CHEMICAL ABUNDANCE CHANGES IN STARS DURING THE FIRST DREDGE-UP

Marie Martig

Liverpool John Moores University

WHY SHOULD YOU CARE?

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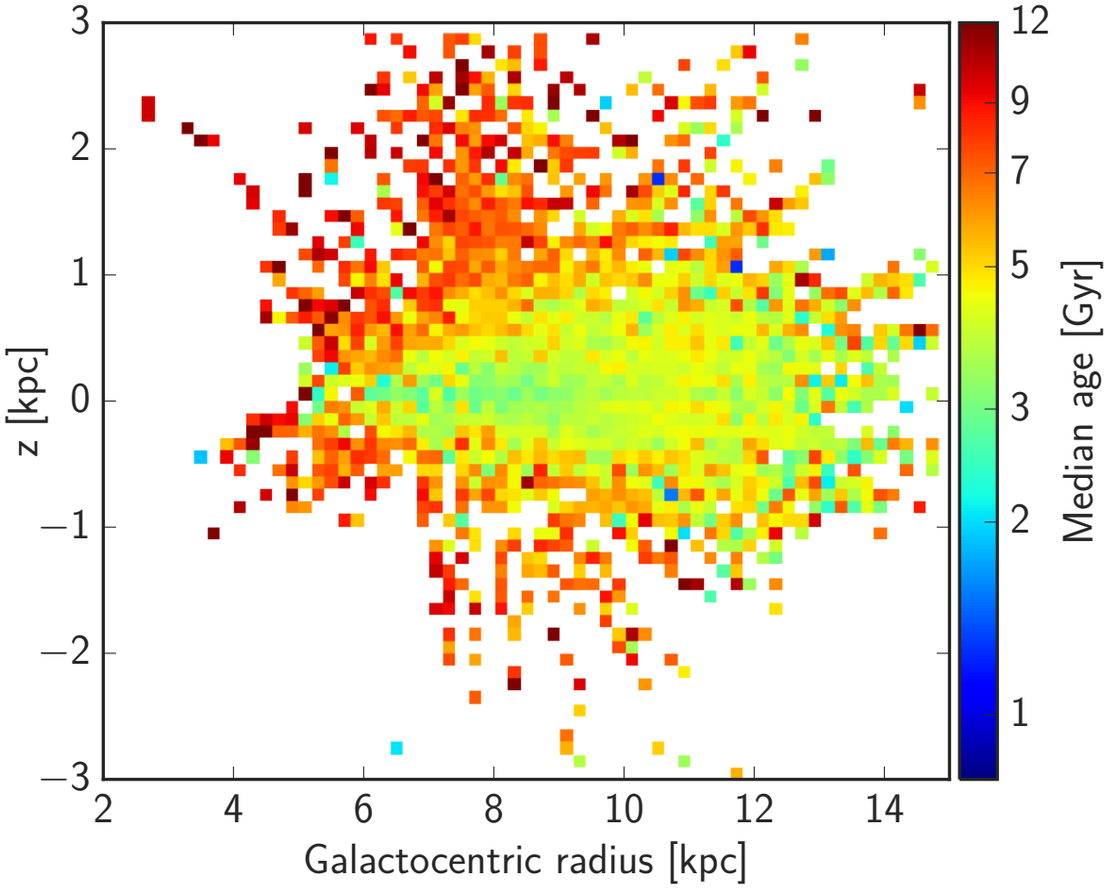
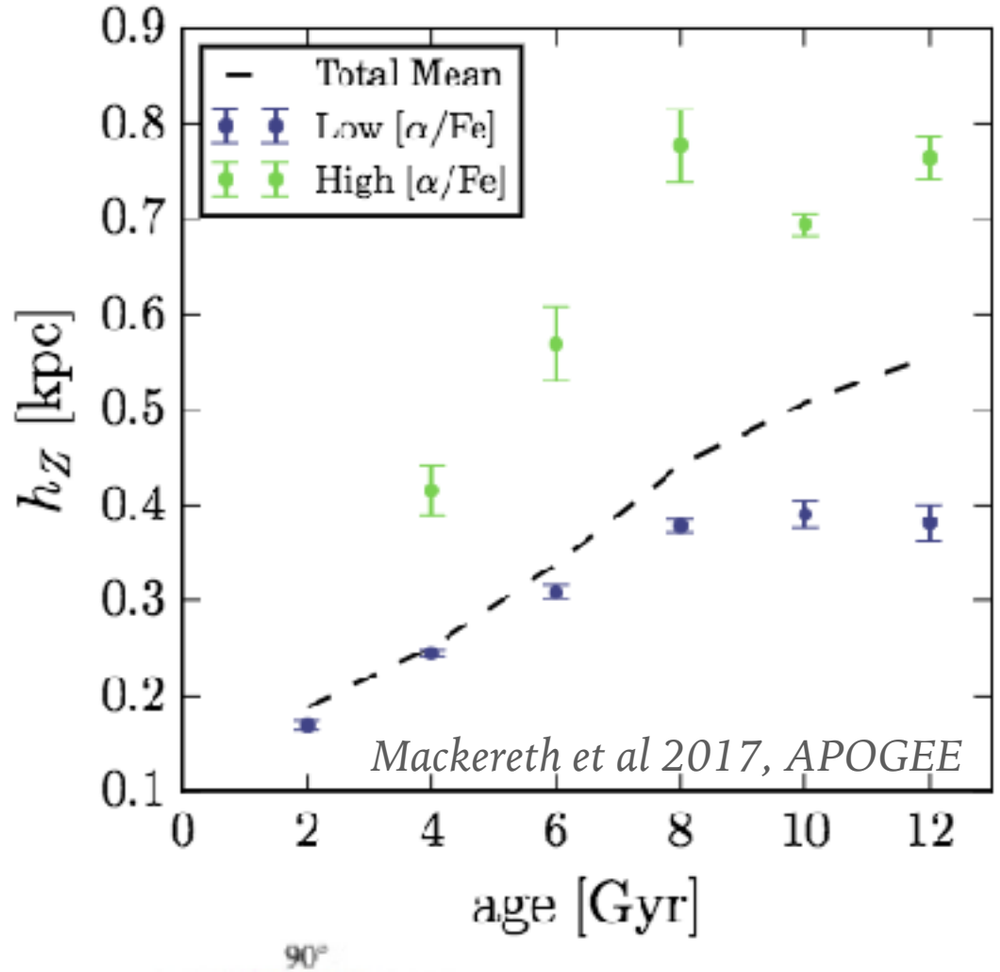
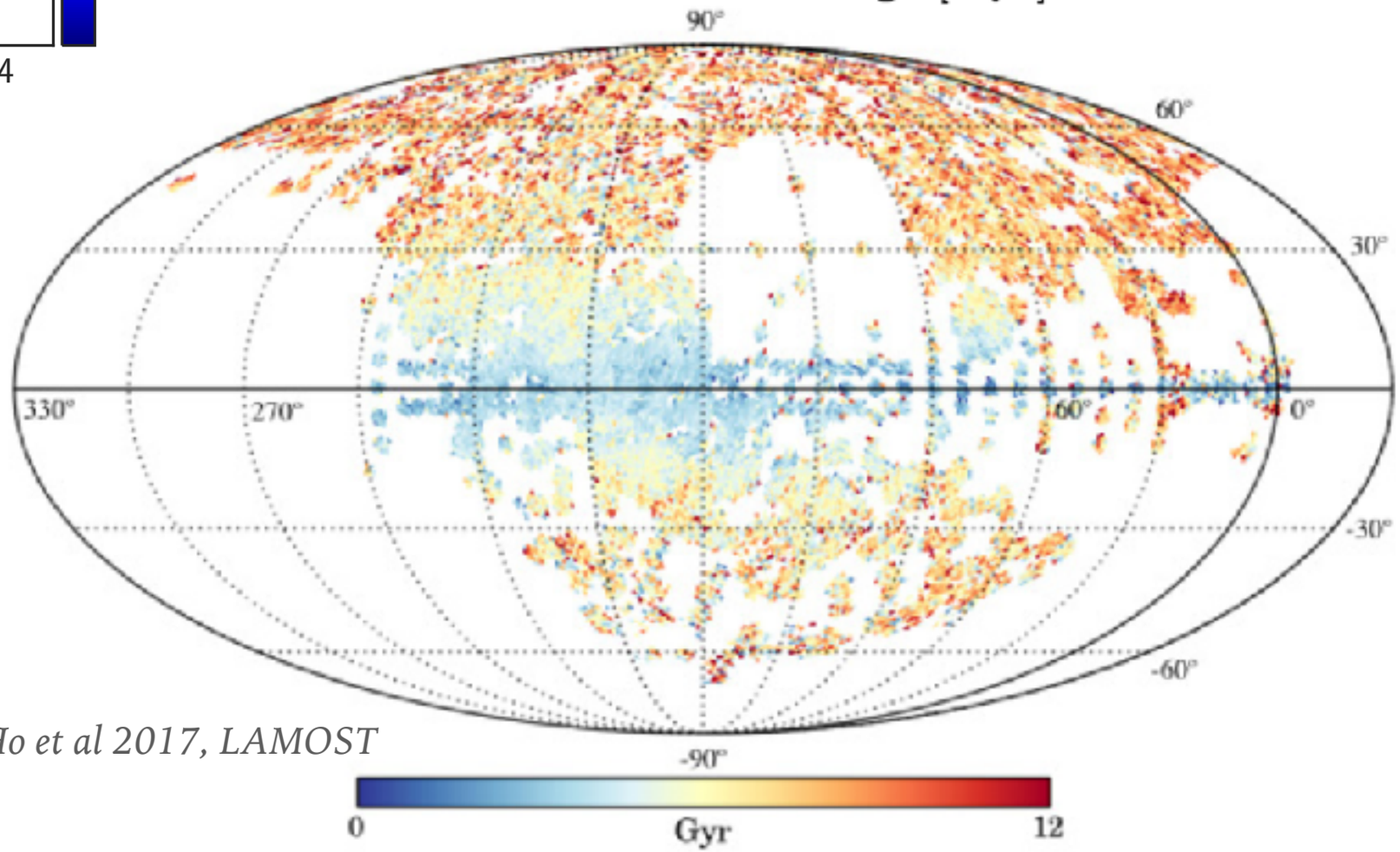


Martig et al 2016, APOGEE

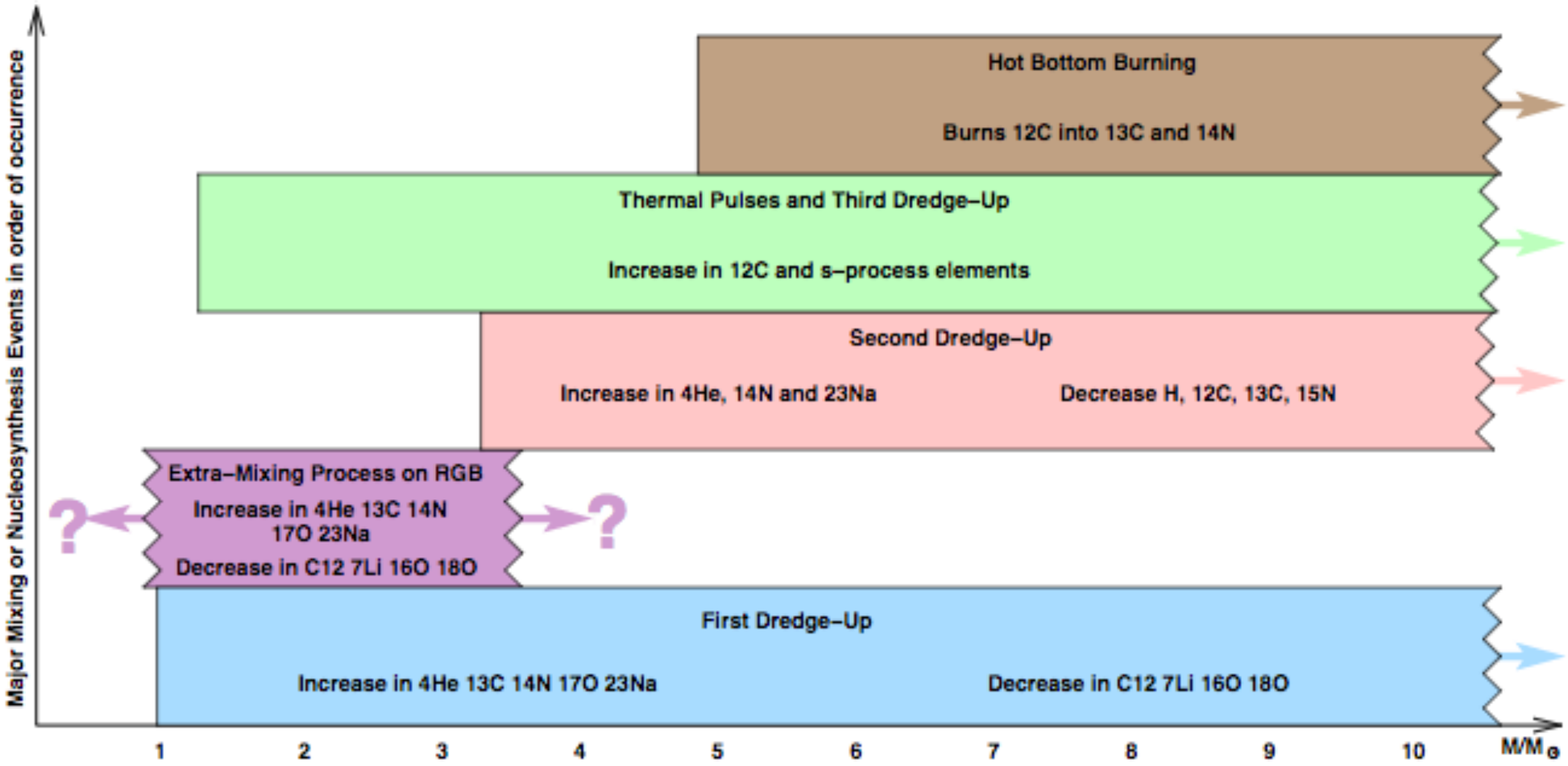
a way to determine ages for giants stars !





