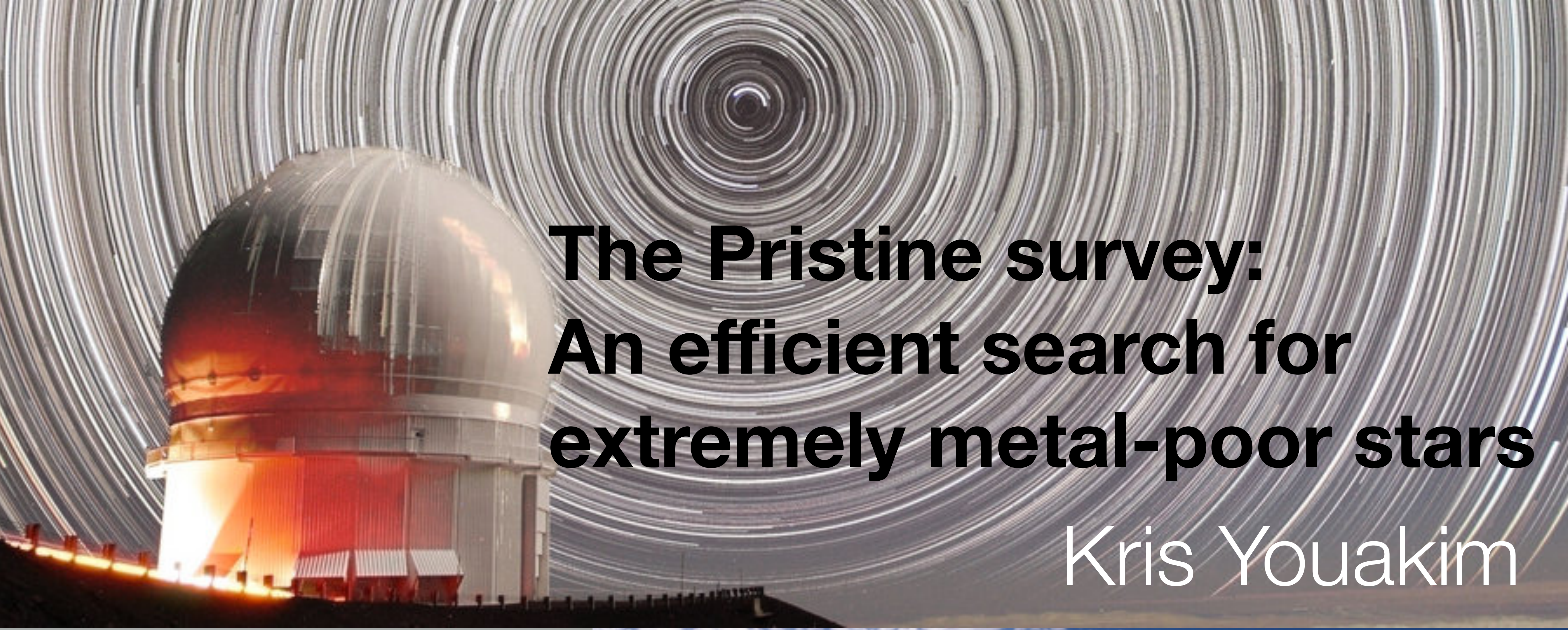


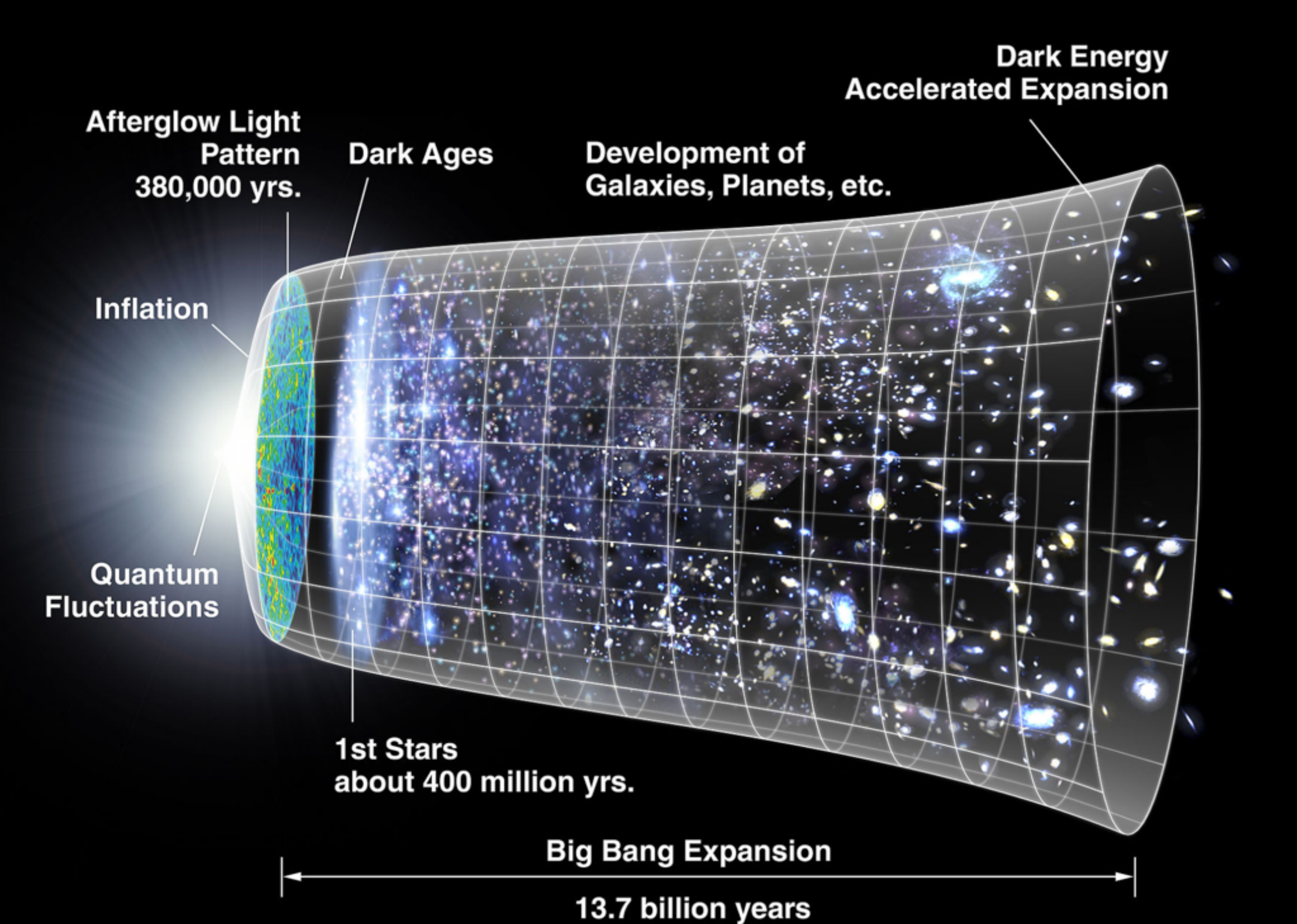
The Pristine survey: An efficient search for extremely metal-poor stars

