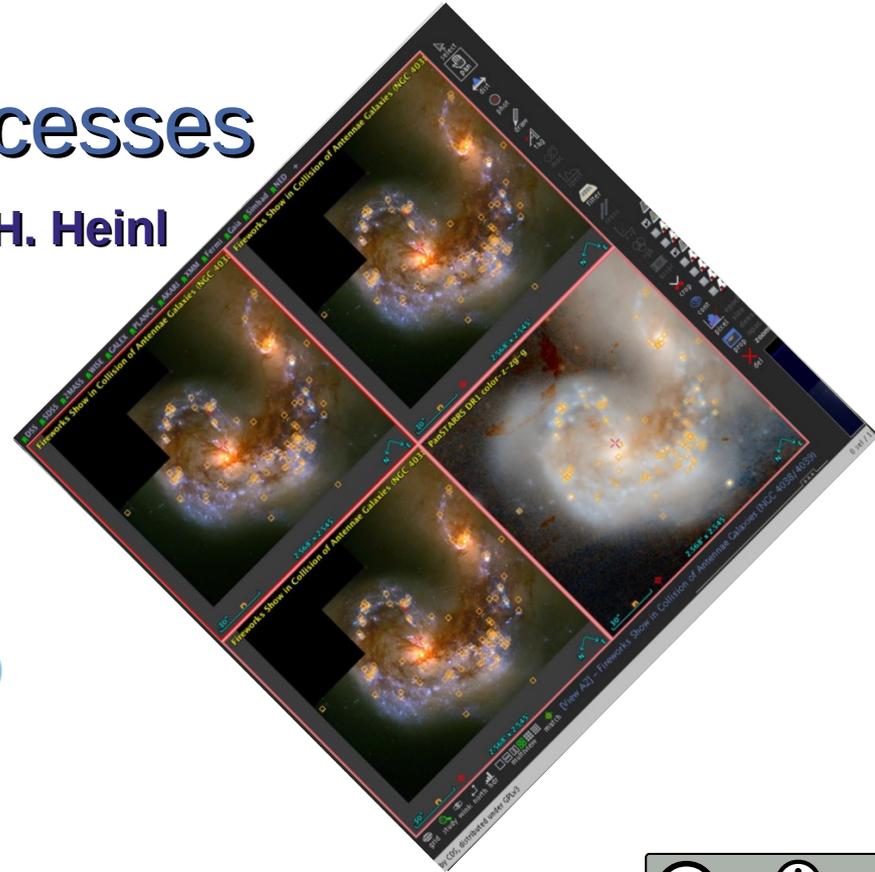


International Virtual Observatory Alliance

organisation & processes

M. Molinaro, S. Bertocco, H. Heini



Introduction to the VO
Wednesday 11 March 2026 - INAF-OATs Sala Hack
USC-C General Assembly 2026



Summary: IVOA why and how

- The challenge
- Archive concepts
- IVOA:
 - Vision
 - Interoperability
 - Standards
 - Organization
 - Architecture
 - Example products
 - How to participate

The *observational* challenge

//
**Any area of the sky not
observed in a certain
moment in time is
missing data.** **//**

...and its consequences

- **Preservation**
 - *"forever"*
- **Sharing**
 - **Open/Public** accessibility
- **Interoperability**
 - Technical & **Semantic**



D
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Store vs. Archive



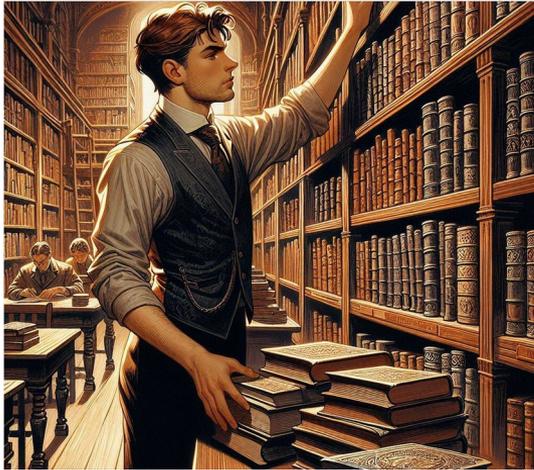
To store:

placing something in a specific location for future use, whether immediate or distant. To archive means

To archive:

to catalogue, sort, and preserve documents or data in an archive

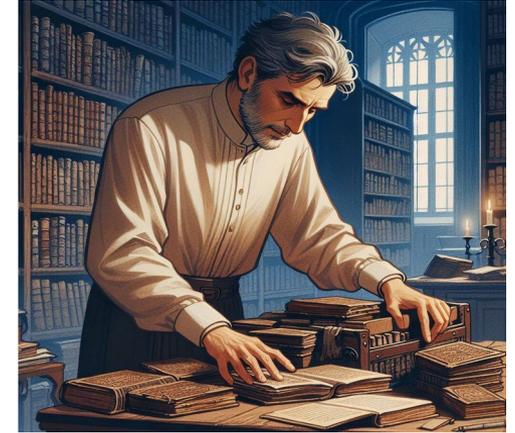
To archive



"The librarian organized the **collection** of books."



"The librarian meticulously **classifies** all the books."



"The librarian **organized** an **exhibition** of books."



"The reader **found** the book he were looking for."

// To archive means
to catalogue, sort, and preserve
documents or data in an archive

//

FITS: a first (technical?) solution



https://fits.gsfc.nasa.gov/fits_home.html

- Discussion started end of '70s
- First formal document in 1981
 - focus: archive & share
- Today it's FITS v.4.0 (2018)
- Maintained by an IAU Working Group, it is an official standard for astronomical data approved by the International Astronomical Union (IAU) and NASA.
 - Challenged by a growing number of other formats [Examples: HDF5 (Hierarchical Data Format v5), ASDF (Advanced Scientific Data Format), CASA MeasurementSet (MS)]

IVOA: interoperable ecosystem



<https://ivoa.net/>

- **International Virtual Observatory Alliance**
- Formed in 2002
- Open standards organisation
- **Interoperability as the core goal**
- **FAIR-enabler standards for astronomy**

IVOA vision

“The Virtual Observatory (VO) is the vision that astronomical datasets and other resources should work as a seamless whole. [...] The International Virtual Observatory Alliance (IVOA) is an organisation that debates and agrees the technical standards that are needed to make the VO possible.”

