The composition of Barium stars and the s process in AGB stars

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Introduction – Ba stars

- G−K giants + dwarfs, [Fe/H] > -1.0
- strong spectral features: carbon molecular bands + s-process elements
- radial velocity variation → binary systems
  → not intrinsic overabundance!
  → mass transfer
  → test: AGB s-process nucleosynthesis

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  → not intrinsic overabundance!
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  → test: AGB s-process nucleosynthesis
- [hs/ls] ← s=? hs/ls=?
  (2./1. peak)

Sample data

- e. g.: Yang+ (2016): 19 stars, Allen&Barbuy (2006): 26 stars, Antipova+ (2004): 16 stars
- de Castro et al. (2016) sample:

  - 182 giants (certain, candidate)

  - high resolution spectra (FEROS, R = 48000)

  - wide range in T_{eff} (4100-5400 K), mass (1-6 M_{Sun}), metallicity

  - Ba star? here: if [s/Fe] ≥ 0.25 → 13 stars rejected (s = Y, Zr, La, Ce, Nd)

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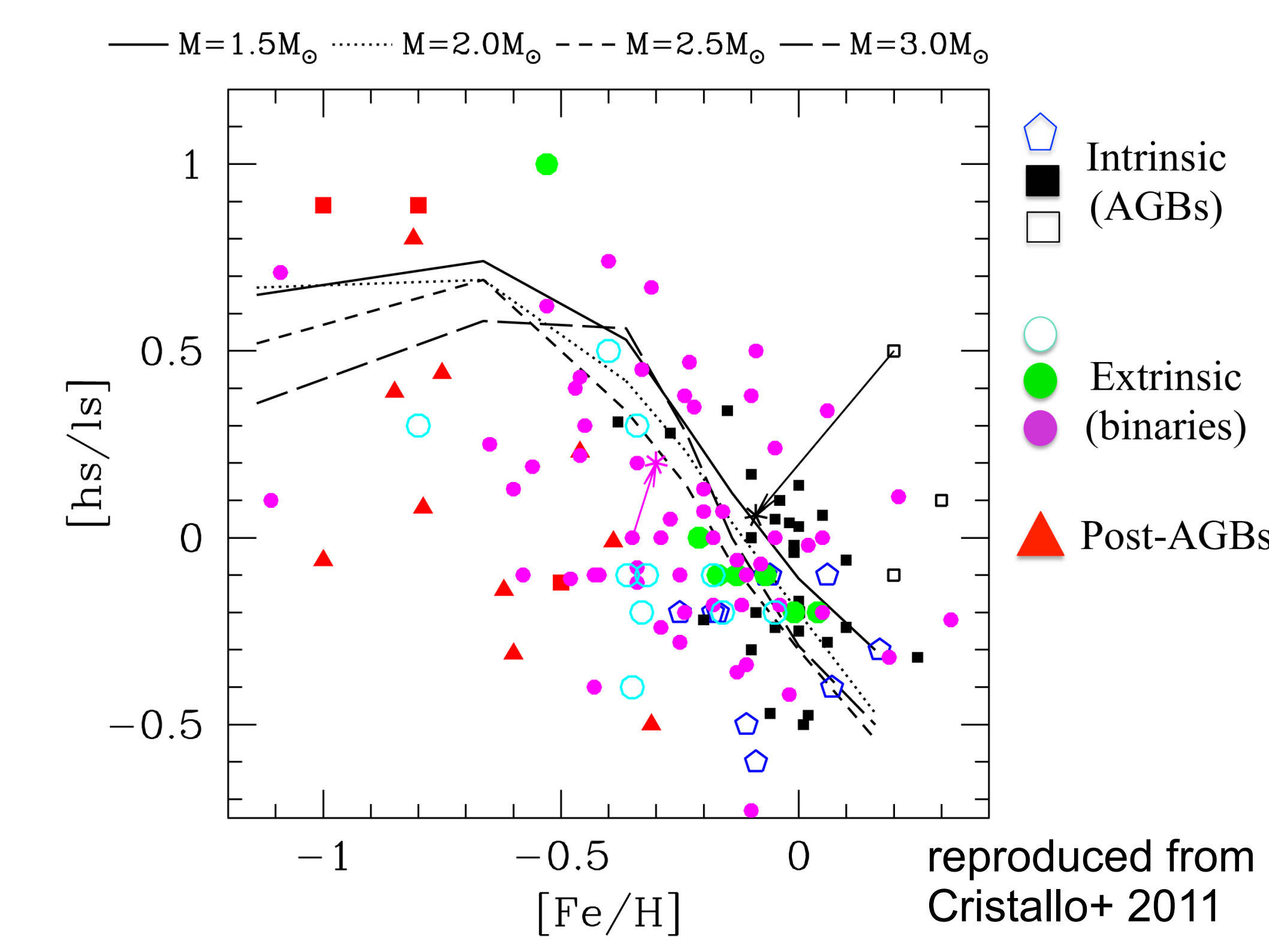
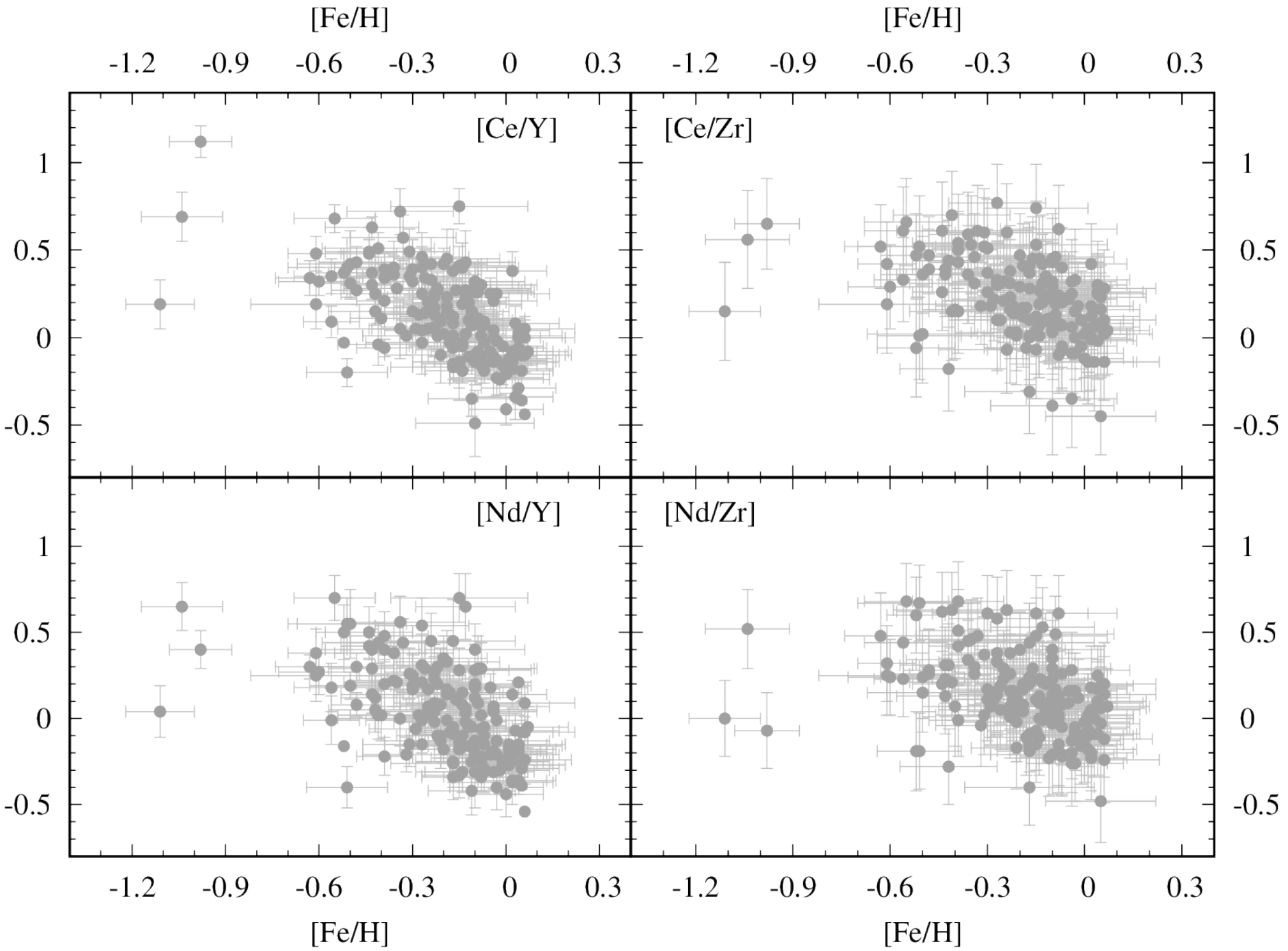
- estimated error → first time proper error calculations
  [hs/ls] → [Ce/Y], …


