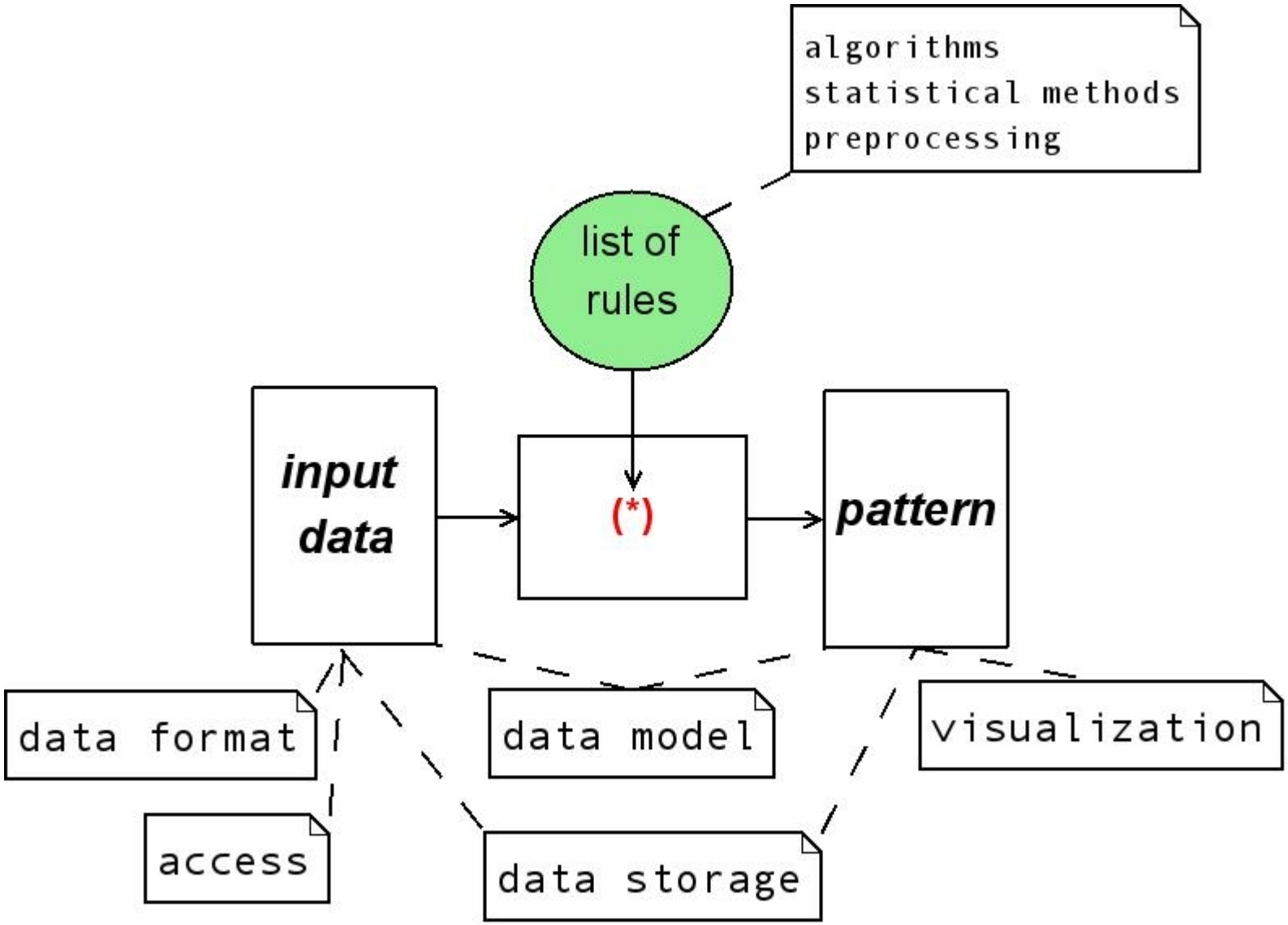
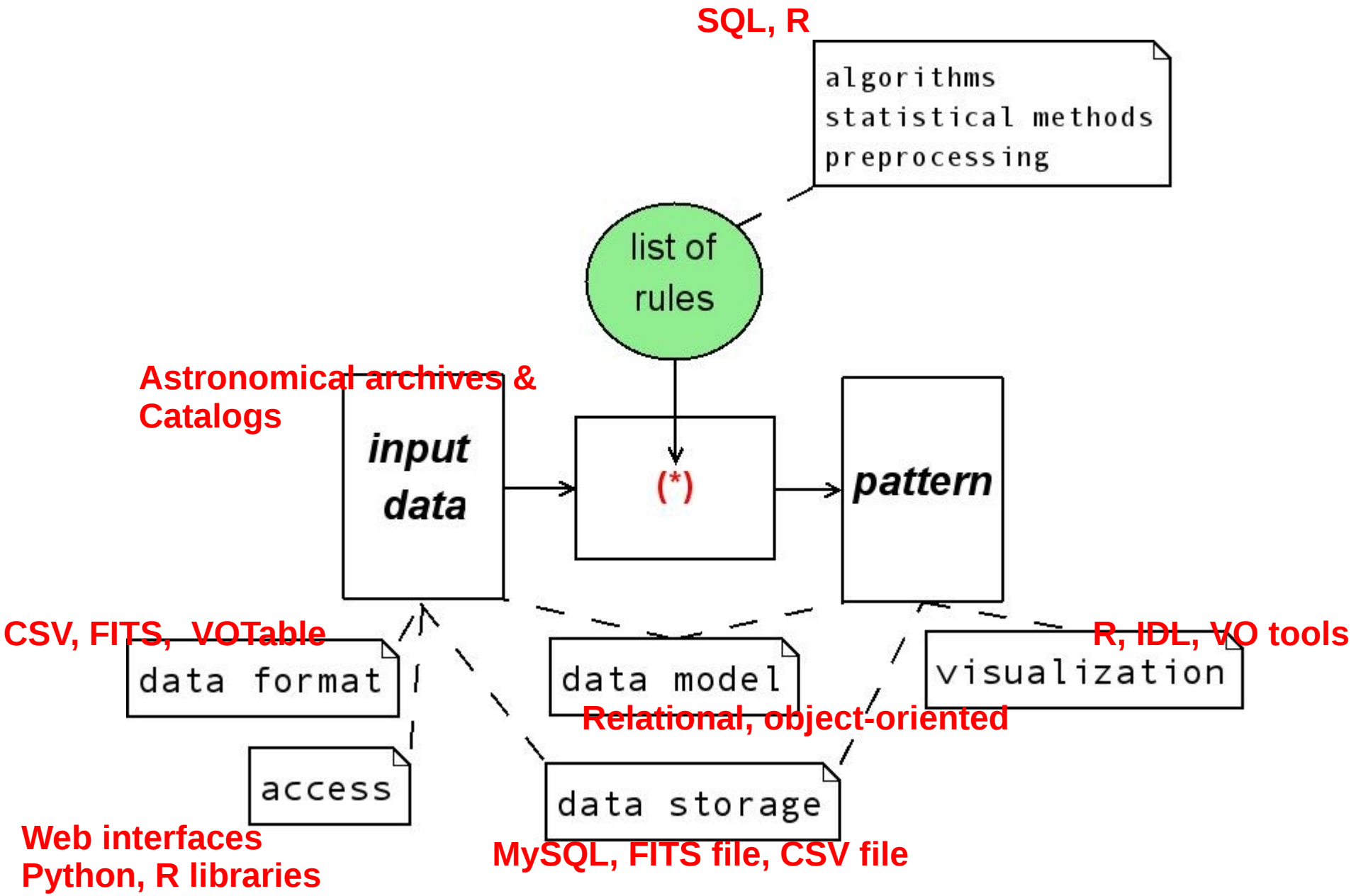
Virtual Observations 2016

Virtual Observatory

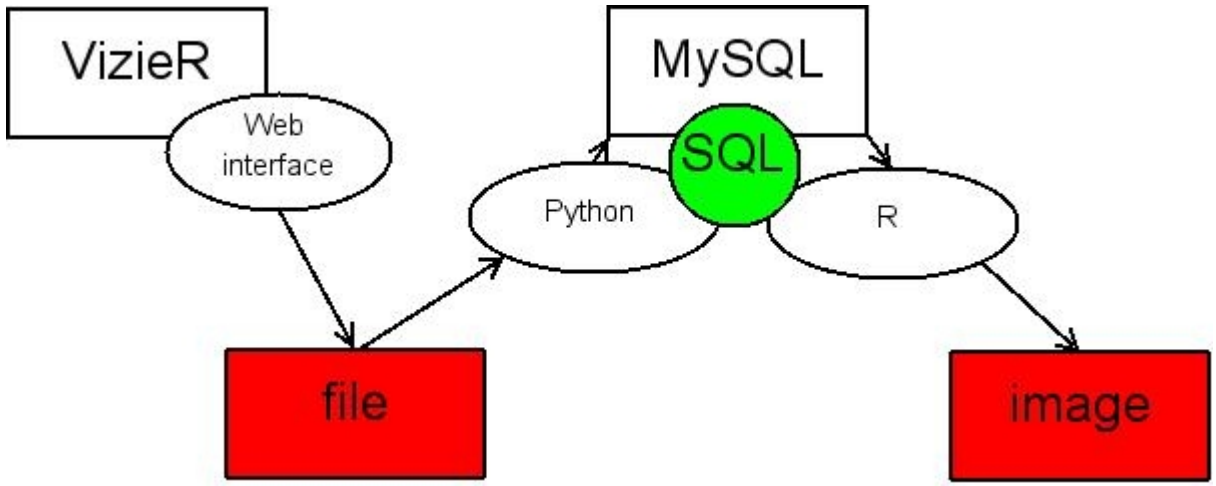
Data Mining


algorithms
statistical methods
preprocessing
list of rules
input data
(*)
pattern
data format
data model
visualization
access
data storage

Data Mining: lectures so far

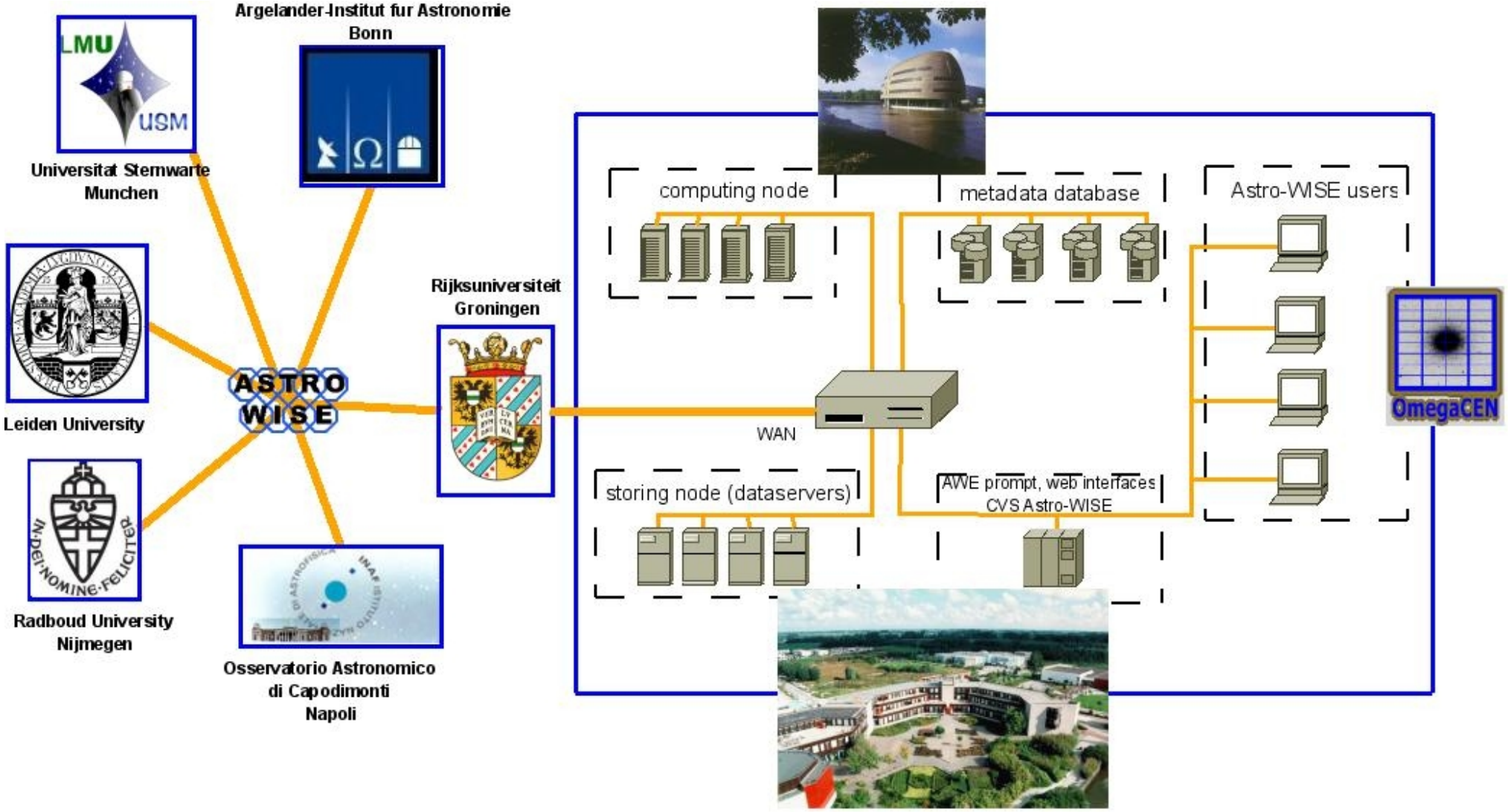


Data Mining: do it yourself



- MySQL data storage
- Python, R data processing & visualization
- Topcat visualization
- XML data format

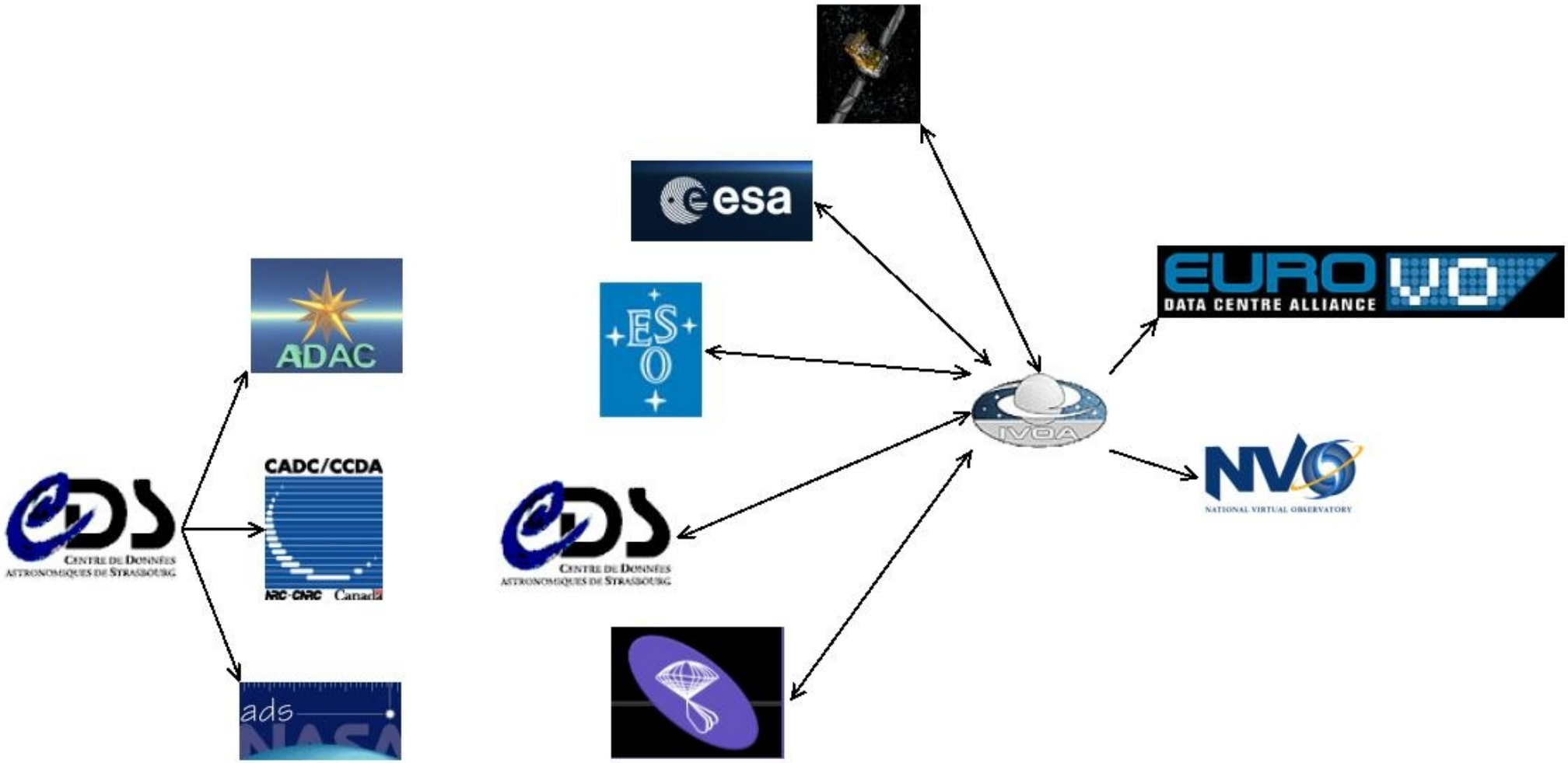
Information System



Data Mining: Global Information System

- SED coverage: optical & IR photometry, X rays, radio)
- Add-on values
- Multi-tasks – no predefined pipeline or data processing chain
- Data publishing

