Some Pending Problems in Stellar Population Synthesis

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Updated evolutionary tracks

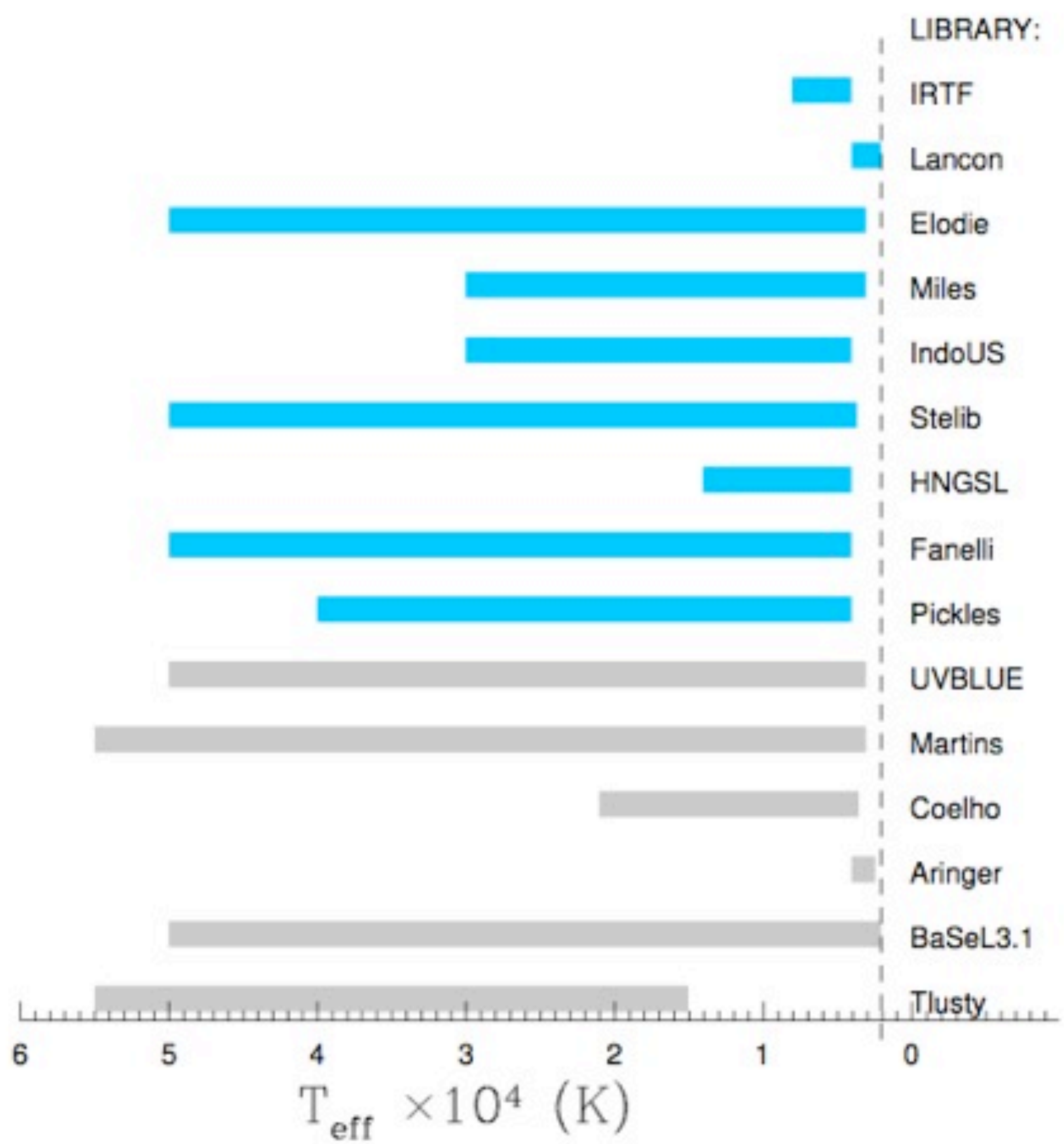
Bertelli et al. (2008):

Z = 0, 0.0001, 0.0004, 0.001, 0.002, 0.004, 0.008, 0.017, 0.040, 0.070

TP-AGB evolutionary prescriptions by:

Marigo & Girardi (2007, 2010): calibrated with MC clusters and star counts

Bertelli et al (2008): extrapolate results from the Marigo and Girardi prescription to different chemical content of the stellar envelope.

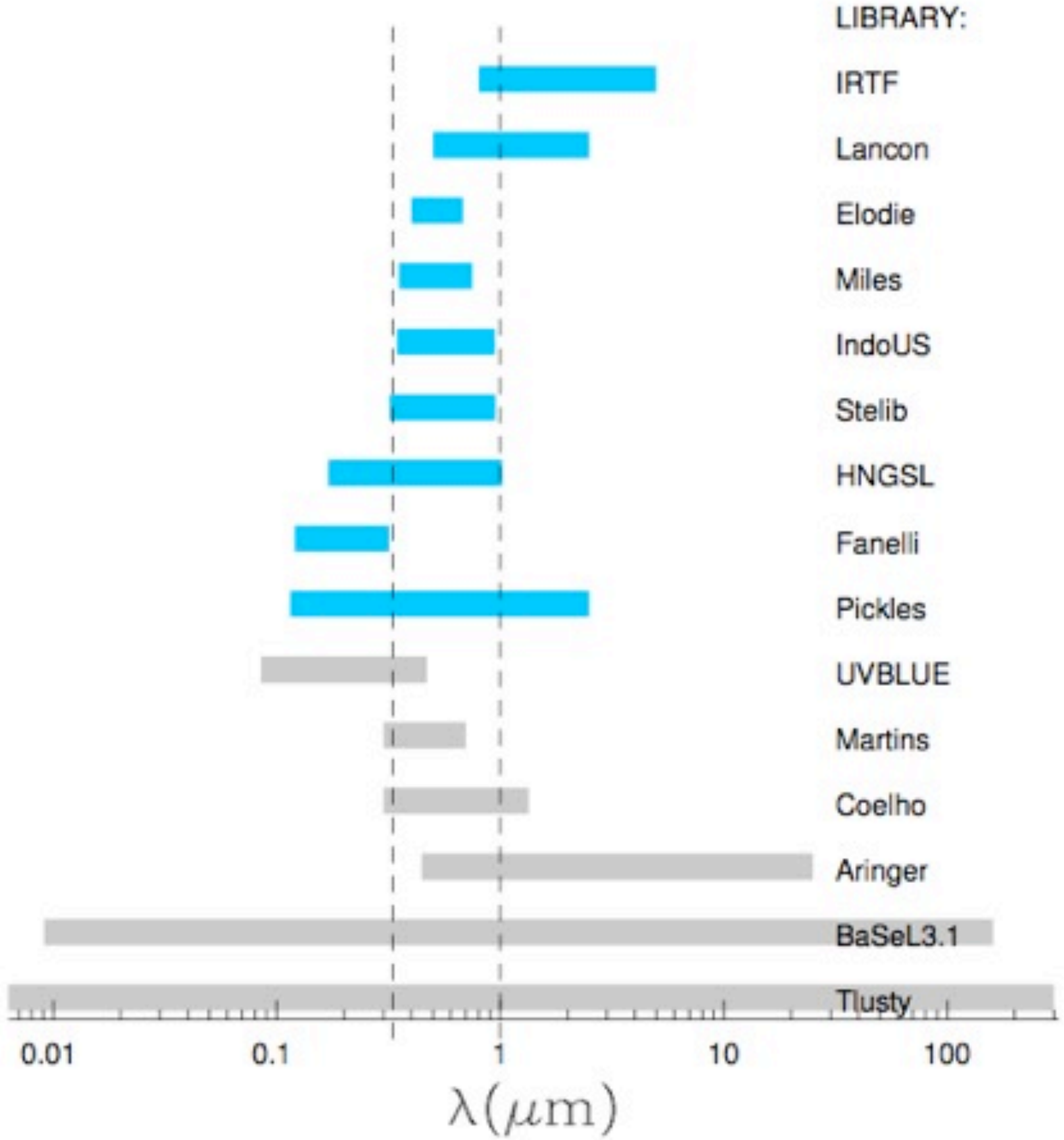


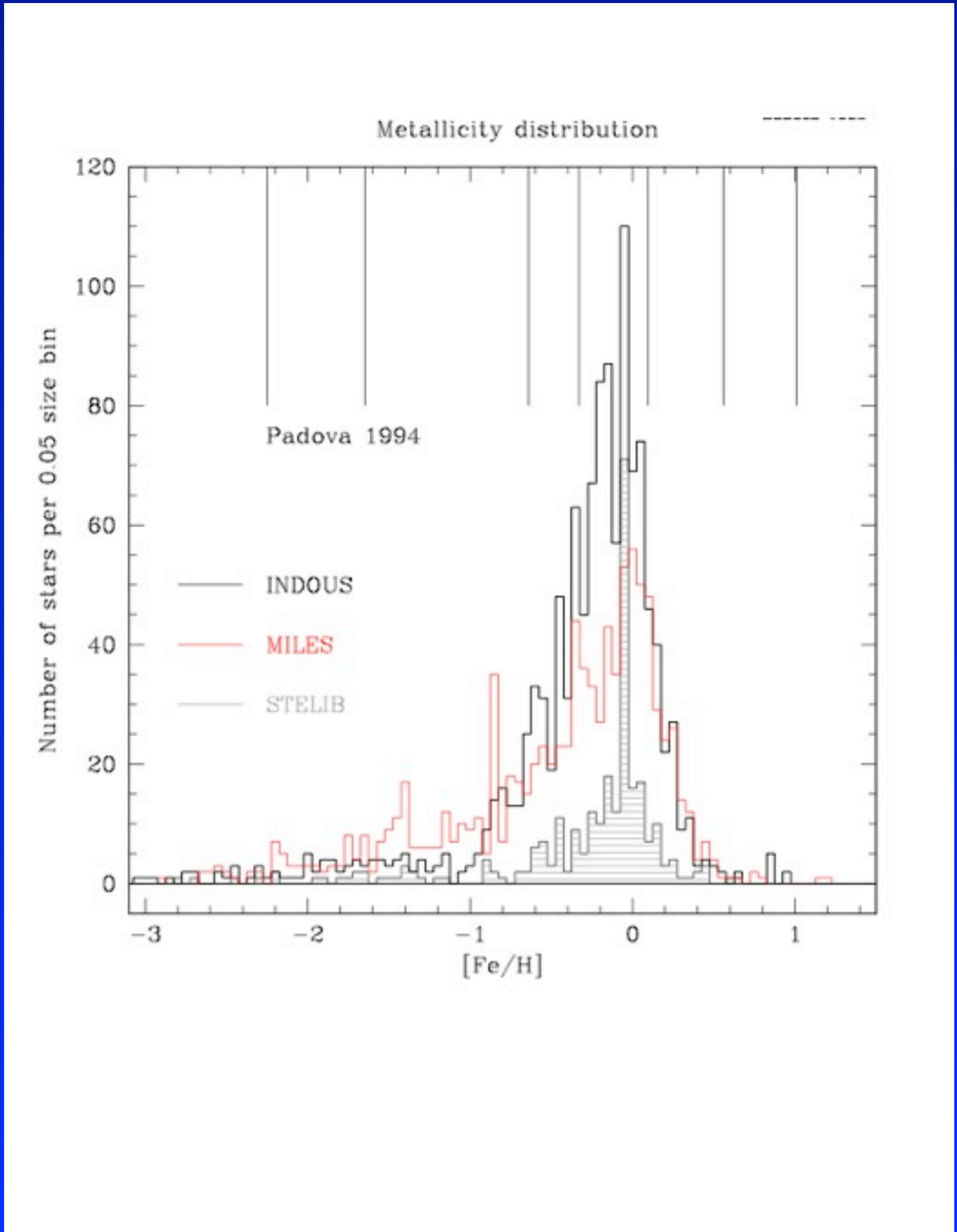
Stellar spectral libraries:

Temperature coverage

Stellar spectral libraries:

Wavelength coverage



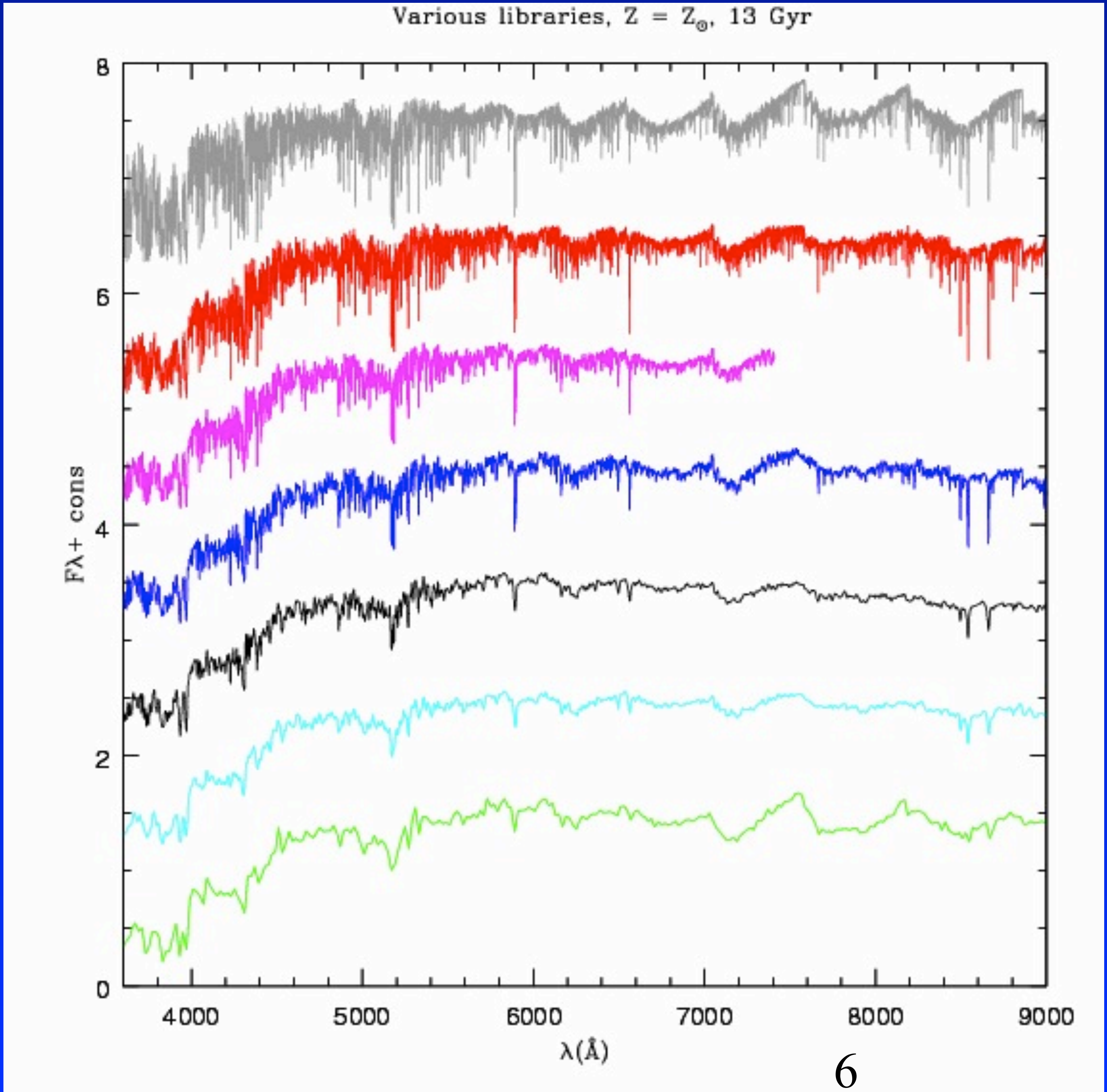


IndoUS, Miles, and Stelib

[Fe/H] Distribution

Complete near Solar (more or less)

Increasing spectral resolution



- Coelho (< 1Å)

- IndoUS (~ 1Å)
- Miles (2.4 Å)

- Stelib (3 Å)

- HNGSL (~ 5Å)
- Pickles (5 Å)
- Kurucz (20 Å)

Padova 94 tracks

Incompleteness of stellar libraries

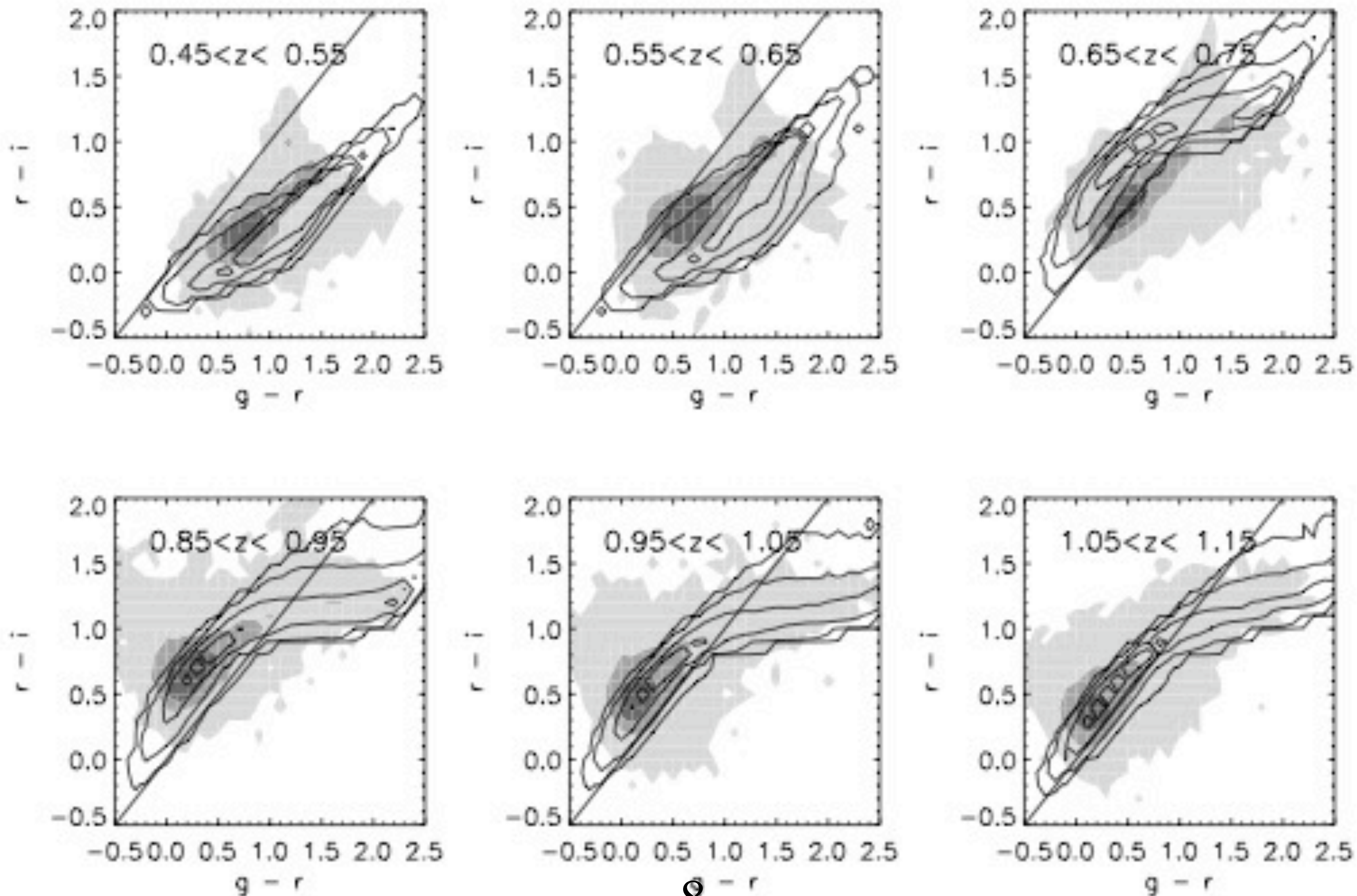
U-UV spectral range.

Excess of U flux in population models built using incomplete stellar libraries.

Completeness matters

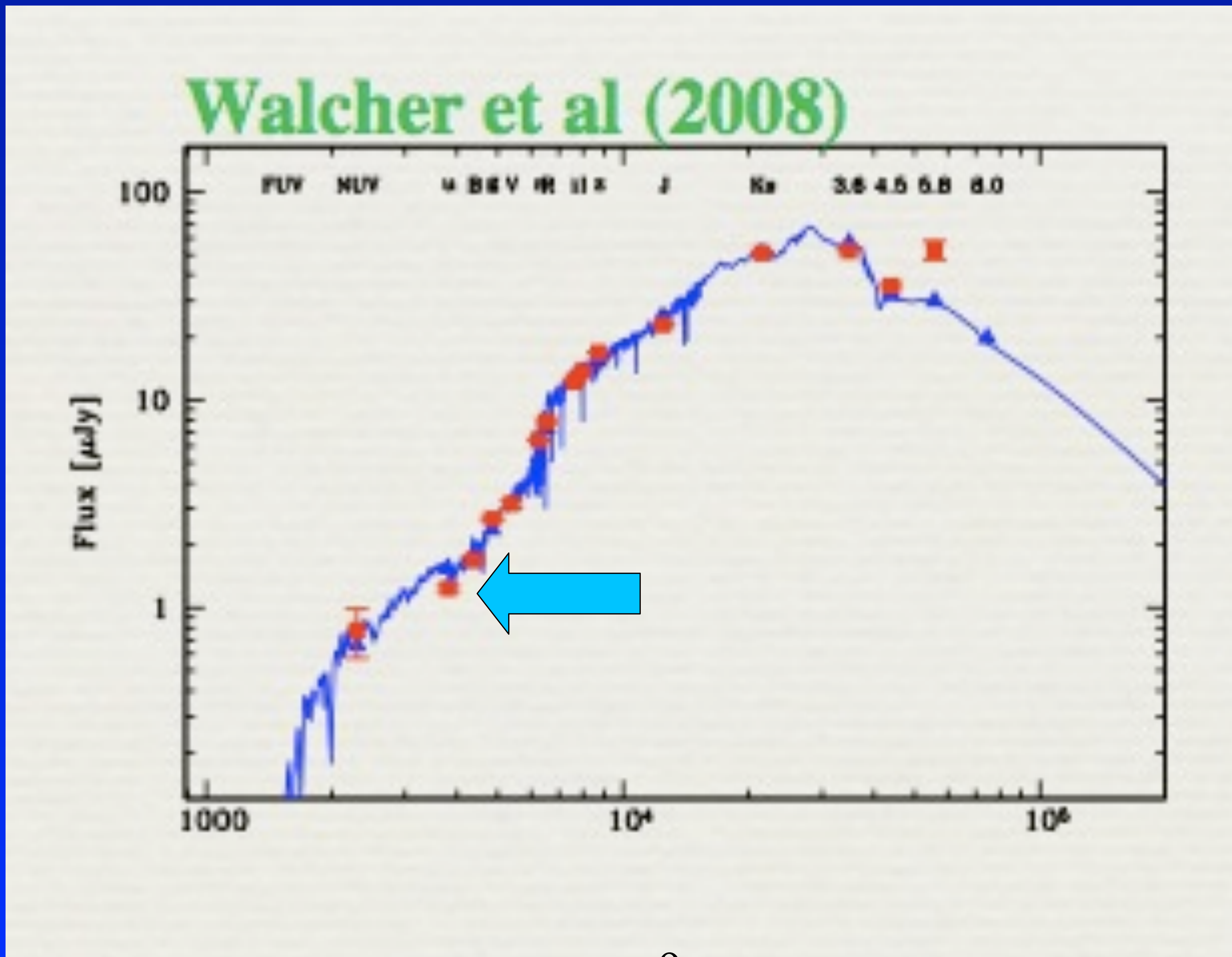
Walcher et al. (2008): VVDS data (grey shading) vs. models (contours)

Conclude that the wavelength range from 3300 to 4050 Å is not correctly reproduced by models based mostly in the Miles library, which contains few hot stars.



