
HIGH-RESOLUTION SPECTRAL POPULATION MODELS FOR SOLAR AND α -ENHANCED RATIOS

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Fine Tunning Stellar Population Models - Leiden - June 2006



INTRO: SED MODELS WITH THEORETICAL LIBRARIES

- SED models built with synthetic libraries are well known, and often made use of Lejeune et al. (1998, 1998) and Westera et al. (2000) low resolution flux distributions.
- Recently many high resolution spectral libraries were made available
 - Bertone et al. (2003), [Brott & Hauschildt \(2005\)](#), [Coelho et al. \(2005\)](#), [Gustafsson et al. \(2005\)](#), Martins et al. 2004, [Munari et al. \(2005\)](#), Rodriguez-Merino et al. 2005;
- and some high-res. SED models are being computed (Gonzalez-Delgado et al. 2004).



INTRO:

THE α -ENHANCEMENT AND SEDS

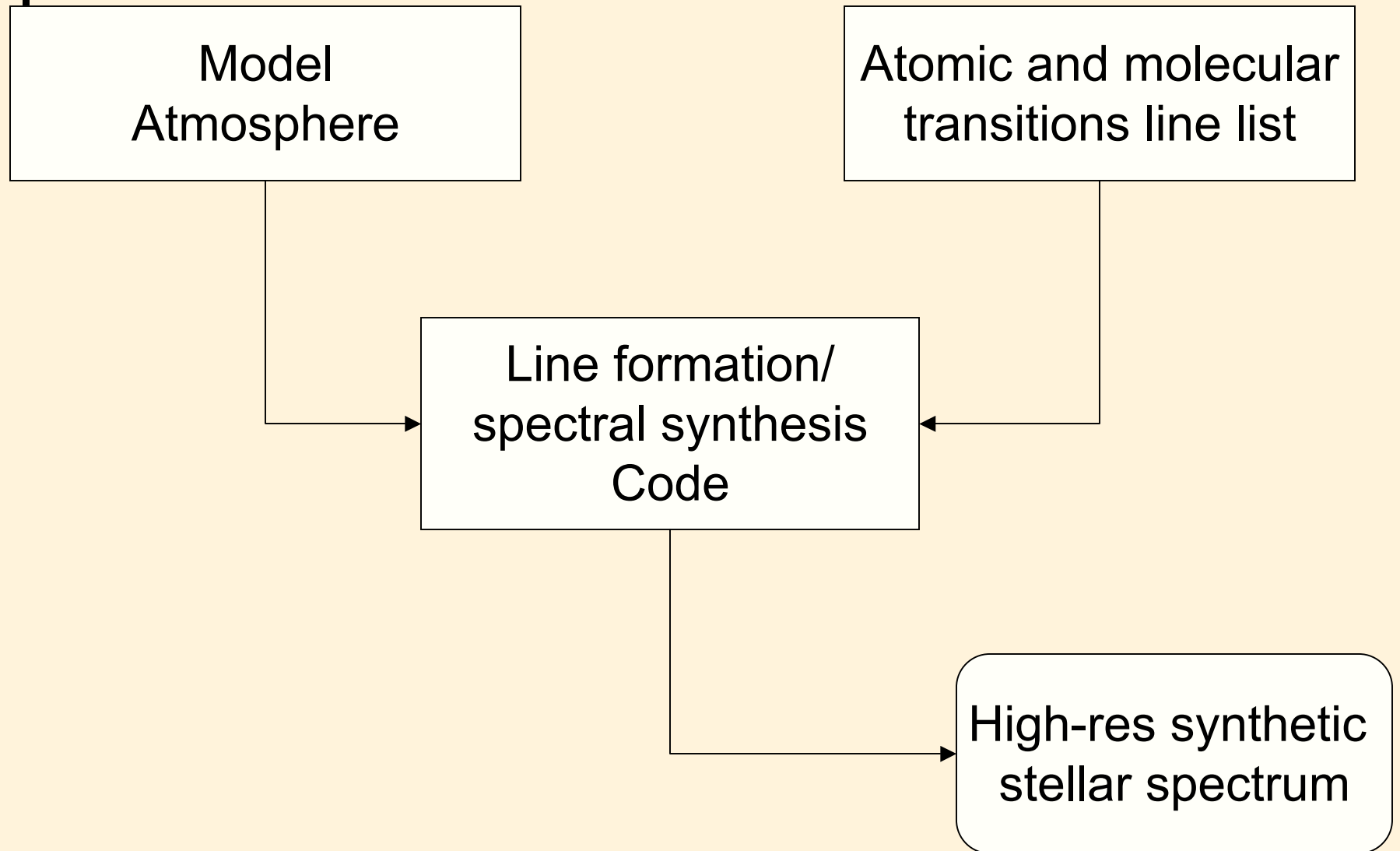
- Model Lick/IDS indices can account for the α -enhancement effect, combining fitting functions
 - e.g. Worthey et al. (1994)
- and response functions
 - e.g. Trippico & Bell (1995), Korn et al. (2005)
- Trager et al. (1998), Proctor & Samson (2002), Thomas et al. (2003), Proctor et al. (2004), Tantalo & Chiosi (2004), Lee & Worthey (2005), Schiavon (2006).
- “High”-resolution current SED models (Vazdekis 1999), Bruzual & Charlot (2003), Sanchez-Blazquez et al. (2006) uses empirical libraries (STELIB, Indo-US, Jones) and thus are attached to the chemical history of the Milky Way
- Synthetic libraries that includes α -enhanced ratios (e.g. Coelho et al. 2005, Munari et al. 2005) open a way to fill this gap



INTRO: SOME PROS AND CONS OF SYNTHETIC LIBRARIES

- Advantages
 - Can cover a wide wavelength range
 - High-resolution
 - Explore many observables (colors, Lick-like indices, flux-ratios indices, D4000, full spectrum analysis...)
- Beware
 - To compute different chemical ratios is time consuming
 - Synthetic libraries are not as accurate as real stars (see Martins & Coelho poster in this conference)

A SYNTHETIC STELLAR SPECTRUM





ELEGANCE VS. PRAGMATISM ?

- Model atmospheres uncertainties:
 - 3-D convection not modeled
 - Sphericity effects
 - N-LTE
 - Chromospheric contribution
- Atomic and molecular line lists uncertainties:
 - Few oscillator strengths and broadening constants are derived (with precision) in laboratory
 - To include or not to include predicted level energy lines?
 - Unidentified lines in solar spectrum
 - Dependence of the broadening parameters adopted with the model atmosphere
- **Fortunately:**
 - **Synthetic spectra have been widely and successfully (as far as we know) used in the derivation of abundances in high resolution stellar spectroscopy**

Quoting D. Kelson & R. Kurucz : "The first step in solving a problem is to admit the problem exists".

