The Exceptionally Bright Carbon-Enhanced Metal-Poor Star BD+44°493

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Ito et al. 2009, ApJL, in press. (arXiv:0905.0950)

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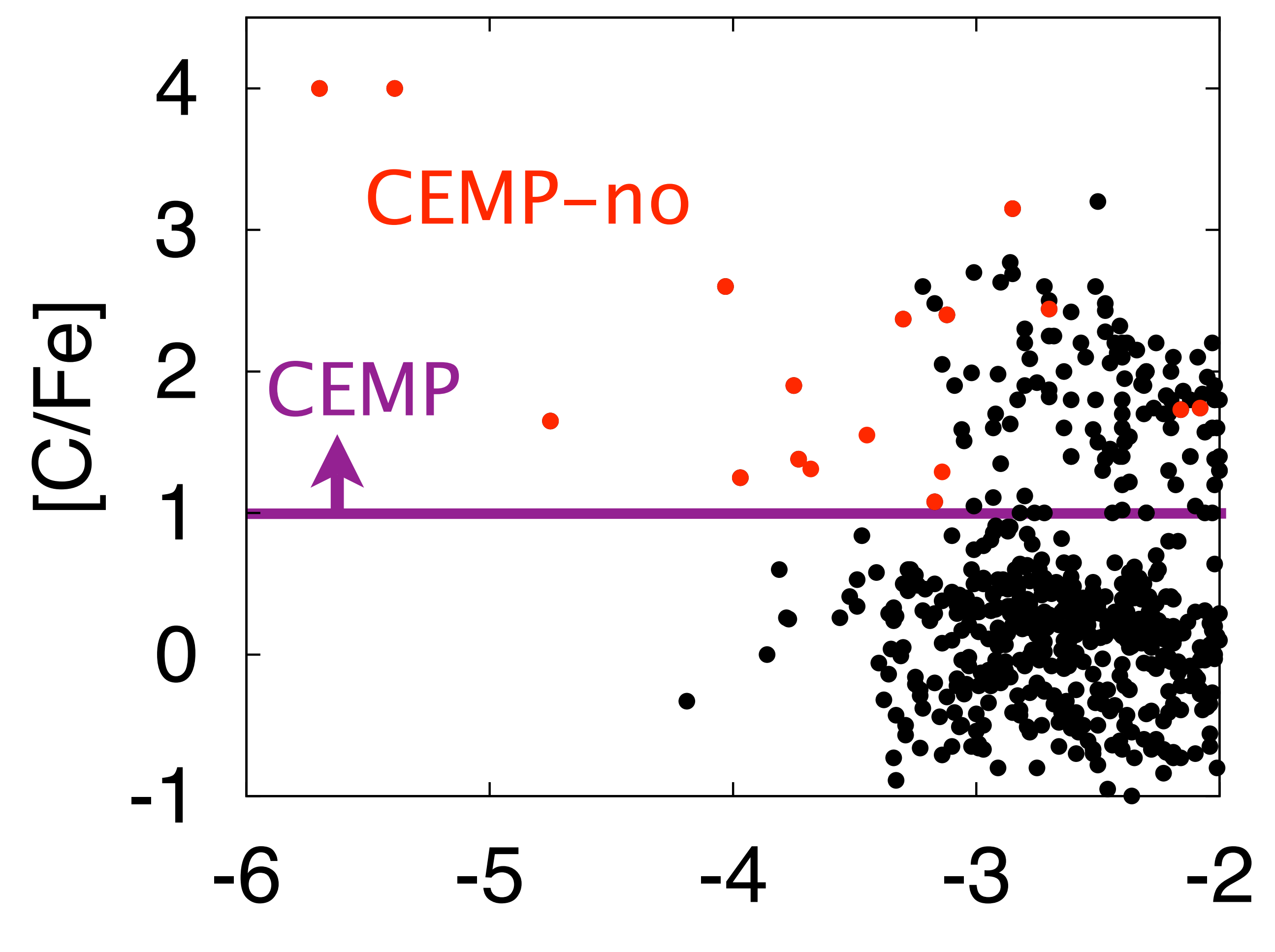
Carbon-Enhanced Metal-Poor stars with no Ba excess ("CEMP-no" stars)

cf. Aoki-san's talk



(SAGA database)

- Many CEMP-no stars were found at lowest metallicity.
- Lowest metallicity stars record the first stage of cosmic chemical enrichment.

Revealing the origin of CEMP-no stars is important to understand nucleosynthesis in first-generation stars.