Interoperability

//
Interoperability is the ability of two or more systems to exchange information and to use the information that has been exchanged
//

IVOA Standards

The Language of Astronomy

Just like human beings need a **shared language** to communicate, telescopes and archives need a shared framework to exchange data. This is what the IVOA provides.

Vocabulary (The 'What'):

"In a language, we agree on what words mean. In the Virtual Observatory, we use Unified Content Descriptors (UCDs). They ensure that when two different archives talk about 'brightness', they are using the exact same 'word' or tag, avoiding a Tower of Babel scenario."

Grammar (The 'How'):

"Grammar gives **structure** to words. Data Models like ObsCore act as our grammar; they define the mandatory relationship between a metadata field and its observation context."

Dialogue (The 'Action'):

"Finally, we need a way to ask questions. Protocols like TAP (Table Access Protocol) are the formal rules of **conversation** that allow a scientist to query any compliant archive worldwide using the same syntax: ADQL."

Interoperability through Common Rules

<u>Linguistic Element</u>	<u>IVOA Equivalent</u>	<u>Technical Role</u>
Vocabulary	UCDs & Semantics	Assigns unambiguous names to physical concepts (e.g., flux, velocity)
Grammar	Data Models (DM)	Defines how different pieces of information relate to each other
Syntax	VOTable (XML)	The formal structure and format used to write and read the data
Dialogue	Protocols (TAP, SIA)	How a client (you) "talks" to a server to request specific data



What is the IVOA?

IVOA founded in 2002.

23 Member Organizations/Projects

A **group of people** that agrees on **standards** on which to build applications that **interoperate** across data providers

Two **interoperability** meetings per year:

- “Northern Spring”
- “Southern Spring” (typically after ADASS)



ivoa.net

JJ Kavelaars
IVOA Chair

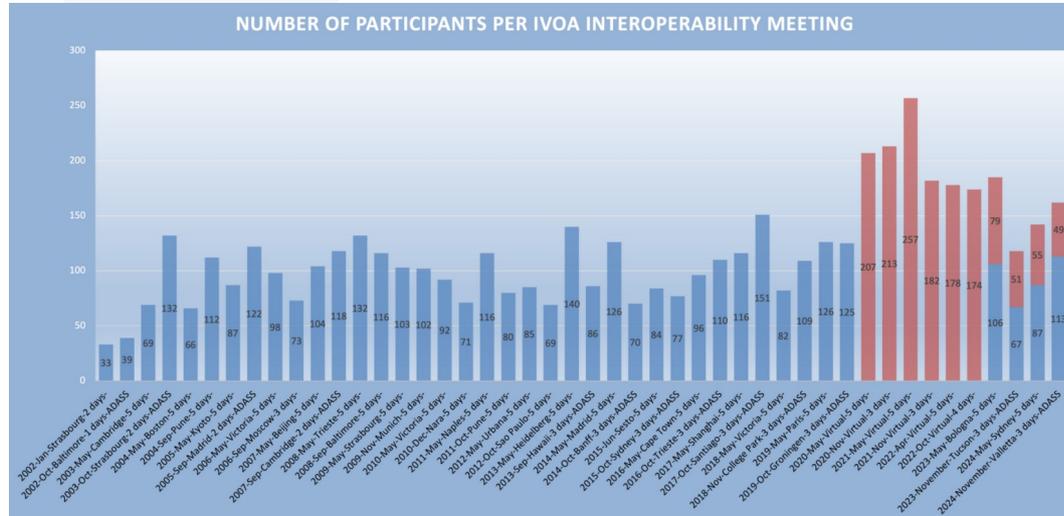
14-16 Nov 2025
Southern Spring Interoperability Meeting
Görlitz, Germany



IVOA "family picture"

