Beryllium Abundances in Solar Mass Stars

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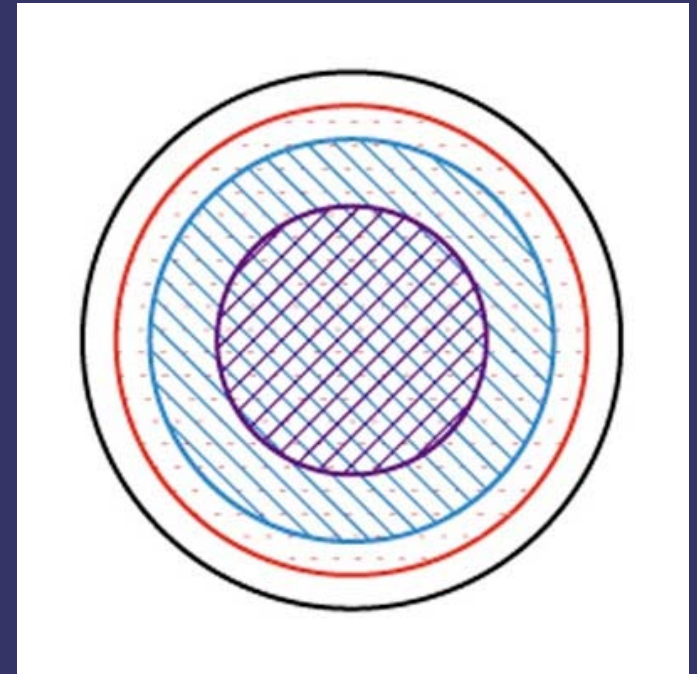# The Light Elements

- Lithium
  - burns at 2.5×10^6 K
  - many sites for creation
  - Resonance line at 6708 Å

- Boron
  - burns at 5.0×10^6 K
  - Resonance lines in the "satellite" UV

- Beryllium
  - Burns at 3.5×10^6 K
  - One production site
  - Resonance lines located at 3130.421 and 3131.065 Å

Lithium
Beryllium
Boron

Previous Studies

- Boesgaard et al. (2004)

  - Li and Be abundances for field and cluster dwarfs

  - Rotationally induced slow mixing in Li-Be dip region (6300-6650 K)

- Santos et al. (2004)

  - Be abundances in solar-type stars

  - Peak at ~6100 K

Previous Studies

- Lambert & Reddy (2004)

  - Li abundances of 451 F and G local thin disk stars

  - Complete set of stellar parameters: T_{eff}, log g, [Fe/H]

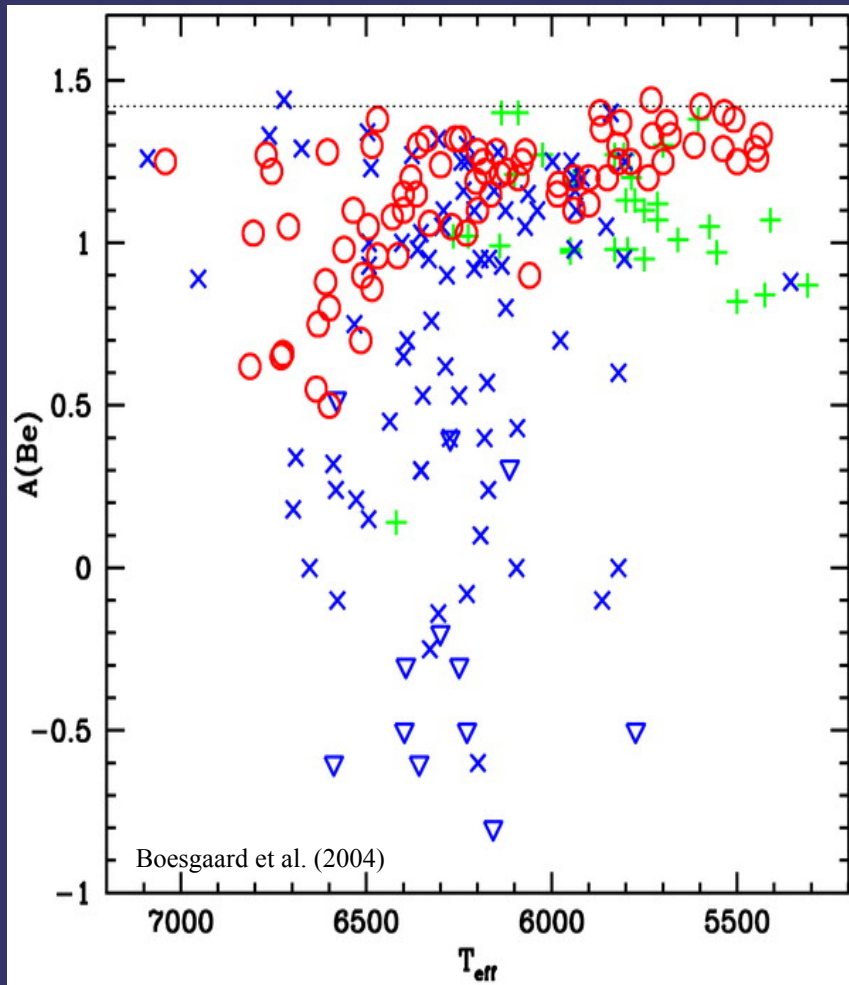 - Age and mass calculations

  - Li, mass increase with [Fe/H]

Motivation

Boesgaard et al. (2004)

- A(Be) → log(N(Be) / N(H)) + 12.00

- A(Be)$_{meteoritic}$ = 1.42 Grevesse & Sauval (1998)

- Spread in Be over a large T_{eff} range seen in Boesgaard et al. (2004)

  - Two temperature regimes

- Mass constraints

  - See how Be trends with [Fe/H], T_{eff}, and age at 1 M_{solar}

Sample Selection

- Stars taken from Lambert & Reddy (2004)

