Li abundances in very metal-poor, main-sequence turn-off stars

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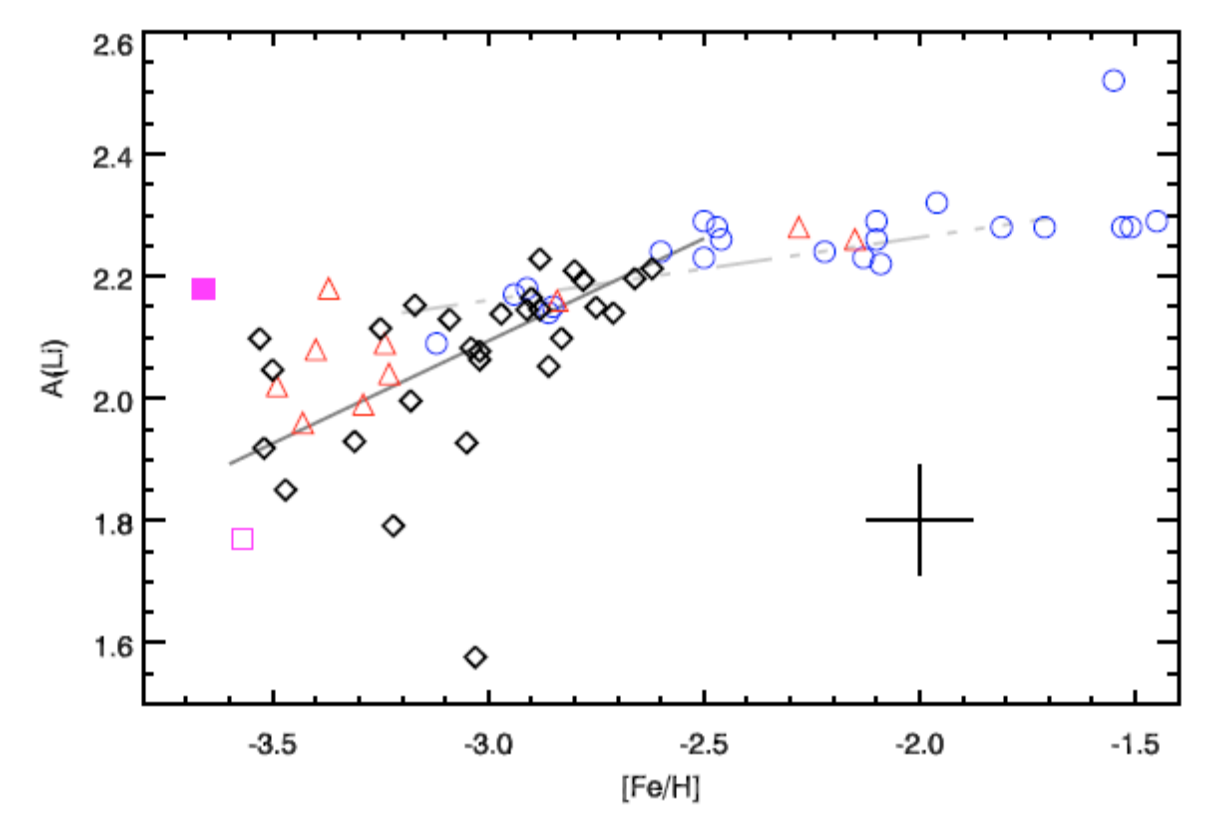
Li abundances in very metal-poor, main-sequence turn-off stars

(1)Li abundances of Extremely Metal-Poor turn-off stars from SDSS sample

(2)Li abundances of the double-lined spectroscopic binary G166-45 ([Fe/H]=-2.5)

Li depletion/scatter in EMP stars

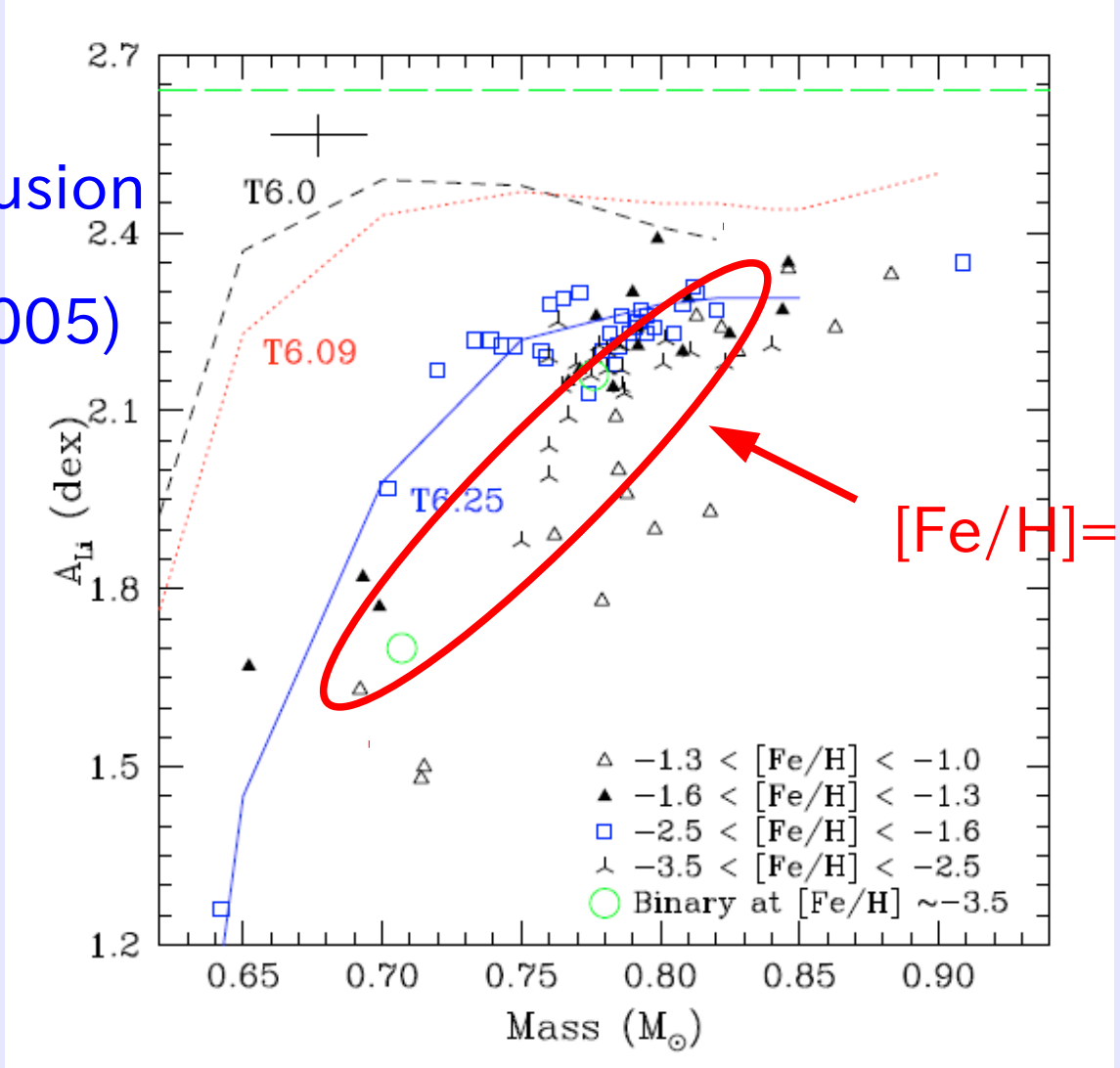


Sbordone et al. (2010)

Ryan et al. (1999), Bonifacio et al. (2007), Aoki et al. (2009) etc.

Mass & metallicity dependent Li depletion?

Models with diffusion and turbulence (Richard et al. 2005)

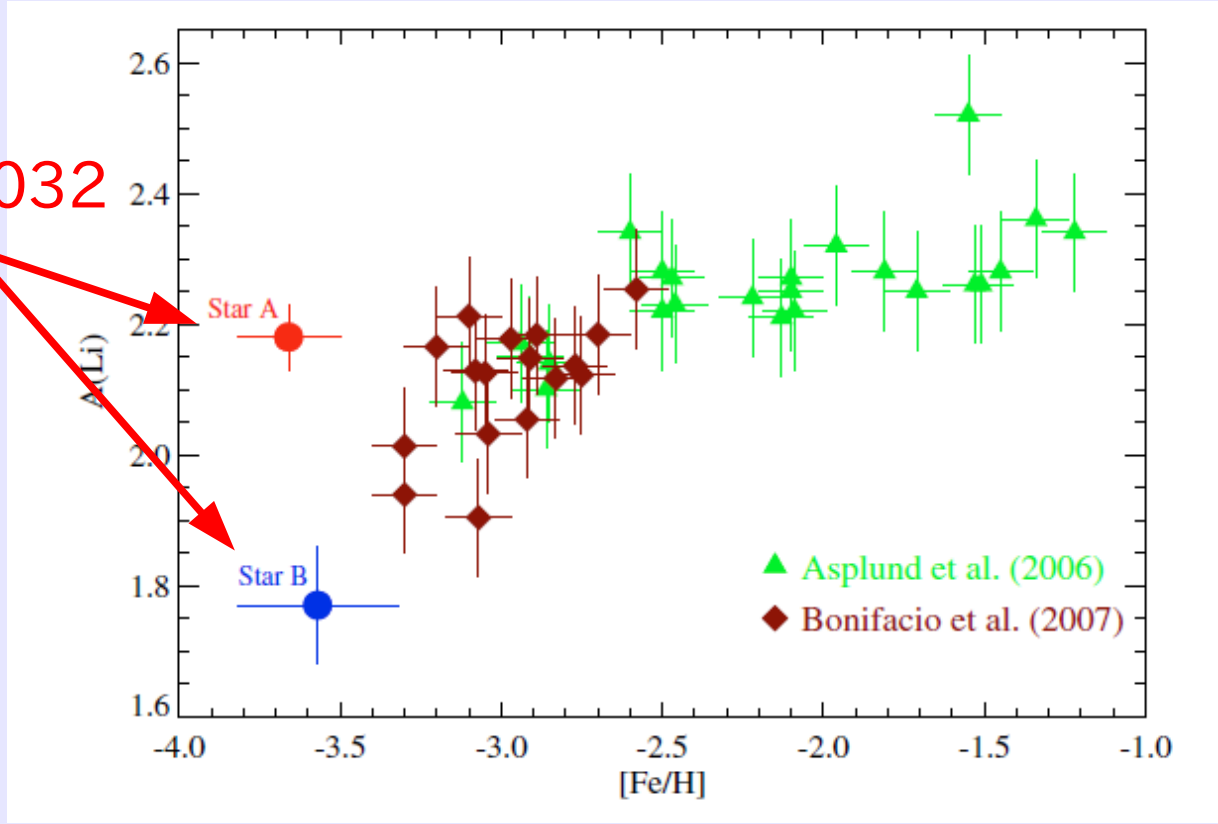


Melendez et al. (2010)