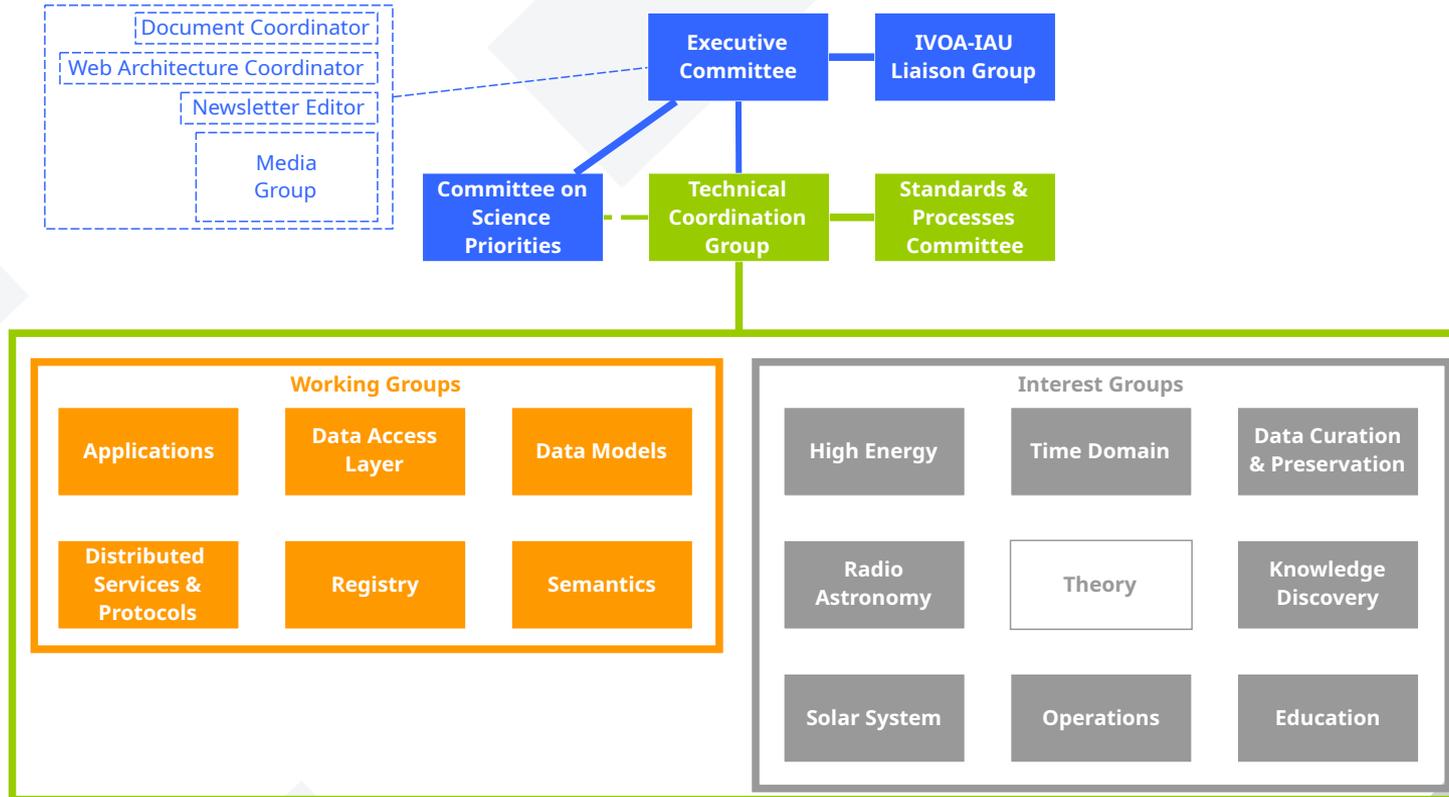


IVOA community

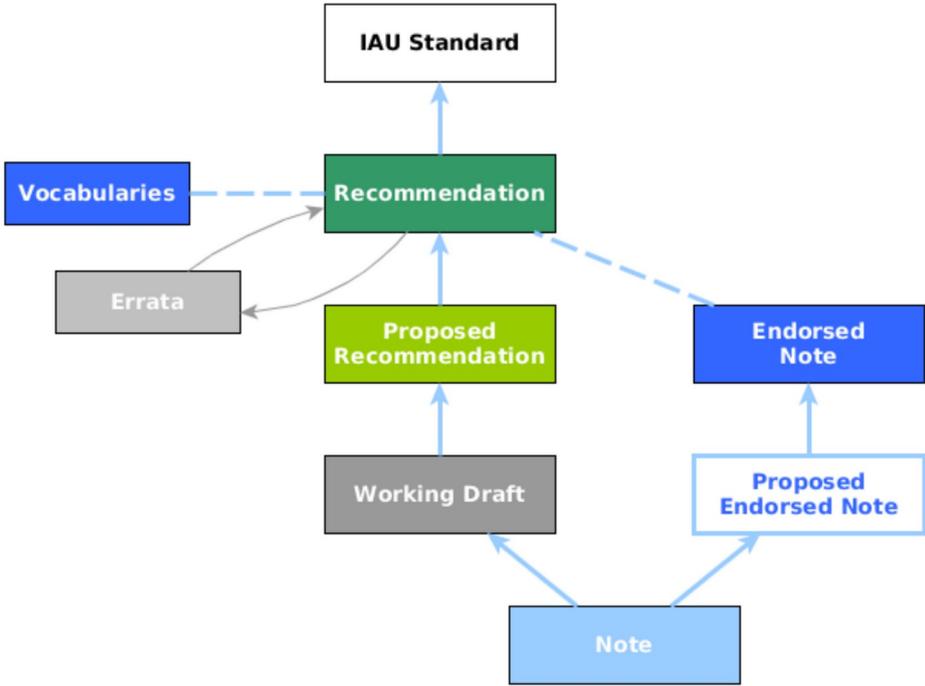


Semestral “Interoperability” Meetings
~100 participants

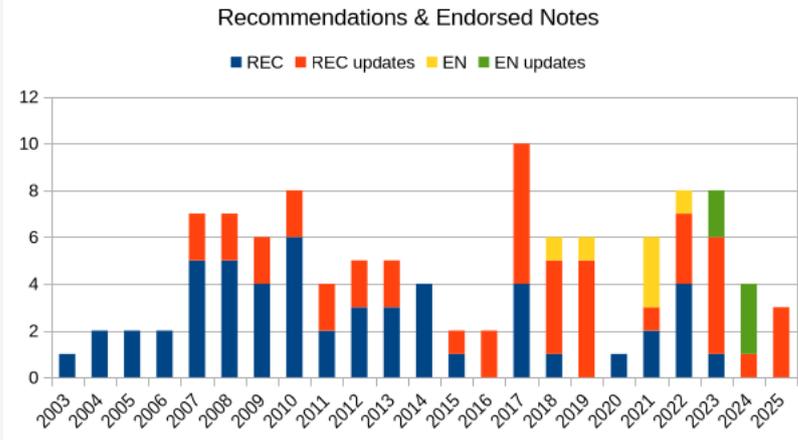
IVOA organisation



IVOA processes



- **IVOA Document Standards 2.0**
 - 10.5479/ADS/bib/2017ivoa.spec.0517G
- **Vocabularies in the VO 2.1**
 - 10.5479/ADS/bib/

