Intro to the IVOA

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The VO and the IVOA: what?

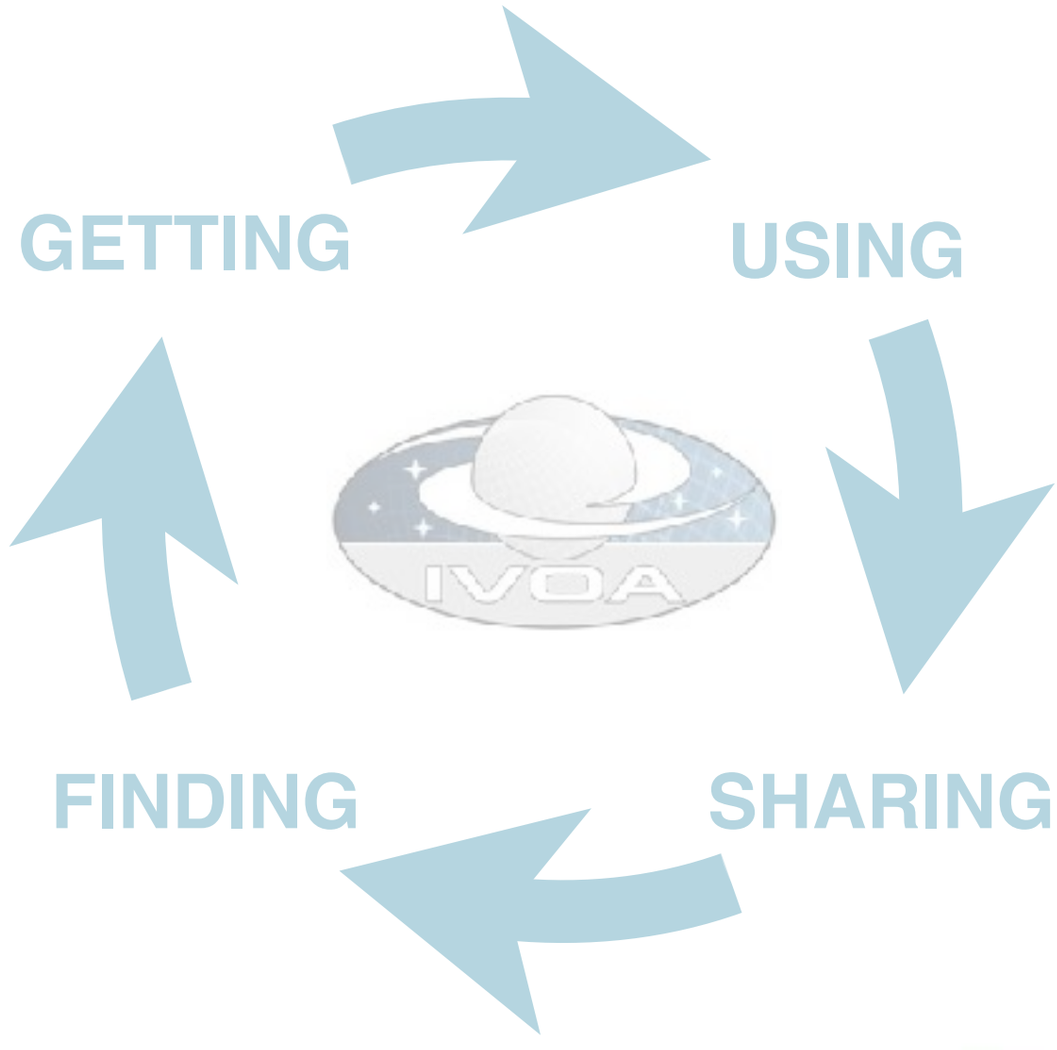
"A multi-wavelength digital sky that can be searched, visualised and analysed in new and innovative ways" P. Fabianno

What is the Virtual Observatory?

- Framework for astronomical datasets, tools, services to work together in a seamless way

What is the International Virtual Observatory Alliance?

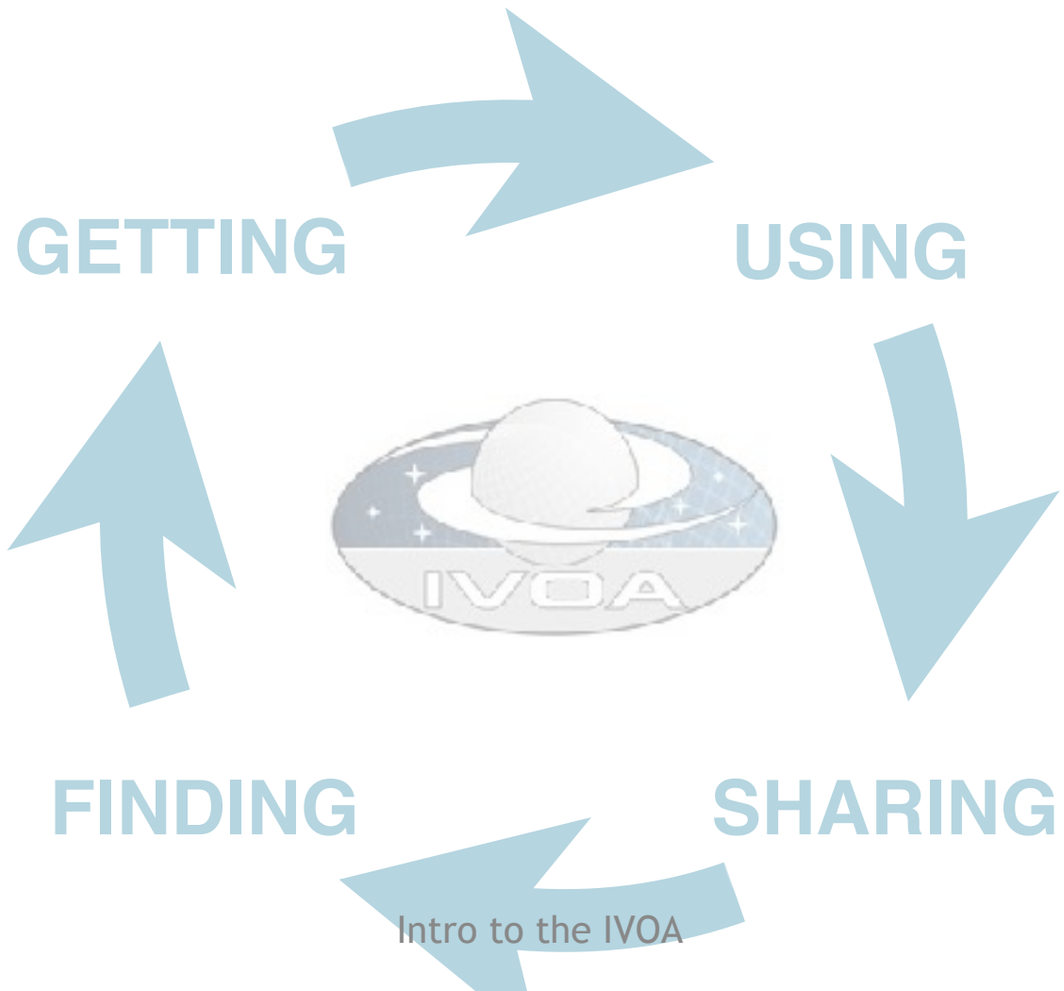
- A science driven organisation that builds the technical standards
- A place for discussing and sharing VO ideas and technology to enable science
- Promoting and publicising the VO



The VO and the IVOA: why?

Clear benefits

- Growth in the scientific return of data
- Capability to discover and fuse multiple data sets
- Application of the VO in planning new observations and observing strategies



The VO and the IVOA: who?

Who is the IVOA?

