Building a master catalogue of unique UV sources

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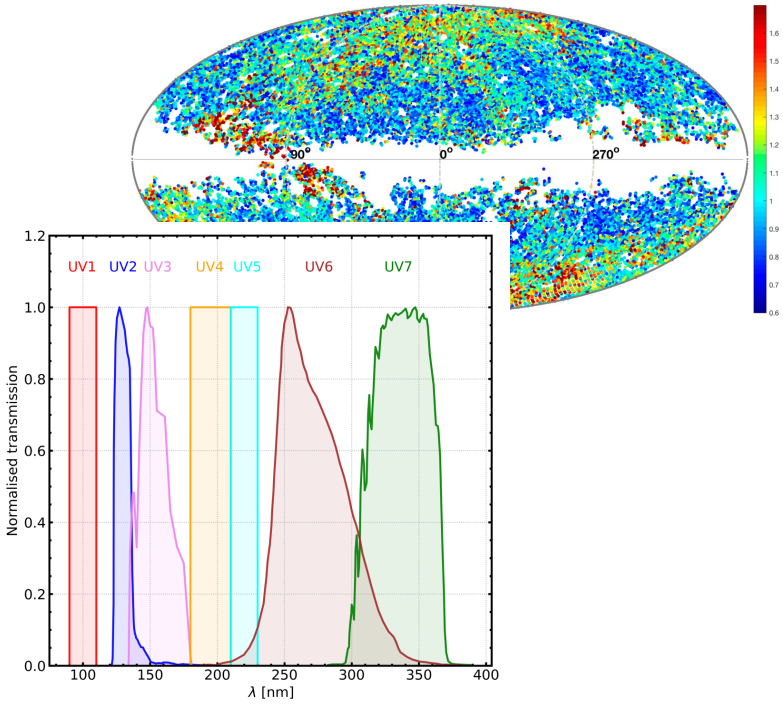
Outline

- Introduction.
- The catalogue.
- The infrastructure.
- Testing through use cases and future work.

Introduction

- UV data is fundamental in many areas of astrophysical research, but there are some **obstacles**,
- The lack of UV standards of reference.
- Existing UV data is dispersed along a variety of photometric and spectral measurements coming from a variety of space missions.



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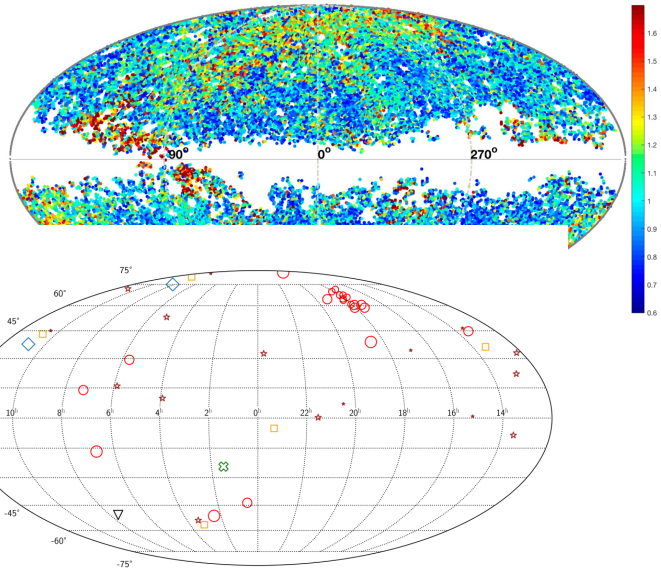

The definition of a standard photometric system in UV astronomy was a first step in overcoming these issues.