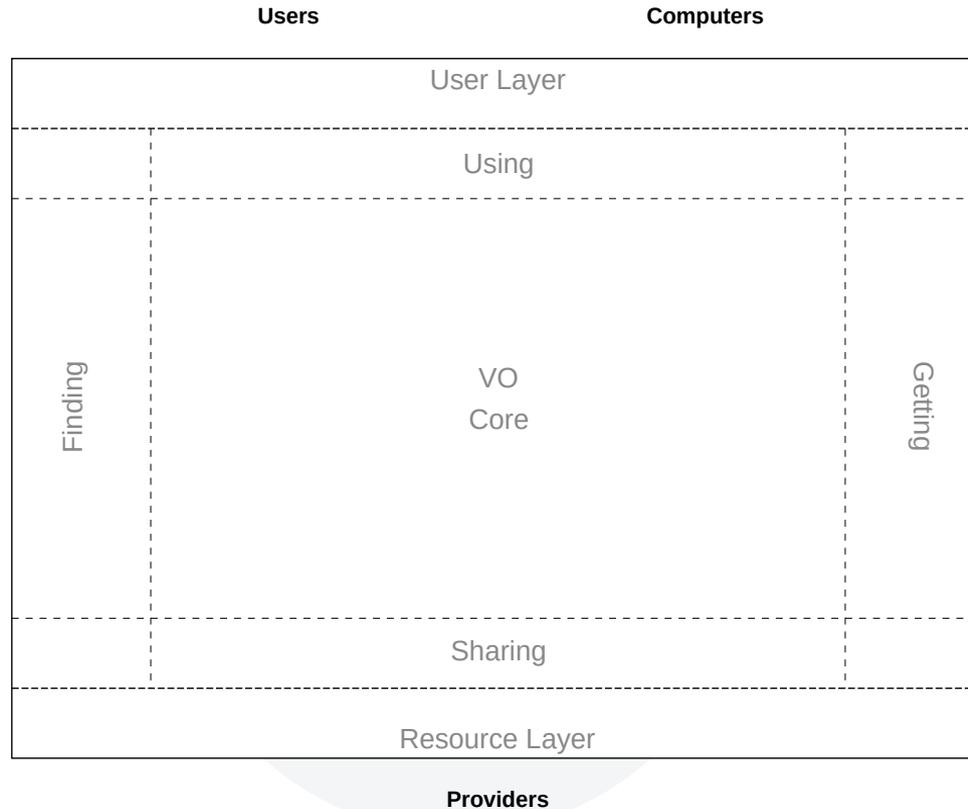


recommendations (standards) are **agreed on consensus**

IVOA architecture

IVOA Architecture 2.1

<https://ui.adsabs.harvard.edu/abs/2024ivoa.spec.1114E>

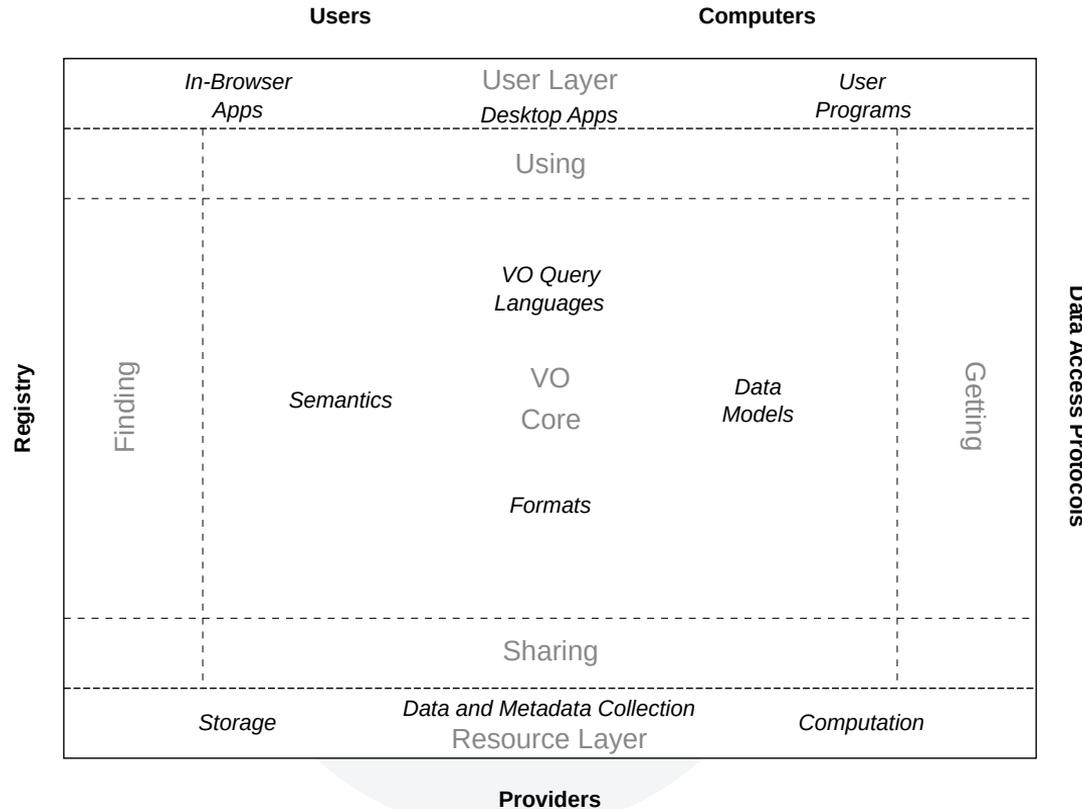


level 0

IVOA architecture

IVOA Architecture 2.1