THE SEDs STEL. POP. MODELS

Stellar library by
Coelho et al. (2005)

- extended to cover cooler giants
- flux corrections applied

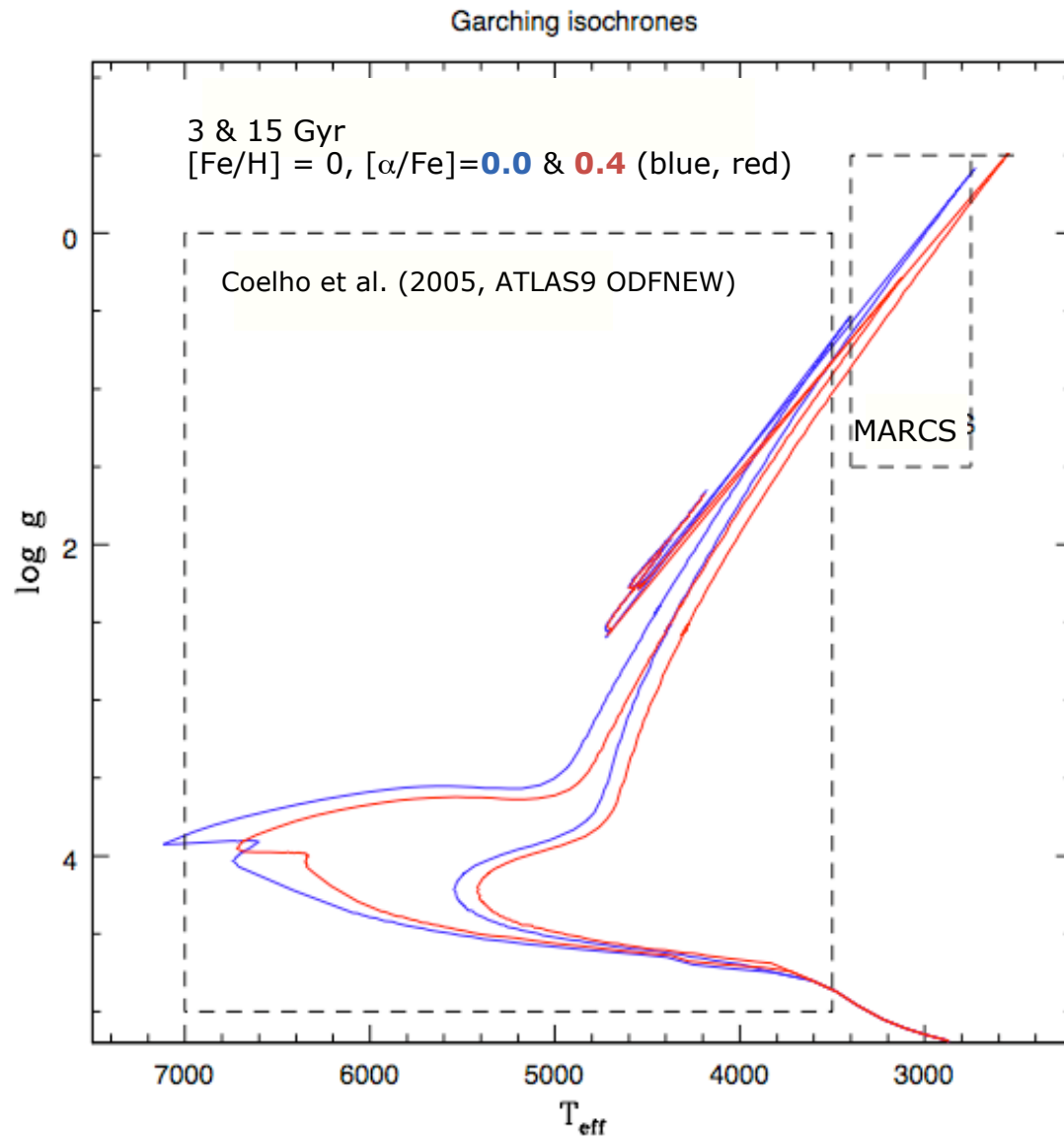
Evolutionary
tracks by A. Weiss

- new Ferguson's opacities
- α -enhanced mixture adopted as in Coelho et al. (2005;
 α -elements are O, Ne, Mg, Si, S, Ca & Ti)

Pop. synthesis code:
GALAXEV by
Bruzual & Charlot

SED models for SSP,
solar & α -enh. mixtures

STELLAR PARAMETER SPACE



ATLAS9:
Castelli & Kurucz (2003)

MARCS:
Plez et al. (1992)



SED PARAMETER SPACE

• Ages	[Fe/H]	[α /Fe]	[Z/H]	Z
• 3 to 15 Gyr	-0.5	0.0	-0.5	0.005
•	-0.5	0.4	-0.2	0.011
•	0.0	0.0	0.0	0.017
•	0.0	0.4	0.3	0.032
•	0.2	0.0	0.2	0.026
•	0.2	0.4	0.5	0.048

