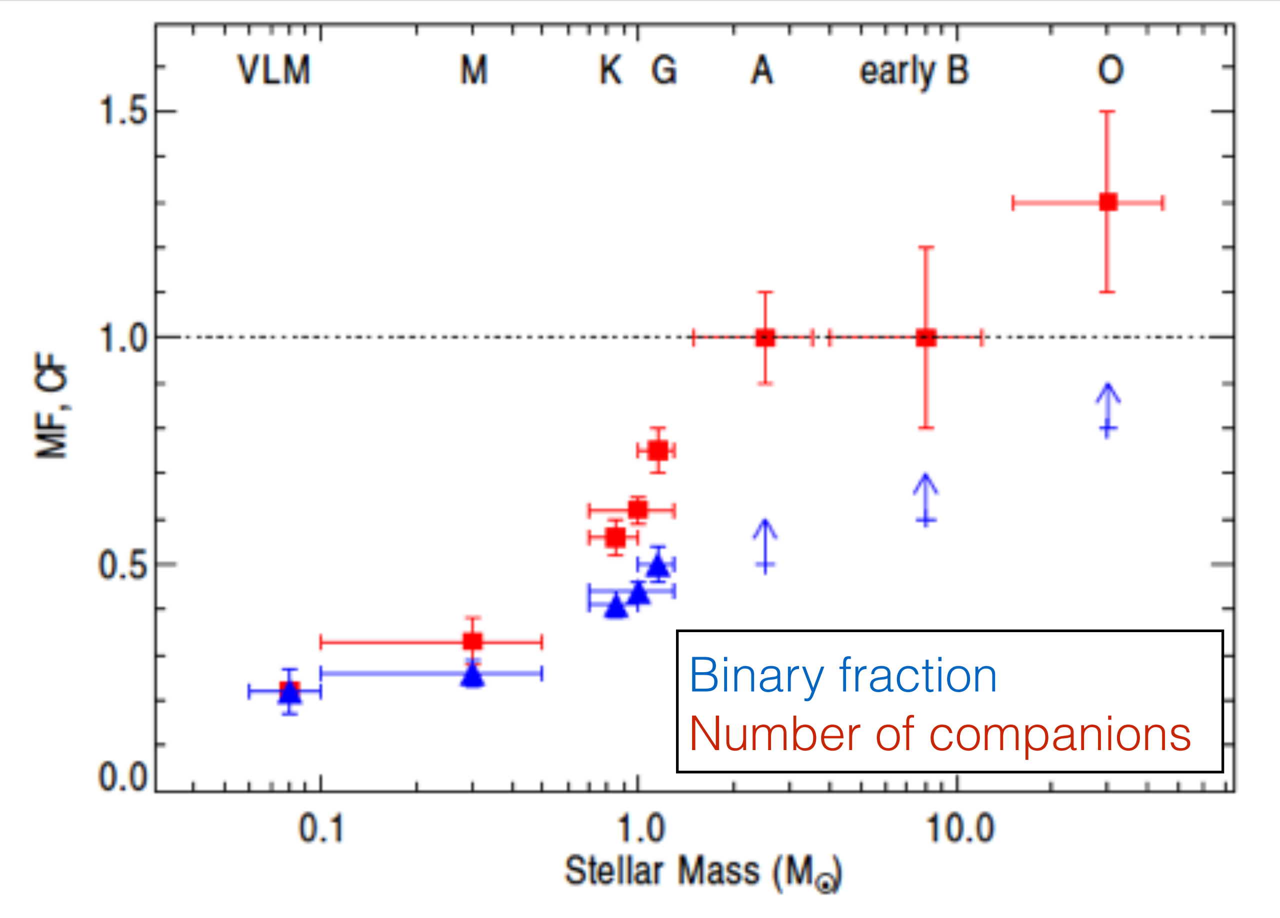
Properties of the massive binary population

Laurent Mahy

Current situation ?

Current situation ?



- <u>In the Galaxy:</u>
  > 70% of the massive stars are binaries or multiple systems (Sana et al. 2012)

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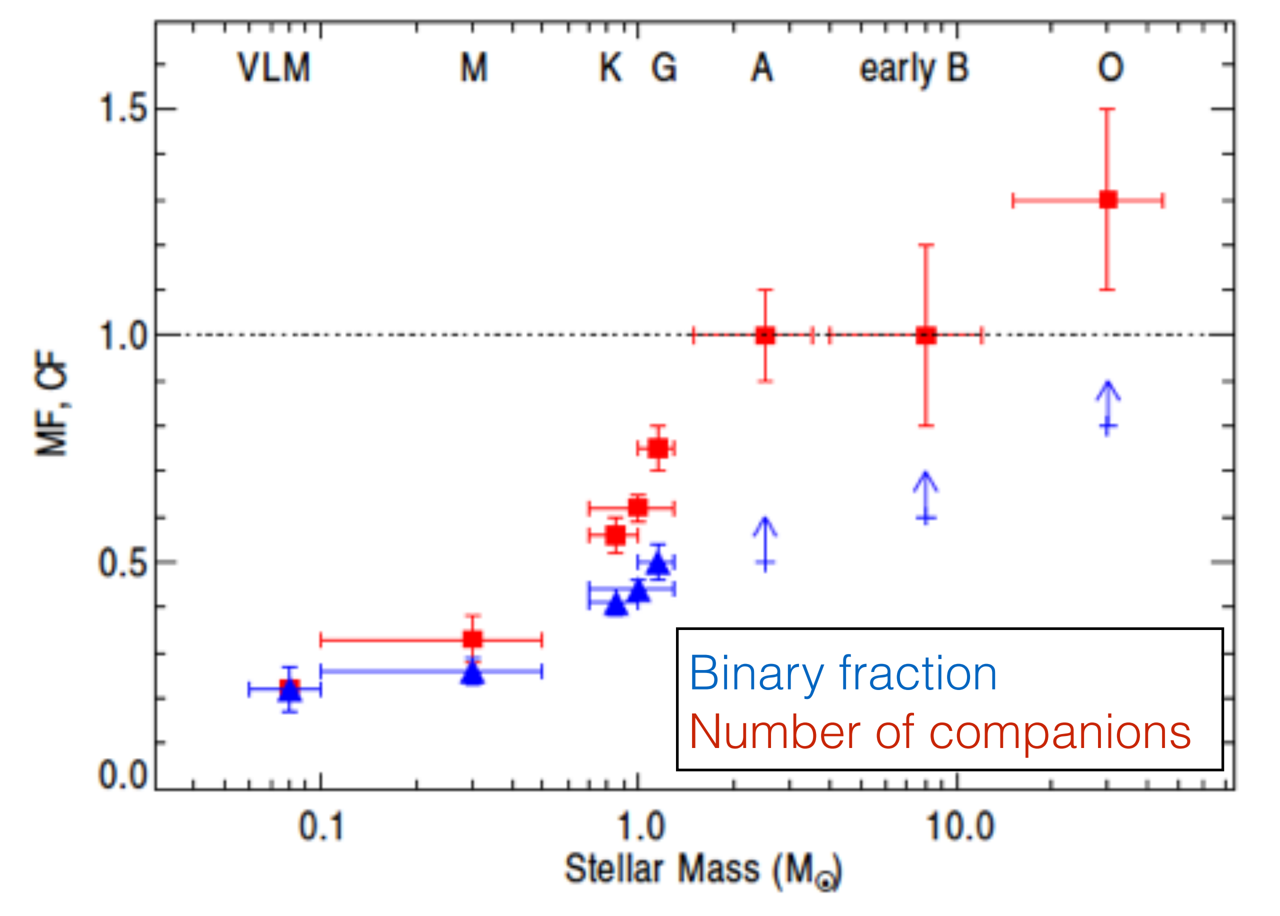

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  > 55% are binaries (Kobulnicky et al. 2014)

