

# Radio (and millimetric) Data in the VO : State of the art



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acknowledges extensive collaborative work with DAL WG, DM WG, TDIG,  
DADI collaborators, Strasbourg CDS and SVOM teams



# Summary

- I ) multi-dimensional data in the VO
  - Examples of projects
  - Problems for interoperability
  - DataModels overview
  - Discovery solutions : ObsCore, SIAV2
  - Access Solutions : DataLink and SODA
- II ) Client-side Interfaces
  - Aladin
  - TOPCAT
- III ) ALMA Science Archive implementation
  - Available data in the archive
  - Archive ObsTAP Interface
- IV ) ASKAP data : CASDA implementation



# Multi-dimensional data

- Radio datacubes
- Xray cubes
- Time dimensions
- Polarisation
- Visibility data



# Radio data Cubes

- ALMA
  - LOFAR, ASKAP
  - Towards SKA
- data discovery by selecting criteria on  
description attributes (metadata)
- data access : extracting useful data from the  
datasets



# DataAccess

Radio Cubes are « huge »

- full retrieval cumbersome
- Cutouts
- eventually regridding, reprocessing ?
- need for detailed data (metadata)  
representation further than ObsCore (Cube  
DM, may come later)....



# VO modelling

## 1 ) Obscore : metadata for discovery

obs_collection	unitless	String	Name of the data collection
obs_id	unitless	String	Observation ID
obs_publisher_did	unitless	String	Dataset identifier given by the publisher
access_url	unitless	String	URL used to access (download) dataset
access_format	unitless	String	File content format (see in App. BB.5.2 )
access_estsize	kbyte	integer	Estimated size of dataset in kilo bytes
target_name	unitless	String	Astronomical object observed, if any
s_ra	deg	double	Central right ascension, ICRS
s_dec	deg	double	Central declination, ICRS
s_fov	deg	double	Diameter (bounds) of the covered region
s_region	unitless	String	Sky region covered by the data product (expressed in ICRS frame)
s_xel1	unitless	integer	Number of elements along the first spatial axis
s_xel2	unitless	integer	Number of elements along the second spatial axis
s_resolution	arcsec	double	Spatial resolution of data as FWHM
t_min	d	double	Start time in MJD
t_max	d	double	Stop time in MJD
t_exptime	s	double	Total exposure time
t_resolution	s	double	Temporal resolution FWHM
t_xel	unitless	integer	Number of elements along the time axis
em_min	m	double	Start in spectral coordinates
em_max	m	double	Stop in spectral coordinates
em_res_power	unitless	double	Spectral resolving power
em_xel	unitless	integer	Number of elements along the spectral axis

# VO modelling

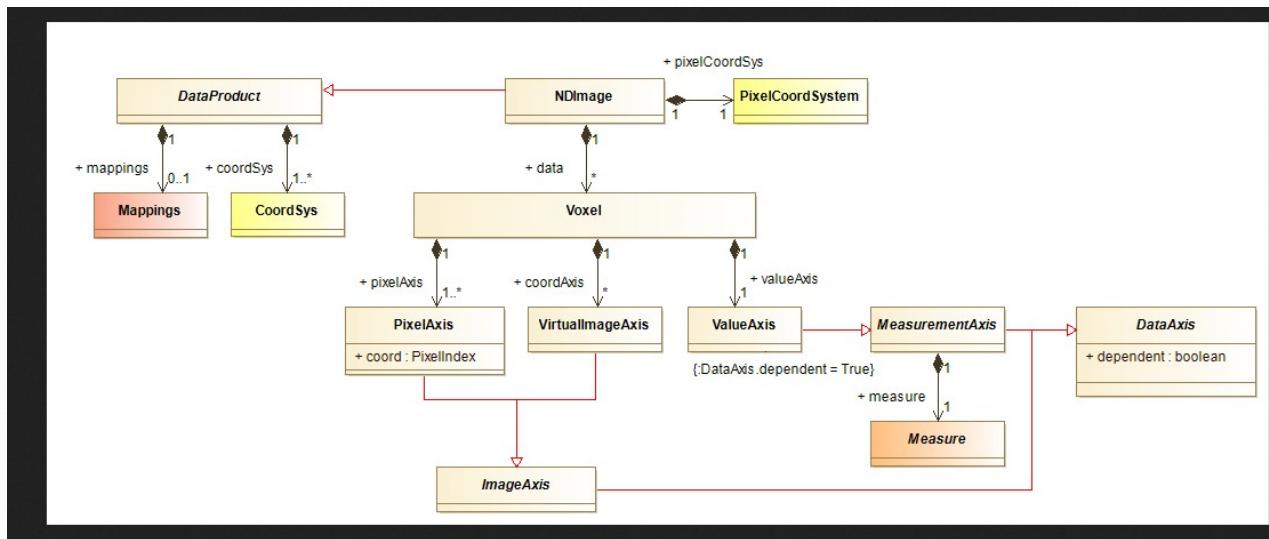
## 2 ) Other existing useful data models

- STC 1.0 : useful concepts, currently under strong revision  
(Coords, Measurements and Transformations)
- PhotDM : mostly for Optical astronomy
- Characterisation 1.0 : reused by other datamodels (such as ObsCore, Cube) under revision
- Spectral Line Data Model : From observation to Physics
- Simulation DataModels. Comparison with Simulations



