

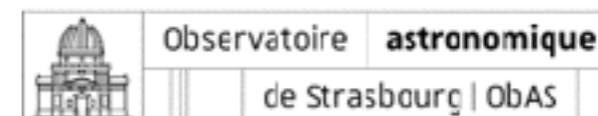


Intro to the IVOA

Interop meeting 25-29 April 2022

Ada Nebot

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□ The VO and the IVOA: what?

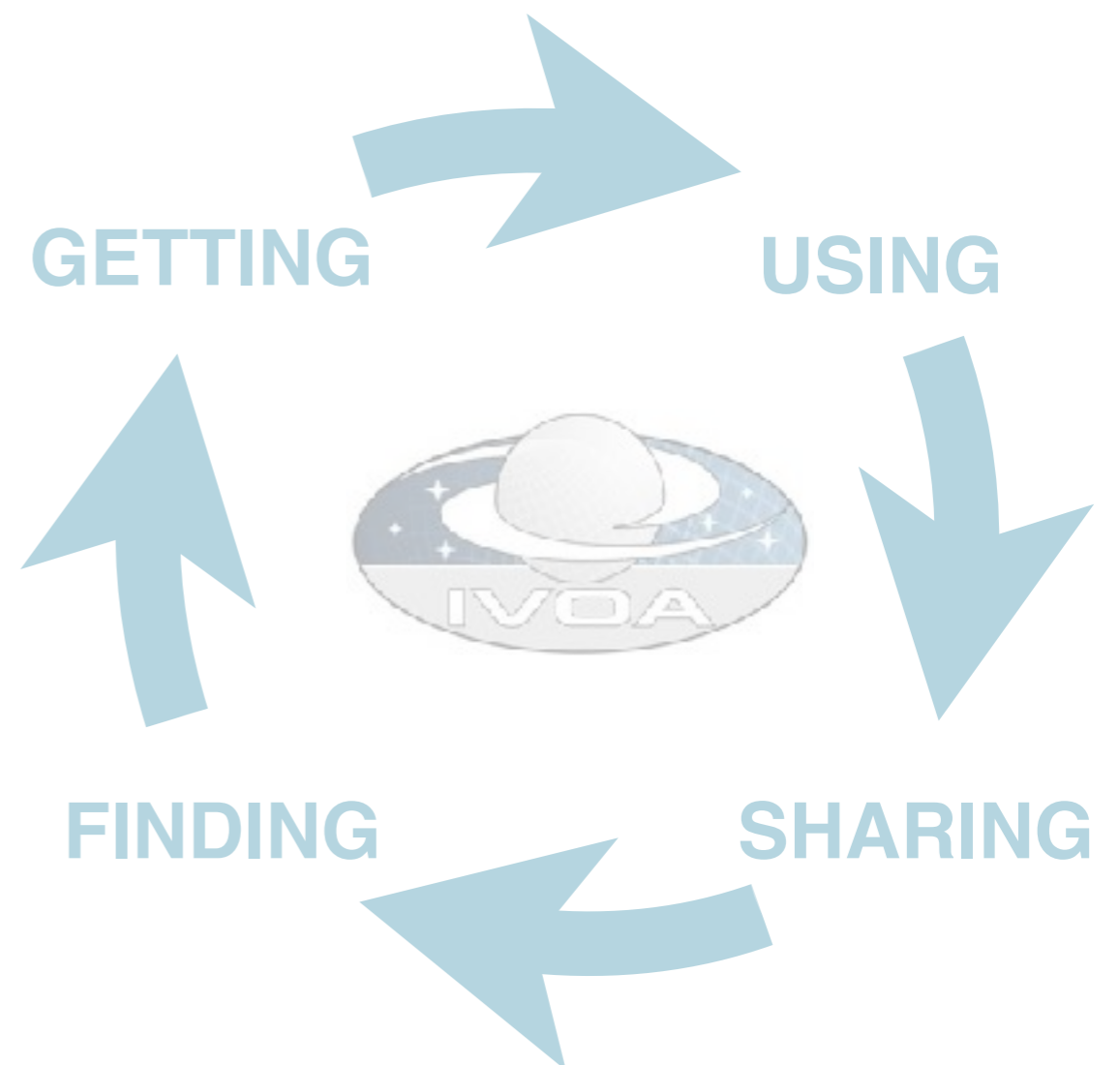
“A multi-wavelength digital sky that can be searched, visualised and analysed in new and innovative ways” P. Fabianno

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?

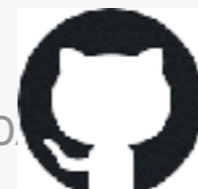
Who is the IVOA?

<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)



