

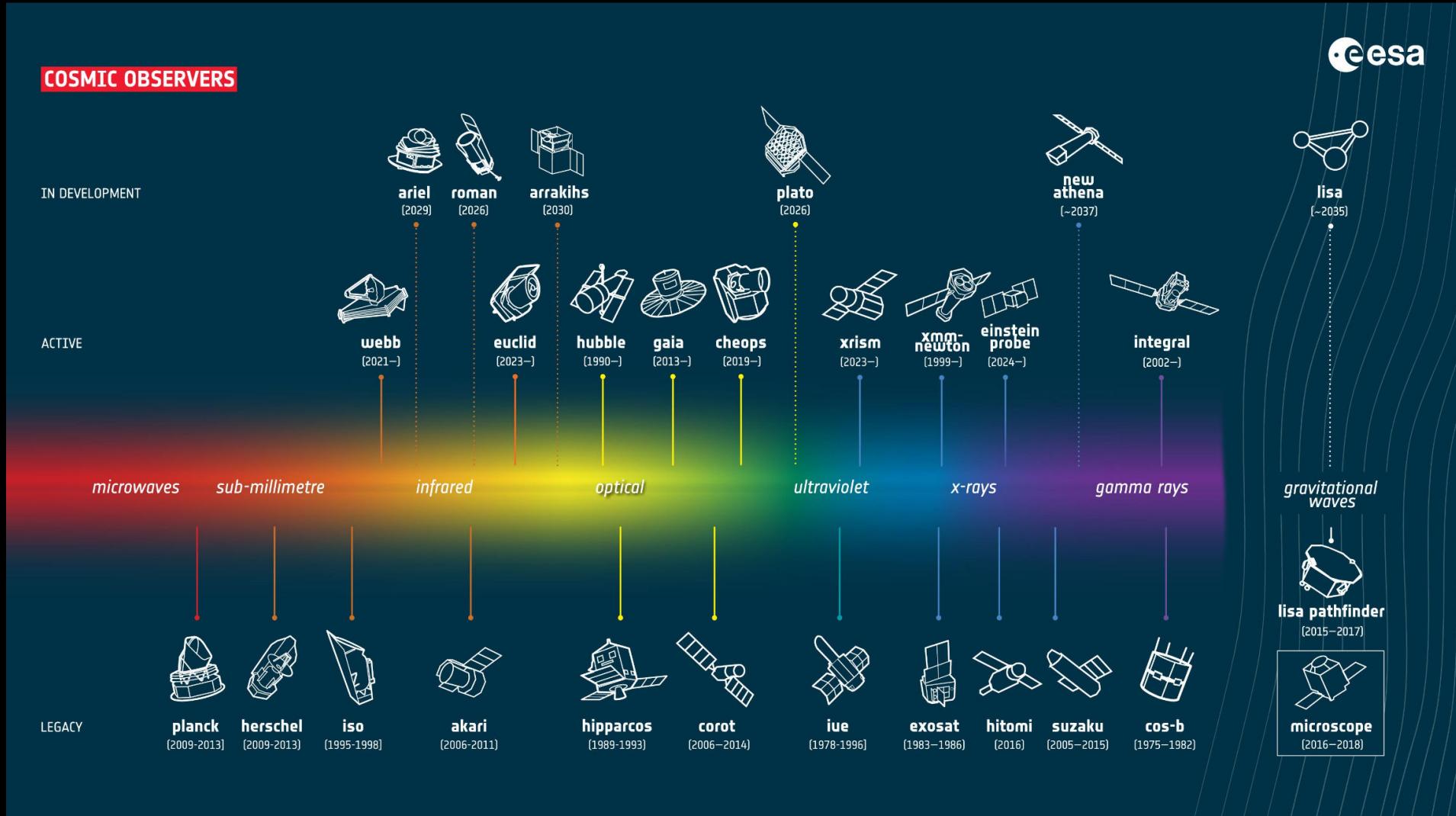


Outline



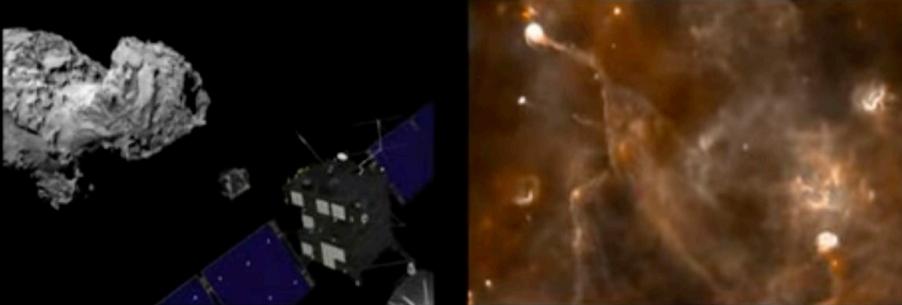
- A world of data
- Many archives
- Archives + tools + services + protocols : the VO
- A special tool: ESASky
- ESASky interface
- Interacting with ESASky
- If time allows: demos

ESA's sky



ESAC: ESA's astronomy centre

European Space Astronomy Centre



European Space Astronomy Centre:

- Science Operations Centres
- Science Archives for Astronomy and Solar System missions

ESA UNCLASSIFIED - For Official Use

ESAC archives

ESAC SCIENCE DATA CENTRE

ESDC Statistics

Monthly Users (*)



32 092

Monthly Downloaded (*)



80.0 TB

Archive Total Size



941.5 TB

* Monthly averages in 2023

Astronomy Science Archives



cheops



esasky



exosat



gaia



herschel



hubble
space
telescope



iso



jwst



lisa
pathfinder



planck



xmm-newton



euclid

Heliophysics Science Archives



cluster



double star



proba-2



soho



solar orbiter



ulysses

The Planetary Science Archive



bepicolombo



cassini huygens



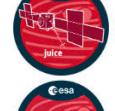
chandrayaan
-1



exomars



giotto



juice



mars express



rosetta



smart-1



venus express

Future Archives



ariel



plato

Human and Robotic Exploration Science Archives*



HRE data archive



ISS- SolACES*



Virtual Observatory VO



International Virtual Observatory Alliance (IVOA)

Before: VO idea born & discussed for many years in main Astro-IT yearly conference



- Argentine Virtual Observatory
- Armenian Virtual Observatory
- AstroGrid, United Kingdom
- Australian All-Sky Virtual Observatory
- Brazilian Virtual Observatory
- Chinese Virtual Observatory
- Canadian Virtual Observatory
- Chilean Virtual Observatory
- European Space Agency
- European Virtual Observatory
- German Astrophysical Virtual Observatory
- Japanese Virtual Observatory
- Kazakhstan Virtual Observatory
- Netherlands Virtual Observatory
- Observatoire Virtuel France
- Russian Virtual Observatory
- Square Kilometer Array Observatory
- South African Astroinformatics Alliance
- Spanish Virtual Observatory
- Italian Virtual Observatory
- Ukrainian Virtual Observatory
- US Virtual Observatory Alliance
- Virtual Observatory India

Virtual Observatory VO

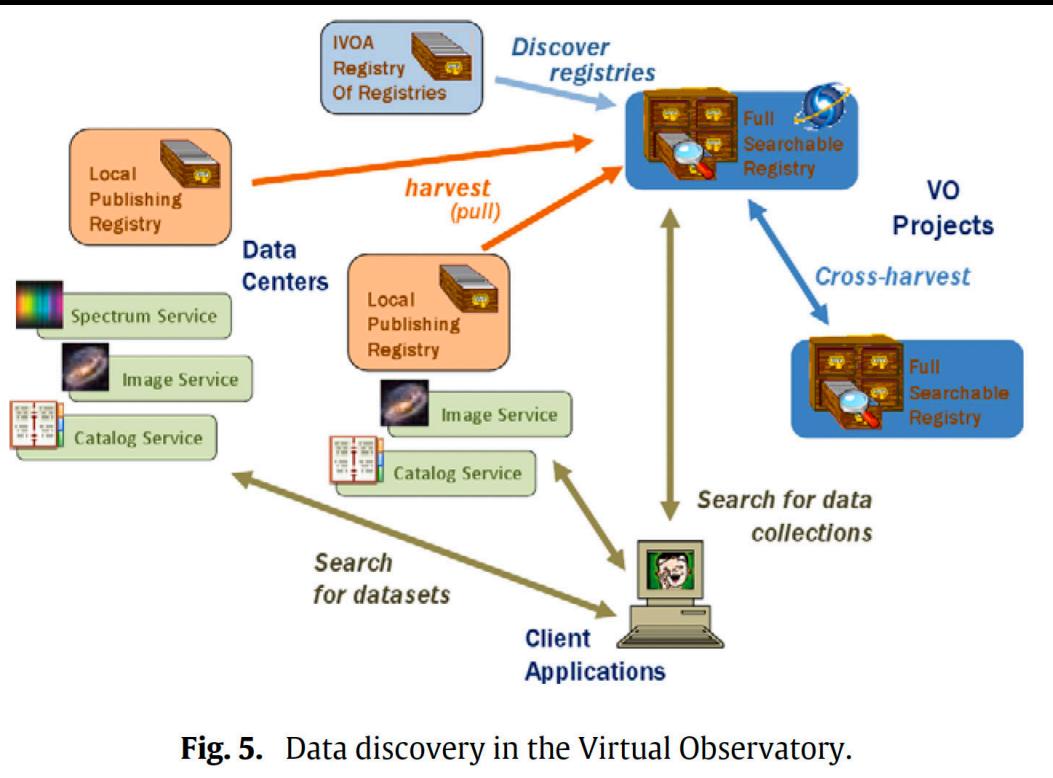
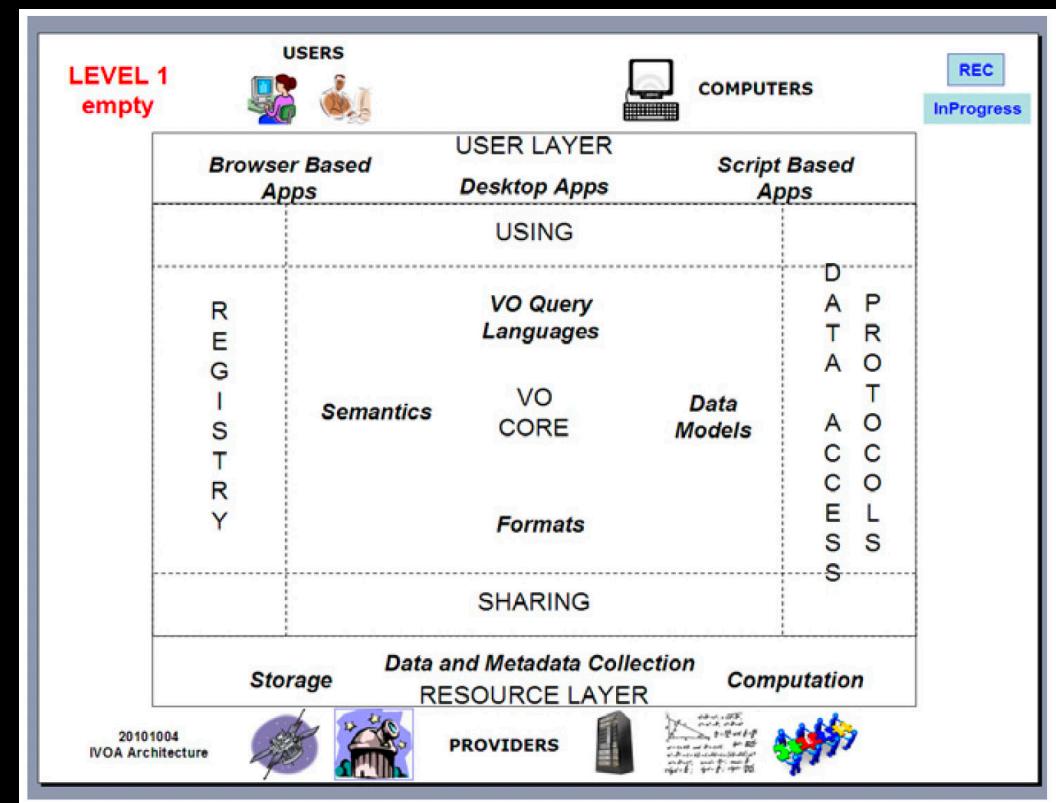


Fig. 5. Data discovery in the Virtual Observatory.



Virtual Observatory VO tools

Start Page | m31 r=1m | m31 r=1m: Spitzer Level 2 | User Guide | Discover Tool v1.5 (6705) | Examples: M101, 14.03.12.6 +54.20.56.7, more...

Displaying 18 of 350 Total Rows

MESSIER 031 (RA: 00:42:44.350, Dec: +41:16:08.62), radius: 0.01667°

Filters

Clear Filters | Edit Facets... | Help...