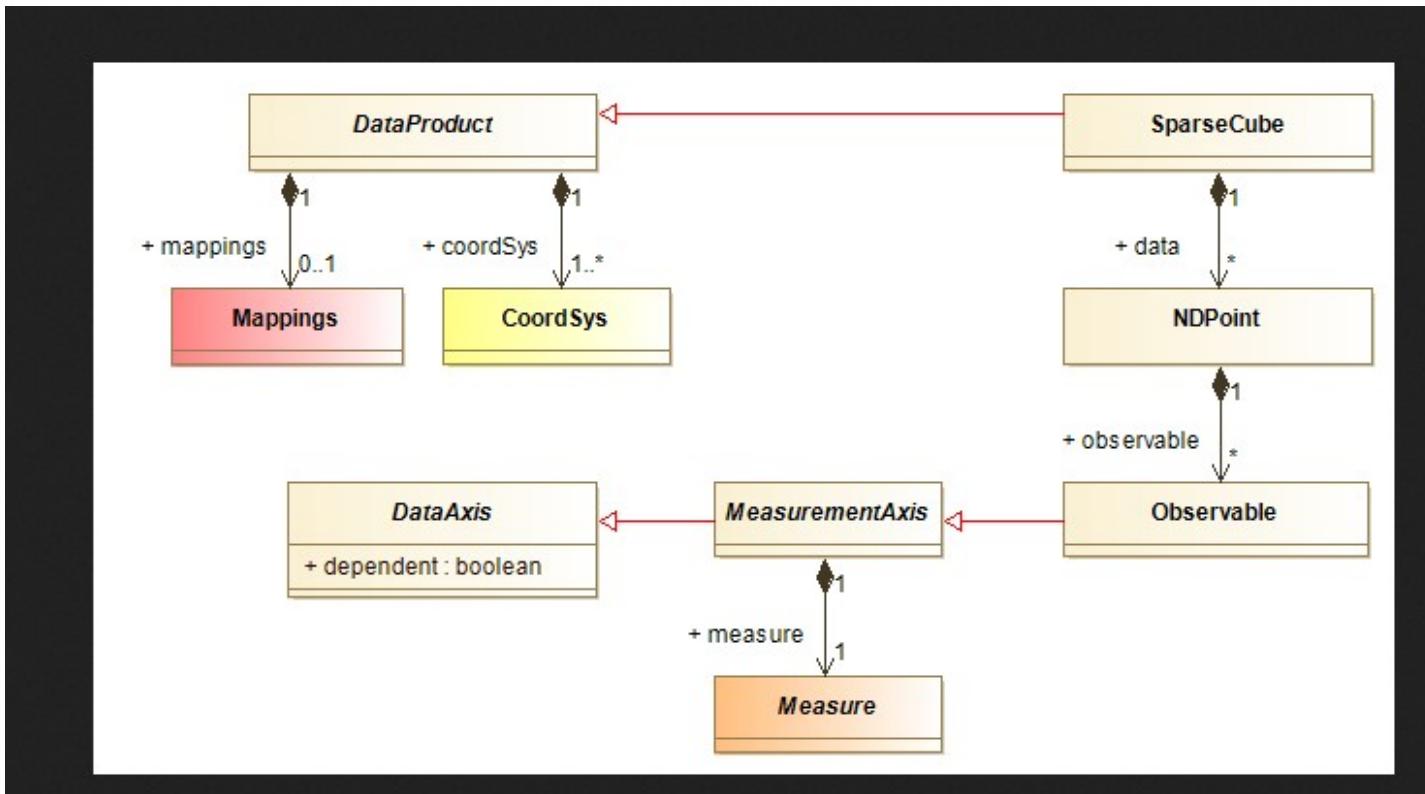
# VO modelling

## 3 ) Cube datamodel (in progress) : ND Image



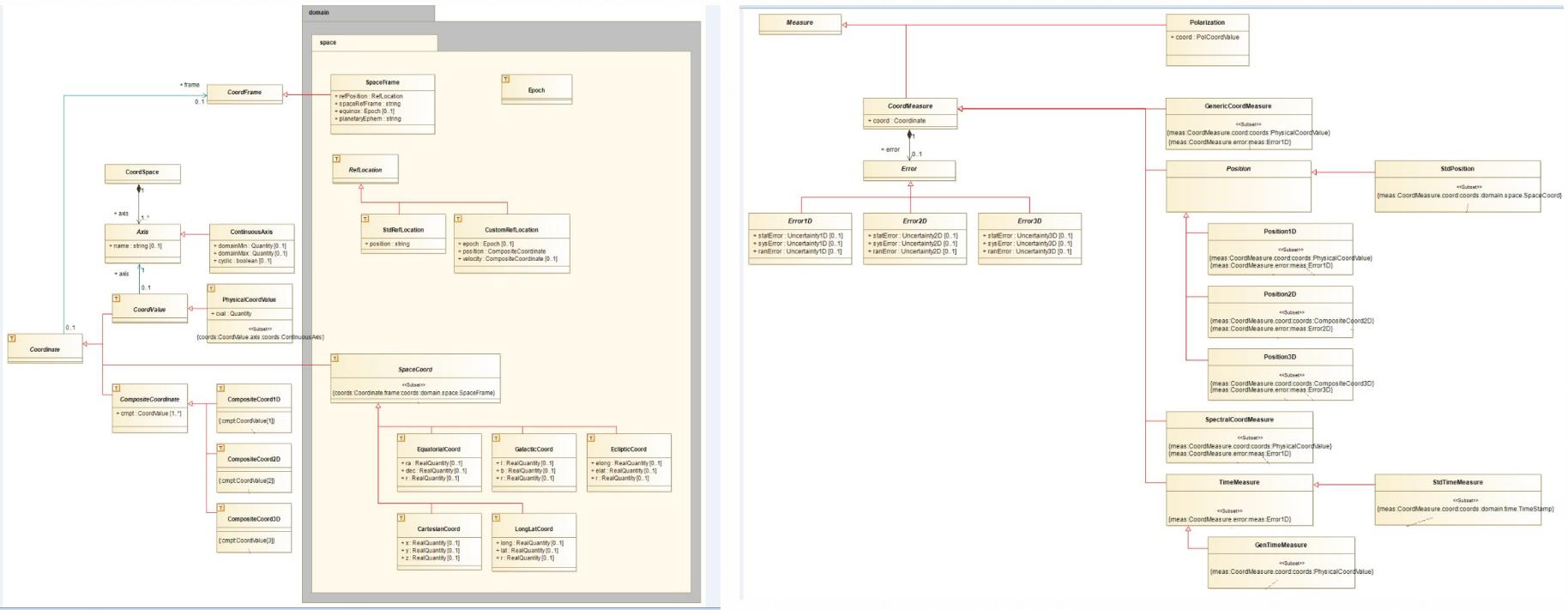
# VO modelling

## 3 bis ) Cube datamodel : sparse cube



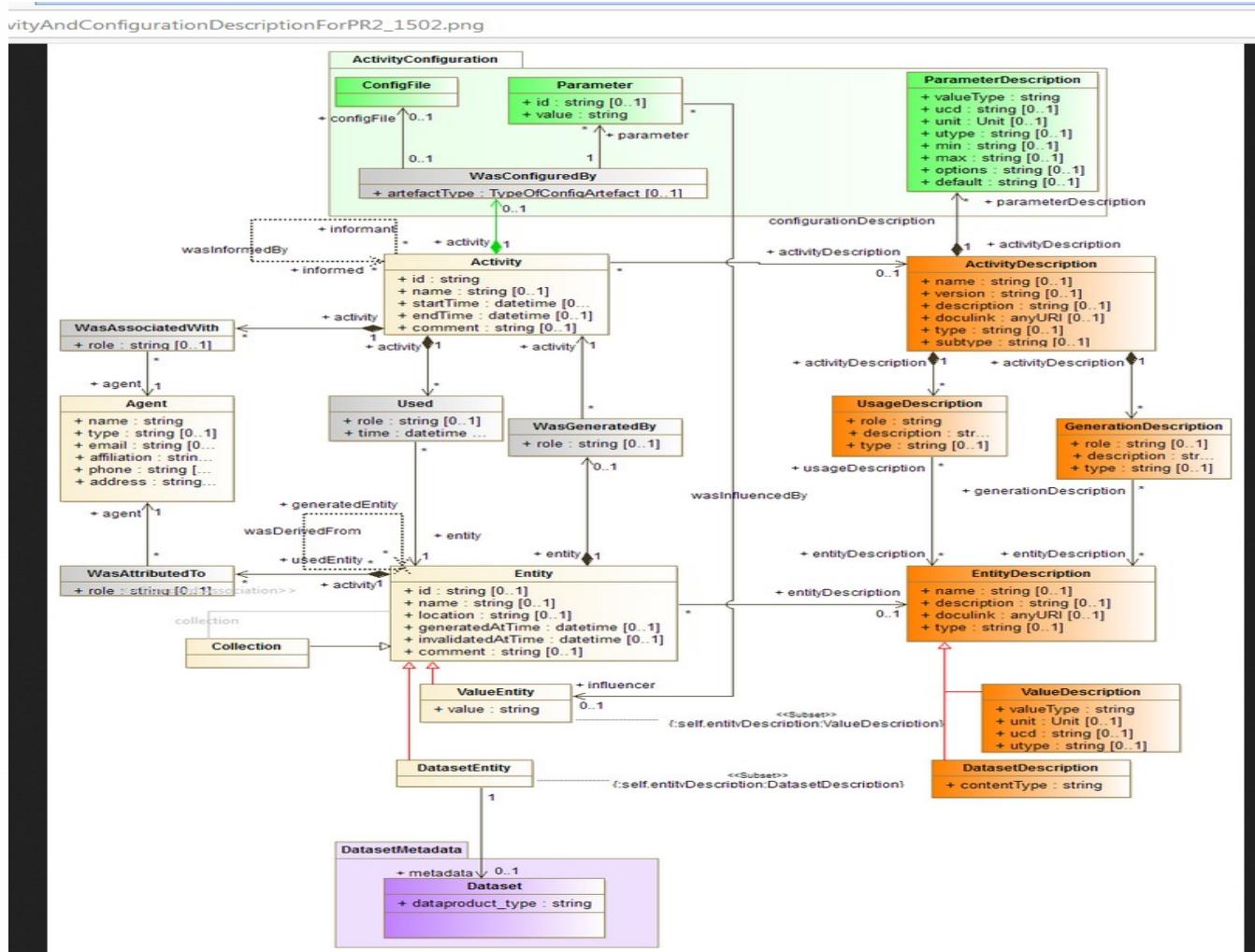
# VO datamodelling

## 4 ) STC : Coords and Measurements (in progress)



# VO datamodelling

## 5) Provenance (in progress)



# VO access layer Solutions

- ObsTAP (serving ObsCORE table) : allows to select datasets on criteria such as dataproduct\_type= cube and characterisation of axes
- SIAV2 : allows queries for images and cubes with PARAMETERS
  - such as DPTYPE = cube, POS = .... BAND = 0.0005 0.0006 TIME = 52618 53700 etc.
- Full Data Retrieval via access\_reference field (if manageable)
  - Or access to DataLink .... and SODA (direct access to SODA also possible)
- Alternative : Discovery , Representation and View via HiPS for cubes



# SIAV2 parameters

POS (spatial constraints)