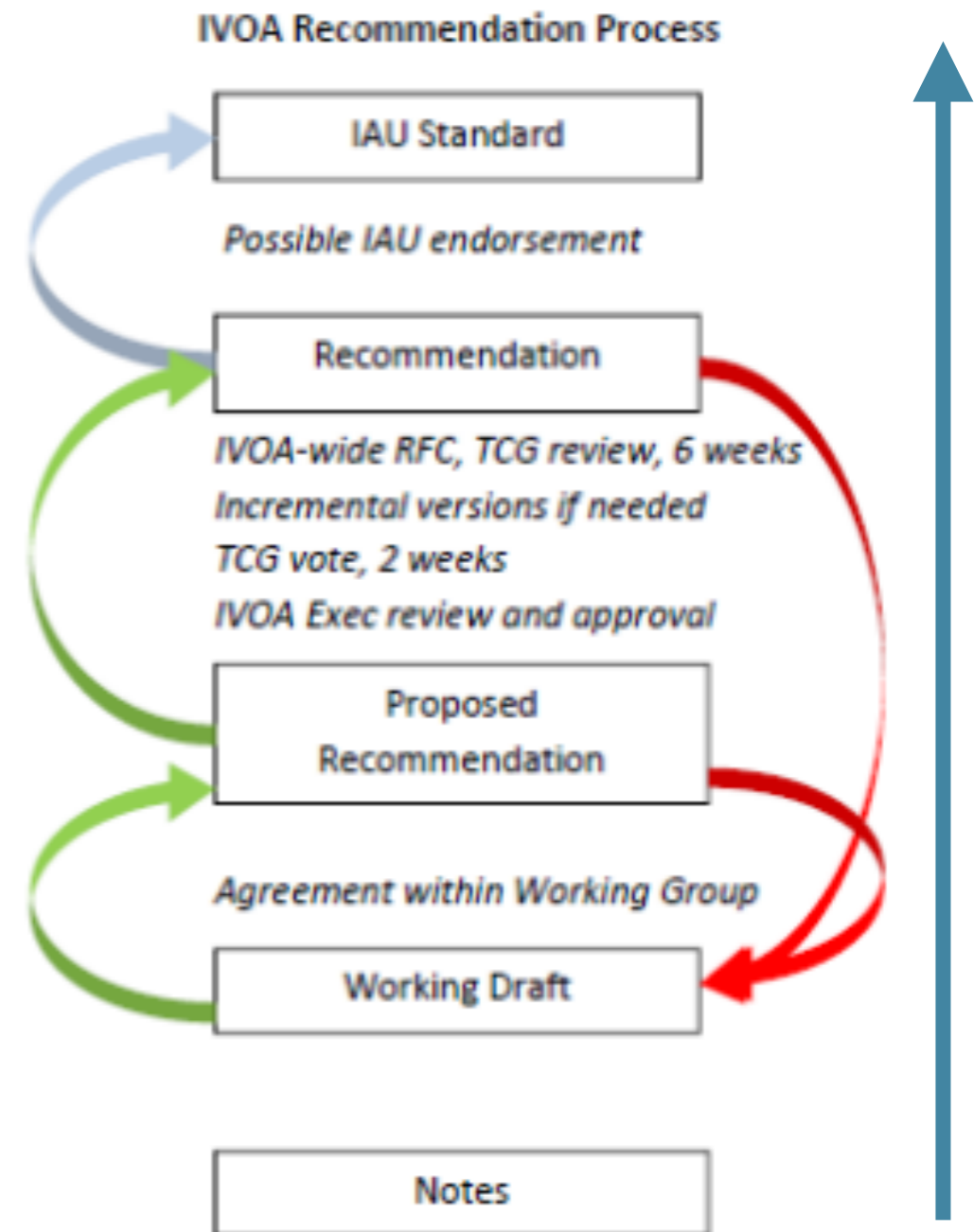
□ The VO and the IVOA: how?

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)