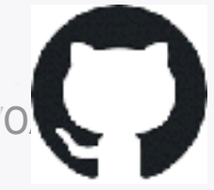
http://ivoa.net/

- **5 Committees:** Exec, Tech Coordination, Standards & processes, Media, Science priorities
- **6 Working Groups (WG):** Applications, access, models, grid & web services, registry, semantics
- **8 Interest Groups (IG):** Time-domain, radio, solar system, education, data curation, knowledge & discovery, theory, operations

Want to get involved?

- Meetings: 2 interoperability meetings per year
- Don’t know where to start? Email any chair/vice-chair of a IG/WG, CSP





The VO and the IVOA: where?

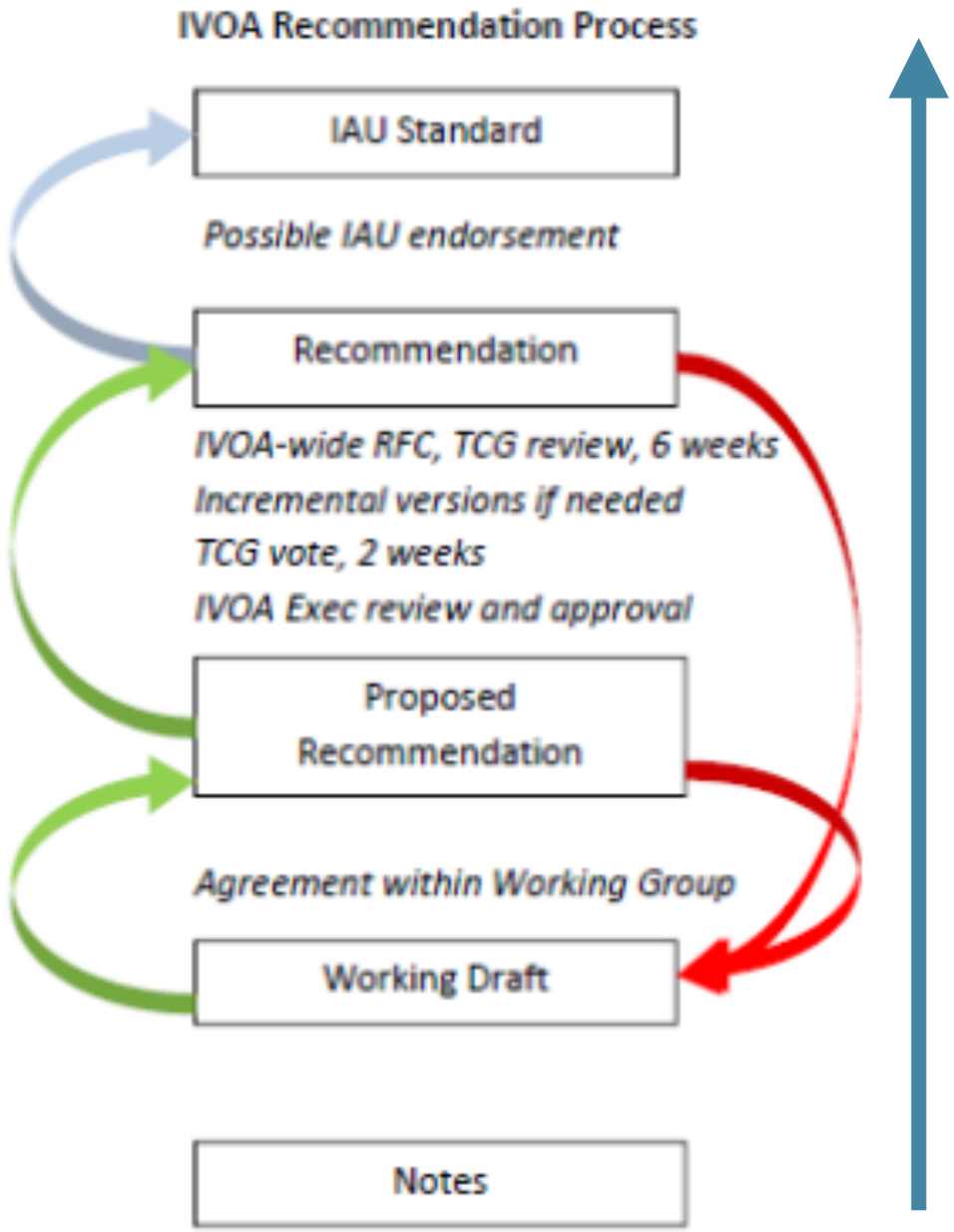
Existing global framework: populated by major data providers (space and ground based) that is heavily used by the community (e.g. Gaia data access is fully VO)

The VO and the IVOA: how?

Through the **development and adoption** of common standards scientifically driven, as an international community effort where astronomers, software engineers and documentalists are involved

IVOA development process of standards

- Build IVOA standards to match users needs:
  - Find and report the community needs
  - Find and report gaps in the existing standards
  - Propose new ways to fill the gaps
  - Implement & validate
  - Standardise when consensus is reached



https://www.ivoa.net/documents/DocStd/index.html

OK, but where do I start?

- A good starting point to newcomers to the IVOA: **the architecture document** (more on slide 22)

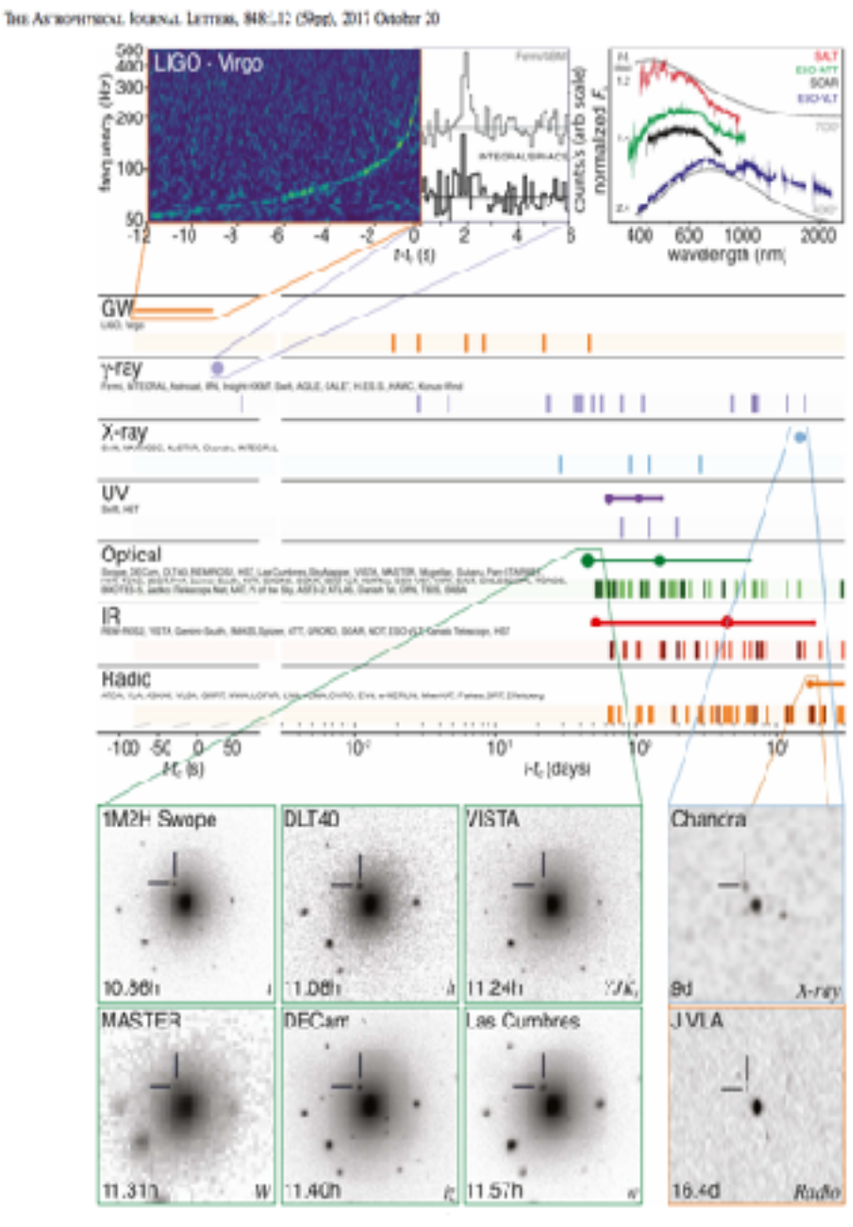
  https://www.ivoa.net/documents/IVOAArchitecture/20211101/index.html

