

Modernizing ESA Science Archives:

Reusable Components and Automated HiPS Generation in a VO-Aligned ecosystem

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Astro-CC European Data Provider Forum (Heidelberg, DE) - 26/03/2026

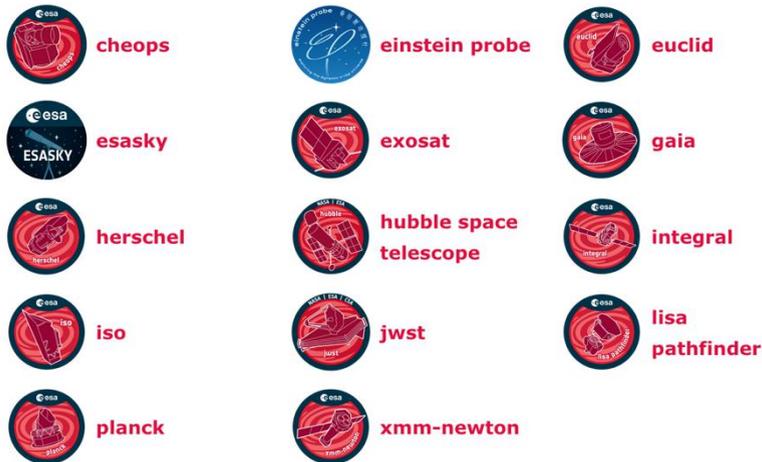
ESA science archives modernization



ESAC Science Data Centre (ESDC)

Designs, develops, and operates **science archives** for the **ESA space science missions**

Astronomy Science Archives



The Planetary Science Archive



Human and Robotic Exploration Science Archives*



* in coordination with the Human Spaceflight and Robotic Exploration directorate

Heliophysics Science Archives

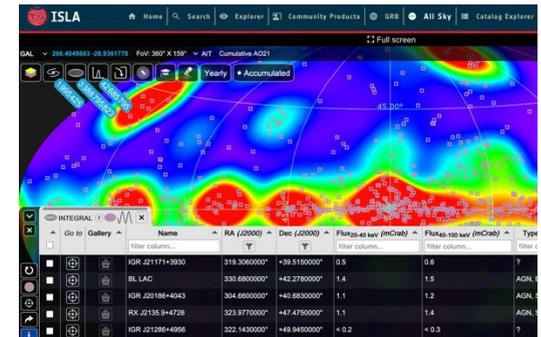
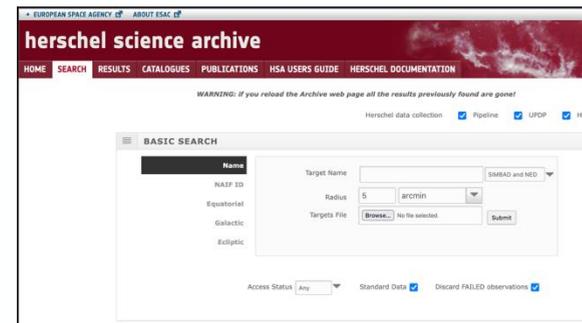
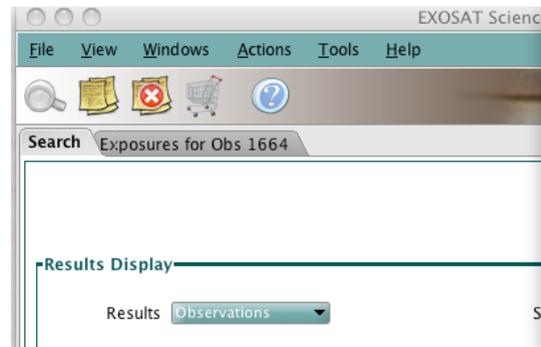


Future Archives



ESA science archives modernization

Over the decades, the software architecture of these archives has experienced **significant changes** passing through several generations of technology:



Each mission archive was historically developed **independently**, with its own bespoke **backend** logic (proprietary endpoints and data delivery mechanisms) and its own custom **frontend** (hardcoded search forms, hard-to-reuse components, ..)

Problems:

- Engineers: obsolete software, specific knowledge per archive, hard to maintain
- Scientists: completely different experience when moving from one archive to another.

Solution (gradually):

The backend of the archives started to be migrated to **IVOA standards** (i.e. **TAP**, **ObsCore**, ..), and the frontend to Angular web technology with a shared **component framework** (widgets).

