Stellar tracers of the Cygnus Arm

Young open clusters in the outskirts of the Galaxy

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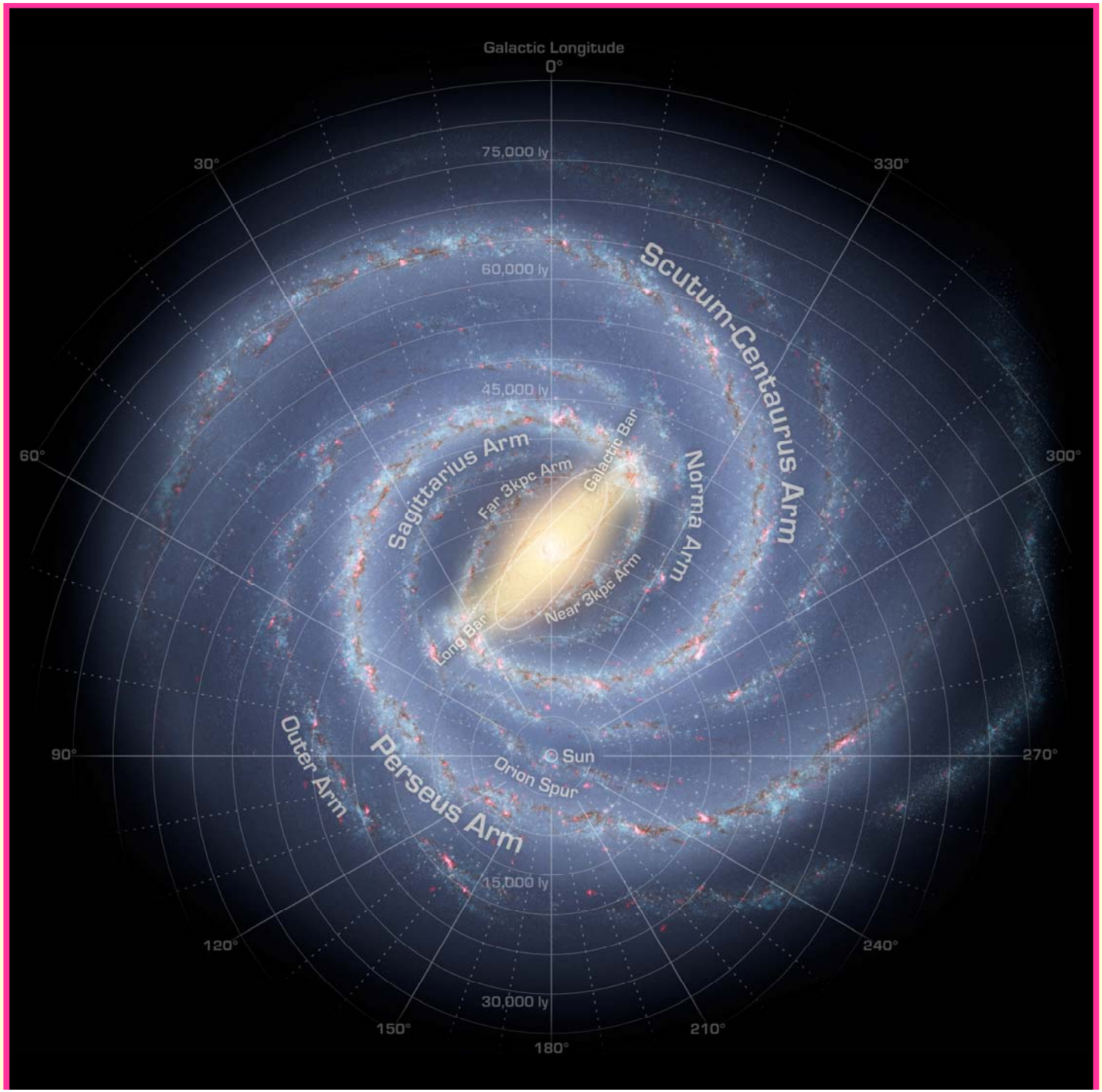

Galactic Longitude
0°
30°
330°
75,000 ly
60,000 ly
45,000 ly
60°
300°
Scutum-Centaurus Arm
Sagittarius Arm
Far 3kpc Arm
Galactic Bar
Norma Arm
Near 3kpc Arm
Long Bar
90°
270°
Outer Arm
Perseus Arm
Sun
Orion Spur
15,000 ly
120°
240°
30,000 ly
150°
210°
180°

Spiral structure tracers

- Molecular Clouds – radial velocities in radio
- HI regions detected at 21 cm - radial velocities in radio
- HII regions detected in emission lines (optical, radio) – radial velocities
- Ionization stars of HII regions - distance.
- Individual OB stars – radial velocities and distances (large dispersion)
- Open clusters and OB associations – more accurate distances
- Cepheids – good distances .

Objectives

✓ Though strong evidence for the existence of the Outer or Cygnus Arm over the second Galactic quadrant is available in the literature, no consistent search for its tracers has been presented.

✓ We started such an investigation by collecting spectra of distant isolated OB stars with OHP telescopes (Negueruela & Marco 2003; A&A 406, 119), finding significant numbers of stars at distances compatible with the Cygnus Arm.

✓ Now, we are continuing this work with optical photometry and spectroscopy of several distant young open clusters to determine their distances and characteristics.

Tracers observed

Photometry

Telescope 1.5-m Calar Alto

- NGC 7067 • NGC 7235 • Be 94 • Be 96

Telescope JKT (La Palma)

- Bochum 1 • Bochum 2 • Ba 9 • Stock 8
- NGC 1893

Telescope 2.2-m (Calar Alto)

