The AMBRE Project

Metallicity Distribution with the ESO:FEROS archived spectra

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Observatoire de la Côte d'Azur

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Summary

- The AMBRE Project
- ESO:FEROS Stellar Parameters
- Metallicity Distribution with FEROS ?

The AMBRE Project

Archéologie avec Matisse: aBondances dans les aRchives de l'Eso

Collaborators: P. de Laverny, A. Recio-Blanco, V. Hill, C. Ordenovic, F. Guitton, J.C. Gazzano and A. Bijaoui

Observatoire de la CÔTE d'AZUR

ESO/OCA project: 2009 - 2012

ESO

ESO Spectrograph	Resolving Power	Spectral Domain	Approximate No. archived spectra
FEROS	48,000	350nm - 920nm	20,000
HARPS	115,000	378nm - 691nm	125,000
UVES	40,000 to 110,000	300nm - 1100nm	100,000
Flames/GIRAFFE	5,600 to 46,000	370nm - 900nm	>1000,000
		Total Sample	>350,000

This extensive dataset covers a large range of wavelengths and resolutions, including the wavelength domain and resolutions of Gaia RVS.

MATISSE: MATrix Inversion for Spectral SynthEsis

Recio-Blanco, Bijaoui, de Laverny (2006);
Bijaoui, Recio-Blanco, de Laverny (2008)

Local multi-linear regression method

- **Stellar parameters ($\theta = T_{eff}$, log g, [M/H], individual chemical abundances) are derived by the projection of an input observed spectrum $O(\lambda)$ on a vector function $B_\theta(\lambda)$.**

$$\hat{\theta}_i = \sum_{\lambda} B_\theta(\lambda) O_i(\lambda)$$

- **The $B_\theta(\lambda)$ function is an optimal linear combination of theoretical spectra $S(\lambda)$ calculated from a synthetic spectra grid (the learning phase).**

$$B_\theta(\lambda) = \sum_{i} \alpha_i S_i(\lambda)$$

The $B_\theta(\lambda)$ function reflects the sensitivity of the spectral region to θ.

The Grid of High Resolution Synthetic Spectra

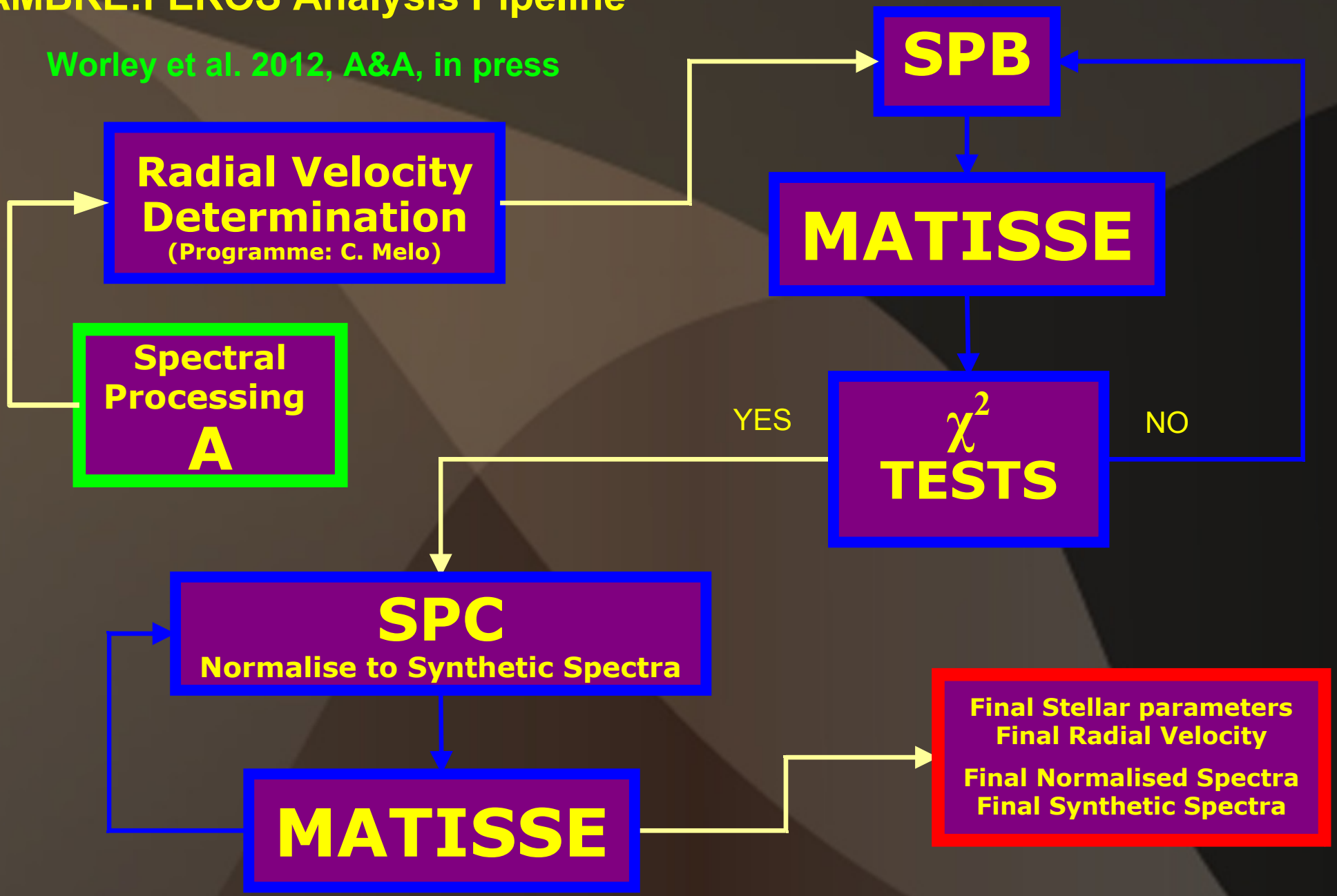
de Laverny, Recio-Blanco, Worley & Plez 2012, A&A, in press