- 156 stars where: $0.9 < M < 1.1\ M_{solar}$

- 52 bright stars in this sample taken at twilight or during cloudy nights
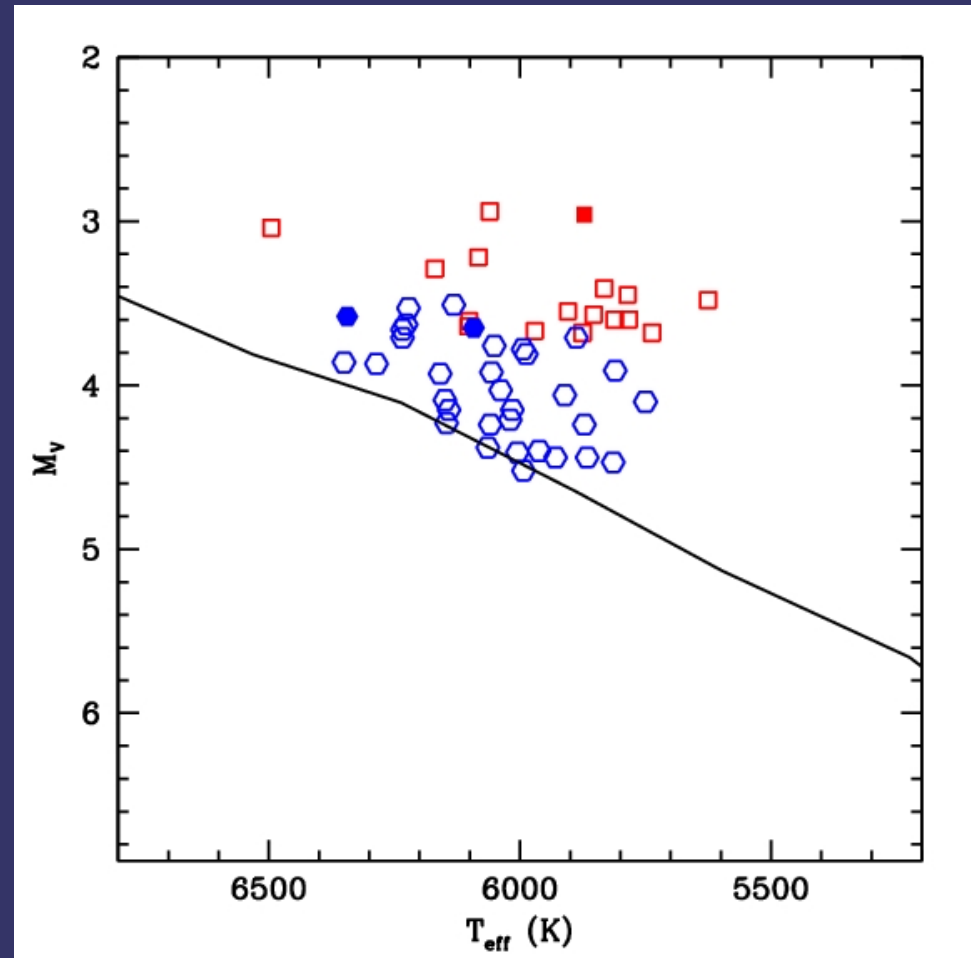
Observations

- High resolution spectra for 52 stars

- 40 stars Keck I HIRES Instrument
  - Three-chip Mosaic CCD
  - R ~78,000

- 6 stars Keck I HIRES Instrument
  - Tektronix CCD
  - R ~48,000

- 6 stars CFHT Gecko Instrument
  - R ~120,000

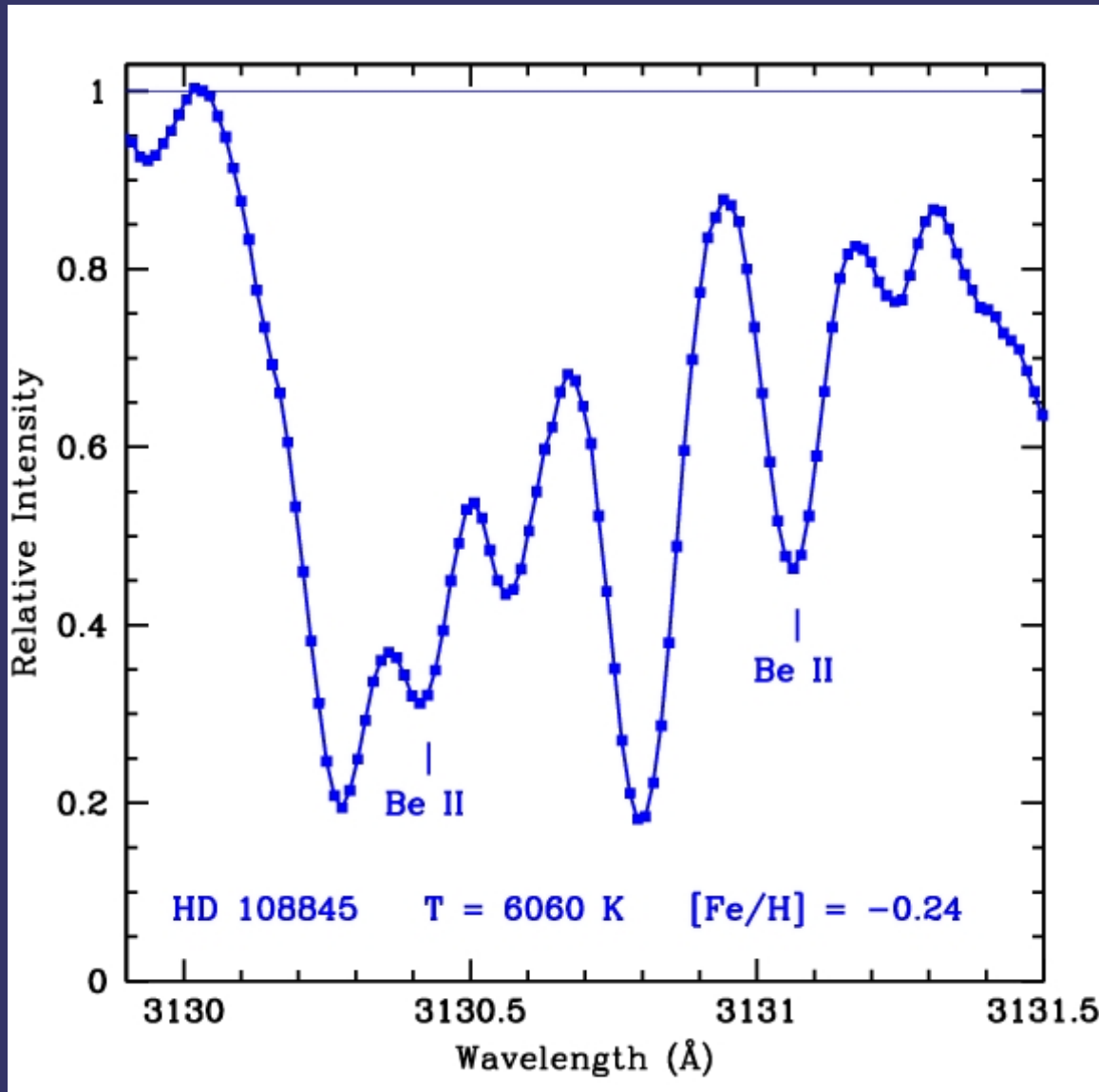# Spectral Synthesis

- Line fitting to determine Be abundance

- MOOG software (Sneden 1976)

