Chemical Abundances and Kinematics of the Galactic bulge

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MWM

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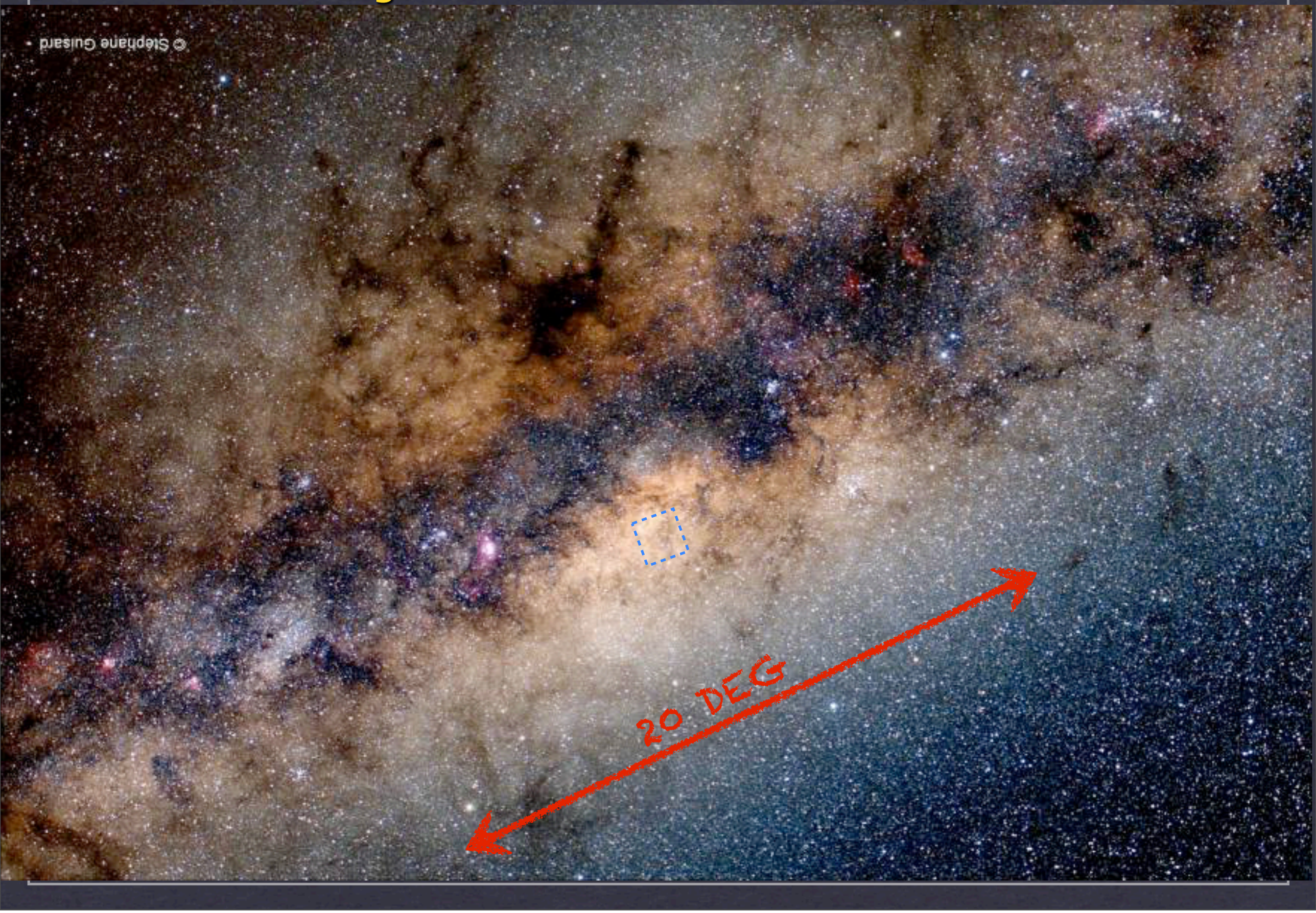
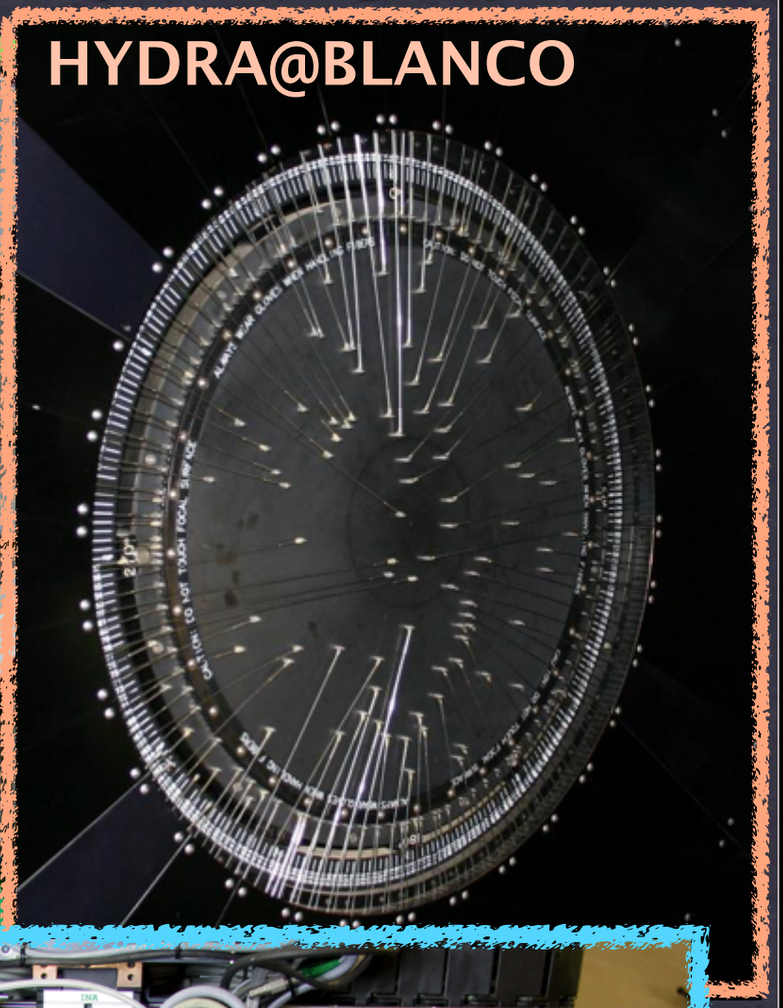
The Galactic bulge



High-res multifibre spectrographs

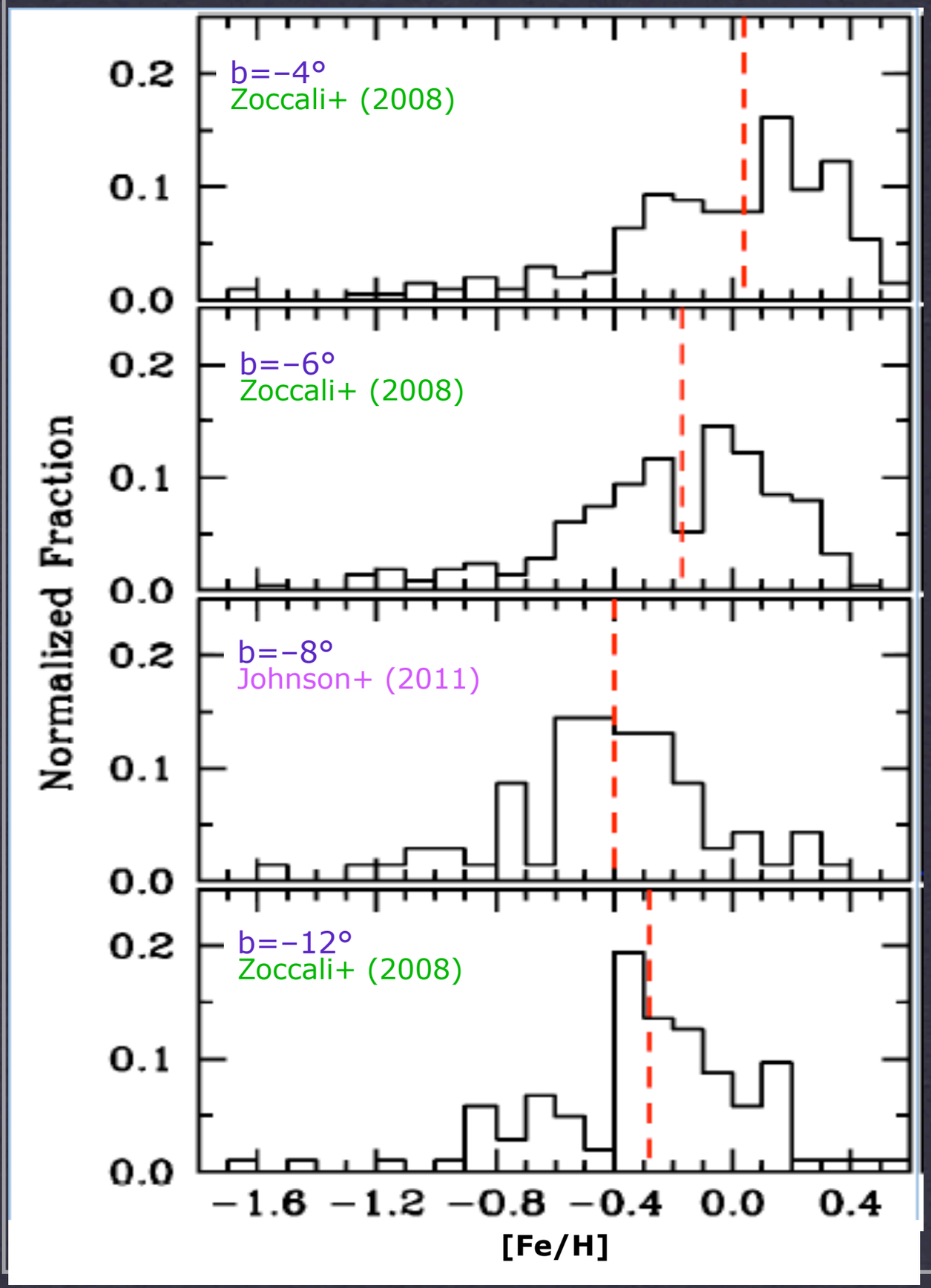
FLAMES@VLT

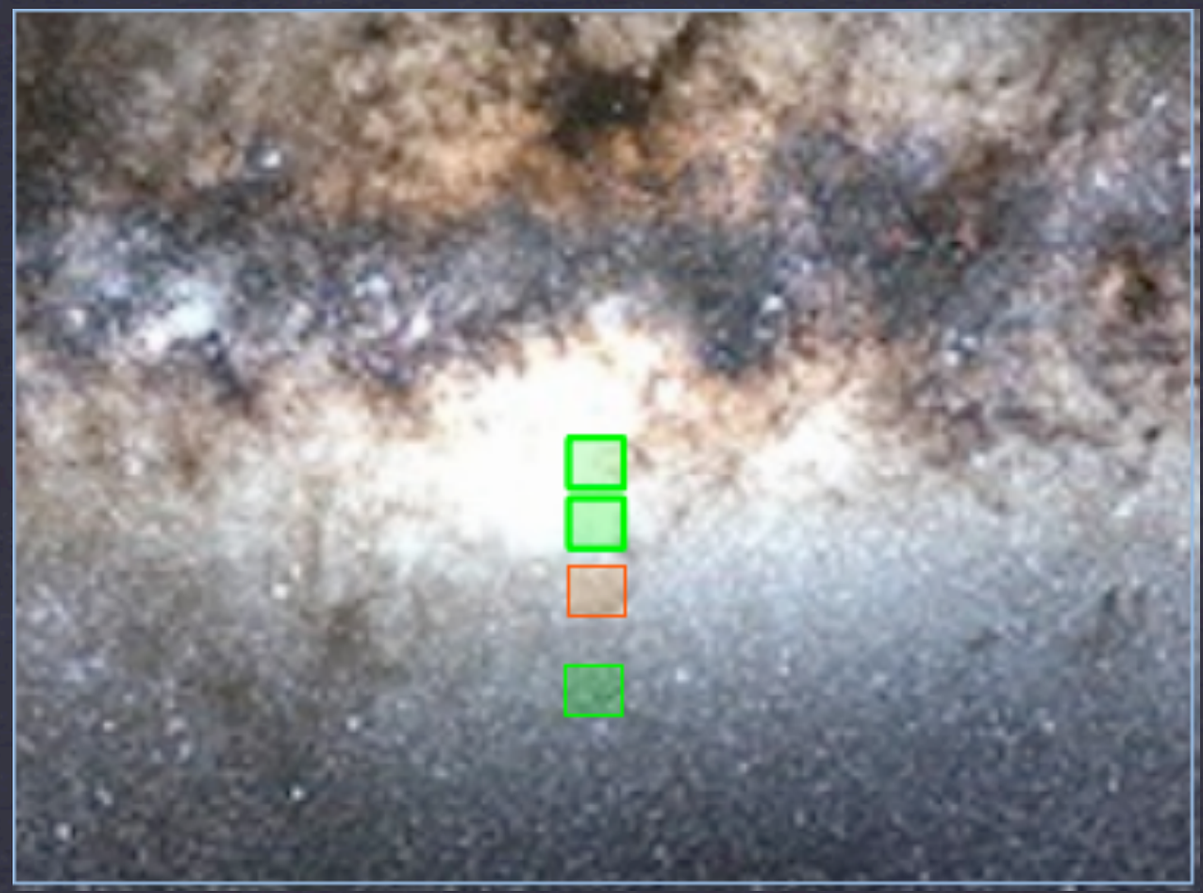
HYDRA@BLANCO



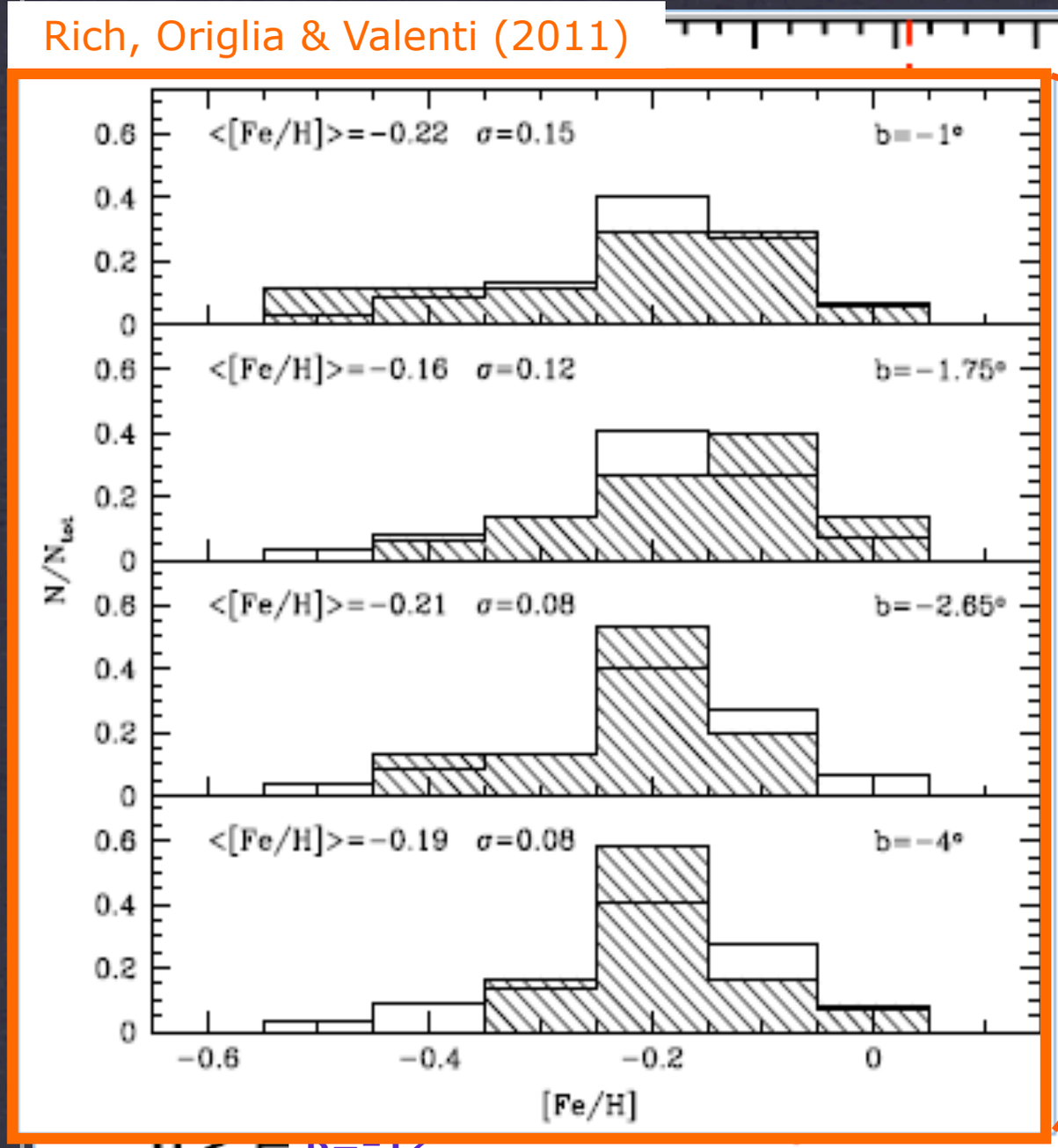
2DF@AAT

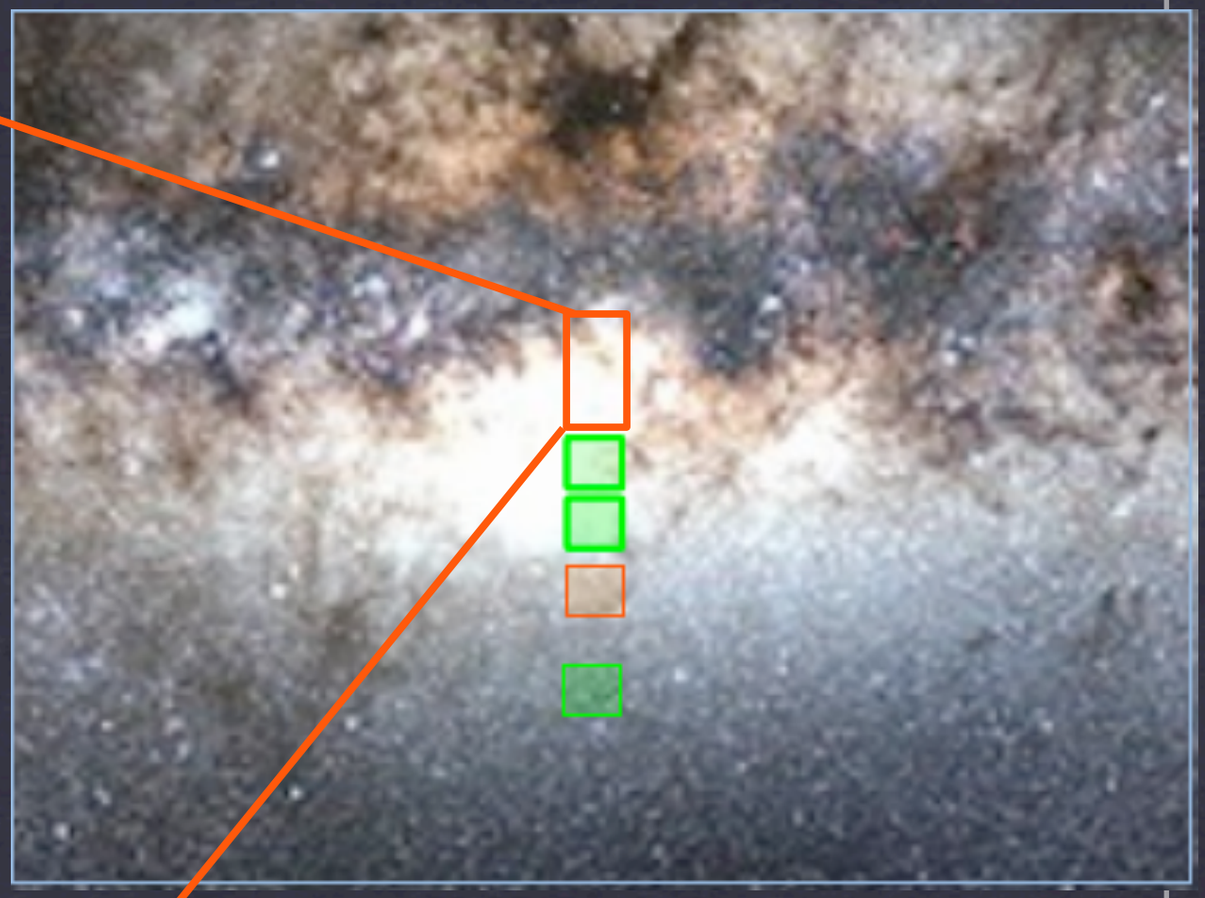
Bulge Metallicity Distribution Function (MDF)

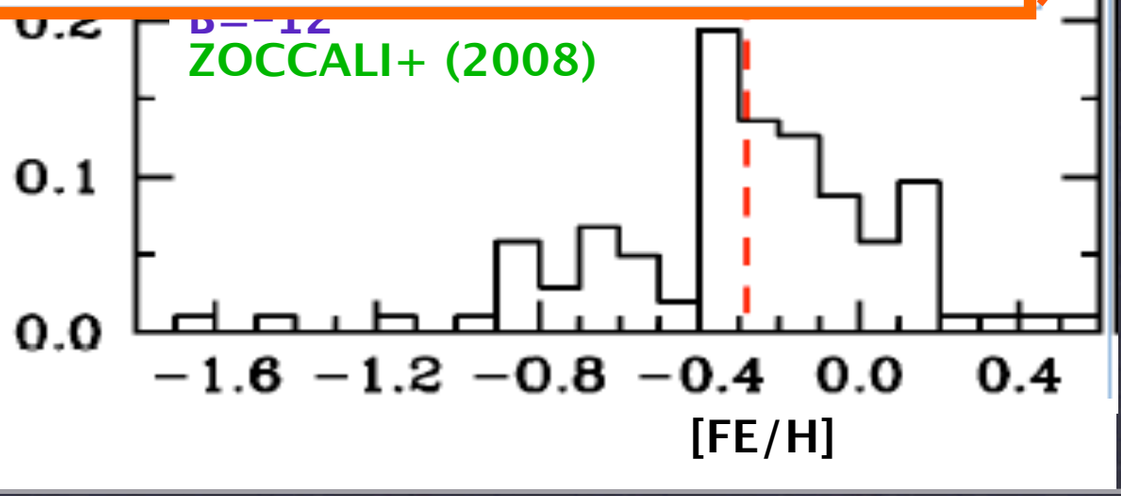




Rich, Origlia & Valenti (2011)