Walcher et al. (2008):

Excess U flux is clearly seen in fit to typical galaxy sed



Improving the U-UV spectral range

Tlusty Models:

Grid of NLTE plane parallel hydrostatic model atmospheres for:

O-stars: Lanz & Hubeny (2003)

B-stars: Lanz & Hubeny (2007)

High spectral resolution from 54.8 Å to FIR (R = 50,000)

15,000 ≤ Teff ≤ 55,000 K;

0 ≤ Z ≤ 2 x Zo

Improving the U-UV spectral range

Martins et al. (2005) Models:

Grid of NLTE plane parallel hydrostatic model atmospheres

Coverage:

$3{,}000 \leq T_{eff} \leq 27{,}500$ K;

$0.10 \times Z_o \leq Z \leq 2 \times Z_o$

3000 to 7000 Å (R = 20,000)

Improving the U-UV spectral range

UVBLUE and BLURED:

Grid of model atmospheres based on Kurucz (1993) model atmospheres:

UVBLUE: Rodriguez-Merino et al. (2005)

Coverage: 3,000 to 50,000 K

850 to 4700 Å (R = 50,000)

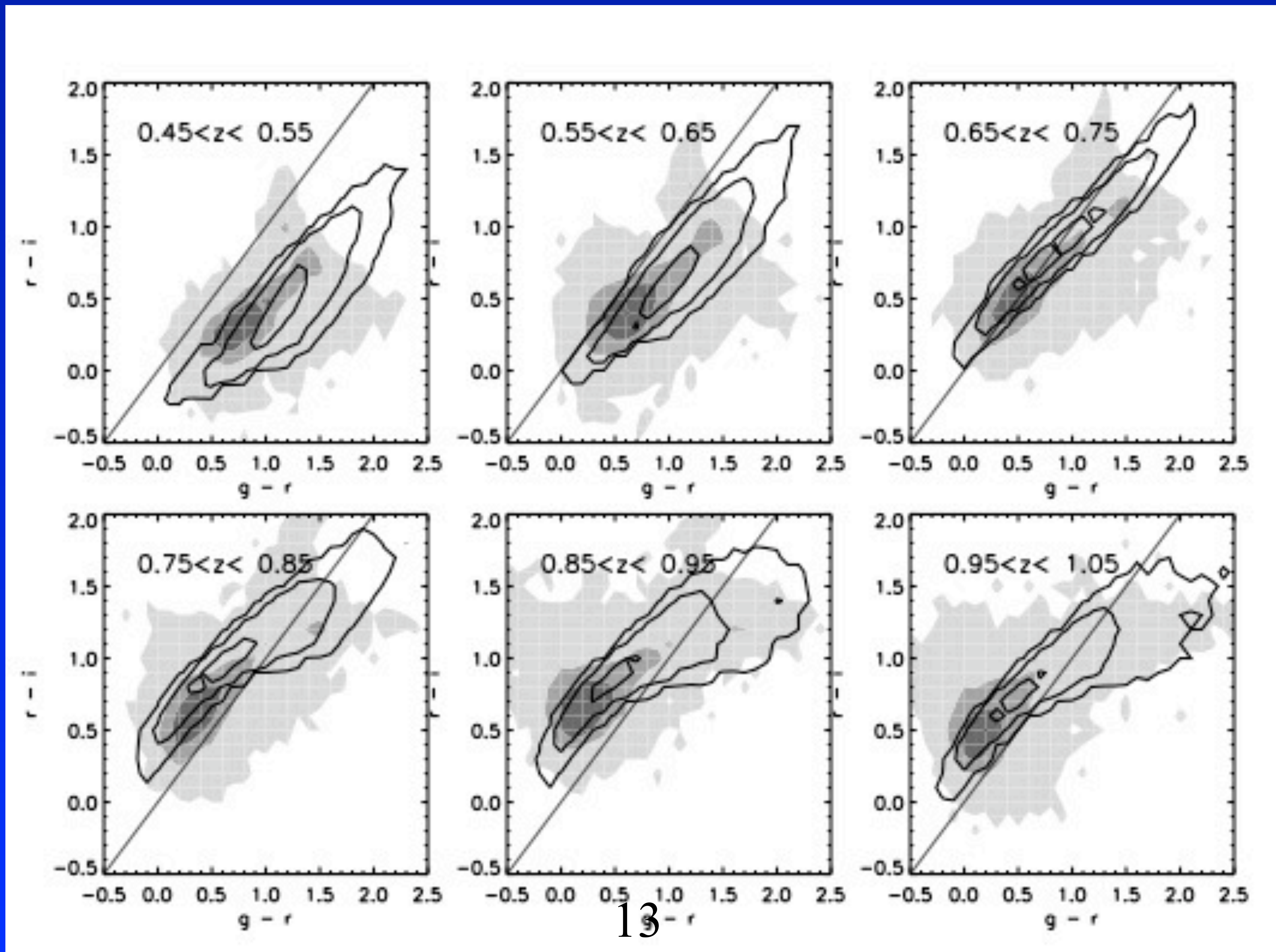
$-2.0 \leq [Fe/H] \leq +0.5$

BLUERED: Bertone et al. (2008)

3500 to 7000 Å (R = 500,000)

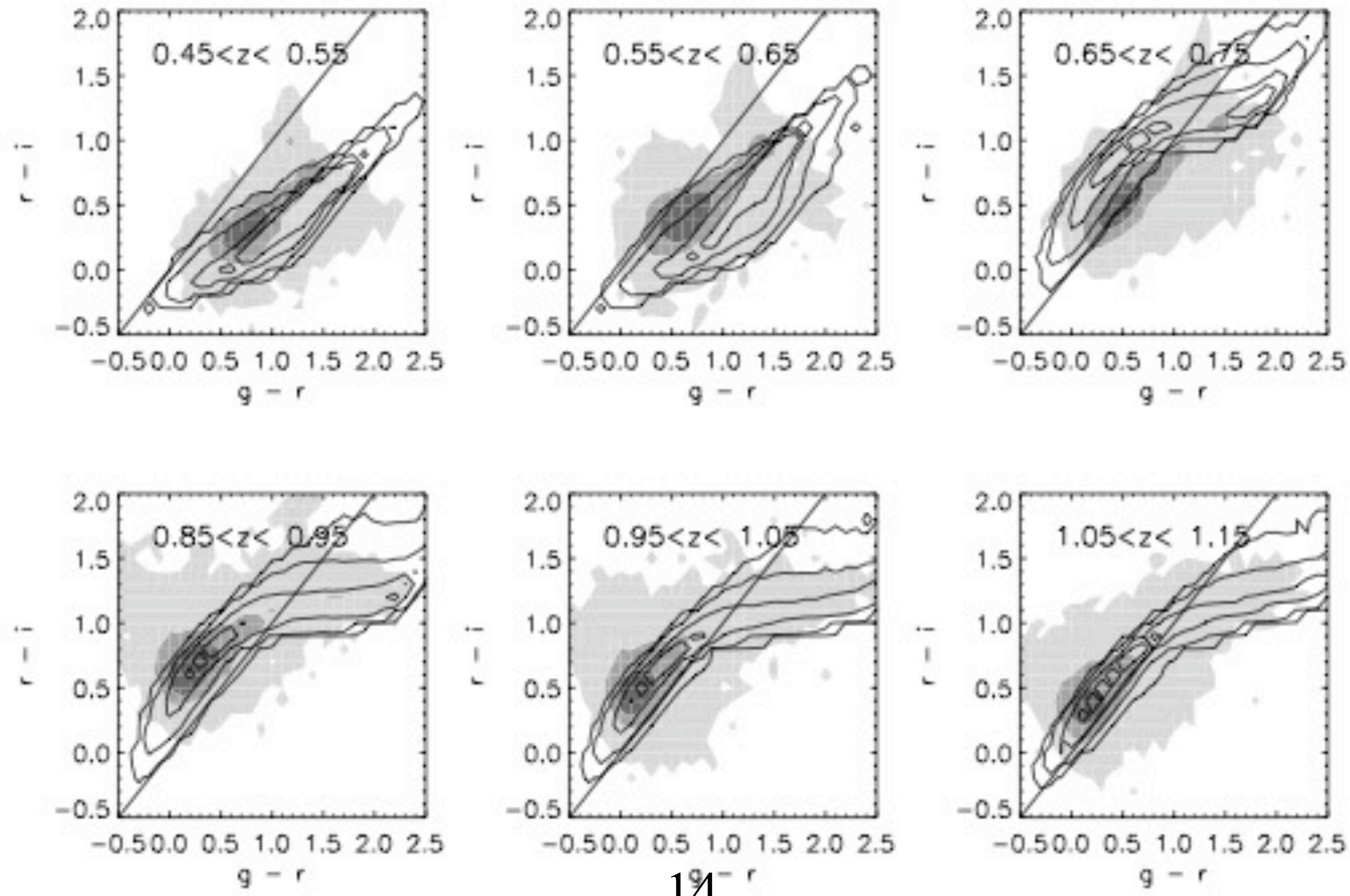
Walcher (2009): VVDS data (grey shading) vs. models (contours)

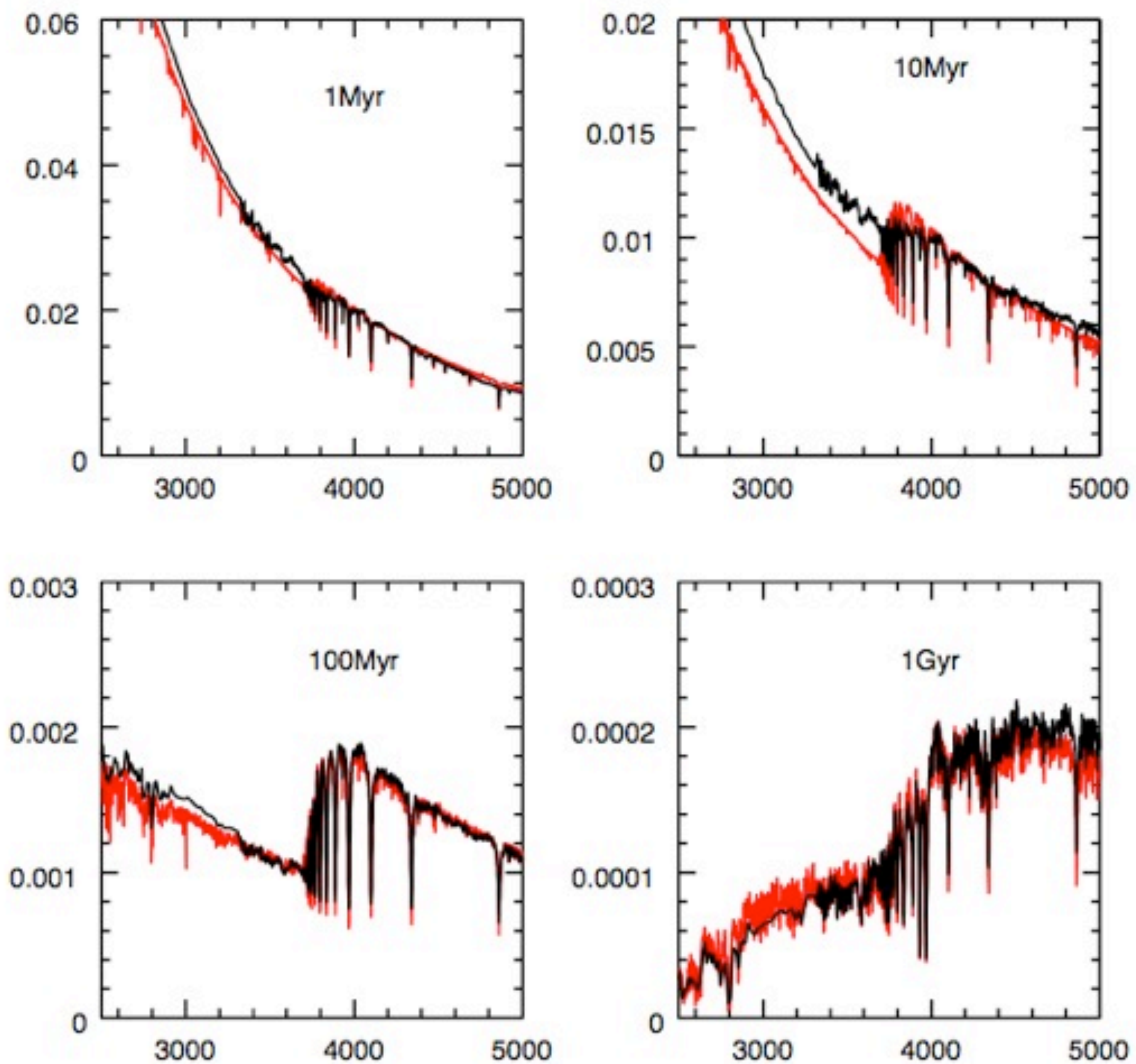
Major improvement after including Tlusty, Martins et al., and UVBLUE stellar atmosphere models to complement MILES library in SSP modelling (work in progress).



