International Virtual Observatory Alliance

organisation & processes

M. Molinaro, S. Bertocco, H. Heinl

[INAF - OATs]

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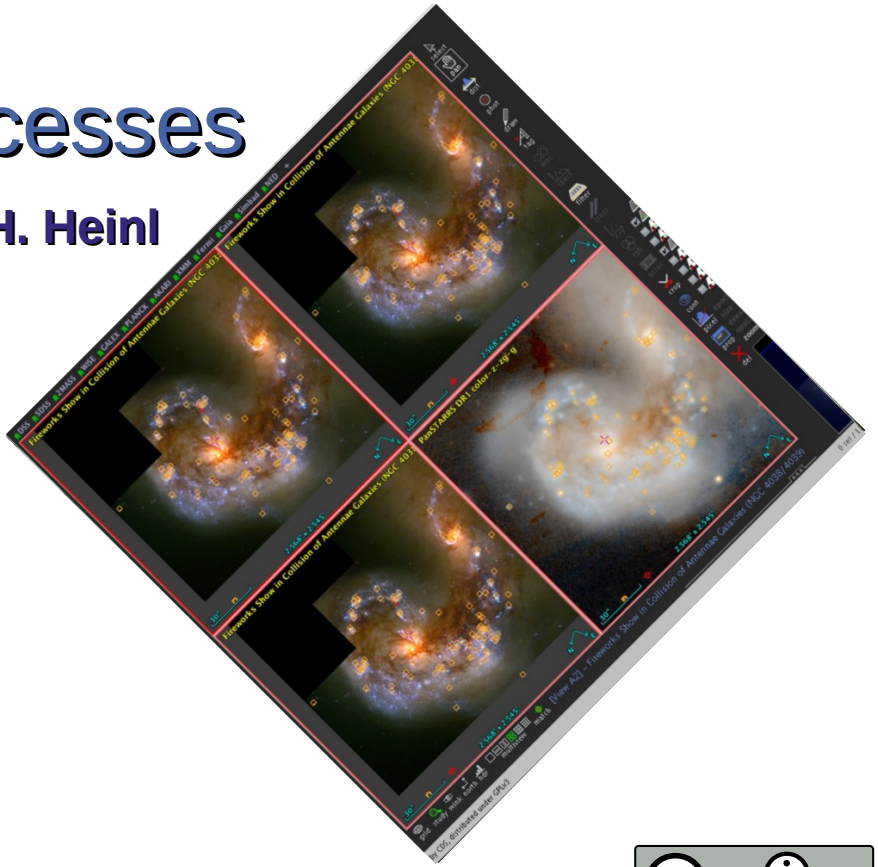


VObs.it

EURO VO

IVOA

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

CC BY

Summary: IVOA why and how

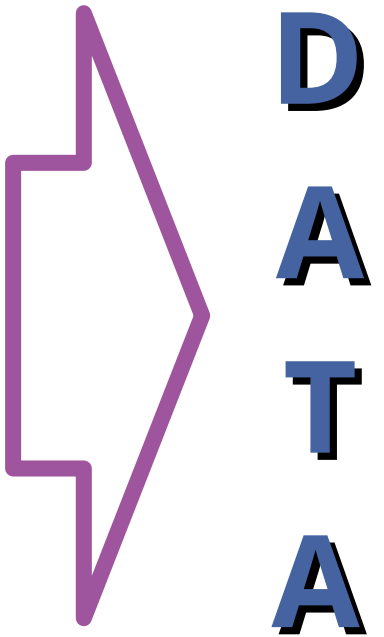
- The challenge
- Archive concepts
- IVOA:
  - Vision
  - Interoperability
  - Standards
  - Organization
  - Architecture
  - Example products
  - How to participate

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



Store vs. Archive

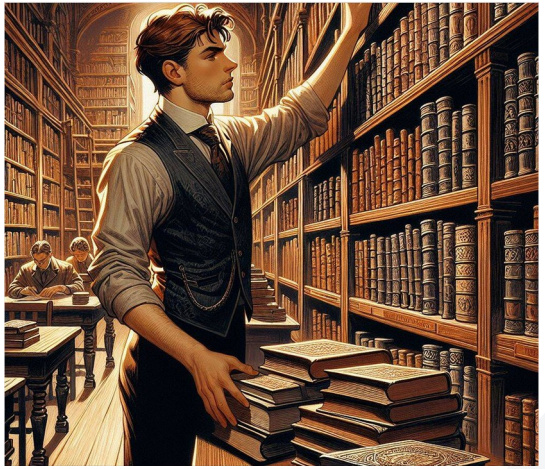
To store:

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

To archive:

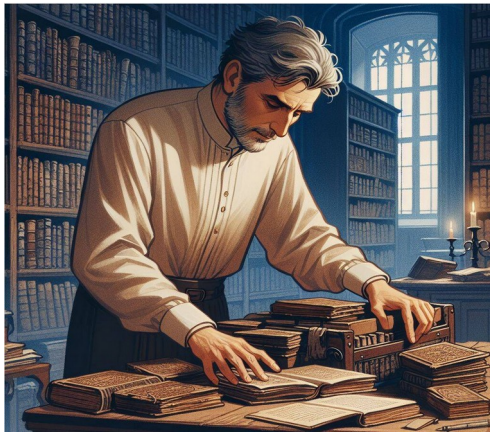
to catalogue, sort, and preserve documents or data in an archive

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)]