λ coverage: 300 to 1340nm

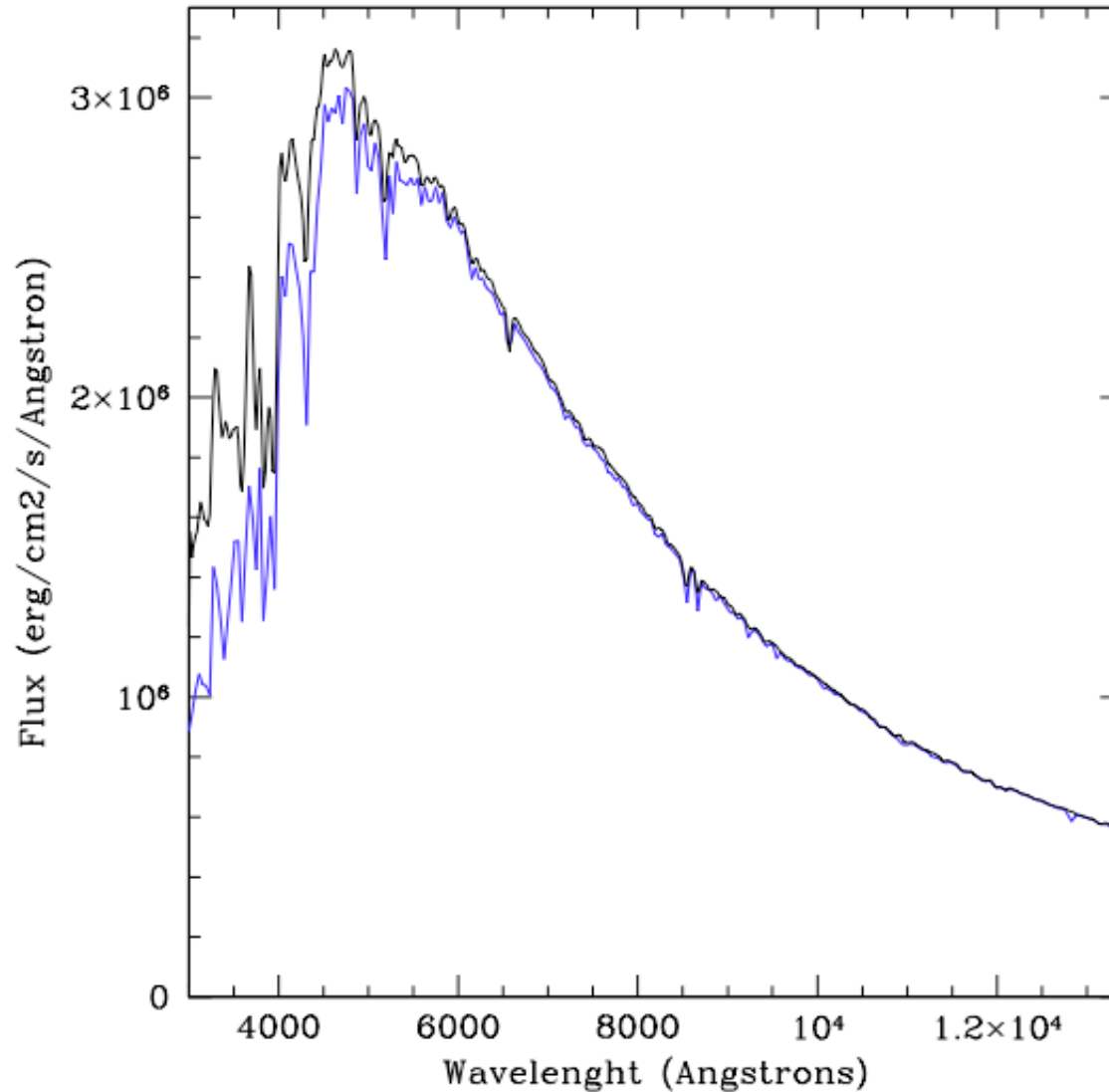
Z_{sun} from Grevesse & Noels (1998)



TO ISOLATE THE PERFORMANCE OF SYNTHETIC LIBRARY

- A set of models were computed with $Z = 0.02$ Padova tracks, GALAXEV code, and compared to models built employing empirical libraries: STELIB (Bruzual & Charlot 2003) and Indo-US (Bruzual, priv. com)

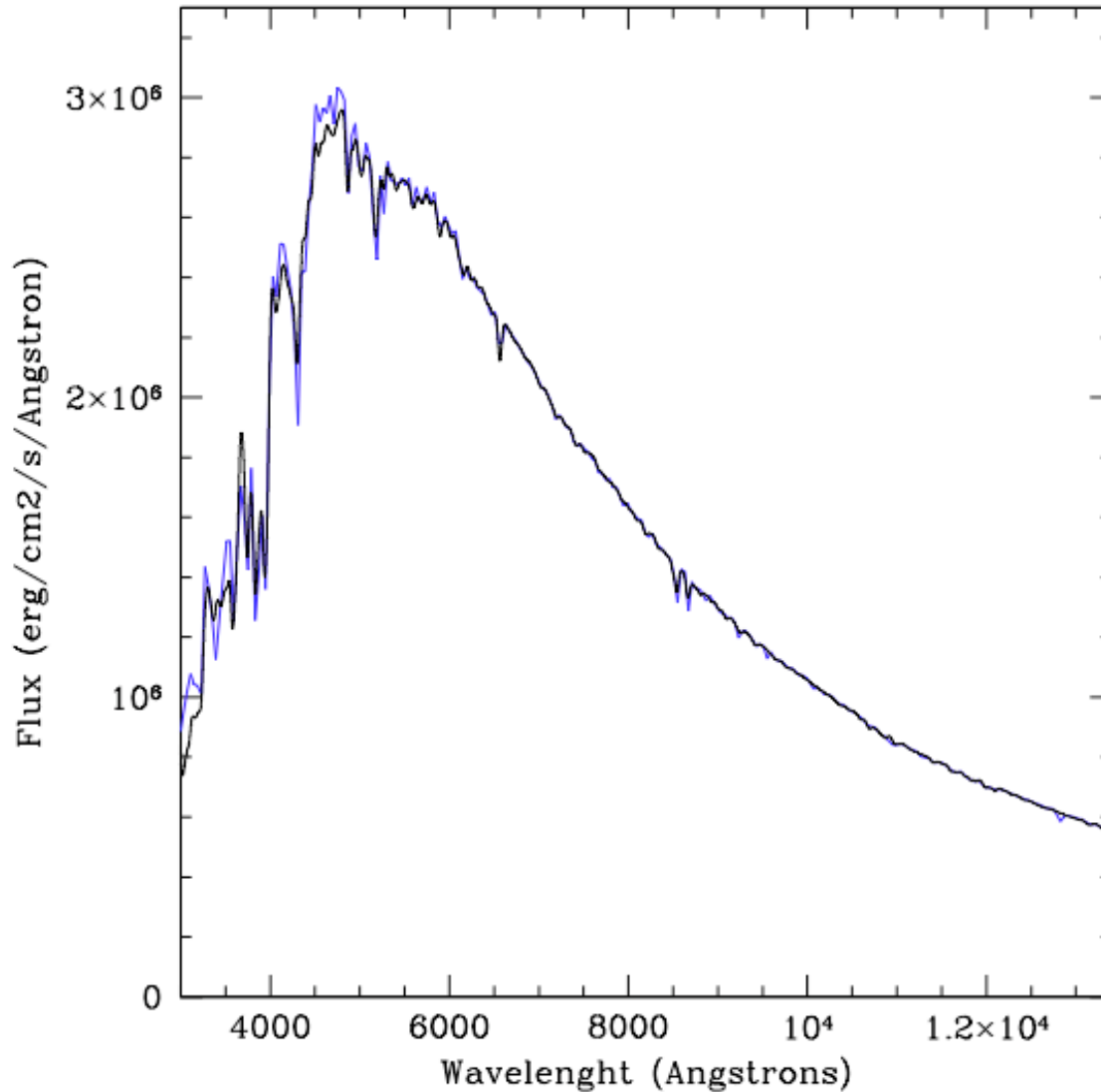
FLUX DISTRIBUTION CORRECTIONS: THE “PREDICTED LINES” MATTER



Flux
distribution
from model
atmosphere
(includes PL)

