Claudia Maraston
University of Portsmouth

STELLAR POPULATION MODELS BASED ON 60,000 EMPIRICAL STELLAR SPECTRA

A tribute to Olivier, July 2022

Outline

- Stellar population models
  overview
  New: Models based on the SDSS stellar library

  - Carbon star spectra for the TP-AGB phase

- Applications

  Because Olivier loved spectra (Mark and Bianca's talks) and was keen in learning about models

Outline

olivier-ages.pdf

1 / 2 147% Tools Sign Co

PORTSMOUTH

Claudia Maraston <claudia.maraston@port.ac.uk>

Re: Thanks.

1 message

Olivier LE FEVRE <olivier.lefevre@oamp.fr> 12 December 2011 at 19:06
Reply-To: olivier.lefevre@oamp.fr
To: Claudia Maraston <Claudia.Maraston@port.ac.uk>
Cc: Olivier Le Fevre <olivier.lefevre@oamp.fr>

Dear Claudia,

Many thanks for your messag
People here really enjoyed yo visit, thanks for taking th me to come over.

I'm looking forward to further anges on ages issues, a to a possible visit in Portsmouth.

Happy holiday season!

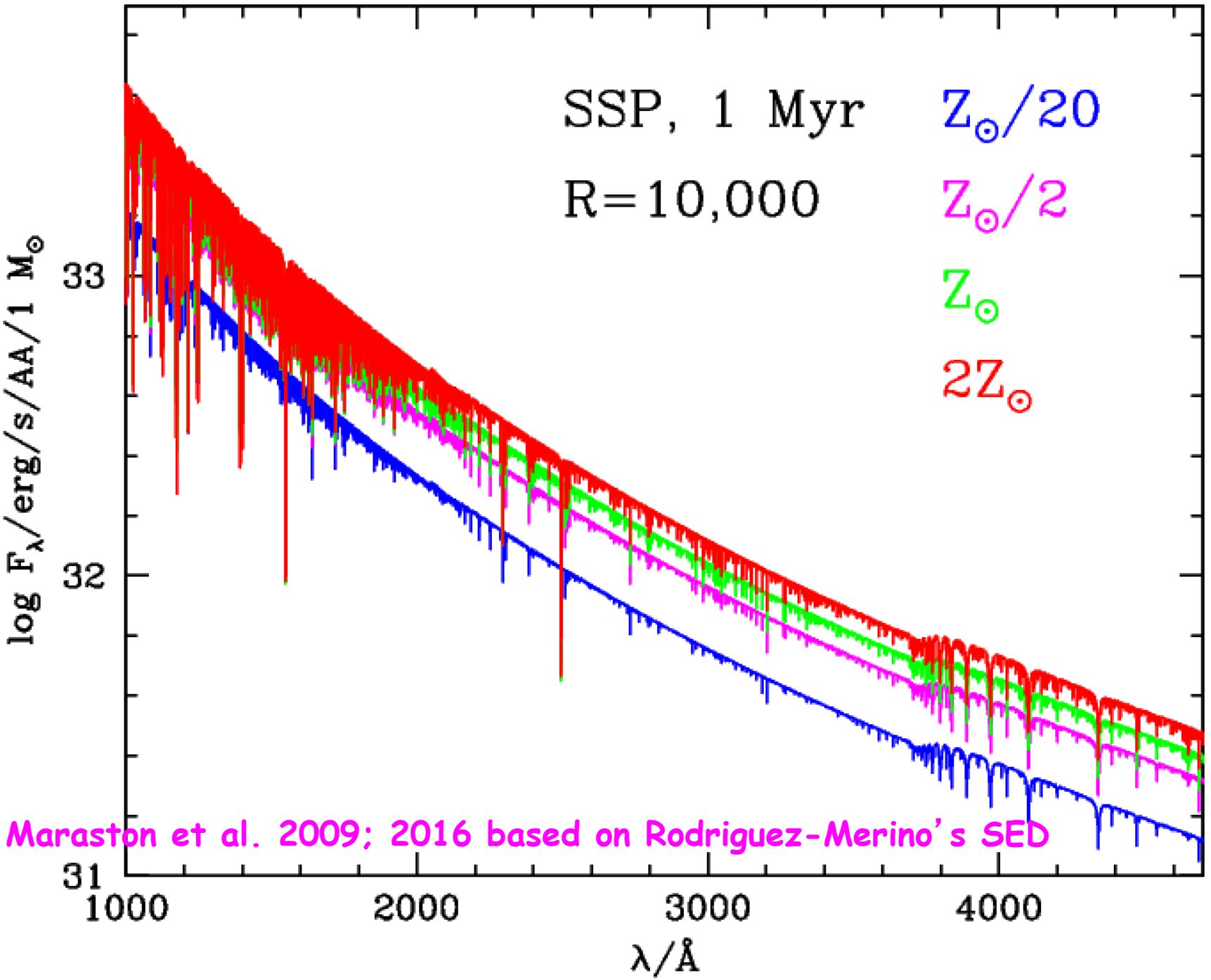
Olivier

Le 11/12/2011 14:00, Claudia Maraston a écrit :

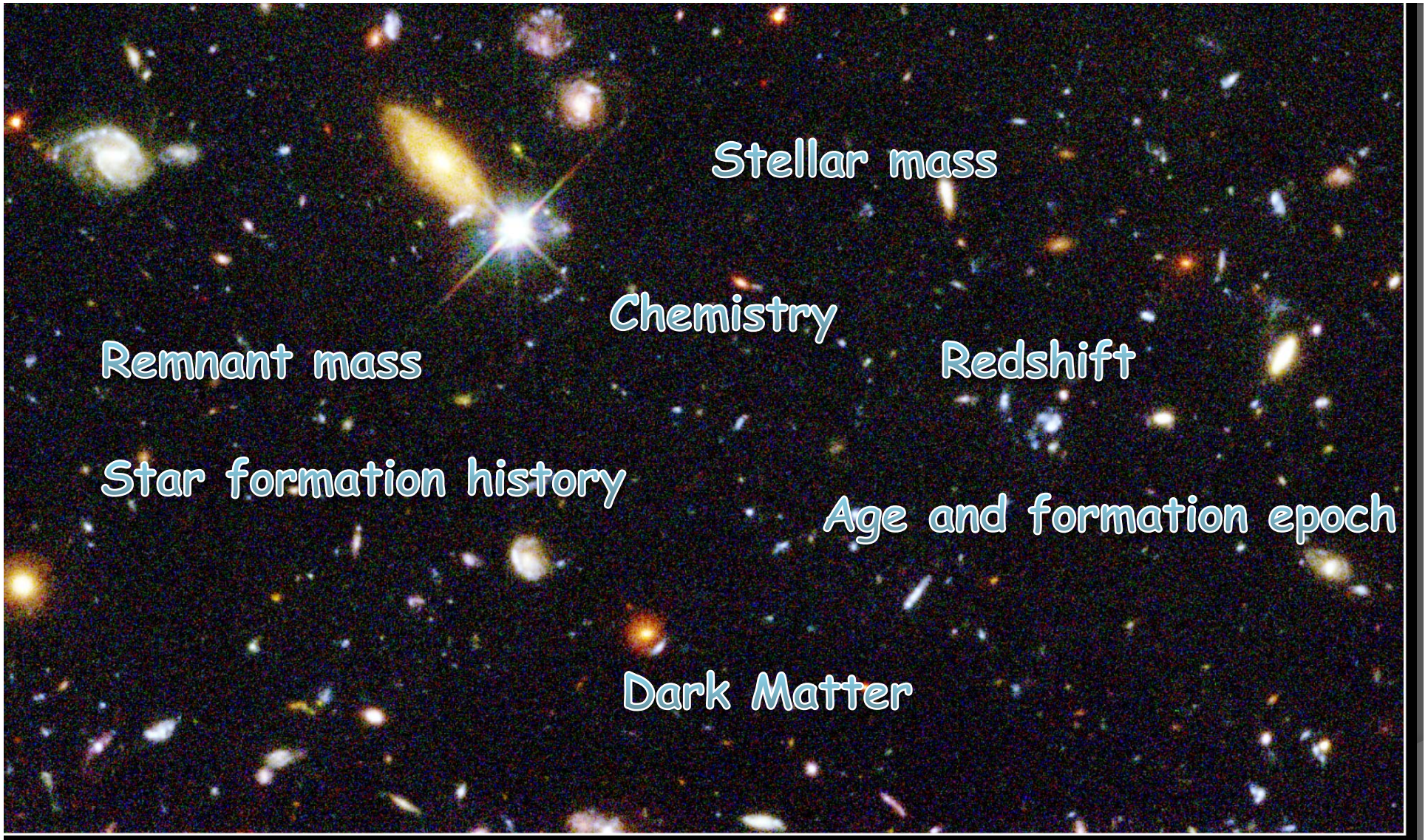
> Dear Olivier,
>
> thank you so much for the splendid visit!
>
> I really enjoyed to be in such a vibrant, joyful observatory where so

"The extended epoch of galaxy formation: Age dating of ~3600 galaxies with 2 < z < 6.5 in the VIMOS Ultra-Deep Survey⋆", Thomas, Le Fevre et al. 2017

0 x 11.00 in

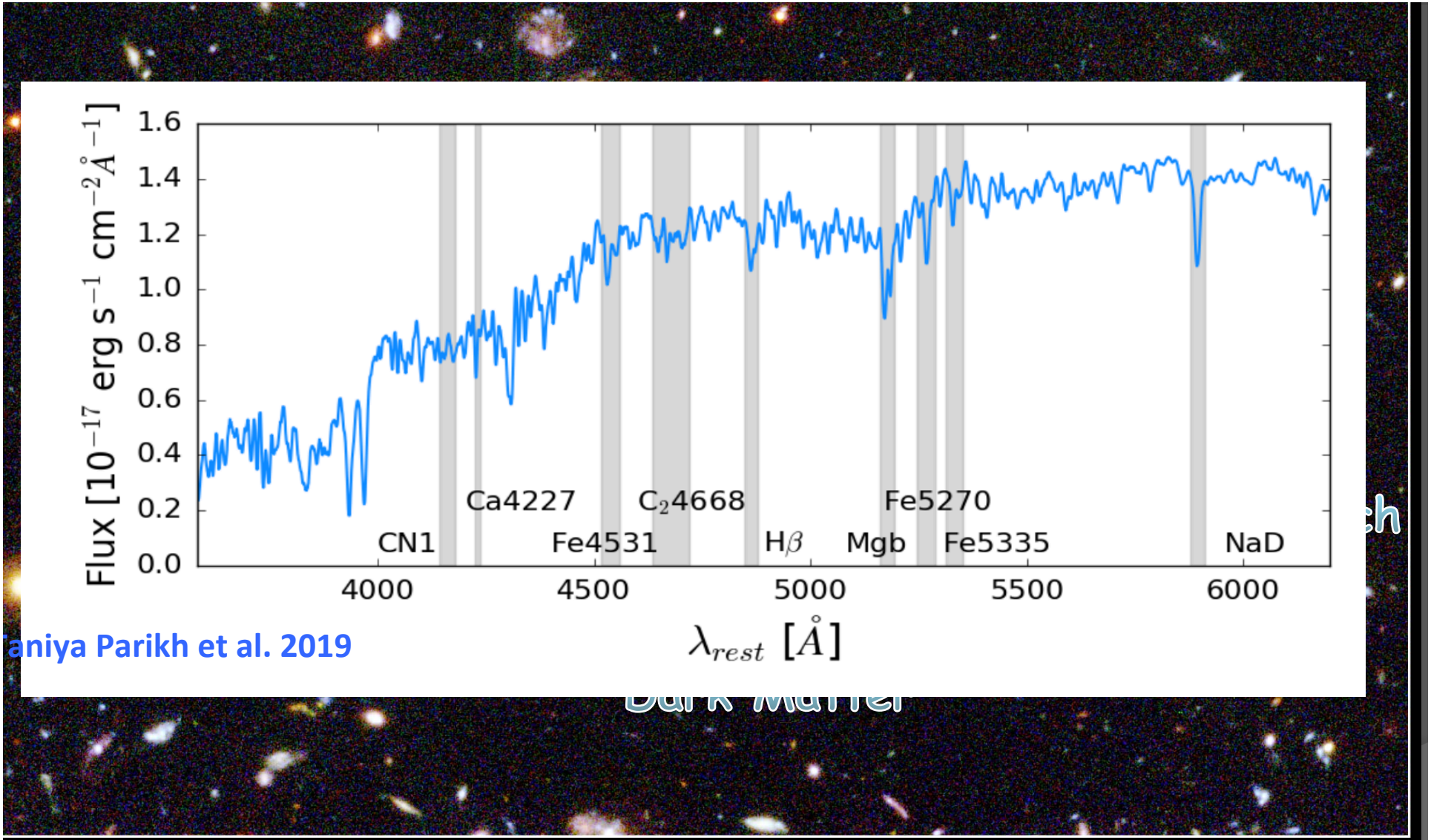


Maraston et al. 2009; 2016 based on Rodriguez-Merino's SED



Hubble Deep Field

Hubble Space Telescope • WFPC2



aniya Parikh et al. 2019

Hubble Deep Field

Hubble Space Telescope • WFPC2

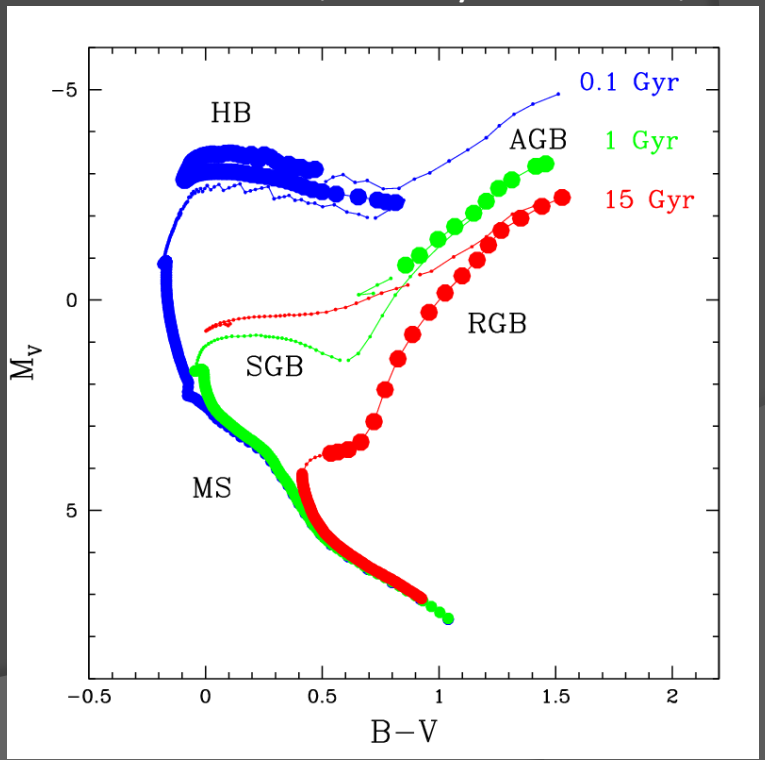
Evolutionary Population Synthesis

Tinsley 1972;Renzini 1981;Bruzual 83; Maraston 1998; 2005; Thomas, Maraston Bender 2003; Vazdekis et al. 1996; Fioc & Rocca-Volmerange 1997; Leitherer et al. 1999; Conroy et al. 2009; Eldridge et al. 2017

The contribution by stars on different phases weighted by energy and timescales according to stellar evolution theory