Li in the double-lined spectroscopic binary CS22876-032

Evidence for the depletion of Li in a main-sequence star

CS22876-032



Gonzalez-Henandez et al. (2008)

Li in the double-lined spectroscopic binary CS22876-032

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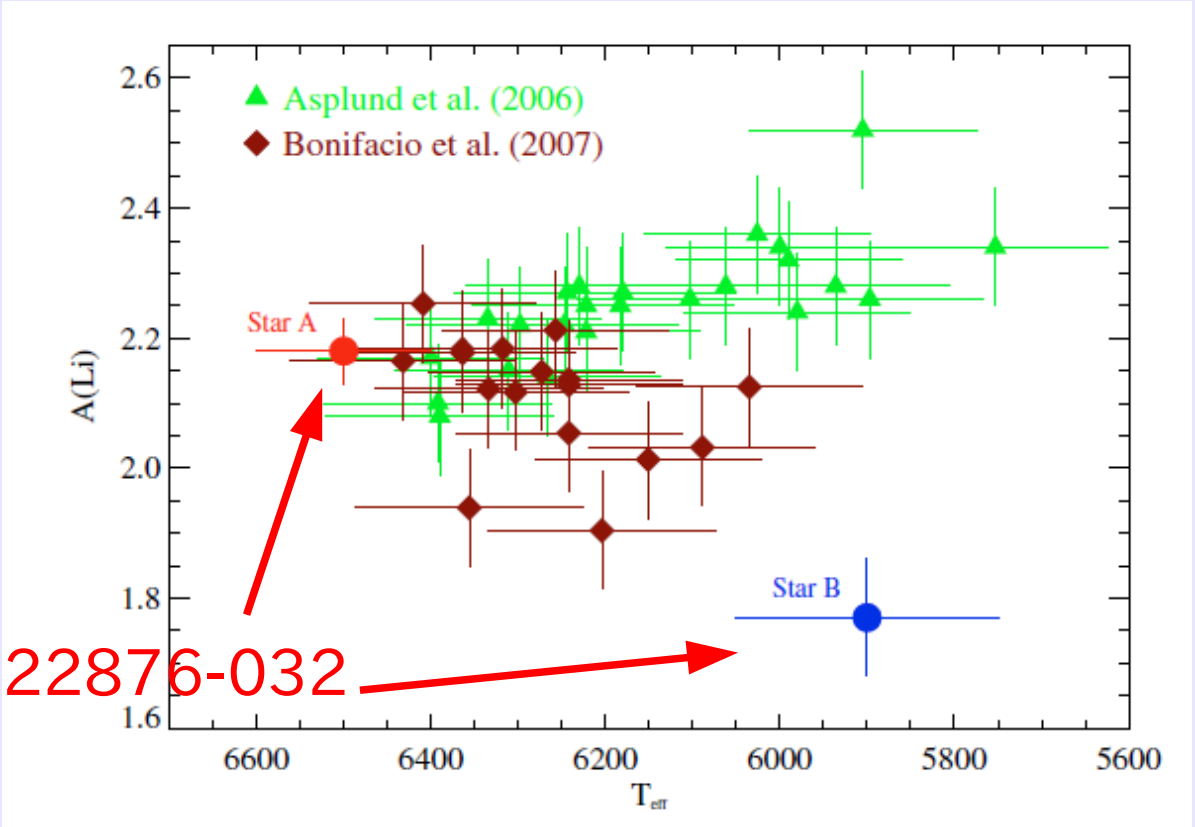


Gonzalez-Henandez et al. (2008)

Uniqueness of the Li abundance measurement for CS22876-032 (Gonzalez-Hernandez et al. 2008):

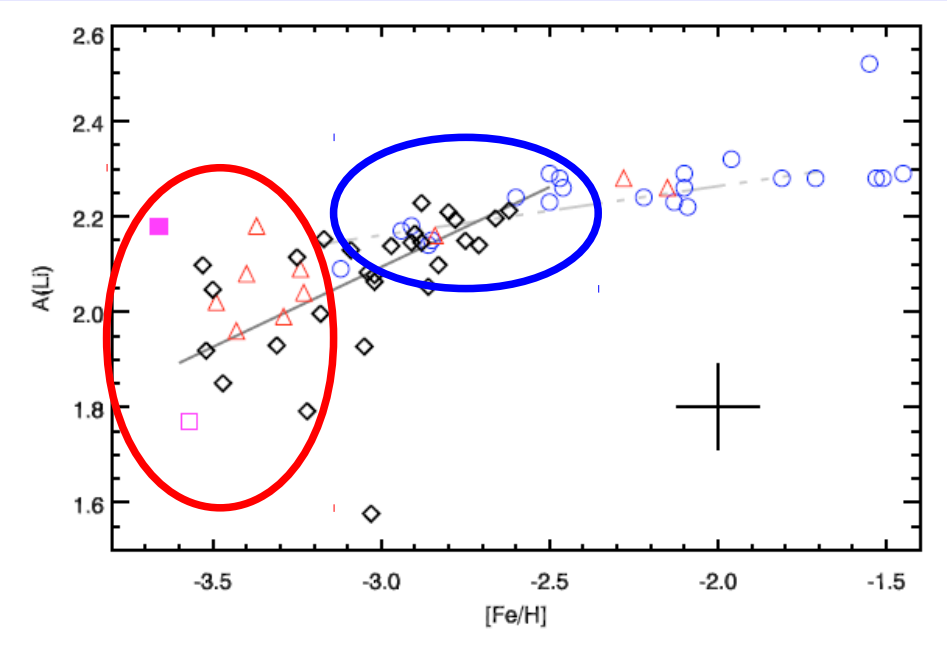
-Lowest metallicity ([Fe/H]<-3.5)
→largest scatter?

-A Double-lined spectroscopic binary: initial abundance should be common
→Li depletion in the secondary

Further investigations for Li depletion (or scatter) in very/extremely metal-poor stars

(1)Investigations of Li abundances in EMP stars
→ SDSS/SEGUE sample

(2)More detailed investigation in [Fe/H]>-3
→ investigation of double-lined spectroscopic binary



Sbordone et al. (2010)

Li abundances of EMP turn-off stars from SDSS sample

Aoki, Ito, Beers et al. (in prep)

Observations:

- Selection of candidates for EMP stars ([Fe/H]<-3) from SDSS spectra
- Snap-shot spectroscopy (～150 stars)
- High S/N spectroscopy (～15 stars, including giants)

Li in EMP

Search for metal-poor stars by Sloan Digital Sky Survey (SDSS)

The 2.5m telescope at Apache Point Observatory

- SDSS spectroscopy:
  R~1800
  Covering 3900-9000A
  14<V<20
- Metallicity estimate from Ca II HK lines
- Standard stars in SDSS-I
- New surveys in SDSS-II (SEGUE)→240,000 stars

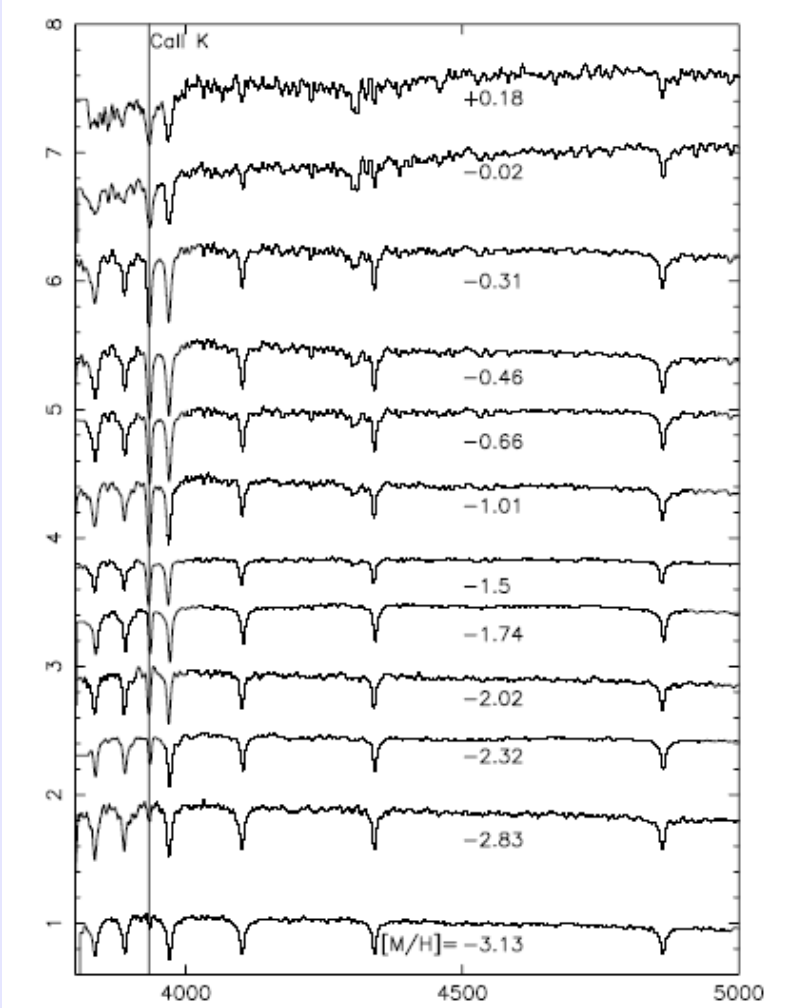


Figure 7. F star metal sequence—a set of SEGUE F stars, selected to show the range of metallicities sampled by the F subdwarf, F/G, spectrophotometric standard and reddening standard categories. All 13 stars have similar effective temperatures, near 6500 K, but the strength of the Ca K line at λ3933 indicates metallicities ranging from less than 0.001–1.5 times Solar.