  - Kurucz models ([Fe/H], T_{eff}, log g, ξ)

  - line list

Spectral Analysis

Be lines at 3130.421 and 3131.065Å

3131.065Å line more reliably determines A(Be)

Trends with [Fe/H]
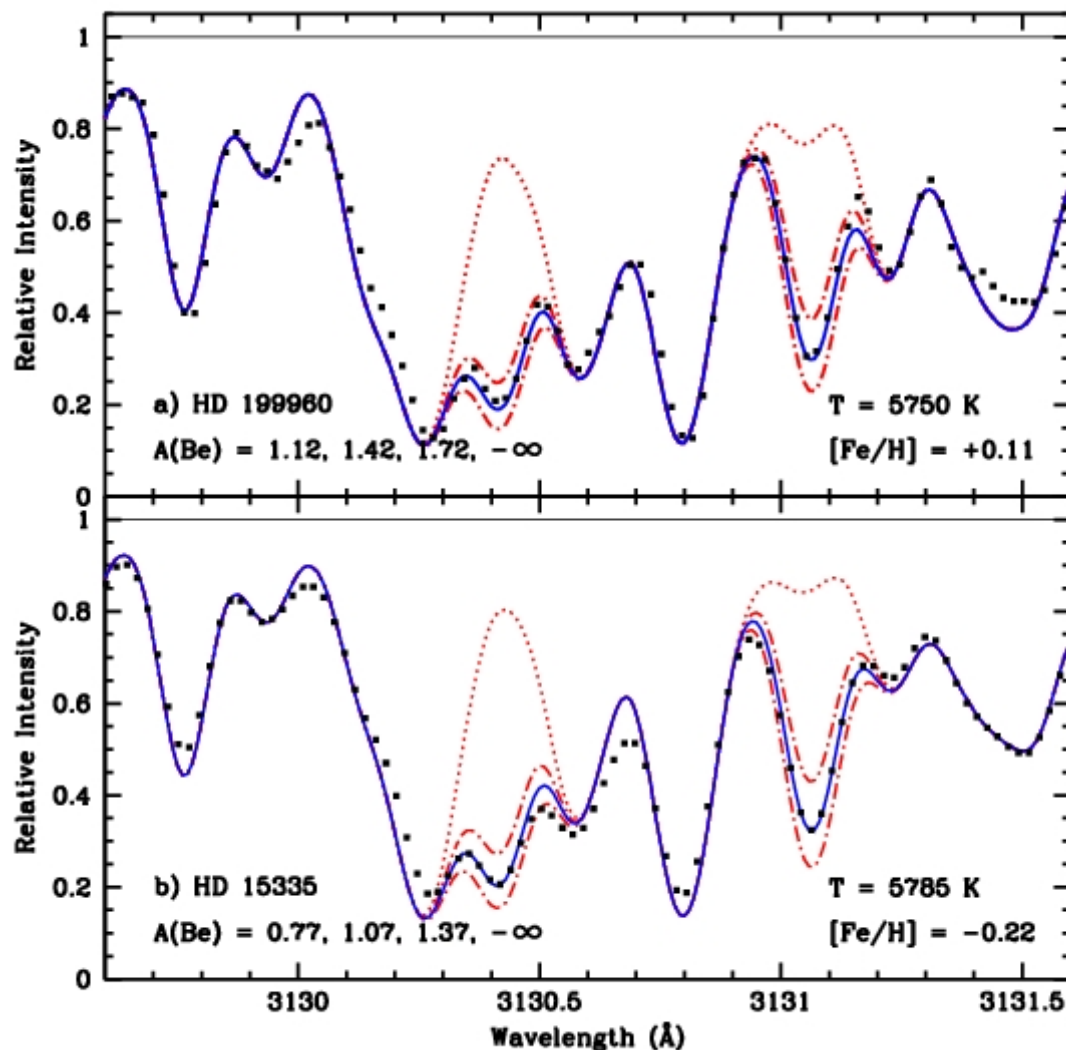
- HD 15535 and HD 199960
  - Both solar T_{eff} and ~6.5 Gyr
  - differ in [Fe/H] and A(Be) by a factor of two

Trends with [Fe/H]