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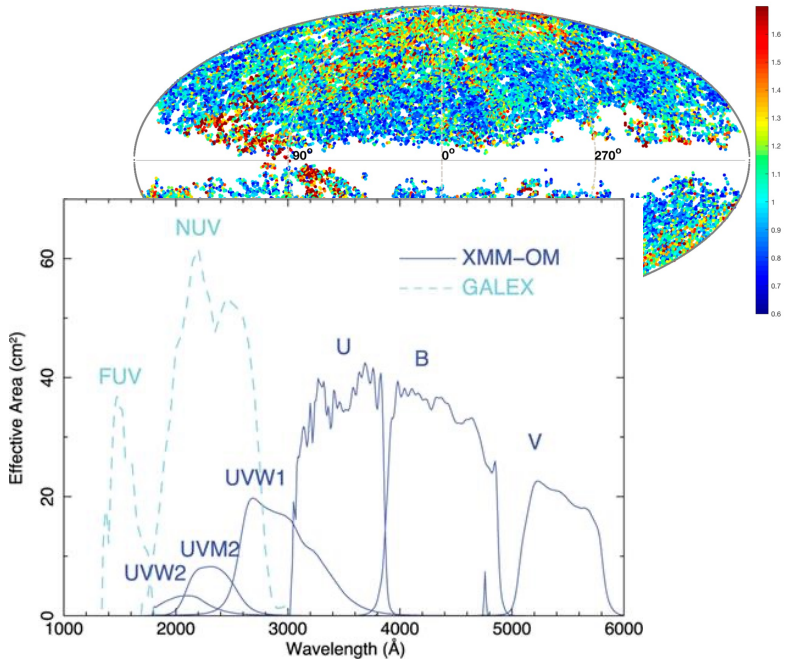
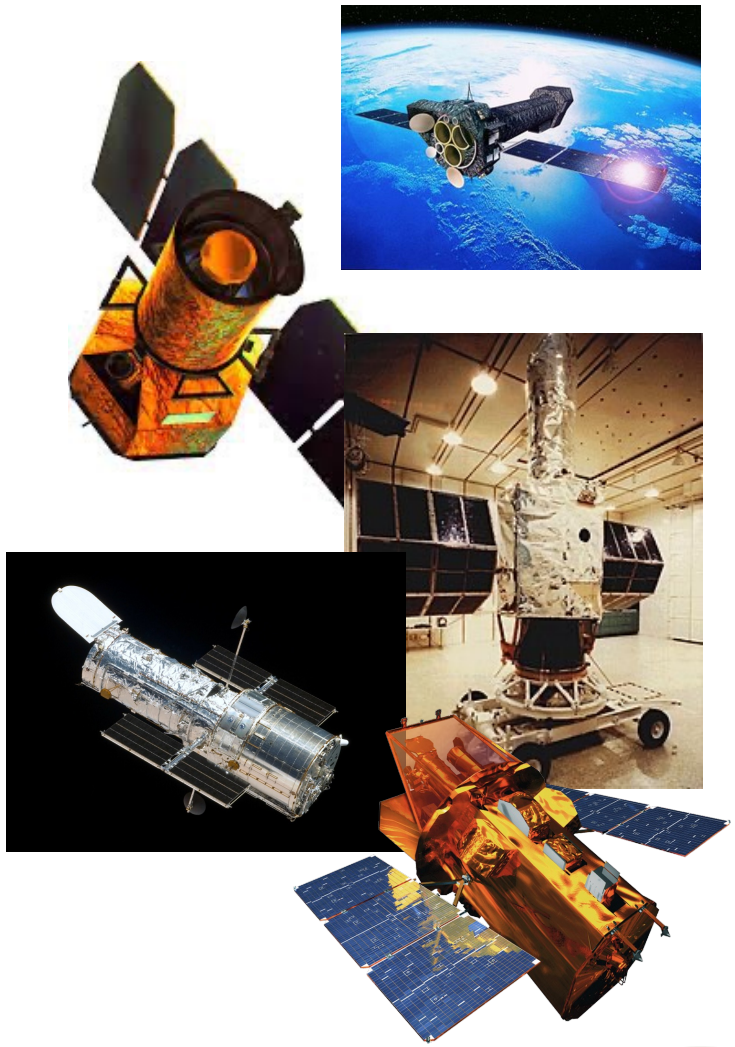


Next step…

Variety of sources

- **UV data** heavily rely on space missions. Their archives are the legacy of the past (and present) missions.
- Classic/old catalogues (UV?) were designed as **standalone archives**: isolation.
- Existing facilities (such as cross match from Vizier, MAST discovery portal, standard libraries for accessing modern archives) help to **mitigate this** isolation.



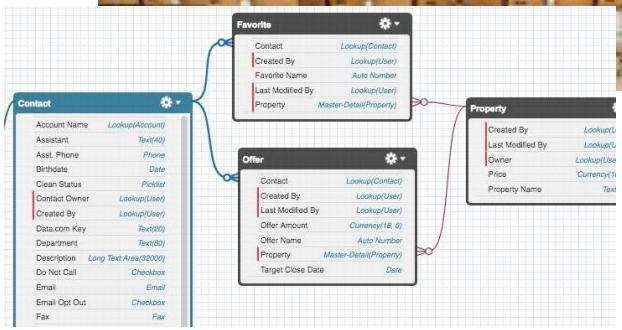
The catalogue

The catalogue

- Hence, AEGORA research group has started the process of creating a master list of **unique UV astronomical sources**.

- This list of unique sources is correlated with an UV-focused approach.

- **Matched metadata allow the extraction of information from parent catalogues.** This will enhance the usefulness of the list and re-enables the science value of old archives/catalogues.



The catalogue (II)

- The catalogue is made up of two main tables,
- **Master**, that contains the list of unique UV sources processed from the other UV catalogues
- **Cross Match**, that collects the information from the master with the rest of the UV catalogues, and it is required as an intermediary to perform massive searches.