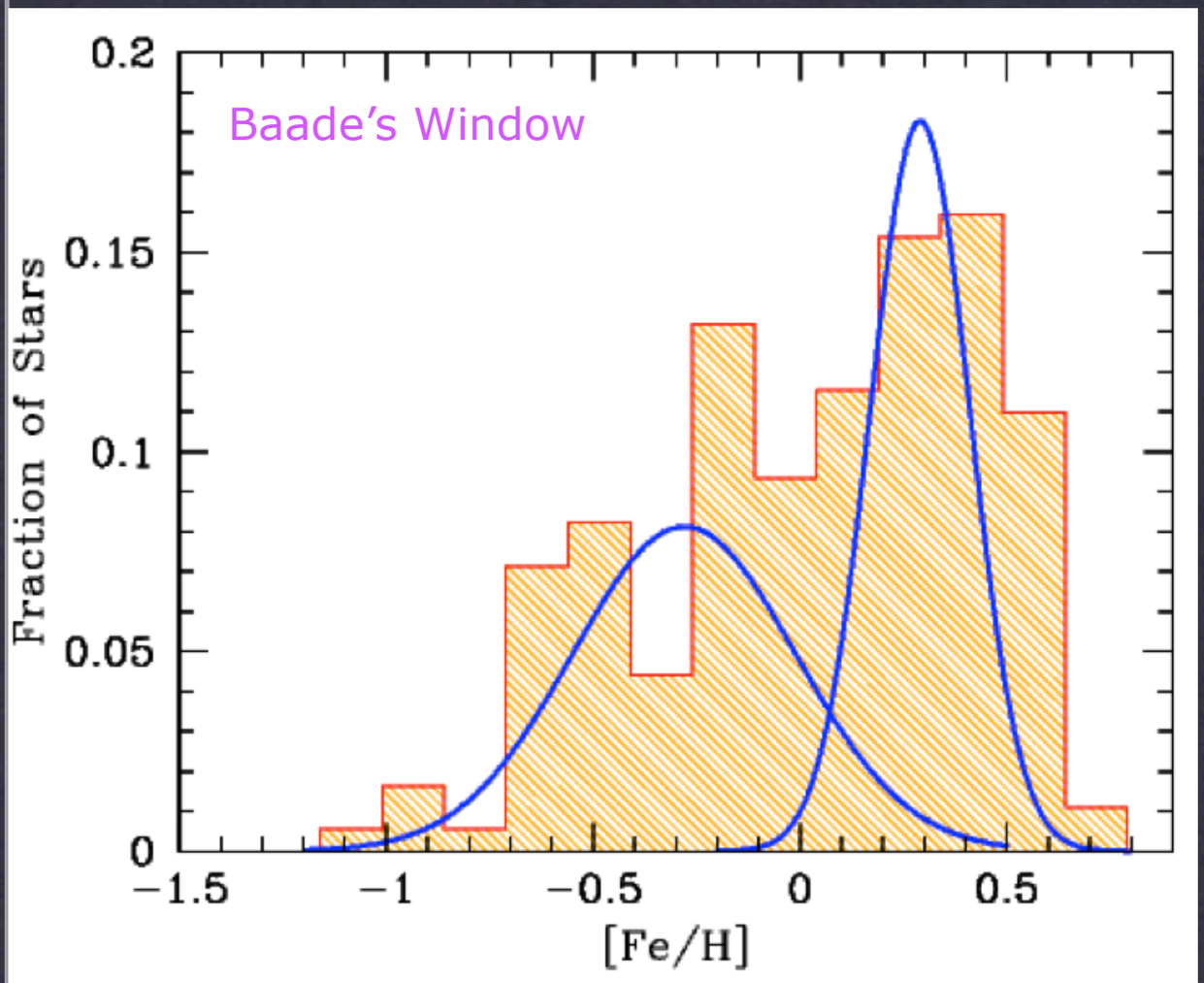




Coupling kinematics with metallicities:

a two-component bulge?

Hill et al. (2011) Two components in the MDF



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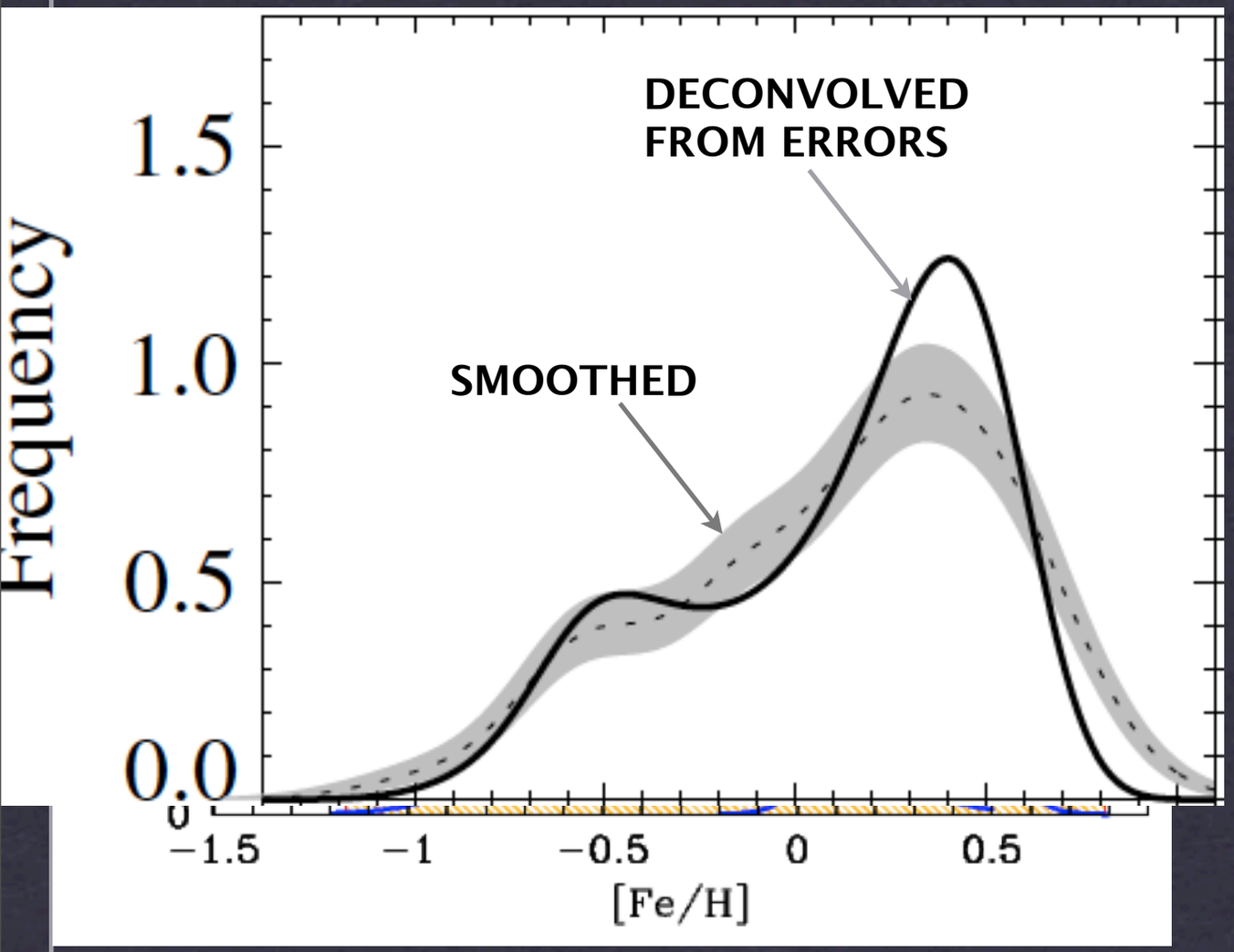

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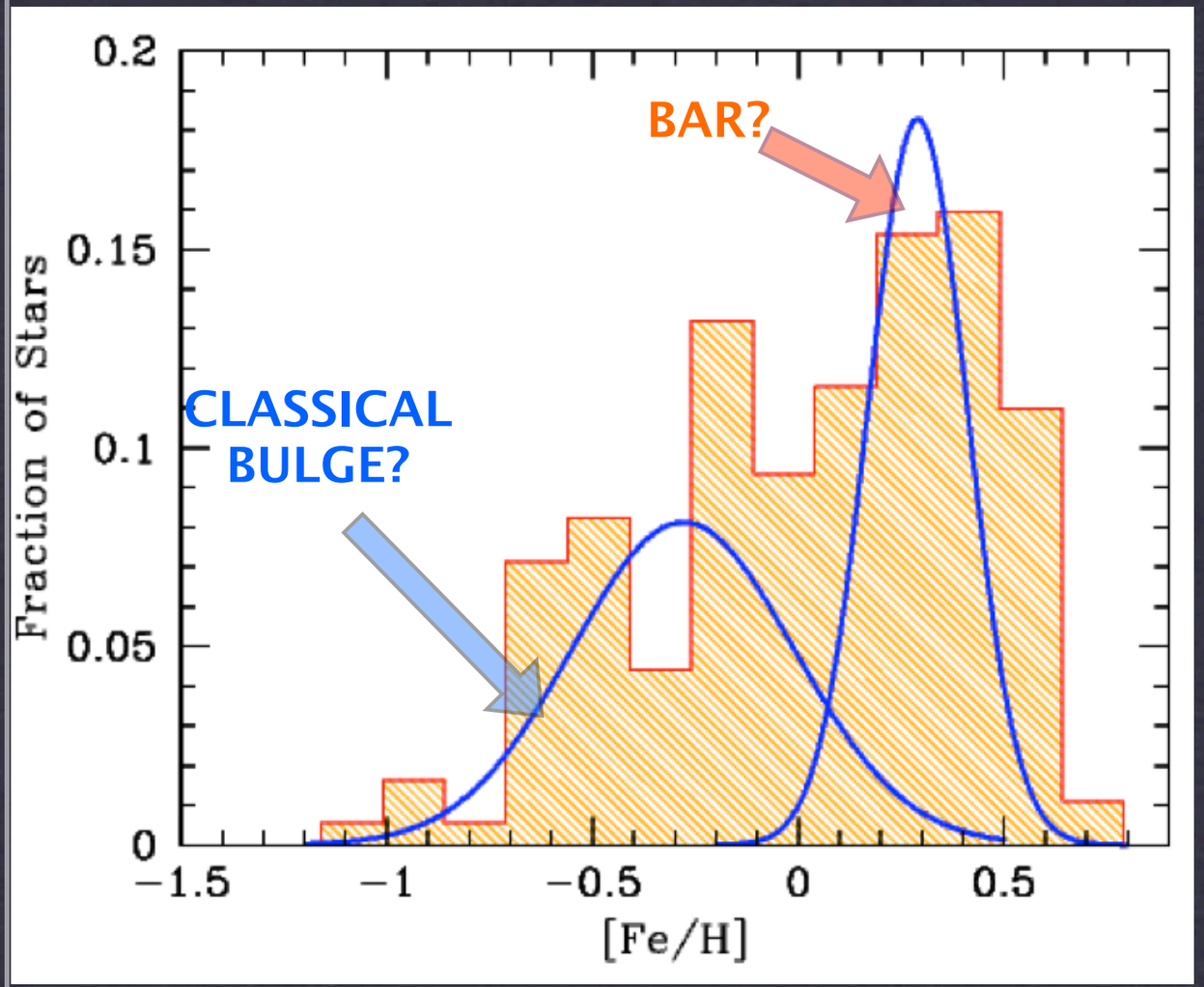
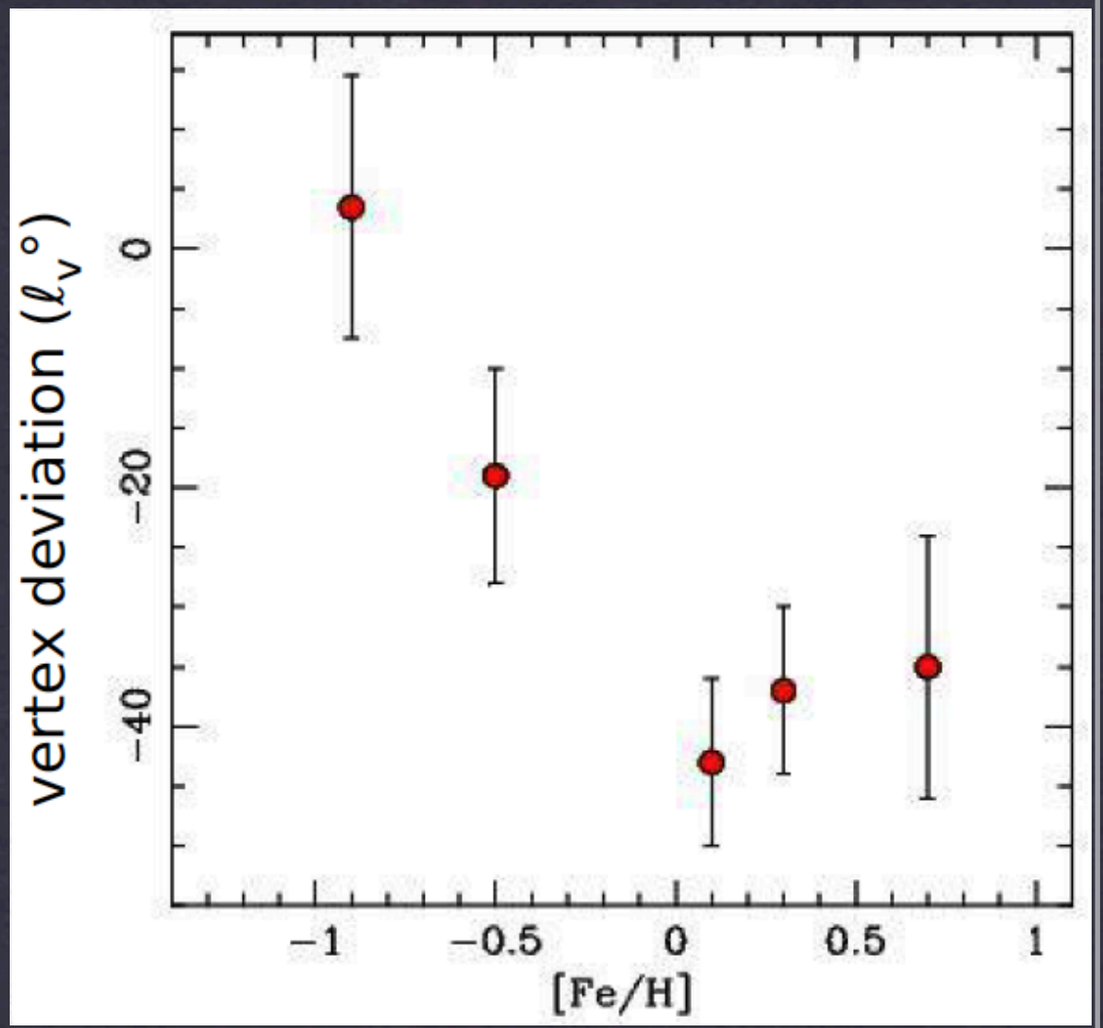


Babusiaux et al. (2010)



Coupling kinematics with metallicities:

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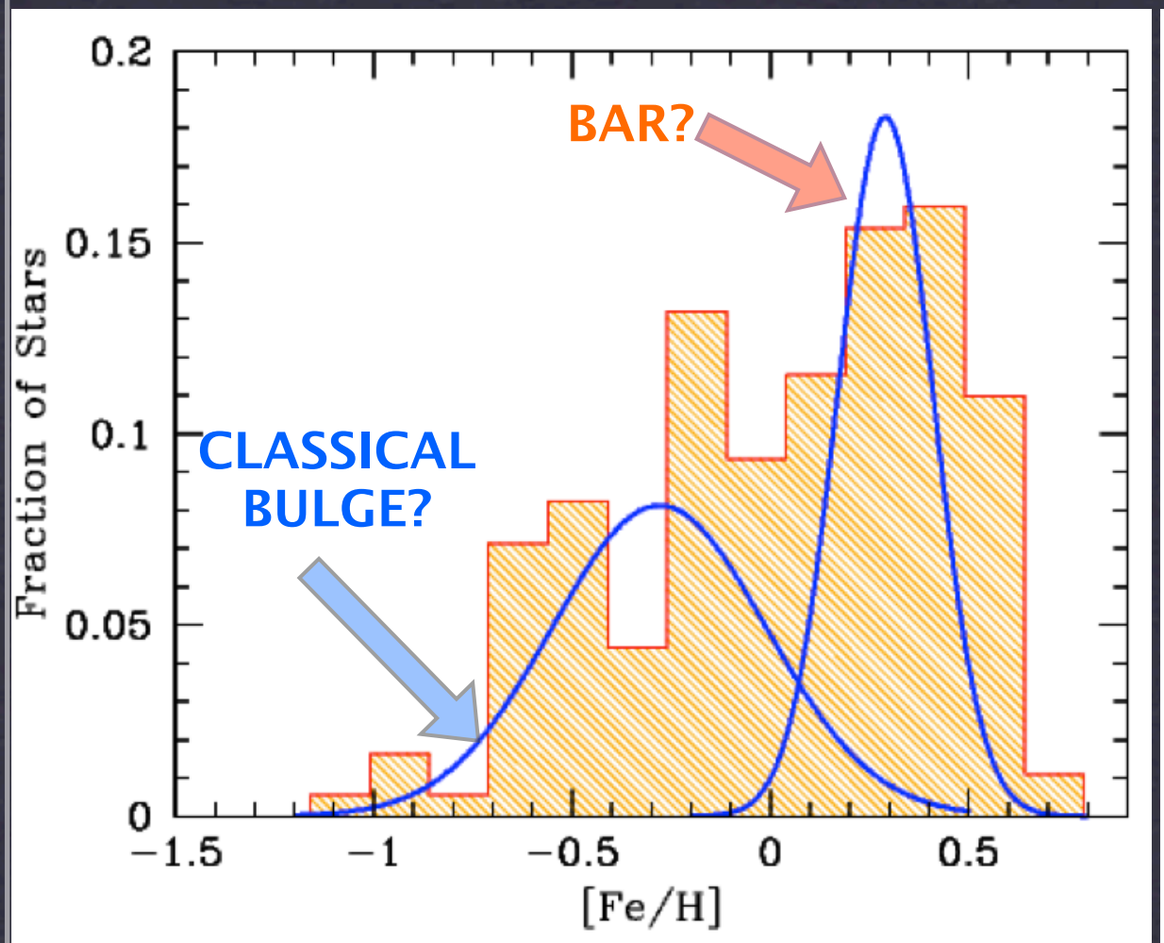
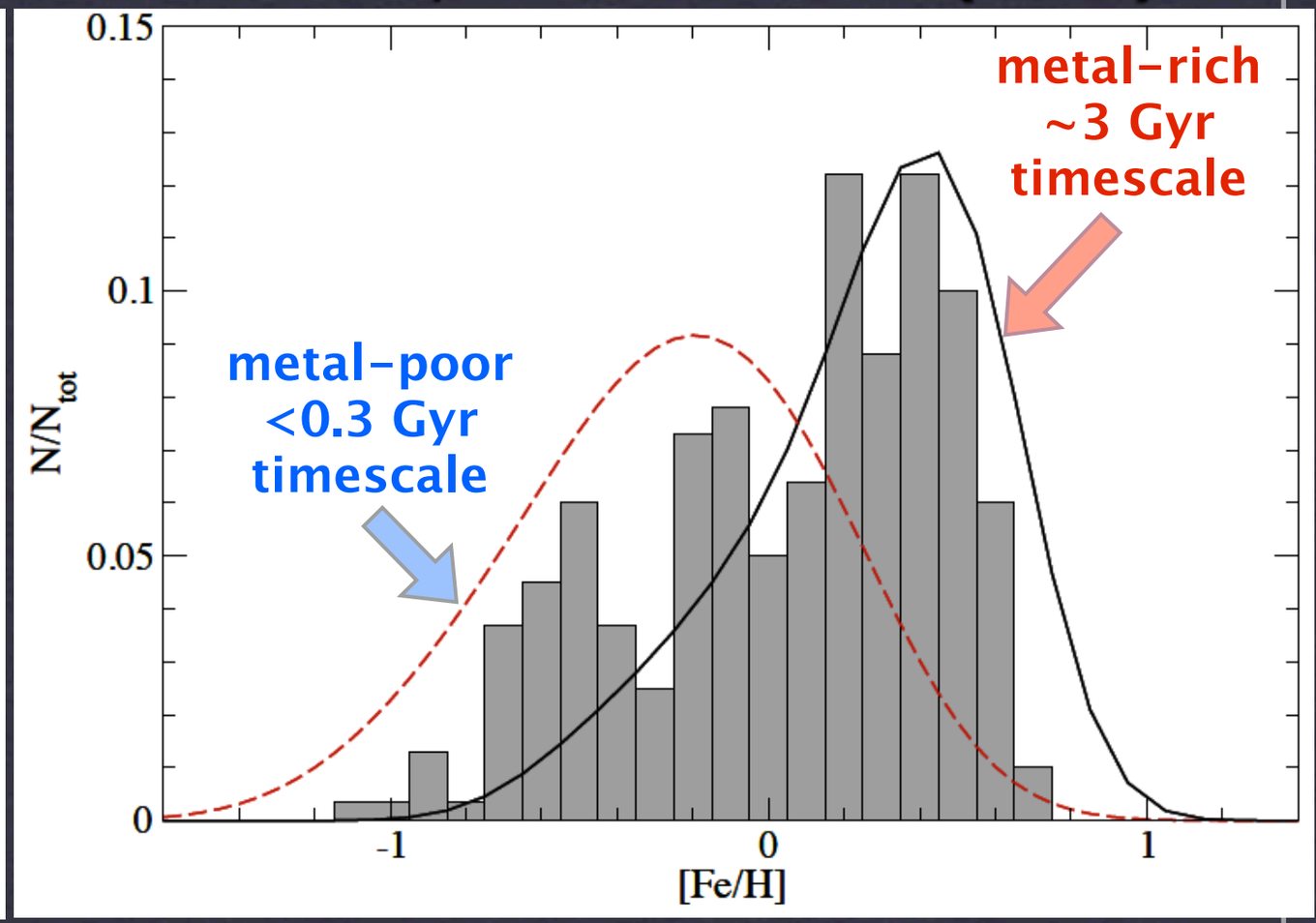
Hill et al. (2011) Two components? **Grieco, Matteucci et al. (2012)**