slope = 0.86 ±0.02

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A(Be) vs [Fe/H]
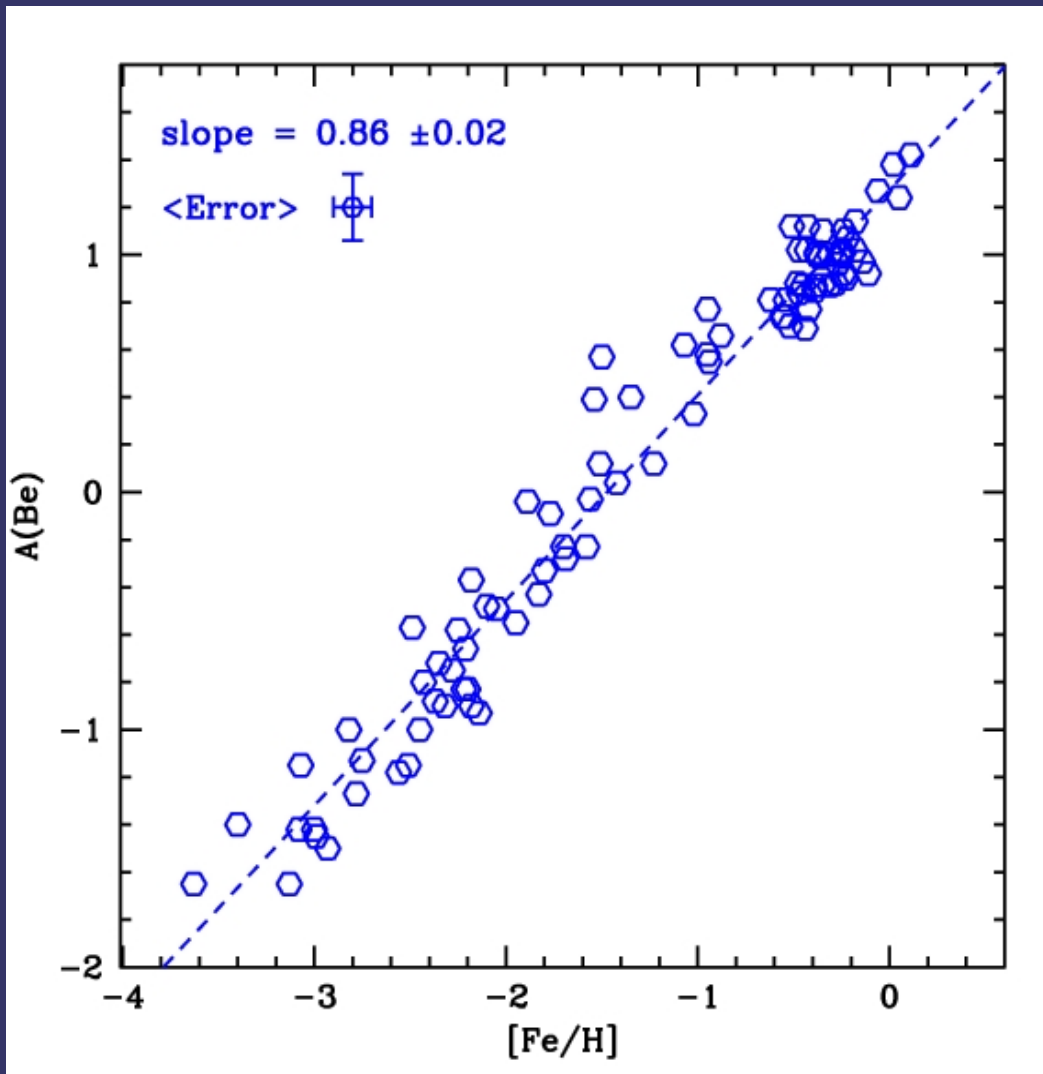
- -0.65 < [Fe/H] < +0.11
- Single linear relation between [Fe/H] and Be
- Be scales with [Fe/H] down to low metallicities