Walcher et al. (2008): VVDS data (grey shading) vs. models (contours)

Conclude that the wavelength range from 3300 to 4050 Å is not correctly reproduced by models based mostly in the Miles library, which contains few hot stars.





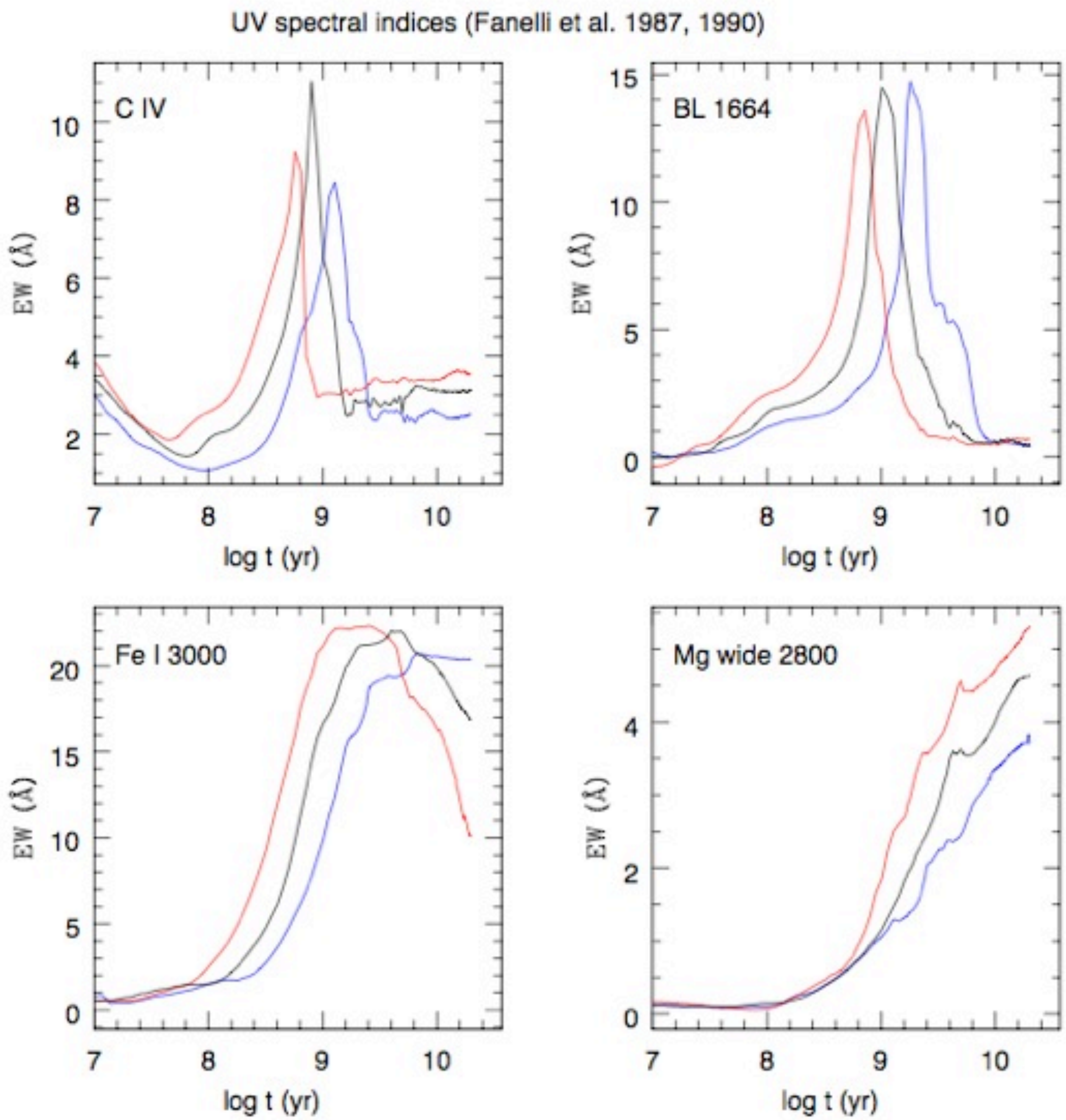
Another look at the problem:

Pure Miles (black)

Extended Miles (red)

In the pure Miles case intermediate Teff stars were represented by hotter stars.

It is important to use a stellar library as complete as possible.



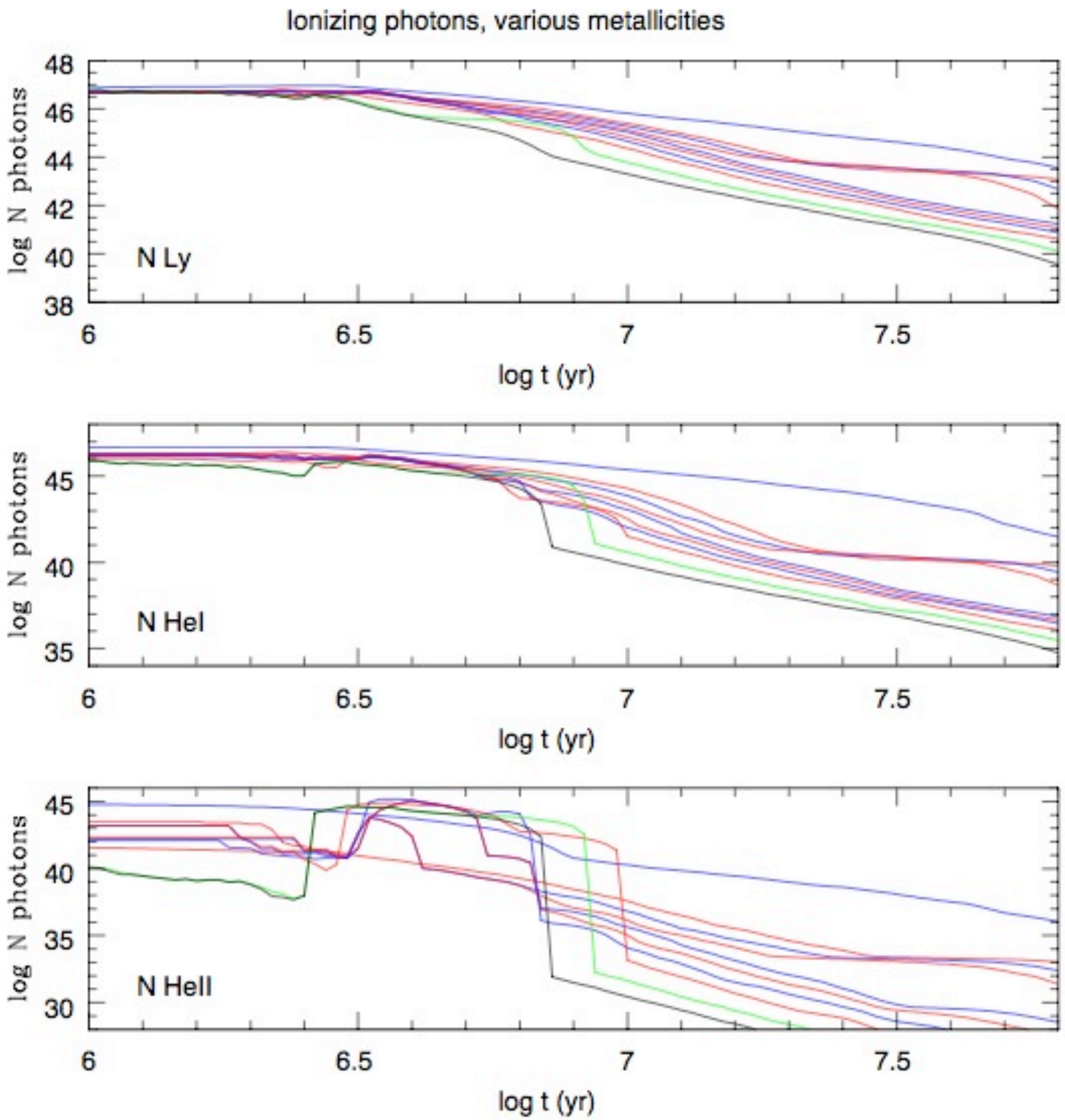
UV spectral indices

Defined by e.g. Fanelli et al., can be computed directly from the UV sed, the same as in the visible range.

Z = 0.5 x Zo (blue)
1.0 x Zo (black)
2.5 x Zo (red)

Recent work on UV indices:

Maraston et al. (2008)
Chavez et al. (2009)



Ionizing photons:

Depend on Tlusty models

For SSP's of

Z = 0
0.0001
0.0004
0.001
0.002
0.004
0.008
0.017
0.040 (green)
0.070 (black)

Improvement over BaSeL Atlas values (e.g. HeII)

M83 HST/WFC3 observations

Fig. 1.— Color image of M83 produced using the *HST*/WFC3 observations described in this work. The F438W image is shown in blue, the F555W image in green, and a combination of the F814W and Hα images in red.

Chandar et al. (2010)

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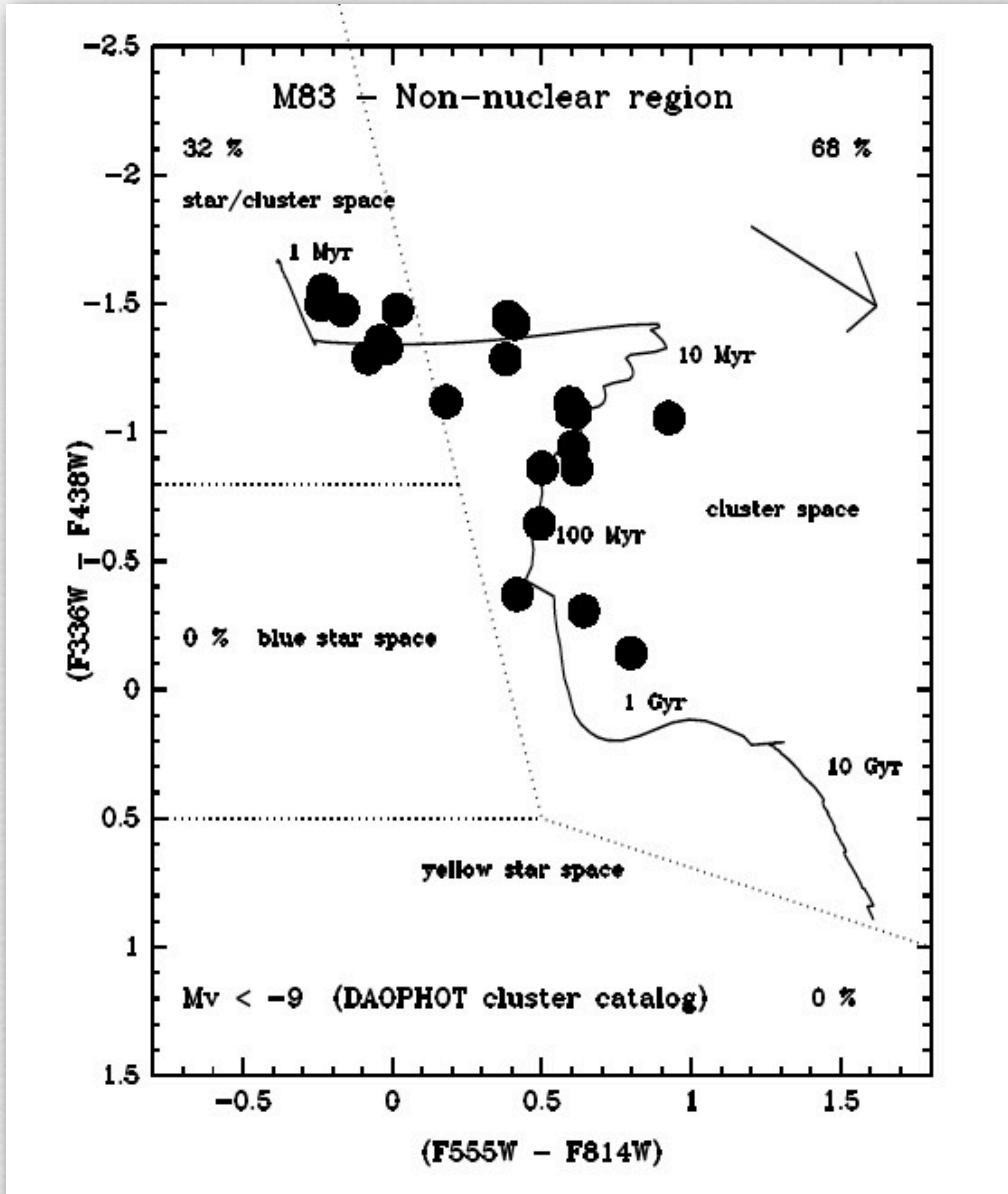
M83 HST/WFC3 observations