Kris Youakim

ING Seminar
Jan 22, 2018

Universität Potsdam

AIP Leibniz-Institut für Astrophysik Potsdam



Credit: NASA / WMAP Science Team

Movie “First Light” Wise, Abel, Kaehler, 2009

Image: Aladin sky atlas

$$[Fe/H] = \log(N_{Fe}/N_{H})_{star} - \log(N_{Fe}/N_{H})_{sun}$$

[Fe/H] = -3 —> iron abundance 1/1000 of the sun

[Fe/H] < -3 —> Extremely metal-poor

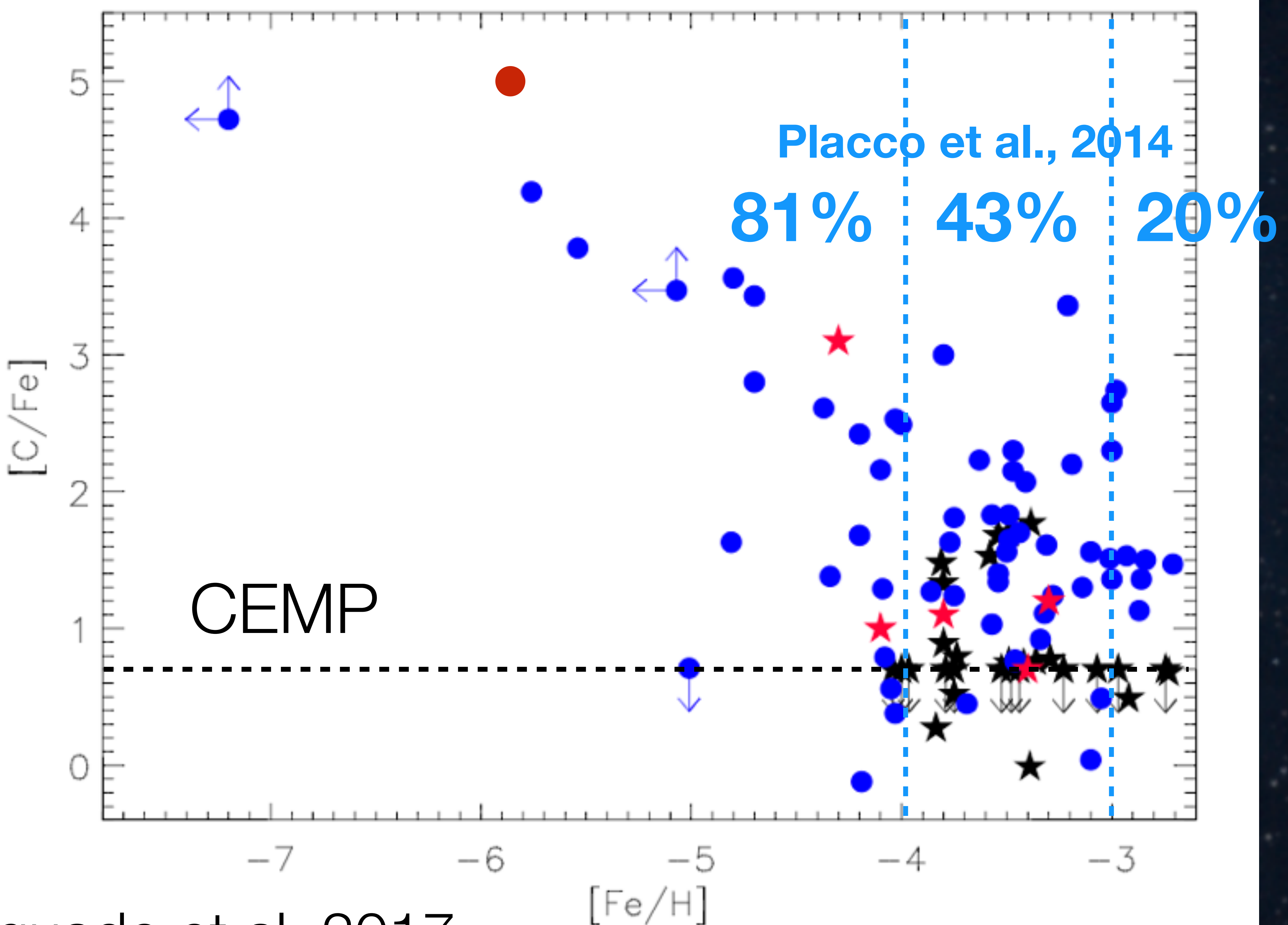
[Fe/H] < -4 —> Ultra metal-poor

[Fe/H] < -5 —> Hyper metal-poor

1 in 800 stars have [Fe/H] < -3

1 in 80 000 have [Fe/H] < -4!

Iron vs Carbon



Aguado et al. 2017

Different kinds of Carbon enhanced stars

CEMP — [C/Fe] > +0.7

Extrinsic

CEMP-s	[Ba/Fe] > +1.0 and [Ba/Eu] > +0.5
CEMP-r/s	0.0 < [Ba/Fe] < +0.5

CEMP-r	[Eu/Fe] > +1.0
CEMP-no	[Ba/Fe] < 0.0

Intrinsic

Where does the high Carbon come from?

Transferred from a Binary companion?

Check binarity - Starkenburg et al., 2014

~100% → CEMP-s

~15% → CEMP-no

Where does the high Carbon come from?

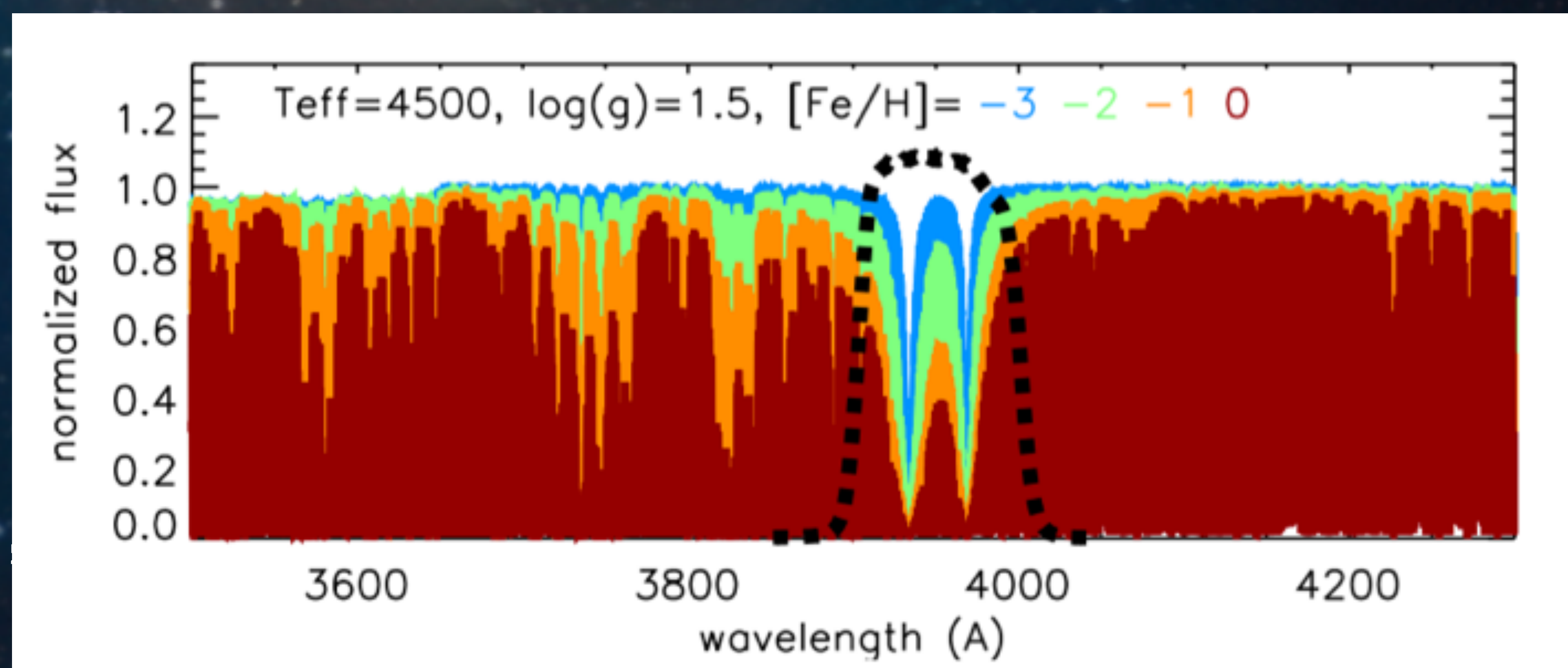
Faint (mixing & fall-back) supernovae?

Previous metal-poor star searches

- HK objective-prism survey (Beers, Preston & Shectman 1985)
- Hamburg ESO survey (Christlieb, Wisotzki & Graßhoff 2002)
- SDSS, SEGUE, BOSS follow-up (e.g. Caffau et al. 2013, Aoki et al. 2013, Allende Prieto et al. 2015, Aguado et al. 2016, 2017)
- CaHK filter (Anthony-Twarog et al. 2000, Koch et al. 2016)
- SkyMapper (e.g. Keller 2007)
- Best and brightest (Schlaufmann & Casey 2014)
- LAMOST (e.g. Cui 2012)