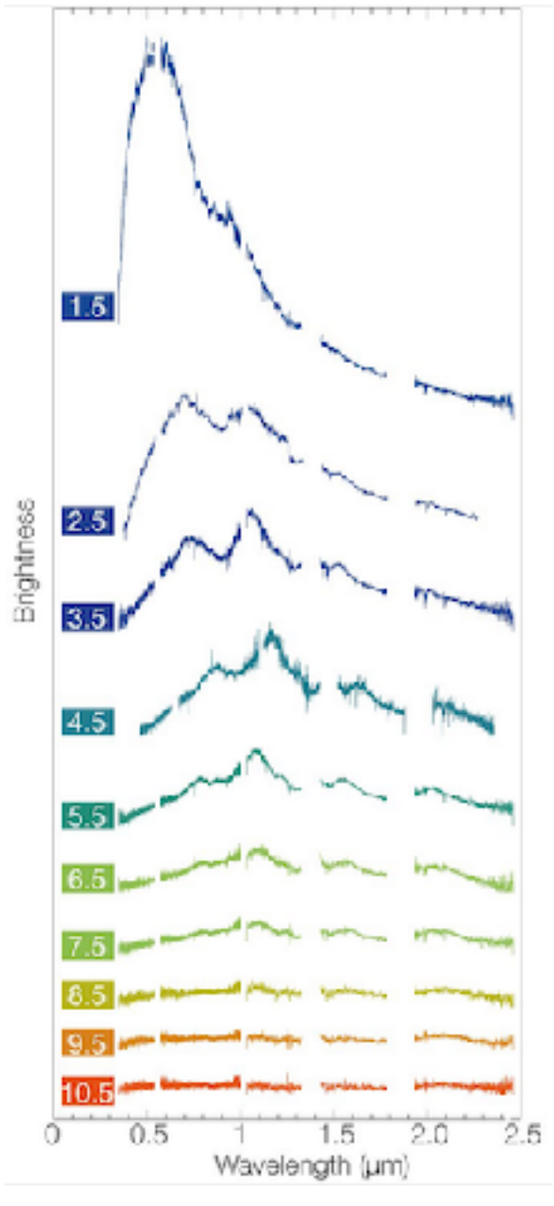
Things to keep in mind:

- The IVOA will not answer your scientific questions nor will it ask the questions for you
- The IVOA provides you with common formats and common ways of describing and accessing the data which when adopted will ease your work

Let’s see it with an example

VO in the multi-messenger landscape





- Multi-wavelength / messenger approach is needed - different data types
- Follow-up observations and reaction time for that can be crucial - alerts
- Analysis, Visualisation & navigation through the data
- Coordination & transmission of information

The IVOA should match user's needs

Some selected standards

1. **VOTable** the format for tabular data for allowing interoperability (coosys, timesys, ucd, utype, VOunits, datalink).
2. **HiPS** more than a format for images - tailored for large data volumes
3. Search for data:
   - **Cone search** — spatial + temporal search
   - **MOC** — spatial and temporal indexing for large data volumes and more complex areas in the sky
   - **TAP + ADQL** — Table Access Protocol & astronomical data query language
   - **ObsCore & ObsTAP** — description of observations
4. Planning of observations:
   - **ObjVisSAP** — visibility of object to plan observations
   - **ObsLocTAP** — facilitate coordination of observations
   - Facilities / observatory list (under dev.)
5. Alerts: **VOEvents**
6. **… many more! SLAP, SIAP, SSA, Provenance, SAMP… each tailored to specific use cases**

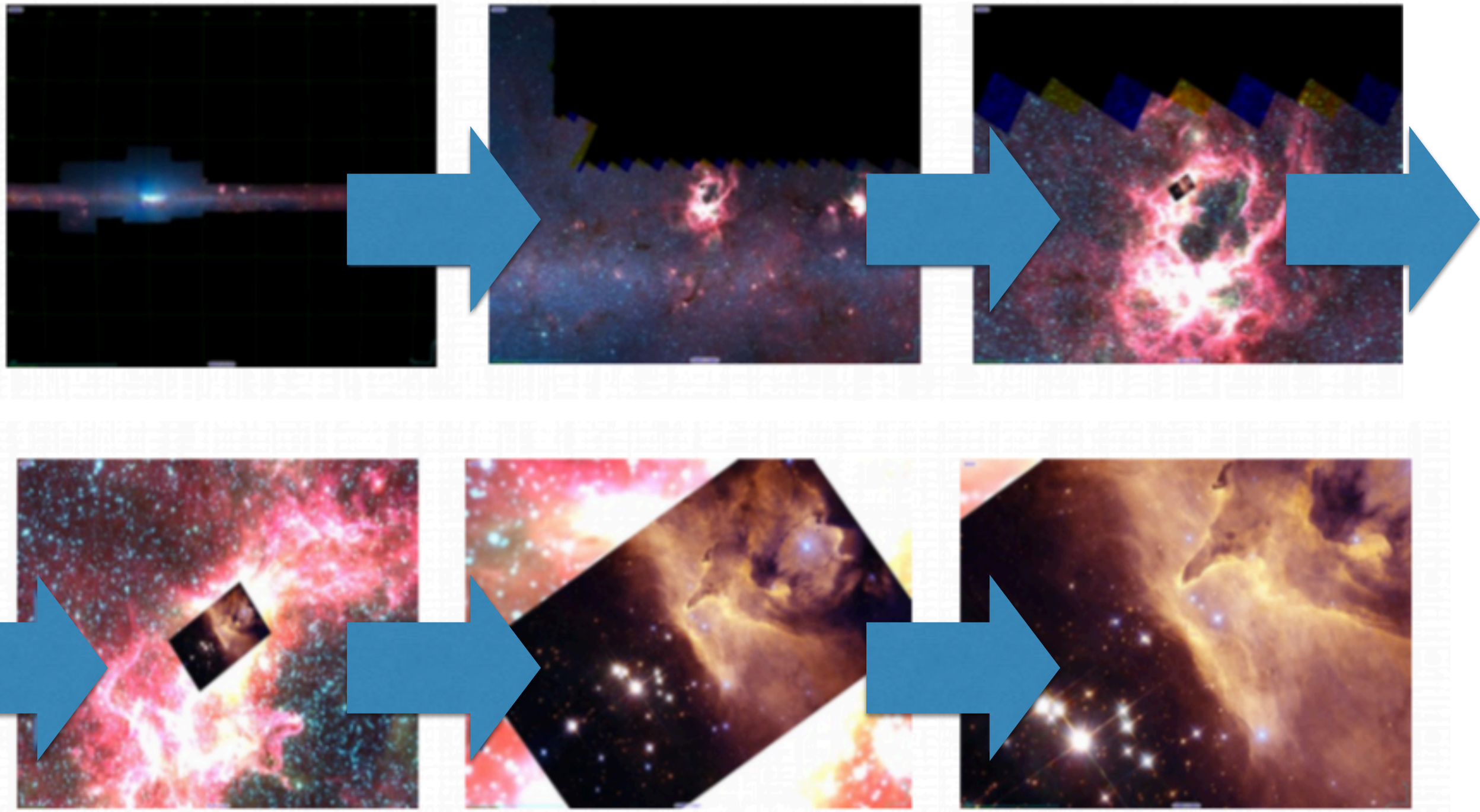
VOTable: format for tabular data

Standardisation of coordinate system annotation (time and space), UCD, utypes, VOUnits, datalink

