VIS and NIR high resolution spectroscopy for field and cluster RR Lyrae

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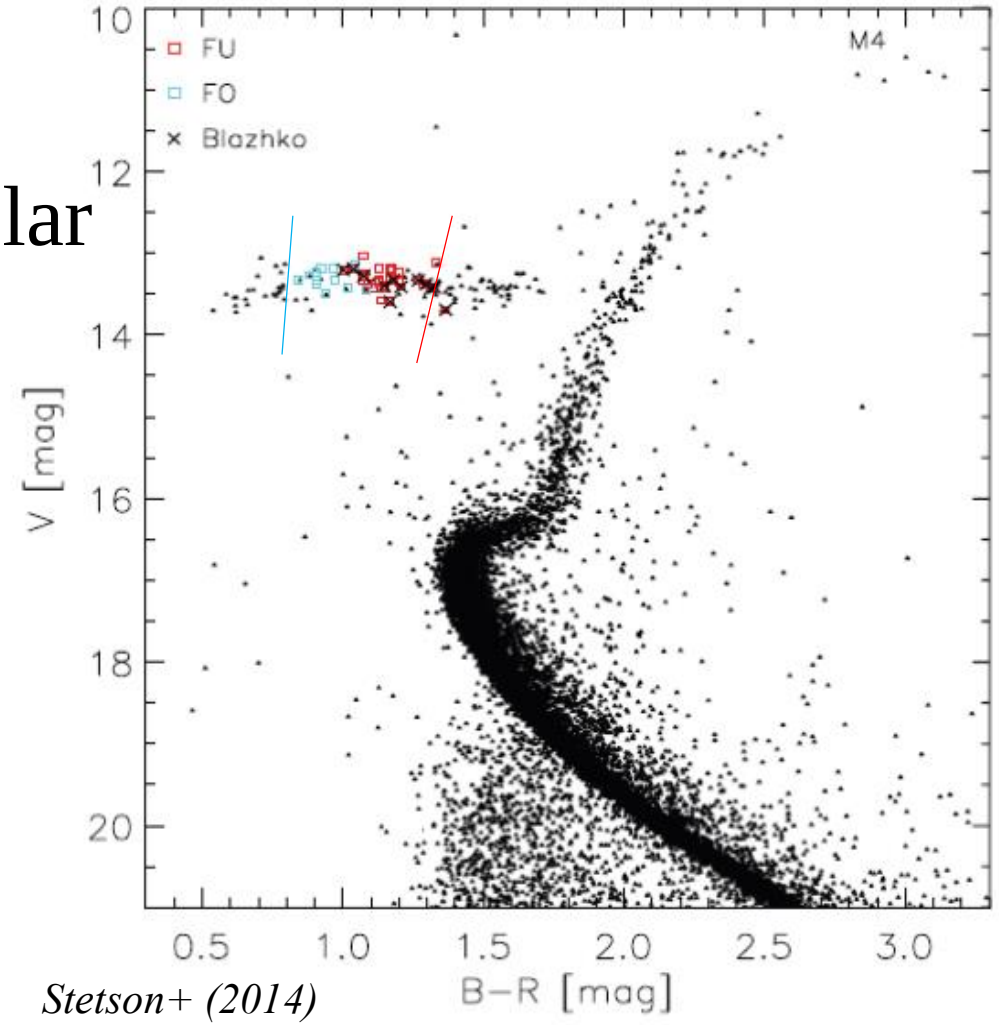
Introduction

In view of **GAIA**, who will provide accurate **parallaxes** for more than 100 billion objects in the next few years, we are working at the **OSIRIS** project (Oscillating Stars with wIneRed near-Infrared Spectroscopy) to obtain homogeneous **photomometry and spectroscopy** for old (RRLs, T2Cs), intermediate age (MIRAs) and young (CCs) **primary distance indicators**.

RR Lyrae

- He core and H shell burning
- > 10 Gyr
- 0.54 - 0.8 $M_{\odot}$
- -2.5 < [Fe/H] < ~solar
- Statistical Sample



Stetson+ (2014)

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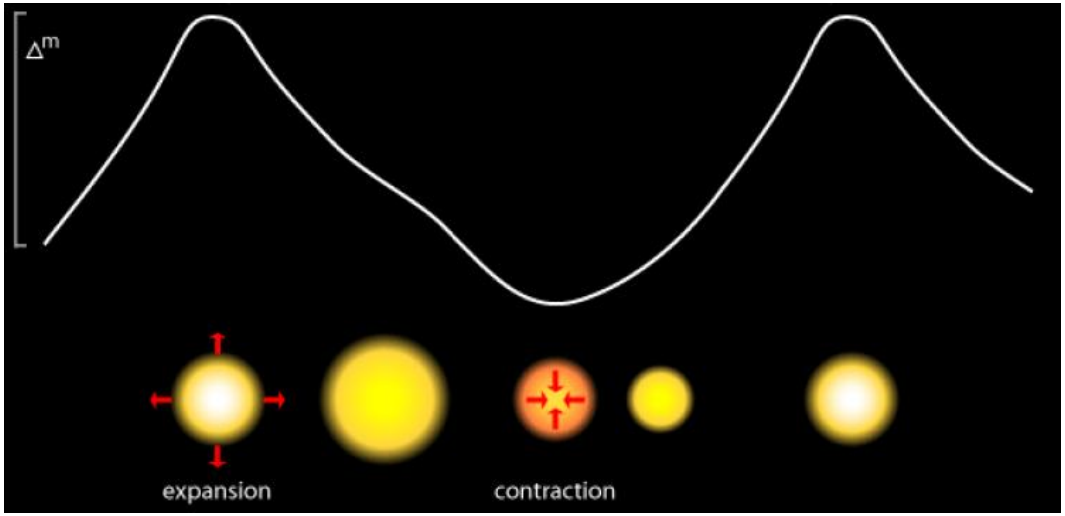


Pulsation properties:

- 0.2d < P < 1d

Variation amplitudes:

- Vmag: 0.2-1.5
- T: 200-2400 K
- R: 5%-18% $R_{\odot}$
- V_r: 20-70 km/s

RRL as primary distance indicators

Visual Magnitude-Metallicity (MZ)

$$M_v = a + b \times [Fe/H]$$

Period-Luminosity (PL)

(*Longmore+, 1986*)

$$M = a + b \times \log(P)$$

Period-Luminosity-Metallicity (PLZ)

