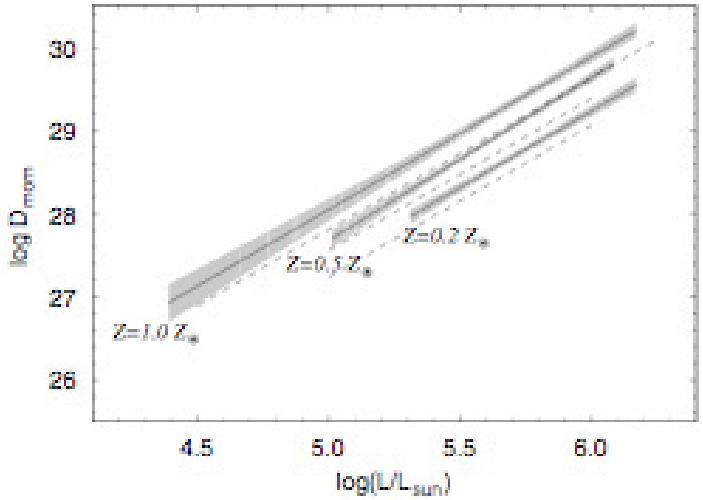
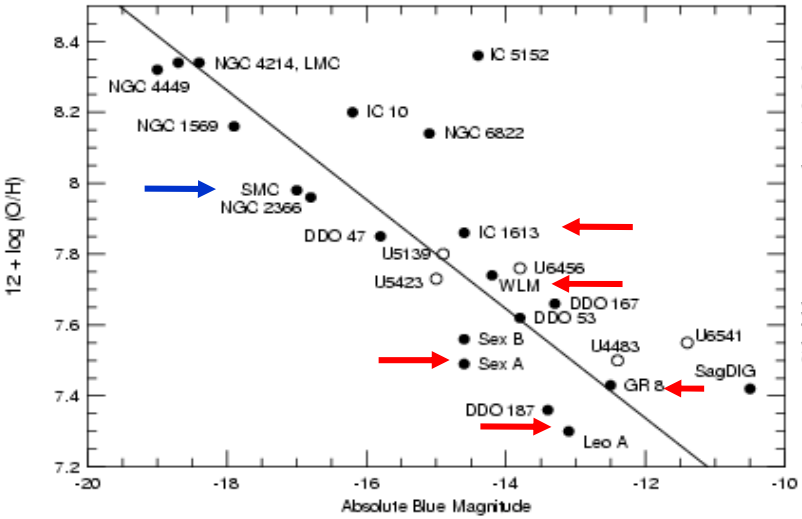
Extragalactic Blue Massive Stars: VLT-VIMOS and INT-WFC Observations of IC1613

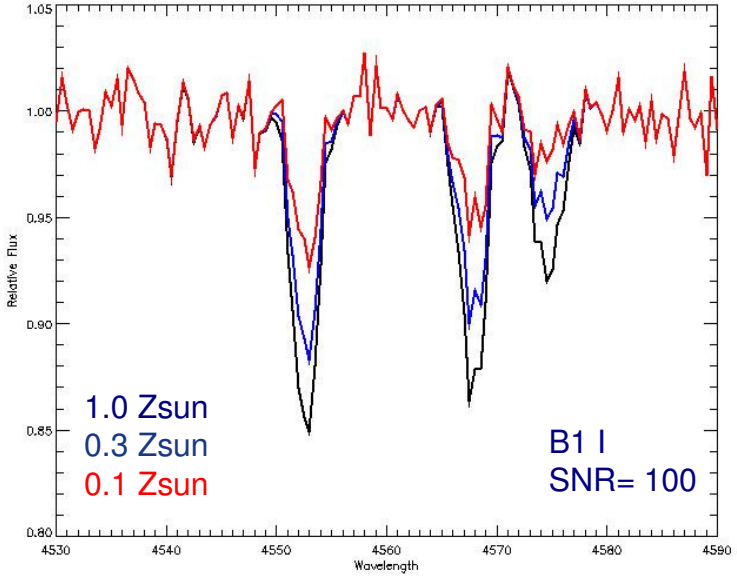
Miriam García
A. Herrero , F. Najarro, L. Corral, K. Uytterhoeven, N. Castro, D. J. Lennon

¿Why IC1613?: Low Metallicity





Skillman et al., 1989, ApJ 347, 875



European Organisation for Astronomical Research in the Southern Hemisphere

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

VISITING ASTRONOMERS DEPARTMENT • Karl-Schwarzschild-Straße 2 • D-85748 Garching bei München • e-mail: visas@eso.org • Tel.: +49-89-32 00 64 73

APPLICATION FOR OBSERVING TIME PERIOD: **80A**

Important Notice:

By submitting this proposal, the PI takes full responsibility for the content of the proposal, in particular with regard to the names of CoIs and the agreement to act according to the ESO policy and regulations, should observing time be granted

1. Title — Category: **D–4**
   Massive Stars in Low Metallicity Environments: IC 1613

2. Abstract
   We propose to obtain VLT-VIMOS spectra of about 60 blue massive stars in the low metallicity galaxy IC 1613. These spectra, secured at R~2100 and S/N~100, will constitute a unique sample to study massive stars in a very low metallicity environment, comparable to what we may expect in many extragalactic systems, particularly in the early universe. Through the analysis of these spectra we will determine the dependence of stellar winds with metallicity and test the predictions of the theory of radiatively driven winds and the evolutionary models of massive stars at metallicities never reached before for a large sample of objects. These predictions are of outstanding importance for our understanding of the chemical evolution of galaxies and the physics of low metallicity systems.

3.

Run	Period	Instrument	Time	Month	Moon	Seeing	Sky Trans.	Obs.Mode
A	80	VIMOS	19h	oct	g	≤ 1.0″	CLR	s
B	80	VIMOS	17h	oct	g	≤ 1.0″	CLR	s

IC1613

Active star formation at the NE

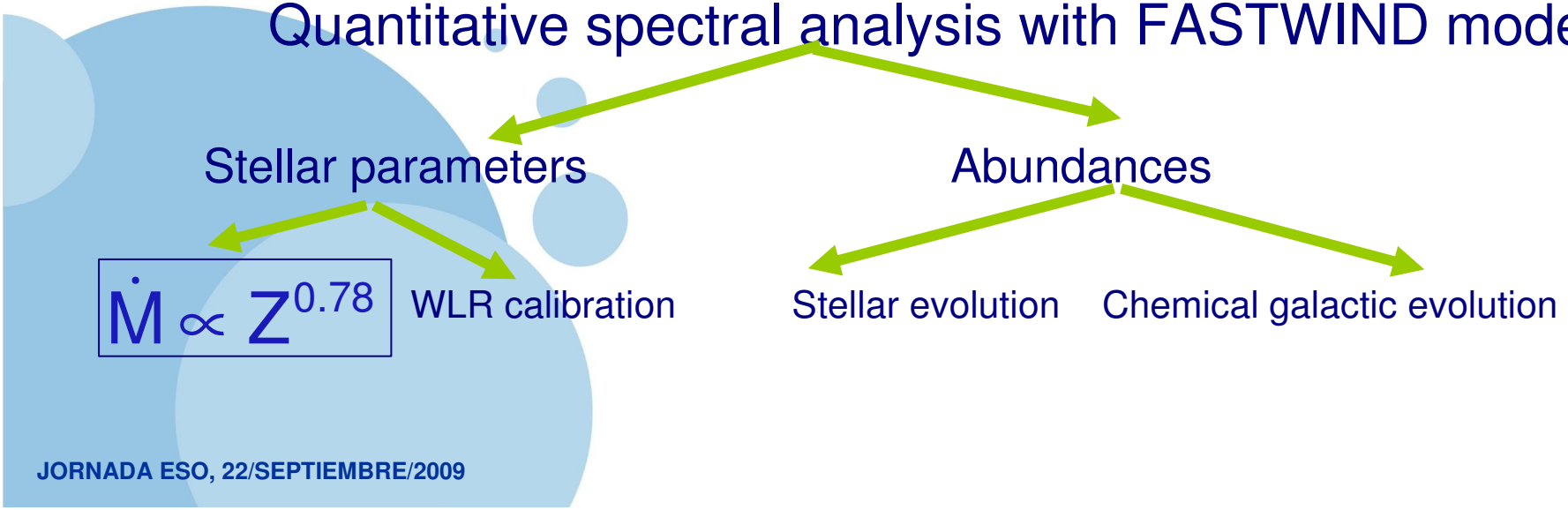
General strategy

I. Photometry:
Blue Massive Star (BMS) candidate list

II. OB association catalogue

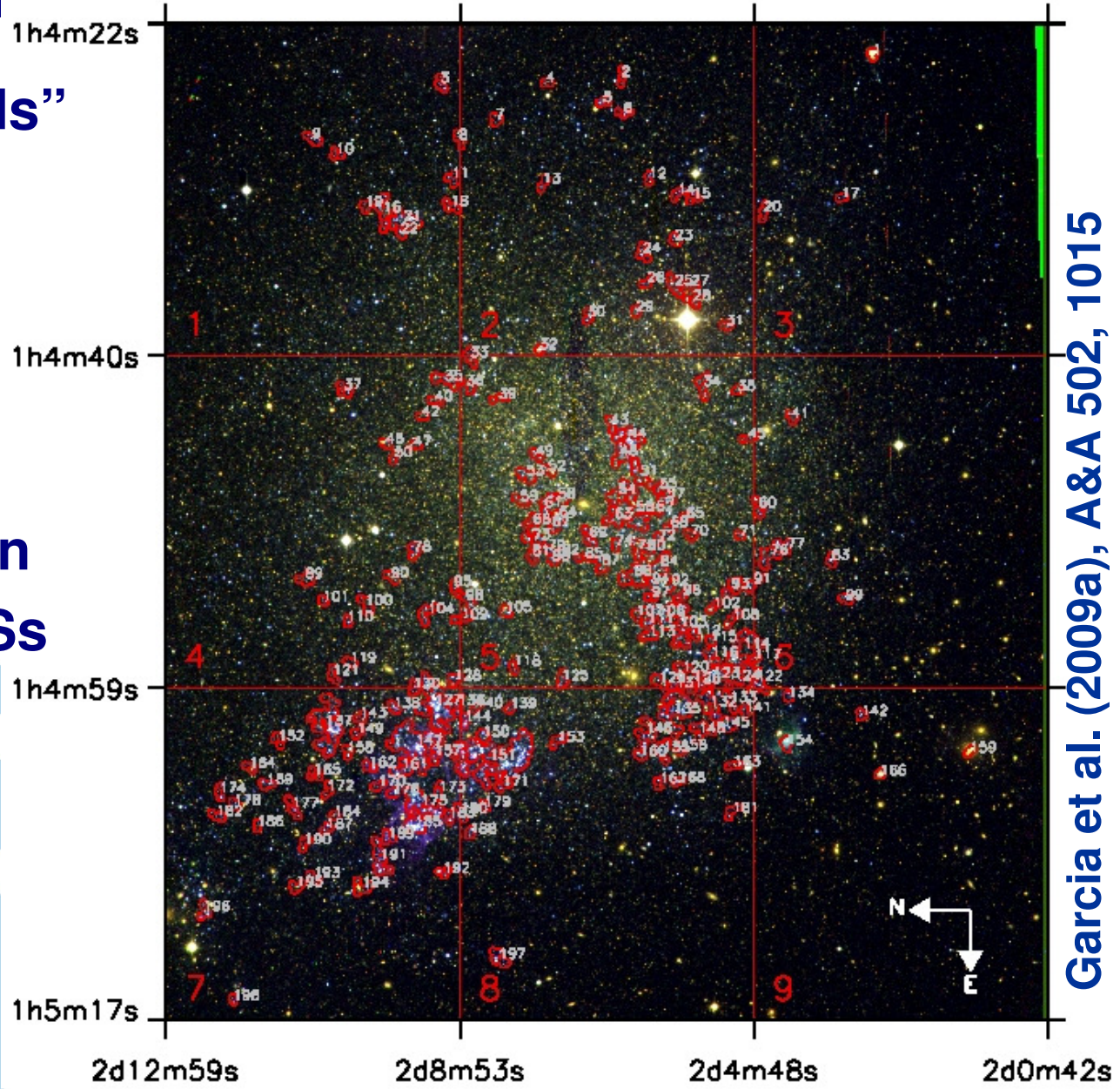
III. Low resolution spectroscopy:
Spectral classification and BMS confirmation