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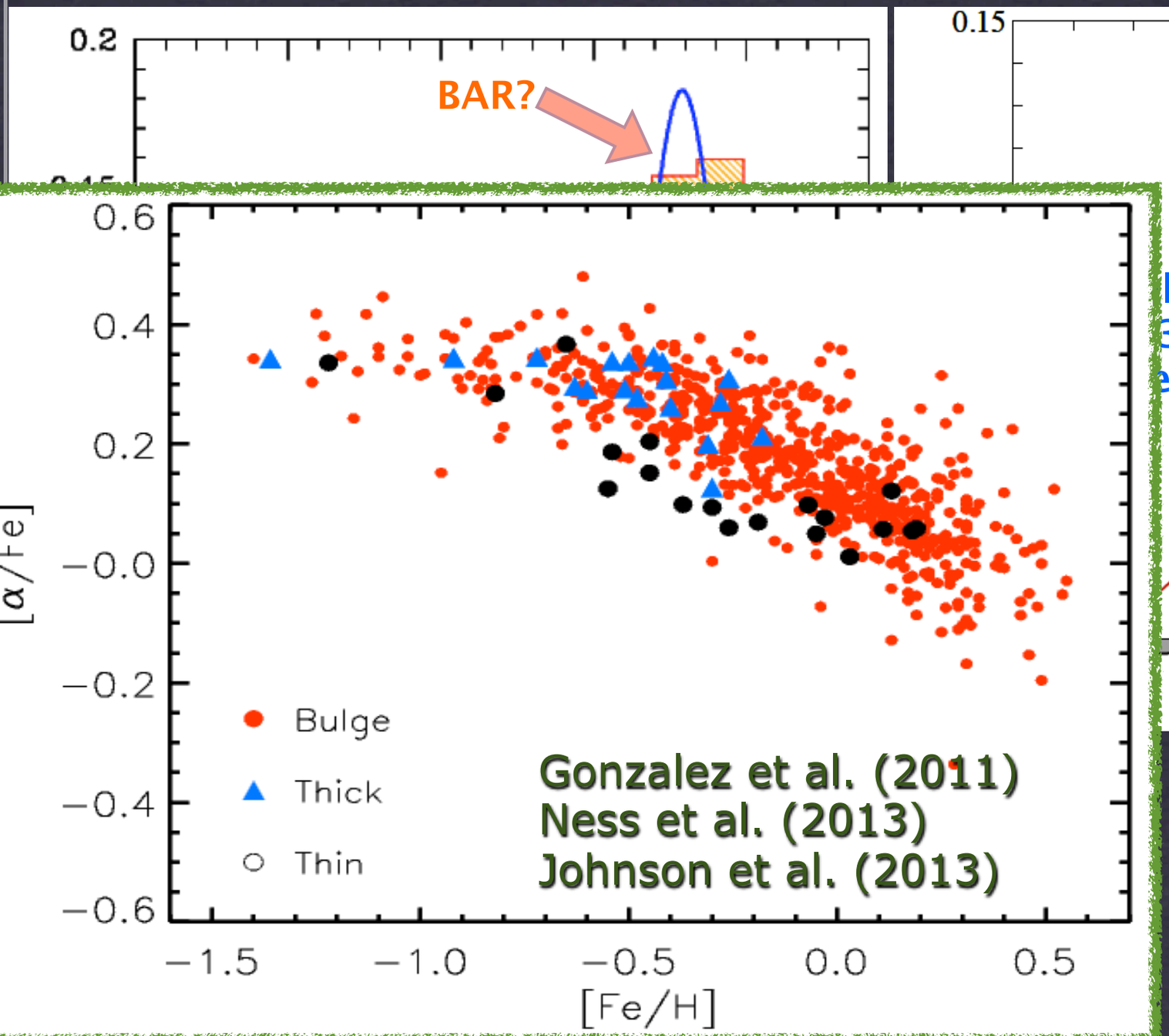
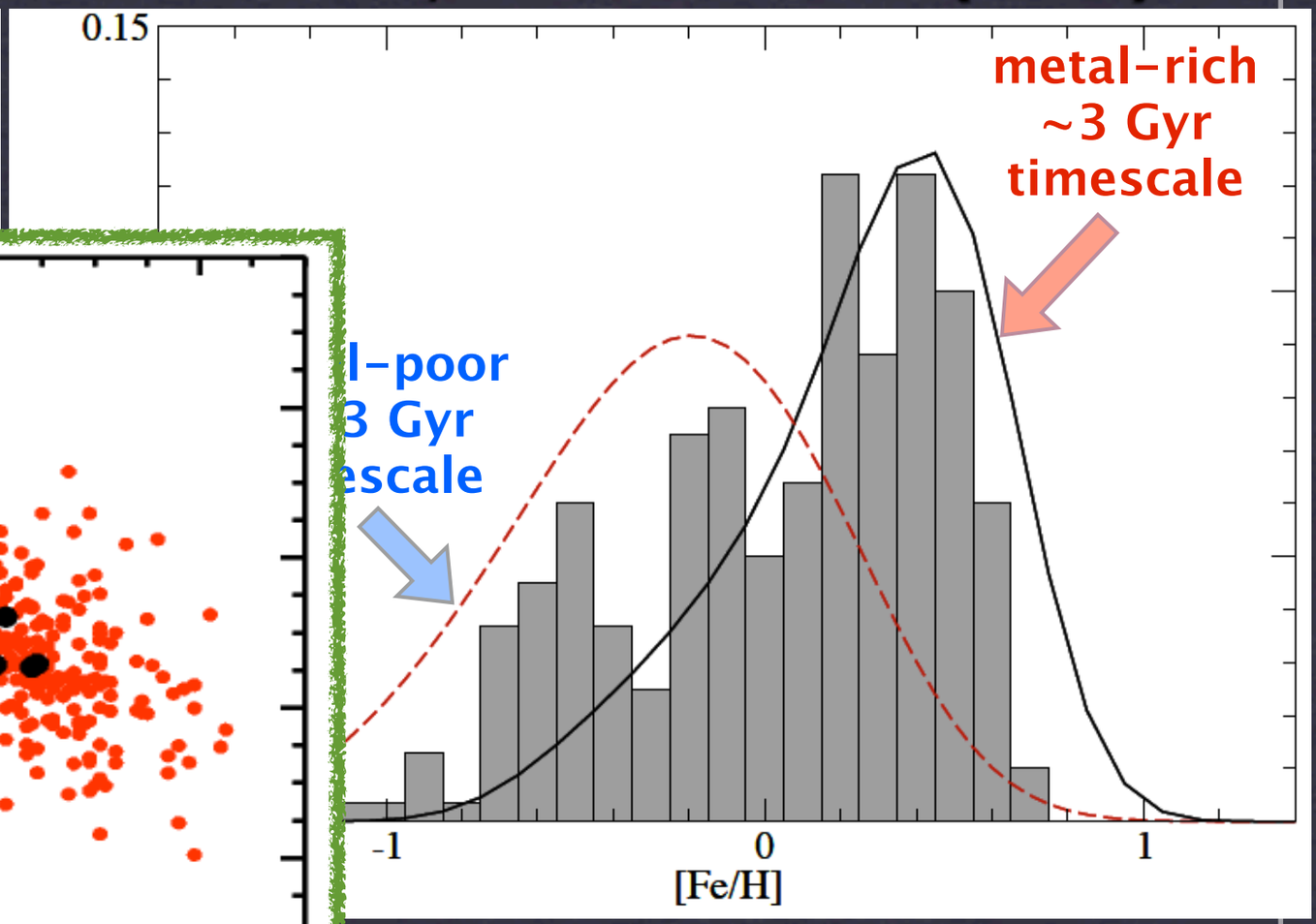


Gonzalez et al. (2011)
Ness et al. (2013)
Johnson et al. (2013)

Grieco, Matteucci et al. (2012)

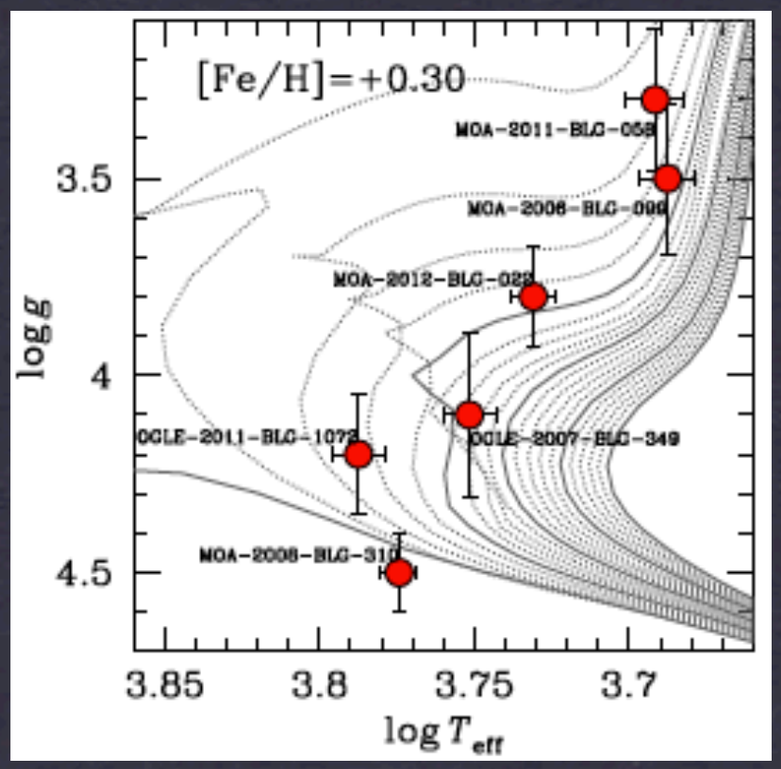


Age-Metallicity Relation from Microlensed Dwarfs:

a two-component bulge?

Bensby et al. (2013)

A significant (~30%) fraction of the microlensed dwarfs have ages<7 Gyr,
with a few as young as 1.5 Gyr.



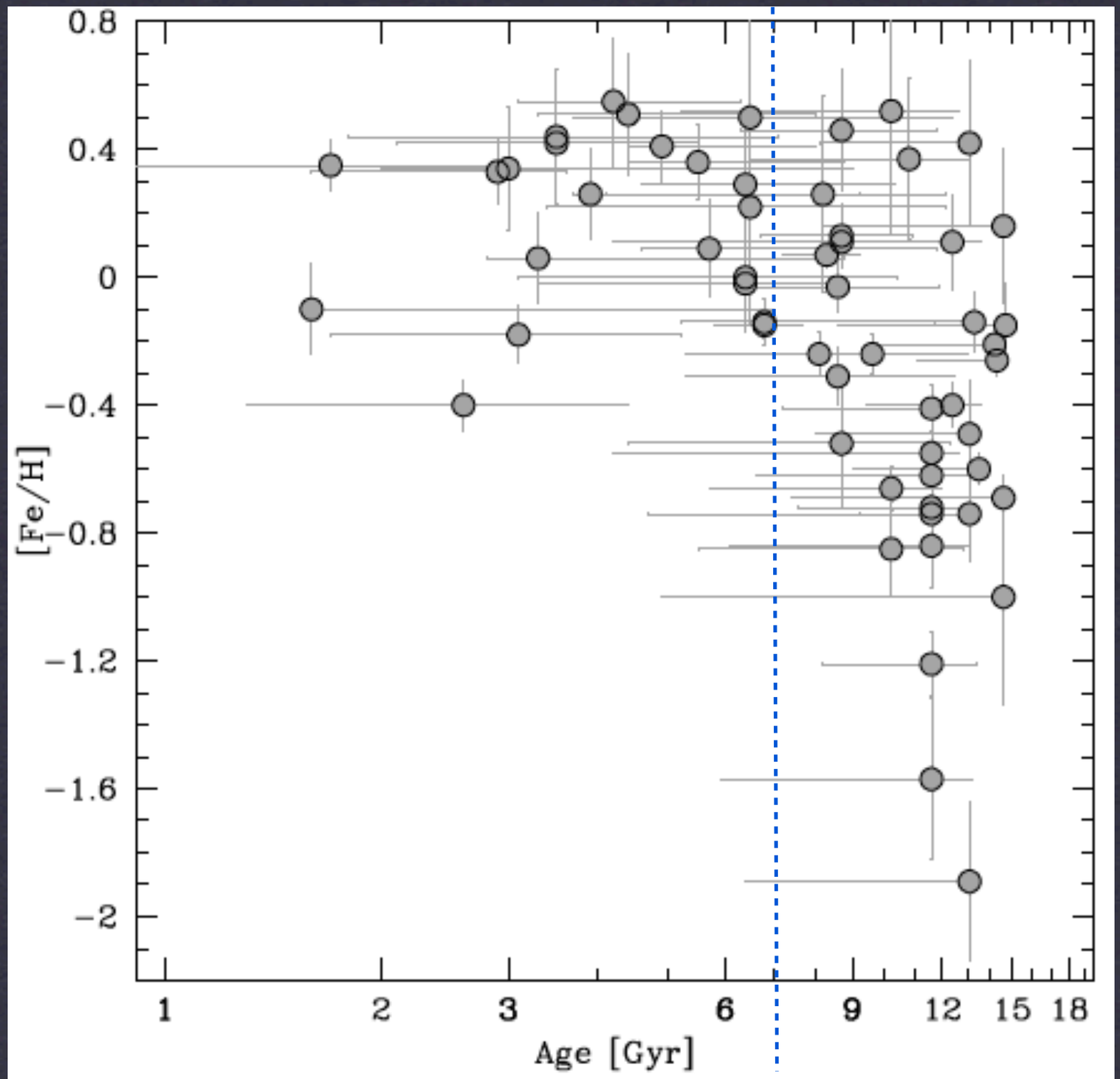


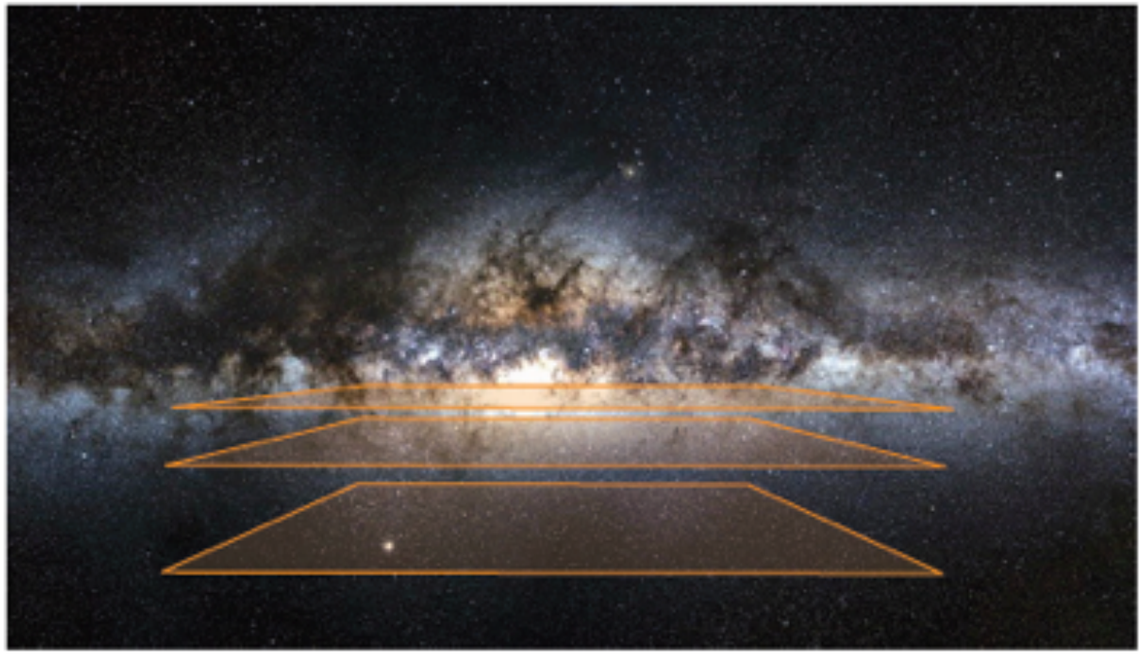
Fig. 15. Age versus [Fe/H] for the microlensed dwarf sample.

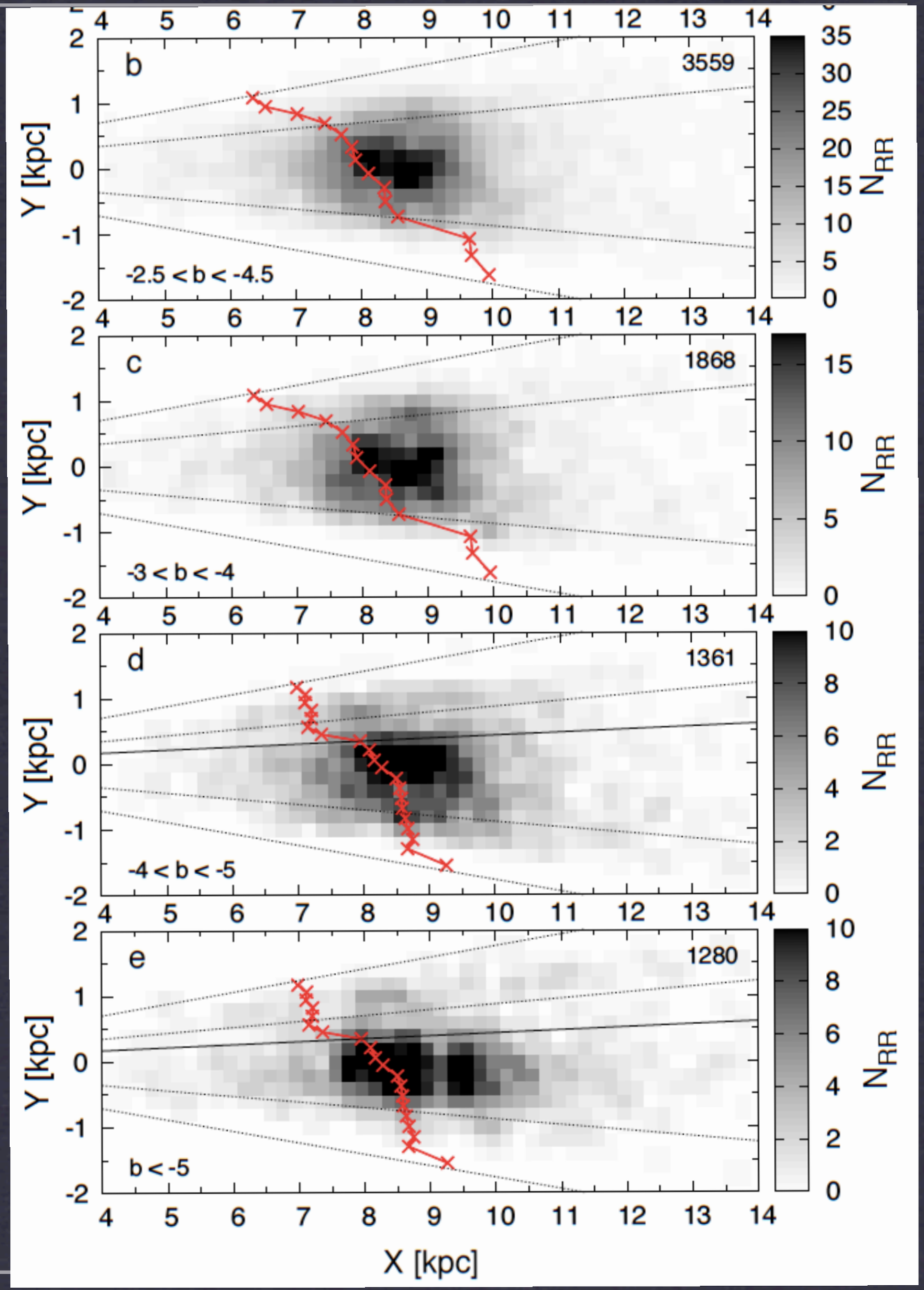
The 3D map from RR Lyrae:

a two-component bulge?