- **COOSYS** ("ICRS", “eq_FK5”,…)
- **TIMESYS** (scale: TT, TAI, …, refposition: barycenter,… timeorigin: JD, MJD,…)
- **Unified Content Descriptor** (**UCD**): controlled vocabulary for describing astronomical data quantities - related to the nature of the values
- **UTypes:** relationship between the columns and the data model components
- **VOUnits:** units expressed as a simplified text label (e.g. m.s-2 instead of m s^{-2})
- **Datalink**: links to other associated data

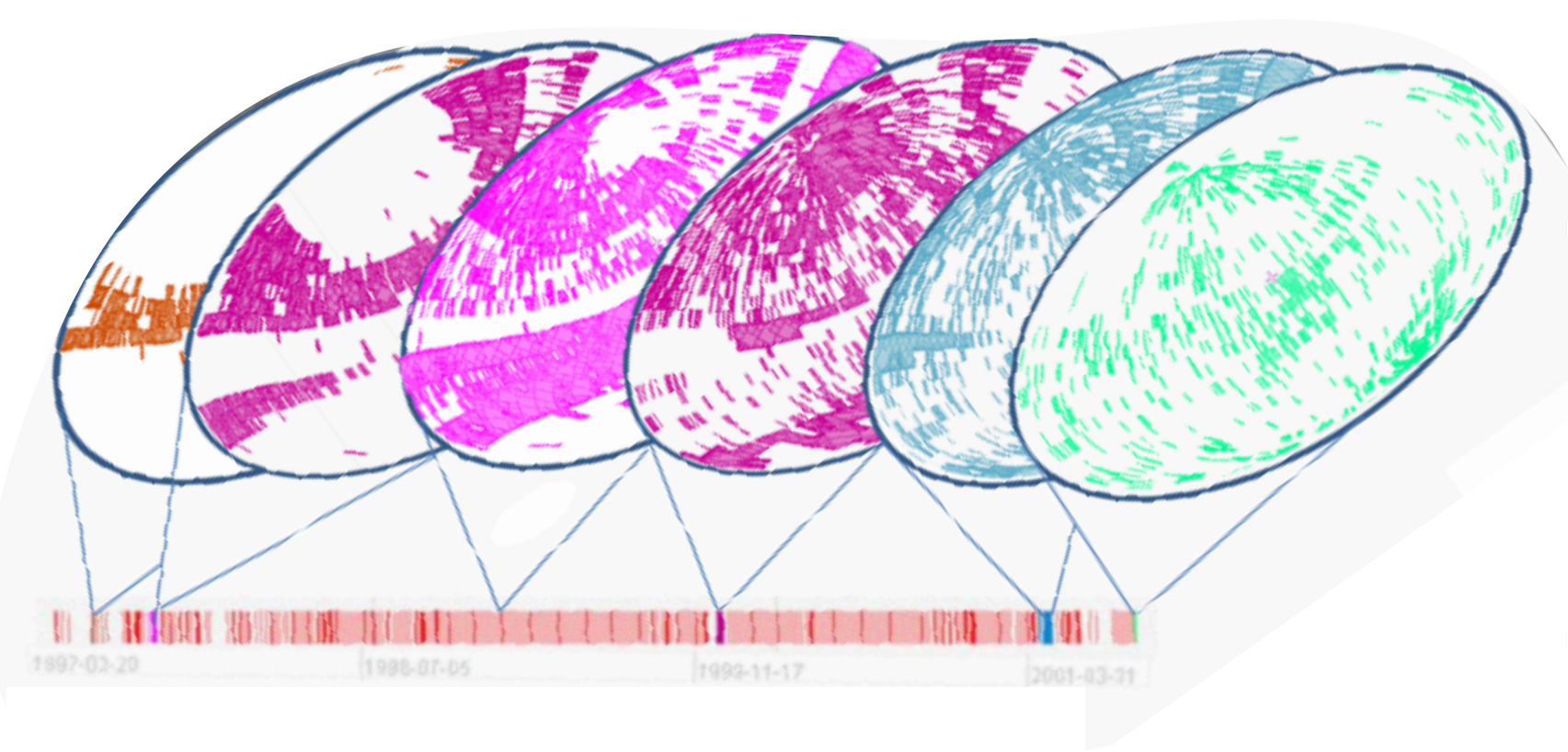
HiPS: Hierarchical image Progressive Survey

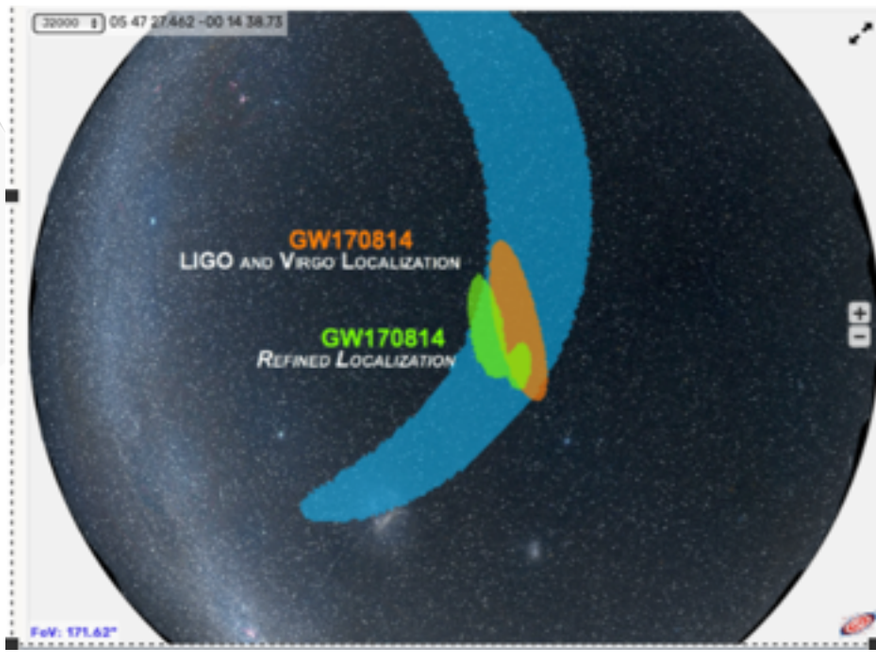
- A hierarchical scheme for the description, storage and access of sky survey data (the more you zoom-in the more the details)



Search: know where & when

- Cone search extension to add a time interval for search in catalogs
- MOC : Search by temporal+spatial coverage of surveys for the more complicated areas





TAP & ADQL

- **Table Access Protocol (TAP)** - defines a service protocol for accessing general table data, including astronomical catalogs as well as general database tables. Access is provided for both database and table metadata as well as for actual table data.

- **Astronomical Data Query Language (ADQL)** Based on Structured Query Language (SQL) with special restrictions and extensions in order to support generic and astronomy specific operations

```
SELECT DISTANCE(
  POINT('ICRS', 266.41683, -29.00781),
  POINT('ICRS', ra, dec)) AS dist, *
FROM gaiaedr3.gaia_source
WHERE 1=CONTAINS(
  POINT('ICRS', 266.41683, -29.00781),
  CIRCLE('ICRS',ra, dec, 0.08333333))
ORDER BY dist ASC
```

ObsCore & ObsTAP

- **Goal: “to give data providers a set of metadata attributes that they can easily map to their database system in order to support queries of the sort listed below.”**

- Science cases:
  - Support multi-wavelength as well as positional and temporal searches.
  - Support any type of science data product (**image, cube, spectrum, time series, instrumental data, etc.**).
  - Directly support the sorts of file content typically found in archives (FITS, VOTable, compressed files, instrumental data, etc.).