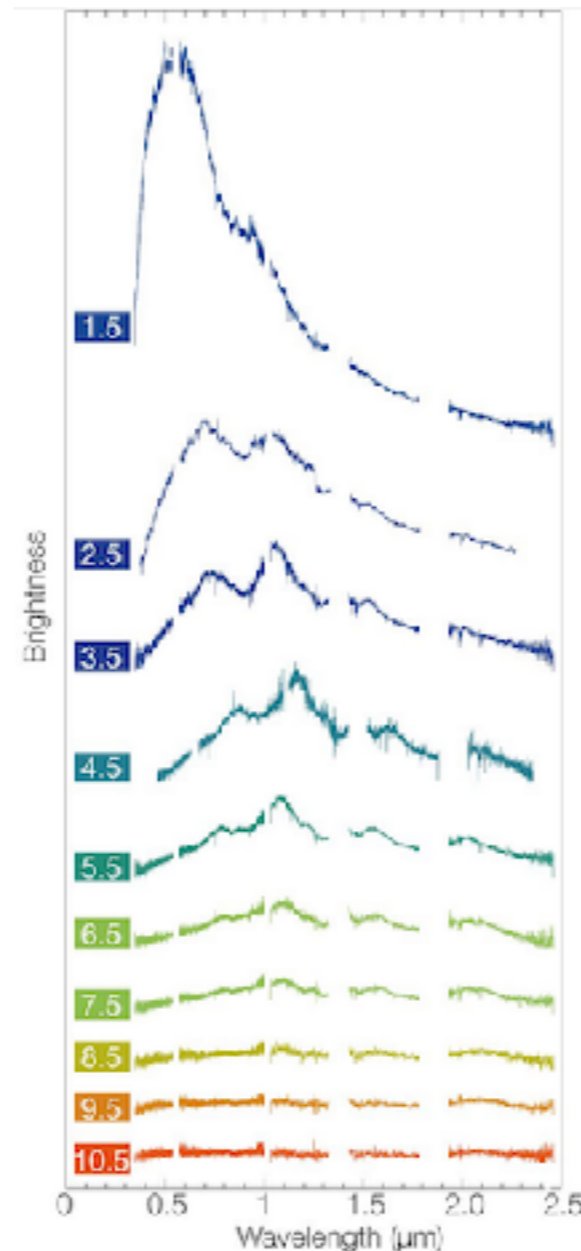
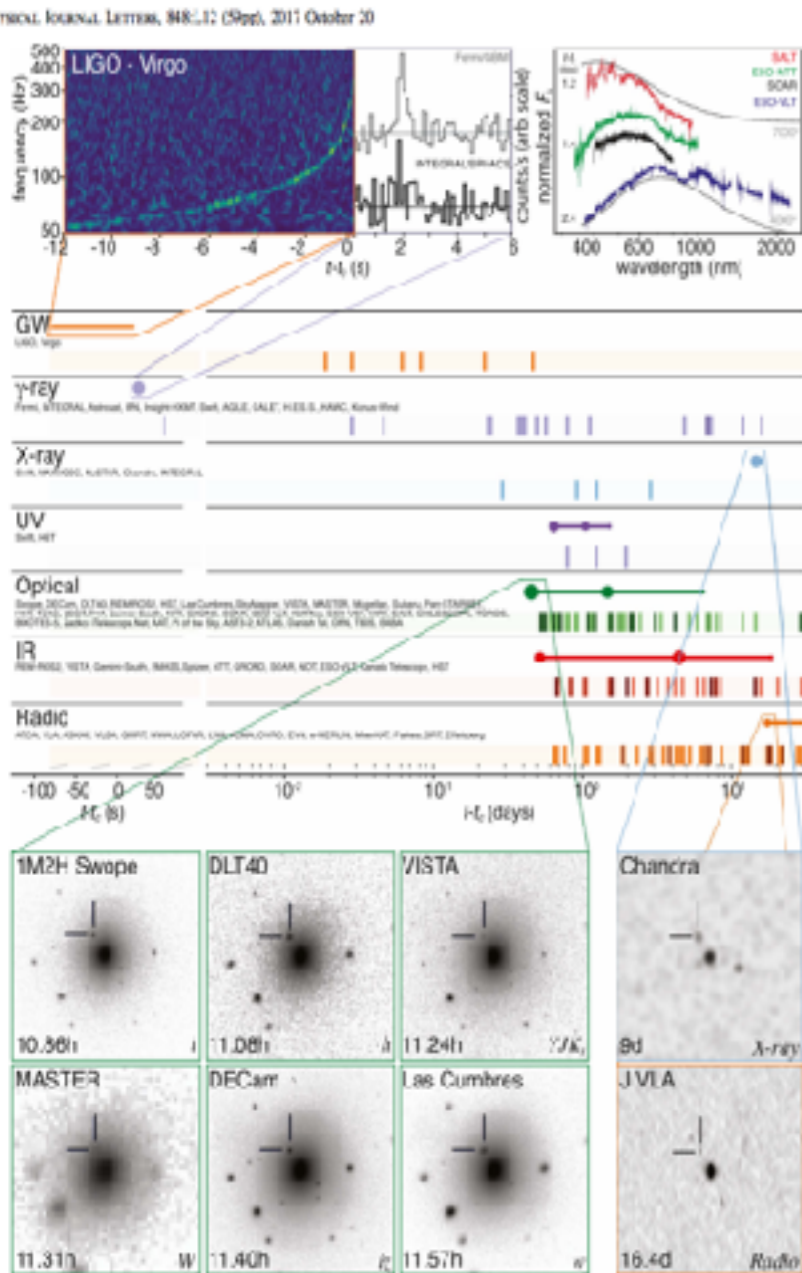
<https://www.ivoa.net/documents/IVOAArchitecture/20211101/index.html>