IV. Medium-high resolution spectroscopy:
Quantitative spectral analysis with FASTWIND models:



OB association catalogue

- **“Friends of friends” algorithm**
  - Battinelli (1991)
  - Bastian et al. (2007)
- **198 associations**
  - 29 discarded
- **21 have more than 10 candidate BMSs**



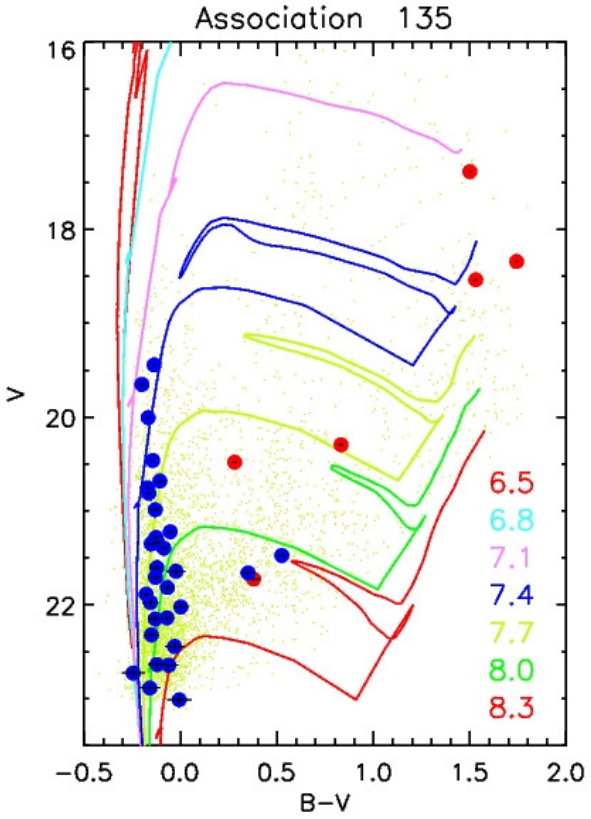
OB association catalogue

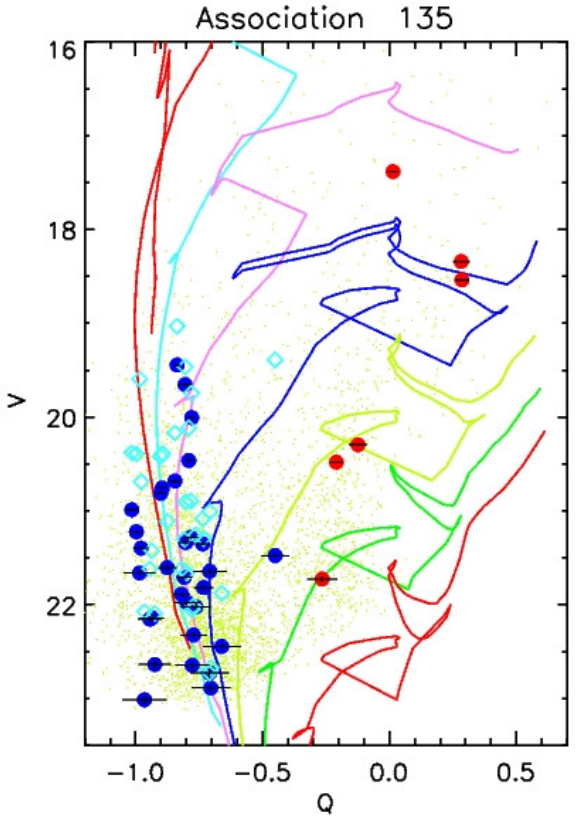
Population analysis:

- Goal: **mass and age** of association members
- Meynet et al. (1994) isochrones, 0.2Zo

+ Candidate lists:

- **LBV**
- **RSG**

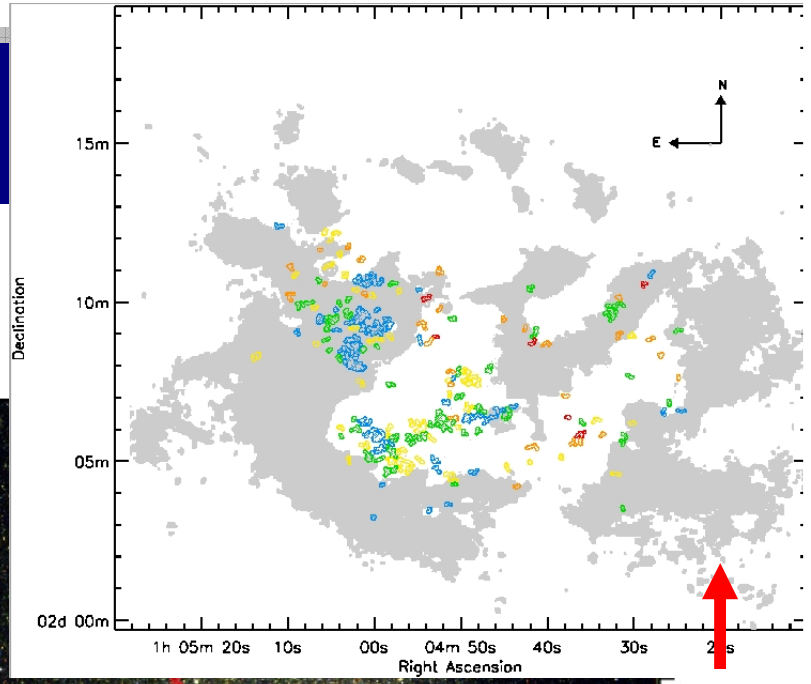


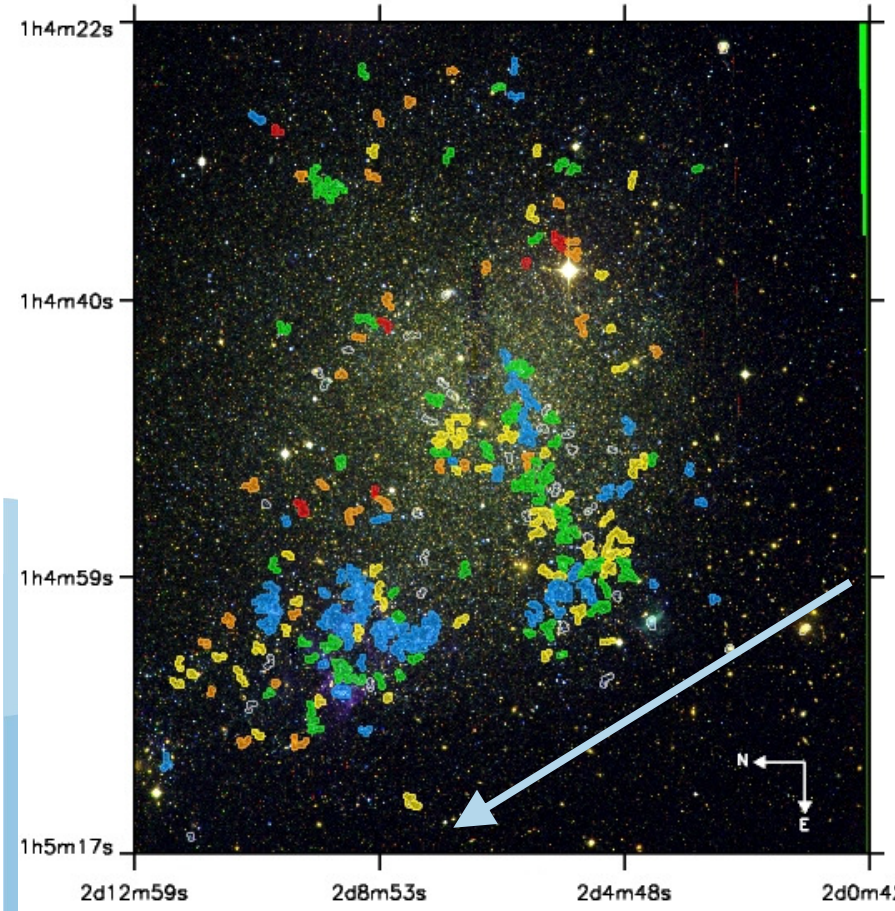


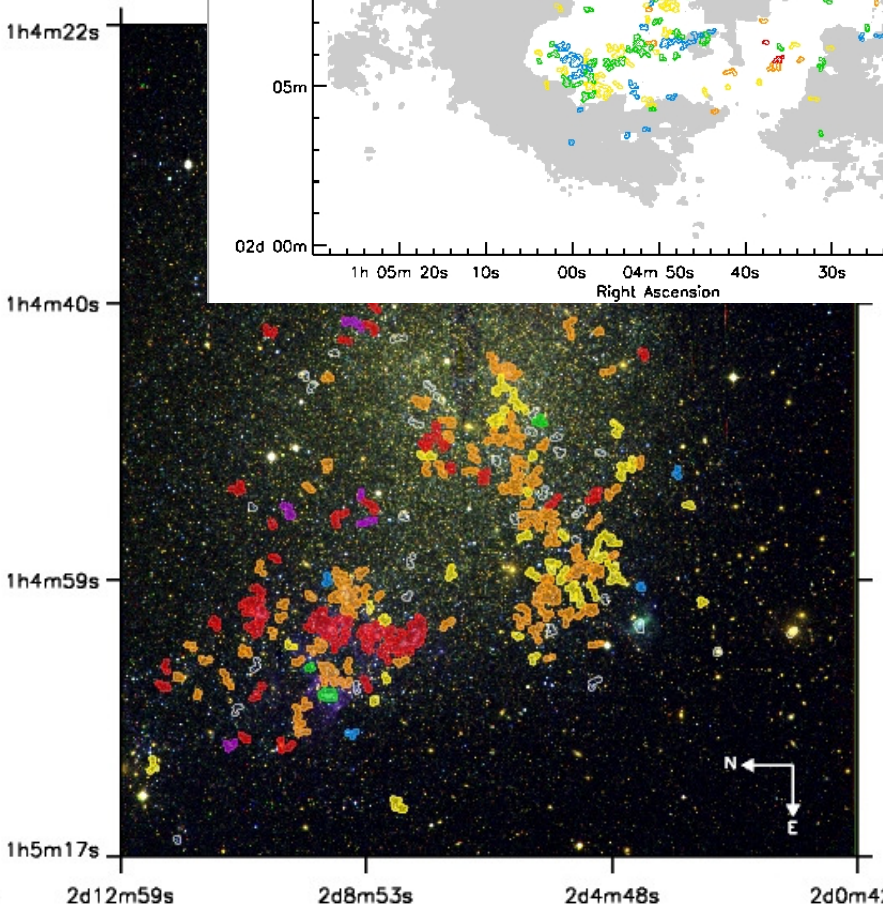
Q=(U-B) – 0.72*(B-V)

Garcia et al. 2009b

OB association catalogue







Triggered star formation?

