Abundance Anomalies in the Composition of Host Stars

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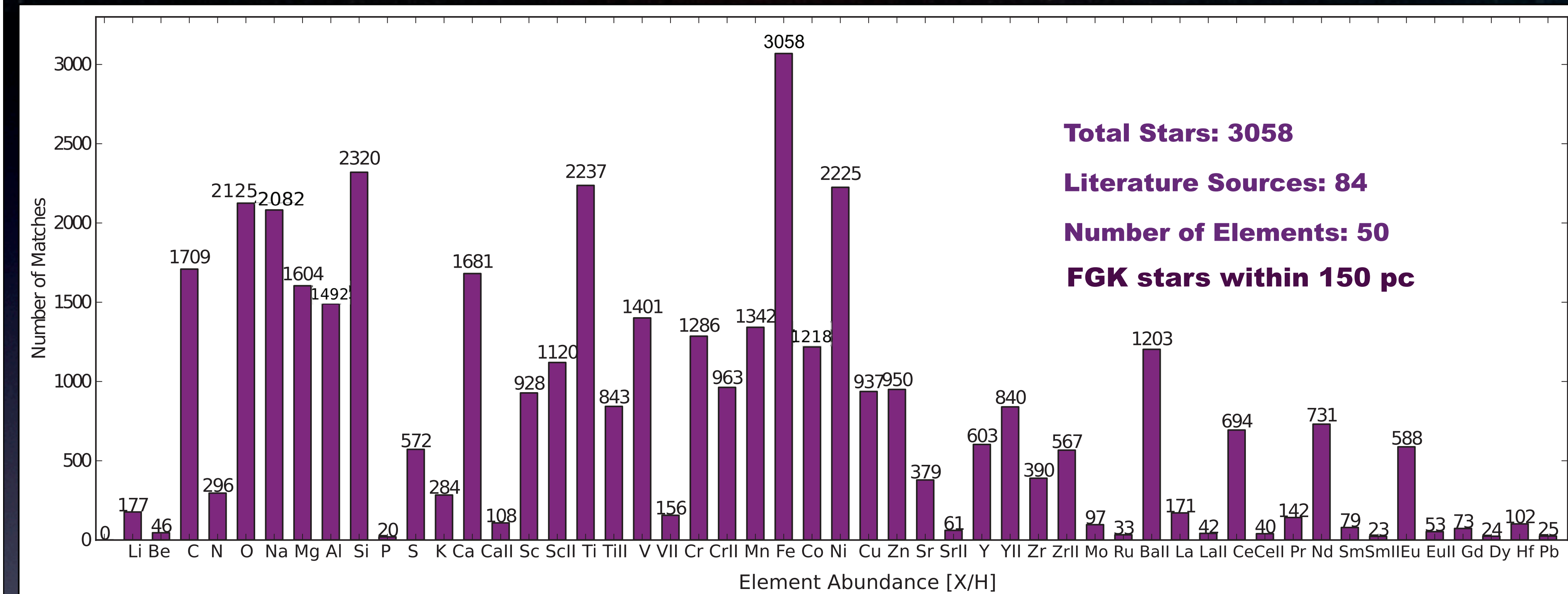
The Hypatia Catalog



Compiled spectroscopic abundance determinations for stars in the solar neighborhood from published literature sources (Hinkel et al. 2014, 148, 54 and Vizier).

But there are many different methods...