Computed using OCA Mesocentre ~ 50,000hrs computing time

- **~16000 synthetic spectra**
- **Optical domain: 3000 Å - 12000 Å**
- **MARCS model atmospheres (Gustafsson et al., 2010)**
  - **T_{eff} : 2500 → 8000 K**
  - **log g : 0.0 → +5.0 dex**
  - **[M/H] : -5.0 → +1.0 dex**
  - **[α/Fe] : -0.4 → +0.8 dex**
- **Molecular line lists from Bertrand Plez**
- **Atomic line lists : VALD**

AMBRE:FEROS Analysis Pipeline

Worley et al. 2012, A&A, in press

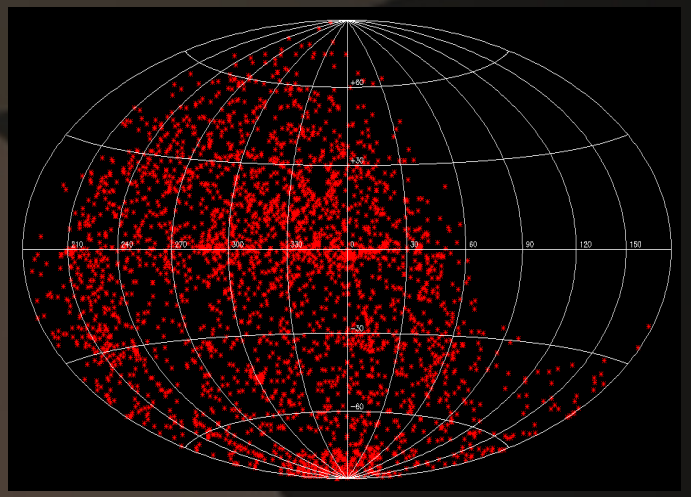


The AMBRE:FEROS Stellar Parameters

Worley, de Laverny, Recio-Blanco, Hill, Bijaoui & Ordenovic, 2012, A&A, in press

The AMBRE:FEROS Analysis

FEROS Targets in Galactic Coordinates



Majority of Southern Sky is sampled

FEROS: **MPG/ESO 2.2m Telescope, La Silla**

Instrument Resolution ~ 48,000

Wavelengths →350nm to 920nm

October 2005 → December 2009

No. Archived Spectra → 21551

No. Stars → ~ 6285

MATISSE SET-UP: **17 Wavelength Regions → 1500 Å from 4000 Å to 7000 Å**

→ Mg triplet (~5160 Å), H_β (4861 Å)

Validation: Homogeneous Reference Samples

Standard Star Atlases: Sun, Arcturus, Procyon

Spectral Libraries: S^4N, PASTEL

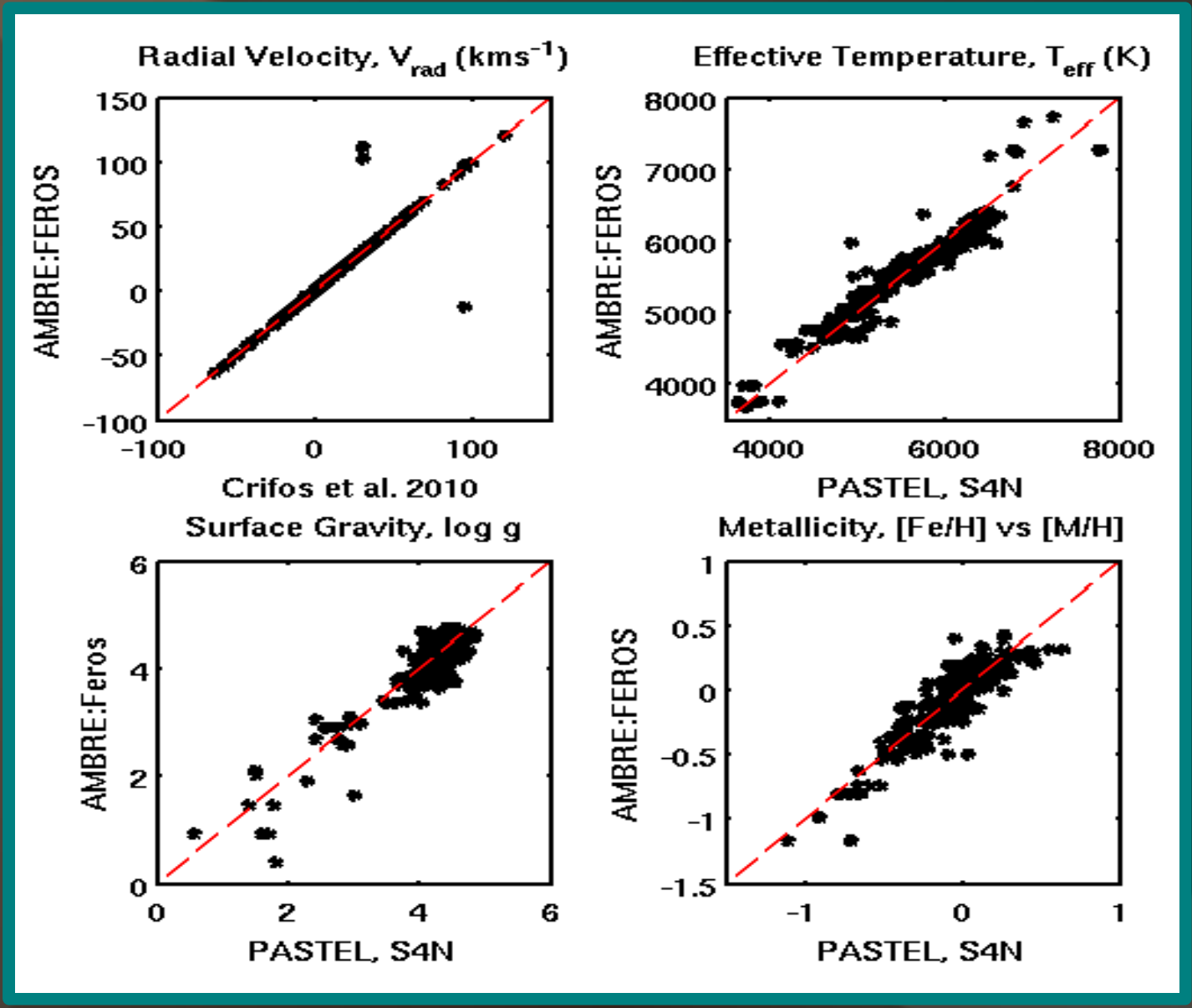
Key Studies: Crifo et al. 2010 → Gaia RVS Standards