Suggested Scenarios for CEMP-no Stars
cf. Aoki-san's talk

Carbon enhancement after the formation of CEMP-no star

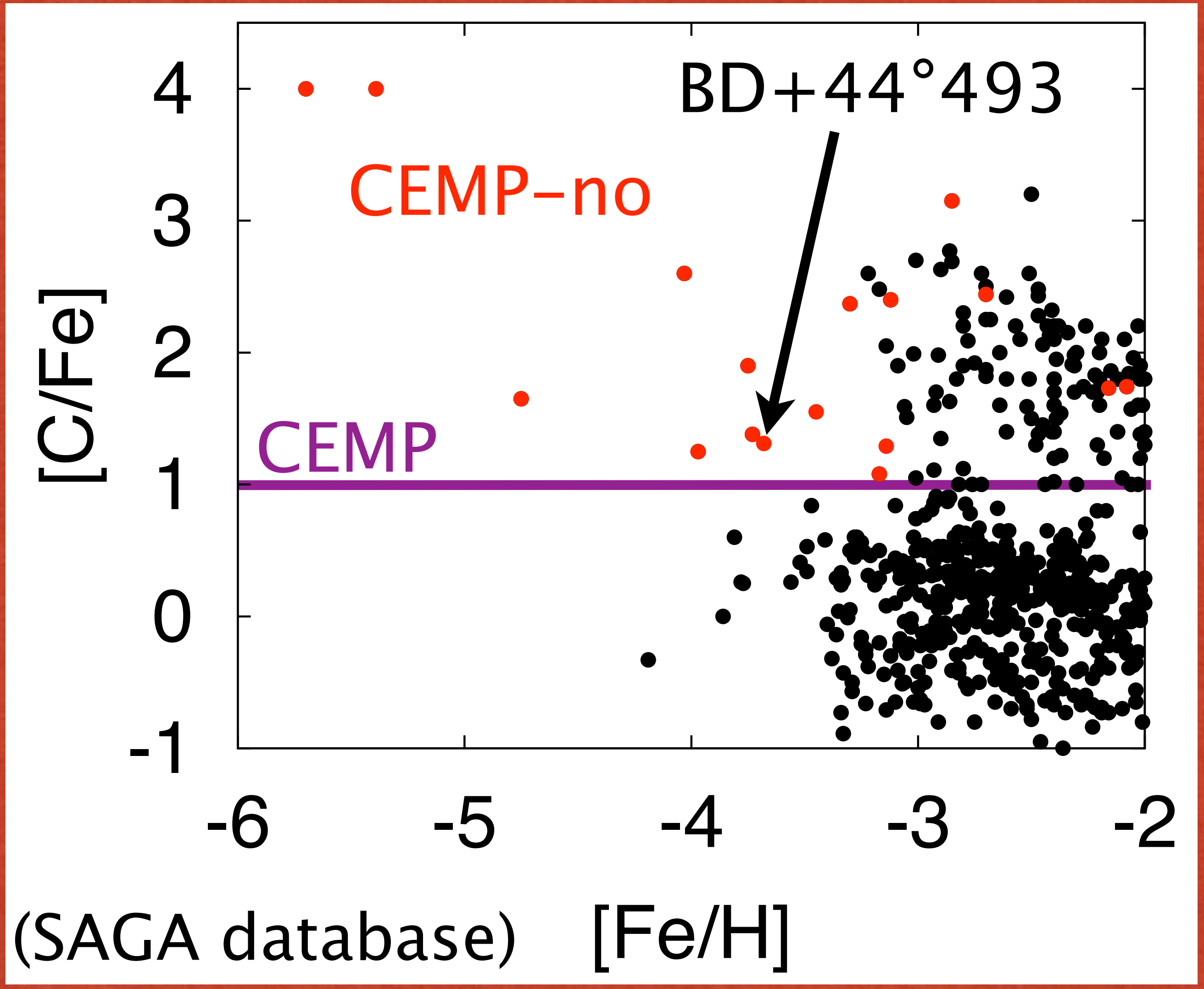
- (1) binary mass transfer from an AGB companion
  (e.g., Suda+04)

Carbon enhancement before the formation of CEMP-no star

- (2) mass loss from rapidly rotating massive stars
  (e.g., Meynet+06)
- (3) “faint” supernovae of first-generation stars
  (e.g., Umeda & Nomoto 03)

However, previous studies of CEMP-no stars could not clearly identify the origin of Carbon.