Goals: interoperability, **reusability**, **maintainability**

'M' is for 'Maintainability' (FAIRM?)

- Every mission archive was building and maintaining the components independently
- ESDC's answer: a shared, common widget library across all services
- Built on open standards: TAP-aligned, VO-compatible, and mission-agnostic

Modernizing the Archives: from bespoke platforms...



XMM-Newton Science Archive



HOME SEARCH COMMAND & URL ACCESS INTERACTIVE ANALYSIS TAP QUERIES ASTROQUERY IMAGE GALLERY



XMM-Newton Science Archive Search

Single Object Search Multi-Object Search Search Clear

Name
 Equatorial
 Galactic

Target in Field Of View Circle Box

Name Resolve Given by Proposer

► Filters for Observation, Proposal and Catalogue Searches

▼ Display options

Observations	PPS Sources	Slew Observations	Catalogues/Upper Limits
<input checked="" type="checkbox"/> Pointed Observations <input type="checkbox"/> Exposures <input type="checkbox"/> EPIC Exposures <input type="checkbox"/> OM Exposures <input type="checkbox"/> RGS Exposures <input type="checkbox"/> Proposals <input type="checkbox"/> Publications	<input type="checkbox"/> EPIC PPS Sources <input type="checkbox"/> OM PPS Sources <input type="checkbox"/> Slew PPS Sources	<input type="checkbox"/> Slew Observations <input type="checkbox"/> Slew Obs. Segments <input type="checkbox"/> Slew Publications	<input type="checkbox"/> 4XMM-DR14 Filtered Catalogue <input type="checkbox"/> 4XMM-DR14s Filtered Stack Cat <input type="checkbox"/> OM Source Catalogue <input type="checkbox"/> Slew Survey Clean Catalogue <input type="checkbox"/> Upper Limits

Select All

► Radiation Monitor Files

Search Clear



Modernizing the Archives: ...to a common approach



The screenshot shows the eHST website interface. At the top, there is a navigation bar with the eHST logo and links for Home, Advanced Search, Image Viewer, Spectra Viewer, HCV Explorer, and User Guides. On the right, there is a SIGN IN button and the ESA logo. The main content area features a large background image of a galaxy with the text "HUBBLE The premier UV and visible light telescope in orbit". A search bar is centered, with the placeholder text "Search by Coordinates, Target or Proposal ID" and a magnifying glass icon. Below the search bar is an "Advanced Search >" link. To the right of the search bar, there is a text box that says "A treasure trove of astronomical data". Below this, there are six service tiles: HELPDESK, ESA HUBBLE, HCV EXPLORER, ASTROQUERY, and DOI ARCHIVE. Each tile contains an icon, a title, a brief description, and a "MORE" link with a right-pointing arrow.



Data Discovery: a simple search



eHST Home Advanced Search Image Viewer Spectra Viewer HCV Explorer User Guides SIGN IN

Search ADQL Console

Search History: target=crab,radius=0.05, data_typ...

Expand All

Basic Search

Target/ Coord RA DEC
crab

Radius (°)

Target List

Target 'crab' resolved. ✓

Observation Proposal Instrument Additional Filters CLEAR SEARCH

Observations (2793) Proposals (42) Publications (60)

J2000 05 34 31.983 +22 00 52.57 FoV: 9.2' X 2.9' SIN DSS2 color Sci. Mode En Feedback

2591 40089 399 Load HSC

Search...

Observation ID	Preview	Viewer	Products	Proposals	HCV	Target	RA (deg)	Dec (deg)	Instrument Name
hst_hsla_vscmtau--0937						V* CM Tau	83.633263590295	22.014603058605	COS-STIS
hst_17500_10_wfc3_uvis_total_if8510						CRAB-MOSAIC	83.62538280013197	21.990449638046087	WFC3/UVIS
if8510010						CRAB-MOSAIC	83.63399205634725	21.983465264159122	WFC3/UVIS
if8510beq						CRAB-MOSAIC	83.63456558885943	21.98305685386225	WFC3/UVIS
hst_17500_10_wfc3_uvis_f547m_if8510bd						CRAB-MOSAIC	83.62479053654614	21.990884935217665	WFC3/UVIS
hst_17500_10_wfc3_uvis_f547m_if8510bf						CRAB-MOSAIC	83.62593565088322	21.99007054736768	WFC3/UVIS
if8510bfq						CRAB-MOSAIC	83.63513911380927	21.982648436896582	WFC3/UVIS

Retrieved 25 of 2793 rows



Additional Filters ^

+ 🗑️

Please add a new filter to refine your search.