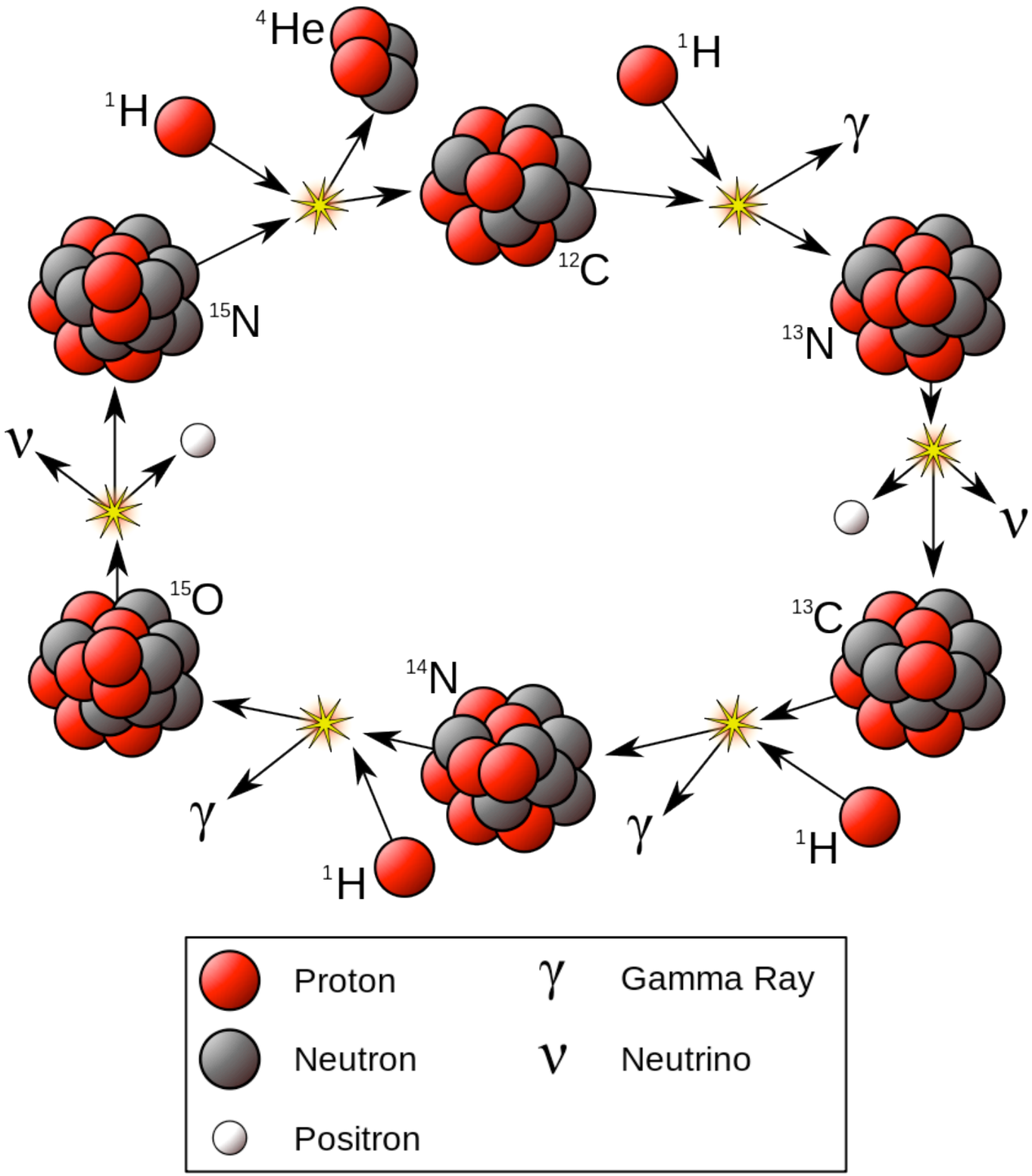
Ho et al 2017, LAMOST

MIXING PROCESSES



Karakas & Lattanzio 2014

CNO CYCLE

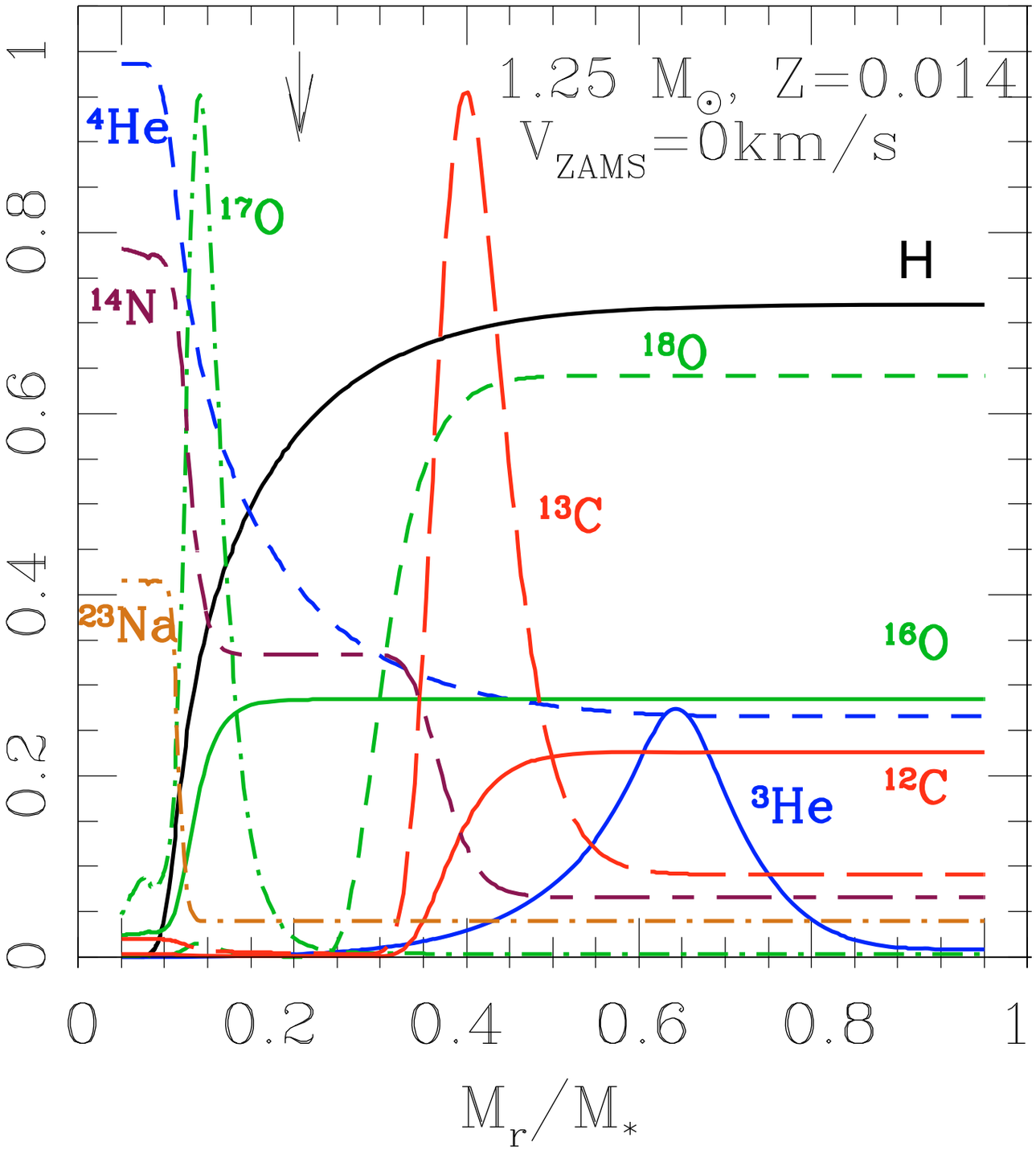


C, N, O isotopes act as catalysts in the fusion of H into He

Proton capture on ^{14}N is slow

- ➤ ^{14}N accumulates in the core

STRUCTURE OF STAR AT END OF MAIN SEQUENCE



Charbonnel & Lagarde 2010

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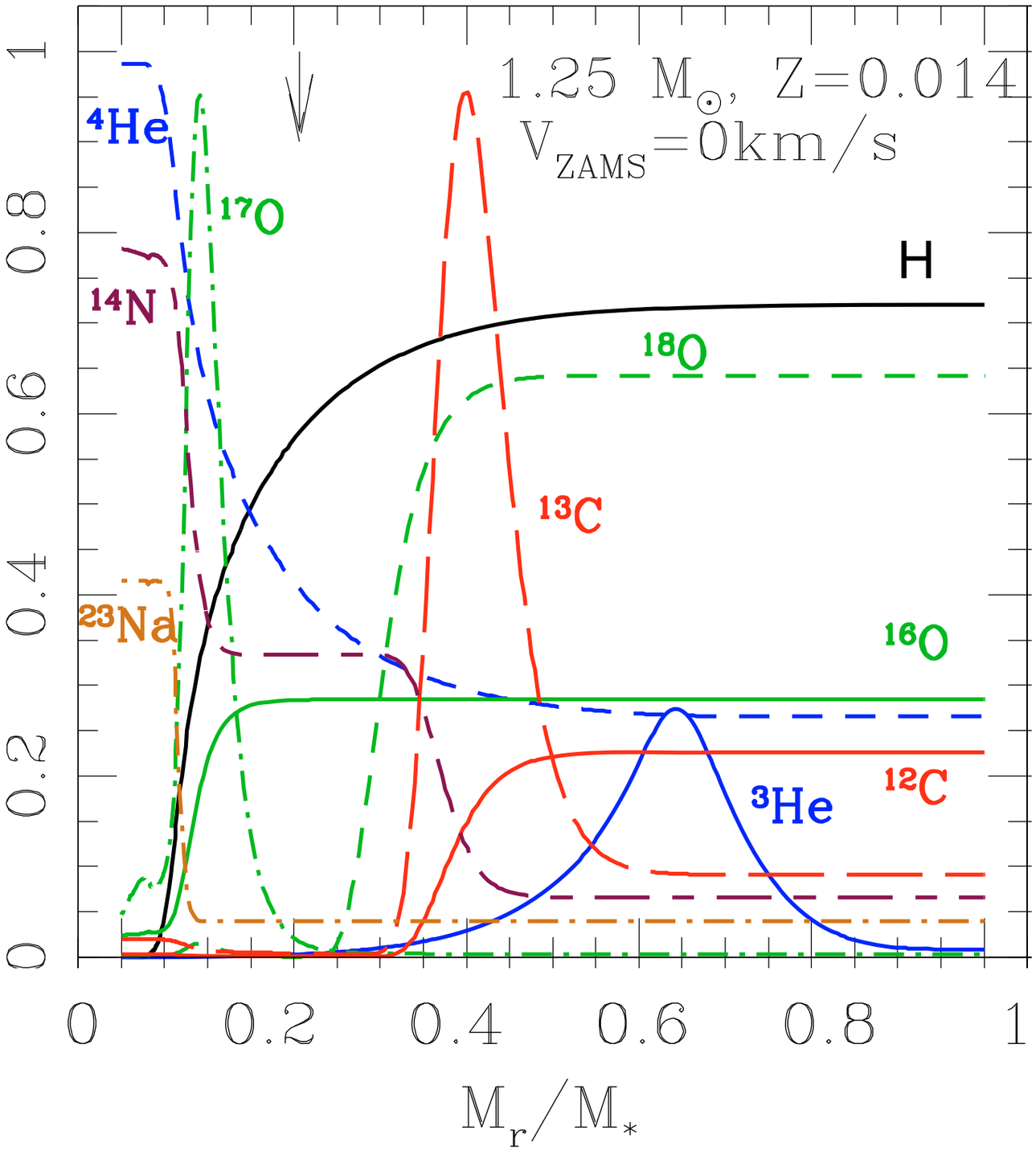


