ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures

22 November 2021
UNISTRA OA Week

ESCAPE : *Toward Open Science in the context of EOSC*

Mark Allen - Director Centre de Données astronomiques de Strasbourg (CDS)

- H2020 ESCAPE: WP4 Leader. EOSC Association TF: *User Engagement and Adoption.*
- *with thanks to G. Lamanna and the ESCAPE project team*

ESCAPE - The European Science Cluster of Astronomy & Particle Physics ESFRI Research Infrastructures has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n° 824064.

Outline

* Some first introduction to CDS

- ❑ What is EOSC?
- ❑ ESCAPE as an example of an EOSC project.
- ❑ Focus on: Integrating astronomy interoperability in EOSC.
  - Connecting to the global ‘Virtual Observatory’ interoperability framework.
  - Enabling open science example – gravitational wave follow-up
- ❑ Intersections of ESCAPE work with UNISTRA / ObAS / CDS ambitions.
- ❑ Summary

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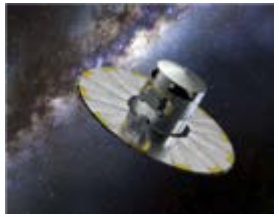
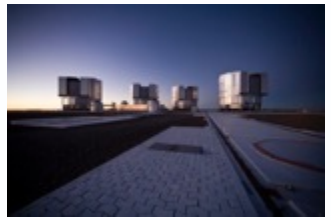
Horizon 2020 - Grant N° 824064

Centre de Données astronomiques de Strasbourg (CDS)

Collaboration with Observatories and Agencies

Ground and Space Observatories, Instruments and missions

ESO · esa · cnes · NASA

CDS

cnrs INSU Observer & comprendre

Université de Strasbourg

Journals

Astronomy & Astrophysics · AAS · Monthly Notices · + ...

Astronomy Data Centres:

astrophysics data system

NED

CADC, MAST, HEASARC, IPAC, + ...

Virtual Observatory:

EURO VO · France · IVOA

H2020 projects: ESCAPE · EOSC FUTURE

Data e-Infrastructures:

RDA RESEARCH DATA ALLIANCE · EUROPEAN OPEN SCIENCE CLOUD

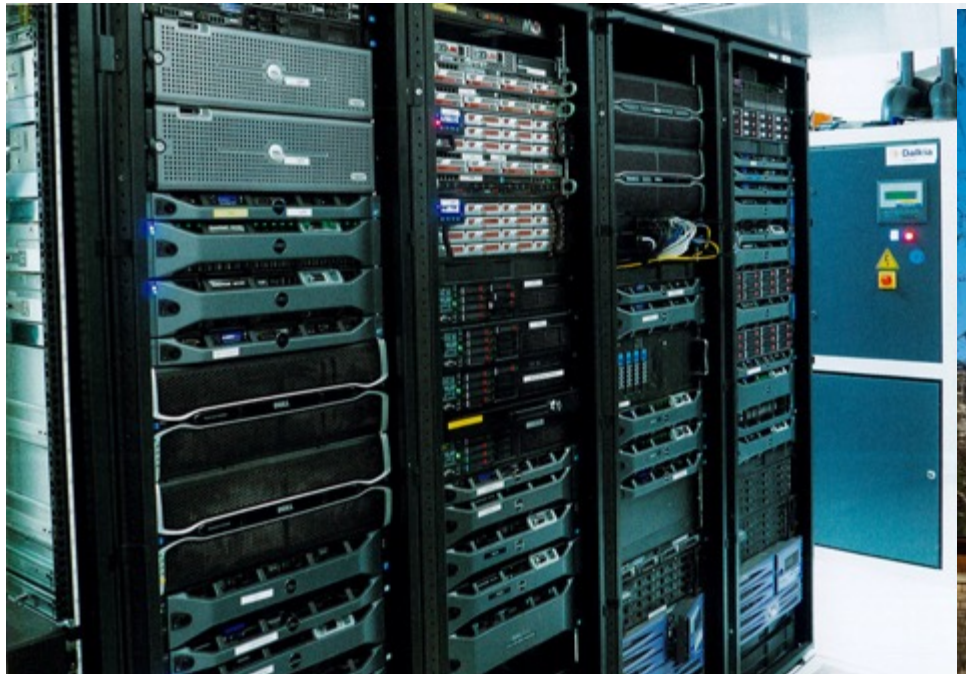
Certification: CORE TRUST SEAL · ICSU WORLD DATA SYSTEM

CDS - Astronomy Data Centre

An integrated team of:

Scientists **Engineers** **Documentalists**

French *"Research Infrastructure", ~38 people*



CDS - a data centre for astronomy ***reference*** data… since 1972

Our mission:

- Collect useful data on objects in electronic form
- Improve them by critical evaluation and combination
- Distribute the results to the international community
- Conduct research using the data

Science Driven:

- ***Necessary evolutions*** *to meet needs of the astronomy community*

Open Science:

- FAIR principles: **F**indable, **A**ccessible, **I**nteroperable, **R**e-useable

- Contributions to development of the disciplinary level interoperability framework – the Virtual Observatory

- Connections between research data and publications

What is EOSC ?

EOSC

What the European Open Science Cloud is

The ambition of the European Open Science Cloud (EOSC) is to develop "Web of FAIR Data and services' for science in Europe. EOSC will be a multi-disciplinary environment where researchers can publish, find and re-use data, tools and services, enabling them to better conduct their work.

EOSC builds on existing infrastructure and services supported by the EC, Member States and research communities. It brings these together in a federated 'system of systems' approach, adding value by aggregating content and enabling services to be used together.

This environment will operate under well-defined conditions to ensure trust and safeguard the public interest. Expectations of service providers and users will be made explicit to ensure appropriate behaviour.

EOSC will improve the situation for researchers in many ways, namely:

- Seamless access to content and services via common AAI,
- Access to data from various sources which is FAIR and ideally open,
- Access to services for storage, computation, analysis, preservation and more,
- Adoption of standards so data and services can be combined,
- Helpdesk, training and support to improve use of EOSC.

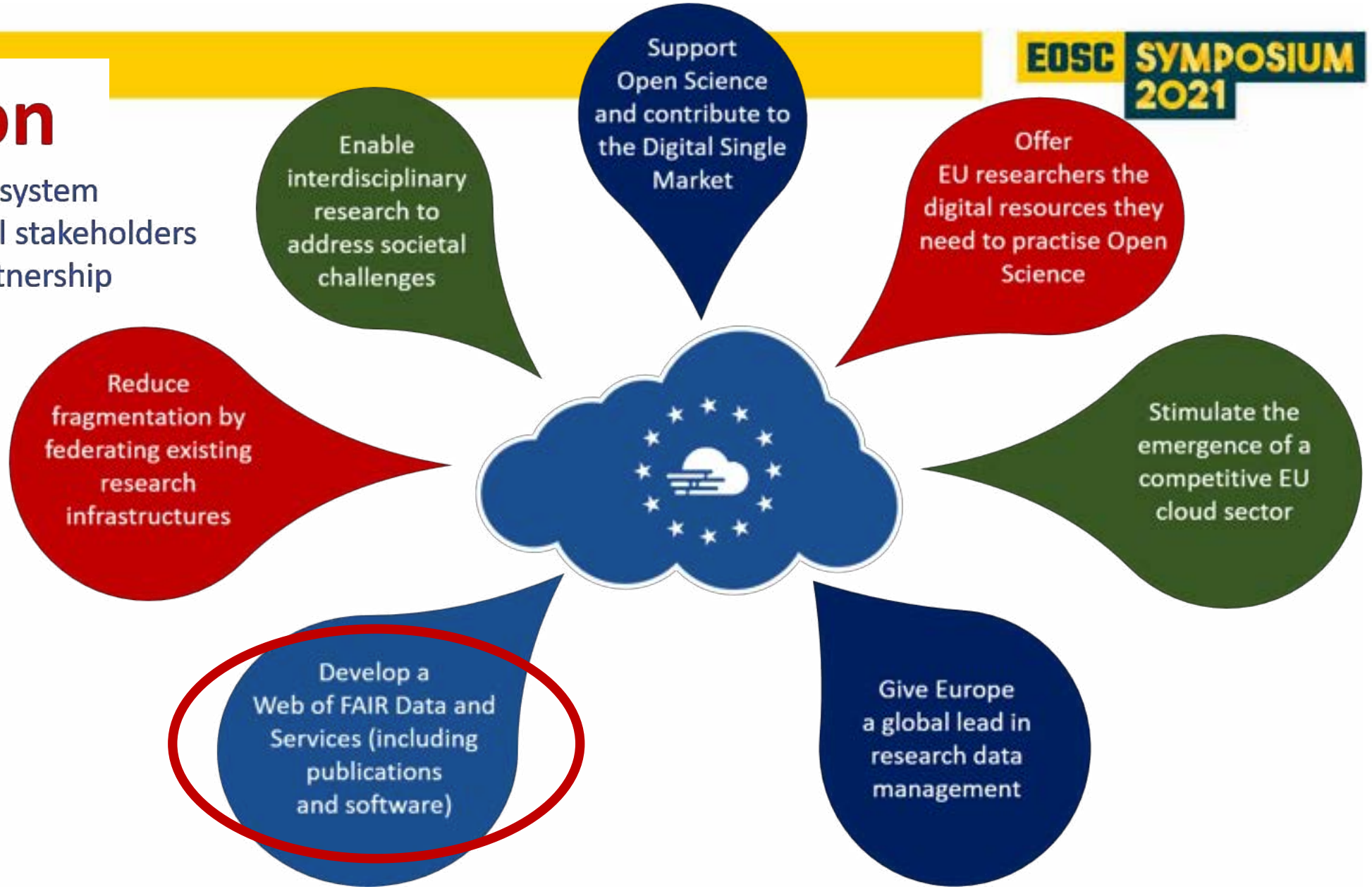
EOSC is recognised by the Council of the European Union as the pilot action to deepen the new European Research Area (ERA). It is also recognised as the science, research and innovation data space which will be fully articulated with the other sectoral data spaces defined in the European strategy for data.

Source: European Commission

From https://eosc.eu

The Vision

Building the EOSC ecosystem collaboratively with all stakeholders through the EOSC Partnership



EOSC – first phase 2018-2020

EOSC EB wraps up activities by releasing key documents for the European Open Science Cloud

2019-2020: EOSC Working Groups produced key documents:

- 20 documents which are key to the EOSC Strategic Research and Innovation Agenda (SRIA)

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Led to a MOU in August 2021

- The multi-annual Strategic Research and Innovation Agenda (SRIA) agreed by the Partners will provide the basis for the development of the co-operation under this Memorandum of Understanding, and for defining the annual priorities in line with the Strategic Plan for Horizon Europe;

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ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures

INTERNATIONAL CONSORTIUM

- 31 partners including 2 SMEs
- 10 ESFRI projects & landmarks: CTA, EST, FAIR, HL-LHC, KM3NeT, SKA, LSST, VIRGO, ESO, JIVE
- 2 pan-European International Organizations: CERN, ESO with their world-class established infrastructures, experiments and observatories
- 2 European Research Infrastructures: EGO and JIV-ERIC
- 1 involved initiative/infrastructure: EURO-VO
- 4 supporting European consortia: APPEC, ASTRONET, ECFA and NuPECC

- Budget: **15.98 M€**
- Started: **1/2/2019**
- Duration: **48 months** (end date 31/1/2023)
- Coordinator: **CNRS-LAPP**

H2020-INFRAEOSC-04-2018 call

Clusters to ensure the connection of the ESFRI RIs with EOSC (and the construction of EOSC)

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ESCAPE – one of the 5 ‘Science Clusters’

Science Clusters of Research Infrastructures (RIs) proposed in 2018 in response to a dedicated H2020 call. Five Science Clusters to ensure the connection of the ESFRI RIs with European Open Science Cloud (EOSC).

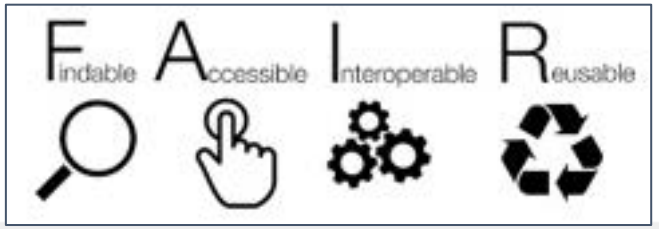
Expected impact:

- *Improve access to data and tools leading to new insights and innovation*
- *Facilitate access of researchers to data and resources for data driven science.*
- *Create a cross-border open innovation environment.*
- *Rise the efficiency and productivity of researchers through open data services and infrastructures for discovering, accessing, and reusing data.*
- *Foster the establishment of global standards.*
- *Develop synergies and complementarity between involved research infrastructures.*
- *Adopt common approaches to the data management for economies of scale.*

Five thematic Science Clusters

More than 80% of ESFRI RIs, plus other world-class RIs and new emerging ones.

