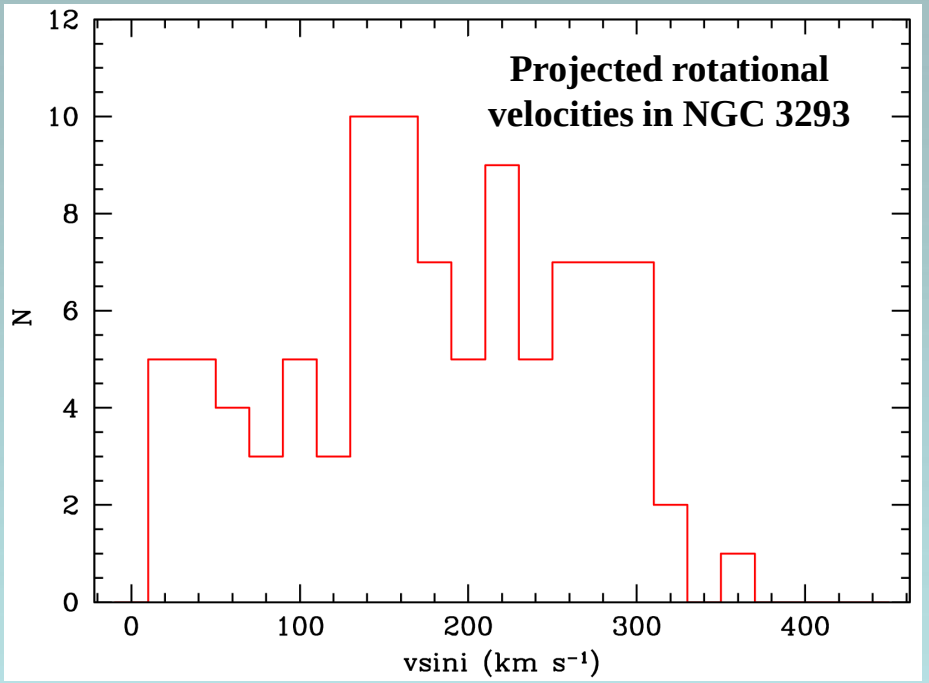
The young open cluster NGC 3293 revisited by the Gaia-ESO Survey

Morel, T., Semaan, T., Gosset, E., Blomme, R., Lobel, A., Frémat, Y., and the WG13 team

The analysis of hot stars

Line formation in non LTE
Stellar winds may need to be taken into account
Fewer chemical species can be determined with respect to cool stars
OB stars are usually fast rotators



WG13

Analysis of OBA stars

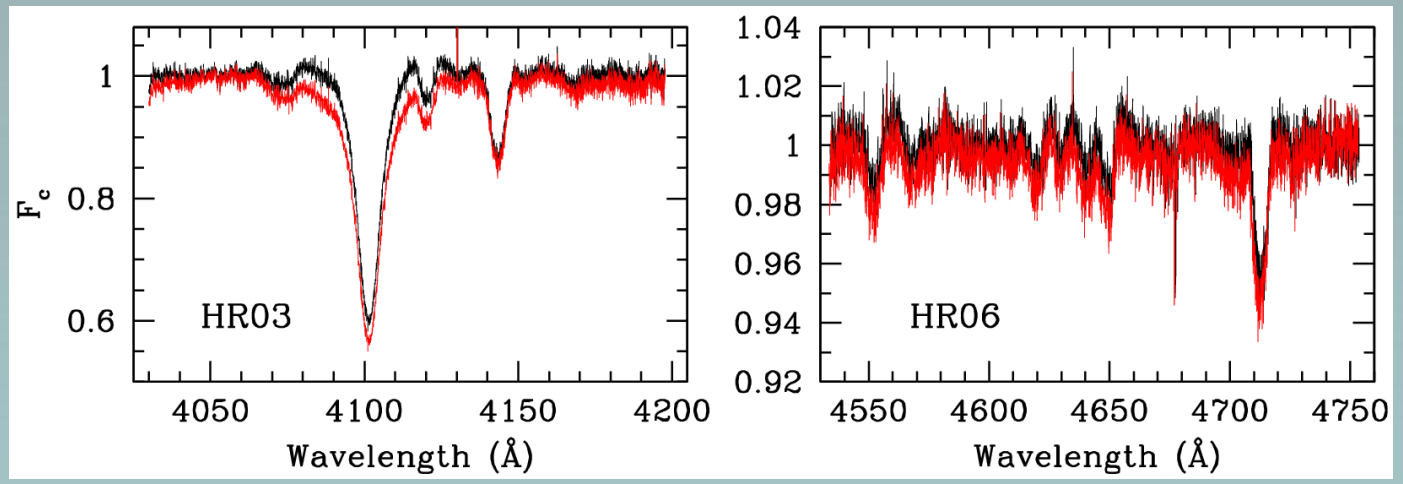
Currently 6 nodes involved in spectral analysis:

Node	Tools and methods	Stars analysed
ROBGrid	Model grids from the literature + spectral fitting	all stars
Montpellier	CMFGEN + spectral fitting	O stars
IAC	FASTWIND + spectral fitting	O stars
Liège	TLUSTY or DETAIL/SURFACE + spectral fitting	B stars
ROB	Refined Kurucz models + LTE spectrum synthesis + EWs	A stars
Leuven	SYNTHV + LTE spectrum synthesis	A stars

The results presented in the following are only those obtained by the Liège node

Liège node analysis

Manual renormalisation of all spectra



Default
Renormalised

Two-step approach:

- Stellar parameters (Teff, logg, vsini, ξ, Vr) from global fitting of spectrum with a grid of non-LTE TLUSTY synthetic spectra (solar chemical composition assumed).
- Chemical abundances from spectral synthesis of selected wavelength regions. Performed with Kurucz models and non-LTE line-formation code DETAIL/SURFACE.

SB2 and Be stars discarded

The open cluster NGC 3293

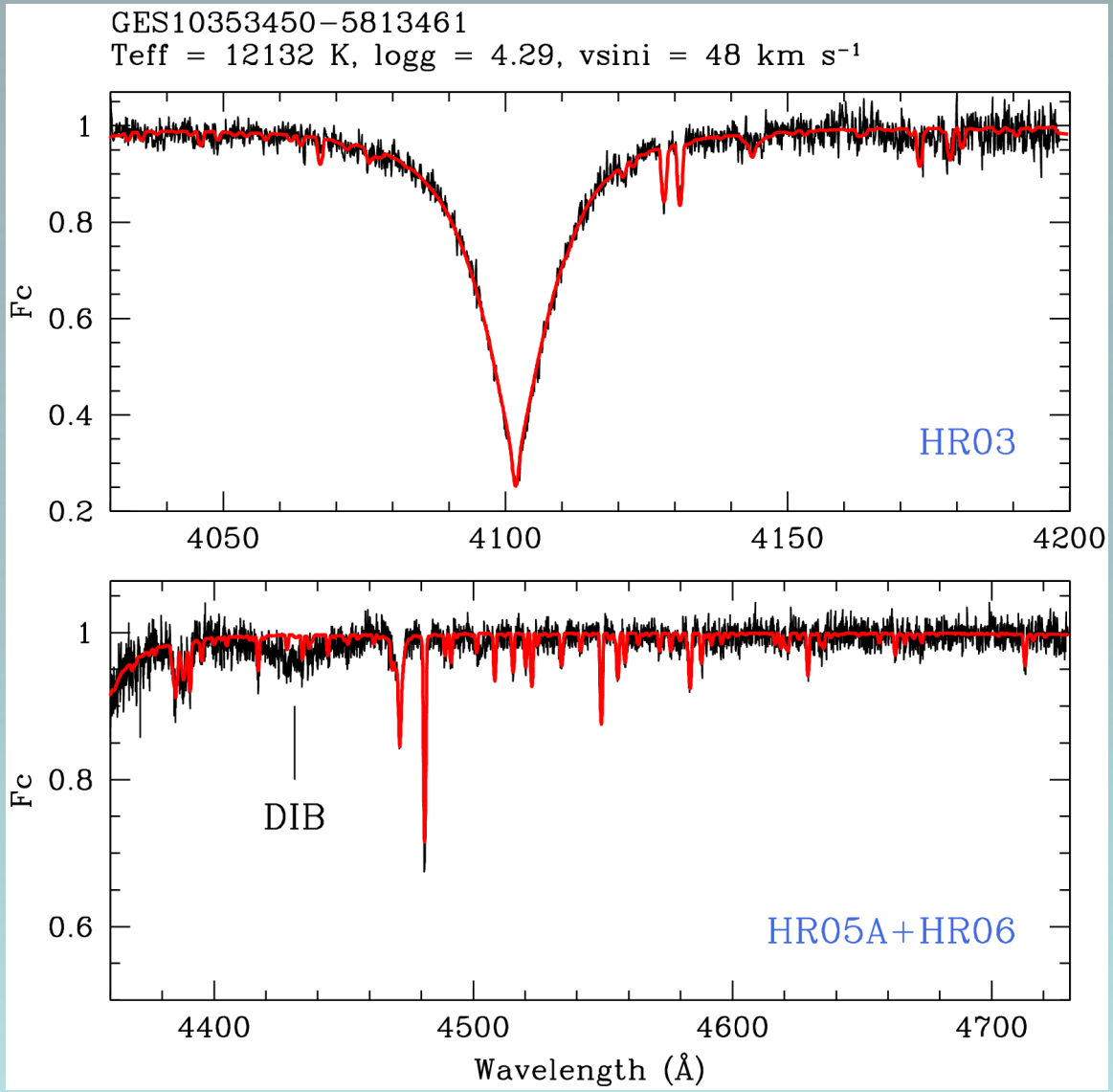
Young open cluster (~15 Myrs)
Located at ~2.3 kpc
R_G ~ 7.7 kpc

Observed by the "VLT FLAMES Survey of Massive Stars" (Evans et al. 2005, Hunter et al. 2009)

This study
95 Stars
B9-B1.5
HR03, HR05A, HR06, HR14A
+UVES520
Spectral synthesis
He, N, O, Mg, Si

VLT FLAMES Survey
99 Stars
B5-B1.5
HR02, HR03, HR04, HR05, HR06, HR14
+FEROS
EWs
C, N, O, Mg, Si