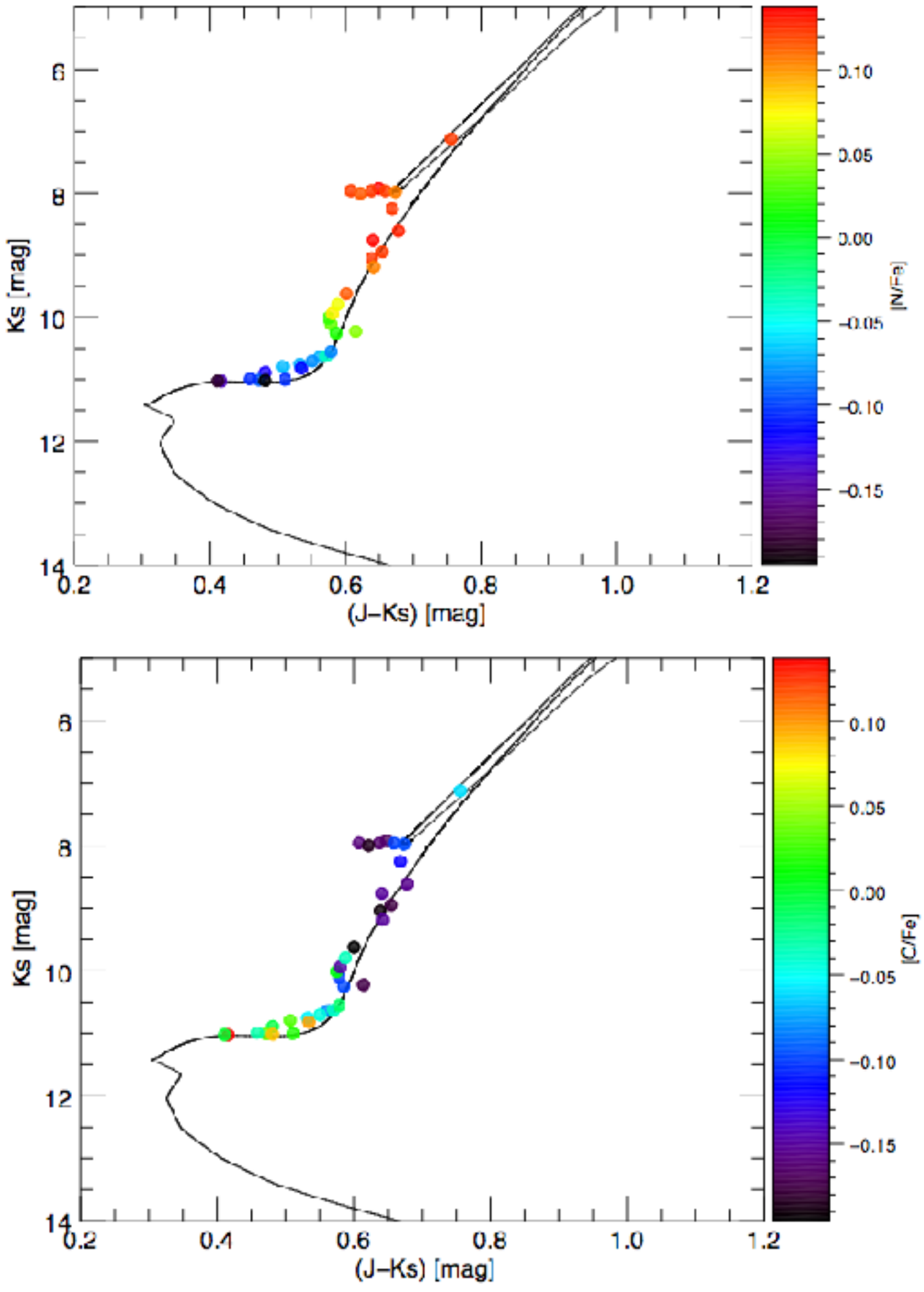
Charbonnel & Lagarde 2010

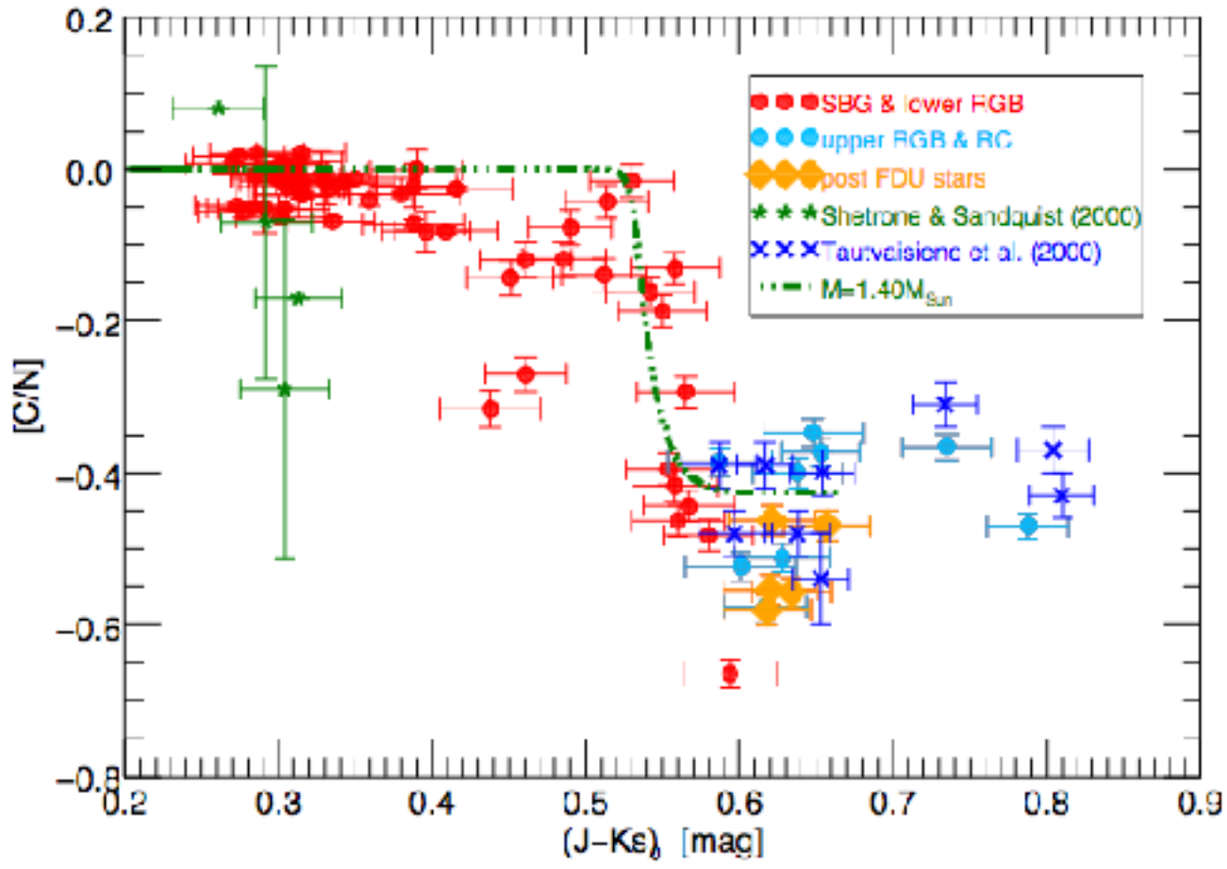
After the first dredge-up, the surface abundances change:

- N, He increase
- C, Li, $^{12}C/^{13}C$ decrease

Bertelli Motta et al, 2016

[C/N] DECREASES AFTER THE 1ST DREDGE-UP

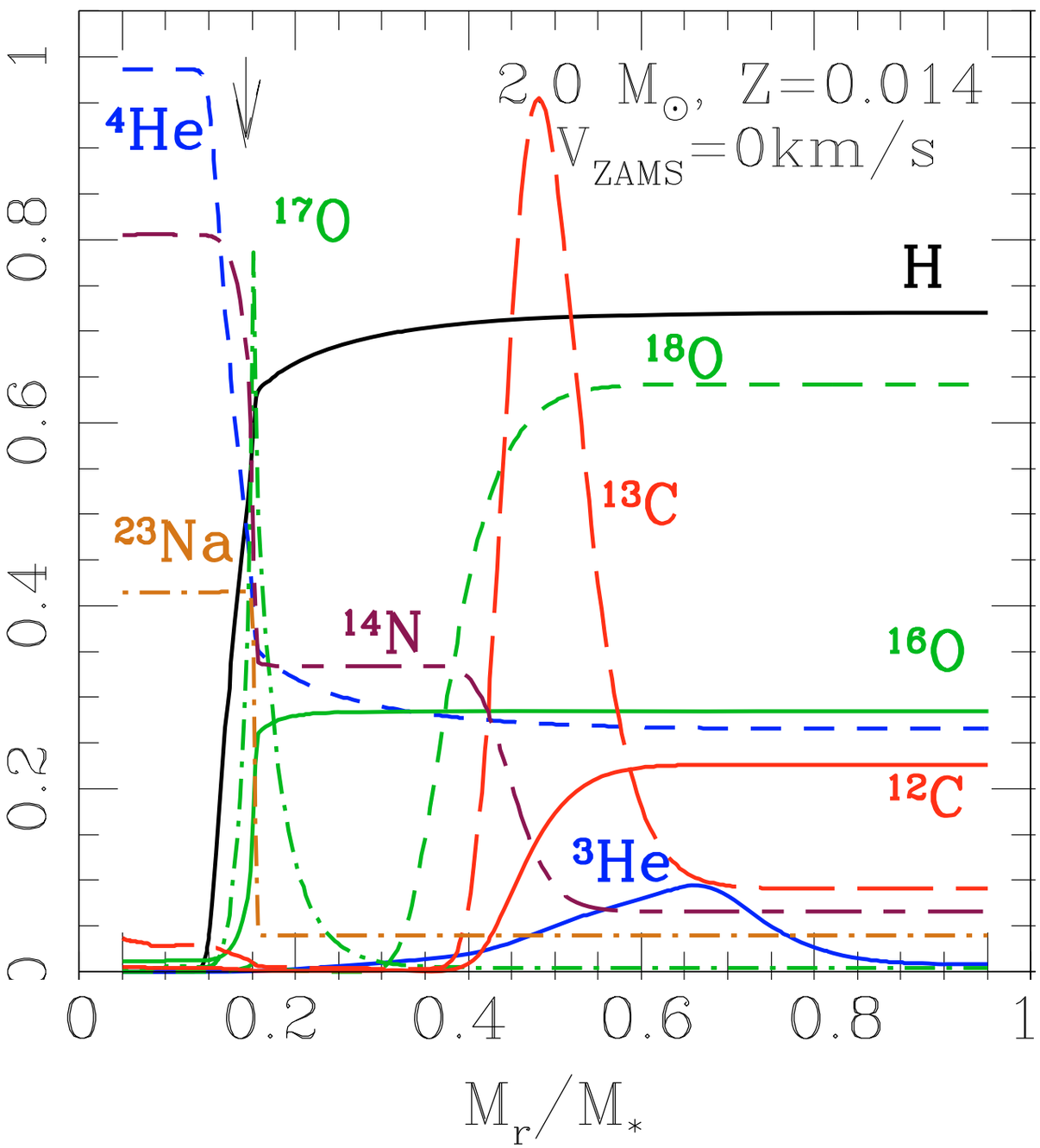




APOGEE data

M67, 4 Gyr old open cluster

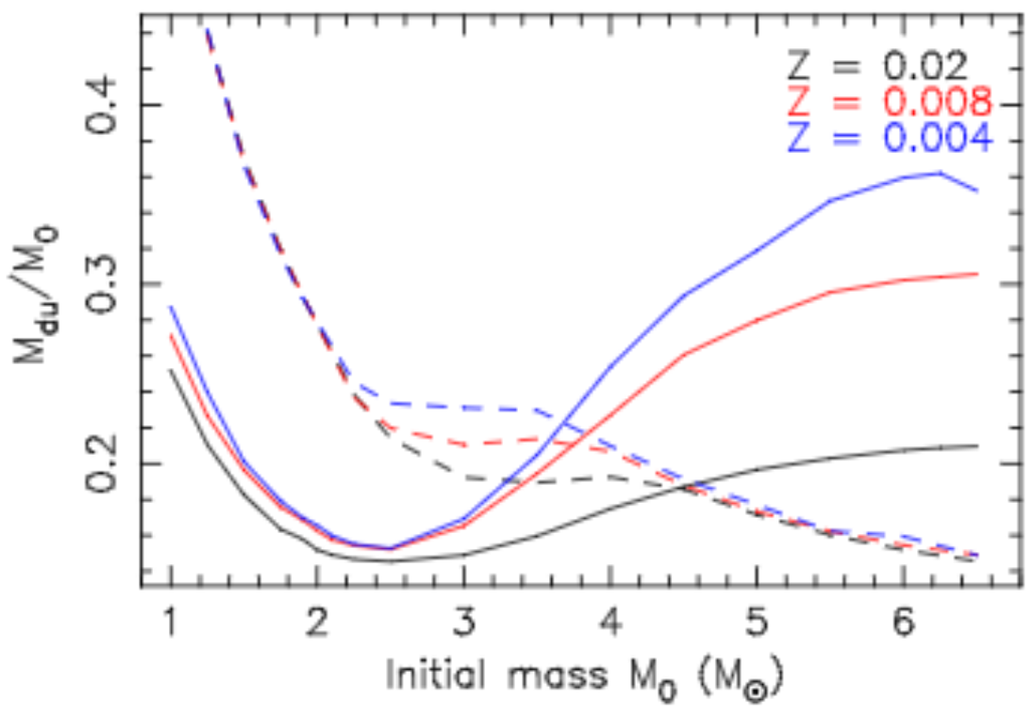
SURFACE [C/N] AFTER THE FIRST DREDGE-UP DEPENDS ON STELLAR MASS



Charbonnel & Lagarde 2010

Higher mass star:

- larger zone where ^{12}C burned into ^{14}N
- convective envelope goes deeper during dredge-up



Karakas & Lattanzio 2014

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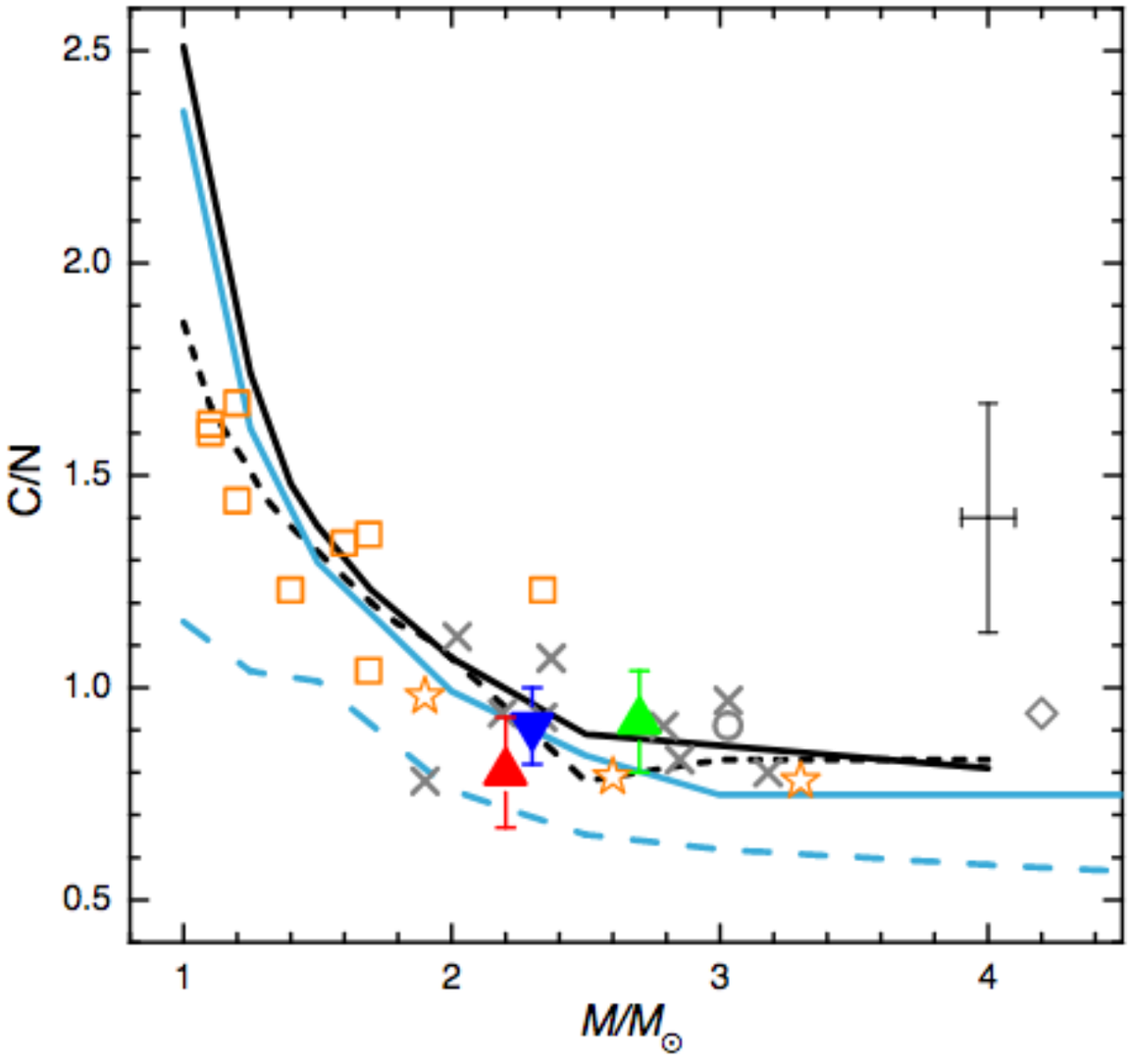