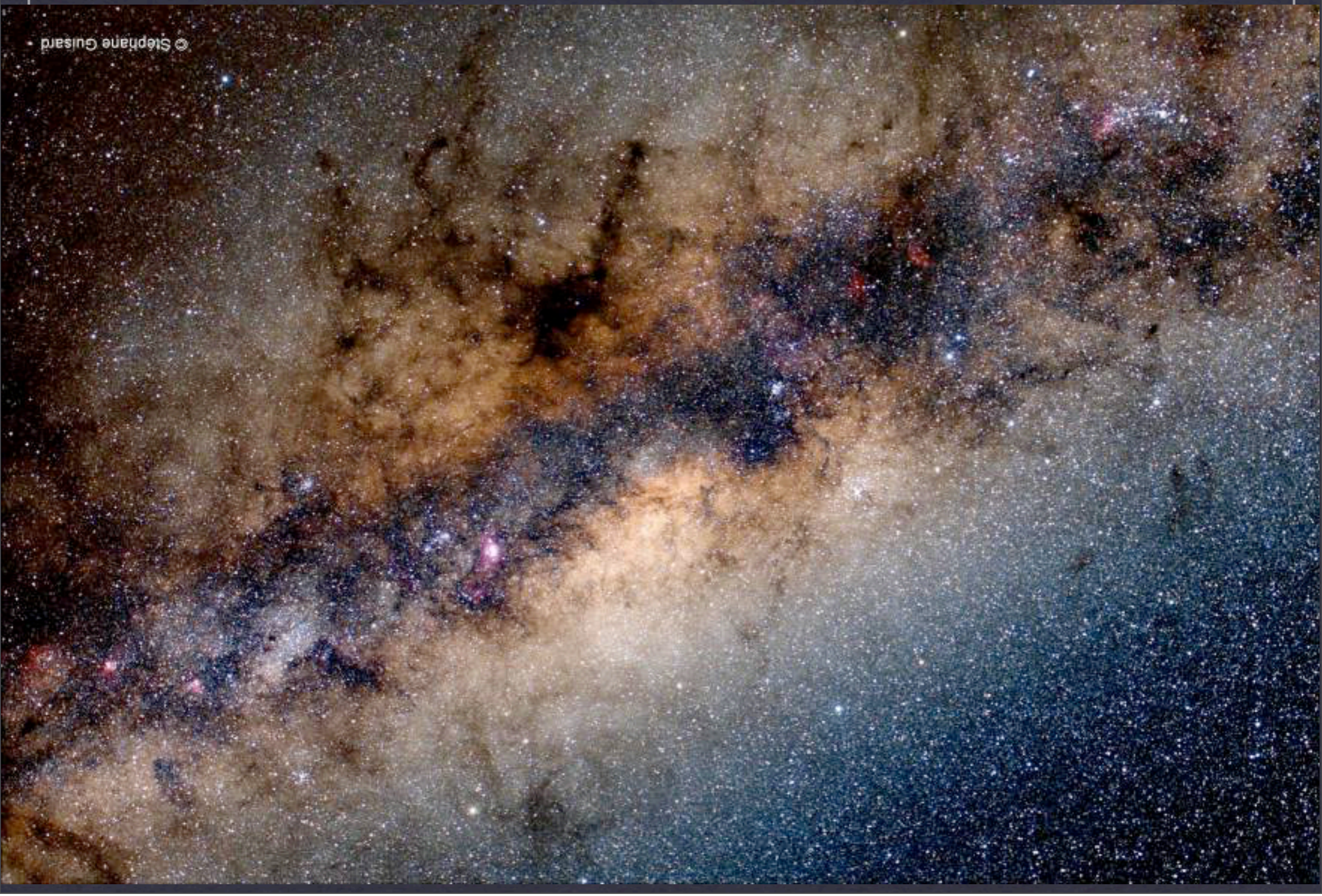
Dekany et al. (2013, *ApJL in press*)

RR Lyrae stars do not show the bar traced by RC stars





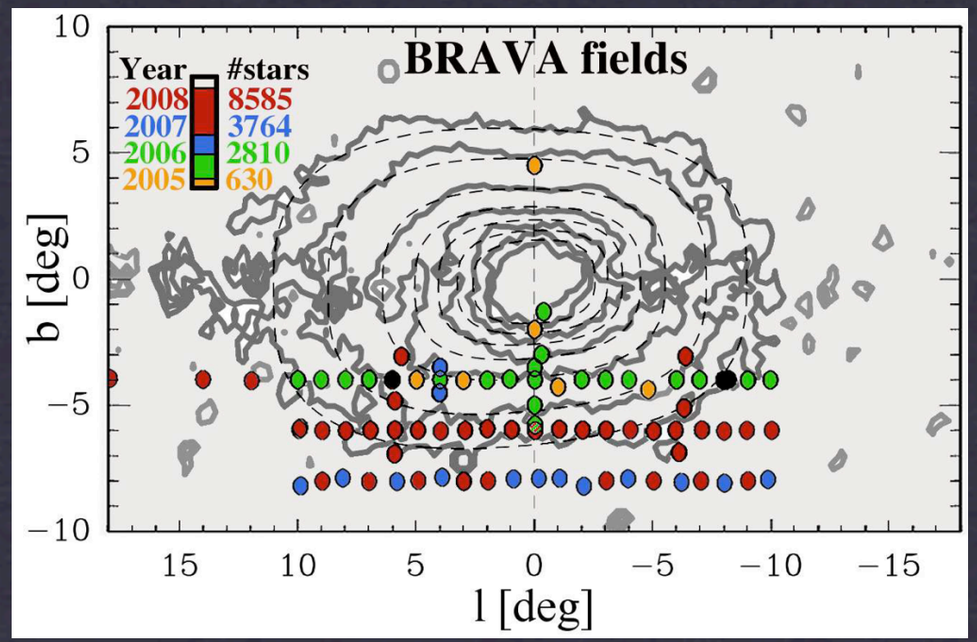
Entering the Era of Surveys

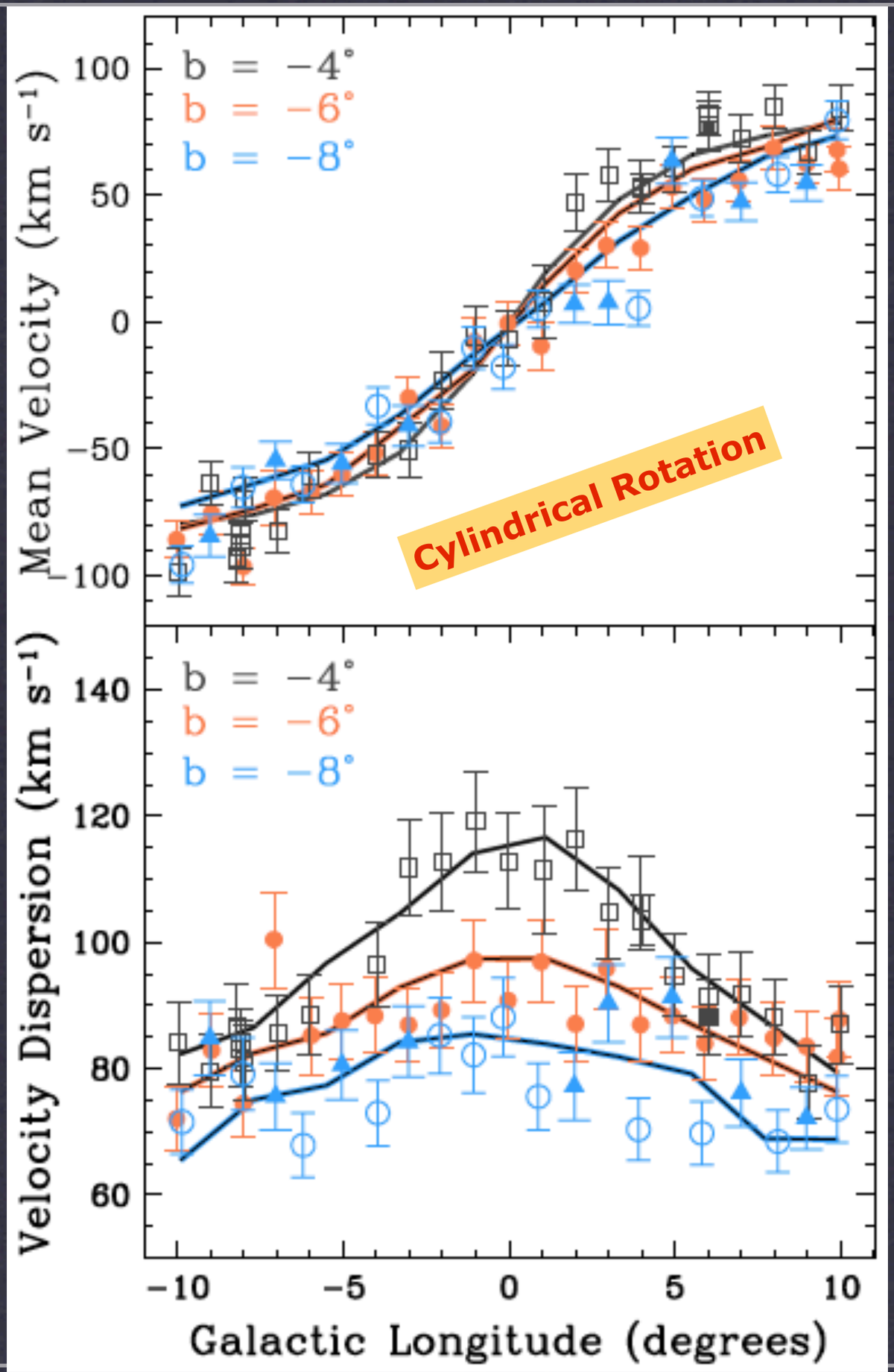


The BRAVA Survey

Rich et al. (2007)
Howard et al. (2009)
Shen et al. (2010)
Kunder et al. (2012)

Radial Velocities for 10,000 bulge M giants

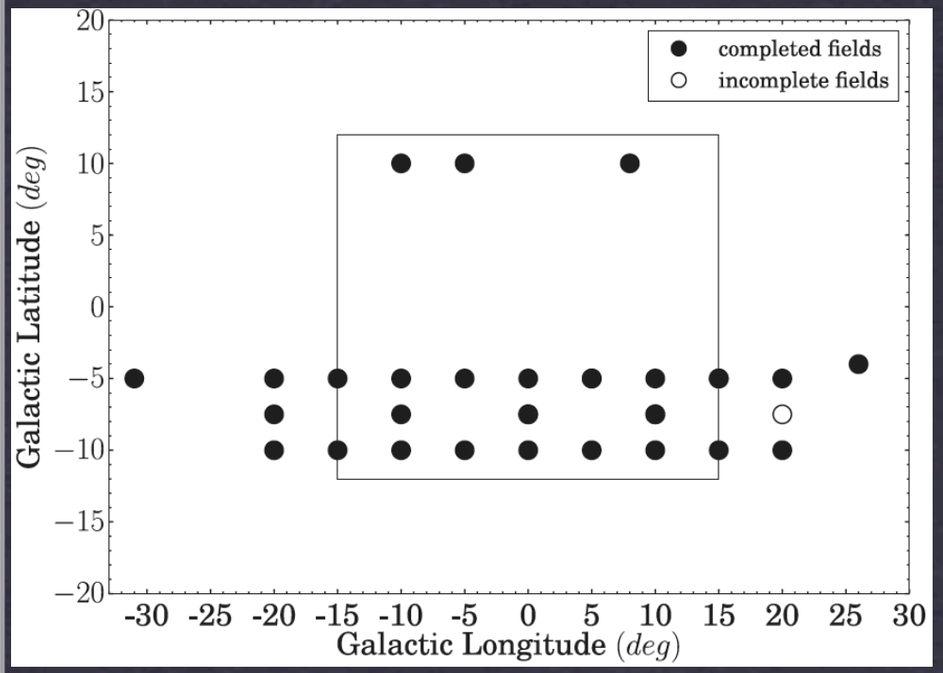


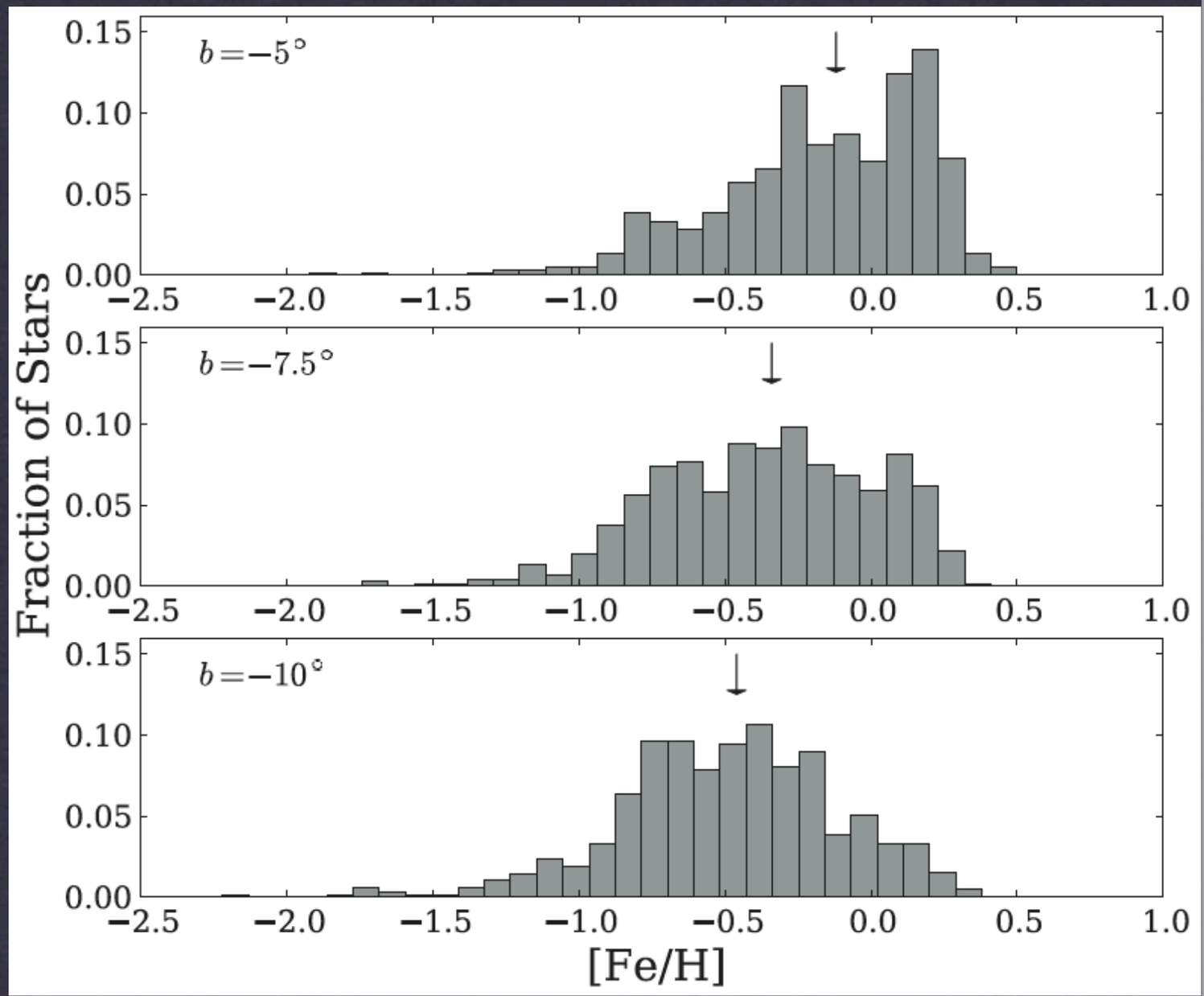


The ARGOS Survey

Freeman et al. (2012)
Ness et al. (2013a, 2013b)

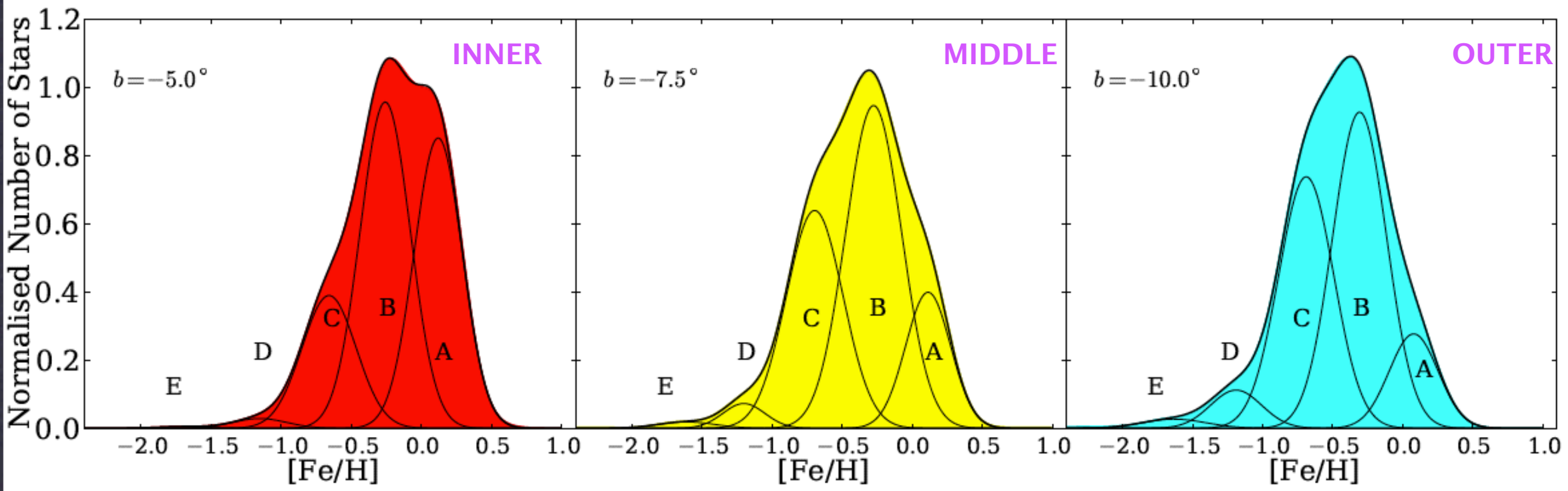
28,000 stars 14,150 stars within 3.5 kpc from the Galactic center - R=11,000





The ARGOS Survey

Ness et al. (2013a)



A: The metal rich boxy/peanut bulge <[Fe/H]>∼+0.15

B: The vertically thicker boxy/peanut bulge <[Fe/H]>∼−0.25

C: The Inner thick disk <[Fe/H]>∼−0.70

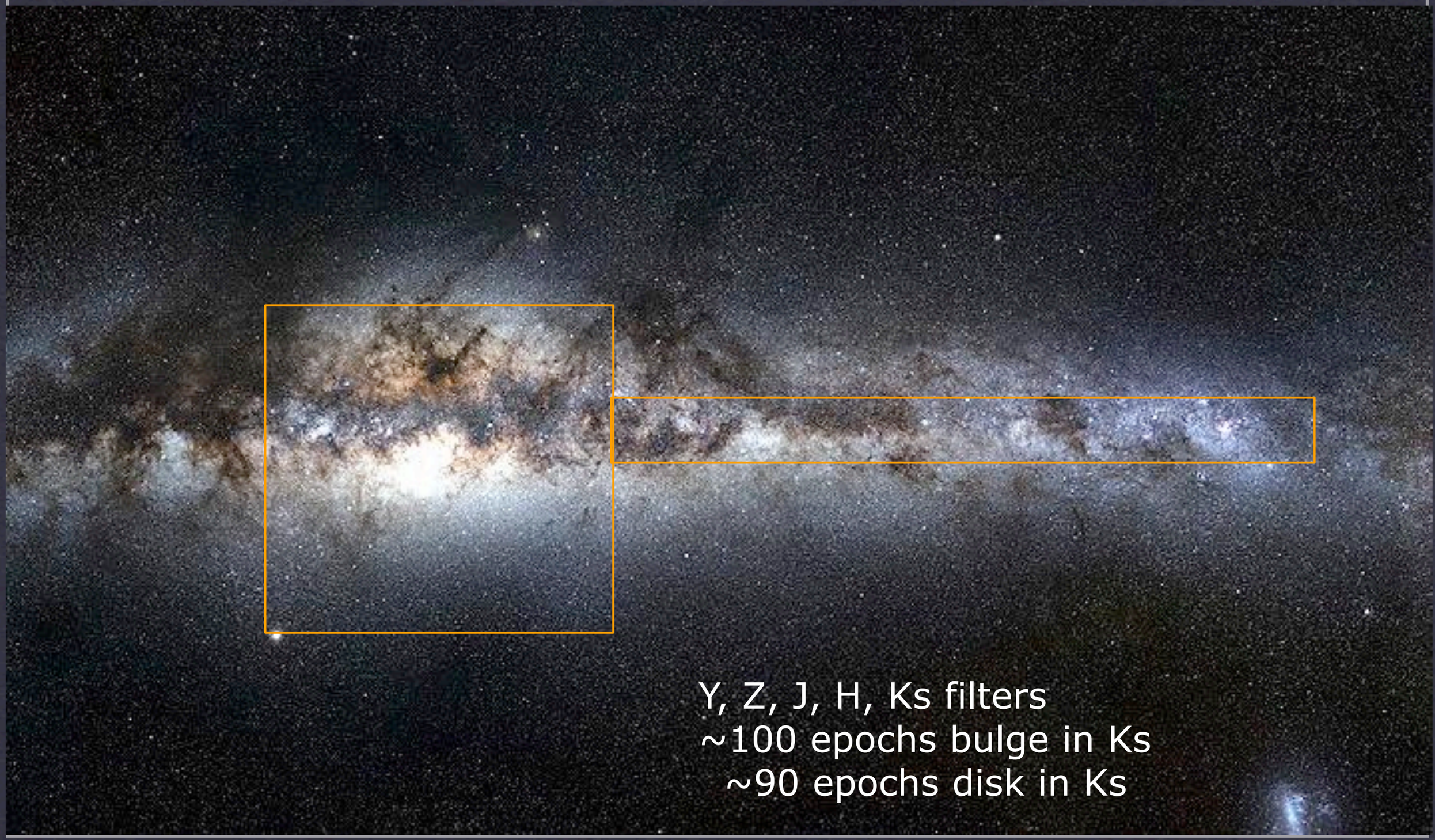
D: The Metal weak thick disk <[Fe/H]>∼−1.20

E: The Halo

The *VISTA Variables in the Vía Láctea* survey (**VVV**)

