

LBVs and Star-Forming Regions in MW

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Åke Nordlund



My daughter

DARK, NBI
May 2016



Outline:

- P Cyg, a luminous blue variable (LBV), should undergo the next great eruption in the near future according to long-term photometric data;
- LBVs are isolated -asocial,
- P Cygni - association Cygnus OB1 and star-forming complex of Cygnus X;
- Other LBVs in Milky Way are also connected with spiral arms ...
- Possible role of density waves in star formation

Shortly about P Cyg

distance of 1.7 kps

$M = 30 M_{\odot}$

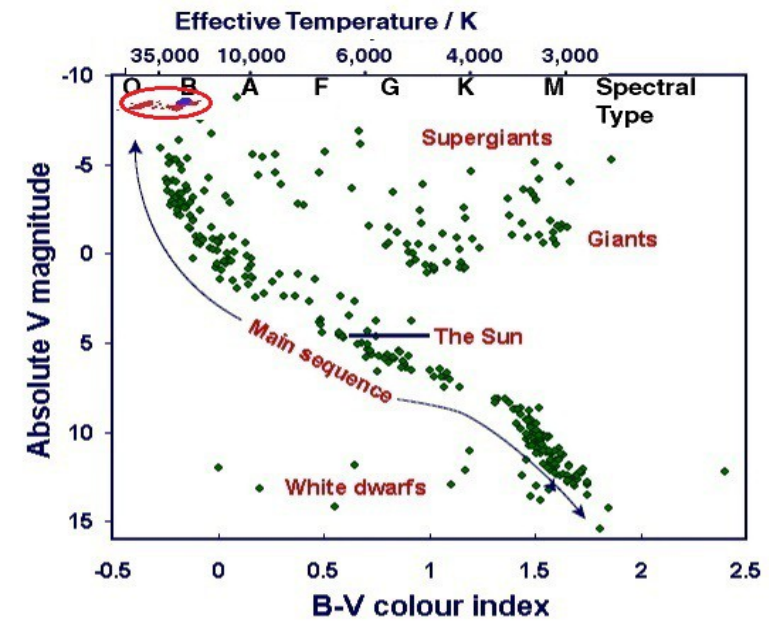
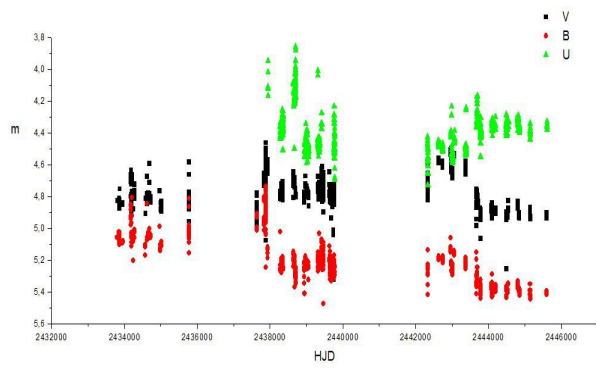
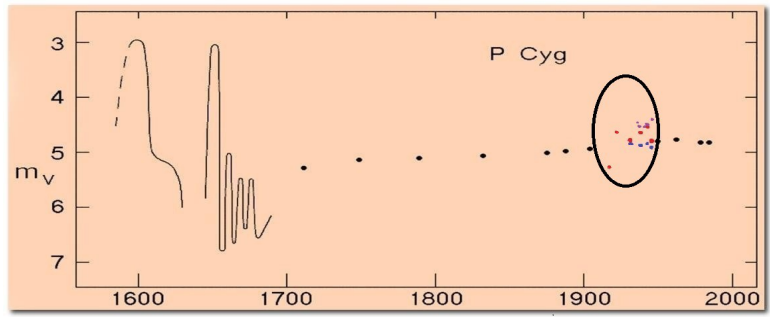
$T_{\text{eff}} = 18\,200\text{ K}$,

