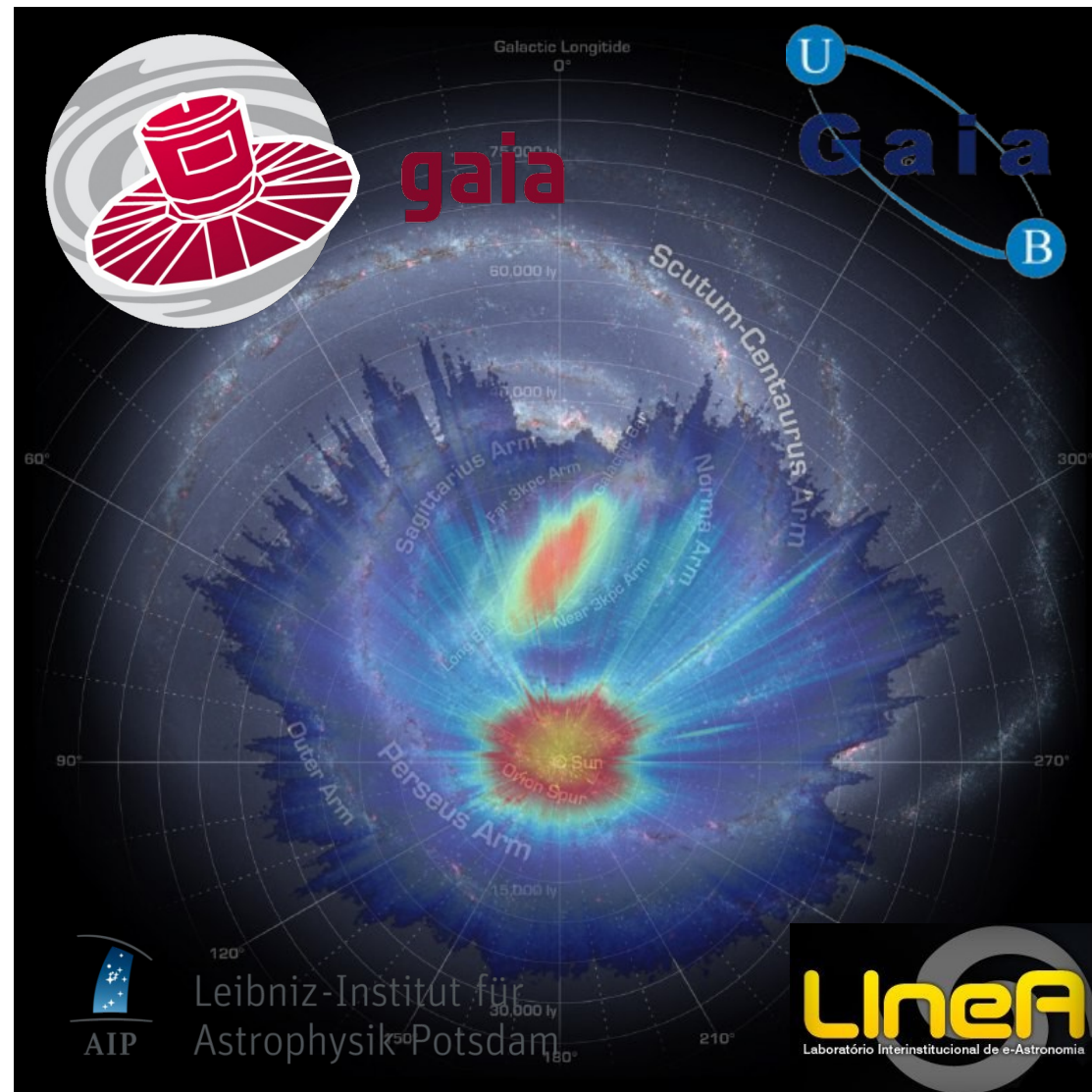


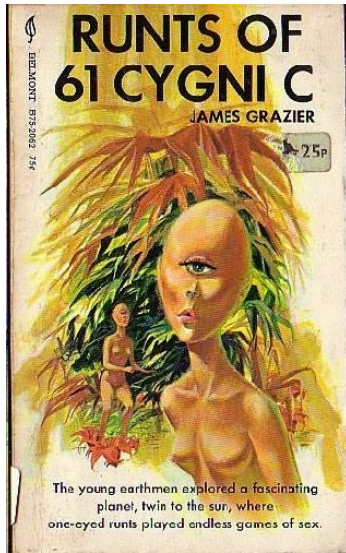
Determining distances and other stellar properties for millions of stars

Friedrich Anders (U Barcelona)

Cristina Chiappini, Arman Khalatyan,
Anna Barbara Queiroz (AIP)
Basilio X. Santiago (UFRGS)



A short history of stellar distance measurements



1838: first parallax measurement (Bessel)

1901: 58 parallaxes measured (Kapteyn)

1920s: first distance ladder controversy

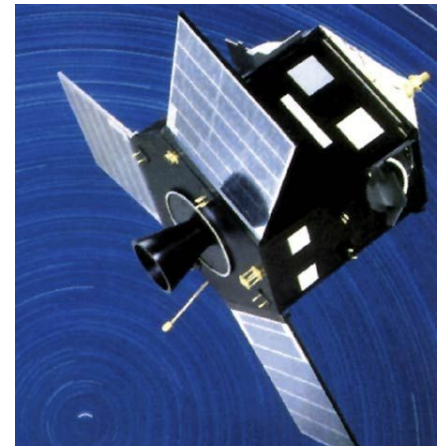
1950s-today: main-sequence fitting for star clusters

1980s-2000s: statistical photometric distances to field stars

1990s-2010s: *Hipparcos* and its legacy: 100,000 stars with parallaxes (100)

2000s-2010s: spectroscopic surveys ($\sim 10^6$ stars)

2018: Gaia DR2 ($\sim 10^9$ stars)

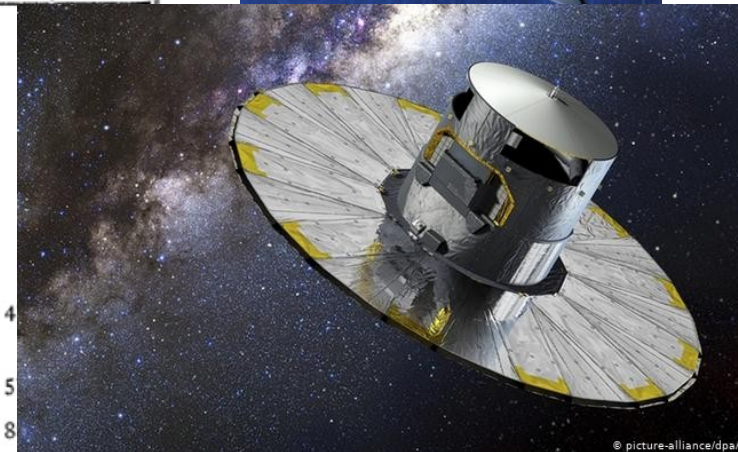


24

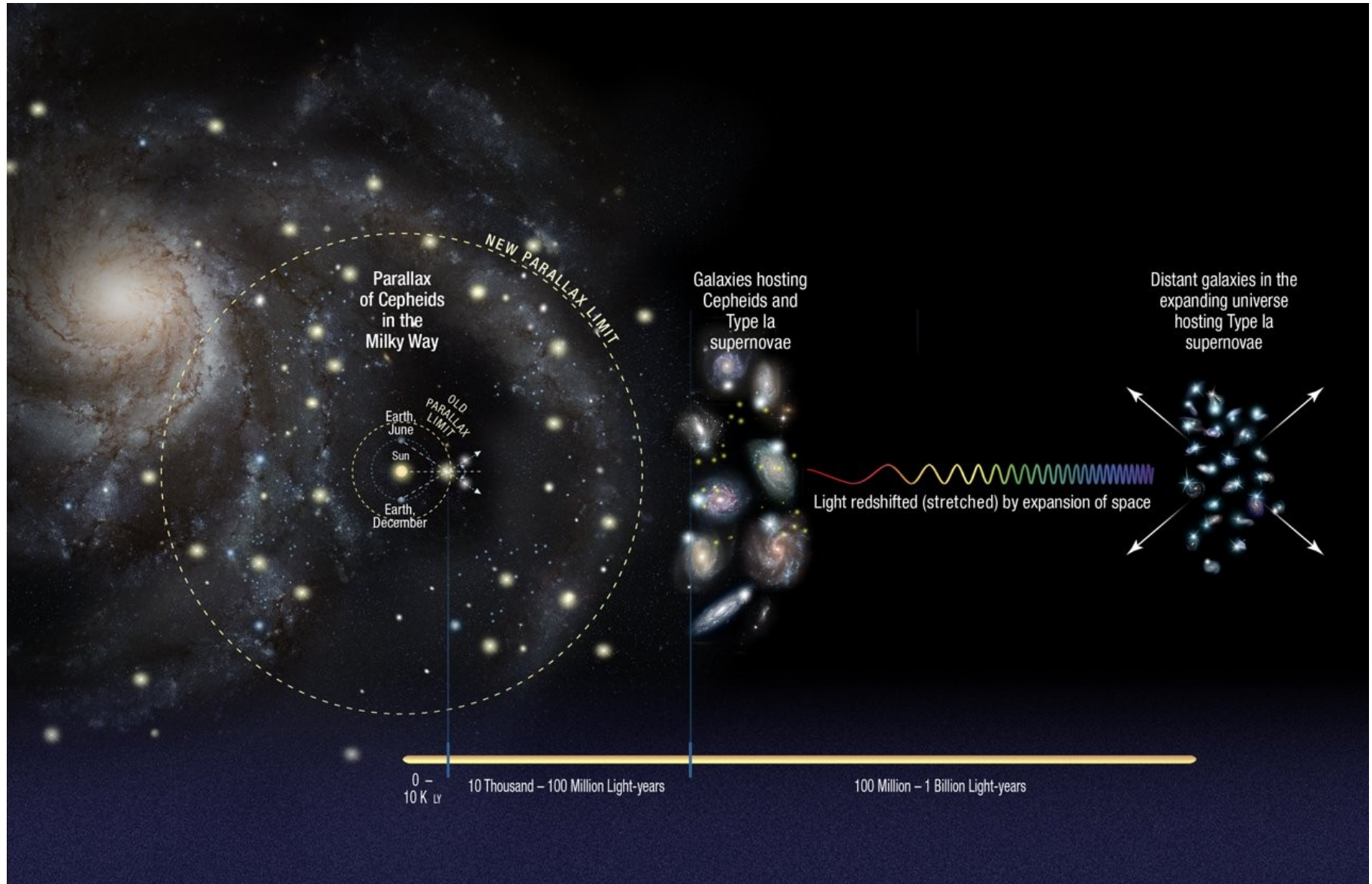
PARALLAX DETERMINATIONS.