Working together making data FAIR …



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Astrophysics and Particle Physics

Aligned expectations:

- **Large volumes of data** generators (up to multi-Exabyte scale level)
- **"Observatory" and "Facility"** type of operation requires global open access and long-term sustainability of research data
- The **astrophysics** and the **accelerator-based** particle/nuclear physics **ESFRI** facilities joined for a **multi-probe approach** towards the understanding of the Universe.
  - Addressing expectations of new generation researchers for a **"virtual space"** sharing workflows and interoperate data.
  - To acknowledge and reward commitment of scientists (on transversal research and FAIR-data actions).
- Engage with society and citizens

Decide to enhance the coordination:

- leveraging two major complementary excellences in data stewardship:
  - the astronomy **Virtual Observatory** infrastructure;
  - a long-standing expertise of the **HEP** community in large-scale distributed computing and big-data management.
- operating a shared open innovation environment, adopting cooperatively the FAIR/Open-Science principles

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ESFRI and RI PROJECTS PARTNERS

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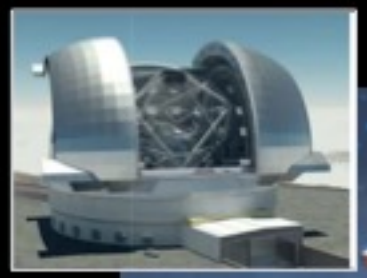
Radio

JIVE-VLBI

SKA

Visible light



ELT

ESO

EST

Gamma rays

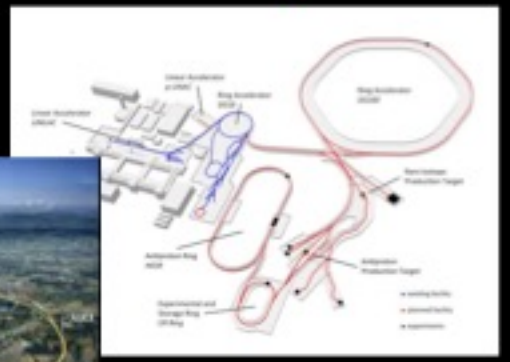
CTA

Accelerator-based
Particle Physics

HL-LHC

CERN

Accelerator-based
Nuclear Physics

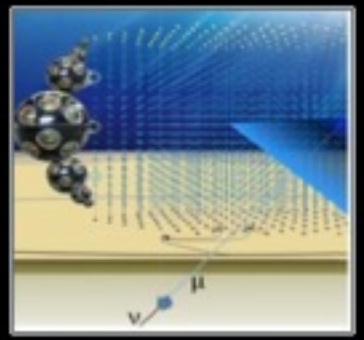


FAIR

Gravitational Waves

EGO-VIRGO

Cosmic-rays
Neutrinos



KM3NeT

Work Program

Data Lake:

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Software Repository:

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Science Platforms:

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Citizen Science:

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Interoperability Standards
Metadata / Protocols
International context -

Virtual Observatory:

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ESCAPE Work Programme

Data Lake:

- Build a scalable, federated, data infrastructure as the basis of open science for the ESFRI projects within ESCAPE. Enable connection to compute and storage resources.

Software Repository:

- Repository of "scientific software" as a major component of the “data” to be curated in EOSC. Implementation of a community-based approach for the continuous development of shared software and for training of researchers and data scientists.

Virtual Observatory:

- Extend the VO *FAIR* standards, methods within a broader scientific context; prepare the VO to interface the large data volumes anticipated from new facilities.

Science Platforms:

- Flexible science platforms to enable the open data analysis tailored by and for each facility as well as a global one for transversal workflows.

Citizen Science:

- Open gateway for citizen science on ESCAPE data archives and ESFRI community

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Making data FAIR with the Virtual Observatory.

The Virtual Observatory is:

- **An operational framework** for interoperable access to astronomical data and services
- **A pioneer of FAIR data sharing** - **an existing global framework** – populated by major data providers (space and ground based) that is heavily used by the community *(e.g. ESA Gaia mission data access is fully VO)*
- **Built on International Virtual Observatory Alliance (IVOA) standards**
  - *Recognised in the ESFRI roadmap (2018)*
  - **Supported in Europe** *by* ***Euro-VO*** *(VO Partners + EC projects since ~2001)*
  - *Recognised in ASTRONET roadmaps (2008, 2014, 2021)*

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Astronomy Virtual Observatory framework as part of EOSC

Integration of an operational interoperability framework for FAIR

- Domain specific thematic services supporting Open Science
- **IVOA standards for implementation of FAIR**

Brings Astronomy metadata standards into EOSC context

- IVOA standards responding to the needs of ESFRI, RIs and researchers
- *See Astronomy use case in SRIA, and EOSC Interoperability Framework*

EOSC to enable next steps of the astronomical Virtual Obsevatory

- Connection to computing and integration into ESCAPE platform
- Scalability for big data

Data stewardship practices of Astrophysics in EOSC context

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The way of working:
Community Engagement on Interoperability Standards

Astronomy Interoperability Standards community

- Representation of ESCAPE priorites
- Development of standards for ESFRIs/RIs

Astronomy Data and Software Services community

Presentation of ESCAPE results

Invited talks, tutorials, focus demos

Research Community

ESCAPE VO Schools

Community Meetings and conferences (EAS, SCIOPS, LISA)

Open Science Community

- EOSC events
- RDA plenaries
- FAIRsFAIR
- EUDAT
- NEANIAS

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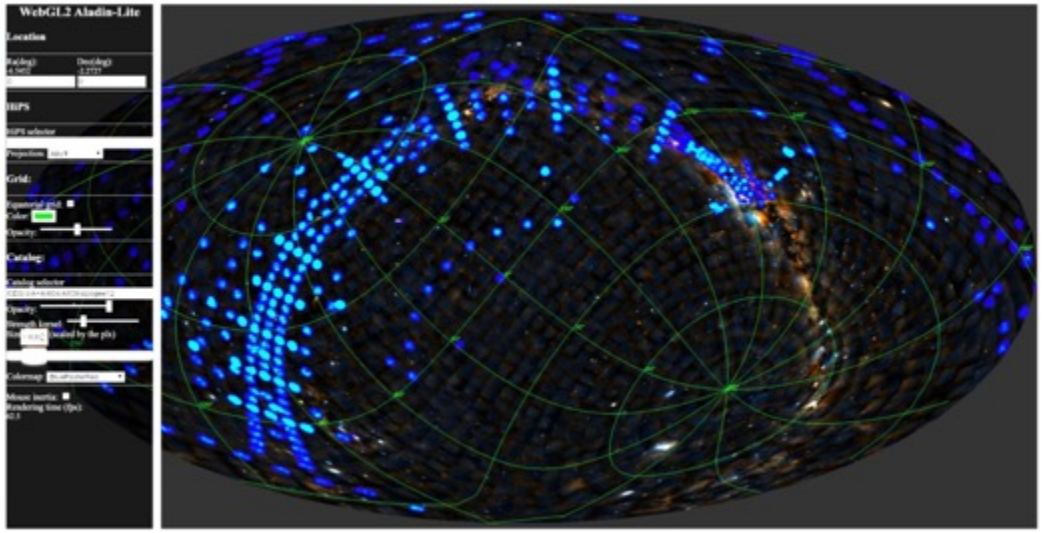
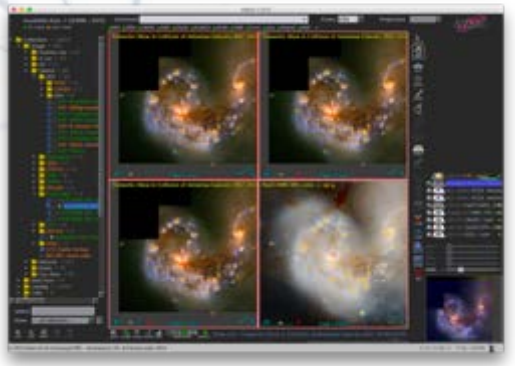
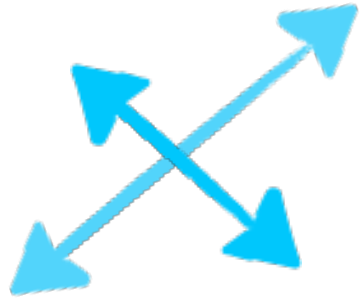
CEVO: VO interoperability in context of ESCAPE / EOSC