BAND (spectral constraints)

TIME (time constraints)

POL (polarisation constraints)

SPATRES (spatial resolution constraints)

SPECRES (spectral resolution constraints)

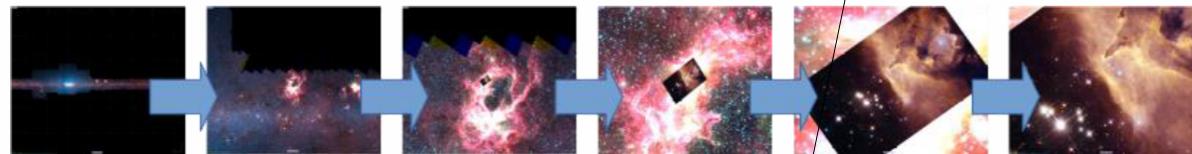
COLLECTION (restrict to a data collection)

FACILITY (restrict to a facility)



## □ HiPS ? What is it ?

- Hierarchical Progressive Survey  
*“The more you zoom in on a particular area, the more details show up”*
- Multi-resolution HEALPix data structure
- for Images, Catalogues, 3-dimensional data cubes, ...
- Conserves scientific data properties alongside visualisation considerations
- No databases or dedicated servers are required, just http



3

And MOC for discovery

View, Access, Discovery of DataCube

# DataLink

- Link a list of RESOURCEs to a DataSet via a small votable giving url, media type, semantics, description, size of the linked resource
- Useful for linking :
  - Additional metadata (provenance, fine characterisation)
  - Auxiliary or associated files
  - Other formats
  - Previews
  - Services applied to the dataset
- DataLink service descriptor

A resource to describe a service (included in main DAL service or {links} resource response)



# SODA parameters

Similar to SIAV2, but with a different meaning

ID : ivo ID of the dataset to process

POS : spatial area to be matched

BAND : spectral range to match

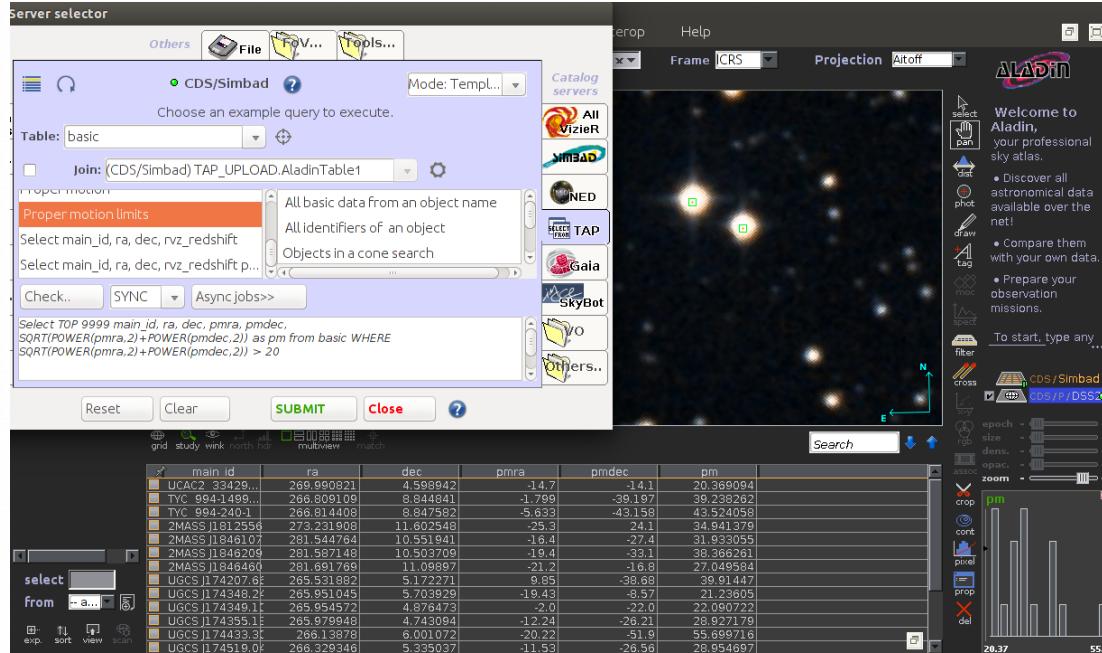
TIME : time range to match

POL : selection of polarisation states



# Interface : Aladin

- ASTERICS developments : discovery tree, SIA interface, DataLink interface and SODA interface (see above)
- ASTERICS development :
  - TAP interface
    - ADQL control and assistance
    - Synchronous, asynchronous
    - JOIN
    - UPLOAD

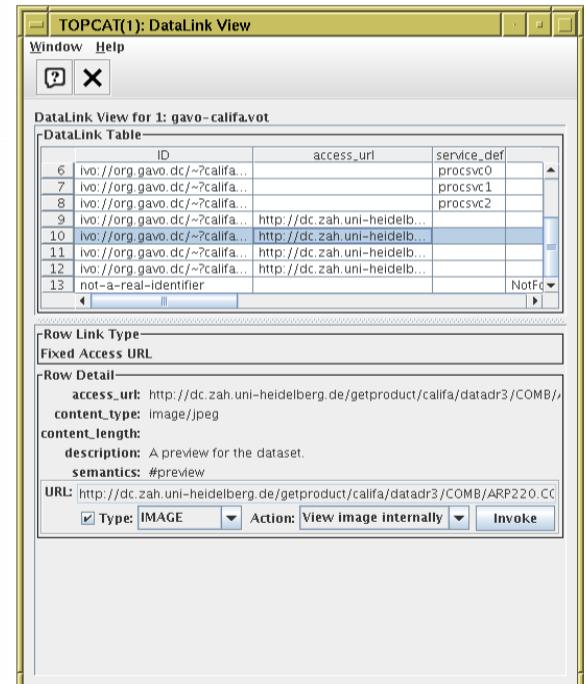


# Interface : TOPCAT

- TOPCAT is an interface to ObsTAP
  - Discovery, SAMP to other Tools
- TOPCAT takes into account

