

The AMBRE Project

Exploring the chemical & kinematic information
in the ESO:FEROS archived spectra

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Outline

- The AMBRE Project
- AMBRE:FEROS Stellar Parameters
- Cross-matching to Catalogues
- 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



ESO/OCA project: 2009 - 2012



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 ($\theta = T_{\text{eff}}, \log g, [\text{M}/\text{H}]$, 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

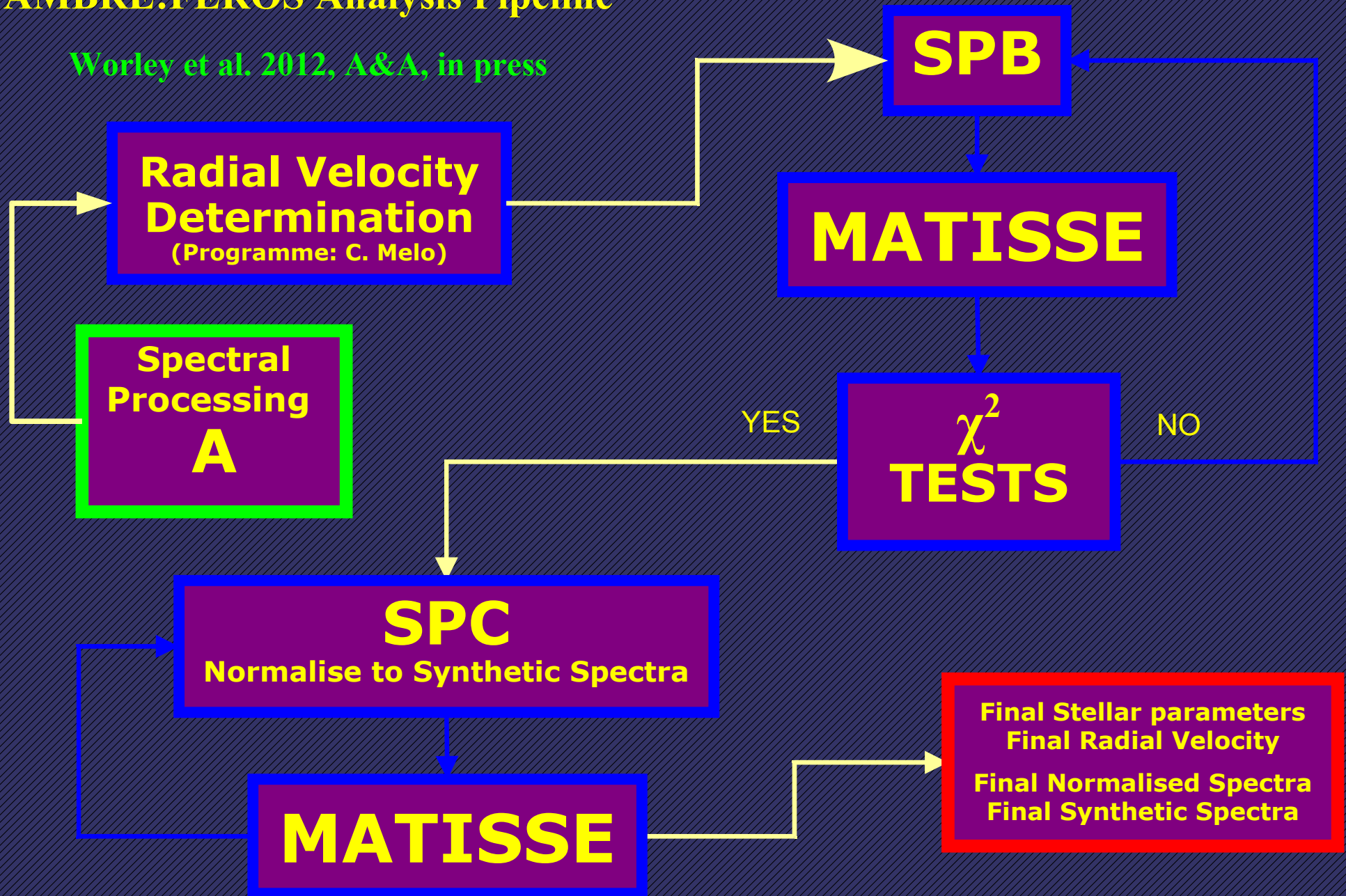
de Laverny, Recio-Blanco, Worley & Plez 2012, A&A, in press

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

FEROS: MPG/ESO 2.2m Telescope, La Silla

Instrument Resolution $\sim 48,000$

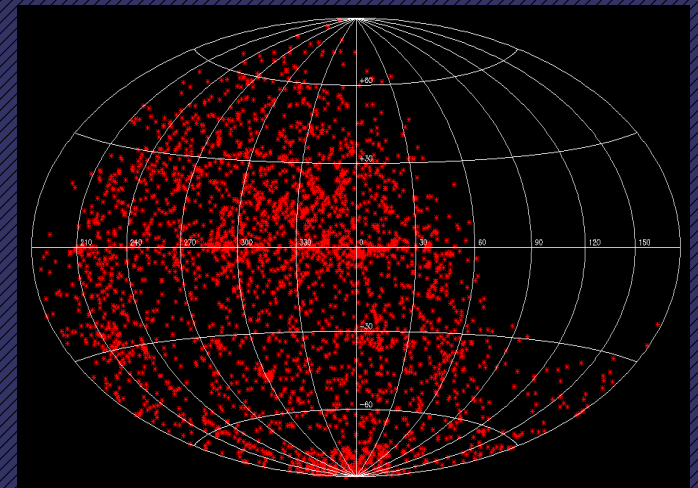
Wavelengths $\rightarrow 350\text{nm}$ to 920nm

October 2005 \rightarrow December 2009

No. Archived Spectra $\rightarrow 21551$

No. Stars $\rightarrow \sim 6285$

FEROS Targets in Galactic Coordinates



Majority of Southern Sky is sampled

MATISSE SET-UP: 17 Wavelength Regions $\rightarrow 1500 \text{ \AA}$ from 4000 \AA to 7000 \AA
 \rightarrow Mg triplet ($\sim 5160 \text{ \AA}$), H_{β} (4861 \AA)

