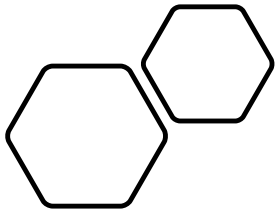
State of the IVOA:
Virtual IVOA Interoperability Meeting, November 2021.

https://www.ivoa.net/

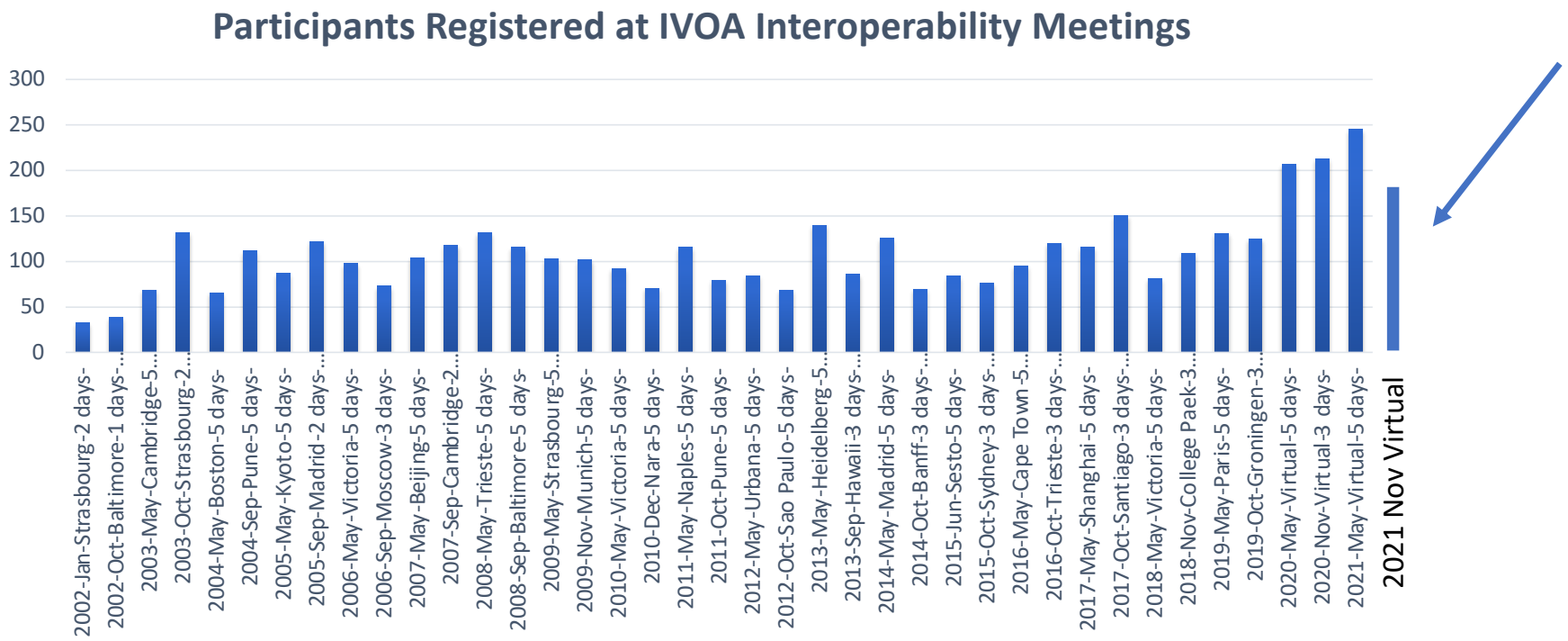


G. Bruce Berriman

Chair, IVOA Executive Committee

(Caltech/IPAC)

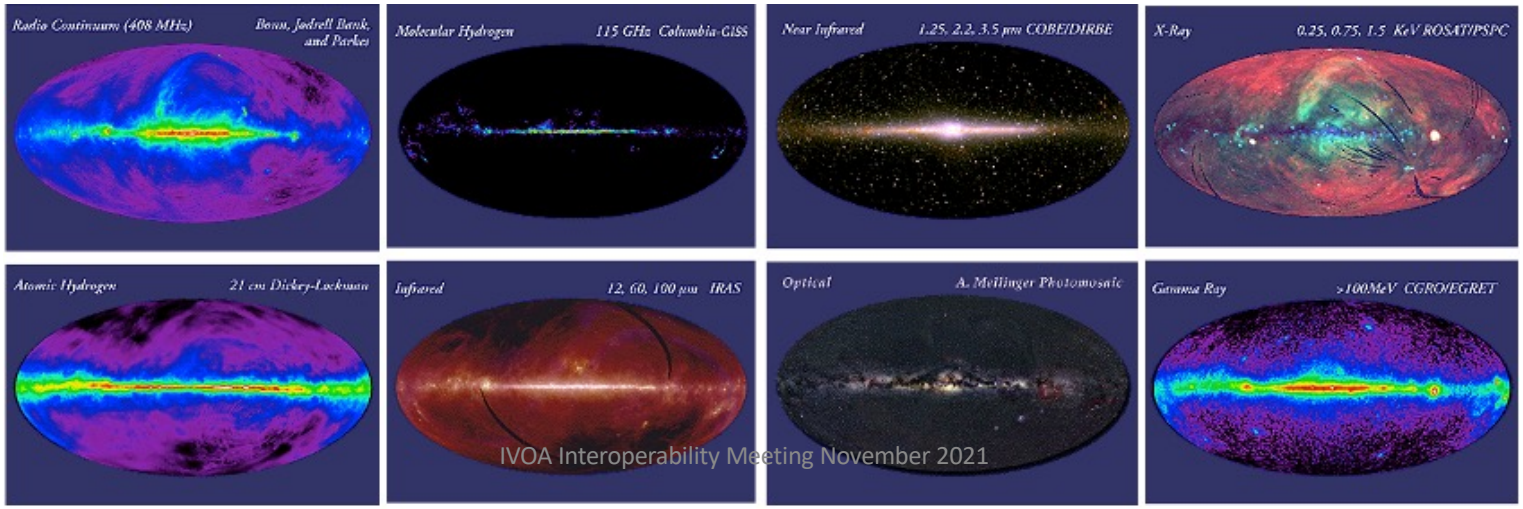
Participation – 171 registered



The Idea of the Virtual Observatory

“A multi-wavelength digital sky that can be searched, visualized, and analyzed in new and innovative ways.”