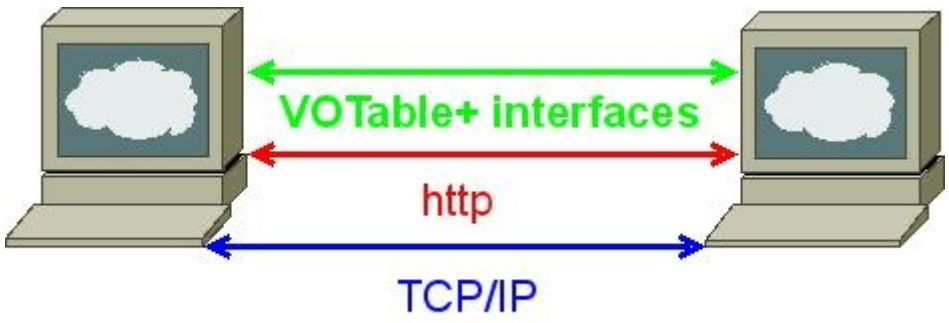
Data Storage in Astronomy



IVOA

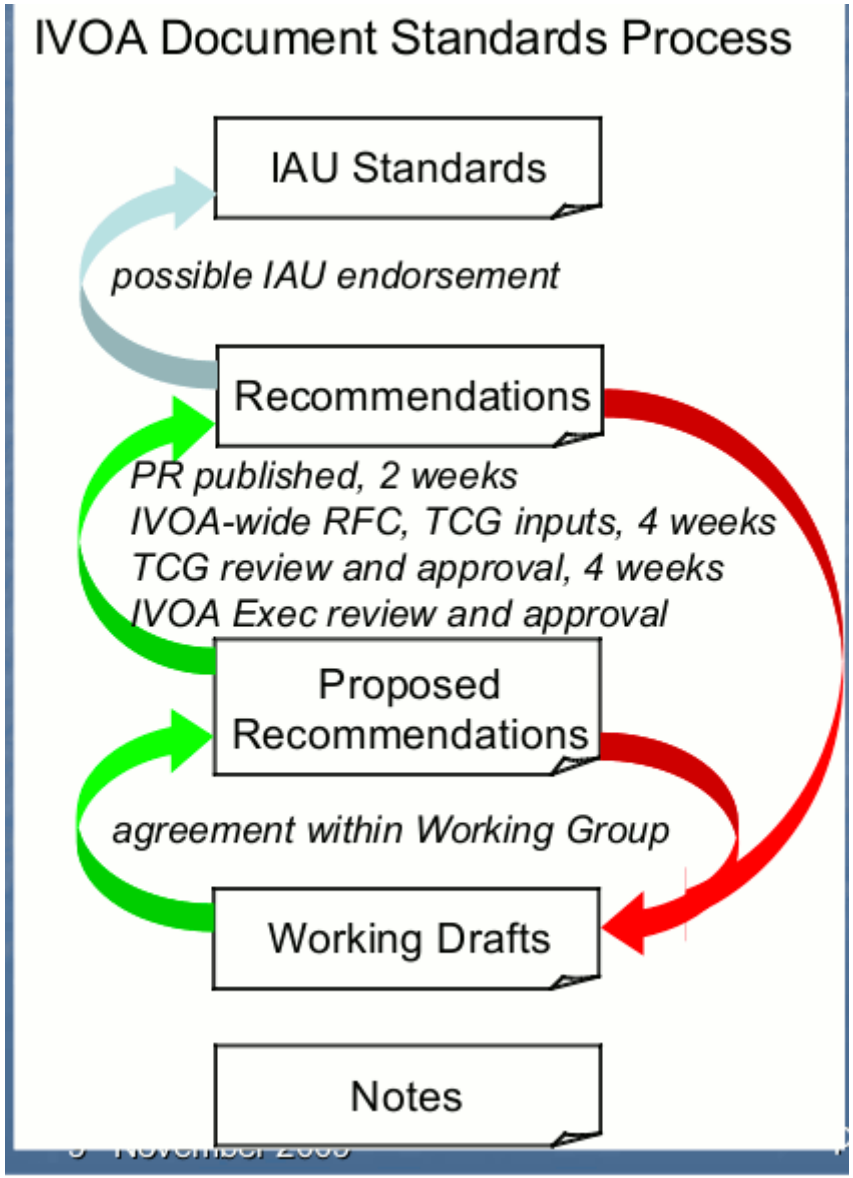
www.ivoa.net

Virtual Observatory: Concept



- Unified approach to data access
- Common data knowledge repository
- Standards for applications

Virtual Observatory: Creation



- 2002 created as an alliance of international efforts
- Working Groups
- Draft, review period, standard accepted

Virtual Observatory: Standards & Interfaces

Technical Specifications

Group	Title	Most stable	In progress	Version history
App	SAMP - Simple Application Messaging Protocol	1.3		1.3 1.3 1.3 1.3 1.3 1.2 1.2 1.2 1.11 1.11 1.10 1.00
	VOTable - VOTable Format Definition	1.3		1.3 1.3 1.3 1.2 1.2 1.2 1.20 1.20 1.10 1.00
	MOC - HEALPix Multi-Order Coverage Map	1.0		1.0 1.0 1.0 1.0 1.0
DAL	DALI - Data Access Layer Interface	1.0	1.1	1.1 1.1 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
	DataLink	1.0		1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
	Simple Cone Search	1.03		1.03 1.02 1.01 1.00
	SIA - Simple Image Access	2.0		2.0 2.0 2.0 2.0 2.0 2.0 2.0 1.0 1.0 1.0 1.01 1.00
	SLAP - Simple Line Access	1.0		1.0 1.0 1.0 1.0 1.0 1.0
	SSA - Simple Spectral Access	1.1		1.1 1.1 1.1 1.1 1.04 1.03 1.02 1.01 1.01 1.00
	STC-S: Space-Time Coordinate Metadata Linear String Implementation	1.0		1.0
	TAP - Table Access Protocol	1.0	1.1	1.1 1.0 1.0 1.0 1.0 1.0 1.00
	TAPRegExt - A VOResource Schema Extension for Describing TAP Services	1.0		1.1 1.0 1.0 1.0 1.0 1.0 1.0 1.0
	ADQL - Astronomical Data Query Language	2.00	2.1	2.1 2.00 2.00 2.00 1.01 1.00
	SNI - IVOA SkyNode Interface	1.01		1.01 1.00
	SimDAL - Simulation Data Access Layer	1.00	1.00	1.00 1.00
	VOEvent Transport Protocol	1.00	RFC	2.00 1.00
	SODA - Server-side Operations for Data Access		1.00	1.00 1.00
DaM	PHOTDM - Photometry Data Model	1.0		1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
	SimDM - Simulation Data Model	1.0		1.0 1.0 1.0 1.0 1.0 1.0
	STC - Space-Time Coordinate Metadata for the Virtual Observatory	1.33		1.33 1.31 1.30 1.21 1.20 1.10 1.00
	Data Model for Astronomical DataSet Characterisation	1.13		1.13 1.12 1.12 1.11 1.10 1.00
	SSLDM - Simple Spectral Lines Data Model	1.0		1.0 1.0 1.0 1.0 1.0
	SpectralDM - IVOA Spectral Data Model	1.1	RFC	2.0 2.0 2.0 2.0 2.0 2.0 2.0 1.1 1.1 1.1 1.03 1.02 1.01 1.01 1.01 1.00
	ObsCore - Observation Data Model Core Components and its Implementation in the Table Access Protocol	1.0	RFC	1.1 1.1 1.1 1.1 1.0 1.0 1.0 1.0 1.0 1.0
GWS	PDL - Parameter Description Language	1.0		1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 0.1
	SSO - Single-Sign-On Profile: Authentication Mechanisms	1.01	RFC	2.0 2.0 2.0 1.01 1.01 1.00 1.00
	VOSpace service specification	2.0	2.1	2.1 2.1 2.1 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 1.15 2.0 1.15 1.15 1.14 1.13 1.12 1.12 1.11 1.10 1.02 1.02 1.01 1.00 1.00
	Credential Delegation Protocol	1.0		1.0 1.0 1.01 1.01 1.00
	UWS - Universal Worker Service	1.0	RFC	1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.0 1.0 1.0 1.0 1.0 1.0
	VOSI - IVOA Support Interfaces	1.0	RFC	1.1 1.1 1.0 1.0 1.0 1.0 1.0 1.0
	IVOA Web Service Basic Profile	1.0		1.0 1.0 1.0 1.0 1.0
ReR	IVOA Identifiers	2.0		2.0 2.0 2.0 2.0 1.12 1.11 1.10 1.10 1.10 1.00
	IVOA Registry Interfaces	1.0	1.1	1.1 1.0 1.0 1.00 1.02 1.01 1.00
	RM - Resource Metadata for the Virtual Observatory	1.12		1.12 1.12 1.10 1.10 1.01 1.01 1.00 1.00
	StandardsRegExt: a VOResource Schema Extension for Describing IVOA Standards	1.0		1.0 1.0 1.0 1.0 1.0 1.0 1.0
	SimpleDALRegExt - Describing Simple Data Access Services	1.0	1.1	1.1 1.0 1.0 1.0 1.0 1.0
	VOResource - an XML Encoding Schema for Resource Metadata	1.03		1.03 1.02 1.02 1.01 1.00
	VODataService - A VOResource Schema Extension for Describing Collections and Services	1.1		1.1 1.1 1.1 1.1 1.1 1.10
	RegTAP - Registry Relational Schema	1.0		1.0 1.0 1.0 1.0 1.0 1.0 1.0
Semantics	VOUnits - Units in the VO	1.0		1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
	UCD - An IVOA standard for Unified Content Descriptors	1.10		1.10 1.10 1.06 1.05 1.03
	UCD1+ Controlled Vocabulary	1.23	1.3	1.3 1.23 1.22 1.21 1.20 1.20 1.11 1.11 1.10 1.02 1.00
	Maintenance of the list of UCD words	1.20		1.20 1.20 1.10 1.00
	Vocabularies in the Virtual Observatory	1.19		1.19 1.18 1.16 1.15 1.13 1.00
SDP	DocStd - IVOA Document Standards	1.2		1.2 1.2 1.2 1.2 1.2 1.1 1.1 1.0 1.0
VOE	VOEvent - Sky Event Reporting Metadata (VOEvent)	2.0		2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 1.11 1.11 1.10 1.01
	VOEventRegExt - An XML Encoding Schema for Resource Metatdata for Collections of Events		1.0	1.0

Data Description: Before VO

Byte-by-byte Description of file: main.dat

Bytes	Format	Units	Label	Explanations
1- 6	I6	---	HIC	[1/120313]+ Hipparcos Input Catalogue running number.
8- 11	A4	---	Comp	Component(s) considered in this entry
13	A1	---	Target	*[A-Hjg] Satellite target in case of joint entry
15- 16	I2	h	RAh	Right ascension J2000 (hours), at Epoch
18- 19	I2	min	RAm	Right ascension (minutes)
21- 26	F6.3	s	RAs	Right ascension (seconds)
28	A1	---	DE-	Declination J2000 (sign)
29- 30	I2	deg	DEd	Declination (degrees)
32- 33	I2	arcmin	DEm	Declination (minutes)
35- 39	F5.2	arcsec	DEs	Declination (seconds)
41- 44	I4	a	Epoch	*Epoch for the position, generally 2000
46- 49	F4.2	arcsec	e_RAs	*Mean error of the right ascension
51- 54	F4.2	arcsec	e_DEs	Mean error of the declination
56	A1	---	r_RAs	*Source of position code (see Table B1)
58- 67	F10.6	deg	RAdeg	Right ascension J2000 (decimal degrees)
69- 78	F10.6	deg	DEdeg	Declination J2000 (decimal degrees)
80- 85	F6.2	deg	GLON	[0.0/360.0] Galactic longitude (decimal degs)
87- 92	F6.2	deg	GLAT	Galactic latitude (decimal degrees)
94- 99	F6.2	deg	ELON	[0.0/360.00] Ecliptic longitude (decimal deg)
101-106	F6.2	deg	ELAT	Ecliptic latitude (decimal degrees)
108-109	I2	h	RA1950h	Right ascension B1950, epoch=1950.0 unless Epoch differs from 2000 (hours)
111-112	I2	min	RA1950m	Right ascension (minutes)
114-119	F6.3	s	RA1950s	Right ascension (seconds)
121	A1	---	DE1950-	Declination sign, B1950
122-123	I2	deg	DE1950d	Declination (degrees)
125-126	I2	arcmin	DE1950m	Declination (minutes)
128-132	F5.2	arcsec	DE1950s	Declination (seconds)
134-143	F10.6	deg	RA1950deg	Right ascension B1950 (decimal degrees)
145-154	F10.6	deg	DE1950deg	Declination B1950 (decimal degrees)
156-161	F6.3	arcsec/a	pmRA	*?Proper motion in RA, Equinox J2000.0
163-168	F6.3	arcsec/a	pmDE	?Proper motion in dec, Equinox J2000.0
170-173	F4.3	arcsec/a	e_pmRA	?Error of pmRA
175-178	F4.3	arcsec/a	e_pmDE	?Error of pmDE

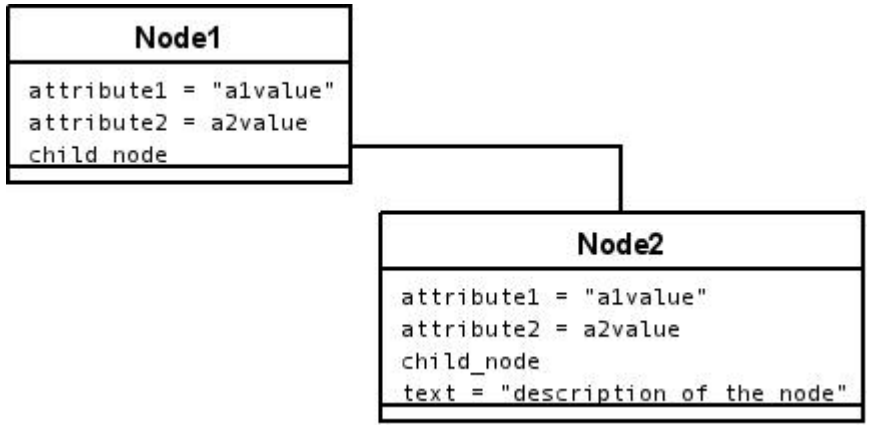
- Direct specification of format
- User-defined description
- Positional format
- Units

XML

- Extensible Markup Language
- Self-describing format
- Standard Generalized Markup Language
- HTML
- XML Schema
- XSLT

XML: structure

- Node (Element)
- Text
- Attributes




```
- <ROOT xlmns="the reference to the scheme">
  - <NODE1 attribute1="a1value" attribute2="a2value">
      <NODE2 attribute1="a1node2value" attribute2="a2node2value"> Just an example </NODE2>
    </NODE1>
  </ROOT>
```

XML example

```
- <cross-id>
  - <cross>
      <id>1</id>
      <RA2000>20.000195</RA2000>
      <DEC2000>29.996469</DEC2000>
      <B>17.9</B>
      <R>17.3</R>
      <J>15.65</J>
      <H>15.295</H>
      <K>15.174</K>
    </cross>
  - <cross>
      <id>2</id>
      <RA2000>20.006404</RA2000>
      <DEC2000>29.995581</DEC2000>
      <B>17.2</B>
      <R>17.0</R>
      <J>15.984</J>
      <H>15.613</H>
      <K>15.345</K>
    </cross>
```

- Self-defined tags
- Tree-like structure
- Object

- make_xml.py

XML example

```
- <cross-id>
  - <cross>
      <id>1</id>
      <RA2000>20.000195</RA2000>
      <DEC2000>29.996469</DEC2000>
      <B>17.9</B>
      <R>17.3</R>
      <J>15.65</J>
      <H>15.295</H>
      <K>15.174</K>
    </cross>
  - <cross>
      <id>2</id>
      <RA2000>20.006404</RA2000>
      <DEC2000>29.995581</DEC2000>
      <B>17.2</B>
      <R>17.0</R>
      <J>15.984</J>
      <H>15.613</H>
      <K>15.345</K>
    </cross>
```

```
- <cross-id>
  - <cross>
      <id>1</id>
      <RA EQUINOX="J2000">20.000195</RA>
      <DEC EQUINOX="J2000">29.996469</DEC>
      <MAG FILTER="B">17.9</MAG>
      <MAG FILTER="R">17.3</MAG>
      <MAG FILTER="J">15.65</MAG>
      <MAG FILTER="H">15.295</MAG>
      <MAG FILTER="K">15.174</MAG>
    </cross>
  - <cross>
      <id>2</id>
      <RA EQUINOX="J2000">20.006404</RA>
      <DEC EQUINOX="J2000">29.995581</DEC>
      <MAG FILTER="B">17.2</MAG>
      <MAG FILTER="R">17.0</MAG>
      <MAG FILTER="J">15.984</MAG>
      <MAG FILTER="H">15.613</MAG>
      <MAG FILTER="K">15.345</MAG>
    </cross>
```

XML Schema

http://www.w3.org/XML/Schema

```
- <schema>
  + <annotation></annotation>
  + <simpleType name="FILTER"></simpleType>
  + <simpleType name="EQUINOX"></simpleType>
  + <complexType name="RA"></complexType>
  + <complexType name="DEC"></complexType>
  + <complexType name="MAG"></complexType>
  + <complexType name="cross"></complexType>
  + <complexType name="cross-id"></complexType>
 </schema>
```

```
- <schema>
  + <annotation></annotation>
  + <simpleType name="FILTER"></simpleType>
  + <simpleType name="EQUINOX"></simpleType>
  + <complexType name="RA"></complexType>
  + <complexType name="DEC"></complexType>
  - <complexType name="MAG">
    - <simpleContent>
      - <extension base="double">
          <attribute name="FILTER" type="FILTER"/>
        </extension>
      </simpleContent>
    </complexType>
  + <complexType name="cross"></complexType>
  + <complexType name="cross-id"></complexType>
 </schema>
```

```
- <schema>
  + <annotation></annotation>
  + <simpleType name="FILTER"></simpleType>
  + <simpleType name="EQUINOX"></simpleType>
  - <complexType name="RA">
    - <simpleContent>
      - <extension base="double">
          <attribute name="EQUINOX" type="EQUINOX"/>
        </extension>
      </simpleContent>
    </complexType>
  + <complexType name="DEC"></complexType>
  + <complexType name="MAG"></complexType>
  + <complexType name="cross"></complexType>
  + <complexType name="cross-id"></complexType>
 </schema>
```