Log age= 6.5, 6.8, 7.1, 7.4, 7.7, 8.0

Stellar catalogue, target selection

- **INT-WFC, UBVRI**

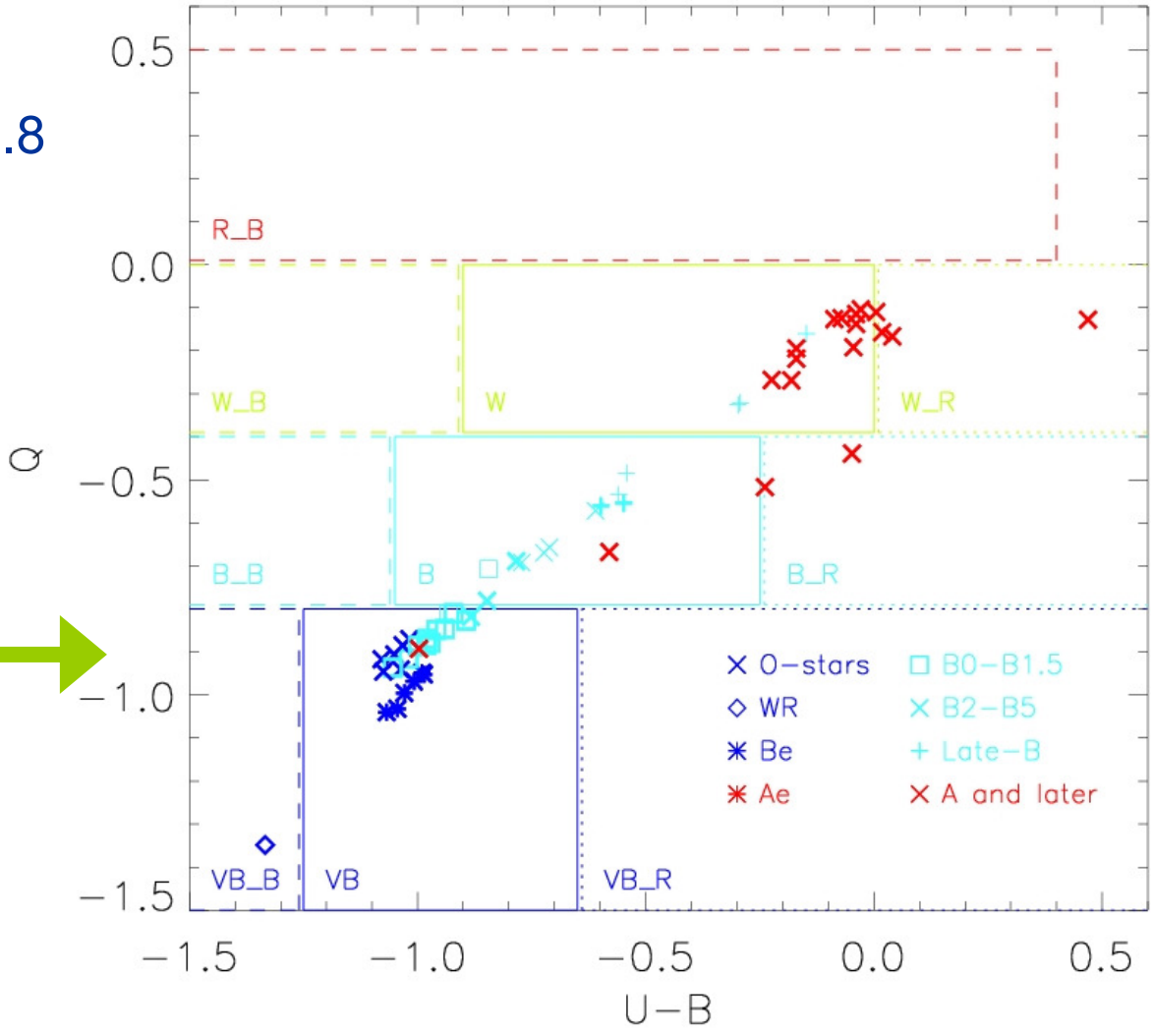
34'x34', 0.33''/px, seeing<0.8

- **PSF Photometry**
- **Astrometry**

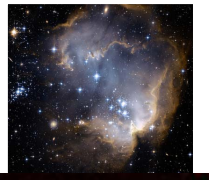
stdv with 2MASS:

0.2'' at V=20

- **Target selection:**



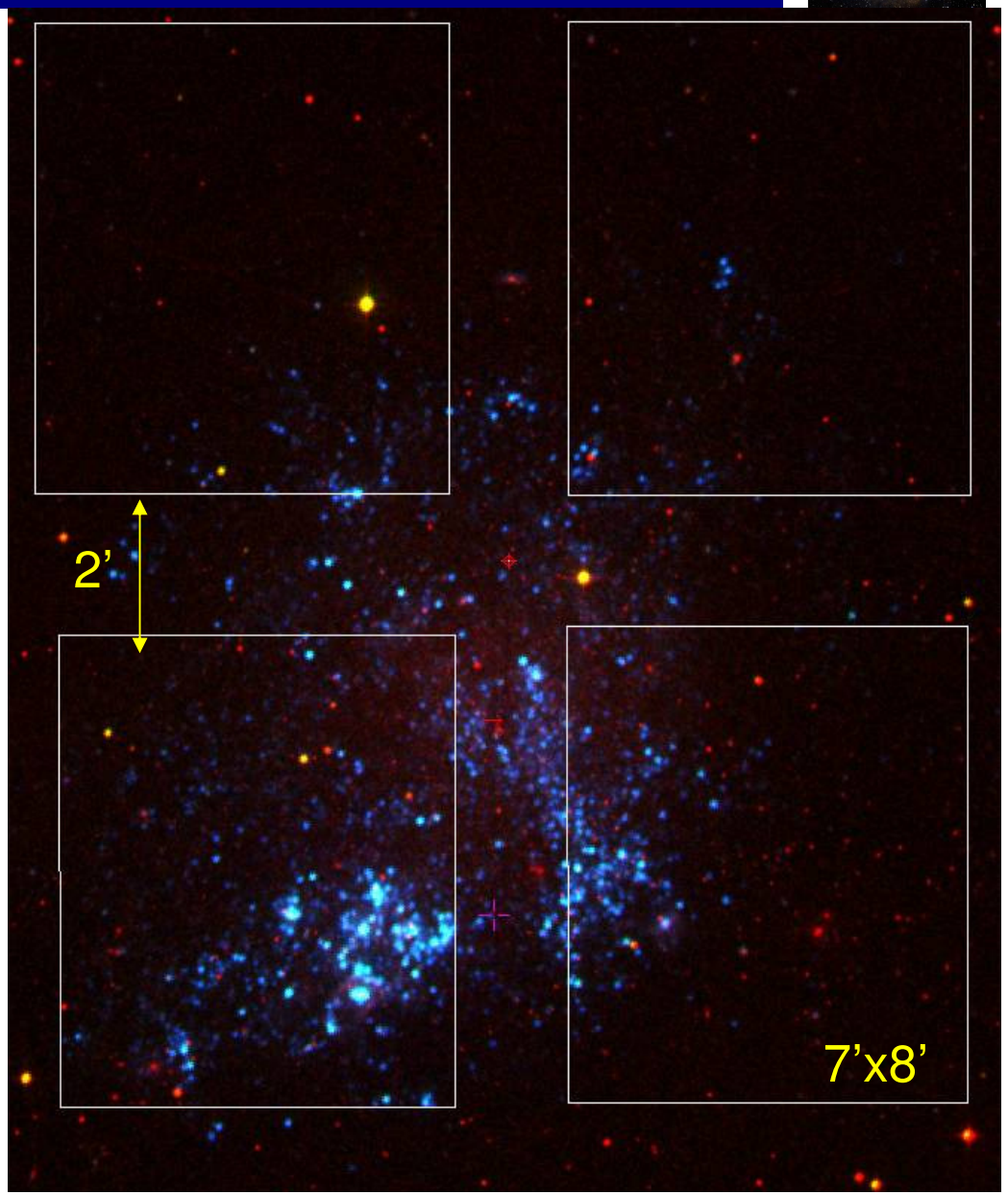
VLT-VIMOS spectroscopy

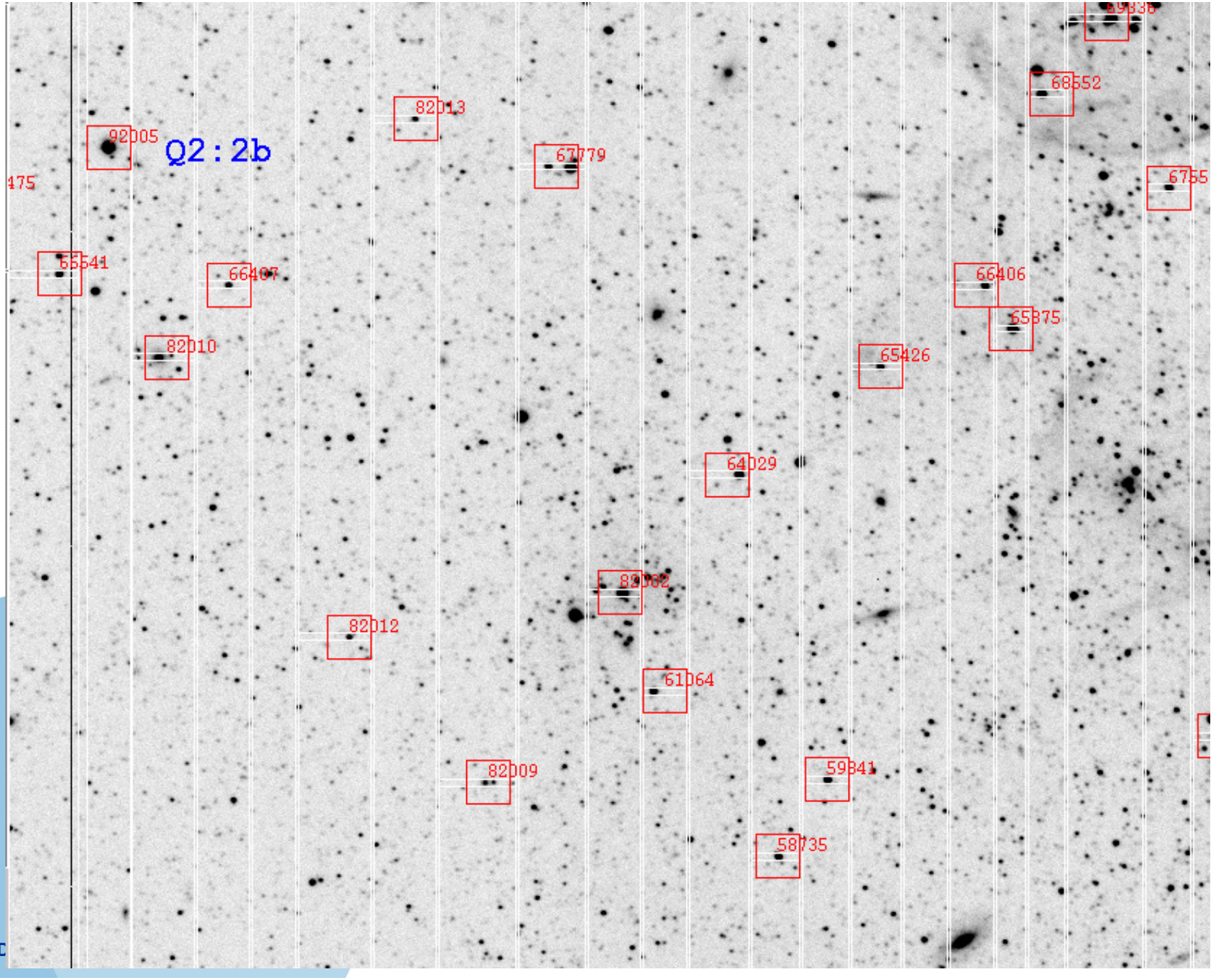


Spectral classification for about 60 OB-type stars

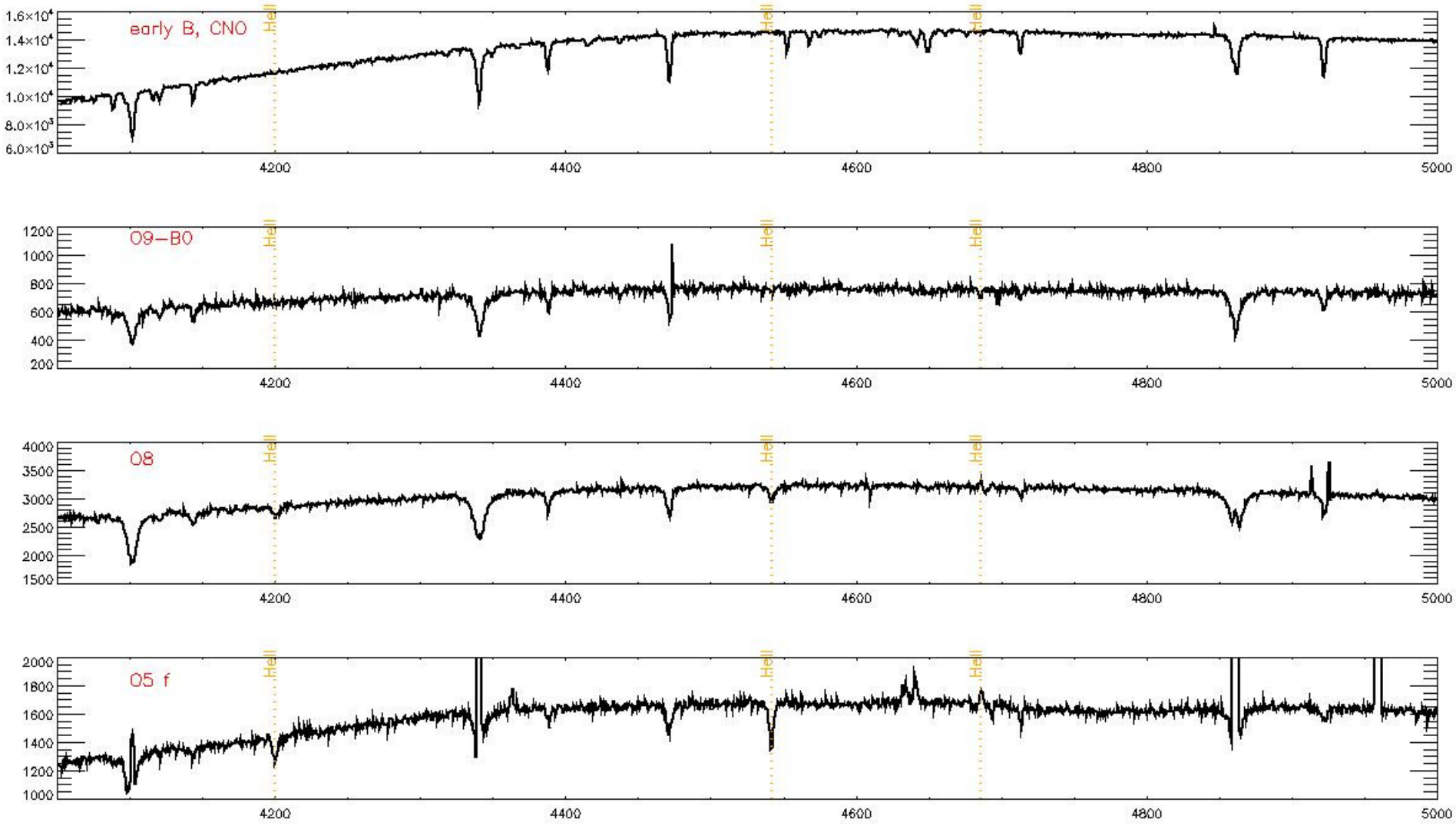
<u>Configuration</u>:

- Multiobjet MOS
  - HR-Blue
  - HR-Orange

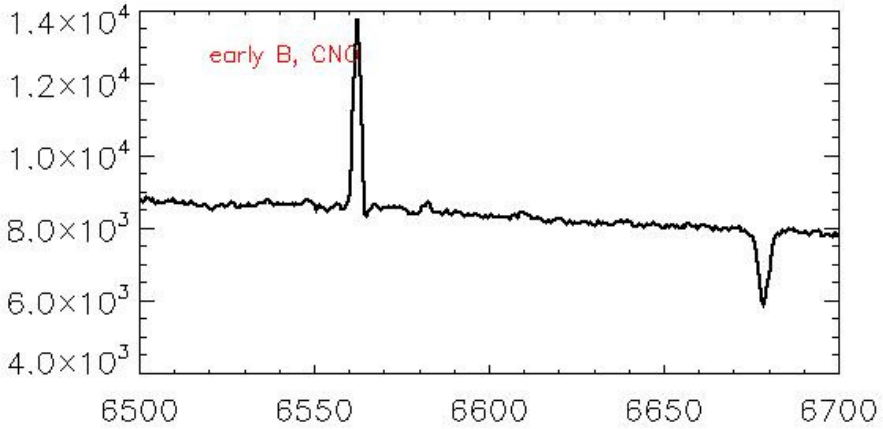


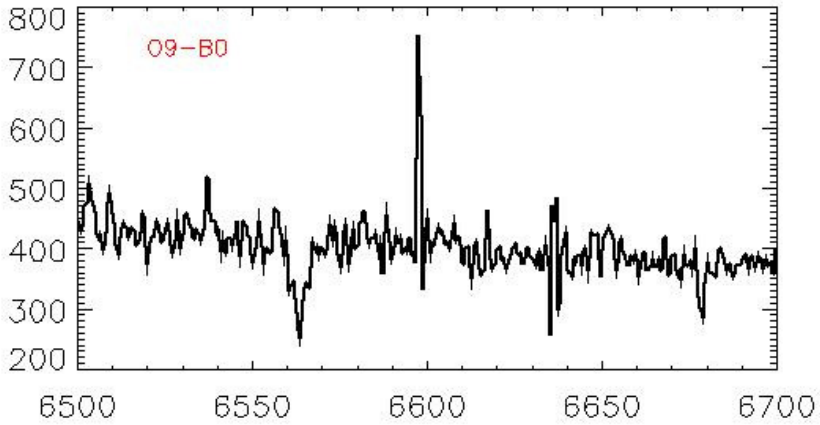

Q2 : 2b
92005
82013
67779
68652
6755
475
65541
66407
66406
65375
82010
65426
64029
82012
61064
82009
59341
58735