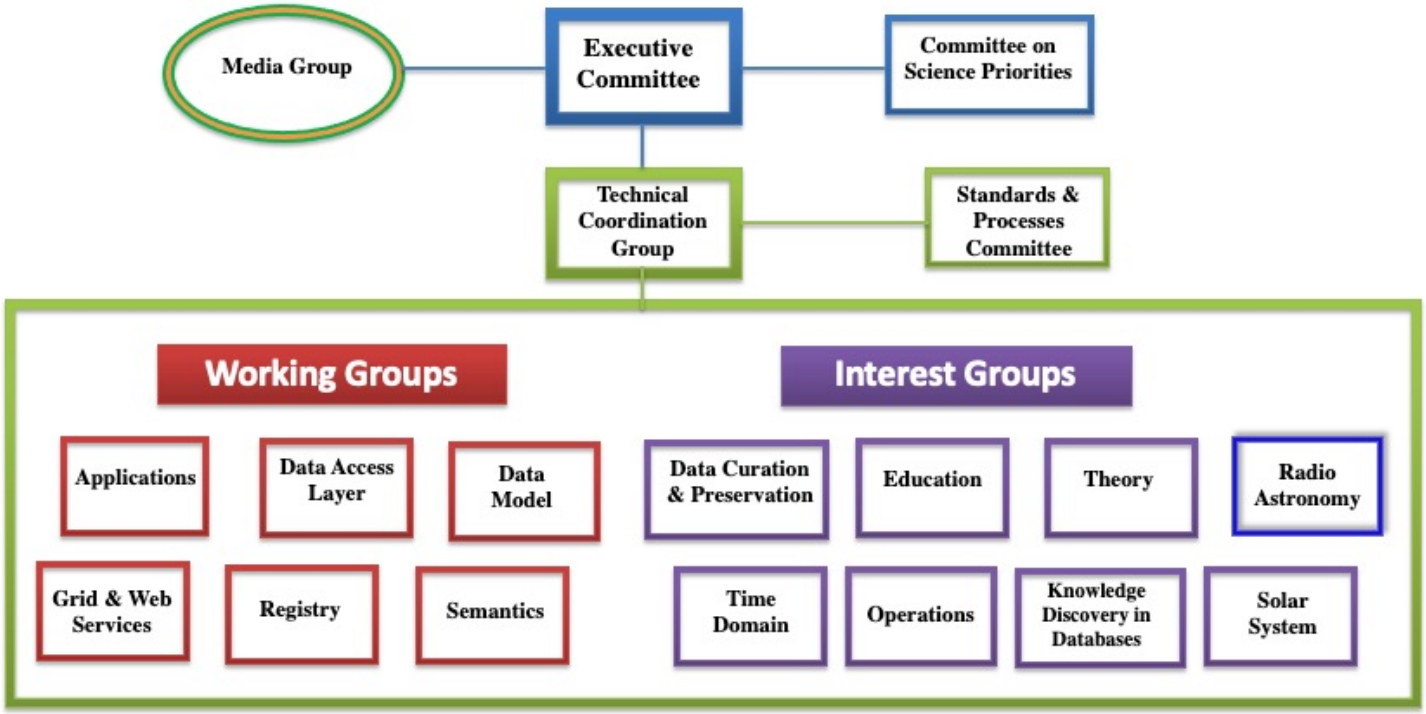
- The VO enables queries to multiple data centers in a seamless and transparent way, provides new powerful analysis and visualization tools within that system, and gives data centers a standard framework for publishing and delivering services using their data.
- Like the World Wide Web, the VO is not a fixed system, but rather a *way of doing things.*



The International Virtual Observatory Alliance

- The IVOA develops the technical standards needed to make the VO possible.
- Created in 2002
- 22 member VO projects
- 6 Working Groups, 8 Interest Groups
- 2 Interoperability meetings per year
  - May
  - Oct/Nov, consecutive with ADASS
- *~ 50 interoperability standards*

IVOA Organization Chart



Open positions

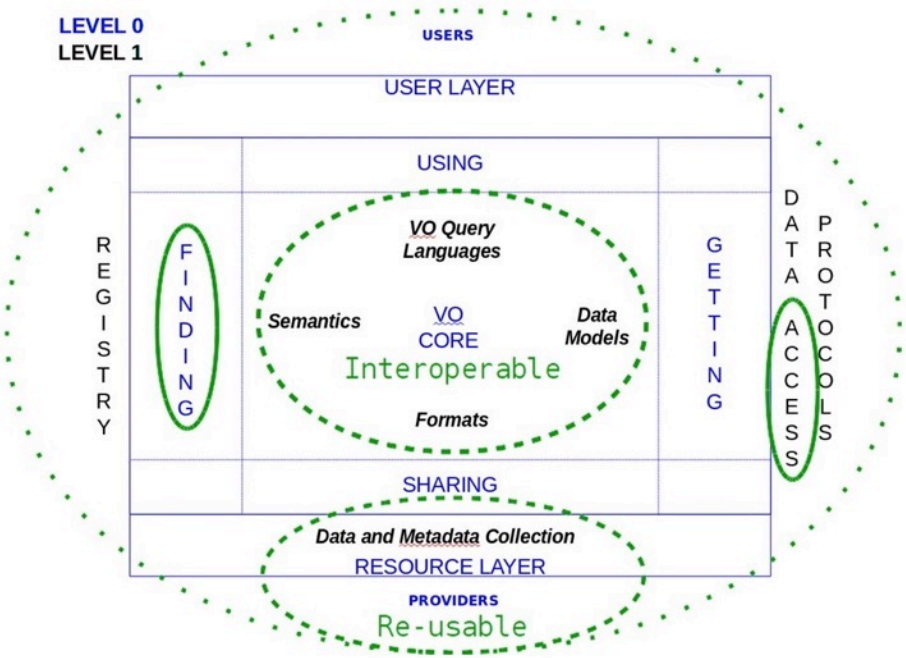
- Vice-chair of CSP
- Vice-chair of KDD

➔ Please consider nominating if you are interested and able to serve

The VO Is FAIR!

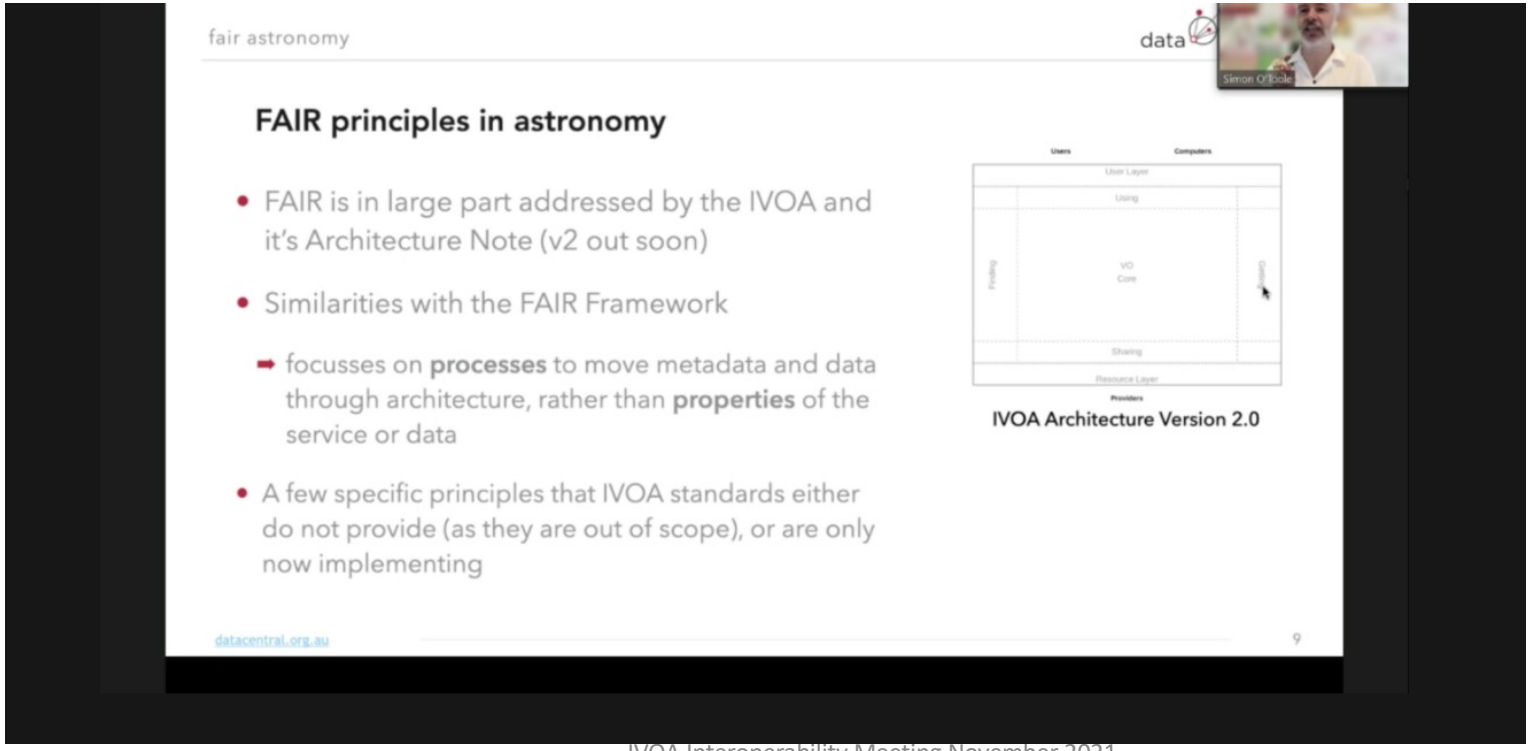
- FAIR Principles make data:

- ***F**indable*
- ***A**ccessible*
- ***I**nteroperable*
- ***R**eusable*



*Wilkinson et al 2016 "*The FAIR Guiding Principles for scientific data management and stewardship. doi: 10.1038/sdata.2016.18."