M=1.5M⊙
M=2.0M⊙
M=2.5M⊙
M=3.0M⊙
[hs/ls]
[Fe/H]
1
0.5
0
−0.5
−1
−0.5
0
Intrinsic
(AGBs)
Extrinsic
(binaries)
Post-AGBs
reproduced from
Cristallo+ 2011

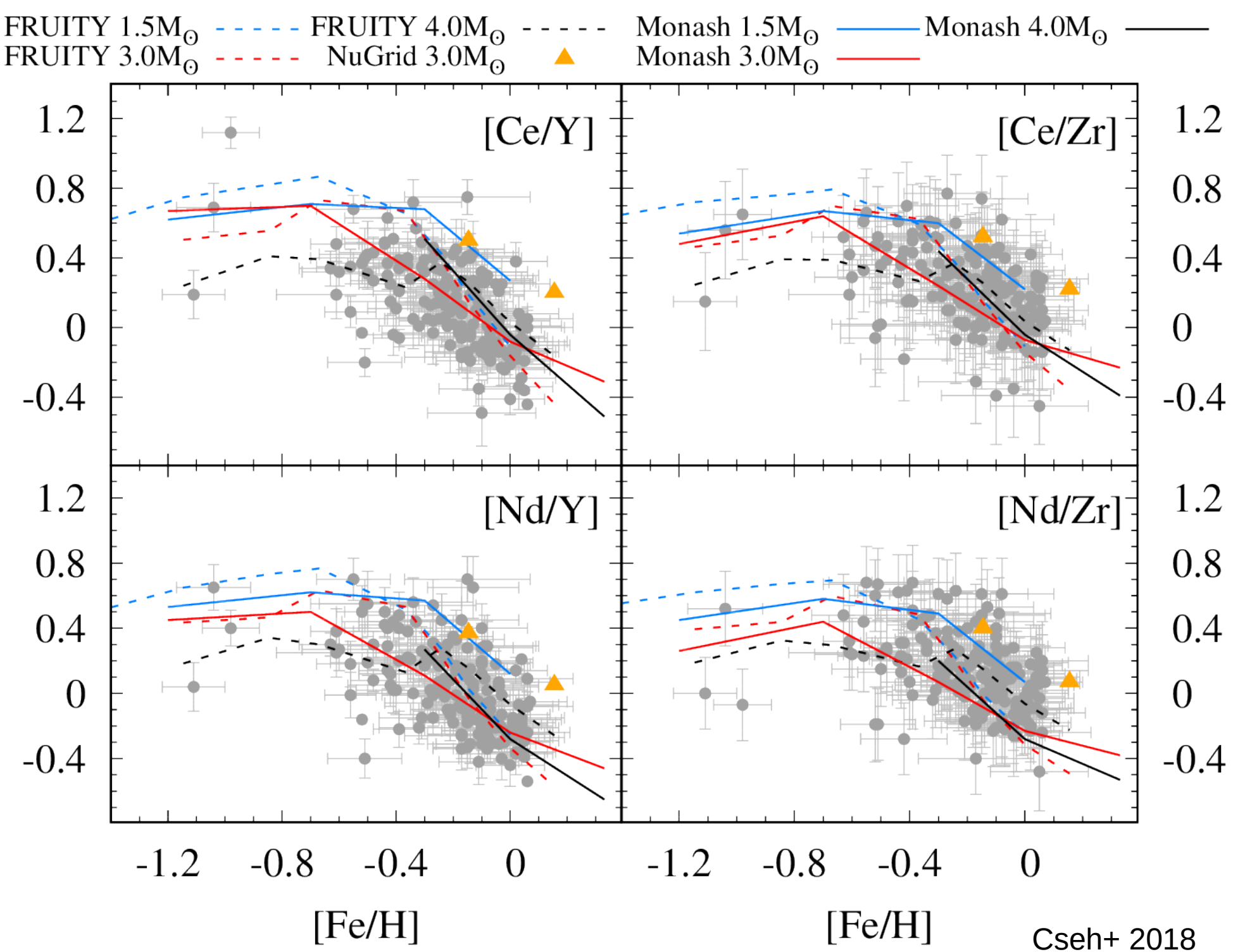

[Fe/H]
-1.2
-0.9
-0.6
-0.3
0
0.3
[Ce/Y]
[Ce/Zr]
[Nd/Y]
