# BENCHMARK STARS
# WHAT'S OLD & WHAT'S NEW

PAULA JOFRE

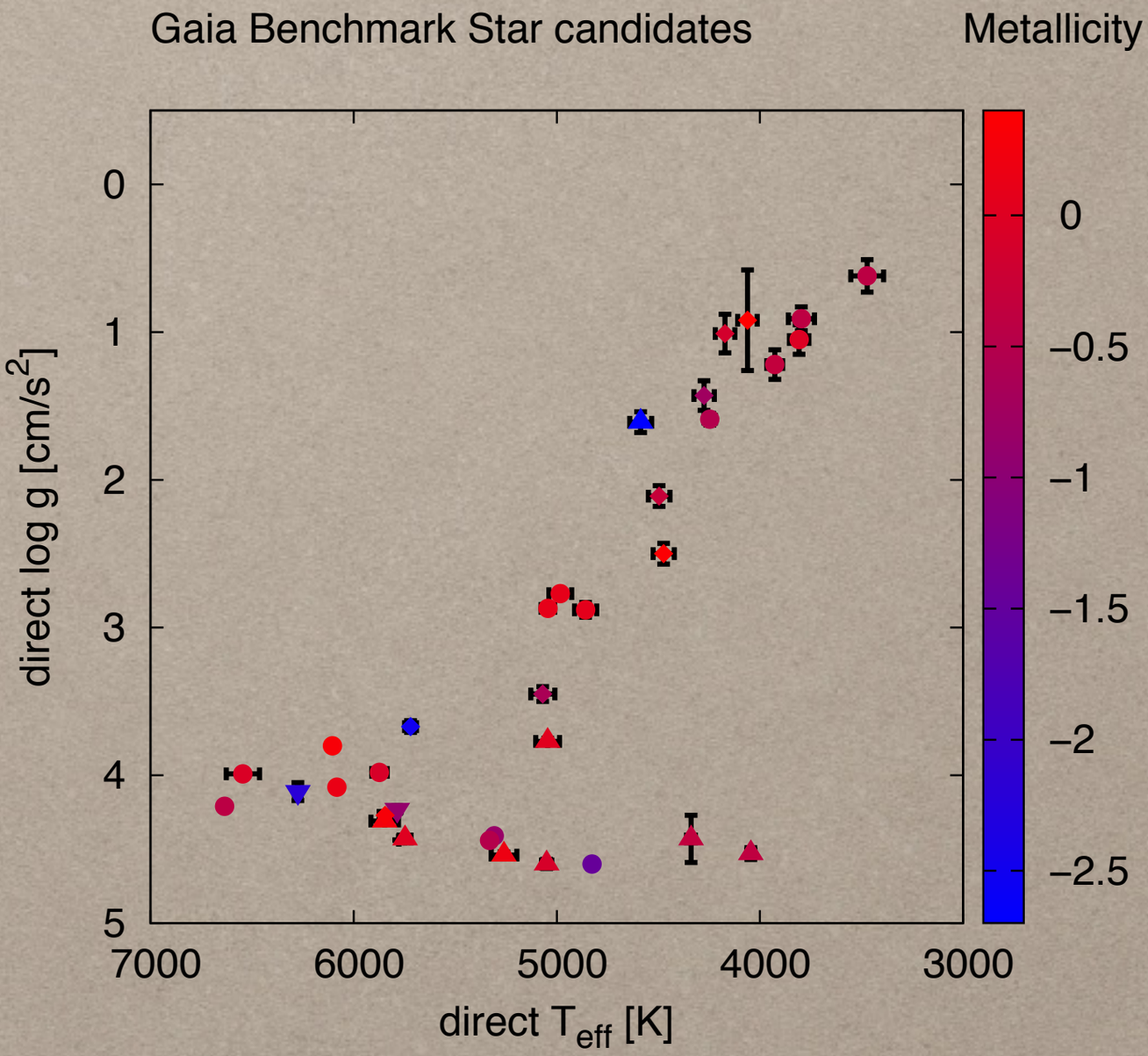
CAROLINE SOUBIRAN & ULRIKE HEITER

*Blanco-Cuaresma, Hawkins, Cantat-Gaudin, Nordlander, Guiglion*

*Chemin, Sordo, Bergemann, Lind, Pancino, Vallenari, Magrini, Delgado-Mena, Sousa, Tabernero, Montes, Masseron, Casey, Worley, Hourihane, Gonzalez Hernandez, Hill, de Laverny, Recio-Blanco, Mikolaitis, Karovicova, Adibekyan, Van Eck, Thevenin, Lardo, Mucciarelli, Gustafsson, Korn, Smiljanic, Gilmore, Randich…..*

# OLD: INITIAL SAMPLE - 34 STARS

- Very bright (V ~ 4 mag)
- Accurate parallaxes (~1% )
- Well studied (~10 spectroscopic studies using modern techniques)
- large parameter coverage (T: 3000 - 7000 K, G: 0.5 - 5, M: -3 - +0.5)




*Heiter et al (soon)*

# PARAMETERS
# EFFECTIVE TEMPERATURE

Heiter et al (soon)

*Direct & fundamental*

$$L \propto T_{\rm eff}^4$$

$$T_{\rm eff} = \left(\frac{F_{\rm bol}}{\sigma}\right)^{0.25} (0.5\,\theta_{\rm LD})^{-0.5}$$

Flux measurement across the spectrum

18/34

Literature:

Blackwell & Lynas-Gray 1998
Griffin & Lynas-Gray 1999
Koch & McWilliam 2008
di Benedetto 1998

Interferometry

25/34

Literature:

Richichi+ 2005
Pasinetti Frascassini+2001
Mozurkewich+2003
Bazot+2011, Bigot+2011
Creevey+2012, van Belle+2007

CHARA, VINCI, PAVO, VEGA...

# PARAMETERS
# EFFECTIVE TEMPERATURE

Heiter et al (soon)

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$$T_{\mathrm{eff}} = \left(\frac{F_{\mathrm{bol}}}{\sigma}\right)^{0.25} (0.5\,\theta_{\mathrm{LD}})^{-0.5}$$

Empirical calibrations using photometry

Alonso+1996, Alonso+1995,

Empirical surface brightness Relations

Cohen+1999, Kervella+ 2004
Alonso+1996, van Belle 1999

# PARAMETERS
# SURFACE GRAVITY

Heiter et al (soon)

