OB stars and associations with *Gaia*

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(+ Michelangelo Pantaleoni González
+ Gonzalo Holgado + …)
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Napoli, Italy, Tuesday 20 September 2022

What I will talk about

- Setting up the scene.
  - ★ What are OB stars and OB associations?
  - ★ Other projects: GOSSS, LiLiMaRlin, and ALS.
- EDR3 results.
  - ★ The Villafranca project: OB stellar groups.
  - ★ The ALS project: OB stars and associations.
  - ★ Other results.
- DR3 results from survey papers.
  - ★ Extinction, $T_{\rm eff}$, and spectral classification.

What are OB stars?

- Three alternative (quasi-equivalent) definitions:
  - ★ Massive stars (> 8 M_{Sol}) of spectral types O and B.
  - ★ Hot (> 10 kK) massive stars (if we include WR stars).
  - ★ O-B2 V + O-B5 III + O-B9 I.
- Ages up to ~30 Ma.
- Great Galactic influencers:
  - ★ UV radiation + winds + SNe + stellar ejections.
- They are not stars of spectral types O and B.
  - ★ Sample dominated by mid and late-type B dwarfs.
  - ★ Ages up to several hundreds of Ma.

What are OB stars?

A&A 650, A112 (2021)
https://doi.org/10.1051/0004-6361/202039726

Astronomy & Astrophysics

Mapping luminous hot stars in the Galaxy★

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Received 20 October 2020 / Accepted 16 February 2021

ABSTRACT

Luminous hot stars ($M_{K_s} \lesssim 0$ mag and $T_{\rm eff} \gtrsim 8000$ K) dominate the stellar energy input to the interstellar medium throughout cosmological time, are used as laboratories to test theories of stellar evolution and multiplicity, and serve as luminous tracers of star formation in the Milky Way and other galaxies. Massive stars occupy well-defined loci in colour–colour and colour–magnitude spaces, enabling selection based on the combination of *Gaia* EDR3 astrometry and photometry and 2MASS photometry, even in the presence of substantive dust extinction. In this paper we devise an all-sky sample of such luminous OBA-type stars, which was designed to be complete rather than very pure, providing targets for spectroscopic follow-up with the SDSS-V survey. To estimate the purity and

Gaia Data Release 3: Hot-star radial velocities

R. Blomme[1★], Y. Frémat[1], P. Sartoretti[2], A. Guerrier[3], P. Panuzzo[2], D. Katz[2], G. M. Seabroke[4], F. Thévenin[5], M. Cropper[4], K. Benson[4], Y. Damerdji[6,7], R. Haigron[2], O. Marchal[8], M. Smith[4], S. Baker[4], L. Chemin[9], M. David[10], C. Dolding[4], E. Gosset[7,11], K. Janßen[12], G. Jasniewicz[13], A. Lobel[1], G. Plum[2], N. Samaras[1,14], O. Snaith[2], C. Soubiran[15], O. Vanel[2], T. Zwitter[16], N. Brouillet[15], E. Caffau[2], F. Crifo[2], C. Fabre[17,3], F. Frakgoudi[2], H.E. Huckle[4], A. Jean-Antoine Piccolo[3], Y. Lasne[3], N. Leclerc[2], A. Mastrobuono-Battisti[2,18], F. Royer[2], Y. Viala[2], and J. Zorec[19]

(Affiliations can be found after the references)

Received <date>; accepted <date>

ABSTRACT

Context. The second *Gaia* data release, DR2, contained radial velocities of stars with effective temperatures up to $T_{\rm eff}$ = 6900 K. The third data release, *Gaia* DR3, extends this up to $T_{\rm eff}$ = 14 500 K.
Aims. We derive the radial velocities for hot stars (i.e. in the $T_{\rm eff}$ = 6900–14 500 K range) from data obtained with the Radial Velocity Spectrometer (RVS) on board *Gaia*.

What are OB associations?

- Two types of stellar groups:
  - ★ Clusters: born together and bound at the present time.
  - ★ Associations: born together and unbound at the present time
- Difficult to distinguish between them:
  - ★ Distances, proper motions, and radial velocities.
  - ★ Membership and ejections (runaway and walkaway stars).
- Two hypothesis for how associations are formed:
  - ★ Nature: born that way, slowly dispersing.
  - ★ Nurture: dissolved clusters currently expanding.

What are OB associations?

REVIEWS OF MODERN PHYSICS VOLUME 30, NUMBER 3 JULY, 1958

On the Problem of the Mechanism of the Origin of Stars in Stellar Associations

V. A. AMBARTSUMIAN

Burakan Astrophysical Observatory Academy of Sciences of the Armenian S. S. R., Erevan, Armenian S. S. R., U. S. S. R.

ALMOST ten years have passed since the idea of stellar associations as nonstable stellar systems was formulated.[1] The complex of observational data obtained during this time indicates that stars contained in the associations are young objects of some million years of age. We would like to stress here that this concerns both the O and T associations. It is also known that those O associations which could be sufficiently investigated in this respect, contain, as a rule, T Tauri type stars and are consequently T associations as well. There are, on the other hand, T associations which do not contain hot giants. But apparently the mechanisms of stellar formations must be similar in O and T associations. This means that any theory of stellar origin for a given type of association must permit variations, which will provide an explanation of the origin of stars in associations of other type.

Two hypotheses on the origin of stellar associations have been thus far discussed. One of them, suggested by the author at the initial stage of the idea about associations, supposes that each association has originated as a result of an expansion from a body or a system, the volume of which was initially very small. The dimensions of the latter was in any case less than one parsec. According to this point of view, these initial bodies (protostars) have either not been observed up to the present, or have not yet been identified with any known object. This point of view does not give any indication about a concrete mechanism of stellar origin, postponing its explanation to the time, when the earliest stages of the expansion of the association may be studied in detail.

On the other hand, Oort[2] and Oort and Spitzer[3] suggested a very interesting mechanism of the influence of radiation of O stars on large gaseous clouds in their surroundings. This mechanism leads to the possibility of transformation of a part of the radiative energy of the stars into kinetic energy of interstellar gaseous clouds. It seems to us that the role of the mentioned mechanism in the total balance of the kinetic energy of interstellar matter is very important. According to Oort, in the cold HI regions which surround the HII zone formed around an O star, a very high gas pressure

[1] V. A. Ambartsumian, *Stellar Evolution and Astrophysics* (Erevan, U.S.S.R., 1947).
[2] J. H. Oort, "Gas dynamics of cosmic clouds," *I. A. U. Symposium No. 2* (North-Holland Publishing Company, Ansterdam, The Netherlands, 1955), p. 147.
[3] J. H. Oort and L. Spitzer, Astrophys. J. **121**, 6 (1955).

can arise, which may lead as a result of condensation to the origin of stars when the limit of gravitational instability is passed. Oort's views were reported at the Second Symposium on gas dynamics of cosmical clouds so we shall not present them here in detail.

What are OB associations?

Astrophys Space Sci
DOI 10.1007/s10509-009-0131-6

INVITED REVIEW

A pressure dependence for bound and unbound clusters

Bruce G. Elmegreen

Received: 4 January 2008 / Accepted: 2 April 2008

Abstract Hierarchical structure in gas and young stars produces clusters in high-density regions where the individual stellar orbits rapidly mix. For a fixed density at the onset of gas collapse (e.g. determined by changes in the ionization equilibrium and grain properties), the efficiency of star formation is automatically high in the high-density regions of giant molecular clouds. Thus, bound cluster formation follows somewhat trivially from hierarchical structure. The density where the efficiency is high enough to produce a bound cluster depends on the dispersion of the density probability distribution function (pdf), decreasing for higher dispersions and making bound cluster formation more likely. Similarly, the mass fraction of star formation in the form of bound clusters increases with the pdf dispersion. Because this dispersion is related to the turbulent Mach number, and also to the interstellar medium pressure and star-formation rate per unit volume, it follows that high-pressure or highly active regions tend to produce bound clusters, while low-pressure and inactive regions tend to produce stars in unbound associations.

Annu. Rev. Astron. Astrophys. 2003. 41:57–115
doi: 10.1146/annurev.astro.41.011802.094844

EMBEDDED CLUSTERS IN MOLECULAR CLOUDS

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The production of a bound cluster from a dense cloud core clearly requires special physical conditions. Hence, this must be a rare occurrence. The observed low SFEs for embedded clusters can account for the high infant mortality rate of clusters inferred from the relatively large numbers and high birthrates of embedded clusters compared to classical open clusters. Most (∼90–95%) embedded clusters must emerge from molecular clouds as unbound systems. Only the most massive ($M_{EC} > 500\ M_{\odot}$) embedded clusters survive emergence from molecular clouds to become stable, open clusters. Thus, although most stars form in embedded clusters, these stellar systems evolve to become the members of unbound associations, not bound clusters. However, bound classical clusters form at a sufficiently high rate,

Other projects: GOSSS

- GOSSS: Galactic O-Star Spectroscopic Survey.
- Blue-violet *R*~2500 spectroscopy of ~5000 stars.
- 2077-2022, private data from multiple telescopes.
- Data available at https://gosc.cab-inta.csic.es.
- Three major papers published, fourth in preparation.
- Most complete O-star spectroscopic survey: ~1000 O stars with high S/N spectra and accurate and homogeneous spectral types.
- Most of the rest are B stars.

Other projects: LiLiMaRlin

- LiLiMaRlin: a Library of Libraries of Massive-Star high-Resolution spectra.
- High-resolution $R \geq 25\,000$ spectroscopy of 1000+ O+B stars with 65 000+ epochs.
- 1994-2022, private+public data from multiple telescopes.
- Largest collection of high-resolution ground-based massive-star spectroscopy.
- Used for binary orbits, stellar-parameter determination, and ISM studies.

Other projects: ALS

- ALS: Alma Luminous Star catalog.
- Reed (2003): compilation of 18 693 luminous hot stars ("OB stars") from the literature.
- Some with spectral types, many without them.
- Coordinate errors and duplicates.
- Pantaleoni González et al. (2021): cross-match with *Gaia* DR2, 18 300 entries after eliminating duplicates but some of them are likely not massive stars.

EDR3: The Villafranca catalog of OB groups

A&A 643, A138 (2020)
https://doi.org/10.1051/0004-6361/202038228

Astronomy & Astrophysics

The Villafranca catalog of Galactic OB groups

I. Systems with O2–O3.5 stars

J. Maíz Apellániz[1], P. Crespo Bellido[1,2], R. H. Barbá[3], R. Fernández Aranda[1,2], and A. Sota[4]

A&A 657, A131 (2022)
https://doi.org/10.1051/0004-6361/202142364

Astronomy & Astrophysics

The Villafranca catalog of Galactic OB groups

II. From *Gaia* DR2 to EDR3 and ten new systems with O stars

J. Maíz Apellániz[1], R. H. Barbá[2,†], R. Fernández Aranda[1,3,4], M. Pantaleoni González[1,3], P. Crespo Bellido[1,3], A. Sota[5], and E. J. Alfaro[5]

A third paper is being written

EDR3: The Villafranca catalog of OB groups

- Long-term project to catalog all stellar groups, clusters or (sub-)associations, with massive stars in the solar neighborhood (26 so far) based on *Gaia* complemented with:
  - ★ GALANTE: Images and photometry from T-80 Javalambre telescope.
  - ★ GOSSS, LiLiMaRlin, WEAVE: Spectroscopy.
- Distances, membership, structure, IMF…
  - ★ Currently (EDR3), 1% distances at 1 kpc, 3% distances at 3 kpc.
  - ★ Limited by angular covariance term in uncertainty estimation.
- …and surprises: Runaway/walkaway stars and orphan clusters.

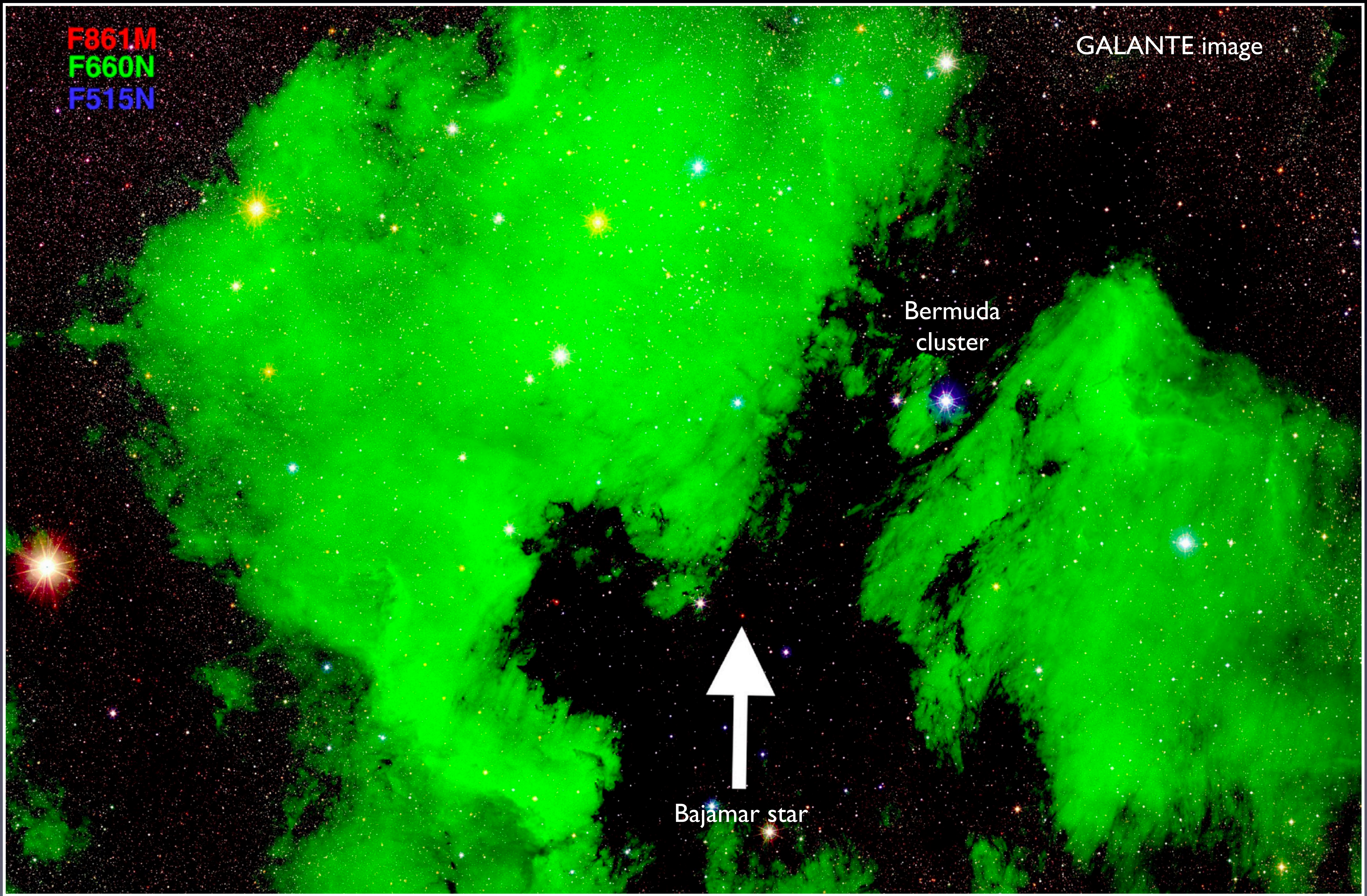
A&A 657, A72 (2022)
https://doi.org/10.1051/0004-6361/202142366

Astronomy & Astrophysics

Escape from the Bermuda cluster: Orphanization by multiple stellar ejections

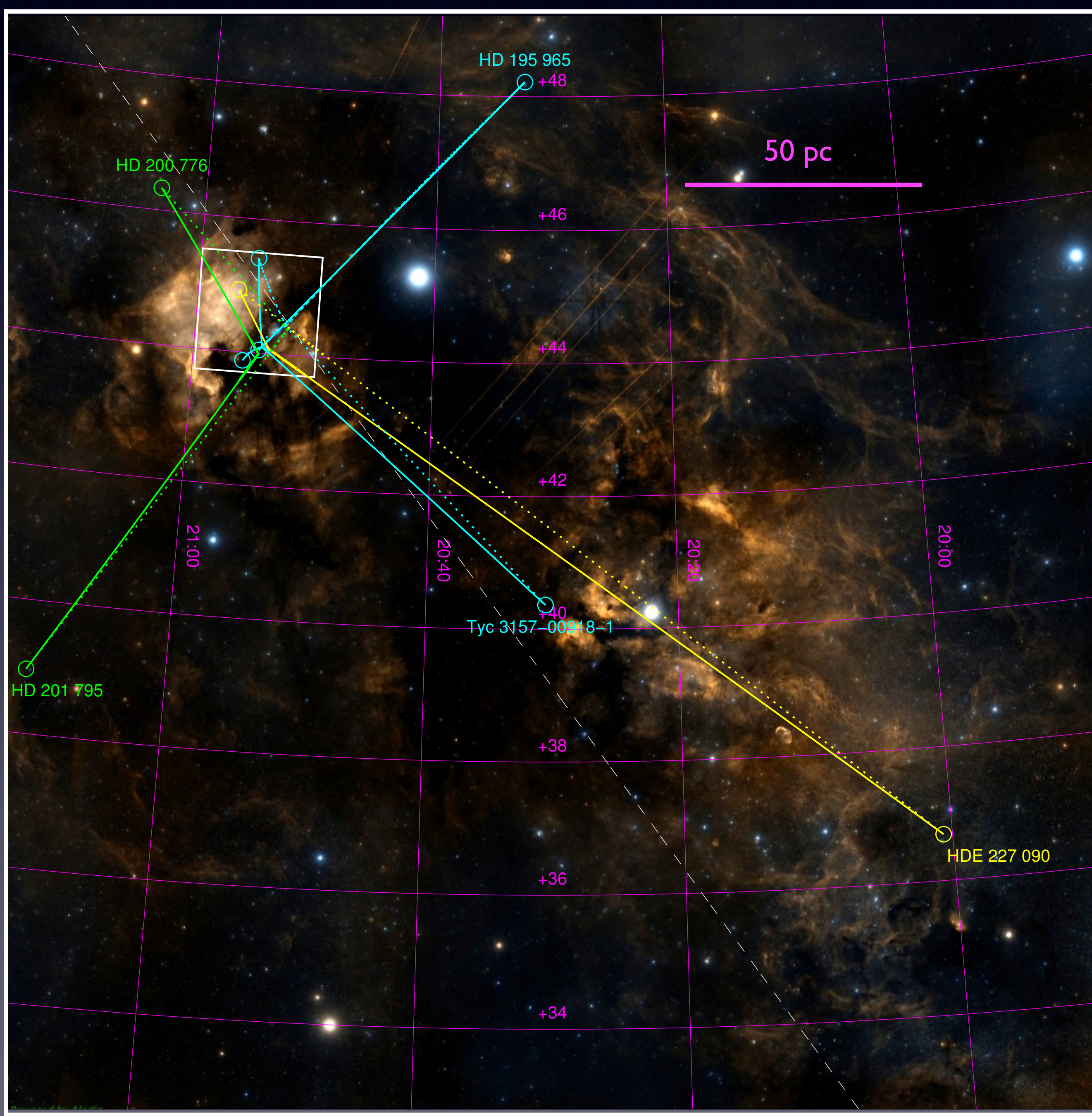
J. Maíz Apellániz[1], M. Pantaleoni González[1,2], R. H. Barbá[3,†], and M. Weiler[4]

