

Abundances of massive stars in Carina Nebula within the Gaia- ESO Survey

Laurent Mahy

University of Liège / KU Leuven

F. Martins, A. Blazère, S. Rodriguez Berlanas, A. Herrero, E. Gosset, ...
(and the GES WG13)

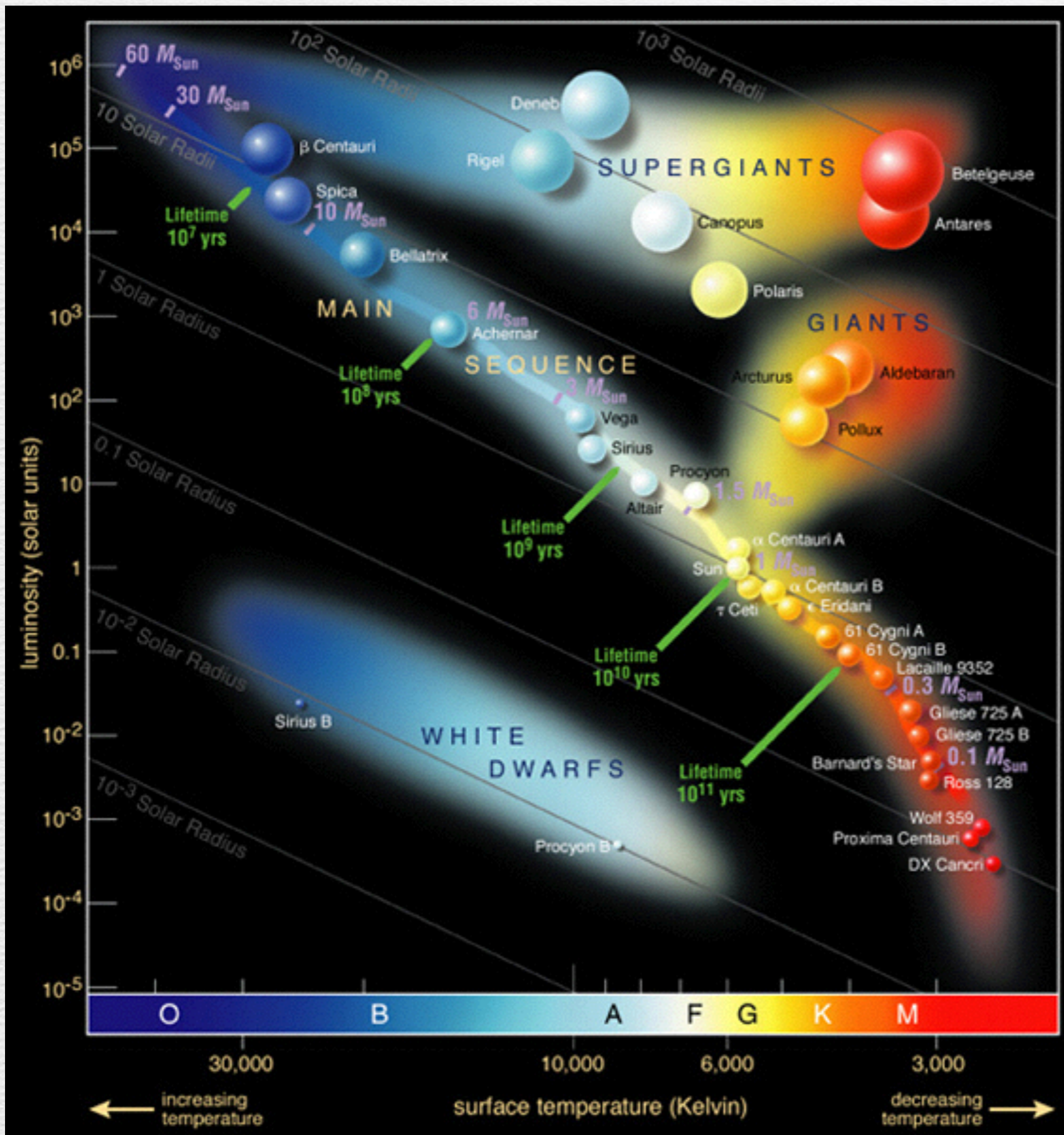


Overview

- Massive stars
- Multiplicity
- Determination of surface abundances
 - Helium abundance
 - CNO abundances and comparison with another survey
- Conclusion and perspectives

Overview

- **Massive stars**
- Multiplicity
- Determination of surface abundances
 - Helium abundance
 - CNO abundances and comparison with another survey
- Conclusion and perspectives



