First stars with MOONS: some ideas for the Bulge

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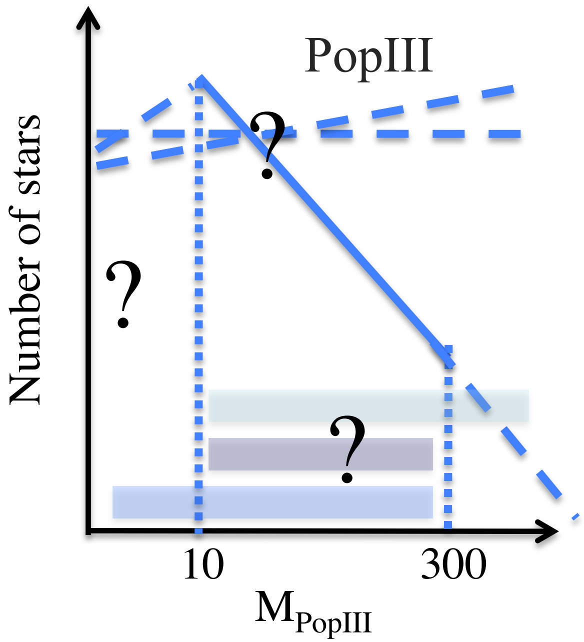
Paris, September 17th 2016

THE FIRST STARS

e.g. Omukai&Nishi98;Abel+02;Bromm+02;Omukai&Palla03;Bromm&Loeb04;Tan&McKee04/08;O'Shea&Norman06; Ripamonti+02; Schleicher+09;Turk+09/11;Yoshida+06/08;H osokawa+11/15; Clark+11; Greif+12; Hirano+14/15; Stacy+14/16

FIRST STARS



-What was the mass range of the first stars?

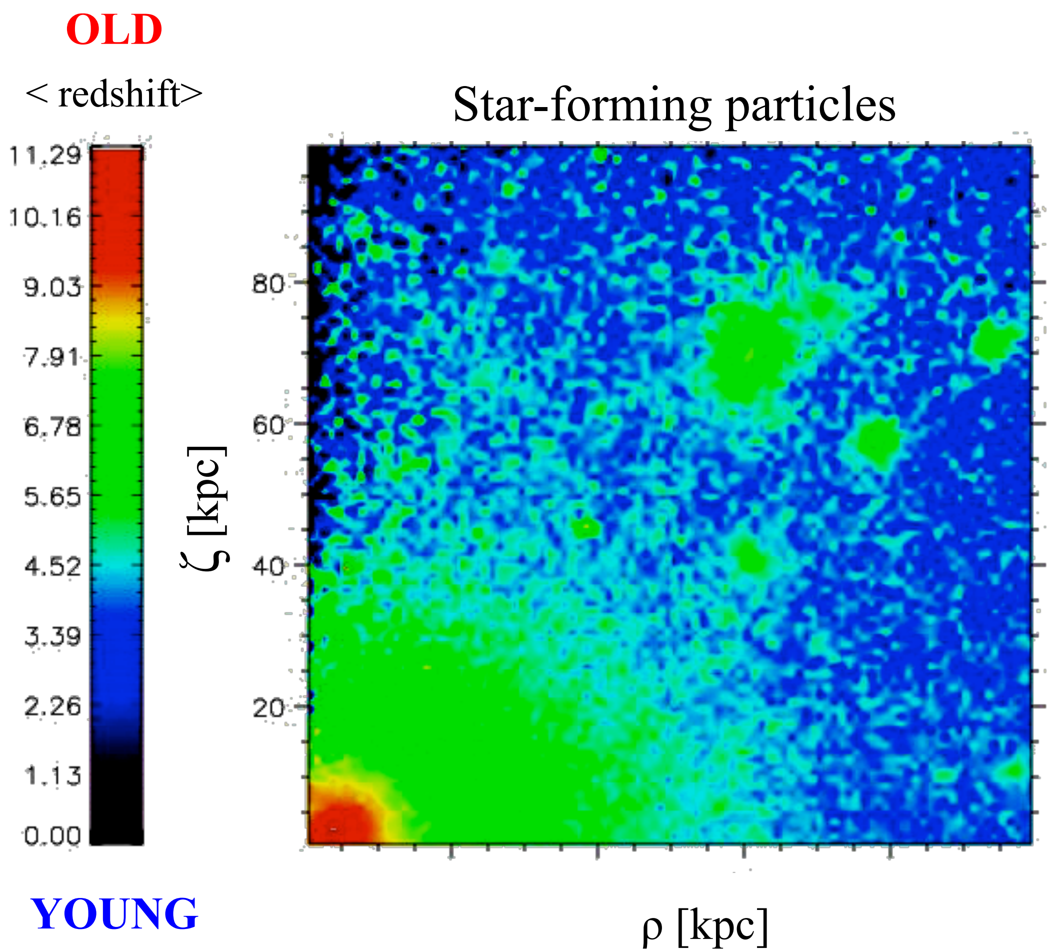
-The Initial Mass Function?