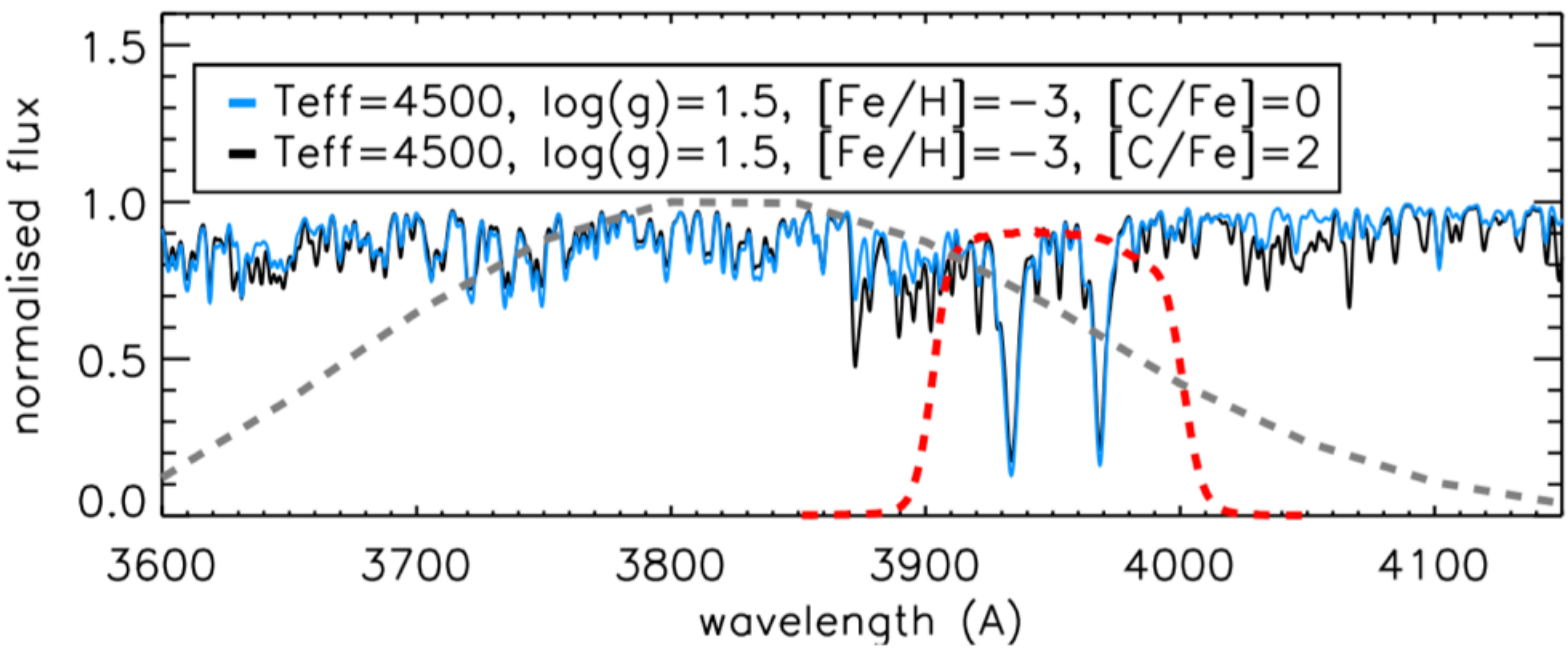
The Pristine survey

CaHK filter



Starkenburg et al. 2017a

Pristine vs SkyMapper filter



The Pristine team

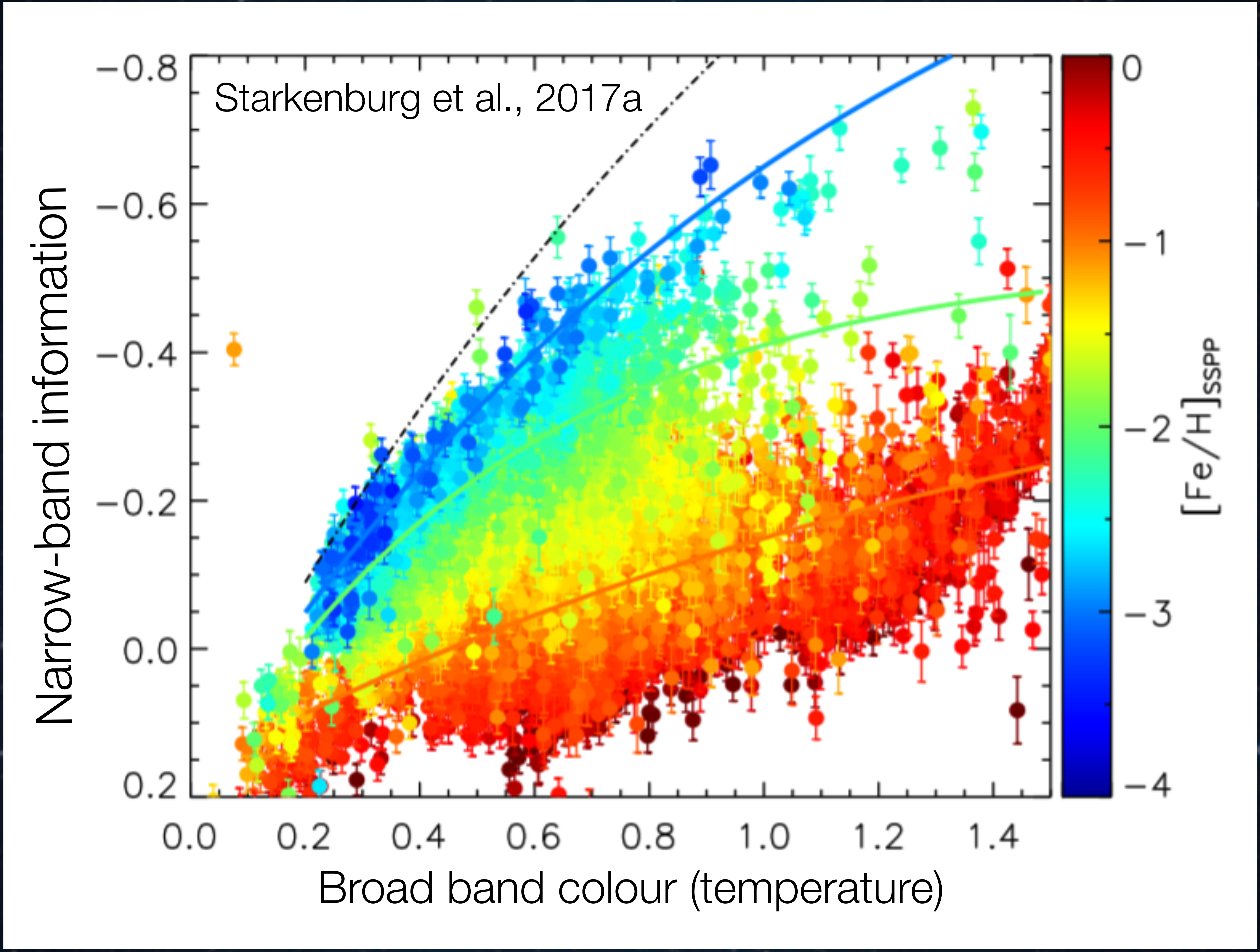
 

- PIs: Else Starkenburg and Nicolas Martin
- CoIs: David S. Aguado, Carlos Allende Prieto, **Anke Arentsen**, Edouard Bernard, Piercarlo Bonifacio, Elisabetta Caffau, Raymond Carlberg, Patrick Cote, Morgan Fouesneau, Patrick Francois, Oliver Franke, Jonay Gonzalez Hernandez, Stephen Gwyn, **Vanessa Hill**, Rodrigo Ibata, Pascale Jablonka, **Nicolas Longeard**, Alan McConnachie, Julio Navarro, Ruben Sanchez-Janssen, Eline Tolstoy, Kim Venn

Advantages of Pristine

- Fully within the SDSS footprint
  - SDSS ugriz broad band photometry available
  - SDSS, SEGUE, and BOSS spectra available for metallicity calibration
- 4-m class telescope, probing fainter magnitudes
- Narrow filter avoiding CN and CH molecular bands

CaHK + SDSS



Starkenburg et al., 2017a
−0.8
−0.6
−0.4
−0.2
0.0
0.2
Narrow-band information
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Broad band colour (temperature)
0
−1
−2
−3
−4
[Fe/H]SSPP