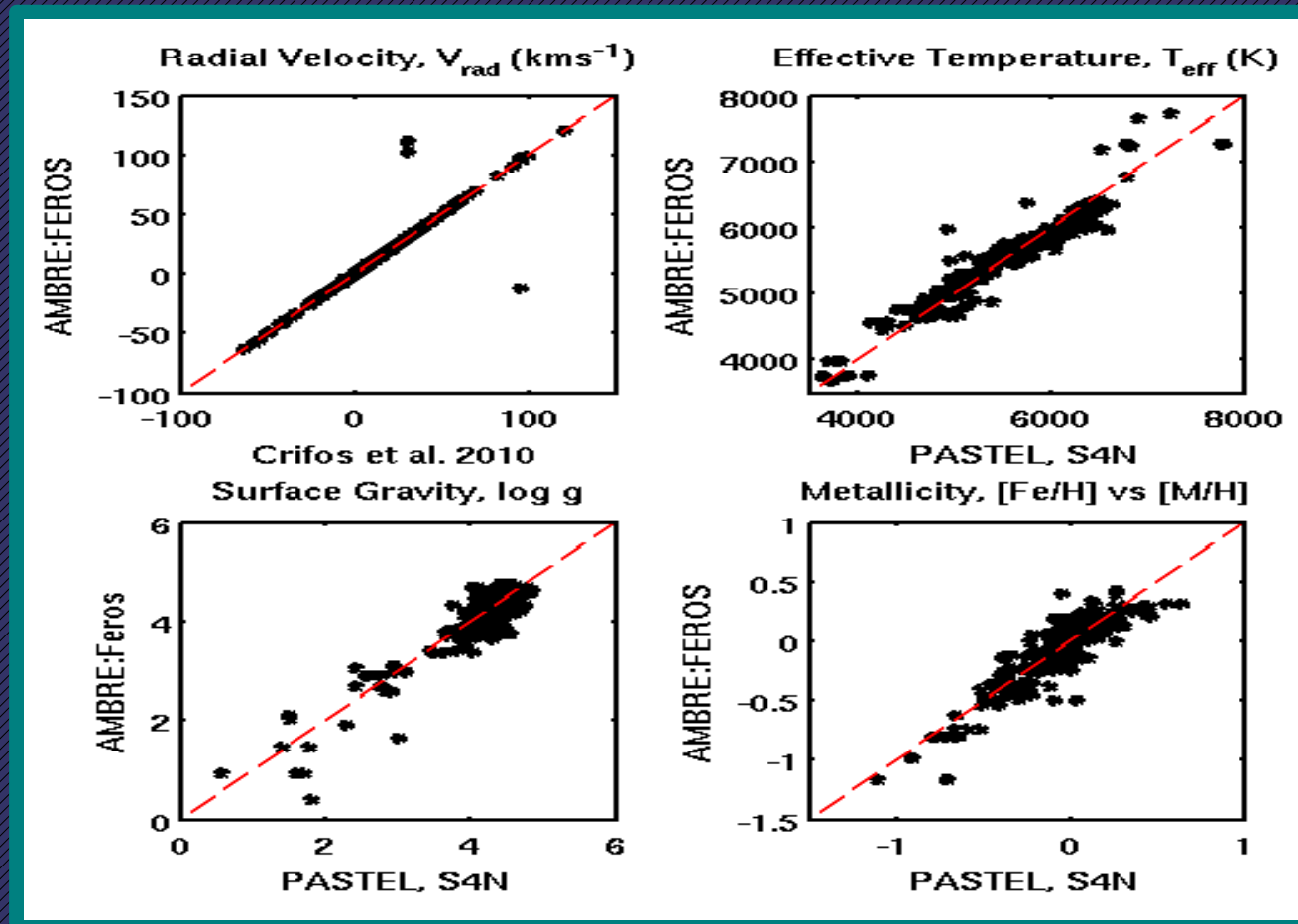
Validation: Homogeneous Reference Samples