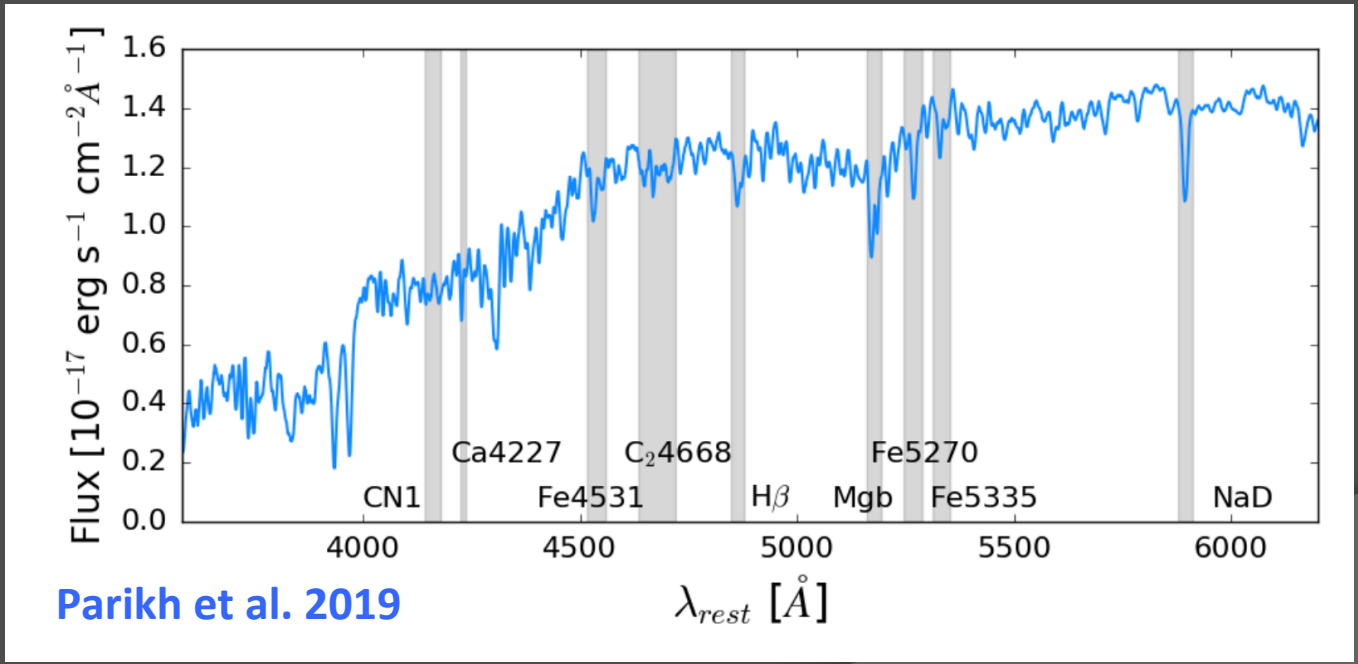
The Fuel Consumption Theorem

Renzini 81; Buzzoni 89; Maraston98;05



Model input physics

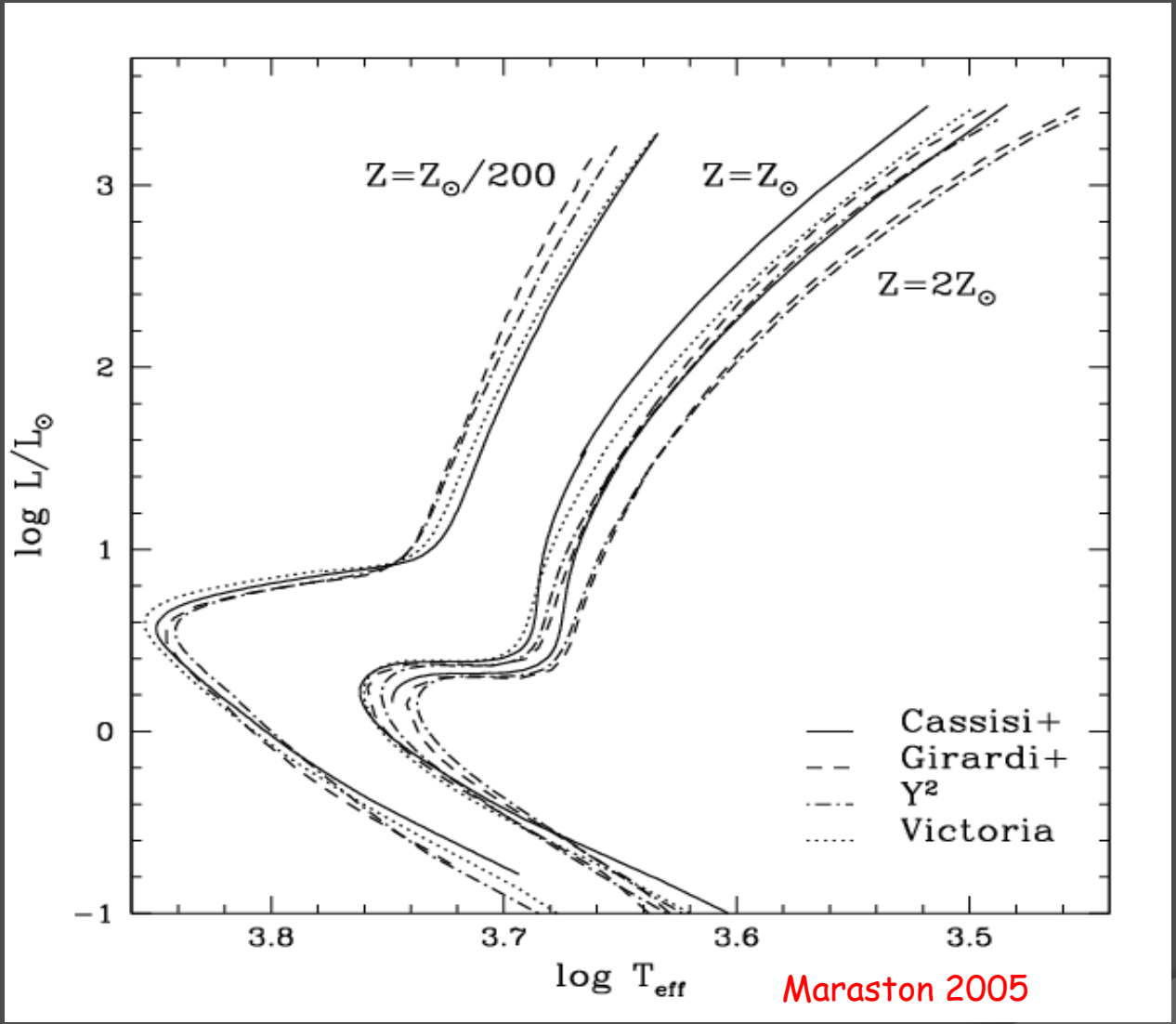
- ENERGY emission per star mass E /erg
- TIMESCALE: How long energy is emitted t
- SPECTRA distribution function of E per wavelenght $F\lambda d\lambda$
- MASS DISTRIBUTION: # stars per mass bin N(M)dM
- Remnant Mass Distribution: mass and type of remnant



Parikh et al. 2019

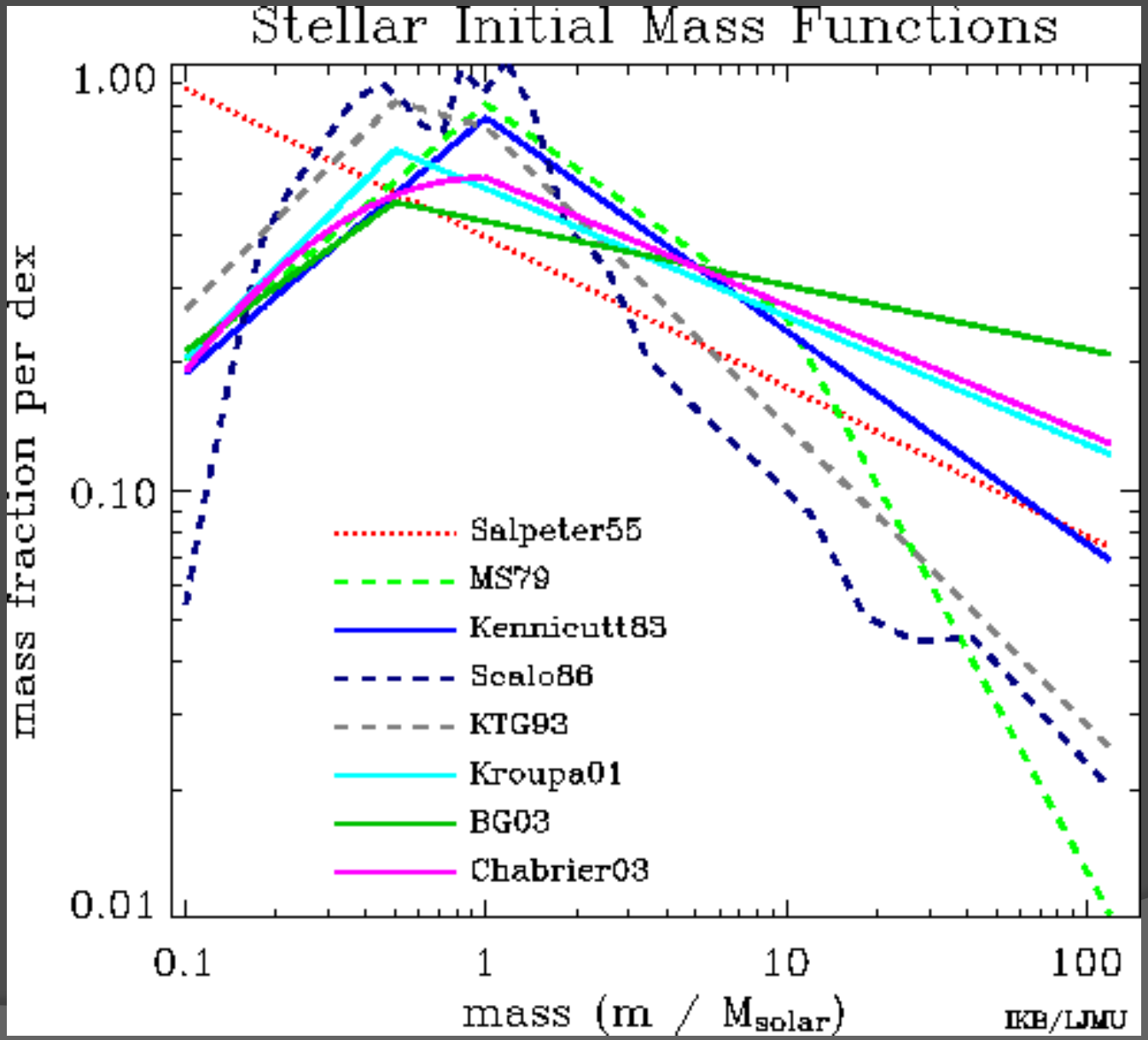
Extras: binaries, emission-lines/nebular continuum

Energy and timescales: Stellar Models



- Core convective overshooting - AGE
- Mixing-length - - METALLICITY
- Equation of state

Stellar Mass distribution



Based on star counts in the solar neighborhood (Salpeter 55, Kroupa 01, Chabrier 03)

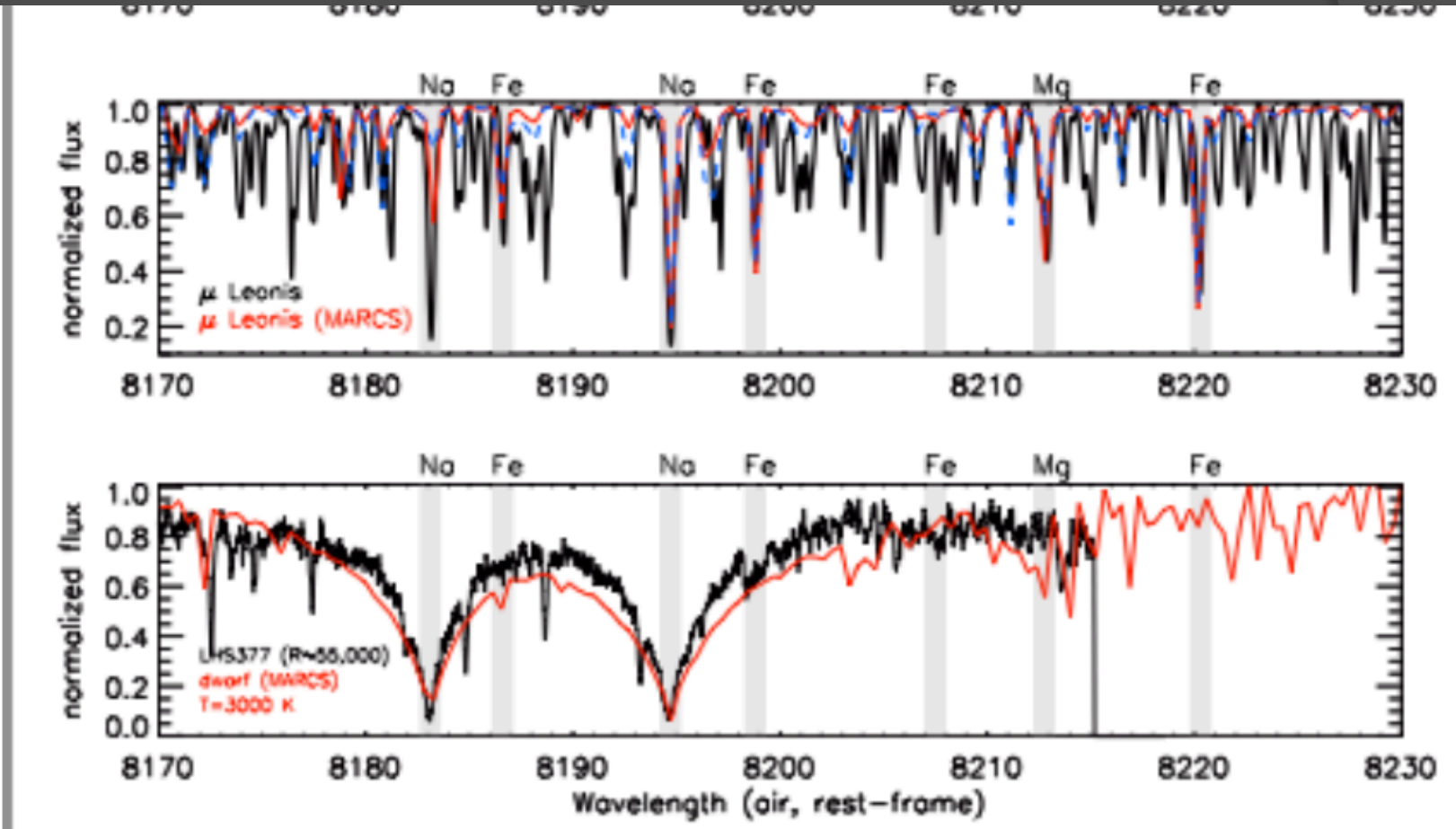
Bottom-heavy in massive galaxies Conroy & van Dokkum 2010

Top-heavy in starbursts Lacey et al. 2013 Kauffmann et al. 2020; her talk.

Stellar Spectra
atmosphere models

Kurucz 1979
Gustaffson et al. 2008

- arbitrary resolution and wavelength extension ✔
- wide coverage of stellar parameters ✔
- inaccuracies in line-lists ✖

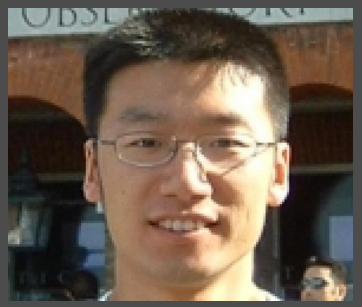


Data from Manuela Zoccali

Stellar Spectra empirical libraries

MaStar – the SDSS stellar library

Yan et al. 2019; 22



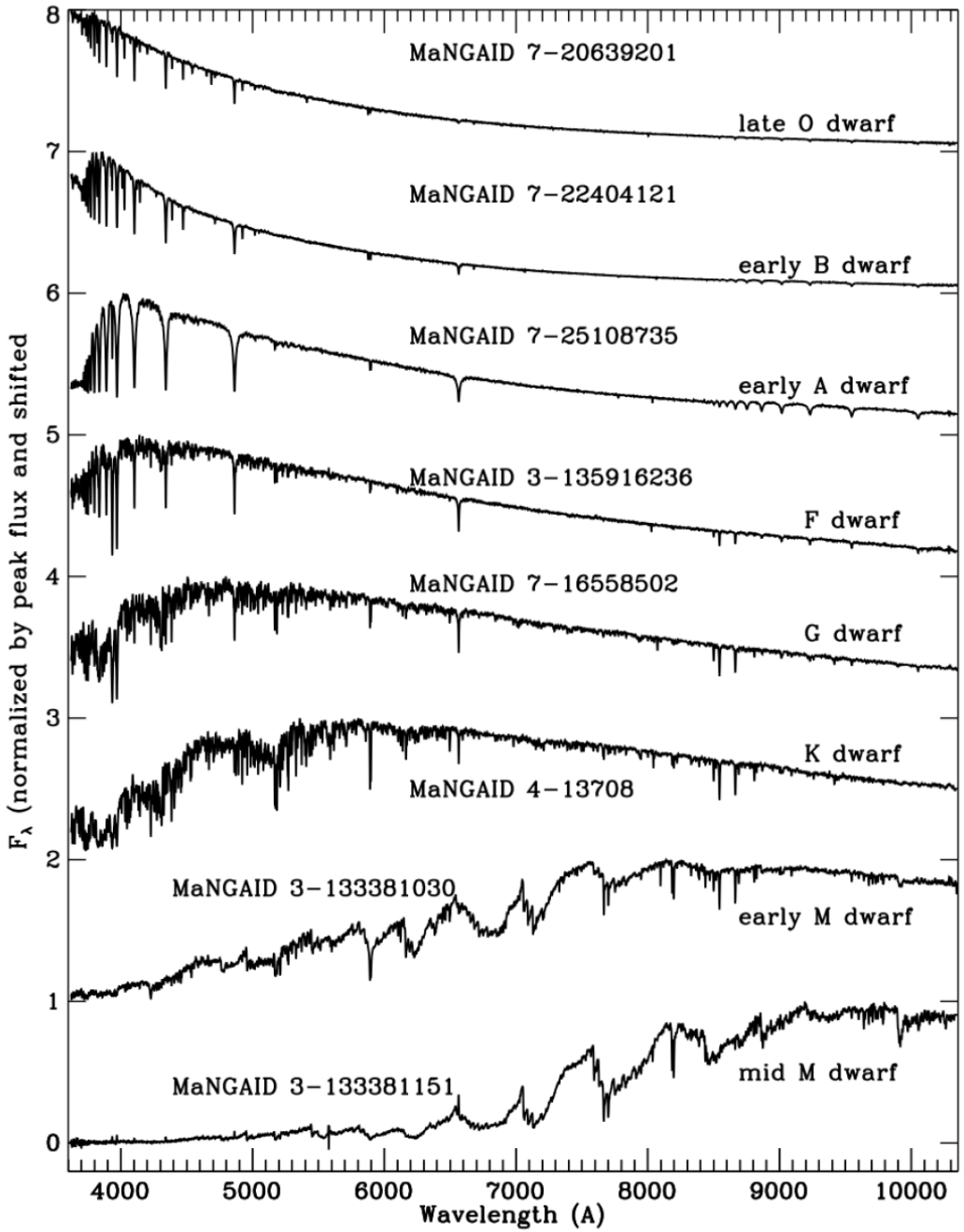


Figure 3. Example per-visit spectra for some main sequence stars in the MaStar Library.