[Nd/Zr]
1
0.5
0
-0.5

Model comparison

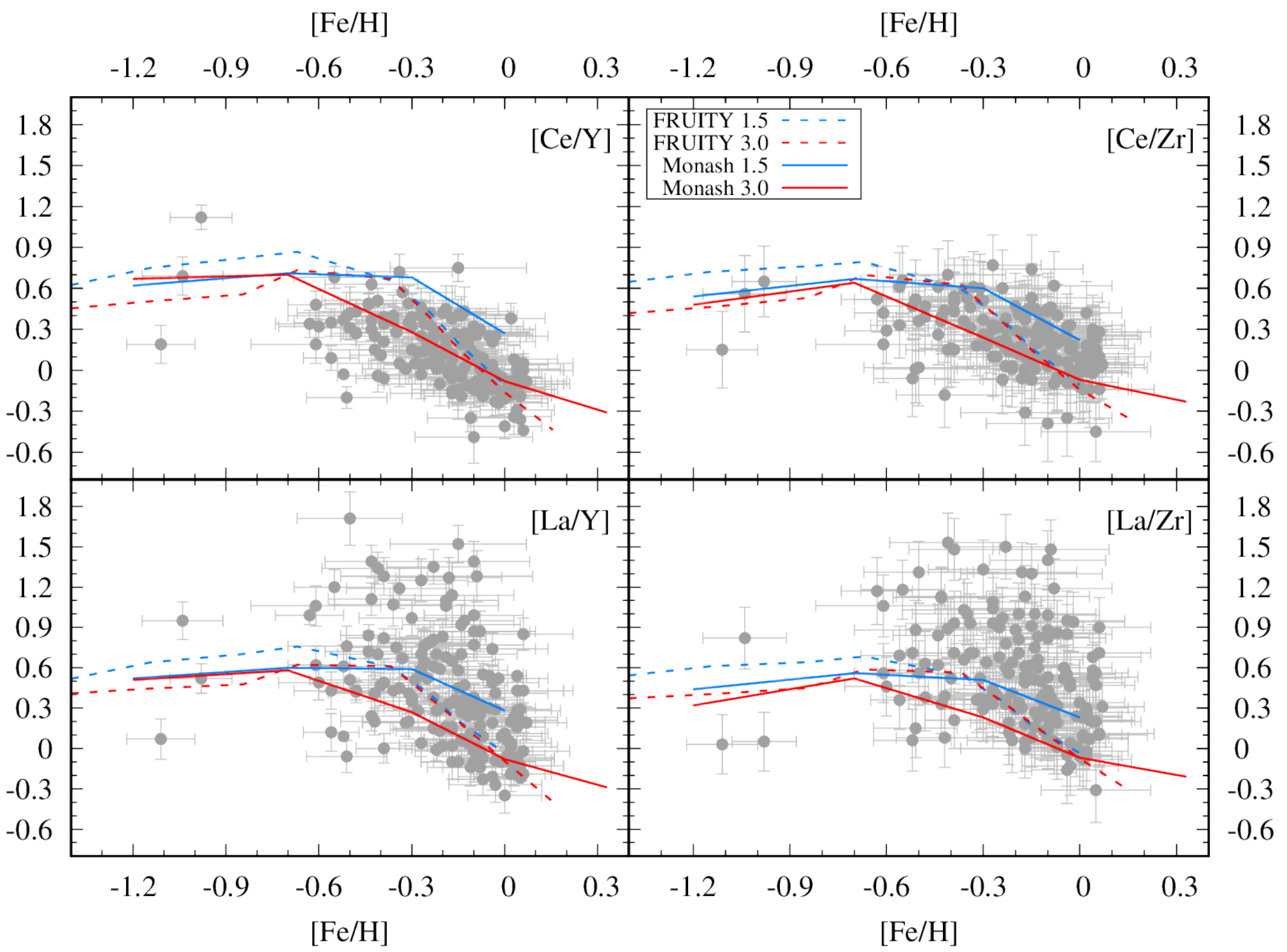
- final surface composition, without rotation,
  [s/Fe] ≥ 0.25
  (s = Y, Zr, La, Ce, Nd)
- different metallicities, masses
- FRUITY + Monash + NuGrid: Battino+ 2016

