IVOA standards potentially useful for CTA / KM3net : current status

F.Bonnarel, CDS, ESCAPE-CEVO task 2

Data levels

- DL6 / catalogues
- DL5 / images, spectra, timeseries
- DL3 / filtered event lists
- DL4 / binned data → ?

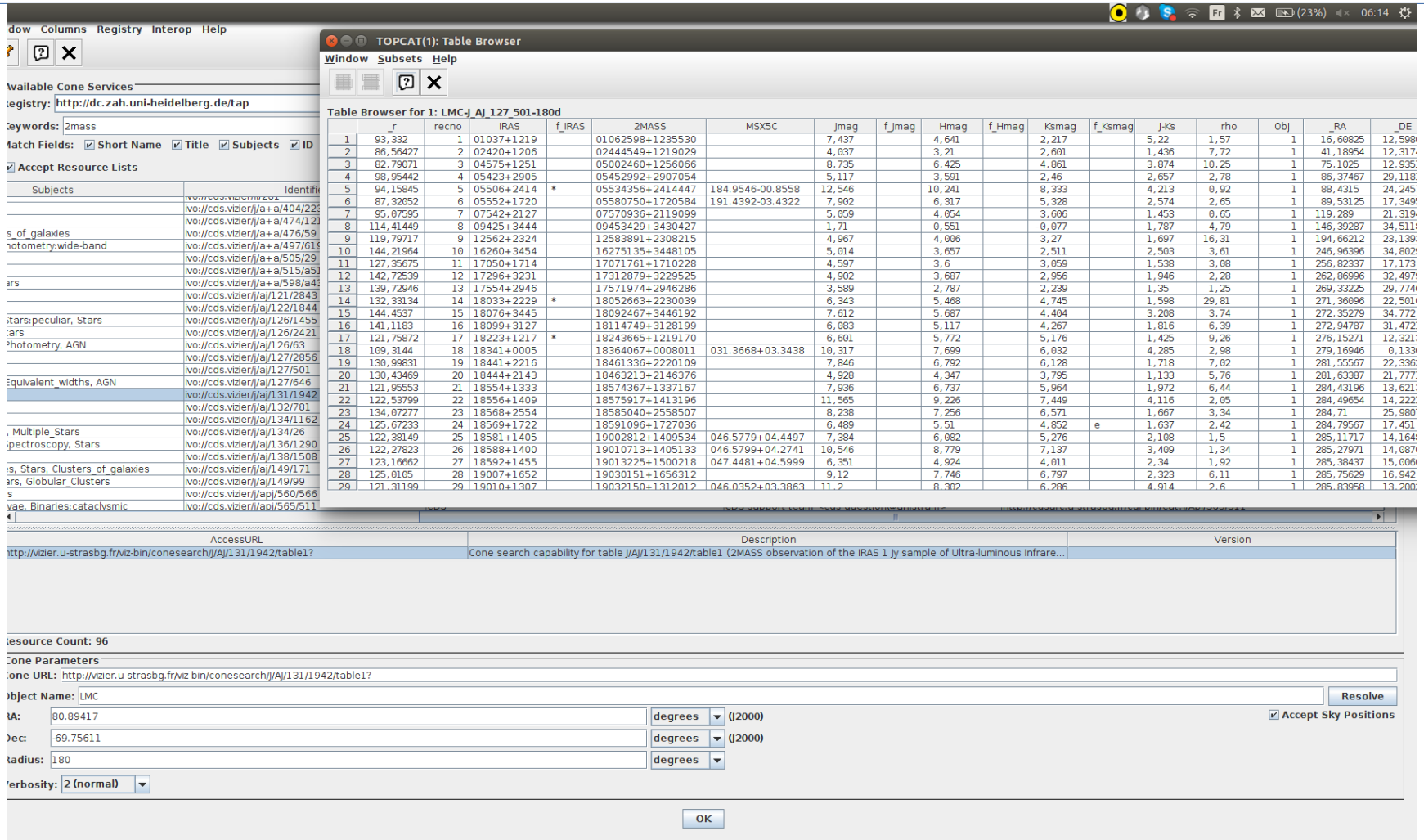
DL6 : catalogues

- Choose basic SCS :
  - Very simple interface
  - Response is in VOTable = XML standard for tables.
  - FIELD attributes = name, datatype, unit, ucd (standardized vocabulary)
  - *(+utype = pointer to datamodel leaves)*

DL6 : catalogues

- Or more advanced TAP :
  - interoperable remote access interface for relational databases
  - Using ADQL, a SQL-like query langage
  - Database described in the TAP_SCHEMA
- HiPS also possible (see next section)

SCS access through TOPCAT application (VizieR catalogues)



VOTable : header

```
<?xml version="1.0" encoding="UTF-8"?>
<VOTABLE xmlns="http://www.ivoa.net/xml/VOTable/v1.2" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" version="1.2">
  <RESOURCE type="results">
    <INFO name="QUERY_STATUS" value="OK" />
    <INFO name="QUERY" value="SELECT * FROM ivoa.ObsCore WHERE dataproduct_type IN ( 'image', 'cube' ) AND (INTERSECTS(CIRCLE('ICRS',20.0,30.0,0.2), s_region) = 1)" />
    <TABLE>
      <FIELD name="dataproduct_type" datatype="char" ucd="meta.id;class" utype="obscore:ObsDataset.dataProductType" xtype="adql:VARCHAR" arraysize="128*">
        <DESCRIPTION>type of product</DESCRIPTION>
      </FIELD>
      <FIELD name="calib_level" datatype="int" ucd="meta.code;obs.calib" utype="obscore:ObsDataset.calibLevel" xtype="adql:INTEGER">
        <DESCRIPTION>calibration level (0,1,2,3)</DESCRIPTION>
      </FIELD>
      <FIELD name="obs_collection" datatype="char" ucd="meta.id" utype="obscore:DataID.collection" xtype="adql:VARCHAR" arraysize="128*">
        <DESCRIPTION>short name for the data colection</DESCRIPTION>
      </FIELD>
      <FIELD name="facility_name" datatype="char" ucd="meta.id;instr.tel" utype="obscore:Provenance.ObsConfig.Facility.name" xtype="adql:VARCHAR" arraysize="128*">
        <DESCRIPTION>telescope name</DESCRIPTION>
      </FIELD>
      <FIELD name="instrument_name" datatype="char" ucd="meta.id;instr" utype="obscore:Provenance.ObsConfig.Instrument.name" xtype="adql:VARCHAR" arraysize="128*">
        <DESCRIPTION>instrument name</DESCRIPTION>
      </FIELD>
      <FIELD name="obs_id" datatype="char" ucd="meta.id" utype="obscore:DataID.observationID" xtype="adql:VARCHAR" arraysize="128*">
        <DESCRIPTION>internal dataset identifier</DESCRIPTION>
      </FIELD>
      <FIELD name="obs_release_date" datatype="char" ucd="time.release" utype="obscore:Curation.releaseDate" xtype="adql:TIMESTAMP" arraysize="*">
        <DESCRIPTION>timestamp of date the data becomes publicly available</DESCRIPTION>
      </FIELD>
      <FIELD name="access_url" datatype="char" ucd="meta.ref.url" utype="obscore:Access.reference" xtype="adql:CLOB" arraysize="*">
        <DESCRIPTION>URL to download the data</DESCRIPTION>
      </FIELD>
      <FIELD name="access_format" datatype="char" ucd="meta.id;class" utype="obscore:Access.format" xtype="adql:VARCHAR" arraysize="128*">
        <DESCRIPTION>format of the data file(s)</DESCRIPTION>
      </FIELD>
      <FIELD name="access_estsize" datatype="int" ucd="phys.size;meta.file" unit="kB" utype="obscore:Access.size" xtype="adql:INTEGER">
        <DESCRIPTION>estimated size of the download</DESCRIPTION>
      </FIELD>
      <FIELD name="target_name" datatype="char" ucd="meta.id;src" utype="obscore:Target.name" xtype="adql:VARCHAR" arraysize="32*">
        <DESCRIPTION>name of intended target</DESCRIPTION>
      </FIELD>
      <FIELD name="s_ra" datatype="double" ucd="pos.eq.ra" unit="deg" utype="obscore:Char.SpatialAxis.Coverage.Location.Coord.Position2D.Value2.C1" xtype="adql:DOUBLE">
        <DESCRIPTION>RA of central coordinates</DESCRIPTION>
      </FIELD>