The virtues of MaStar (much to Olivier's liking)

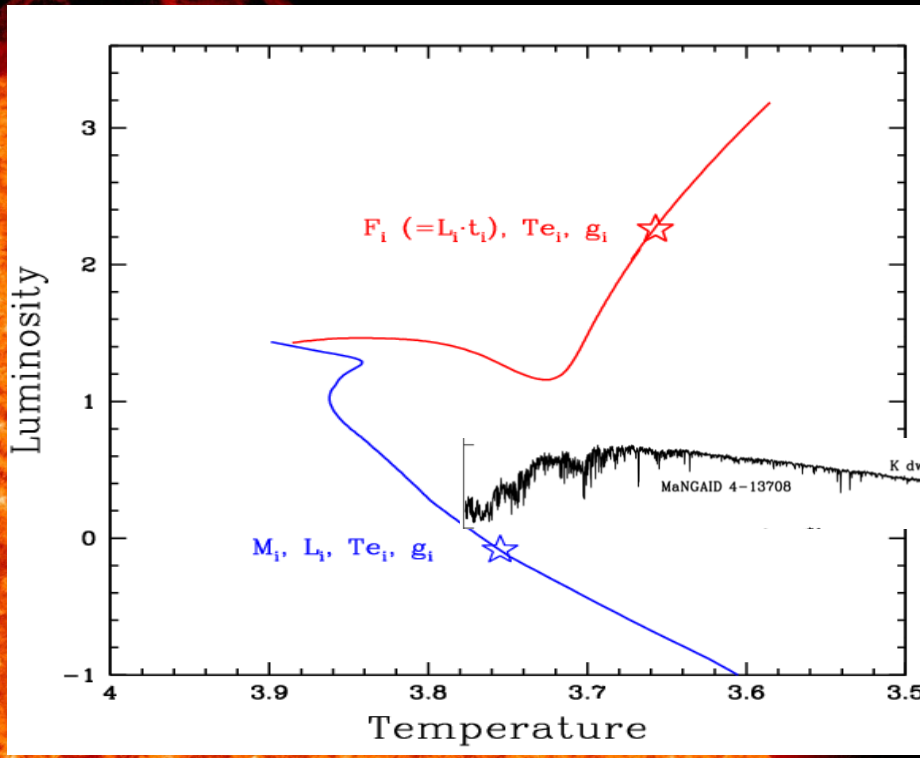
- 60,000 spectra for 25,000 stars
(previously 900 spectra, MILES)

- R=1800, S/N>50 (~150)

- wide wavelength range - 0.36-1.03 μ - Na@8200

- same instrumental effects as for galaxy spectra

- wider coverage of stellar parameters, including the bottom Main Sequence, Carbon stars and hot spectra – a range in [alpha/Fe]



Effective temperature

Surface gravity

Chemical composition

Portsmouth calculation of Stellar Parameters

Lewis Hill, PhD student,
University of Portsmouth

Individual full spectral fits with grids of *theoretical spectra* (from MARCS, Kurucz) + constraints from GAIA to break degeneracies

Hill et al. 2022, MNRAS, 509, 4308

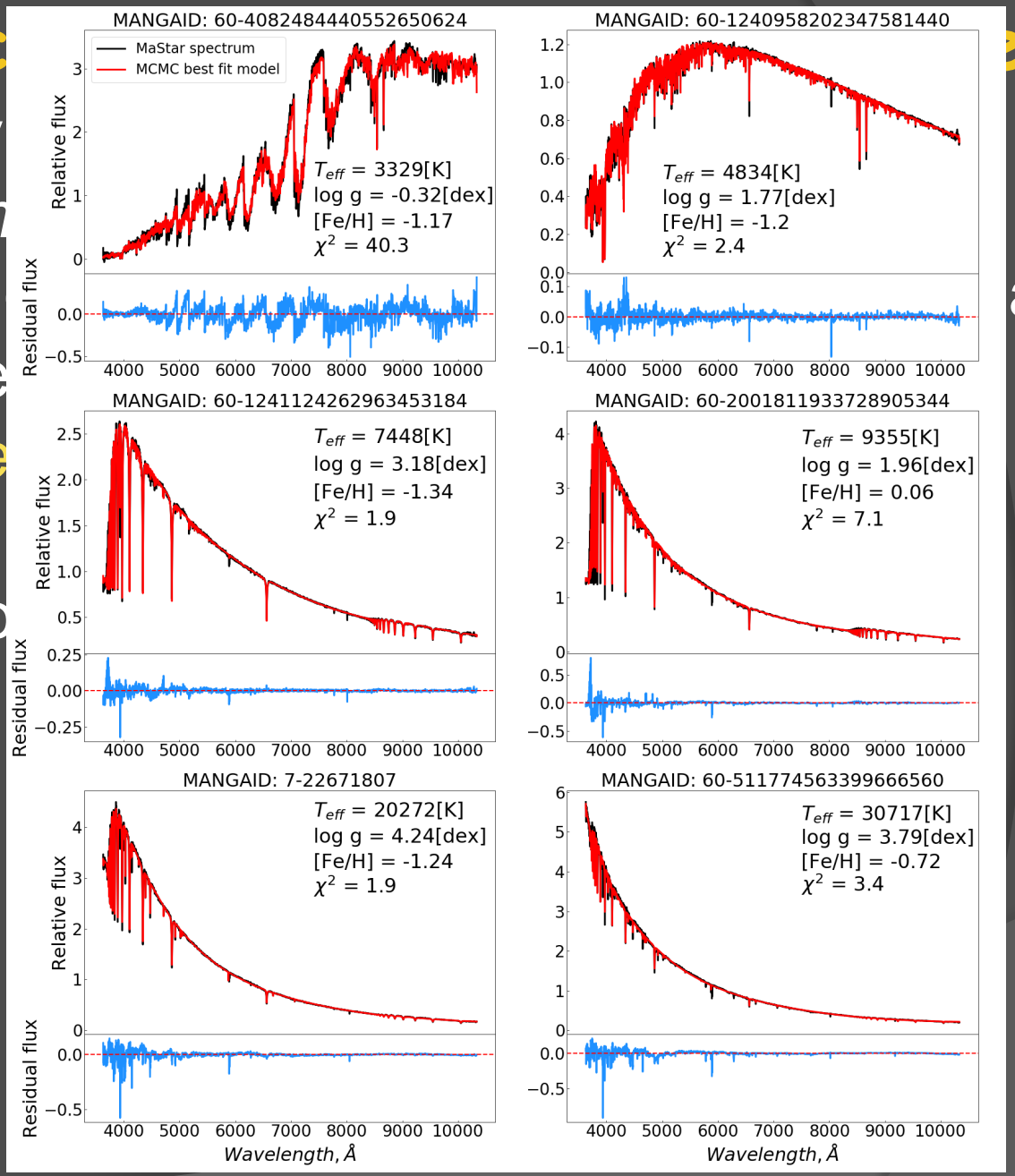
Theoretical parameters - Th

Portsmouth calc … ers

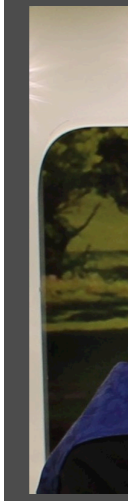
Indiv … *th* … Kuru … dege … *Hill e* … ak