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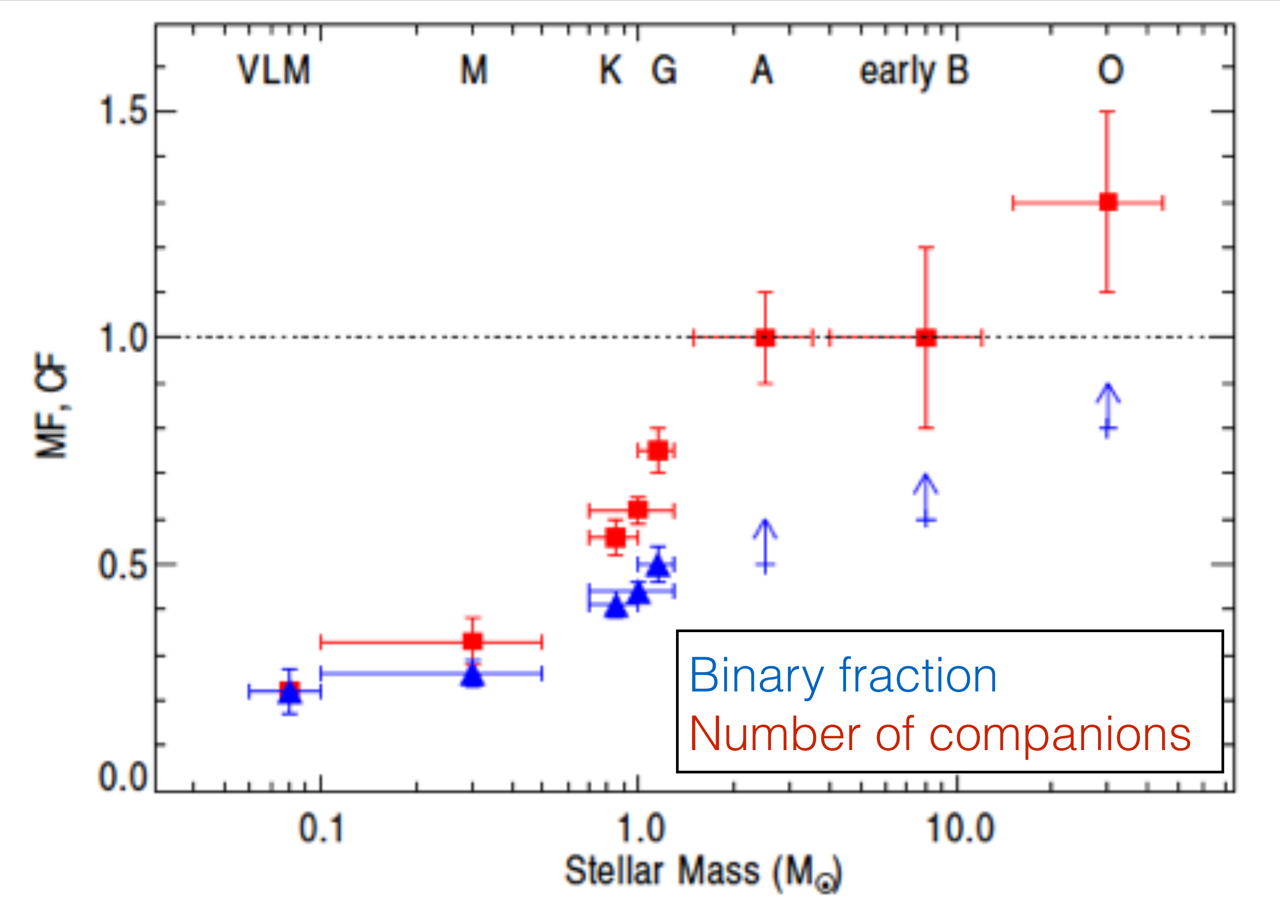

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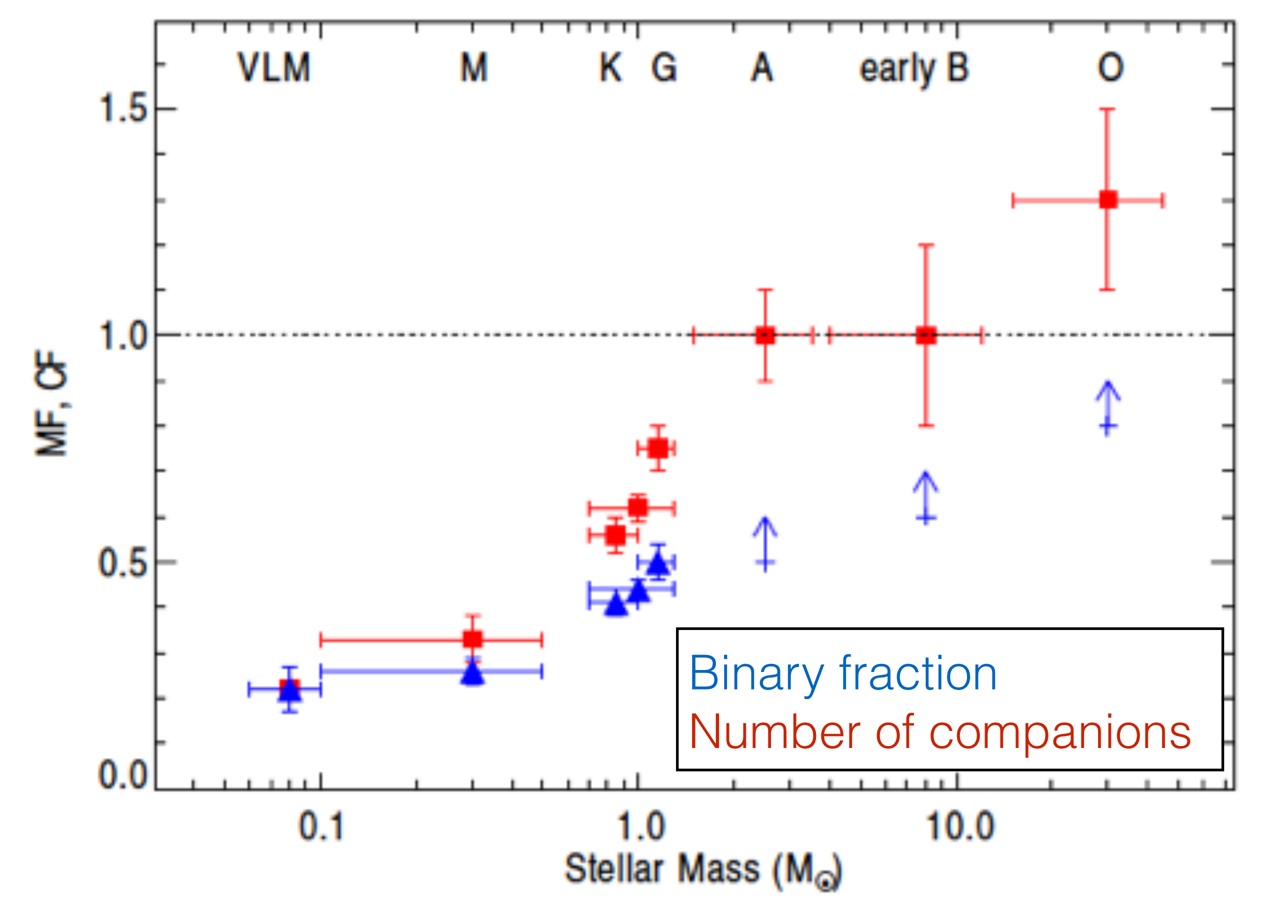

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NGC 2244	7	14 %
NGC 6231	16	63 %
NGC 6611	9	44 %
IC 2944	14	53 %
IC 1805	8	38 %
Cyg OB1,3,8,9	4	21 %

Impact of the binarity on stellar evolution ?

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Wide orbit:

Both components
evolve as single stars

Impact of the binarity on stellar evolution ?