Filter All Record Fields

Waveband

- EUV (2 of 7)
- Gamma-ray (2 of 8)
- Infrared (18 of 19)
- Millimeter (2 of 7)
- Optical (7 of 212)
- Radio (0 of 1)
- X-ray (6 of 42)
- (2 of 45)

Publisher

- Canadian Astronomy Data Centre (2 of 4)
- CDS (0 of 269)
- ESO (0 of 1)
- European Space Agency (0 of 1)
- German Astrophysical Virtual Observatory (1 of 10)
- IAU - Astrophysics Data System (0 of 1)
- NASA/GSFC HEASARC (2 of 11)
- NASA/HEASARC (1 of 1)
- NASA/IPAC Infrared Science Archive (10 of 12)
- Observatory of Strasbourg, SIS Team (0 of 1)
- Smithsonian Astrophysical Observatory (0 of 1)

Actions Short Name Type Title

- 1 CADC CADC Image Search
- 2 Spitzer Level 1 Spitzer Level 1 / Basic Calibrated Data
- 3 CADC/CFHT CADC/CFHT Image Search
- 4 Spitzer Level 2 Spitzer Level 2 / post Basic Calibrated Data
- 5 HLA [1] Hubble Legacy Archive
- 6 NED(images) The NASA/IPAC Extragalactic Database Image
- 7 WISE All-Sky LIB WISE All-Sky 4-band Single-Exposure Images
- 8 MAST-Scrapbook The MAST Image Scrapbook
- 9 SkyView SkyView Virtual Observatory
- 10 MAST Scrapbook MAST Image Scrapbook
- 11 2MASS QL 2MASS All-Sky Quicklook Image Service
- 12 2MASS ASKY AT 2MASS All-Sky Atlas Image Service
- 13 Wise [1] WISE Micron All-Sky Survey
- 14 2MASS [1] Two Micron All Sky Survey (-Band)
- 15 USSA The USAS Sky Survey Atlas

Data Discovery Tool (DDT) (after a search for M31)

Scalable Cross Comparison Service
(User uploaded table cross-matched with SDDS catalogue)

R.J. Hanisch et al. / Astronomy and Computing 11 (2015) 190–209

VAO Catalog Cross-Comparison Tool

User Guide | Sample Tables | VAO Home | Contact

Compared: csv_table_example.tbl (10 sources)

With Catalog: SDSS_DR9 (1233343212 sources)

Using: Max Match Distance: 3 arcsec

Results:

Input Records Matched	4
Max Distance Found	1.9114
Min Distance Found	0.0538
Average Distance Found	0.5688
Matches File	matches.tbl Broadcast (14 records)
Unmatched Input	unmatched.tbl Broadcast (6 records)
Bad Input	bad.tbl Broadcast (0 records)
Processing Time	1.19 sec

Upload a table

Max Match Distance: 3 arcsec

User Tables

Catalog	# Rows	# Columns	Size
USNO_B1	104517562	56	
PPMXL	910469430	25	
WISE	563921584	285	
TWOMASS_PSC	470992970	127	

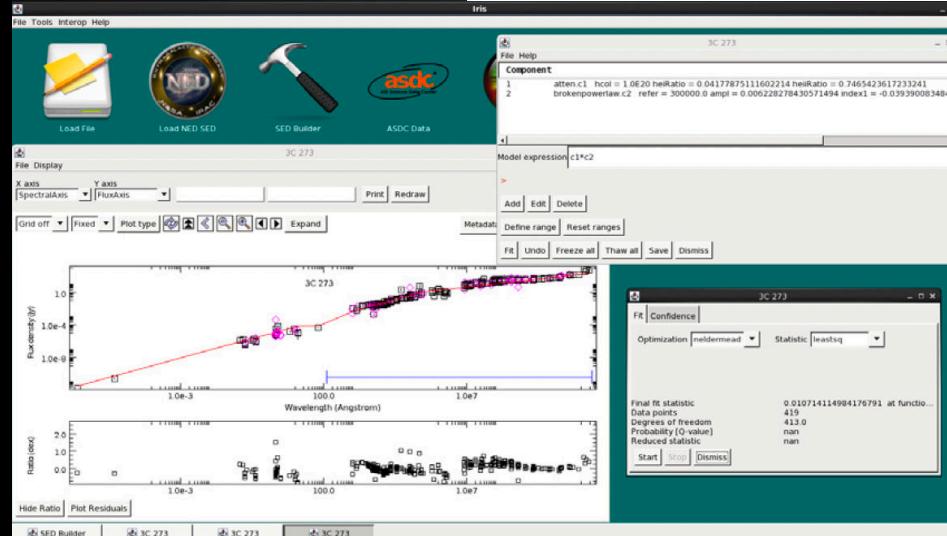
On-line Catalogs

Catalog	# Rows	# Columns	Size
SDSS_DR9	10	4	792

History

Delete	User Table	Catalog	Max Dist (arcsec)	Max Match Dist	Min Match Dist	Avg Match Dist	Input Rows Matched	# Matches	# Bad Records	# Unmatched Records	Time
	csv_table_example.tbl	SDSS_DR9	3	1.9114	0.0538	0.5688	4	14	0	6	1.19

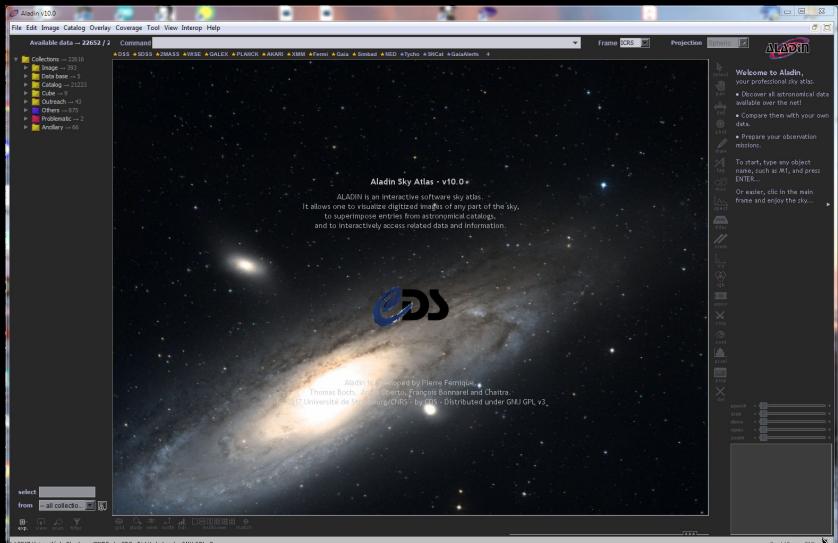
SAMP: Registered: No



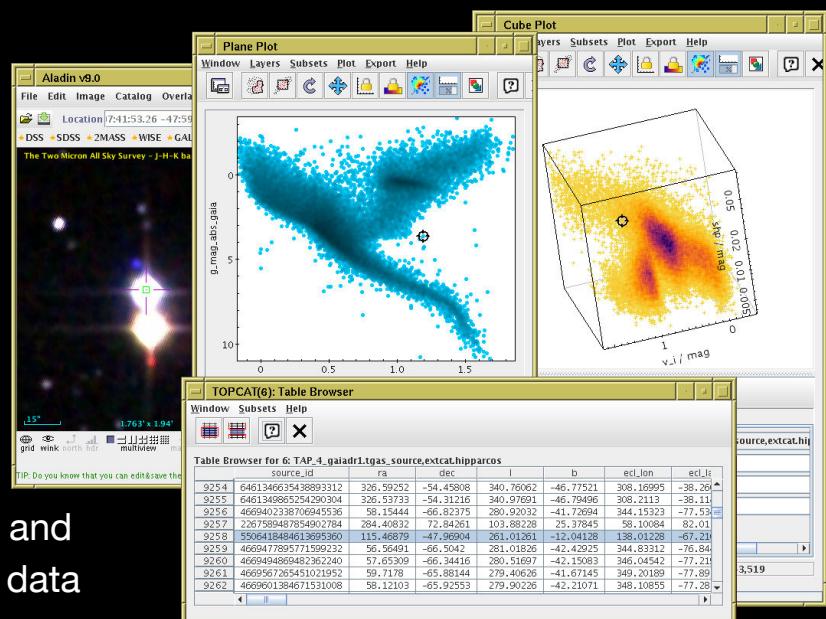
SED access and analysis tool Iris
(model fit of 3C273 with i/a control of parameters)



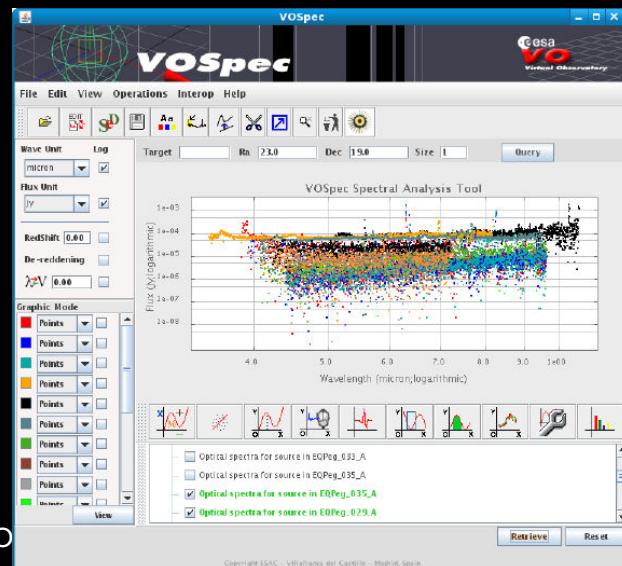
Virtual Observatory VO tools



Aladin - CDS -
Universal I/A
Sky Atlas



TOPCAT (UK)
graphical viewer and
editor for tabular data



VOSpec - ESA - multi-wavelength spectral
analysis tool with access to spectra, theoretical
models and atomic and molecular line databases

... and many,
many more...



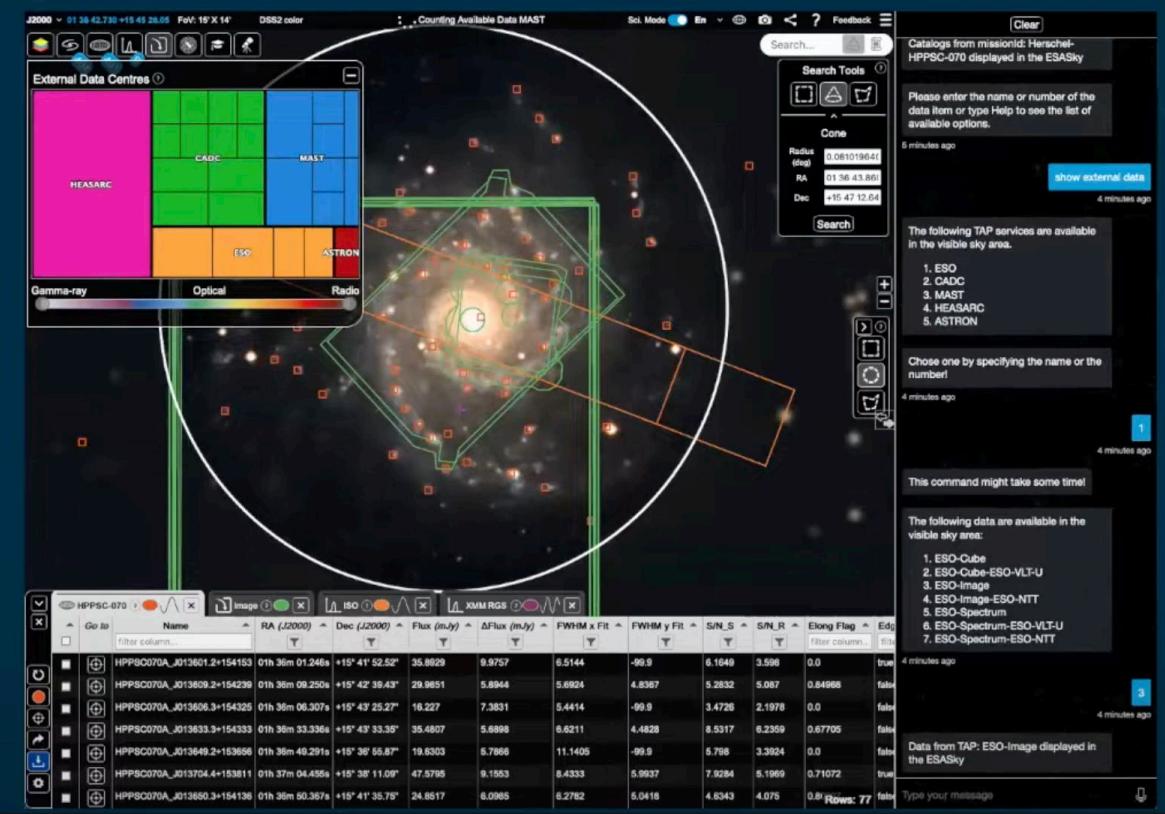
The cherry on the cake: ESASky

ESASKY – sky.esa.int

ESASky is a multi-mission, multi-frequency science driven discovery portal developed by the Data Science and Archives Division at ESAC.

ESASky users can access data from a wide variety of missions ESA, NASA, CSA, JAXA, and others, and also give the possibility to explore the data contents from other partner data centres using IVOA protocols to interoperate.

Very recently it also became multi-messenger with the addition of GW and neutrino alerts.