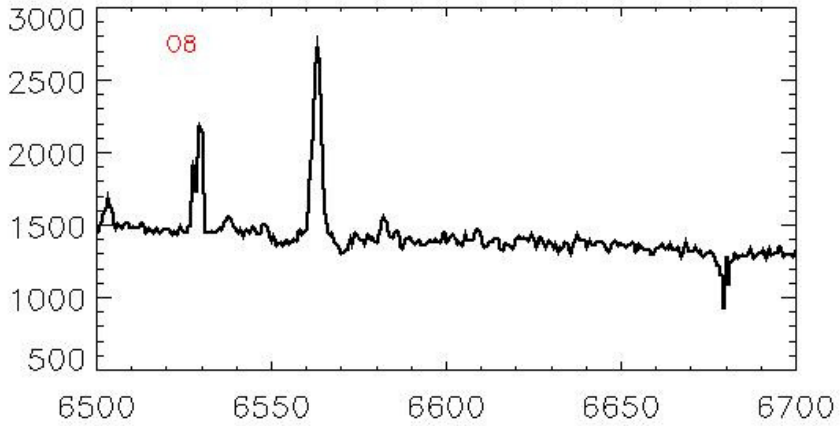
Blue spectra (HR-Blue) of OB stars

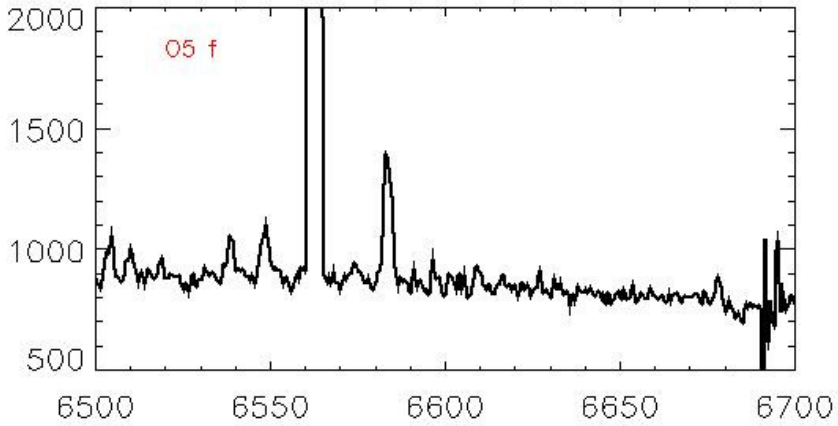


Red spectra (HR-Orange) of OB stars

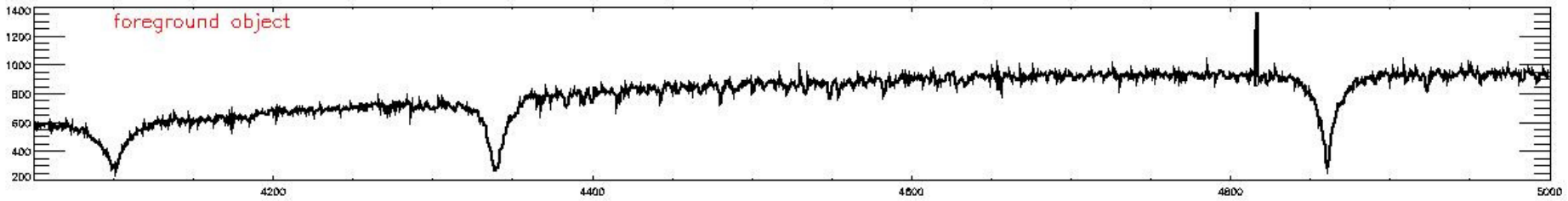


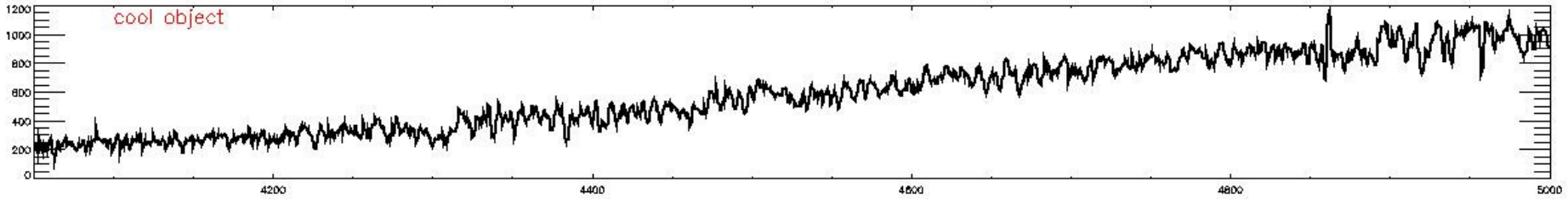


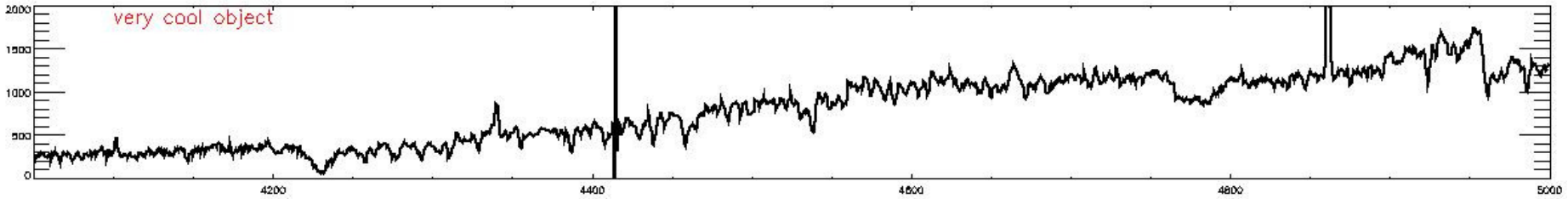


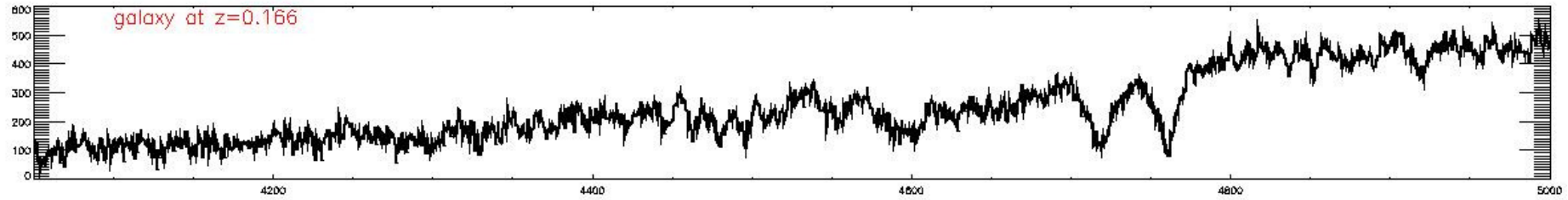


Blue spectra (HR-Blue) of serendipitous objects





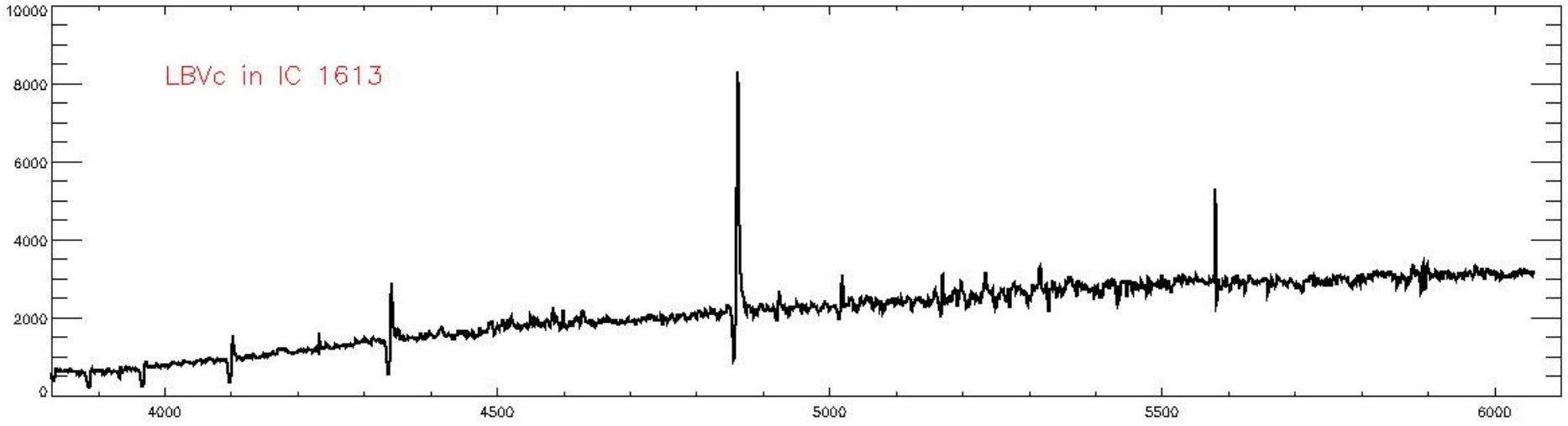


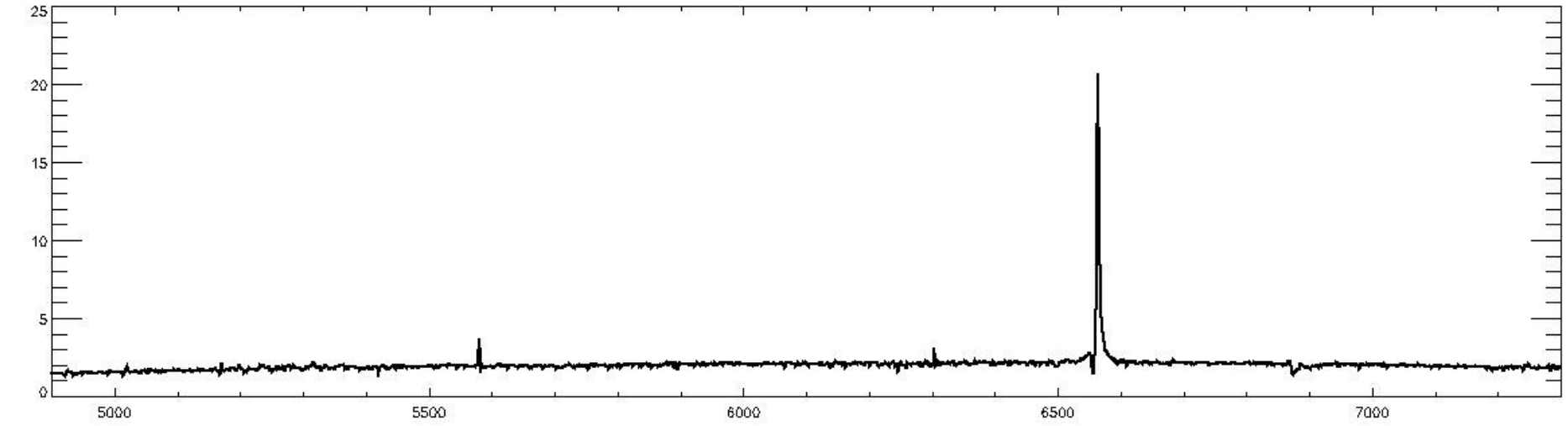


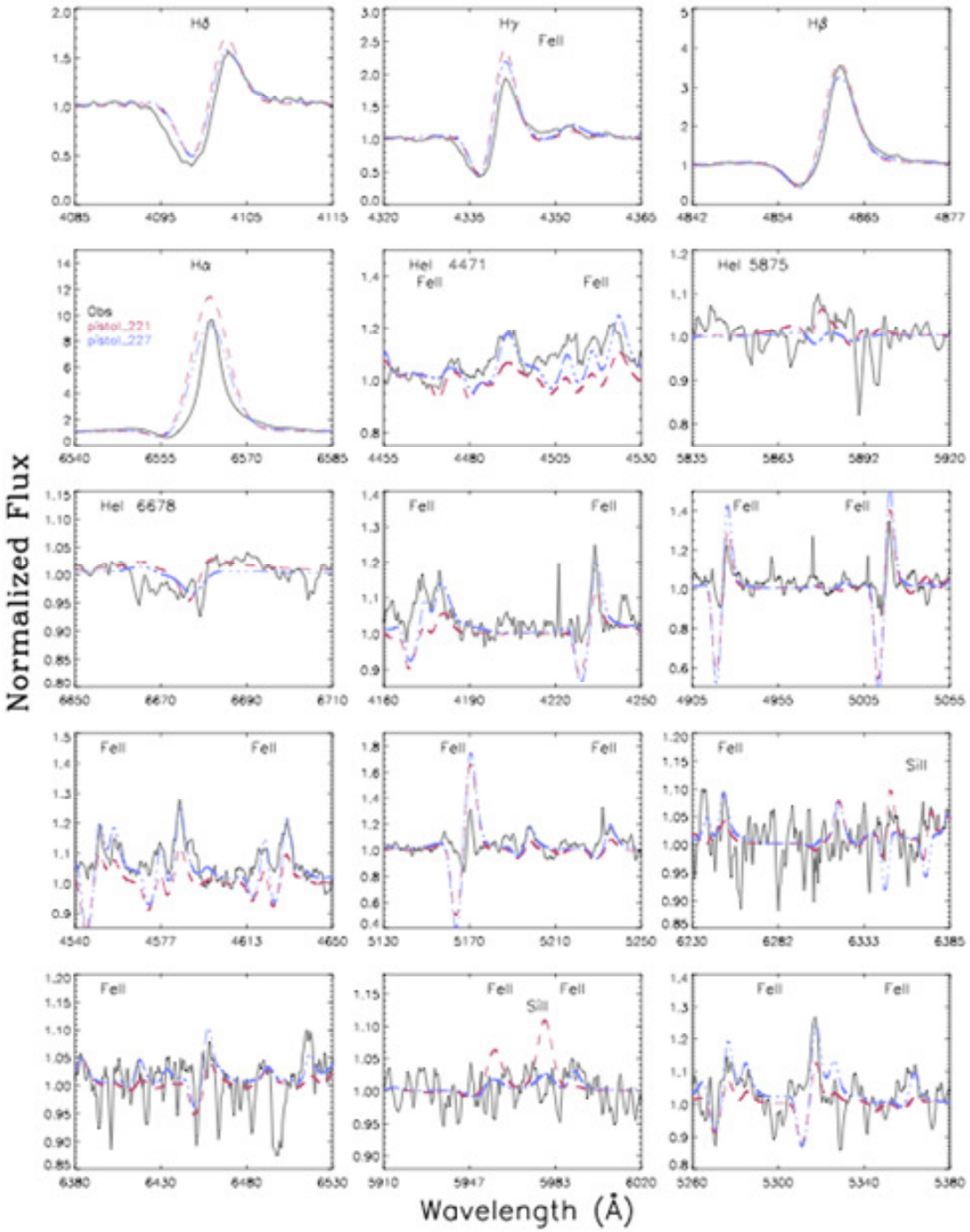
Preliminar spectral classification: statistics

	WR/ LBV	OBA	Emi. Line	Cool Objects	Galaxies	TBD	Total
Q1	1	9	4	7	7	5	33
Q2	1	21	1	5	3	6	37
Q3	0	13	2	4	1	3	23
Q4	0	7	2	13	1	6	29
Total	2	50	9	29	12	20	122

Luminous Blue Variable (LBV) candidate:







CMFGEN models (F.Najarro)

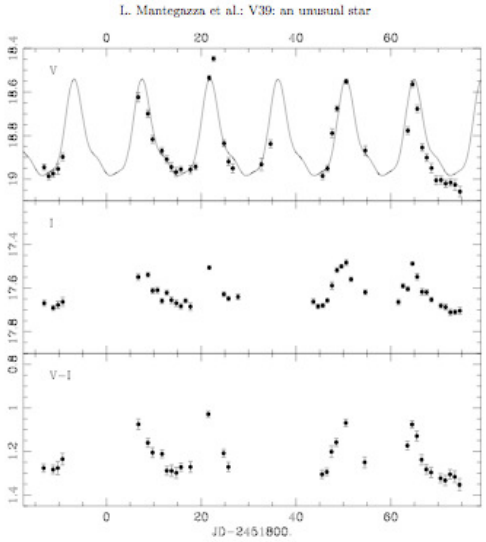
Model 227

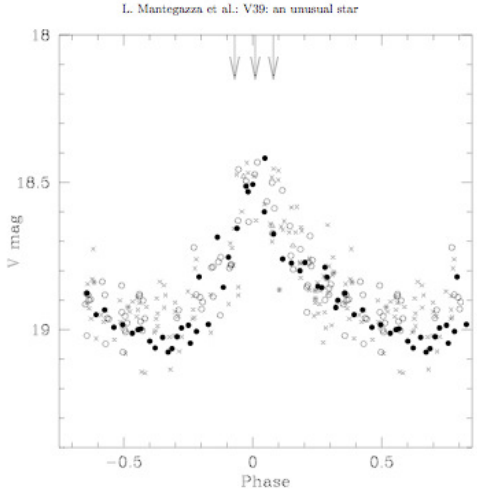
Teff= 9395 K
R= 370 Rsun
Log(L/Lsun)= 5.98
Mdot= 5×10^{-5}
Fe= 1.0xFe(Sun)