25

No.	Star.	Mag.	Comp. *	Δ mag.	α 1900	δ 1900	Sp.	μ	ν	$\pi_{\text{aut.}}$	r	Author.	$\pi_{\text{abs.}}$	Relat. weight.	$\pi_{\text{adopt.}}$	Abs. mag.	Lum.
177	Lal. 23917	8.3	7.7		^h 12 ^m 44.6	^s + 1 45	G	0.68	183	+ 0.01 + 0.025	± 0.049 18	Ch Y 2 Schl	+ 0.020 + 0.031	1 5	+ 0.029		
178	δ Virginis	3.66	7.6		50.6	+ 3 56	Ma	0.481	263	— 0.04	39	Ch Y 2	— 0.030		— 0.030		
179	Lal. 24414—'6	6.91	8.7		13 3.8	+ 5 46		0.72	175	— 0.00	48	Ch Y 2	+ 0.008		+ 0.008		
180	Lal. 24504	8.5	8.6		6.4	+ 10 9		0.55	297	+ 0.02	51	Ch Y 2	+ 0.028		+ 0.028		
181	43 Comae Ber.	4.32	8.5 7.4 8.5	— 0.3	7.2	+ 28 23	G	1.183	318	+ 0.11 + 0.08 + 0.12	14 53 52	Pet 2 Fli Ch Y 2	+ 0.118 + 0.090 + 0.128	7 1 1	+ 0.116	4	
182	61 Virginis	4.80	5.4	— 0.6	13.2	— 17 45	G5	1.51	225	+ 0.14	33	Fli	+ 0.157		+ 0.157	5	
183	Weisse ₂ 13 ^h , 241	9.3	7.6		14.9	+ 35 39	K**	0.92	154	+ 0.07	52	Ch Y 2	+ 0.080		+ 0.080	8	



The parallax horizon: Gaia's transversal impact on astronomy



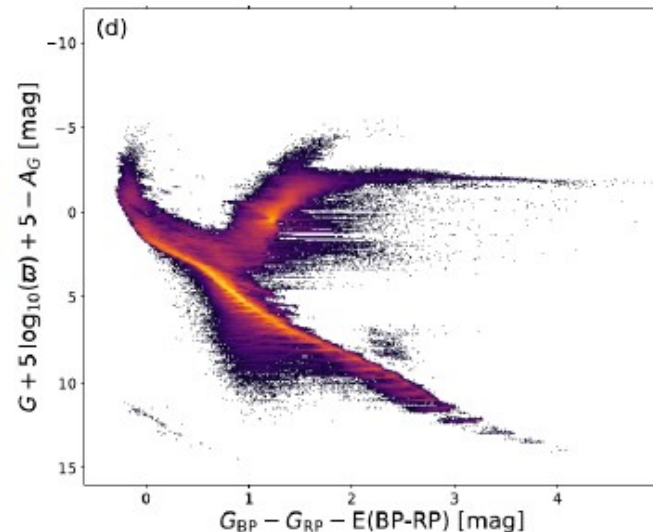
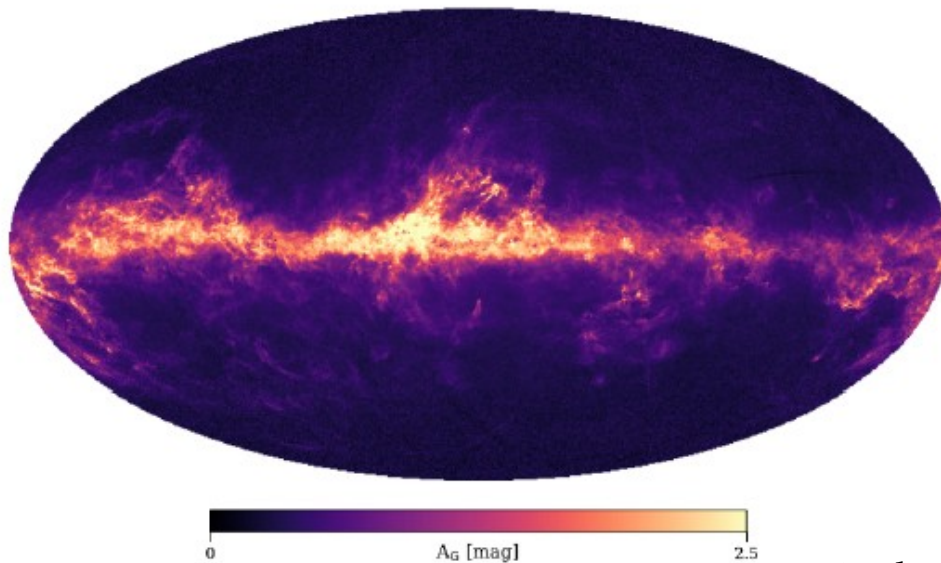
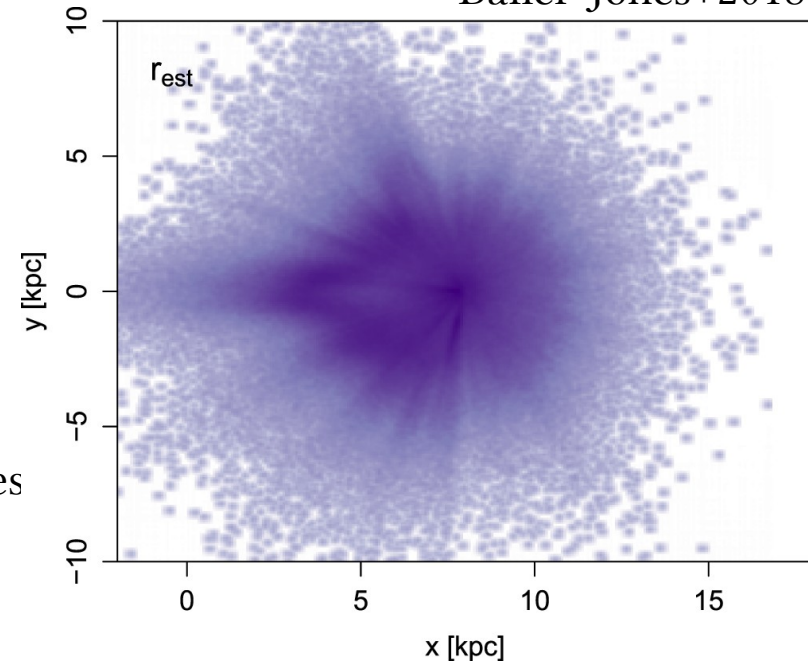
A new era: What Gaia DR2 brought us

- 1.7 billion stars with 5D astrometric parameters
- New parallax horizon: **100 pc \rightarrow 2 kpc**
- Radial velocities for 7M stars up to $G < 12$
- Extinction and temperatures for 80M stars
- ...