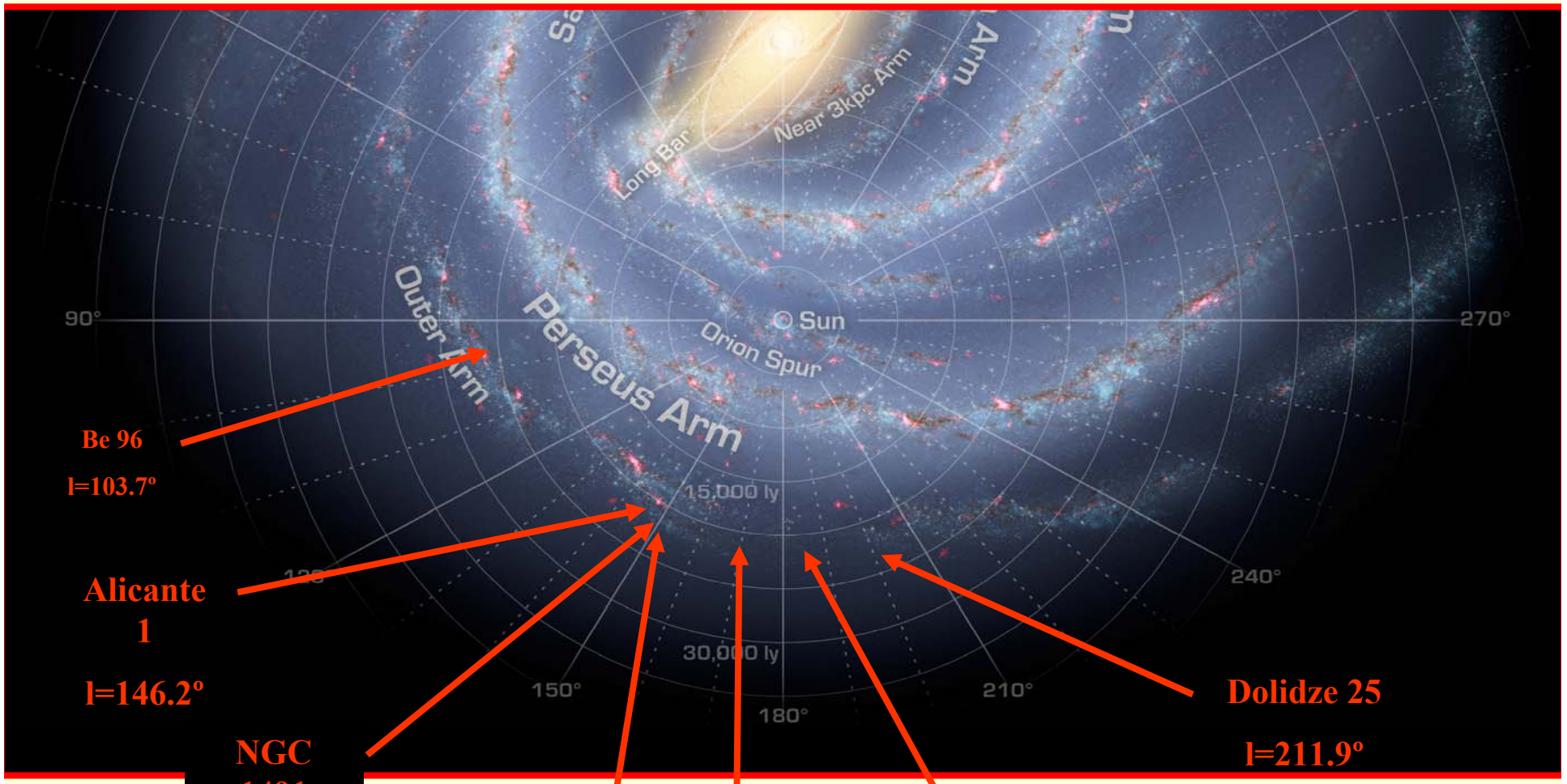
- Alicante 1

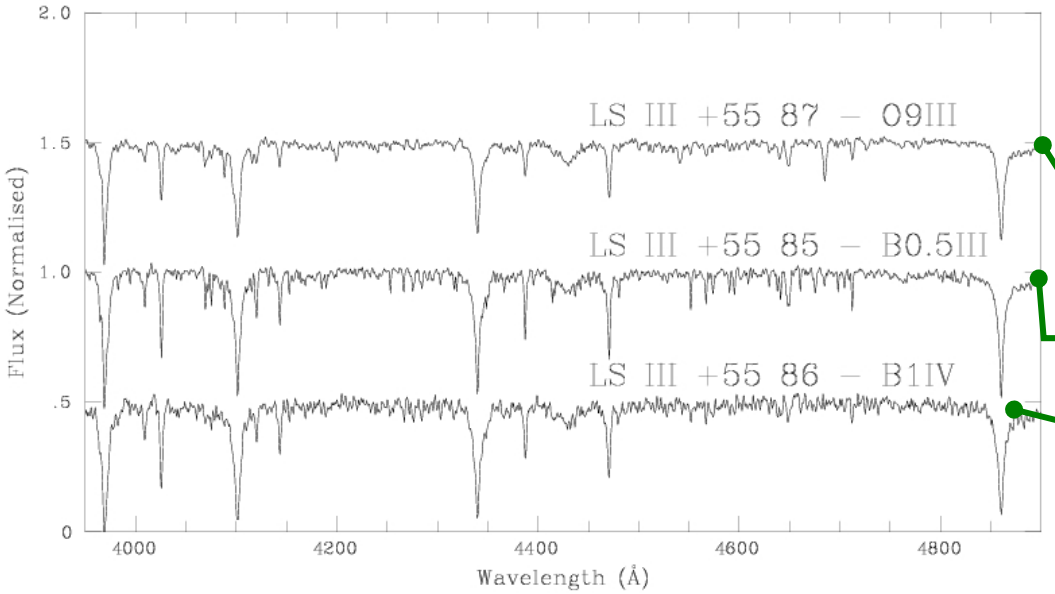
Tracers observed

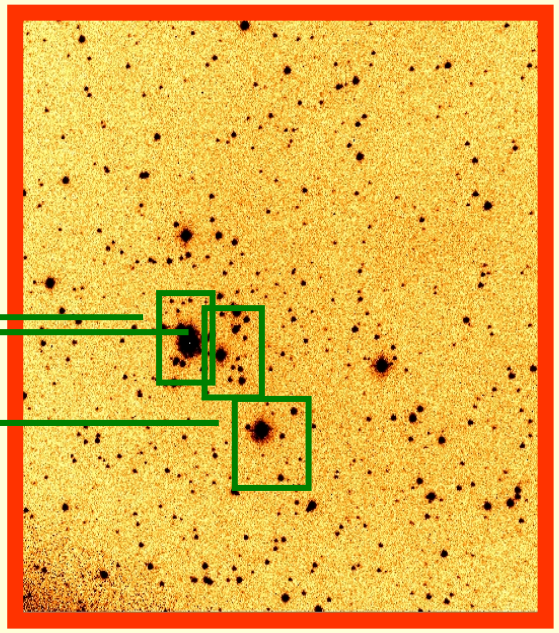
Spectroscopy

- Do 25

- Telescopes used in spectroscopy mode
  (NOT, WHT, INT, Haute-Provence)

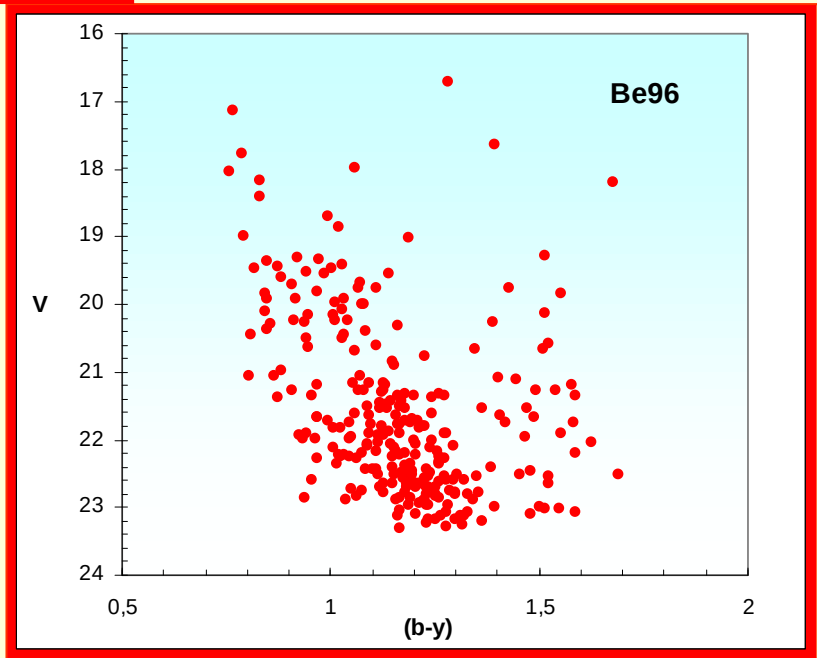

Long Bar
Near 3kpc Arm
Outer Arm
Perseus Arm
Sun
Orion Spur
90°
270°
15,000 ly
30,000 ly
150°
180°
210°
240°
Be 96
l=103.7º
Alicante 1
l=146.2º
NGC 1491
l=150.6º
Waterloo 1
l=151.2º
NGC 1893
l=175.6º
Bochum 1
l=192.4º
Dolidze 25
l=211.9º