The VO IS FAIR!



This is the bottom part of Simon's head.

See invited talak by Simon O'Toole at ADASS XXXI.

"Make your data VO compliant and you are nearly there."

It takes more than a pandemic to stop us!

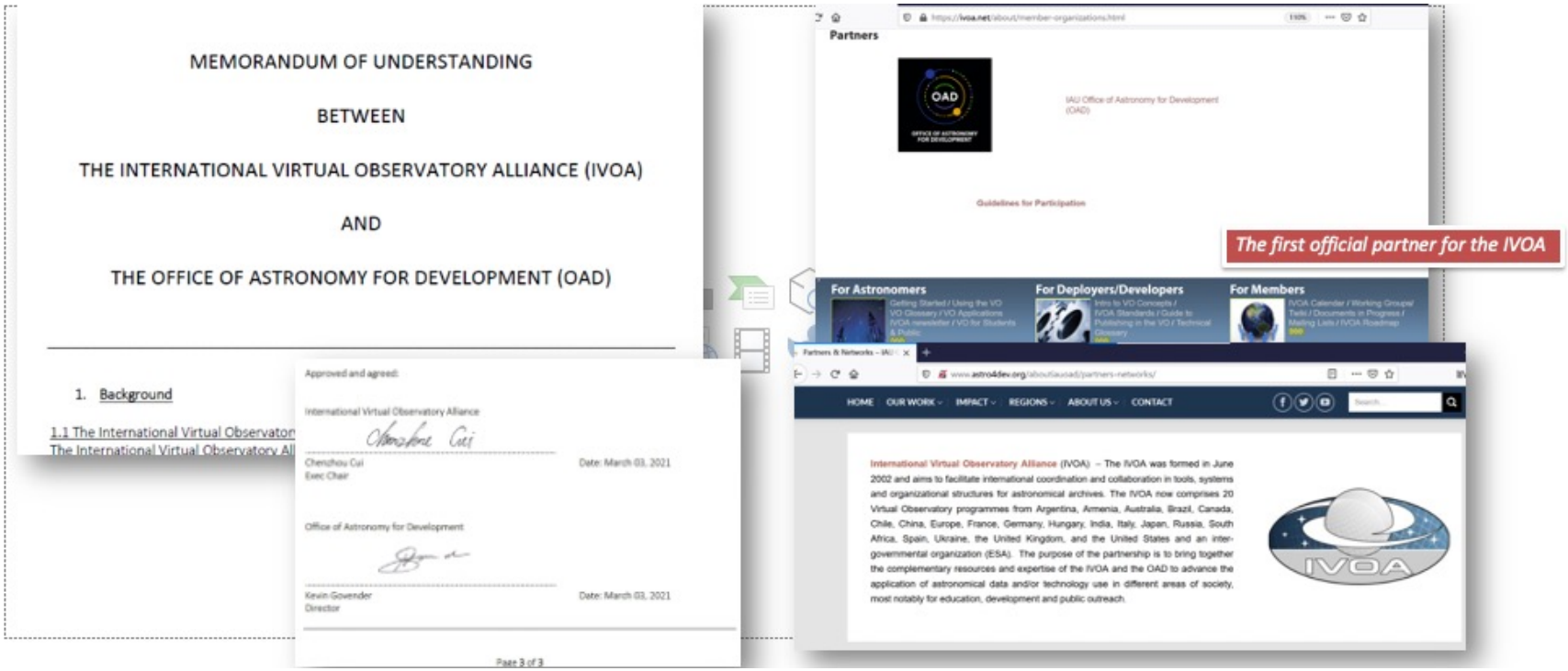
- We have now run three successful virtual meetings …
- … and I am sure we are about to have a fourth.
- Very full program for this meeting
- Full suite of Working Group and Interest Groups activity since May

Programme

Session	Time (UTC)	Elapse time	Session	Notes
Monday Nov 01, 2021				
ZOOM LINK for Monday: sessions complete				
Intro1	20:30 UTC	60 min	Newcomers Intro - IVOA 'How To'	Henrik Heinl/Dave Morris
	21:30	*Break - 30 min*		
Intro2	22:00	60 min	Newcomers Intro - IVOA Examples	Henrik Heinl/Dave Morris
	23:00	*End of Session*		

Session	Time (UTC)	Elapse time	Session	Notes
Tuesday Nov 02 2020 @ 06:00 UTC				
ZOOM LINK for Tuesday: meeting ended - recordings available below				
1	06:00 UTC	10 min	Welcome and Logistics	Marco Molinaro
		20 min	State of the IVOA	Bruce Berriman
		10 min	Committee on Science Priorities (CSP) report	Ada Nebot
		20 min	State of the Technical Coordination Group (TCG)	Janet Evans
	07:00 UTC	Break - 10 min		
2		50 min	Charge to WG/IGs	WG/IG Chairs
	08:00	*Break - 5.5 hours*		
3	13:30	60 min	DAL/SSIG	James Dempsey/Gregory Mantelet
	14:30	*Break - 30 min*		
4	15:00	60 min	DM	Laurent Michel/Jesus Salgado
	16:00	*Break - 4.5 hours*		
5	20:30	60 min	CSP	Ada Nebot
	21:30	*Break - 30 min*		
6	22:00	60 min	Apps	Tom Donaldson/Adrian Damian
	23:00	*End of Session*		

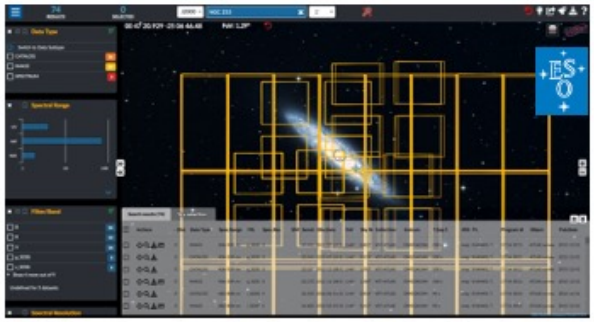
Collaboration between IVOA and IAU OAD



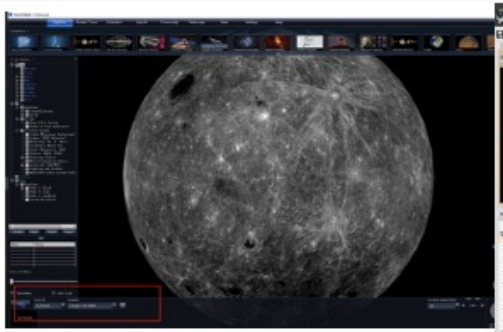
IVOA's Standing in the IAU

- The executive committee wishes to improve our standing and visibility within the IAU.
- The IVOA was asked to be a member of the newly approved Division B working group: "Laboratory Astrophysics Data Compilation, Validation and Standardization : from the Laboratory to FAIR usage in the Astronomical Community''
- The IVOA submitted a proposal to Division B of the IAU to form a Functional Working Group on the "Virtual Observatory."

