When binaries keep track of recent nucleosynthesis

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AGB Stars: an introduction

Why are AGB stars important?

- Evolutionary stage
- Heavy-element nucleosynthesis (s-process)
- Contribution to galactic chemical evolution

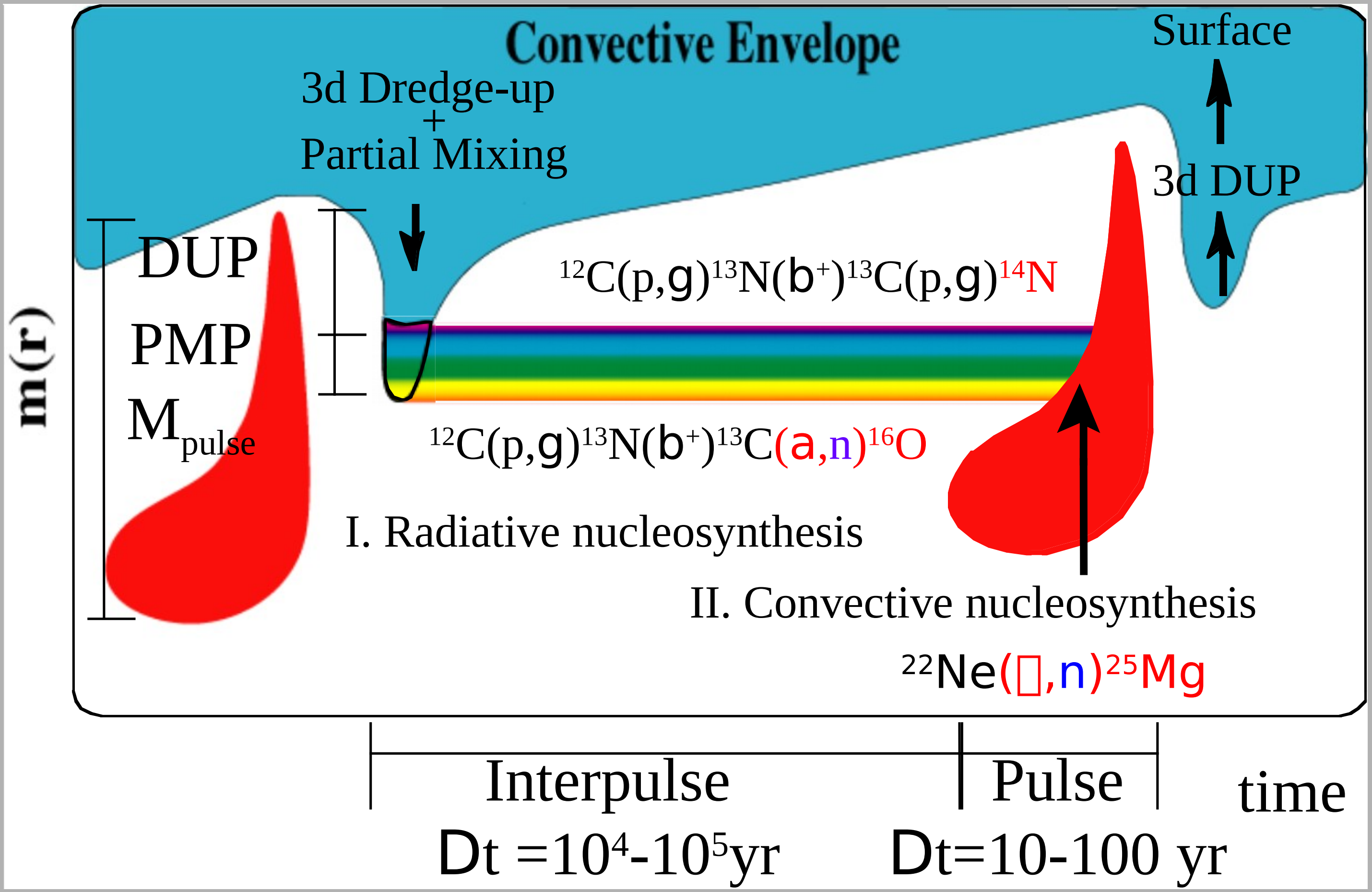
s-process neutron source

- $^{12}C(p,\gamma)^{13}N(\beta)^{13}C(\alpha,n)^{16}O$ [^{13}C pocket]

  (low mass (1- 3 $M_\odot$)AGB stars T = 0.9 x 10^8 K)

- $^{22}Ne(\alpha,n)^{25}Mg$

  (For AGB stars with masses > 4 $M_\odot$, T > 3.5 x 10^8 K)



Credit: S . Goriely and S. Van Eck

The sample: Extrinsic stars

- 9 extrinsic S-stars (Neyskens, Van Eck et al. 2015, Nature, 517, 174-176)
- 20 highly-enriched barium stars

