

The Gaia Archive

Present and future

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Astronomy Archives User Group. Virtual. 2020-10-01

1. The Gaia mission

2. Gaia: parallaxes → distances

Stellar parallax: Measuring the distance of stars

Earth's position in June



Earth's position in December



June view



December view



Source: University of Virginia

<https://socratic.org/questions/how-stellar-parallax-is-measured>

2. Parallax + proper motion



Scientific Mission Goals

Astrometry ($G < 20$ mag)

completeness to 20 mag (on-board detection) $\Rightarrow 10^9$ stars

accuracy: **26 μarcsec at $G=15$ mag** (Hipparcos: 1 milliarcsec at 9 mag)

scanning satellite, two viewing directions

\Rightarrow global accuracy, with optimal use of observing time

principle: global astrometric reduction (as for Hipparcos)

Photometry ($G < 20$ mag)

astrophysical diagnostics (low-dispersion photometry) + chromaticity

$\Rightarrow \Delta T_{\text{eff}} \sim 100$ K, $\log g$, $[\text{Fe}/\text{H}]$ to 0.2 dex, extinction (at $G=15$ mag)

Radial velocity ($G_{\text{RVS}} < 16$ mag)

accuracy: **15 km s⁻¹ at $G_{\text{RVS}}=16$ mag**

application:

third component of space motion, perspective acceleration

dynamics, population studies, binaries

spectra for $G_{\text{RVS}} < 12$ mag: chemistry, rotation

principle: slitless spectroscopy in Ca triplet (845-872 nm) at $R = \sim 10,800$

Gaia mission status

Gaia spacecraft is fine and operating nominally

Nominal 5 yr mission finished. Could be extended up to 2023+ (9+ yr)

Large scientific production: ~4000 ADS publications (S. Jordan library)

CURRENT DATE AND TIME	2020-09-30T05:24:36 (TCB)
MISSION STATUS	
Satellite distance from Earth (in km)	1,542,475
Number of days having passed since 25 July 2014	2259
Number of days in mission extension	441
OPERATIONS DATA (collected since 2014/07/25)	
Volume of science data collected (in GB)	84,376
Number of object transits through the focal plane	160,302,302,176
Number of astrometric CCD measurements	1,580,122,692,873
Number of photometric CCD measurements	318,822,631,538
Number of spectroscopic CCD measurements	31,098,683,964
Number of object transits through the RVS instrument	10,423,839,792



ADS Public Library

Gaia DR2

Number of Papers:

4191

Date Created:

Apr 23 2019, 11:57am

Date Last Modified:

Sep 30 2020, 7:52am

Gaia DR2 in numbers



position & brightness on the sky

1 692 919 135

●
14 099
Solar System
objects

●
550 737
variable sources

●
7 224 631
radial velocity

surface temperature
161 497 595

parallax and proper motion

1 331 909 727

red colour

1 383 551 713

blue colour

1 381 964 755

●
76 956 778
radius & luminosity

●
87 733 672
amount of dust along
the line of sight

New items in Gaia DR3 (2022)



Astrometric non-single star solution types

- acceleration, 7 and 9 parameters
- orbital solutions, 12 parameters
- stochastic solutions
 - single star source model or basic binary star model does not fit
- NOTE: no epoch astrometry or epoch radial velocities will be released as part of Gaia DR3

Mean BP/RP/RVS spectra

- For subset of sources only
- Tool to handle BP/RP spectra will be provided

Solar system objects

- Orbits
- Reflectance spectra

Astrophysical parameters based on BP/RP/RVS spectra

- T_{eff} , A_G , $E(G_{\text{BP}} - G_{\text{RP}})$, $\log g$, metallicity, abundances, distances, radii, masses, activity index
 - solutions from multiple algorithms will be provided
 - rotational velocity for bright subset of stars (TBC)
- Extinction map
- Sourceclassification(star,binary,galaxy,...)

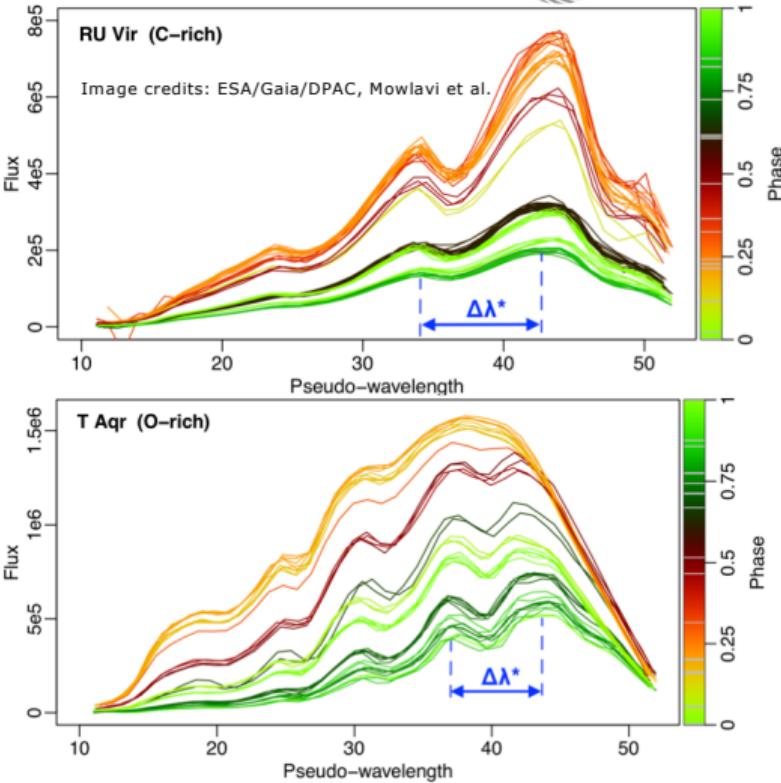
Gaia DR4



- Final release for the nominal mission
 - 60 months input data; schedule TBD
- Foreseen data products
 - Full astrometric, photometric, and radial-velocity catalogues
 - All variable-star and non-single-star solutions
 - Source classifications (probabilities) plus multiple astrophysical parameters (derived from BP/RP, RVS, and astrometry) for stars, unresolved binaries, galaxies, and quasars
 - Catalogue of binaries and exo-planets
 - Image reconstruction results
 - All epoch and transit data for all sources, including all BP/RP/RVS spectra

Overall gain in precision for DR3 and DR4: factors 1.2 and 1.7 with respect to DR2

- proper motions improve by factors 1.9 and 4.5



2. The Gaia Archive

Gaia Archive: Data and components



Catalogues: TAP service. VO+. ADQL queries

Most popular service. Most queried catalogue ever

Ancillary data: DataLink service. VO + own API. Feasible for DR4+?

Less frequently used. Vast legacy value

Bulk download. Files. Everything. Feasible for DR4+?

Comprehensive users and data centres

Visualisation: DPAC product, integrated by ESDC

2.1 The Gaia Archive: catalogues

Main catalogue: gaia_source



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gaia archive

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Simple Form ADQL Form Query Results

No job id ×

Columns

solution_id	source_id	random_index	ref_epoch	ra	ra_error	dec	dec
			Time[Julian Years]	Angle[deg]	Angle[mas]	Angle[deg]	Angle[mas]
1635378410781933568	4211025012066010880	131410931	2015	290.2477074583974	93407	-6.331946167262529	2.53
1635378410781933568	4210922757482661248	856561327	2015	289.9415787981672	8632	-6.530635341768221	2.32
1635378410781933568	4210681380320174592	550360955	2015	294.267178592206	46088	-3.528292017227317	1.73
1635378410781933568	4211002098420565888	960015464	2015	289.5976320267487	16.94528450659924	-6.172833023239273	15.4
1635378410781933568	4210638499362703872	1004419411	2015	294.7500861075622	1.773955896855794	-3.636699368670485	1.56
1635378410781933568	4210847269136626304	557493500	2015	295.4382050078335	5.478051207928527	-2.6135820036757322	3.81
1635378410781933568						3415569492926	1.95
1635378410781933568						0625664414796	0.20
1635378410781933568						5804587432753	8.28
1635378410781933568						05552472134493	3.21
1635378410781933568	4210974851146901888	328770579	2015	289.70073316760386	2.956057395439199	-6.431398708912356	3.49
1635378410781933568	4210815658174807040	606797458	2015	294.9216310943188	15.266550937744302	-3.003298897829963	11.3
1635378410781933568	4210579125738498304	809666698	2015	296.07094455894094		329158240998	11.6
1635378410781933568	4210980653642584704	62717479	2015	289.9065131739514		728845502425	3.78
1635378410781933568	4210998864301014784	65705465	2015	289.67240825545065		376208601118	0.27

Data: one entry (row) per object

Units Data model

Gaia Data Model Show query in ADQL form

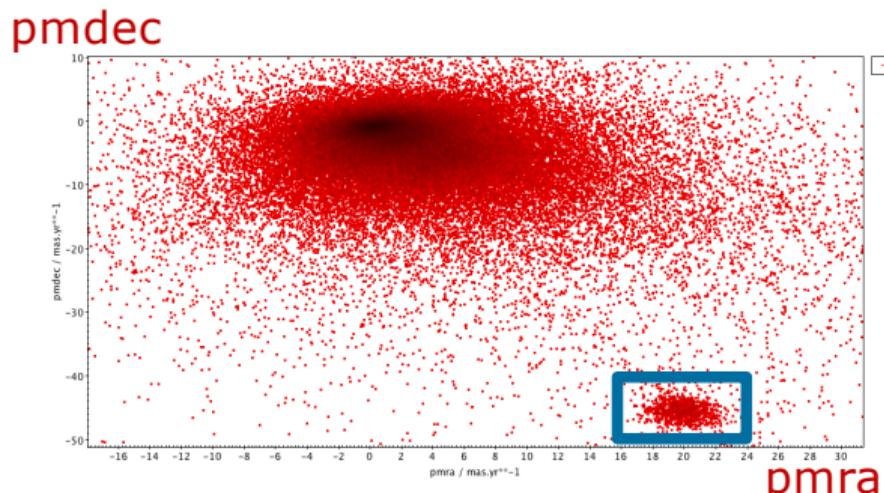
1-20 of 20

ADQL: query language

- SQL dialect. Essential in large surveys (SDSS, LSST, Euclid, ...)
- Gentle learning curve (0.5 day for starters)
- Basic tutorial: Help → Tutorials → White dwarfs exploration
- Many resources (Topcat, GAVO reference sheet, DPAC cookbook)

Pleiades 2° cone search

```
SELECT pmra, pmdec
FROM gaiadr2.gaia_source
WHERE 1 = CONTAINS(
    POINT('', 56.75, 24.1167),
    CIRCLE('' , ra, dec, 2))
```



Catalogues I/F : web GUI



gea.esac.esa.int

Gala Archive

Juan Gonzalez ([jgonza01])

gaia archive

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Simple Form ADQL Form Query Results

Job name:

Query examples

```

1 SELECT DISTANCE(POINT('ICRS',ra,dec), POINT('ICRS',266.41683,-29.00781)) AS dist, *
2 FROM galadr1.gaia_source
3 WHERE 1<=CONTAINS(POINT('ICRS',ra,dec),CIRCLE('ICRS',266.41683,-29.00781, 0.08333333)) ORDER BY dist ASC

```

[Reset Form](#) [Submit Query](#)

Job	Creation date	Num. rows	Size	Actions
14783021932170	05-Nov-2016, 00:29:53	1316	258 KB	
xmatch_hipparcos_hubble_sc	28-Oct-2016, 12:26:29		0 KB	
xmatch_hipparcos_hubble_sc	28-Oct-2016, 12:26:01		0 KB	
14774939207270	26-Oct-2016, 16:58:40	81445	14 MB	
14774939002120	26-Oct-2016, 16:58:20	500	93 KB	
14774938904970	26-Oct-2016, 16:58:10	500	92 KB	
14774930634300	26-Oct-2016, 16:44:23	647	186 KB	
14774930493480	26-Oct-2016, 16:44:09		0 KB	
14774920422820	26-Oct-2016, 16:27:22	488	142 KB	
1-20 of 106				Apply jobs filter
				Select all jobs <input type="checkbox"/> Delete selected jobs

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<http://archives.esac.esa.int/gaia>

Catalogues I/F: Python Astroquery



- Very popular. Only interface for many users
- Free format manipulation. To be upgraded (authenticated access, DataLink, ...)
- Jupyter tutorial: Help → Tutorials → Cluster analysis (Python)

```
In [1]: import astropy.units as u
from astropy.coordinates.sky_coordinate import SkyCoord
from astropy.units import Quantity
from astroquery.gaia import Gaia
```

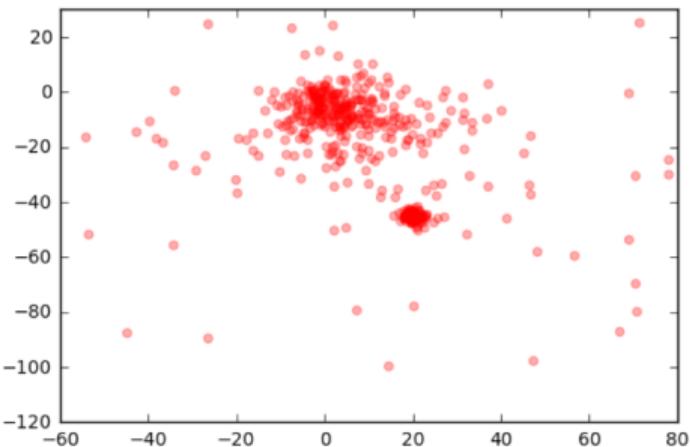
Module

```
Created TAP+ (v1.0) - Connection:
  Host: gea.esac.esa.int
  Use HTTPS: False
  Port: 80
  SSL Port: 443
```

```
In [4]: job = Gaia.launch_job_async("SELECT * \
FROM gaiadr1.gaia_source \
WHERE CONTAINS(POINT('ICRS',gaiadr1.gaia_source.ra,gaiadr1.gaia_source.dec \
),CIRCLE('ICRS',56.75,24.1167,2))=1;" \
, dump_to_file=True)

print (job)
```