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, ..., 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⁻²)
- **Datalink**: links to other associated data

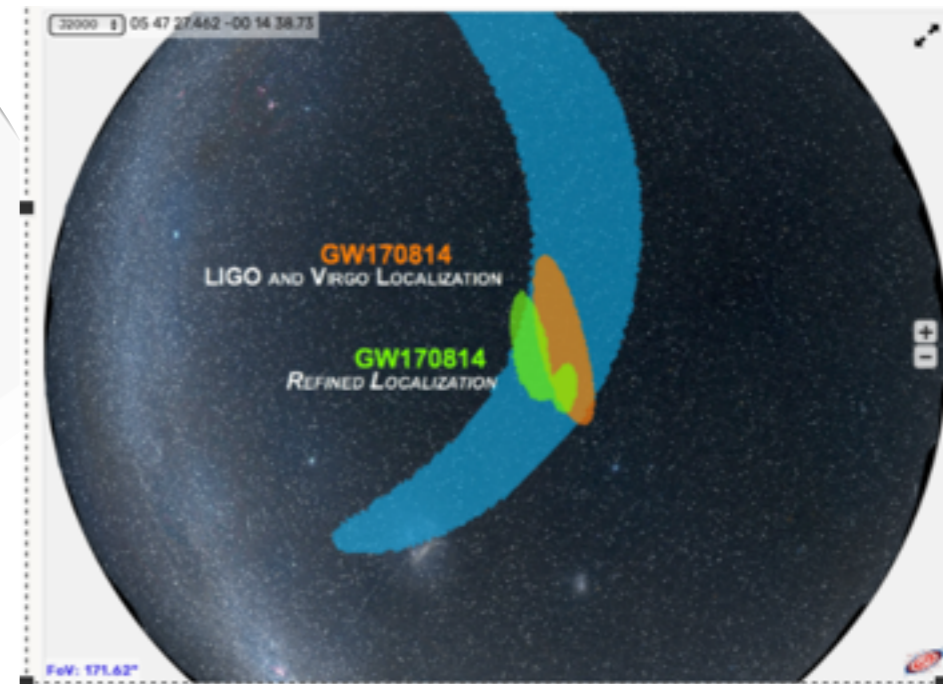
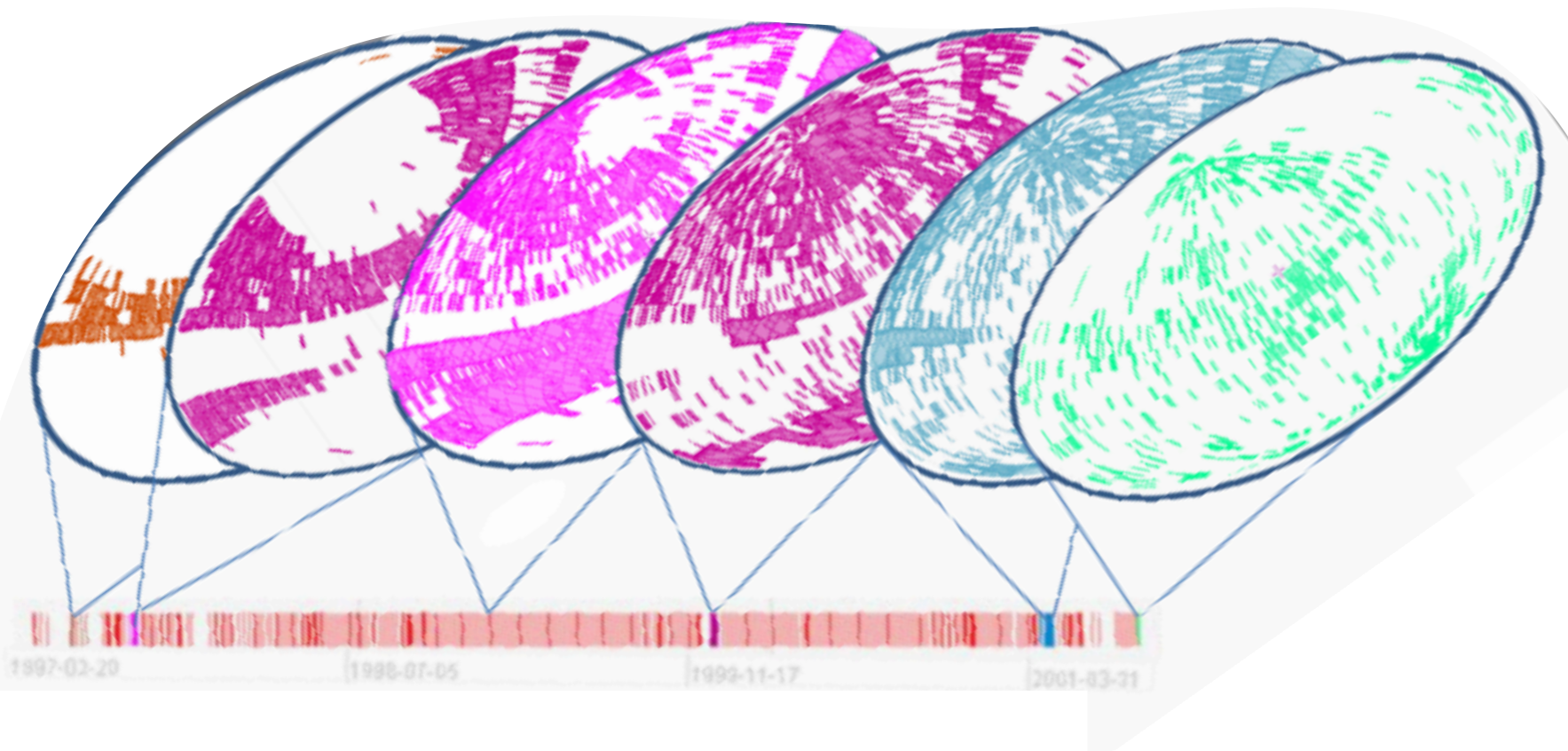
□ HiPS: Hierarchical image Progressive Survey

- 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

ESO - European Southern Observatory

Object Observability

See also [Object Observability - Airmass](#) - [Dark Sky](#) - [Extranet](#)

Observability for 05 23 34.5 -69 45 22

Paranal Observatory (VLT)

RA & Dec: 5 23 34.5, -69 45 22, epoch 2000.0
Site Longitude: -4 45 35.6 [hours] North, -24 37 39 North

Shows local rise, delay, moon pl (2) natural center of night, or nighttime hours during which of night (and twilight) is defined

The ESO Sky Calendar Tool

Date (eve)	rise	set	moon	night hr:min:sec:z
2017 Nov 3 F	-6:52 3.1	-2:45 3.6	+1:22 3.3	2.0 5.0 3.3
2017 Nov 17 M	-5:44 2.4	-3:49 3.5	+2:07 3.5	2.3 5.7 3.0

XMM-NEWTON MULTI-TARGET VISIBILITY CHECKER

YOU CAN LOOKUP SIMBAD OR NED AGAIN, OR RUN THE VISIBILITY CHECKER USING

TargetName: [M3] (eg: M31)

Simbad Lookup NED Lookup

Please note that it is a 30 second delay for SIMBAD or NED retrieval.

SIMBAD LOOKUP RESULTS:

Target Details:

largename: [M3] (eg: M31) (eg: M31)

RA: 00:42:44.330 (L21m 00sec 21mm 33.0 (eg: 12:30:12.3))

Dec: +41:16:07.00 (Declination 20 MM 07.0 (eg: -11:00:27.0))

Visibility Details:

Select filter: [None]

Resolution Range: [First Resolution: 3300] (default is 60/7 resolution range: 3300 to 3500)

or

Resolution Range: [None]

From Date: [11 May 2018] (default is 10/17 range: 01 May 2018 - 31 Sep 2018)

To Date: [30 Apr 2019]

Minimum Visibility: [0.33] (minimum time the star must be visible. Default is 0.00)

[Kahla]

OPTIONAL TARGET TABLE

Target Name	RA	Dec
M31	00:42:44.330	+41:16:07.00

ISAAC NEWTON GROUP OF TELESCOPES

Object Visibility - STARALT

StarAlt is a program that shows the observability of objects in various ways: either you can plot altitude against time for a particular night (StarAlt), or plot the path of your objects across the sky for a particular night (StarTrack), or plot how altitude changes over a year (StarObs), or get a table with the best observing dates for each object (StarObs). For further information, click on the "Help" button at the bottom of the page.

Mode: [StarAlt]

Night: [12] [October] [2017] or date when the local night starts. StarAlt/StarTrack only.