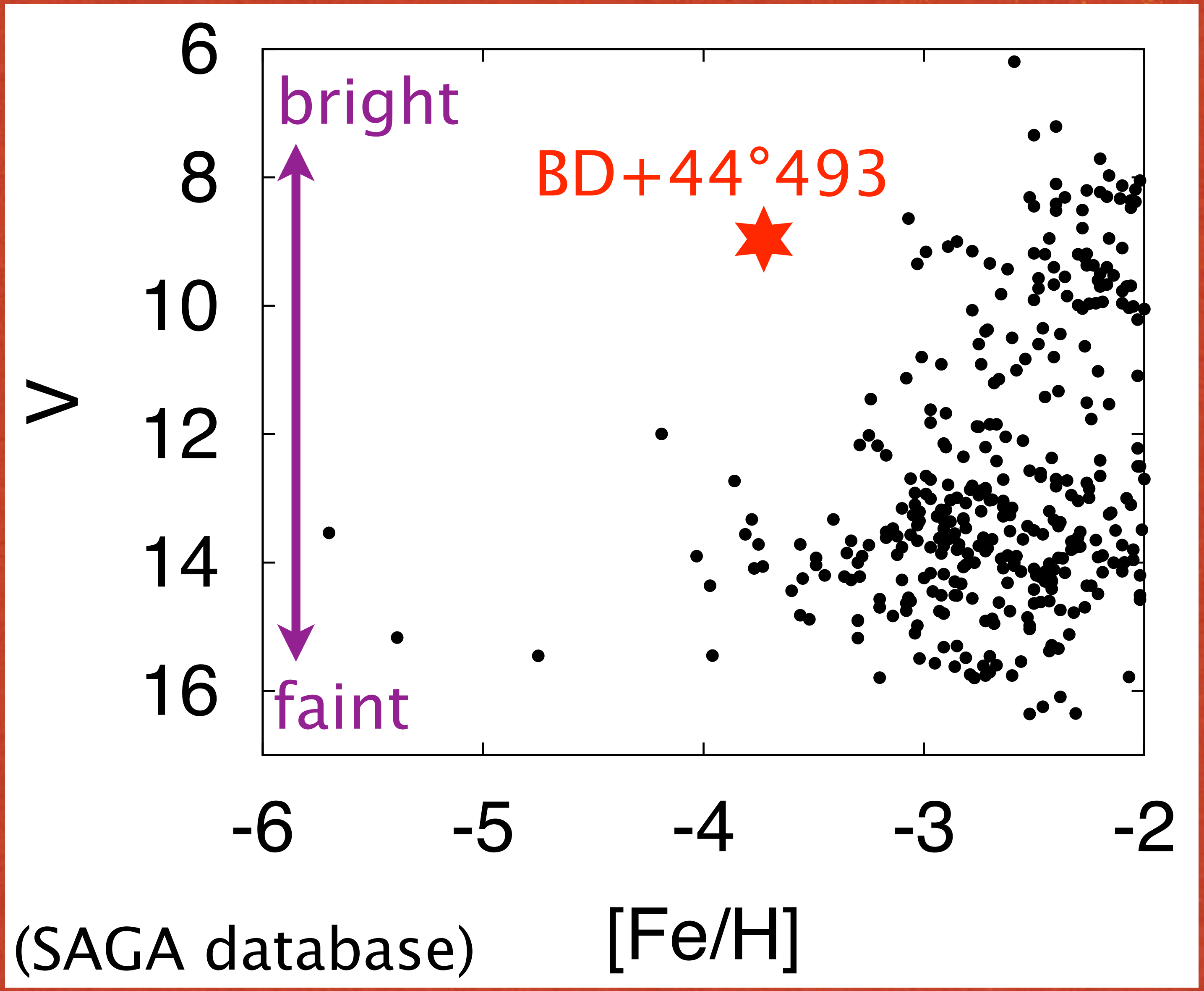
This Study :
a Newly Unveiled CEMP-no Star BD+44°493



- Very Bright (V=9.1)
  We can measure abundances of various elements from a high-quality spectrum.
- properties
  - [Fe/H]=−3.7
  - [C/Fe]=+1.3
  - subgiant
  - Teff=5500K

Chemical Abundance Analysis of BD+44°493
→ Comparison with the Predictions of the Scenarios

