STELLAR HELIUM:

IMPACT ON IMF AND HOW TO MEASURE IT

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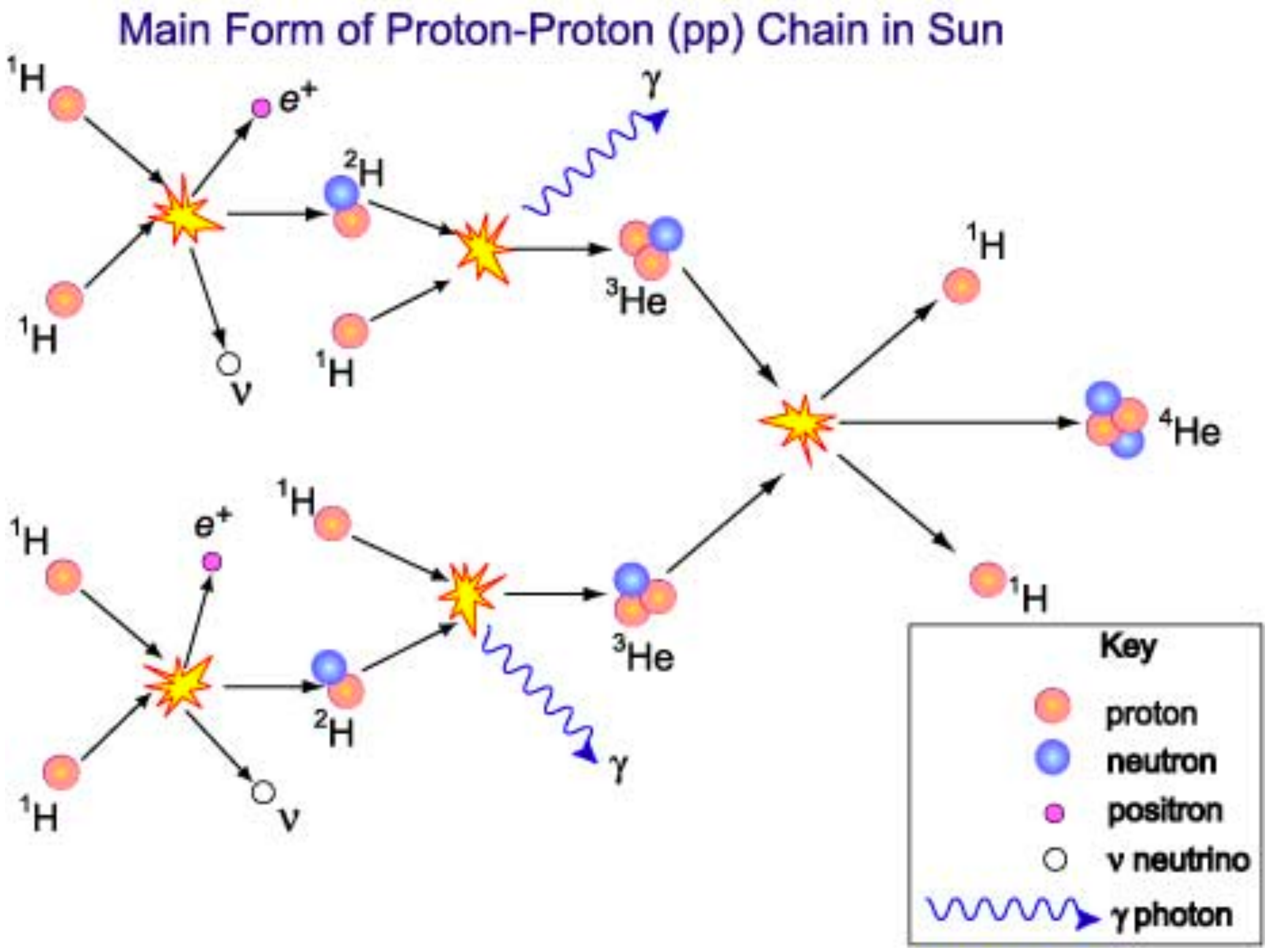
STELLAR HELIUM:

IMPACT ON IMF AND HOW TO MEASURE IT

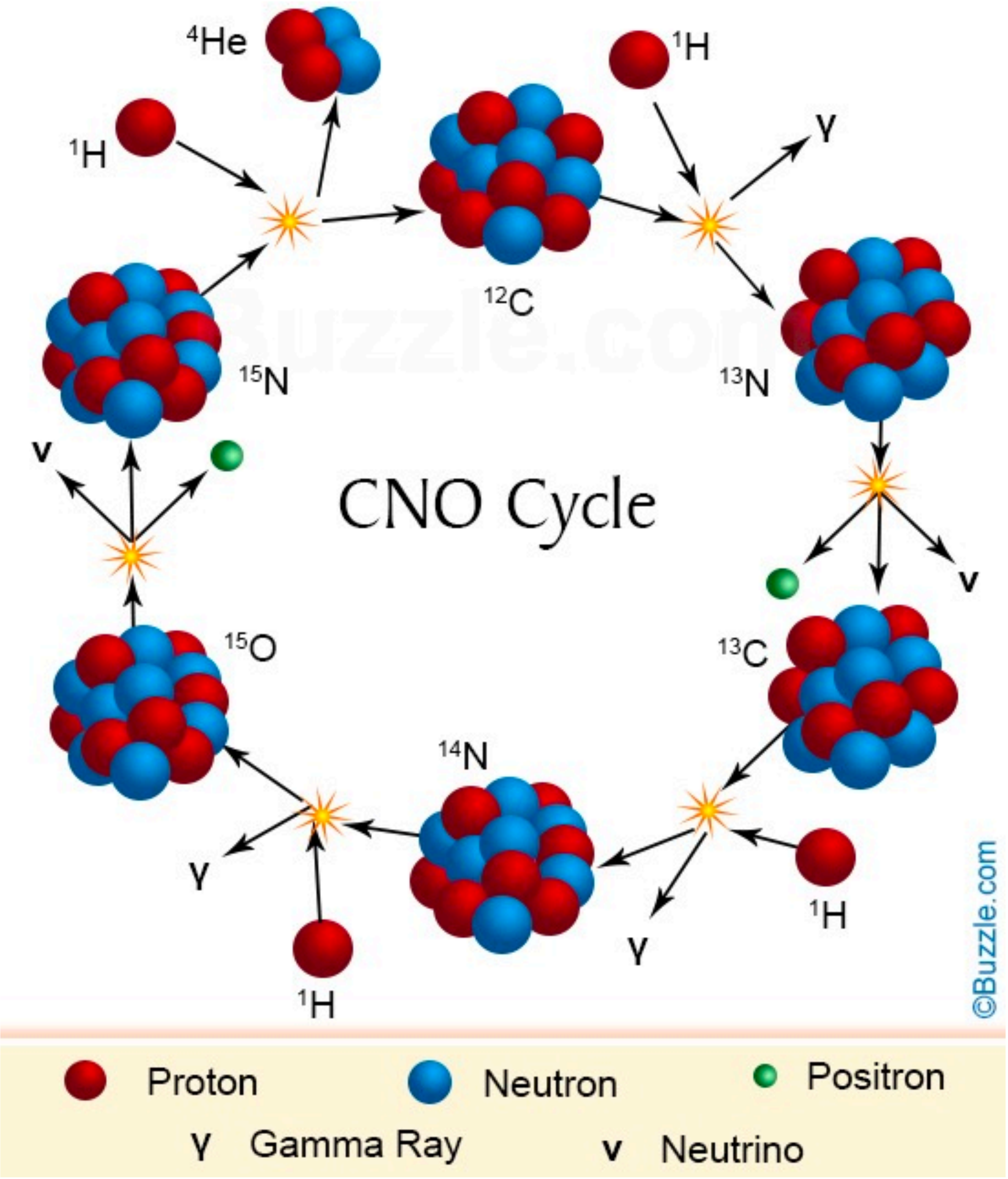
- What is stellar helium content
- Impact on IMF determinations
- How to measure it

What is stellar helium content

hydrogen fusion **$4\ ^1H \rightarrow\ ^4He$ + energy**



P-P chain



CNO cycle

What is stellar helium content

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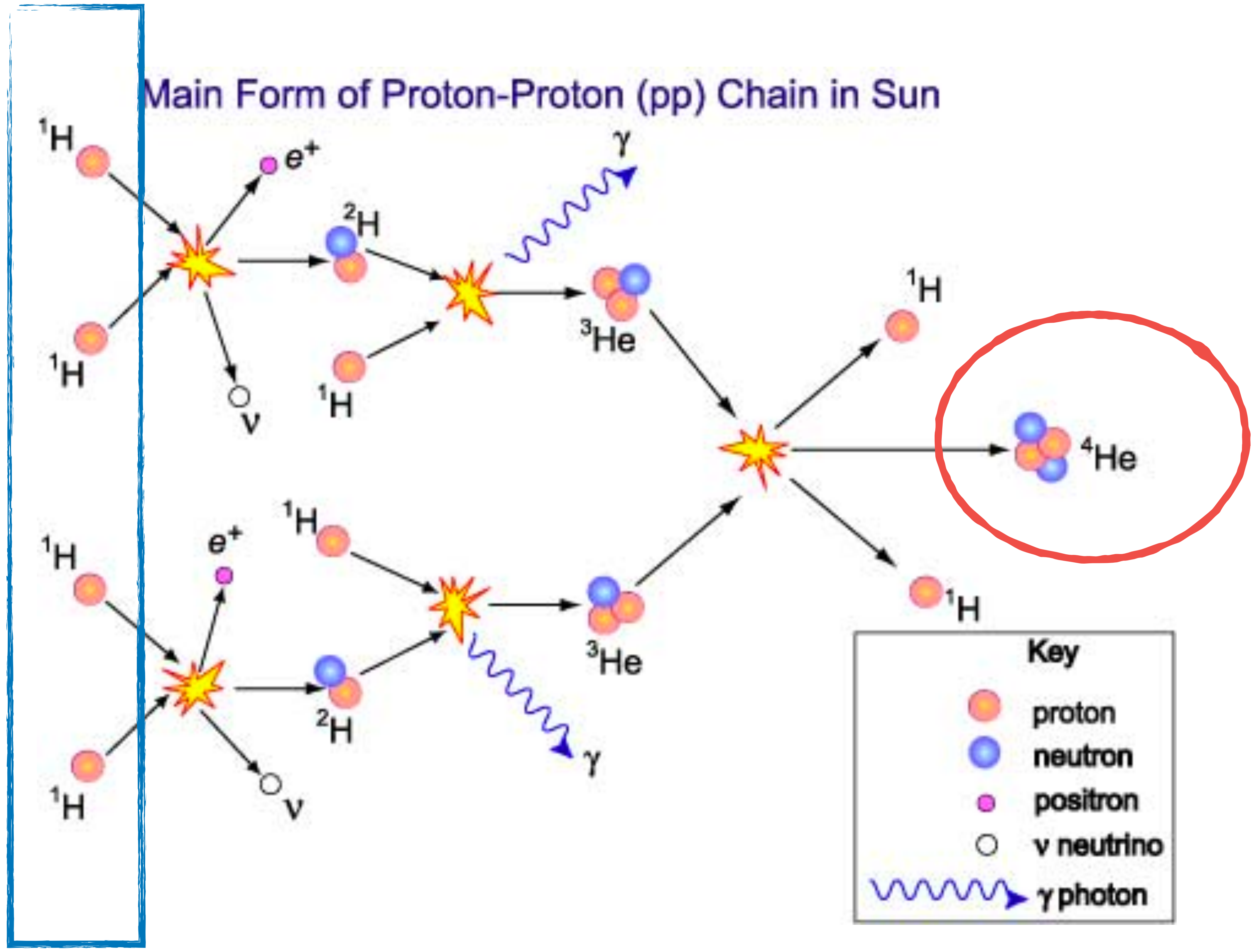

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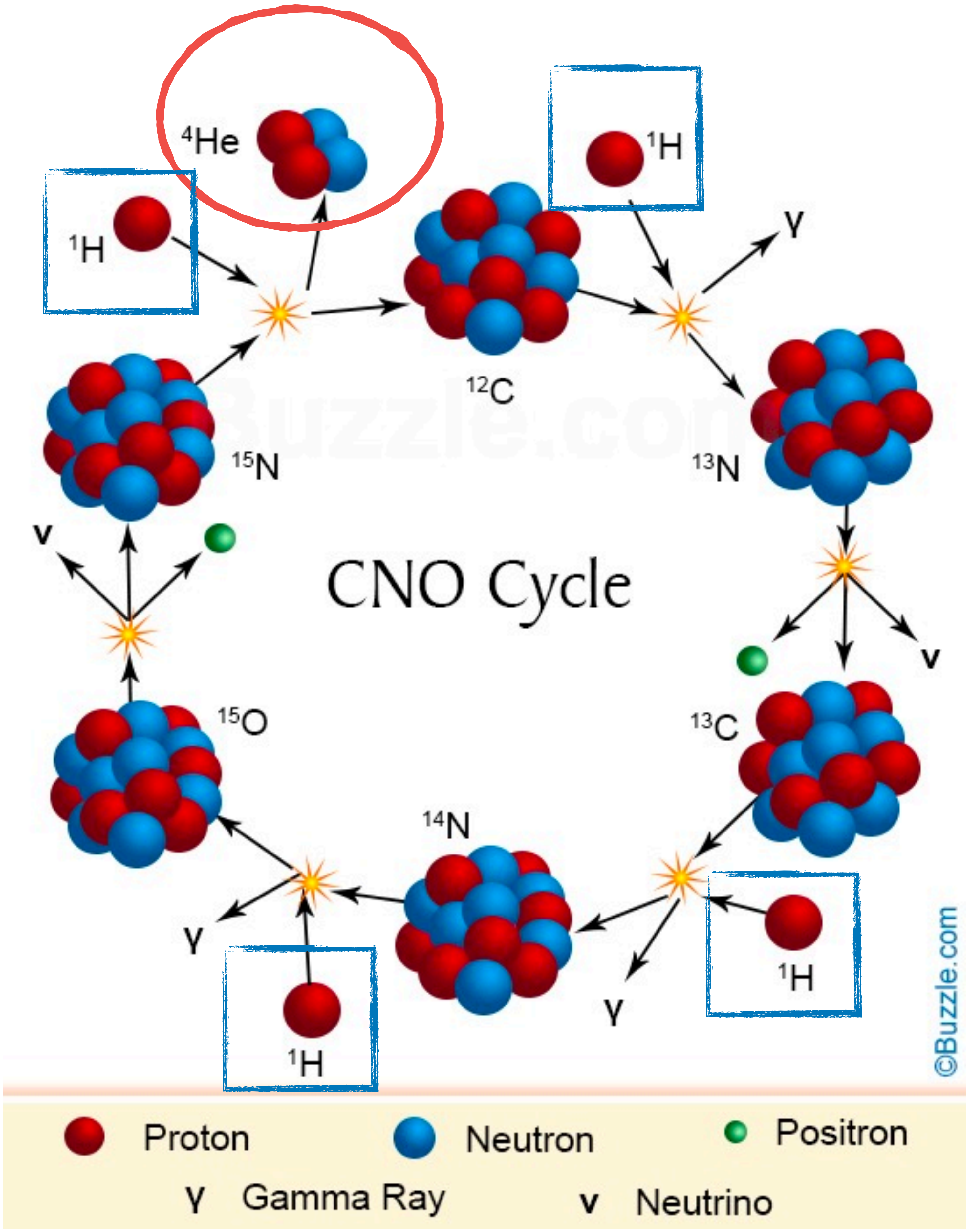


CNO cycle

What is stellar helium content

Mass fraction

$$\underset{\text{hydrogen}}{X} + \underset{\text{helium}}{Y} + \underset{\text{metal}}{Z} = 1$$

What is stellar helium content

Mass fraction

$$X + Y + Z = 1$$

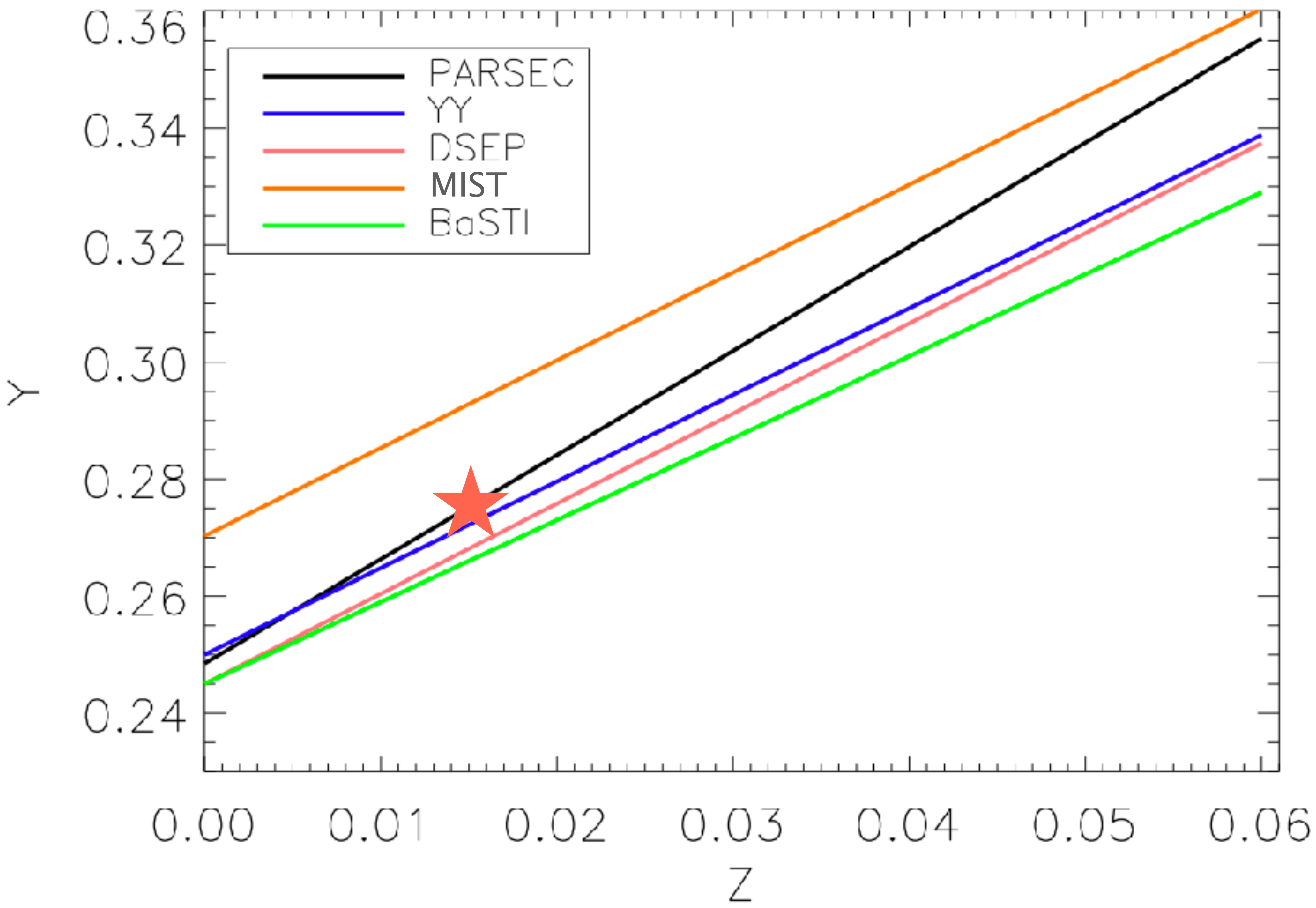
hydrogen helium metal

Solar value in PARSEC:

X= 0.7363, Y=0.2485, Z= 0.01524

What is the helium content in other stars?

