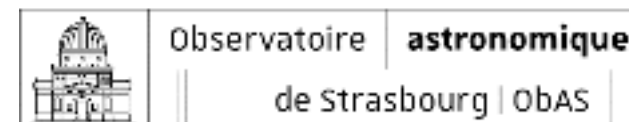


# Intro to the IVOA

Interop meeting 25-29 April 2022

Ada Nebot



[ada.nebot@astro.unistra.fr](mailto:ada.nebot@astro.unistra.fr)

# □ The VO and the IVOA: what?

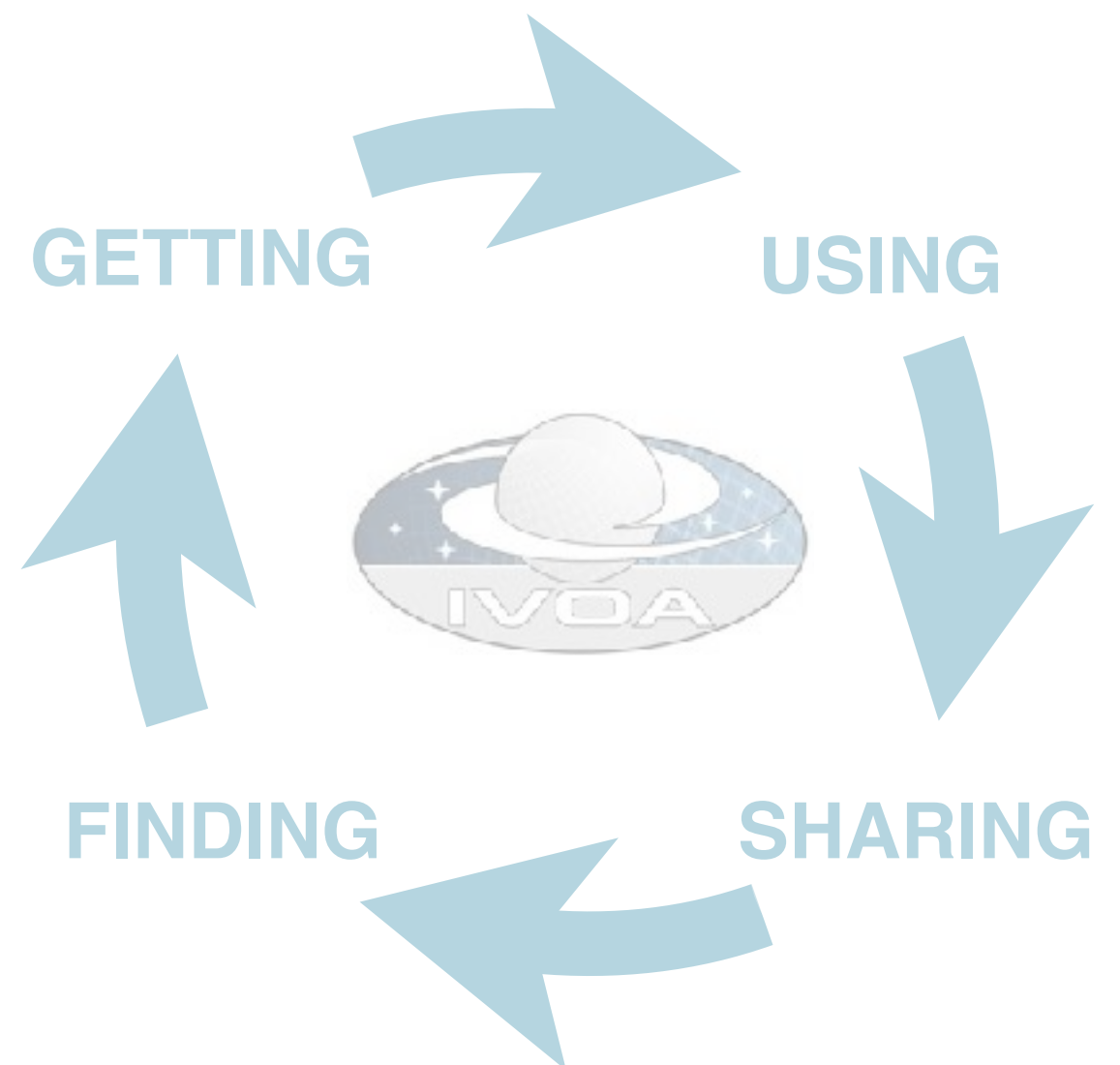
*“A multi-wavelength digital sky that can be searched, visualised and analysed in new and innovative ways” P. Fabianno*