Cristallo+ 2016,
Cristallo+ 2015,
Straniero+ 2014,
Piersanti+ 2013,
Cristallo+ 2011,
Cristallo+ 2009

Karakas+ 2018,
Karakas & Lugaro 2016,
Fishlock+ 2013

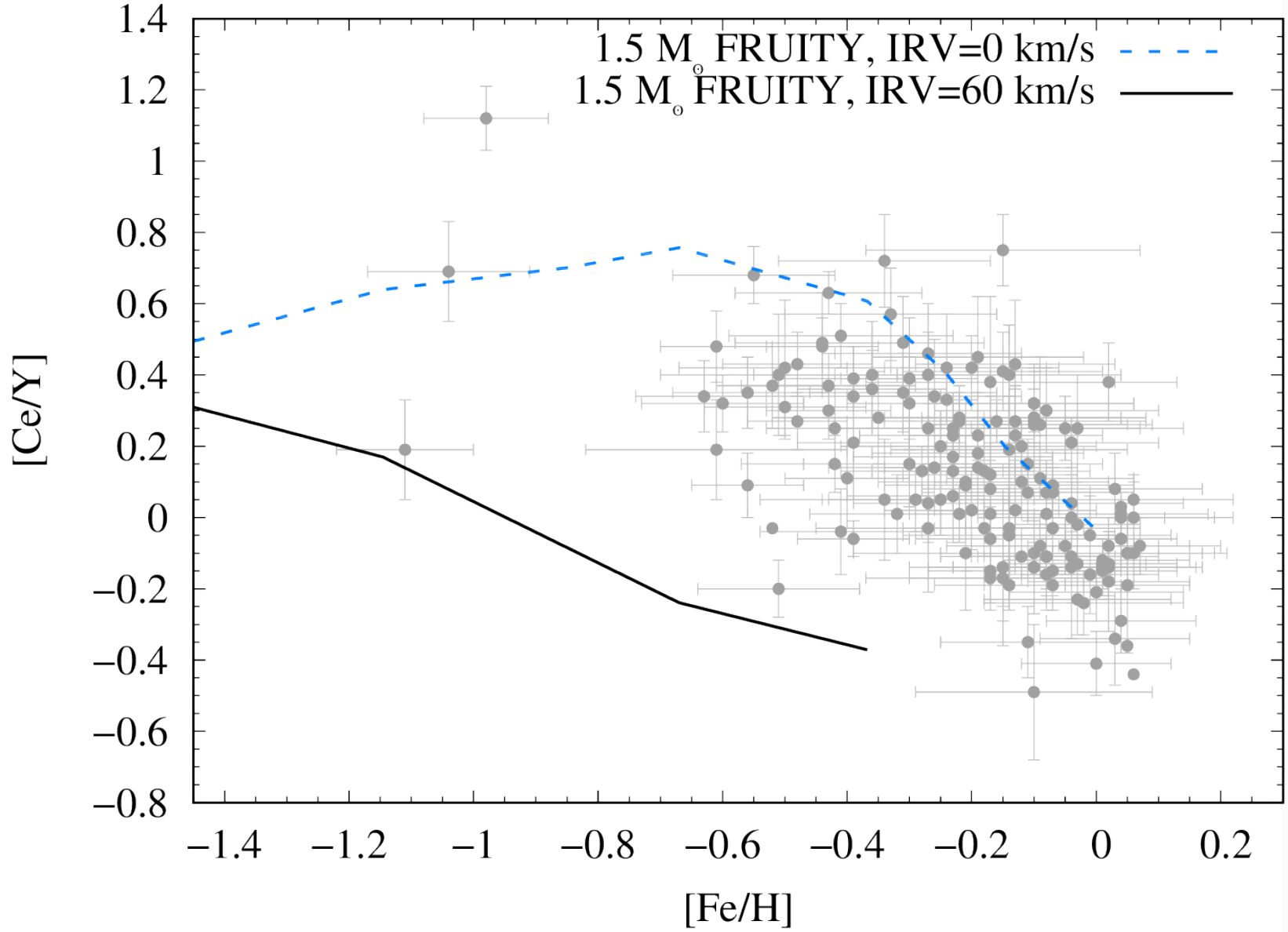

FRUITY 1.5M⊙
FRUITY 4.0M⊙
Monash 1.5M⊙
Monash 4.0M⊙
FRUITY 3.0M⊙
NuGrid 3.0M⊙
Monash 3.0M⊙
[Ce/Y]
[Ce/Zr]
[Nd/Y]
[Nd/Zr]
1.2
0.8
0.4
0
-0.4
-1.2
-0.8
-0.4
0
[Fe/H]
[Fe/H]

