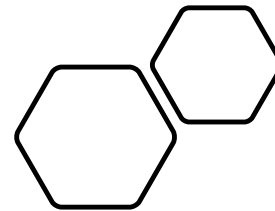# FAIR Principles in the IVOA

Division B Days, IAU General Assembly (August 2022)

G. Bruce Berriman

(Caltech/IPAC-NExScI)

Chair, IVOA Exec Committee, May 2021 – Oct 2022.
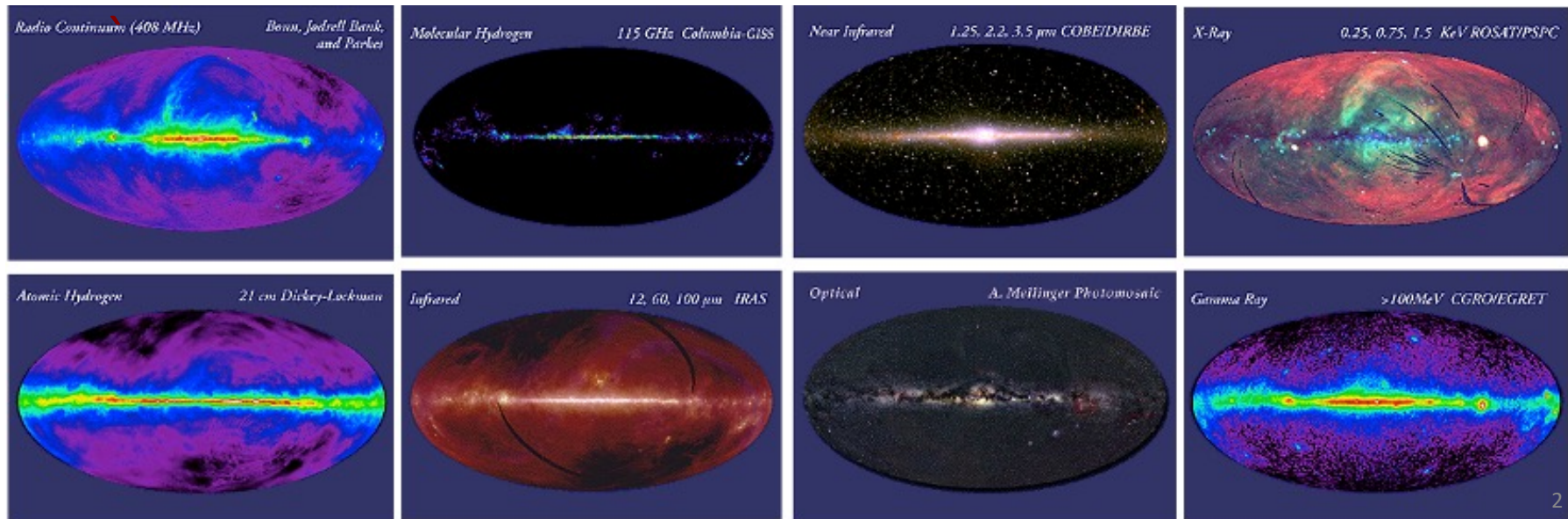
What Is The Virtual Observatory?

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

- Pepi Fabbiano

The International Virtual Observatory Alliance: How The VO Gets Built

- Data are in archives distributed worldwide ➜ define standards that enable archives to interoperate seamlessly.
- The International Virtual Observatory Alliance (IVOA) is the international body that defines these standards (https://ivoa.net/)
- Founded in 2002, the IVOA today has 22 national VO member projects and two IGO's.
  - The SKAO is the newest member (June 2022)
- Goal from the outset was to enable seamless **interoperability** of **open** data and services **-> Implementing FAIR principles before they were formalized as such.**
- **Implementing IVOA standards makes your data *almost* FAIR.**