- …plus several mission specific tables.

The Master, currently contains 105,864,244 unique UV sources (Id, Ra, Dec, Common Name, Ancillary).
The cross match contains 20,311,662 entries.

The mission tables

CAT_(CATALOGUE_VERSION)

Catalogue	***Data*** (see ***cross_observation***)	***Type*** (see ***cross_observation_type***)
CAT_GALEX_V2	Sources	Photometry and Spectroscopic
CAT_HSC_V0	Sources	Photometry
CAT_HST_V0	Observations	Photometry and Spectroscopic
CAT_HST_V0_D1	Observations	Photometry and Spectroscopic
CAT_IUE_V6	Observations	Spectroscopic
CAT_OM_V2	Sources	Photometry
CAT_SWIFTOBS_V0	Observations	Photometry
CAT_SWIFTSC_V0	Sources	Photometry

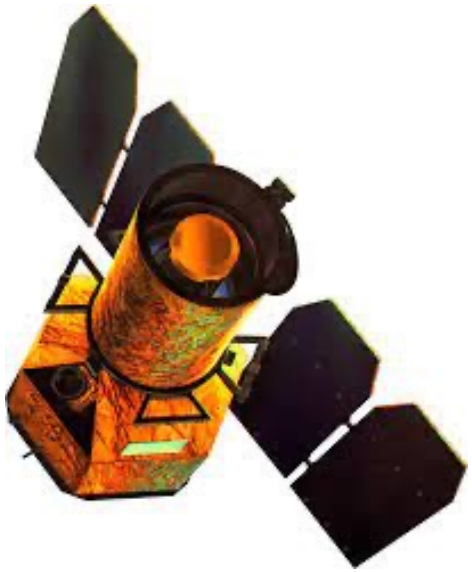
All these catalogues contain:

- all the columns corresponding to their original catalogue with a name of the form ***catalogue_version_originalcolumn***
- two added columns that allows to join those catalogues with the CAT_CROSS_MATCHING table:

- ***catalogue_version_id***: varchar identifier of the row in the catalogue. Corresponds to *cross_external_id*.
- ***catalogue_version_source_id***: Source varchar identifier in the catalogue. Corresponds to *cross_external_source_id*.

The GALEX revised catalogue

- The catalogue revised by Bianchi et al. (2017) includes **sources from observations** with both FUV and NUV detectors on.
- Within the central 0.55 radius of the field of view to avoid sources with poor photometry and astrometry near the edge of the field, and rim artifacts.
- With NUV magnitude errors ≤ 0.5 mag.
- Unique, i.e., duplicate measurements of the same source are identified and removed.



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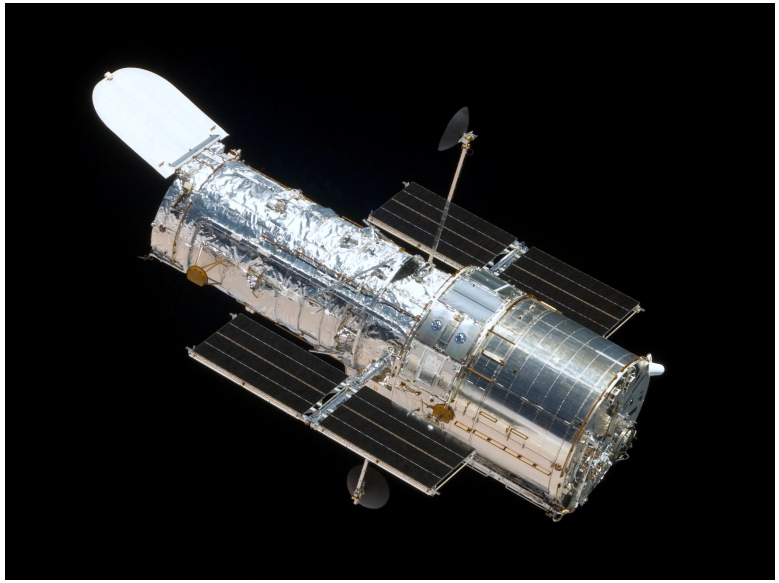
The HST catalogues

- The **HST catalogue**, catalogue of photometric and spectrometric observations made with UV instrumentation of the Hubble Space Telescope (HST).
- The **HST source catalogue**, Whitmore et al. 2016, designed to optimise science by combining the tens of thousands of visit-based source lists in the Hubble Legacy Archive (HLA) into a single master catalogue.