<u>Wide orbit:</u>

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<u>close systems:</u>

Effects of the tides

Mass transfer

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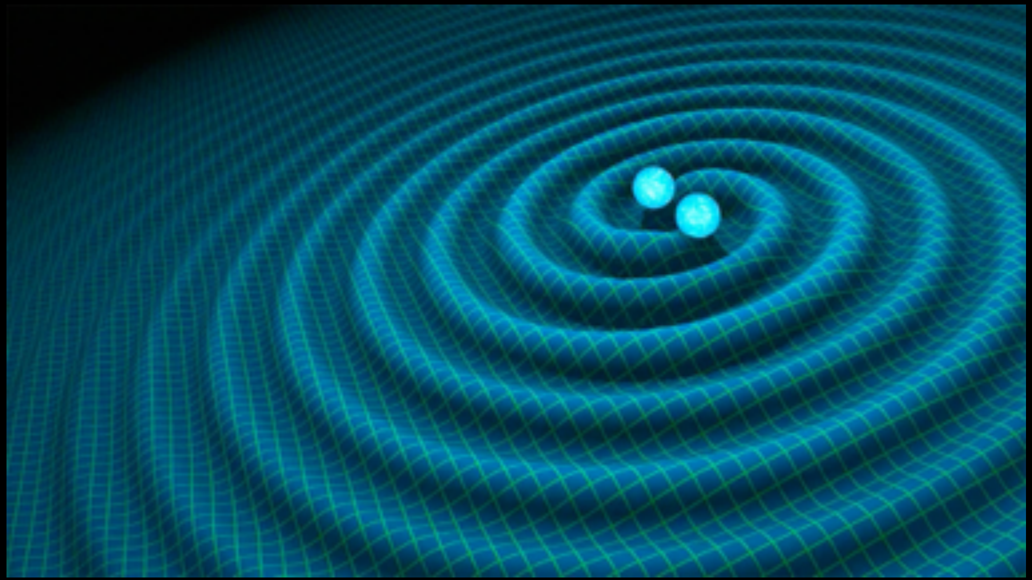


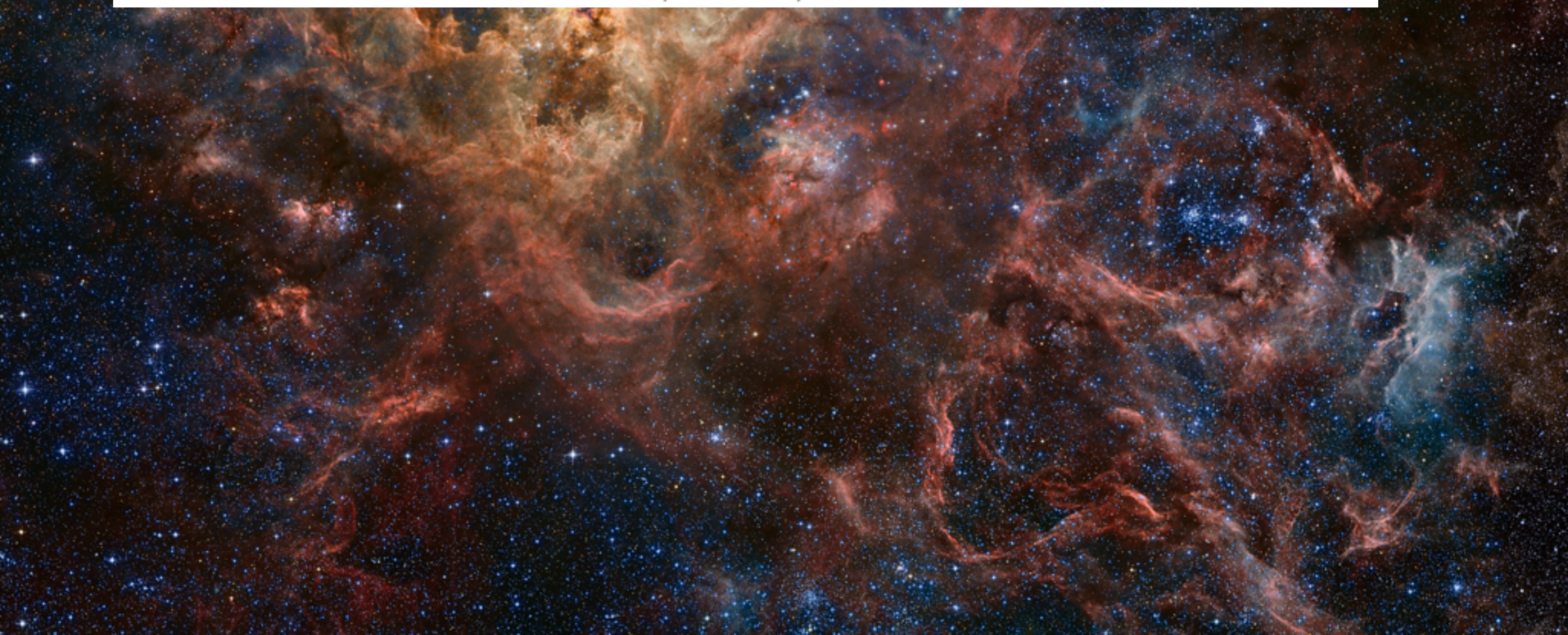
A&A 530, A108 (2011)
DOI: 10.1051/0004-6361/201116782

Astronomy & Astrophysics

The VLT-FLAMES Tarantula Survey

I. Introduction and observational overview[⋆]

C. J. Evans[1], W. D. Taylor[2], V. Hénault-Brunet[2], H. Sana[3], A. de Koter[3,4], S. Simón-Díaz[5,6], G. Carraro[7], T. Bagnoli[3], N. Bastian[8,9], J. M. Bestenlehner[10], A. Z. Bonanos[11], E. Bressert[9,12,13], I. Brott[4,14], M. A. Campbell[2], M. Cantiello[15], J. S. Clark[16], E. Costa[17], P. A. Crowther[18], S. E. de Mink[19,⋆⋆], E. Doran[18], P. L. Dufton[20], P. R. Dunstall[20], K. Friedrich[15], M. Garcia[5,6], M. Gieles[21], G. Gräfener[10], A. Herrero[5,6], I. D. Howarth[22], R. G. Izzard[15], N. Langer[15], D. J. Lennon[23], J. Maíz Apellániz[24,⋆⋆⋆], N. Markova[25], F. Najarro[26], J. Puls[27], O. H. Ramirez[3], C. Sabín-Sanjulián[5,6], S. J. Smartt[20], V. E. Stroud[16,28], J. Th. van Loon[29], J. S. Vink[10], and N. R. Walborn[19]



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Astronomy & Astrophysics

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The VLT-FLAMES Tarantula Survey.*

XXIX. Massive star formation in the local 30 Doradus starburst

F.R.N. Schneider[1]**, O.H. Ramírez-Agudelo[2], F. Tramper[3], J.M. Bestenlehner[4,5], N. Castro[6], H. Sana[7], C.J. Evans[2], C. Sabín-Sanjulián[8], S. Simón-Díaz[9,10], N. Langer[11], L. Fossati[12], G. Gräfener[11], P.A. Crowther[5], S.E. de Mink[13], A. de Koter[13,7], M. Gieles[14], A. Herrero[9,10], R.G. Izzard[14,15], V. Kalari[16], R.S. Klessen[17], D.J. Lennon[3], L. Mahy[7], J. Maíz Apellániz[18], N. Markova[19], J.Th. van Loon[20], J.S. Vink[21], and N.R. Walborn[22]***

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The VLT-FLAMES Tarantula Survey

A&A 598, A84 (2017)
DOI: 10.1051/0004-6361/201629844

The Tarantula Massive Binary Monitoring

I. Observational campaign and OB-type spectroscopic binaries★

L. A. Almeida[1,2], H. Sana[3,4], W. Taylor[5], R. Barbá[6], A. Z. Bonanos[7], P. Crowther[8], A. Damineli[1], A. de Koter[9,3], S. E. de Mink[9], C. J. Evans[5], M. Gieles[10], N. J. Grin[12], V. Hénault-Brunet[11], N. Langer[12], D. Lennon[13], S. Lockwood[4], J. Maíz Apellániz[14], A. F. J. Moffat[15], C. Neijssel[9], C. Norman[2], O. H. Ramírez-Agudelo[5], N. D. Richardson[16], A. Schootemeijer[12], T. Shenar[17], I. Soszyński[18], F. Tramper[13], and J. S. Vink[19]