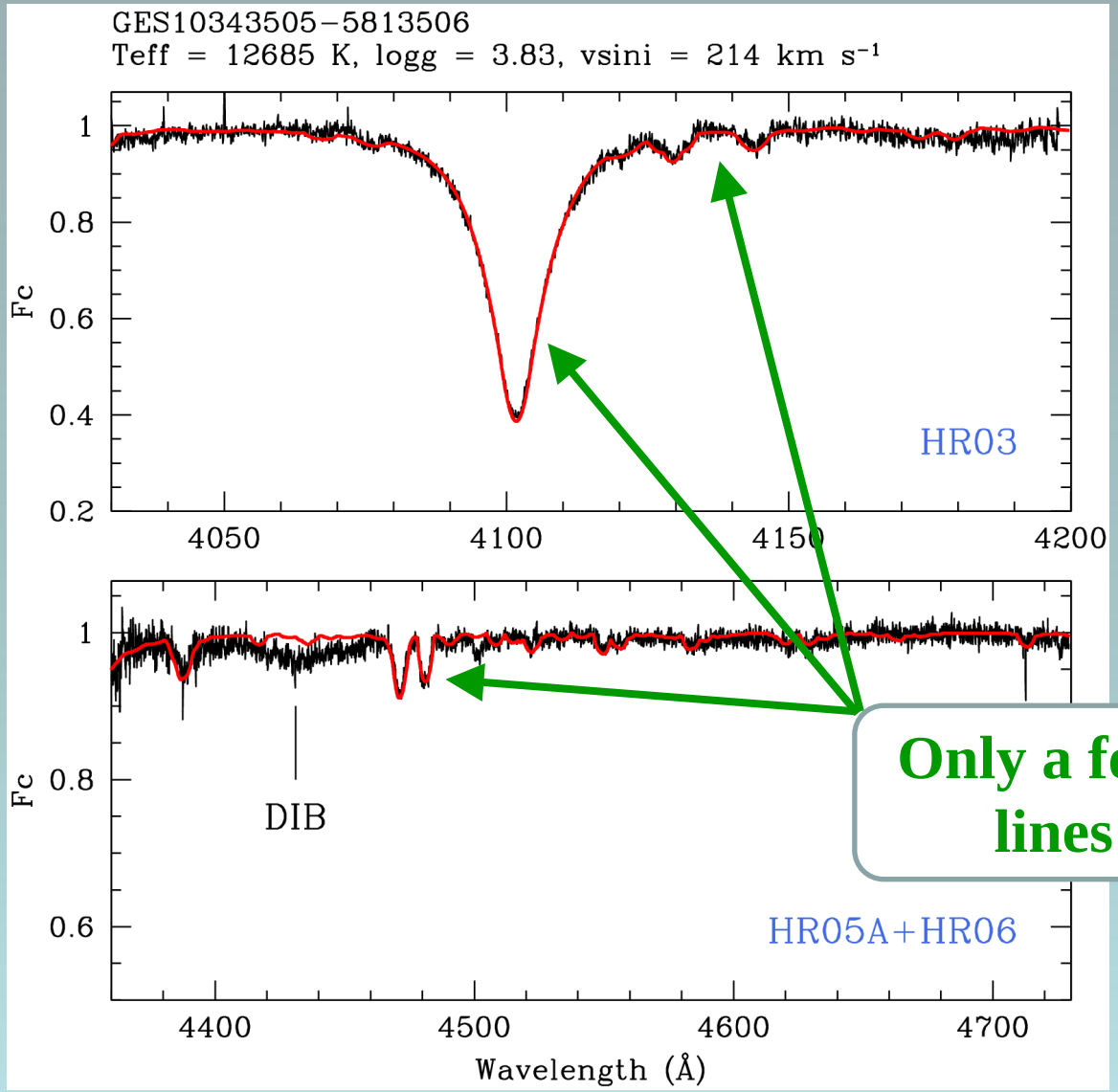
Determination of atmospheric parameters



Observations
Best fit

A cool, slow rotator

Determination of atmospheric parameters

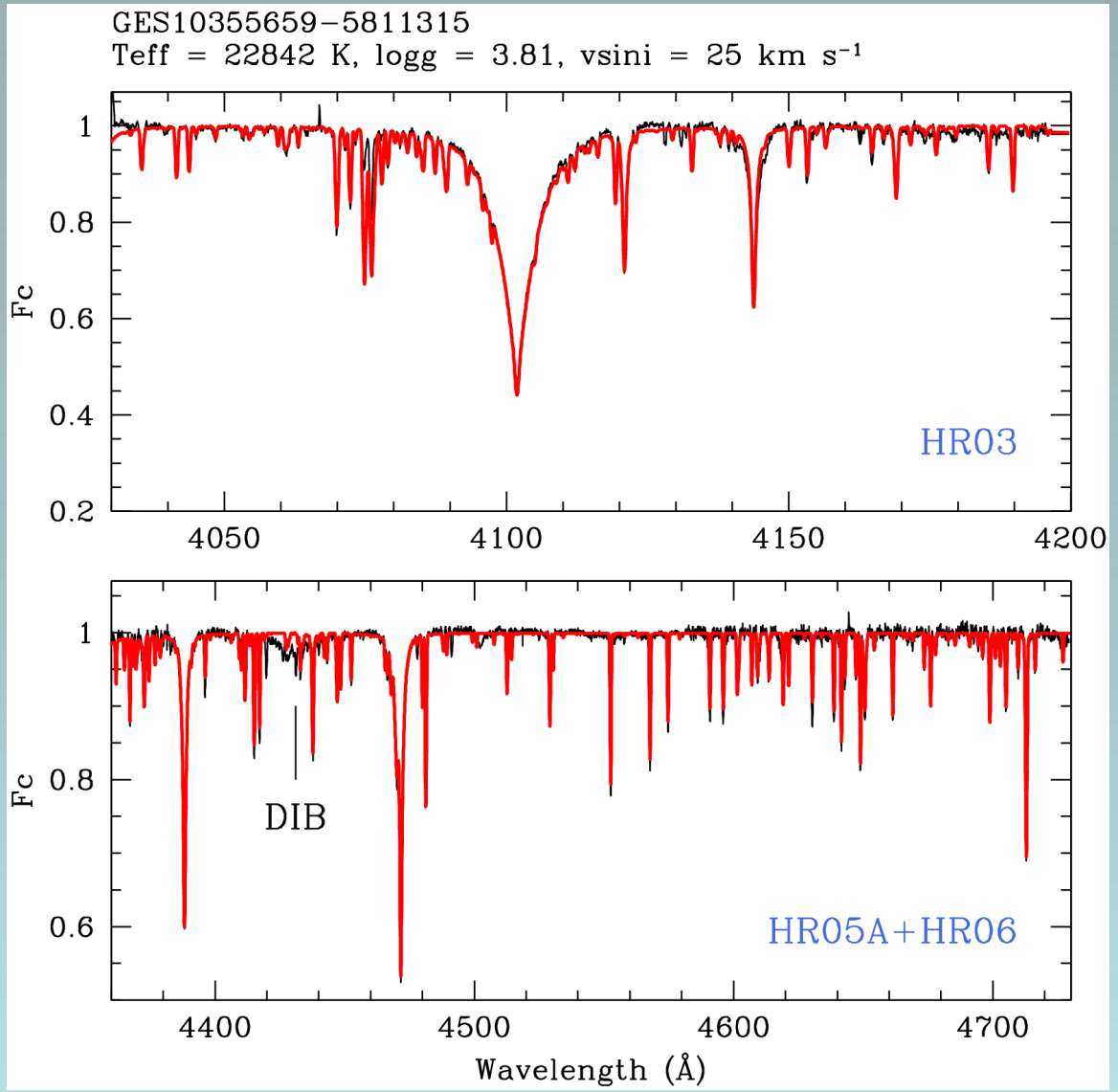


Observations
Best fit

A cool, fast rotator

Only a few diagnostic lines available

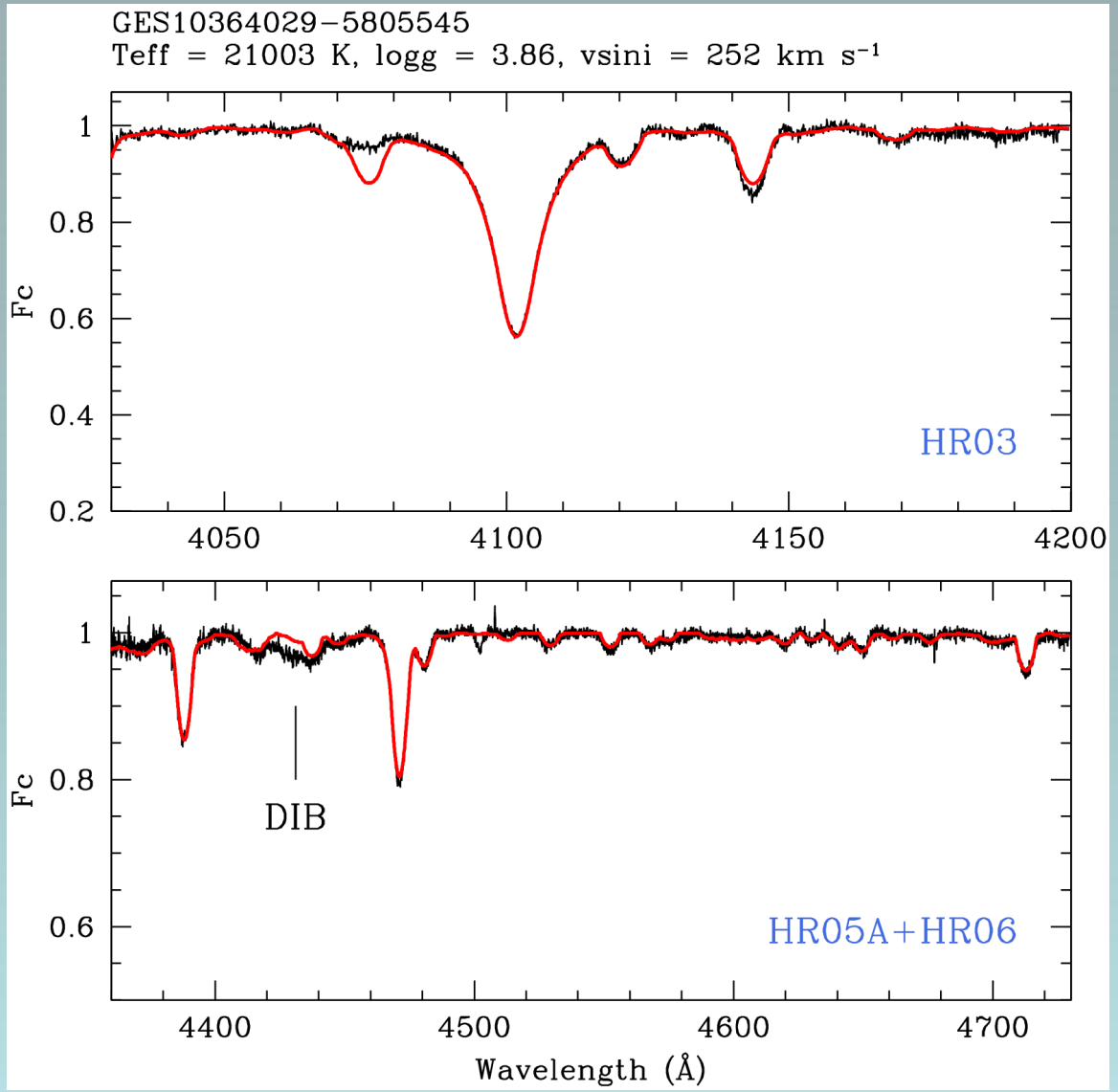
Determination of atmospheric parameters



Observations
Best fit

A hot, slow rotator

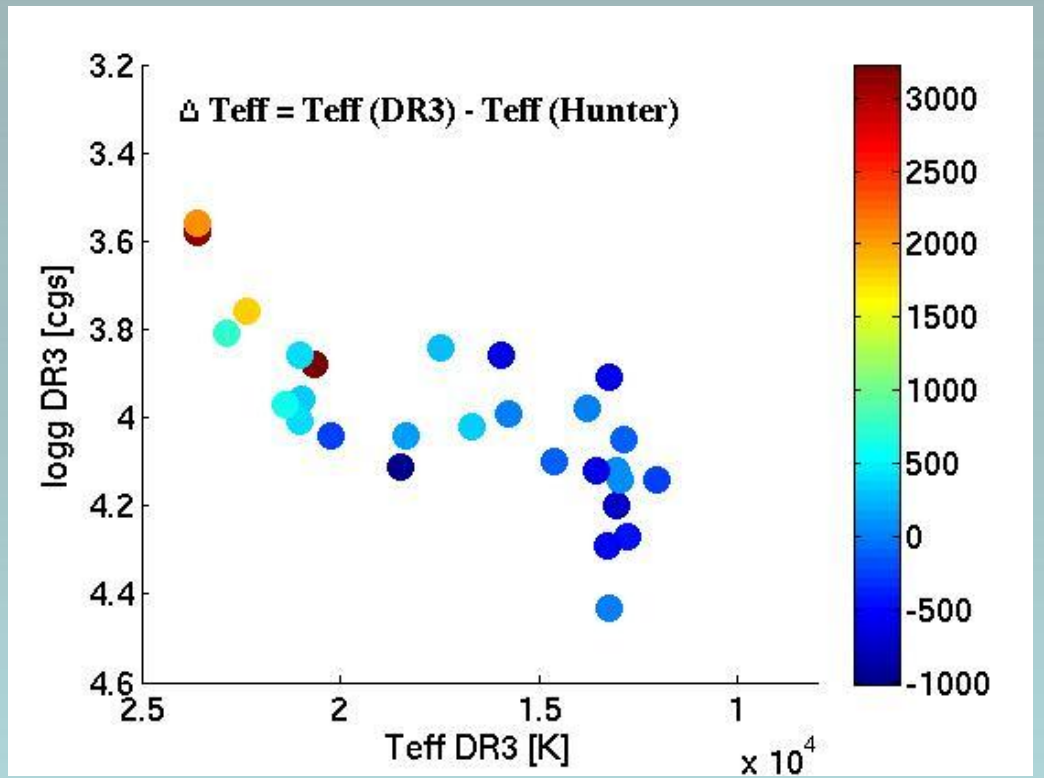
Determination of atmospheric parameters

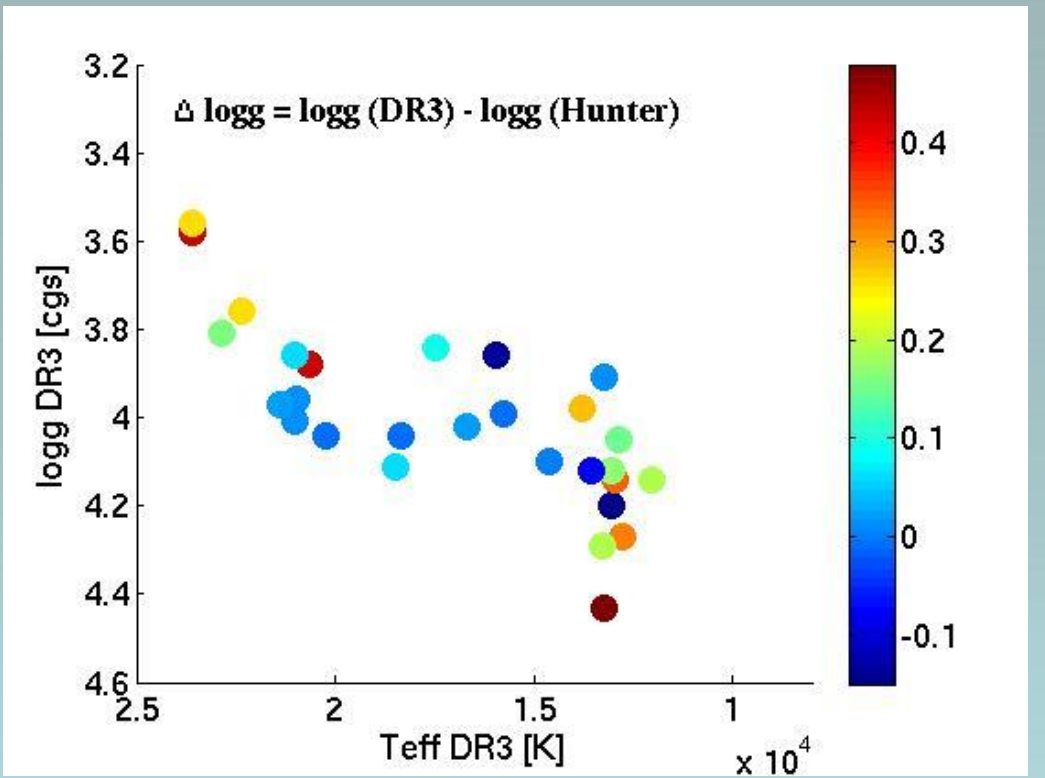


