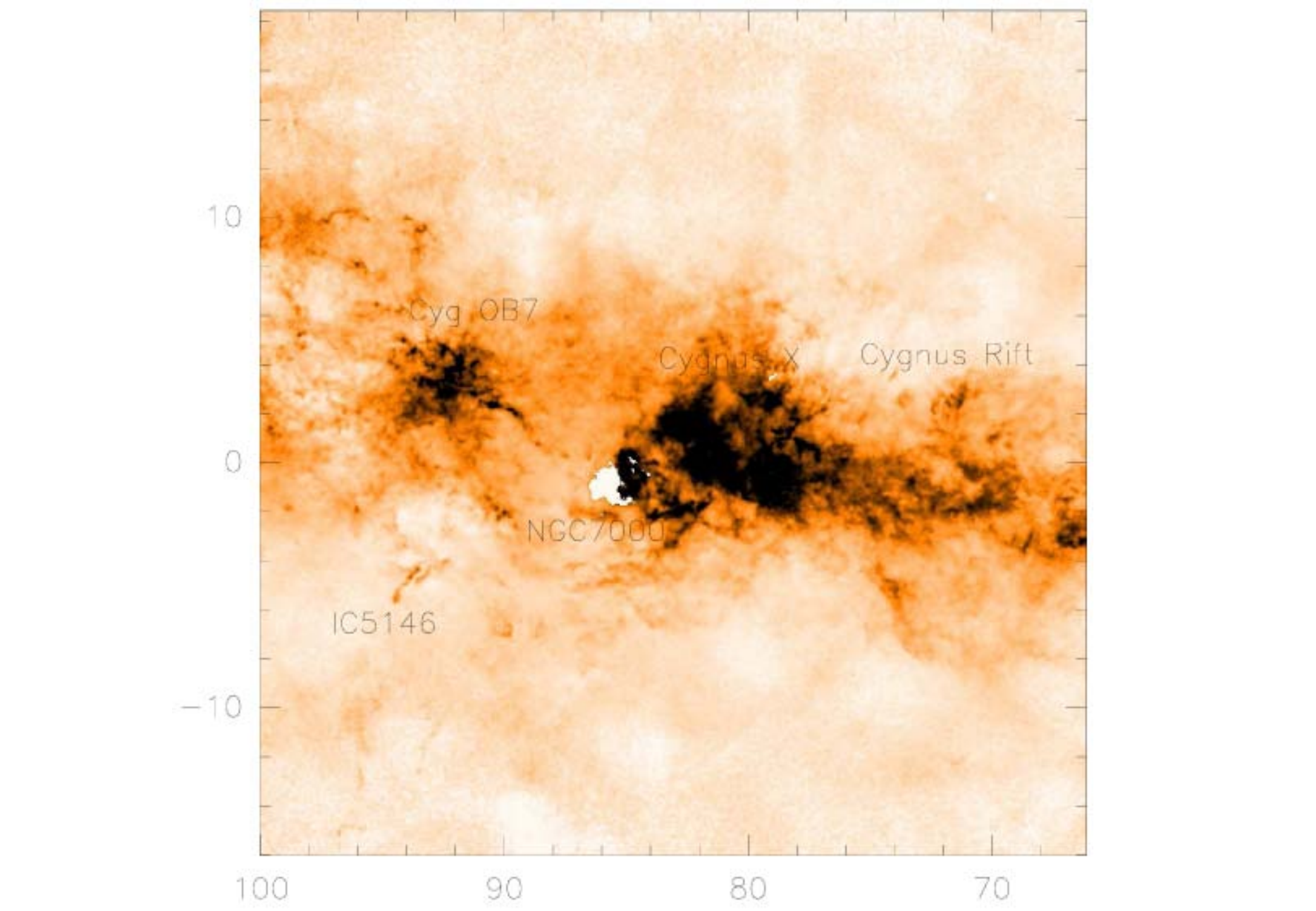
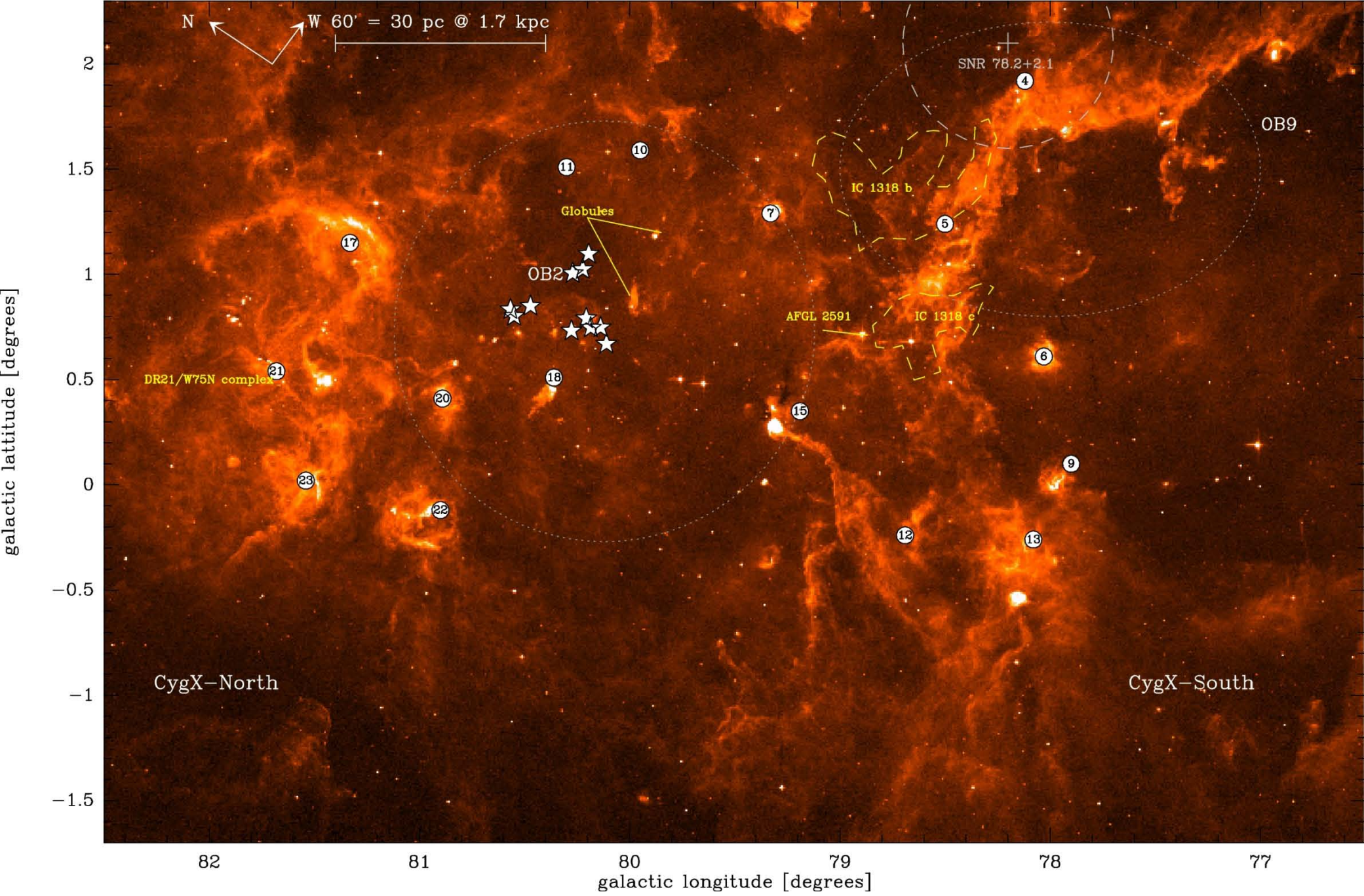
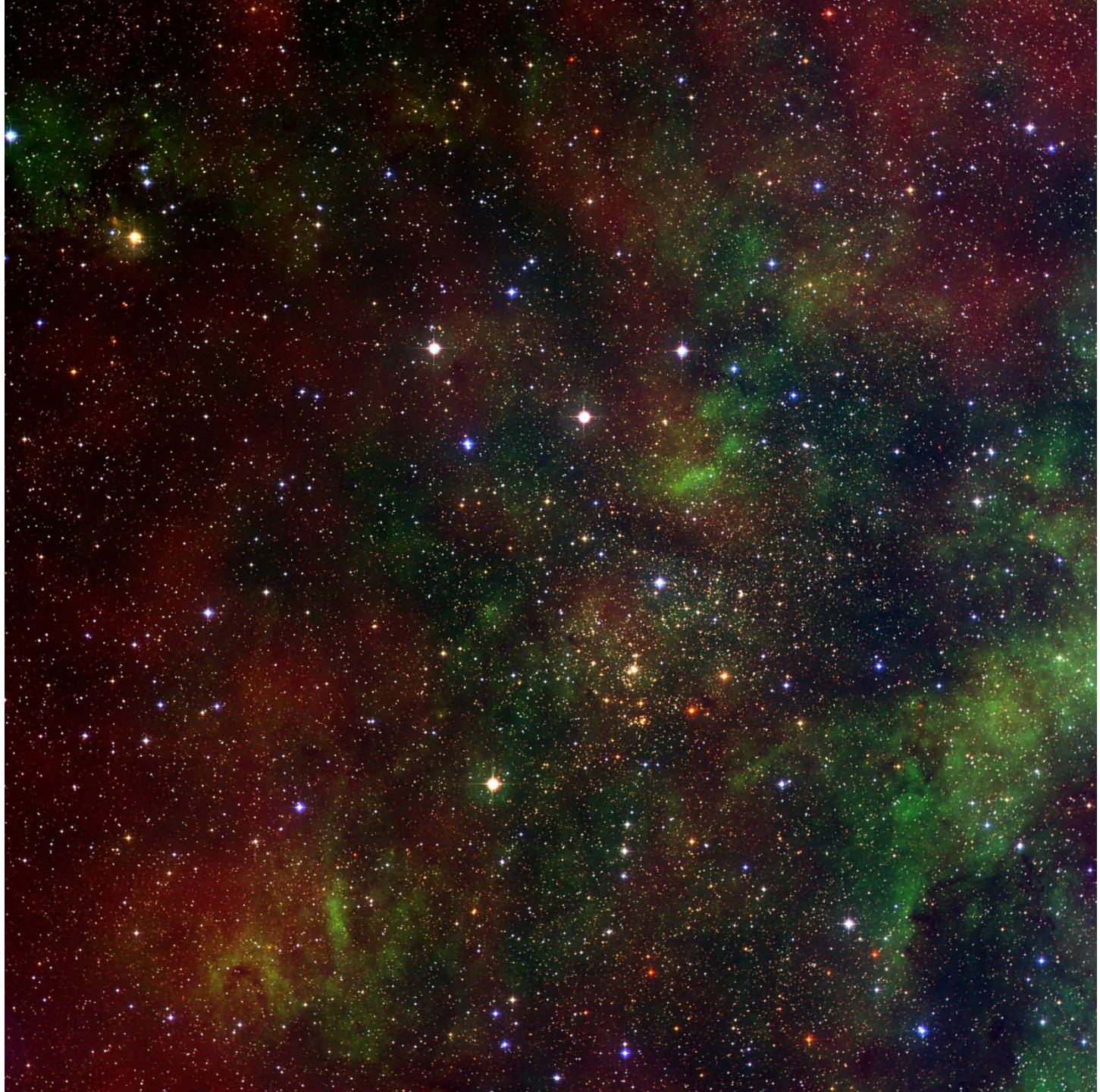

In and around
the rich association Cygnus OB2
F. Comerón
50
YEARS
1962–2012
ESO


10
0
−10
100
90
80
70
Cyg OB7
Cygnus X
Cygnus Rift
NGC7000
IC5146


N
W 60' = 30 pc @ 1.7 kpc
SNR 78.2+2.1
OB9
IC 1318 b
Globules
OB2
AFGL 2591
IC 1318 c
DR21/W75N complex
CygX−North
CygX−South
galactic lattitude [degrees]
galactic longitude [degrees]
2
1.5
1
0.5
0
−0.5
−1
−1.5
82
81
80
79
78
77



Why Cygnus OB2 and its surroundings?

- The nearest very massive association (comparable to Westerlund 1, NGC 3603...), at 1.5 kpc
- Cygnus OB2 displays examples of the whole upper main sequence zoo: LBVs, Of, B[e], WR…, in addition to main sequence.
- Lighly obscured stellar component relatively well studied, but census far from complete and very inhomogeneously studied
- Related to nearby associations and nearby star forming regions (Cyg OB9, Cygnus X…)

How are superclusters born?