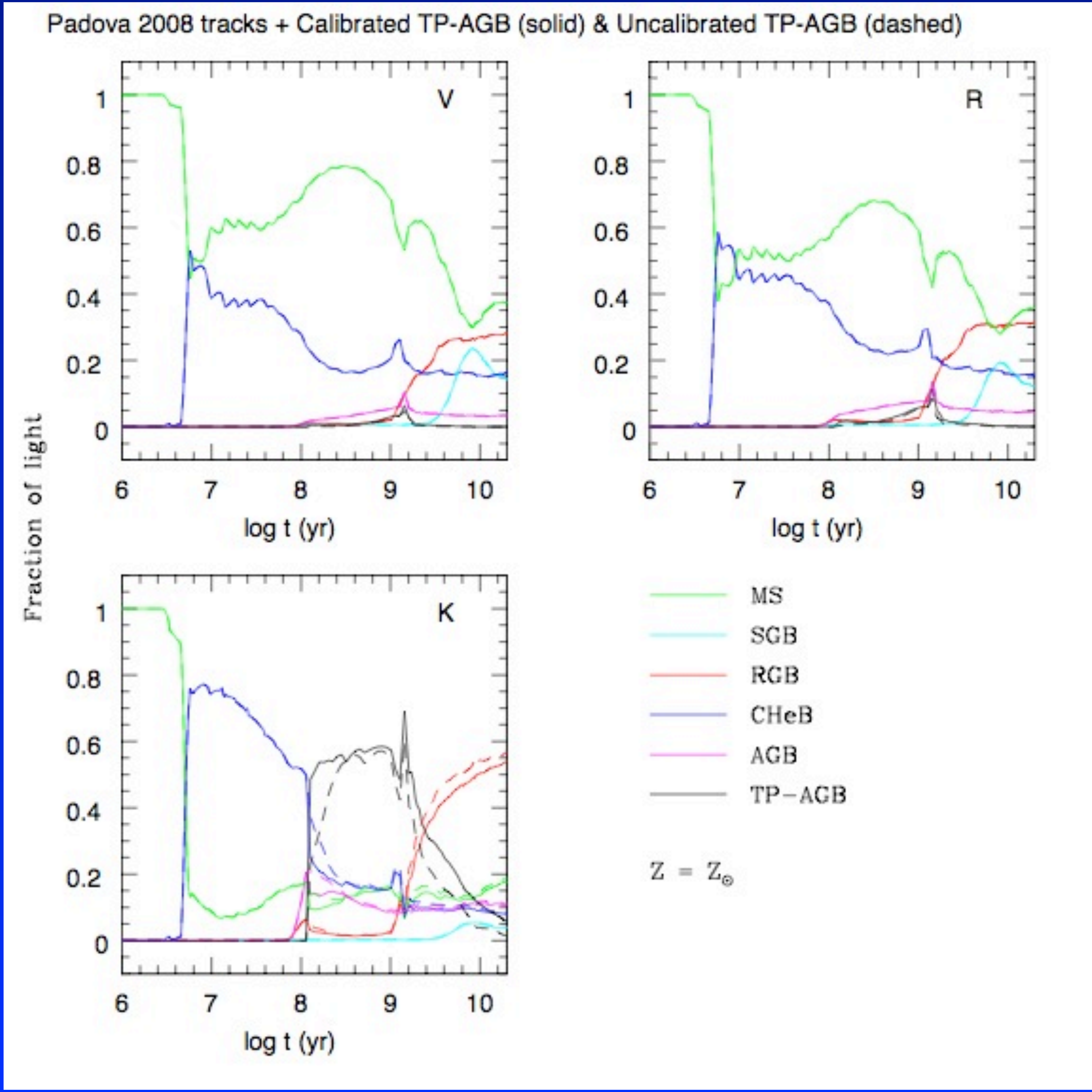
- Good match between models and data
- These are massive clusters
- Chandar et al. (2010)

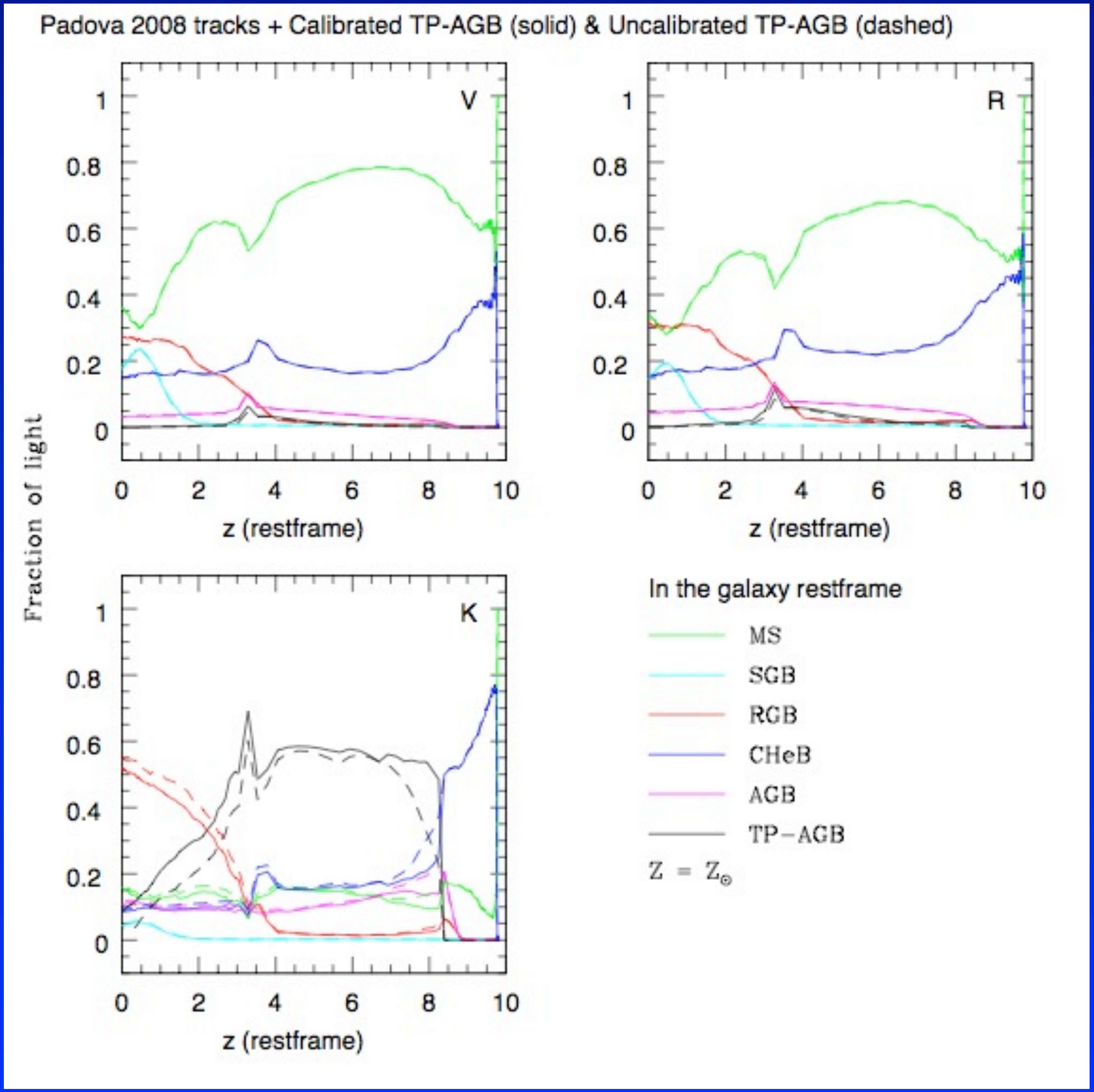
TP-AGB:

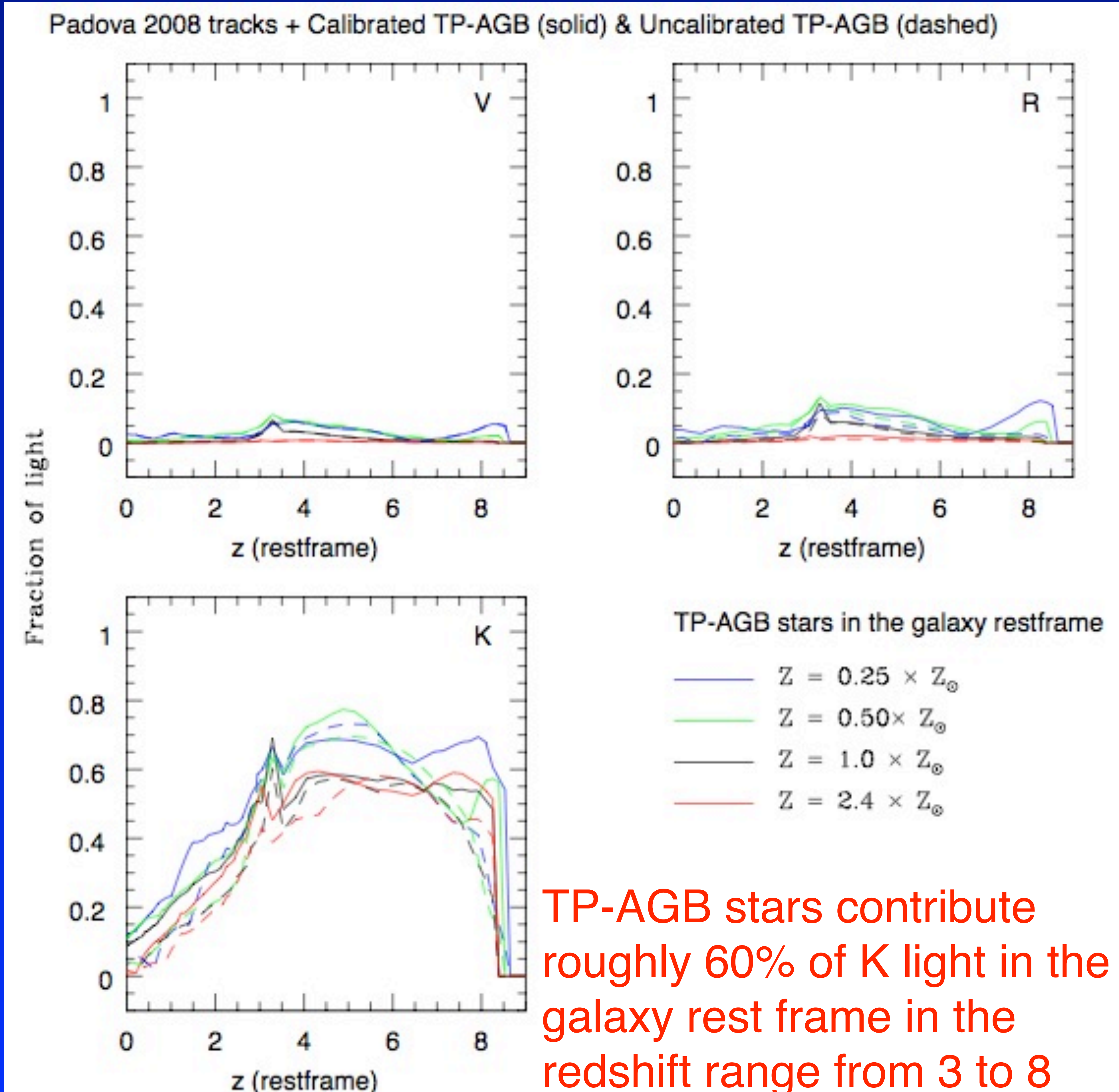
Tracks should predict the right number of stars, at least in most relevant evolutionary phases (e.g. TP-AGB):