Observations
Best fit

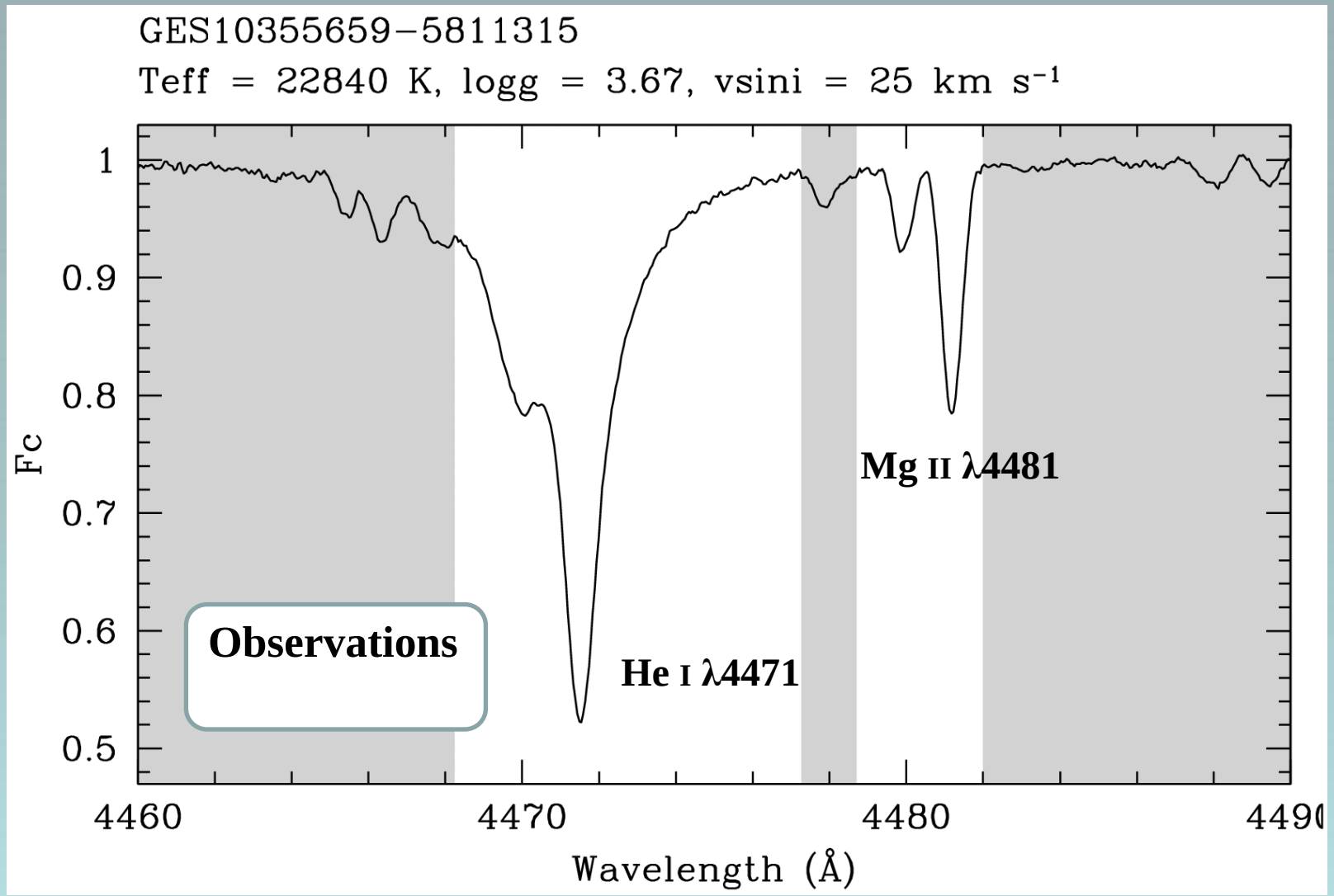
A hot, fast rotator

Comparison atmospheric parameters with values from VLT FLAMES Survey





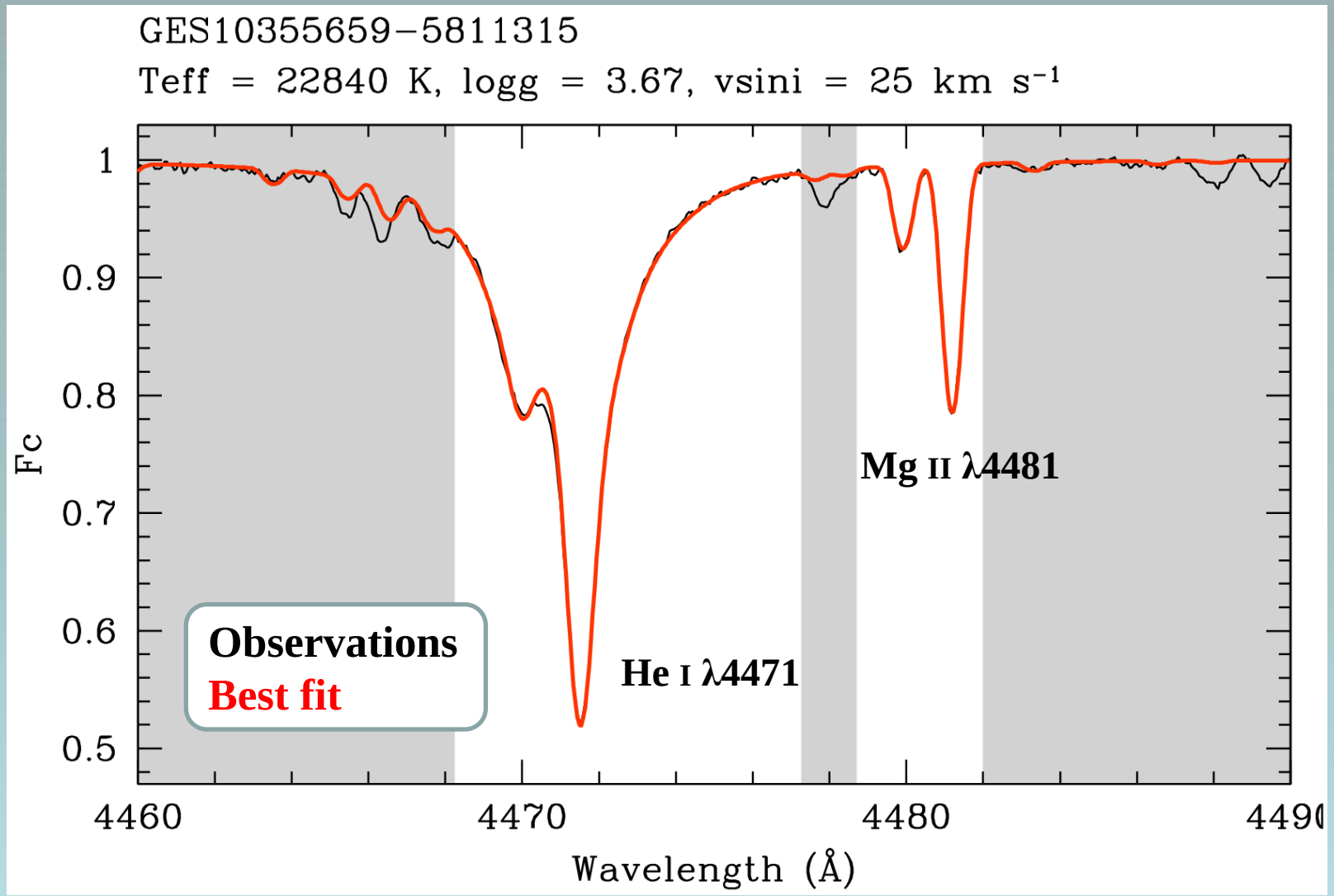
Determination of He and Mg abundances



Region excluded

A hot, slow rotator

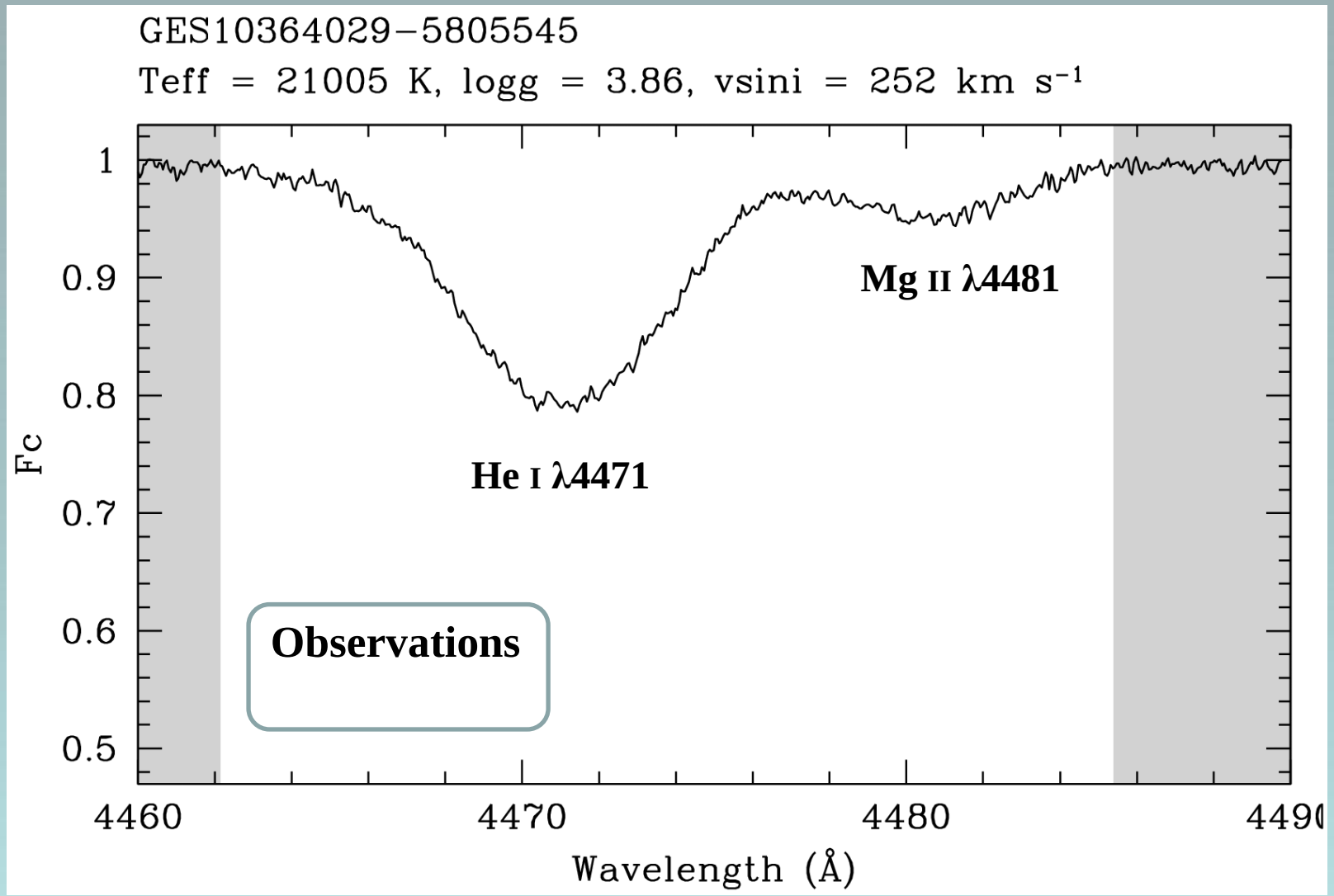
Determination of He and Mg abundances



Region excluded

A hot, slow rotator

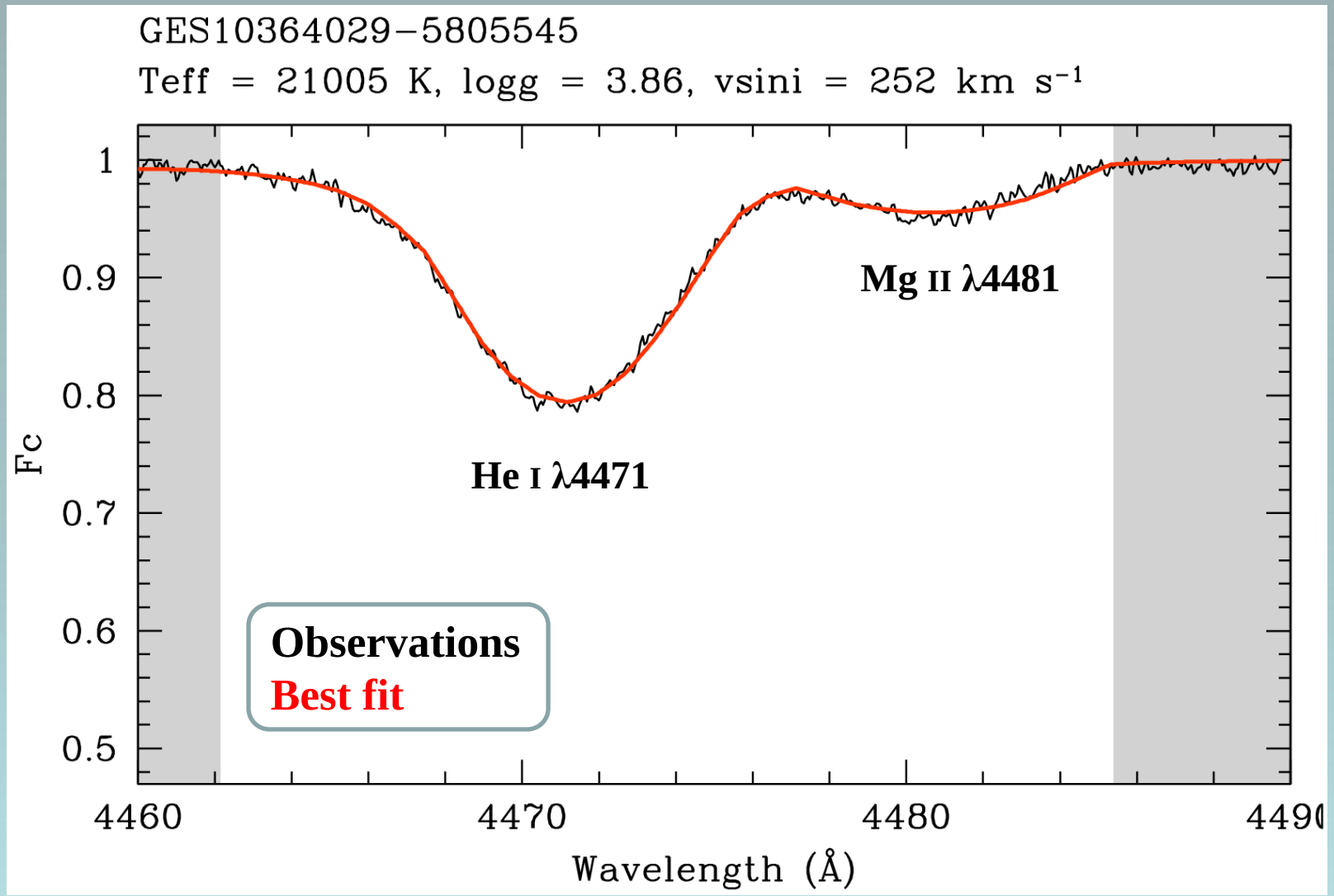
Determination of He and Mg abundances



Region excluded

A hot, fast rotator

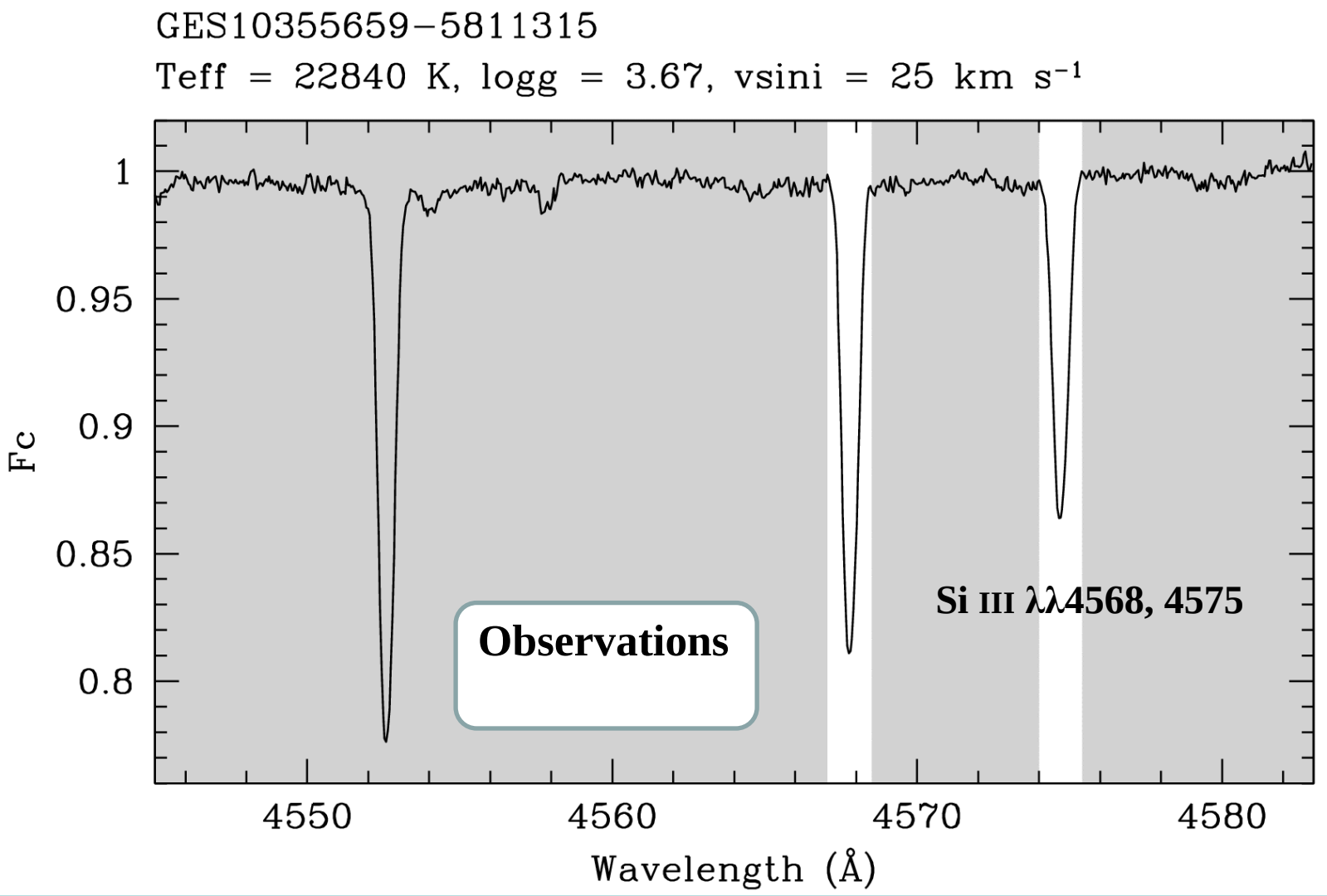