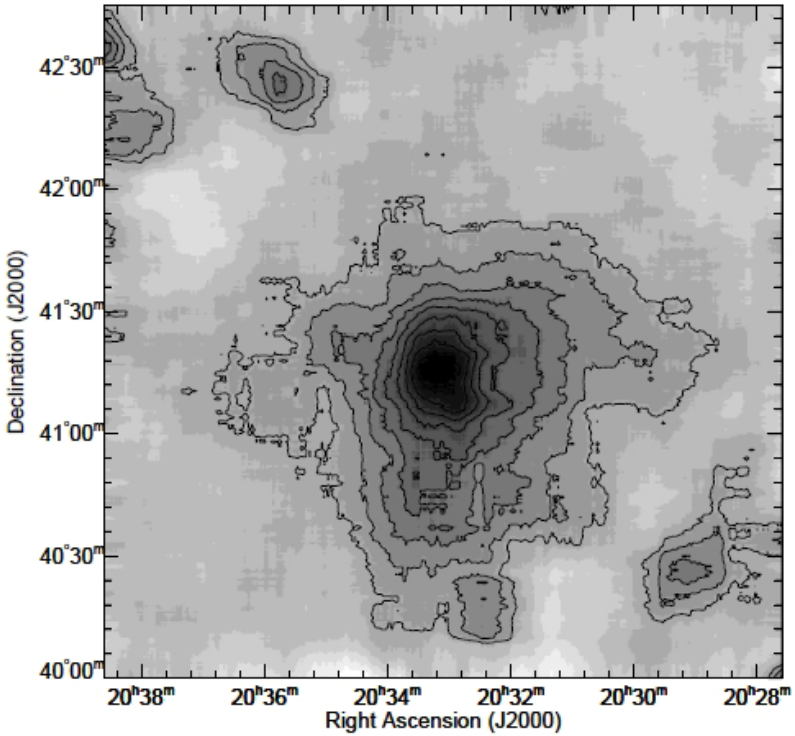
What is its star formation history?

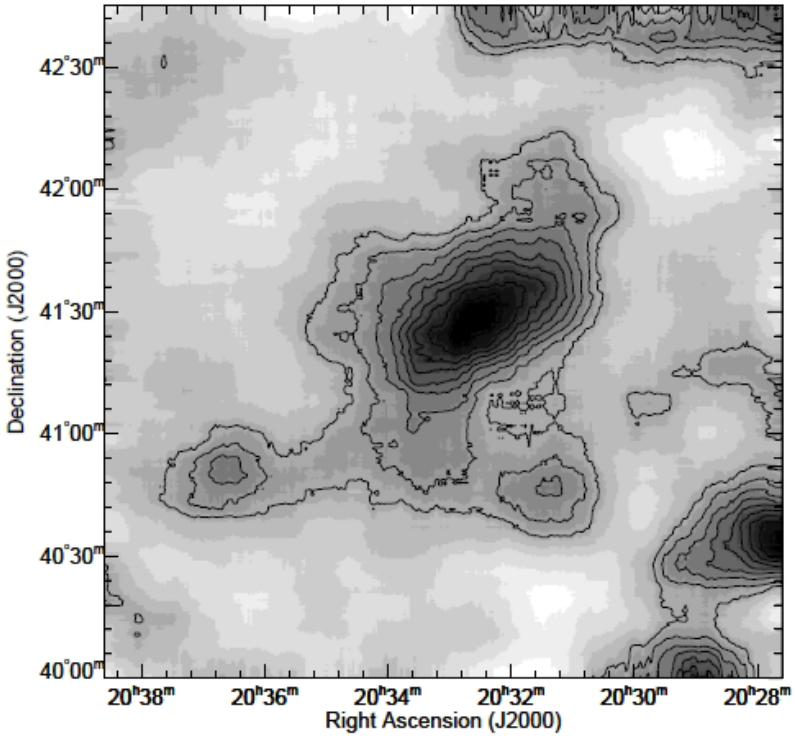
How has it shaped the interstellar medium in the region?

What is its energy input in its surroundings?

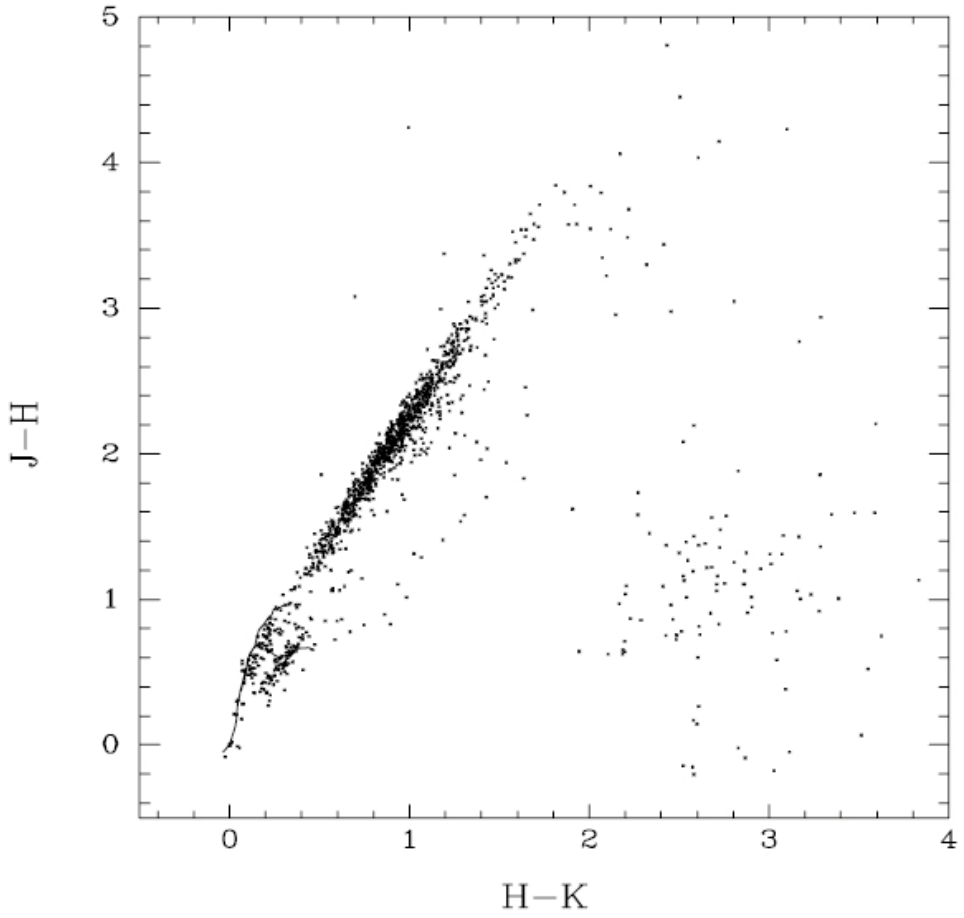
Unveiling the stellar component…

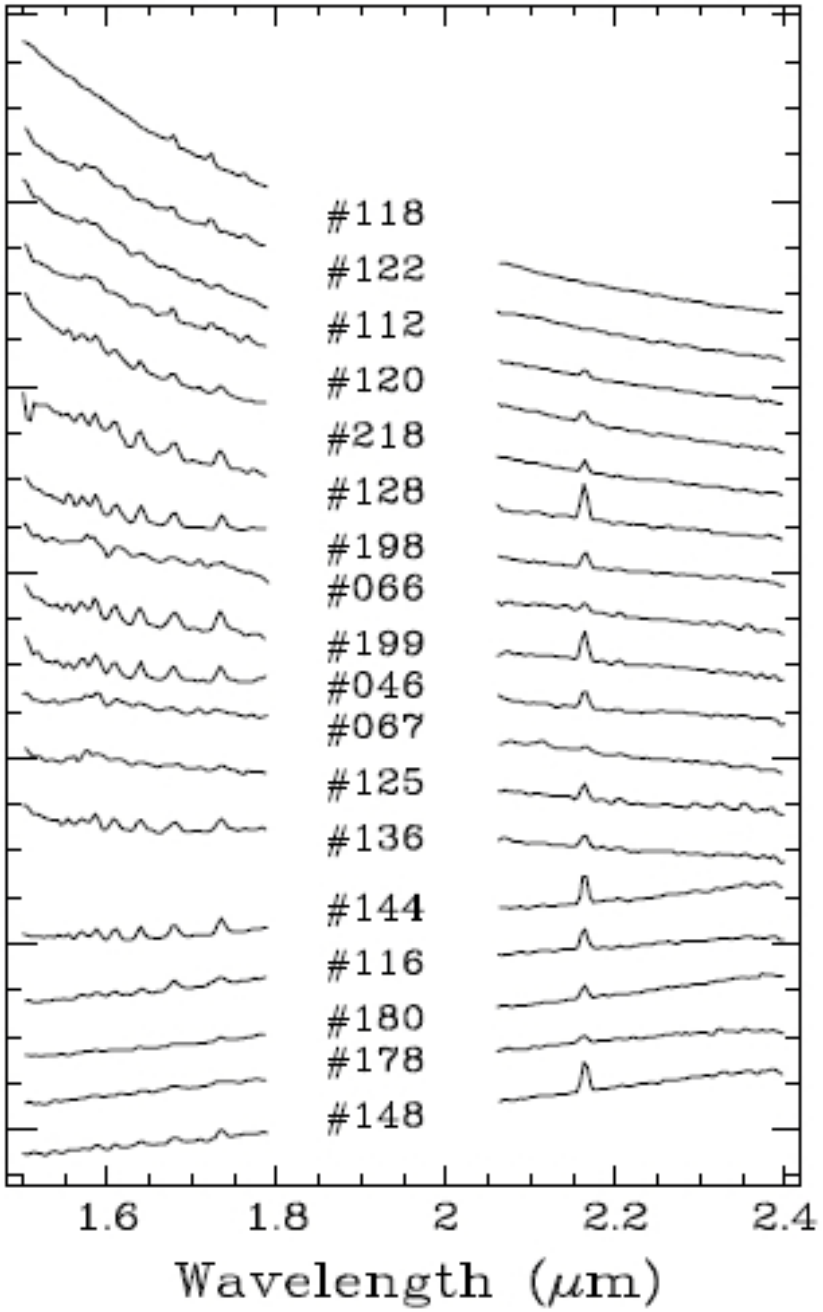
- 1953: association discovered by Münch and Morgan
- 1956-1958: further members added by Schulte
- 1991-1995: most thorough study in the visible, region around the central cluster, by Massey et al.
- 2000: 2MASS starcount-based study by Knödlseder suggests that Cyg OB2 may be as rich as a young globular cluster and shows more deeply embedded extensions



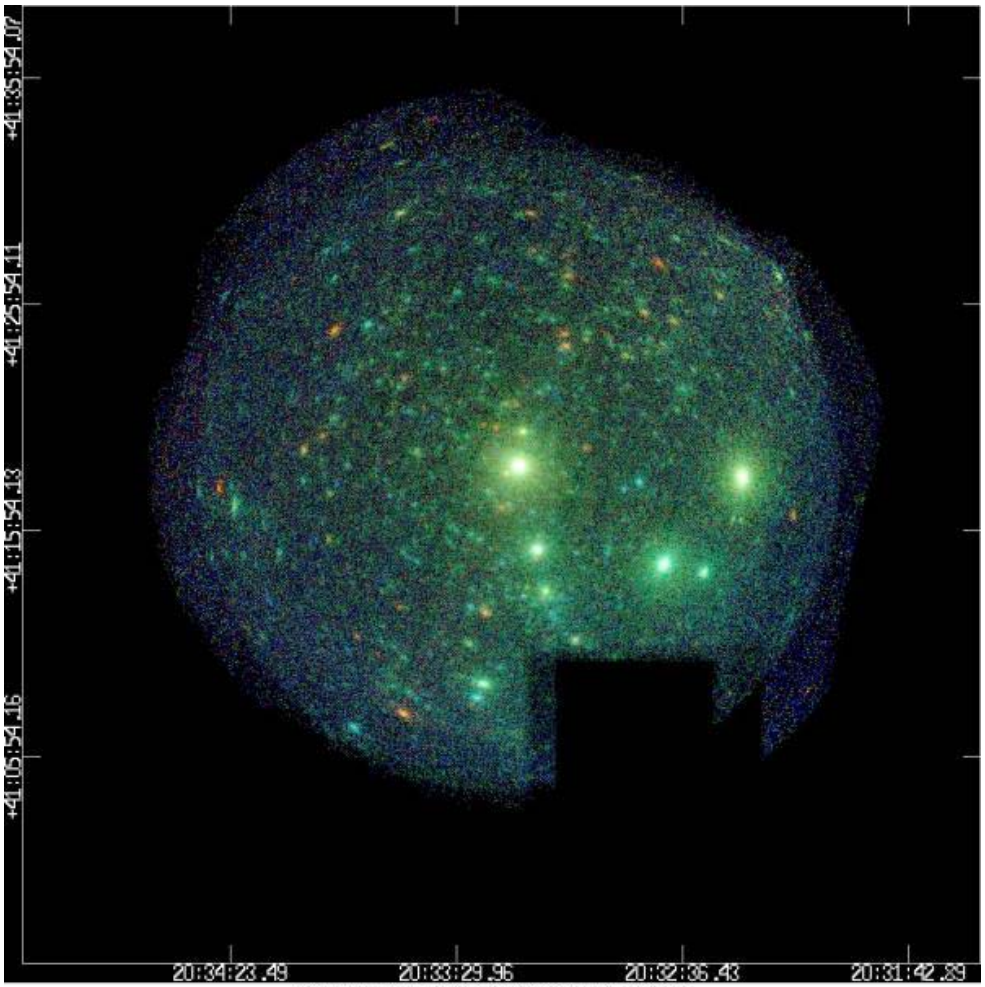


- 2002: NIR spectroscopy of (J-H), (H-K)-selected members by Comerón et al. provides many new embedded O- and B-star candidates