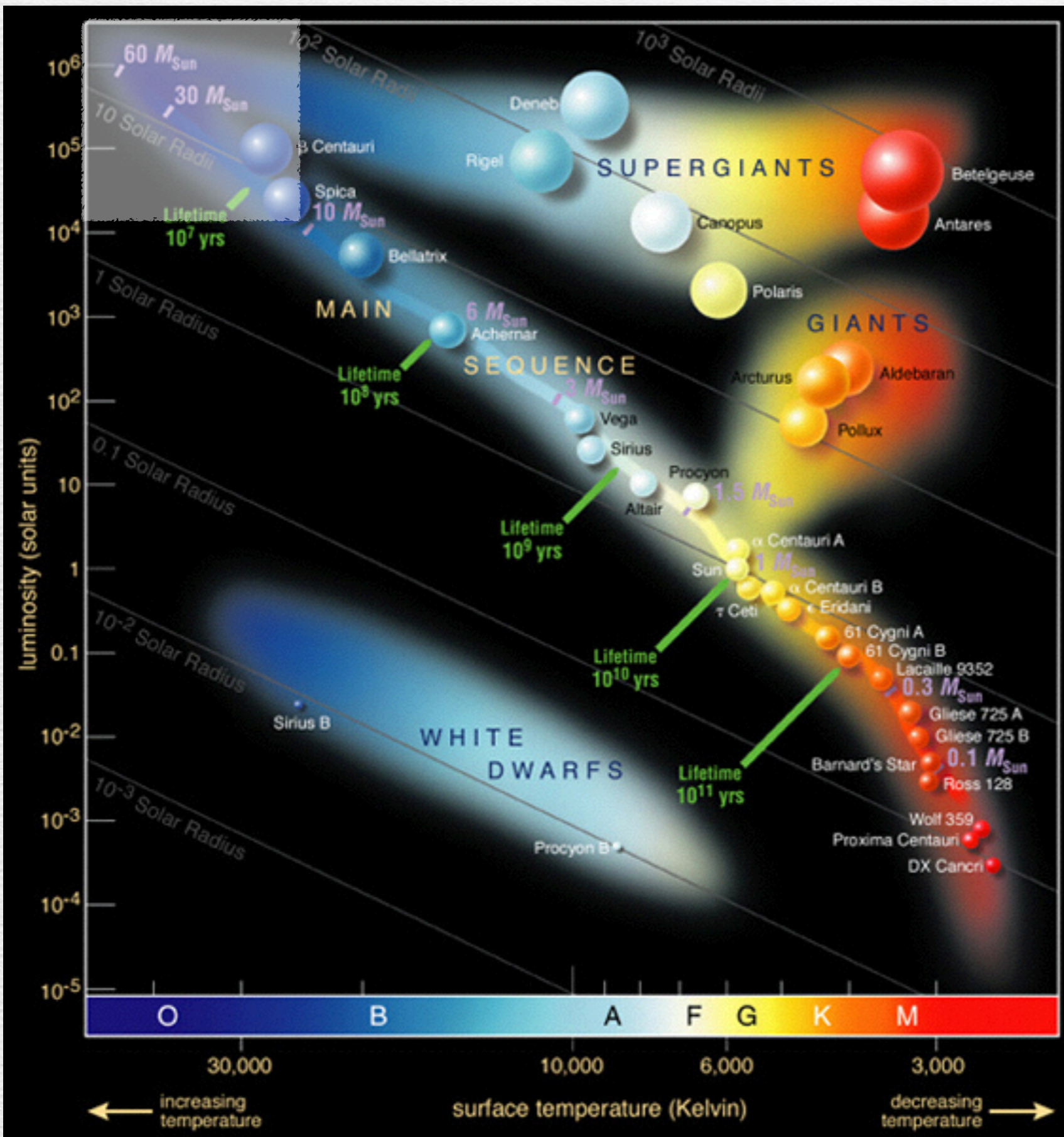
$M > 8 M$

$\log (L/L_{\text{Sun}})$

$\dot{M} \sim 10$

Age < 10 Myr

➔ Rare



$M > 8 M_{\text{Sun}}$

$\log(L/L_{\text{Sun}})$

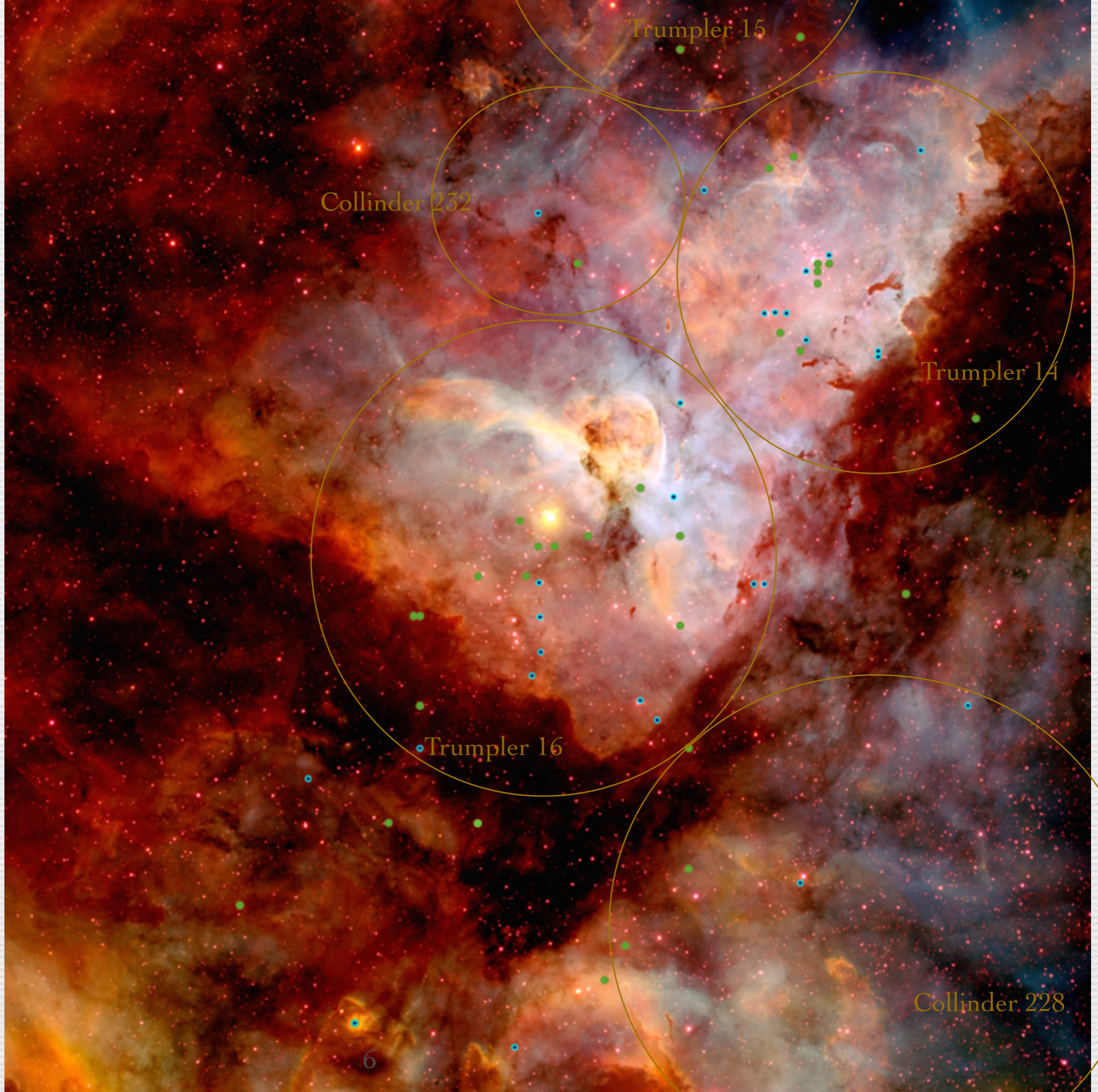
$\dot{M} \sim 10$

Age < 10 Myr

➔ Rare

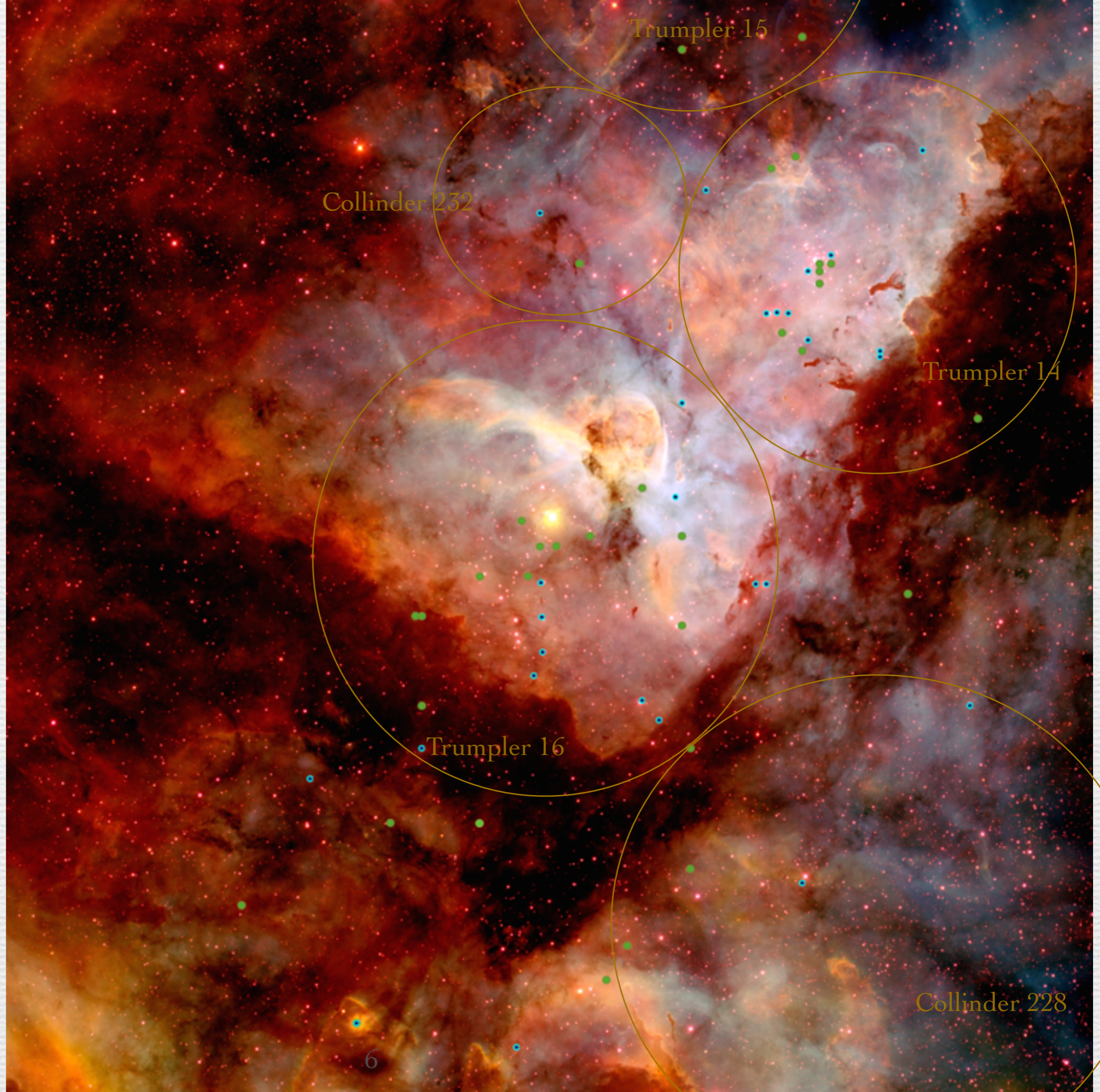
Overview

- Massive stars
- Multiplicity
- Determination of surface abundances
 - Helium abundance
 - CNO abundances and comparison with another survey
- Conclusion and perspectives



 presumably
single

 SB2



Trumpler 15

Collinder 232

Trumpler 14

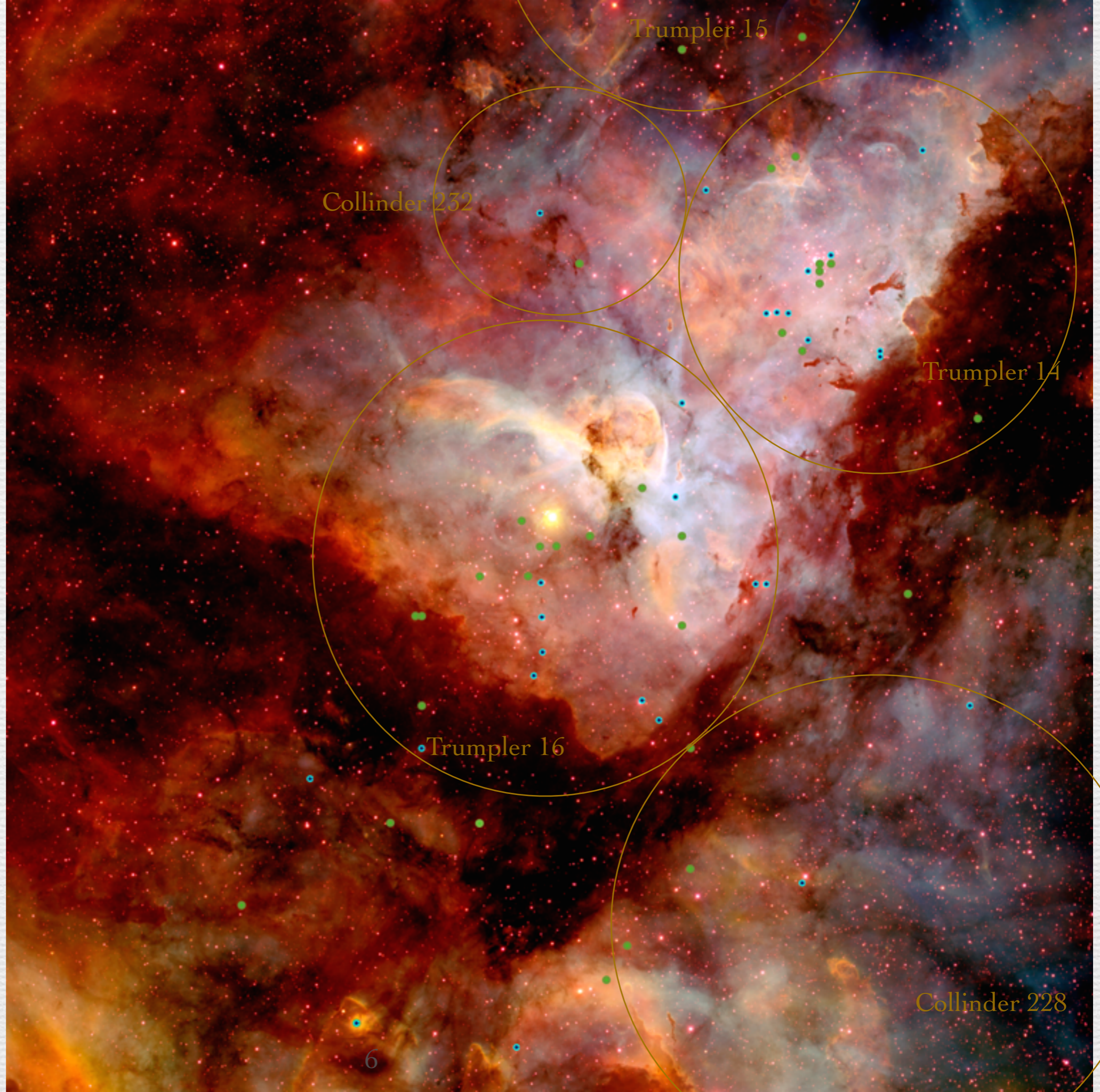
Trumpler 16

Collinder 228

6

-  presumably single
-  SB2

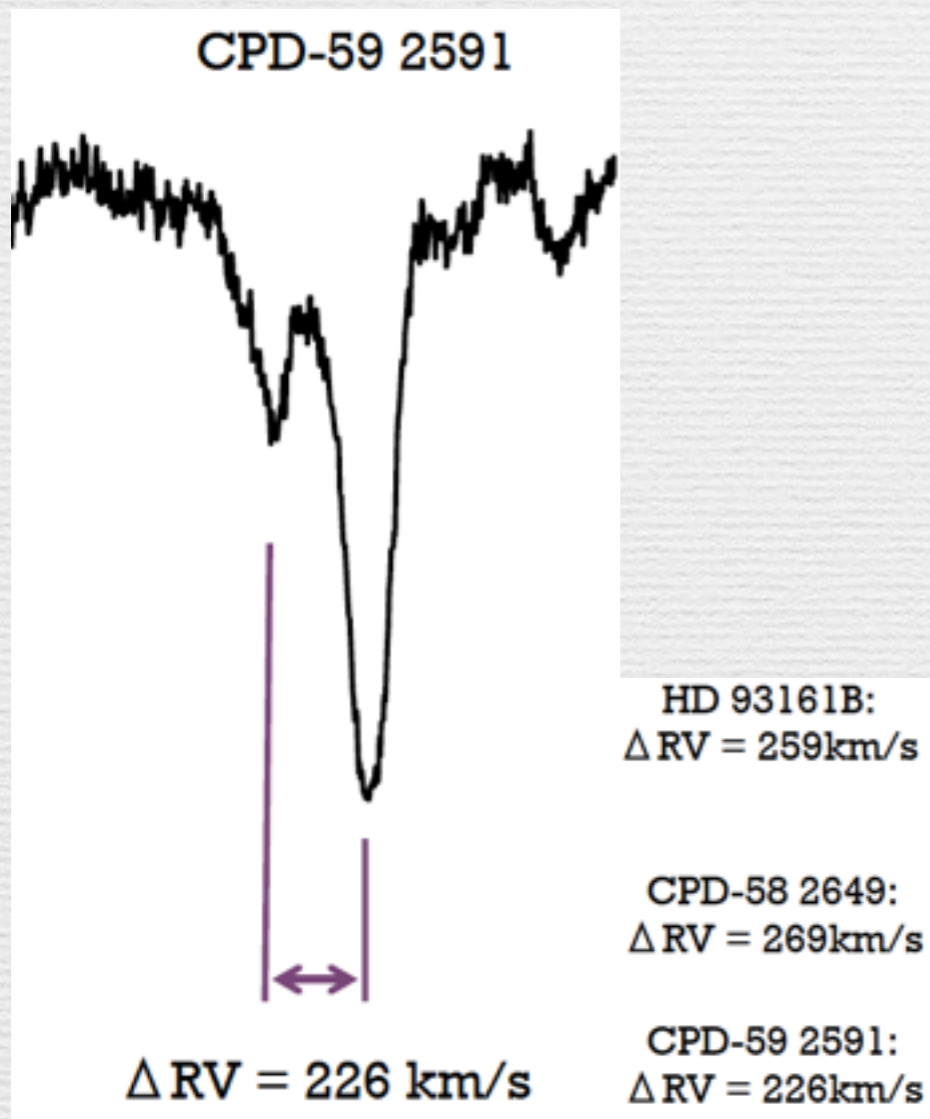
But other
brighter
massive stars
exist in
Carina nebula



