The GaiaPortal and the Cross-Match algorithms and software developed at SSDC: unique solutions to complex scientific and technological challenges.

P.M. Marrese S. Marinoni
M. Fabrizio G. Altavilla
G. Fanari

A cross-match is not a cone search

A cross-match is always a trade-off 

A fraction of mismatched and/or missed objects is always present

Large stellar catalogues : density variations +
angular resolution differences +
stellar motion

→ Missed counterparts +
Single counterpart is not always the right answer

→ Barnard star: pm_{total} ~10393.59 mas/yr
star motions -› standard model: full covariance matrix for positions, proper motions and parallax

What's "large" : number of sources
number of columns needed by the cross-match

Example Gaia DR2 : **1 692 919 135** sources
gaiaMinimal = 40GB (3 columns, no indexes)
gaiaBasecat = 308 GB + 40 GB (24 columns, 1 primary key, 1 index)
gaiaSource = 583 GB + 45 GB (94 columns, 1 primary key, 1 index)

sizes refer to MyISAM tables

Marrese et al. 2017, A&A 607, 105
Marrese et al. 2019, A&A 621, 144

External catalogues number of sources + basecat size

Pan-STARRS1 DR1	: 138GB	+ 52GB	(8 columns)
GSC2.3	: 64GB	+ 21GB	(8 columns)
PPMXL	: 98GB	+ 16GB	(12 columns)
AllWISE	: 65GB	+ 17GB	(9 columns)
2MASS PSC	: 30GB	+ 8GB	(9 columns)
SDSS DR9	: 35GB	+ 12GB	(9 columns)
URAT-1	: 17GB	+ 5GB	(8 columns)
APASS DR9	: 4.3GB	+ 1.4GB	(8 columns)
Tycho 2	: 292MB	+ 65MB	(12 columns)
RAVE DR5	: 32MB	+ 20MB	(8 columns)
Hipparcos 2	: 14MB	+ 3.1MB	(12 columns)

~ 585 GB

GaiaPortal DB: 2.6 TB

XM: data curation & preservation

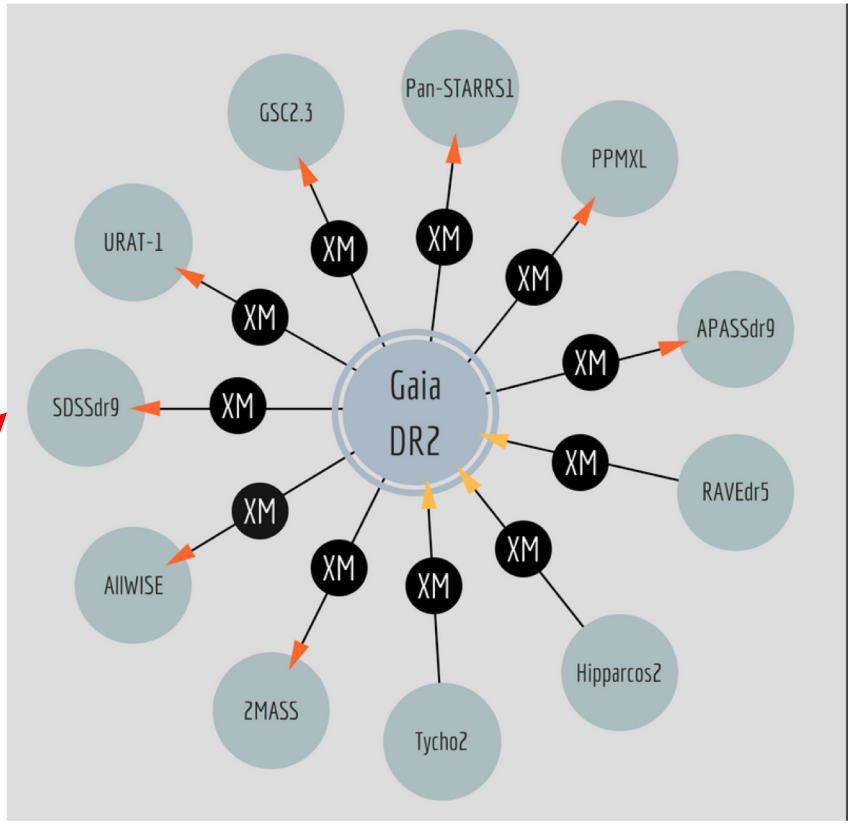
Is the **active and ongoing management of data** through its life cycle of interest and usefulness.
Preserving: Collecting and taking care of research data.
Sharing: Revealing data's potential across domains
Discovering: Promoting the re-use and new combinations of data

The processes of **collecting** data from diverse sources and **integrating** it into repositories that are many more times more valuable than the independent parts.

The **process of caring for data**, including to organizing, describing, cleaning, enhancing and preserving data for public use **providing meaningful and enduring access** to data allowing for users engaging in **data discovery and analysis**.

XM general principles

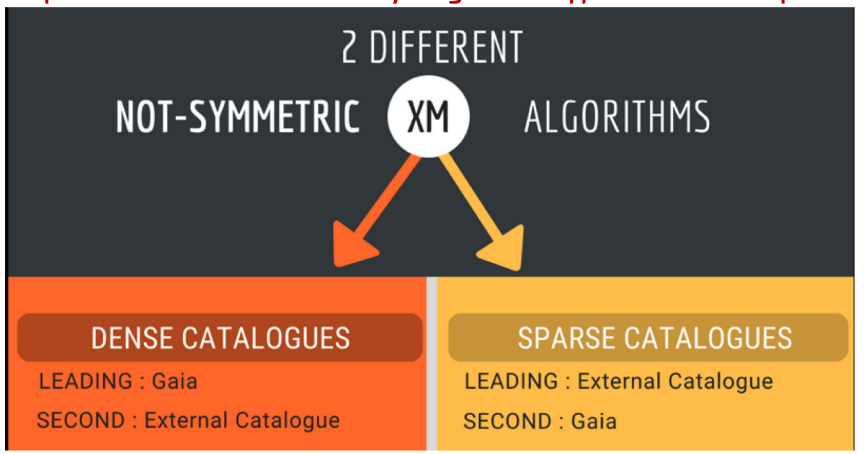
- Large size -› precomputed + best match
- Collaboration framework -› performances + general purpose
- Trade-off between correctness and completeness
- Spider not chain for multiple catalogues XM: independent but homogeneous
- Consistency -› positional XM, no photometry



- Trust your data and use the catalogues position errors (2D equivalent of 5σ)
- Get to know and understand your data
- XM is efficient in finding out if there is something wrong in the astrometry or there is an effect which was not accounted for
- Use a priori knowledge (see Panstarrs1) but no prejudices (2MASS)
- Beware of wavelength differences (AllWISE)
- Beware of binaries with an astrometric signature

Apply a special treatment (position error broadening) **ONLY IF** reason is known and affected sources can be identified

sparse vs dense (small/big are different concepts)

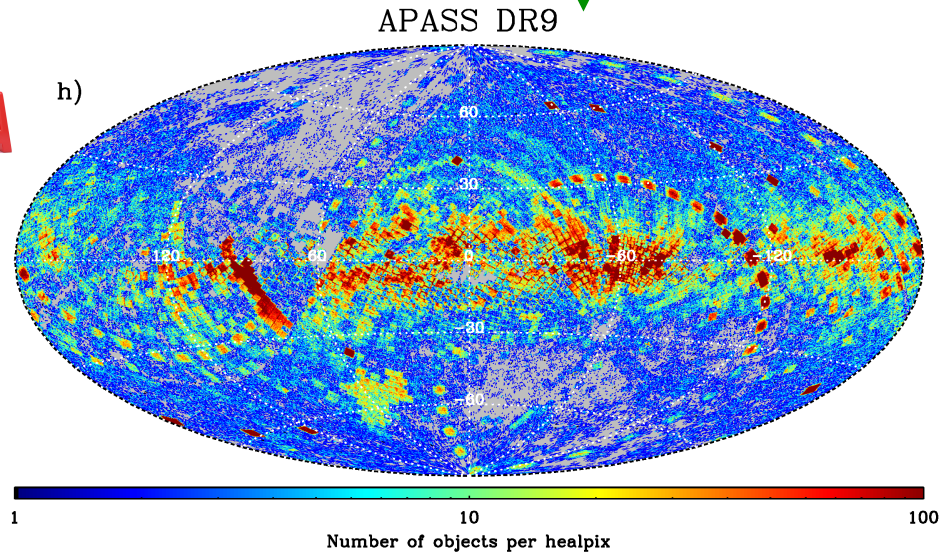


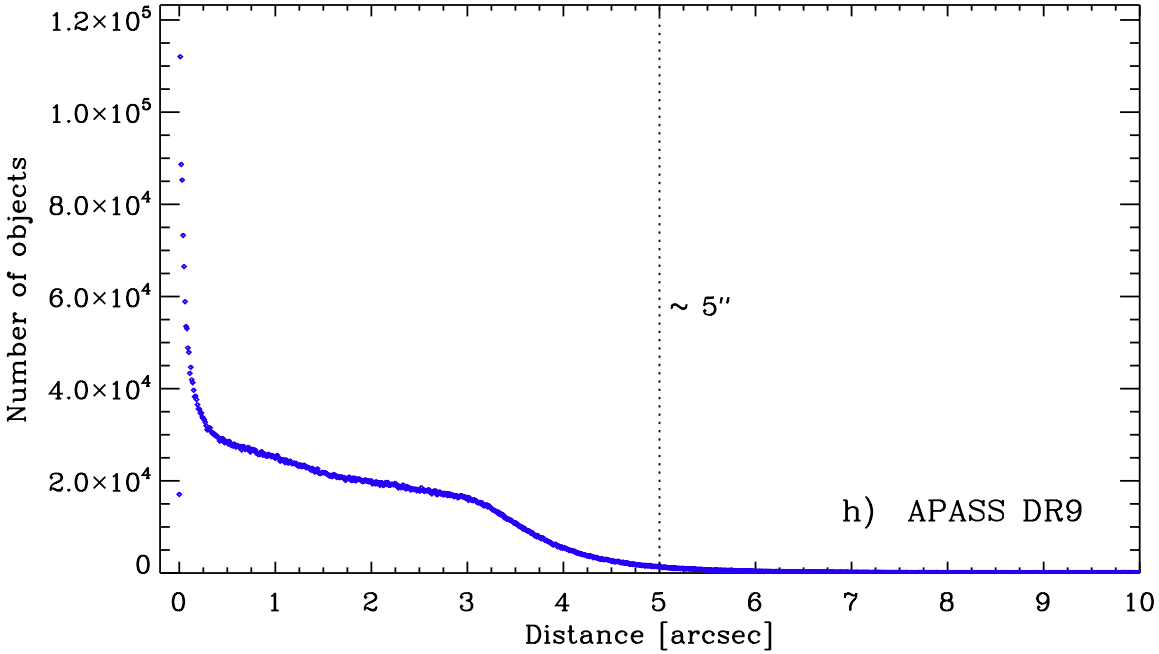
Catalogues preparation

- Catalogue acquisition (from original repositories)
- Catalogue ingestion
- Catalogue homogenization
- Basecat production
- Basecat cleaning (when needed)
- Basecat + Catalogue update
- Local density computation
- Basecat update

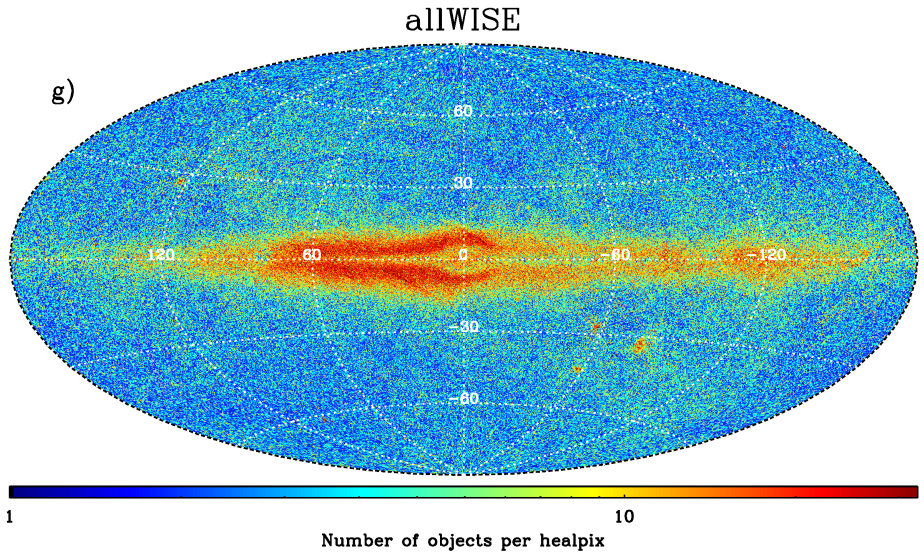
Catalogue	$Radius_{max}$ (arcsec)
Gaia DR2	300
Pan-STARRS1 DR1	120
GSC 2.3	480
PPMXL	480
SDSS DR9	600
URAT-1	480
2MASS PSC	600
allWISE	480
APASS DR9	600