How Exceptionally Bright BD+44°493 is



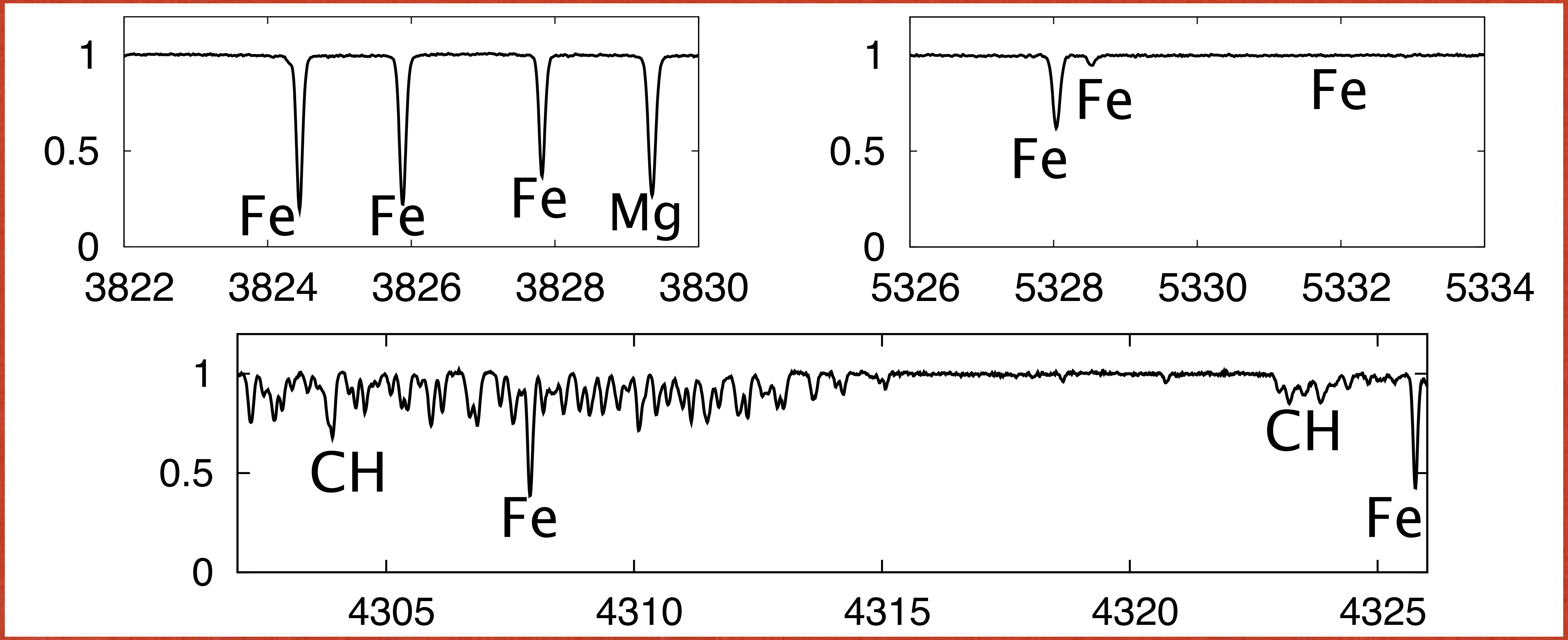
The First Example with [Fe/H]<−3.5 and V<12

Story of BD+44°493
– Why had it been Unmarked ? –

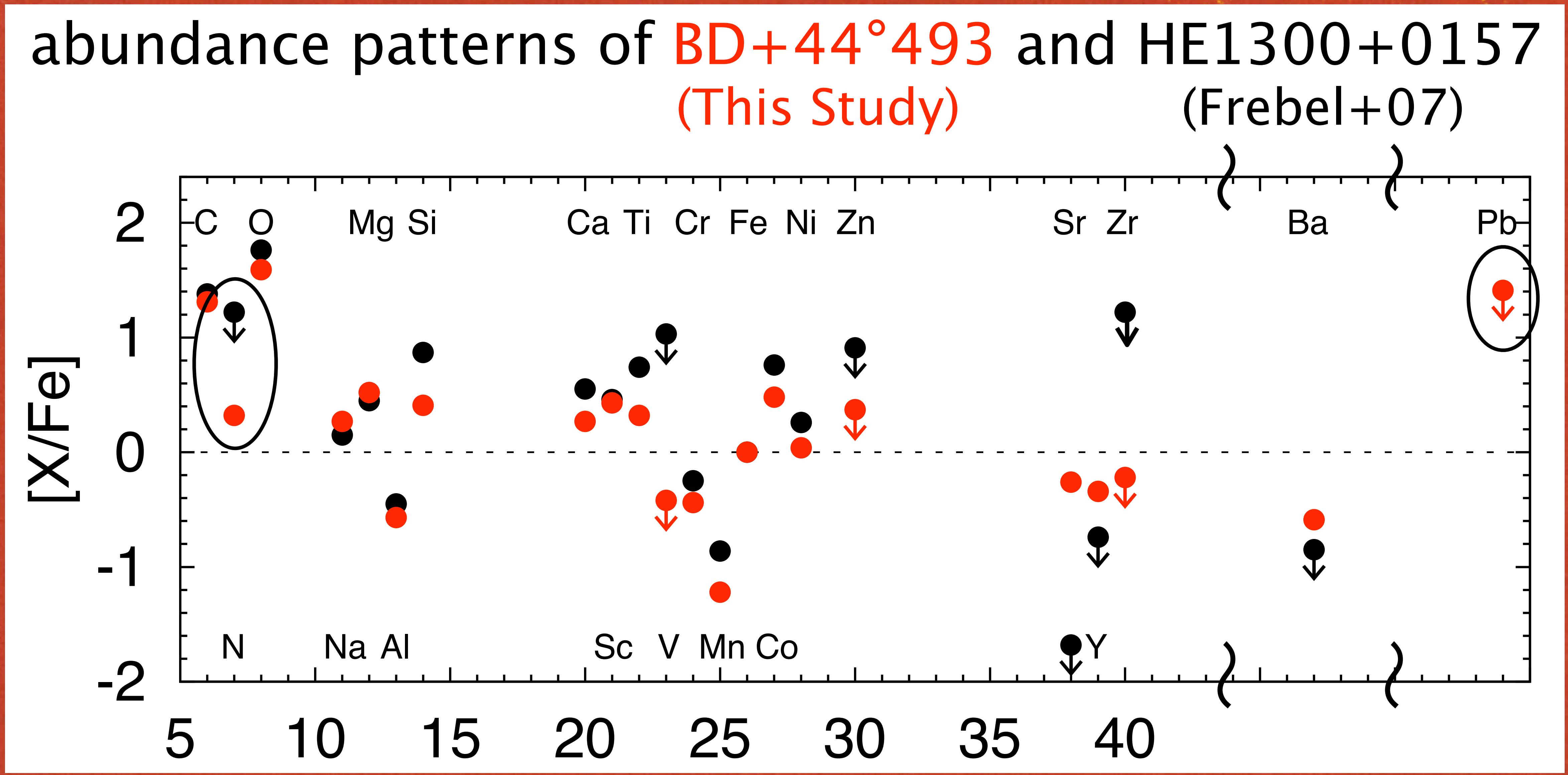
- Anthony-Twarog & Twarog 1994
  metallicity estimate from uvby photometry : [Fe/H]=−2.7
- Carney et al. 2003
  spectroscopy for radial velocity measurement
  But they did not measure metallicity spectroscopically.
- Our Subaru/HDS Observation (2008)
  It was one of the bright stars we observed at dawn.
  5min exposure → [Fe/H]<−3.5 Surprising!
  → go to an extensive observation