PIs: Minniti, Lucas

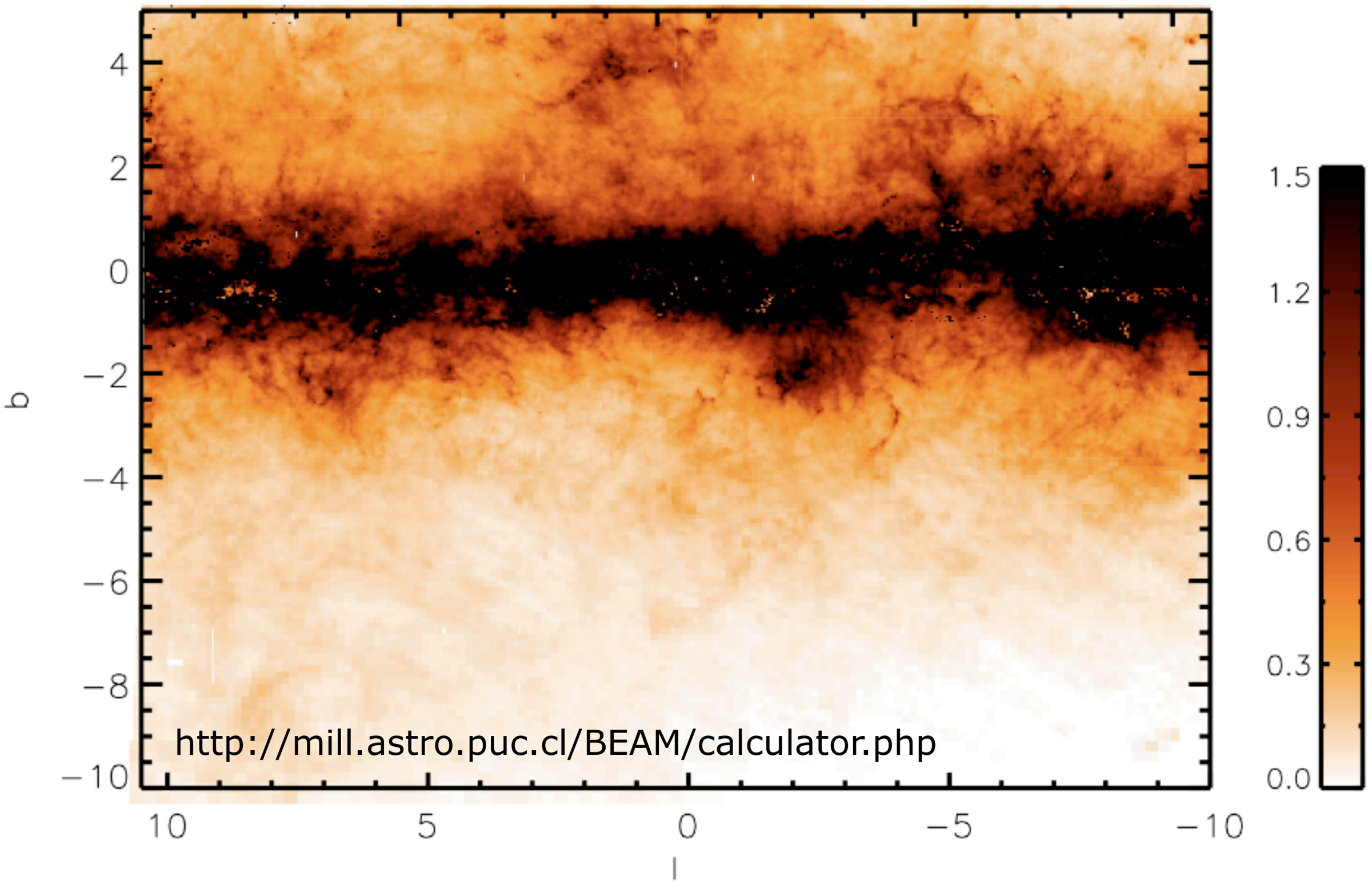
DR2: http://archive.eso.org/cms/eso-data/eso-data-products



Bulge Extinction Map from VVV

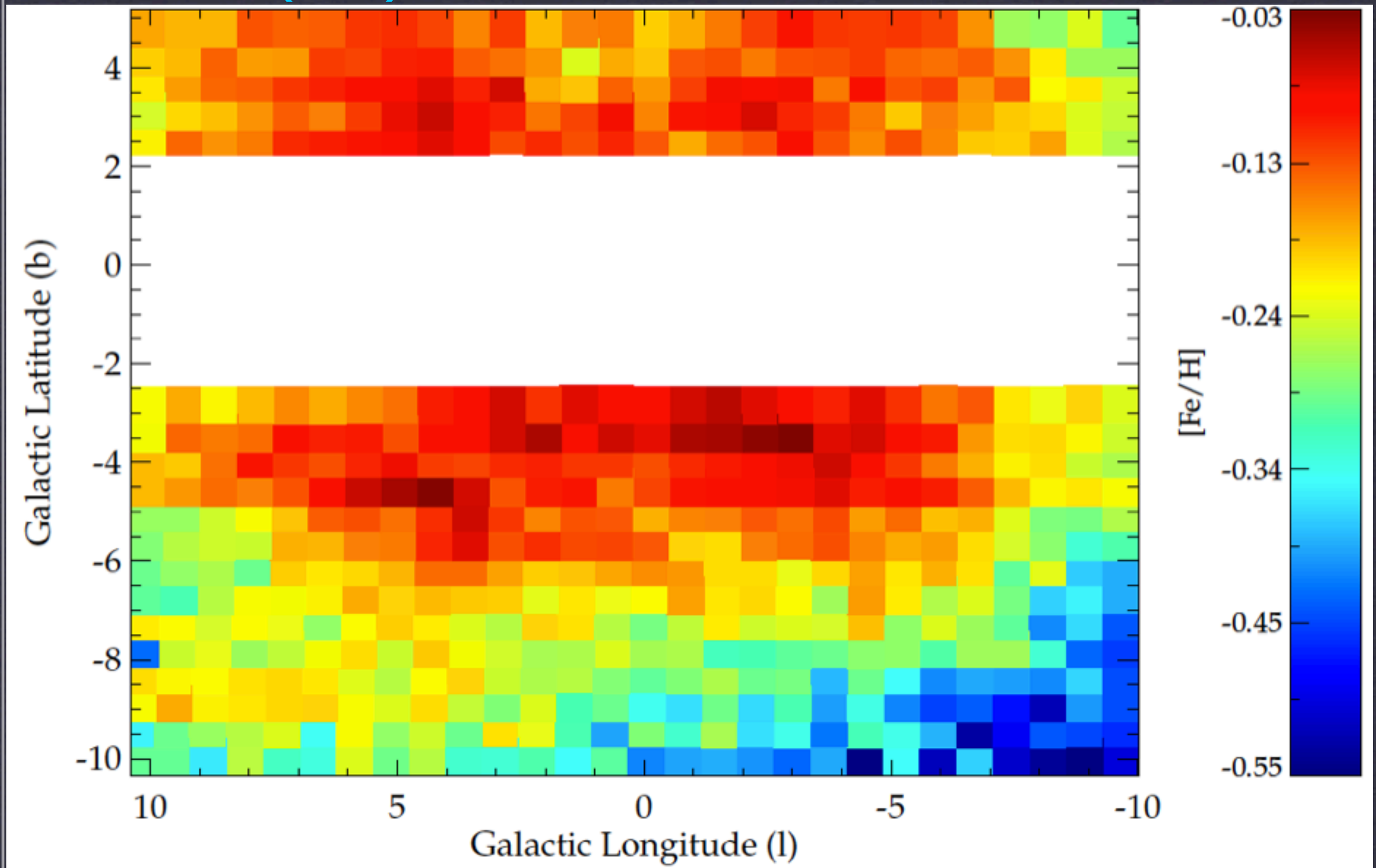
SPATIAL RESOLUTION 2’- 6’

Gonzalez et al. (2012)



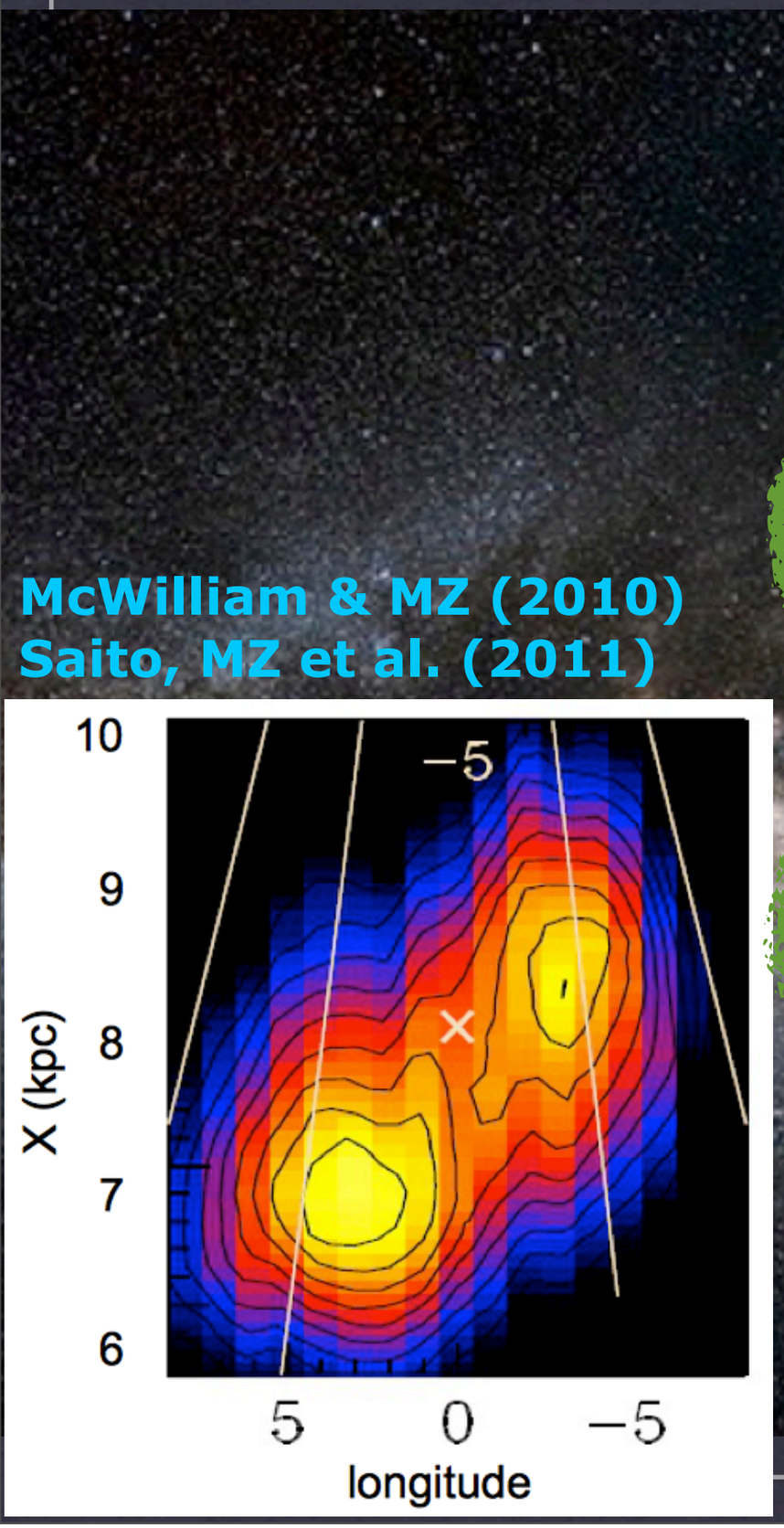
A complete (photometric) metallicity map of the bulge

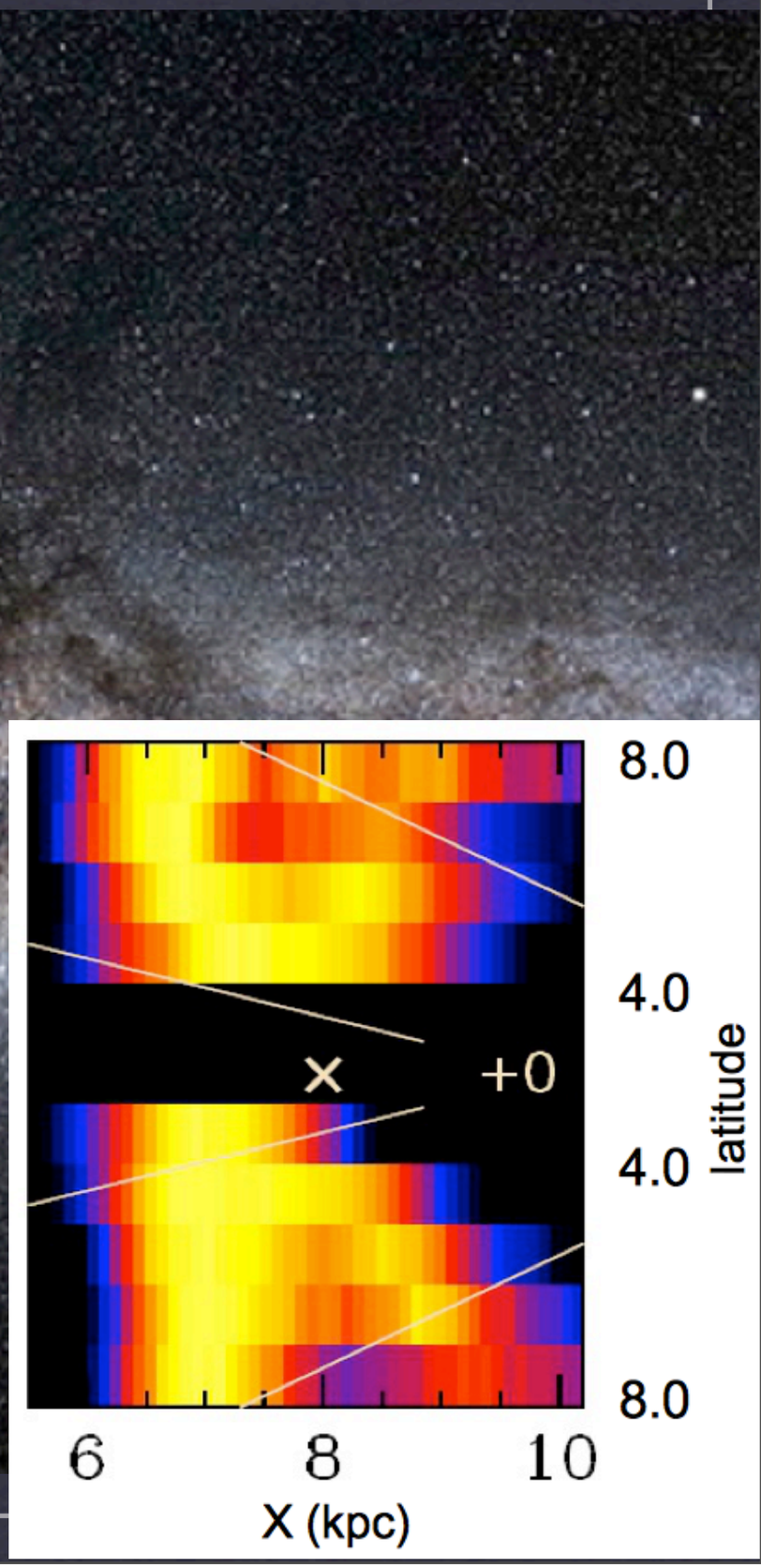
Gonzalez et al. (2013)



The X-shaped Galactic bulge

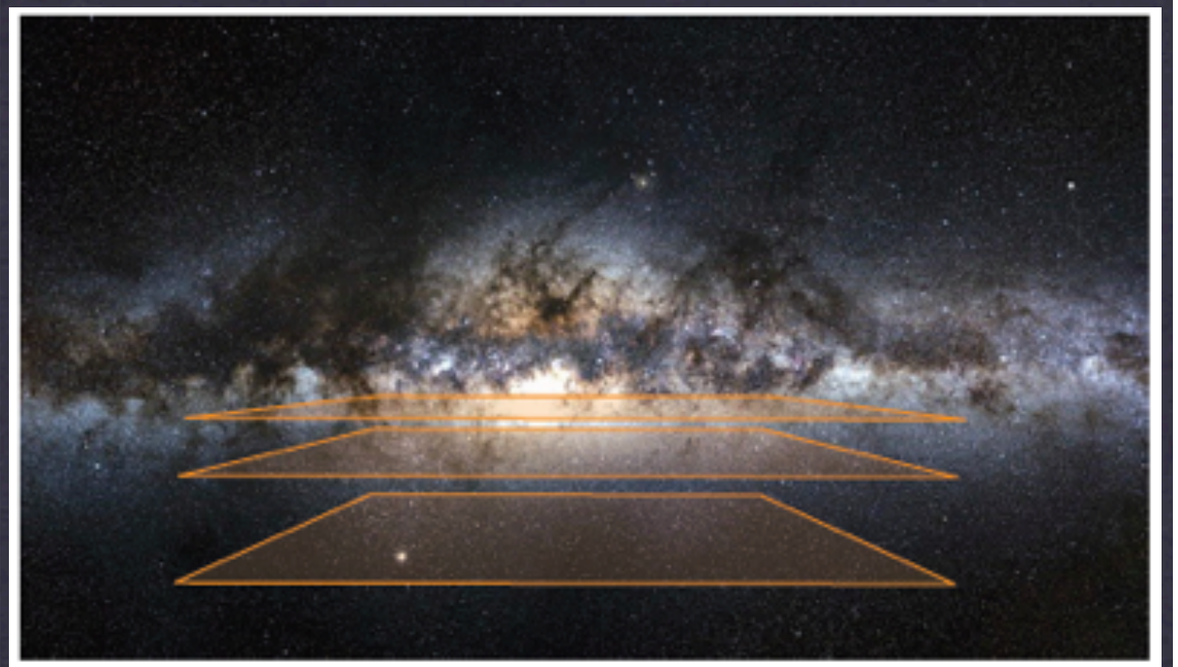
McWilliam & MZ (2010)
Saito, MZ et al. (2011)

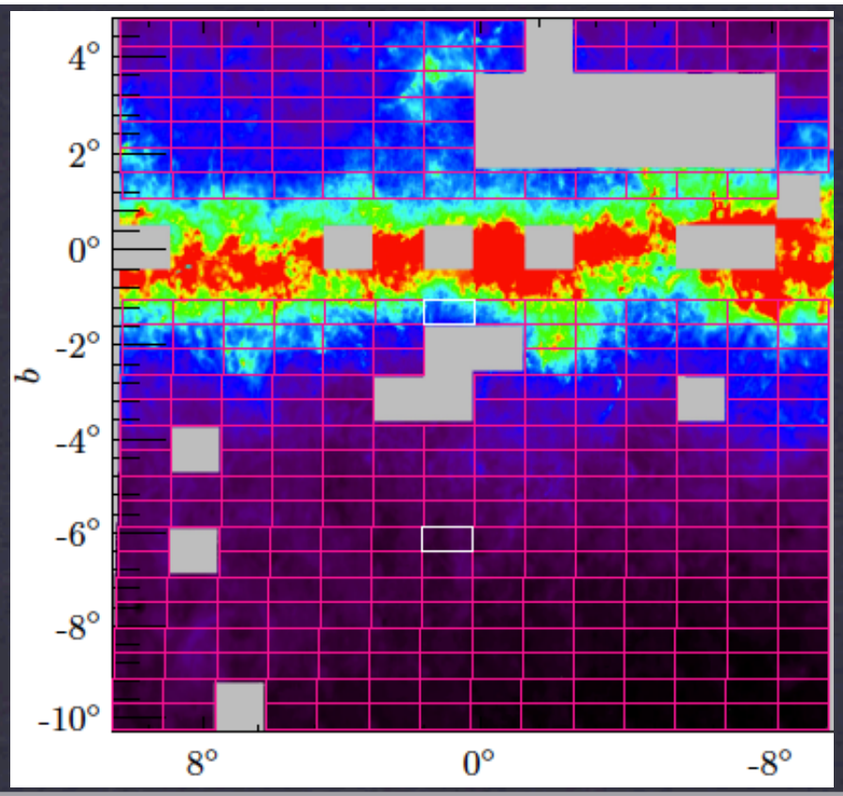


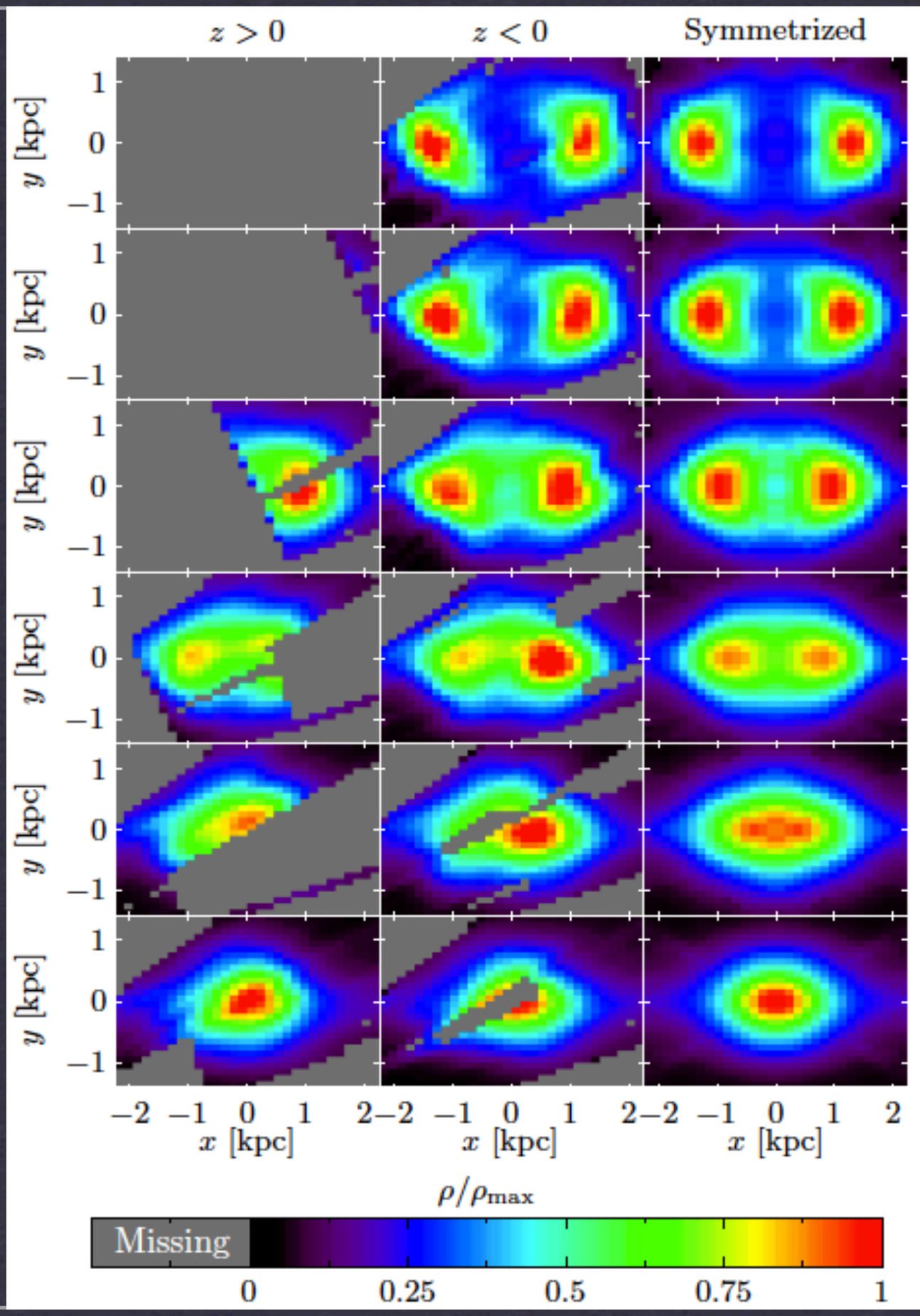


The X-shaped Galactic bulge

Wegg & Gerhard (2013)