Coupled with spectroscopic surveys:

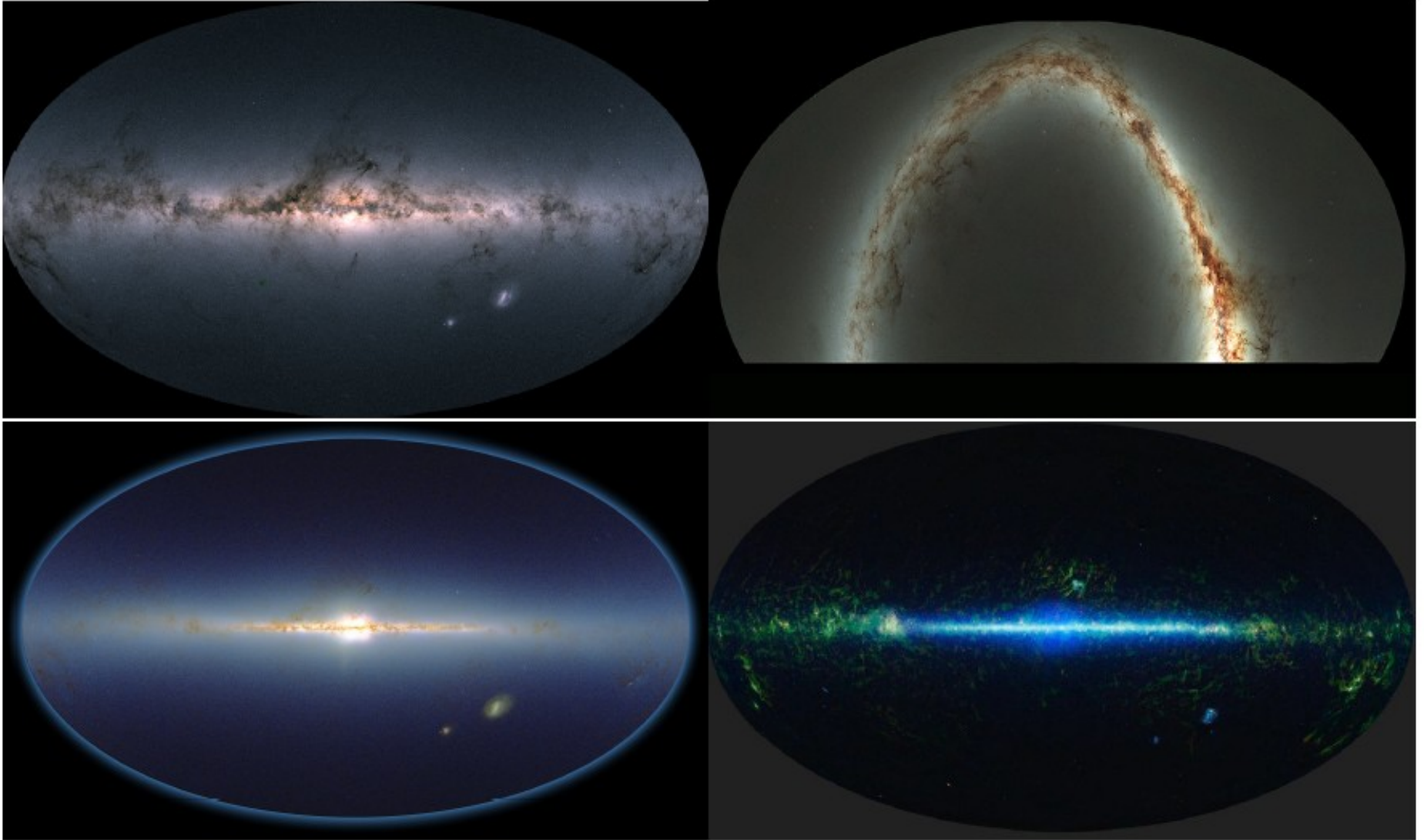
- High-precision chemical abundances, possibly also okay ages
- Distances for stars farther than 3 kpc
- Radial velocities for the fainter stars

Bailer-Jones+2018



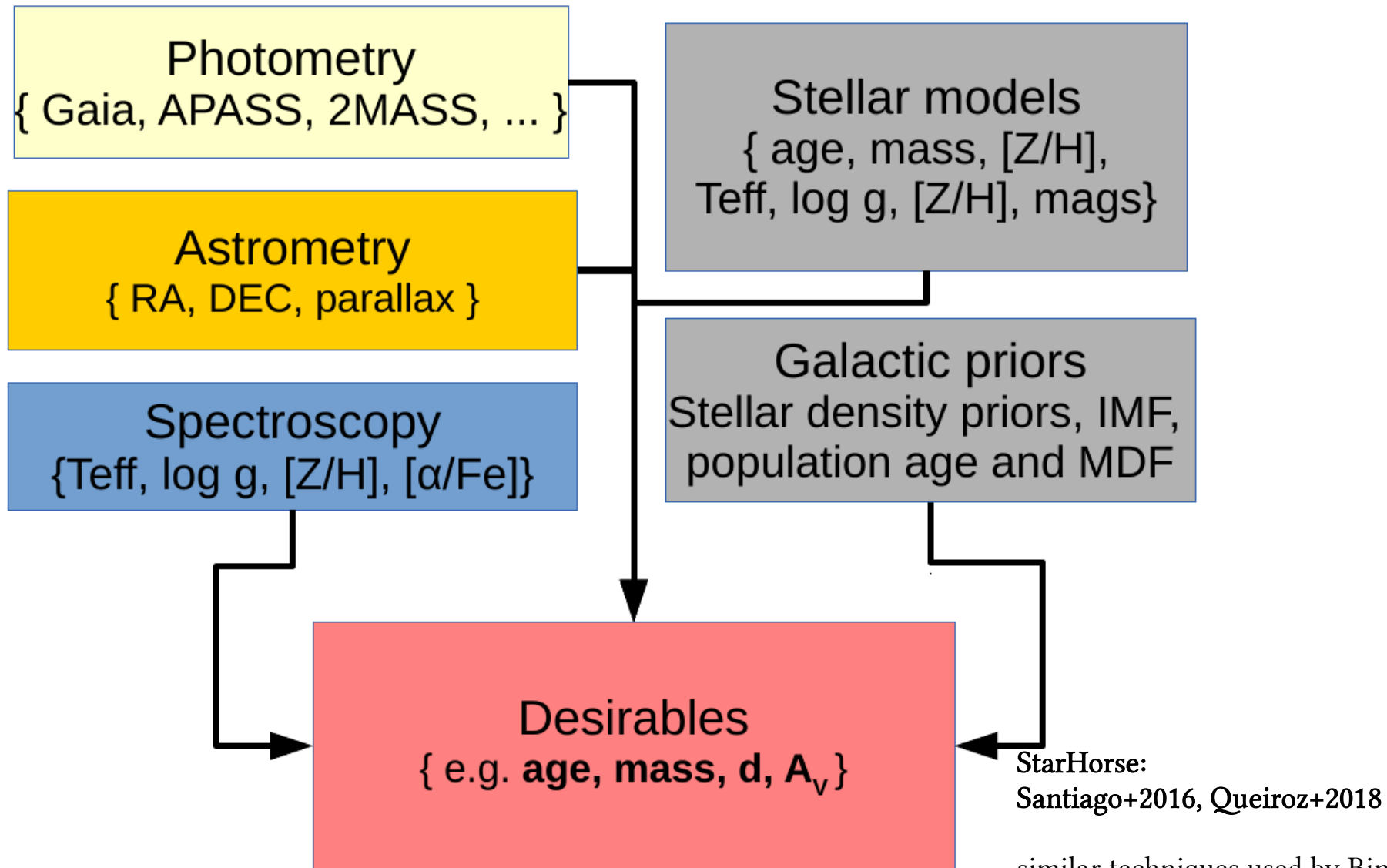
Andrae+2018

Combining Gaia with other surveys: StarHorse2019 project



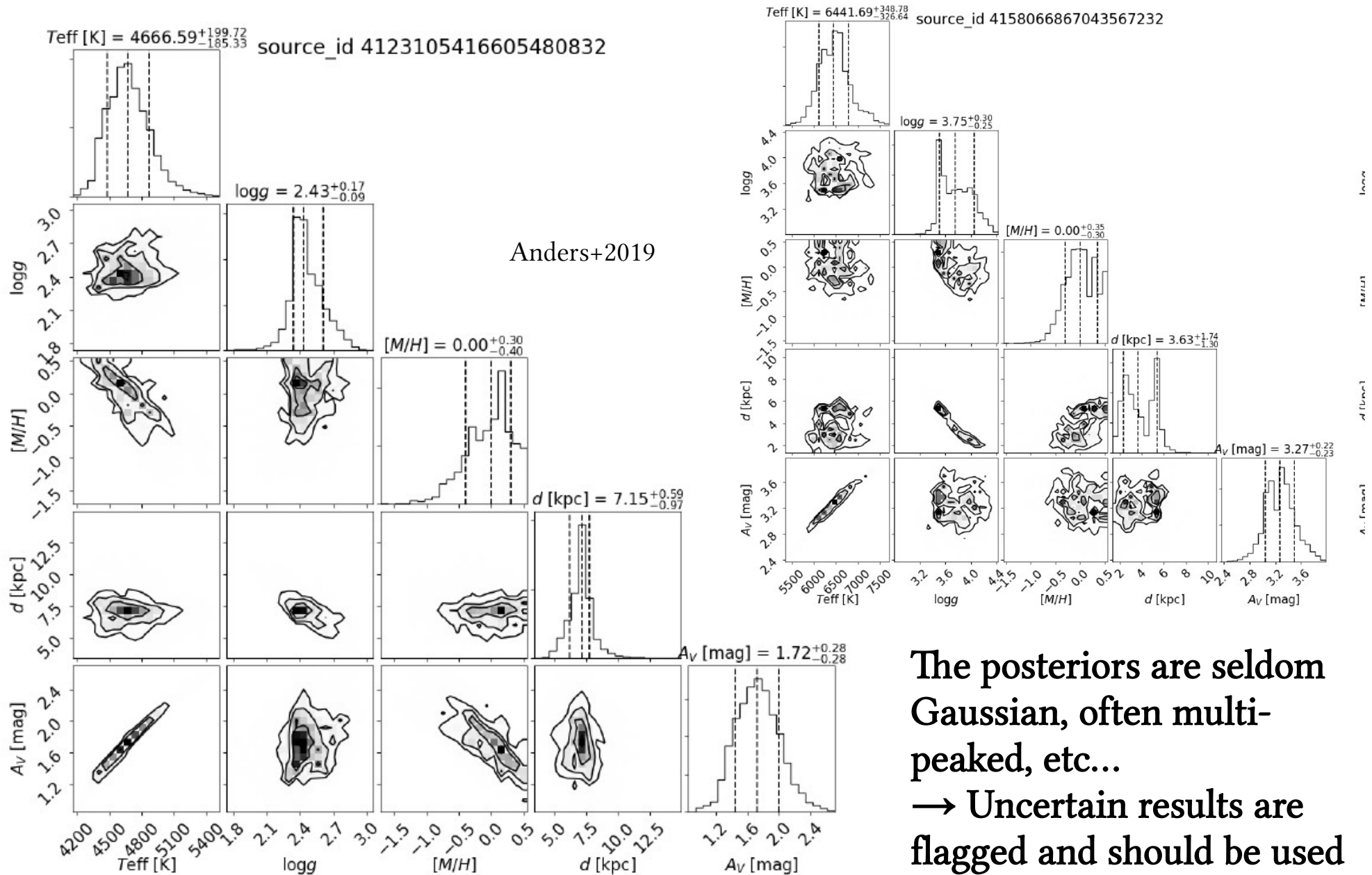
Gaia DR2, Pan-STARRS1, 2MASS, and WISE all-sky maps