## 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?

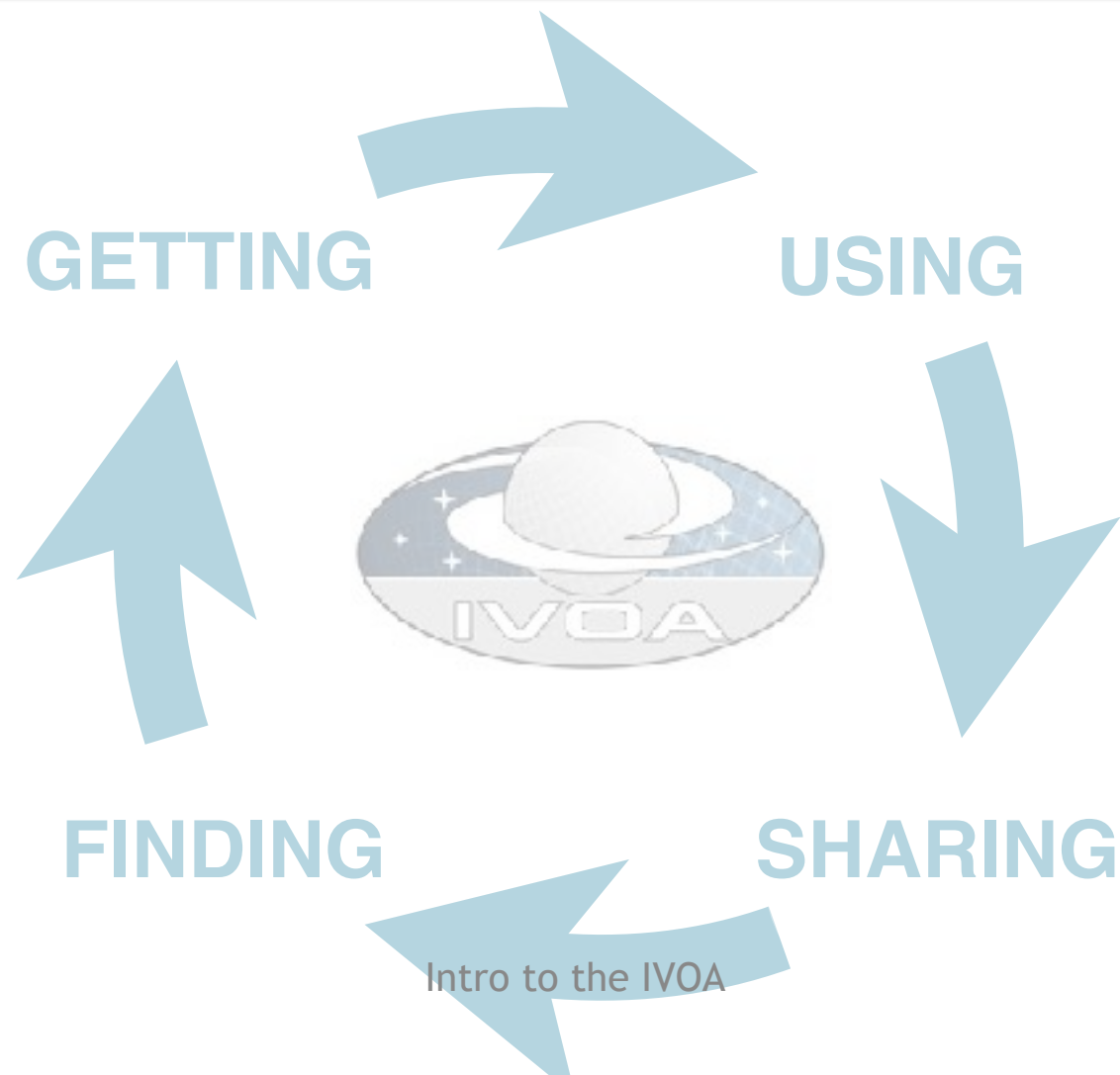
- A science driven organisation that builds the technical standards
- A place for discussing and sharing VO ideas and technology to enable science
- Promoting and publicising the VO



# □ 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
- Register to email lists: <https://www.ivoa.net/members/index.html>
- GitHub: <https://github.com/ivoa-std>
- Slack: [https://join.slack.com/t/ivoa/shared\\_invite/zt-17kd0v93b-b32~KReWd1T96gDyYFDLPQ](https://join.slack.com/t/ivoa/shared_invite/zt-17kd0v93b-b32~KReWd1T96gDyYFDLPQ)
- 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)



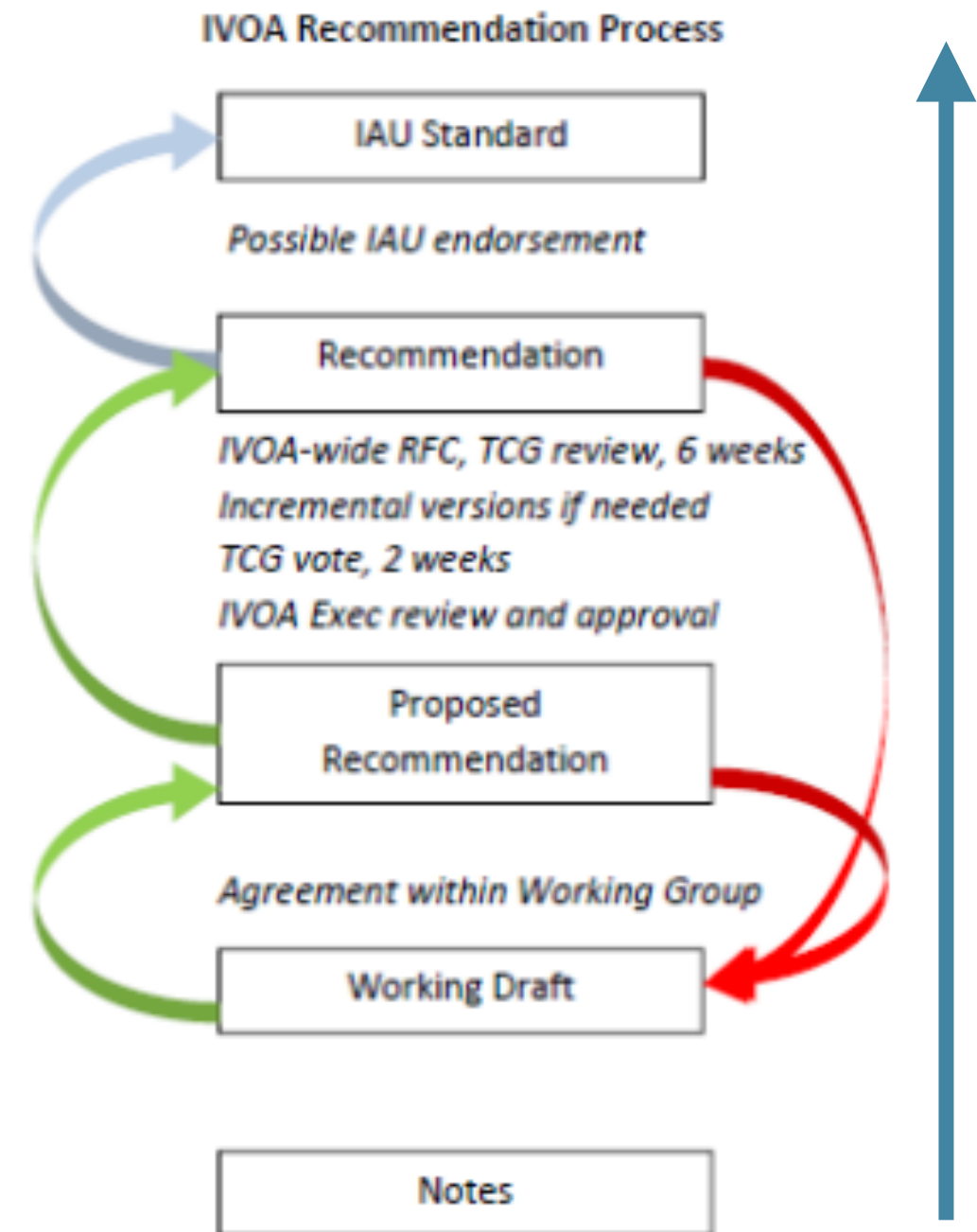
# □ The VO and the IVOA: how?