      <FIELD name="s_dec" datatype="double" ucd="pos.eq.dec" unit="deg" utype="obscore:Char.SpatialAxis.Coverage.Location.Coord.Position2D.Value2.C2" xtype="adql:DOUBLE">
        <DESCRIPTION>DEC of central coordinates</DESCRIPTION>
      </FIELD>
      <FIELD name="s_fov" datatype="double" ucd="phys.angSize;instr.fov" unit="deg" utype="obscore:Char.SpatialAxis.Coverage.Bounds.Extent.diameter" xtype="adql:DOUBLE">
        <DESCRIPTION>size of the region covered (~diameter of minimum bounding circle)</DESCRIPTION>
      </FIELD>
      <FIELD name="s_region" datatype="char" ucd="phys.area;obs" unit="deg" utype="obscore:Char.SpatialAxis.Coverage.Support.Area" xtype="adql:REGION" arraysize="*">
        <DESCRIPTION>region bounded by observation</DESCRIPTION>
      </FIELD>
      <FIELD name="s_resolution" datatype="float" ucd="pos.angResolution" unit="arcsec" utype="obscore:Char.SpatialAxis.Resolution.Refval.value" xtype="adql:REAL">
        <DESCRIPTION>typical spatial resolution</DESCRIPTION>
      </FIELD>
      <FIELD name="s_xel1" datatype="long" ucd="meta.number" utype="obscore:Char.SpatialAxis.numBins1" xtype="adql:BIGINT">
        <DESCRIPTION>dimensions (number of pixels) along one spatial axis</DESCRIPTION>
      </FIELD>
      <FIELD name="s_xel2" datatype="long" ucd="meta.number" utype="obscore:Char.SpatialAxis.numBins2" xtype="adql:BIGINT">
        <DESCRIPTION>dimensions (number of pixels) along the other spatial axis</DESCRIPTION>
      </FIELD>
```

VOTable : data

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<DATA>
  <TABLEDATA>
    <TR>
      <TD>image</TD>
      <TD>1</TD>
      <TD>CFHT</TD>
      <TD>CFHT 3.6m</TD>
      <TD>MegaPrime</TD>
      <TD>1022444</TD>
      <TD>2008-01-01T00:00:00.000</TD>
      <TD>http://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/caom2ops/datalink?runid=q8p071gzw9v2rxkf&amp;ID=caom%3ACFHT%2F1022444%2F1022444o</TD>
      <TD>application/x-votable+xml;content=datalink</TD>
      <TD />
      <TD>FM33_09</TD>
      <TD>20.6621229608811</TD>
      <TD>30.2998934335786</TD>
      <TD>1.40046285285166</TD>
      <TD>Polygon ICRS UNKNOWNREFPOS SPHERICAL2 21.23053934693744 29.801543490109047 20.098218552646575 29.798156162746917 20.08852659238419 30.7960764114054 21.231225994547927 30.799206638194327</TD>
      <TD />
      <TD>18984</TD>
      <TD>19274</TD>
      <TD>54713.4549109</TD>
      <TD>54713.4554322542</TD>
      <TD>45.045</TD>
      <TD>45.045</TD>
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      <TD>4.078E-7</TD>
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      <TD>3.01108374384</TD>
      <TD>1</TD>
      <TD />
      <TD />
      <TD />
      <TD>phot.count</TD>
      <TD>445576258379037328</TD>
      <TD>2015-06-29T23:28:05.340</TD>
      <TD>caom:CFHT/1022444/1022444o</TD>
    </TR>
    <TR>
      <TD>image</TD>
      <TD>1</TD>
      <TD>CFHT</TD>
      <TD>CFHT 3.6m</TD>
      <TD>MegaPrime</TD>
      <TD>1022574</TD>
      <TD>2008-01-01T00:00:00.000</TD>
      <TD>http://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/caom2ops/datalink?runid=q8p071gzw9v2rxkf&amp;ID=caom%3ACFHT%2F1022574%2F1022574o</TD>
      <TD>application/x-votable+xml;content=datalink</TD>
      <TD />
      <TD>FM33_09</TD>
      <TD>20.6621229608811</TD>
      <TD>30.2998934335786</TD>
      <TD>1.40046285285166</TD>
      <TD>Polygon ICRS UNKNOWNREFPOS SPHERICAL2 21.23053934693744 29.801543490109047 20.098218552646575 29.798156162746917 20.08852659238419 30.7960764114054 21.231225994547927 30.799206638194327</TD>
      <TD />
      <TD>18984</TD>
      <TD>19274</TD>
      <TD>54714.4055485</TD>
      <TD>54714.4060700278</TD>
      <TD>45.06</TD>
```

UCD
(unified content descriptor)

- Standard terms for each astronomical « property »
  - Hierarchical structure and possible composition
  - Possibility to add new terms/branches
  - Do we need that for high energy catalogues ?