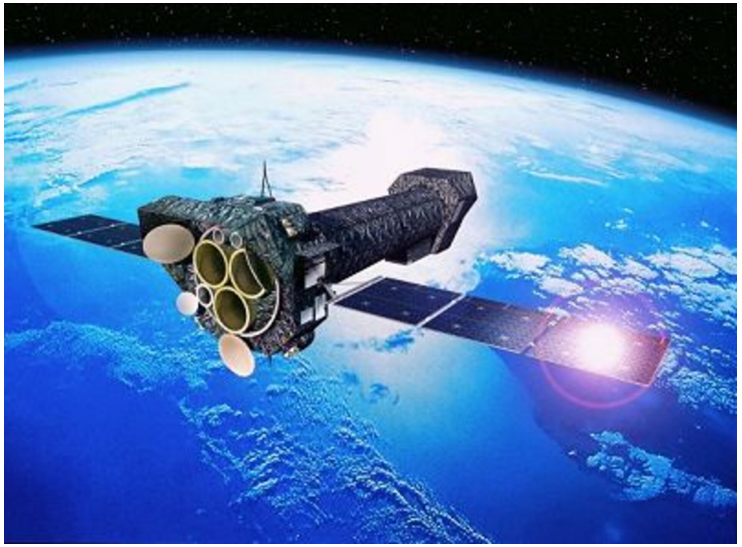


Final merged log of IUE observations

- The Final Merged Log of IUE Observations (NASA-ESA, 2000).
- Summary of all IUE Newly Extracted Spectra (INES) which resulted from a post-processing effort at Vilspa (nowadays ESAC).
- Constructed by using verified data from the IUE Final Archive Master Catalogue.

The XMM-Newton OM serendipitous source survey

- The XMM-Newton Optical Monitor Serendipitous Source Survey Catalogue (Page et al. 2012)
- Ultraviolet (UV) **sources detected serendipitously by the XMM-OM**.
- UV-detected sources collected from 2417 XMM-OM observations in one to six broad-band UV and optical filters.
- The primary contents of the catalogue are source positions, magnitudes and fluxes in one to six passbands, profile diagnostics, variability statistics.



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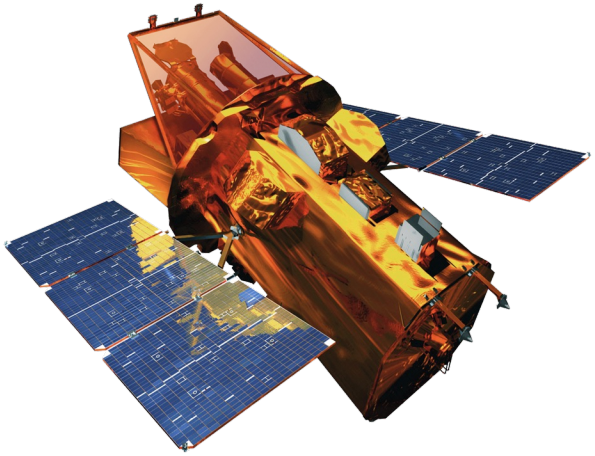
The Swift catalogues

- The Ultraviolet Optical Telescope (UVOT) **observation catalogue**, list of all targets observed with UVOT onboard the Swift observatory.
- The Swift UVOT **Serendipitous Source Catalogue** (UVOTSSC), Page et al. 2015, produced by processing the data obtained from the Swift, that contains positions, photometry in three UV and three optical bands, morphological information and quality flags.



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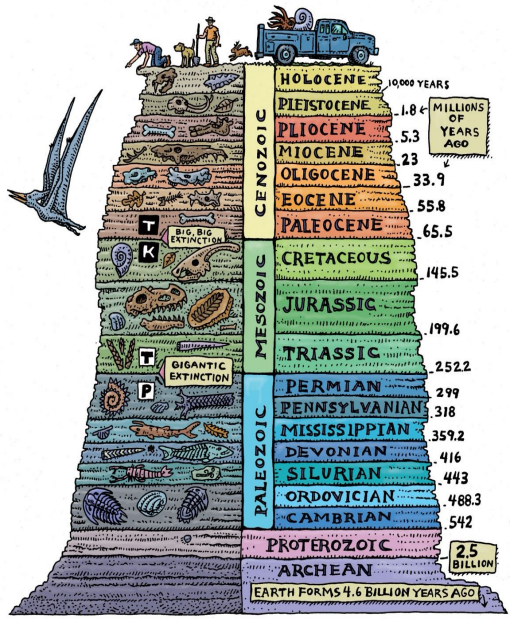
Building the prototype

Timescales are important

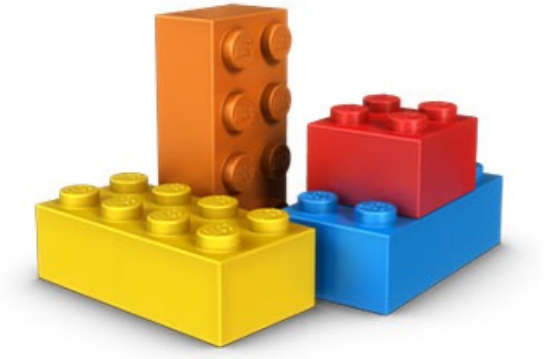
- Archives are “forever”.
- A period of one decade (or even shorter) in s/w and h/w is like a geological era: archives systems must cope with this.