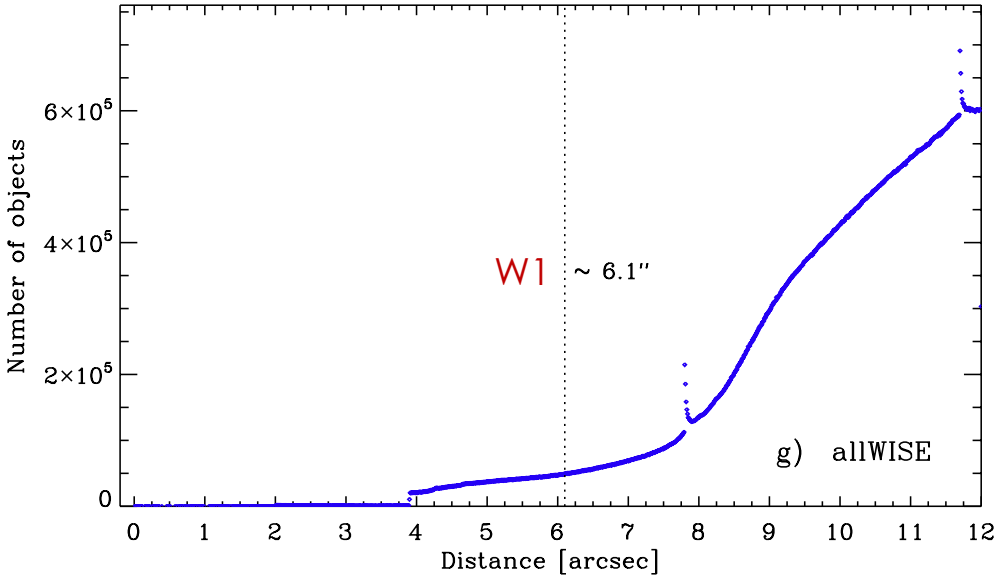
CPU intensive:
slowest part of XM:
~ 1 week for Gaia

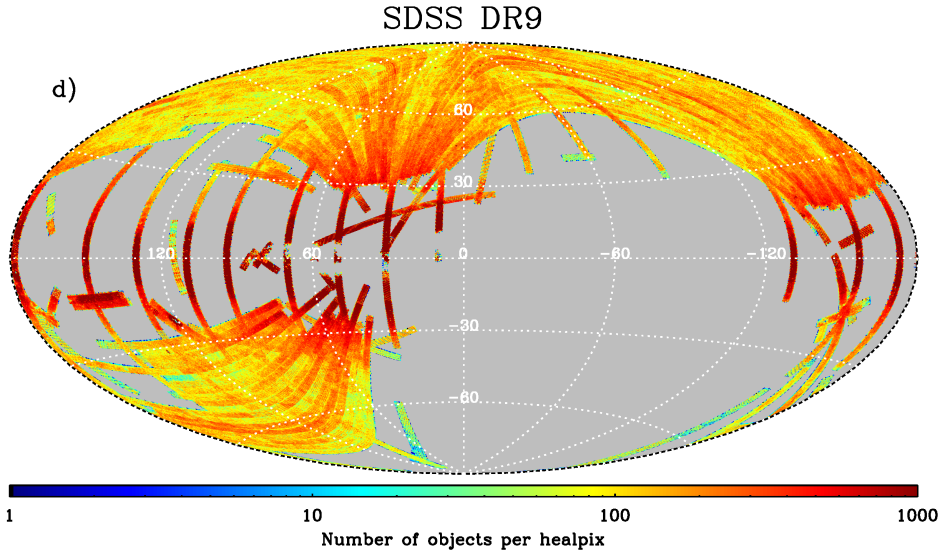


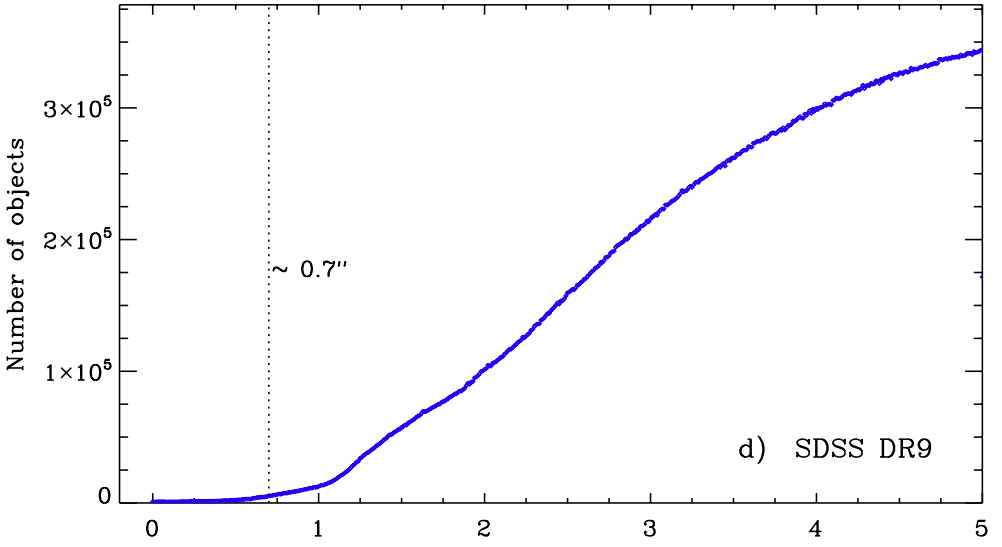


Possible duplicates: well behaved catalogues



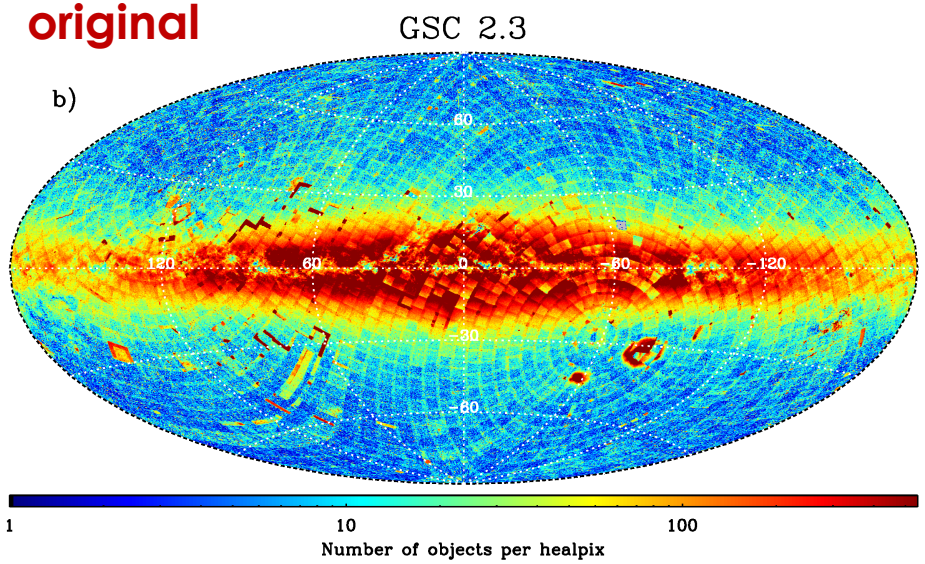


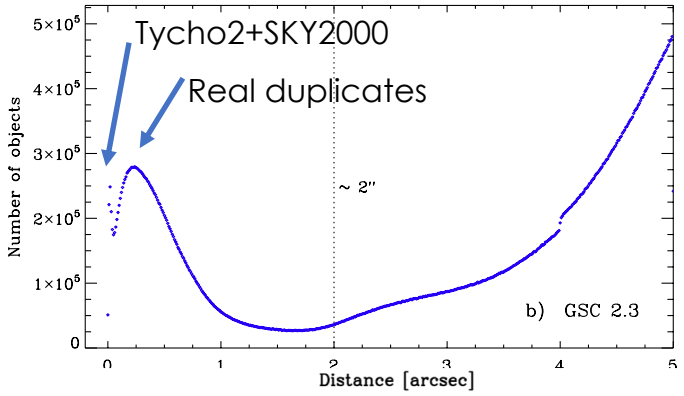




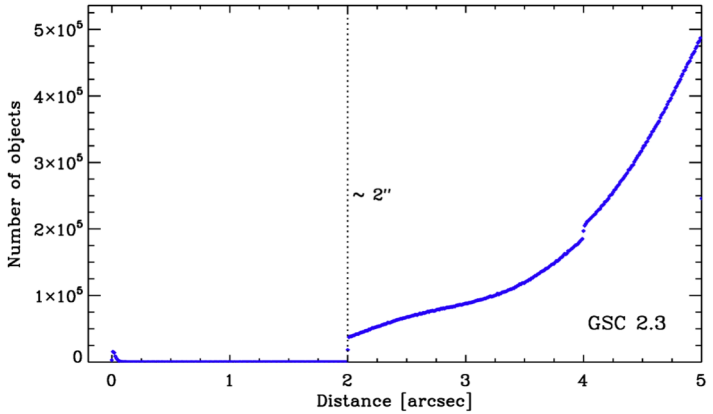
XM steps - Possible duplicates: solution -› self cross-match

