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Insights on the first stars from CEMP-no stars

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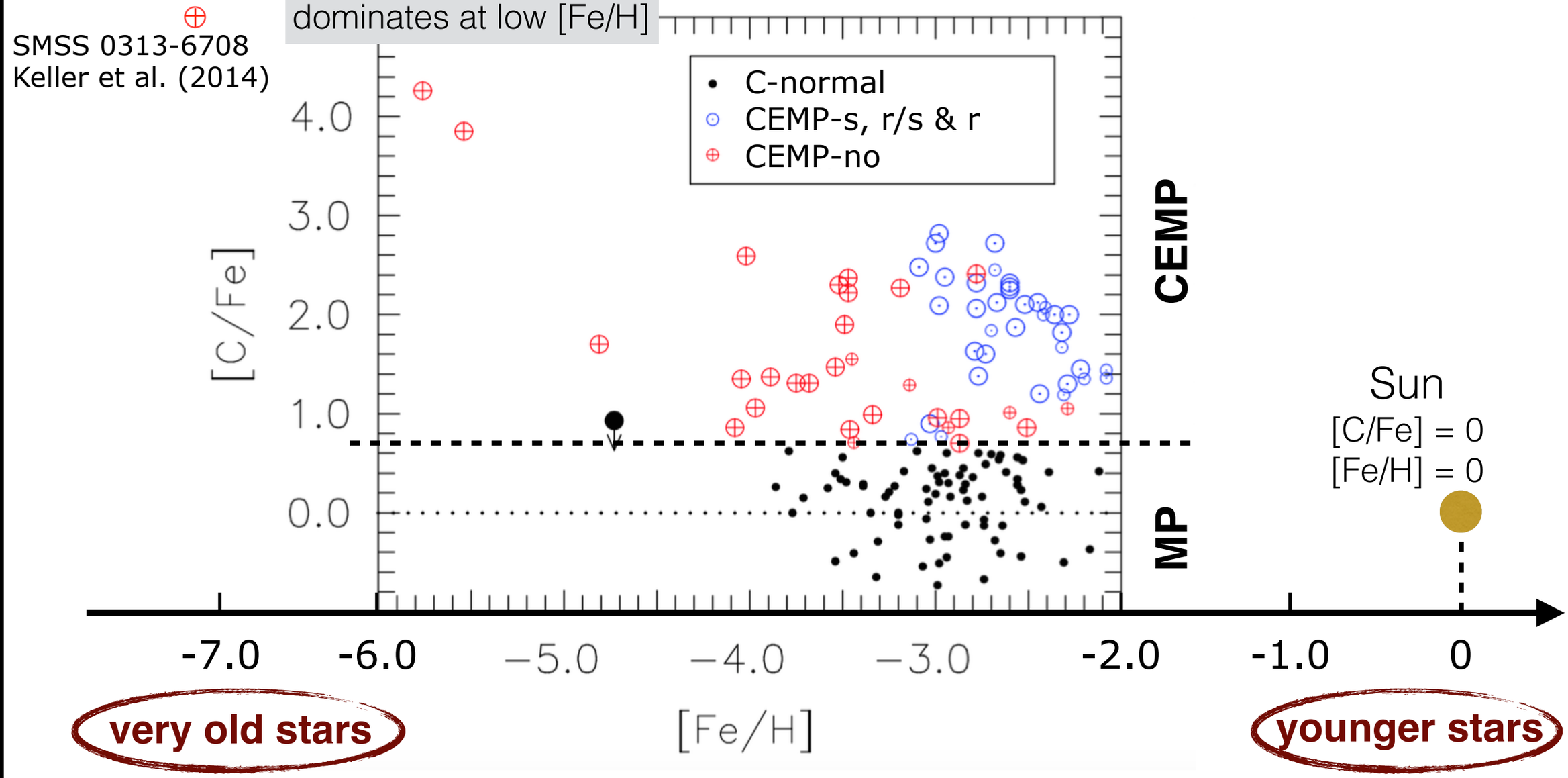
What are CEMP stars?