Coelho et al.
05 (no PL)

FLUX DISTRIBUTION CORRECTIONS: THE “PREDICTED LINES” MATTER



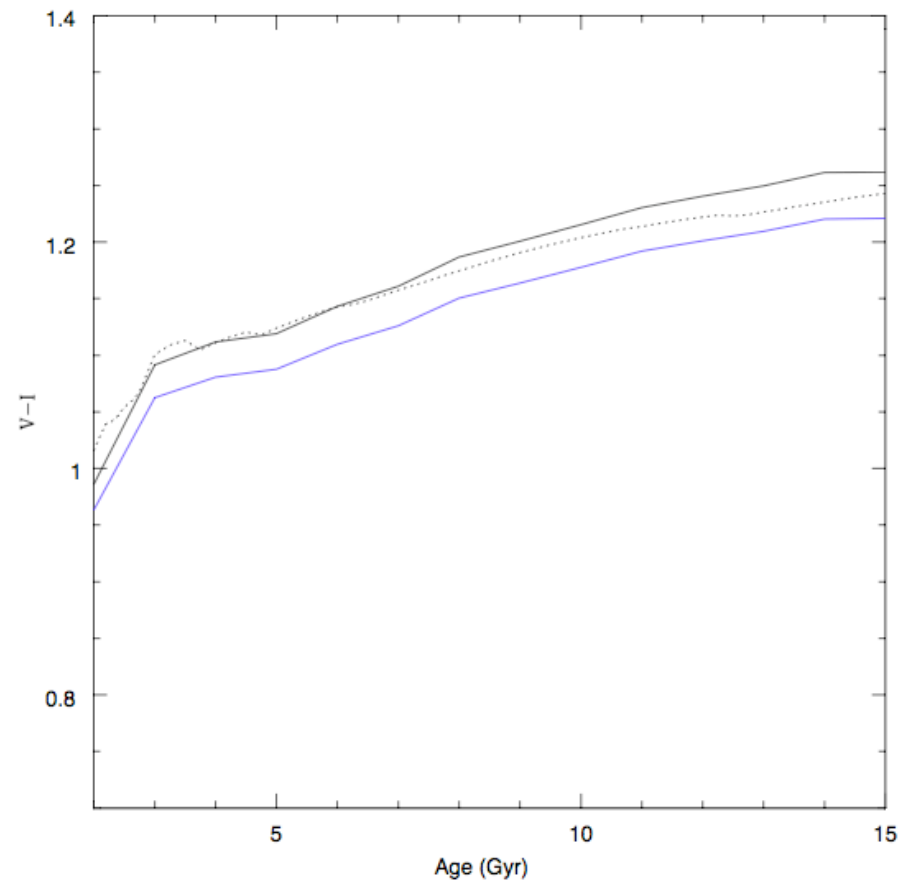
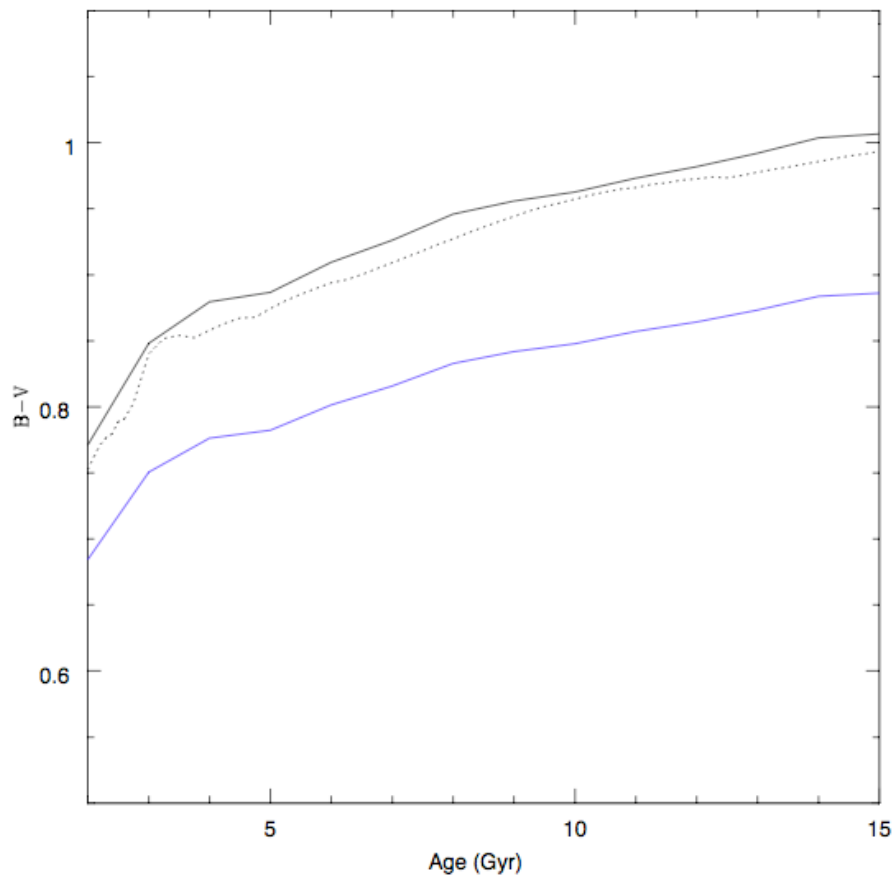
Flux
distribution
from model
atmosphere
(includes PL)

Coelho et al.
05 (corrected)