original



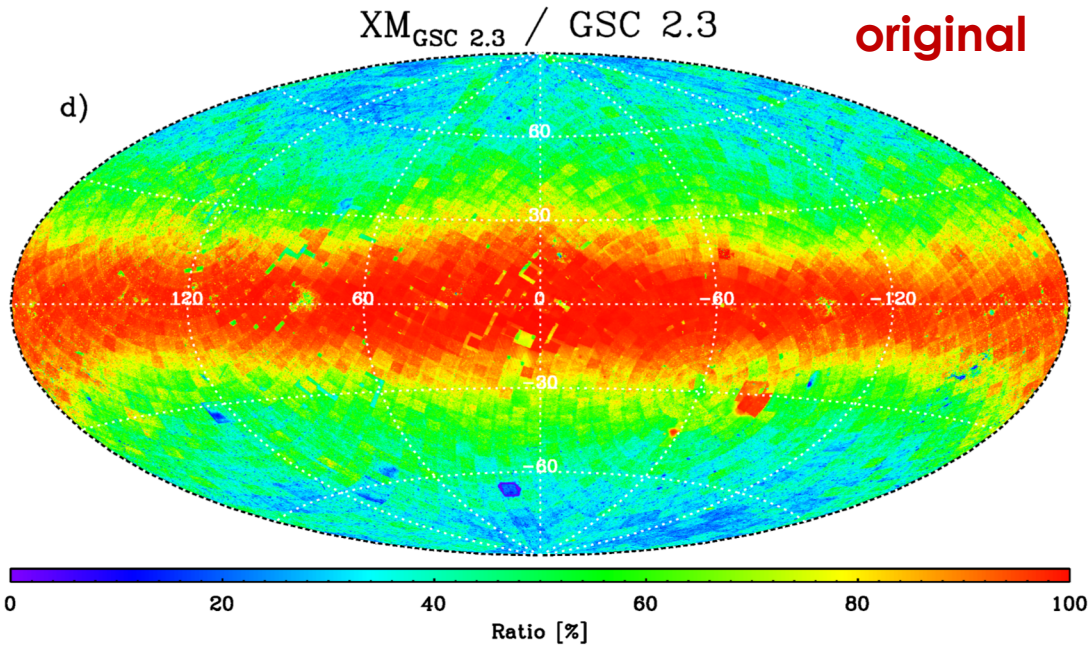


original

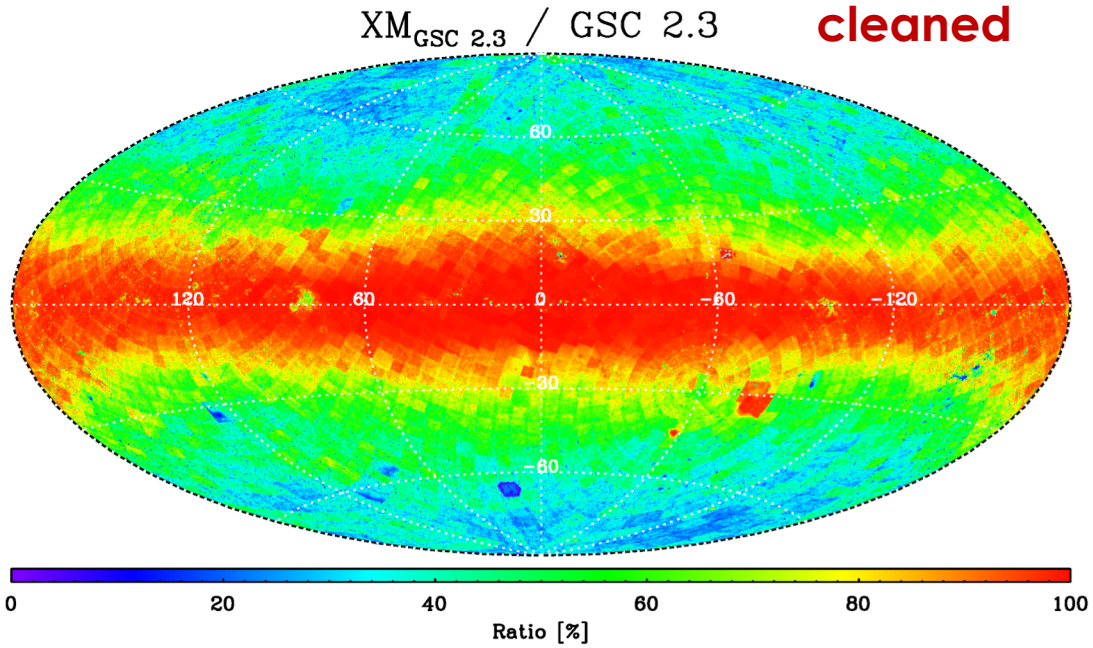


cleaned

-11 million objects

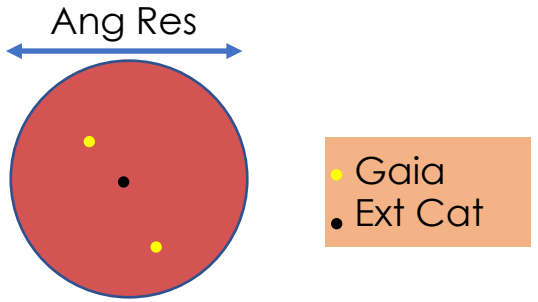


original



cleaned

XM steps -› Reverse cone-search to account for angular resolution differences

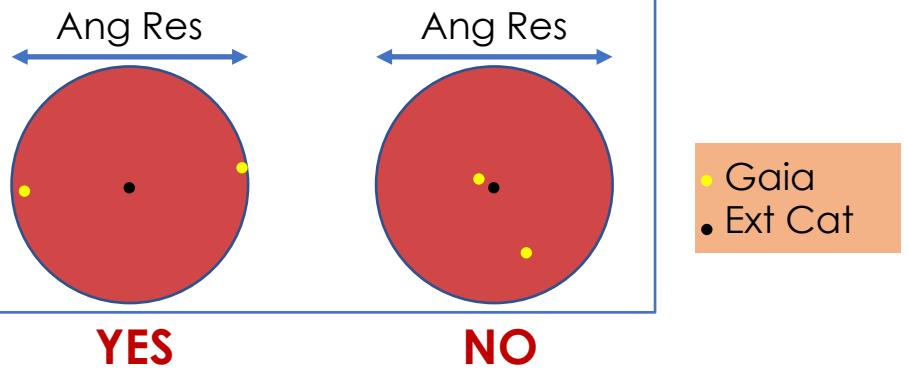


- Calculate a cone search extcat vs Gaia (with proper motions propagation)

  with fixed radius = effective angular resolution / 2
- Find ext Cat sources with 2 or 3 Gaia neighbours (more than 3 means projected geometry needs to be evaluated, crowded field)
- Delete couples/triplets with one or more Gaia sources with no proper motion
- Delete couples/triplets where Δangular distance › angular resolution / 4
- Remaining ext cat sources will be flagged in the basecat

  and their position errors will be broadened

  by effective angular resolution / 2



Ang res difference results: URAT1, 2MASS, allWISE

URAT1 sources:	228 276 482	
best (Gaia sources)	188 071 510	
best (URAT1 sources)	187 922 547	82.32%
reverse cone (URAT1 sources)	224 286 814	98.25%
added (URAT1 sources)	3 069 477	1.34%
2MASS PSC sources:	470 992 970	
best (Gaia sources)	450 688 227	
best (2MASS sources)	437 576 291	92.91%
reverse cone (2MASS sources)	447 763 481	95.07%
added (2MASS sources)	1 124 445	0.24%
allWISE sources:	747 634 026	
best (Gaia sources)	300 207 917	
best (allWISE sources)	297 775 002	39.83%
reverse cone (allWISE sources)	390 343 451	52.21%
added (allWISE sources)	21 131 648	2.83%

R = 1.25”

Ang Res = 2.5”
RAerr (peak) = 0.01”
DECerr (peak) = 0.01”

R = 1.25”

Ang Res = 2.5”
errMaj (peak) = 0.06”

R = 3”

Ang Res (W1) = 6.1”
RAerr(peak) = 0.05”
DECerr (peak) = 0.04”

XM requirements

Performances :

- parallelization
- minimize number of pairs evaluated by selecting the minimal initial search radius on an object-by-object basis
- read data once
- perform calculations in RAM with no intermediate products on disk
- optimize engine to speed output writing
- minimize mysql connections

Scientific :

- Define best neighbours using a Figure of Merit
- Best and Good neighbours in two separate outputs
- XM is both a source-to-source and a local problem -› take into account the surroundings of the Gaia sources in the ExtCat (local density) + surroundings of ExtCat matched sources in Gaia (mates) .

XM solutions: algorithm

(dense catalogues)

- Declination strips definition: independent runs of the XM program (each strip has same number of sources)
- Plane sweep technique: define active list
  δ_A-maxD ≤ δ_B ≤ δ_A+maxD
  requires data ordered by declination and definition of oid
- filter and refine technique:
  - first filter: square on active list in RA (neighbours)
  - second filter : position errors convolution, haversine distance, mahalanobis distance → $\frac{d}{\sigma_{x_C}\sqrt{1-\rho_C^2}} \leq K_\gamma,$ (good neighbours)
- Likelihood (figure of merit) calculation
  highest -› best neighbour
- Mates: Two or more Gaia objects with the same best neighbour.

Architecture, DB design and C code optimization for XM

XM servers:

2 processors with 8 cores (with hyper-threading)
at 2.0 GHz, for a total of 32 cores
256GB RAM
2 disks 1.2TB SAS, 10 K rpm
-› Normal use 4 servers

DB requirement -›

read-intensive
write-intensive

MariaDB 10.1 DBMS

Input data: MyISAM engine (light MySQL storage engine)
Output data: Percona XtraDB engine (concurrent writing)

Mysql connections -› for each strip 2 reading + 2 writing

Bottlenecks:

- Optimisation compromises between CPU usage and I/O
- I/O: writing rather than reading
- Performances (execution time) depends on the characteristics of the external catalogues (stellar density, position errors size)

Writing performance: ~200.000 inserts/s
Execution time : 1-5 hours
(slowest is allWISE, reason is access to C data structures)

The code is written in **C language**

C code data structures:

active list (updated, not re-created), large square (neighbours), small square (good neighbours), mates, best neighbours.

C code buffers:

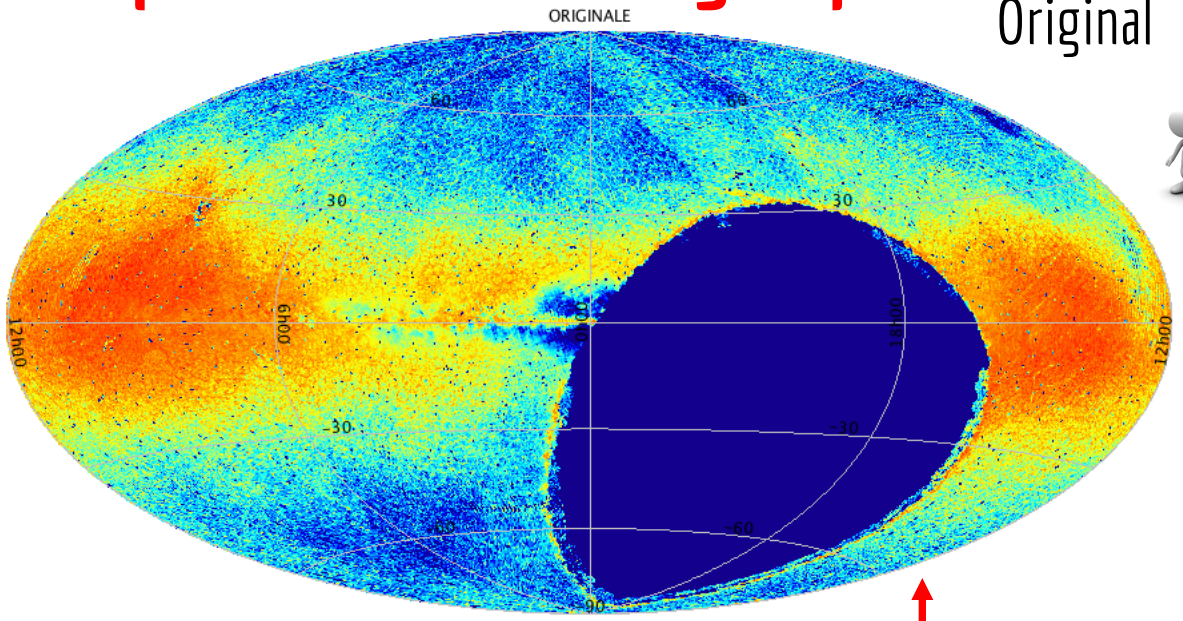
best neighbours & good neighbours writing buffers.

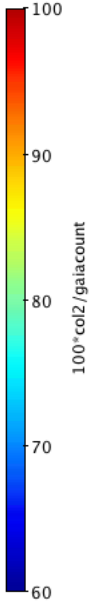
C data structures, number of Gaia strips, size of active lists, .. have been optimised for performance.

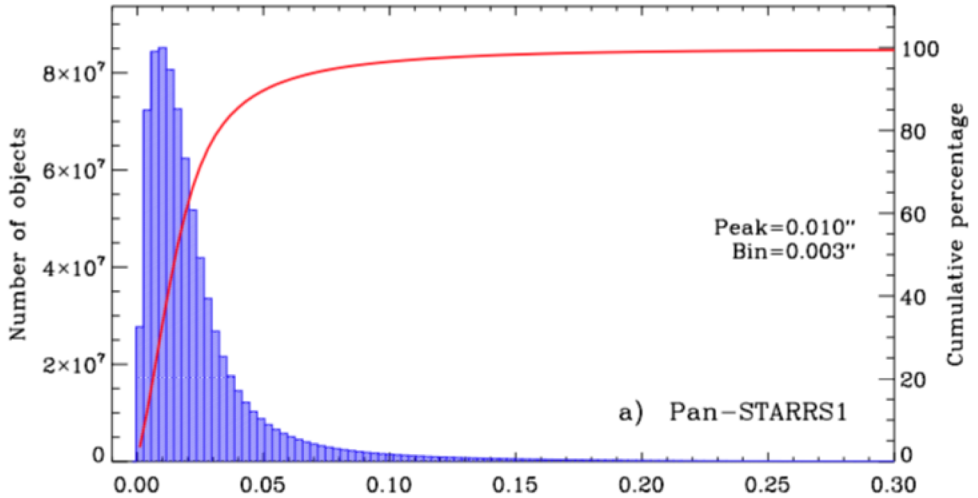
BaseCat preparation and XM validation (in particular consistency tests) are longer than an XM run