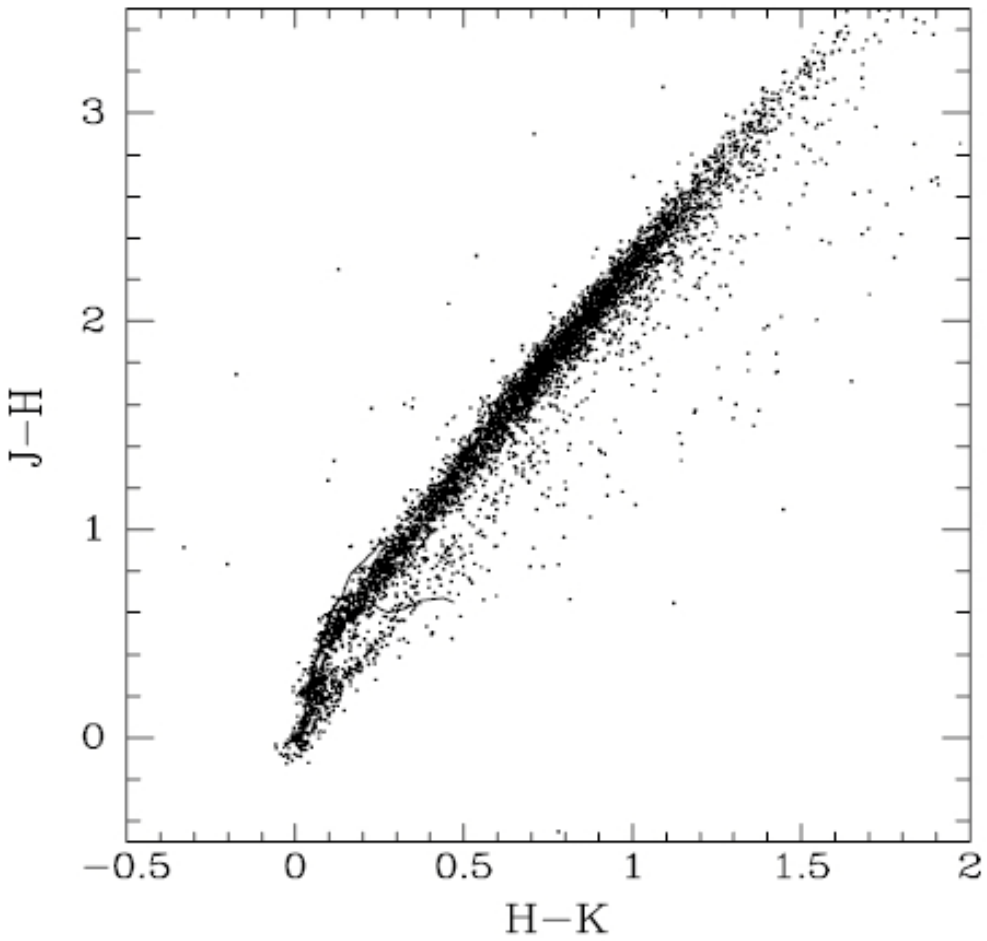


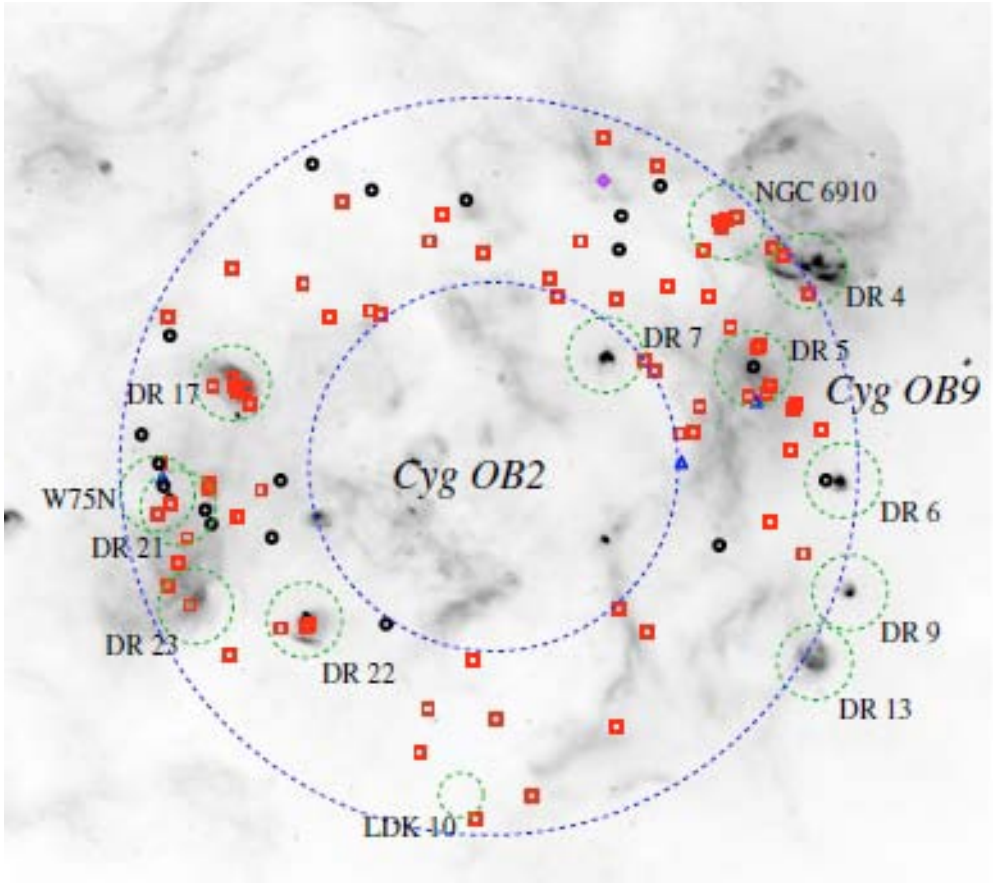


- 2003: Hanson confirms that all of the lightliest embedded stars from Comerón et al. 2002 are early-type, but most of them evolved B stars, suggesting an older population
- 2008: Drew et al. (IPHAS) find many likely A stars, mainly adjacent to the visible cluster, also suggesting an old age
- 2007-2011: XMM and Chandra X-ray imaging by Albacete Colombo et al. and Wright et al. reveal lower-mass components, reinforcing evidence for an older population

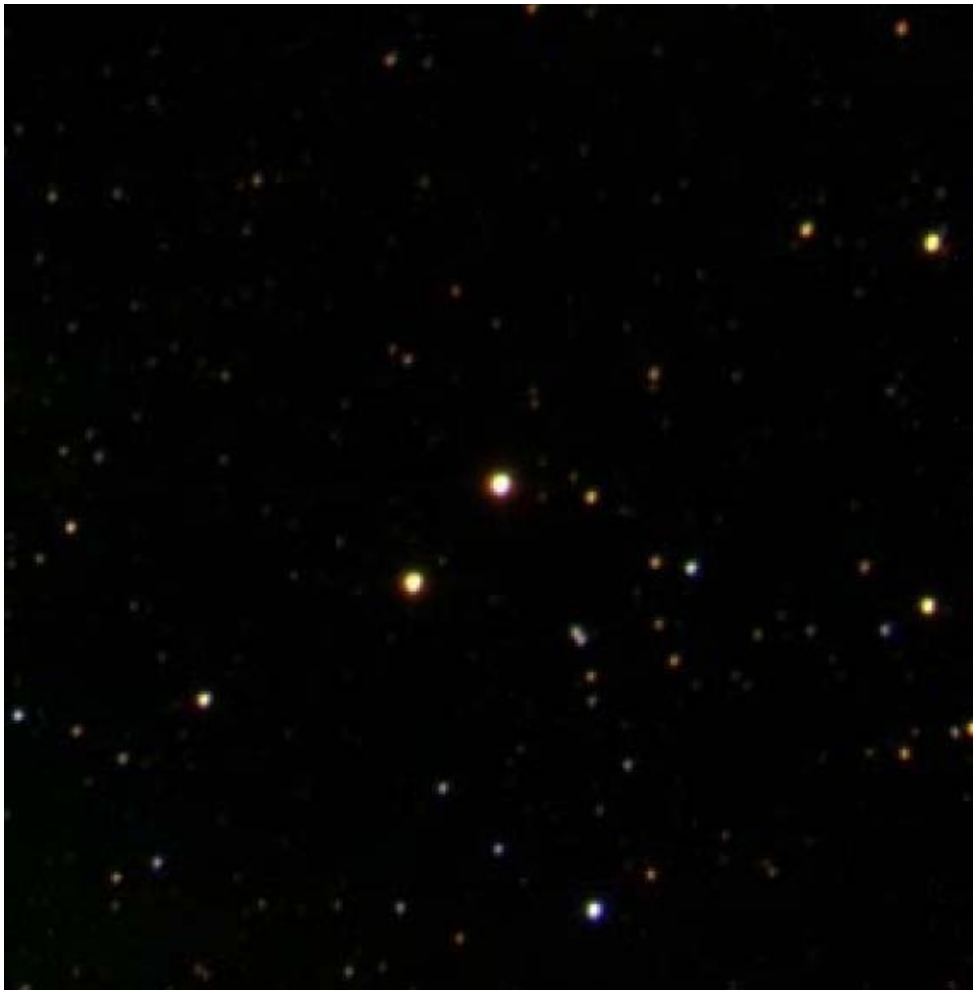


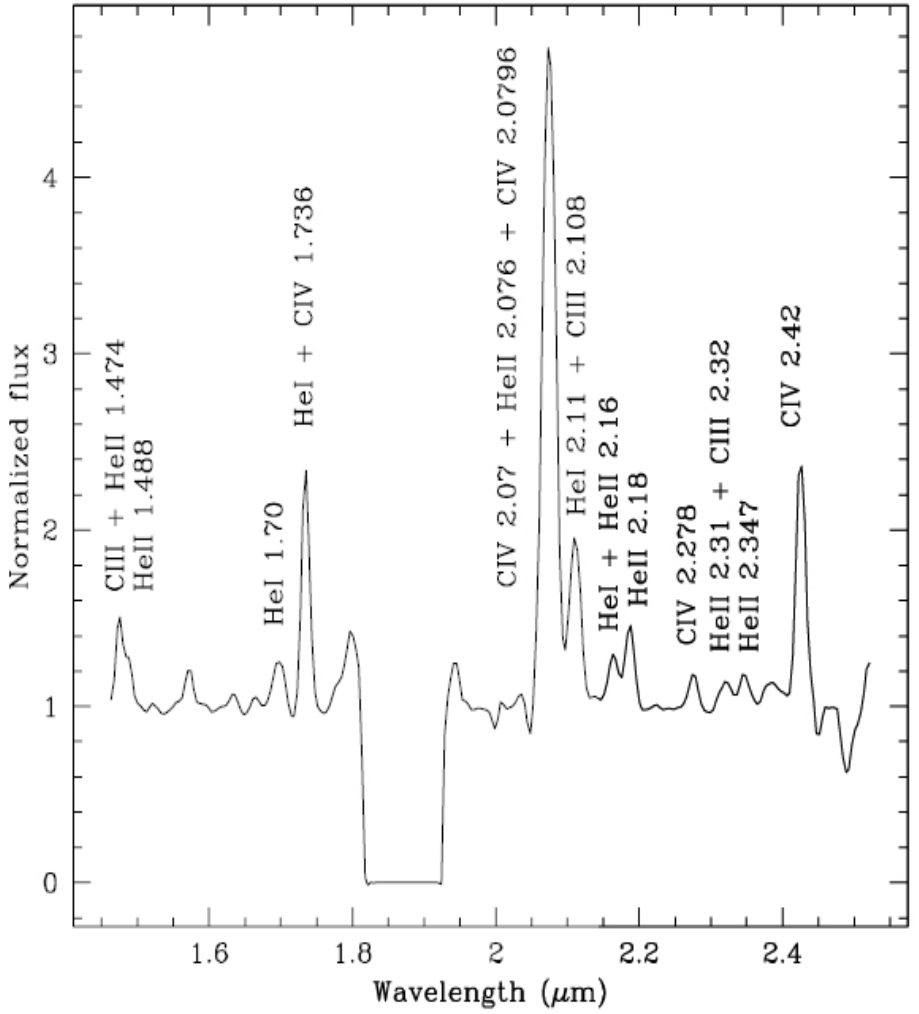
- 2008: Comerón et al. find new (J-H), (H-K)-selected members, spectroscopically confirmed, in the outskirts of Cygnus OB2 and adjacent structures, including Cygnus X