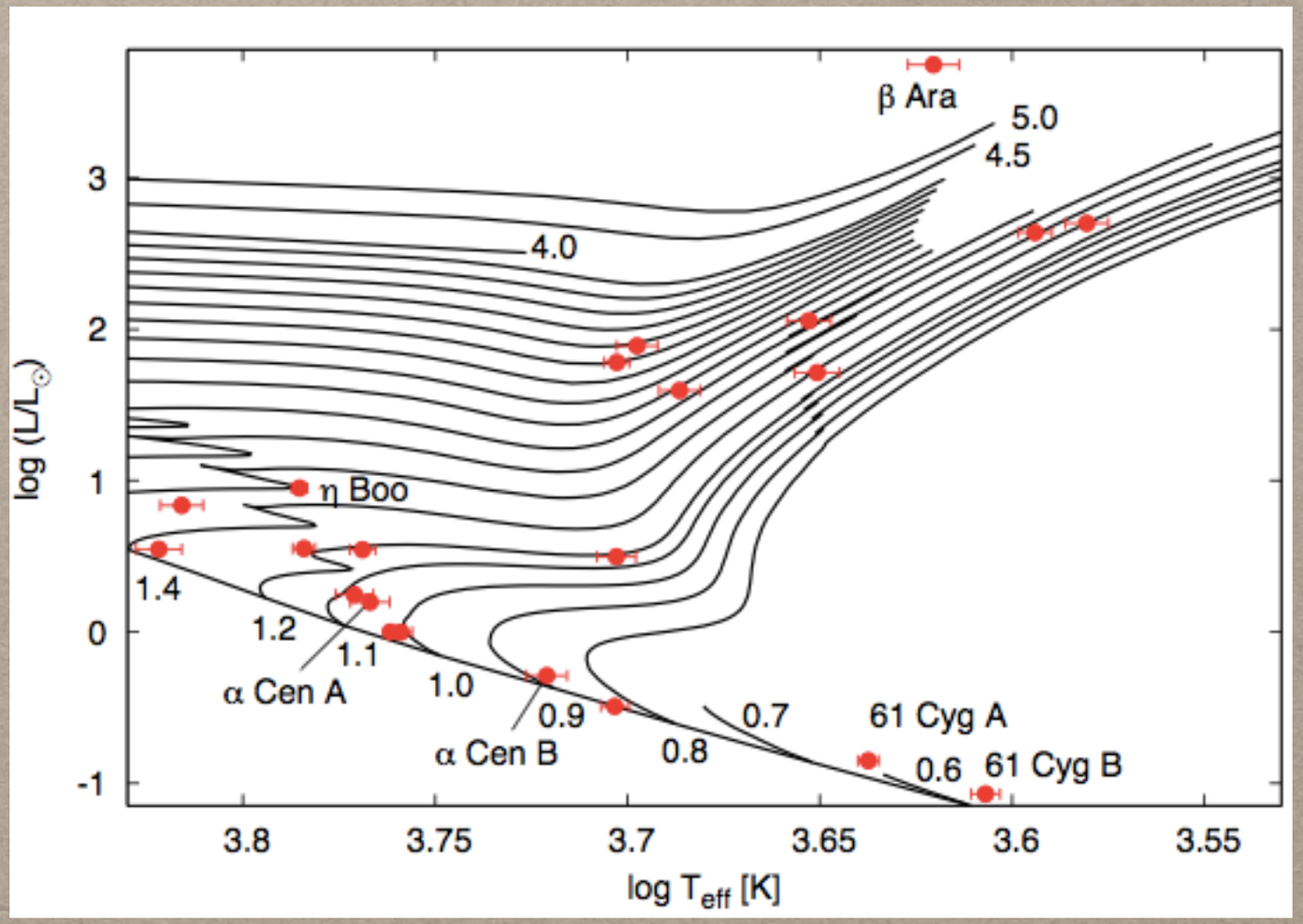
$$g = GM/R^2$$

$$g = \frac{GM}{(0.5\theta_{\rm LD}/\pi)^2}$$

Stellar Tracks

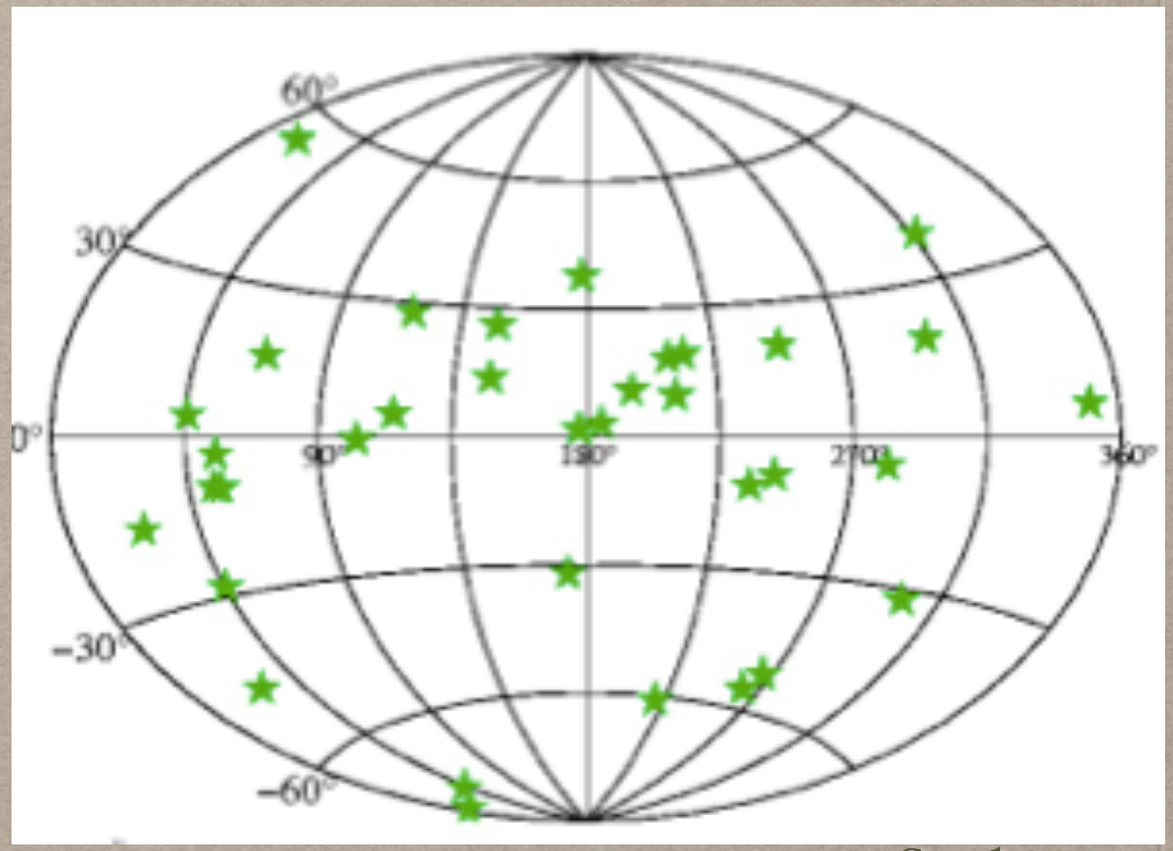
As before

**Comparisons of masses from asteroseismology (when available) show good agreement**



# PARAMETERS METALLICITY

Jofre et al 2014

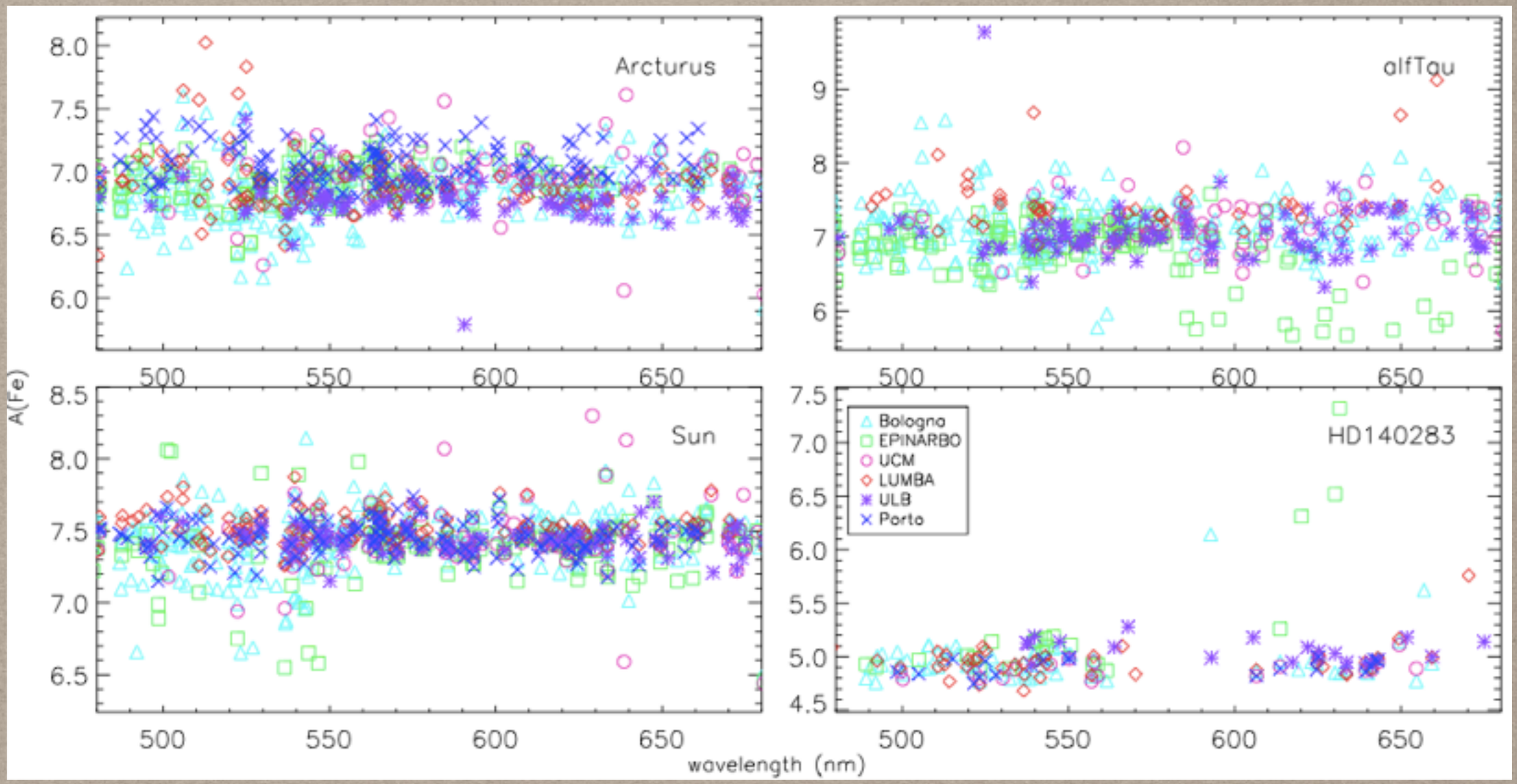



Soubiran

- Not possible to observe them all with the same telescope.
  - Creation of libraries
    Blanco Cuaresma et al 2014
- Literature is highly inhomogeneous
  - New homogeneous determination