F.R.N. Schneider[1]★★, O.H. Ramírez-Agudelo[2], F. Tramper[3], J.M. Bestenlehner[4,5] N. Castro[6], H. Sana[7], C.J. Evans[2], C. Sabín-Sanjulián[8], S. Simón-Díaz[9,10], N. Langer[11], L. Fossati[12], G. Gräfener[11], P.A. Crowther[5], S.E. de Mink[13], A. de Koter[13,7], M. Gieles[14], A. Herrero[9,10], R.G. Izzard[14,15], V. Kalari[16], R.S. Klessen[17], D.J. Lennon[3], L. Mahy[7], J. Maíz Apellániz[18], N. Markova[19], J.Th. van Loon[20], J.S. Vink[21], and N.R. Walborn[22]★★★

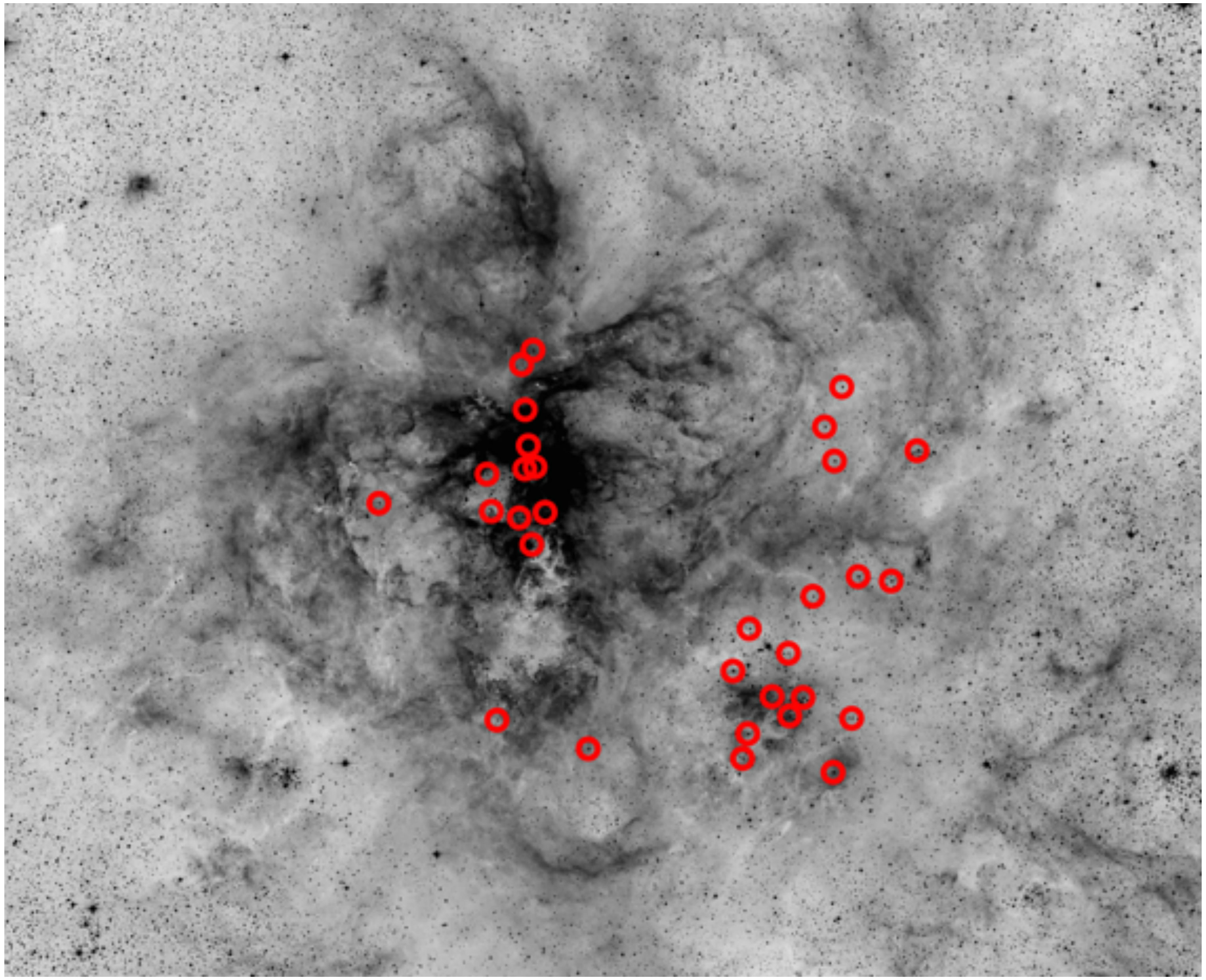
TMBM:

- 32 epochs randomly observed
- FLAMES spectra:

  [3950:4560] A

  [H, He I, He II, C III, N III, Si IV]

- 31 SB2 systems:
  - 19 only spectroscopic
  - 13 photometric + spectroscopic
    - ➡ 5 showing eclipses
    - ➡ 2 (over-)contact
    - ➡ 6 ellipsoidal var.



METHODOLOGY:

- Almeida et al. (2017) measured the radial velocities for all the epochs and compute the orbital periods, mass ratios, and eccentricities
- Fourier spectral disentangling (Simon & Sturm 1994, Ilijic et al. 2004)
- Use the CMFGEN atmosphere code (Hillier & Miller 1998)
  - Determination of the Teff, log g
  - Determination of the C and N abundances - no O lines
  - Hydrogen and Helium lines used to scale the disentangling spectra for non-photometric systems i.e. $l_1+l_2 = 1$.
- Comparaison with BONNSAI (Bayesian tool) for the theoretically predicted values