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**

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

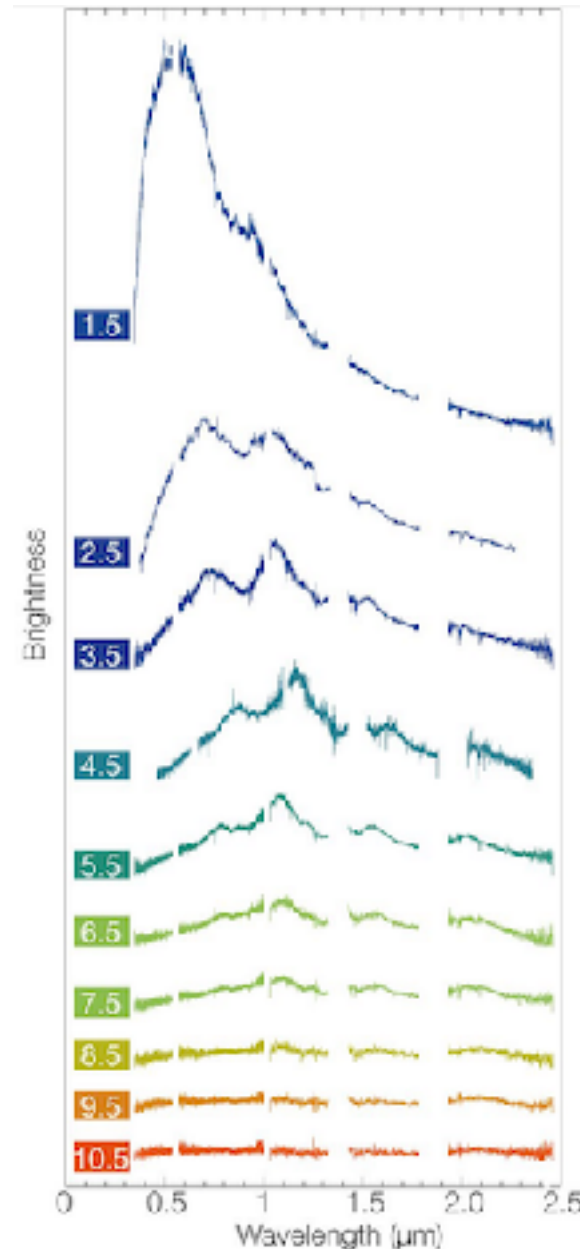
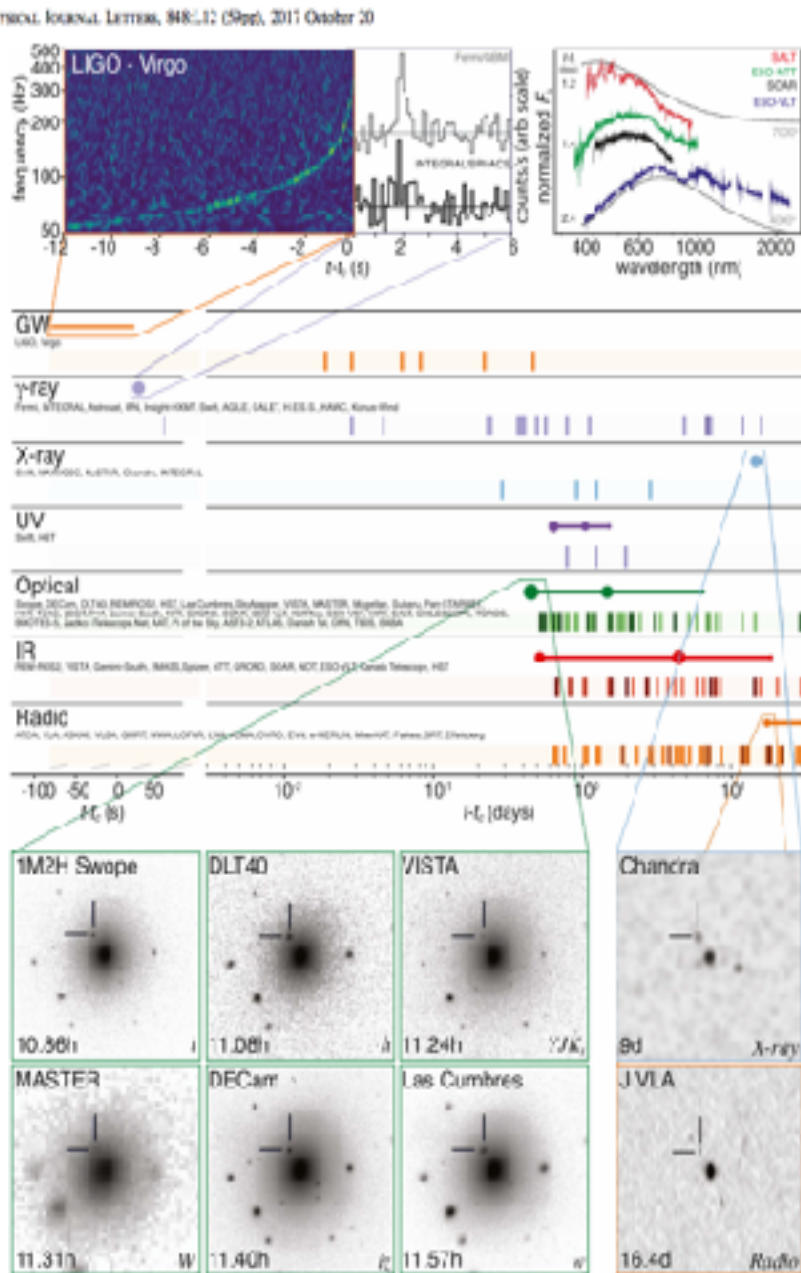
Things to keep in mind:

- 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

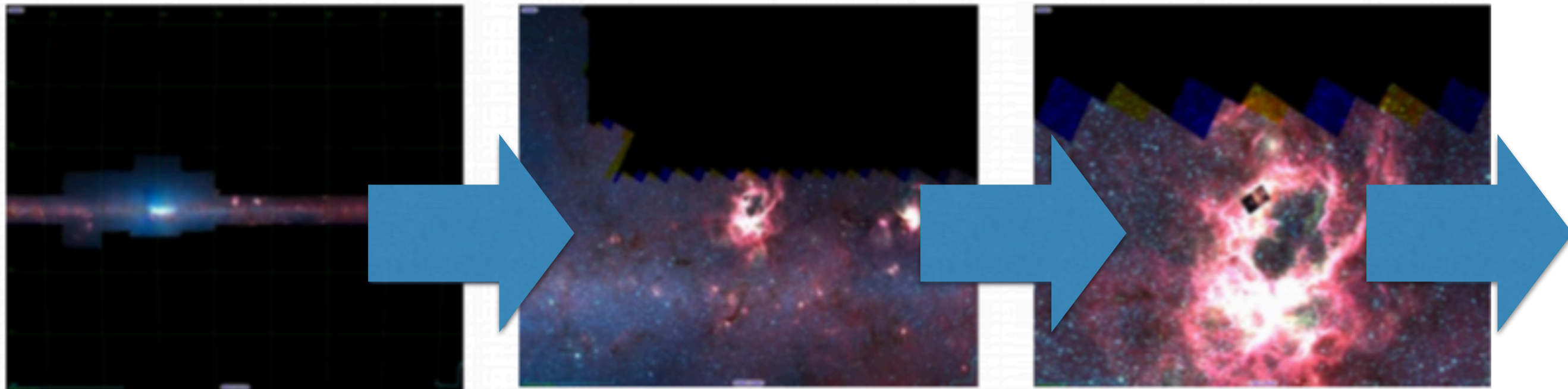
Standardisation of coordinate system annotation (time and space), UCD, utypes, VOUnits, datalink

- **COOSYS** ("ICRS", "eq\_FK5",...)
- **TIMESYS** (scale: TT, TAI, ..., reposition: 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<sup>-2</sup>)
- **Datalink**: links to other associated data



