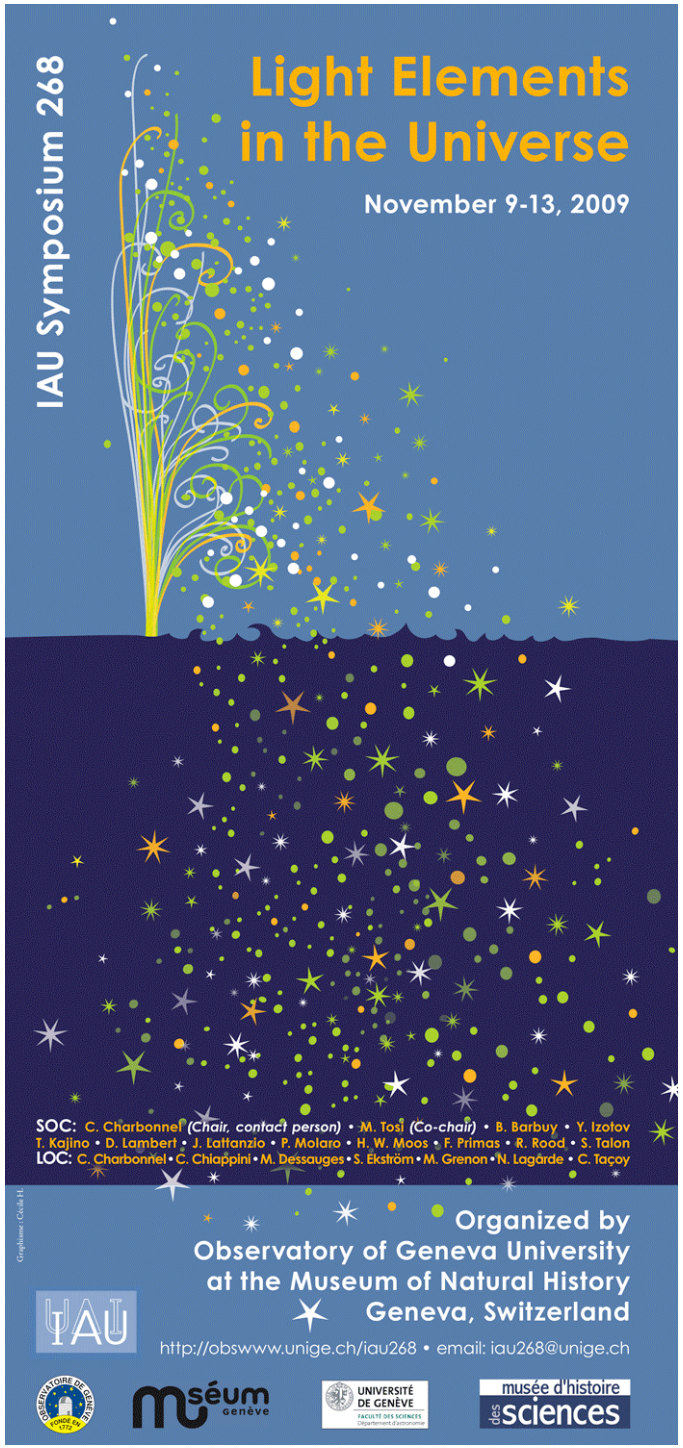


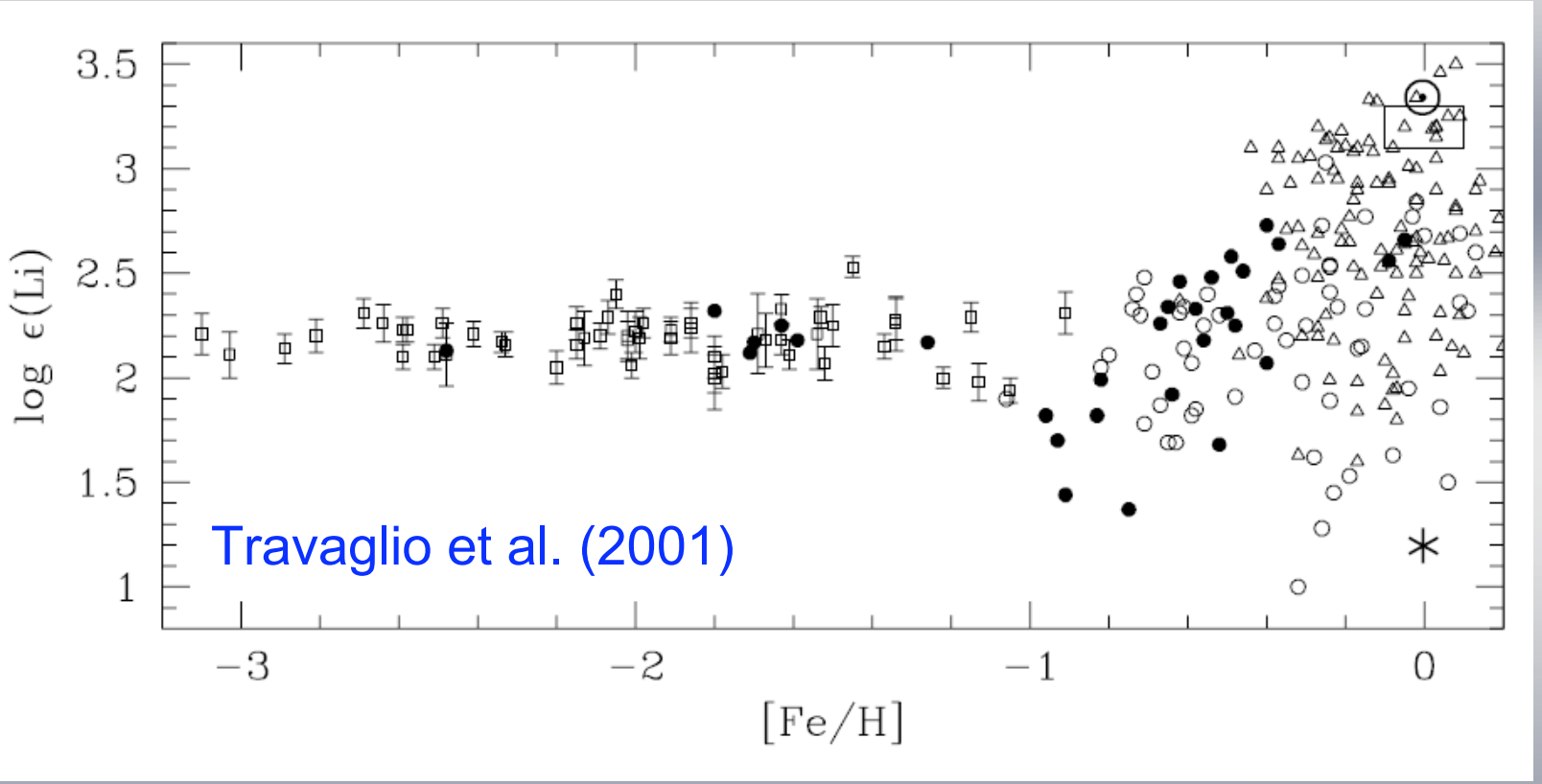
Li, Be, and ~~B~~ in Pop. I dwarf stars (Sun, field and open clusters)

Sofia Randich

INAF

Osservatorio Astrofisico di Arcetri

^{7}Li increases during Galactic evolution: initial for Pop. I~ (initial for Pop. II)x10

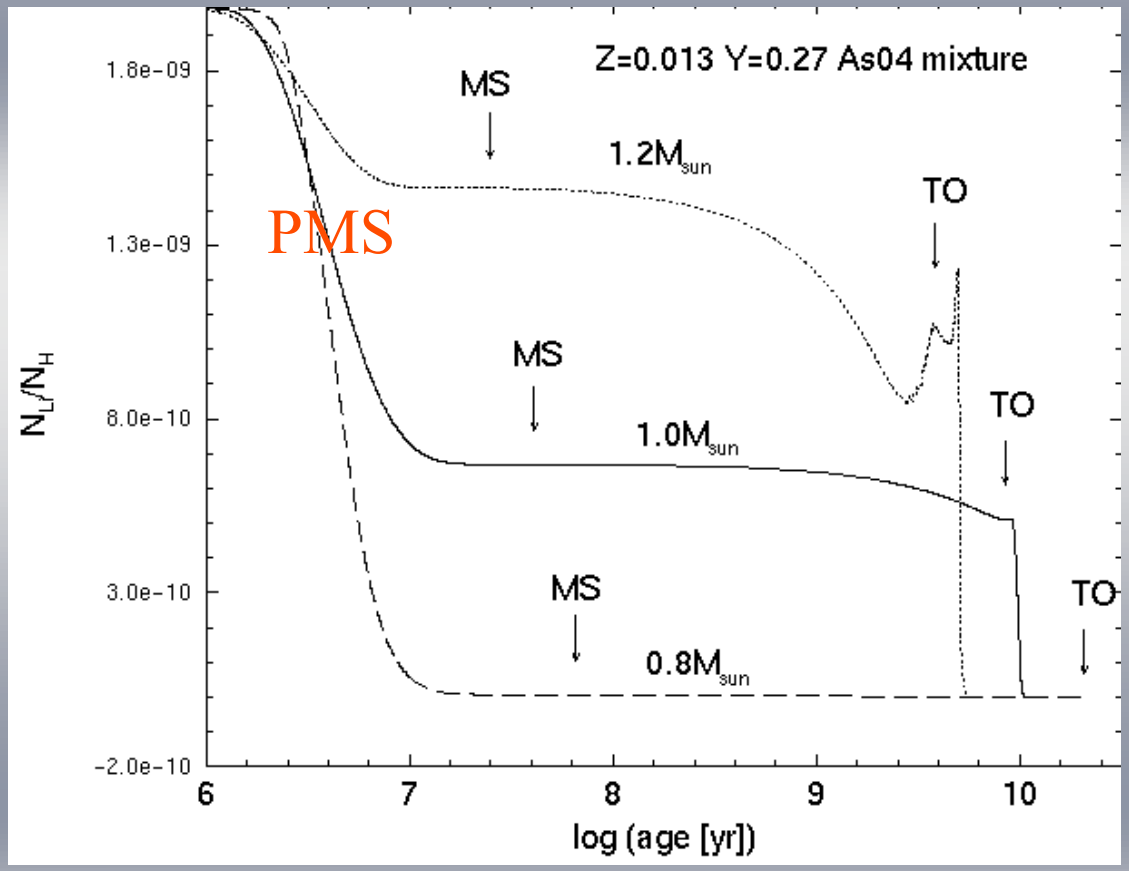


See also e.g. Romano et al. (2003), talk by F. Matteucci

^{7}Li is destroyed during the evolution of Pop. I stars

Predictions of standard models

Li (Be) depletion occurs if/when the base of CZ reaches the Li(Be) burning layer(s)



Sestito et al. (2006)

i. **PMS Li depletion (amount depends on input physics and chemical composition)**