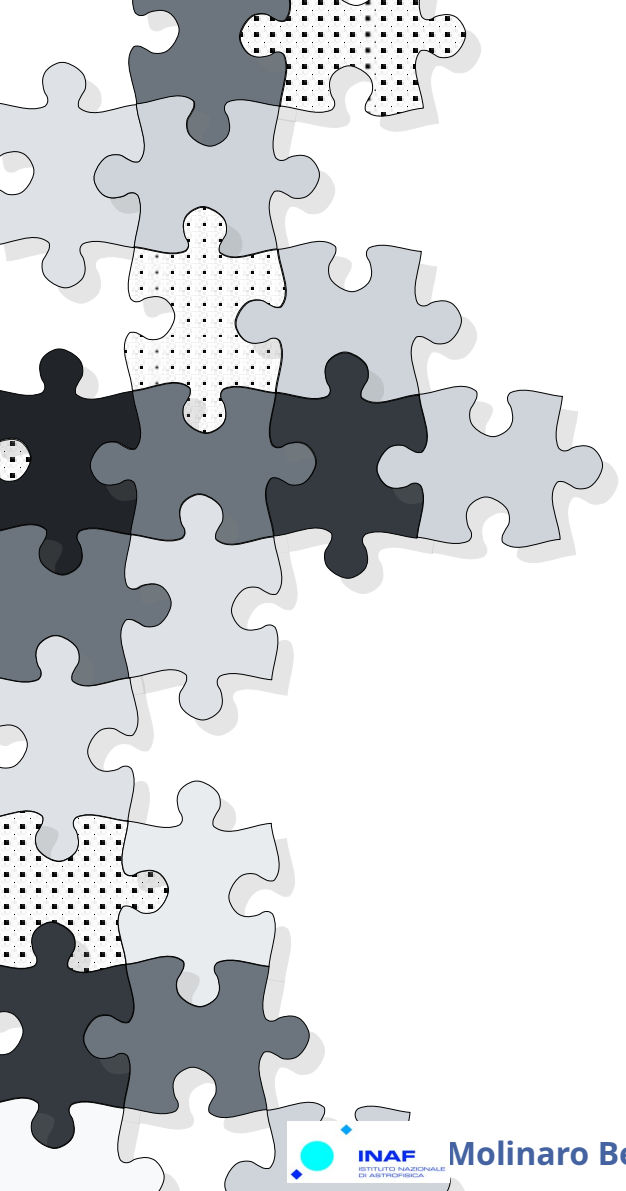
IVOA: interoperable ecosystem

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

Linguistic Element	IVOA Equivalent	Technical Role
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)

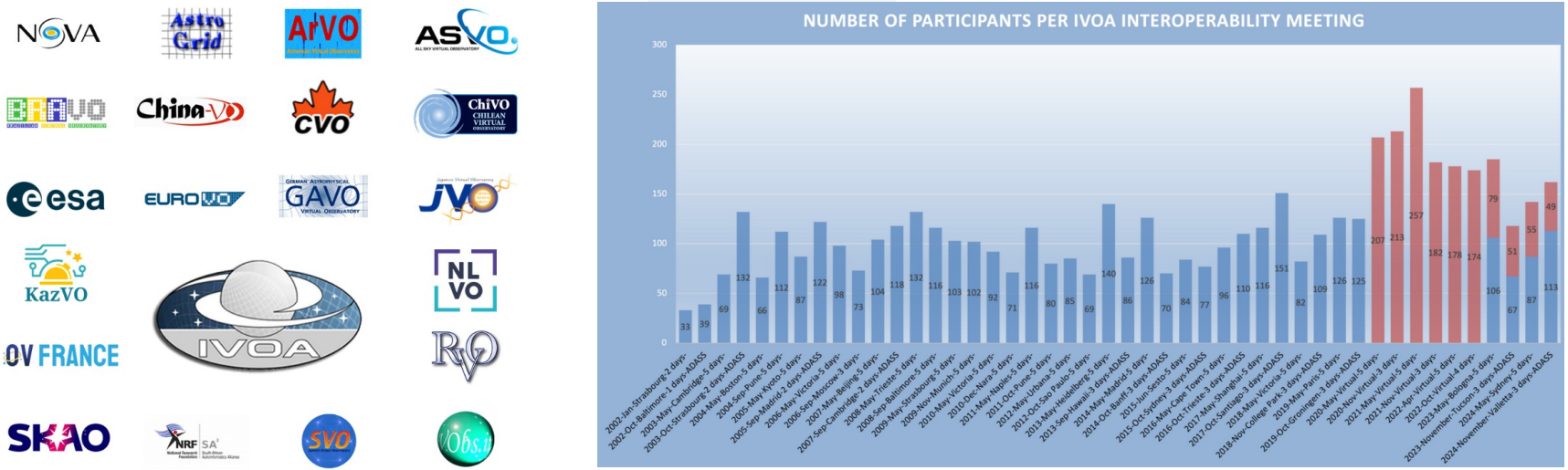
JJ Kavelaars
IVOA Chair

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

ivoa.net

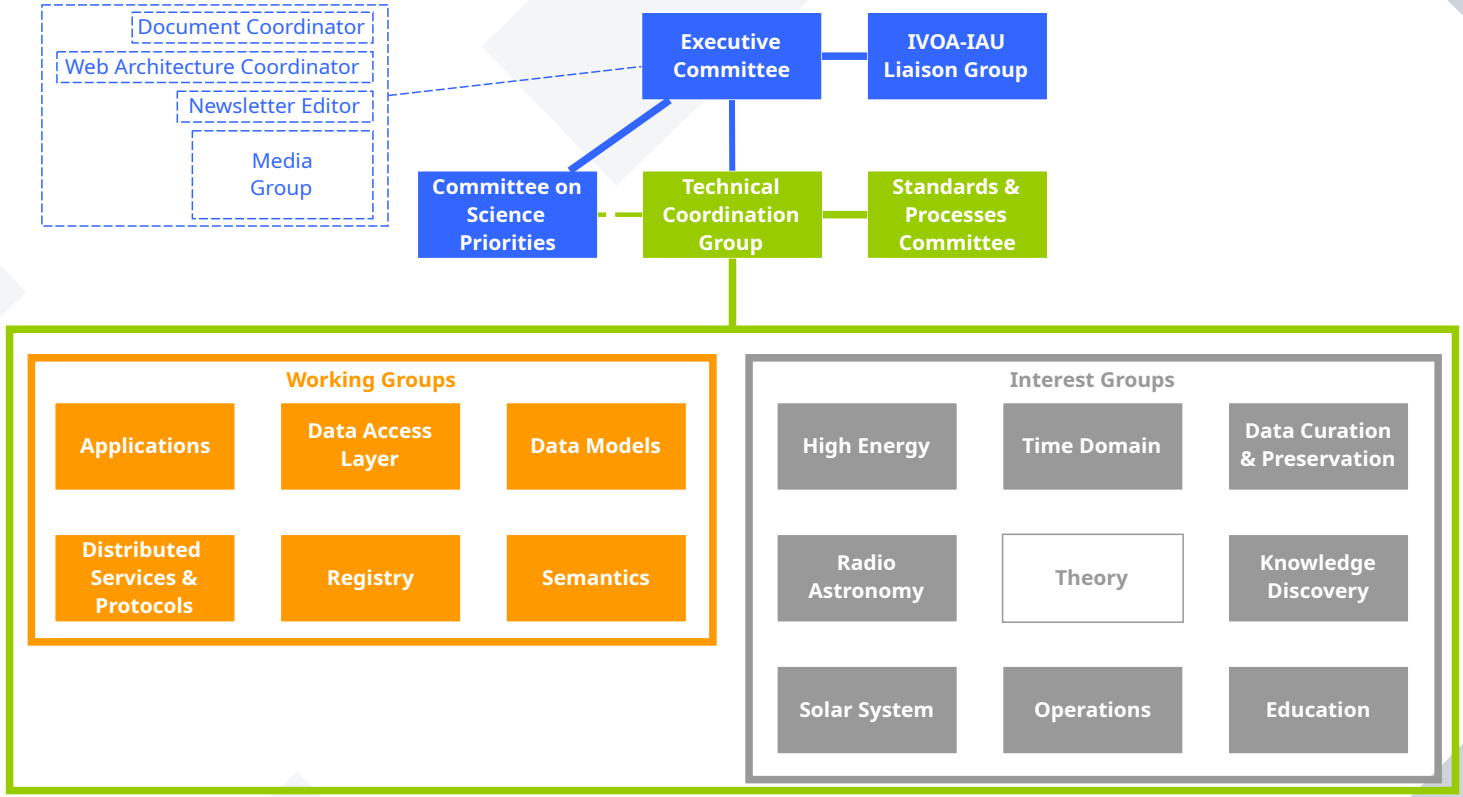
IVOA “family picture”