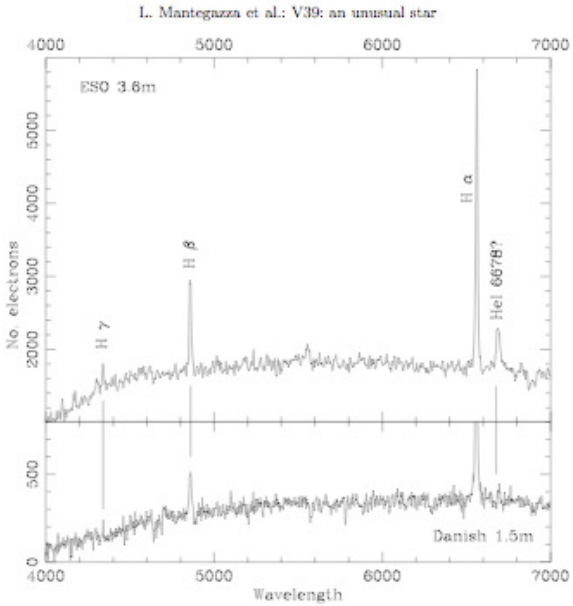
Model 221

Teff= 12250 K
R= 264 Rsun
Log(L/Lsun)= 6.15
Mdot= 1.6×10^{-4}
Fe= 0.4xFe(Sun)

LBVc in IC1613 is v39

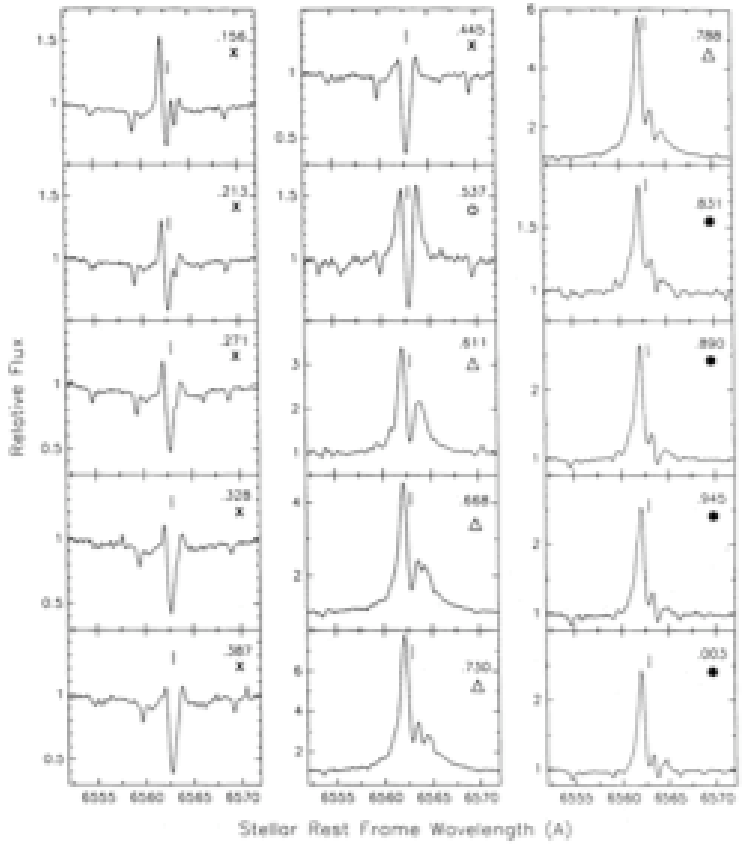




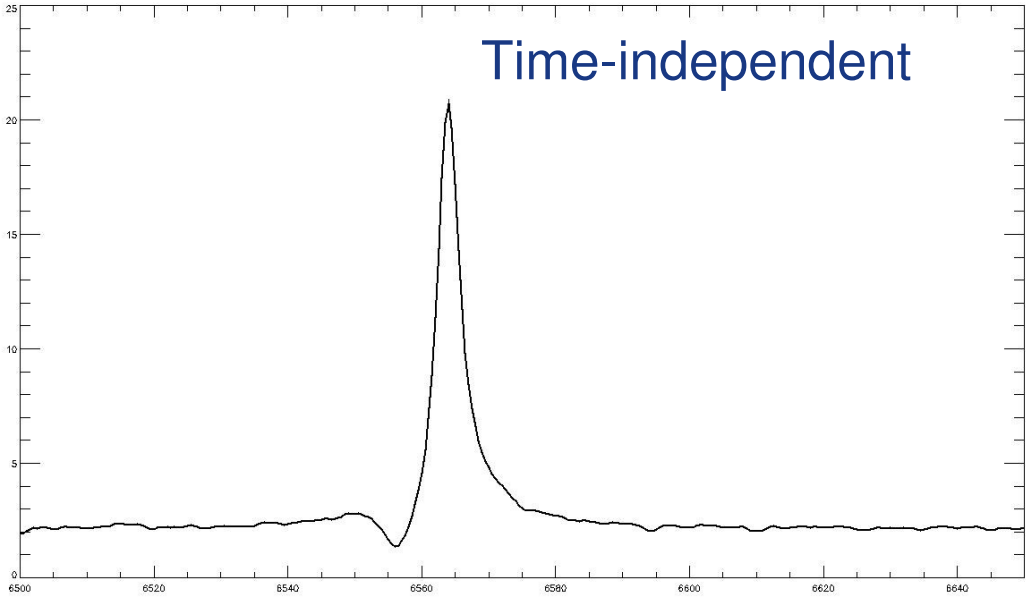


- Mantegazza et al. (2002, A&A 388, 861) classified V39 as a W Vir star at 115 kpc
  - This would mean v39 is the farthest known Milky Way star, calling into question the real extension of the Galactic halo.
- P= 14.347 days; Balmer lines in emission
  - But strange lightcurve and atypical spectrum

LBVc in IC1613 is NOT a W Vir star



Lebre & Gillet, 1992, A&A 255, 221



Plus, the radial velocity matches that of the other stars in the same masks

CONCLUSION

- VIMOS is an excellent stellar machine for galaxies of projected size 15'x15' or more
- The pipeline fails to correctly find several objects in the same slit at times. To secure extraction of faint objects, the reduction must be manual.
- In addition to spectral classification, we will be able to provide stellar and wind parameters for the brightest targets.
- Some of our results will provide constraints for evolutionary models at low metallicity.
- We have found a candidate LBV, V39.

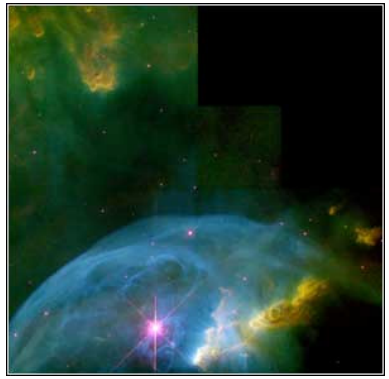
  Its analysis is in progress.

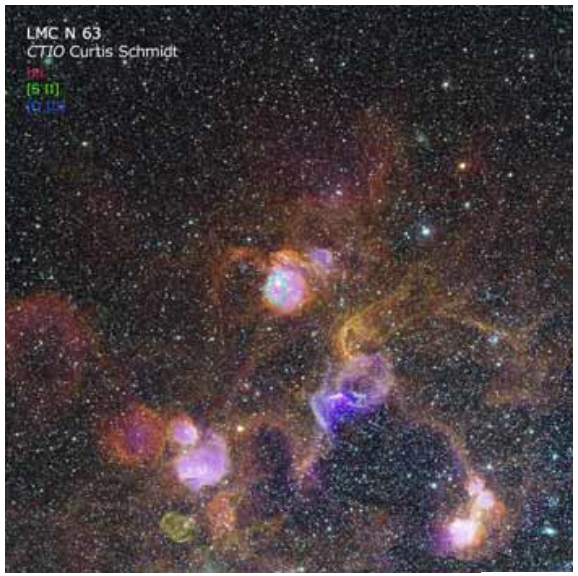
JORNADA ESO, 22/SEPTIEMBRE/2009

Desarrollo

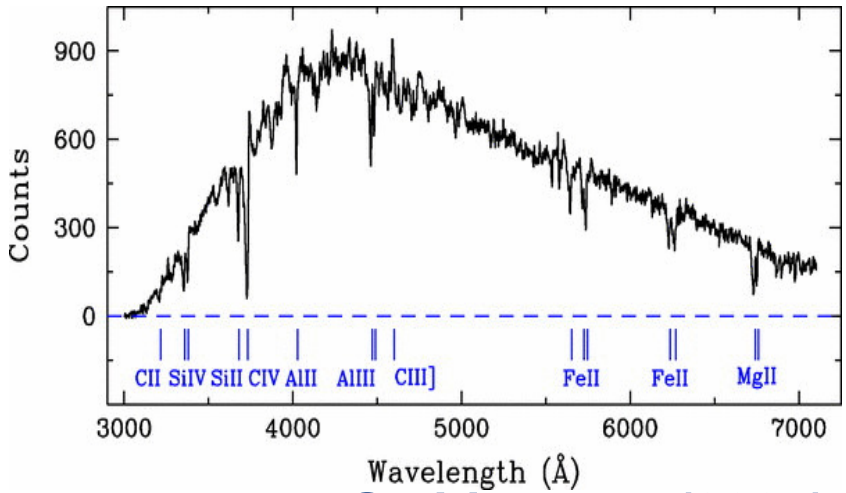
- **INTRODUCCIÓN:**
  - El papel de las estrellas masivas azules (EMAs) y sus vientos en el Universo.
  - Vientos impulsados por radiación.
  - El problema de los vientos débiles.
- **OBJETIVOS Y MUESTRA**
  - Objetivo: explorar la hipótesis de juventud en Orión.
  - Espectros UV de 5 estrellas O y B.
- **MÉTODO DE ANÁLISIS:**
  - Estudio cuantitativo de espectros IUE
  - Red de modelos WM-Basic
- **RESULTADOS**
  - WLR en Orión
- **CONCLUSIONES**

EMAs: Motores del Universo





Q1307-BM1163 (star-forming galaxy at z = 1.409)



Steidel et al. (2004)

Ionización

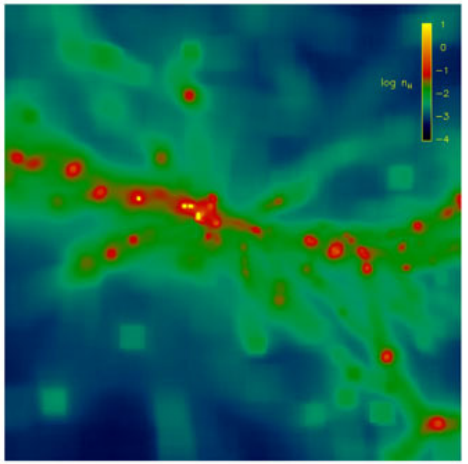
- Regiones HII
- WIM

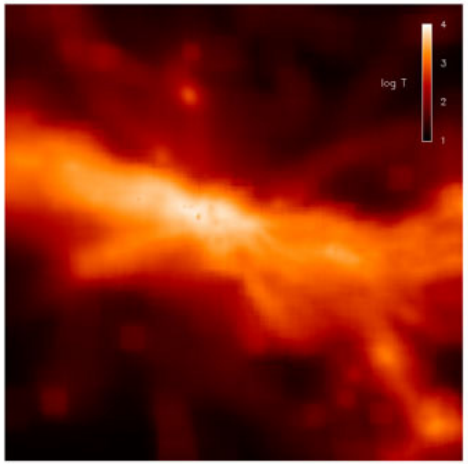
Artesanía

- Burbujas y superburbujas
- Vientos galácticos

Primeras estrellas

- Reionización

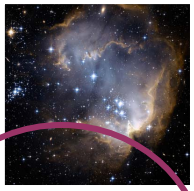




Johnson (2008)

- Progenitores de Supernovas de colapso de núcleo (SNIbIc,SNII) y de GRB-largos

Searching OB Associations



"FRIENDS OF FRIENDS"