Lewis Hill, PhD student, University of Portsmouth

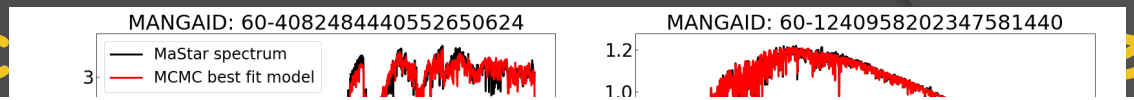
Theo …

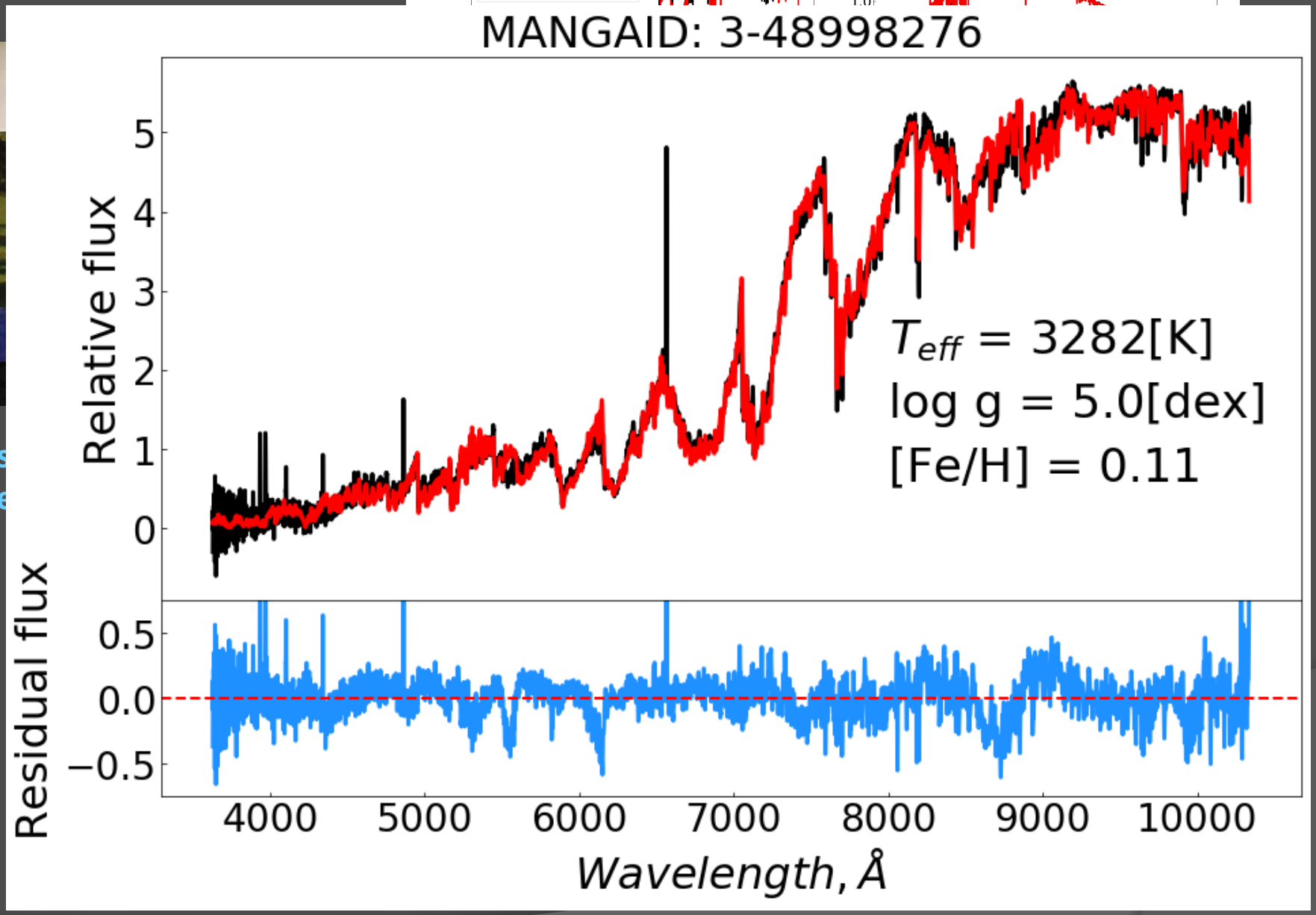


Portsmouth calc…ers

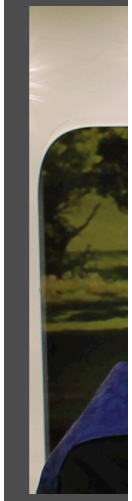


Lewis…
Unive…

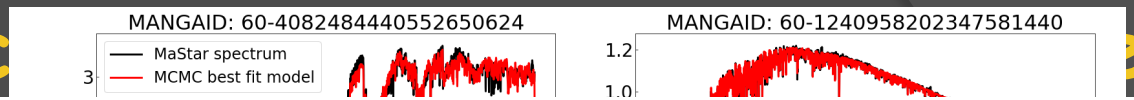


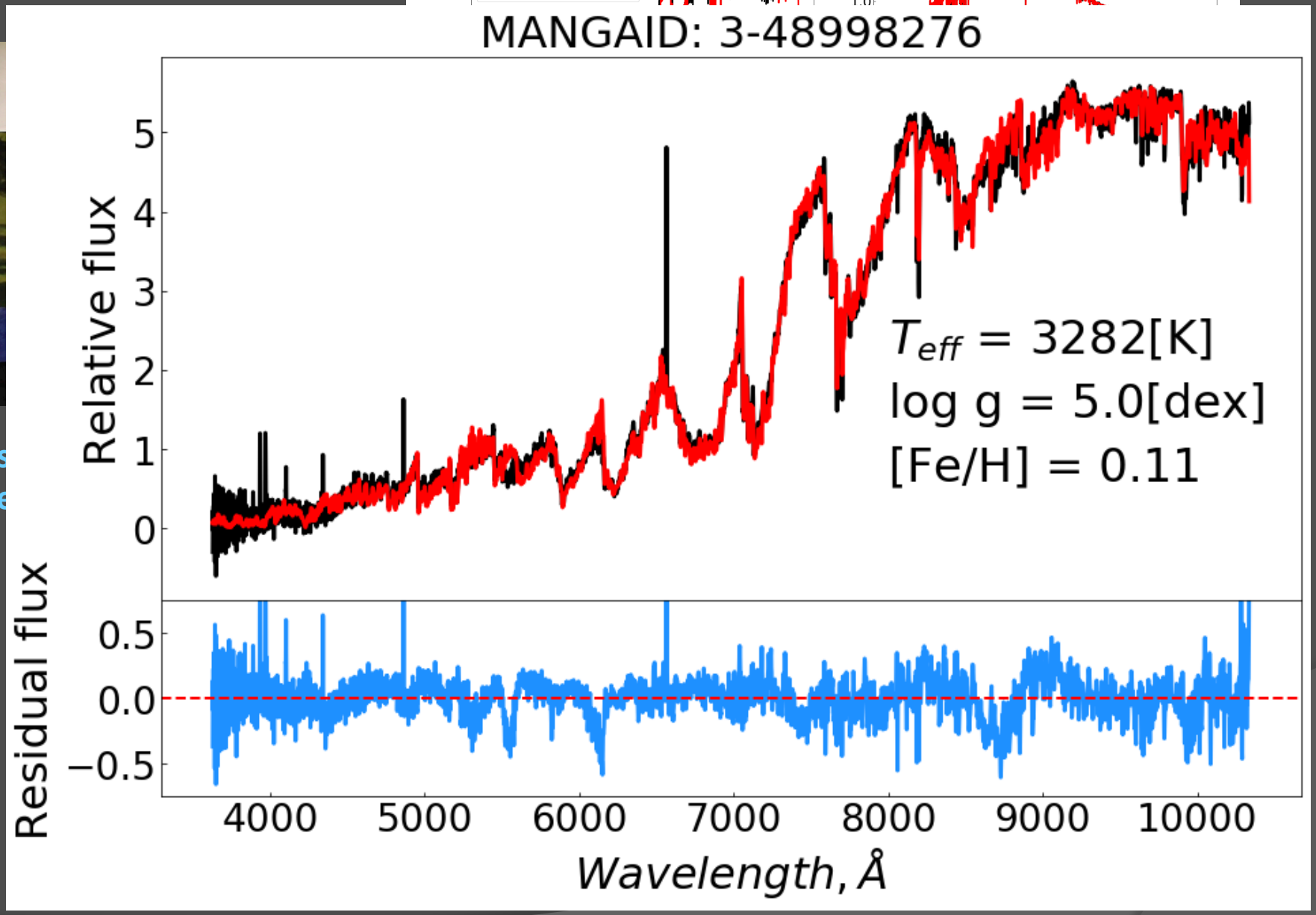


Portsmouth calc…ers

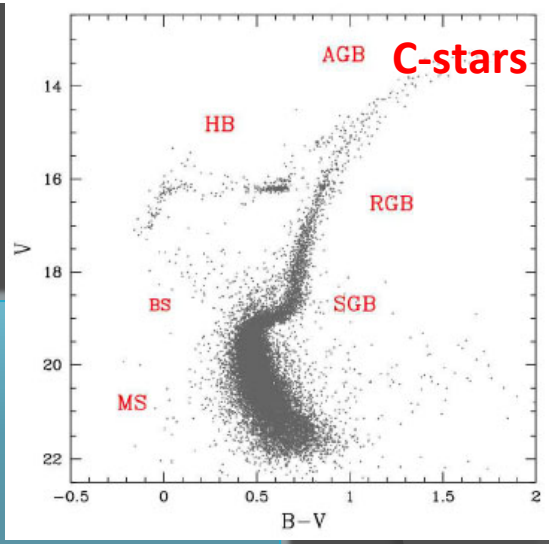


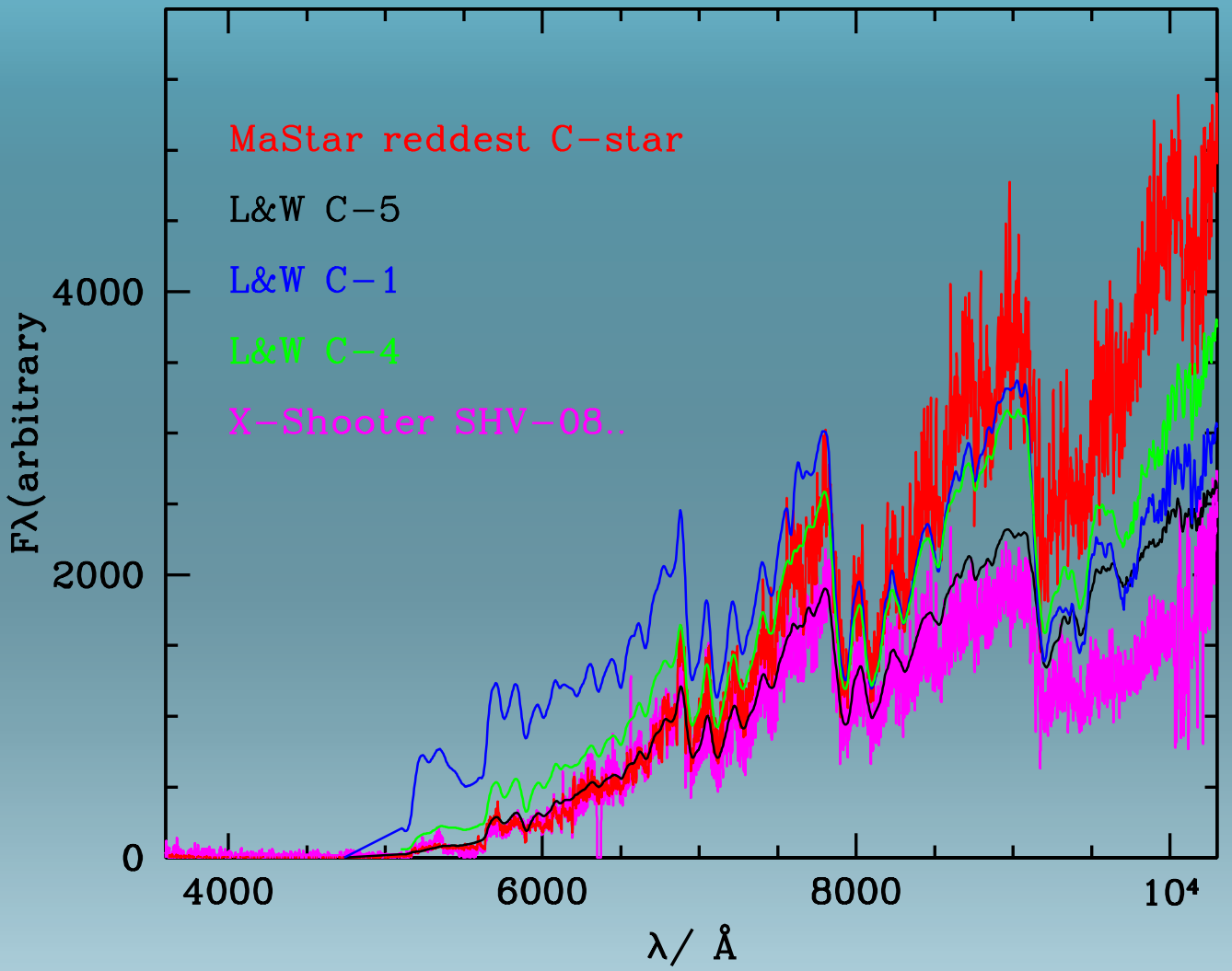
Lewis…
Unive…



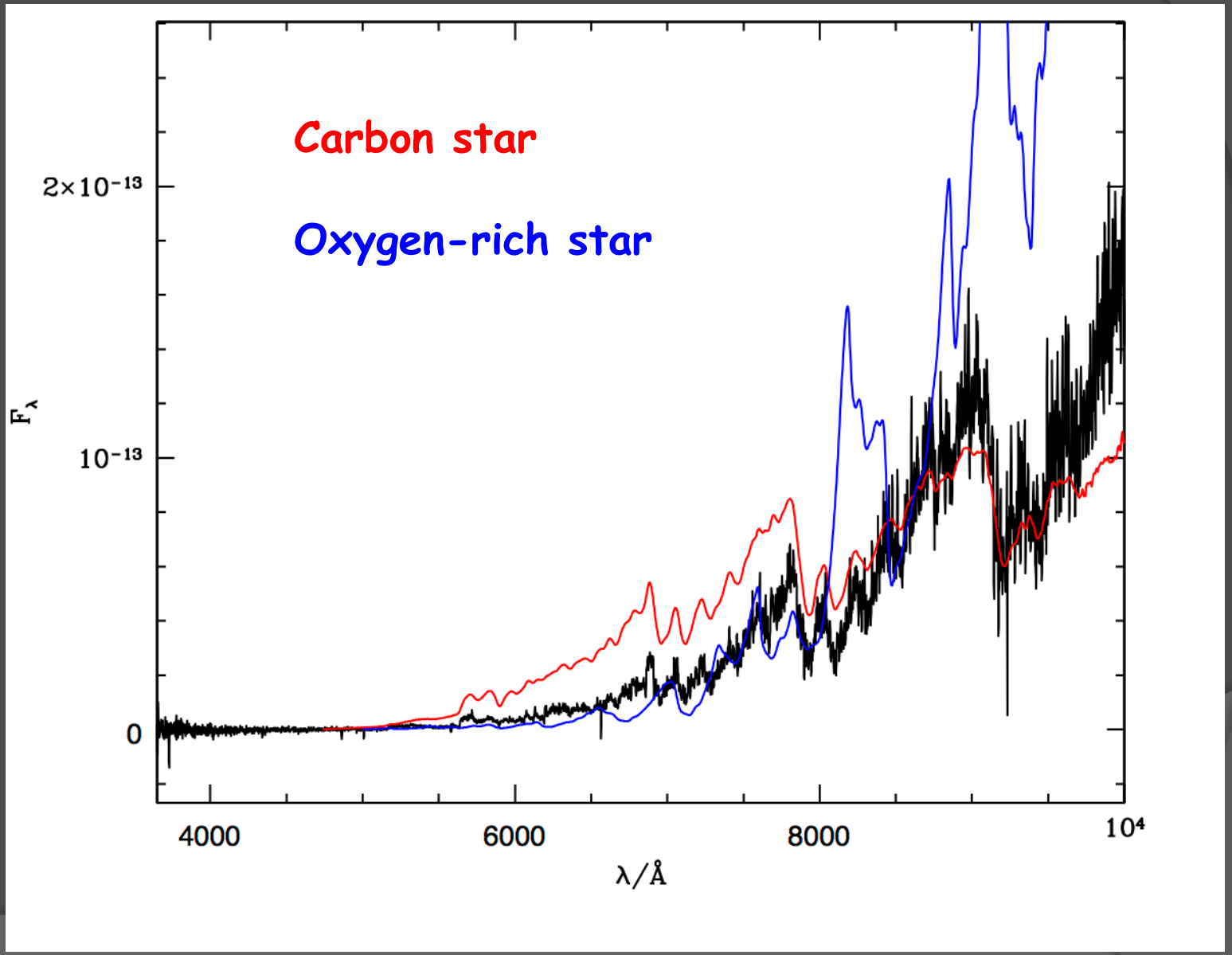


Carbon stars are included

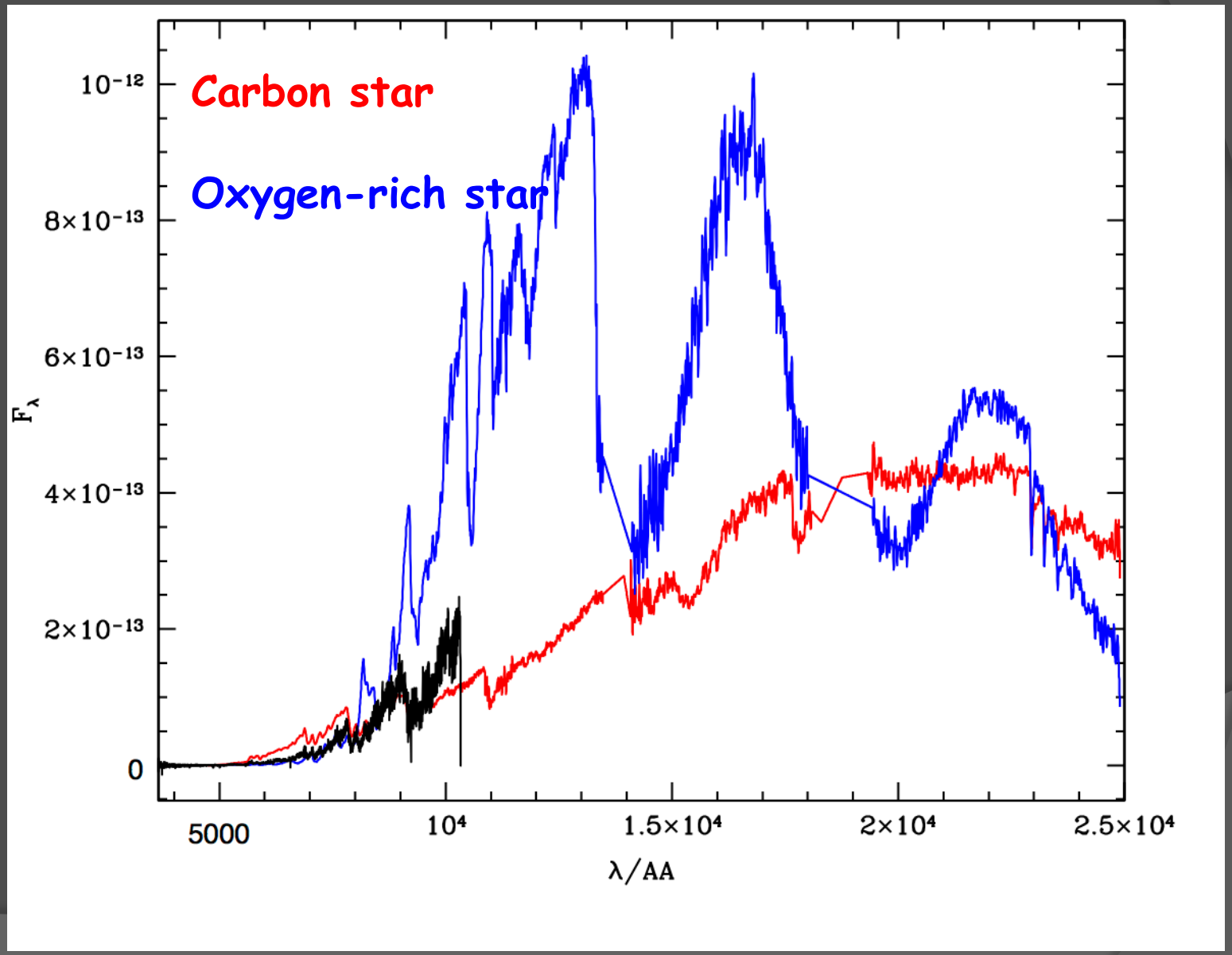




MaStar vs near-IR spectra

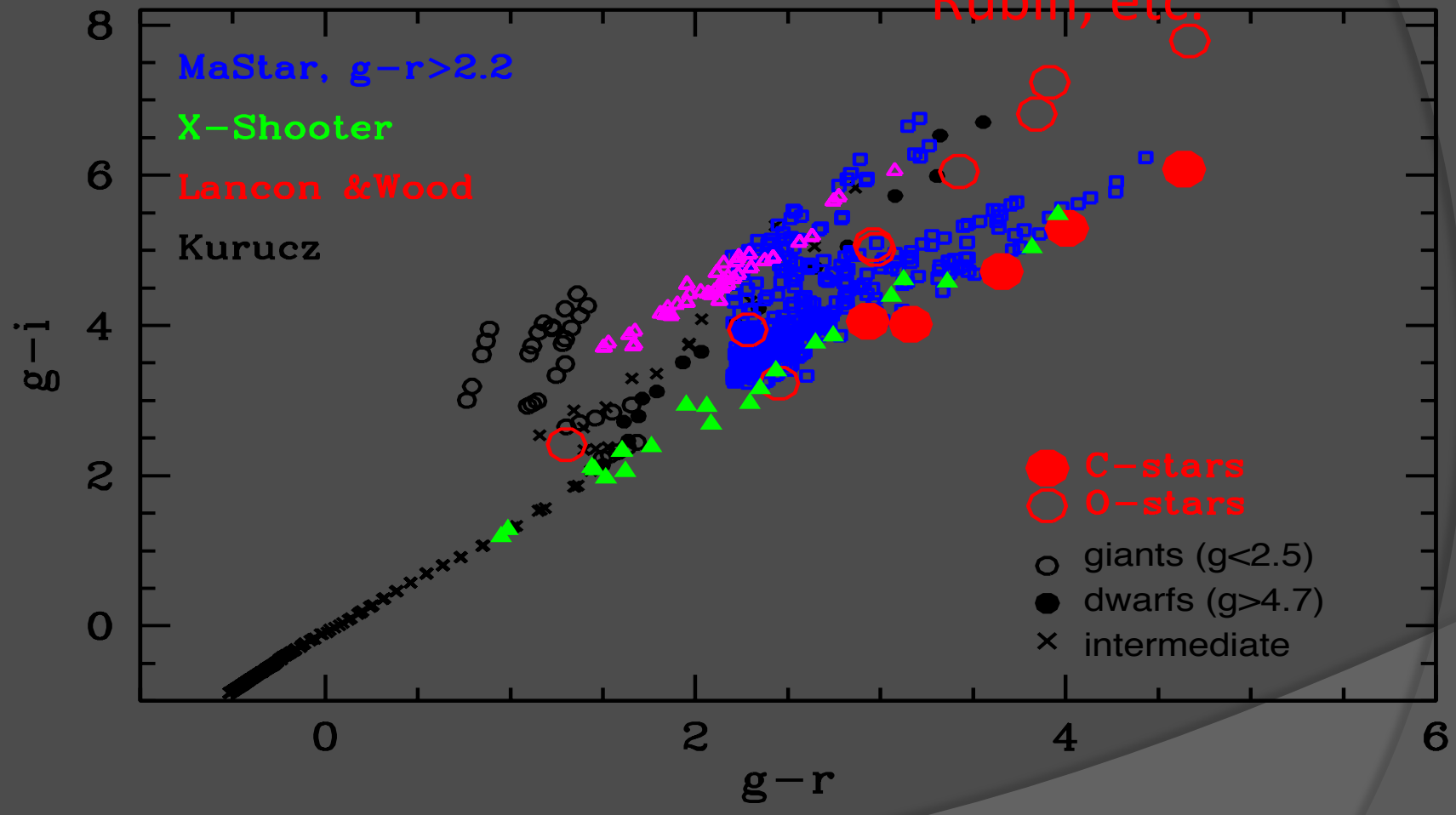


MaStar vs near-IR spectra



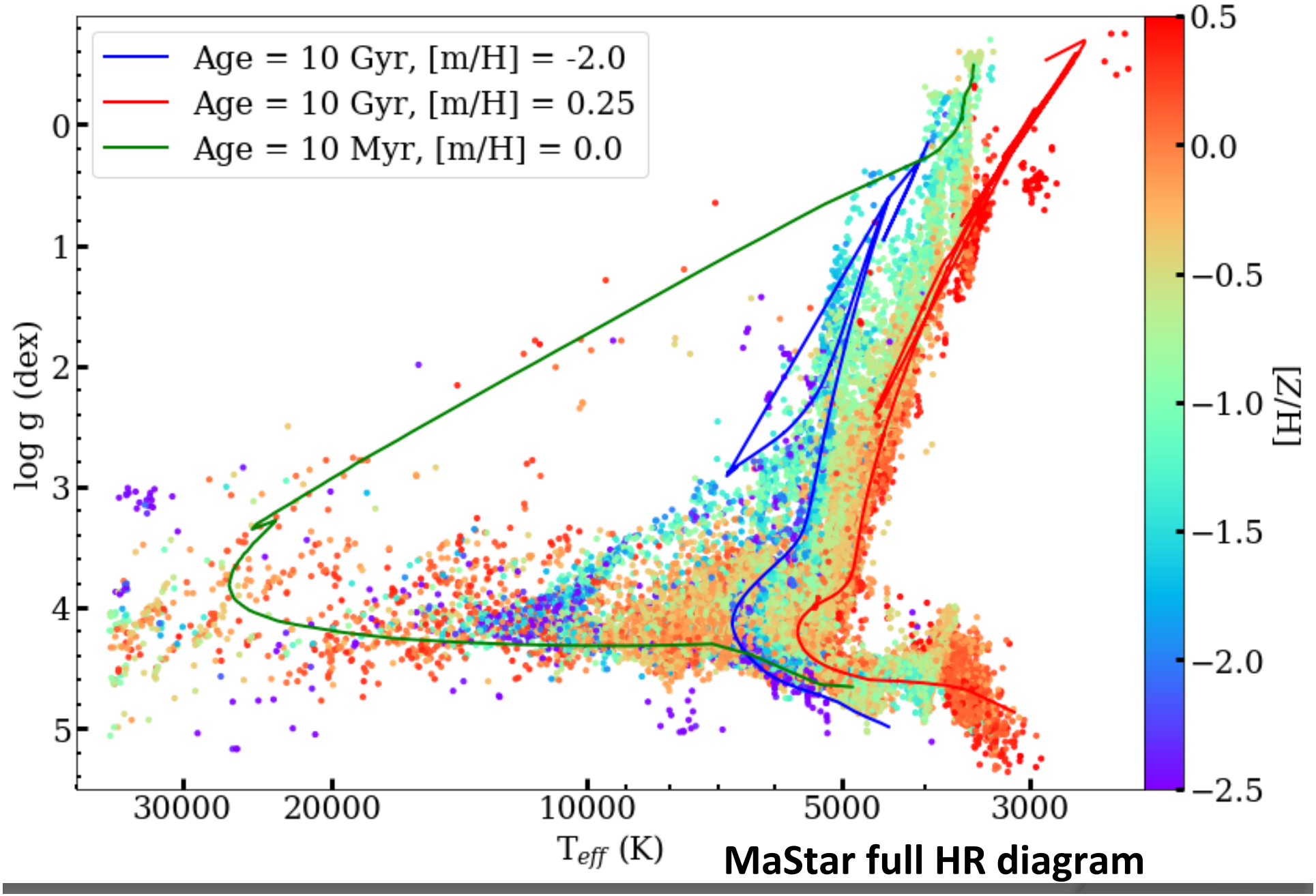
Over 200 C/O spectra

Simple colour selection highly effective applicable to Euclid, Rubin, etc.