# PARAMETERS METALLICITY

Jofre et al 2014




- Common line list, atmospheric models, spectra
- Fixing effective temperature and surface gravity
- 7 different methods (Eq. Widths to Synthesis)

# WHAT'S NEW ELEMENTAL ABUNDANCES

- 26 elements (Na, Mg, Al, Si, S, Ca, Sc, Ti, N, Cr, Mn, Co, Ni, Cu, Zn, Sr, Y, Zr, Mo, Ru, Ba, La, Ce, Pr, Nd)

- 8 methods (Nice, Cambridge, Porto, Madrid, Bologna, Padova, Bordeaux)

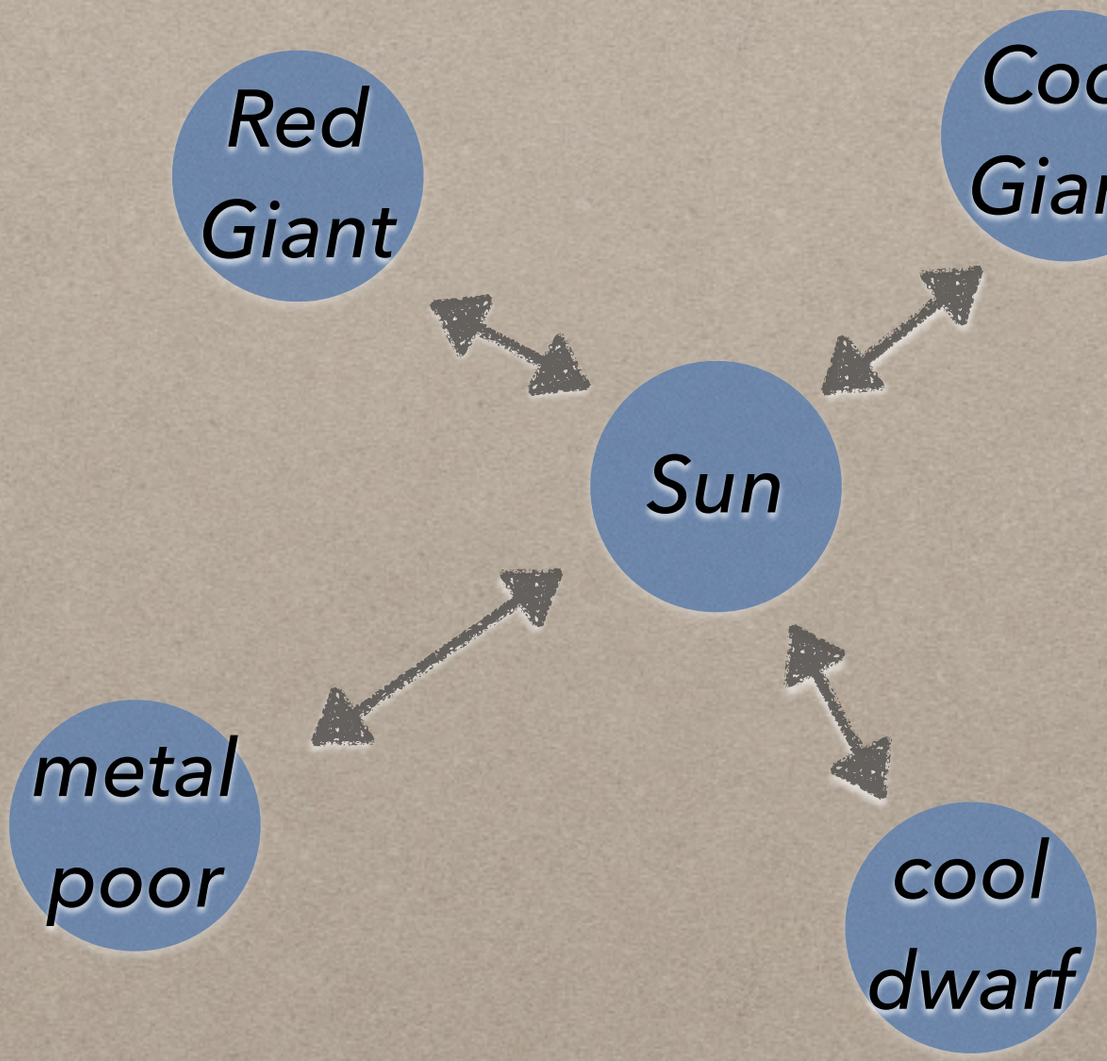
- Dedicated NLTE calculations

- UVES580+HR21 in high-res

*Common GES linelist - atmosphere models*
*Teff, logg, [Fe/H], vmic*

# WHAT'S NEW ELEMENTAL ABUNDANCES

*Differential approach to a "reference" benchmark*




*Separate the stars into 5 groups*

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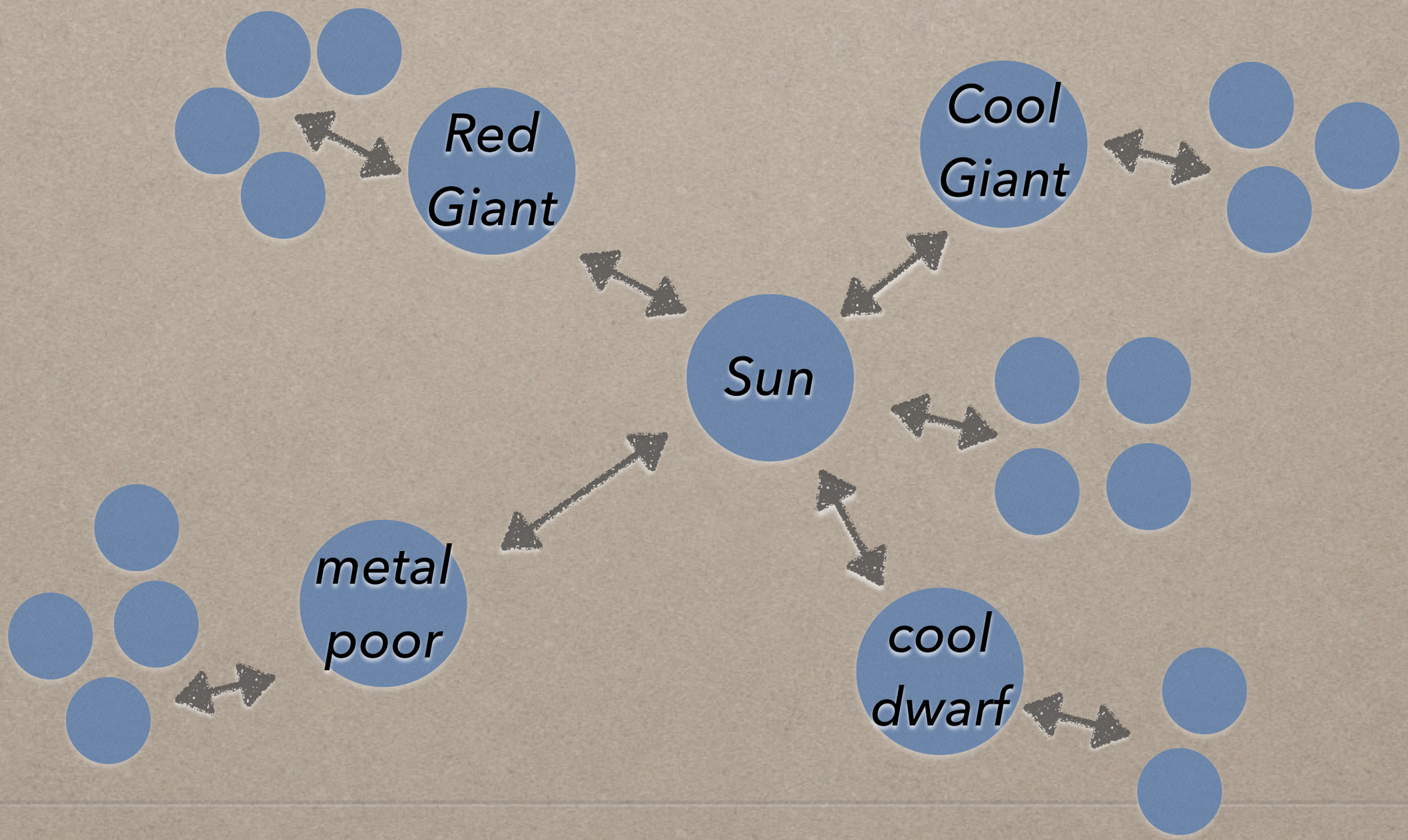