Bayesian inference of distances and stellar parameters



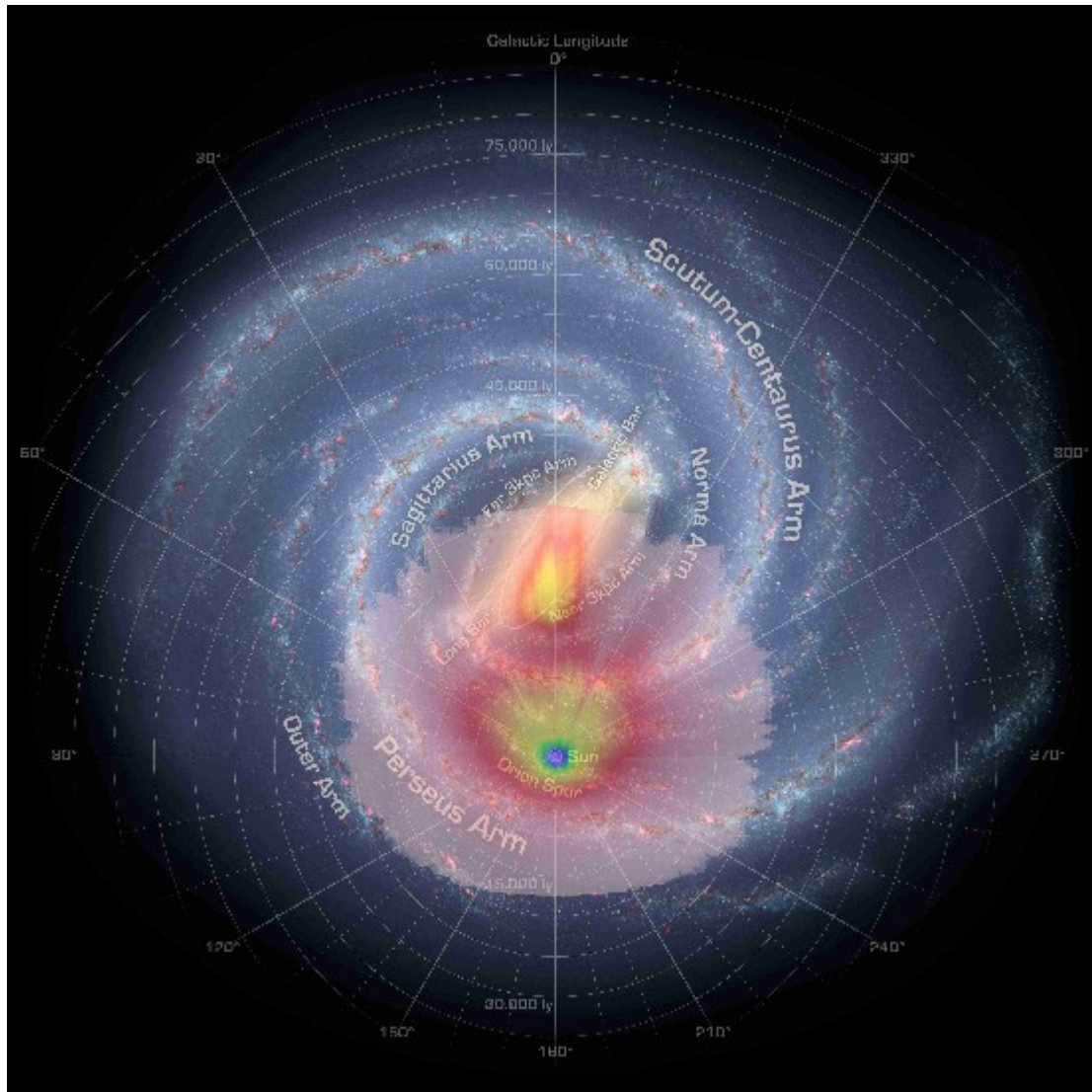
similar techniques used by Binney+2014, McMillan 2017, Mints&Hekker 2017, ...
Simpler techniques used by Gaia DPAC, Astraatmadja+2016, Bailer-Jones+2018..

StarHorse: joint posterior PDFs



The posteriors are seldom Gaussian, often multi-peaked, etc...
 → Uncertain results are flagged and should be used with care...

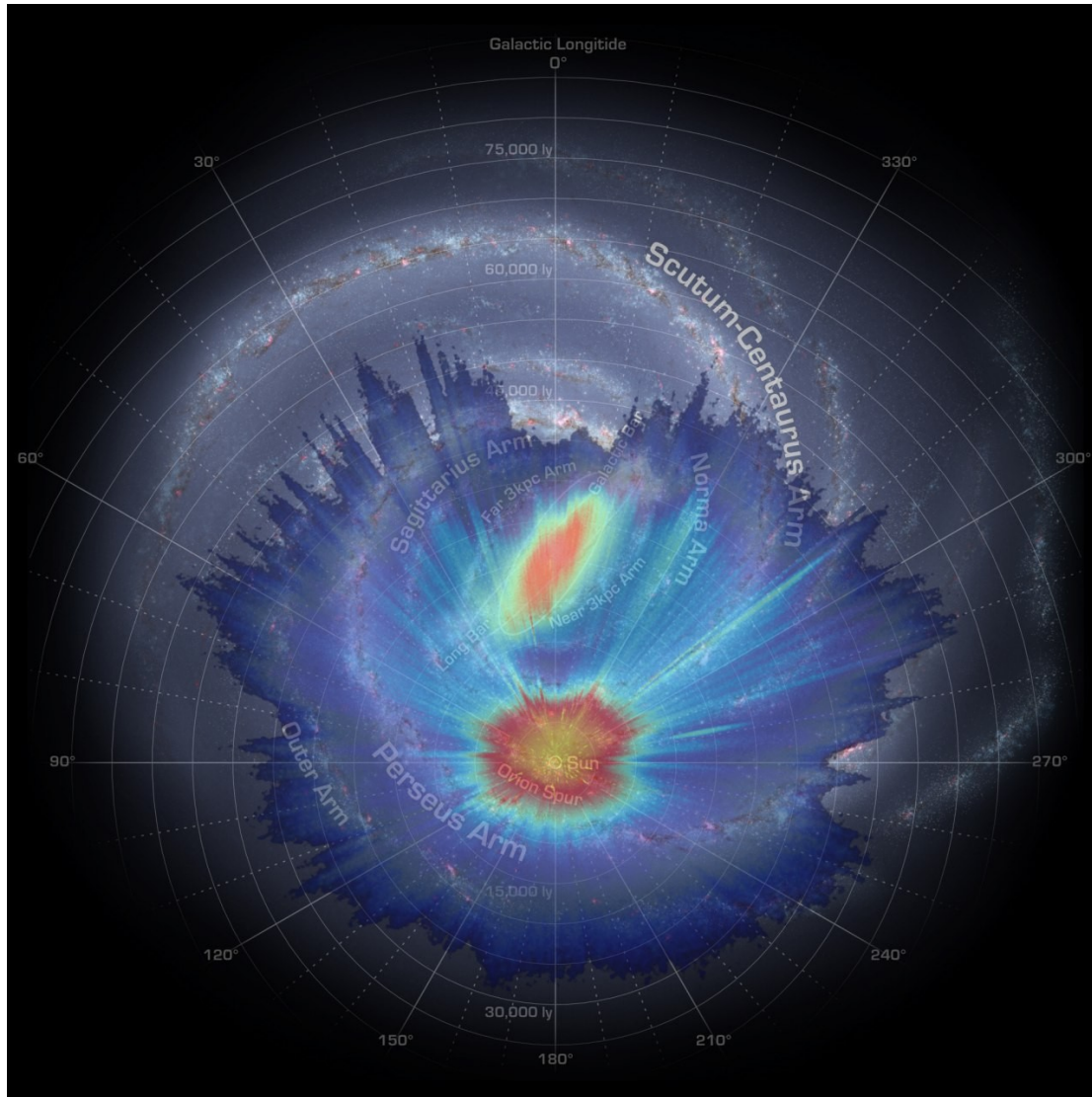
A sharpened view of the Galaxy



- Extension of the Gaia parallax horizon:
More accurate distances for stars with imprecise parallaxes
- Masses and age estimates for stars with good parallaxes
- Better HRDs, more precise chemo-dynamics, stellar orbits, etc.