Tautvaišiene et al 2016

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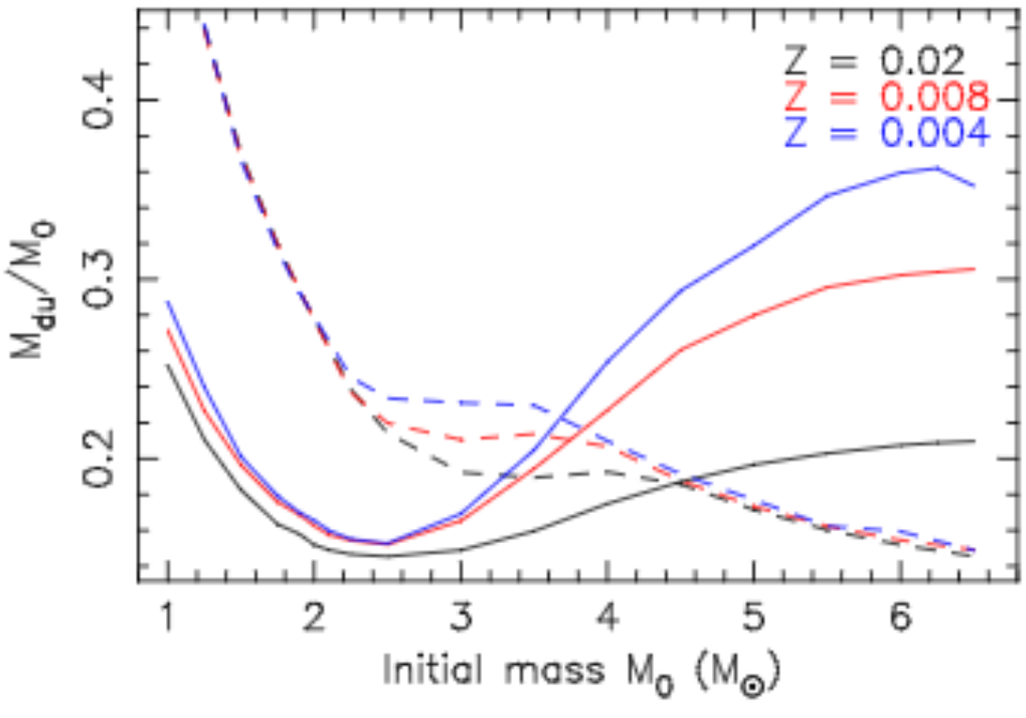
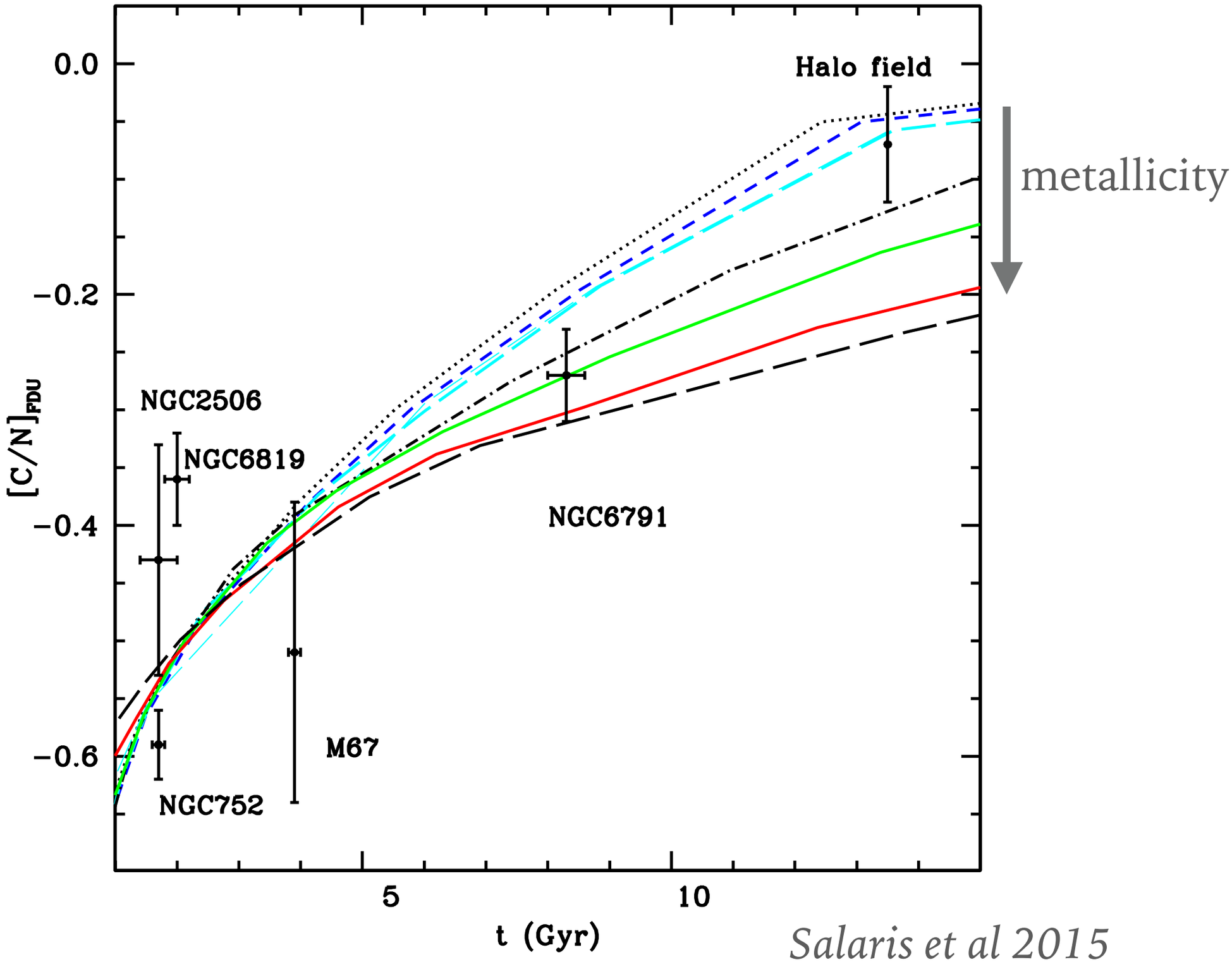


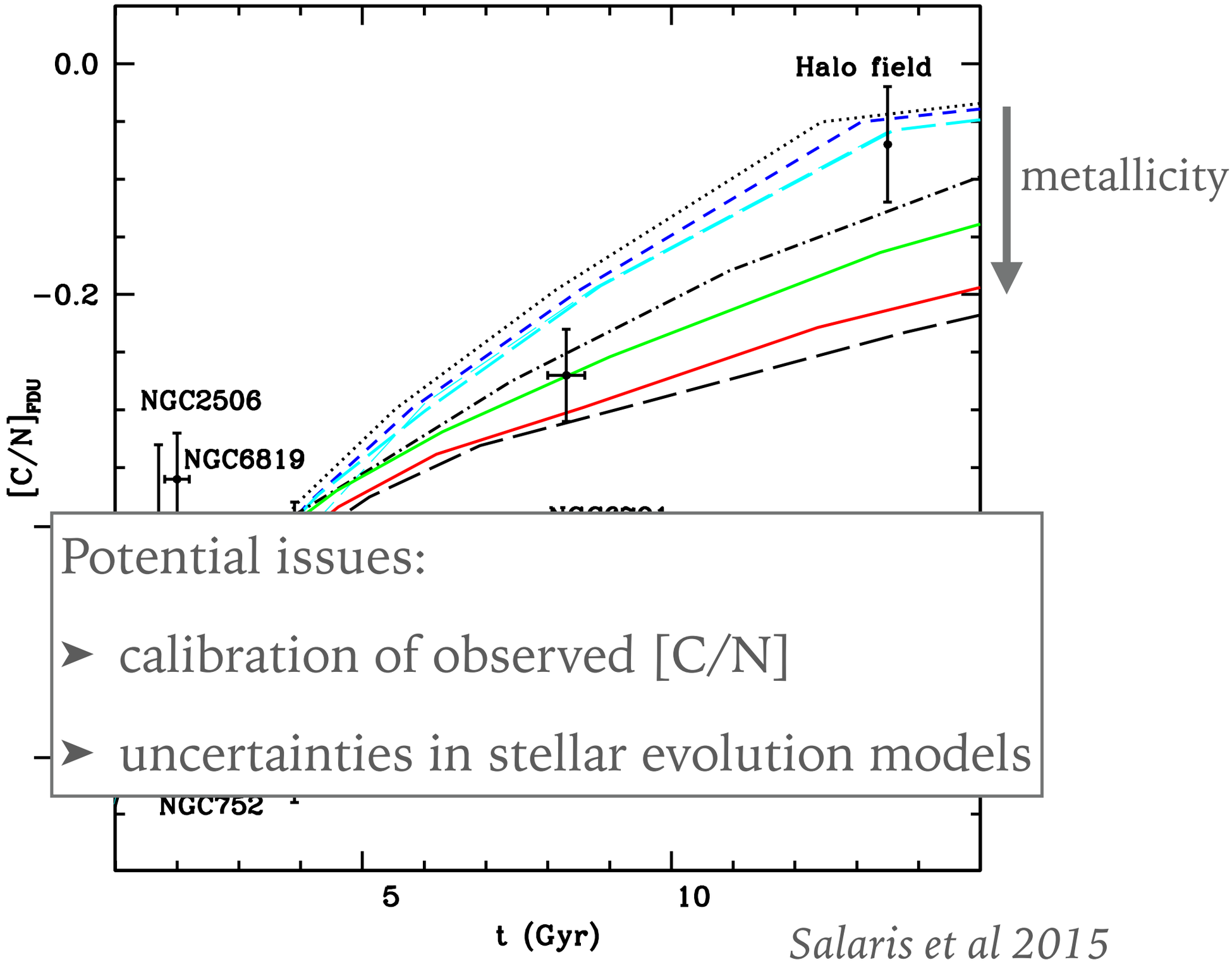
Karakas & Lattanzio 2014

[C/N] AS AN AGE INDICATOR



Salaris et al 2015

[C/N] AS AN AGE INDICATOR?

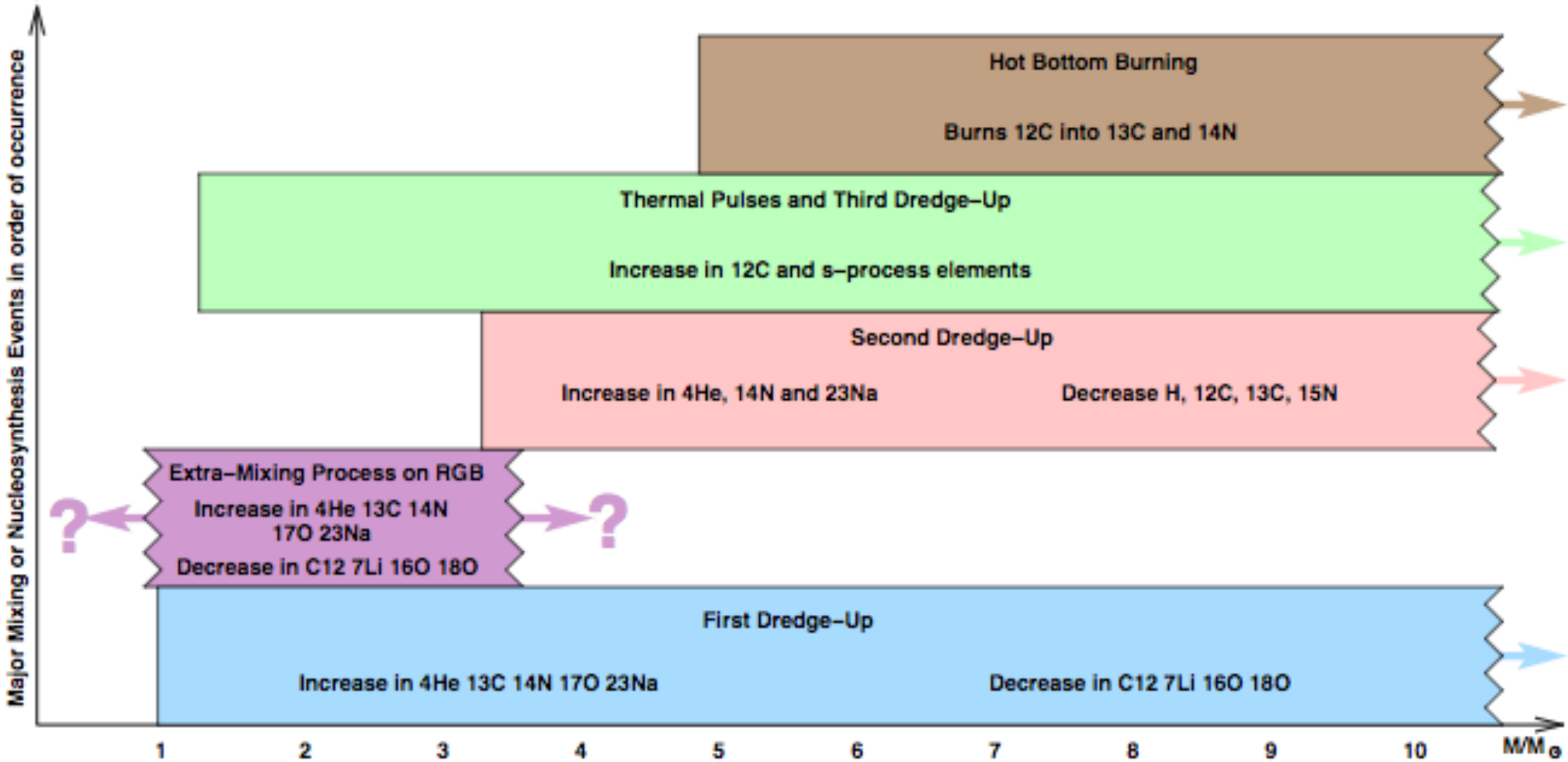


Potential issues:

- calibration of observed [C/N]
- uncertainties in stellar evolution models

Salaris et al 2015

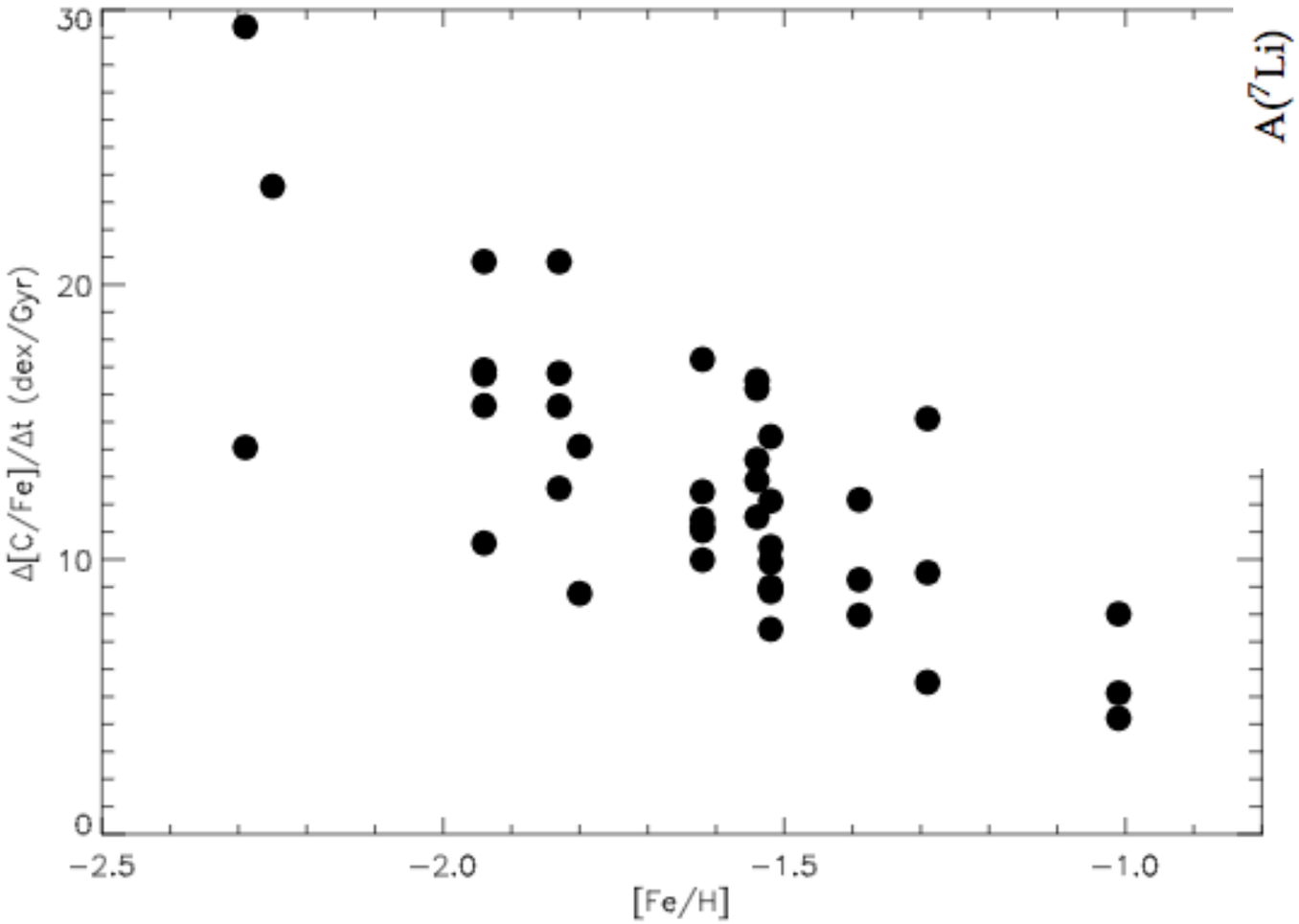
THE FIRST DREDGE-UP IS NOT THE ONLY MIXING PROCESS



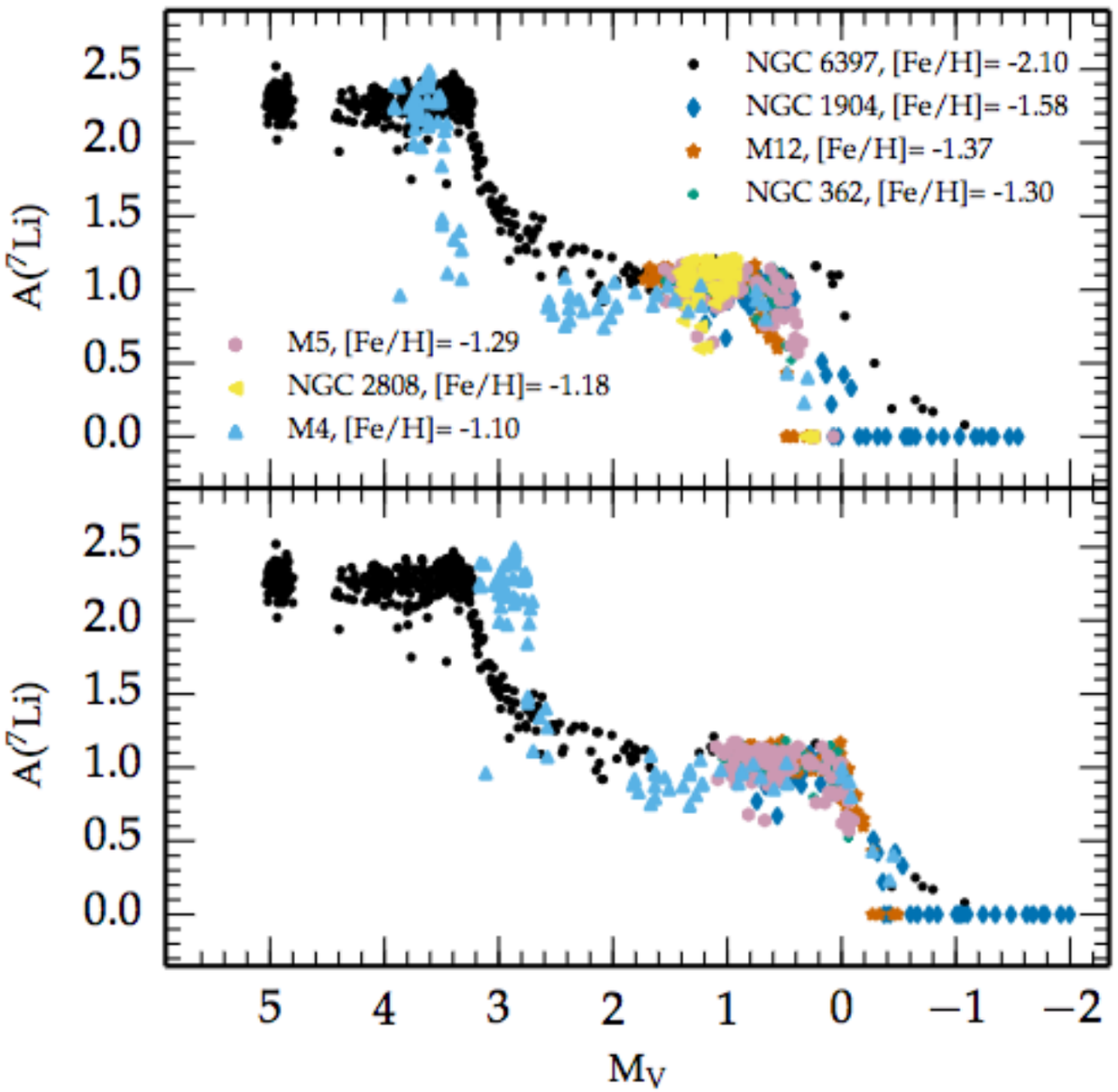
Karakas & Lattanzio 2014

EXTRA-MIXING ALONG THE RGB

Mixing efficiency increases for small masses and low [Fe/H]