Observational Data

- Subaru/HDS in October 2008
- R=90,000
- wavelength : 3100-9300A
- S/N=100-500



Chemical Abundance Analysis



This study determined elemental abundances more precisely than a previous study of a similar star.

Scenario (1)
binary mass transfer from an AGB companion
(e.g., Suda et al. 2004)

A metal-poor star was polluted with C-rich material.

Theoretical Predictions

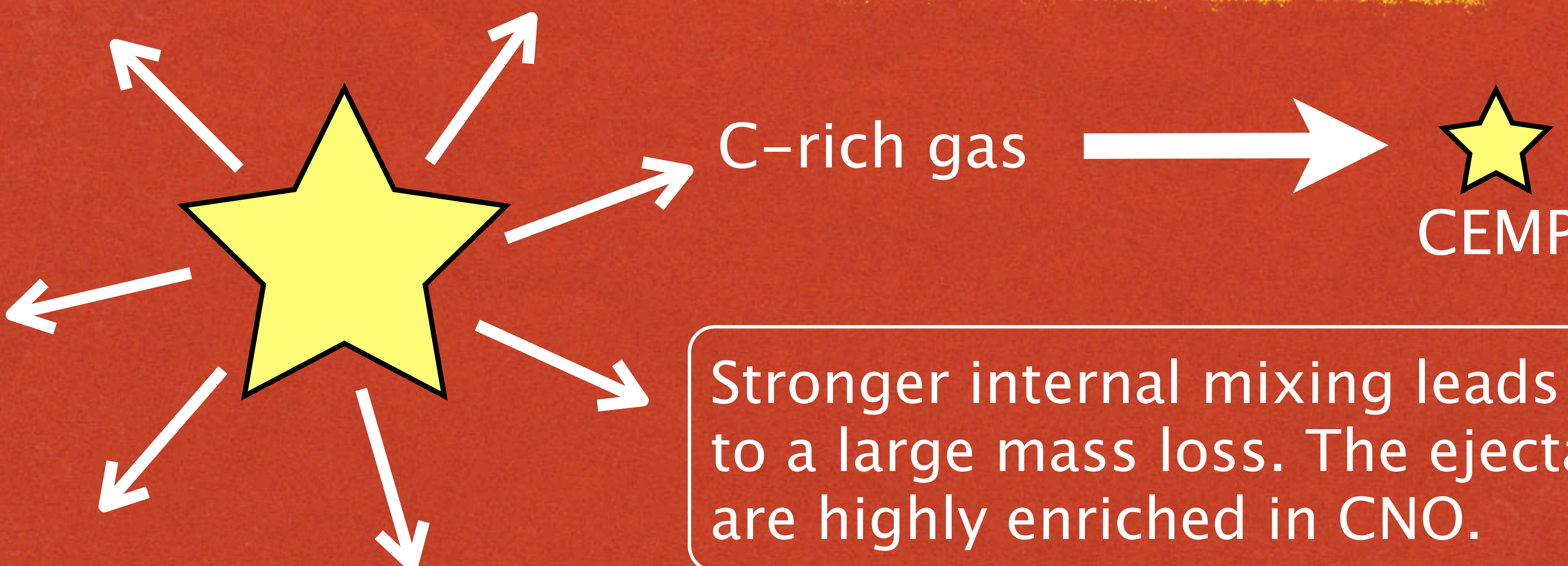
- Ba-rich or Pb-rich
- C/O > 1
- binarity