IVOA community

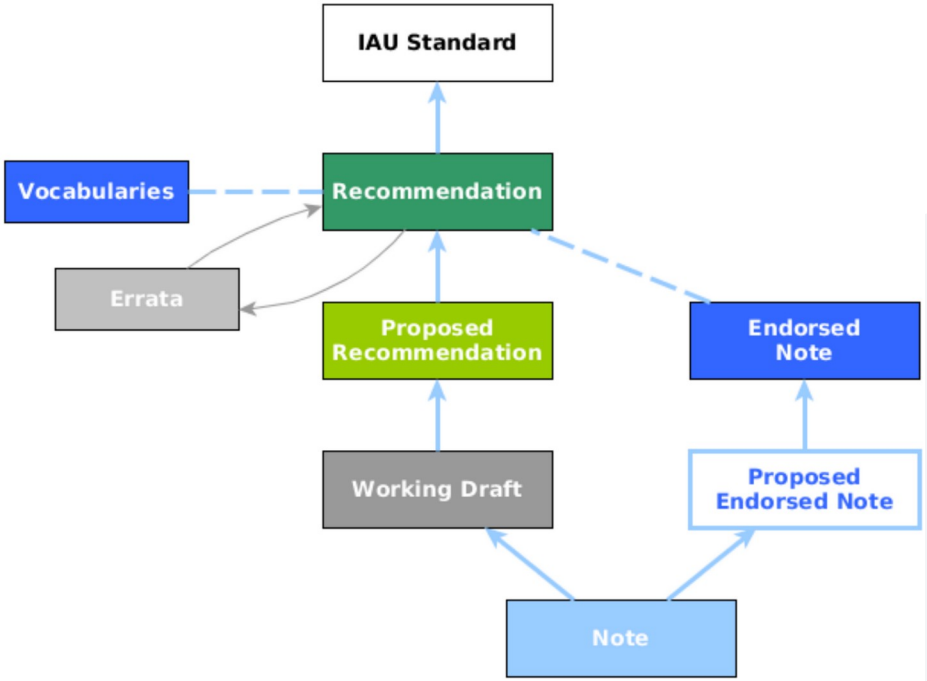


Semestral “Interoperability” Meetings
~100 participants

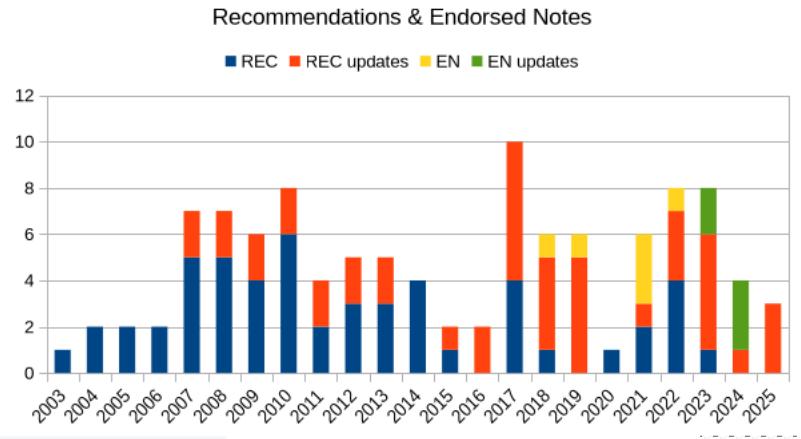
IVOA organisation



IVOA processes

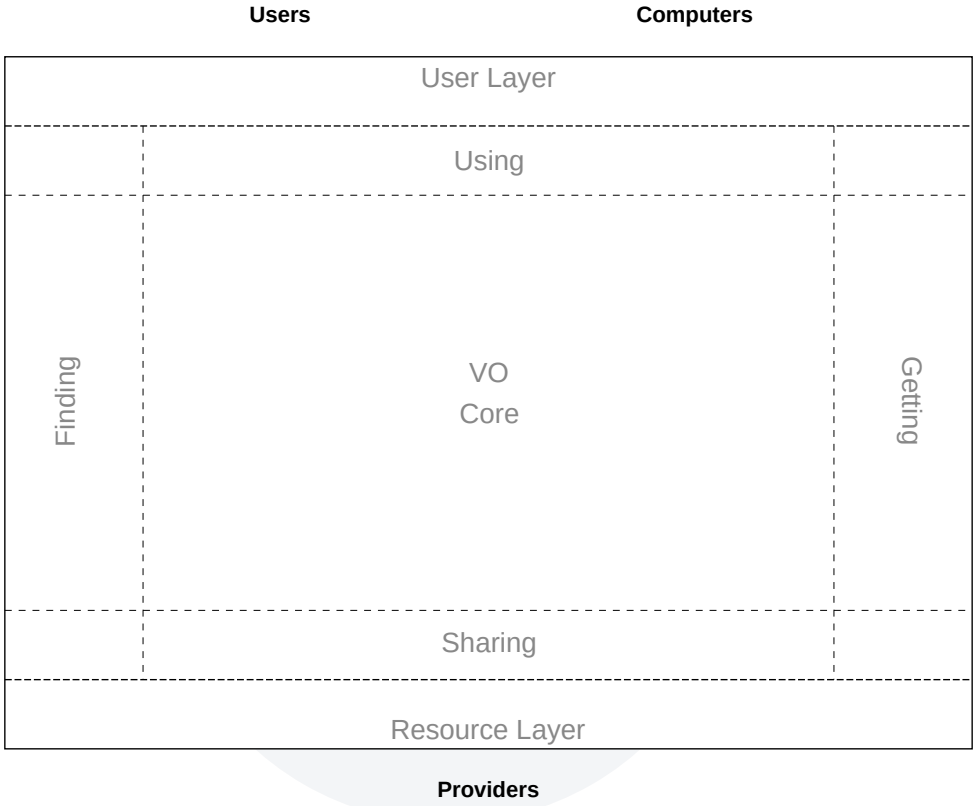


- **IVOA Document Standards 2.0**
  - 10.5479/ADS/bib/2017ivoa.spec.0517G
- **Vocabularies in the VO 2.1**
  - 10.5479/ADS/bib/