What is stellar helium content



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What is the helium content in other stars?

The default helium to metal enrichment law: $Y = Y_P + \frac{\Delta Y}{\Delta Z} Z$

What is stellar helium content

The default helium to metal enrichment law:

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What is the helium enrichment
What is the helium scatter
at different metallicity?

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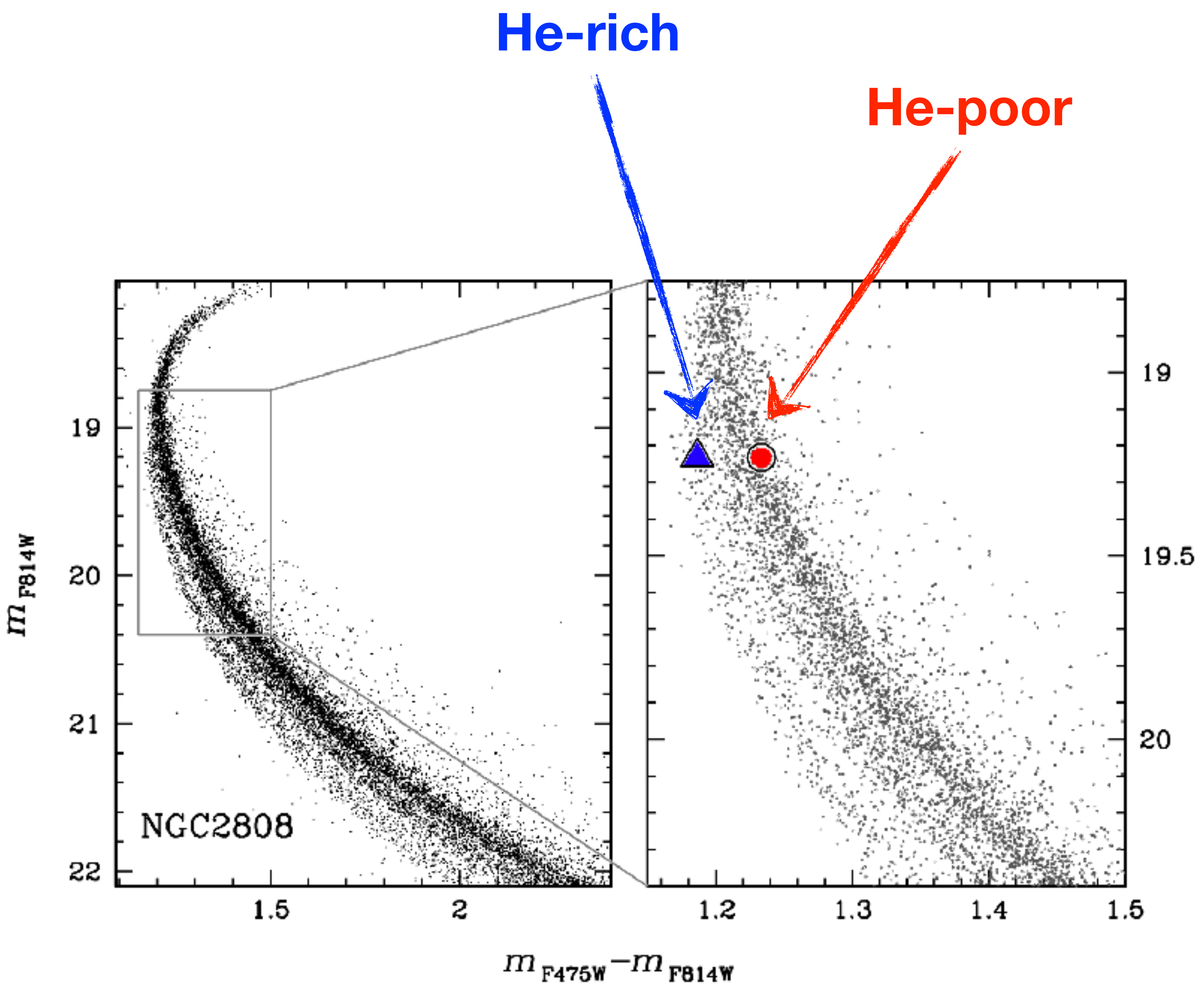


Bragaglia et al., 2010a

example in MW

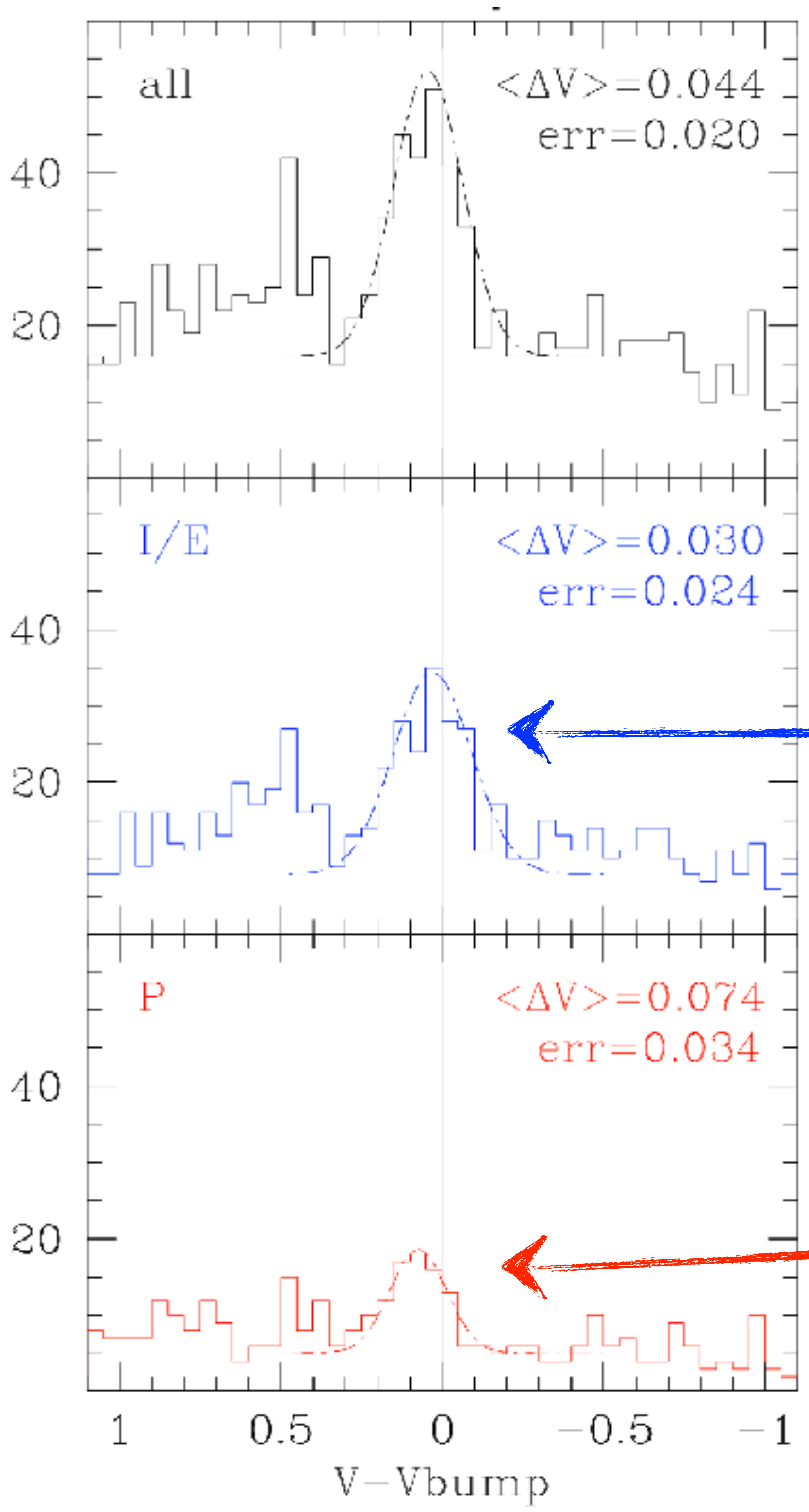
Globular Clusters

Very similar metallicity, different He contents

He-rich population is hotter

Usually associate with the 2nd pop of GC
N-rich, Na-rich

What is stellar helium content



Bragaglia et al., 2010b

He-rich

He-poor

What is the helium enrichment
What is the helium scatter
at different metallicity?

example in MW

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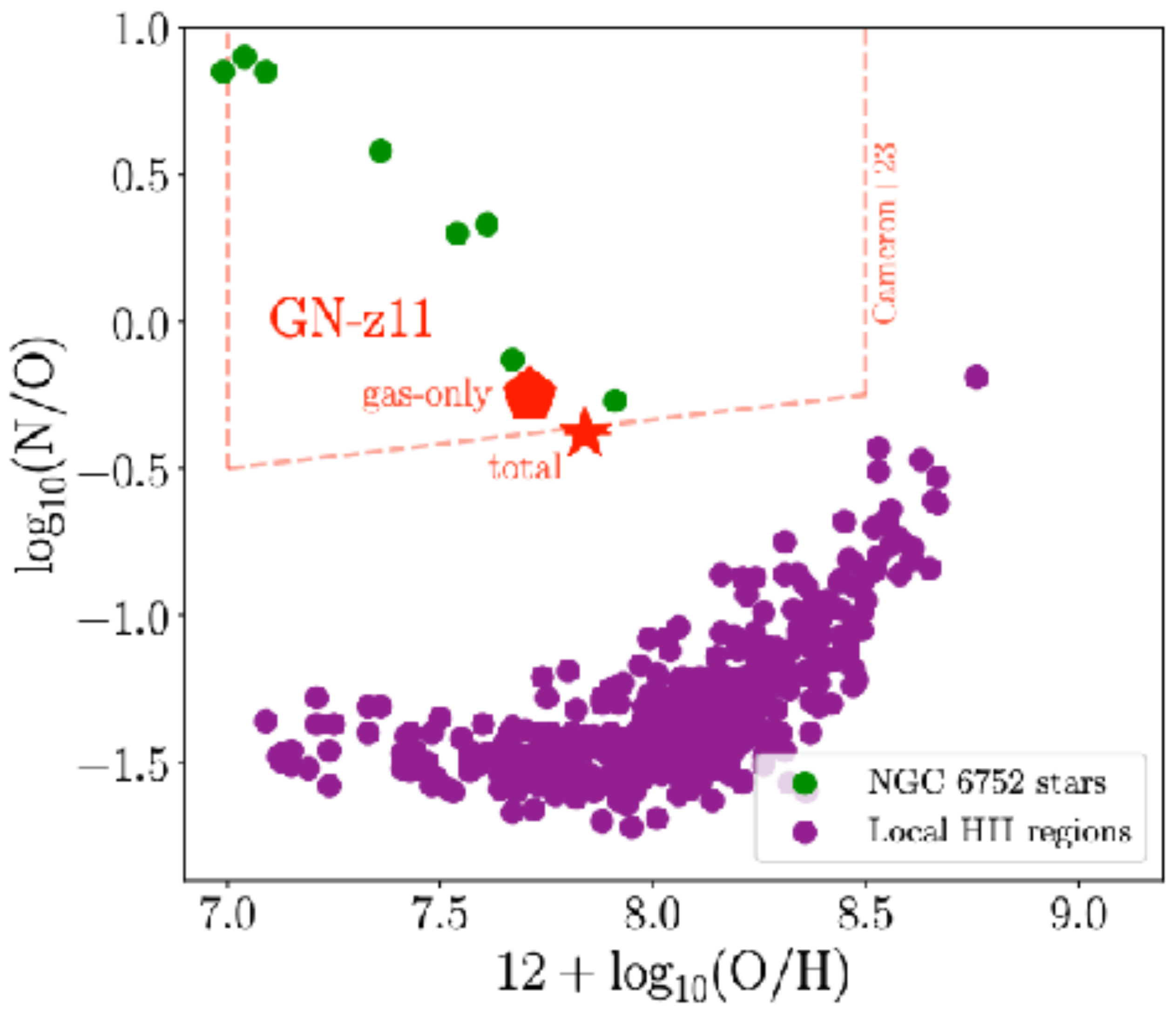
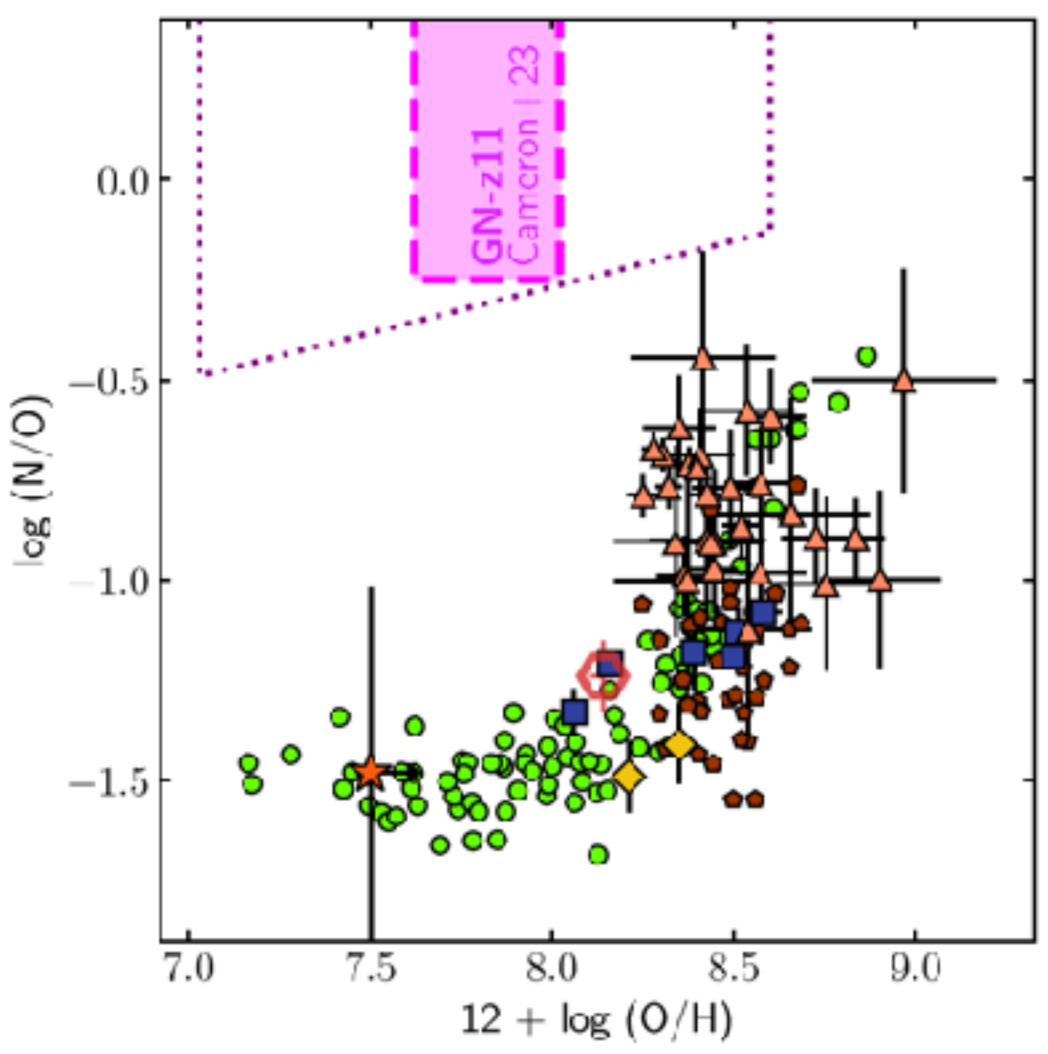


Senchyna, et al., 2023



Cameron, et al., 2023

example in high redshift

GN-z11

N-rich, compact z = 10.6 galaxy

very similar to the 2nd pop of GC

What is stellar helium content

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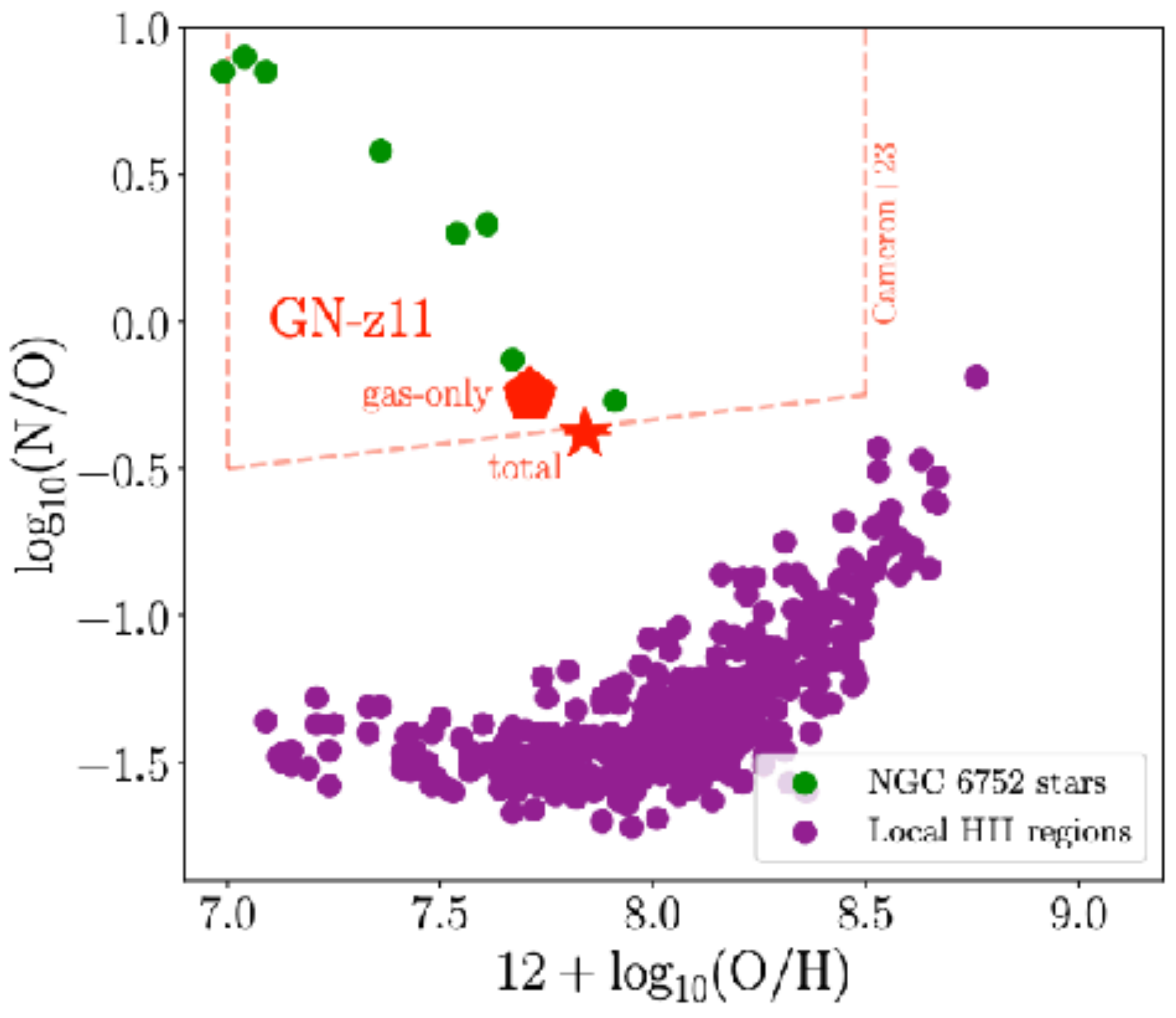