Bensby et al. 2003 → alpha element abundances

Source	Papers	Abbrv.	No. Stars	No. Spectra
S^4N	Allende-Prieto et al. 2004 ($T_{\rm eff}$, logg, [Fe/H], [α/Fe], V_{rad})	AP04	30	338
Gaia RVS Standards	Crifo et al. 2010 (V_{rad})	C10	158	318
	Bensby et al. 2003 ($T_{\rm eff}$, log g, [Fe/H],[α/Fe])[a]	B03	68	68
PASTEL	**$T_{\rm eff}$, log g, [Fe/H]**			
Soubiran et al (2010)	Fuhrmann et al. 1997, 1998a&b, 2000, 2004 2008	F97-08	49	206
	Gratton et al. 1982, 1989, 1996, 2003	G82-03	23	118
	Hekker & Melendez 2007	H&M07	6	27
	Luck & Heiter 1983, 1991, 2005, 2006	L&H83-06	41	224
	McWilliam 1990	McW90	10	41
	Mishenina & Kovtyukh 2001; Mishenina et al. 2003, 2004, 2006, 2008	M&K01; M04-08	42	227
	Ramirez et al. 2007	R07	26	151
	Valenti & Fischer 2005	V&F05	81	310
	$T_{\rm eff}$ only			
	Alonso et al. 1996,1999	A96,99	22	147
	Blackwell & Lynas-Gray 1998	B&LG98	20	152
	di Benedetto 1998	dB98	18	163
	Gonzalez-Hernandez & Bonificio 2009	GH&B09	26	162
	Kovtyukh et al. 2003, 2004, 2006	K03-06	48	354
	Masana et al. 2006	M06	57	306
	Ramirez & Melendez 2005	R&M05	37	197
	PASTEL Total		148	618

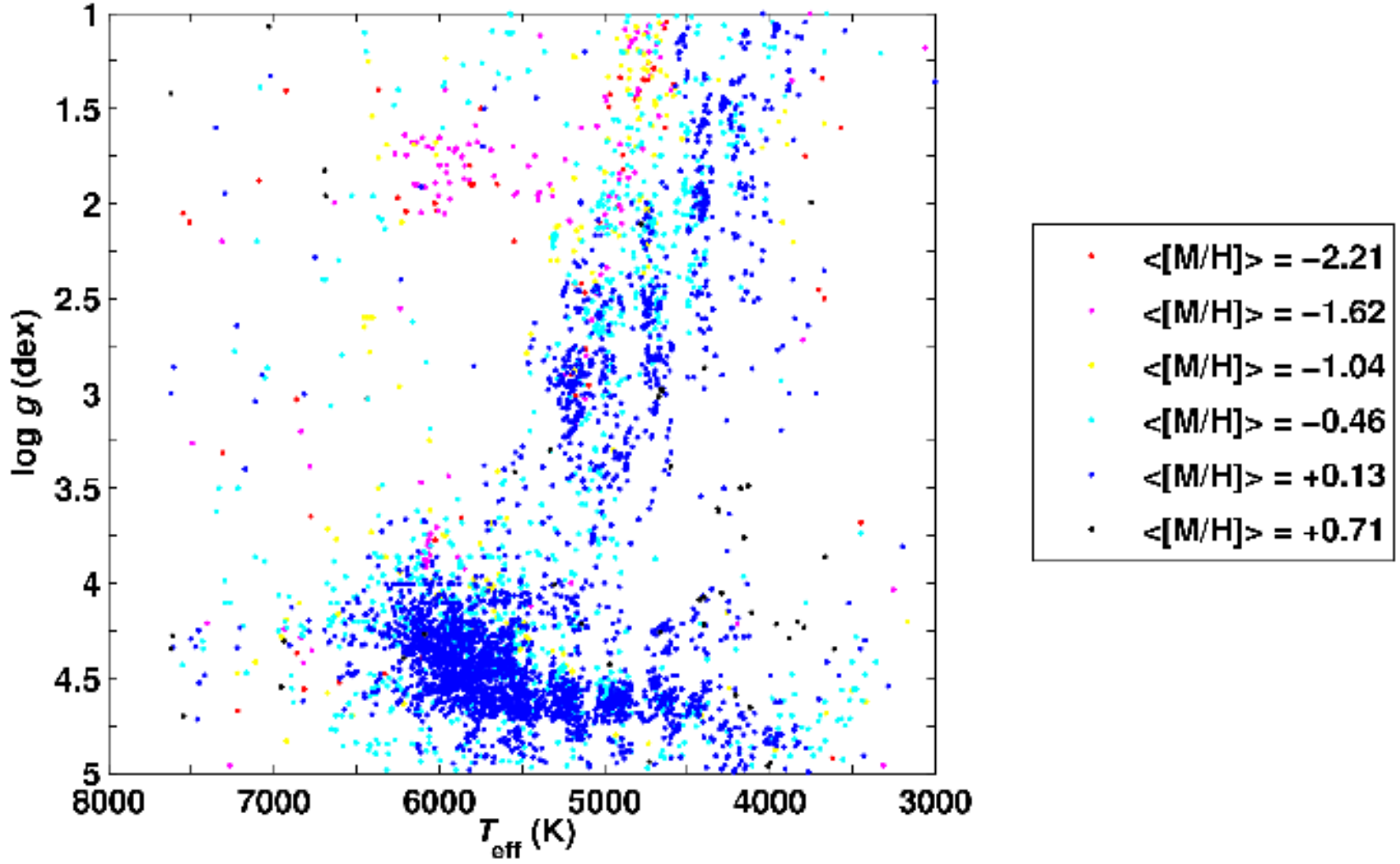
[a] FEROS Observations 2000-2001

Validation: Homogeneous Reference Samples



FEROS Spectra: The Parameters

6508 spectra → 3087 stars → 30.2 % of archived sample



FEROS Spectra: Distances

$$D = 10^{0.2(m - M + 5)}$$

- Absolute Magnitudes using Isochrones: M_V, M_B, M_J, M_K

  Kordopatis et al., 2011a&b

- Extraction of Apparent Magnitudes: V, B, J, K (PPMXL, 2MASS)
- Interstellar Reddening Determination from Theoretical Colours