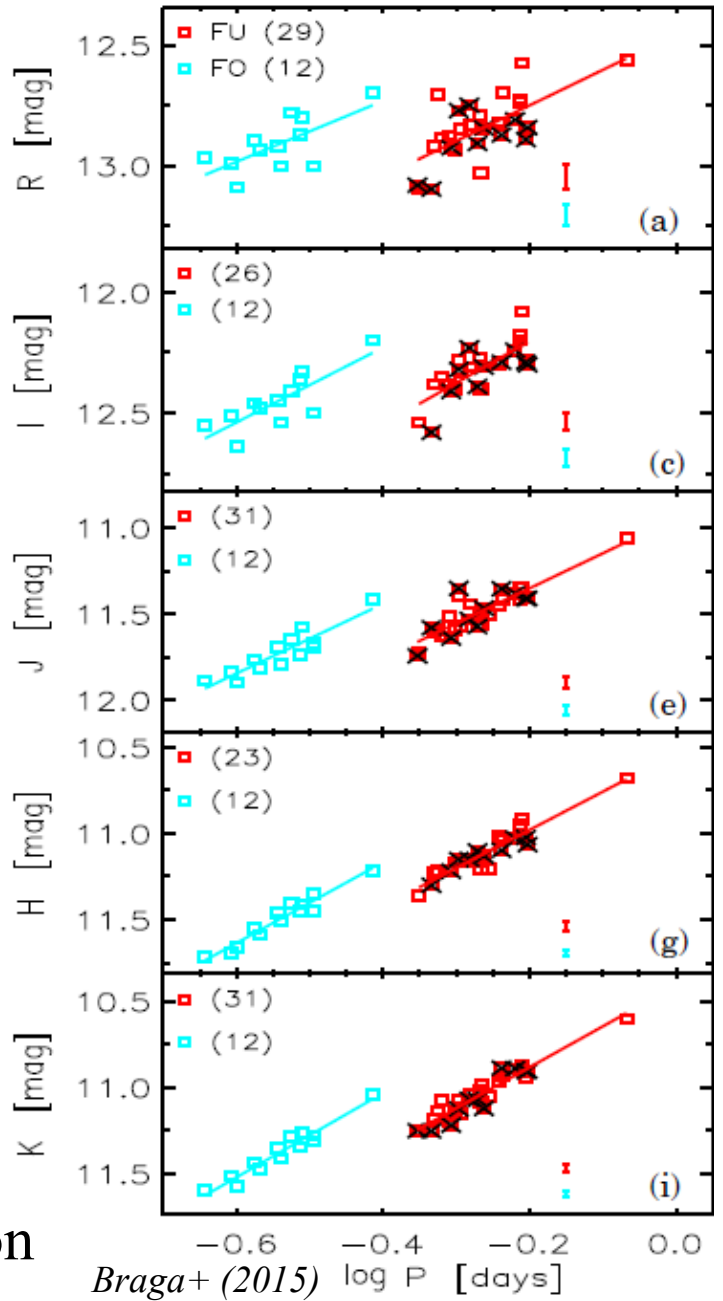
(*Bono+, 2001,2003*)

$$M = a + b \times \log(P) + c \times [Fe/H]$$

Precise (2-3%) and accurate **distances** (up to ~3.5 Mpc)

$$d = 10^{1/5(m - M + 5 - A)}$$

The extinction dependence can be overcome with the reddening free **Period-Wesenheit-Metallicity** (PWZ) relation



Braga+ (2015)

Empirical calibration of the PLZ-PWZ

What do we need to calibrate PLZ-PWZ?

- New **parallaxes** from GAIA (1° data release in 2016, 2° data release in 2018).
- New **metallicity estimates** from VIS-NIR high resolution spectroscopy.

NIR vs VIS

- No PLZ-PWZ in the VIS
- Lower amplitudes
- Not affected by non-linearities
- Less affected by reddening
- More interesting lines (C,O,…)