XML Schema

http://www.w3.org/XML/Schema

```
- <schema>
  + <annotation></annotation>
  + <simpleType name="FILTER"></simpleType>
  + <simpleType name="EQUINOX"></simpleType>
  + <complexType name="RA"></complexType>
  + <complexType name="DEC"></complexType>
  + <complexType name="MAG"></complexType>
  + <complexType name="cross"></complexType>
  + <complexType name="cross-id"></complexType>
 </schema>
```

```
- <schema>
  + <annotation></annotation>
  + <simpleType name="FILTER"></simpleType>
  + <simpleType name="EQUINOX"></simpleType>
  + <complexType name="RA"></complexType>
  + <complexType name="DEC"></complexType>
  - <complexType name="MAG">
    - <simpleContent>
      - <extension base="double">
          <attribute name="FILTER" type="FILTER"/>
        </extension>
      </simpleContent>
    </complexType>
  + <complexType name="cross"></complexType>
  + <complexType name="cross-id"></complexType>
 </schema>
```

```
- <schema>
  + <annotation></annotation>
  + <simpleType name="FILTER"></simpleType>
  + <simpleType name="EQUINOX"></simpleType>
  - <complexType name="RA">
    - <simpleContent>
      - <extension base="double">
          <attribute name="EQUINOX" type="EQUINOX"/>
        </extension>
      </simpleContent>
    </complexType>
  + <complexType name="DEC"></complexType>
  + <complexType name="MAG"></complexType>
  + <complexType name="cross"></complexType>
  + <complexType name="cross-id"></complexType>
 </schema>
```

XML Schema

http://www.w3.org/XML/Schema

```
- <schema>
  + <annotation></annotation>
  + <simpleType name="FILTER"></simpleType>
  + <simpleType name="EQUINOX"></simpleType>
  + <complexType name="RA"></complexType>
  + <complexType name="DEC"></complexType>
  + <complexType name="MAG"></complexType>
  + <complexType name="cross"></complexType>
  + <complexType name="cross-id"></complexType>
 </schema>
```

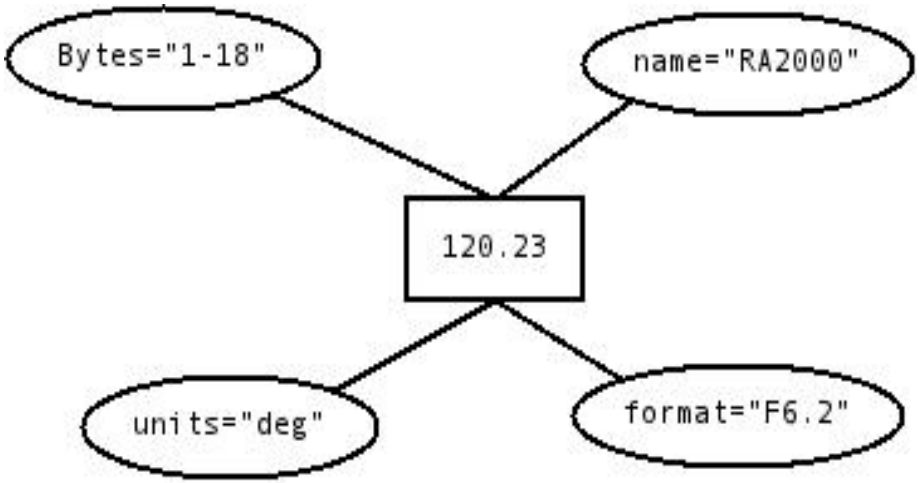
```
- <schema>
  + <annotation></annotation>
  + <simpleType name="FILTER"></simpleType>
  + <simpleType name="EQUINOX"></simpleType>
  + <complexType name="RA"></complexType>
  + <complexType name="DEC"></complexType>
  + <complexType name="MAG"></complexType>
  + <complexType name="cross"></complexType>
  - <complexType name="cross-id">
    - <complexContent>
      - <sequence>
          <element name="cross" type="cross"/>
        </sequence>
      </complexContent>
    </complexType>
 </schema>
```

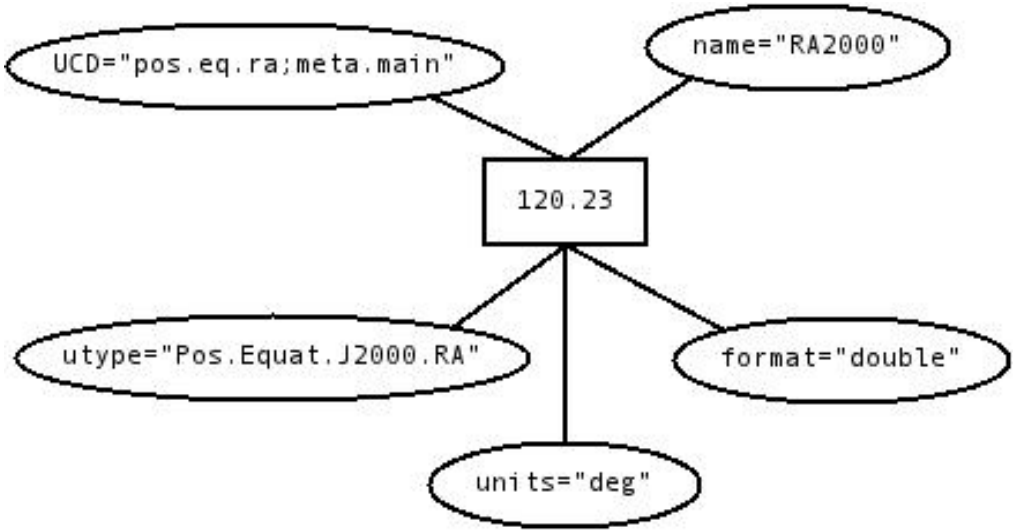
```
- <schema>
  + <annotation></annotation>
  + <simpleType name="FILTER"></simpleType>
  + <simpleType name="EQUINOX"></simpleType>
  + <complexType name="RA"></complexType>
  + <complexType name="DEC"></complexType>
  + <complexType name="MAG"></complexType>
  - <complexType name="cross">
    - <complexContent>
      - <sequence>
          <element name="id" type="int" minOccurs="1" maxOccurs="1"/>
          <element name="RA" type="RA"/>
          <element name="DEC" type="DEC"/>
          <element name="MAG" type="MAG" minOccurs="1" maxOccurs="5"/>
        </sequence>
      </complexContent>
    </complexType>
  + <complexType name="cross-id"></complexType>
 </schema>
```

XML Schema

- Object-oriented format of data
- Reference to the format (schemaLocation)
- Generation of structures from the schema
- User-defined types

General Data Description

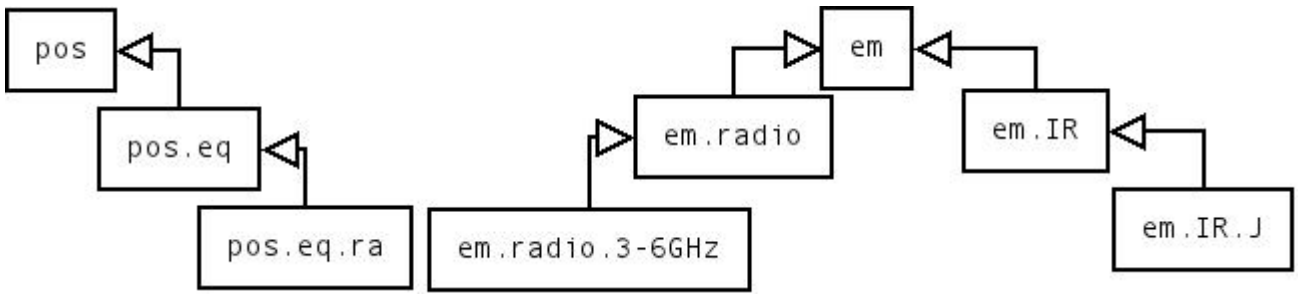




- Data Model
- Translation

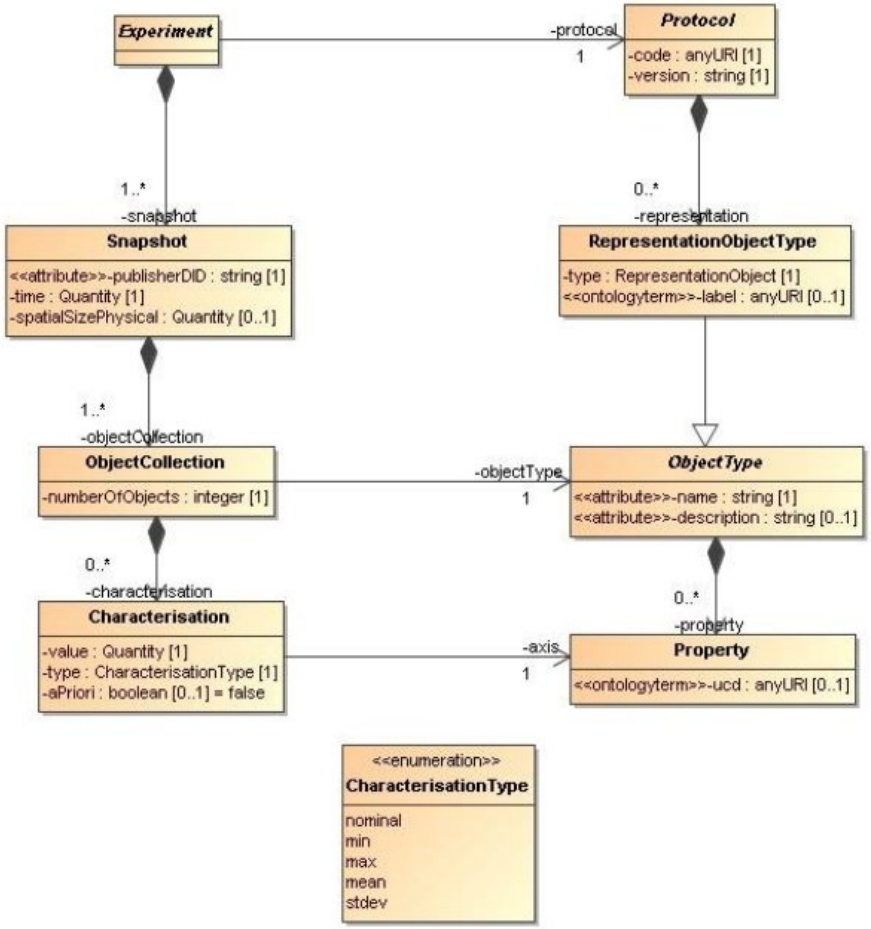
UCD: Unified Content Descriptor

- Most general data model
- Vocabulary
- Translation from original namespace to general namespace



utype

- User-defined data model



utype

```
<SpatialAxis>                              Corresponding UTYPE
<axisName>spatial</axisName>
<ucd>pos</ucd>
<unit>deg</unit>
<coordsystem id="TT-ICRS-TOPO"             <----->cha:SpatialAxis.Coordsystem
xlink:type="simple xlink:href="ivo://STClib/CoordSys#TT-ICRS-TOPO"/>
<coverage>
<location>                                 <----->cha:SpatialAxis.coverage.location
    <coord coord_system_id="TT-ICRS-TOPO">
        <stc:Position2D>
            <stc:Name1>RA</stc:Name1>
            <stc:Name2>Dec</stc:Name2>
            <stc:Value2>
            <stc:C1>132.4210</stc:C1>      <----->cha:SpatialAxis.coverage.location.Position2D.Value2D.C1
        <stc:C2>12.1232</stc:C2>
            </stc:Value2>
        </stc:Position2D>
    </coord>
</location>    ...
</coverage>
</SpatialAxis>
```

VO: VOTable


```
<?xml version="1.0"?>
<VOTABLE version="1.2" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns="http://www.ivoa.net/xml/VOTable/v1.2"
 xmlns:stc="http://www.ivoa.net/xml/STC/v1.30" >
  <RESOURCE name="myFavouriteGalaxies">
    <TABLE name="results">
      <DESCRIPTION>Velocities and Distance estimations</DESCRIPTION>
      <GROUP ID="J2000" utype="stc:AstroCoords">
        <PARAM datatype="char" arraysize="*" ucd="pos.frame" name="cooframe"
               utype="stc:AstroCoords.coord_system_id" value="UTC-ICRS-TOPO" />
        <FIELDref ref="col1"/>
        <FIELDref ref="col2"/>
      </GROUP>
      <PARAM name="Telescope" datatype="float" ucd="phys.size;instr.tel"
             unit="m" value="3.6"/>
      <FIELD name="RA"   ID="col1" ucd="pos.eq.ra;meta.main" ref="J2000"
             utype="stc:AstroCoords.Position2D.Value2.C1"
             datatype="float" width="6" precision="2" unit="deg"/>
      <FIELD name="Dec"  ID="col2" ucd="pos.eq.dec;meta.main" ref="J2000"
             utype="stc:AstroCoords.Position2D.Value2.C2"
             datatype="float" width="6" precision="2" unit="deg"/>
      <FIELD name="Name" ID="col3" ucd="meta.id;meta.main"
             datatype="char" arraysize="8*"/>
      <FIELD name="RVel" ID="col4" ucd="spect.dopplerVeloc" datatype="int"
             width="5" unit="km/s"/>
      <FIELD name="e_RVel" ID="col5" ucd="stat.error;spect.dopplerVeloc"
             datatype="int" width="3" unit="km/s"/>
      <FIELD name="R" ID="col6" ucd="pos.distance;pos.heliocentric"
             datatype="float" width="4" precision="1" unit="Mpc">
        <DESCRIPTION>Distance of Galaxy, assuming H=75km/s/Mpc</DESCRIPTION>
      </FIELD>
      <DATA>
        <TABLEDATA>
        <TR>
          <TD>010.68</TD><TD>+41.27</TD><TD>N  224</TD><TD>-297</TD><TD>5</TD><TD>0.7</TD>
        </TR>
        <TR>
          <TD>287.43</TD><TD>-63.85</TD><TD>N 6744</TD><TD>839</TD><TD>6</TD><TD>10.4</TD>
        </TR>
        <TR>
          <TD>023.48</TD><TD>+30.66</TD><TD>N  598</TD><TD>-182</TD><TD>3</TD><TD>0.7</TD>
        </TR>
        </TABLEDATA>
      </DATA>
    </TABLE>
  </RESOURCE>
</VOTABLE>
```

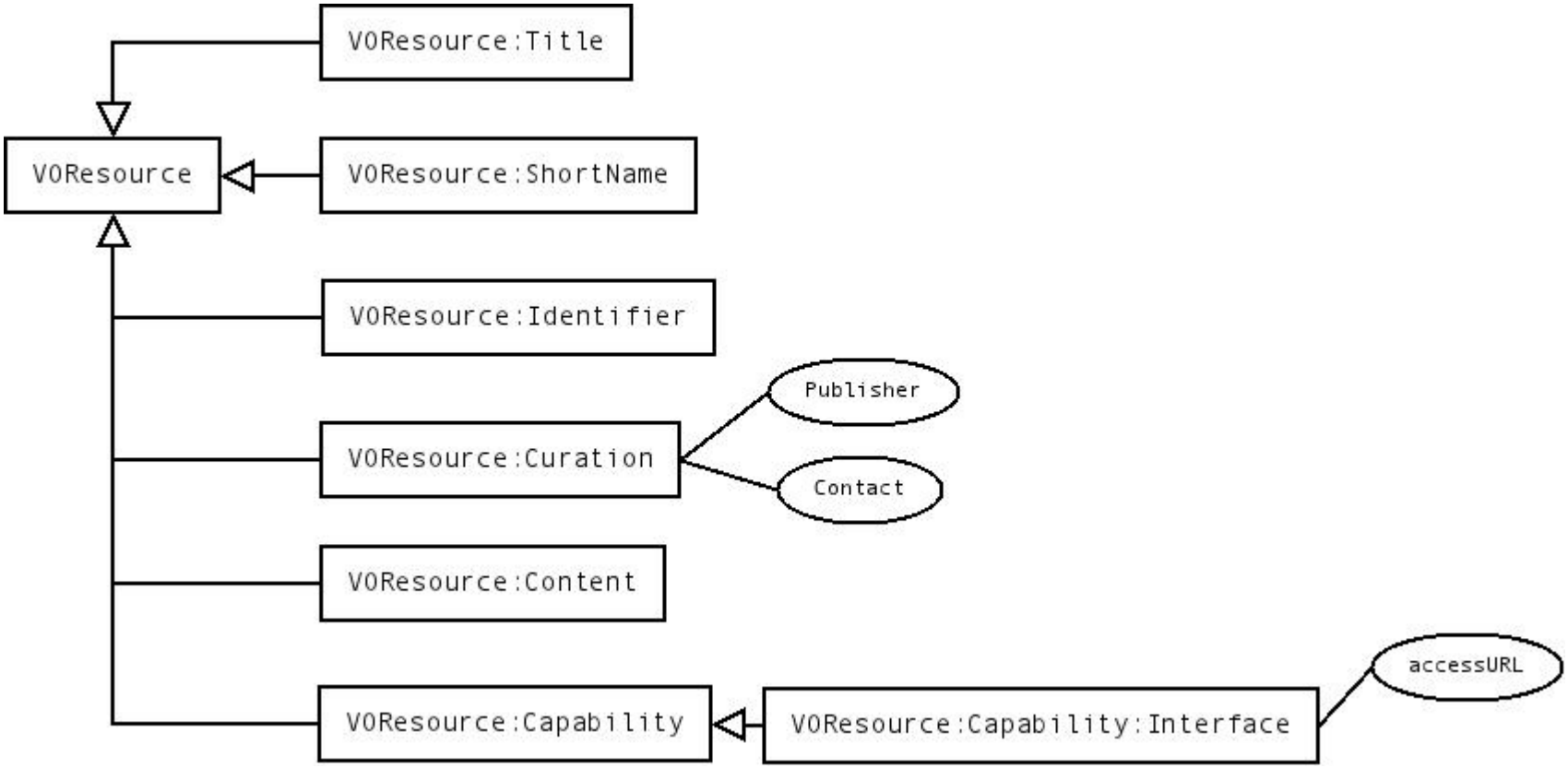
VOTable: FIELD

```
<FIELD name="RA" ID="col1" ucd="pos.eq.ra;meta.main" ref="J2000"
       utype="stc:AstroCoords.Position2D.Value2.C1"
       datatype="float" width="6" precision="2" unit="deg">
  <VALUES ID="RAdomain">
    <MIN value="0"/>
    <MAX value="360" inclusive="no"/>
  </VALUES>
</FIELD>
```