Hill et al. 2022c, in prep.

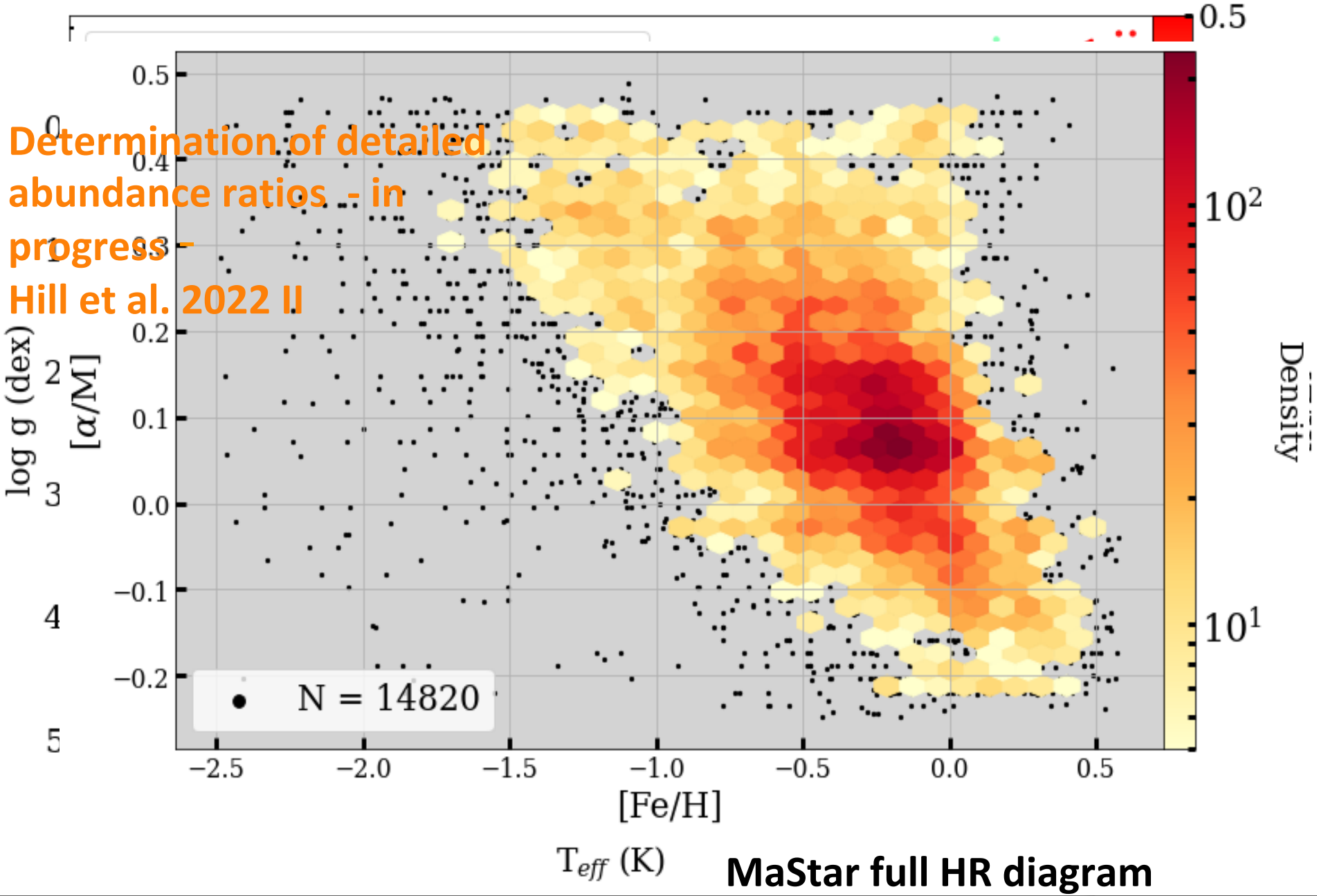
The HR diagram of 60,000 spectra - Hill et al. 2022a



MaStar full HR diagram

The HR diagram of 60,000 spectra - Hill et al. 2022a

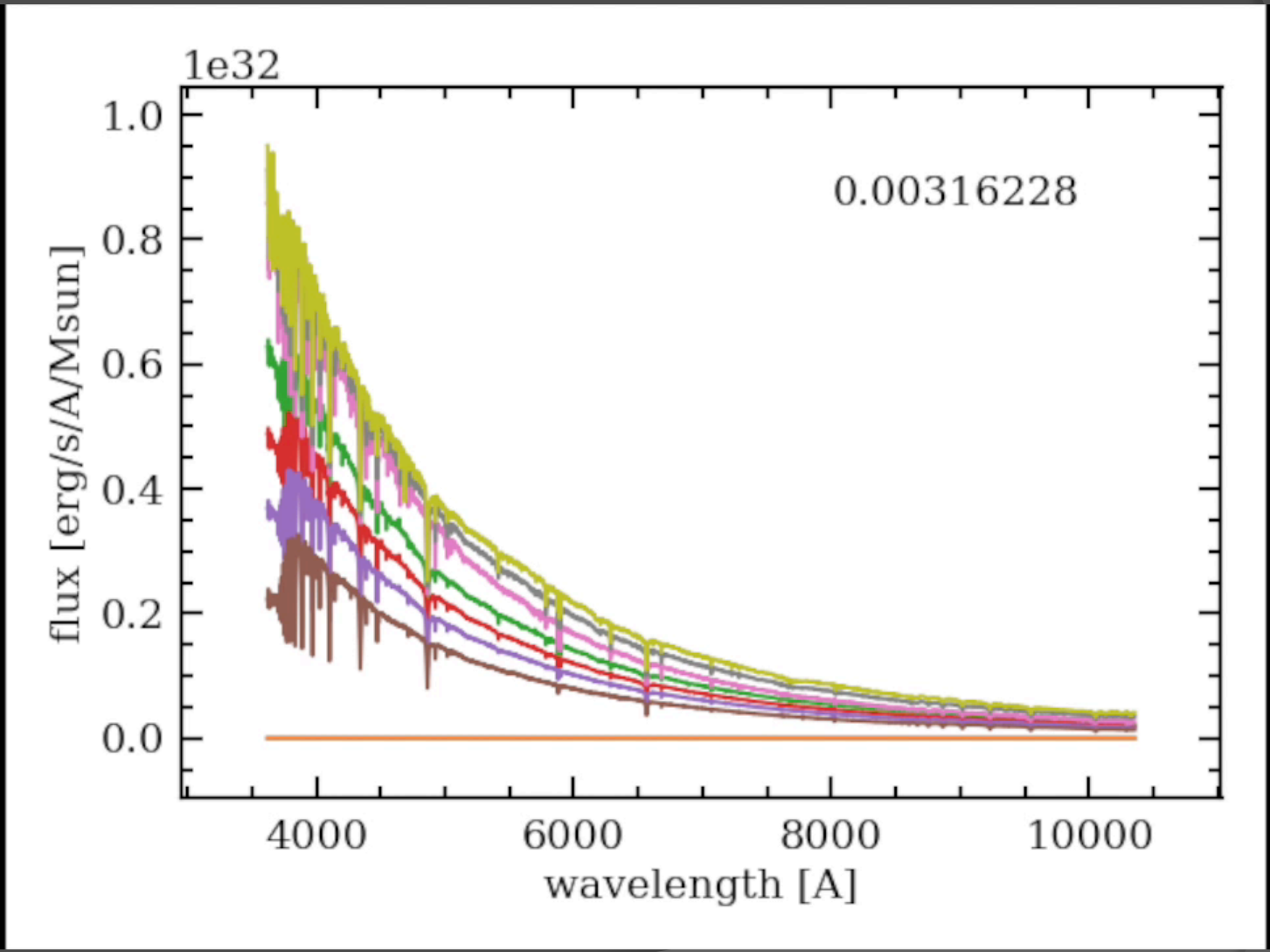
Determination of detailed abundance ratios - in progress -
Hill et al. 2022 II



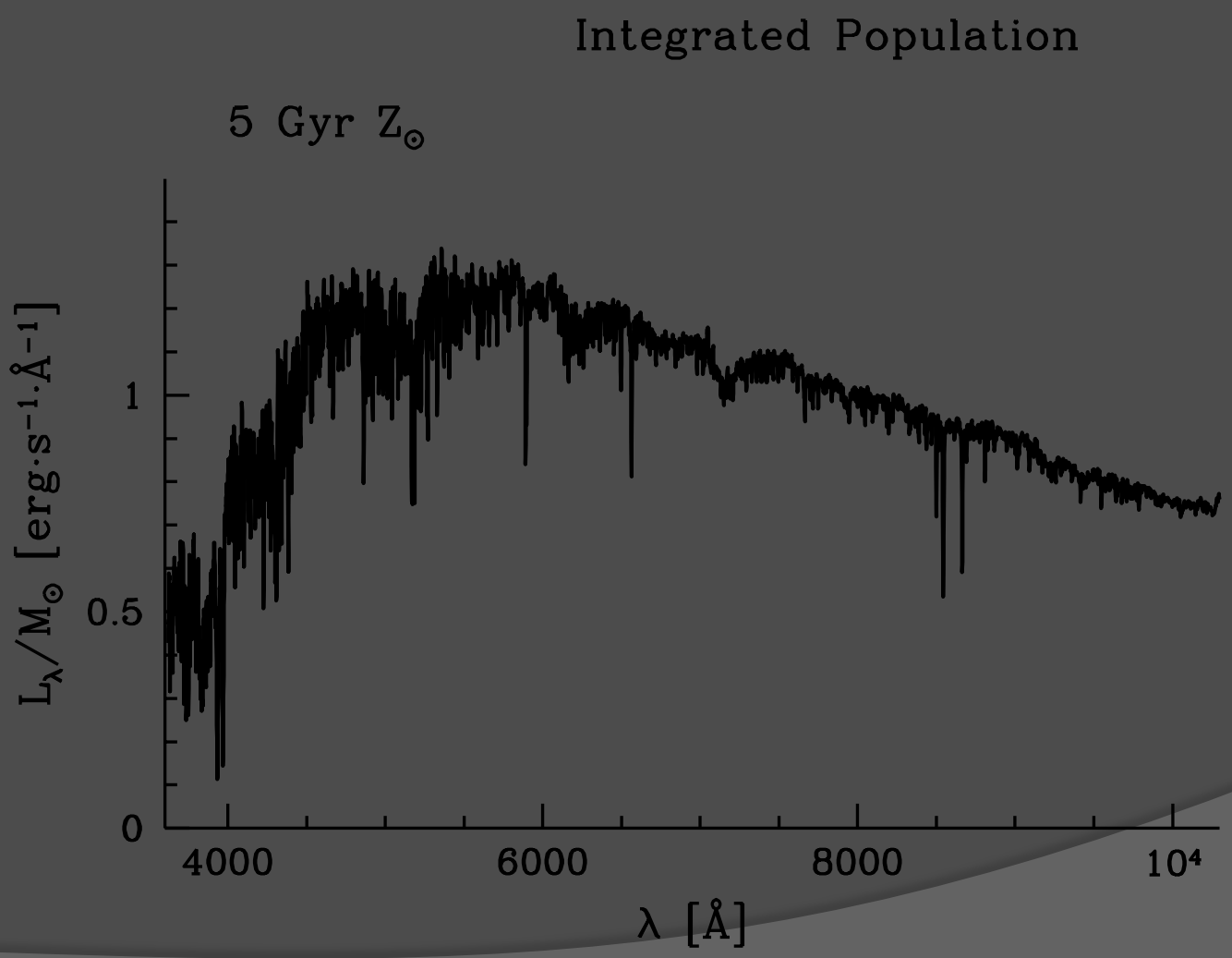
MaStar full HR diagram

Results - MaStar Stellar Population Models

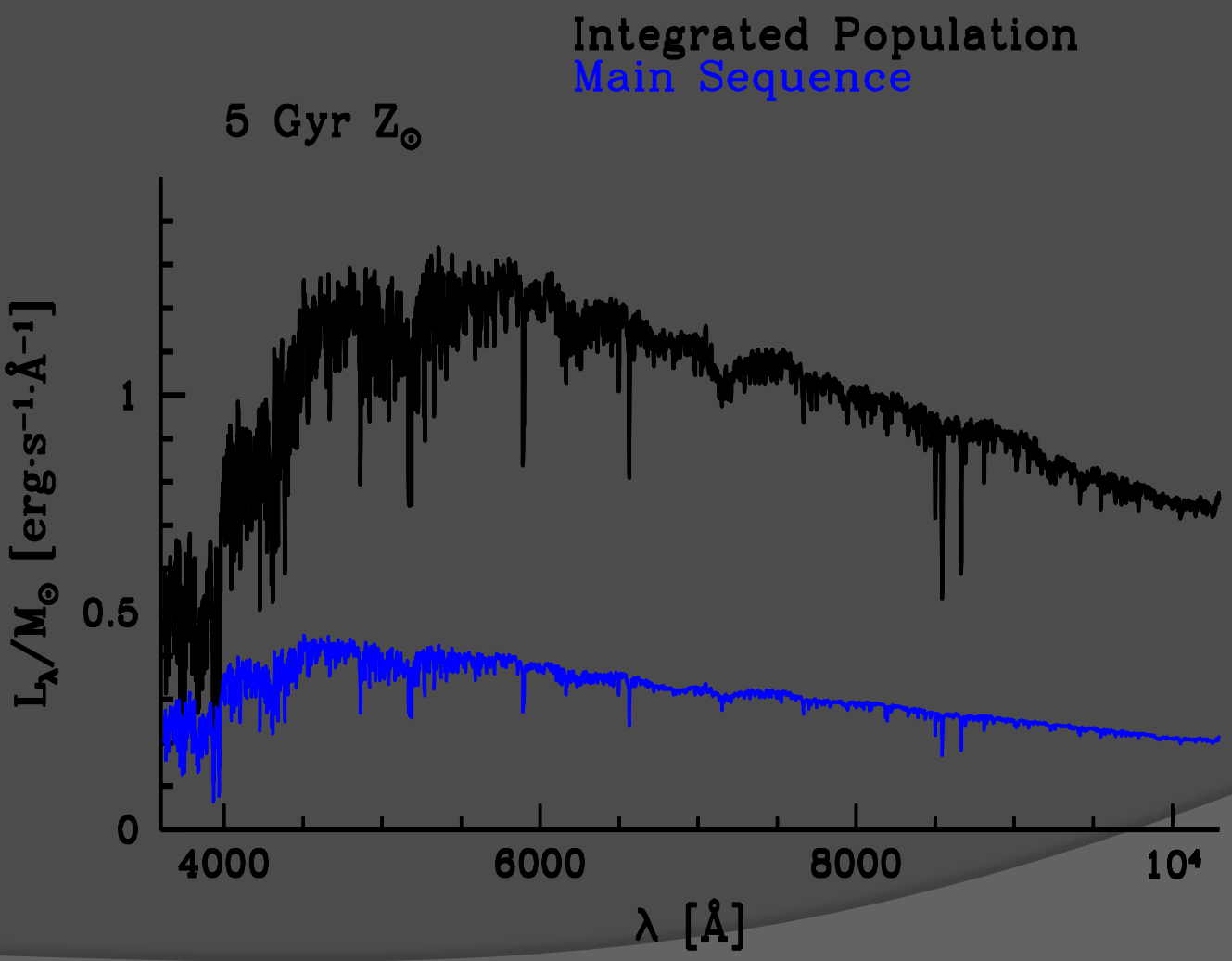
Maraston et al. 2020;22, MNRAS http://www.icg.port.ac.uk/MaStar/