- Some interesting members found along the way: WR 142a, a late-type WC star in the outskirts of Cygnus OB2





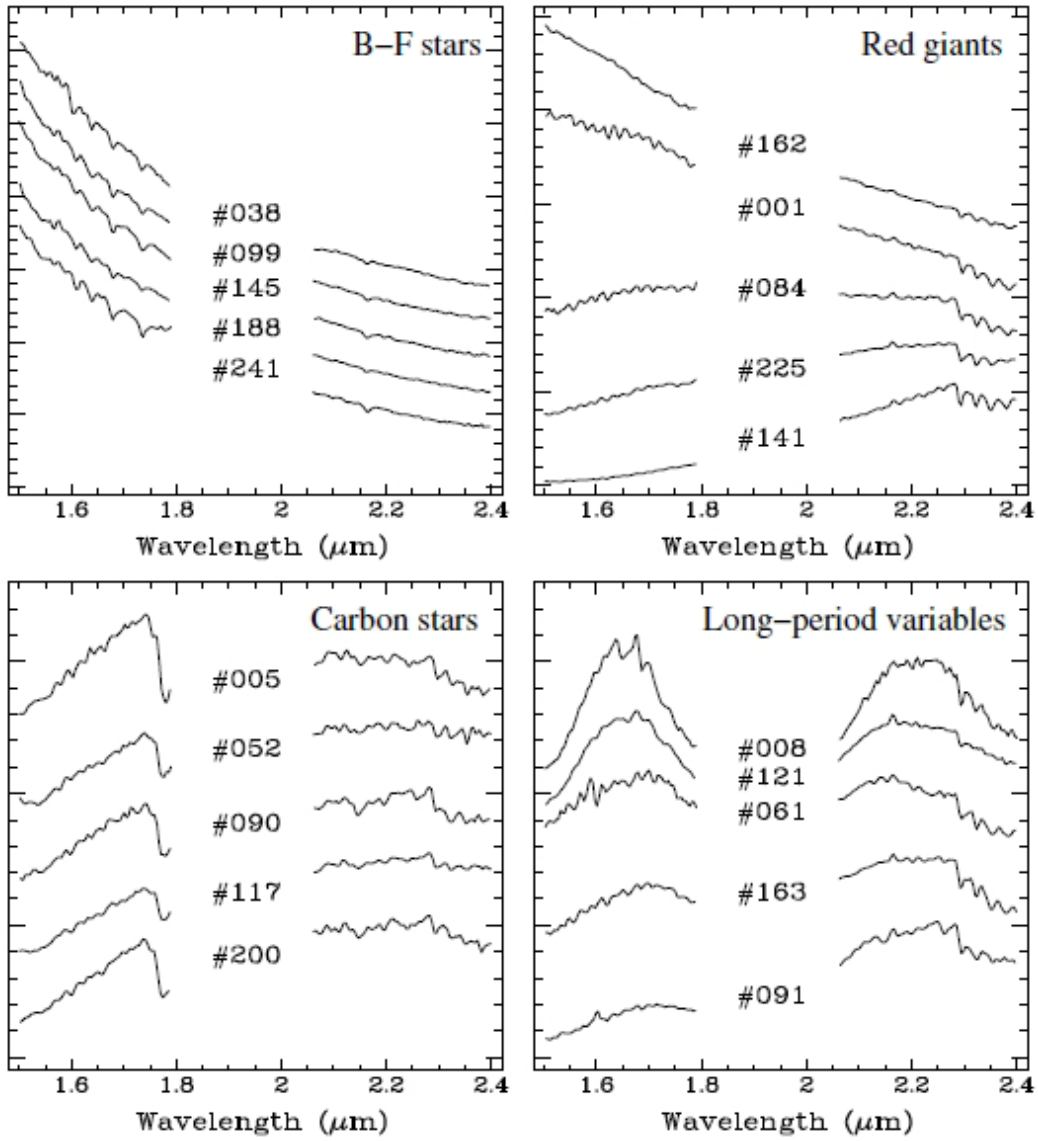
The current view on Cygnus OB2

- Distance well established at ~1.5 kpc
- Evidence for Cygnus X complex to be at the same distance (well determined for masers observer with VLBI)
- Cygnus OB9 likely to be at the same distance too
- Traditionally assumed age of 3 Myr (from the main visible concentration) challenged: a significantly older population is present too, with important implications on the energy output history (sufficient time for massive stars to have exploded as SNe)
- Most of the stellar census is still pending characterization, even among its most massive members

New optically visible members

- NIR-selection criterion is fine, but prone to contamination: spectroscopically confirmed early-type stars are ~50% of selected candidates
- Many previously unidentified, NIR-selected early-type stars are lightly embedded: the census is very incomplete, even among stars accessible to visible observations

Including B flux helps breaking the confusion between intrinsically red stars and reddened blue stars. The NOMAD or UCAC3 catalogs (including 2MASS photometry) make this possible.



Using the reddening-free criteria

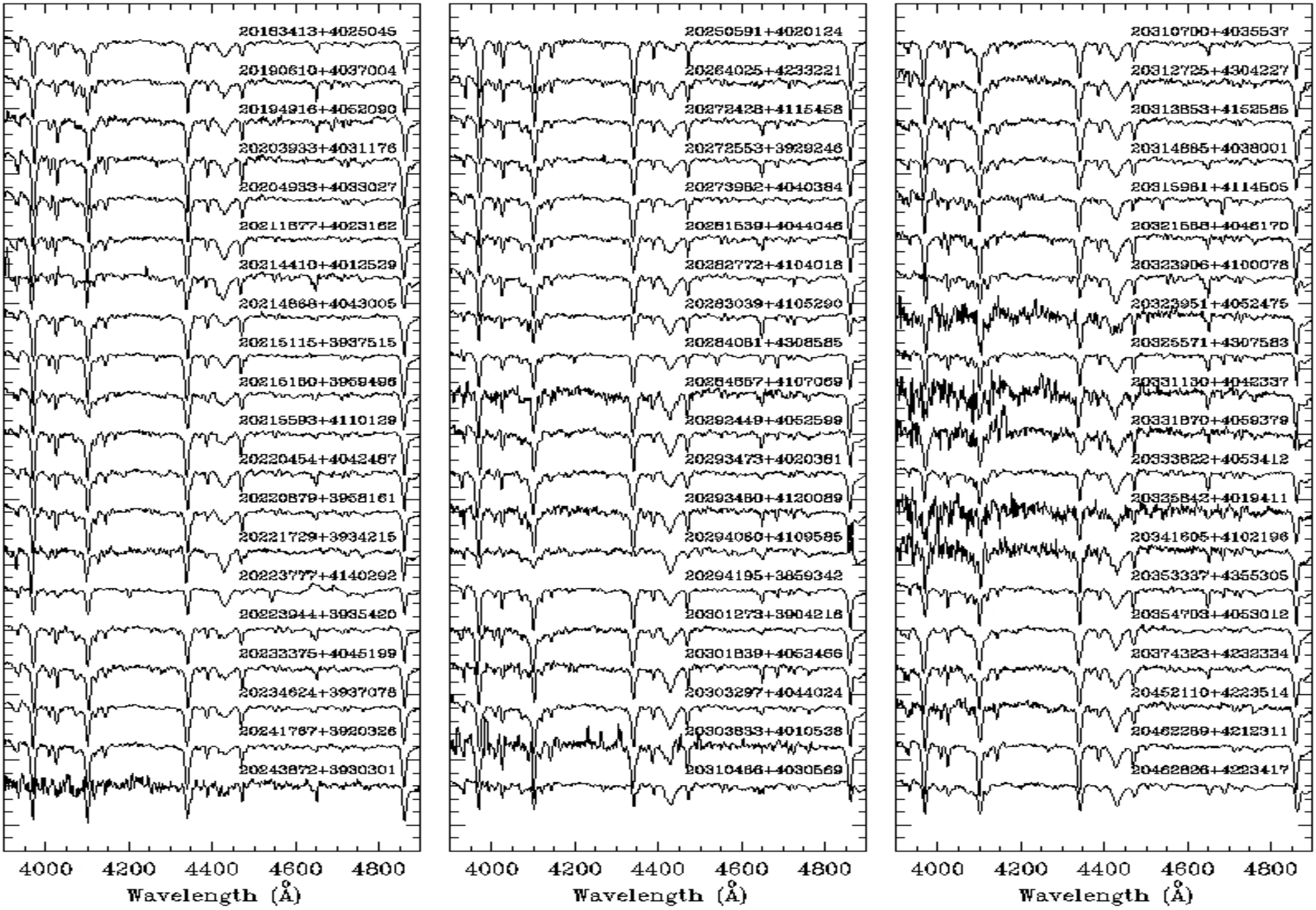
$$Q_{BJK} = 0.196(B-J) - 0.981(J-K) - 0.098 > 0$$

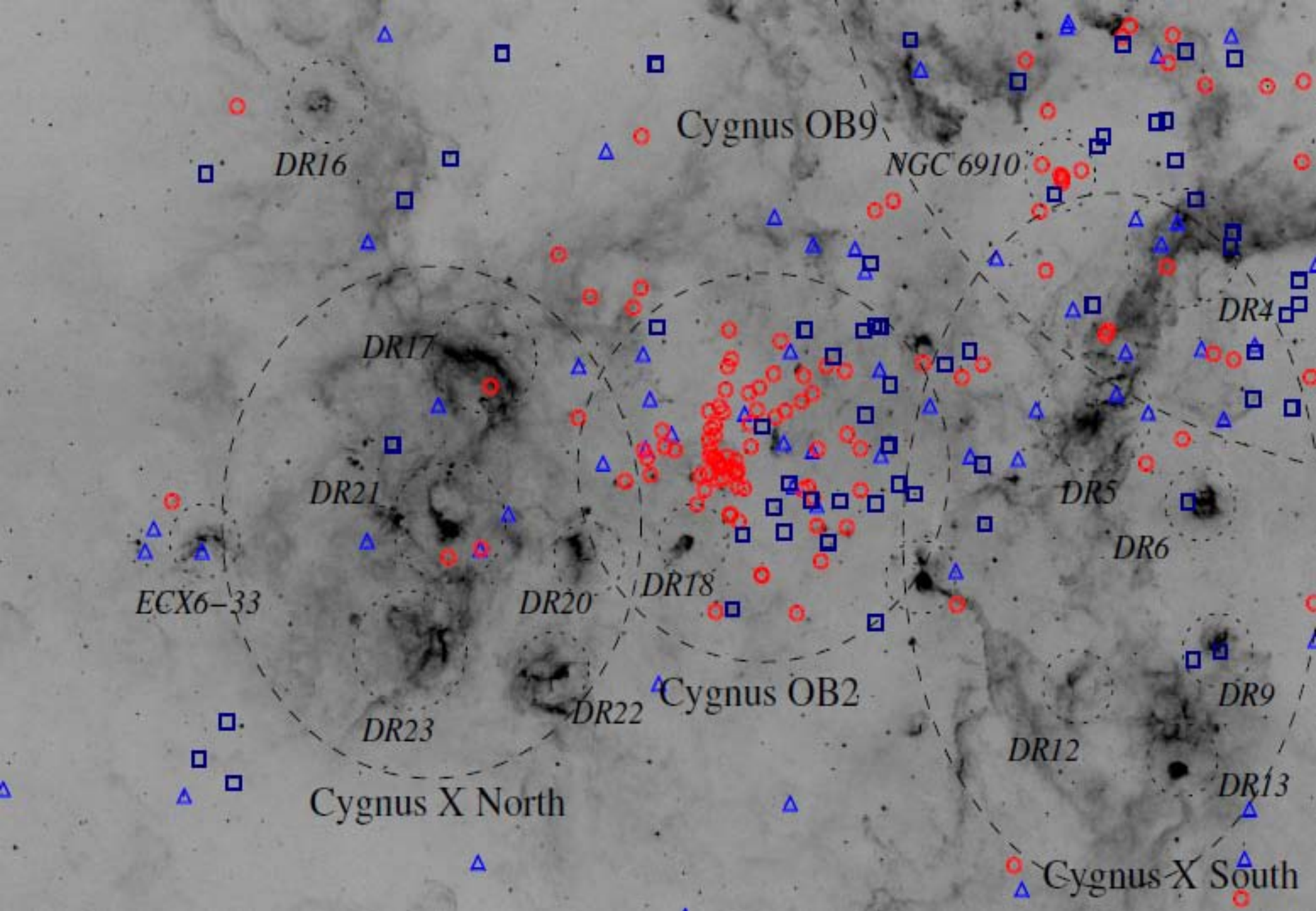
$$Q_{JHK} = 0.447(J-H) - 0.894(H-K) - 0.089 < 0$$