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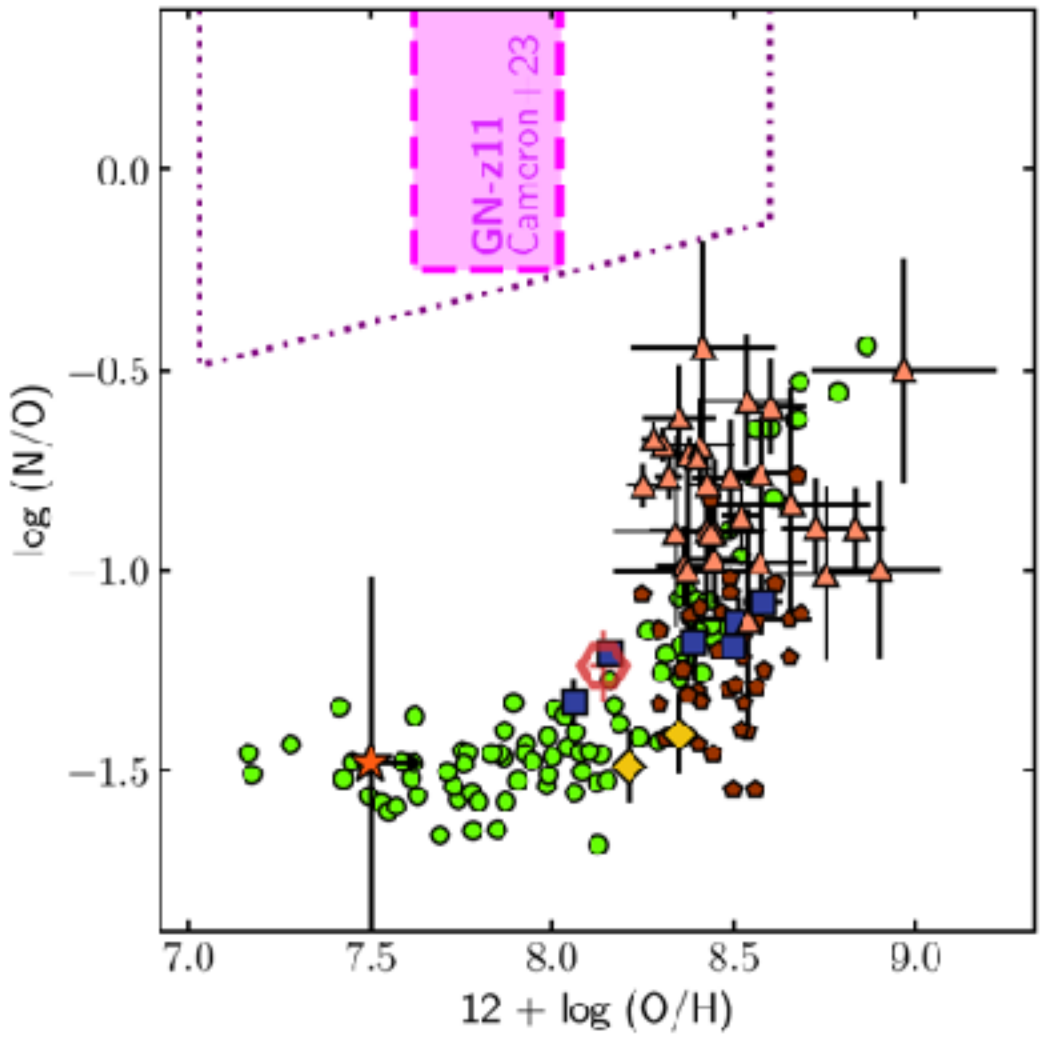

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How to make such a N-rich galaxy?

D'Antona et al., 2023: massive (4–7.5 M⊙) AGBs

Charbonnel et al., 2023: Super massive stars of ~10000 M⊙

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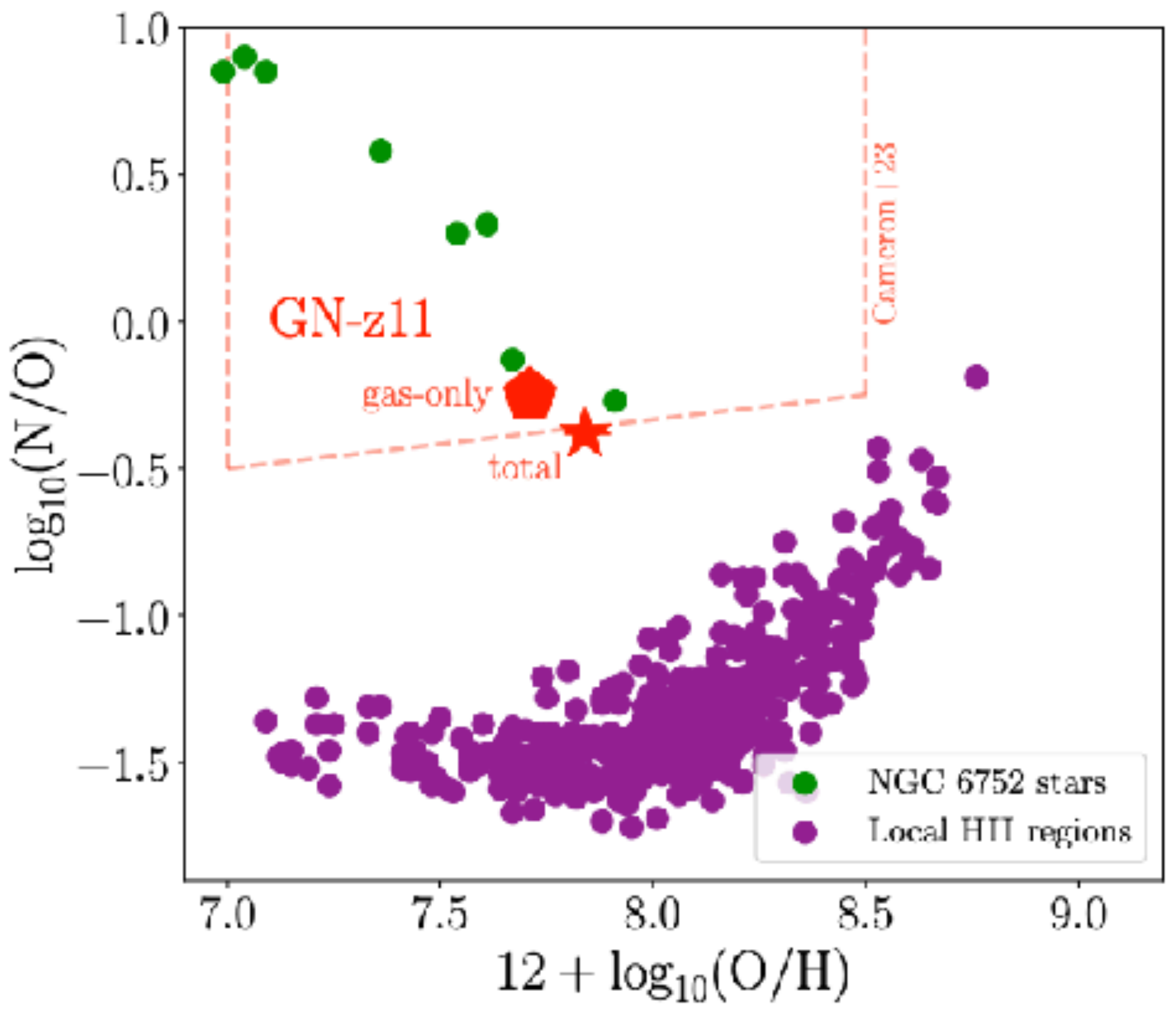

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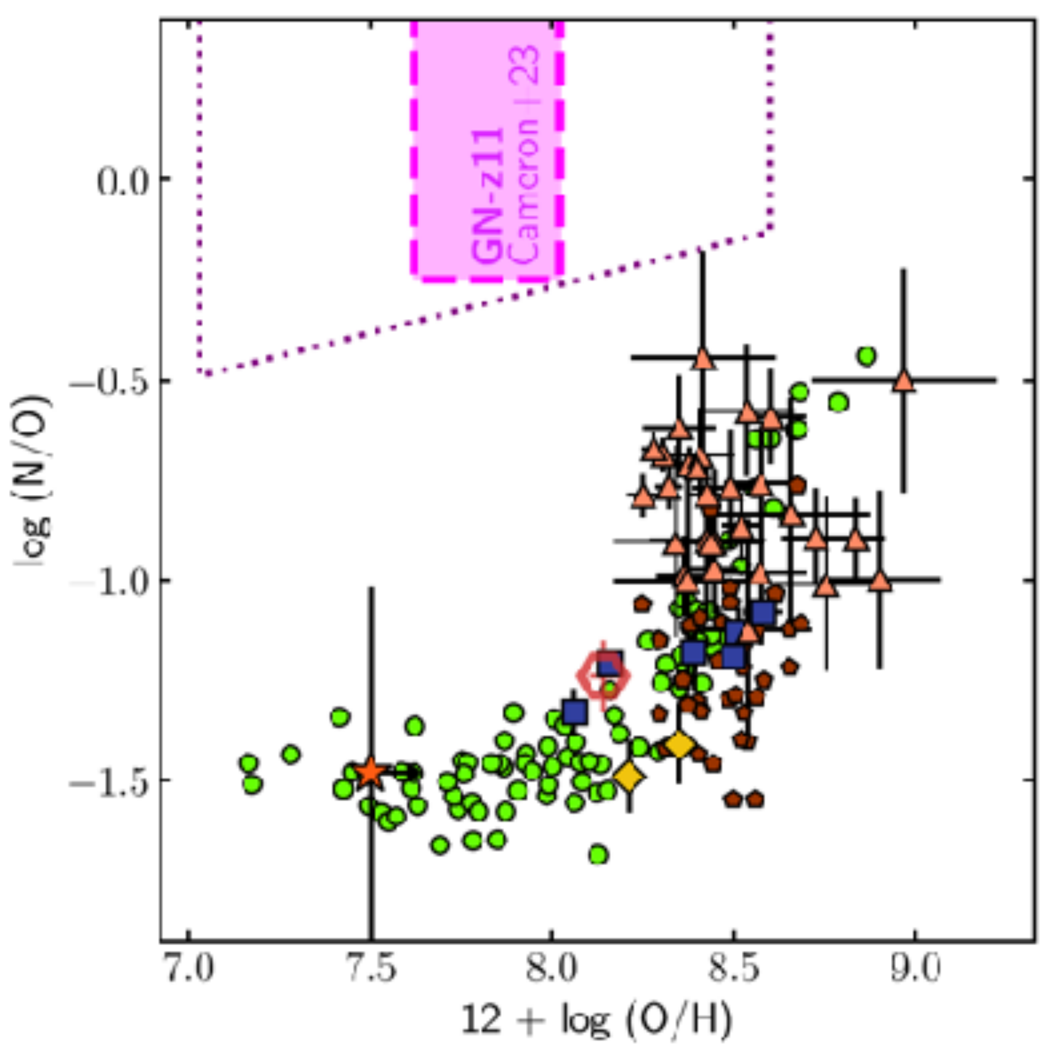

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GN-z11

N-rich, compact z = 10.6 galaxy

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must be helium-rich

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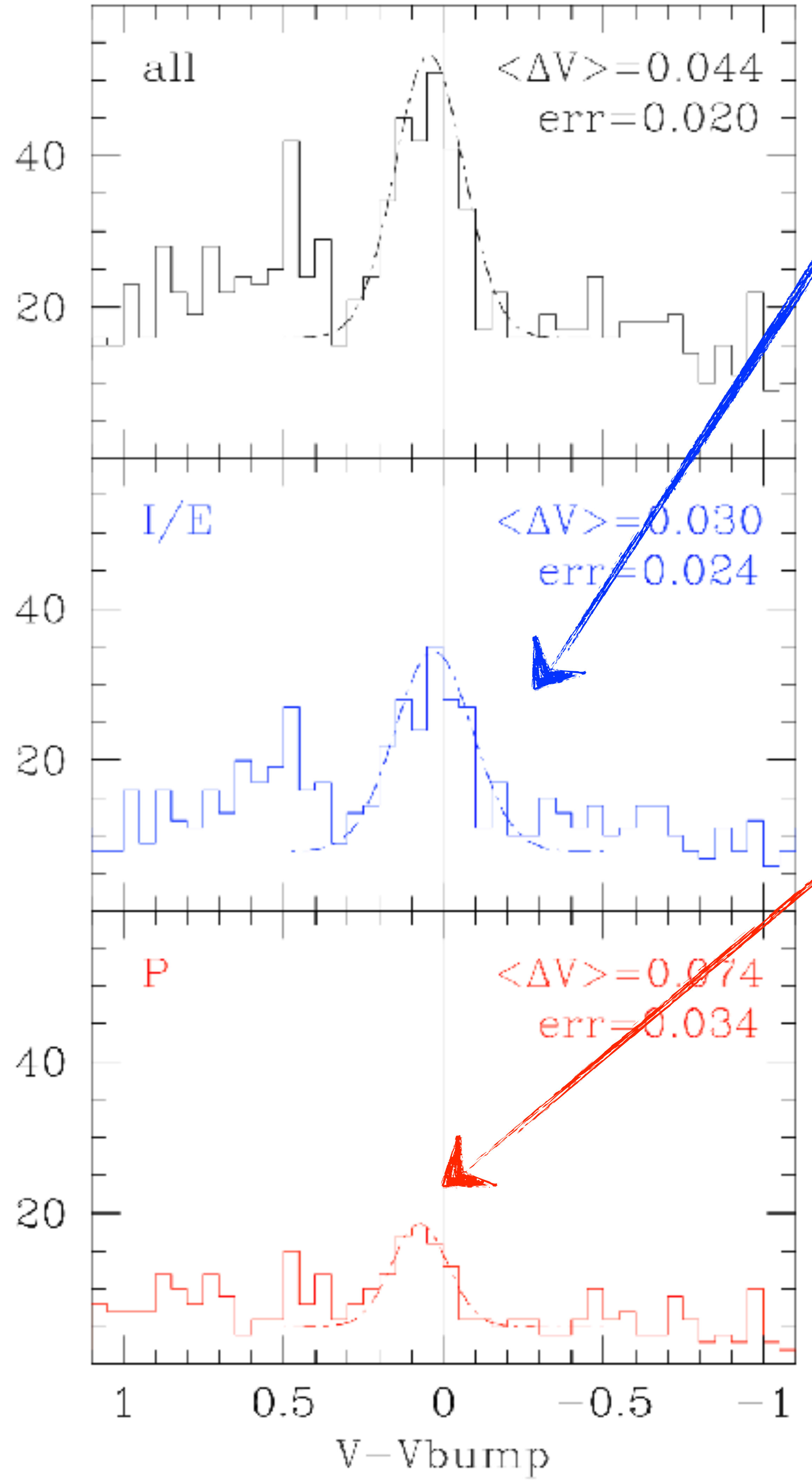
What is stellar helium content

What do stellar models say about He-rich?