Cseh+ 2018


[Fe/H]
-1.2
-0.9
-0.6
-0.3
0
0.3
[Ce/Y]
[Ce/Zr]
[La/Y]
[La/Zr]
FRUITY 1.5
FRUITY 3.0
Monash 1.5
Monash 3.0
1.8
1.5
1.2
0.9
0.6
0.3
0
-0.3
-0.6

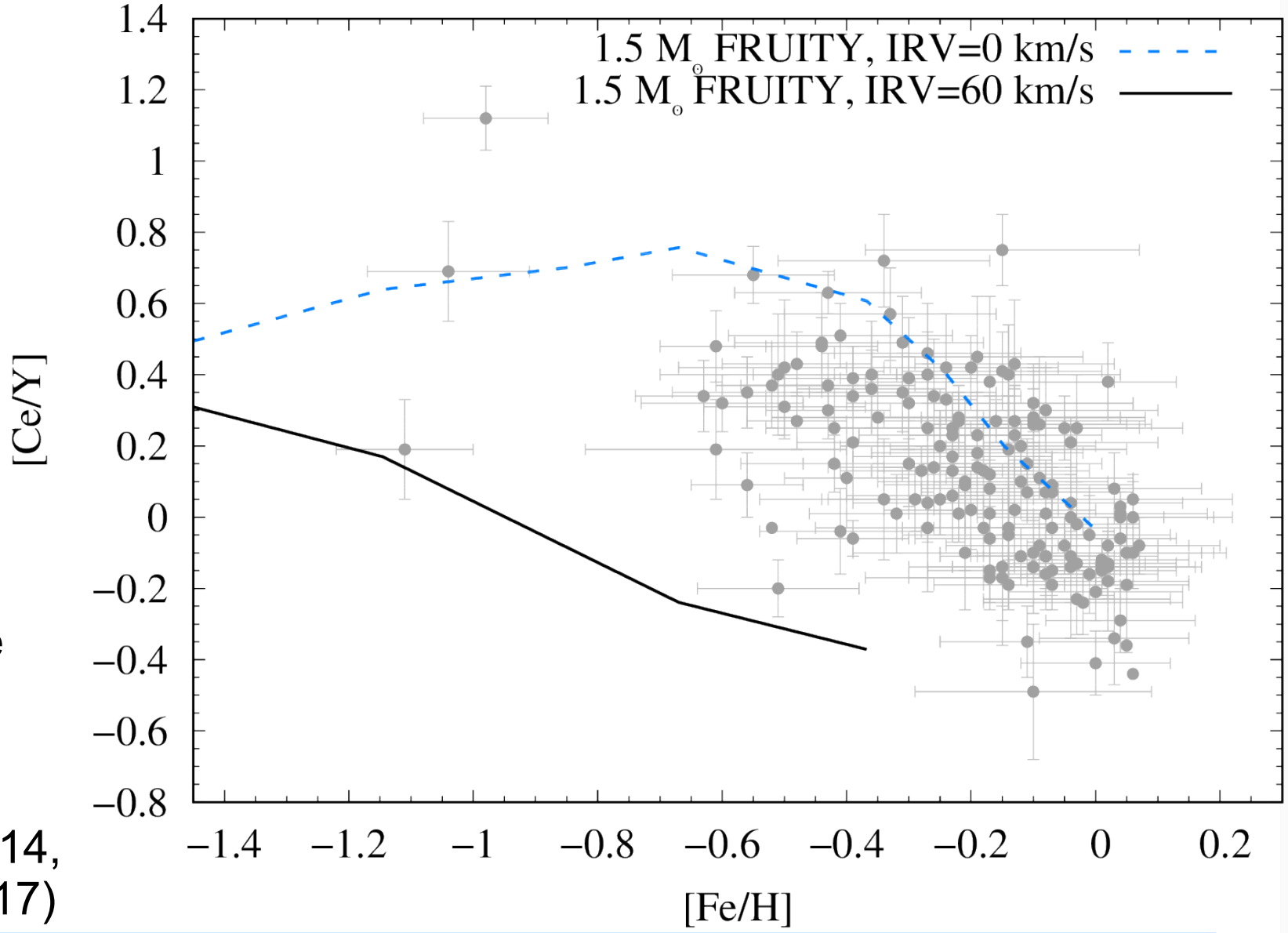
…with rotation

Cseh+ 2018



…with rotation

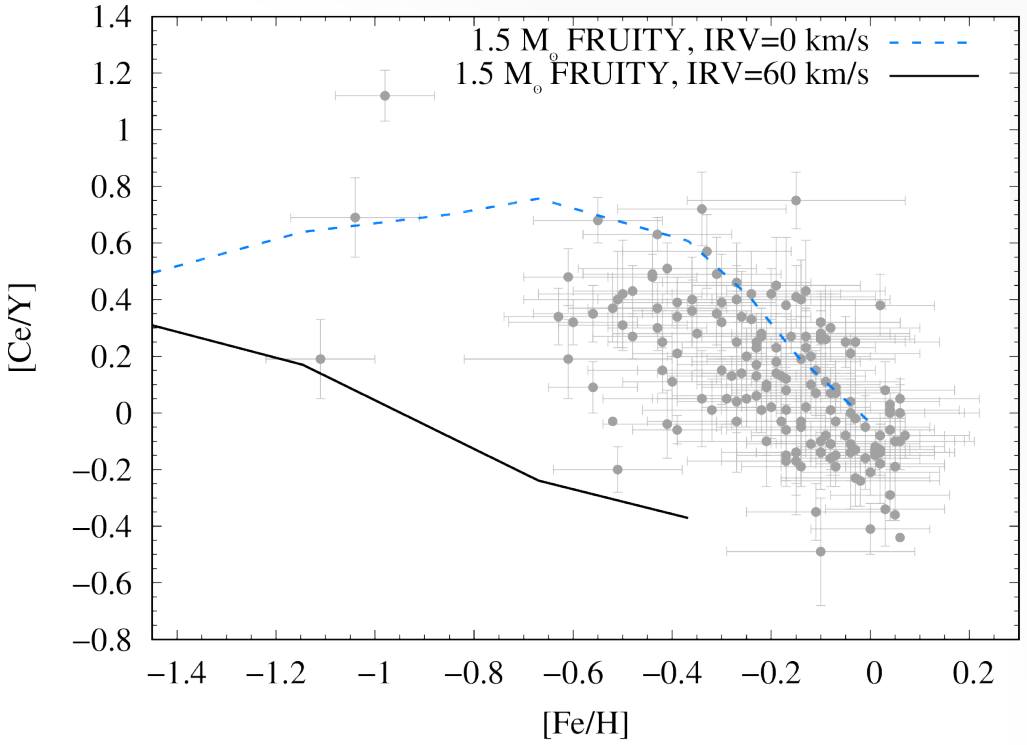
Cseh+ 2018



- rotation: minor effect
- coupling: to slow down the core in giants
- agreement with asteros. (Cantiello+ 2014, Hermes+ 2017)

Summary

- new Ba star observations
  → split elements, own error bar
- trend agrees with models → main n source: ^{13}C nuclei
- rotational mixing: minor effect
  → in agreement with asteroseismology (Cantiello+ 2014, Hermes+ 2017)