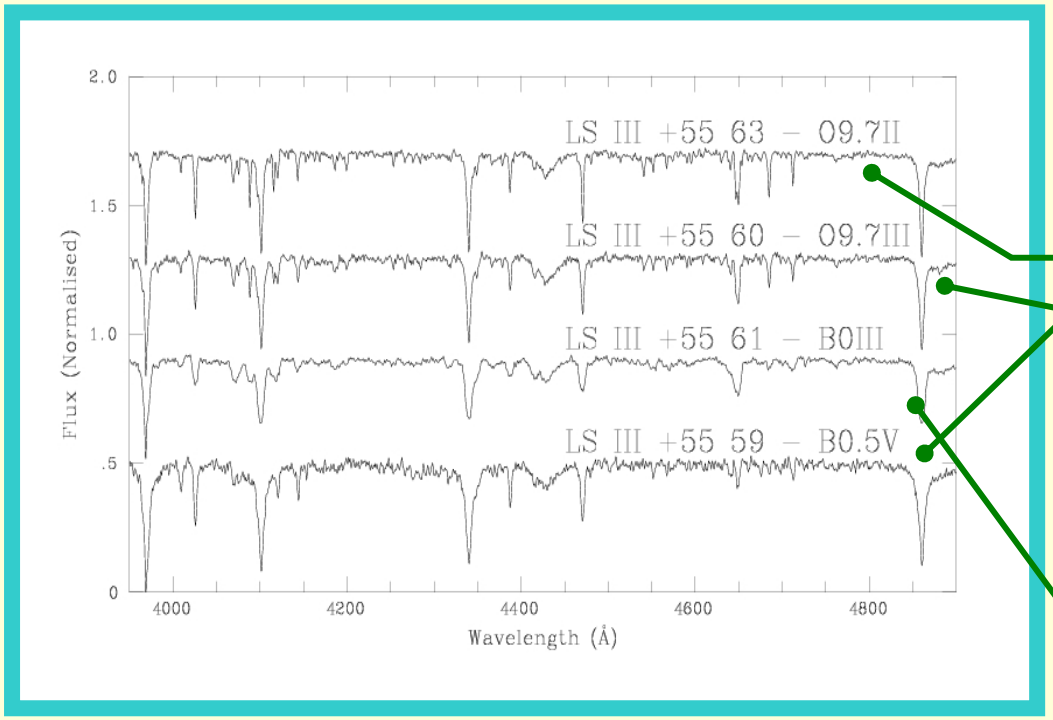


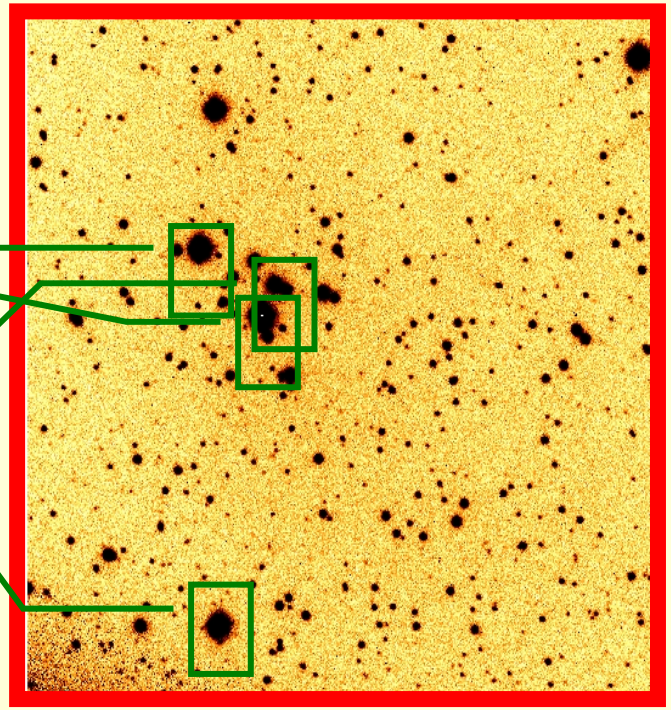


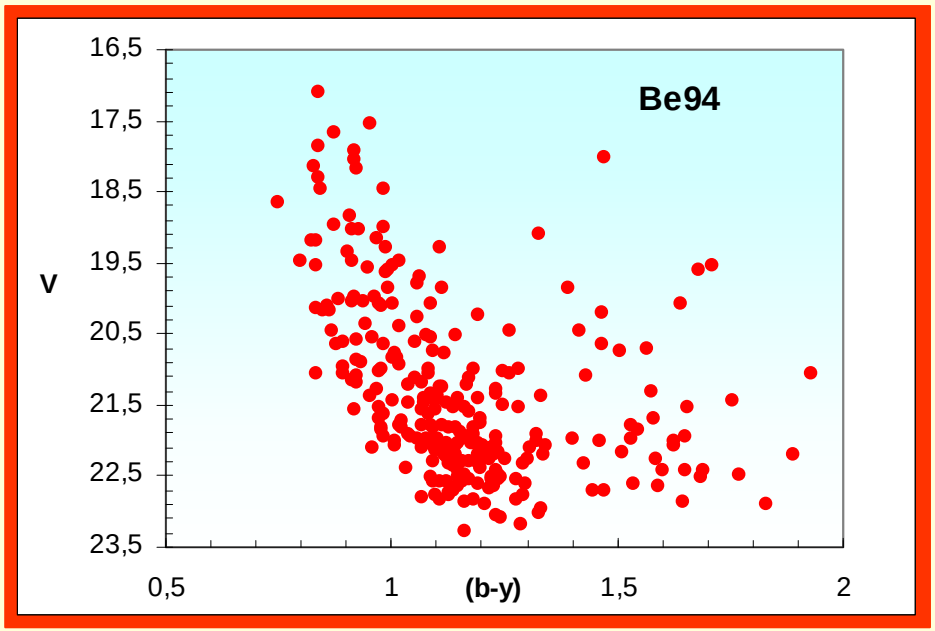
Berkeley 96

The image is a 200 s *b*-band exposure of the field. Our photometric diagram is in instrumental magnitudes. Spectroscopic distance is 14.2±0.2 based on 3 members (photometry from del Río 1984, A&AS 56, 289)



