

The evolution of chromospheric activity in solar type stars

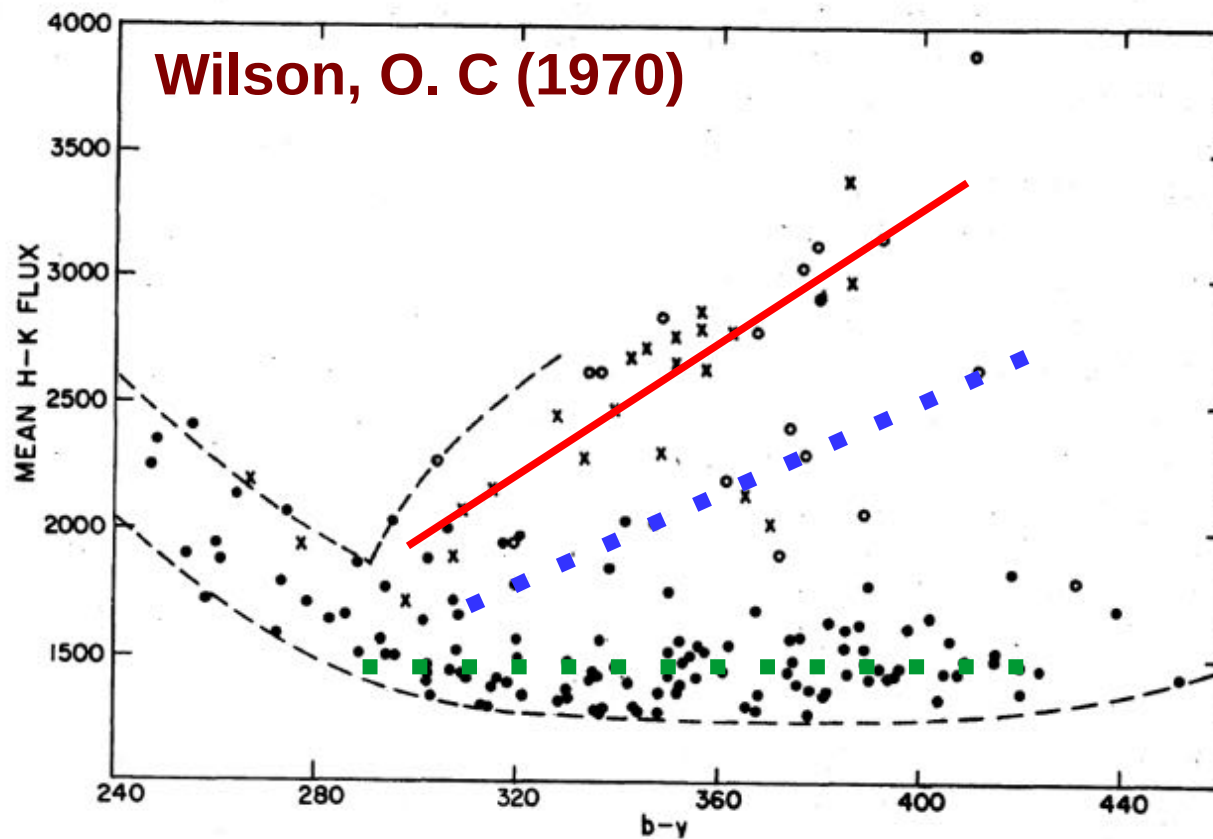
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SAMPA group



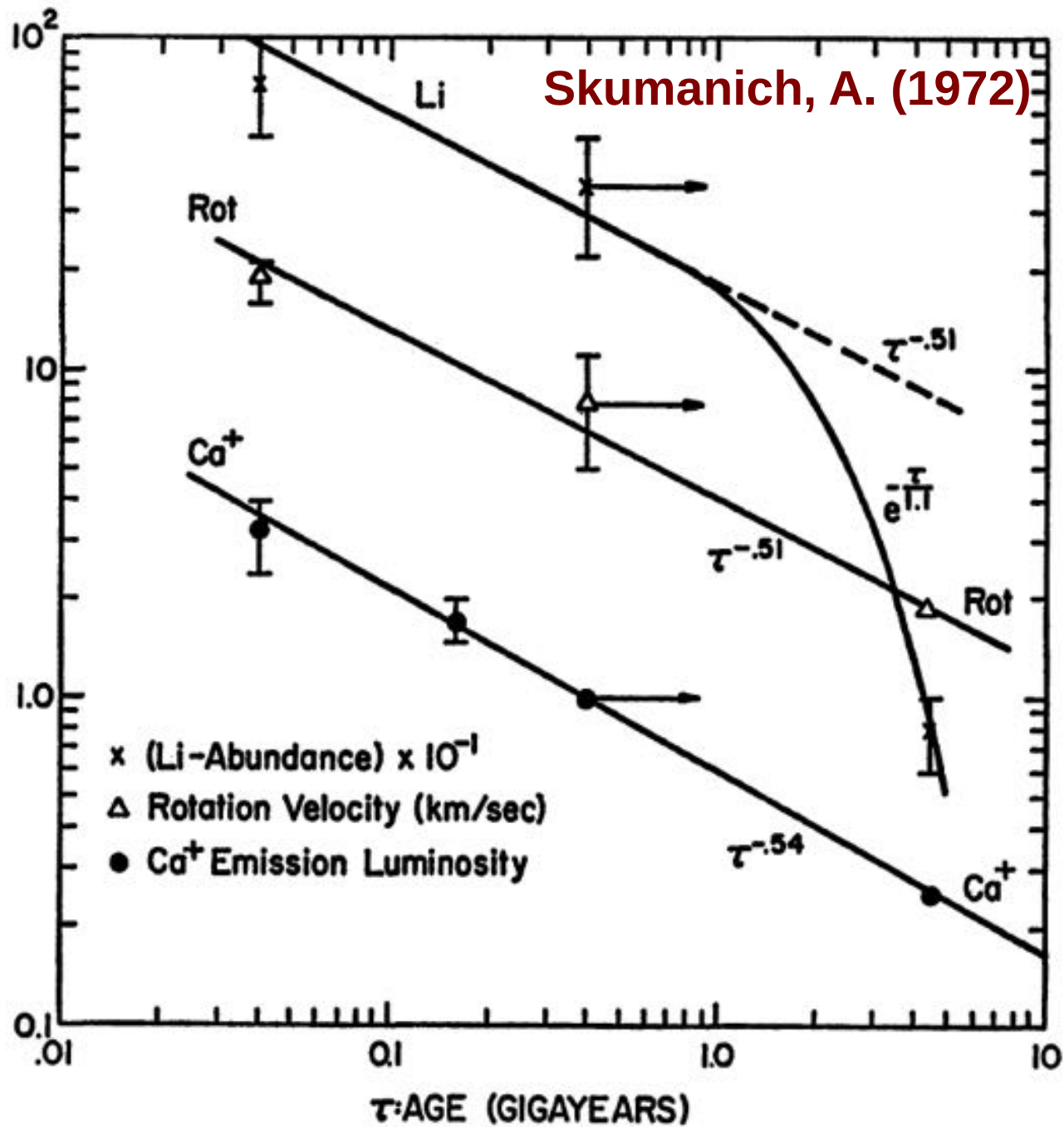
Clues about AC evolution

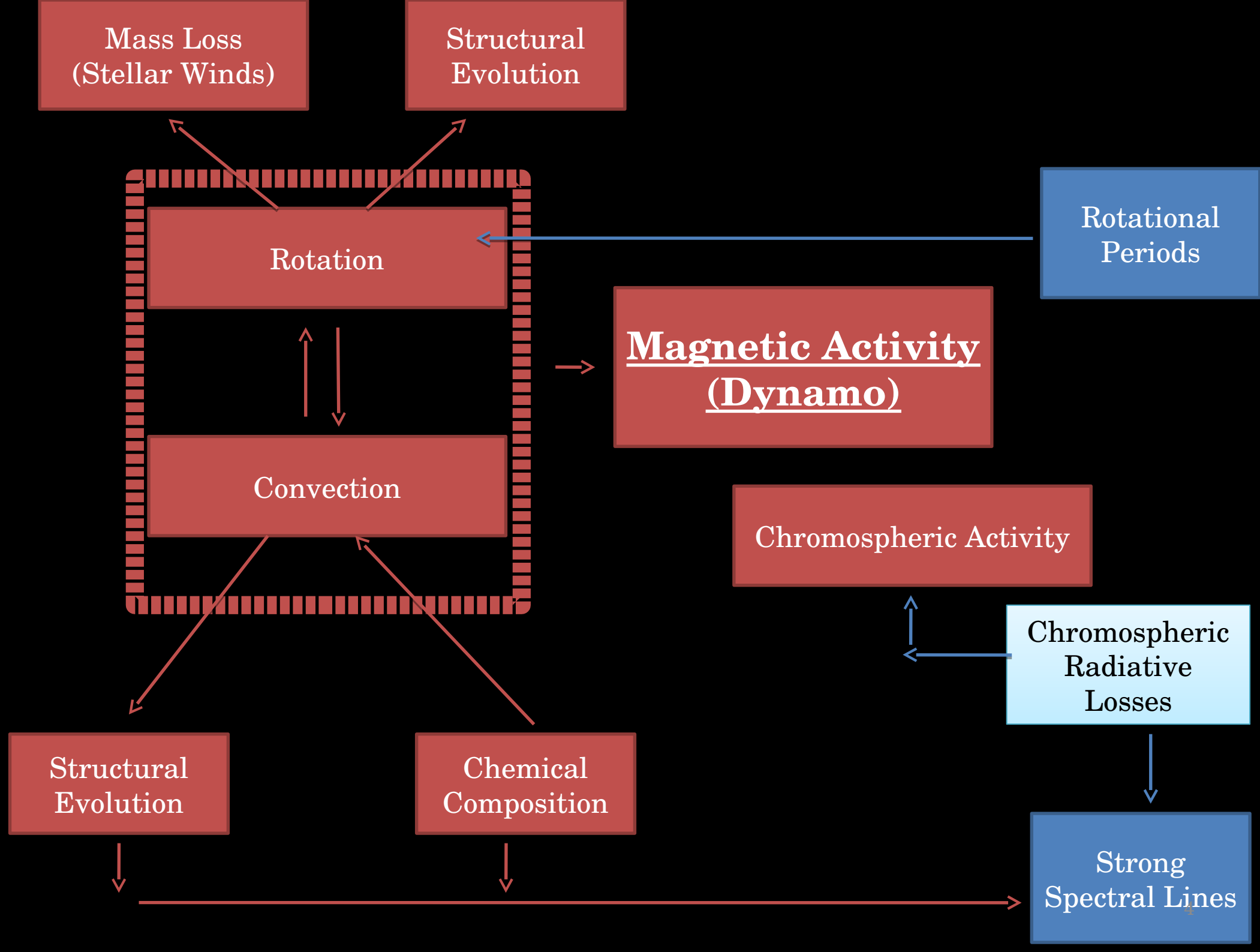
In some recent work (Wilson 1962) it was noted, among other things, that H and K reversals are very much more nearly universal among main-sequence stars in the Hyades Cluster than among similar stars of the same spectral types in the local field.