<https://ui.adsabs.harvard.edu/abs/2024ivoa.spec.1114E>

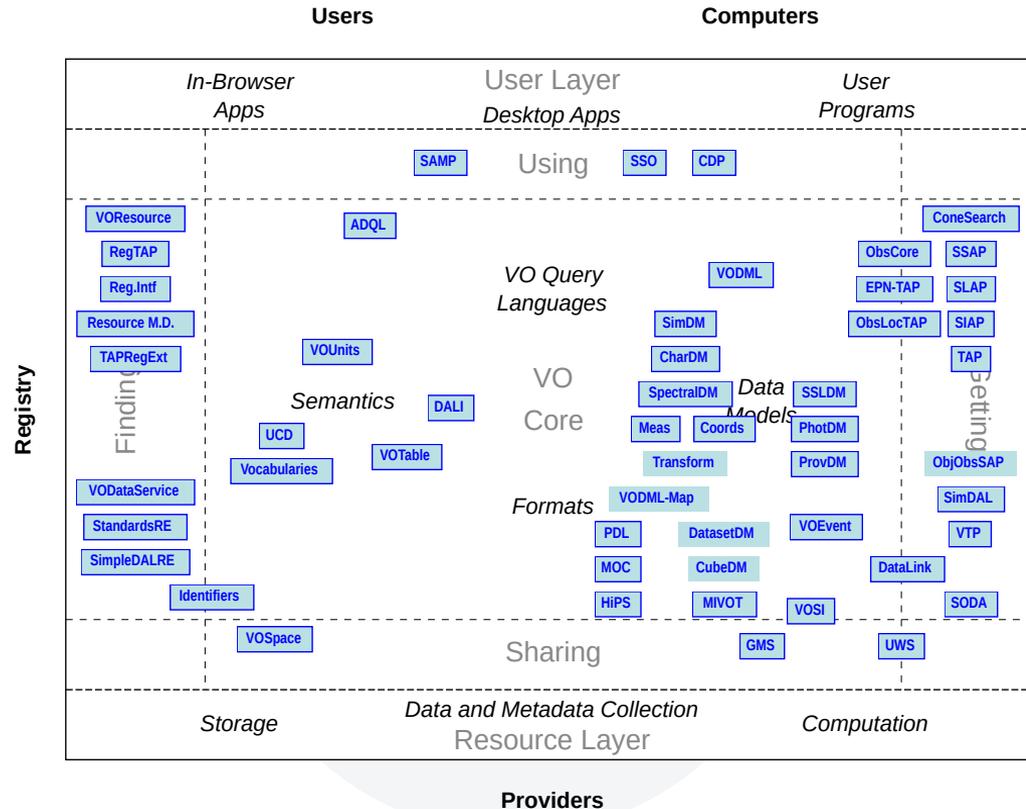


level 1

IVOA architecture

IVOA Architecture 2.1

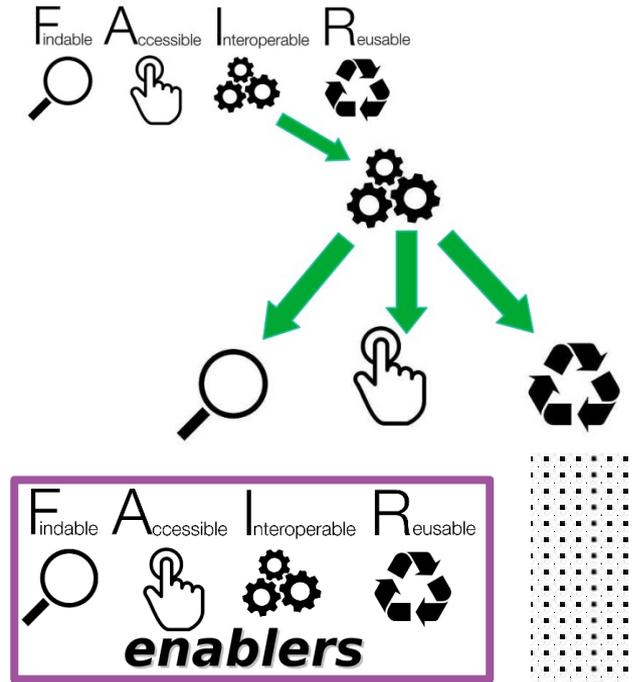
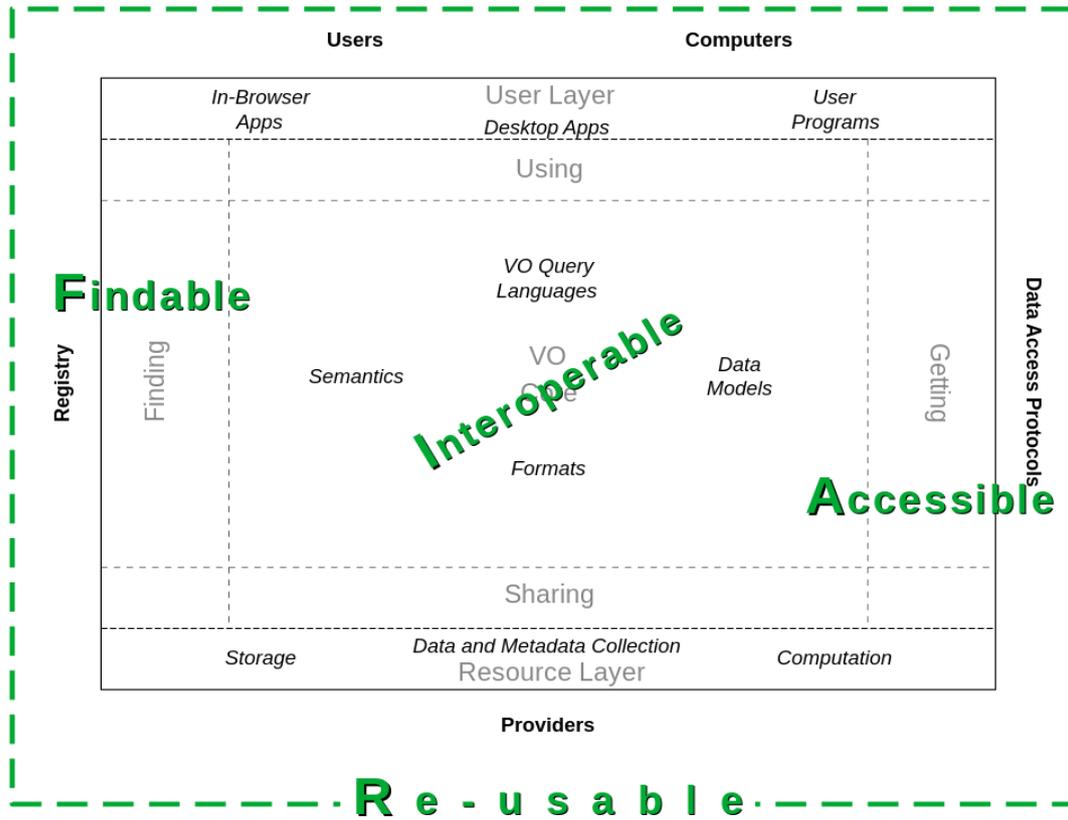
<https://ui.adsabs.harvard.edu/abs/2024ivoa.spec.1114E>