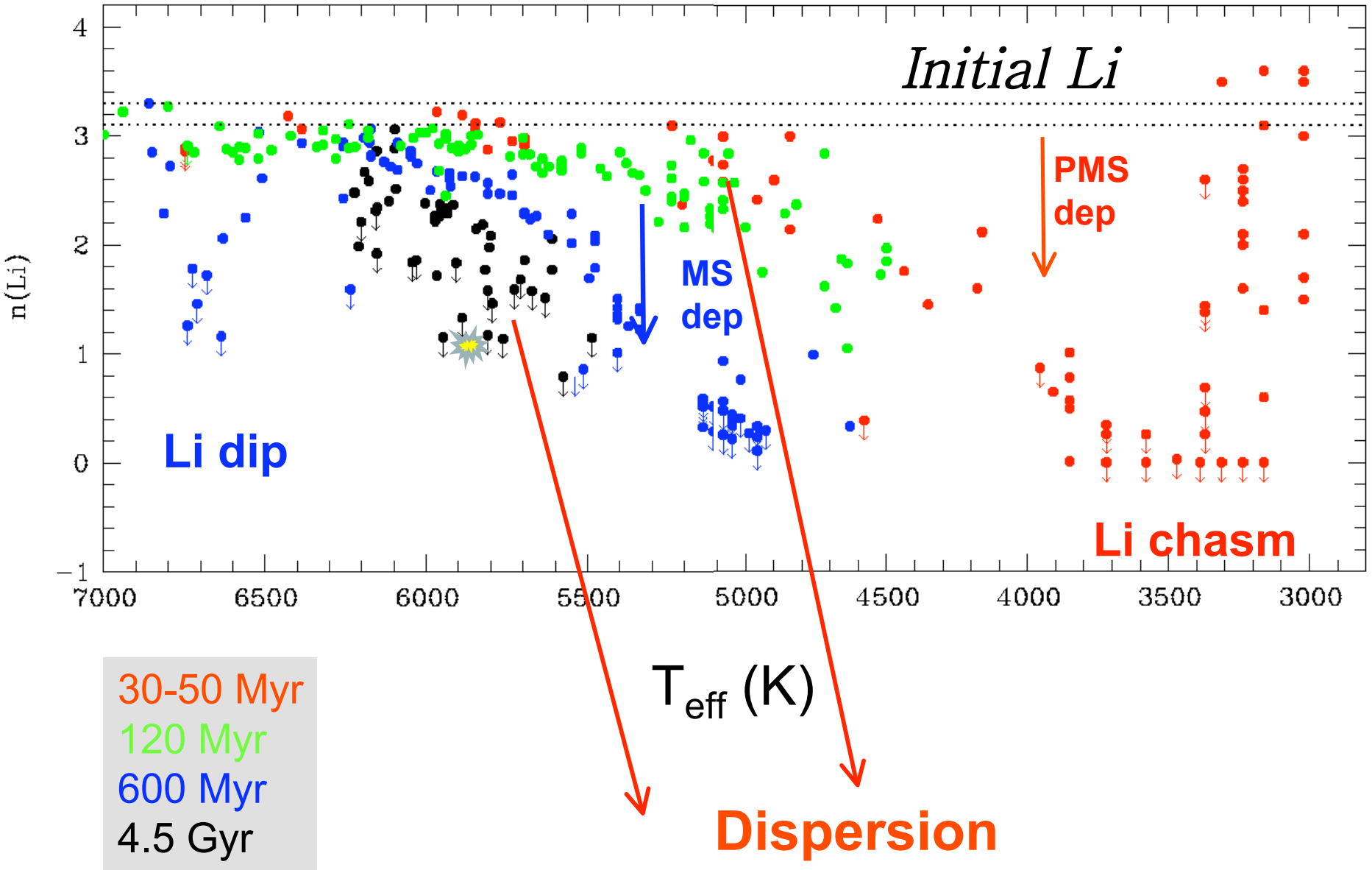
ii. **No MS Li (and Be) depletion for solar-mass stars and above (base of CZ too cool)**

iii. **Mass dependent depletion; similar stars same amount of depletion**

iv. **Fully convective stars: Li depletion depends on central T → age**

Sestito et al. (2006)

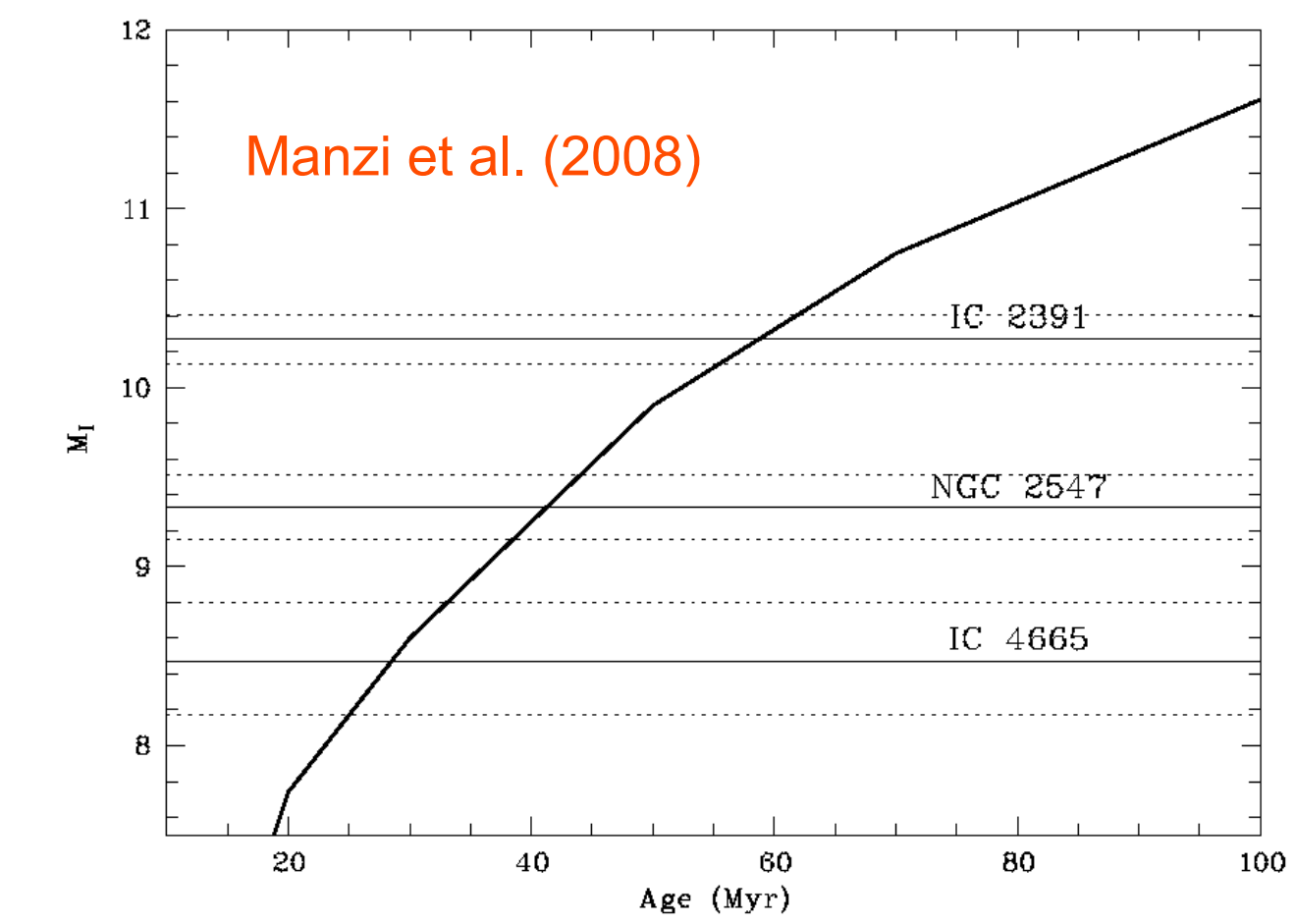
Overview of depletion pattern



What we do understand

- Li depletion in fully convective stars →

Use of Li to age date young clusters



What we do not understand

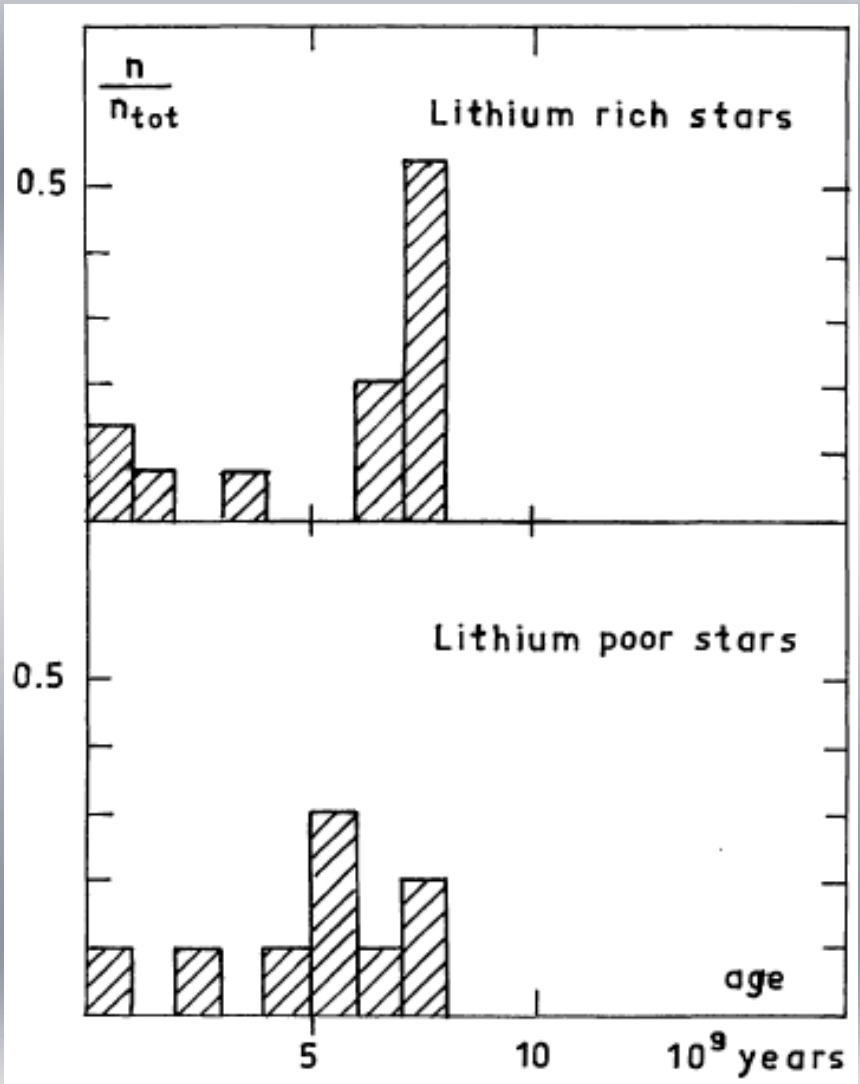
- Li dip among F-type stars
- Smaller than predicted PMS depletion for solar-type stars
- Solar MS Li depletion
- Dispersion in otherwise similar stars in M67 and among field solar analogs
- Dispersion among K-type stars in young clusters