Multiplicity

GES: 1 epoch

In massive star population: ~ 70% of binaries
up to 90% if $P > 3500$ days

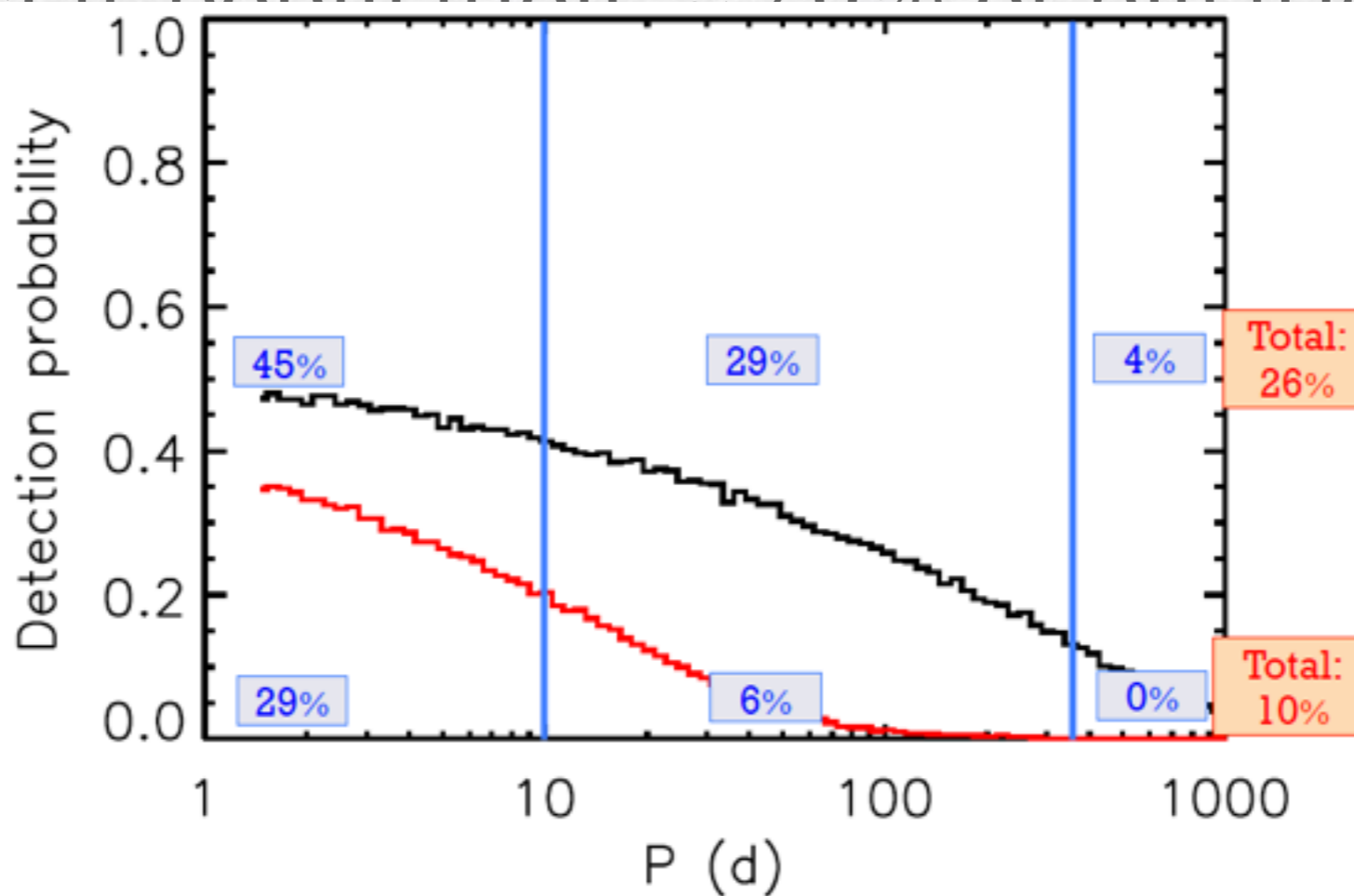
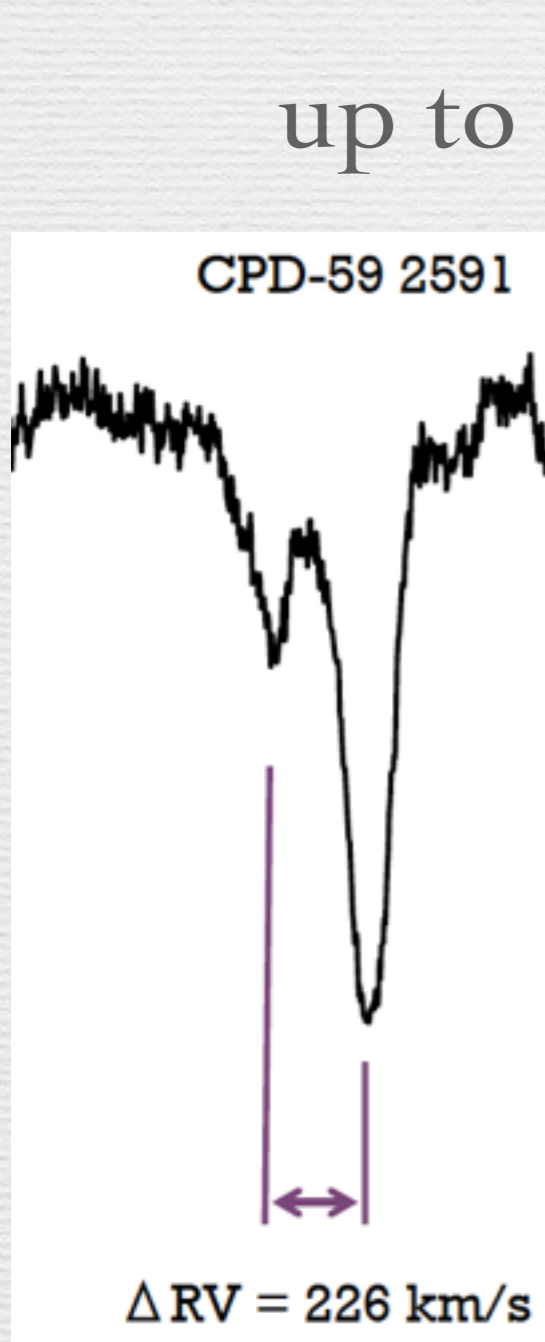


Object	# O stars	Binary fraction ^a	Ref
Nearby clusters			
NGC 6611	9	0.44	1
NGC 6231	16	0.63	2
IC 2944	14	0.53	3
Tr 16	24	0.48	4
IC 1805	8	0.38	5
IC 1848	5	0.40	5
NGC 2244	6	0.17	6
Tr 14	6	0.00	7
Col 228	15	0.33	8

Multiplicity

GES: 1 epoch

In massive star population: 70% of binaries



$\Delta RV = 259 \text{ km/s}$

CPD-58 2649:
 $\Delta RV = 269 \text{ km/s}$

CPD-59 2591:
 $\Delta RV = 226 \text{ km/s}$

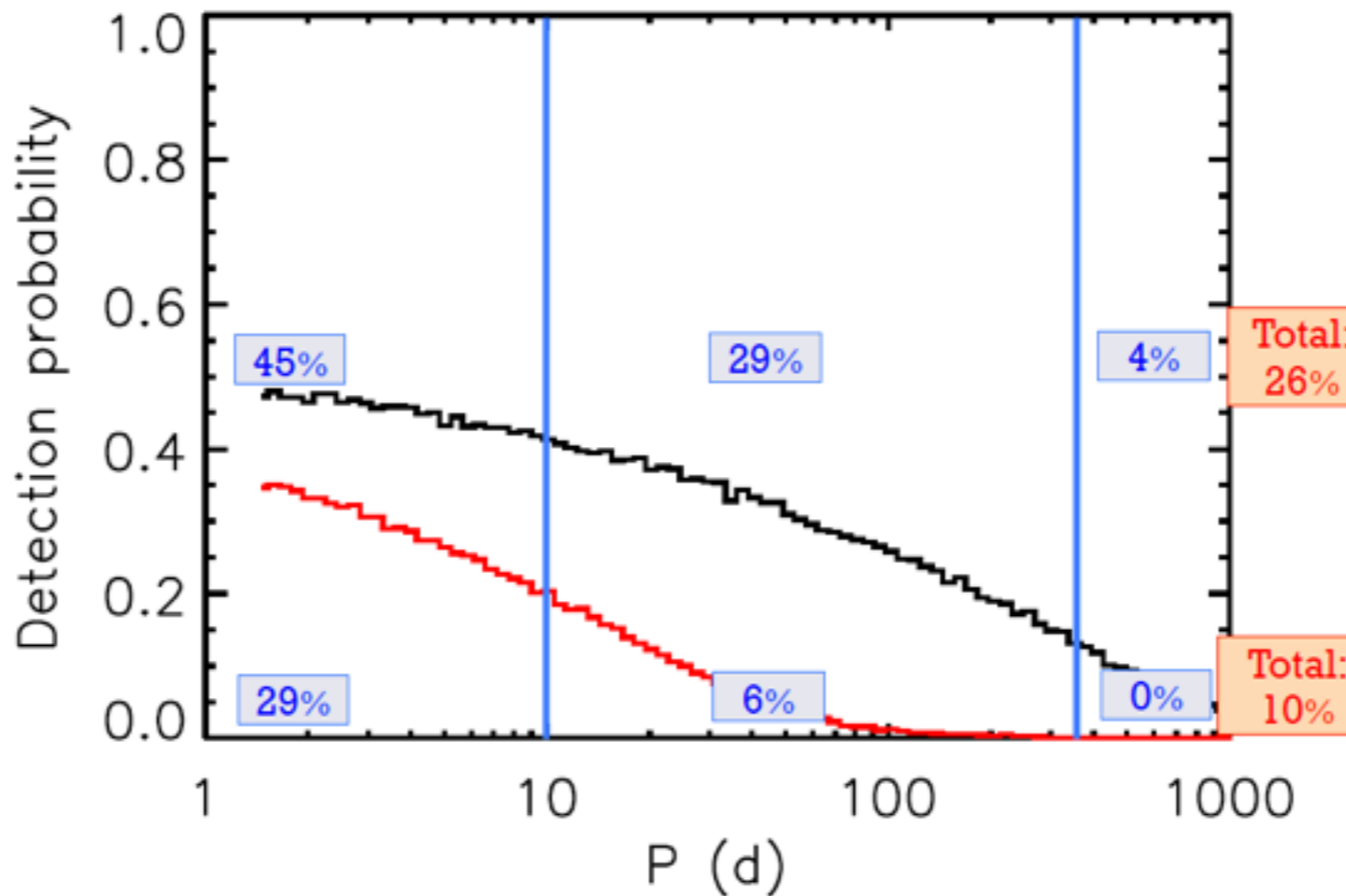
Cluster	Number of Stars	Binary fraction ^a	Ref
IC 1805	8	0.38	5
IC 1848	5	0.40	5
NGC 2244	6	0.17	6
Tr 14	6	0.00	7
Col 228	15	0.33	8