CEMP = Carbon-Enhanced Metal-Poor

CEMP classification : Beers & Christlieb (2005)

The CEMP-no class dominates at low [Fe/H]

SMSS 0313-6708
Keller et al. (2014)



Adapted from Norris et al. (2013)

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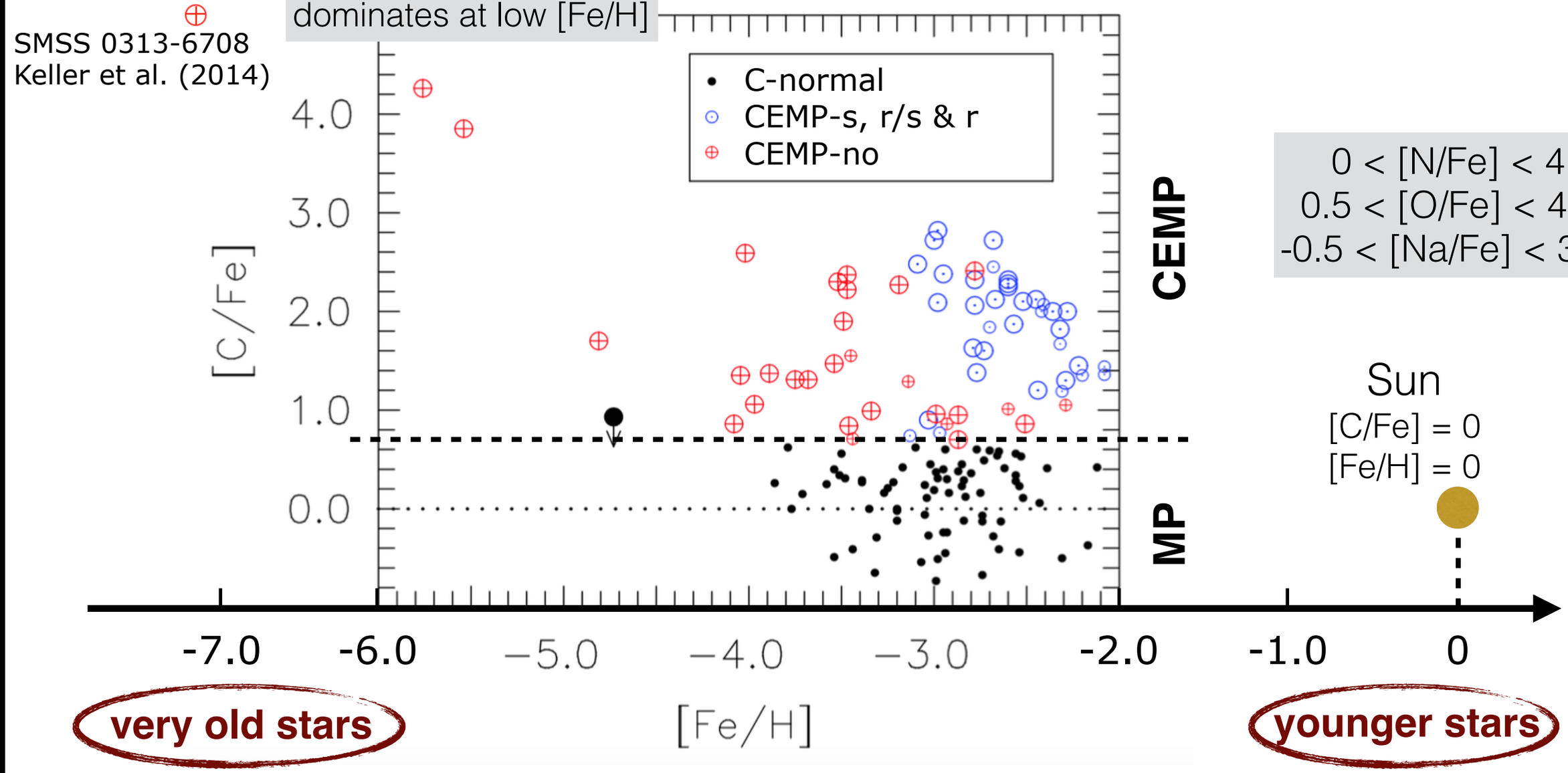