NIR stellar sed's

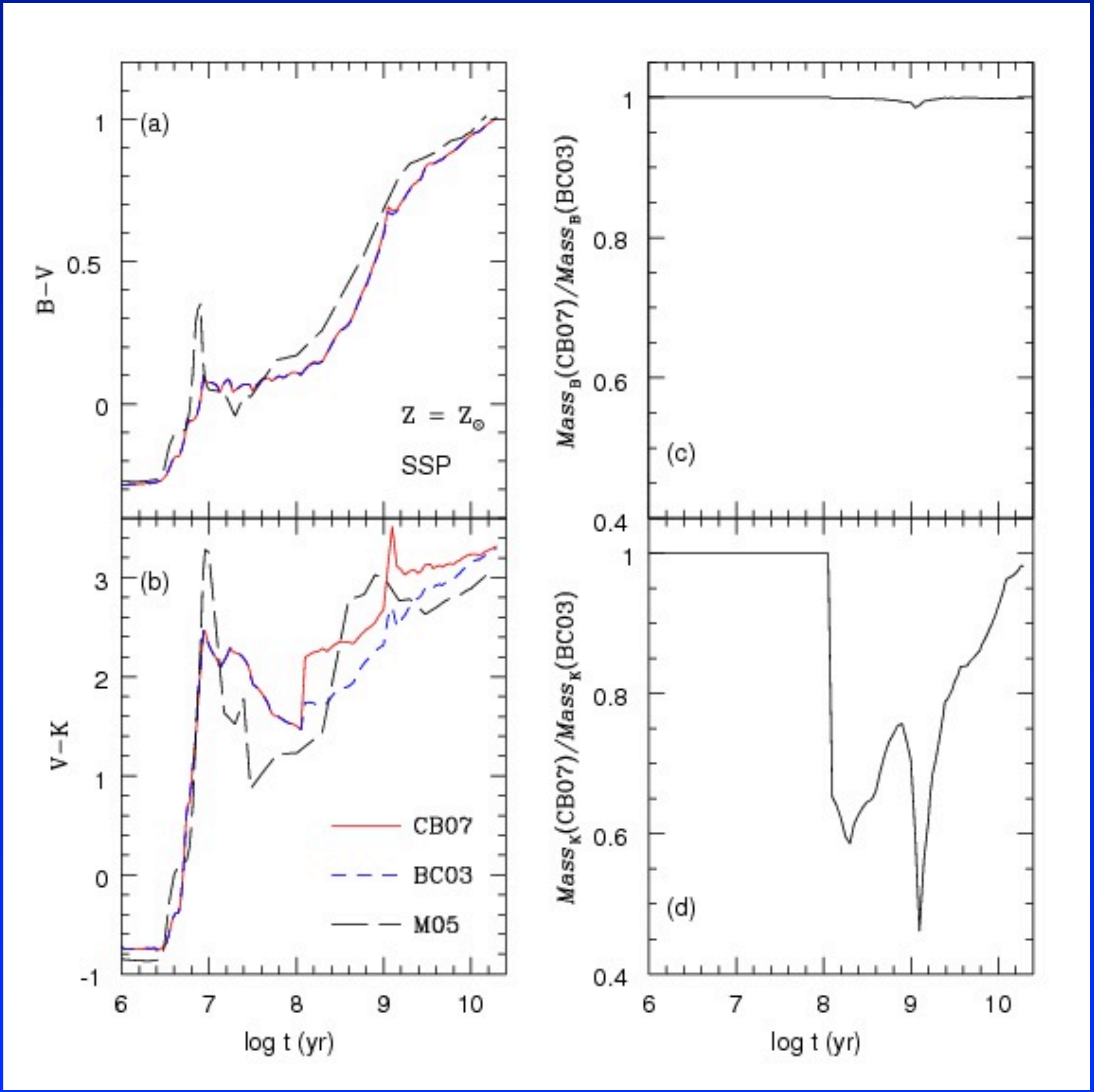
Evolutionary tracks and the mass of galaxies


Padova 2008 tracks + Calibrated TP-AGB (solid) & Uncalibrated TP-AGB (dashed)
V
R
K
Fraction of light
log t (yr)
MS
SGB
RGB
CHeB
AGB
TP−AGB
Z = Z⊙


Padova 2008 tracks + Calibrated TP-AGB (solid) & Uncalibrated TP-AGB (dashed)
V
R
K
Fraction of light
z (restframe)
In the galaxy restframe
MS
SGB
RGB
CHeB
AGB
TP−AGB
Z = Z⊙



TP-AGB stars contribute roughly 60% of K light in the galaxy rest frame in the redshift range from 3 to 8



Inferred mass

in B and K

Improving the NIR spectral range

IRTF library:

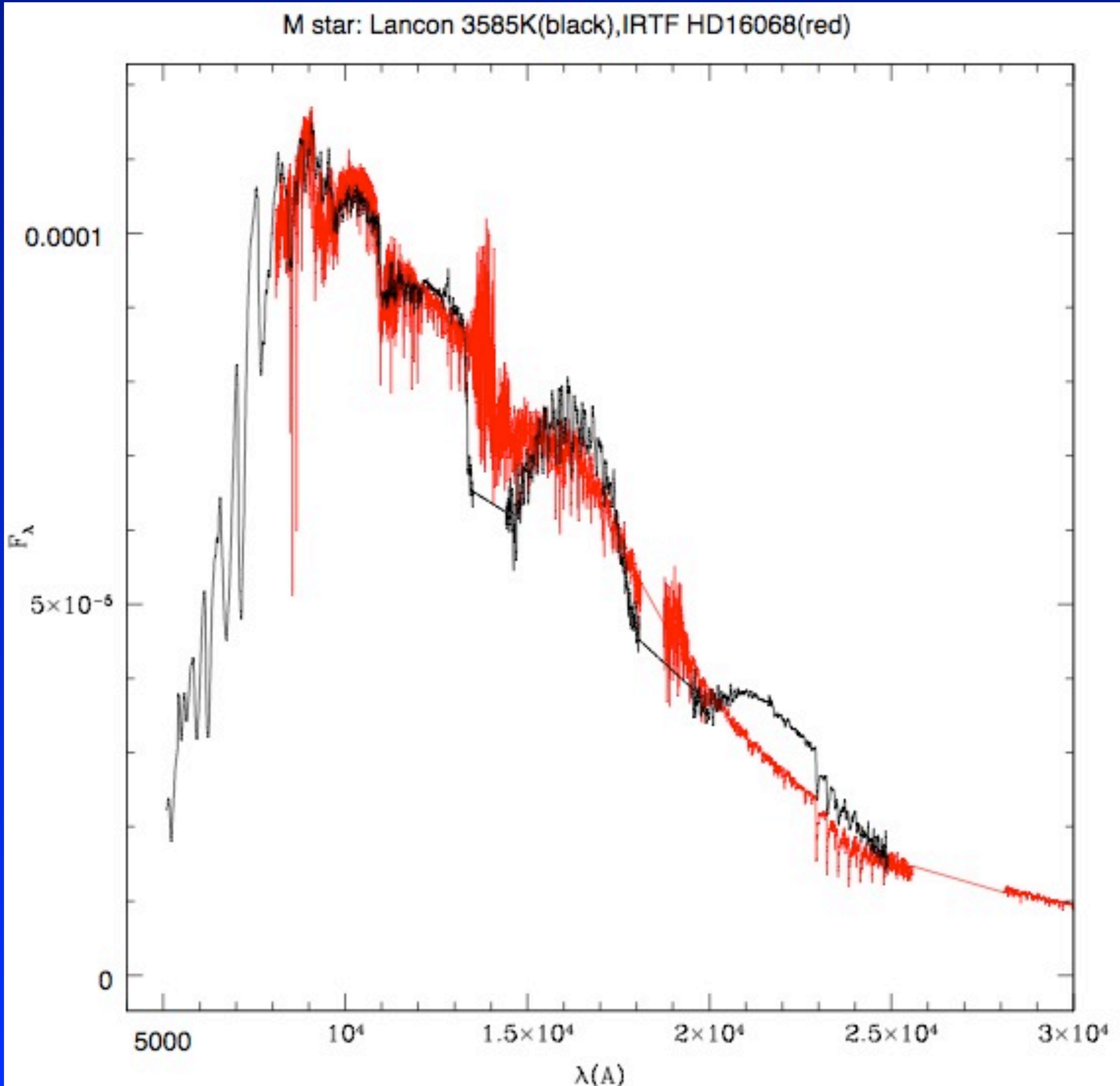
Infrared Telescope Facility Spectral Library (Cool Stars)

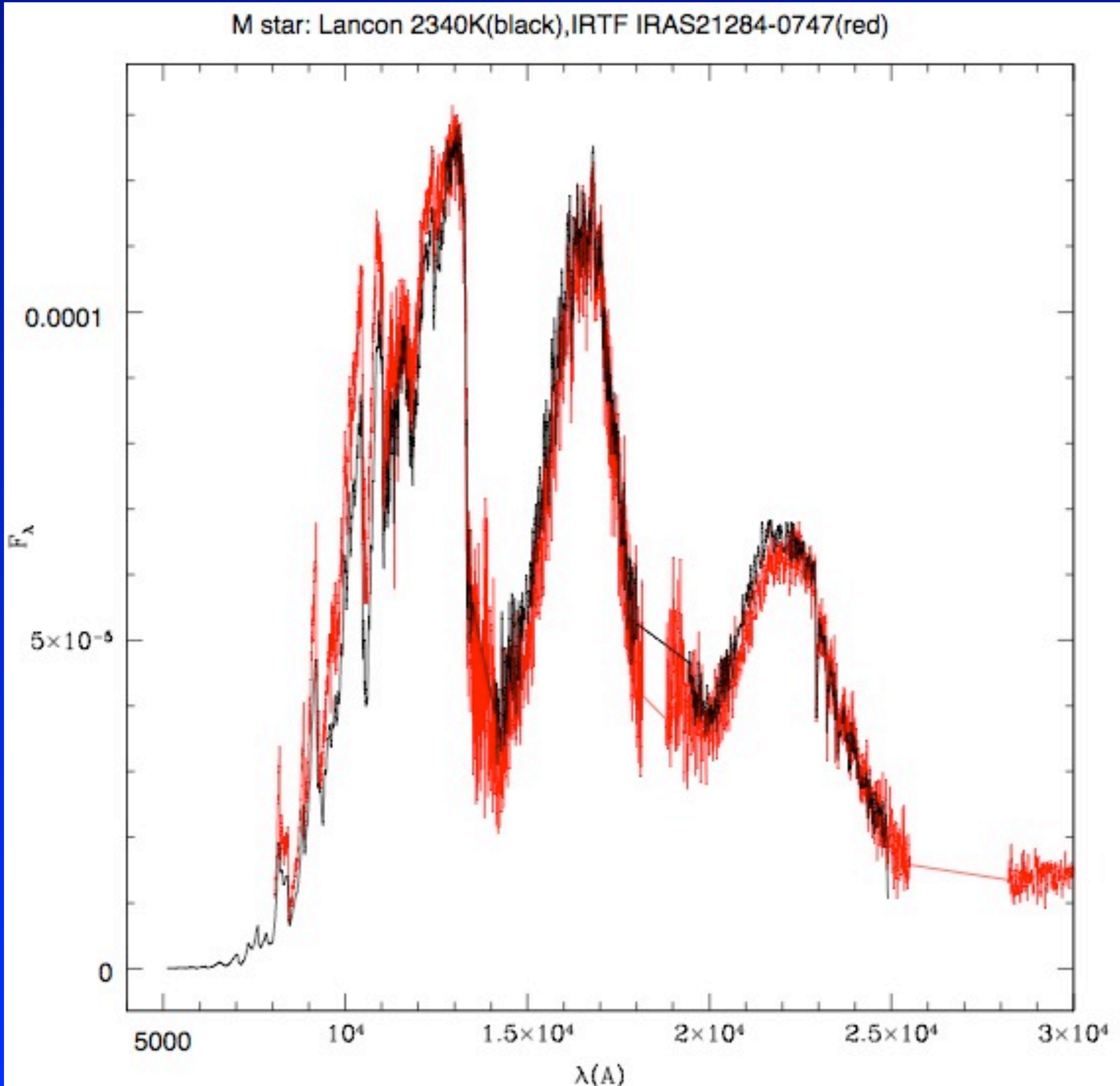
Rayner et al. (2009)