Gaia end-of-mission expectation in 2012.
Credit: X. Luri/ A. Robin

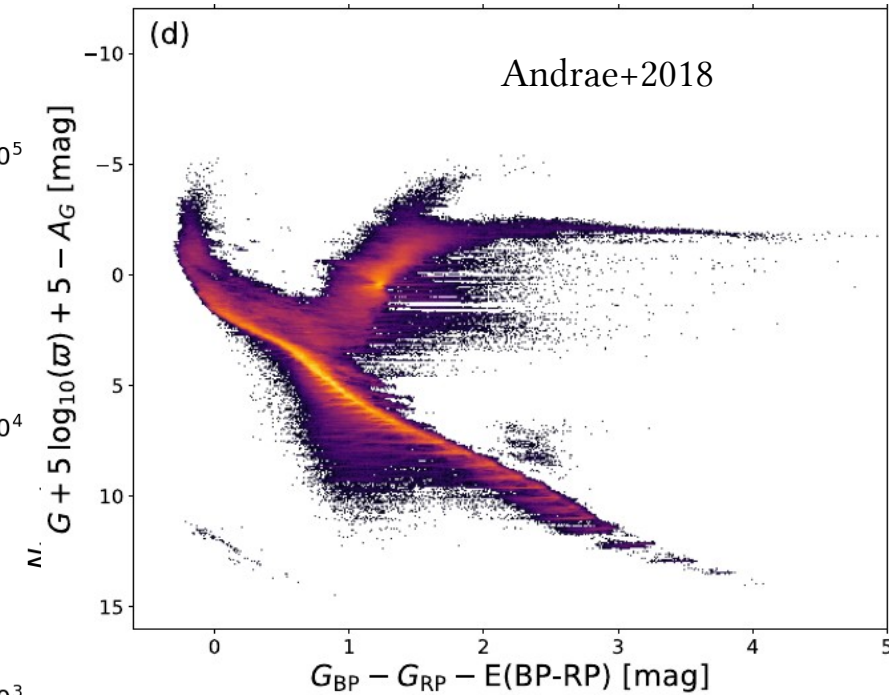
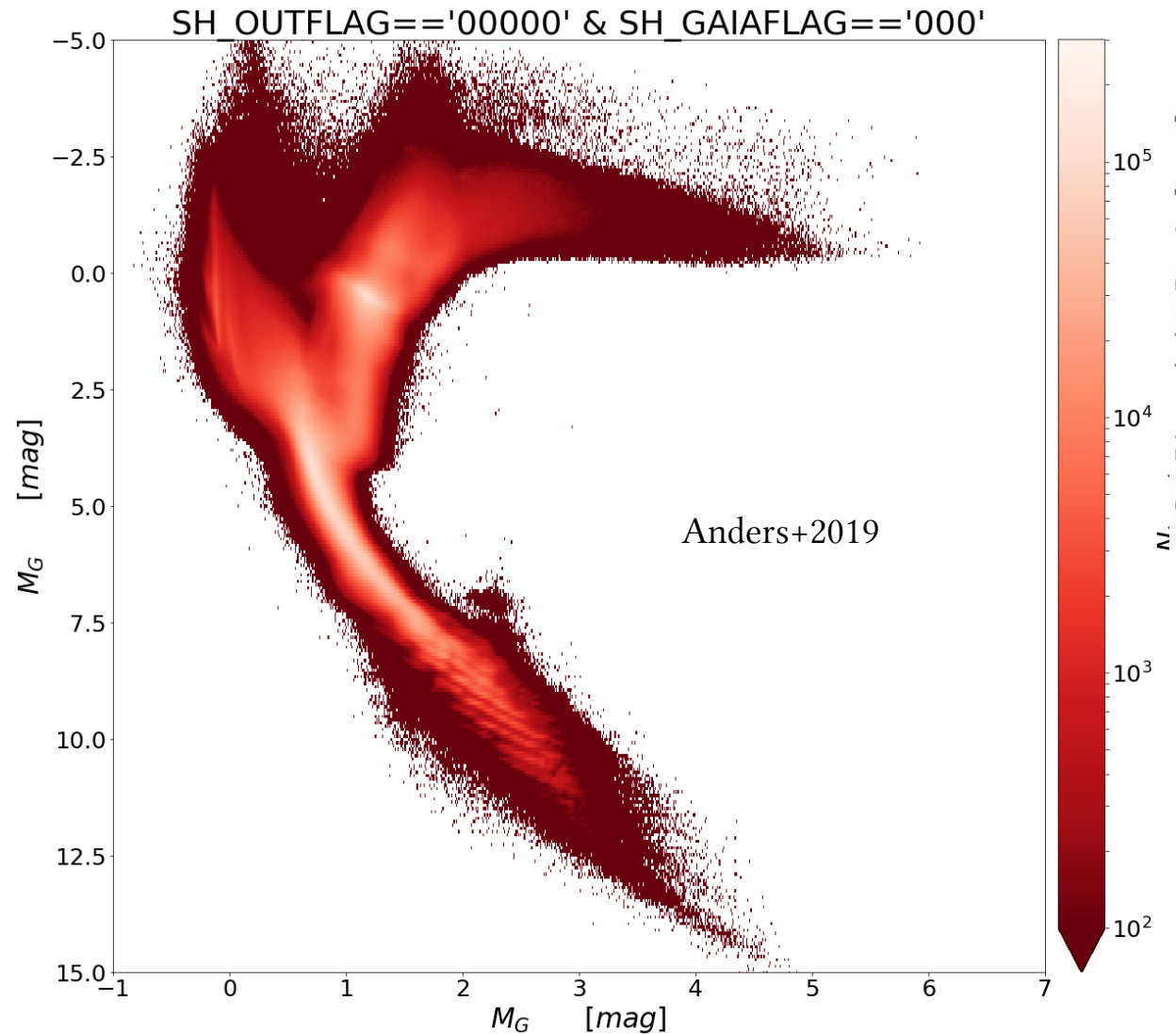
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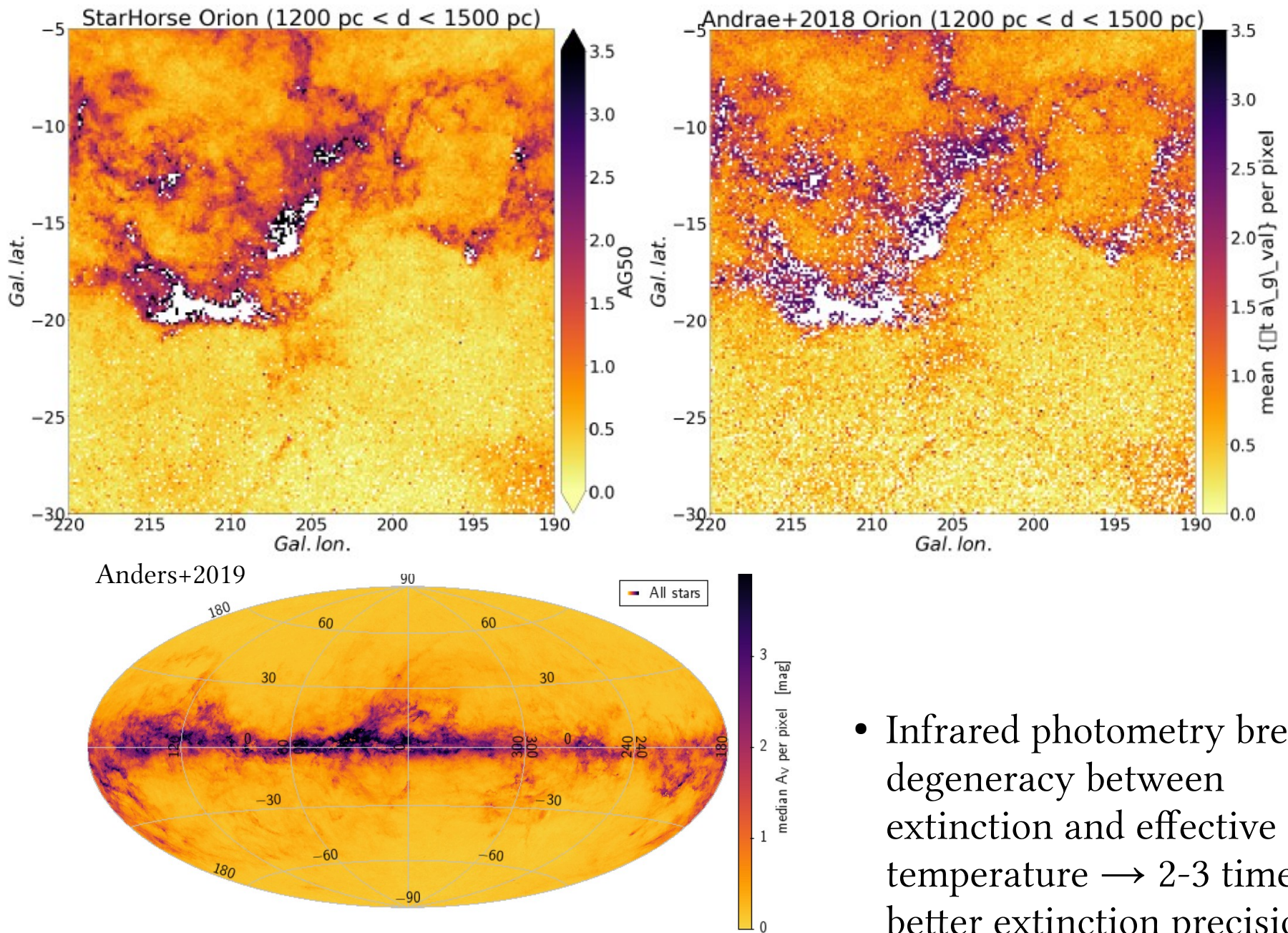
Gaia DR2 StarHorse view (22 months of data)
Credit: A. Khalatyan/F. Anders

Improved HR diagrams with more stars



- Infrared photometry breaks degeneracy between extinction and effective temperature → Nicer dereddened CMDs

Improved extinction maps with more stars



- Infrared photometry breaks degeneracy between extinction and effective temperature → 2-3 times better extinction precision

Data access: gaia.aip.de

Database status

You are using 24.9 GB of your quota of 1.0 TB.