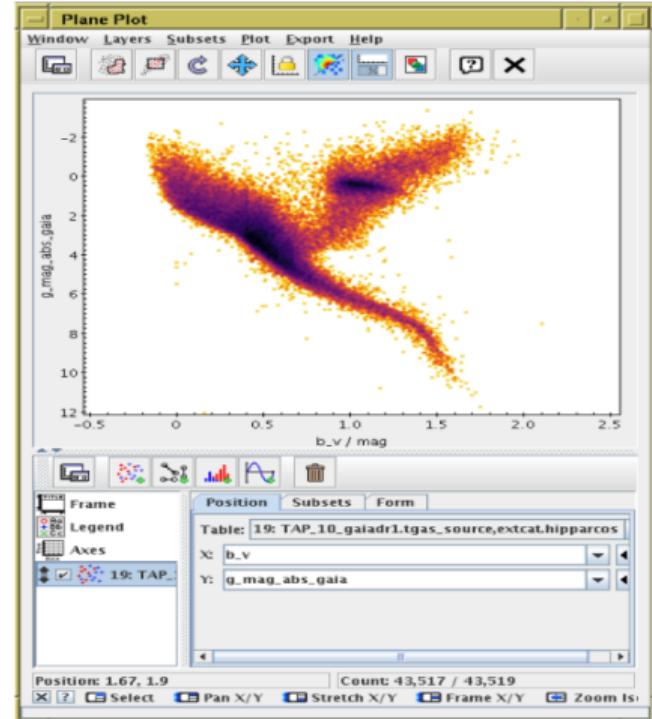
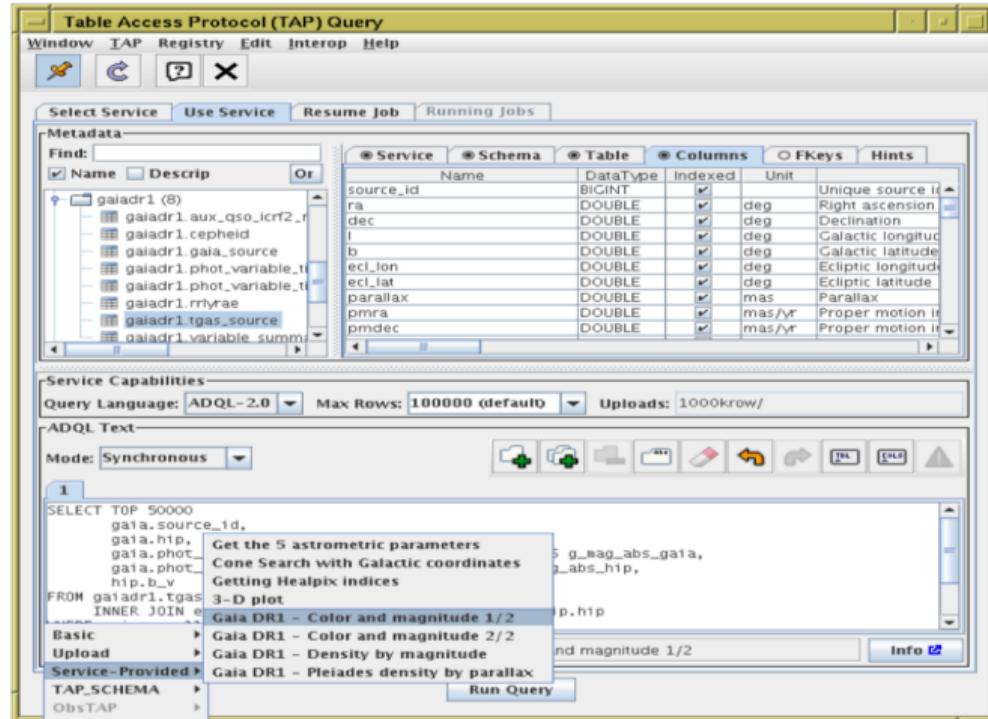
ADQL query



Catalogues I/F : 3rd party VO



Topcat (M. Taylor): Data query (**TAP**), reception (**SAMP**) & plotting



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2.2 The Gaia Archive: ancillary

NB. All data shown are fake. Used in preparation for DR3

Source list → Ancillary data



source_id	designation	has_epoch_photometry	has_rvs_spectra	has_xp_basis	has_xp_spectra	has_mcmc
5821127338457218432	Gaia DR2 5821127338457218432	true	false	false	false	false
4759132353075234816	Gaia DR2 4759132353075234816	true	false	false	false	false
4111843295154181504	Gaia DR2 4111843295154181504	true	false	false	false	false
4292123482200267264	Gaia DR2 4292123482200267264	true	false	false	false	false
4657091970360446464	Gaia DR2 4657091970360446464	true	false	false	false	false
5346754484133997696	Gaia DR2 5346754484133997696	true	false	false	false	true
5867336066976444288	Gaia DR2 5867336066976444288	true	false	false	false	true
2206826700034196480	Gaia DR2 2206826700034196480	true	false	false	false	true
6029163524055915648	Gaia DR2 6029163524055915648	true	false	false	false	true
5971198198755738368	Gaia DR2 5971198198755738368	true	false	true	true	true
2069942415815800832	Gaia DR2 2069942415815800832	true	false	true	true	true
4156032392547427584	Gaia DR2 4156032392547427584	true	false	false	false	true
4663538578794027392	Gaia DR2 4663538578794027392	true	false	true	true	true
5867559199129411456	Gaia DR2 5867559199129411456	true	false	true	true	true
4327652478161878528	Gaia DR2 4327652478161878528	true	false	true	true	true
5237624935739071872	Gaia DR2 5237624935739071872	true	false	true	true	true
2961913286749454848	Gaia DR2 2961913286749454848	true	false	true	true	true

Ancillary data: structure x format



Gaia Job DataLink

Job ID: 1579776229096D

IDs Column: Show Data

Data release: Gaia DR2 | Data structure: INDIVIDUAL COMBINED RAW

Light curve data (20)	
RVS spectra (20)	
Xp mean spectra: basis functions (20)	
XP sampled mean spectra (20)	
Mcmc (20)	

Download format:

Close

Gaia Job DataLink

Job ID: 1579776229096D

IDs Column: Show Data

Data release: Gaia DR2 | Data structure: INDIVIDUAL

Light curve data (20)	
RVS spectra (20)	
Xp mean spectra: basis functions (20)	
XP sampled mean spectra (20)	
Mcmc (20)	

Download format: VOTable VOTable (plain) CSV FITS

Ancillary data: availability flags



source_id	designation	has_epoch_photometry	has_rvs_spectra	has_xp_basis	has_xp_spectra	has_mcmc
5821127338457218432	Gaia DR2 5821127338457218432	true	false	false	false	false
4759132353075234816	Gaia DR2 4759132353075234816	true	false	false	false	false
4111843295154181504	Gaia DR2 4111843295154181504	true	false	false	false	false
4292123482200267264	Gaia DR2 4292123482200267264	true	false	false	false	false
4657091970360446464	Gaia DR2 4657091970360446464	true	false	false	false	false
5346754484133997696	Gaia DR2 5346754484133997696	true	false	false	false	true
5867336066976444288	Gaia DR2 5867336066976444288	true	false	false	false	true
2206826700034196480	Gaia DR2 2206826700034196480	true	false	false	false	true
6029163524055915648	Gaia DR2 6029163524055915648	true	false	false	false	true
5971198198755738368	Gaia DR2 5971198198755738368	true	false	true	true	true
2069942415815800832	Gaia DR2 2069942415815800832	true	false	true	true	true
4156032392547427584	Gaia DR2 4156032392547427584	true	false	false	false	true
4663538578794027392	Gaia DR2 4663538578794027392	true	false	true	true	true
5867559199129411456	Gaia DR2 5867559199129411456	true	false	true	true	true
4327652478161878528	Gaia DR2 4327652478161878528	true	false	true	true	true
5237624935739071872	Gaia DR2 5237624935739071872	true	false	true	true	true
2961913286749454848	Gaia DR2 2961913286749454848	true	false	true	true	true

Source list: from ADQL query



Sources of interest can be obtained from a query

Example: Bright LMC cepheids (3 deg radius, G < 15)

```
select source_id from gaiadr2.vari_cepheid
join gaiadr2.gaia_source using(source_id)
where 1 = contains(
    point('', 80.89, -69.76),
    circle('', ra, dec, 3.)
)
and phot_g_mean_mag < 15
```

Status	Job	Creation date	Num. rows	Size	
✓	<input type="checkbox"/> <input checked="" type="checkbox"/> 15548429797470	09-Apr-2019, 22:49:39	241	2 KB	



Gaia Job DataLink

Job ID: 1579776229096D

IDs Column: source_id

Data release: Gaia DR2 Data structure: ✓ INDIVIDUAL COMBINED RAW

Light curve data (20)

RVS spectra (20)

Xp mean spectra: basis functions (20)

XP sampled mean spectra (20)

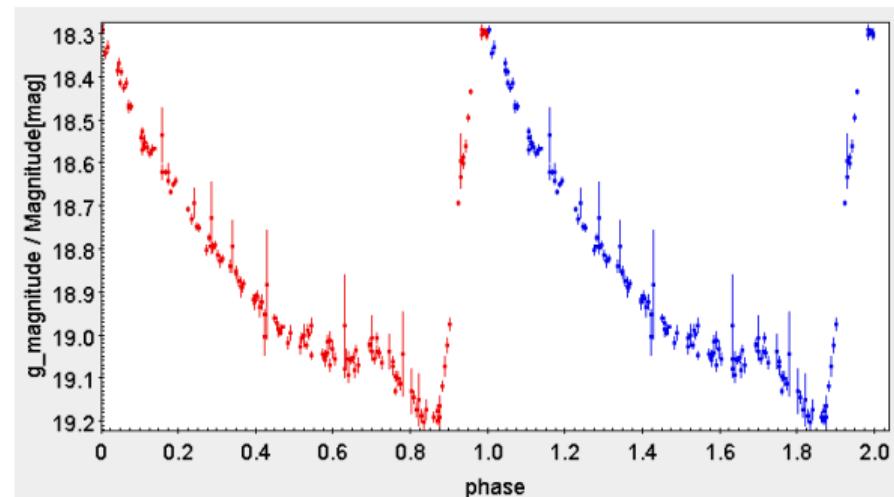
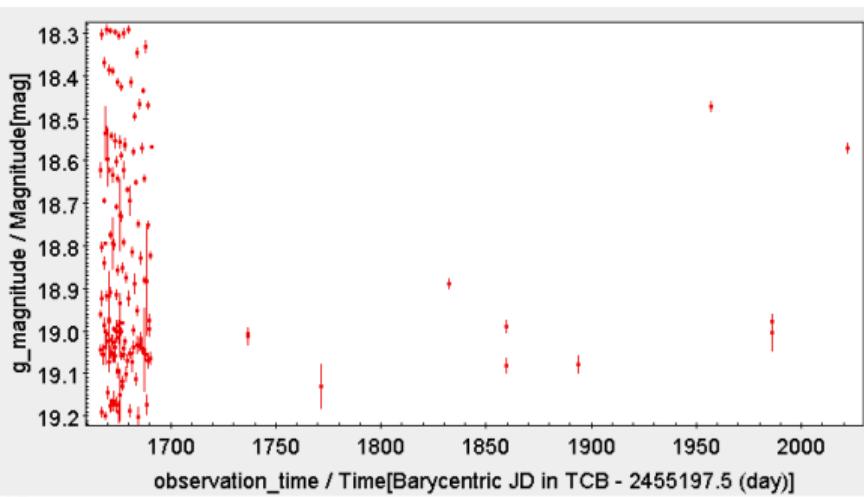
Mcmc (20)

Download format: VOTable

Light curves: G, BP, RP

Unfolded calibrated light curves: flux vs time

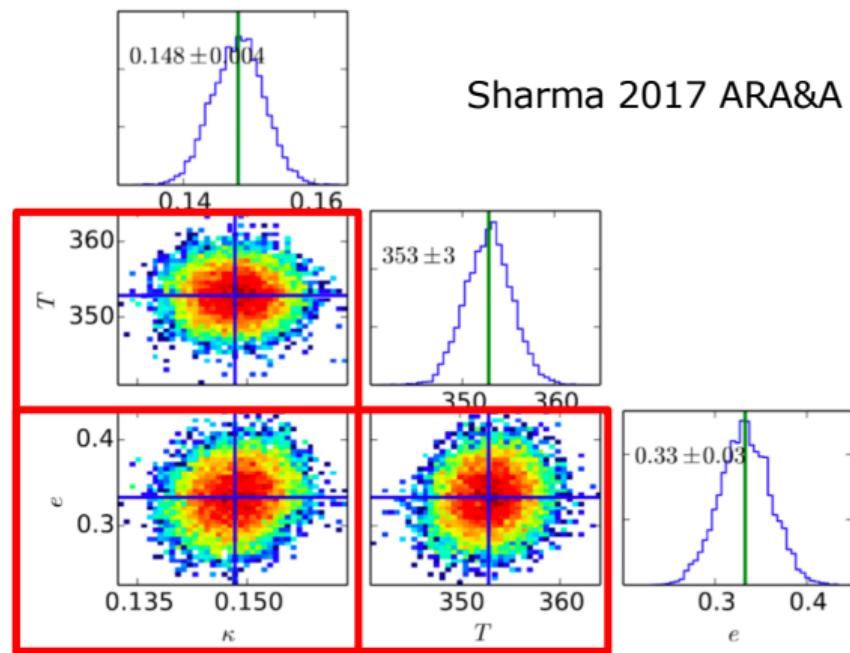
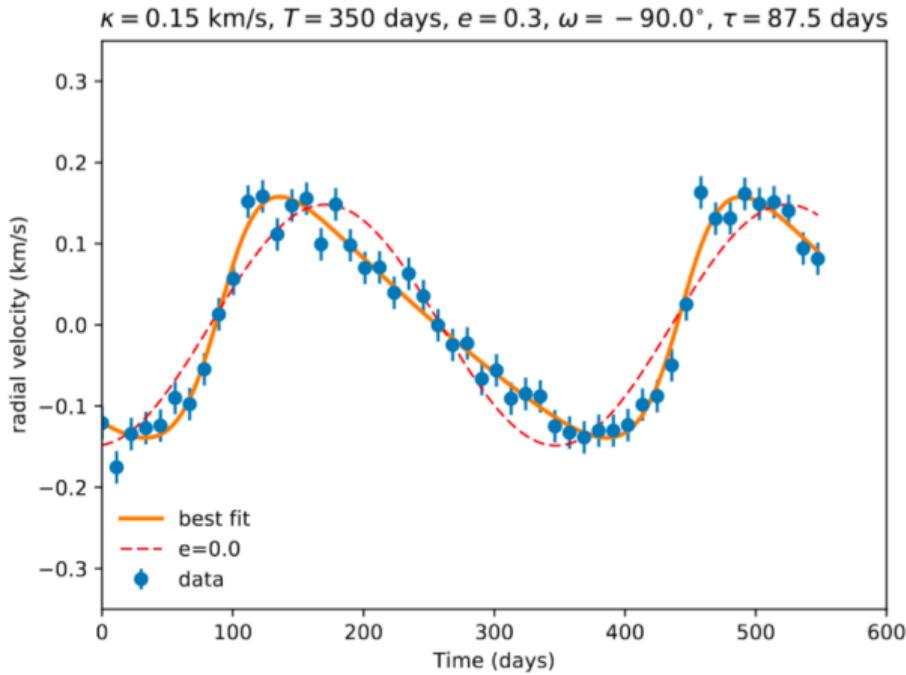
Plain data model: sparse cube