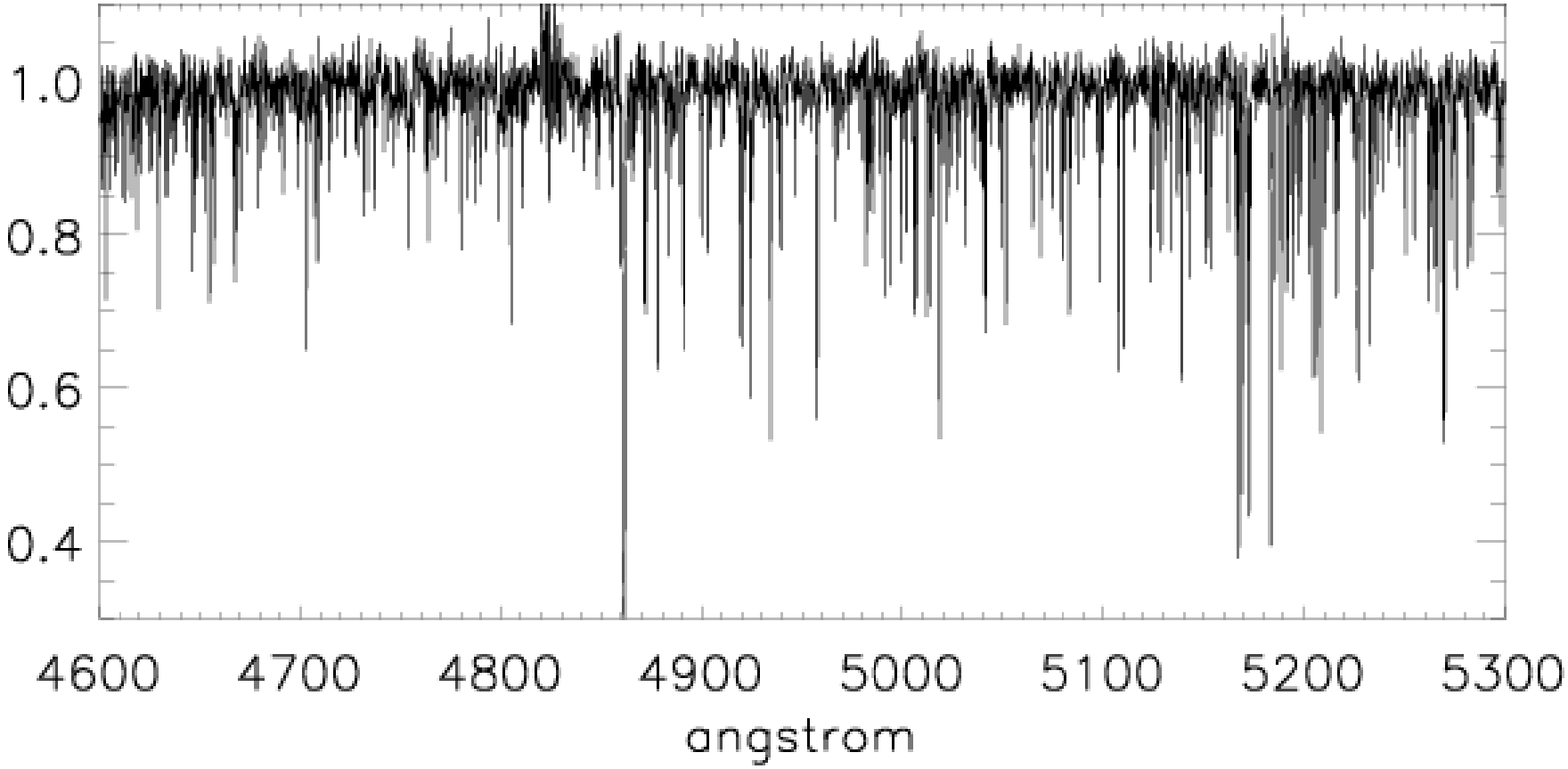
VIS Spectral Analysis

13 target **RRLs** in **NGC 3201**

High-Res optical spectra from **M2FS@Magellan**

4600-5300 Å, R~ 25000 , SNR~50

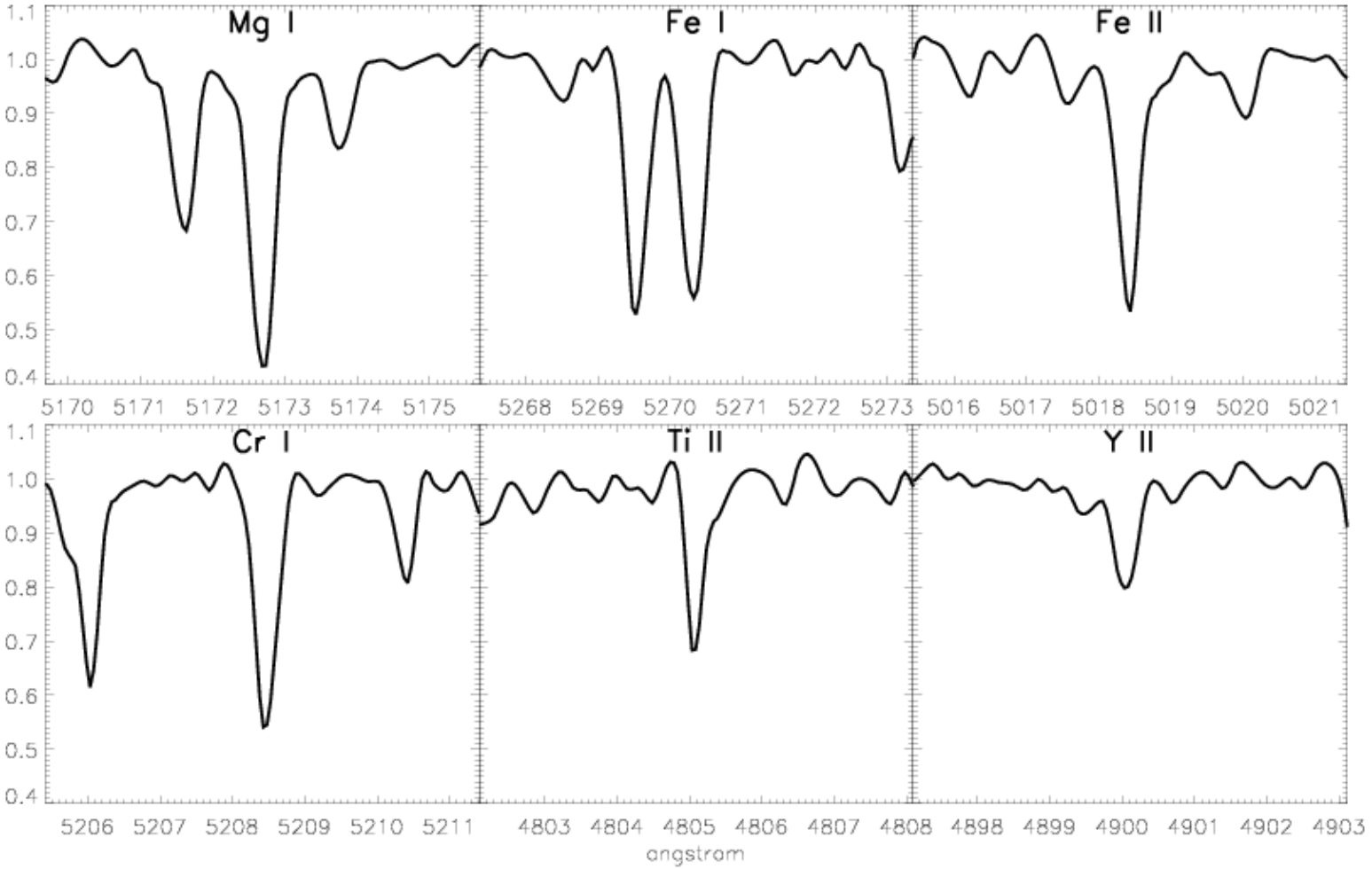
Monometallic Cluster → good calibrator



Lines Identification

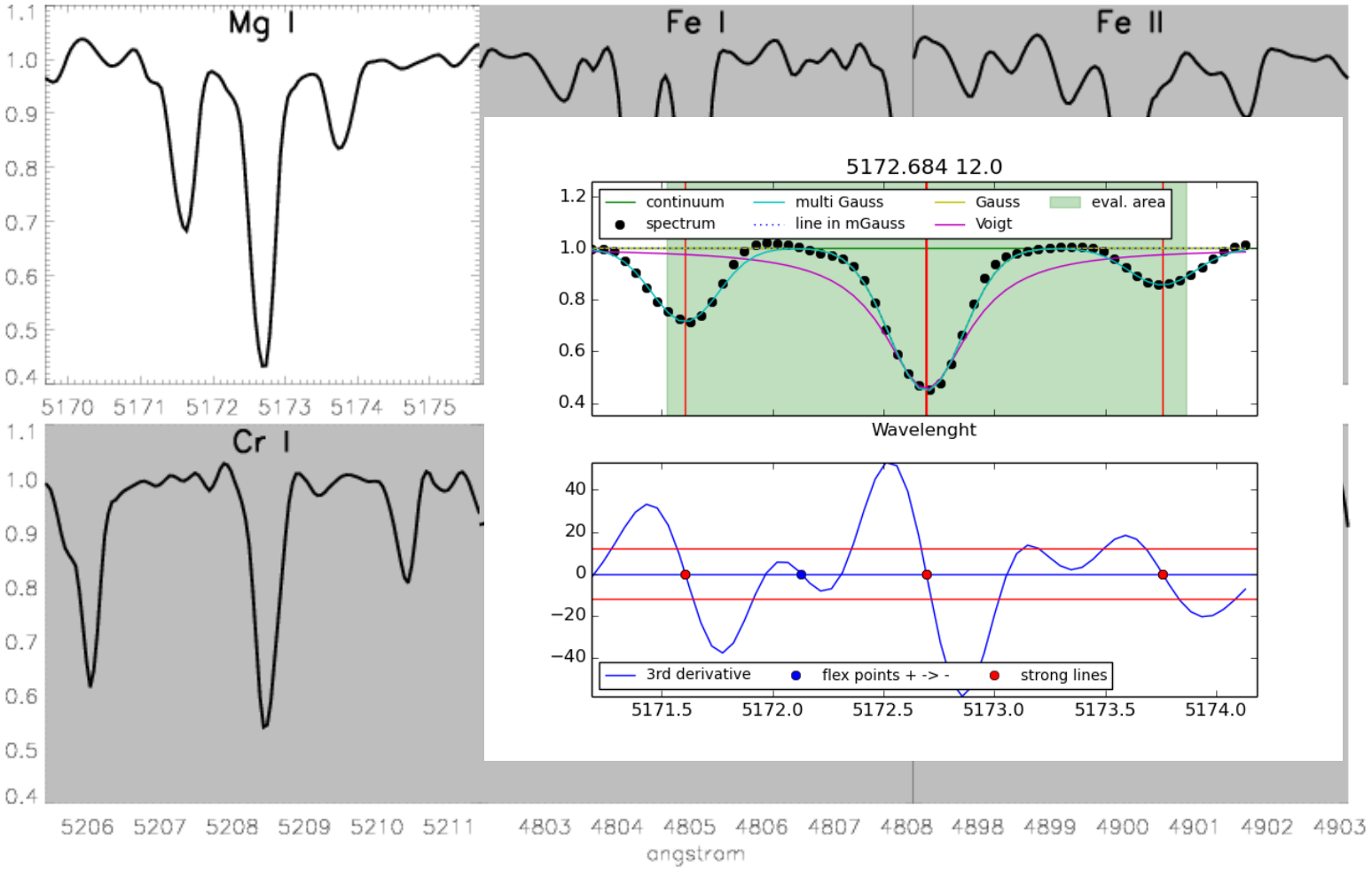
About 100 lines per spectrum identified

Mg, Ca, Ti, Cr, Fe, Ni, Y



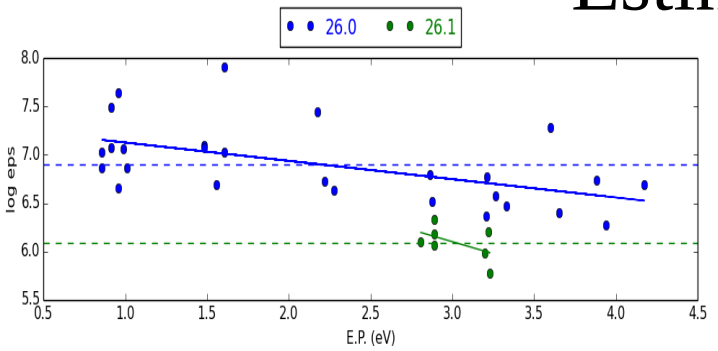
