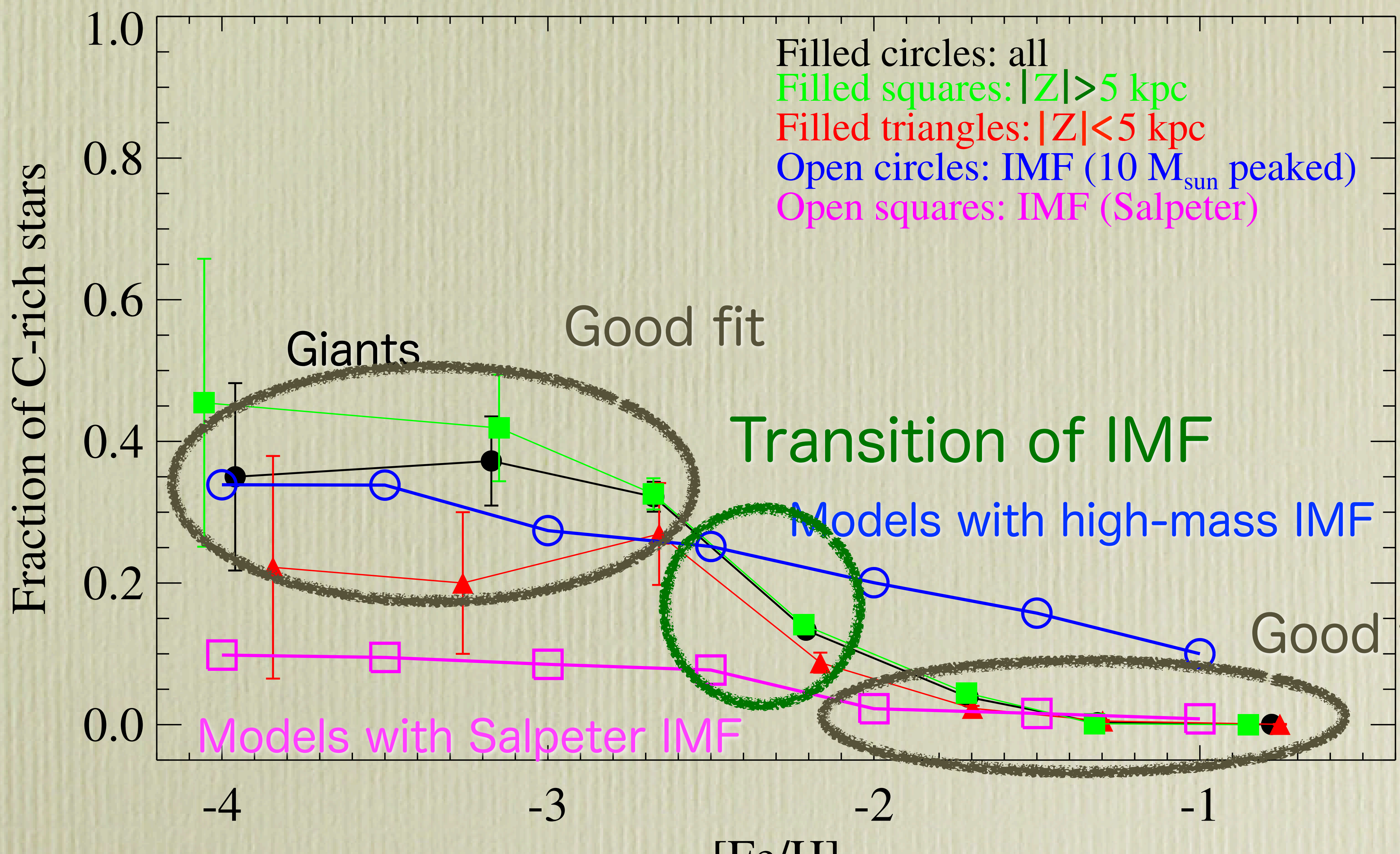
- M < 3.5 M for CEMP-s.
- 3.5 < M / M < 6-8 M for CEMP-no.
- Inefficient NEMP production by suppressing the hot bottom burning or mass loss. (Wood11, TS+13)



# Fraction of C-rich stars

Comparison of models and observations using binary population models




Lee, TS+14

# Summary

- Origins of the most iron-poor stars have been explored based on the scenario of binary mass transfer and nucleosynthesis.
- We propose that the abundance patterns of three most iron-poor stars are results of nucleosynthesis in AGB stars
- To identify the origin of the most iron-poor stars, we should care about the origin of CEMP stars:
    - *Why CEMP-no fraction increases / CEMP-s fraction decreases with decreasing [Fe/H]?*
    - *Why total CEMP fraction (CEMP-s+CEMP-no) is continuous?*
    - *Why the most iron-poor stars are so rare?*
- This scenario suggests that the IMF of the first stars are dominated by massive stars with the non-negligible contribution of low-mass stars.