Comparisons

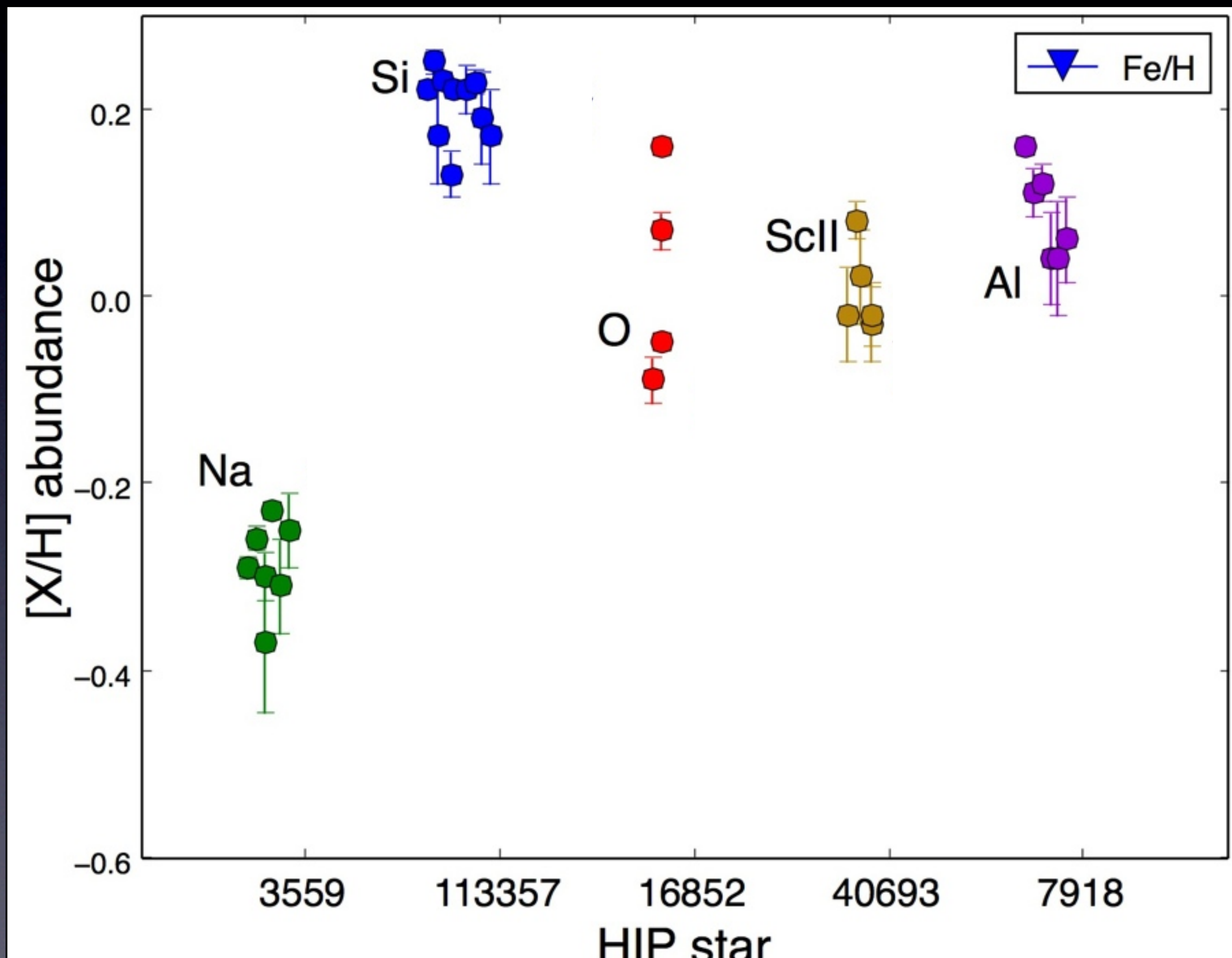
There can be a huge variation between which telescope(s) was used, resolution, and models.

When comparing datasets, there is no standardized method. Sometimes statistics are used to quantize deviations, but not always.

> We compare our results for barium to the data of [17, 19] in Fig. 8. The good agreement between our abundances and those found in these other studies is obvious.