- Did low-mass Z = 0 stars form?

WHERE ARE THE MOST ANCIENT STARS ?

e.g. White+03; Diemand+04; Scannapieco+06; de Lucia & Helmi 08; Salvadori+10; Tumlinson 10; Zolotov+10; Chiappini+

N-body simulation of a Milky Way analogue + semi-analytical chemical evolution model



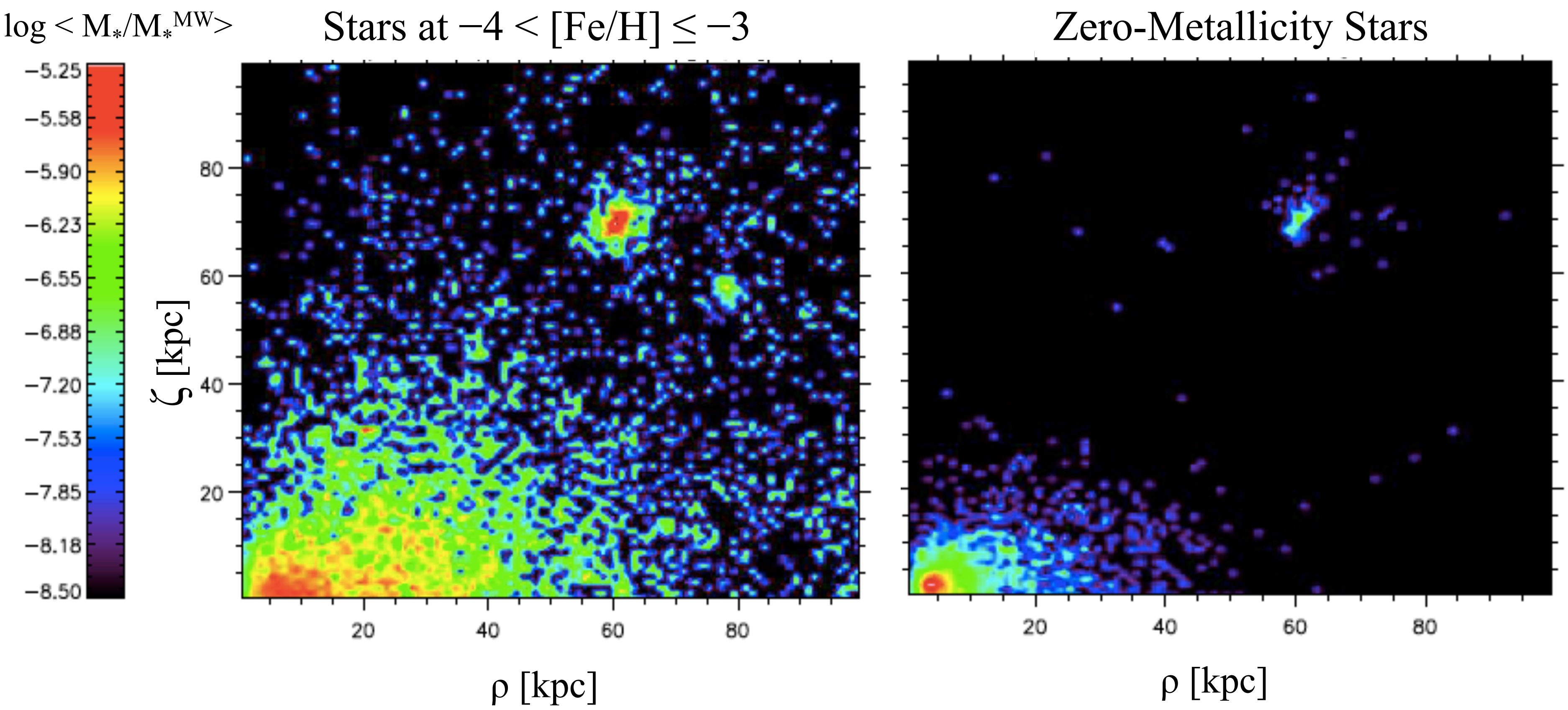
Salvadori+10

The oldest stars are concentrated into the inner part of the Galaxy
(see also Diemand+05; Tumlinson 10)