Li in EMP

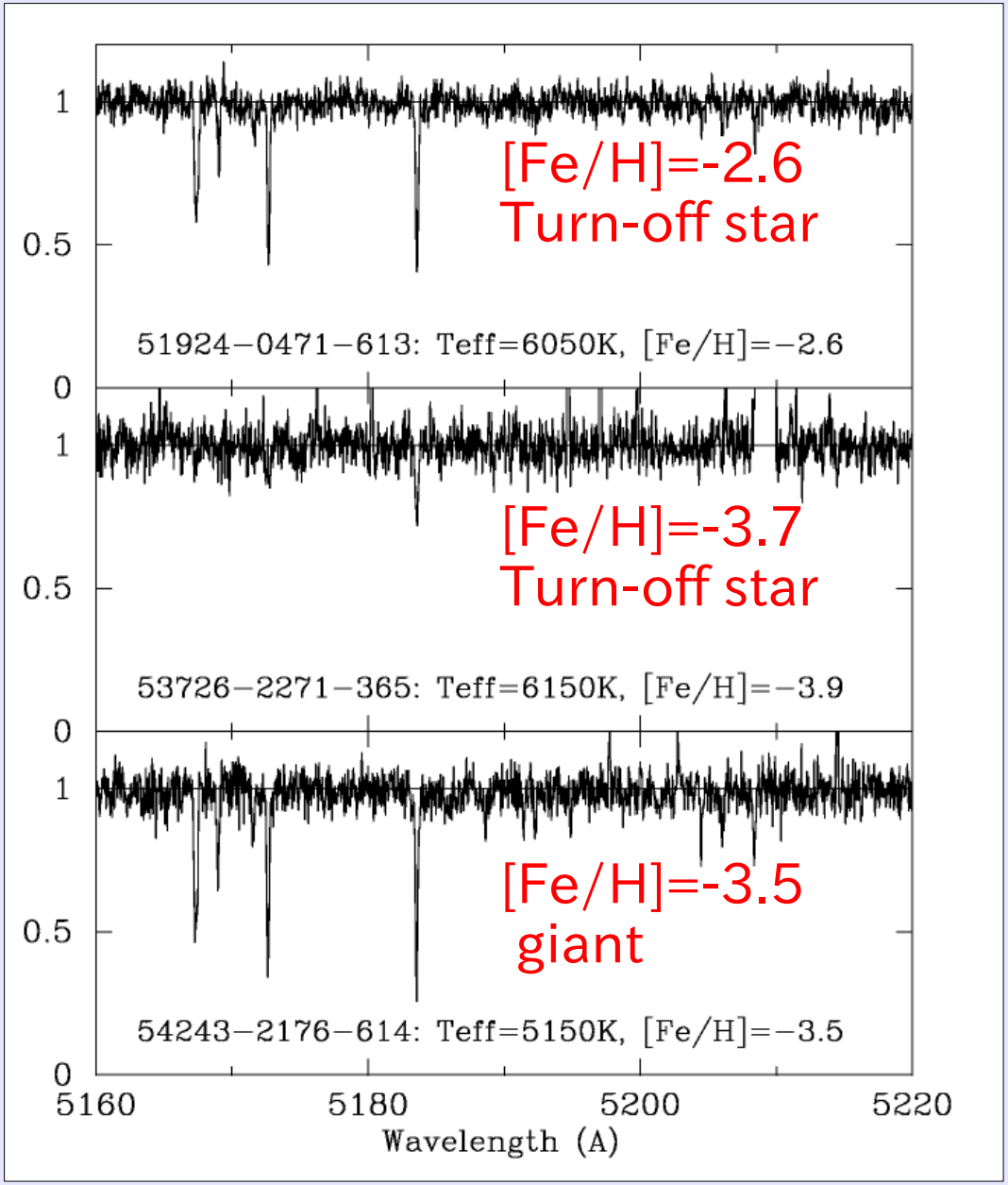
"Snap-shot" spectroscopy with Subaru/HDS

High-resolution, low S/N spectroscopy:

- R=30,000
- 4030-6800A
- S/N~25-30
- ~150 objects

Example: Mg triplet around 5170A →

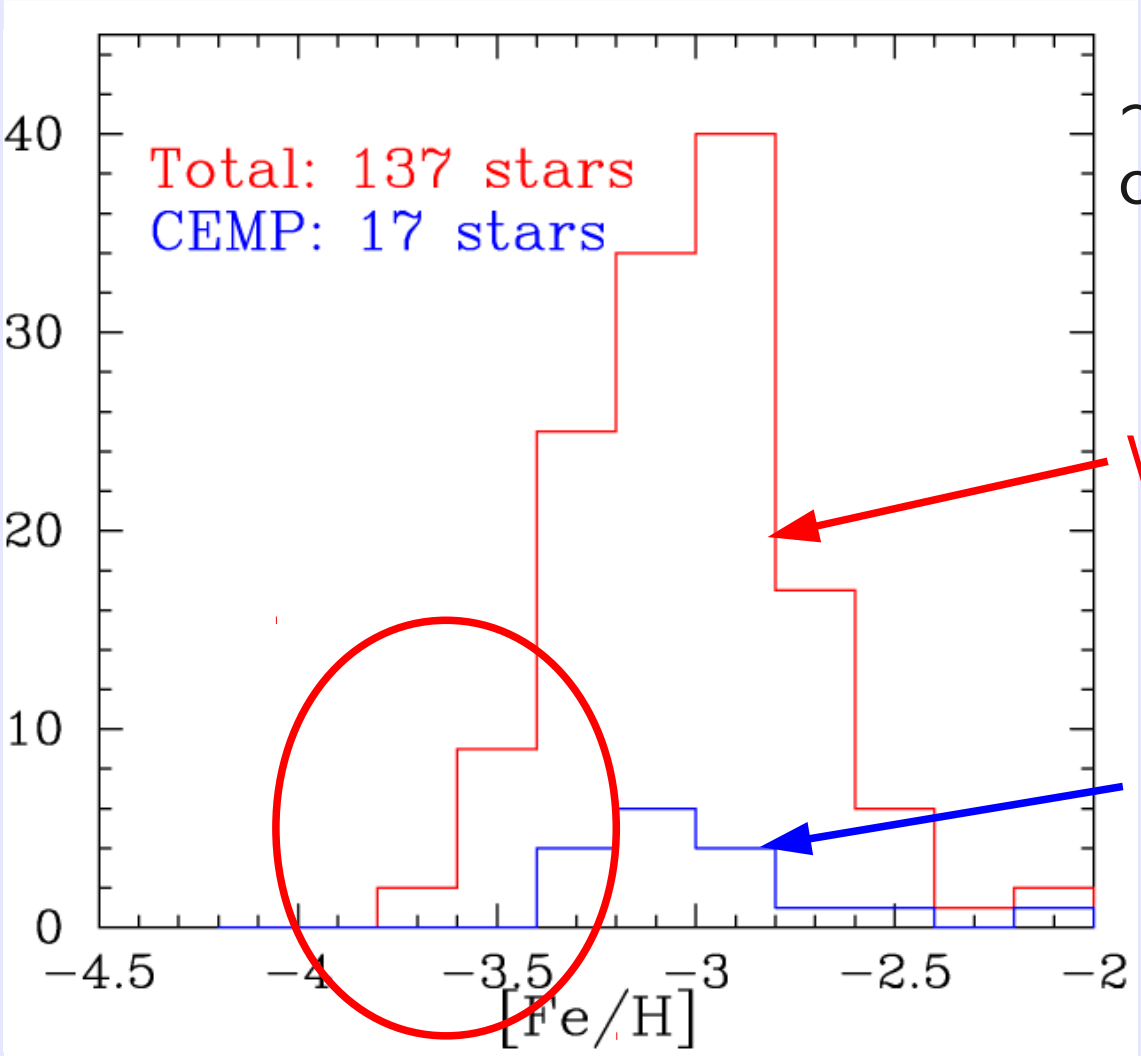
High S/N spectra with R=60,000 for ~15 selected stars have been obtained.



