Constraining the evolution of massive stars with BlueMUSE

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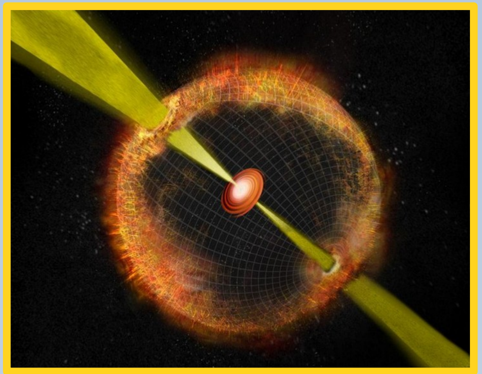
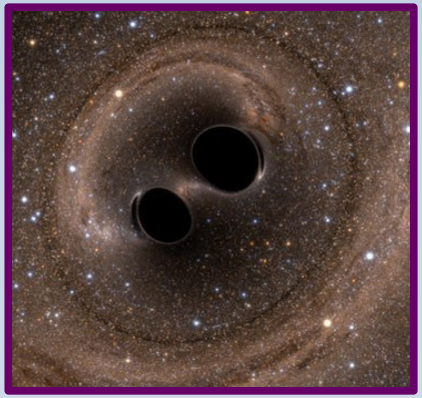
BlueMuse Science workshop, 9-10 nov 2020

Star formation across the Universe

Core collapse
supernovae
Long-soft GRBs

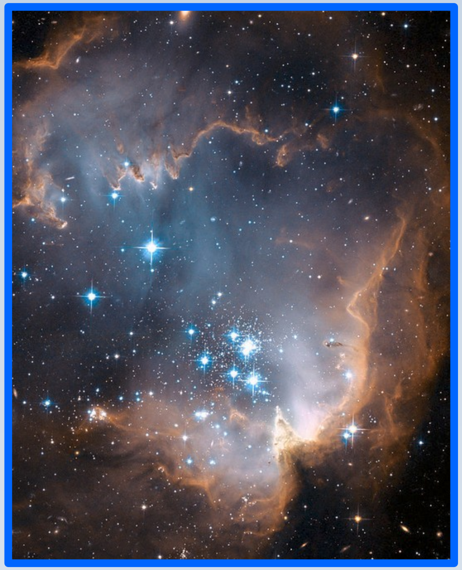


Black holes and
gravitational waves



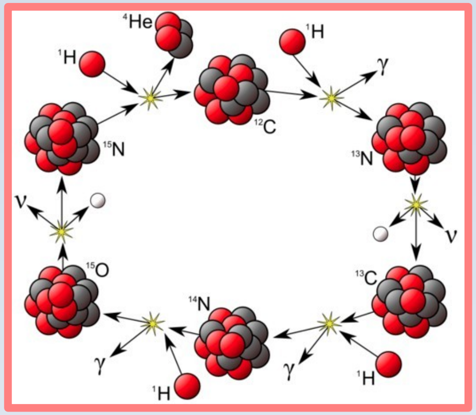
Massive stars

$M > 8\text{-}10\ M_{sun}$

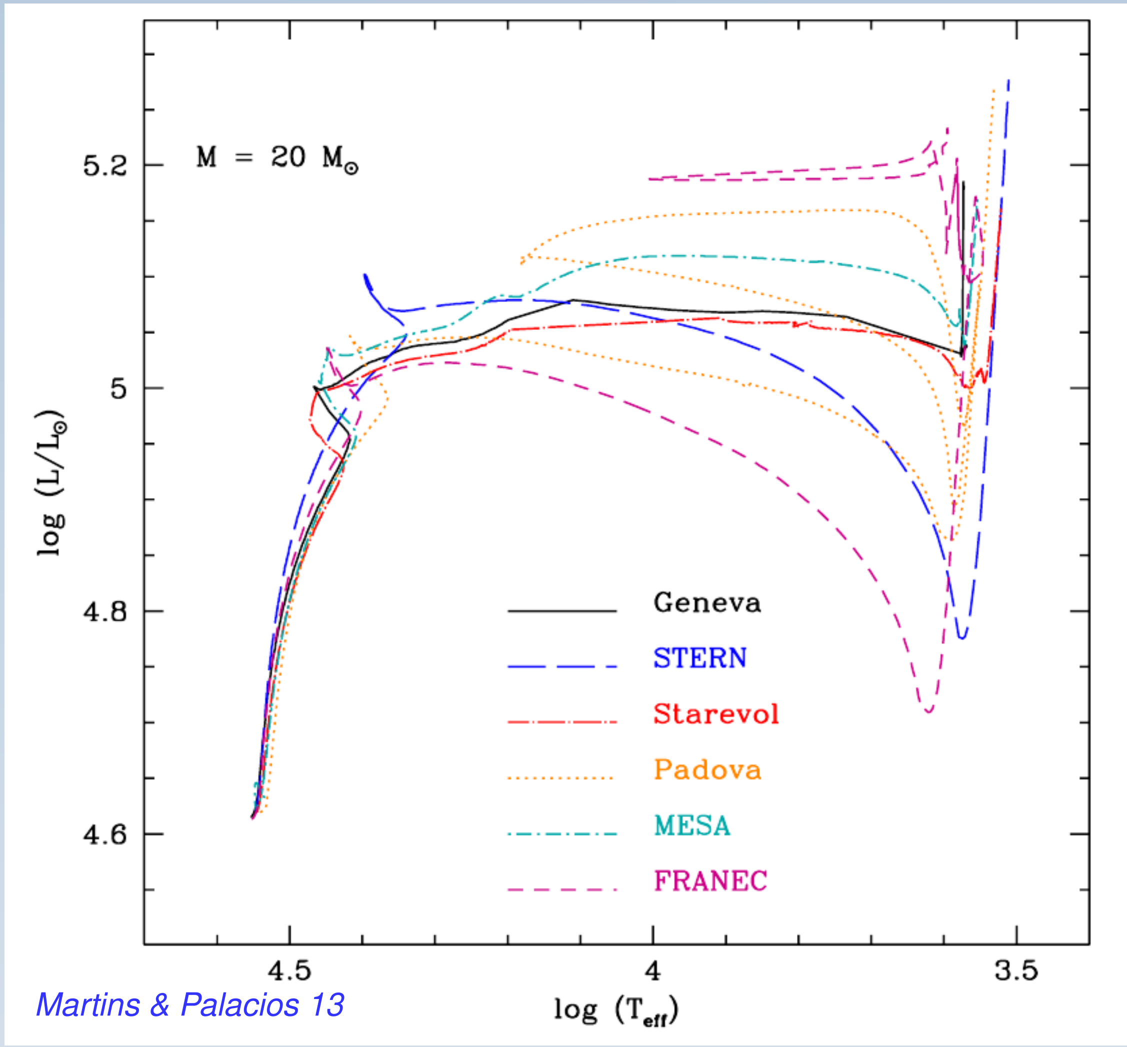


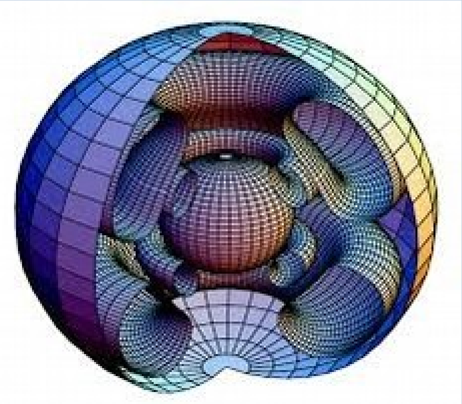
HII regions
Feedback effects
(winds, ionizing fluxes)