Multiplicity

GES: 1 epoch

In massive star population: 70% of binaries

up to



Optimist case:

- $|v_1 - v_2| > 75 \text{ km/s}$
- $M_2/M_1 > 0.5$

Binary fraction^a Ref

Clusters	Binary fraction ^a	Ref
	0.44	1
	0.63	2
	0.53	3
	0.48	4
	0.38	5
	0.40	5
	0.17	6
Tr 14	0.00	7
Col 228	0.33	8

$\Delta RV = 259 \text{ km/s}$

CPD-58 2649:
 $\Delta RV = 269 \text{ km/s}$

CPD-59 2591:
 $\Delta RV = 226 \text{ km/s}$

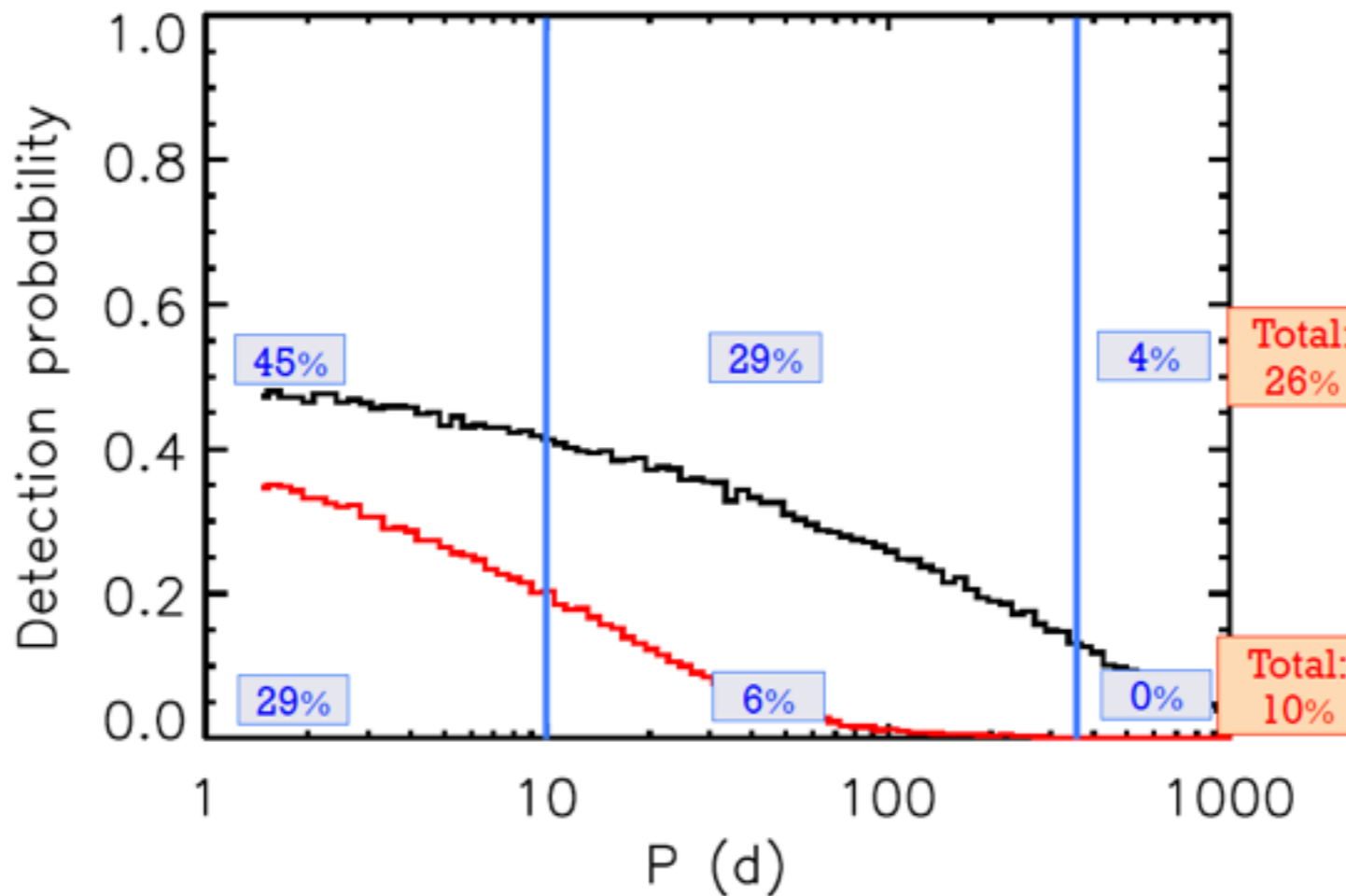
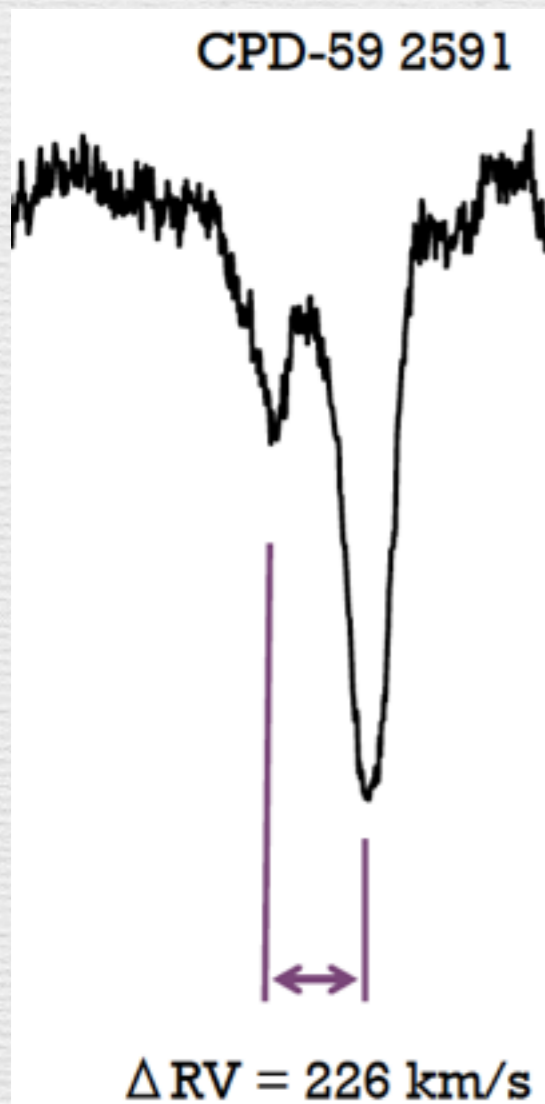
IR ID	24	Binary fraction ^a	Ref
IC 1805	8	0.38	5
IC 1848	5	0.40	5
NGC 2244	6	0.17	6
Tr 14	6	0.00	7
Col 228	15	0.33	8

Multiplicity

GES: 1 epoch

In massive star population: 70% of binaries

up to



Optimist case:

- $|v_1 - v_2| > 75 \text{ km/s}$
- $M_2/M_1 > 0.5$

Measured SB2 case:

- $|v_1 - v_2| > 200 \text{ km/s}$
- $M_2/M_1 > 0.5$

$\Delta RV = 259 \text{ km/s}$

CPD-58 2649:
 $\Delta RV = 269 \text{ km/s}$

CPD-59 2591:
 $\Delta RV = 226 \text{ km/s}$

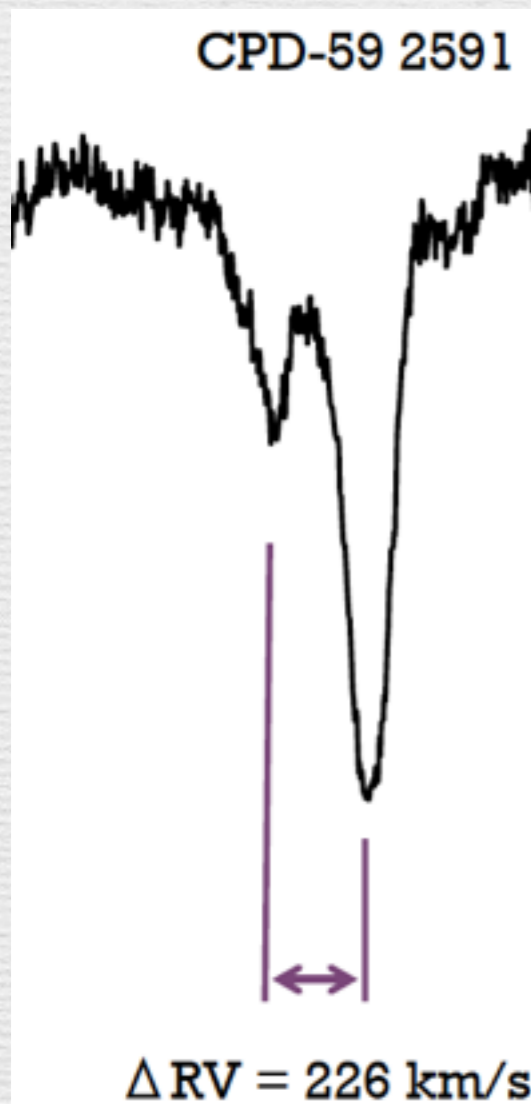
Cluster	Number of binaries	Binary fraction ^a	Ref
IC 1805	8	0.38	5
IC 1848	5	0.40	5
NGC 2244	6	0.17	6
Tr 14	6	0.00	7
Col 228	15	0.33	8