Li in EMP

Metallicity distribution of the Subaru snap-shot sample

Metallicity is determined from Fe lines in high resolution spectra obtained with Subaru (137 stars)



~80% are turn-off or subgiant stars

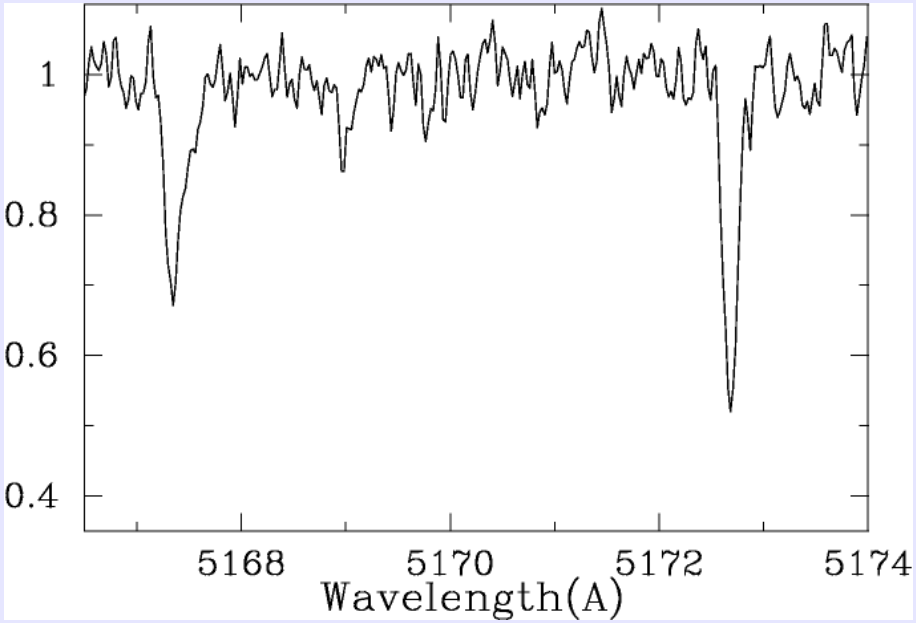
Whole sample

Carbon-enhanced stars

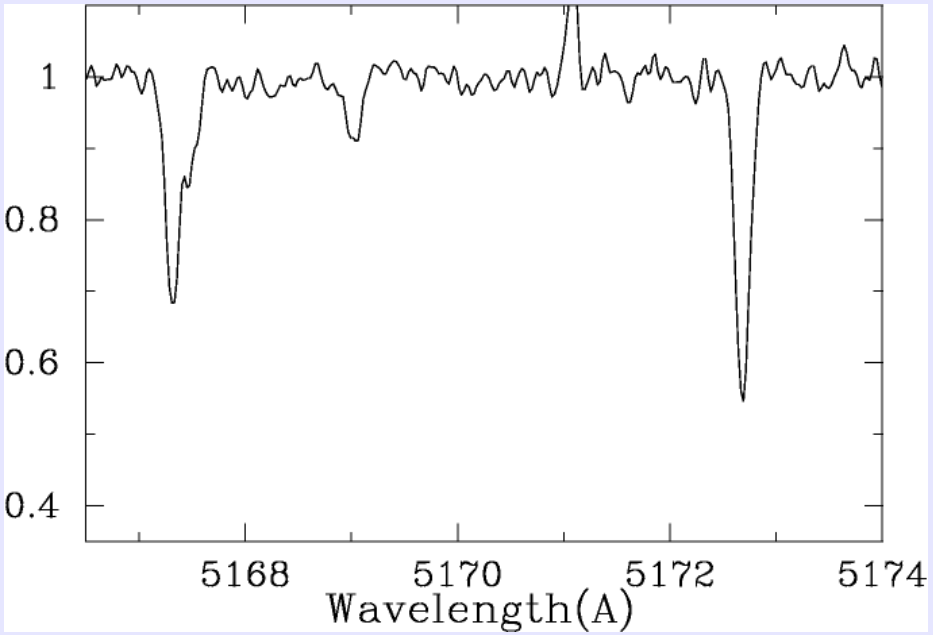
High S/N spectra for 9 turn-off stars

Example:
SDSS J1522+3055

R=30,000
snap-shot



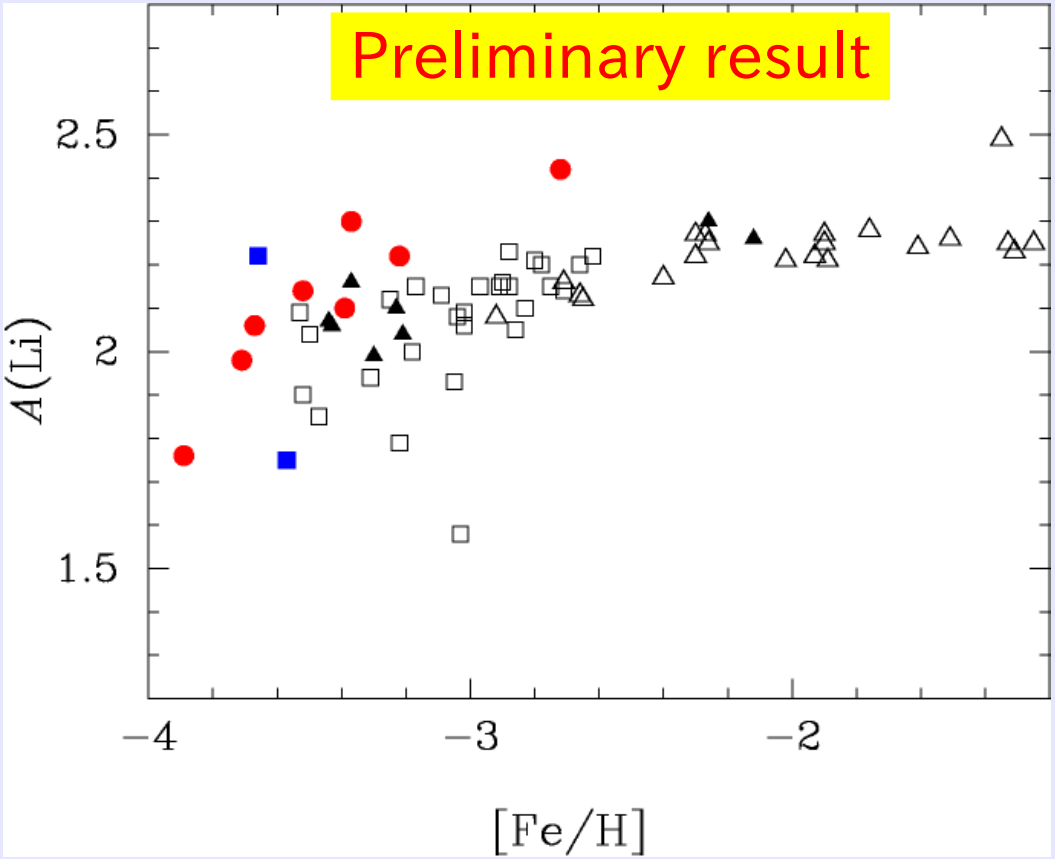
R=60,000
High S/N



Li in EMP

Li abundances of EMP stars in SDSS/Subaru sample

- Based on high-res (R=60,000) and high S/N (~70) spectra
- Effective temperature (Teff) from colors (g-r) and ATLAS models

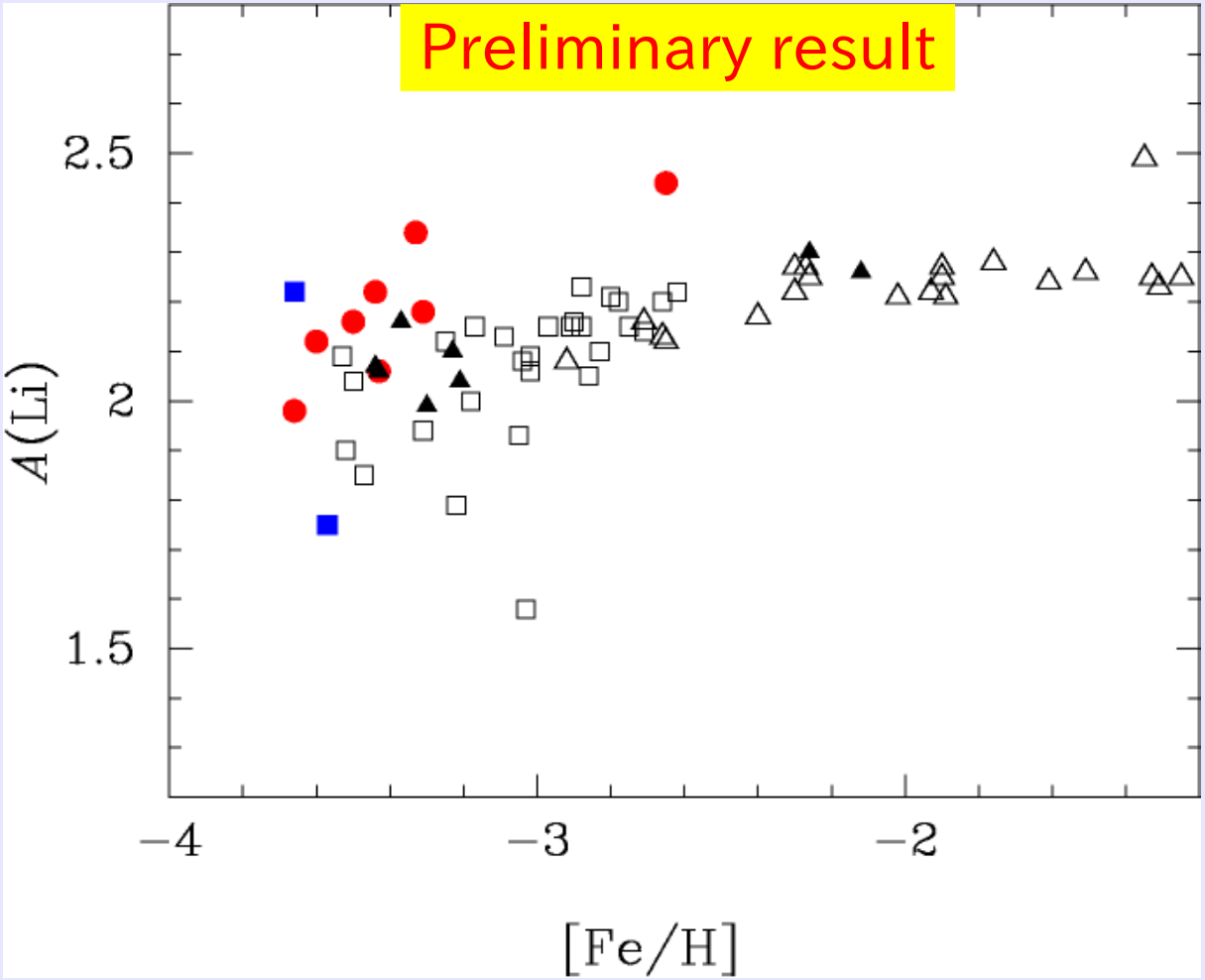


- ●This study
- ■CS22876-032 (Gonzalez-Hernandez et al. 2008)
- □Sbordone et al. 2010
- △Asplund et al. 2006
- ▲Aoki et al. 2009

Li in EMP

Li abundances of EMP stars in SDSS/Subaru sample

Effective temperature (Teff) from SDSS pipline (SSPP)