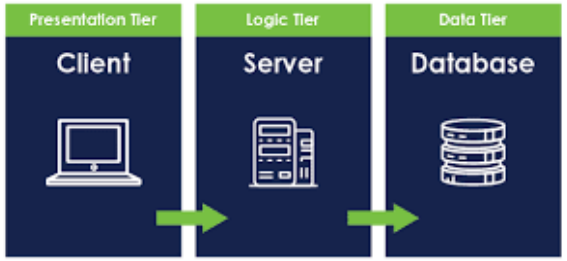
- A pluggable blocks approach allows future enhancements and major changes.
- Allows future paradigms which at the moment are not mature enough.
- Clean/Clear interfaces are a key issue.



Modular approach

- **Modularity** isolates technologies and allows future replacements or migrations.
- Need of tight control of interface layers.
- Reuse of “old” modules possible, reuse of proven tools reduces cost and resources.
- Might increase heterogeneity.





- Well proven approach (old fashioned?) for starting: three tier architecture, which **separates database from application from GUI**.
- We must also tackle mission catalogues evolution, aka **versioning**.

Catalogue versioning

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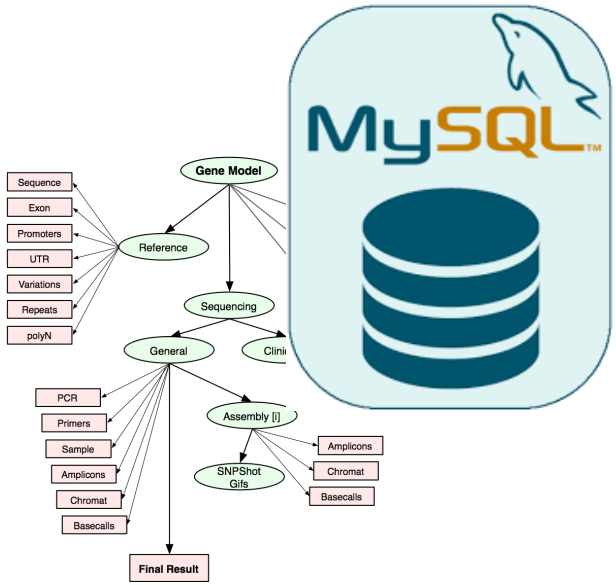
Data model, data formats

- **Free storage**: plainfiles, metainformation is encoded in the filename and any hierarchical relationship relies on the file system folder structure.
- **Structured storage**: data is kept in a RDBMS. Each type of cohesive data is placed in a separate table, maintaining explicit relations among tables that contain related data.
- **Mixed storage**: Metadata in RDBMS, with pointers to Data in Files.

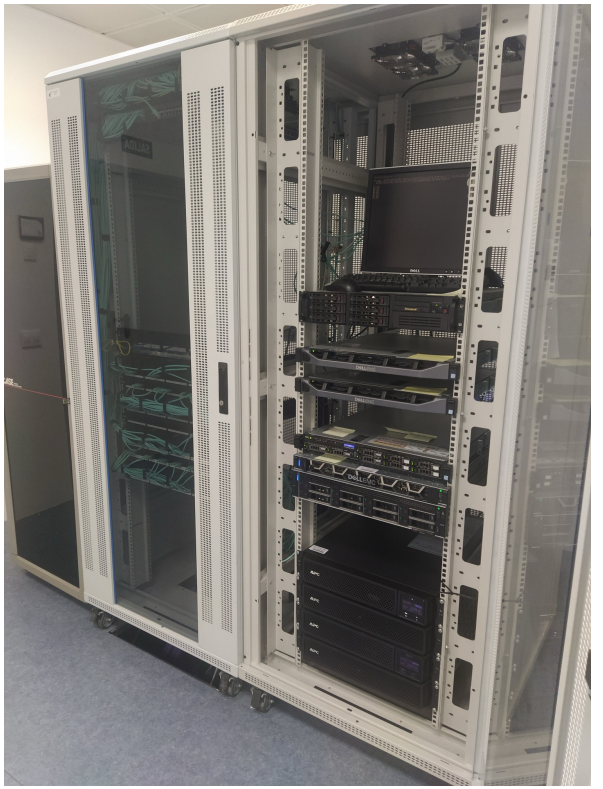


Here, pointers can link to existing external facilities, And use external services.