about 70% of the contaminants can be removed

This has been applied to an area of 6 x 4 sq. deg. centered on Cygnus OB2, limited to K<9, B<16:

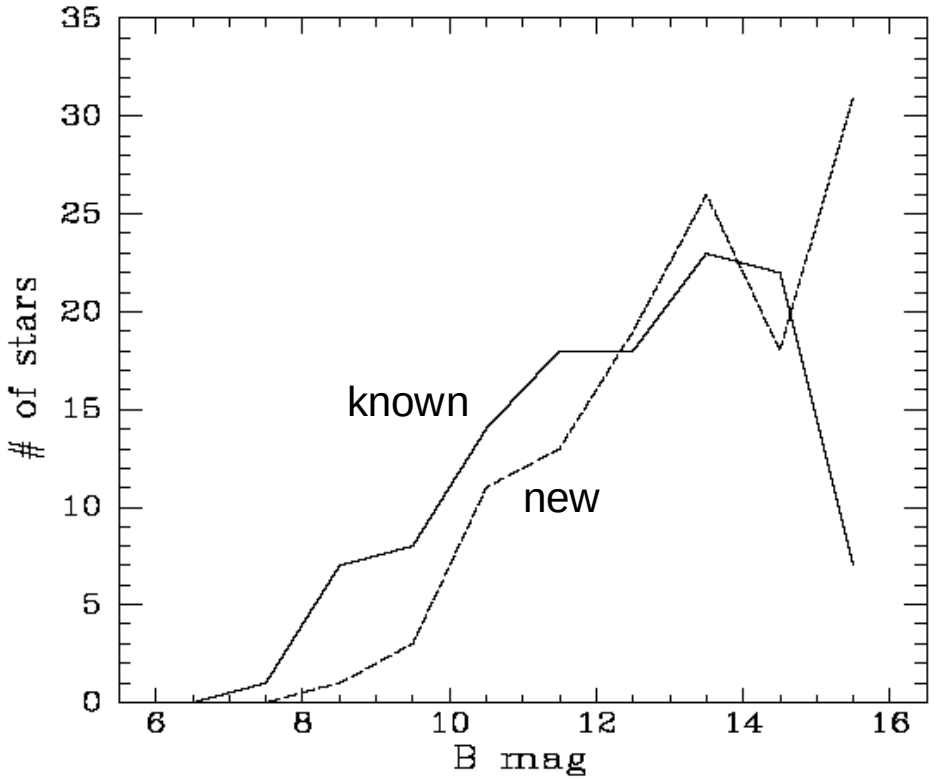
- About 240 candidate O and B stars selected
- Only 50% were known in advance
- Spectroscopy obtained for 81 new stars
- 61 of them confirmed as new O and B stars
- 20 non-OB
- 62 more candidates with no spectroscopy yet

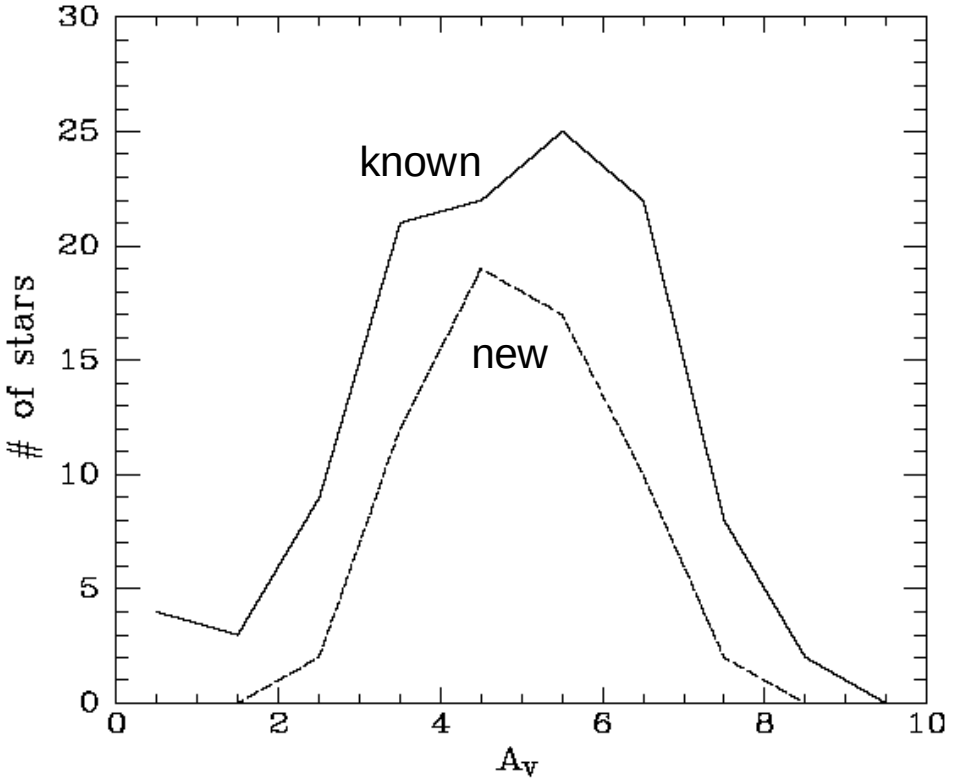

20163413+4025045
20190610+4037004
20194916+4052090
20203933+4031176
20204933+4033027
20211577+4023162
20214410+4012529
20214868+4043005
20215115+3937515
20216160+3959496
20215593+4110129
20220454+4042487
20220879+3958161
20221729+3934215
20223777+4140292
20223944+3935420
20233375+4045199
20234624+3937078
20241767+3920326
20243872+3930301
20250591+4020124
20264025+4233221
20272428+4115458
20272553+3929246
20273982+4040384
20281539+4044046
20282772+4104018
20283039+4105290
20284081+4308585
20284557+4107069
20292449+4052599
20293473+4020361
20293480+4120089
20294060+4109585
20294195+3859342
20301273+3904218
20301839+4053466
20303297+4044024
20303833+4010538
20310486+4030569
20310700+4035537
20312725+4304227
20313853+4152585
20314885+4038001
20315981+4114505
20321588+4046170
20323906+4100078
20323951+4052475
20325571+4307583
20331130+4042337
20331870+4059379
20333822+4053412
20335842+4019411
20341605+4102196
20353337+4355305
20354703+4053012
20374323+4232334
20452110+4223514
20462289+4212311
20462826+4223417
4000
4200
4400
4600
4800
Wavelength (Å)
4000
4200
4400
4600
4800
Wavelength (Å)
4000
4200
4400
4600
4800
Wavelength (Å)


Cygnus OB9
DR16
NGC 6910
DR4
DR17
DR21
DR5
DR6
ECX6−33
DR20
DR18
Cygnus OB2
DR9
DR22
DR23
DR12
DR13
Cygnus X North
Cygnus X South

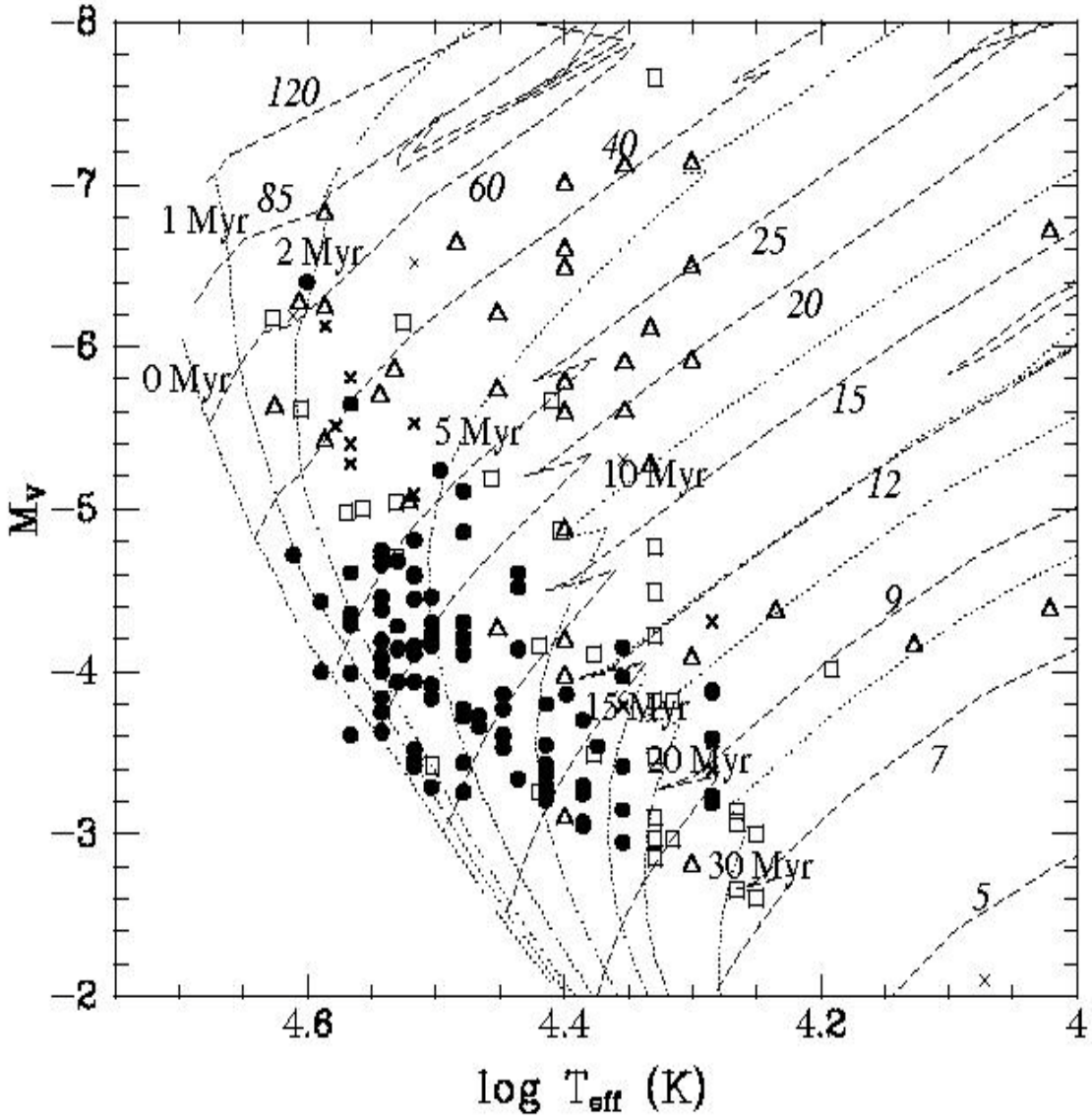
- Most new stars in the field or in Cyg OB9
- Very few new stars in the main concentration of Cygnus OB2
- Many new stars in the low-galactic-longitude part of Cygnus OB2