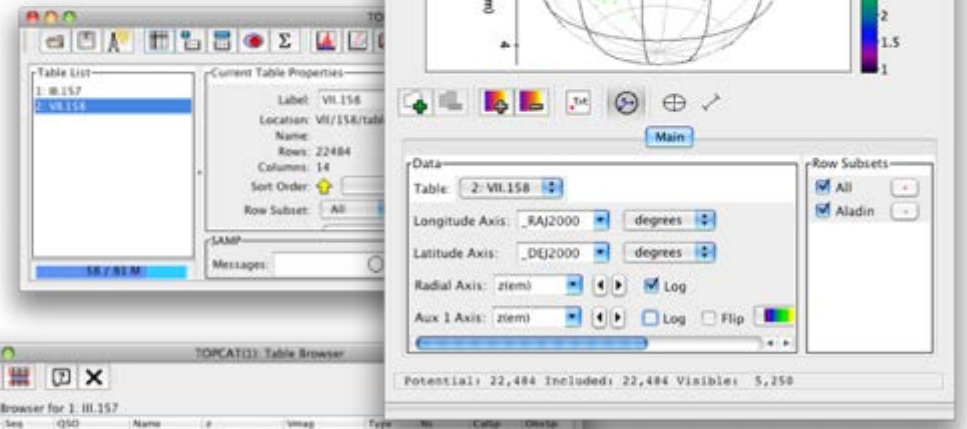


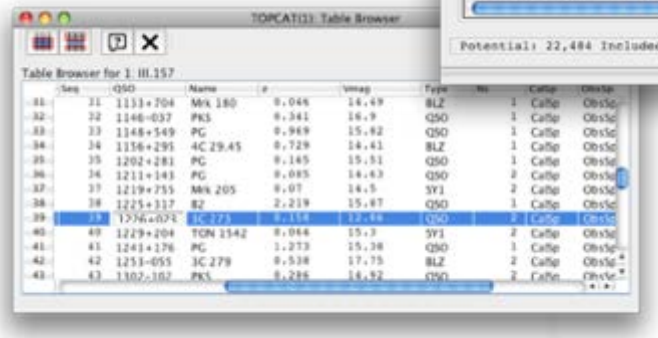
New improved WebGL Aladin Lite

Notebooks & Platforms









TOPCAT

Broadcast

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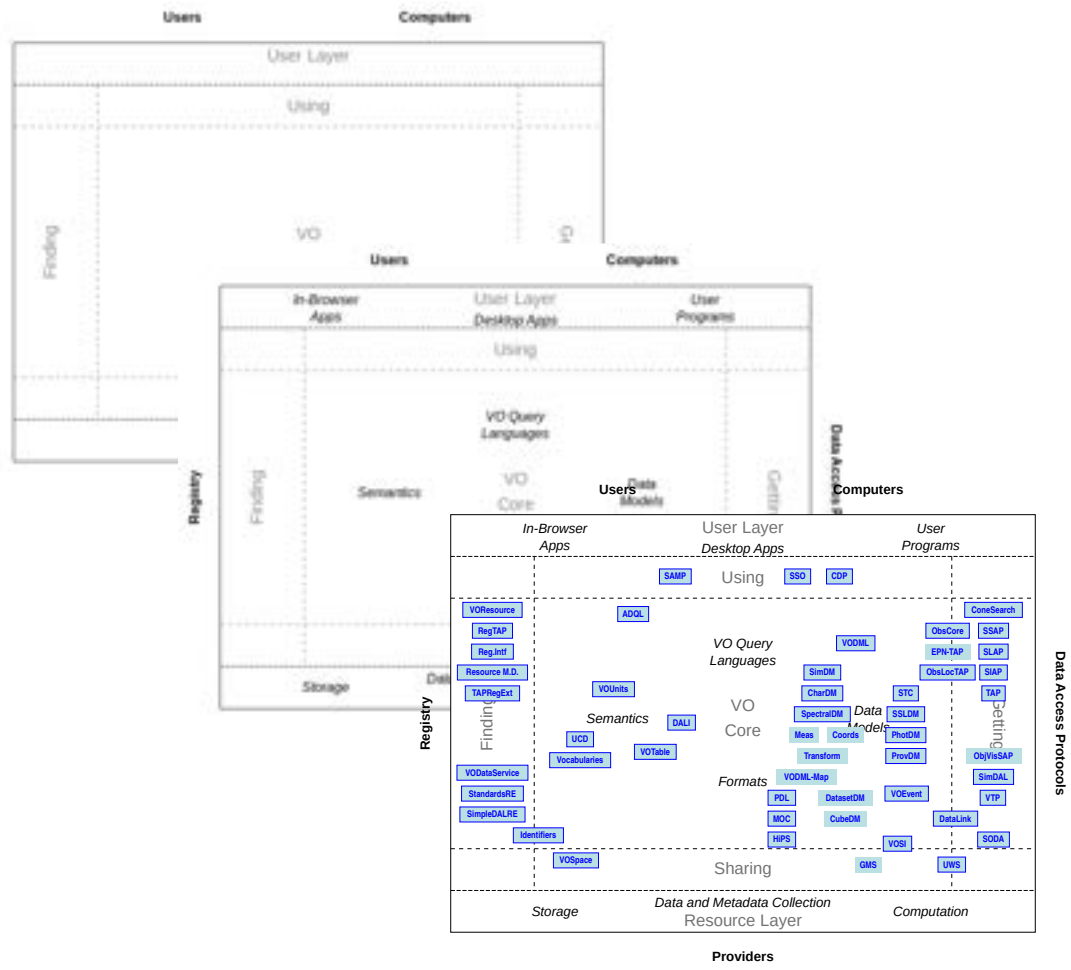
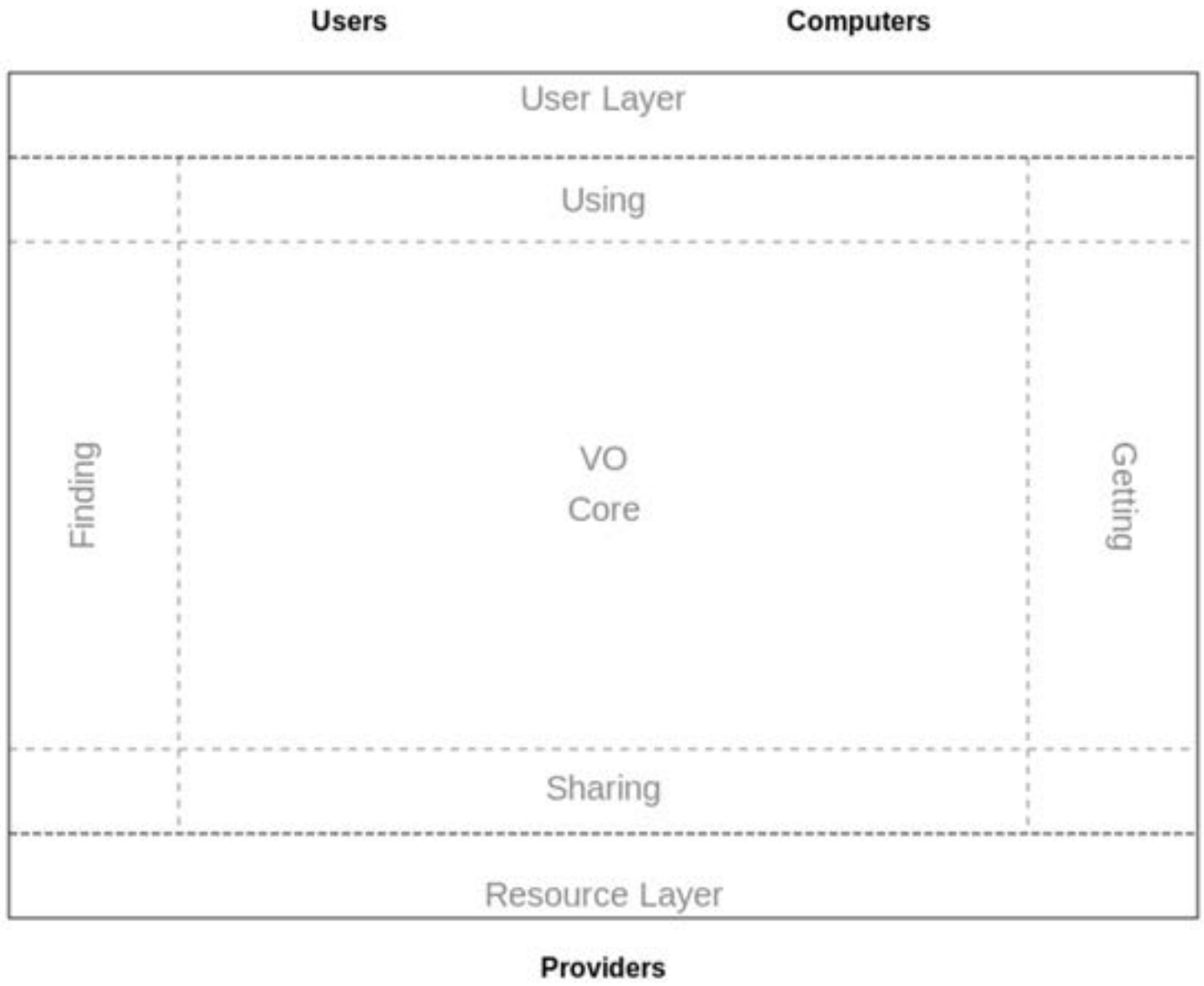
IVOA Architecture – 3 levels

47 IVOA standards

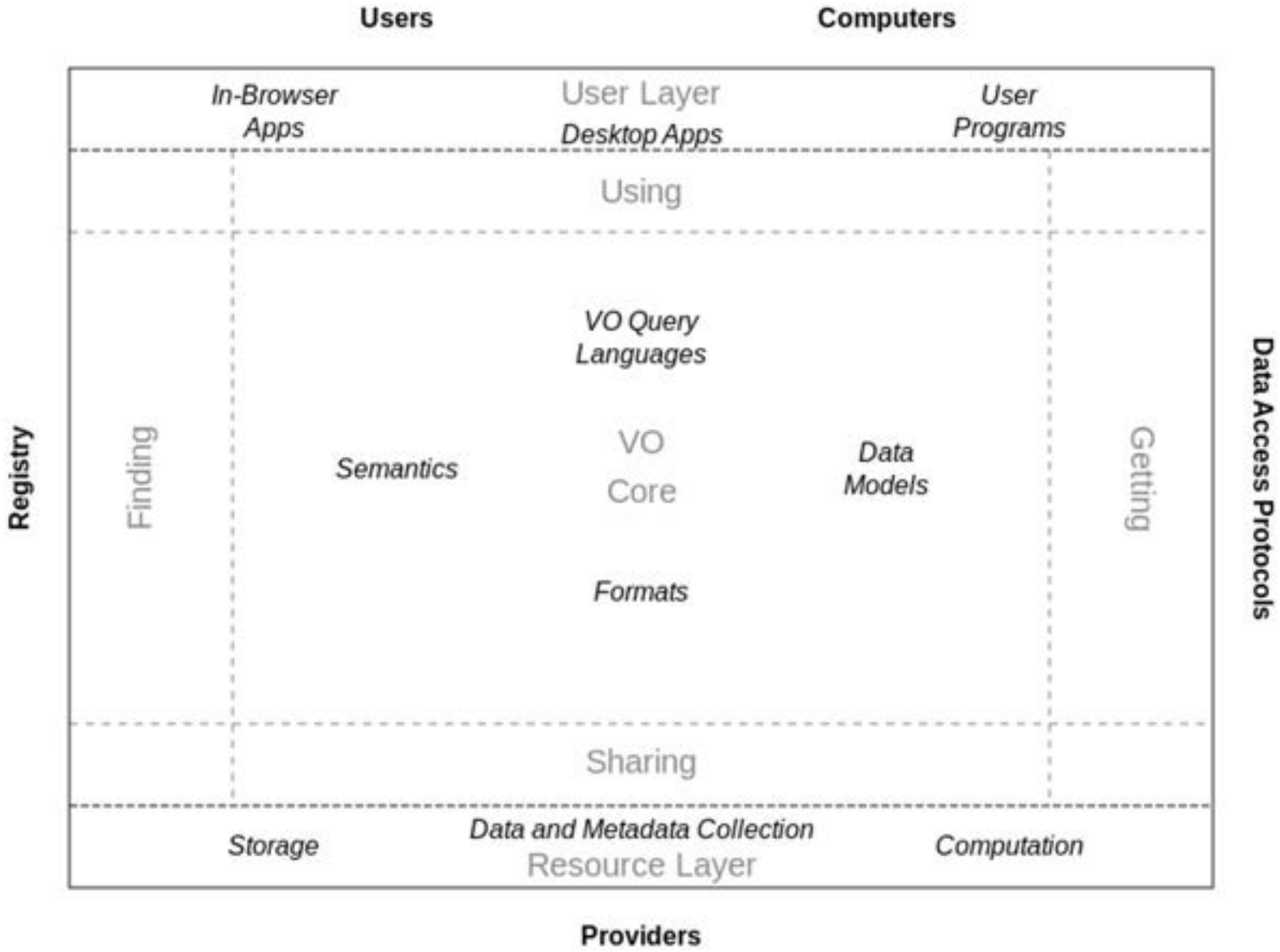
- Authentication and Authorization – 3
- Application and Format – 4
- Semantics – 3
- Registry – 9
- Data Model – 13
- Data Access – 11
- Infrastructure Resource – 4



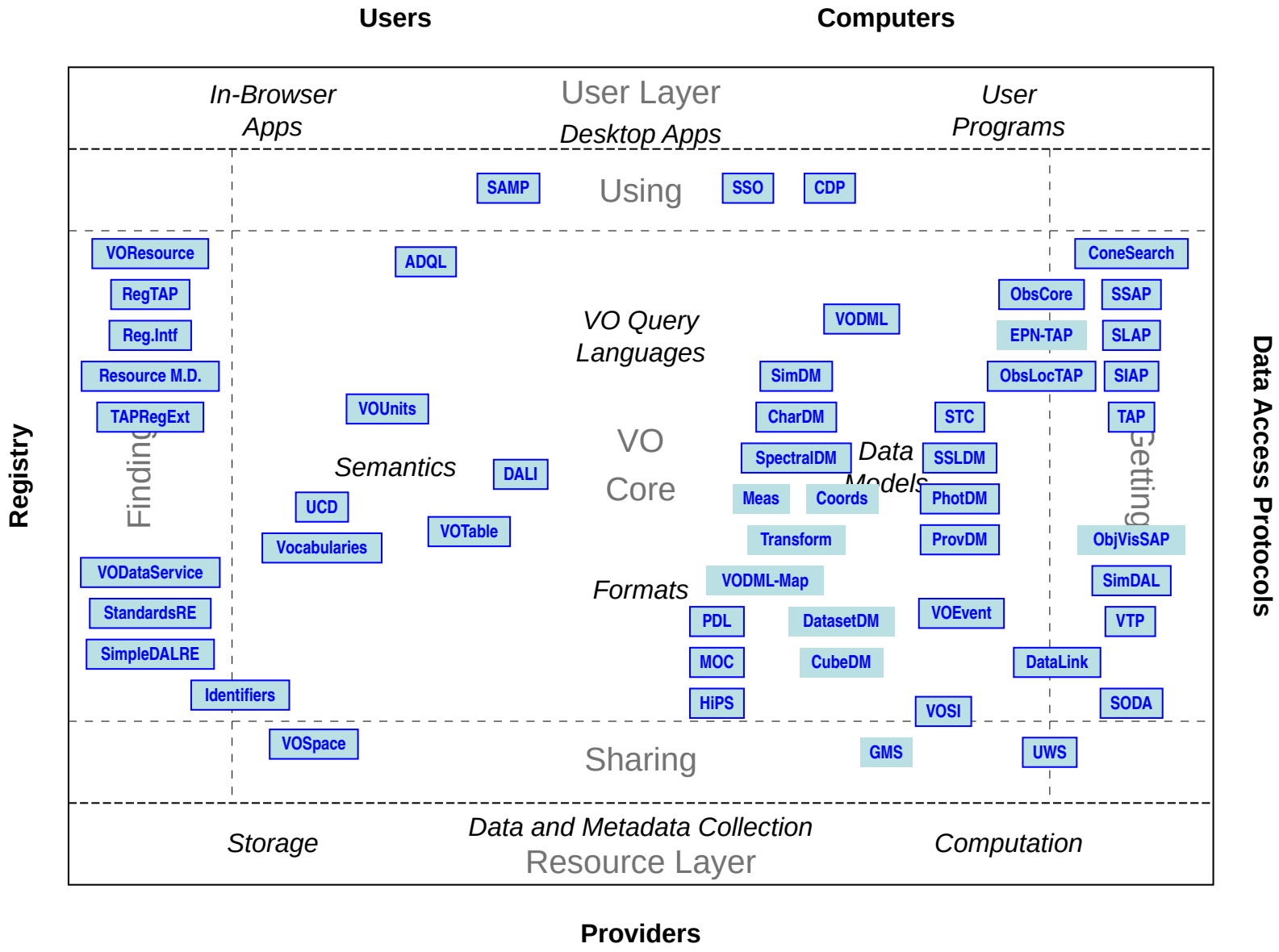
IVOA Architecture - Level 0



IVOA Architecture - Level 1

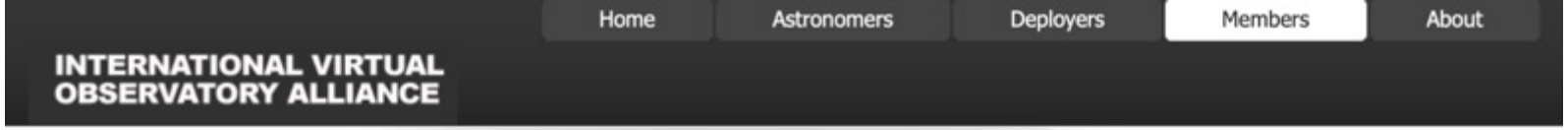


IVOA Architecture - Level 2



REC

WD



Documents & Standards

DOCUMENTS XML SCHEMA TEMPLATES DOC SUBMISSION

- *Technical Specifications*
- *Notes*
- *Promotion process*
- *IVOA Technical Assessment and Roadmap Documents*
- *Submission Log*