## DataLink

- Feedback
- Improvement proposals



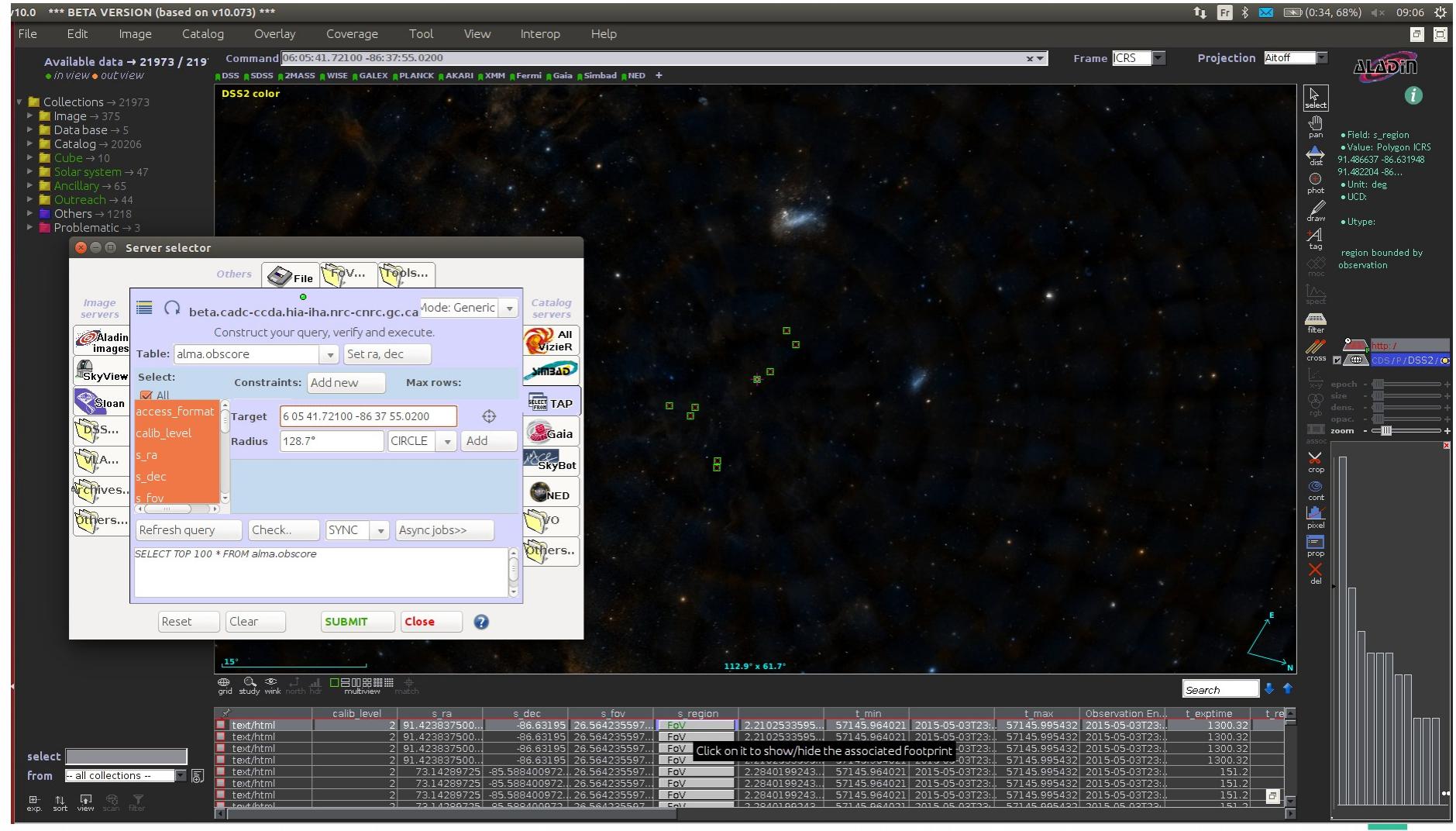
# ALMA science archive

- ALMA provides interferometric data in the millimetric domain
- Science archive has a specific interface
- Imaging data are not available everywhere
- Alma science archive slowly releasing VO interface blocks :
  - An ObsTAP service is available (see next slides)
  - MOC is available
  - Integrated in ESA Sky
  - Plans to integrate : DataLink, SIAV2, SAMP interface
  - Service for reprocessing installed as UWS (maybe SODA extension)



# ALMA science archive

## Tap service within Aladin



# ALMA science archive

url in ObscOre response links to a page displayed in the browser  
(no data download available yet)

Alma Science Archive - Mozilla Firefox

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 21973 / 21973 Command

DSS SDSS 2MASS WISE GALEX PLANCK AKARI XMM Fermi Gaia Simbad HED

DSS2 color

Collections → 21973

- Image → 375
- Data base → 5
- Catalog → 20206
- Cube → 10
- Solar system → 47
- Ancillary → 65
- Outreach → 44
- Others → 1218
- Problematic → 3

J2000 06:05:41.721 -86:37:55.02

FoV: 2.22' ALADIN

More columns Showing 1 of 1 rows.

	Project code	Source name	RA	Dec	Band	Integration	Release date	Velocity resolution	Frequency support
	2013.1.00623.S	ESO005-G004	06:05:41.72	-86:37:55.0	6	1300.320	2016-12-12	38006.03	227.81_246.51GHz

select [ ] from [ all collections -- ]

grid study wink north hdf multiview match

order by res power [ access url [ access estsize [ obs.publisher\_id [ obs.collection

1	7353.7783250...	<a href="http://almascient">http://almascient</a>	ADS/JAO ALMA #2 ALMA
2	7888.0240400...	<a href="http://almascient">http://almascient</a>	ADS/JAO ALMA #2 ALMA
3	7820.3918826...	<a href="http://almascient">http://almascient</a>	ADS/JAO ALMA #2 ALMA
4	7423.7358826...	<a href="http://almascient">http://almascient</a>	ADS/JAO ALMA #2 ALMA
5	7353.7783250...	<a href="http://almascient">http://almascient</a>	ADS/JAO ALMA #2 ALMA
6	7423.7358826...	<a href="http://almascient">http://almascient</a>	ADS/JAO ALMA #2 ALMA
7	7820.3918826...	<a href="http://almascient">http://almascient</a>	ADS/JAO ALMA #2 ALMA
8	7888.0240400...	<a href="http://almascient">http://almascient</a>	ADS/JAO ALMA #2 ALMA

exp sort view scan filter

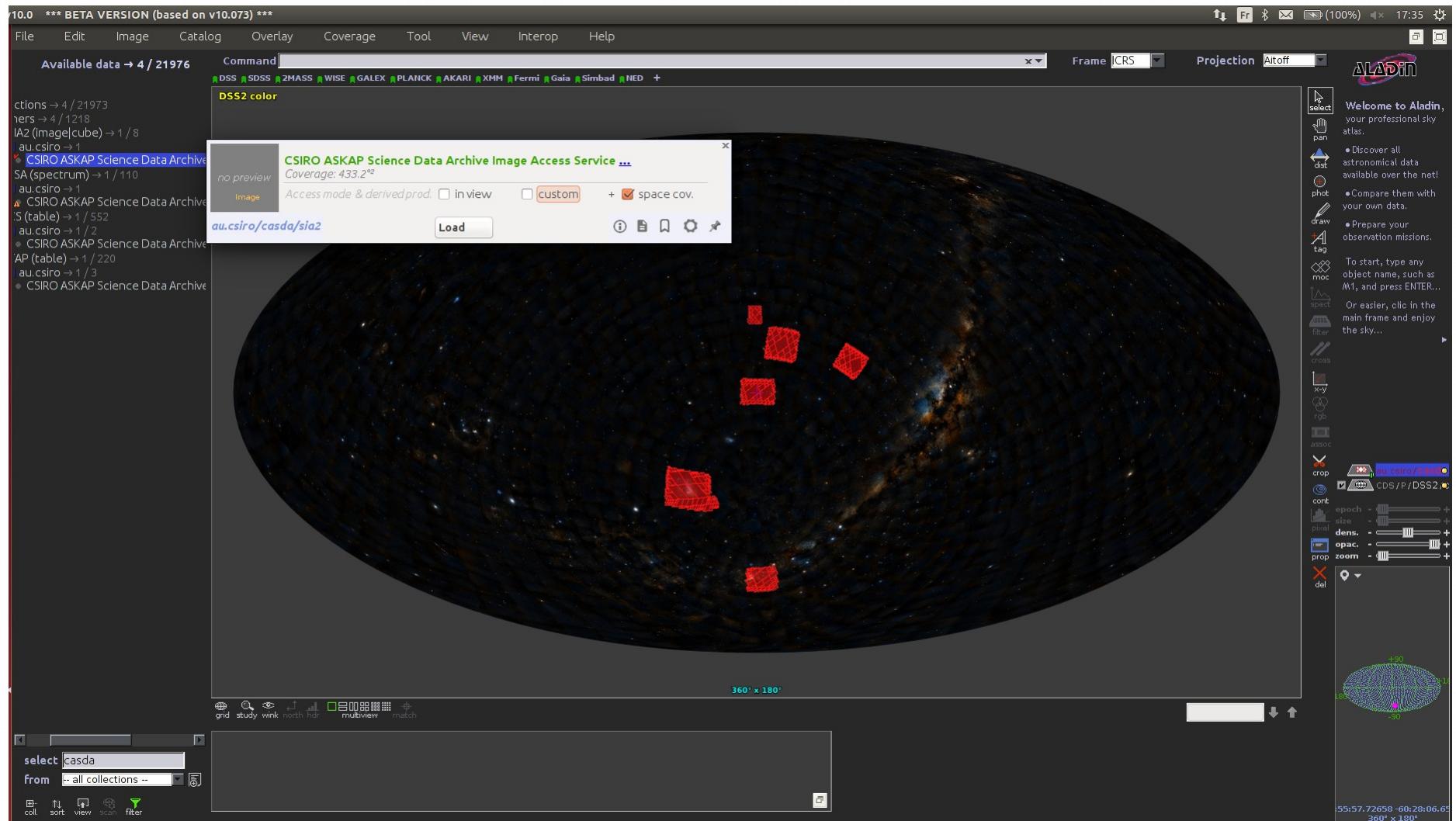
12:02:55 020 -86:36:44.43 112.9° x 61.7°

# ASKAP data : CASDA services

- CASDA implemented
  - MOC
  - ObsTAP, SIA services available
  - DataLink with Cutouts
  - SODA interface
  - Scripts



# CASDA (= ASKAP data) (allsky datacubes distribution)



# ASKAP data : CASDA services

## SIAP 2.0

Aladin v10.0 \*\*\* BETA VERSION (based on v10.073) \*\*\*

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 4   Command [16:29:08.41 -18:02:00.0]   Frame ICRS   Projection Aitoff

DSS SDSS 2MASS WISE GALEX PLANCK AKARI XMM Fermi Gaia Simbad NED +

DSS2 color

ctions → 4 / 22454  
ers → 4 / 1248  
IA2 (image|cube) → 1 / 6  
au.csiro → 1  
CSIRO ASKAP Science [SA (spectrum) → 1 / 115  
au.csiro → 1  
CSIRO ASKAP Science [S (table) → 1 / 565  
au.csiro → 1 / 2  
CSIRO ASKAP Science [AP (table) → 1 / 224  
au.csiro → 1 / 3  
CSIRO ASKAP Science [

**Server selector**

Others File Fav... Tools...