MCMC samples (non-Gaia example)

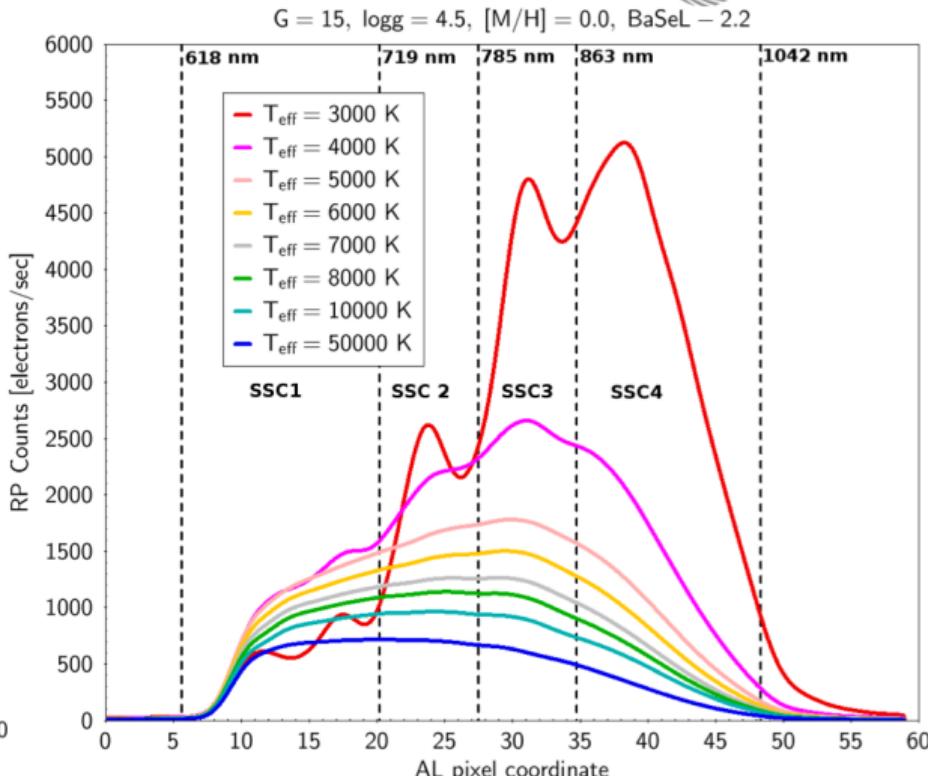
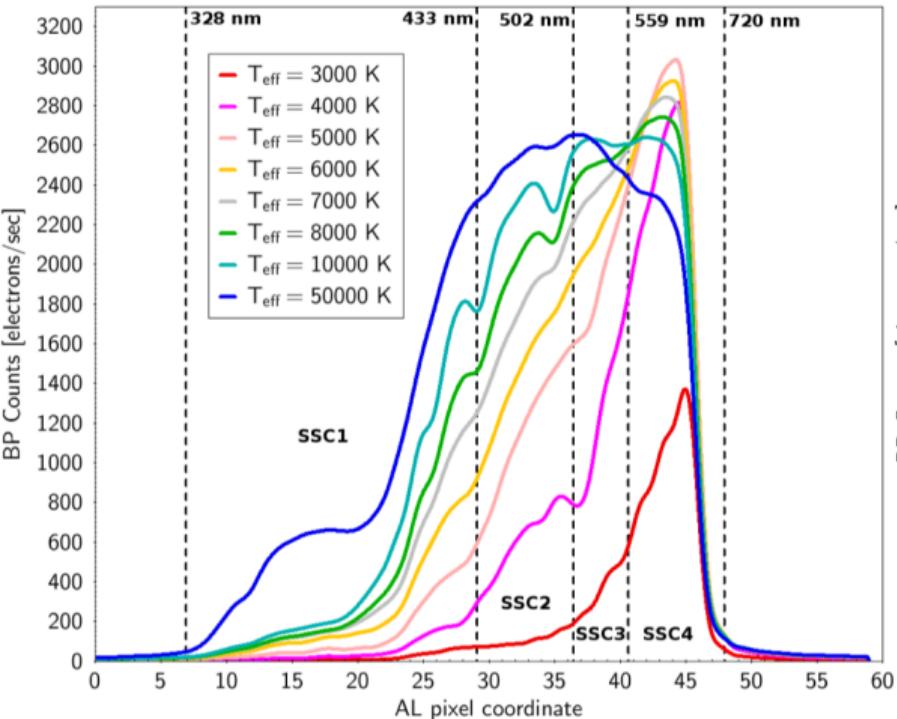


- DR3+ Astrophysical parameters are distributions, not single values



XP spectra: PCA + samples

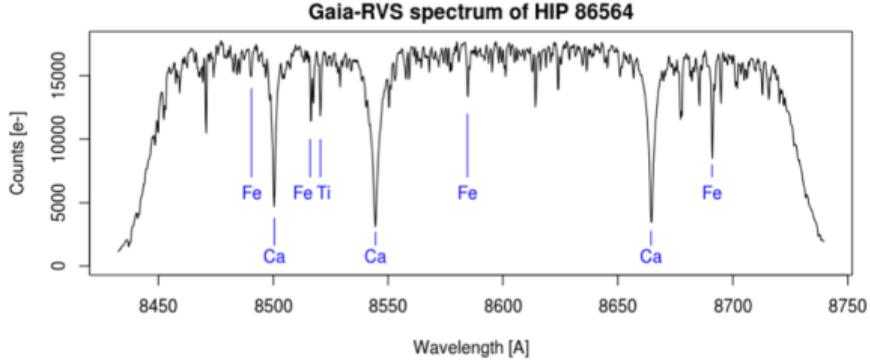
$G = 15$, $\log g = 4.5$, $[M/H] = 0.0$, BaSeL – 2.2



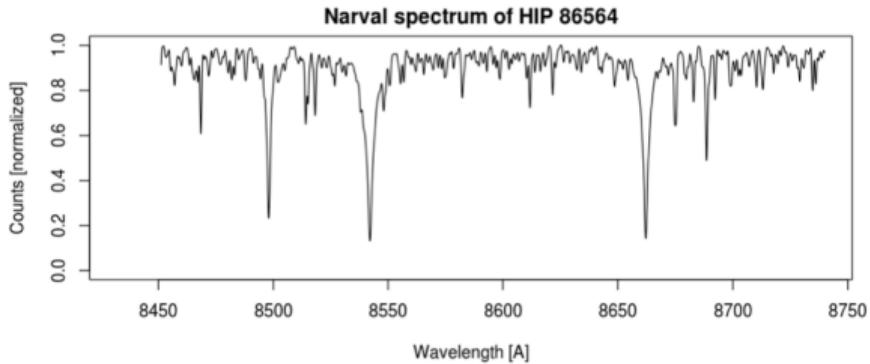
https://gea.esac.esa.int/archive/documentation/GDR2/Data_processing/chap_cu5pho/sec_cu5pho_intro/ssec_cu5pho_intro_ssc.html
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RVS spectra: average



- Several million spectra
- Largest spectroscopic survey!**
- Classical grating spectra
- Heritage: formats, VO protocols



https://www.cosmos.esa.int/web/gaia/iow_20140605

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Light curve: plain (sparse cube)



Table Browser for 15: EPOCH_PHOTOMETRY-Gaia DR2 4039969040325998208.xml

	source_id	transit_id	band	time	mag	flux	flux_error	flux_over_error
1	4039969040325998208	16942682502656567	G	1703.24622	19.56622	281.09779	8.5297	32.9552
2	4039969040325998208	16942682502656567	G	1703.42237	19.27023	369.19522	3.82024	96.642
3	4039969040325998208	16942682502656567	G	1744.05389	19.45956	310.11418	4.62728	67.0187
4	4039969040325998208	16942682502656567	G	1744.12787	19.3125	355.09699	3.70715	95.7869
5	4039969040325998208	16942682502656567	G	1776.78275	19.60699	270.73952	4.41185	61.3665
6	4039969040325998208	16942682502656567	G	1776.85676	19.22457	385.04975	4.85299	79.3429
7	4039969040325998208	16942682502656567	G	1839.22556	19.47777	304.95714	3.40999	89.4304
8	4039969040325998208	16942682502656567	G	1839.29957	19.37342	335.72054	4.66681	71.9379
9	4039969040325998208	16942682502656567	G	1854.30201	19.22221	385.88763	41.71043	9.25159
10	4039969040325998208	16942682502656567	G	1894.74734	19.44472	314.38212	4.64501	67.6816
11	4039969040325998208	16942682502656567	G	1894.9235	19.19455	395.84605	7.65413	51.7166
12	4039969040325998208	16942682502656567	G	1914.92317	19.27096	368.944	6.65298	55.4555
13	4039969040325998208	16942682502656567	G	1914.9972	19.34809	343.64516	4.49391	76.4691
14	4039969040325998208	16942682502656567	G	1951.14468	19.23832	380.20523	5.39028	70.5353
15	4039969040325998208	16942682502656567	G	1951.21869	19.47257	306.42115	6.20435	49.3881
16	4039969040325998208	16942682502656567	G	1984.6326	19.14338	414.94901	5.35153	77.5384
17	4039969040325998208	16942682502656567	G	1984.70663	19.27324	368.17042	6.47041	56.9007
18	4039969040325998208	16942682502656567	G	2013.38205	19.41514	323.06386	3.56521	90.6157
19	4039969040325998208	16942682502656567	G	2013.45605	19.32397	351.36407	54.77476	6.41471
20	4039969040325998208	16942682502656567	G	2058.86714	19.25023	376.05788	5.31045	70.8147
21	4039969040325998208	16942682502656567	G	2058.94116	19.30802	356.56499	5.00966	71.1755
22	4039969040325998208	16942682502656567	G	2086.11747	19.13995	416.26172	6.54325	63.617
23	4039969040325998208	16942682502656567	G	2086.19147	19.31143	355.44563	2.91161	122.079
24	4039969040325998208	16942682502656567	G	2155.1468	19.59968	272.56643	15.58475	17.4893



European Space Agency

XP sampled: VO fields → header



Table Parameters for 17: XP_SPECTRA-Gaia DR2 4036595158937173760.xml

Name	Value	Shape	Units	Description
Name	XP_SPECTRA-Gaia%20DR2%204036595158937173760.xml			Table name
Column Count	3			Number of columns
Row Count	307			Number of rows
source_id	4036595158937173760			Source Id. A unique single numerical identifier
solution_id	4545082002063228933			All Gaia data processed by the Data Processing Pipeline
spatialLocation	(48.40570874569695, 37.286086023688334)	2	deg	
TimeAxisCoverageLocation	2016.0		yr	Reference Epoch
TimeAxisCoverageBoundsExtent	2.83		yr	Total elapsed time
spectralAccuracyStatError	0.0		nm	
spectralLocation	0.0		nm	
spectralCoverageBoundsExtent	725.0		nm	
spectralCoverageBoundsStart	325.0		nm	
spectralCoverageBoundsStop	1050.0		nm	
SpatialExtent	5.8932666E-4		deg	Spectrum aperture: nominal across-scan width
DataModel	Spectrum 1.01			
Publisher	European Space Agency			
Title				
SpectralAxisUcd	em.wl		em.wl	
SpectralAxisUnit	nm		nm	
FluxAxisUcd	phot.fluence;em.wl			
FluxAxisUnit				

Raw: XP continuous PCA



Table Browser for 32: XP_BASIS.xml

	source_id	bp_basi...	bp_deg...	bp_nu...	bp_nu...	bp_nu...	bp_standar...	bp_chi_squ...	bp_coefficients	bp_coefficient_errors
1	4062570944942640768	1	15	45	60	0	0.61337	0.	(-29.70443182426942, 241.0043492232446...	(51.16215, 414.3, 2379
2	4118020454618350976	1	15	45	60	0	4.52628	0.	(-12027.40036399573, 96381.45699199238...	(3612.2236, 28954.51,
3	4119700714519664512	1	716	45	761	0	0.5613	0.	(17.252251380849476, -21.1470349008606...	(0.31077603, 0.330467
4	4062687115218852992	1	915	45	960	0	0.65252	0.	(136.13882931717066, -128.942126720805...	(0.6035556, 0.6365413
5	4039969040325998208	1	615	45	660	0	0.60952	0.	(19.121276731793504, -22.7241397289990...	(0.33985975, 0.364685
6	4036595158937173760	1	134	45	179	0	0.61817	0.	(2.996979527144153, 3.9243940698840496...	(0.8563134, 4.3254094
7	4045760477345525504	1	15	45	60	0	0.5977	0.	(7.8417362196396025, 56.24893651908282...	(8.2644415, 64.16737,
8	6028137409255262080	1	15	45	60	0	0.8449	0.	(21.991518699813955, -61.1683772229535...	(26.06312, 146.92723,
9	4038578192478344320	1	729	45	774	0	0.60081	0.	(6.91101801945335, -4.63180287710391, 5...	(0.28191105, 0.285469
10	4037134263247895936	1	374	45	419	0	0.67412	0.	(1.3410685403053155, -1.58940188122634...	(0.39628506, 0.399517

No header, just columns

Table Parameters for 15: EPOCH_PHOTOMETRY-Gaia DR2 4039969040325998208.xml...