Equivalent Widths

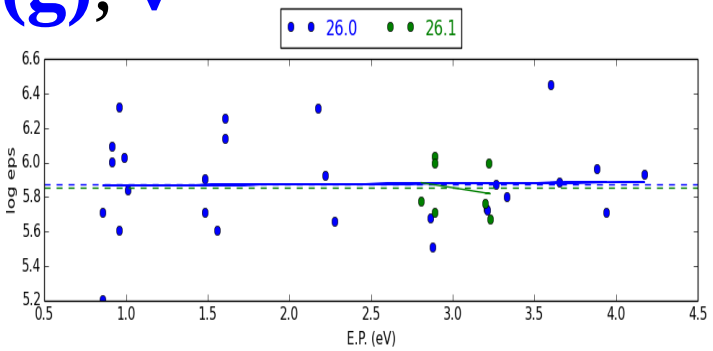
Line profile is fitted and EW is measured



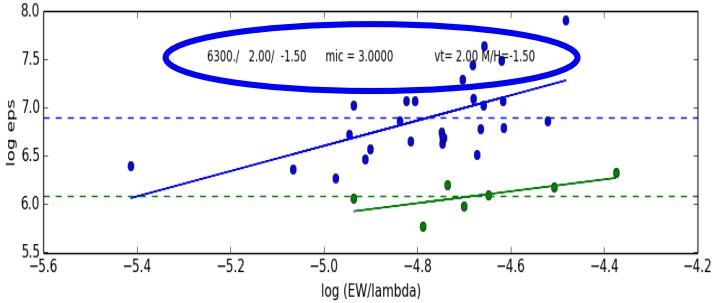
Parameter estimates

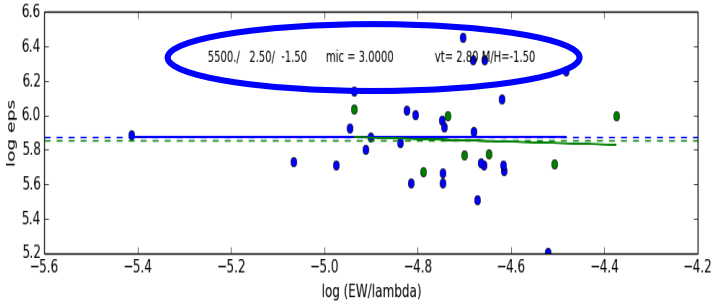
Known: EP, log(gf); Measured: EW;
Estimated: **T_{eff}, log(g), v**



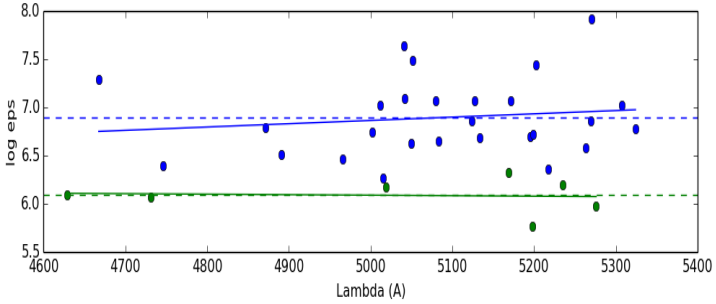


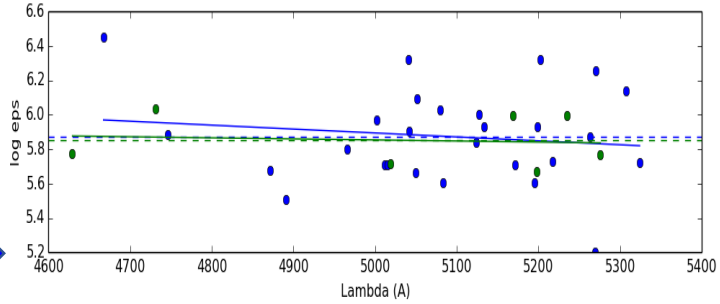
Bad estimate:
- Trends
- Neutrals-Ions incompatibility