Generic SIAv2 query

Target (ICRS, name) rho oph  
Radius 14°  
Server IVOID or ba... au.csiro/casda/sia2  
Data set identifier  
Collection name  
Telescope name  
Instrument name  
Target  
Calibration level (0...  
Maximum number ... 99999

Reset Clear SUBMIT Close ?

Image servers

Aladin images SkyView Sloan DSS... VLA... Archives... Others...

Catalog servers

All VizieR NED TAP Gaia SkyBot NED VO Others...

1.491° x 46.2°

Search

grid study wink north star multiview match

access url dataproduct t... calib level obs collection obs id obs publisher ... access format access estsize target name s ra

https://data.csiro.au/casda/v0/proxy/vo/datalink/links?ID=cube-729	cube	3	P248	P248	cube-729	application/x-vot	54467	246.2870972
https://data.csiro.au/casda/v0/proxy/vo/datalink/links?ID=cube-778	cube	3	P248	P248	cube-778	application/x-vot	54456	247.2850553

select casda from -- all co... coll. sort view scan

epoch size lens. opac. zoom

Rho Oph

16:25:35.12 -23:26:49.0 1.491° x 46.2°

1 sel / 2 src 875Mb

# ASKAP data : CASDA services response FOV

Aladin v10.0

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 4  
in view out view

Command 16:25:08.90 -26:02:00.0

DSS SDSS 2MASS WISE GALEX PLANCK AKARI XMM Fermi Gaia Simbad NED +

actions → 4 / 22454  
bers → 4 / 1248  
IA2 (image|cube) → 1 / 6  
au.csiro → 1  
CSIRO ASKAP Science! SA (spectrum) → 1 / 115  
au.csiro → 1  
CSIRO ASKAP Science! S (table) → 1 / 565  
au.csiro → 1 / 2  
CSIRO ASKAP Science! AP (table) → 1 / 224  
au.csiro → 1 / 3  
CSIRO ASKAP Science!

DSS2 color

results

select pan dist phot draw tag moc spect filter cross x-y rgb assoc crop cont pixel prop del

au.csiro / casda CDS/P/DSS2

epoch size lens. opacity zoom

Rho Oph

15° 83.29° x 47.17° E N

Click on it to load the corresponding archive data in the stack

grid study wink north hdr multiview match

access url calib level obs id target name s ra s dec

access url	calib level	obs id	target name	s ra	s dec
<a href="https://data.csiro.au/casda/v0/proxy/v0/datalink/">https://data.csiro.au/casda/v0/proxy/v0/datalink/</a> cube	3   P248	F248	cube-729	54467	246.28709726...
	3   P248	P248	cube-778	54456	247.28505537...
			application/x-votable		-18.03333018...
				120.8	

# ASKAP data : CASDA services

## DataLink

Aladin v10.0 \*\*\* BETA VERSION (based on v10.073) \*\*\*

Aladin v10.0 \*\*\* PROTOTYPE VERSION (based on v10.098) \*\*\*

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 4 Command 18:19:23.82 -29:05:24.8

DSS SDSS 2MASS WISE GALAXY PLANCK AKARI XMM Fermi Gaia Simbad NED +

639675.618

Collections → 4 / 22  
Others → 4 / 1258  
SIA2 (image|cut  
au.csiro → 1  
CSIRO ASKAI  
SSA (spectrum)  
au.csiro → 1  
CSIRO ASKAI  
CS (table) → 1 /  
au.csiro → 1 /  
CSIRO ASKAI  
TAP (table) → 1 /  
au.csiro → 1 /  
CSIRO ASKAI

Frame ICRS Projection AltOff

select  
pan  
dist  
phot  
draw  
tag  
moc  
spect  
diff  
filter  
cross  
x-y  
rgb  
assoc  
crop  
cont  
pixel  
prop  
del  
CDS/P/DSS2/color

15° 94.06° x 50.27° E N

grid study winks north hdr multiview match

access url dataproduct t... calib level obs collection obs id obs publisher ... access format access esize target name s.ra s.dec

https:// Download data product via web (size 55774208 byte)

Download data at Pawsey Centre. Note: Only users from within PSC network can access the data through this link. Only use if you currently have access to Pawsey facilities. (size 55774208 byte)

Scripted file access via Web (size 55774208 byte)

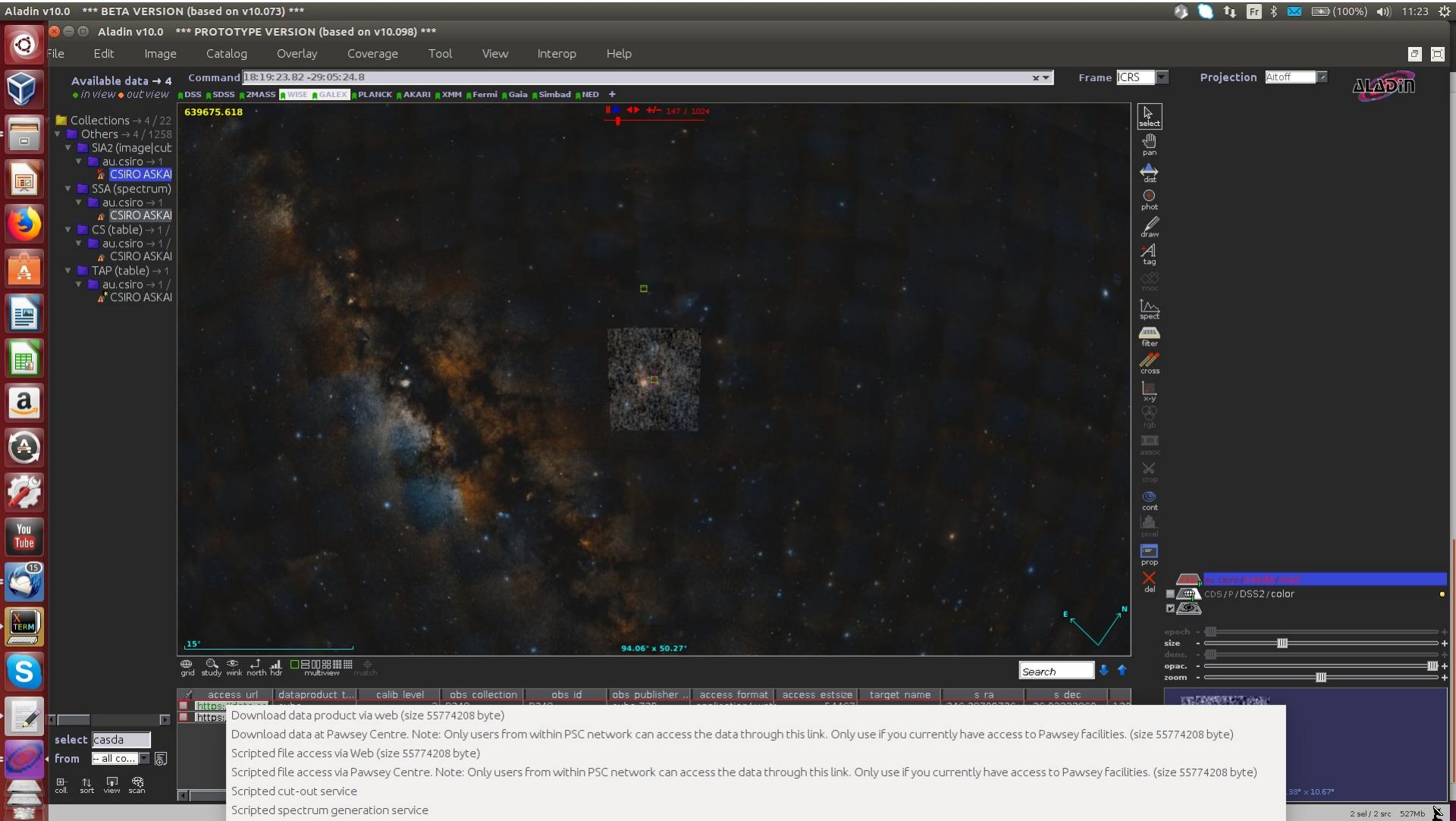
Scripted file access via Pawsey Centre. Note: Only users from within PSC network can access the data through this link. Only use if you currently have access to Pawsey Facilities. (size 55774208 byte)