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

IVOA architecture

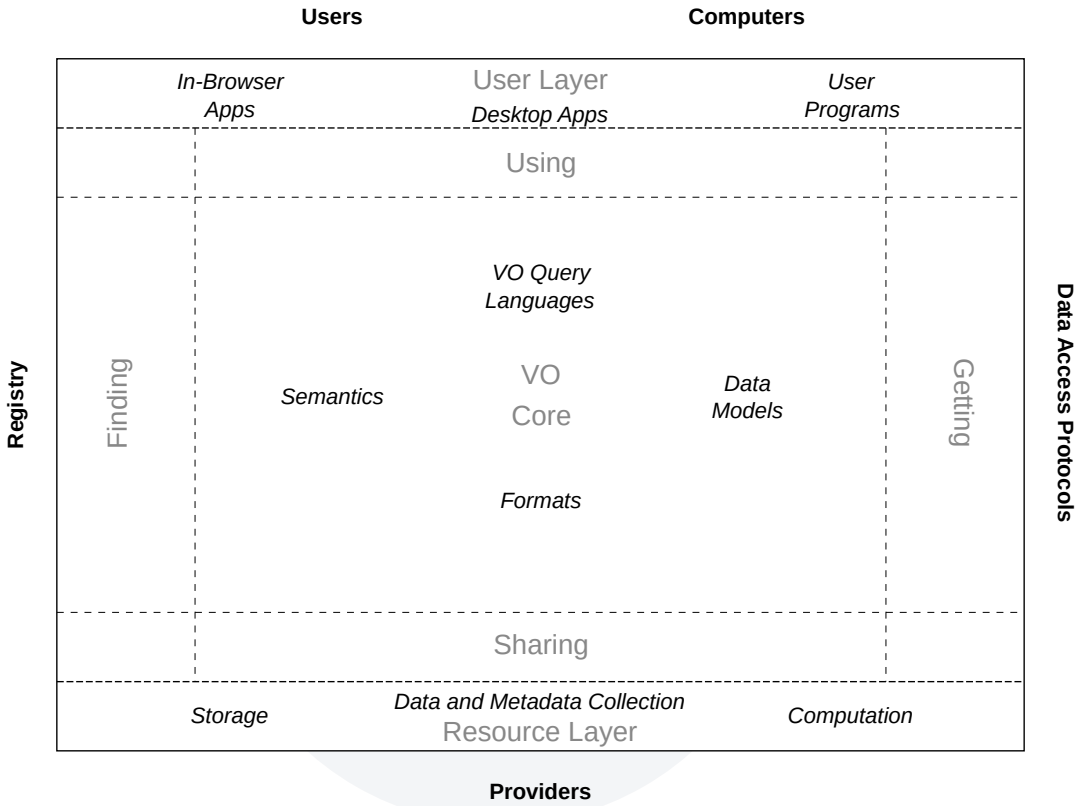


IVOA Architecture 2.1
https://ui.adsabs.harvard.edu/abs/2024ivoa.spec.1114E

level 0

IVOA architecture

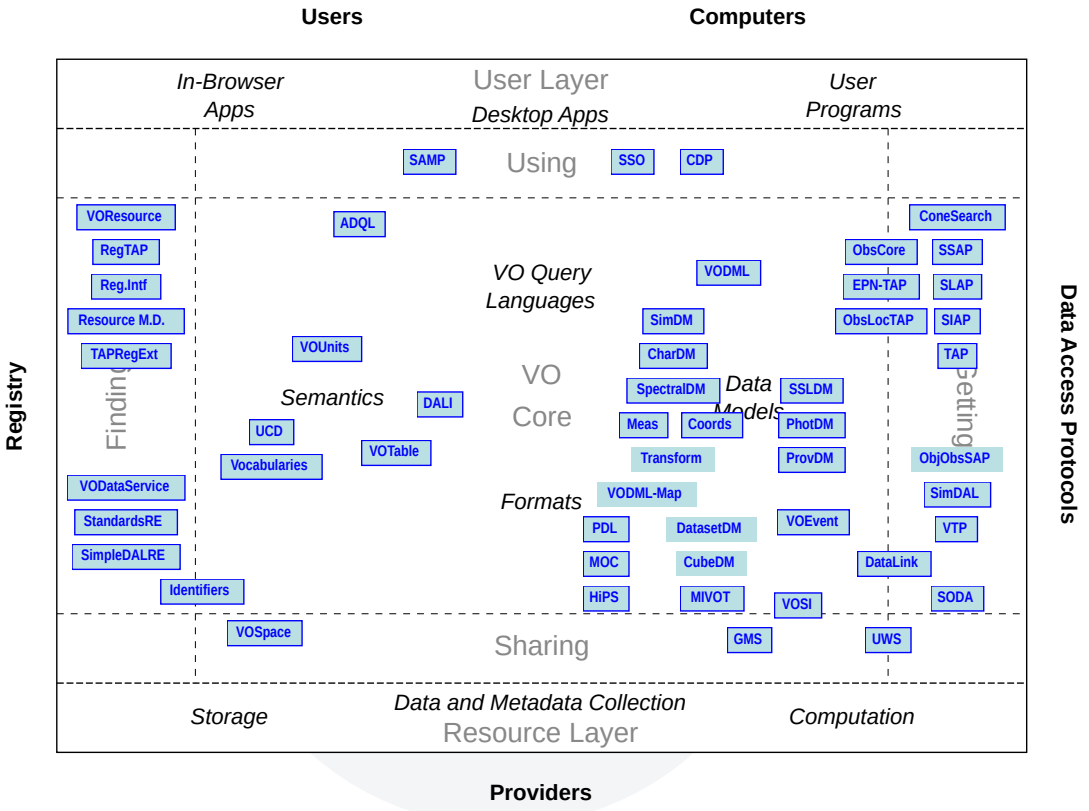
IVOA Architecture 2.1
https://ui.adsabs.harvard.edu/abs/2024ivoa.spec.1114E