Non standard processes

Depletion in solar-type stars: observer's perspective (constraints on extra-mixing models)

- Is the Sun representative of Pop. I solar-type stars?
- Is the scatter in M67 a typical feature?
- Timescales of Li depletion
- Li patterns vs. [Fe/H]
- Beryllium vs. Li (T_{burn} 3.0 vs. 2.5 MK)

Several evidences of old solar-type stars with 'high' Li. Sun not representative. No clear age-Li relation

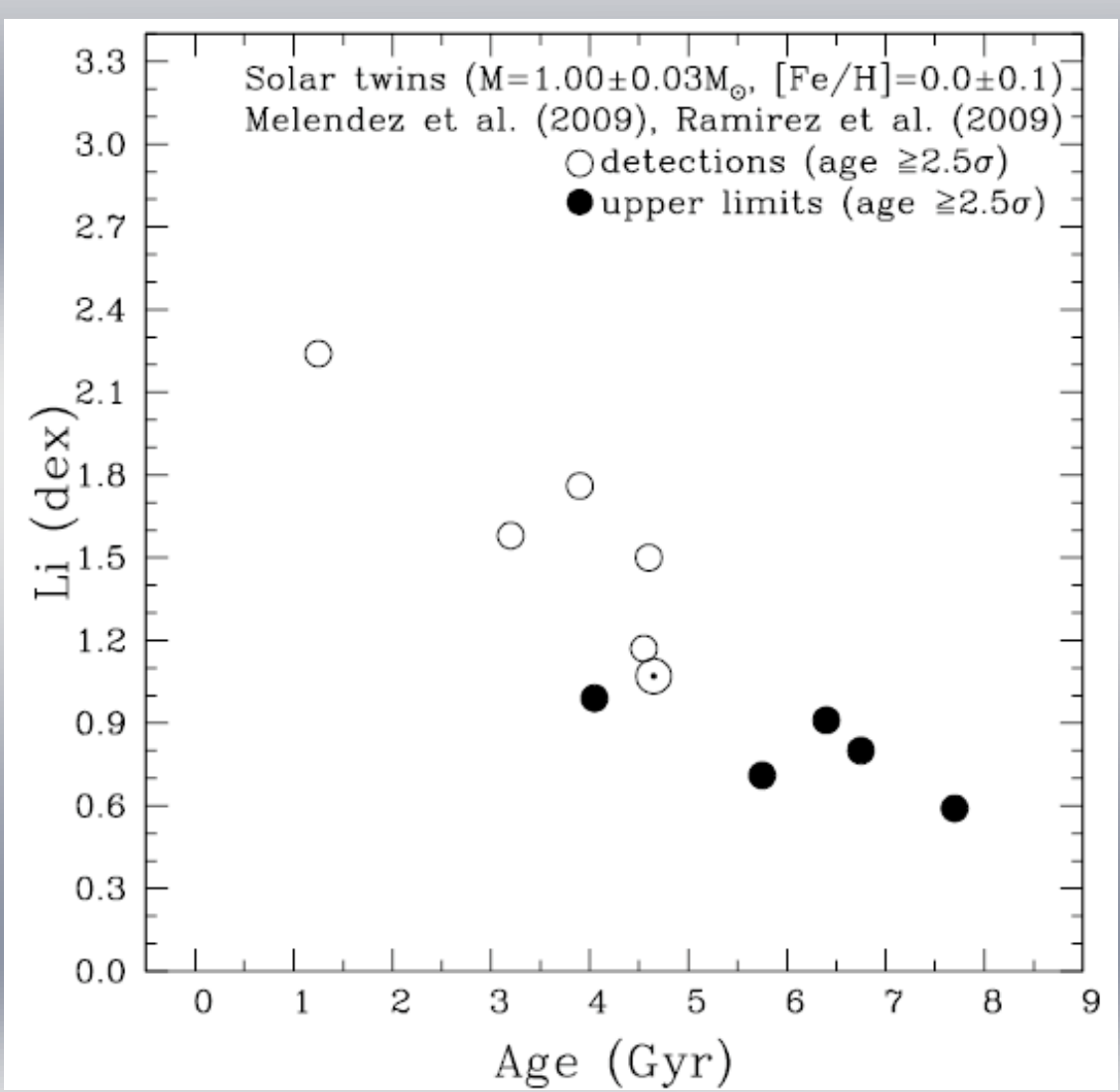


Spite & Spite (1982)

See also:
Duncan (1981)
Pallavicini et al. (1987)
Pasquini et al. (1994)
Lambert & Reddy (2004)

(ages derived in different ways, samples include solar [Fe/H] stars)

Opposite view: Sun is representative



Previous results due to biases in sample selection and/or and/or to not accurate Teff scales and/o to not considering true solar analogs

Melèndez et al. (2009) see also poster

Open Clusters

→ **2005:** ~20 OCs, mostly younger than the Hyades
Sestito & Randich (2005) : re-analysis, hom. scale

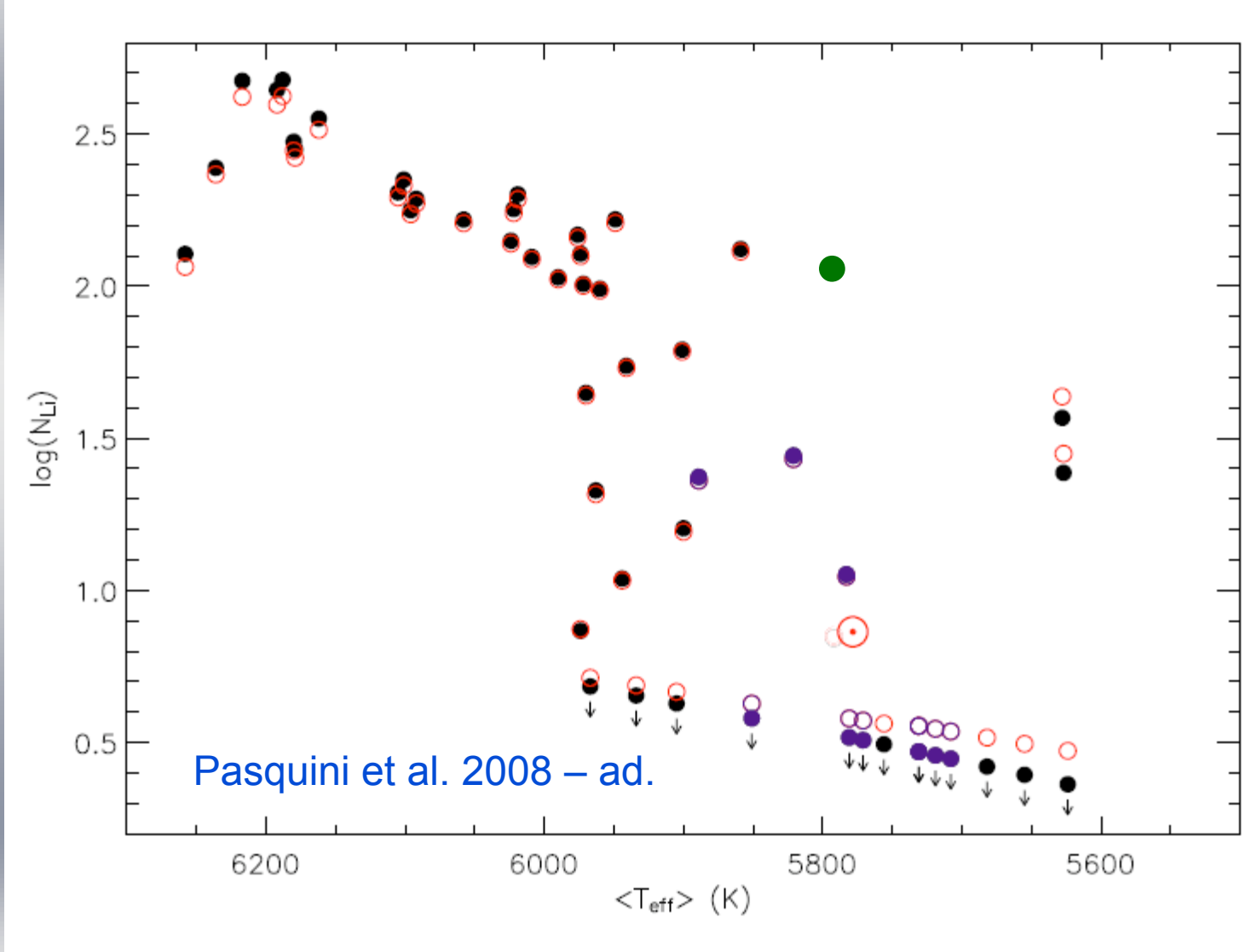
After 2005: ▶VLT/FLAMES/Giraffe observations by our group Randich et al. (2005, 2007, 2008), Pallavicini et al. (2006), Spanò et al. (2006)

9 Ocs; 0.9 < age < 8 Gyr, -0.38 < [Fe/H <0.35
40 to 140 members/clusters

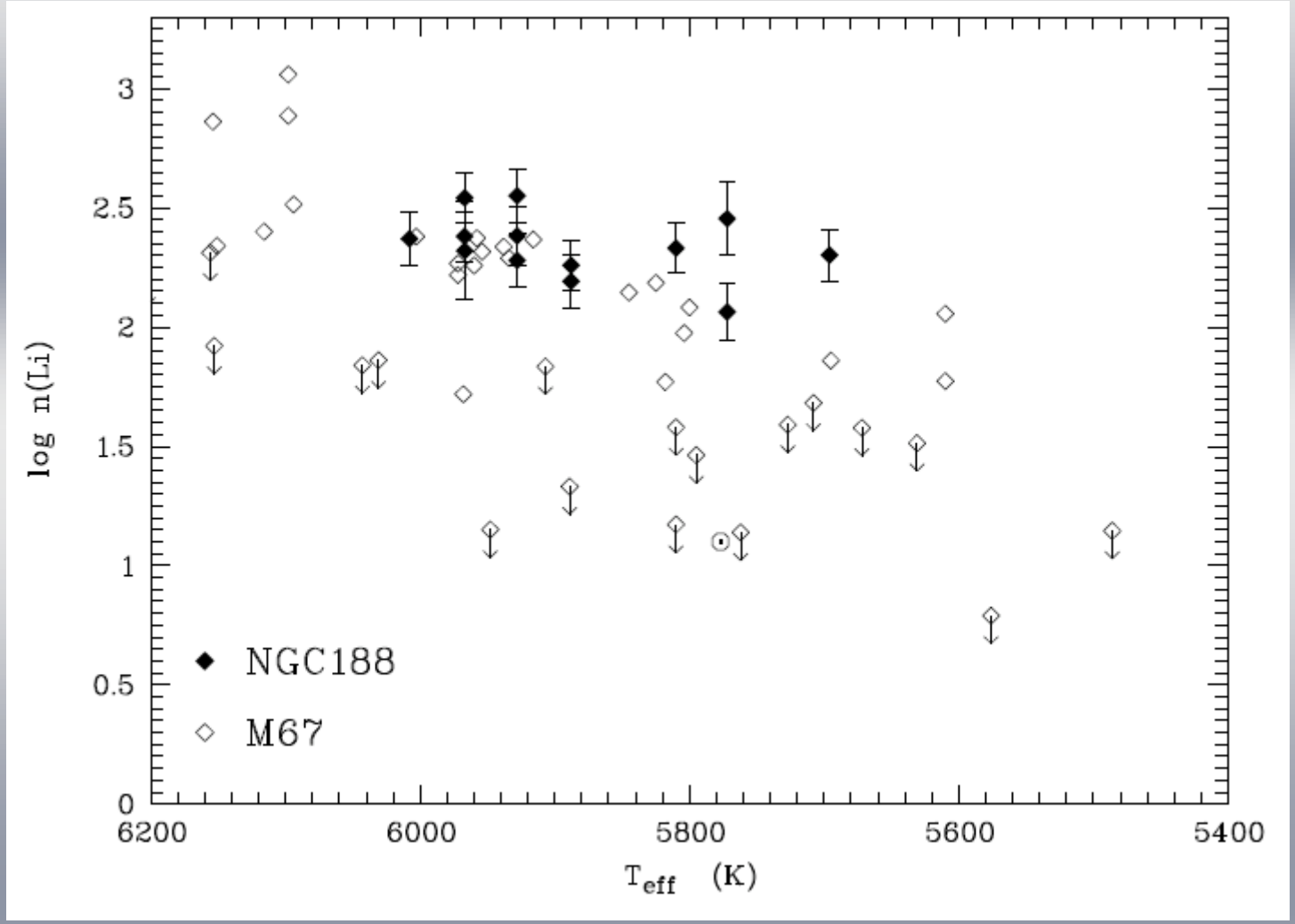
▶New observations of M67 (Pasquini et al. 2008)