●This study
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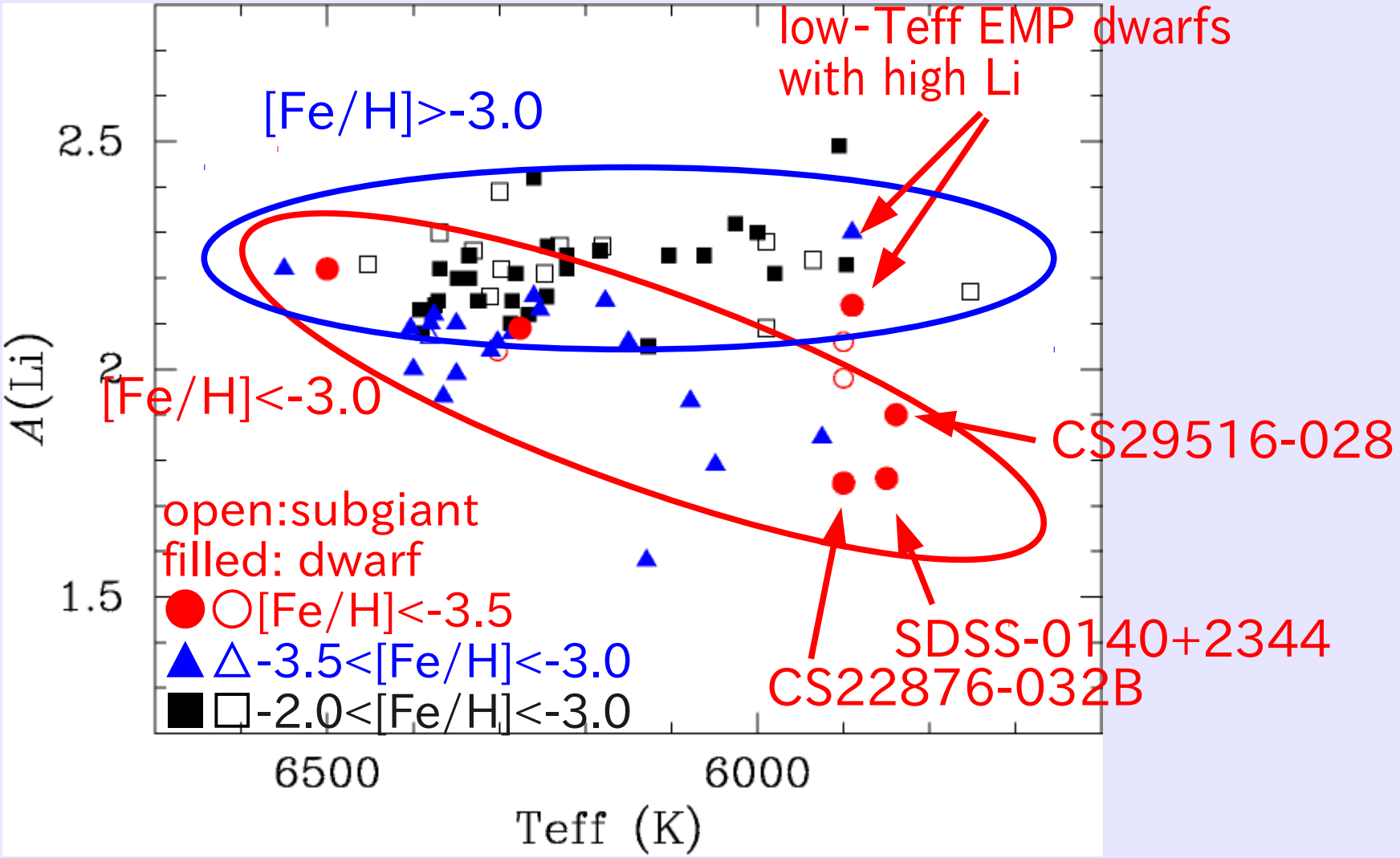
Li in EMP

Correlation of Li abundance with temperature: Main-sequence stars with lower temperature (lower mass) have lower Li?



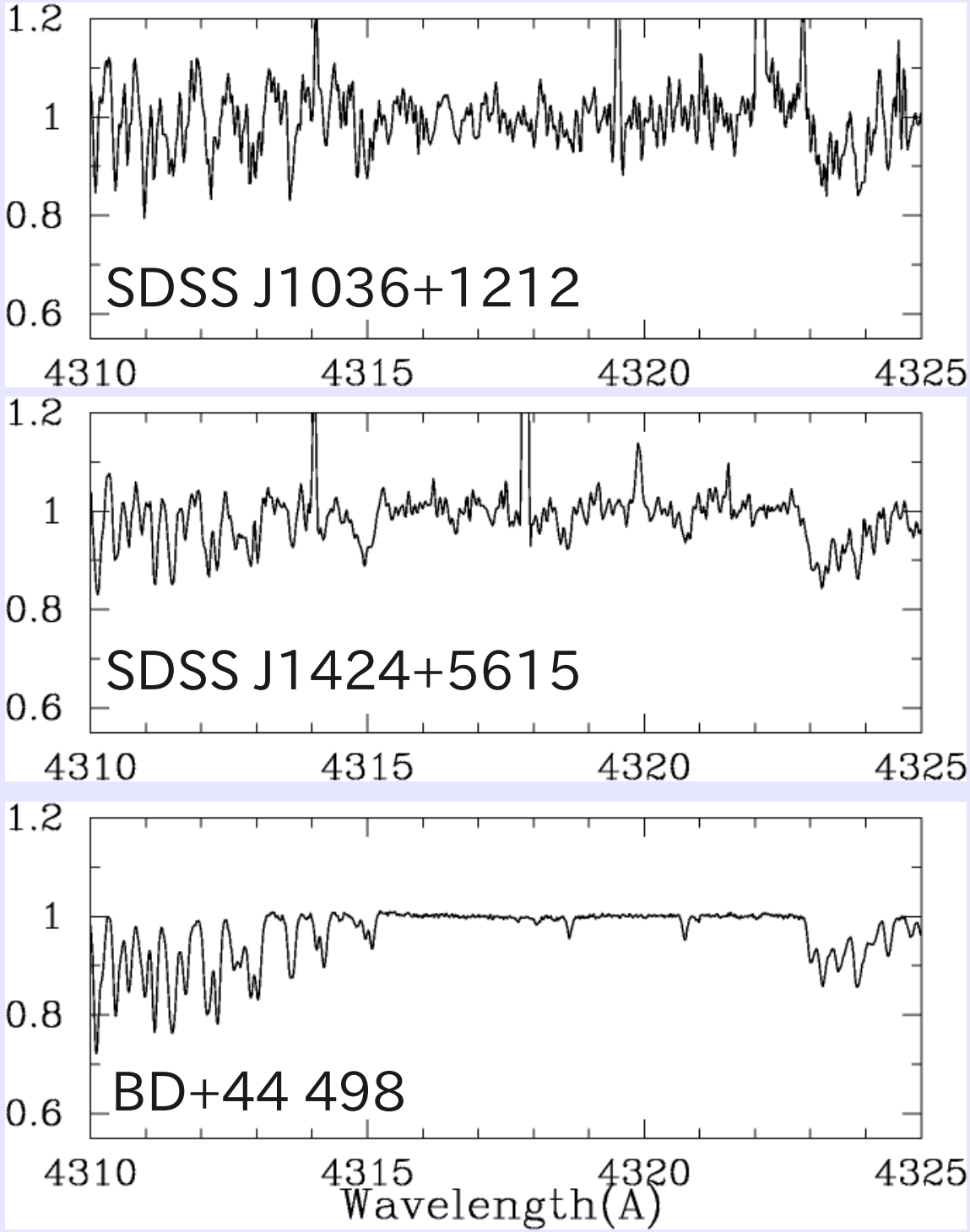
Li in EMP

Two objects are CEMP stars!

[Fe/H]=-3.3
CEMP-s

[Fe/H]=-2.7
CEMP-no(?)

cf. CEMP-no subgiant
(Ito et al. 2009)



Li in EMP

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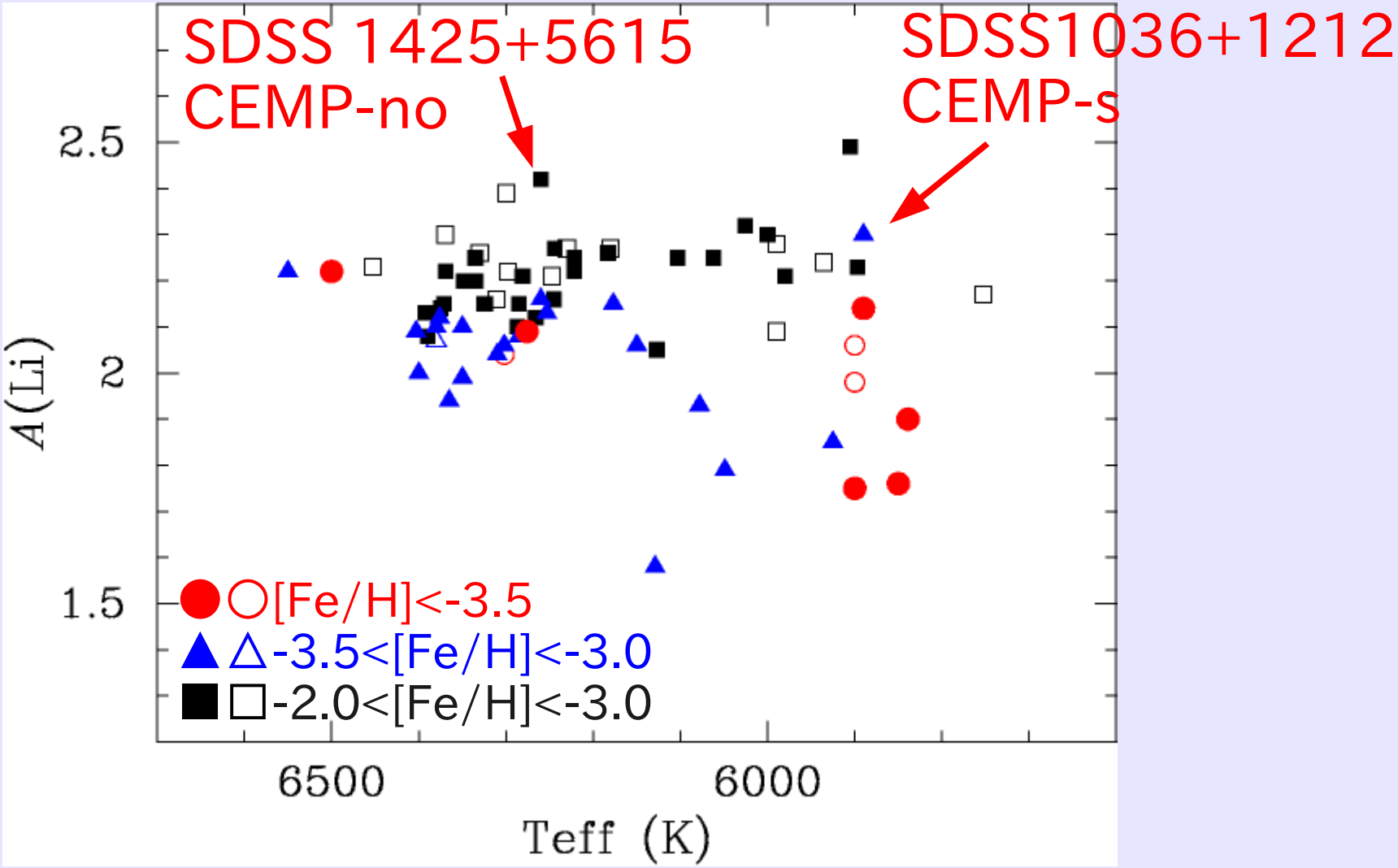