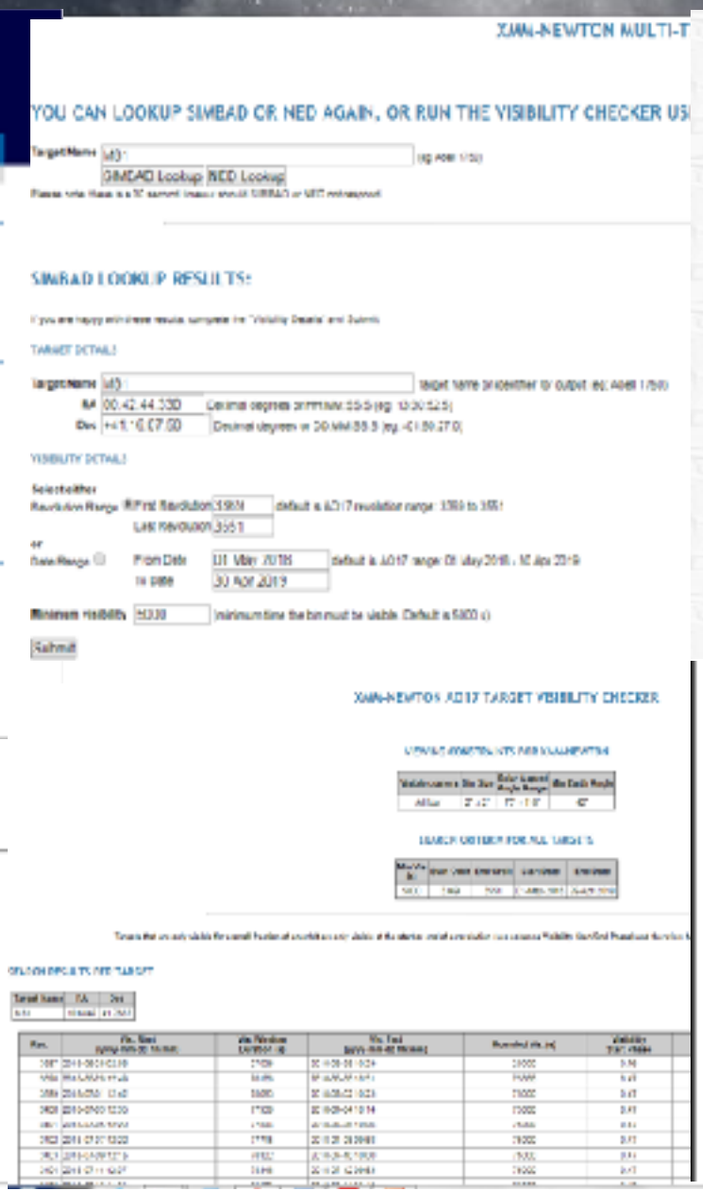
ObsCore & ObsTAP are Key IVOA standards for searching, finding and combining all sorts of data and allow for interoperability

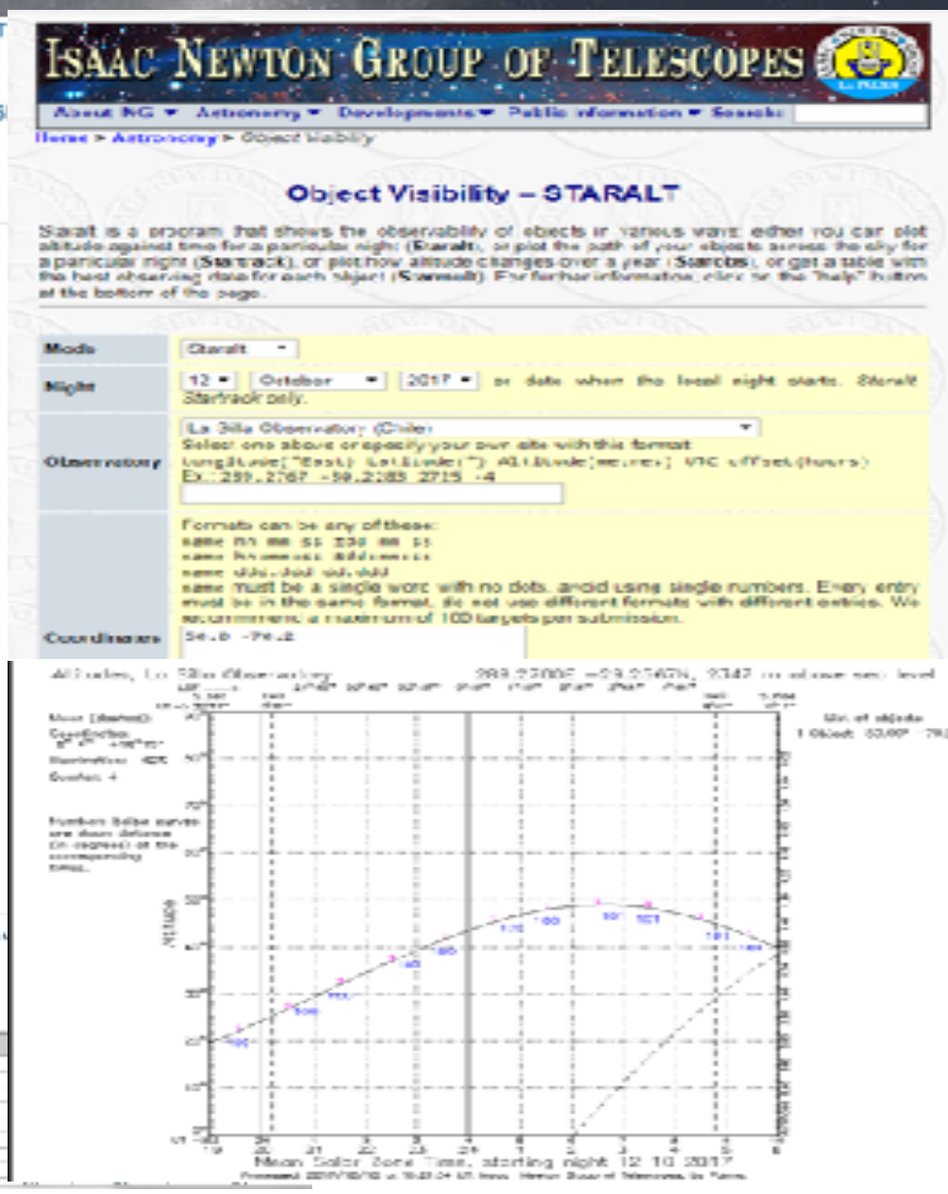
ObsCore & ObsTAP

- Map the METADATA of your project data into ObsCore Keywords
- Set a TAP Service
- Register it! —> *“The yellow pages of the IVOA”*