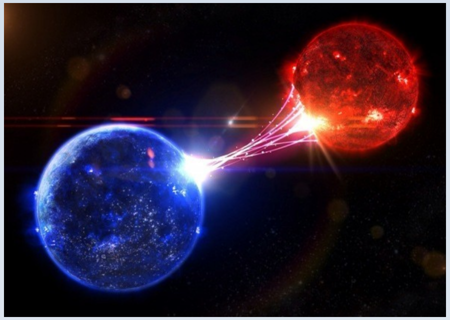
Nucleosynthesis O-Fe peak



The evolution of massive stars



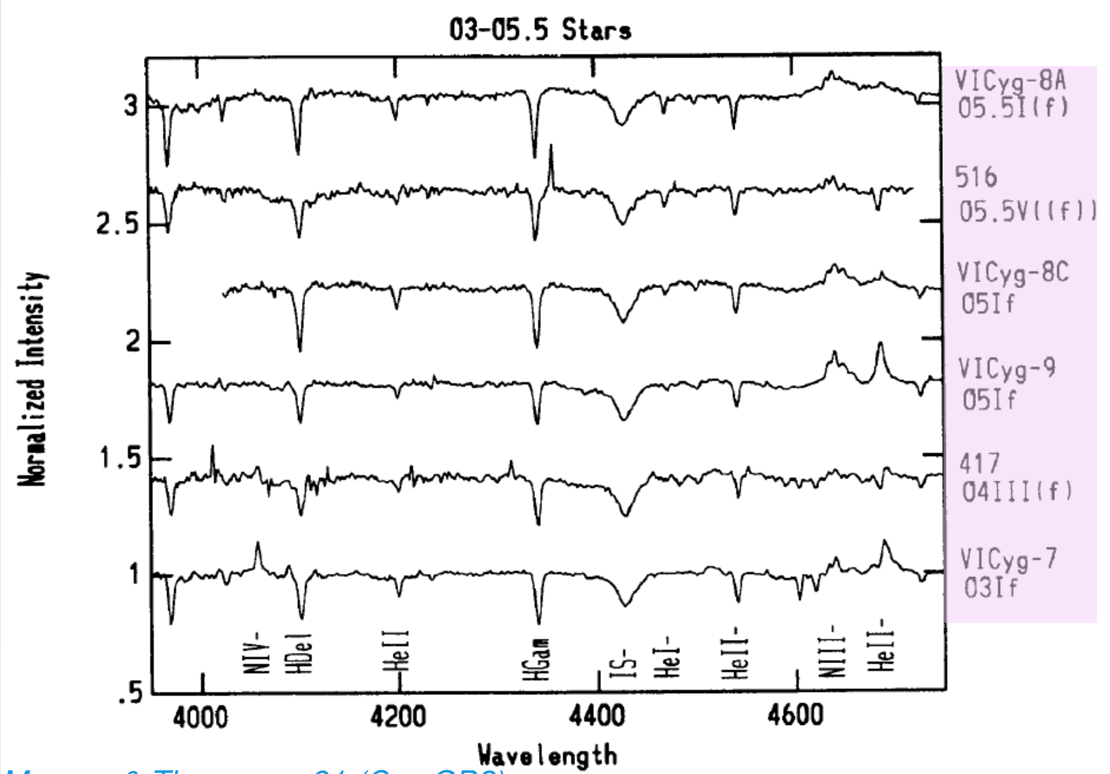




Evolution ruled by

- stellar rotation
- stellar winds
- binarity
- magnetism

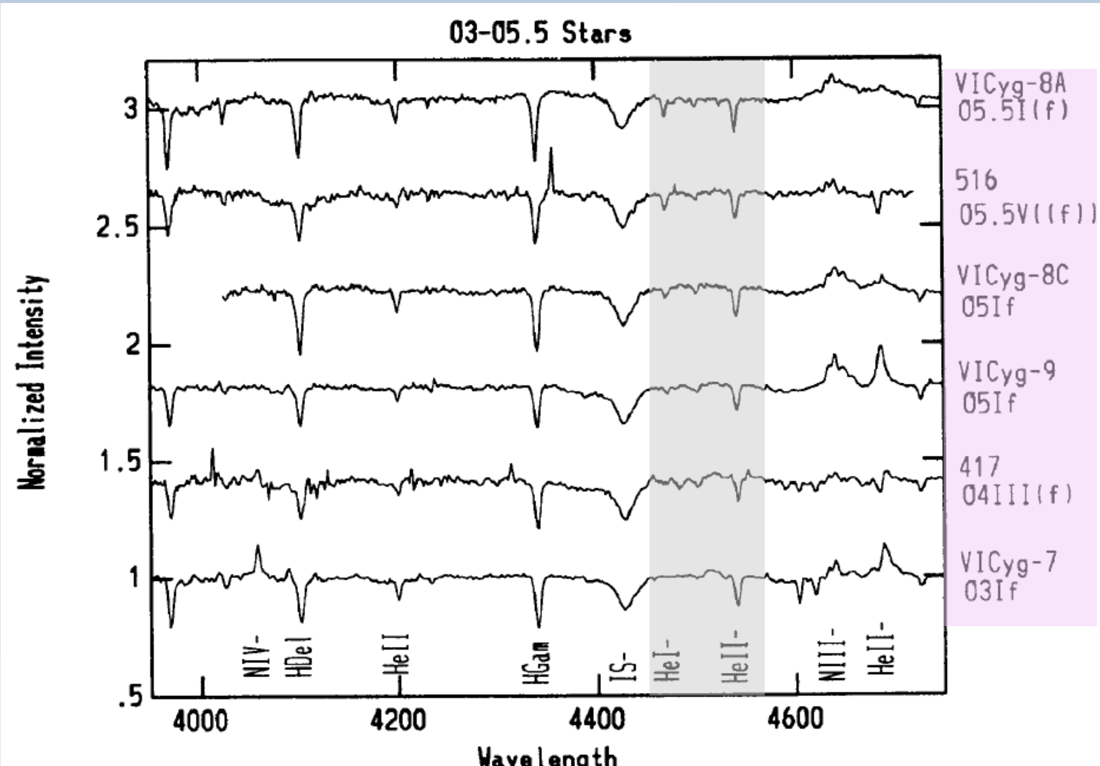
First step in the analysis of newly observed stars: classification



Massey & Thompson 91 (Cyg OB2)