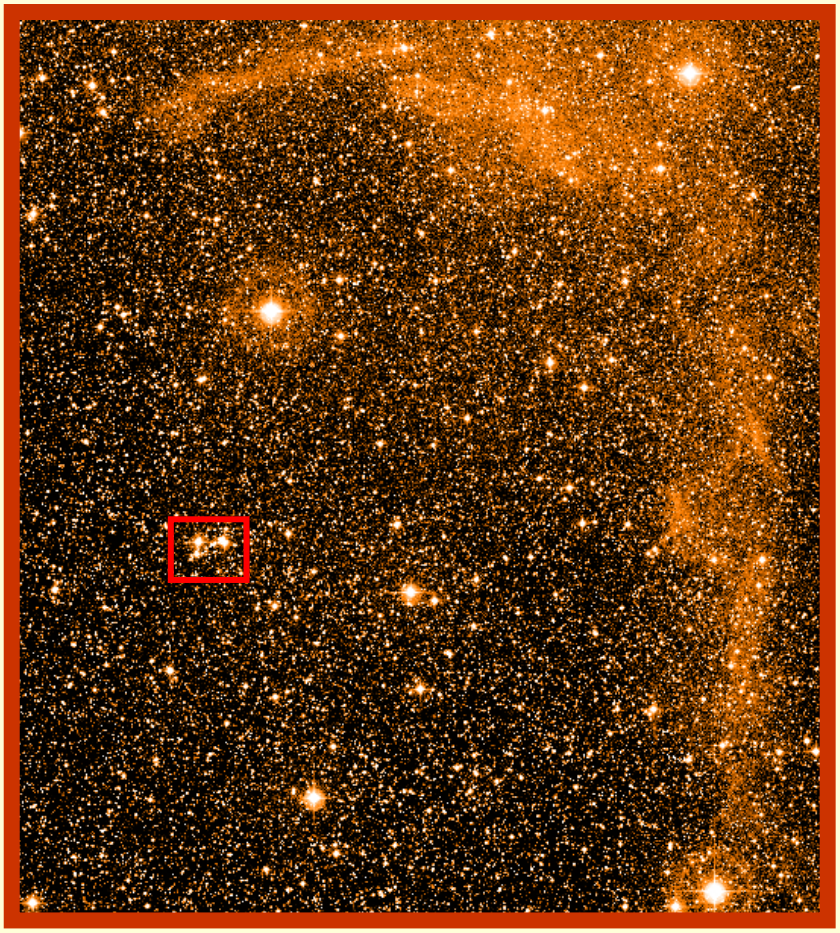




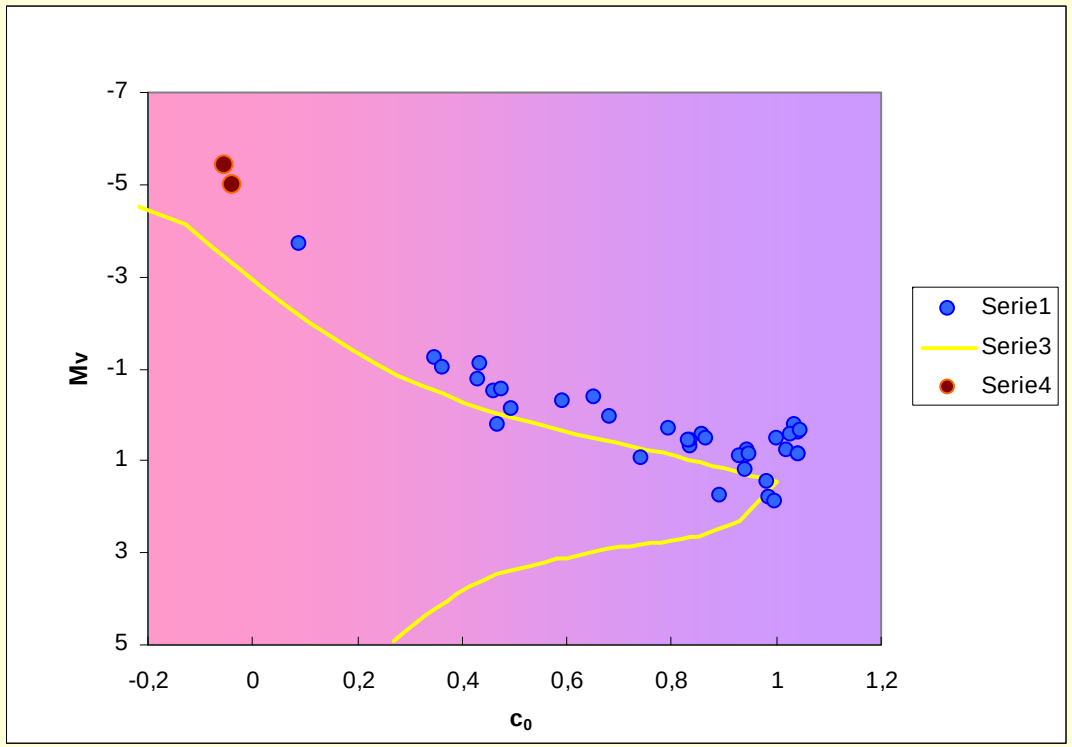


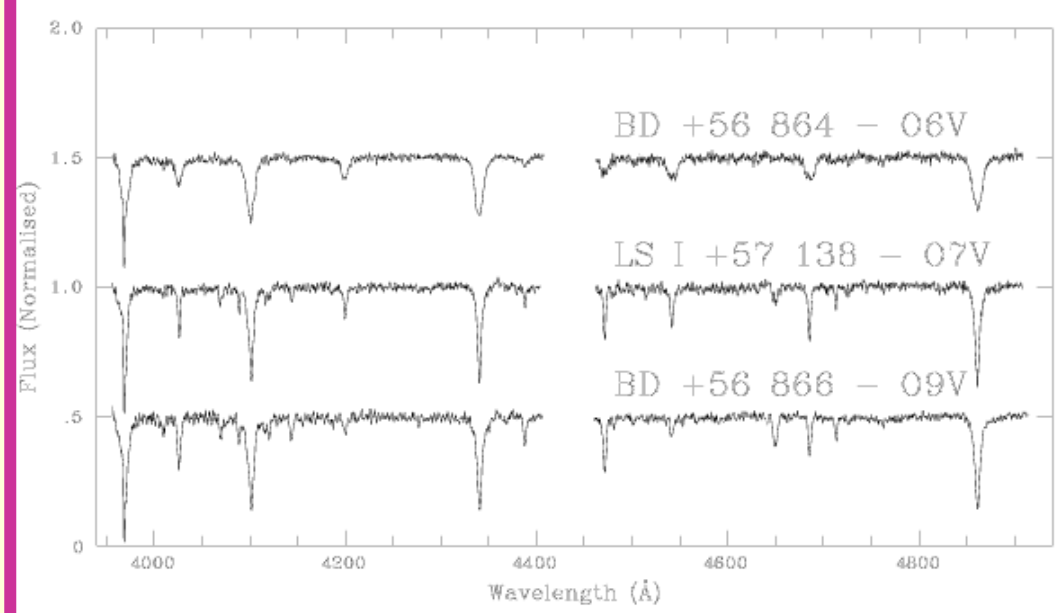
Berkeley 94

The image is a 200 s *b*-band exposure of the field. Our photometric diagram is in instrumental magnitudes. Spectroscopic distance is 13.6±0.5 based on 4 members (photometry from Wramdemark 1978, A&A 66, 137)