$R = 75 R_{\odot}$

$L = 5.6 \times 10^5 L_{\odot}$

Mass loss = $3 \times 10^{-5} M_{\odot}/\text{yr}$

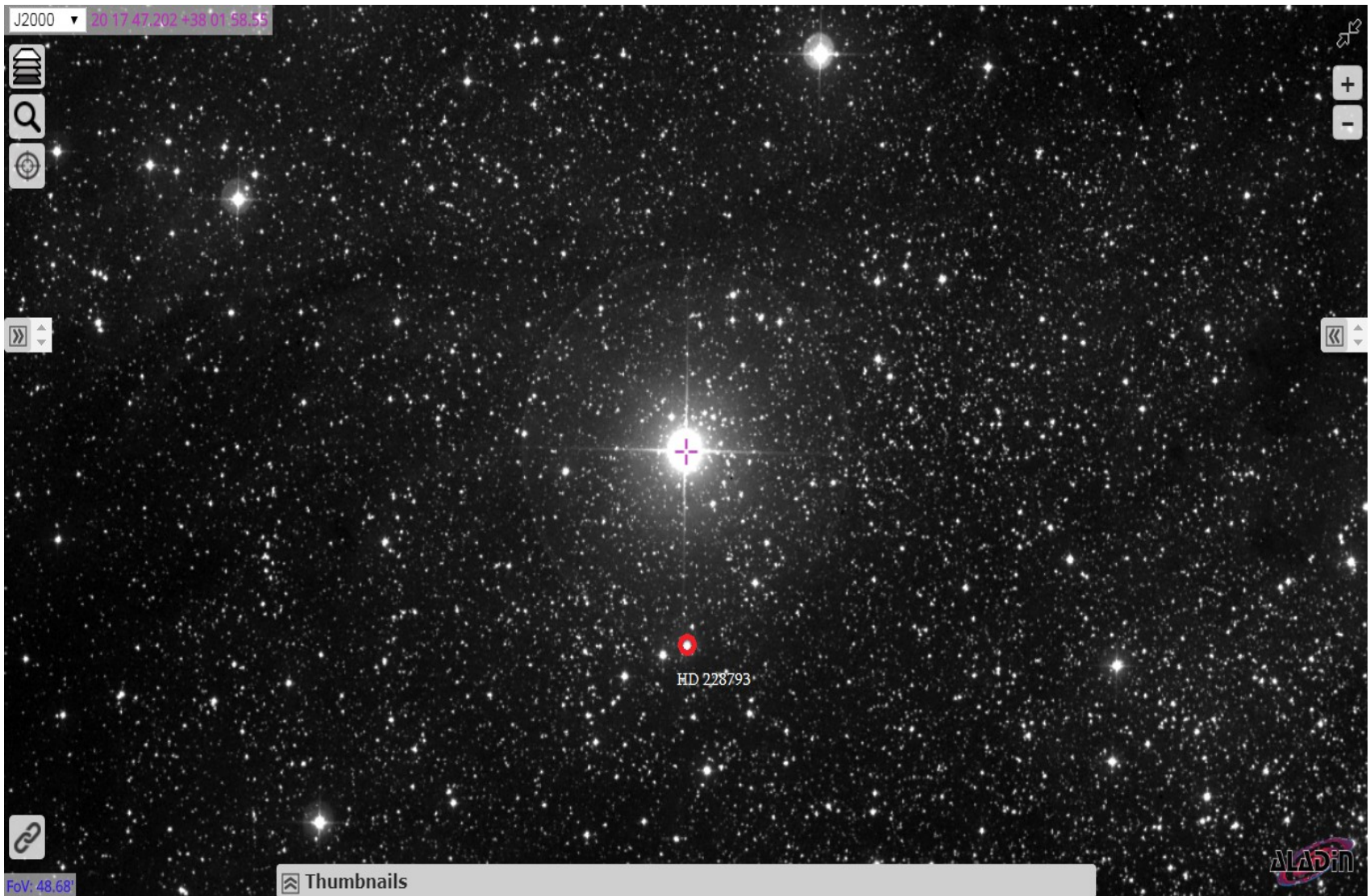
(Najarro et al, 1997).