AND THE MOST METAL-POOR STARS ?

e.g. White+03; Scannapieco+06; de Lucia & Helmi 08; Salvadori+10; Tumlinson 10; Zolotov+10; Starkenburg+17; Chiappini+16

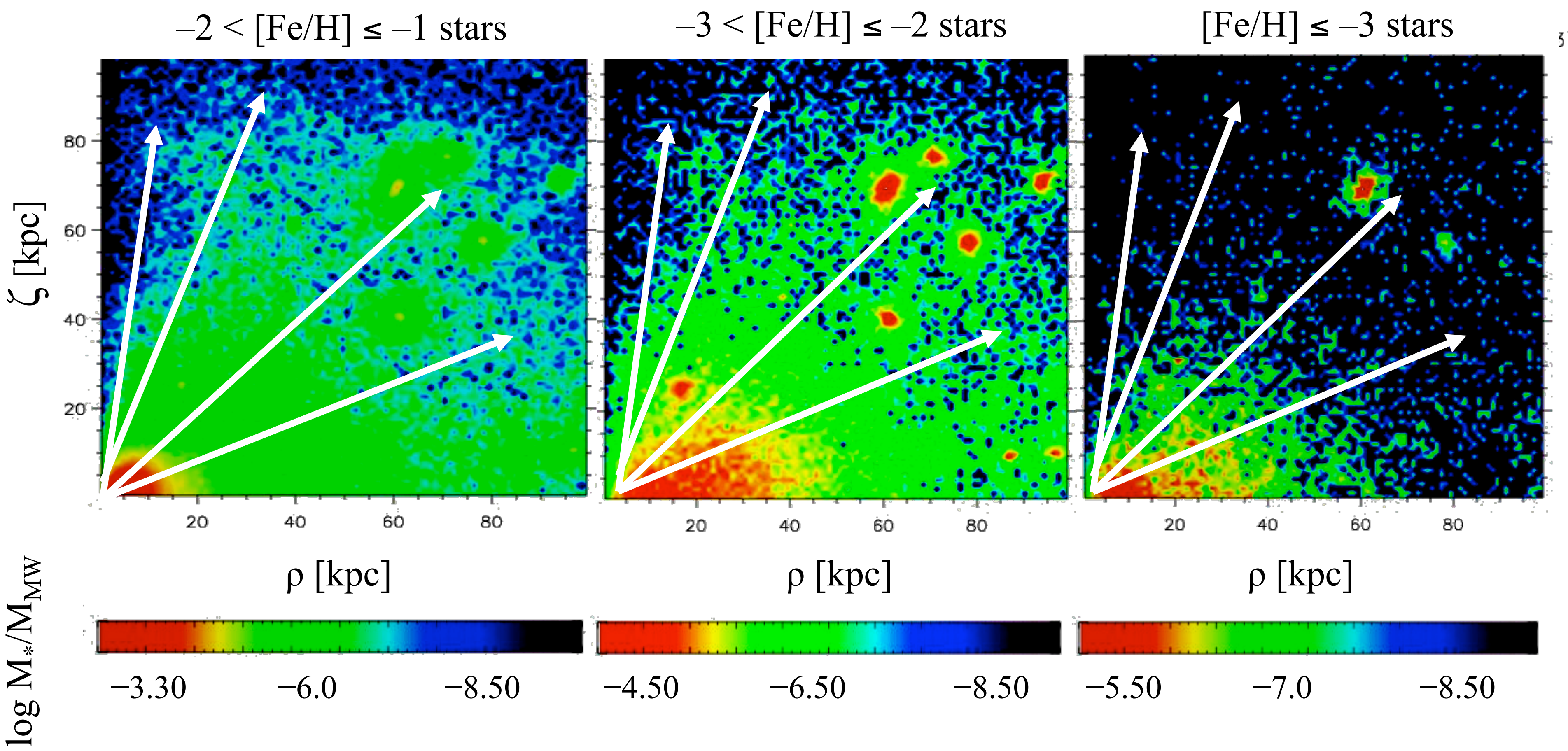
Salvadori+10



Extremely metal-poor stars are more concentrated into the inner part of the Galaxy
(see also e.g. Scannapieco+06; Tumlinson 10; Zolotov+10; Starkenburg+ submitted)