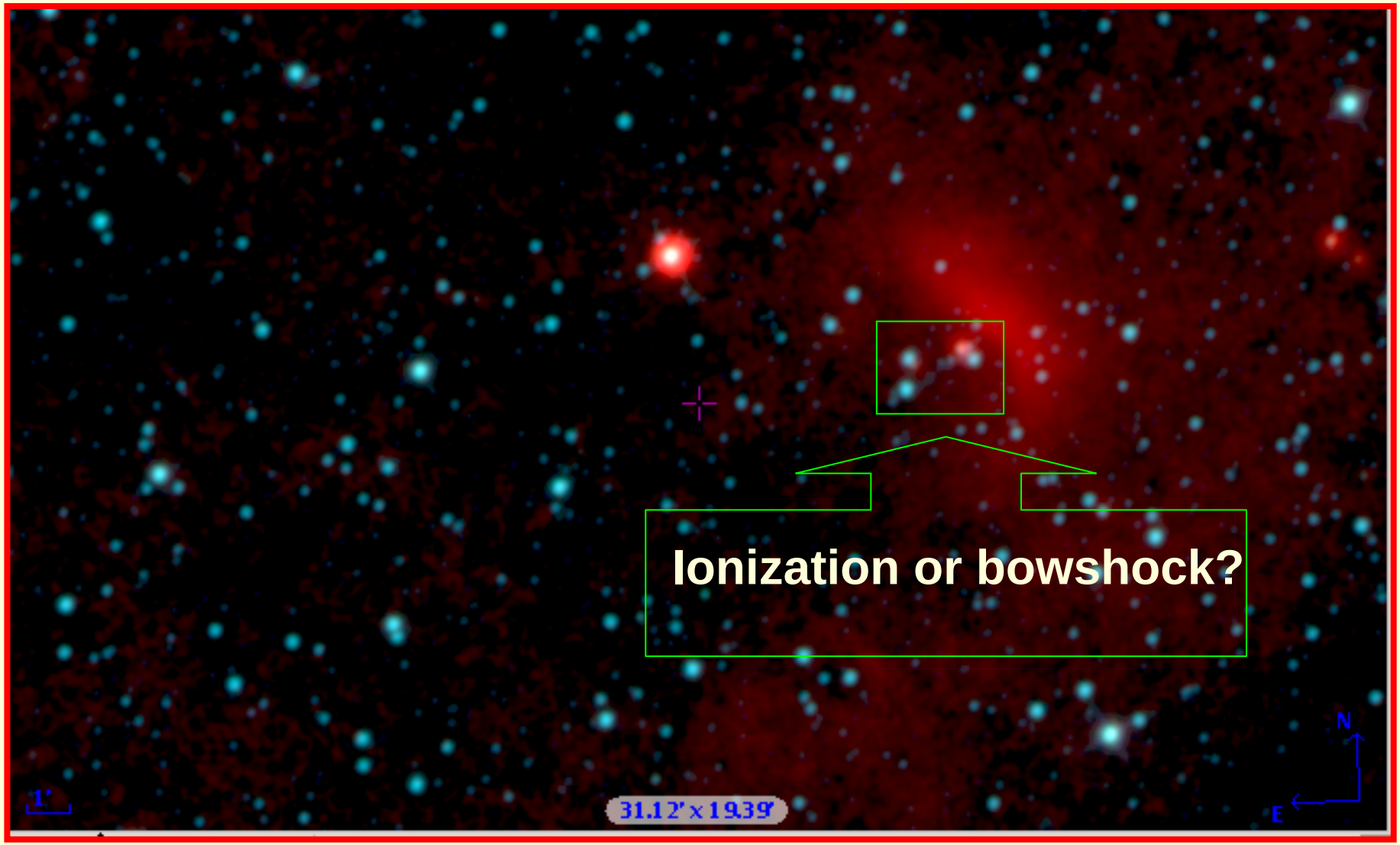


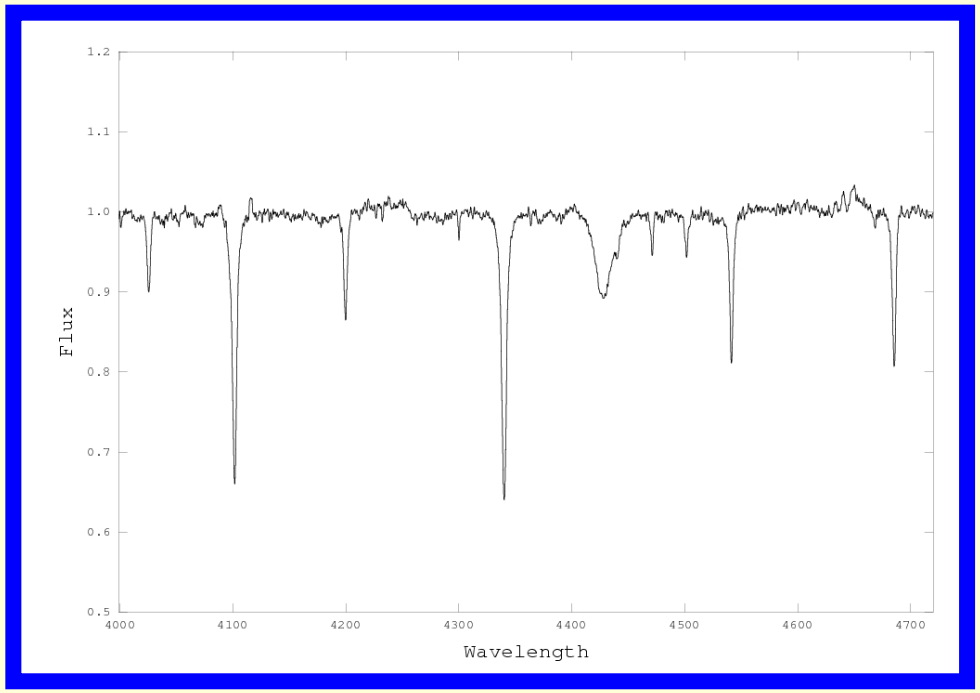
Alicante1 **is the first open cluster found in the Cam OB3 association (Negueruela & Marco 2008; A&A 492, 441). We have determined a distance of 4.0 kpc to this cluster and the surrounding association. As shown by the top figure, the two O-type stars in Alicante 1 are the ionisation source of the H II region Sh2-204.**