He-rich stars:

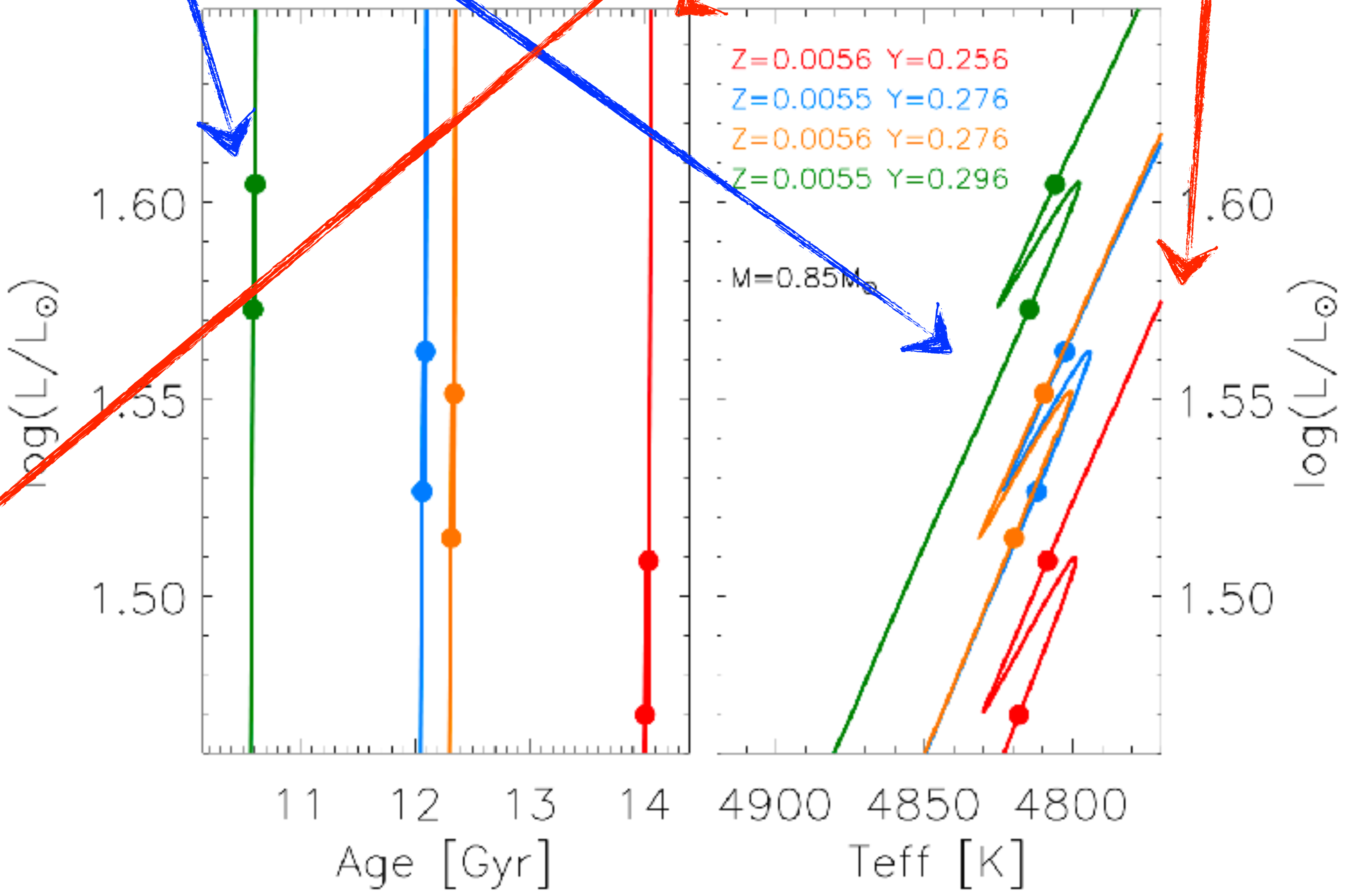
- hotter,
- brighter,
- evolve faster



Bragaglia et al., 2010b

He-rich

He-poor



Fu, PhD. Thesis

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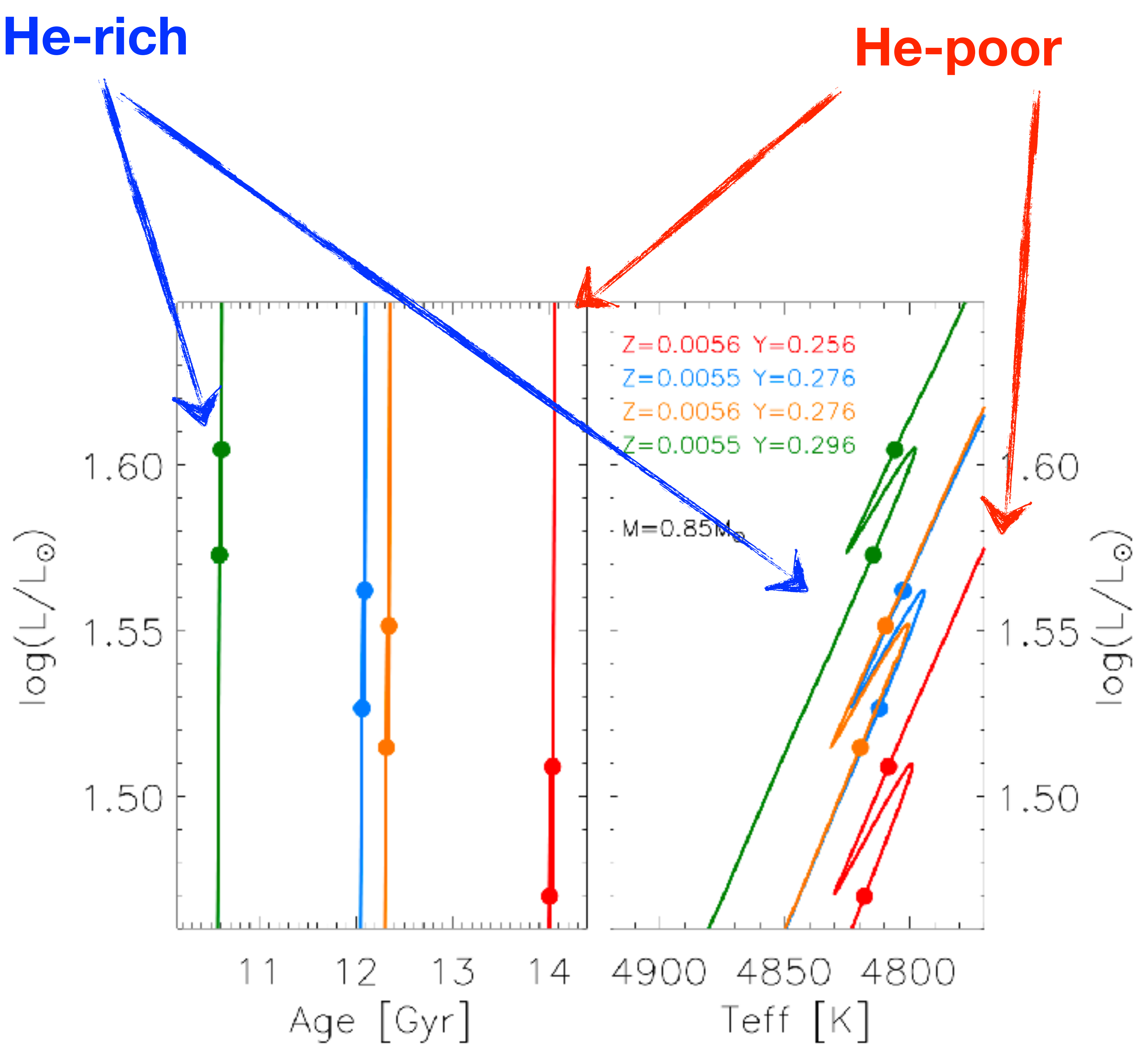

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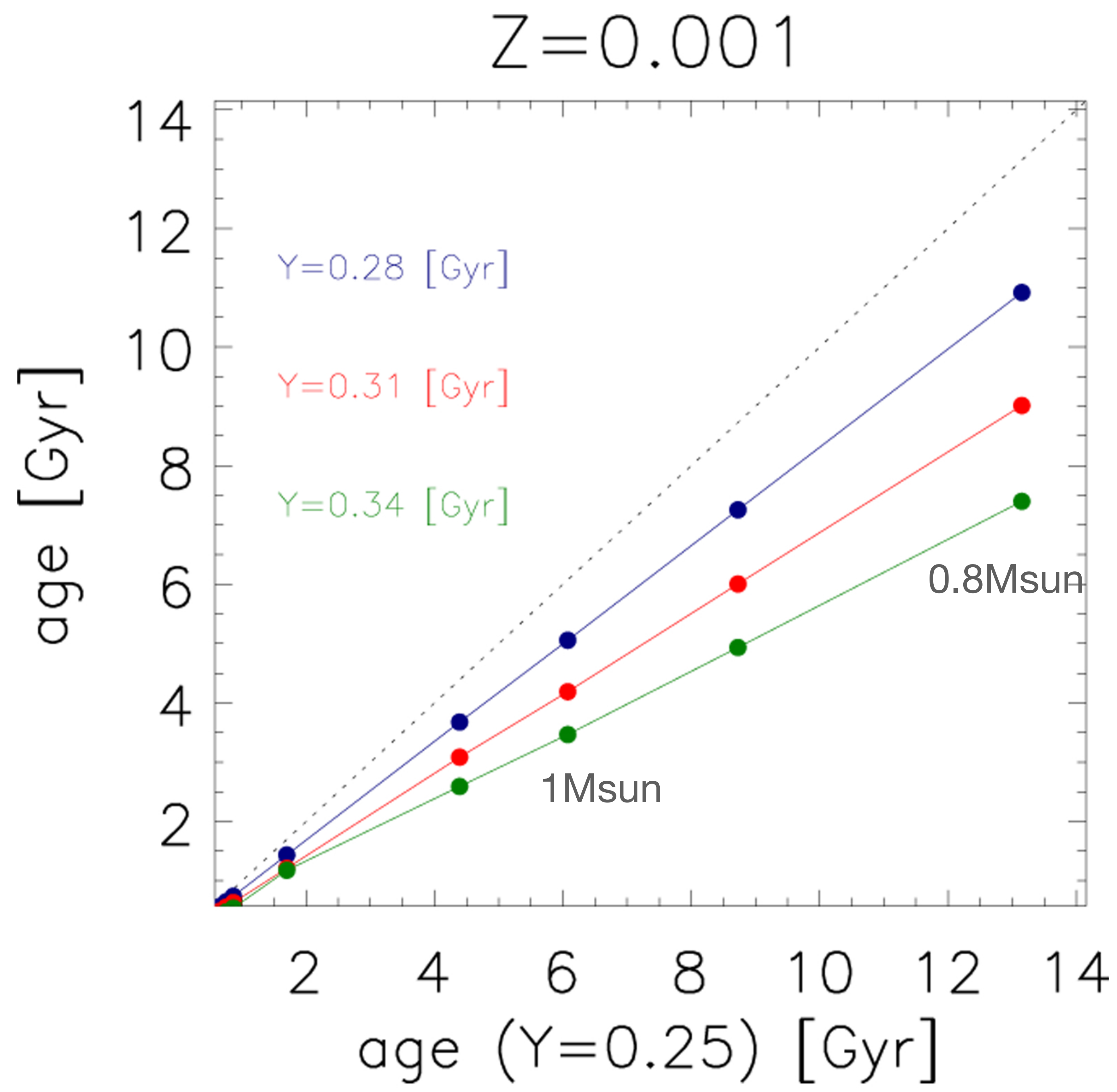

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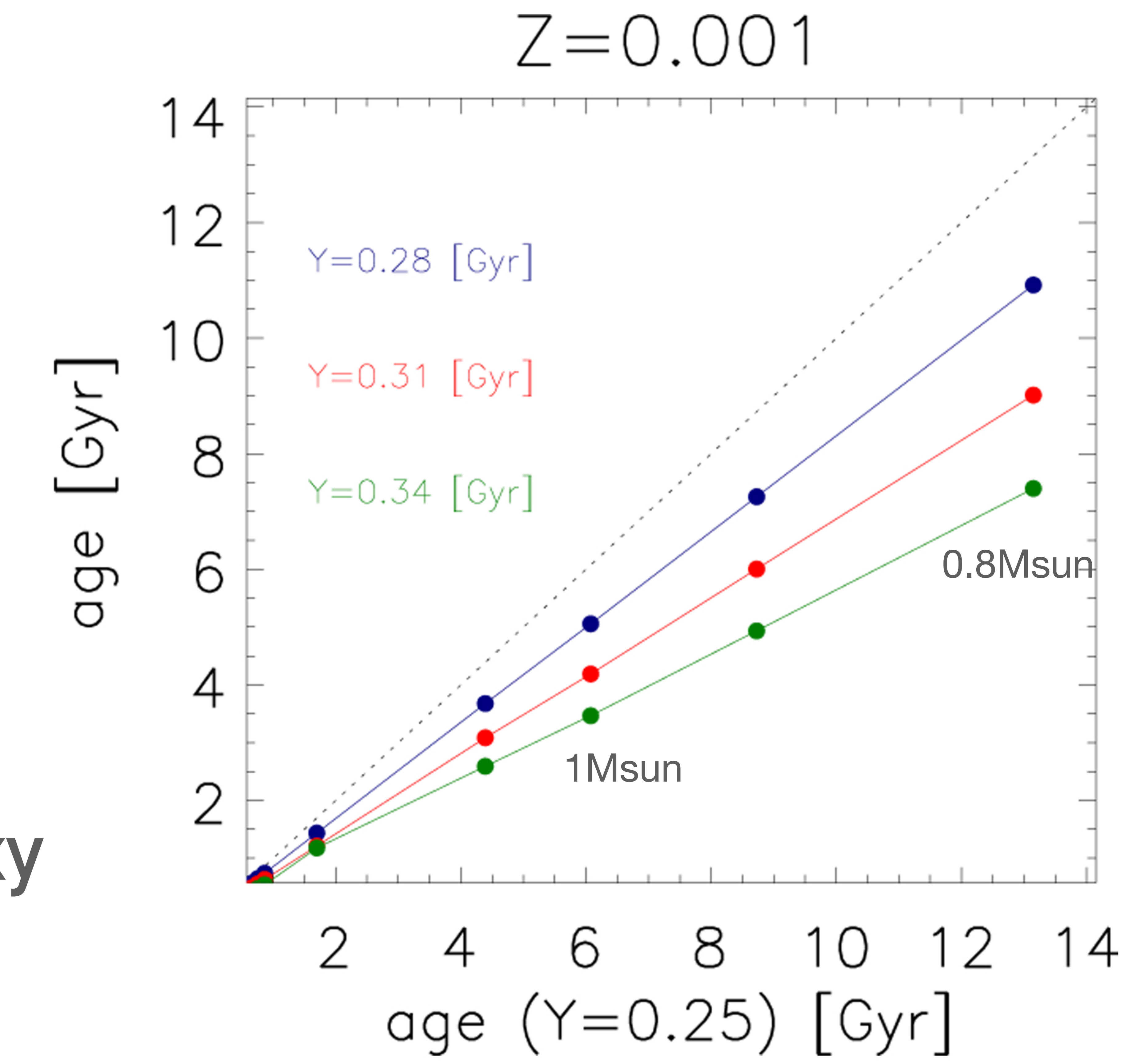

Huge effect on chemical evolution in galaxy

(WHEN? HOW? WHICH stellar mass?)

What is stellar helium content

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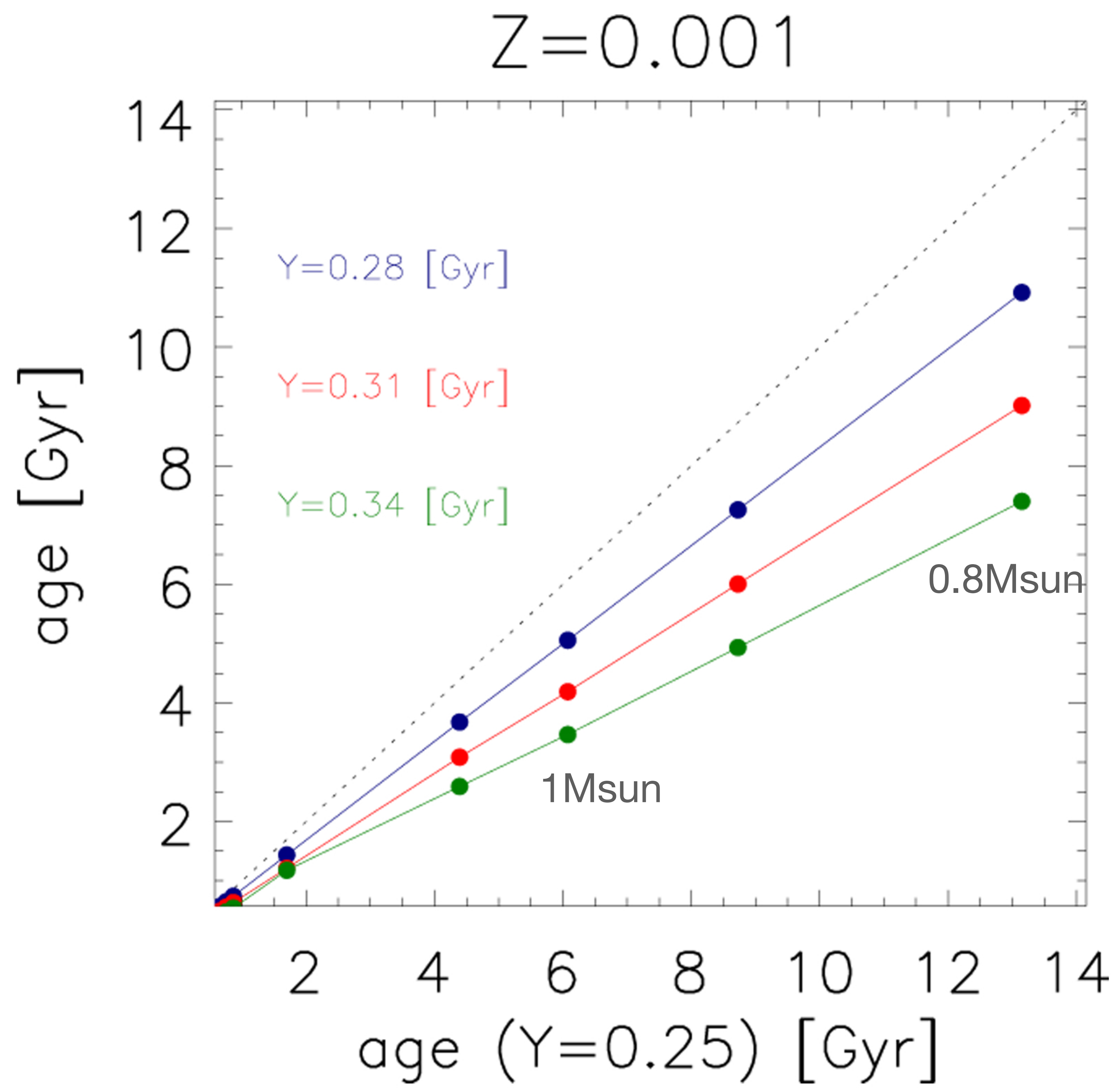
Impact on IMF ?