SOLAR PADOVA CASE: SPP COLORS

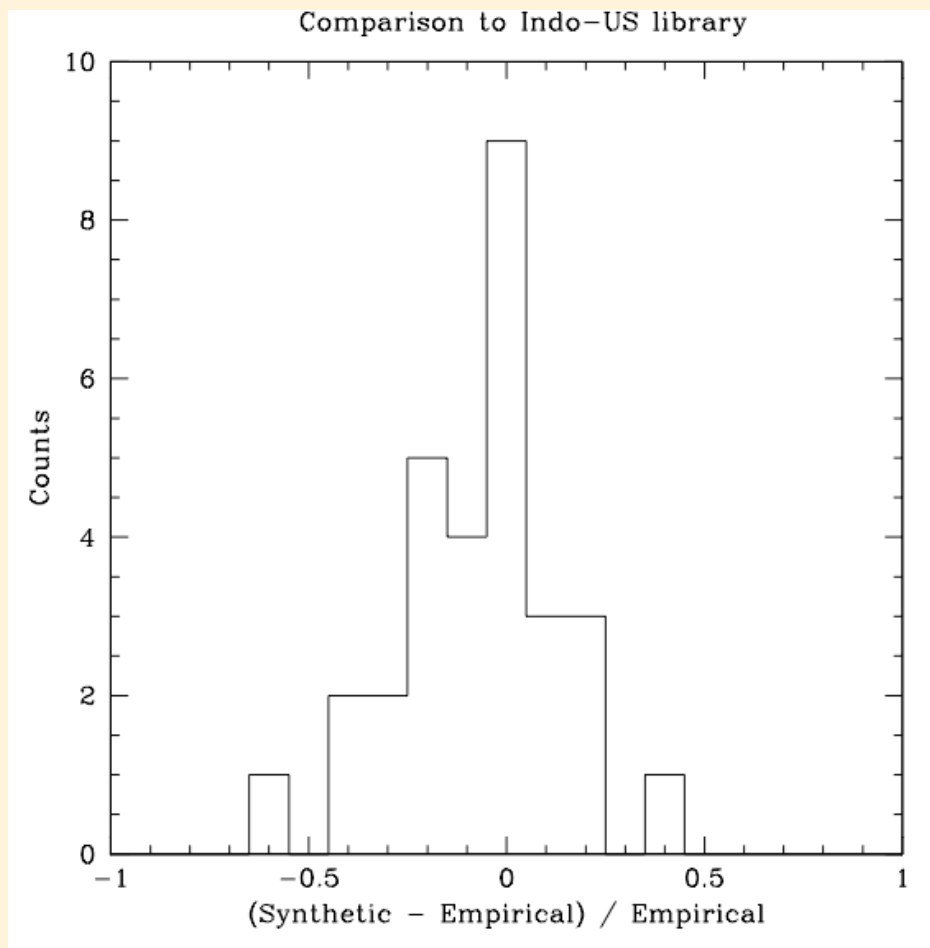
Dotted line: BC2003 colors

Blue: original Coelho et al. 2005, **Black: corrected Coelho et al. 2005**



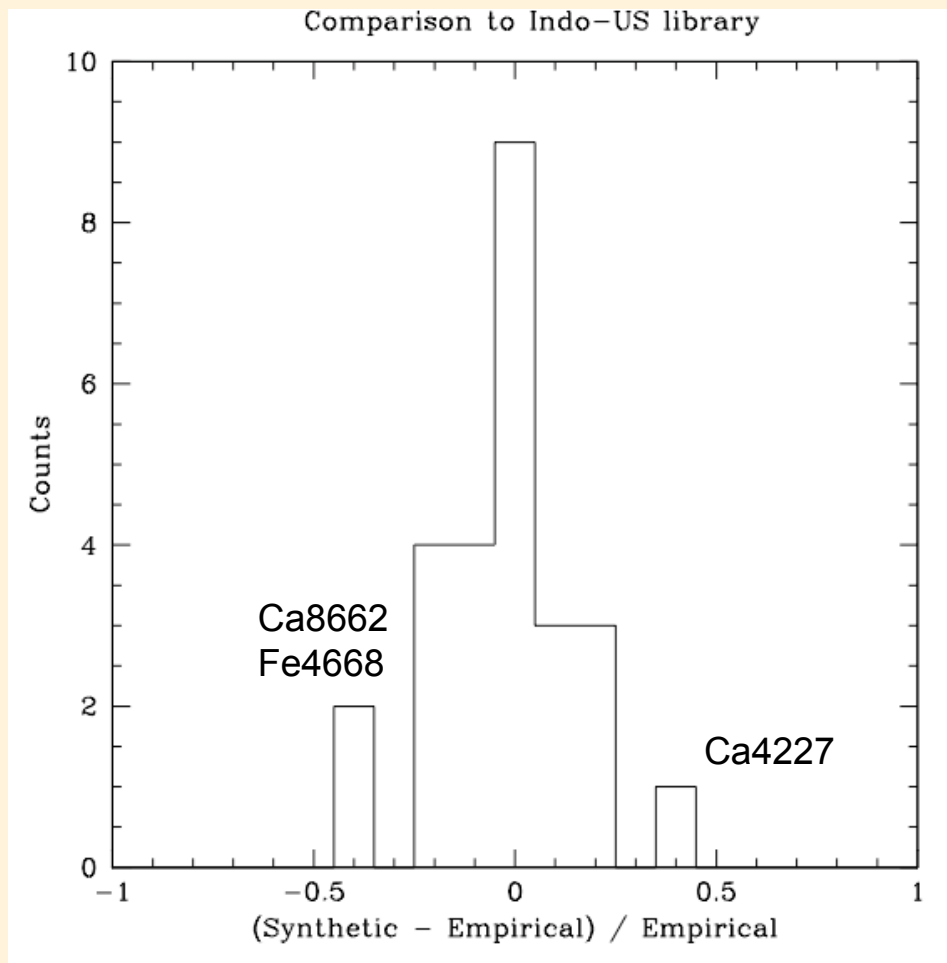
SOLAR PADOVA CASE: CLASSICAL SPECTRAL INDICES

- Residuals of SSP built with synthetic library compared to empirical library, for 30 indices (Lick/IDS indices, D4000, Higher order Balmer lines, Ca and Mg indices by Diaz, Terlevich & Terlevich 1989)