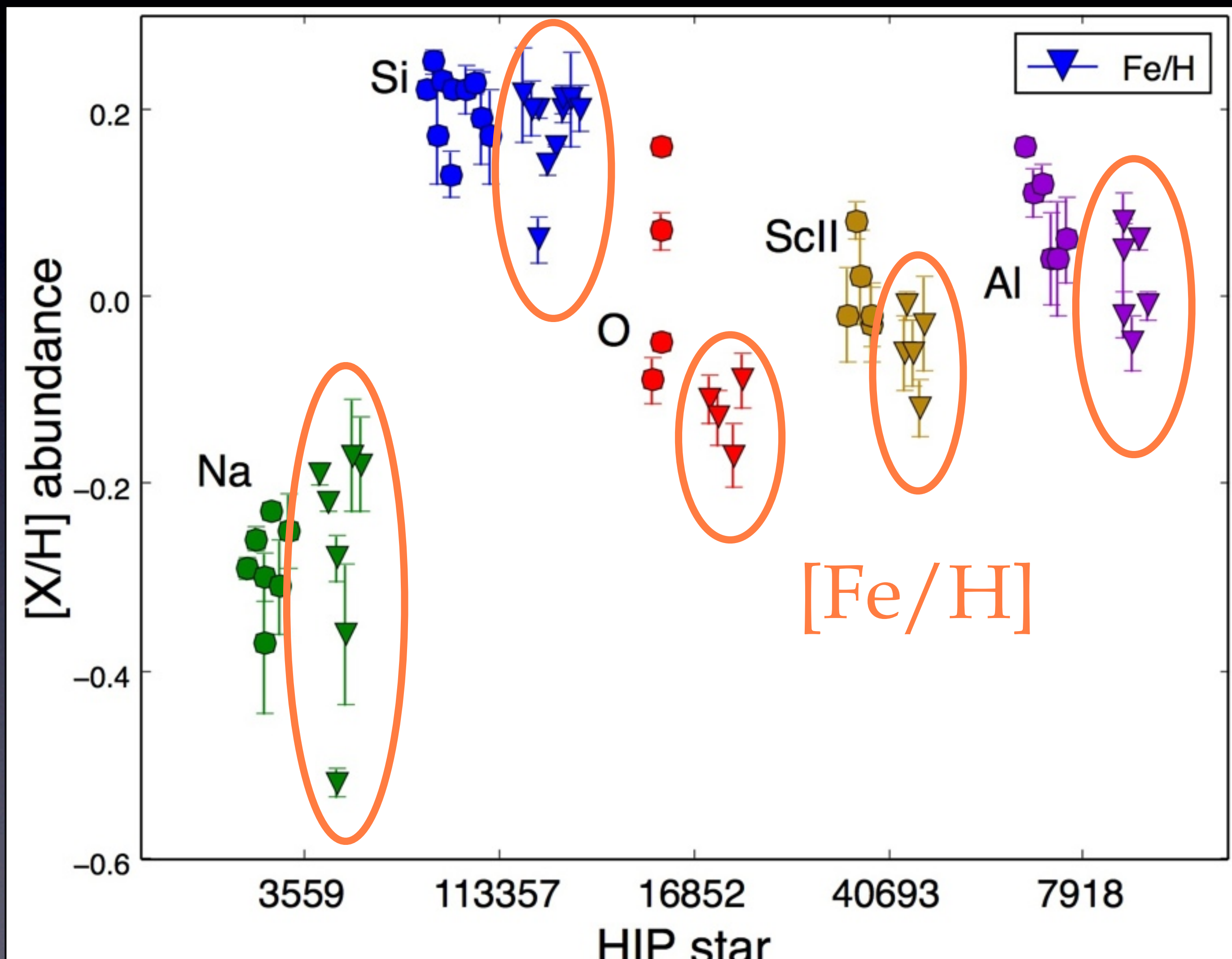
> We do not know the origin of these differences. However, the differences are, in general, small and systematic, implying that, from a relative point of view, all studies agree well.

The Spread



Fe/H
Si
O
ScII
Al
Na
0.2
0.0
−0.2
−0.4
−0.6
[X/H] abundance
3559
113357
16852
40693
7918
HIP star

The Spread



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Solar Renormalization

Catalogs do not necessarily use the same solar abundance scale when determining their abundances...there are dozens.

Average absolute difference between independent and re-normalized abundances: 0.06 dex

In Hypatia, we used Lodders et al. (2009) as the standard and did not analyze element abundances that didn't "agree."