International Virtual Observatory Alliance

The UCD1+ controlled vocabulary
Version 1.3

Update including new terms for Planetary and Solar data

Submitted 20180219

IVOA recommendation 2018 may 27

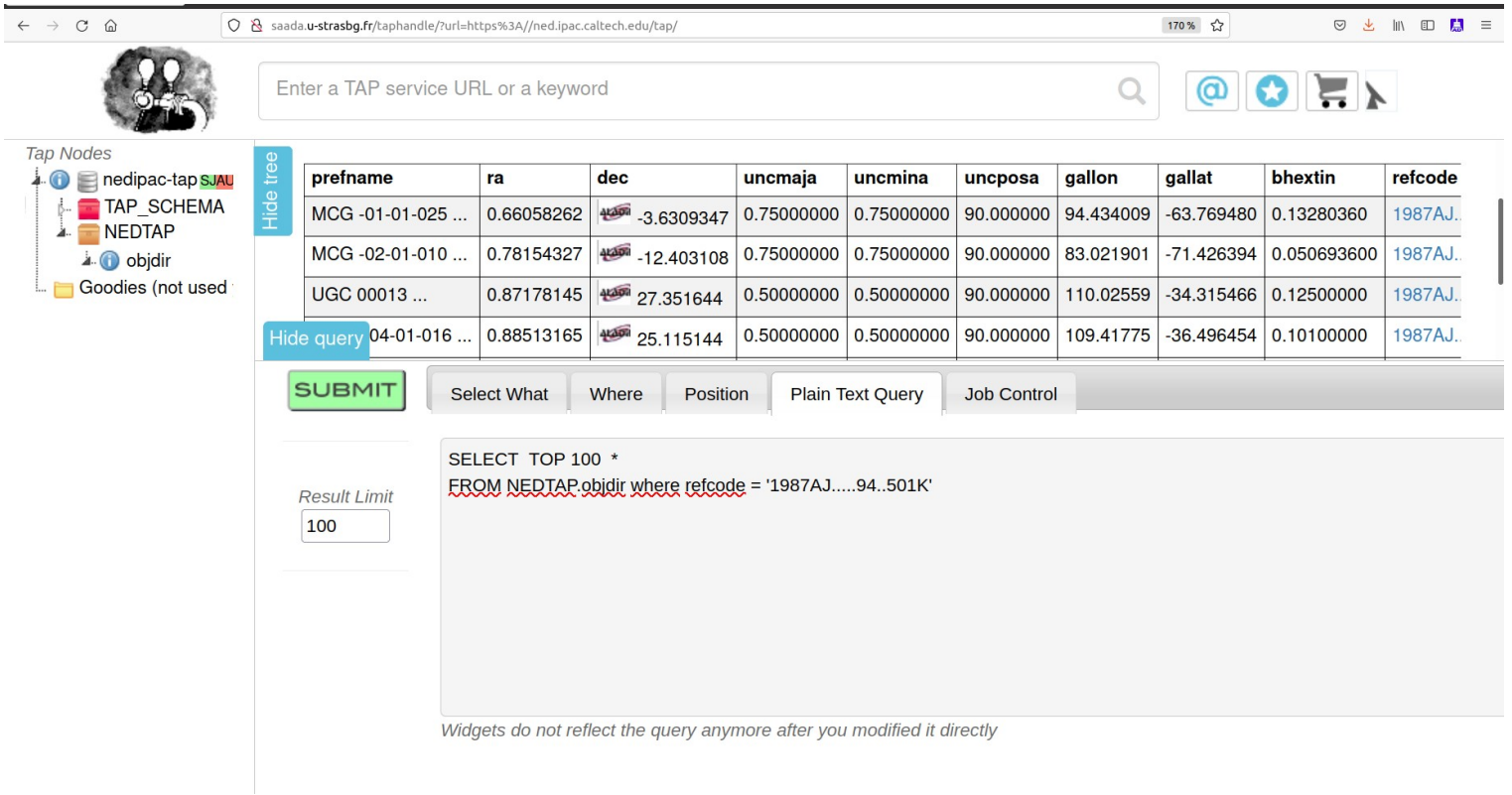
This version:
http://ivoa.net/documents/UCD1+/20180527/REC-UCDlist-1.3-20180527.pdf
Latest version :
http://ivoa.net/documents/UCD1+/20180219/PR-UCDlist-1.3-20180219.pdf
Previous version(s):
http://www.ivoa.net/Documents/REC/UCD/UCDlist-20070402.html
Editor(s):
A. Preite Martinez, M. Louys
Author(s):
Andrea Preite Martinez, Mireille Louys, Baptiste Cecconi, Sebastien Derriere, François Ochsenbein, and the IVOA Semantic Working group.

Abstract

This document describes the list of controlled terms used to build the Unified Content Descriptors, Version 1+ (UCD1+). The document describing the UCD1+ can be found at the URL: http://www.ivoa.net/Documents/latest/UCD.html. This document reviews the structure of the UCD1+ and presents the current vocabulary.

S	em.IR.J	Infrared between 1.0 and 1.5 micron
S	em.IR.H	Infrared between 1.5 and 2 micron
S	em.IR.K	Infrared between 2 and 3 micron
S	em.IR.3-4um	Infrared between 3 and 4 micron
S	em.IR.4-8um	Infrared between 4 and 8 micron
S	em.IR.8-15um	Infrared between 8 and 15 micron
S	em.IR.15-30um	Infrared between 15 and 30 micron
S	em.IR.30-60um	Infrared between 30 and 60 micron
S	em.IR.60-100um	Infrared between 60 and 100 micron
S	em.IR.NIR	Near-Infrared, 1-5 microns
S	em.IR.MIR	Medium-Infrared, 5-30 microns
S	em.IR.FIR	Far-Infrared, 30-100 microns
S	em.UV	Ultraviolet part of the spectrum
S	em.UV.10-50nm	Ultraviolet between 10 and 50 nm EUV extreme UV
S	em.UV.50-100nm	Ultraviolet between 50 and 100 nm
S	em.UV.100-200nm	Ultraviolet between 100 and 200 nm FUV Far UV
S	em.UV.200-300nm	Ultraviolet between 200 and 300 nm NUV near UV
S	em.X-ray	X-ray part of the spectrum
S	em.X-ray.soft	Soft X-ray (0.12 - 2 keV)
S	em.X-ray.medium	Medium X-ray (2 - 12 keV)
S	em.X-ray.hard	Hard X-ray (12 - 120 keV)
Q	em.bin	Channel / instrumental spectral bin coordinate (bin number)
Q	em.energy	Energy value in the em frame
Q	em.freq	Frequency value in the em frame
Q	em.freq.cutoff	cutoff frequency
Q	em.freq.resonance	resonance frequency
S	em.gamma	Gamma rays part of the spectrum
S	em.gamma.soft	Soft gamma ray (120 - 500 keV)
S	em.gamma.hard	Hard gamma ray (>500 keV)

TAP service within TapHandle (here NED)



prefname	ra	dec	uncmaja	uncmina	uncposa	gallon	gallat	bhextin	refcode
MCG -01-01-025 ...	0.66058262	-3.6309347	0.75000000	0.75000000	90.000000	94.434009	-63.769480	0.13280360	1987AJ..
MCG -02-01-010 ...	0.78154327	-12.403108	0.75000000	0.75000000	90.000000	83.021901	-71.426394	0.050693600	1987AJ..
UGC 00013 ...	0.87178145	27.351644	0.50000000	0.50000000	90.000000	110.02559	-34.315466	0.12500000	1987AJ..
04-01-016 ...	0.88513165	25.115144	0.50000000	0.50000000	90.000000	109.41775	-36.496454	0.10100000	1987AJ..