Spectroscopic follow-up

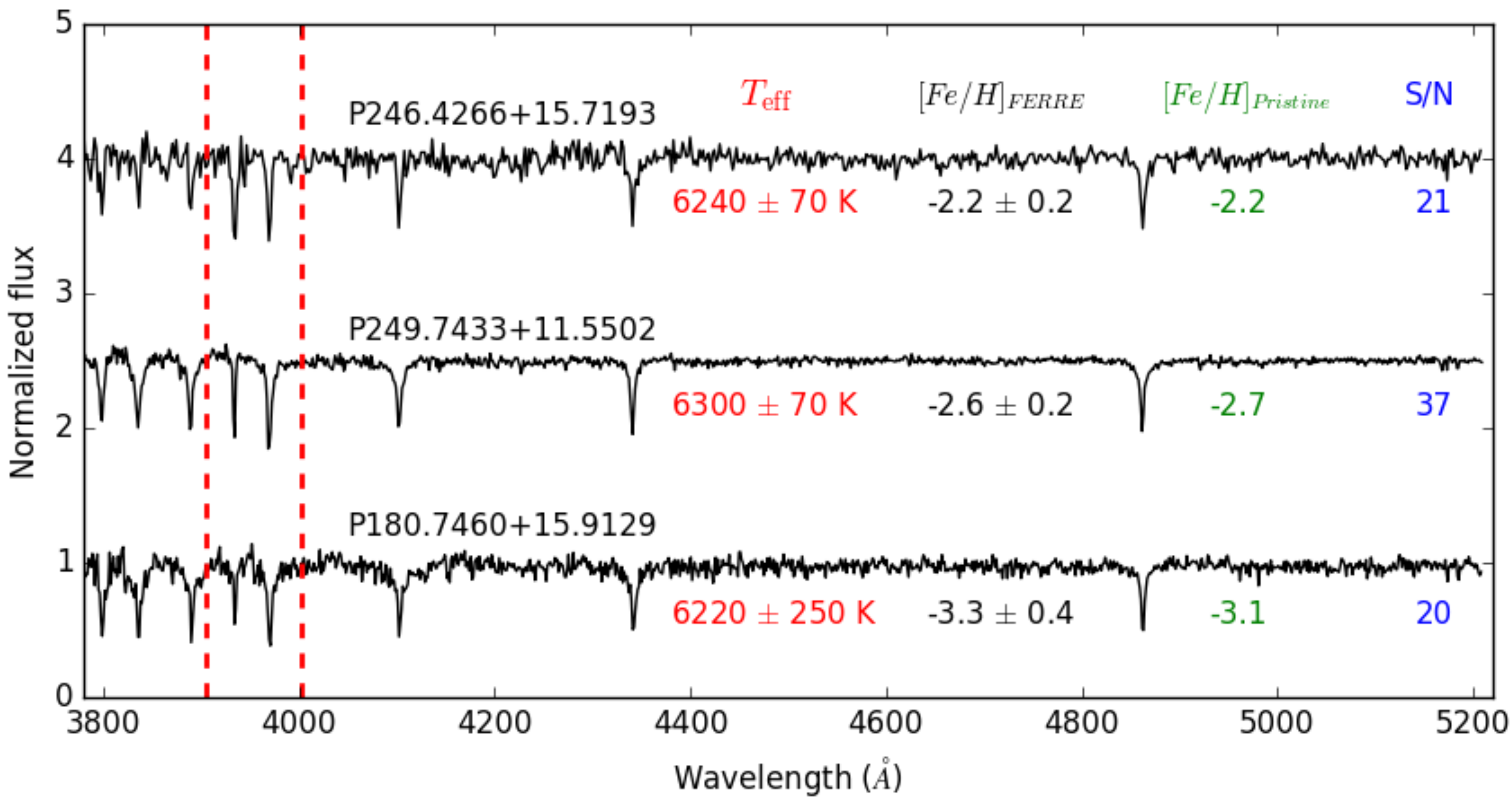
2016 A,B

Sample of ~200 stars

2017 A,B

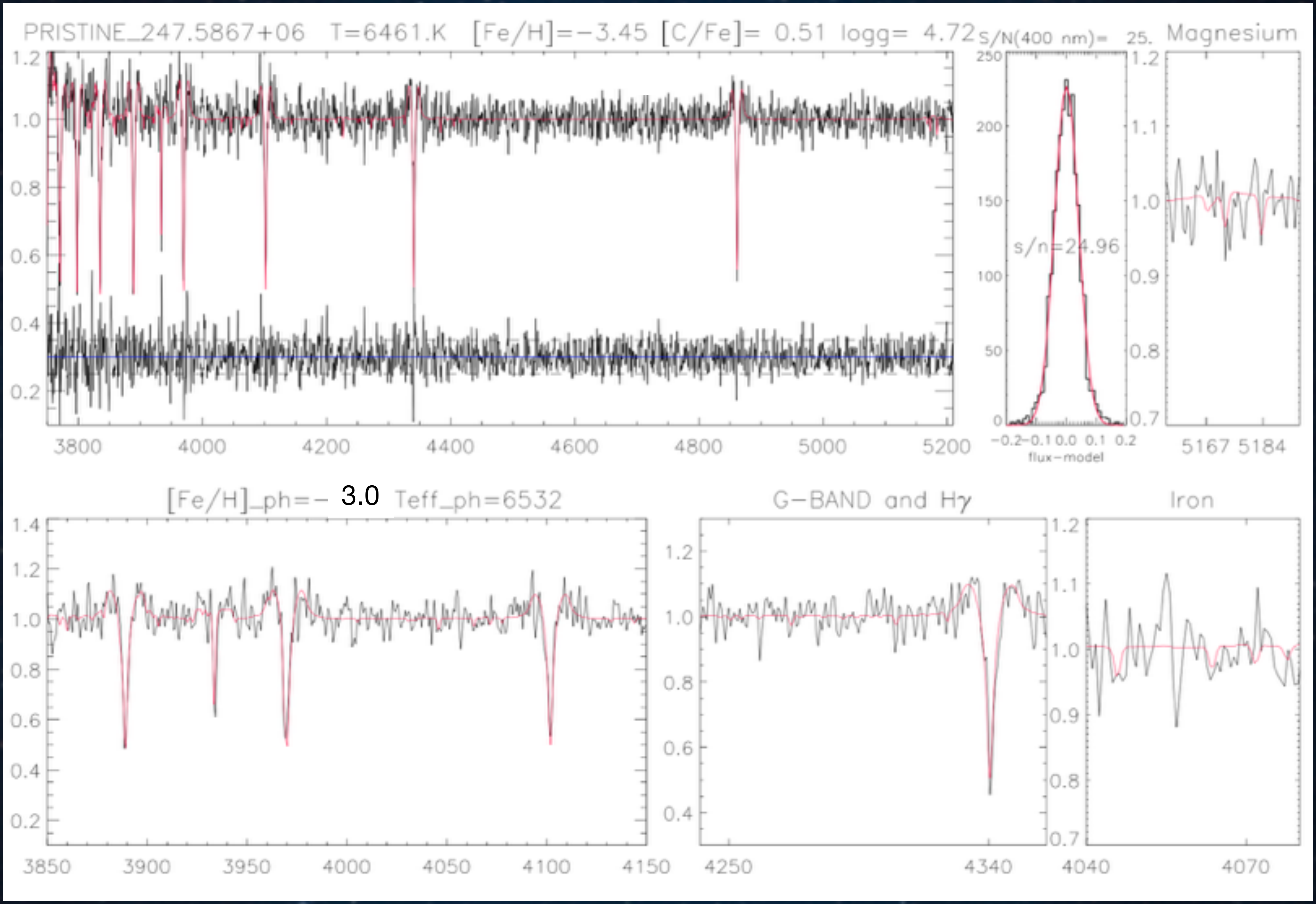
Sample of ~250 stars

What the spectra look like



Youakim et al., 2017

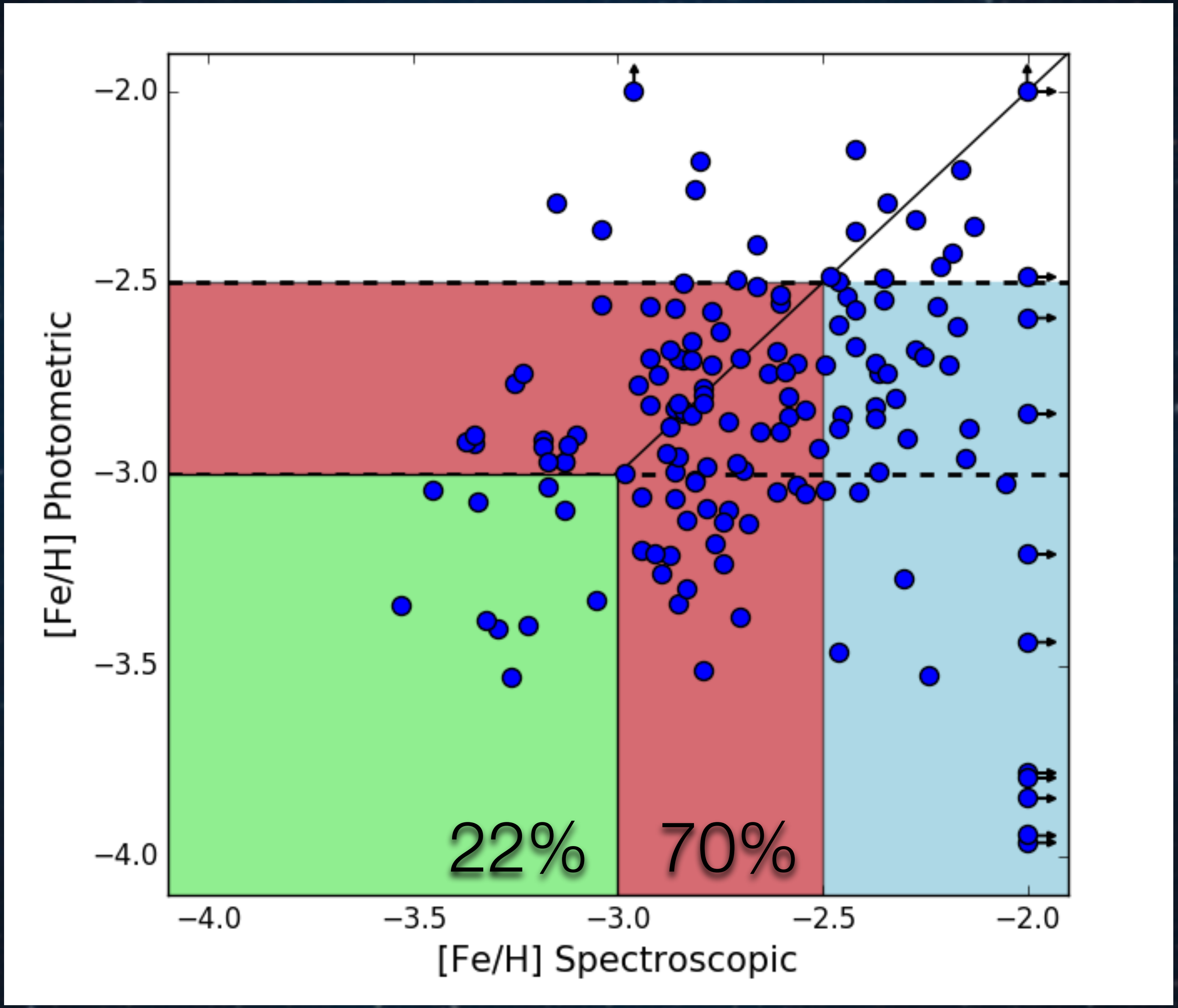
Spectral analysis with FERRE



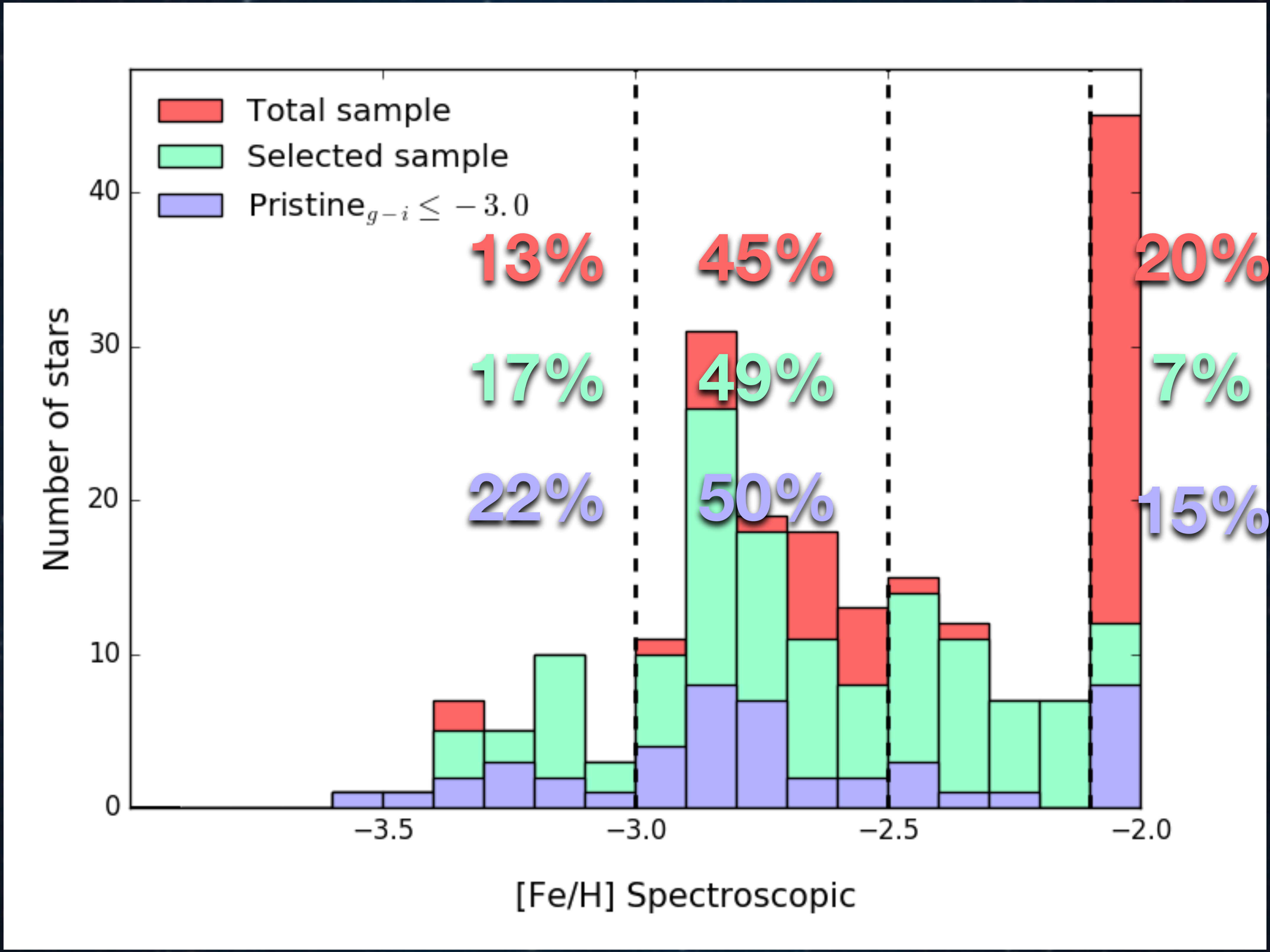
David Aguado

Efficiency and success rates

Photometric vs spectroscopic [Fe/H]



Success rates for finding [Fe/H] < -3



Comparison to other surveys

	[Fe/H] < -3	[Fe/H] < -2.5	-3 < [Fe/H] < -2
Pristine	22 %	70 %	73 %
HES	4 %	22 %	40 %
SC14	3.8 %	-	32 %

Hamburg ESO survey - Schörck et al. 2009

Best and brightest - Schlaufman & Casey 2014

Projections