# □ HiPS: Hierarchical image Progressive Survey

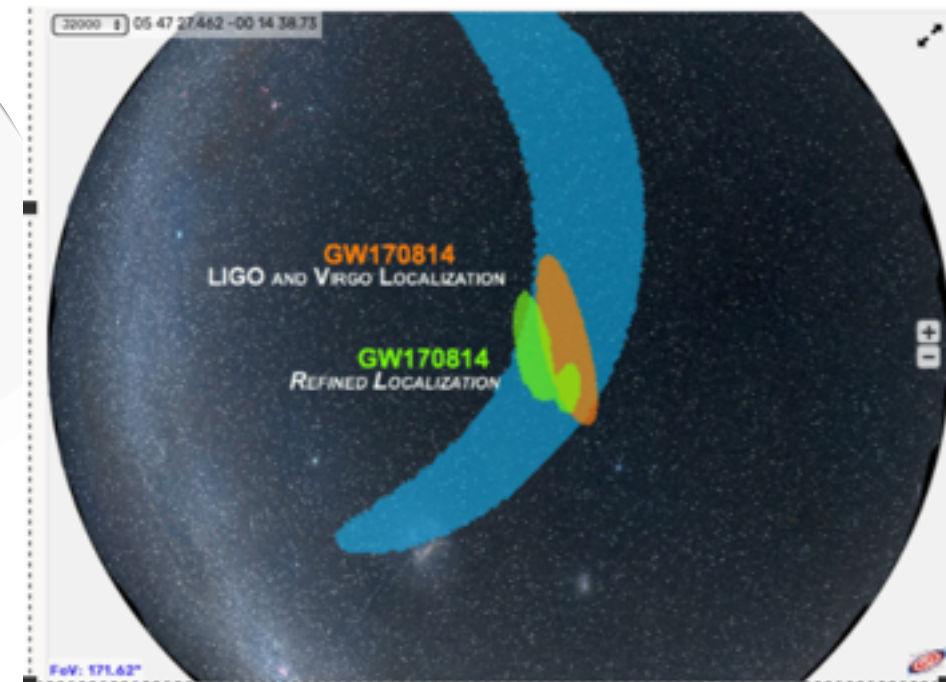
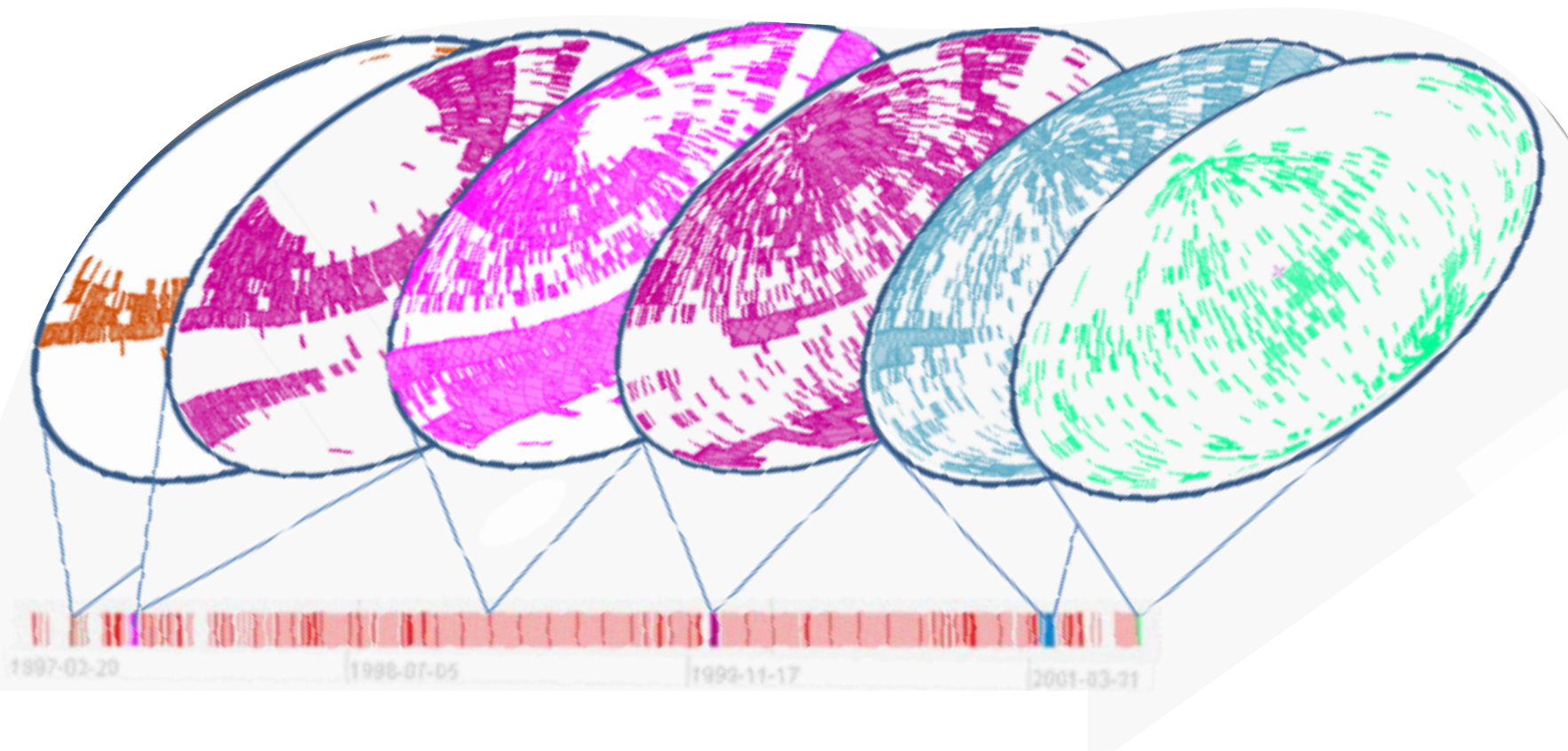
- A hierarchical scheme for the description, storage and access of sky survey data (the more you zoom-in the more the details)





# □ 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





# Coordination of observations

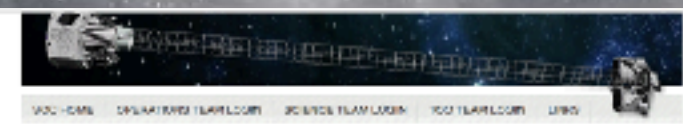
### Integral Target and Scheduling Information

Schedule: **All executed** **Current revolution 1872** **Future schedule** Revolution 1872 to 1872 **Show...** show plot

## Schedule for revolution 1872

(this list is also available in csv-format, click [here](#) to download)

Rev	Start time (UTC)	End time (UTC)	Exp. time (s)	Target	Ra (J2000)	Dec (J2000)	Pattern	PI	Propo
1872	2017-10-10 10:29:15	2017-10-10 17:10:51	12690	Gal. Bulge region	17:45:06.00	-26:56:00.0	LICK	Erik Saulkers	142001
1872	2017-10-10 17:13:34	2017-10-11 07:55:58	50080	Galactic Center	17:52:11.21	-25:21:49.7	5x5_Seq	Joem Wilms	142002
1872	2017-10-11 08:16:48	2017-10-11 11:58:32	12690	Galaxy (l=0, b=0)	17:42:23.76	-29:38:02.4	HEX	Rashid Sunyaev	142003
1872	2017-10-11 12:26:36	2017-10-11 12:56:36	1890	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	HEX	Rashid Sunyaev	142004
1872	2017-10-11 13:27:21	2017-10-11 14:29:17	3690	Galaxy (l=0, b=30)	19:59:40.90	-41:05:16.8	LICK	Rashid Sunyaev	142005
1872	2017-10-11 15:00:12	2017-10-11 17:38:07	9080	Galaxy (l=0, b=30)	19:59:40.80	-41:05:16.8	HEX	Rashid Sunyaev	142006
1872	2017-10-11 18:41:00	2017-10-12 08:01:56	45060	GRS 1915+105	19:15:11.79	+10:56:45.7	5x5_Seq	Jerome Rodriguez	142007
1872	2017-10-12 08:01:56	2017-10-12 13:47:54	12690	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	HEX	Rashid Sunyaev	142008
1872	2017-10-12 13:47:54	2017-10-12 18:47:54	12690	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	LICK	Rashid Sunyaev	142009



### Observing schedules

Short Range Observatory Schedule [update]

This is the intended schedule of XMM observations. This schedule of observations has been generated in the observatory and will execute automatically unless interrupted by a team action. Targets of observations, or instrument and seasonal constraints. This schedule will cover narrow time ranges depending on the exposure time goal of the observations, but will usually be for a series of at least one week.