Name	Value	Description
Name	EPOCH_PHOTOMETRY-Gaia%20DR2%204039969040325998208.xml	Table name
Column Count	12	Number of columns
Row Count	88	Number of rows

Table Columns for 15: EPOCH_PHOTOMETRY-Gaia DR2 4039969040325998208.xml...

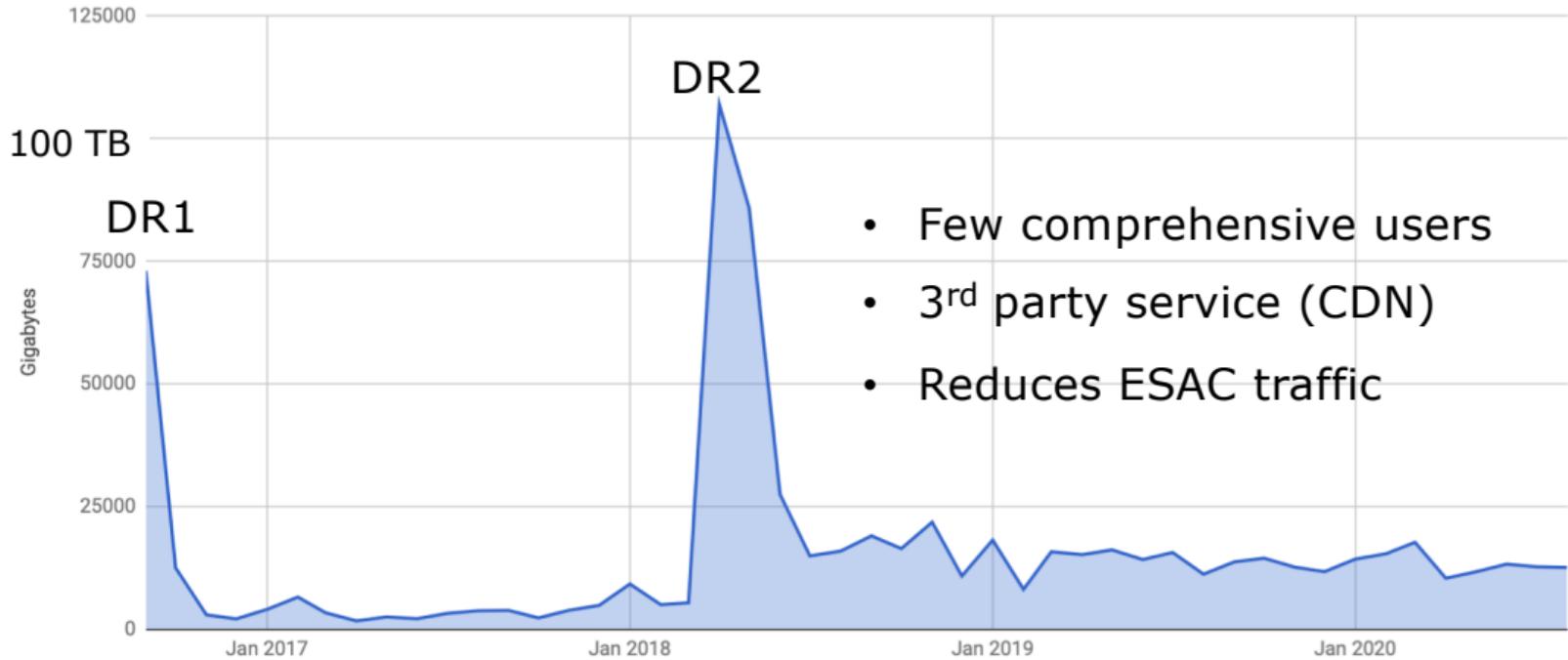
Δ	Index	Visible	Name	\$ID	Class	Units	Description
0		<input type="checkbox"/>	Index	\$0	Long		Table row index
1	1	<input checked="" type="checkbox"/>	source_id	\$1	Long		Source Id. A unique single numerical identifier.
2	2	<input checked="" type="checkbox"/>	transit_id	\$2	Long		Transit unique identifier. For a given object
3	3	<input checked="" type="checkbox"/>	band	\$3	String		Photometric band. Values: G (per-transit)
4	4	<input checked="" type="checkbox"/>	time	\$4	Double	d	Observing time (double, Time[Barycentric])
5	5	<input checked="" type="checkbox"/>	mag	\$5	Double	mag	Vega magnitude. It is computed from the
6	6	<input checked="" type="checkbox"/>	flux	\$6	Double	e-/s	Band flux value for the transit. For G band
7	7	<input checked="" type="checkbox"/>	flux_error	\$7	Double	e-/s	Flux error. The uncertainty flux_error on the
8	8	<input checked="" type="checkbox"/>	flux_over_error	\$8	Float		Band flux divided by its error.
9	9	<input checked="" type="checkbox"/>	rejected_by_photometry	\$9	Boolean		Rejected by DPAC photometry processing
10	10	<input checked="" type="checkbox"/>	rejected_by_variability	\$10	Boolean		Rejected by DPAC variability processing (
11	11	<input checked="" type="checkbox"/>	other_flags	\$11	Long		Additional processing flags. This field corresponds to the other_flags field in the Data Processing
12	12	<input checked="" type="checkbox"/>	solution_id	\$12	Long		All Gaia data processed by the Data Processing

2.3. Gaia Archive: bulk download

Bulk download: file repository



Data downloaded per month (GB)

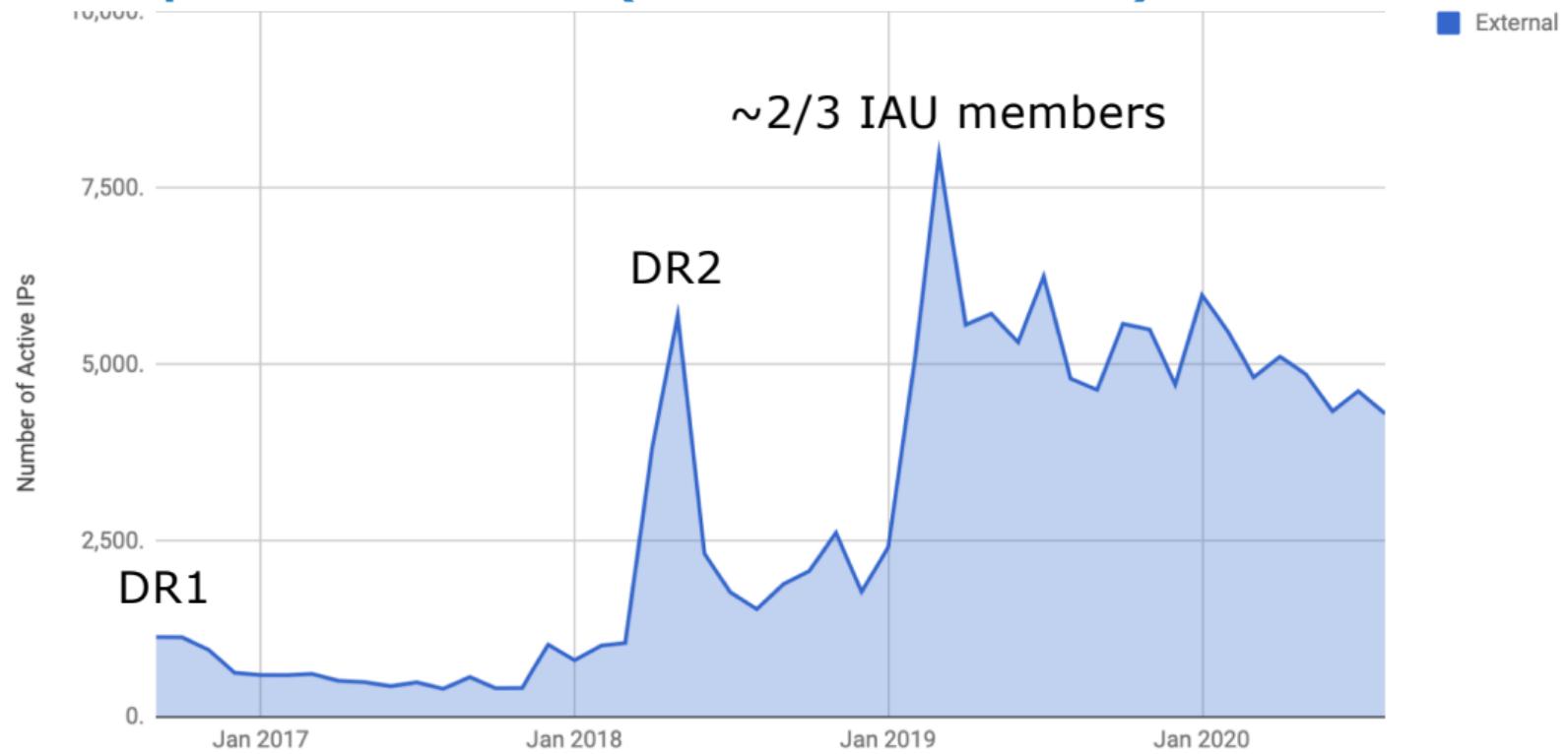


- Few comprehensive users
- 3rd party service (CDN)
- Reduces ESAC traffic

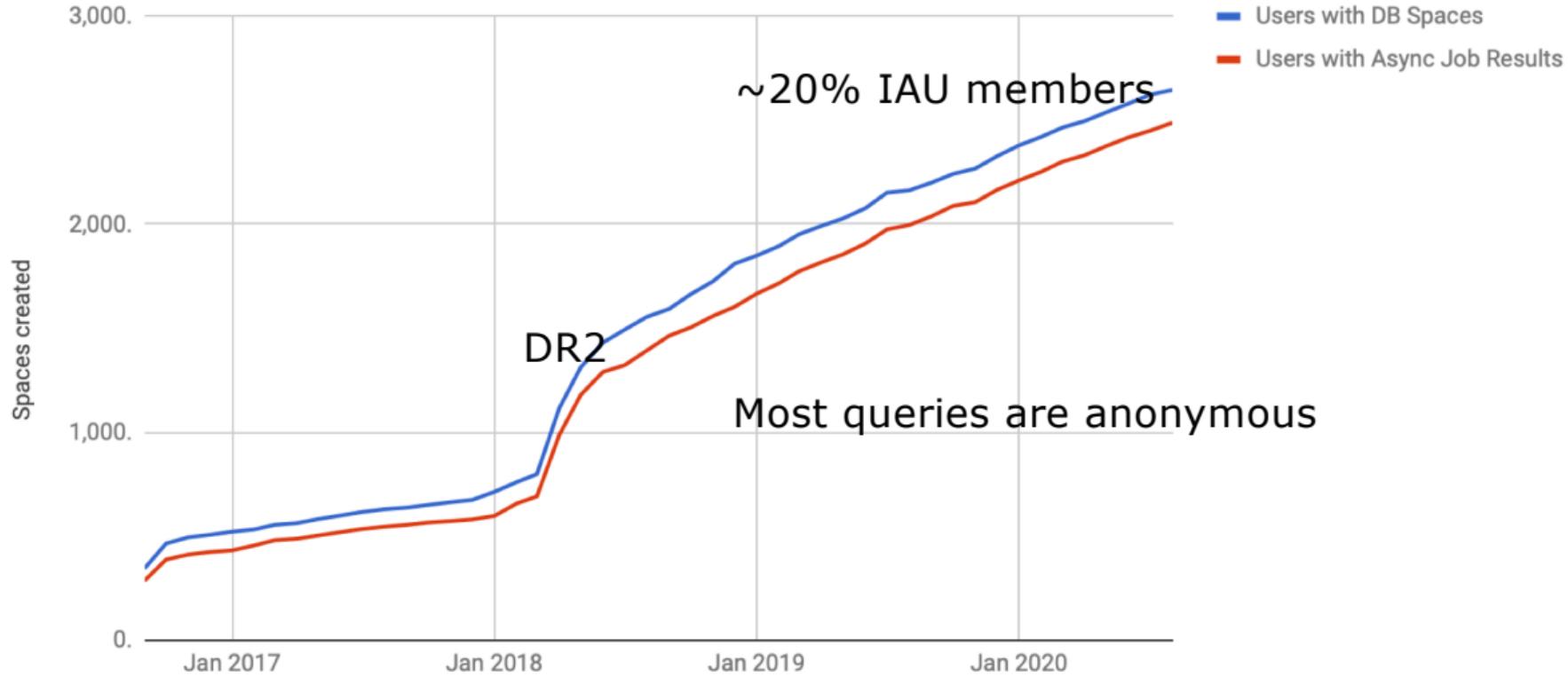
3. Usage statistics

Users per month (different IPs)