A science driven discovery portal

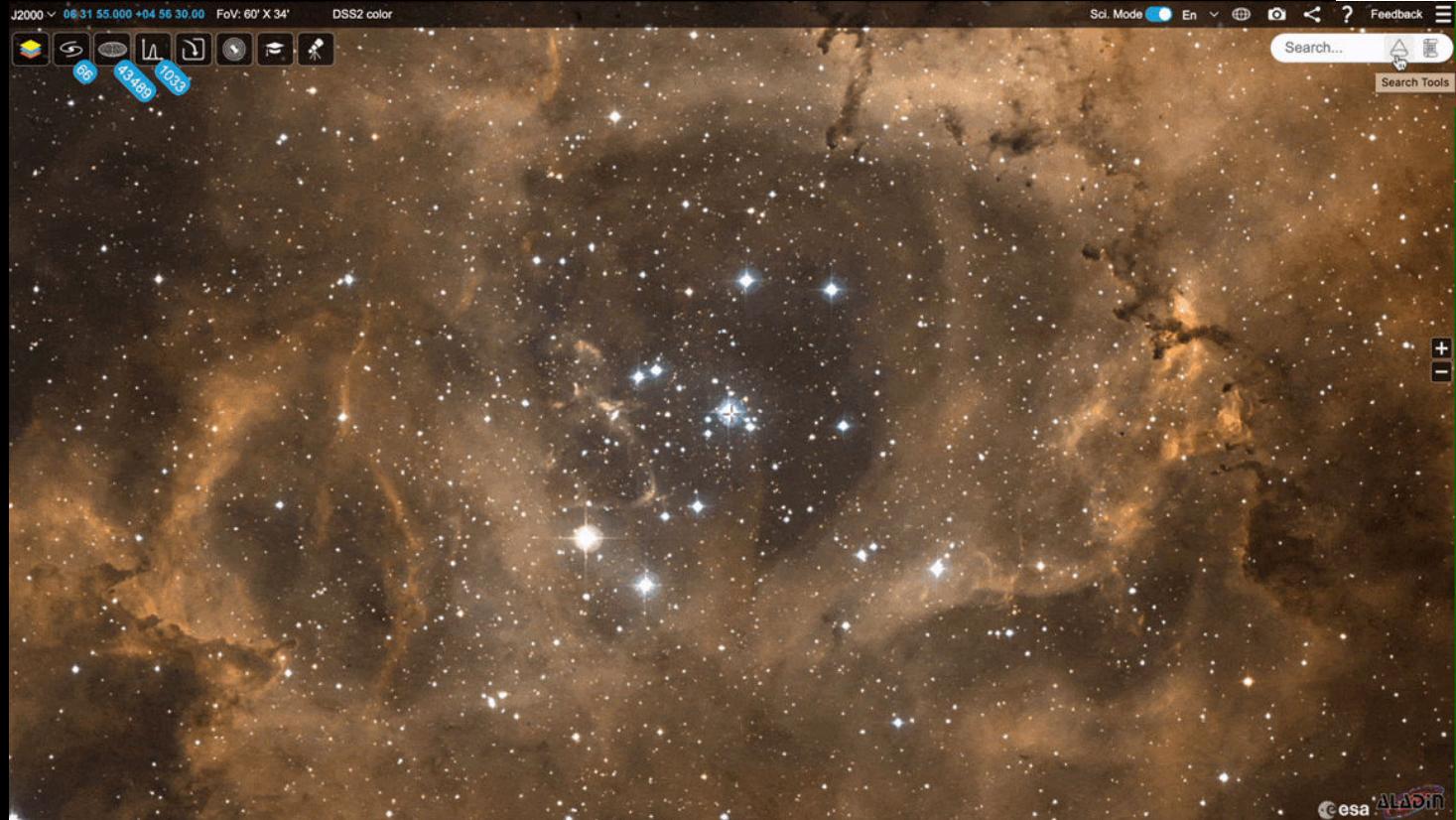


Full access to the entire sky

Data from space, ground base + multi-messenger astronomy (ESA, NASA, JAXA, ESO, CADC, MAST...)

Science-mode or Explorer mode

Planning tool for JWST & XMM-Newton

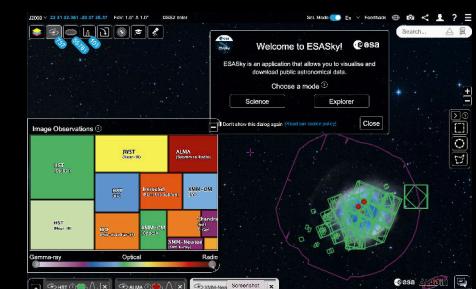


What is ESASky?

ESASky is:

- A platform and suite of tools for scientists, driven by scientific use cases, responding to needs from the scientific community

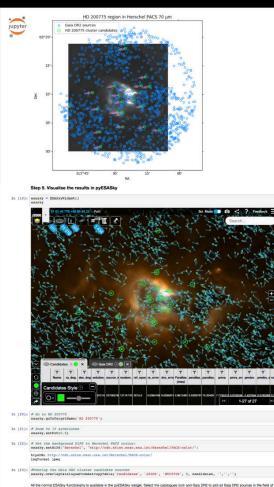
ESASky interface
sky.esa.int



ESA Legacy Archive
(Table Access
Protocol, TAP)

#!/bin/bash
export proposal_id=130f18
export tap_url=https://vs.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/argus/tap/tap.cgi
export REQUESTS_TIMEOUT=10
export LANG=AOEL
export USERWHEEL_TIMEOUT=10
export GOMAT_CLOUDS=1
export QUERYSELECT=planckURL+?FromRow=2,Observation+as+3DN+caon+2,Plan+as+<+on+obs.ID%3Dp.obs.ID+where+o.proposal_ID%3Dp.proposal.ID+&
#>

Programmatic access (scripts, notebooks, etc)



pyESASky
Jupyter widget

Astroquery & TAP

```
Using astroquery
All astroquery modules are designed to follow the same API. In the simplest form, the API involves queries based on coordinates or object names. Some simple examples using GNRAD.

>>> from astroquery import Table
>>> result_table = Table.query_object("m1")
>>> result_table.printout()
MAIN_ID RA DEC ... COO_BCODE SCRIPT_NUMBER_ID
-----"m1"----- ...
M 1 05 34 36.9 +22 08 53 ... 1995AJPB..48..143S
1

All query allow coordinate-based queries:
>>> from astroquery import Coordinates
>>> result_table = Coordinates.query_region("000:00:00.0,000:00:00.0", radius="0.01deg")
>>> result_table.printout(unit=True, max_width=80, max_lines=5)
MAIN_ID RA ... COO_BCODE SCRIPT_NUMBER_ID
-----"m1"----- ...
NAME Ori Region 05 35 17.39 ... 1
... ...
Length = 3272 rows
```

Javascript API

INFO:
All commands should be sent to the ESASky element as continuations. For example by:
document.getelementbyid('esaskyframename').
contentwindow.postMessage(command,
"http://www.esa.int")
where esaskyframename is the elementId
where the esasky page is embedded, command
is a JSON object and message is the message
and content with all parameters.
There are a number of commands that will send
raw events to the client. These will also be
sent as http messages directed to the sender
element. If you want to send raw events otherwise specified this will probably be the main
way to interact with the API. If you
want to handle the data sent back
window.addEventListener("message",function(e){
var data = e.data;
// Code to handle the data
});
Available events described here and can be
sent to the client by sending a message to the
command. If there is a submit button written will send it
to the iframe and paste it to the custom function
in the event. All events will respond from
ESASky are also displayed.
Click on the headers to expand them

ESASky - the interface



The screenshot displays the ESASky interface with the following key elements:

- Top Bar:** Includes coordinates (J2000 12 42 08.009 +32 32 29.44), FoV: 24' X 15', DSS2 color, Sci. Mode (on), Feedback, and a search bar.
- Left Panel:** Equatorial/Galactic Coordinates (hh:mm:ss / dec. degrees).
- Middle Panel:** Buttons for "Which Sky", "Observations" (355), "Sources" (508881), "Spectra & light curves" (199), "Multi-messenger events", and "External Data Centres".
- Right Panel:** Buttons for "Cursor position", "FOV size", "HiPS map", and "Target List".
- Bottom Right:** COSPAR logo and a small crosshair icon.

Red arrows point from the "Which Sky" button to the "Observations", "Sources", and "Spectra & light curves" buttons. Red arrows also point from the "Multi-messenger events" button to the "Observations planning tool" and "Publications" buttons.

Labels with red arrows pointing to specific features:

- Which Sky → Observations, Sources, Spectra & light curves
- Observations → Observations planning tool
- Sources → Publications
- Spectra & light curves → Multi-messenger events
- Multi-messenger events → Observations planning tool, Publications
- External Data Centres → Multi-messenger events

Bottom left corner: ESASky and Data!

Different skies

The screenshot shows the ESASky application interface. At the top, it displays coordinates J2000 190.5333708 +32.5415111 and a Field of View (FoV) of 24' X 15'. The color mode is set to 2MASS color JHK. On the right side, there are various controls: Sci. Mode (on), En (English), Feedback, a globe icon, camera icon, a person icon, a question mark icon, and a three-line menu icon. Below these are search fields and icons for a triangle and a clipboard.

Select Sky (with a question mark icon)

- Soft X-ray (dropdown: EPIC color) - icon: rainbow cube
- Optical (dropdown: DSS2 color) - icon: rainbow cube
- Far-Infrared (dropdown: Herschel PACS RGB Gal. plane) - icon: rainbow cube
- Optical (dropdown: DSS2 color) - icon: rainbow cube
- Near-Infrared (dropdown: 2MASS color JHK)** - icon: rainbow cube (highlighted with a red circle)
- Mid-Infrared (dropdown: AllWISE color) - icon: rainbow cube
- Far-Infrared (dropdown: Herschel PACS RGB 70, 160 micron) - icon: rainbow cube
- Submillimetre (dropdown: Herschel SPIRE RGB 250, 350, 500 micron) - icon: rainbow cube
- Radio (dropdown: Planck LFI 030 GHz) - icon: rainbow cube

Controls: +, -, zoom slider, back, forward, and a central crosshair.

Bottom right corner: esa ALadin logo and a speech bubble icon.



Direct access of all ESA archives, poststamps, metadata



The screenshot illustrates the ESASky interface, which provides direct access to various ESA archives, poststamps, and metadata. The top portion shows a multi-wavelength visualization of a celestial object (NGC6720) with overlaid observation contours from different space telescopes. The bottom portion shows a detailed search results page for a specific observation ID: jw01558005001_04103_00001.

Top Panel (Multi-wavelength Visualization):

- Coordinates: J2000 18 53 39.300 +33 00 45.67
- FoV: 9.4' X 5.3'
- Filter: 2MASS color JHK
- Instrument Legend:
 - HST (Optical)
 - JWST (Near-IR)
 - HST (Near-IR)
 - JWST (Mid-IR)
 - HST (UV)
 - Spitzer (Mid-IR to Far-IR)
 - Herschel (Far-IR to Submm)
 - Chandra (soft X-ray)
- Color Bar: Gamma-ray, Optical, Radio

Bottom Panel (Search Results):

- jwst science archive**
- SEARCH RESULTS
- HOME | SEARCH | RESULTS | ESASKY SEARCH | ADQL SEARCH | GUIDE
- RESULTS #1
- JWST Observations (1)
- Observation ID: jw01558005001_04103_00001
- Target name: NGC6720
- RA: 18h 53m 35.07s
- Dec: +33d 01' 45.03"
- Instrument: NIRCAM/IMAGE
- Obs. Mode: 1558

Images...archives...images



J2000 $18^{\circ} 54' 14.847''$ $+32^{\circ} 55' 43.53''$ FoV: $42'' \times 26''$ 2MASS color JHK

Sci. Mode En Feedback Search...

Image Observations

HST (Optical)	JWST (Near-IR)	HST (Near-IR)
JWST (Mid-IR)	HST (UV)	Spitzer (Mid-IR to Far-IR)
ISO (Mid-IR to Far-IR)		Herschel (Far-IR to Submm)

Gamma-ray Optical Radio

JWST **Herschel** **HST**

Observation ID	RA (J2000)	Dec (J2000)	Target name	Instrument	Collection	Obs Type	Filter
hst_06119_33_w...	18h 53m 31.430s	$+33^{\circ} 01' 39.86''$	NGC6720	WFPC2	HLA	HLA Visit A...	F814...
hst_07632_01_w...	18h 53m 38.889s	$+33^{\circ} 01' 54.50''$	NGC6720	WFPC2	HLA	HLA Visit A...	F469N
hst_07632_01_w...	18h 53m 36.488s	$+33^{\circ} 01' 47.31''$	NGC6720	WFPC2	HLA	HLA Visit A...	F469N
hst_07632_01_w...	18h 53m 38.889s	$+33^{\circ} 01' 54.50''$	NGC6720	WFPC2	HLA	HLA Visit A...	F502N
hst_07632_01_w...	18h 53m 36.483s	$+33^{\circ} 01' 47.37''$	NGC6720	WFPC2	HLA	HLA Visit A...	F502N
hst_07632_01_w...	18h 53m 38.889s	$+33^{\circ} 01' 54.50''$	NGC6720	WFPC2	HLA	HLA Visit A...	F658N
hst_07632_01_w...	18h 53m 36.490s	$+33^{\circ} 01' 47.37''$		WFPC2	HLA	HLA Visit A...	F658N

Rows: 258

One of Isa's favourites

J2000 **05 46 57.184 -51 11 21.36** FoV: 1.2° X 42' DSS2 color

Sci. Mode En Feedback      

 COSPAR
COMMITTEE ON SPACE RESEARCH

Image Observations

HST (Optical)	JWST (Mid-IR)	HST (UV)	
HST (Near-IR)	JWST (Near-IR)	ALMA (Submm to Radio)	Spitzer (Mid-IR to Far-IR)
Herschel (Far-IR to Submm)	Herschel (Far-IR to Submm)	Chandra (Soft X-ray)	