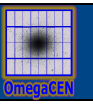
datatype	Meaning	FITS	Bytes
"boolean"	Logical	"L"	1
"bit"	Bit	"X"	*
"unsignedByte"	Byte (0 to 255)	"B"	1
"short"	Short Integer	"I"	2
"int"	Integer	"J"	4
"long"	Long integer	"K"	8
"char"	ASCII Character	"A"	1
"unicodeChar"	Unicode Character		2
"float"	Floating point	"E"	4
"double"	Double	"D"	8
"floatComplex"	Float Complex	"C"	8
"doubleComplex"	Double Complex	"M"	16

```
<VOTABLE version="1.2" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns="http://www.ivoa.net/xml/VOTable/v1.2"
 xmlns:stc="http://www.ivoa.net/xml/STC/v1.30" >
  <RESOURCE name="myFavouriteGalaxies">
```

VO: Registry: VOResource



VO: Registry: VOResource




```
- <ri:VOResources xsi:schemaLocation="http://www.ivoa.net/xml/VOResource/v1.0">
  - <ri:Resource status="active" updated="2007-05-14" xsi:type="cs:ConeSearch" created="2007-04-26">
    - <vr:title>
        Cone Search interface for Objects for Wide-Field Imager at 2.2m, La Silla
      </vr:title>
      <vr:shortName>WFI@2.2m</vr:shortName>
    - <vr:identifier>
        ivo://astro-wise/Project/ConeSearch/SourceList/WFI@2.2m
      </vr:identifier>
    - <vr:curation>
        <vr:publisher ivo-id="ivo://astro-wise/Registry"> Astro-Wise local publishing register</vr:publisher>
      - <vr:contact>
          <vr:name>Andrey Belikov</vr:name>
          <vr:email>A.N.Belikov@astro.rug.nl</vr:email>
        </vr:contact>
      </vr:curation>
    - <vr:content>
        <vr:subject>data repositories</vr:subject>
      - <vr:description>
          The Wide-Field Imager (WFI) is an 8K x 8K pixel optical detector imaging one half degree on a side (approximately one full moon in area) permanently mounted on the 2.2m MPG/ESO telescope at La Silla in Chile.
        </vr:description>
        <vr:referenceURL>http://www.astro-wise.org/projects/OCAMVSTGT/</vr:referenceURL>
        <vr:contentLevel>Research</vr:contentLevel>
        <vr:contentLevel>University</vr:contentLevel>
      - <vr:relashionship>
          <vr:relashionshipType>service-for</vr:relashionshipType>
          <vr:relatedResource ivo-id="ivo://astro-wise/Project/DataCollection/SourceList/WFI@2.2m">Objects for Wide-Field Imager at 2.2m, La Silla</vr:relatedResource>
        </vr:relashionship>
      </vr:content>
    - <vr:interface xsi:type="vr:ParamHTTP" qtype="GET">
      - <vr:accessURL use="base">
          http://vo.astro-wise.org/ConeSearch?FORM=VOTABLE\&PROJECT=WFI@2.2m
        </vr:accessURL>
        <vs:resultType>text/xml+votable</vs:resultType>
        <vs:resultType>text/html</vs:resultType>
      </vr:interface>
    </ri:Resource>
  </ri:VOResources>
```

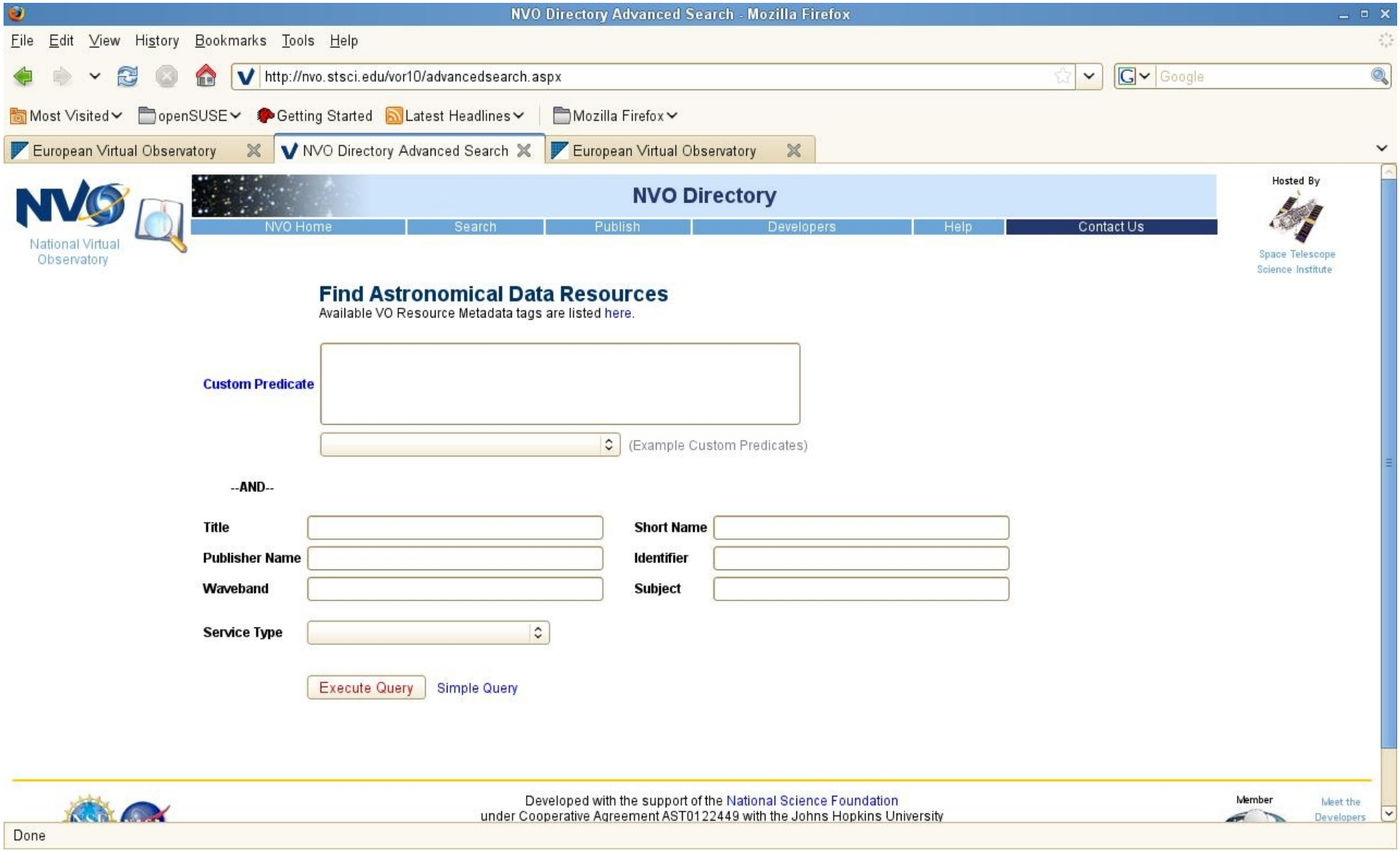
Done

VO: Register

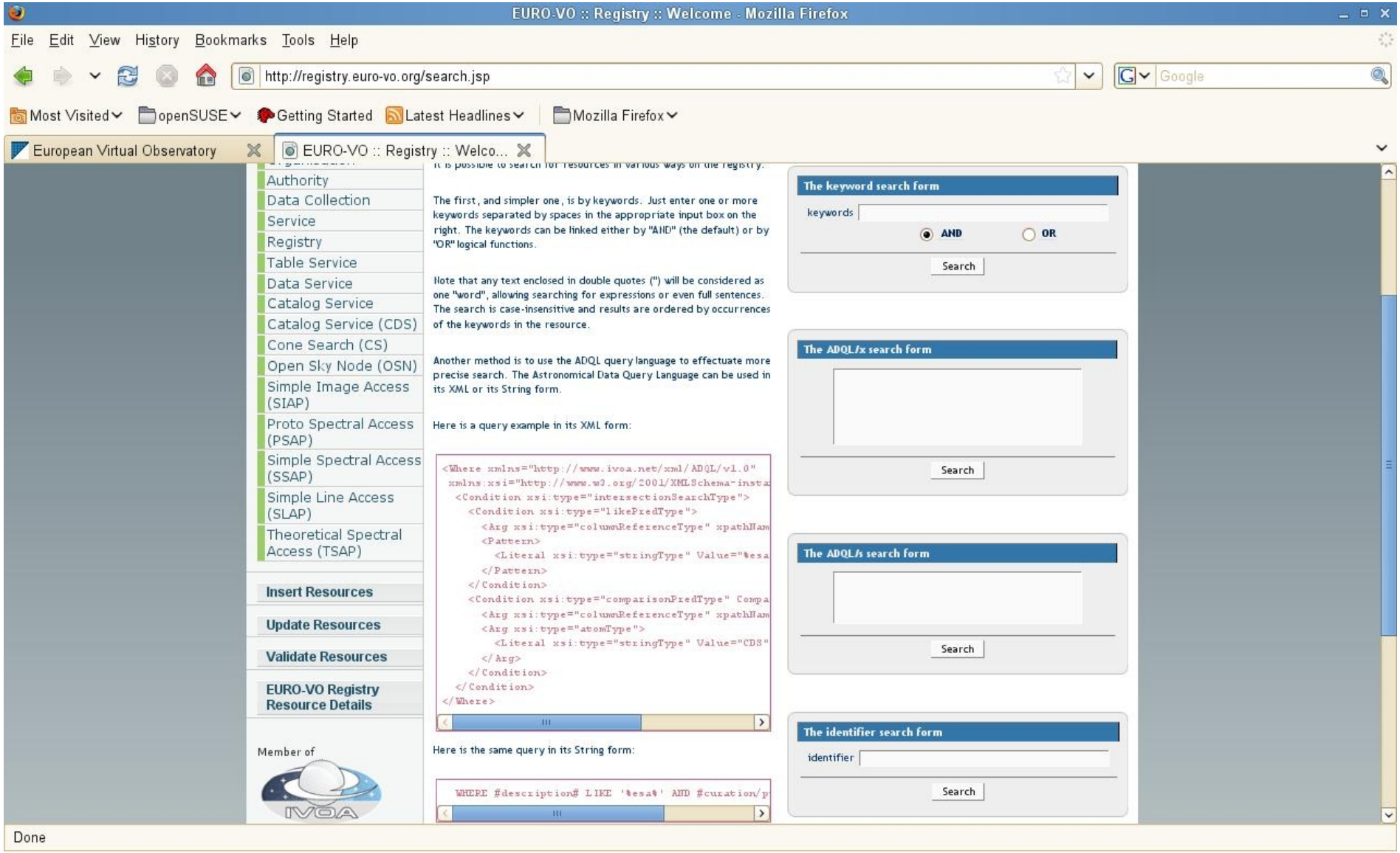
http://www.us-vo.org/

http://www.euro-vo.org/pub/

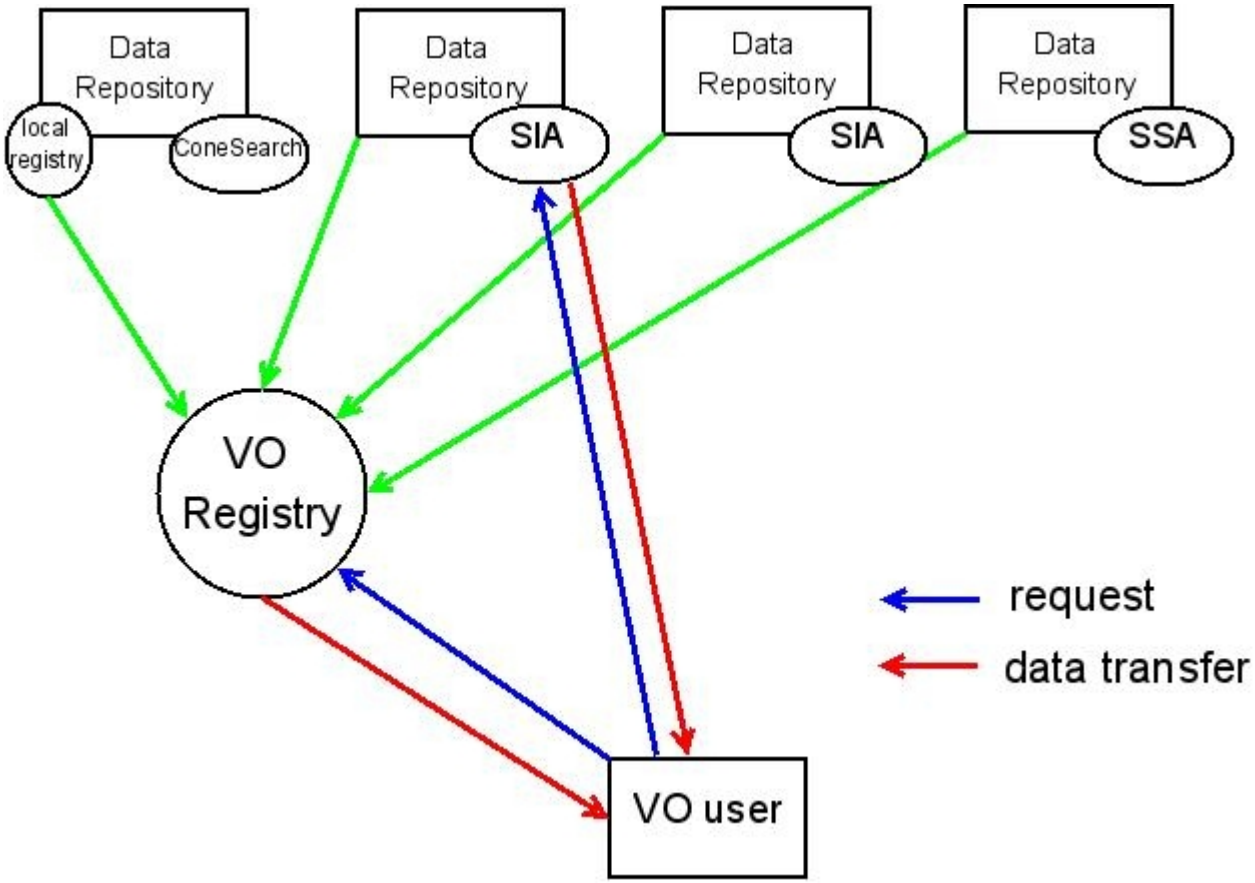
NVO Registry



EuroVO Registry



VO: Register


Data Repository
local registry
ConeSearch
Data Repository
SIA
Data Repository
SIA
Data Repository
SSA
VO Registry
VO user
request
data transfer

VO: ConeSearch

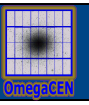
- Browse catalogs by coordinates
- RA, DEC, SR
- Input: desired coordinates
- Output: VOTable in internal format

```
- <vr:interface xsi:type="vr:ParamHTTP" qtype="GET">
  - <vr:accessURL use="base">
      http://vo.astro-wise.org/ConeSearch?FORM=VOTABLE\&PROJECT=WFI@2.2m
    </vr:accessURL>
    <vs:resultType>text/xml+votable</vs:resultType>
    <vs:resultType>text/html</vs:resultType>
  </vr:interface>
```

http://vo.astro-wise.org/ConeSearch?FORM=VOTABLE&PROJECT=WFI@2.2m
&RA=0.0&DEC=0.0&SR=1.0

- Browsing repository of images
- POS=ra,dec SIZE=size1,size2
- Input: a rectangular area
- Output: VOTable with list of images

VO: SIA



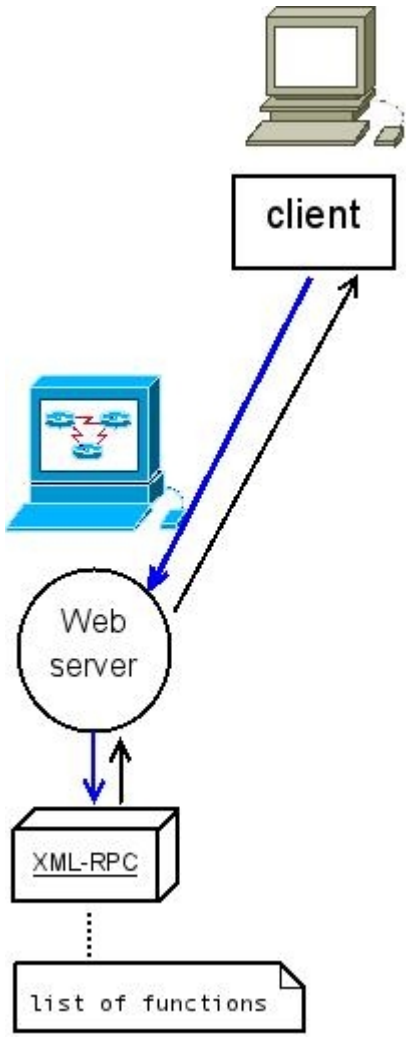

```
- <VOTABLE version="1.0">
    <COOSYS ID="J2000" equinox="2000." epoch="2000." system="eq_FK5"/>
  - <RESOURCE type="results">
      <INFO name="QUERY_STATUS" value="OK"/>
    - <PARAM name="AWE-Observer" datatype="char" arraysize="*" value="AWE anonymous">
      - <DESCRIPTION>
          This parameter is designed to store the observer's name
        </DESCRIPTION>
      </PARAM>
    - <TABLE name="VOTABLE ALL">
        <DESCRIPTION>Table generated by AWVOTS</DESCRIPTION>
        <FIELD name="OBJECT" datatype="char" ucd="VOX:Image_Title" arraysize="*"/>
        <FIELD name="INSRUMENT" datatype="char" ucd="INST_ID" arraysize="*"/>
        <FIELD name="CRVAL1" datatype="double" ucd="POS_EQ_RA_MAIN" width="20"/>
        <FIELD name="CRVAL2" datatype="double" ucd="POS_EQ_DEC_MAIN" width="20"/>
        <FIELD name="Naxes" datatype="int" ucd="VOX:Image_Naxes" width="20"/>
        <FIELD name="Naxis" datatype="int" ucd="VOX:Image_Naxis" arraysize="*"/>
        <FIELD name="Scale" datatype="double" ucd="VOX:Image_Scale" arraysize="*"/>
        <FIELD name="Format" datatype="char" ucd="VOX:Image_Format" arraysize="*"/>
        <FIELD name="Filename" datatype="char" ucd="VOX:Image_AccessReference" arraysize="*"/>
      - <FIELD name="OBJID" datatype="char" ucd="OBJID" arraysize="*">
          <LINK href="http://quality.astro-wise.org/QualityWISE?object_str=ReducedScienceFrame&object_id=${OBJID}&project=ALL"/>
        </FIELD>
        <FIELD name="QUALITY_LINK" datatype="char" ucd="QLINK" arraysize="*"/>


- <DATA>
  - <TABLEDATA>
    - <TR>
        <TD>ALL NGC7626_6</TD>
        <TD>MPI-2.2.WFI</TD>
        <TD>350.083600268</TD>
        <TD>8.21692095067</TD>
        <TD>2</TD>
        <TD>2046 4098</TD>
        <TD>-6.61111111111e-05 6.61111111111e-05</TD>
        <TD>image/fits</TD>
      - <TD>
          http://ds.astro.rug.astro-wise.org:8000/Sci-GSIKKEMA-WFI-----%23844-ccd52---Sci-53262.7024522.fits
        </TD>
        <TD>'E40F8D26C73AF6DCE0307D814C066DB6'</TD>
      - <TD>
          http://quality.astro-wise.org/QualityWISE?object_str=ReducedScienceFrame&amp;project=ALL&amp;object_id='E40F8D26C73AF6DCE0307D814C066DB6'
        </TD>
      </TR>
```