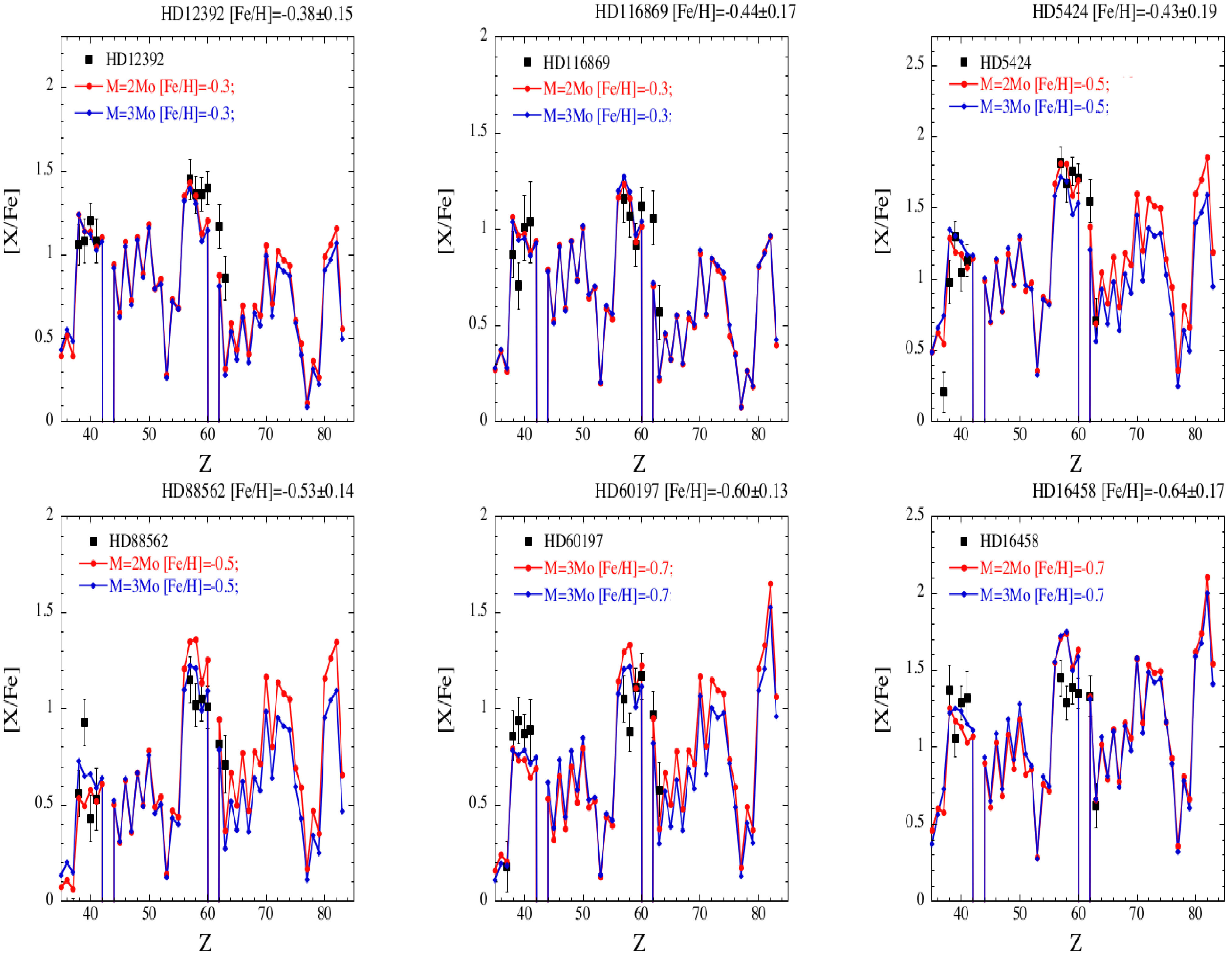
observed using HERMES spectrograph mounted on the 1.2m Mercator telescope (KULeuven)
Resolution: ~85000
Wavelength coverage: 3750 – 9000 Å.

Parameter and abundance determination

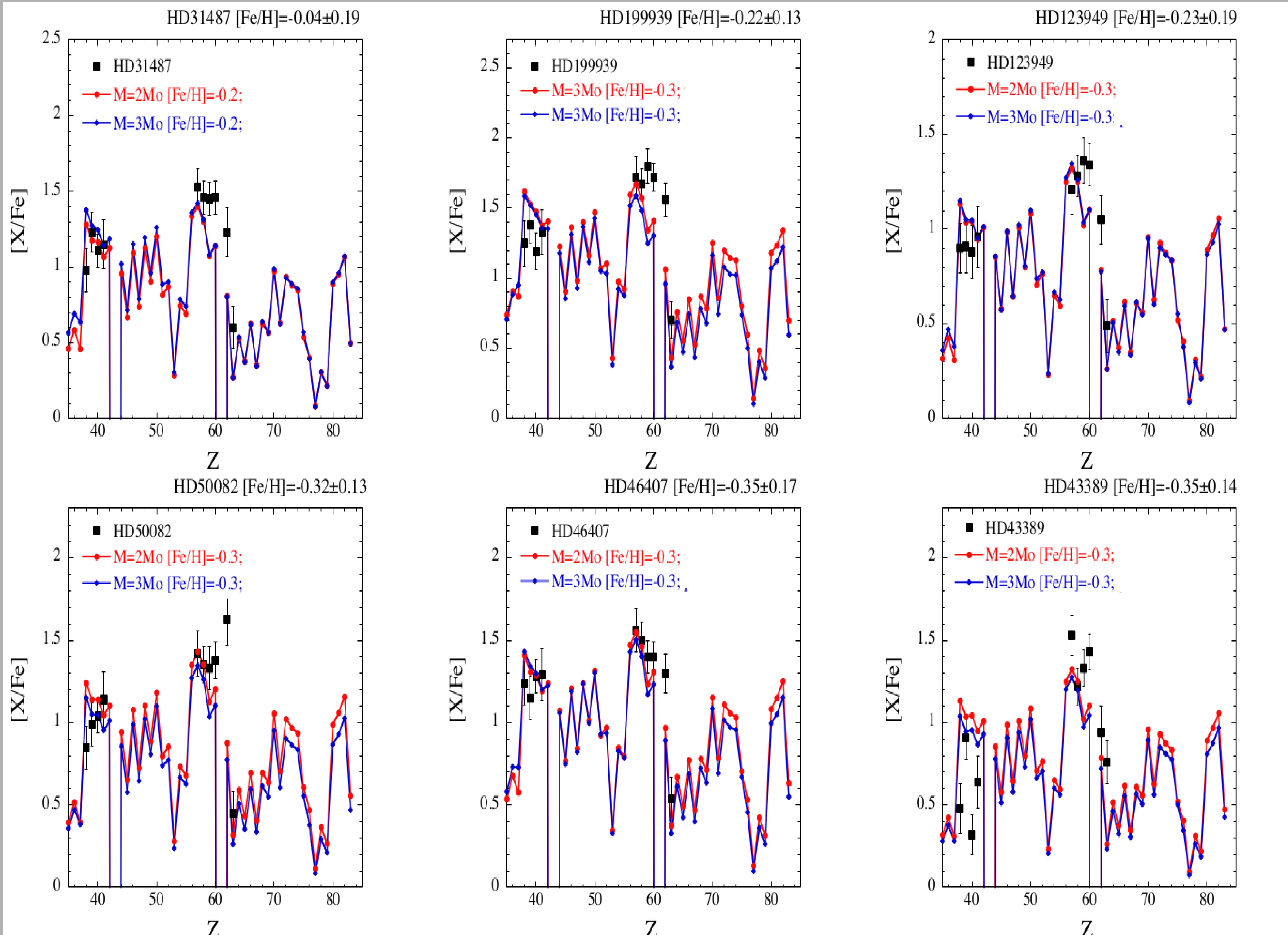
- MARCS model atmospheres
- Parameters: using BACCHUS (Masseron et al.)
- Abundances: using TURBOSPECTRUM radiative transfer code (Alvarez et al.)