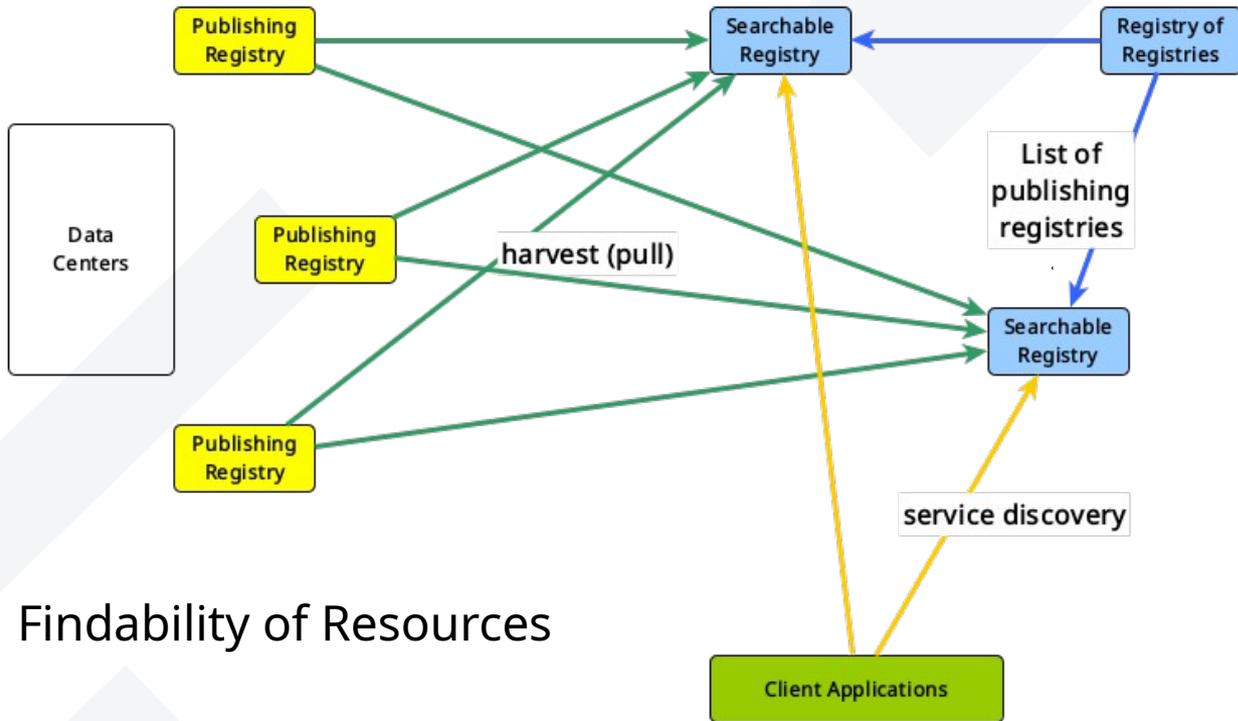
level 2

Data Access Protocols

IVOA - FAIR mapping



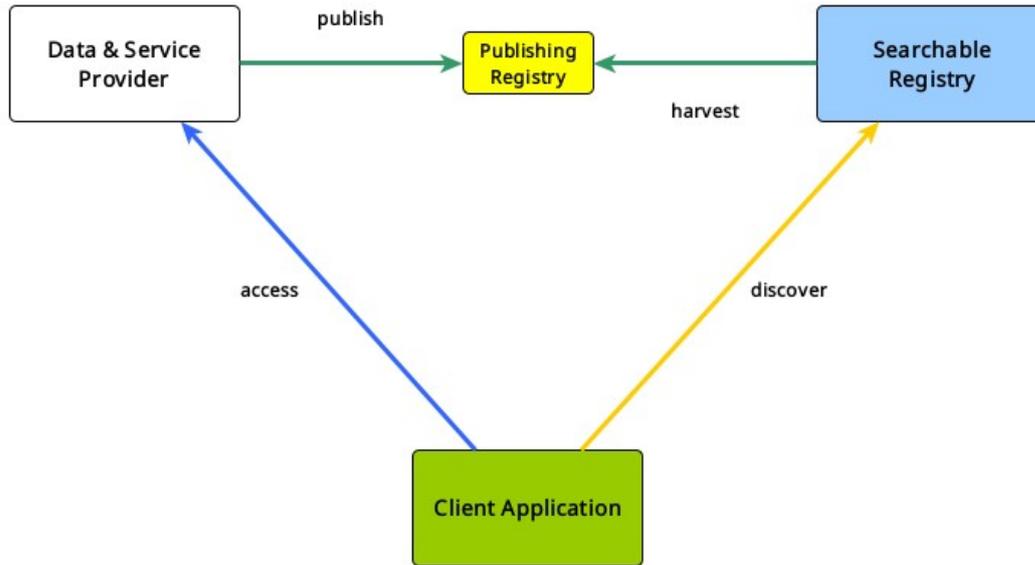
The IVOA Registry



Findability of Resources

- Data Collections
- Source Catalogues
- Access Services
 - (standardised) Protocols
 - Registries (themselves)
- IVOA standards

Access action-ability



- Client applications that are aware of
 - Registry
 - Access Layer (protocol)
 - Formats
- Can automatically move
 - from the resource description document
 - to consuming its endpoints
 - and use the meta/data contents

(archives)

Select a collection... and enter target: andromeda

MAST Observations by Object Name or RA/Dec

Upload Target List

Actions	Observation T.	Mission	Provenance Name	Instrument	Project	Filters	Wavelength	Target Name	Target Classification
1	***	science	WUPPE	ASTRO-2 W...	UV	EG-AND			
2	***	science	WUPPE	ASTRO-2 W...	UV	EG-AND			
3	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	TESS FFI
4	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	TESS FFI
5	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	TESS FFI
6	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	1005000001
7	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	1005000001
8	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	1005000001
9	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	42825804
10	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	25905630
11	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	25905630
12	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	47899072
13	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	42400672
14	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	42400672
15	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	115745971
16	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	115745971
17	***	science	TESS	SPOC	Photometer	TESS	TESS	Optical	115745971