New query job

SQL query

Cone search

Job list

Run Id: gdr2_1percent

No run Id

g18_1percent_parallax_ag

gaiaflags_g1800

gaiaflags_g1779

gaiaflags_g1755

gaiaflags_g1730

Database

Columns

Simbad

VizieR

Examples

SQL query

1
SELECT g.source_id, s.MG0, s.BPRP0
FROM gdr2.gaia_source AS g,
 gdr2_contrib.starhorse AS s
WHERE g.source_id = s.source_id
AND s.SH_OUTFLAG LIKE '00000'
AND s.SH_GAIAFLAG LIKE '000'
AND 1=CONTAINS(POINT('GALACTIC',g.l,g.b),
 CIRCLE('GALACTIC',74.,8.5, 1.))

Table name

Run id

Query language

Queue

ADQL

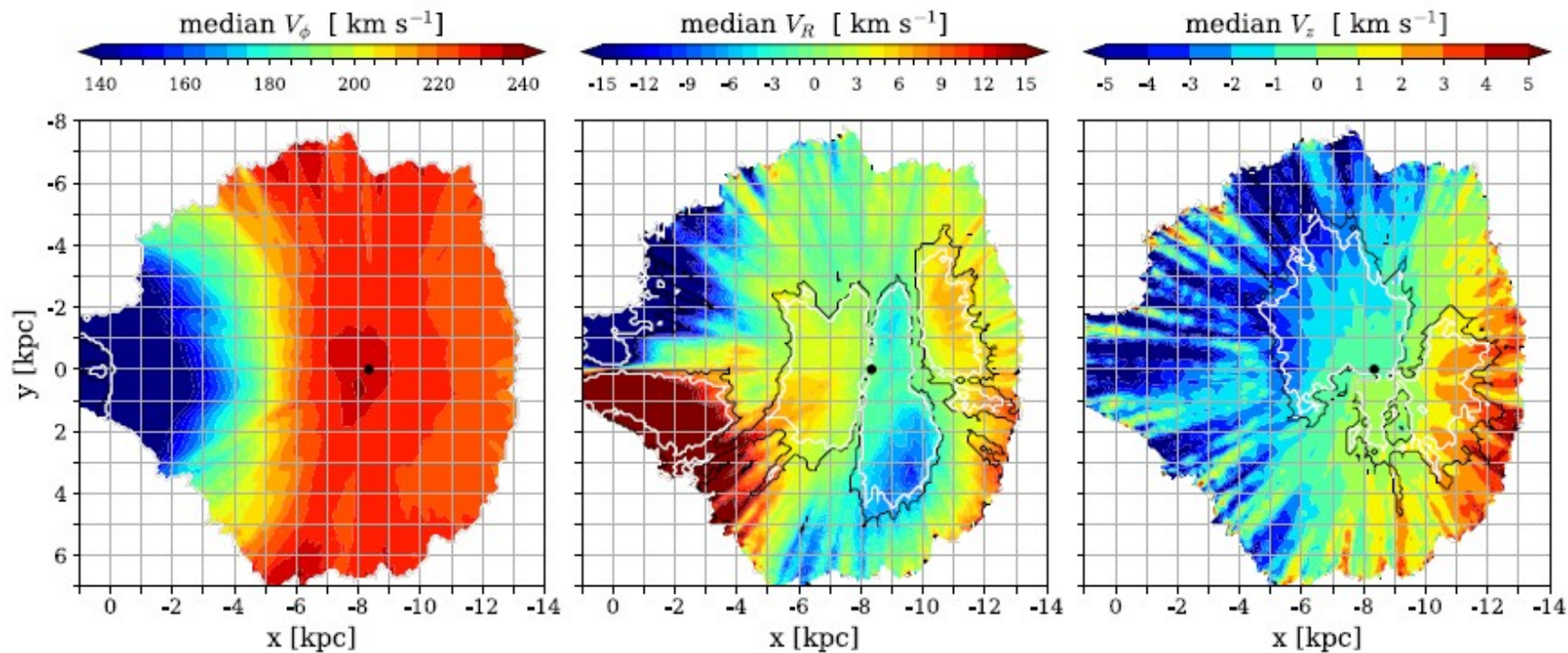
30 Seconds

Submit new SQL Query

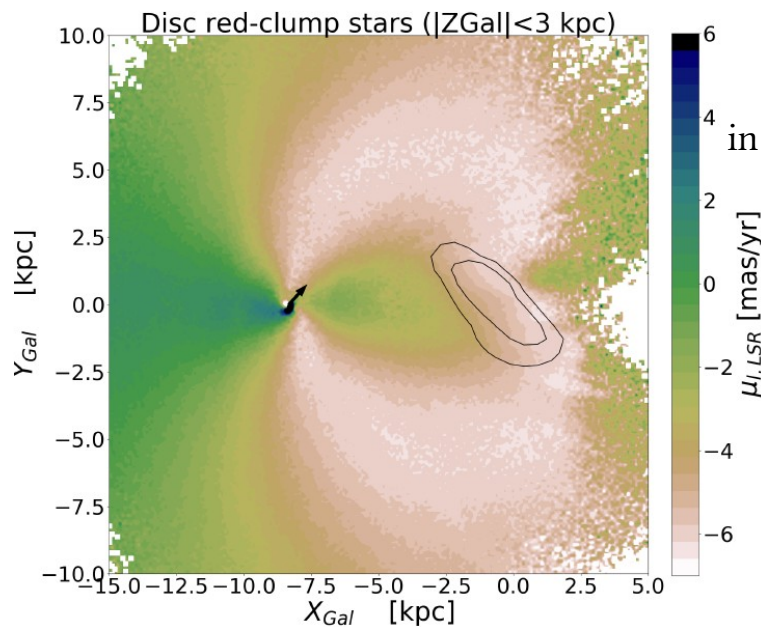
Clear input window

fanders@icc.ub.edu, akhalatyan@aip.de