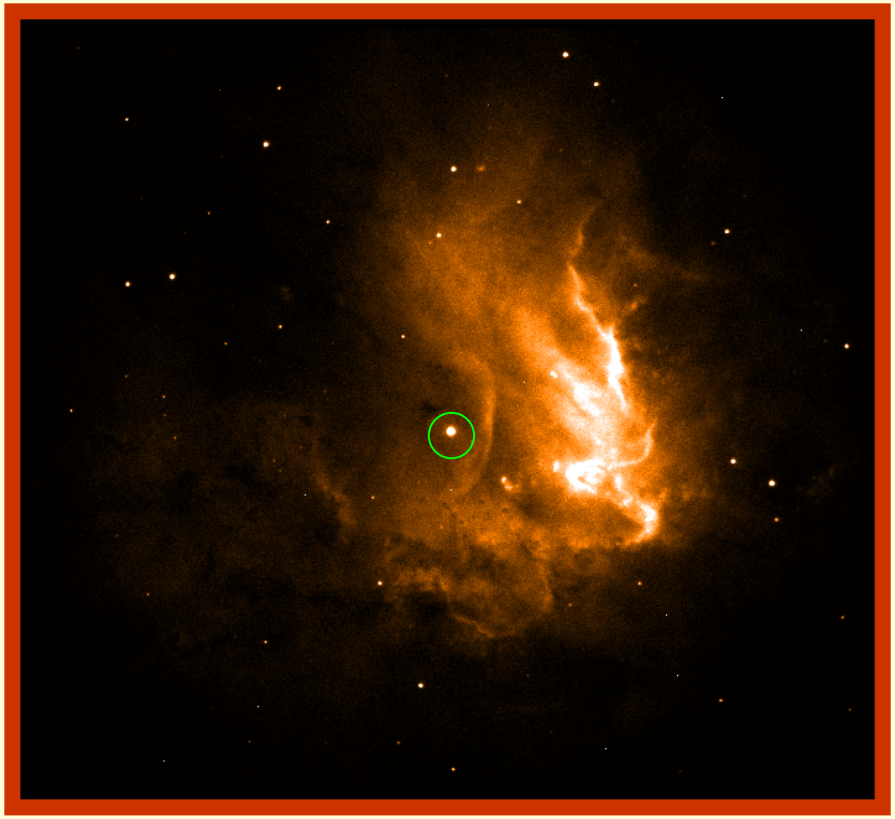

-7
-5
-3
-1
1
3
5
Mv
-0,2
0
0,2
0,4
0,6
0,8
1
1,2
c0
Serie1
Serie3
Serie4


2.0
1.5
1.0
.5
0
Flux (Normalised)
BD +56 864 – O6V
LS I +57 138 – O7V
BD +56 866 – O9V
4000
4200
4400
4600
4800
Wavelength (Å)

WISE image (mid-infrared)

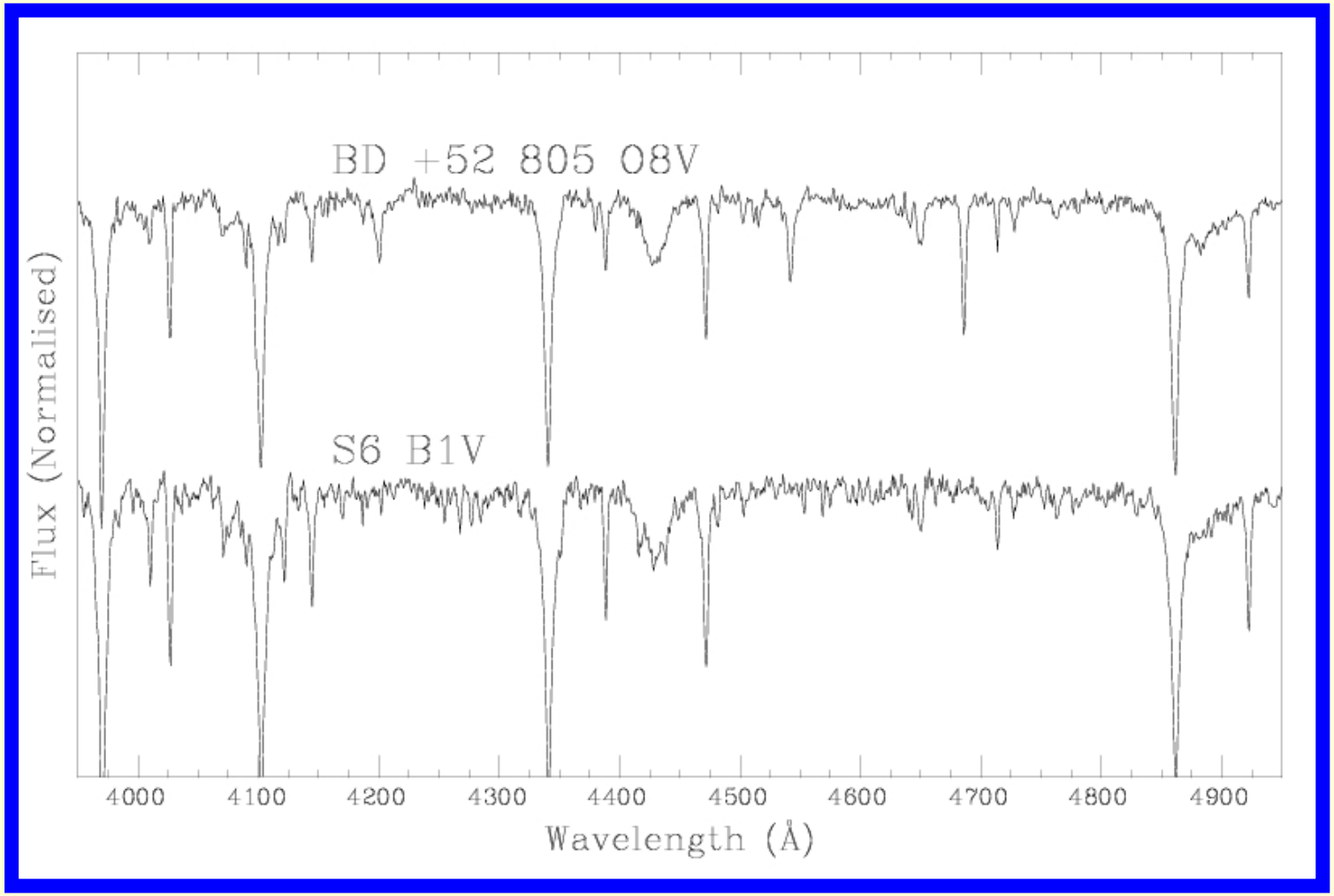






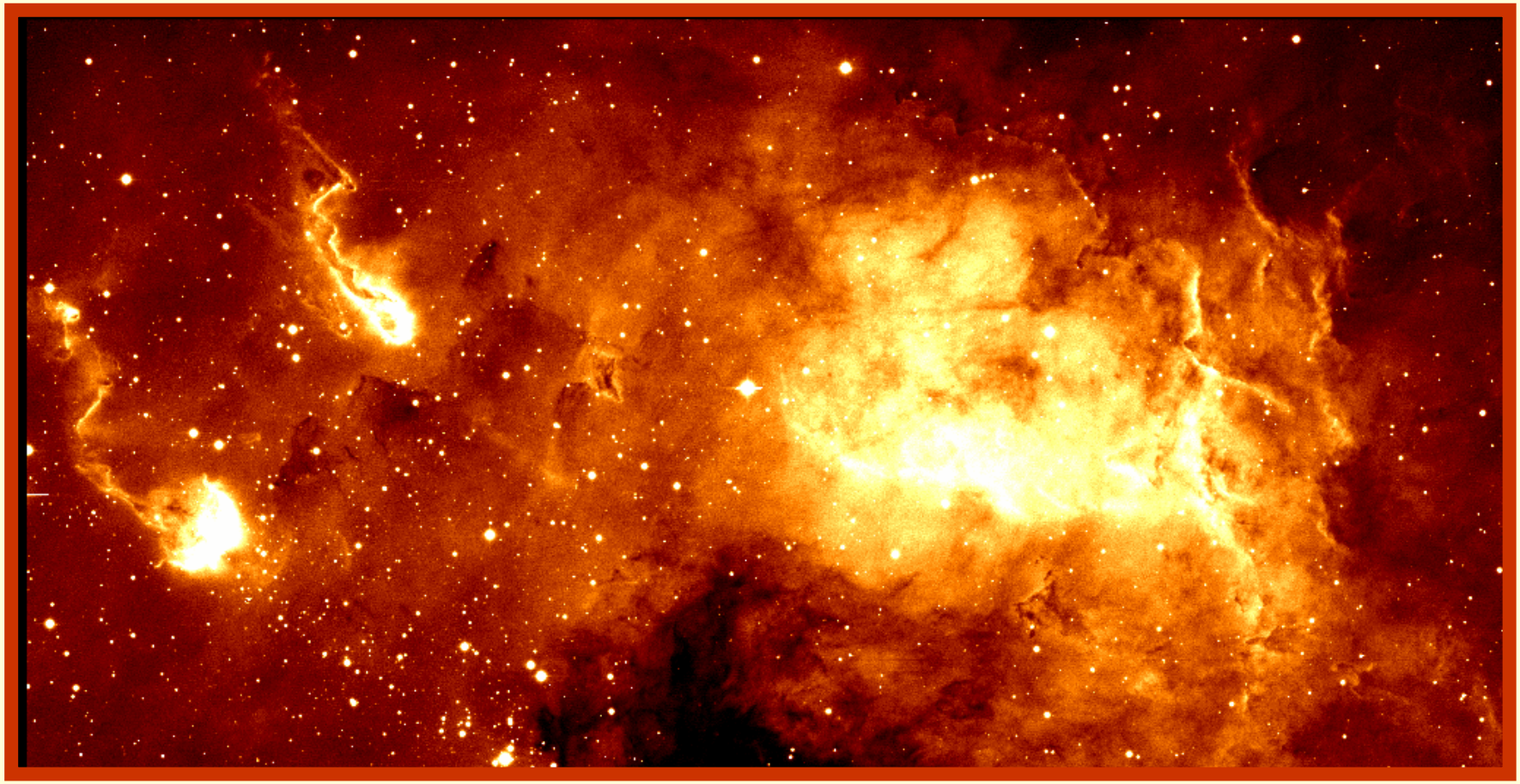
NGC 1491 (shown in a NOT/ALFOSC Hα image) is ionised by the star BD +50° 886. Our spectrum shows that it is an O4 V star, likely to be very massive, but it seems to be isolated. We are searching for other stars that may be cluster members.