- Access to spectral data
- Positional and wavelength (band) coordinates
- Input: POS=ra,dec; SIZE=sr; BAND=K;TIME=Epoch; FORMAT=votable
- Output: VOTable

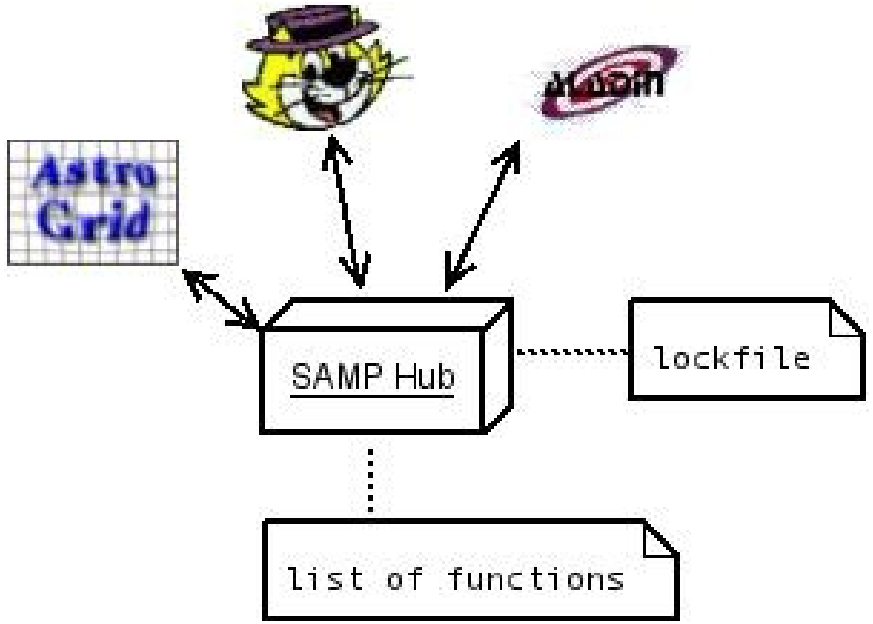
VO: ADQL & TAP

- ADQL: extention of SQL+astronomy-specific functions
- TAP: Table Access Protocol : synchronious/asynchronious queries
- TAP: ADQL support

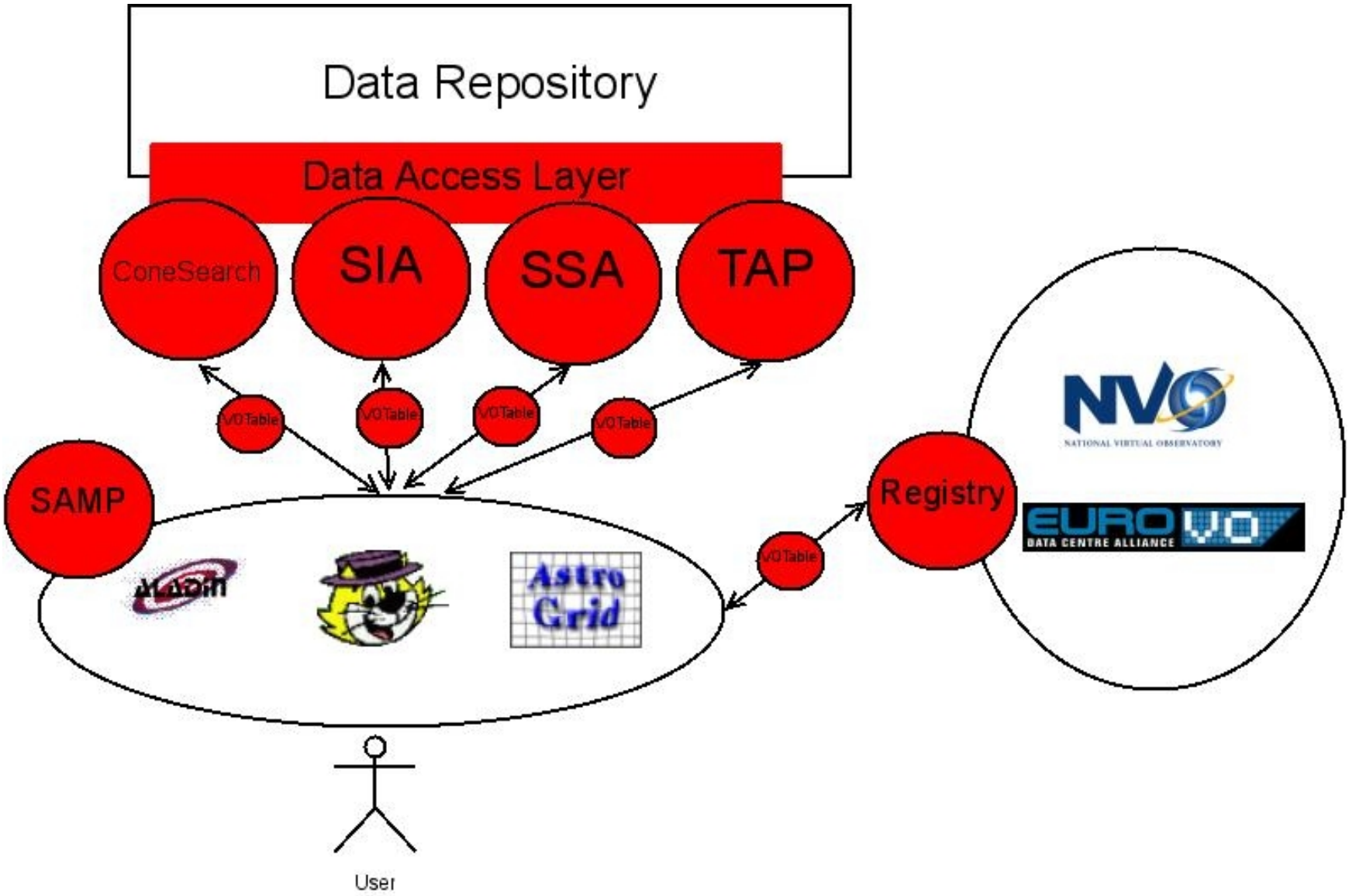
VO: SAMP



- Simple Application Messaging Protocol
- XML-RPC server



VO


Data Repository
Data Access Layer
ConeSearch
SIA
SSA
TAP
VOTable
VOTable
VOTable
VOTable
SAMP
Registry
VOTable
Astro Grid
NVO
NATIONAL VIRTUAL OBSERVATORY
EURO VO
DATA CENTRE ALLIANCE
User

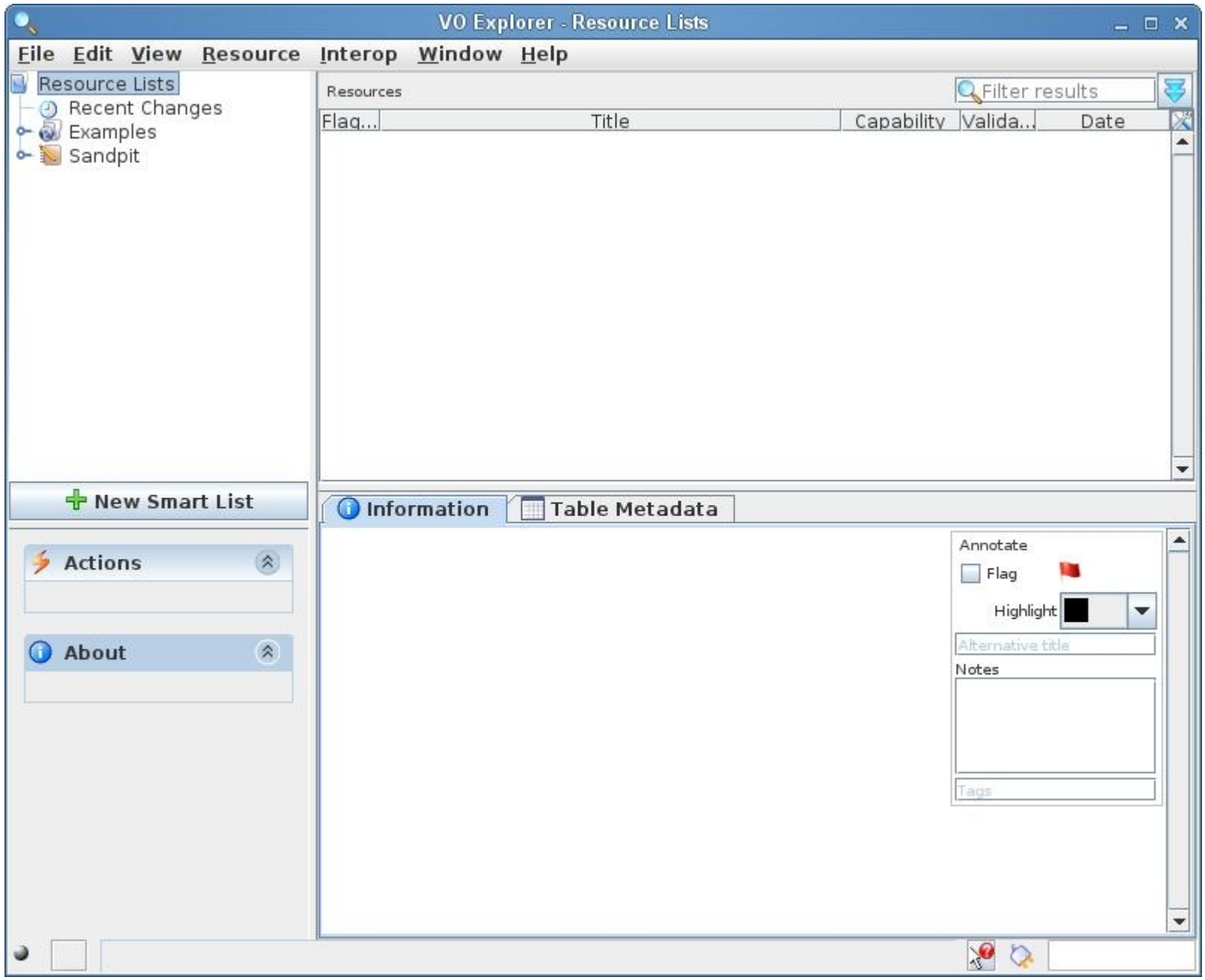
VO Tools

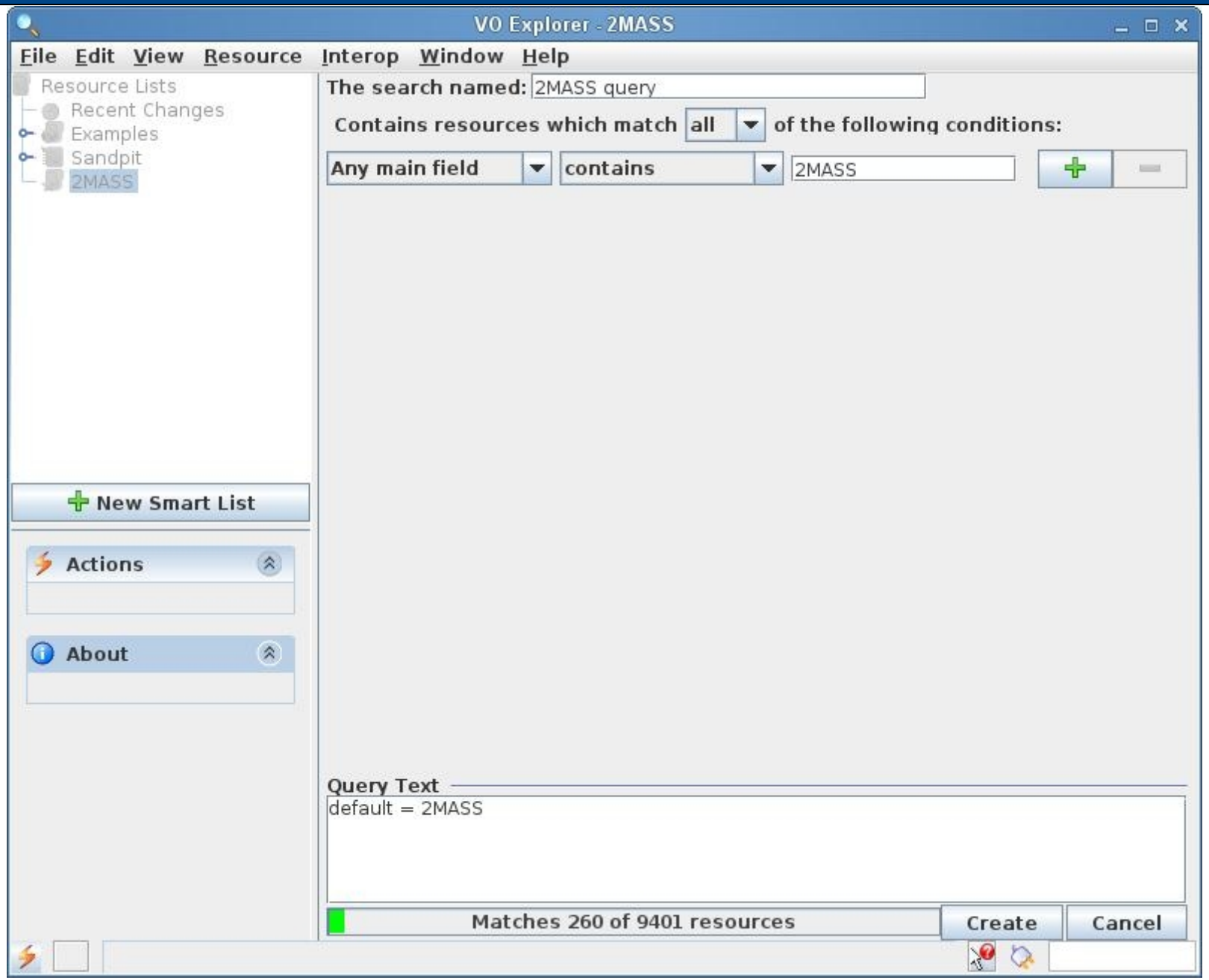
topcat **R,V,C** http://www.star.bris.ac.uk/~mbt/topcat/

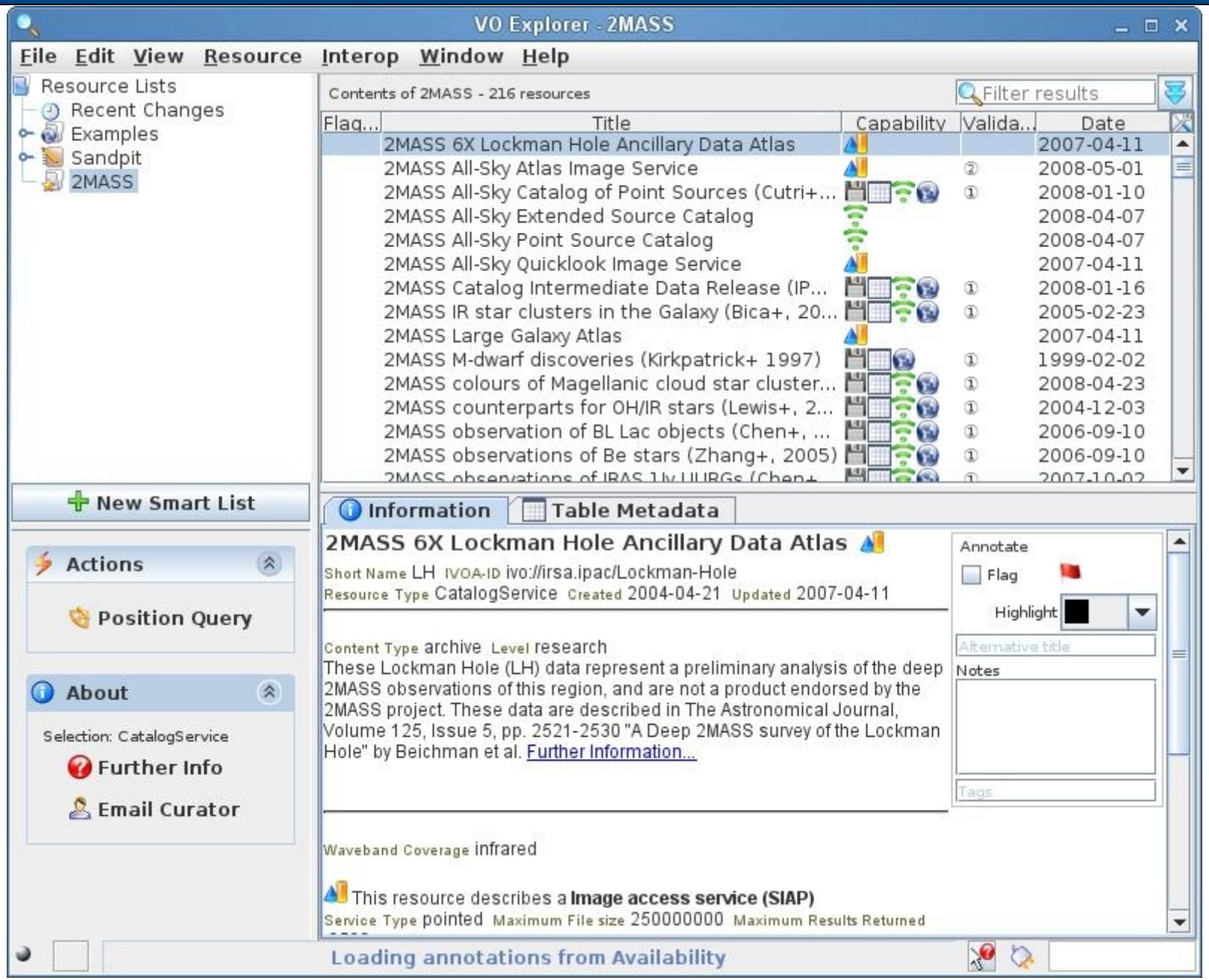
Aladin **R*,V*,C** http://aladin.u-strasbg.fr/