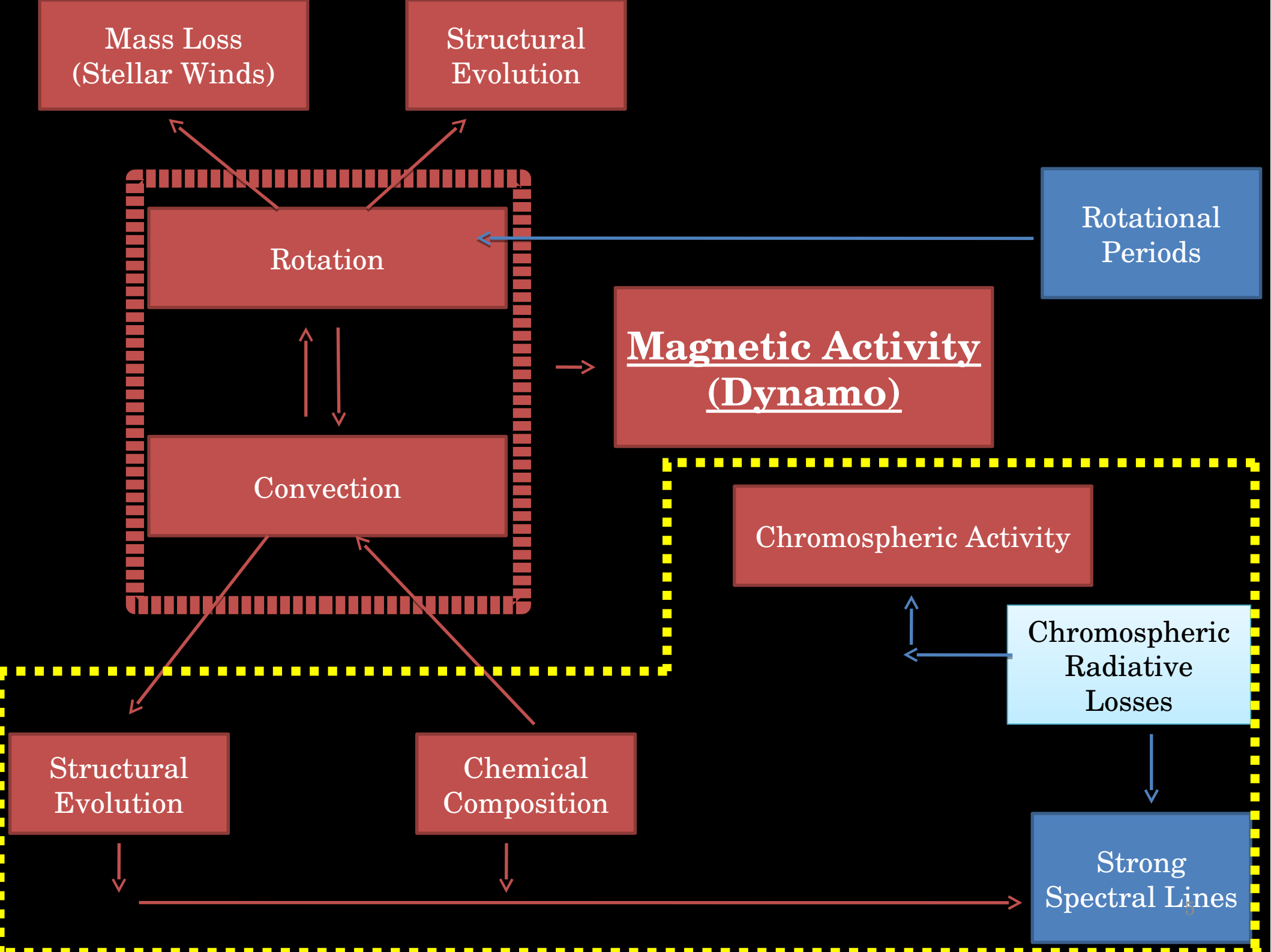
Wilson, O. C (1963)



Age-Activity Relations



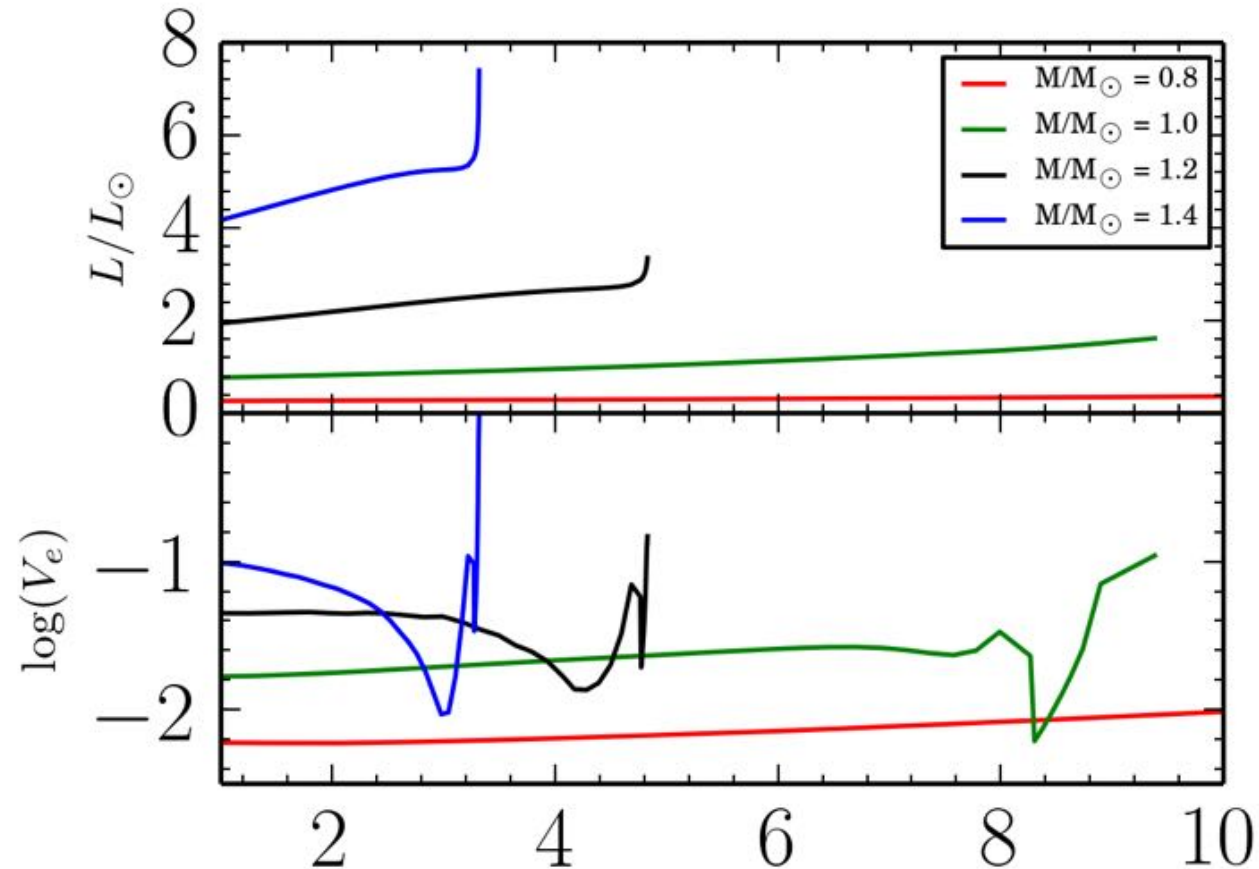




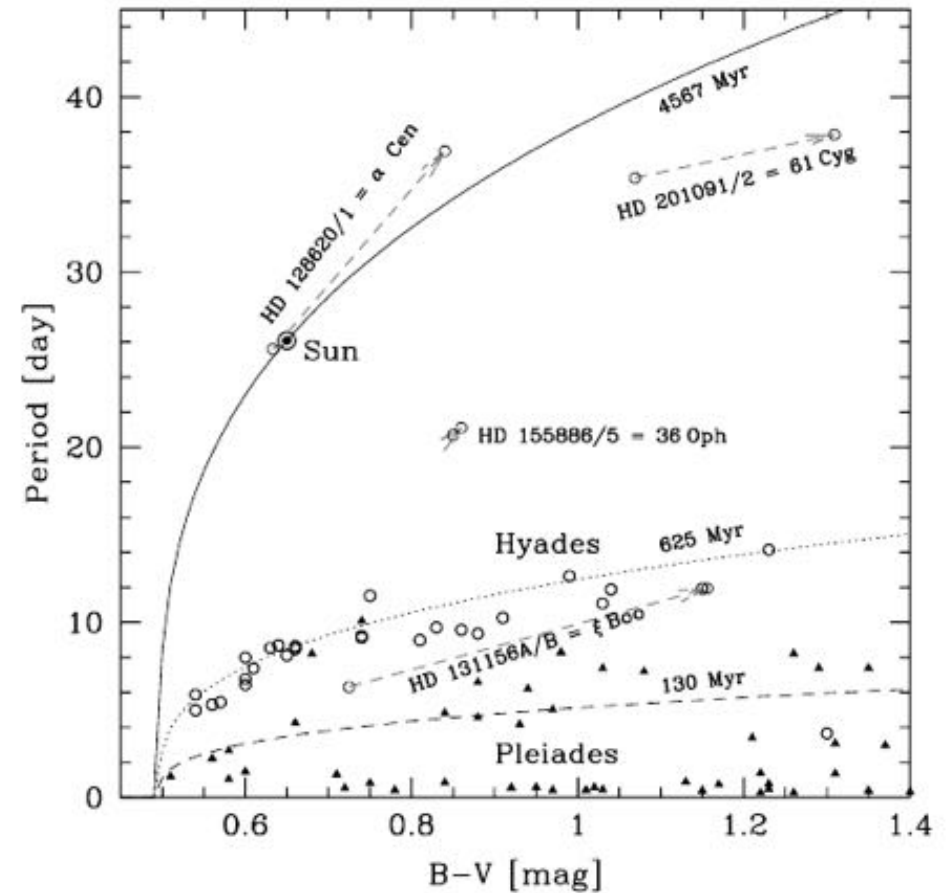
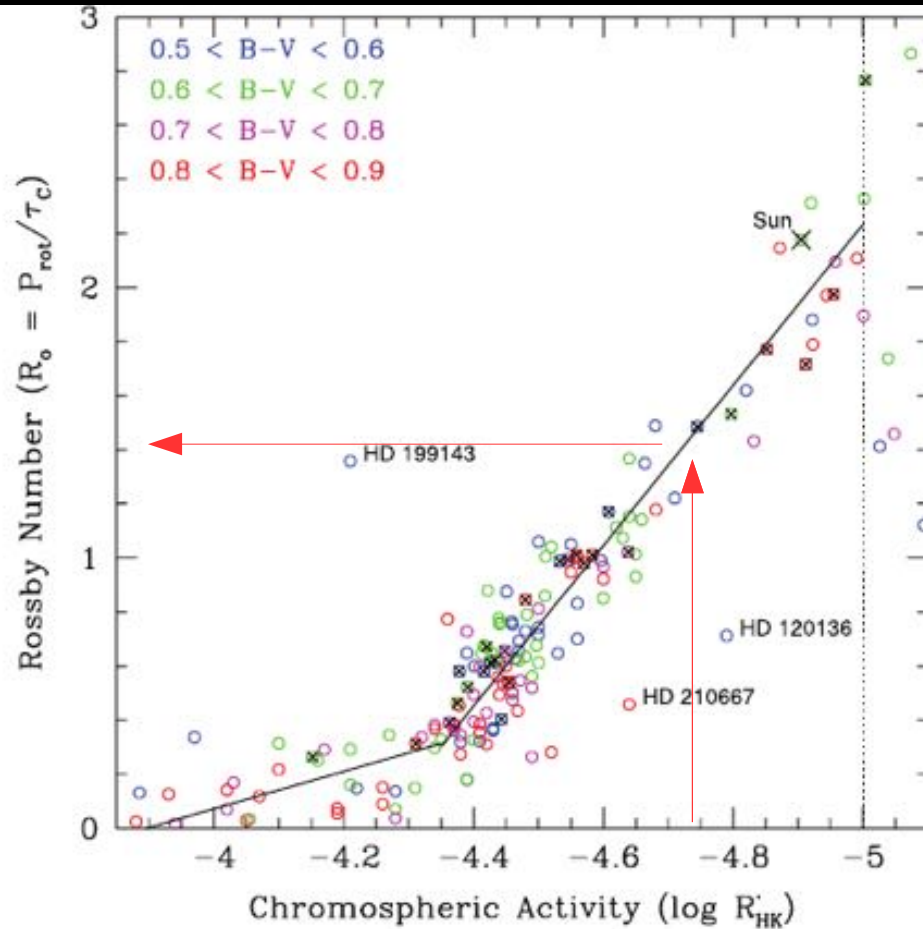
Stellar Ages: Age-Dating Methods

- ✓ Seismology (Chaplin & Miglio 2013)
- ✓ Rotation (Barnes 2007)
- ✓ Isochrones (Pont & Eyer 2004)
- ✓ Magnetic (Mamajek & Hillenbrand 2008)
- ✓ Kinematics (Rocha-Pinto et al. 2004)
- ✓ Chemical (Spina et al. 2016)

And others...