level 1

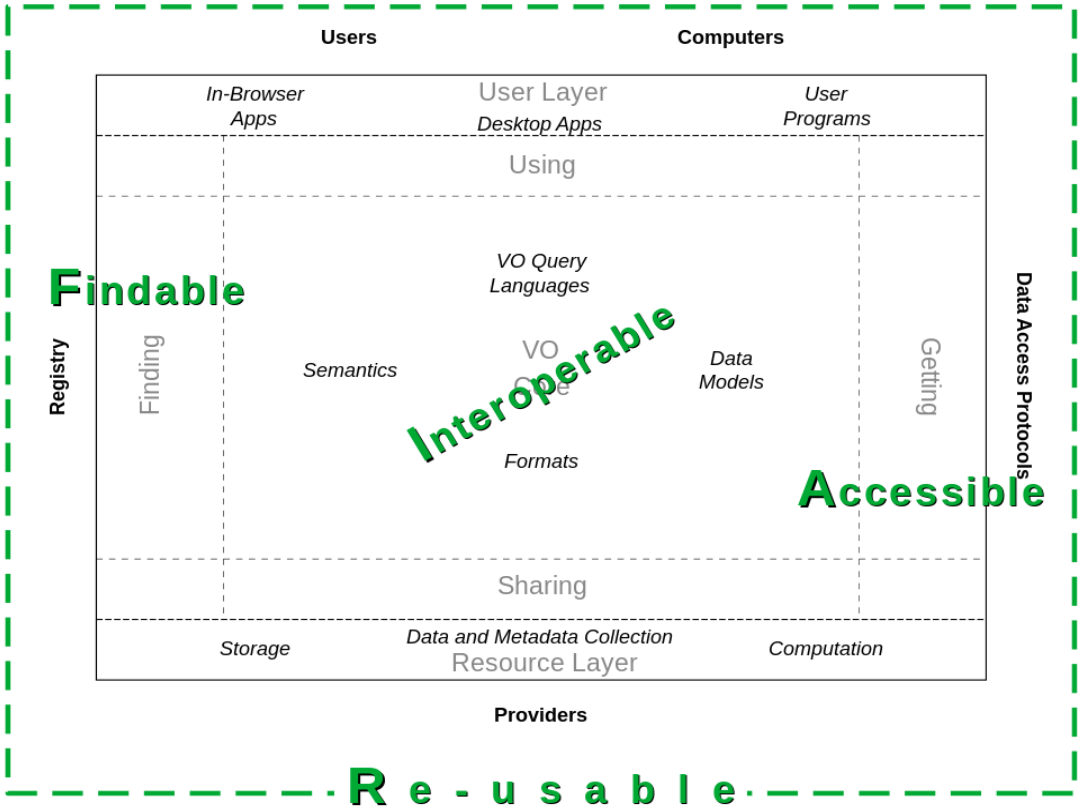
IVOA architecture

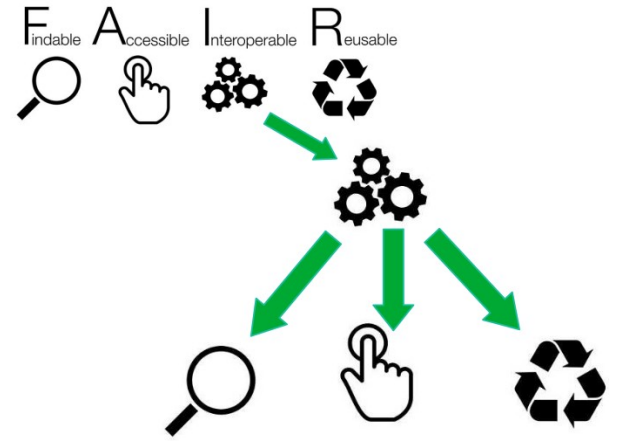
IVOA Architecture 2.1
https://ui.adsabs.harvard.edu/abs/2024ivoa.spec.1114E