Standard Star Atlases: Sun, Arcturus, Procyon

Spectral Libraries: S⁴N, PASTEL

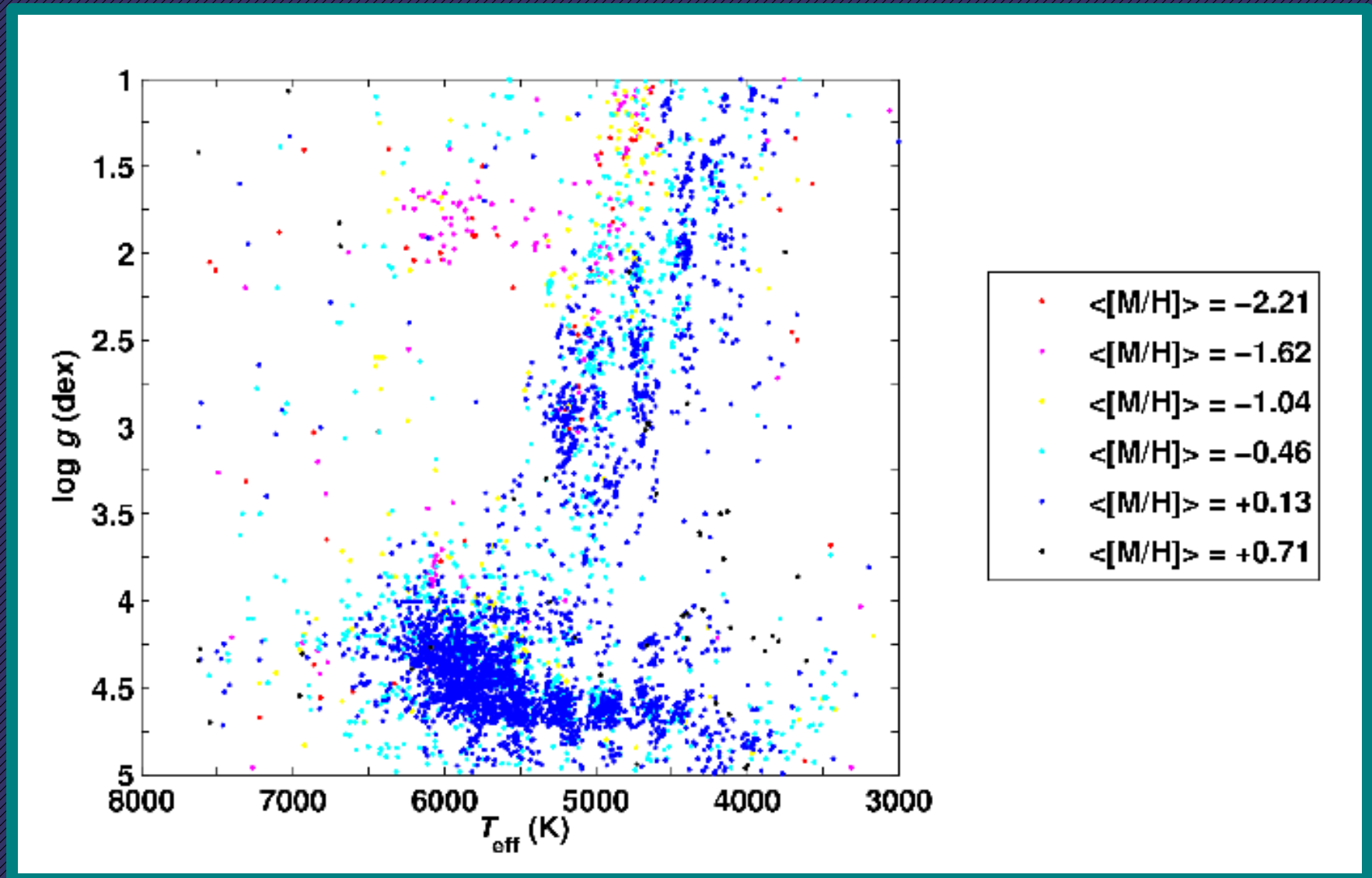
Key Studies: Crifo et al. 2010 → Gaia RVS Standards

Bensby et al. 2003 → alpha element abundances



FEROS Spectra: The Parameters

6508 spectra \rightarrow \sim 3087 stars \rightarrow 30.2 % of archived sample



FEROS Stars: Cross-matching Catalogues

- Apparent Magnitudes: V, B, J, K (PPMXL)
- Distances
 - 1 Hipparcos new reduction (van Leeuwen 2007)