Data Server

- In its **initial** shape, the catalogue is just a RDBMS in a server plus a web-based app (application+GUI).
  - RDBMS MySQL, Dell PowerEdge R550 (4Tb disk)
  - Reuse of JCUVA Web infrastructure.

- In its **final** shape, the catalogue will be a "storage service“, exposing the operations that let client applications to access heterogeneous resources in an homogeneous manner.



Pre-processing of mission data

- Data selection and preprocessing activities are required **before the actual ingestion**.
- Because of data size, files grouped by region were downloaded and merged into a single file.
- Headers are deleted, ….
- Final csv files corresponding to every catalogue are produced and ingested into the RDBMS engine, by adding two new columns/fields.

The cross-match (I)

- Identifier corresponding to the match.
- Id corresponding to the master source.
- There will be several sources sharing this field, since sources are found in more than one secondary catalogue.
- External id: link to the original secondary catalogue, corresponding to the added field.
- External source id: source identifier in the original secondary catalogue, corresponding to the added field.

The cross-match (II)

- Cone criteria: If the source has a counterpart in master, this field contains the distance at which the match was successful.
- If there was not any matching sources and the object was added to master, the value of this field is -1.

- The matching in all cases was done using a criteria of 2 arcsec[(1)].
- Observation/Source flag: If the source comes from a secondary catalogue of observations or a (point) source catalogue.
- Phot/Spec flag.

[(1)] See Gómez de Castro et al, Astrop.Space Sci, 335, 97,(2011)

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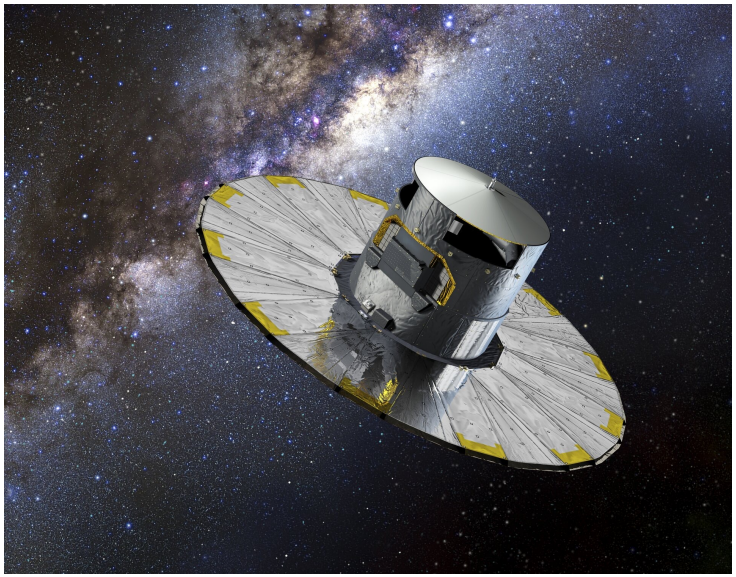
Preliminar use cases, Next steps

First use case: GAIA cross match

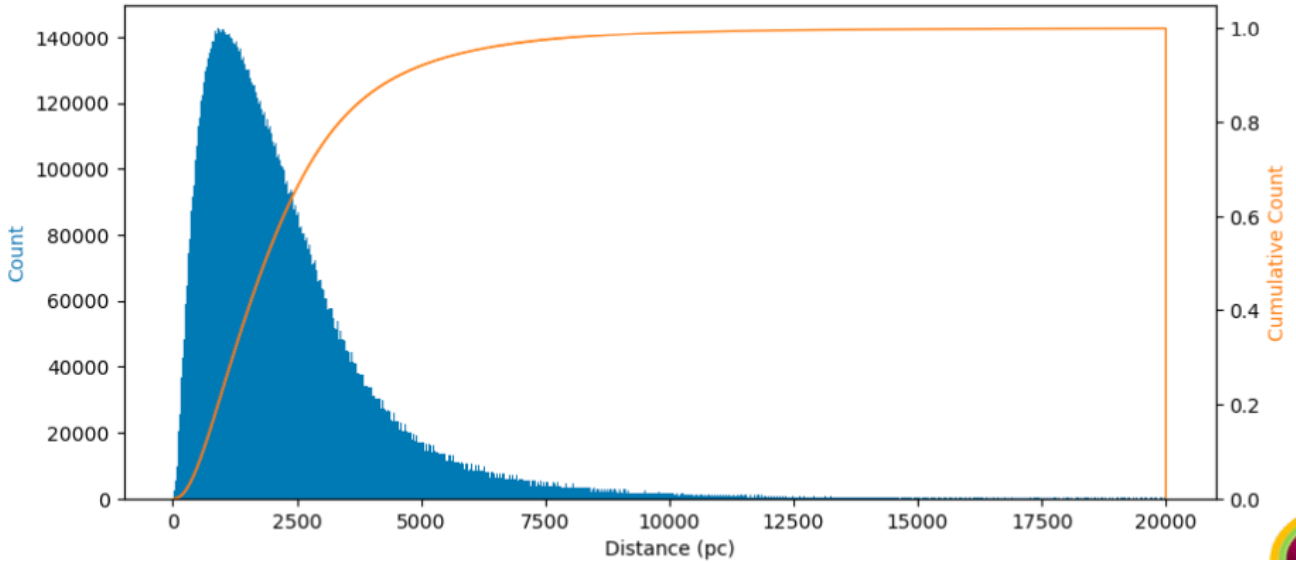
- **Science** Use Case: to obtain three-dimensional coordinates of the UV sources and make a 3D map of the sky.