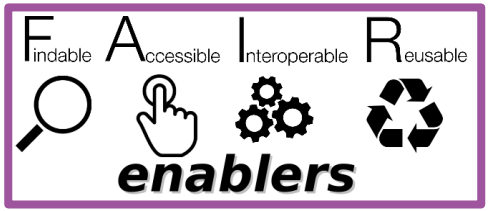


level 2

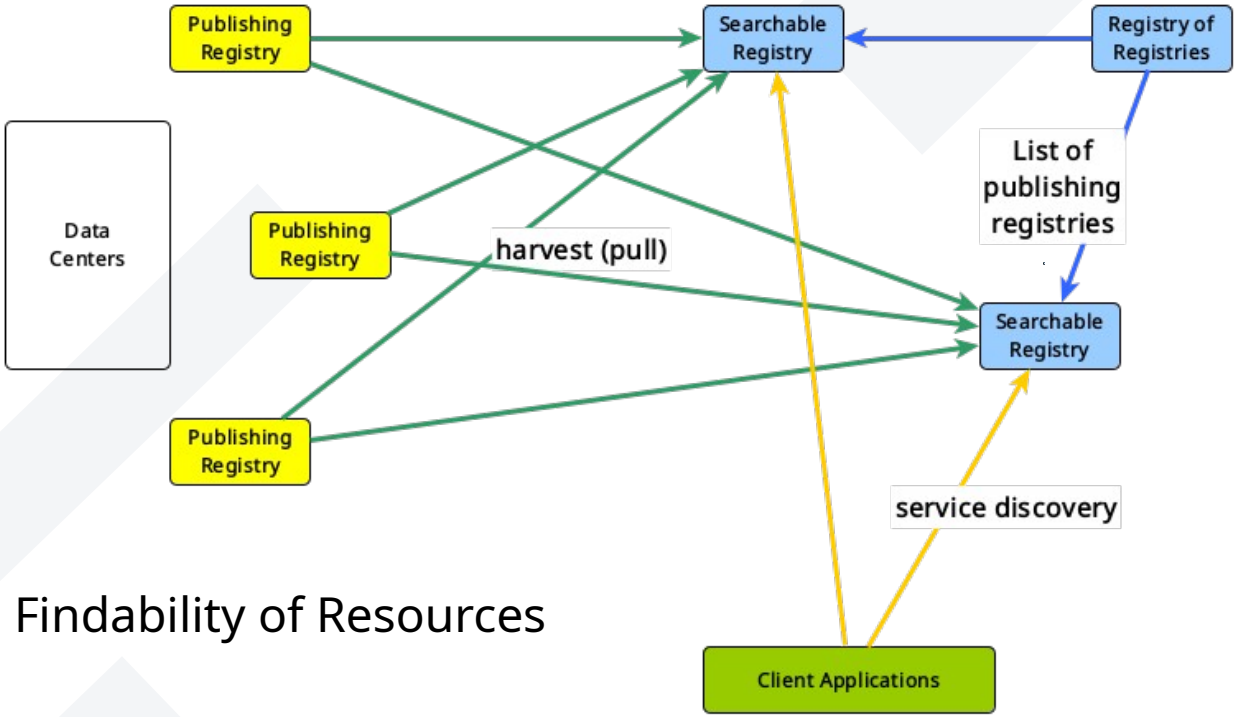
IVOA – FAIR mapping







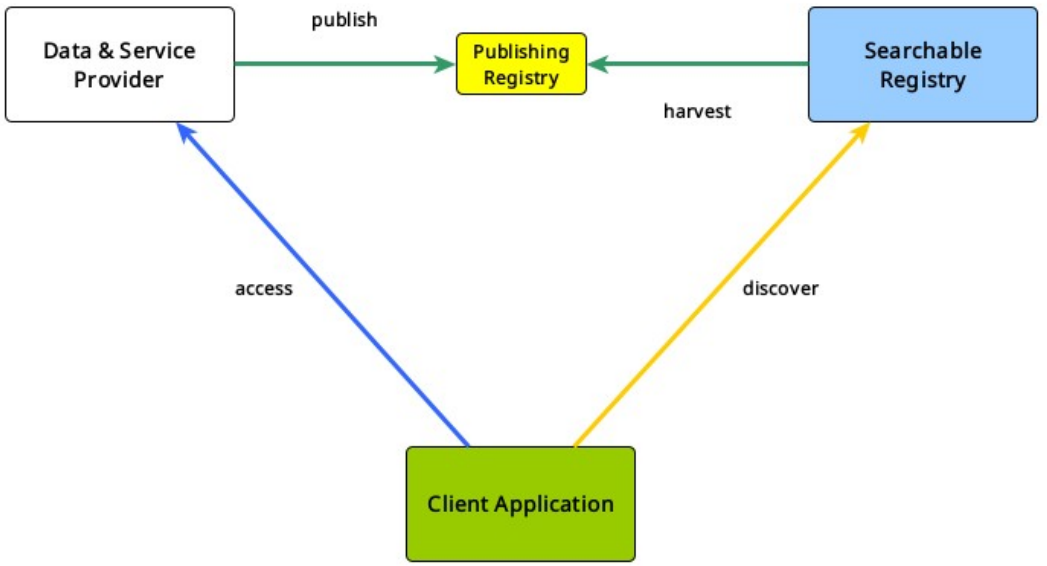
The IVOA Registry



Findability of Resources

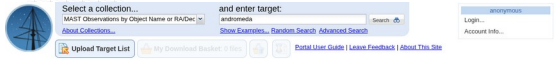
- Data Collections
- Source Catalogues
- Access Services
  - (standardised) Protocols
  - Registries (themselves)
- IVOA standards

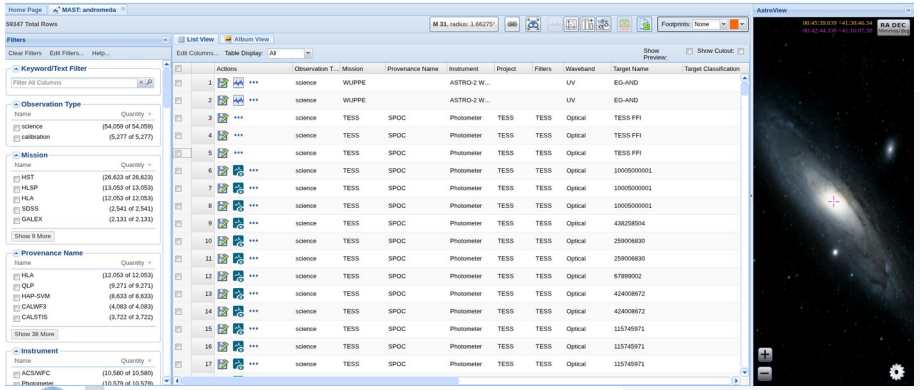
Access action-ability



- 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

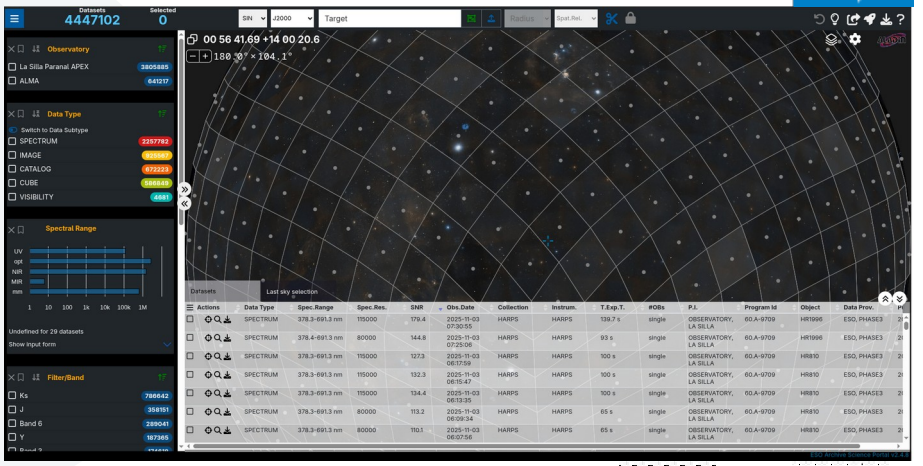
(archives)