Technical Specifications

>

Group	Title	Most stable	In progress	Version history
App	SAMP - Simple Application Messaging Protocol	1.3		1.3 1.3 1.3 1.3 1.3 1.2 1.2 1.2 1.11 1.11 1.10 1.00
	VOTable - VOTable Format Definition	1.4		1.4 1.4 1.4 1.4 1.4 1.4 1.3 1.3 1.3 1.2 1.2 1.2 1.20 1.20 1.10 1.00
	MOC - HEALPix Multi-Order Coverage Map	1.1		1.1 1.1 1.1 1.1 1.1 1.0 1.0 1.0 1.0 1.0
	HiPS - Hierarchical Progressive Survey	1.0		1.0 1.0 1.0 1.0 1.0 1.0
DAL	DALI - Data Access Layer Interface	1.1		1.1 1.1 1.1 1.1 1.1 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
	DataLink	1.0		1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
	Simple Cone Search	1.03	1.1	1.1 1.03 1.02 1.01 1.00
	SIA - Simple Image Access	2.0		2.0 2.0 2.0 2.0 2.0 2.0 2.0 1.0 1.0 1.0 1.01 1.00
	SLAP - Simple Line Access	1.0	2.0	2.0 2.0 1.0 1.0 1.0 1.0 1.0 1.0
	SSA - Simple Spectral Access	1.1		1.1 1.1 1.1 1.1 1.04 1.03 1.02 1.01 1.01 1.00
	STC-S: Space-Time Coordinate Metadata Linear String Implementation	1.0		1.0
	TAP - Table Access Protocol	1.1		1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.0 1.0 1.0 1.0 1.0 1.00
	TAPRegExt - A VOResource Schema Extension for Describing TAP Services	1.0		1.1 1.0 1.0 1.0 1.0 1.0 1.0 1.0
	ADQL - Astronomical Data Query Language	2.00	2.1	2.1 2.1 2.1 2.00 2.00 2.00 1.01 1.00
	SimDAL - Simulation Data Access Layer	1.0		1.0 1.00 1.00 1.00 1.00 1.00 1.00
	VOEvent Transport Protocol	2.00		2.00 2.00 2.00 1.00

http://ivoa.net/documents

astrophysics data system

Available via ADS, with DOI

FAIRsharing.org
standards, databases, policies

Listed in FAIRsharing

European Union's
Grant N° 824064

ESFRI / RIs	Results for ESCAPE work toward FAIR standards and tools
ESO-ELT ESO, CNRS-ObAS, INTA, INAF,UHEI UEDIN, HITS	- Data access and visualisation standards and tools - Support of **VO standards in ESO archive** services – used as exemplary case to help others - Relevant IVOA standards updated …
EGO/VIRGO EGO (INFN), CNRS-ObAS,	- Development of **MOC2.0 and mocpy** - Tools / libraries integrated into GW community software - Paper submitted to Astronomy & Computing
SKA, JIVE, ALMA (LOFAR) JIVE, ASTRON, SKAO, ESO/ALMA, UHEI, CNRS-ObAS	- Creation and support of the **IVOA Radio Astronomy** Interest Group - Example TAP services, accessible in VO tools and in the ESCAPE platform
CTA & KM3NeT CTAO, Obs-Paris, CNRS (ObAS+CPPM) UHEI	- Data Provenance standards approved by IVOA - Many activities for adoption and implementation (Workshop held) - Reference paper published on a: ***Management System for Provenance Information***
EST ORB, KIS, CNRS-ObAS, INTA, UHEI	- VO metadata developed for Solar Physics - Prototype TAP services for solar data

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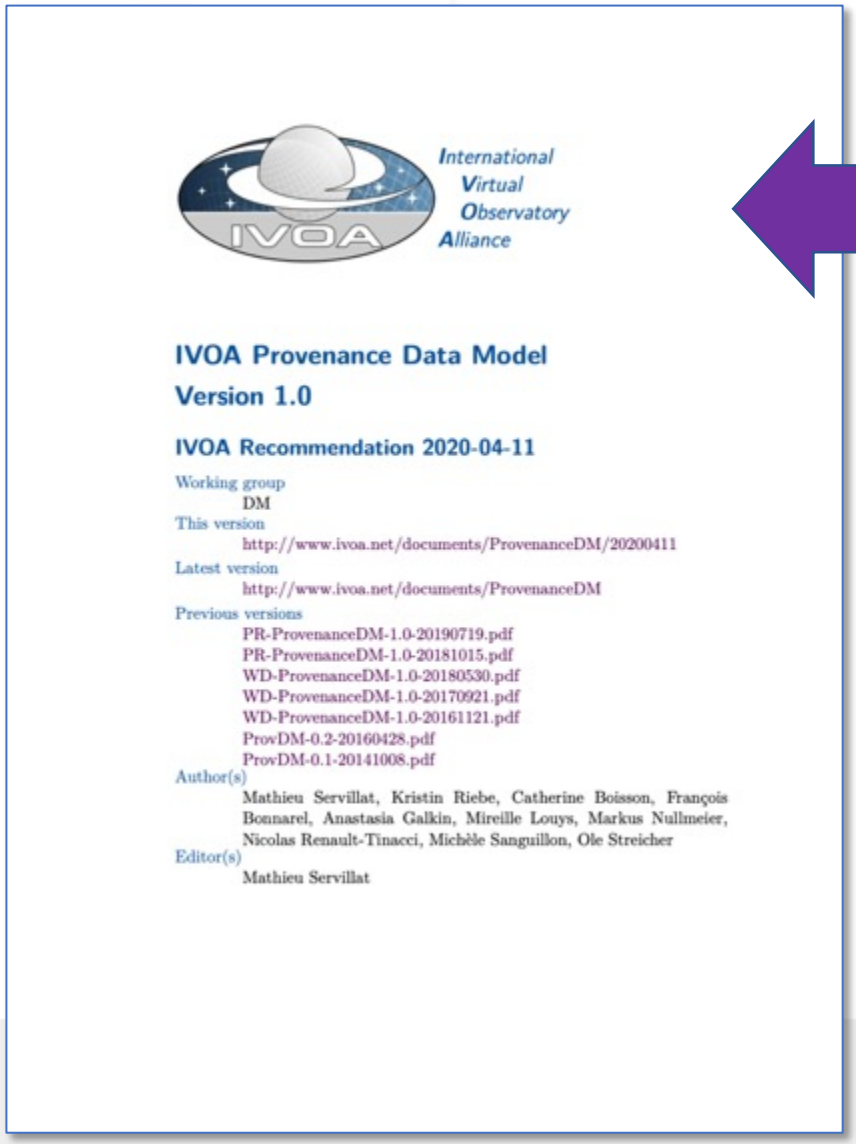
Example – 2 of the standards led/contributed to by ESCAPE partners



International Virtual Observatory Alliance

IVOA Provenance Data Model

Version 1.0

IVOA Recommendation 2020-04-11

Working group
DM
This version
http://www.ivoa.net/documents/ProvenanceDM/20200411
Latest version
http://www.ivoa.net/documents/ProvenanceDM
Previous versions
PR-ProvenanceDM-1.0-20190719.pdf
PR-ProvenanceDM-1.0-20181015.pdf
WD-ProvenanceDM-1.0-20180530.pdf
WD-ProvenanceDM-1.0-20170921.pdf
WD-ProvenanceDM-1.0-20161121.pdf
ProvDM-0.2-20160428.pdf
ProvDM-0.1-20141008.pdf
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Editor(s)
Mathieu Servillat

Provenance Data Model

Finalised and approved April 2020

Brought to community via **ESCAPE Provenance workshop** September 2020
- **Published -** Servillat et al. – SPIE

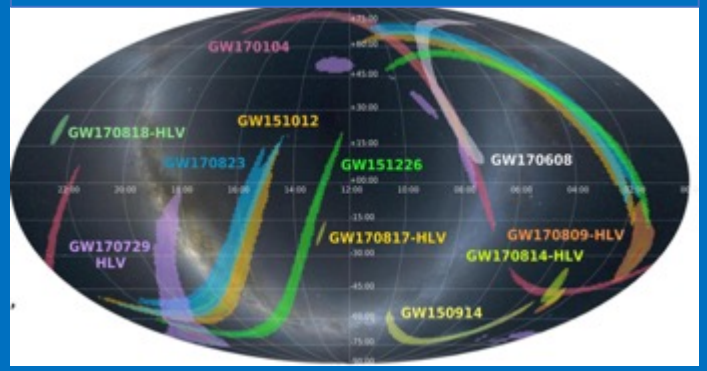
Multi-Order Coverage 2.0

Space coverage extended with TIME coverage. Draft in progress 2021.

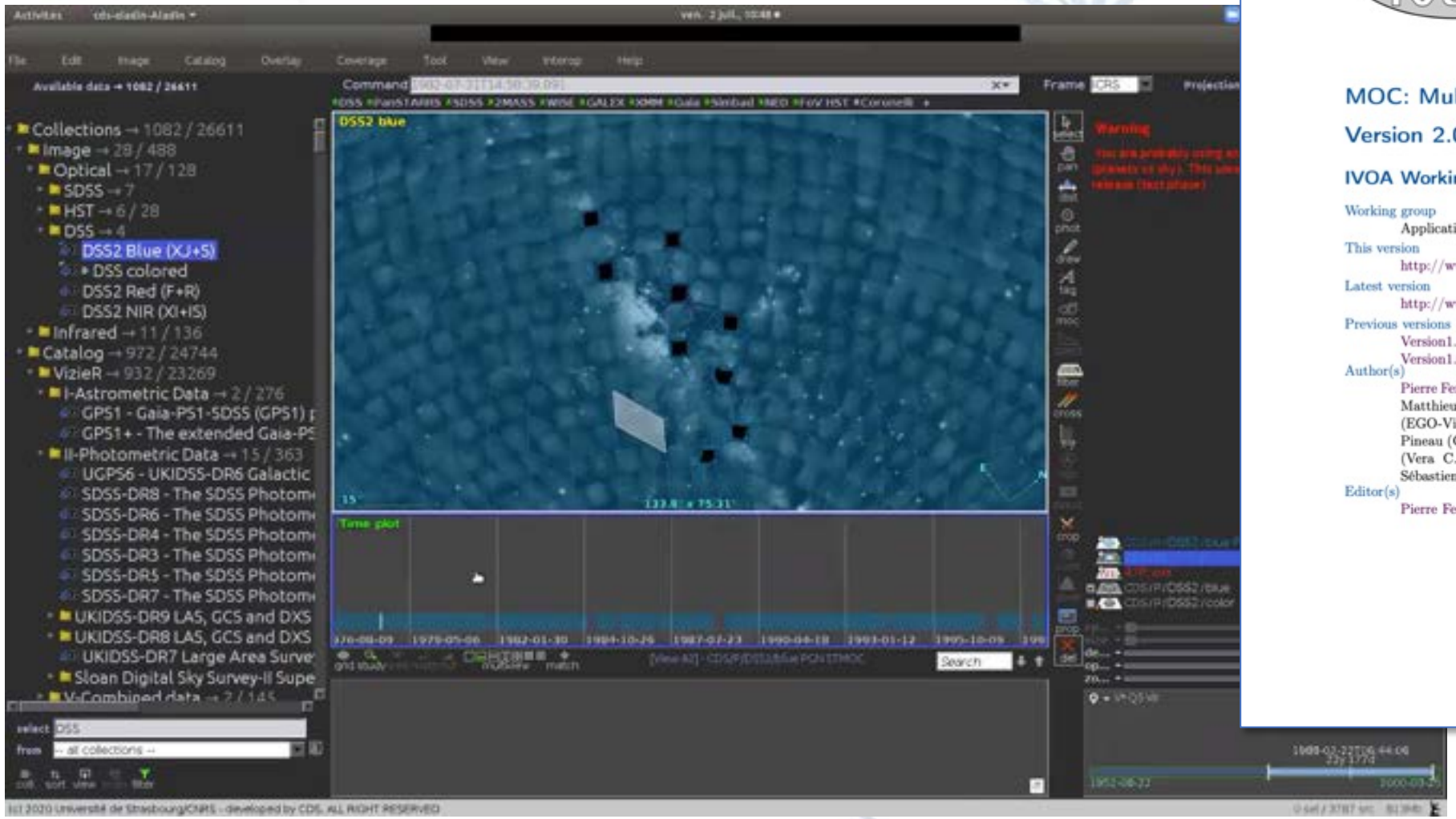
Driven by ESFRI/RI needs (EGO, ESO, Radio astronomy,+++)