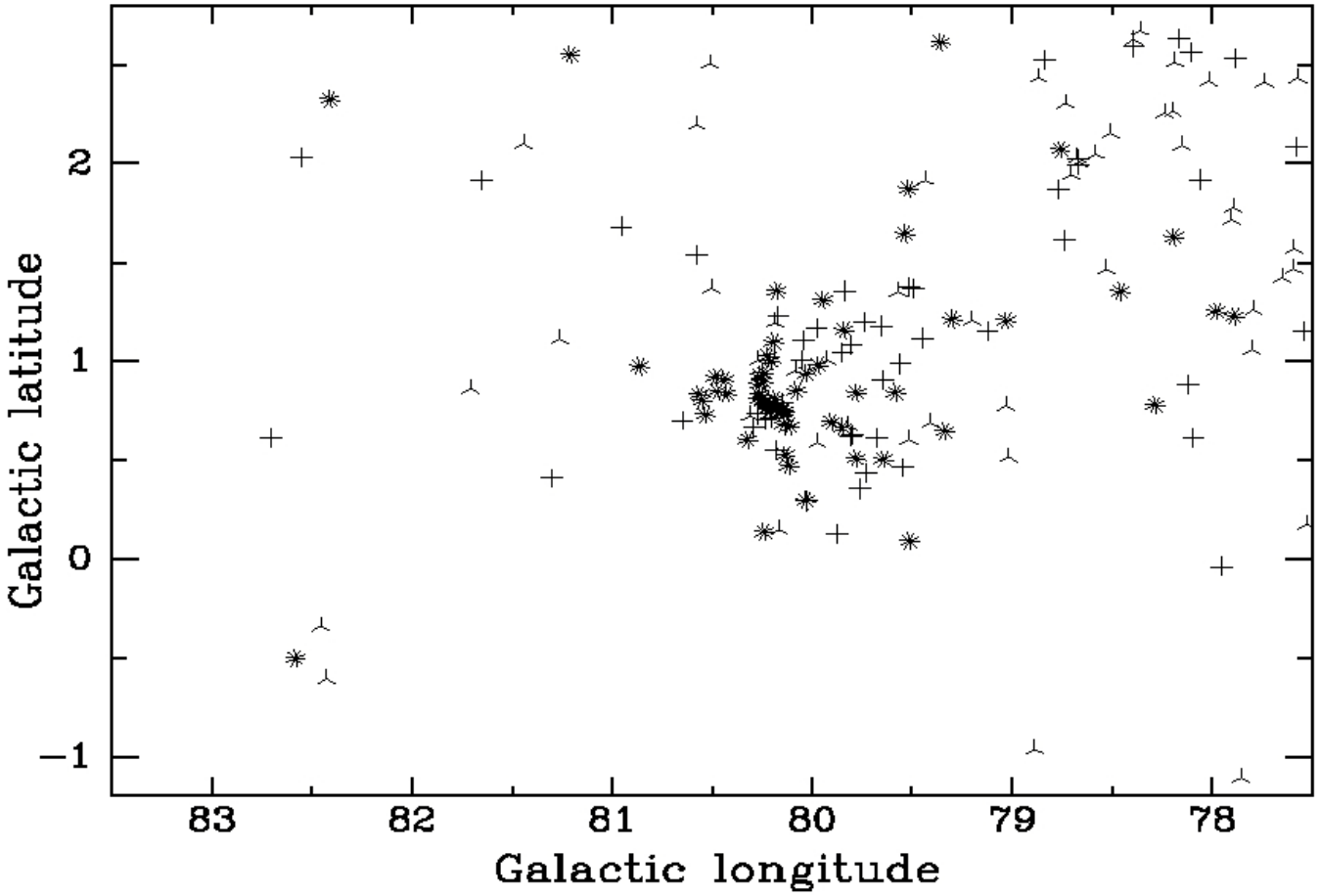
…found mainly because nobody had looked for them there before!





- T_{eff}-M_V diagram for all the selected candidates (new and known) with spectroscopy is consistent with a single distance
- Well-defined main sequence locus
- Giants and supergiants well separated on the average
- Significant spread in ages

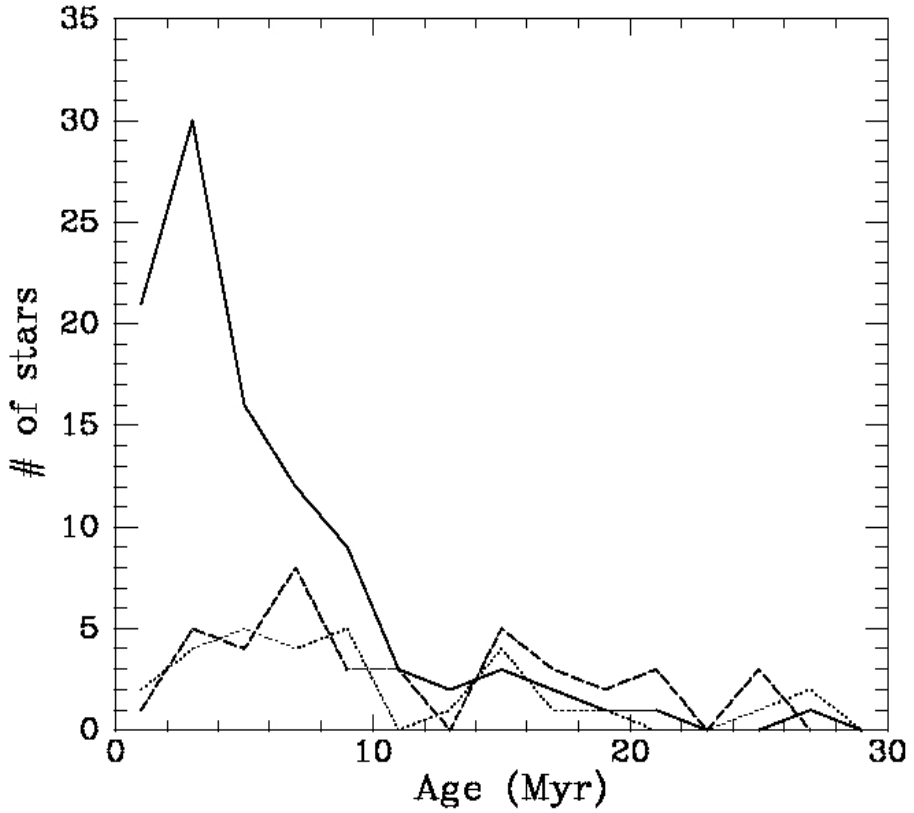


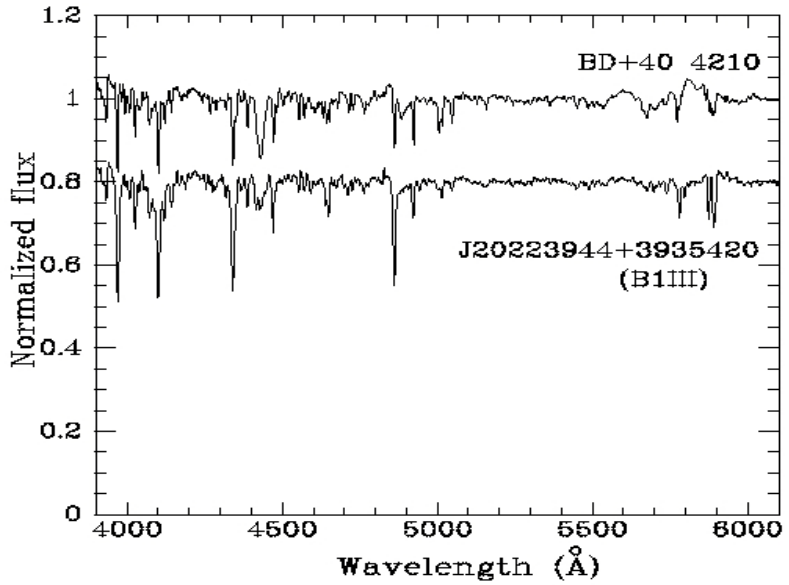


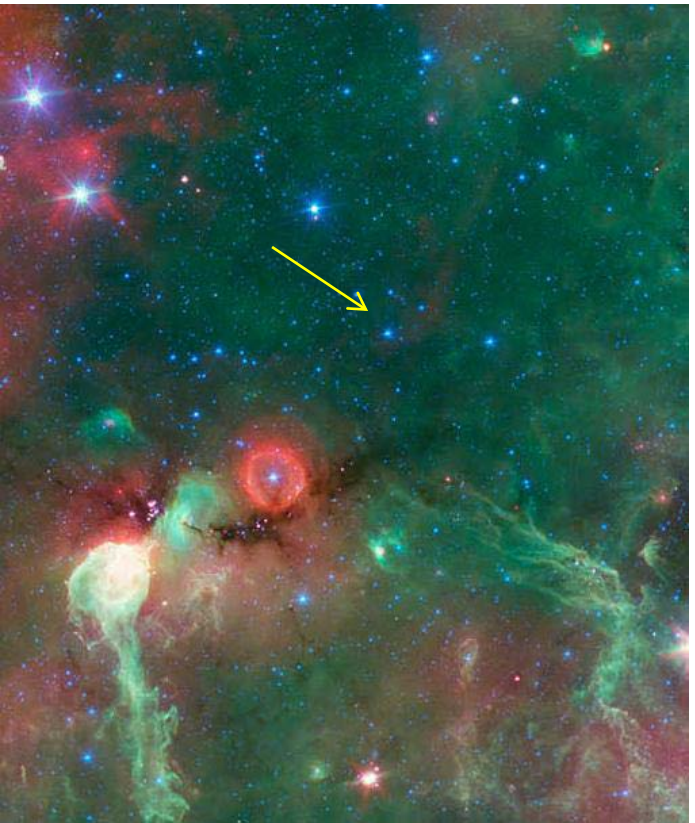
- Most young stars in Cygnus OB2, but also some elsewhere
- Extended Cygnus OB2 (toward lower galactic longitudes) is older
- Some young stars in the field too

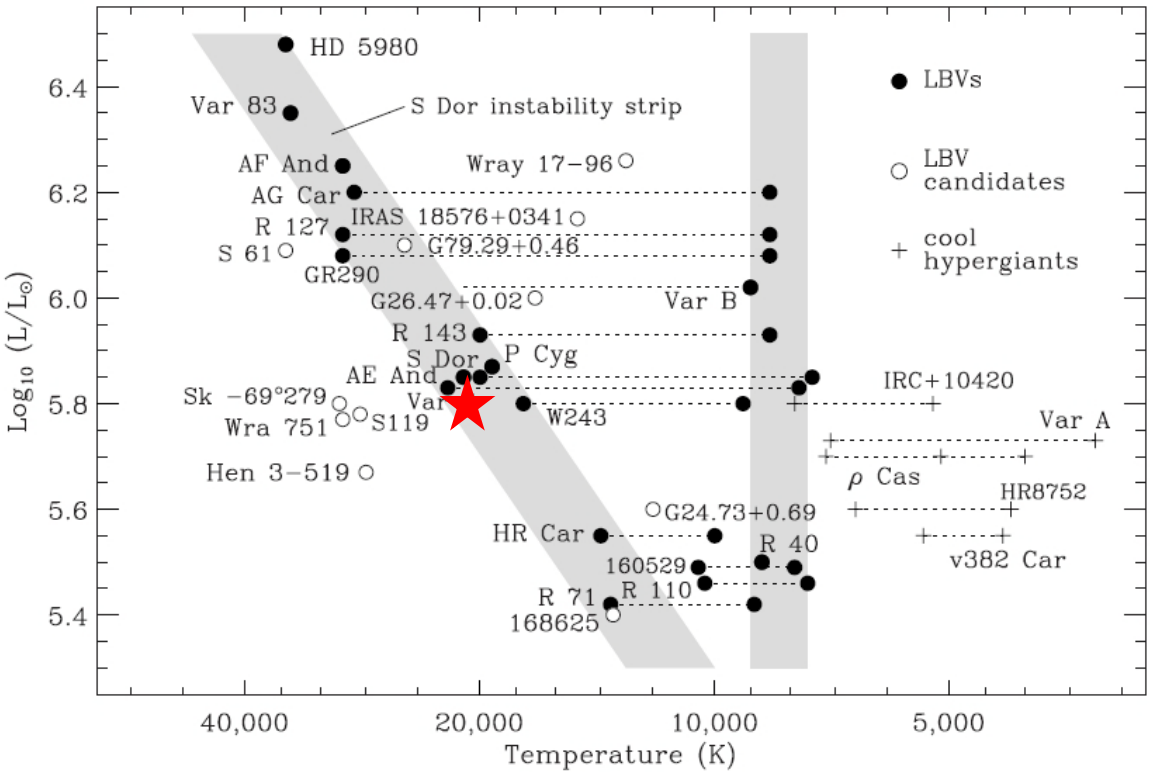
The confirmation of an old, massive component in Cygnus OB2 is very important to understand its relation with its surrounding medium:

- Longer time to shape the structure
- Action of core-collapse supernovae must have been important
- Energy input into the ISM has acted for much longer than 3 Myr
- Derivation of the IMF in Cygnus OB2 is complicated by non-coevality: slope virtually unconstrained by our data

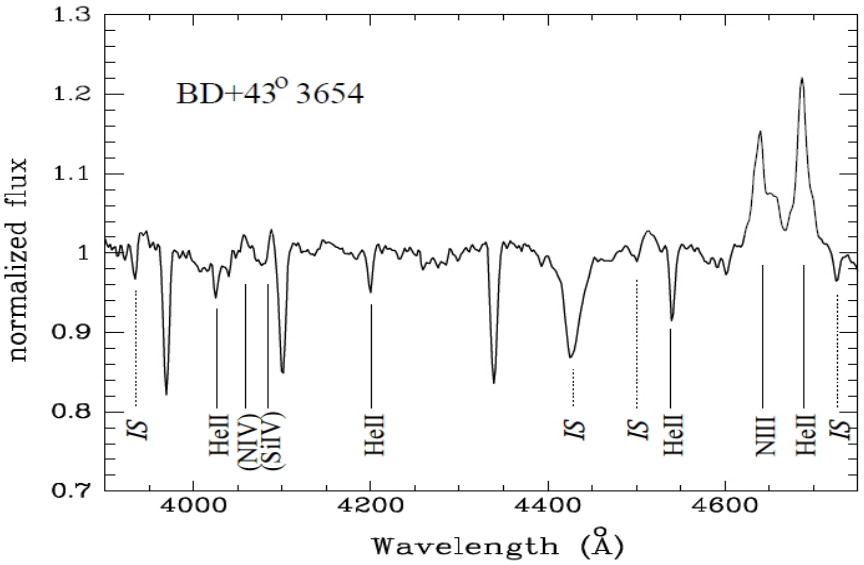


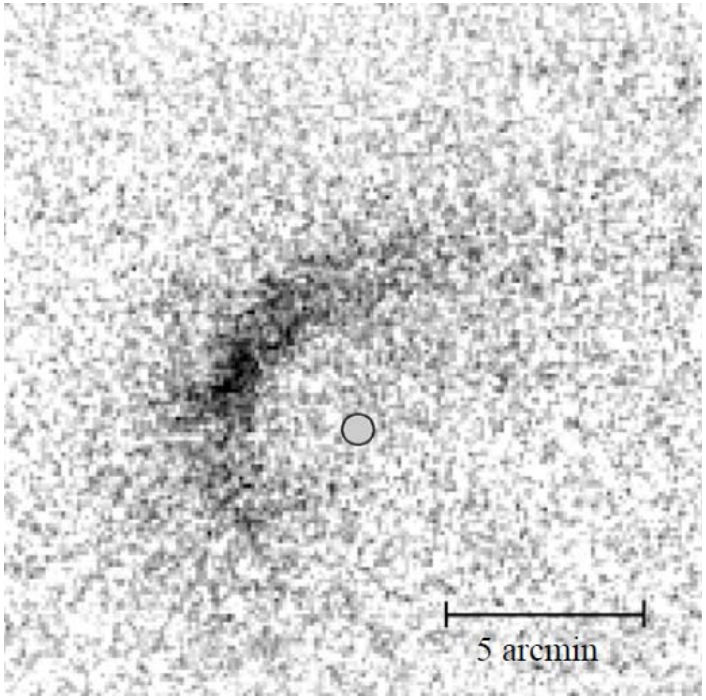


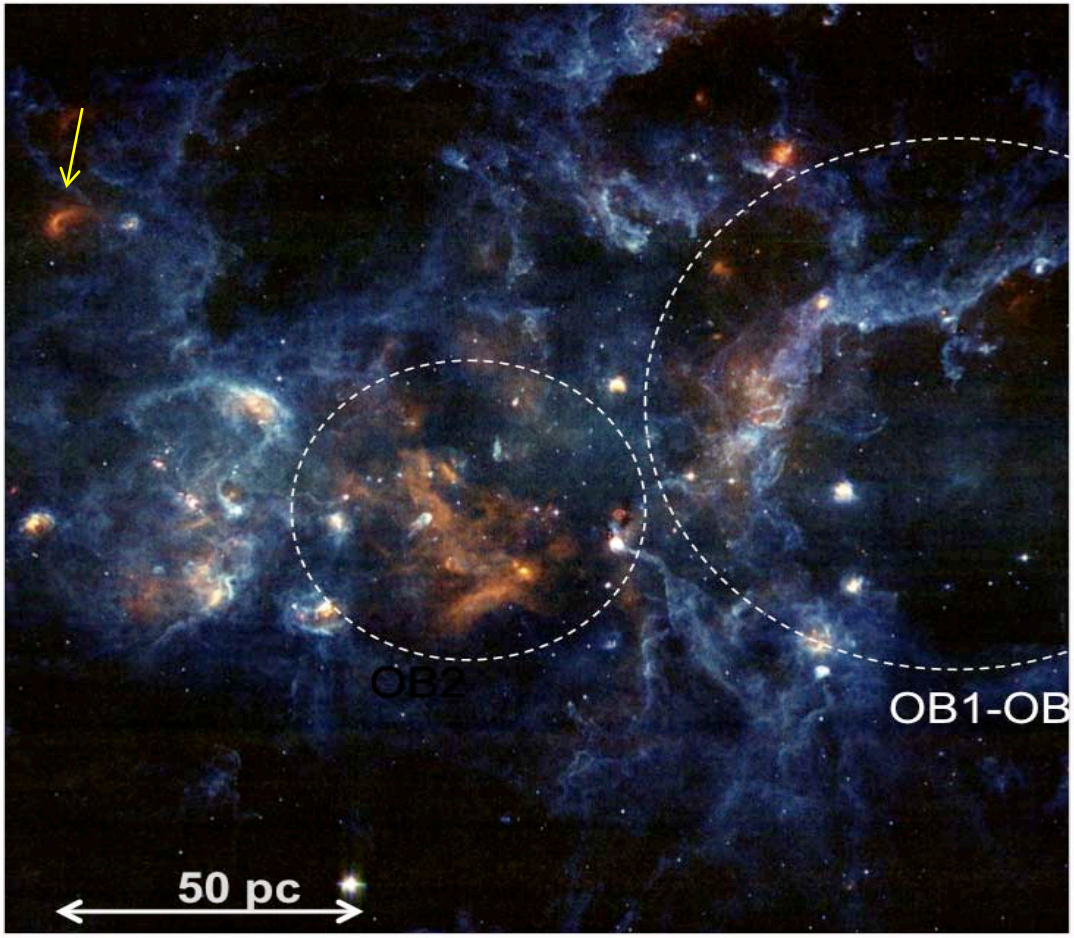




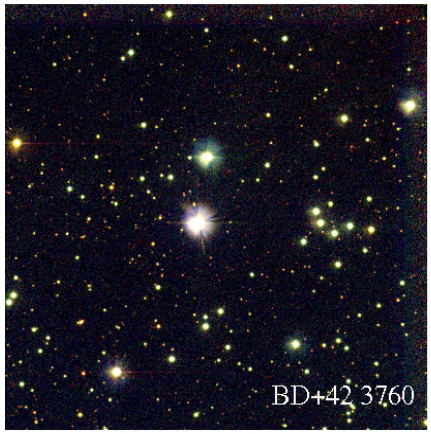
- The newly found BD+40 4210 is one of the most luminous stars of Cygnus OB2!
- Some characteristics common with LBVs, it is in the S Dor instability strip, but no evidence for past eruptions
- …and it is just 5 pc of projected distance from a LBV candidate nebula, G79.29+0.46

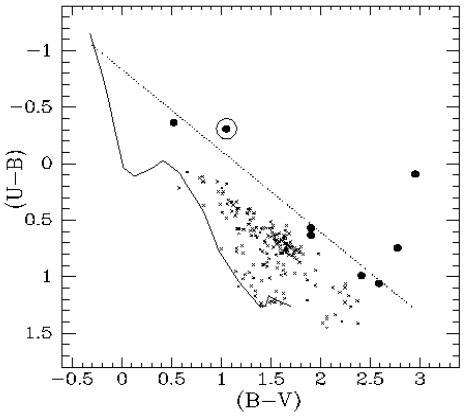


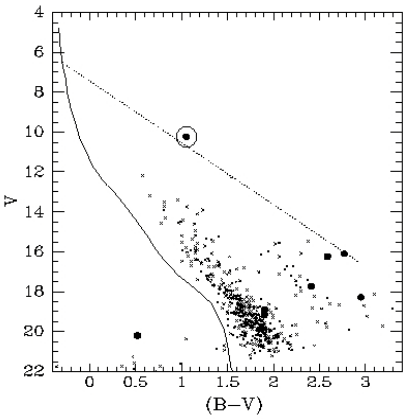


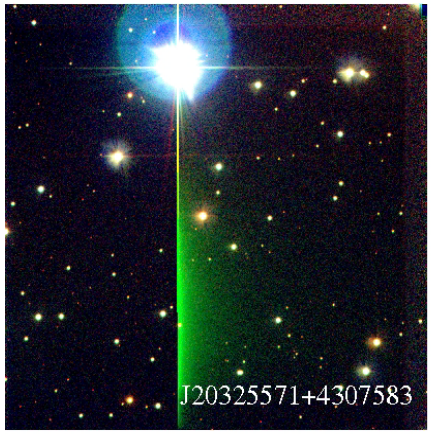


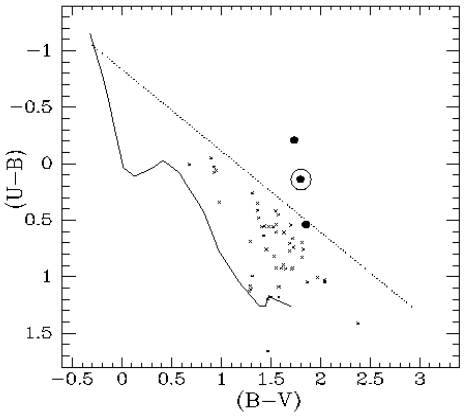
- BD+43 3654, a O4If runaway from Cygnus OB2
- One of the three most massive runaways known
- Mass and ejection age suggest dynamical ejection mechanism