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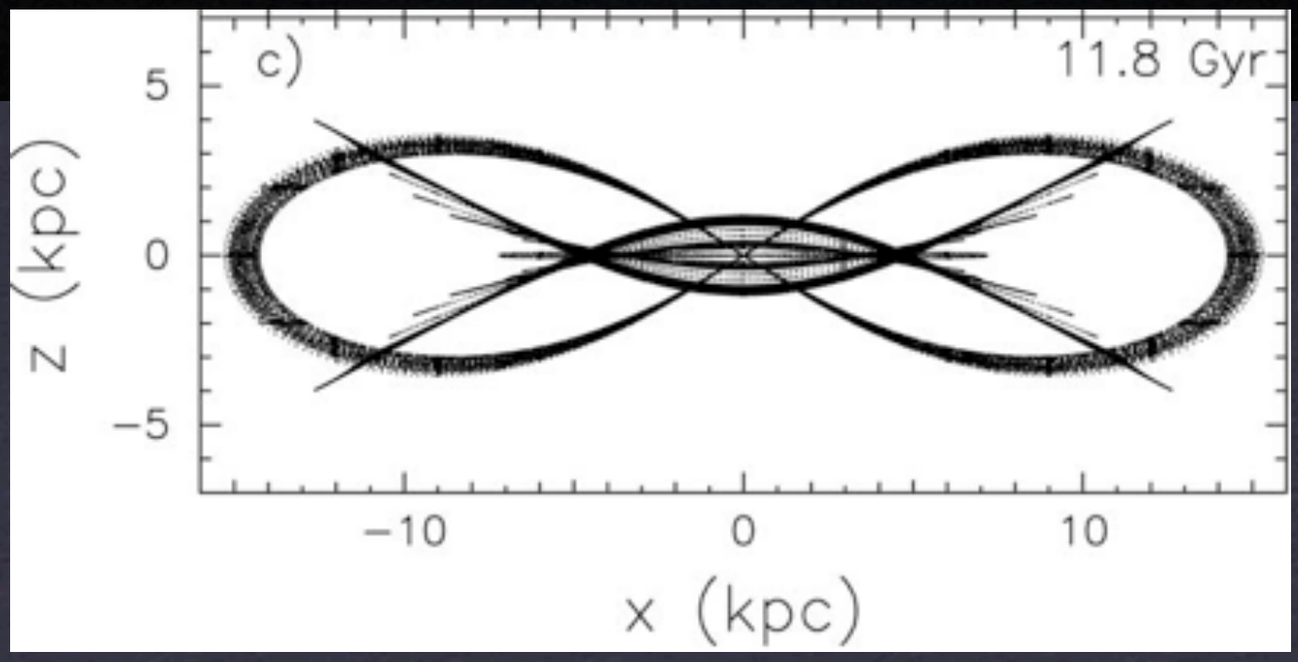
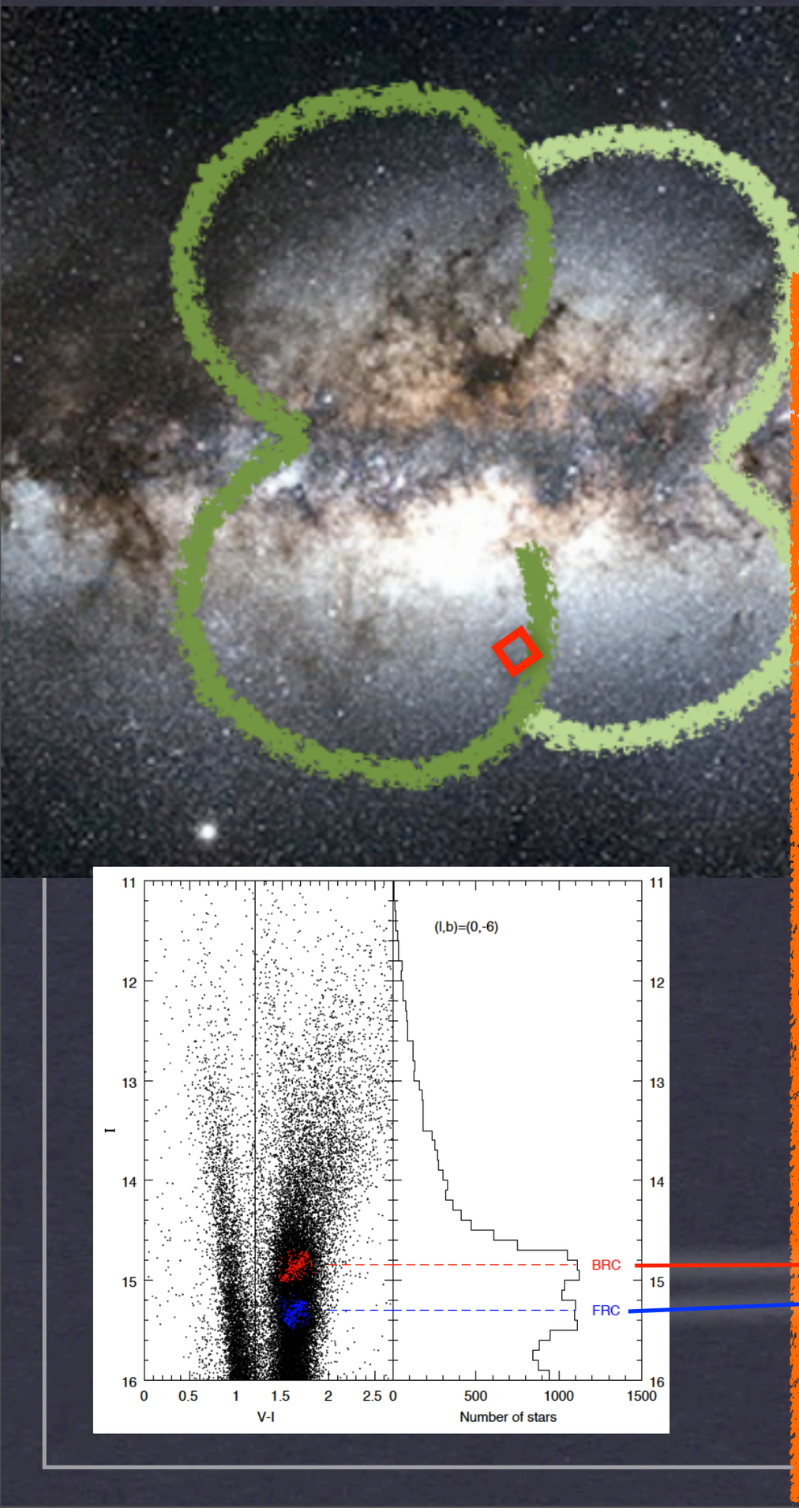
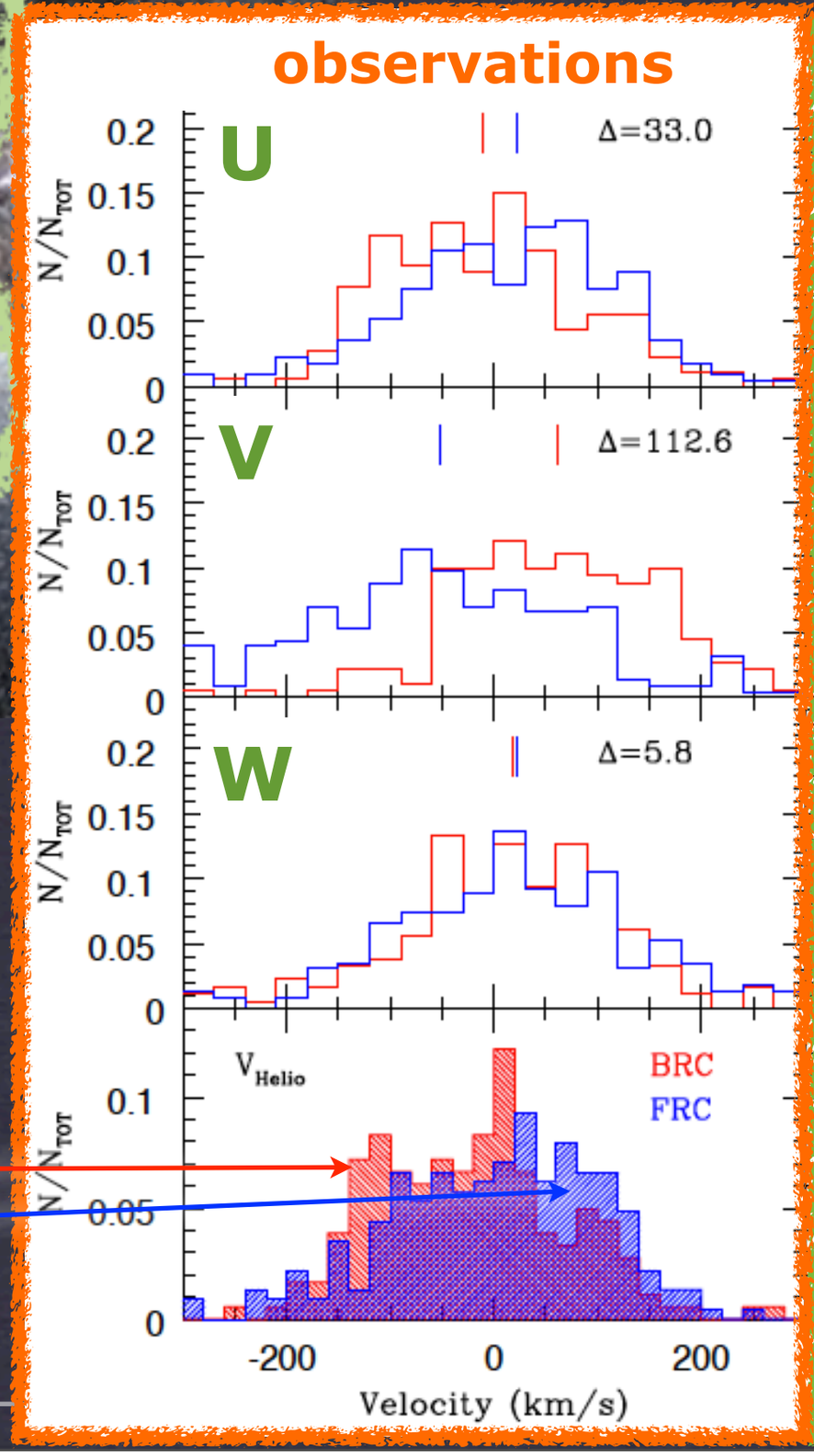
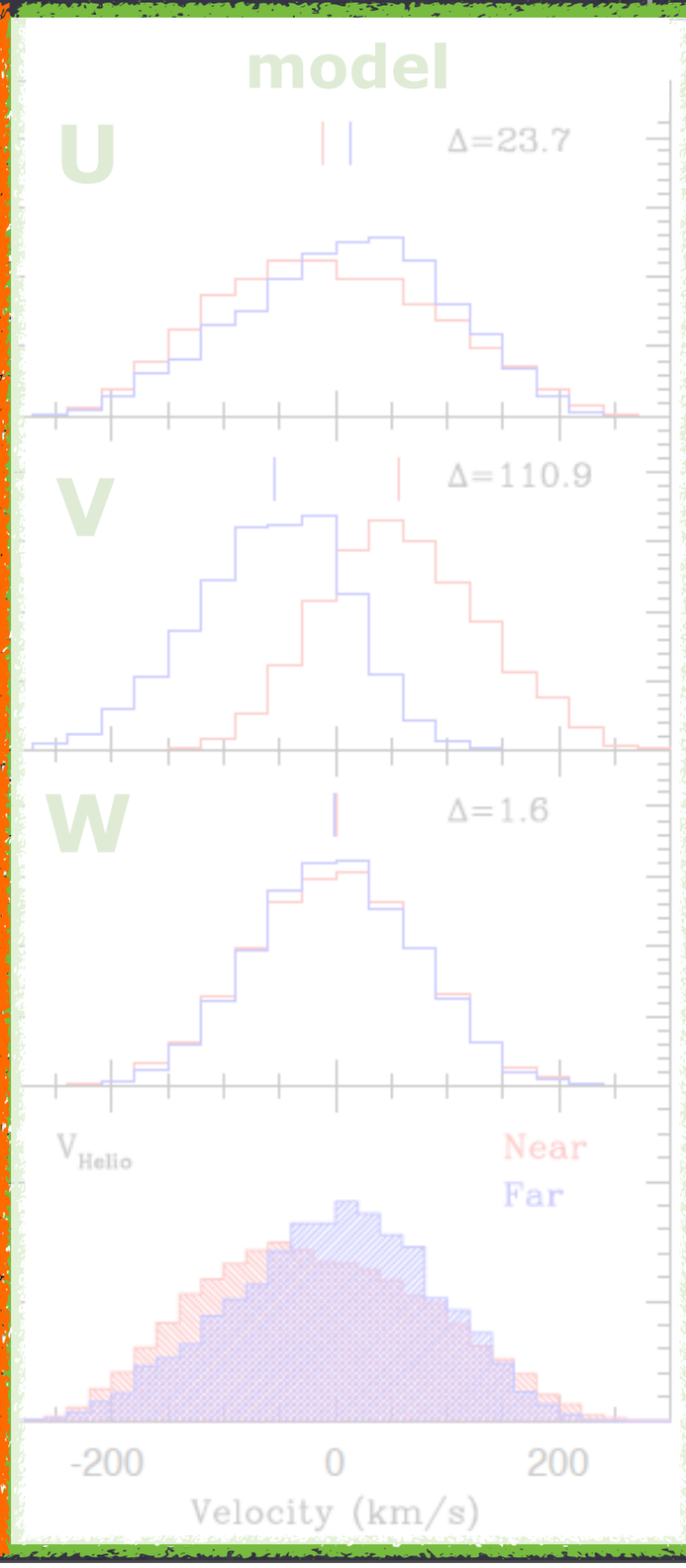


3D kinematics

Vásquez, MZ et al. (2013)







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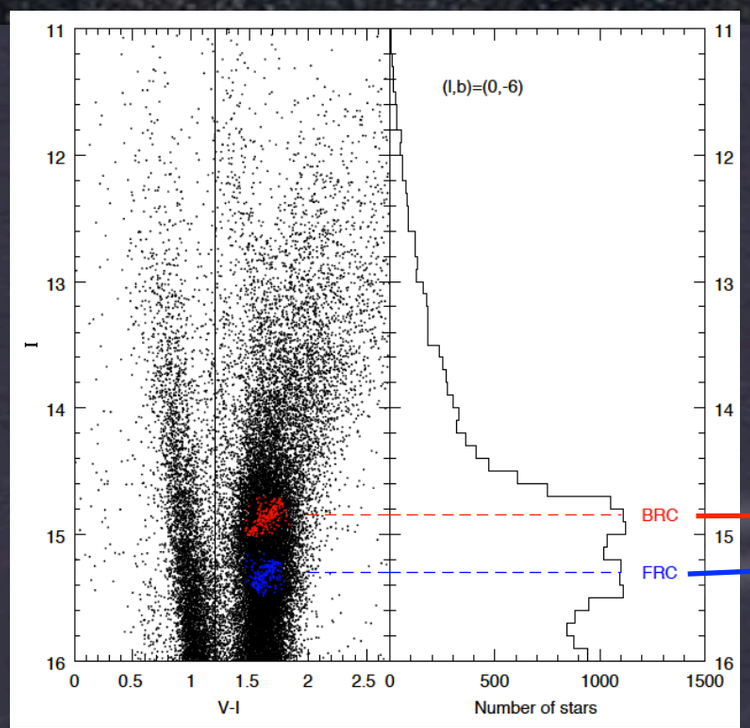
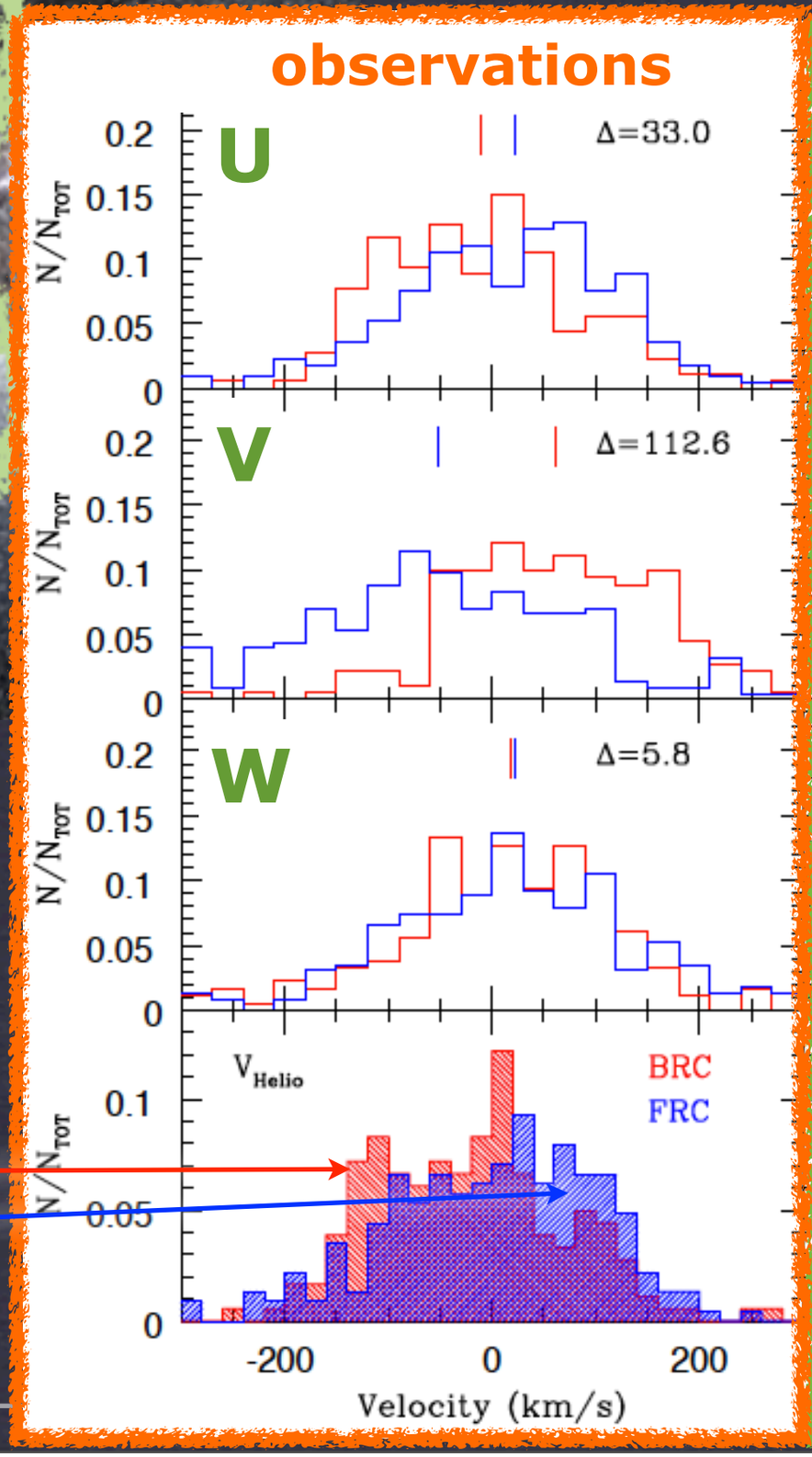
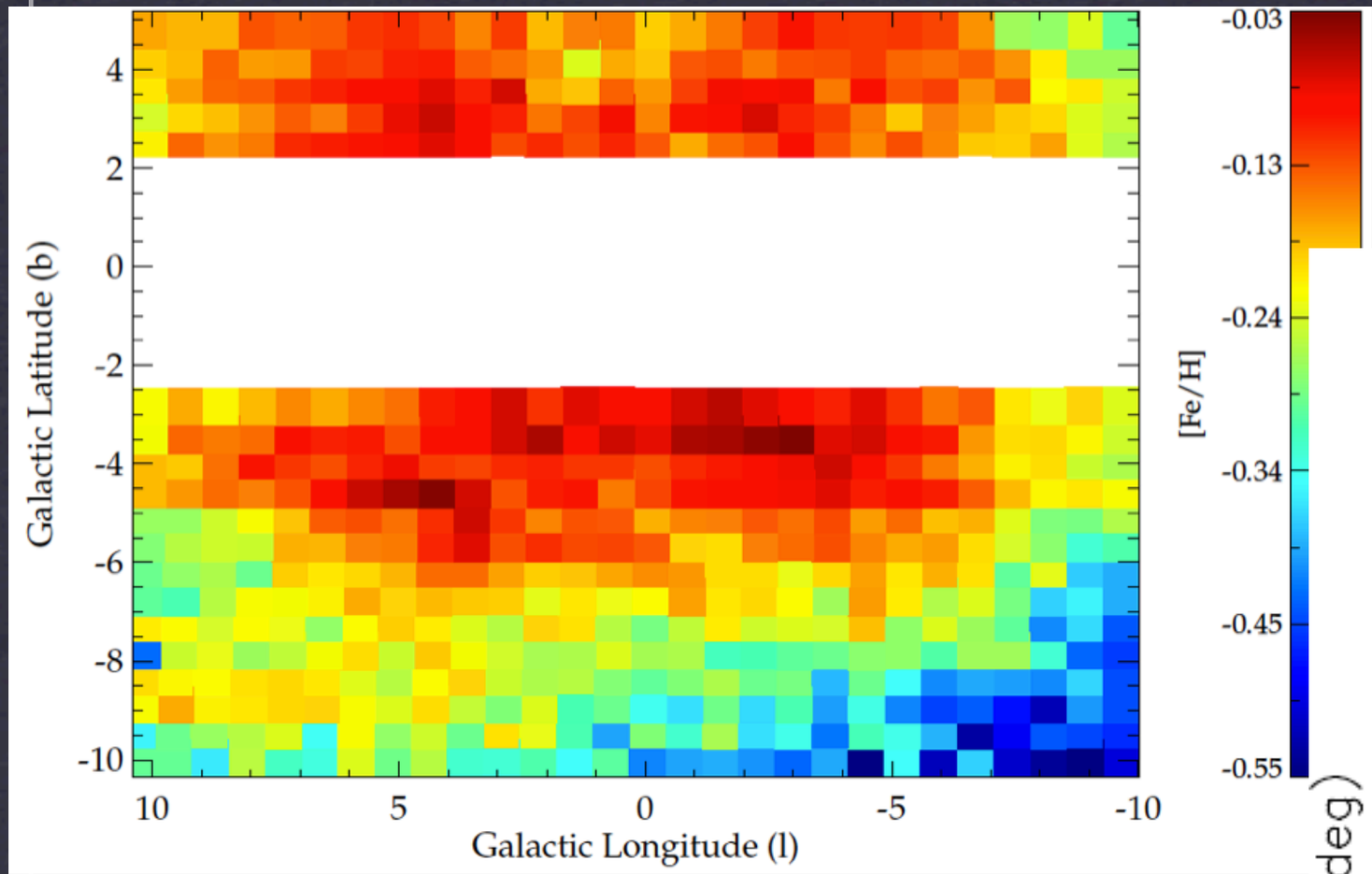