International Virtual Observatory Alliance

e.g. IVOA metadata for Sky Coverage maps of Gravitational Wave detections



Demo



International Virtual Observatory Alliance

MOC: Multi-Order Coverage map

Version 2.0

IVOA Working Draft 2021-03-24

Working group
Applications

This version
http://www.ivoa.net/documents/moc/20210324

Latest version
http://www.ivoa.net/documents/moc

Previous versions
Version1.1
Version1.0

Author(s)
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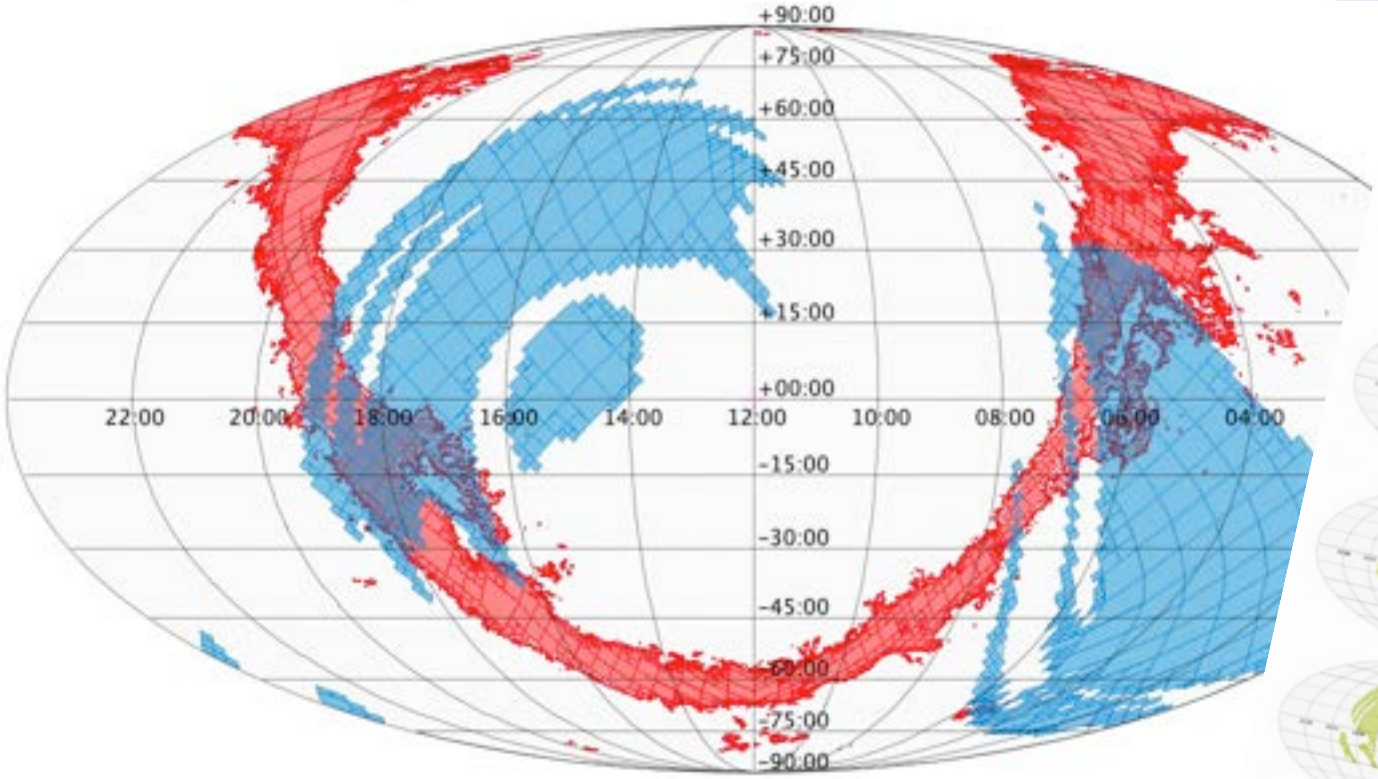
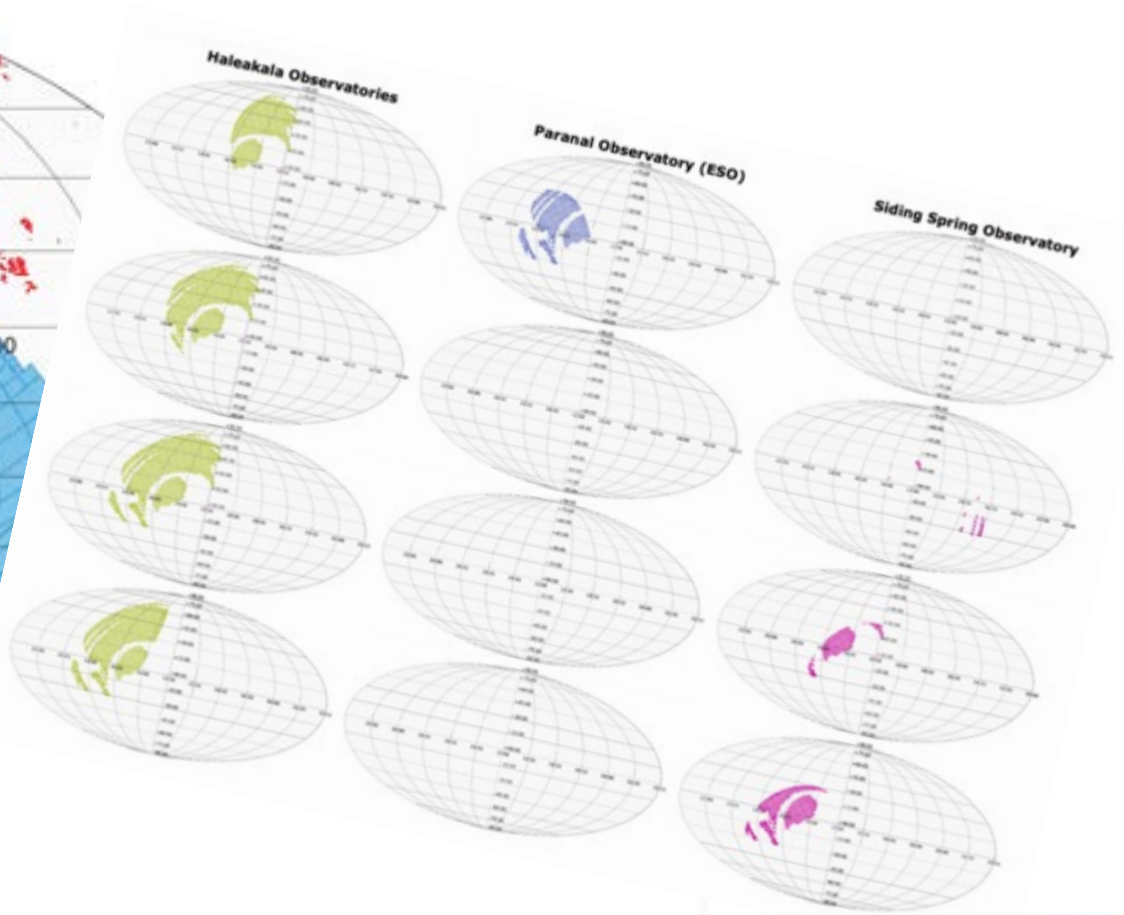
Application – Planning of GW follow-up observations





