Radio astronomy and the VO

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Why the VO?

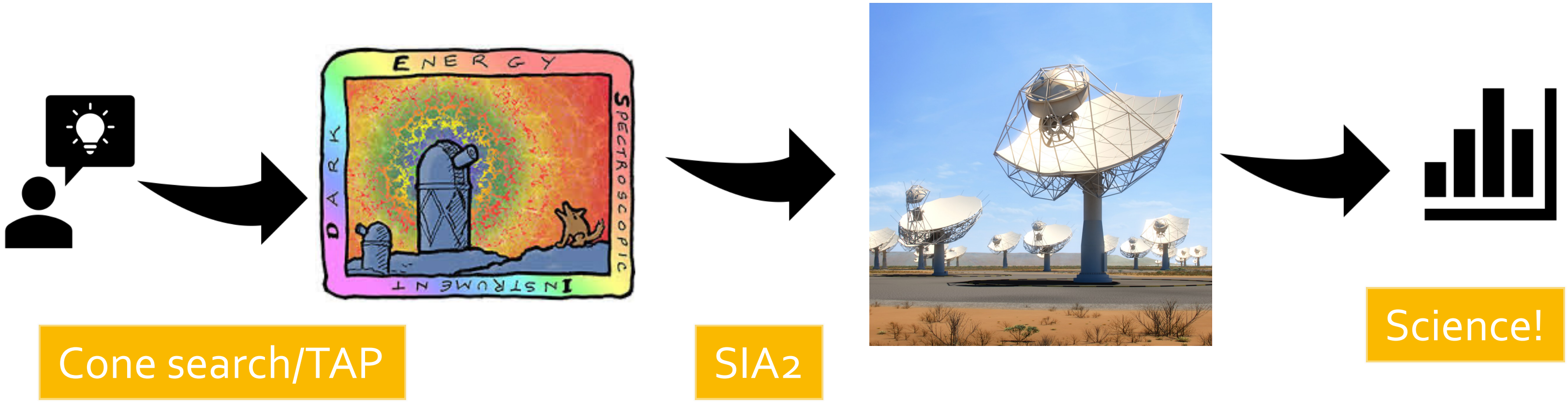
- The VO provides a set of standards that allow the interoperability of archives via common metadata standards and protocols.
- Adherence to the VO standards means that an astronomer can search archives in any wavelength domain using common interfaces (or tools that use those interfaces under the hood).
- By including radio data products in the VO, it opens up the radio domain to astronomers whose specialties may lie in other wavebands, and also allows easy and flexible archive searches for radio astronomers themselves.
- VO protocols are not tied to particular software or programming language - VO services can be accessed from your laptop, a server at a data center, or from the Cloud.
- VO standards are the underpinning that allow astronomy data to satisfy the **FAIR** data Principles (**Fi**ndability, **A**ccessibility, **I**nteroperability and **R**euse).

The IVOA Radio Interest Group
(Chair: M. Lacy, Vice-Chair F. Bonnarel)

- Provides a platform for discussion of how best to integrate radio data into the VO, including development of use cases for data discovery, access and visualization.
- Identifies any metadata concepts needed by radio astronomy data that are not currently supported by the VO.
- Provides a well identified point of contact for radio projects with IVOA, and actively encourages their use of VO standards and protocols.
- Implementation note for radio data in the VO being written.

VO in the era of huge radio datasets

- VO queries lend themselves easily to scripting.
  - Example use case: stacking of HI in the SKA era:
    - Send a cone search to the NOAO archive to find objects from the DESI optical spectroscopy catalog in a given redshift range
    - Send SIA queries to the SKA archive to identify images cubes covering HI at those redshifts and positions.
    - Use VO Datalink/SODA services to download cutouts from the cubes for coaddition.
    - Maybe you want to check the ALMA archive for CO? No problem, just send an SIA query to that too.
    - Can easily scale from tens to millions of objects, and analysis can be integrated into Science platforms via VOSpace.



Current VO holdings by collection – image data (including cubes)

Collection/Facility	SIA1	SIA2	TAP	Datalink	SODA	HIPS	MOC
ALMA							
Apertif (ASTRON)							
ASKAP (CASDA)							
CGPS (CADC)							
DRAO (CADC)							
FIRST (Skyview/GSFC)							
NVSS (Skyview/GSFC)							
LoFAR surveys (ASTRON)							
TGSS-ADR (ASTRON)							
SKA (sims)							
VGPS (CADC)							
VLASS (CADC)							

Work In Progress!

Current VO holdings by collection – catalog data

Collection/Facility	ConeSearch	TAP
ALMA		
Apertif		
ASKAP (CASDA)		
ATOA		
PSRDA		
CGPS (CADC)		
DRAO (CADC)		
FIRST (CDS)		
NVSS (CDS)		
LoFAR surveys (ASTRON)		
TGSS-ADR (ASTRON)		
VGPS (CADC)		
VLASS (CADC)		

Work In Progress!

Current VO holdings by collection – correlated visibilities/raw SD data

Collection/Facility	ObsTAP	TAP	Datalink	SCS
ALMA				
Apertif				
ASKAP (CASDA)				
ATOA				
PSRDA				
MWA				
DRAO (CADC)				
FIRST/NVSS (Legacy VLA)				
JIVE				
LoFAR surveys (ASTRON)				
VLASS (Jy-VLA)				
Nancay/NenuFAR				

Outstanding metadata issues

- How to describe visibility data. Visibility data searches may not make sense for all interferometers e.g. SKA, it may just be cheaper to retake the data, but EHT is a good example where several imaging algorithms were tried on one set of calibrated visibilities.
  - Distribution in the uv-plane
  - Concept of largest angular scale (LAS) – expansion to ObsCore? How to define LAS and resolution for uv-data (longest/shortest baseline, Nth-percentiles of uv distribution?).
  - LAS also applies to images made from the data.
- How to map radio observations to ObsCore, especially wide-band observations with footprints that change dramatically as a function of frequency.
  - Maybe have dynamic generation of footprints (and uv-plane distribution of visibilities) based on search criteria?
- How to treat visibility data (TAP for lists of uv datasets; ALMA – ancillary to image product; calibrated vs raw visibilities; use of science platforms/VOSpace for producing user-specified images.)