<https://archive.eso.org/>



4447102

00 56 41.69 +14 00 20.6

180.87° × 104.1°

Observatory: La Silla Paranal APEX, ALMA

Data Type: SPECTRUM, IMAGE, CATALOG, CUBE, VISIBILITY

Spectral Range: UV, opt, NIR, MIR, mm

Actions	Data Type	Spec. Range	Spec. Res.	SMR	Obs. Date	Collection	Instrum.	T. Exp. T.	#Obs	P.I.	Program Id	Object	Data Prev.
	SPECTRUM	378.3-491.3 nm	150000	176.4	2025-11-03 07:30:05	HARPS	HARPS	136.7 s	single	OBSERVATORY, LA SILLA	60.A-9709	H81966	ESO_PHASE3
	SPECTRUM	378.3-491.3 nm	80000	144.8	2025-11-03 07:25:06	HARPS	HARPS	93 s	single	OBSERVATORY, LA SILLA	60.A-9709	H81966	ESO_PHASE3
	SPECTRUM	378.3-491.3 nm	150000	127.3	2025-11-03 08:17:56	HARPS	HARPS	100 s	single	OBSERVATORY, LA SILLA	60.A-9709	H81970	ESO_PHASE3
	SPECTRUM	378.3-491.3 nm	150000	132.3	2025-11-03 08:16:47	HARPS	HARPS	100 s	single	OBSERVATORY, LA SILLA	60.A-9709	H81970	ESO_PHASE3
	SPECTRUM	378.3-491.3 nm	150000	134.4	2025-11-03 08:13:35	HARPS	HARPS	100 s	single	OBSERVATORY, LA SILLA	60.A-9709	H81970	ESO_PHASE3
	SPECTRUM	378.3-491.3 nm	80000	113.2	2025-11-03 08:08:34	HARPS	HARPS	65 s	single	OBSERVATORY, LA SILLA	60.A-9709	H81970	ESO_PHASE3
	SPECTRUM	378.3-491.3 nm	80000	110.1	2025-11-03 08:07:06	HARPS	HARPS	65 s	single	OBSERVATORY, LA SILLA	60.A-9709	H81970	ESO_PHASE3



<https://archive.stsci.edu/>

(platforms)

The screenshot shows the CANFAR Science Platform homepage. At the top, there is a navigation bar with 'CANFAR v1.0.4' and a search bar. Below the navigation bar, the main heading reads 'CANFAR Science Platform'. A central text box states: 'Canadian Advanced Network for Astronomical Research is a scalable, cloud-native workspace for astronomy research. Spin up JupyterLab, submit batch jobs, and collaborate in shared project spaces. The CANFAR Science Platform gives researchers the tools they need with minimal setup.' Below this, a grid of links offers various features: Interactive Sessions (e.g., JupyterLab), Batch Processing for large-scale analysis, Shared Storage for collaborative datasets, Software Containers with astronomy tools, Collaboration Tools with group permissions, Help & Support for research workflows, Python API for access and automation, CLI for terminal users, Publications of DataCite DOIs, Release Notes for the latest updates, Try out CANFAR Science Platform, and a link for 'and much more...'. At the bottom, there is a section for acknowledgments and a note that the platform is built on IVOA standards & FAIR principles.

<https://www.canfar.net/>



The screenshot shows the ESA Datalabs website. The header includes the ESA logo and 'THE EUROPEAN SPACE AGENCY'. The main content area features a large quote: '«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.»' attributed to Jim Gray, eScience: A Transformed Scientific Method. Below the quote, there is a section titled 'BRING YOUR QUESTIONS TO THE DATA' which discusses a data-intensive approach to science and the challenges of transferring large datasets. To the right of the text is a circular visualization of data points.

<https://datalabs.esa.int/>

VizieR

Search Criteria

Preferences

max: 50

HTML Table

 All columns

▶ Compute

Mirrors

CDS, France

[VizieR home](#) · [Photometry viewer](#) · [Query VizieR using TAP](#) · [X-match tables](#) · [Query images/spectra](#)

The VizieR service is now hosted by CDS domain (cds.unistra.fr). Please, modify your configuration for the new domain.

Find catalogs among 26799 available

Expand search

🔍 *Catalog, author's name, word(s) from title, description, etc. e.g.: AGN, Veron, I/239, or bibcodes...*

▶ Search for catalogs by column descriptions (UCD) ?

▶ Search for catalogs containing additional data

Search by Position across 30413 tables

Target Name (resolved by [Sesame](#)) or Position:

Target dimension:

 J2000

NB: The epoch used for the query is the original epoch of the table(s) Radius Box size

[More about VizieR](#)