- Based on success rates, we expect to find ~1 200 stars with [Fe/H] < -3 with V < 18
- Pristine does go fainter (V < 20.5), we could potentially find a lot more UMP stars with full follow-up
- We expect to find ~12 stars over 1000 deg^2 footprint with [Fe/H] < -4 for V < 18
- We plan to collect at least ~3000 deg^2
- Multi-object spectrographs (e.g. WEAVE, 4MOST)

Summary

22%

- Pristine shows unprecedented success rates for finding EMP stars with [Fe/H] < -3
  - Characterization of the metal poor tail of the MDF
- Very promising projections for uncovering UMP stars with [Fe/H] < -4

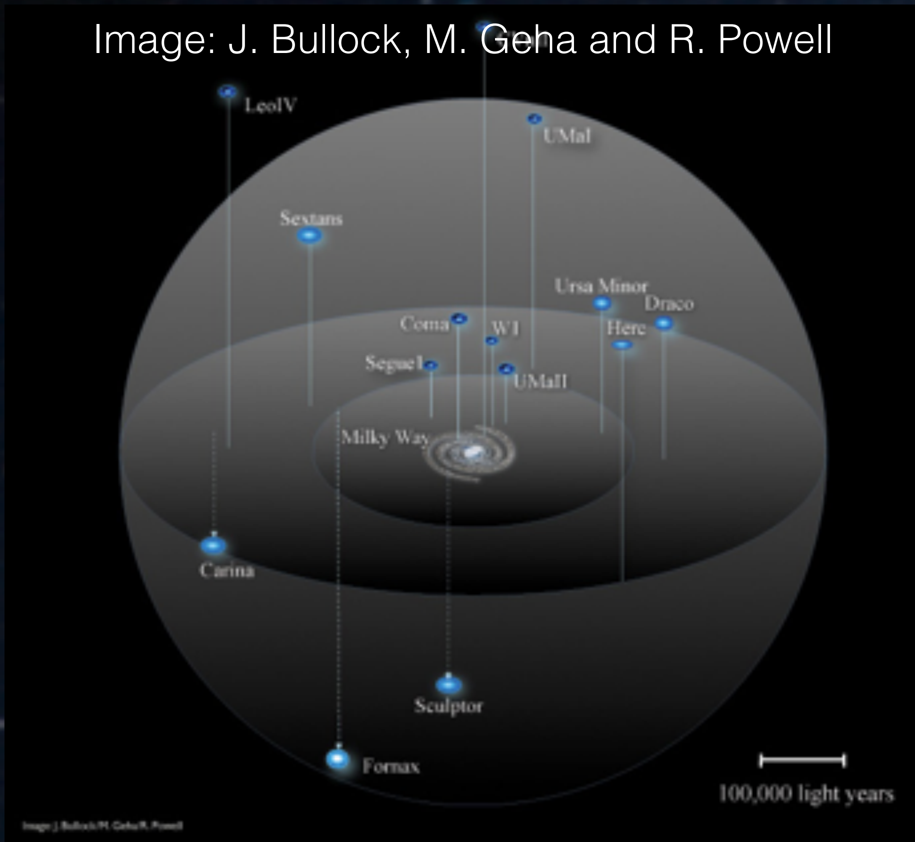
~12 per 1000 deg^2

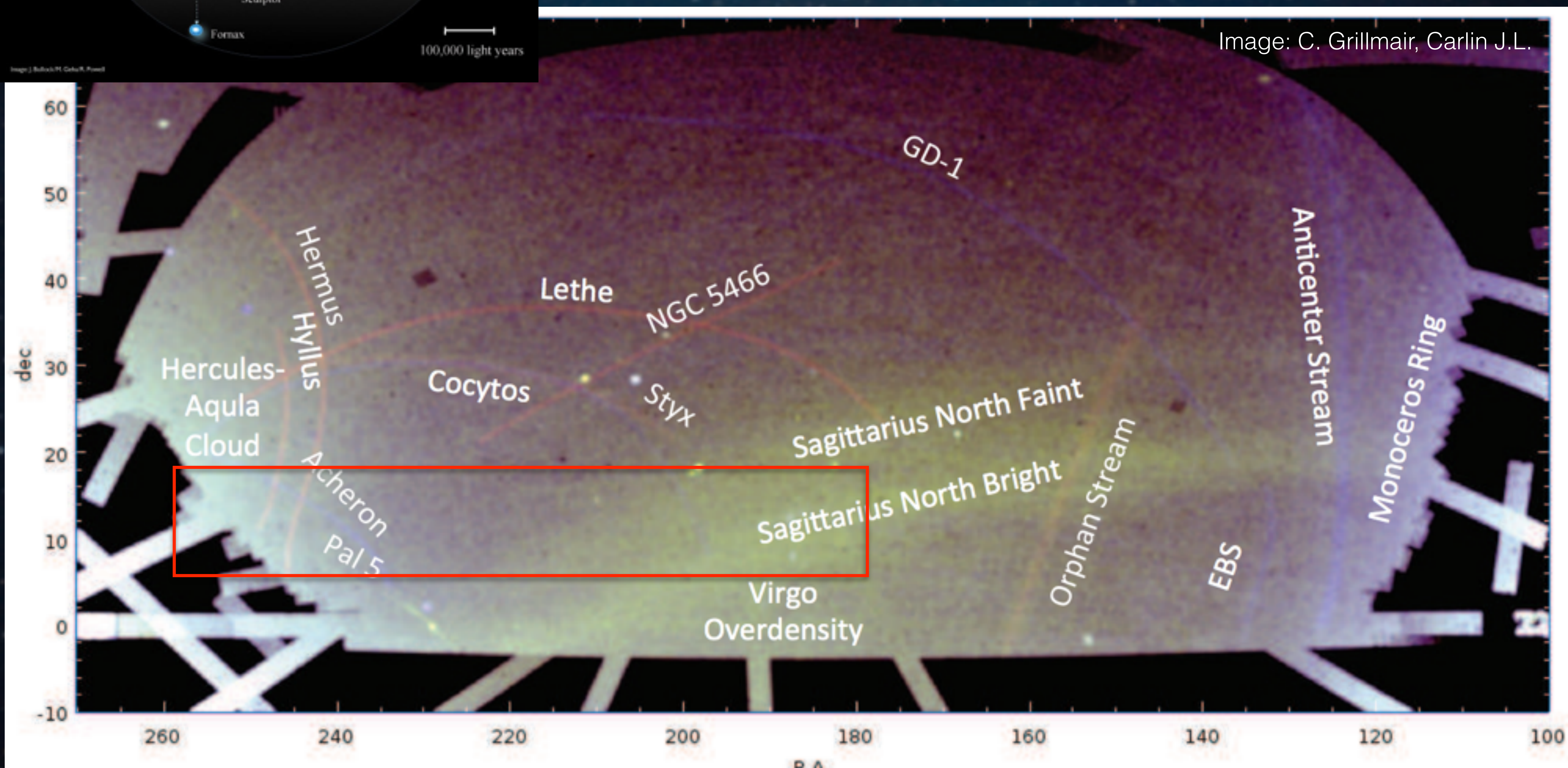
What else can we do with Pristine?