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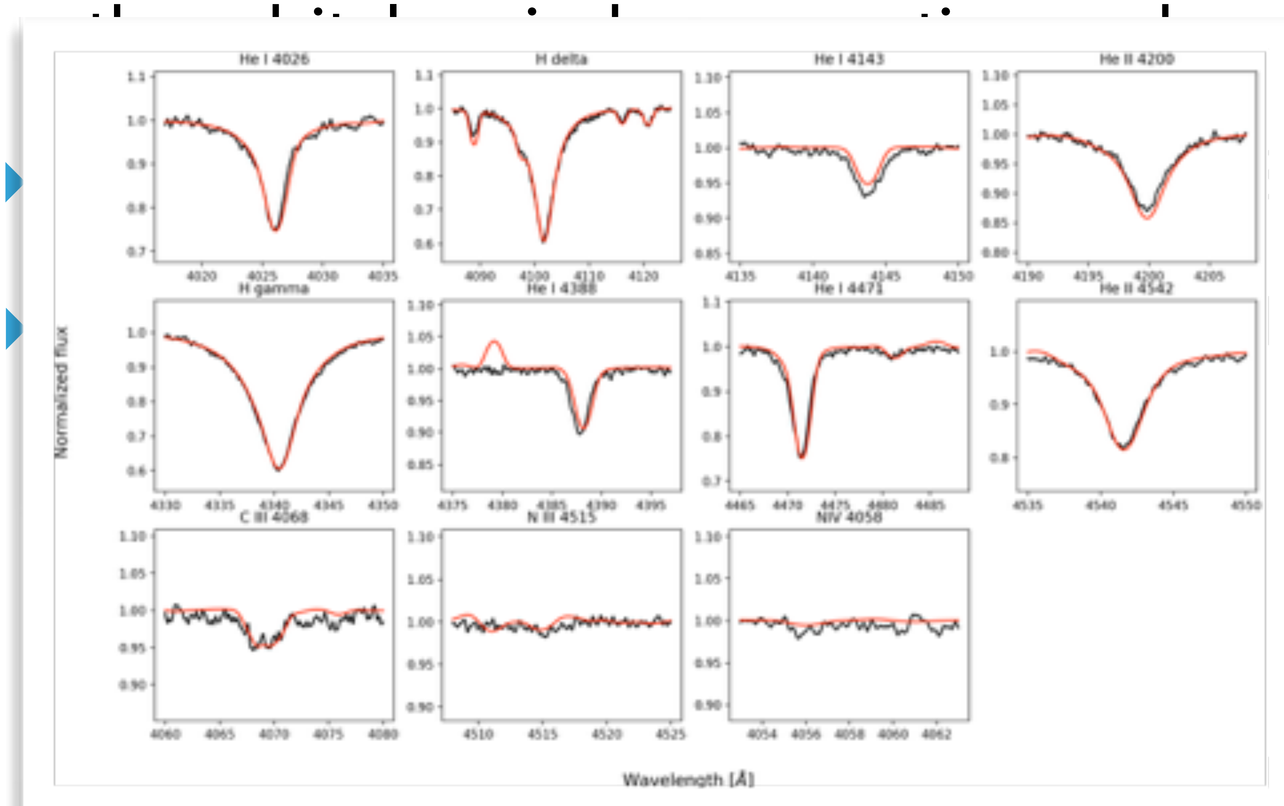
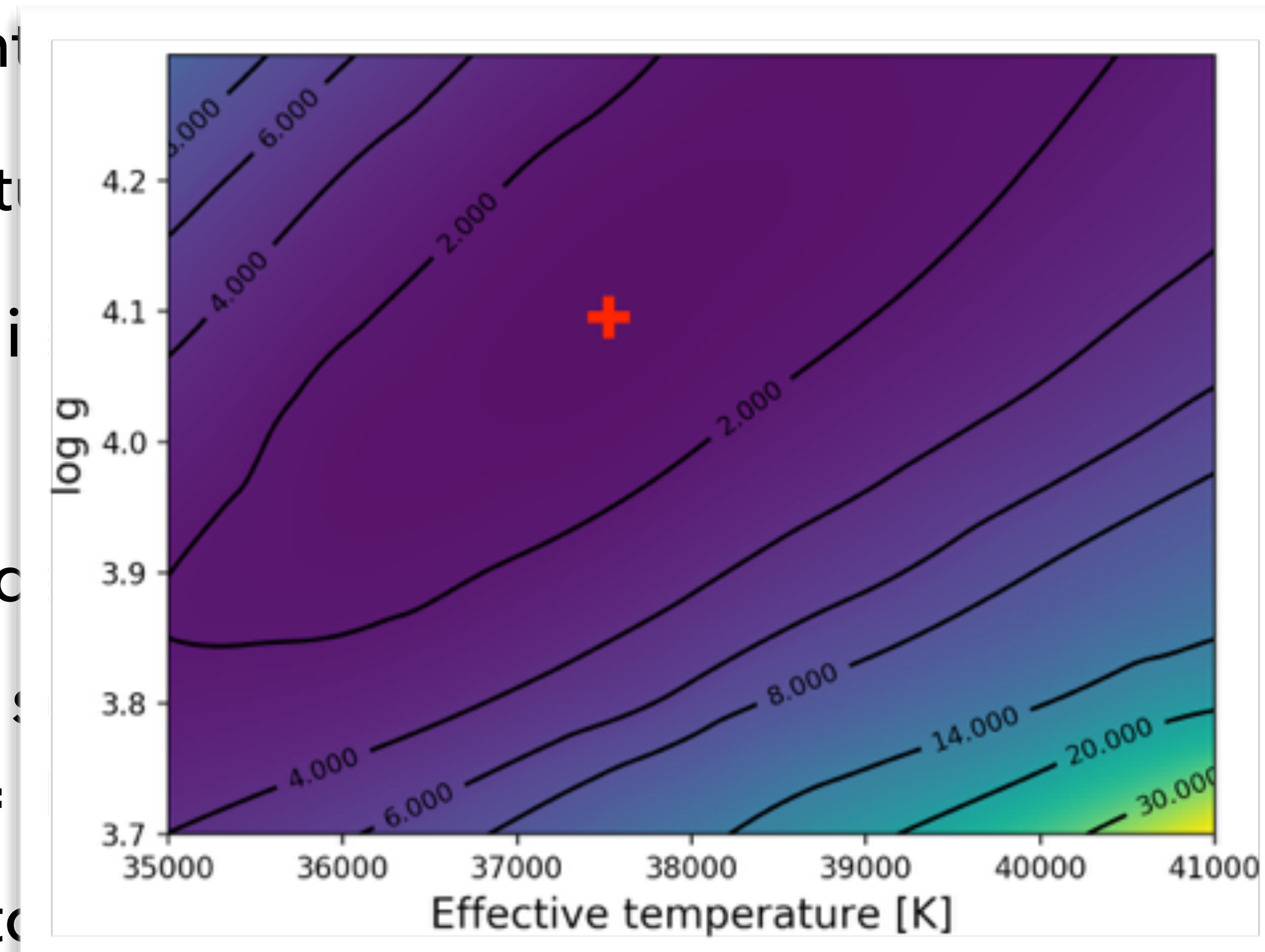
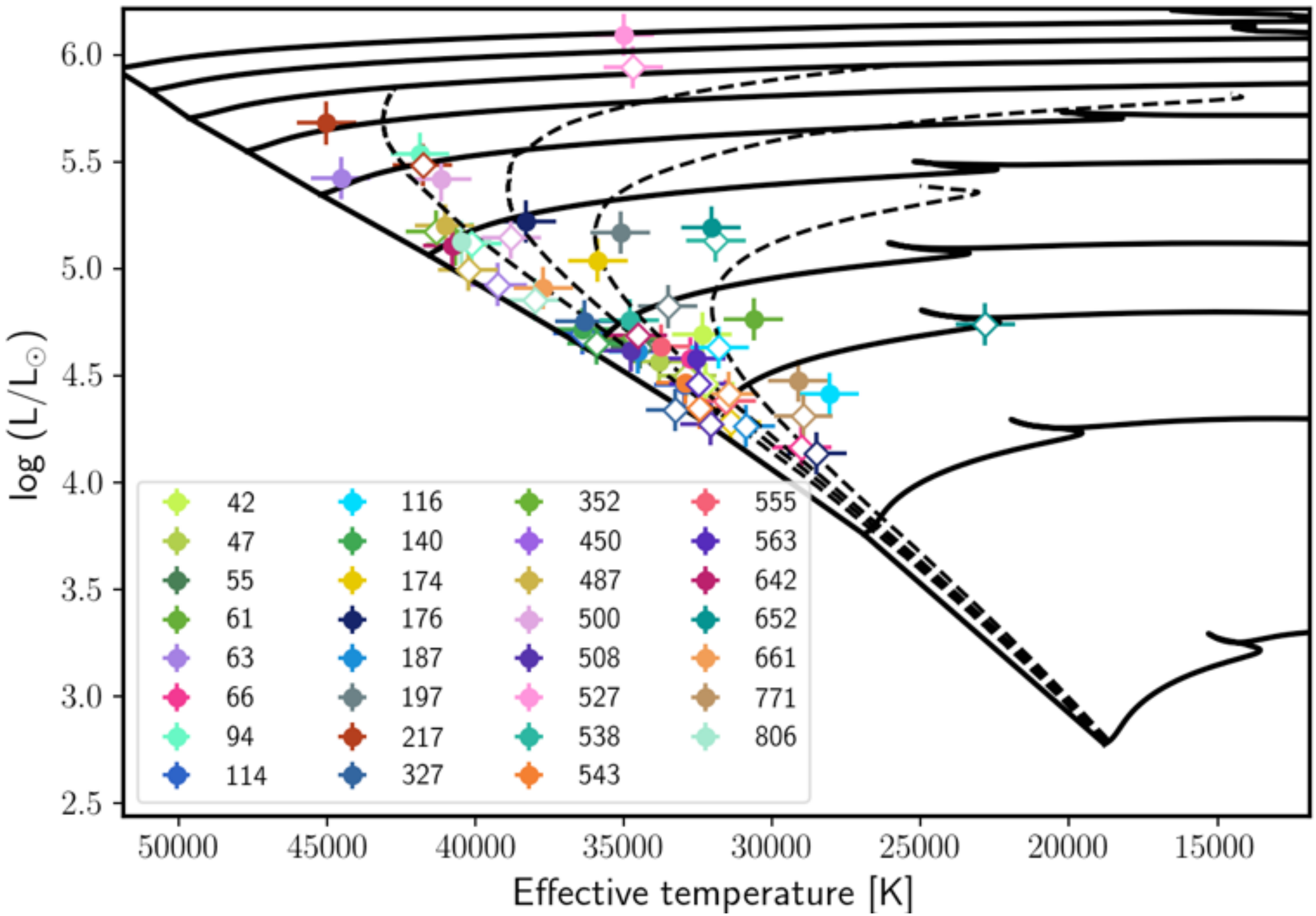