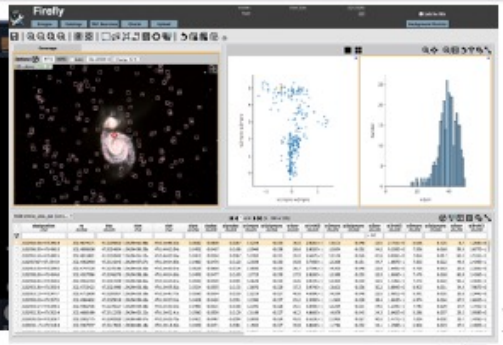
VO embedded in astronomy services



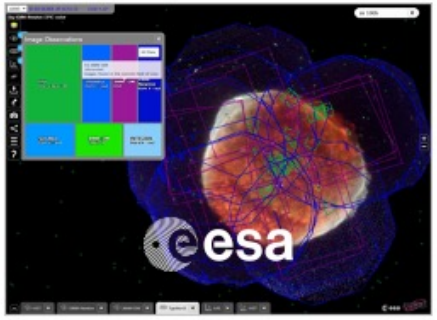
ESO Science Portal



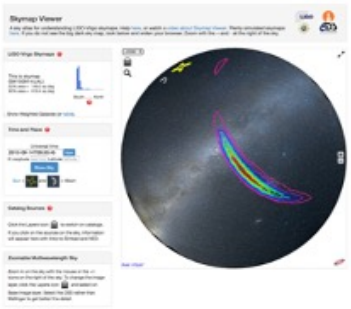
WWT



Firefly
Caltech-IPAC



ESA Sky

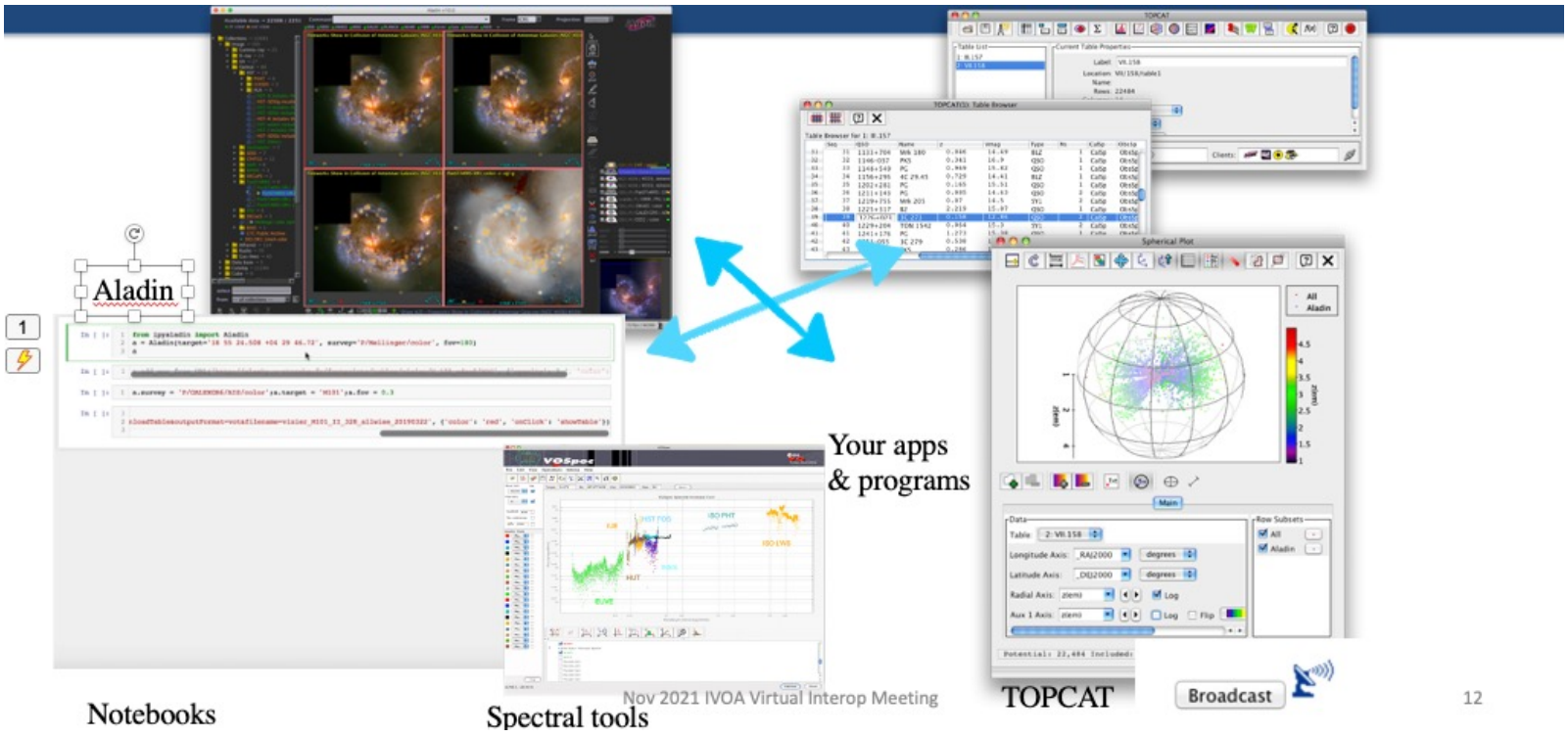


Grav. waves

CDS reference data service

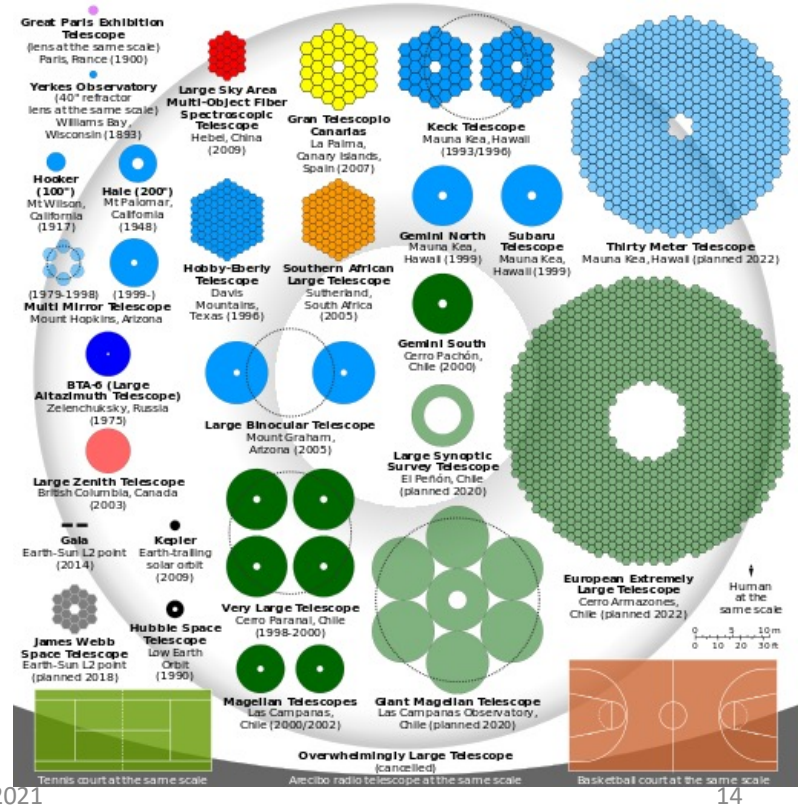
SVO Filter Profile service

Interoperable applications and services



Challenges for the IVOA In 2021 And Beyond

- **PB scale missions will be commissioned!**
- **Big new telescopes!**
- **Support "science platforms" with analysis close to data.**
- Support new data-type adoption, driven by the growth in size and complexity of data sets.
  - Columnar storage formats for large datasets, such as Apache Parquet.
- Support time-domain astronomy and multi-messenger astonomy
- New radio projects.
- Machine learning.