Li abundances of EMP turn-off stars from SDSS sample (summary)

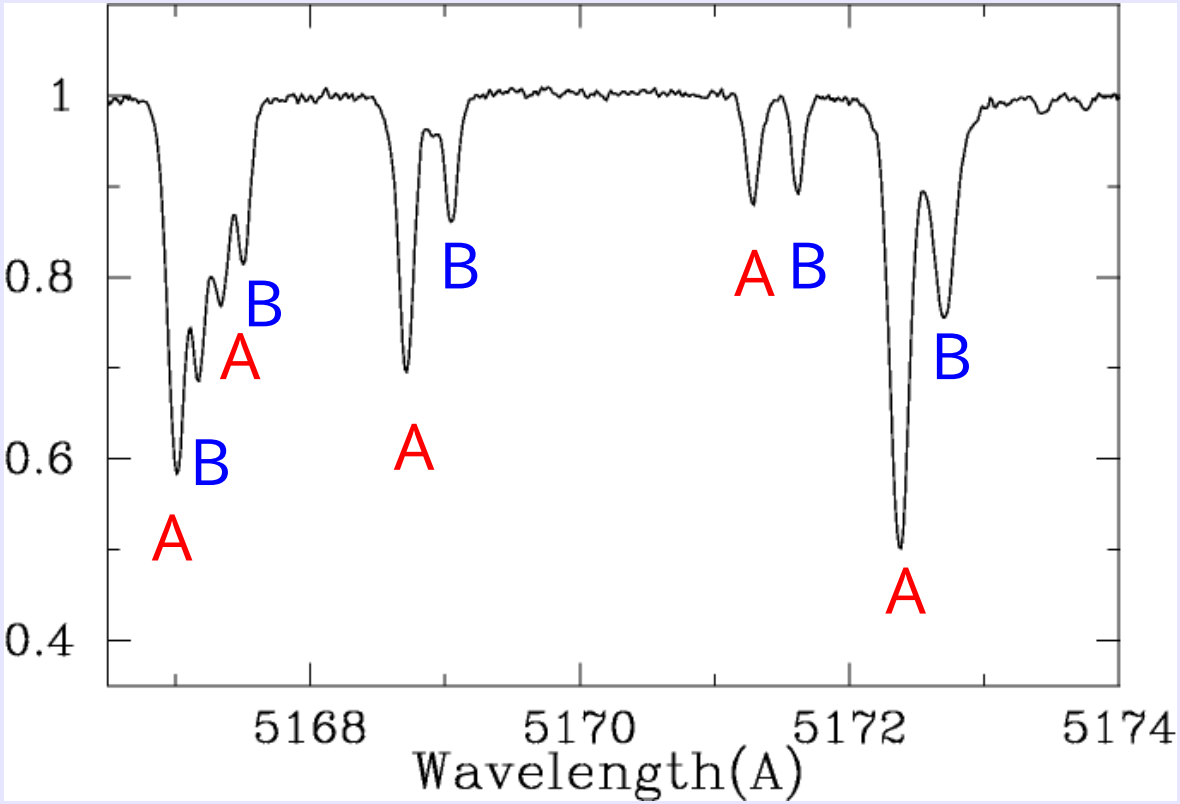
- EMP stars include objects having Li abundances as high as the Spite plateau value (A(Li)=2.2). There exists scatter, rather than a simple decreasing slope with decreasing metallicity.

- For main-sequence stars with [Fe/H]<-3.0, a correlation between Li abundance and Teff (mass) is suggested, though exceptions exist.

- High Li abundance is found also in a CEMP-s star ([Fe/H]=-3.3) with Teff=5850K, indicating no significant destruction of Li through mass transfer from AGB, or some contribution of Li by AGB.

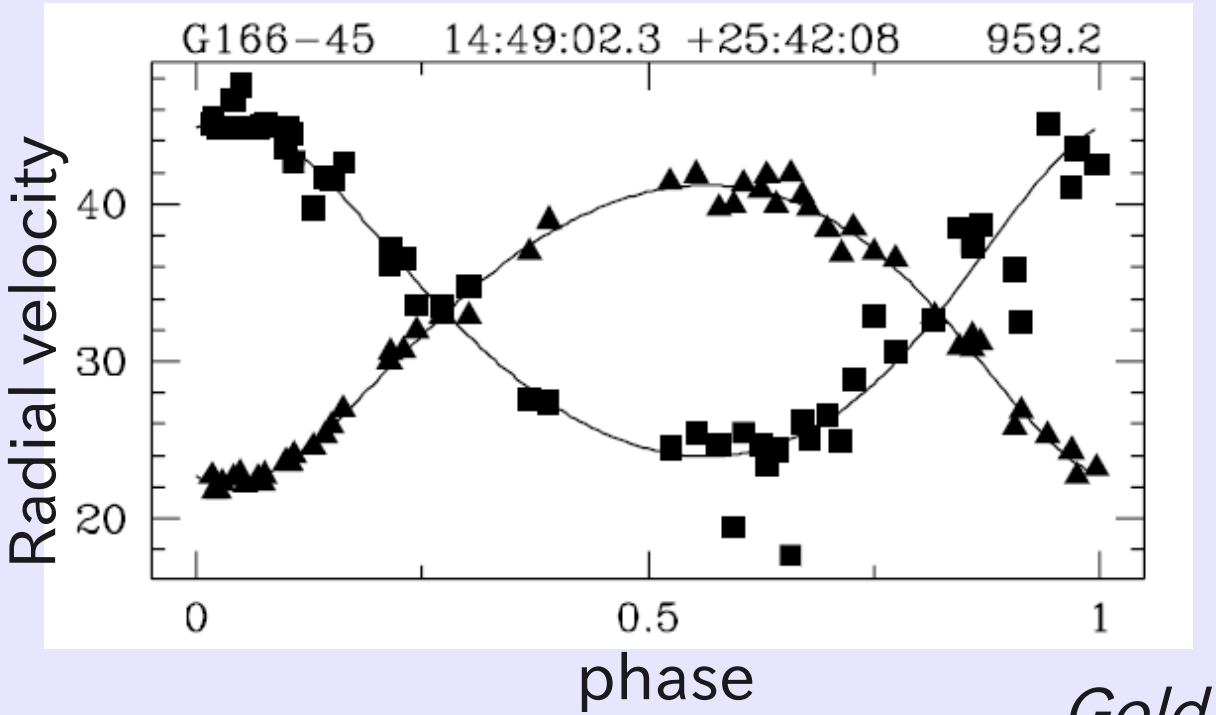
Li abundances of the double-lined spectroscopic binary G166-45 ([Fe/H]=-2.5)

Aoki, Ito, Tajitsu (in prep)



The double-lined spectroscopic binary G166-45 ([Fe/H]=-2.5)

G166-45 was selected from the sample of Goldberg et al., who studied 34 double-lined spectroscopic binaries found from Carney-Lathum' s sample.