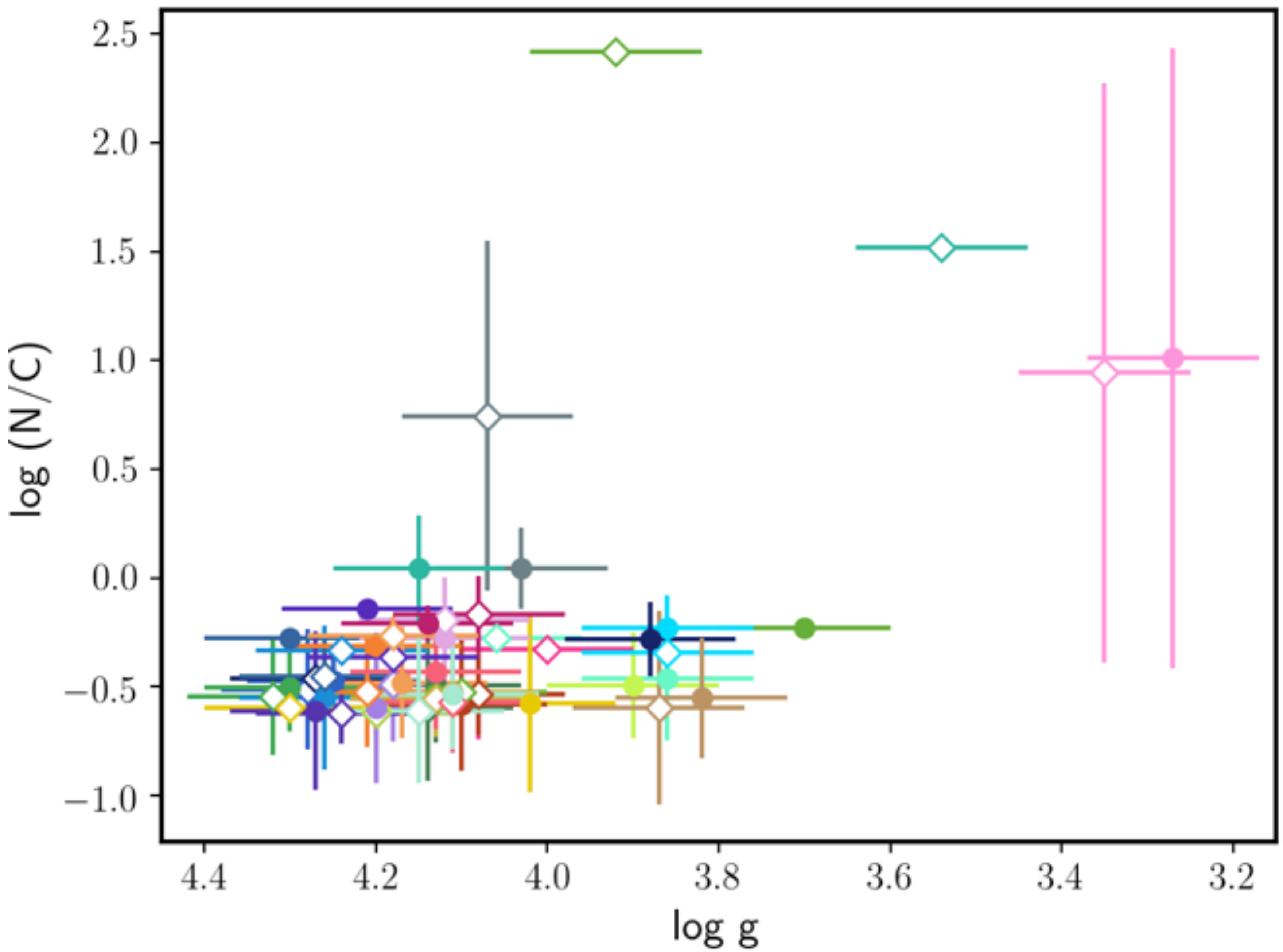


HERTZSPRUNG-RUSSELL DIAGRAM



SURFACE ABUNDANCES

No line to derive the oxygen surface abundance



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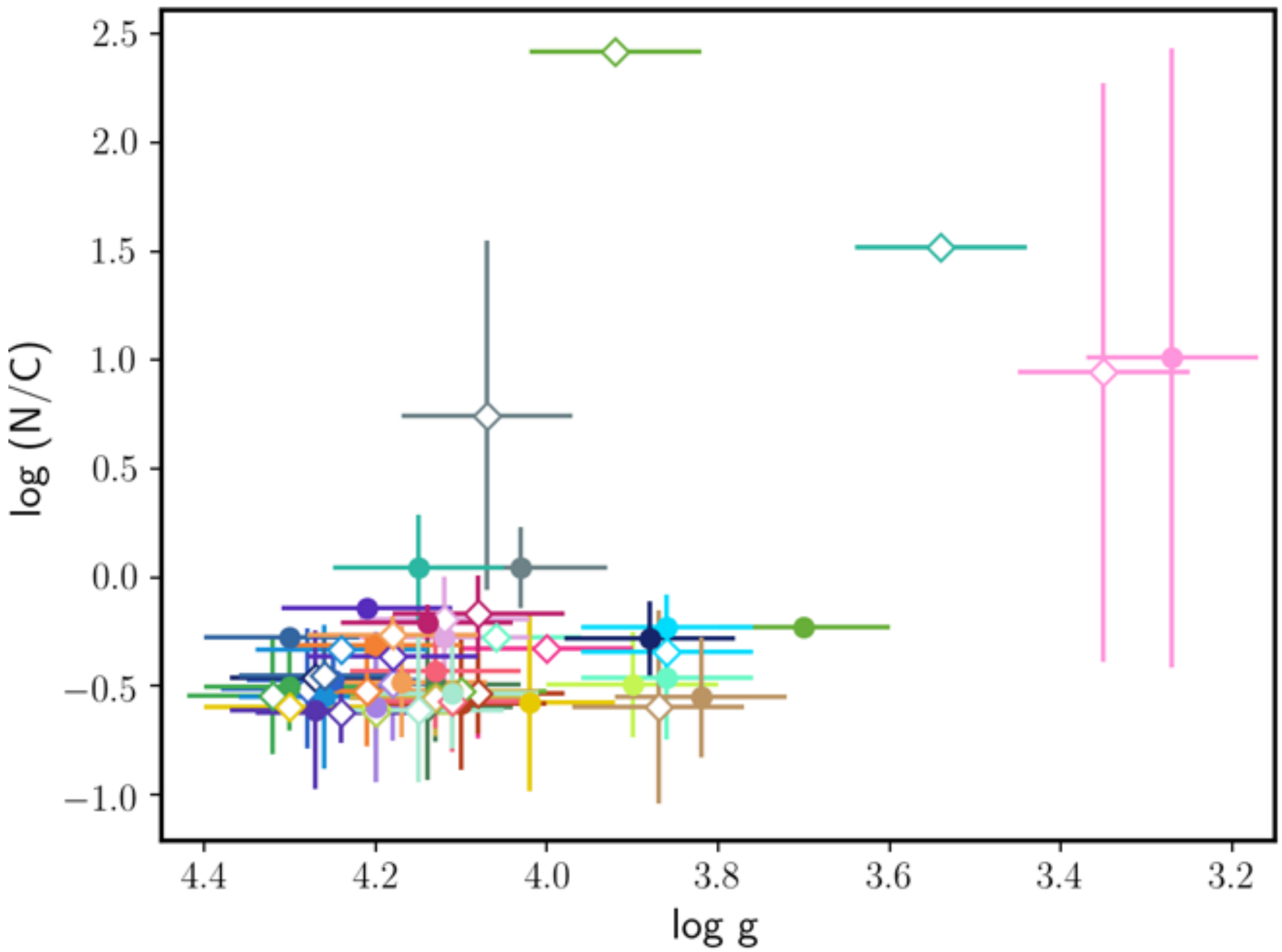

