### Multi-dimensional Data Priority Area Mark Allen

Technology Forum Trieste, May 11, 2014







# science priority Multi-dimensional Data

Radio astronomy, Integral Field Spectroscopy, high energy, polarization, simulation, data mining datasets + ...

 Need to ensure that these are accessible and useable within the VO

### Status

### • Focus Sessions (Heidelberg May 2013)

engagement with projects, minimal requirements

- Prototype demos (Hawaii Sept 2013)
  - Multiple approaches, ~agreement on stds. needed
- Ist stds. to satisfy minimal requirements
- aiming for RFCs < May Interop 2014
- Follow-up Focus Session (Madrid May 2014)

## Projects engaged

- ALMA
- LOFAR
- SKA
- ASKAP
- JVLA / NRAO
- MUSE

- CALIFA
- LSST
- CTA



image: CALIFA Project

## VO already in use/plans

- ALMA using OpenCADC TAP, voview, will use SAMP, ObsCore, SIAPv2
- CyberSKA VO access option via CADC
- CALIFA data access via TAP and SSA
- MUSE VO publishing via AstroWise
- ASKAP all data through VO protocols
- CoRoT avail from SVO, Kepler avail from MAST
- LOFAR VOEvent broker

- Identify implementation hurdles
  - description/access to cubes
  - query by time parameters
  - expense
- mismatch of expectations/approach
  - implementation of 'standards' cf. 'libraries'

in progress

- "Rough consensus and running code"
- Java and Python...
- Importance of ...

## Prototype demos



### JVO ALMA VO Portal and Vissage

| Date Set ID     ALMA01000766 | Object Name     Circinus galaxy | •RA.<br>14h13m10.12s | + Dec.<br>-65620m21.818s   | Observation Date (     2012-07-04T01:47                         | (JTC)<br>1:01.0962   |                                     |
|------------------------------|---------------------------------|----------------------|--|---|--|-------------------------------------|
| Main Perspective             |                                 |                      | Resolution :<br>Zoom :<br>Doct to<br>Book to<br>Coordinate<br>Res. : 2:400 ac<br>Zoom : s1<br>RA : : 56:13m<br>Dec: : -65:20 | Enumerate<br>Feld Mode<br>Orid<br>sectjóx<br>00.37%<br>133.338s | 1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000<br>1000 | *<br> <br> <br> <br> <br> <br> <br> |



### Demonstration



#### (9) ALMA / NRO45m / Spitzer / Subaru / HST / Chadra images



Applications Session at IVOA Interop Meeting, Heidelberg, 13/05/2013

#### ImageDM metadata for the cube: SIA2Query response

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|  |   | Stick FoV in stack LOAD Close                  |   |   | -           |
|  |   |  | 1.099" = 96.0"                            | ■ ■   | 1.2         |
| 1.007 ± 50.0*  | · 나 ■ 귀비하프로 (************************************ |  |   | Search  | ++          |
|  |   |  |   |   |             |

- VAO development
- http://vaosa-vml.aoc.nrao.edu/ivoa-dal/siav2query.html

| National Radi                      | o Astronomy                                   | Observatory                     | Wednesday, Marc            |  |  |
|------------------------------------|---|---------------------------------|----------------------------|--|--|
|                                    |   |                                 |                            |  |  |
| SIAPV2 Prototype Service           |   | (V.                             | (VAO Test Data Collection) |  |  |
| Query Parameters (Debug 🗆) ( 🖪     | eset ):                                       |                                 |                            |  |  |
| POS ("ra,dec" in degrees):         | 180.0,1.0                                     | SIZE (decimal degrees):         | 360.0                      |  |  |
| BAND (meters):                     | 1.0E-8/5.0                                    | TIME (ISO time):                | 1990-07-04/2014            |  |  |
| POL (state, "any", "stokes"):      |   | MODE ("archivallcutoutlmatch"): | archival                   |  |  |
| TYPE ("image", or "cube"):         |   | SUBTYPE (archive-specific):     | SDM.BDF                    |  |  |
| SPECRES (min spectral resolution): |   | SPECRP (min spectral respower): |                            |  |  |
| COLLECTION (e.g., "alma,jvla"):    |   | ASTCALIB (e.g., "absolute"):    |                            |  |  |
| PUBDID (dataset ID"):              |   | MAXREC:                         |                            |  |  |
| mage Data Collections:             | ○Null/Echo Test   ●VAO Cube Project Test Data |                                 |                            |  |  |
| Output Data Formats:               | •All available formats (                      | FITS image OGraphics image      |                            |  |  |
| Query Response Format:             | OTable ○Text ○CSV                             |                                 |                            |  |  |
| Submit                             |   | Reset Form                      |                            |  |  |