→ abundance determination of:
C, $^{12}C/^{13}C$, N, O, Fe, Rb, Sr, Y, Zr, Nb, Ba, La, Ce, Nd, Pr, Sm, Eu

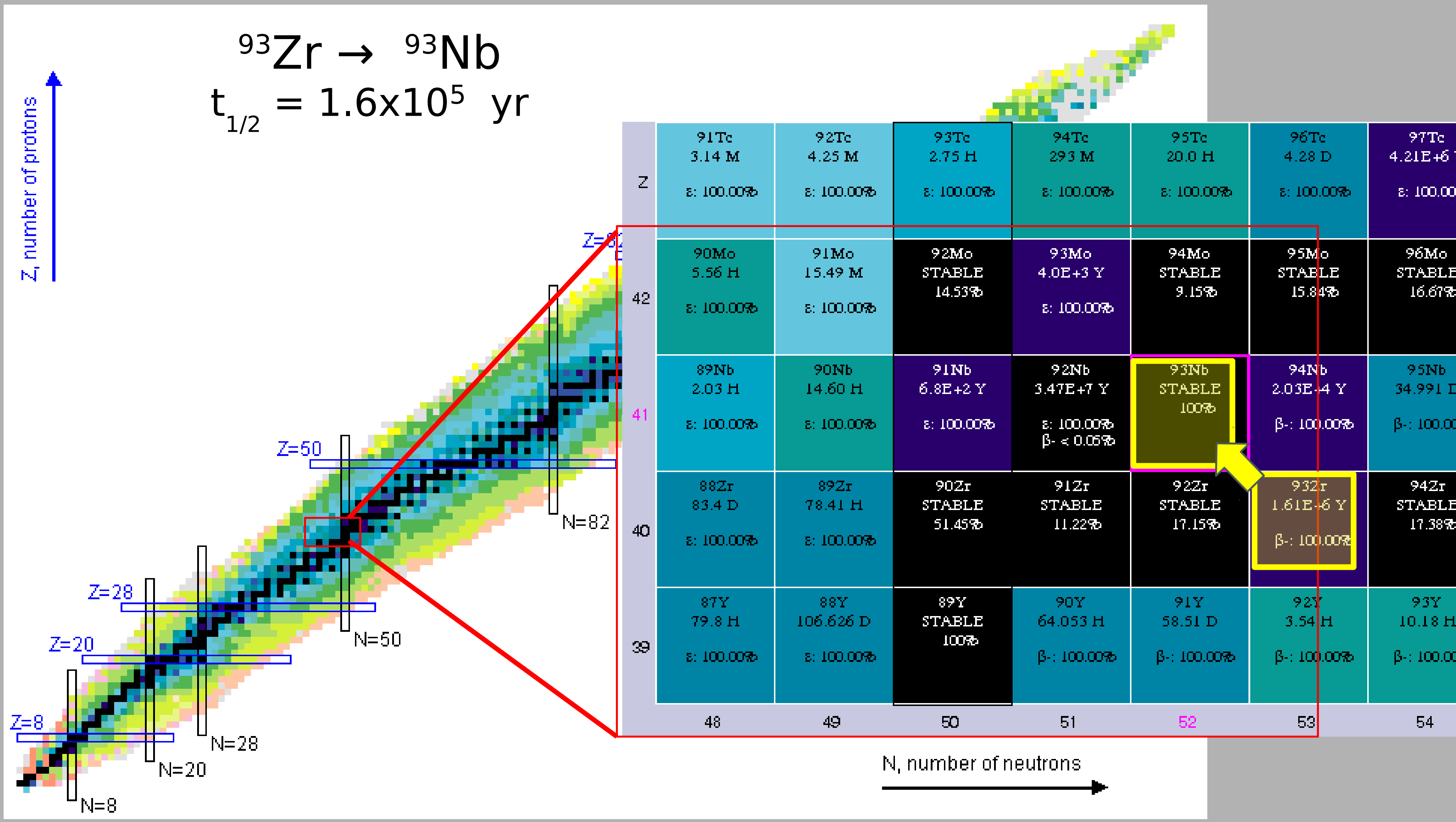
→ Comparison with stellar evolution models (STAREVOL) coupled with nucleosynthesis network (Goriely and Siess 2017)