  Gazzano et al. 2010, 2012; Gonzalez, Hernandez & Bonifacio, 2009

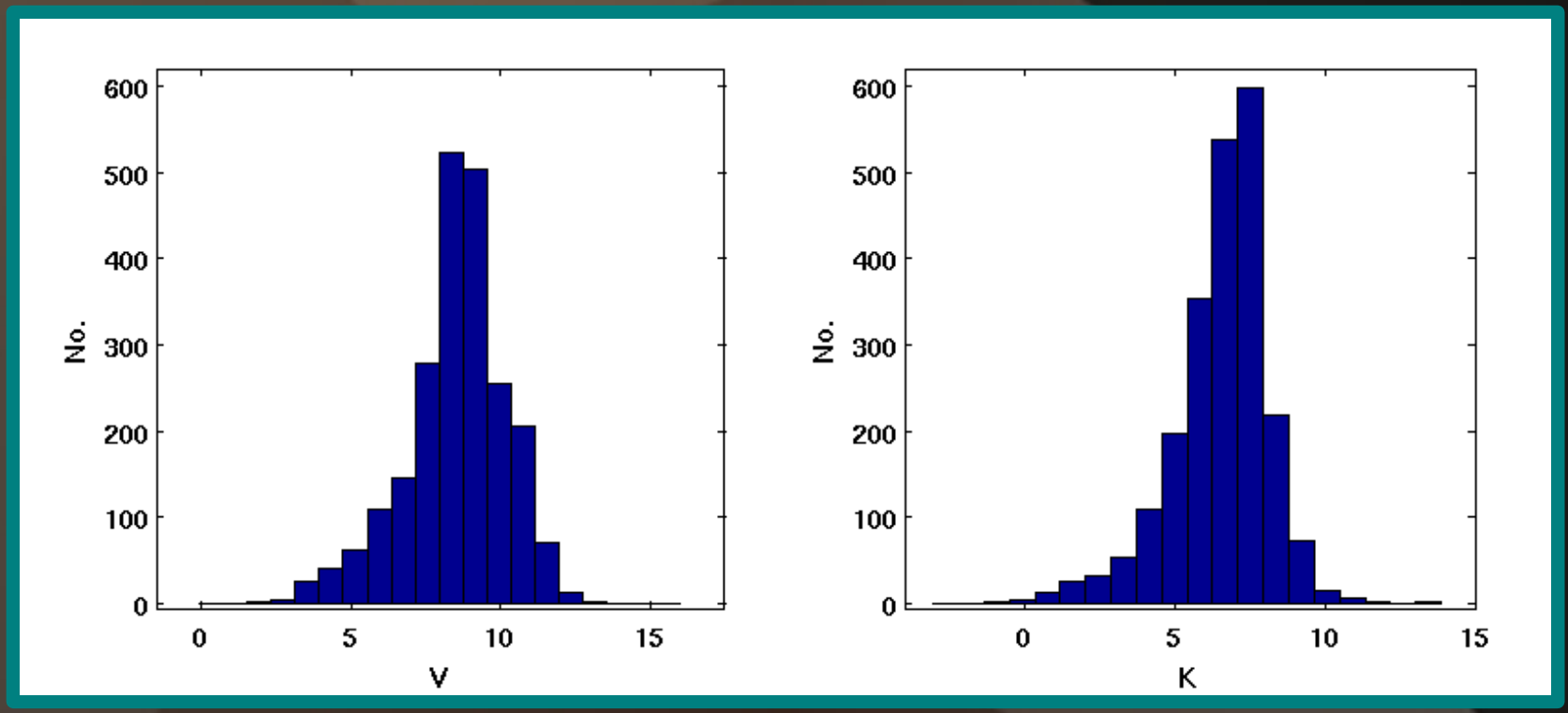
Calculation of Distance above Galactic Plane

$$Z_{GC} = Z_{\odot} + D \sin b$$

FEROS Spectra: Photometric Sample

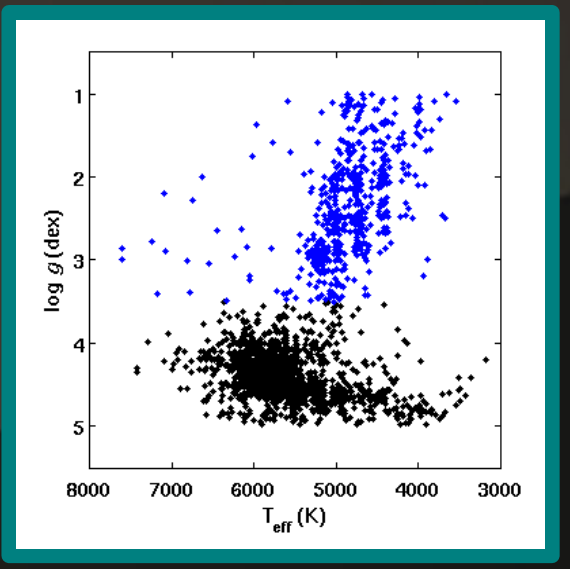
V,B → 6136 spectra **J,K → 6093 spectra**