Determination of He and Mg abundances



Region excluded

A hot, fast rotator

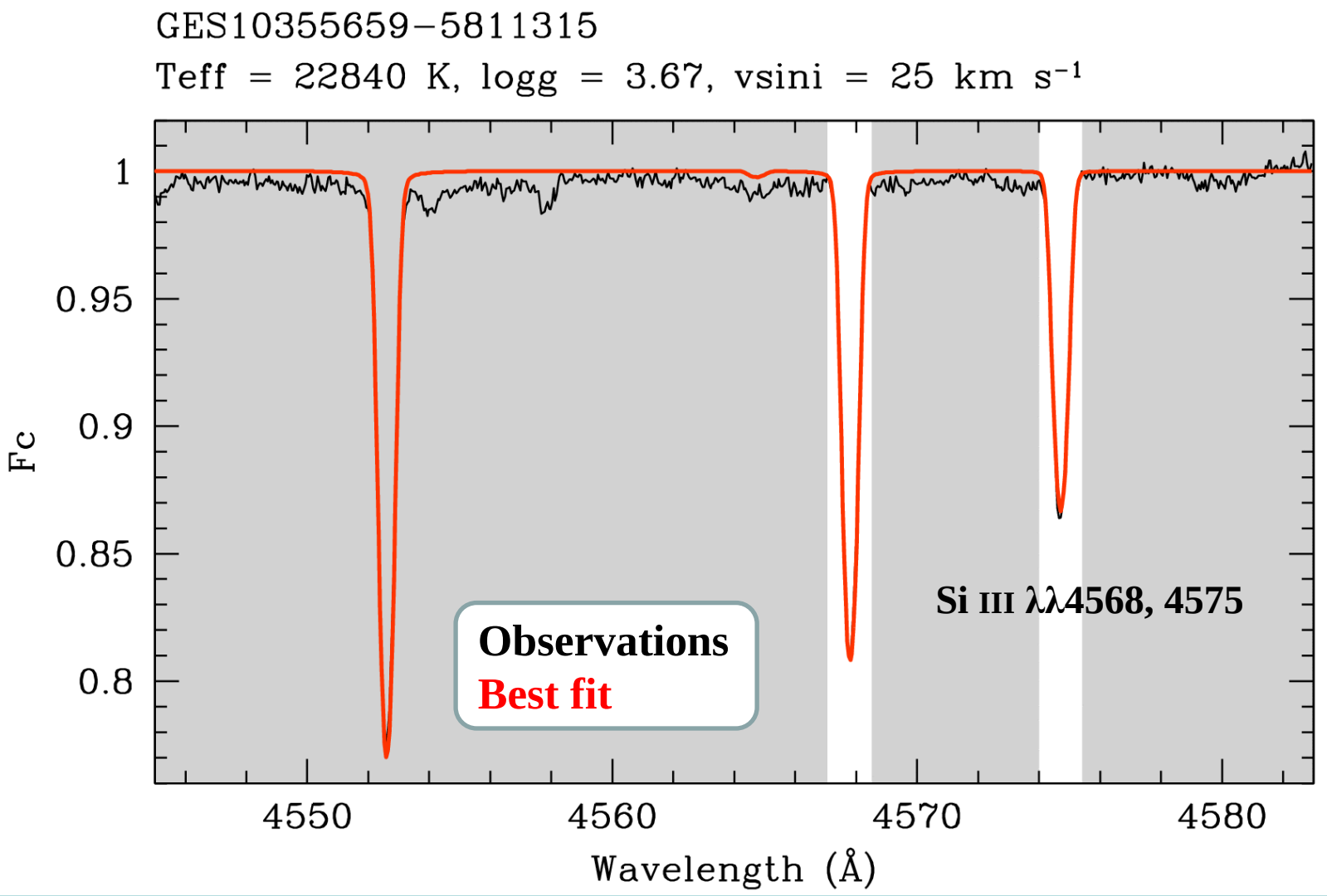
Determination of Si abundance



Region excluded

A hot, slow rotator

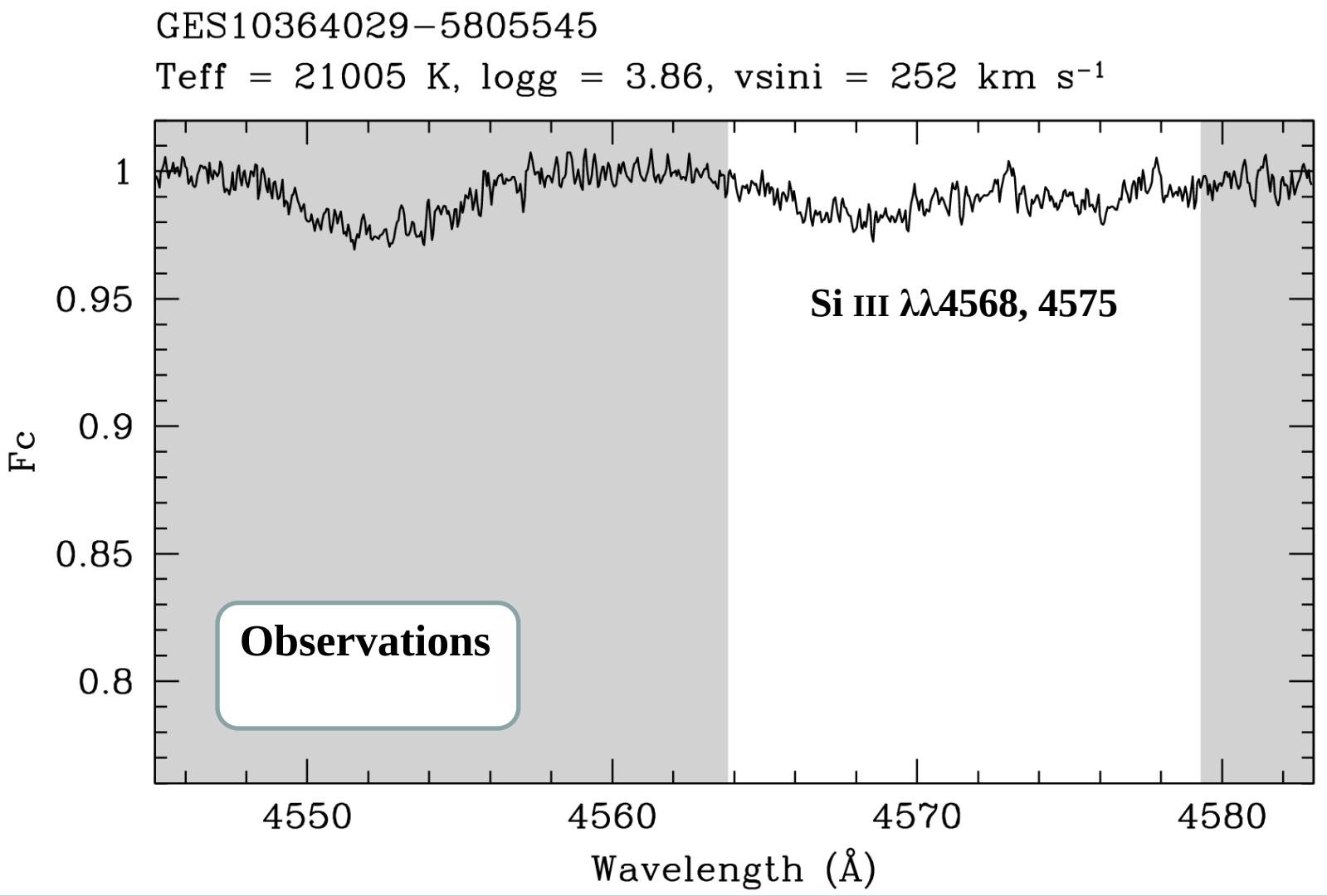
Determination of Si abundance



Region excluded

A hot, slow rotator

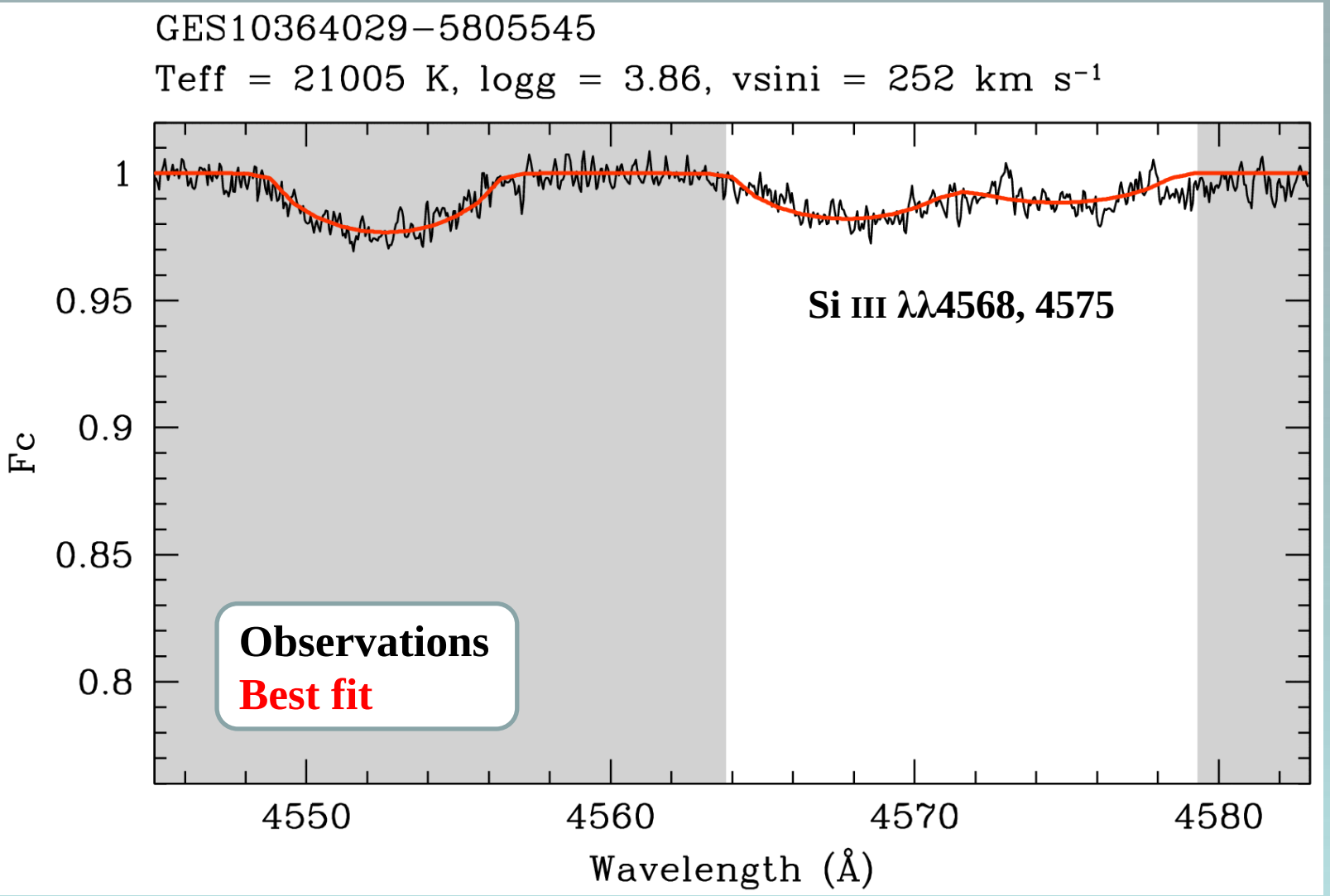
Determination of Si abundance



Region excluded

A hot, fast rotator

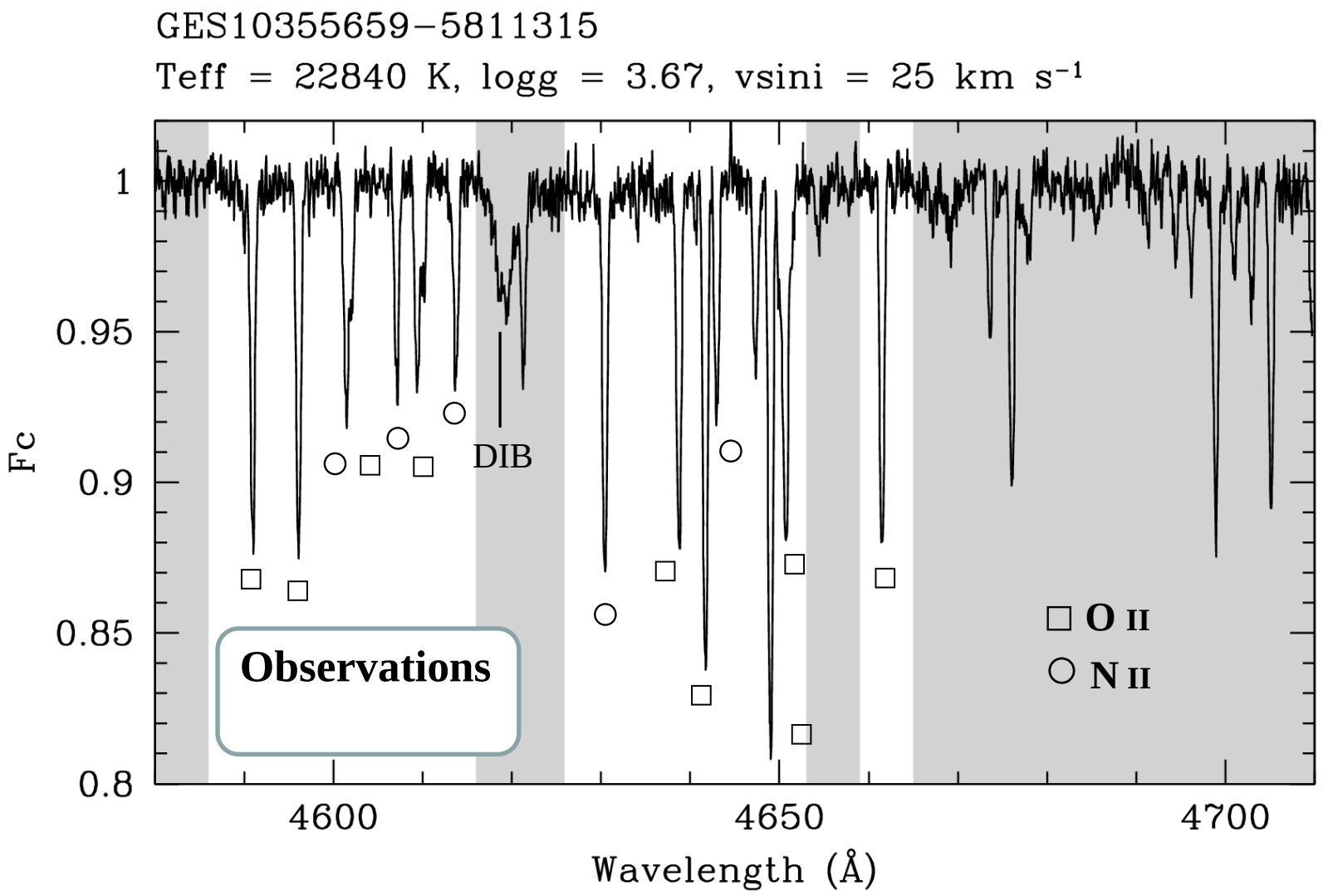
Determination of Si abundance



Region excluded

A hot, fast rotator

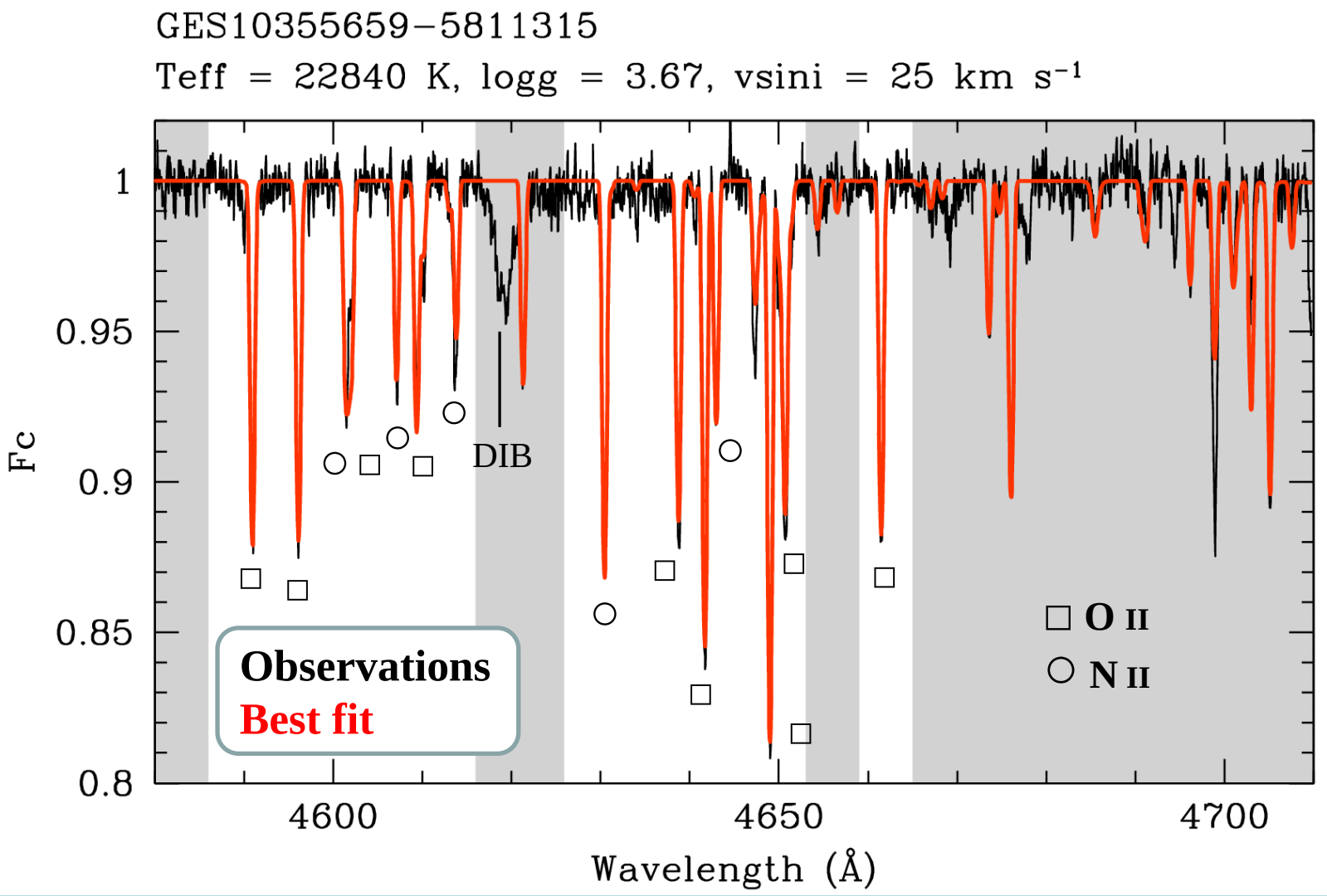