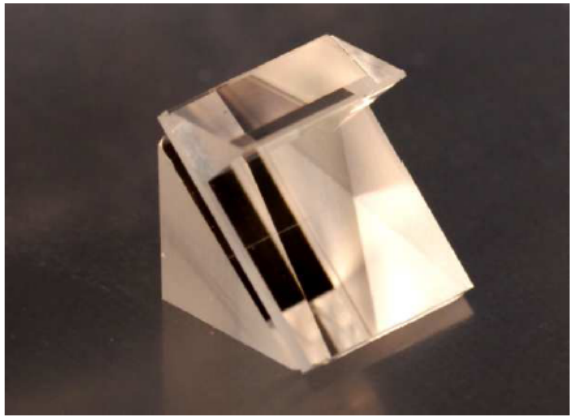


- P=959 days
- Mass ratio
  $q=m_1/m_2$
  $=0.89+/-0.04$

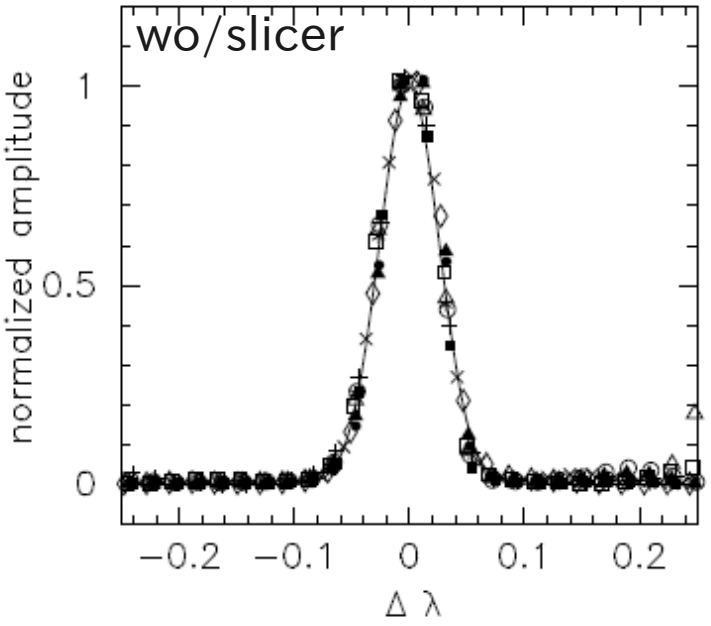
Goldberg et al. (2002)

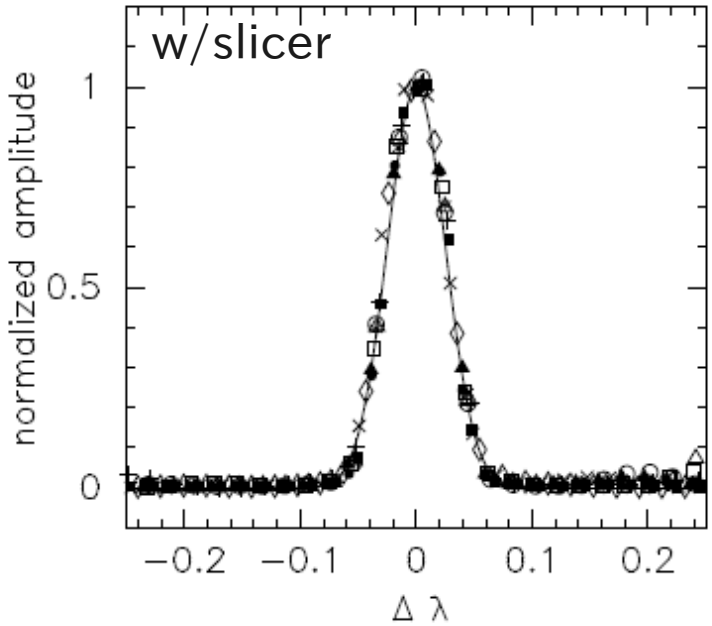
Observations of G166-45 with Subaru/HDS+image slicer

- Installed in 2010-2011
- R=110,000 (0.3arcsec slit)



Tajitsu, Aoki, Yamamuro (2012)





Li in G166-45

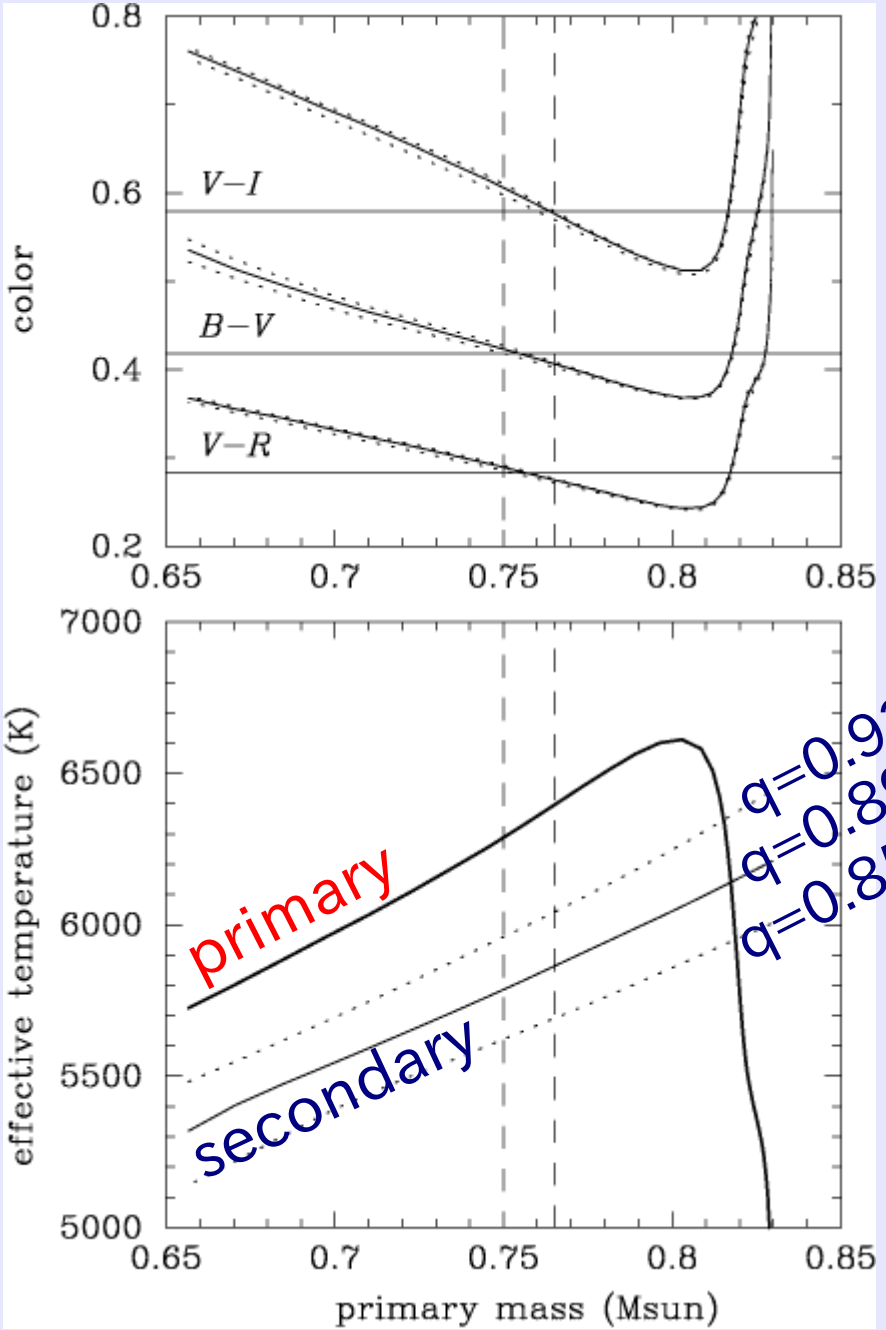
Stellar parameters of G166-45 A and B

- mass ratio
  $q=m_1/m_2=0.89$ +/- 0.04
- isochrones (Y^2)

→colors of the binary system

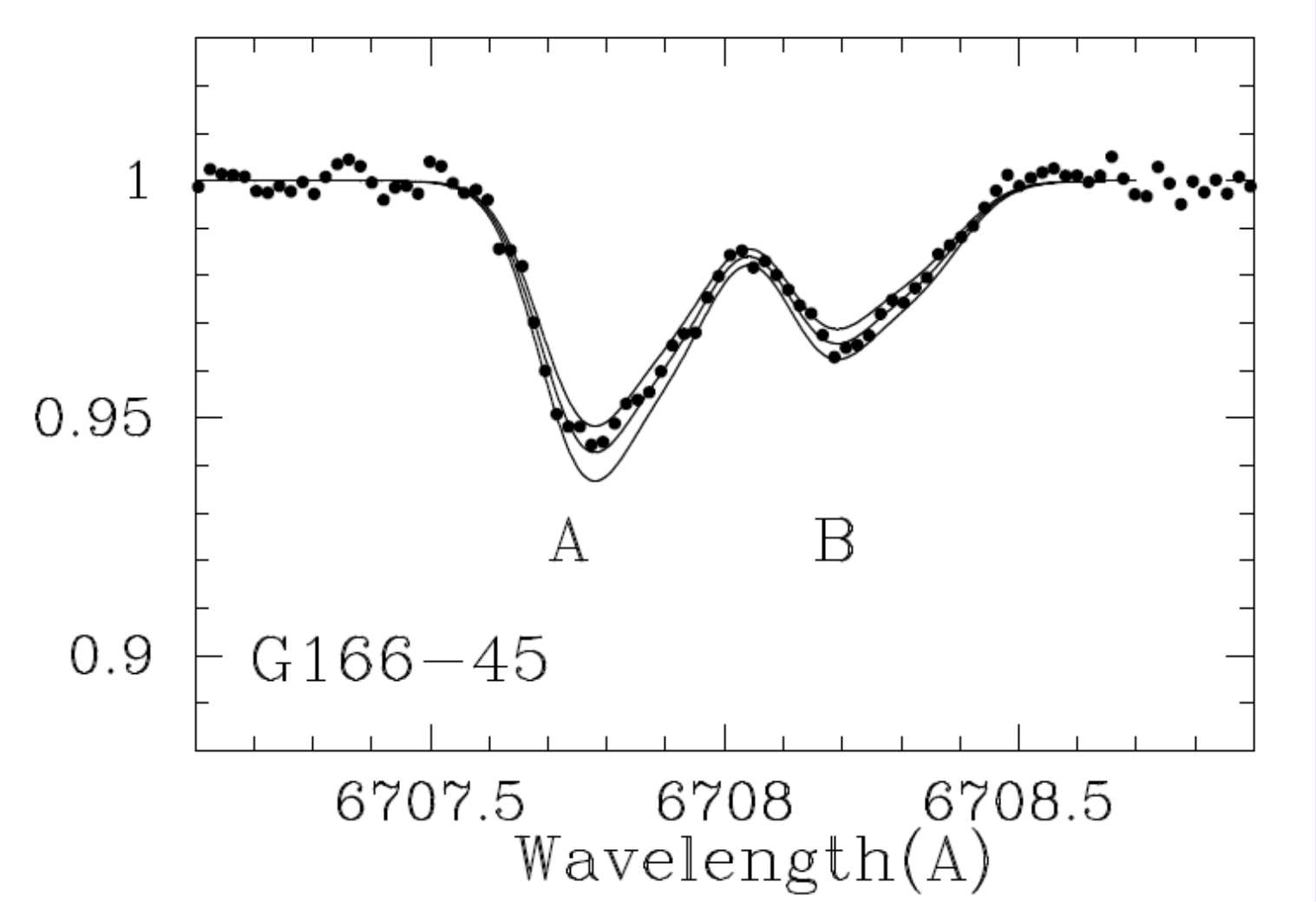
- colors of G166-45(A+B)
  (Landolt & Uomoto 2007)
  →-Teff of G166-45 A/B
  -contribution of each component to continuum flux (f: $f_A+f_B=1$)