A priori knowledge: fraction of Gaia sources matched with PS1

Original



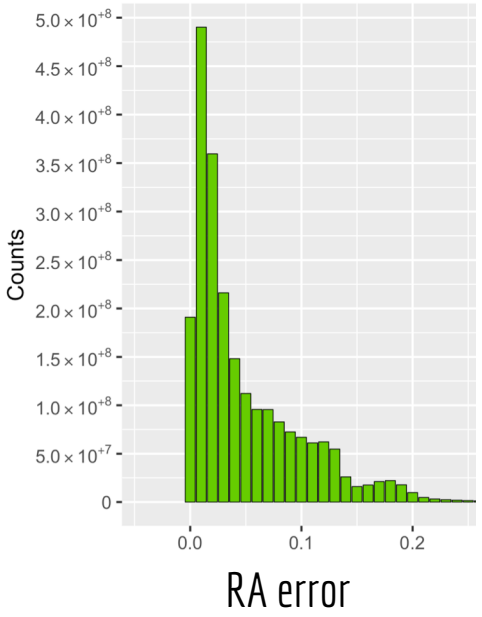




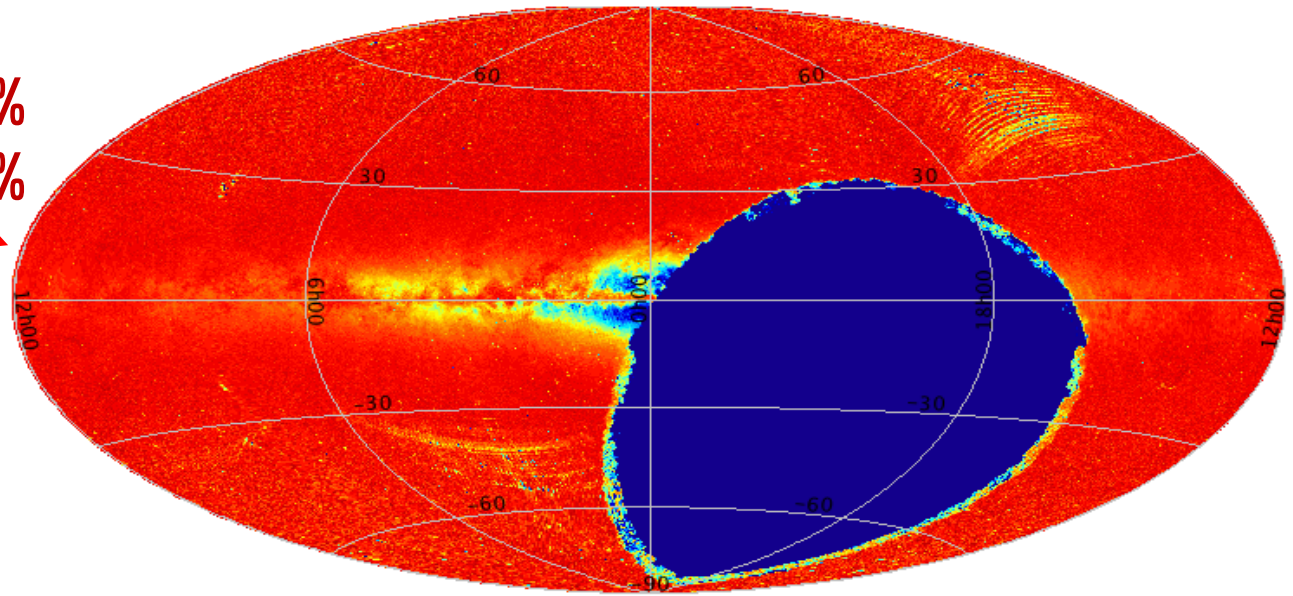
XM results:

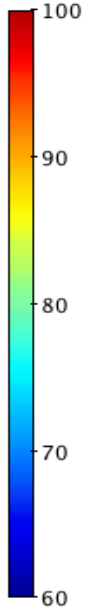
810 359 898 80.5%

887 805 323 88.2%



Threshold 40 mas, broadening 40 mas





FUTURE

DR3:
SSDC Gaia
Cross-match
tool →

Spectroscopic surveys

M dwarfs catalogues

RR Lyrae catalogues

XM basic | XM advanced | Query Results

WARNING

The cross-match of Gaia with several surveys is computed and available in
QUERY => XMatched External Catalogues

Spectral domain

Radio | IR | Optic. | UV | EUV | X-ray | γ-ray

Cross-Match Algorithm

● Nearest neighbours [Gaia *vs* UserCat]

Algorithm parameters

Searching radius: ____ (arcsec)

● Apply GaiaCat PM
○ Apply UserCat PM

Upload your catalogue

Input file: ____

Help | Browse | UPLOAD

csv format with mandatory fields:
ID, RA [deg], DEC [deg], errRA [mas], errDEC [mas], Epoch [Jul.yr]

Output setup

Format
○ csv
○ fits
○ VOtable

Gaia columns
☐ ALL
☐ RA [deg]
☐ err.RA
☐ DEC [deg]
☐ err.DEC
☐ G_{band} [mag]
☐ …
☐ …

Download
■ bestNeighbour
☐ Neighbourhood

Reset Query Form | SUBMIT Query

GARBG

GaiaPortalDR2@SSDC

Gaia DR2 @ SSDC: Architecture and Database Design for data access

General Requirements:

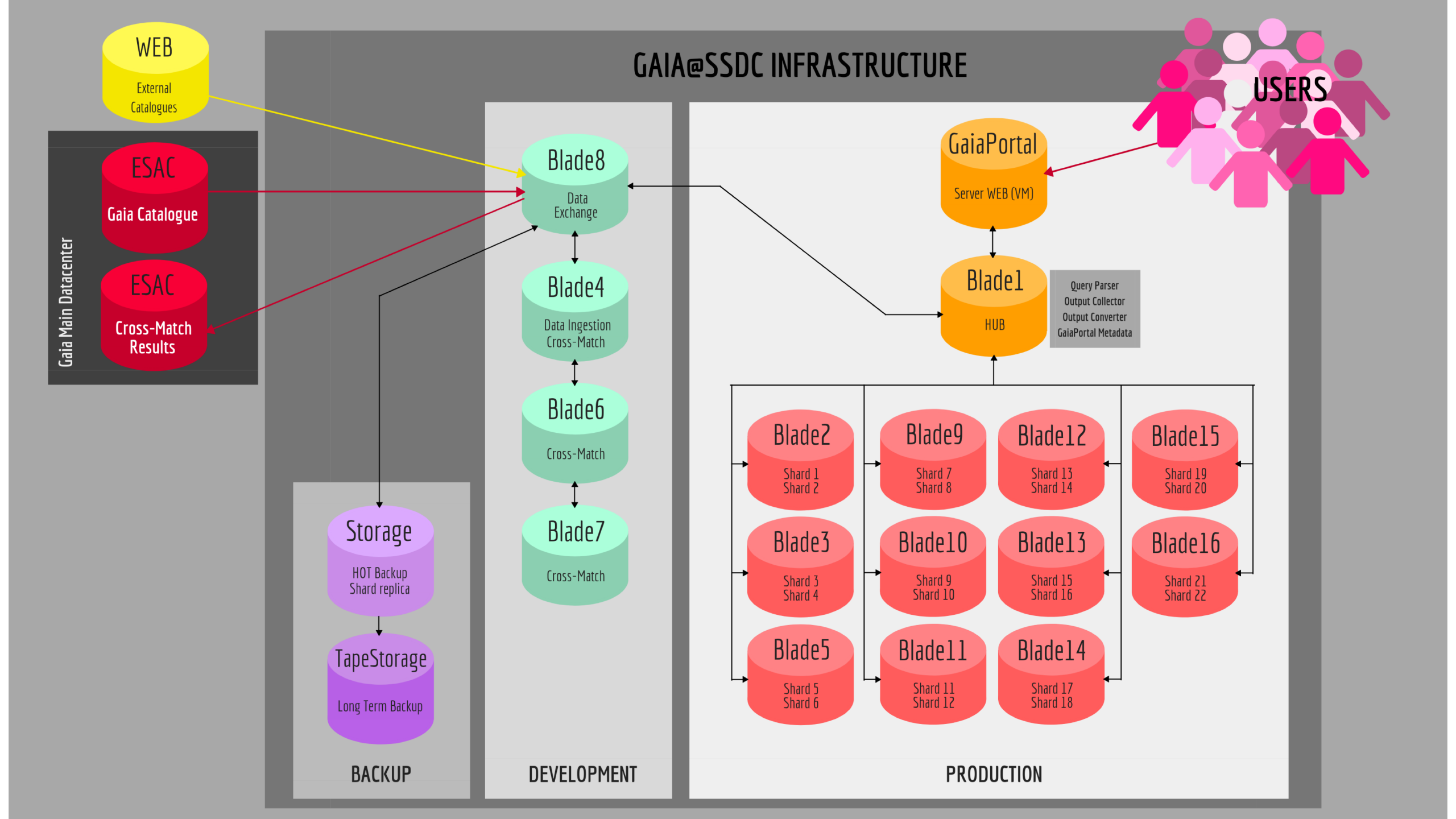
1. **scalability** :
   at each Release, more data will be published
2. **complexity** :
   combinatin of different surveys
   catalogue contents + epoch data
3. **query flexibility** :
   no typical queries, but variety of scientific cases
4. **static archive** :
   no frequent updates (needed only for adding new catalogues and / or new releases)

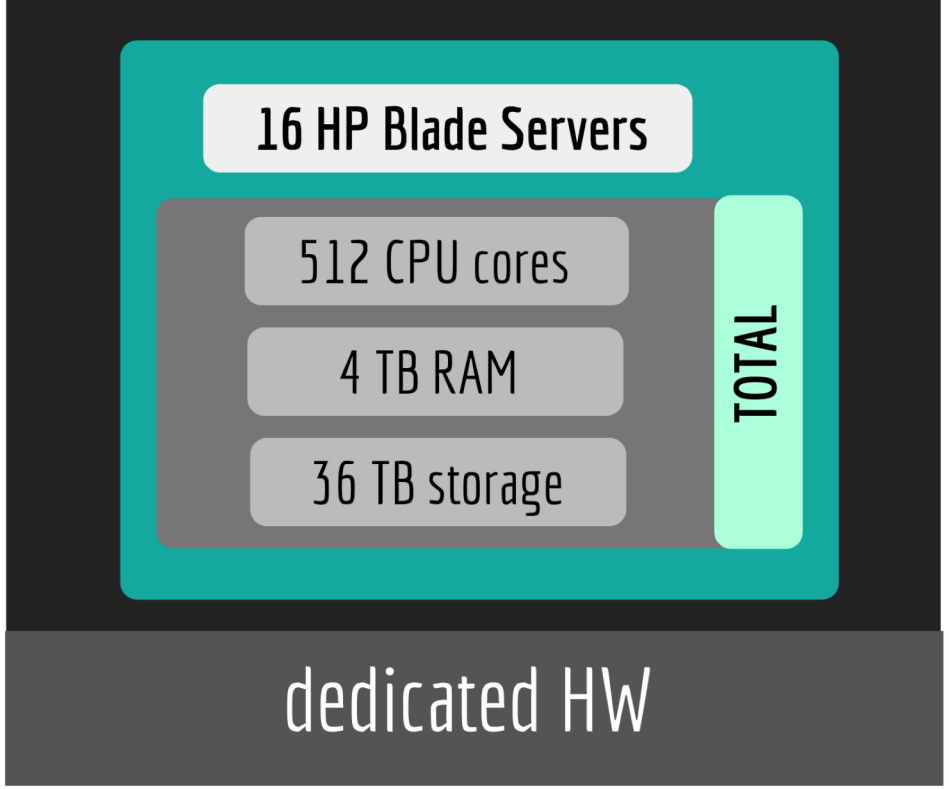
Requirements for data access:

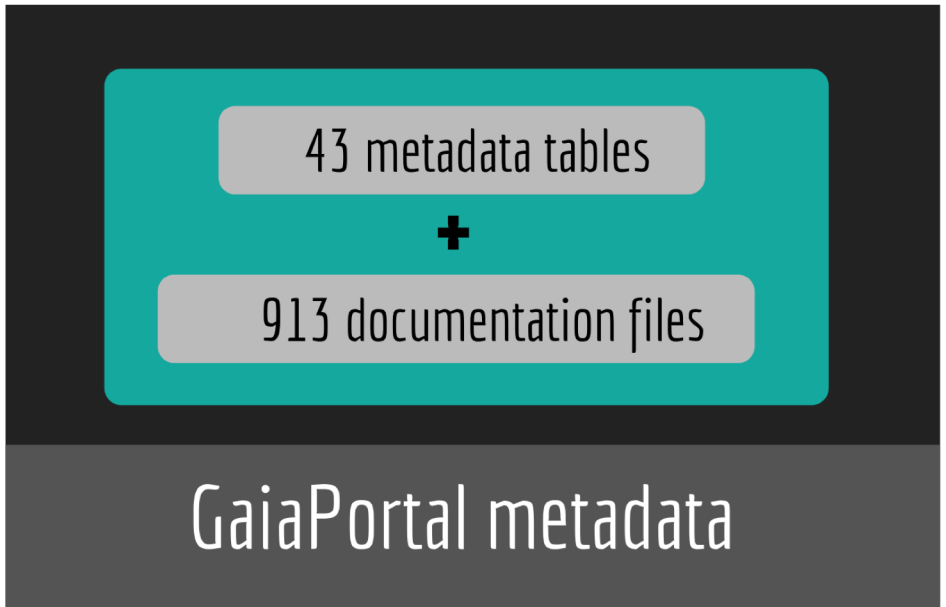
1. read-intensive use of the database
2. complex queries