Waterloo 1

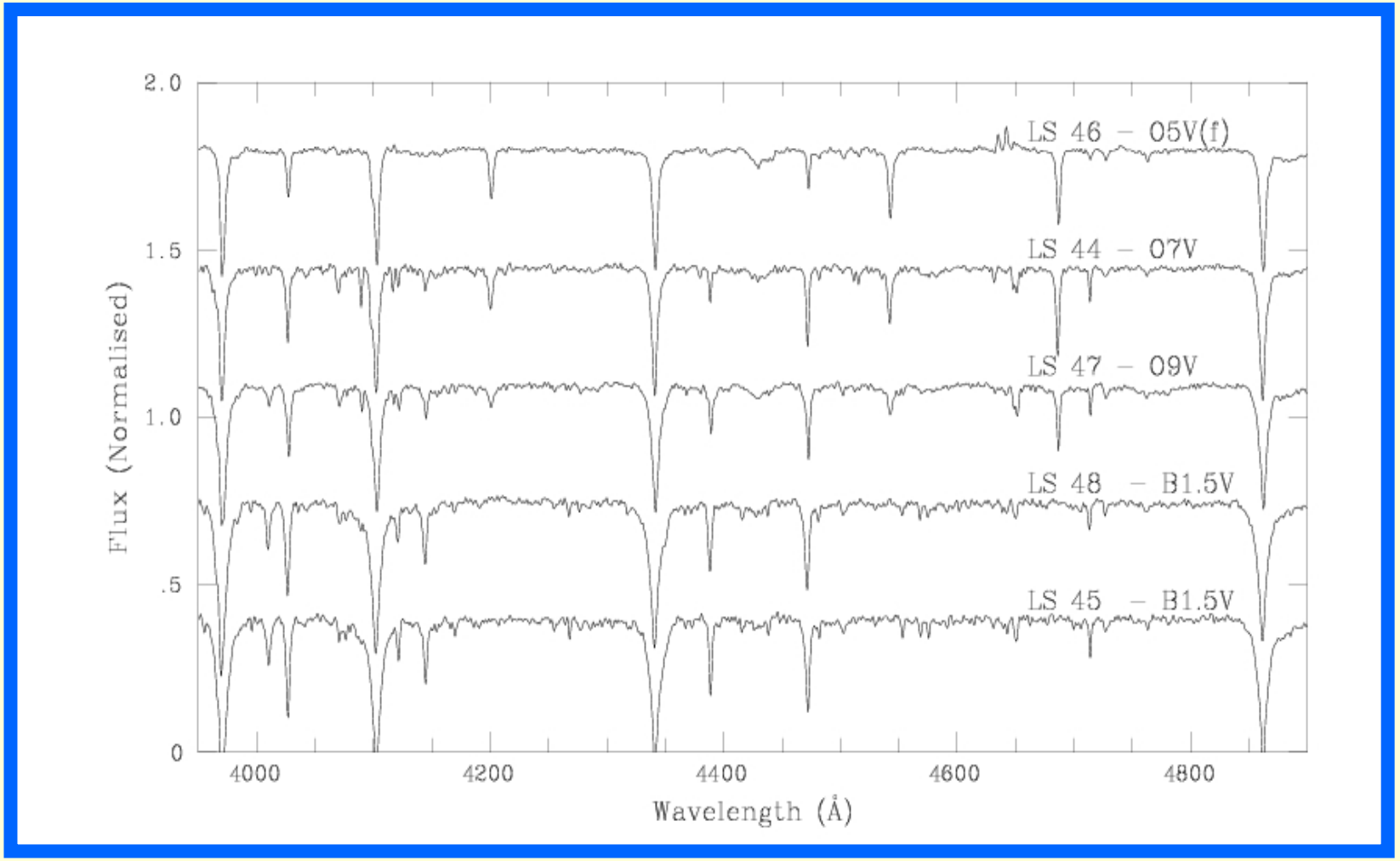


Previous study: Moffat et al. 1979, A&AS, 38, 197M

NGC 1893



NGC 1893 is likely the most massive cluster known in the Cygnus Arm, at a distance of ~5 kpc. We have studied its IMF and triggered star formation in the area (Negueruela et al. 2007, A&A 471, 485)