Determination of N and O abundances



Region excluded

A hot, slow rotator

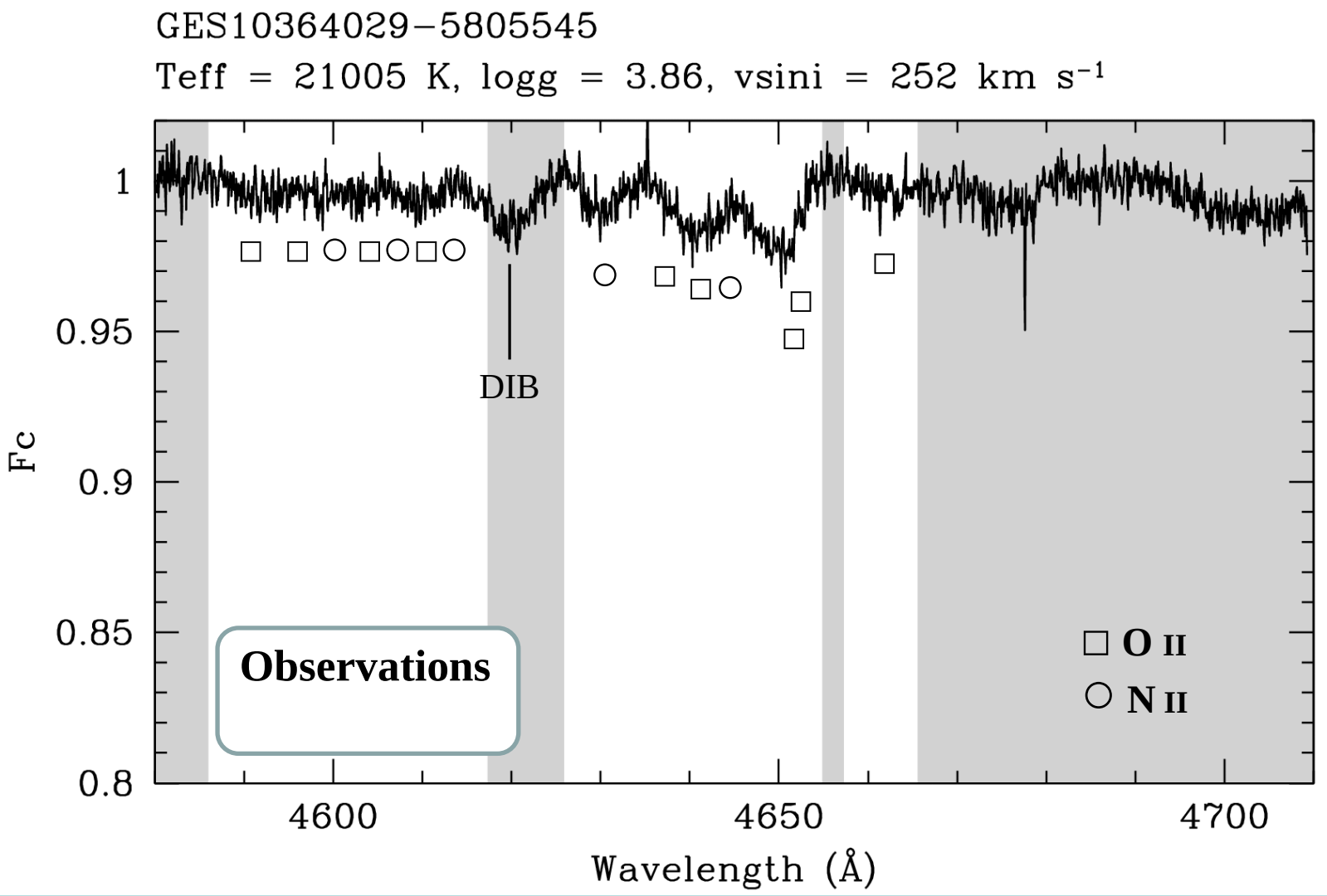
Determination of N and O abundances



Region excluded

A hot, slow rotator

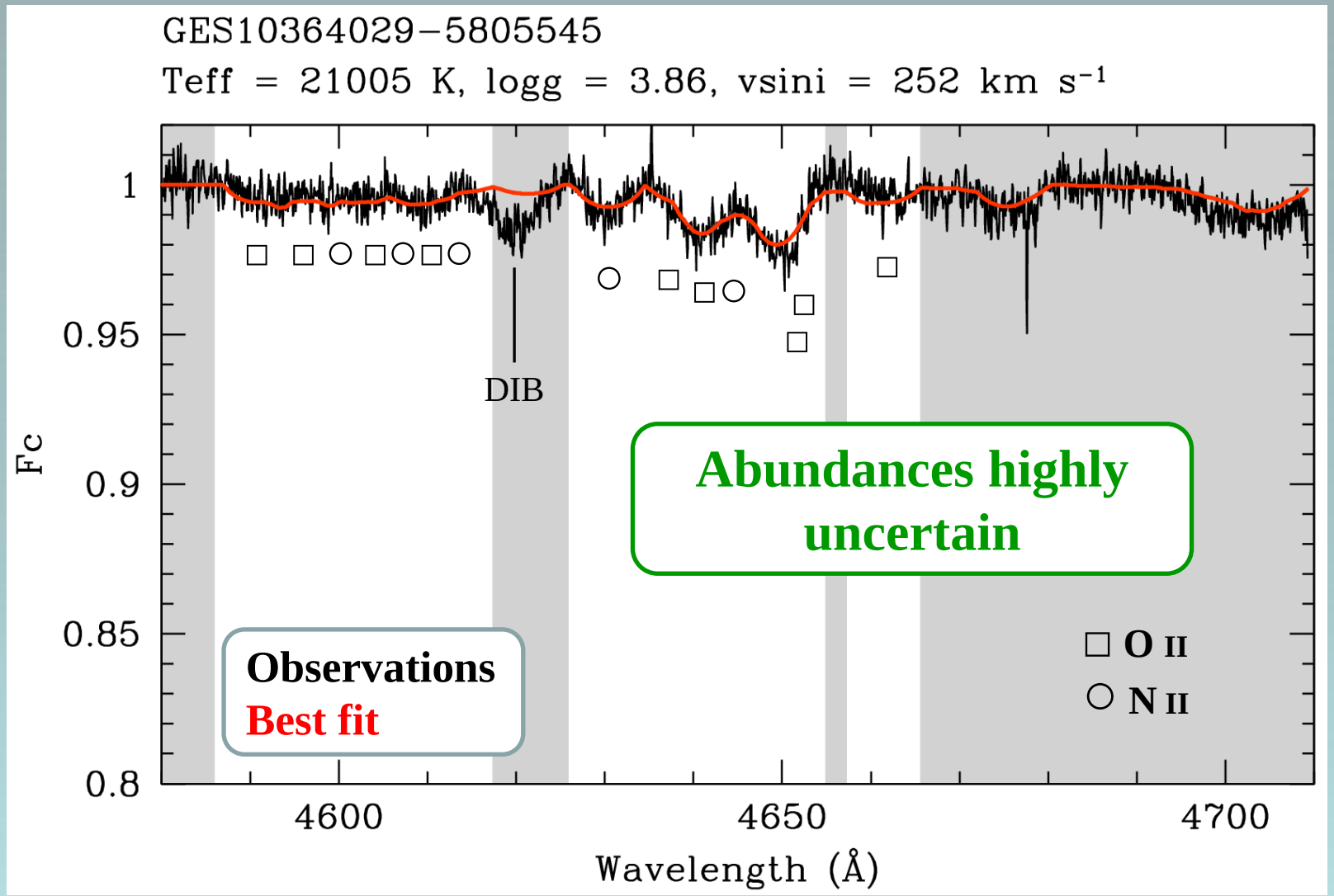
Determination of N and O abundances



Region excluded

A hot, fast rotator

Determination of N and O abundances



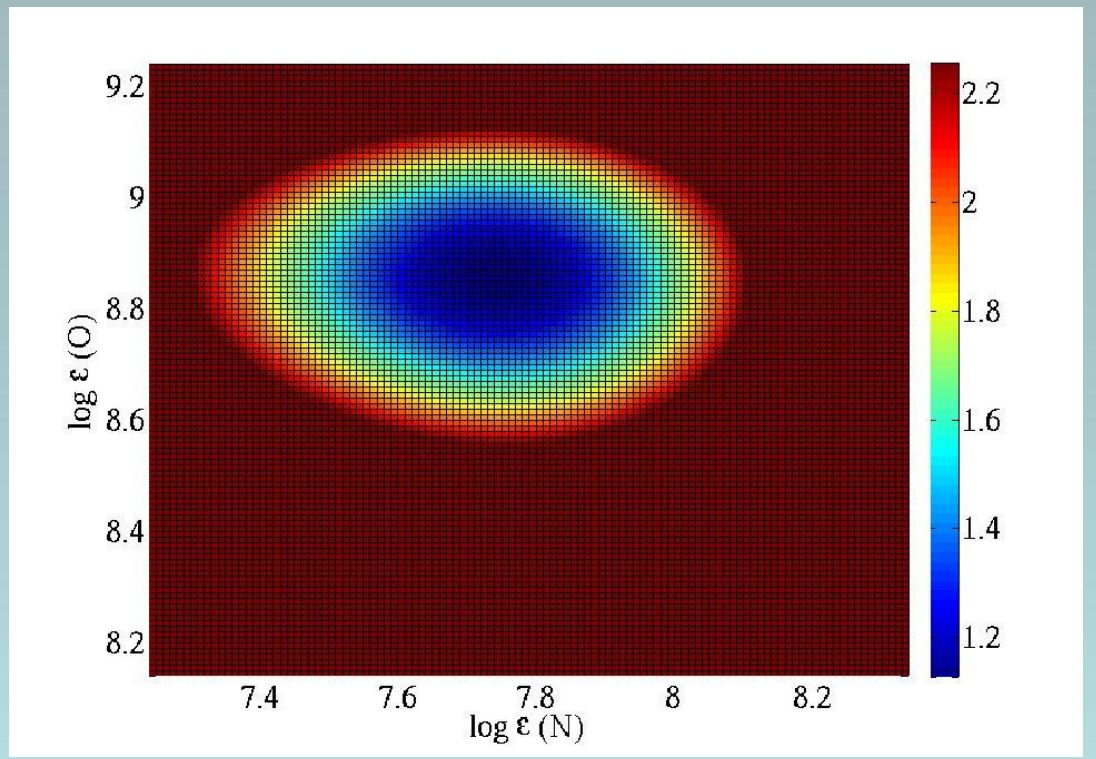
Region excluded

A hot, fast rotator

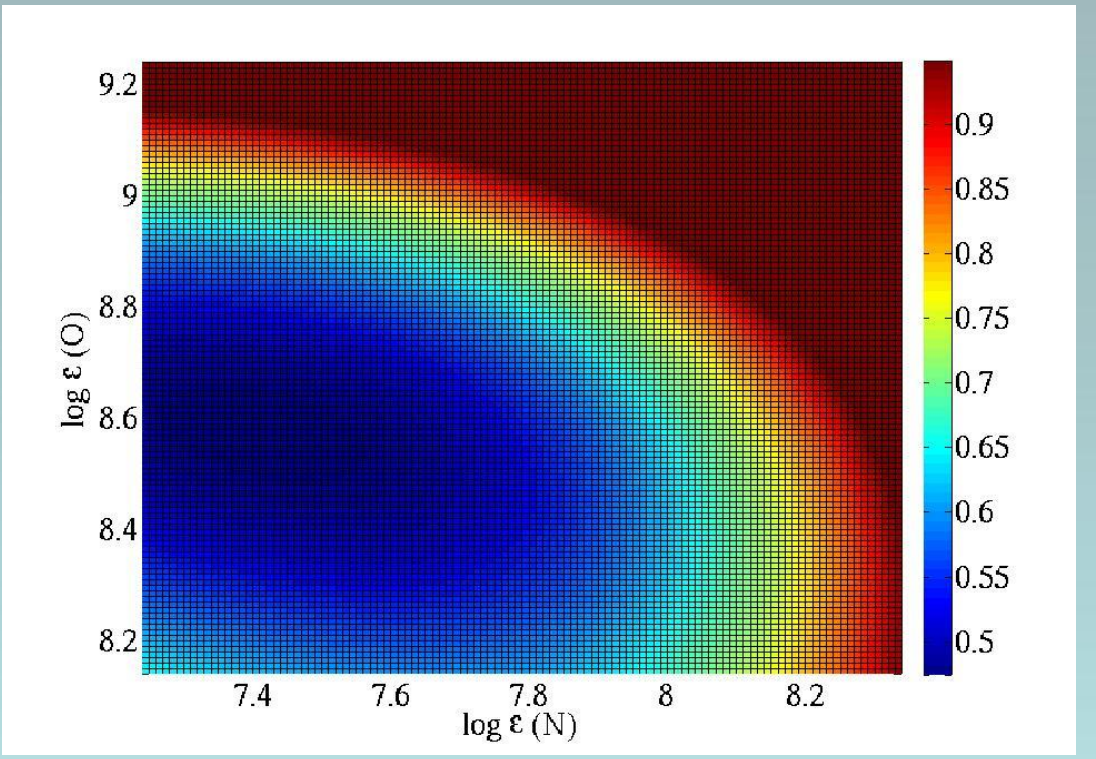
Determination of N and O abundances

χ_r^2 maps

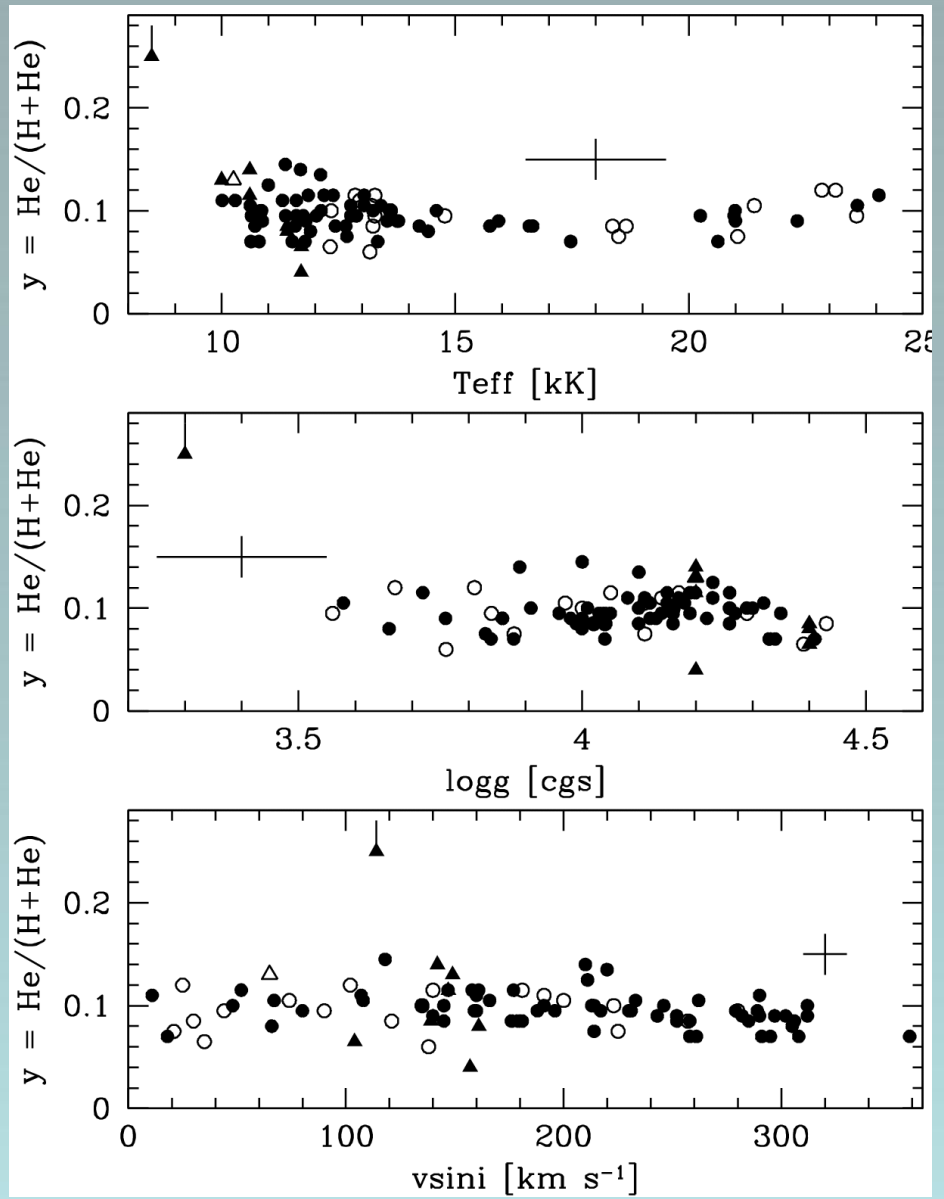