 - 2 Absolute Magnitudes using Isochrones: M_V, M_B, M_J, M_K

Kordopatis et al, 2011a&b

& Interstellar reddening from Theoretical Colours

Gazzano et al. 2010, 2012; Gonzalez et al, 2009

Distance from Sun & above Galactic Plane

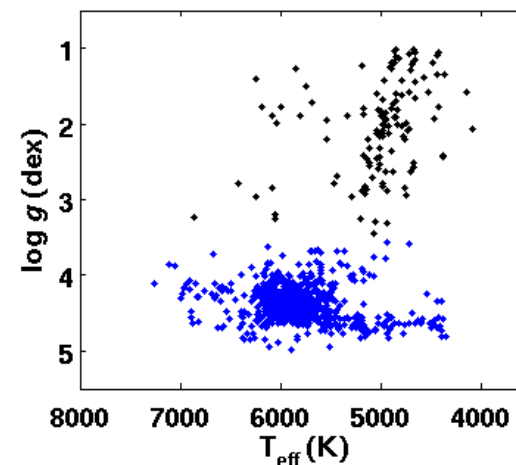
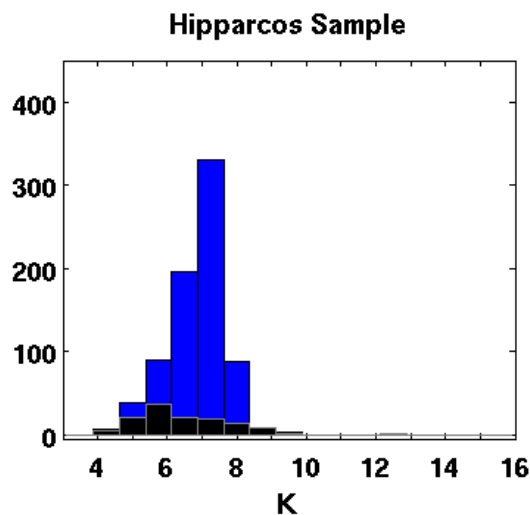
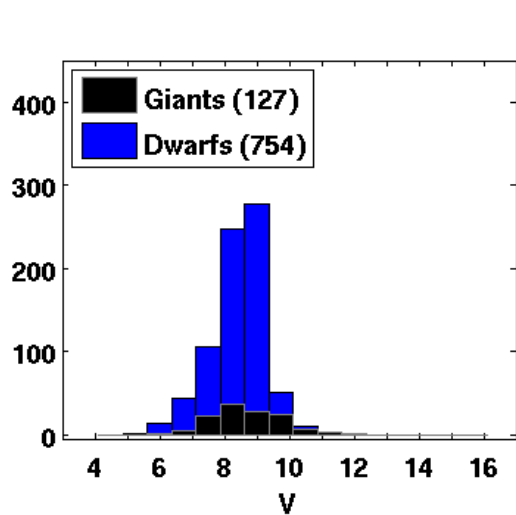
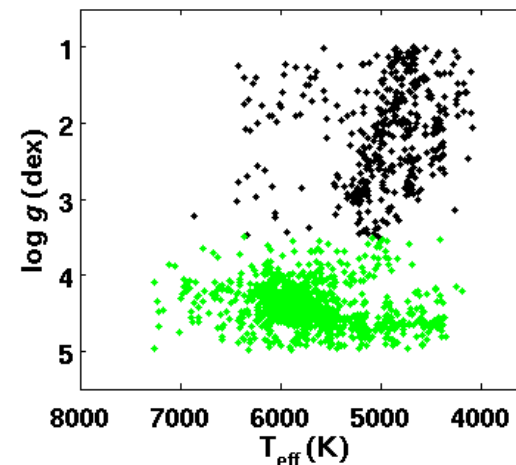
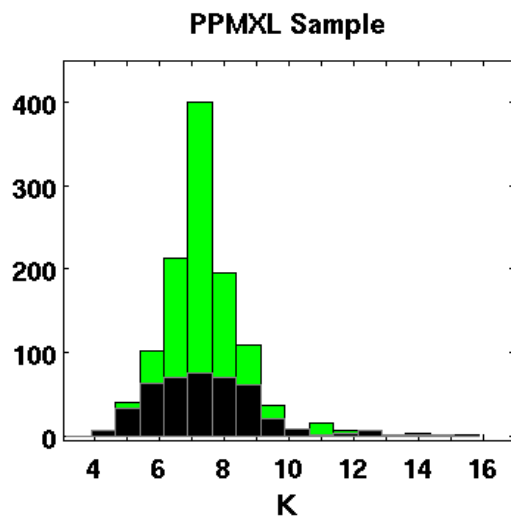
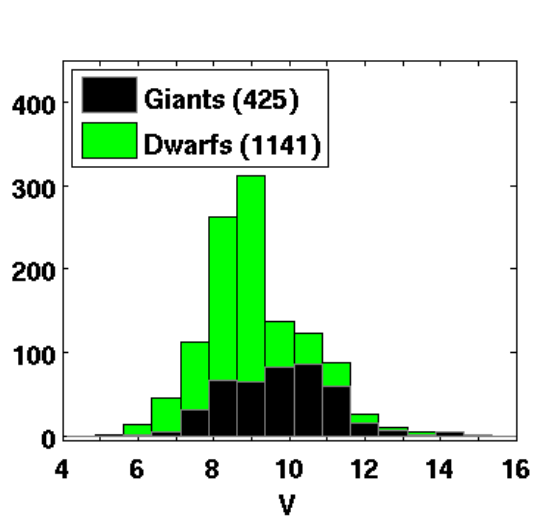
$$D = 10^{0.2(m - M + 5)}$$