Gamma-ray Optical Radio

Observation Details

Observation ID: jw01411-c1000_t001_miri_f2300c-masklyot

Target name: -BET-PIC

RA (J2000): 05h 47m 17.099s

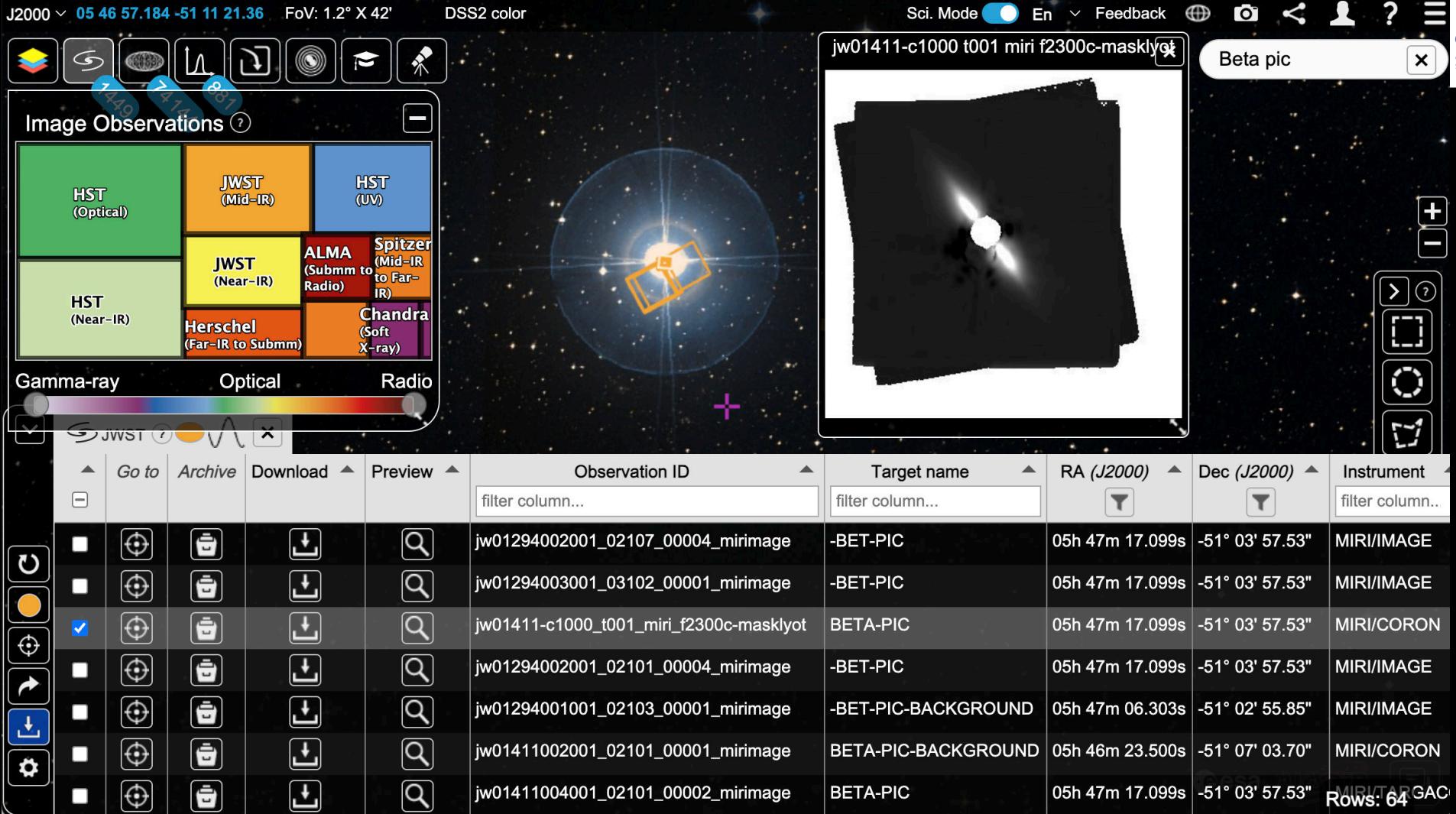
Dec (J2000): -51° 03' 57.53"

Instrument: MIRI/IMAGE

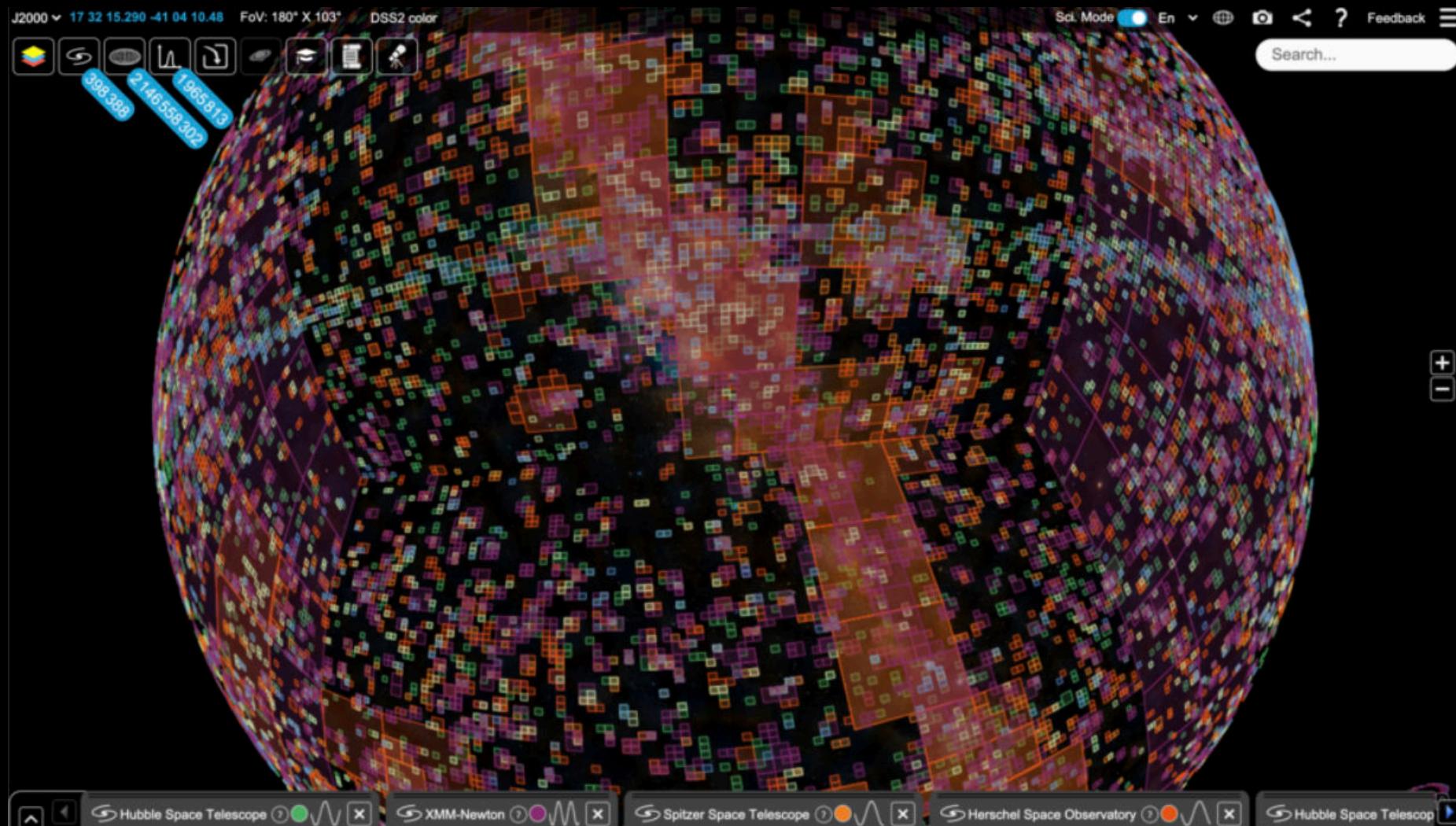
Table of Observations

	Observation ID	Target name	RA (J2000)	Dec (J2000)	Instrument
<input type="checkbox"/>	jw01294002001_02107_00004_mirimage	-BET-PIC	05h 47m 17.099s	-51° 03' 57.53"	MIRI/IMAGE
<input type="checkbox"/>	jw01294003001_03102_00001_mirimage	-BET-PIC	05h 47m 17.099s	-51° 03' 57.53"	MIRI/IMAGE
<input checked="" type="checkbox"/>	jw01411-c1000_t001_miri_f2300c-masklyot	BETA-PIC	05h 47m 17.099s	-51° 03' 57.53"	MIRI/CORON
<input type="checkbox"/>	jw01294002001_02101_00004_mirimage	-BET-PIC	05h 47m 17.099s	-51° 03' 57.53"	MIRI/IMAGE
<input type="checkbox"/>	jw01294001001_02103_00001_mirimage	-BET-PIC-BACKGROUND	05h 47m 06.303s	-51° 02' 55.85"	MIRI/IMAGE
<input type="checkbox"/>	jw01411002001_02101_00001_mirimage	BETA-PIC-BACKGROUND	05h 46m 23.500s	-51° 07' 03.70"	MIRI/CORON
<input type="checkbox"/>	jw01411004001_02101_00002_mirimage	BETA-PIC	05h 47m 17.099s	-51° 03' 57.53"	MIRI/IMAGE