(Beradze, Kochiashvili, et. al., 2014, 2015, 2017, 2018;)

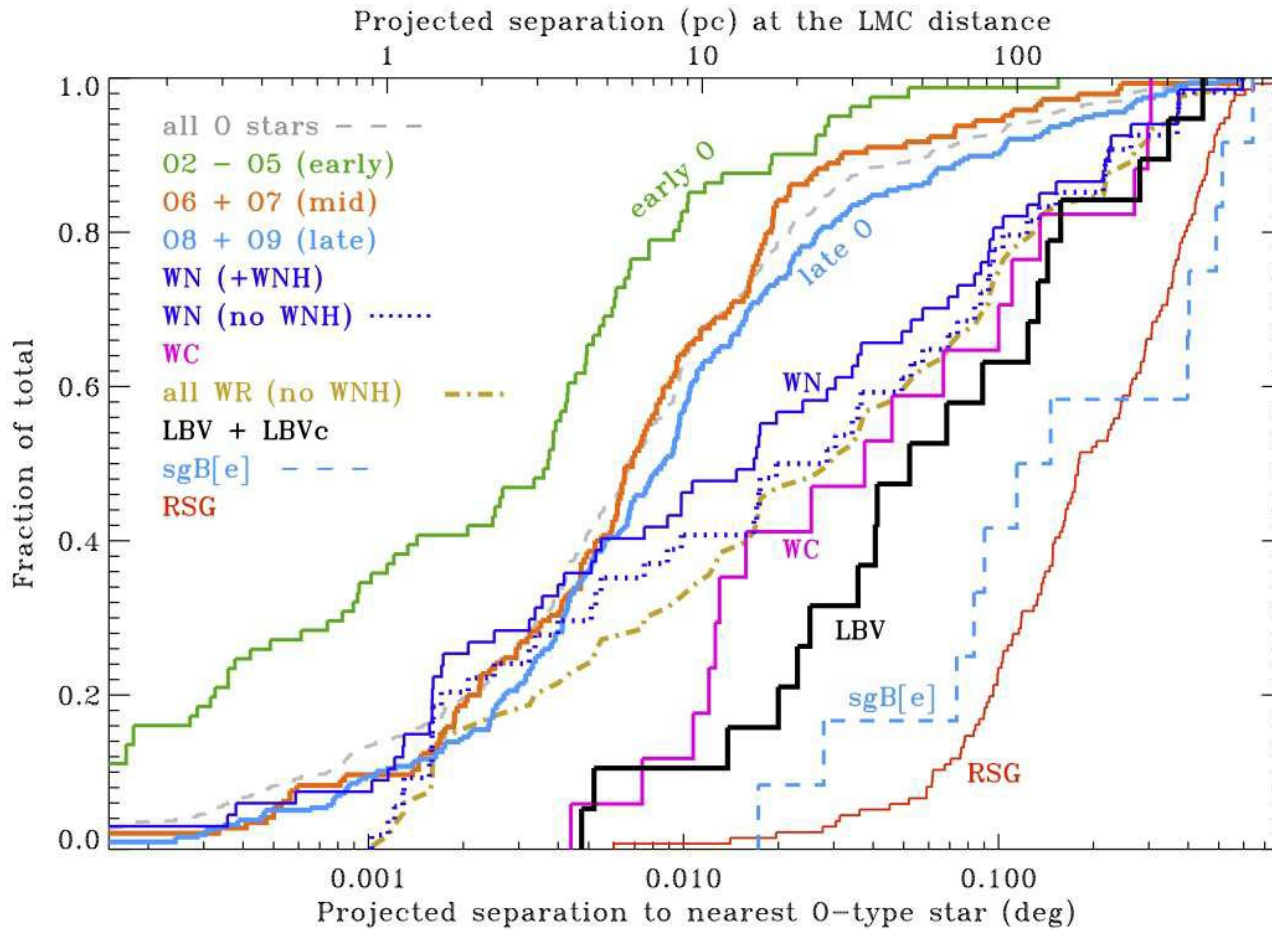
(Kochiashvili, Beradze, et.al., 2014, 2015, 2017 a, b; 2018 a,b)