Observatory: [La Silla Observatory (Chile)]

Coordinates: [05:23:34.5] [-69:45:22]

Graph showing Altitude vs. Mean Solar Time (starting night 12 10 2017)

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	17:45:36.00	-26:56:30.0	LICK	Erik Saulkers	142001
1872	2017-10-10 17:13:34	2017-10-11 07:55:58	30090	Galactic Center	17:52:11.21	-25:21:49.7	5x5_Seq	Joem Wilms	142002
1872	2017-10-11 08:16:46	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	3090	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	9090	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	45090	GRS 1915+105	19:15:11.79	+10:56:45.7	5x5_Seq	Jerome Rodriguez	142007
1872	2017-10-12 09:00:19	2017-10-12 13:43:54	12690	Galaxy (l=0, b=0)	17:42:23.76	-29:38:02.4	HEX	Rashid Sunyaev	142008
1872	2017-10-12 13:46:19	2017-10-12 14:17:54	1890	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	LICK	Rashid Sunyaev	142009

Observing schedules

Short Range Observatory Schedule

This is the intended schedule of XMM-Newton observations. This schedule of observations has been generated in the observatory and will contain adjustments unless indicated by a team scientist. Target of opportunity, or instrument and seasonal constraints. This schedule will cover narrow time ranges depending on the exposure time goal of the observations, but will usually last for a series of at least one week.

The XMM-Newton team will be happy to accept requests for observations, but will usually only accept requests for observations that are consistent with the current schedule. The XMM-Newton team will accept requests for observations that are consistent with the current schedule, but will usually only accept requests for observations that are consistent with the current schedule.

ObsID	Start	End	Target	RA	DEC	PI	Propo
001181	2017-10-10 10:29:15	2017-10-10 17:10:51	Galaxy	17:45:36.00	-26:56:30.0	LICK	Erik Saulkers
001182	2017-10-10 17:13:34	2017-10-11 07:55:58	Galactic Center	17:52:11.21	-25:21:49.7	5x5_Seq	Joem Wilms
001183	2017-10-11 08:16:46	2017-10-11 11:58:32	Galaxy (l=0, b=0)	17:42:23.76	-29:38:02.4	HEX	Rashid Sunyaev
001184	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	HEX	Rashid Sunyaev
001185	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	LICK	Rashid Sunyaev
001186	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	HEX	Rashid Sunyaev
001187	2017-10-11 18:41:00	2017-10-12 08:01:56	GRS 1915+105	19:15:11.79	+10:56:45.7	5x5_Seq	Jerome Rodriguez
001188	2017-10-12 09:00:19	2017-10-12 13:43:54	Galaxy (l=0, b=0)	17:42:23.76	-29:38:02.4	HEX	Rashid Sunyaev
001189	2017-10-12 13:46:19	2017-10-12 14:17:54	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	LICK	Rashid Sunyaev

Observing schedules

Long Range Observatory Schedule

This is the intended schedule of XMM-Newton observations. This schedule of observations has been generated in the observatory and will contain adjustments unless indicated by a team scientist. Target of opportunity, or instrument and seasonal constraints. This schedule will cover narrow time ranges depending on the exposure time goal of the observations, but will usually last for a series of at least one week.

The XMM-Newton team will be happy to accept requests for observations, but will usually only accept requests for observations that are consistent with the current schedule. The XMM-Newton team will accept requests for observations that are consistent with the current schedule, but will usually only accept requests for observations that are consistent with the current schedule.

Scheduling Unit	Begin UT	End UT	RA	DEC	Principal Investigator	Target	Instrument	Aperture	Exposure	PI	Propo
2017-289	2017-10-10 10:29:15	2017-10-10 17:10:51	17:45:36	-26:56:30	Lockwood	Galaxy	EPIC	50	12690	Erik Saulkers	142001
2017-290	2017-10-10 17:13:34	2017-10-11 07:55:58	17:52:11	-25:21:49	Lockwood	Galactic Center	EPIC	50	30090	Joem Wilms	142002
2017-291	2017-10-11 08:16:46	2017-10-11 11:58:32	17:42:23	-29:38:02	Lockwood	Galaxy (l=0, b=0)	EPIC	50	12690	Rashid Sunyaev	142003
2017-292	2017-10-11 12:26:36	2017-10-11 12:56:36	20:02:16	-41:20:31	Lockwood	Galaxy (l=0, b=30)	EPIC	50	1890	Rashid Sunyaev	142004
2017-293	2017-10-11 13:27:21	2017-10-11 14:29:17	19:59:40	-41:05:16	Lockwood	Galaxy (l=0, b=30)	EPIC	50	3090	Rashid Sunyaev	142005
2017-294	2017-10-11 15:00:12	2017-10-11 17:38:07	19:59:40	-41:05:16	Lockwood	Galaxy (l=0, b=30)	EPIC	50	9090	Rashid Sunyaev	142006
2017-295	2017-10-11 18:41:00	2017-10-12 08:01:56	19:15:11	+10:56:45	Lockwood	GRS 1915+105	EPIC	50	45090	Jerome Rodriguez	142007
2017-296	2017-10-12 09:00:19	2017-10-12 13:43:54	17:42:23	-29:38:02	Lockwood	Galaxy (l=0, b=0)	EPIC	50	12690	Rashid Sunyaev	142008
2017-297	2017-10-12 13:46:19	2017-10-12 14:17:54	20:02:16	-41:20:31	Lockwood	Galaxy (l=0, b=30)	EPIC	50	1890	Rashid Sunyaev	142009

XMM-Newton Short-Term Schedule

The Short-Term Schedule gives an overview of scheduled observations covering the time range from the past week until the upcoming 24 weeks.

Background: The planning and scheduling procedure is described in Sec. 3.2 of the *Policy and Procedures*. In addition, the process of scheduling XMM-Newton observations is described in a *Guided tour to the scheduling user interface*.