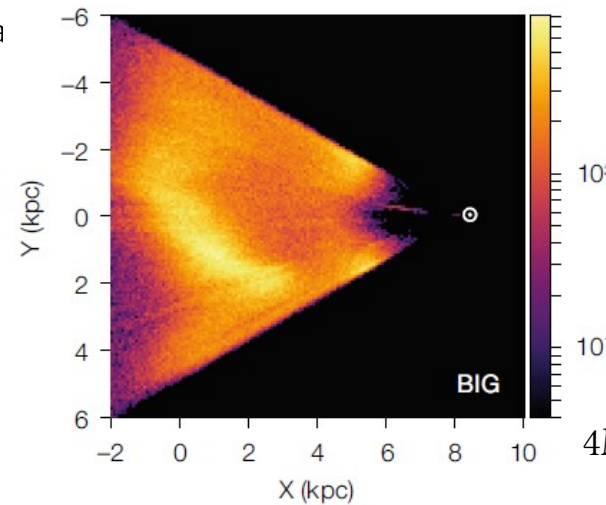
First science applications



6D Kinematics of the Galactic disc:
Carrillo+2019

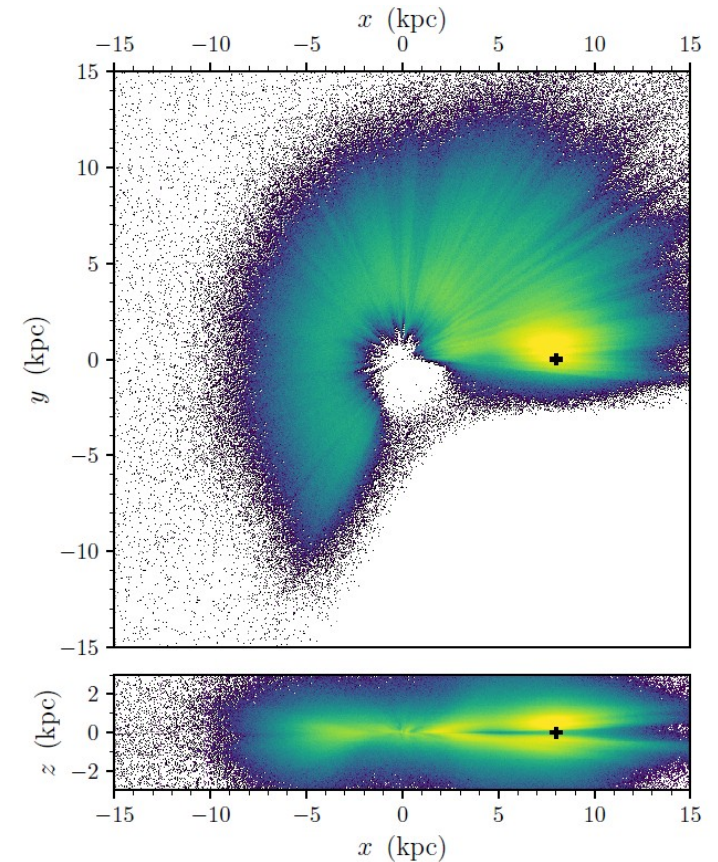
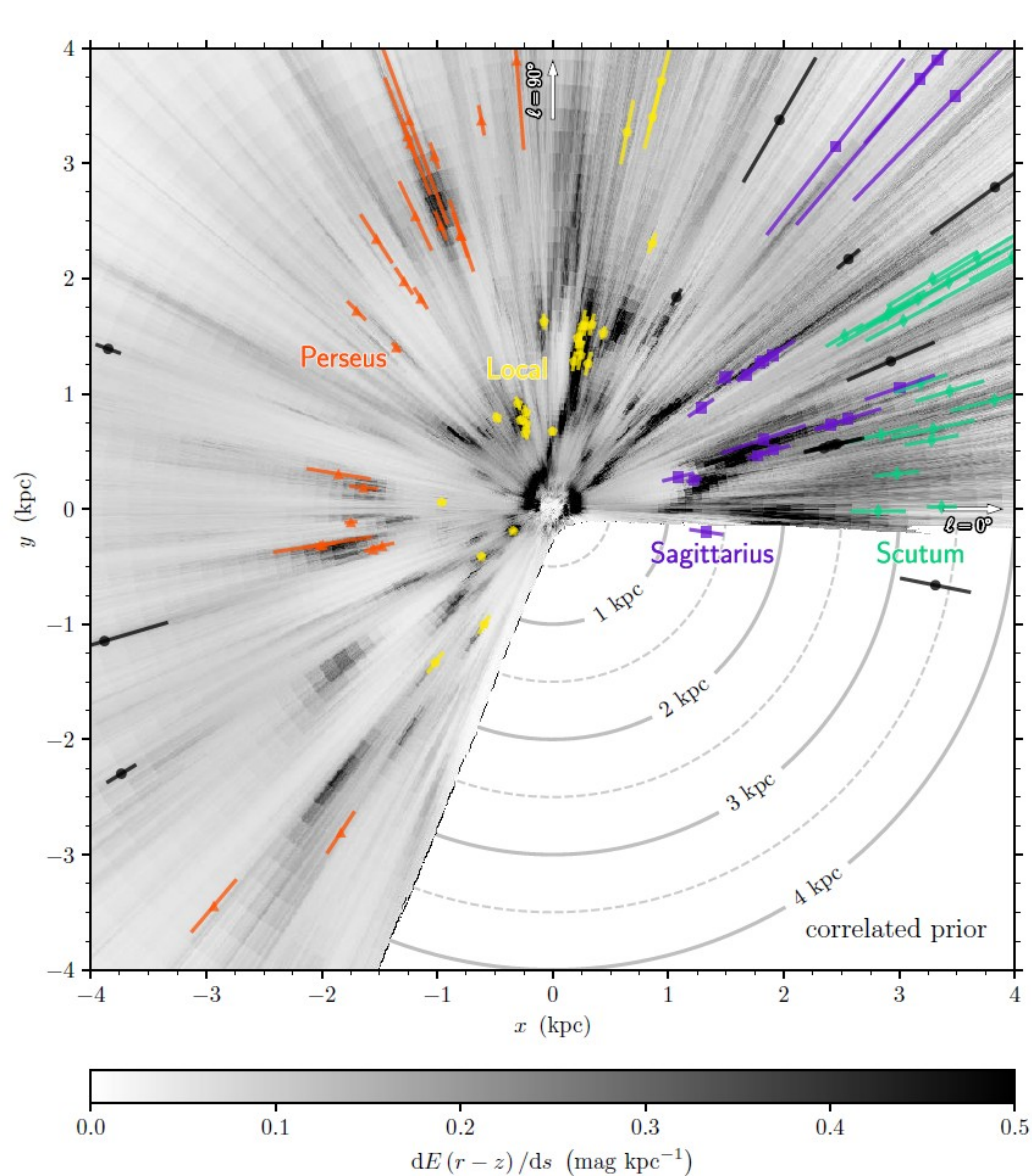


Kinematic imprint
of the Galactic bar
in proper motion spa
Anders+2019



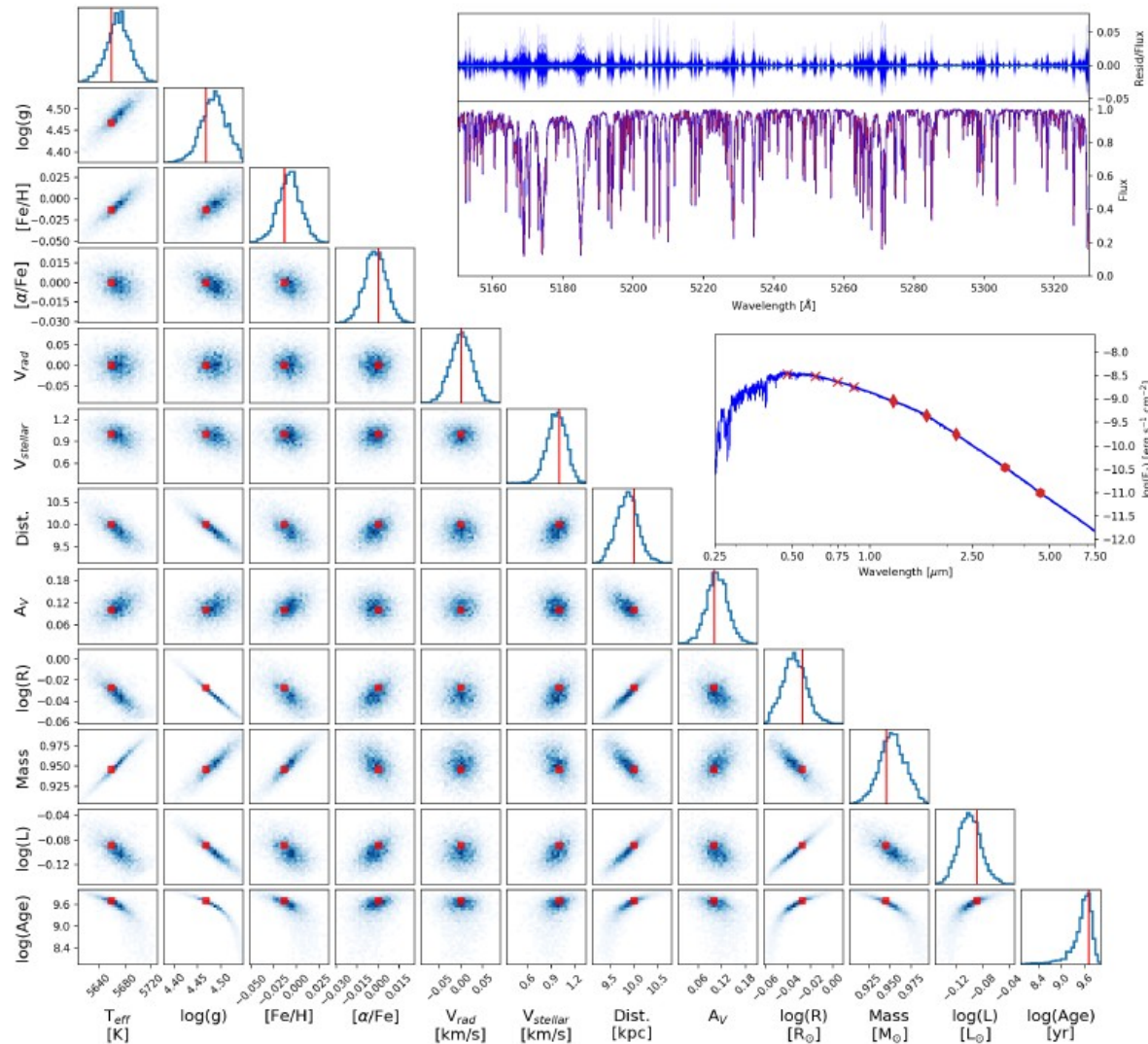
4MOST survey planning:
Chiappini+2019

The future: Beyond „trad.“ Bayesian isochrone fitting



- Green+2019: used Gaussian processes to measure the 3D extinction structure + distances + stellar parameters simultaneously

The future: Beyond „trad.“ Bayesian isochrone fitting



- Cargile+2019: use neural networks to fit spectra, photometry, and astrometry to determine stellar parameters + distances + extinction simultaneously