ESDC Search Panel: flexible data discovery

(exposed by the TAP)

```
<column std="false" esatplusplus:flags="0" esatplusplus:ref="">
  <name>calibration_level</name>
  <description>IVOA ObsCore calibration level + extensions
  (1,2,3)</description>
  <ucd>caom:Plane.calibrationLevel</ucd>
  <dataType xsi:type="vod:VOTableType">int</dataType>
</column>
```

```
<column std="false" esatplusplus:flags="0" esatplusplus:ref="">
  <name>dataproductype</name>
  <description>IVOA ObsCore data product type +
  extensions</description>
  <utype>caom:Plane.dataProductType</utype>
  <dataType xsi:type="vod:VOTableType">char</dataType>
</column>
```

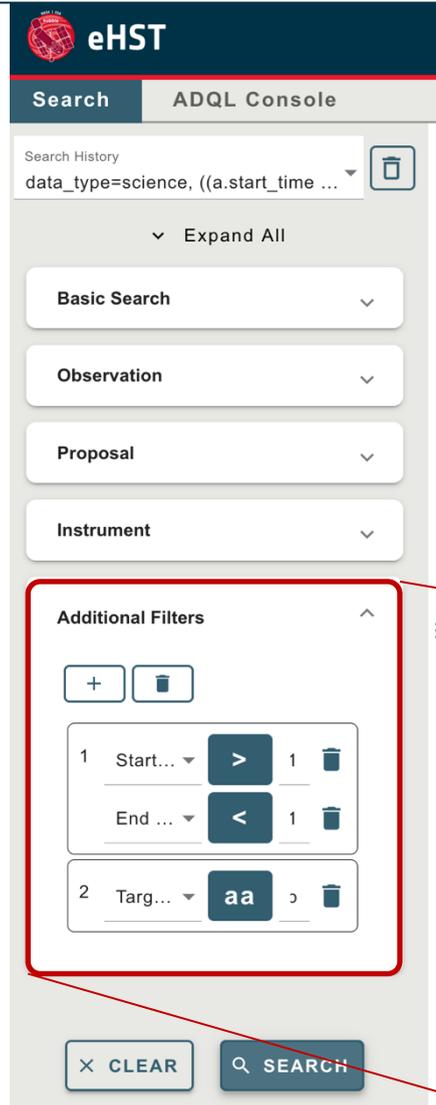
```
<column std="false" esatplusplus:flags="0" esatplusplus:ref="">
  <name>main_science_plane</name>
  <description>Flag to indicate if it is the upper level associated to
  an observation</description>
  <dataType xsi:type="vod:VOTableType">boolean</dataType>
</column>
```

The screenshot shows a search panel with various filters and a data table. The filters are arranged in a grid:

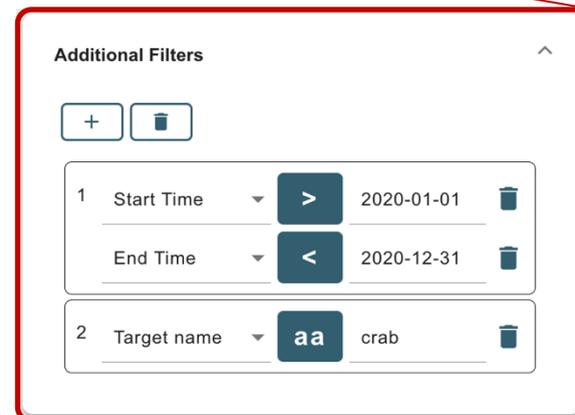
- Available for Image viewer** (boolean | No available description)
- Available for Spectra viewer** (boolean | No available description)
- Calibration Level** (int | IVOA ObsCore calibration level + extensions (1,2,3))
- Data Product Type** (char | IVOA ObsCore data product type + extensions)
- DOI** (char | ESA DOI Associated to the proposal)
- End Time** (timestamp | Upper bound on time axis (timestamp))
- End Time MJD (d)** (double | Upper bound on time axis (Modified Julian Day))
- Exposure Duration (s)** (double | Median exposure time per pixel)
- Filter** (char | Collection-specific name for energy band (e.g. filter name))
- Fov Size** (double | Size of the polygon bounds (diameter of minimum spanning circle))
- Instrument Configuration** (char | Instrument keywords (separated by |))
- Instrument Name** (char | Name of instrument used to acquire observation)
- Last Modified** (timestamp | Timestamp of last modification of this row)
- Main Science Plane** (boolean | Flag to indicate if it is the upper level associated to an observation)
- Members** (char | Members of a composite observation (space-separated list of Observation URIs))
- Members Number** (integer | Number of members of a composite observation (space-separated list of Observation URIs))
- Proposal - Program ID** (char | Collection-specific unique proposal identifier)
- Proposal PI** (char | Proposal principal investigator)
- provenance_reference** (char | No available description)
- Release Date** (timestamp | Date the data for a plane is public (UTC))
- Start Time** (timestamp | Lower bound on time axis (timestamp))