PROBLEM: HIGHLY POPULATED REGION

Salvadori+10

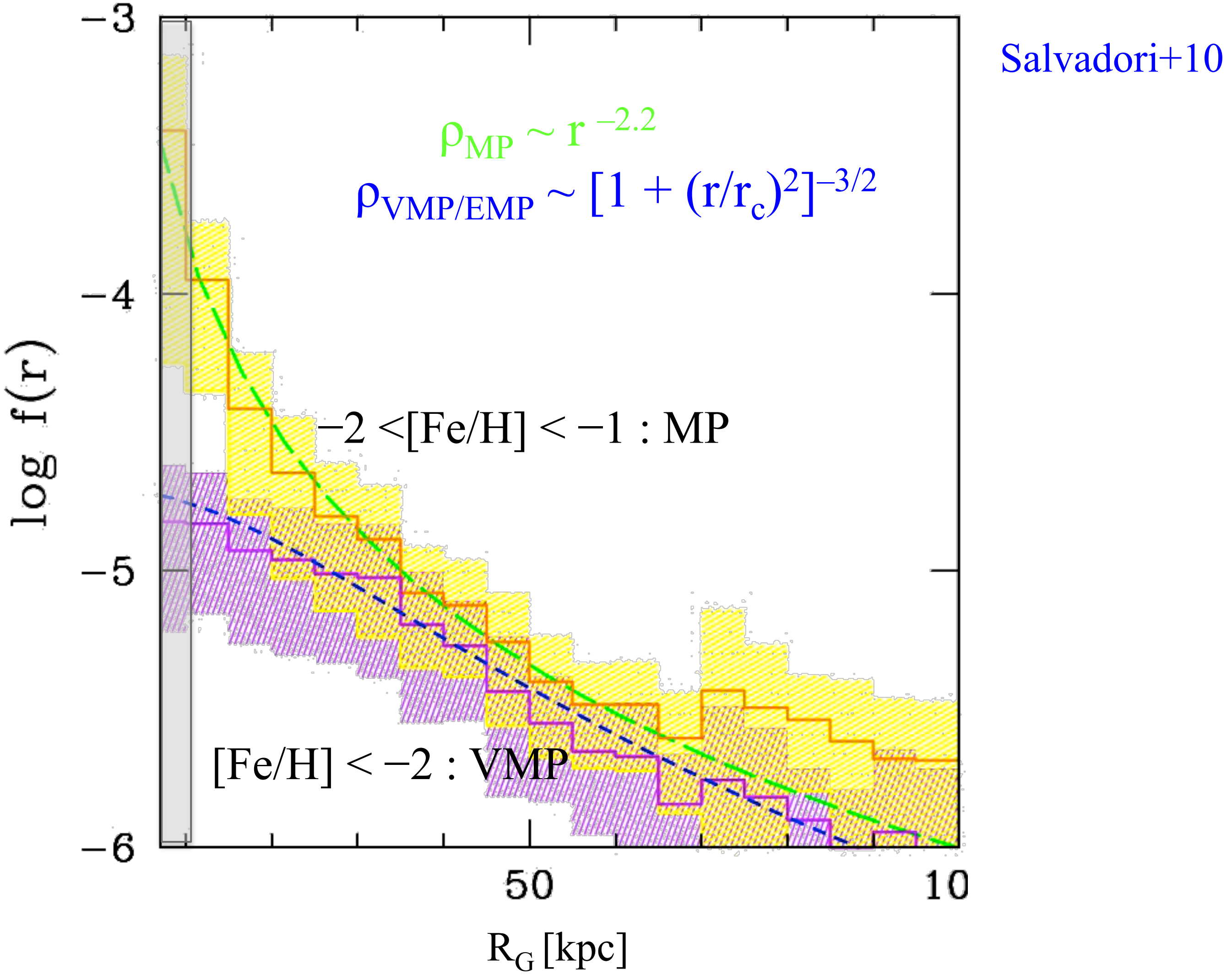


Quantifying the density distribution of stars with different [Fe/H] at different R_G