Greco et al, submitted Astronomy & Computing 2021

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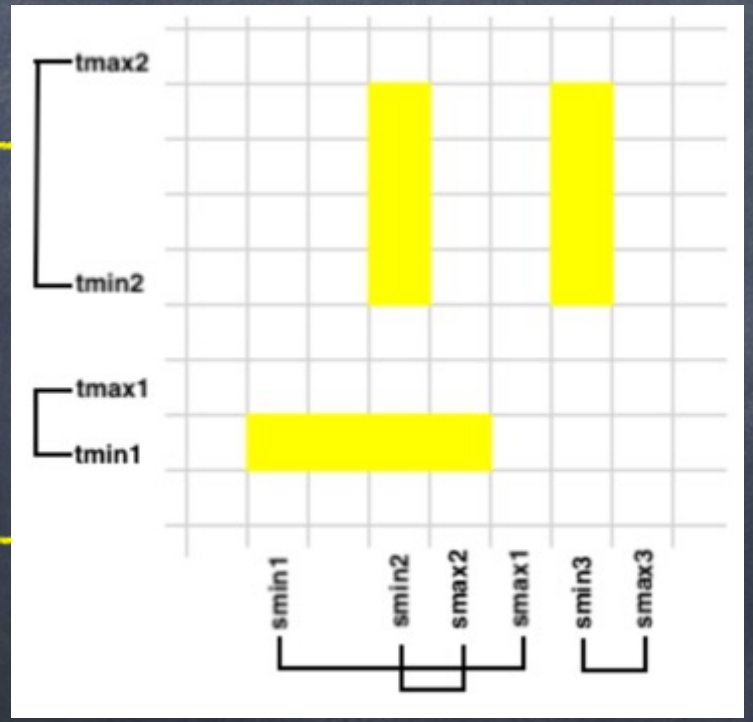
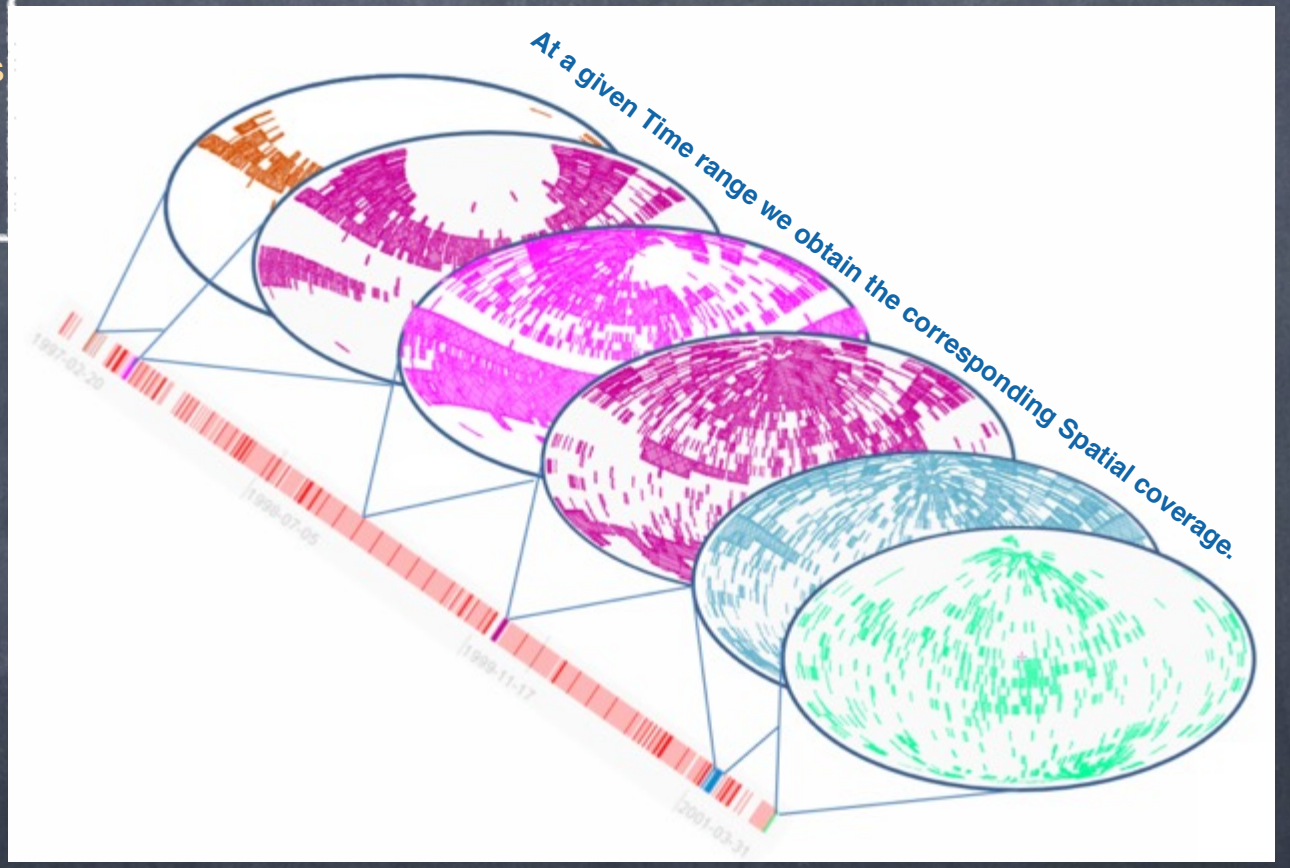
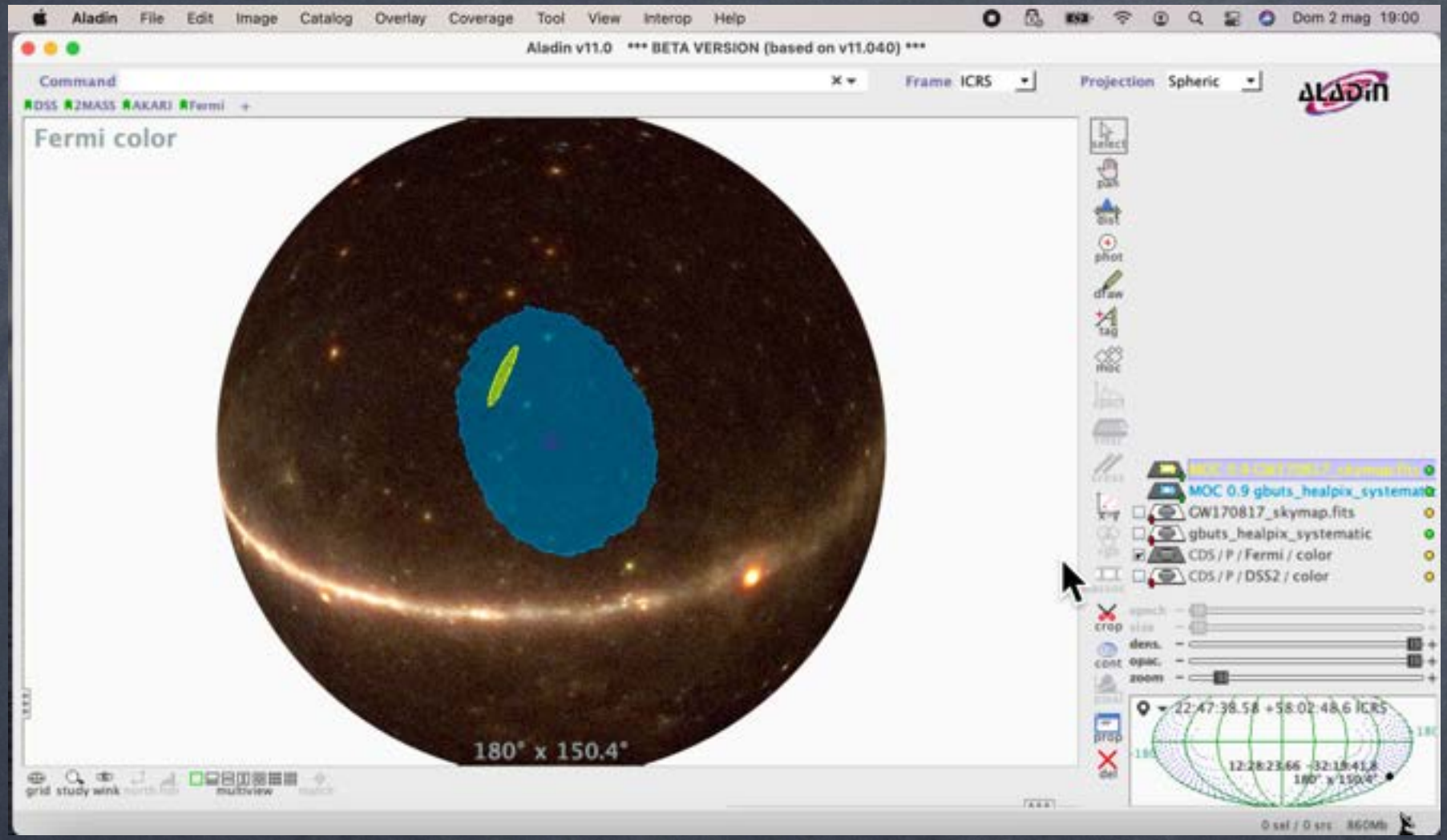
Space-Time MOC

For each element of a temporal coverage we list the associated spatial coverage. The time scale is hierarchically divided in intervals grouped 2 by 2 with 62 orders and the time coverage for the deepest order is 1 µs.

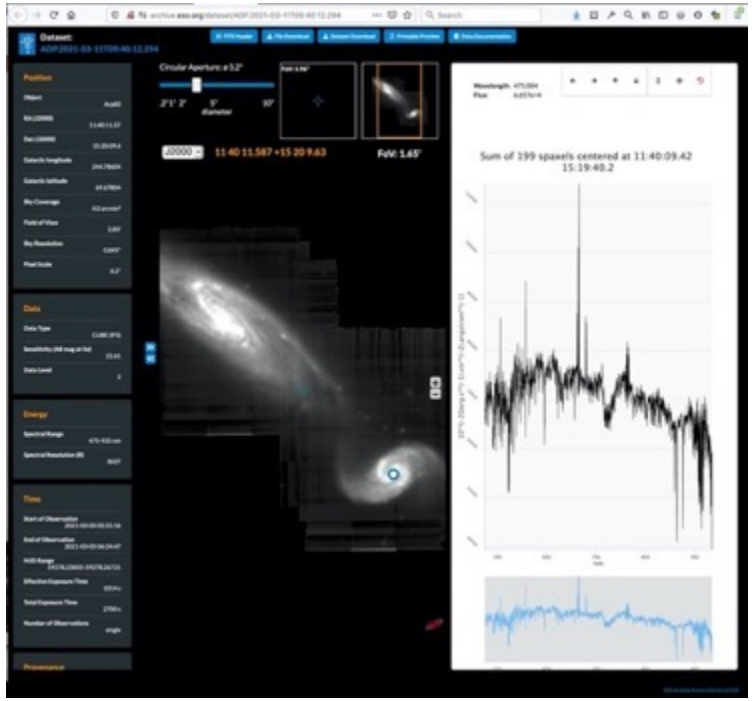
Interleaving approach has the advantage of making the resolutions chosen for time and for space independent.

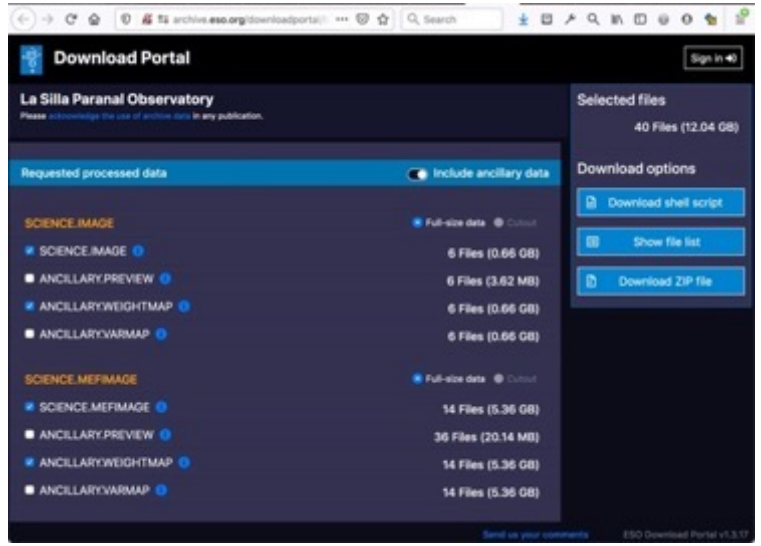






Through the Aladin graphical interface, we simultaneously visualize the spatial and temporal coincidence between the GW170817 and the short GRB170817.





ESO Science Portal (web interface)

Science Archive Programmatic and Tools Access

Demo page

The purpose of this page is to help you to learn:

1. *how to compose URLs to interact with the different ESO science archive services, either programmatically or via tools;*
2. *how to construct queries to interrogate the various database tables of the ESO science archive, using ADQL and TAP;*
3. *how to put it all together and script your access to the ESO science archive, using the pyvo python module.*

If some terms in this page are not familiar to you, please read the overview page first.

In this page: [open] click here to read the page description...

Query a TAP Service | async Query Manager | Script your access | Configure tools | Learn dataset actions | VO standards & software | Change Log

TAP Service: tap_obs (http://archive.eso.org/tap_obs): raw, reduced and ambient data — its list of jobs: /async | ESO TAP Query Manager

/capabilities | /availability | /tables | /examples

TAP_SCHEMA database diagram

Service type: /sync
REQUEST: doQuery
FORMAT: votable | votable/td | votable/b | votable/b2 | votable/fits | fits | text | json
LANG: ADQL
MAXREC: 200
QUERY : ObsCore: Find spectra of sources observed in the H band by the VVV public survey

```
SELECT spectrum.* FROM
    (select * FROM ivoa.Obscore WHERE dataproduct_type='spectrum' and snr > 50

    (select * FROM ivoa.Obscore WHERE dataproduct_subtype ='tile'
    AND obs_collection = 'VVV'  AND em_min < 1.66E-6 AND em_max > 1.66E-6 ) V

WHERE CONTAINS( spectrum.s_region , VVV_H.s_region)=1
```

Submit the Query | Decode the ADQL string | Show the URL | Parse/Validate the ADQ

4. Spatial joins

Are you interested in finding images in different bands of the same sky region, for photometrical studies?

The following example shows how you can compose a spatial join, so to find:

- HAWKI images,
- within 10 degrees from the galactic plane,
- taken in the J and H filters,
- where the J and H images overlap,
- and ensuring that they overlap for at least 80% of the J band image area.

In [12]:
```
query = """SELECT J.* FROM
      (select * FROM ivoa.Obscore WHERE dataproduct_subtype ='srctbl'
      AND obs_collection = 'HAWKI'
      AND gal_lat < 10 AND gal_lat > -10
      AND em_min < 1.265E-6 AND em_max > 1.265E-6 ) J,

      (select * FROM ivoa.Obscore WHERE dataproduct_subtype ='srctbl'
      AND obs_collection = 'HAWKI'
      AND gal_lat < 10 AND gal_lat > -10
      AND em_min < 1.66E-6 AND em_max > 1.66E-6 ) H
```

In this page: [open] click here to read the page description...