Rows: 64



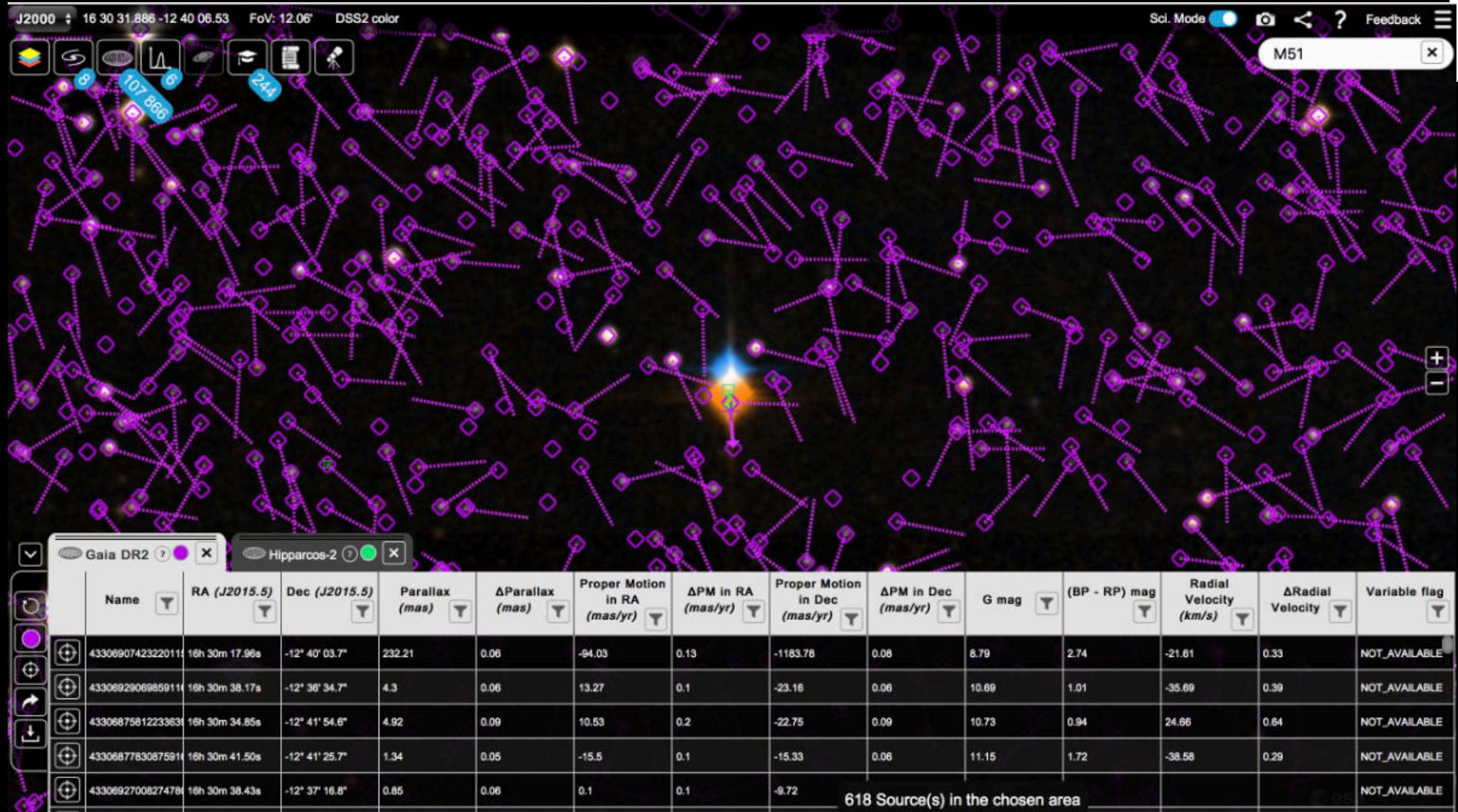
Images, images, images



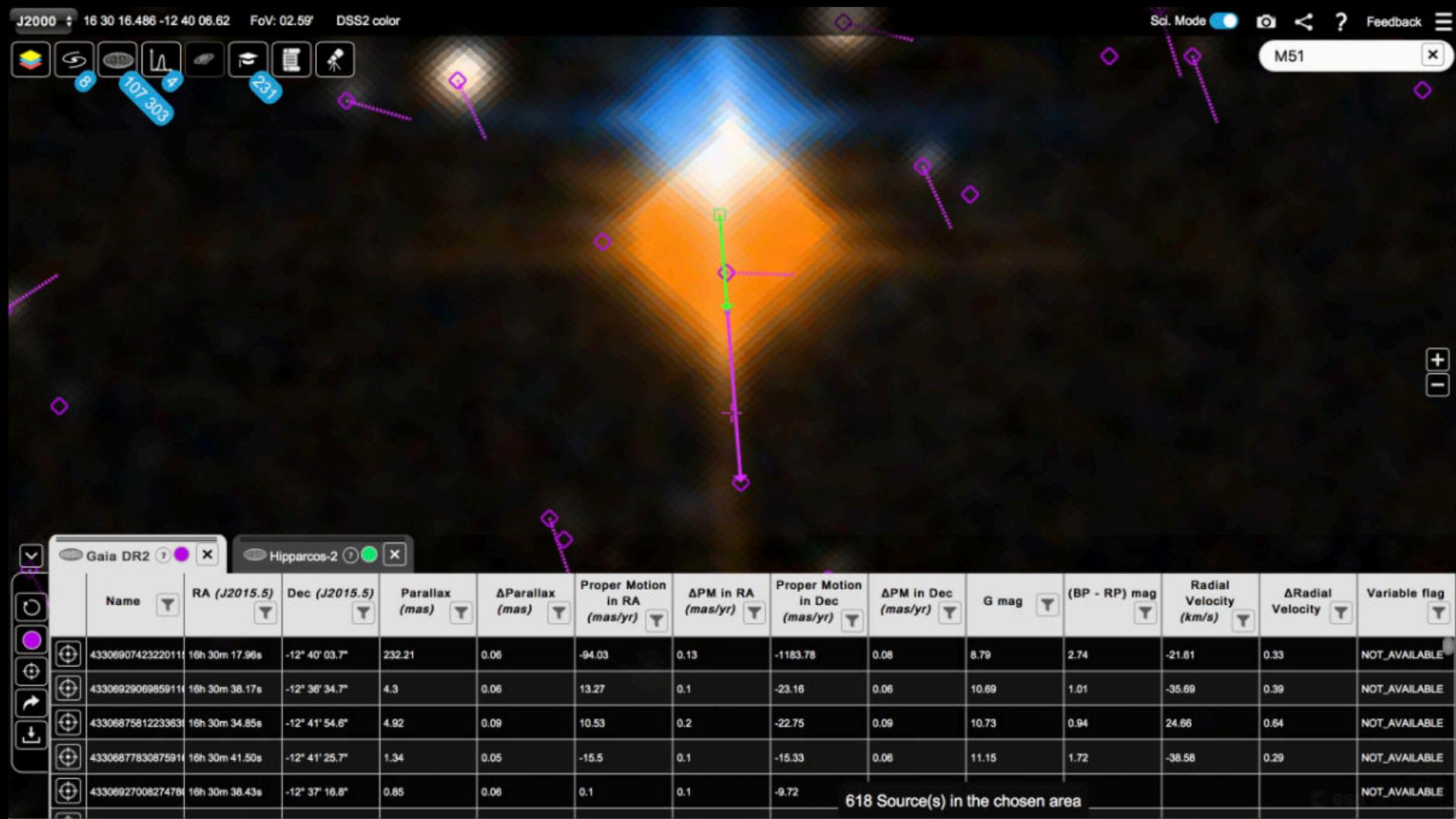
Catalogues



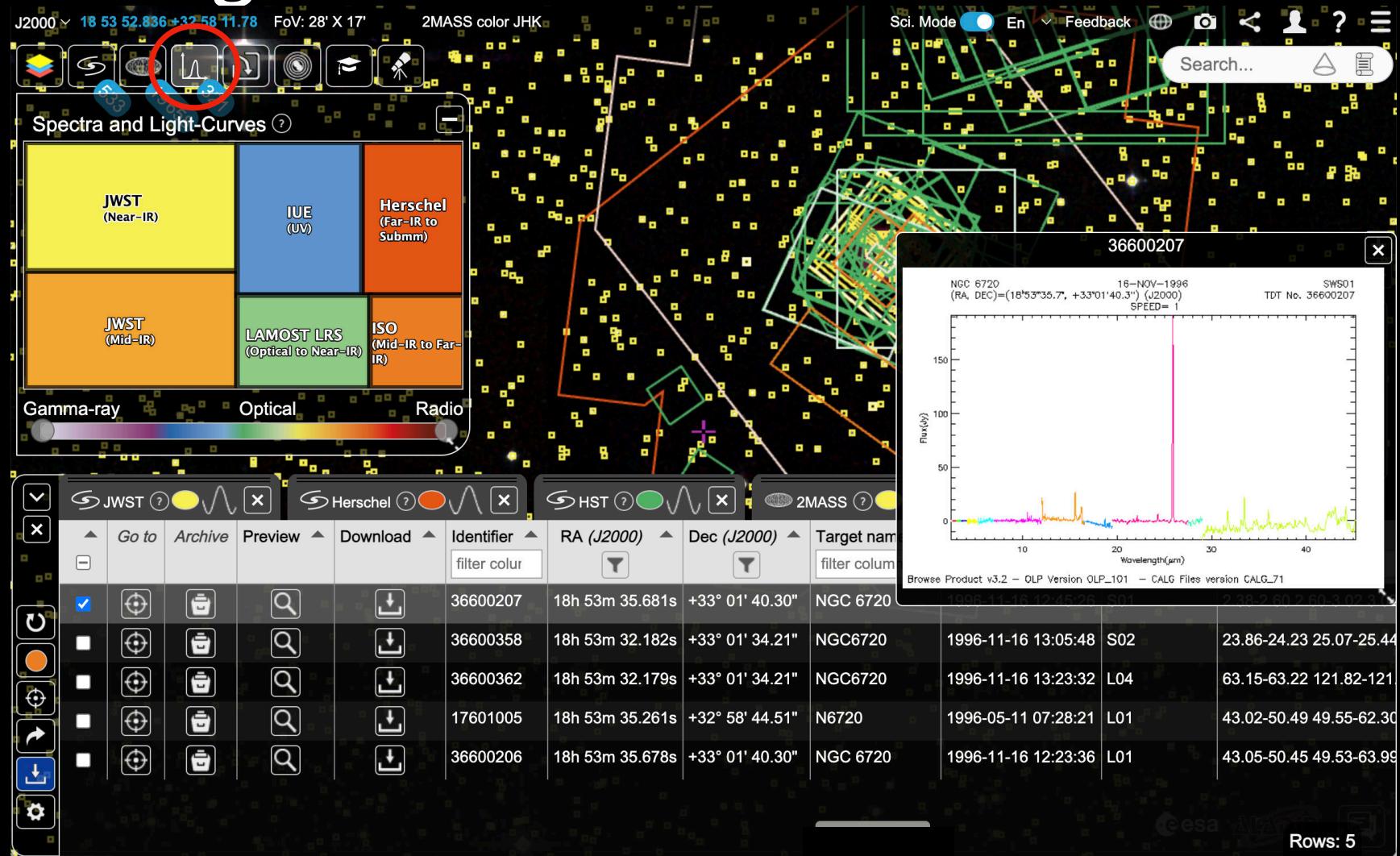
Accessing catalogues... and proper motions



Eppur si muove



Spectra + Light curves



Other providers

The screenshot shows the DataLabs interface with a star field background. At the top, it displays coordinates J2000 05 34 57.325 +21 57 51.29 and a FoV of 25' X 15'. It also shows 2MASS color JHK. On the right, there's a COSPAR logo.

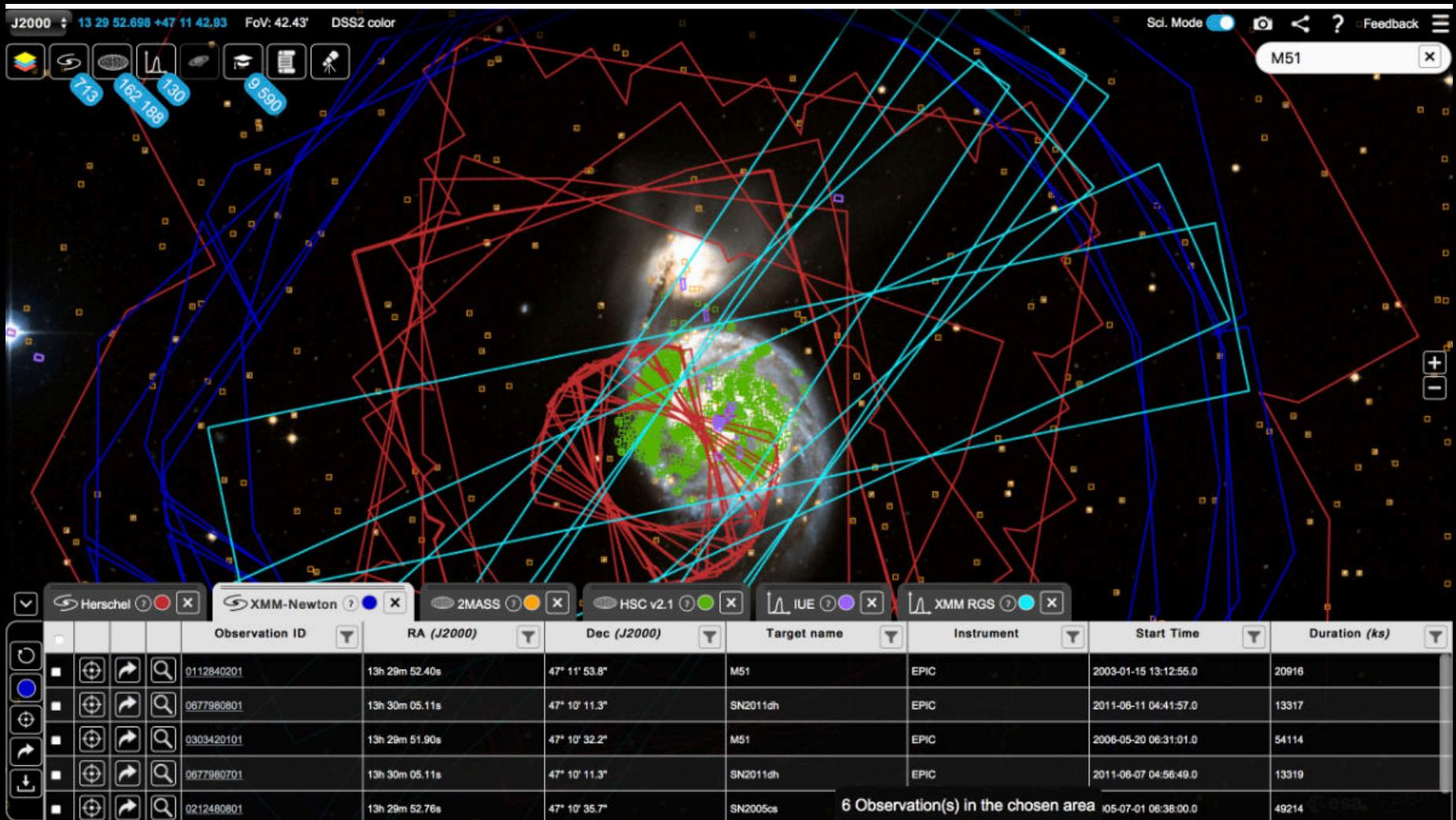
On the left, there are several icons representing different data sources, with three specifically highlighted with blue labels and circled in red: '2619', '88363', and '88363' again.

A central window titled 'External Data Centres' is open, showing tabs for Dashboard, TAP Registry, VizieR, and ESA. The TAP Registry tab is active, displaying a list of tables under the 'hipparcos1' schema. The table 'hipparcos1' has 119 rows. Below this, there are three smaller windows for 'xSHOOTER', 'UVES', and 'ESASky Legacy', each showing a table of data. The 'ESASky Legacy' window is the most prominent, showing a detailed table of solution parameters:

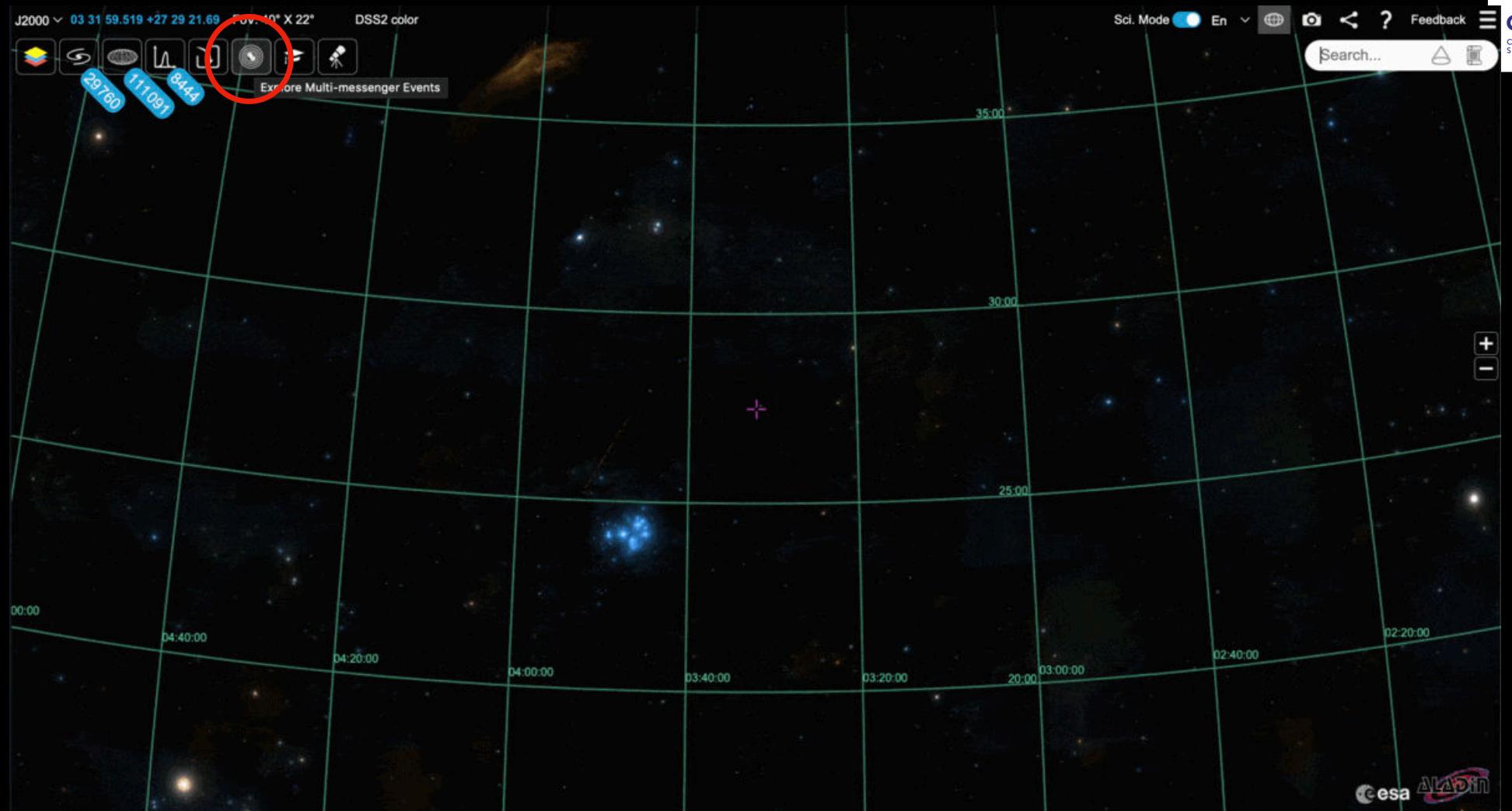
Arraysize	Column Index	Column Name	Datatype	Db Column Name	Description	Indexed	Principal	Schema
*	1	CCDM	char		CCDM number (DC1)	0	0	hipparcos
*	3	S	short		Solution identifier (DC2)	0	0	hipparcos
*	4	Type	char		[FIL]Type of solution (DC3)	0	0	hipparcos
*	5	Source	char		[CFN] Solution source (DC4)	0	0	hipparcos
*	6	Qual	char		[ABCD] Solution quality (DC5)	0	0	hipparcos
*	7	Notes	char		[DGPWXYZ] Existence of notes (DC6)	0	0	hipparcos
*	8	Nsys	short		Number of solutions for the system (DCM1)	0	0	hipparcos

At the bottom right, it says 'Rows: 37'.

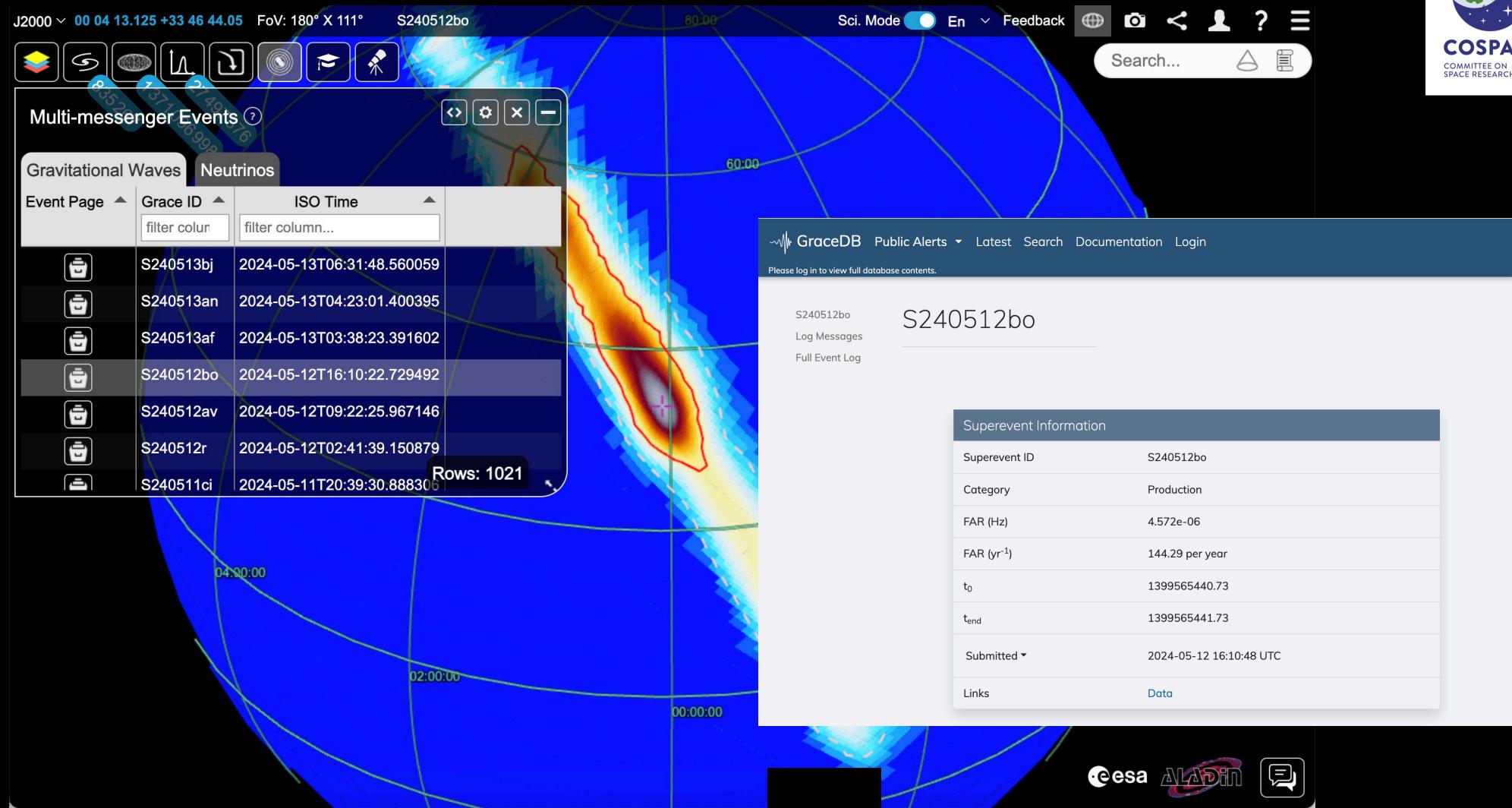
Exploring images, catalogues, spectra, light curves...



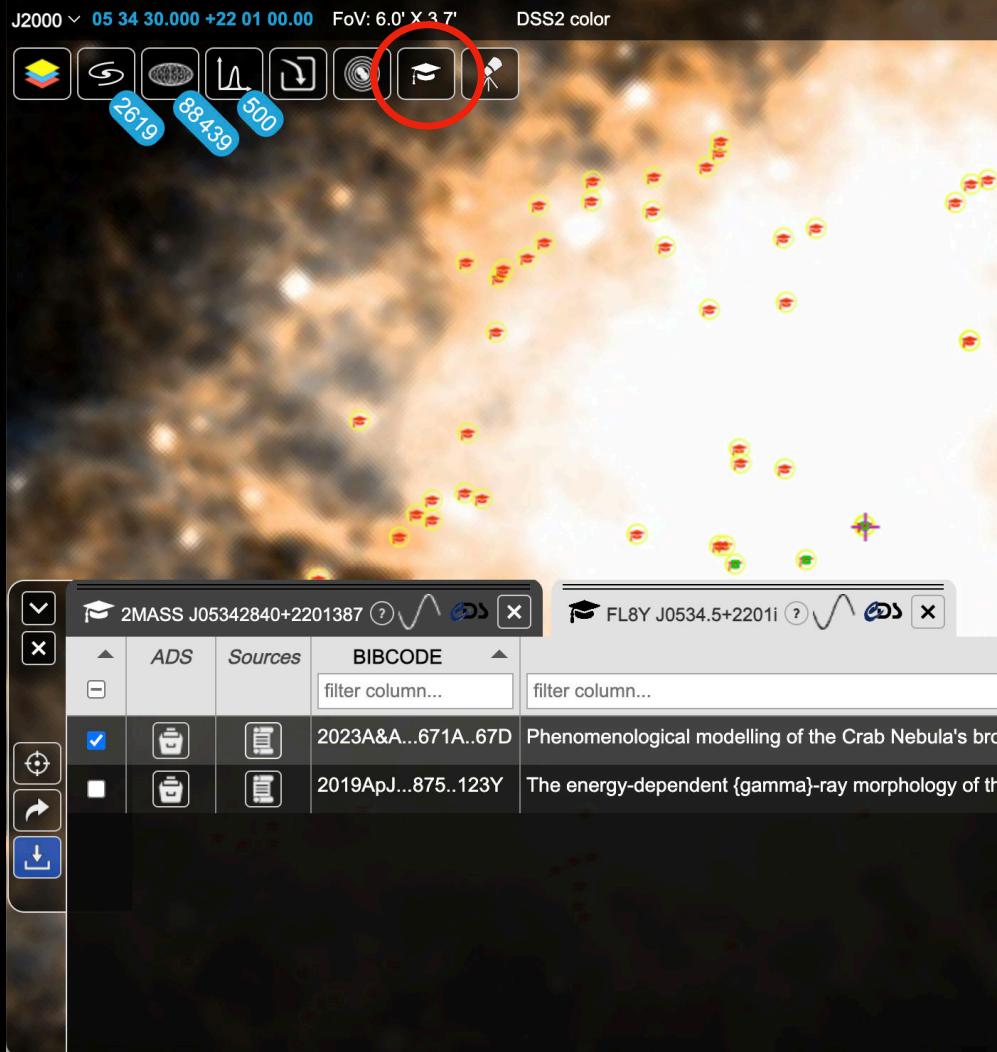
The message can be of different nature



Gravitational waves



Publications



J2000 v 05 34 30.000 +22 01 00.00 FoV: 6.0' X 3.7' DSS2 color

Sci. Mode En Feedback 🔍 📸 🗺️ 🚶 ? ⌂

M1

Target List

Phenomenological modelling of the Crab Nebula's broadband energy spectrum and its apparent extension.

Bibcode: 2023A&A...671A..67D

Authors: DIRSON L., HORNS D.

Journal: A&A, 2023

ads

Feedback ORCID About Sign Up Log In

QUICK FIELD: Author First Author Abstract All Search Terms

2MASS J05342840+2201387 FL8Y J0534.5+2201i

ADS Sources BIBCODE

filter column... filter column...

2023A&A...671A..67D Phenomenological modelling of the Crab Nebula's broadband energy spectrum and its apparent extension

2019ApJ...875..123Y The energy-dependent $\{\gamma\}$ -ray morphology of the

FULL TEXT SOURCES

Publisher Preprint

DATA PRODUCTS

SIMBAD (6) IRSA (2) Chandra (1)

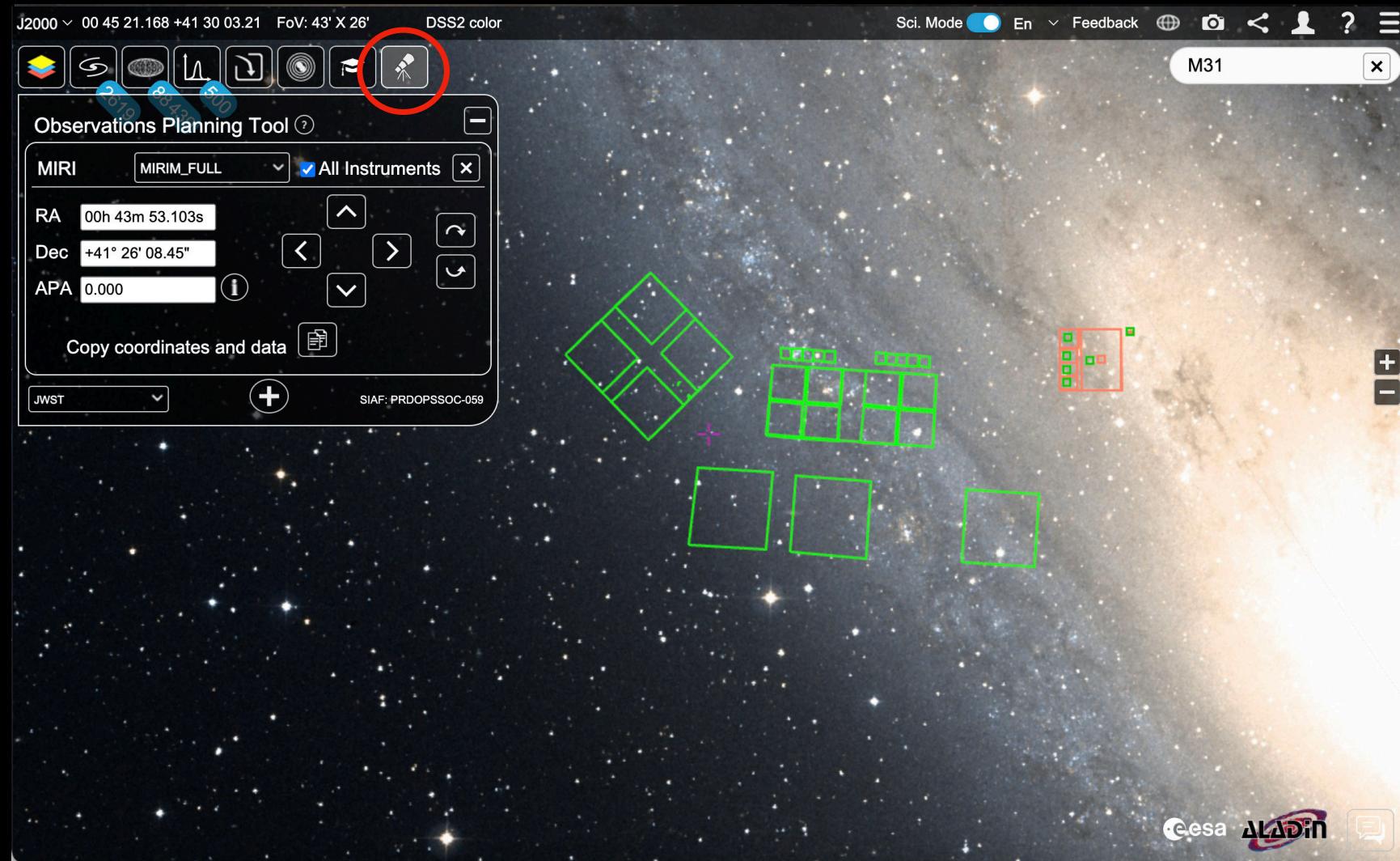
GRAPHICS

Click to view more

The screenshot shows the ESASky software interface. At the top, it displays coordinates (J2000 05 34 30.000 +22 01 00.00), field of view (FoV: 6.0' X 3.7'), and a color-coded map of the Crab Nebula. A red circle highlights a specific icon in the top toolbar. Below the map, there are two search results for the star 2MASS J05342840+2201387 and the pulsar FL8Y J0534.5+2201i. The first result is a bibcode entry for a paper by Dirson and Horns. The right side of the screen shows a detailed view of this paper, including the title, authors, journal, abstract, and a figure titled "Phenomenological modelling of the Crab Nebula's broadband energy spectrum and its apparent extension". The figure is a log-log plot of flux density versus frequency or energy. The bottom right corner features the COSPAR logo.