Observational Facts

- normal Ba & Pb abundances
- C/O < 1
- Radial velocity monitoring over 10 years did not find any binarity signature. (Carney+03)

This Scenario is Not Favored.

Scenario (2)
mass loss from rapidly rotating massive stars
(e.g., Meynet et al. 2006)



Stronger internal mixing leads to a large mass loss. The ejecta are highly enriched in CNO.

Theoretical Predictions

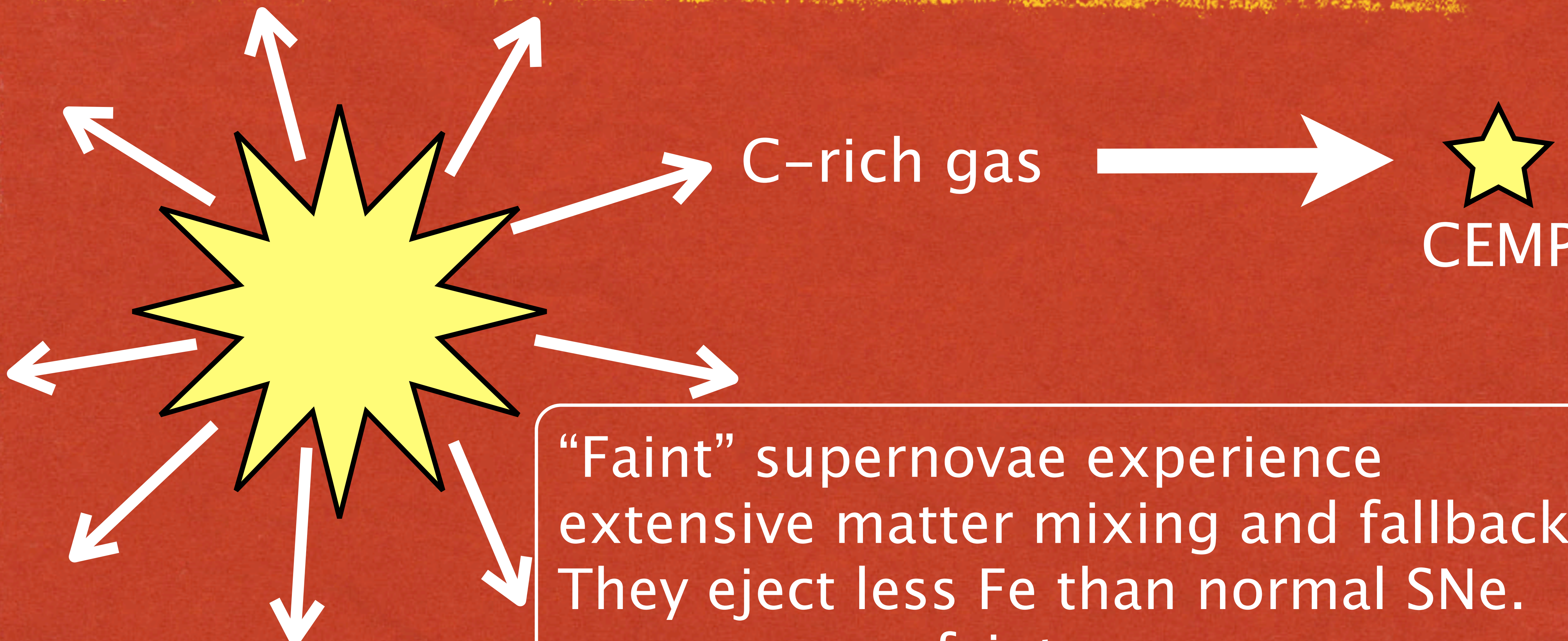
- N-rich (due to CNO cycle)

Observational Facts

- low N abundance

This Scenario is Not Favored.

Scenario (3)
"faint" supernovae of first-generation stars
(e.g., Umeda & Nomoto 2003)



"Faint" supernovae experience extensive matter mixing and fallback.
They eject less Fe than normal SNe.

→ faint

→ high [C/Fe]

This Scenario is Consistent with our Observation.

A “Faint” Supernova Can Reproduce the Abundance Pattern of BD+44°493

Preliminary

Sorry!