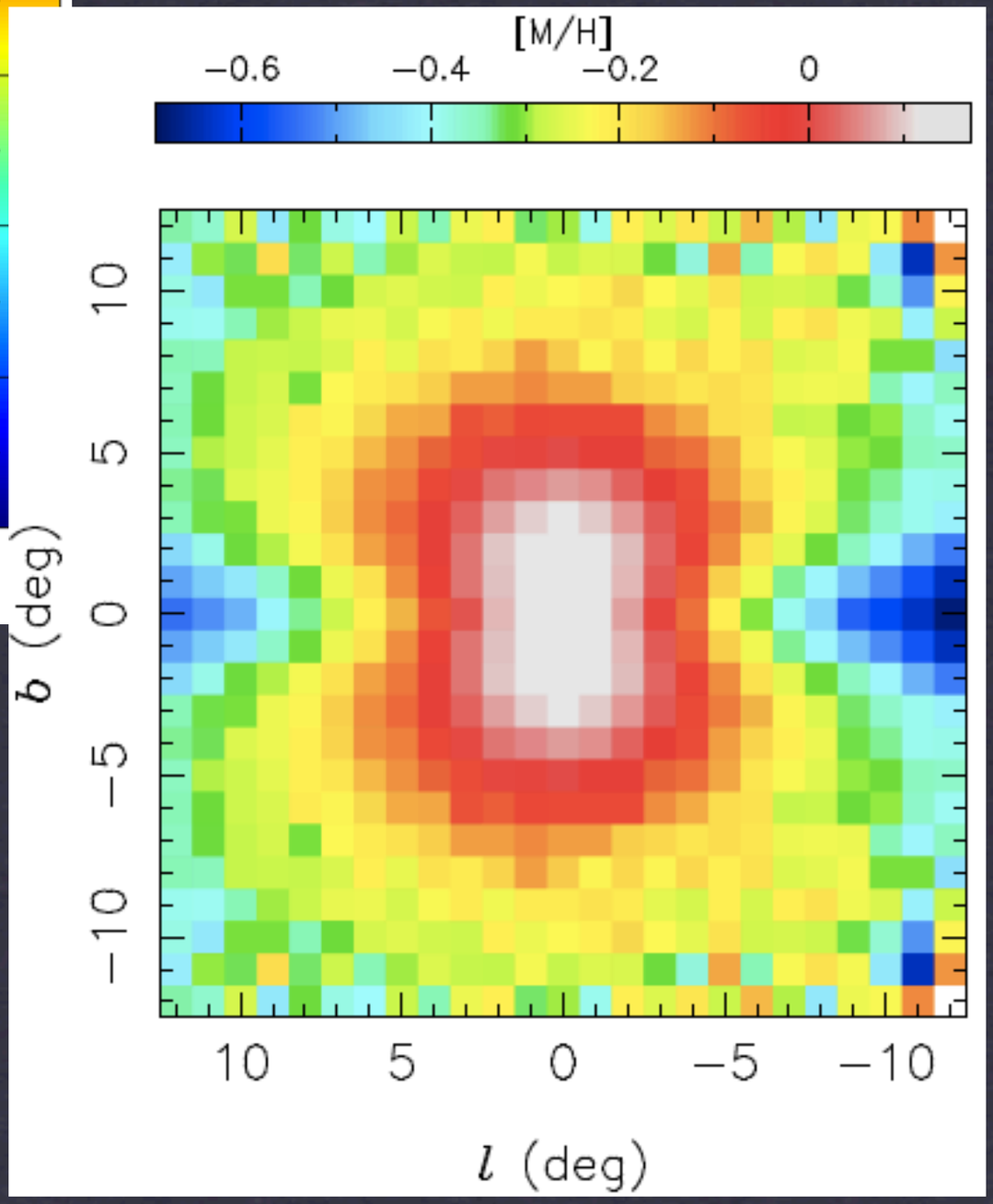


The radial metallicity gradient in the bulge

OBSERVED: Gonzalez et al. (2012)



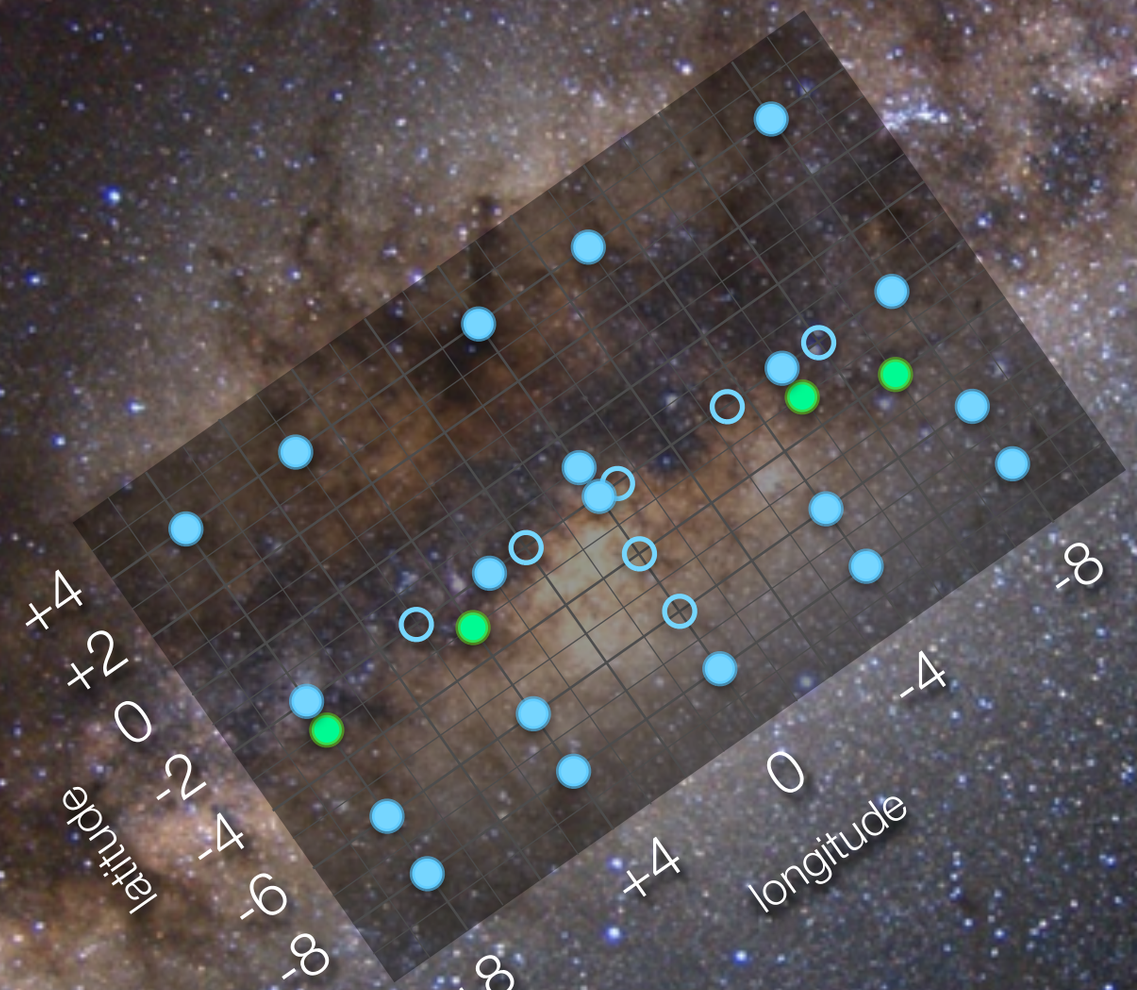
THEORETICAL:
Martinez-Valpuesta & Gerhard (2013)

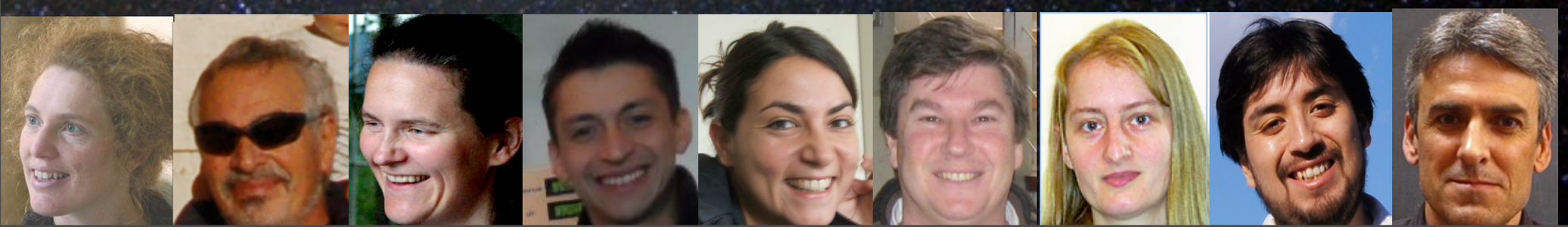


The Giraffe Inner Bulge Survey

PI: Zoccali

~ 5000 stars on CaT
~ 450 stars at R~22,000





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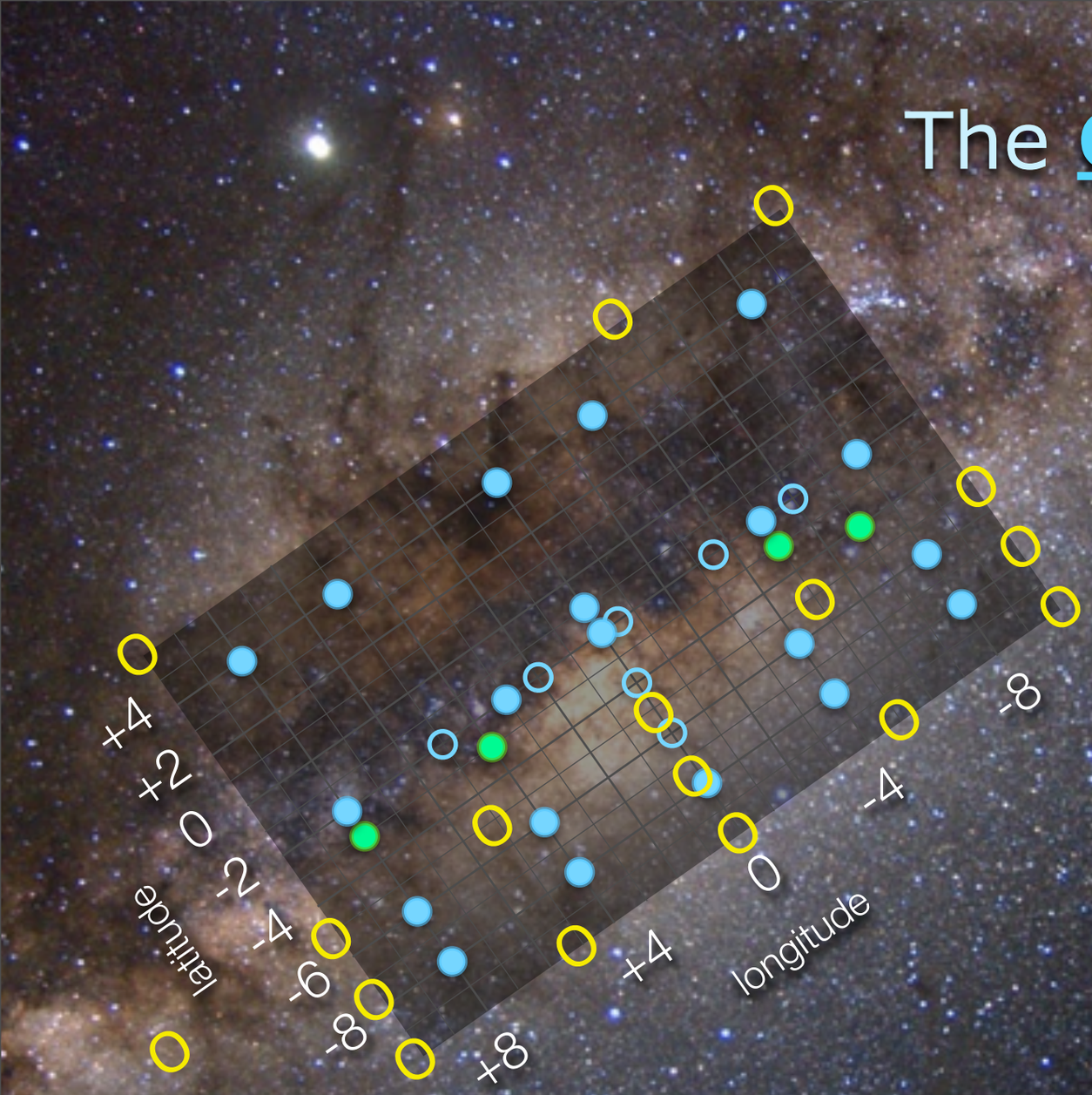
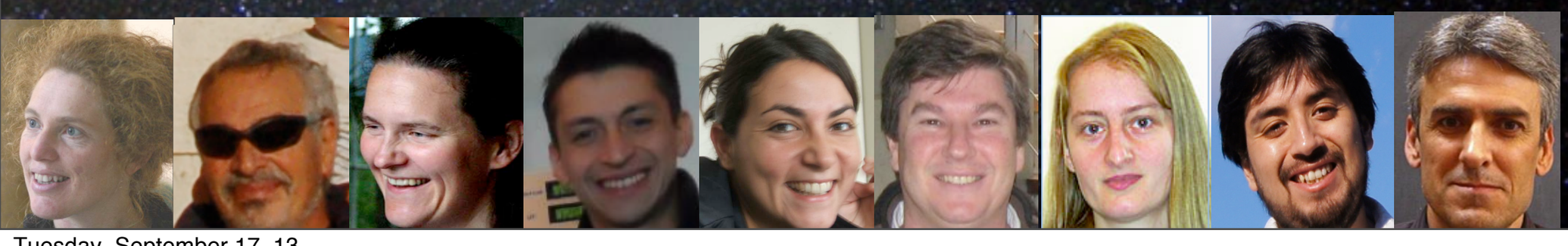


ARGOS fields



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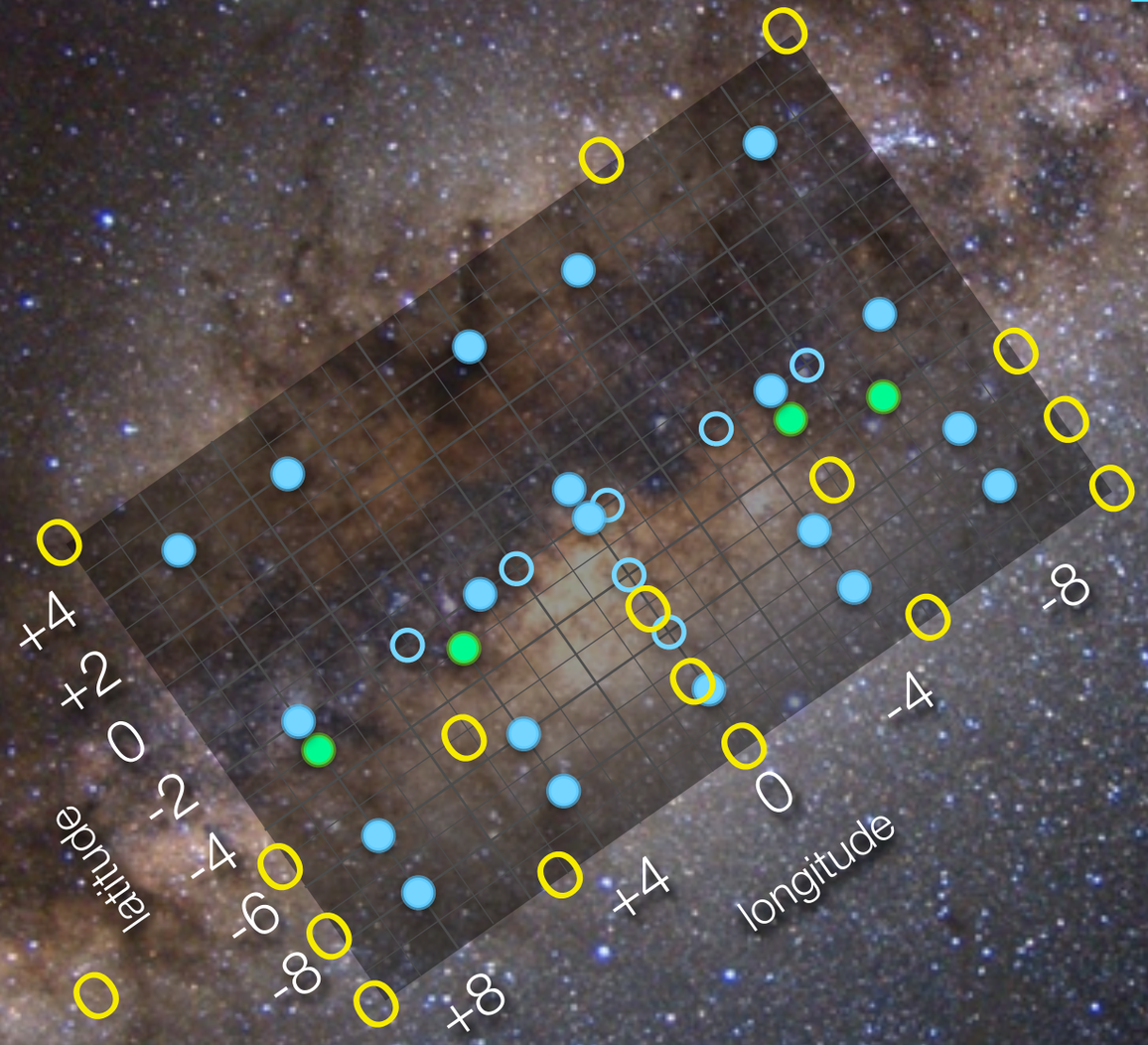
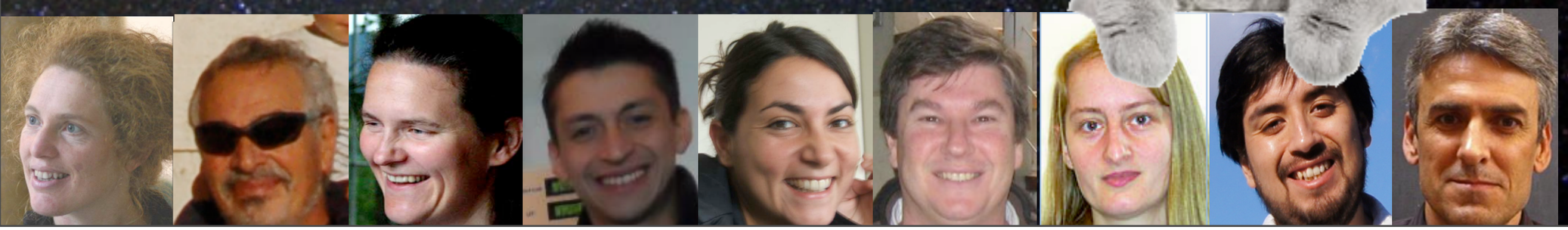
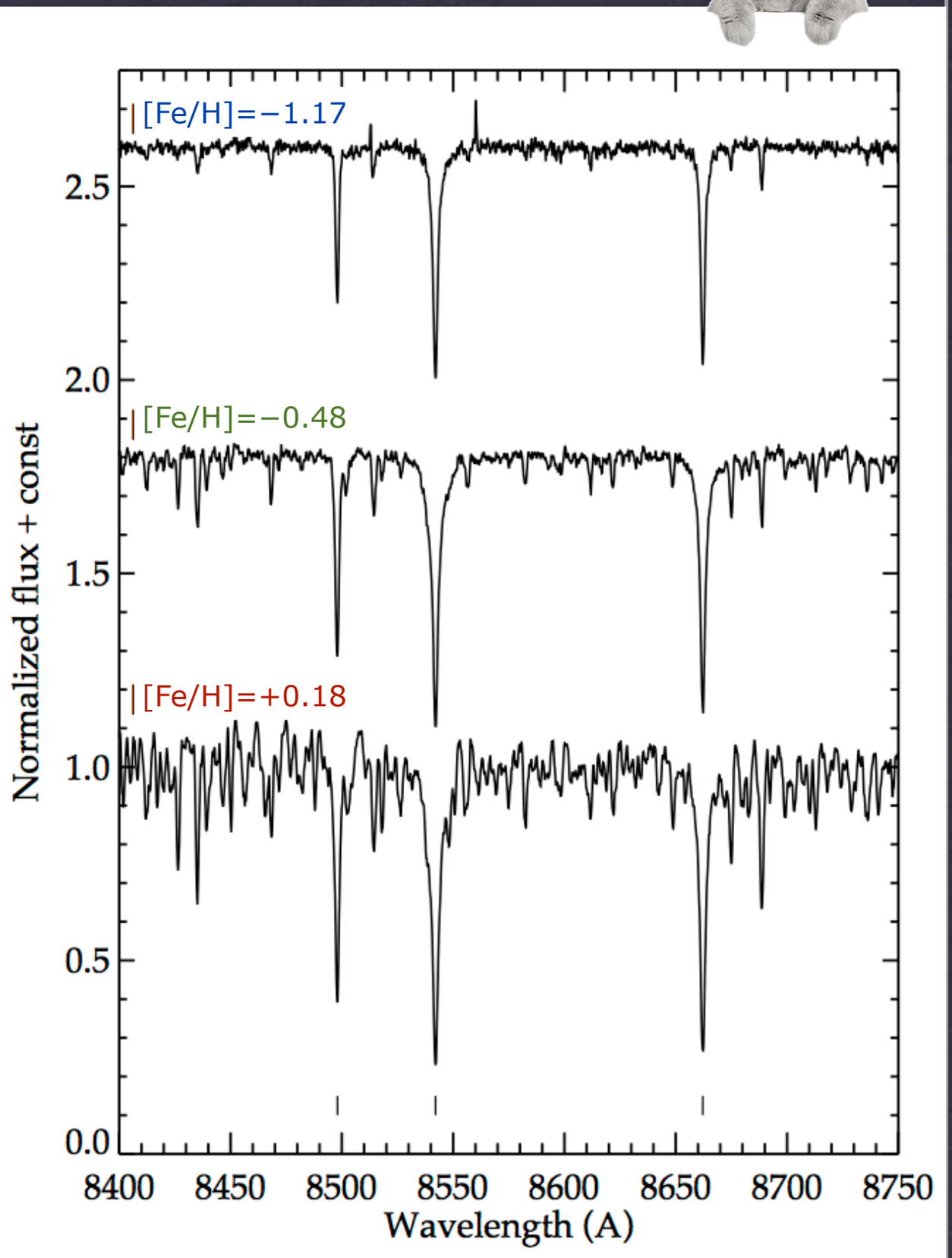