Multiplicity

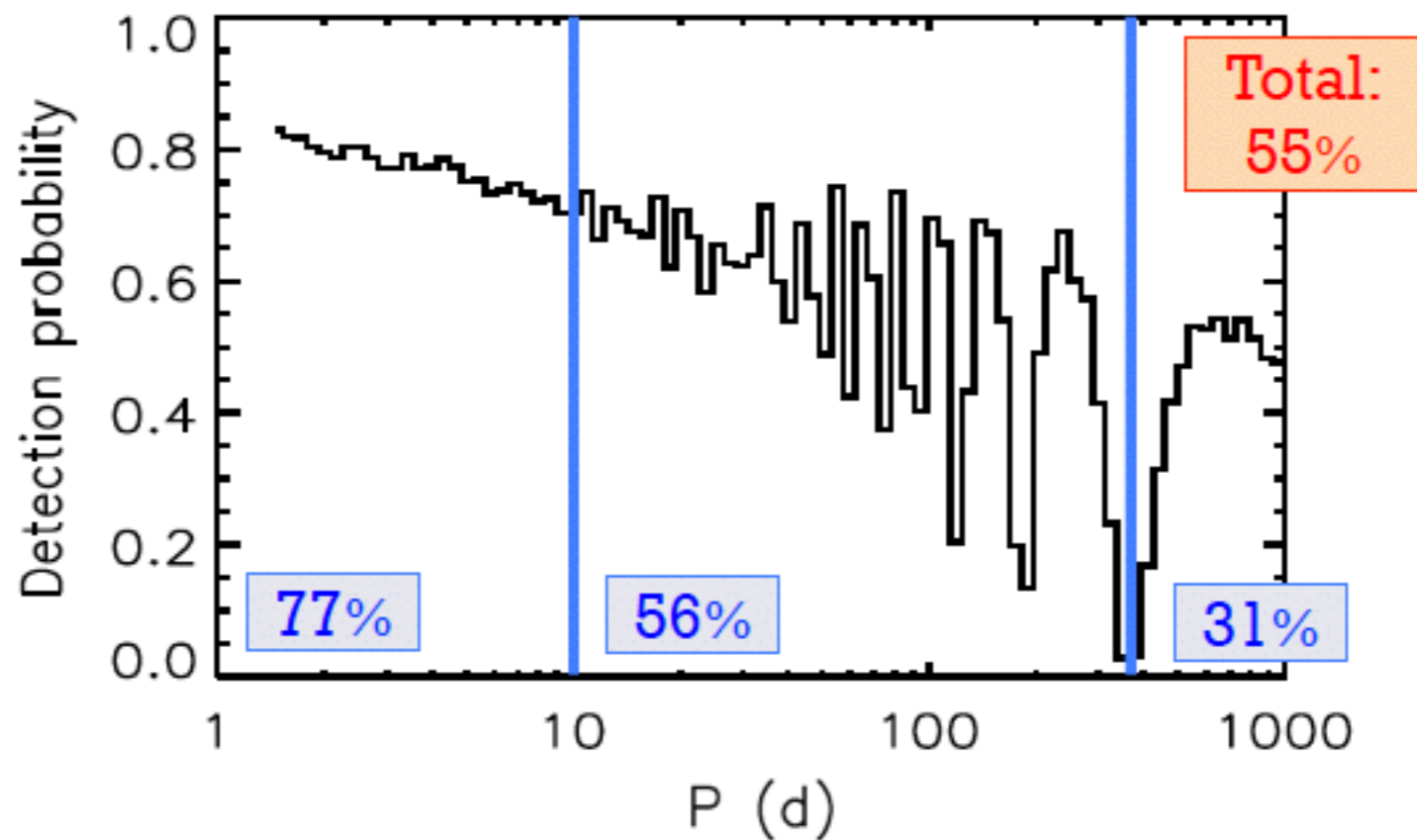
GES: 1 epoch

In massive star population: 70% of binaries

up to



■ 2 epochs ($\Delta t = 1 \text{ yr}$)



$\Delta RV = 259 \text{ km/s}$

CPD-58 2649:
 $\Delta RV = 269 \text{ km/s}$

CPD-59 2591:
 $\Delta RV = 226 \text{ km/s}$

Optimist case:

- $|v_1 - v_2| > 75 \text{ km/s}$
- $M_2/M_1 > 0.5$

Measured SB2 case:

- $|v_1 - v_2| > 200 \text{ km/s}$
- $M_2/M_1 > 0.5$

Binary fraction^a Ref

clusters

0.44	1
0.63	2
0.53	3
0.48	4

IC 1805	8	0.38	5
IC 1848	5	0.40	5
NGC 2244	6	0.17	6
Tr 14	6	0.00	7
Col 228	15	0.33	8

Multiplicity

- Lower binary fraction in Tr14 $\sim 13.7\%$ (see S. Rodriguez Berlanas)
- Doubts on the multiplicity of 34 out of 76 objects ($\sim 45\%$ of possible binaries in the GES sample)
 - ➔ first remove it from the analysis
 - ➔ Waiting for the analysis of Hanes & McSwain (priv. communication) about RV measurements of OB stars in Carina

Multiplicity

- Lower binary fraction in Tr14 ~ 13.7% (see S. Rodriguez Berlanas)
- Doubts on the multiplicity of 34 out of 76 objects (~ 45% of possible binaries in the GES sample)
 - ➔ first remove it from the analysis
 - ➔ Waiting for the analysis of Hanes & McSwain (priv. communication) about RV measurements of OB stars in Carina

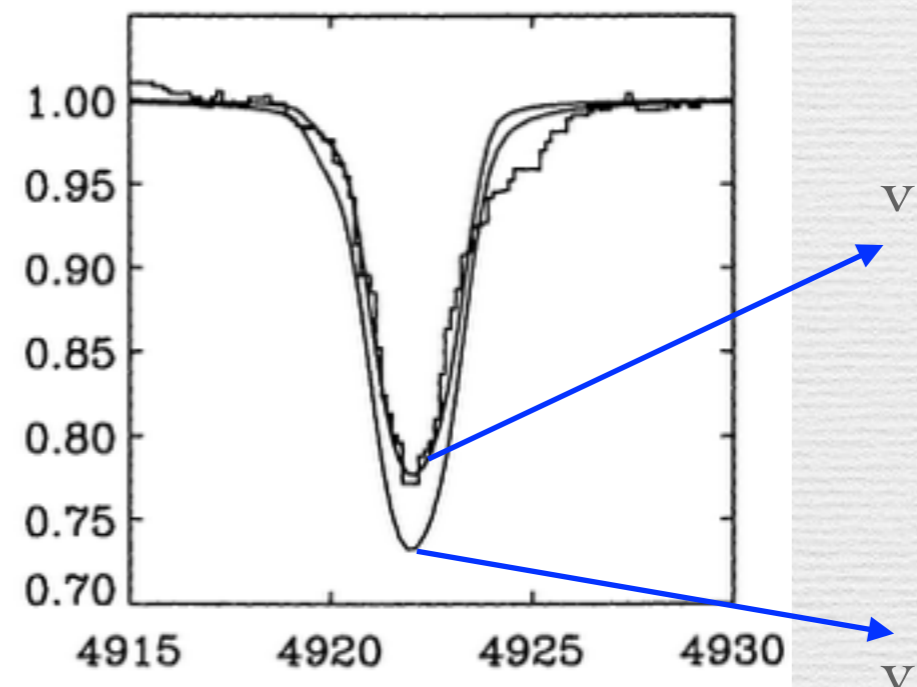
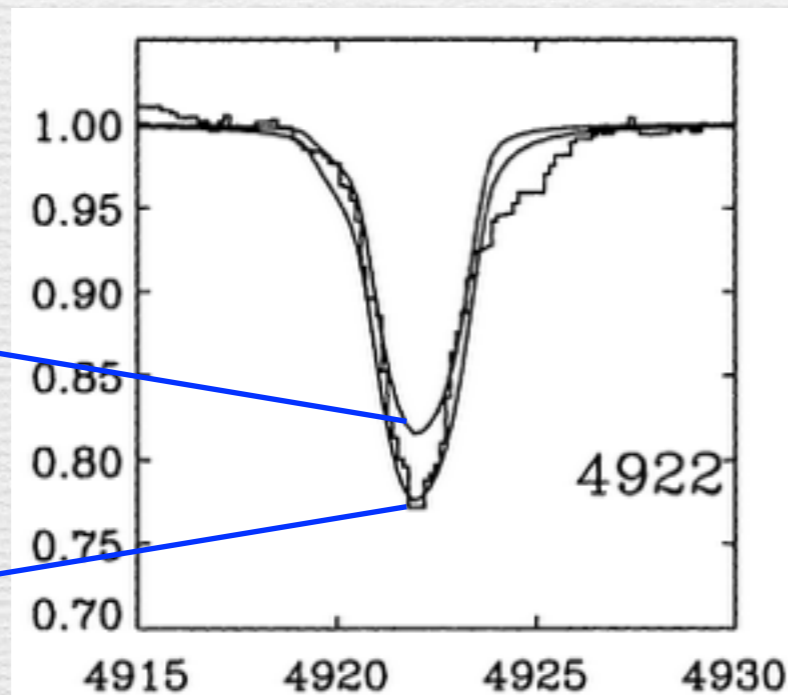
Requesting additional observing time on several objects
of the GES sample

Overview

- Massive stars
- Multiplicity
- Determination of surface abundances
 - Helium abundance
 - CNO abundances and comparison with another survey
- Conclusion and perspectives

Determination of the surface abundances

- Non-LTE CMFGEN atmosphere code
- Helium abundance sets to 0.1 (by number) at first approximation
- Effect of the micro-turbulence on the Helium surface abundance determination



• (McErlean et al. 1998)

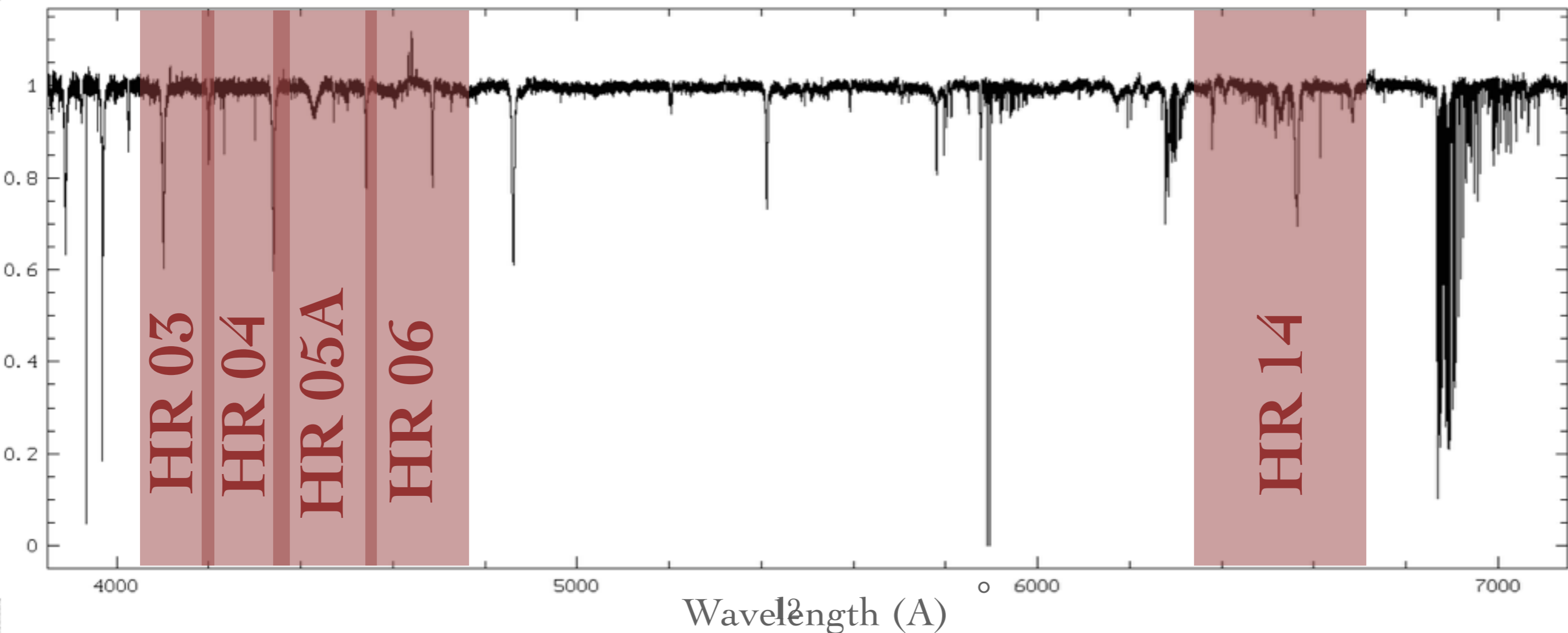
Overview

- Massive stars
- Multiplicity
- Determination of surface abundances
 - Helium abundance
 - **CNO abundances and comparison with another survey**
- Conclusion and perspectives