Because this figure is not published,

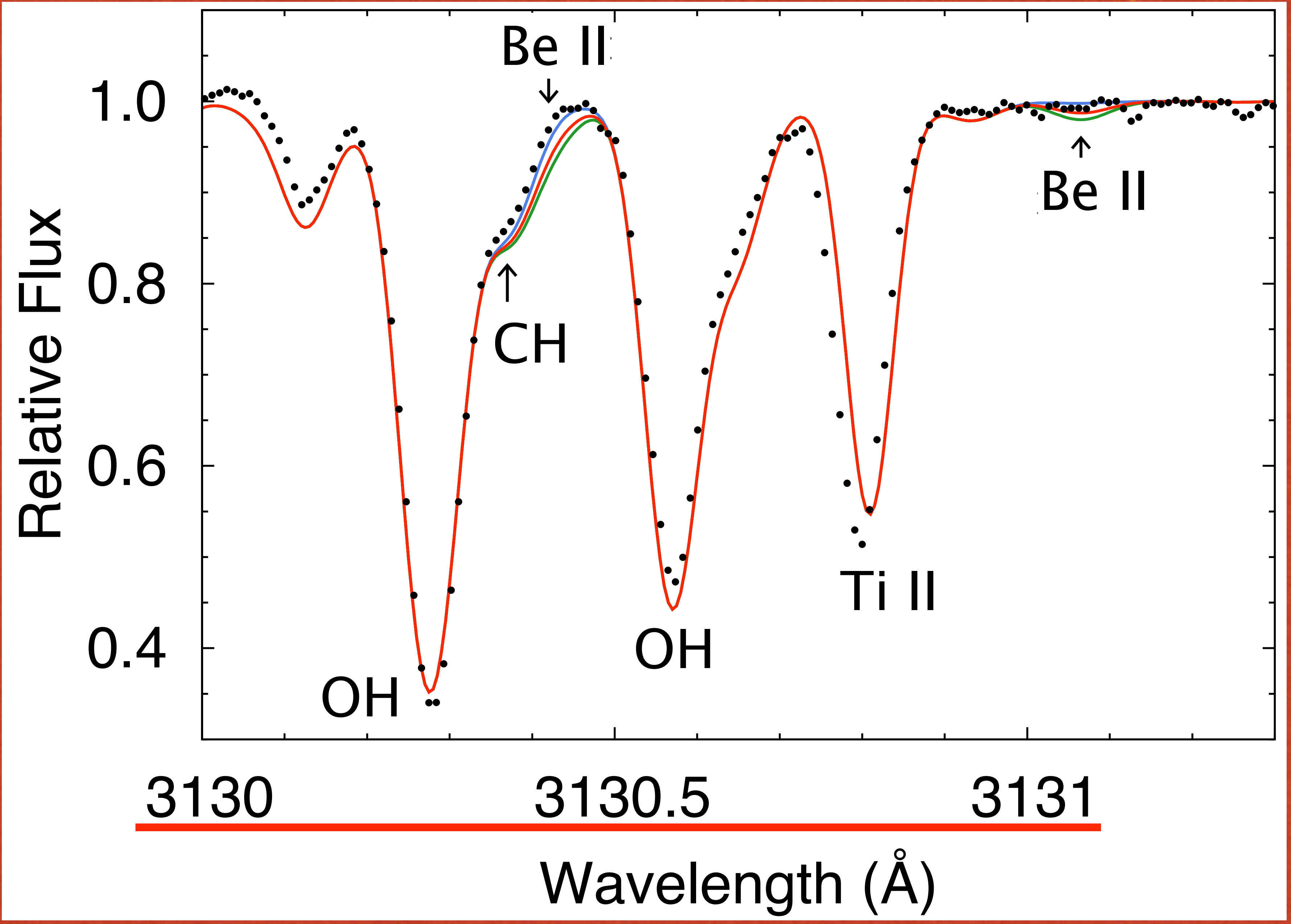
I can’t show it.

5 10 15 20 25 30

Ito, Aoki, Honda, Beers, Tominaga in prep.

A Faint Supernova is the Most Promising Origin.