A slow rotator (vsini = 25 km s^{-1})
GES10355659-5811315



A fast rotator (vsini = 252 km s^{-1})
GES10305545-5805545



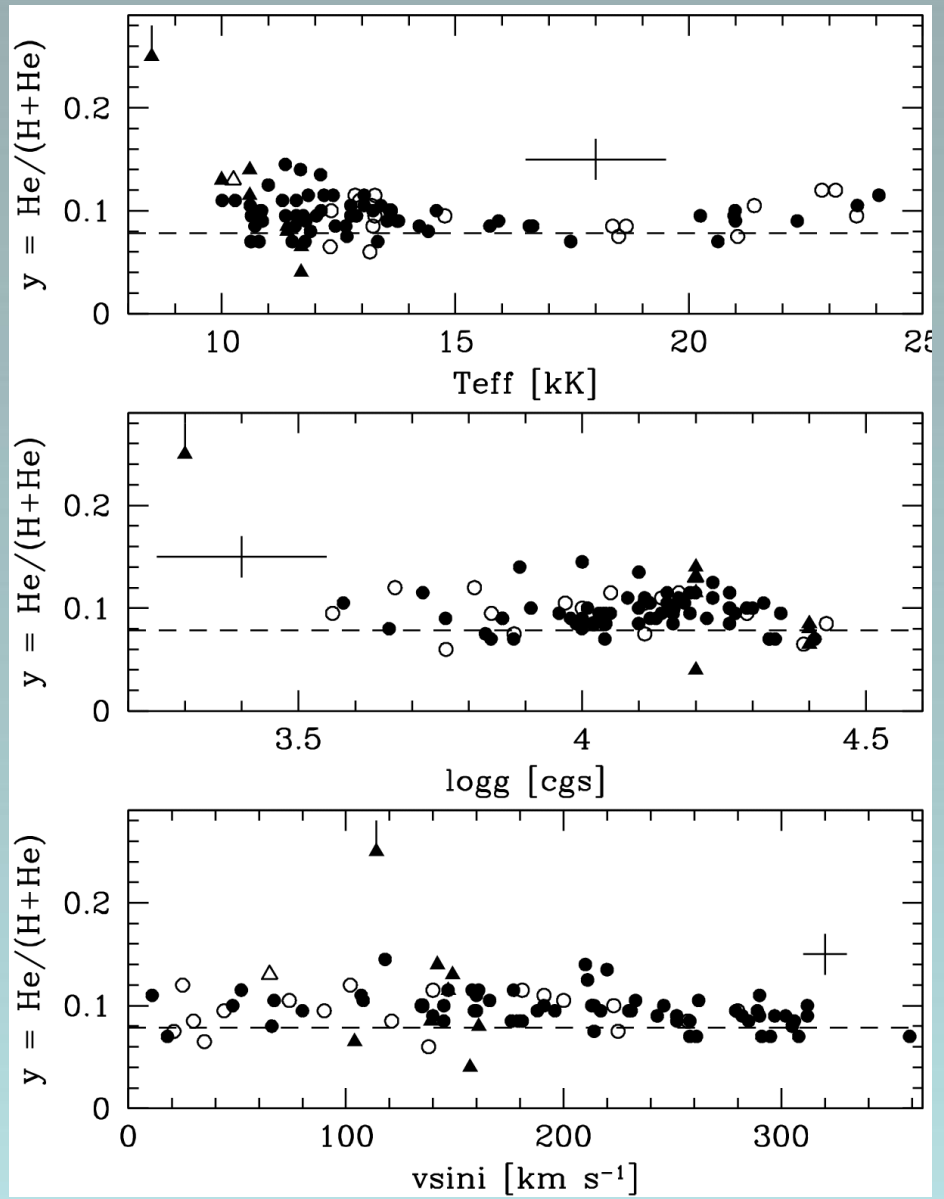
Behaviour of abundances as a function of parameters



● Apparently single

○ Binary?

Behaviour of abundances as a function of parameters

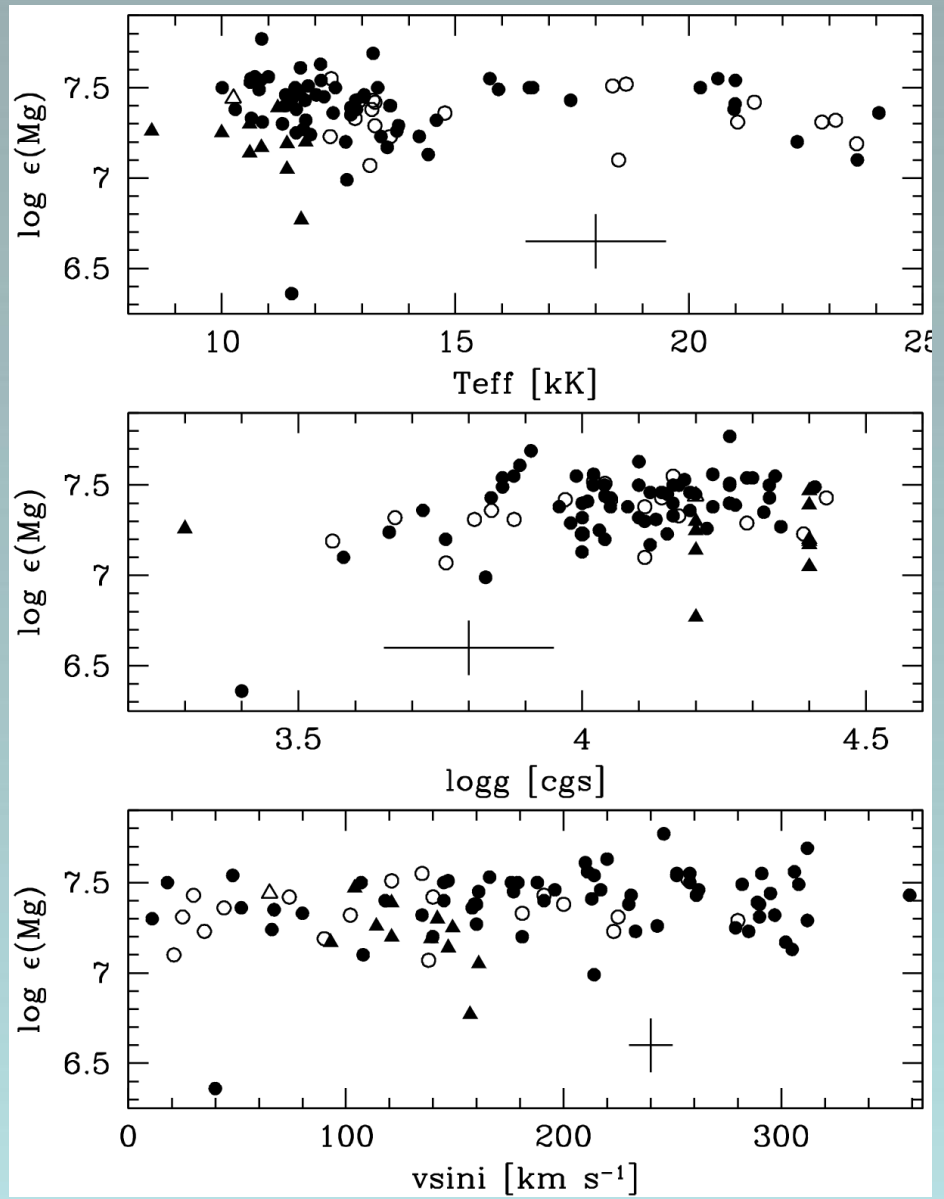


● Apparently single

○ Binary?

- - - - - - Asplund et al. (2009)

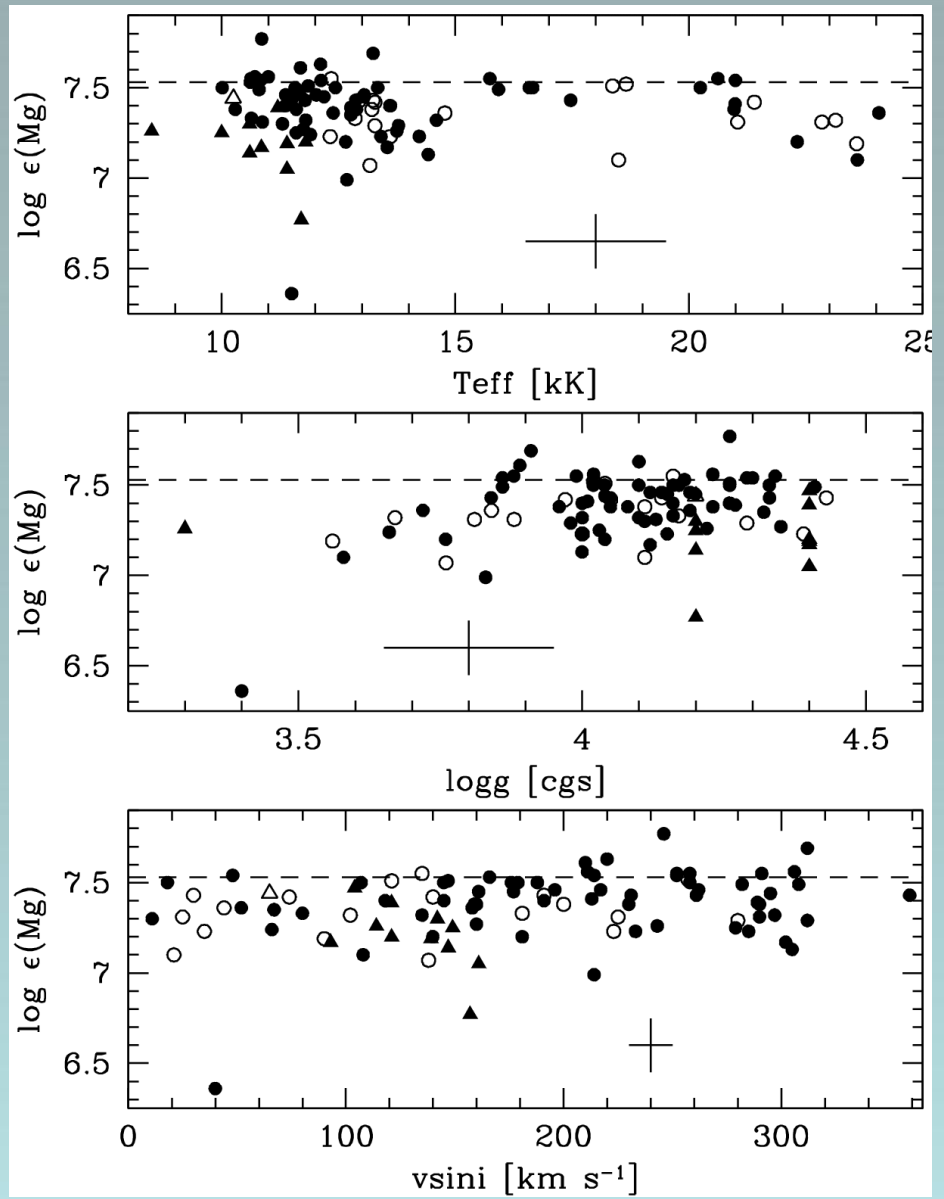
Behaviour of abundances as a function of parameters



● Apparently single

○ Binary?