## Minimal requirements

#### Data Discovery (Query)

- A service shall be able to receive queries regarding its data collection(s) from a client, with the client placing one or more of the following constraints:
  - RA,Dec
  - Frequency/wavelength
  - Polarization states
  - Spatial size
  - Angular resolution
  - Integration time
  - Time of observation
- A service shall return to the client a list of observations, and the corresponding metadata for each observation, meeting the user-imposed constraints. In the event that the user places no constraints, the entire list of observations, and the corresponding metadata for each data set, shall be returned. In the event that no data meet the user's constraints, the service shall indicate the absence of any matches.

#### Data Access

- Once a user has the list of observations that satisfy the constraints, they select all or a subset of the observations and:
  - Download the complete science data for each of the selected observations (the service shall return the complete multi-dimensional science data and metadata for each selected observation) or;
  - Download simple cutouts of the science data for each of the selected observations (the service shall be able to extract and return a user-specified subset of the complete multi-dimensional science data and metadata for each selected observation).

#### Simple Cutout

- For a simple cutout, the user-specified subset is restricted to be a contiguous interval within each dimension of the multi-dimensional science data. The user should \*not\* be allowed to specify subsets with "gaps" or resampling or anything like that.
  - Spatial: a circle (a coordinate and a radius)
  - Energy: one interval (from energy1 to energy2)
  - Time: one interval (from time1 to time2)
  - Polarization: a list

Mostly accepted as reasonable requirements

### Data Discovery, Data Access

### Some discussion about spatial cutout

- **Cutout:** For a simple cutout, the user-specified subset is restricted to be a contiguous interval within each dimension of the multi-dimensional science data. The user should \*not\* be allowed to specify subsets with "gaps" or resampling or anything like that.
  - Spatial: a circle (a coordinate and a radius)
  - Energy: one interval (from energy1 to energy2)
  - Time: one interval (from time1 to time2)
  - Polarization: a list

### TCG to WGs :

Practically speaking, the endorsement of the minimum requirements for the first version of the multi-dimensional data access standards means:

- The preparation of the standards cannot be held up by discussion of "features" that are not necessary to meet the minimum standards
- The WGs should be thinking in an agile sense where subsequent versions of a given standard with more "features" come rapidly after the first version.

Standards that need to be RFC-ready by the May InterOp:

- 1.SIAv2 (query capability only)
- 2. DataLink
- 3. AccessData (for simple cutouts only)

### Cutouts



 simple cutout (without re-computing), along the cube axes, no gaps, transforms

image: JVO



Considering cutouts simple to complex

- Data Discovery
- Available Data
- Download



- Data Discovery
- Available Data
- Download



- Data Discovery
- Available Data
- Cutout (circle)
- Download



- Data Discovery
- Available Data
- Cutout (rectangle)
- Download



### • Data Discovery

- Available Data
- Cutout = Data discovery cone
- Download



- Data Discovery
- Available Data
- Cutout (circle) what's valid?
- Download



- Data Discovery
- Available Data
- Simple Mosaiced product
- Download



- Data Discovery
- Available Data
- More complex mosaiced product
- Download



- Data Discovery
- Available Data
- More complex mosaiced product
- Download

## Focus Session Madrid

The topics of this focus session at the 2014 May IVOA Interoperability Meeting include

- Summary of the progress towards the protocols and prototype implementations.

- Identification of the next steps in the widespread adoption of the IVOA standards and services.

- Description of the additional functionality or enhancements likely to be needed. What are the highest priorities?

- Invited presentations / Panel Discussion
- Follow-on WG sessions and break-outs

## expected topics

- Address the 'rough consensus and running code' needs of projects
- Implementation schedule
- Implementation assistance what form?
- Tools SAMP enable cube viz. tools
- Remote Visualisation goals