Impact on IMF determinations with star counting

He-rich stars:

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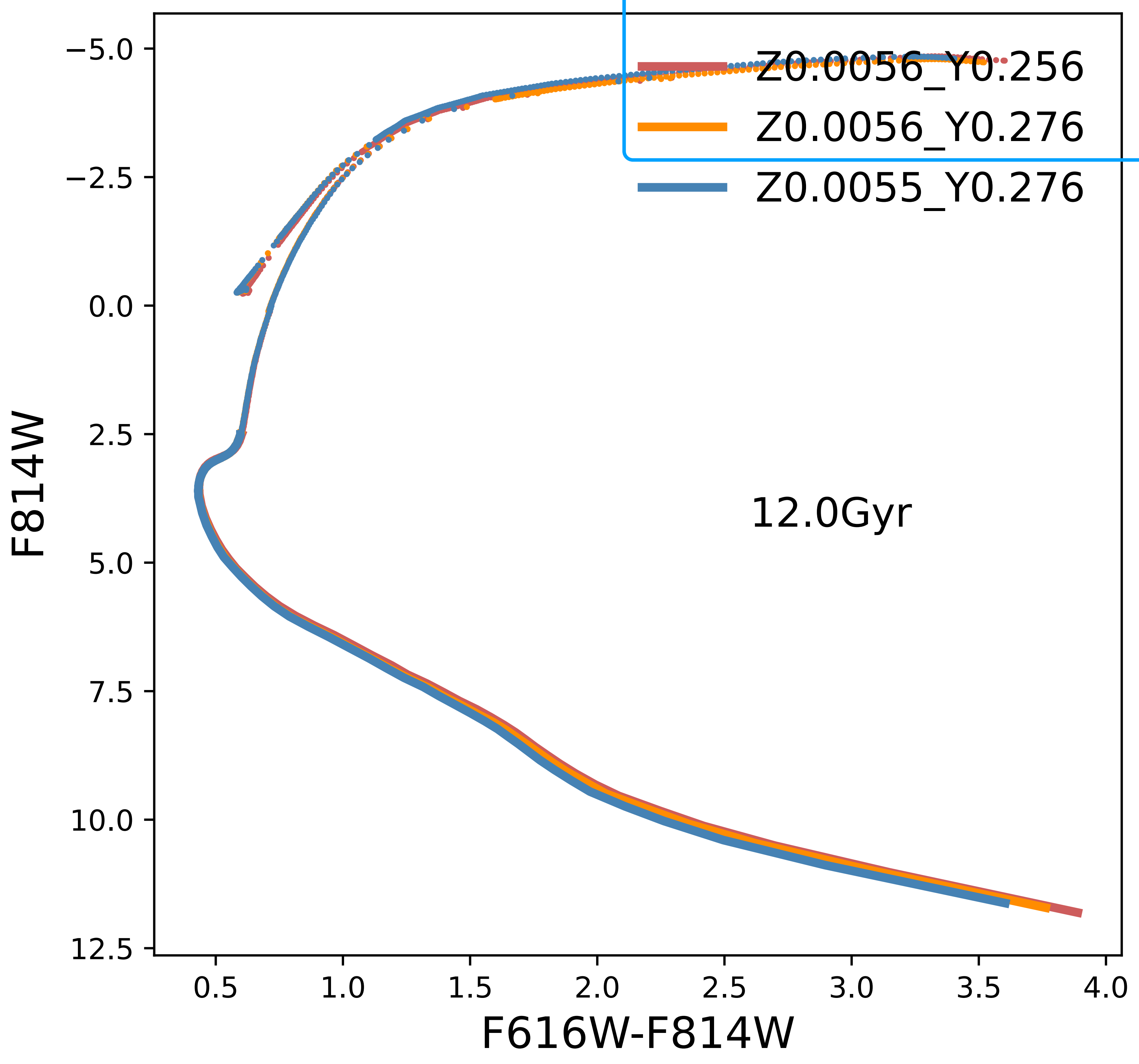
Helium difference: 2%



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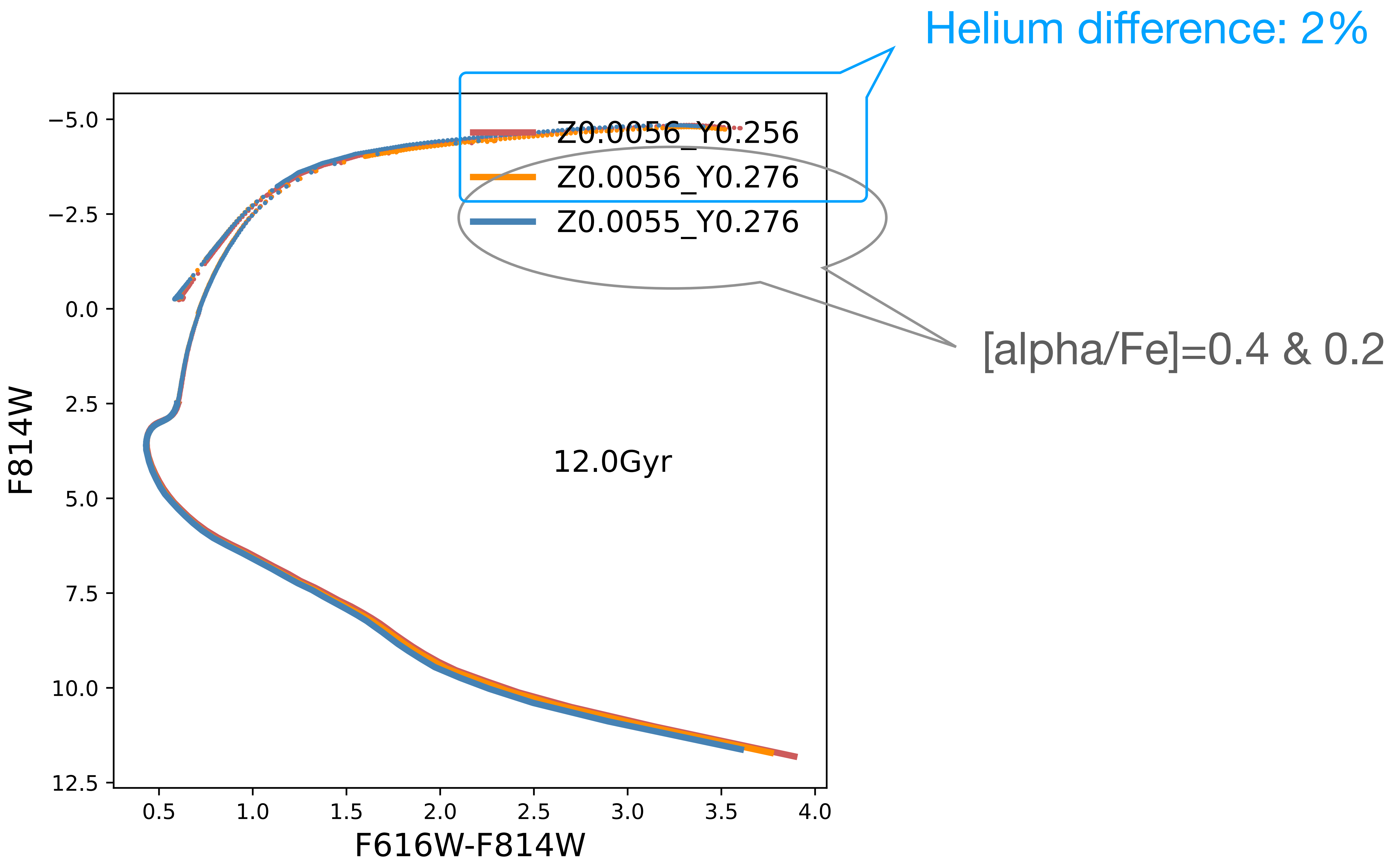

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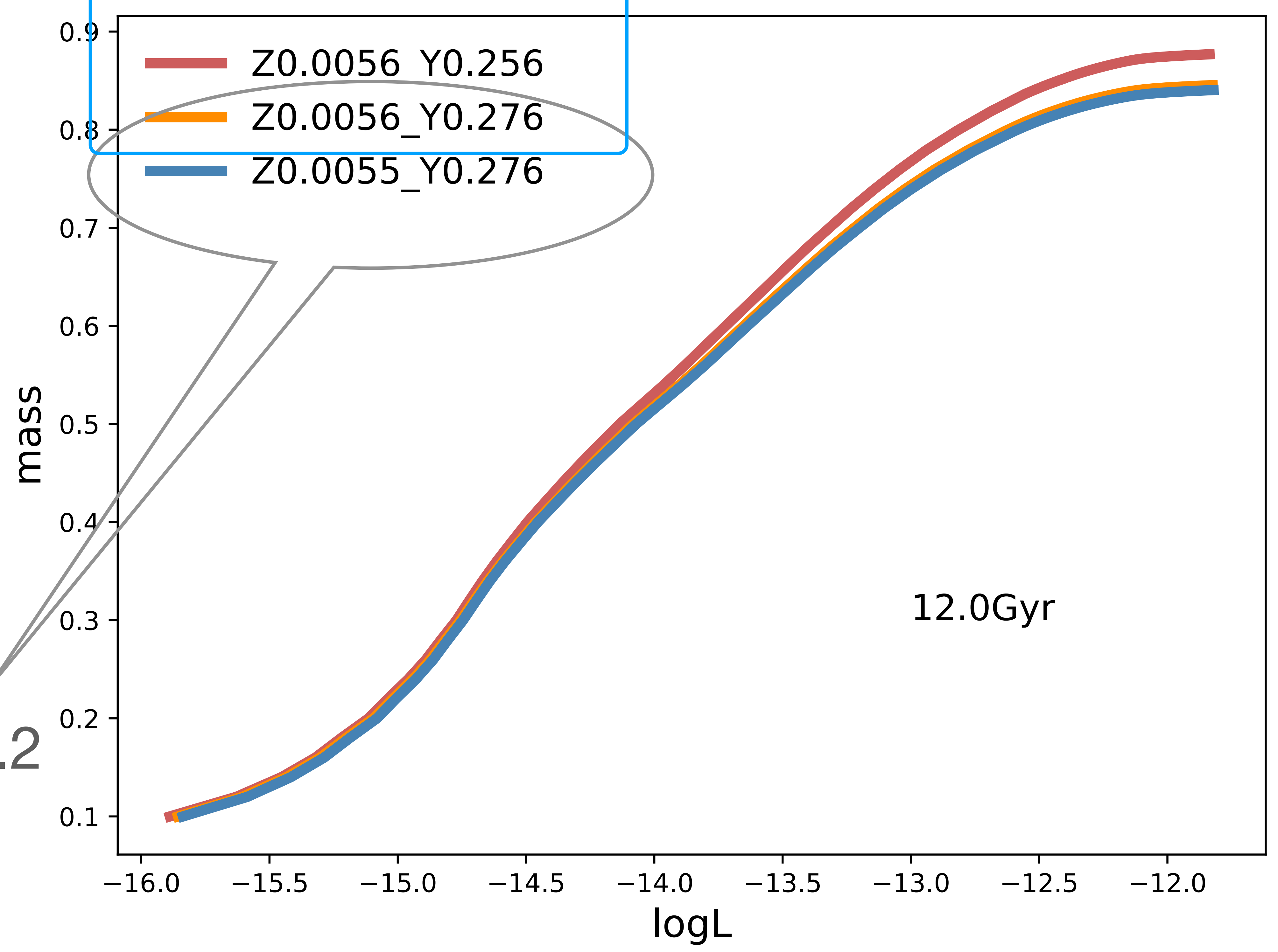
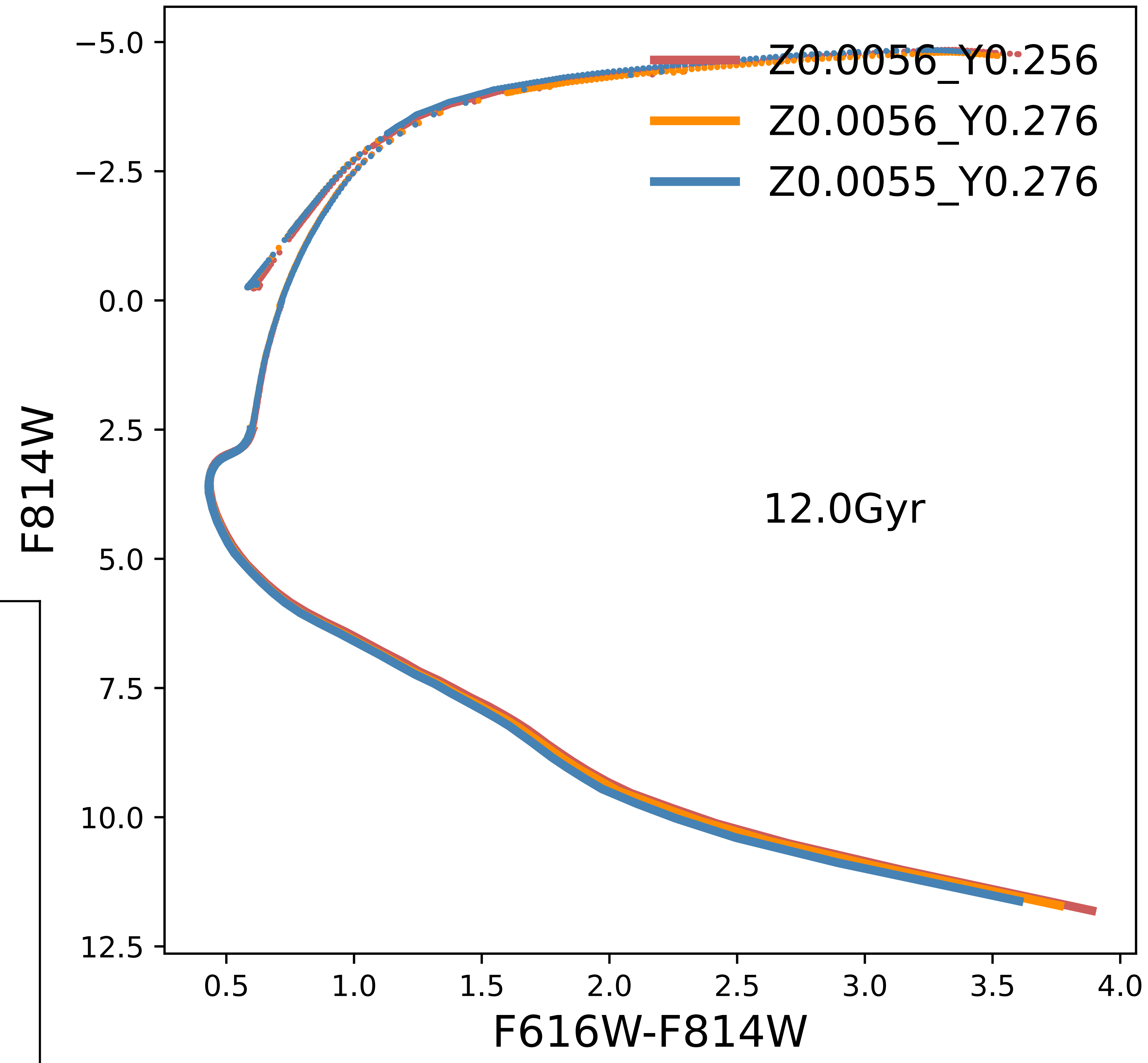