P Cyg and the comparison star – HD 228793



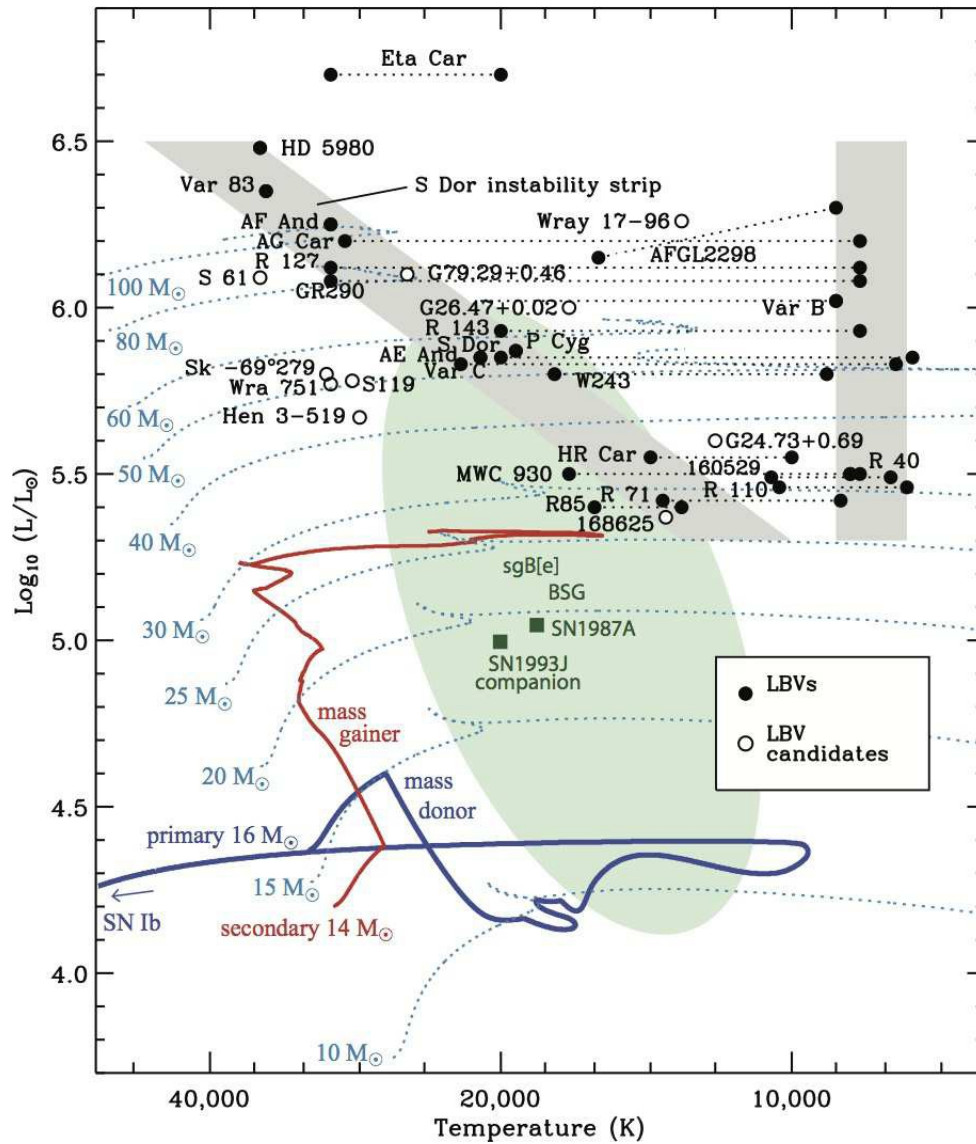
Luminous Blue Variables are Antisocial: Their Isolation Implies they are Kicked Mass Gainers in Binary Evolution

(Smith & Tombleson, MNRAS, 2015)



Known LBVs

MW	-	18
LMC	-	11
SMC	-	2
M31	-	6
M33	-	5
NGC 2403	-	3



Nathan Smith & Ryan Tombleson, MNRAS, 2015

Evolutionary Scenario.

$m > 85 M_{\odot}$: O \longrightarrow LBV \longrightarrow WN \longrightarrow WC \longrightarrow SN

$40 > m > 85 M_{\odot}$: O \longrightarrow WN \longrightarrow WC \longrightarrow SN

$25 > m > 40 M_{\odot}$: O \longrightarrow RSG \longrightarrow WN \longrightarrow WC \longrightarrow SN

$20 > m > 25 M_{\odot}$: O \longrightarrow RSG \longrightarrow WN \longrightarrow SN

$10 > m > 20 M_{\odot}$: OB \longrightarrow RSG \longrightarrow BSG \longrightarrow SN.