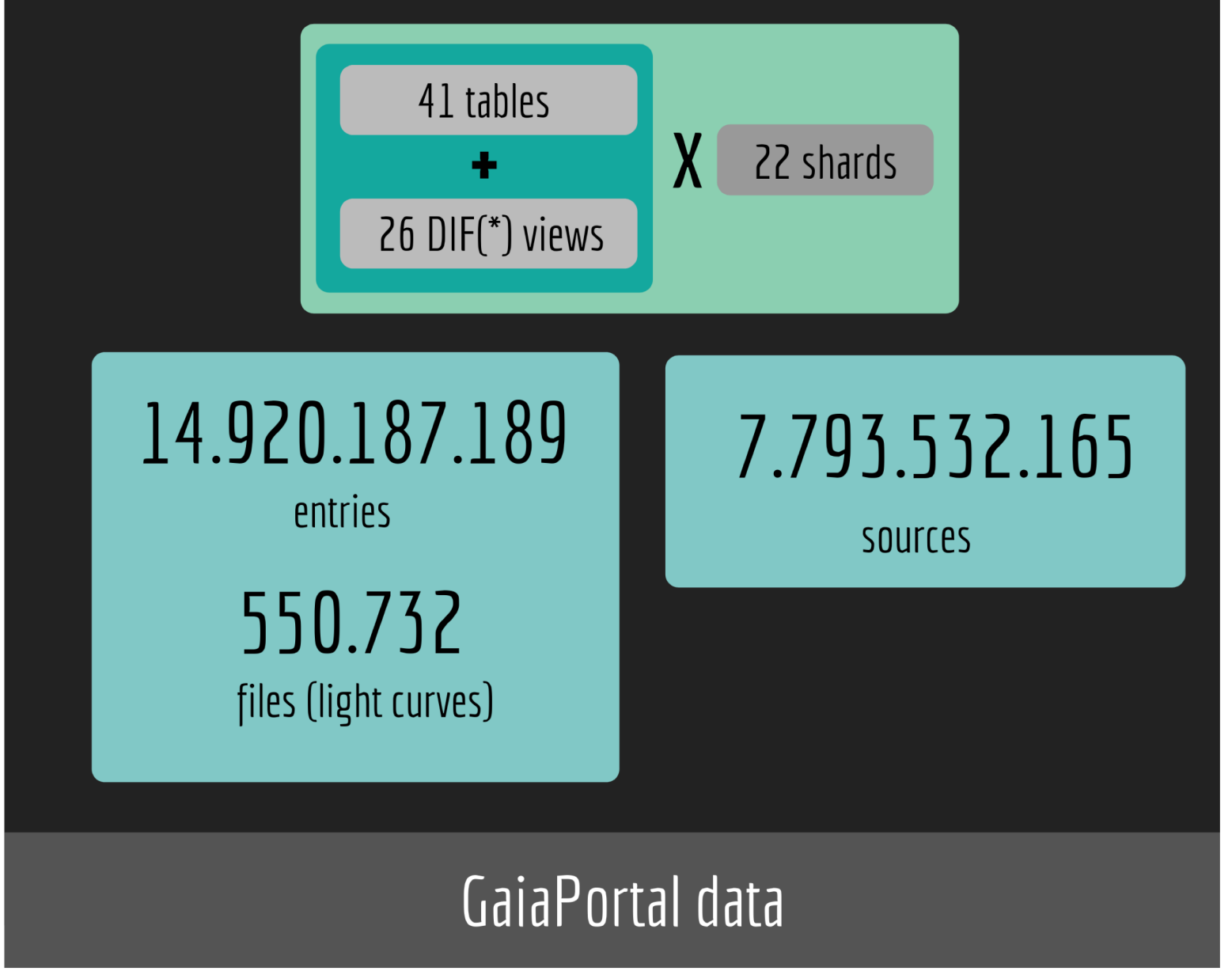
Solution adopted for data access:

- distributed and scalable system (Blade HP Gen8+Gen9)
- Shared-Nothing paradigm:
  - each node is independent and autonomous (no shared RAM and storage)
  - horizontally-distributed data and paralle queries (DB sharding, no join between different nodes)
- relational DBMS: MariaDB
  - efficient join
  - engines MyISAM, XtraDB/InnoDB, TokuDB, FederatedX -› **flexibility, highly configurable and customizable**
  - data size reduction: normalization
  - data redundancy: very limited (shards "edges")
  - small tables
  - small indices


GAIA@SSDC INFRASTRUCTURE
WEB
External Catalogues
Gaia Main Datacenter
ESAC
Gaia Catalogue
ESAC
Cross-Match Results
USERS
Blade8
Data Exchange
Blade4
Data Ingestion Cross-Match
Blade6
Cross-Match
Blade7
Cross-Match
GaiaPortal
Server WEB (VM)
Blade1
HUB
Query Parser
Output Collector
Output Converter
GaiaPortal Metadata
Blade2
Shard 1
Shard 2
Blade9
Shard 7
Shard 8
Blade12
Shard 13
Shard 14
Blade15
Shard 19
Shard 20
Blade3
Shard 3
Shard 4
Blade10
Shard 9
Shard 10
Blade13
Shard 15
Shard 16
Blade16
Shard 21
Shard 22
Blade5
Shard 5
Shard 6
Blade11
Shard 11
Shard 12
Blade14
Shard 17
Shard 18
Storage
HOT Backup
Shard replica
TapeStorage
Long Term Backup
BACKUP
DEVELOPMENT
PRODUCTION

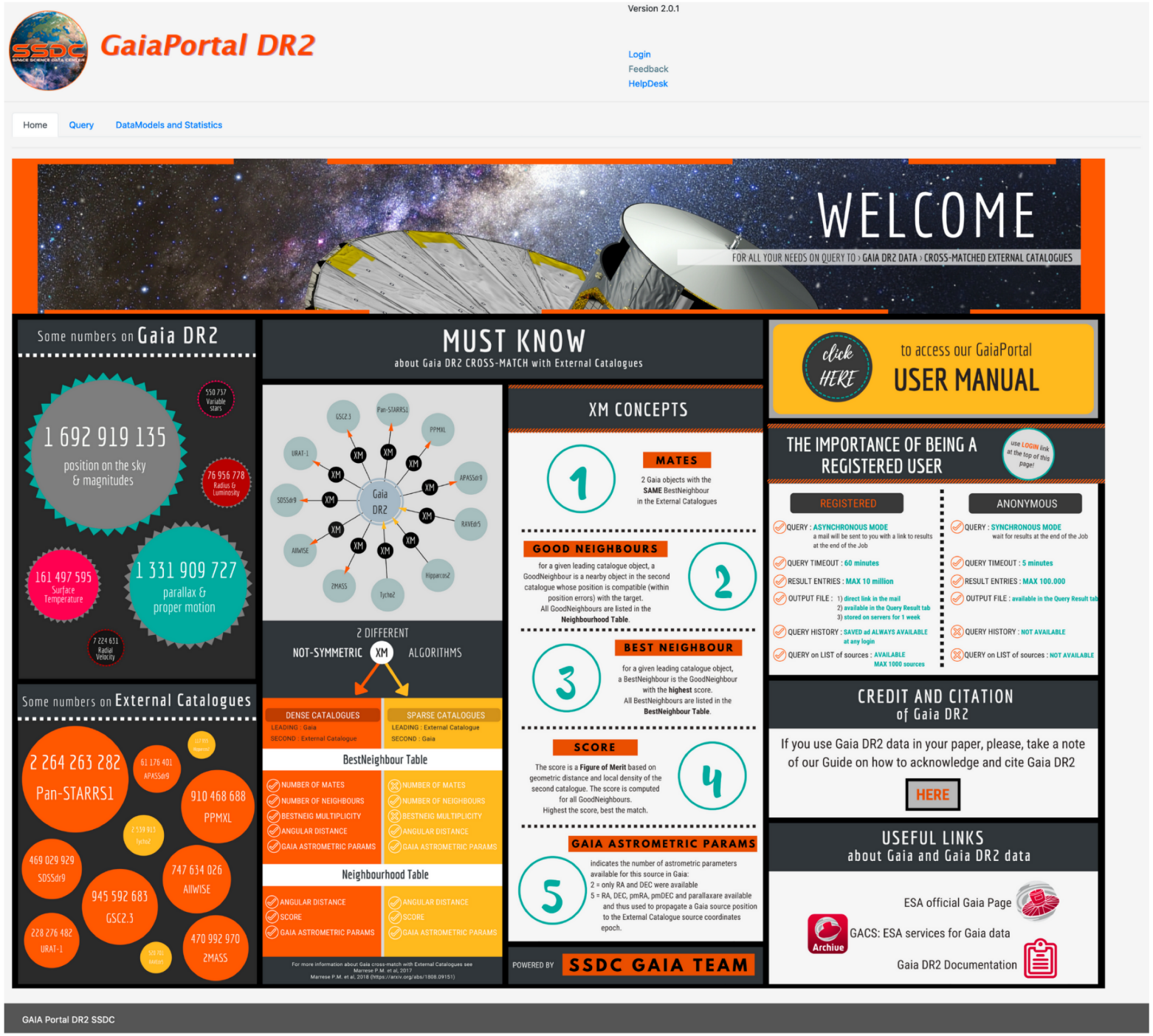






GaiaPortalDR2@SSDC

(*) DIF: Calderone & Nicastro, http://ross.iasfbo.inaf.it/MCS/



GaiaPortalDR2@SSDC
data access

gaiaportal.ssdc.asi.it

HOME page

Basic info on Gaia DR2 and External Catalogues
Basic info on Cross-match
Useful links: user manual, official DR2 documentation, ESA official page, GACS (main Gaia datacenter),...

QUERY form

allows users to query quickly and easily:

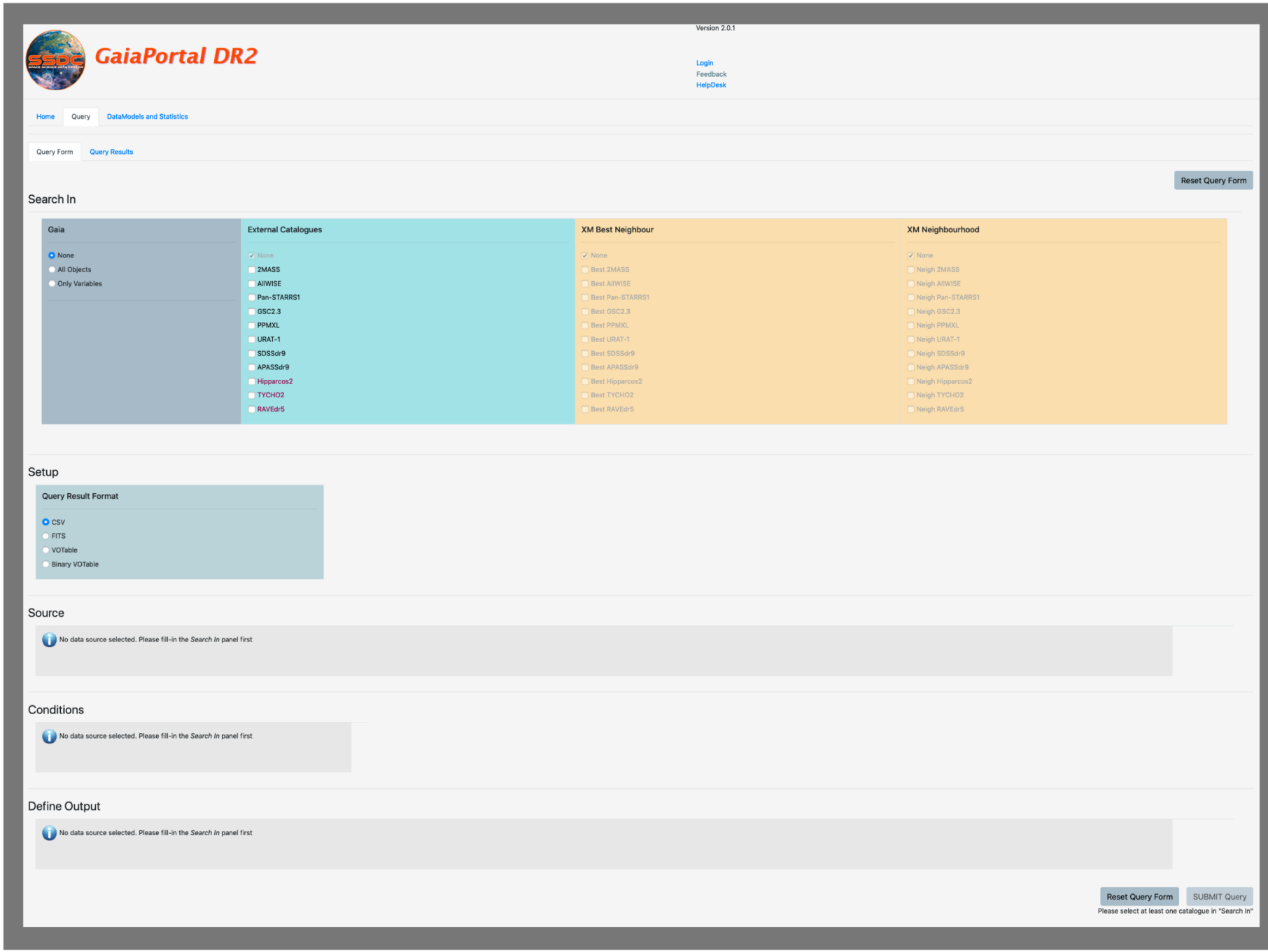
- Gaia DR2 data
- External catalogues
- both simultaneously through the cross-match results

without worrying neither to have in depth knowledge on the structure and organization of the data in the database, nor to correctly write intricate SQL based queries.