Determination of the surface abundances

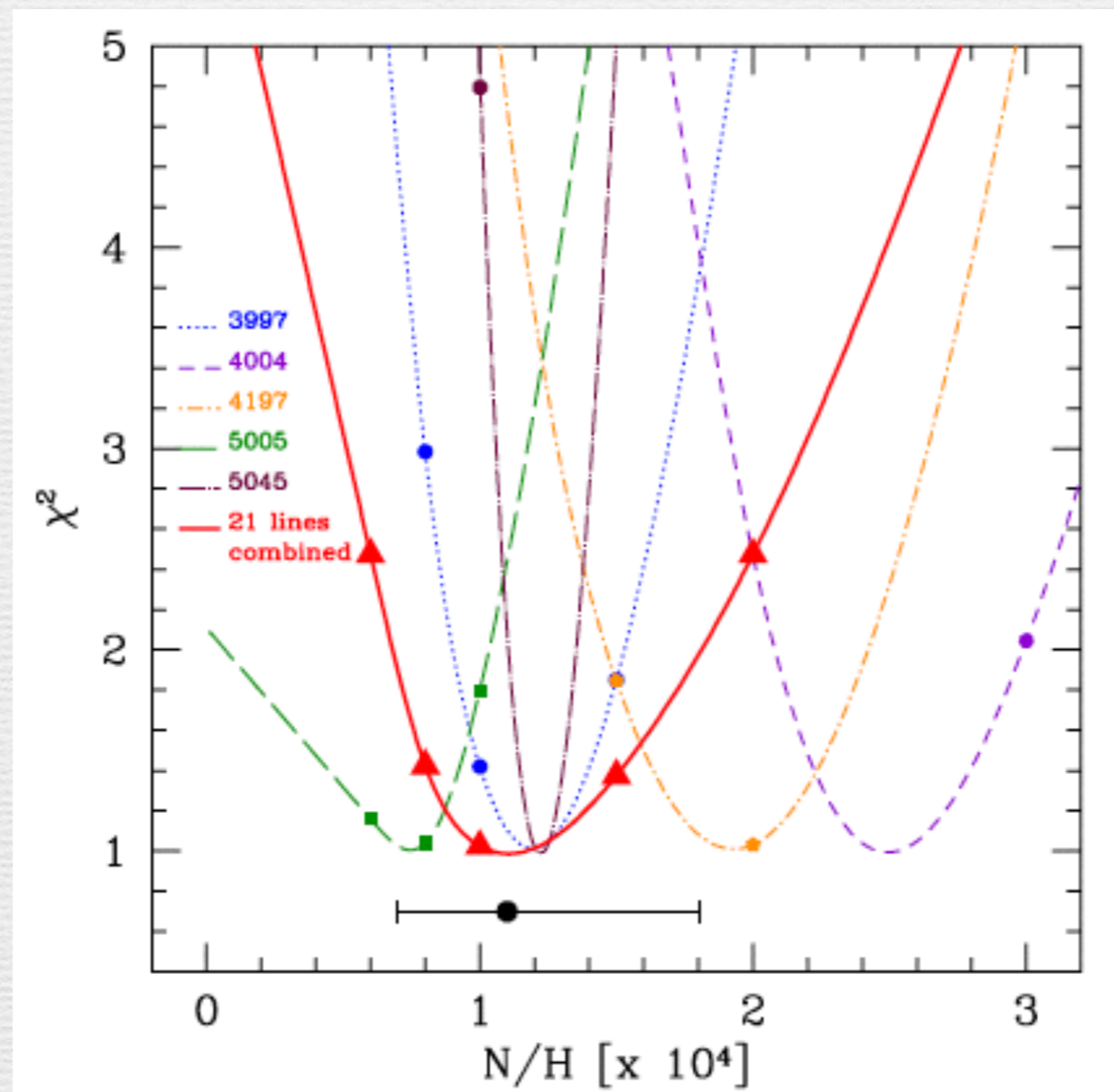
With the wavelength coverage of the GES spectra, we have access to:

1. Carbon: CIII 4058-60, CIII 4153, CIII 4156, CIII 4163, CIII 4187, CII 4267, CII 6578, CII 65
2. Nitrogen: NII 4035, NII 4041, NIII 4044, NII 4236, NII 4447, NIII 4511, NIII 4515, NIII 4518, NIII 4524, NII 4530, NII 4601, NII 4607, NII 4614, NII 4621, NII 4630
3. Oxygen: OII 4120, OII 4284, OII 4305, OII 4318, OII 4321, OII 4368, OII 4592, OII 4597, OII 4603, OII 4611, OII 4663, OII 4678, OII 4700, OII 4707



Determination of the surface abundances

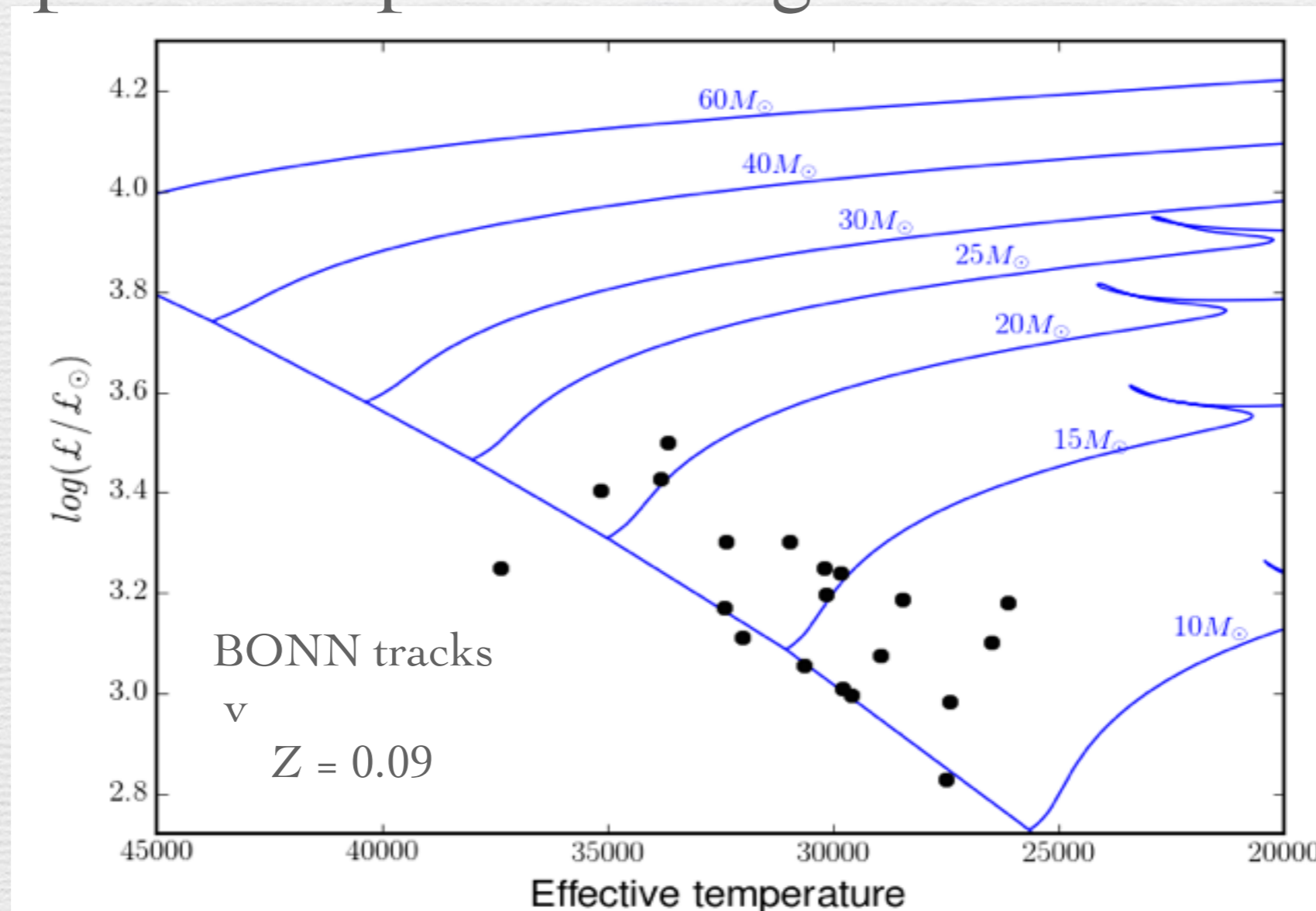
- CNO abundances have been determined from fixed homogenized parameters T_{eff} - $\log g$ given for iDR5



Determination of the surface abundances

- Preliminary values for 20 O and early B-type stars out of 42 objects.