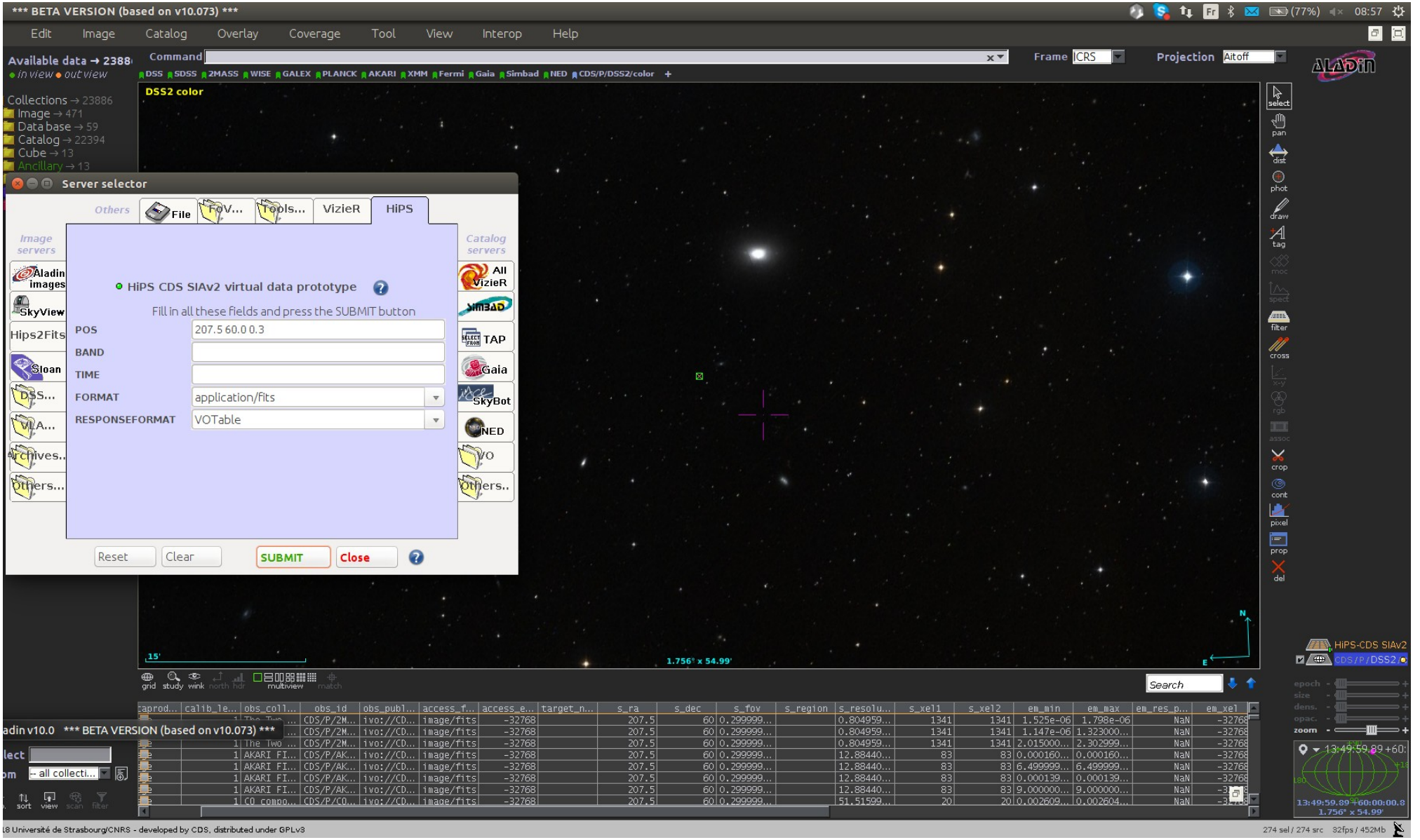
DL6 catalogue - new : MANGO

- Model for ANnotation of Generic Objects
- A data model intended to organize parameters associated to a source or any kind of root feature according to a specific view
- Coupled with the new «Mapping syntax in VOTable » may add a specific datamodel view on TOP of tabular data

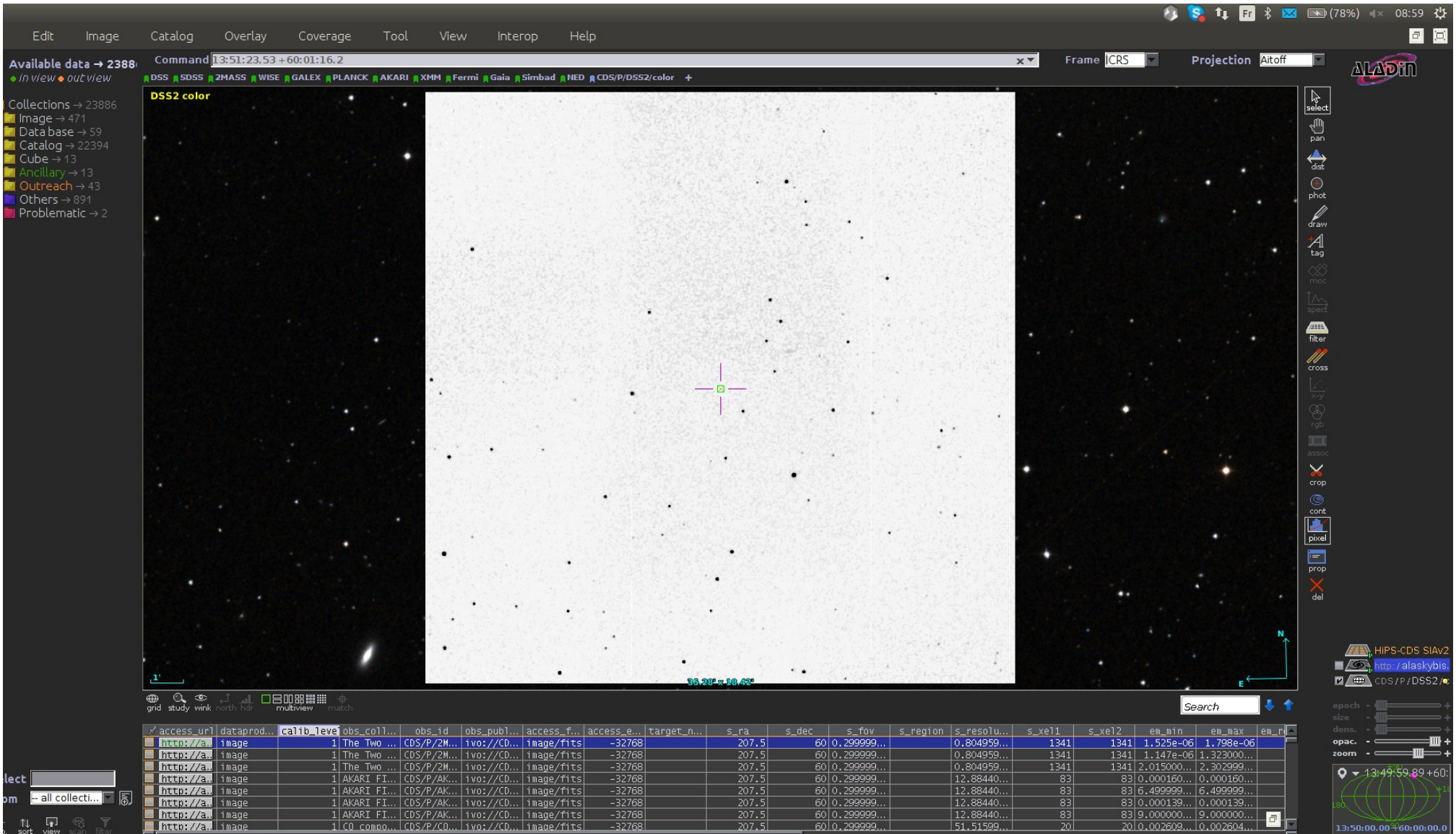
DL5 data : images

- Create a « Simple Image Access » (SIA) service
- Query parameters allow to select on
  - POSITION, BAND , TIME, POL,
  - FORMAT, COLLECTION, INSTRUMENT, DataID
- FORMAT of images is generally in fits but could be in jpeg, png, etc…
- Response is an ObsCore table .