AstroGrid VODesktop **R** http://www.astrogrid.org/wiki/Home/AboutAGDesktop

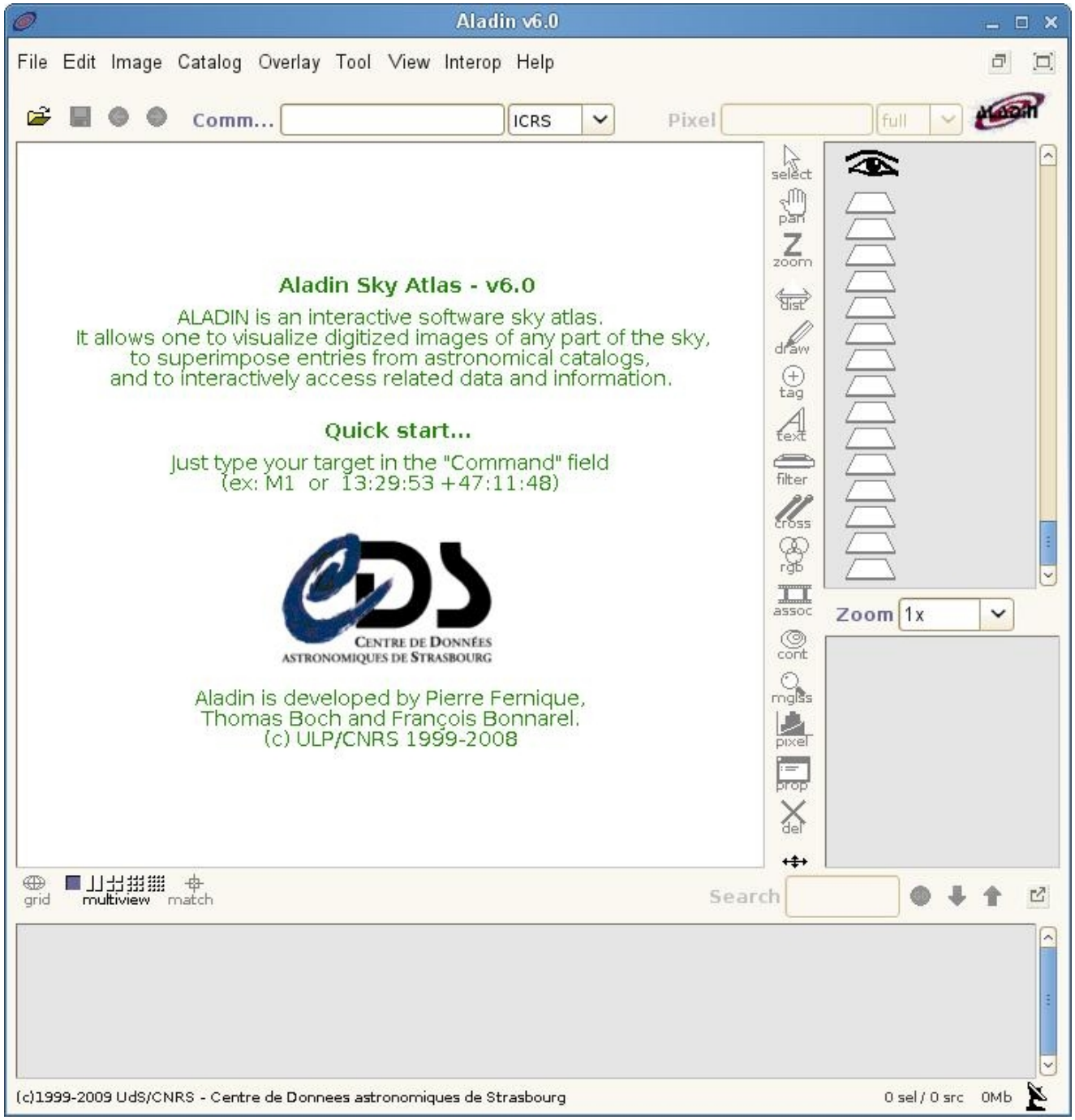
VO Tools: Astrogrid



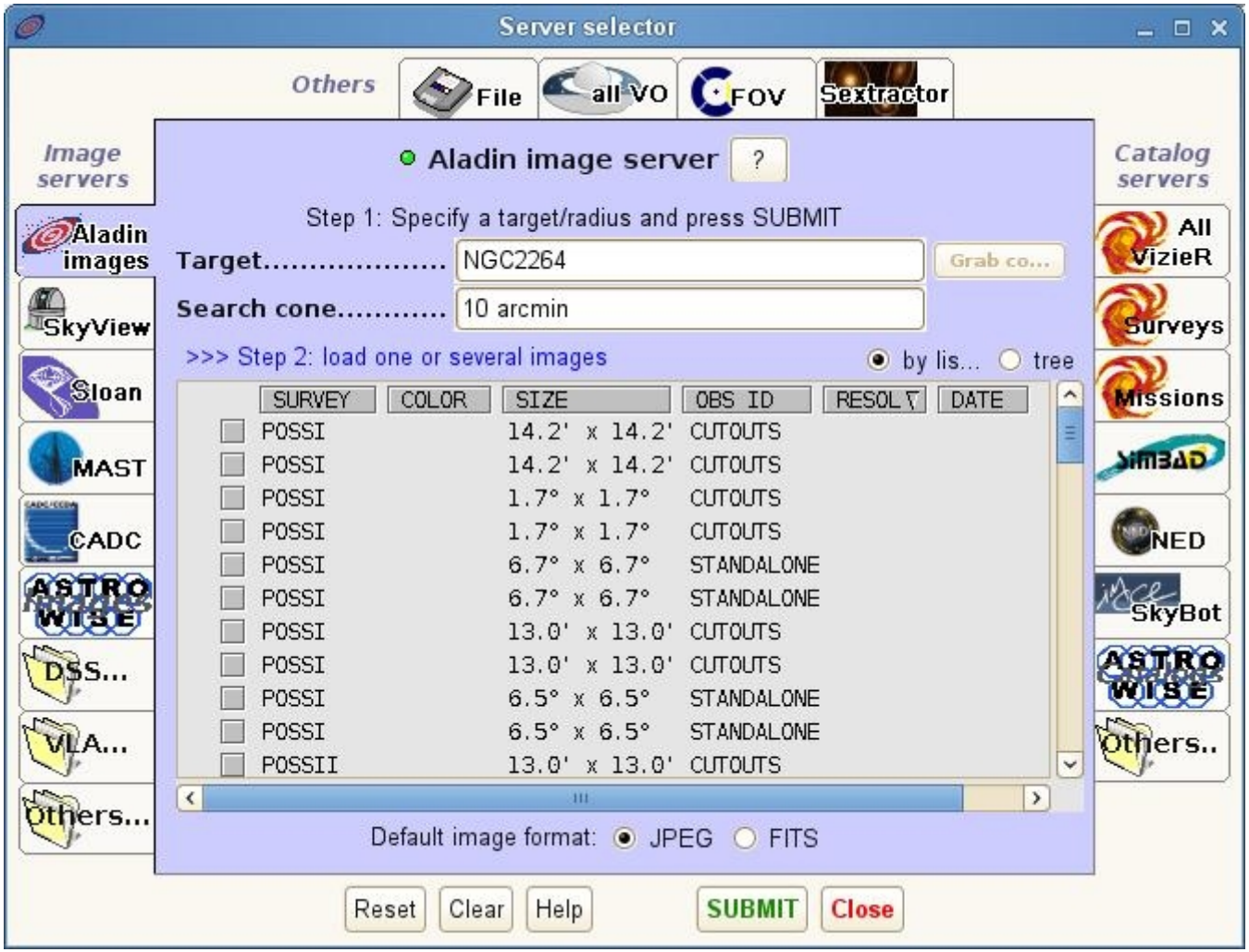

VO Explorer - 2MASS
File Edit View Resource Interop Window Help
Resource Lists
Recent Changes
Examples
Sandpit
2MASS
New Smart List
Actions
About
The search named: 2MASS query
Contains resources which match all of the following conditions:
Any main field
contains
2MASS
Query Text
default = 2MASS
Matches 260 of 9401 resources
Create
Cancel

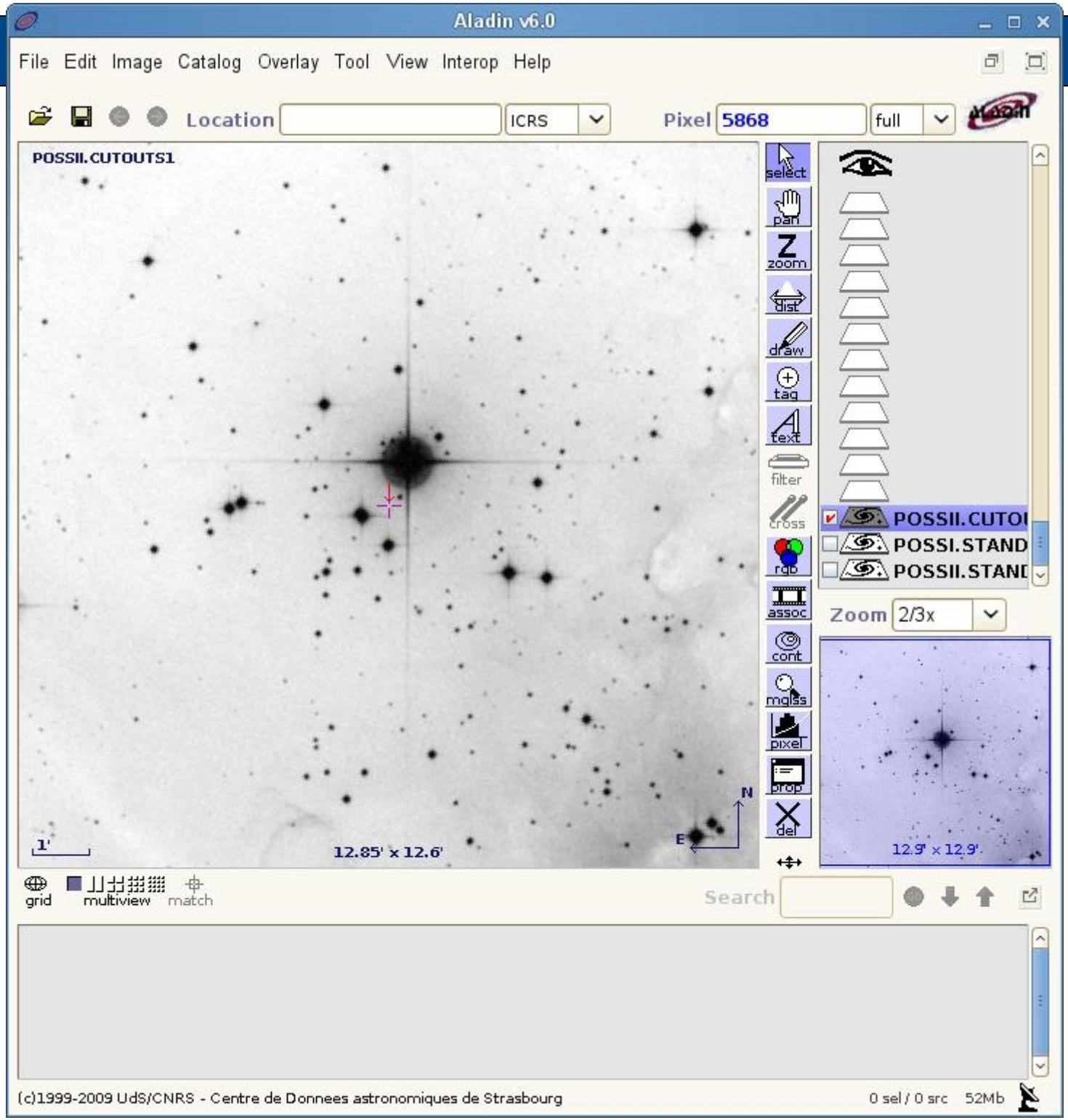

VO Explorer - 2MASS
File Edit View Resource Interop Window Help
Resource Lists
Recent Changes
Examples
Sandpit
2MASS
Contents of 2MASS - 216 resources
Filter results
Flag... Title Capability Valida... Date
2MASS 6X Lockman Hole Ancillary Data Atlas 2007-04-11
2MASS All-Sky Atlas Image Service 2008-05-01
2MASS All-Sky Catalog of Point Sources (Cutri+... 2008-01-10
2MASS All-Sky Extended Source Catalog 2008-04-07
2MASS All-Sky Point Source Catalog 2008-04-07
2MASS All-Sky Quicklook Image Service 2007-04-11
2MASS Catalog Intermediate Data Release (IP... 2008-01-16
2MASS IR star clusters in the Galaxy (Bica+, 20... 2005-02-23
2MASS Large Galaxy Atlas 2007-04-11
2MASS M-dwarf discoveries (Kirkpatrick+ 1997) 1999-02-02
2MASS colours of Magellanic cloud star cluster... 2008-04-23
2MASS counterparts for OH/IR stars (Lewis+, 2... 2004-12-03
2MASS observation of BL Lac objects (Chen+, ... 2006-09-10
2MASS observations of Be stars (Zhang+, 2005) 2006-09-10
New Smart List
Actions
Position Query
About
Selection: CatalogService
Further Info
Email Curator
Information
Table Metadata
2MASS 6X Lockman Hole Ancillary Data Atlas
Short Name LH IVOA-ID ivo://irsa.ipac/Lockman-Hole
Resource Type CatalogService Created 2004-04-21 Updated 2007-04-11
Content Type archive Level research
These Lockman Hole (LH) data represent a preliminary analysis of the deep 2MASS observations of this region, and are not a product endorsed by the 2MASS project. These data are described in The Astronomical Journal, Volume 125, Issue 5, pp. 2521-2530 "A Deep 2MASS survey of the Lockman Hole" by Beichman et al. Further Information...
Annotate
Flag
Highlight
Alternative title
Notes
Tags
Waveband Coverage infrared
This resource describes a Image access service (SIAP)
Service Type pointed Maximum File size 250000000 Maximum Results Returned
Loading annotations from Availability