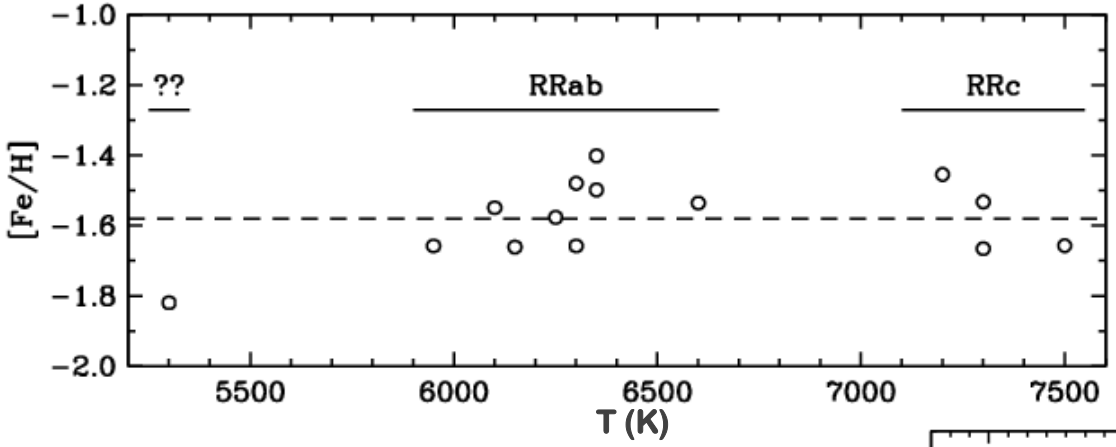


Good estimate:
- No trends
- Neutrals-Ions compatibility



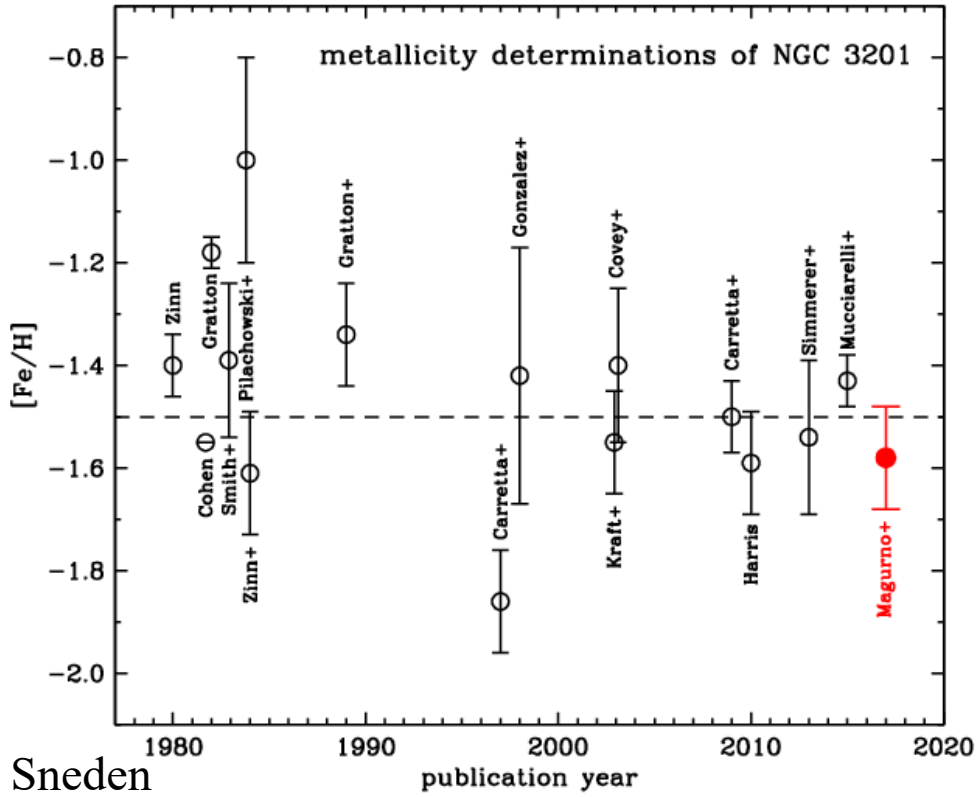


NGC 3201



T_{eff} distribution suggests **different type of RRLs**

Average [Fe/H] estimate from M2FS spectra in **agreement with the literature**



Plots by Chris Sneden

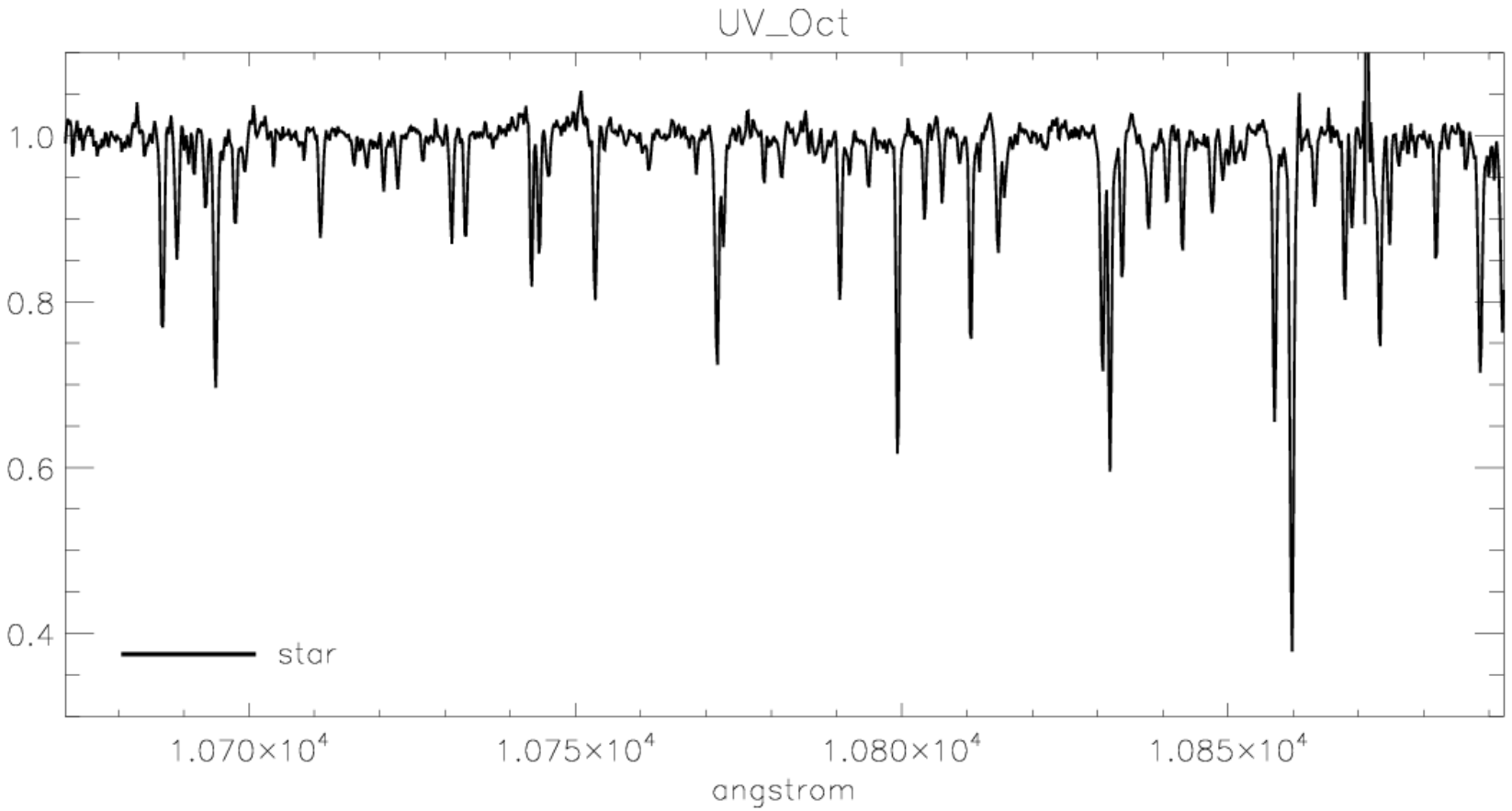
NIR Spectral Analysis

~150 target variables (RRLs, CCs, T2Cs, MIRAs)

High-Res NIR spectra from **WINERED@NTT**

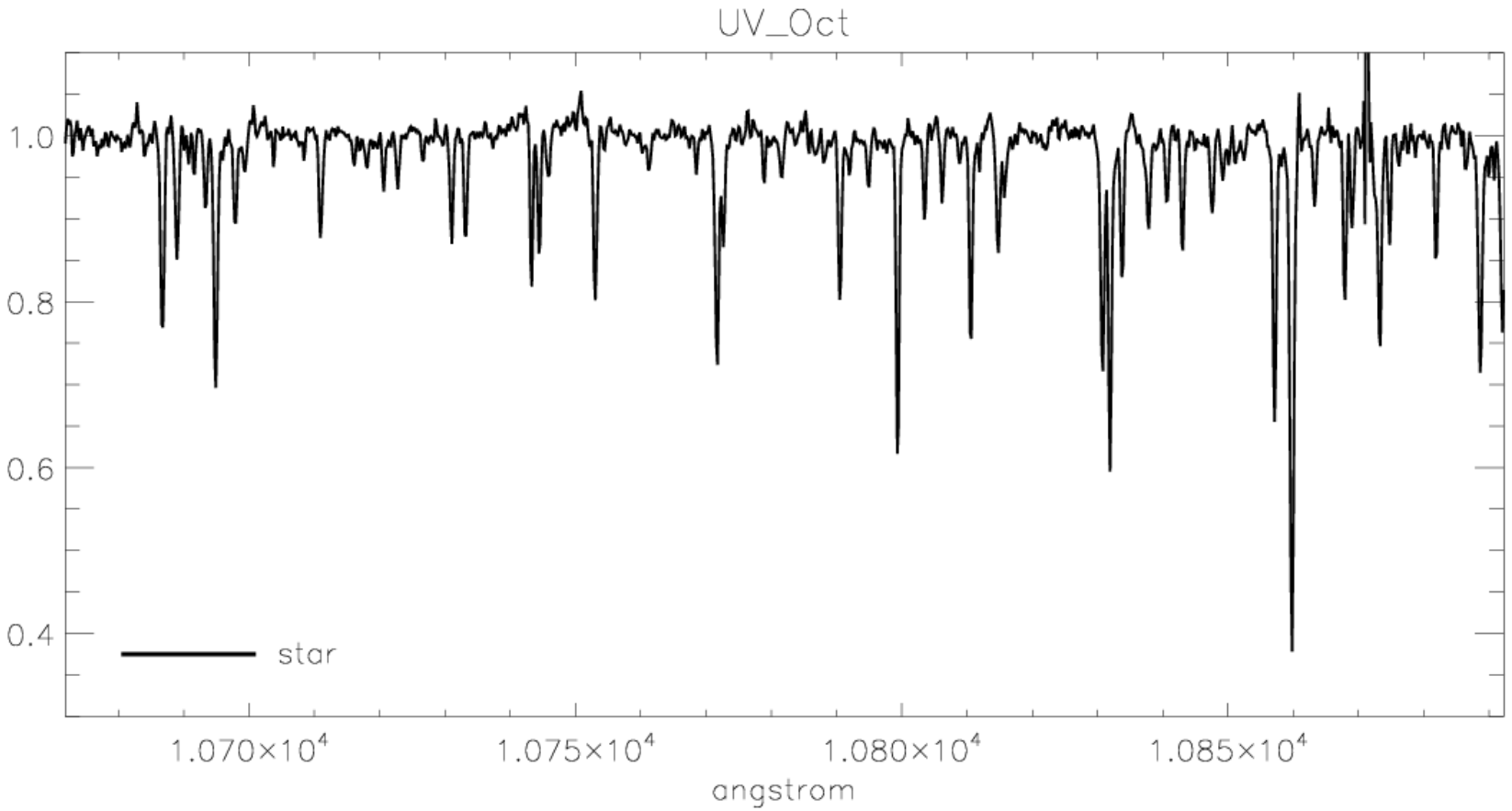
(visitor instrument)