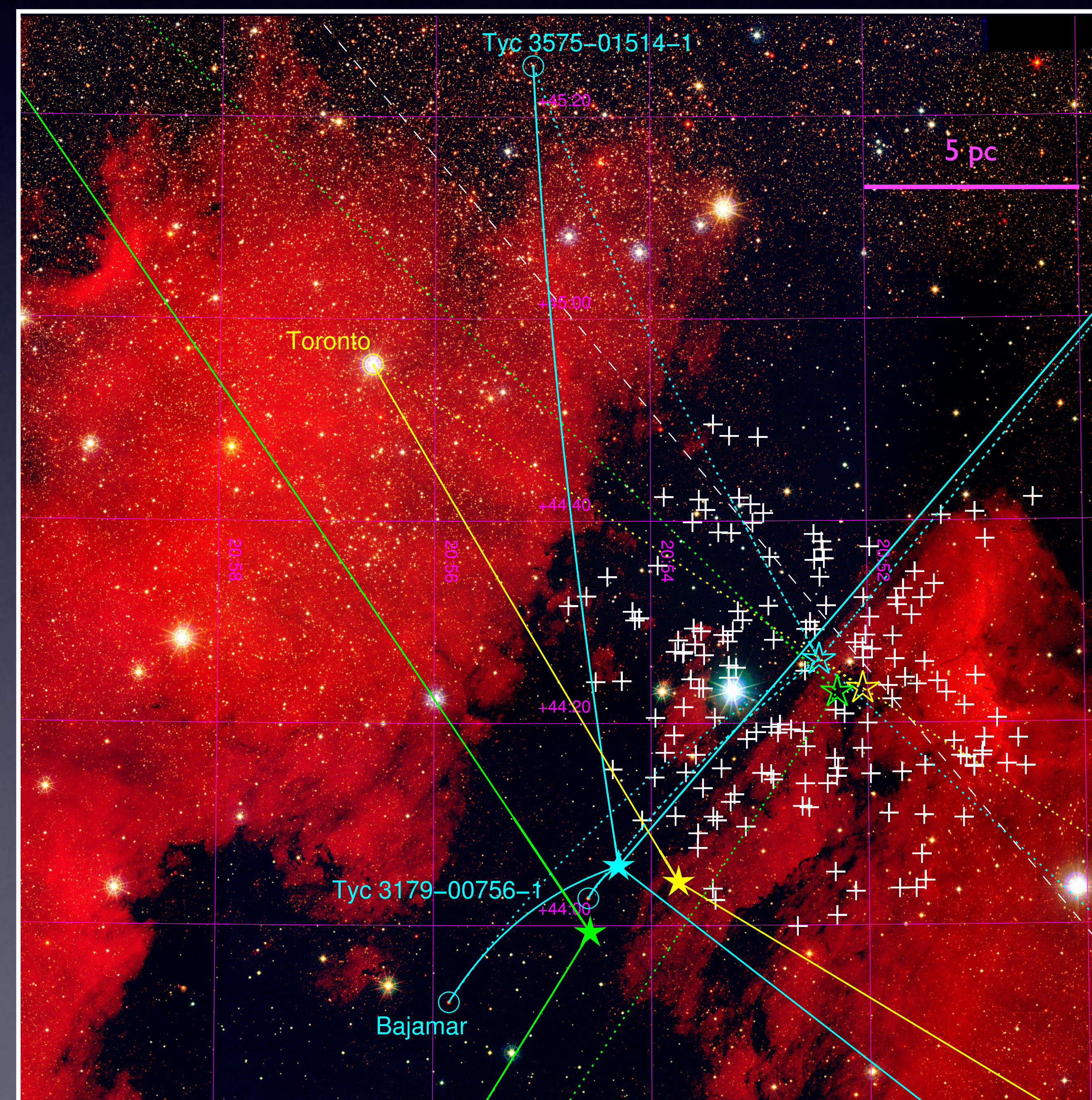
The North America and Pelican nebulae



Three ejection events

- Orphan clusters, a new phenomenon: 12+ ejected stars, including the three most massive.
- The observed MFs may not be the IMFs even for 1-2 Ma old clusters.
- The population of runaway/walkaway neutron stars and black holes.
- The cluster mass lost is so high that the Bermuda cluster has become unbound.





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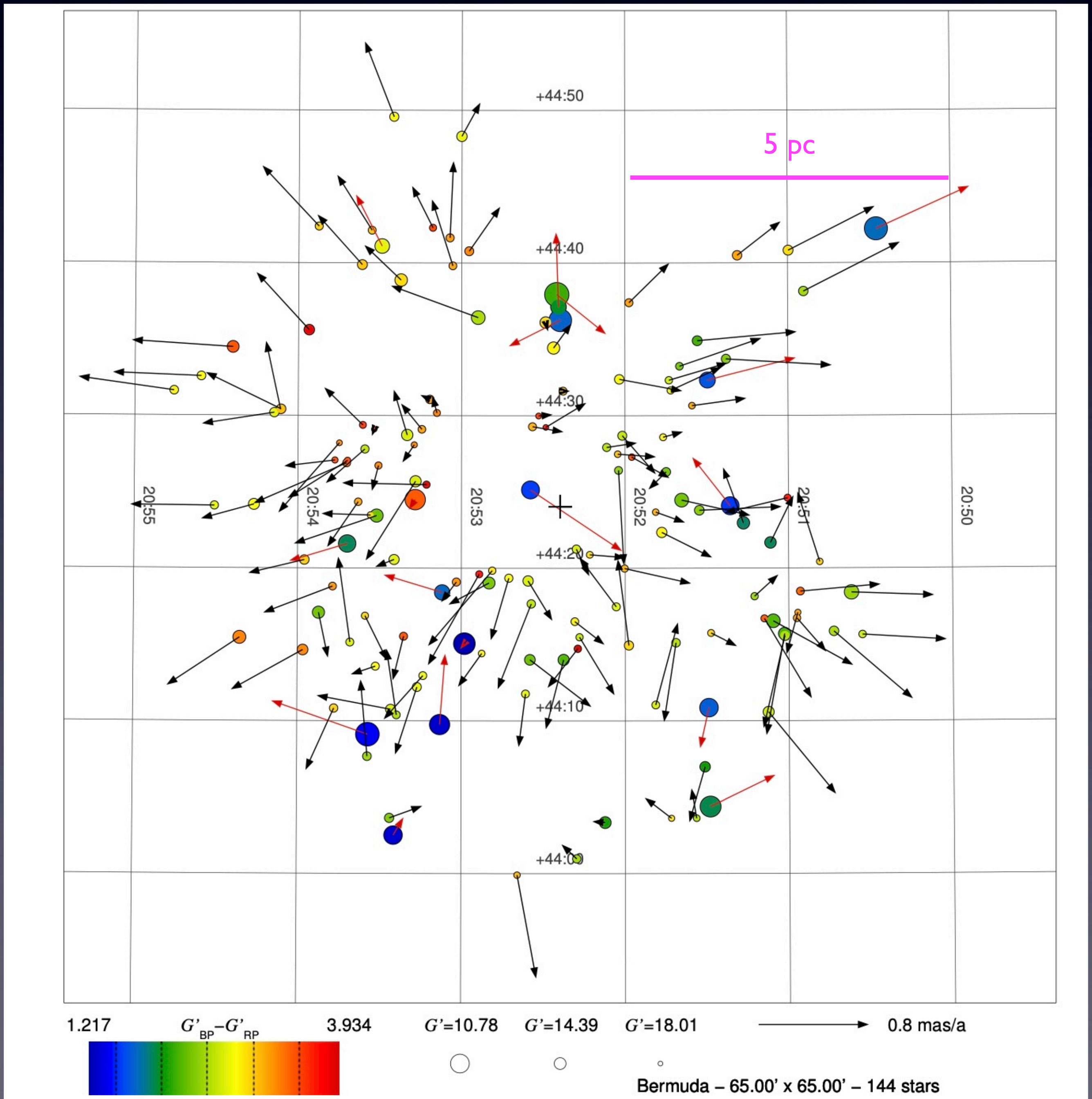
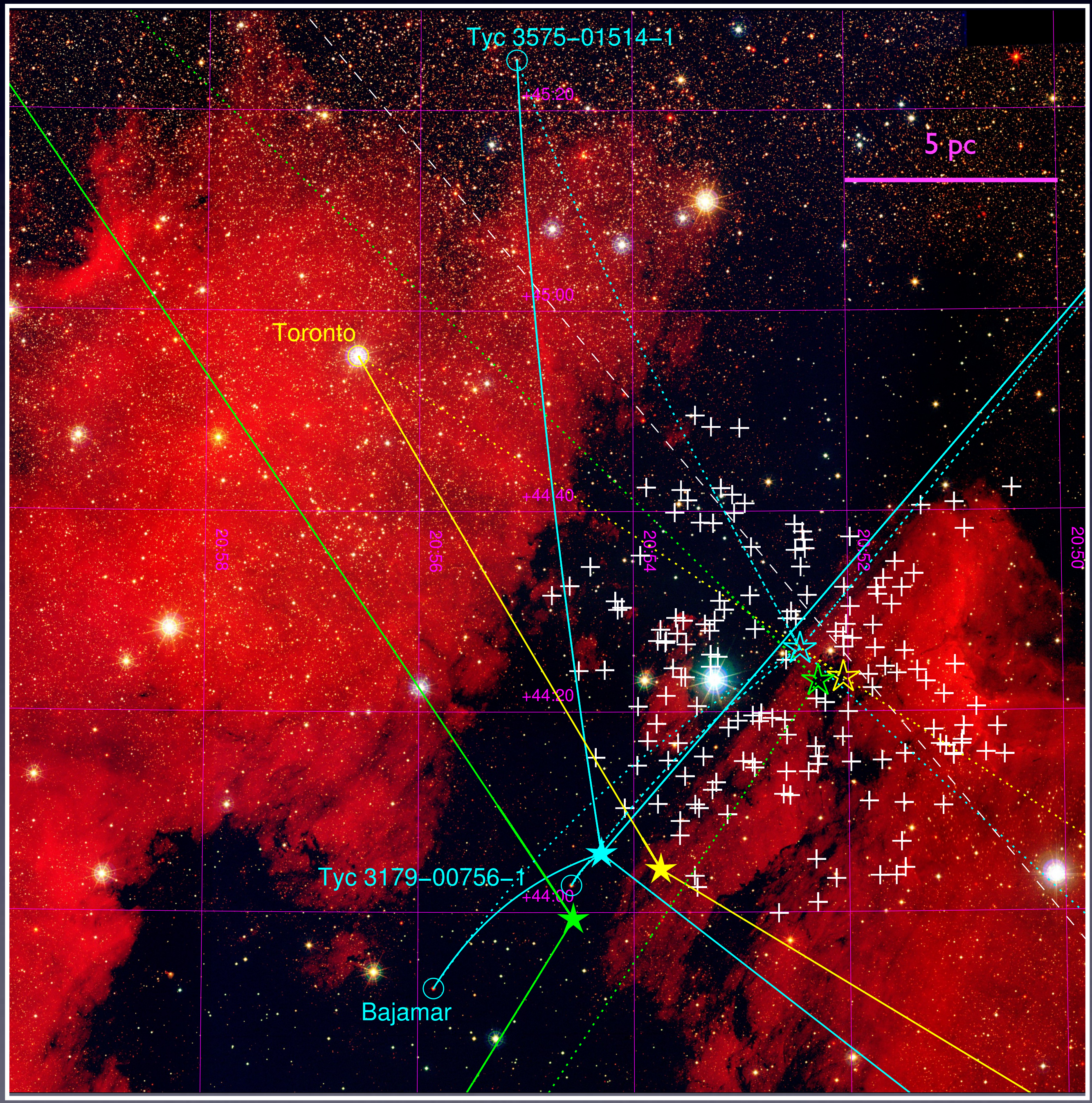




Bow shocks from the ejected stars

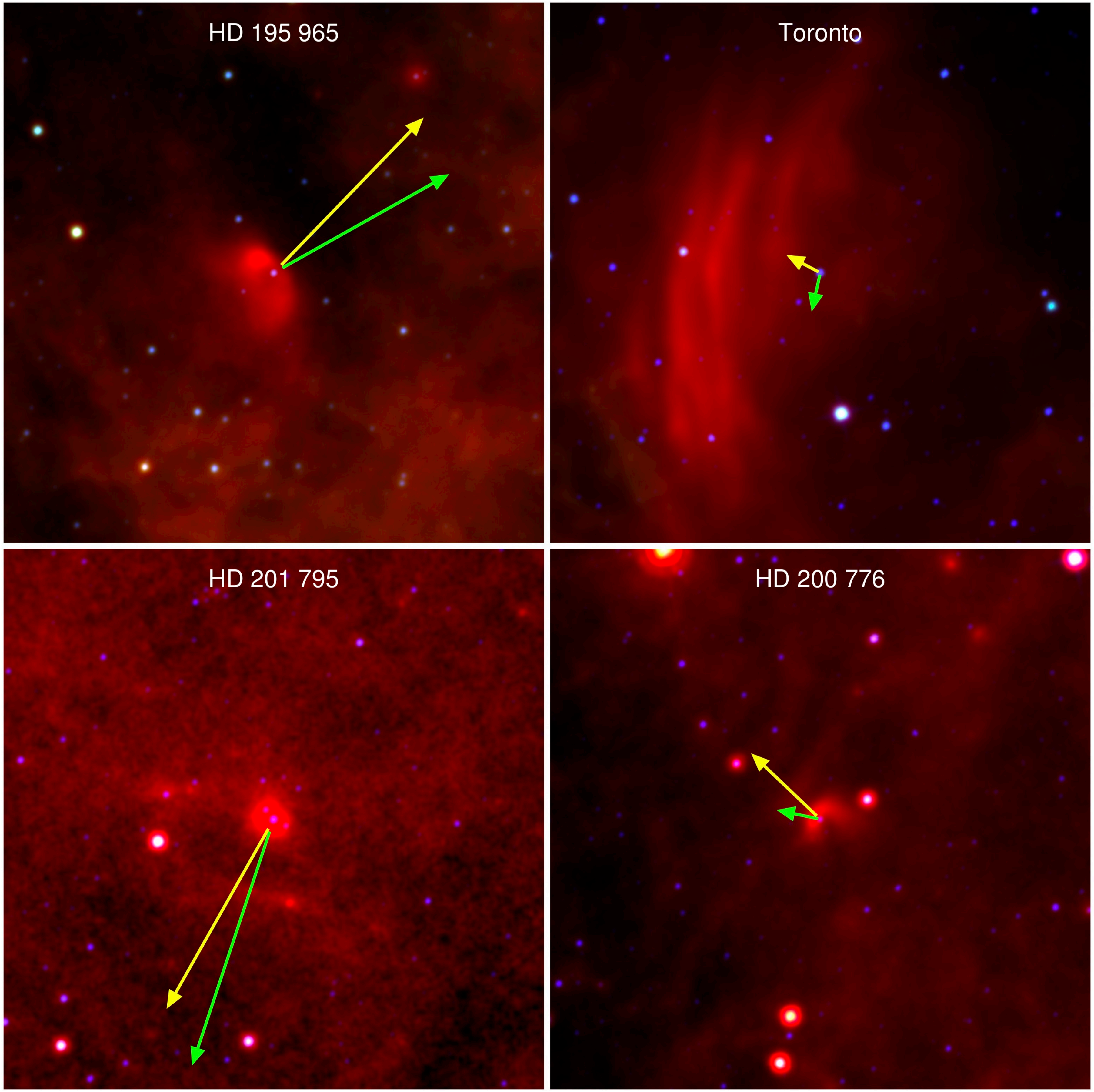


Fig. B.1. *WISE* W4+W3+W2 RGB mosaics for four walkaway/runaways systems. Each field is 20′ × 20′ (4.7 pc × 4.7 pc at a distance of 798 pc) and is oriented with north toward the top and east toward the left. In each mosaic the runaway candidate is at the center and the arrows show the absolute (green) and the relative-to-the cluster proper motions (yellow).

Gaia EDR3 astrometric calibration

A&A 649, A2 (2021)
https://doi.org/10.1051/0004-6361/202039709

Gaia Early Data Release 3

Astronomy & Astrophysics

Special issue

Gaia Early Data Release 3

The astrometric solution

L. Lindegren[1], S. A. Klioner[2], J. Hernández[3], A. Bombrun[4], M. Ramos-Lerate[5], H. Steidelmüller[2], U. Bastian[6], M. Biermann[6], A. de Torres[4], E. Gerlach[2], R. Geyer[2], T. Hilger[2], D. Hobbs[1], U. Lammers[3], P. J. McMillan[1], C. A. Stephenson[7], J. Castañeda[8], M. Davidson[9], C. Fabricius[10], G. Gracia-Abril[11,6], J. Portell[10], N. Rowell[9], D. Teyssier[7], F. Torra[8], S. Bartolomé[10], M. Clotet[10], N. Garralda[10], J. J. González-Vidal[10], J. Torra[†,10], U. Abbas[12], M. Altmann[6,13], E. Anglada Varela[14], L. Balaguer-Núñez[10], Z. Balog[6,15], C. Barache[13], U. Becciani[16], M. Bernet[10], S. Bertone[17,18,12], L. Bianchi[19], S. Bouquillon[13], A. G. A. Brown[20], B. Bucciarelli[12], D. Busonero[12], A. G. Butkevich[12], R. Buzzi[12], R. Cancelliere[21], T. Carlucci[13], P. Charlot[22], M.-R. L. Cioni[23], M. Crosta[12], C. Crowley[4], E. F. del Peloso[6], E. del Pozo[24], R. Drimmel[12], P. Esquej[25], A. Fienga[26,27], E. Fraile[25], M. Gai[12], M. Garcia-Reinaldos[3], R. Guerra[3], N. C. Hambly[9], M. Hauser[15,28], K. Janßen[23], S. Jordan[6], Z. Kostrzewa-Rutkowska[20,29], M. G. Lattanzi[12,30], S. Liao[12], E. Licata[12], T. A. Lister[31], W. Löffler[6], J. M. Marchant[32], A. Masip[10], F. Mignard[33], A. Mints[23], D. Molina[10], A. Mora[24], R. Morbidelli[12], C. P. Murphy[3], C. Pagani[34], P. Panuzzo[35], X. Peñalosa Esteller[10], E. Poggio[12], P. Re Fiorentin[12], A. Riva[12], A. Sagristà Sellés[6], V. Sanchez Gimenez[10], M. Sarasso[12], E. Sciacca[16], H. I. Siddiqui[36], R. L. Smart[12], D. Souami[37,38], A. Spagna[12], I. A. Steele[32], F. Taris[13], E. Utrilla[24], W. van Reeven[24], and A. Vecchiato[12]

A&A 649, A4 (2021)
https://doi.org/10.1051/0004-6361/202039653

Gaia Early Data Release 3

Astronomy & Astrophysics

Special issue

Do not apply *Gaia* EDR3 parallaxes out of the box!!!