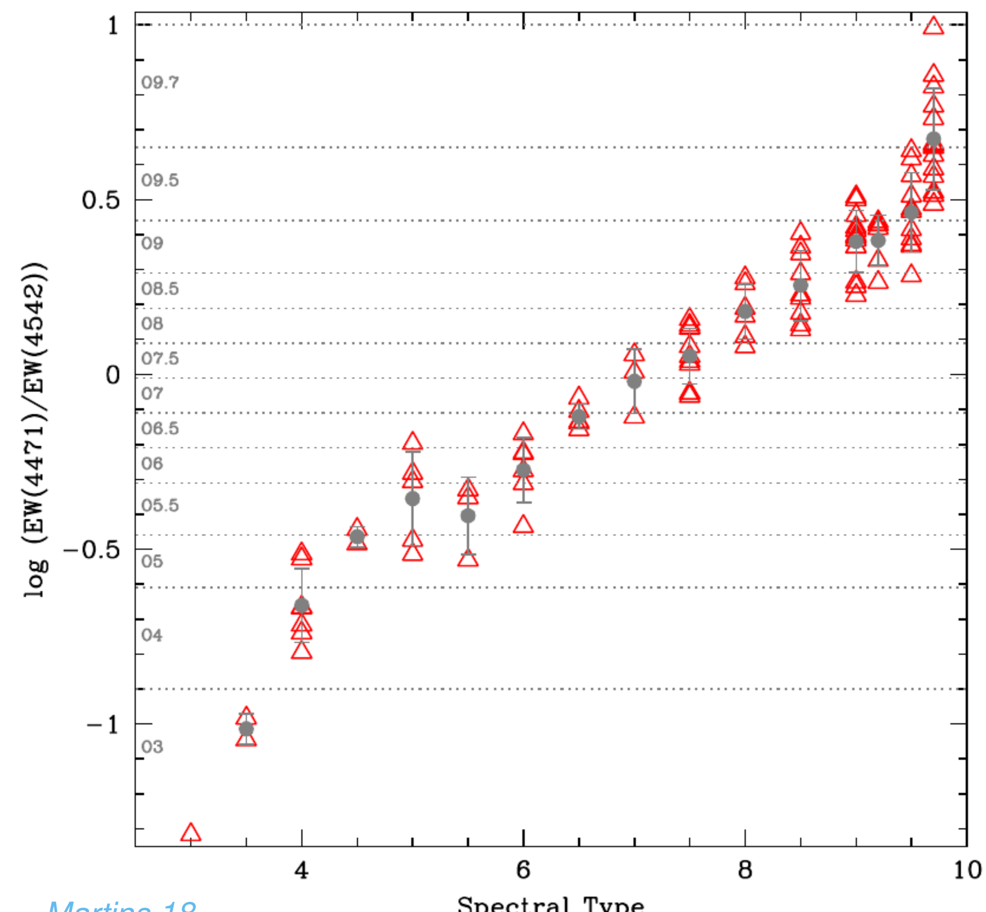
See talks by N. Castro, M. Garcia

First step in the analysis of newly observed stars: classification



Massey & Thompson 91 (Cyg OB2)