Scripted cut-out service

Scripted spectrum generation service

epoch size dens. opacity zoom

2 sel / 2 src 527Mb



# ASKAP data : CASDA services SODA interface

Aladin v10.0 \*\*\* BETA VERSION (based on v10.073) \*\*\*

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 4   Command 16:25:08.90334 -26:01:59.9830   Frame ICRS   Projection Aitoff

DSS SDSS 2MASS WISE GALEX PLANCK AKARI XMM Fermi Gaia Simbad NED +

ctions → 4 / 22641 hers → 4 / 1258 IA2 (image|cube) → 1 / 8 au.csiro → 1 CSIRO ASKAP Science! SA (spectrum) → 1 / 114 au.csiro → 1 CSIRO ASKAP Science! S (table) → 1 / 566 au.csiro → 1 / 2 CSIRO ASKAP Science! AP (table) → 1 / 219 au.csiro → 1 / 3 CSIRO ASKAP Science!

Service casda.csiro.au

Cutout prototype for SODA server ?  
Fill in all these fields and press the SUBMIT button

Target (ICRS, name)

Radius

Time

Band  0.21015484916529545 0.220026116655881

Pol

ID  IAwjdlcT1HlEq7251deoebNLMEEsqZ3bmz

Pol  ASYNC

Reset Clear Submit Close

23.42° x 13.87°

5°

grid study wink north hor multiview match

Search

access url dataproduct t... calib level obs collection obs id obs publisher ... access format access estsize target name s ra s dec

<https://...> Download data product via web (size 55774208 byte)

Scripted file access via Web (size 55774208 byte)

Scripted file access via Pawsey Centre. Note: Only users from within PSC network can access the data through this link. Only use if you currently have access to Pawsey Facilities. (size 55774208 byte)

Scripted cut-out service

Scripted spectrum generation service

select casda

from -- all co... (radio)

coll sort view scan

au.csiro/casda/sia2~1

CDS/P/DSS2/color

epoch - size - dens - opac - zoom -

258.1981 ICRS

23.2649.9150 13.87°

2 sel / 3 src 449Mb

The screenshot shows the Aladin software interface, version v10.0, running on a Linux desktop. The title bar indicates it's a beta version based on v10.073. The main window displays a star map with various celestial objects, including a prominent blue nebula and several bright stars. A context menu is open over one of the objects. On the left, there's a vertical toolbar with icons for different functions like File, Edit, and View. The right side features a toolbar with various astronomical tools and a color calibration panel for DSS2 color images. A central dialog box is open, titled 'Service casda.csiro.au', specifically for creating a 'Cutout prototype for SODA server'. It contains fields for Target (ICRS, name), Radius, Time, Band, Pol, ID, and Pol, along with buttons for Reset, Clear, Submit, and Close. At the bottom of the dialog, there are zoom controls and a search bar. The status bar at the bottom provides information about selected data products and system performance.

# ASKAP data : CASDA services Ready for SODA query

Aladin v10.0 \*\*\* BETA VERSION (based on v10.073) \*\*\* Aladin v10.0 \*\*\* PROTOTYPE VERSION (based on v10.098) \*\*\*

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 4 Command 13:58:08.23 -60:42:26.6 Frame CRS Projection Alt/Off

DSS SDSS 2MASS WISE GALEX PLANCK AKARI XMM Fermi Gaia Simbad NED +

actions → 4 / 22641 hers → 4 / 1258 IA2 (Image/cube) → 1 / 8 au\_csiro → 1 CSIRO ASKAP Science SA (spectrum) → 1 / 114 au\_csiro → 1 CSIRO ASKAP Science S(table) → 1 / 566 au\_csiro → 1 / 2 CSIRO ASKAP Science AP(table) → 1 / 219 au\_csiro → 1 / 3 CSIRO ASKAP Science

Service casda.csiro.au

● Cutout prototype for SODA server ?  
Fill in all these fields and press the SUBMIT button

Target (ICRS, name) 16 34 13.5 -25 43 46.0  
Radius 0.73°  
Time  
Band 0.21015484917063945 0.2200261166617463  
Pol  
ID T21AwjdclT1HIEpZLk-AQYkeot5LMtVlqlUX  
ASYNC

Reset Clear Submit Close

15° 122.2° × 69.91° E N

grid study wink north hdr multiview match Search

access url	dataproduct type	calib level	obs collection	obs id	obs publisher	access format	access estsize	target name	s ra	s dec
https://data.csi...	cube	3	P248	P248	cube-729	application/x-vot...	54467	246.28709726...	-26.03332860...	120
https://data.csi...	cube	3	P248	P248	cube-778	application/x-vot...	54456	247.28505537...	-18.03333018...	120

select casda from -- all co... coll. sort view scan Job controller

ALADIN

au\_csiro / casda / sia2 ~1 CDS/P/DSS2/color epoch size dens. opac. zoom

180° -180° 17:01:25.83163 35:56:35.1887 122.2° × 69.91°

# ASKAP data : CASDA services

## Asynchronous SODA task completed

Aladin v10.0 \*\*\* BETA VERSION (based on v10.073) \*\*\*

Aladin v10.0 \*\*\* PROTOTYPE VERSION (based on v10.098) \*\*\*

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 4   Command 16:29:08.41329 -18:01:59.9887

DSS SDSS 2MASS WISE GALEX PLANCK AKARI XMM Fermi Gaia Simbad NED +

actions → 4 / 22641  
hers → 4 / 1258  
IA2 (image|cube) → 1 /  
au\_csiro → 1  
CSIRO ASKAP Science SA (spectrum) → 1 / 11  
au\_csiro → 1 / 1  
CSIRO ASKAP Science S (table) → 1 / 566  
au\_csiro → 1 / 2  
CSIRO ASKAP Science AP (table) → 1 / 219  
au\_csiro → 1 / 3  
CSIRO ASKAP Science

Service casda.csiro.au

Cutout prototype for SODA server ?

Fill in all these fields and press the SUBMIT button

Target (ICRS, name) 16 34 13.5 -25 43 46.0

Radius 0.73°

Time

Band 0.21015484917063945 0.2200261166617463

Pol

ID T21AwjdLcT1HiEpZLK-AQYke0t5LMtVlqjUX

Job controller

Asynchronous jobs of current session:

● COMPLETED , Start time: 2019-01-10T02:00:39.680+0800 (server: [SODA]casda.csiro.au)

Or choose an already submitted job:

○ Job URL  GO

Load From /results/result ABORT DELETE  Delete on closing Aladin

Job details:

Load on Aladin: <http://casda.csiro.au/download%2Fweb%2Fa0b425e-9fc8-43fb-b58e-e0474563cb0b%2Fcutoout-12881-imagecube-729.fits> LOAD