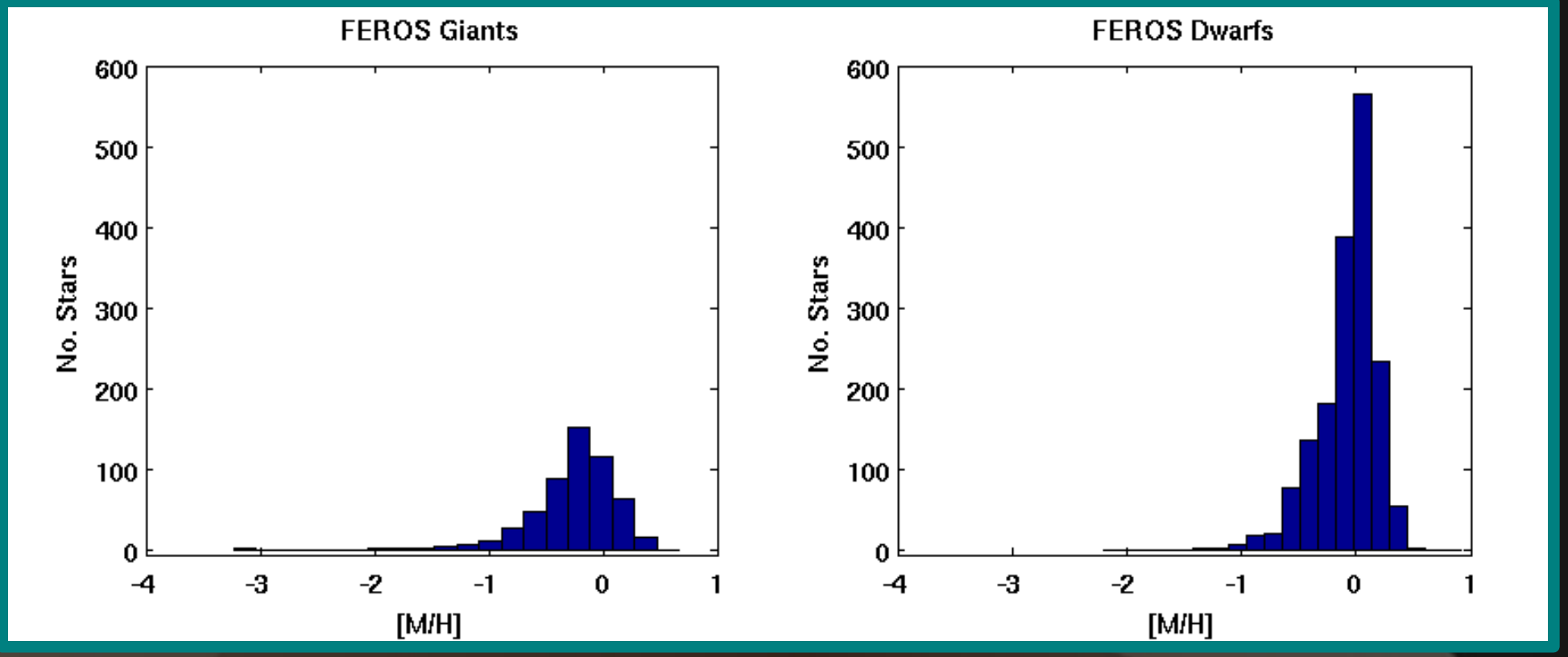
Final Sample: 5135 spectra → 2248 stars



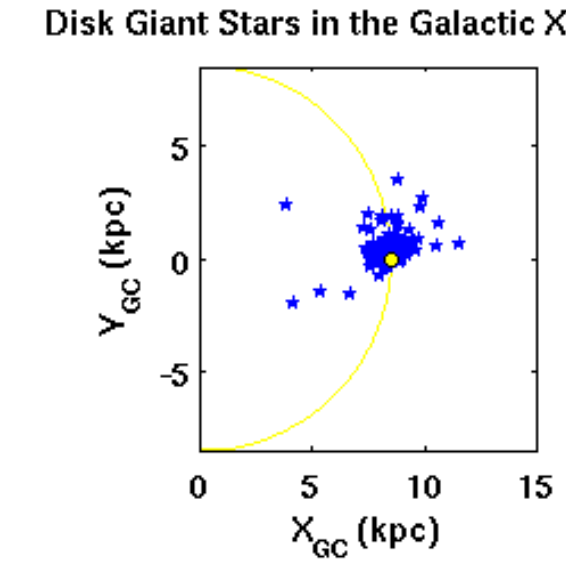
FEROS Spectra: Photometric Sample

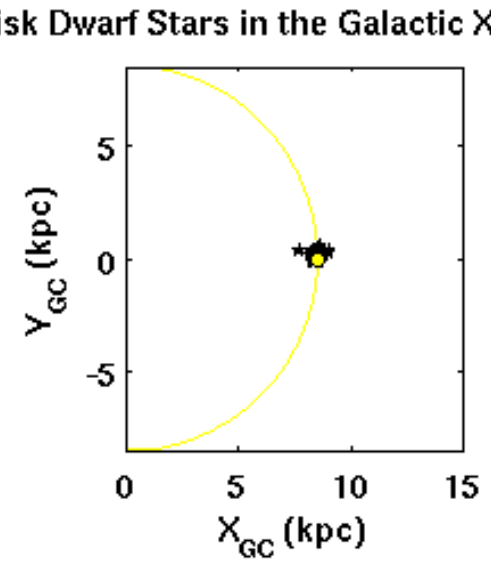
Number of Giant Stars: 552
Number of Dwarf Stars: 1696

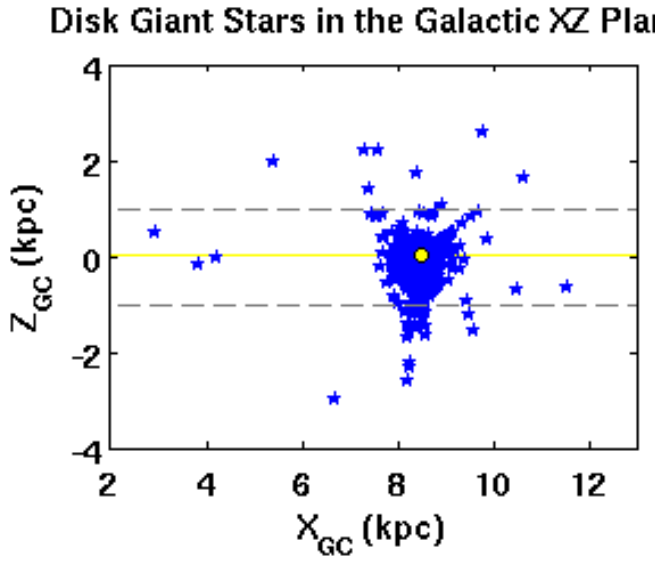


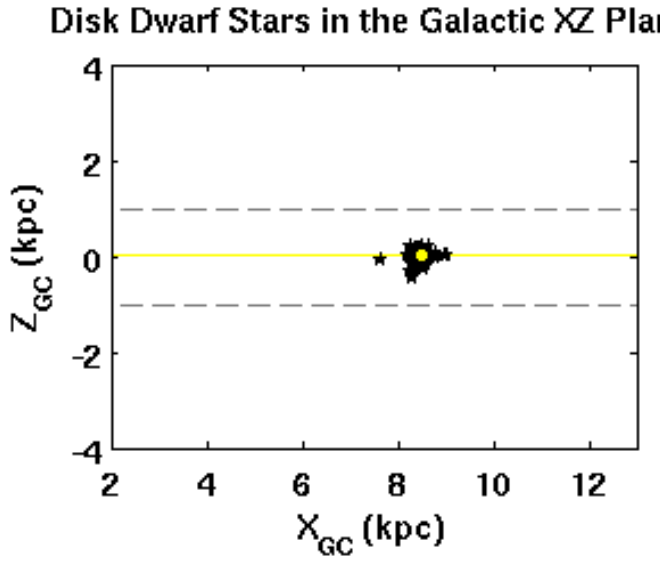


FEROS Spectra: Where are they?