Gaia Early Data Release 3

Parallax bias versus magnitude, colour, and position

L. Lindegren[1], U. Bastian[2], M. Biermann[2], A. Bombrun[3], A. de Torres[3], E. Gerlach[4], R. Geyer[4], J. Hernández[5], T. Hilger[4], D. Hobbs[1], S. A. Klioner[4], U. Lammers[5], P. J. McMillan[1], M. Ramos-Lerate[6], H. Steidelmüller[4], C. A. Stephenson[7], and F. van Leeuwen[8]

Gaia EDR3 astrometric calibration

A&A 649, A4 (2021)
https://doi.org/10.1051/0004-6361/202039653

Gaia Early Data Release 3

Astronomy & Astrophysics
Special issue

Gaia Early Data Release 3

Parallax bias versus magnitude, colour, and position

L. Lindegren[1], U. Bastian[2], M. Biermann[2], A. Bombrun[3], A. de Torres[3], E. Gerlach[4], R. Geyer[4], J. Hernández[5], T. Hilger[4], D. Hobbs[1], S. A. Klioner[4], U. Lammers[5], P. J. McMillan[1], M. Ramos-Lerate[6], H. Steidelmüller[4], C. A. Stephenson[7], and F. van Leeuwen[8]

7. Way forward

The bias functions Z_5 and Z_6 provide a recipe for the systematic correction of the EDR3 parallaxes based on the particular choices of data, method, and bias models described in the preceding sections. These choices contain considerable elements of uncertainty and arbitrariness, and are no doubt also coloured by our preconceived notions. The results should therefore not be regarded as definitive. On the contrary, it is vitally important that alternative routes are explored towards better compensating for the systematics in *Gaia* data. *Gaia* Data Release 3, which

More and different data: increasing the amount of data included in a global analysis could improve the precision of the bias estimation and perhaps extend its validity in magnitude–colour space. Examples of datasets that should be explored are the stars in open and globular clusters, which have the potential to cover a wide range in magnitudes and different environments,

Gaia EDR3 astrometric calibration

A&A 649, A13 (2021)
https://doi.org/10.1051/0004-6361/202140418

Astronomy & Astrophysics

Includes cookbook

Validation of the accuracy and precision of *Gaia* EDR3 parallaxes with globular clusters

J. Maíz Apellániz[1], M. Pantaleoni González[1,2], and R. H. Barbá[3]

A&A 657, A130 (2022)
https://doi.org/10.1051/0004-6361/202142365

Astronomy & Astrophysics

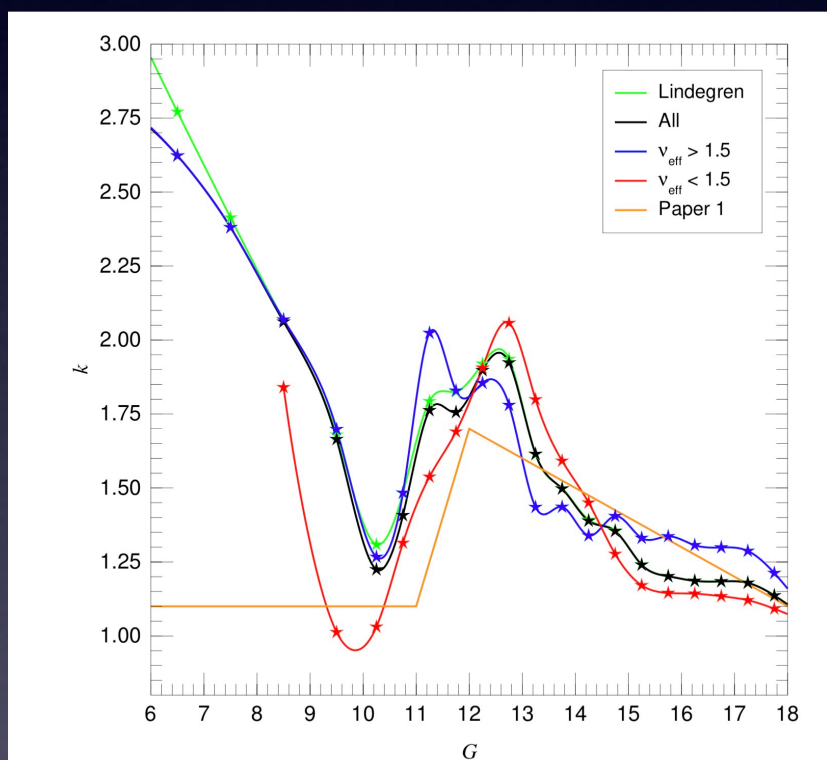
Includes bias correction improved upon Lindegren's and an IDL implementation

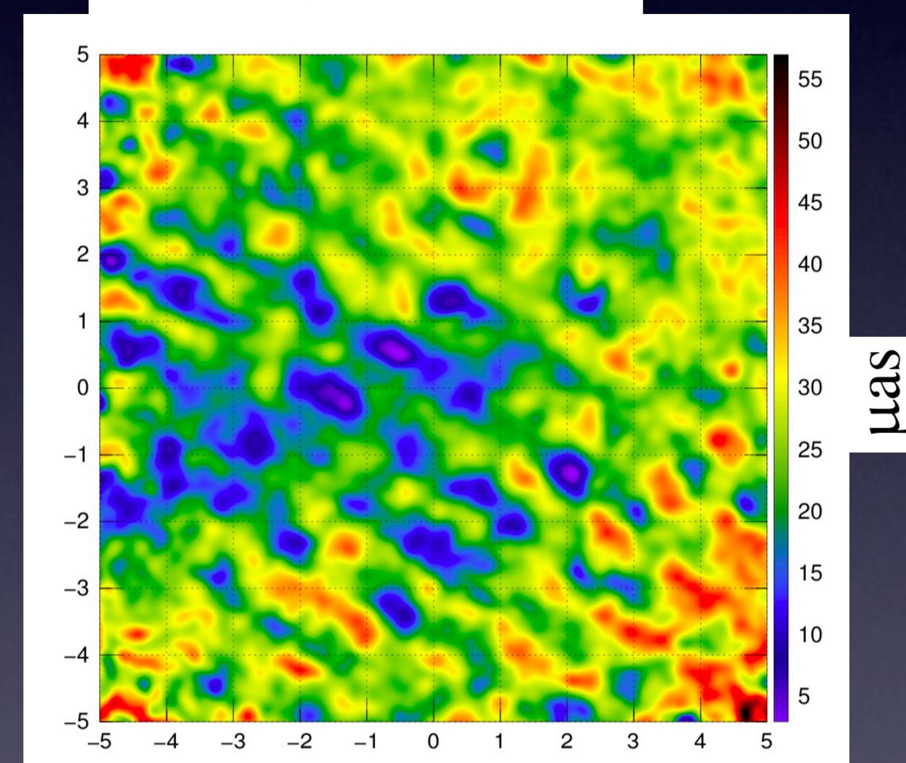
An estimation of the *Gaia* EDR3 parallax bias from stellar clusters and Magellanic Clouds data

J. Maíz Apellániz

Gaia EDR3 astrometric calibration

- There is a correctable parallax bias. $\varpi_{\rm c} = \varpi - Z_{\rm EDR3}$ $$Z_{\rm EDR3}(G, \nu_{\rm eff}, \beta) = \sum_{j=0}^{4} \sum_{k=0}^{2} q_{jk}(G)\, c_j(\nu_{\rm eff})\, b_k(\beta)$$
- There is an uncorrectable parallax bias whose effects need to be accounted for.
- Catalog parallax uncertainties are underestimated. $\sigma_{\rm ext} = \sqrt{k^2\sigma_{\rm int}^2 + \sigma_{\rm s}^2},$ $\sigma_{\rm s} = 10.3\ \mu{\rm as}$





- Parallaxes are spatially correlated: main limitation for cluster distances.
- Stars with 1.4 < RUWE < 8.0 are valid but with worse uncertainties.
- 6-parameter solutions are valid but with worse uncertainties.

Gaia EDR3 astrometric calibration

- There is a correctable parallax bias. $\varpi_{\rm c} = \varpi - Z_{\rm EDR3}$ $Z_{\rm EDR3}(G, \nu_{\rm eff}, \beta) = \sum_{j=0}^{4}\sum_{k=0}^{2} q_{jk}(G)\, c_j(\nu_{\rm eff})\, b_k(\beta)$
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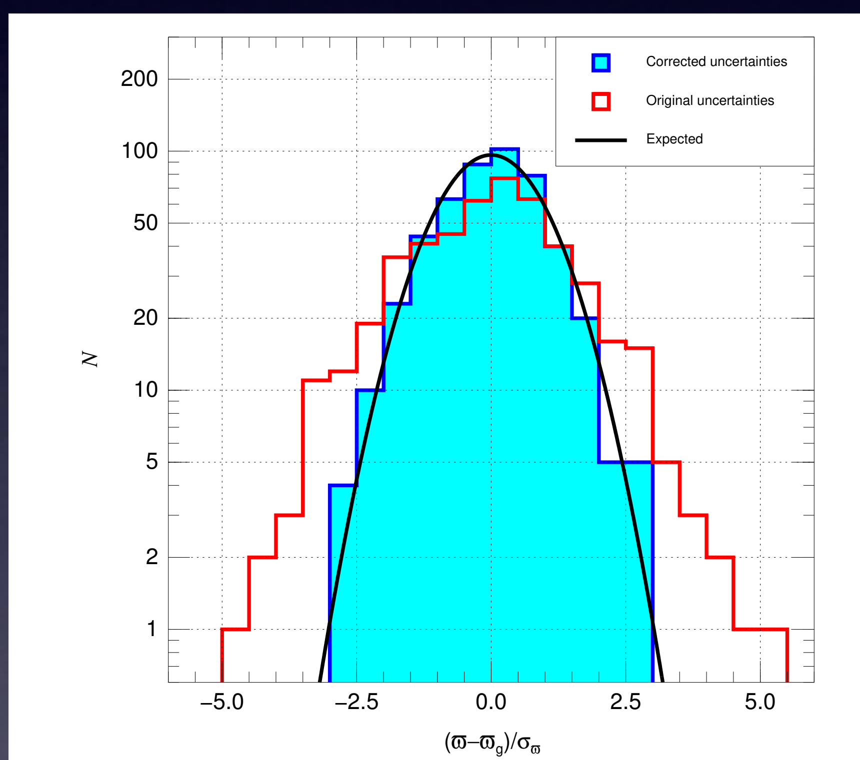

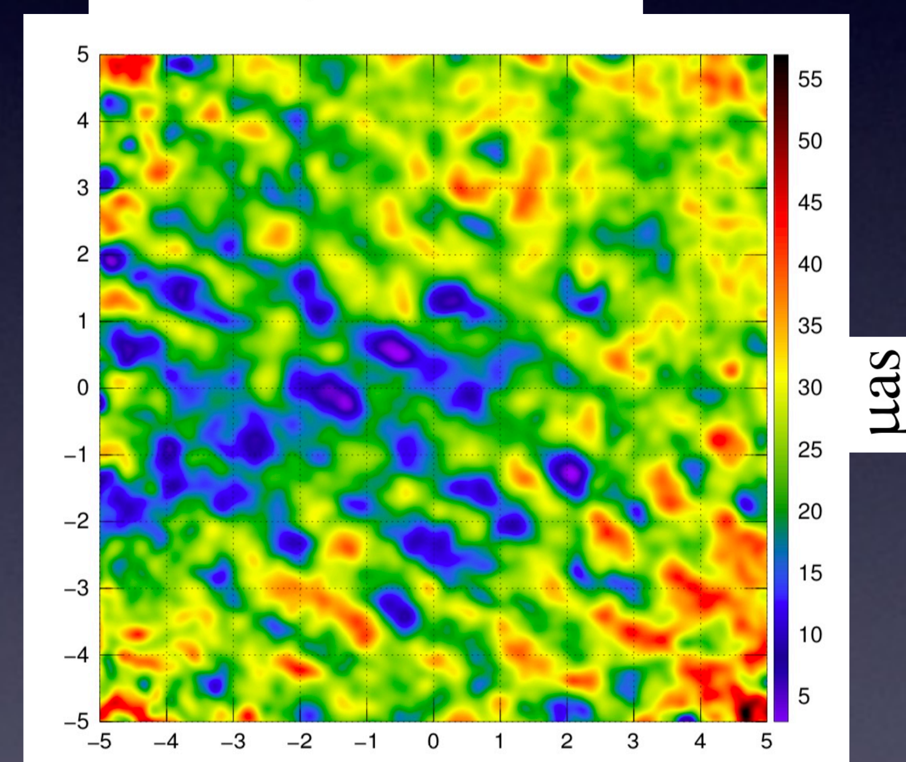

- Parallaxes are spatially correlated: main limitation for cluster distances.
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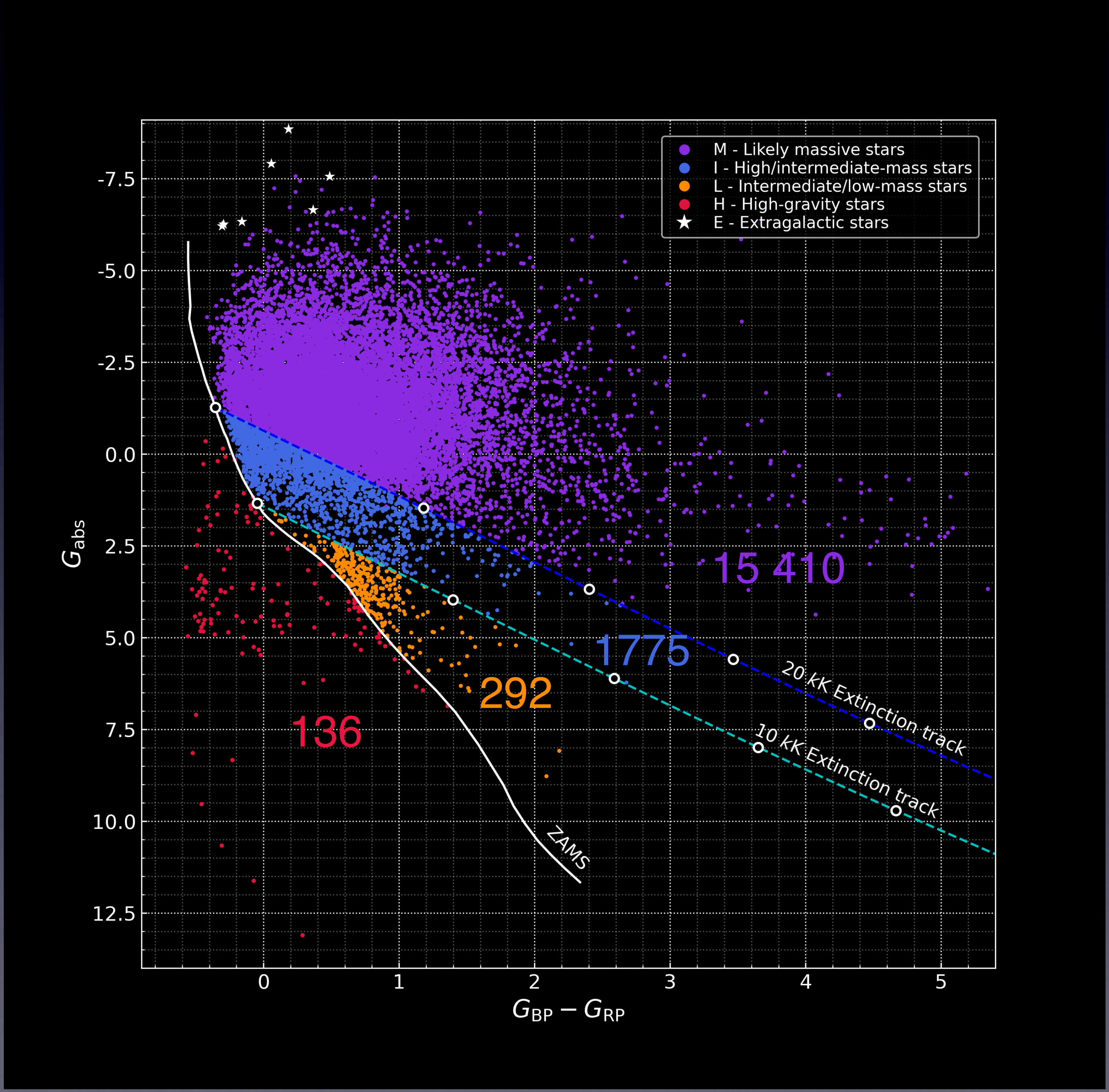
- 6-parameter solutions are valid but with worse uncertainties.

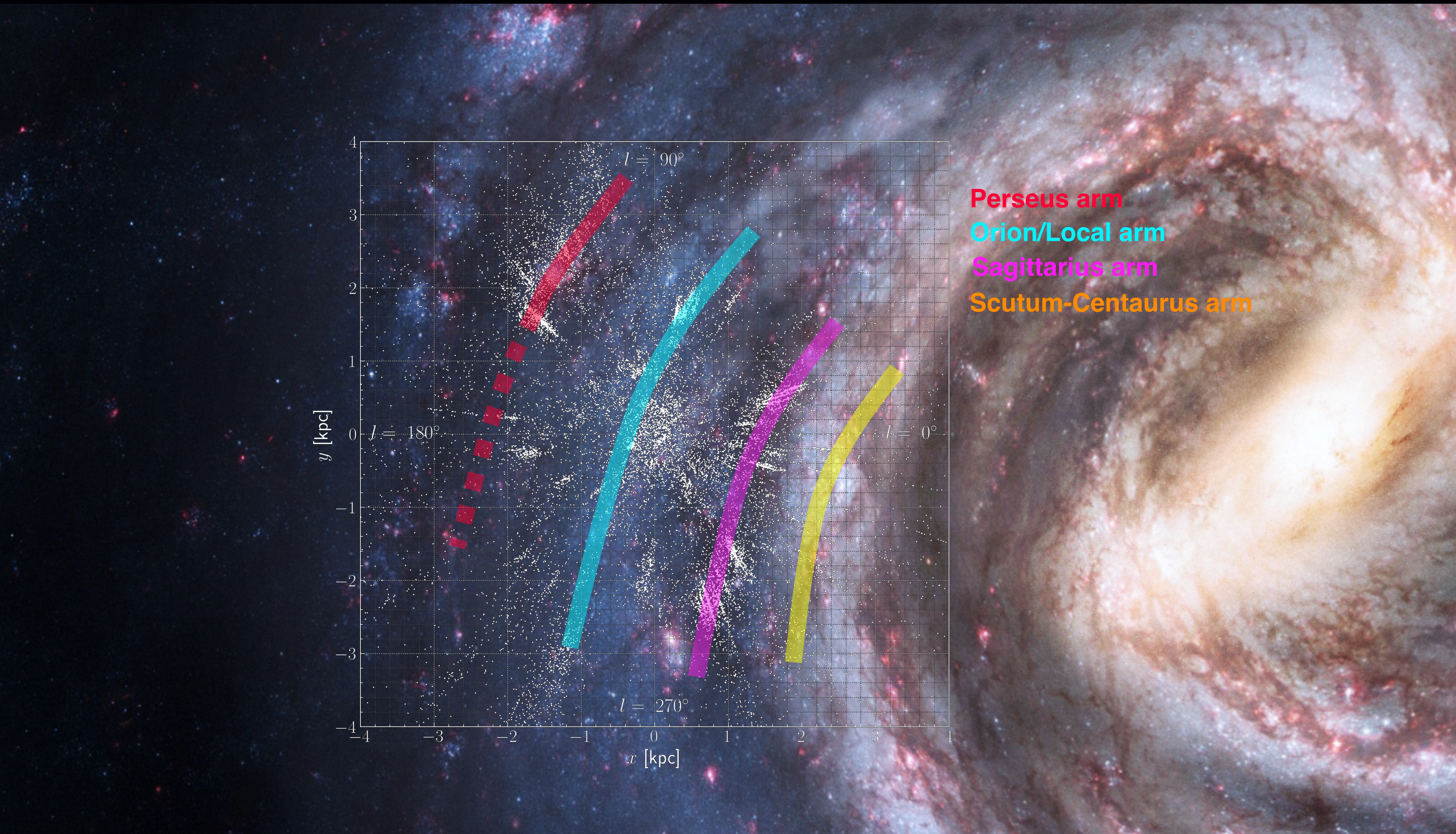
EDR3: the ALS catalog

ALS II (DR2, Pantaleoni González et al. 2021)		ALS III (EDR3 + new sources from GOSSS+)	
Initial entries	18 693	Initial entries	20 498
-300 duplicates	18 300	-421 duplicates	20 077
-211 unmatched	18 089	-408 unmatched	19 669
-2336 bad astrometry	15 753	-1847 bad astrometry	17 822
-91 bad photometry	15 662	-202 bad photometry	17 620