Trends with T_{eff}

a) HD 186379
A(Be) = 0.72, 1.02, 1.32, − ∞
T = 5811 K
[Fe/H] = −0.43

b) HD 94012
A(Be) = 0.72, 1.02, 1.32, − ∞
T = 6064 K
[Fe/H] = −0.47
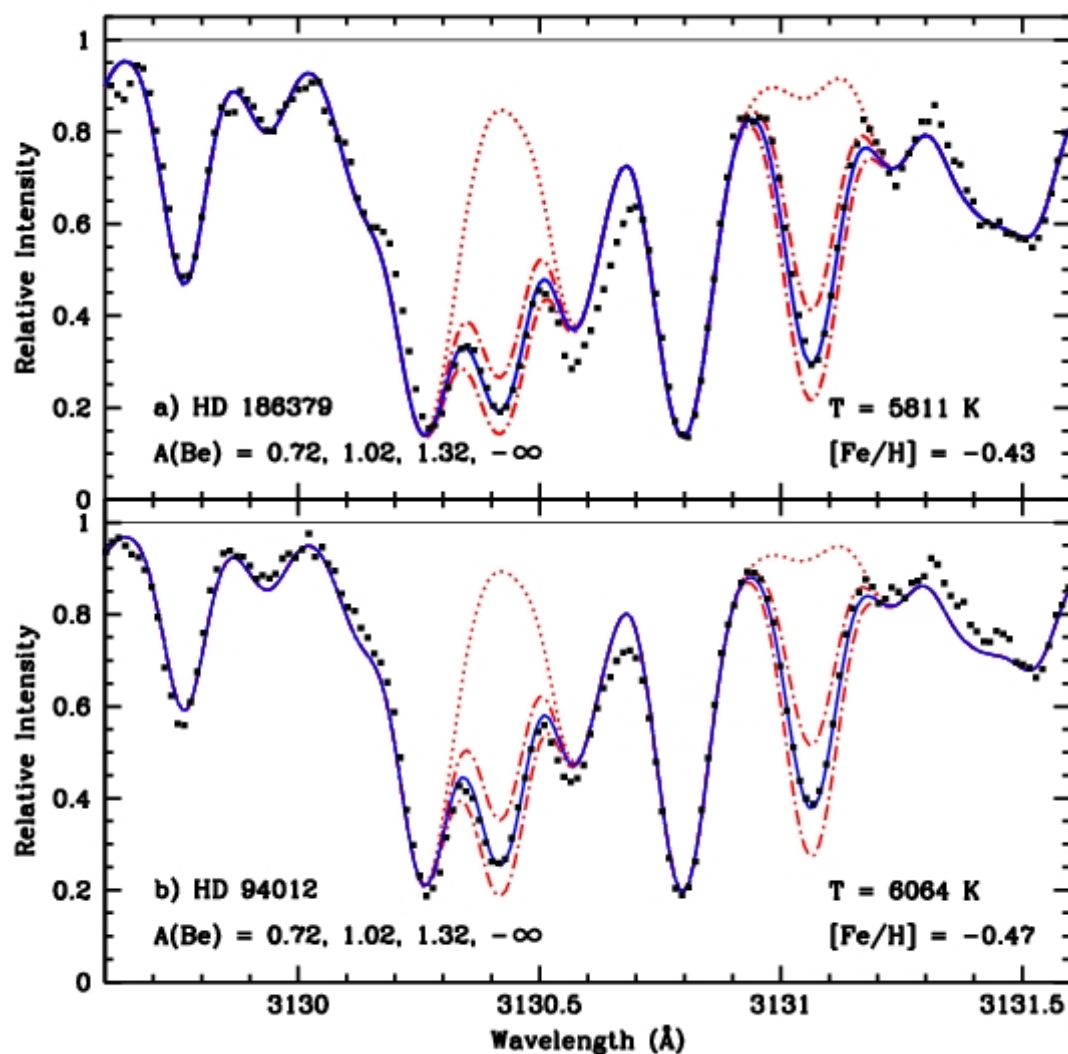
- HD 186379 and HD 94012
  - differ in T_{eff} by ~250 K
  - same [Fe/H]
  - same A(Be)
- A(Be) and T_{eff} relation not as strong as metallicity correlation
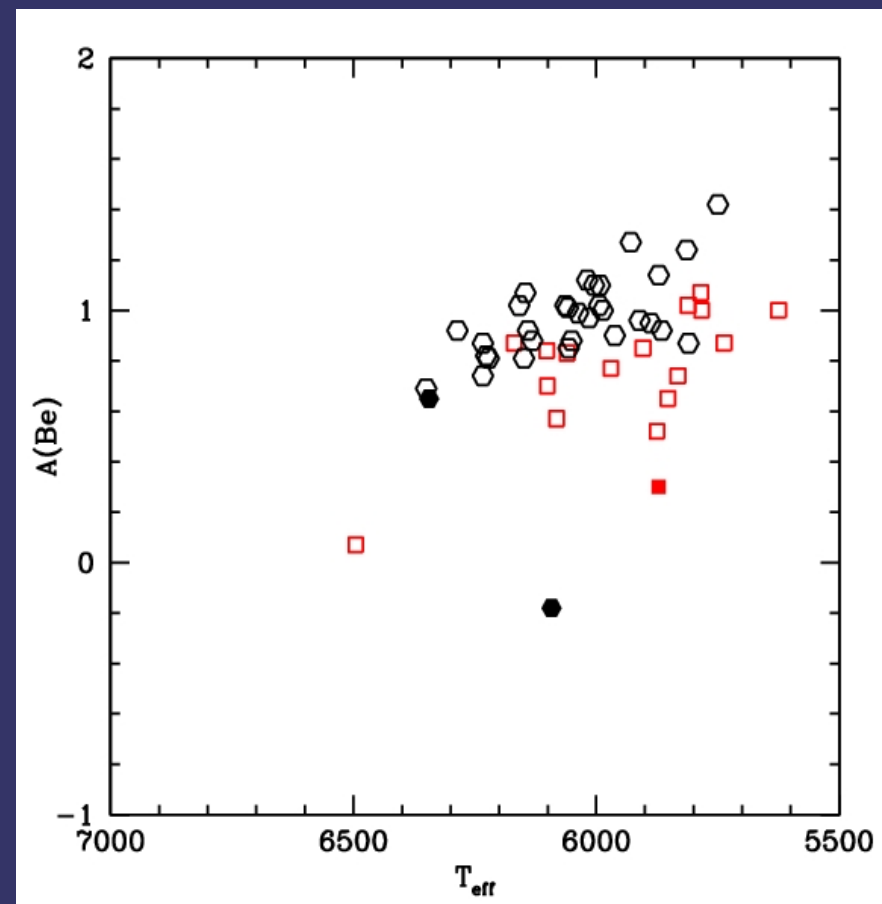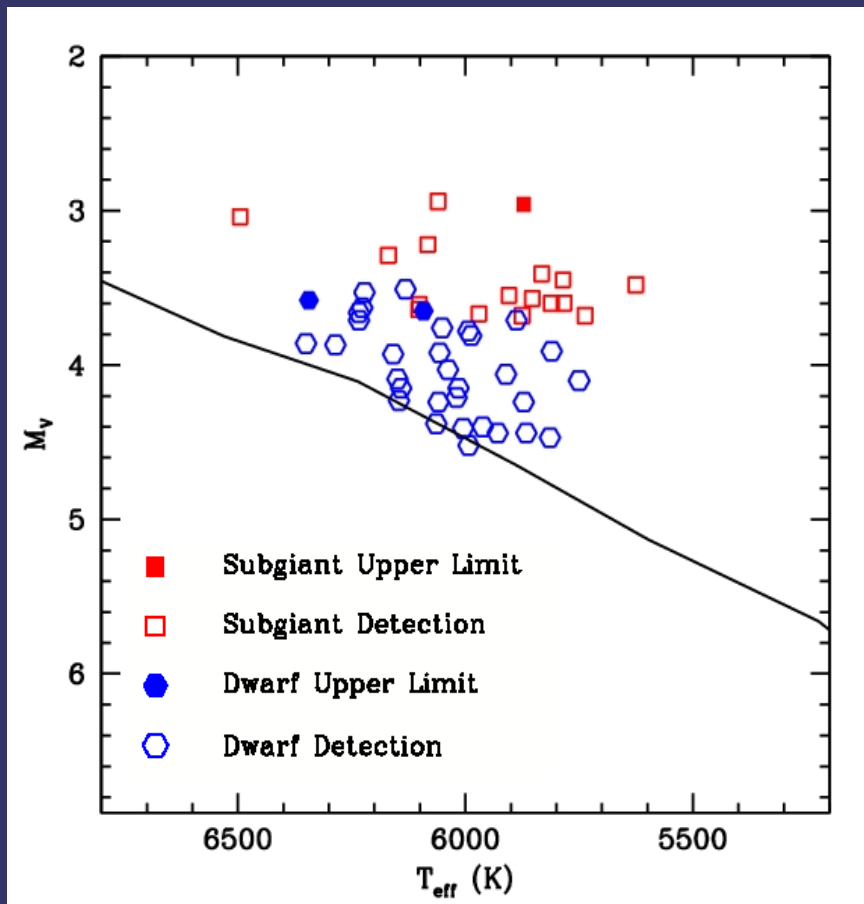
Trends with T_{eff}