International Collaboration

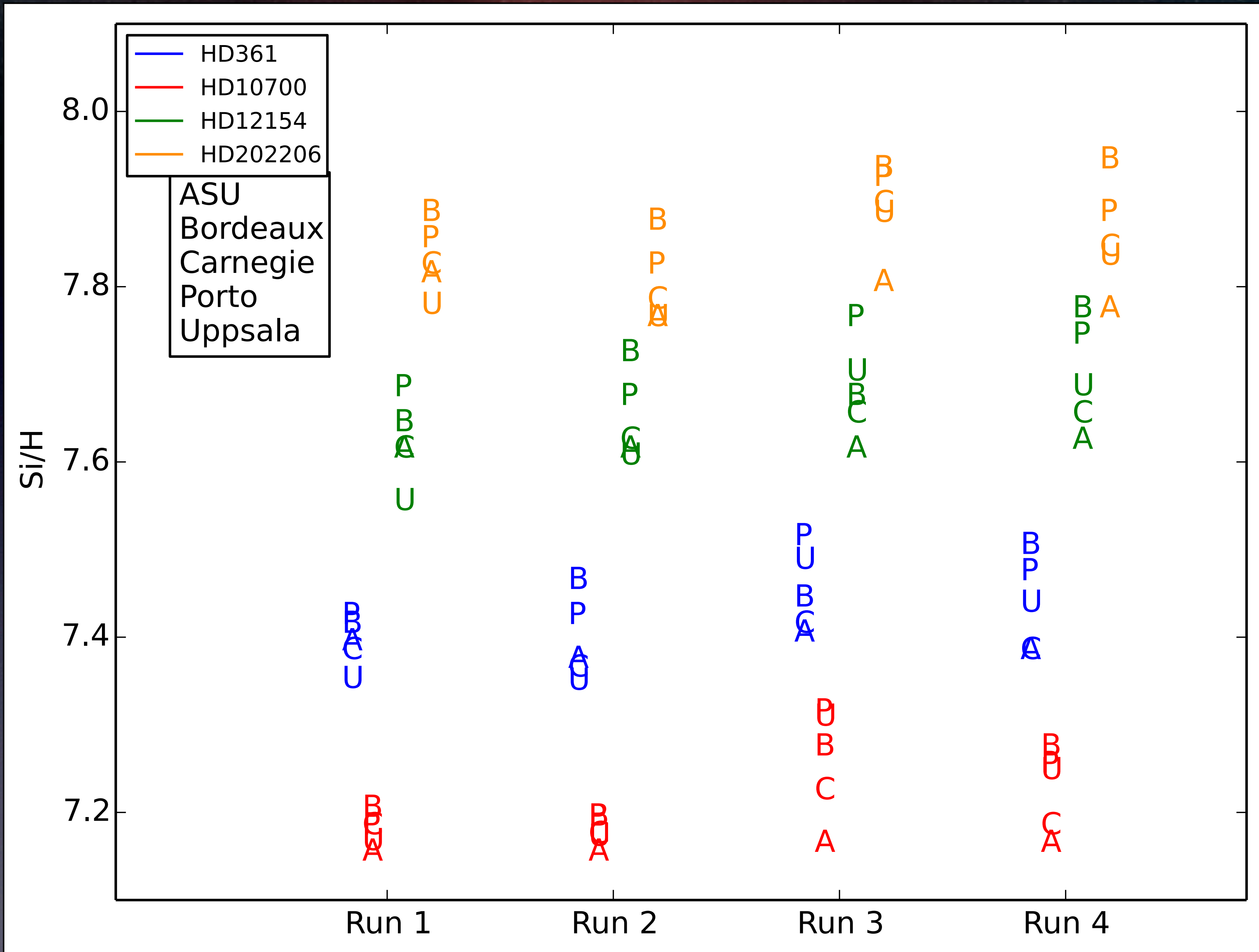
ASU held a "Stellar Stoichiometry" Workshop where five groups were given the same spectra to analyze for 4 stars in order to understand how the methods, stellar parameters, & line lists affected the element abundance determinations. Similar to Smiljanic et al (2014), we sought to understand important systematic differences between models (Hinkel et al. in prep).

Specifically chose metal-rich to metal-poor stars:
HD 202206, HD 121504, HD 361, HD 10700

Planet hosts

Models for the Homework

Name	Stellar Atmo	EQ Width	CoG/Spec Fit
ASU	ATLAS9	ARES/IRAF	MOOG
Bordeaux	MARCS	SPECTRUM	SF via Spectrum
Carnegie	MARCS	ARES/IRAF	MOOG
Porto	ATLAS9	ARES/IRAF	MOOG
Uppsala	MARCS	SME	SF via SMe