  - What is ObsCore ? See Mireille's talk
- The ObsCore table can be accessed in a TAP service.
  - This is called « ObsTAP ».
  - → ADQL constraints set on table columns
- DataLink (in access_url) allows to link several resources to the dataset record :
  - data, preview, documentation, standardized metadata, etc…

SIA2 server at CDS



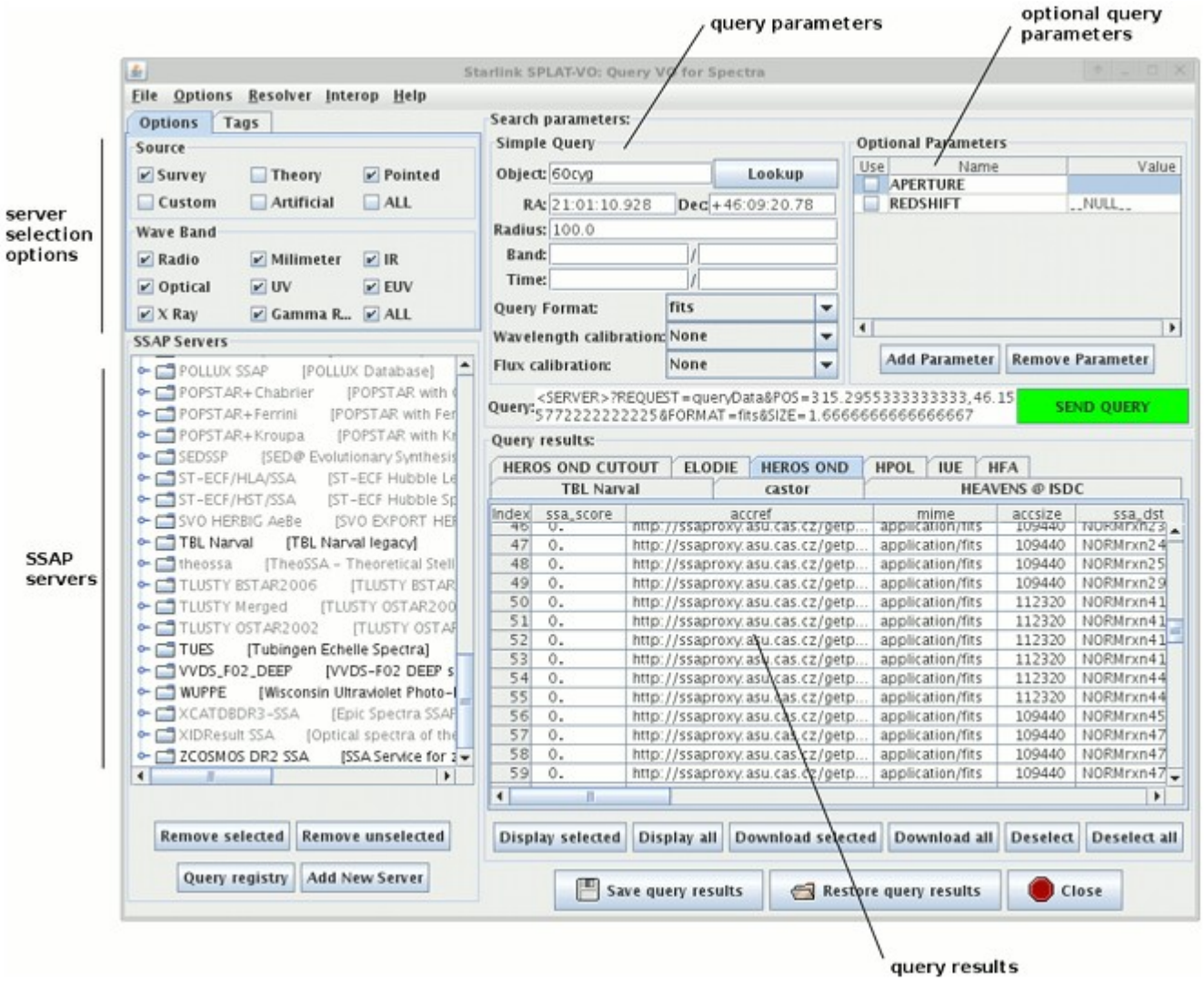
SIA2 server at CDS



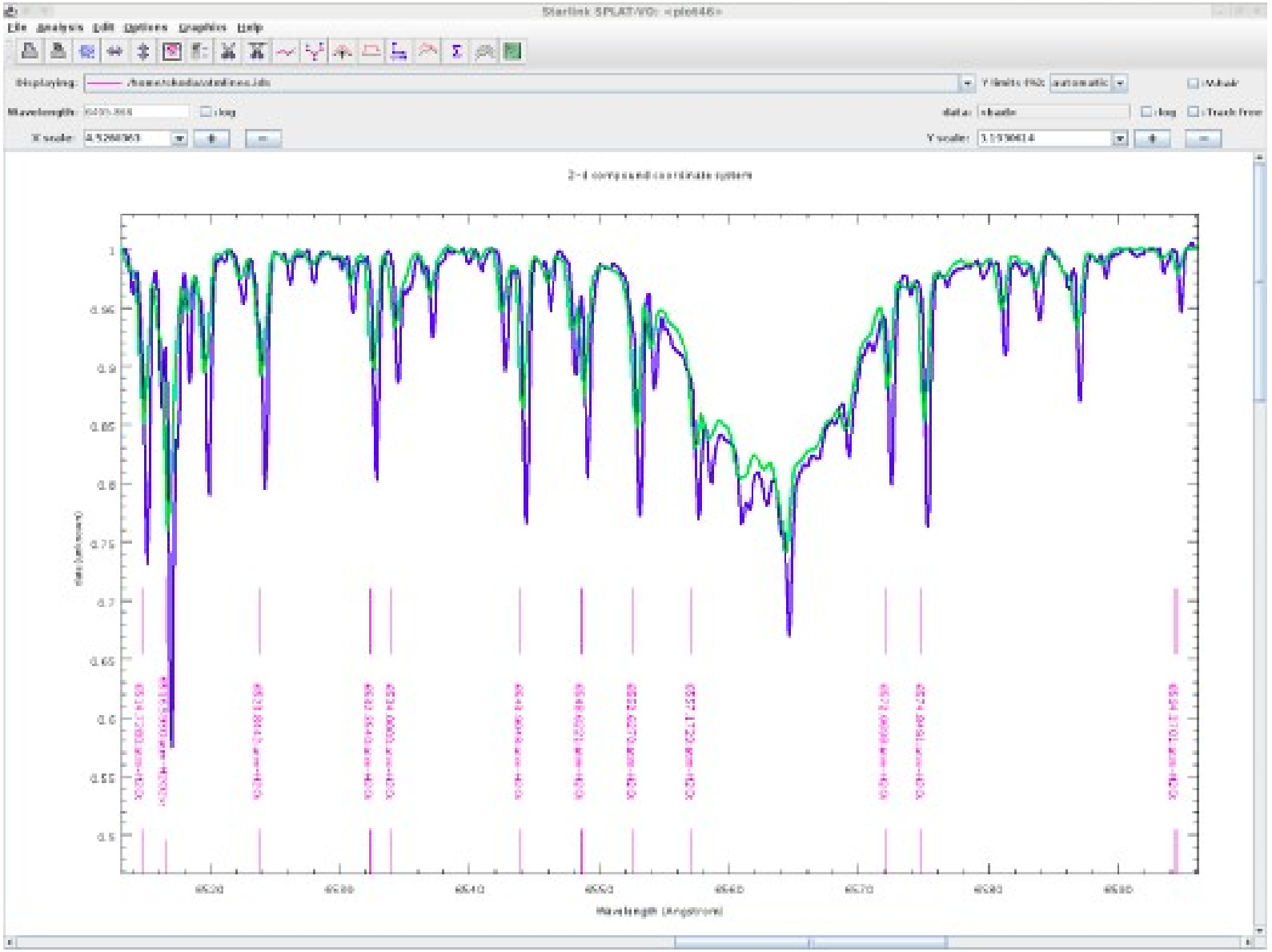
DL5 data : spectra

- Create a « Simple Spectrum Access » (SSA) service
- Query parameters allow to select on :
  - POS, SIZE, BAND , TIME, SPECRP, APERTURE, FORMAT, etc…
- Response is an SSA table.