- filling of the Roche lobe
- (Pseudo-) Synchronization
- Rotational velocities

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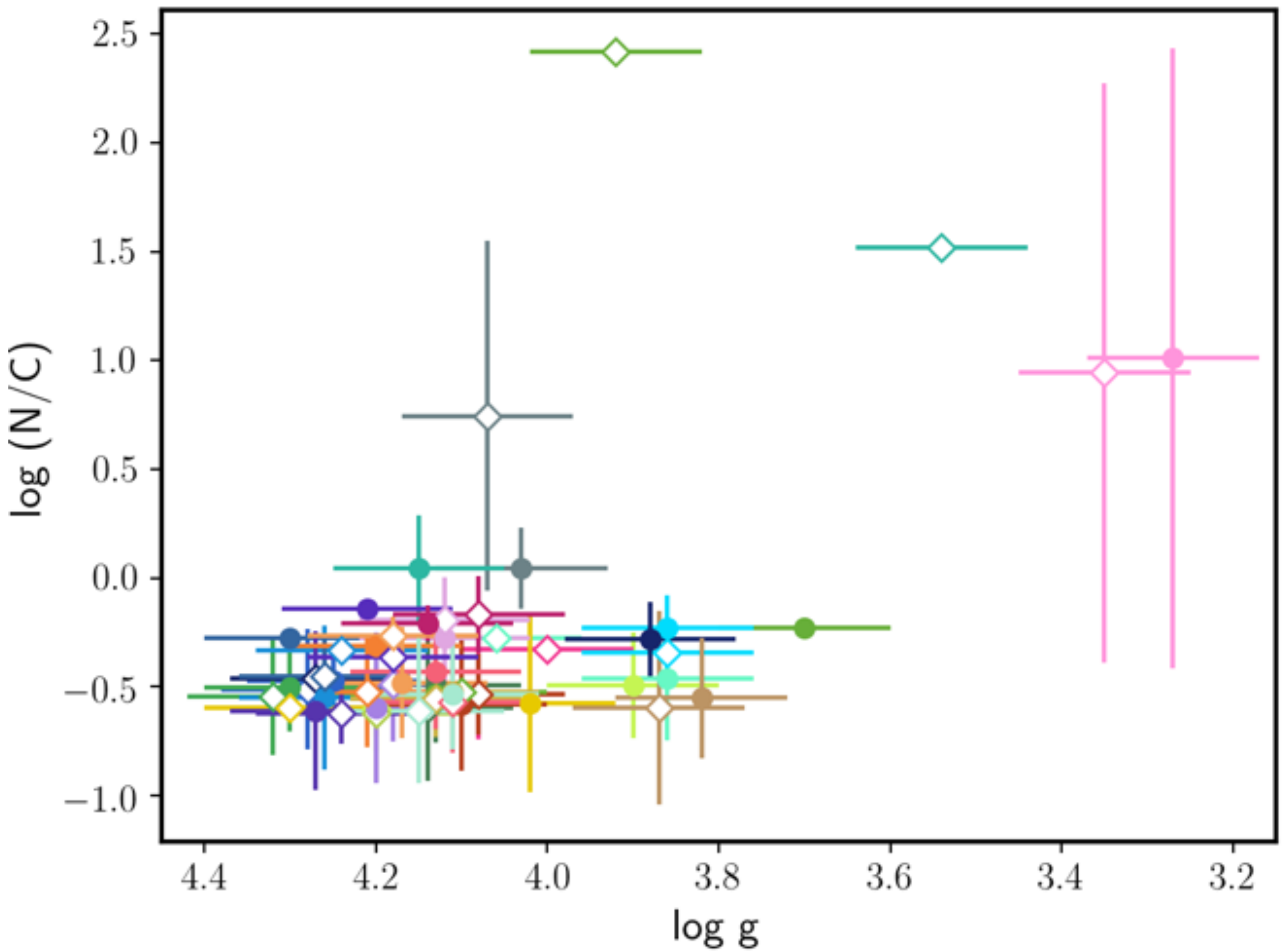

- filling of the Roche lobe
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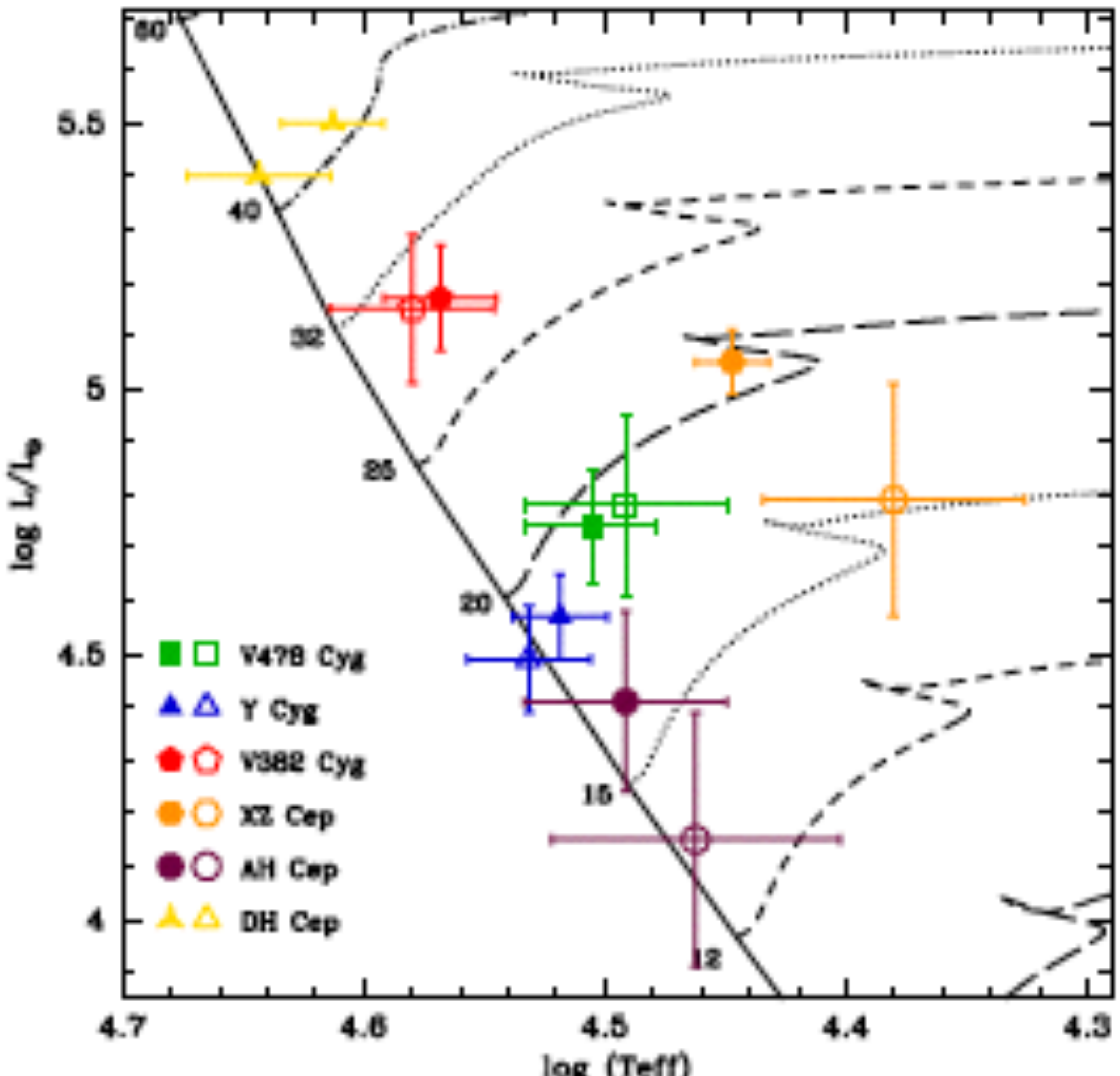
Mahy et al. (in prep.)