Below the filters is a data table with columns for instrument name, V* CM Tau, and other parameters. The first row is highlighted in blue:

hst_hsla_vscmtau--0937	V* CM Tau	83.633263590295	22.014603058605	COS-STIS
hst_17500_10_wfc3_uvis_total_if8510	CRAB-MOSAIC	83.62538280013197	21.990449638046087	WFC3/UVIS



- Replaces large forms with a dynamic, column-based filter builder
- Select a column, choose a comparator, define a value: create any filter instantly
- Combine conditions: OR within a group, AND across groups
- Backed by TAP metadata: column names, types, descriptions and UCDs included



ESDC Search Panel: flexible data discovery (bonus)

[Home](#) | [Advanced Search](#) | [Image Viewer](#) | [Spectra Viewer](#) | [HCV Explorer](#) | [User Guides](#)

Search
ADQL Console
SIGN IN

Search History
data_type=science, ((a.start_time ...

Expand All

Basic Search

Observation

Proposal

Instrument

Additional Filters

1 Start... > 1

End ... < 1

2 Targ... aa >

CLEAR SEARCH

Observations (2462)
Proposals (29)
Publications (50)

J2000 05 34 32.433 +21 58 57.53 FoV: 31' X 9.6' SIN DSS2 color
Sci. Mode En Feedback

Observation ID	Preview	Viewer	Products	Proposals	HCV	Target	RA (deg)	Dec (deg)	Instrument Name
							Min Max	Min Max	
if8510bfq						CRAB-MOSAIC	83.63513911380927	21.982648436896582	WFC3/UVIS
if8510beq						CRAB-MOSAIC	83.63456558885943	21.98305685386225	WFC3/UVIS
hst_17500_10_wfc3_uvis_f547m_if8510bf						CRAB-MOSAIC	83.62593565088322	21.99007054736768	WFC3/UVIS
hst_17500_10_wfc3_uvis_f547m_if8510						CRAB-MOSAIC	83.62536818031897	21.9904685423966	WFC3/UVIS
if8510bdq						CRAB-MOSAIC	83.63399205634725	21.983465264159122	WFC3/UVIS
hst_17500_10_wfc3_uvis_total_if8510						CRAB-MOSAIC	83.62538280013197	21.990449638046087	WFC3/UVIS
if8510010						CRAB-MOSAIC	83.63399205634725	21.983465264159122	WFC3/UVIS

Retrieved 25 of 2462 rows

Programmatic Access

Query



```
select * from ehst.archive a where (a.intent = 'science') and ((a.start_time > '2019-12-31') OR (a.end_time < '2020-12-30')) AND ((a.target_name ilike '%crab%')) order by a.release_date desc
```

CURL



```
curl -o file.vot "https:// hst.esac.esa.int / tap-server/tap/sync?LANG=ADQL&REQUEST=doQuery&FORMAT=VOTABLE&TAPCLIENT=ehst-6.0.0-rc2&QUERY=select * from ehst.archive a where (a.intent = %27science%27) and ((a.start_time > %272019-12-31%27) OR (a.end_time < %272020-12-30%27)) AND ((a.target_name ilike %27%25crab%25%27)) order by a.release_date desc"
```