Autonomous Std. Params Std. Lines Std. Params/Lines

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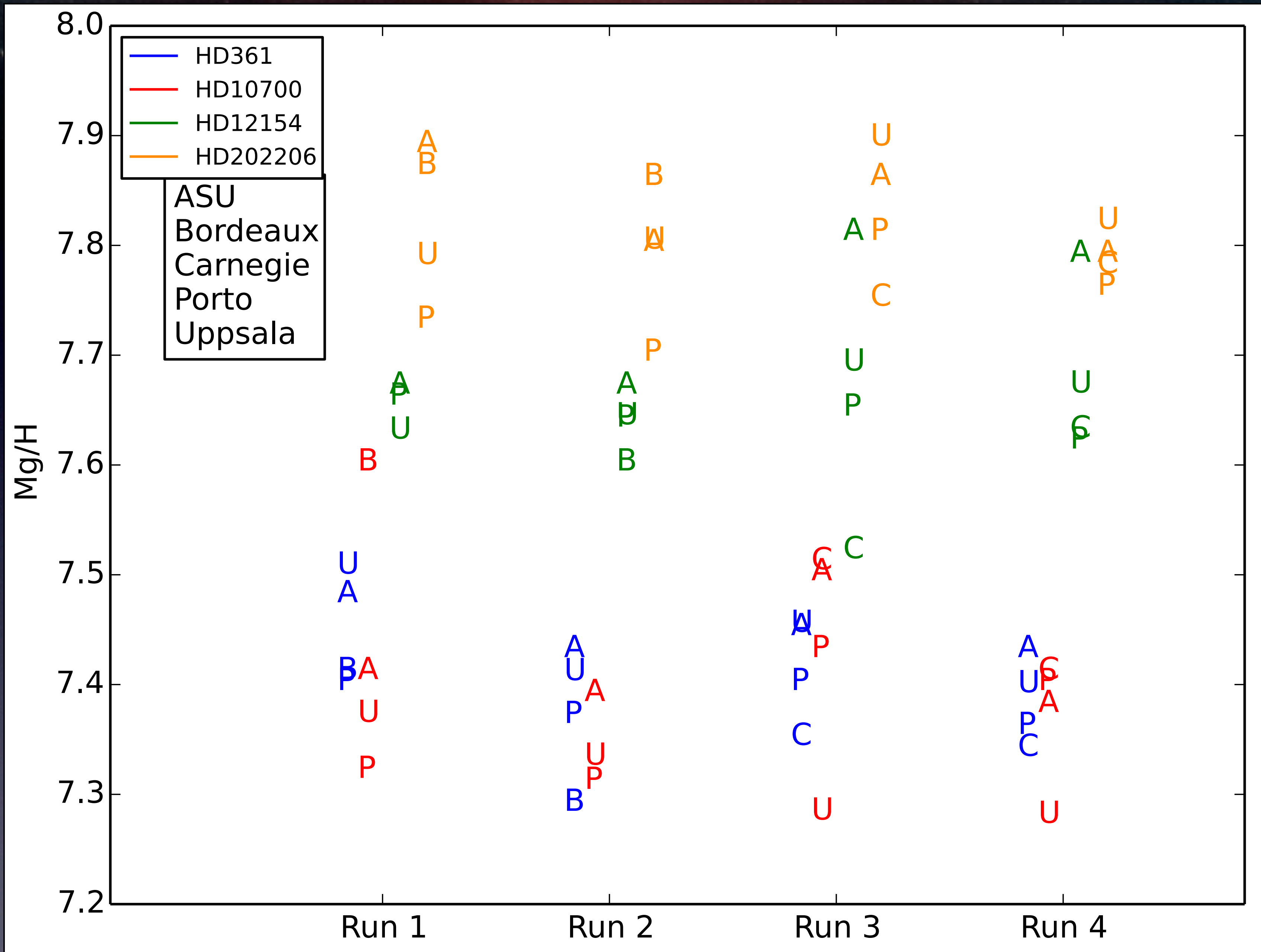