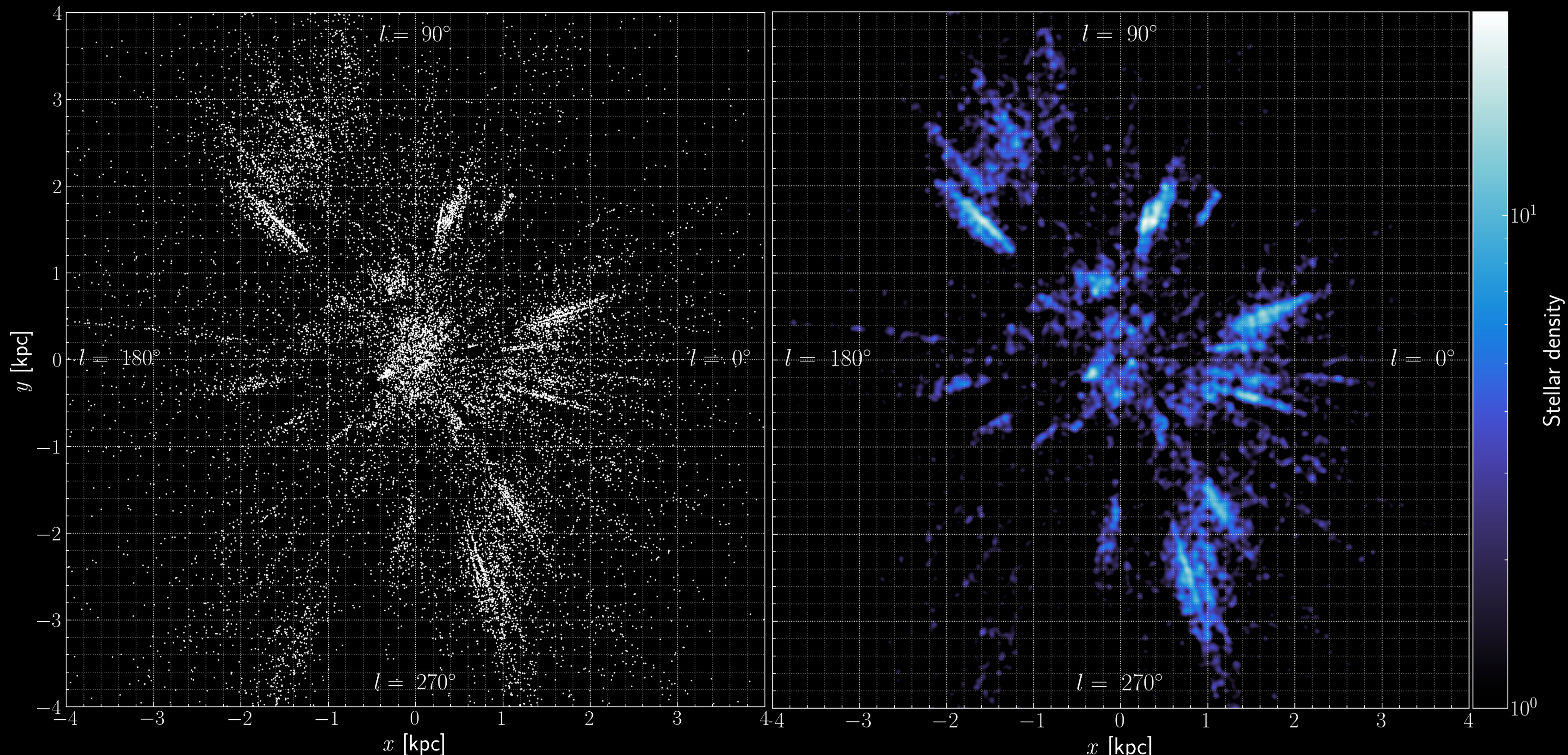
EDR3: The ALS III H-R diagram



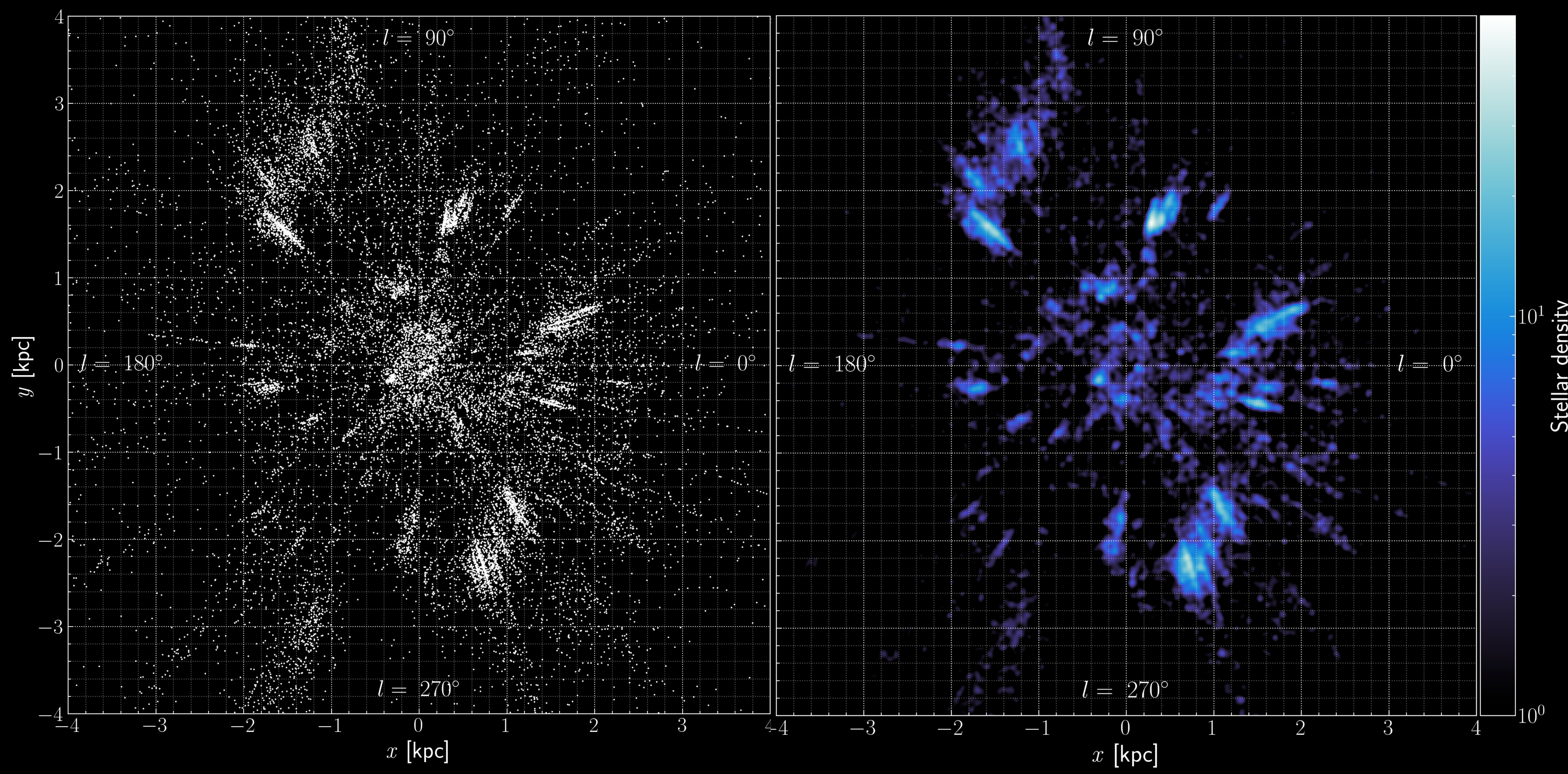
EDR3: the spiral arms with ALS III



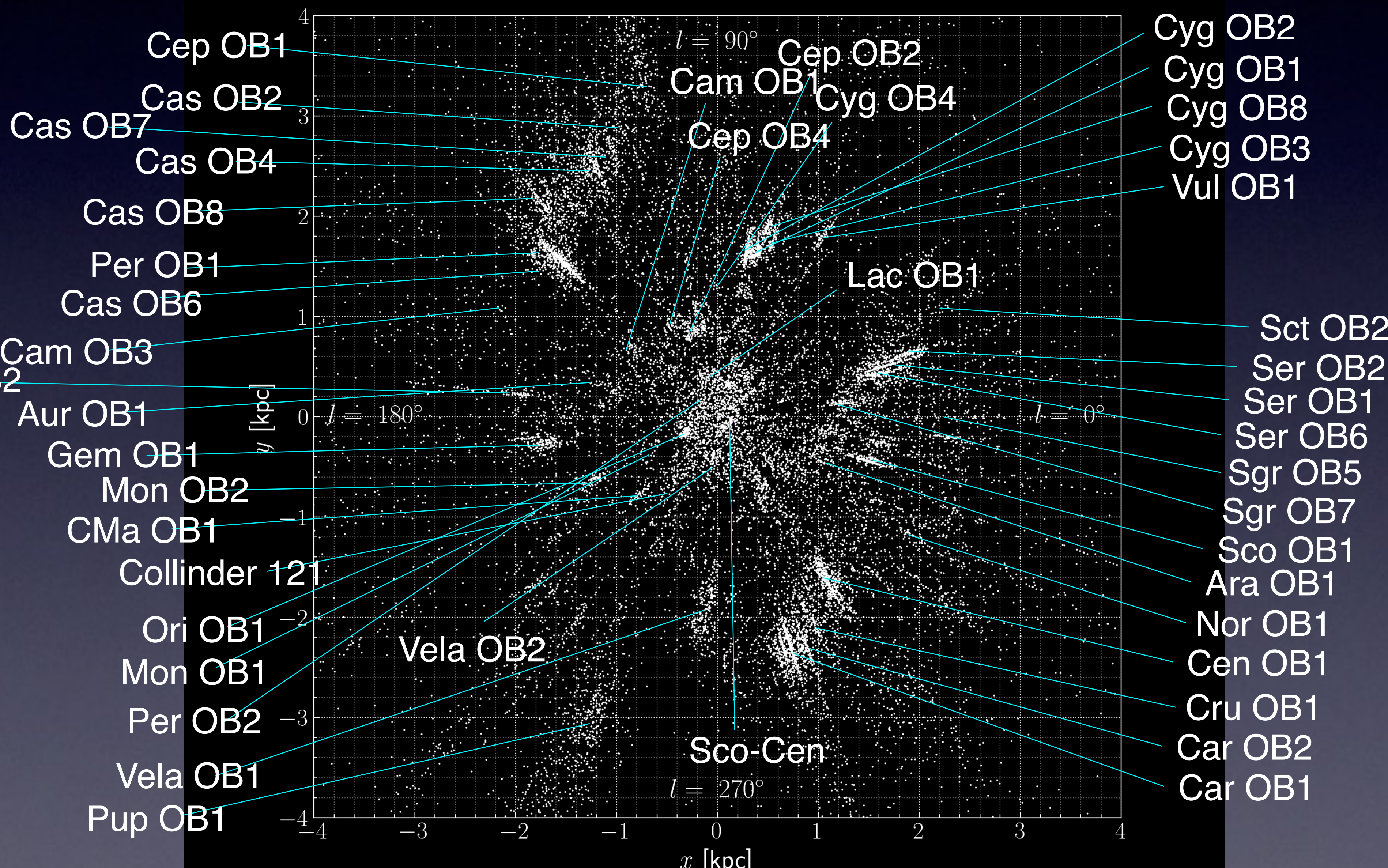
DR2: ALS II



EDR3: ALS III

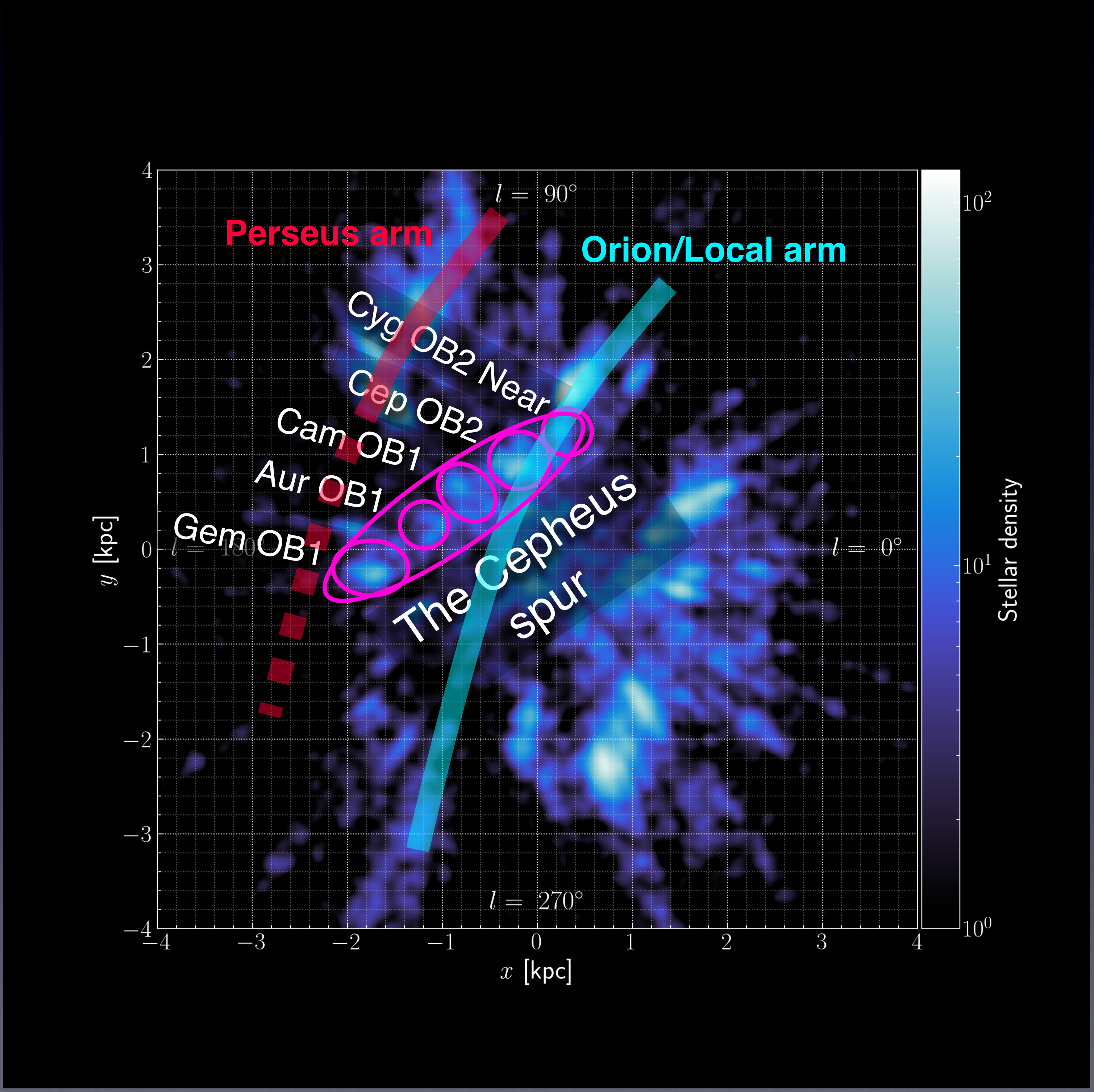


EDR3: OB associations from ALS III

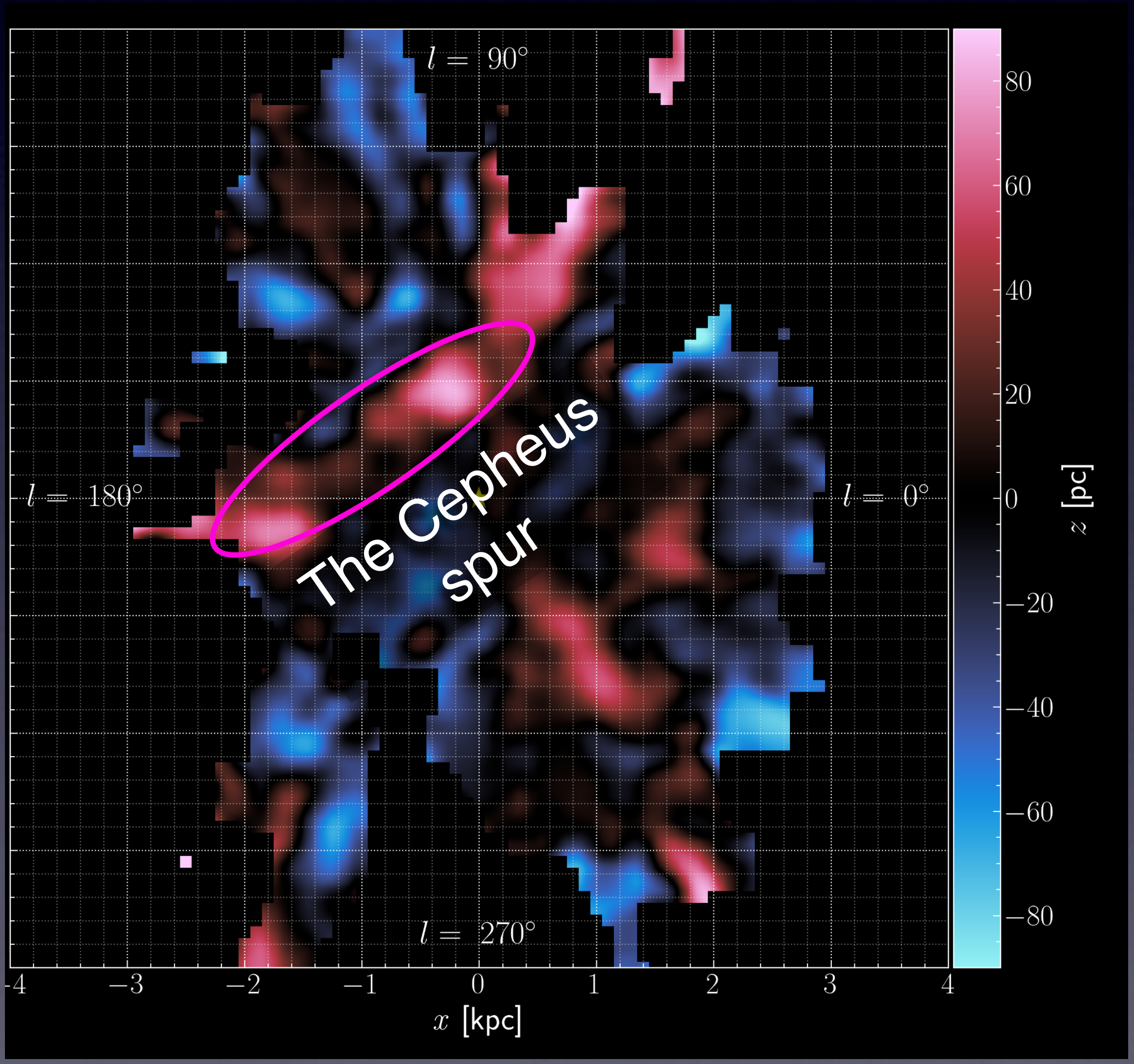


OB associations defined by Wright (2020)