0 < [N/Fe] < 4.5
0.5 < [O/Fe] < 4
-0.5 < [Na/Fe] < 3

Sun
[C/Fe] = 0
[Fe/H] = 0

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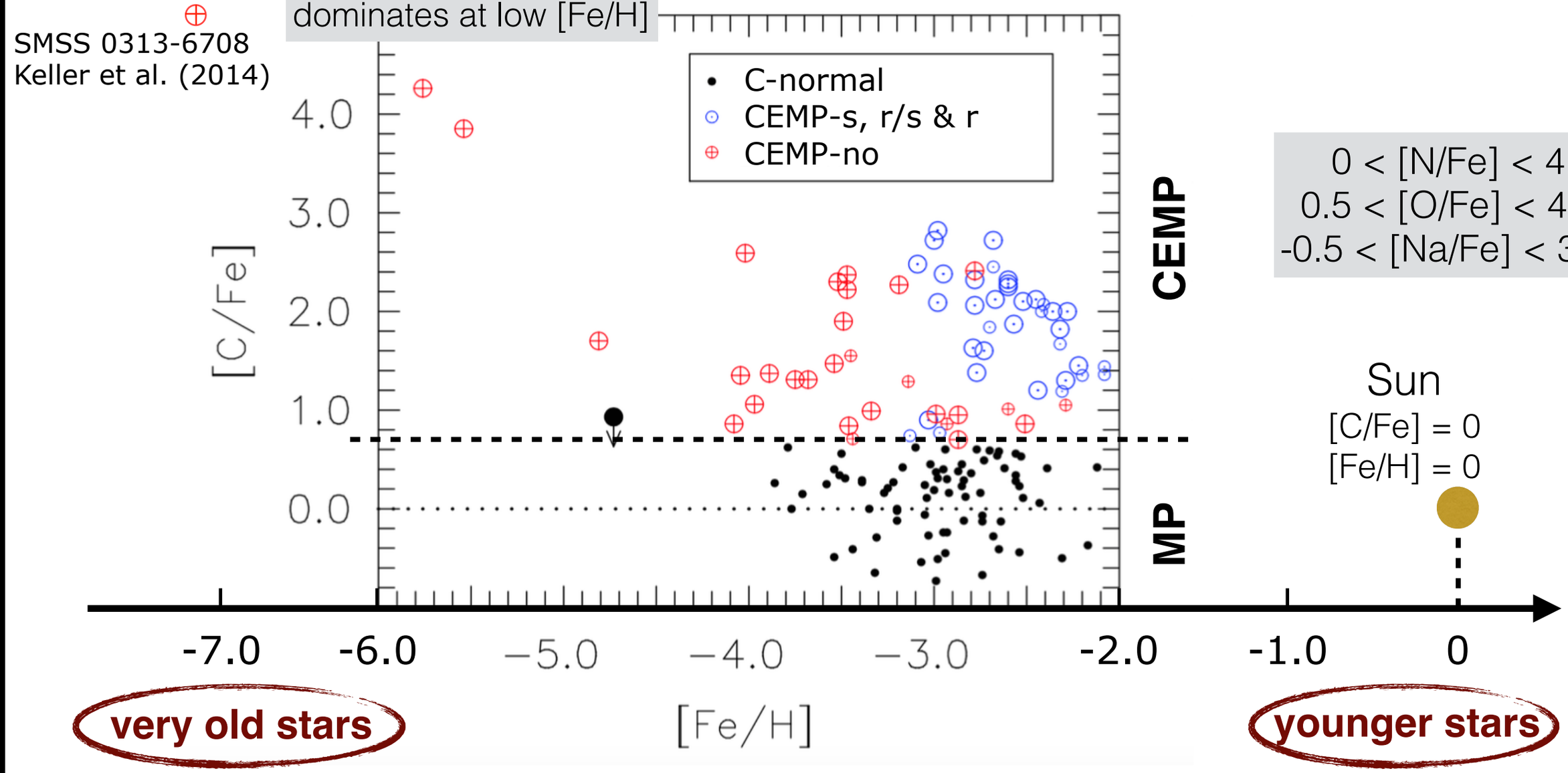