Datamodels and Statistics

offers an easy way to navigate through the documentation of all tables available via Query Form

GaiaPortalDR2@SSDC
Query form



Which catalogue(s)?

Which format for the query output?

Are you interested in specific objects?

Do you want to apply some filters?

Define the output content

GaiaPortalDR2@SSDC
Query form

Example: select in GaiaDR2:
- all type RRab RRLyrae
- in a circle of 2 degrees radius centered on Omega Centauri
- having a counterpart in 2MASS and in AllWISE

obtaining in output:
- Gaia DR2 ID, position, proper motion, parallax, and magnitudes
- 2MASS counterparts IDs and magnitudes
- AllWISE counterparts IDs and magnitudes
- angular distance between the source in Gaia and its counterparts in 2MASS and AllWISE

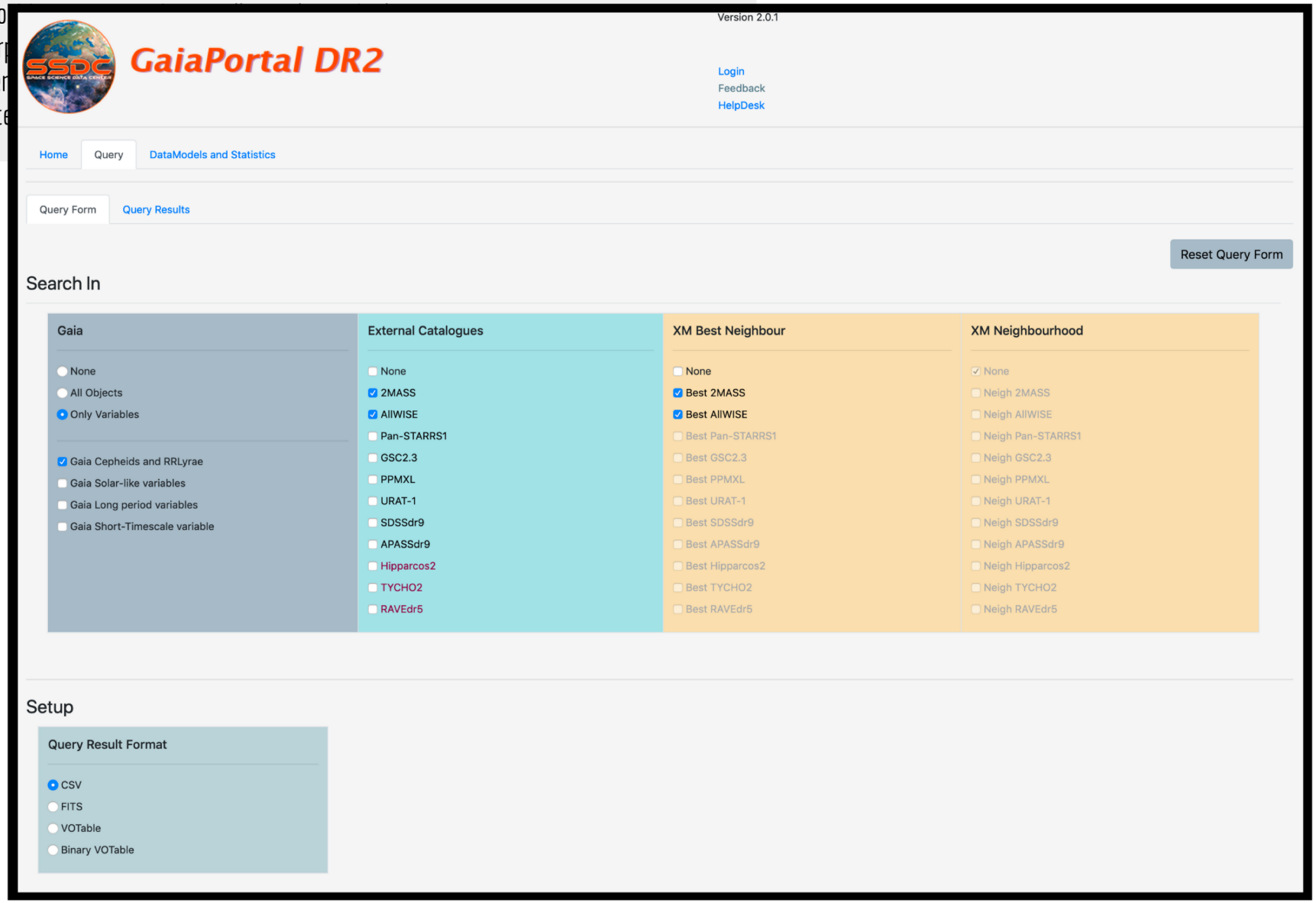
Advanced query (ADQL) via TAP:

```
SELECT gaia.source_id, gaia.ra, gaia.dec, gaia.parallax, gaia.pmra, gaia.pmdec,
       rr.int_average_g, rr.int_average_bp, rr.int_average_rp,
       besttmass.original_ext_source_id, tmass.j_m, tmass.h_m, tmass.ks_m,
       bestwise.original_ext_source_id, wise.w1mpro, wise.w2mpro, wise.w3mpro, wise.w4mpro,
       bestwise.angular_distance, besttmass.angular_distance
FROM  gaiadr2.gaia_source AS gaia
JOIN gaiadr2.vari_rrlyrae  AS rr ON gaia.source_id=rr.source_id
JOIN gaiadr2.allwise_best_neighbour AS bestwise ON bestwise.source_id=gaia.source_id
JOIN gaiadr1.allwise_original_valid AS wise ON wise.allwise_oid=bestwise.allwise_oid
JOIN gaiadr2.tmass_best_neighbour AS besttmass ON besttmass.source_id=gaia.source_id
JOIN gaiadr1.tmass_original_valid AS tmass ON tmass.tmass_oid=besttmass.tmass_oid
WHERE rr.best_classification='RRab'
AND 1=CONTAINS(POINT('ICRS',gaia.ra,gaia.dec),CIRCLE('ICRS',201.69700,-47.47947 ,2.0))
```

GaiaPortalDR2@SSDC
Query form

Example: select in GaiaDR2:
- all type RRab RRLyrae
- in a circle of 2 degrees radius centered on Omega Centauri
- having a counterpart in 2MASS and in AllWISE

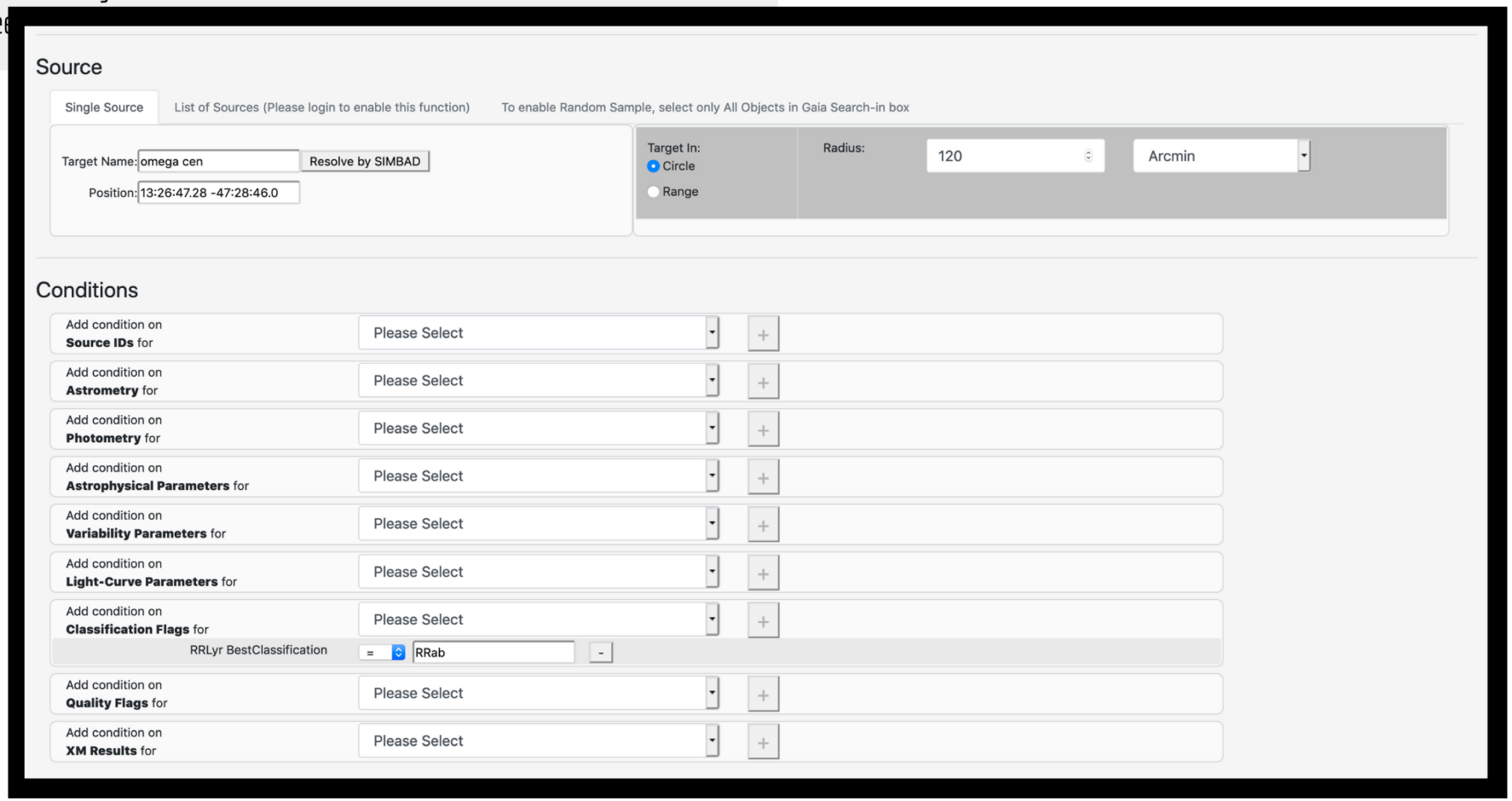
obtaining in output:
- Gaia DR2 ID, po
- 2MASS counterp
- AllWISE counter
- angular distance



GaiaPortalDR2@SSDC
Query form

Example: select in GaiaDR2:
- all type RRab RRLyrae
- in a circle of 2 degrees radius centered on Omega Centauri
- having a counterpart in 2MASS and in AllWISE

obtaining in output:
- Gaia DR2 ID, position, proper motion, parallax, and magnitudes
- 2MASS counterparts IDs and magnitudes
- AllWISE counterparts IDs and magnitudes
- angular distance betwee