STELLAR DENSITY PROFILES AT DIFFERENT [Fe/H]

see also De Lucia & Helmi 08; Zolotov+10; Tumlinson+10; Carollo+08/12

@ $R_G \leq 10$ kpc
$F(VMP/MP) \simeq 3.5$ %



The Fraction of VMP to MP stars increases with Galacto-centric distance:
17% @ r < 20kpc, > 40% @ r < 20kpc – see also Carollo+

METALLICITY DISTRIBUTION OF BULGE STARS

e.g. Ness+12; Chiappini+12; Griego+13; Howes+14; Howes+16

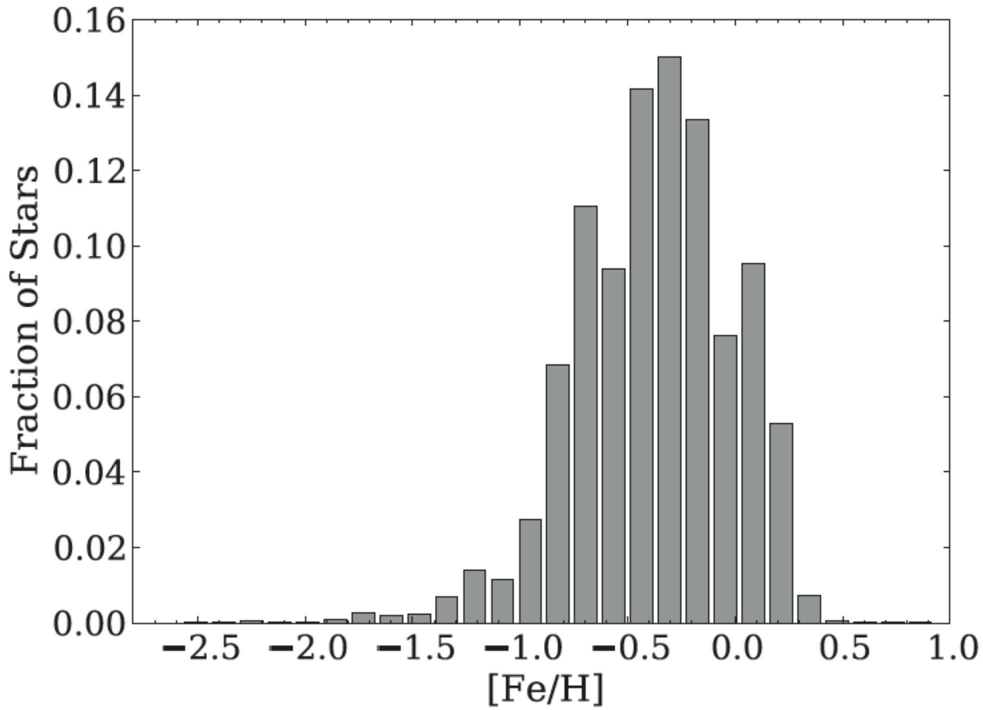
Ness+12

ARGOS Bulge Survey

Table 1. Metallicity distribution of the 14 150 stars with $|R_G| \leq 3.5$ kpc.

Number of stars	[Fe/H] range
16 stars	$[Fe/H] \leq -2.0$
84 stars	$-2.0 < [Fe/H] \leq -1.5$
522 stars	$-1.5 \leq [Fe/H] < -1.0$
4219 stars	$-1.0 < [Fe/H] \leq -0.5$
6914 stars	$-0.5 < [Fe/H] \leq 0$
2392 stars	$[Fe/H] > 0$

Metallicity Distribution Function (MDF)