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

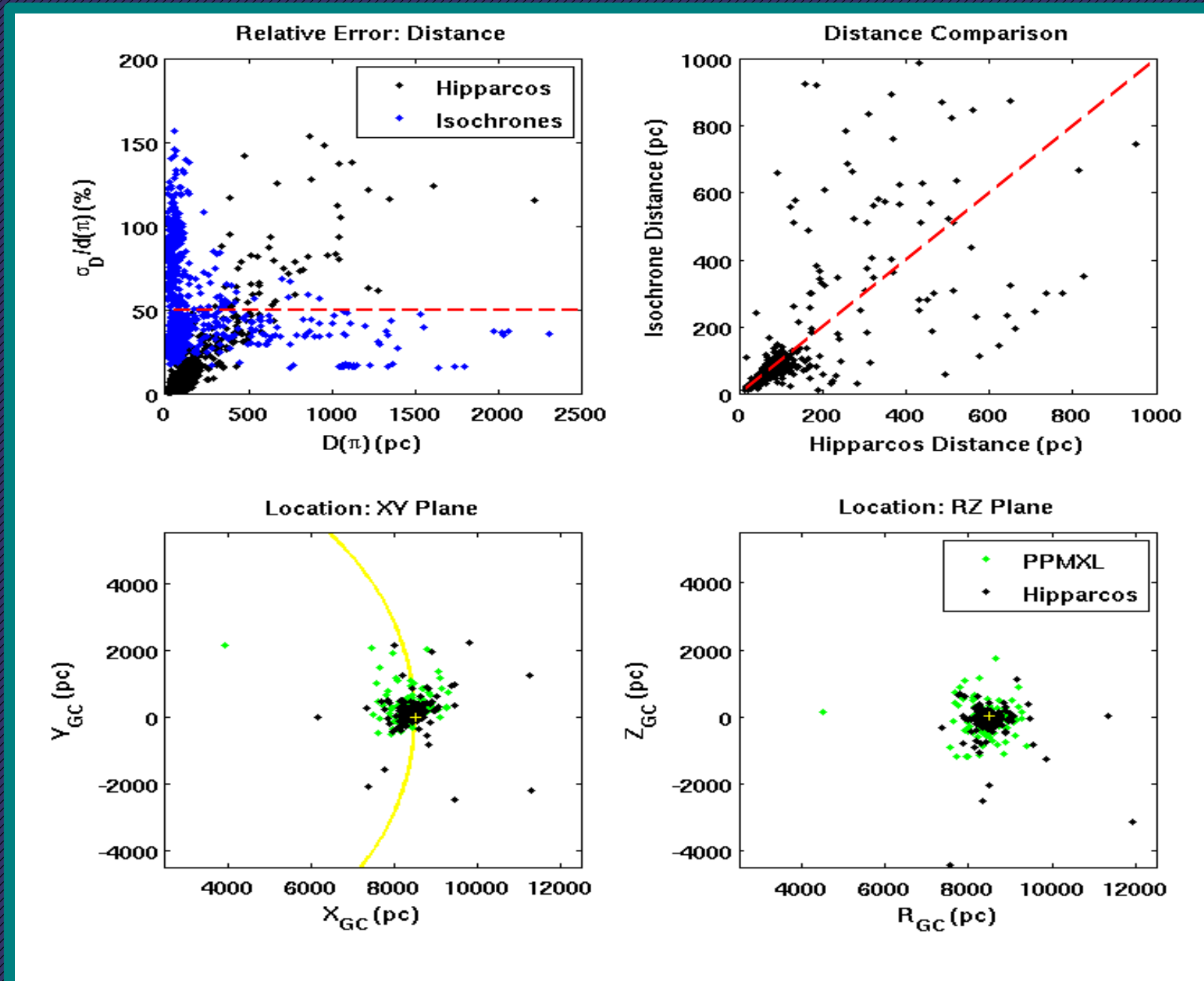
FEROS Stars: Photometry

PPMXL: V, B, J, K, Proper Motions

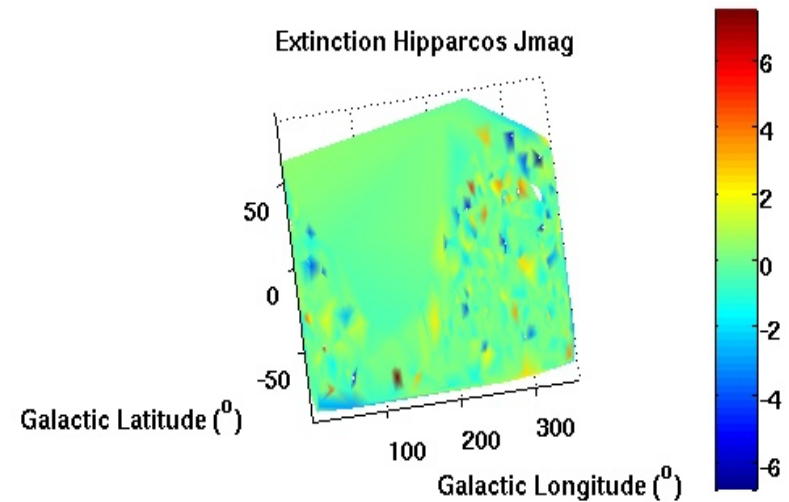
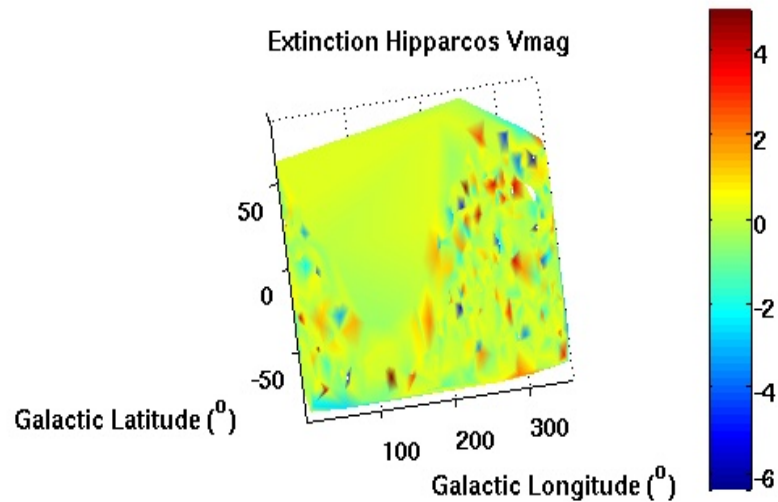
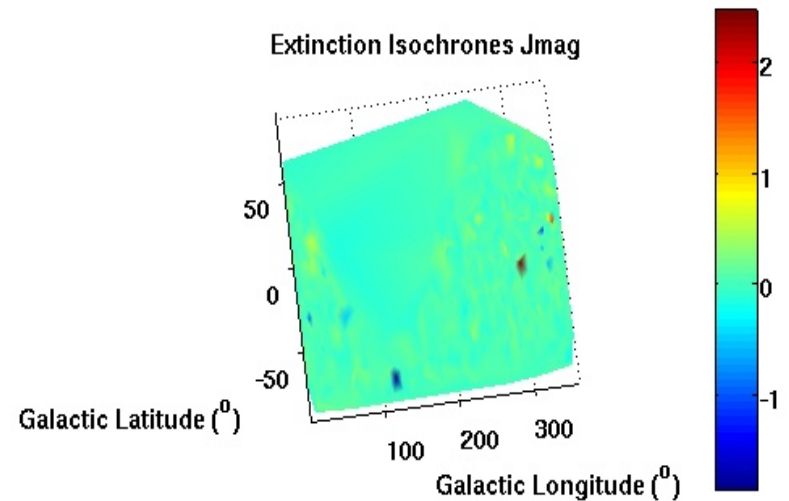
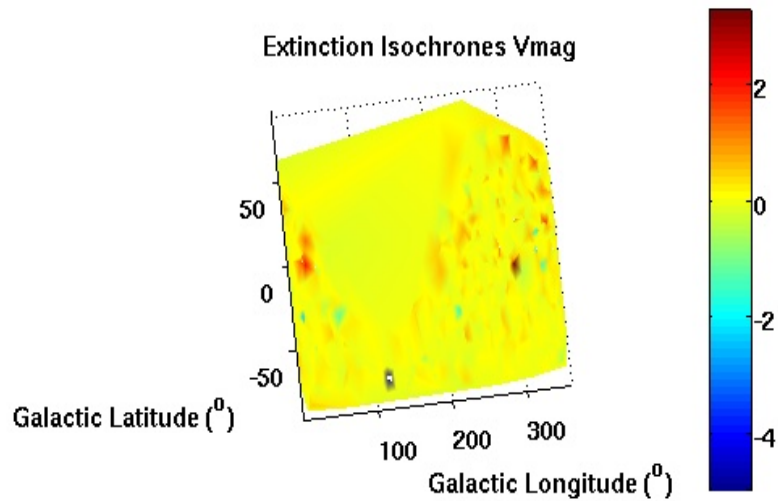
Hipparcos: V, B-V, Parallaxes, Proper Motions