Job ID: a0b425e-9fc8-43fb-b58e-e0474563cb0b  
Run ID: null  
URL: [https://casda.csiro.au/casda\\_data\\_access/data/async/a0b425e-9fc8-43fb-b58e-e0474563cb0b](https://casda.csiro.au/casda_data_access/data/async/a0b425e-9fc8-43fb-b58e-e0474563cb0b)

https://casda.csiro.au/casda_data_access/data/async/a0b425e-9fc8-43fb-b58e-e0474563cb0b	cube	3	P248	P248	cube-729	application/x-vot	54407	246.28709728...	-26.03332860...	120
https://casda.csiro.au/casda_data_access/data/async/a0b425e-9fc8-43fb-b58e-e0474563cb0b	cube	3	P248	P248	cube-778	application/x-vot	54456	247.28505537...	-18.03333018...	120

select casda  
from -- all co...  
coll sort view scan

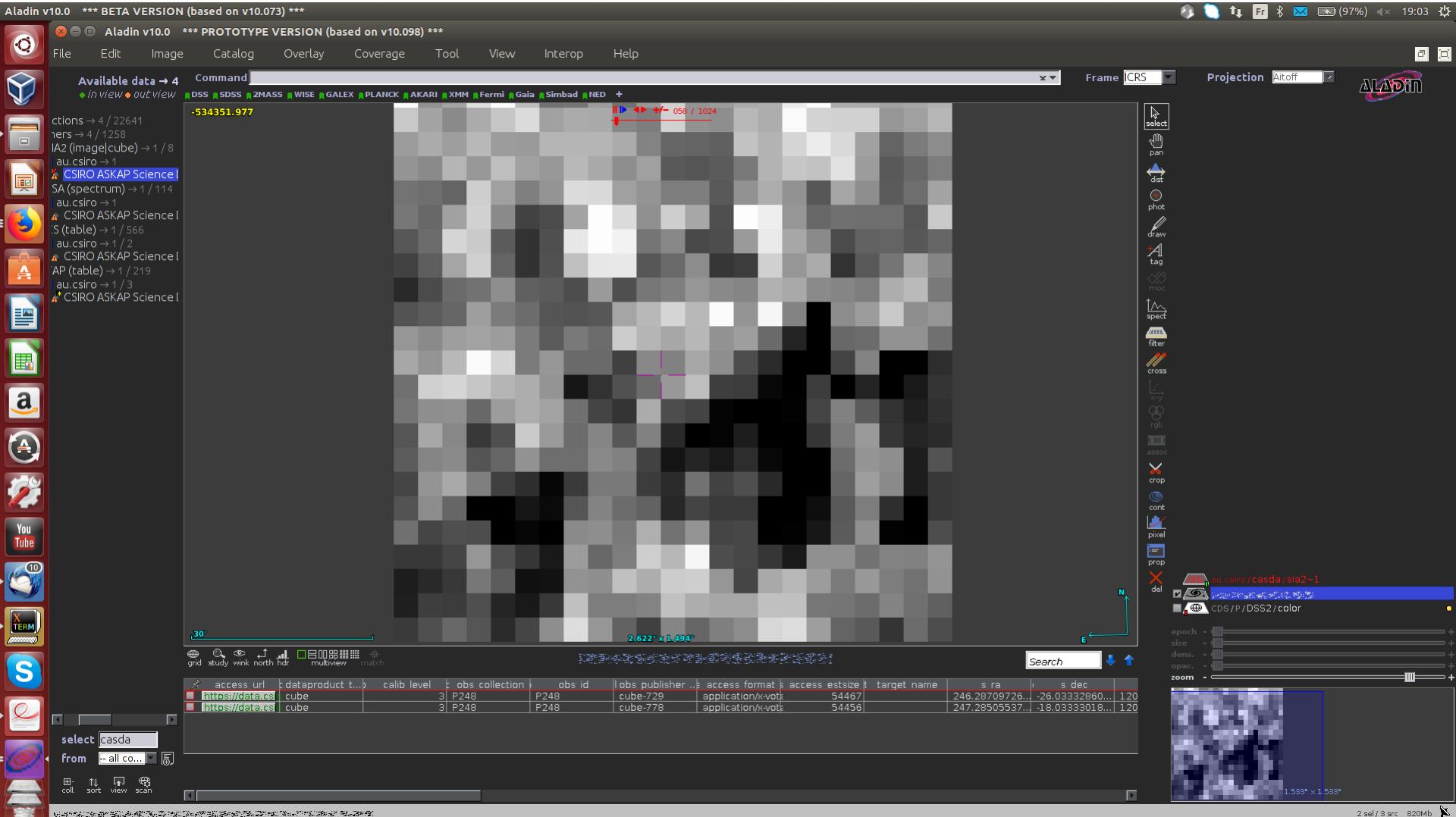
Frame ICRS Projection Aitoff ALADIN

select pan dist phot draw A tag rmw spec ann Filter cross

17:01:25.83163 -35:56:35.1887  
122,2° x 69,9°

2 sel / 3 src 676Mb

# ASKAP data : CASDA services cutout cube loaded



# ASKAP data : CASDA services spectrum cutout

Aladin v10.0 \*\*\* BETA VERSION (based on v10.073) \*\*\*

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 4   Command [16:28:09.05 -25:58:01.6]

DSS SDSS ZMASS WISE GALEX PLANCK AKARI XMM Fermi Gaia Simbad NED +

actions → 4 / 22641  
bers → 4 / 1258  
IA2 (image/cube) → 1 / 8  
au.csiro → 1  
CSIRO ASKAP Science [1]  
SA (spectrum) → 1 / 114  
au.csiro → 1  
CSIRO ASKAP Science [1]  
S (table) → 1 / 566  
au.csiro → 1 / 2  
CSIRO ASKAP Science [1]  
AP (table) → 1 / 219  
au.csiro → 1 / 3  
CSIRO ASKAP Science [1]

DSS2 color

Service casda.csiro.au

Cutout prototype for SODA server ?  
Fill in all these fields and press the SUBMIT button

Target (ICRS, name) 16 27 46.15903 -25 44 54.2702  
Radius 25.26'

Time

Band 0.21015484916529545 0.220026116655881

Pol

ID IAwjdlcT1HIEq7251deoebNLMEEsqZ3bmz  
ASYNC

Reset Clear Submit Close

23.42° x 13.87°

grid study wink north hdr multiview match

Search

N E

au.csiro/casda/sia2~1

DSS/P/DSS2/color

epoch - size - dens - opac -

zoom -

180 16:29:35.11766 -23:26:49.9150 13.87°

0 sel / 3 src 345Mb

select casda  
from -- all co...  
coll. sort view scan

The screenshot shows the Aladin software interface, version v10.0, running on a Linux desktop. The main window displays a star field with several prominent nebulae and galaxies. A service dialog box from 'casda.csiro.au' is open in the foreground, prompting the user to enter target coordinates (16 27 46.15903 -25 44 54.2702), a radius (25.26'), and other parameters like band and ID. The background shows a dark sky with numerous stars and some faint nebulae. On the left, there's a vertical toolbar with various icons for file operations, and on the right, a column of tool icons. The bottom of the screen has a taskbar with several application icons.

# ASKAP data : CASDA services spectrum cutout

Aladin v10.0 \*\*\* BETA VERSION (based on v10.073) \*\*\*

Aladin v10.0 \*\*\* PROTOTYPE VERSION (based on v10.098) \*\*\*

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 4    Service casda.csiro.au

Cutout prototype for SODA server

Fill in all these fields and press the SUBMIT button

Target (ICRS, name): 16 25 18.95162 -26 02 18.7137

Radius: 2.704'

Time:

Band: 0.21015484917063945 0.2200261166617463

Pol:

ID: iERxaCEZ6GFbCQEBVu8wpW4ALYUAttPlA

ASYNC

Reset Clear Submit Close

FITS header

SIMPLE	= T / conforms to FITS standard
BITPIX	= -64 / array data type
NAXIS	= 3 / number of array dimensions
NAXIS1	= 1
NAXIS2	= 1
NAXIS3	= 1024
DATAMIN	= -8.000000E+00
DATAMAX	= 3.200000E+01
BMAJ	= 2.583333E-01
BMIN	= 2.583333E-01
BPA	= 0.000000E+00
BUNIT	= 'Jy' / Brightness (pixel) unit
EPOCH	= 2.000000000000E+03
LONPOLE	= 1.800000000000E+02
CTYPE1	= 'RA-- SIN'
CRVAL1	= 2.462500000000E+02
CDELT1	= -6.66667014360E-02
CROTA1	= 0.000000000000E+00
CRPIX1	= 3.
CUNIT1	= 'deg'
CTYPE2	= 'DEC-- SIN'
CRVAL2	= -2.600000000000E+01
CDELT2	= 6.666667014360E-02
CROTA2	= 0.000000000000E+00
CRPIX2	= 3.
CUNIT2	= 'deg'
CTYPE3	= 'VELO-HEL'
CRVAL3	= -4.024387640672E+05
CDELT3	= 1.319132129105E+04
CROTA3	= 0.000000000000E+00
CRPIX3	= 68.
CUNIT3	= 'Hz'

Hz) reference value  
cy reference pixel  
ity: radio convention  
6 SOU, 7 GAL

Save Undo Close

Load from /results/result ABORT DELETE  Delete on closing Aladin

epoch size dens. opacity zoom

120

4' × 4'

1 sel / 3 src 808Mb

Aladin: http://casda.csiro.au%2Fcasda.csiro.au%2Fdownload%2Fweb%2F880a27f9-8ba9-4dc0-8046-7a3a66d58f1c%2Fspectrum-12883-imagecube-729.fits

http://casda.csiro.au/casda\_data\_access/data/async/880a27f9-8ba9-4dc0-8046-7a3a66d58f1c

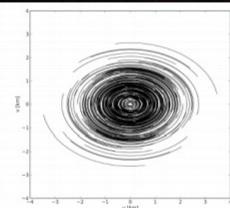
# Visibility data ?