Fraction ([Fe/H] ≤−2/[Fe/H] ≤−1) ≈ 2.5%

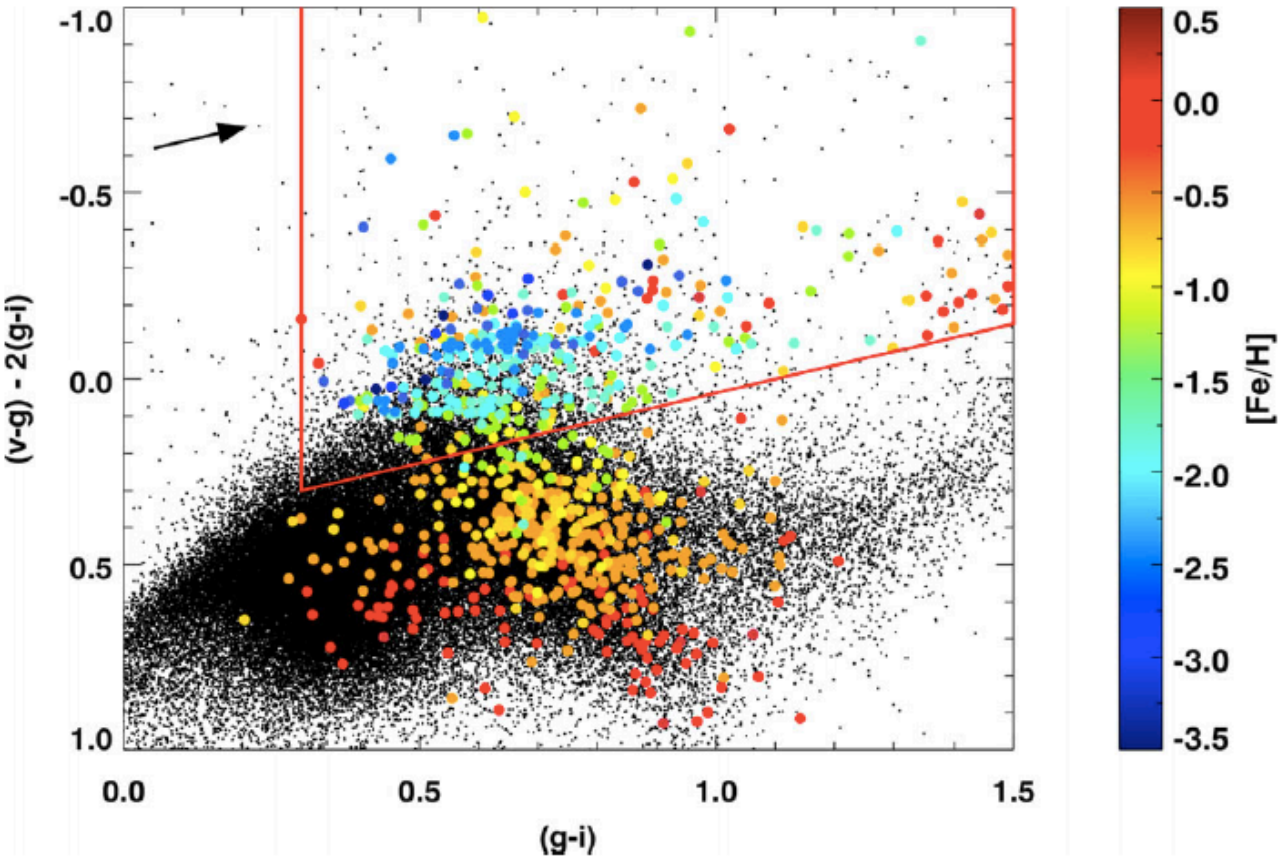
Fraction ([Fe/H] ≤−2/total) ≈ 0.1%

EXTREMELY METAL-POOR BULGE STARS

EMBLA survey – Howes+

A 3 step process to get chemical abundances of the most metal-poor Bulge stars