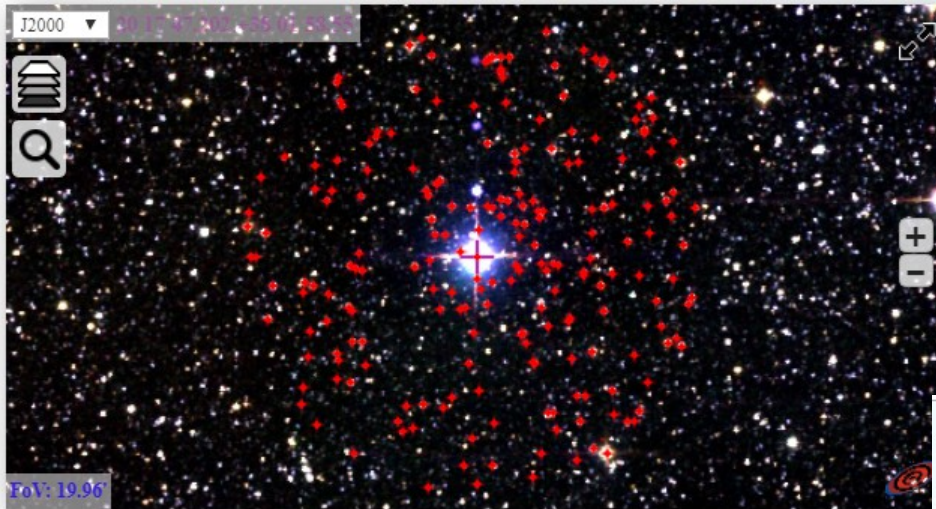
Highly dependent on metallicity.

“P Cyg's cluster”

(Turner, et al., 1985, 2003)

Clusterix2.0, GAIA/DR2

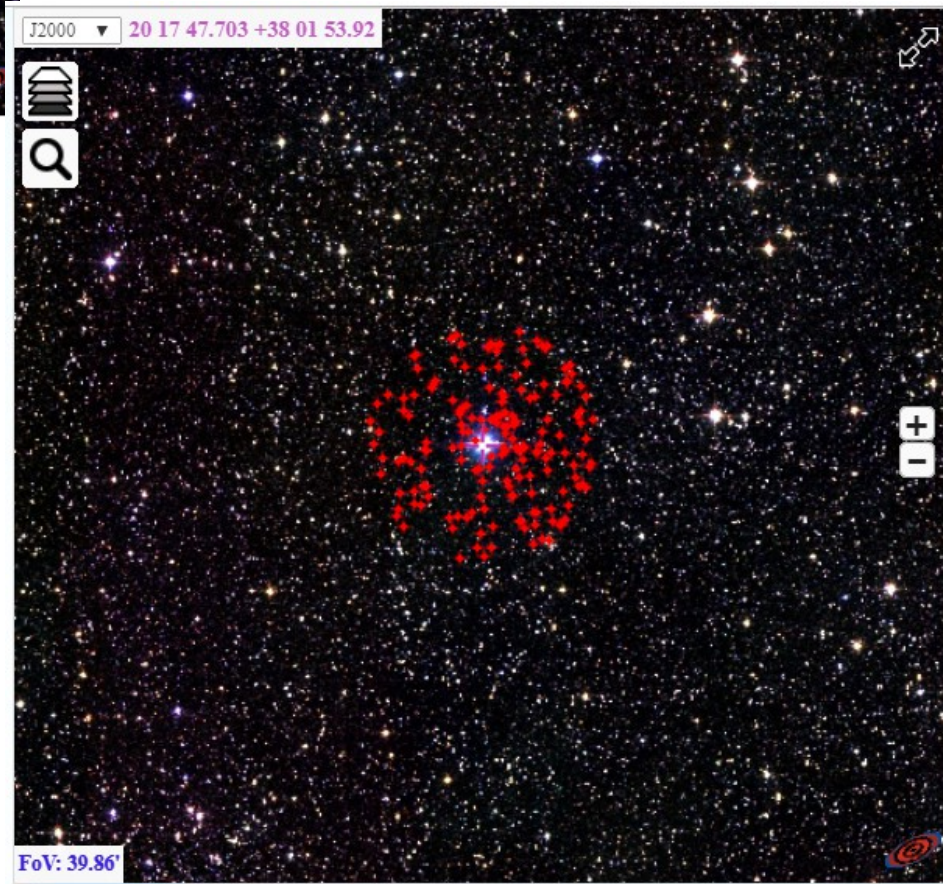
5arcmin around P Cyg 211 stars, 4-16 mag (Kochiashvili, Beradze, in prep.)