The XMM-Newton mission has the capability to observe a wide range of astronomical objects. It is designed to observe X-ray sources in the 0.3-10 keV energy range. The XMM-Newton mission is designed to observe X-ray sources in the 0.3-10 keV energy range. The XMM-Newton mission is designed to observe X-ray sources in the 0.3-10 keV energy range.

ObsID	Start	End	Target	Ra	Dec	PI	Propo
20171010100000	2017-10-10 10:29:15	2017-10-10 17:10:51	Galaxy	17:45:06.00	-26:56:00.0	Erik Saulkers	142001
20171010170000	2017-10-10 17:13:34	2017-10-11 07:55:58	Galactic Center	17:52:11.21	-25:21:49.7	Joem Wilms	142002
20171011080000	2017-10-11 08:16:48	2017-10-11 11:58:32	Galaxy (l=0, b=0)	17:42:23.76	-29:38:02.4	Rashid Sunyaev	142003
20171011120000	2017-10-11 12:26:36	2017-10-11 12:56:36	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	Rashid Sunyaev	142004
20171011130000	2017-10-11 13:27:21	2017-10-11 14:29:17	Galaxy (l=0, b=30)	19:59:40.90	-41:05:16.8	Rashid Sunyaev	142005
20171011150000	2017-10-11 15:00:12	2017-10-11 17:38:07	Galaxy (l=0, b=30)	19:59:40.80	-41:05:16.8	Rashid Sunyaev	142006
20171011180000	2017-10-11 18:41:00	2017-10-12 08:01:56	GRS 1915+105	19:15:11.79	+10:56:45.7	Jerome Rodriguez	142007
20171012080000	2017-10-12 08:01:56	2017-10-12 13:47:54	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	Rashid Sunyaev	142008
20171012130000	2017-10-12 13:47:54	2017-10-12 18:47:54	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	Rashid Sunyaev	142009

### Long Range Observatory Schedule [update]

This is the intended schedule of XMM observations. This schedule of observations has been generated in the observatory and will execute automatically unless interrupted by a team action. Targets of observations, or instrument and seasonal constraints. This schedule will cover narrow time ranges depending on the exposure time goal of the observations, but will usually be for a series of at least one week.

The XMM-Newton mission has the capability to observe a wide range of astronomical objects. It is designed to observe X-ray sources in the 0.3-10 keV energy range. The XMM-Newton mission is designed to observe X-ray sources in the 0.3-10 keV energy range. The XMM-Newton mission is designed to observe X-ray sources in the 0.3-10 keV energy range.

ObsID	Start	End	Target	Ra	Dec	PI	Propo
20171010100000	2017-10-10 10:29:15	2017-10-10 17:10:51	Galaxy	17:45:06.00	-26:56:00.0	Erik Saulkers	142001
20171010170000	2017-10-10 17:13:34	2017-10-11 07:55:58	Galactic Center	17:52:11.21	-25:21:49.7	Joem Wilms	142002
20171011080000	2017-10-11 08:16:48	2017-10-11 11:58:32	Galaxy (l=0, b=0)	17:42:23.76	-29:38:02.4	Rashid Sunyaev	142003
20171011120000	2017-10-11 12:26:36	2017-10-11 12:56:36	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	Rashid Sunyaev	142004
20171011130000	2017-10-11 13:27:21	2017-10-11 14:29:17	Galaxy (l=0, b=30)	19:59:40.90	-41:05:16.8	Rashid Sunyaev	142005
20171011150000	2017-10-11 15:00:12	2017-10-11 17:38:07	Galaxy (l=0, b=30)	19:59:40.80	-41:05:16.8	Rashid Sunyaev	142006
20171011180000	2017-10-11 18:41:00	2017-10-12 08:01:56	GRS 1915+105	19:15:11.79	+10:56:45.7	Jerome Rodriguez	142007
20171012080000	2017-10-12 08:01:56	2017-10-12 13:47:54	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	Rashid Sunyaev	142008
20171012130000	2017-10-12 13:47:54	2017-10-12 18:47:54	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	Rashid Sunyaev	142009

2017-10-10 10:29:15 --- Preliminary XMM Observing Timeline Report for ObsID: 1420001 --- Page 1  
ObsID: 142001, 2017-10-10 10:29:15 (15-00-2017 22:11:03), Mode: 2017-10-10 10:29:15 (15-00-2017 02:13:00)

Scheduling Unit	Begin UT	End UT	Sci Id	Principal Investigator	Exp #	Target	Instrument	Aperture	Exposure	Time (s)	Obs ID
2017-1010100000	2017-10-10 10:29:15	2017-10-10 17:10:51	142001	Erik Saulkers	1	Galaxy	EPIC	1200	12690	10:29:15	142001
2017-1010170000	2017-10-10 17:13:34	2017-10-11 07:55:58	142002	Joem Wilms	1	Galactic Center	EPIC	1200	50080	17:13:34	142002
2017-1011080000	2017-10-11 08:16:48	2017-10-11 11:58:32	142003	Rashid Sunyaev	1	Galaxy (l=0, b=0)	EPIC	1200	12690	08:16:48	142003
2017-1011120000	2017-10-11 12:26:36	2017-10-11 12:56:36	142004	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	1890	12:26:36	142004
2017-1011130000	2017-10-11 13:27:21	2017-10-11 14:29:17	142005	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	3690	13:27:21	142005
2017-1011150000	2017-10-11 15:00:12	2017-10-11 17:38:07	142006	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	9080	15:00:12	142006
2017-1011180000	2017-10-11 18:41:00	2017-10-12 08:01:56	142007	Jerome Rodriguez	1	GRS 1915+105	EPIC	1200	45060	18:41:00	142007
2017-1012080000	2017-10-12 08:01:56	2017-10-12 13:47:54	142008	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	12690	08:01:56	142008
2017-1012130000	2017-10-12 13:47:54	2017-10-12 18:47:54	142009	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	12690	13:47:54	142009