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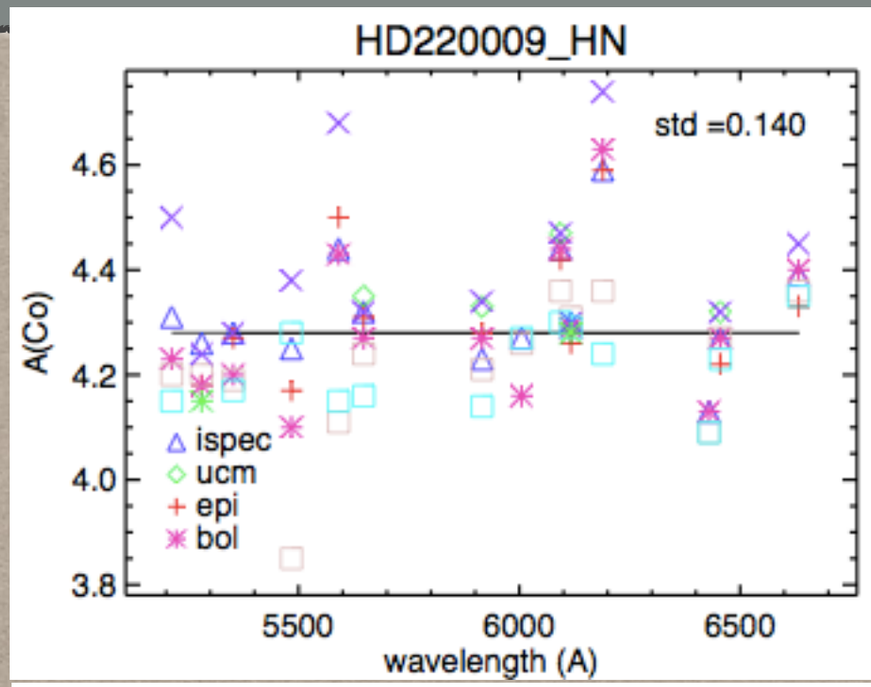
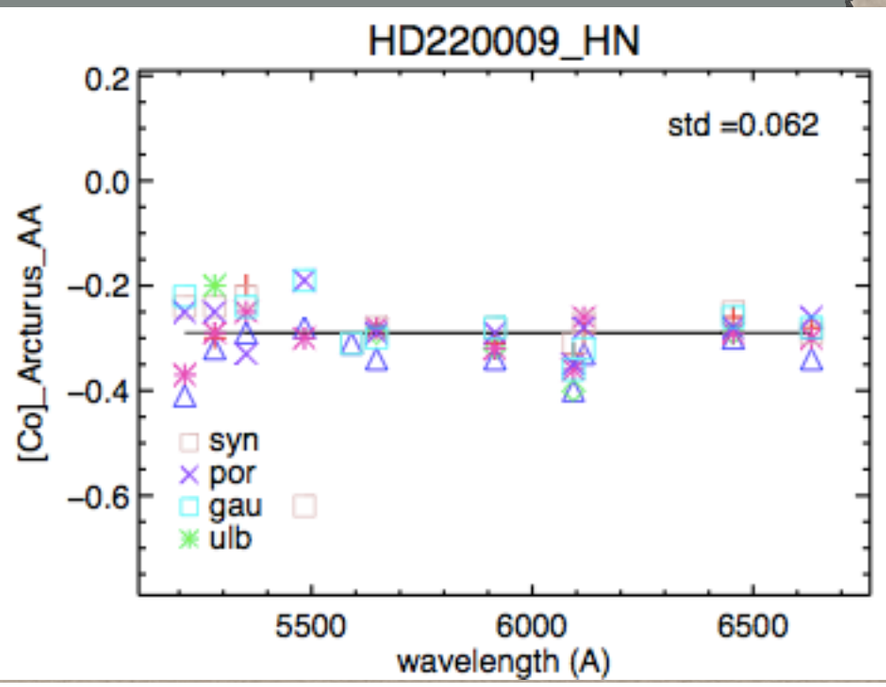
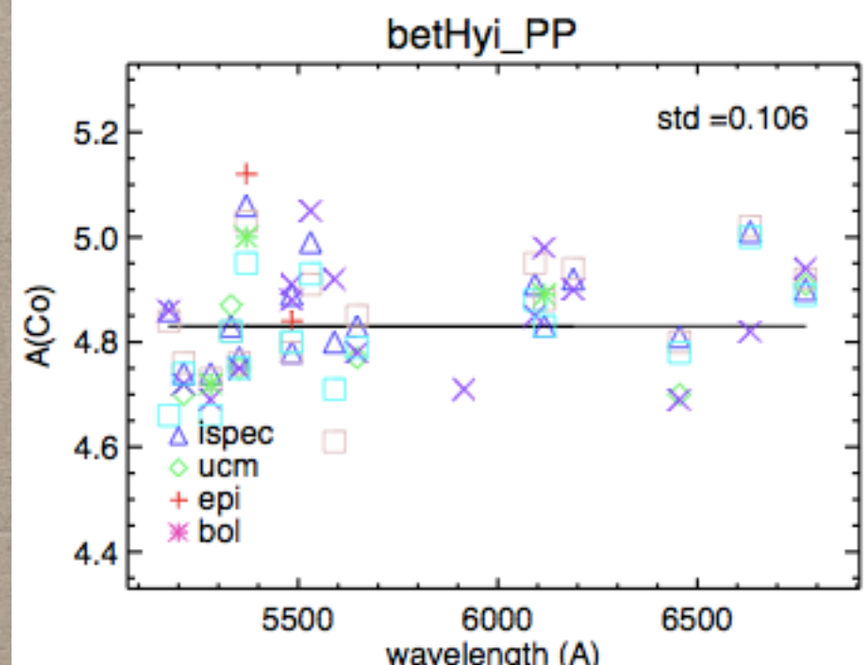
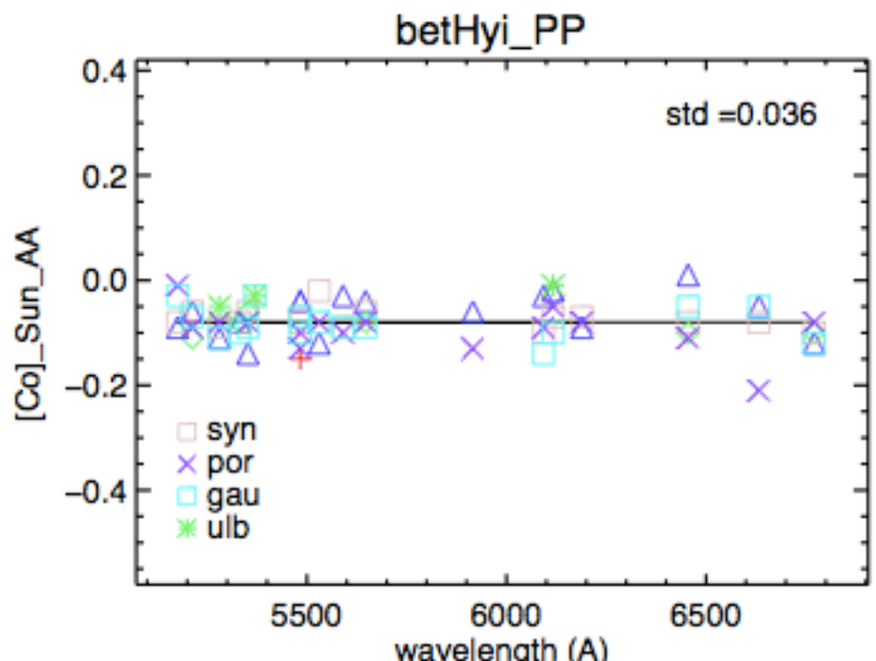