Conti & Alschuler 71, Walborn 71, Mathys 88, 89, Sota+11,14

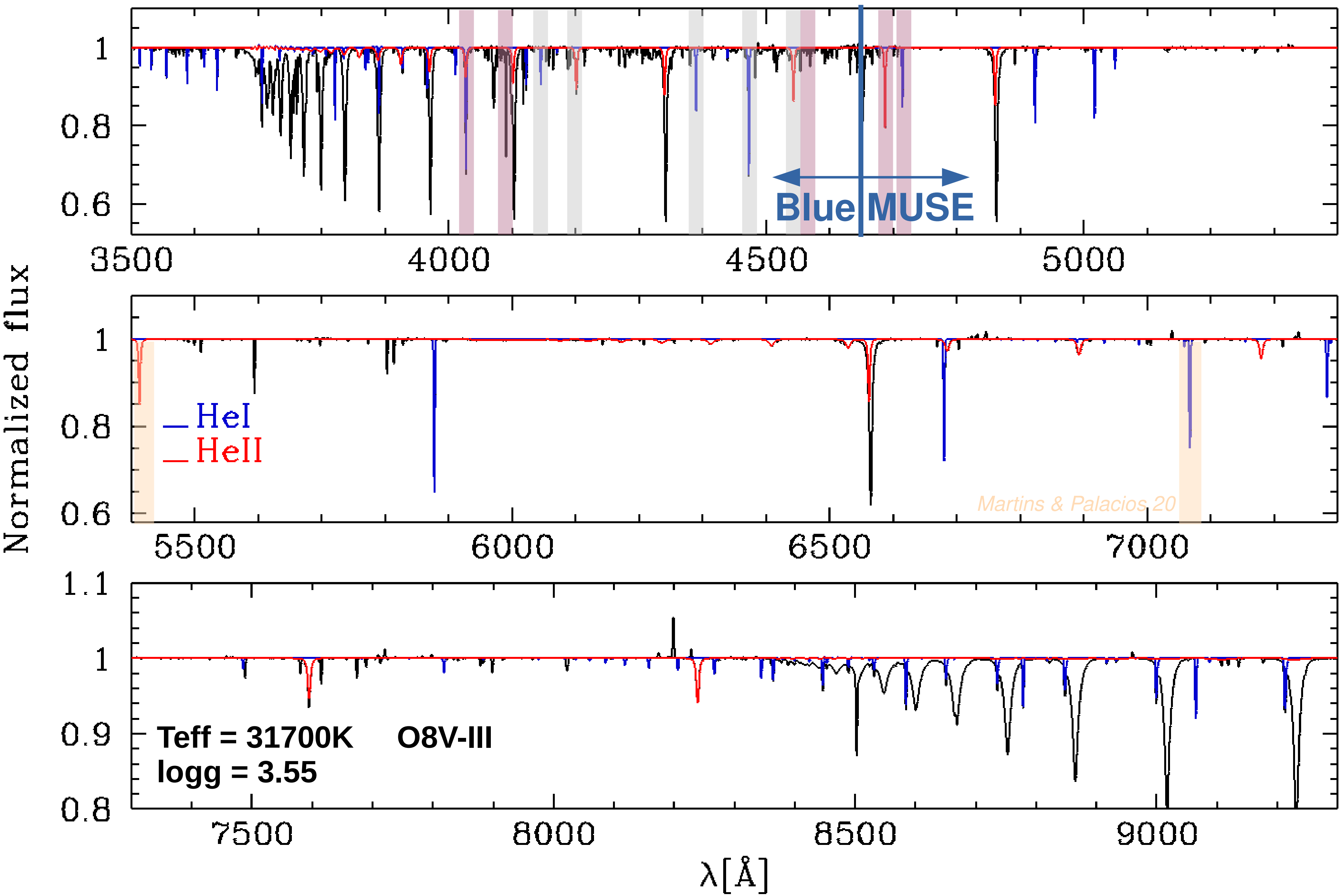


Martins 18

Spectral features also used to determine effective temperature

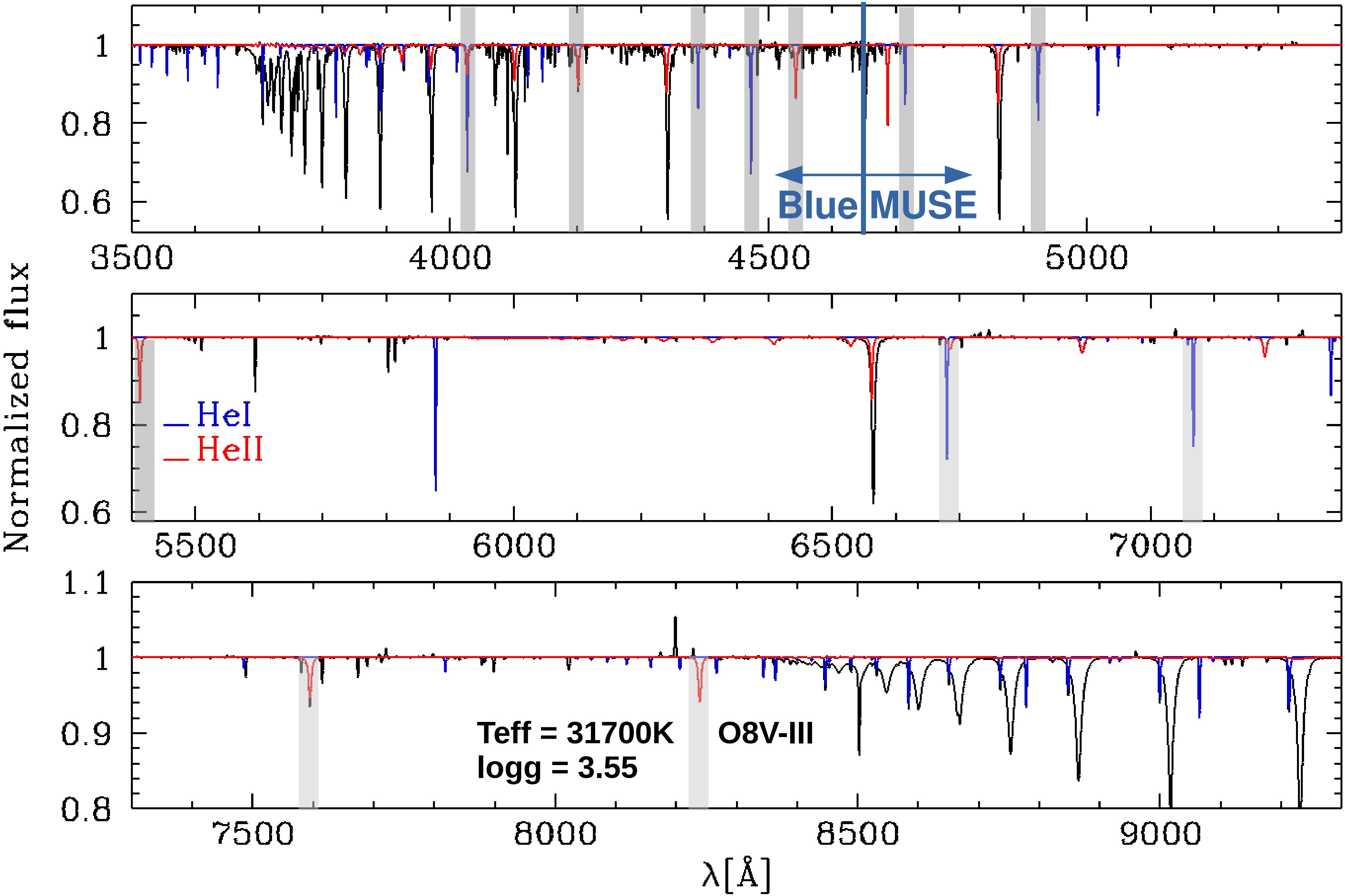
All classical lines used for spectral classification (ST & LC) are in the optical blue

Conti & Alschuler 71, Walborn 71, Mathys 88, 89, Sota+11,14, Martins 18

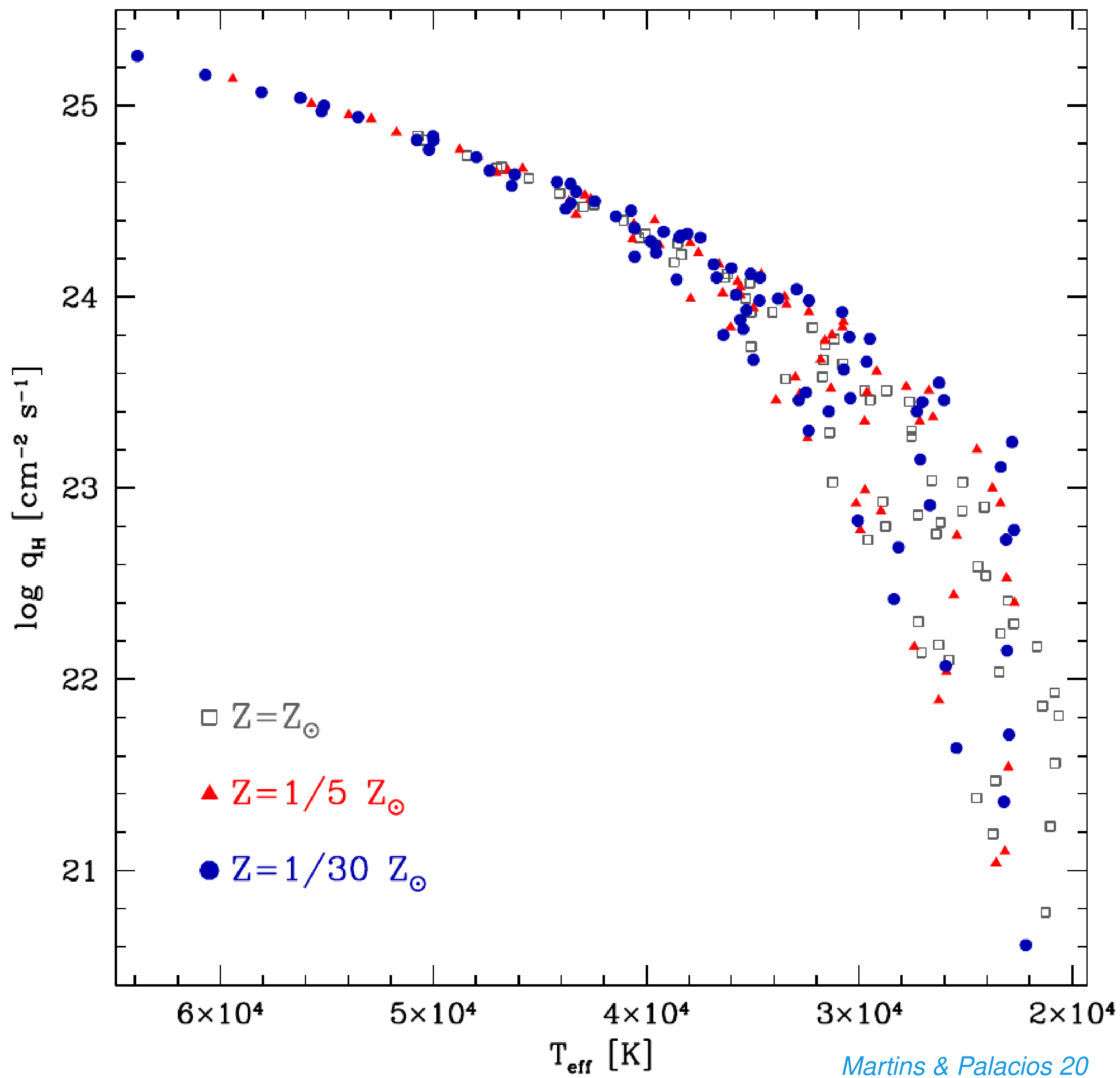


Most helium lines used for Teff determination are in the optical blue

Herrero+92, Puls+96, Mokiem+07, Rivero-Gonzalez+12, Martins+05,15, Gonzalez-Holgado+18, Ramachandran+20...