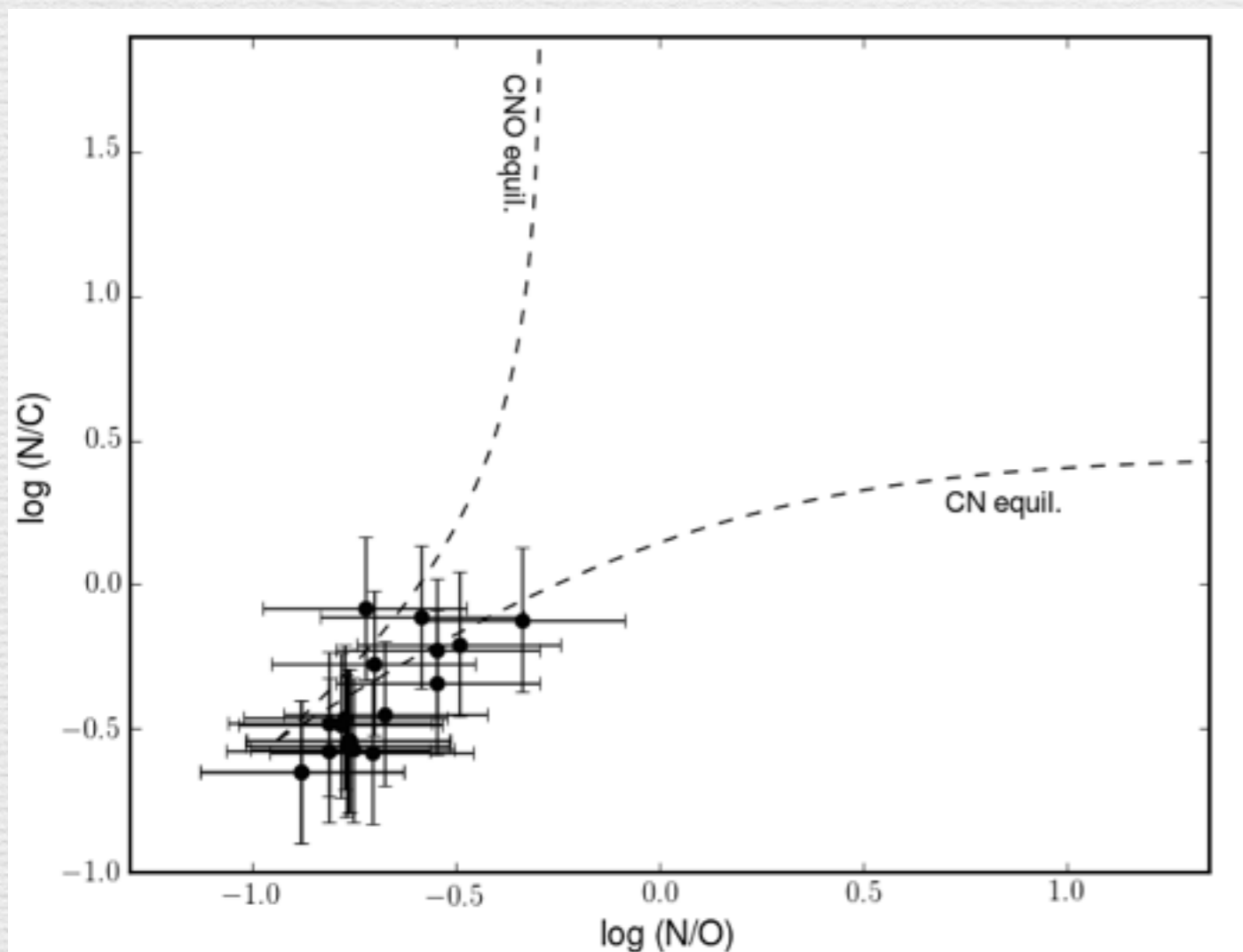
Spectroscopic HR diagram



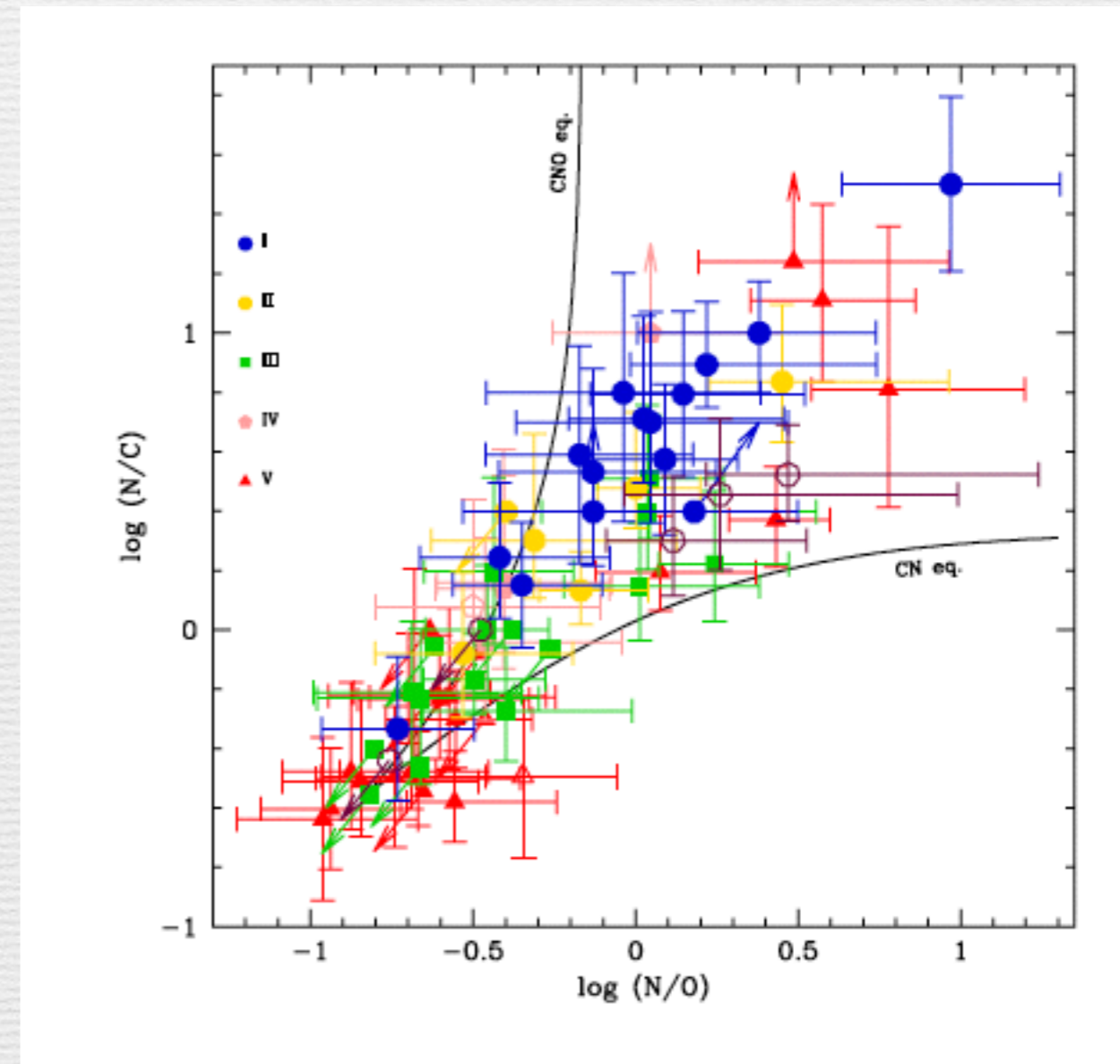
Determination of the surface abundances

- Preliminary values for 20 O and early B-type stars out of 42 objects.