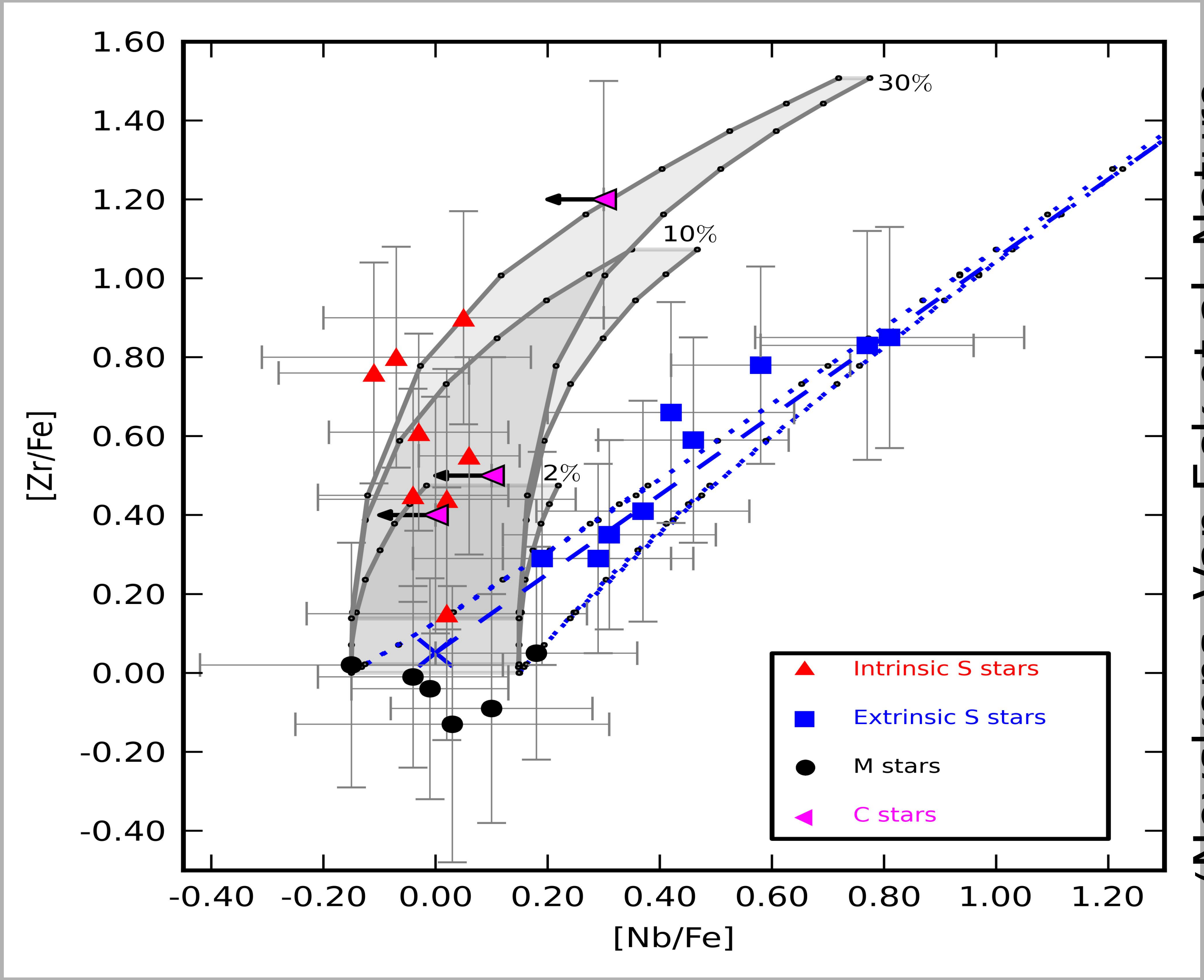
HD12392 [Fe/H]=-0.38±0.15
HD12392
M=2Mo [Fe/H]=-0.3;
M=3Mo [Fe/H]=-0.3;
[X/Fe]
Z
HD116869 [Fe/H]=-0.44±0.17
HD116869
M=2Mo [Fe/H]=-0.3;
M=3Mo [Fe/H]=-0.3;
[X/Fe]
Z
HD5424 [Fe/H]=-0.43±0.19
HD5424
M=2Mo [Fe/H]=-0.5;
M=3Mo [Fe/H]=-0.5;
[X/Fe]
Z
HD88562 [Fe/H]=-0.53±0.14
HD88562
M=2Mo [Fe/H]=-0.5;
M=3Mo [Fe/H]=-0.5;
[X/Fe]
Z
HD60197 [Fe/H]=-0.60±0.13
HD60197
M=3Mo [Fe/H]=-0.7;
M=3Mo [Fe/H]=-0.7
[X/Fe]
Z
HD16458 [Fe/H]=-0.64±0.17
HD16458
M=2Mo [Fe/H]=-0.7
M=3Mo [Fe/H]=-0.7
[X/Fe]
Z


HD31487 [Fe/H]=-0.04±0.19
HD31487
M=2Mo [Fe/H]=-0.2;
M=3Mo [Fe/H]=-0.2;
HD199939 [Fe/H]=-0.22±0.13
HD199939
M=3Mo [Fe/H]=-0.3;
M=3Mo [Fe/H]=-0.3;
HD123949 [Fe/H]=-0.23±0.19
HD123949
M=2Mo [Fe/H]=-0.3;
M=3Mo [Fe/H]=-0.3;
HD50082 [Fe/H]=-0.32±0.13
HD50082
M=2Mo [Fe/H]=-0.3;
M=3Mo [Fe/H]=-0.3;
HD46407 [Fe/H]=-0.35±0.17
HD46407
M=2Mo [Fe/H]=-0.3;
M=3Mo [Fe/H]=-0.3;
HD43389 [Fe/H]=-0.35±0.14
HD43389
M=2Mo [Fe/H]=-0.3;
M=3Mo [Fe/H]=-0.3;
[X/Fe]
Z