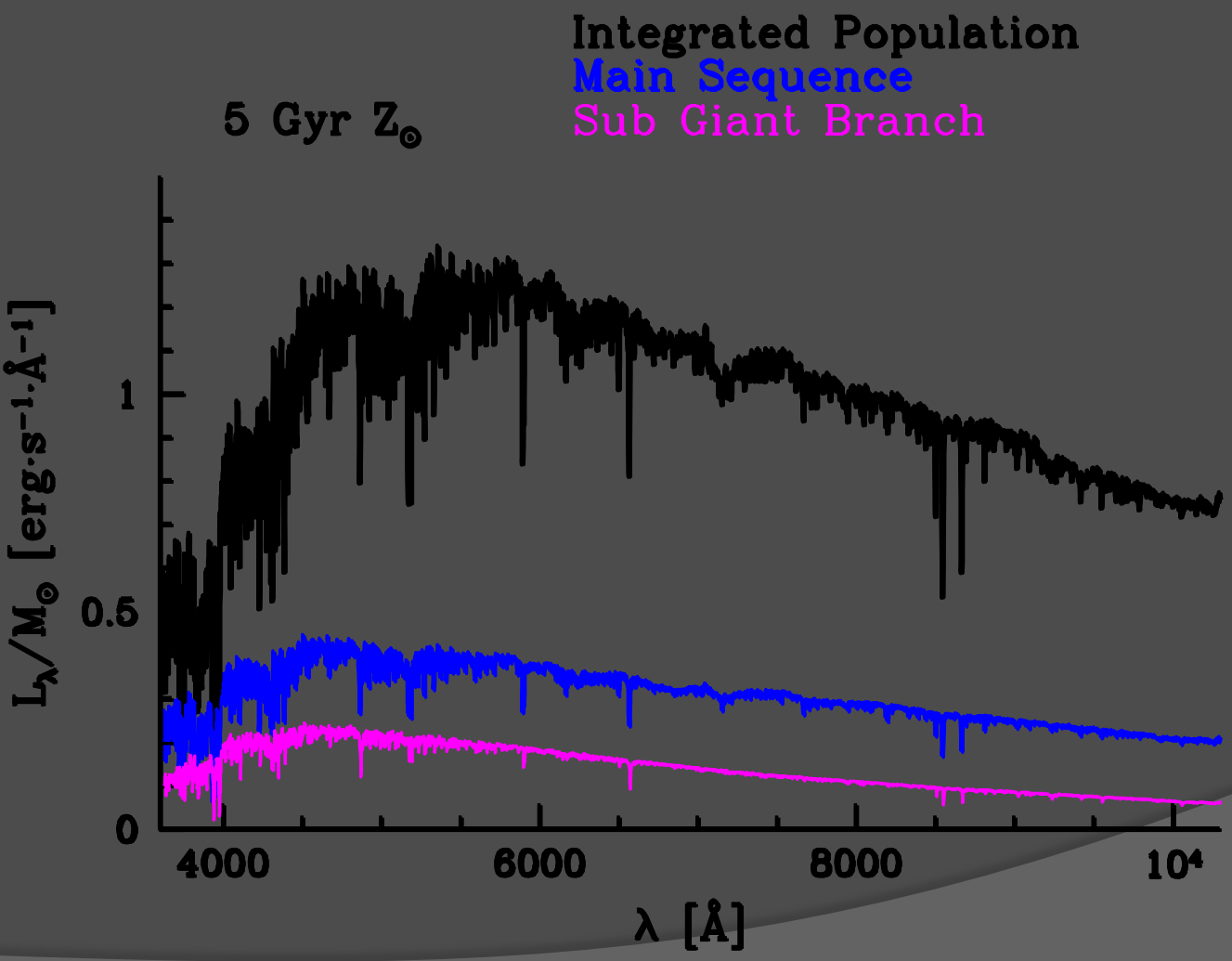
Ages from integrated light



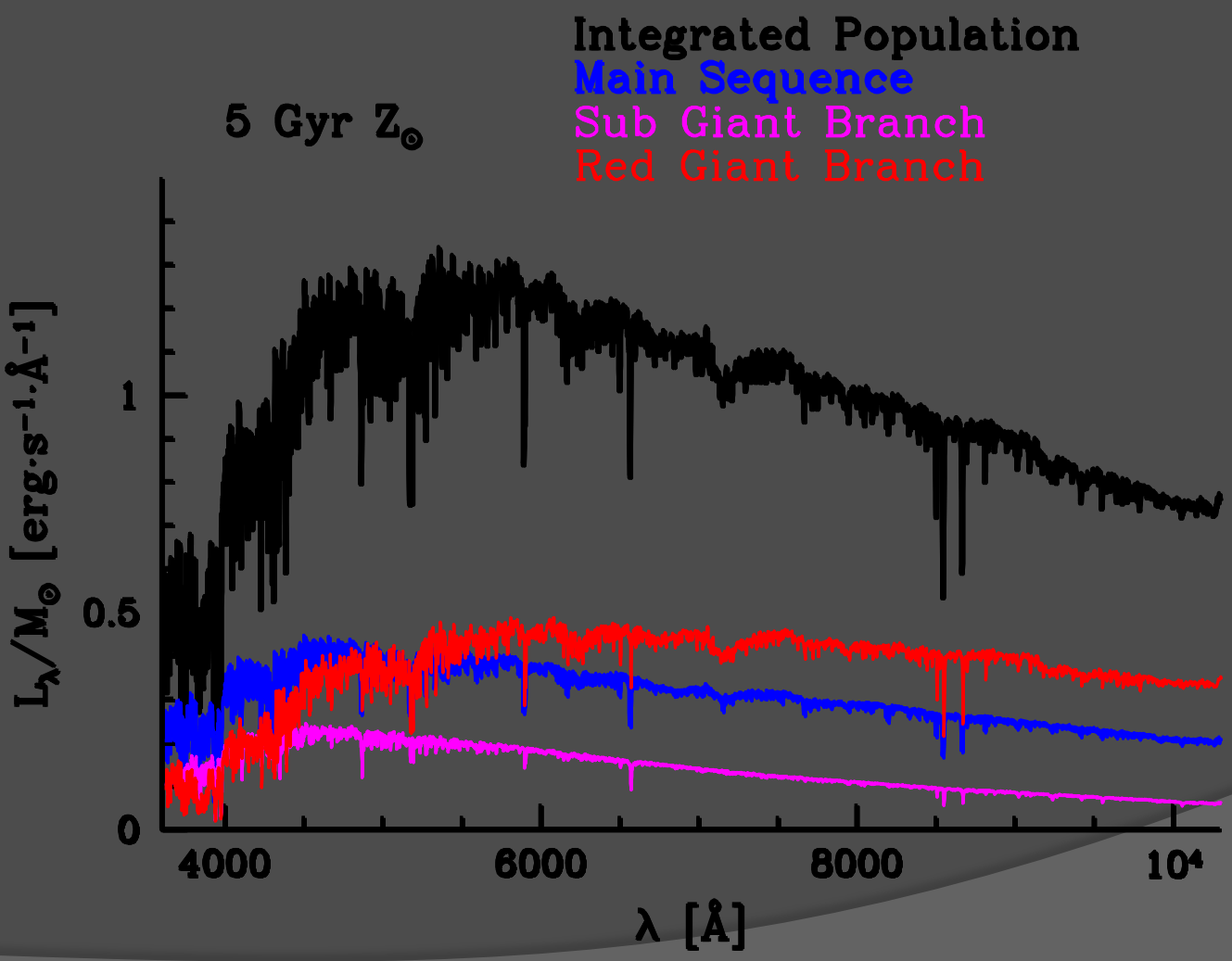
Ages from integrated light



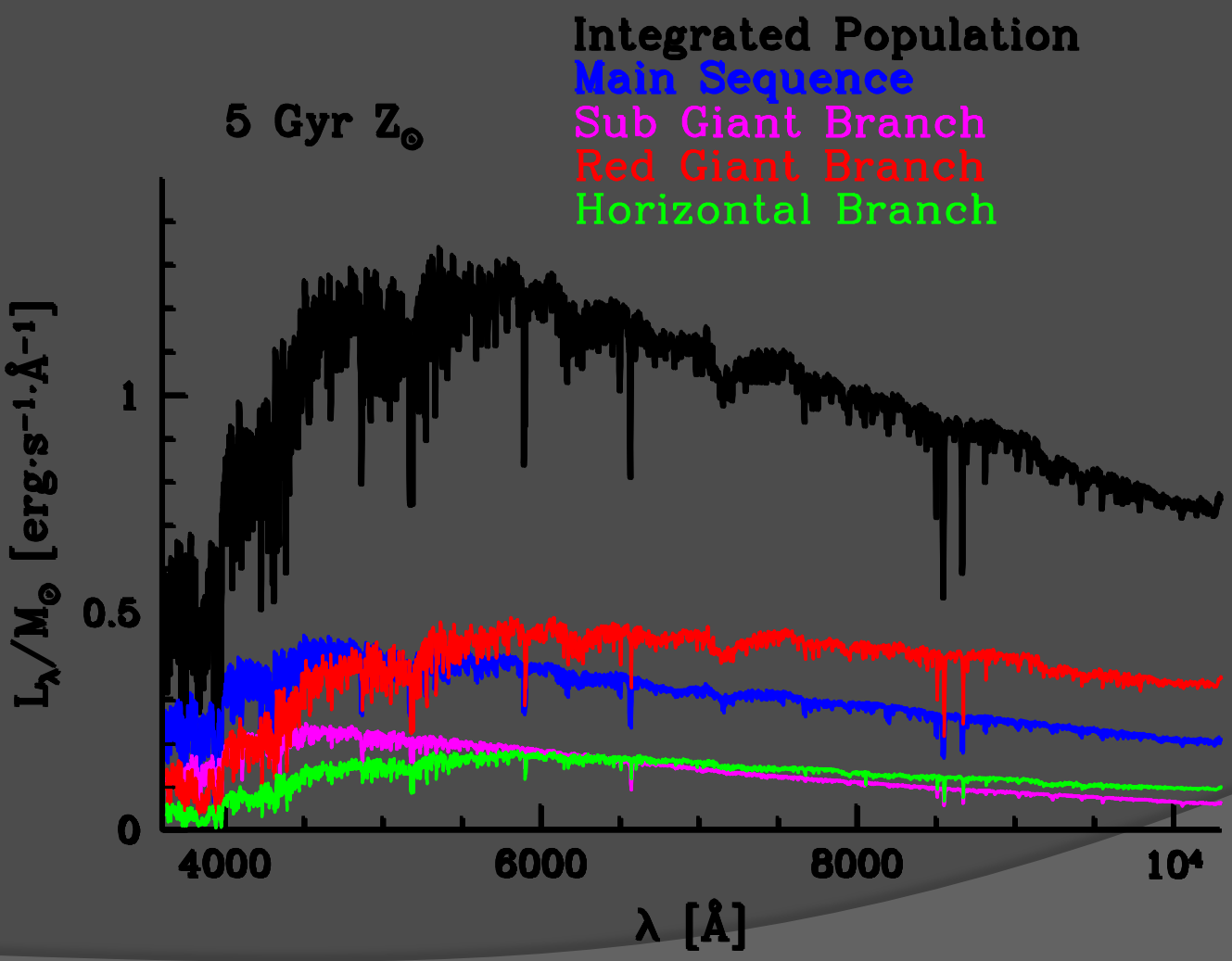
Ages from integrated light



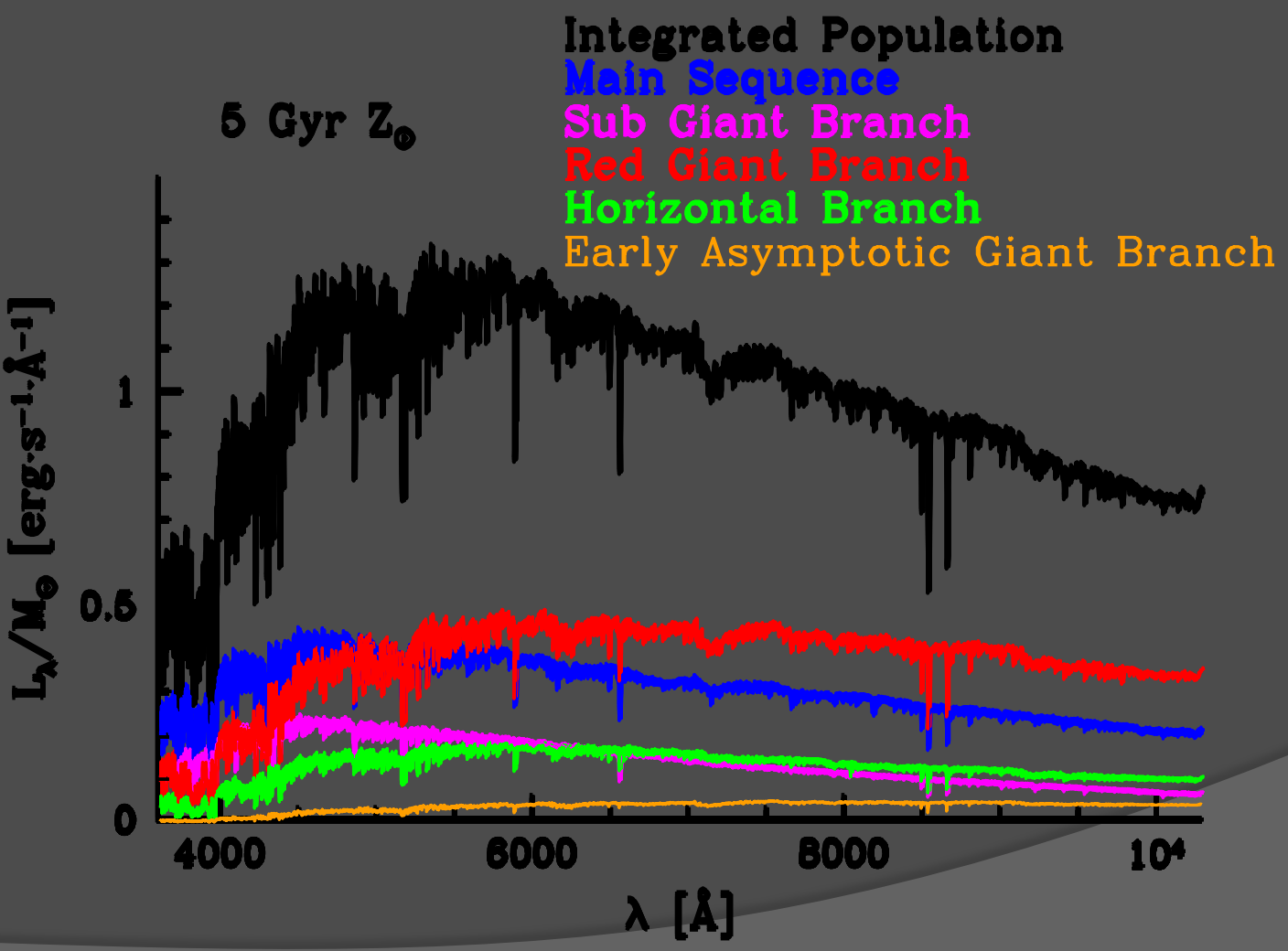
Ages from integrated light



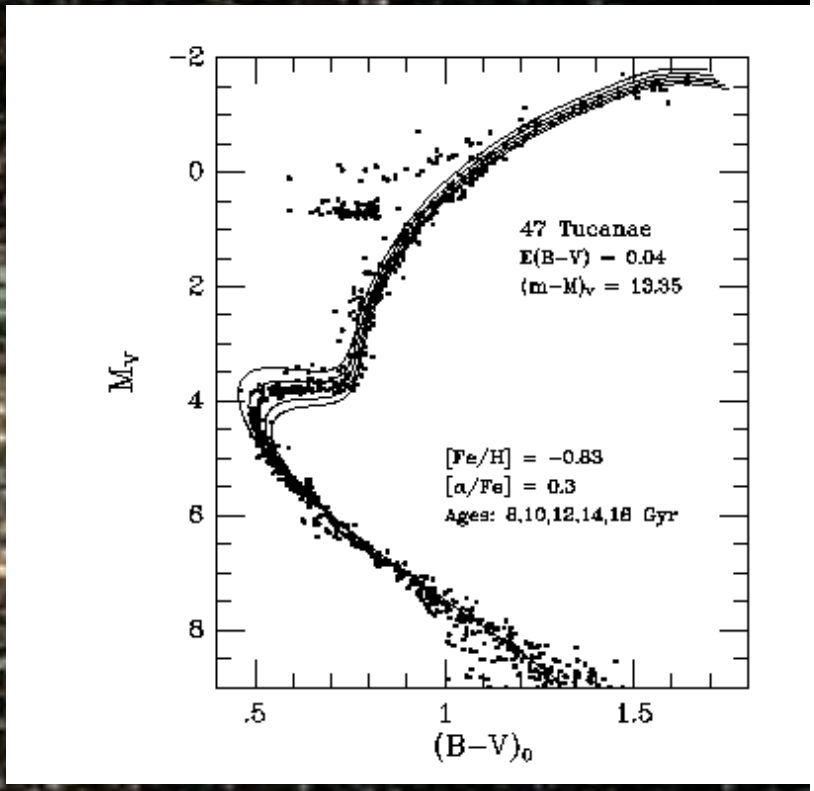
Ages from integrated light



Ages from integrated light



Testing models with nearby Globular Clusters

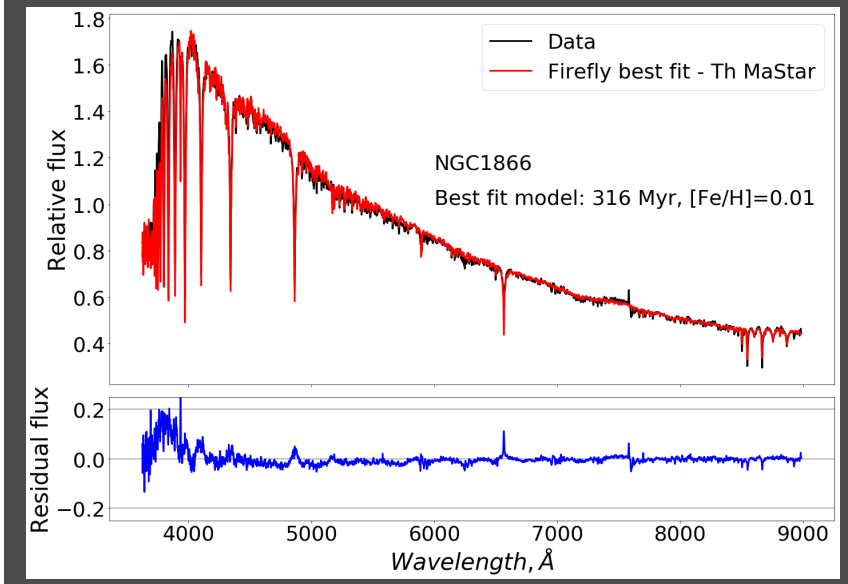


Renzini & Fusi Pecci ARAA 1988
Maraston 1998;2005;2011;2020
Thomas, Maraston, Bender 2003