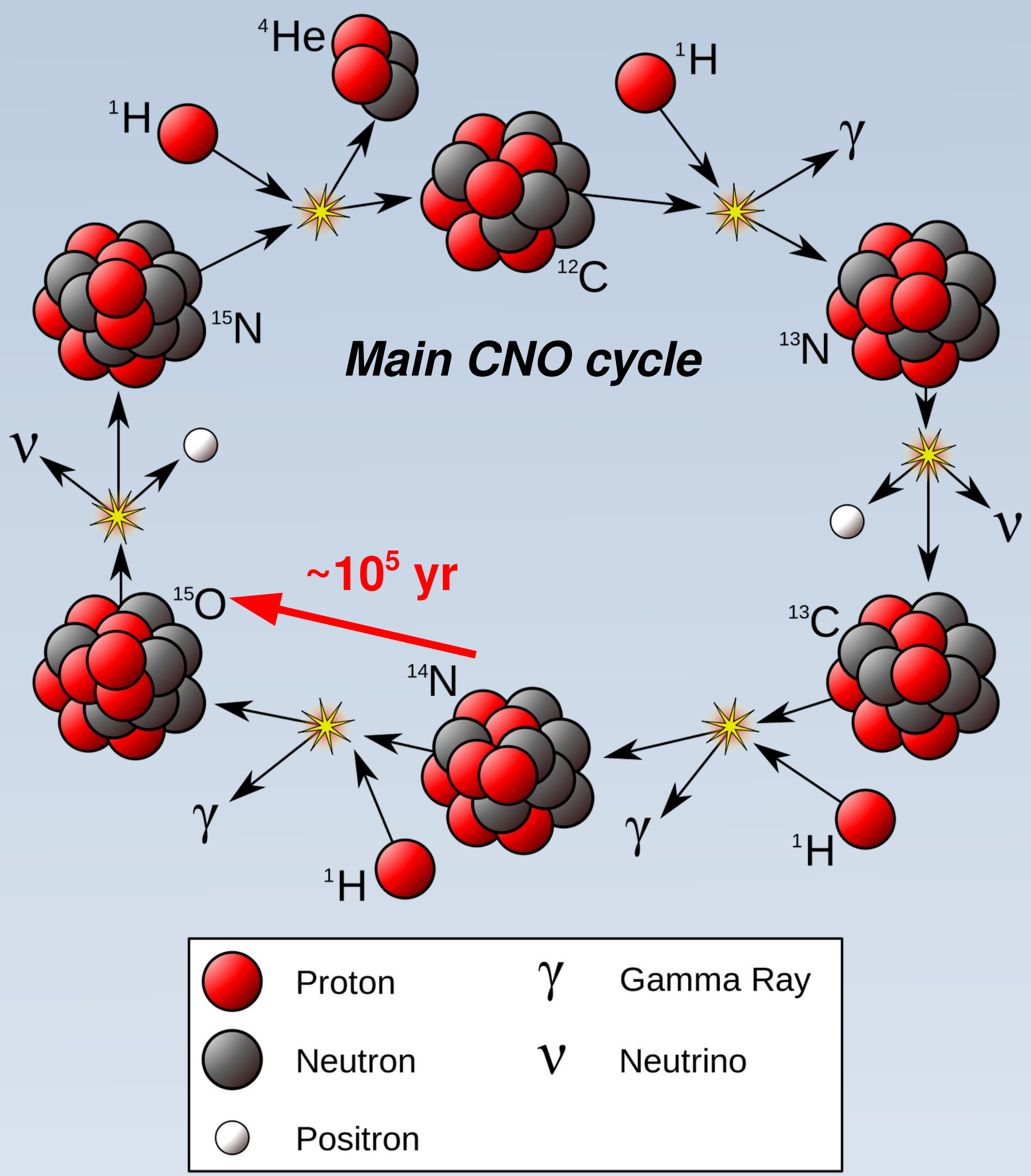


Accurate Teff needed to estimate ionizing fluxes



Martins & Palacios 20

Surface abundances



H burning through CNO cycle

Timescale for nuclear burning longer than mixing timescale (e.g. in rotating stars)