Understanding s-process from elemental abundances



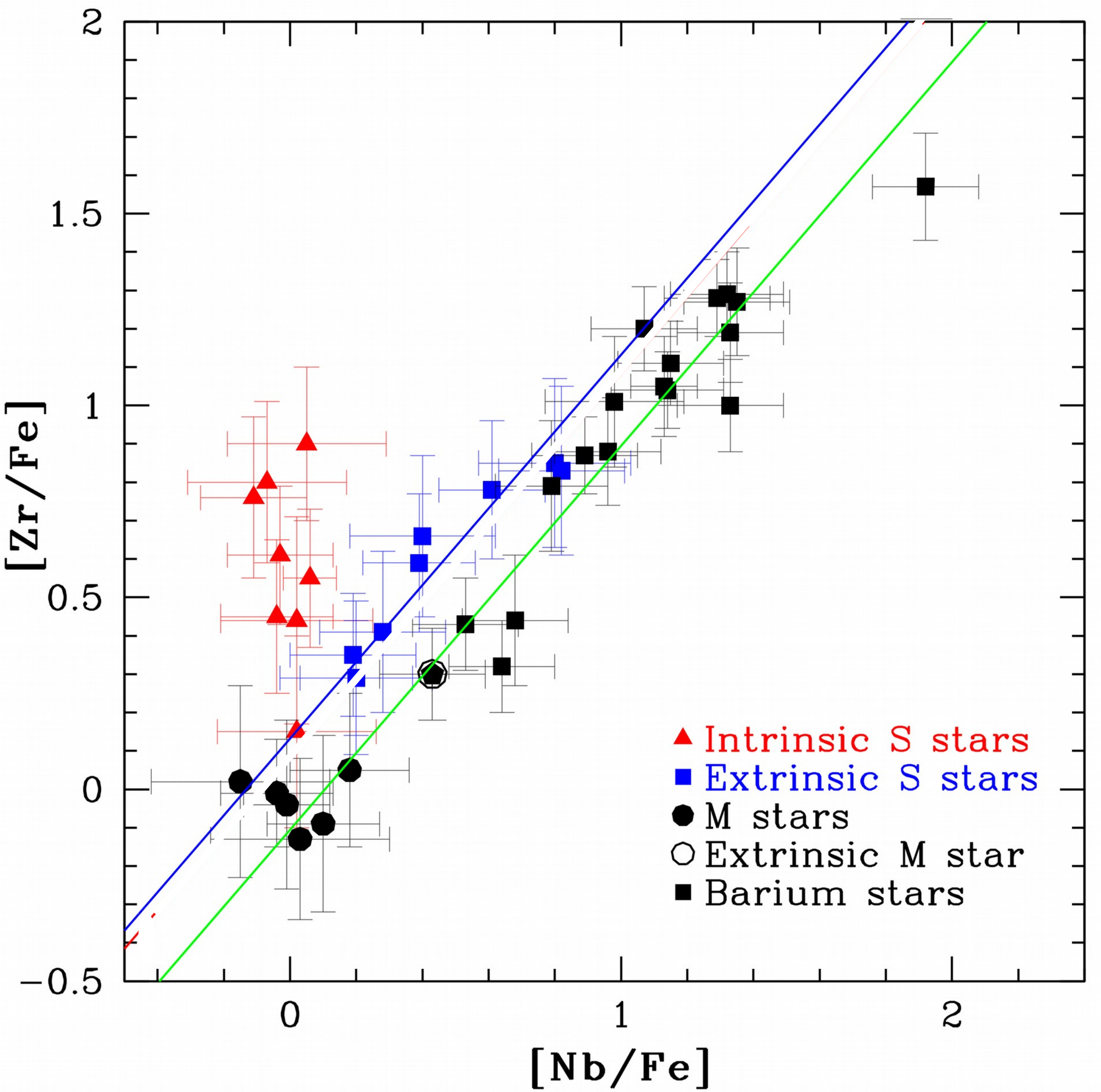
Application: S- stars



(Neyskens, Van Eck et al. Nature 2015)