ia

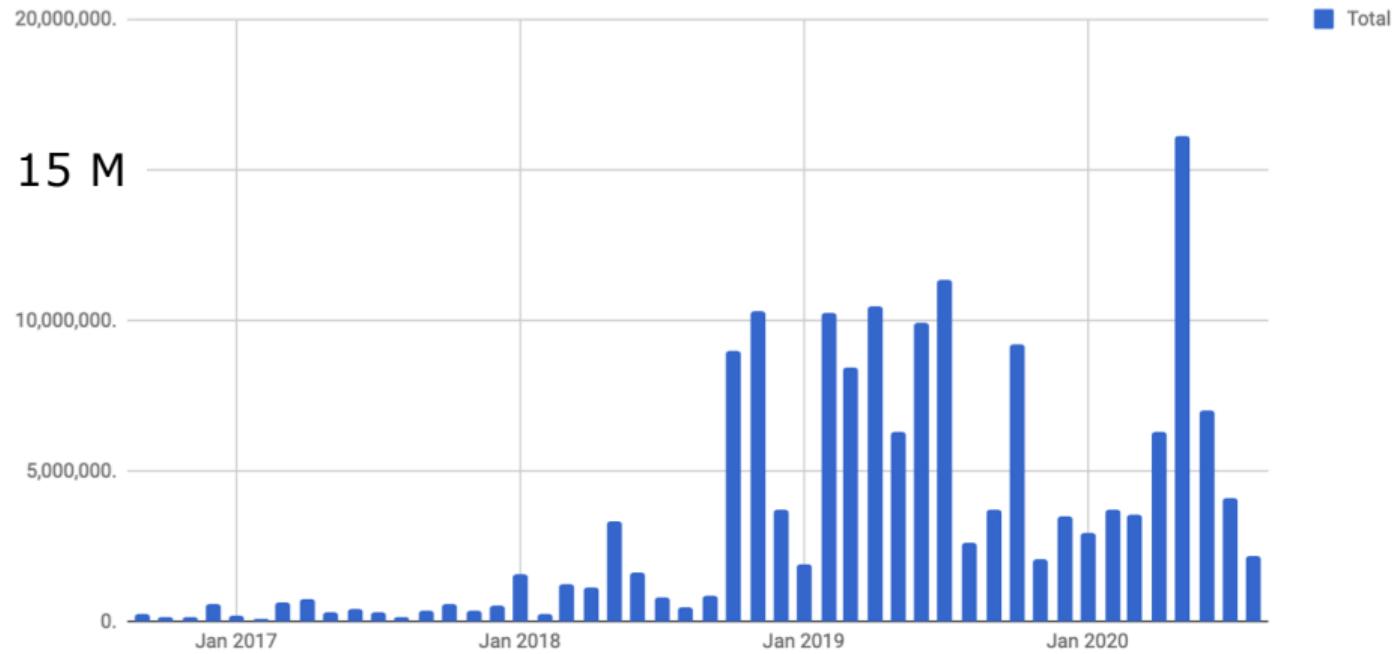


Registered users. Active 1+ times

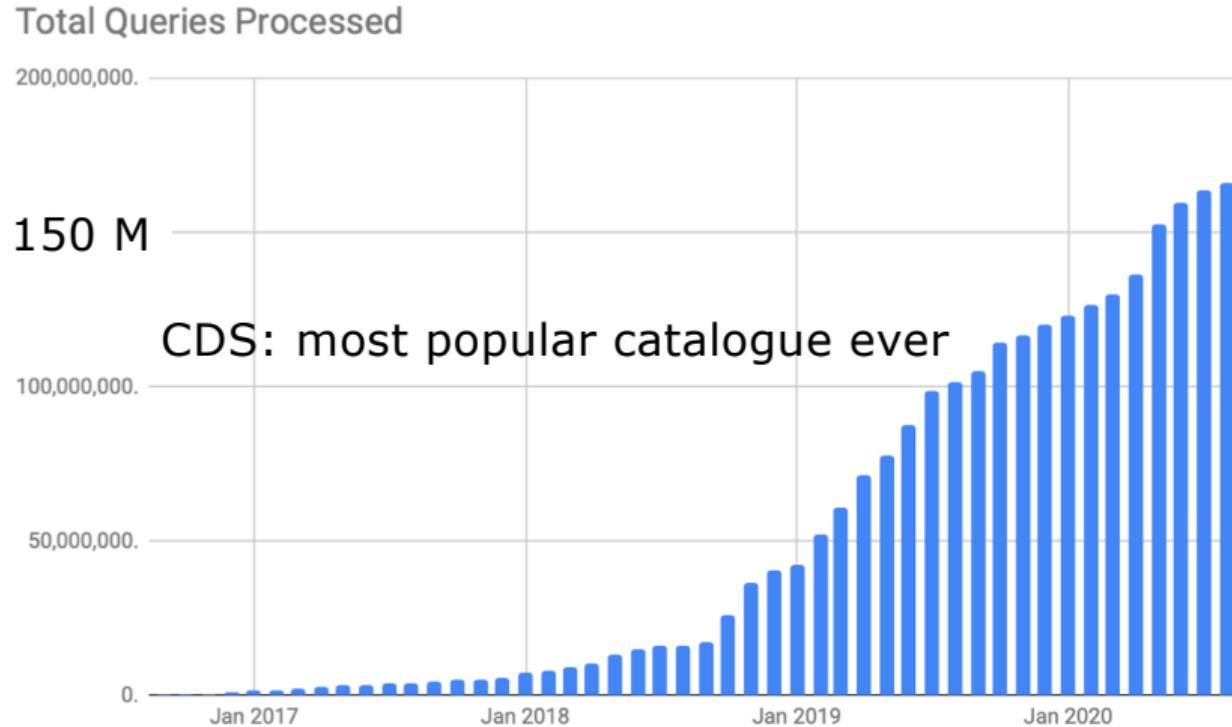


Queries per month

Queries received per month



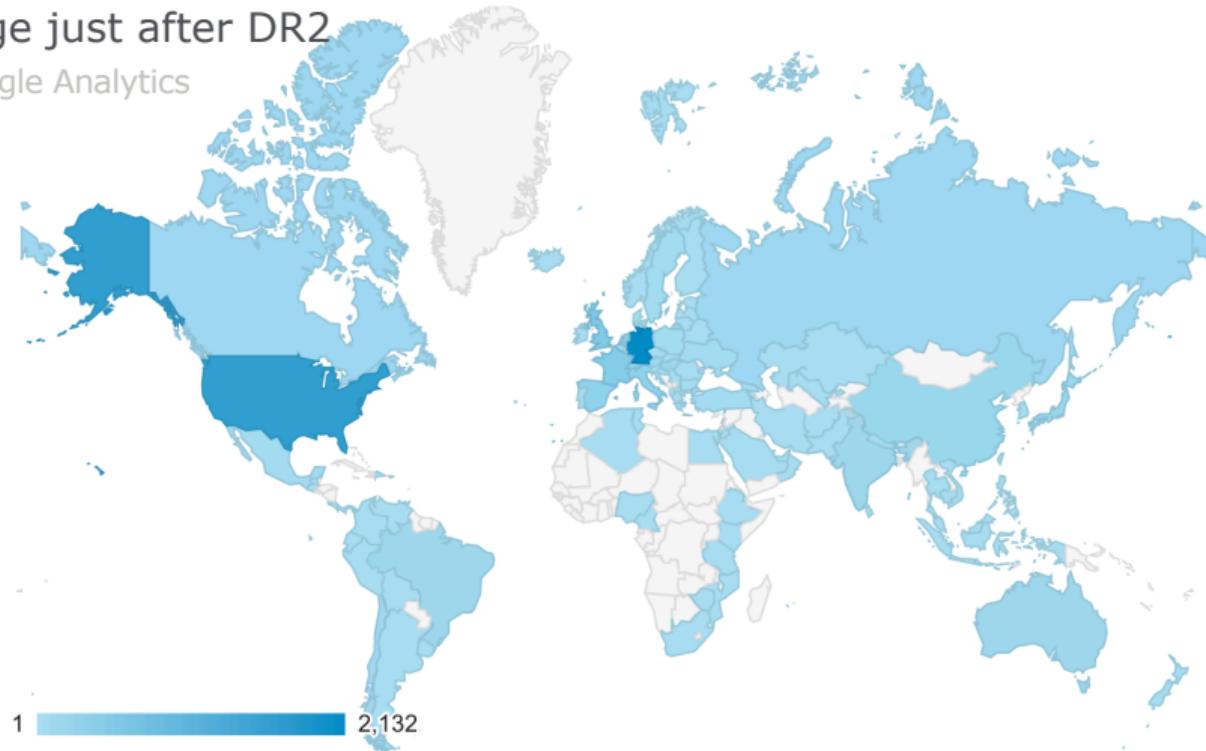
Cumulative queries



Global science

Archive usage just after DR2

Unweighted Google Analytics



4. Feedback from this Group

Priorities? Feedback welcome!

Non-exhaustive list. Some for Gaia, some for ESDC as a whole

1. Integration between archives
2. Single object exploration
3. Look & Feel: technology obsolescence
4. Visualisation: query output
5. Visualisation: general improvement, binary orbits
6. ESASky. Add data. Add HIPS. Binary orbits?
7. Jupyter notebook repository
8. Massive computing: DataLabs, SOC, Cloud
9. Cross-match assistant
10. ADQL: contribution toward 2.1 and beyond

Needed: What? Priorities?
Not needed: Who? How?

Integration between archives

~10-20 different ESA astronomical archives

Single entry point at e.g. ESA planetary, CDS, IRSA, MAST

Lots of duplication, e.g. How many ALLWISE versions?

Replicate **Gaia** within **Euclid** and viceversa?

Cross-mission queries are difficult

Change of focus: **Archives → Services**

TAP (catalogues), DataLink (ancillary), Visualisation, ...

Each mission could use a selection of services

Resources might be optimized

TAP: Gaia vs Euclid vs Herschel



gaia archive

HOME SEARCH STATISTICS VISUALISATION HELP

Basic Advanced (ADQL) Query Results



⊕ Other

⊕ Gaia Data Release 1

⊖ Gaia Data Release 2

⊕ Auxiliary

⊕ Cross match

⊕ Solar System

⊕ Variability

⊕ gaiadr2.gaia_source

⊕ gaiadr2.ruwe

Job name:

Query examples

```
1 SELECT TOP 20 *
2 FROM gaiadr2.gaia_source
```

Ctrl+Space for query autocomplete

Reset Form

Submit Query

Status	Job	Creation date	Num. rows	Size	Actions
✓	16015142951560	01-Oct-2020, 03:04:55	20	10 KB	

1-1 of 1

Download format:

VOTable

Apply jobs filter

Filter this session

Select all jobs

Delete selected jobs

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TAP: Gaia vs Euclid vs Herschel



Euclid Science Archive System



SEARCH ADQL FORM RESULTS BASIC FORM RESULTS

Job name: Query examples

1 | `select top 100 * from public.kids_dr4`
Ctrl+Space for query autocompletion

Reset Form Submit Query

Status	Job	Creation date	Num. rows	Size
<input checked="" type="checkbox"/> <input type="checkbox"/>	1601514165499TO	01-Oct-2020, 03:02:45	100	124 KB

1-1 of 1 Download format: VOTable Apply jobs Filter this session Select all jobs Delete selected

The screenshot shows the Euclid Science Archive System's search interface. On the left is a sidebar with icons for home, search, and other archive systems like IVOA and SDSS. The main area has tabs for SEARCH, ADQL FORM, RESULTS, and BASIC FORM RESULTS. The ADQL FORM tab is active. It contains a job name input field, a code editor with a sample query, and buttons for Reset Form and Submit Query. Below this is a table of search results with columns for Status, Job, Creation date, Num. rows, and Size. A single job is listed with status checked. At the bottom are navigation buttons (1-1 of 1), download format selection (VOTable), and various job management buttons.

[SAS 0.10.3] COPYRIGHT © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED.

TAP: Gaia vs Euclid vs Herschel



herschel science archive

HOME SEARCH RESULTS CATALOGUES PUBLICATIONS HSA USERS GUIDE HERSCHEL DOCUMENTATION

Simple Form ADQL Form Query Results

catalogues

- hsa.hifi_spectral_line_native
- hsa.hifi_spectral_line_smother
- hsa.pacs_point_source_070
- hsa.pacs_point_source_100
- hsa.pacs_point_source_160
- hsa.spire_point_source_250
- hsa.spire_point_source_350
- hsa.spire_point_source_500
- hsa.spire_spectral_feature_find

hsa

Job name:

Query examples

```
1 SELECT TOP 20 * FROM hsa.pacs_point_source_070
```

Ctrl+Space for query autocompletion

Reset Form Submit Query

Status	Job	Creation date	Num. rows	Size	Actions
<input checked="" type="checkbox"/>	<input type="checkbox"/> 16015142348890	01-Oct-2020, 03:03:54	20	6 KB	

1-1 of 1

Download format: VOTable

Apply jobs filter Filter this session Select all jobs Delete selected jobs

COPYRIGHT 2019 © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED. [v9.2.2]

Single object: inspired by Simbad



C.D.S. - SIMBAD4 rel 1.7 - 2020.10.01CEST03:07:55

Available data : [Basic data](#) • [Identifiers](#) • [Plot & images](#) • [Bibliography](#) • [Measurements](#) • [External archives](#) • [Notes](#) • [Annotations](#)

Basic data :

V* UX Ori -- Herbig Ae/Be star

SIMBAD [query around](#) with radius 2 arcmin

Other object types: * (HD,BD,...), V* (AN,ASAS,...), IR (IRAS,2MASS,...), Em* (EM*,HBC), Ae* ([Ref](#))
ICRS coord. (ep=J2000) : 05 04 29.9881676817 -03 47 14.288047238 (Optical) [0.0445 0.0332 90] A [2018yCat.1345....0G](#)
FK4 coord. (ep=B1950 eq=1950) : 05 02 00.5725318272 -03 51 19.759672827 [0.0445 0.0332 90]
Gal coord. (ep=J2000) : 203.6342949327450 -25.4429572839084 [0.0445 0.0332 90]
Proper motions mas/yr: 0.785 -3.924 [0.087 0.064 90] A [2018yCat.1345....0G](#)
Radial velocity / Redshift / cz : V(km/s) 100.306 [25.736] / z(spectroscopic) 0.000335 [0.000086] / cm 100.32 [25.74]
(Opt) C [2013AJ....146..134K](#)
Parallaxes (mas): 3.0772 [0.0509] A [2018yCat.1345....0G](#)
Spectral type: A4IVe C [2001A&A...378..116M](#)
Fluxes (9) : U 10.25 [-] D [2012A&A...543A..59M](#)
B 10.93 [0.06] D [2000A&A...355L..27H](#)
V 8.70 [-] C [2002yCat.2237....0D](#)
R 9.62 [-] D [2012A&A...543A..59M](#)
G 10.4031 [0.0219] C [2018yCat.1345....0G](#)
I 9.43 [-] D [2012A&A...543A..59M](#)
J 8.707 [0.021] C [2003yCat.2246....0C](#)
H 8.044 [0.034] C [2003yCat.2246....0C](#)
K 7.214 [0.020] C [2003yCat.2246....0C](#)