▶others – see posters by Mallik et al, Pace et al
Jeffries et al. (2009, -ic4665)
Twarog et al. (2009, -ngc3680)

New observations of M67

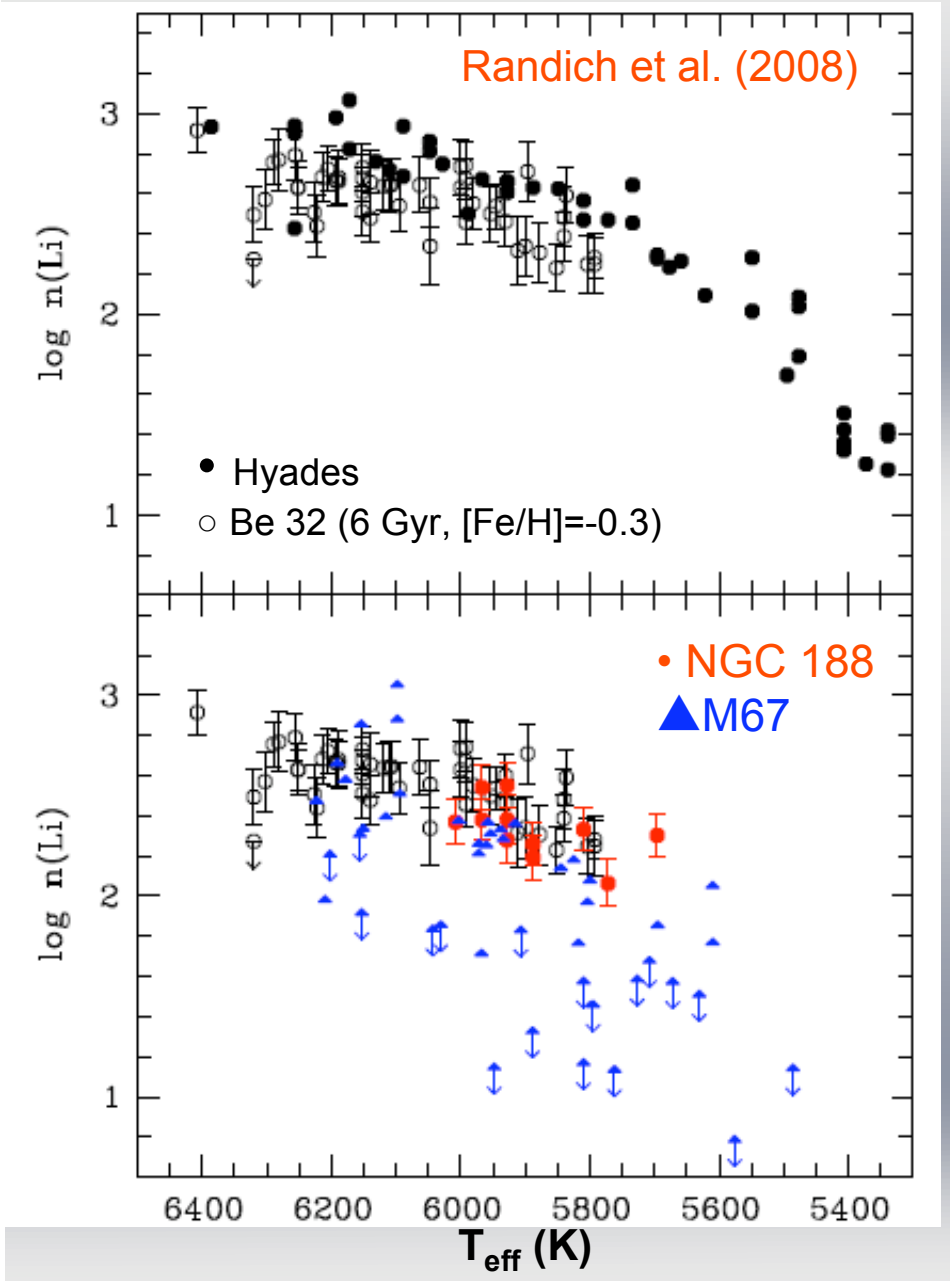


The very old NGC 188 ([Fe/H]~solar)

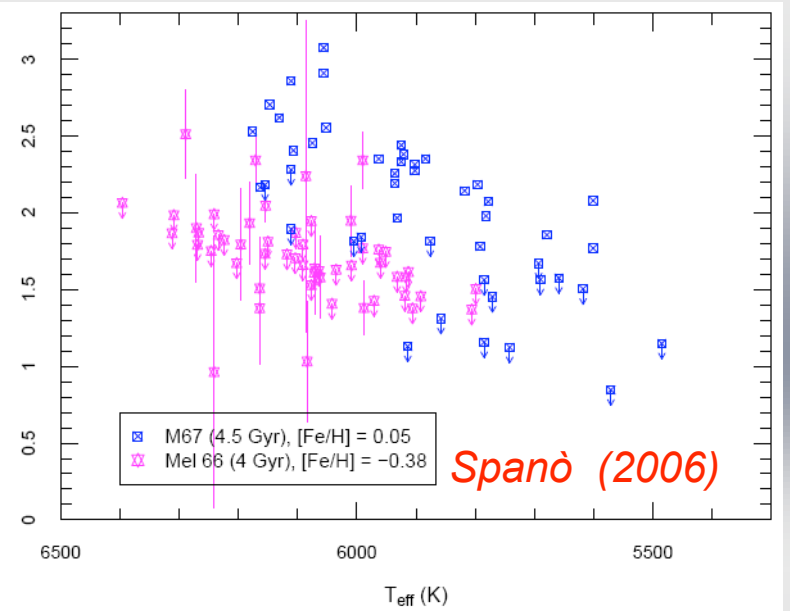


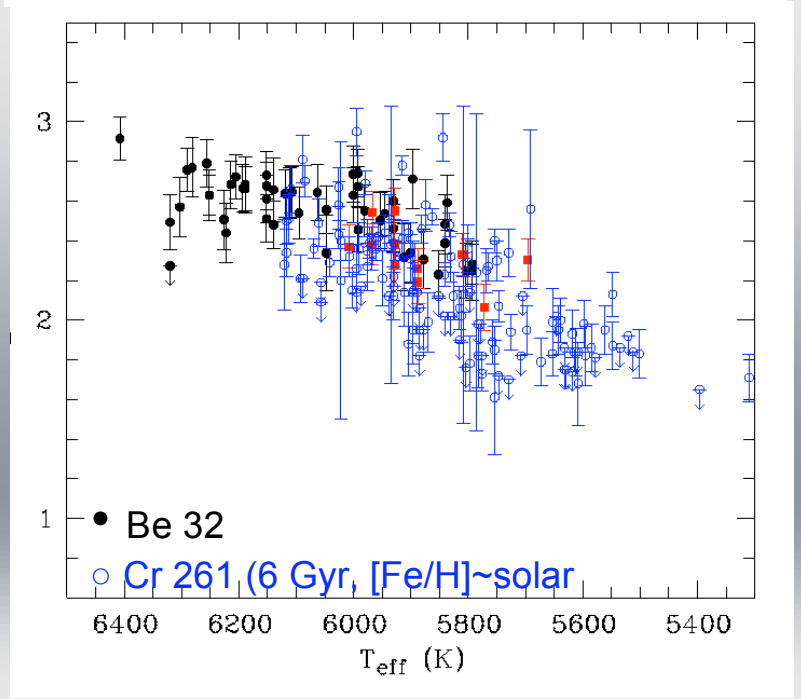
Randich et al. (2003)

GIRAFFE SURVEY: RESULTS



log n(Li)