Autonomous Std. Params Std. Lines Std. Params/Lines

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Comparisons

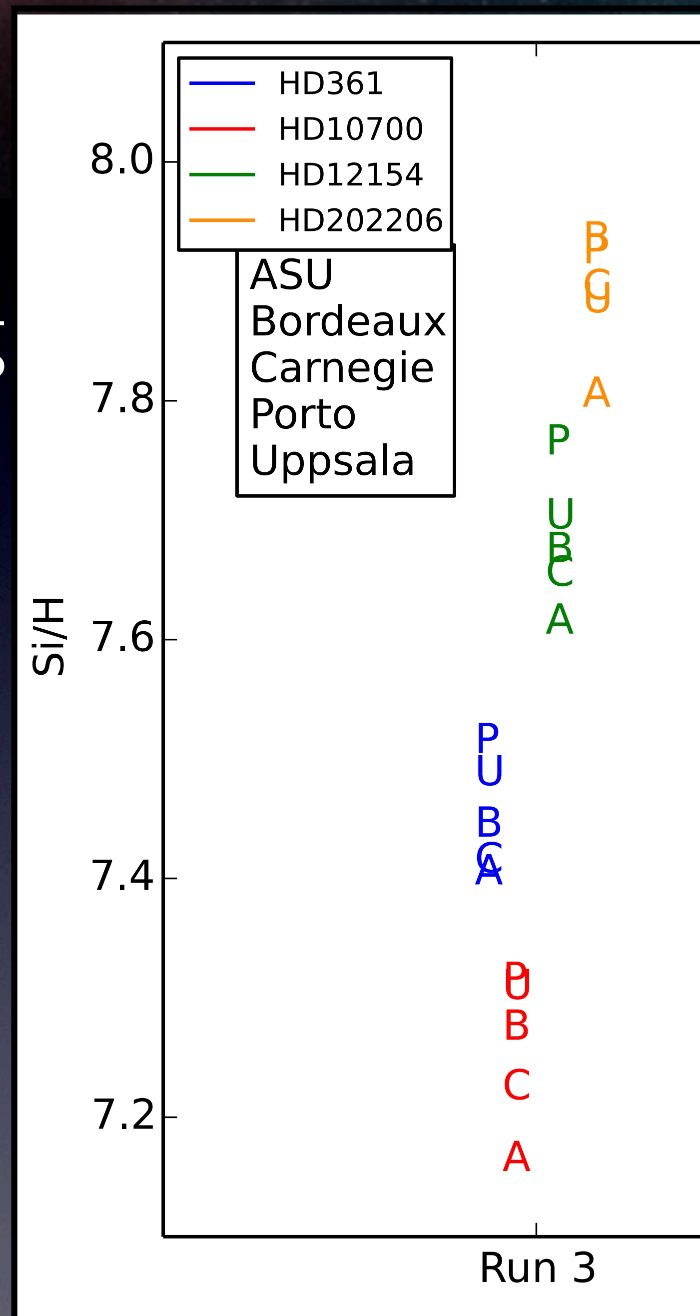
We have a promising place to start on what needs to change for the abundances to be more copacetic. Not trying to determine what method is best, just to find a way to standardize.

Spread:	mean	max
Run 1 (Autonomous)	0.41	1.22 (CrII/O)
Run 2 (Std Star Params)	0.27	1.24 (CrII)
Run 3 (Std Line List)	0.44	1.73 (O)
Run 4 (Std Params/Line)	0.44	2.01 (O)