WGET



```
wget -O file.vot "https:// hst.esac.esa.int / tap-server/tap/sync?LANG=ADQL&REQUEST=doQuery&FORMAT=VOTABLE&TAPCLIENT=ehst-6.0.0-rc2&QUERY=select * from ehst.archive a where (a.intent = %27science%27) and ((a.start_time > %272019-12-31%27) OR (a.end_time < %272020-12-30%27)) AND ((a.target_name ilike %27%25crab%25%27)) order by a.release_date desc"
```

Astroquery



```
from astroquery.esa.hubble import ESAHubble  
esahubble = ESAHubble()  
query = "select * from ehst.archive a where (a.intent = 'science') and ((a.start_time > '2019-12-31') OR (a.end_time < '2020-12-30')) AND ((a.target_name ilike '%crab%')) order by a.release_date desc"  
result = esahubble.query_tap(query)
```

ESDC ADQL Console: query without limits



Navigation: Home | Advanced Search | Image Viewer | Spectra Viewer | HCV Explorer | User Guides | SIGN IN | ESA

Search | **ADQL Console**

Database tree

- caom2 [14]
- ehst [18]
 - ehst.archive [38]
 - ehst.archive_proposal [18]
 - ehst.artifact [28]
 - ehst.doi_proposal [2]
 - ehst.energy [12]
 - ehst.instrument [1]
 - ehst.mv_doi_generation [9]
 - ehst.observation [25]
 - ehst.obs_simple_obs_composite [2]
 - ehst.plane [13]
 - ehst.position [13]
 - ehst.proposal [9]
 - ehst.proposal_id_proposal_type [2]
 - ehst.proposal_num_observations [2]
 - ehst.publication [10]
 - ehst.publication_num_observations [2]
 - ehst.publication_proposal [2]
 - ehst.target [4]
- hcv [3]
- hsc [2]

ADQL Query Content Ctrl + Space to autocomplete

```
1 select * from ehst.archive a where (a.intent = 'science') and ((a.start_time > '2019-12-31') OR (a.end_time < '2020-12-
```

Background Immediate CLEAR SUBMIT

- Full TAP tree with metadata, directly in the interface
- Write and execute custom ADQL queries
- Cross-table queries supported
- The only limit is the user's expertise: custom logic with no restrictions



ESDC ADQL Console: multiple formats available



eHST Home Advanced Search Image Viewer Spectra Viewer HCV Explorer User Guides SIGN IN

Search **ADQL Console**

Database tree

- caom2 [14]
- ehst [18]
 - ehst.archive [38]
 - ehst.archive_proposal [18]
 - ehst.artifact [28]
 - ehst.doi_proposal [2]
 - ehst.energy [12]
 - ehst.instrument [1]
 - ehst.mv_doi_generation [9]
 - ehst.observation [25]
 - ehst.obs_simple_obs_composite [2]
 - ehst.plane [13]
 - ehst.position [13]
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 - ehst.proposal_id_proposal_type [2]
 - ehst.proposal_num_observations [2]
 - ehst.publication [10]
 - ehst.publication_num_observations [2]
 - ehst.publication_proposal [2]
 - ehst.target [4]
- hcv [3]
- hsc [2]

ADQL Query Content

Ctrl + Space to autocomplete

```
1 select * from ehst.archive a where (a.intent = 'science') and ((a.start_time > '2019-12-31') OR (a.end_time < '2020-12-
```

Background Immediate Easily switch between synchronous/asynchronous jobs CLEAR SUBMIT

Asynchronous Jobs

Status	Job ID	Creation date	Number of rows	Size
	j9803fc-26fe-11f1-8e0c-44a8421ba408-BETA	2026-03-23T21:20:28.524Z	2462	939721

Download format:

- JSON
- VOTable
- VOTable (gzip)
- VOTable (plain)
- CSV
- ECSV
- FITS

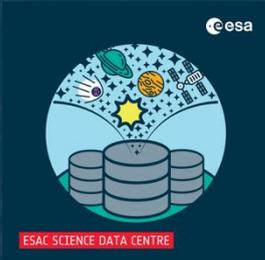
Data downloadable in preferred format for user

Showing 1-1 of 1 rows First Prev 1 Next Last



- ESDC's commitment to interoperability and the Virtual Observatory community
- **HiPS Pipeline**: continuous, automated sky maps that are always current, and fully VO-compatible
- **Reusable ESDC widgets**: flexible discovery tools, consistent across every archive
- Together: data more accessible and exploitable

Thank you



ESAC Science Data Centre

<https://www.cosmos.esa.int/web/esdc>

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