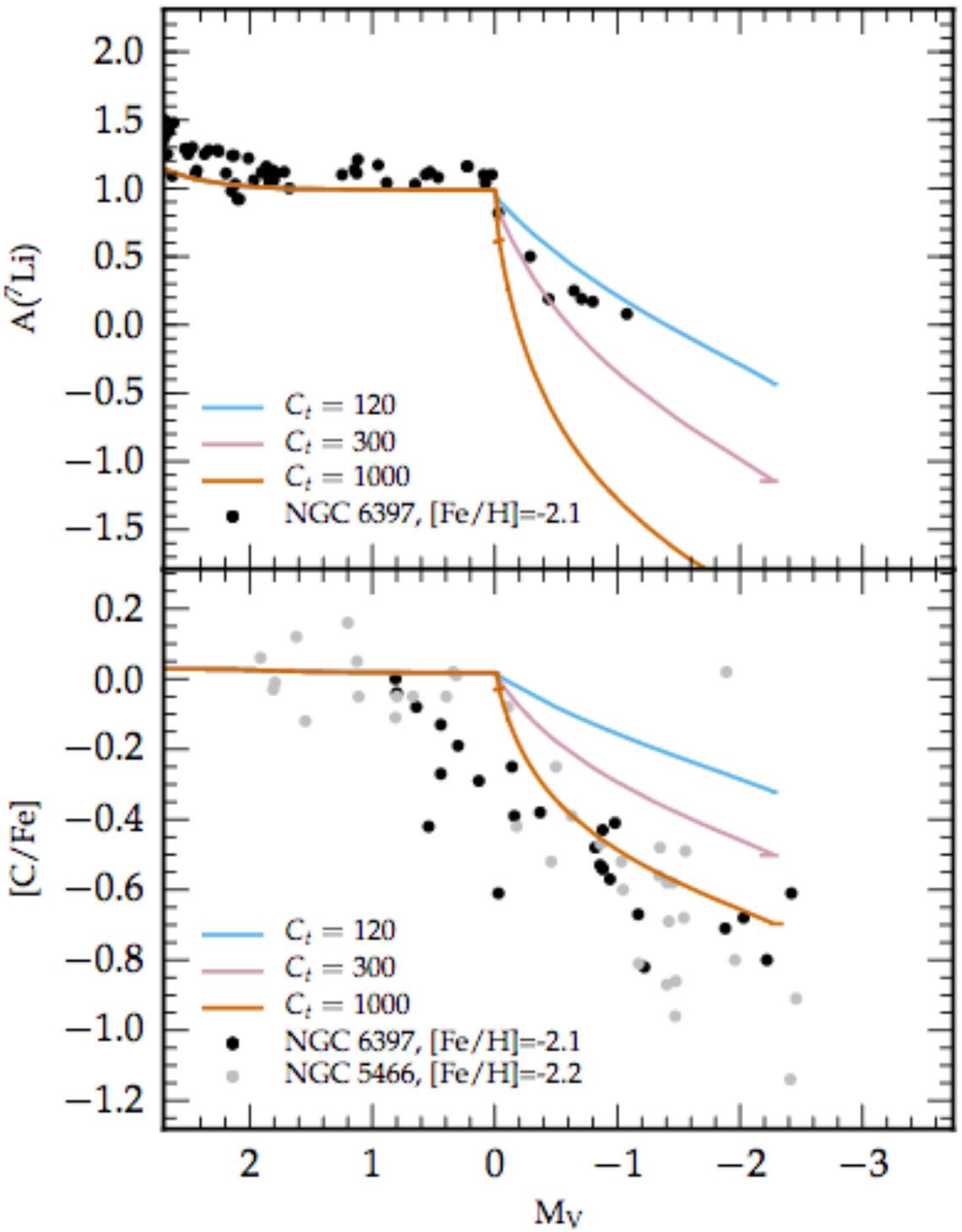
Martell et al 2008



Angelou et al 2015

THERMOHALINE MIXING

Karakas & Lattanzio 2014

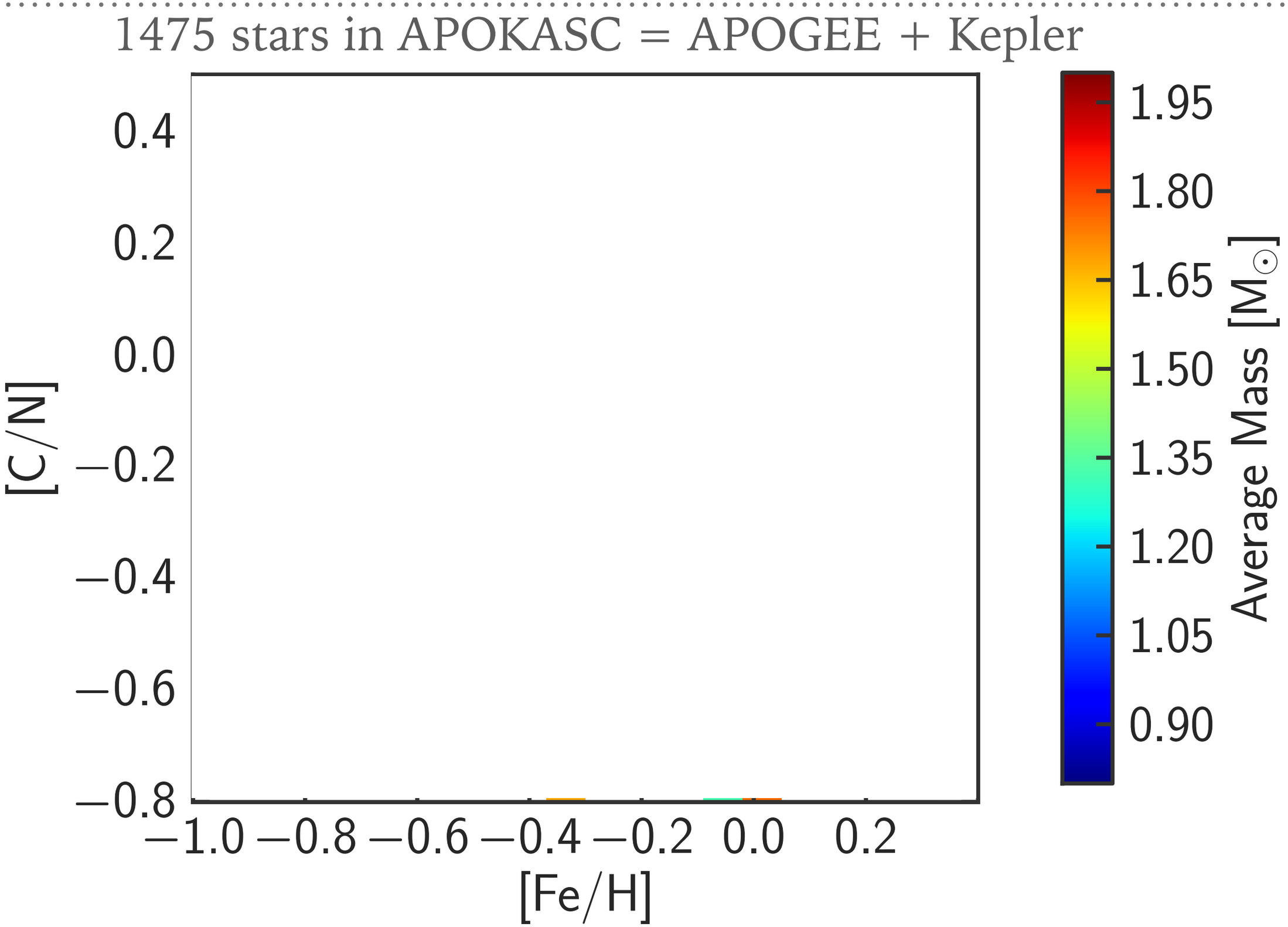


Angelou et al 2015

Favourite mechanism to date but uncertainties

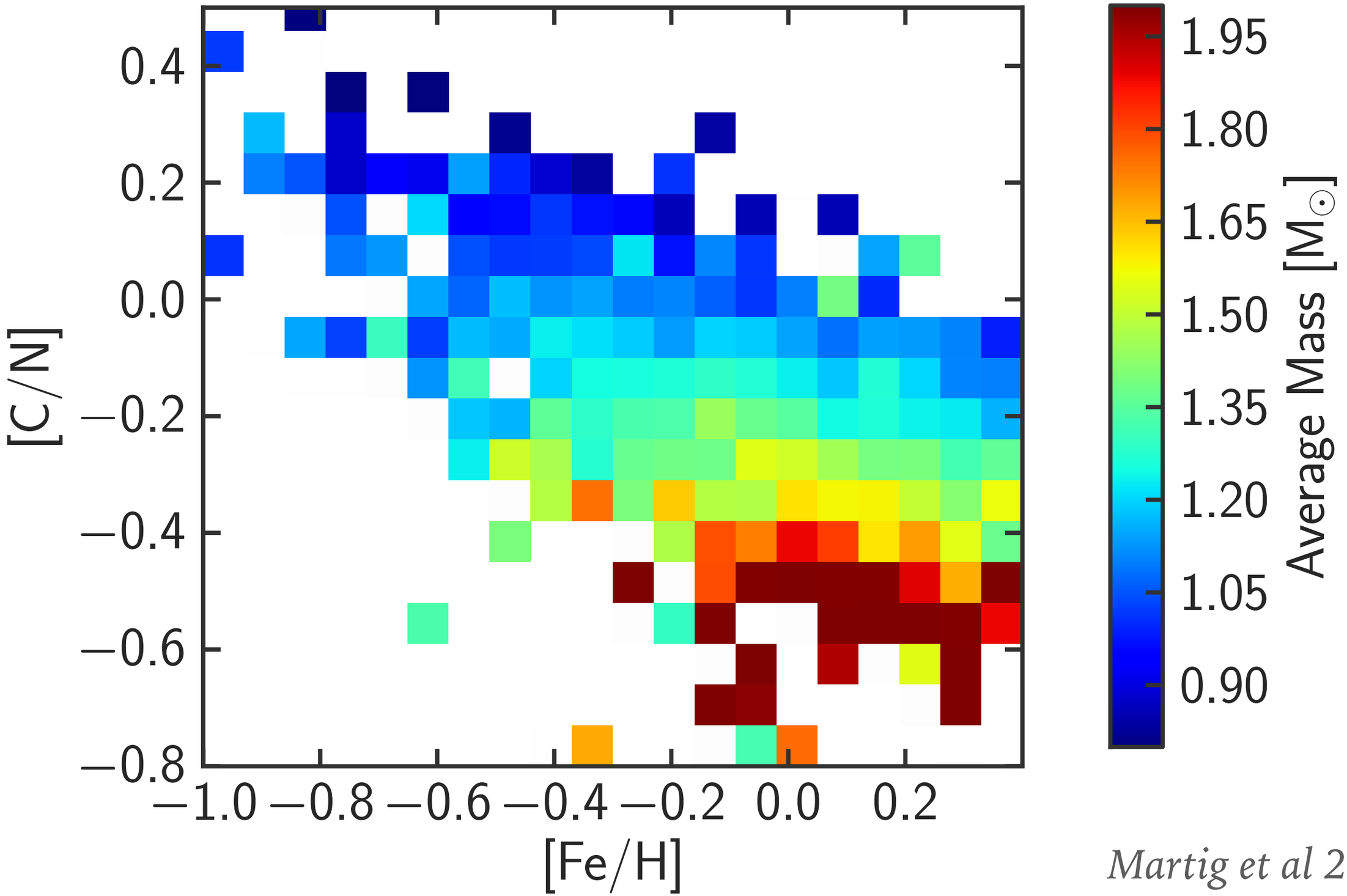
- ➤ upper mass limit
- ➤ value of mixing efficiency
- ➤ mismatch between stellar models and 3D simulations

OBSERVED CORRELATION BETWEEN [C/N] AND MASS



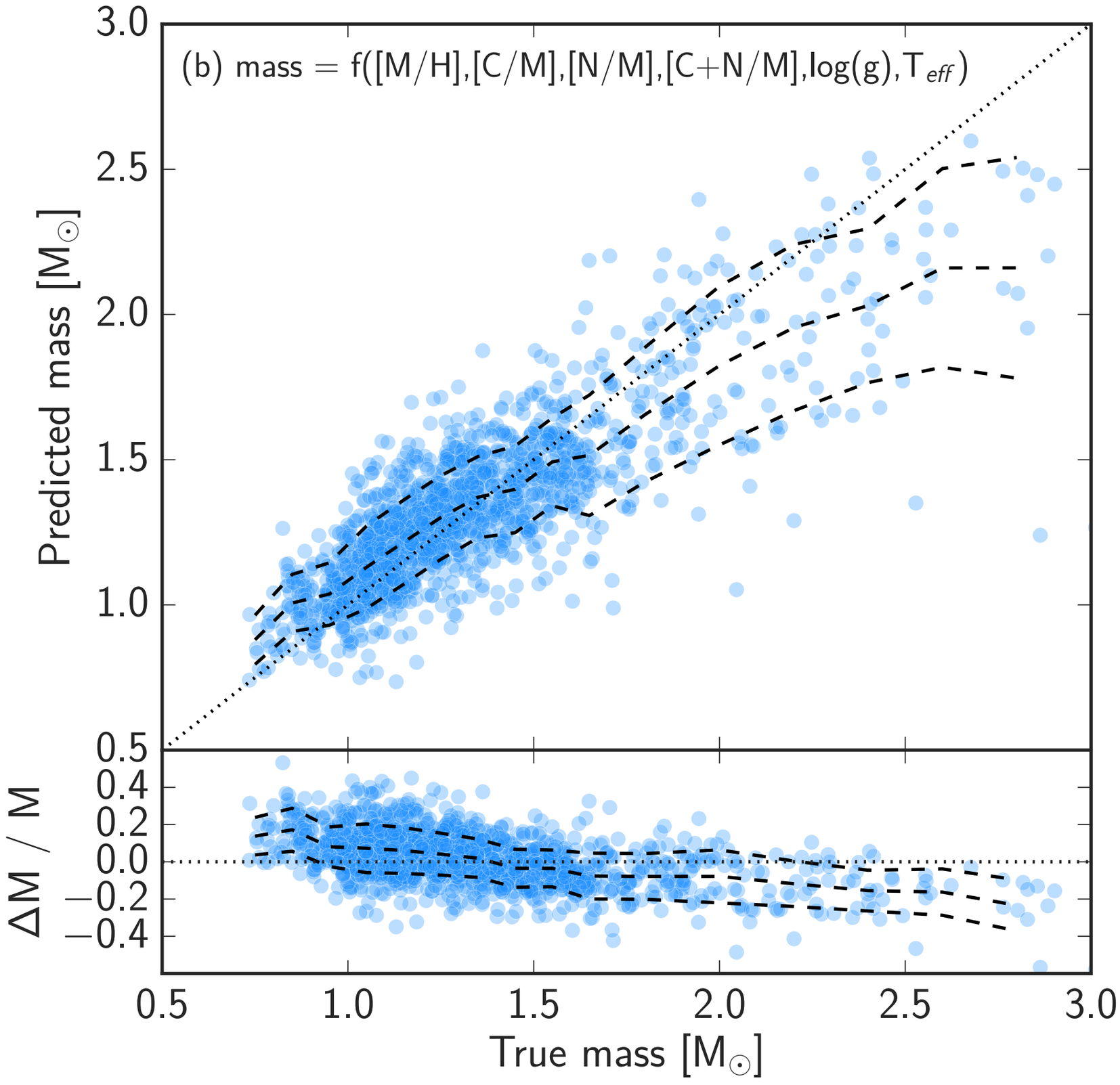
OBSERVED CORRELATION BETWEEN [C/N] AND MASS

1475 stars in APOKASC = APOGEE + Kepler



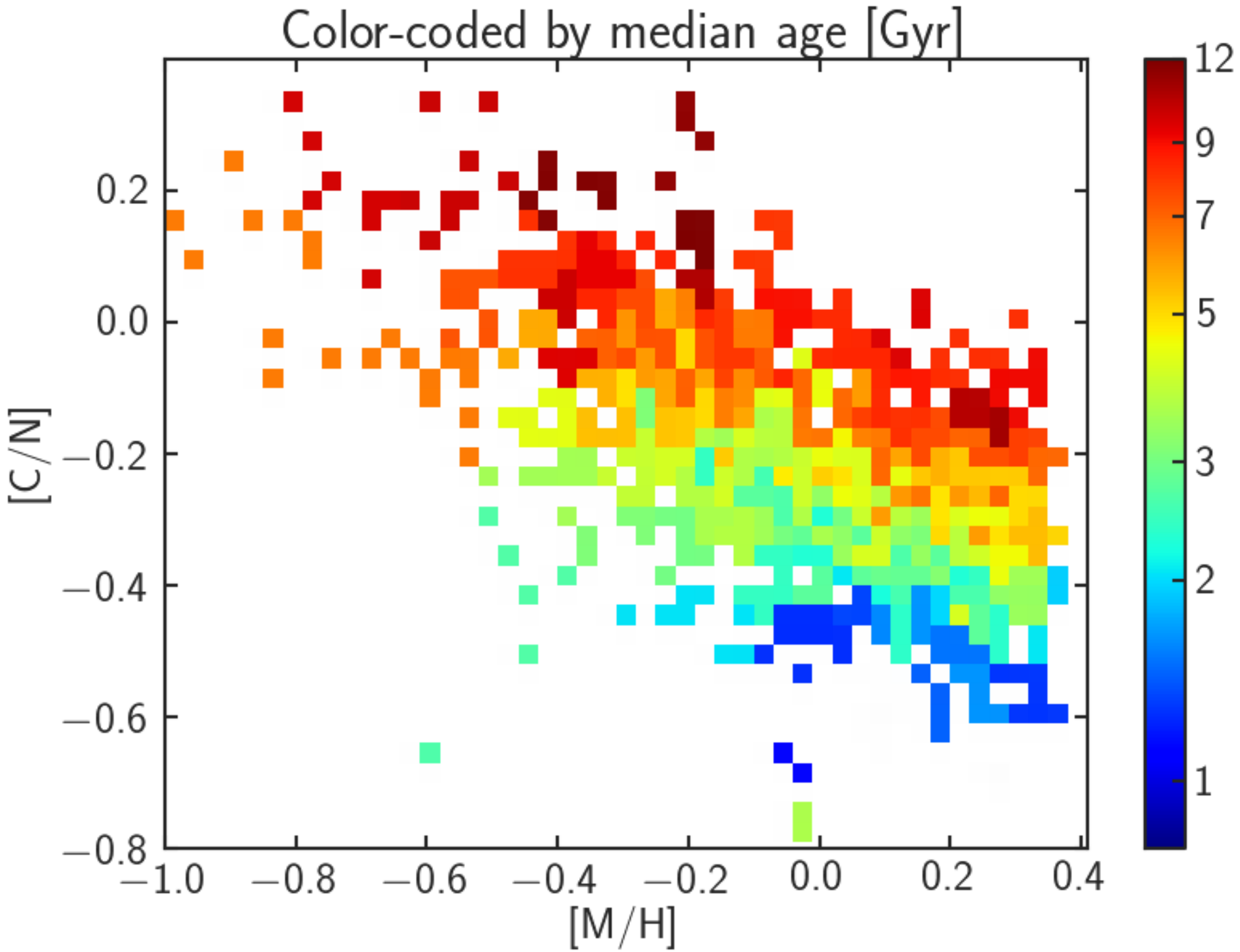
Martig et al 2016

EMPIRICAL MODEL FOR MASS AS A FUNCTION OF SPECTROSCOPIC LABELS

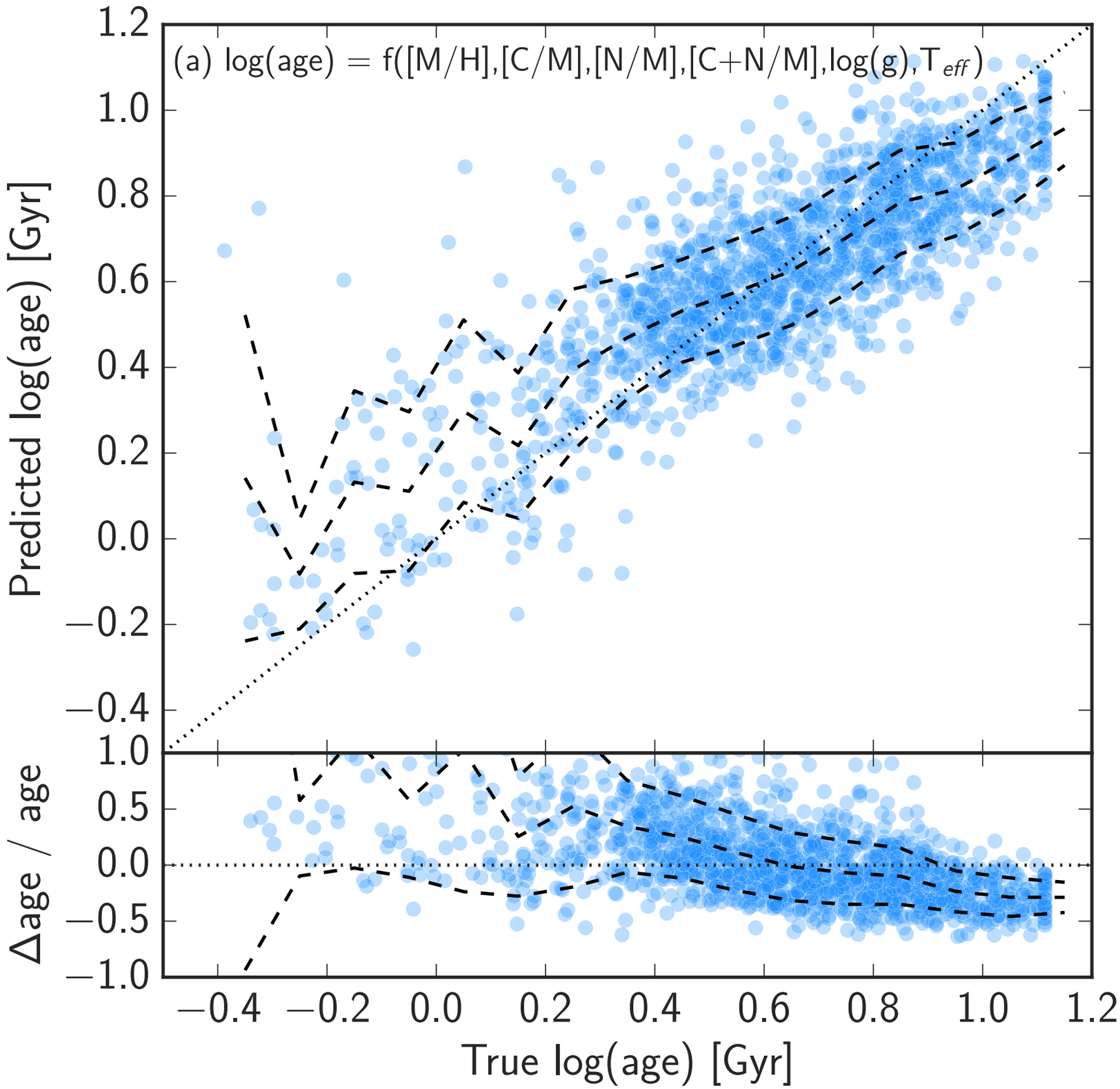


Training set: 1475 giants in APOKASC (APOGEE+Kepler)