GES



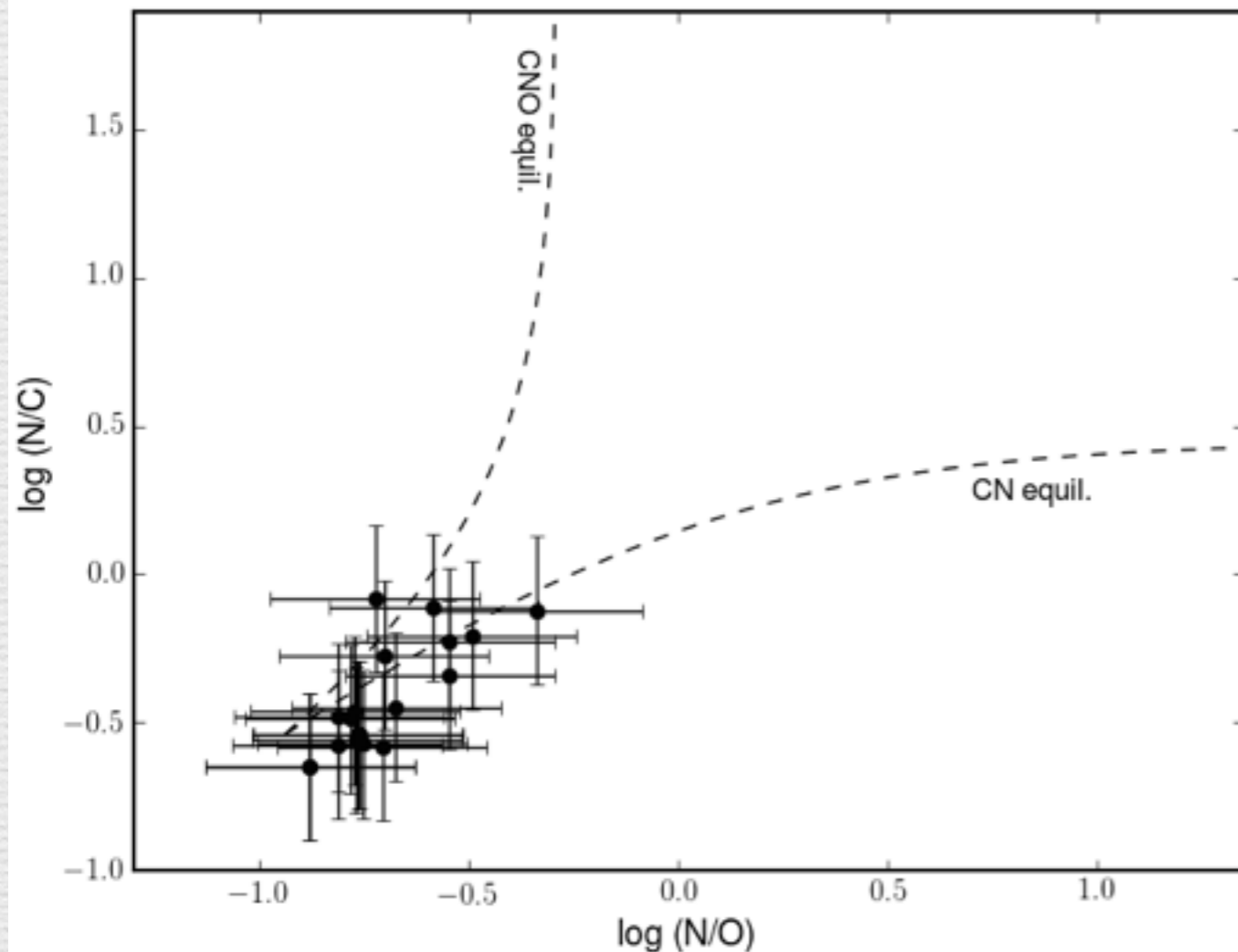
MiMES



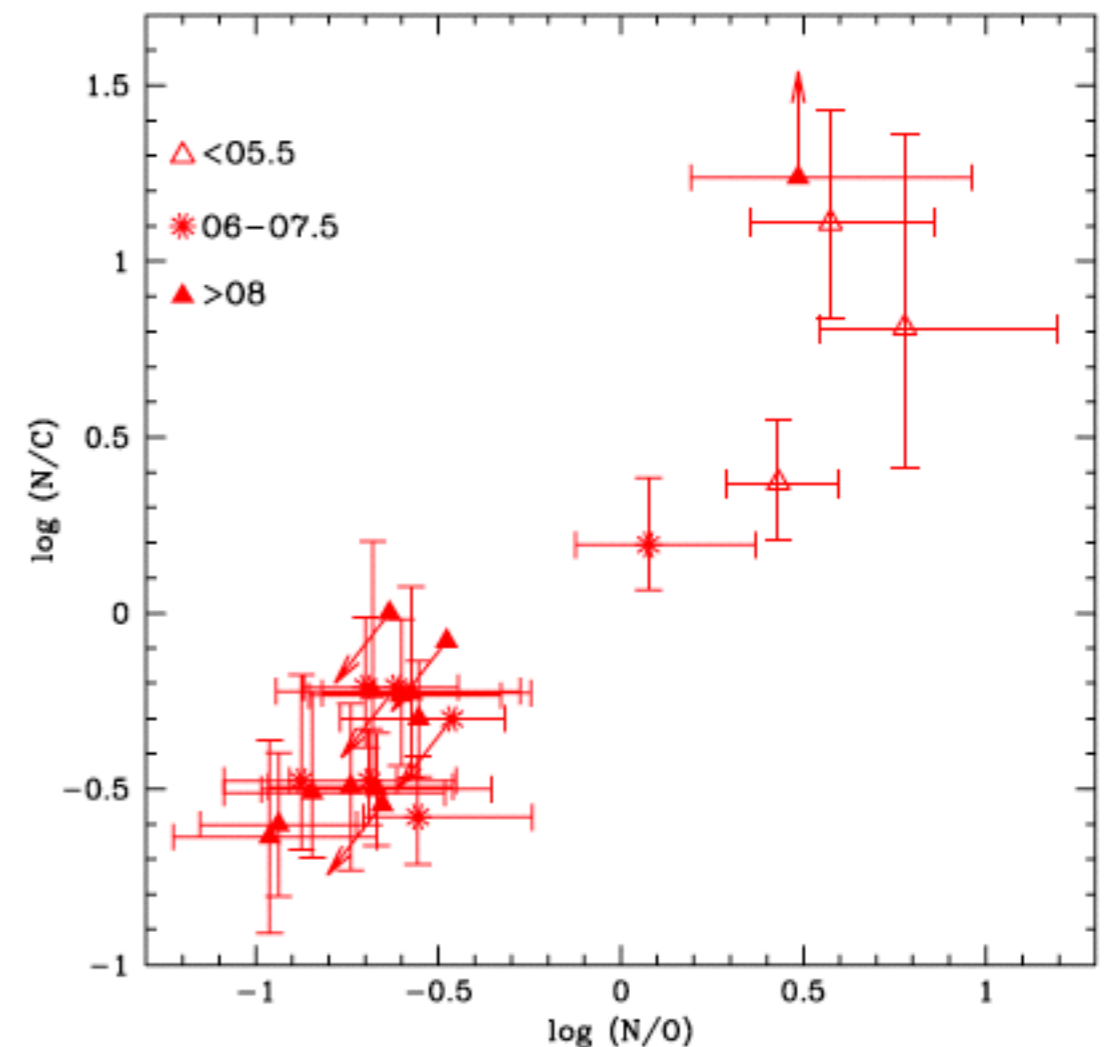
Determination of the surface abundances

- Preliminary values for 20 O and early B-type stars out of 42 objects.

GES



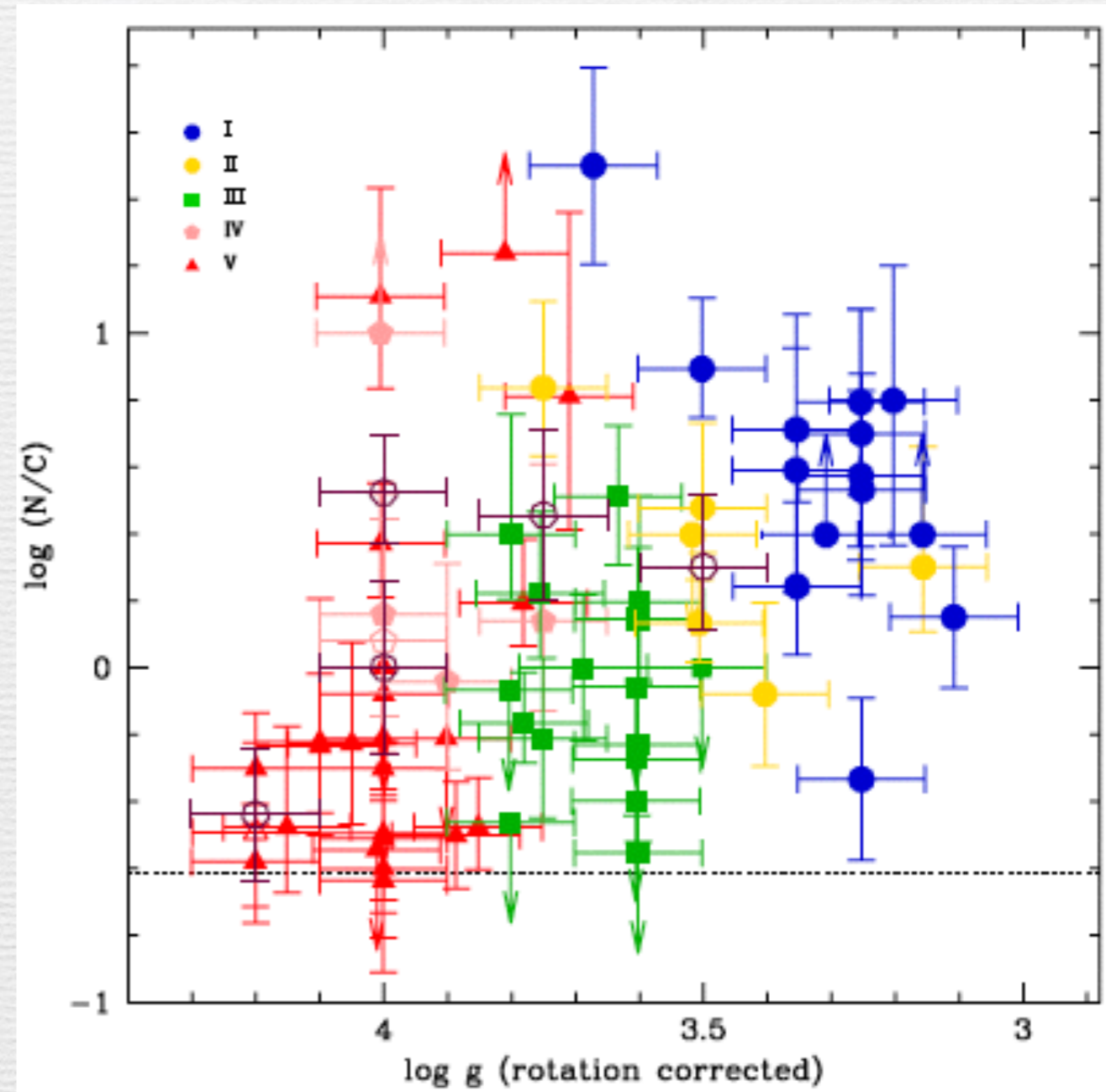
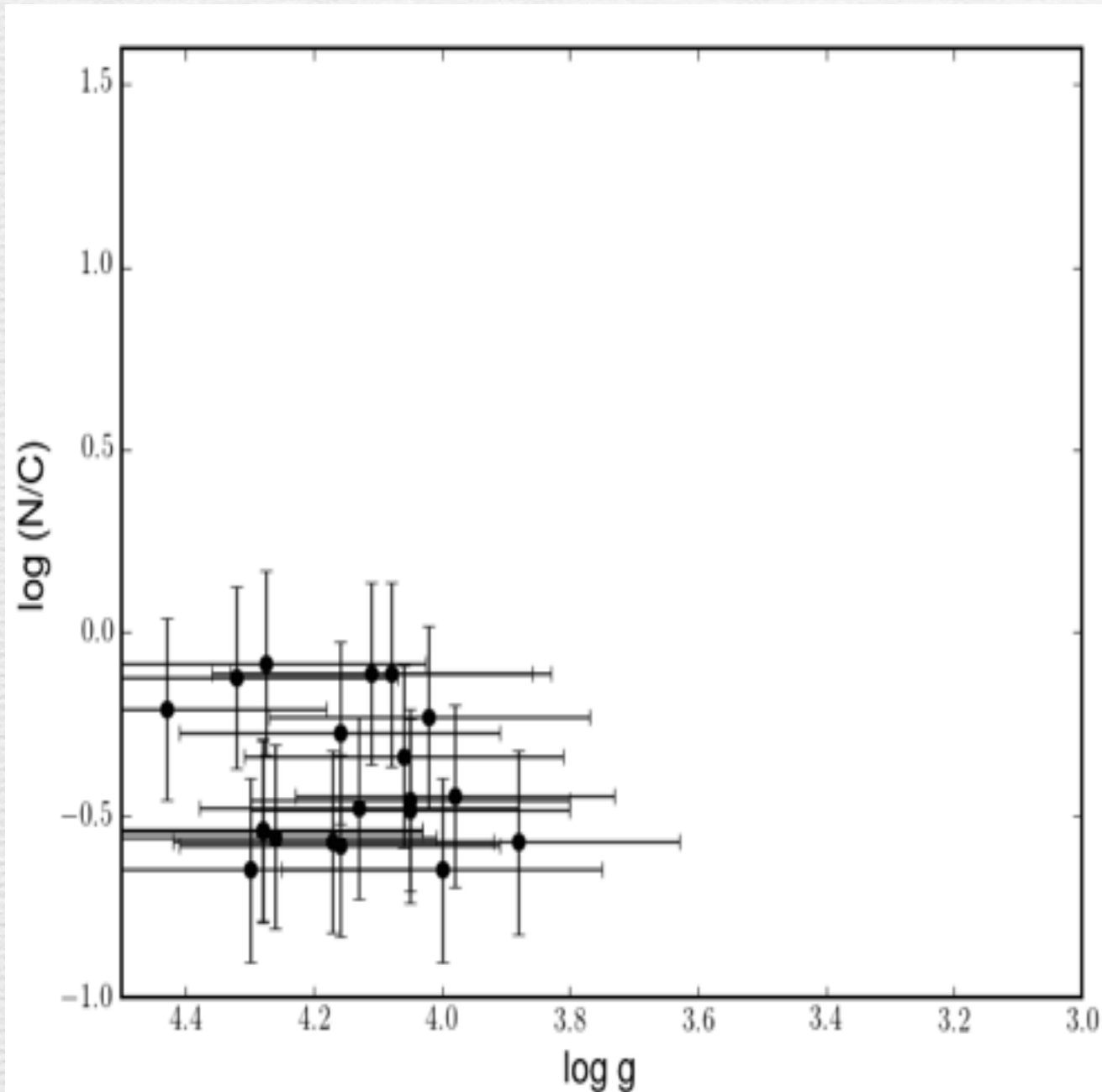
MIMES



Determination of the surface abundances

GES

MiMES



Overview

- Massive stars
- Multiplicity
- Determination of surface abundances
 - Helium abundance
 - CNO abundances and comparison with another survey
- **Conclusion and perspectives**

Conclusions and future perspectives

- Massive stars from Carina in the Gaia-ESO survey do not seem to show large enrichments in CNO
- Trend of strong chemical mixing in more evolved objects?
- Correlation between chemical mixing and more massive objects?
- Constrain the multiplicity of each object
- Abundances & Multiplicity - spatial location correlation?