2017-10-10 10:29:15 --- Preliminary XMM Observing Timeline Report for ObsID: 1420001 --- Page 2  
ObsID: 142001, 2017-10-10 10:29:15 (15-00-2017 22:11:03), Mode: 2017-10-10 10:29:15 (15-00-2017 02:13:00)

Scheduling Unit	Begin UT	End UT	Sci Id	Principal Investigator	Exp #	Target	Instrument	Aperture	Exposure	Time (s)	Obs ID
2017-1010100000	2017-10-10 10:29:15	2017-10-10 17:10:51	142001	Erik Saulkers	1	Galaxy	EPIC	1200	12690	10:29:15	142001
2017-1010170000	2017-10-10 17:13:34	2017-10-11 07:55:58	142002	Joem Wilms	1	Galactic Center	EPIC	1200	50080	17:13:34	142002
2017-1011080000	2017-10-11 08:16:48	2017-10-11 11:58:32	142003	Rashid Sunyaev	1	Galaxy (l=0, b=0)	EPIC	1200	12690	08:16:48	142003
2017-1011120000	2017-10-11 12:26:36	2017-10-11 12:56:36	142004	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	1890	12:26:36	142004
2017-1011130000	2017-10-11 13:27:21	2017-10-11 14:29:17	142005	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	3690	13:27:21	142005
2017-1011150000	2017-10-11 15:00:12	2017-10-11 17:38:07	142006	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	9080	15:00:12	142006
2017-1011180000	2017-10-11 18:41:00	2017-10-12 08:01:56	142007	Jerome Rodriguez	1	GRS 1915+105	EPIC	1200	45060	18:41:00	142007
2017-1012080000	2017-10-12 08:01:56	2017-10-12 13:47:54	142008	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	12690	08:01:56	142008
2017-1012130000	2017-10-12 13:47:54	2017-10-12 18:47:54	142009	Rashid Sunyaev	1	Galaxy (l=0, b=30)	EPIC	1200	12690	13:47:54	142009