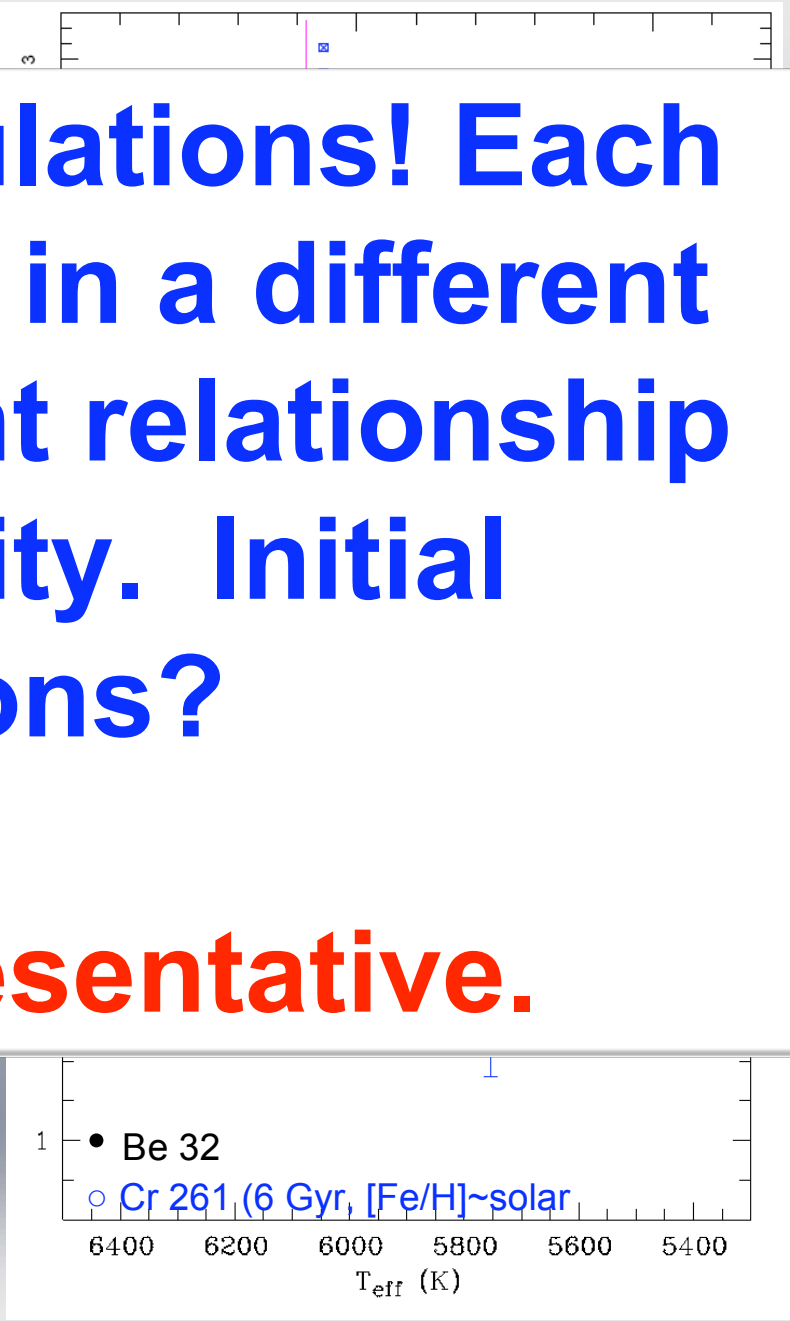




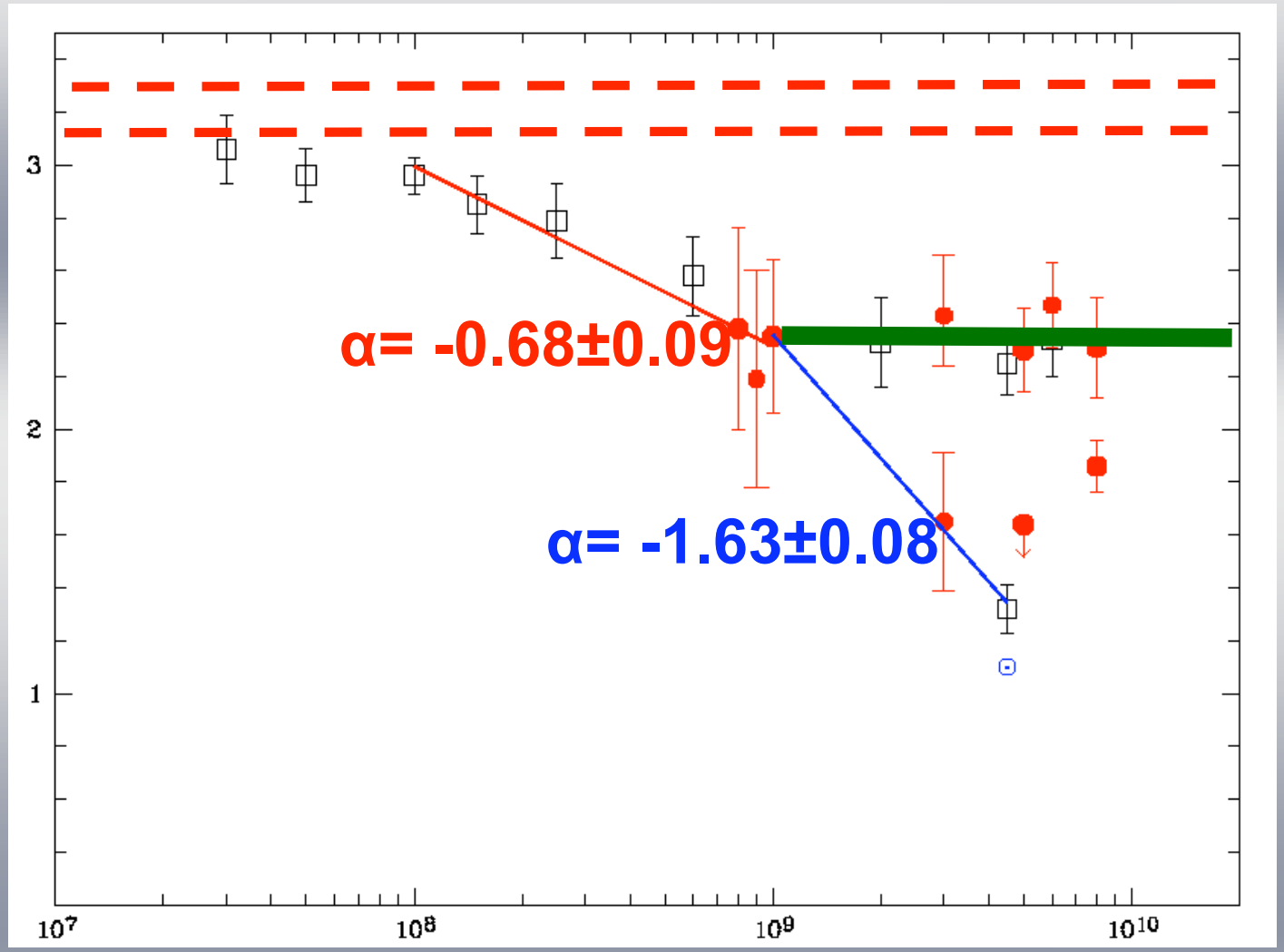
GIRAFFE SURVEY: RESULTS

A variety of populations! Each cluster behaves in a different way. No apparent relationship with metallicity. Initial conditions?

Sun not representative.

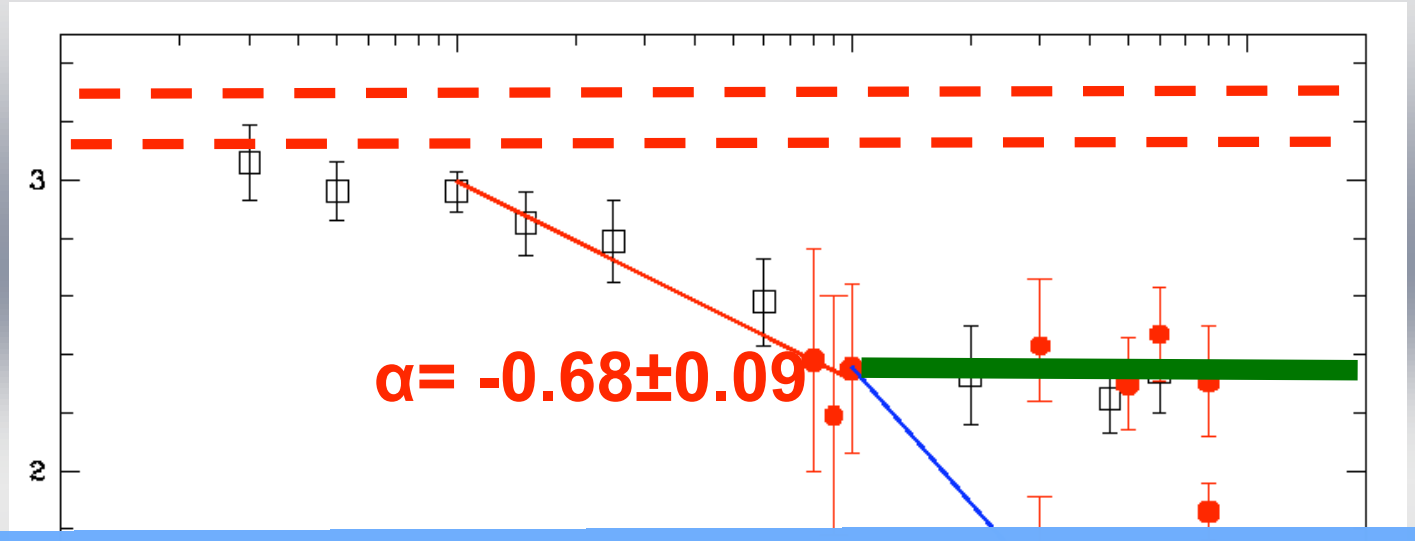


TIMESCALES: USE OF Li AS AGE TRACER



Teff:5750-6050 K

TIMESCALES: USE OF Li AS AGE TRACER



Little depletion up to 100 Myr, continuous depletion up to 1 Gyr, then bimodal

fast depletion or no depletion →

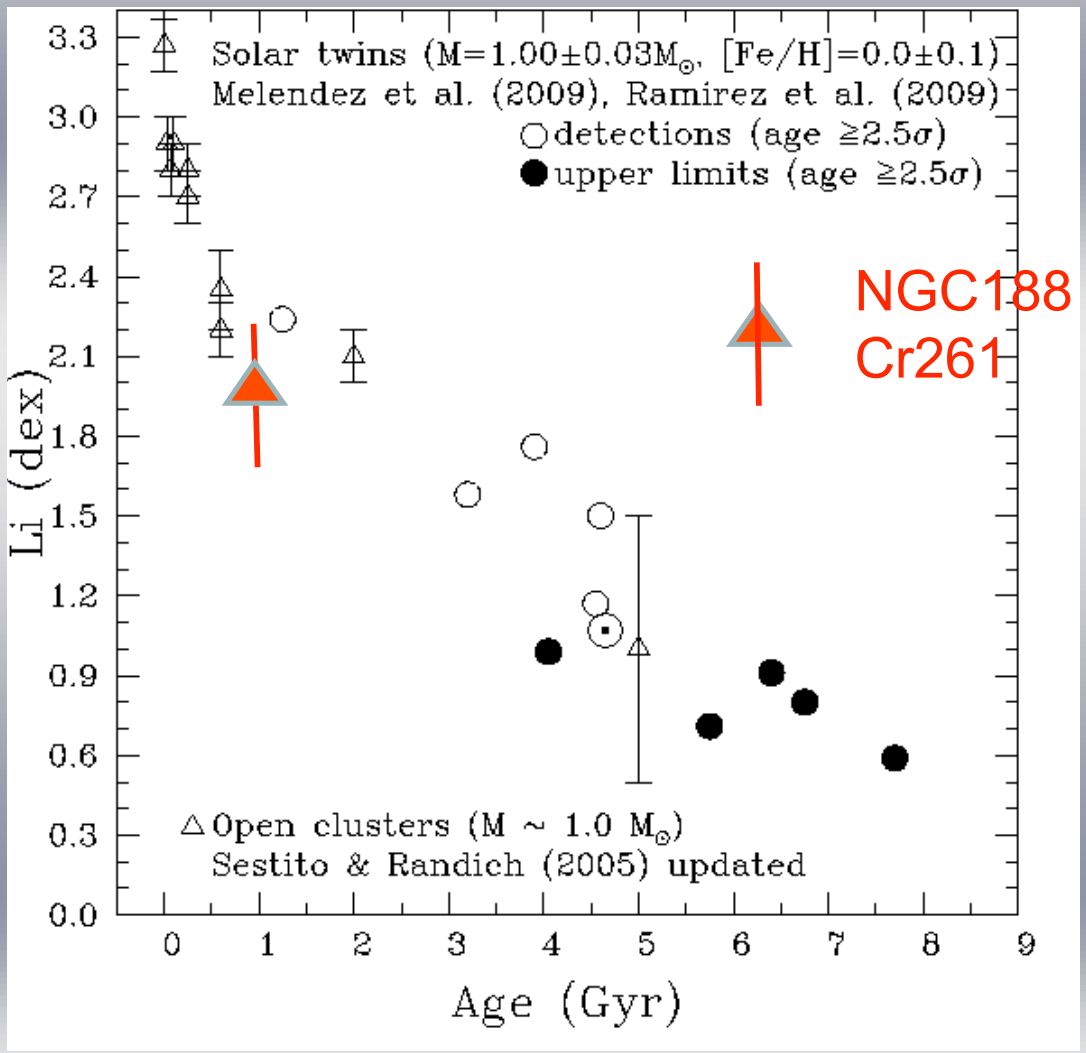
‘low’ Li (solar) ≡ old (+peculiar evolution)