Let's plan an observation... (and ignore the oversubscription)



SSOs in ESASky



ESASky 6.2 | Login a Mi Cuenta Amex | American Express España | Sci. Mode | En | Feedback | [Feedback](#) | [Profile](#) | ? | [Help](#)

J2000 04 50 01.973 +20 12 11.22 FoV: 29° X 17° DSS2 color

psyche

Select Sky (Optical)

Science with ESASky

ESASky SSOSS: Solar System Object Search Service

The Case of Psyche

E. Racero^{1,2}, F. Giordano^{2,3}, B. Carry^{4,5}, J. Berthier⁵, T. Müller⁶, M. Mahlke⁴, I. Valtchanov⁷, D. Baines⁷, S. Kruk⁸, B.

- Created a pipeline using slw from IMCCE Paris (in collaboration with J. Berthier and B. Carry): **satellite frame (spacecraft kernels) → orbital path of object seen by the satellite (ephemerides) → Geometric match against mission observations (public logbooks) → footprint detection**.
- 800,000 asteroids and 2,000 comets (~all SSOs) in the SSOSS, available through ESASky (targeted and serendipitous).
- For this 1st release, 3 missions chosen as priorities:
 - XMM-Newton (X-Rays), HST (UV – optical), SPIRE (far-IR). XMM-OM also reported in previous work.

Science with ESASky

ESASky SSOSS: Solar System Object Search Service

The Case of Psyche

E. Racero^{1,2}, F. Giordano^{2,3}, B. Carry^{4,5}, J. Berthier⁵, T. Müller⁶, M. Mahlke⁴, I. Valtchanov⁷, D. Baines⁷, S. Kruk⁸, B.

Results:

- Catalogue with potential detections of asteroids within estimated limiting mag or flux limit in Herschel, XMM & HST images.
- Includes serendipitous detections: 909 Herschel; 985 XMM-OM; 32,000+ HST → HST images used in the Hubble Asteroid Hunter citizen science project (See S. Kruk seminar on 4th March 2021).
- Thermal properties of Psyche: 4 Herschel serendipitous detections (of predominantly the object's southern hemisphere) + previously published thermal IR measurements to perform radiometric study.

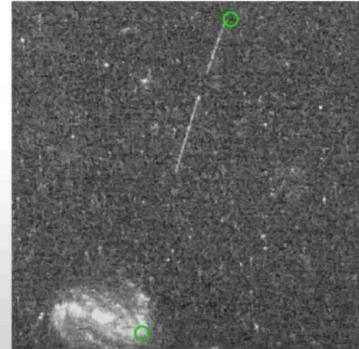
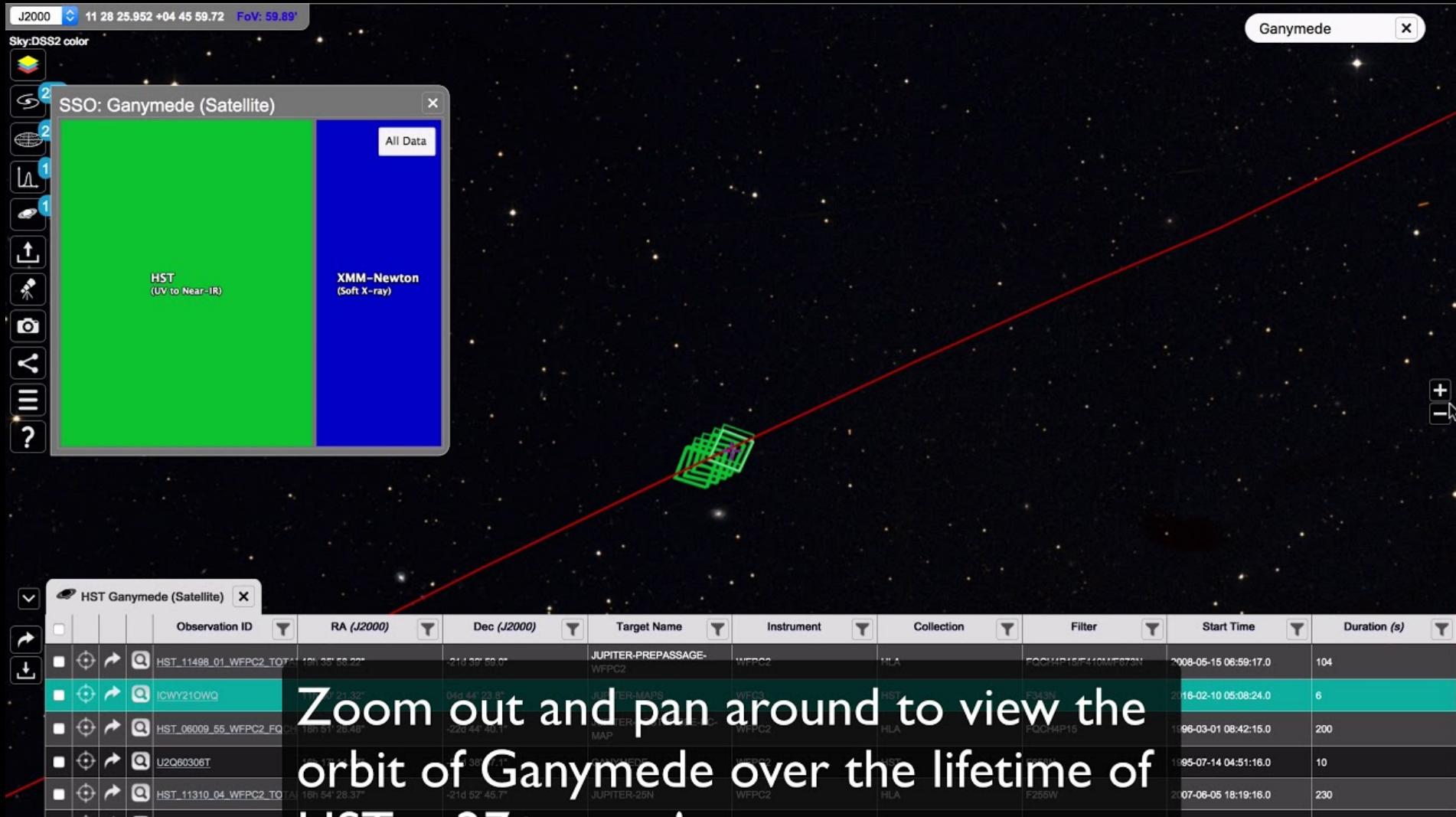


Fig. 10: A serendipitous observation of asteroid 2000 NH10 by the ACS on-board HST is visible towards the upper part of the image. The green markers indicate the predicted start- and end-position of the asteroid as computed by the pipeline. The observation itself targeted the galaxy cluster MACS1115+0129.

Rows: 4

SSOs in ESASky



Zoom out and pan around to view the orbit of Ganymede over the lifetime of

	Observation ID	RA (J2000)	Dec (J2000)	Target Name	Instrument	Collection	Filter	Start Time	Duration (s)
■	HST_11498_01_WFPC2_TOT	18h 35m 22s	-21d 39m 0.0s	JUPITER-PREPASSAGE-WFPC2	WFPC2	HLA	F001W/F110W/F673N	2008-05-15 06:59:17.0	104
■	ICWY21OWQ	18h 21m 32s	04d 44m 23.8s	JUPITER-MAPS	WFPC2	HST	F343N	2016-02-10 05:08:24.0	6
■	HST_06009_55_WFPC2_TOT	18h 51m 25.4s	-22d 44m 40.1s	JUPITER-MAPS	WFPC2	HLA	F004W/F110W/F673N	1998-03-01 08:42:15.0	200
■	U2Q60306T	18h 38m 41s	-21d 51m 45s	JUPITER-GANYMED	WFPC2	HST	F255W	1995-07-14 04:51:16.0	10
■	HST_11310_04_WFPC2_TOT	18h 54m 28.3s	-21d 52m 45.7s	JUPITER-25N	WFPC2	HLA	F255W	2007-06-05 18:19:16.0	230

AI is also present in ESASky: EVA



"A Virtual Assistant or Chatbot is a computer program that uses AI, namely Natural Language Processing, to have a conversation with humans. Users can ask questions, make requests and respond to chatbot questions and statements using natural language. A chatbot could support text input, audio input, or both."

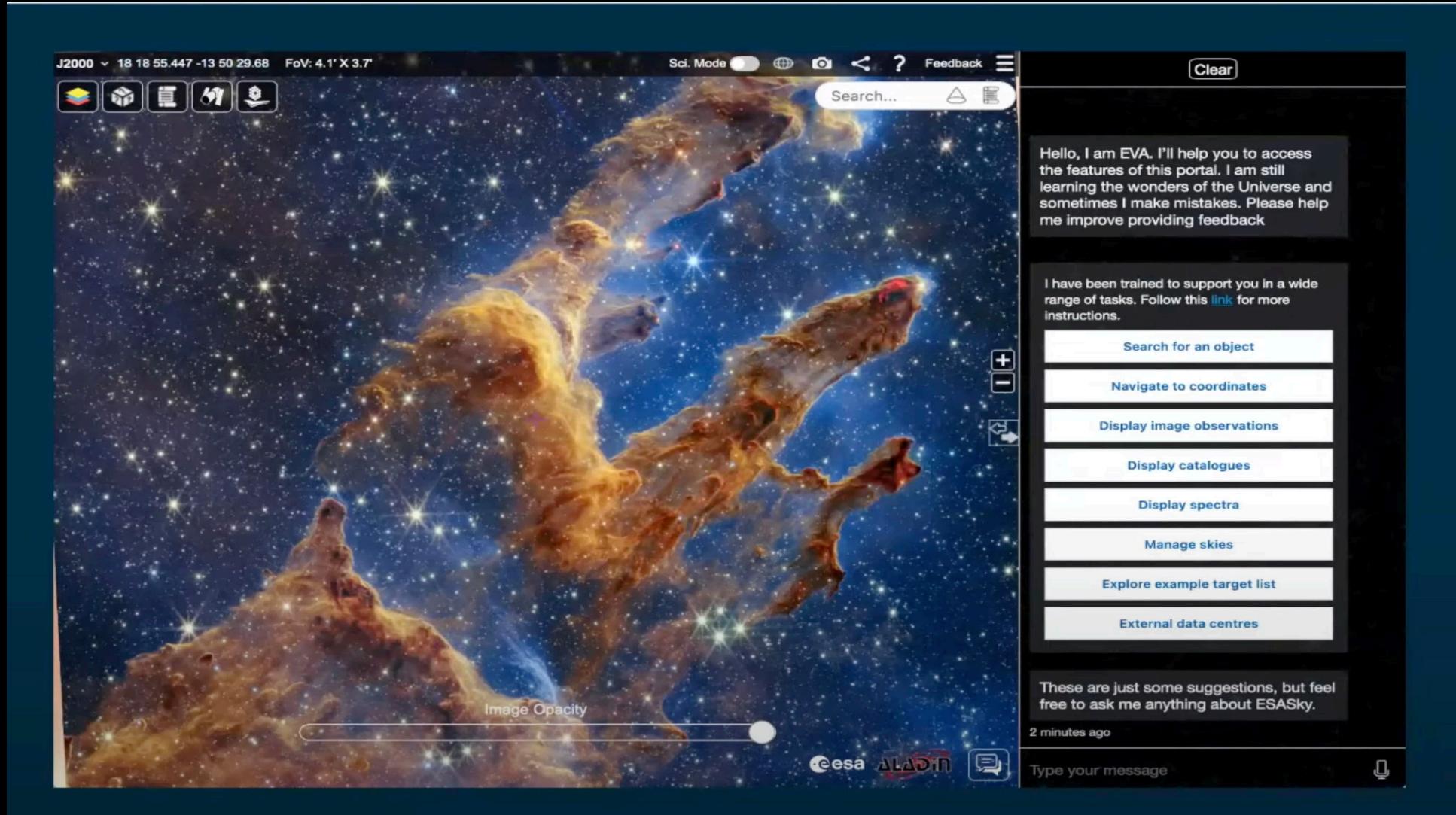
— IBM —

Benefits

- Responds immediately
- Provides assistance 24x7
- Keep it conversational
- Advanced information searching
- Improve loyalty and accessibility



EVA can help, especially newcomers



The screenshot shows the ESASky web application interface. The main view displays a detailed image of a nebula, likely the Pillars of Creation, with a color palette ranging from deep blues to bright yellows and reds. At the top, there are navigation controls including a coordinate selector (J2000, 18 18 55.447 -13 50 29.68), a field of view indicator (FoV: 4.1' X 3.7'), and a science mode toggle. A search bar and various tool icons are also present.