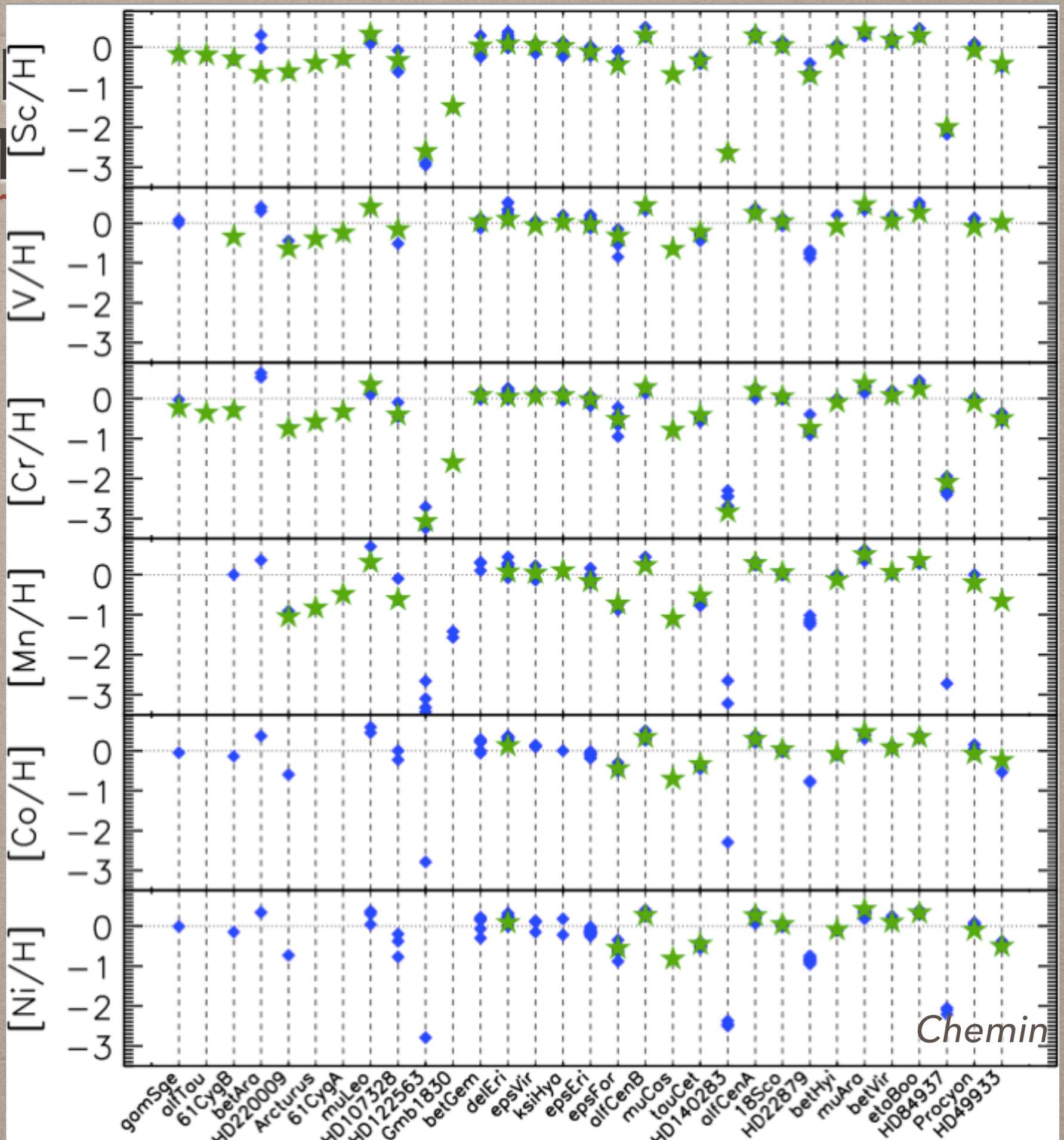



# WHAT'S I
# ELEMENT

*iron-peak elements*

*blue: literature (Worley, Hourihane, Van Eck, Heiter)*

*green: our results*



# WHAT'S I
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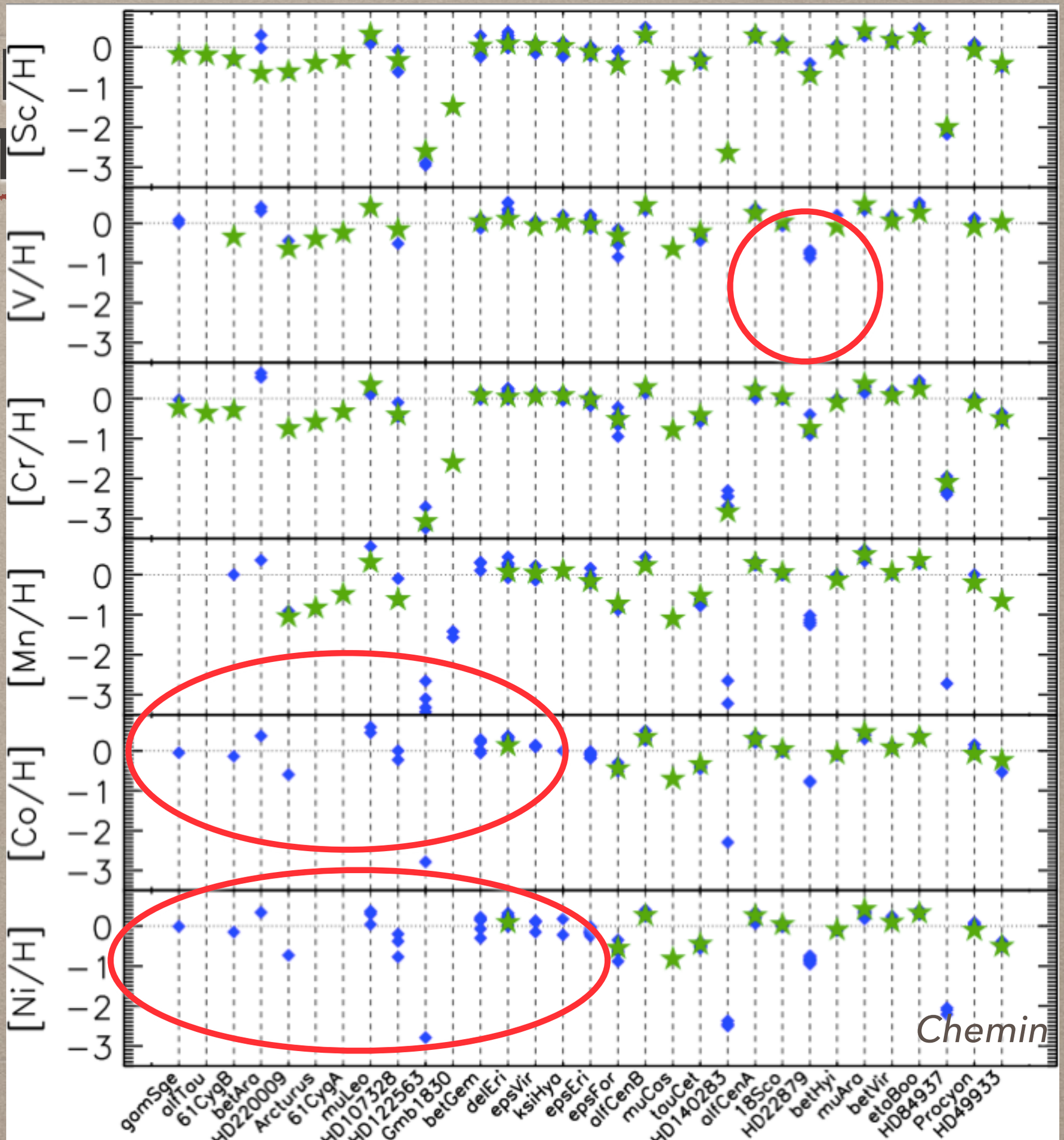
*iron-peak elements*