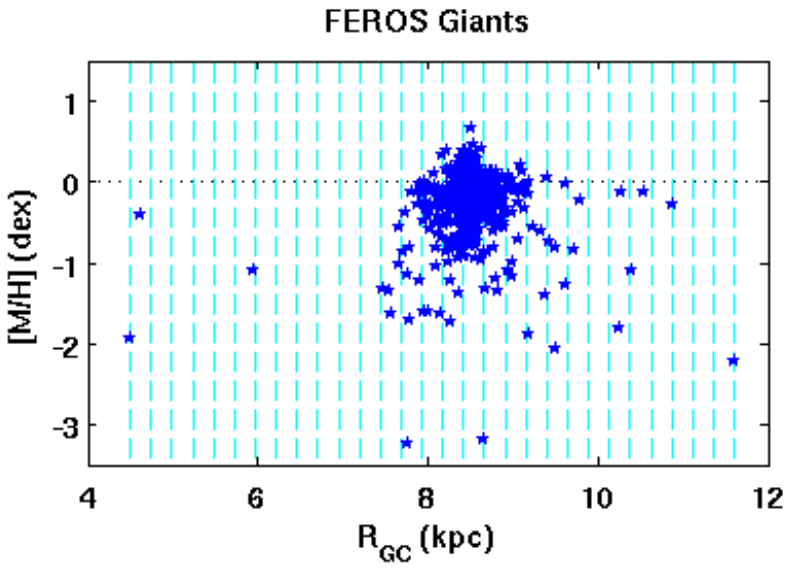


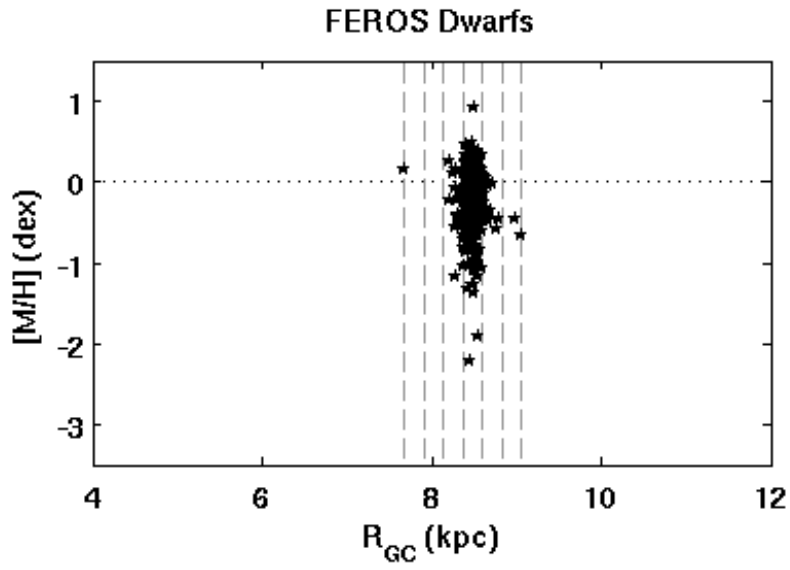


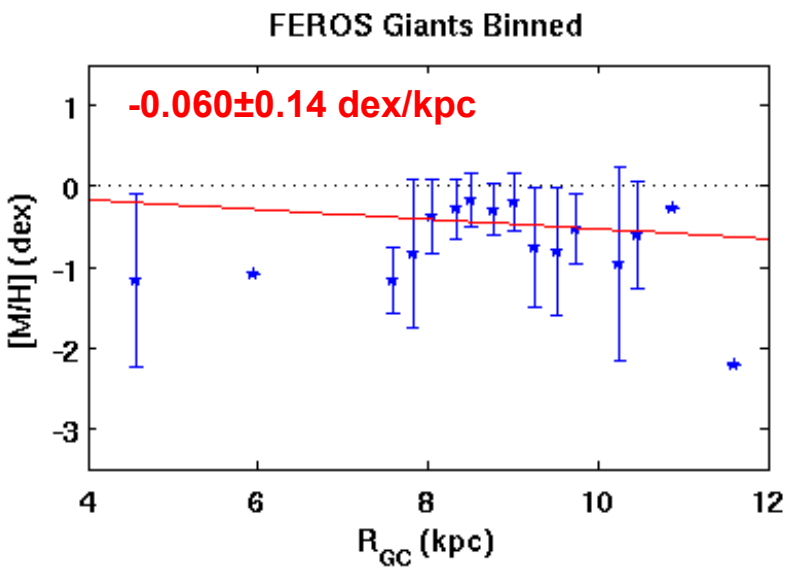


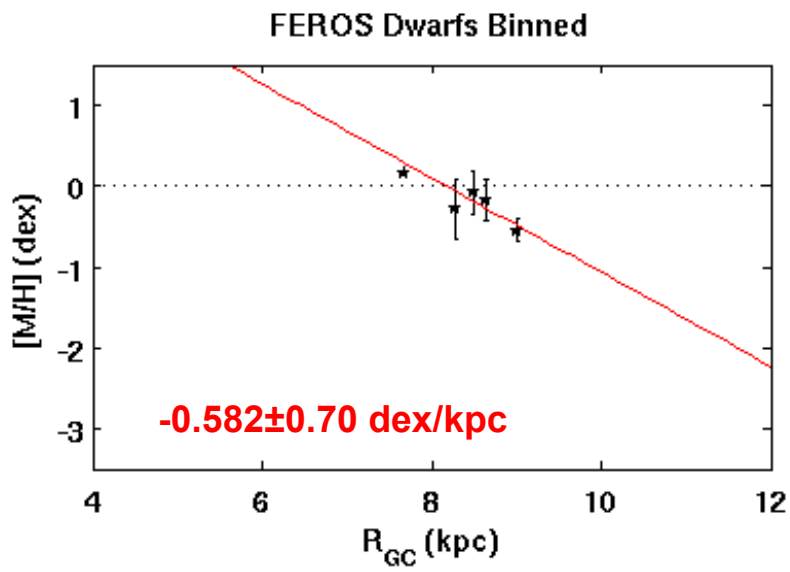
Radial Metallicity Gradient?