  - See next slide for example (close but not identical to ObsCore)
- The FORMAT can be fits, VOTable, etc…
- DataLink also available

SSA query response in SPLAT



Spectrum plot in SPLAT



DL5 data : TimeSeries

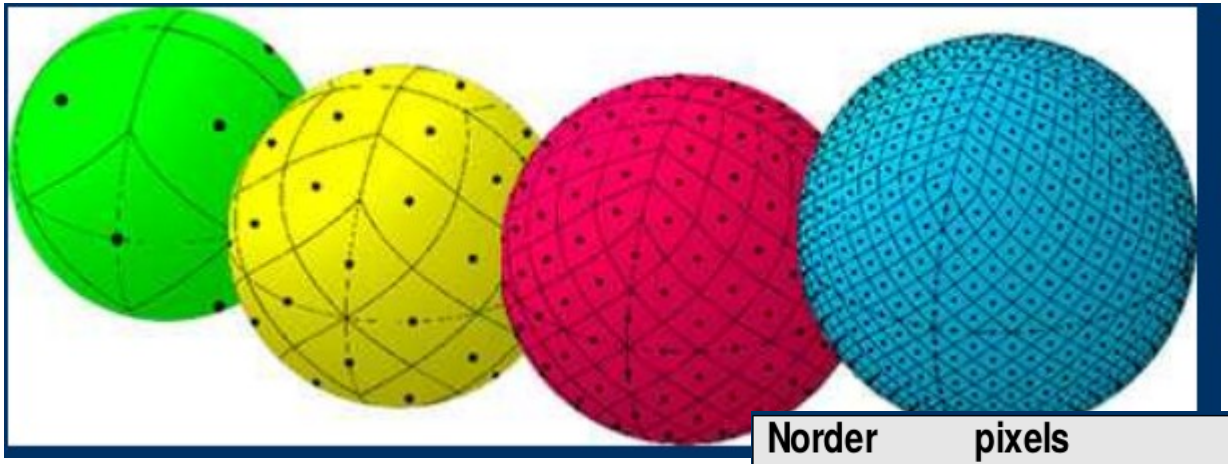
- Create an ObsTAP service dedicated to « timeseries » datasets
  - There is no « simple access » protocol for TimeSeries at the moment (see next slide)
- ADQL query allows to select on
  - s_ra, s_dec, em_min , em_max t_min, t_max, pol_states
  - obs_collection, instrument, facility, obs_publisher_did,
- Response is an ObsCore table .
- The FORMAT can be fits, VOTable, etc.
  - TIMESYS element in VOTable for time system + PhotCal GROUP (for light curves)
- DataLink also available

DL5 data : Generic « Simple Dataset acces » ?

proposal

- Extending SIA2 features to all productypes in ObsCore (spectra, timeseries, event lists…)
- Possibly for ObsCore + extension for specific data protuct type

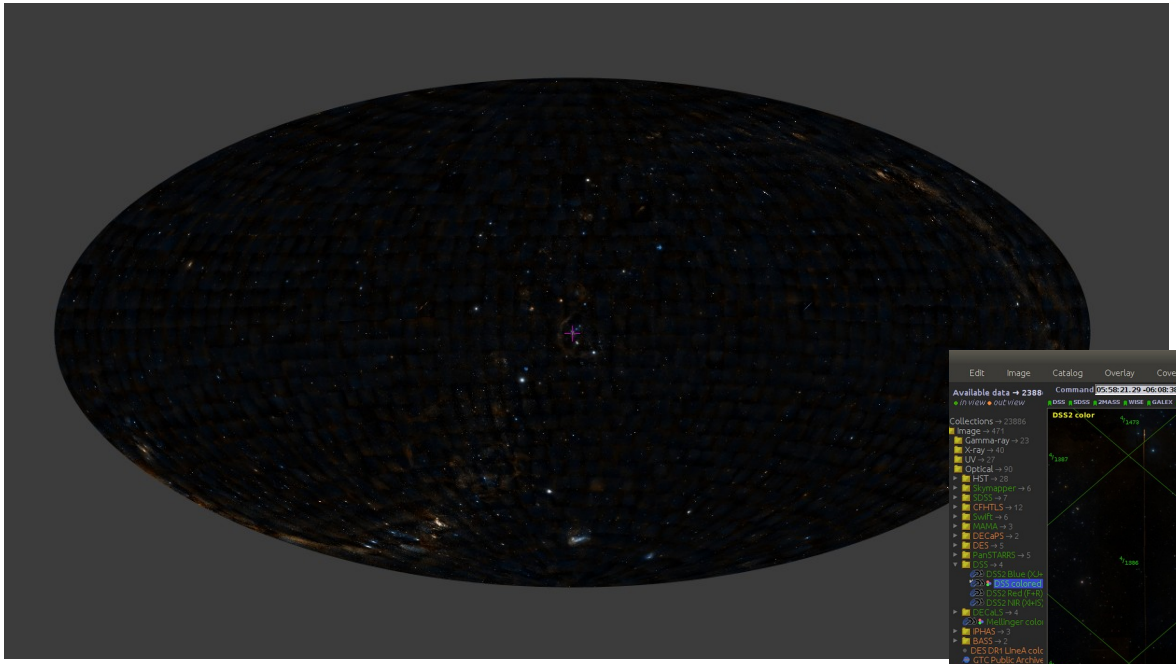
DL5 images and cubes :
HiPS - Hierachical Progressive survey

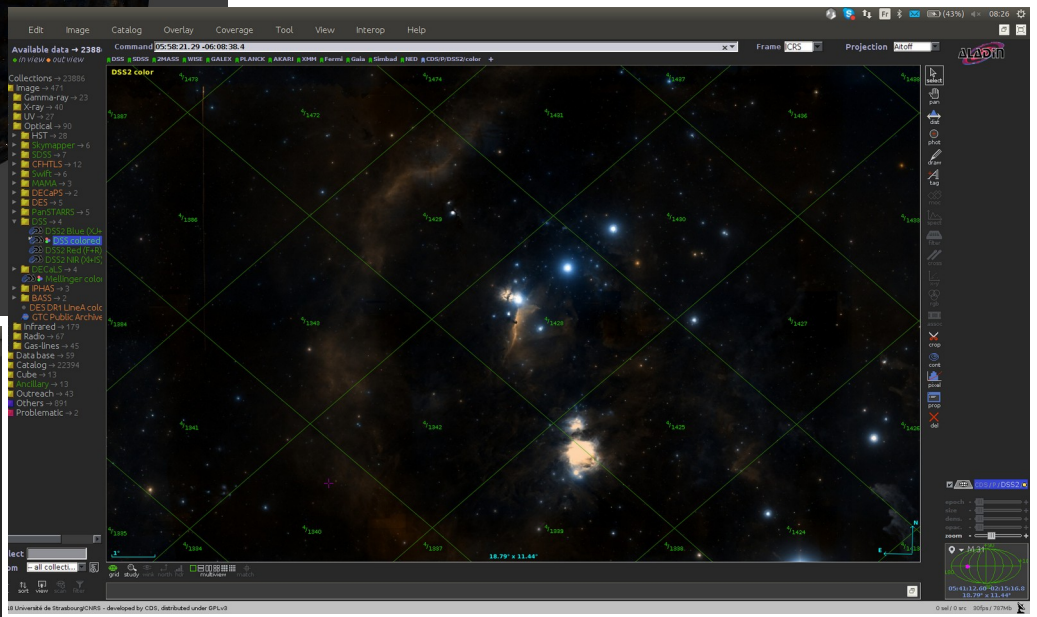