*blue: literature*

*(Worley, Hourihane, Van Eck, Heiter)*

*green: our results*

*If we don't trust the lines the abundance is not provided*



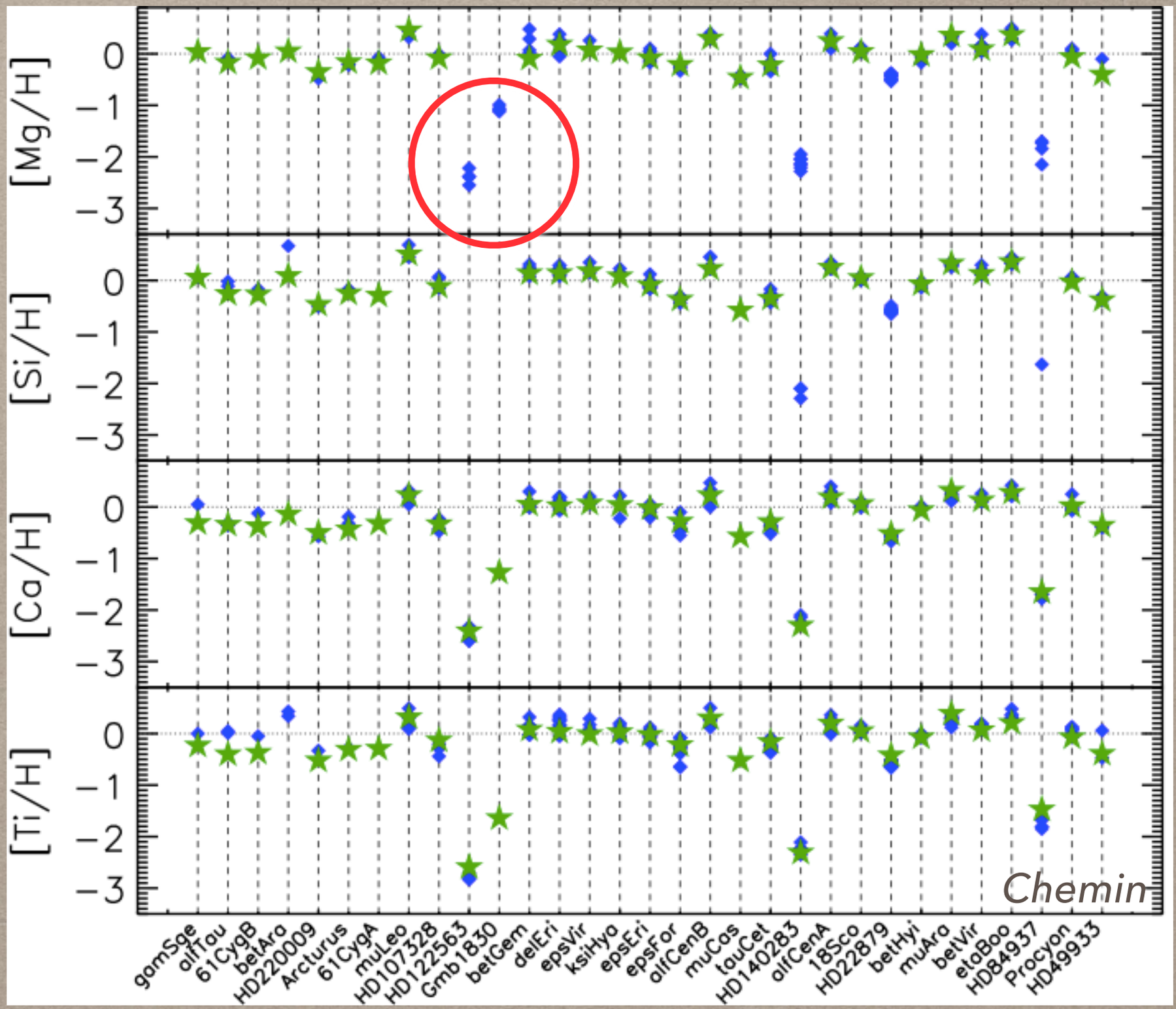
# WHAT'S NEW ELEMENTAL ABUNDANCES

*alpha elements*

*blue: literature (Worley, Hourihane, Van Eck, Heiter)*

*green: our results*

*to get Mg we will work on absolute values for metal-poor stars*

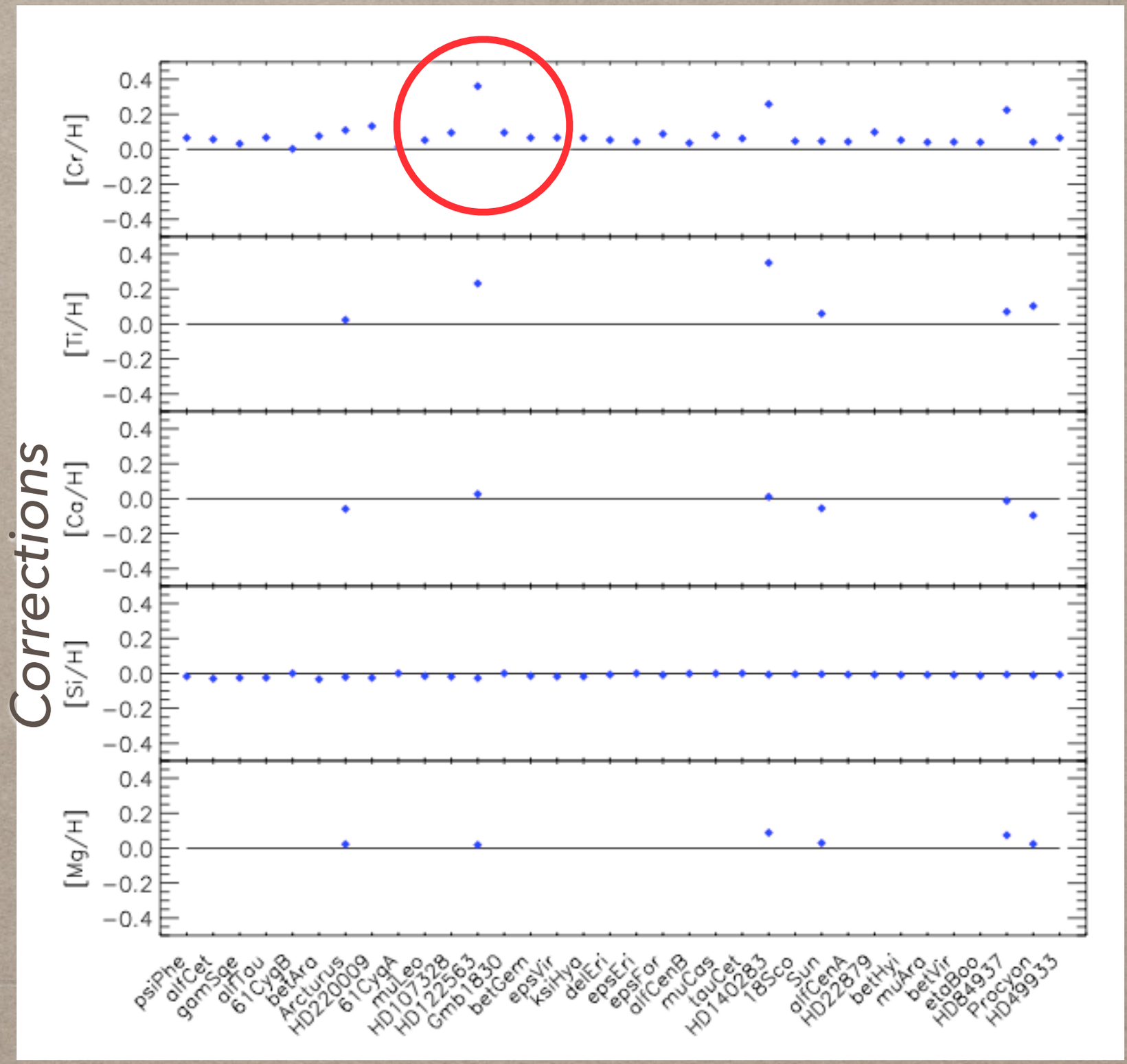


# WHAT'S NEW ELEMENTAL ABUNDANCES

***NLTE corrections***

*(Nordlander, Lind, Bergemann)*

*Usually small, but some cases up to 0.3 dex*



# WHAT'S NEW
# MORE METAL-POOR STARS

| Node | MRD | MRG | MPS |
|---|---|---|---|
| Bologna | 1.000 | 0.546 | – |
| CAUP | 0.971 | 0.495 | – |
| Concepcion | 0.694 | 0.495 | 0.306 |
| EPINARBO | 1.000 | 0.781 | 0.585 |
| IACAIP | 0.862 | 0.901 | 0.935 |
| Liege | 0.676 | 0.386 | – |
| LUMBA | 1.000 | 0.602 | 0.758 |
| Nice | 0.870 | 0.794 | 1.000 |
| OACT | 0.741 | 0.. | |
| ParisHeidelberg | 1.000 | 0. | |
| UCM | 0.893 | 0. | |
| ULB | – | | |
| Vilnius | 1.000 | 0. | |