[alpha/Fe]=0.4 & 0.2

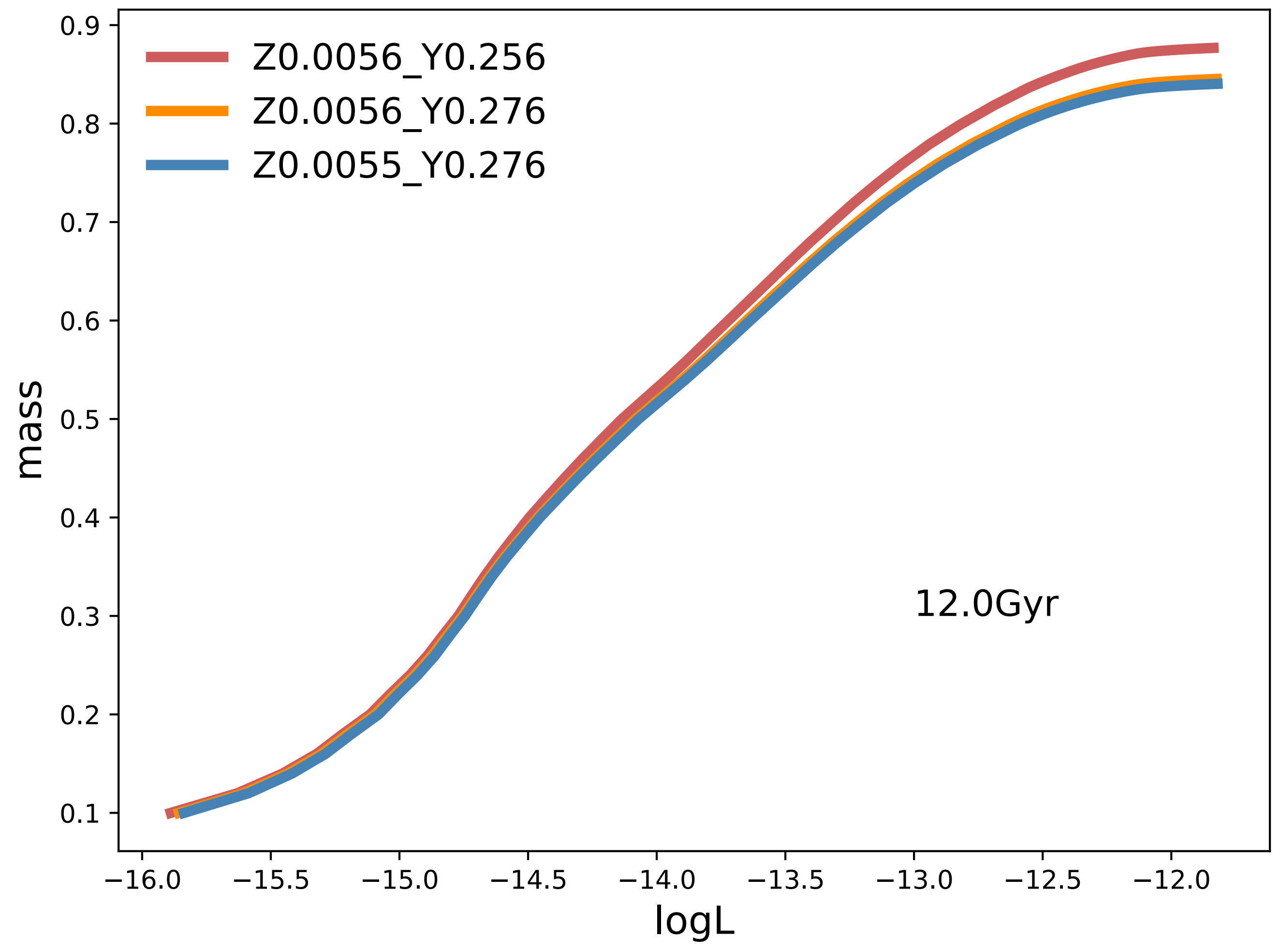


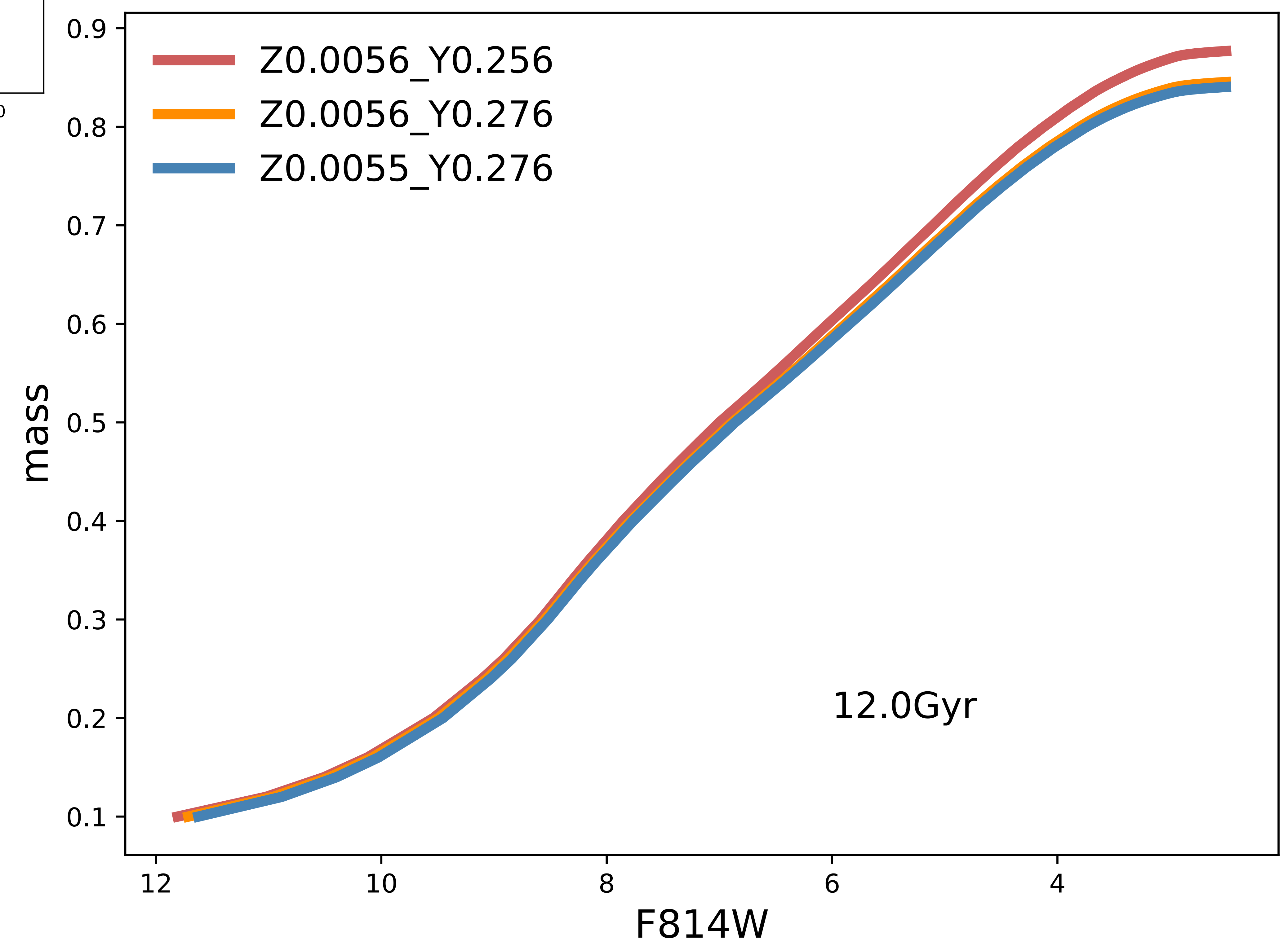
Even a small **He-enrichment**

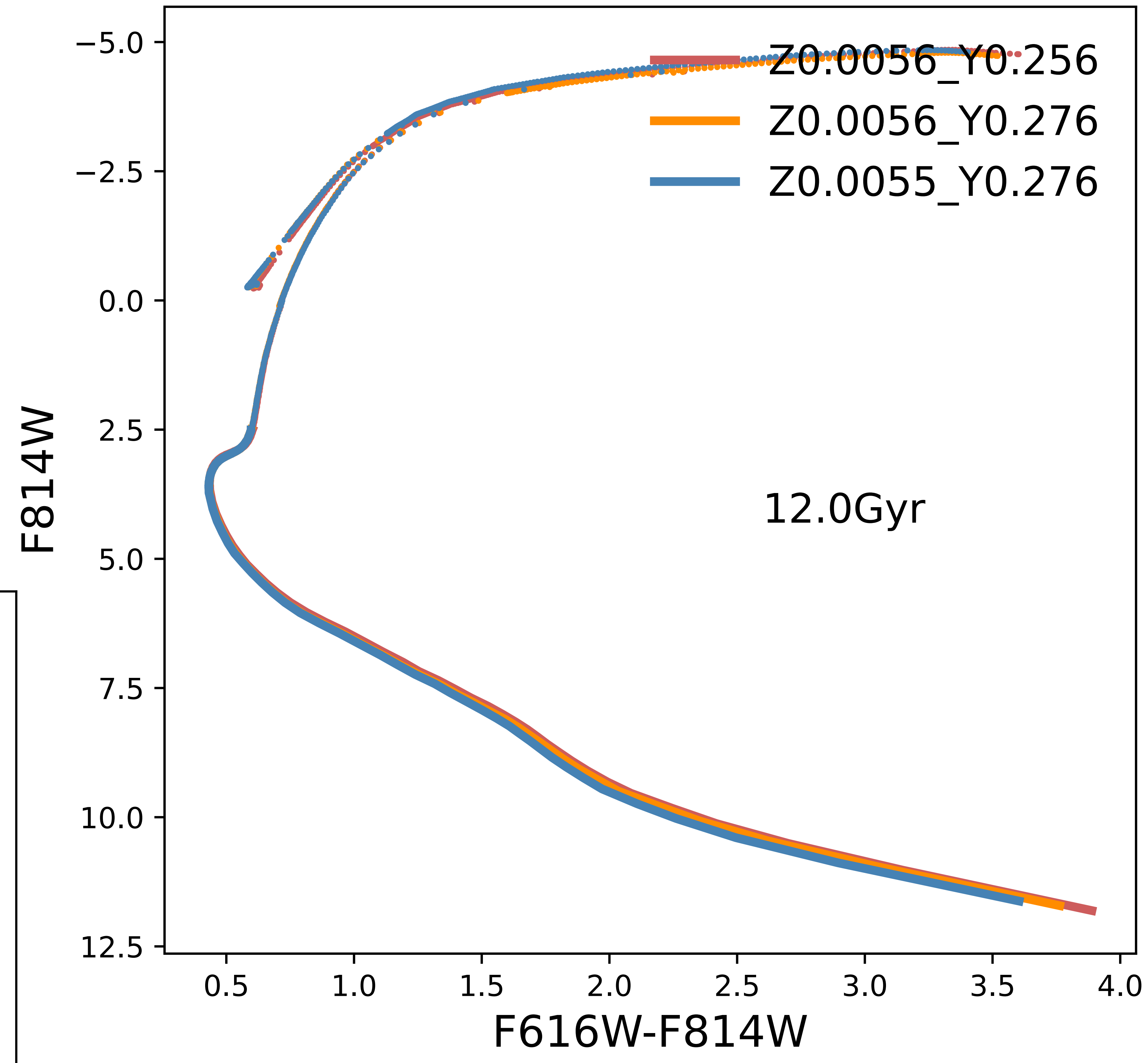
Changes the M-L relation

He-rich star has smaller mass at the same luminosity

Impact on IMF determinations with star counting





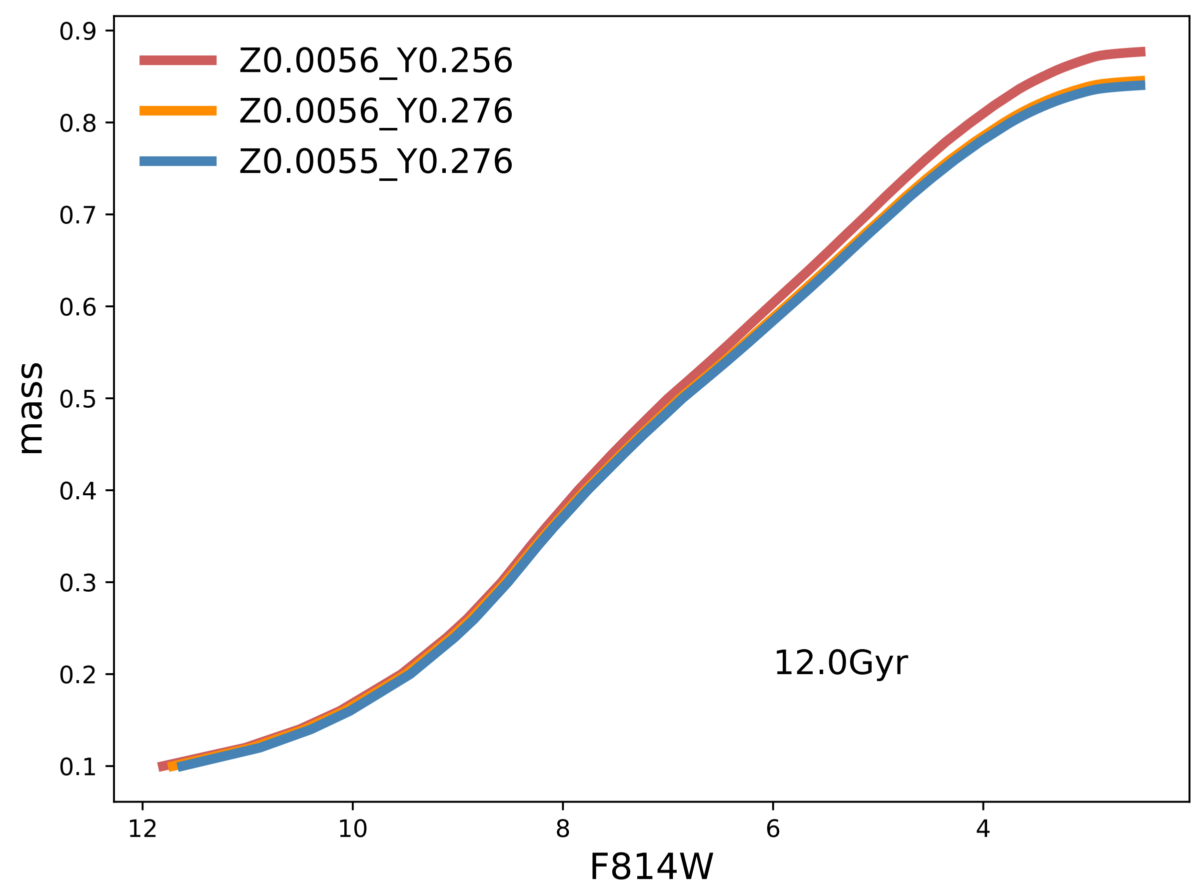


Even a small **He-enrichment**

Changes the M-L relation

He-rich star has smaller mass at the same magnitude

Impact on IMF determinations with star counting



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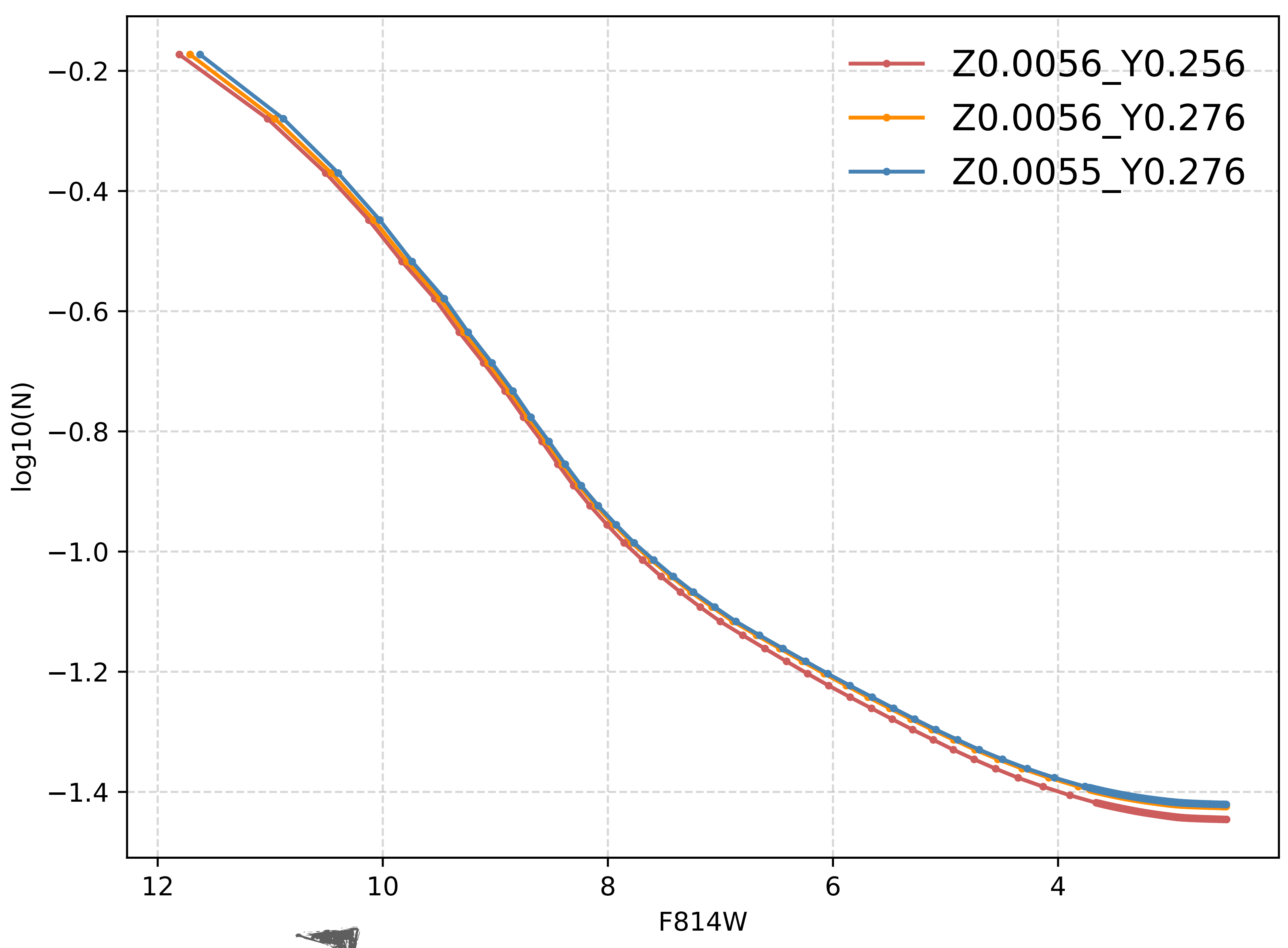
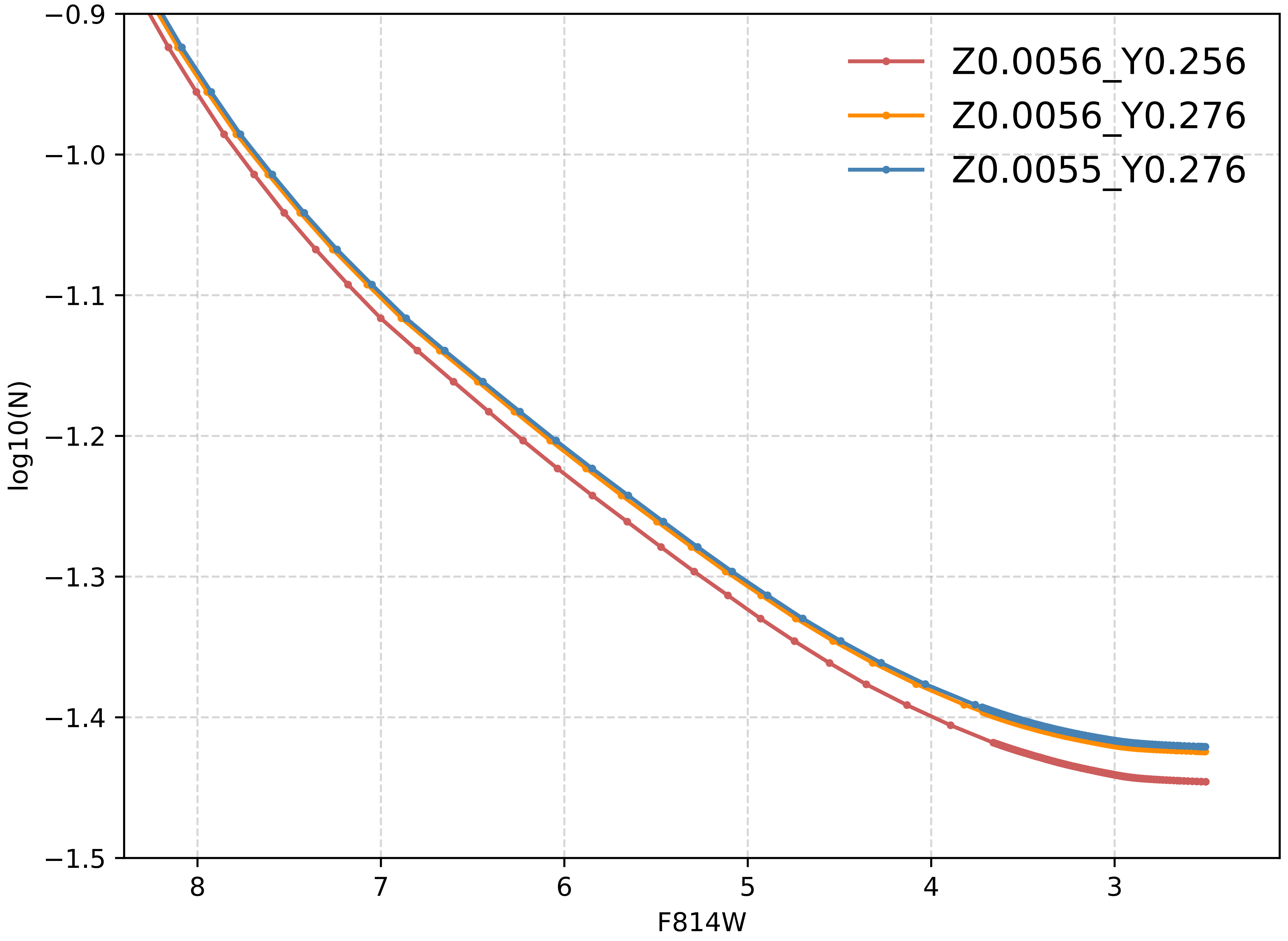
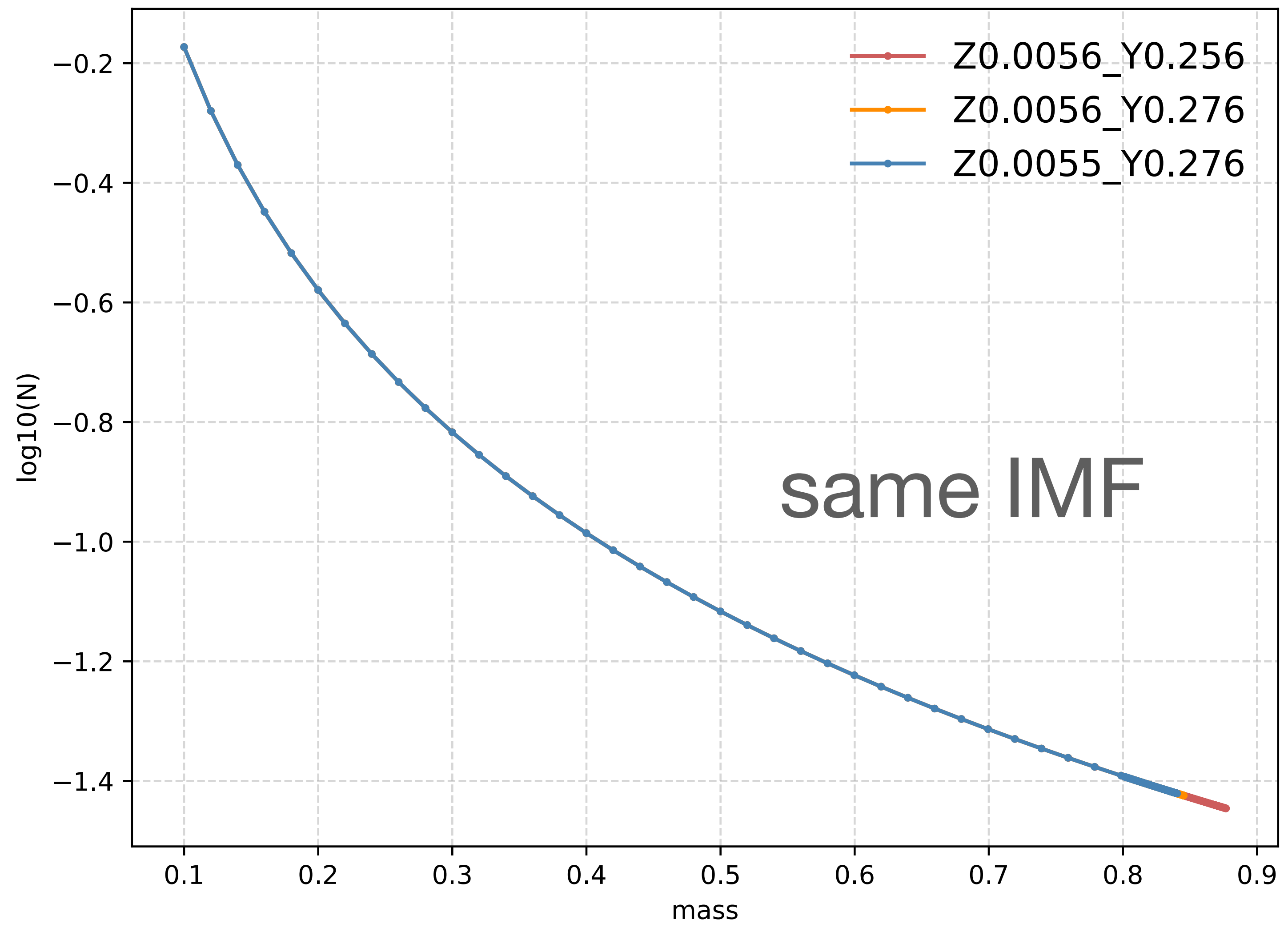