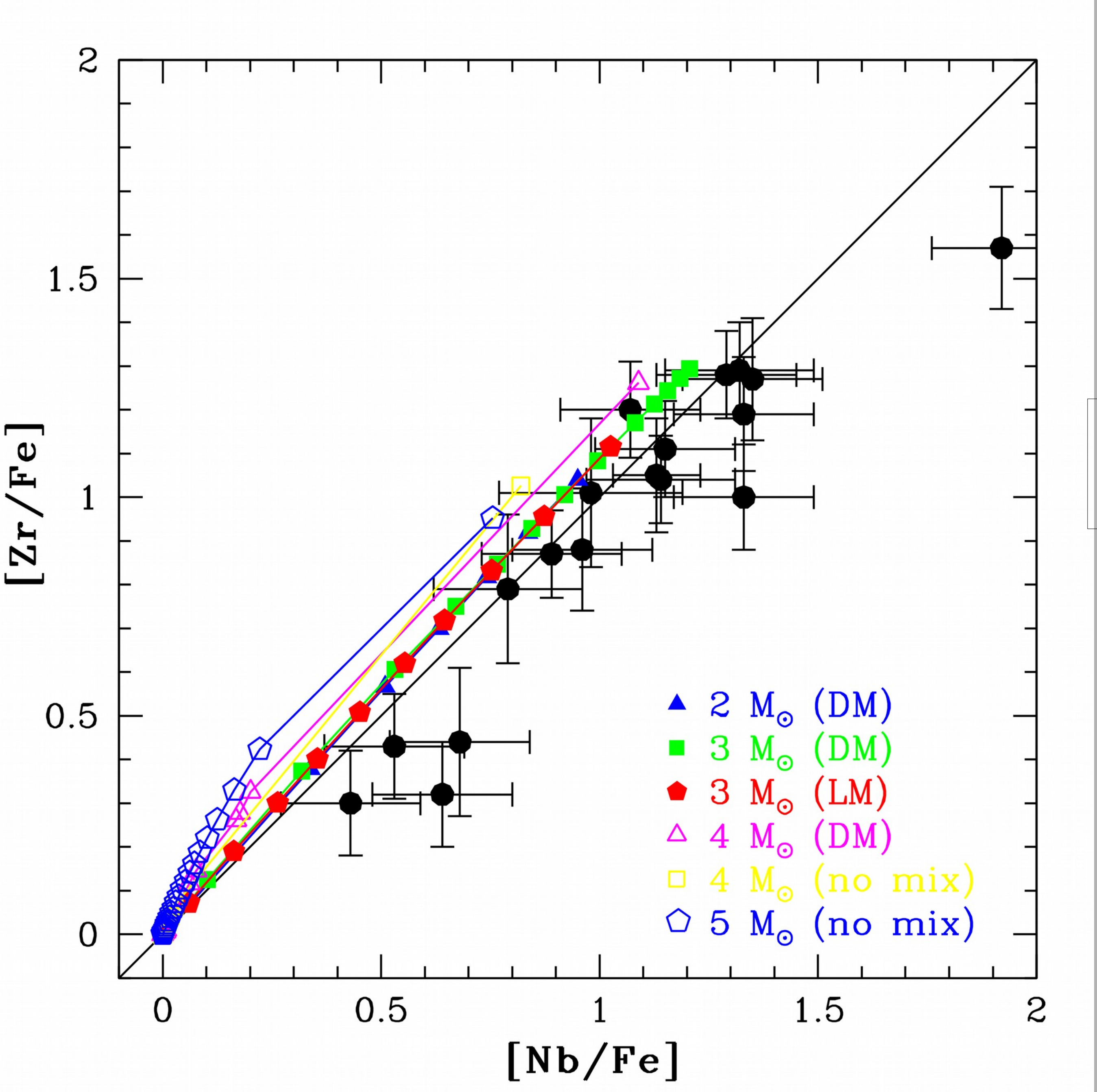
$$[Zr/Fe] = [Nb/Fe] + \log (N_s(Zr)/N_s(Nb)) - \log (N_\odot(Zr)/N_\odot(Nb))$$

Extending the sample with barium stars



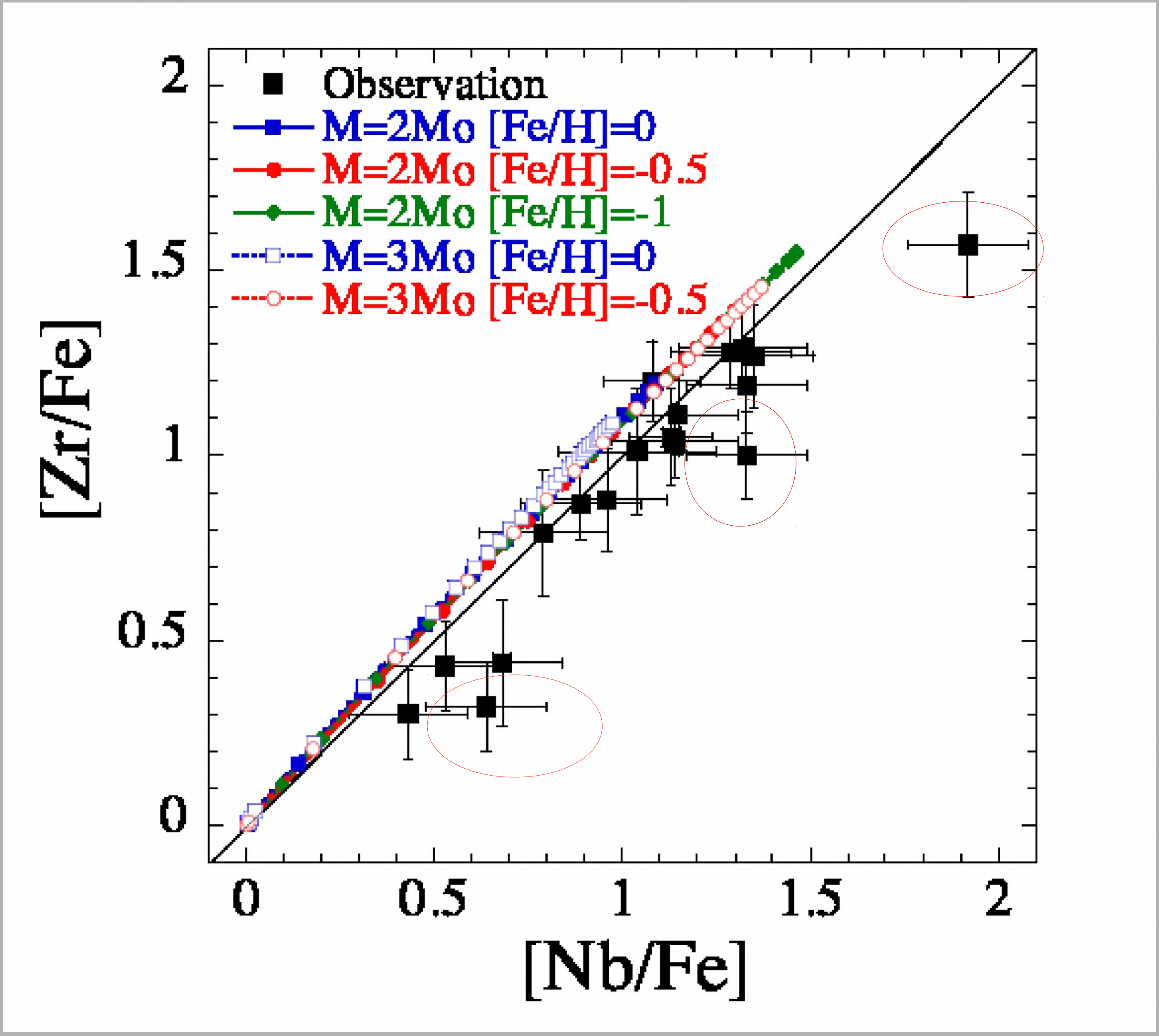
Blue line: extrinsic S stars
Green line: Ba stars