The VO In Action

NASA archives have implemented IVOA standards across distributed archives of heterogeneous data over 15 decades of frequency
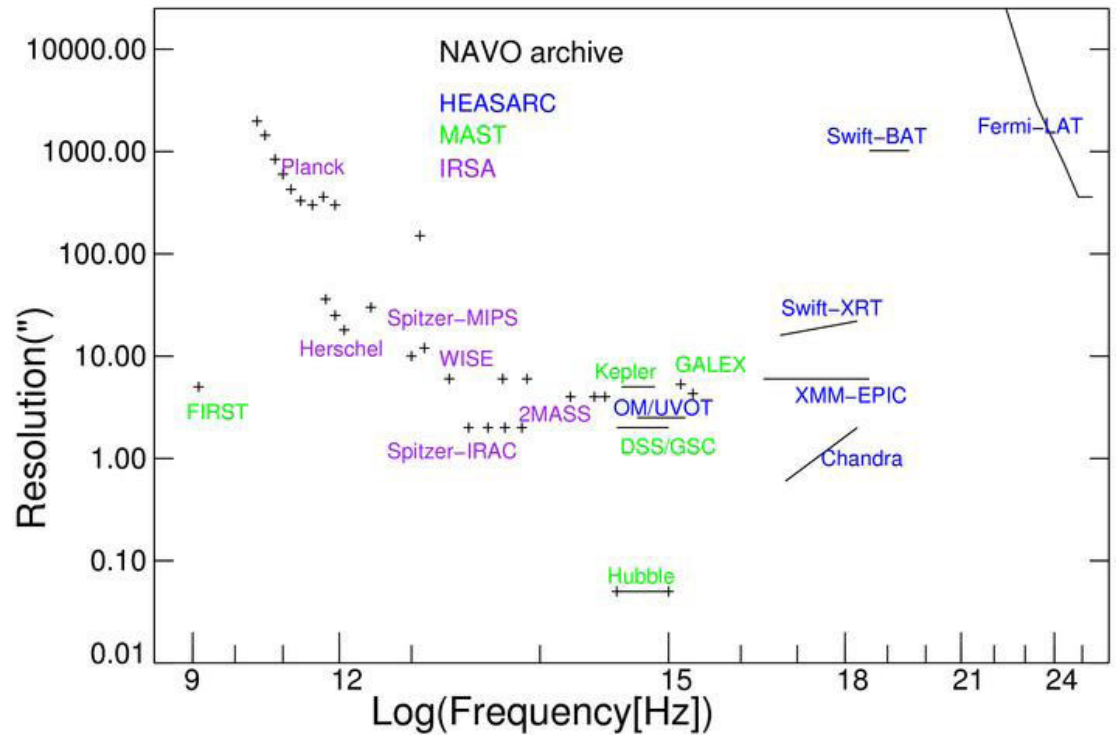
- Access to all of these data through common set of machine-based APIs.
- First such large-scale *distributed* implementation of VO standards.

# VO protocols Are At The Heart of ESASky

IVOA in the Community –ESASky

FAIR Principles and The IVOA

- The IVOA Architecture has strong parallels with the FAIR framework.
  - Focus on processes to move metadata and data through architecture rather than properties of the service or data

- To a large degree, implementing IVOA standards goes a long way to implementing FAIR principles.

- There are a few specifics that IVOA standards do not provide (out of scope or we are just implementing)

IVOA Architecture and FAIR Principles
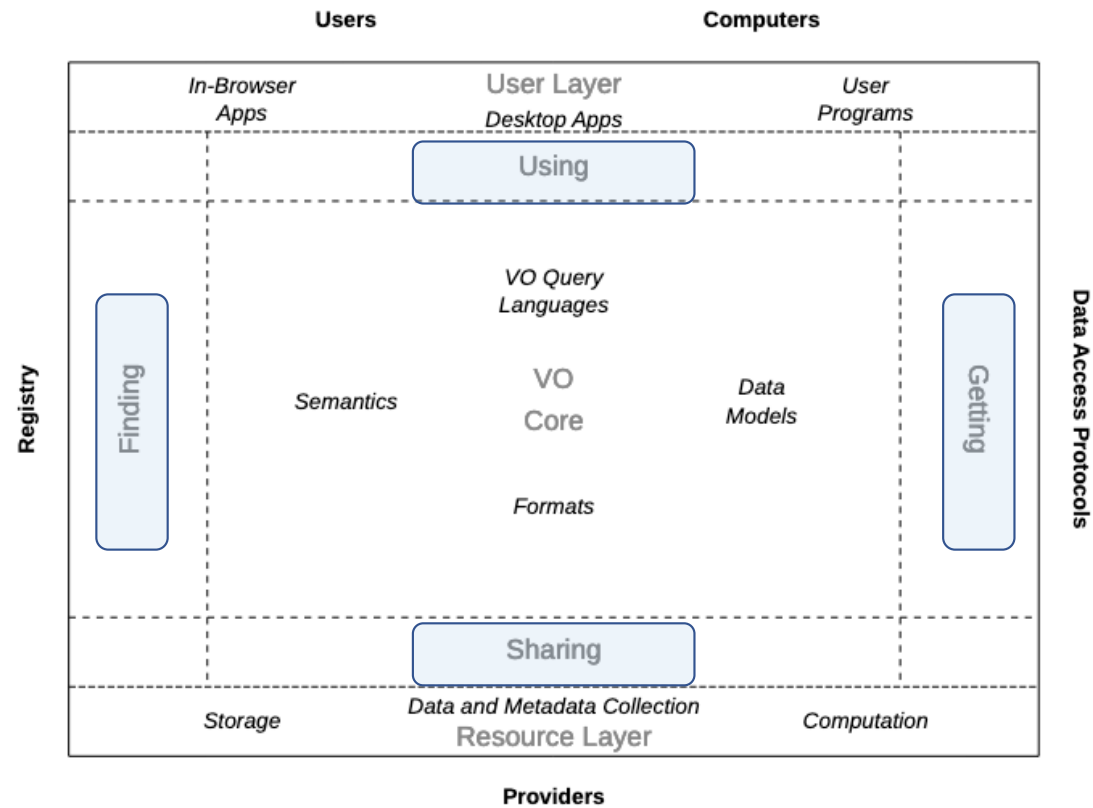
IVOA Standards are (Mainly) Findable