9100-13500 Å, R~ 28000 , SNR~100



Tellurics Subtraction

NIR bands highly affected by **sky features**.



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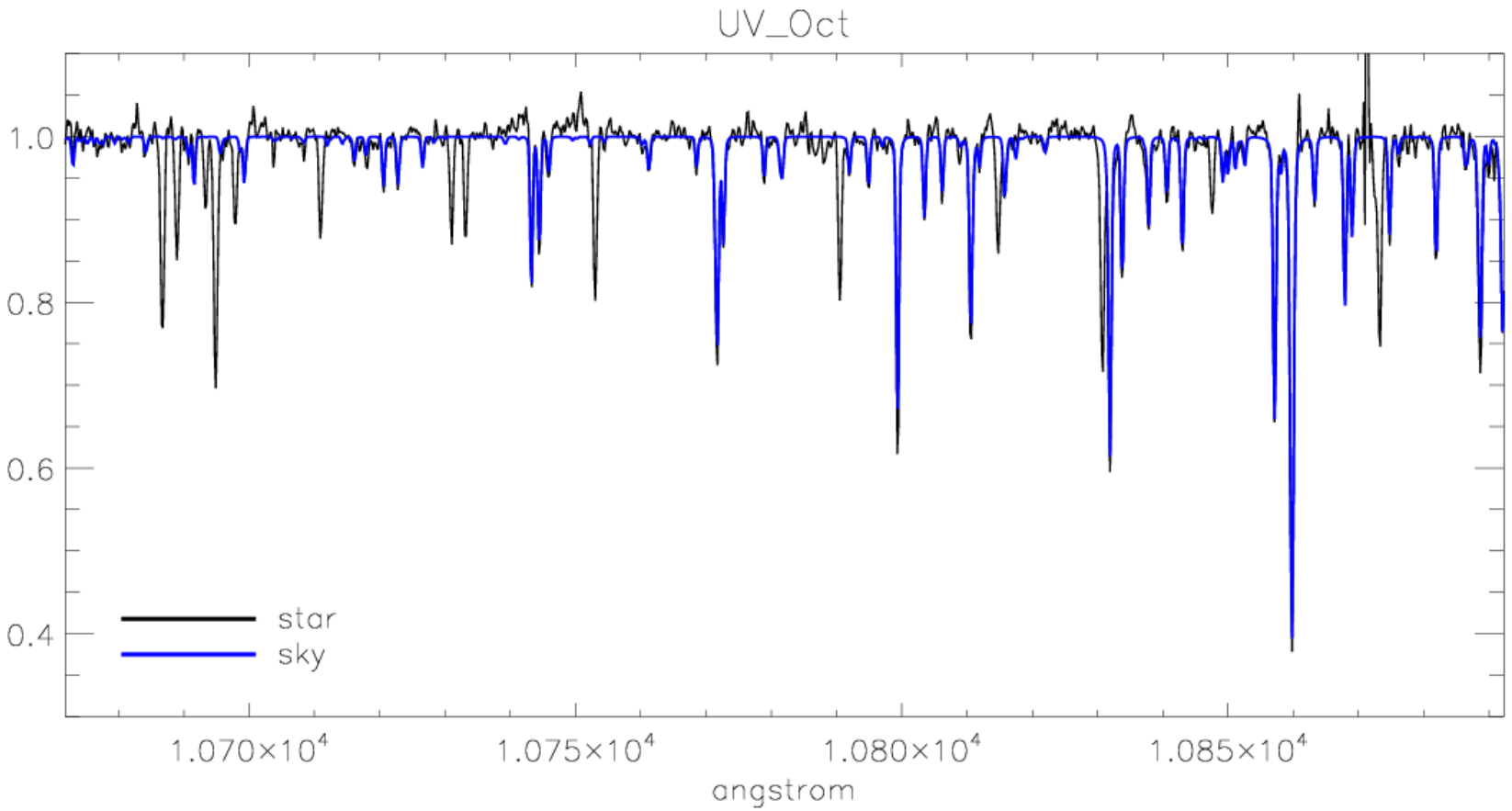

Tellurics Subtraction

NIR bands highly affected by **sky features**.
Tellurics are modelled on each spectrum …
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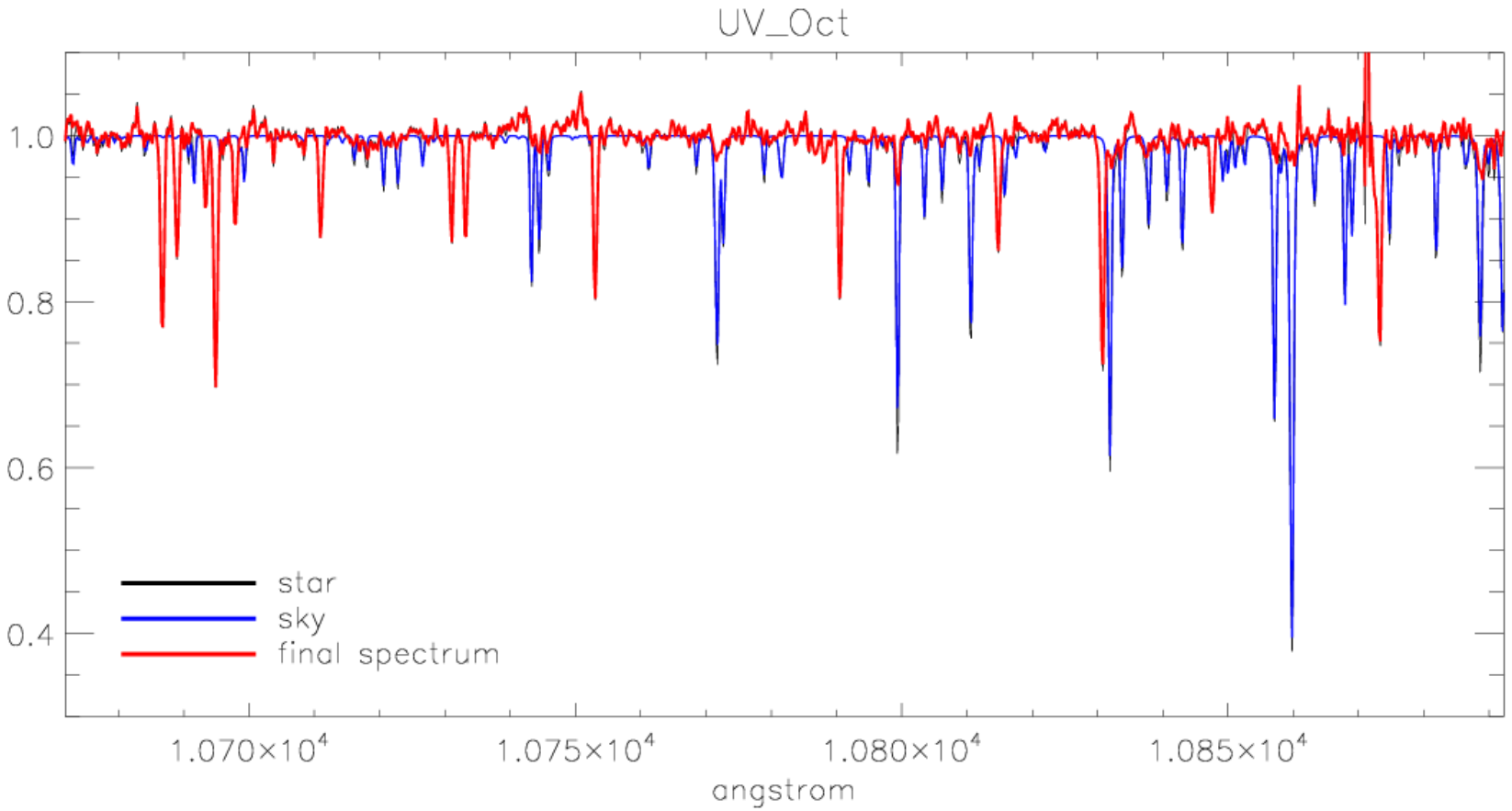