Query a TAP Service | async Query Manager | Script your access | Configure tools | Learn dataset actions | VO standards & software | Change Log

Implemented IVOA Standards:	ADQL 2.0	DataLink v1.0	ObsCore v1.1	SSAP v1.1	TAP v1.0	UWS v1.1	DALI v1.1 2017-05-17
Software:	github taplib implements: ADQL, TAP, and UWS; by Grégory Mantelet (ARI - Astronomisches Rechen Institut, Heidelberg)						
	github SSAPServer implements SSAP v1.1; by Vincenzo Forchi (ESO)						
	ESO code (not distributed) implements DataLink, ObsCore; by DFI/ESO						

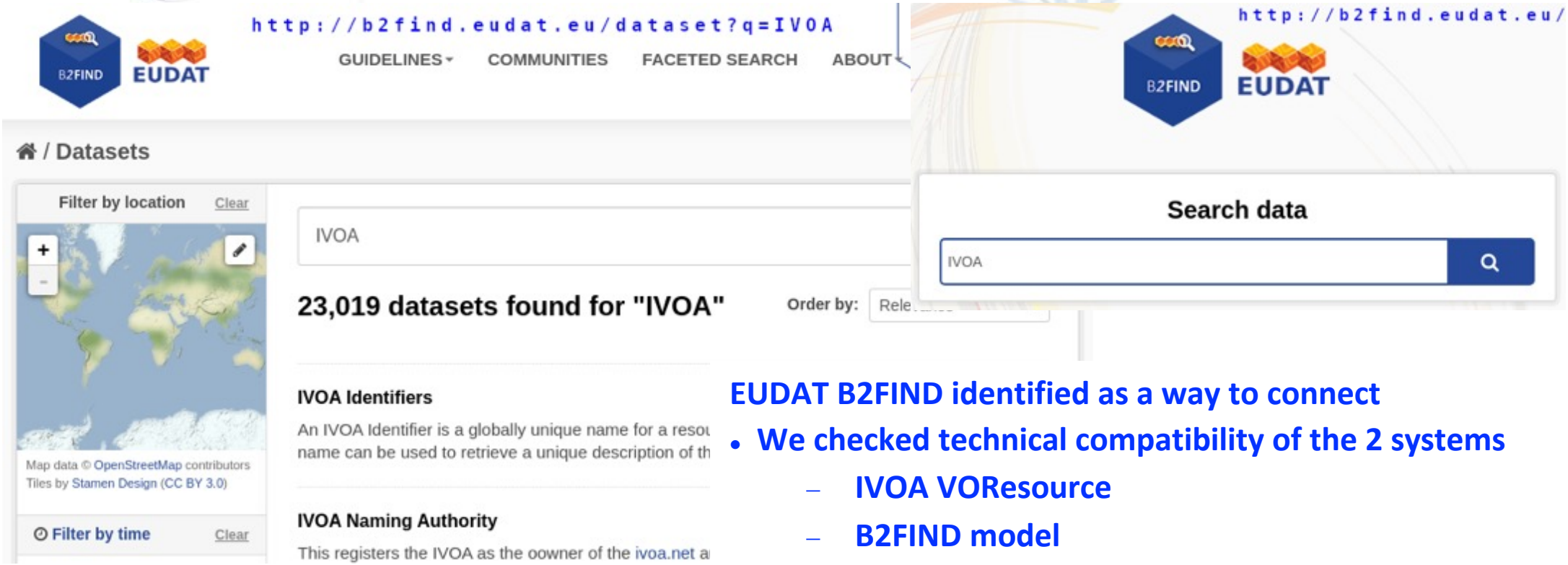
Last modification date of *IVOA standards & ESO software*: 2018-07-02

+ SODA

Programmatic and Tool Access

E.g. technical interoperability of metadata

IVOA Registry into EOSC via EUDAT B2FIND



EUDAT B2FIND identified as a way to connect

- **We checked technical compatibility of the 2 systems**
  - **IVOA VOResource**
  - **B2FIND model**
- **Both use OAI-PMH**
- **IVOA RegTAP service (@GAVO) has a DataCite extension**
  - **works as the harvest-able endpoint for the IVOA Registry**

Results are reported in D4.4: ***Intermediate analysis report of VO data and service integration into EOSC***

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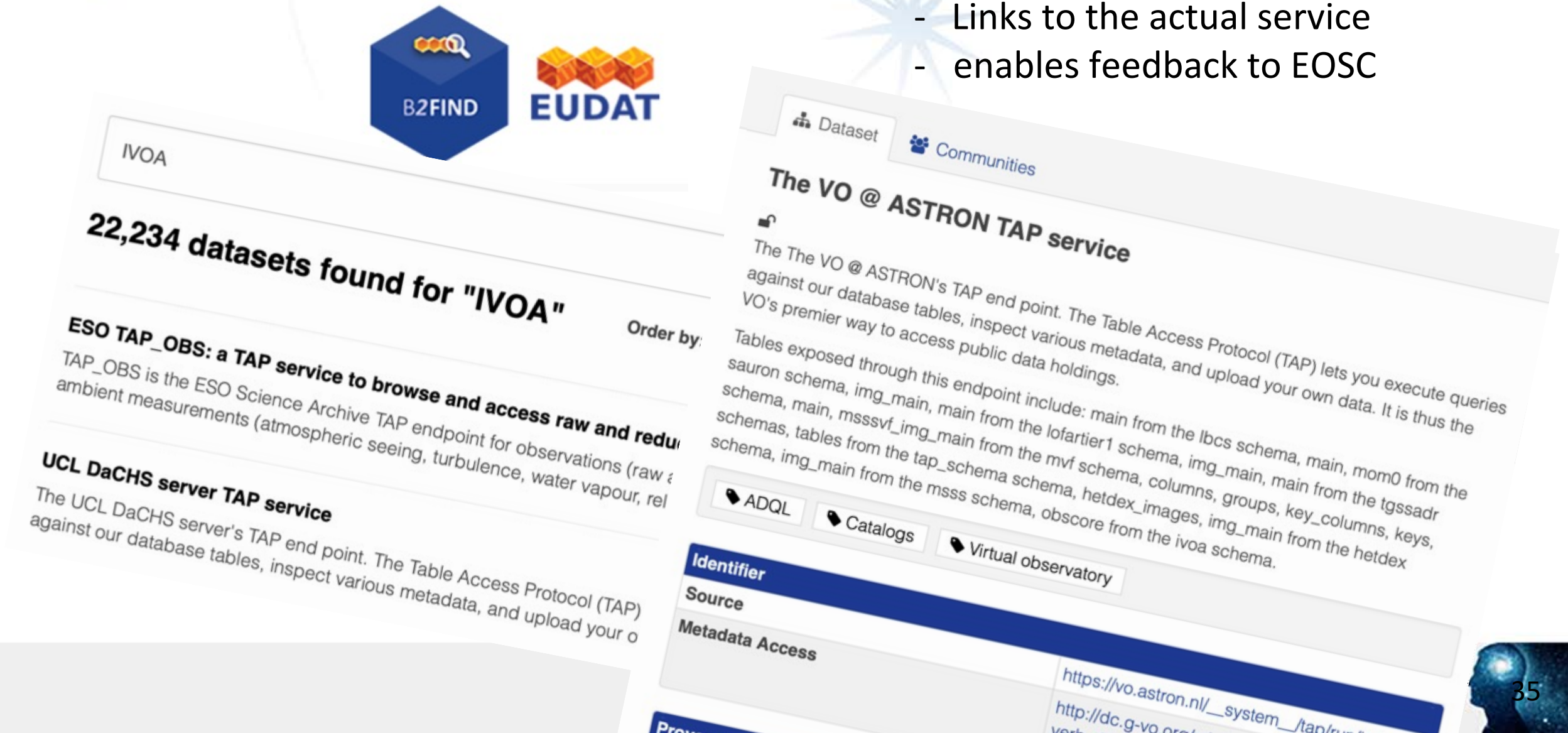
VO in B2FIND

- **Demonstrates 1st level of metadata compatibility**
  - Links to the actual service
  - enables feedback to EOSC



ESCAPE deliverable reports for use of FAIR Virtual Observatory framework in EOSC:

- D4.2 ***: Intermediate Analysis Report on Use of IVOA Standards for FAIR ESFRI and Community Data*** *– March 2020 (link)*

- D4.4 ***: Intermediate analysis report of VO data and service integration into EOSC*** *– November 2020 (link)*

Connecting to EOSC… a work in progress

Data Lake
Software Repository

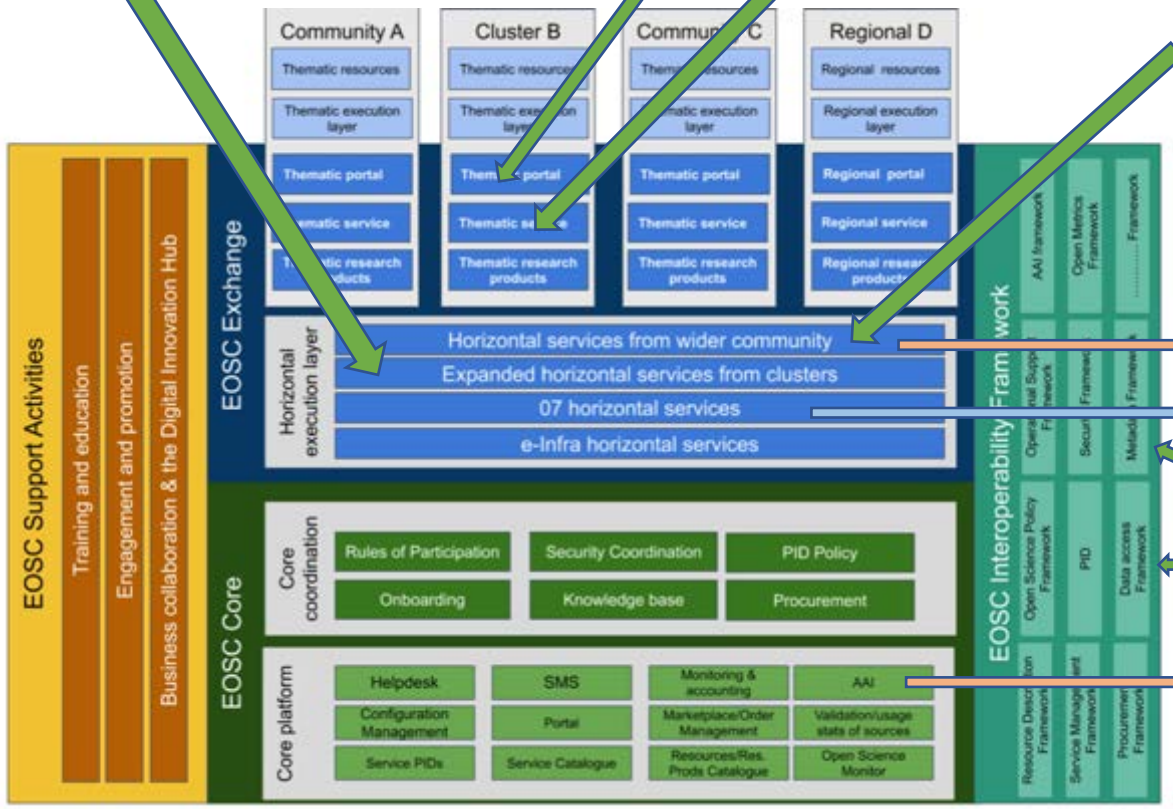
ESCAPE

Science Analysis Platform

Virtual Observatory services, ESFRI workflows

Citizen Science

+ Test Science Projects to enhance the researcher participation in EOSC



Generic services, e.g. notebook service, citizen science frameworks, …

Funded compute & storage resources

IVOA and other existing standards

AAI integration with DIOS

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ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures

Next steps for ESCAPE in theEuropean Landscape

Five thematic Science Clusters (80% of ESFRI RIs)

EOSC FUTURE

INFRAEOSC-07 Projects

EUROPEAN OPEN SCIENCE CLOUD

EuroHPC Joint Undertaking

PRACE PARTNERSHIP FOR ADVANCED COMPUTING IN EUROPE

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ESCAPE 2022-23

Wrapping up the project by January 2023

- Many integration activities between work packages
  - **Data Lake – Software Repository – VO – Analysis Platform – Citizen Science**
  - Test science projects that are supported in EOSC future.
    - 1 -- Dark Matter, 2 – Extreme Universe
- Inputs to next version of the EOSC SRIA
- Interaction with EOSC future for integration of ESCAPE services into EOSC
- Finalisation of the project – Events, Deliverables, Milestones, Reviews

- Participation in EOSC association Task Forces

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Some intersections of interest!

ESCAPE
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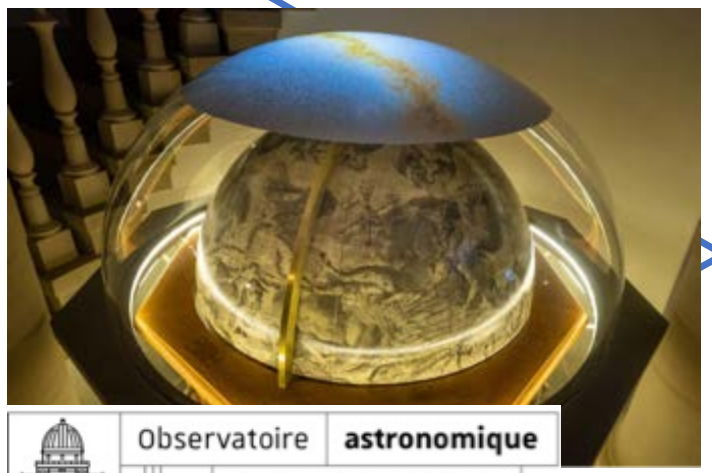
Open Science systems
- interdisciplinarity



Observatoire astronomique de Strasbourg | ObAS

Université de Strasbourg

CDS

Research data on the dome of the new planetarium!
- *IVOA Standards*
- *CDS data servers*
- *Digistar implementation*

Data stewardship
- *Sharing experience*
- *Training*

IVOA

EUROPEAN OPEN SCIENCE CLOUD

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Summary

- ❑ **EOSC is here and is developing quickly.**
- ❑ **ESCAPE addresses Open Science challenges in Astronomy and Particle Physics.**
- ❑ **Involvement in Open Science widens our horizons.**
  - Opportunities – Horizon Europe : Building EOSC for Open Science.
    -- Being connected to the ESFRI.
    -- Support for innovation at CDS.
  - Challenges – Integrating with the ‘generic infrastructures’
    -- Very high expectations for cross-disciplinary aspects.
  - Aspirations – CDS, UNISTRA to continue to be at the forefront of data sharing.