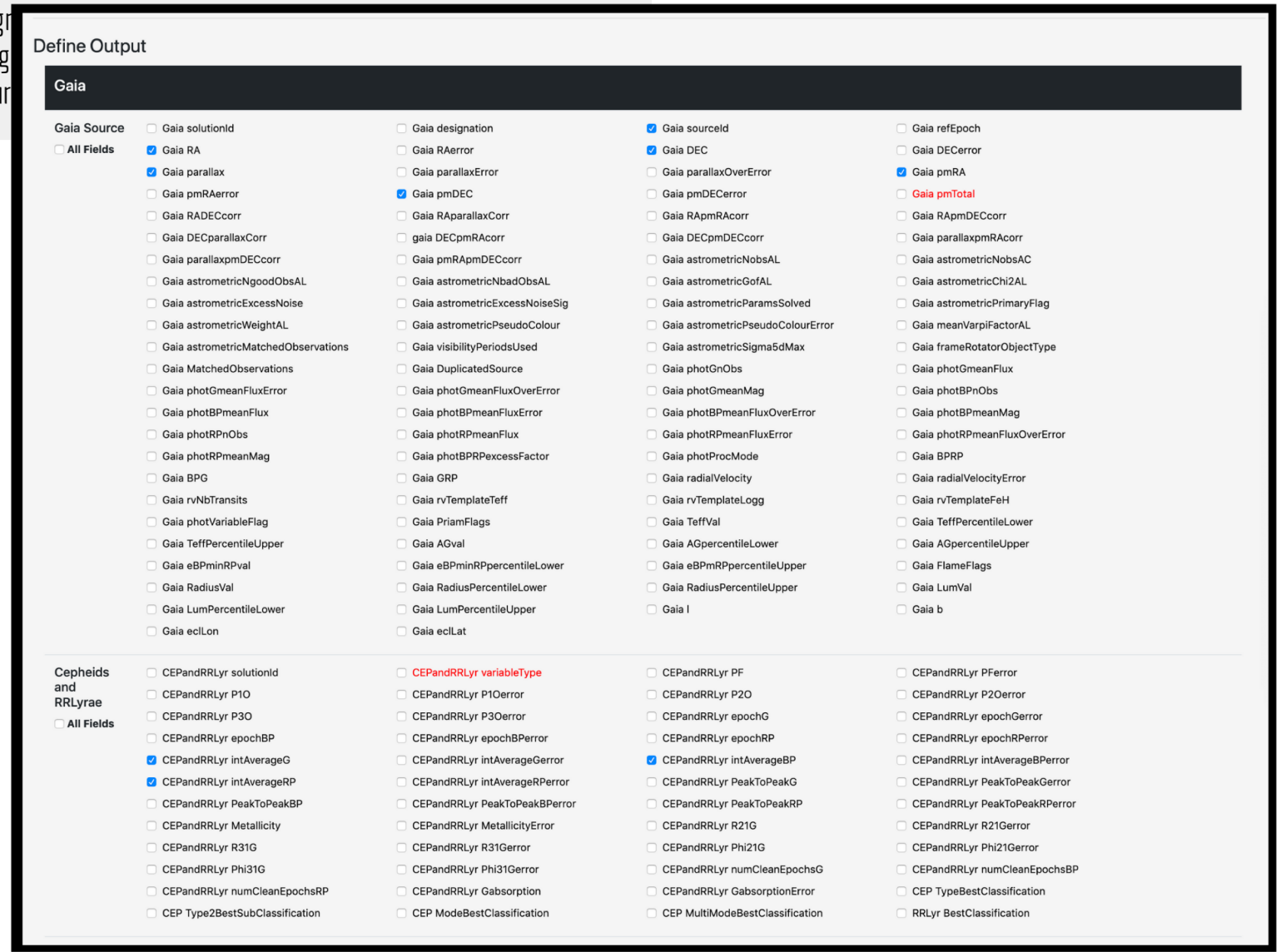
GaiaPortalDR2@SSDC
Query form

Example: select in GaiaDR2:

- all type RRab RRLyrae
- in a circle of 2 degrees radius centered on Omega Centauri
- having a counterpart in 2MASS and in AllWISE

obtaining in output:

- Gaia DR2 ID, position, proper motion, parallax, and magnitudes
- 2MASS counterparts IDs and magr
- AllWISE counterparts IDs and mag
- angular distance between the sour

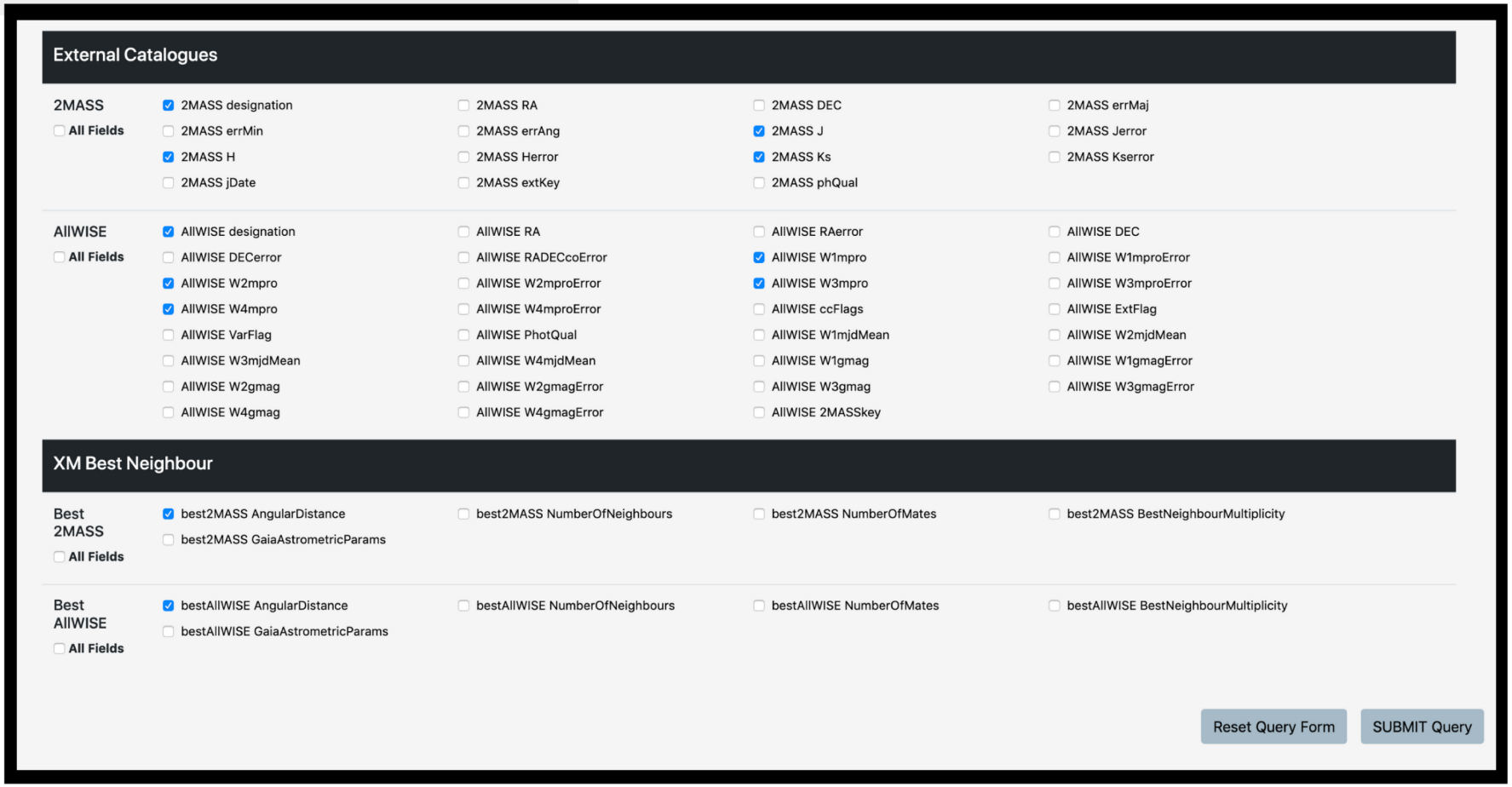


GaiaPortalDR2@SSDC
Query form

Example: select in GaiaDR2:
- all type RRab RRLyrae
- in a circle of 2 degrees radius centered on Omega Centauri
- having a counterpart in 2MASS and in AllWISE

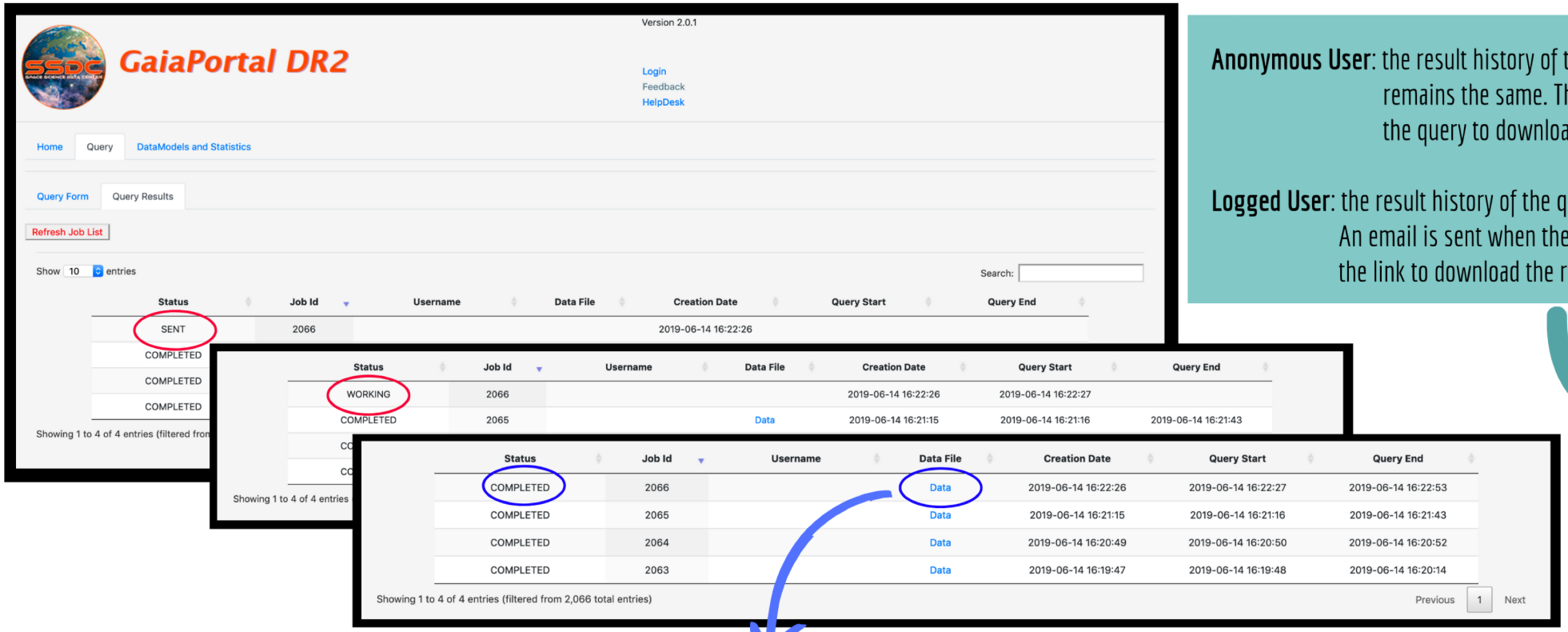
obtaining in output:
- Gaia DR2 ID, position, proper motion, parallax, and magnitudes
- 2MASS counterparts IDs and magnitudes
- AllWISE counterparts IDs and magnitudes
- angular distance between the source in Gaia and its counterparts in 2MASS and AllWISE

SUBMIT Query:
the chosen parameters are passed to the Query Parser which deals with the composition of a syntactically correct mySQL query.
The query is then launched on the shards.
Once the query ends, the output is converted into the user desired format.