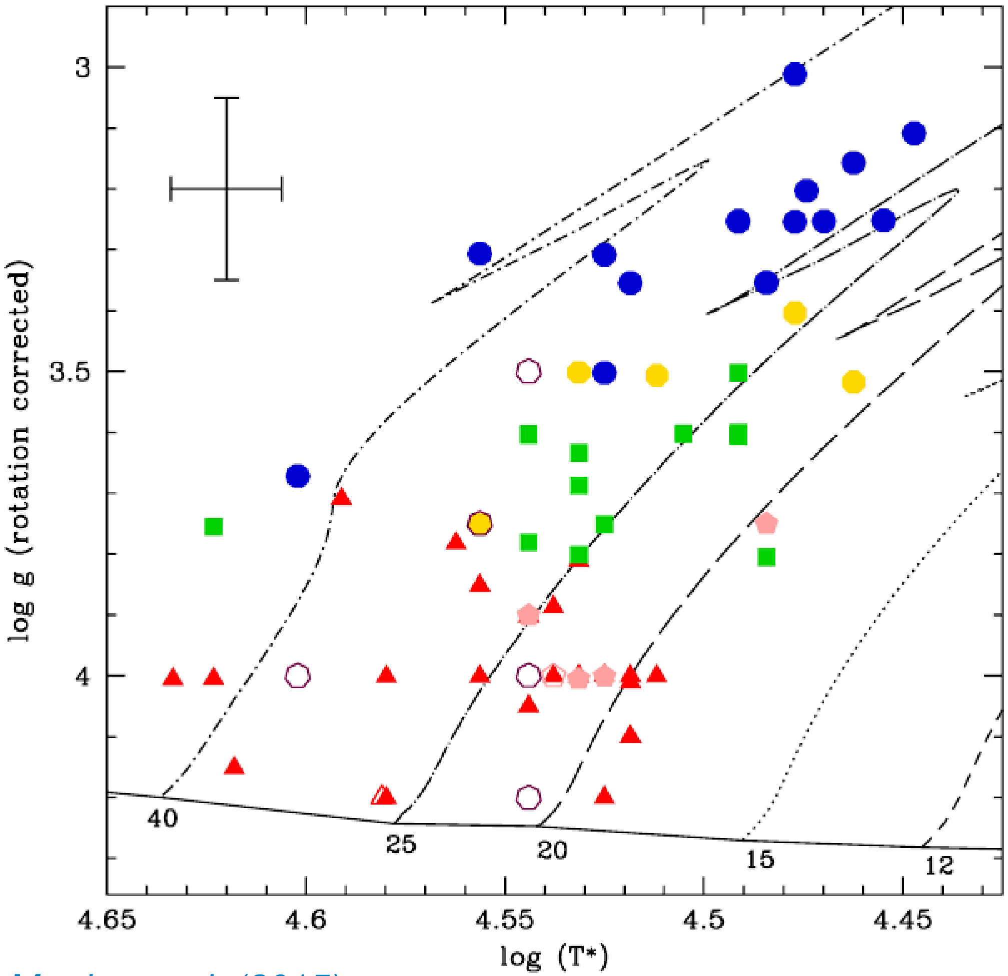
C (and O) converted to N

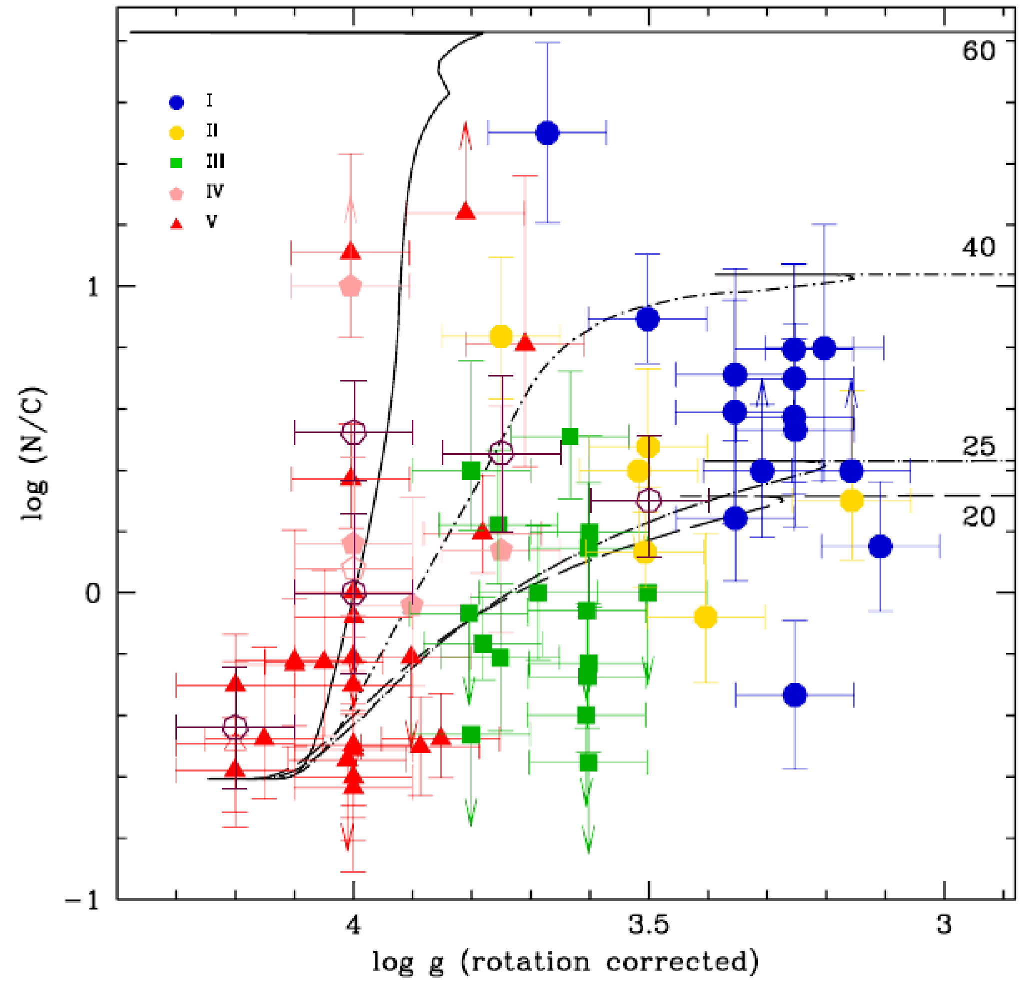
→ *chemical patterns should be observed at surface of stars*