- F1. (meta)data are assigned a globally unique and persistent identifier
- F2. data are described with rich metadata (defined by R1 below)
- F3. metadata clearly and explicitly include the identifier of the data it describes
- F4. (meta)data are registered or indexed in a searchable resource

- F1. IVOA IDS are not citable
- F4. IVOA standards do not require that the data identifier be returned in all cases
- Left up to service providers

IVOA Standards are (Mainly) Accessible

- A1. (meta)data are retrievable by their identifier using a standardized communications protocol
- A1.1 the protocol is open, free, and universally implementable
- A1.2 the protocol allows for an authentication and authorization procedure, where necessary
- A2. metadata are accessible, even when the data are no longer available

- A2. IVOA standards have no rules about reliability and longevity.

- Again, left up to service provider.

- IVOA monitors services and provides regular weather reports on availability.

IVOA Standards are (Mainly) Interoperable

- I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.

- I2. (meta)data use vocabularies that follow FAIR principles

- I3. (meta)data include qualified references to other (meta)data

- IVOA standards implement vocabularies and in particular Universal Content Descriptors that mean I1, I2, I3 are all met but …

- … Strictly: Need a cross-referencing framework between data that describe the same object or phenomena - in development.
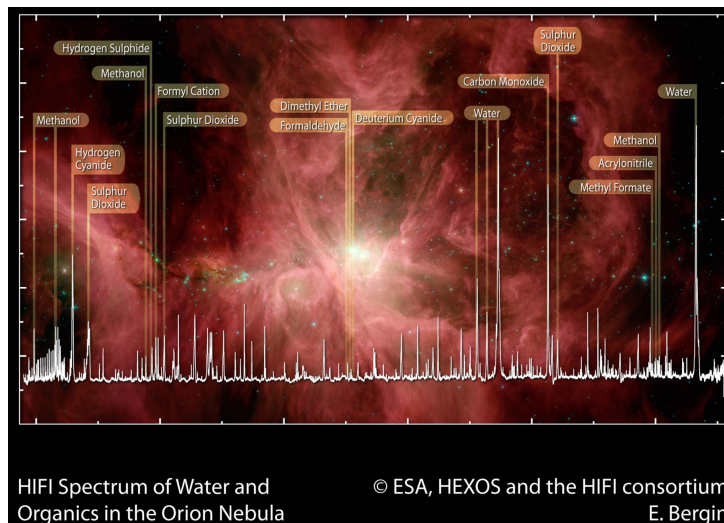
IVOA Standards are (Mainly) Re-usable

- R1. meta(data) are richly described with a plurality of accurate and relevant attributes
- R1.1. (meta)data are released with a clear and accessible data usage license
- R1.2. (meta)data are associated with detailed provenance
- R1.3. (meta)data meet domain-relevant community standards.

- R1.1 IVOA has no specifications about licenses - this is up to the provider
- R1.2 There is an IVOA Provenance Data Model was recently published and not all providers implement it.

Lab Astro and the IVOA

The Virtual Observatory needs laboratory data !

Main usage : identify lines in spectra

HIFI Spectrum of Water and Organics in the Orion Nebula

© ESA, HEXOS and the HIFI consortium
E. Bergin

Need access to line lists with interoperable tools
A first standard approved in 2010 : SLAP

International
Virtual
Observatory
Alliance

Simple Line Access Protocol

Version 1.0
IVOA Recommendation 09 December 2010

This version:
REC-SLAP-1.0-20101209
Latest version:
http://www.ivoa.net/Documents/SLAP
Previous version(s):

Editor(s):
Pedro Osuna
Jesus Salgado

Author(s):
Jesus Salgado
Pedro Osuna
Matteo Guainazzi
Isa Barbarisi
Marie-Lise Dubernet
Doug Tody

Lab Astro and the IVOA

New requirements :

- Better selection of lines in databases to simplify line identifications in VO applications :

    Filters on upper energy level, A_{ij}, number of atoms, isotopologues, …

- Access to the bibliographic references (DOI of the articles)

- Link / compatibility whenever possible with VAMDC/XSAMS

- Integration in the IVOA standards ecosystem

- Focus on atoms & molecules (solids/materials will be treated later)

Bedtime Entertainment

- Simon O'Toole. Invited presentation at ADASS XXX (Nov 2021) "Fair Standards for Astronomical Data." https://youtu.be/IBzGBEWF7Rs

- " FAIR standards for astronomical data." 2022. Simon O'Toole and James Tocknell. https://arxiv.org/pdf/2203.10710.pdf. To appear in Proc. ADASS XXXI.

- IVOA Architecture Document. https://ivoa.net/documents/IVOAArchitecture/20211101/EN-IVOAArchitecture-2.0-20211029.pdf