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

# □ 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



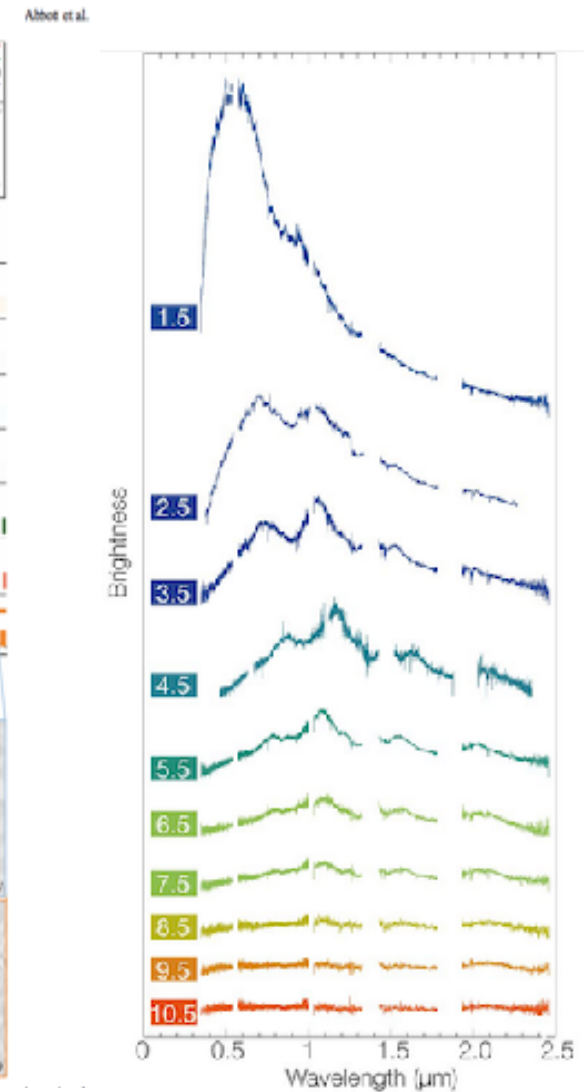
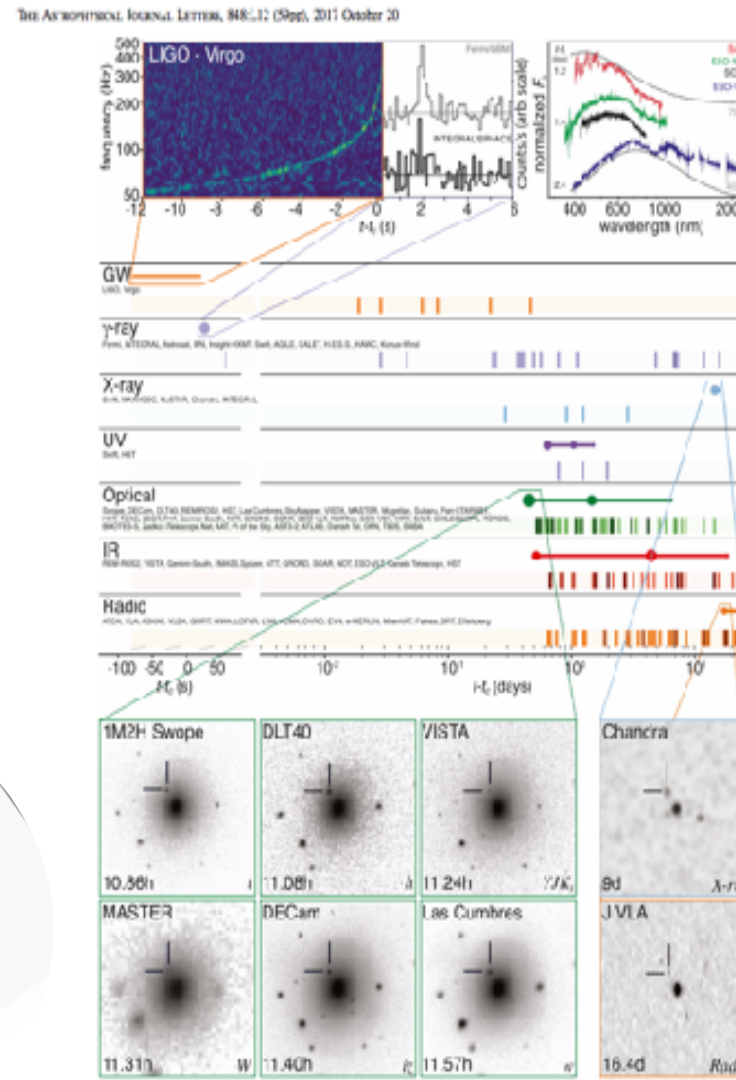
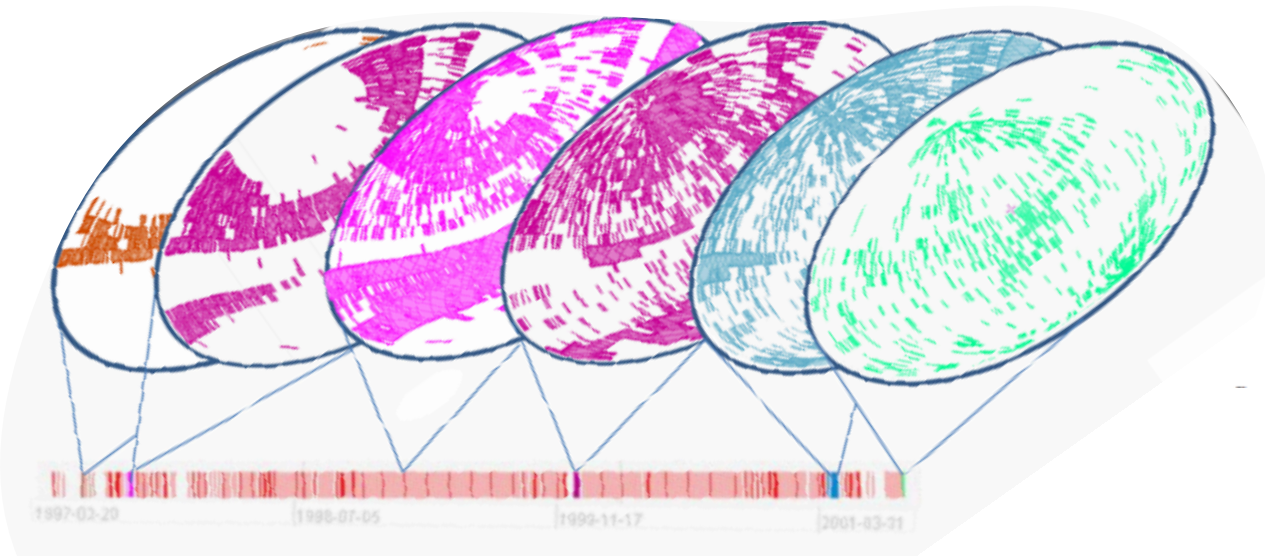
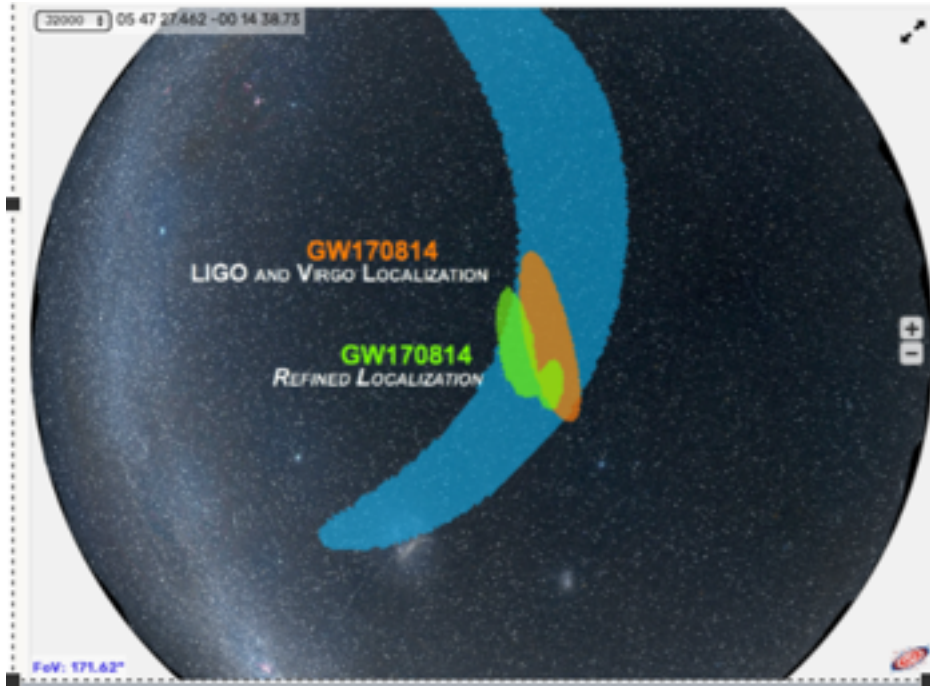
# □ Register your services

- 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
Ada Nebot	Summary of the Project Survey + Intro to the panel	10 + 2
Dongwei Fan	LAMOST and the China Virtual Observatory	10 + 2
Tamara Civera	Observatorio de Javalambre in Spain	10 + 2
Alberto Micol	European Southern Observatory	10 + 2
Yan Grange	ASTRON - Netherlands Institute for Radio Astronomy	10 + 2
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/IVOOArchitecture/20211101/index.html>