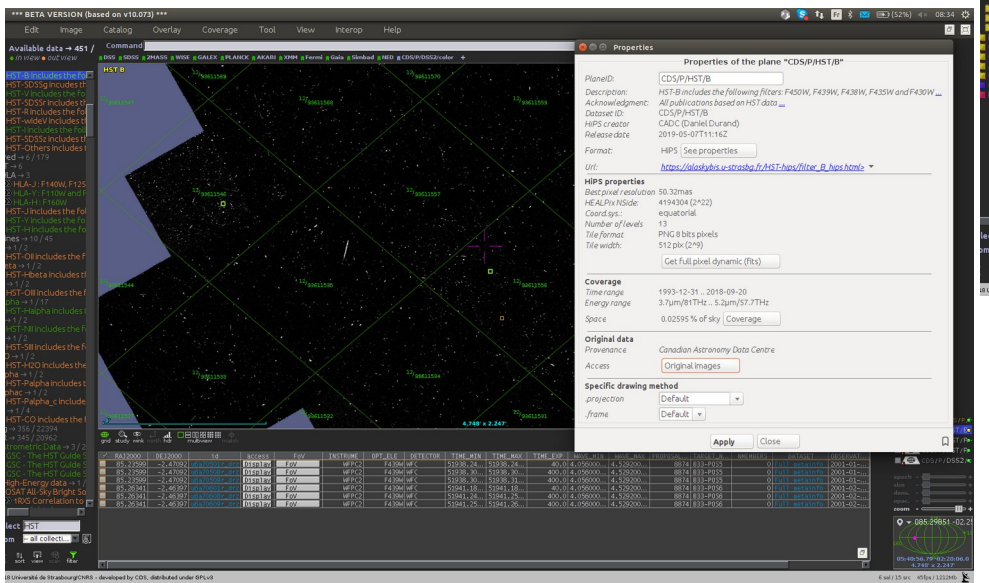
- Tessellation of celestial sphere thanks to Healpix (Hierachical equal area pixelisation)
- Tiles at some order stored with metadata in directories
- Addition of pixels from higher orders by zooming

Norder	pixels	16bits	Pix res	
0	12	24B	58.63°	
1	48	96B	29.32°	
:	:		:	
6	49152	96KB	54.97'	
:	:		:	
8	786432	1,5MB	13.74'	
9	3145728	6MB	6.87'	
:	:		:	
12	201326592	384MB	51.53"	
:	:		:	
18	8,25E+011	1,5TB	0.81"	
:	:		:	
29	3,46E+018	6 ZetaB	0,39mas	
30	1,38E+019	24 ZetaB	0,2mas	*Healpix 64 bits limit*

HiPS within Aladin







More adapted Datamodels ?

ongoing work

- Full dataset datamodels :
  - Cube datamodel ?
  - Mango ?
- Discovery/description metadata
  - More characterization parameters ?
    - Is that common between neutrino/particule/gamma ?
    - And X-Ray ?
    - ObsCore extension ?
  - Access to characterization maps/functions : response functions

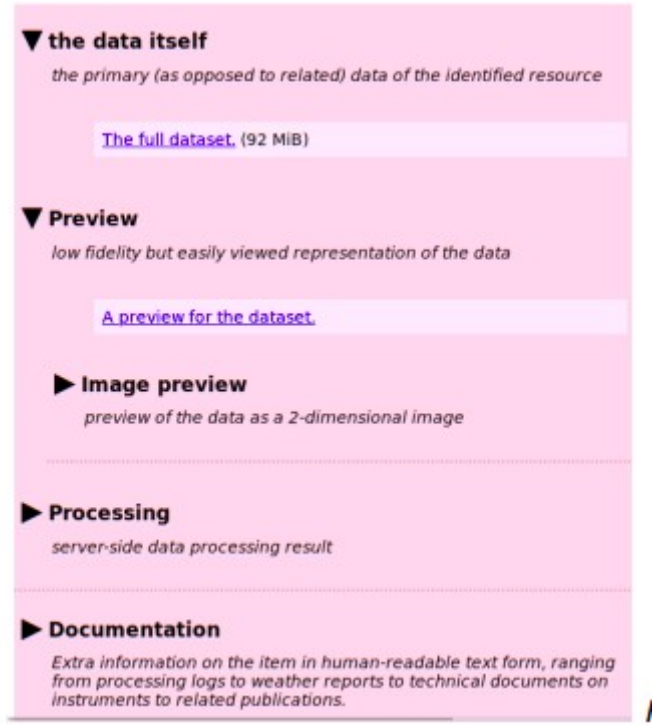
DL3 data : different strategies

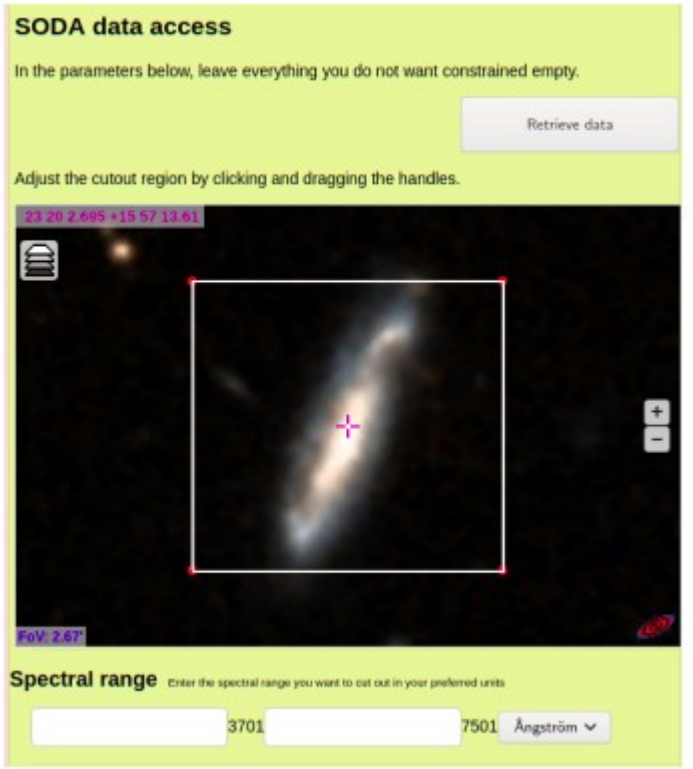
- Progenitor in HiPS
- Progenitor link in DataLink response
- Direct discovery with ObsTAP (with extension?)