Dwarf Galaxies

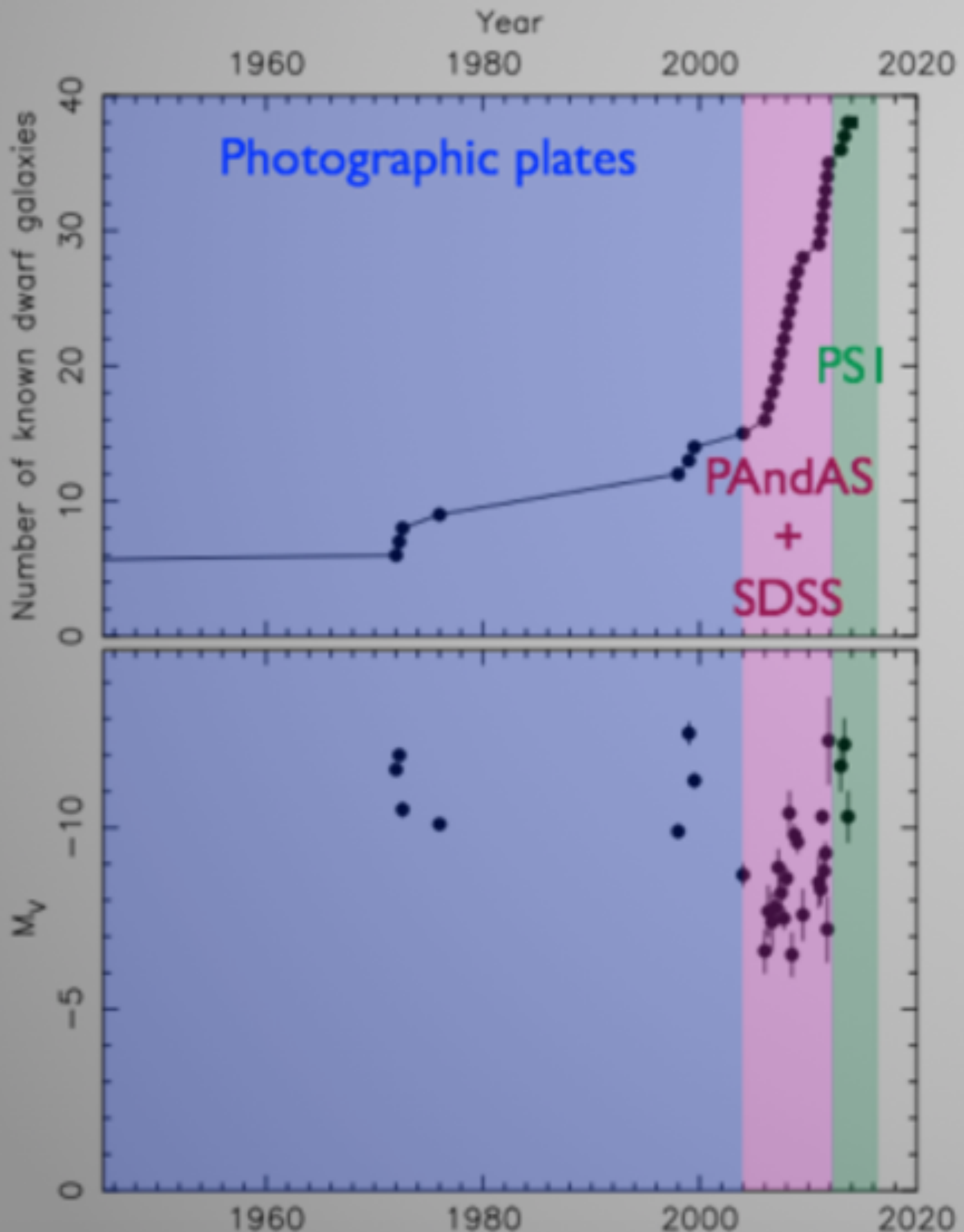
Galactic Bulge

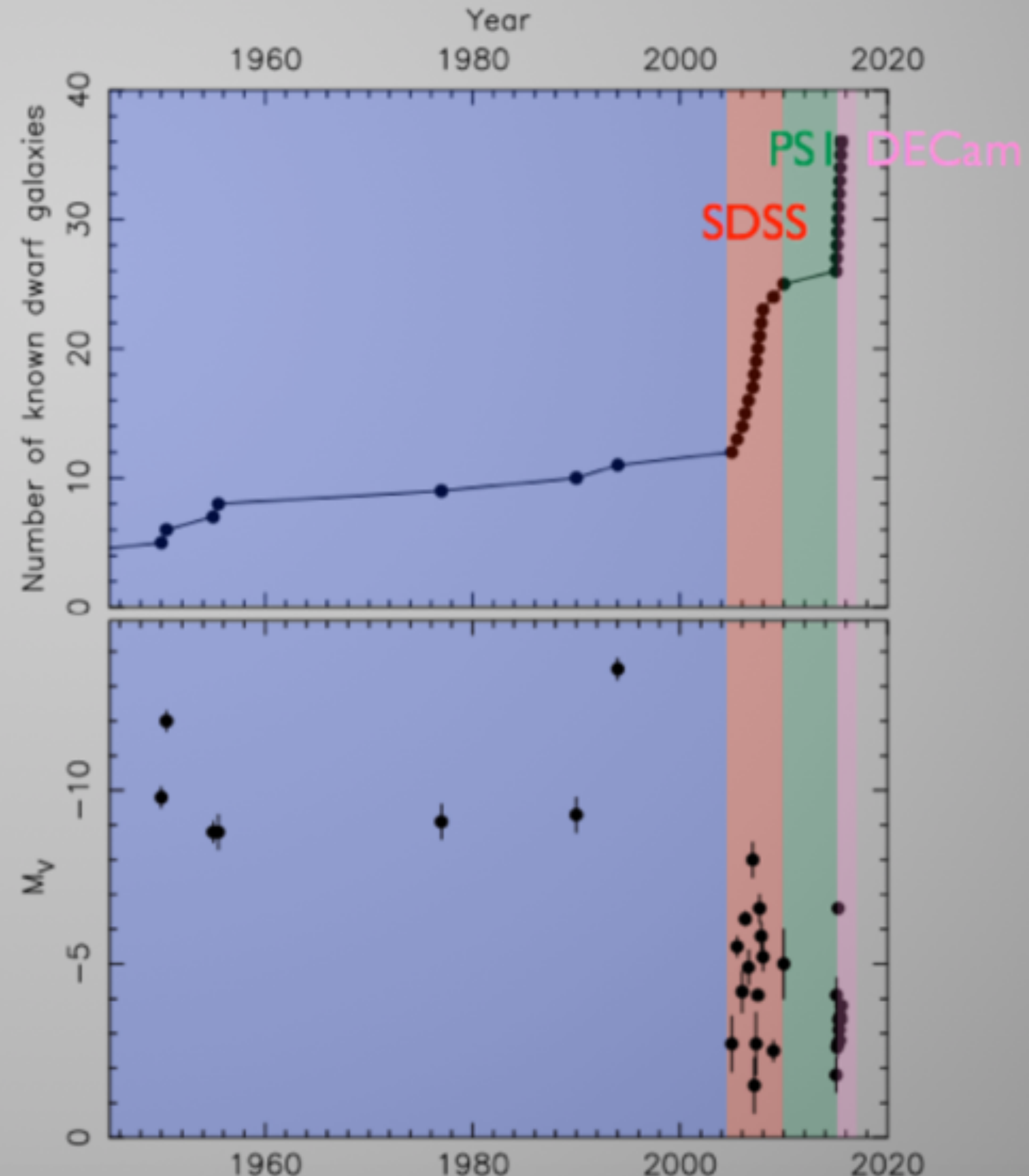
Dwarf Galaxies





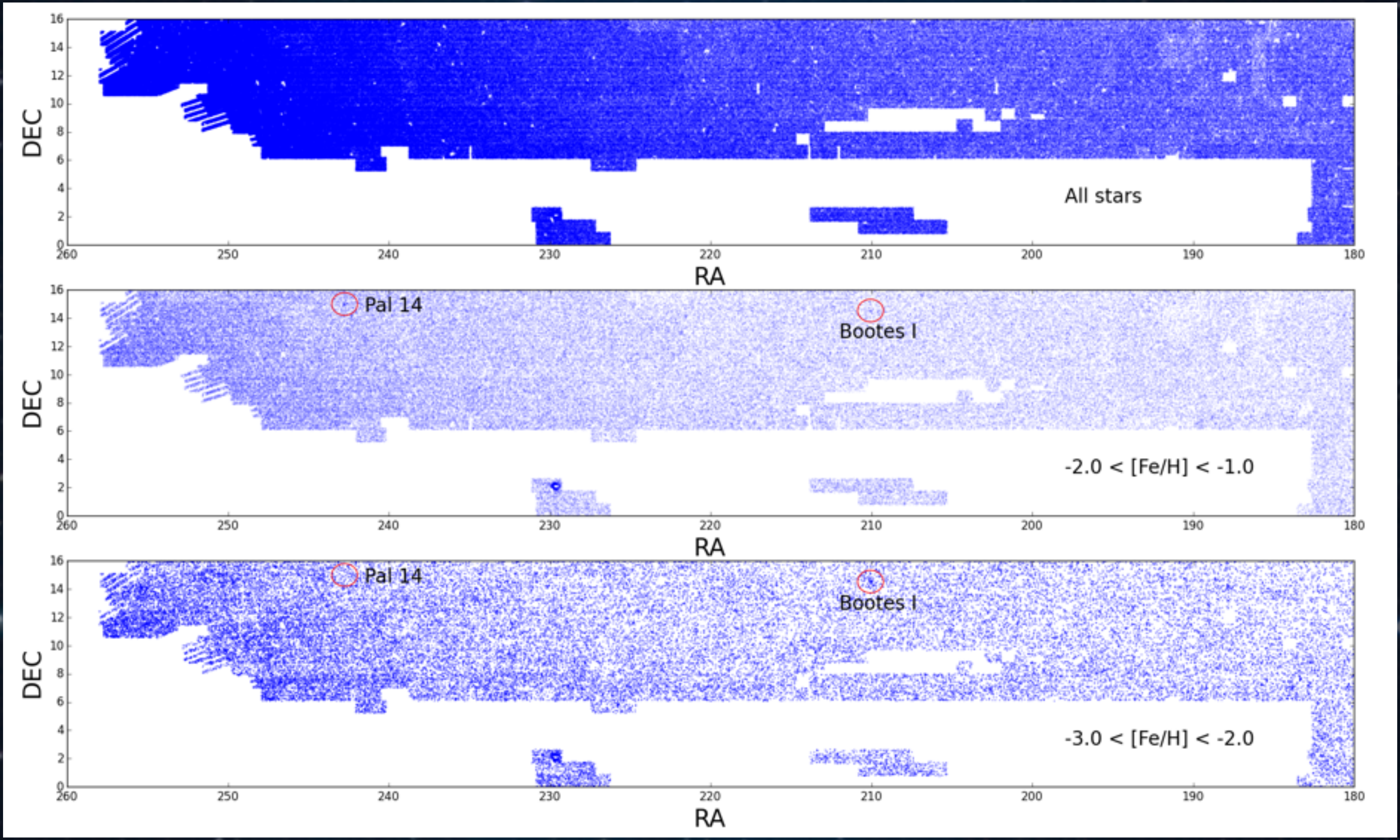
Number of known dwarf galaxies



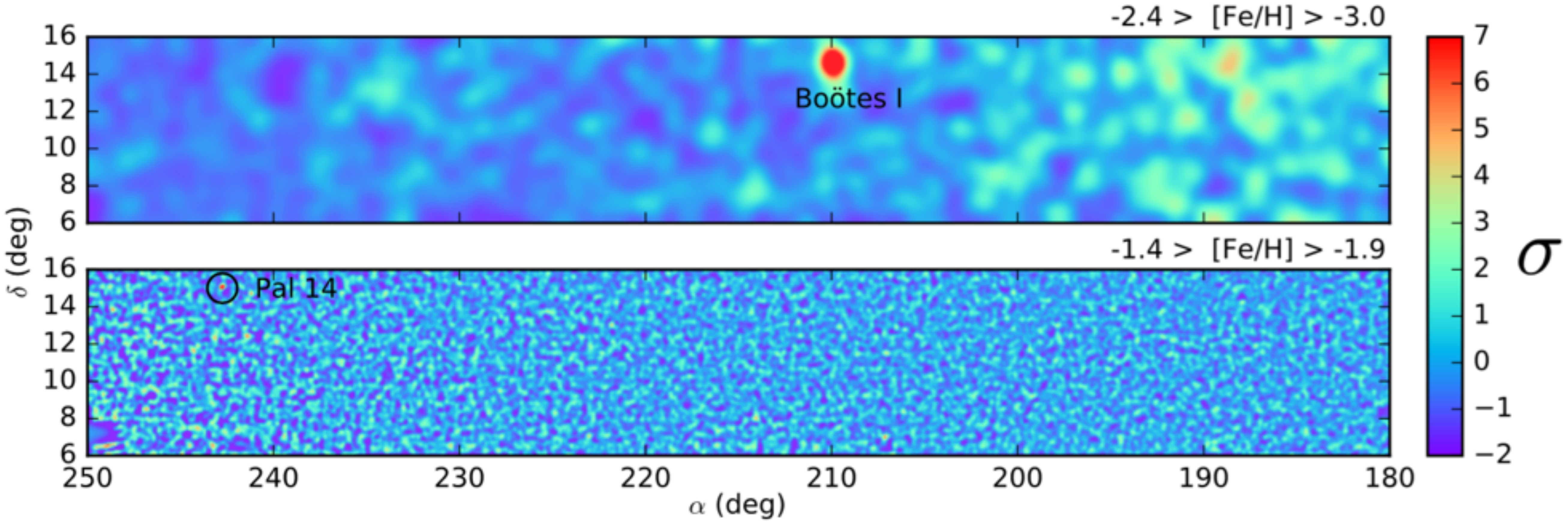


Credit: N. Martin

Stellar density maps



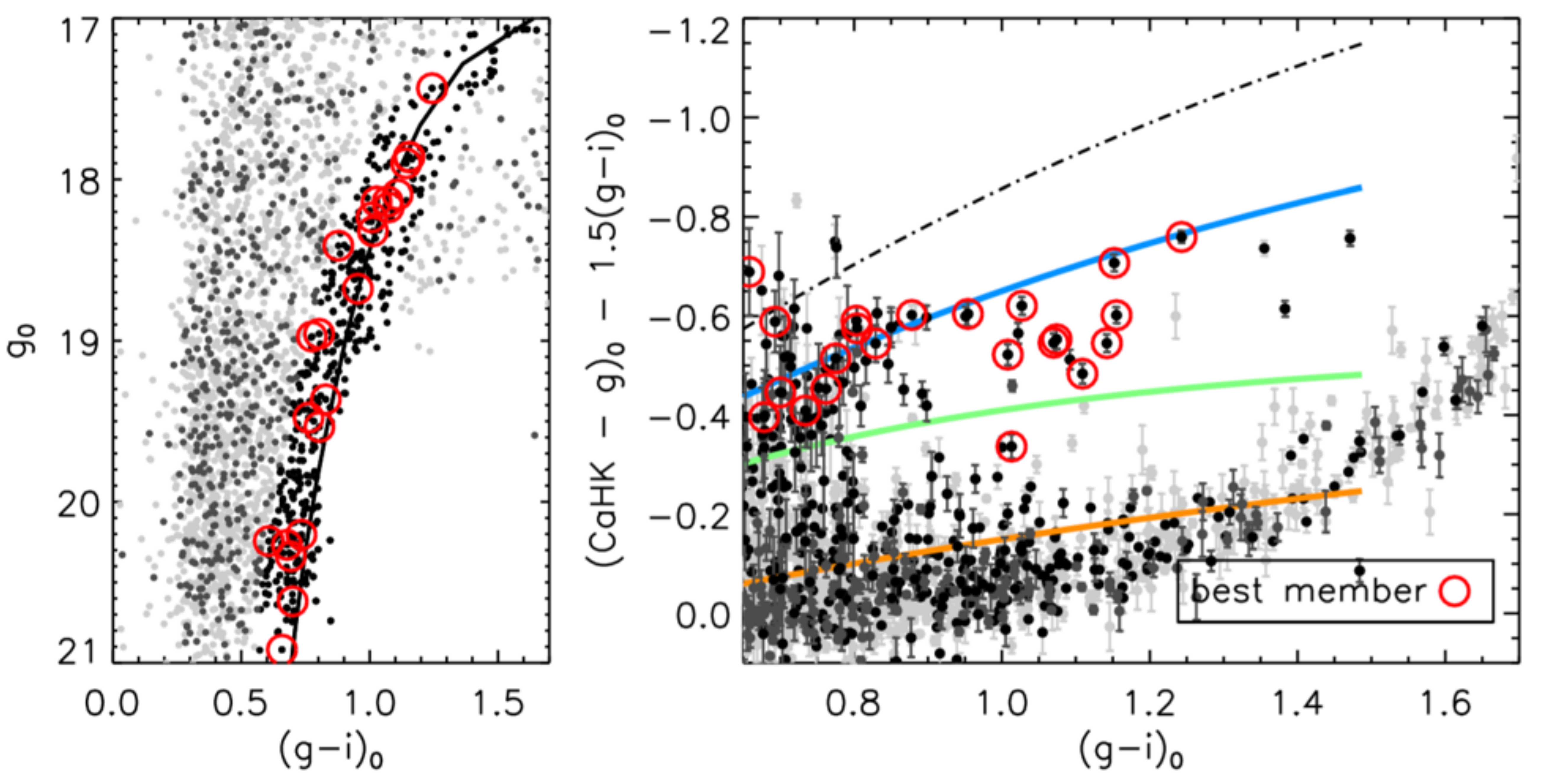
Stellar density maps