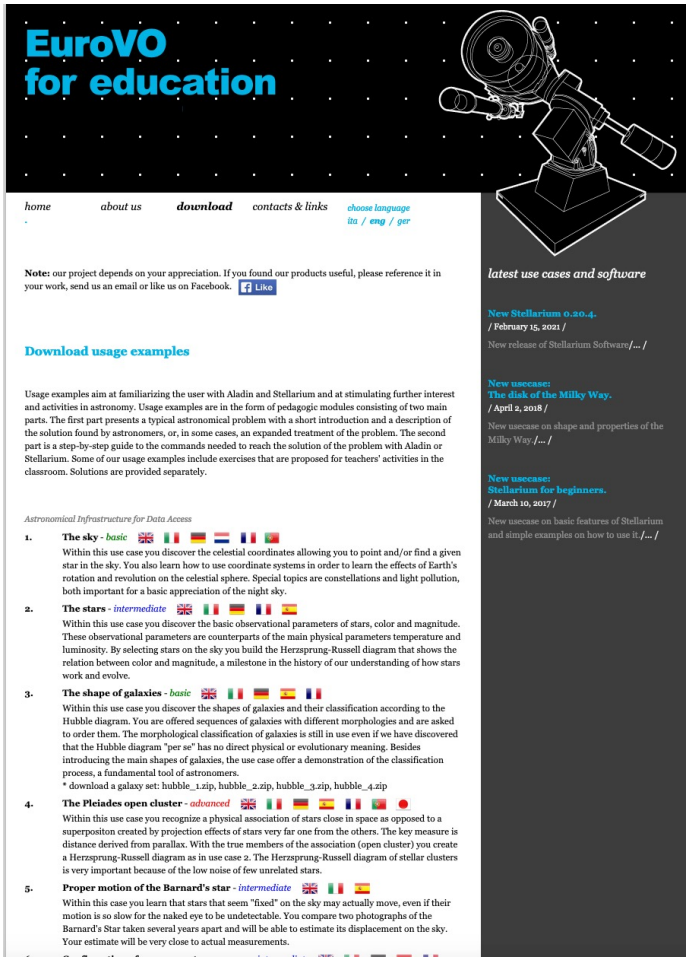


Education and Outreach

TUTORIALS	DESCRIPTION	Link
Abell 1656: The Coma Cluster of Galaxies	This tutorial uses the advanced VO functionalities of Aladin (interactive sky atlas), TOPCAT (tools to work on catalogs) and Cassis (interactive spectrum analyzer) to study interactively the Coma cluster of galaxies. The user can visualize the Coma cluster of galaxies and build a subset of these galaxies with Aladin. With TOPCAT, they can analyze this subset. Finally, they can study an HST power spectrum with Cassis.	Jupyter Notebook
Discovery of Brown Dwarfs mining the 2MASS and SDSS databases	This tutorial uses the advanced VO functionalities of Aladin (interactive sky atlas) to find brown dwarfs in the 2MASS and SDSS surveys. The user learns about the filtering, cross-matching and visualization functions, the implementation of scripts in Aladin and many more Aladin features to identify brown dwarfs in these surveys. This tutorial has been last updated for the first ESCAPE "Science with interoperable data school", previous versions of this tutorial repeated the same discovery steps with TOPCAT and STILTS. For this tutorial you will need a parameter and script file.	Jupyter Notebook
The CDS tutorial	This tutorial describes the basis of the VO program hosted at CDS. The three major VO programs are described: SIMBAD (astronomical database), VizieR (catalog service) and Aladin (interactive sky atlas). The user gets familiar with the programs while 1) searching for the galaxy NGC4039 through the CDS portal to get direct access to SIMBAD, VizieR and Aladin, 2) comparing the sky coverage between SDSS and GALEX surveys using Aladin and 3) selecting interacting galaxies with Aladin.	Jupyter Notebook
Determination of stellar physical parameters using VOSA	This tutorial uses the advanced VO functionalities of VOSA (VO Sed Analyzer) and TOPCAT to determine empirically the masses and radii of stars surrounded by planets. The user needs to register to get access to the functionalities of VOSA (online tool). They can then upload a list of objects to study, build their SEDs and analyze them (by fitting models). Using the interoperability between VOSA and TOPCAT, the user can compare the empiral values obtained with VOSA to those published in papers.	
Accessing and cross matching big datasets with ADQL	This tutorial allows the user to get familiar with ADQL (Astronomical Data Query Language) and TAP (Table Access Protocol) through using GAIA data. ADQL and TAP are widely used in VOs to handle large datasets that cannot be handled locally.	
Electromagnetic follow-up of gravitational-wave event	This online tutorial uses mostly Aladin functionalities to locate the sources of latest gravitational wave events on the sky	
Exploring Gaia with TopCAT and STILTS	This tutorial uses TOPCAT and STILTS to study the Pleiades open star cluster. The user starts with getting TGAS data for the Pleiades and identifies its as a comoving subset. In a second step, the user matches HST data with Gaia observations using the interoperability of TOPCAT with VizieR to access the catalogs. The cross-match is refined using a color-magnitude diagram. The user can also use the TAP (Table Access Protocole) service of TOPCAT to run scripts for Gaia data. Finally, the user can upload the full TGAS catalog and investigate it with STILTS.	
Advanced usage of HiPS and MOCs	This is a hands-on tutorial demonstrating an advanced usage of Hierarchical Progressive Surveys (HiPS) and Multi-Order Coverage (MOC) maps in Aladin. Using this document, you will learn how to handle a problem like : I have an image survey. I would like to select regions in my observations that are above a given threshold in another survey (e.g. at low extinction), retrieve objects from very large catalogs (e.g. Gaia + WISE) in these non-trivial shapes and not-necessarily-connected regions, and combine them to visualise some quantities (e.g. color magnitude diagram).	Jupyter Notebook
Classifying the SEDs of Herbig Ae/Be stars	Herbig Ae/Be stars are 2-8 solar mass. These stars show Balmer emission lines in their stellar spectrum and infrared excess due to circumstellar dust. They roughly fall into two groups: Group I sources have a relatively strong far-IR flux. Group II sources show a similar near-IR excess as group I sources but their flux falls off strongly towards the far-IR. In this tutorial, you will learn how to use VO tools and services to access observed photometric SEDs and spectra in the near and far infrared of different stellar objects. You will compare the stars and classified them.	
Multi-instrument, multi-wavelength study of high energy sources with the virtual Observatory	This tutorial makes extensive use of the cross-matching and selection (based on criteria) functionalities of the VO tools to study high energy sources observed at different photon energy bands and with various instruments. The user queries SIMBAD to get HESS sources and overlays them on a Fermi LAT image in Aladin. They then cross-match HESS sources with the Fermi LAT catalog that they download from VizieR via its interoperability with TOPCAT. Applying selection criteria with TOPCAT functionalities, they can identify different classes of objects in a color-color diagram to finally get SEDs for the objects of interest.	Jupyter Notebook
Handling gravitational-wave sky maps for EM-followUP observations	This tutorial uses the functionalities of Aladin to visualize probability sky maps. It also makes extensive use of the MOC (Multi-Order Coverage) capabilities of Aladin to query a given region of the sky and access the catalogs with information in that region via the interoperability with VizieR. Finally the additional interoperability with TOPCAT permits sending the data available in that region to the latter for further studies.	
Determination of stellar physical parameters using SPECFLOW	This tutorial provides an overview of the usage of SPECFLOW also in combination with other VO tools like CASSIS. The goal of the tutorials is the evaluation of physical properties of the stars HD232862 and VEGA.	

https://www.euro-vo.org/scientific-tutorials/

See talk by Chenzhou Cui, ADASS XXXI

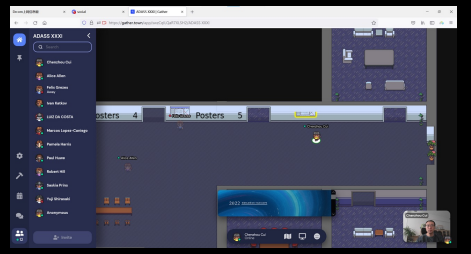


http://vo-for-education.oats.inaf.it/index_eng.html

The 1st International WWT Tour Contest launched at ADASS

https://contest.worldwidetelescope.org/

IWTC poster at ADASS gather.town and the venue

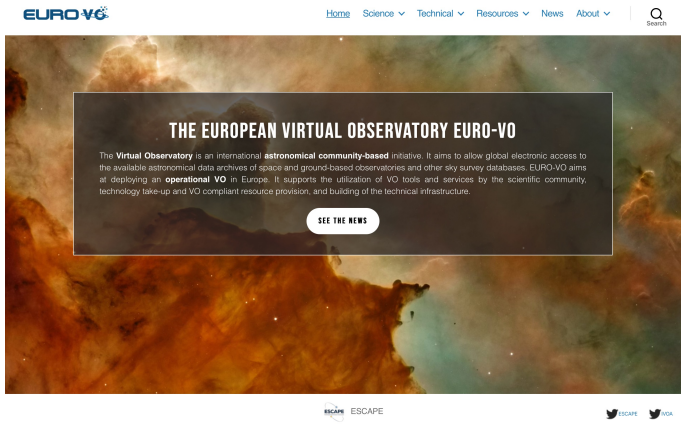


Euro-VO Activities

- Activities are being pursued within the EC funded **ESCAPE** Project
  - In the work package: **CEVO "C**onnecting ESFRI to the **E**OSC via **VO"**
- Euro-VO partners working with large Astronomy, Astroparticle Physics and Solar Physics partners
- ESCAPE is bringing VO into the European Open Science Cloud (EOSC)