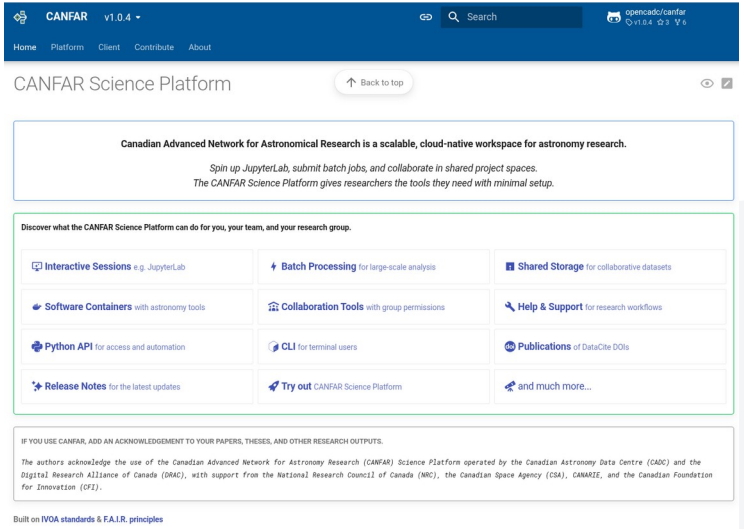


https://archive.stsci.edu/

https://archive.eso.org/

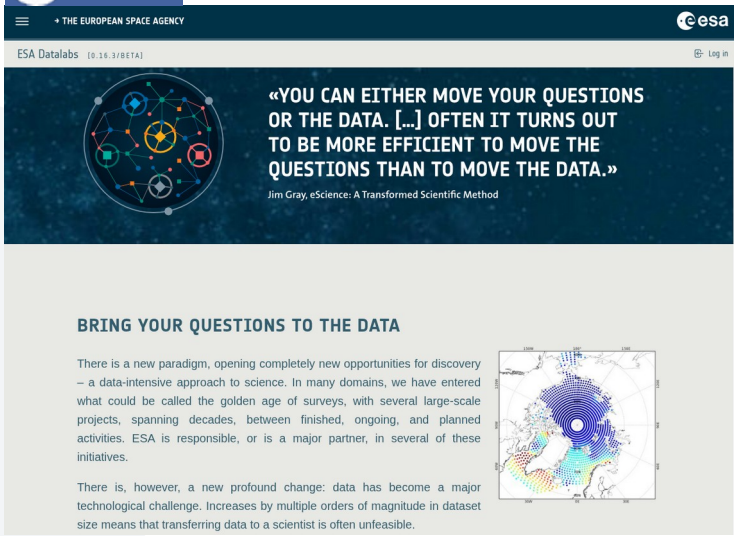


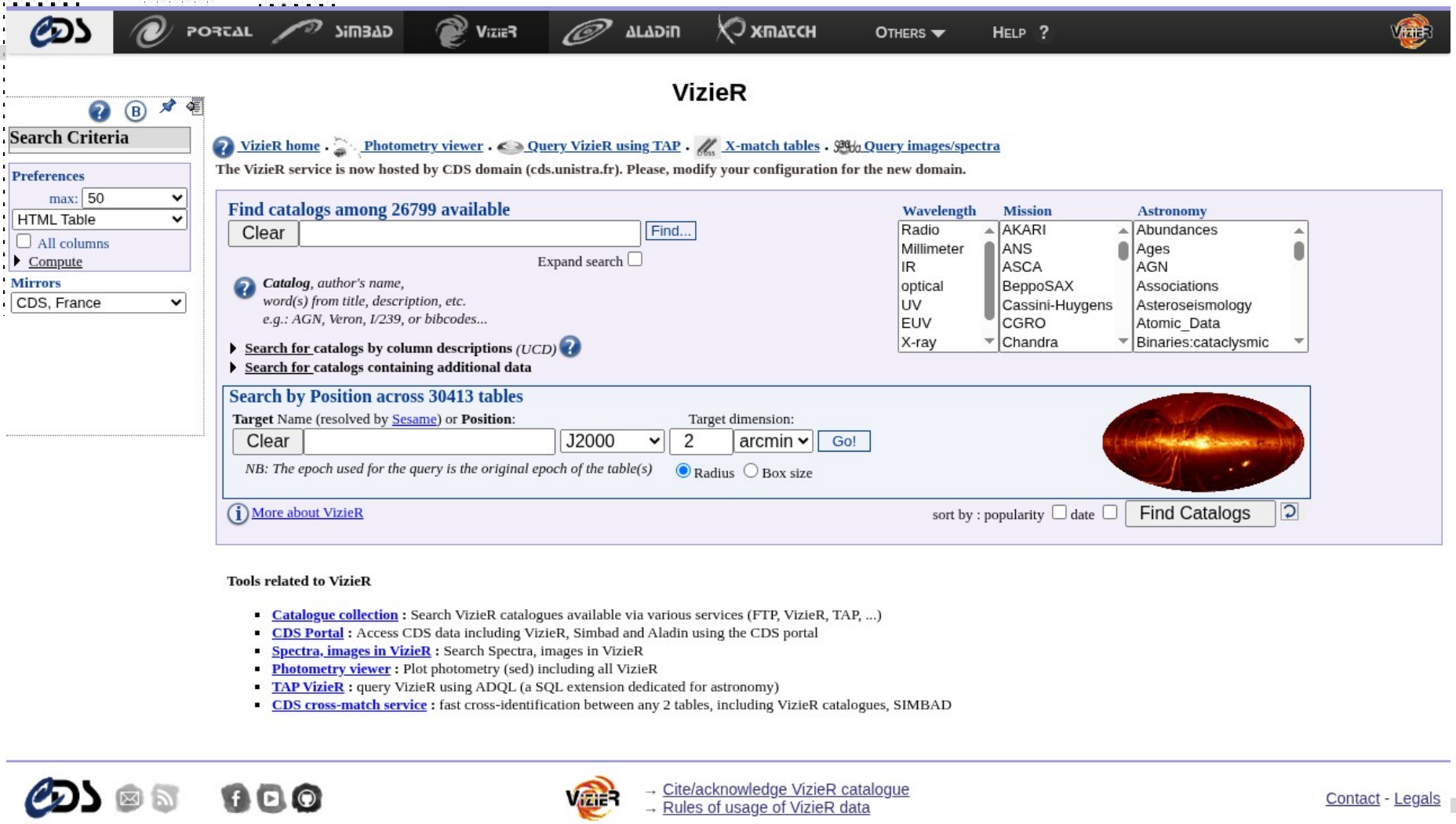
(platforms)