*Smiljanic et al 2014*

### 7.1.1. The accuracy of the Node results

We divided the benchmark stars into three groups to judge separately the accuracy of the results in different corners of the parameter space. The groups were: 1) *metal-rich dwarfs* (MRD): stars with [Fe/H] $> -1.00$ and $\log g > 3.5$ (contains 11 benchmark stars); 2) *metal-rich giants* (MRG): stars with [Fe/H] $> -1.00$ and $\log g \leq 3.5$ (contains 7 benchmark stars); and 3) *metal-poor stars* (MPS): stars with [Fe/H] $\leq -1.00$ (contains three benchmark stars). Only one group of metal-poor stars was defined because only three benchmark stars with [Fe/H] $\leq -1.00$ are available.

# WHAT'S NEW
# MORE METAL-POOR STARS

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| ULB | – | | |
| Vilnius | | 0.. | |

*Smiljanic et al 2014*

*We need more metal-poor stars …*

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# PARAMETERS
# EFFECTIVE TEMPERATURE

Heiter et al (soon)

$$L \propto T_{\mathrm{eff}}^4$$

$$T_{\mathrm{eff}} = \left(\frac{F_{\mathrm{bol}}}{\sigma}\right)^{0.25} (0.5\,\theta_{\mathrm{LD}})^{-0.5}$$

Empirical calibrations using photometry

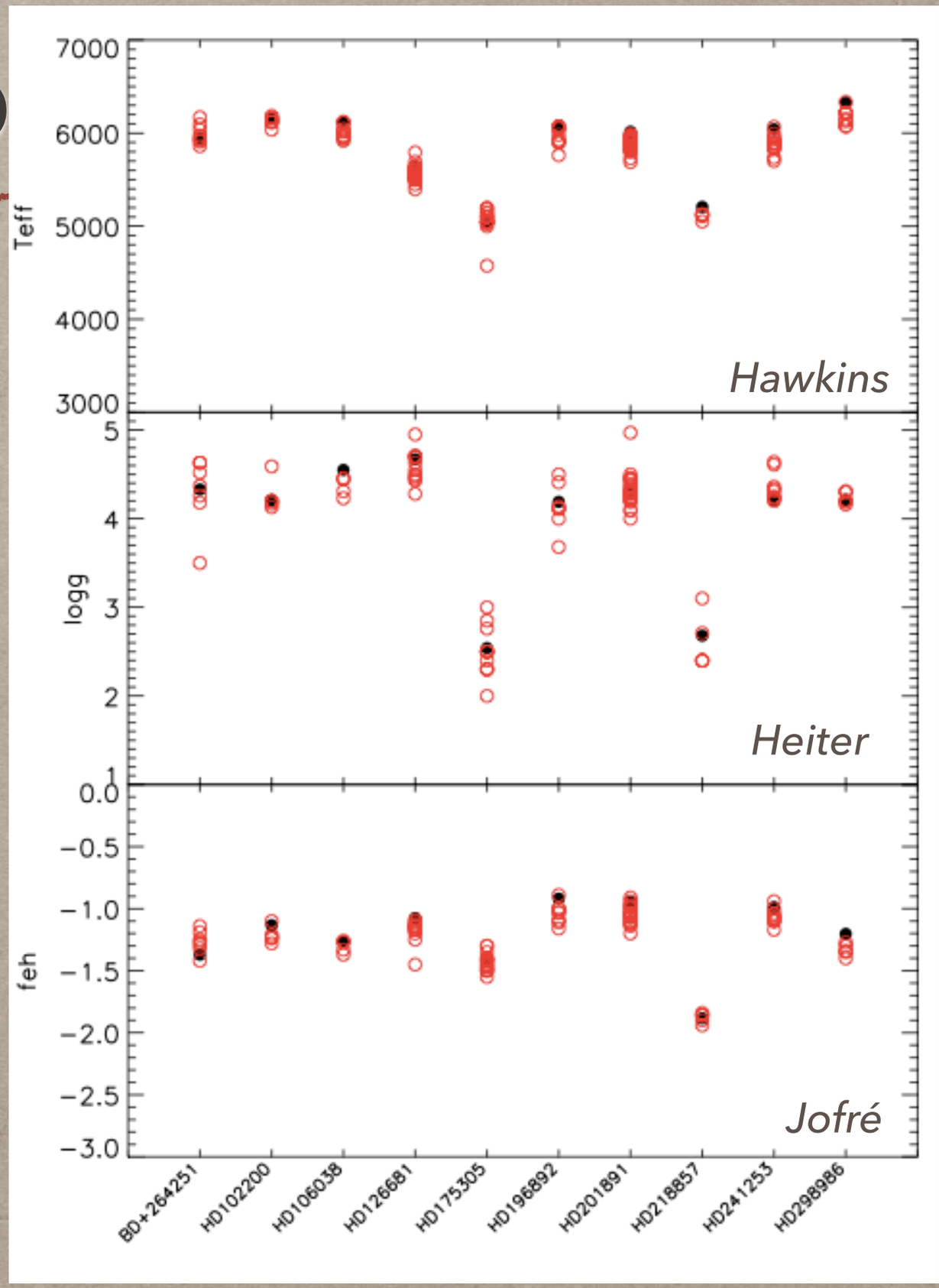
Alonso+1996, Alonso+1995,

Empirical surface brightness Relations

Cohen+1999, Kervella+ 2004
Alonso+1996, van Belle 1999

# WHAT'S NEW
# MORE METAL-PO

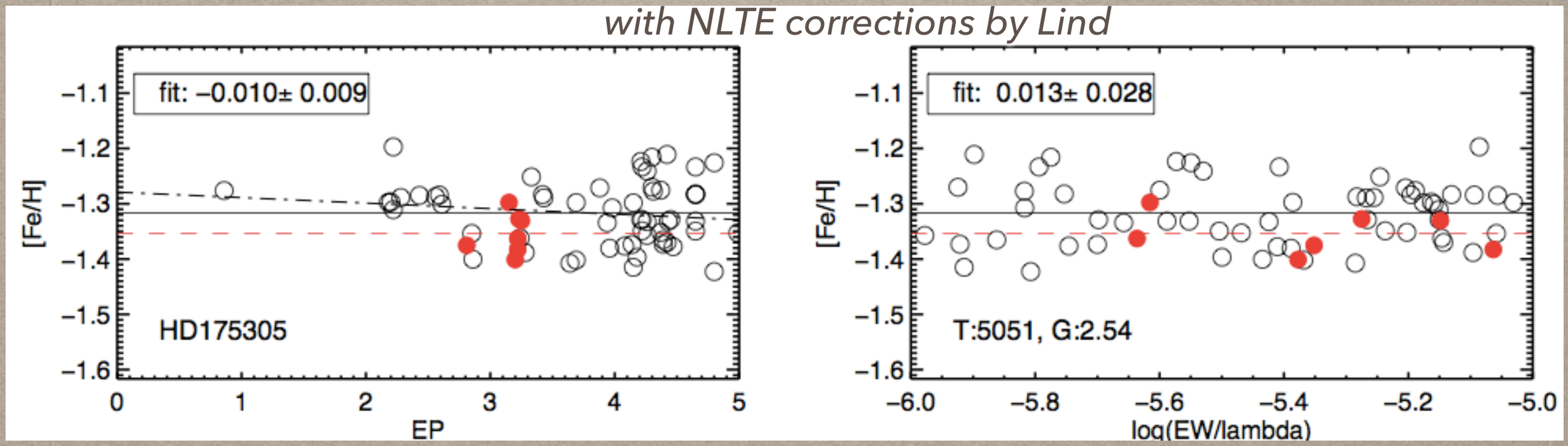
- ~10 candidates from PASTEL with accurate parallax and photometry (Soubiran)
- Teff and logg as in Heiter
- Library as in Blanco-Cuaresma et al (2014)
- 4 methods (2xEW/2xSYN) to do iron abundances with selected lines from Jofré et al (2014)