Euro-VO Status and Highlights

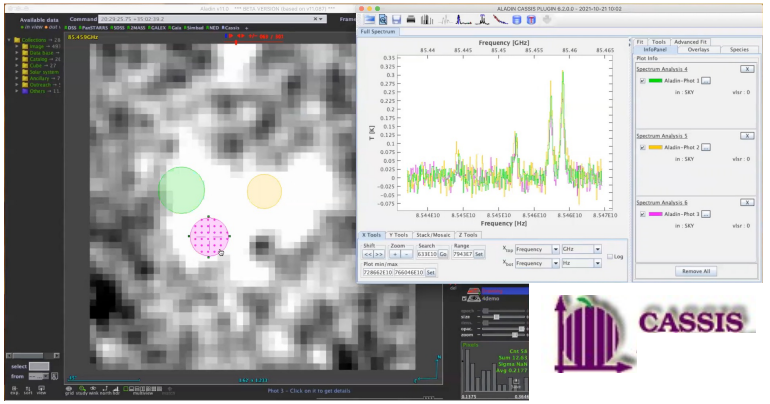
- **ESCAPE project Feb 2019- Jan 2023** (https://projectescape.eu)
- **Recent Activities:**
  - **Progress meeting** held in September – slides available: (https://indico.in2p3.fr/event/24500/)
  - **Participation in European Open Science Cloud events** (see -- https://www.eosc.eu)
    - E.g. ESCAPE and IVOA presented at EOSC Symposium (https://www.eoscsecretariat.eu/events/eosc-symposium-2021) 15-18 June 2021
  - **Presentations at European Astronomical Society conference** (28 June – 02 July, 2021)
    - **Topics: Radio astronomy, Space-Time coverage, demos at CDS Virtual Exhibit**
  - **ADASS presentations of ESCAPE VO activities/results**
- **Upcoming:**
  - **Hands-on workshop for Data Providers** *(On-line 23-26 Nov)* *https://indico.in2p3.fr/event/23987/*
  - **VO School –** *(Hybrid Strasbourg/on-line 22-24 Feb 2022)* *https://indico.in2p3.fr/event/25225/*



VO-France

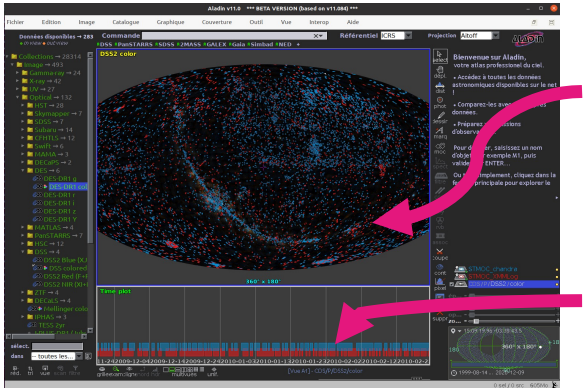
VO-Tools

ALADIN + CASSIS
(CDS & OV-GSO / Toulouse)
Easy access to **spectral data cubes**
- analyse spectra at each spatial pixel
- combination of spectra



Also in Aladin
Promoting a **new approach to space and time coverage of data sets using MOC 2.0**

IVOA standards (supported in part by ESCAPE)
- MOC 2.0 standard and implementations in Aladin and mocpy (see MOCRustLib – ADASS poster)



Sky coverage

Temporal coverage

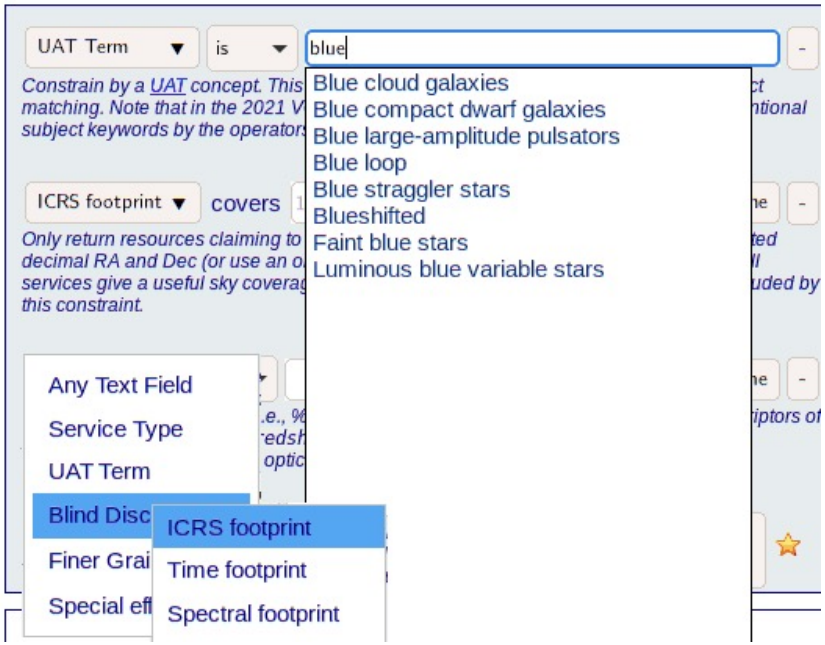
- Provenance DM
  - **Workshop : "*Provenance in practice*"** - December 2021
- EPNTap 2
  - Progress towards recommendation

Data

New CDS publishing registry released (June 2021):
Includes: description of VizieR mirrors, MOC footprints, catalogue DOIs, keyword mapping of the Unified Astronomy Thesaurus (UAT)

German Astrophysical VO

- GAVO's publication suite DaCHS: Release 2.5 in November with improved UCD validation, HDF5 support, updates to EPN-TAP, and a lot more.
- Still working towards blind discovery, e.g., through updates to the Registry interface WIRR http://dc.g-vo.org/WIRR.
- If you are in ~ CET: Invite your data providers to the Escape Data Provider Workshop, https://indico.in2p3.fr/e/edp2021.



Netherlands VO

- NVO Team met before summer
- Our first activity will be to reach out to the community to present the VO (basically a colloquium tour).
- * And we have a mailing list for interested people to join.

Spanish VO

- Funding secured till the end of 2024
- VO archives: GTC, Calar Alto,…
- VO tools: VOSA, Clusterix, SVO DiscTool, FPS,…
- VO science:
  - BDs, VLM stars, Wds, PNs, AGBs, asteroids,…
  - Training schools.
- Big Data: Automated classification, deep learning.
- Outreach: Pro-am collaborations, citizen science projects.