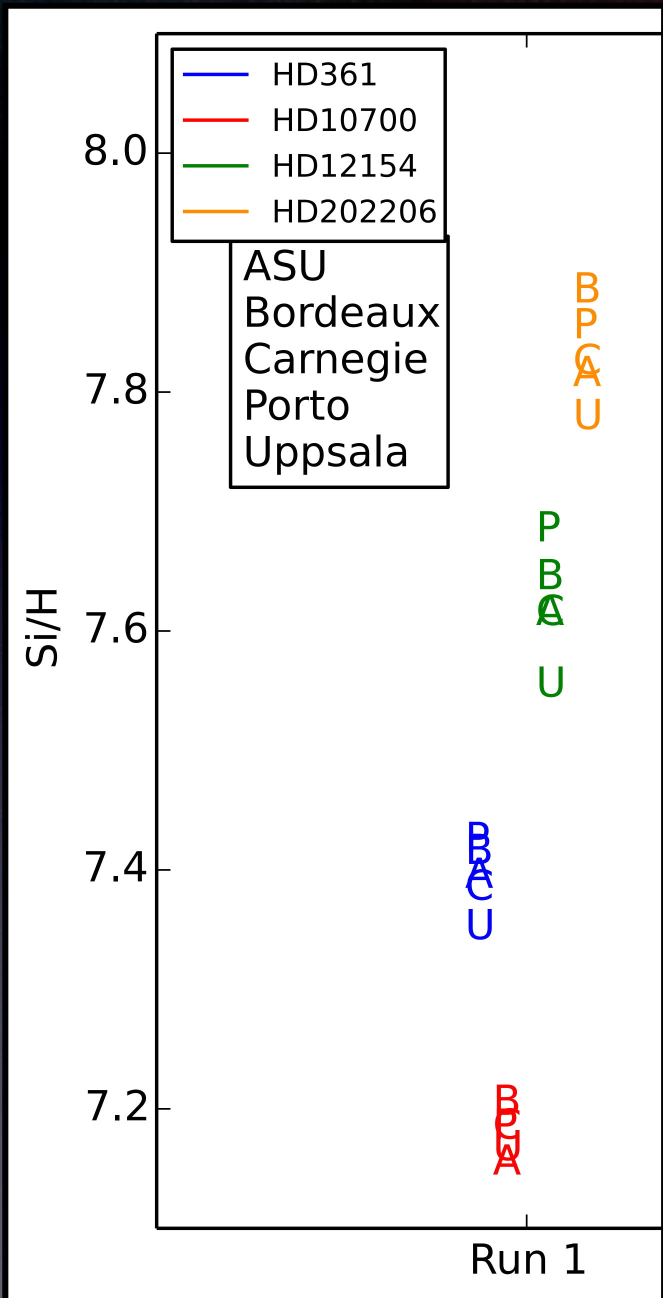
Standard Line List

Bordeaux, Uppsala both used spectral fitting when determining EWs, the rest used MOOG.

Average absolute difference between the EWs for the 5 standardized Si I lines = 5.1 mÅ.
When comparing:
SF to MOOG = 7.7 mÅ **(26%)**
MOOG to MOOG = 2.9 mÅ **(8%)**



Autonomous EWs



Bordeaux, Uppsala both used spectral fitting when determining EWs, the rest used MOOG.

Average absolute difference between the EWs for the autonomous Si I lines = 7.6 mÅ. When comparing:

SF to MOOG = 11.8 mÅ (19%)

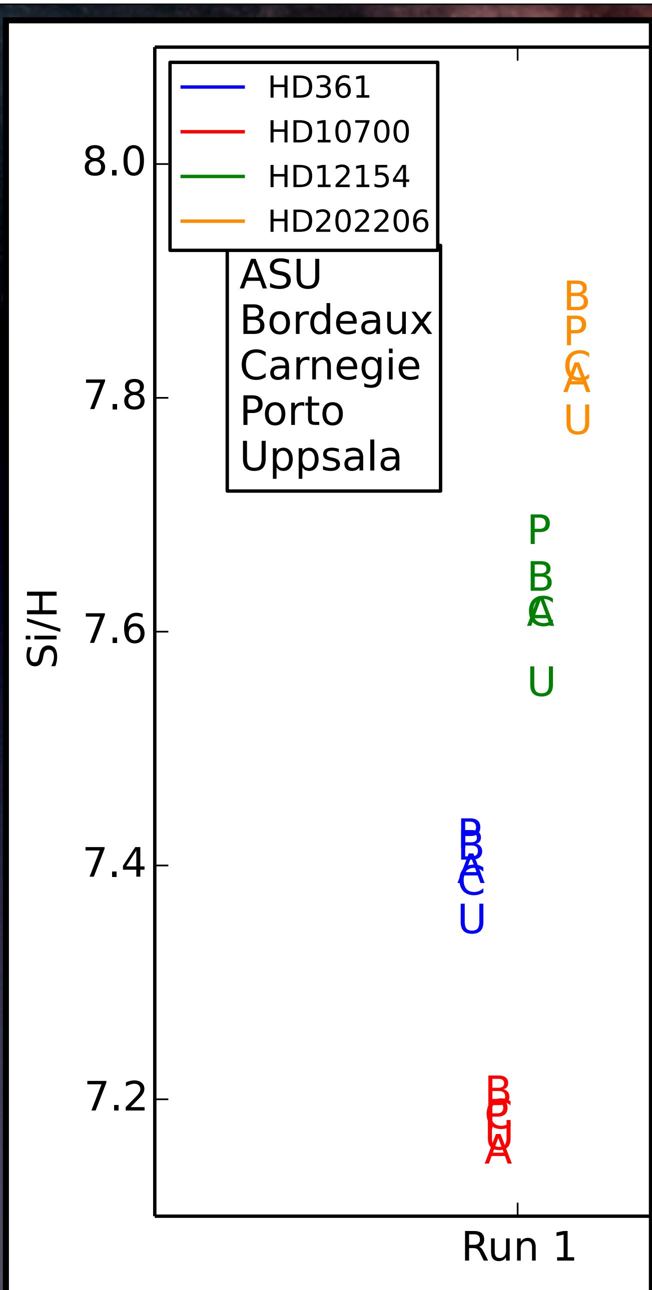
MOOG to MOOG = 3.4 mÅ (7%)

Equivalent Widths?