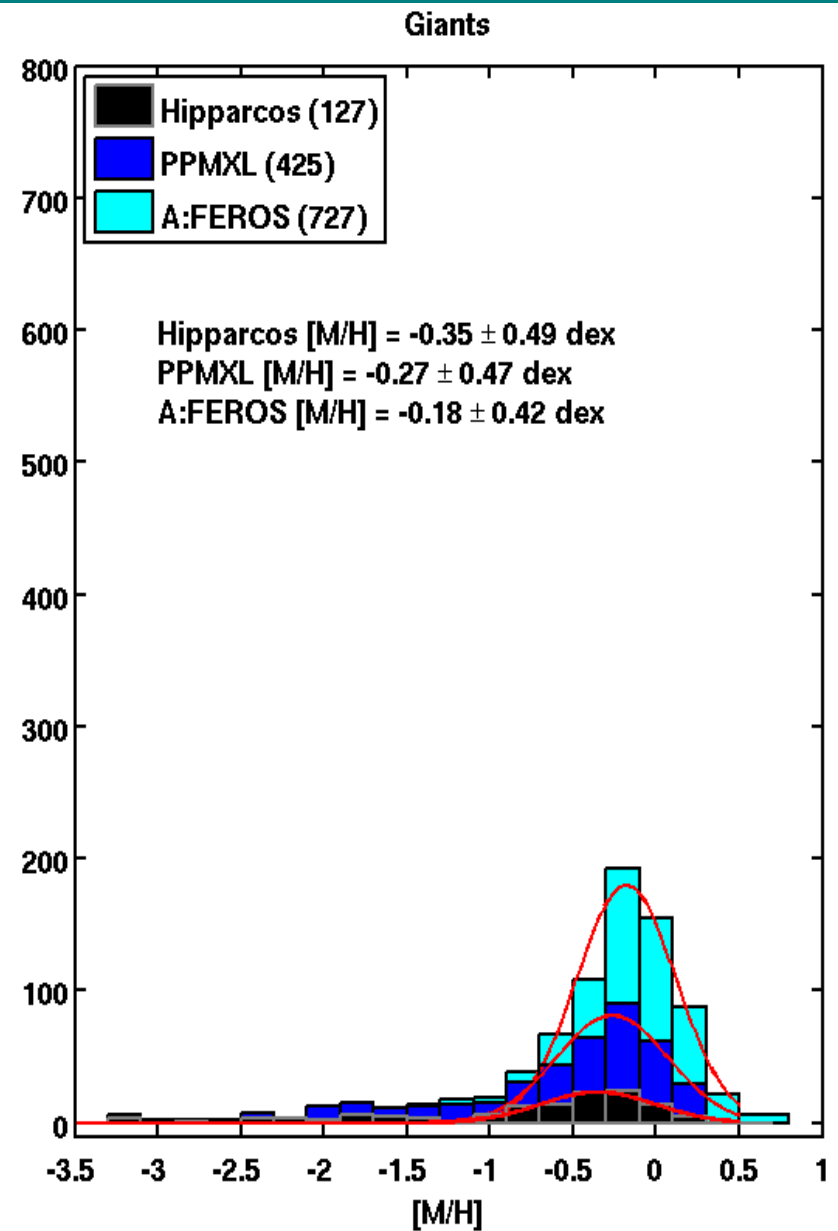
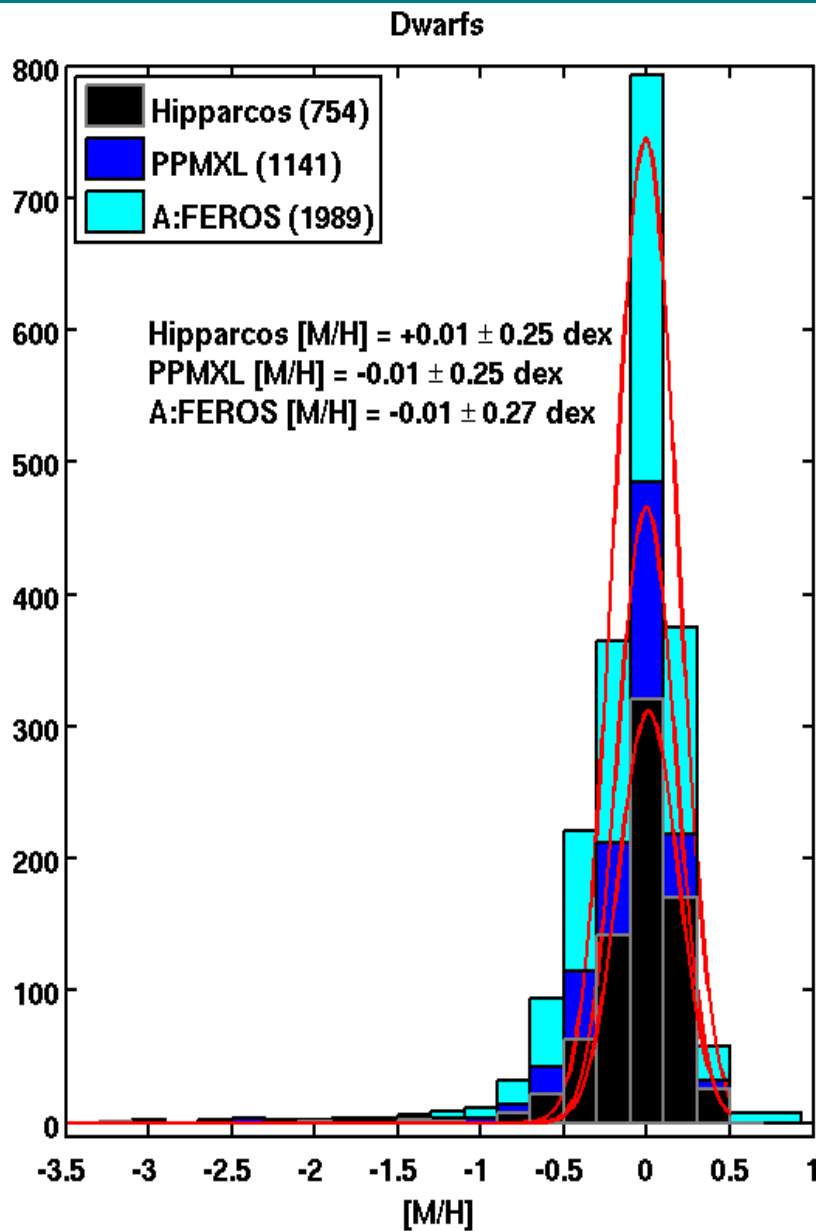
FEROS Stars: Where and how far?



Extinction from Theoretical Colours & Hipparcos



FEROS Stars: Metallicity Distribution



Chemically & Kinematically Characterised Stellar Sample in the Local Solar Neighbourhood

Stellar Populations: Thick & Thin Disk

Toomre Diagram of Hipparcos Sample

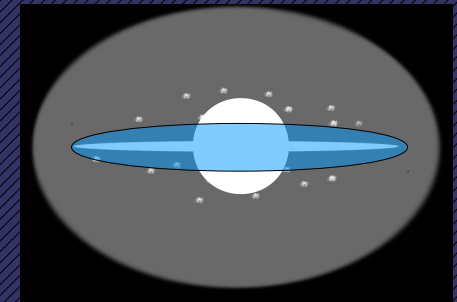
→ Total kinetic energy of stars vs their rotational energy.