➡Search, find, and combine the data coming from multiple missions

Visibility of an object





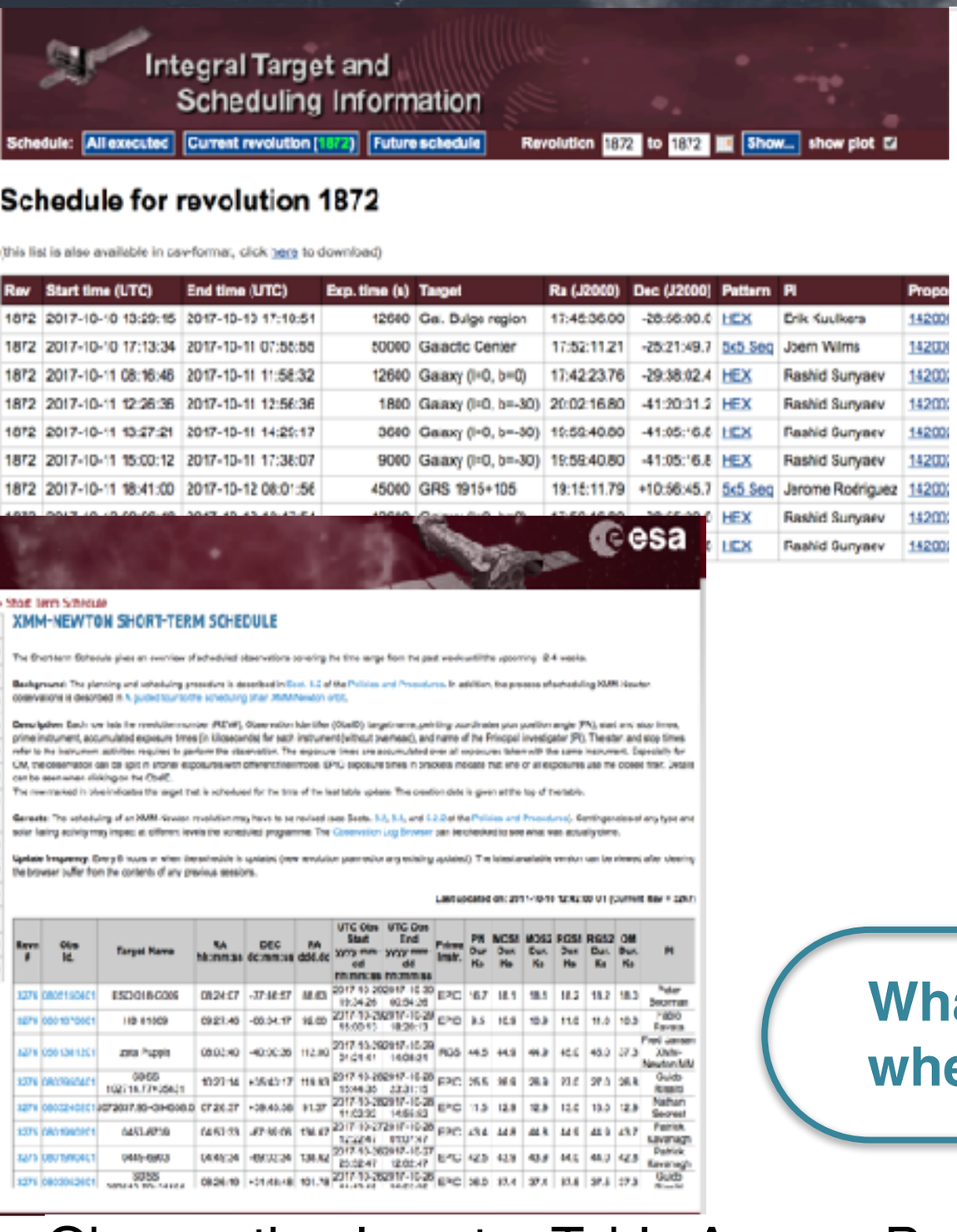
Different services have different inputs / outputs

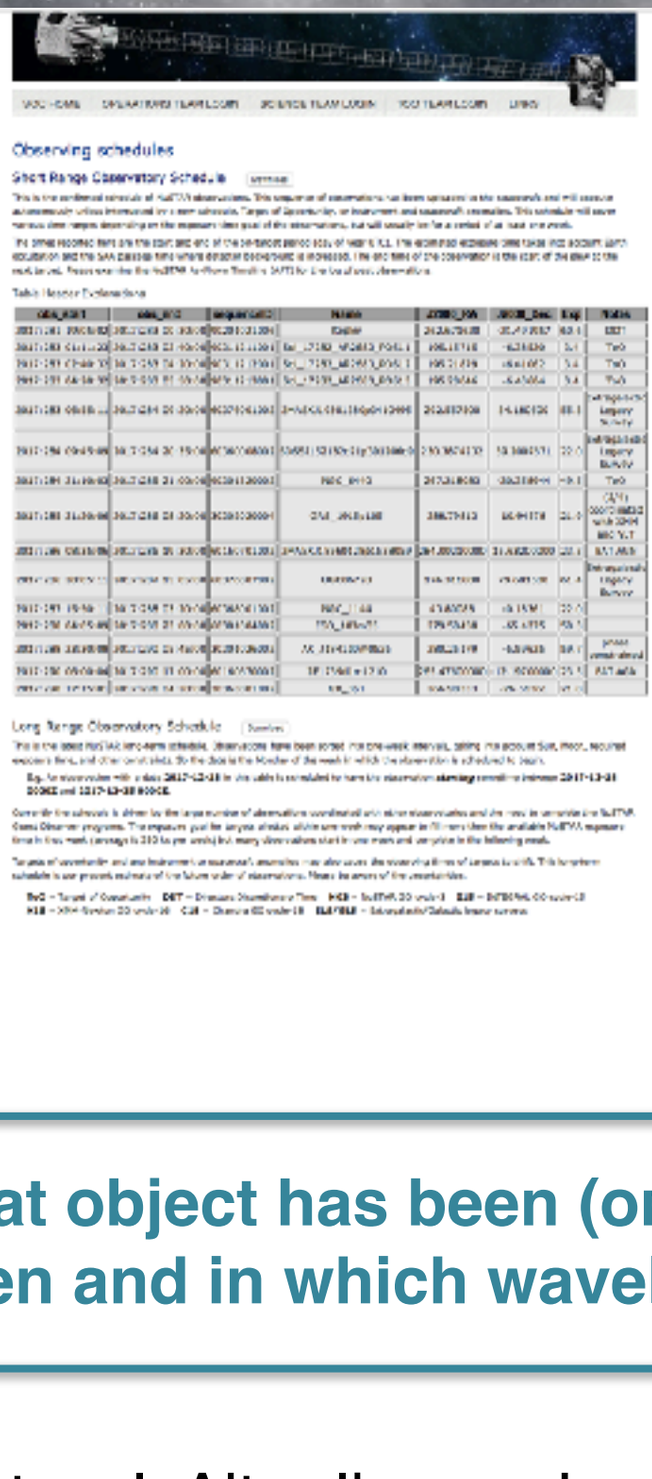
Facilitate the work by having some level of standardised input / output

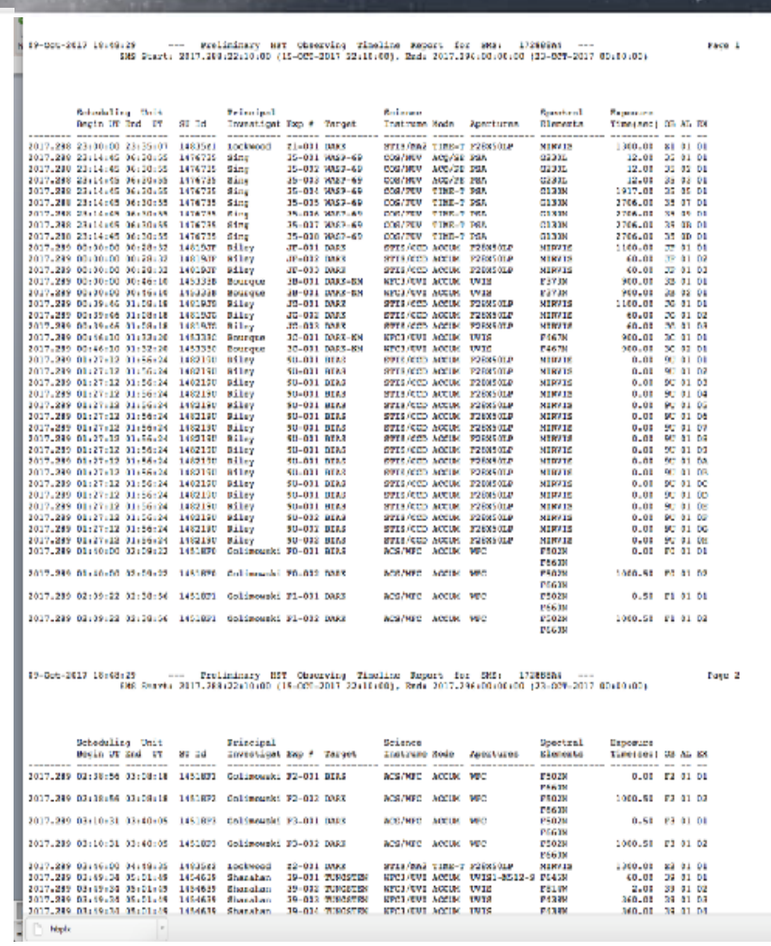
Object Visibility Simple Access Protocol, Aitor Ibarra, Richard Saxton, Jesús Salgado et al. 2020