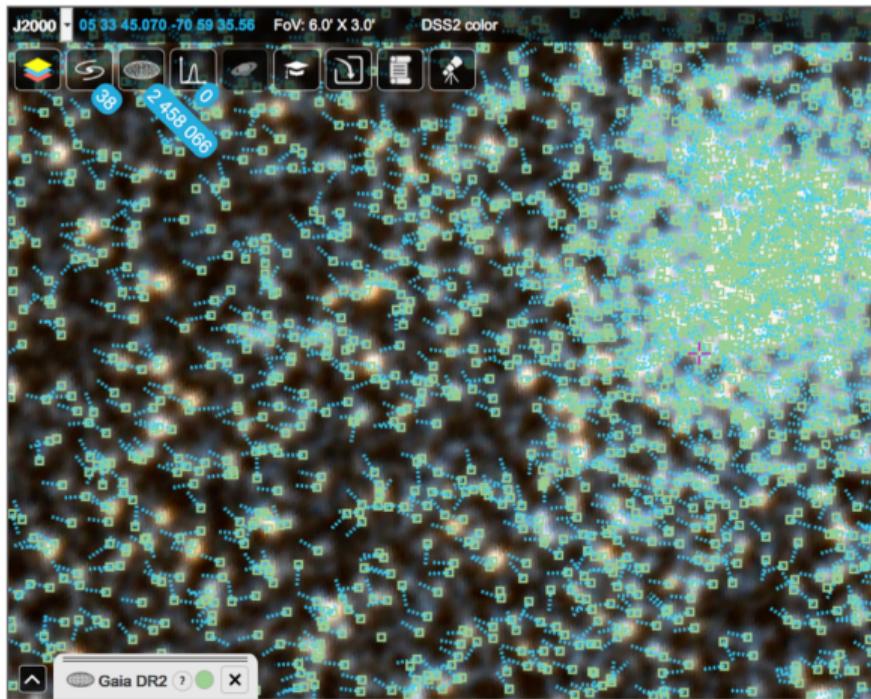
Gaia single object: proof of concept



4651091037707087488

[GO](#) [SHOW RESULTS](#)[Go to Simbad](#)

parameter	value
source_id	4651091037707087488
other_ids	b'Gaia DR2 4651091037707087488'
ra	83.43782010073791
dec	-70.99320819949837
l	281.7370524259029
b	-31.836984178985485
ecl_lon	295.1589293352555
ecl_lat	-84.97746906016201
parallax	0.07216211648011088
pmra	2.1554333396725274
pmdec	0.8359992687897111
phot_g_mean_mag	15.86286735534668



Gaia single object: RVS



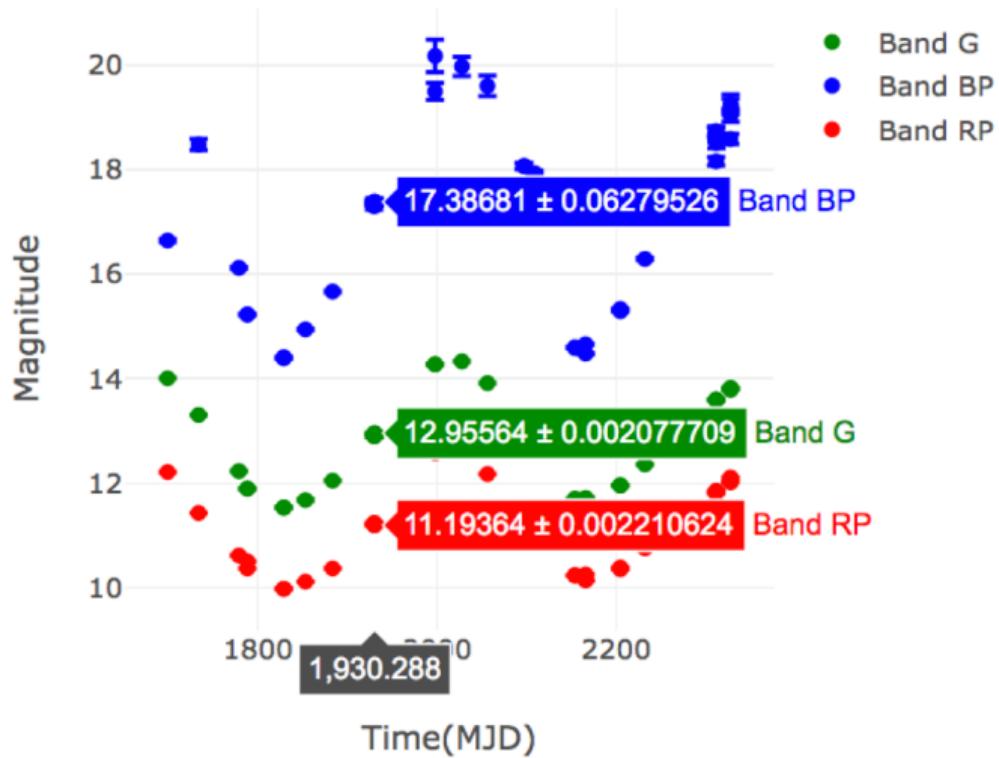
RVS Spectra



ESA UNCLASSIFIED - For Official Use

A. Mora et al. | The Gaia Archive | ESLAB #53. ESTEC | 2019-04-09 | Slide 47

Gaia single object: Light curve

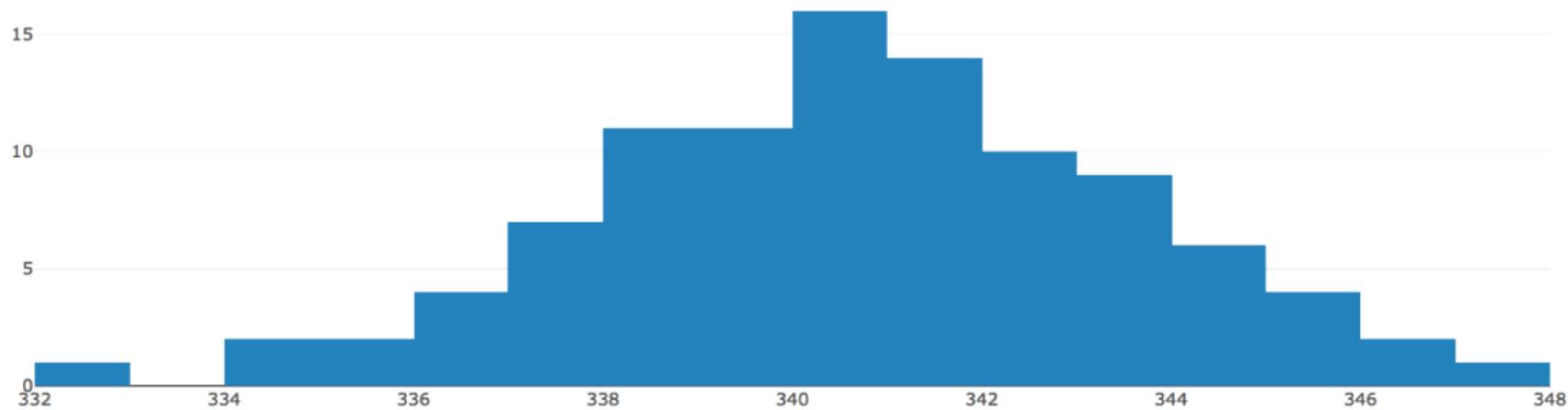


Gaia SO: stellar parameters MCMC



Markov Chain Monte Carlo

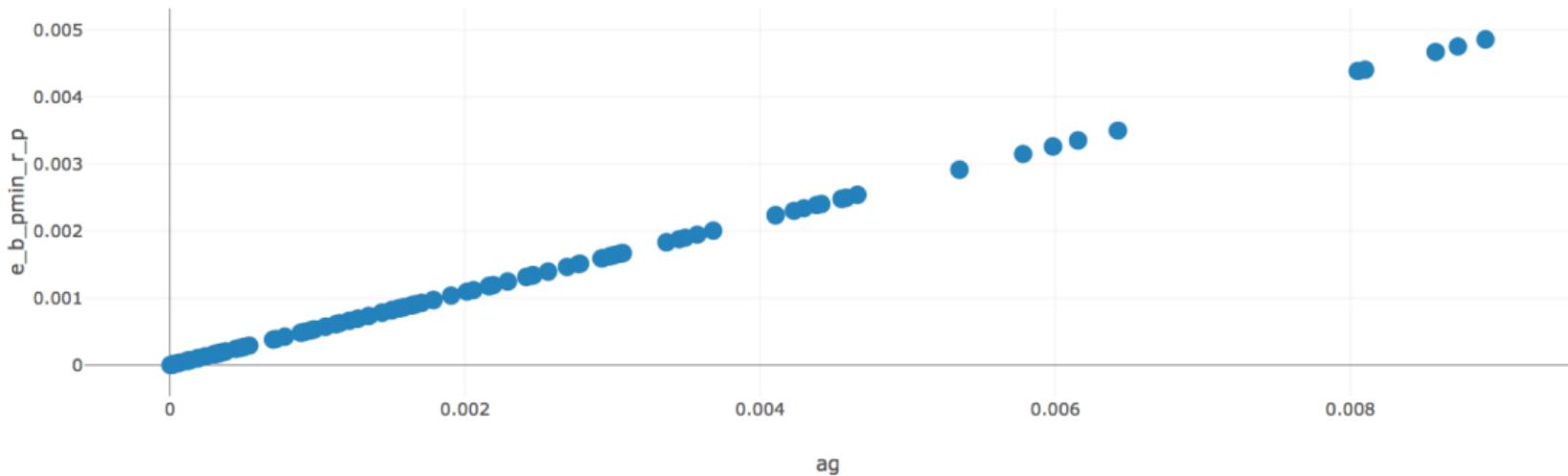
distance



Gaia SO: stellar parameters MCMC



ag	x ▾
e_b_pmin_r_p	x ▾



Look & feel: improve GUI experience



ARI's Gaia Services

Home Data & Statistics Single Source Search Cone Search TAP FAQ News

Job list 1 All Running Completed

?

TAP

SAMP

Query

```
select top 20 * from gaiadr2.gaia_source
```

Ctrl+Space for auto-completion

Format:

VOTable (BINARY)

Size limit: Duration limit:

100000 rows 30 minutes

Start Reset

Examples

- ▶ ADQL SNIPPETS
- ▶ HEALPIX FEATURES
- ▶ MISCELLANEOUS
- ▶ Gaia DR1 QUERIES
- ▼ Gaia DR2 QUERIES
 - ↳ Gaia DR2 - Local Hertzsprung-Russell diagram for nearby sources
 - >Show description
 - ↳ Gaia DR2 - Solar system objects by number of observation
 - >Show description
 - ↳ Gaia DR2 - Sources with 6D phase space
 - >Show description

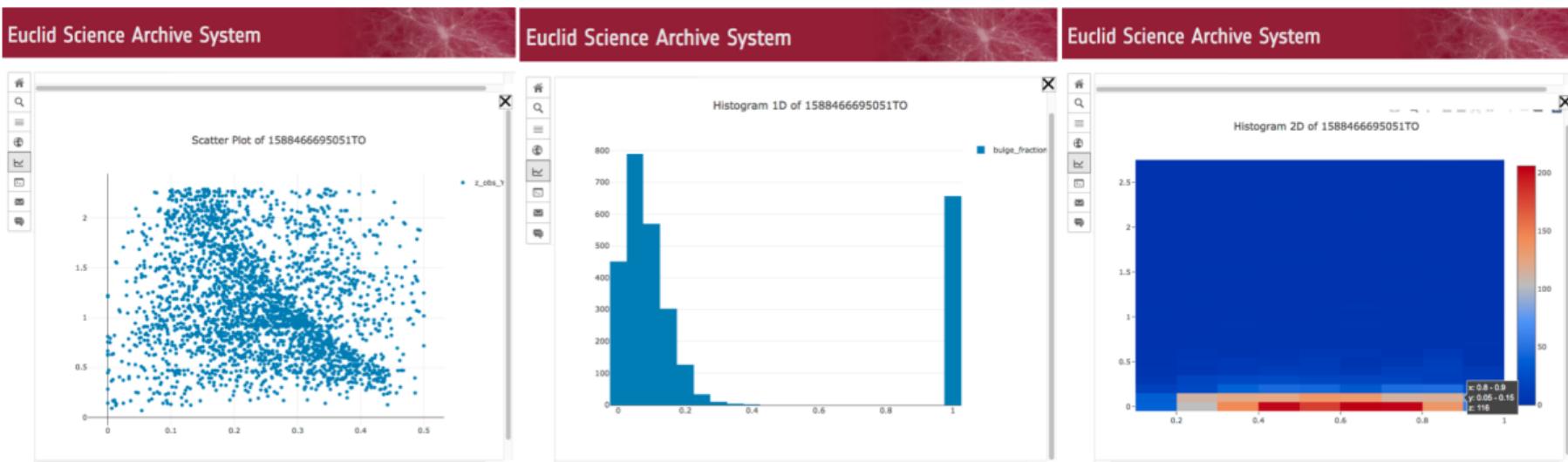
- ESDC tech GWT: obsolete?
- Tabs → Icons
- Single authentication
 - Cosmos, TAP, DataLink, ...