https://www.canfar.net/

https://datalabs.esa.int/




PORTAL
SIMBAD
VIZIER
ALADIN
XMATCH
OTHERS
HELP ?
VizieR
Search Criteria
Preferences
max: 50
HTML Table
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Mirrors
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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
Clear
Find...
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
Wavelength
Radio
Millimeter
IR
optical
UV
EUV
X-ray
Mission
AKARI
ANS
ASCA
BeppoSAX
Cassini-Huygens
CGRO
Chandra
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Binaries:cataclysmic
Search by Position across 30413 tables
Target Name (resolved by Sesame) or Position:
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Clear
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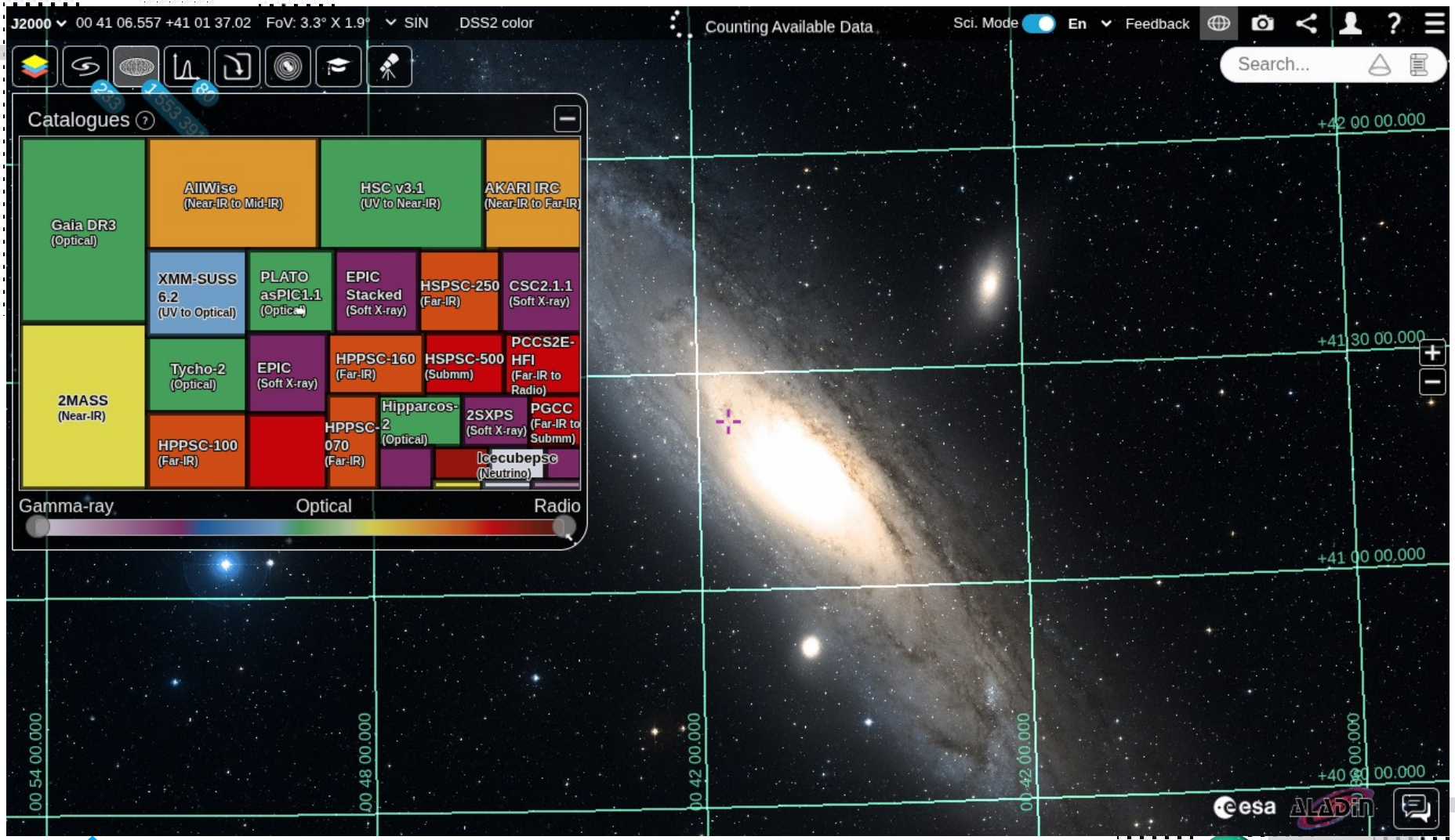
NB: The epoch used for the query is the original epoch of the table(s)
Radius
Box size
More about VizieR
sort by : popularity
date
Find Catalogs
Tools related to VizieR
Catalogue collection : Search VizieR catalogues available via various services (FTP, VizieR, TAP, ...)
CDS Portal : Access CDS data 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
→ Cite/acknowledge VizieR catalogue
→ Rules of usage of VizieR data
Contact - Legals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Counting Available Data
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Feedback
Search...
Catalogues
Gaia DR3 (Optical)
AllWise (Near-IR to Mid-IR)
HSC v3.1 (UV to Near-IR)
AKARI IRC (Near-IR to Far-IR)
XMM-SUSS 6.2 (UV to Optical)
PLATO asPIC1.1 (Optical)
EPIC Stacked (Soft X-ray)
HSPSC-250 (Far-IR)
CSC2.1.1 (Soft X-ray)
2MASS (Near-IR)
Tycho-2 (Optical)
EPIC (Soft X-ray)
HPPSC-160 (Far-IR)
HSPSC-500 (Submm)
PCCS2E-HFI (Far-IR to Radio)
Hipparcos-2 (Optical)
2SXPS (Soft X-ray)
PGCC (Far-IR to Submm)
HPPSC-100 (Far-IR)
HPPSC-070 (Far-IR)
Icecubepsc (Neutrino)
Gamma-ray
Optical
Radio
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+41 30 00.000
+41 00 00.000
+40 30 00.000
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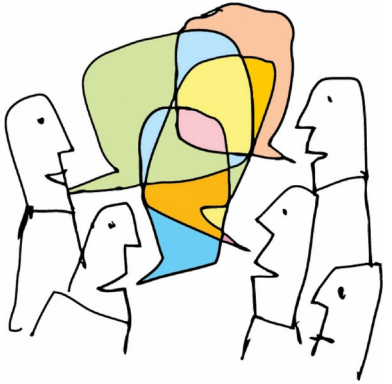
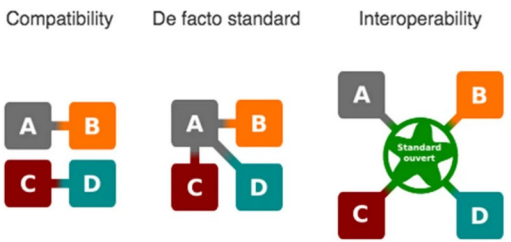
esa
ALADIN

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

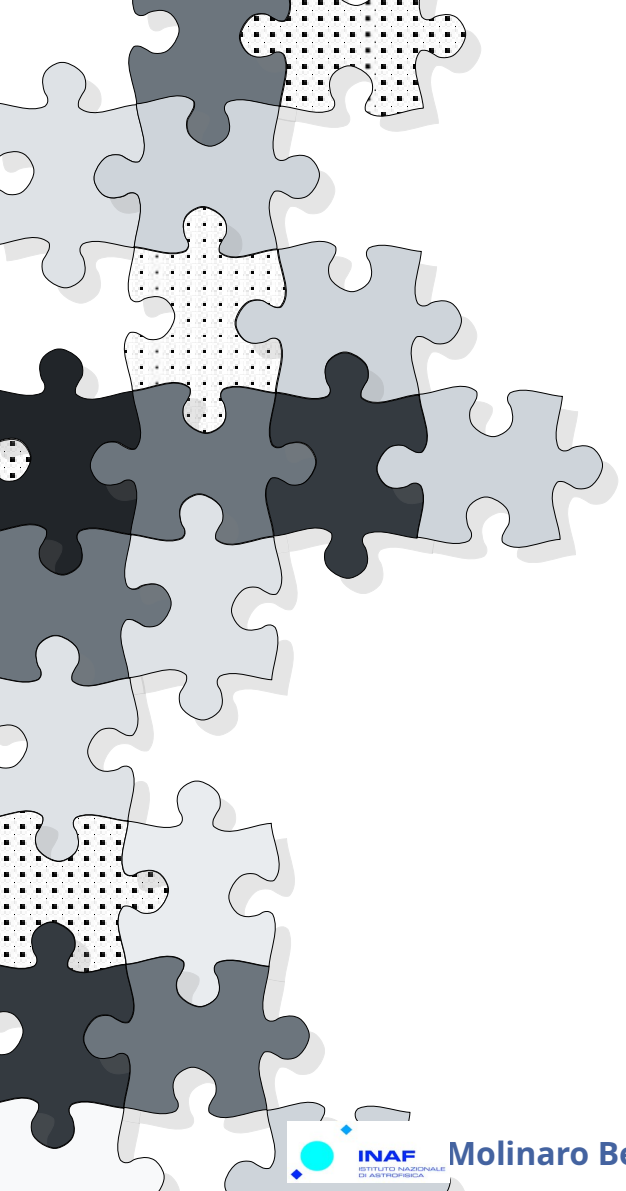




community shared conventions :: open standards

engage the community

establish agreement on conventions



What to do?

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

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]