http://www.ivoa.net/documents/ObjVisSAP/index.html

Coordination of observations







What object has been (or will be) observed when and in which wavelength?

Observation Locator Table Access Protocol, Aitor Ibarra, Jesús Salgado et al. 2021
http://www.ivoa.net/documents/ObsLocTAP/

VOEvent: Sky Event Reporting Metadata

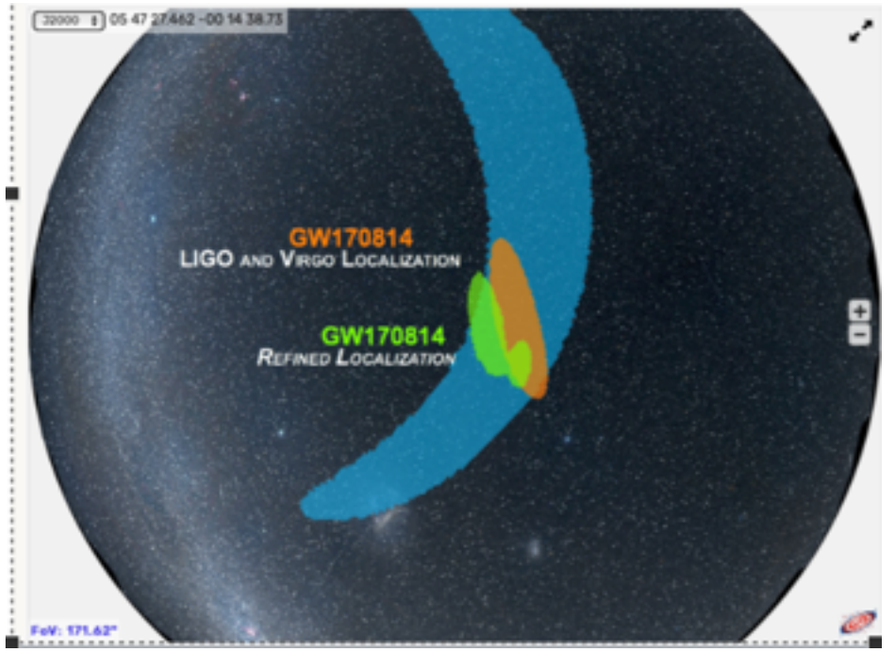
- **"Defines the content and meaning of a standard information packet for representing, transmitting, publishing and archiving information about a transient celestial event, with the implication that timely follow-up is of interest"**
  - **Who**: Identification of scientifically responsible Author
  - **What**: Event Characterization modeled by the Author
  - **WhereWhen**: Space-Time Coordinates of the event
  - **How**: Instrument Configuration
  - **Why**: Initial Scientific Assessment
  - **Citations**: Follow-up Observations
  - **Description**: Human Oriented Content
  - **Reference**: External Content

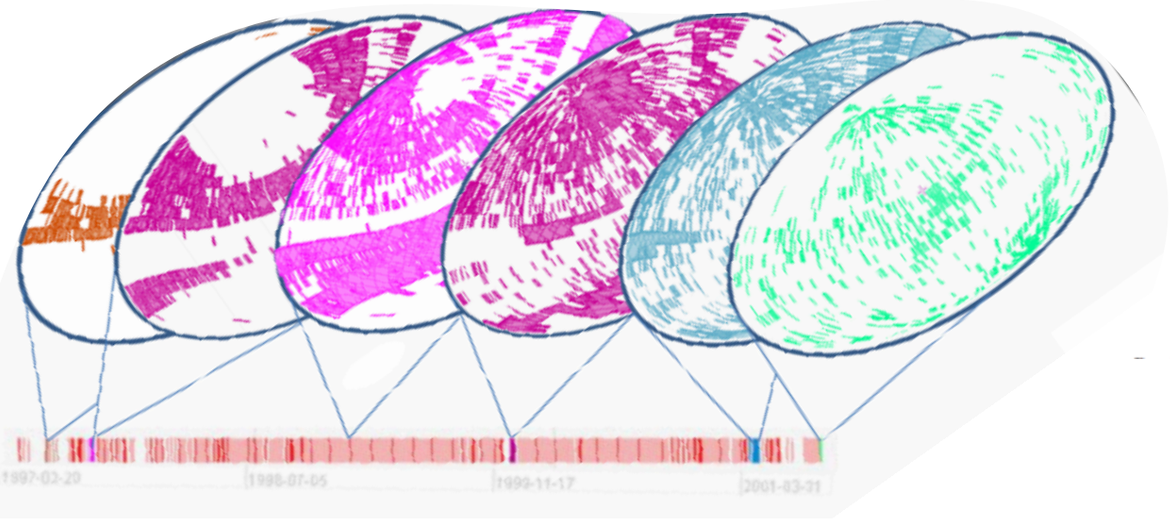
Register your services

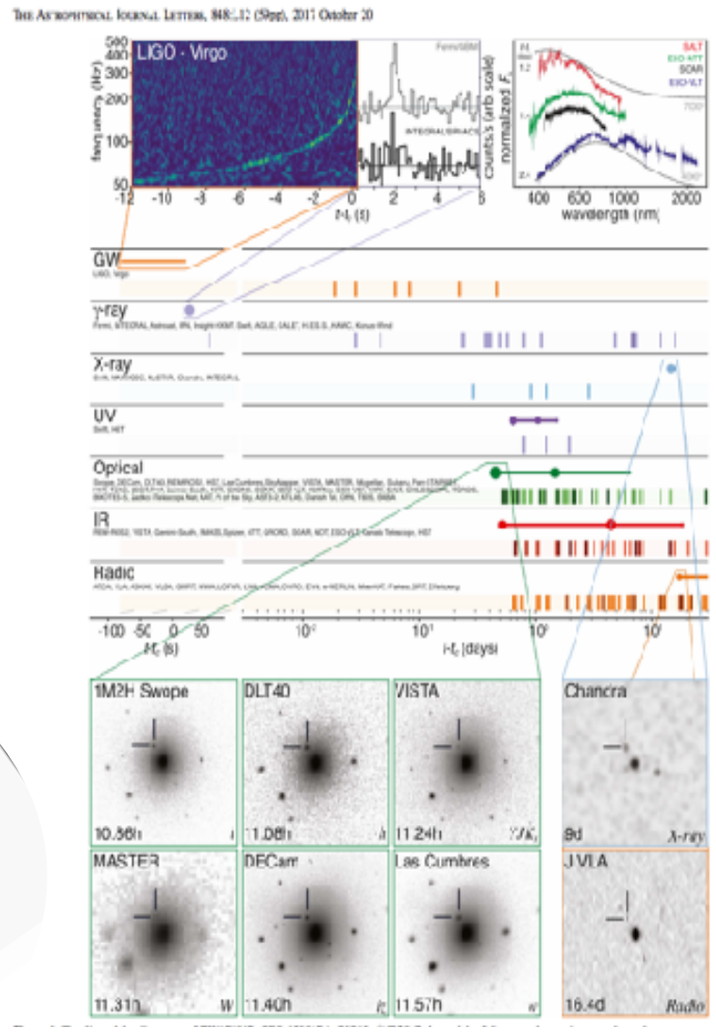
- Describe what data and computational facilities are available where, and once identified, how to use them.