EDR3: the Cepheus spur



EDR3: the Cepheus spur



EDR3: other results

OB Associations

Wright et al. (2022)

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Robin D. Jeffries
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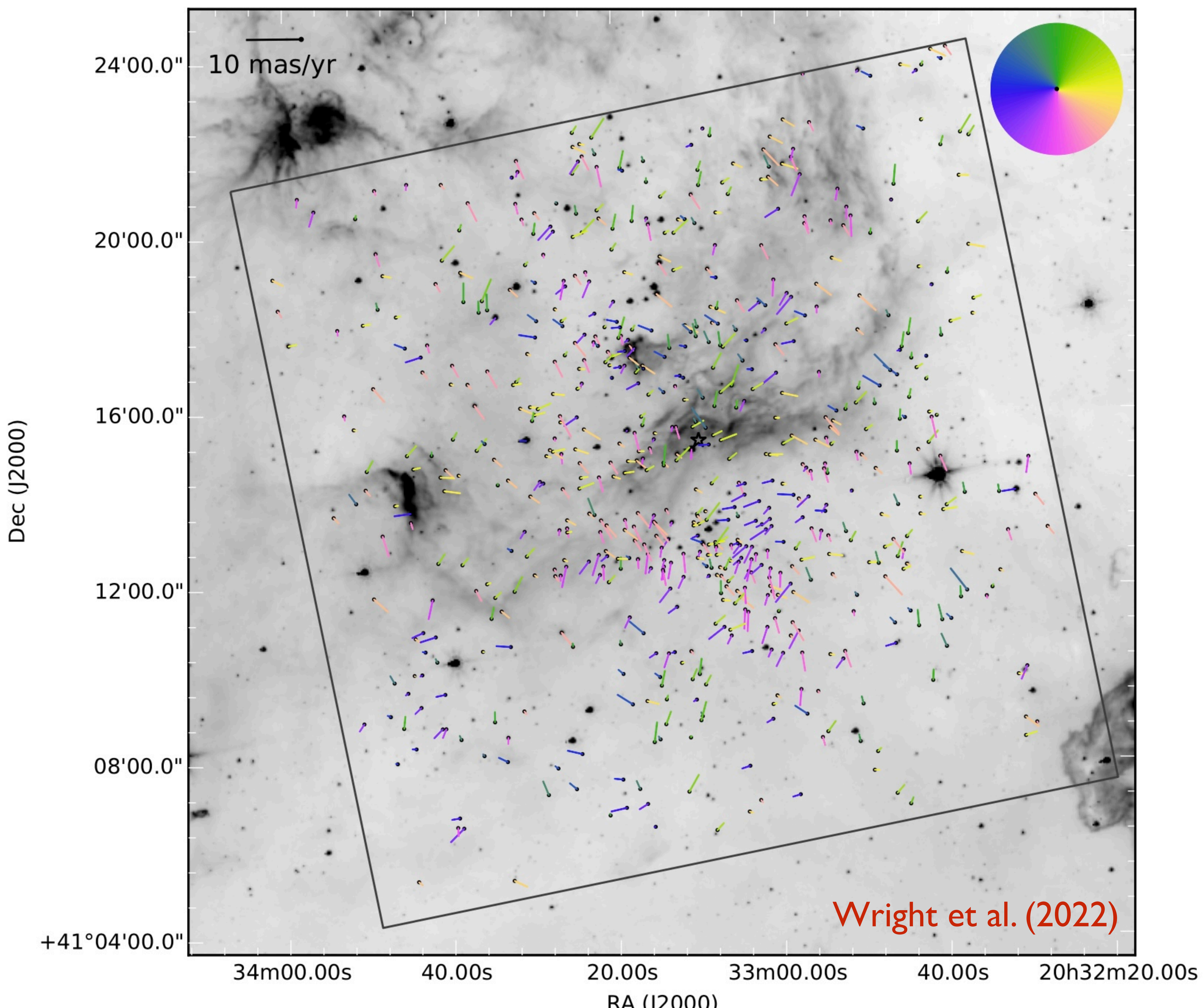
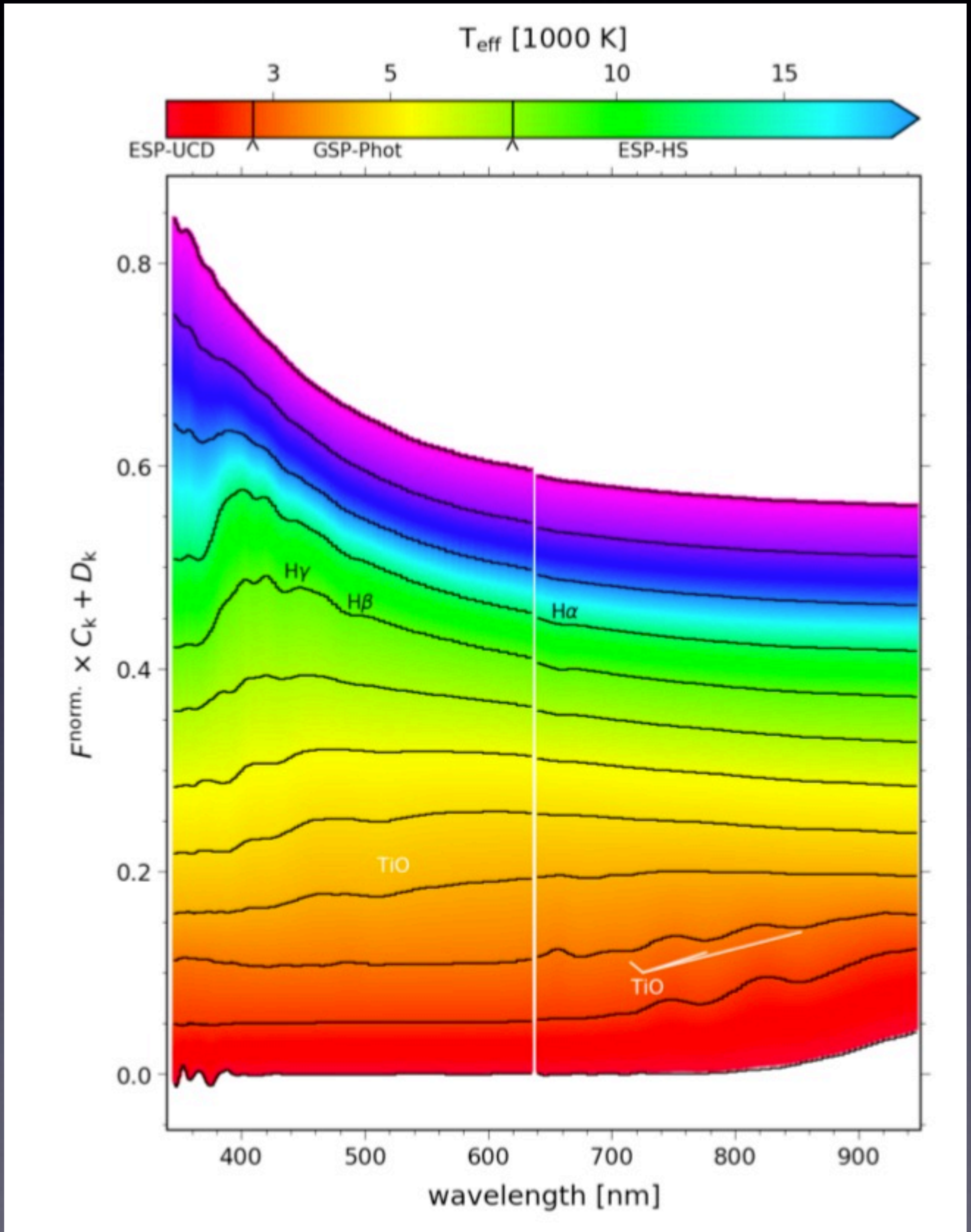
OB associations are low-density groups of young stars that are dispersing from their birth environment into the Galactic field. They are important for understanding the star formation process, early stellar evolution, the properties and distribution of young stars and the processes by which young stellar groups disperse. Recent observations, particularly from *Gaia*, have shown that associations are highly complex, with a high degree of spatial, kinematic and temporal substructure. The kinematics of associations have shown them to be globally unbound and expanding, with the majority of recent studies revealing evidence for clear expansion patterns in the association subgroups, suggesting the subgroups were more compact in the past. This expansion is often non-isotropic, arguing against a simple explosive expansion, as predicted by some models of residual gas expulsion. The star formation histories of associations are often complex, exhibit moderate age spreads and temporal substructure, but so far have failed to reveal simple patterns of star formation propagation (e.g., triggering). These results have challenged the historical paradigm of the origin of associations as the expanded remnants of dense star clusters and suggests instead that they originate as highly substructured systems without a linear star formation history, but with multiple clumps of stars that have since expanded and begun to overlap, producing the complex systems we observe today. This has wide-ranging consequences for the early formation environments of most stars and planetary systems, including our own Solar System.

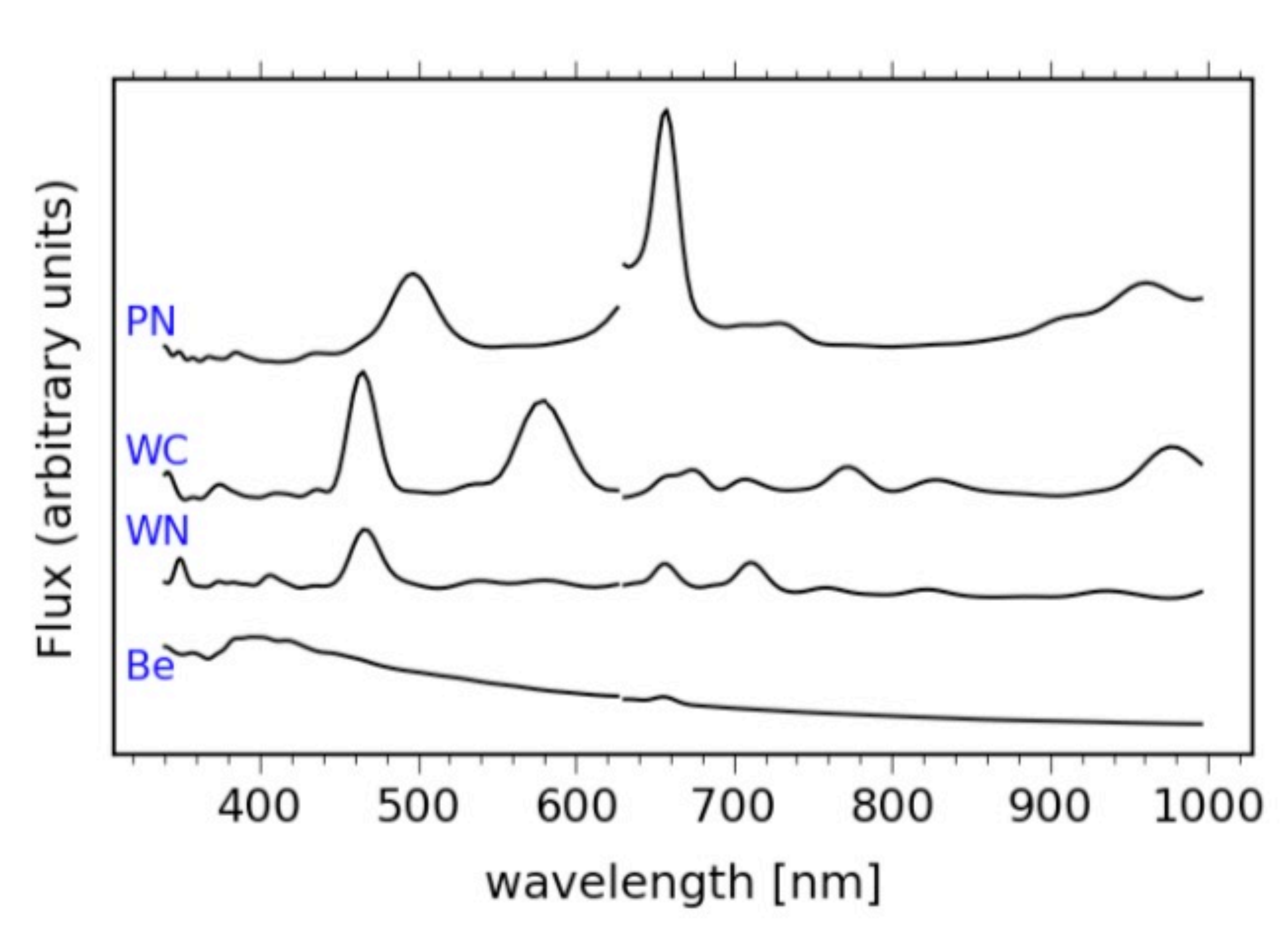
EDR3: other results



OB associations are (mostly) born that way

Gaia DR3 contents: XP





- Peculiar data presentation:
  - ★ Not as $f_\lambda(\lambda)$ or equivalent.
  - ★ Expansion in orthogonal bases.
  - ★ All components or selection.

DR3: General Stellar Parameters (GSP)

Astronomy & Astrophysics manuscript no. AA_2022_43462 ©ESO 2022
June 14, 2022

Gaia Data Release 3: Analysis of the Gaia BP/RP spectra using the General Stellar Parameterizer from Photometry

R. Andrae[1★], M. Fouesneau[1], R. Sordo[2], C.A.L. Bailer-Jones[1], T.E. Dharmawardena[1], J. Rybizki[1], F. De

- GSP-Phot: 471 M sources.
- Astrometry+photometry+XP spectrophotometry.
- Input isochrones and distances.
- Fitted parameters: age, initial mass, metallicity, and A_0.
- Derived parameters: $T_{\rm eff}$, log g, R, and M_G.
- Two types of fits:
  - ★ Using general SEDs (different sources, algorithm selects one).
  - ★ Using OB-type SEDs (provided by Y. Frémat).

DR3: Extended Stellar Parameters (ESP)

Astronomy & Astrophysics manuscript no. output ©ESO 2022
2022-06-08

Gaia Data Release 3: Astrophysical parameters inference system (Apsis) I - methods and content overview

O.L. Creevey[1], R. Sordo[2], F. Pailler[3], Y. Frémat[4], U. Heiter[5], F. Thévenin[1], R. Andrae[6],

- Extended Stellar Parameterizer for Emission-Line Stars (ESP-ELS):
  - ★ Spectral classification: O, B, A, F, G, K, M, C star.
  - ★ Hα EWs for 235 M objects.
  - ★ Emission-Line IDs: PN, WC, WN, Be, Herbig Ae/Be, T Tauri, dMe.
- Extended Stellar Parameterizer for Hot Stars (ESP-HS):
  - ★ Applied to stars identified as O, B, or A by ESP-ELS: 2.4 M.
  - ★ If available, it also uses RVS spectra.
  - ★ Fitted parameters: $T_{\rm eff}$, log g, v sin i, and A_0 (plus A_G and $E(G_{\rm BP}-G_{\rm RP})$).

DR3: The comparison samples

- Objects with GOSSS or LiLiMaRlin reliable spectral type classifications.
- Includes the GOSSS-IV stars to appear soon.
  - ★ 1046 O stars.
  - ★ 81 WR stars.
  - ★ 959 B0-B1-5 stars.
  - ★ 1245 B2-B9 + Be stars.
  - ★ 3331 of any of the above (O+B+WR).
- The 120 early-type stars from Maíz Apellániz & Barbá (2018) and Maíz Apellániz et al. (2021) with accurate extinction measurements.

DR3: Why the extinction parameters have to be (mostly) wrong

A&A 564, A63 (2014)
DOI: 10.1051/0004-6361/201423439

Astronomy & Astrophysics

The VLT-FLAMES Tarantula Survey

XVI. The optical and NIR extinction laws in 30 Doradus and the photometric determination of the effective temperatures of OB stars★

J. Maíz Apellániz[1], C. J. Evans[2], R. H. Barbá[3], G. Gräfener[4], J. M. Bestenlehner[4], P. A. Crowther[5], M. García[6], A. Herrero[7,8], H. Sana[9], S. Simón-Díaz[7,8], W. D. Taylor[2], J. Th. van Loon[10], J. S. Vink[4], and N. R. Walborn[9]

A&A 613, A9 (2018)
https://doi.org/10.1051/0004-6361/201732050

Astronomy & Astrophysics

Optical-NIR dust extinction towards Galactic O stars★

J. Maíz Apellániz[1] and R. H. Barbá[2]

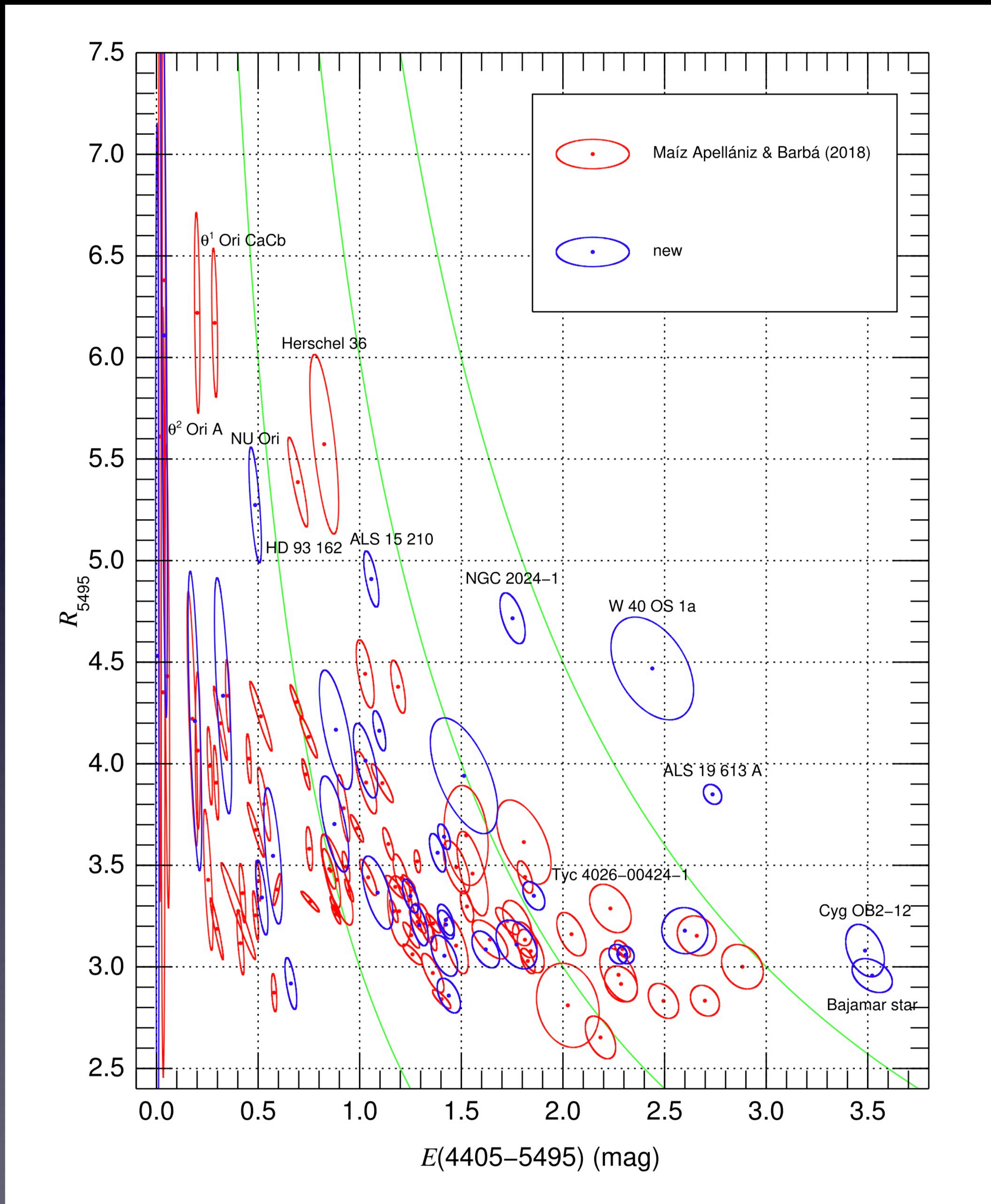
Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY
MNRAS **501**, 2487–2503 (2021) doi:10.1093/mnras/staa2371
Advance Access publication 2020 August 25