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ESCAPE

European Science Cluster of Astronomy &
Particle physics ESFRI research Infrastructures

THANK YOU!

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Horizon 2020 - Grant N° 824064

Extra slides

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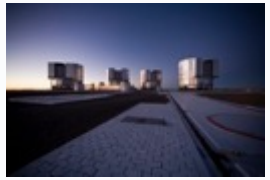
References

- **CDS:** https://cds.unistra.fr
- **ESCAPE:** https://projectescape.eu
- **IVOA:** https://www.ivoa.net
- **EOSC Association** : https://www.eosc.eu
- **Strategic Research and Innovation Agenda for EOSC** (v1): https://www.eosc.eu/sria
- **EOSC Partnership Proposal:** https://ec.europa.eu/info/sites/info/files/research_and_innovation/funding/documents/ec_rtd_he-partnership-open-science-cloud-eosc.pdf
- **EOSC Partnership MOU**: https://www.eosc.eu/sites/default/files/EOSC_Memorandum_30_July_2021.pdf
- **ESFRI Roadmap:** https://www.esfri.eu/esfri-roadmap
- **Turning FAIR into Reality report:** https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_1.pdf
- **Six Rec. for Implementation of FAIR Practice report**: https://op.europa.eu/en/publication-detail/-/publication/4630fa57-1348-11eb-9a54-01aa75ed71a1/language-en/format-PDF/source-166584930
- **French National Plan for Open Science**: https://www.ouvrirlascience.fr/the-national-plan-for-open-science/

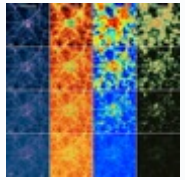
Astronomy data infrastructure

Archives and data services of Terrestrial and Space Observatories, Instruments and missions and projects



+ many more…

Simulation and modeling data



Astronomy Data Centres

Strasbourg astronomical Data Centre

CADC, MAST, HEASARC, IPAC, + …

Data published in, and associated with Journals

+ more…

Virtual Observatory (VO)

22 national / international members

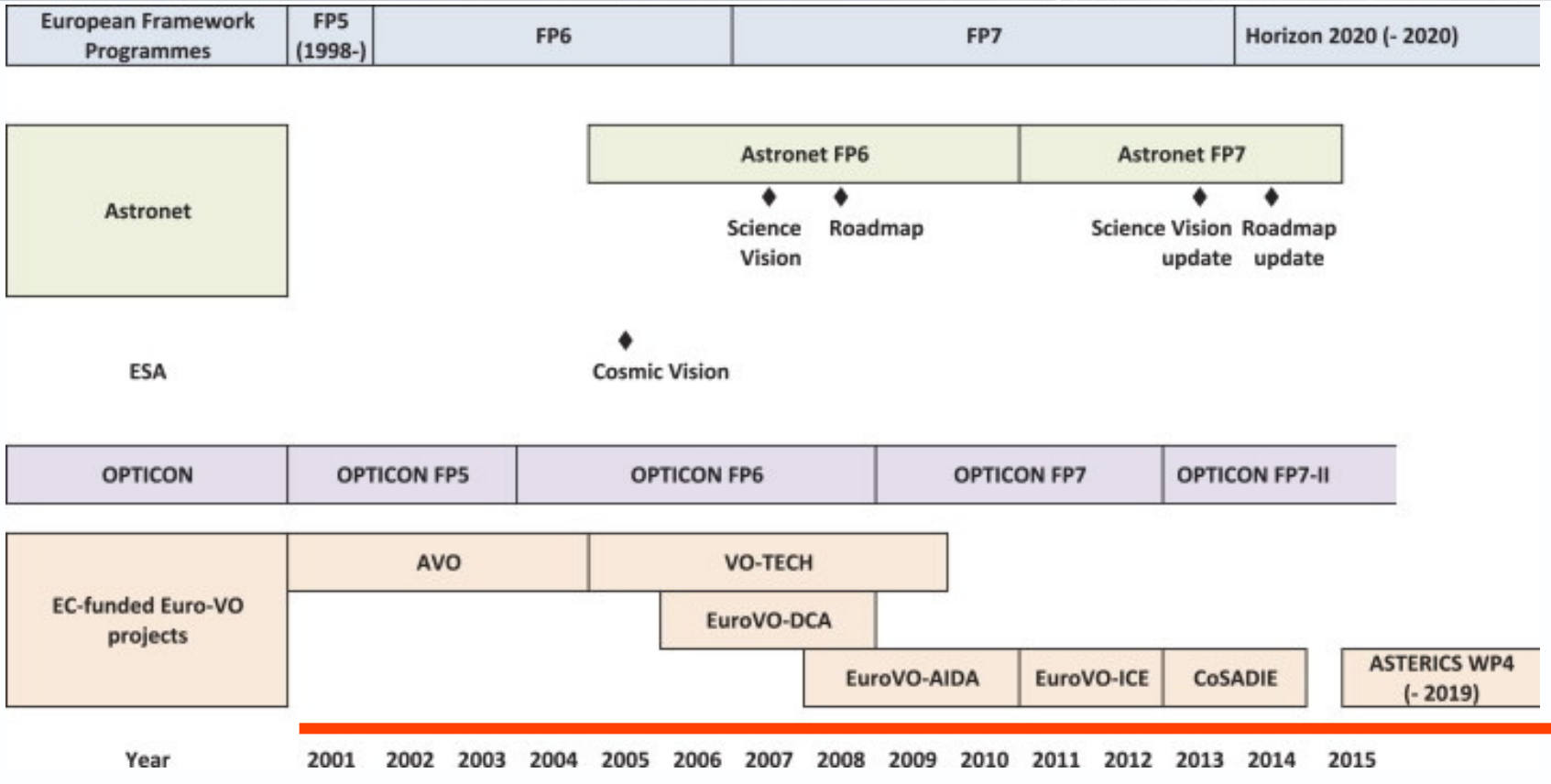
Related initiatives around Open Science

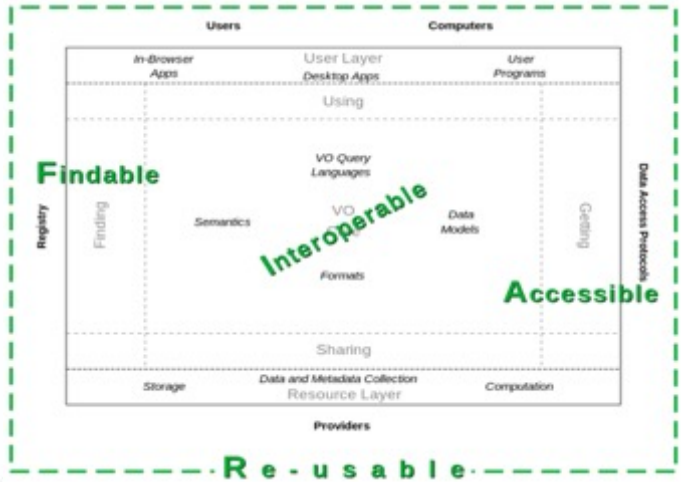
e.g.

Research data, e-Infrastructures and other wider initiatives …

Commercial Cloud services…

FAIR Astrophysics in Europe - historical overview



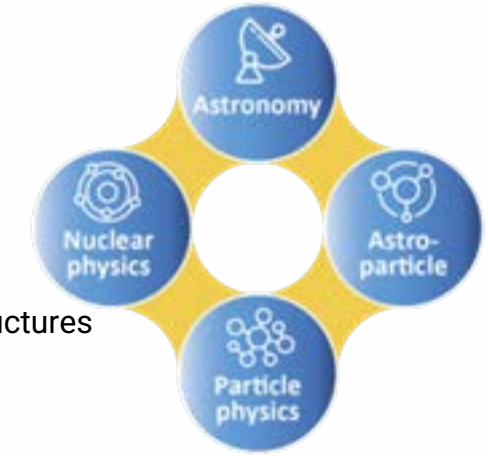


Genova & al. (2015)

ESCAPE Science Projects - background

- Two large Science Projects will be deployed with a number of high-level objectives:
  - To demonstrate new cutting-edge science capabilities, in particular those involving inter-RI collaboration and science outcomes;
  - To validate, that the software, tools, services, and infrastructure developed within ESCAPE are what is required by the science use cases;
- The SP objectives are supported by the thematic consortia (of the national funding agencies):
  - ECFA, APPEC, ASTRONET, NuPECC, and the collaboration of those bodies within JENAA.
- The European Strategy for Particle Physics update in 2020 encouraged synergies between these research infrastructures, via ESCAPE.
- *The communities are large, global, with collaborators across all areas of the world; users are typically physicists*
- *Many commonalities – common facilities and funding agencies*

European
Science
Cluster of
Astronomy &
Particle physics
ESFRI research infrastructures



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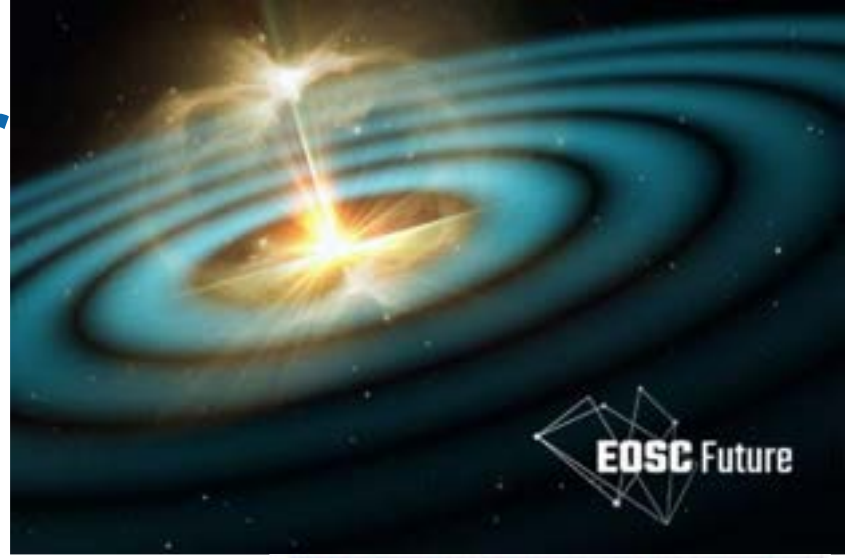
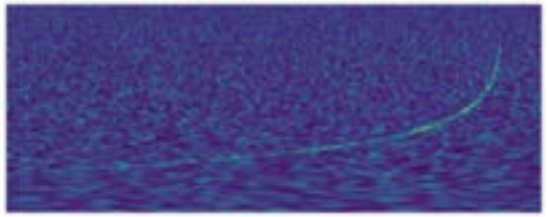
Gravitational Waves & Extr
Ambition, Impact, Challenge





- The **Extreme Universe** project intends to develop a **sustainable platform** within which to enable **multi-messenger/multi-probe astronomy** (MMA).
- There are many studies of **transient astrophysical** phenomena that benefit from the **combined use of many instruments** at different wavelengths and different probe types.
  - Many of these are based on the **trigger** of one instrument generating follow-ups from others at different timescales from seconds to days.
- The intention within ESCAPE is to **build such a platform for MMA** science in such a way as to make it sustainable.

- Multi-messenger observations could lead to images of strong gravitational effects that are expected near a black hole. **Extreme energetic astrophysical transient** phenomena such as GRB, AGN, FRB are also high-energy phenomena not yet fully understood. A **data sharing** and **open-science approach** are key to adding knowledge and progressing towards an understanding.

- A **holistic approach** to black holes and **exploiting gravitational waves** for fundamental physics are the main guidelines of this SP. The 'frontier' for multi-messenger science is to understand **extreme matter and particle processes in strongly curved spacetime**. The SP (also to be accessible from the EOSC portal) would implement an **integrated platform for Multi-Messenger** Astronomy where data from different wavelengths/messengers can be easily **gathered, analyzed and modelled holistically,** and not remain fragmented as at present.