- Liège has a large expertise in analyzing binaries
- Use TIGRE and other facilities to study a large fraction of massive binaries
- With TIGRE, monitoring of about 15 massive eclipsing binaries (with O/early B stars)
- To constrain the effects of the interactions (rotational mixing, surface abundances, tidal effects…)

Pilot study: 6 massive (eclipsing) systems:

AH Cep, DH Cep, XZ Cep, V382 Cyg, V478 Cyg, Y Cyg



Martins, Mahy, and Hervé (2017)

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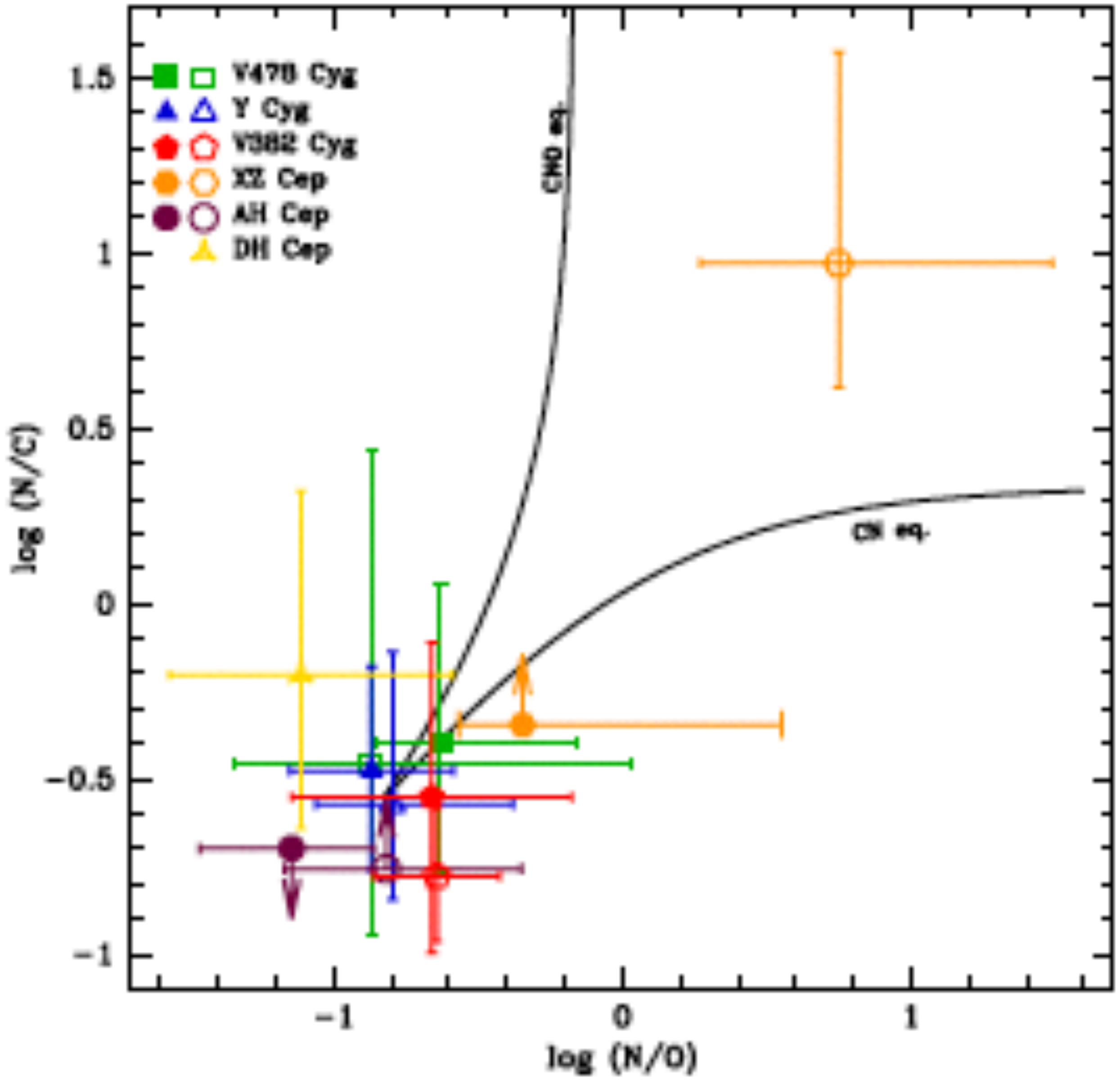

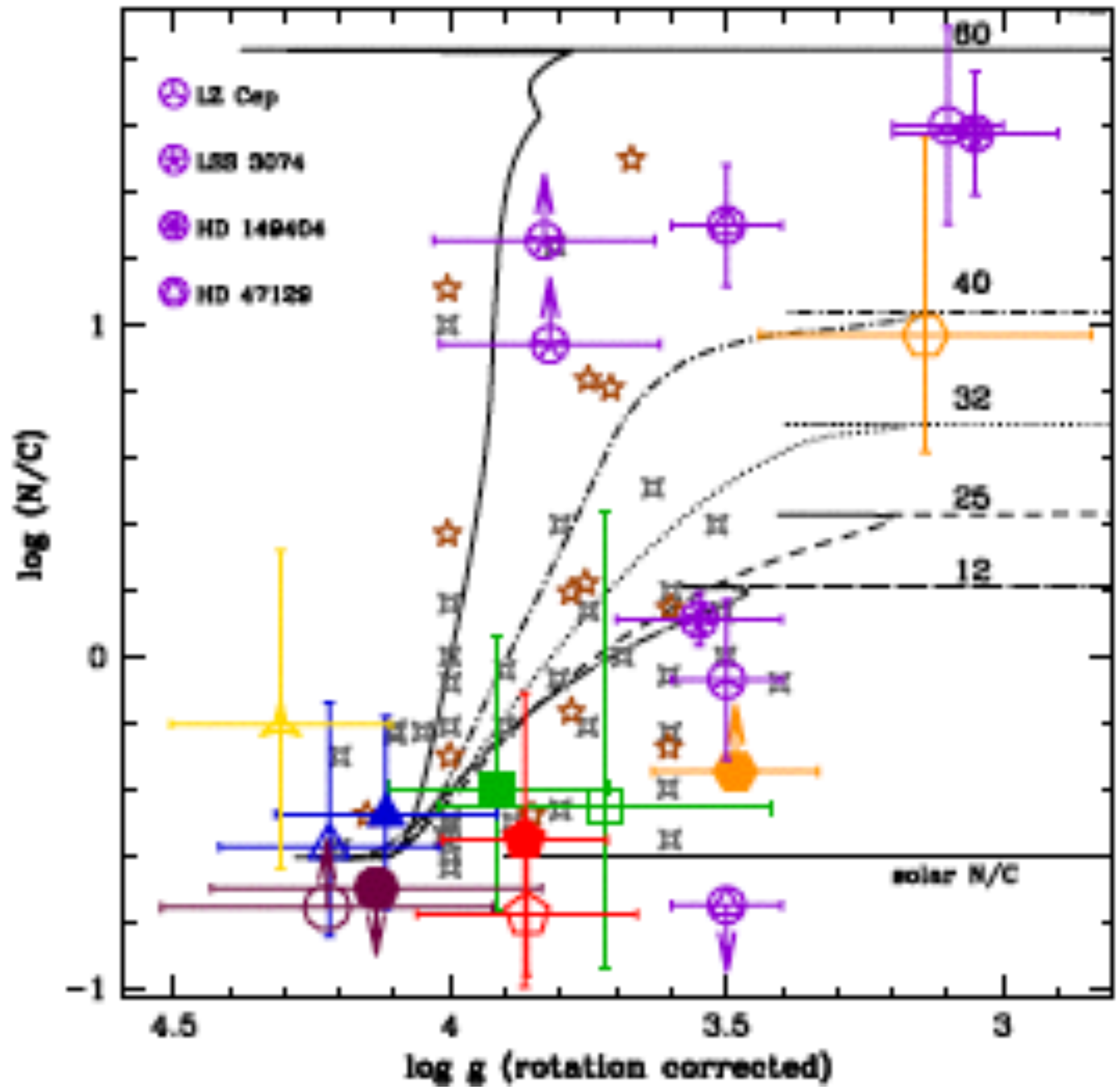

The effect of tides on chemical mixing is limited, whereas the mass transfer leads to the appearance of chemically processed material at the surface

THE END

…for this year…

THANK YOU