- The JCUVA UV Catalogue was cross-matched with the Gaia DR3 catalogue.



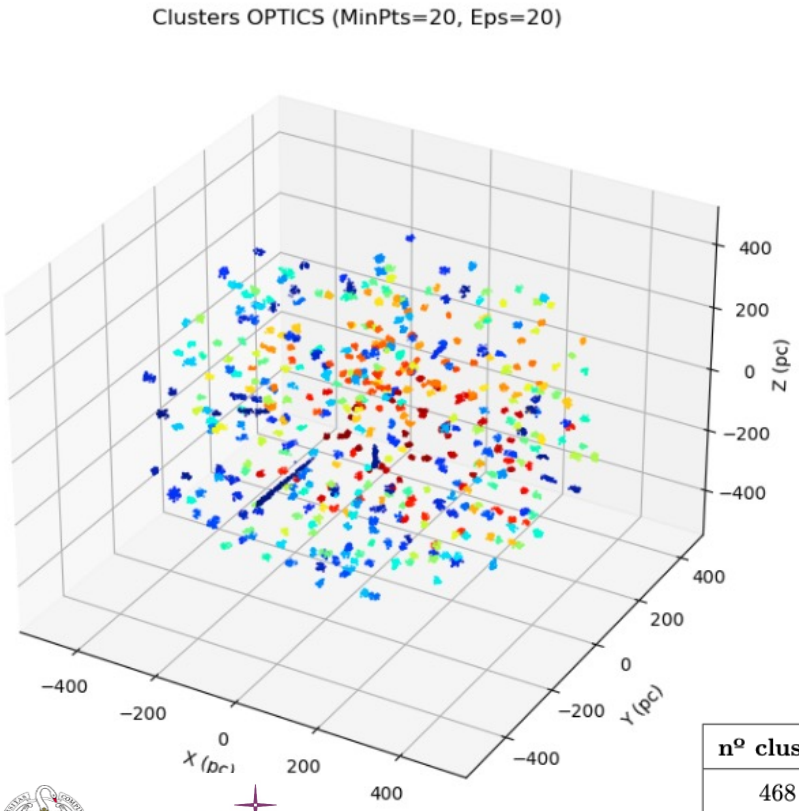
Performance test bed

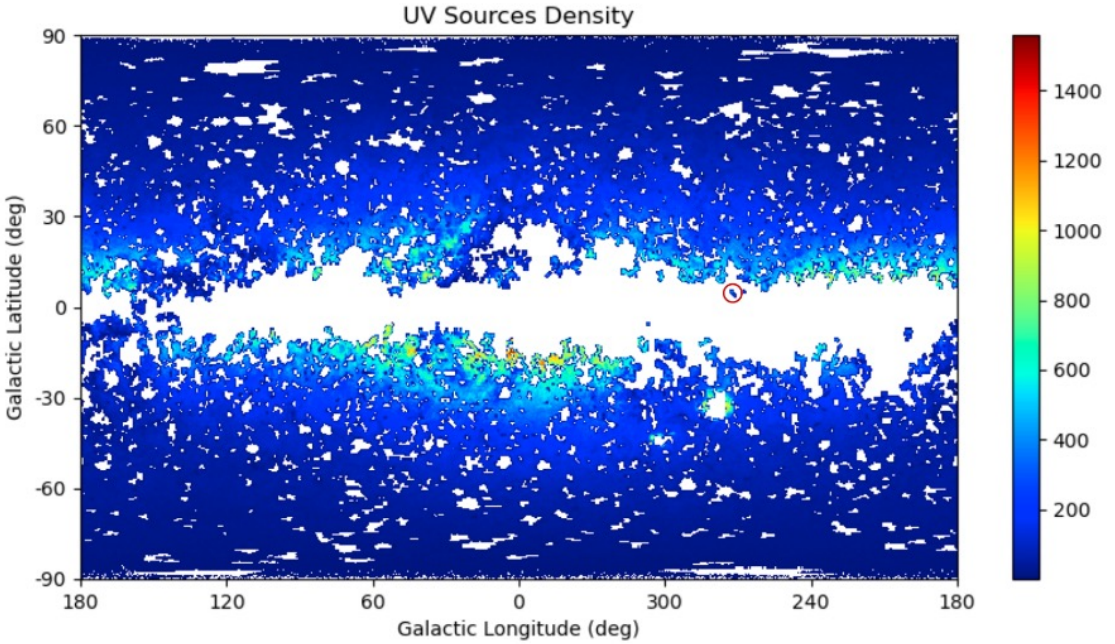
- A good testing of performance in addition to scientific uses.
- A good testing for 2arc sec criteria, additional catalogues needed for GAIA.
- 25,8 millions UV entries. Once proper ruwe index and positive parallaxes are taken into account, 22,45 millions entries.
- Then one takes into account positive G and NUV, plus ”good” values of FUV (blanking flag from GALEX): 1,1 millions.