Age-Mass(Color)-Activity Relations



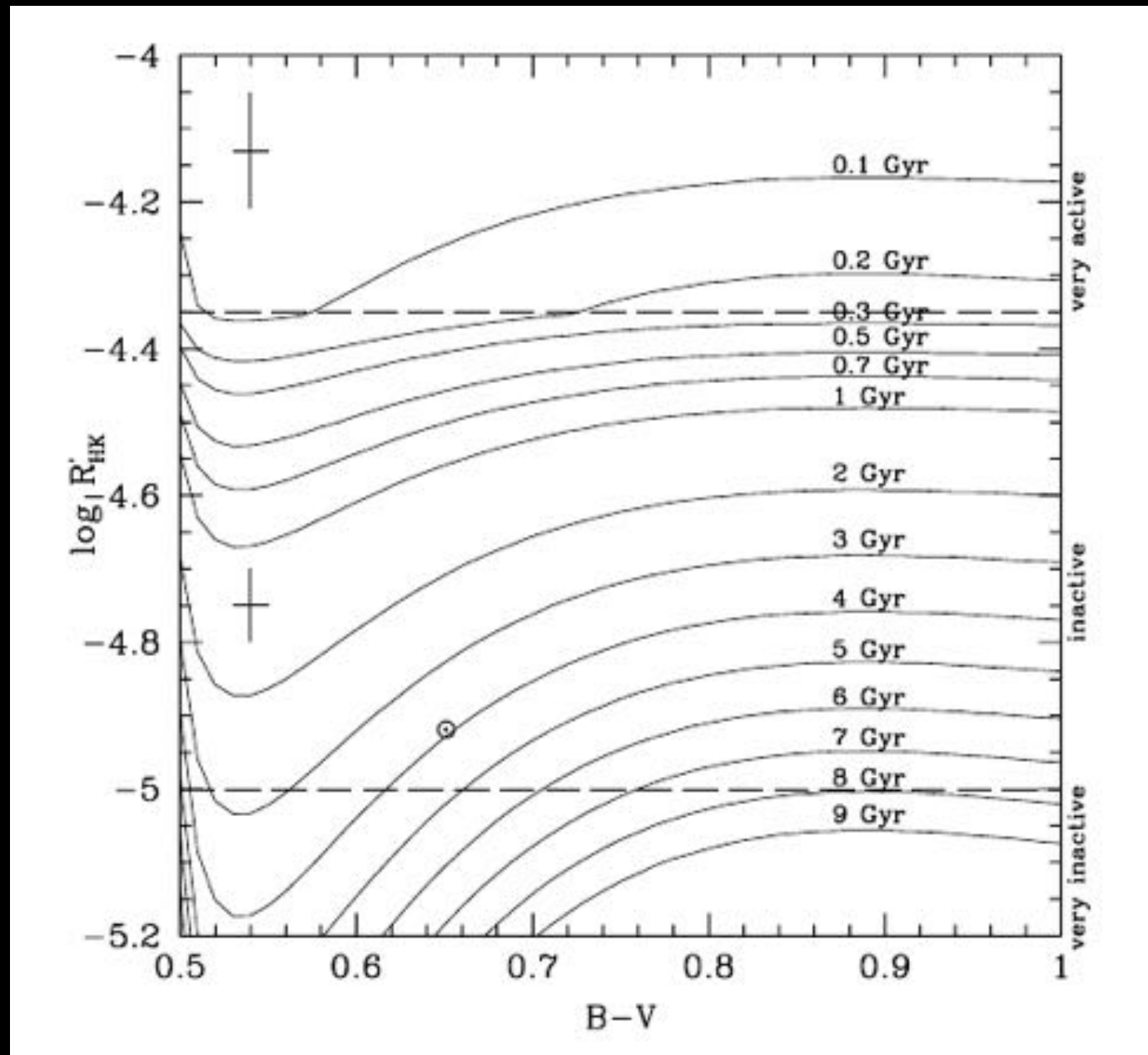
Activity \rightarrow Rossby \rightarrow Prot

$$P(B-V, t) = f(B-V)g(t),$$

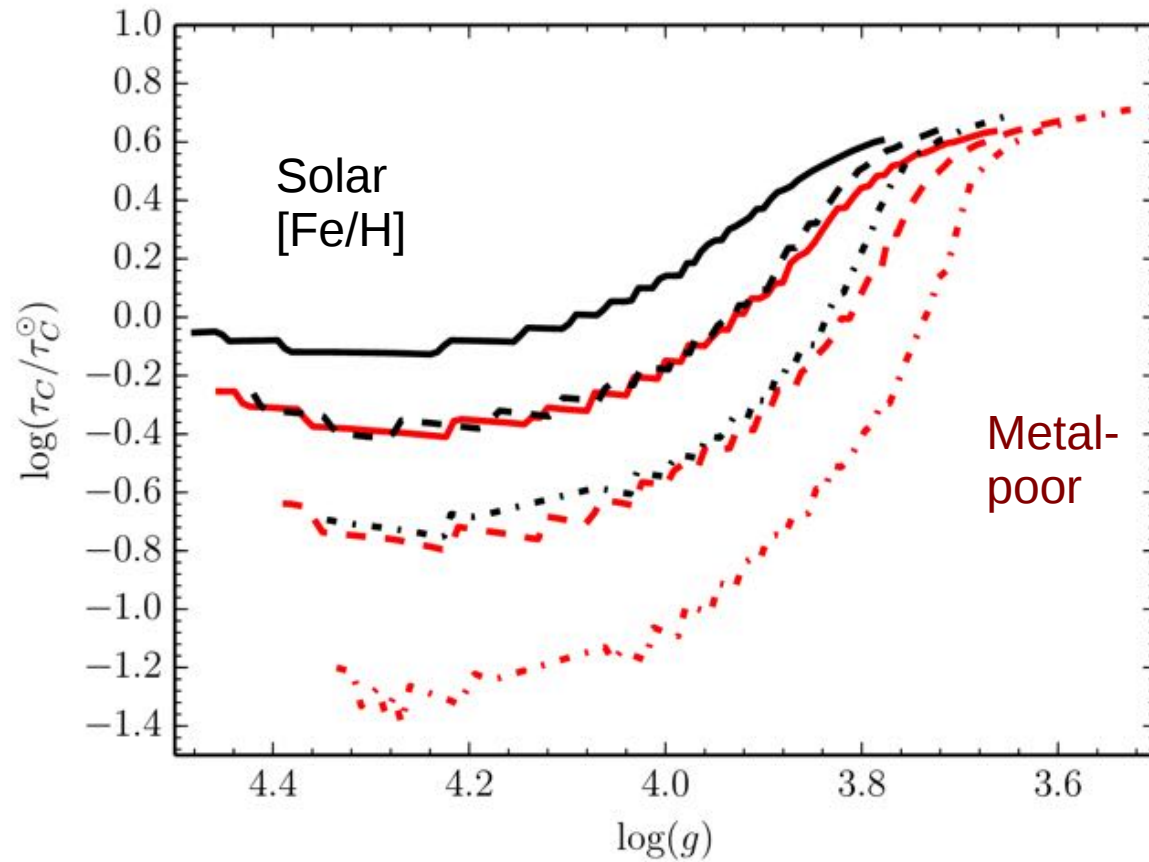
$$f(B-V) = a[(B-V)_0 - c]^b,$$

$$g(t) = t^n.$$

Age-Mass(Color)-Activity Relations



Age-Mass(Color)-Activity Relations



Chromospheric Indicators

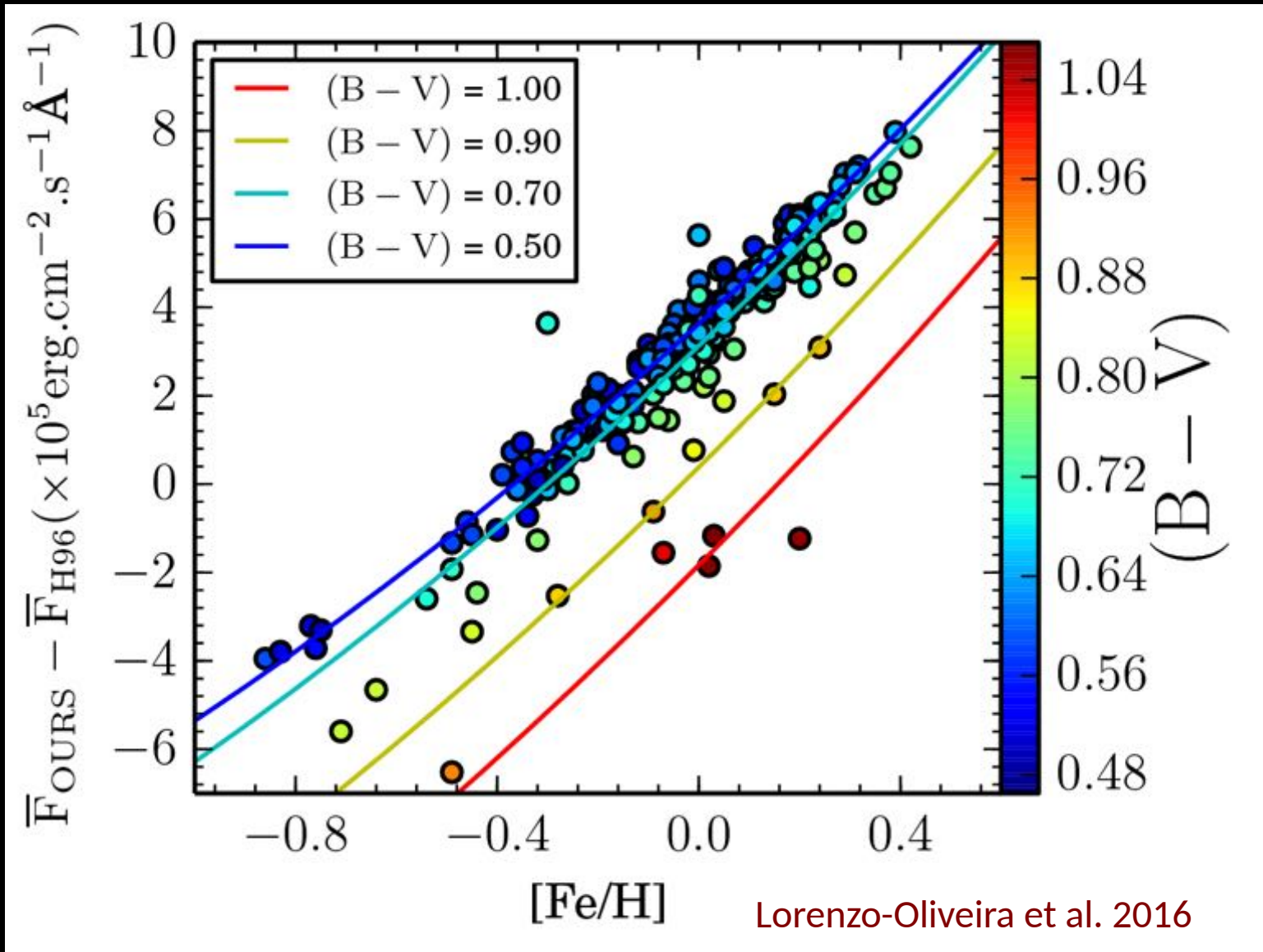
Fluxes (erg/cm²/s)

Strong Spectral Lines
(Ca II, Balmer lines, Na I, He I ...)

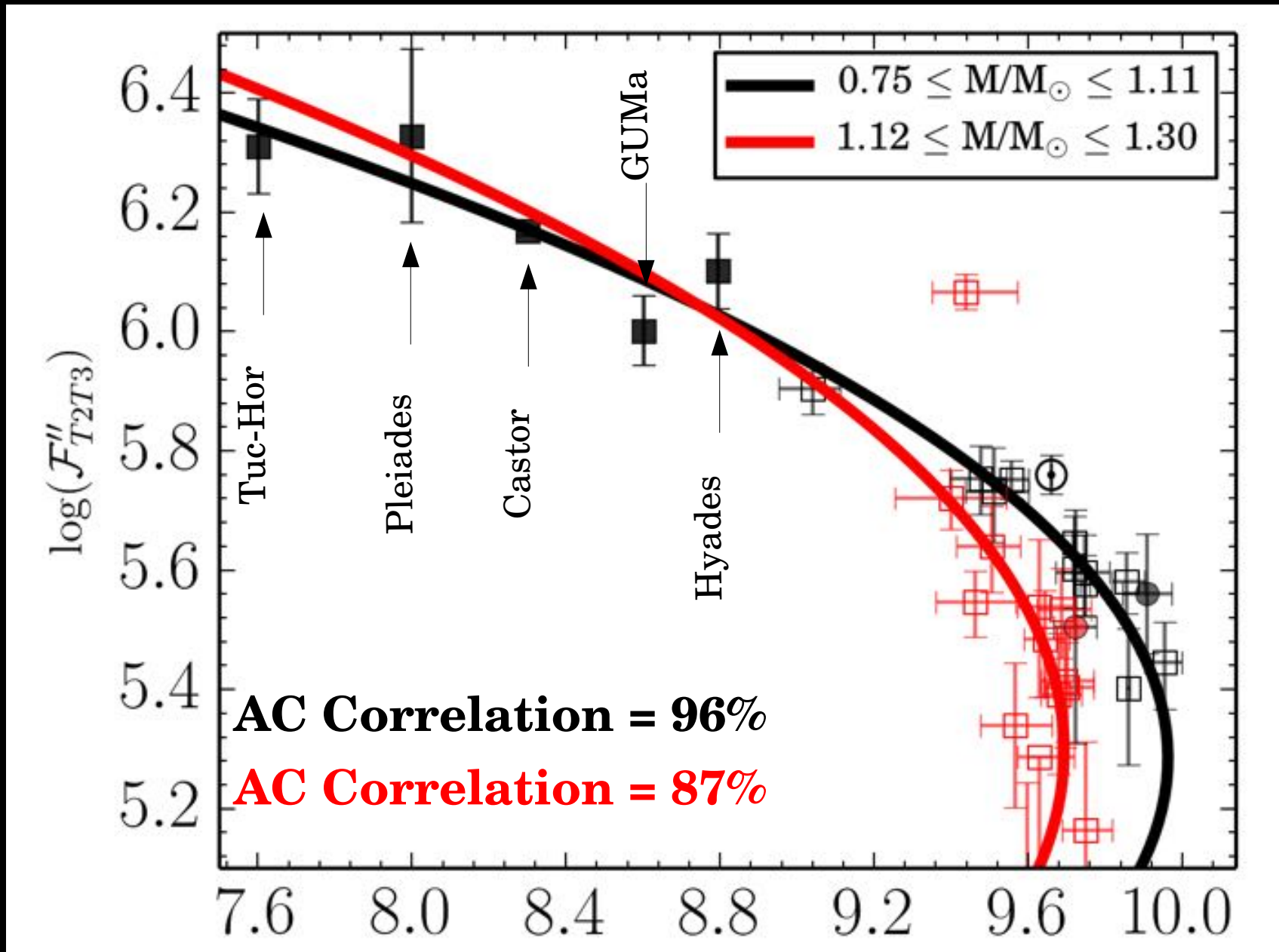
Chemical composition + T_{eff} + $\log(g)$