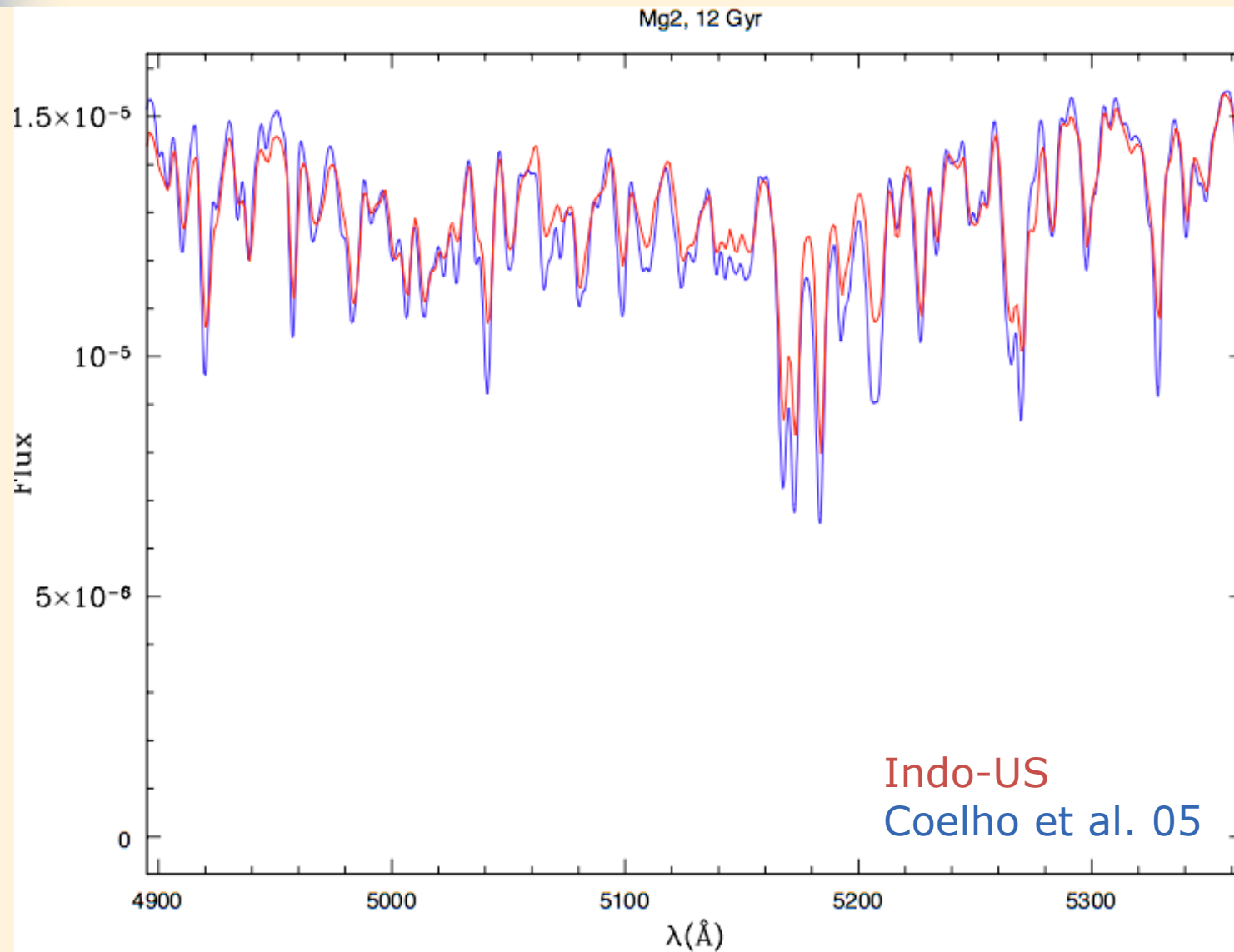


SOLAR PADOVA CASE: CLASSICAL SPECTRAL INDICES

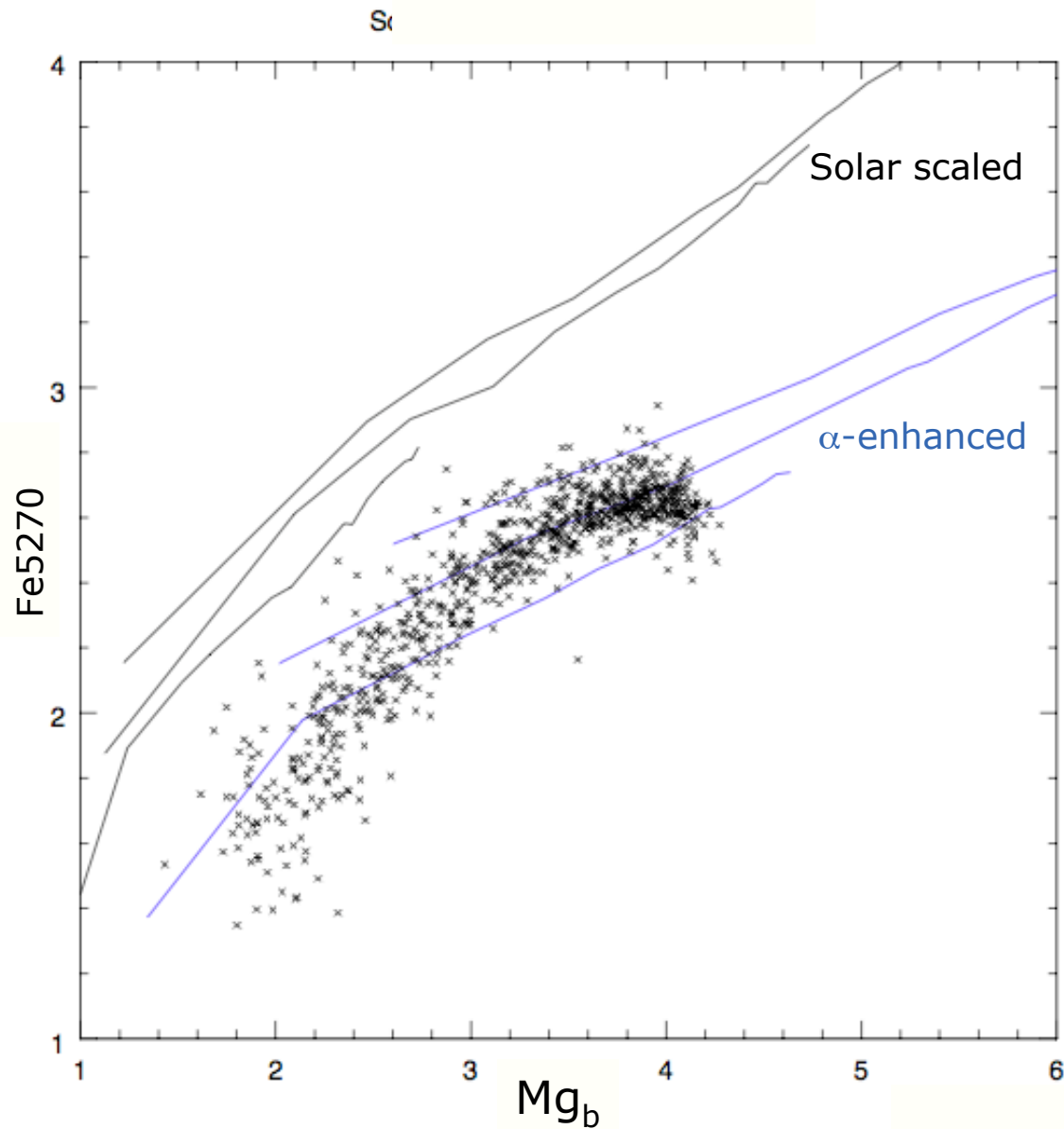
- And excluding the balmer indices...