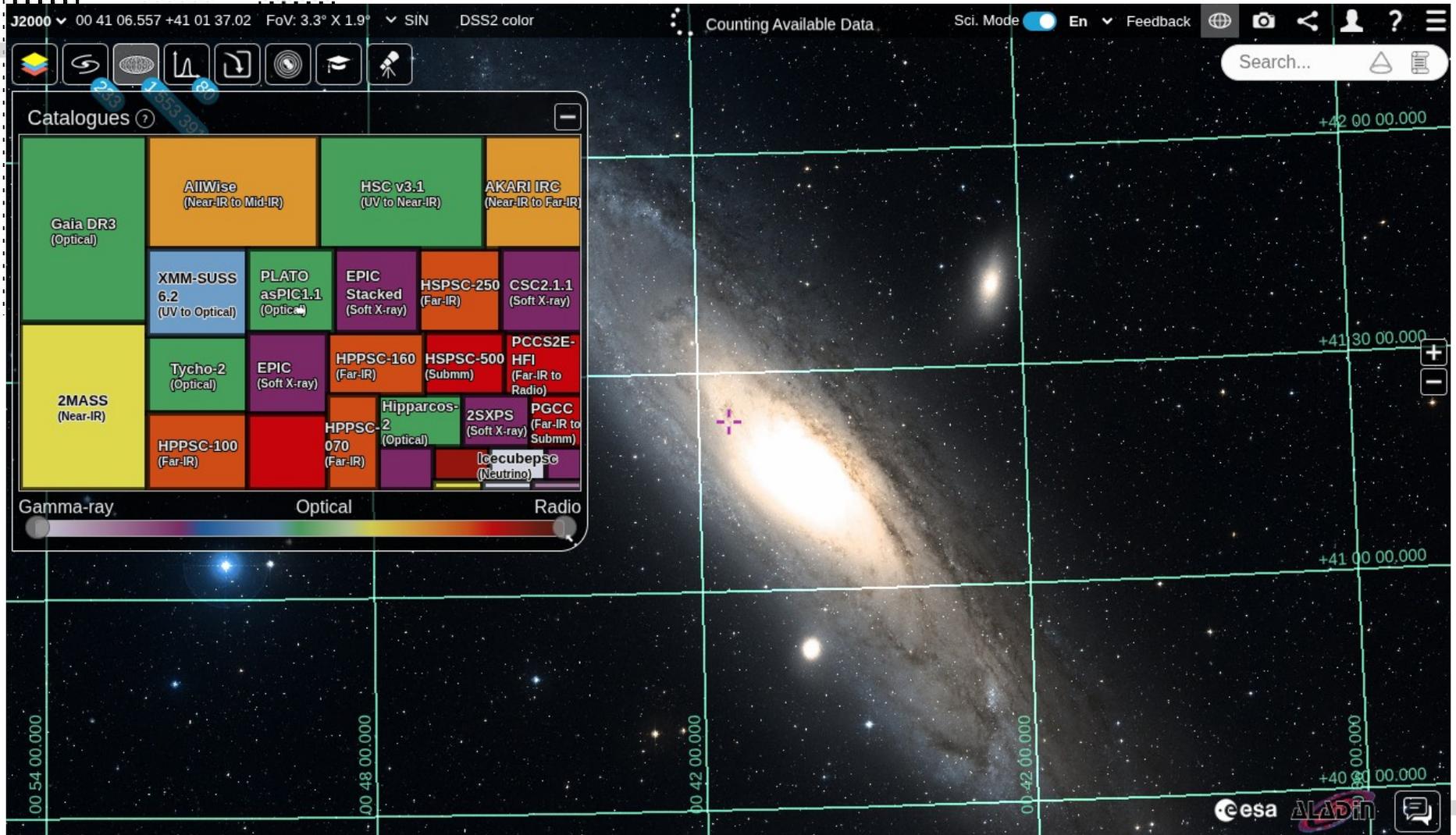
sort by : popularity date



Wavelength	Mission	Astronomy
Radio	AKARI	Abundances
Millimeter	ANS	Ages
IR	ASCA	AGN
optical	BeppoSAX	Associations
UV	Cassini-Huygens	Asteroseismology
EUV	CGRO	Atomic_Data
X-ray	Chandra	Binaries:cataclysmic

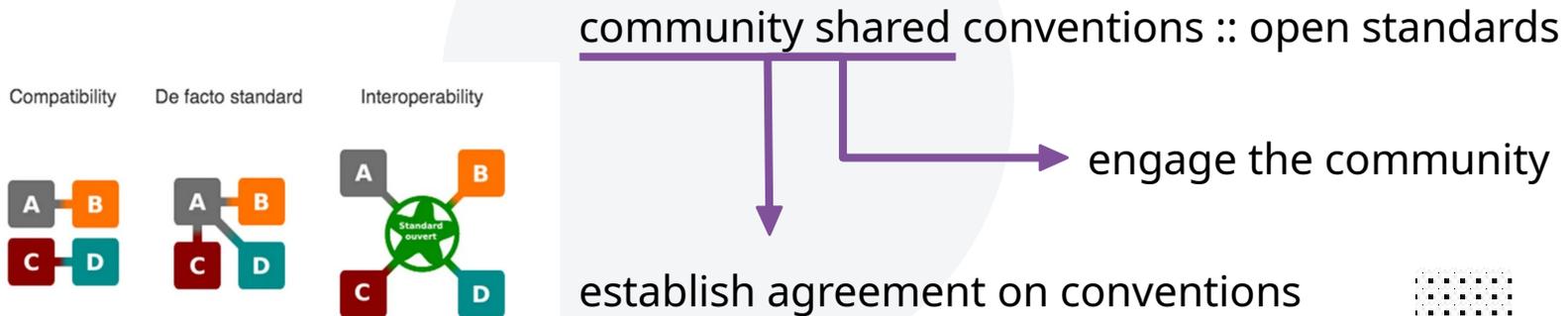
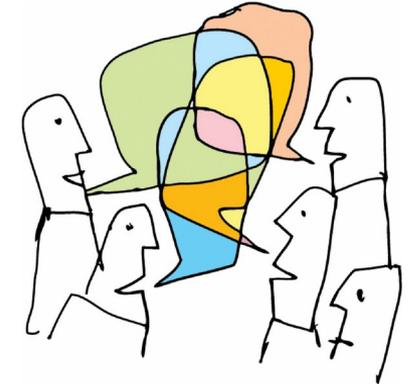
Tools related to VizieR

- [Catalogue collection](#) : Search VizieR catalogues available via various services (FTP, VizieR, TAP, ...)
- [CDS Portal](#) : Access CDS data including VizieR, Simbad and Aladin using the CDS portal
- [Spectra, images in VizieR](#) : Search Spectra, images in VizieR
- [Photometry viewer](#) : Plot photometry (sed) including all VizieR
- [TAP VizieR](#) : query VizieR using ADQL (a SQL extension dedicated for astronomy)
- [CDS cross-match service](#) : fast cross-identification between any 2 tables, including VizieR catalogues, SIMBAD



Driven by “open community”

- Open Science <> opposite of bad science
- Digital resources -> leverage FAIR principles
- Principle ≠ Rule/Convention/Norm
- Research domain -> Intrinsic characteristics
- Characteristics -> turn principles into conventions
- Conventions -> Standards
- Research domain :: Community



What to do?

“ As a data providers, manager, describe your resources, add them to the Registry, and let the applications connect. **”**



EUROVO

*If you want to go fast, go alone.
If you want to go far, go together.*



Introduction to the IVOA

Thank you for your attention!

Marco Molinaro, Sara Bertocco

[INAF - OATs]



INAF
ISTITUTO NAZIONALE
DI ASTROFISICA