Behaviour of abundances as a function of parameters

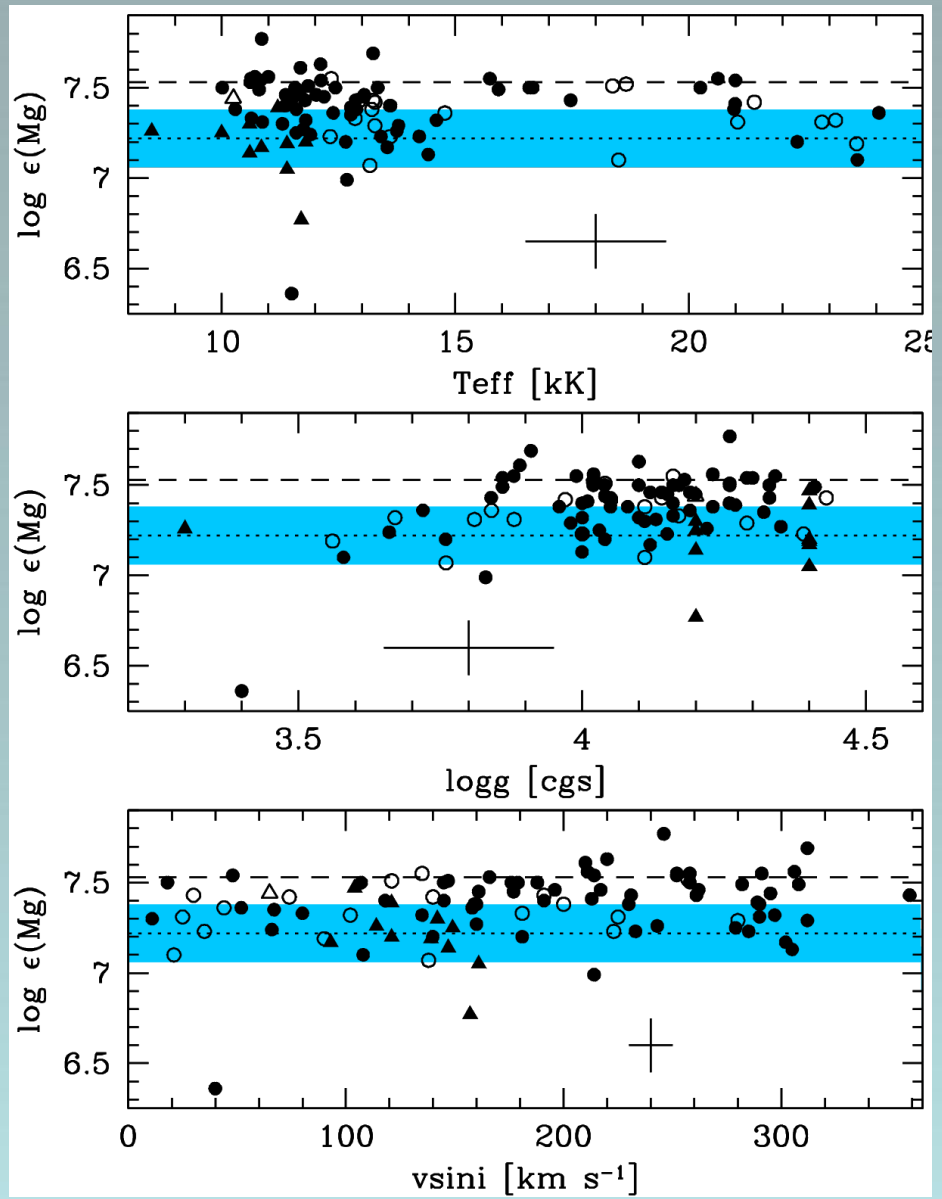


● Apparently single

○ Binary?

- - - - - - Asplund et al. (2009)

Behaviour of abundances as a function of parameters



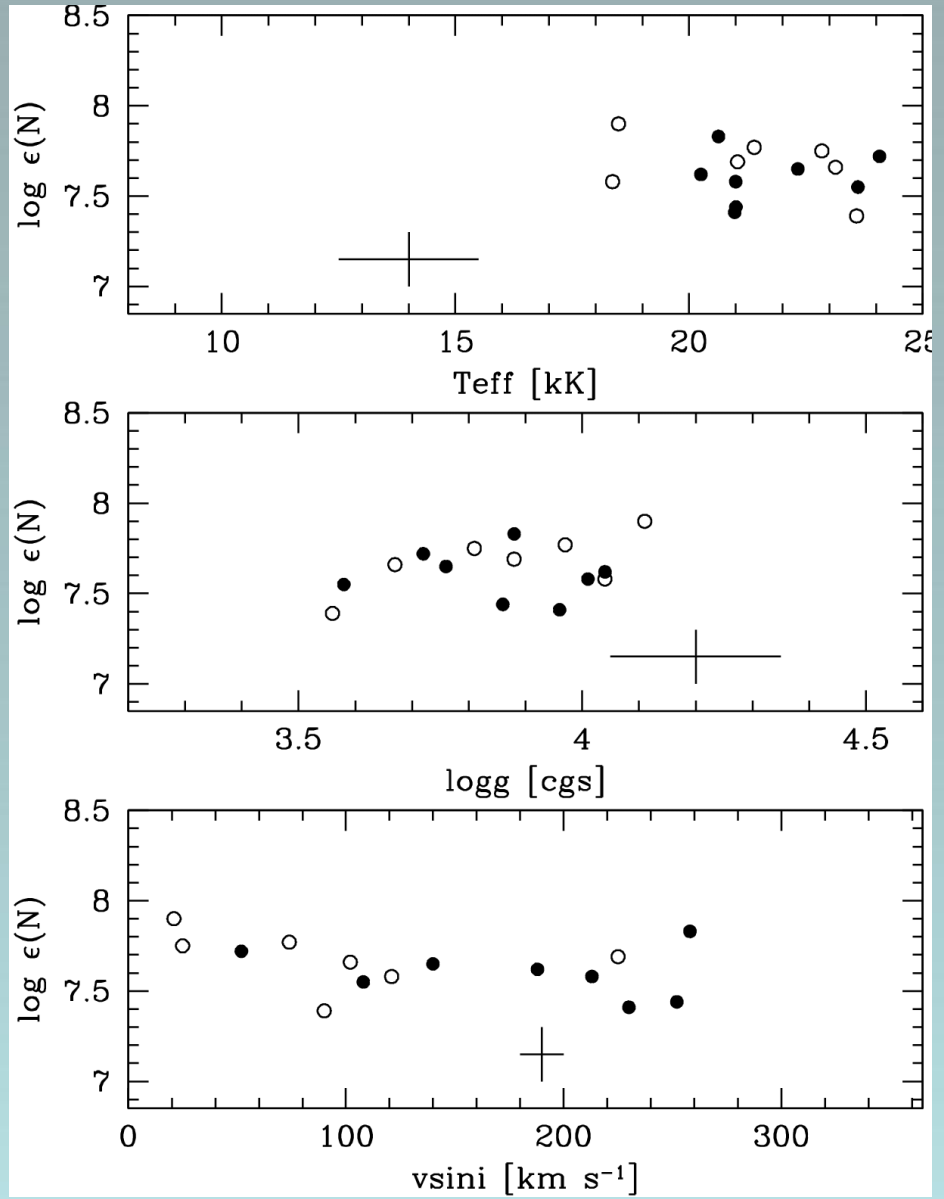
● **Apparently single**

○ **Binary?**

- - - - - - **Asplund et al. (2009)**

Mean value of VLT FLAMES Survey (± 1σ)

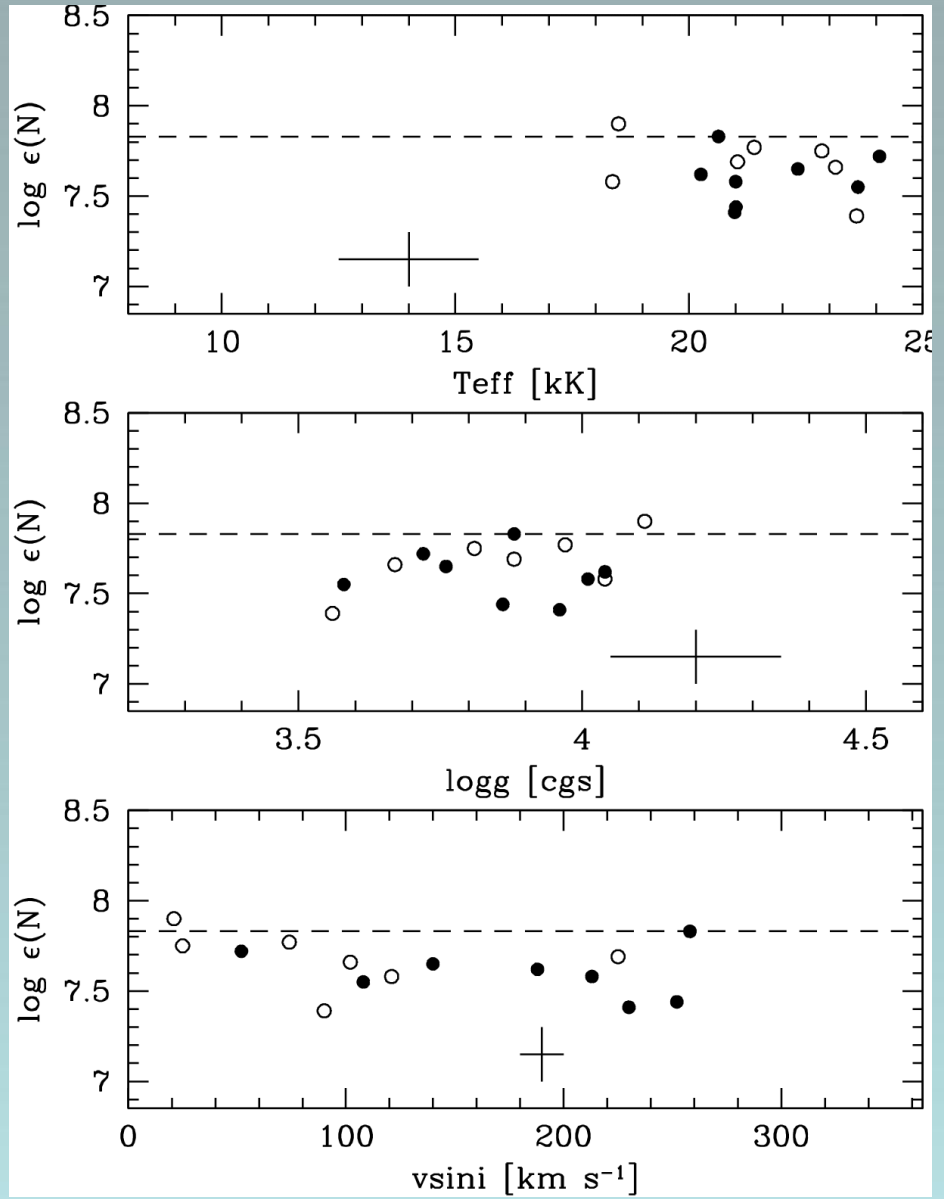
Behaviour of abundances as a function of parameters



● **Apparently single**

○ **Binary?**

Behaviour of abundances as a function of parameters

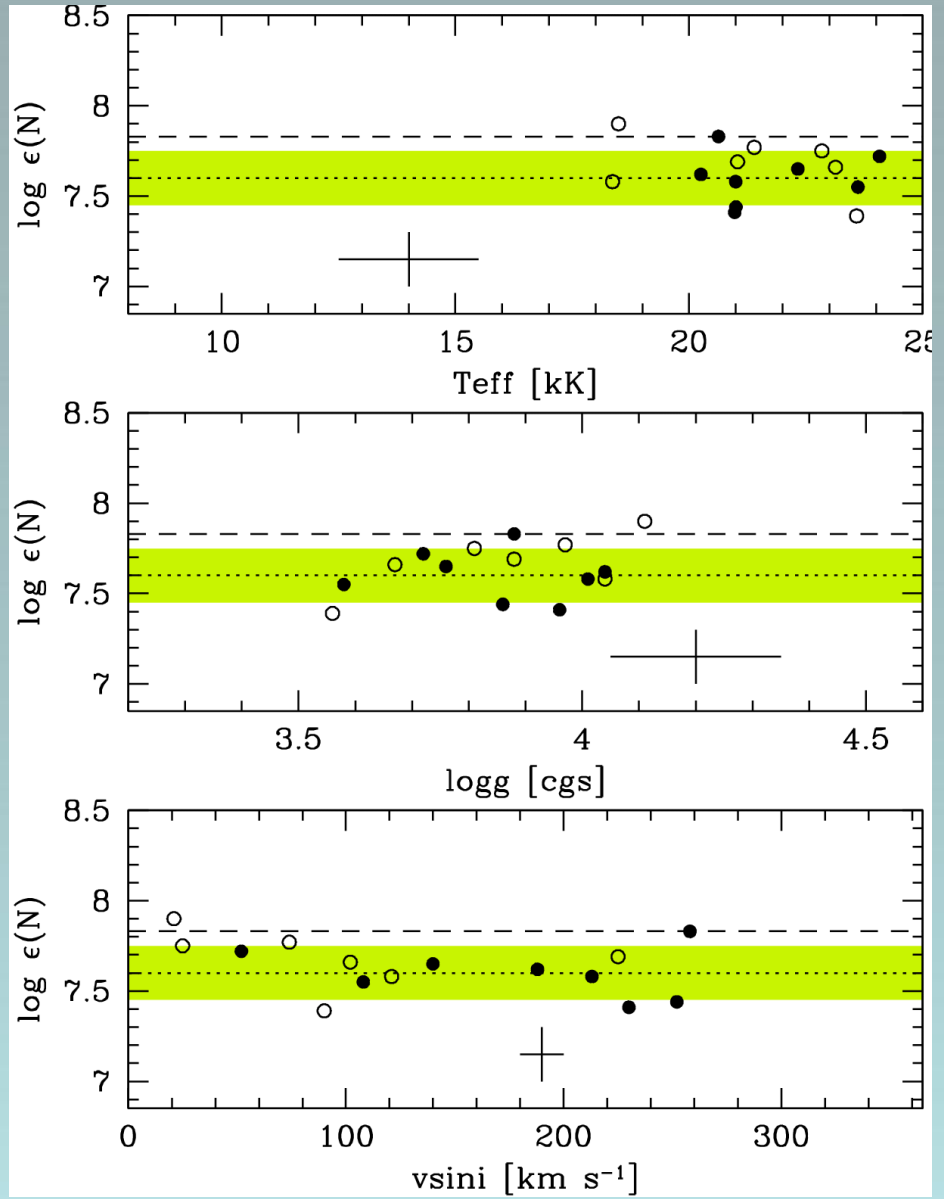


● Apparently single

○ Binary?