Literature: -0.1 to -0.04 dex/kpc

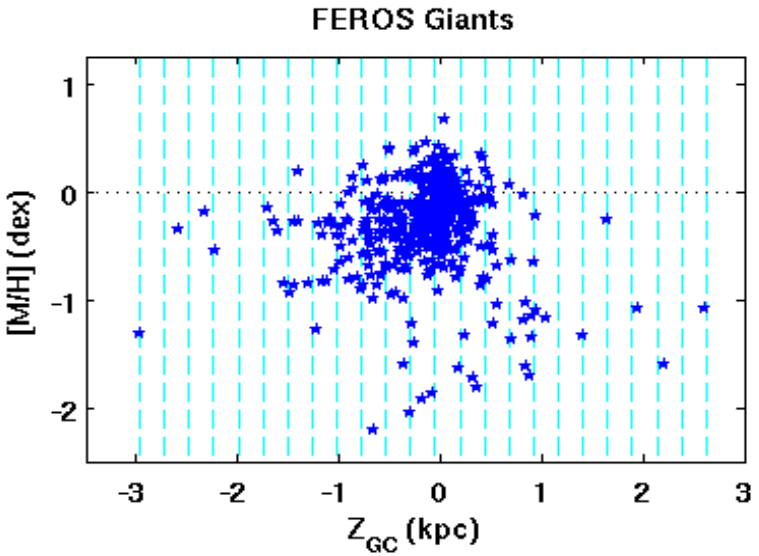


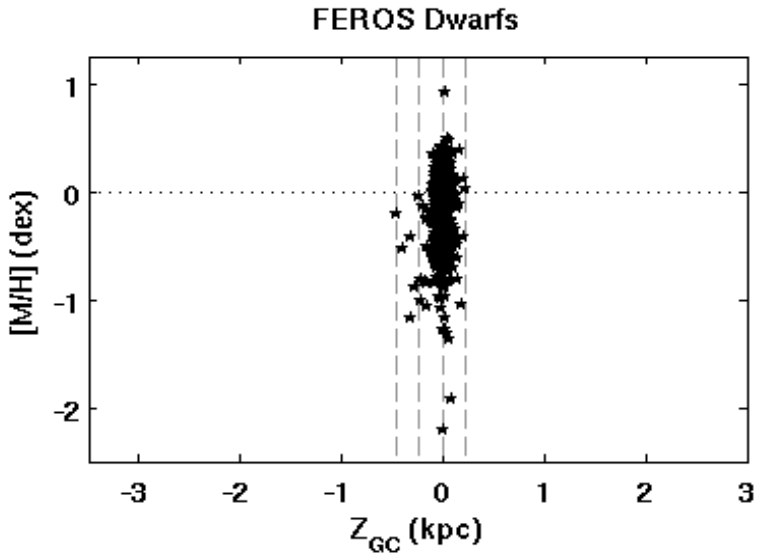


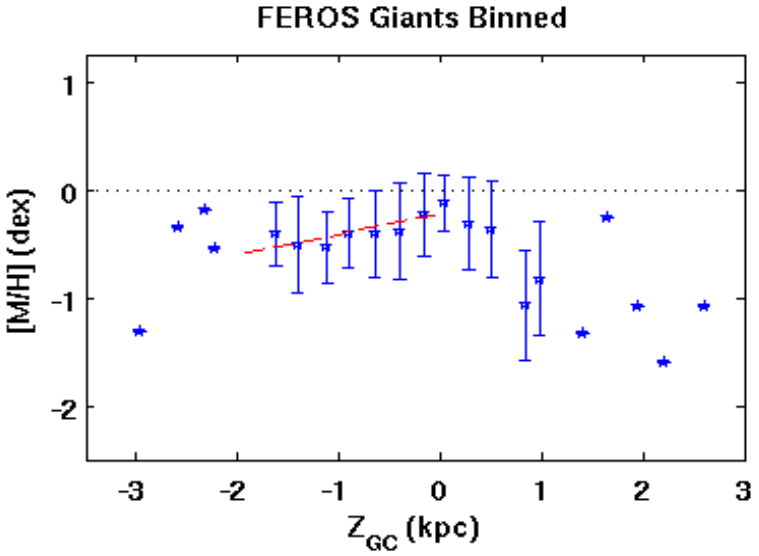


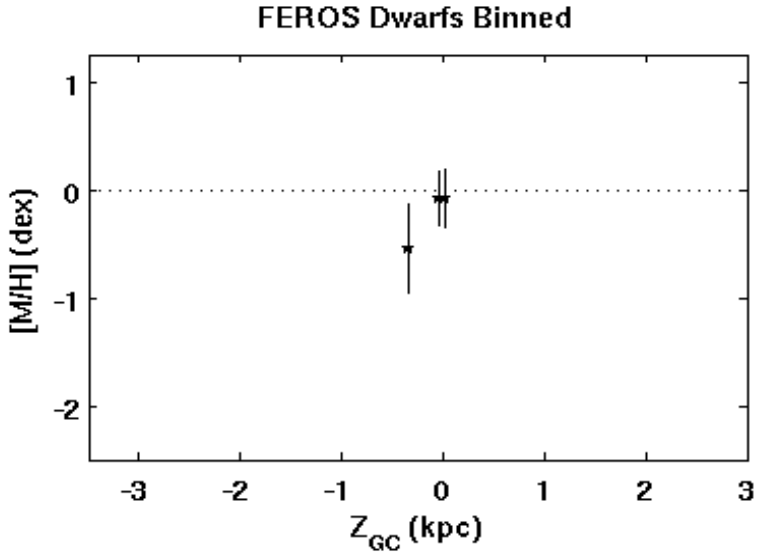


Vertical Metallicity Gradient?