“Metallicity Blind” Chromospheric Indices

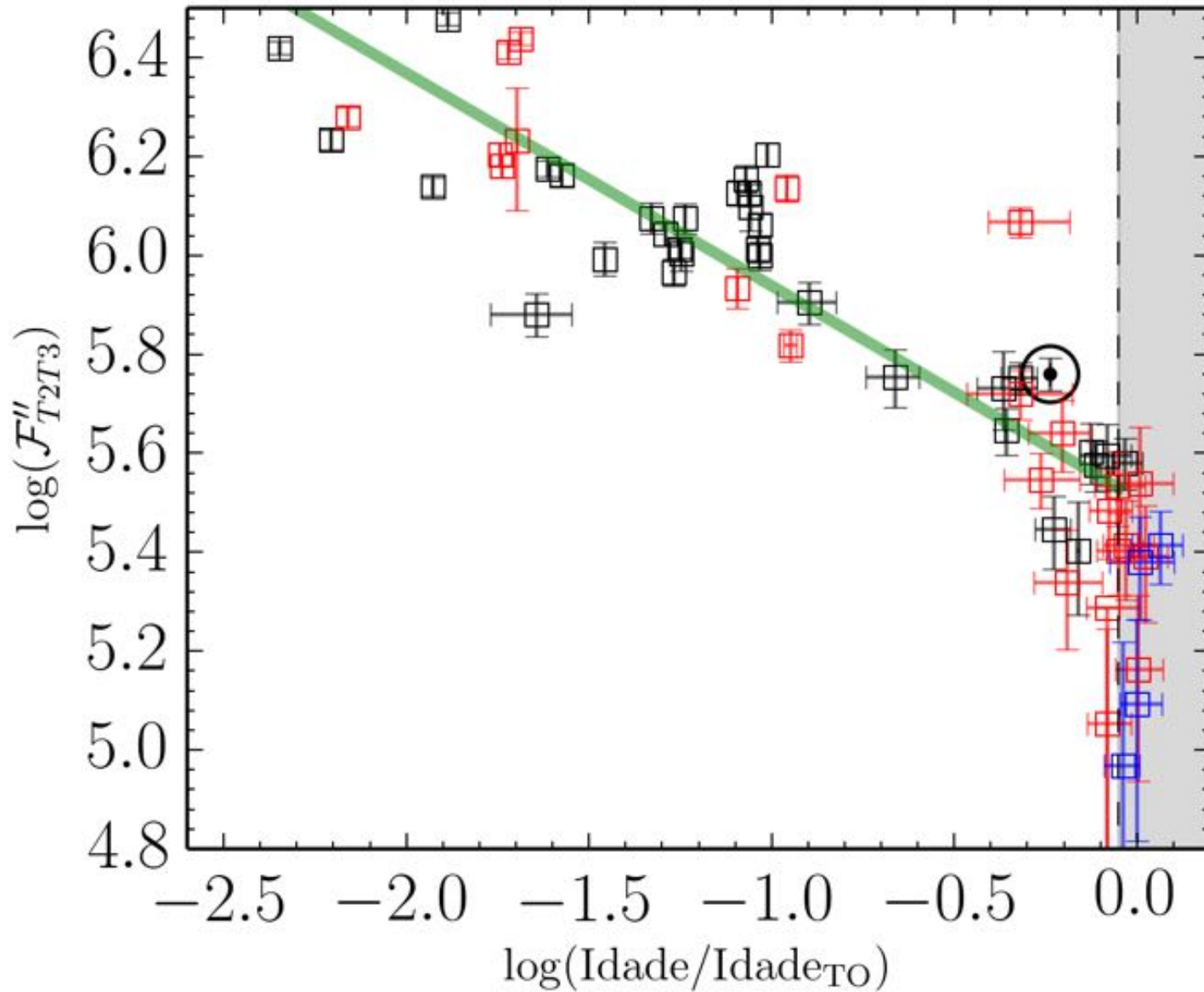
Near-infrared
continuum fluxes (around Ca II IRT lines)



The Age-Activity Relation (NIR)

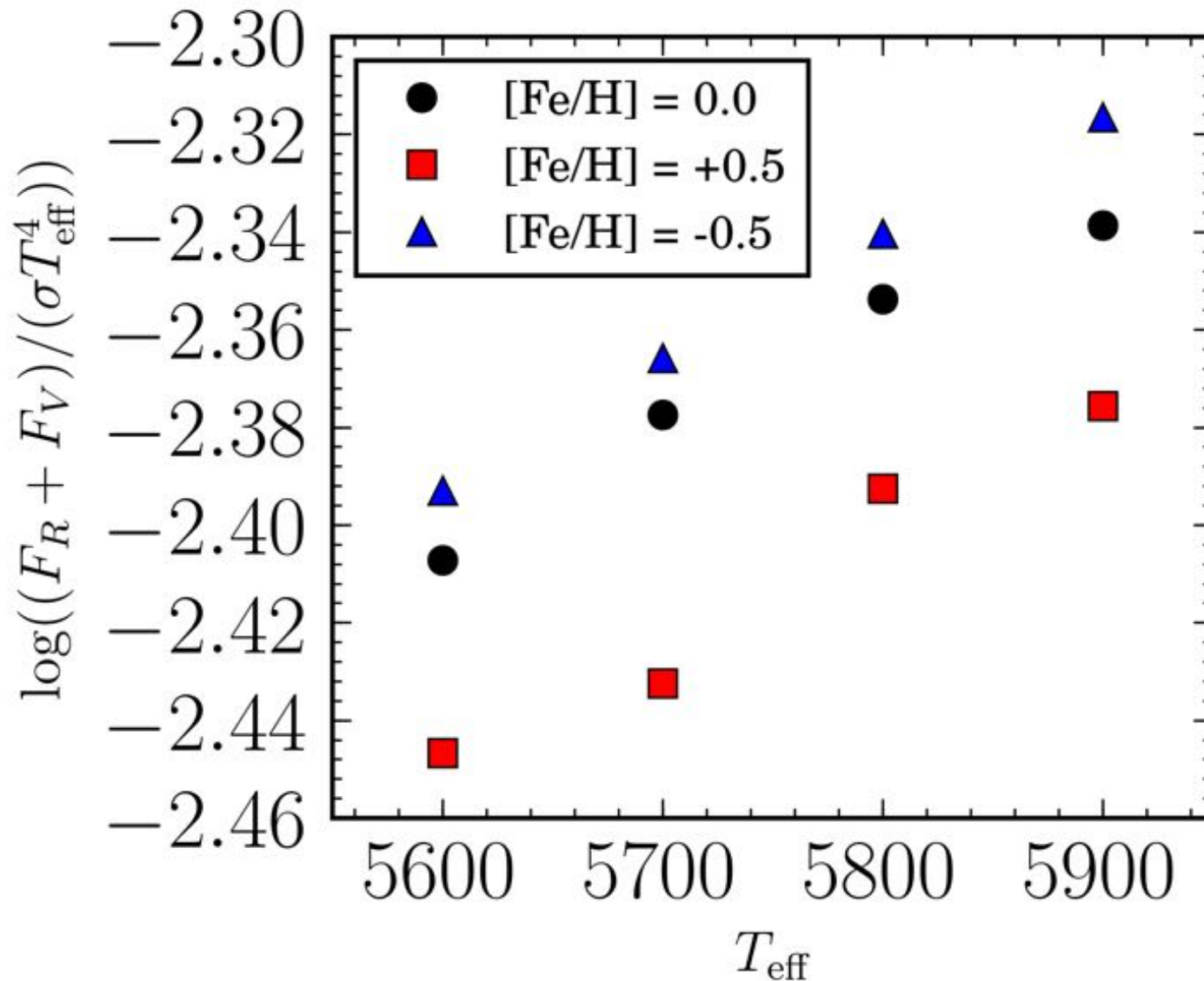


Activity(NIR)-Evolutionary State



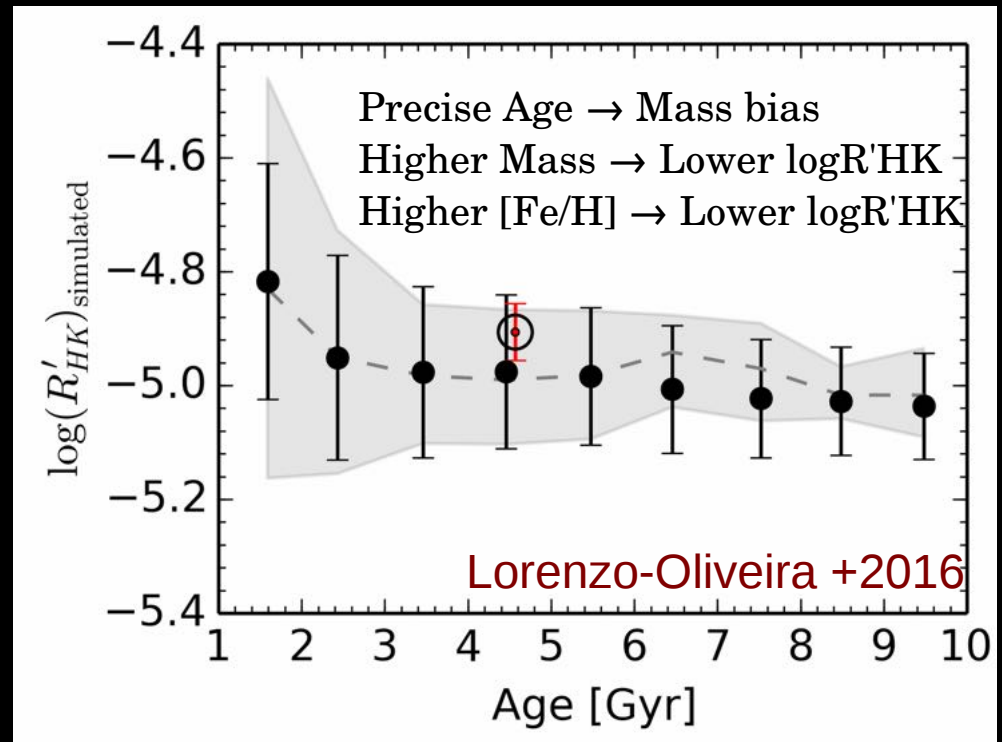
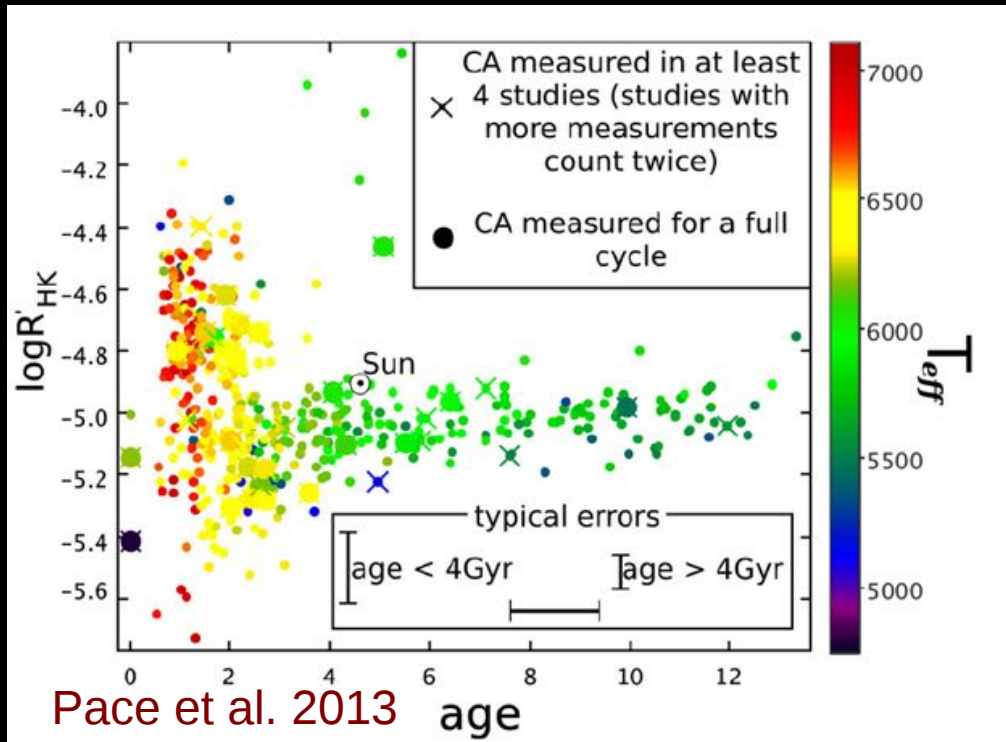
“Metallicity Blind” Chromospheric Indices

UV continuum fluxes (around Ca II H&K lines)



Lack of Evolution?