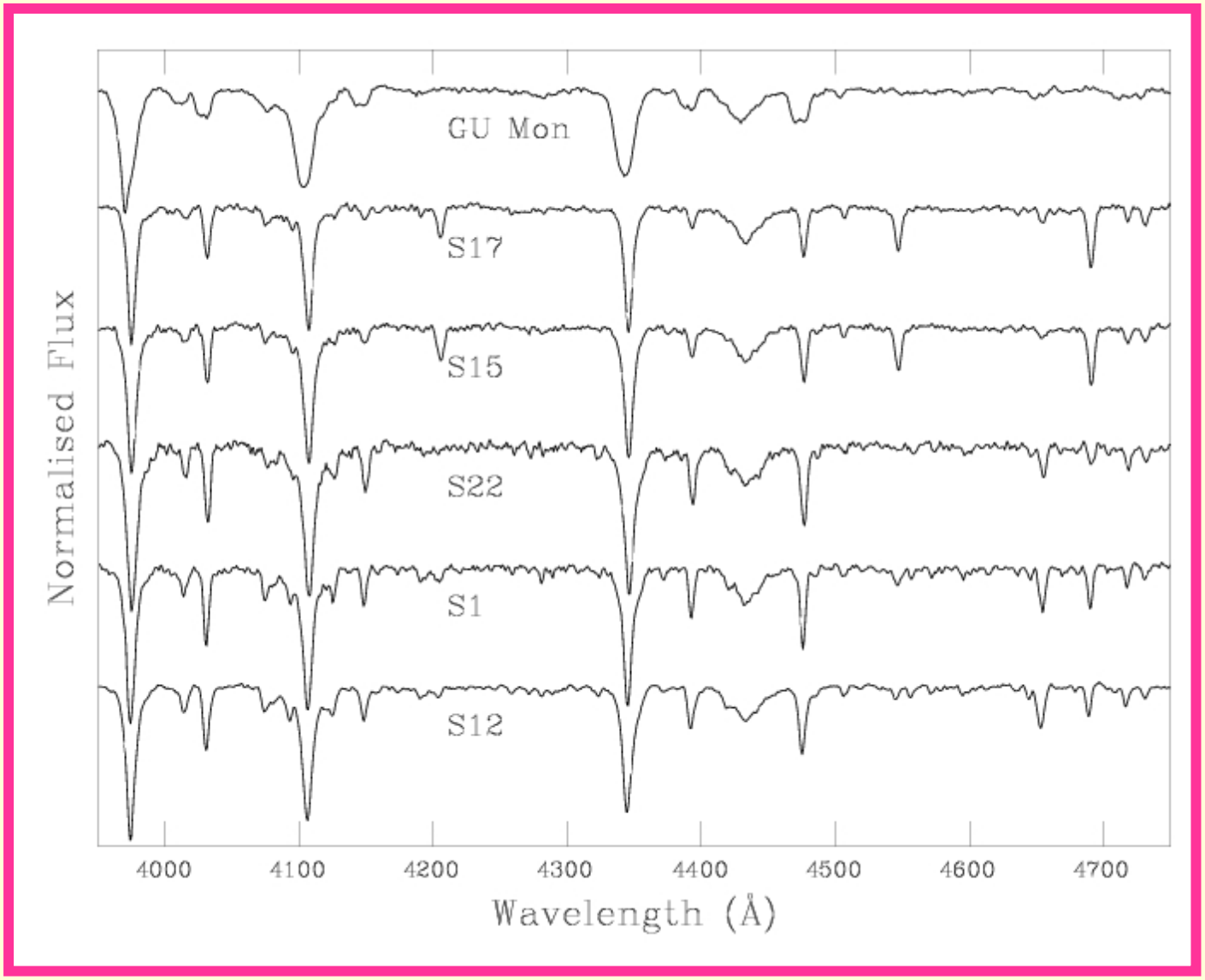
Bochum1. **Spectra of 5 stars in Bochum 1. The spectroscopic distance is $(M\text{-}m)_0 = 13.7 \pm 0.3$, based on the spectral types for 5 members and photometry from Moffat & Vogt (1975, A&AS 20, 85). However, there are 3 other OB stars in the field which have $(M\text{-}m)_0 = 12.0$.**


RGBimg~2
4206 5717 5003
1'
45.35' x 37.76'
N
E

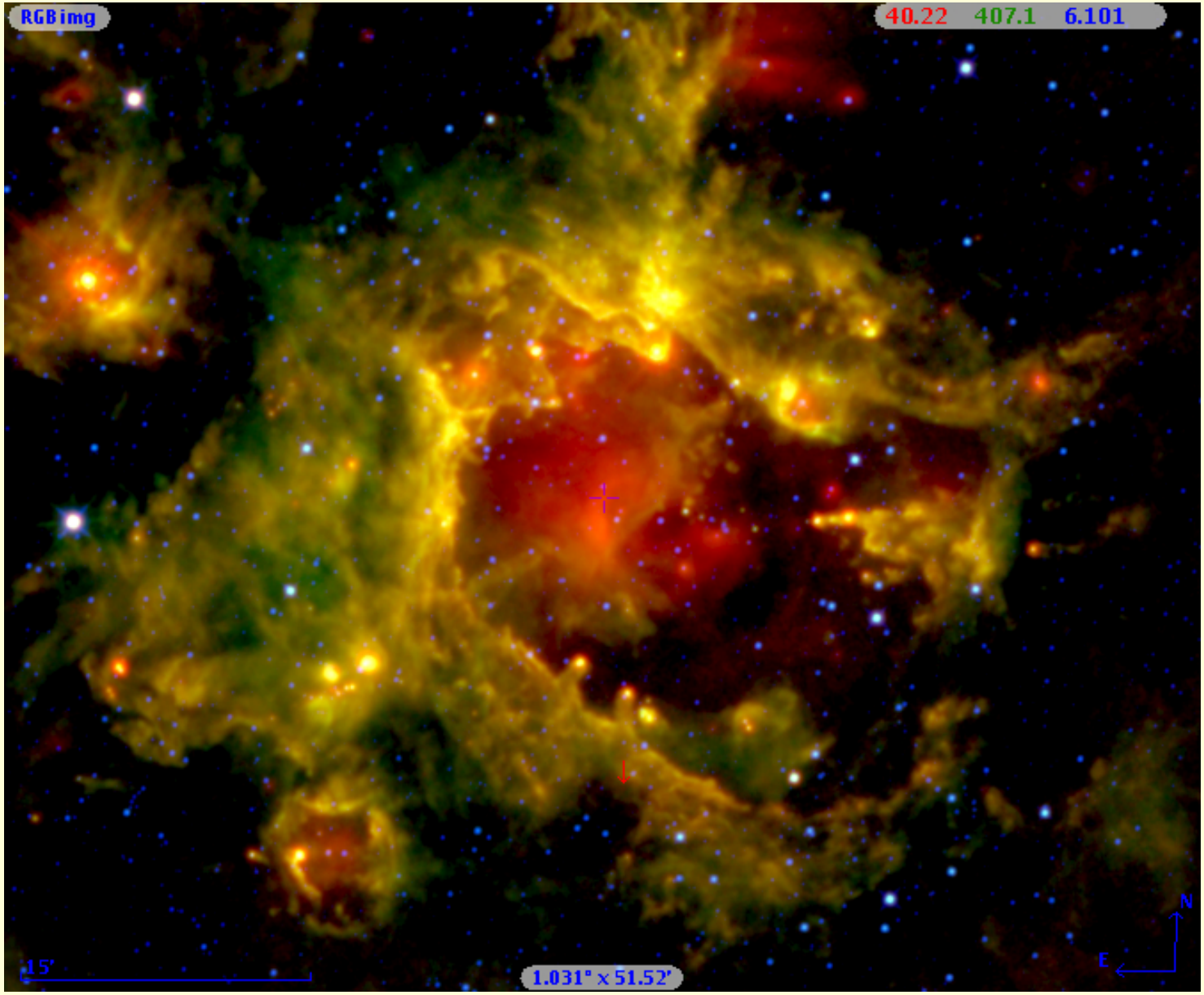
Dolidze 25

- Star forming cluster in the Anticenter (d=5-6 kpc)
- Claimed to have low metallicity (Lennon et al. 1990, A&A, 240, 349)
- In COROT field
- Studied with Spitzer data (Puga et al. 2009, A&A, 503, 107)
- FIES spectra to determine metallicity (Sergio Simón)

Dolidze 25


GU Mon
S17
S15
S22
S1
S12
Normalised Flux
4000
4100
4200
4300
4400
4500
4600
4700
Wavelength (Å)

WISE image (mid-infrared)



Future needs

- High resolution spectroscopy
  (Radial velocity and abundances)
- High multiplexing spectroscopy
  (Low mass PMS stars)
- GAIA to determine accurate distances and proper motions