Stellar Models for C-stars:

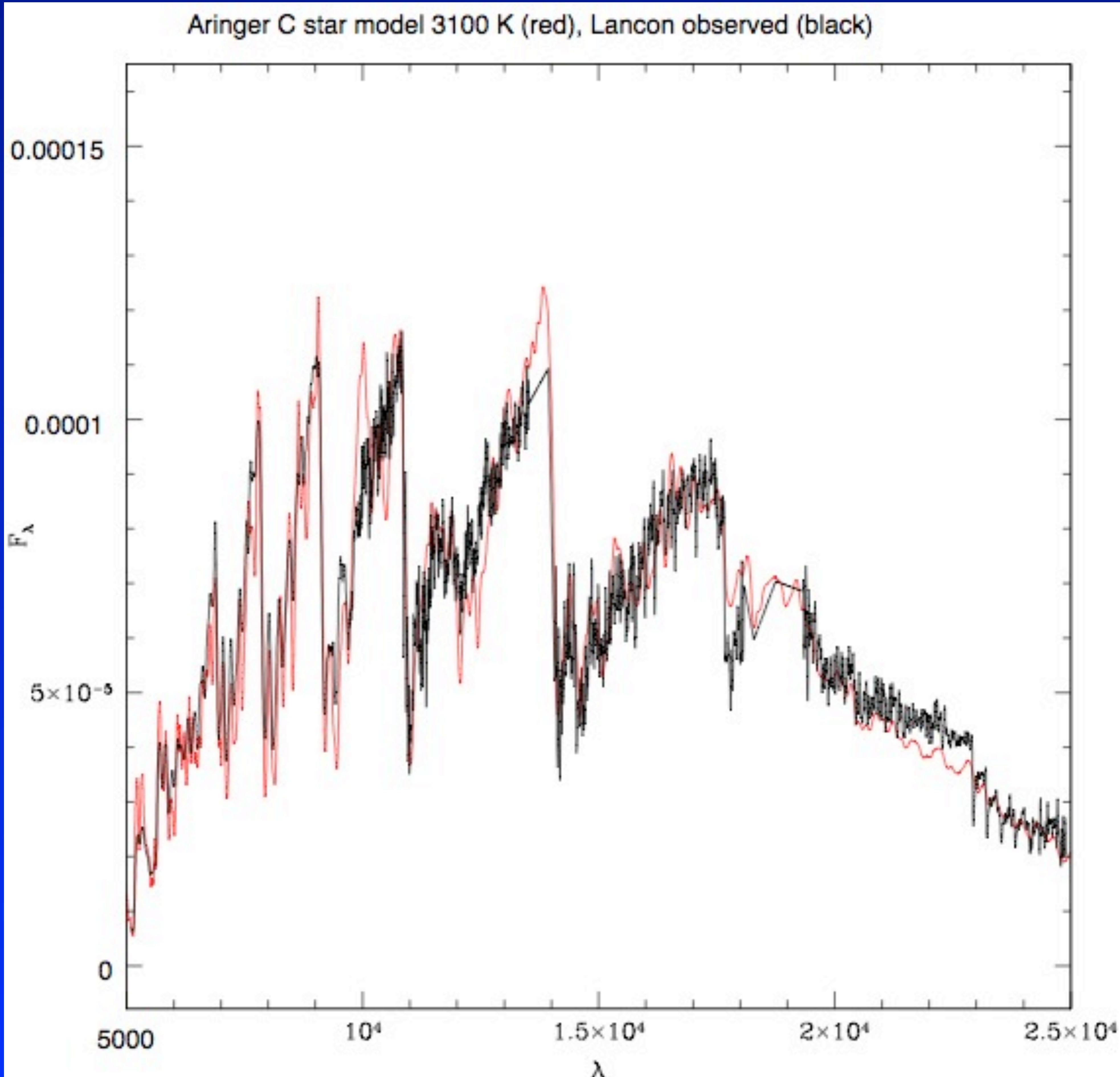
Aringer et al. (2009)

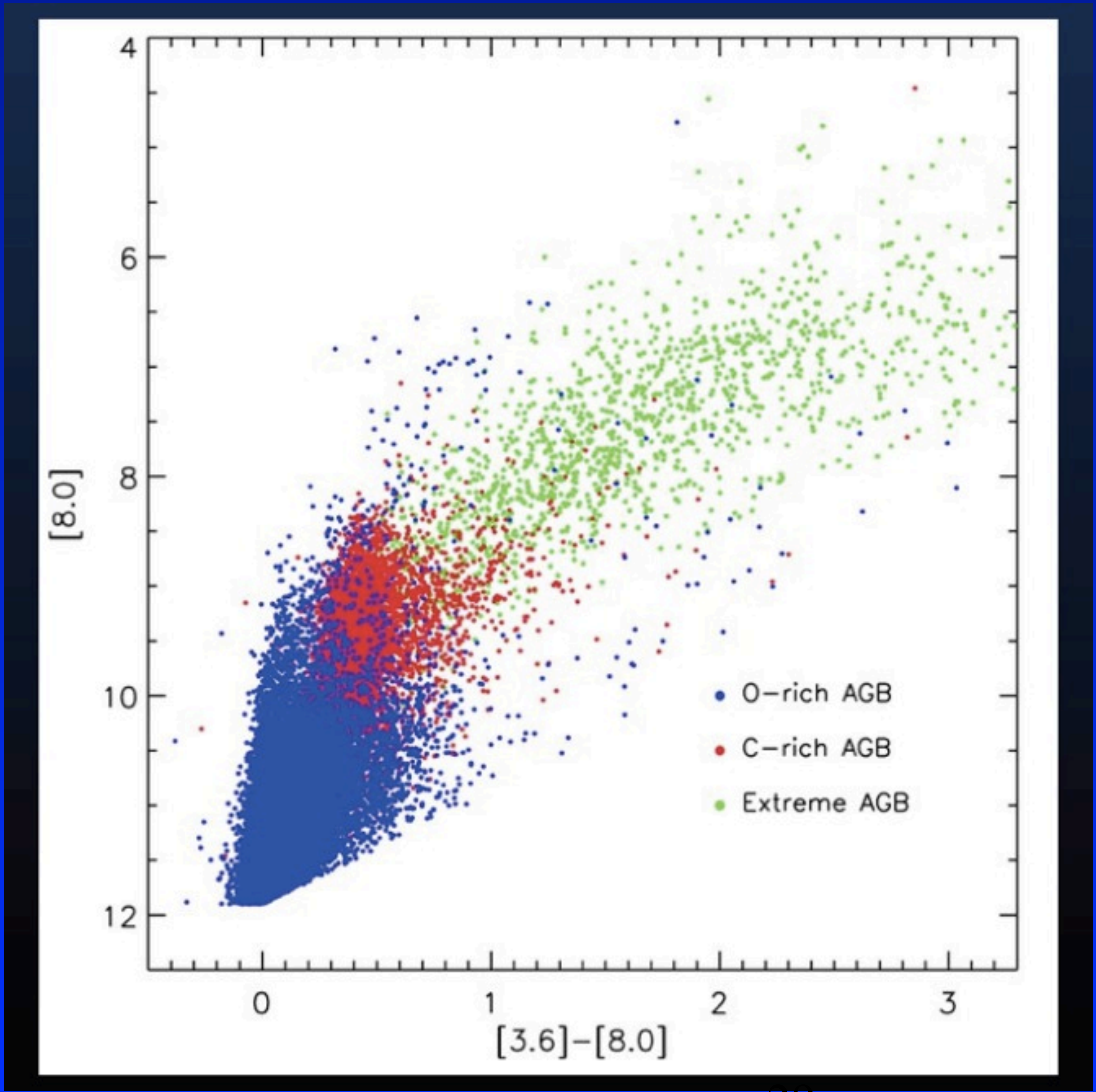
Both represent big improvements over previous data sets.


M star: Lancon 3585K(black),IRTF HD16068(red)
0.0001
5×10⁻⁵
0
Fλ
5000
10⁴
1.5×10⁴
2×10⁴
2.5×10⁴
3×10⁴
λ(A)



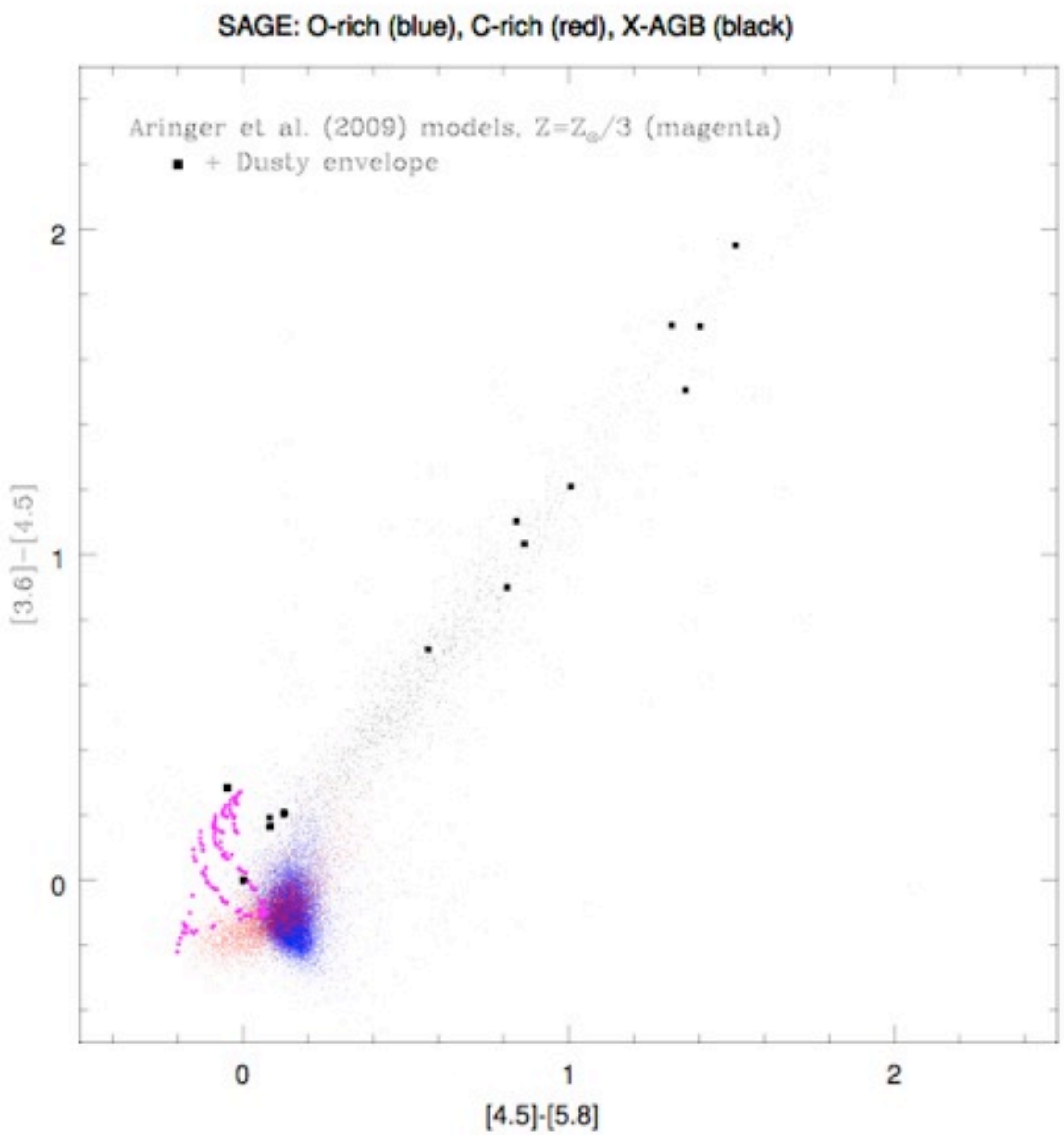
M star: Lancon 2340K(black),IRTF IRAS21284-0747(red)
0.0001
5×10⁻⁵
0
F_λ
5000
10⁴
1.5×10⁴
2×10⁴
2.5×10⁴
3×10⁴
λ(A)