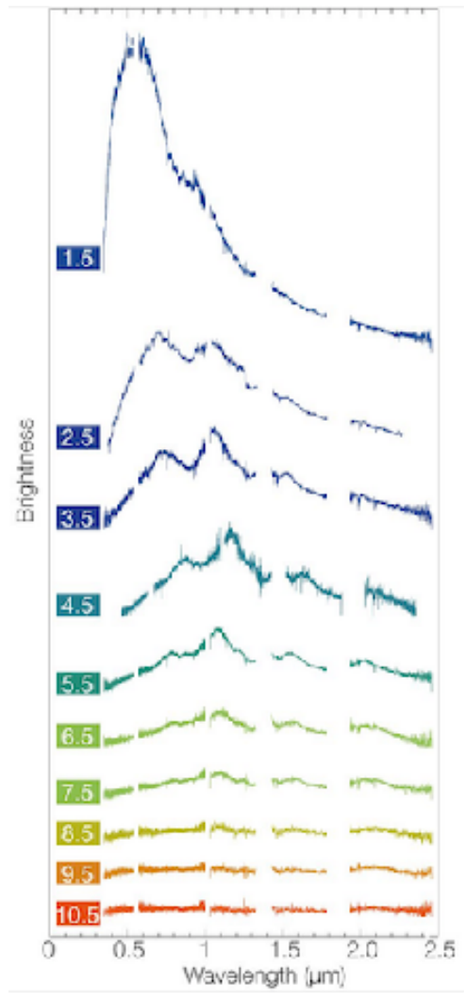
- **The yellow pages**

In a multi-messenger landscape









What else?

- Many more standards!
- Want to know more? Don't know what an acronym means?
- Have a look at the architecture document!
  - A summary of each standard plus a table with acronyms
- https://www.ivoa.net/documents/IVOAArchitecture/20211101/index.html

9.9 SODA

The Server-side Operations for Data Access (SODA) (Bonnarel and Dowler et al., 2017) is an API for low-level data access or server side data processing. The initial version describes operations for extracting a subsection of a data file using astronomical coordinates; Future evolution is expected to include performing various kinds of operations: transformations, pixel operations, and applying functions to the data.

Acronym	Expansion
ADQL	Astronomical Data Query Language - standard
API	Application programming Interface
CDP	Credential Delegation Protocol - standard
CharDM	Characterisation Data Model - standard
ConeSearch	Cone Search - simple positional search service standard

Want to publish your data in the VO?

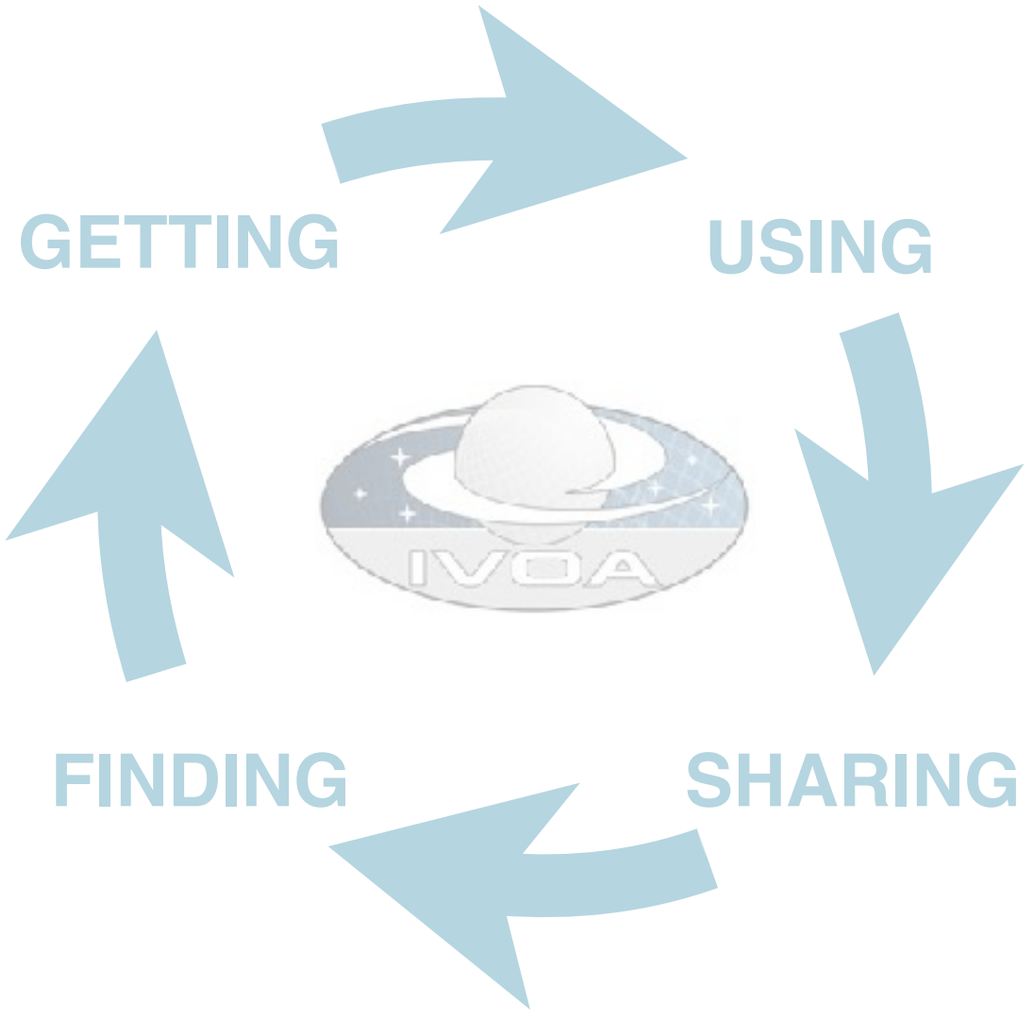
- Have a look here:
- https://wiki.ivoa.net/twiki/bin/view/IVOA/PublishingInTheVO
  - Check the Q&A section! (How do I publish images? spectra? catalogues or generic data tables?…)
- And come to the dedicated panel session

Tuesday April 26 - 15:00 UTC

Speaker	Title	Time	Materials
Ada Nebot	Summary of the Project Survey + Intro to the panel	12'	pdf
Dongwei Fan	LAMOST and the China Virtual Observatory	12'	pdf
Tamara Civera	Observatorio Astrofísico de Javalambre: VO Services	12'	pdf
Alberto Micol	European Southern Observatory	12'	
Yan Grange	ASTRON - Netherlands Institute for Radio Astronomy	12'	
All	Open discussion	30'	

Summary

The IVOA standards are built to enable access, discovery and ultimately **interoperability**



Meeting **FAIR** principles by design

The IVOA needs the community to participate!

Some useful links

- https://www.ivoa.net
- Docs : https://www.ivoa.net/documents/
- GitHub : https://github.com/ivoa
- Mailing list : https://www.ivoa.net/members/index.html
- Architecture: https://www.ivoa.net/documents/IVOAArchitecture/20211101/index.html
- Slack: https://join.slack.com/t/ivoa/shared_invite/zt-17kd0v93b-b32~KReWd1T96gDyYFDLPQ