Details: Each row lists the observation ID (ObsID), observation start time (UTC), target name, pointing coordinates (right ascension (RA) and declination (DEC)), instrument, prime instrument, accumulated exposure times (in kiloseconds) in kiloseconds for each instrument (without overhead), and name of the Principal Investigator (PI). The start and stop times refer to the instrument activities required to perform the observation. The exposure times are accumulated over all exposures taken with the same instrument. Especially for UV, the observation can be split in multiple exposures with different instruments (SPI), exposure times in brackets indicate that one or all exposures use the color filter. Details can be seen when clicking on the ObsID.

The normalized flux indicates the target that is scheduled for the time of the last table update. The position data is given at the top of the table.

Targets: The scheduling of an XMM-Newton revolution may have to be revised (see Secs. 3.3, 3.4, and 3.5 of the *Policy and Procedures*). Getting a target of any type and solar flaring activity may impact at different levels the scheduled programme. The *Observation Log Browser* can be checked to see what was actually done.

Update frequency: Every 6 hours an updated table is updated (new revolution parameters are updated). The latest available version can be viewed after clicking the browser button for the contents of any previous sessions.

LAST UPDATE ON: 2017-10-11 12:42:33 UT (Current Rev = 1872)

Rev #	Obs ID	Target Name	RA	DEC	PI	UTC Obs Start	UTC Obs End	Prime Inst.	PI	NCSP	MOSS	EPIC	EPIC	EPIC	EPIC	EPIC	PI
1872	001181	ESCI018C006	08:24:27	-37:16:57	Lockwood	2017-10-10 10:29:15	2017-10-10 17:10:51	EPIC	Erik Saulkers	18.7	18.1	18.5	18.2	18.2	18.3	18.3	7800
1872	001182	118 81109	09:21:40	-00:34:17	Lockwood	2017-10-10 17:13:34	2017-10-11 07:55:58	EPIC	Joem Wilms	9.5	10.9	10.9	11.0	11.0	10.9	10.9	7800
1872	001183	zeta Puppi	09:02:40	-40:00:30	Lockwood	2017-10-11 08:16:46	2017-10-11 11:58:32	EPIC	Rashid Sunyaev	44.9	44.9	44.9	45.0	45.0	45.0	45.0	7800
1872	001184	0005	09:02:40	-40:00:30	Lockwood	2017-10-11 12:26:36	2017-10-11 12:56:36	EPIC	Rashid Sunyaev	35.6	36.0	36.3	37.0	37.0	36.8	36.8	7800
1872	001185	102 118 17 25 24 1	09:02:40	-40:00:30	Lockwood	2017-10-11 13:27:21	2017-10-11 14:29:17	EPIC	Rashid Sunyaev	11.3	12.8	12.8	13.0	13.0	12.8	12.8	7800
1872	001186	0005	09:02:40	-40:00:30	Lockwood	2017-10-11 15:00:12	2017-10-11 17:38:07	EPIC	Rashid Sunyaev	43.4	44.8	44.8	44.9	44.9	43.7	43.7	7800
1872	001187	0445-0953	09:02:40	-40:00:30	Lockwood	2017-10-11 18:41:00	2017-10-12 08:01:56	EPIC	Jerome Rodriguez	42.9	43.9	43.9	44.0	44.0	42.9	42.9	7800
1872	001188	0005	09:02:40	-40:00:30	Lockwood	2017-10-12 09:00:19	2017-10-12 13:43:54	EPIC	Rashid Sunyaev	38.0	33.4	37.4	33.8	37.1	37.3	37.3	7800