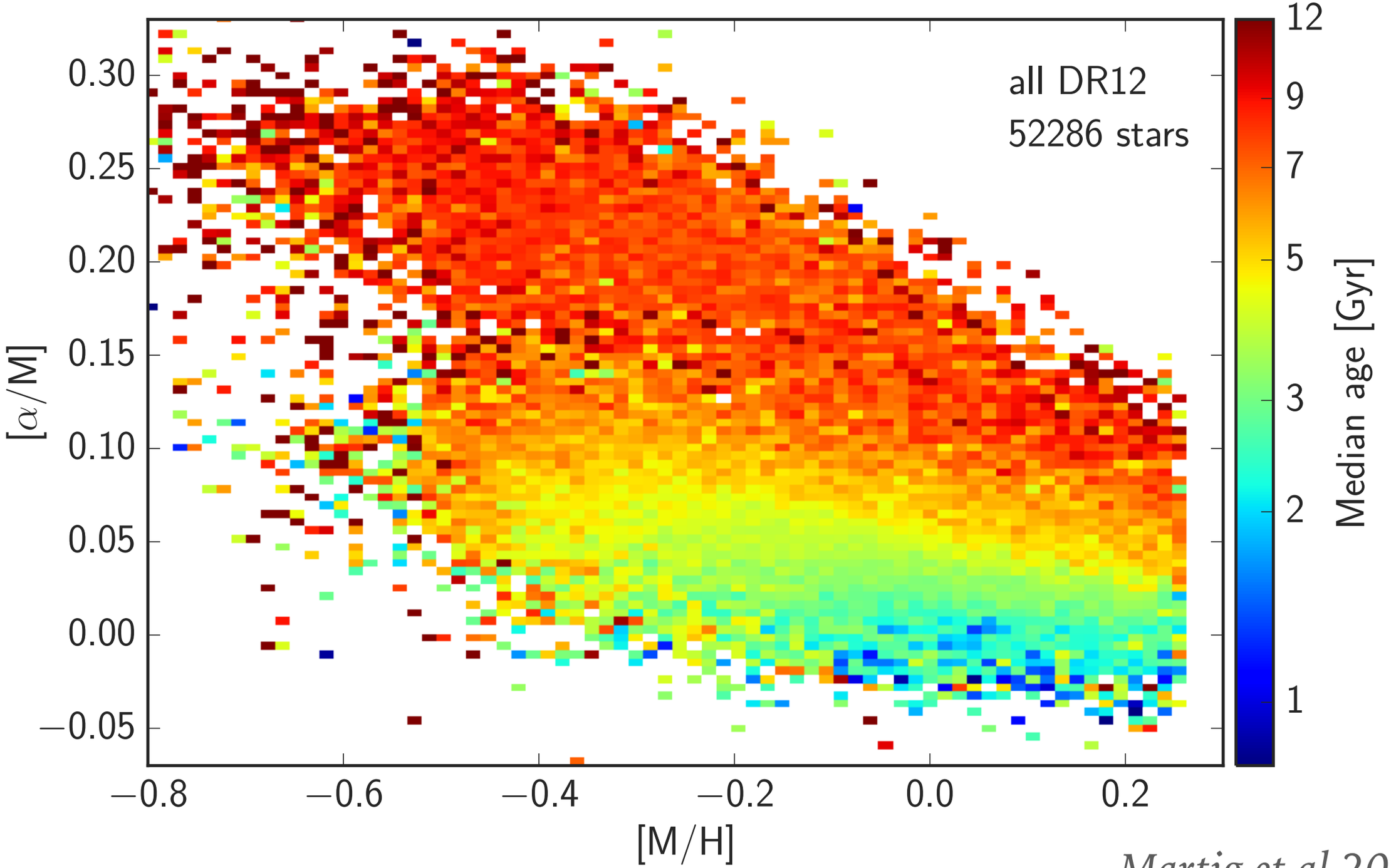
MASS AND AGE ARE CORRELATED



WE ALSO BUILD A MODEL FOR AGE

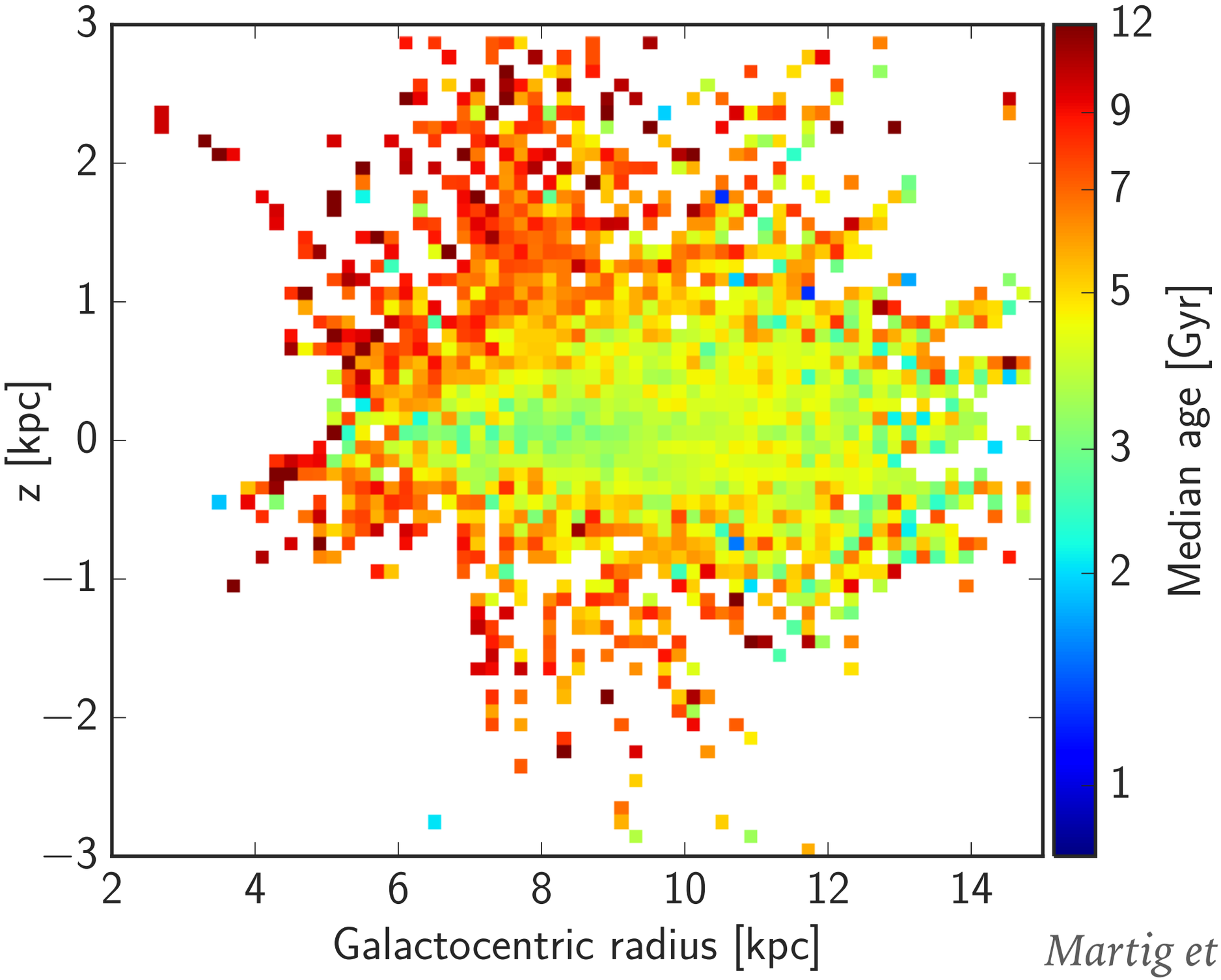


MASS/AGE TABLES TRANSFERRED TO APOGEE DR12 STARS



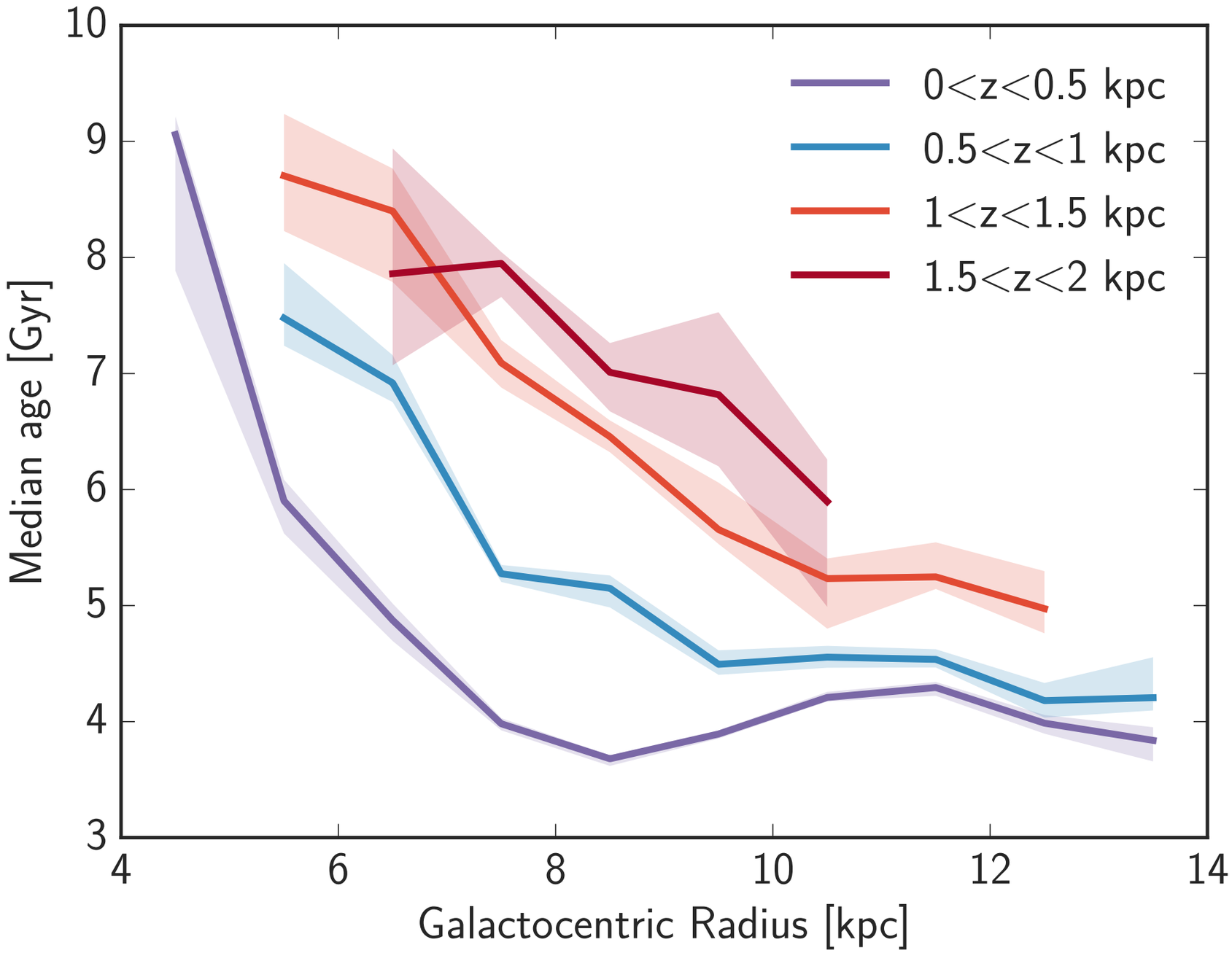
Martig et al 2016

AGES FOR RED CLUMP STARS



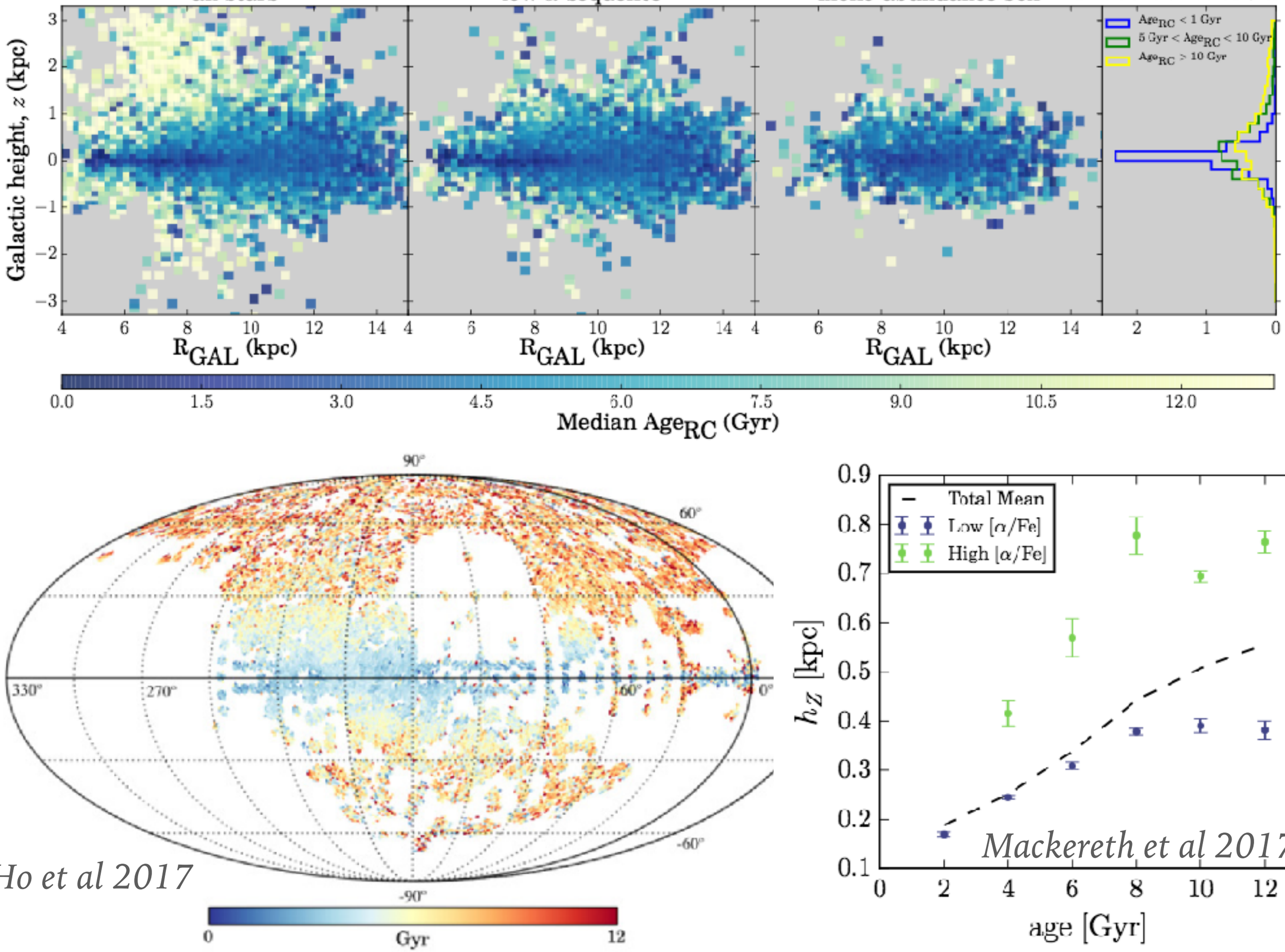
Martig et al 2016

RADIAL AGE GRADIENT AT A GIVEN HEIGHT ABOVE THE PLANE



Martig et al 2016b

Ness et al 2016



Ho et al 2017

Mackereth et al 2017

WHERE DO WE GO NEXT?