→ *surface abundances = good indicators of mixing processes*

Rotation, winds and binarity impact differently surface abundances

Surface abundances



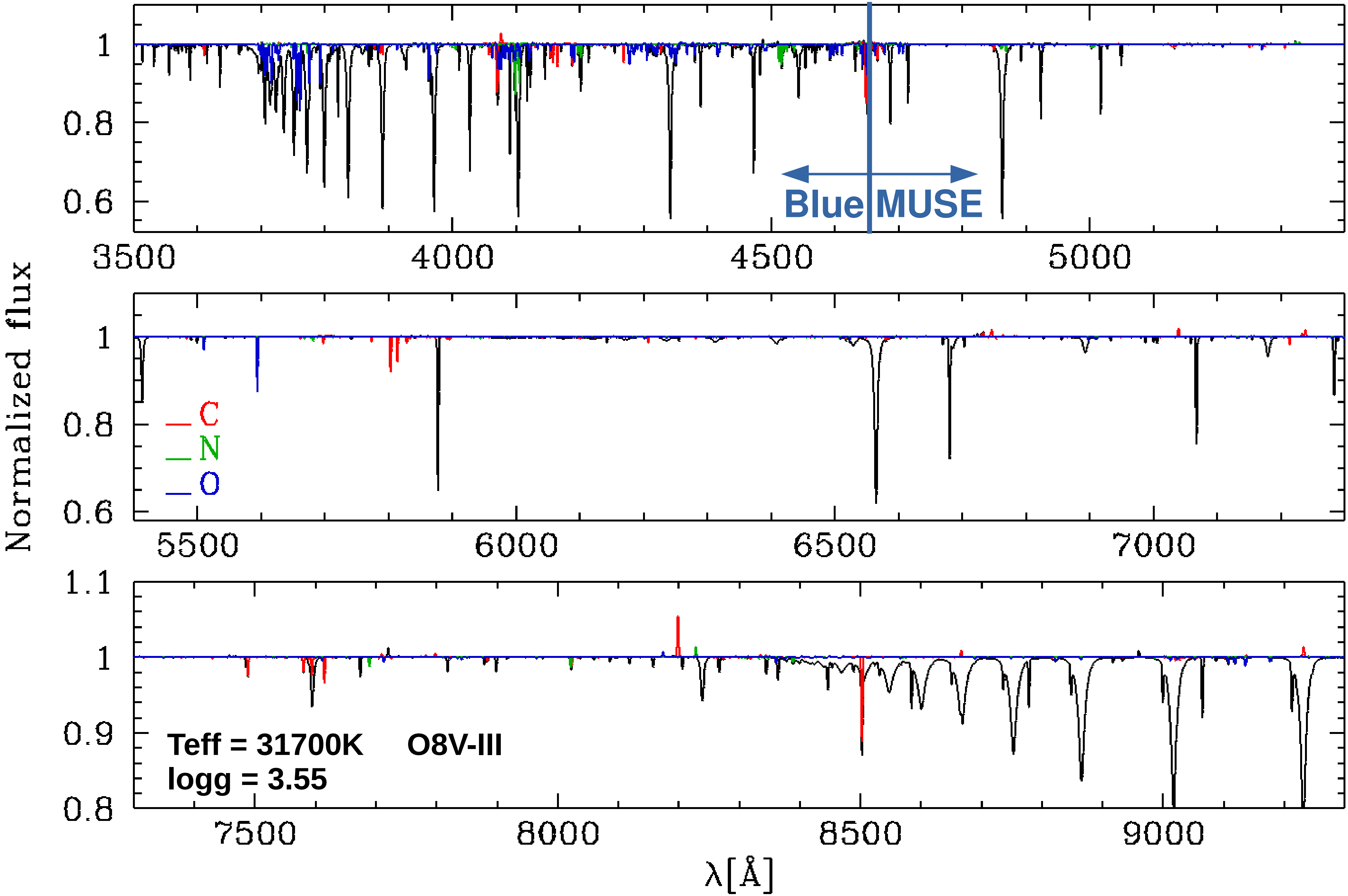


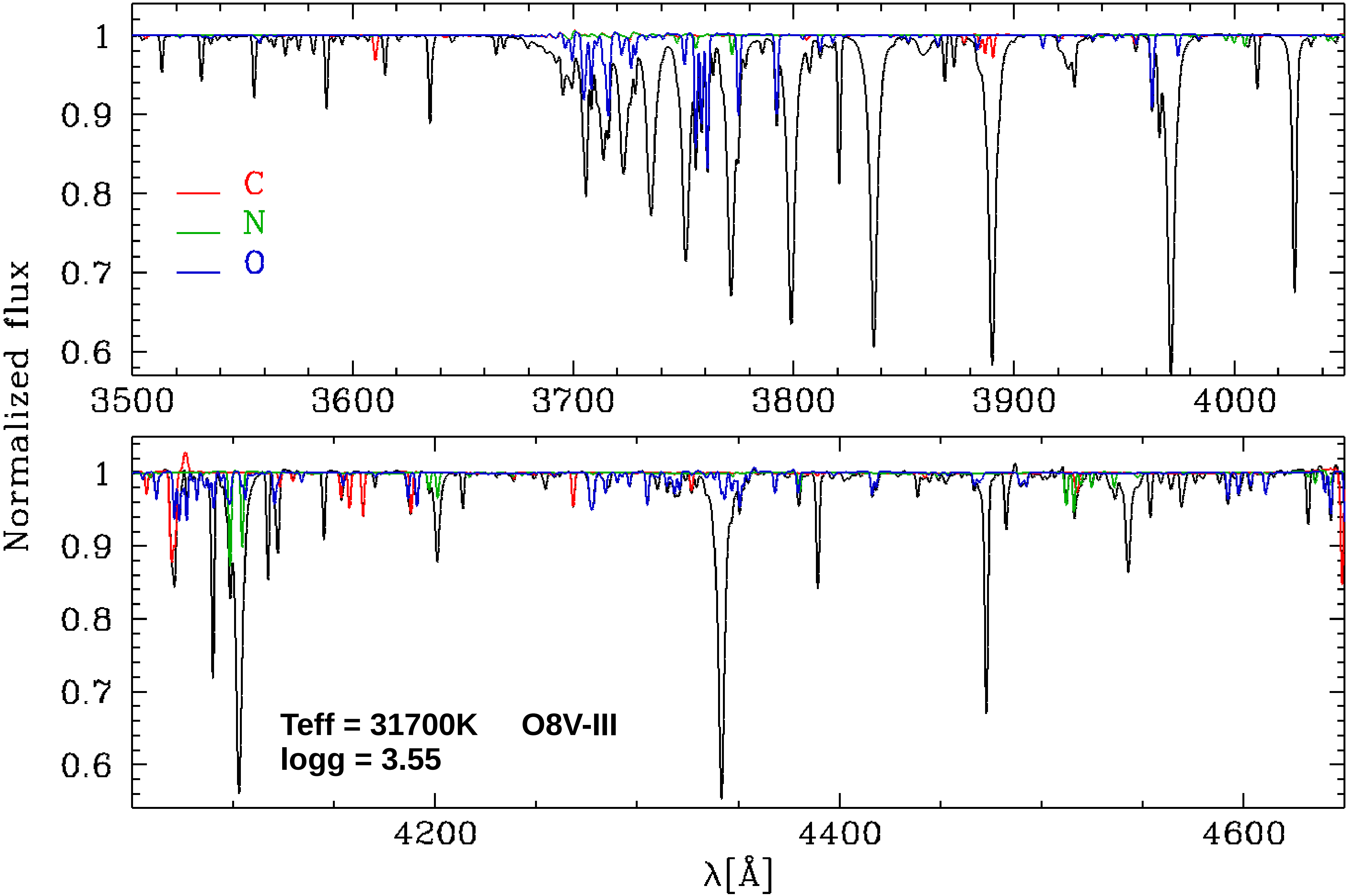
Martins et al. (2015)

More evolved stars show more surface chemical processing

This is confronted to predictions of models including various mixing processes

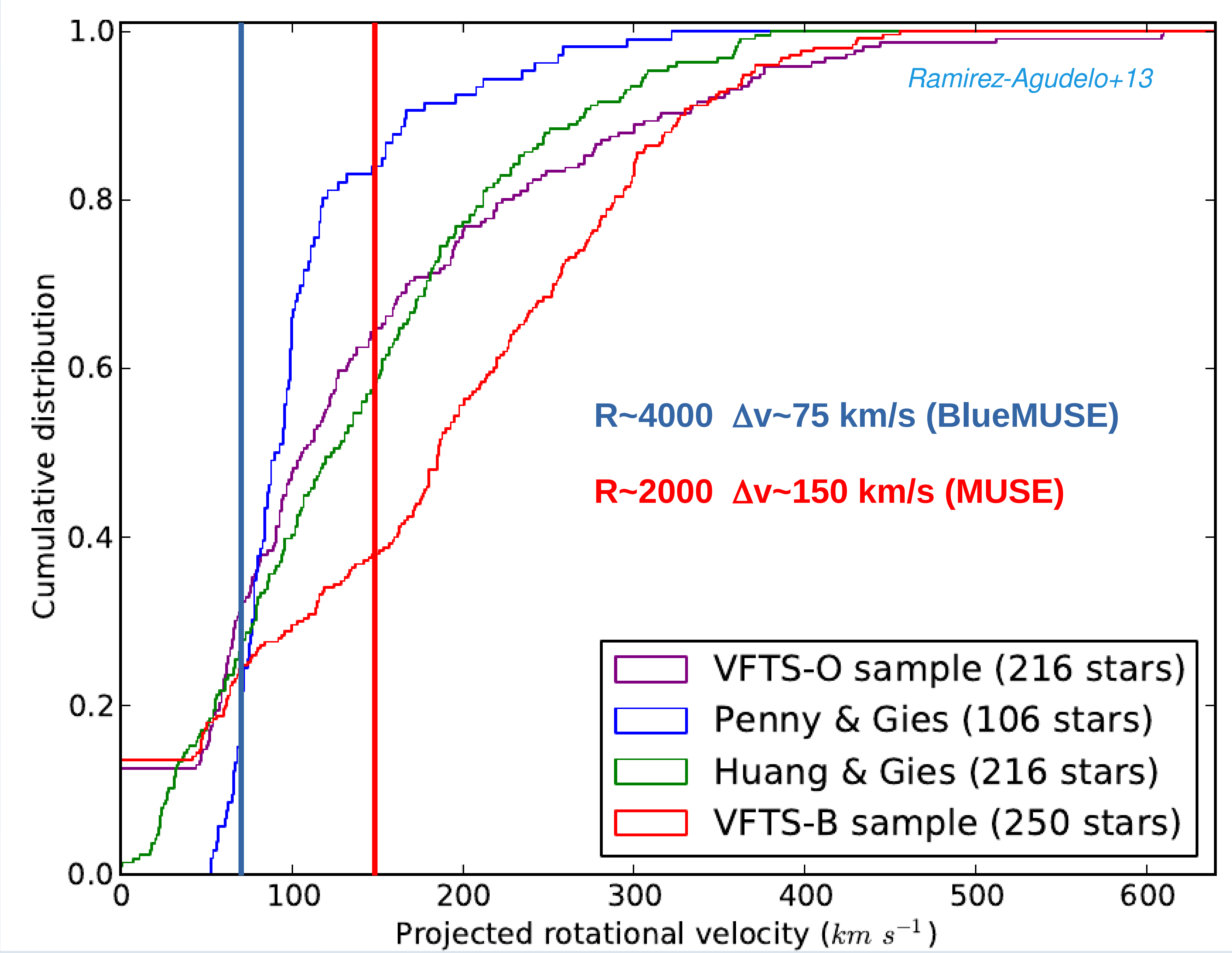
Most lines from C, N & O are in the blue part of the optical, covered by BlueMUSE





Normalized flux
1
0.9
0.8
0.7
0.6
C
N
O
3500
3600
3700
3800
3900
4000
4200
4400
4600
Teff = 31700K O8V-III
logg = 3.55
λ[Å]