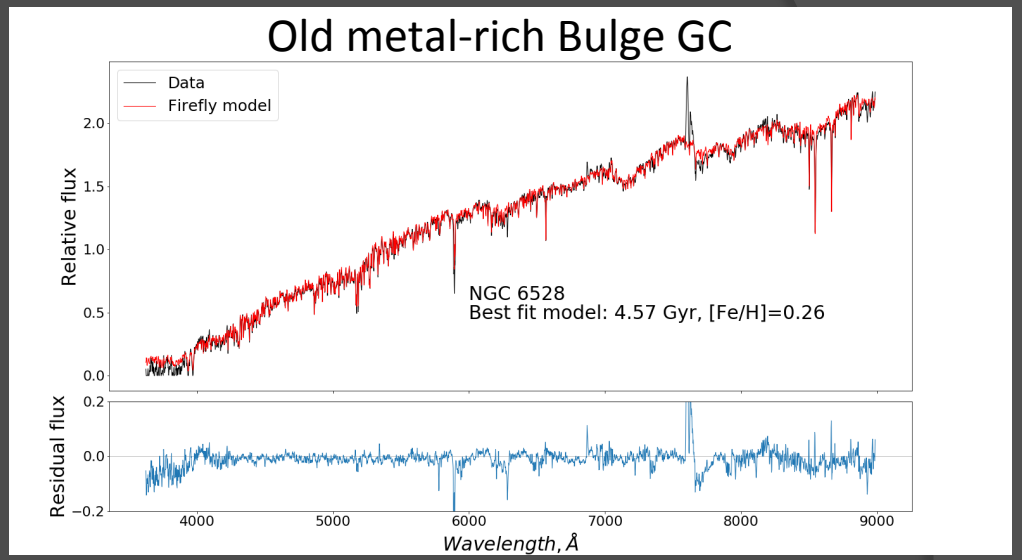
Full spectral fitting of GC spectra

Fitting code: **Firefly**, Wilkinson et al. 2017
GC Data: Usher et al. 2017

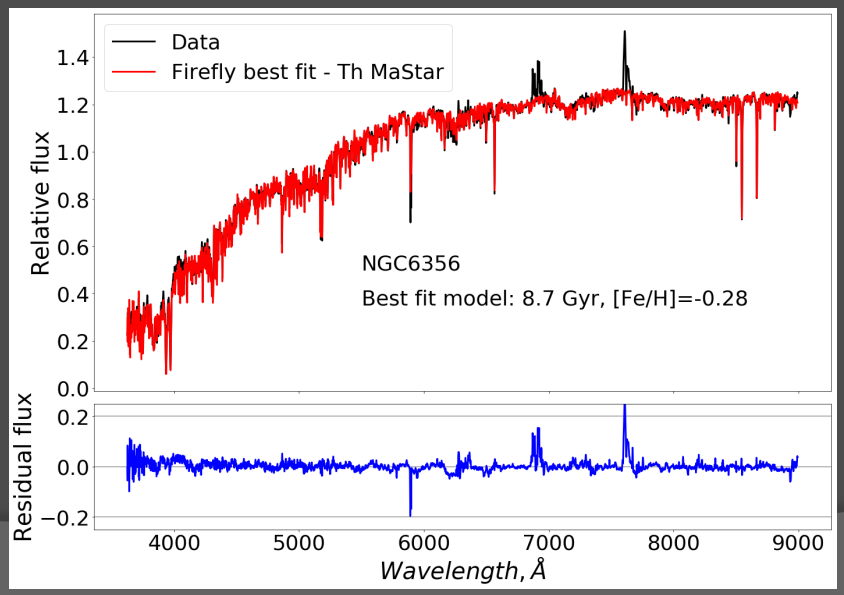
Young LMC GC



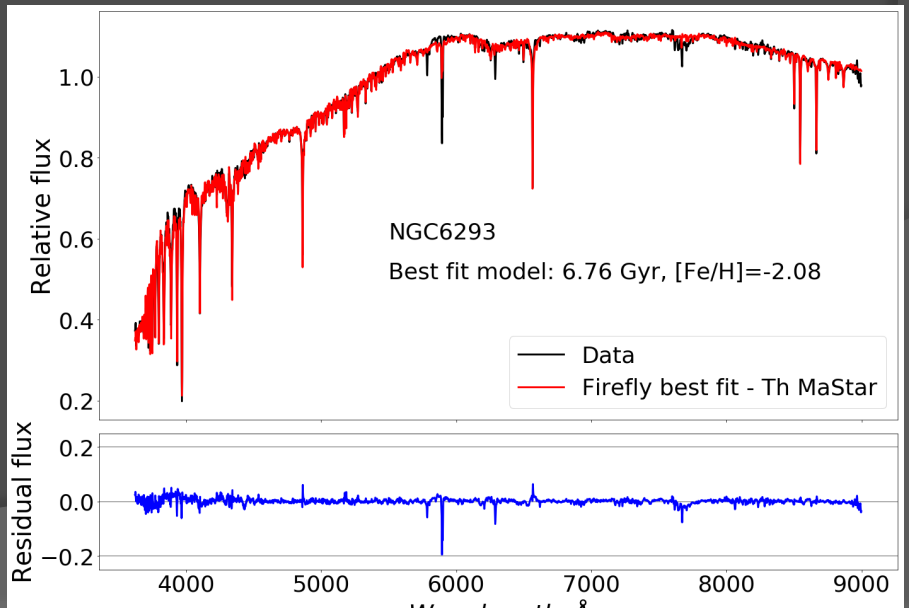
Old metal-rich Bulge GC



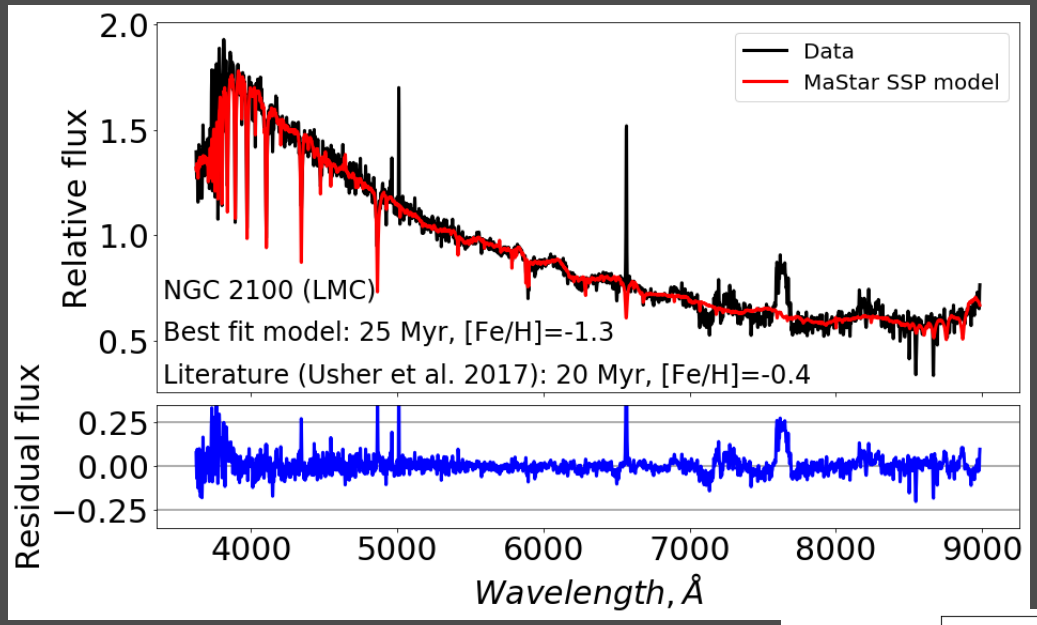
Old intermediate Z, MW GC



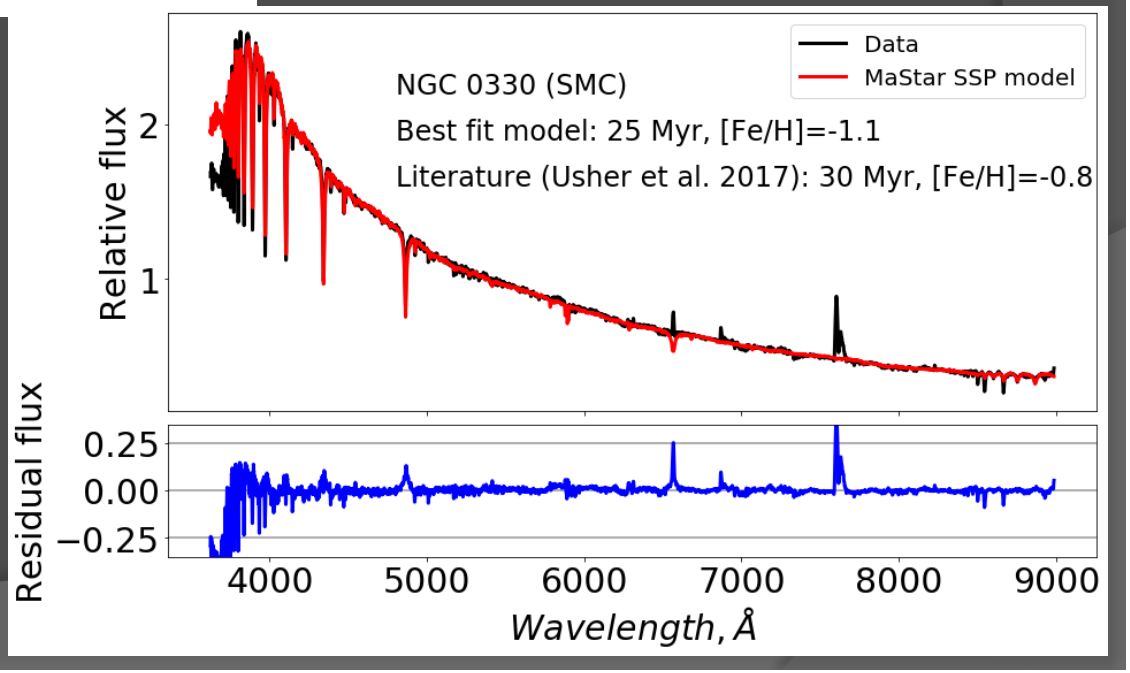
Old metal-poor MW GC



Testing down to very young ages



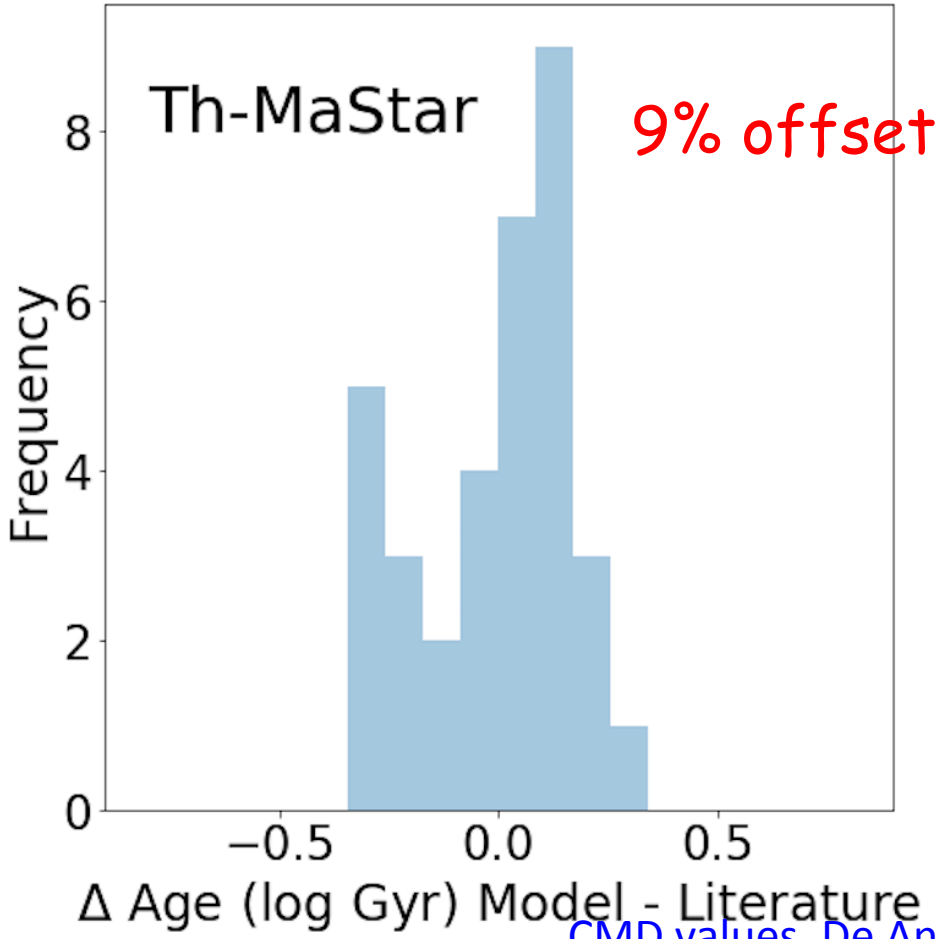
Spectroscopic ages at high-redshift was a scope for Olivier

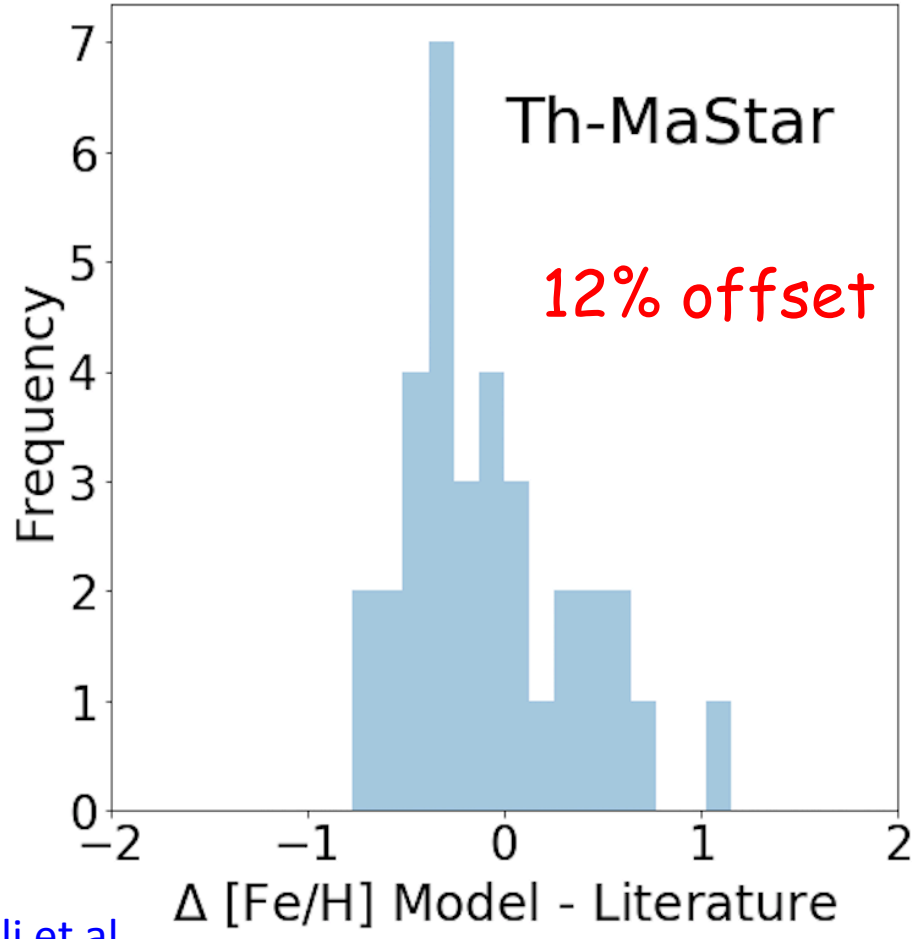


How well can we recover the properties of the simplest stellar systems?