Age-mass-[Fe/H]-Activity Relation



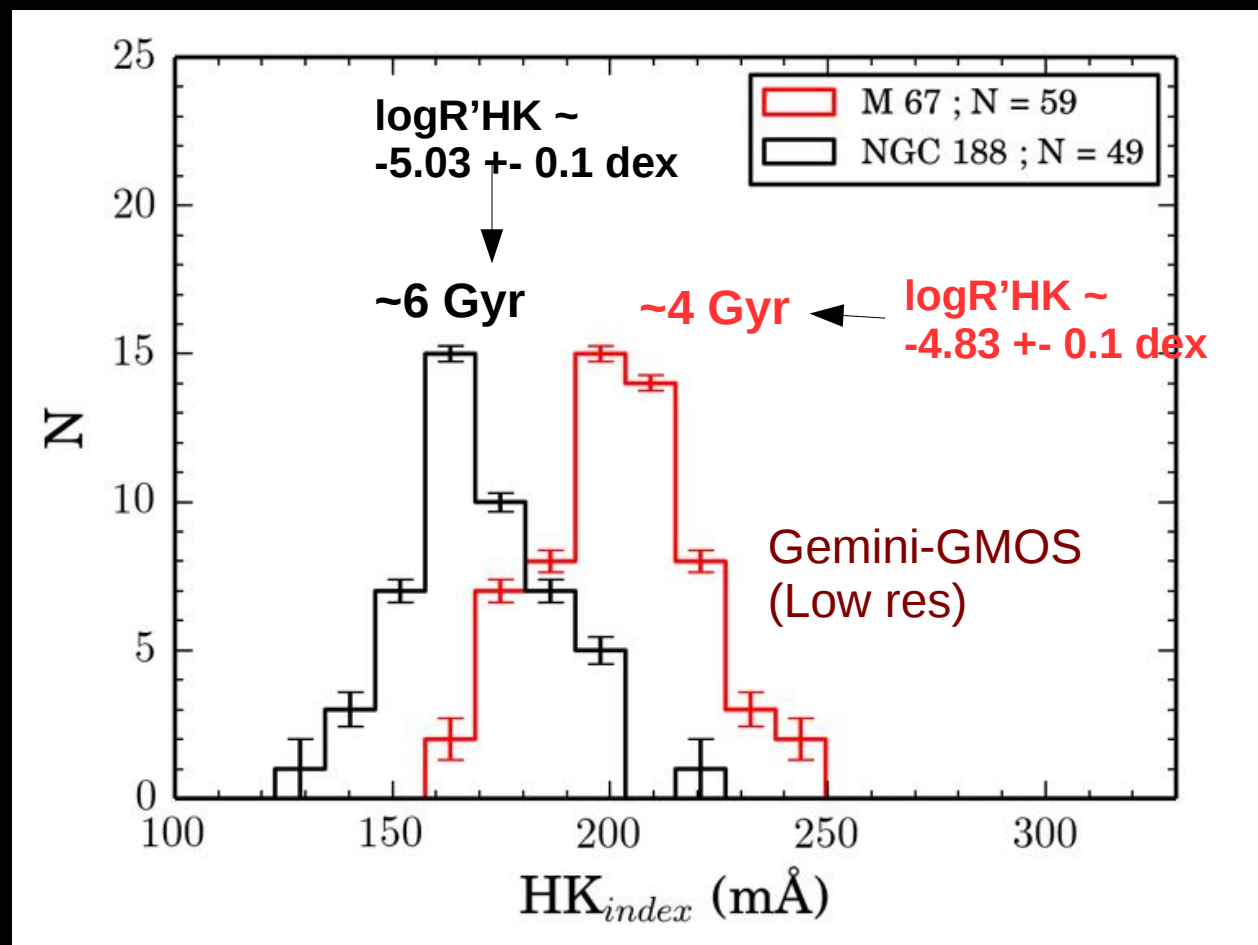
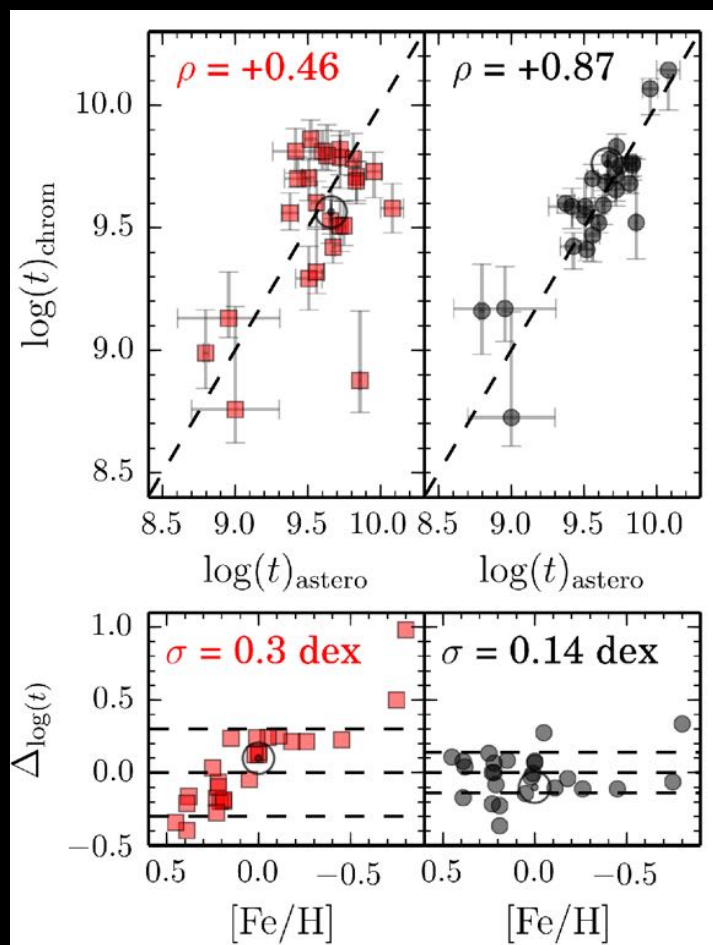
Selection effects.

Age \rightarrow mass bias (younger stars are more massive)

Higher [Fe/H] \rightarrow lower $\log R'_{HK}$ \rightarrow older chrom. age

Lower [Fe/H] \rightarrow higher $\log R'_{HK}$ \rightarrow younger chrom. age

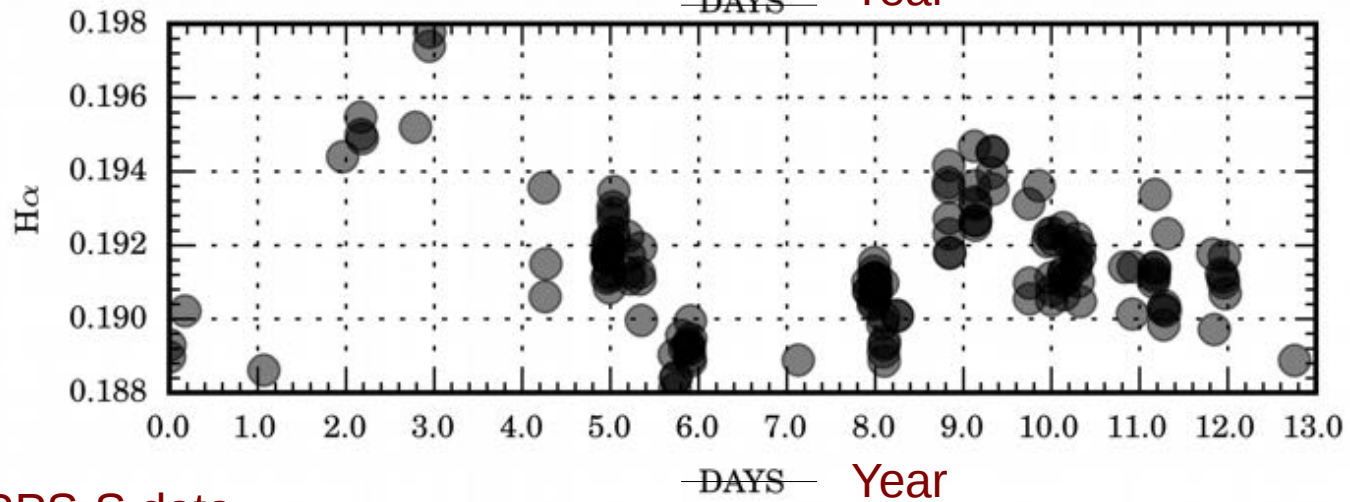
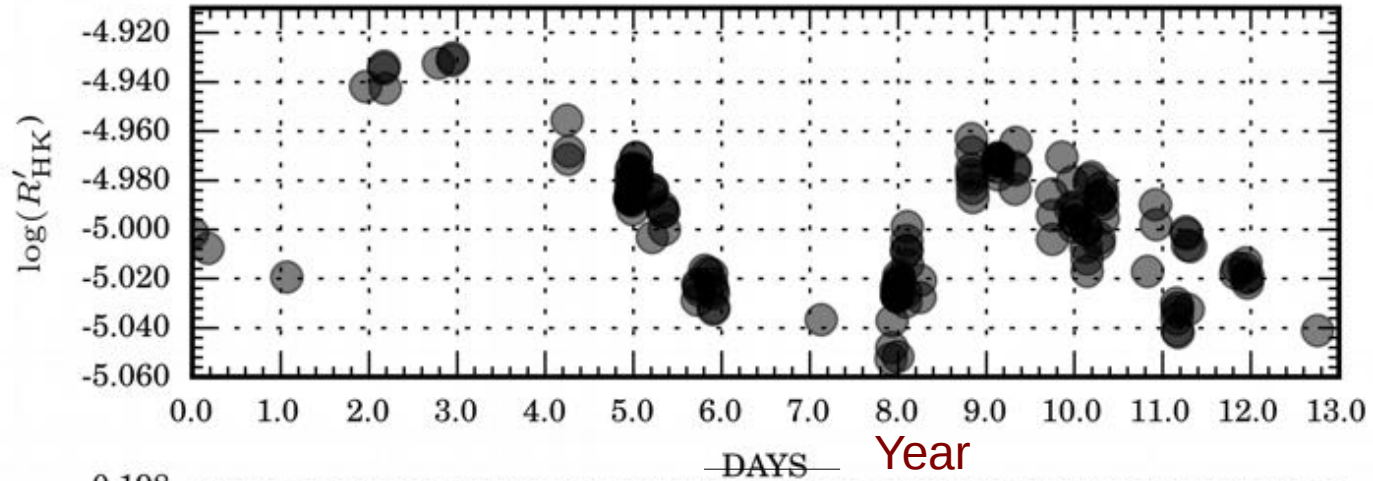
Asteroseismology & Open Clusters



Lorenzo-Oliveira, Porto de Mello & Schiavon 2016

Activity Evolution of Solar Twins (magnetic cycle)