0 < [N/Fe] < 4.5
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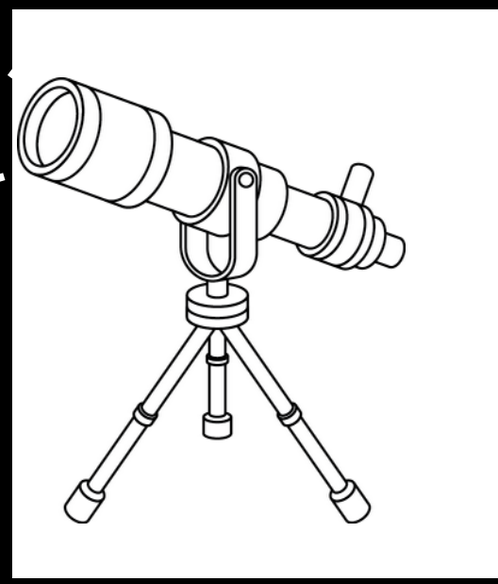
An external source seems to be needed

Mother star
= 1st star ?

?

O
N
Na
C
Mg

Daughter star
= CEMP-no



1st stars birth

1st stars death

2nd generation birth

Now

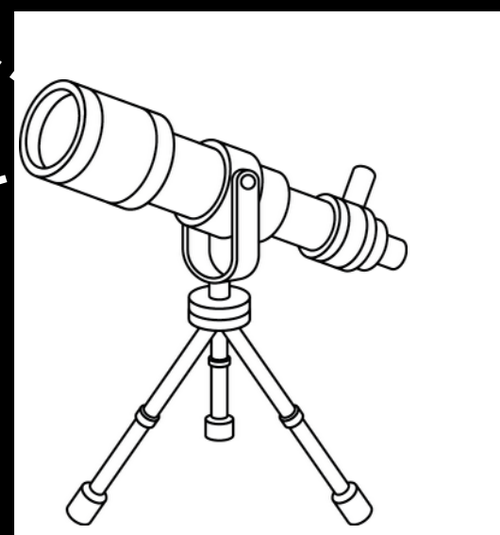
Time

Mother star
= 1st star ?

?

O
N
Na
C
Mg

Daughter star
= CEMP-no



1st stars birth

1st stars death

2nd generation birth

Now

Time

Chemical composition of the mother star ejecta
= observed CEMP-no abundances?

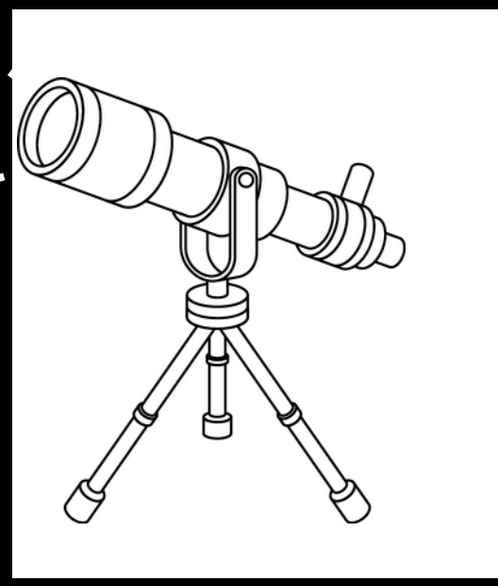
Mother star —> fast rotator?
e.g. Chiappini et al. (2006)

= 1st star ?

?

O
N
Na
C
Mg

Daughter star
= CEMP-no



1st stars birth
1st stars death
2nd generation birth
Now

Time

Chemical composition of the mother star ejecta
= observed CEMP-no abundances?