Visualisation: query output

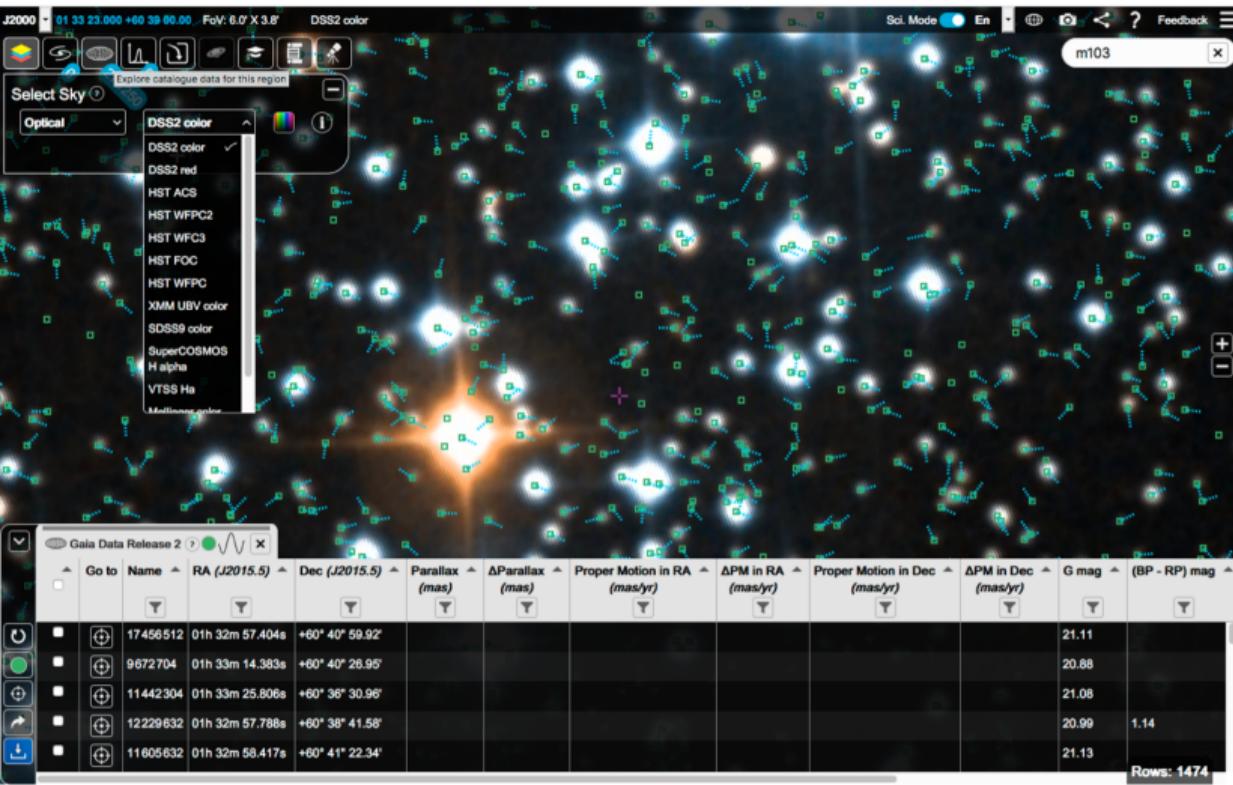
In-house vs Consortium: ESDC cannot do everything

Gaia visualisation workpackage: Lisbon University

ESDC already has a prototype solution for Euclid



ESA Sky: collaboration



Different projects and objectives

DR2: data available on day 1

EDR3+: repeat agreement?

Gaia does not have images

Could HIPS maps be added?

ESASky is adding visualisations

Might use spectra, light curves

Non-single star trajectories

Jupyter notebook repository



Help support

Should you have any question, please check the Gaia FAQ section or contact the Gaia Helpdesk

Lots of code in different places

Help, Astroquery, ESA DataLabs

Gaia Python tutorial: Cluster analysis

Authors: Deborah Baines

This tutorial has taken the [Cluster analysis tutorial](#) and adapted it to python. The tutorial uses the Gaia TAP+ ([astroquery.gaia](#)) module .

Centralized repository

This tutorial is focused on a possible scientific exploration exercise for a known cluster, the Pleiades (M45), using data from the Gaia Archive.

Visibility, indexing

You can import and run this tutorial in your own Jupyter Notebook using this file: [Download](#)

How to seamlessly share code

First, we import all the required python modules:

Big problem: **Licenses**

```
In [1]: import astropy.units as u
from astropy.coordinates.sky_coordinate import SkyCoord
from astropy.units import Quantity
from astroquery.gaia import Gaia
```

License board difficult for users

```
Created TAP+ (v1.0) - Connection:
  Host: gae.esac.esa.int
  Use HTTPS: True
  Port: 80
  SSL Port: 443
```

Cross-match: great CDS service



CDS X-Match Service

X-match

Tables management

Documentation

Login Preferences Register

Choose tables to cross-match

e.g. VII/260/dr7qso, or select in list



e.g. VII/233/xsc, or select in list

VizieR

SIMBAD

My store

VizieR

SIMBAD

My store

Show options

Begin the X-Match

No need to replicate!
Limited data sets and customization

Visualize and manage your cross-match jobs

List of X-match jobs

Table 1	Table 2	Options	Begin	Status	Actions
No job in list					

For the selected job(s): Delete

Cross-match assistant

```

select * from (
  select * from (
    select num, source_id, ra, dec, parallax, pmra, pmdec,
    vmag, imag, phot_g_mean_mag, phot_bp_mean_mag, phot_rp_mean_mag
    from user_amora.gouliermis_2006 as gouliermis
    join gaiadr2.gaia_source as gaia
      on 1 = contains(
        point('', col_raj2000, col_dej2000),
        circle('', ra, dec, 1. / 3600)
      )
    offset 0
  ) as subquery
  join gaiadr2.ruwe using(source_id)
  offset 0
) as subquery2
where abs(vmag - phot_g_mean_mag) < 2
  and ruwe < 1.4

```

Gaia vs external table
Cone search + V-G + RUWE

XM is science!

Ad-hoc problem

- User tables
- Extra conditions
- Proper motion

...

Queries are difficult

Tutorial available

Assistant?

Priorities? Feedback welcome!

Non-exhaustive list. Some for Gaia, some for ESDC as a whole

1. Integration between archives
2. Single object exploration
3. Look & Feel
4. Visualisation: query output
5. Visualisation: general improvement, binary orbits
6. ESASky. Add data. Add HIPS. Binary orbits?
7. Jupyter notebook repository
8. Massive computing: DataLabs, SOC, Cloud
9. Cross-match assistant
10. ADQL: contribution toward 2.1 and beyond

Thank you for your attention!!



EXTRA SLIDES

TAP+: user tables + xmatch



The screenshot shows the Gaia Data Processing Pipeline interface. On the left, there's a sidebar with icons for Gaia tables, User tables, and Shared to me (from satgalia). The User tables section is expanded, showing several tables: user_jsalgado.cata, user_jsalgado.dwarfs, user_jsalgado.early_stars, user_jsalgado.radial_velocities, user_jsalgado.t1404481668974d, user_jsalgado.visual_binaries, user_jsalgado.xmatch_cata_igsl_source, user_jsalgado.xmatch_igsl_source_dwarfs, user_jsalgado.xmatch_igsl_source_radial_velocities, and user_jsalgado.xmatch_igsl_source_visual_binaries_2. The Shared to me section lists various tables related to satgalia.

GAIA Catalogue Upload

Select a file my_sources.vot
(*) Table name
Table description
Ra column name
Dec column name
(*) mandatory field

Cancel

Persistent Upload



GAIA Share Item

user_jsalgado.radial_velocities

Description
Shared to group:

Share now to group

Update

Table sharing

GAIA Cross-Match

Table A: user_jsalgado.cata Table B: public/gpt_source

Radius: 1.0 (in arcseconds)

Cancel

Server Crossmatch



TAP+

- ADQL query

DataLink

- Source ID retrieval
- Future extensions



➤ Catalogue Database

- Catalogues, source classification, SSOs.
- Efficiently “indexable” data
- Benefits from storage in RDBMS

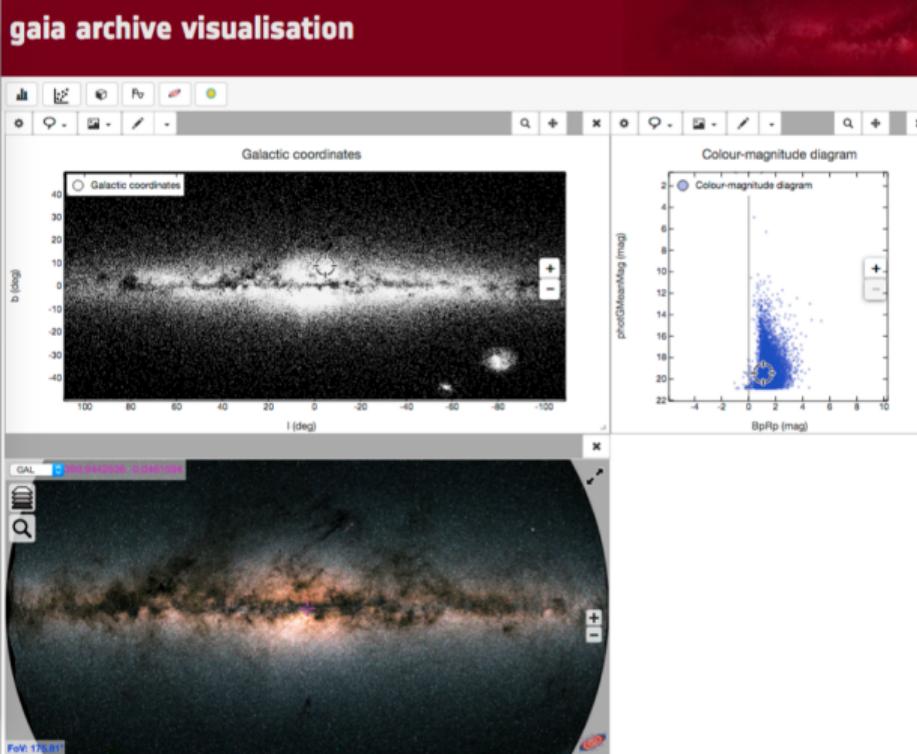


➤ Cluster Storage

- Associated data products (Spectra, Light Curves).
- Scales to DR3/4 data volumes