## (direct discovery or via )

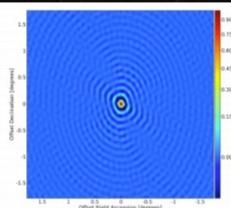
### Data Types: Visibilities

ASTRON

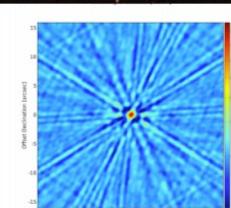
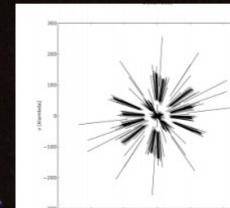
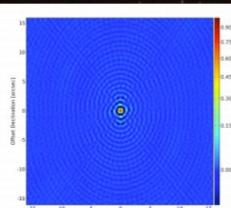
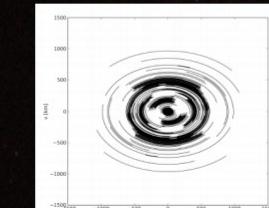
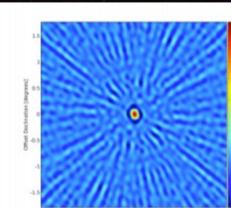
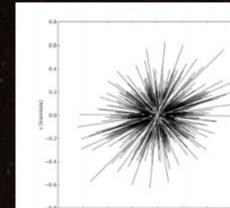
- Interferometer: Creating virtual aperture up to  $\sim 2000\text{km}$  ( $\lambda/D$ )
- Incomplete coverage
- Typical use of Radio Telescopes: imaging depending on science
- LOFAR: Projection effects (No moving dish/mirror)



6 hours



1 second

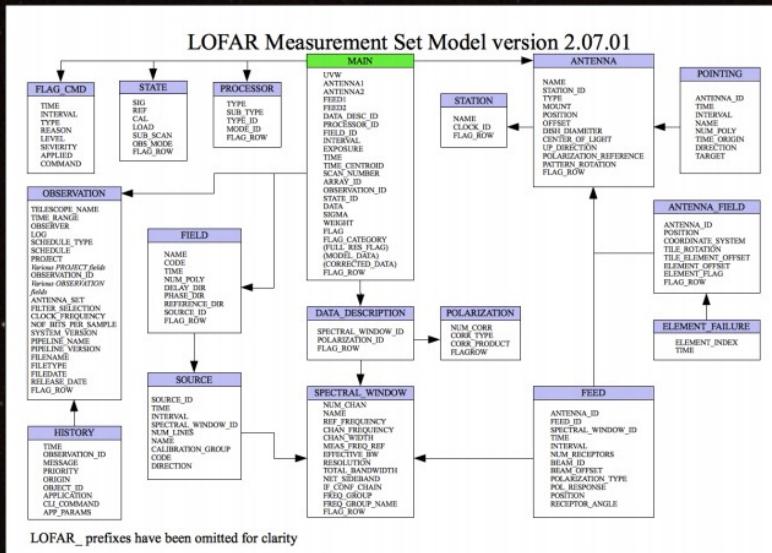


# Visibility data ? (LOFAR measurement sets model : )

## Data Types: Visibilities

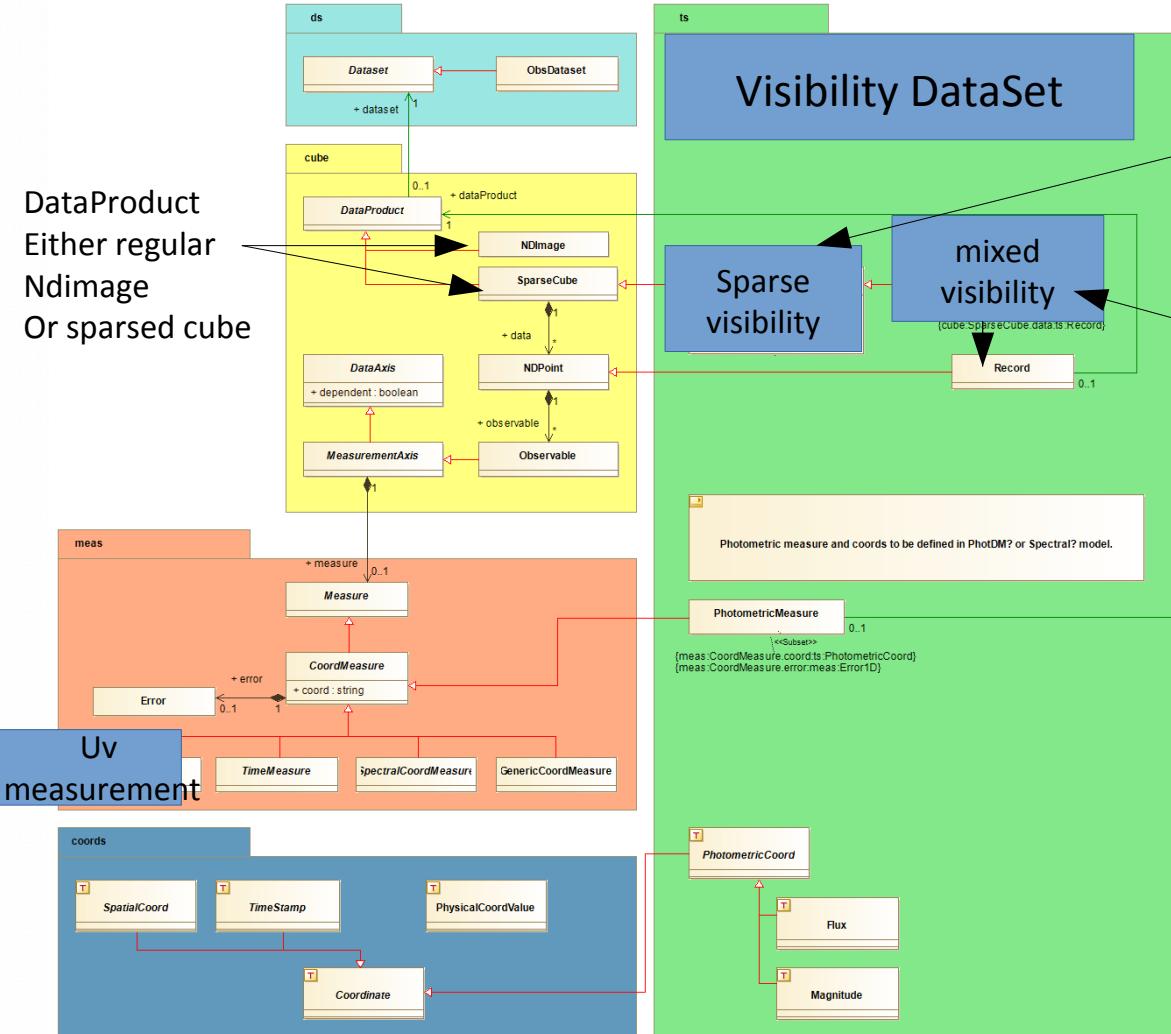
ASTRON

- Stored as CASA Measurement Sets
  - 10 MB - 100 GB in size, per 192 kHz frequency band
  - Usually 400-488 per observation
  - Relational structure
  - Each cell can have multiple dimensions (pol x freq)



# Visibility datamodel ?:

derived from cube datamodel  
inspired by TimeSeries datamodel



Sparse Visibility : set of uv, time  
Spectral, polarization,  
Photometric tuples (ND points)

Mixed visibility : set of  
Spectro-polarization Ndimages  
for some sparsed uv, time