# WHAT'S NEW
# MORE METAL-POOR STARS

## *Validation checks*

*with NLTE corrections by Lind*



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# MORE METAL-POOR STARS

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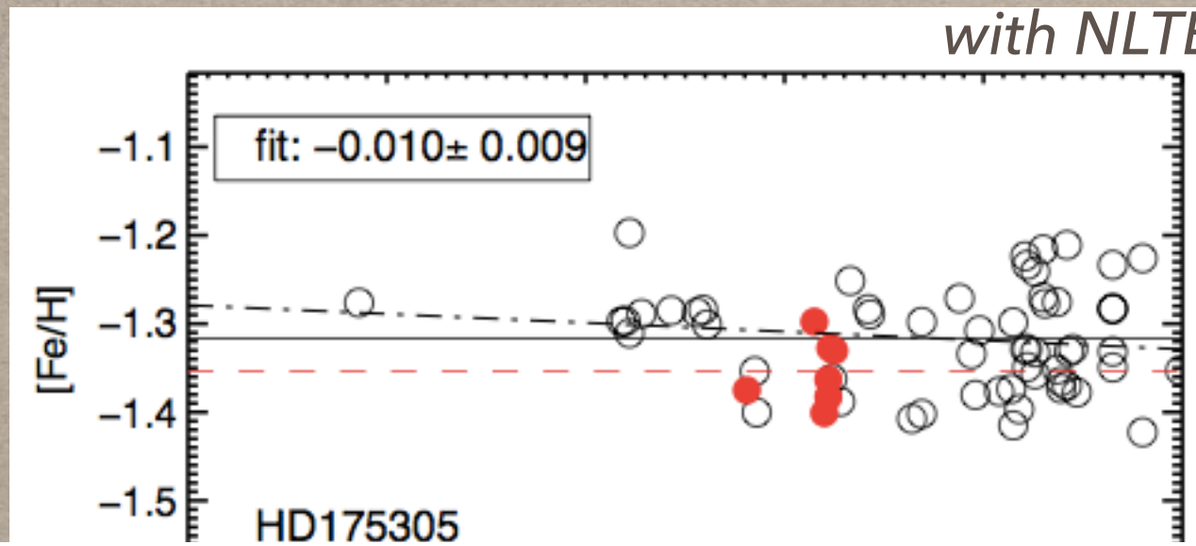


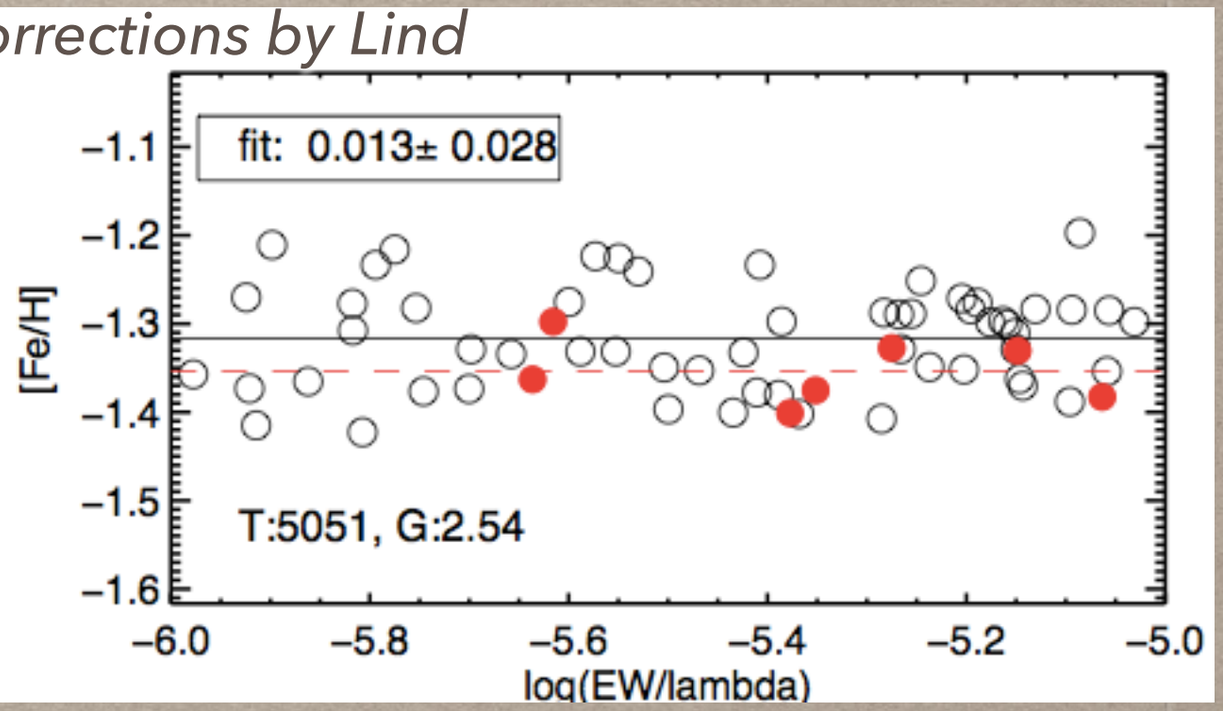


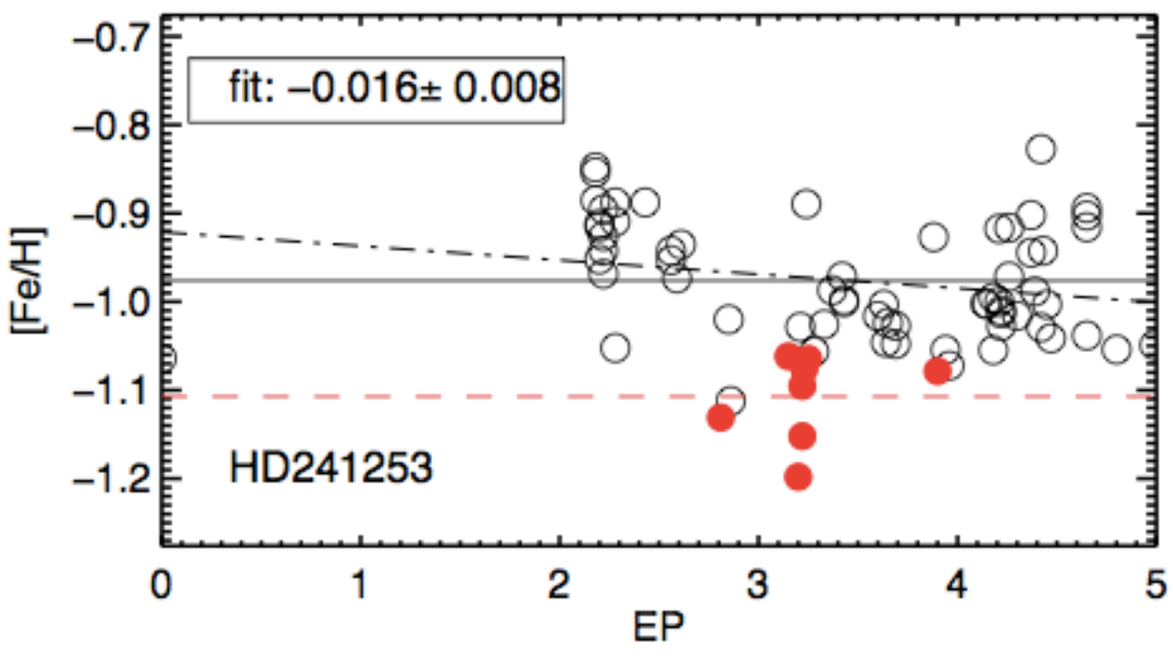


*Why FeI and Fe II don't agree?*
*Why is there a trend of FeI as a function of EP?*

# WHAT'S NEW
# MORE ANGULAR DIAMETERS

*PI. Karovicova:*

*Observational campaign of 84 hours granted with VLTI to observe 27 new stars*

*Observations are taking place now*

*Time will allow for 3 observations per target*

# SUMMARY

- Benchmark stars are useful and if many surveys use them to scale their parameters, we can link the data of milky way stars easier
- Through our studies we attempt not only to provide the best reference value for their parameters, but we attempt to improve our understanding on modelling atmospheres in general