Different magnitude function



same IMF

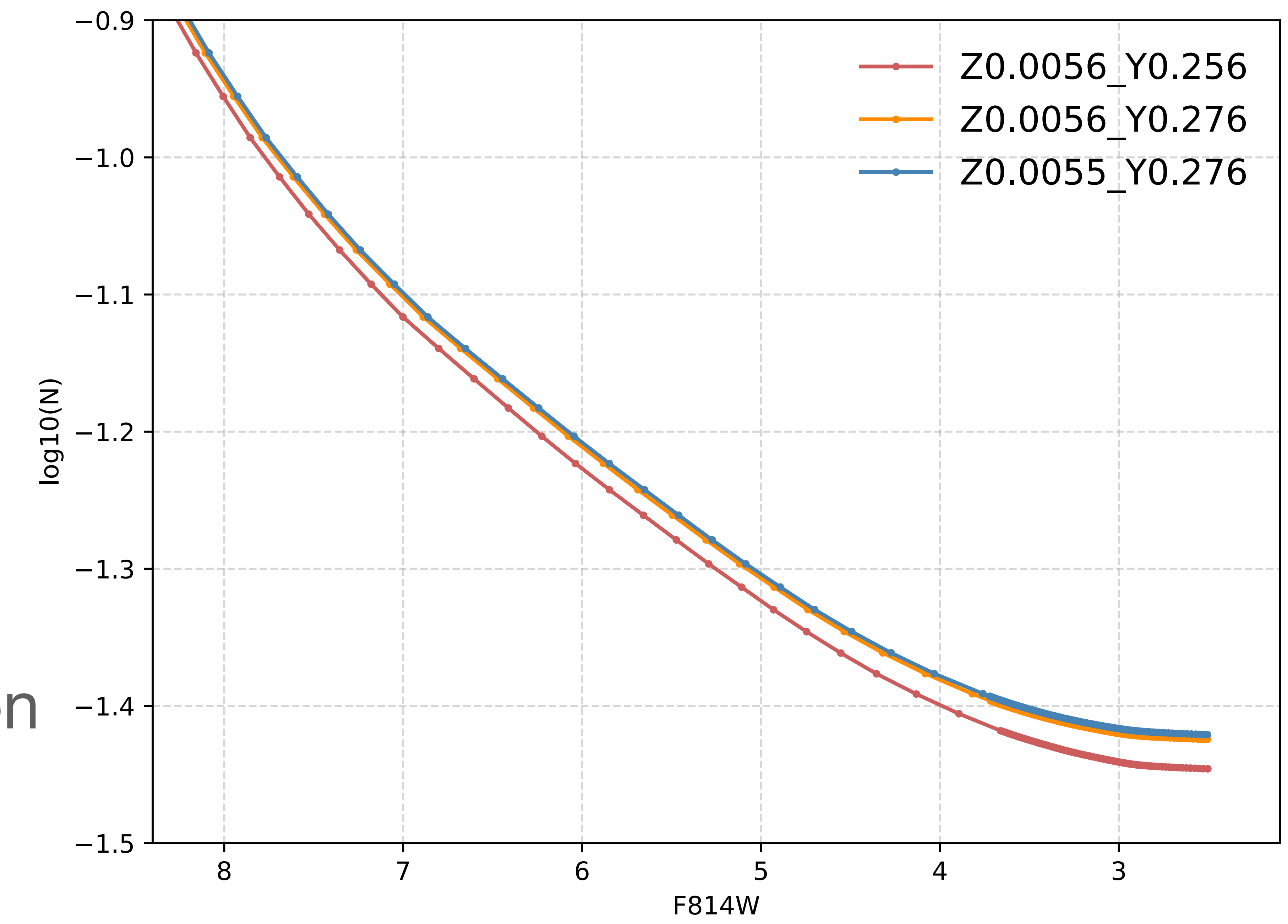
Even a small **He-enrichment**

Changes the M-L relation

Impact on IMF determinations with star counting

He-rich star has smaller mass at the same magnitude

same IMF
Different magnitude function



If the He-rich population is not considered one may end with more higher mass stars

How to measure it ?

Even a small **He-enrichment**

Changes the M-L relation

How to measure it

He

- The splitting on sequences in CMD both of GC in Milky Way (e.g. Bedin et al., 2004; Villanova et al., 2007; Piotto et al., 2007; Milone et al., 2008; Di Criscienzo et al., 2010) and in Magellanic Cloud clusters;
- Brightness of the RGB bump (Bragaglia et al., 2010)
- Seismology result (Bragaglia et al., 2010)
- Direct He I measurement hot blue horizontal branch star (e.g. Villanova, Piotto & Gratton, 2009; Mucciarelli et al., 2014; Marino et al., 2014; Gratton et al., 2015), on giant stars (Dupree, Strader & Smith, 2011; Pasquini et al., 2011);

How to measure it

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CMD
Indirect

- Brightness of the RGB bump (Bragaglia et al., 2010)
- Seismology result (Bragaglia et al., 2010)

Long-term seismology data
Indirect

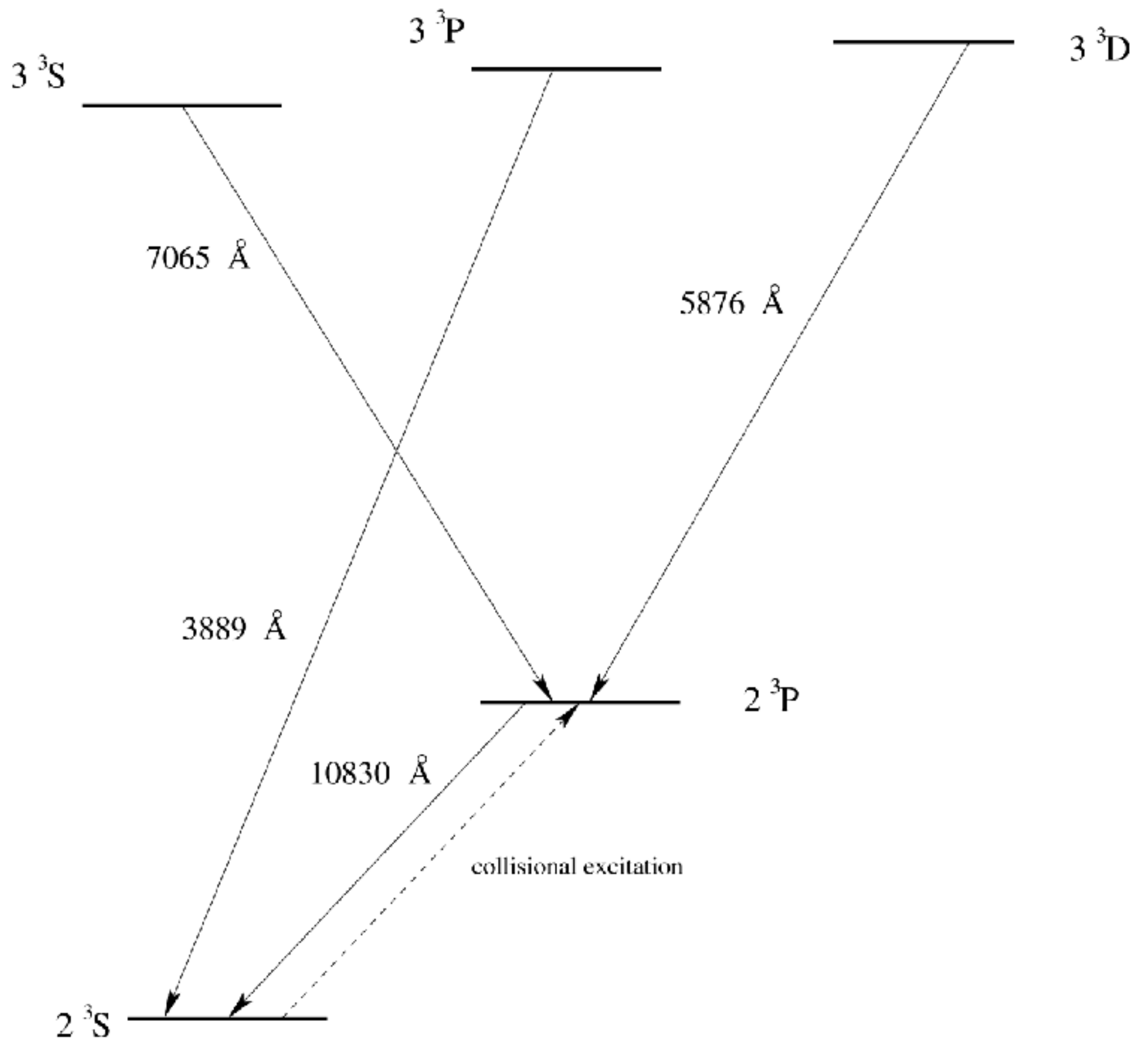
- Direct He I measurement hot blue horizontal branch star (... ; Mucciarelli et al., 2014; Marino et al., 2014; Gratton et al., 2015), on giant stars (... Pasquini et al., 2011);

Photosphere
EP > 20 eV; $Teff$ > 10000K

How to measure it

- He line at 10830Å

For lower temperature stars



10830Å triplet series:

$2s^3S \rightarrow 2p^3P_0$ ($\lambda = 10\,829.09$ Å),
$2s^3S \rightarrow 2p^3P_1$ ($\lambda = 10\,830.25$ Å),
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formed in the upper chromosphere.

How to measure it

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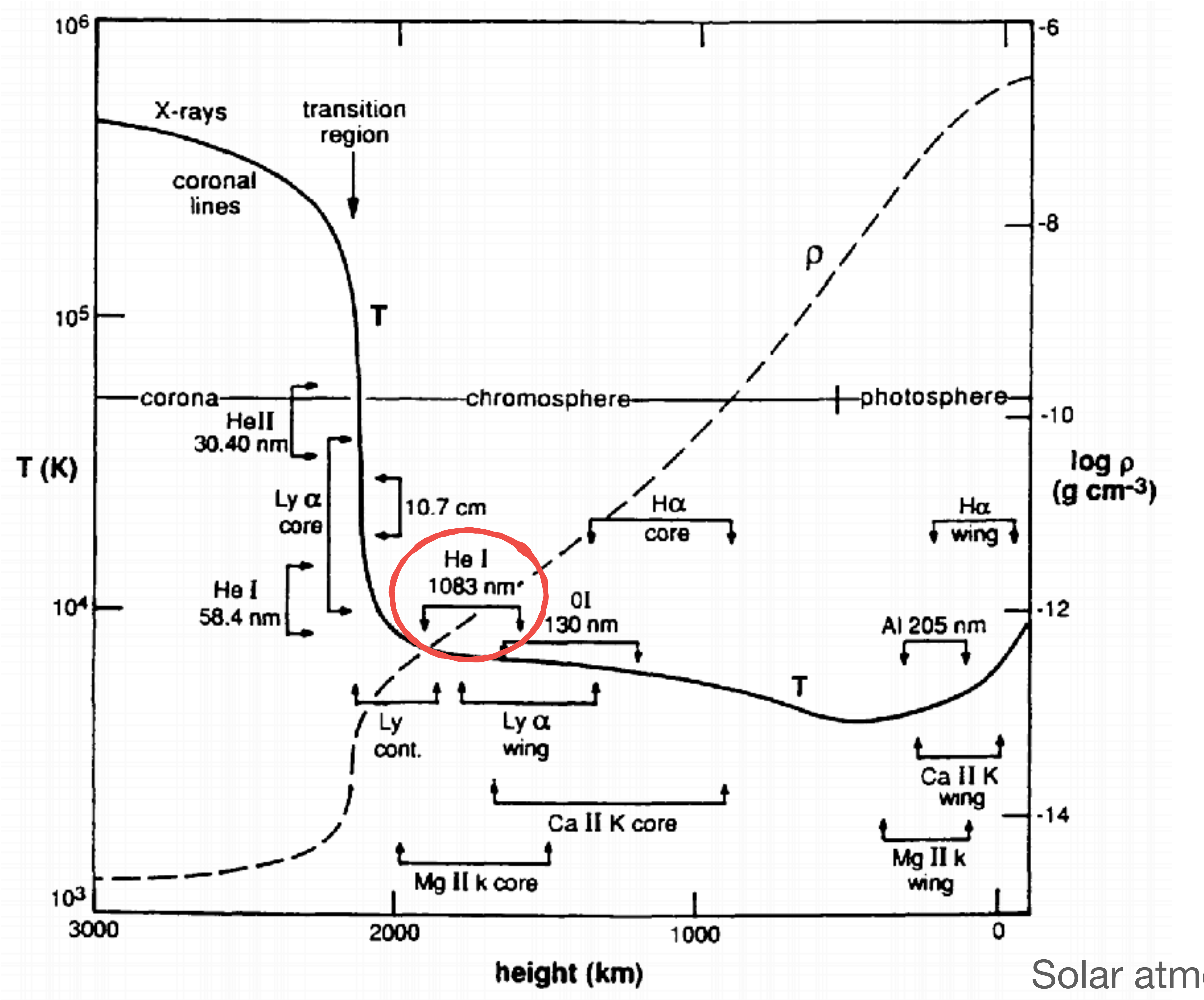

Solar atmosphere, Avrett & Loeser 1992

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How to measure it

Stellar population astrophysics (SPA) with the TNG: Measurement of the He I 10830 Å line in the open cluster Stock 2 ★

Mingjie Jian (简明杰)[1,2], Xiaoting Fu (符晓婷)[3,4], Noriyuki Matsunaga (松永典之)[2], Valentina D'Orazi[5,6], Angela Bragaglia[4], Daisuke Taniguchi (谷口大輔)[7], Min Fang (房敏)[3], Nicoletta Sanna[8], Sara Lucatello[6], Antonio Frasca[9], Javier Alonso-Santiago[9], Giovanni Catanzaro[9], and Ernesto Oliva[8]