Aringer C star model 3100 K (red), Lancon observed (black)
0.00015
0.0001
5×10⁻⁵
0
F_λ
5000
10⁴
1.5×10⁴
2×10⁴
2.5×10⁴
λ



TP-AGB candidates from SAGE LMC survey

(Srinavasan et al. 2009)

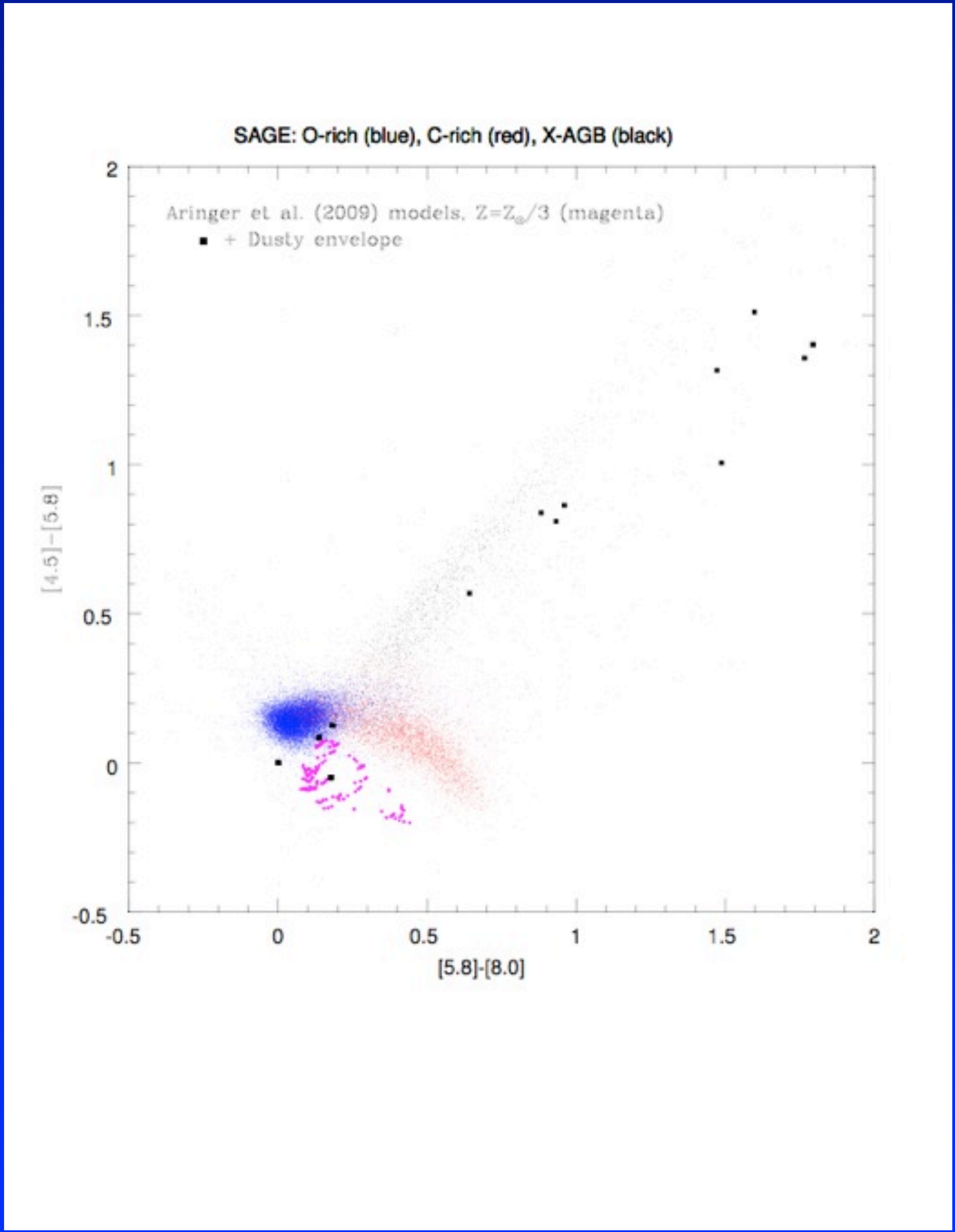


TP-AGB candidates from SAGE LMC survey

Must take into account effects of dusty envelope and mass loss.

Dusty code

Work with González-Lopezlira et al.



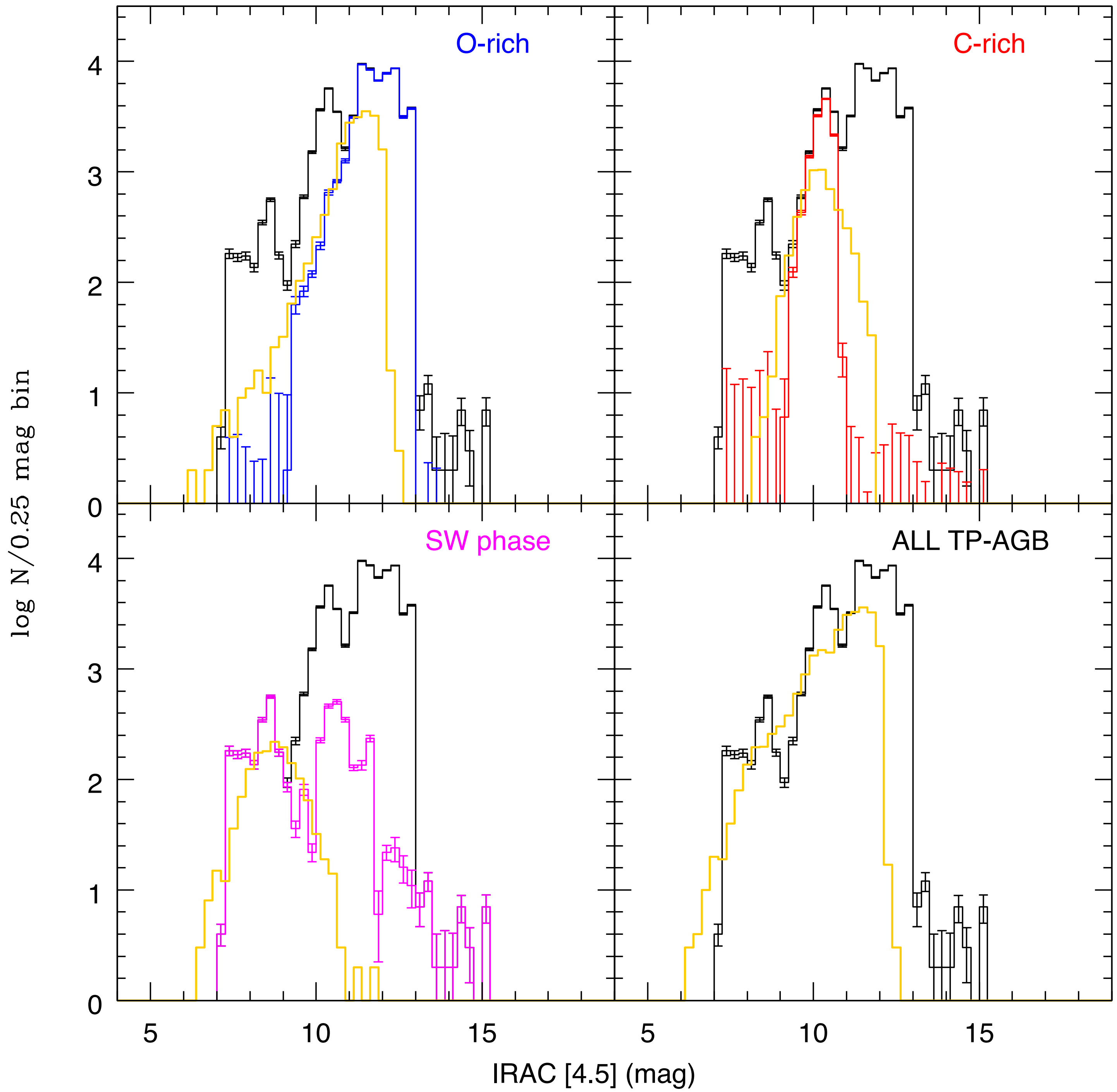
TP-AGB candidates from SAGE LMC survey

Must take into account effects of dusty envelope and mass loss.

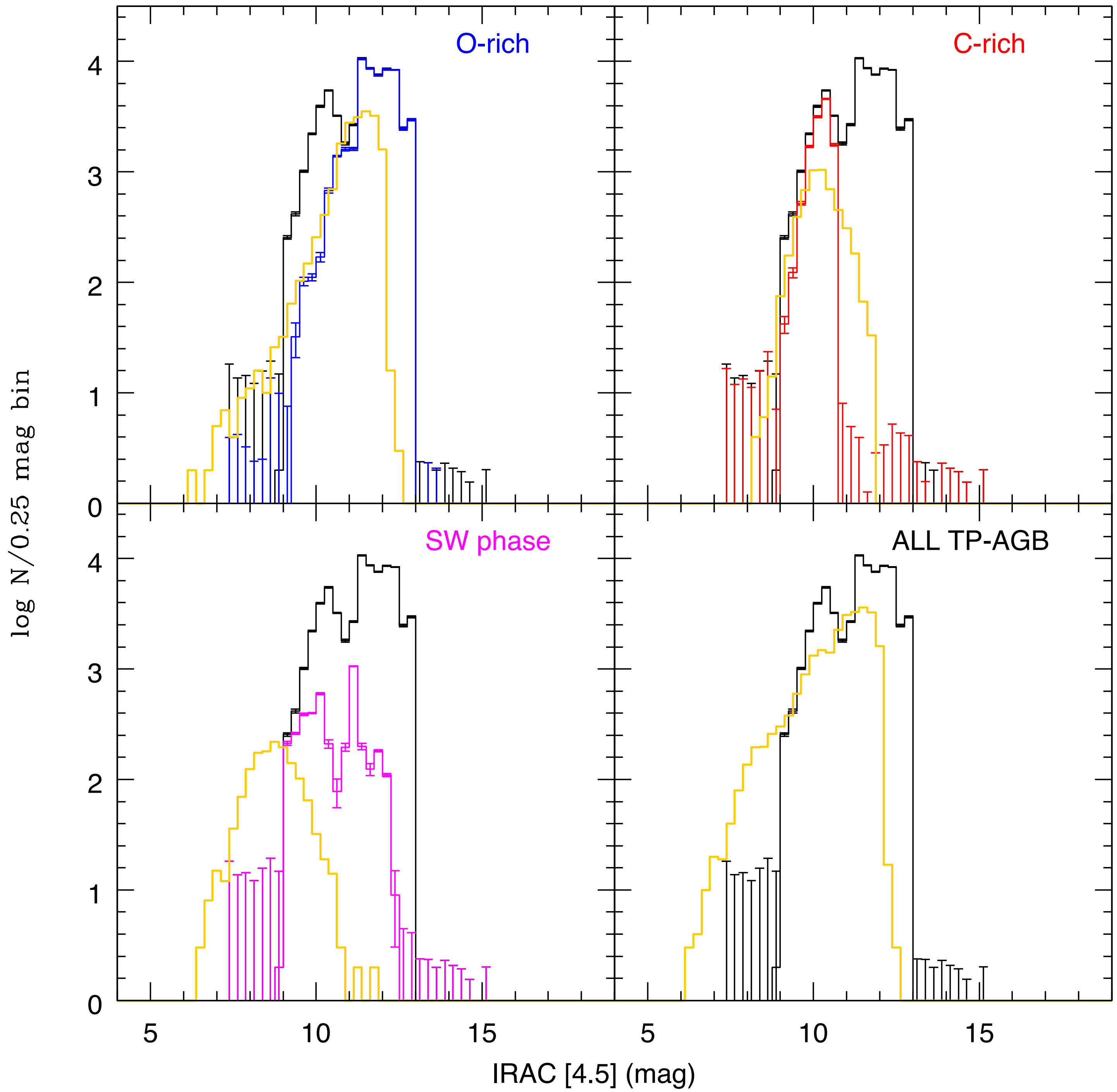
Dusty code

Work with González-Lopezlira et al.

LF of stars brighter than I = -4, DM = 18.50, Z = 0.008 (n: normal mass loss)



LF of stars brighter than I = -4, DM = 18.50, Z = 0.008 (f: dust free sed's)



Conclusions

Slow progress, but key issues remaining in stellar population synthesis models are being solved, as new ingredients (empirical and theoretical) become available.