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

□ VOEvent: Sky Event Reporting Metadata

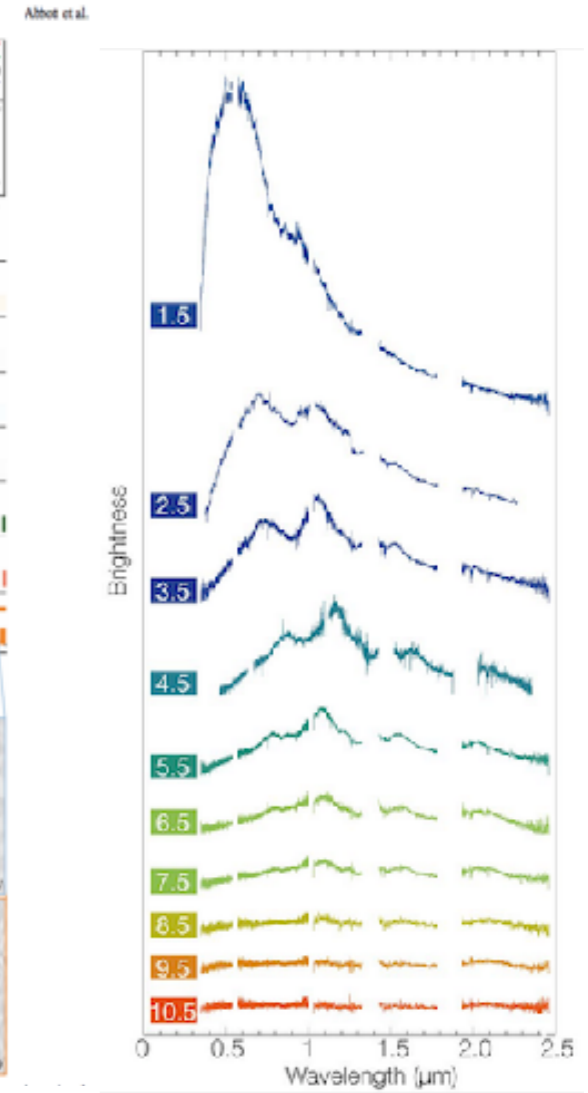
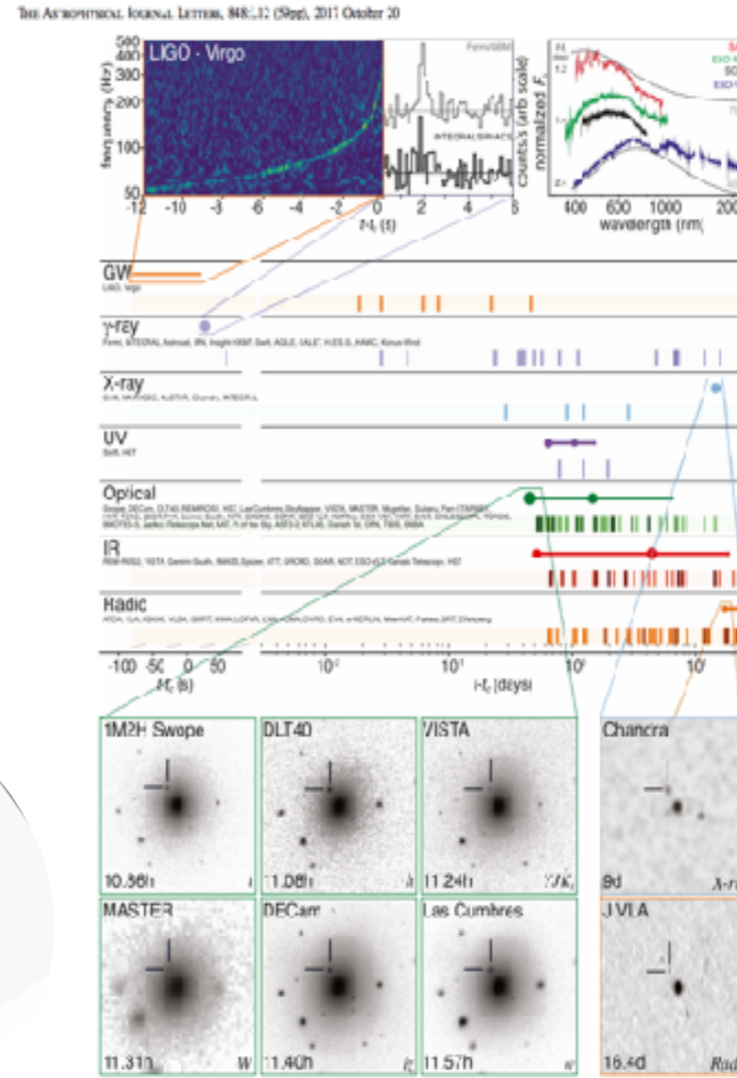
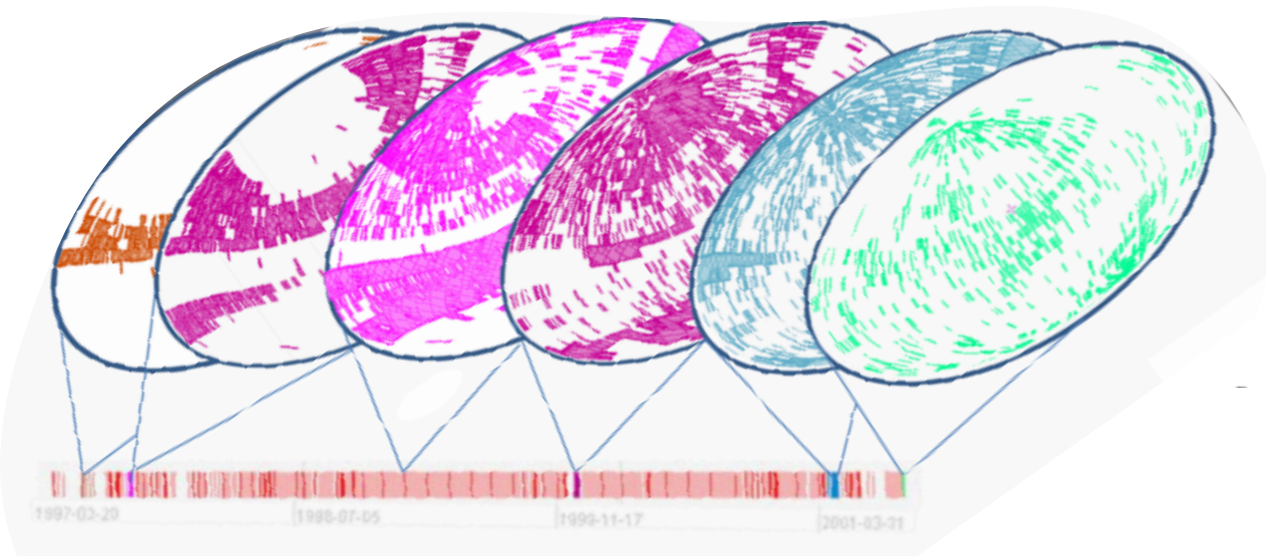
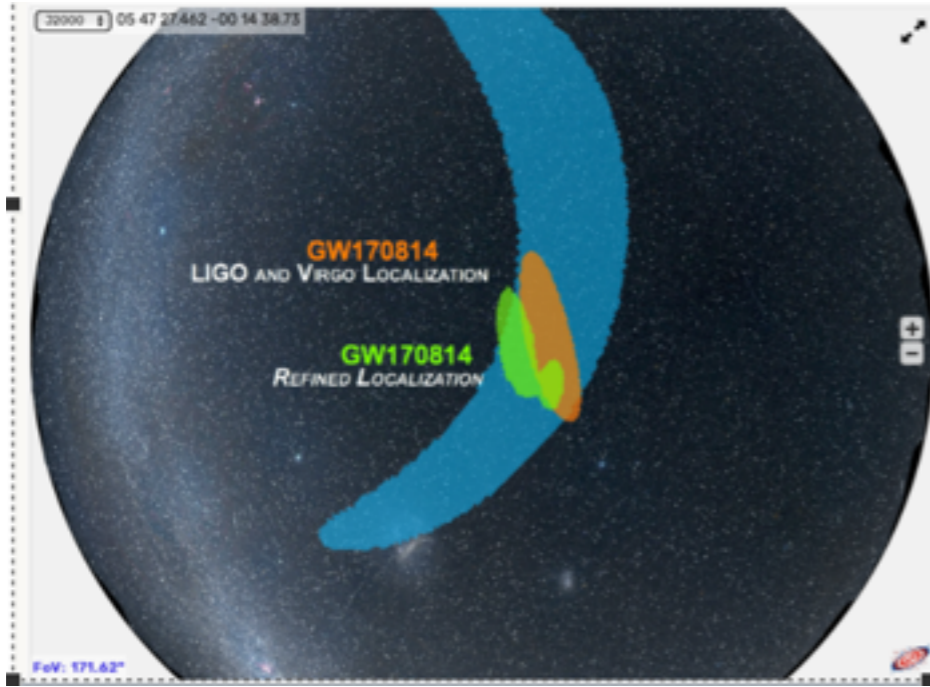
- “Defines the content and meaning of a standard information packet for representing, transmitting, publishing and archiving information about a transient celestial event, with the implication that timely follow-up is of interest”
 - **Who**: Identification of scientifically responsible Author
 - **What**: 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?