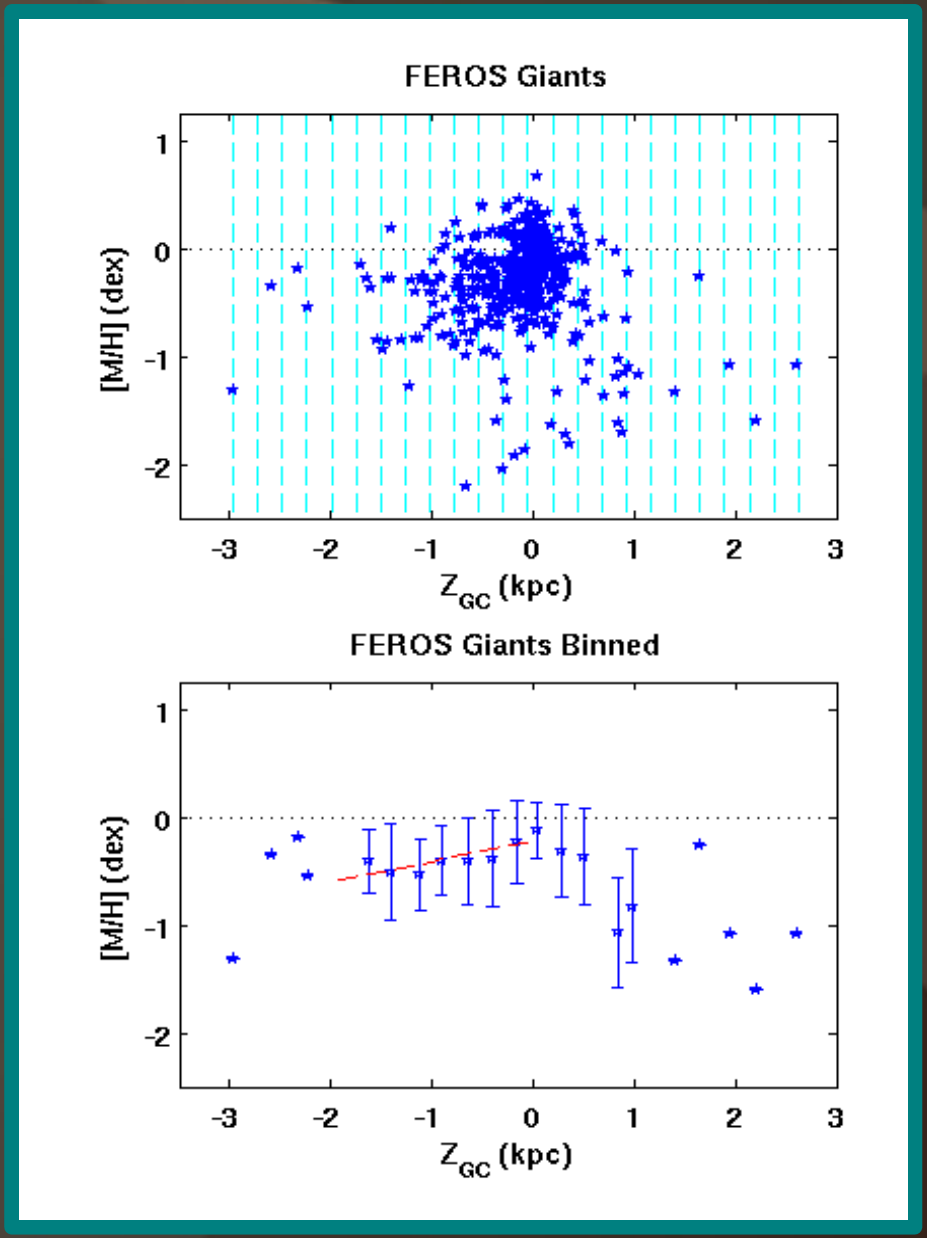






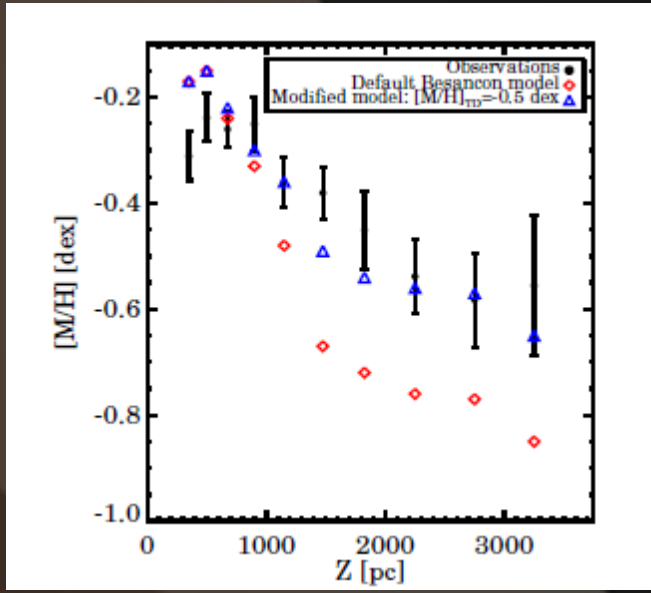


Vertical Metallicity Gradient?



From Z ~ 0 to -2 kpc
-0.19 +/- 0.15 dex/kpc

Kordopatis et al. 2011
-0.14 +/- 0.05 dex/kpc
for Z > 1kpc
(Fig. 11)



Conclusions & Future Work

- **Volume-limited Sample**
- **Too constrained in R_{GC} & Z_{GC},**
- **Extensive Disk Sample: 1696 Dwarfs, 552 Giants**
  - **Alpha-elements from AMBRE:FEROS**
  - **Individual chemical abundances**
  - **Proper motions for thin/thick disk analysis**
  - **Parallaxes from Hipparchos**

Combining homogeneous stellar parameterisation of archived spectral datasets with other types of catalogues represents an untapped source of data for many studies in galactic archaeology

Acknowledgements

- **LOC of GREAT-ESF Workshop**
- **Observatoire de la Côte d'Azur**
- **European Southern Observatory**
- **Centre National d'Etudes Spatiales**