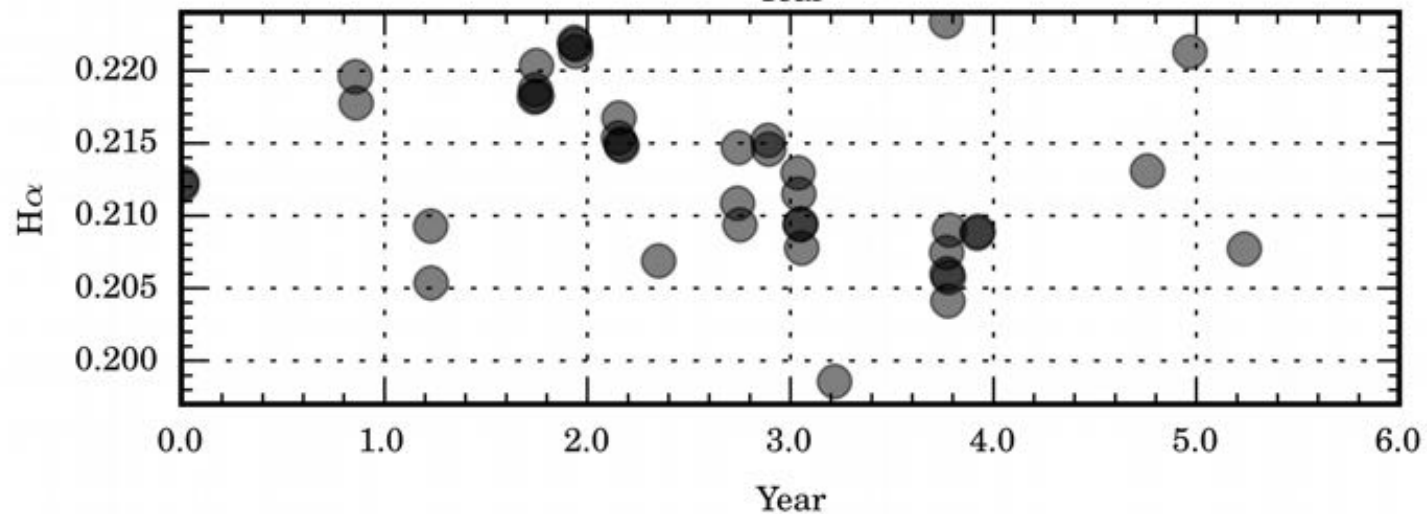
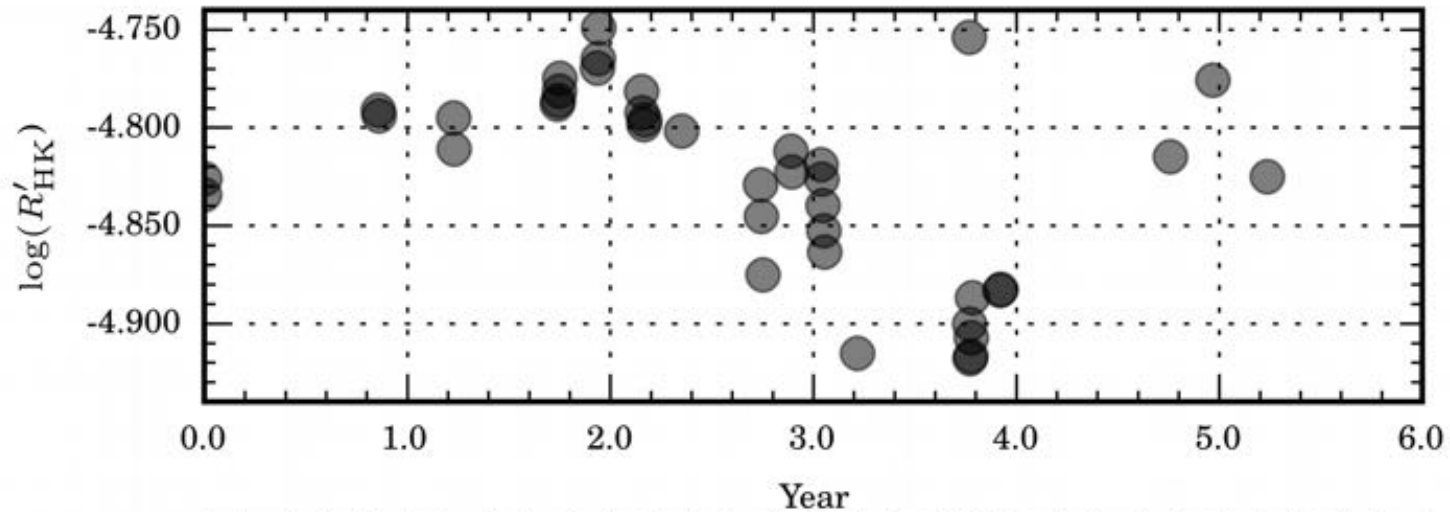
HIP79672: $t = 4.2[-0.5,+0.3]$ timespan = 12.8 years



HARPS-S data

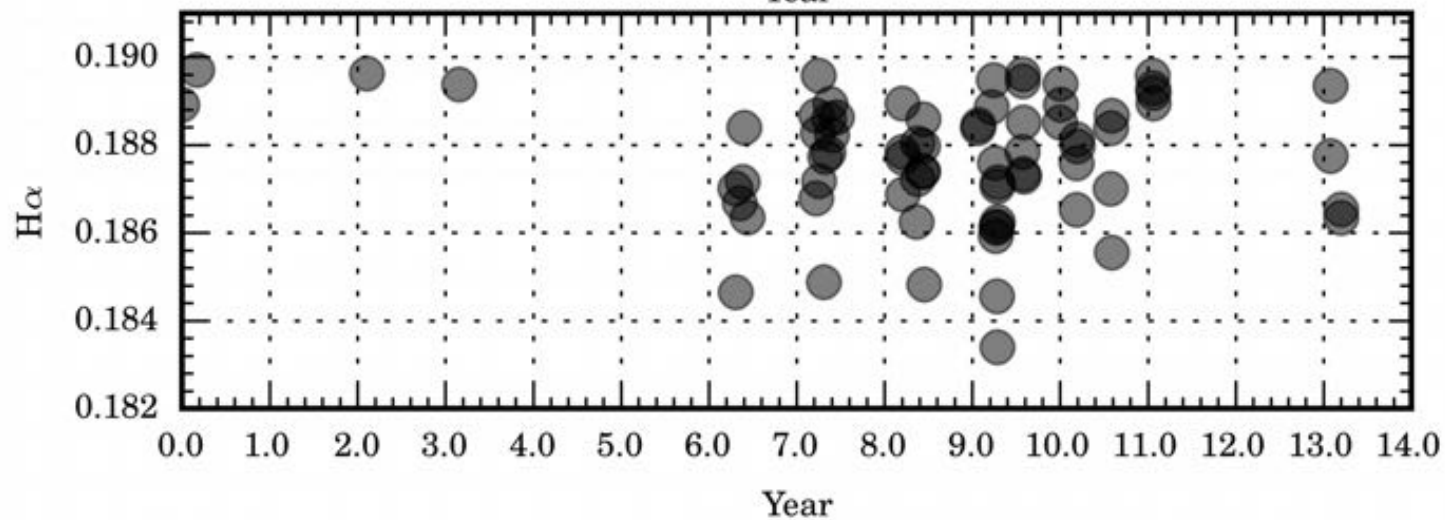
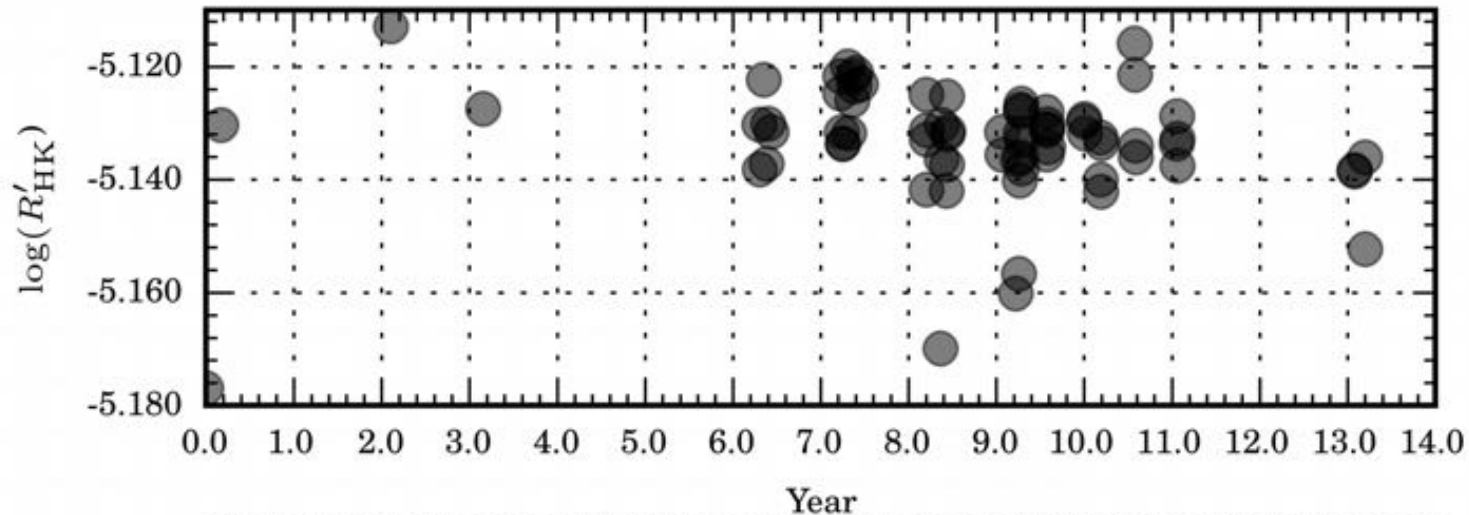
Activity Evolution of Solar Twins (magnetic cycle)

HIP10175: $t = 3.1[-0.3,+0.4]$ timespan = 5.2 years



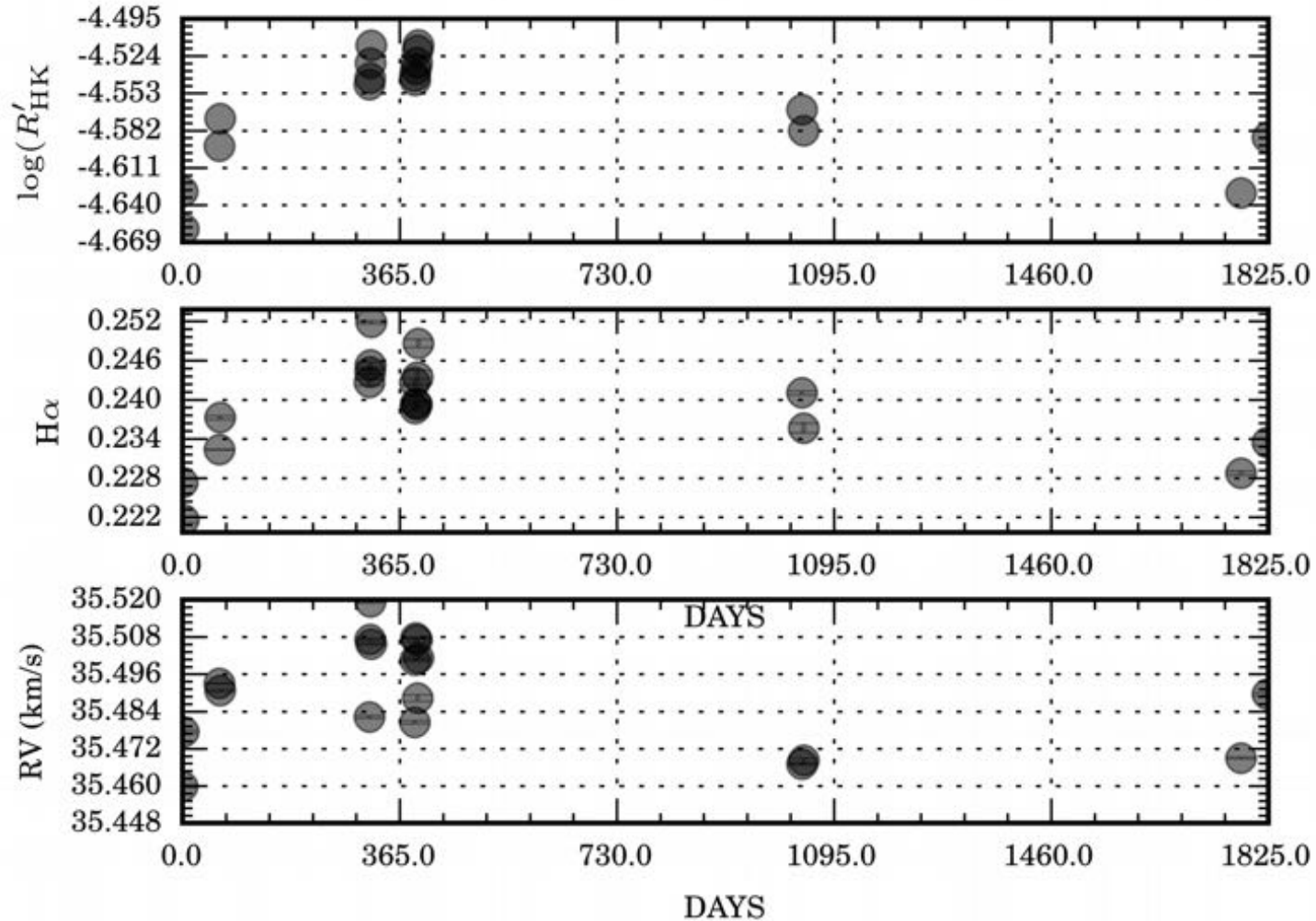
Activity Evolution of Solar Twins (magnetic cycle)