- log g, v_turb and [Fe/H] are determined spectroscopically

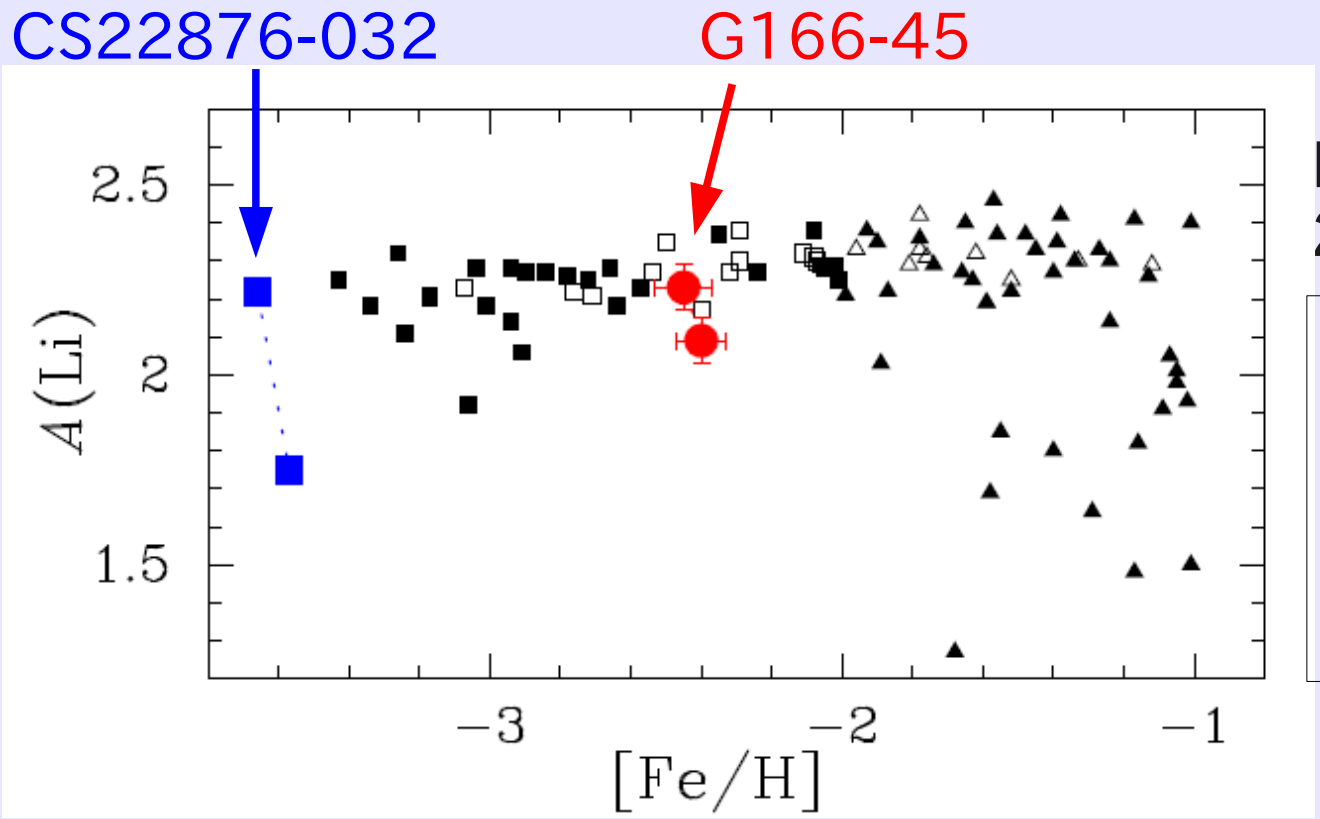


Li lines of G166-45 A and B

G166-45A: A(Li)=2.23 +/- 0.06,
G166-45B: A(Li)=2.11+/- 0.05



Li of G166-45 compared with other stars (1) Fe/H dependence



Melendez et al. 2010

△□ subgiant (log g<4.0)

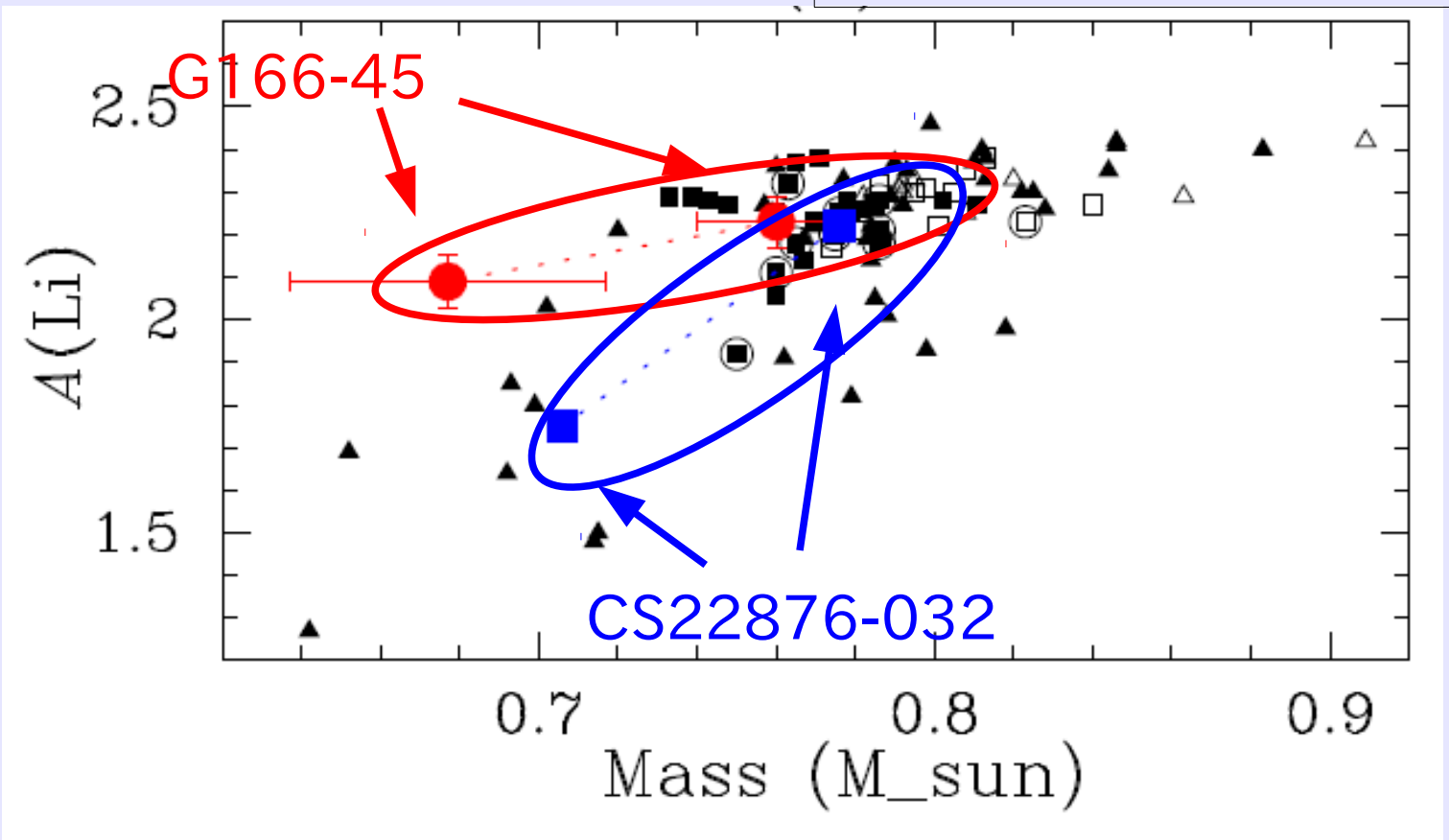
▲■ dwarf (log g>4.0)

Li of G166-45 compared with other stars

(2)mass dependence

Melendez et al. 2010

△▲ [Fe/H]>-2.0
□■ [Fe/H]<-2.0
○(over-plotted) [Fe/H]<-3.0



Li abundances of the double-lined spectroscopic binary G166-45 (summary)

•G166-45 has [Fe/H]=-2.5, Teff(A)=6350K and Teff(B)=5830+/-170K

•The seconday (B) has lower Li abundance than the primary (A), but the difference (0.1dex) is much smaller than that in CS22876-032 ([Fe/H]=-3.6).

•No large scatter of Li abundances is found at [Fe/H]=-2.5, even if the cool (5800K) *main-sequence* star G166-45B (=low mass star) is included.

•Scatter of Li abundances (due to lower Li abundances in lower mass stars?) is a phenomenon only found in the lowest metallicity range ([Fe/H]<-3.0).

Li abundances in very metal-poor, main-sequence turn-off stars summary

- No large scatter is found in objects in -3.0<[Fe/H]<-2.0 with Teff > 5800K, including the double-lined spectroscopic binary G166-45 A and B.

- Scatter of Li abundances exists in [Fe/H]<-3.0 due to lower Li abundances in lower Teff (lower mass) stars (exceptions exist.)
  ←Main-sequence stars and subgiants should be distinguished in the discussion of Li abundances in stars with Teff<6000K.

- Li abundances in CEMP-s turn-off stars can be a constraint on the amount of mass transfer from AGB, or contribution by AGB to observed Li.