2.4. The Gaia Archive: visualisation

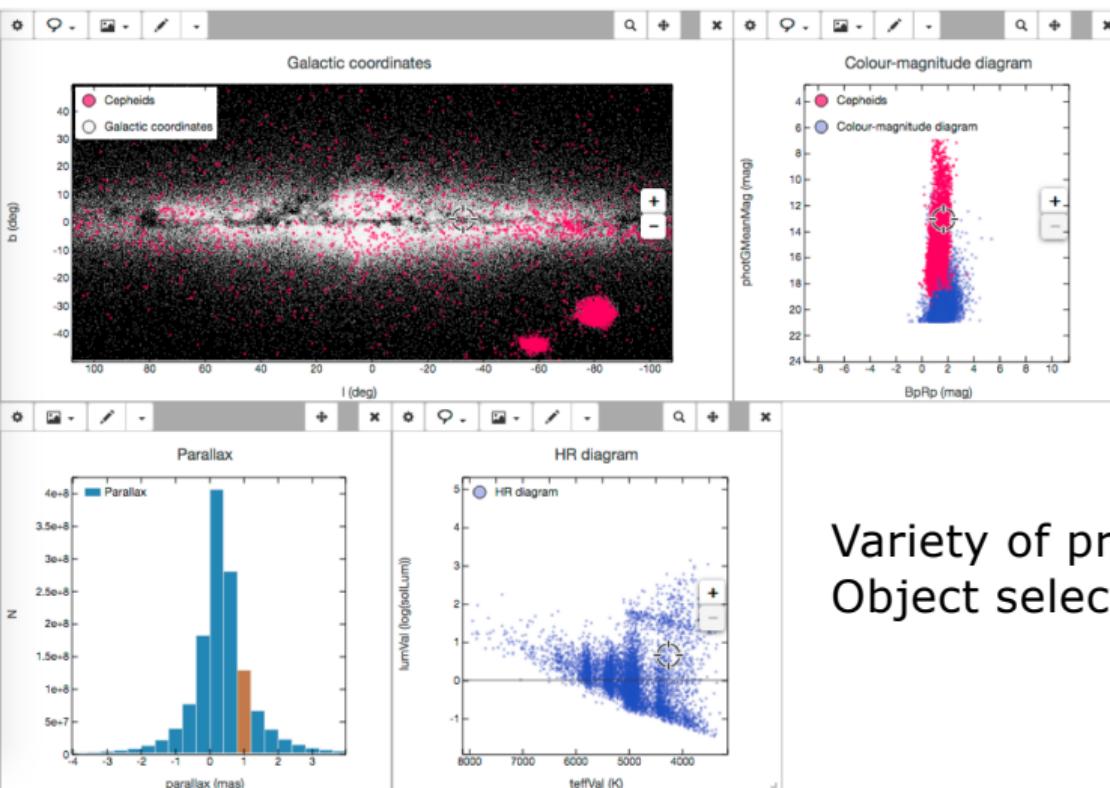
Visualisation: canvas + plots



Customizable canvas

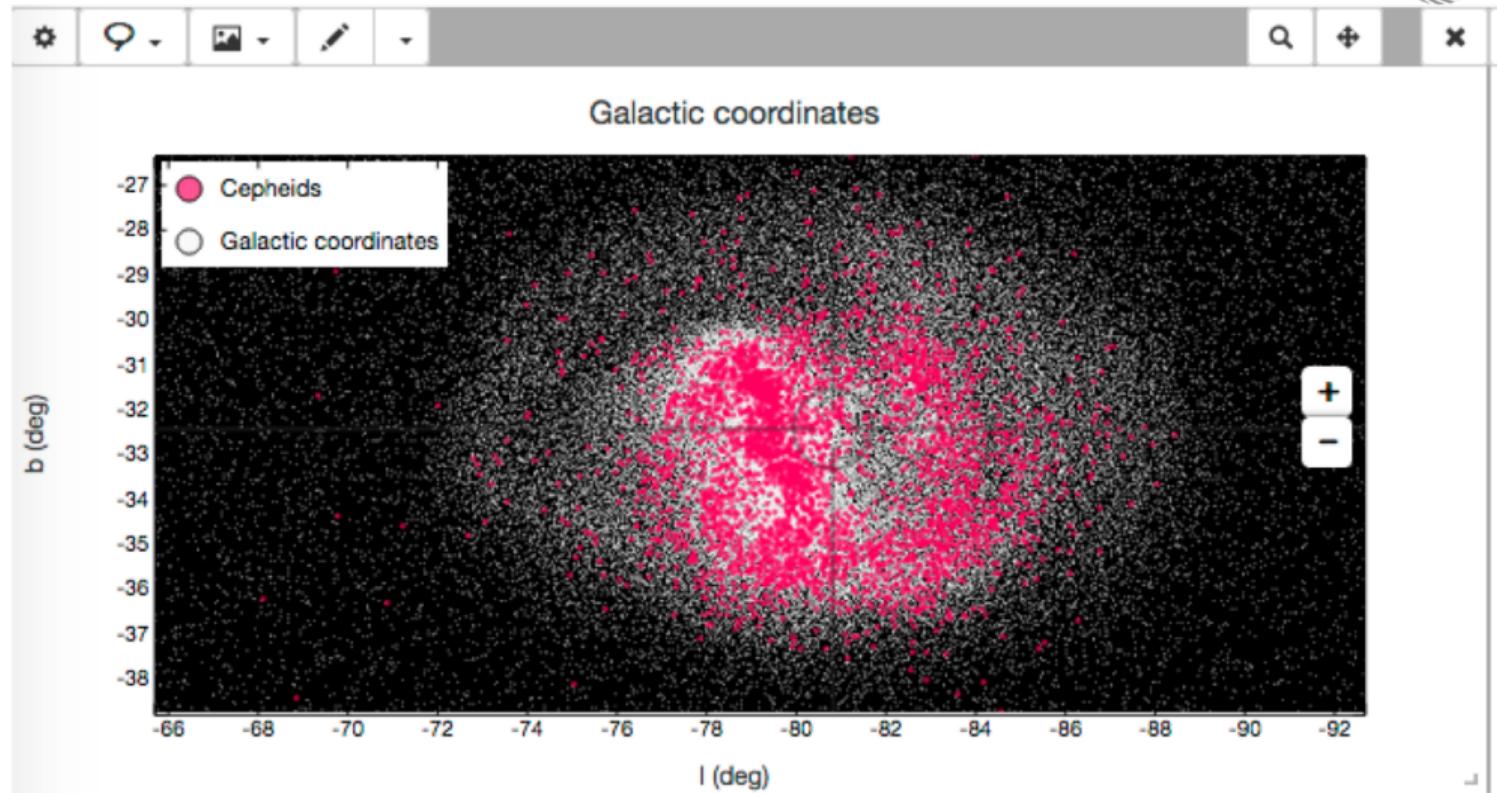
Plots can be added and formatted

Visualisation: linked views + layers

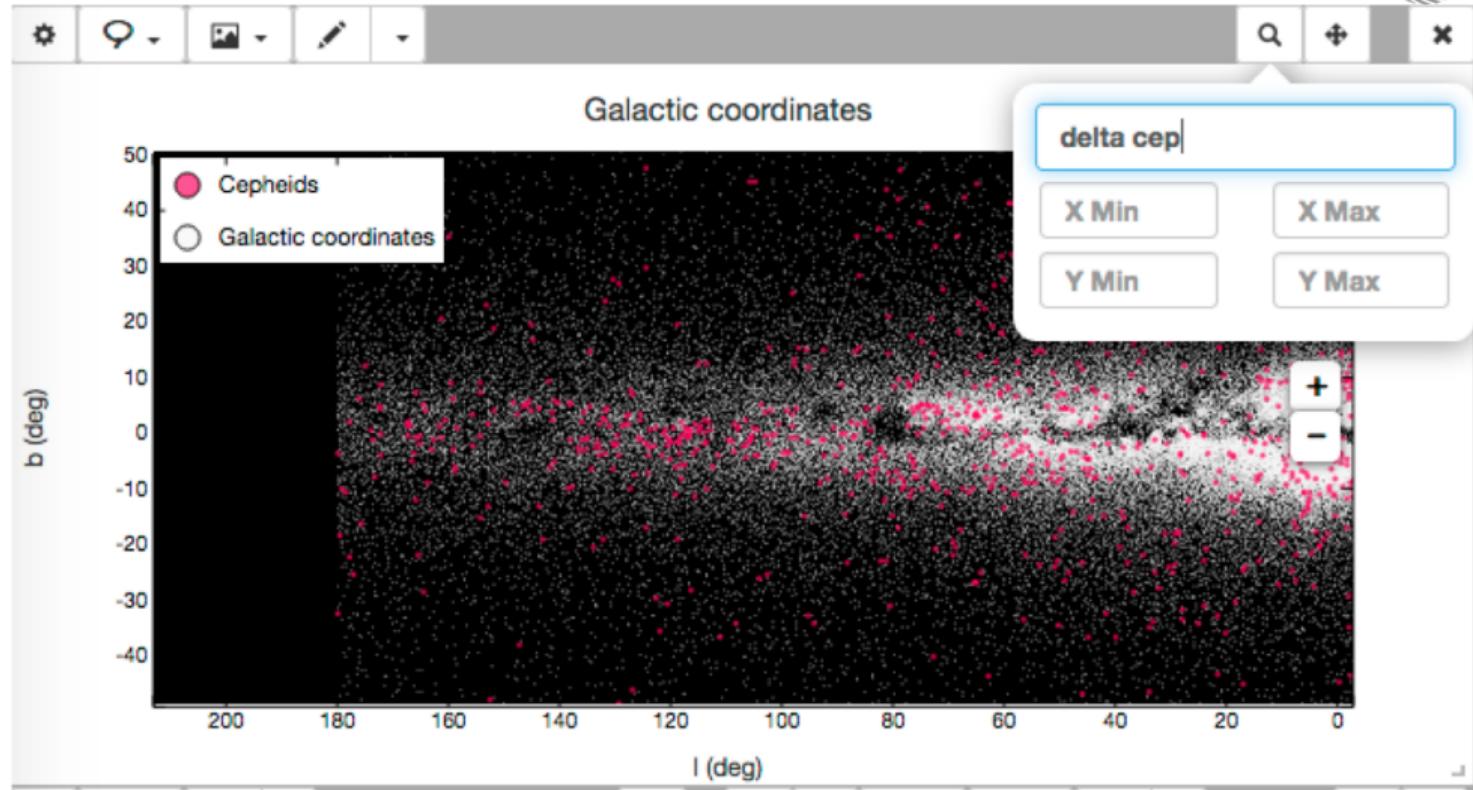


Variety of precomputed plots
Object selection across multiple windows

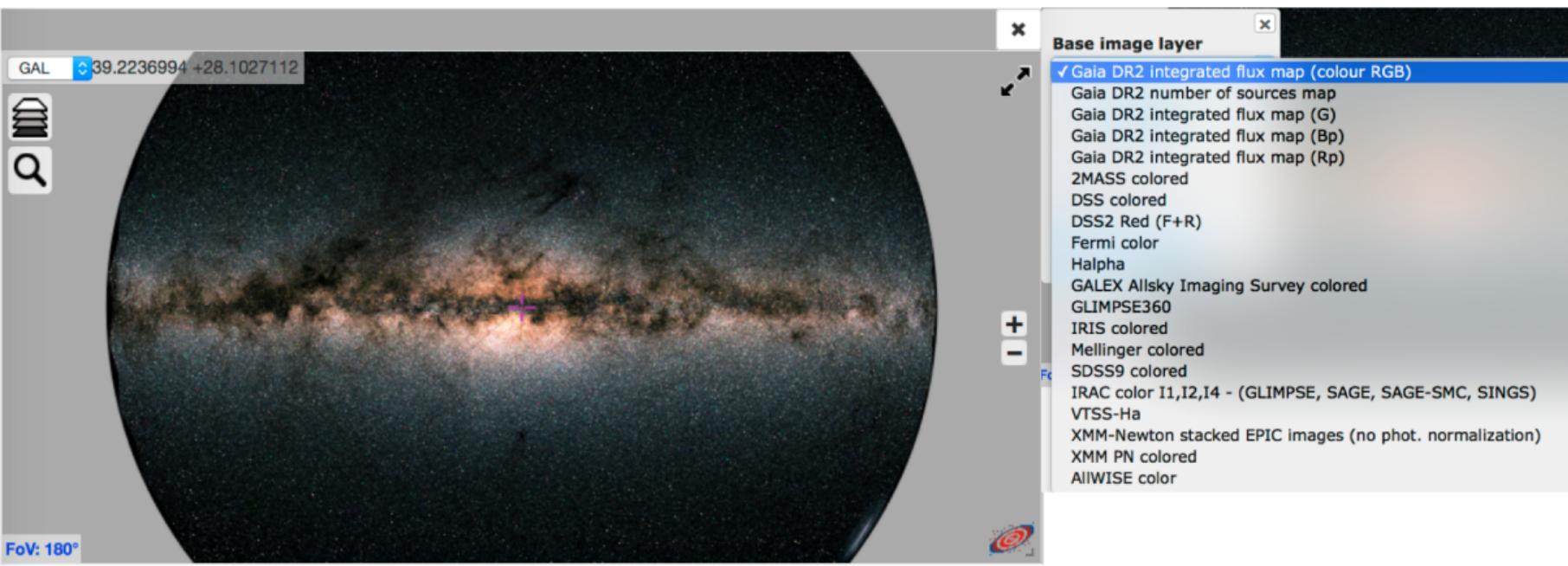
Visualisation: adaptive resolution



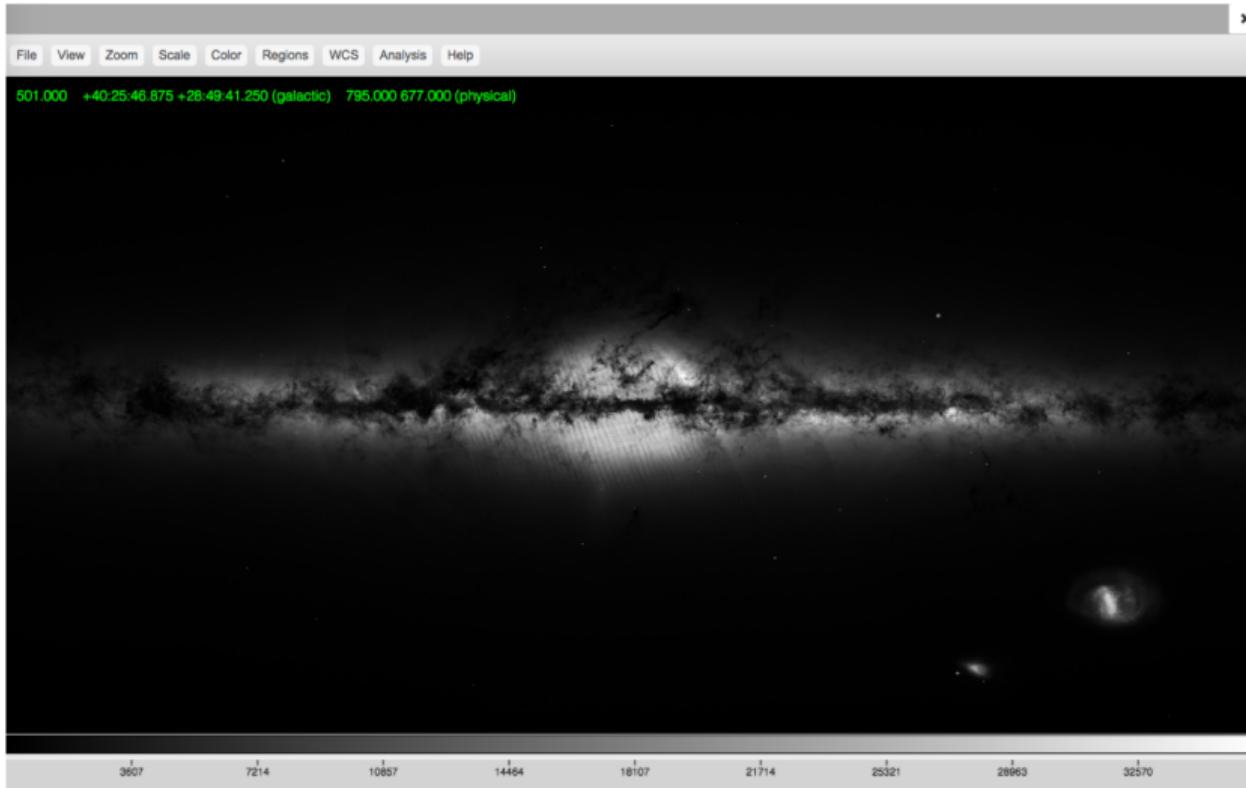
Visualisation: zoom on CDS object



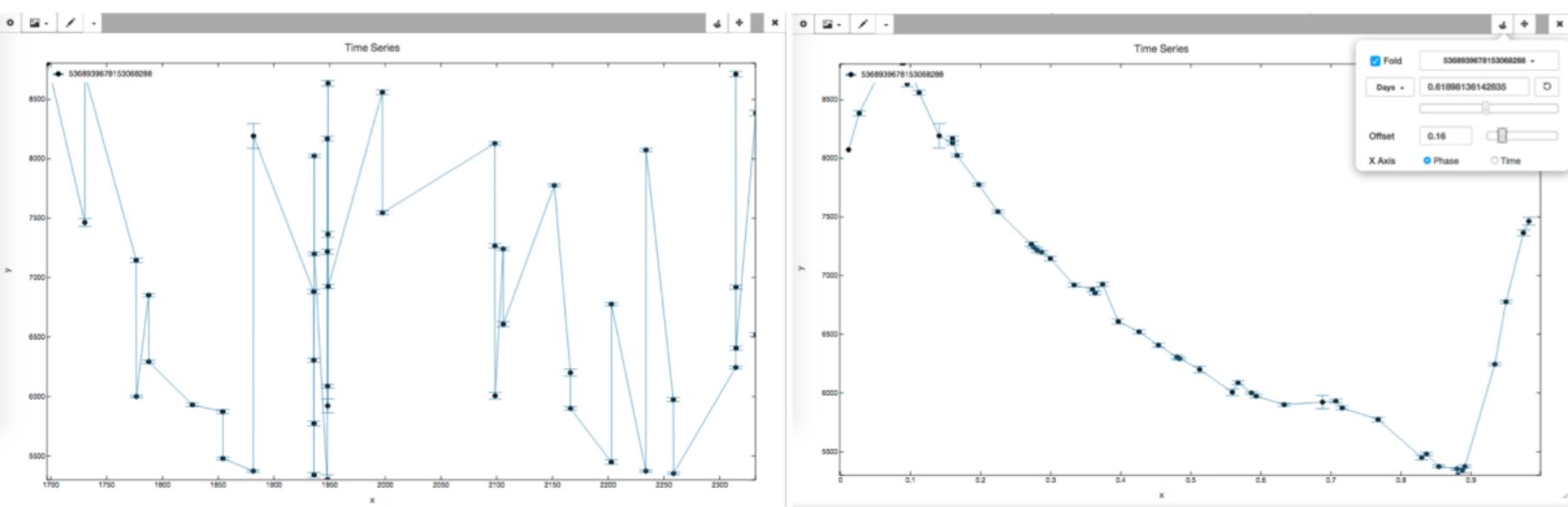
Visualisation: Selected Aladdin HiPS



Vis: JS9 source count image



Visualisation: Light curves



- Can be folded for periodic variables
- Source selection is difficult

Visualisation: 3D (experimental)