- T_{eff} range from 5600-6400 K

- Upper envelope

    – higher Be abundances in cooler stars

- Santos et al. (2004) found peak at ~6100 K

    – peak not seen in this data

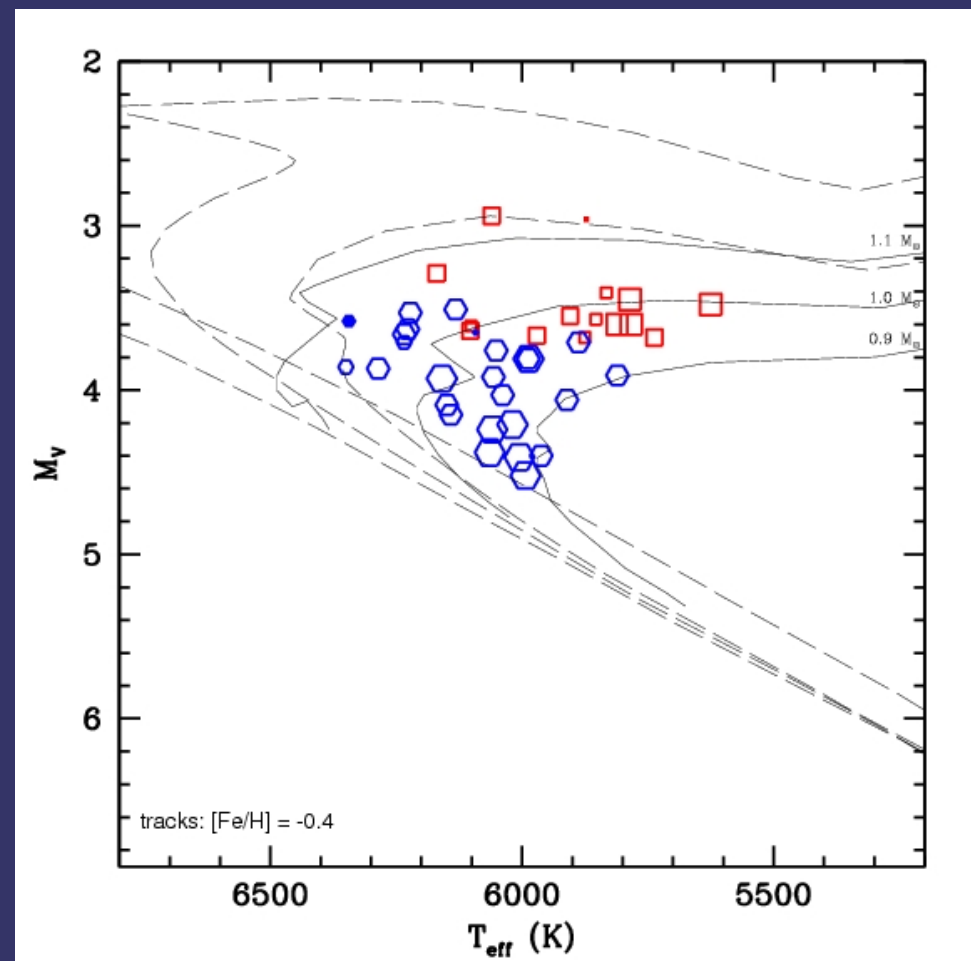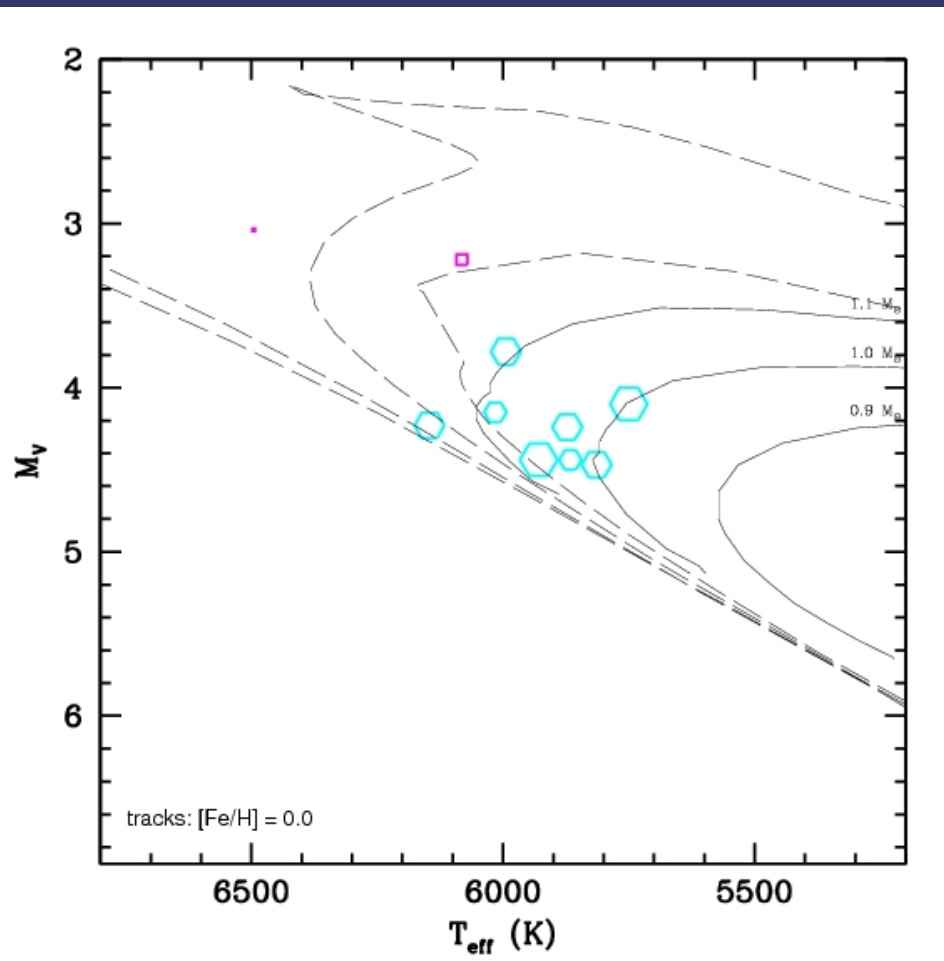   – selection effect