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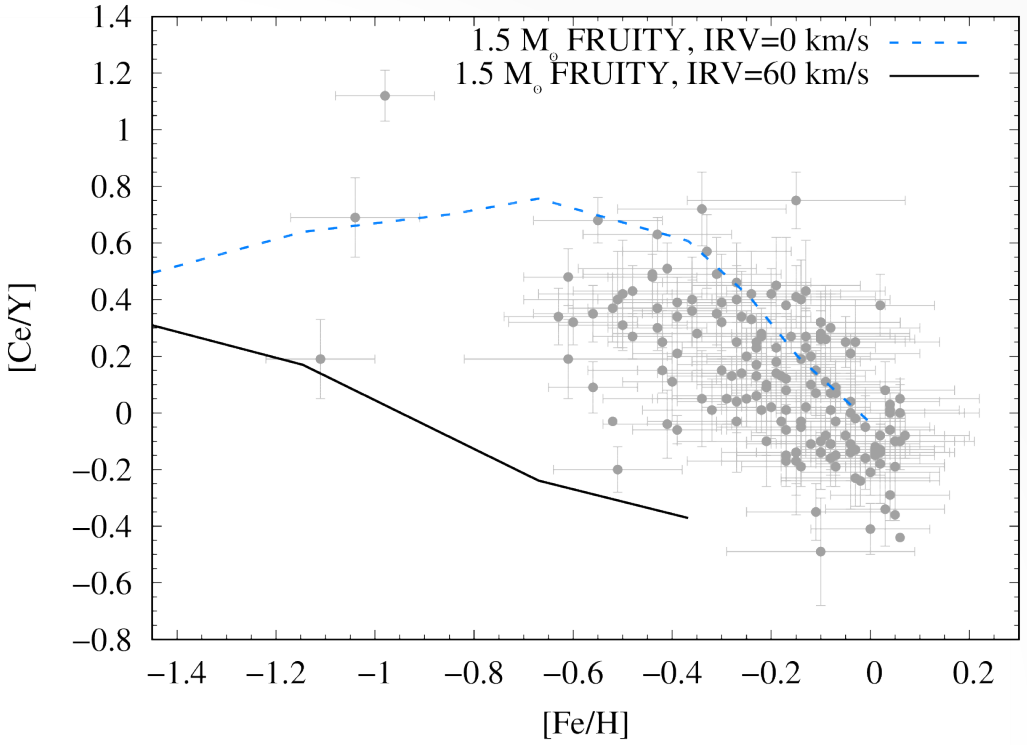

future plans (work in progress):

- other elements, individual stars
- higher metallicity sample
- comparison with other s-process enhanced stars

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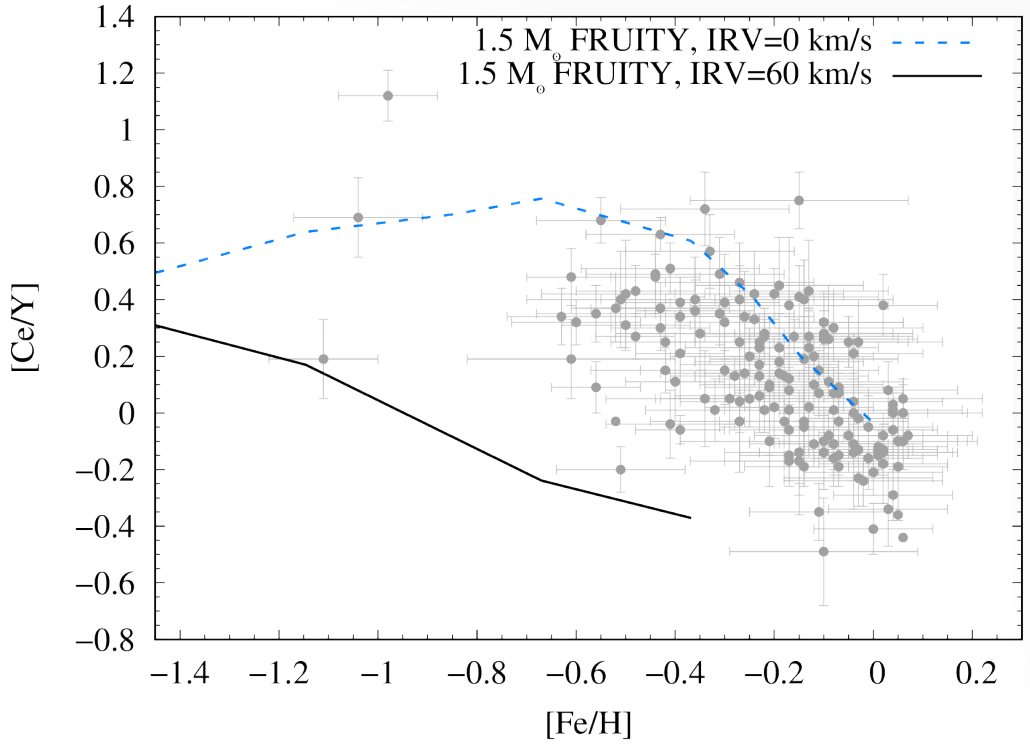

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Thank you for your attention!