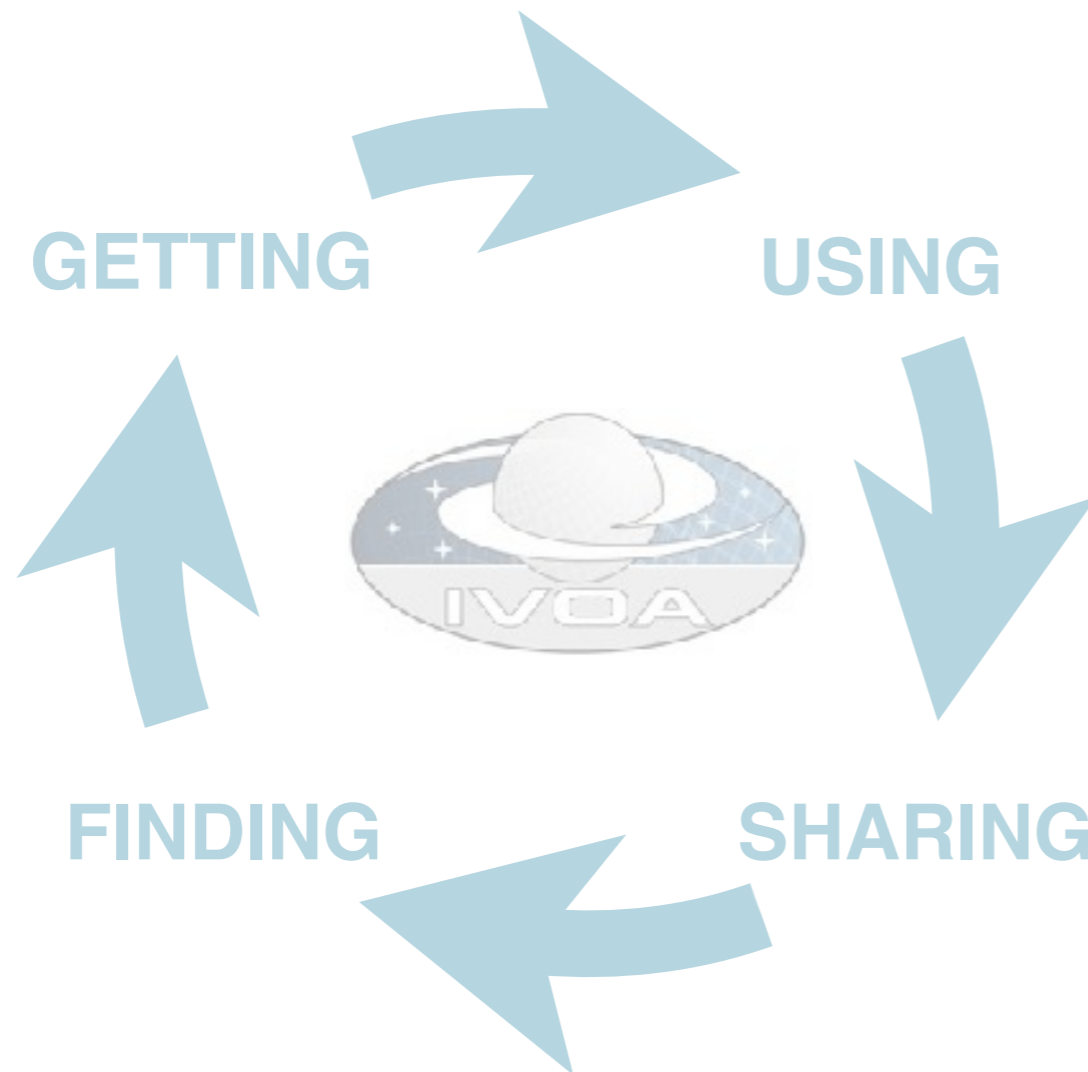
- Have a look here:
- <https://wiki.ivoa.net/twiki/bin/view/IVOA/PublishingInTheVO>
 - Check the Q&A section! (How do I publish images? spectra? catalogues or generic data tables?...)
- And come to the dedicated panel session

Tuesday April 26 - 15:00 UTC

Speaker	Title	Time	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/IVOOArchitecture/20211101/index.html>
- Slack: https://join.slack.com/t/ivoa/shared_invite/zt-17kd0v93b-b32~KReWd1T96gDyYFDLPQ