- Large spread seen ~5900 K
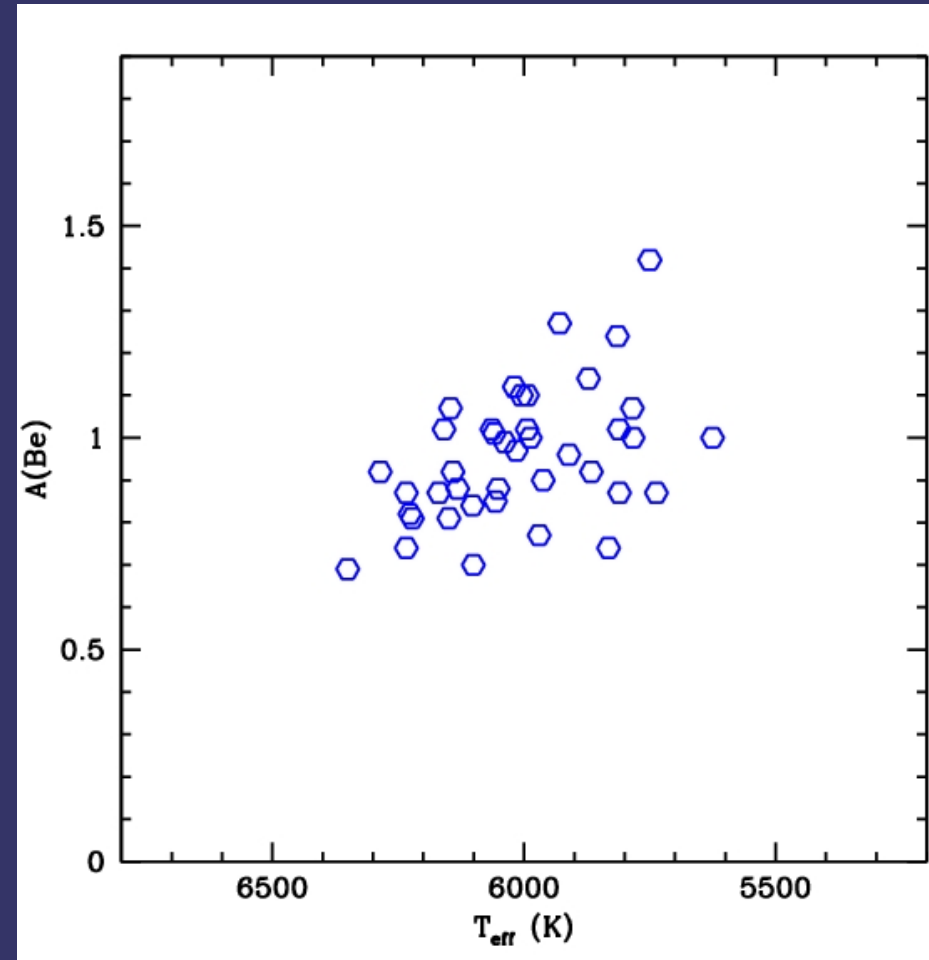
Subgiants

- log g cut off of subgiants 4.1 (Santos et al. 2004)

- more evolved off of ZAMS

- lower Be abundances at a given T_{eff}

HR Diagrams

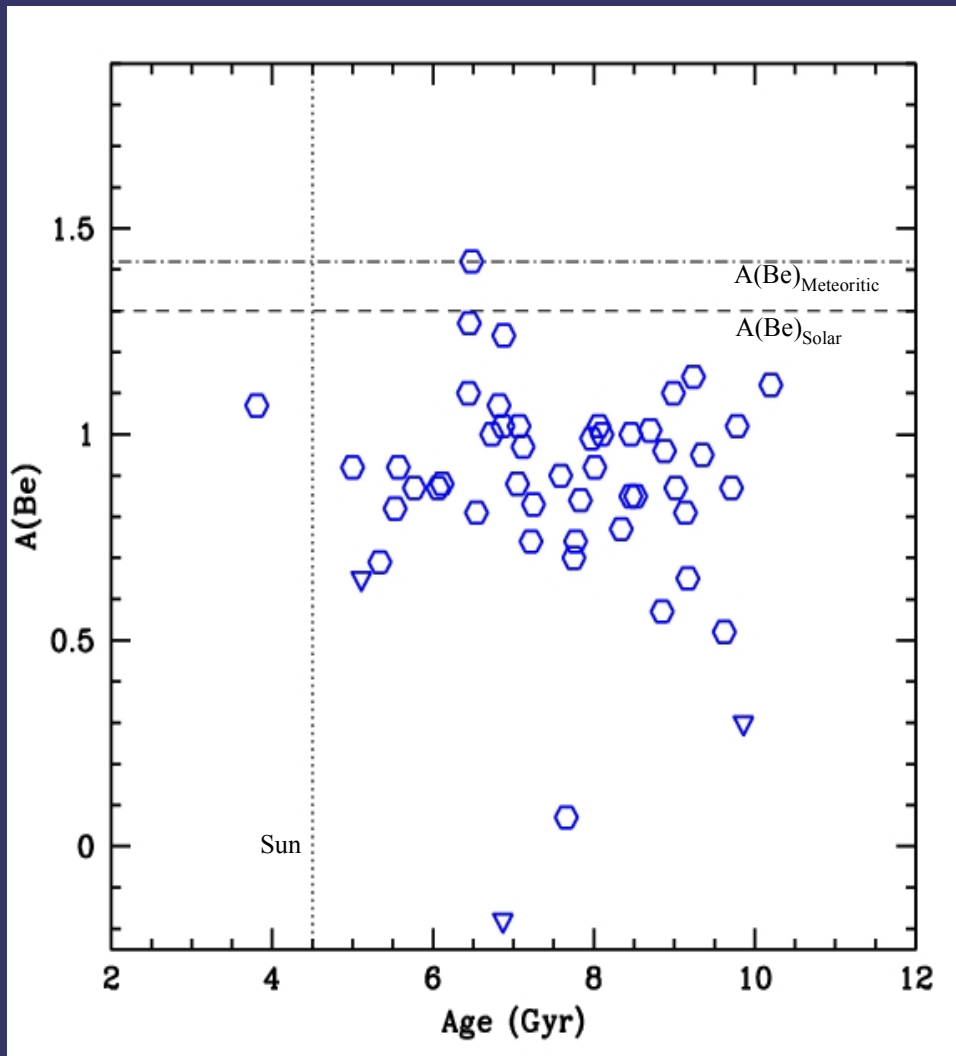- HR diagrams of program stars sorted by [Fe/H]