‘high’ Li (~10xsolar) only lower limit to age

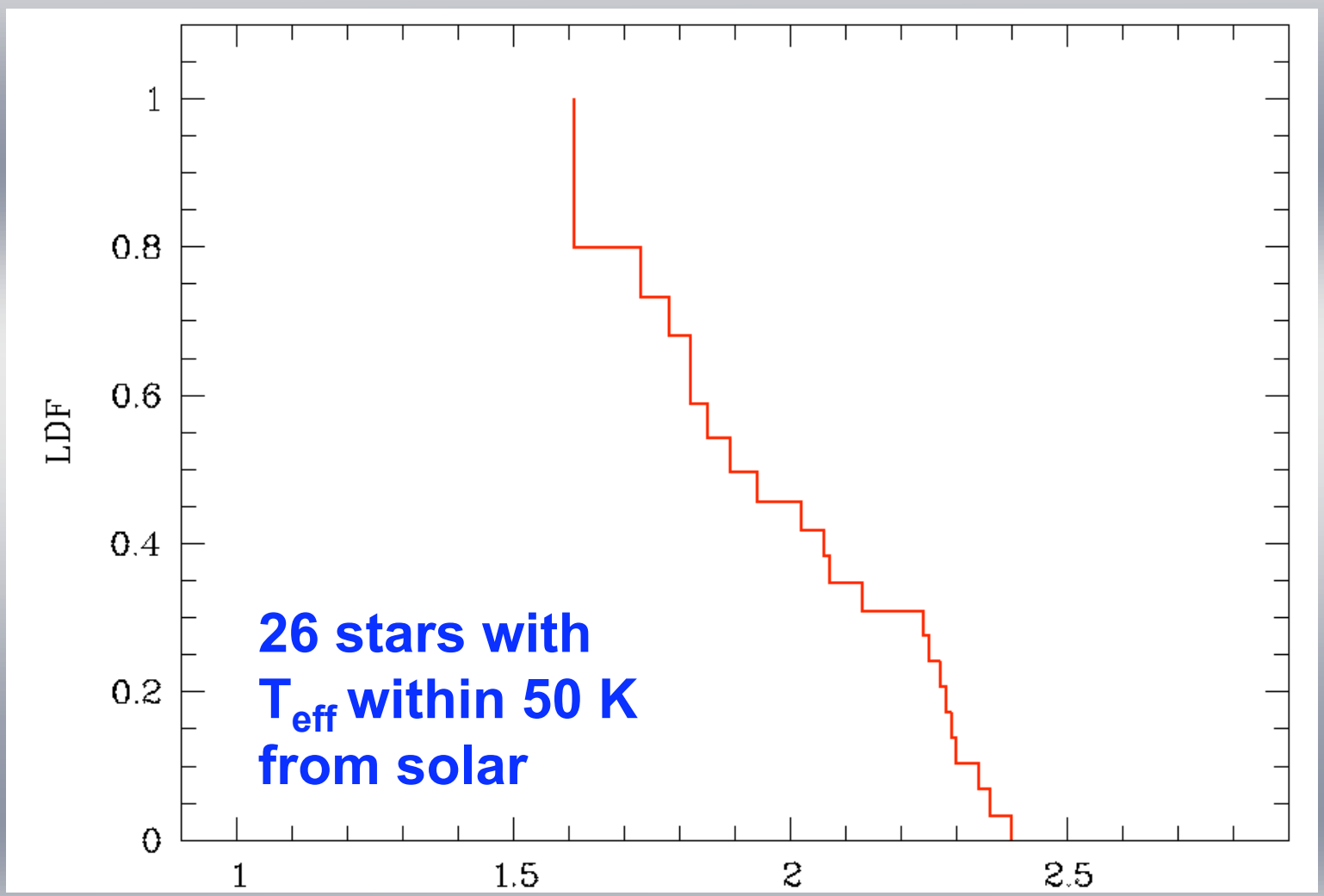
Teff:5750-6050 K

Only solar twins

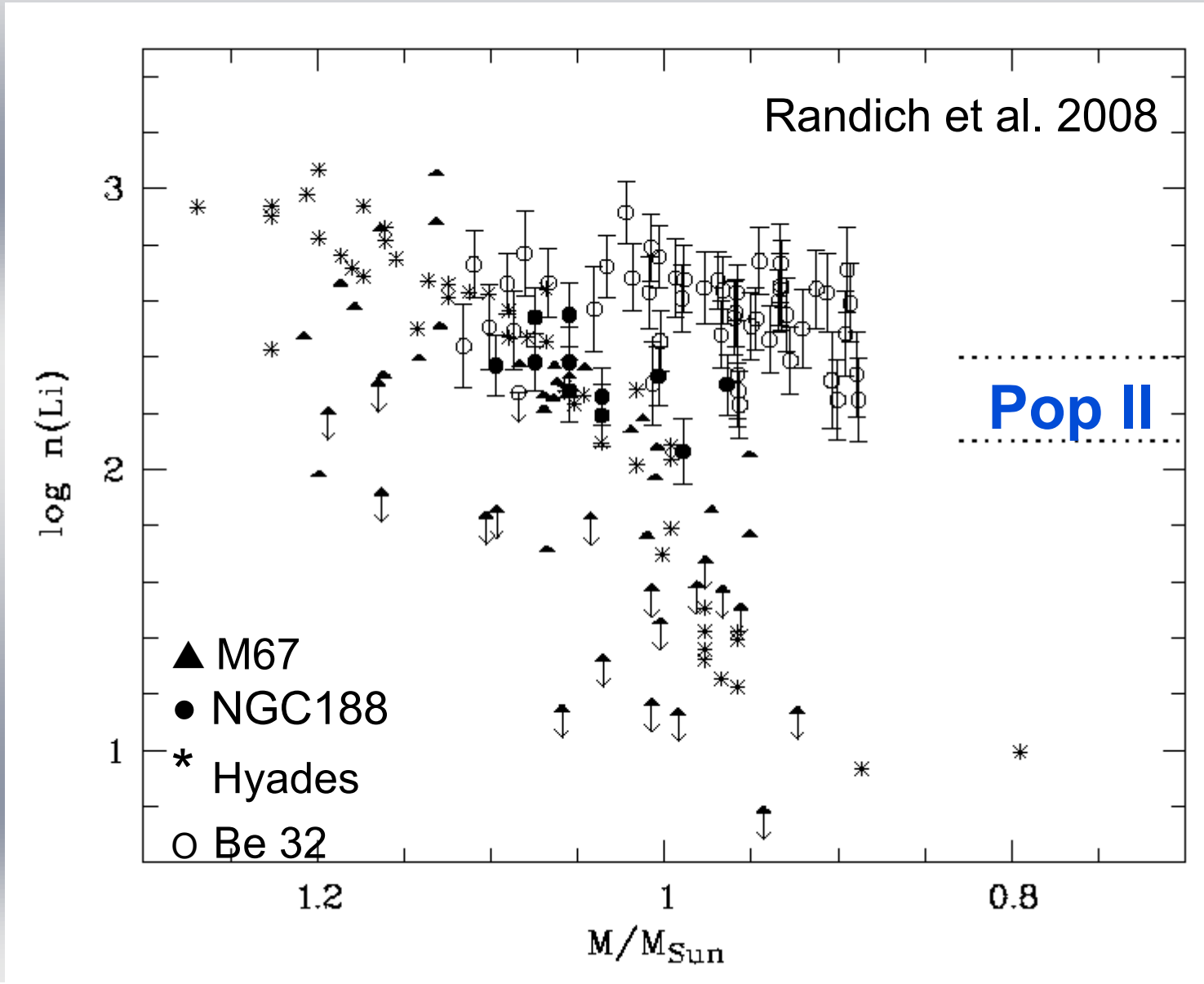
($T_{eff} = T_{effSun} \pm 50$ K, [Fe/H=0])



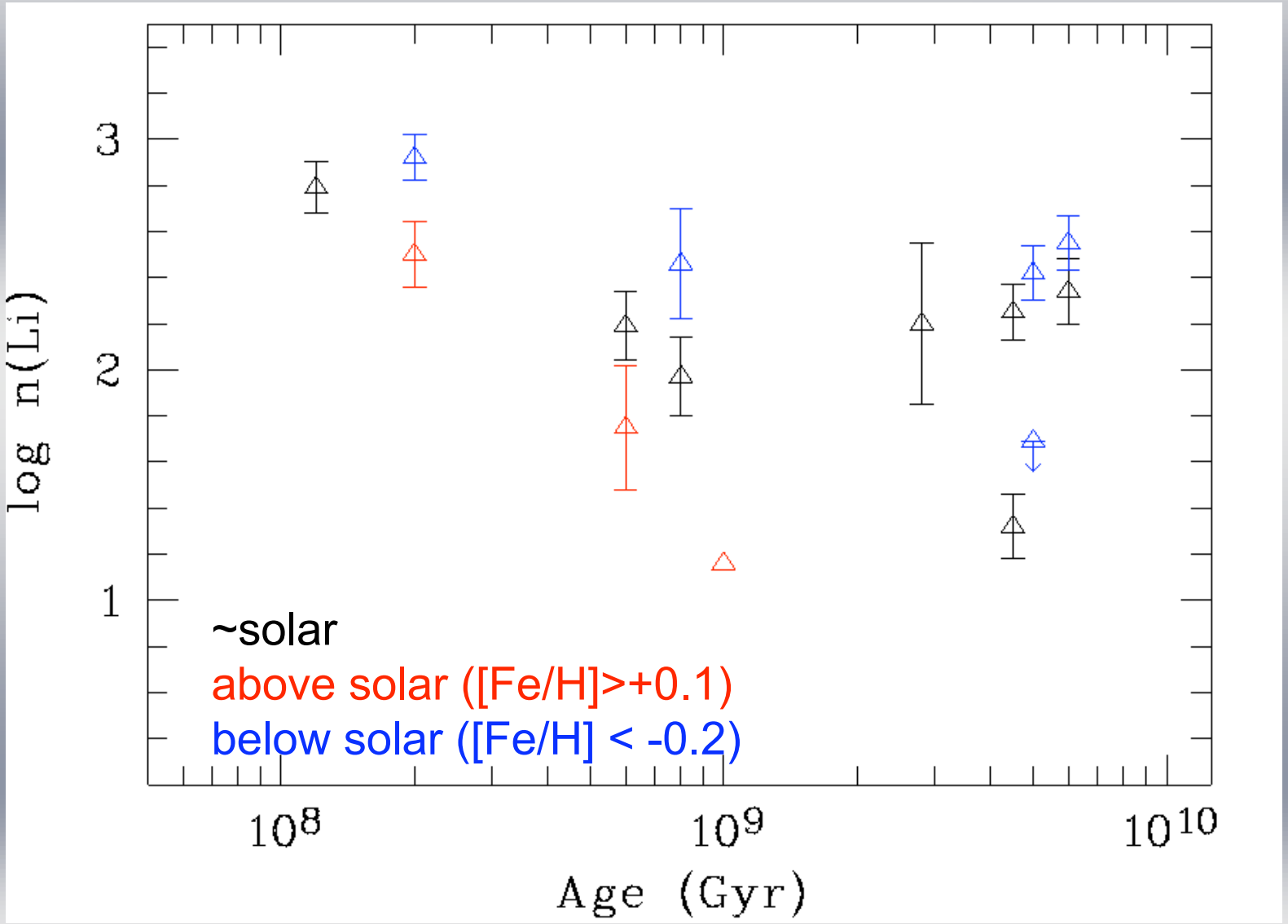
Li distribution in Cr 261



Li vs. mass - Effect of metallicity



Age evolution for different [Fe/H]



Summary 1.