EVA AI Chatbot:

- Welcome Message:** Hello, I am EVA. I'll help you to access the features of this portal. I am still learning the wonders of the Universe and sometimes I make mistakes. Please help me improve providing feedback
- Task Suggestions:**
 - Search for an object
 - Navigate to coordinates
 - Display image observations
 - Display catalogues
 - Display spectra
 - Manage skies
 - Explore example target list
 - External data centres
- Final Message:** These are just some suggestions, but feel free to ask me anything about ESASky.
- Timestamp:** 2 minutes ago
- Input Field:** Type your message

Astroquery accessing ESASky



Access ESASky products with astroquery.esasky

Authors: Ivan Valtchanov, Belén López Martí, H. Norman, Nuria Álvarez Crespo

Last update: Jul 07, 2021

This notebook illustrates some example usages of the ESASky implementation in astroquery.

First you need to install astroquery and esasky.

Astroquery can be installed with `pip install --pre astroquery`, the latest version should come with esasky. Alternatively, you can grab the latest astroquery with esasky from [here](#).

The documentation for astroquery.esasky is available [here](#).

Use Case 1: Retrieve imaging data for a single object

In this use case, imaging data are retrieved for a single object, indicated by its name (resolved by Simbad) or coordinates.

We start by importing the ESASky astroquery module and other necessary packages:

```
In [1]: %matplotlib inline
import matplotlib.pyplot as plt
from matplotlib.colors import LogNorm
import os
from astroquery.esasky import ESASky
```

Created TAP+ (v20200428.1) – Connection:
Host: sky.esa.int
Use HTTPS: True
Port: 443
SSL Port: 443

First, let's check the available maps:

```
In [2]: ESASky.list_maps()
```

```
Out[2]: ['INTEGRAL',
         'XMM',
         'Chandra',
         'HFI/CAII']
```

query ESASky using a dedicated module within the python Astroquery package.

```
In [4]: maps = ESASky.query_object_maps(position='13h29m52.7s +47d11m43s')
print(maps)
```

WARNING: InputWarning: Coordinate string is being interpreted as an ICRS coordinate. [astroquery.utils.common]

TableList with 12 tables:

```
'0:INTEGRAL' with 18 column(s) and 1 row(s)
'1:XMM' with 15 column(s) and 11 row(s)
'2:CHANDRA' with 53 column(s) and 17 row(s)
'3:XMM-OM-OPTICAL' with 17 column(s) and 12 row(s)
'4:XMM-OM-UV' with 17 column(s) and 19 row(s)
'5:HST-UV' with 15 column(s) and 19 row(s)
'6:HST-OPTICAL' with 15 column(s) and 260 row(s)
'7:HST-IR' with 15 column(s) and 41 row(s)
'8:ISO-IR' with 18 column(s) and 7 row(s)
'9:HERSCHEL' with 15 column(s) and 9 row(s)
'10:AKARI' with 11 column(s) and 3 row(s)
'11:SPITZER' with 14 column(s) and 4 row(s)
```

The method has a tolerance of 5 arcsec to allow for positional errors.

Let's check the content of the 'XMM-OM-OPTICAL' table:

```
In [5]: maps['XMM-OM-UV'].info
```

```
Out[5]: <Table length=19>
          name      dtype   unit      description
          -----  -----
            dec_deg float64      s      Total exposure time of observation
            duration int64      s
            end_utc   object
            filter    object
            fov       object
            instrument object
            observation_id object
            observation_oid int32
            position_angle float64
            postcard_url object
            product_url object
            proprietary_end_date object
            ra_deg     float64
            start_utc  object
            stc_s     object
            target    object
            xmm_om_uv_oid int64
```

Jupyter Notebook: pyESASky



jupyter my_first_exercise Last Checkpoint: 21 hours ago (autosaved)

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3 (ipykernel) Logout

In [7]: # Instantiate the pyESASky instance
esasky = ESASkyWidget()

In [8]: ?ESASkyWidget.goToRADec

In [9]: # Load the pyESASky instance
esasky

J2000 × 10 00 17.243 +01 47 19.48 FoV: 2.1° X 1.9°

Feedback Search...

Instrument: XMM-Newton EPIC
Filter: Medium Medium Thin
Exposure level: 30449.58642936
Object: COSMOS FIELD 1
Observer: PRF GUNTERH HARMER
Date-OBS: 2004-11-11T13:23:02
Image size: pixels (65754, 164-373)

XMM-Newton Observation ID Target name Instrument Start Time

Observation ID	Target name	Instrument	Start Time
0302352501	Cosmos field B25	EPIC	2006-05-10T03:09:05.0
0302353401	Cosmos field B14	EPIC	2006-11-27T12:03:15.0
0501170201	Cosmos Field 23C	EPIC	2007-05-18T03:16:35.0

Screenshot 0203360101

jupyter my_first_exercise Last Checkpoint: 21 hours ago (autosaved)

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3 (ipykernel) Logout

In [22]: esasky.setViewHeight('850px')

In [12]: esasky.goToTargetName('COSMOS Field')

In [13]: esasky.goToRADec('150.11917', '+02.20583') #COSMOS Field

In [14]: esasky.setFoV(0.5)

In [15]: esasky.setHiPS('Herschel PACS RGB 70, 160 micron')
type the following to see the available HiPS from ESASky:
esasky.getAvailableHiPS()

In [16]: catCount = esasky.getCataloguesCount()
catCount = pd.DataFrame.from_dict([catCount]).transpose()
catCount.columns = ['Count']
catCount

Out[16]:

	Count
Hipparcos-2	0
Tycho-2	5
Gaia-DR3	921
PLATO asPIC1.1	12
Gaia-FPR	0
eROSITA-eRASS-main	9
Herschel-SPSC-250	461
Planck-PCCS2-HFI	0
Planck-PCCS2-LFI	0
Planck-PSZ2	0
XMM-OM	1986
Herschel-HPPSC-070	0
2RXS	0

Screenshot

pyESASky - Jupyter notebooks



Example notebooks illustrating the capabilities of pyESASky can be found in Github:

<https://github.com/esdc-esac-esa-int/pyesasky/blob/master/samples/>

DEMO

```
[ ]: # Import the required python modules:  
from pyesasky import ESASkyWidget  
from pyesasky import Catalogue  
from pyesasky import CatalogueDescriptor  
from pyesasky import CooFrame  
from pyesasky import ImgFormat  
from pyesasky import FootprintSet  
from pyesasky import FootprintSetDescriptor  
from pyesasky import MetadataDescriptor  
from pyesasky import MetadataType  
  
import pandas as pd  
  
[ ]: # Instantiate the pyESASky instance  
esasky = ESASkyWidget()  
#Es and Zh are available for Spanish or Mandarin
```

All of the functions are now documented. Use the IPython ? magic to read about the function. Use tab to complete function names etc:

```
[ ]: # Load the pyESASky instance  
esasky
```

Go to a target name resolved against SIMBAD

```
[ ]: esasky.goToTargetName('M81')
```

Set the Field of View in degrees

```
[ ]: esasky.setFoV(0.75)
```

Example Notebooks:

<https://github.com/esdc-esac-esa-int/pyesasky>

pyESASky and JupyterLab



JupyterLab Widget for ESASky

<https://github.com/esdc-esac-esa-int/pyesasky/>



Jupyter Lab



The screenshot illustrates the integration of DataLabs into Jupyter Lab. On the left, a large panel displays a real-time visualization of a star field, likely from the pyESASky library, showing various celestial objects and data overlays. On the right, a Jupyter Notebook cell titled "What_can_you_do_with_pyl" is shown, demonstrating the use of the pyESASky library. The code includes imports for FootprintSetDescriptor, MetadataDescriptor, and MetadataType, followed by instantiation of the ESASkyWidget and its goToRADec method. A callout box highlights the text: "Jupyter Lab allows you to create a new view and place this next to the notebook". Below the notebook, another smaller visualization panel shows a different star field with data overlays.

```
from pyesasky import FootprintSetDescriptor
from pyesasky import MetadataDescriptor
from pyesasky import MetadataType

import pandas as pd
# Instantiate the pyESASky instance
esasky = ESASkyWidget()
```

All of the functions are now documented. Use the IPython ? magic to read about the function. Use %% to execute function in step:

```
[1]: ESASkyWidget.goToRADec
```

Signature: ESASkyWidget.goToRADec(self, ra, dec)
Docstring:
Moves the center of the view to the specified coordinate
in current coordinate system

Arguments:
ra -- float or string in sexagesimal or decimal format
dec -- float or string in sexagesimal or decimal format
File: ~anaconda3/envs/pyesasky/lib/python3.7/site-packages/pyesasky/pyesasky.py
Type: function

```
[4]: # Load the pyESASky instance
esasky
```

```
J2000 ♦ 21 01 29.465 +16 11 16.49 FoV: 12' X 16'
[1]: 12 7
[2]: 171 796
```

ESA DataLabs

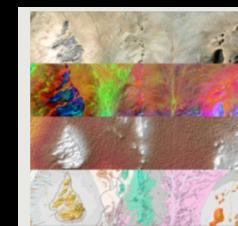
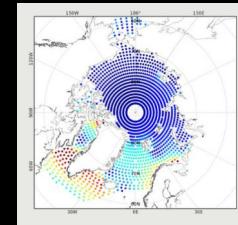


«YOU CAN EITHER MOVE YOUR QUESTIONS OR THE DATA. [...] OFTEN IT TURNS OUT TO BE MORE EFFICIENT TO MOVE THE QUESTIONS THAN TO MOVE THE DATA.»

Jim Gray, eScience: A Transformed Scientific Method



- Bring your questions to the data
- Use new tools and your favourite old ones
- Discover all of ESA's domains
- Keep your data and code safe (and also share it)



Help!!

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

- User Manual
- Examples
- Science use cases
- Videos
- ... and much more

The screenshot shows the ESASky Help page with a navigation bar at the top featuring links for SCIENCE MISSIONS, EUROPEAN SPACE AGENCY, SCIENCE & TECHNOLOGY, and a SIGN IN button. The main content area has a dark background with a starry image. On the left is a sidebar with a navigation menu:

- Home
- About ESDC
- Archival Research Visitor Programme
- Newsletter
- Science Archives
- Archive Image Browser
- ESASky**
- DOIs
- User Survey Results
- Videos
- Scientific Tutorials
- Publications
- VOSpec
- Euro-VO Registry
- Archives User Groups
- Contact Us

The central part of the page displays the ESASky interface, which is a map of the sky with various colored regions representing different astronomical observations from various telescopes. A tooltip for the "ESASky" link in the sidebar is overlaid on the map, listing other related links: ESA Hubble Science Archive, ESASky, Herschel Science Archive Videos, Ulysses Final Archive, and Hubble Space Telescope.

INTRODUCTION
ESASky is a science driven discovery portal providing full access to the entire sky as observed with space, ground based and multi-messenger astronomy missions. Short videos on how to use the tool are shown below and the general documentation can be found here.

HOW TO USE ESASKY

On the right side, there is a "How To" section with a "How To" link and a "General documentation" link. Below this are several video thumbnails:

- What's new in ESA... What's new in ESAS... 2023?
- ANNOUNCING ESASKY VERSION 5.0: ACCESS TO VIZIER AND MORE DATA CENTRES!
- What's new in ESA... Search by polygon
- pyESASky: The Jupyter widget for ESASky
- WHAT'S NEW IN ESASKY IN 2022?
- pyESASKY: THE JUPYTER WIDGET FOR ESASKY
- What's new in ESA... GRAVITY WAVES
- ESASKY - a tool for... Future plans
- WHAT'S NEW IN ESASKY IN 2021?
- Exploring ESASKY
- What's new in ESA... Access to data
- EAS 2021 PRESENTATION: EXPLORING ESASKY
- JupyterCon 2020 P...
- WHAT'S NEW IN ESASKY IN 2020?
- ESASKY: ESA's inter...

On the far right, there are several sidebar links:

- Open ESASky (sky.esa.int)
- Latest ESASky News (ESDC newsletter)
- ESASky & you (Give us feedback! Acknowledge us)
- ESASky Info (Release notes, General Documentation, Publications)
- ESASky related tools (EDDIE Cutout Service, ESASky Astroquery module, pyESASky widget, Javascript API)
- Contributing data to ESASky (Instructions)
- Learning with ESASky (Getting started, Educational Activities)

Summary



- ESASky: developed for scientists to facilitate data discovery and archival science
- Vision: to link all major astronomical data centres worldwide & help enable science
- One of the major accomplishments within the IVOA
- It shows how powerful scientific collaboration and openness of data providers can be
- Importance of protocols and international collaboration between astronomical centres
- ESA DataLabs as an alternative for integrated data analysis