The disparate cross-method EWs held true for other elements as well, such as Ni - where there were 15 standardized lines. Elements with < 5 lines will suffer more from variations betweens methods.

→ EWs aren't the problem (here)!

Now we look at the stellar parameters!



$181 = \Delta T_{eff} = 403$

$0.37 = \Delta \log(g) = 0.82$

$0.12 = \Delta[Fe/H] = 0.24$

$251 = \Delta T_{eff} = 536$

$0.44 = \Delta \log(g) = 0.43$

$0.17 = \Delta[Fe/H] = 0.32$

$236 = \Delta T_{eff} = 412$

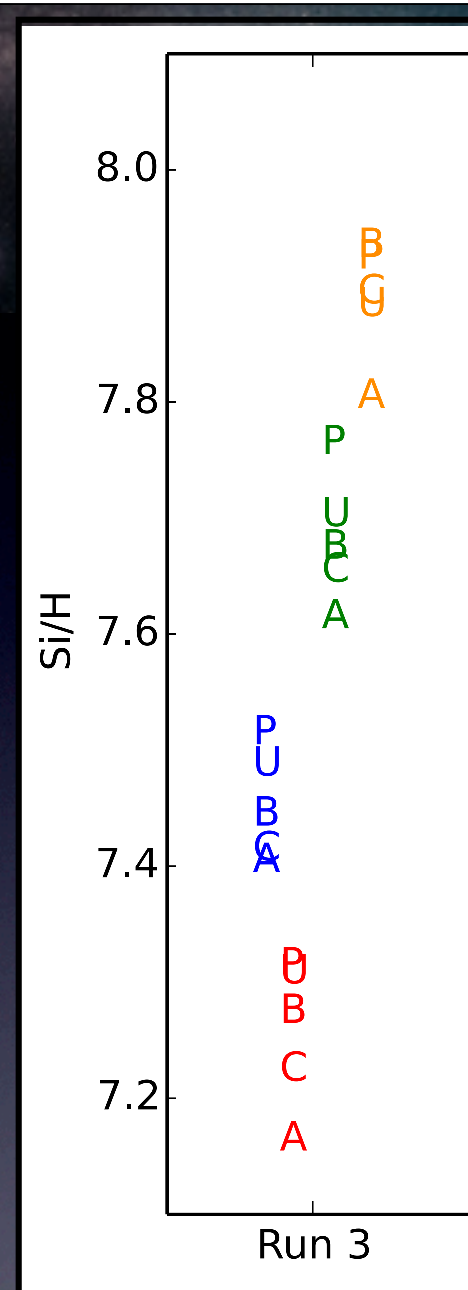
$0.5 = \Delta \log(g) = 0.92$

$0.17 = \Delta[Fe/H] = 0.27$

$127 = \Delta T_{eff} = 296$

$0.23 = \Delta \log(g) = 0.48$

$0.15 = \Delta[Fe/H] = 0.08$



ASU, Porto both used ATLAS9 for their stellar atmospheres, the rest used MARCS.

Summary

Stellar abundances are complicated, by definition. But there are significant issues between datasets due to different techniques, which have not been addressed -- so we see a *spread* in the data. Our measurement techniques need to be more transparent if we are to understand the effects of planets on stellar compositions.

Possible solution: In conjunction with benchmark stars, create a database of EWs measured per star so obvious outlier lines can be identified.

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Shameless Plugs

Mike Pagano's poster on "Using and Improving Stellar Element Abundances" (P3.12)

Transit Ephemeris Refinement Monitoring Survey - Characterizing known planetary systems since 2009. If there's a +Neptune transit around a bright star, we'll find it!

http://www.sciencebarpodcast.com/

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