- Li-rich old stars found in the field and OCs. Depletion stops at ~1 Gyr for part of the stars. Sun is not representative
- Others (including the Sun) undergo fast 10x larger depletion. Dispersion does not depend on obvious cluster parameters.
- Depletion must be driven by additional parameters besides age and mass
- Li vs. Teff patterns do not depend on cluster [Fe/H], but Li vs. mass do

BERYLLIUM
FAR LESS OBSERVATIONS

Garcìa Lòpez et al. 2005: Hyades

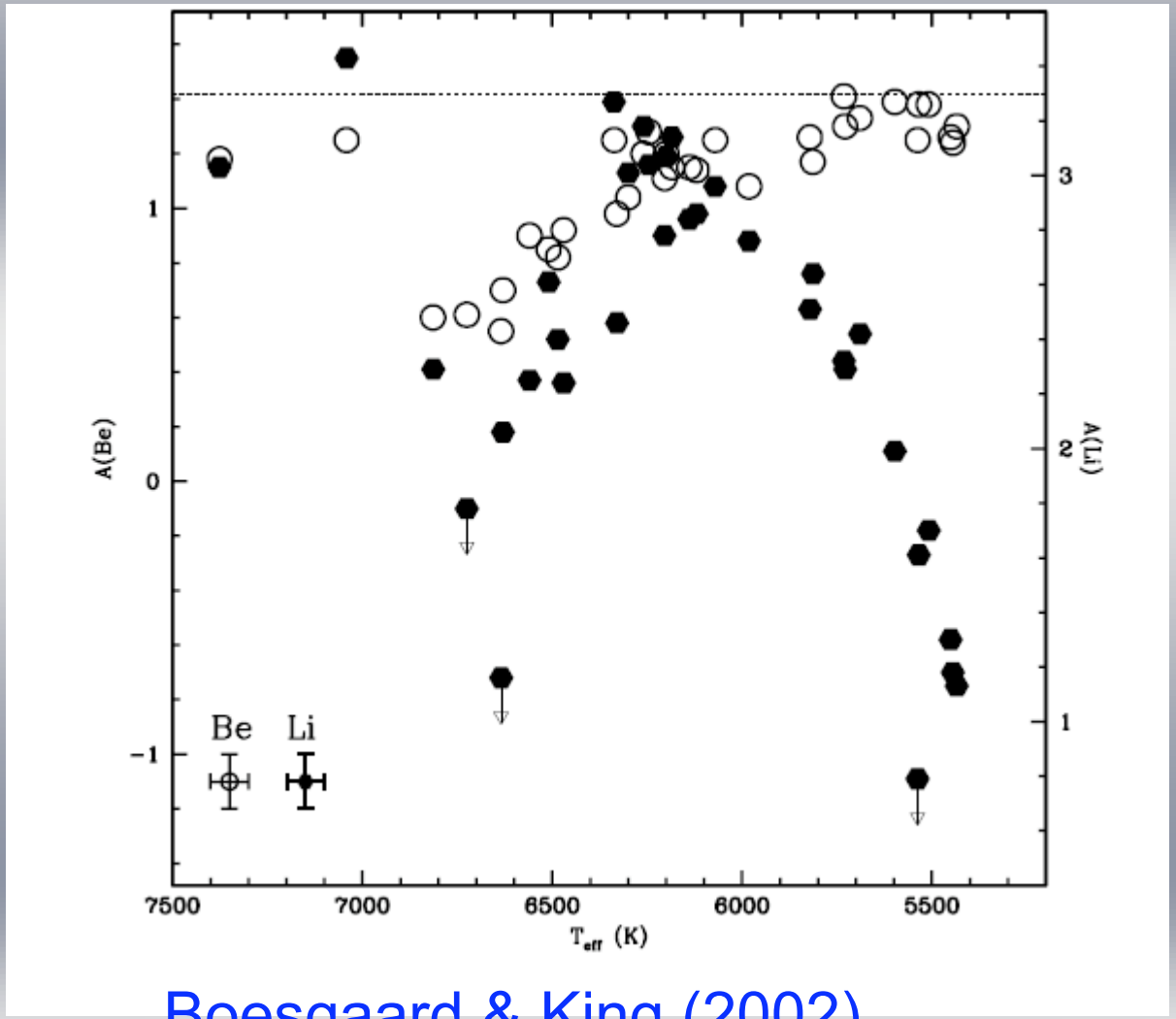
Boesgaard et al. 1977, 1989, 2002, 2003ab, 2004:
Hyades, Pleiades, Alpha Per, Uma, Praesepe

Randich et al. (2002, 2007): IC2391, M67, IC4651, NGC2616, Hyades

Smiljanic et al. (2009): IC4651

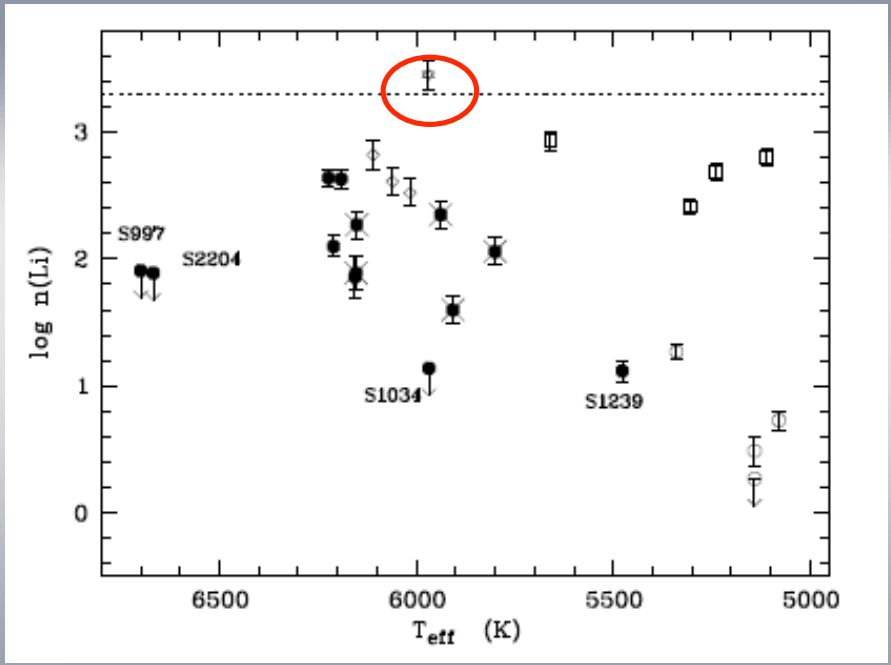
+ studies on field stars (most by Boesgaard et al.)

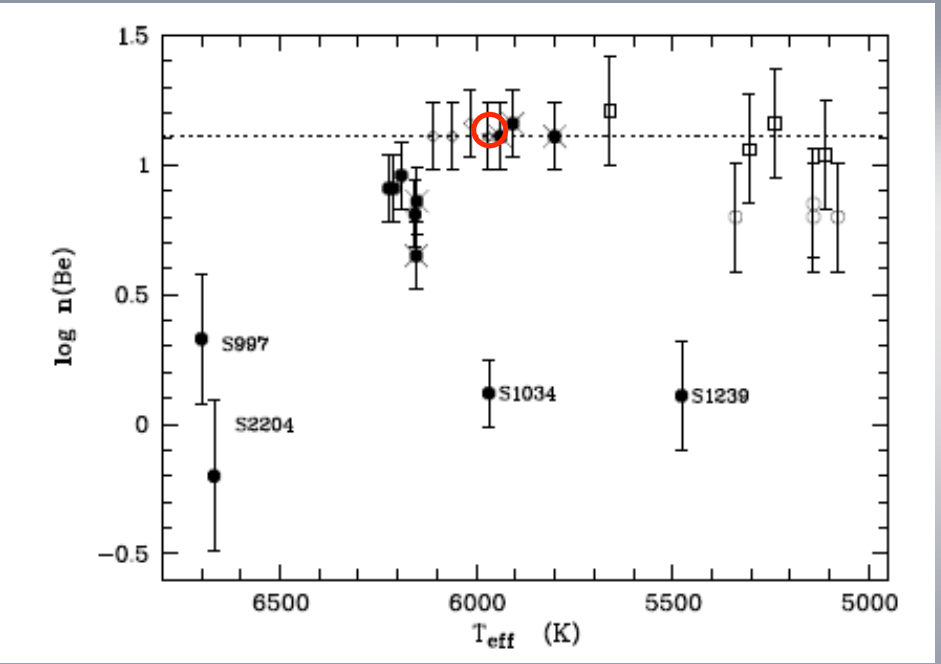
Be vs. Teff - Hyades



Boesgaard & King (2002)