HIP54287: $t = 6.5[-0.4,+0.3]$ timespan = 13.2 years

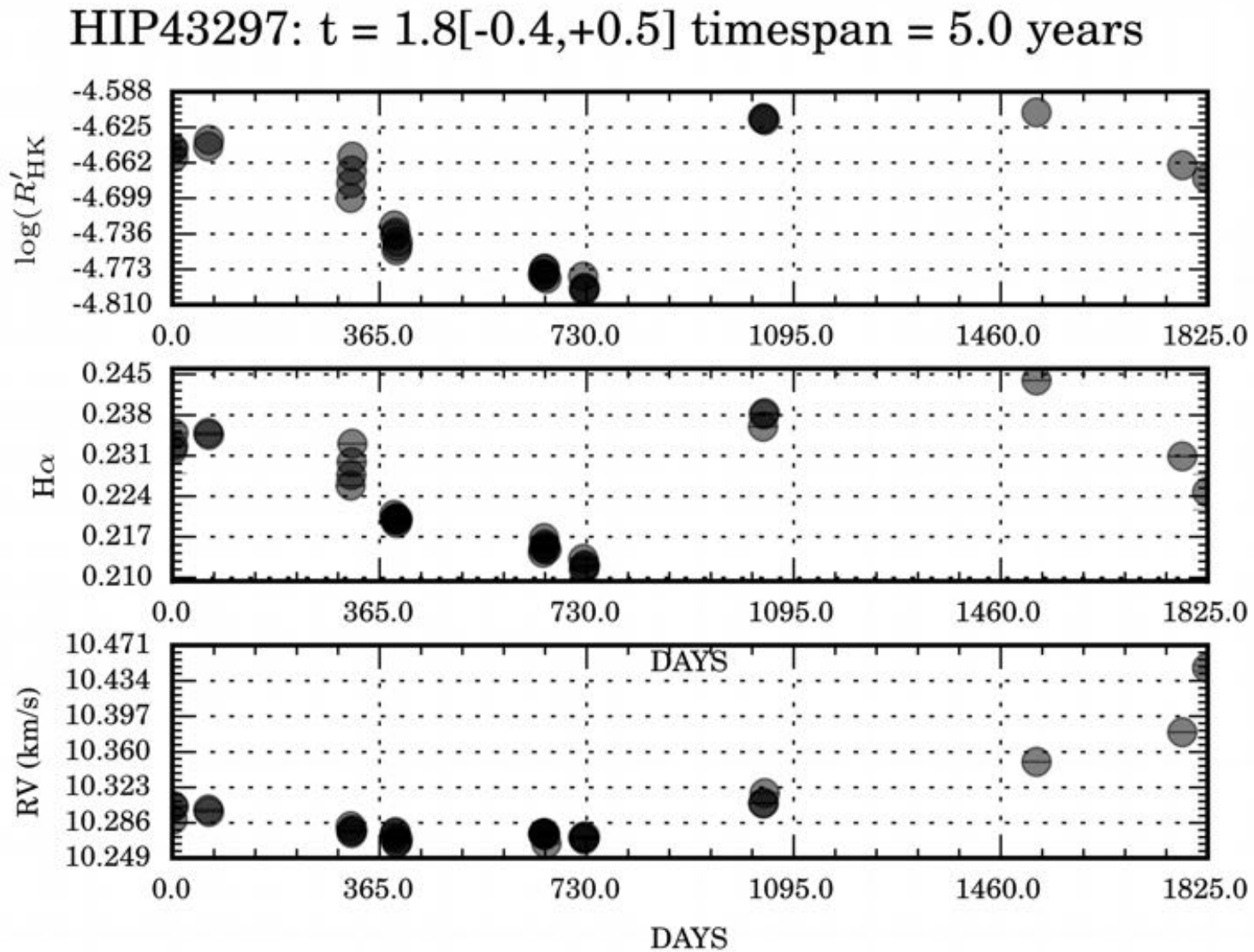


Activity Evolution of Solar Twins (magnetic cycle)

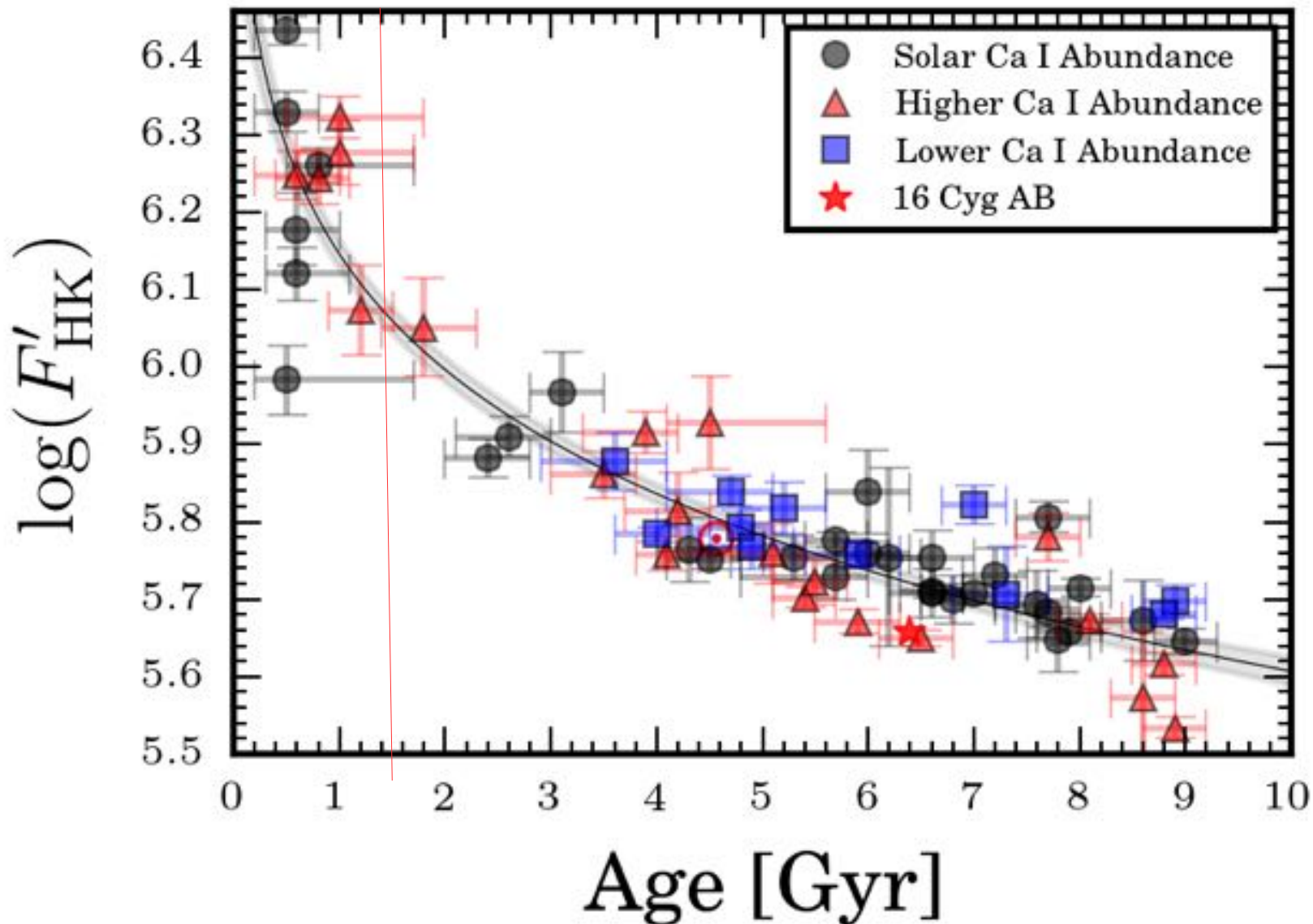
HIP42333: $t = 1.0[-0.4, +0.7]$ timespan = 5.0 years



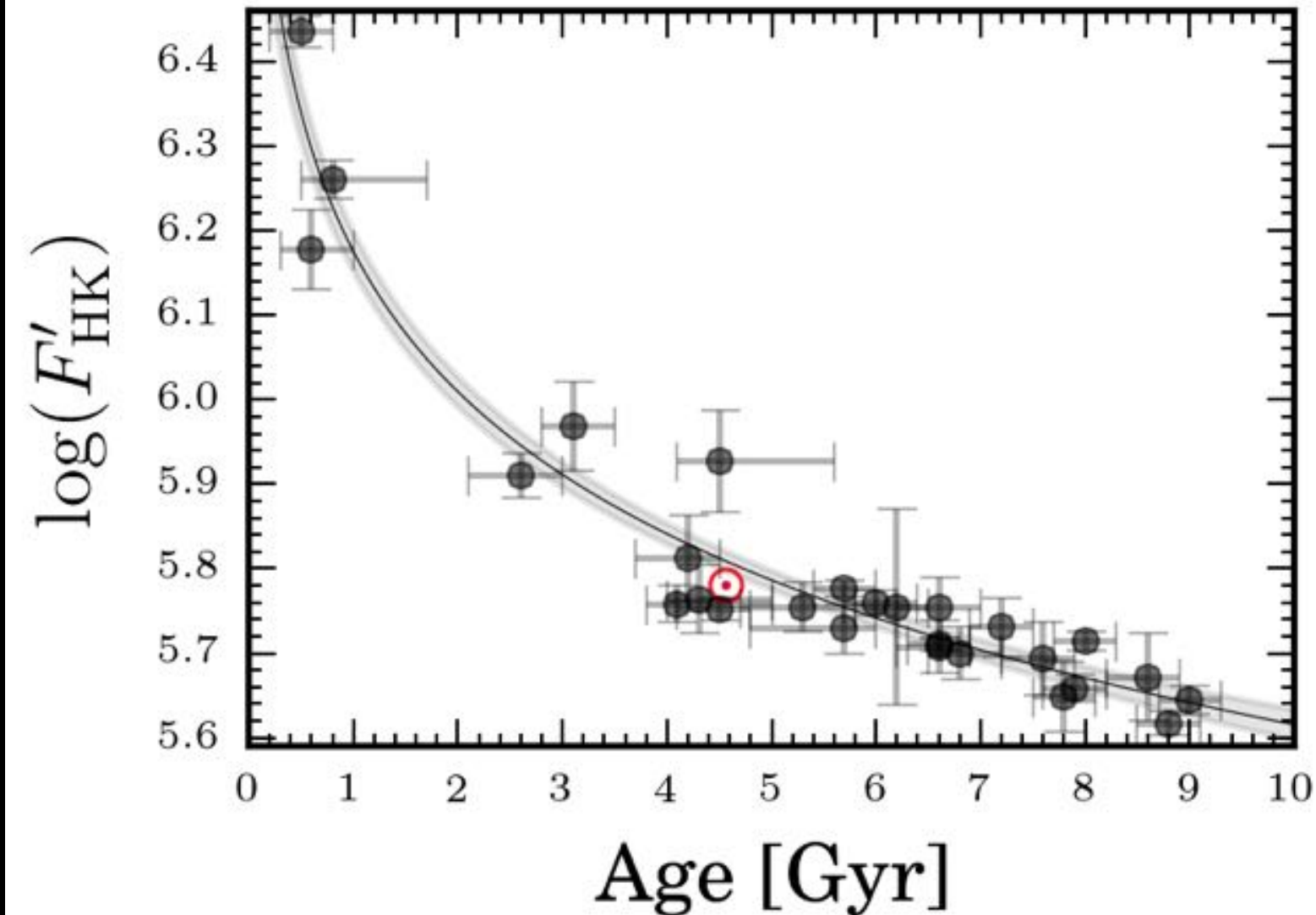
Activity Evolution of Solar Twins (magnetic cycle)



Activity Evolution of Solar Twins (Secular)

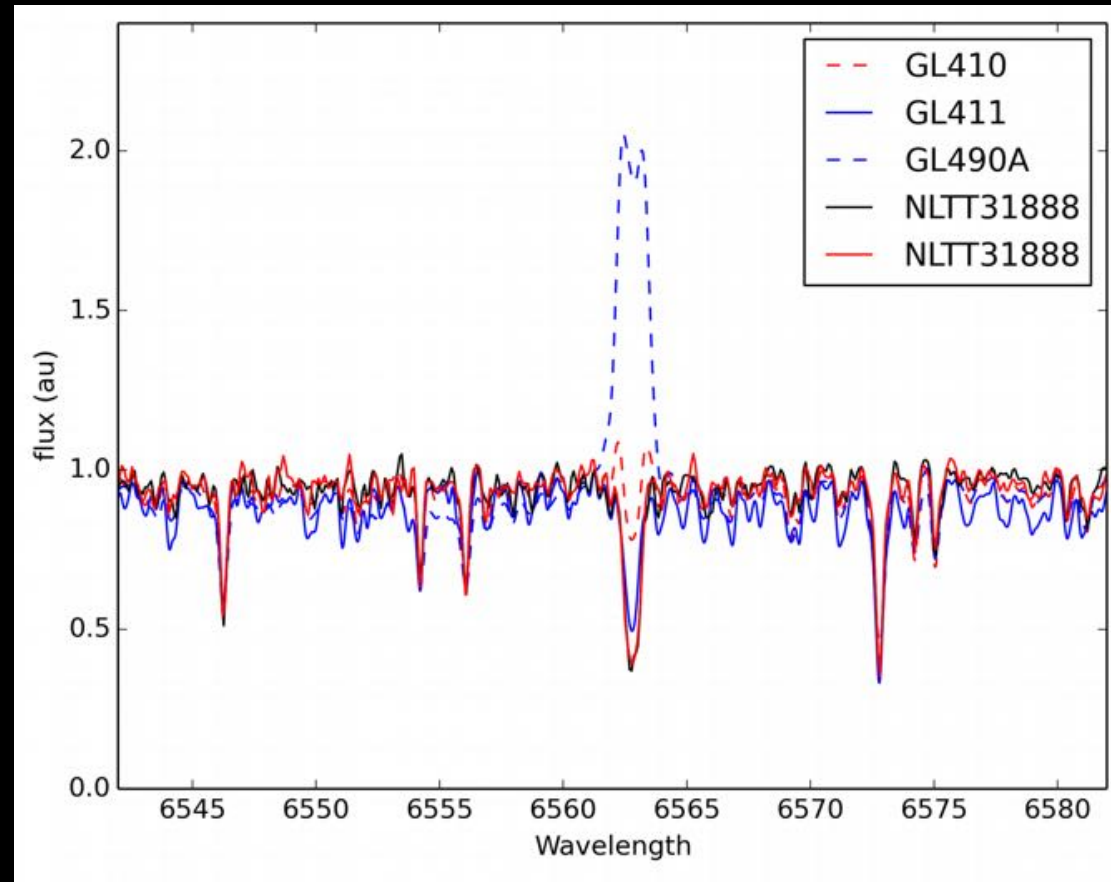


Activity Evolution of Solar Twins (Secular)