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3 Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210023, China
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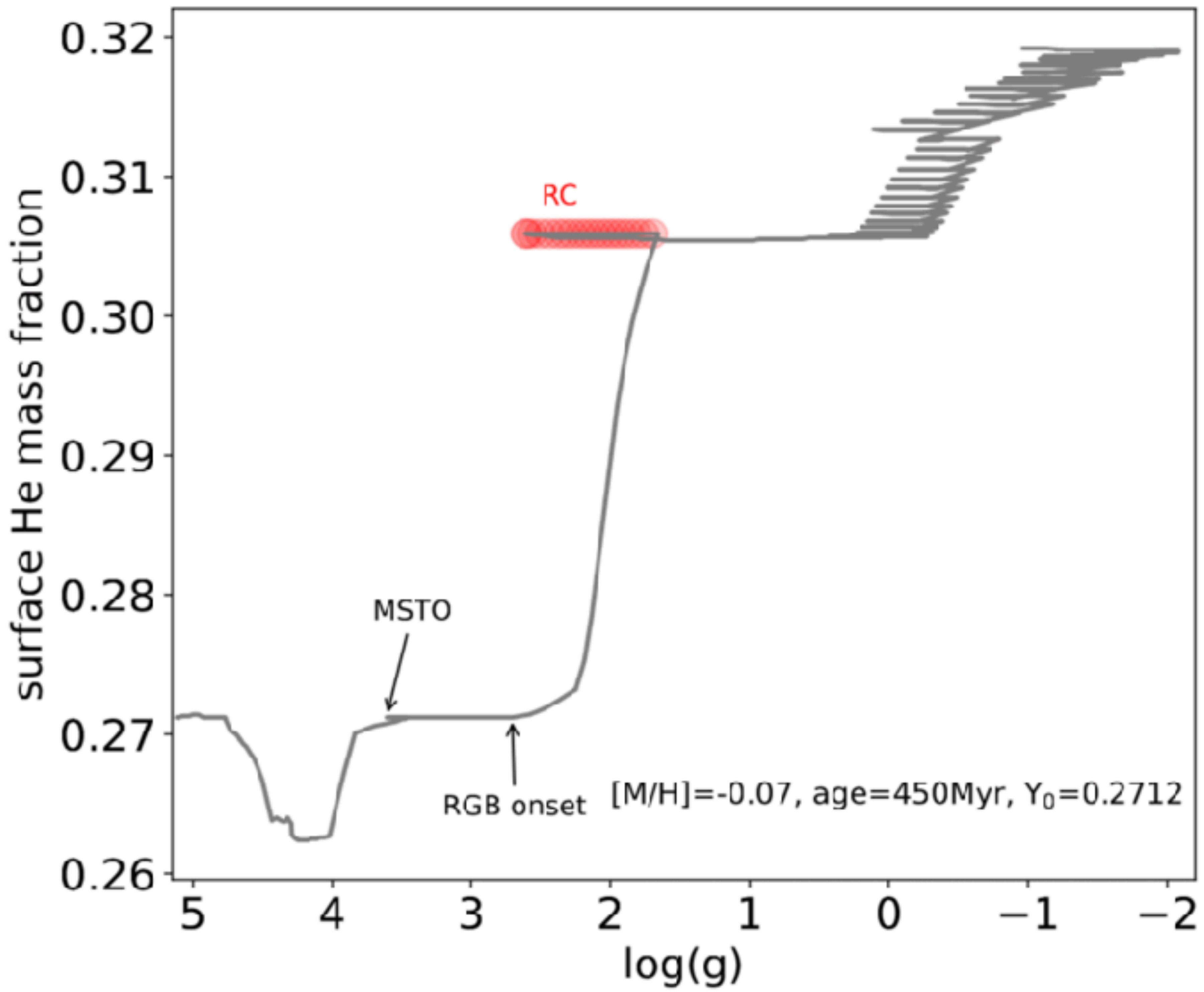
4 INAF – Osservatorio di Astrofisica e Scienza dello Spazio di Bologna, via P. Gobetti 93/3, 40129 Bologna, Italy
5 Department of Physics, University of Rome Tor Vergata, via della Ricerca Scientifica 1, 00133, Rome, Italy
6 INAF - Osservatorio Astronomico di Padova, Vicolo dell' Osservatorio 5, 35122 Padova, Italy
7 National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
8 INAF – Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy
9 INAF–Osservatorio Astrofisico di Catania, via S. Sofia 78, 95123 Catania, Italy

Red Clump stars in open cluster:

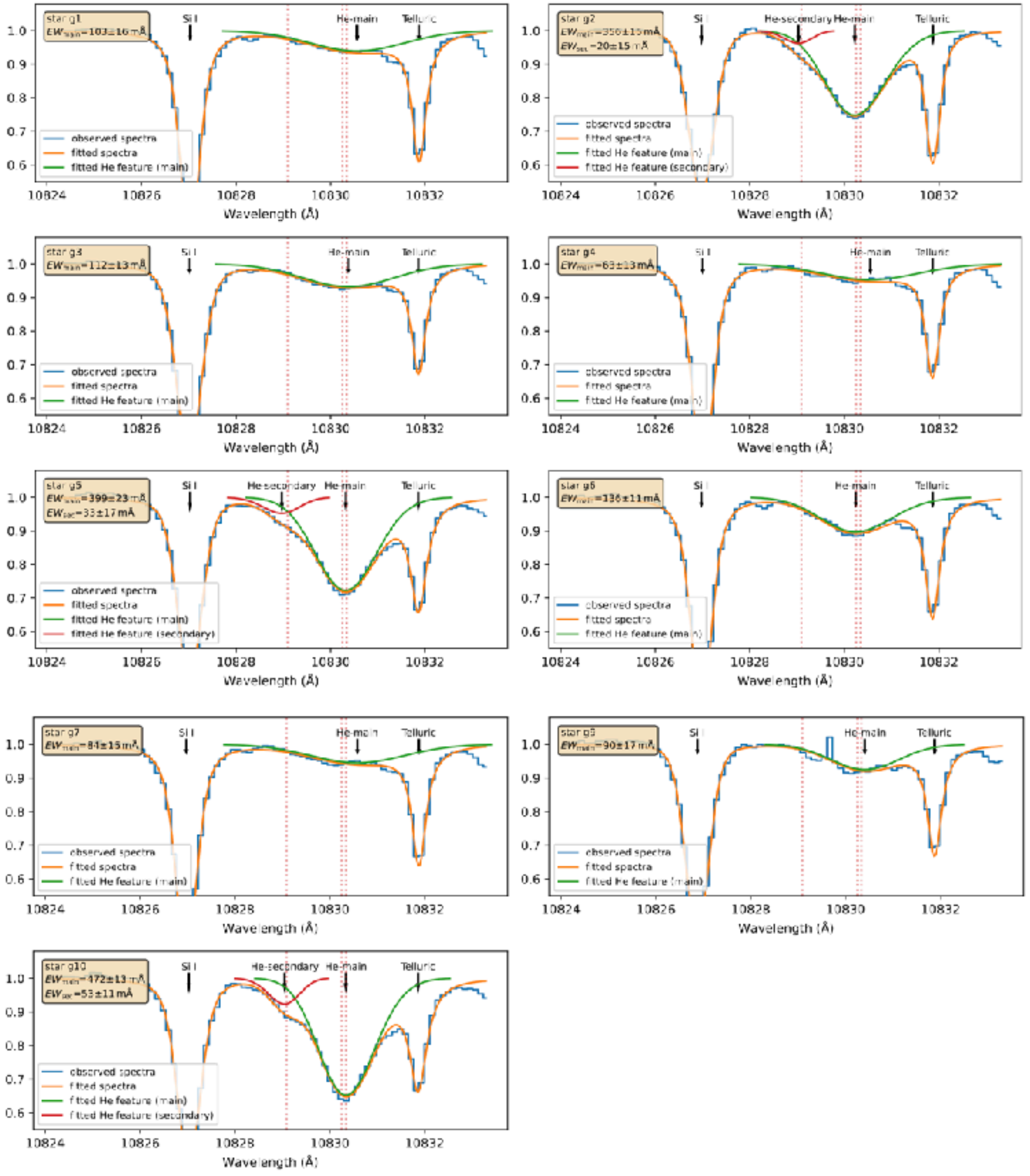
Single stellar population, known age, known distance

Low mass loss, constant surface helium



How to measure it

Fundación Galileo Galilei - INAF
Telescopio Nazionale Galileo
28°45'14.4"N 17°53'20.6"W 2387.2m A.S.L.

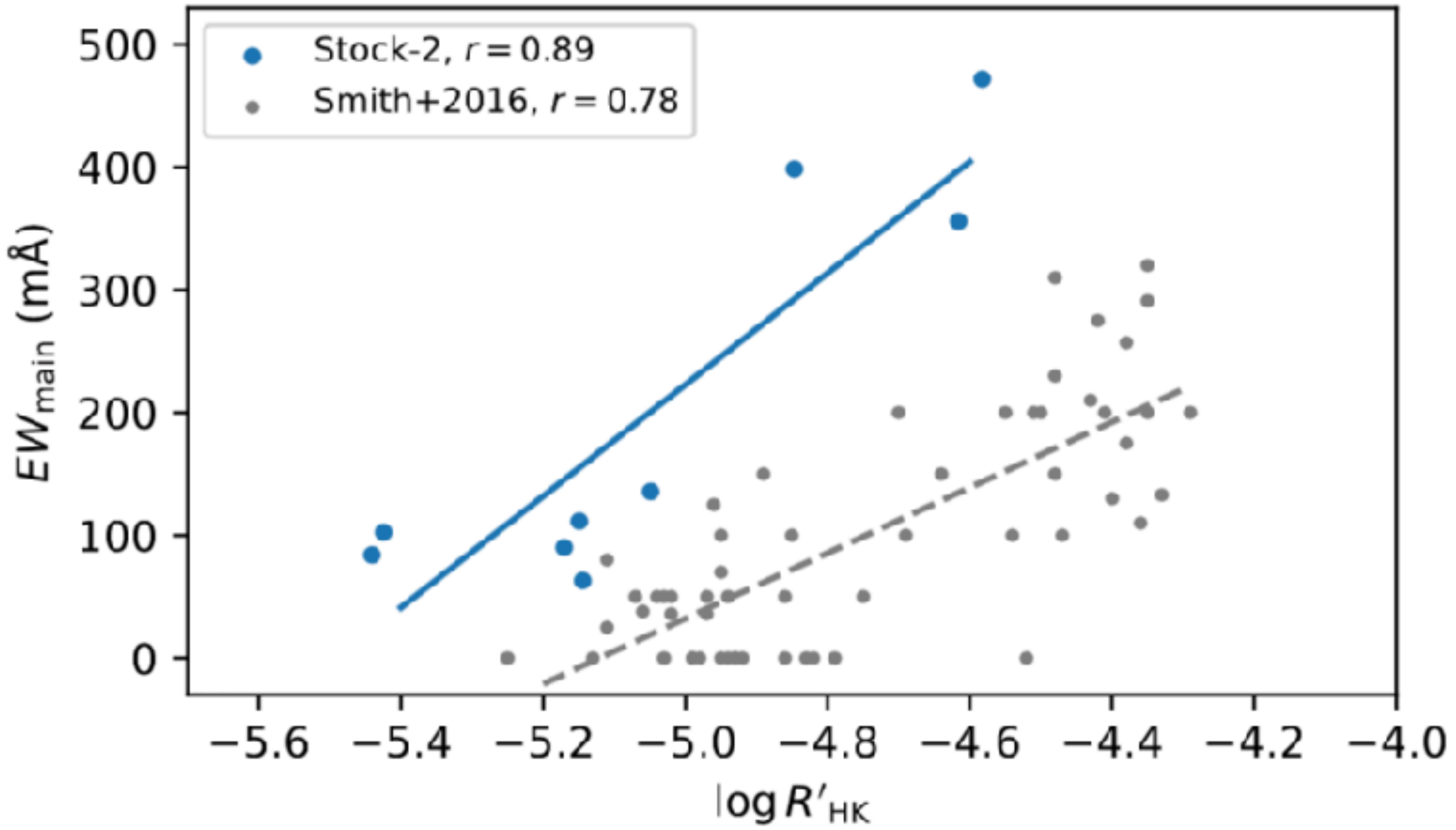


GIARPS @ TNG:

GIARNO-B & HARPS-N

NIR optical

Constrain stellar activity impact



▸How to measure it

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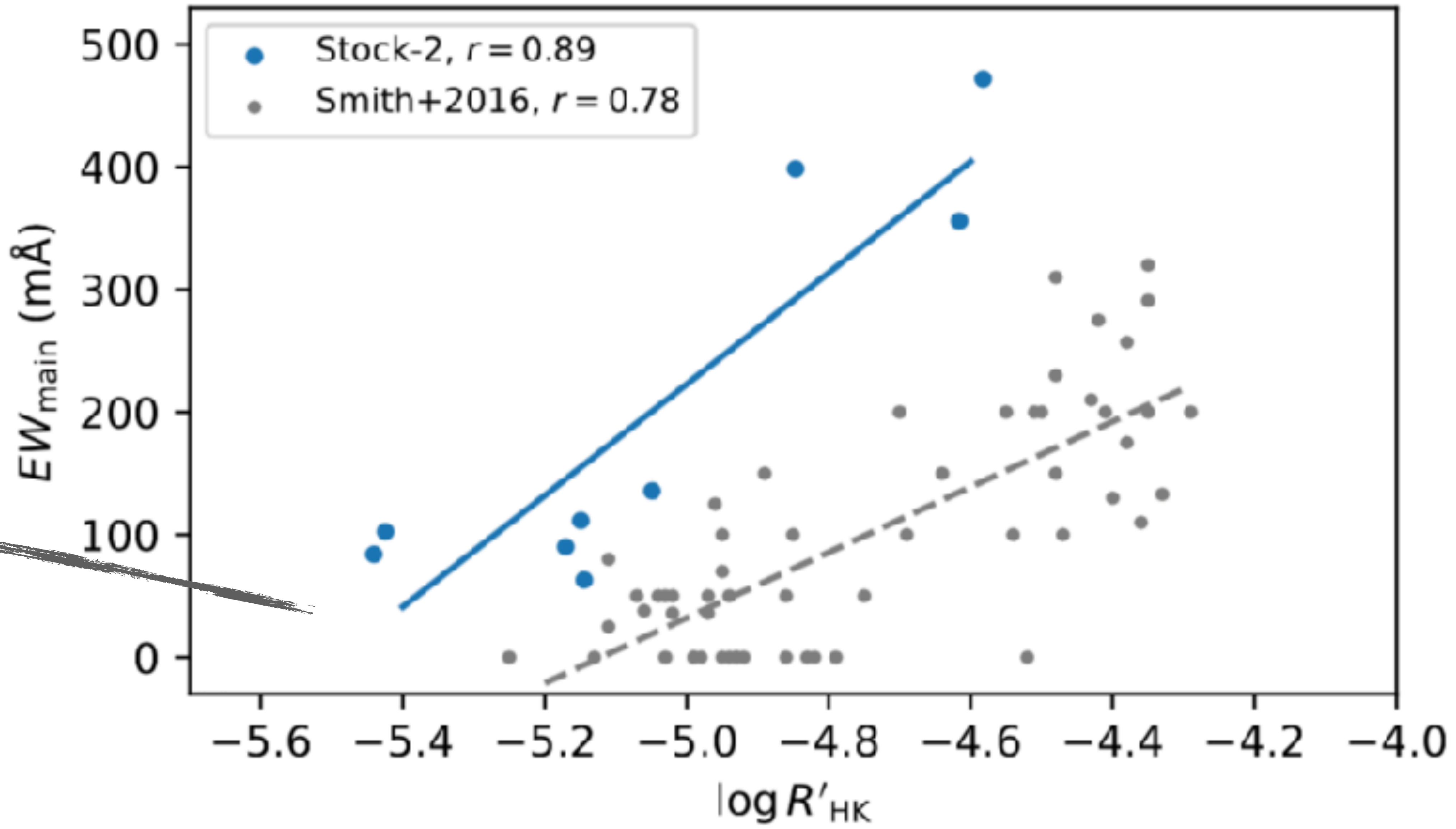
GIARNO-B & HARPS-N
NIR optical

We have **20 more clusters** with GIARPS @ TNG: !

Covering **different locations in MW**

Constrain stellar activity impact

The He-Ca(HK) slope
is an indicator of the He abundance



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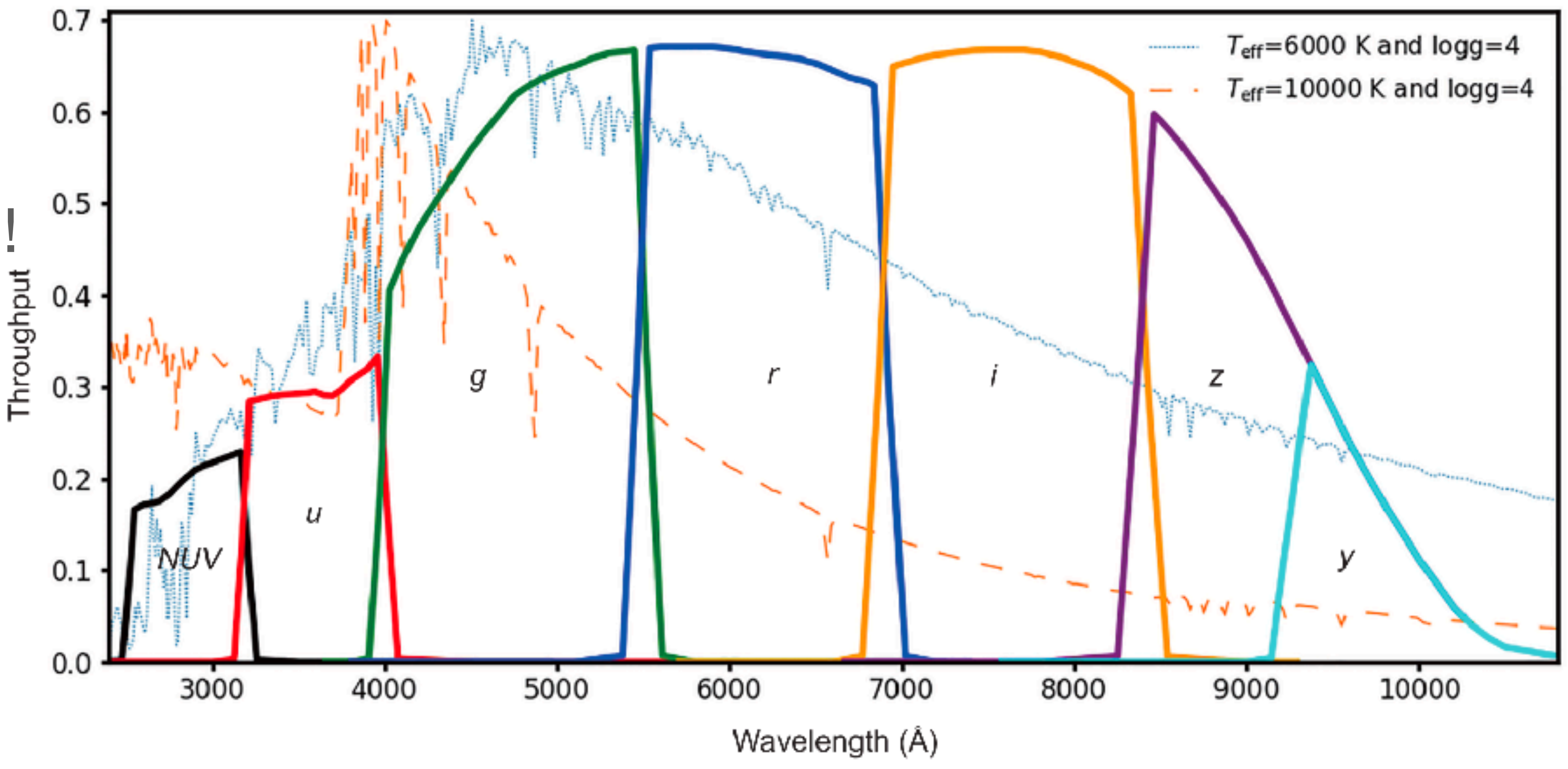

Chinese Space Station Telescope

reaching g=27.5 mag

Summary

He Work frame