Model ejecta vs. observed CEMP-no abundance

20 $M_{\odot}$, $Z=10^{-5}$ mother star with $0 < v_{ini} < 640$ km.s^{-1} → Shellular rotation

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Rotational mixing
=> Exchanges of chemical species between different burning regions

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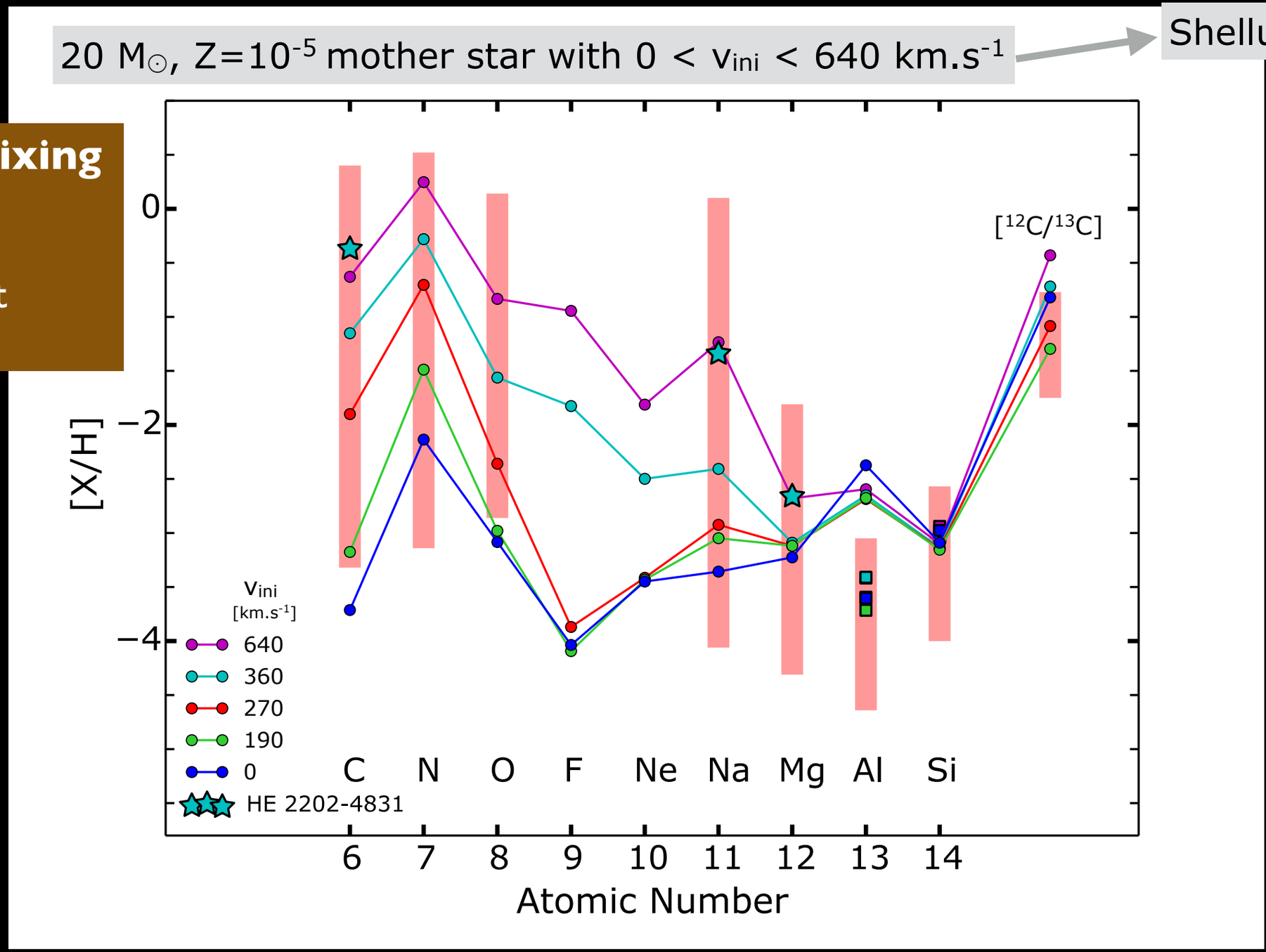