EMPIRICAL VS. SYNTHETIC: MG PROFILE



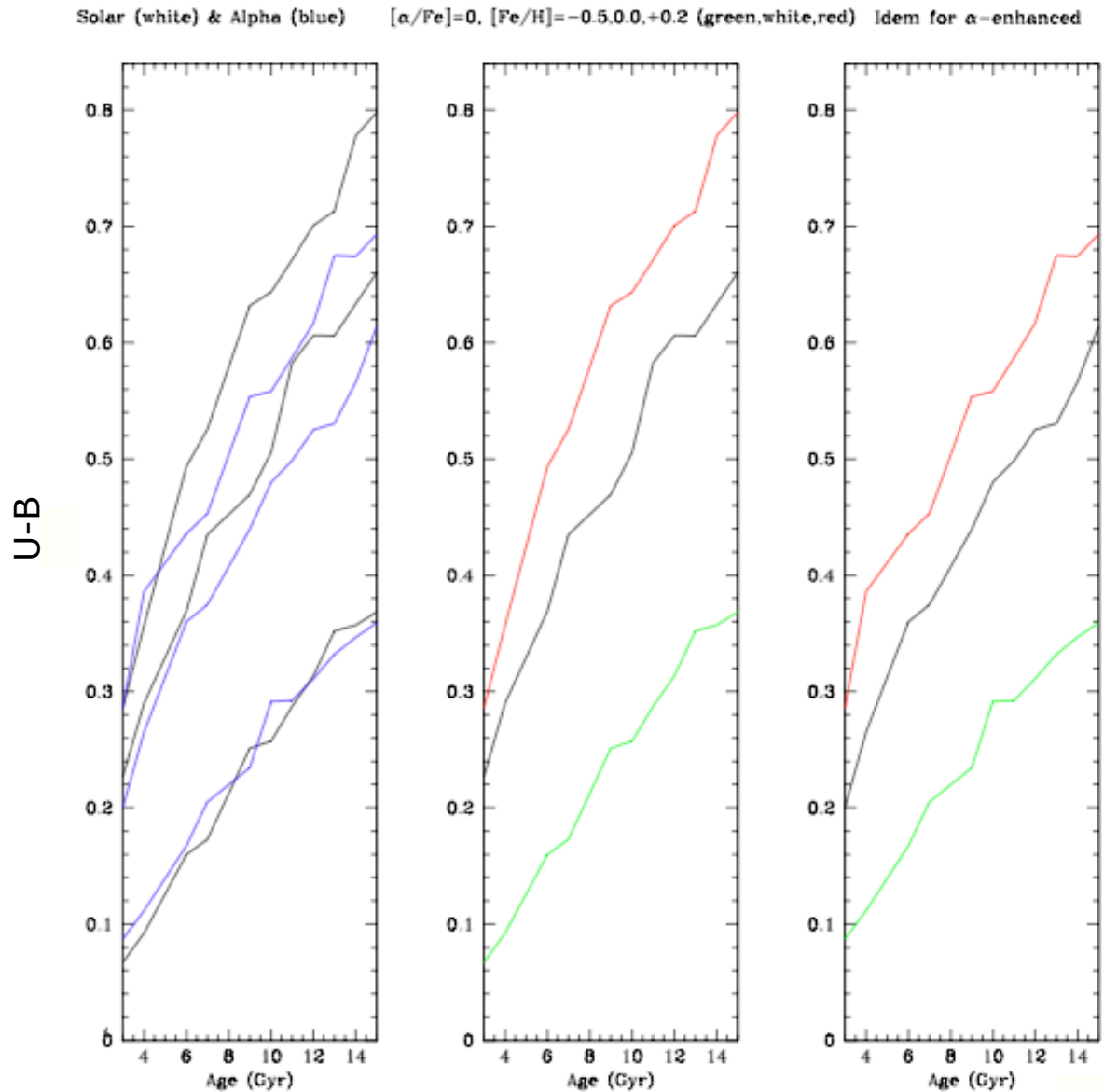
α -ENHANCEMENT: THE CLASSICAL PLOT



Data:
Stacked SDSS galaxies
from J. Brinchmann

α -ENHANCEMENT: EFFECT ON COLORS

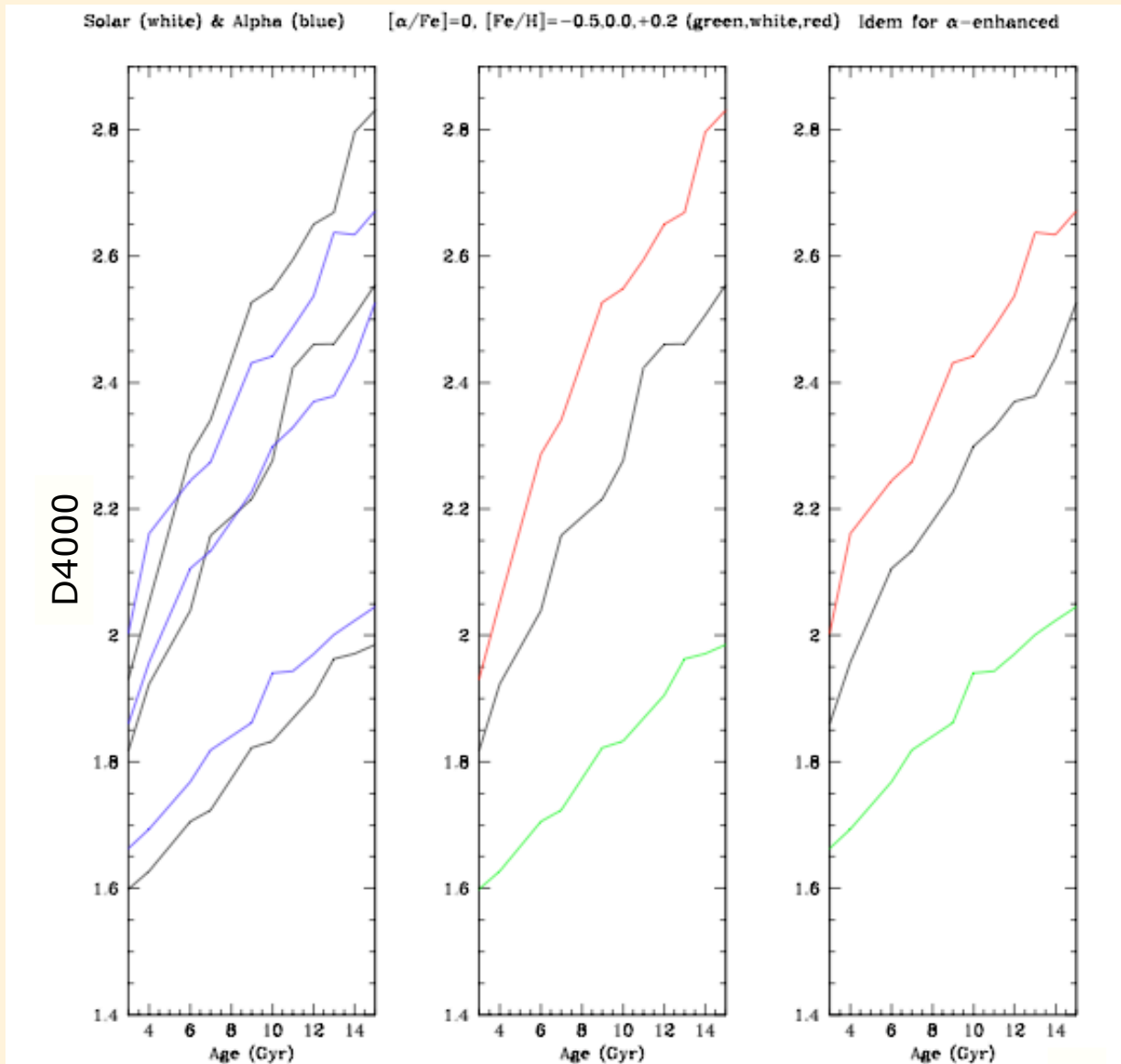
$[\alpha/\text{Fe}] =$
0.0
0.4



$[\text{Fe}/\text{H}] =$
-0.5
0.0
0.2

α -ENHANCEMENT: EFFECT ON D4000

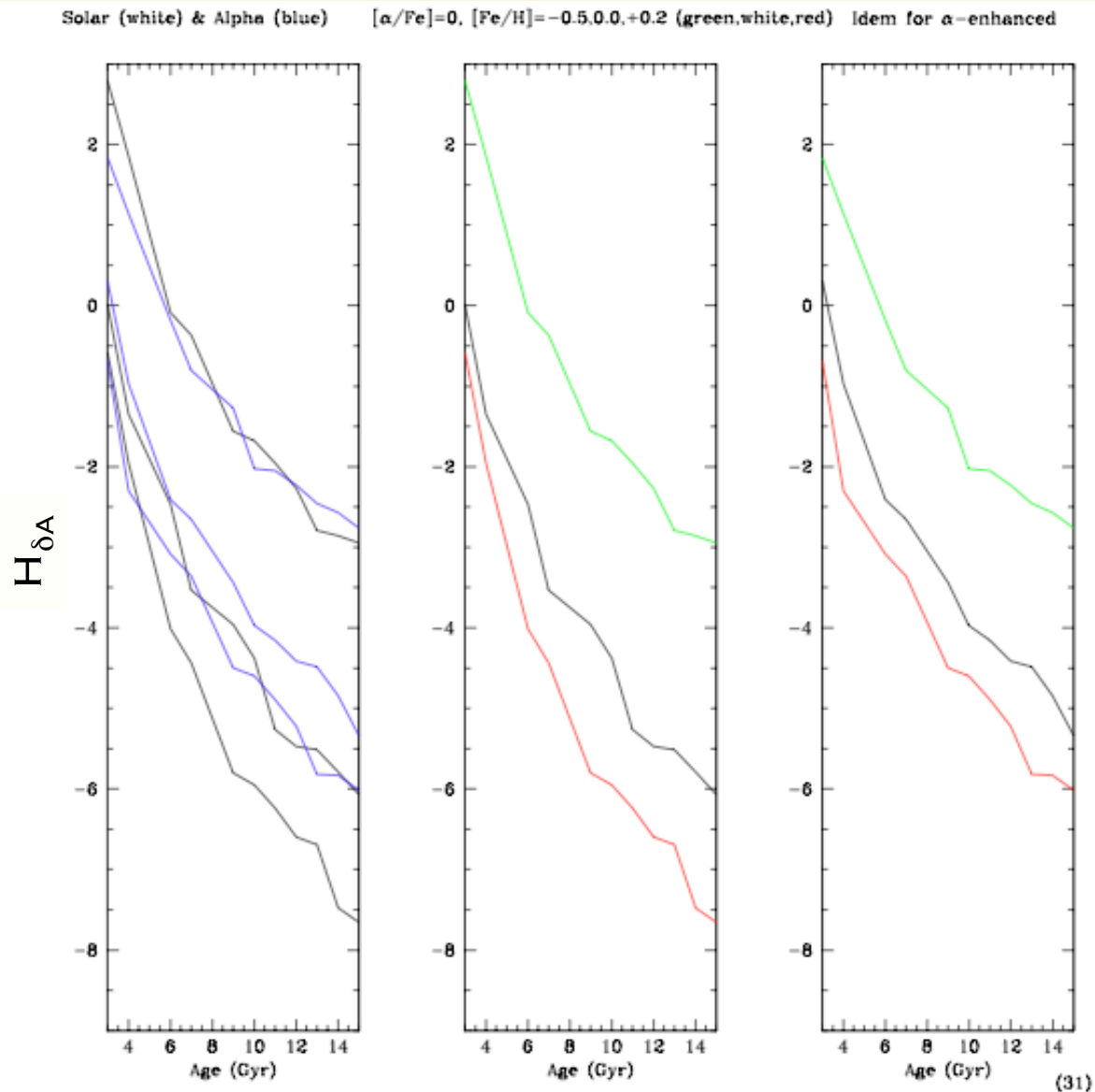
$[\alpha/\text{Fe}] =$
0.0
0.4



$[\text{Fe}/\text{H}] =$
-0.5
0.0
0.2

α -ENHANCEMENT: EFFECT ON $H_{\delta A}$

$[\alpha/\text{Fe}] =$
0.0
0.4



$[\text{Fe}/\text{H}] =$
-0.5
0.0
0.2

FULL SPECTRUM ANALYSIS

- Panter "The MOPED man" et al. (2004, 2005, 2006); Heavens et al. (2005), Mathis, Charlot & Brinchmann (2005); Cid Fernandes et al. (2005).