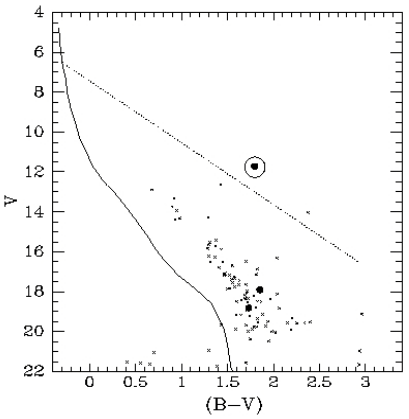


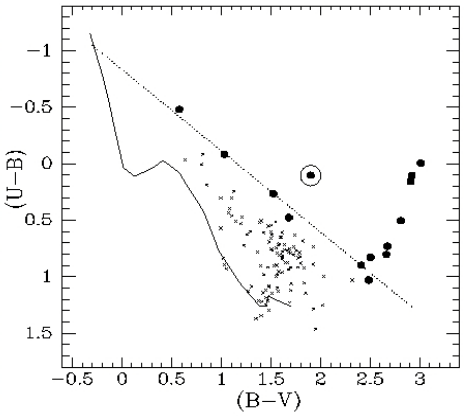


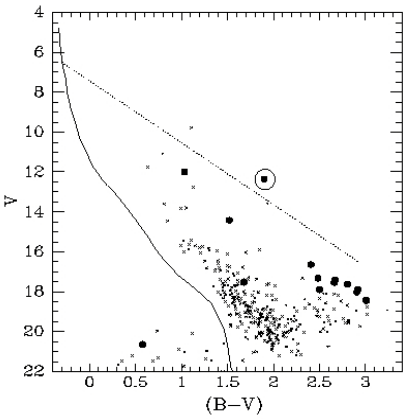






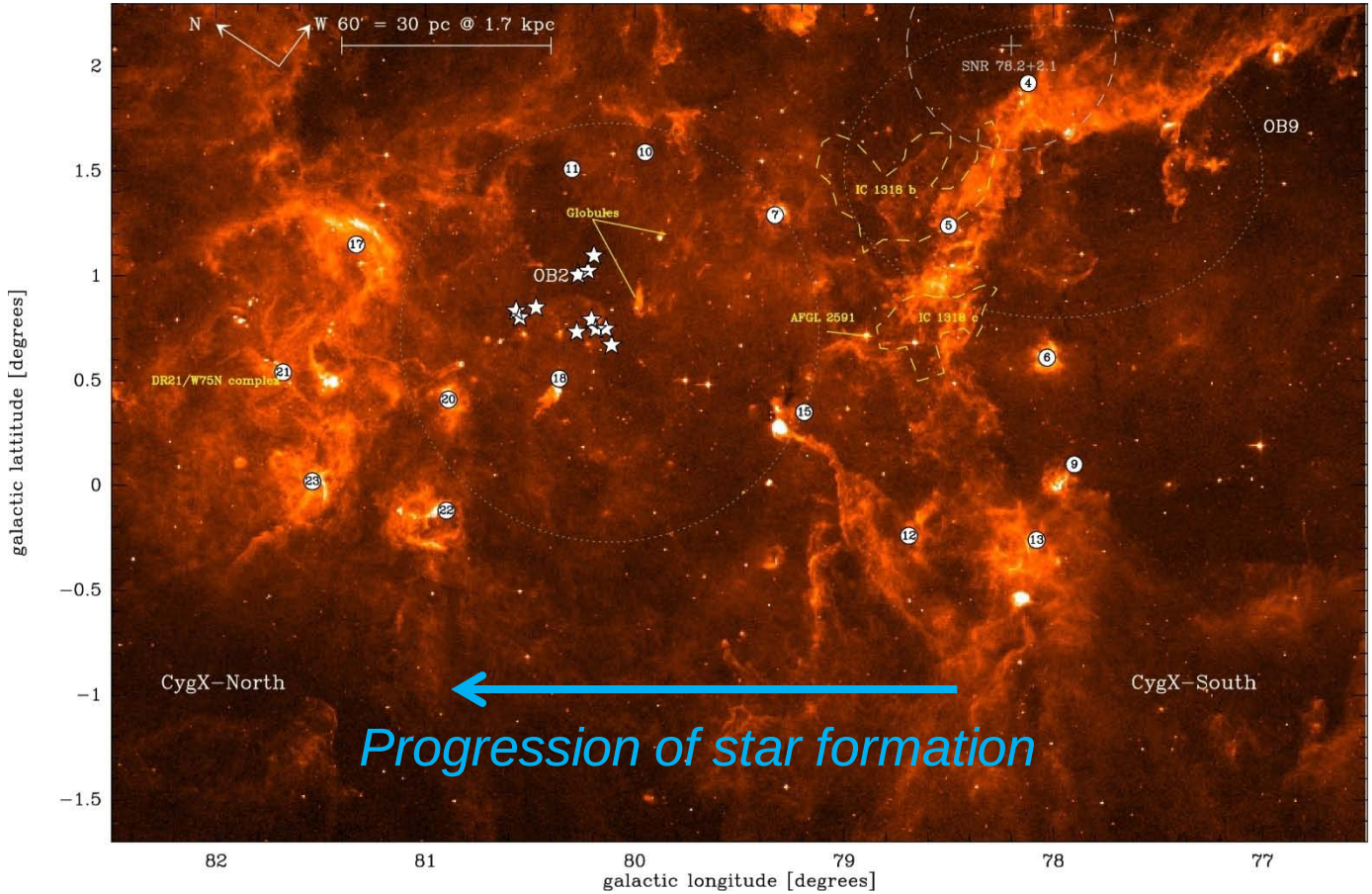




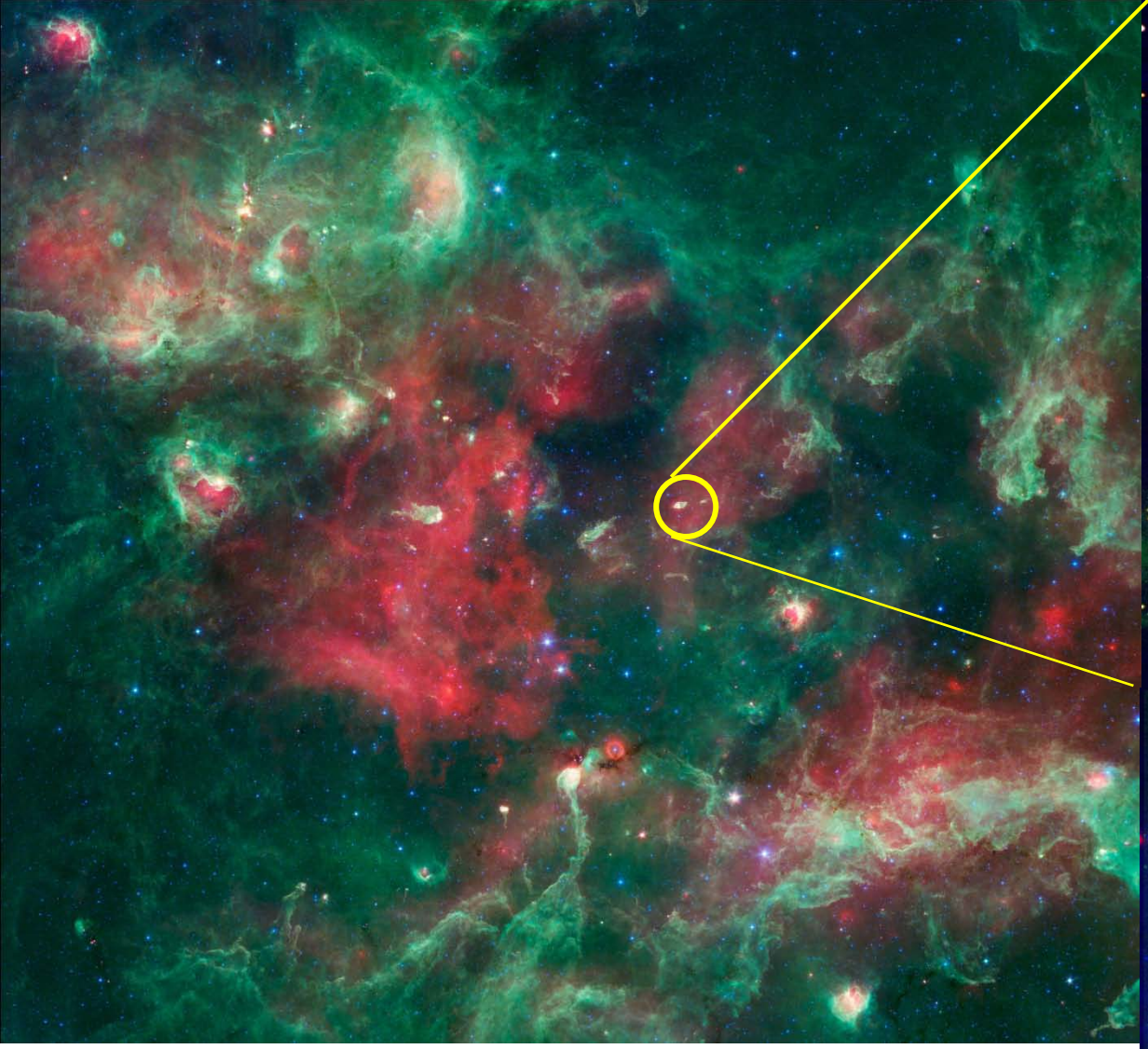


O stars in isolation?

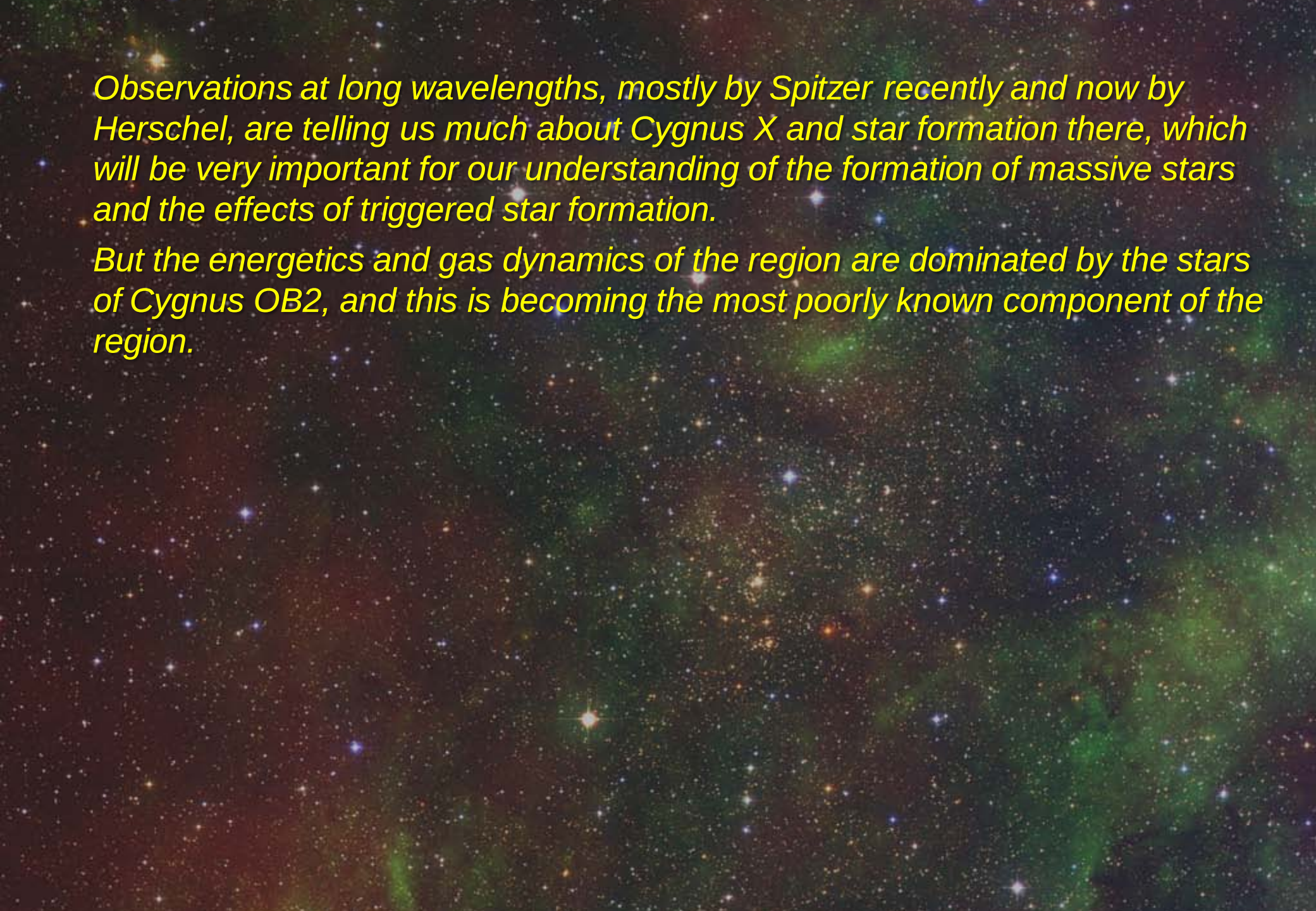
- No obvious cluster around the three youngest isolated O stars in the field
- But very red stars with indications of strong UV excess in the fields of two of them: strongly accreting T Tauri stars? Follow-up spectroscopy will tell…



- Overall results suggest that star formation at large scale progresses from low to high galactic longitude (roughly south to north)
- Same general direction inside Cygnus OB2: intense star formation there started ~10 Myr ago
- DR21 / W75N is the current site of massive star formation: a OB association in the making



Globules with ongoing star formation all over the place: on small scales, star formation history is more complicated



Observations at long wavelengths, mostly by Spitzer recently and now by Herschel, are telling us much about Cygnus X and star formation there, which will be very important for our understanding of the formation of massive stars and the effects of triggered star formation.

But the energetics and gas dynamics of the region are dominated by the stars of Cygnus OB2, and this is becoming the most poorly known component of the region.