Observations from Norris et al. (2013), Allen et al. (2012), Masseron et al. (2010), Keller et al. (2014), Hansen et al. (2015)

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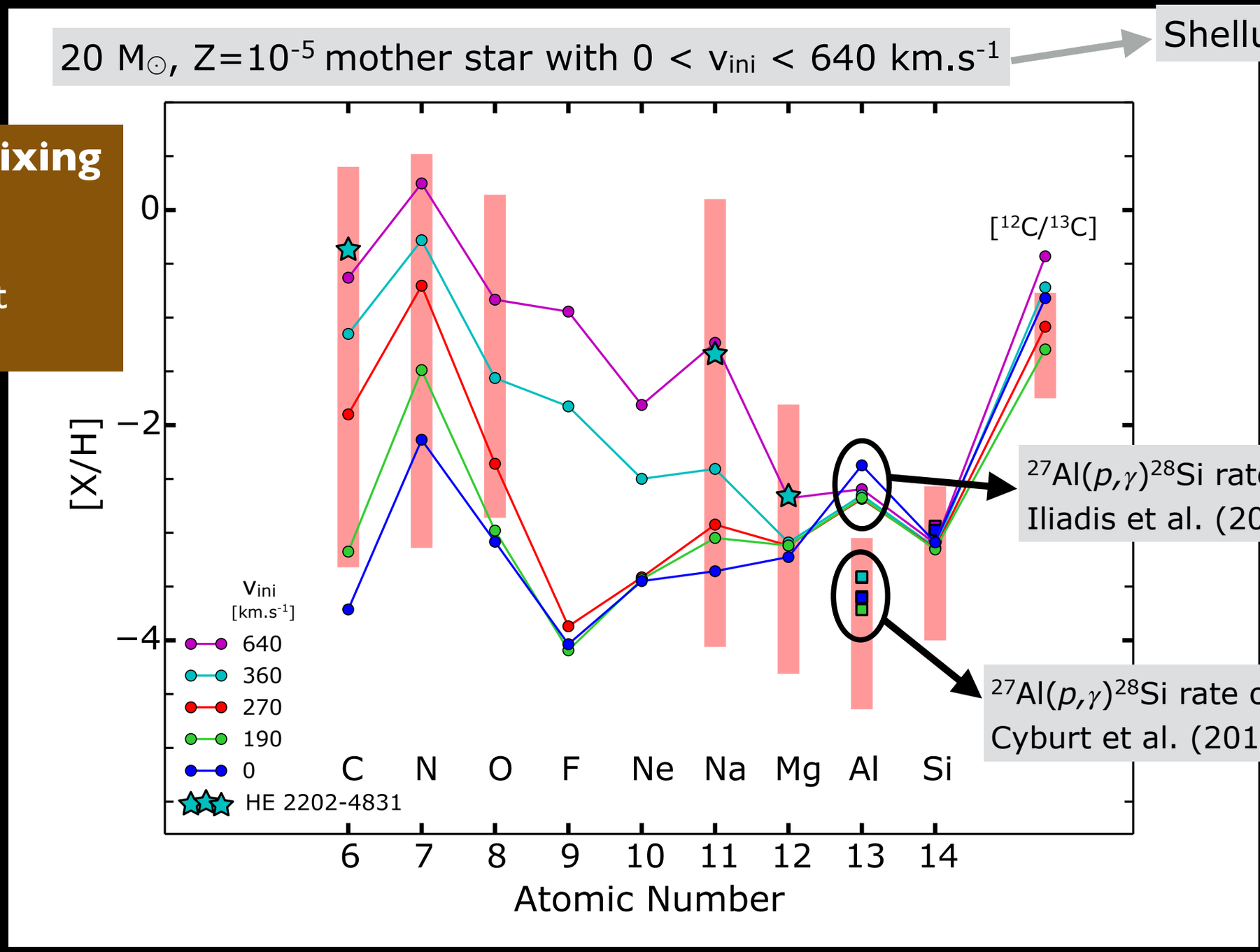