- Access via provenance
- Question :
  - event list + IRF grupped or separated ?
  - (DataLink?) .
  - Change the dataproductype « event » ?

DataLink for several use cases

- Endpoint delivering several links from the main endpoint
  - From catalogues items (sources , …) → to images, spectra, cubes, timeseries, metadata, documentation
  - From dataset « records » → to data, metadata, service interfaces, other data, progenitors, calibration data, documentation
  - Semantics FIELD to characterize the relationship (this, documentation, progenitor, counterpart, etc…)
- Use cases :
  - Source in A catalogue related to provenance or spectra
  - Images related to previews, original DL4 data (or DL3)
  - Spectra related to DL4 or DL3 data
  - DL3 event list Relationship to IRF ?
  - Any level related to provenance record
  - DL5 cubes related tu SODA cutout

DataLink in the browser (GAVO)

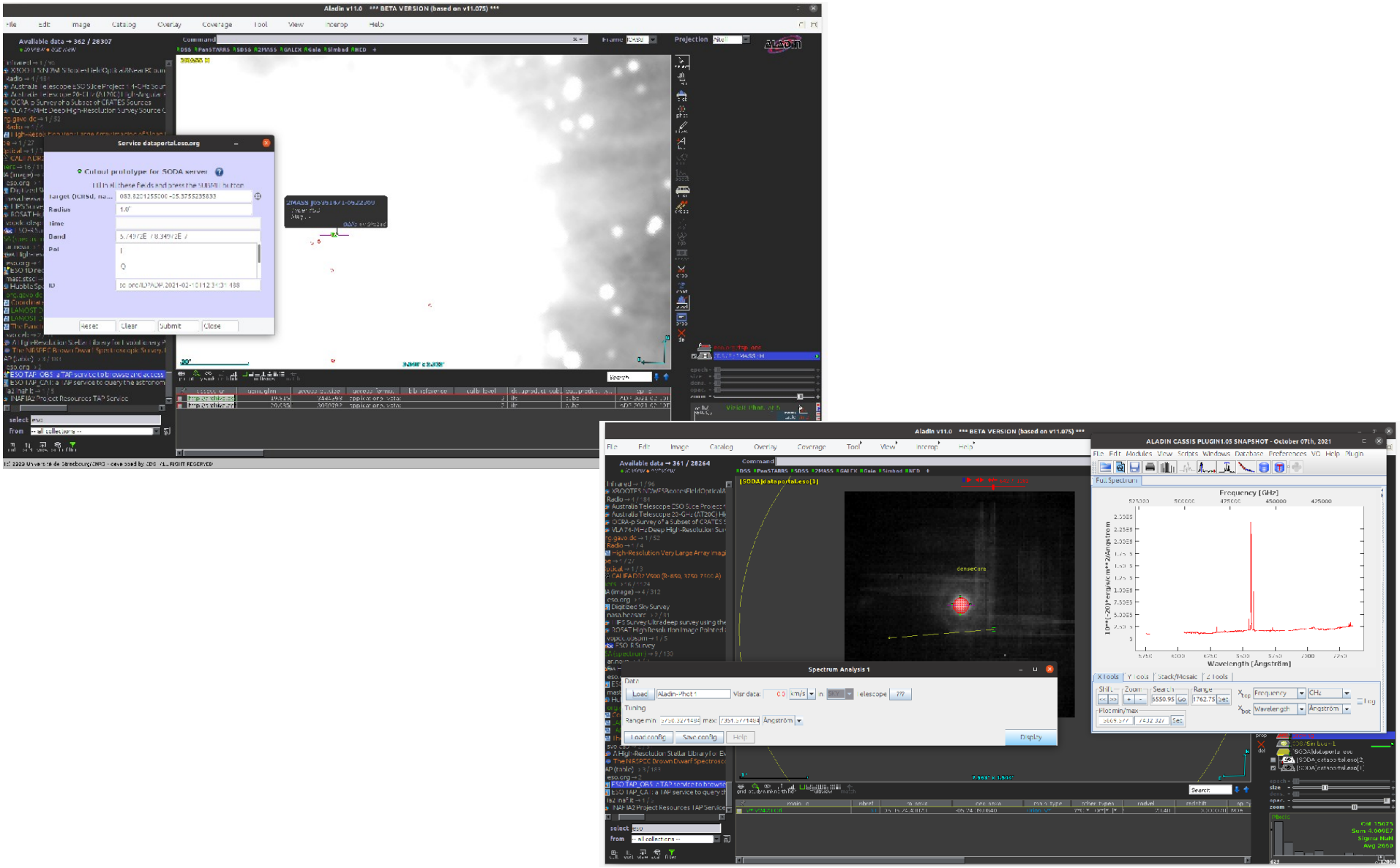




SODA interface evolution

- Originally for « cutouts/selection »
- Interface could be extended to drive server side operation to acces data such as :
  - Extraction of integrated spectra or timeseries from cubes.
  - Spatial/spectral Resampling
  - Other type of reduction ?

SODA for ESO service



Trans use case services

- Coverage in time and space:
  - MOC coverage description
  - MOC servers
- Registration
  - Relational registry database (RegTAP) for any kind of resource
  - hipslists (for HiPS)
- VoEvent ?
- Provenance → other path in CEVO

References

Formats :

VOTable : https://www.ivoa.net/documents/VOTable/20191021/

TimeSeries (ongoing work / no full datamodel behind) : https://www.ivoa.net/documents/Notes/LightCurveTimeSeries/20200429/index.html

Vocabularies :

UCD : https://www.ivoa.net/documents/UCD1+/20210616/index.html

Protocols :

SCS 1.0 : http://www.ivoa.net/documents/latest/ConeSearch.html

SIAP2.0 : http://www.ivoa.net/documents/SIA/20151223/

SSAP 1.0 : http://www.ivoa.net/documents/SSA/20120210/index.html

DataLink : https://www.ivoa.net/documents/DataLink/20150617/index.html

TAP : https://www.ivoa.net/documents/VOTable/20191021

HiPS : https://www.ivoa.net/documents/HiPS/20170519/index.html

Data models (+ObsCore and Provenance):

Mango : https://github.com/ivoa-std/MANGO/

Characterisation : https://www.ivoa.net/documents/latest/CharacterisationDM.html

Cube : https://www.ivoa.net/documents/CubeDM/20180516/index.html

Registration / coverage :

MOC : https://www.ivoa.net/documents/MOC/20211101/index.html

RegTap : https://www.ivoa.net/documents/RegTAP/20191011/index.html

Query Language :

ADQL : https://www.ivoa.net/documents/ADQL/20210528/index.html

Services :

SODA : https://www.ivoa.net/documents/SODA/20170517/index.html