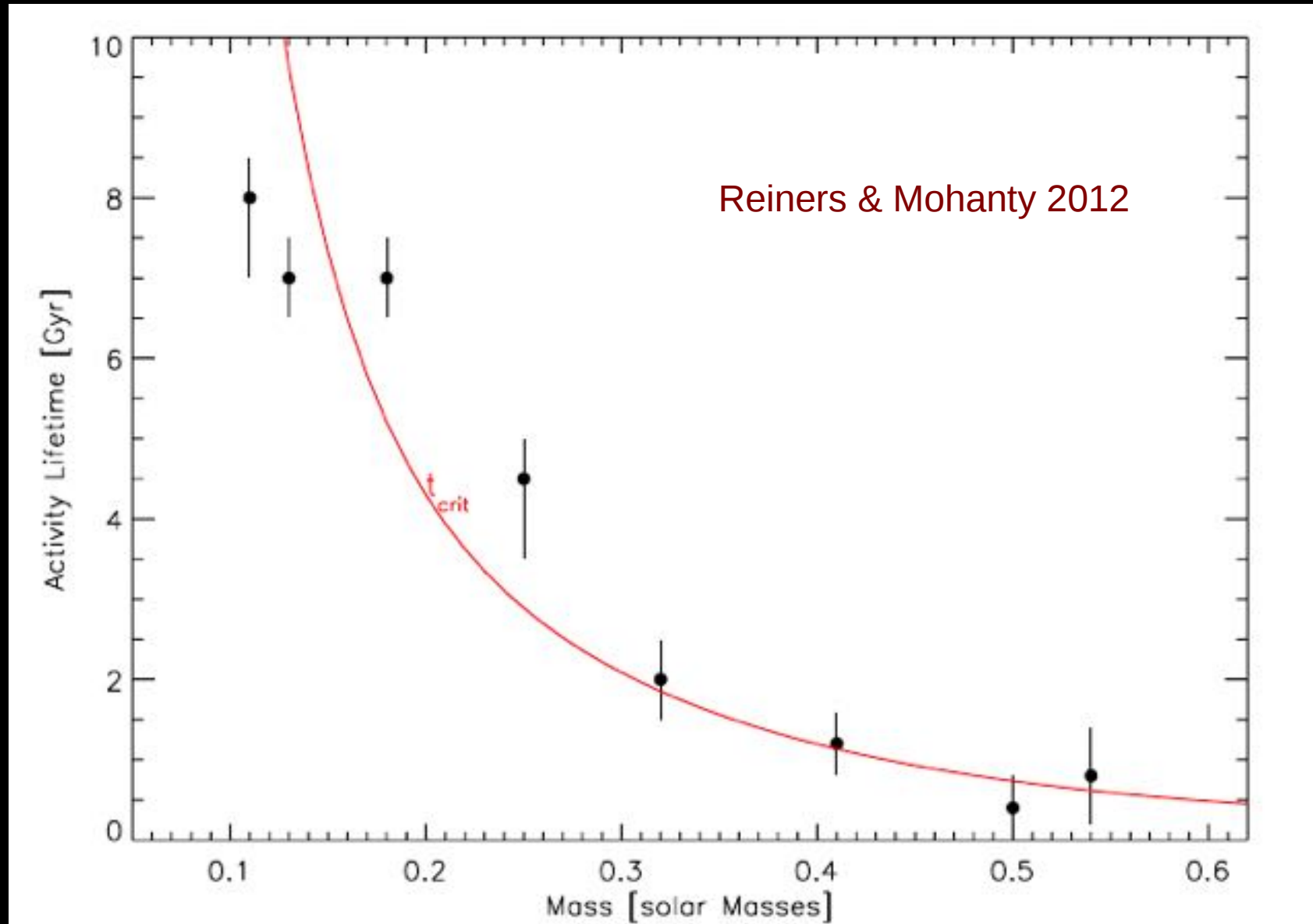


Chromospheric Activity: M Stars

- ✓ No chromospheric activity evolution picture.
- ✓ Lack of stars with known age.
- ✓ Lack of spectroscopic information & accurate distances
- ✓ Fainter and smaller than FGK stars.
- ✓ More complex rotational and magnetic evolution.

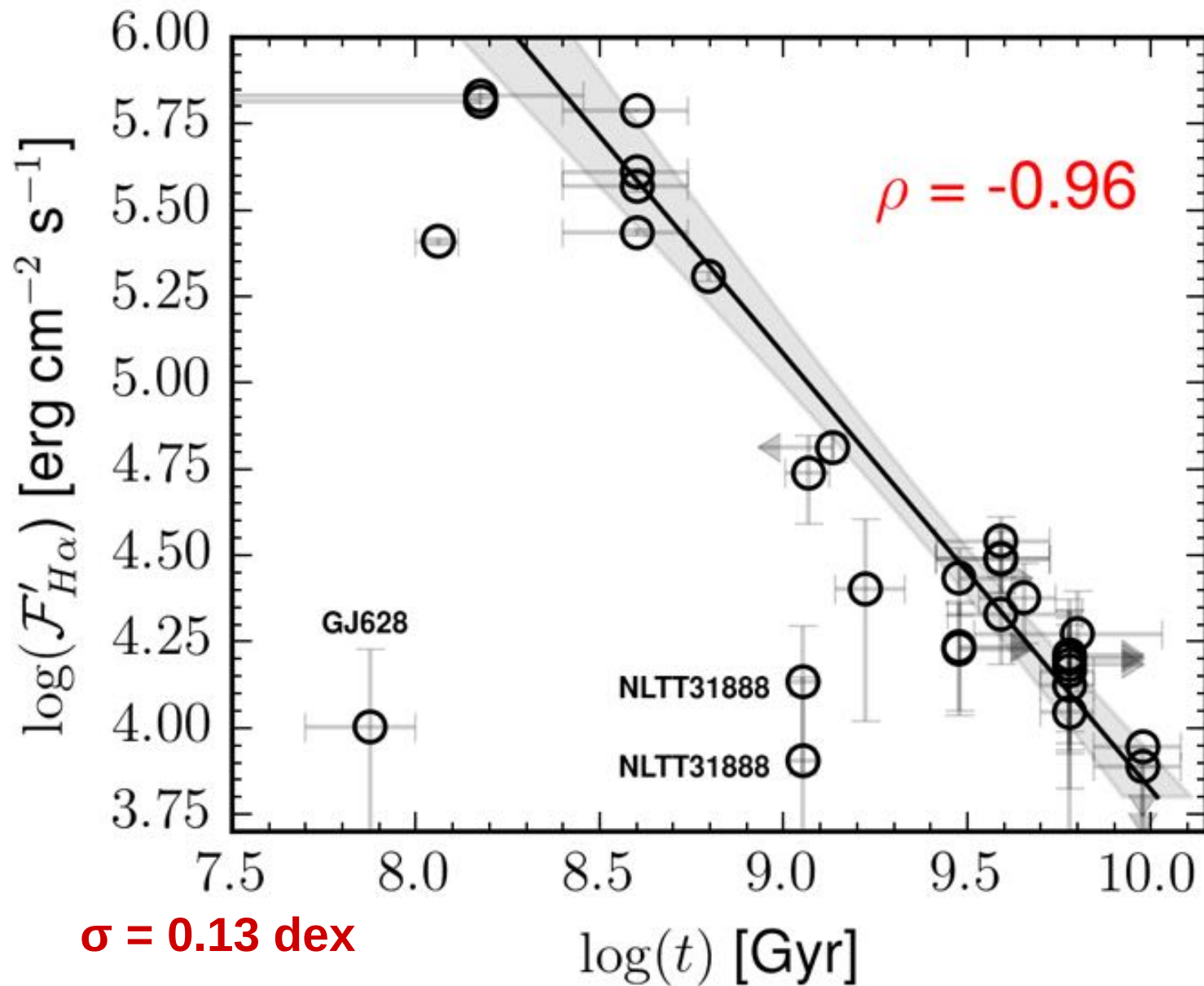


Activity Timescale

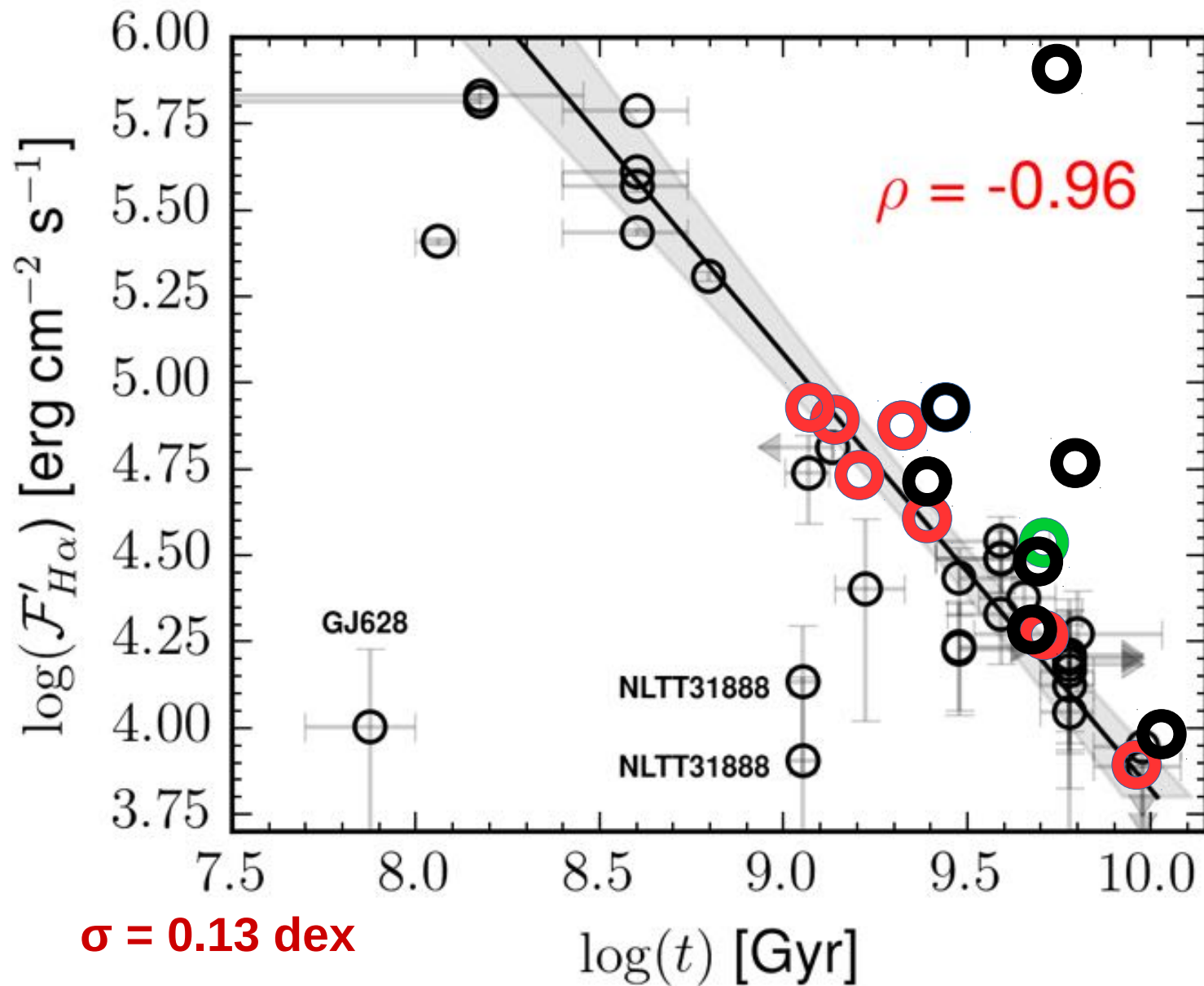


- Proxima b (4.8 Gyr) → 10x FUV radiation & 250x X-rays than Earth (Ribas et al. 2016)
- Kapteyn (11 Gyr) → 1.7x Ly α & 20x X-rays than Earth (Guinan, Engle & Durbin 2016)

M Stars: H α AC Relation



M Stars: H α AC Relation



M Stars: H α Ages