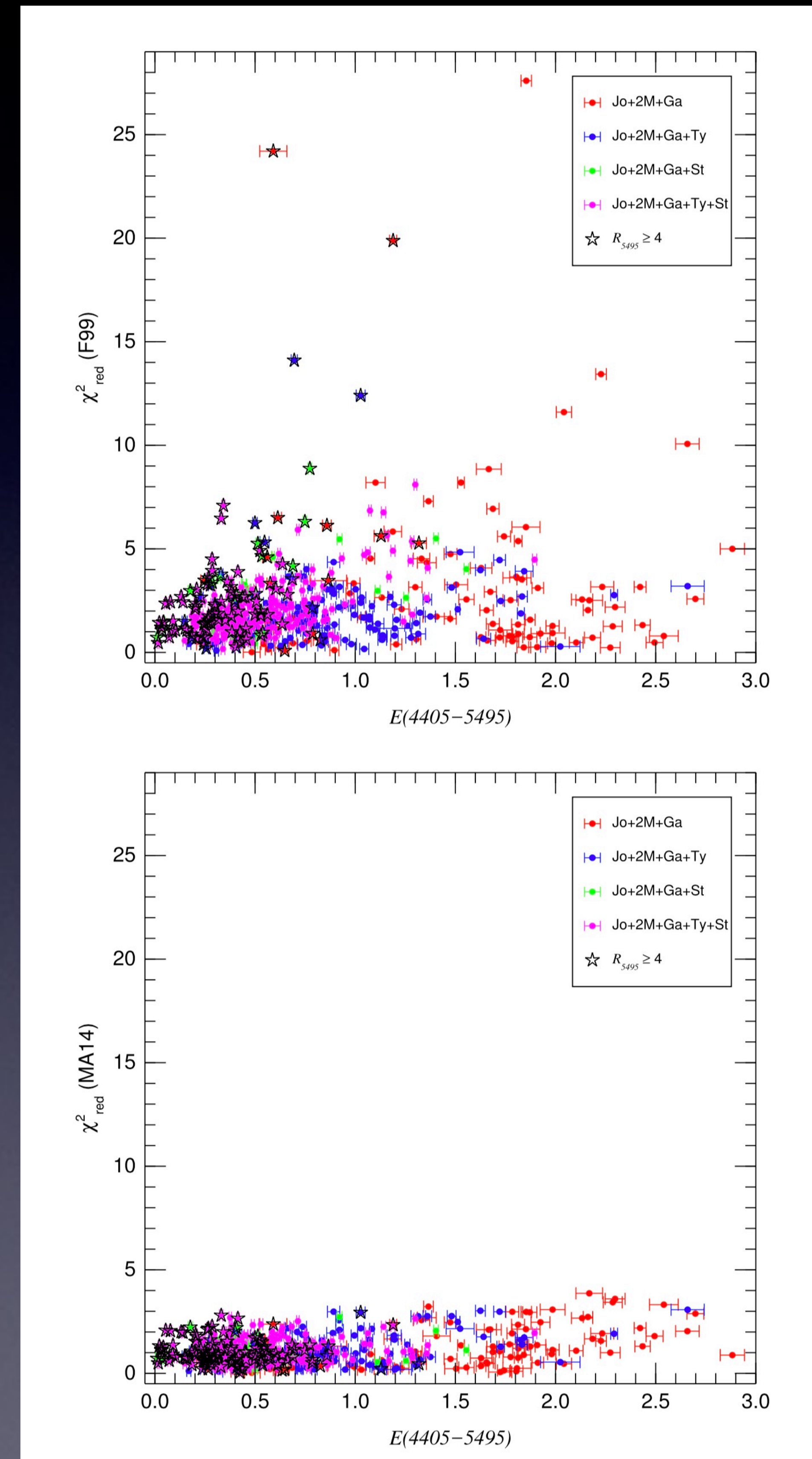
Galactic extinction laws – II. Hidden in plain sight, a new interstellar absorption band at 7700 Å broader than any known DIB

J. Maíz Apellániz,[1★] R. H. Barbá,[2] J. A. Caballero,[1] R. C. Bohlin[3] and C. Fariña[4,5]

- They assume a monochromatic value of *R* of 3.1.
- They use the extinction law of Fitzpatrick (1999).

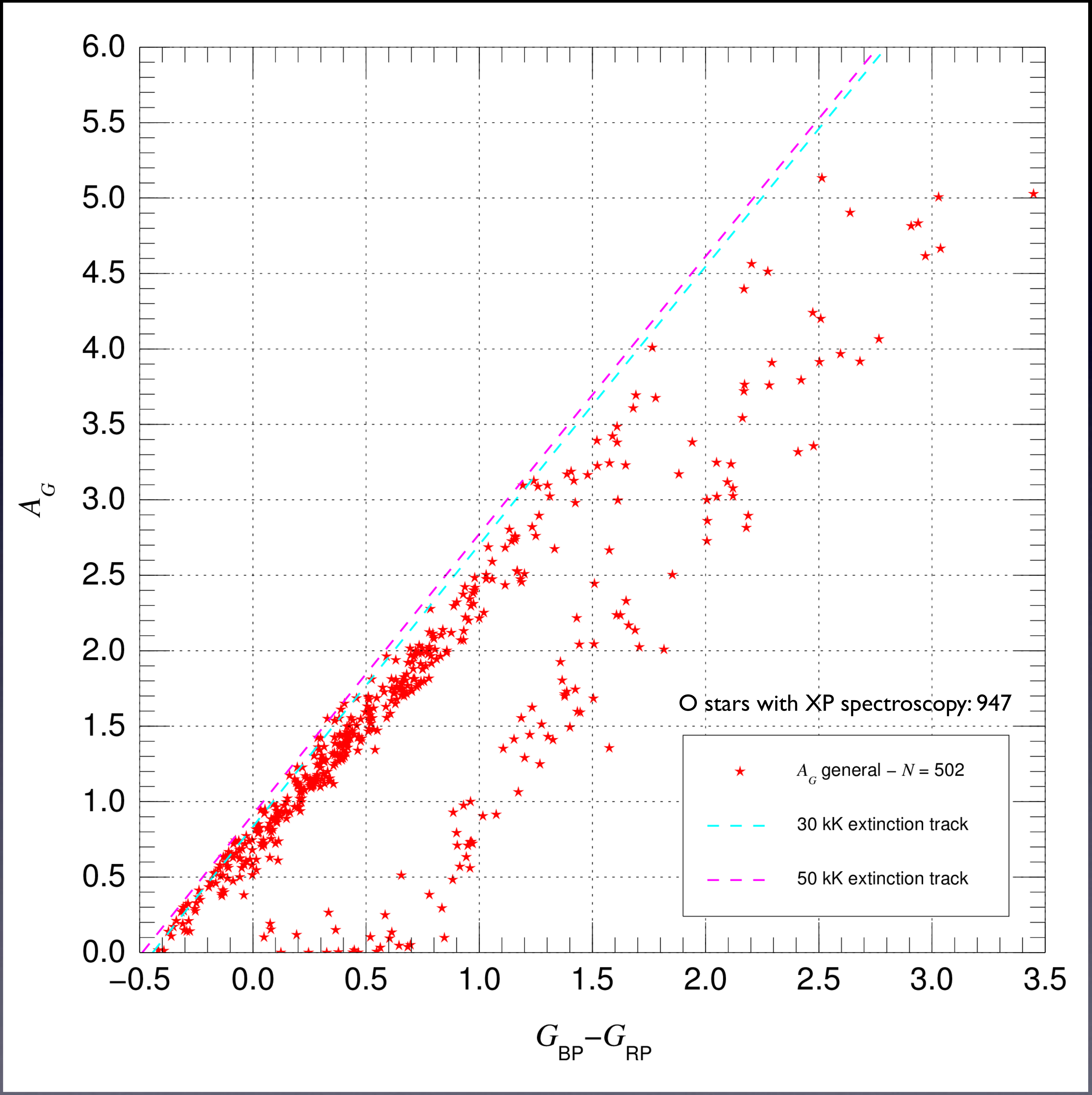
DR3: Why the extinction parameters have to be (mostly) wrong





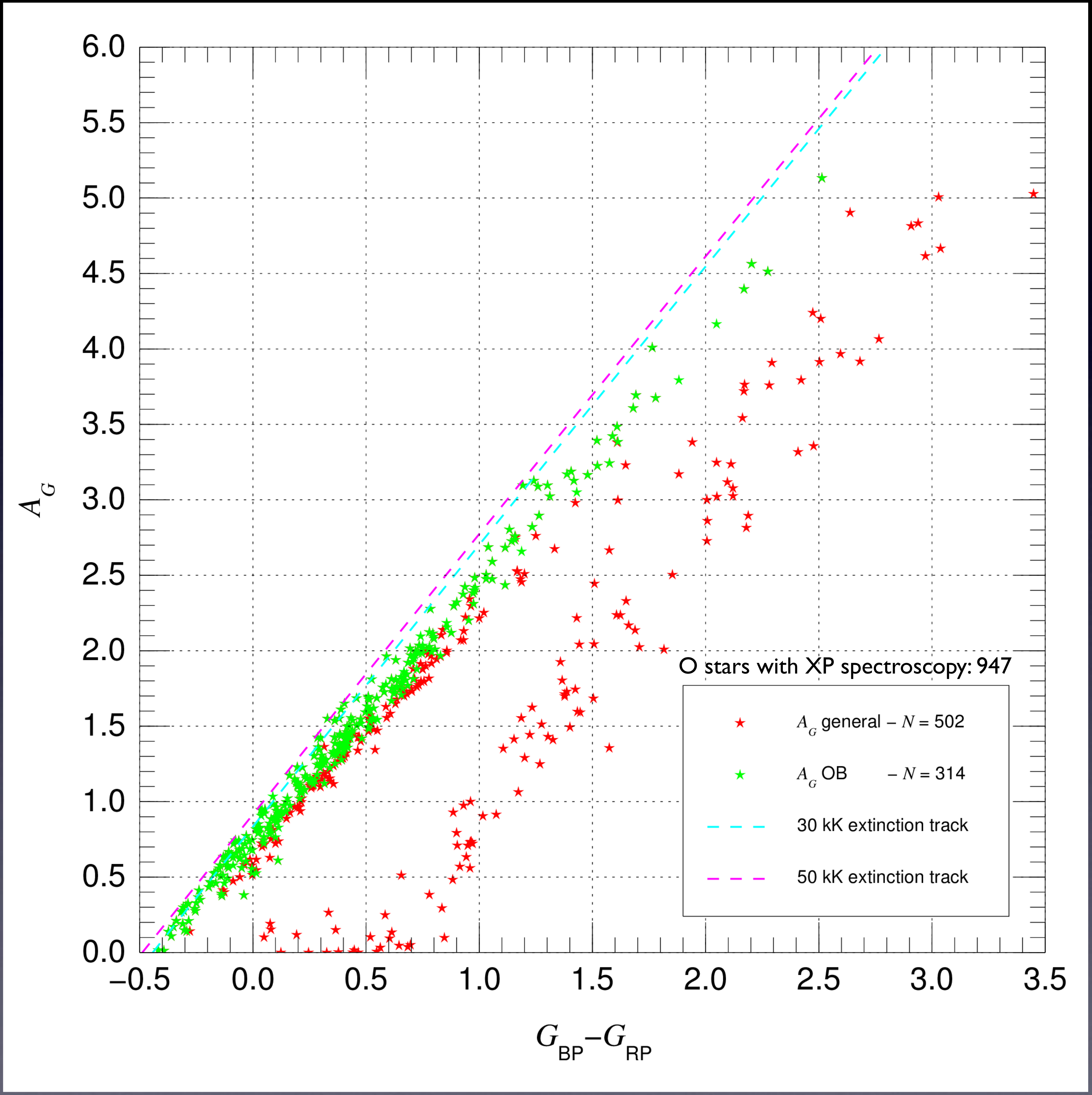
DR3: Why the extinction parameters have to be (mostly) wrong

O stars with confirmed spectral types from GOSSS or LiLiMaRlin



DR3: Why the extinction parameters have to be (mostly) wrong

O stars with confirmed spectral types from GOSSS or LiLiMaRlin



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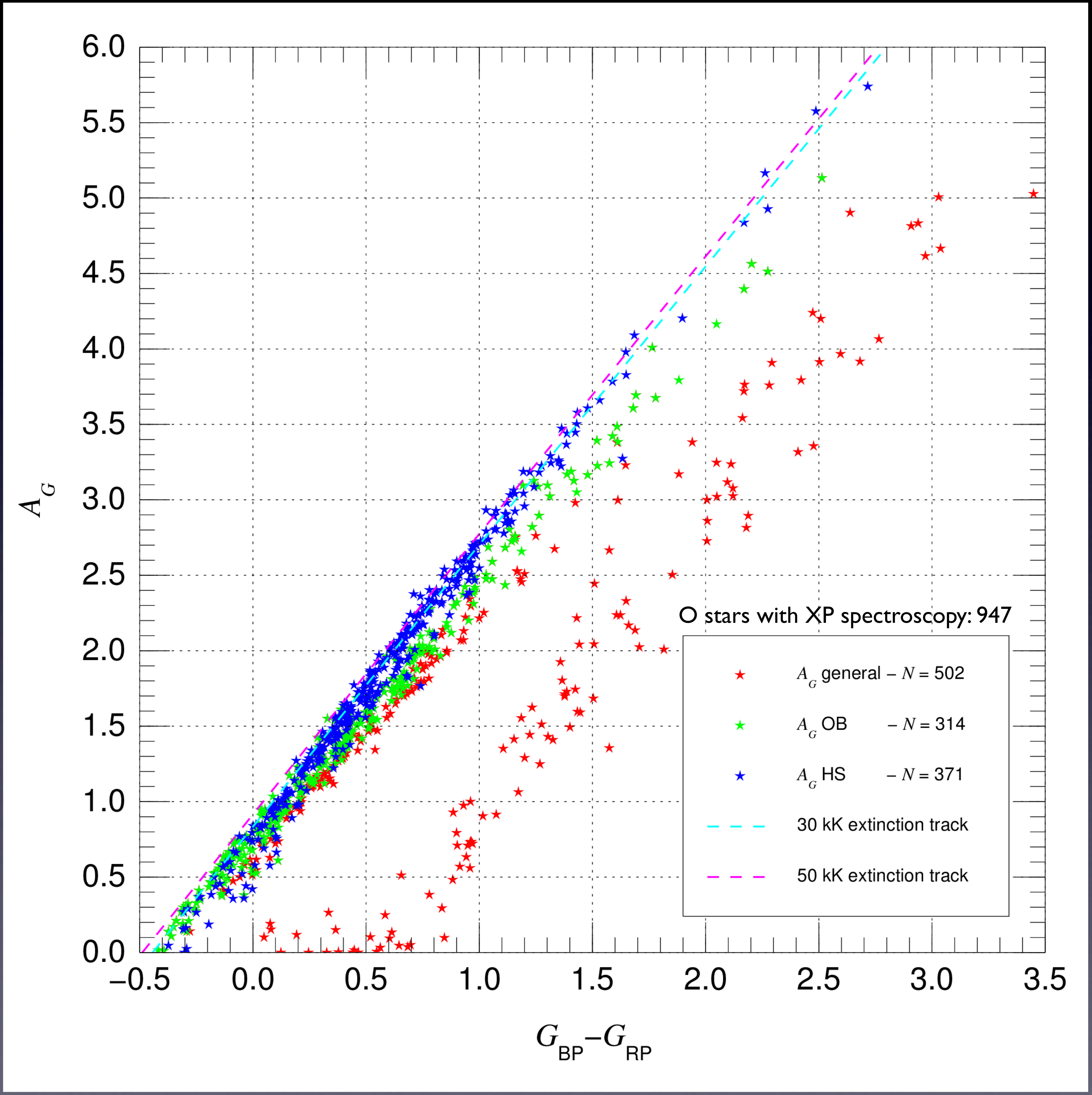
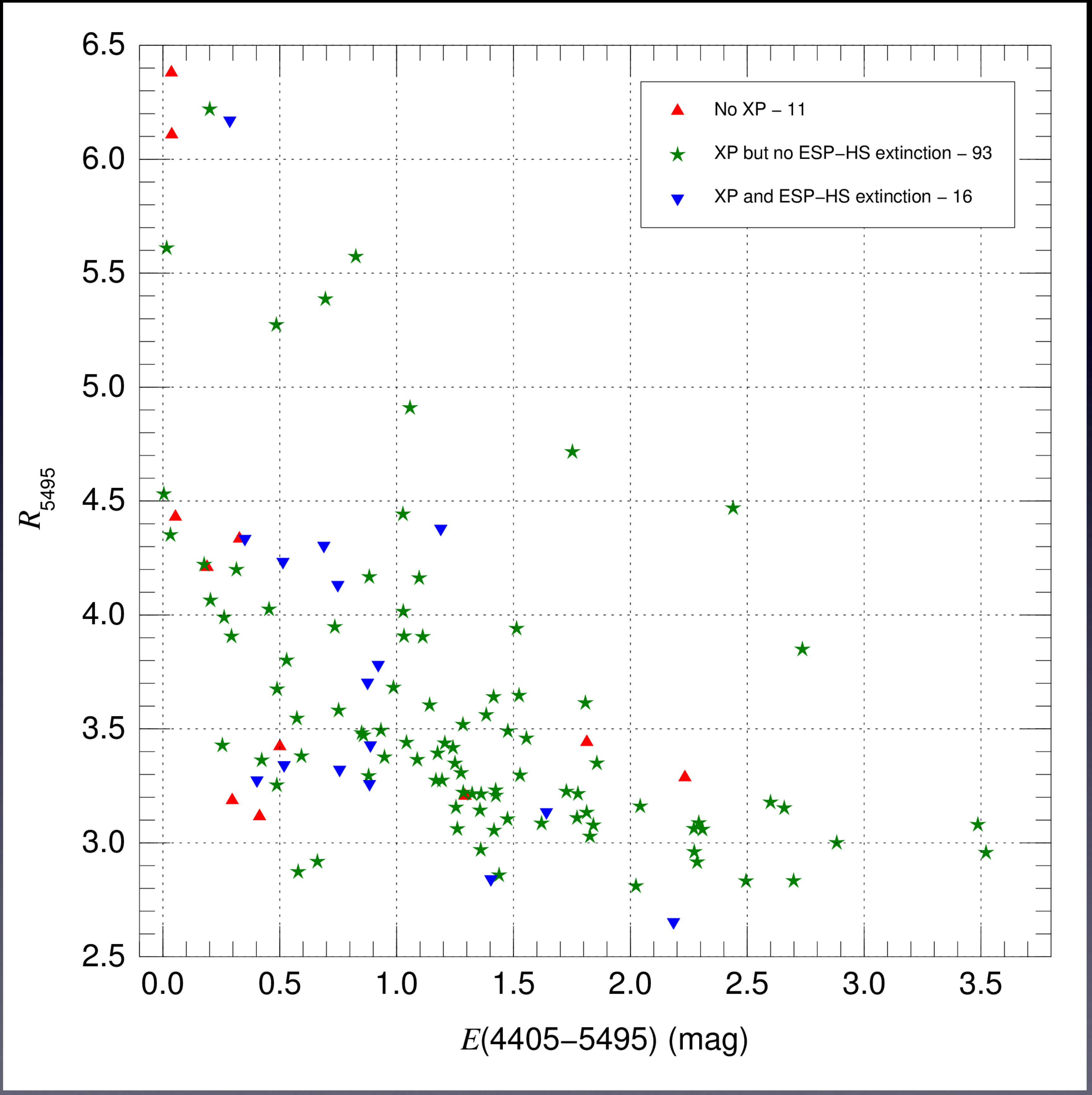
O stars with confirmed spectral types from GOSSS or LiLiMaRlin