- - - - - - Asplund et al. (2009)

Behaviour of abundances as a function of parameters



● **Apparently single**

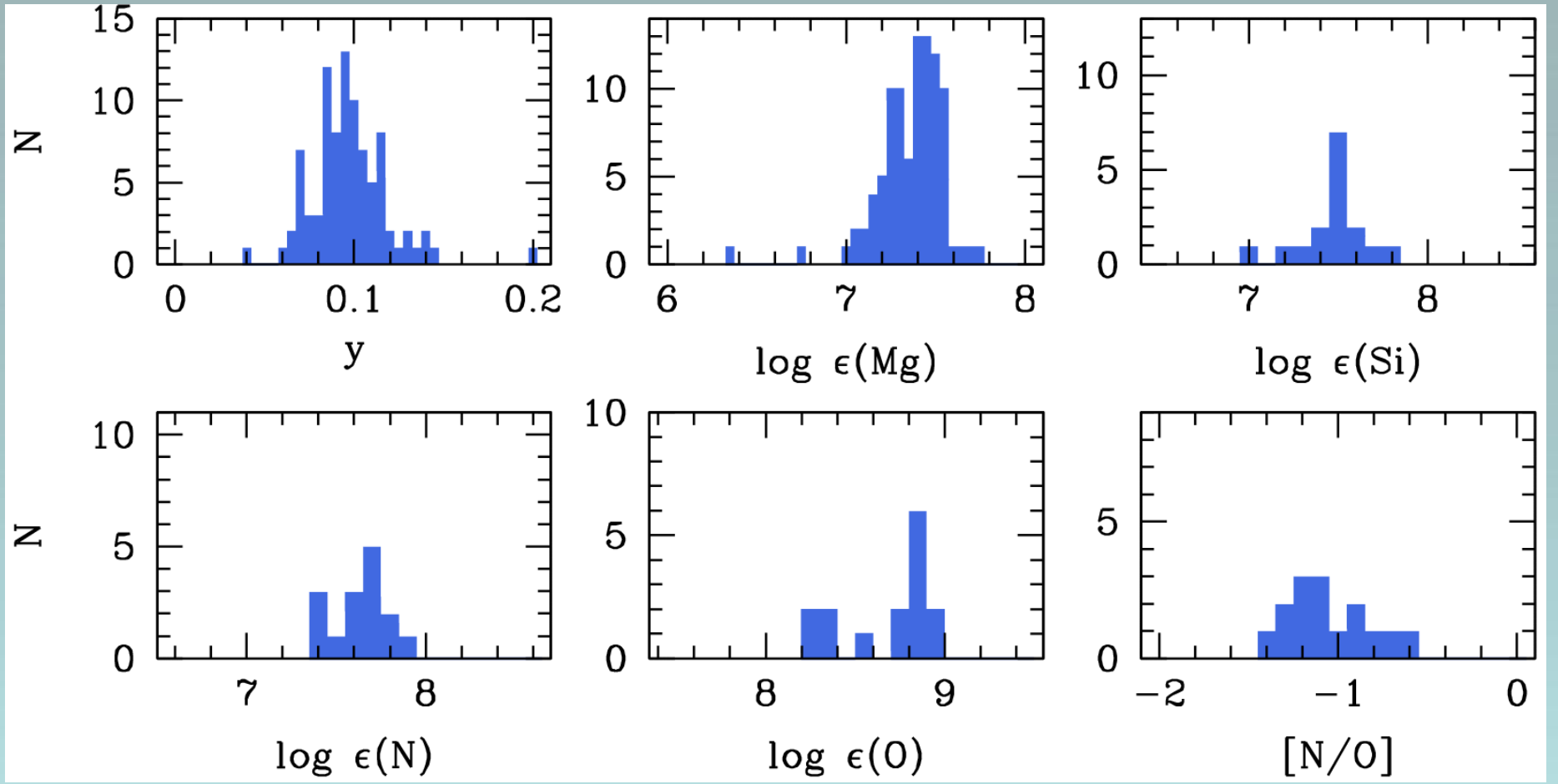
○ **Binary?**

- - - - - - **Asplund et al. (2009)**

Mean value of VLT FLAMES Survey (± 1σ)

Cluster abundances

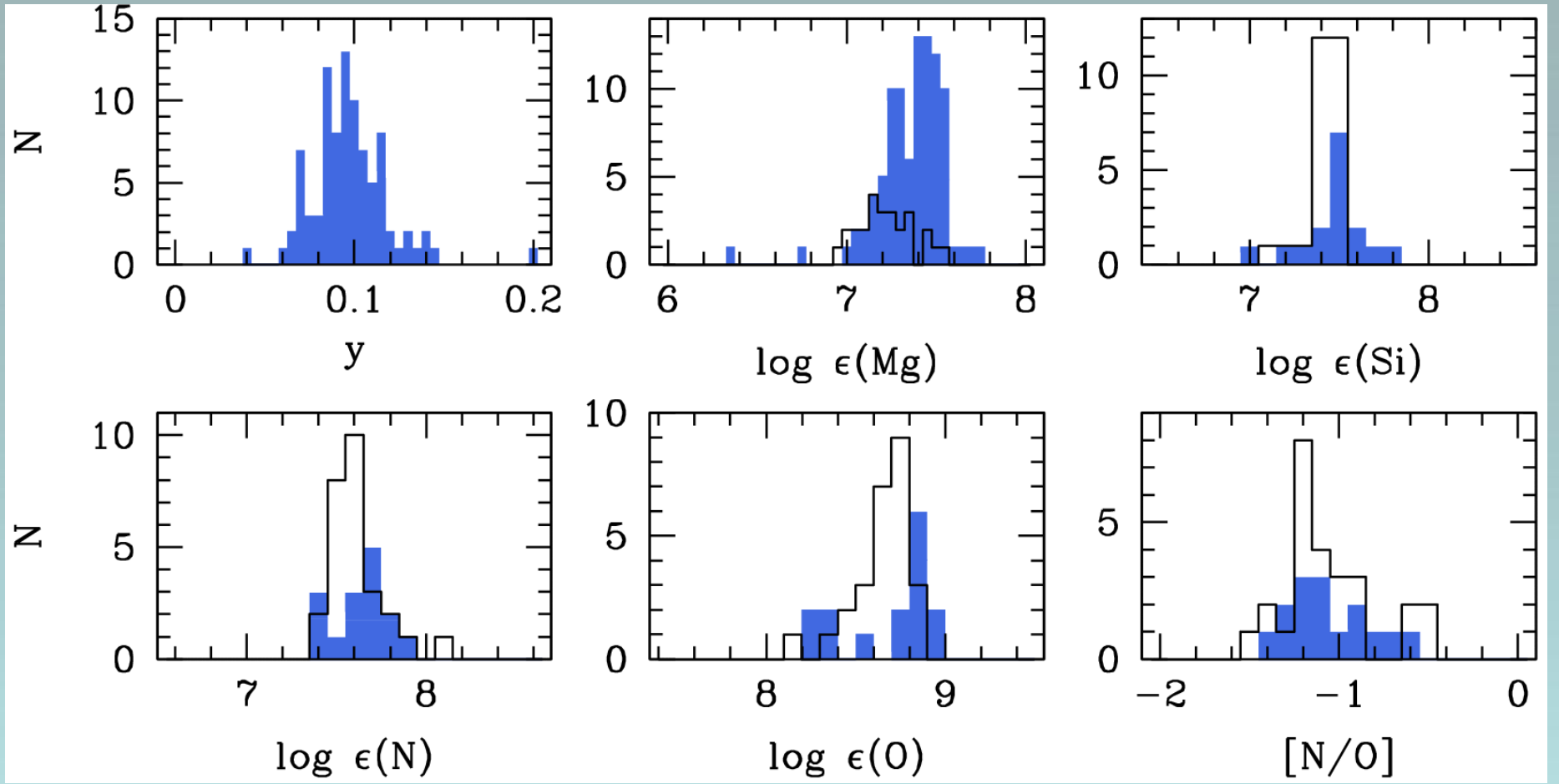
This study



Cluster abundances

This study

VLT FLAMES Survey

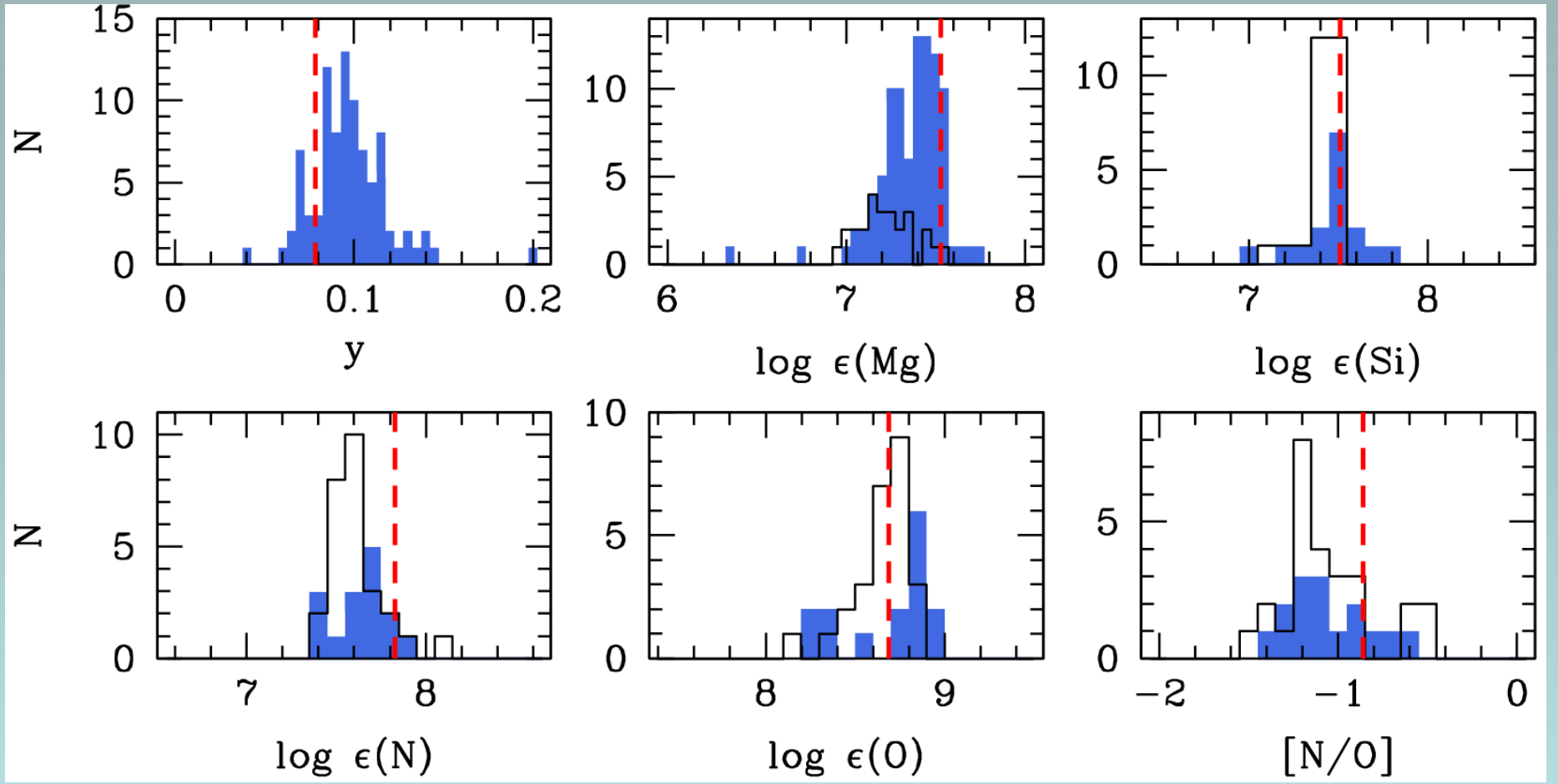


Cluster abundances

This study

VLT FLAMES Survey

Asplund et al. (2009)



Conclusions and future work

NGC 3293

- One of the first homogeneous chemical analyses of an ensemble of stars from B9 up to B1 and with a wide range of vsini values
- No dependence between abundances and stellar parameters
- Only a few chemically-peculiar stars
- Preliminary results presented in Proc. IAUS302 “New Windows on Massive Stars” (Semaan et al. 2014)

Conclusions and future work

NGC 3293

- One of the first homogeneous chemical analyses of an ensemble of stars from B9 up to B1 and with a wide range of vsini values
- No dependence between abundances and stellar parameters
- Only a few chemically-peculiar stars
- Preliminary results presented in Proc. IAUS302 “New Windows on Massive Stars” (Semaan et al. 2014)

Still to be done:

- To complete validation of results
- Effect of gravity darkening for fast rotators
- Computation of uncertainties
- Analysis of UVES spectra (additional chemical elements)
- Isochrone fitting, etc.

Conclusions and future work

NGC 3293

- One of the first homogeneous chemical analyses of an ensemble of stars from B9 up to B1 and with a wide range of vsini values
- No dependence between abundances and stellar parameters
- Only a few chemically-peculiar stars
- Preliminary results presented in Proc. IAUS302 “New Windows on Massive Stars” (Semaan et al. 2014)

Still to be done:

- To complete validation of results
- Effect of gravity darkening for fast rotators
- Computation of uncertainties
- Analysis of UVES spectra (additional chemical elements)
- Isochrone fitting, etc.

Analysis of NGC 6705 spectra

Conclusions and future work

NGC 3293

- One of the first homogeneous chemical analyses of an ensemble of stars from B9 up to B1 and with a wide range of vsini values
- No dependence between abundances and stellar parameters
- Only a few chemically-peculiar stars
- Preliminary results presented in Proc. IAUS302 “New Windows on Massive Stars” (Semaan et al. 2014)

Still to be done:

- To complete validation of results
- Effect of gravity darkening for fast rotators
- Computation of uncertainties
- Analysis of UVES spectra (additional chemical elements)
- Isochrone fitting, etc.

Analysis of NGC 6705 spectra

Young cluster Trumpler 14 (age ~ 2-3 Myrs)

- B stars analysed as those in NGC 3293
- Treatment of O stars with codes taking stellar winds into account (CMFGEN)
- Constraints on rotational mixing

Conclusions and future work

NGC 3293

- One of the first homogeneous chemical analyses of an ensemble of stars from B9 up to B1 and with a wide range of vsini values
- No dependence between abundances and stellar parameters
- Only a few chemically-peculiar stars
- Preliminary results presented in Proc. IAUS302 “New Windows on Massive Stars” (Semaan et al. 2014)

Still to be done:

- To complete validation of results
- Effect of gravity darkening for fast rotators
- Computation of uncertainties
- Analysis of UVES spectra (additional chemical elements)
- Isochrone fitting, etc.

Analysis of NGC 6705 spectra

Young cluster Trumpler 14 (age ~ 2-3 Myrs)

- B stars analysed as those in NGC 3293
- Treatment of O stars with codes taking stellar winds into account (CMFGEN)
- Constraints on rotational mixing

Observations of benchmark B stars badly needed!