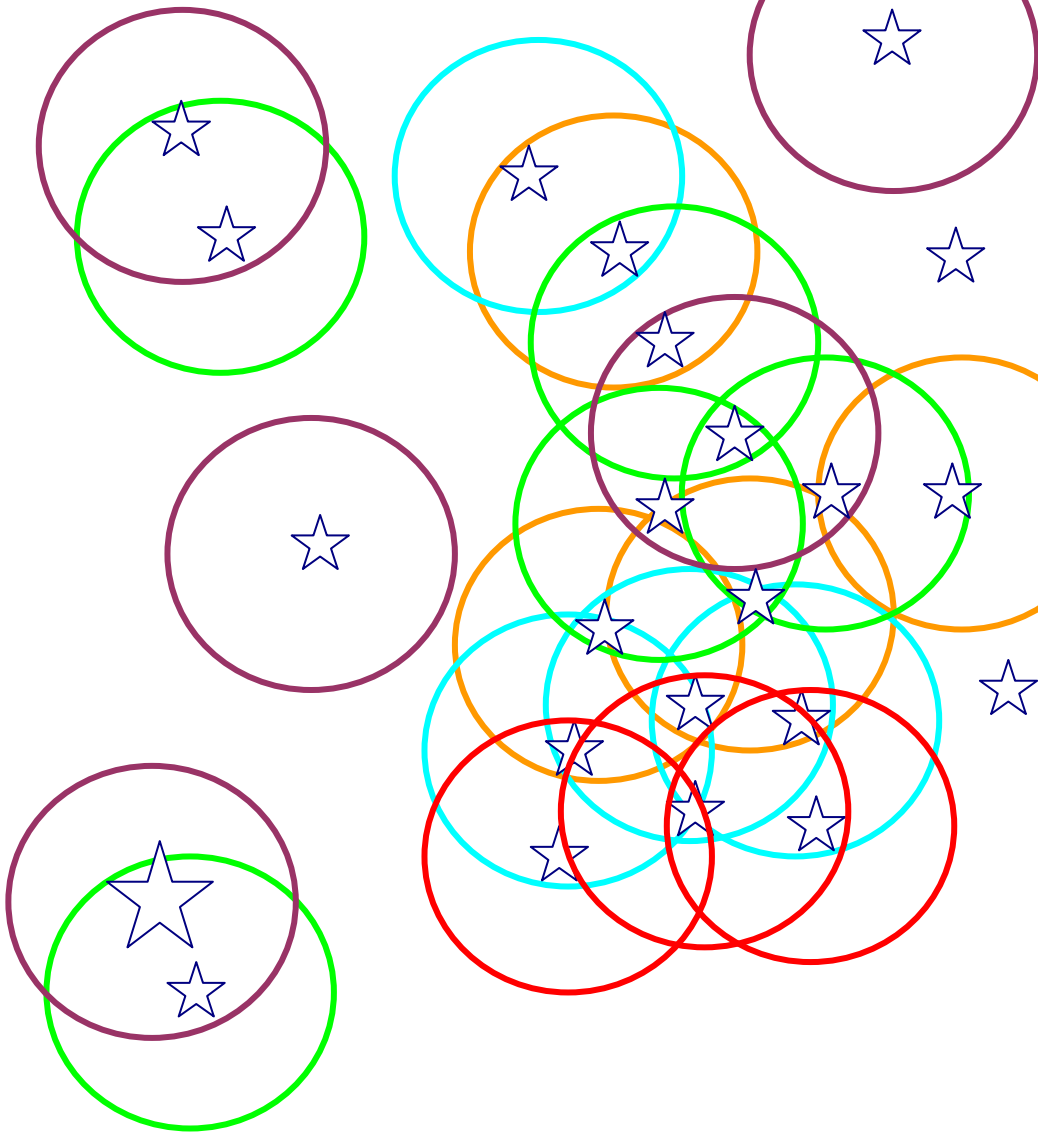
algorithm based on the Path Linkage Criterion (Batinelli 1991) .

Stars a, b belong to OB if:

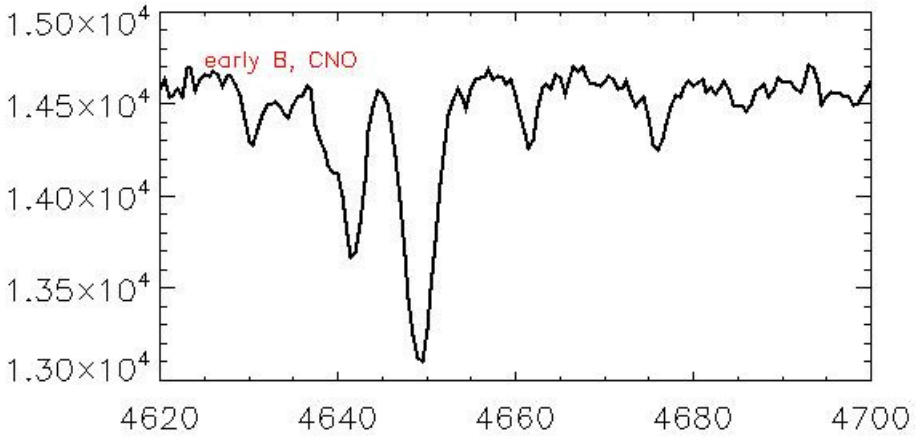
$OB_1=a$, $OB_N=b$

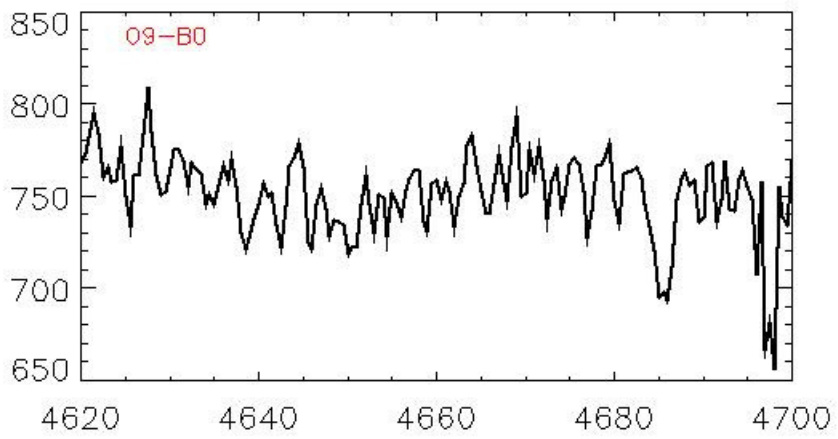
and:

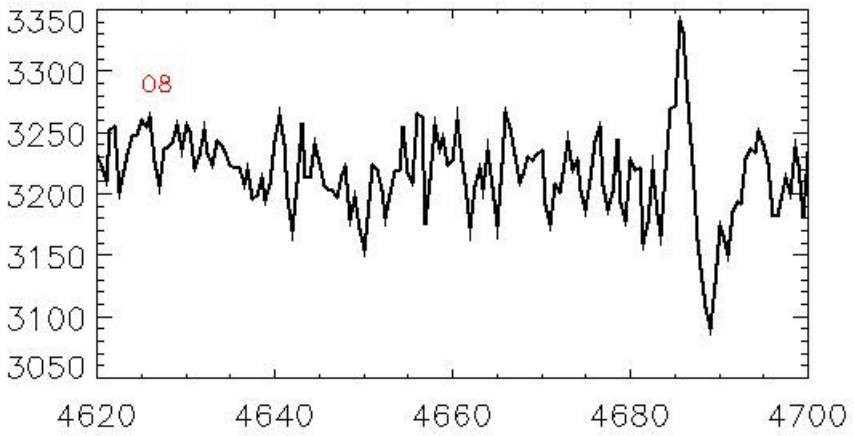
$D(OB_j,OB_{j+1}) \leq OBdist$

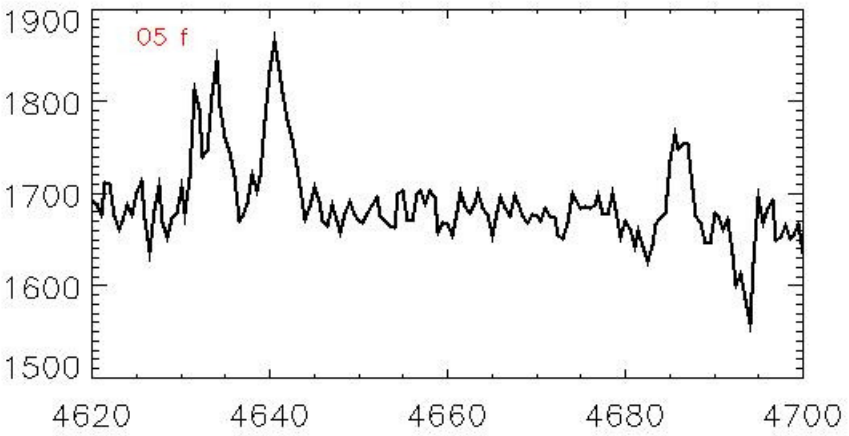


Zoom into HeII 4686 for some O-stars

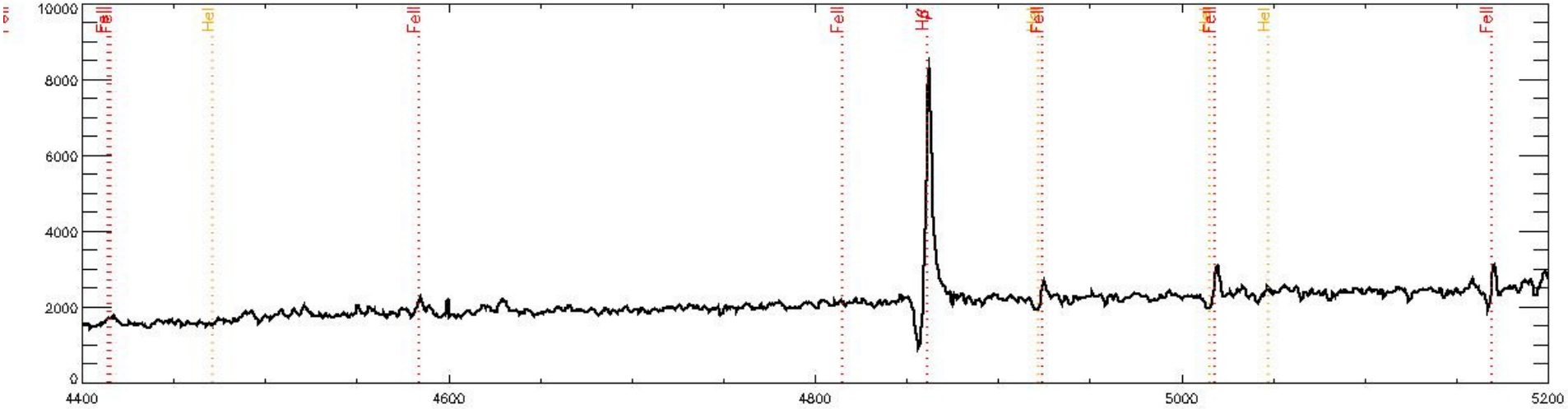




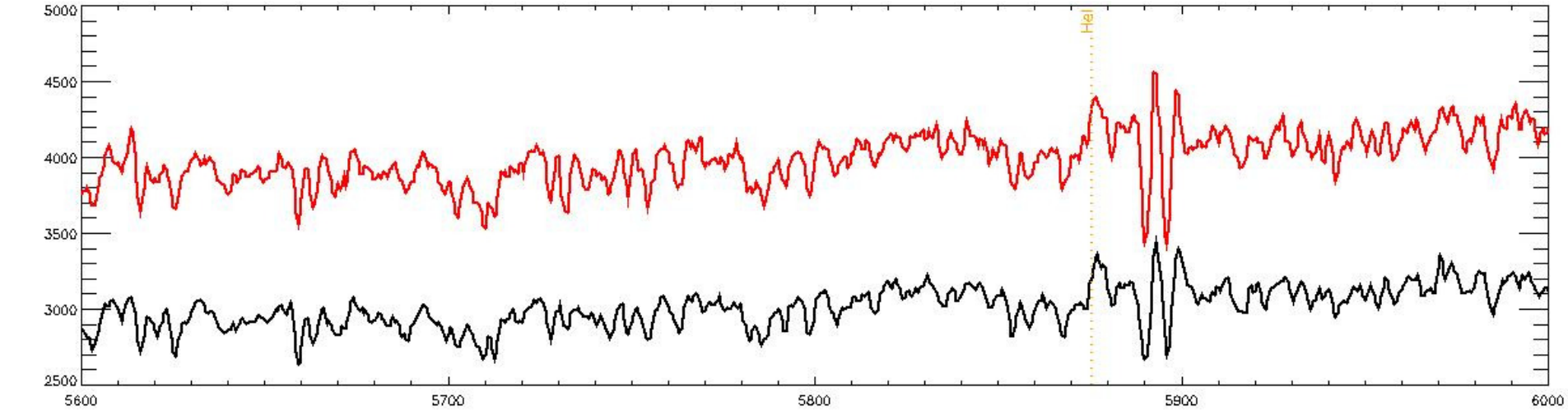


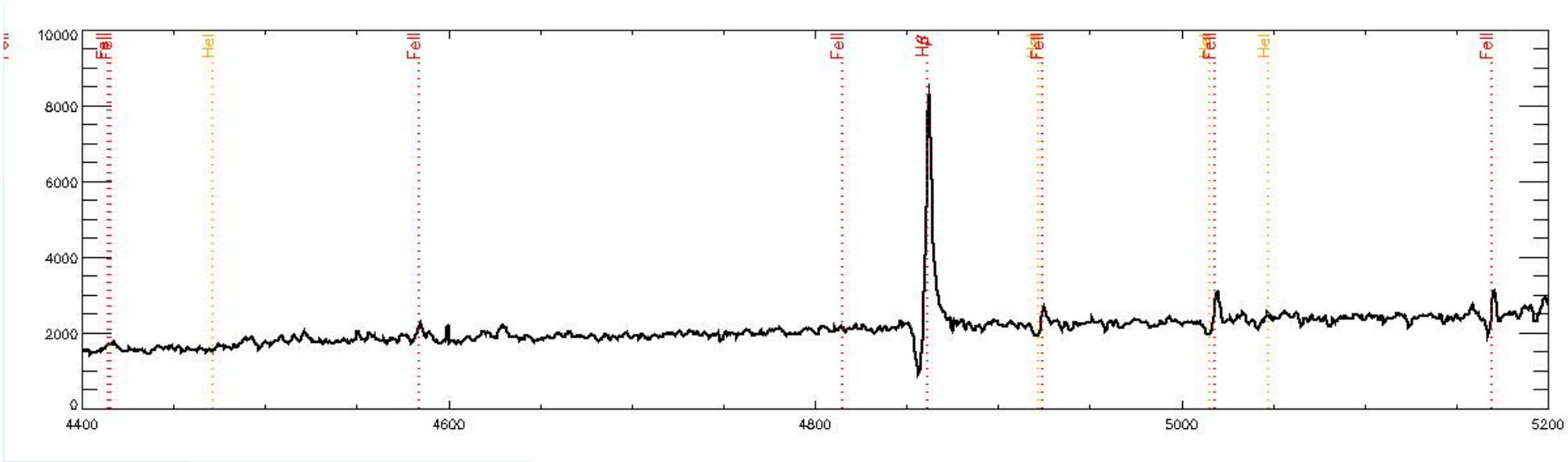


LBVc in IC1613- intermediate temperature



LBVc in IC1613- intermediate temperature





IC1613

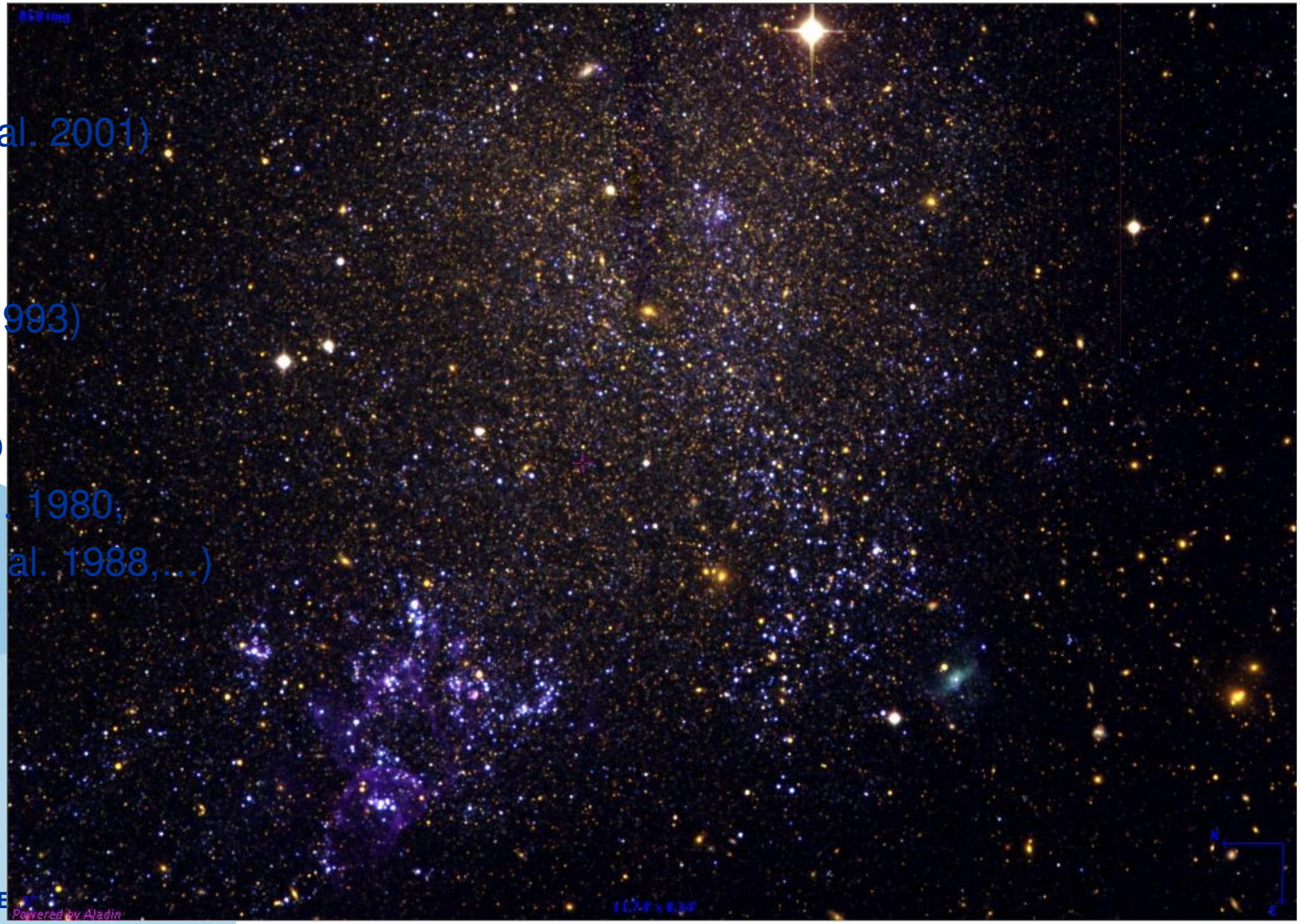
Magellanic Irregular

m-M=24.27
(Dolphin et al. 2001)

E(B-V)=0.02
(Lee et al. 1993)

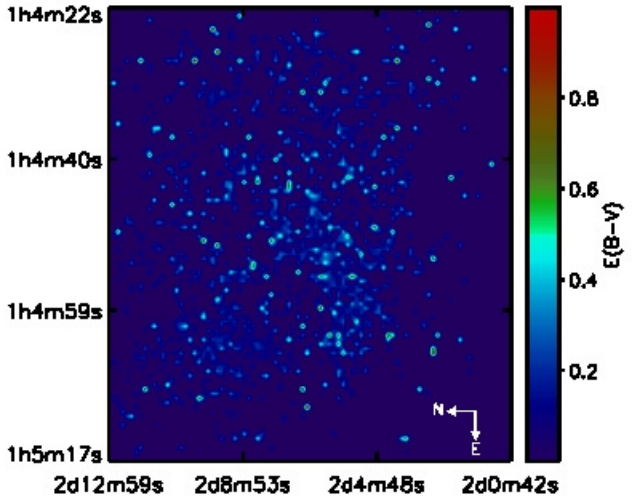
Z=0.04-0.08Zo
(Talent et al. 1980;
Peimbert et al. 1988,...)

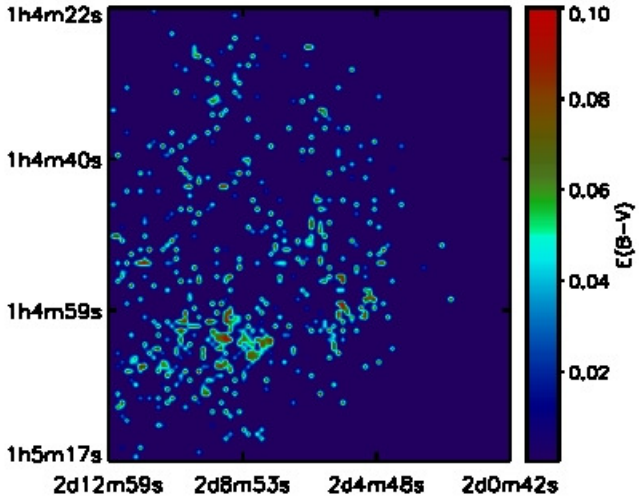
Active
star Formation
at NE

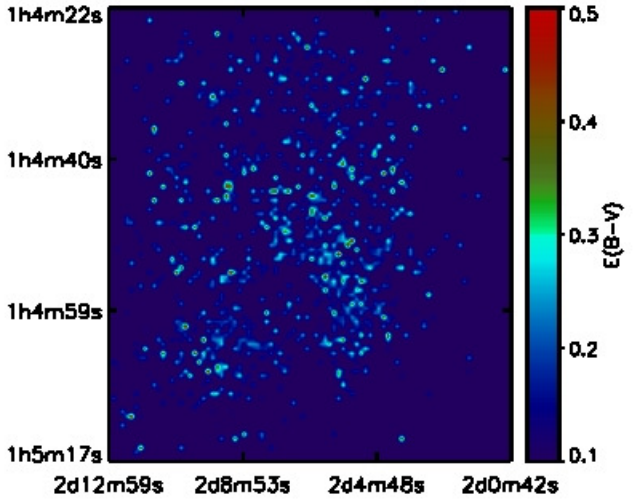


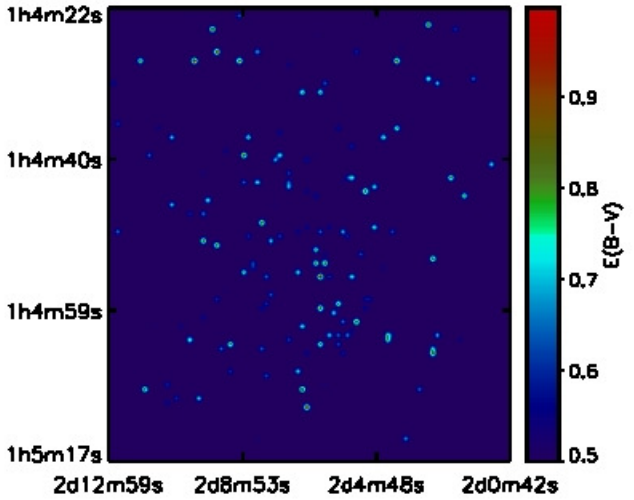
Extinction

Differencial reddening (using Q<->SpType relation)









Red spectra (HR-Orange) of serendipitously found objects