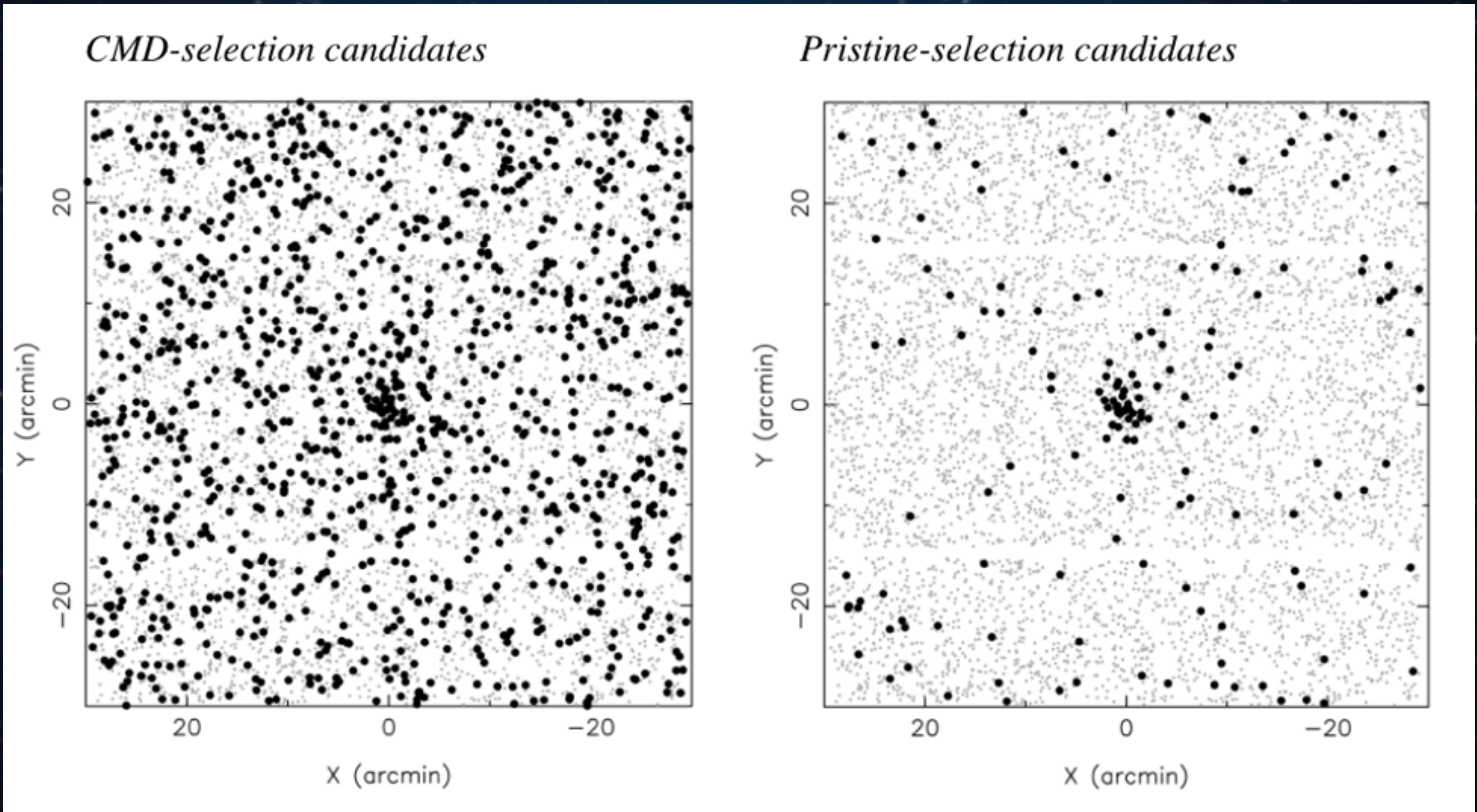
Finding new substructures?

Quantifying substructure as a function of metallicity?

Characterization of known dwarf galaxies - Boötes I

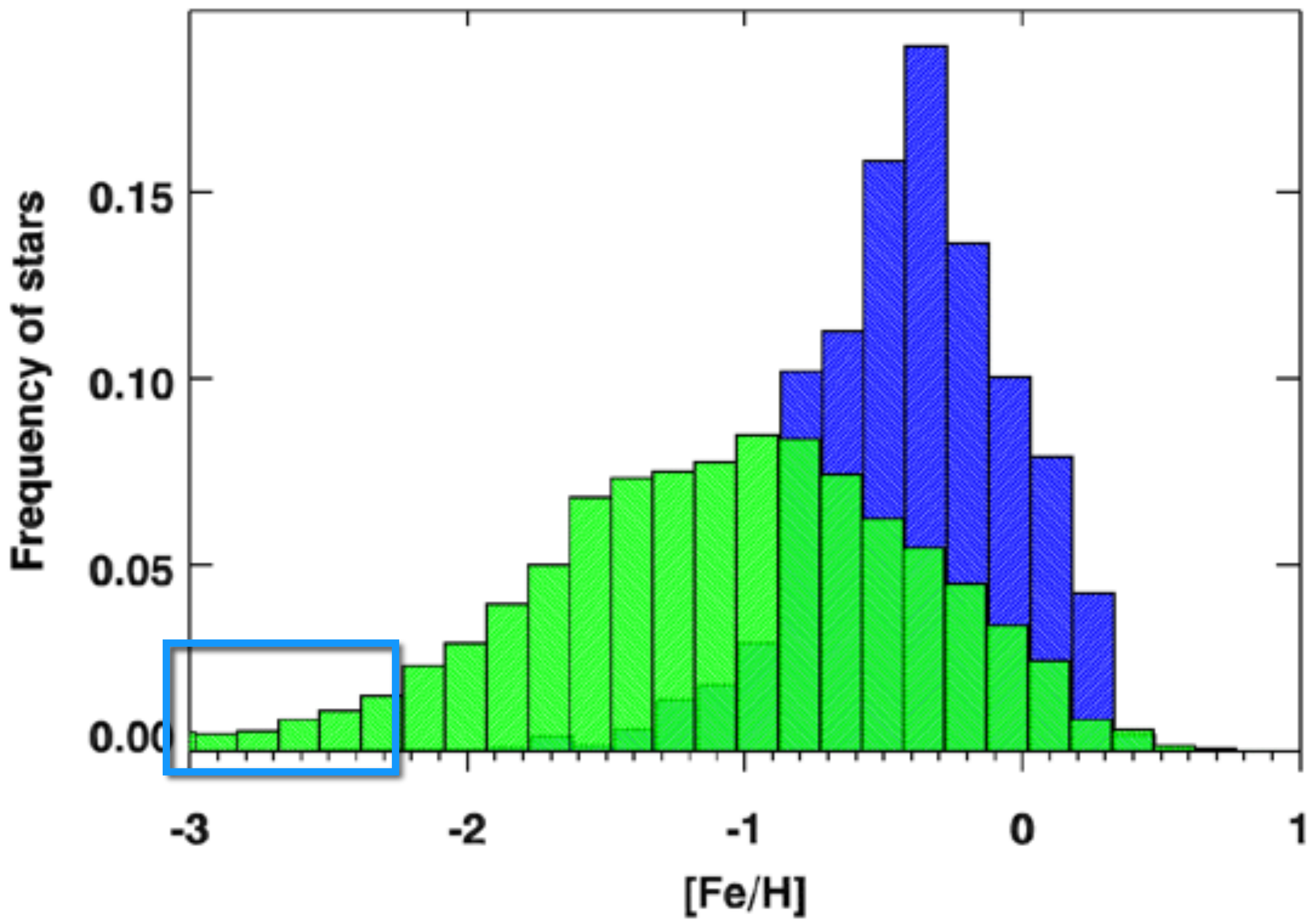


Characterization of known dwarf galaxies - Triangulum II



Anke Arentsen

Pristine in the bulge



MDF in the ***SkyMapper/EMBLA*** *survey (Howes+2016) compared to the* ***ARGOS*** *survey (Ness+2013)*

CEMP stars 3%

Halo > 20%

Only ~150 stars with [Fe/H] < -2.5

9 stars with [Fe/H] < -3

Summary

- Characterize faint Dwarf galaxies
  - Find member stars in outskirts
- Search for substructure and quantify it as a function of metallicity
- Metal poor stars in the Bulge
  - What is the Bulge CEMP fraction?

Thanks!