- Improve age determinations: new APOKASC sample, upcoming K2 data, Gaia + spectroscopic surveys

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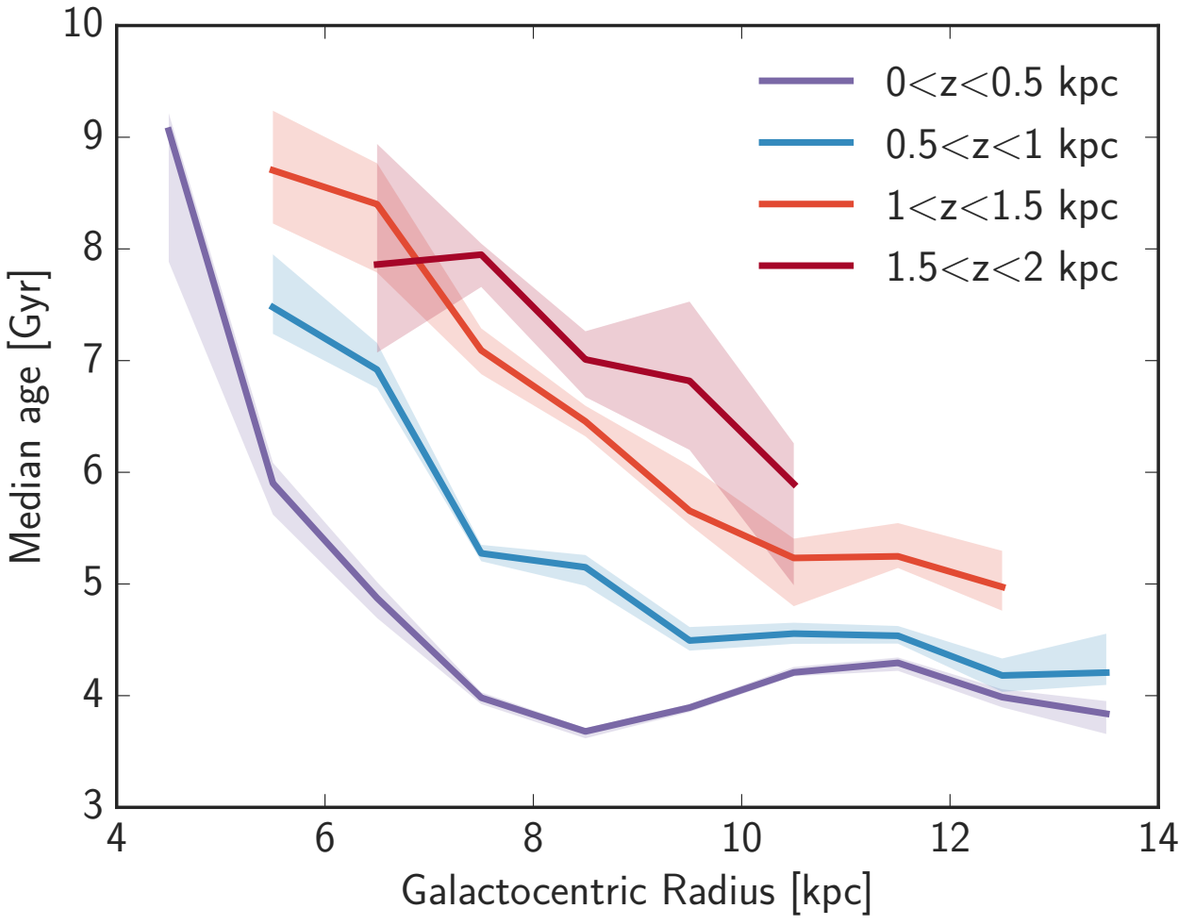

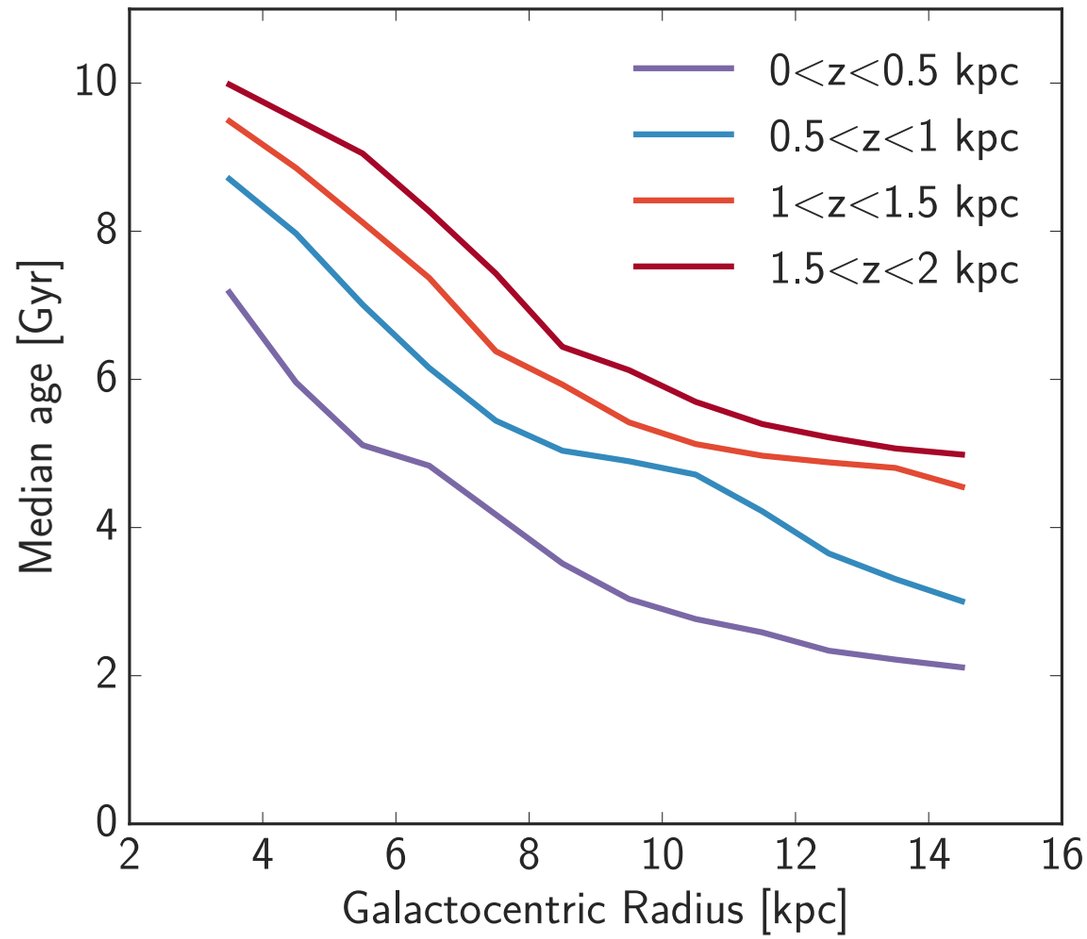

Minchev, Martig et al 2015

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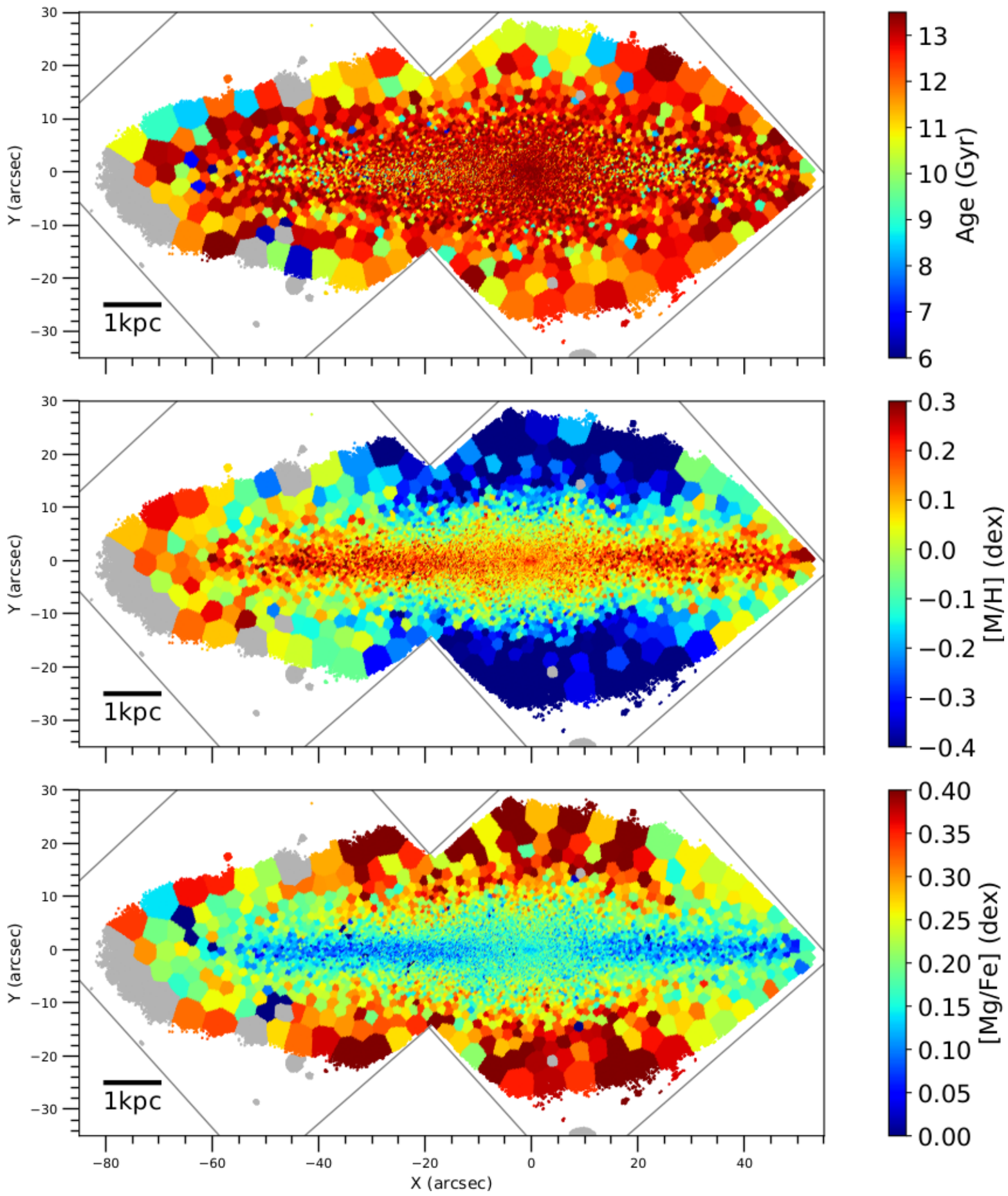
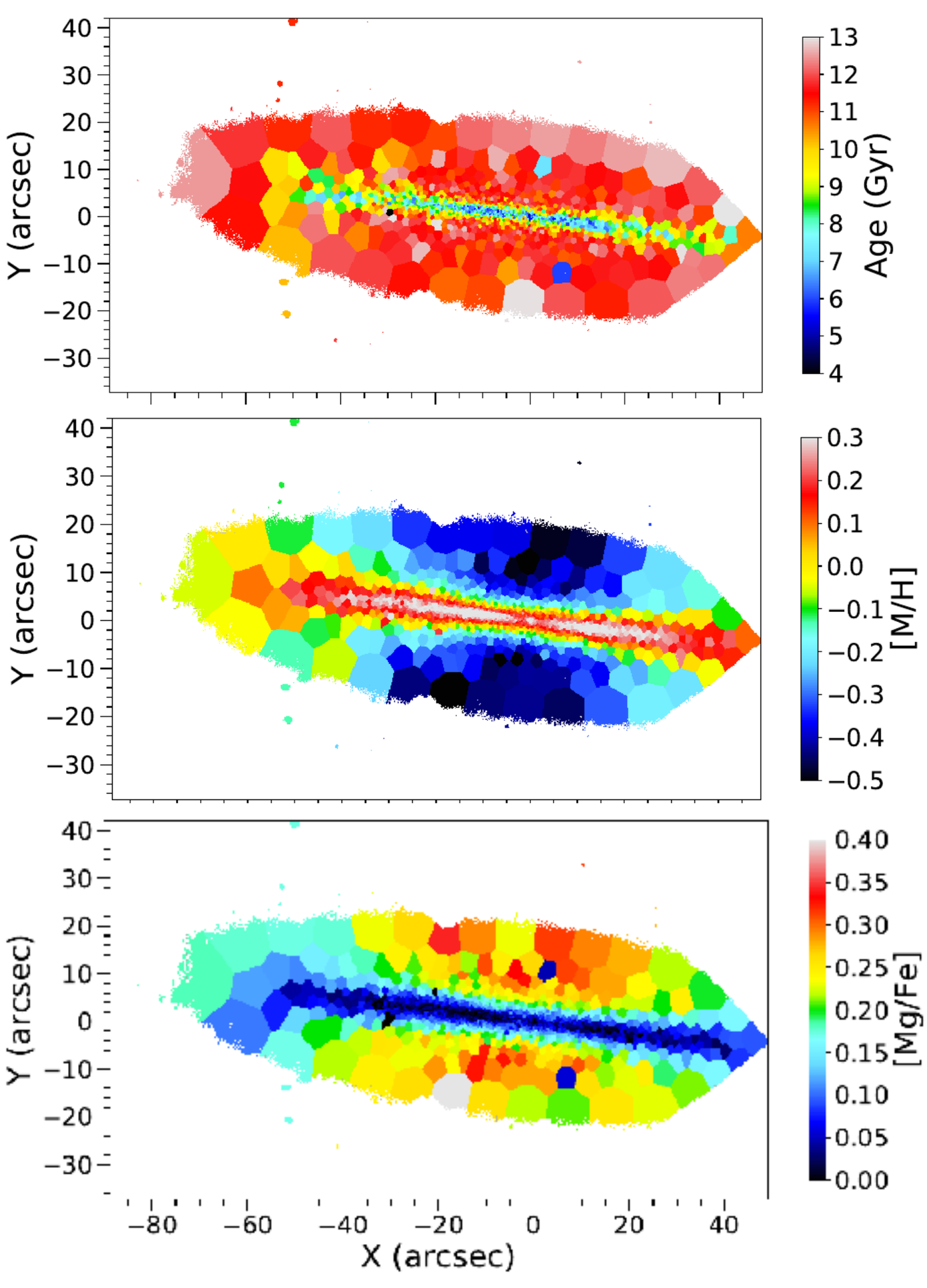
MUSE data for nearby edge-on disk galaxies (2 from own programs + 3 from F3D survey)

Pinna et al submitted + in prep, Martig et al in prep


Y (arcsec)
1kpc
Age (Gyr)
[M/H] (dex)
[Mg/Fe] (dex)
X (arcsec)


Y (arcsec)
40
30
20
10
0
−10
−20
−30
Age (Gyr)
13
12
11
10
9
8
7
6
5
4
[M/H]
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
−0.5
[Mg/Fe]
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
−80
−60
−40
−20
0
20
40
X (arcsec)

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