GaiaPortalDR2@SSDC
Query results

When the user selects the **SUBMIT Query** button, the **Query Results tab** opens automatically



Anonymous User: the result history of the queries is available until the session remains the same. The user must wait online the conclusion of the query to download the results file

Logged User: the result history of the queries is always available.
An email is sent when the job is completed, containing the link to download the result tarfile

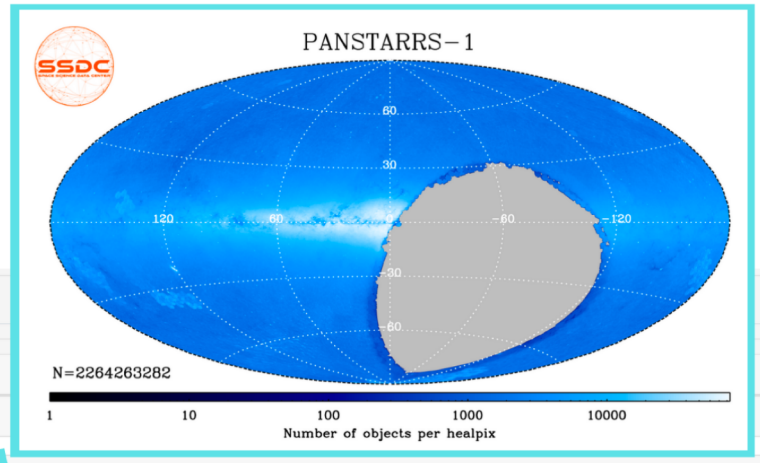
More info in *Home page* & *User Manual*

result_ST-166-H7MR3HtIzhLIPvzisP6U_JOB2066.csv — Apri con NEdit Droplet

gaiaSource_sourceId	gaiaSource_ra	gaiaSource_decl	gaiaSource_parallax	gaiaSource_pmra	gaiaSource_pmdec	gaiaCEPandRRLyr_intAverageG	gaiaCEPandRRLyr_intAverageBp	gaiaCEPandRRLyr_intAverageRp	tmass_designation	tmass_jM	tmass_hM	tmass_ksM	allwise_designation	allwise_w1mpro	allwise_w2mpro	allwise_w3mpro
6083694426040492160	201.2774905190935	-47.39269285128559	0.07998490387319197	-3.772457816293659	-6.747240536805663	14.289011413684651	14.547407825390009	13.82178506070356	13250660-4723335	13.179	12.906	12.762	J132506.59-472333.6	12.884	12.91	12.439
6082592951578172032	202.29536138199725	-48.89349157190899	0.052200422537904634	0.5287700064726006	-1.7936629042859102	16.33002880597719	16.631504489875045	15.876671571617253	13291087-4853366	15.586	15.141	15.21	J132910.89-485336.7	14.911	15.108	13.111
6086786871183499904	200.7447374941185	-46.79010884845046	0.1884669489654821	-16.473888141568587	-4.321672828973421	14.509213208596321	14.698162678490297	14.129037010704874	13225876-4647243	13.426	13.295	13.321	J132258.74-464724.3	13.277	13.265	12.281
6083688103848450816	201.28278500445057	-47.61496368085445	0.012885108172077189	-3.2386532050355585	-7.265373560030717	14.299012178760655	14.597819720224237	13.809046409149321	13250786-4736537	13.268	12.869	12.81	J132507.87-473653.7	12.75	12.778	12.327
6083723219505712000	201.88685252748897	-47.228731006504546	0.3025802843184476	-3.358895387897041	-6.62841878074212	14.305048235969211	14.53171240507106	13.837884192656976	13273284-4713432	13.414	13.134	13.062	J132732.84-471343.2	12.762	12.754	12.711
6087145380693992704	200.79303891630067	-45.59694947780802	0.0347792548033015 9	-13.68956820471773	-0.3489209071390013 7	14.26866108743078	14.456653543152015	13.901601537918342	13231035-4535489	13.391	13.147	13.245	J132310.33-453548.9	13.147	13.141	12.523
6083516438277274112	201.95178705098454	-47.472436888224955	0.17406230429512393	-2.953167357011476	-7.085471894829982	14.639585776420454	14.925612608819259	14.177022333423746	13274843-4728206	13.462	13.331	13.227	J132748.42-472820.5	13.261	13.424	12.802
6083716381917325056	201.59789804527801	-47.31338597772277	0.18722655251872186	-2.967680272902375	-5.996999012437295	14.25193761555466	14.520296433165656	13.775068449919239	13262349-4718481	13.23	12.911	12.8	J132623.49-471848.0	12.784	12.86	12.783
6083901443435439232	202.5003244118268	-47.21825244384749	-0.011402089229550239	-6.812043824061973	-0.3047144677375374	15.907313165044698	16.18907372907801	15.408109665343774	13300009-4713057	14.987	14.638	14.546	J133000.08-471305.5	14.398	14.417	12.651
6083514106115158656	202.1044551819324	-47.49026290660533	0.17314381734405343	-3.505307973648123	-6.762901870492113	14.548017620421723			13282507-4729247	13.31	13.096	13.059	J132825.06-472924.8	13.041	13.063	12.987
6085116468203901824	198.94185051175705	-48.14150795160573	0.1996889571109965	0.22732900202187586	0.0012639616434013171	17.028658784782653	17.331692971566653	16.580308719861044	13154603-4808294	16.007	15.571	15.553	J131546.03-480829.5	15.646	15.627	12.98

GaiaPortalDR2@SSDC

Datamodels and Statistics



Home | Query | DataModels and Statistics

- Gaia DR2
- External Catalogues
  - 2MASS (number of sources: 470.992.970)
  - AllWISE (number of sources: 747.634.026)
  - Pan-STARRS1 (number of sources: 2.264.263.282)

Table Info

	Column Name in DB	Column Name in Query Form	Short Description	Column Unit	Column Origin	Min Value	Max Value	Barplot NotNull/Null	Histogram	Long Description
1	objName	Pan-STARRS1 ObjName	IAU name for this object		original					Info
2	objId	Pan-STARRS1 ObjID	Unique Object Identifier		original					Info
3	ra	Pan-STARRS1 RA	Mean Right Ascension	deg	original	0	360			Info
4	raError	Pan-STARRS1 RAerror	Standard deviation on Mean Right Ascension	arcsec	original	0.000019	0.999990		Histo	Info
5	decl	Pan-STARRS1 DEC	Mean Declination	deg	original	-35	90			Info
6	decError	Pan-STARRS1 DECerror	Standard deviation on Mean Declination	arcsec	original	0	0.999990		Histo	Info
7	epochMean	Pan-STARRS1 EpochMean	Mean Epoch	day	original	50624.21840278	57078.40429398		Histo	Info
8	gMeanPsfMag	Pan-STARRS1 gMeanPSFmag	Mean PSF magnitude in g filter (in mag)	mag	original	-32.69	32.55	BarPlot	Histo	Info
9	gMeanPsfMagError	Pan-STARRS1 gMeanPSFmagError	Error in Mean PSF magnitude in g filter (in mag)	mag	original	0	0.5	BarPlot	Histo	Info
10	gFlags	Pan-STARRS1 gFlags	g filter flags		original					Info
11	rMeanPsfMag	Pan-STARRS1 rMeanPSFmag	Mean PSF magnitude in r filter (in mag)	mag	original	-6.54	29.55	BarPlot	Histo	Info
12	rMeanPsfMagError	Pan-STARRS1 rMeanPSFmagError	Error in Mean PSF magnitude in r filter (in mag)	mag	original	0	0.5	BarPlot	Histo	Info
13	rFlags	Pan-STARRS1 rFlags	r filter flags		original					Info
14	iMeanPsfMag	Pan-STARRS1 iMeanPSFmag	Mean PSF magnitude in i filter (in mag)	mag	original	-4.93	29.13	BarPlot	Histo	Info
15	iMeanPsfMagError	Pan-STARRS1 iMeanPSFmagError	Error in Mean PSF magnitude in i filter (in mag)	mag	original	0	0.5	BarPlot	Histo	Info

GAIA Portal DR2 SSDC

panstarrs1

Reference: Chambers et al. (2016), Waters et al. (2016), Magnier et al. (2016a), Magnier et al. (2016b), Magnier et al. (2016c), Flewelling et al. (2016)

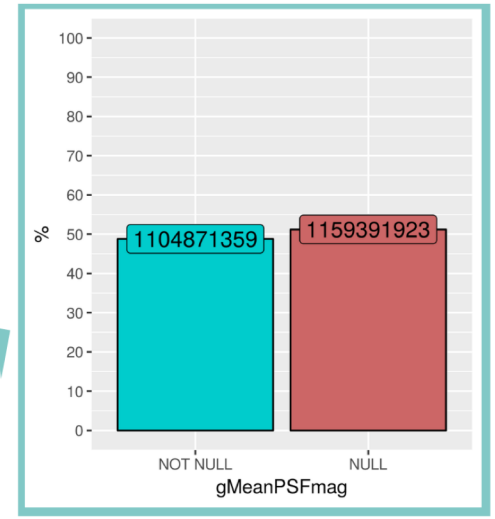
Original Catalogue:

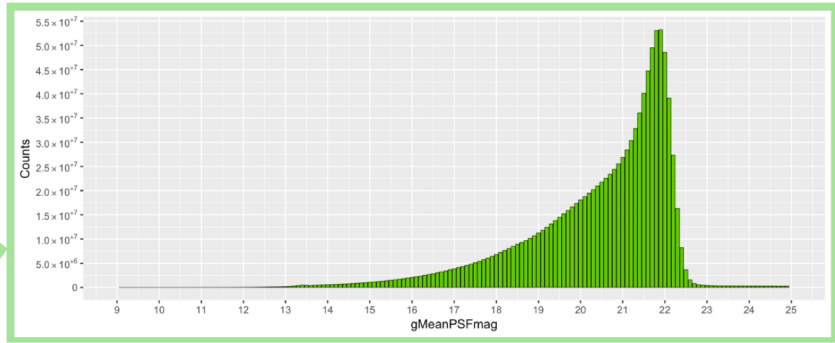
- Available via CasJob here
- Documentation available here

The Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) is a system for wide-field astronomical imaging developed and operated by the Institute for Astronomy at the University of Hawaii. Pan-STARRS1 (PS1) is the first part of Pan-STARRS to be completed and is the basis for Data Release 1.
The PS1 survey used a 1.8 meter telescope and its 1.4 Gigapixel camera to image the sky in five broadband filters (g, r, i, z, y).
The current table contains a filtered subsample of the 10.723.304.629 entries listed in the original `ObjectThin` table. We used only `ObjectThin` and `MeanObject` tables to extract this table, this means that objects detected only in stack images are not included here. The main reason for us to avoid the use of objects detected in stack images is that their astrometry is not as good as the mean objects astrometry: the stack positions (`raStack`, `decStack` in the original tables) have considerably larger systematic astrometric errors than the mean epoch positions (`raMean`, `decMean`). The astrometry for the `MeanObject` positions uses Gaia DR1 as a reference catalog, while the stack positions use 2MASS as a reference catalog.
In details, we filtered out all objects where:

- `nDetections` = 1
- no good quality data in Pan-STARRS: `objInfoFlag` 33554432 not set
- mean astrometry could not be measured: `objInfoFlag` 524288 set
- stack position used for mean astrometry: `objInfoFlag` 1048576 set
- error on all magnitudes equal to 0 or to -999
- all magnitudes set to -999
- error on RA or DEC greater than 1 arcsec.

The number of objects in our Pan-STARRS1 table is 2.264.263.282.
The Pan-STARRS1 table contains only a subset of the columns available in the combined `ObjectThin` and `MeanObject` tables.
A description of the original `ObjectThin` and `MeanObject` tables can be found here.





gFlags

Information flag bitmask for mean object from g filter detections (from original table `MeanObject`).
Flag values and descriptions are:

- **1** = Used within relphot (FEW): skip star.
- **2** = Used within relphot (POOR): skip star.
- **4** = Synthetic photometry used in average measurement.
- **8** = Ubercal photometry used in average measurement.
- **16** = PS1 photometry used in average measurement.
- **32** = PS1 stack photometry exists.
- **64** = Tycho photometry used for synthetic magnitudes.
- **128** = Synthetic magnitudes repaired with zeropoint map.
- **256** = Average magnitude calculated in 0th pass.
- **512** = Average magnitude calculated in 1th pass.
- **1024** = Average magnitude calculated in 2th pass.
- **2048** = Average magnitude calculated in 3th pass.
- **4096** = Average magnitude calculated in 4th pass.
- **8192** = Extended in this band (PSPS only).
- **16384** = PS1 stack photometry comes from primary skycell.

GaiaPortal@SSDC: the future

DR3

- multi-frequency Cross-Match tool:
  cross-match small catalogues or user-defined list of sources with Gaia data choosing among different algorithms and figures of merit

- visualization tool for Gaia photometric epoch data:
  to visualize light-curves in the three Gaia bands

- computation and visualization tool for Gaia BP and RP spectra

- TAP access:
  MySQL translator + management of multiple connections

Waiting for

GAIA eDR3 DATA

Stay tuned !

Work in progress!

MID 2020

save the date!

SSDC
SPACE SCIENCE DATA CENTER

SSDC Gaia team

Gaia SSDC Table Access Protocol

- Starting point: **TAPLib 2.0** (AUG 2016) available on https://github.com/gmantele/taplib
- Inclusion of a ***MySQL*** translator task
  - *Mathematical and trigonometric functions*
  - *JOIN and subqueries*
  - *Search conditions (WHERE, HAVING, ORDER BY, GROUP BY)*
- Geometrical functions based on ***MySQL-SPHERE + d****ynamic* ***i****ndex* ***f****acility (****dif****) allowing a fast query execution on large tables -> AREA, BOX, CIRCLE...*
- Management of **multiple connections** by using the same DB structure of GaiaPortal (Java code)

On going:

Tests on DR2 data (sync/async)

Java code optimization

Future: *Service registration and publication to the VO*

A priori knowledge vs prejudice

2MASS is bright all sources should have a Gaia counterpart

XM results (best neighbours)
450 688 227 matches out of 470 992 970 sources
missed ~20 million 2MASS sources (4.3 %)

- red dots Gaia DR2 sources
- yellow rombs 2MASS PSC sources