Abundance Analysis

Same procedure as in the optical.

Two **metal poor field RRLs**

WY Ant:

[Fe/H]~ -2.00

18 lines

- C I : 1
- Mg I : 1
- Si I : 10
- S I : 2
- Ca I : 1
- Ca II : 2
- Sr II : 1

UV Oct:

[Fe/H] ~ -1.80

40 lines

- C I : 8
- Mg I : 2
- Mg II : 2
- Si I : 15
- S I : 3
- Ca I : 1
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- Fe I : 2
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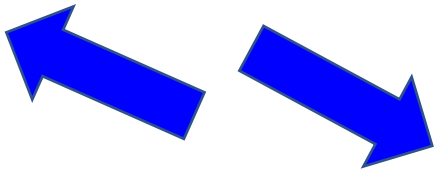
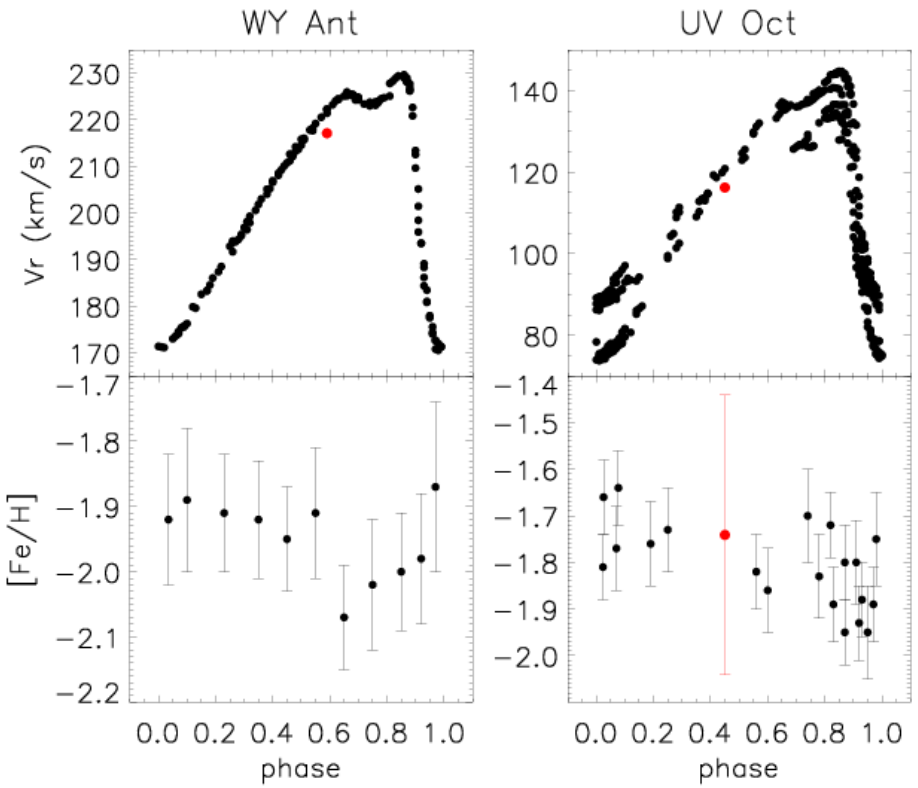
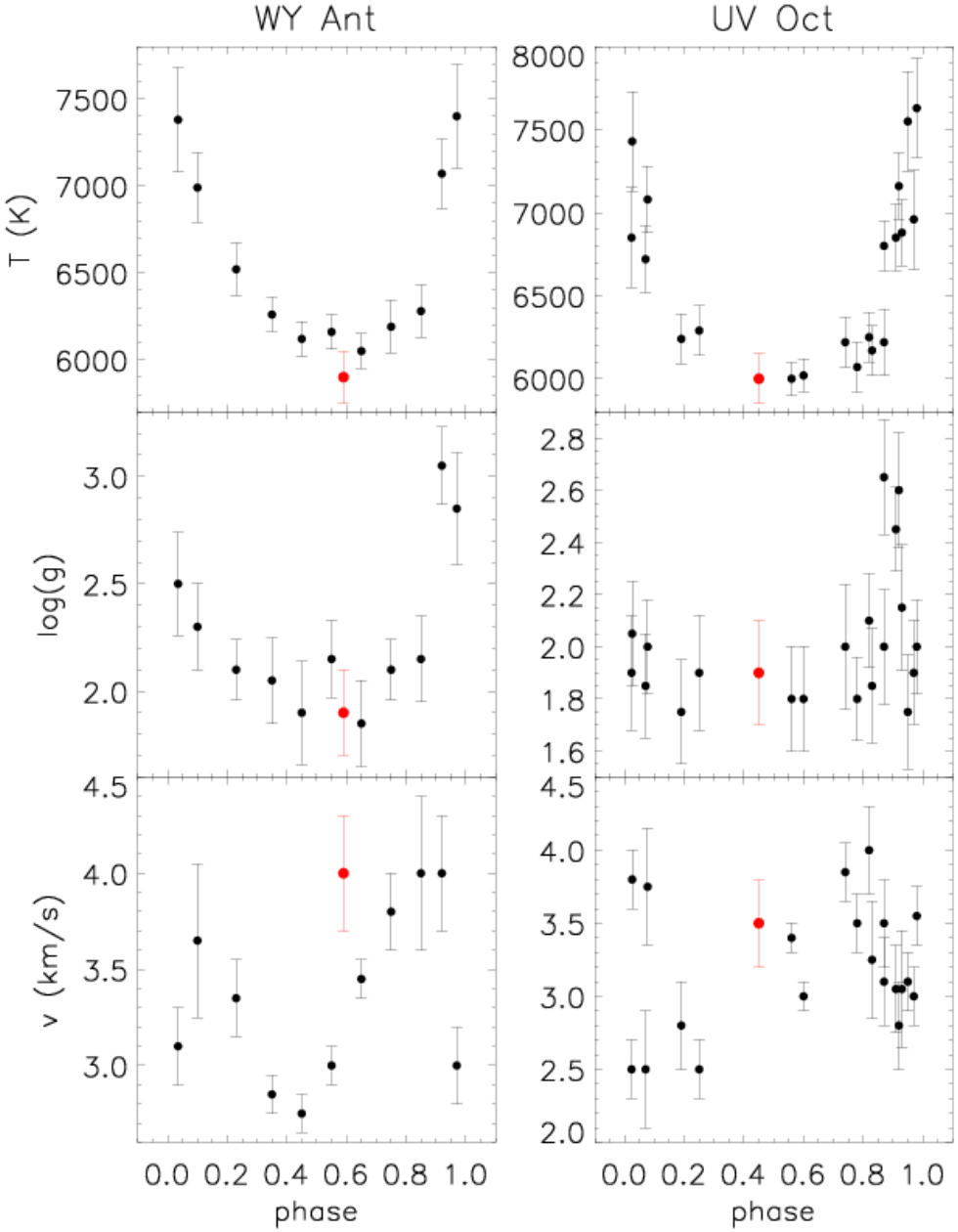