ARGOS fields



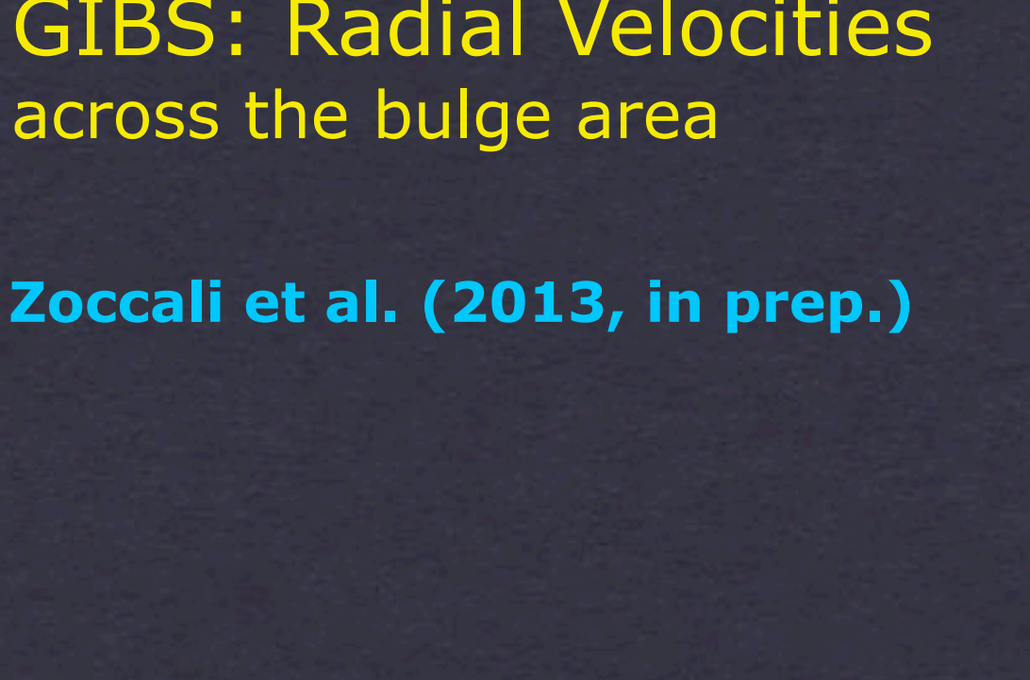
Giraffe **I**nner **B**ulge **S**urvey (GIBS)

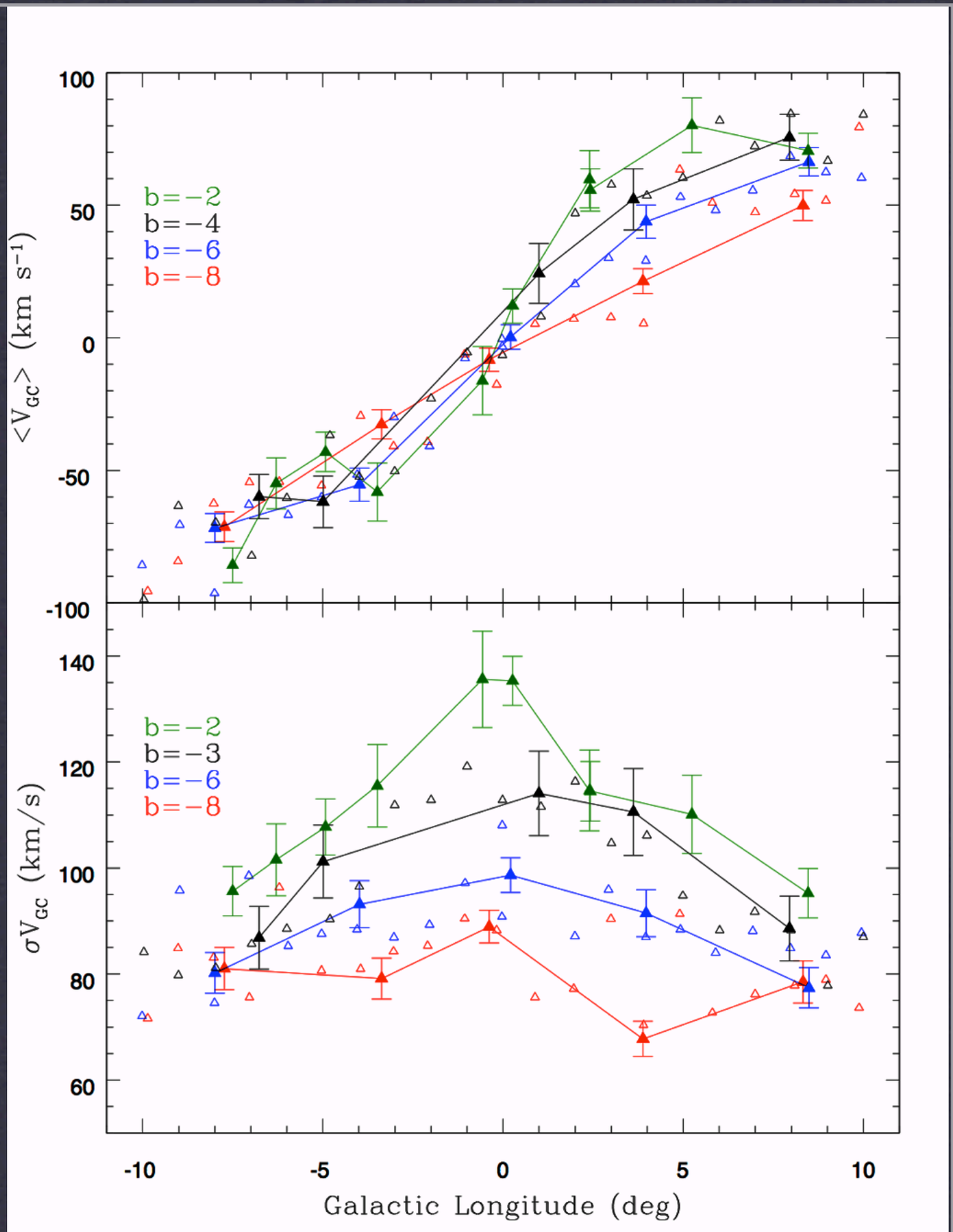
~ 5000 RC stars observed in **CaT**



GIBS: Radial Velocities
across the bulge area

Zoccali et al. (2013, in prep.)

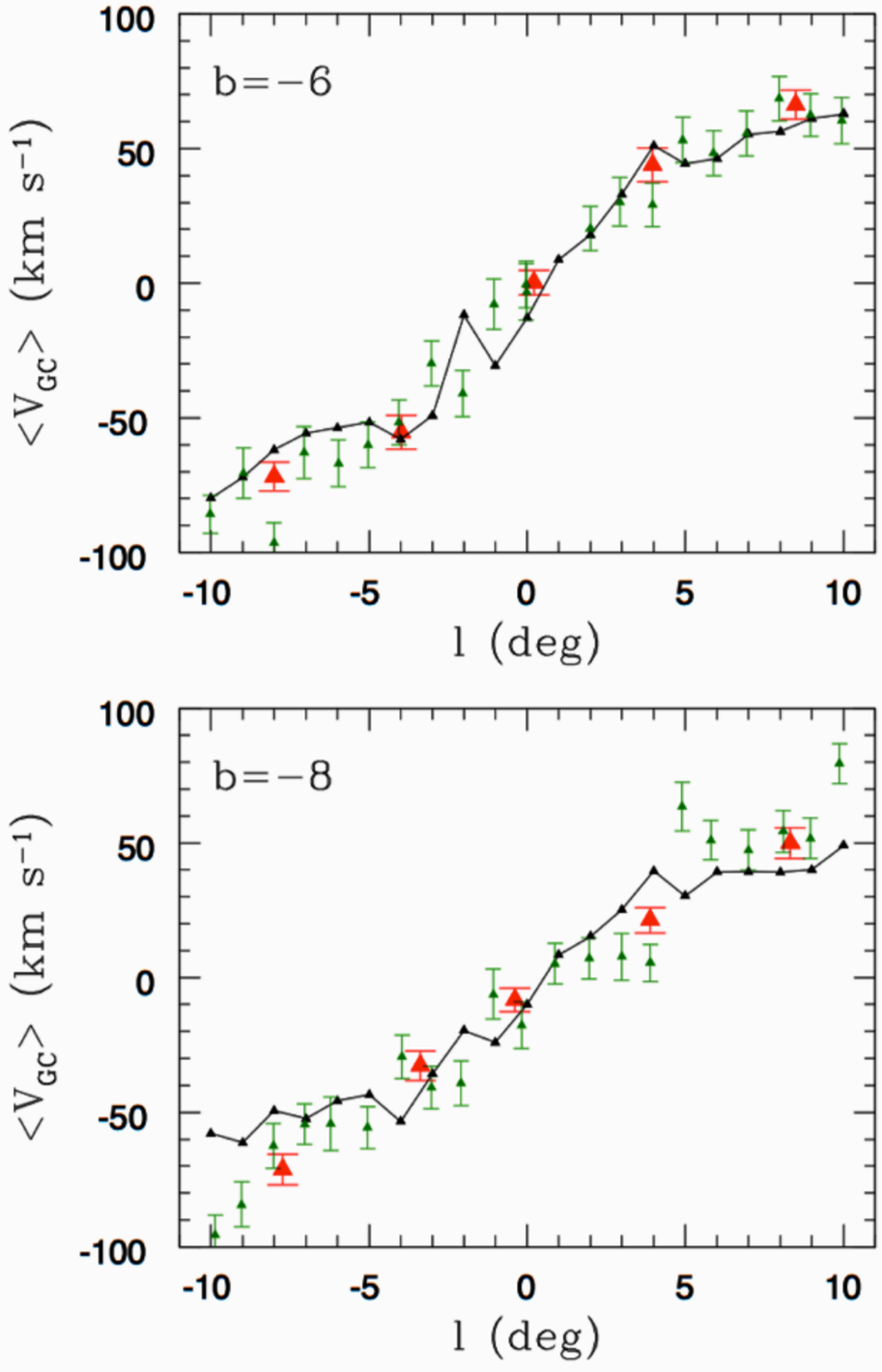




GIBS: Radial Velocities across the bulge area

comparison with models : *cylindrical rotation confirmed*

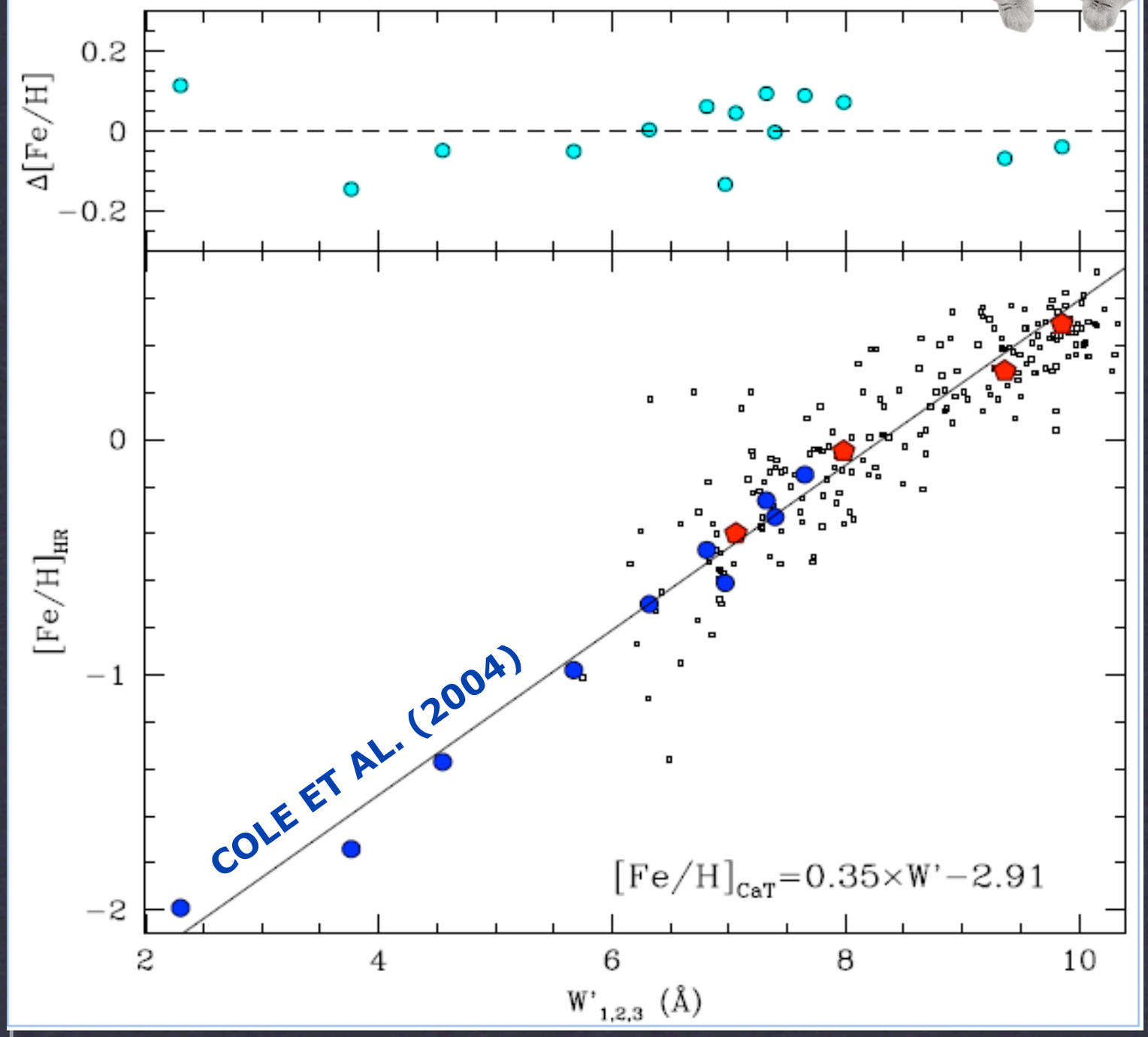
Zoccali et al. (2013, in prep.)



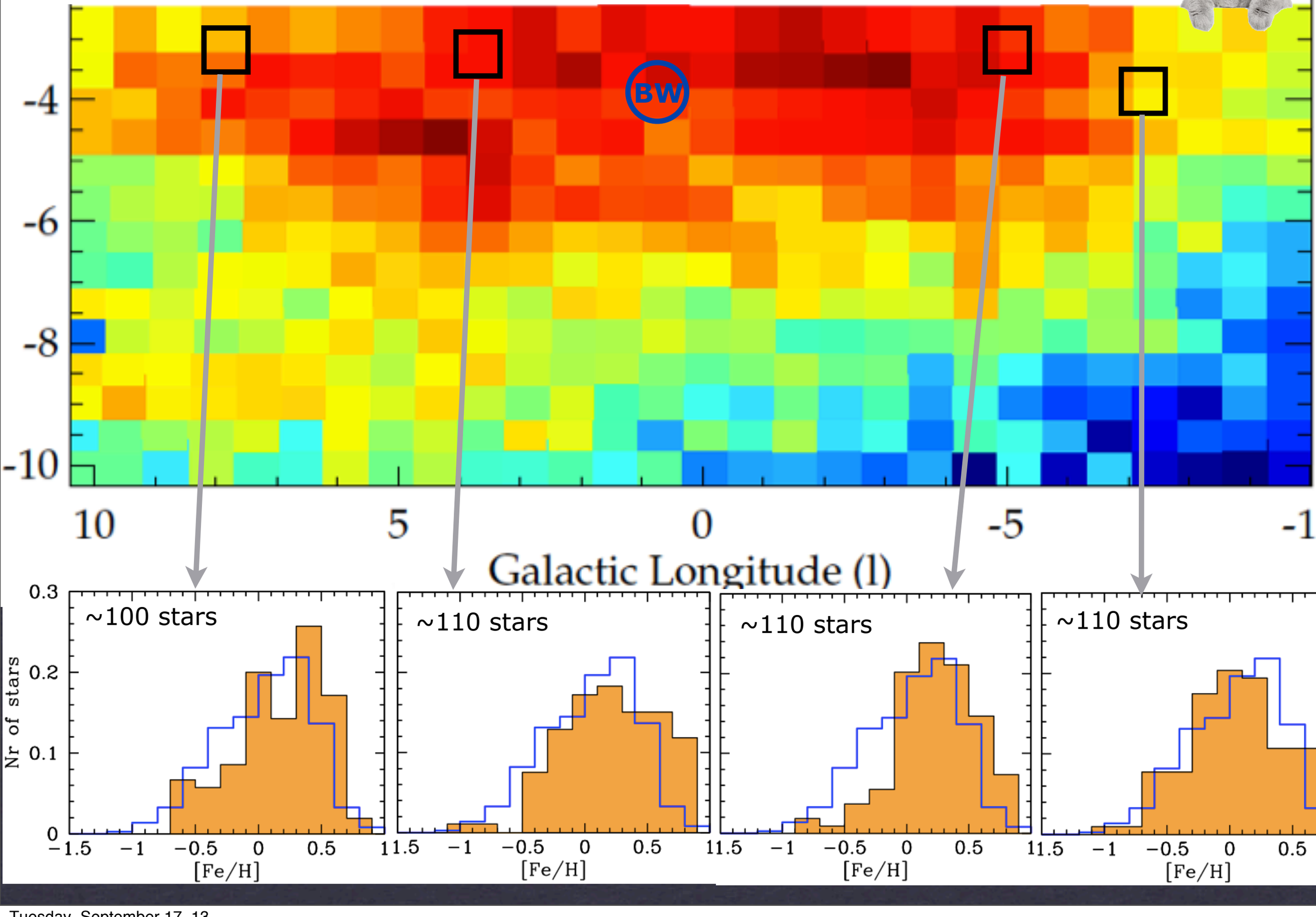
A New Calibration of CaT EW versus [Fe/H]

obtained for bulge K giants in Baade's Window

Vásquez, MZ et al. (2013, in prep.)



GIBS: The **High Resolution** spectra at $b \sim -3^\circ$



Summary

- The bulge hosts a boxy/peanut structure
- Several independent observations suggest the presence of two components
  classical bulge + bar ?
- A metallicity gradient, in the outer bulge, follows the boxy/peanut structure. What about the inner bulge?
  challenge for dynamical models
- Bulge stars are old and metal rich, with high [α/Fe] ratio similar to thick disk
  rapid star formation occurred, ~10 Gyr ago. ~~Secular evolution~~
  most metal-rich stars might have formed over a ~3 Gyr timescale