Pre-selection using SkyMapper photometry



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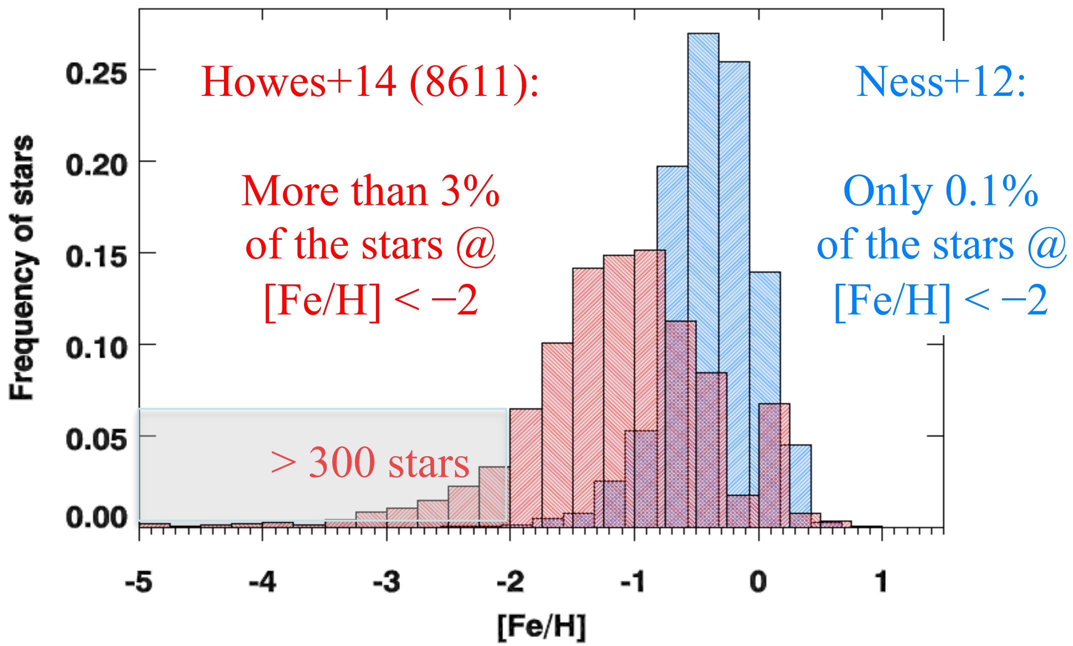

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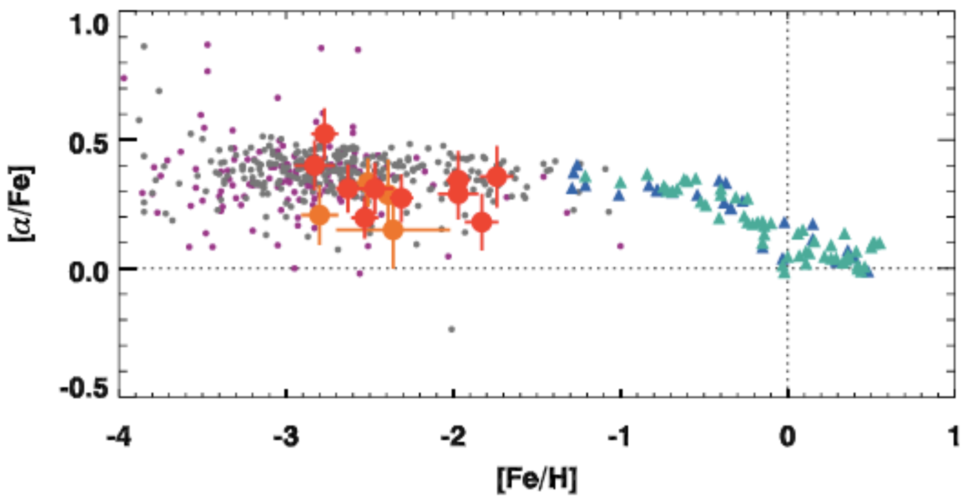
High-resolution spectroscopy of the most metal-poor candidates