VObs.it

the Italian initiative to support the VO

- **Mainly focused on tightening the connection among Italian national research data infrastructures**

- Recently recognised by INAF as a multi-institution "programme" (long-term project), aimed at supporting Italian participation in IVOA and Euro-VO
- Included in INAF Medium-Term (3 yr) Plan

VObs.it

Funding for development of standards and provision of services for IVOA is granted by INAF: fairly constant over time (lower in 2020-21 due to lack of travel)

- Activity in IVOA within WGs and IGs
- Vice-Chair of TCG
- Chairing the GWS WGs
- IVOA documents coordination
- Support to the IVOA Newsletter

Person-power: ~ 3 FTE/year

Additional efforts to develop data access/ retrieval and applications compliant to IVOA standards at the two main Italian centers:

- IA2, the INAF center for Astronomical Archives
- SSDC, the ASI Space Science Data Center (evolution of ASDC)

VObs.it

VObs.it supports (on INAF-provided servers and resources) the following IVOA services:

- web pages (www.ivoa.net)
- wiki (wiki.ivoa.net)
- mail and lists (mail.ivoa.net)
- documents repository (www.ivoa.net/documents)
- vocabulary maintenance (www.ivoa.net/rdf)

It also manages the

- registration of IVOA domains (ivoa.net and ivoa.info)

Current efforts/activities include:

- within EuroVO, active participation in the EU-funded ESCAPE project (on integration of VO services with the European Open Science Cloud)
- a national webinar and a workshop in 2021 (wide interest)
- rebuild IVOA servers after May Interop
- updates to the document repository

All-Sky Virtual Observatory News

Data Central and SkyMapper

- New Optical Data Centre project funded for 12 months, expected extension until 2023
- Data Central Data Aggregation Service released (see DAL/DM talk by Brent Miszalski)
- Data Central services now in IVOA registry
- SkyMapper preparing for Data Release 4

Theoretical Astrophysical Observatory

- New Genesis premade catalogues available: SHARK & Meraxes
- New visualization tool – Vis3D – now released!

All-Sky Virtual Observatory News

MWA

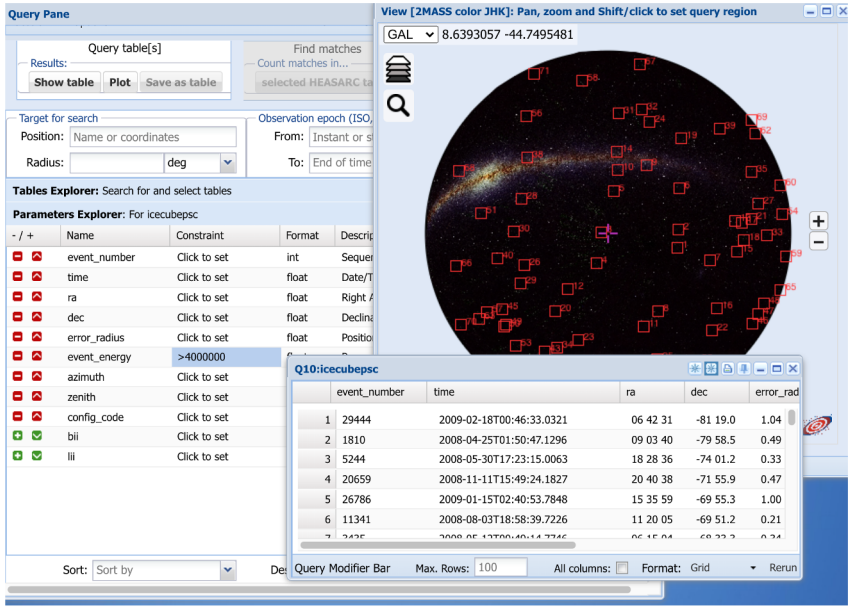
- Working to integrate new MWA correlator into workflow
- Migrating storage to an S3-like object store at Pawsey

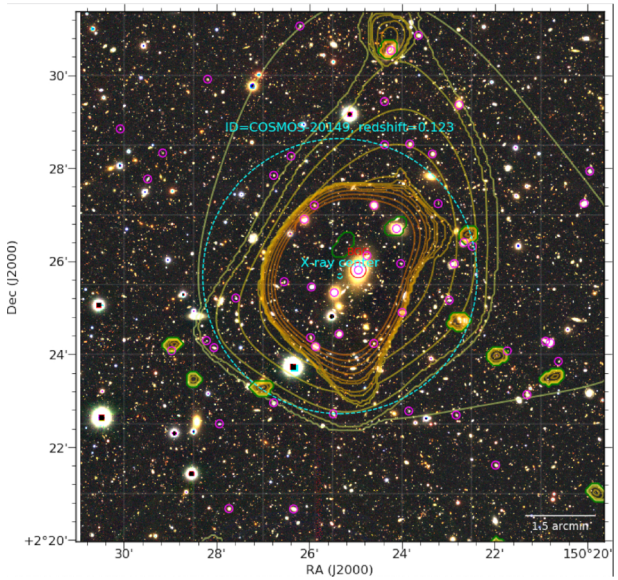
CASDA

- Hosting and registered RACS HiPS maps to improve performance
- Migrating storage to an S3-like object store at Pawsey
- Tagging enabled to allow observations to be associated with more than one project

NASA Astronomical Virtual Observatory

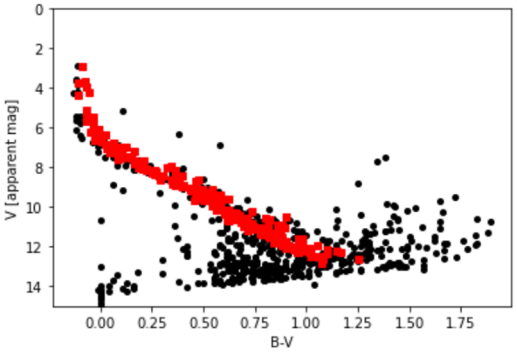
- New data
  - IRSA published COSMOS2015 and COSMOS X-ray Group Catalogs
  - Over 1 million IceCube neutrino events now available through HEASARC TAP service.

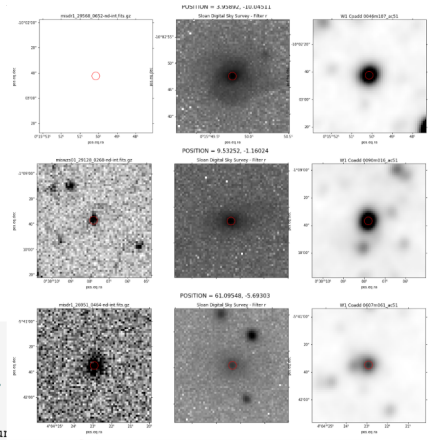




NASA Astronomical Virtual Observatory

- Outreach
  - Summer AAS workshop (17 virtual participants, went smoothly)
  - New Python notebook on making an HR diagram.





```
# For each galaxy,
for galaxy in galaxy_subset:

    # Establish the position.
    ra = galaxy['RA']
    dec = galaxy['DEC']
    pos = SkyCoord(ra, dec, u

    # Set up the plot for this position.
    fig = plt.figure(figsize=(20,6))
    plt.suptitle('POSITION = ' + str(ra) + ', ' + str(dec), fontsize=16)

    # GALEX

    # Find the GALEX ima
    galex_image_table = galex_image_service.search(pos=pos, size=0.25)
```

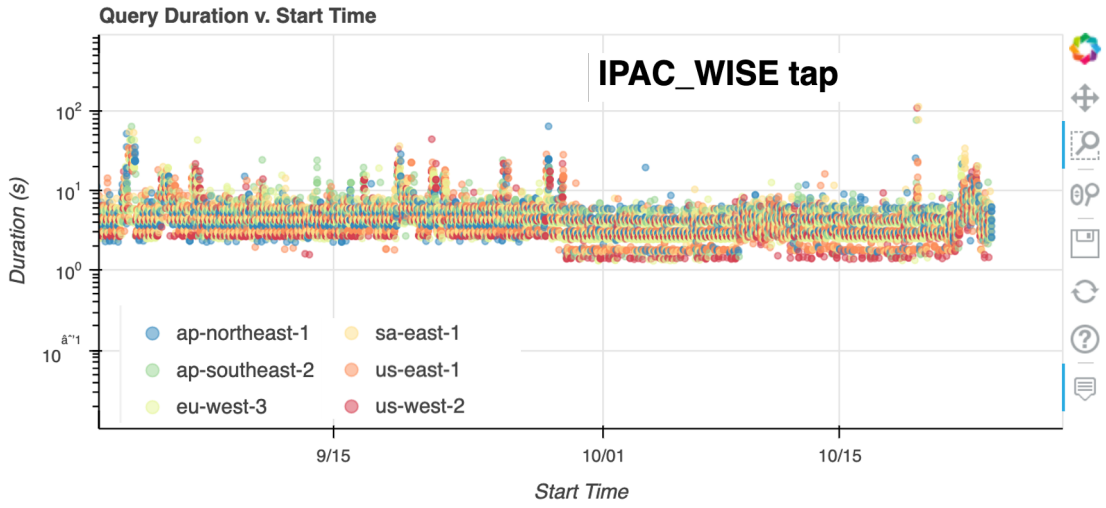
```
query = SELECT * FROM "%s"' %tablename
results = tap_services[uniq_ind[0]].search(query)
R98_color = results.getcolumn('B-V')
R98_mag = results.getcolumn('Vmag')
plt.ylabel("V [apparent mag]")
plt.xlabel("B-V")
plt.plot(color, mag, 'o', markersize=4.0, color='black')
```

NASA Astronomical Virtual Observatory

- Development and Services
  - IRSA participated in testing of Rubin-developed ObsCore Table search in Firefly GUI archive tool set, to be incorporated into IRSA Viewer at next release.
  - IRSA tested new 1-D spectral viewer in Firefly GUI archive tools for any spectra that are compliant with the VO spectral model.
  - MAST ADQL parsing service now independent and public.