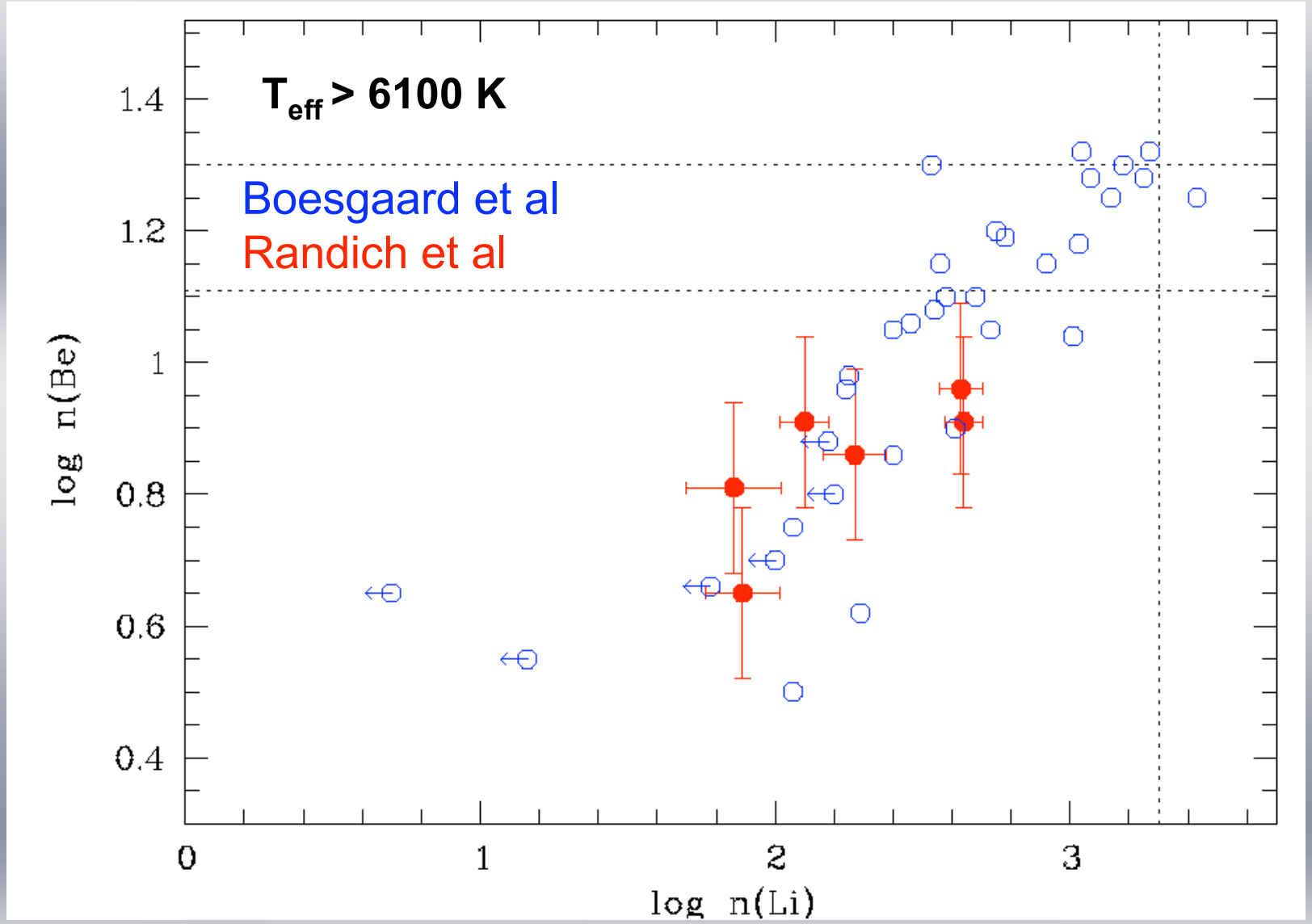
Be vs. T_{eff} – Other clusters



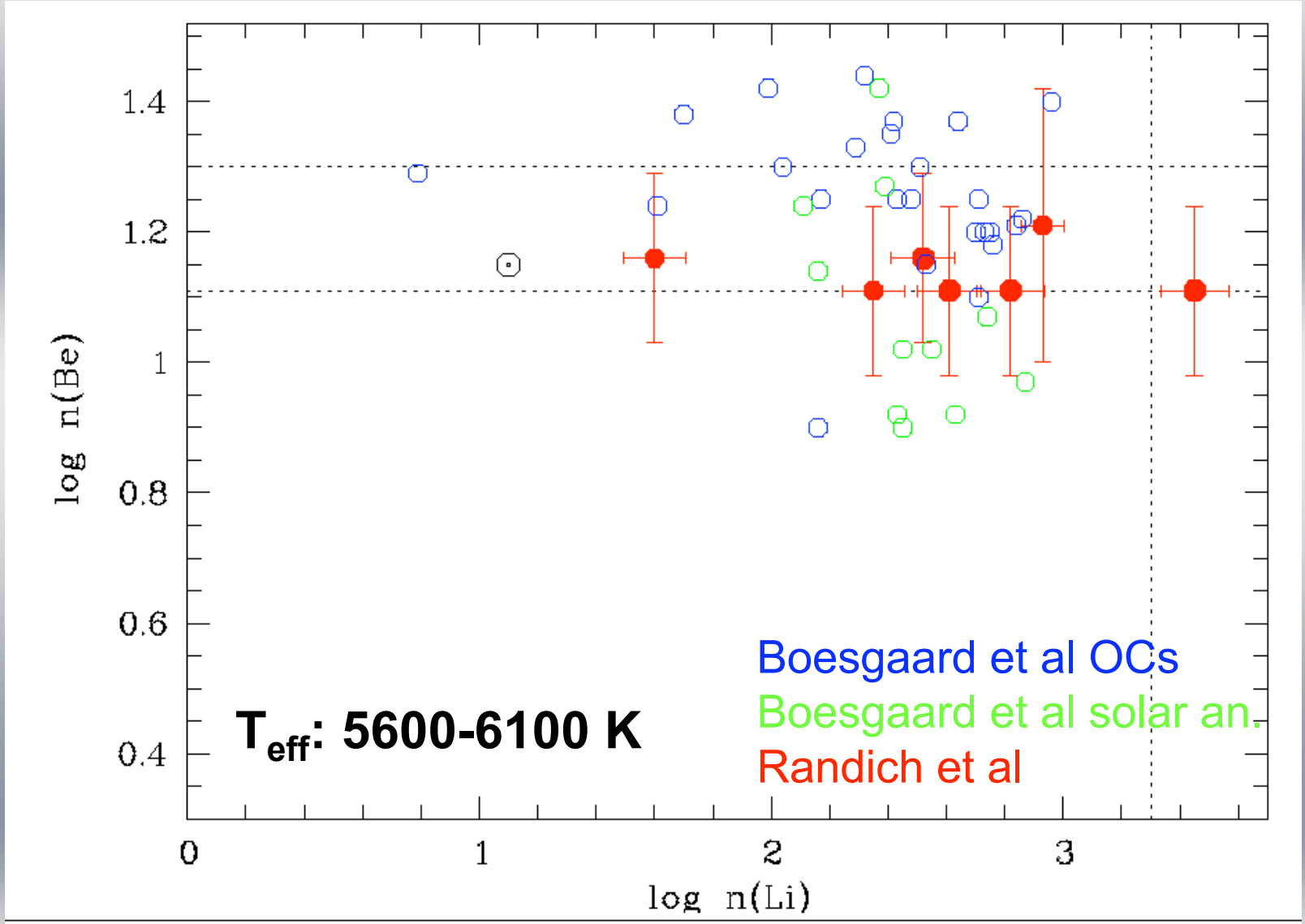


Randich et al. (2007)

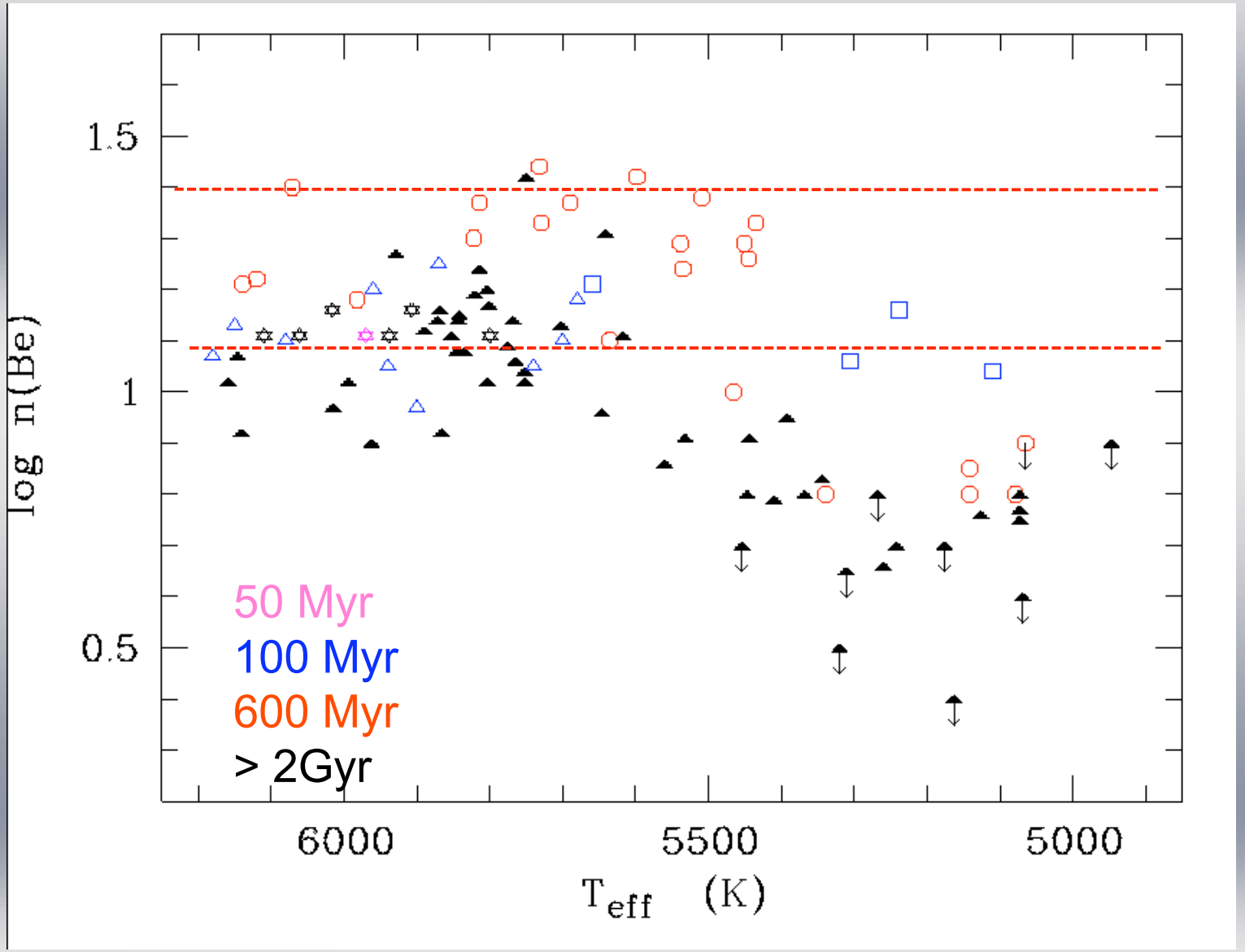
Beryllium vs. lithium



Beryllium vs. lithium



. Beryllium – age evolution



Summary 2.

- Solar-type stars do not deplete Be up to at least the solar age
- Be depletion correlates with Li depletion for stars warmer than 6100 K, while there is no correlation for cooler stars (down to 5600 K
- Be vs. age depletion is present for stars cooler than 5700-5600 K. Not clear for warmer objects
- Metal-rich Hyades might have higher initial Be than solar metallicity clusters