Comparison with model predictions



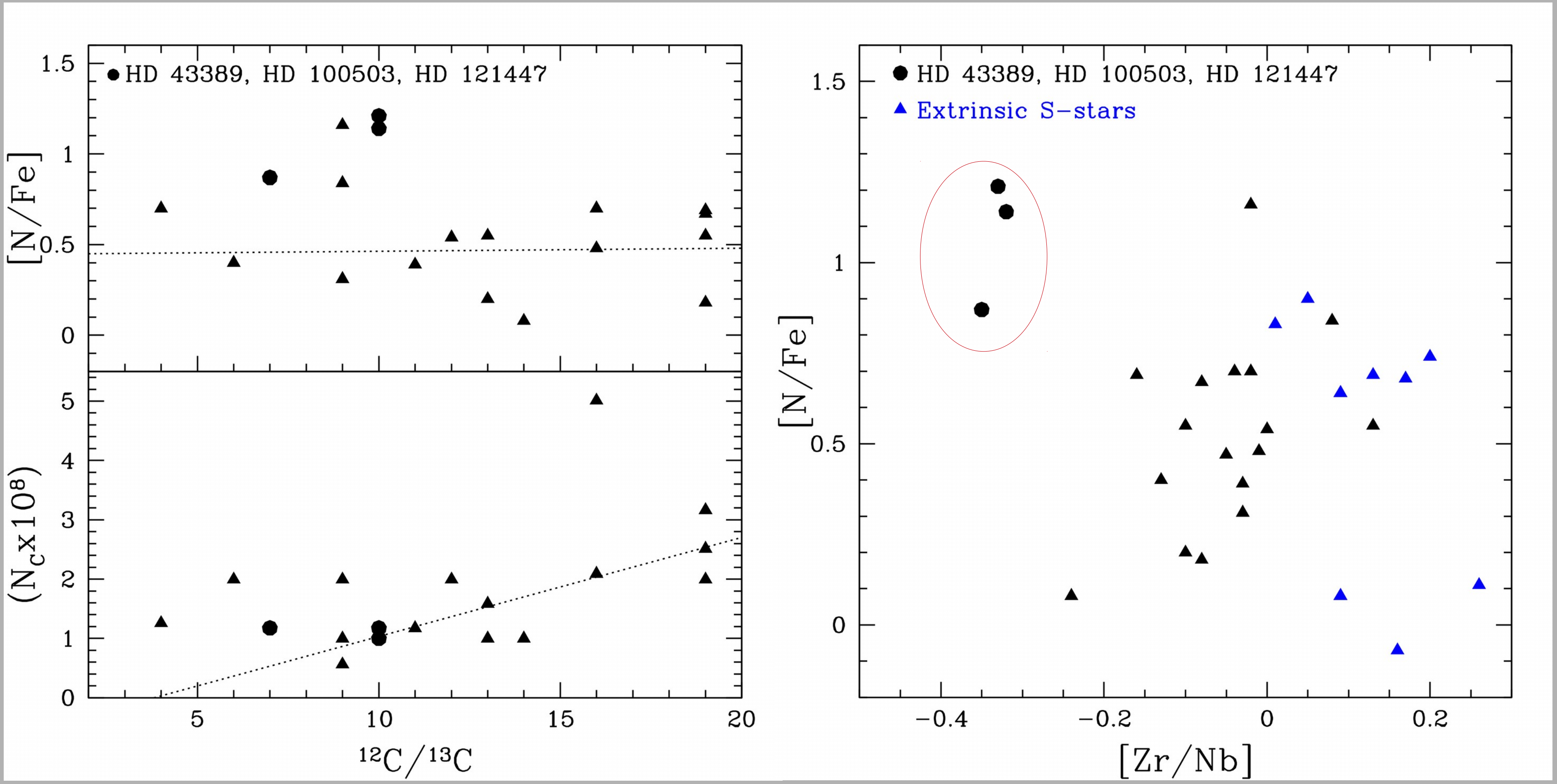
Models:
Goriely and Siess 2017

Discussion of Peculiar objects



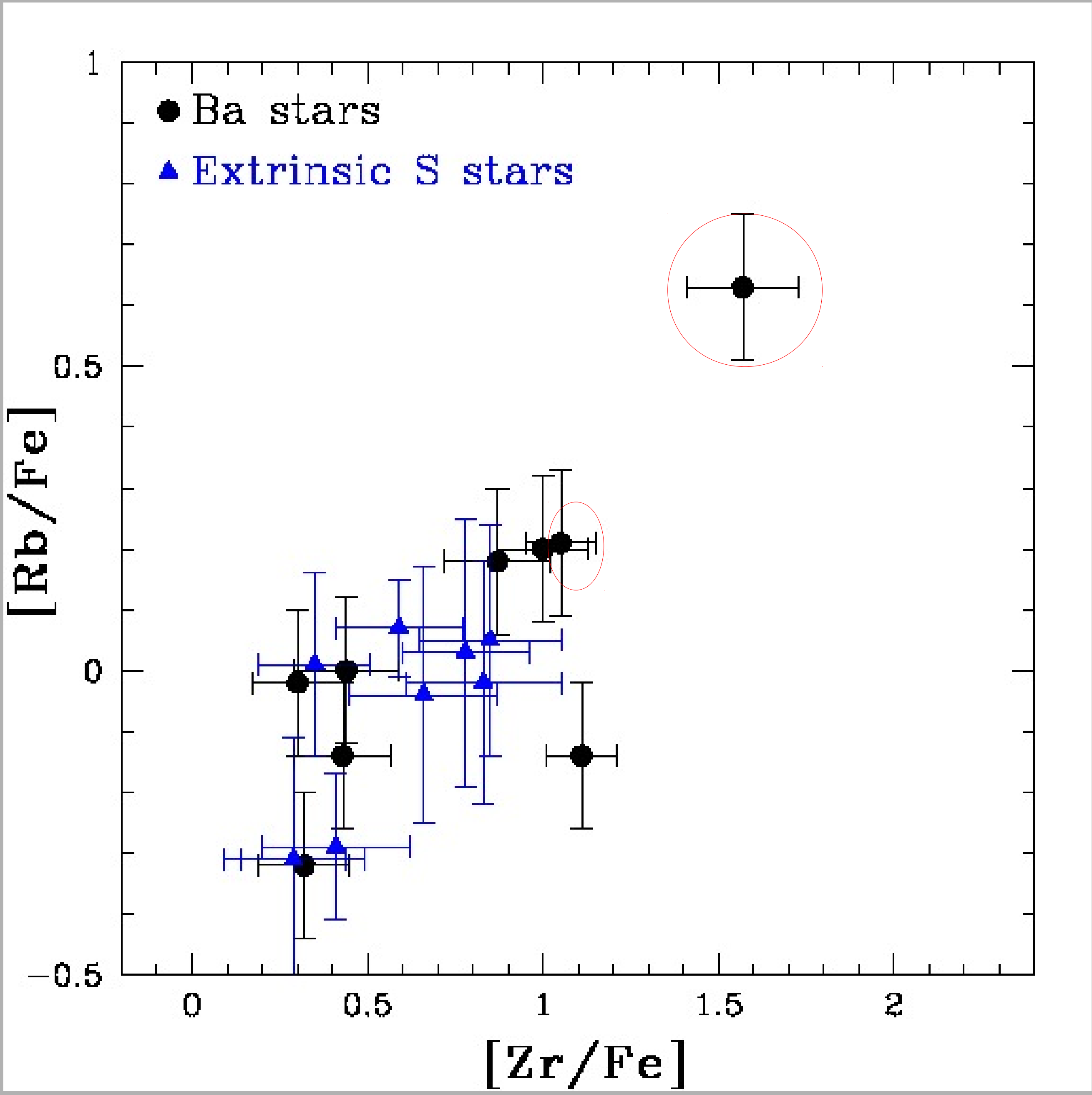
Peculiar stars

Nitrogen abundance



Rb abundance

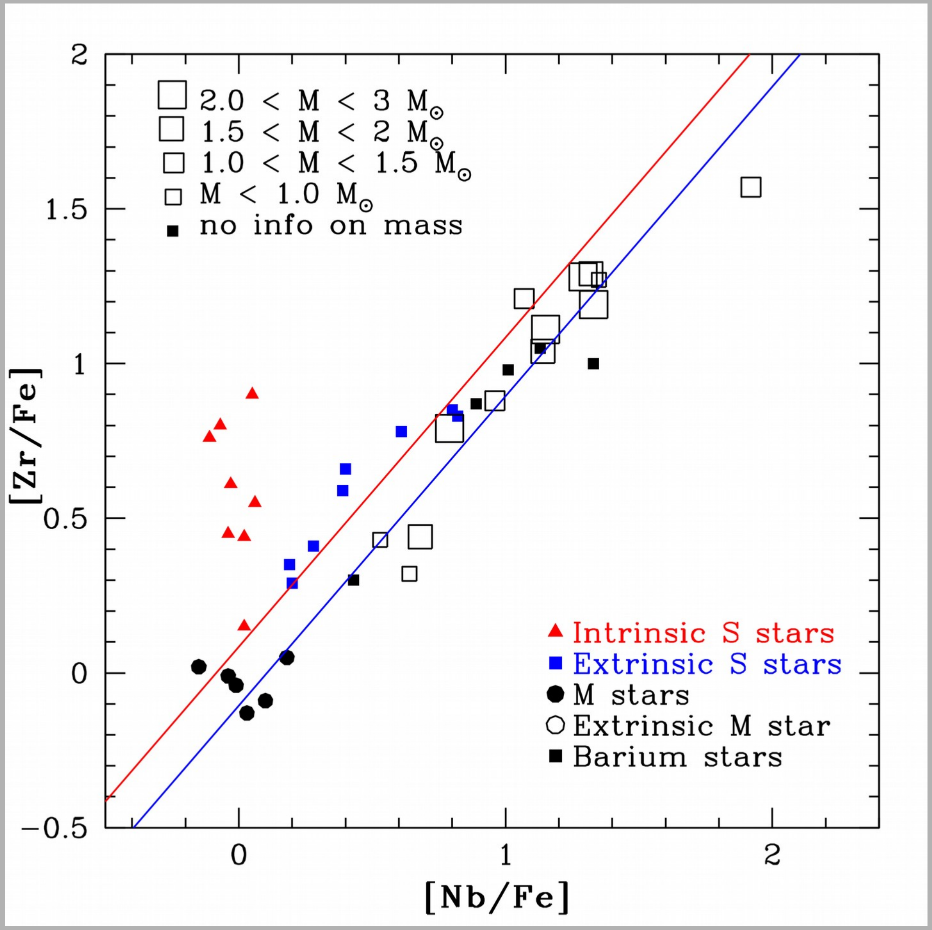
- High [Rb/Fe] observed for high mass stars and it point at ^{22}Ne source.
- [Rb/Fe] larger for Ba stars compared to S stars.



The mass

- Lower limit on the donor mass is derived from the HR diagram:

  STAREVOL evol. tracks; GAIA parallaxes
- All objects are low mass with M < 3 $\mathbf{M_\odot}$
- consistent with lower s-process temperatures operating in low mass stars



Conclusion

- Preliminary results indicate low neutron temperatures for the production of s-process elements in barium stars.
- Theoretical model predictions based on higher masses are in preparation

Thank you for your kind attention!!!!!