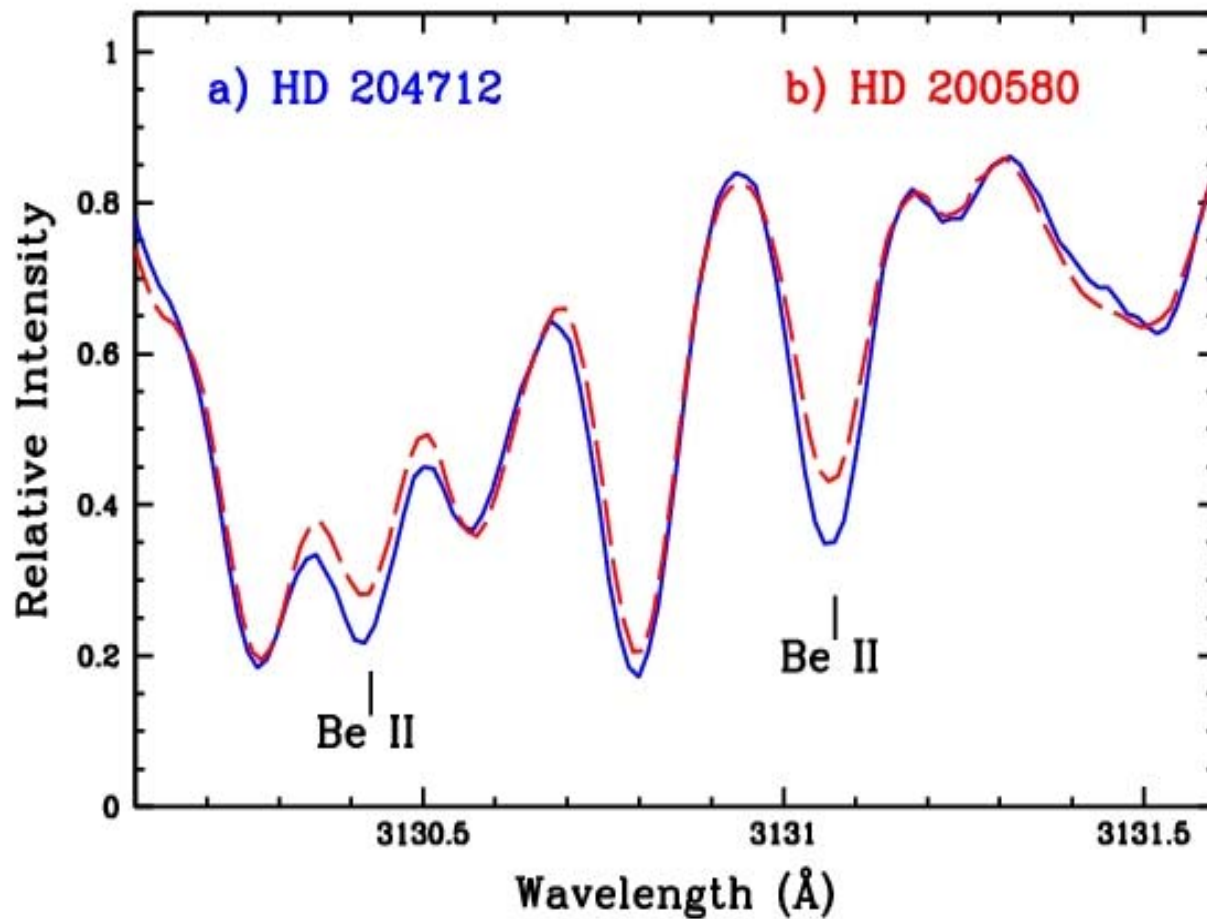- Girardi et al (1999) isochrones and evolutionary tracks

Be-Age relation

- ~1.5 dex spread in A(Be)

- Greatest spread seen from 6-8 Gyr and at low T_{eff}

- 4% of 1 M_{Solar} sample is <5 Gyr

- slow mixing during MS evolution

HD 200580 & HD 204712

Star	HD 200580	HD 204712
A(Be)	0.65 +/- 0.05	0.95 +/- 0.05
[Fe/H]	-0.54	-0.48
Teff	5853	5888
log g	4.12	4.05
Age	9.17	9.35
Mass	0.95	0.96

- A(Be) differs by a factor of 2

- A(Be) spread is real

Trends with Lithium

A(Be) vs A(Li) plot. Legend: △ This study; ⬡ Boesgaard et al. (2004). slope = 0.36. with stars from Boesgaard et al. (2004)
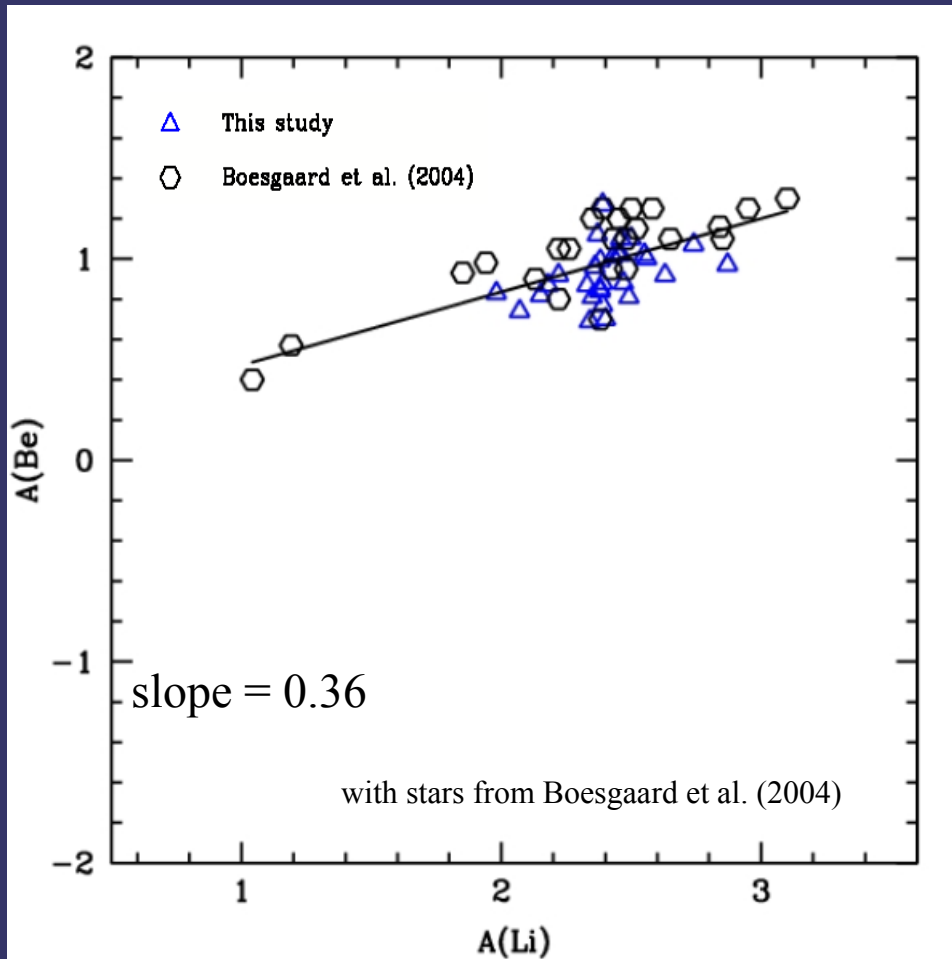
- Linear relation between Be and Li
  - 5900-6300 K
- Lithium more depleted than Be
  - median Li ~2.4
    - meteoritic Li ~3.3
  - median Be~1.0
    - meteoritic Be ~1.42

Conclusions

- For 52 high resolution stellar spectra of the Be II region we find:

  - Linear relation between A(Be) and [Fe/H] to low metallicities

  - Linear relation between A(Be) and A(Li)

  - Large spread in A(Be) is real

  - Subgiants: older, more evolved, less Be

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