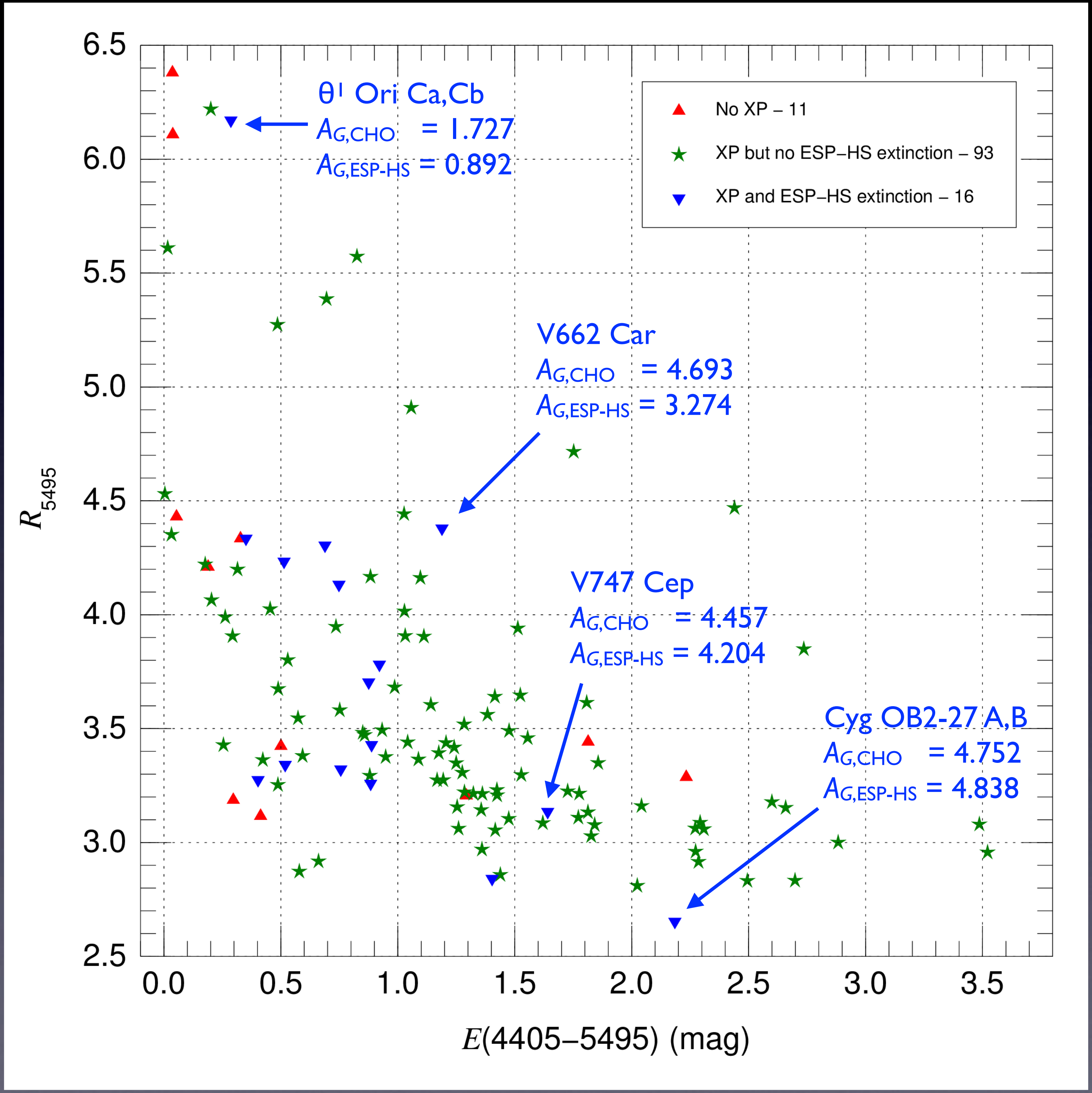
DR3: Why the extinction parameters have to be (mostly) wrong

Extinction golden sample

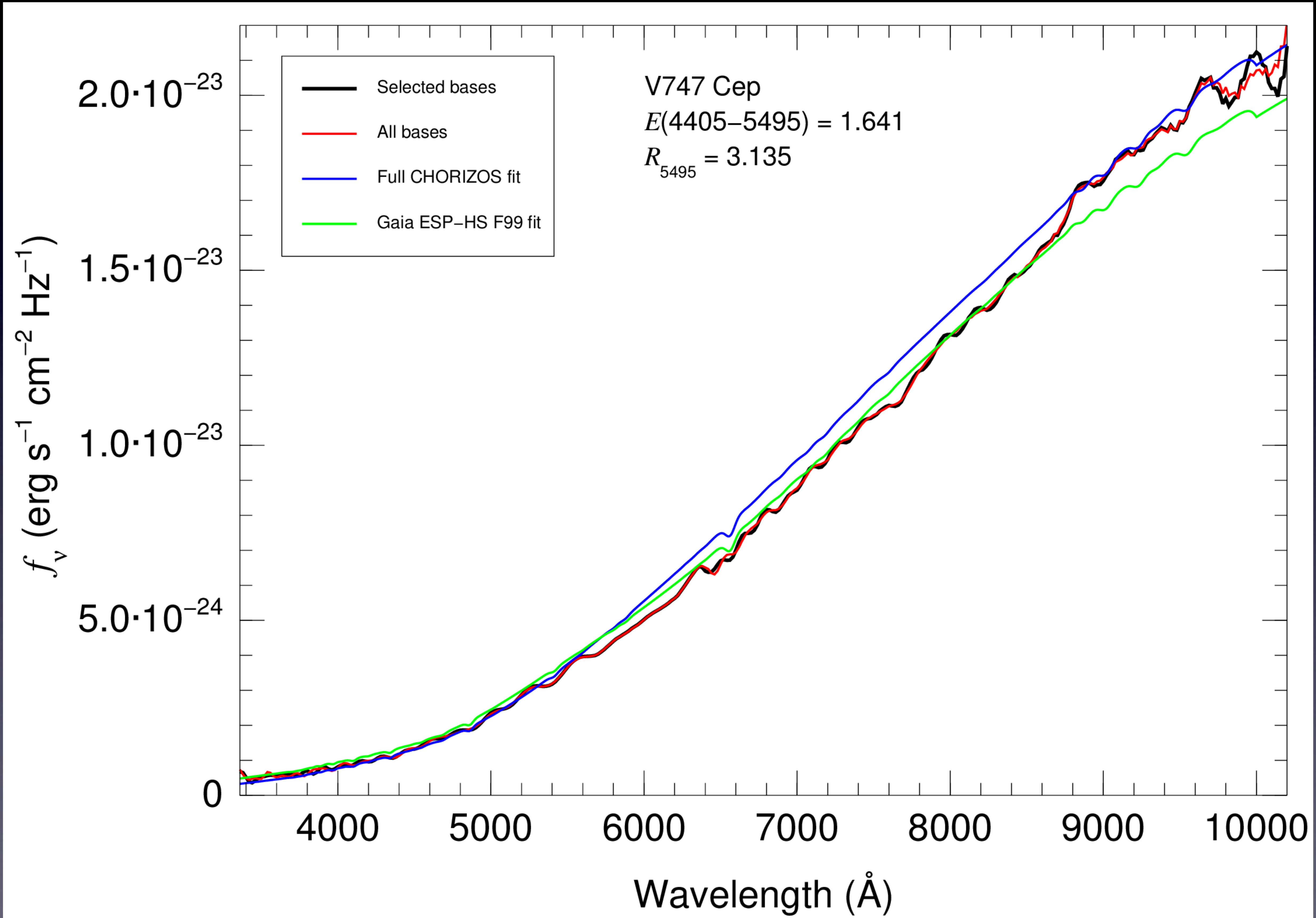


DR3: Why the extinction parameters have to be (mostly) wrong

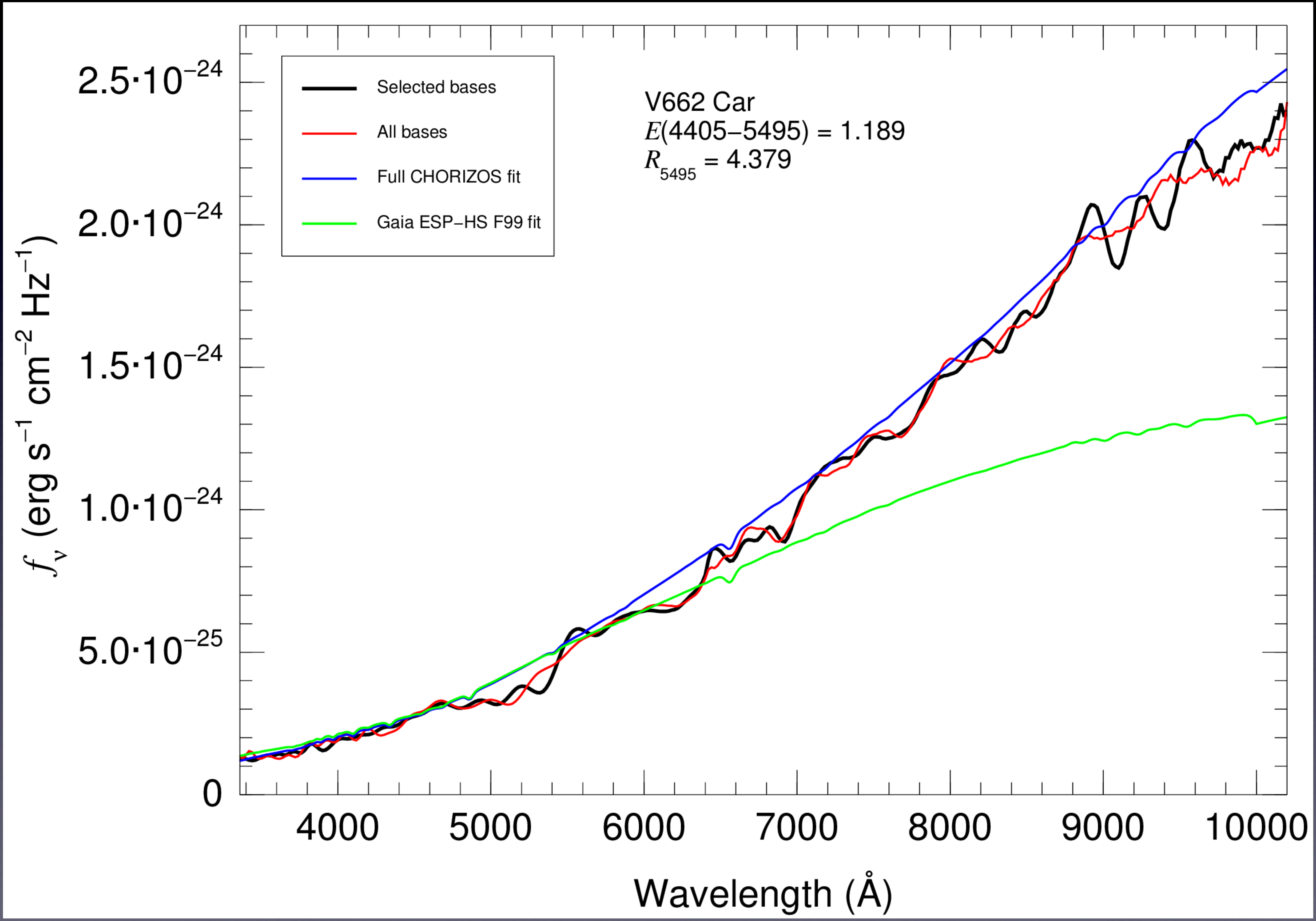
Extinction golden sample



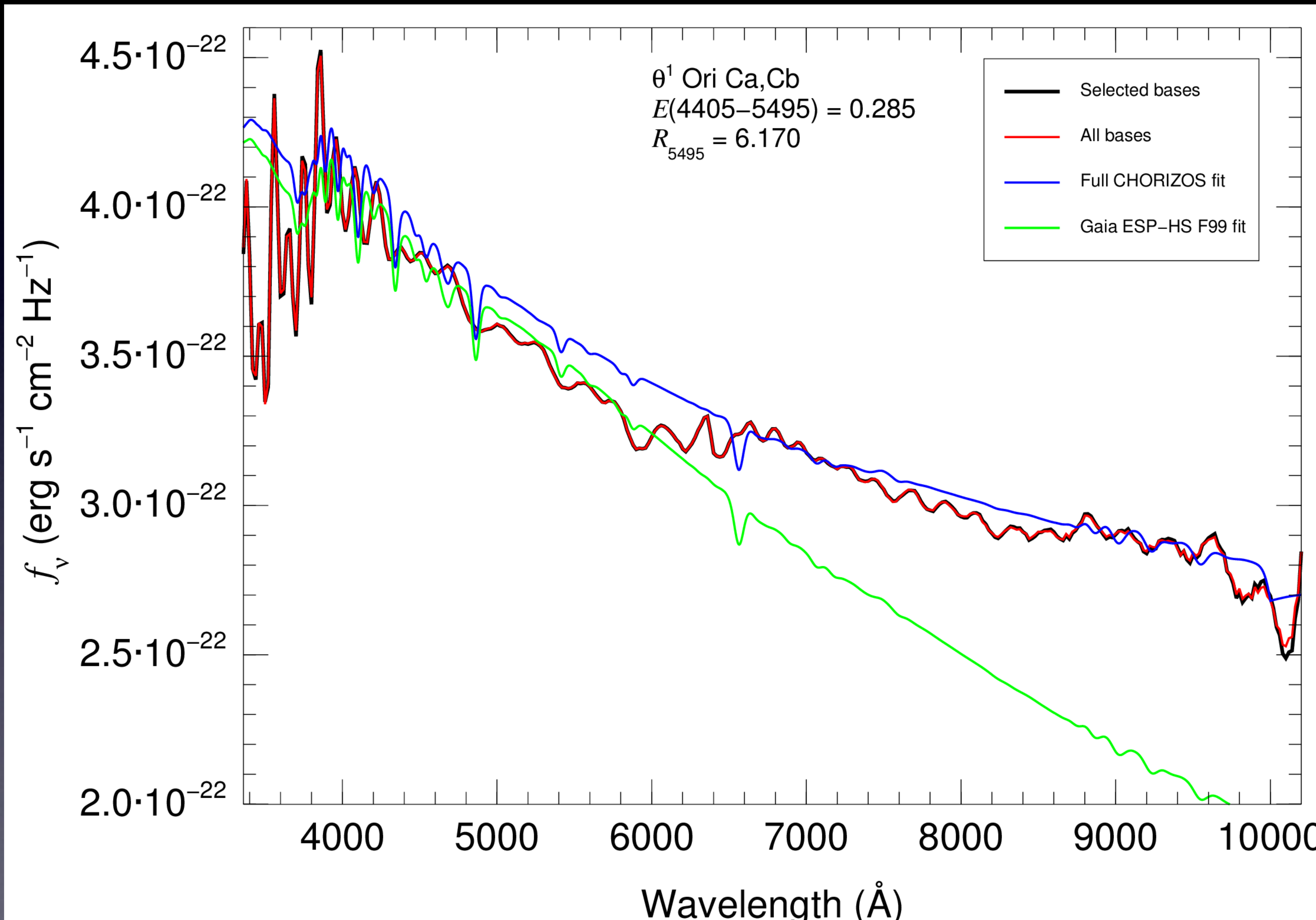
DR3: Why the extinction parameters have to be (mostly) wrong