Science: clustering analyses

- OPTICS algorithm.

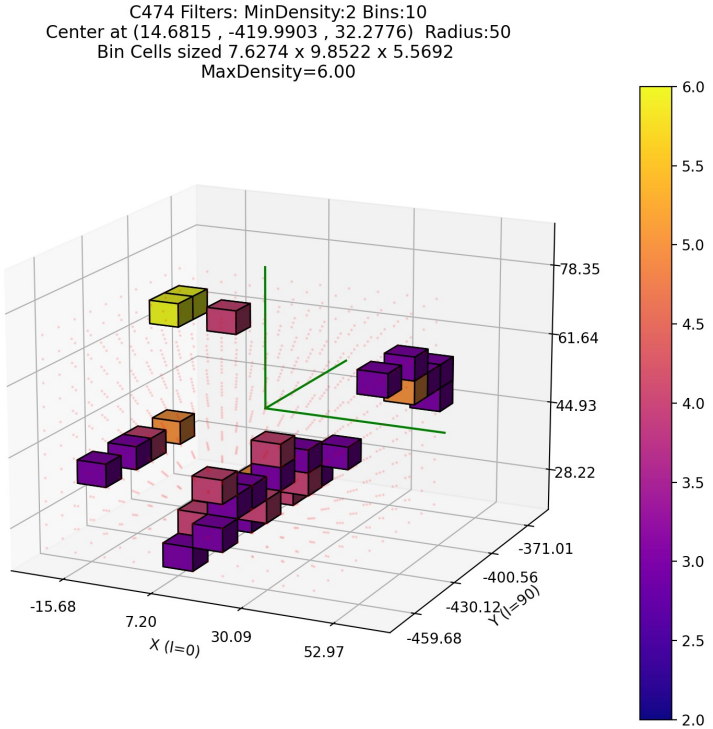


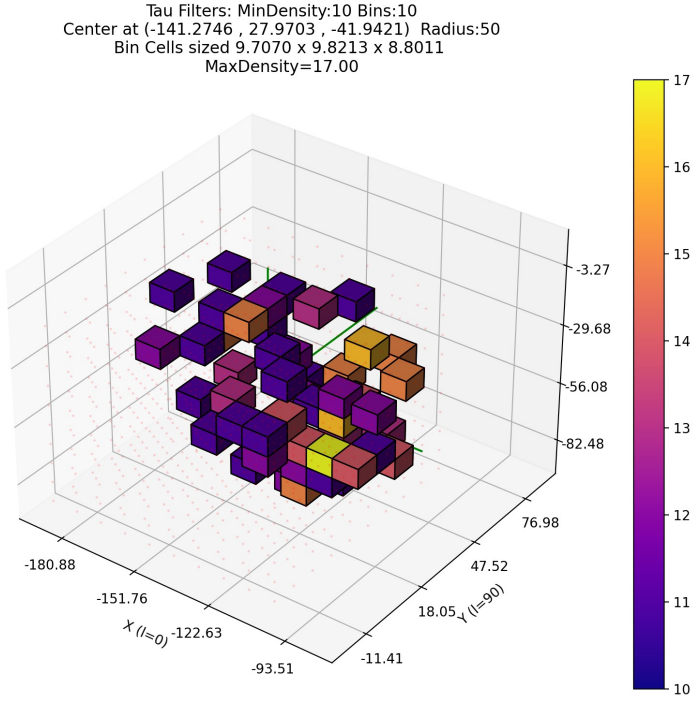


nº cluster	nº sources	X	Y	Z	l	b	fuv	nuv	g
468	148	14,68	-419,99	32,28	272	4,39	19,16	18,42	13,52

Science: density analyses

- Density algorithm.





Future work

- Future steps will aim to develop a user interface.
- Generating a database of UV photometry in the IAU system.
- Multi-epoch variability studies

Thank you for your attention…

- Work in progress, ideas/comments/… are appreciated.
- Questions…?