No or few iron lines

Parameter estimates





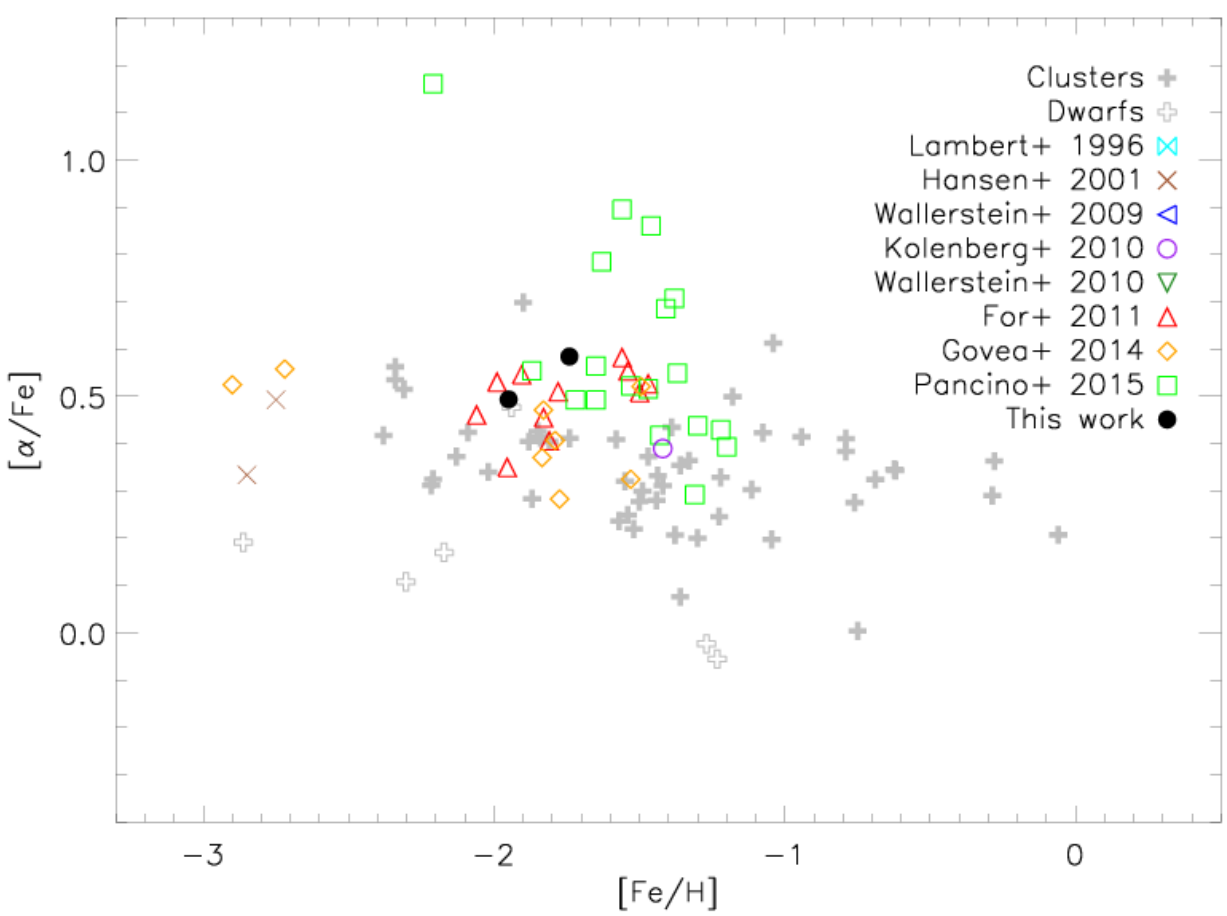
Consistency with results in the VIS from For+ 2011

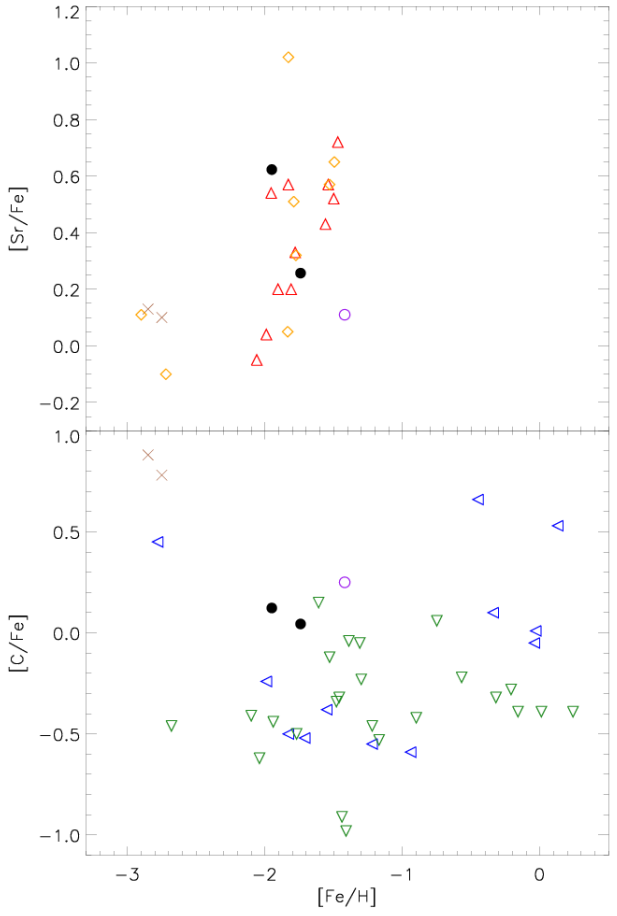
Abundances

Consistency with RRLs high-resolution spectroscopy in the literature for

[α/Fe], [Sr/Fe], [C/Fe].

Assuming [Fe/H] = -1.95 for WY Ant (For+ 2011)





SUMMARY

- RR Lyrae stars are primary distance indicators
- PLZ-PWZ relations permit us to estimate distance with high precision and accuracy, but they need to be calibrated
- Equivalent widths method is effective and consistent both in the VIS and NIR
- Homogeneous metallicity scale can be obtained for cluster and field stars
- Distances and metal abundances will give the base to understand the Milky Way evolution history

THANKS