Thin Disk: $< \sim 50 \text{ km s}^{-1}$

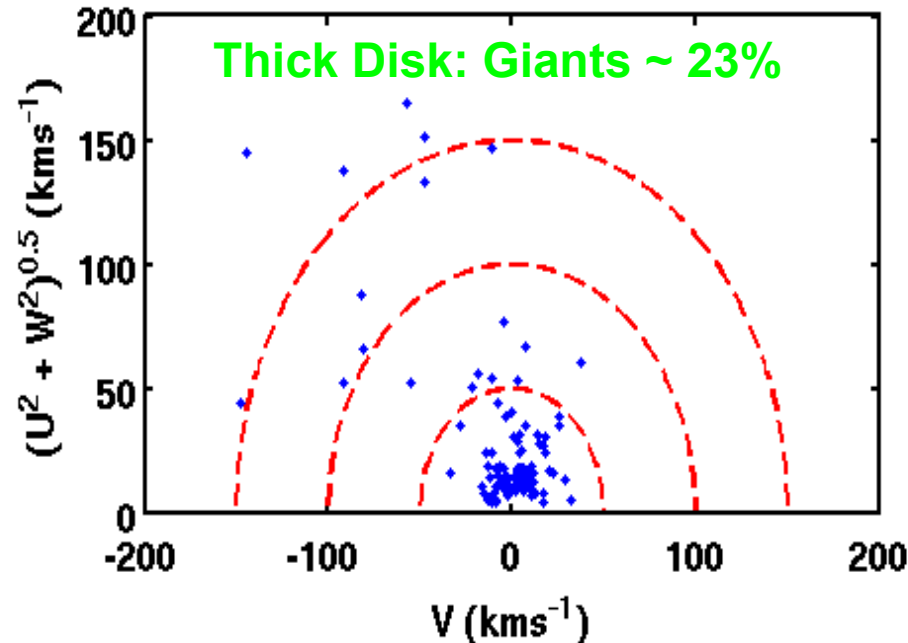
Thick Disk: $\sim 50 \text{ km s}^{-1} \rightarrow \sim 150 \text{ km s}^{-1}$

Halo: $> \sim 150 \text{ km s}^{-1}$

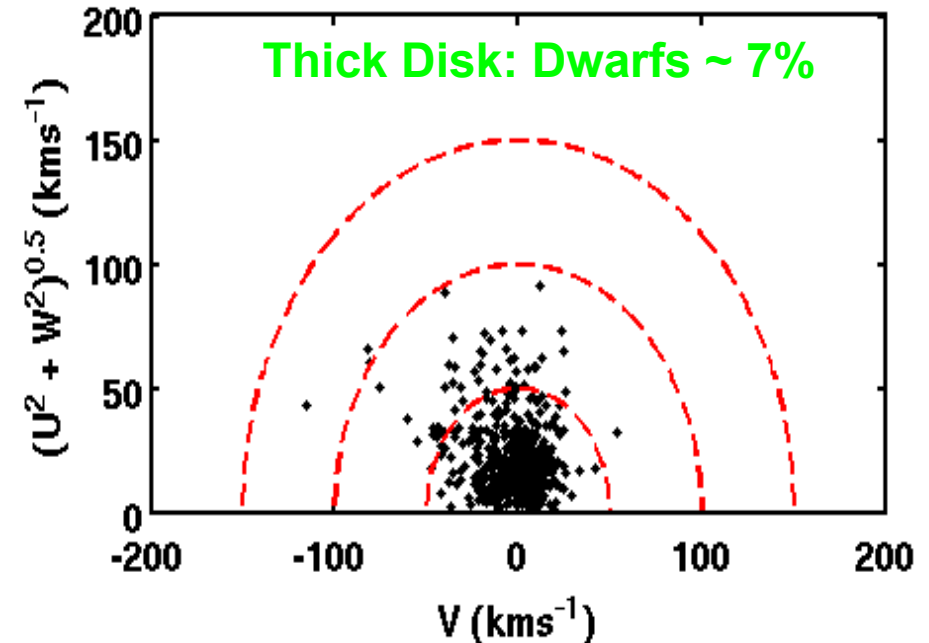
(Bensby 2009)