Take Advantage of Its Brightness
– Beryllium Abundance –



2hr exposure → very low upper limit : A(Be)<−2.0

Beryllium in CEMP-no stars
– A New Insight –

How Beryllium is Produced - spallation process-

- secondary process (standard)
  H, He (cosmic rays) + C, N, O (ISM) → Li, Be, B
- primary process (important in the early universe?)
  C, N, O (cosmic rays) + H, He (ISM) → Li, Be, B

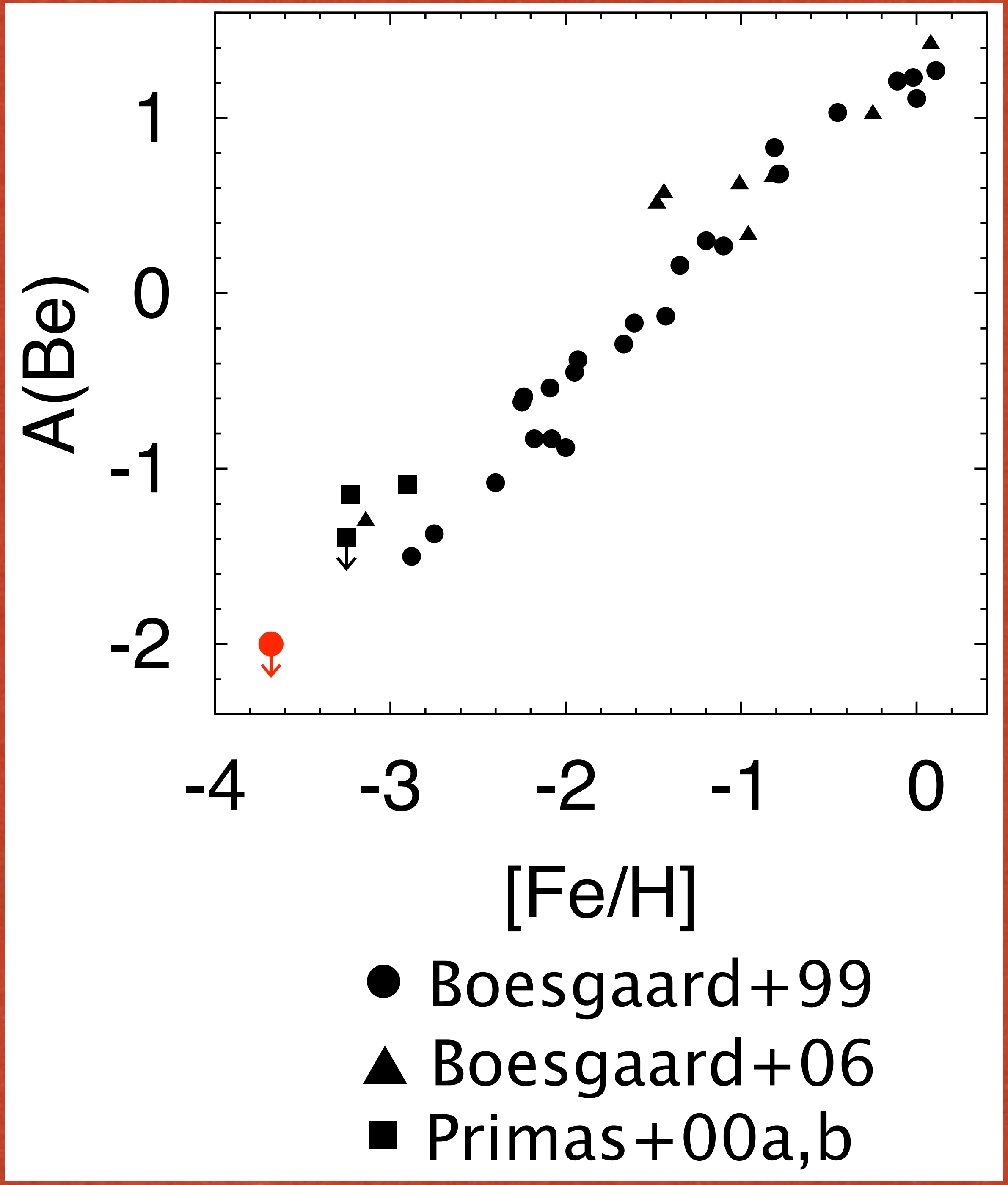
Be is produced from CNO → Correlation Between Be & O

How about CEMP-no stars?

- This study is the first attempt to measure a Be abundance.
- BD+44°493 : C, O enhanced **but** Be poor

The high C, O abundances of CEMP-no stars do not imply high Be abundances

The Linear Correlation Between Be and Fe



- This study offers a Be upper limit at the lowest metallicity ever
- The linear correlation between Be and Fe still holds at [Fe/H]<−3.5.
- constraint on the theories which predict a plateau including inhomogeneous Big Bang Nucleosynthesis.

Summary

- Chemical abundance analysis of a CEMP-no star BD+44°493 is performed based on Subaru/HDS spectra.
- BD+44°493 is exceptionally bright metal-poor star.
- A faint supernova of a first-generation star is the most likely origin of Carbon excess of BD+44°493.
- The high C, O abundances of CEMP-no stars do not imply high Be abundances.
- The Be vs. Fe linear correlation holds at $[Fe/H] < -3.5$.
- Please see our paper for detail.
Ito et al. 2009, ApJL, in press. (arXiv:0905.0950)