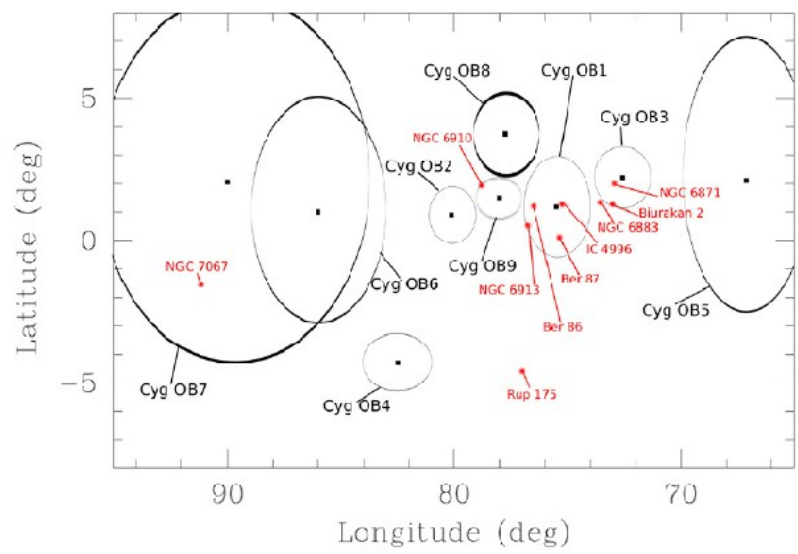
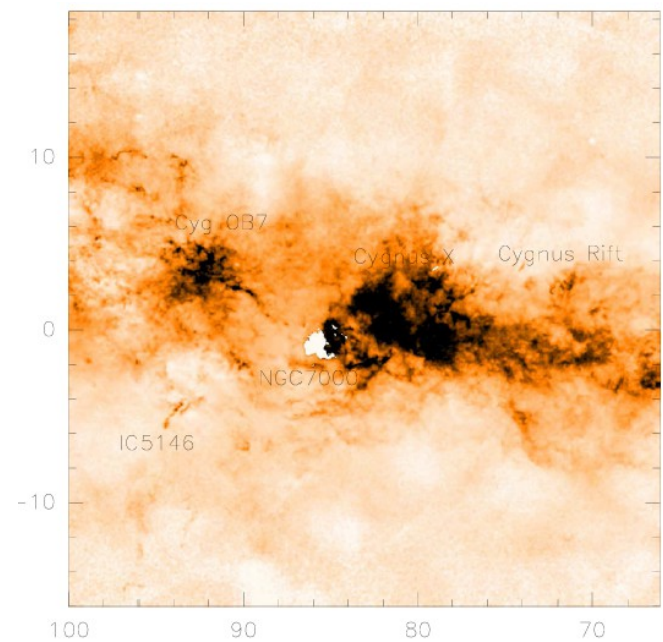
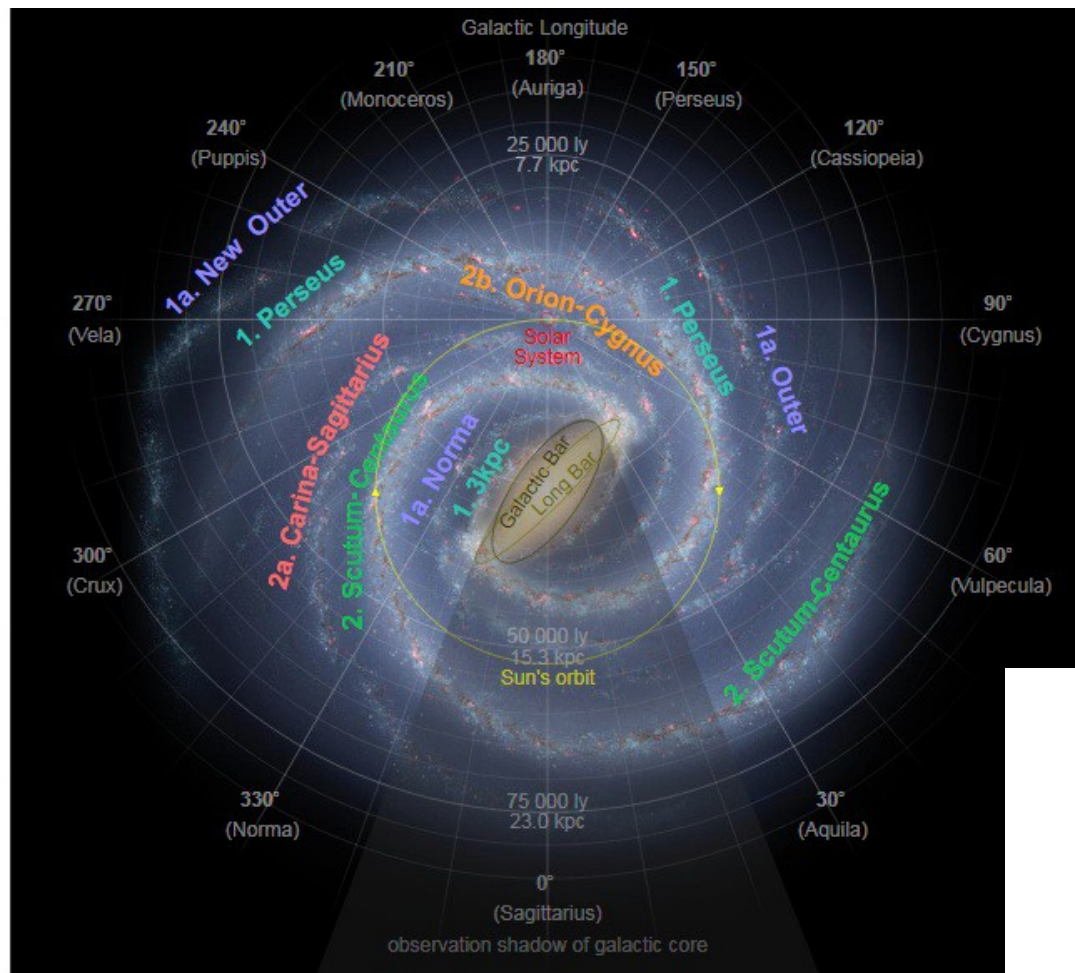


Membership from proper motions :
P Cyg (-3.18; -6.45) mas/yr
Limits: (-3.8 -2; -7 -5) mas/yr
172 stars

For 15 min around P Cyg – 1624 stars

Downloaded the .csv file and after cleaning there are about 300 stars, similar with P Cyg proper motions and radial velocities (12 14) and (-5 -24)





Summary

1. P Cyg, a hypergiant LBV should have the next outburst (or maybe even supernova explosion) in near future, according to old and new photometric data.
2. P Cyg and other LBVs are “asocial”, they could be strugglers which were kicked from binaries...
3. All known LBVs and candidates to LBV are in spiral galaxies and in Magellanic Clouds. LMC is in fact a grand design galaxy with only one spiral.
4. LBVs are connected with spiral arms and star-forming complexes.
5. LBVs are progenitors of SN IIn and they mimic SN IIn spectra and light behavior during their great eruptions but the eruption has lower maximum brightness (see. For example Tartaglia 2015 (AIP conf. proc. 1645). SN II b have progenitor LBVs.
6. Only SN Ia are found in elliptical galaxies. So no LBVs in ellipticals.
7. Dencity waves theory ...



Thank you for your attention!