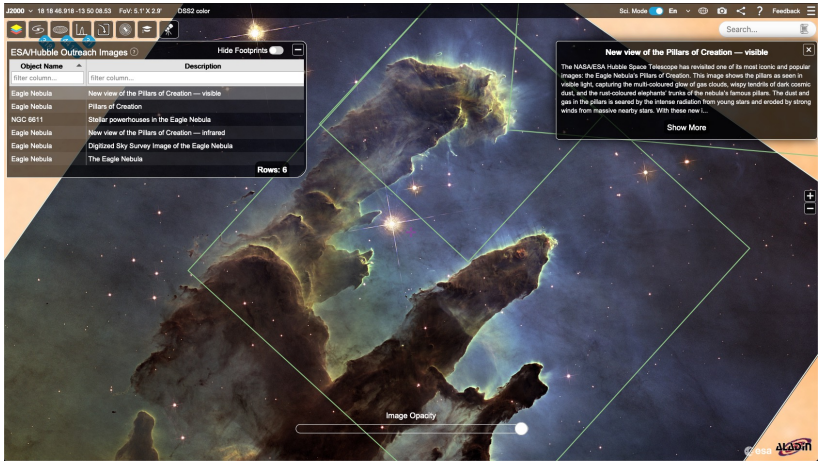
NASA Astronomical Virtual Observatory

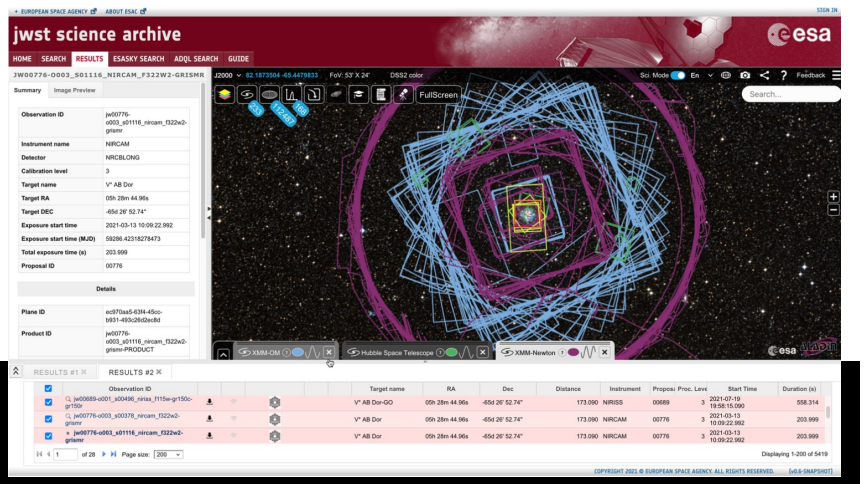
- Metadata
  - NAVO-wide Registry metadata review ongoing.
  - Registry review feeding into discussions on how to improve PyVO *data discovery*
- Operations
  - IRSA dealing with an uptick in questions to help desk regarding complex TAP queries.
  - Performance monitoring integrated into weekly operations meetings.



ESA-VO Activities

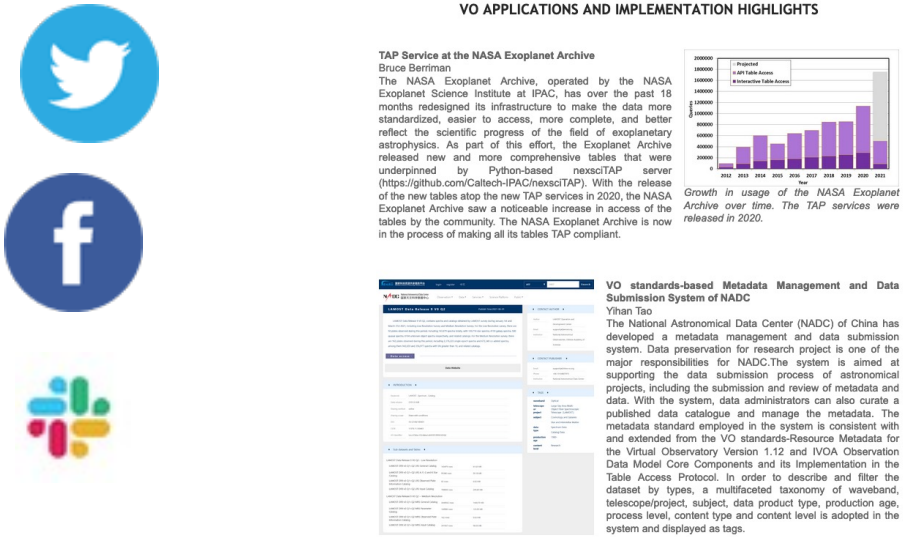
- Gaia archive: New DataLink contents being prepared for DR3 (Mcmc, RVS spectra, Xp mean spectra & Xp sampled mean spectra)
- ESASky: Access to External TAPs (including now MAST, ESO, CADC, HEASARC and ASTRON), access to CHEOPS data products, link to LIGO+VIRGO Gravitational Wave events database plus access to ESA/Hubble Outreach images.
- ObsCore implemented for eHST, eJWST, Euclid & INTEGRAL TAP services
- New eJWST interface with its astroquery module VO-inside being prepared for eJWST launch release
- ObsLocTAP IVOA Recommendation since July 2021
- ObsVisSAP in working draft





Stay connected! …And let's get to work

- IVOA Newsletter. https://www.ivoa.net/newsletter/index.html



VO APPLICATIONS AND IMPLEMENTATION HIGHLIGHTS

TAP Service at the NASA Exoplanet Archive
Bruce Berriman
The NASA Exoplanet Archive, operated by the NASA Exoplanet Science Institute at IPAC, has over the past 18 months redesigned its infrastructure to make the data more standardized, easier to access, more complete, and better reflect the scientific progress of the field of exoplanetary astrophysics. As part of this effort, the Exoplanet Archive released new and more comprehensive tables that were underpinned by Python-based nexsciTAP server (https://github.com/Caltech-IPAC/nexsciTAP). With the release of the new tables atop the new TAP services in 2020, the NASA Exoplanet Archive saw a noticeable increase in access of the tables by the community. The NASA Exoplanet Archive is now in the process of making all its tables TAP compliant.

Growth in usage of the NASA Exoplanet Archive over time. The TAP services were released in 2020.

VO standards-based Metadata Management and Data Submission System of NADC
Yihan Tao
The National Astronomical Data Center (NADC) of China has developed a metadata management and data submission system. Data preservation for research project is one of the major responsibilities for NADC.The system is aimed at supporting the data submission process of astronomical projects, including the submission and review of metadata and data. With the system, data administrators can also curate a published data catalogue and manage the metadata. The metadata standard employed in the system is consistent with and extended from the VO standards-Resource Metadata for the Virtual Observatory Version 1.12 and IVOA Observation Data Model Core Components and its Implementation in the Table Access Protocol. In order to describe and filter the dataset by types, a multifaceted taxonomy of waveband, telescope/project, subject, data product type, production age, process level, content type and content level is adopted in the system and displayed as tags.