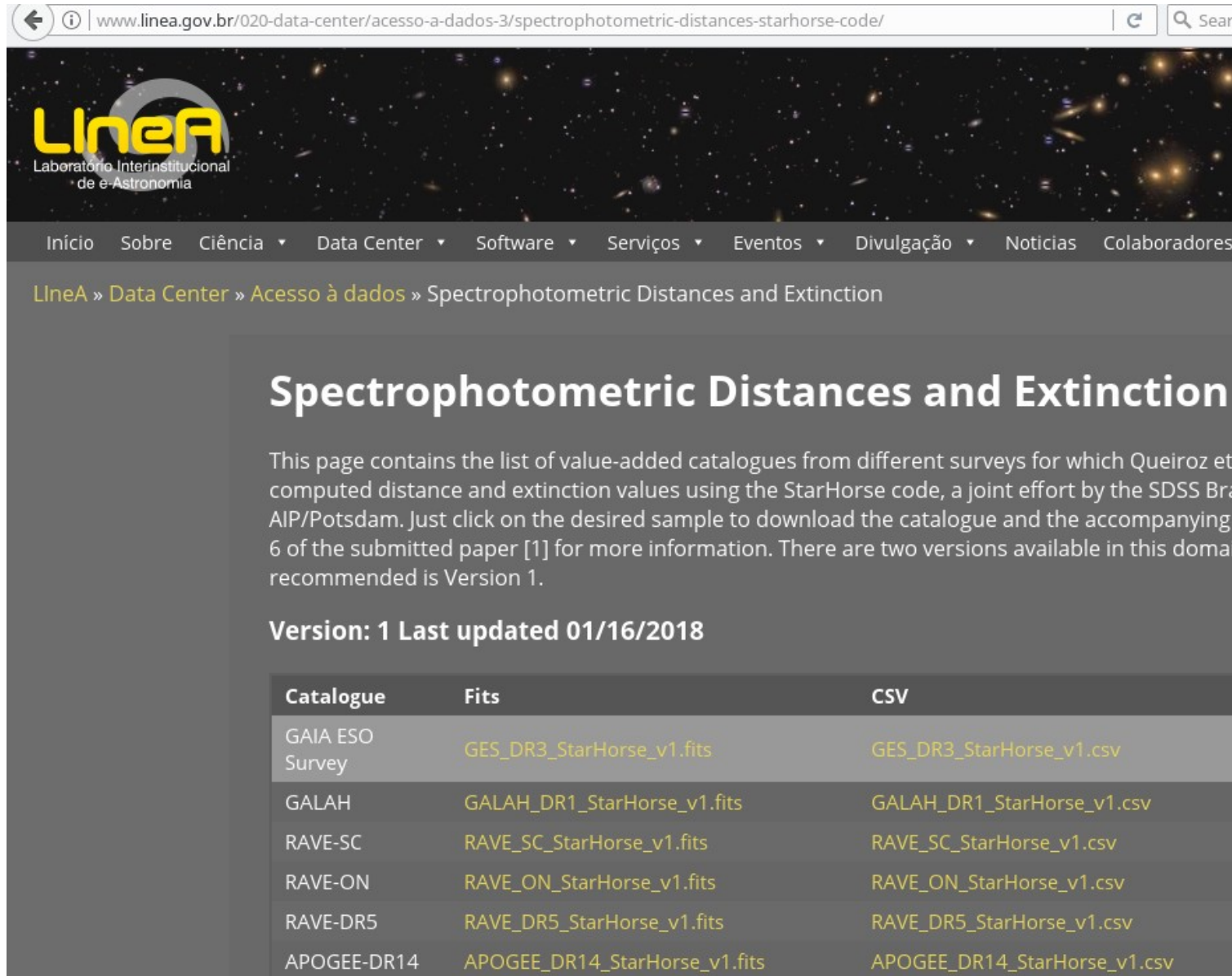
Summary: available StarHorse results

- **Gaia DR1 + {APOGEE DR14, RAVE DR5, GALAH DR1, GES DR3}**: high-quality masses, distances and extinctions for ~1M stars. Results available via **linea.gov.br**
- **Gaia DR2 + photometry**: stellar parameters, distances & extinctions for $G < 18$: Results available via **gaia.aip.de**
- **Gaia DR2 + {APOGEE DR16, RAVE DR5, GALAH DR2, GES DR3, LAMOST DR5}**:
Very soon! Stellar parameters, distances, extinctions for 3M stars

Some caveats

- Accuracy of our approach is limited by systematics in stellar models. Most important: binarity effects.
- Photometric zeropoints and transmission curves matter..
- Spatial variations in the extinction law are not taken into account...
- Different stellar parameter scales for different spectroscopic surveys...
- Extragalactic stellar populations (MCs, Sagittarius, etc) are not included in the prior...

Coming up next: Gaia DR2 + spectroscopic surveys results



LineA
Laboratório Interinstitucional
de e-Astronomia

Início Sobre Ciência ▾ Data Center ▾ Software ▾ Serviços ▾ Eventos ▾ Divulgação ▾ Notícias Colaboradores

LineA » Data Center » Acesso à dados » Spectrophotometric Distances and Extinction

Spectrophotometric Distances and Extinction

This page contains the list of value-added catalogues from different surveys for which Queiroz et al. computed distance and extinction values using the StarHorse code, a joint effort by the SDSS Brazil/PTSDS. Just click on the desired sample to download the catalogue and the accompanying paper [1] for more information. There are two versions available in this domain, the recommended is Version 1.

Version: 1 Last updated 01/16/2018

Catalogue	Fits	CSV
GAIA ESO Survey	GES_DR3_StarHorse_v1.fits	GES_DR3_StarHorse_v1.csv
GALAH	GALAH_DR1_StarHorse_v1.fits	GALAH_DR1_StarHorse_v1.csv
RAVE-SC	RAVE_SC_StarHorse_v1.fits	RAVE_SC_StarHorse_v1.csv
RAVE-ON	RAVE_ON_StarHorse_v1.fits	RAVE_ON_StarHorse_v1.csv
RAVE-DR5	RAVE_DR5_StarHorse_v1.fits	RAVE_DR5_StarHorse_v1.csv
APOGEE-DR14	APOGEE_DR14_StarHorse_v1.fits	APOGEE_DR14_StarHorse_v1.csv

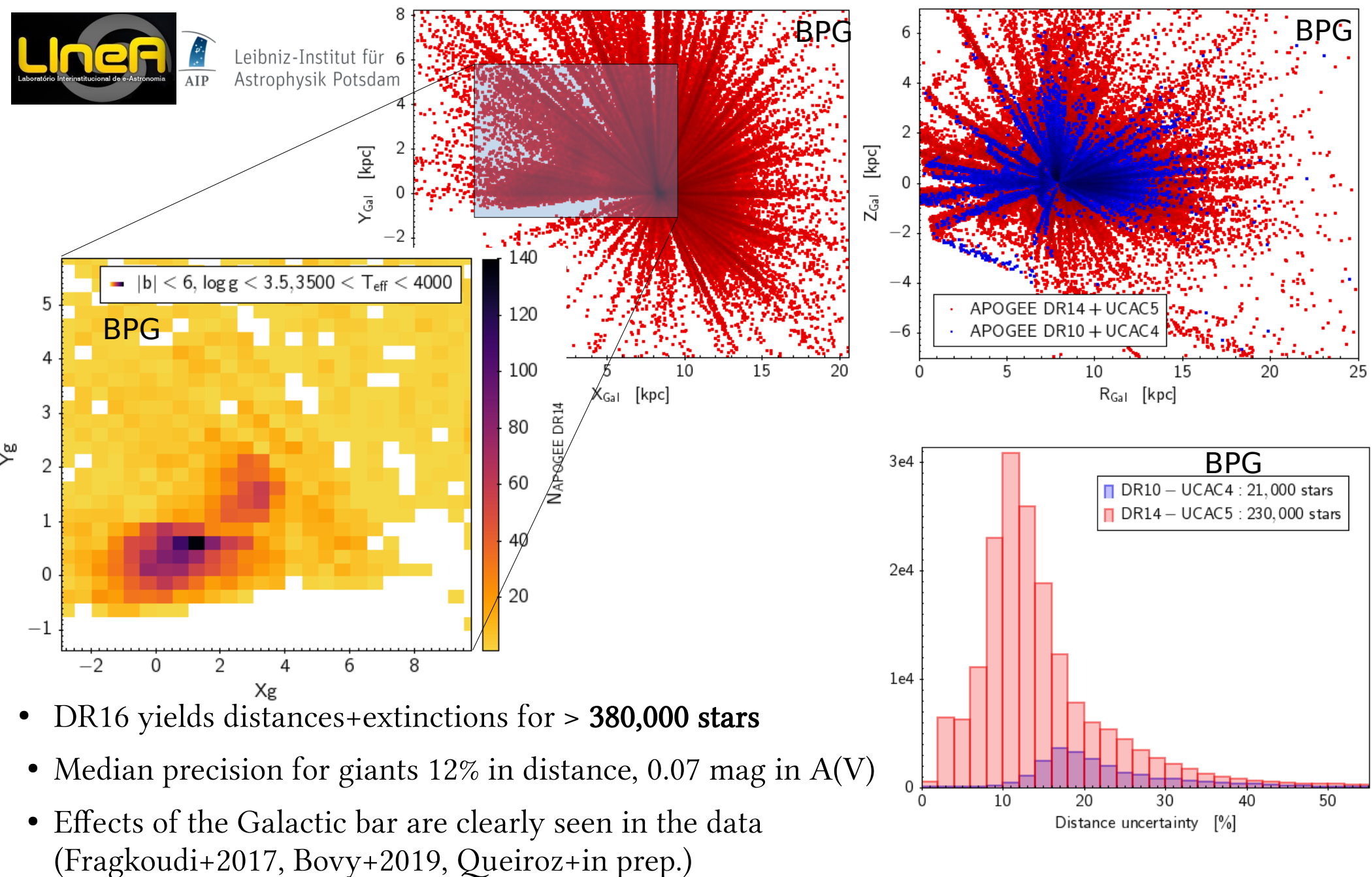
Queiroz+ (in prep.):

Gaia DR2 +
{ APOGEE DR16,
RAVE DR5,
GALAH DR2,
GES DR3,
LAMOST DR5 }

Taking a closer look at the bar with APOGEE



Leibniz-Institut für
Astrophysik Potsdam



- DR16 yields distances+extinctions for **> 380,000 stars**
- Median precision for giants 12% in distance, 0.07 mag in $A(V)$
- Effects of the Galactic bar are clearly seen in the data (Fragkoudi+2017, Bovy+2019, Queiroz+in prep.)