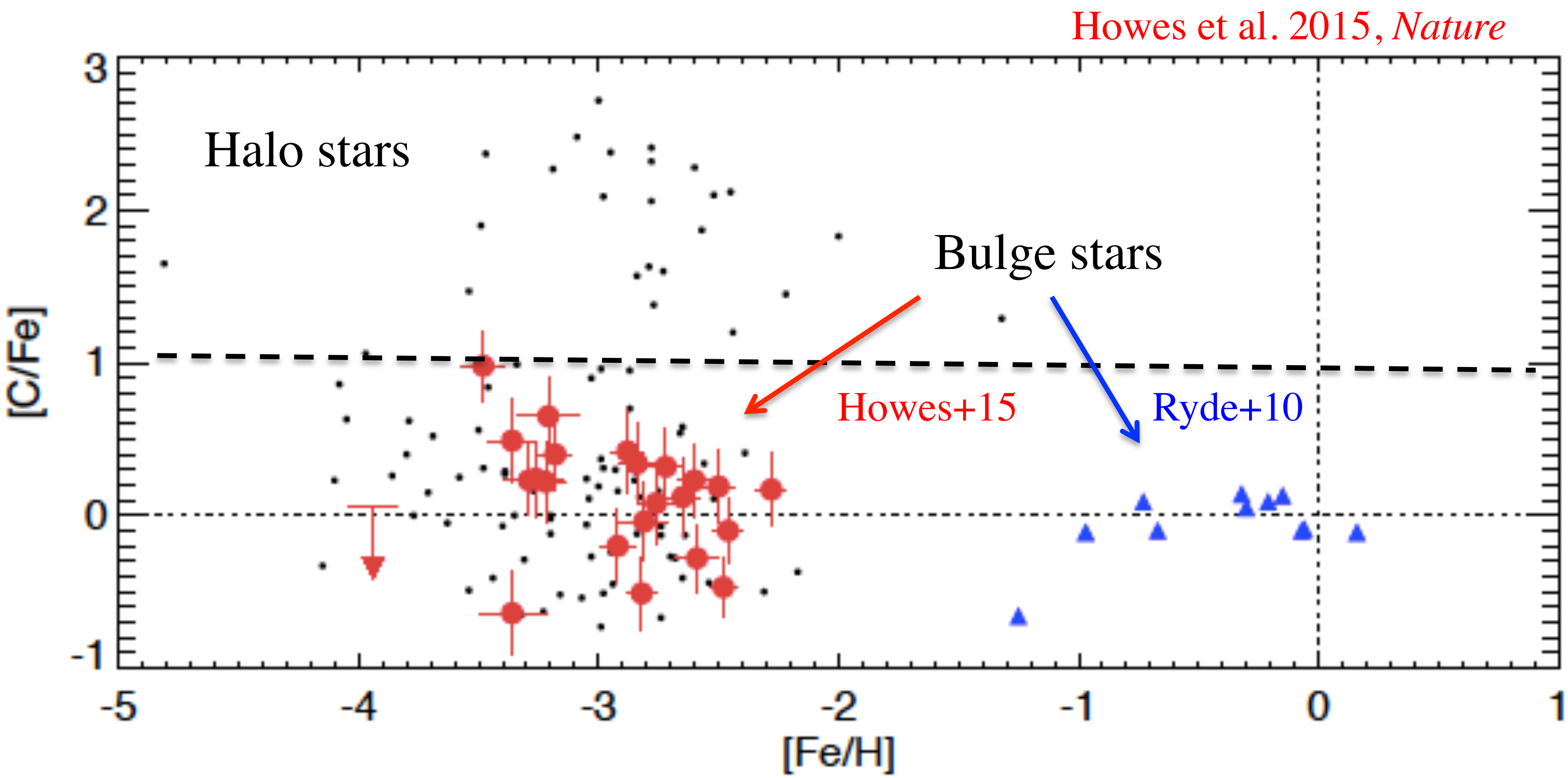
Howes+16:

10 bulge stars @ [Fe/H] < -1.7
(MIKE/Magellan)
Chemical elements from C to Ni



CHEMICAL PROPERTIES OF EMP STARS IN THE BULGE

23 extremely metal-poor stars observed with the Mike/Magellan HR spectrograph



Apparent lack of carbon-enhanced metal-poor stars. Low number statistics ?
Note: only 7 stars with accurate kinematics and tightly bound orbits

THE MOST ANCIENT STARS WITH MOONS?

Candidates pre-selection via photometry. Which data/telescope can we use?

- Skymapper data ? If available! Properties: 1.3m telescope, six bandpasses in 5.7-degree field of view. Narrow v-band filter centered on the CaII K line.
- Gaia data ? Possibly, although the Bulge is only partially covered. Key point: candidates will also have accurate kinematics and distances.
- CFHT ? Properties: 3.6m optical/infrared telescope. Previous experience from the Pristine survey (CaHK filter) can be used to build-up a Bulge survey.
- VST ? Properties: 2.6m telescope, wide weavelength range (0.3-1.0 microns). Ad hoc narrow filter (SkyMapper/Pristine) can be constructed →Bulge survey

Assuming to have enough pre-selected candidates and to observe ~ 200 targets per night we can obtain 20,000 spectra in 100 nights. Expected # of VMPs from Howes+ > 3% meaning > 600 stars. But we can do better with a better filter.