Age

Metallicity

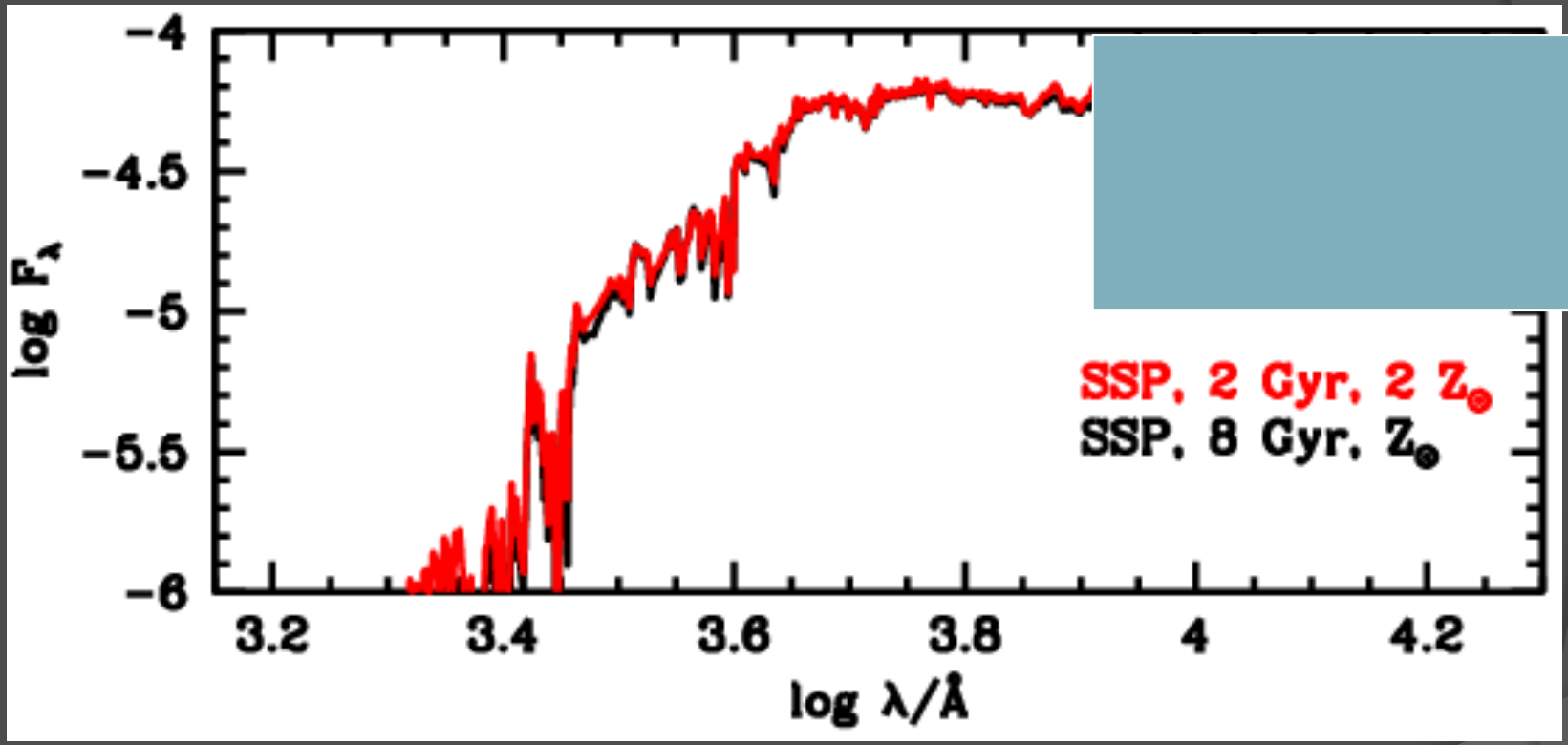




CMD values, De Angeli et al.

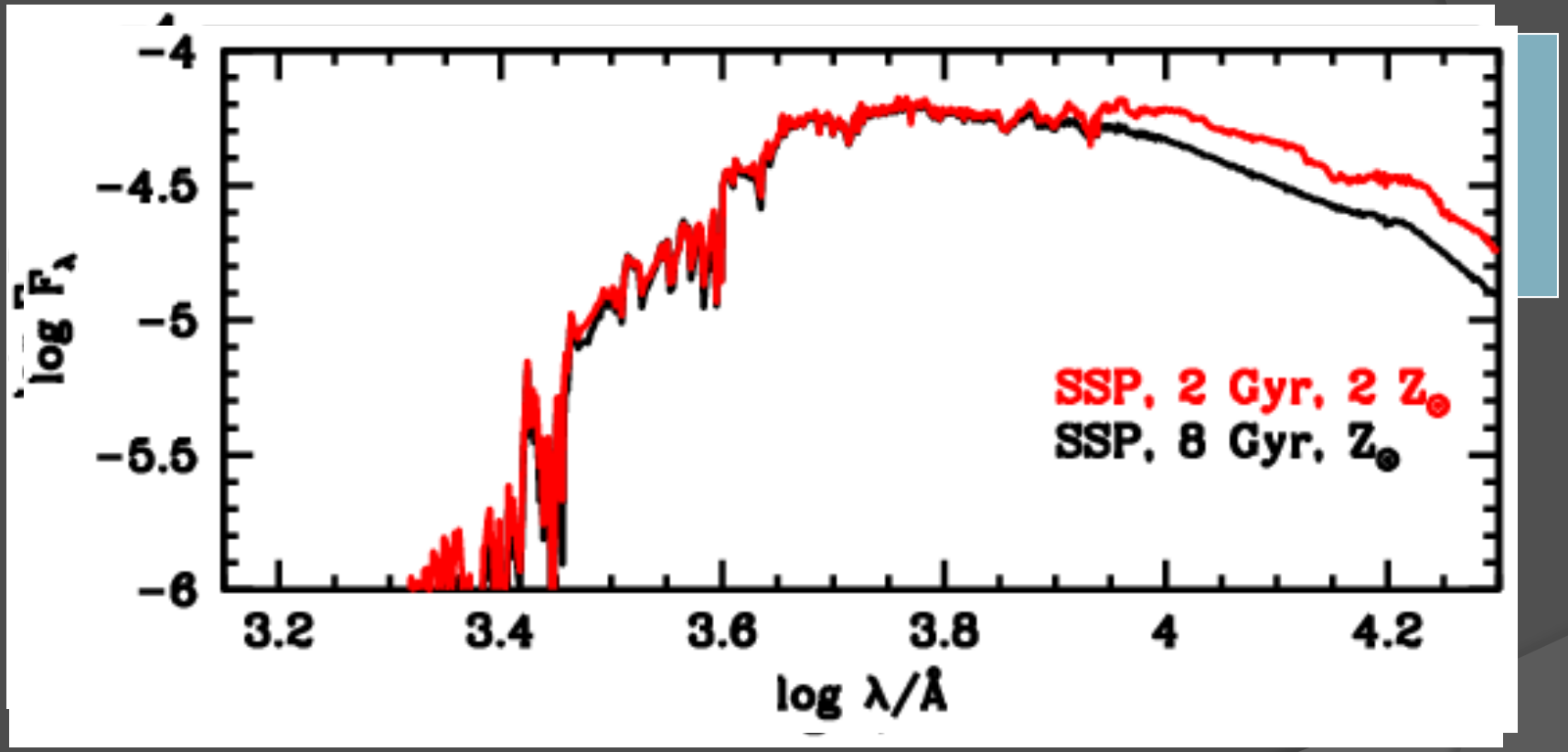
The age/metallicity degeneracy

Classically (Worthey94): **a metal-rich young SSP looks like a less metal-rich older one**



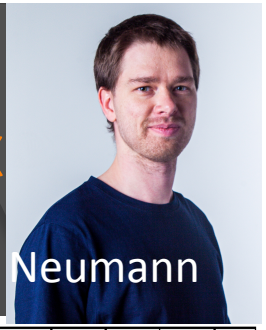
The age/metallicity degeneracy

Classically (Worthey94): **a metal-rich young SSP looks like a less metal-rich older one**

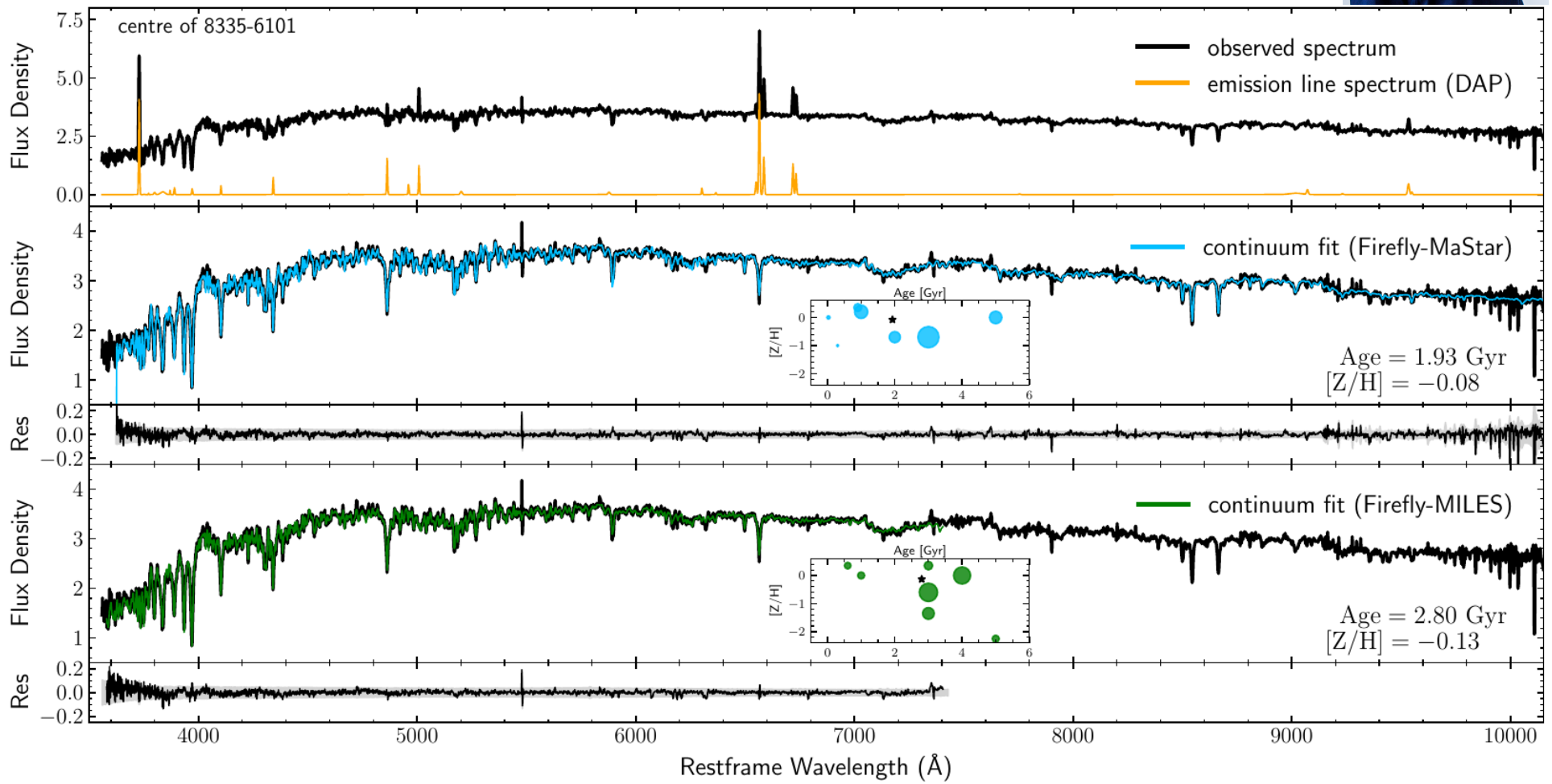


Revised (Maraston05; 06): adding the **near-IR helps breaking the degeneracy**

Portsmouth Value Added Catalogue - VAC Miles and MaStar model fit to SDSS-IV IFU galax spectra - Neumann et al. 2022, MNRAS



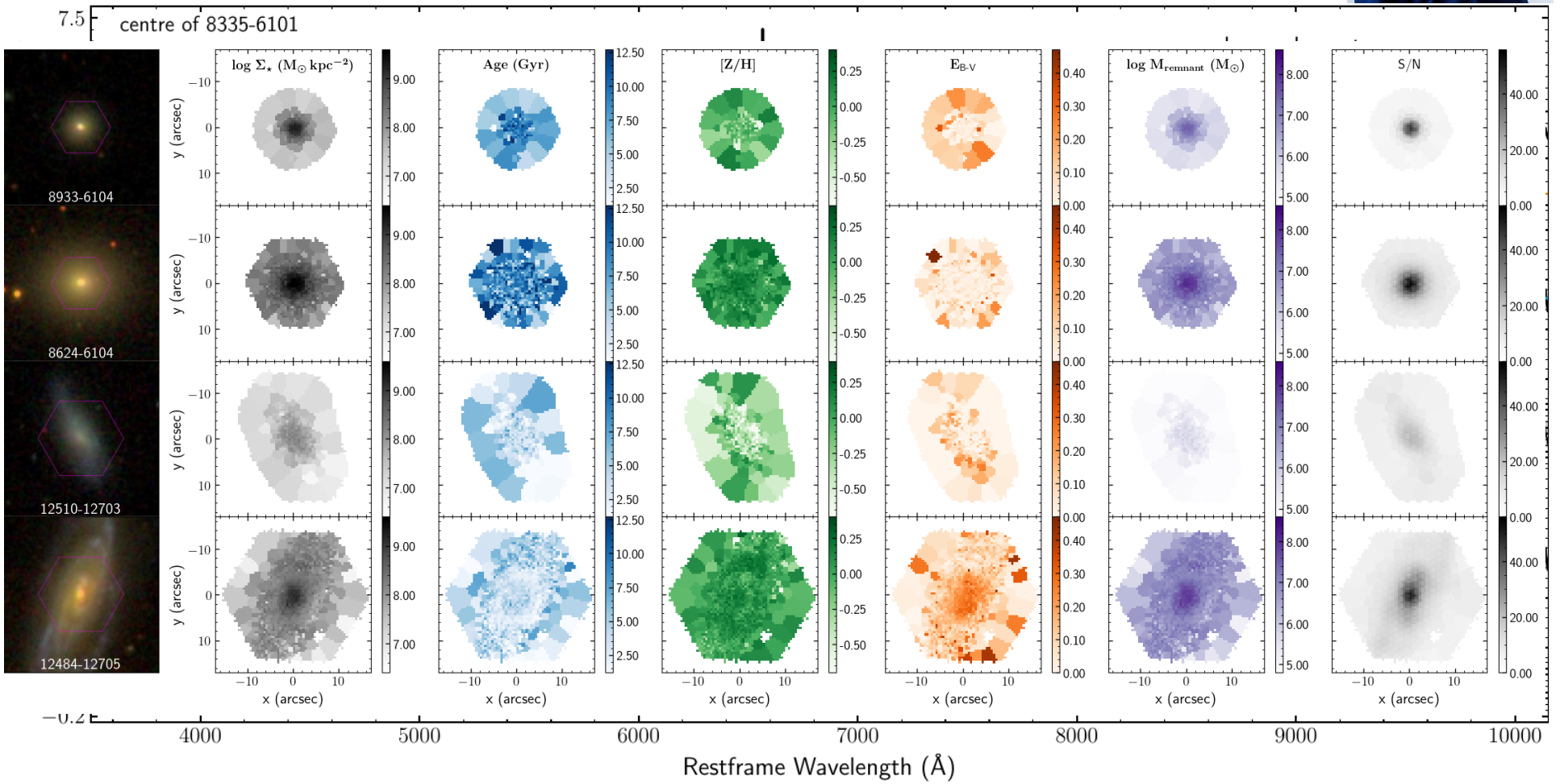
Dr. Justus Neumann



Full spectral fitting code Firefly, www.icg.port.ac.uk/firefly/
SDSS-IV/MaNGA data Bundy et al. 2016

Portsmouth Value Added Catalogue - VAC Miles and MaStar model fit to SDSS-IV IFU galax spectra - Neumann et al. 2022, MNRAS

Dr. Justus Neumann



Full spectral fitting code Firefly, www.icg.port.ac.uk/firefly/
SDSS-IV/MaNGA data Bundy et al. 2016

Summary

- Improved Spectra of stellar population models with the largest stellar spectral library to date
- Calibration of ages from integrated light down to low ages
- Help constraining age/metallicity (dust) degeneracy

Too bad Olivier is no longer with us!