DR3: Why the extinction parameters have to be (mostly) wrong

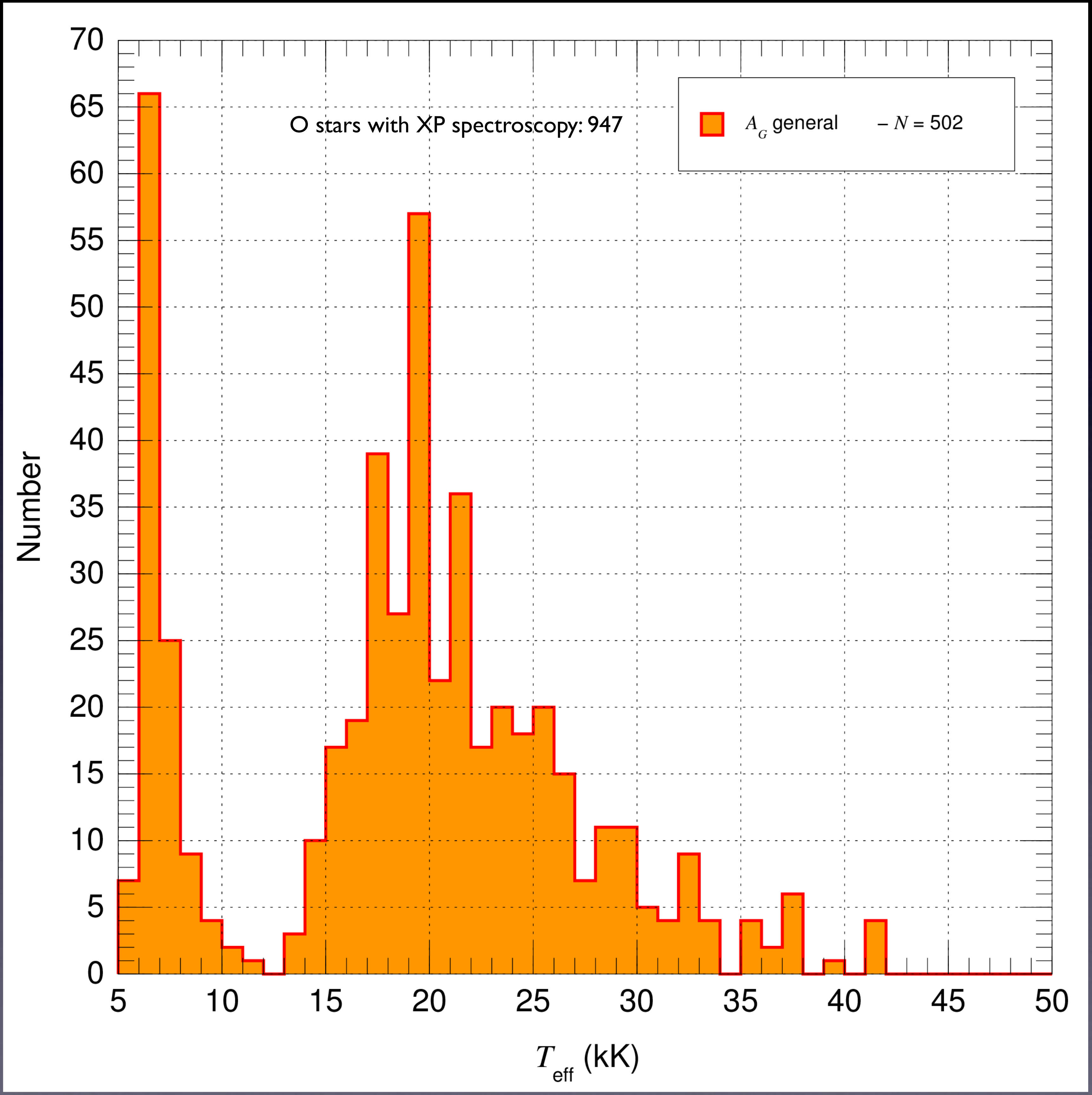


DR3: Why the extinction parameters have to be (mostly) wrong



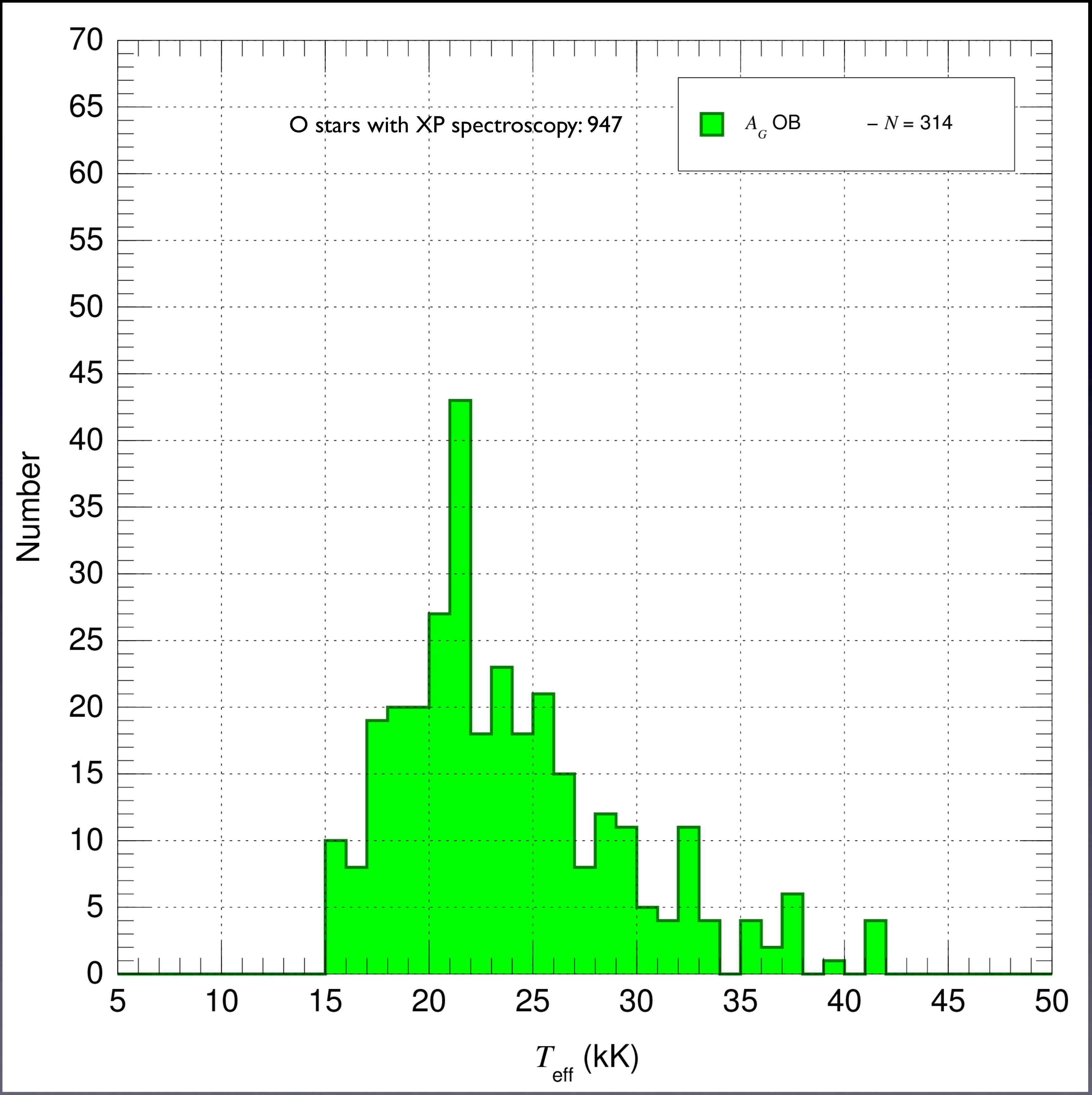
DR3: How reliable are the $T_{\rm eff}$ determinations?

O stars with confirmed spectral types from GOSSS or LiLiMaRlin



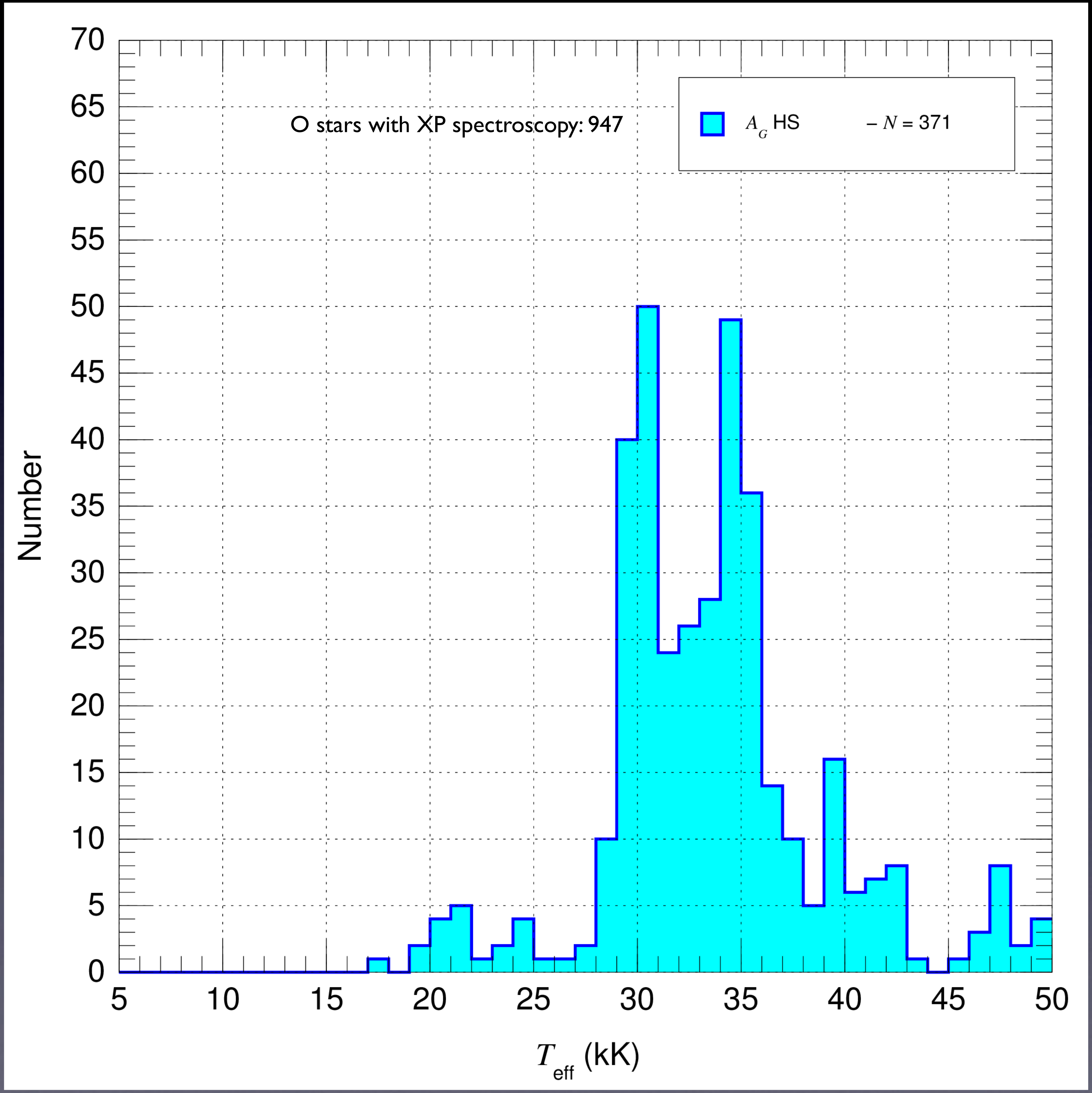
DR3: How reliable are the T_{eff} determinations?

O stars with confirmed spectral types from GOSSS or LiLiMaRlin



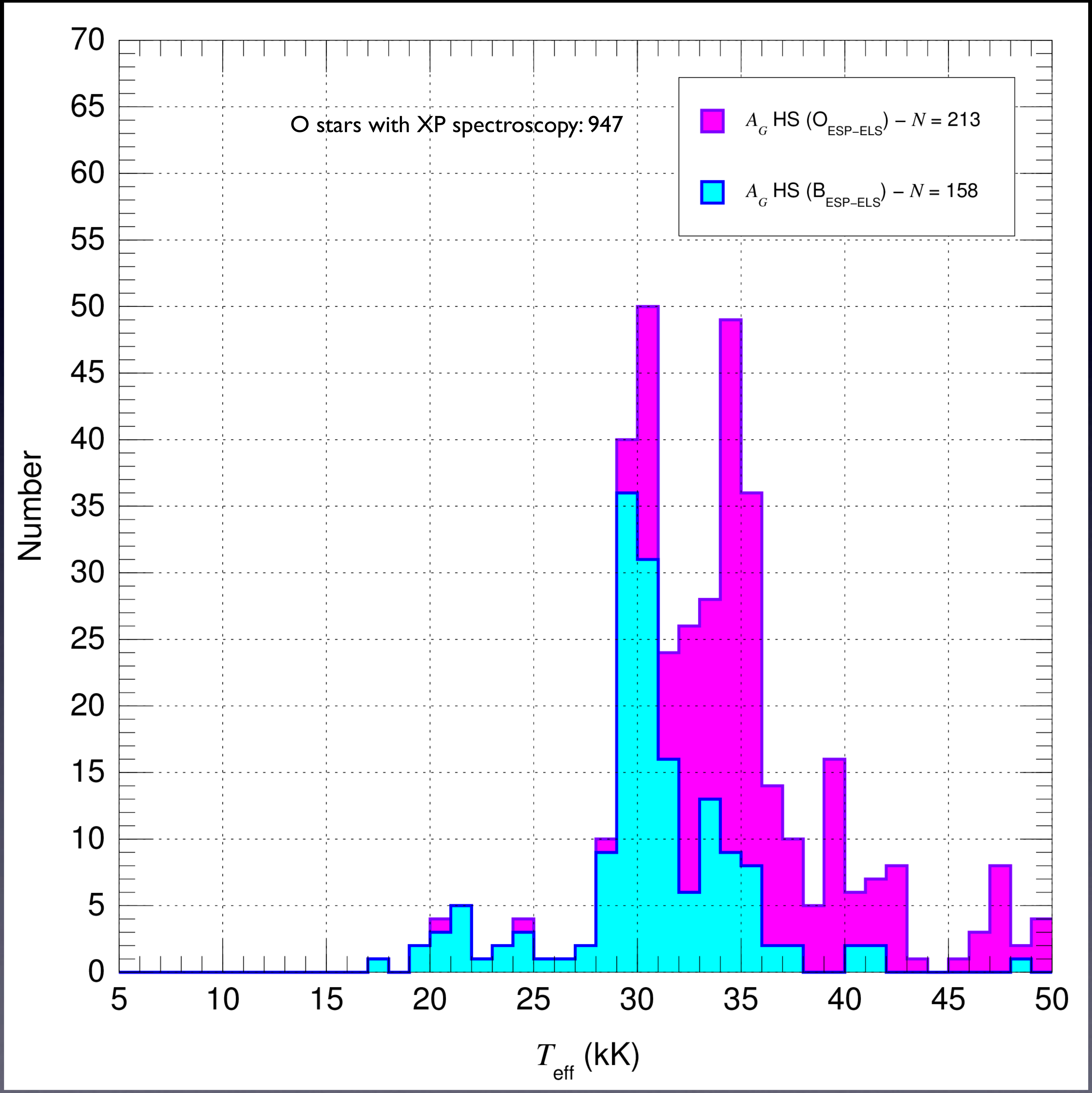
DR3: How reliable are the T_{eff} determinations?

O stars with confirmed spectral types from GOSSS or LiLiMaRlin



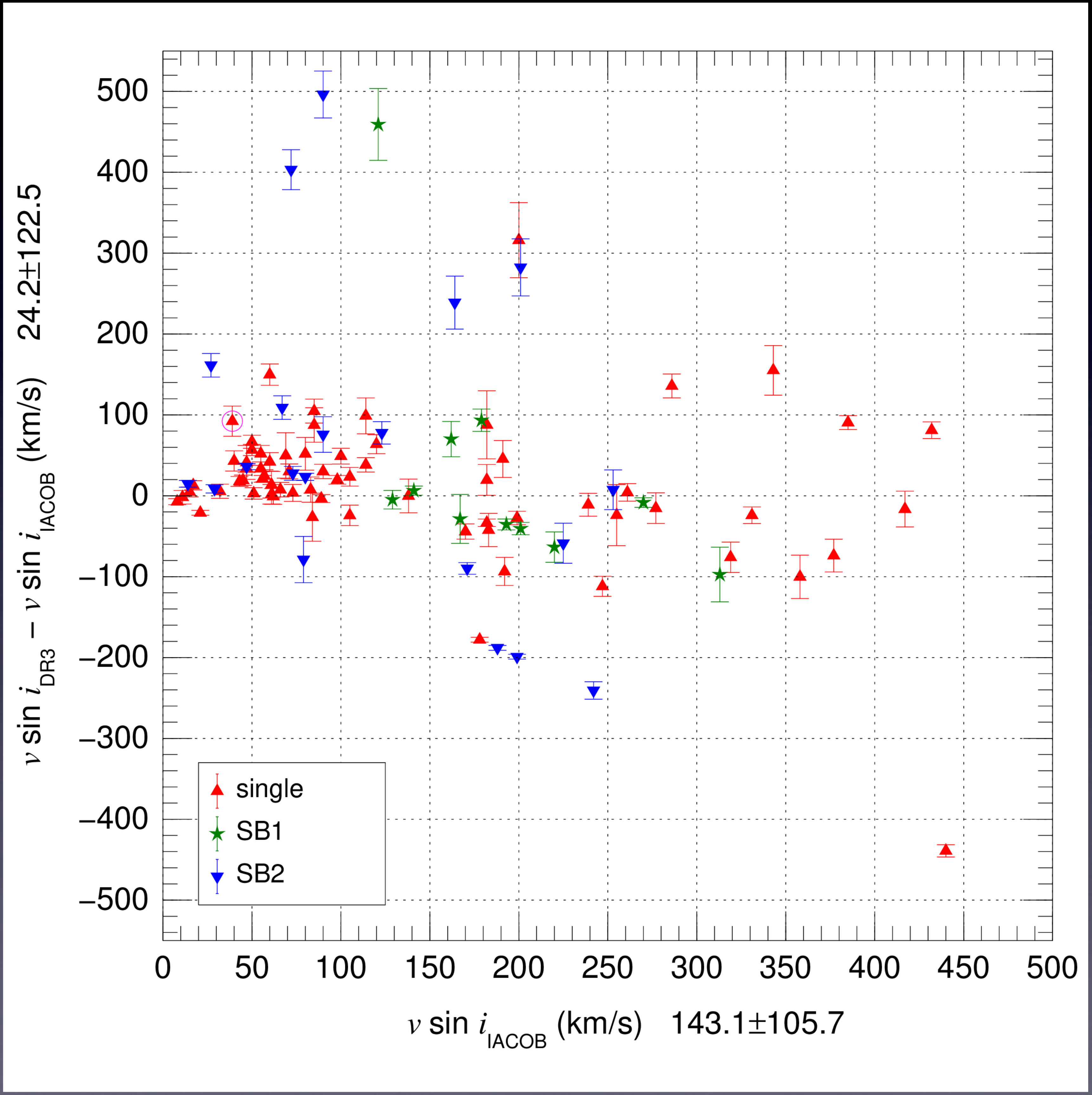
DR3: How reliable are the $T_{\rm eff}$ determinations?

O stars with confirmed spectral types from GOSSS or LiLiMaRlin



DR3: How reliable are the *v* sin*i* determinations?

O stars with confirmed spectral types from GOSSS or LiLiMaRlin and *v* sin*i* IACOB measurements



DR3: Statistics for the comparison samples

What?	O	WR	B0-B1.5	B late	All	ExtGS
All	1046	81	959	1245	3331	120
Gaia DR3 counterpart	1035	80	943	1232	3290	120
G photometry	1033	80	941	1231	3285	120
G+G_{BP}+G_{RP} photometry	1030	80	934	1223	3267	120
XP spectrophotometry	947	79	829	957	2812	109
Radial velocities	81	1	80	247	409	20
G_{RVS} photometry	78	1	71	243	393	20
RVS spectroscopy	8	0	7	170	185	2
DIB equivalent widths	21	0	43	58	122	3
General T_{eff} + A_G measurements	502	31	541	644	1718	47
OB T_{eff} + A_G measurements	314	20	383	376	1093	23
ESP-HS T_{eff} + A_G measurements	371	0	411	429	1211	17
ESP-ELS spectral types	1010	73	900	1124	3107	116
Correct spectral type (O or B) from ESP-ELS	64.6 %	-	70.3 %	90.7 %	-	-
v sin$i$ from ESP-HS	302	0	336	254	892	13
Epoch photometry	158	30	241	249	678	20

Flying through the Galaxy with ALS III