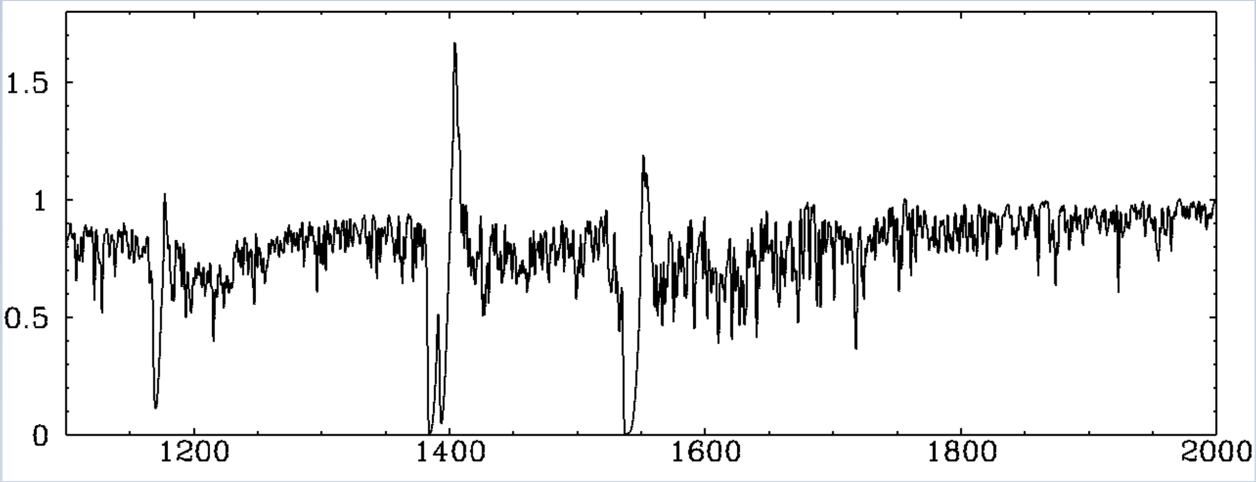
With increased spectral resolution, more OB stars can be analyzed quantitatively



Synergy with other facilities

Diagnostics of stellar winds:

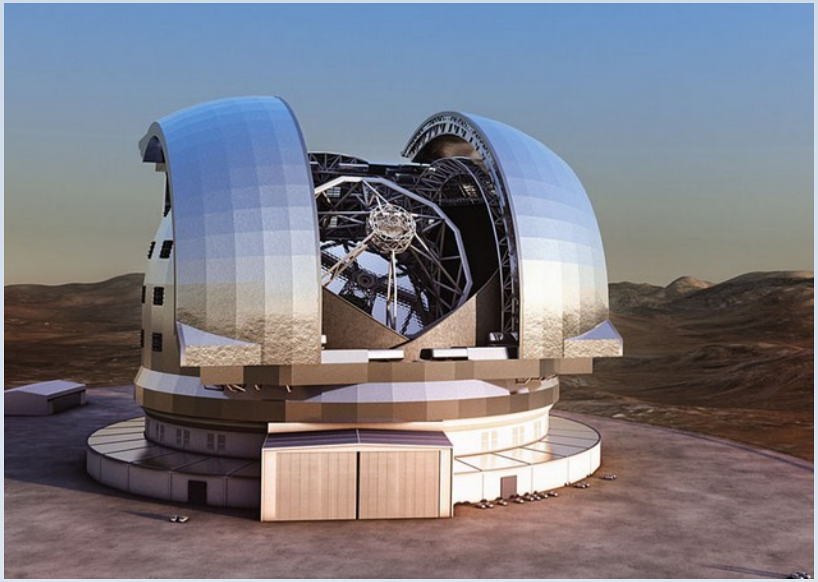
Hα & UV resonance lines – ESO/MUSE + HST



Slow rotators/follow up:

Improved spectral resolution

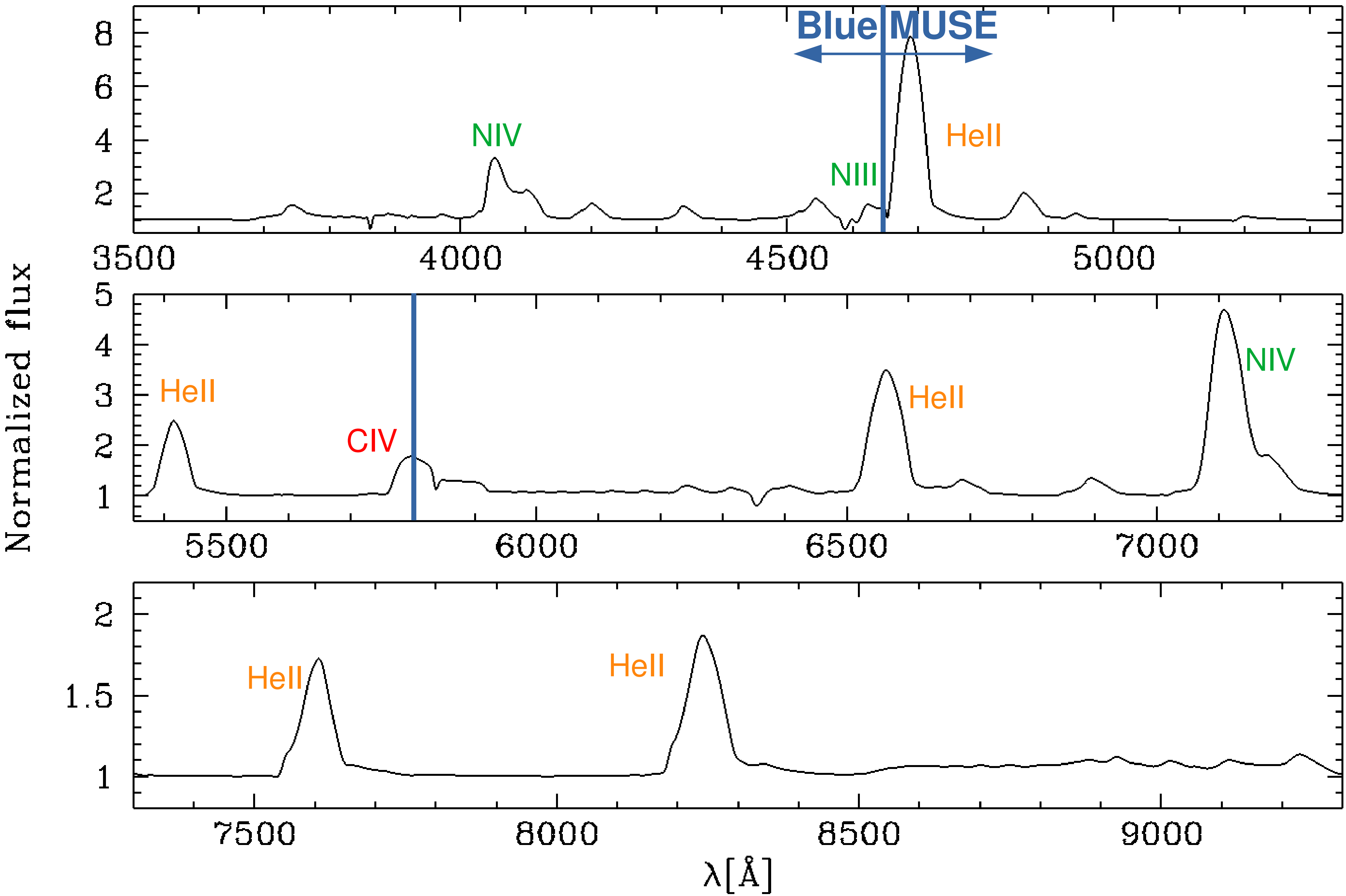
VLT/UVES
ELT/HIRES (ELT/MOSAIC + HARMONI)



Advanced phases of evolution (WR stars):

BlueMUSE + MUSE to cover all important diagnostics

Wolf-Rayet spectrum



Conclusion and final remarks

Blue optical range required for:

Spectral classification

Effective temperature determinations

Surface abundances determinations

Key science questions:

How do massive stars evolve?

What is the relative role of rotation, winds, binarity?

What are, quantitatively, the feedback effects (ionizing fluxes, mechanical energy)?

IFU best suited to study young massive clusters

→ *talks by S. Kamann, N.Castro, M Garcia*

BLUE MUSE multi unit spectroscopic explorer