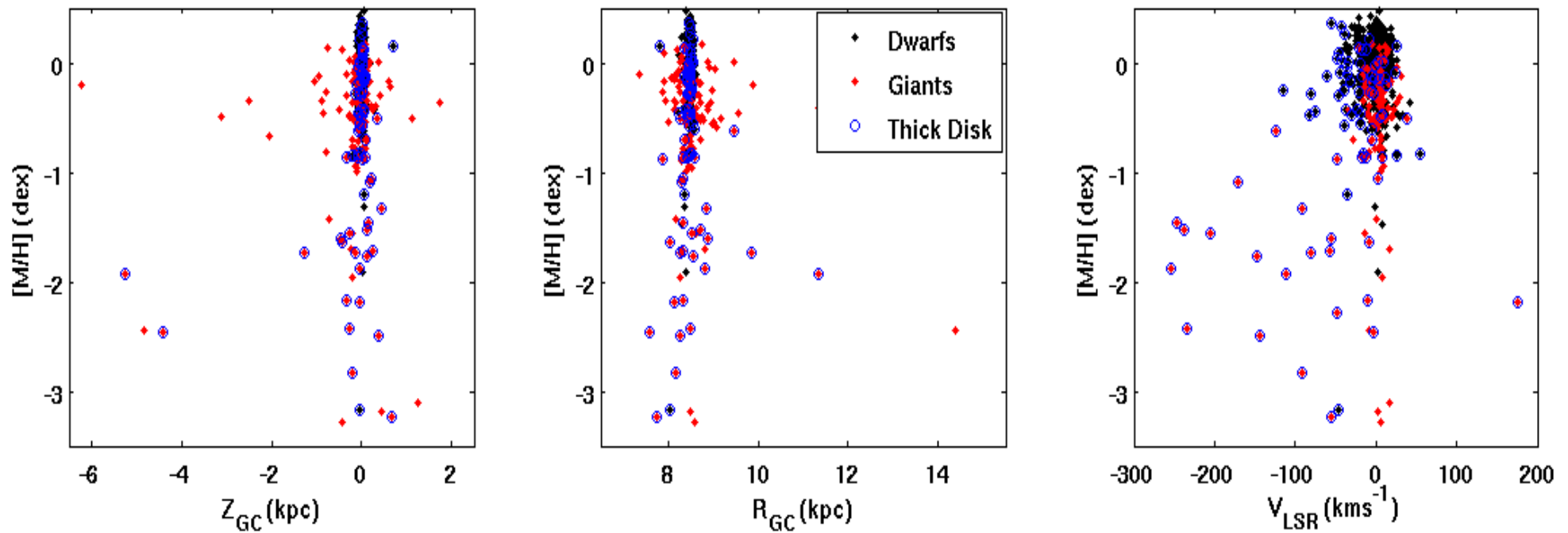
HIP Toomre: Giants



HIP Toomre: Dwarfs



Metallicity Gradients?

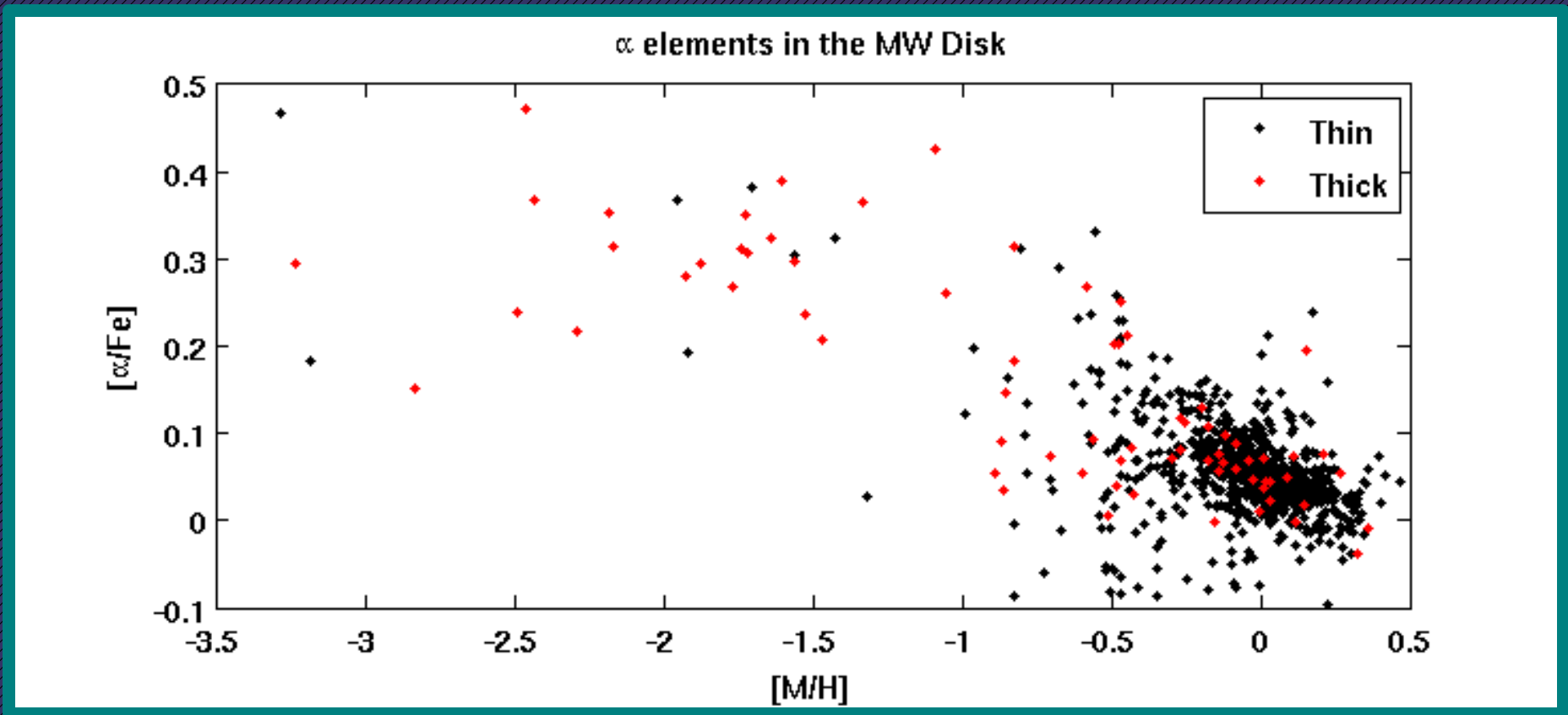


FEROS Sample: $\Delta R_{GC}, \Delta Z_{GC} \sim 1.5$ kpc

→ Not useful for gradients

→ Useful as Volume-limited, Local Solar Neighborhood

Alpha Elements of the Thin Disk



Thin Disk: $[M/H] > \sim 1.0$ dex, $[\alpha/Fe] < \sim 0.2$ dex

Thick Disk: -3.5 dex $< [M/H] < -1.0$ dex, $[\alpha/Fe] > +0.2$ dex
 $[M/H] > -1.0$ dex, $+0.3$ dex $> [\alpha/Fe]$ to Solar

Conclusions & Future Work

- **AMBRE: FEROS analysis complete, UVES & HARPS underway**
- **Supplemental photometric & kinematic information obtain for FEROS stars from PPMXL & Hipparcos**
- **FEROS sample provides an interesting dataset of mainly local solar neighbourhood dwarfs (1989) and giants (727)**
- **Expand kinematics with Gaia distances and photometry**
- **Archived spectral datasets have great potential in complementing large surveys in a range of Milky Studies**