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Non-standard s-process in rotating massive stars

Source of neutrons : $^{22}Ne(\alpha,n)^{25}Mg$

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25 $M_\odot$, Z=10^{-5}

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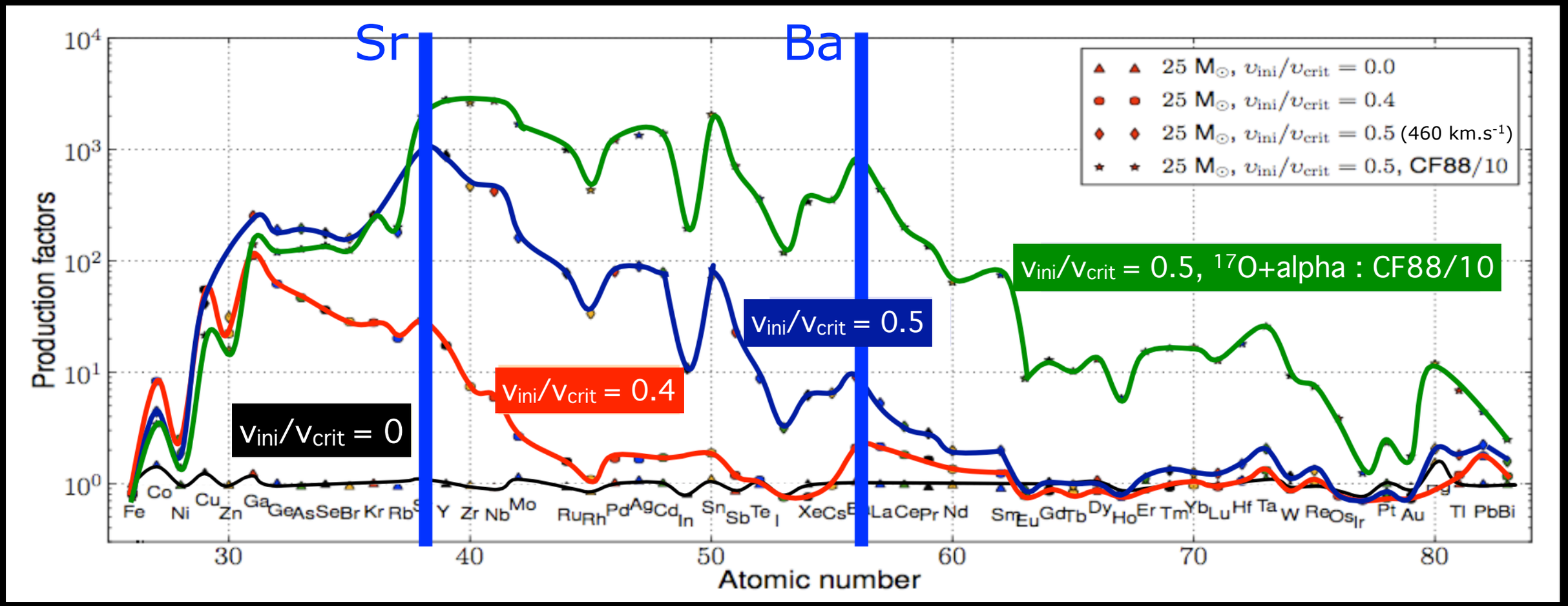

Frischknecht et al. (2012, 2016)

- Rotation boosts the s-process in massive stars
- Some CEMP-no stars show modest enhancements in s-elements

—> BS 16929-005 : [Sr/Fe] = 0.54
—> HE 1327-2326 : [Sr/Fe] = 1.04
} Signature of a fast rotating mother star ?