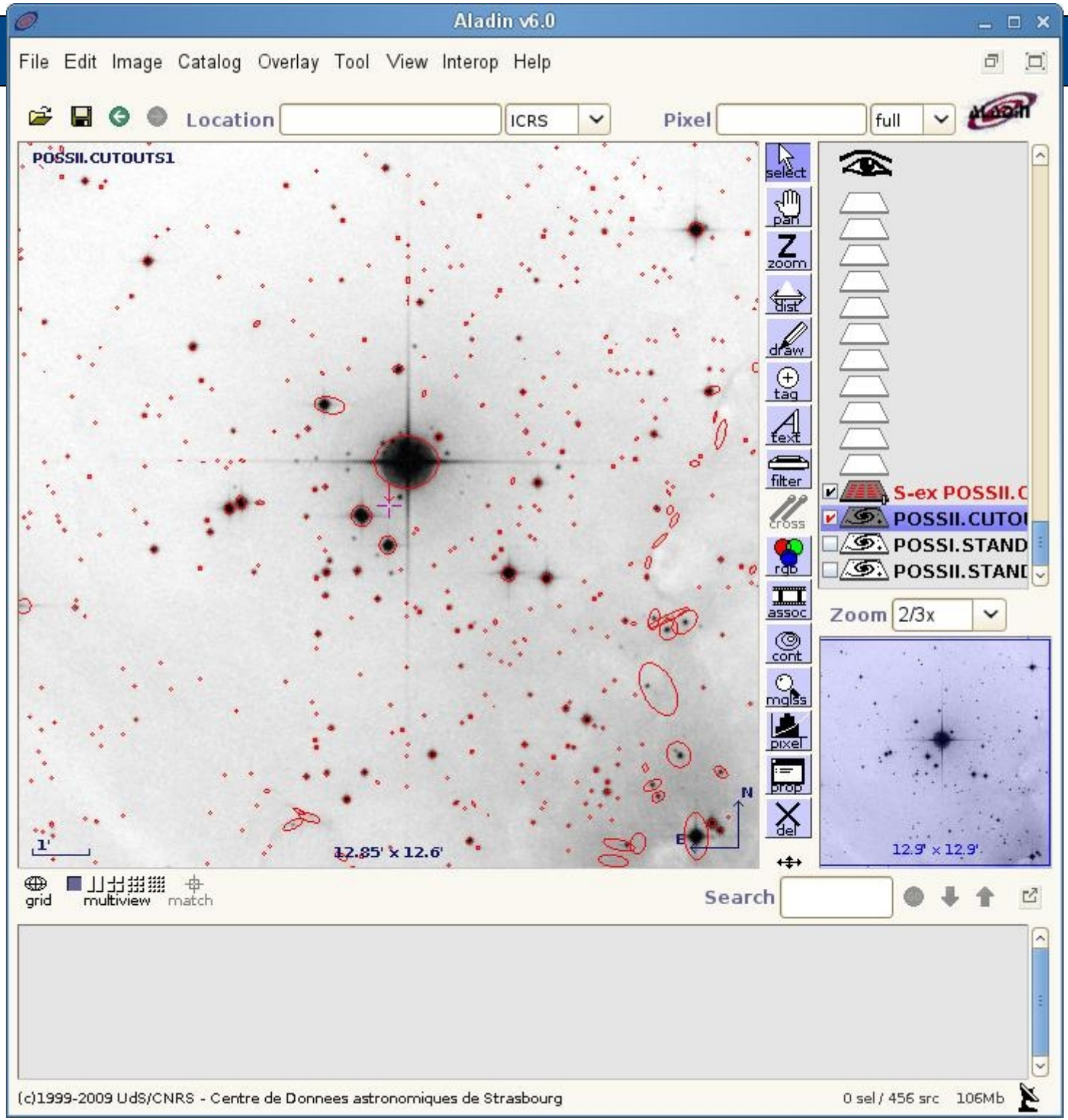
VO Tools: Aladin



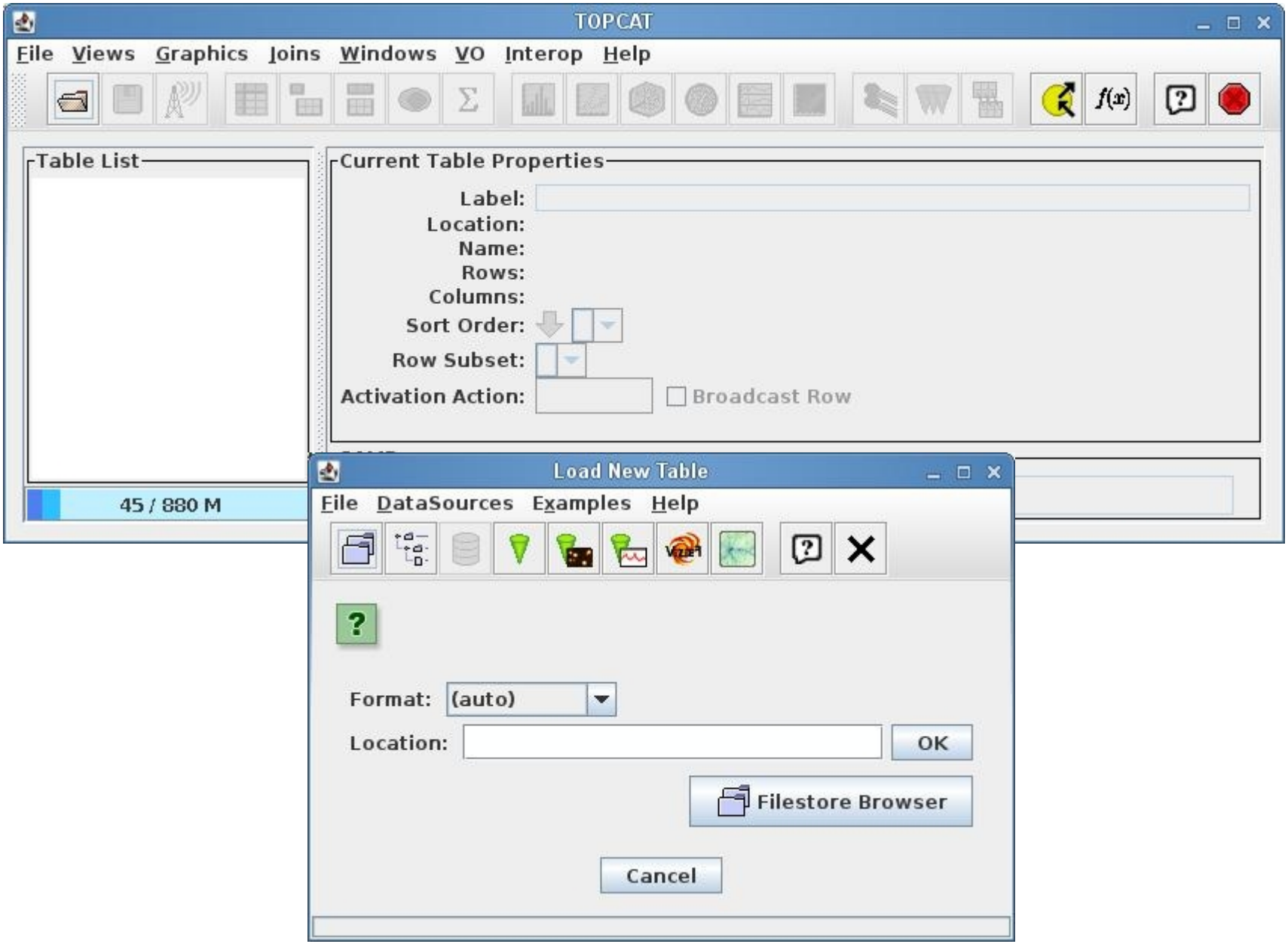

Server selector
Others
File
all VO
FOV
Sextractor
Image servers
Aladin image server
?
>>> Step 1: Specify a target/radius and press SUBMIT
Target.....
Grab co...
Search cone.....
0 arcmin
Step 2: load one or several images
by lis...
tree
Default image format:
JPEG
FITS
Aladin images
SkyView
Sloan
MAST
CADC
ASTRO WISE
DSS...
VLA...
Others...
Catalog servers
All VizieR
Surveys
Missions
SIMBAD
NED
SkyBot
ASTRO WISE
Others..
Reset
Clear
Help
SUBMIT
Close


Server selector
Others
File
allVO
FOV
Sextractor
Image servers
Aladin images
SkyView
Sloan
MAST
CADC
ASTRO WISE
DSS...
VLA...
Others...
Aladin image server
?
Step 1: Specify a target/radius and press SUBMIT
Target.....
NGC2264
Grab co...
Search cone.....
10 arcmin
>>> Step 2: load one or several images
by lis...
tree
SURVEY
COLOR
SIZE
OBS ID
RESOLT
DATE
POSSI 14.2' x 14.2' CUTOUTS
POSSI 14.2' x 14.2' CUTOUTS
POSSI 1.7° x 1.7° CUTOUTS
POSSI 1.7° x 1.7° CUTOUTS
POSSI 6.7° x 6.7° STANDALONE
POSSI 6.7° x 6.7° STANDALONE
POSSI 13.0' x 13.0' CUTOUTS
POSSI 13.0' x 13.0' CUTOUTS
POSSI 6.5° x 6.5° STANDALONE
POSSI 6.5° x 6.5° STANDALONE
POSSII 13.0' x 13.0' CUTOUTS
Default image format:
JPEG
FITS
Reset
Clear
Help
SUBMIT
Close
Catalog servers
All VizieR
Surveys
Missions
SIMBAD
NED
SkyBot
ASTRO WISE
Others..

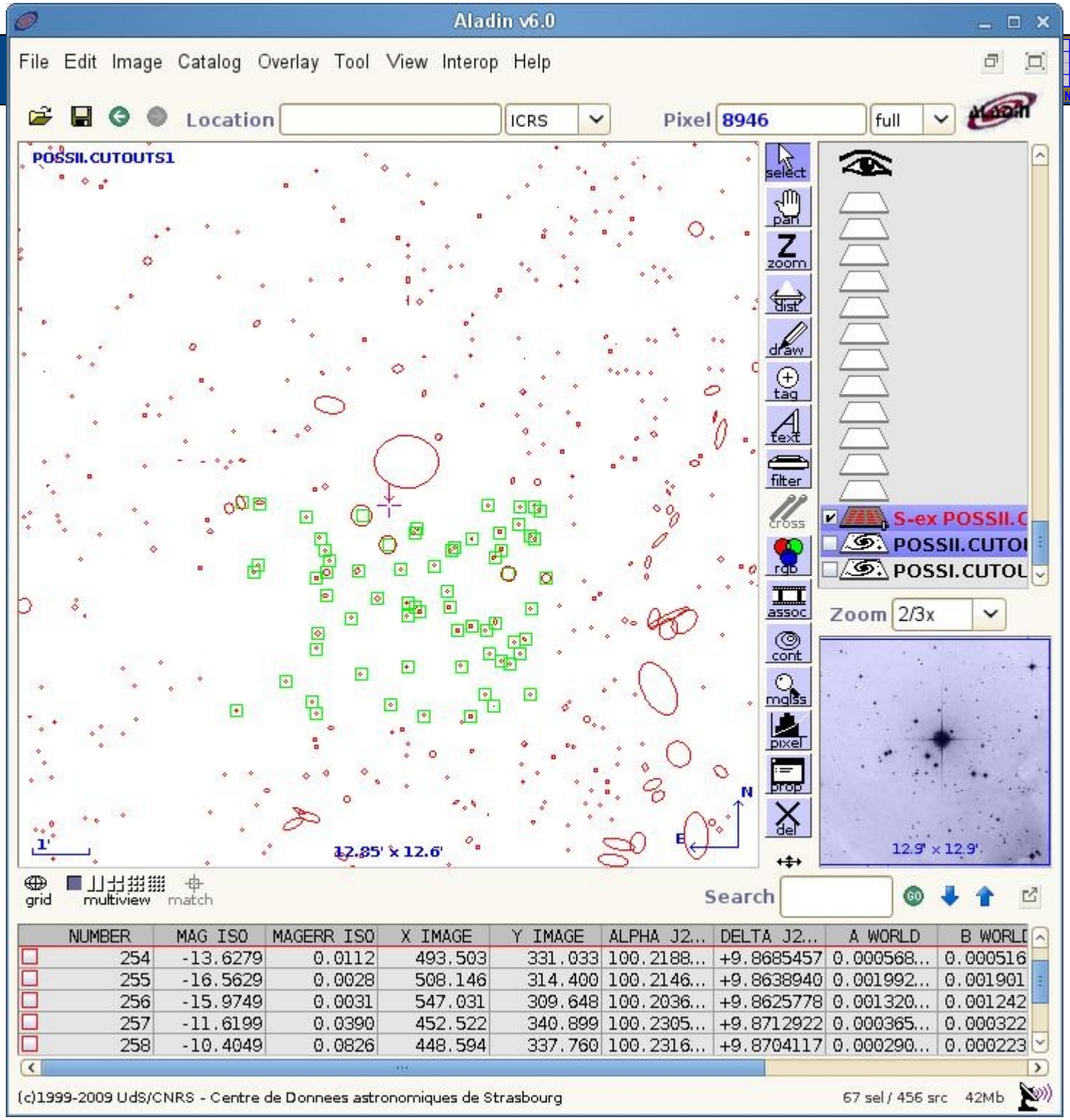

Aladin v6.0
File Edit Image Catalog Overlay Tool View Interop Help
Location
ICRS
Pixel 5868
full
POSSII.CUTOUTS1
select
pan
zoom
dist
draw
tag
text
filter
cross
rgb
assoc
cont
mass
pixel
prop
del
POSSII.CUTOI
POSSI.STAND
POSSII.STAND
Zoom 2/3x
12.9' x 12.9'
1'
12.85' x 12.6'
N
E
grid
multiview
match
Search
(c)1999-2009 UdS/CNRS - Centre de Donnees astronomiques de Strasbourg
0 sel / 0 src
52Mb

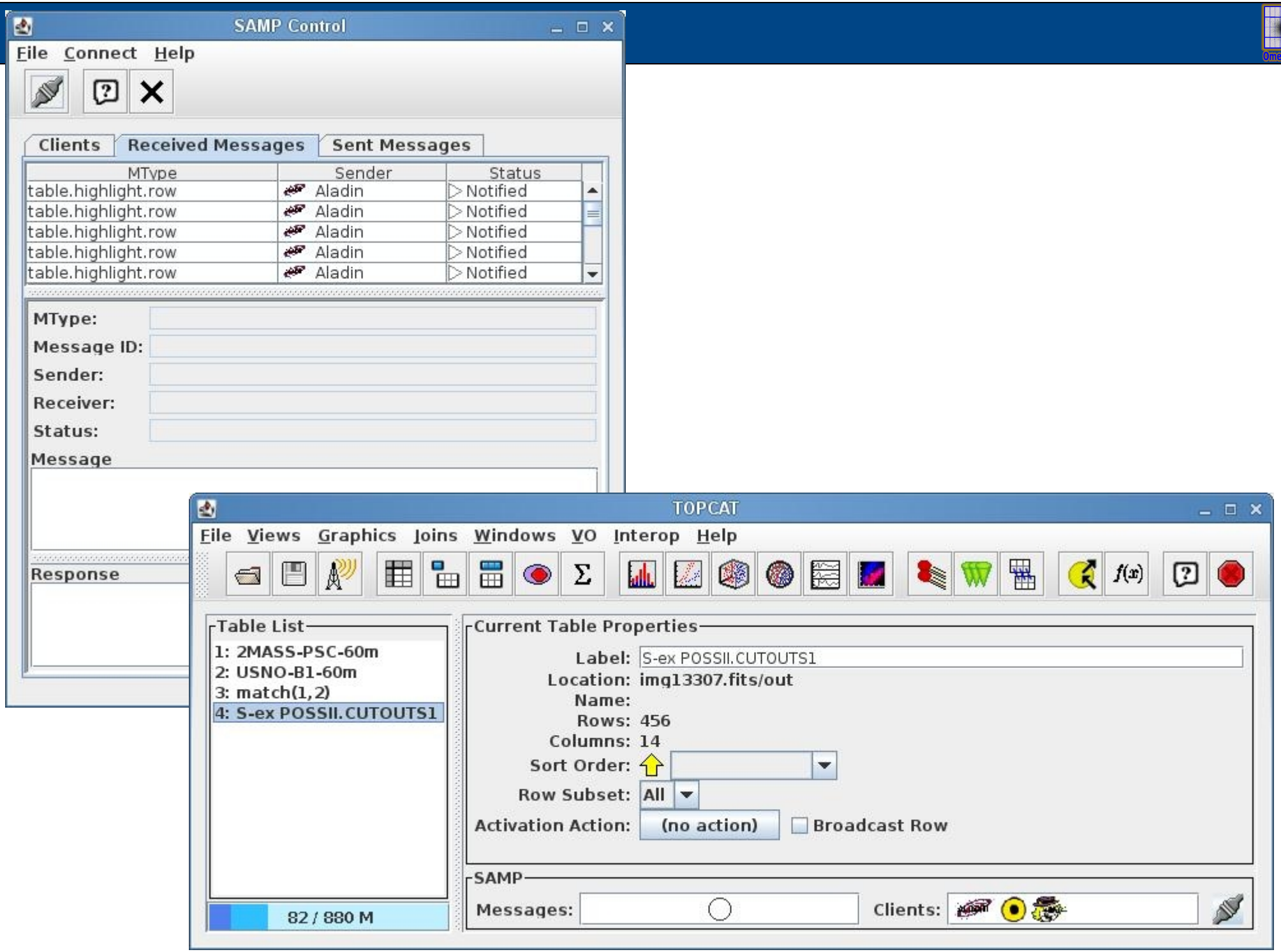

Aladin v6.0
File Edit Image Catalog Overlay Tool View Interop Help
Location
ICRS
Pixel
full
POSSII.CUTOUTS1
select
pan
zoom
dist
draw
tag
text
filter
cross
rgb
assoc
cont
mglss
pixel
prop
del
S-ex POSSII.C
POSSII.CUTOI
POSSI.STAND
POSSII.STAND
Zoom
2/3x
12.9' x 12.9'
1'
12.85' x 12.6'
N
E
grid
multiview
match
Search
(c)1999-2009 UdS/CNRS - Centre de Donnees astronomiques de Strasbourg
0 sel / 456 src
106Mb

VO Tools: topcat



SAMP

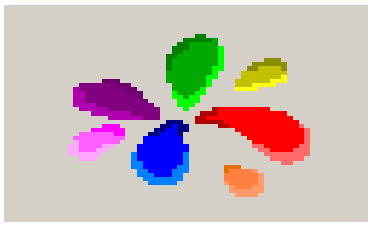

Aladin v6.0
File Edit Image Catalog Overlay Tool View Interop Help
Location
ICRS
Pixel 8946
full
POSSII.CUTOUTS1
select
pan
zoom
dist
draw
tag
text
filter
cross
rgb
assoc
cont
mglss
pixel
prop
del
S-ex POSSII.C
POSSII.CUTOU
POSSI.CUTOU
Zoom 2/3x
12.9' × 12.9'
1'
12.85' x 12.6'
N
E
grid
multiview
match
Search
NUMBER MAG ISO MAGERR ISO X IMAGE Y IMAGE ALPHA J2... DELTA J2... A WORLD B WORLD
254 -13.6279 0.0112 493.503 331.033 100.2188... +9.8685457 0.000568... 0.000516
255 -16.5629 0.0028 508.146 314.400 100.2146... +9.8638940 0.001992... 0.001901
256 -15.9749 0.0031 547.031 309.648 100.2036... +9.8625778 0.001320... 0.001242
257 -11.6199 0.0390 452.522 340.899 100.2305... +9.8712922 0.000365... 0.000322
258 -10.4049 0.0826 448.594 337.760 100.2316... +9.8704117 0.000290... 0.000223
(c)1999-2009 UdS/CNRS - Centre de Donnees astronomiques de Strasbourg
67 sel / 456 src 42Mb


SAMP Control
File Connect Help
Clients
Received Messages
Sent Messages
MType
Sender
Status
table.highlight.row
Aladin
Notified
MType:
Message ID:
Sender:
Receiver:
Status:
Message
Response
TOPCAT
File Views Graphics Joins Windows VO Interop Help
Table List
1: 2MASS-PSC-60m
2: USNO-B1-60m
3: match(1,2)
4: S-ex POSSII.CUTOUTS1
82 / 880 M
Current Table Properties
Label: S-ex POSSII.CUTOUTS1
Location: img13307.fits/out
Name:
Rows: 456
Columns: 14
Sort Order:
Row Subset: All
Activation Action: (no action)
Broadcast Row
SAMP
Messages:
Clients:

VO Tools: Spectra

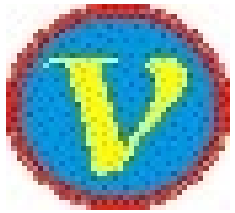
http://www.sciops.esa.int/index.php?project=ESAVO&page=vospec

http://sdc.laeff.inta.es/vosed/index.jsp



http://star-www.dur.ac.uk/~pdraper/splat/splat-vo/

VO Tools: Visualization



http://vo.iucaa.ernet.in/~voi/voplot.htm

http://visivo.oact.inaf.it/index.php

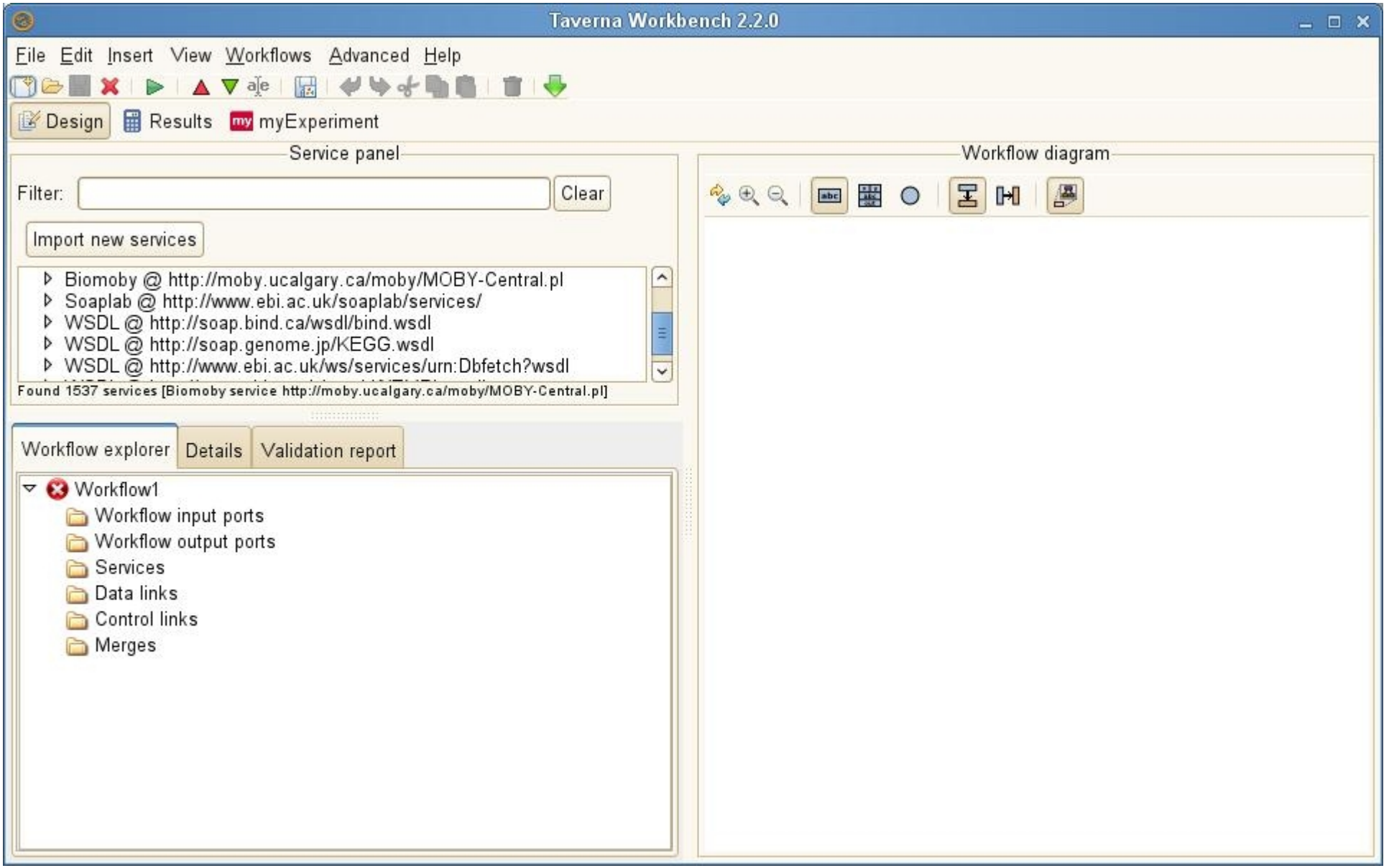
VO Tools: Publishing

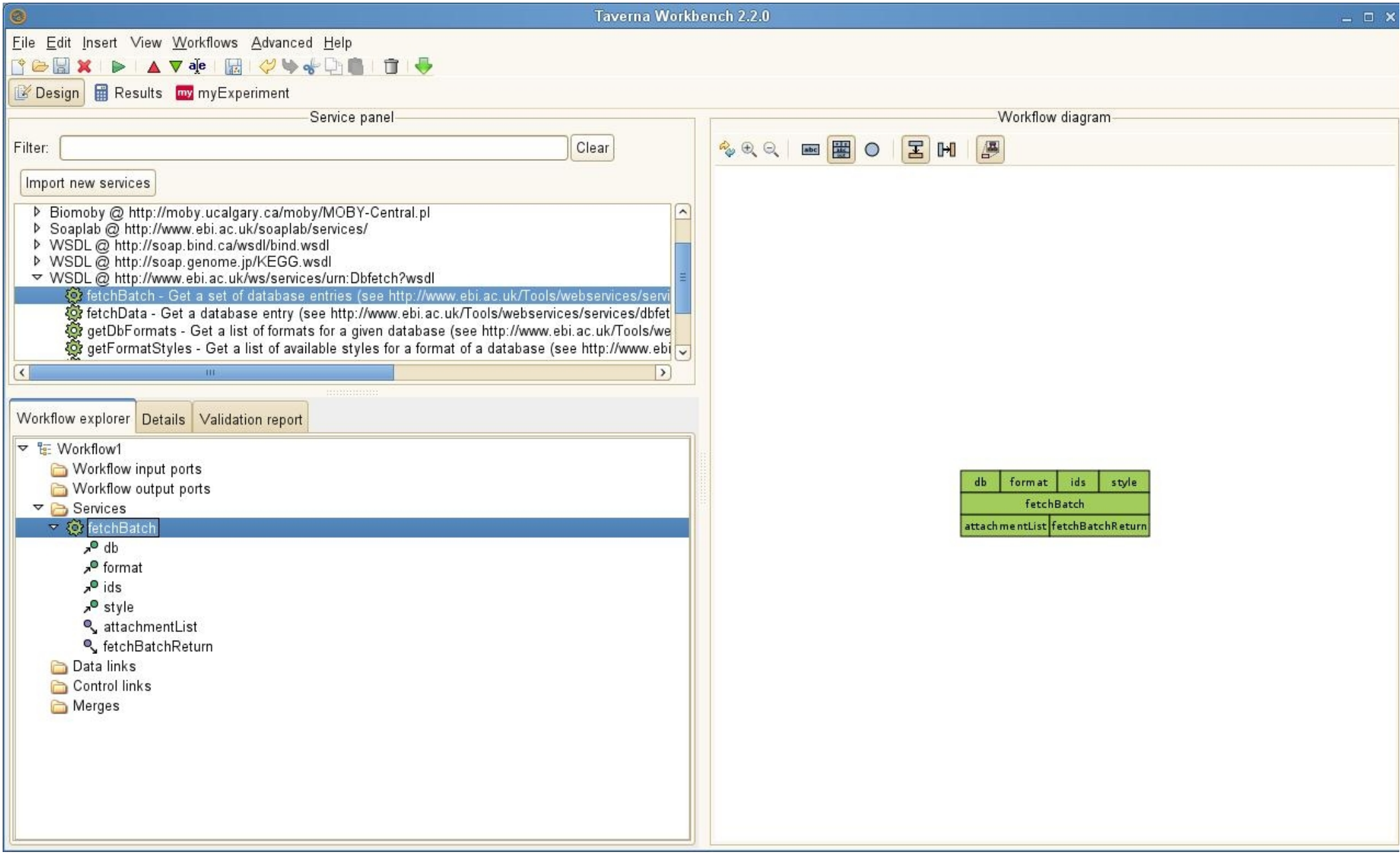
- Automatic publishing – submit data to CDS, reduce data in Astro-WISE

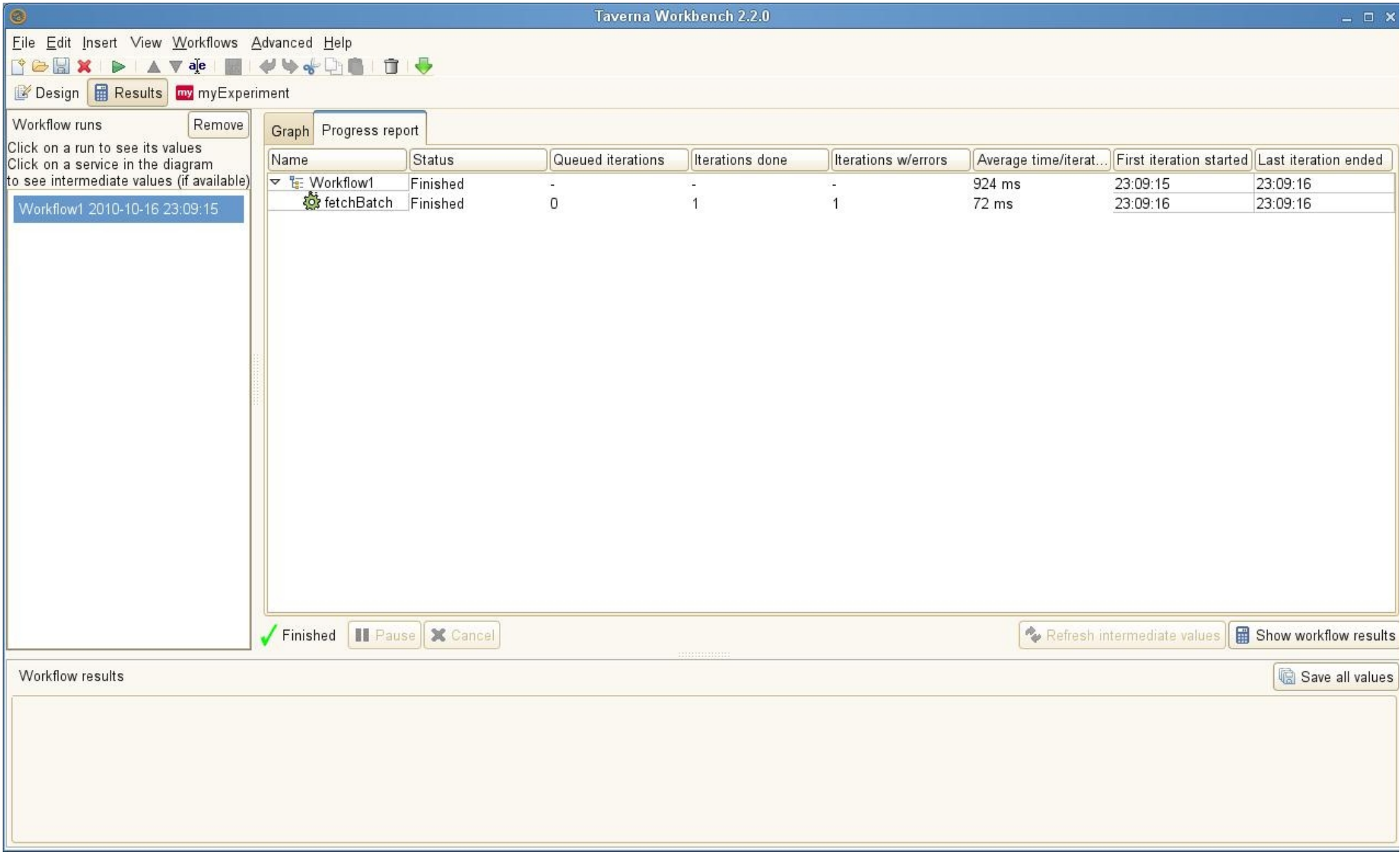
http://saada.u-strasbg.fr/saada/

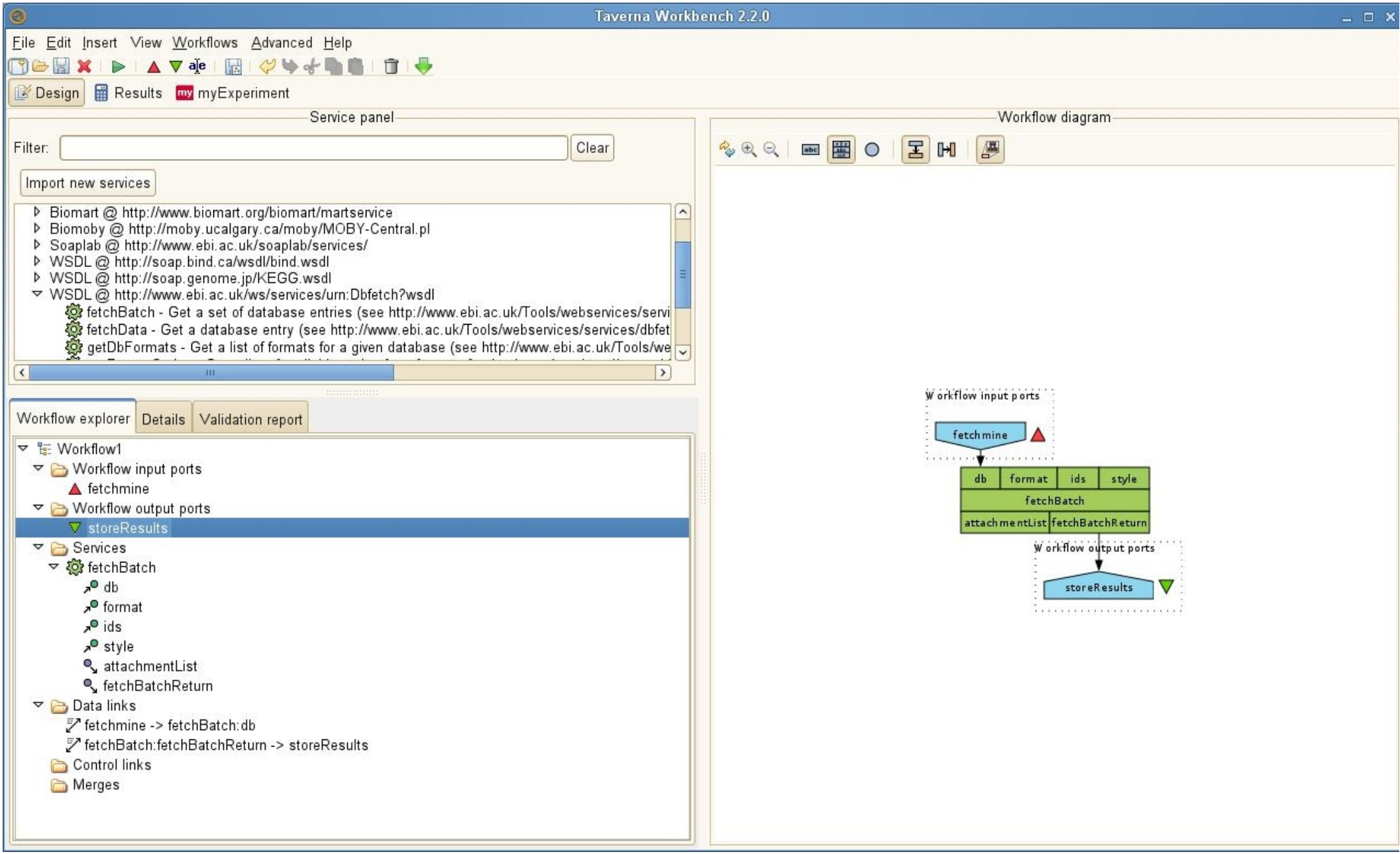
Workflow Management System

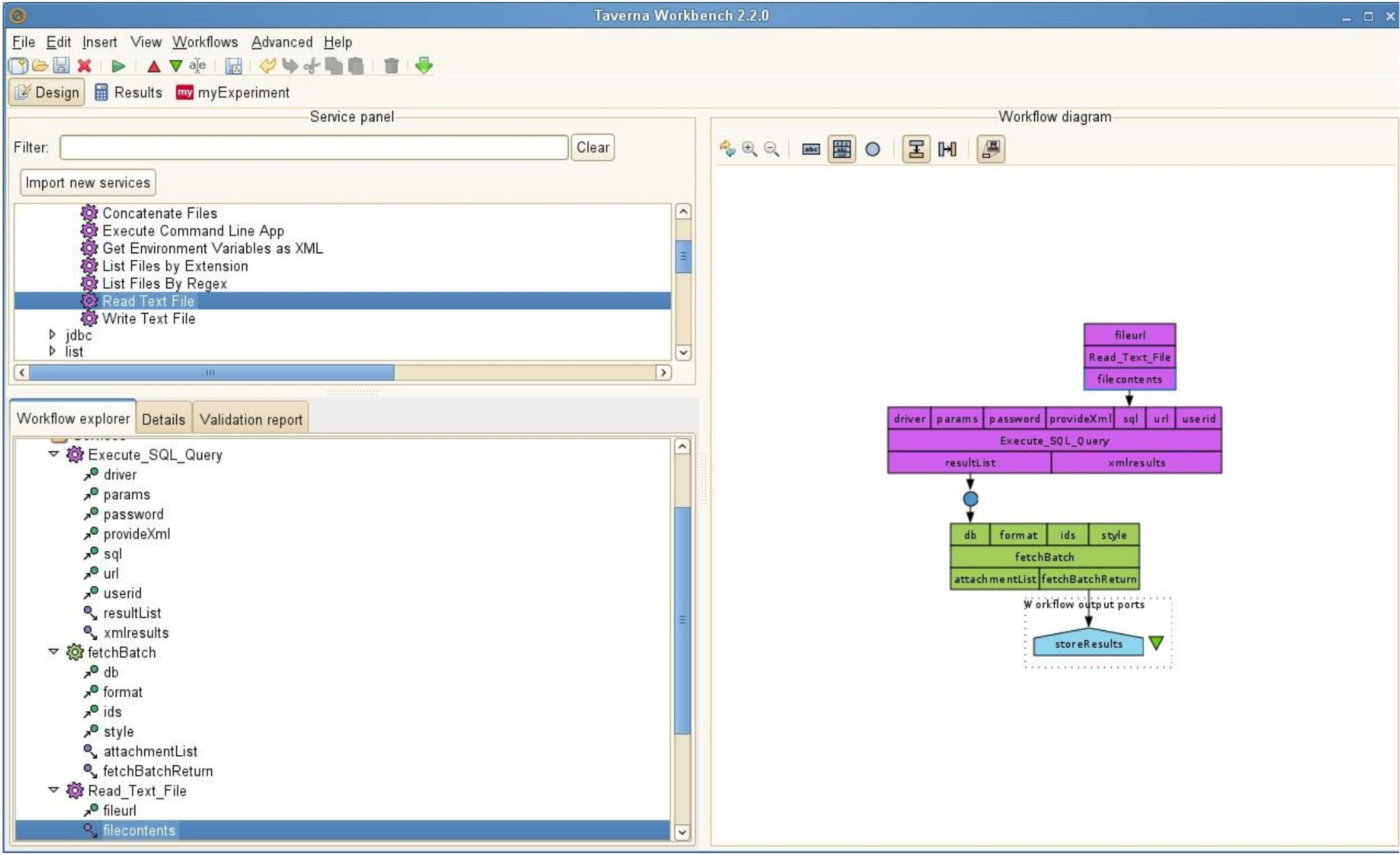
- Eclipse http://www.eclipse.org/
- Taverna http://www.taverna.org.uk/


Taverna Workbench 2.2.0
File Edit Insert View Workflows Advanced Help
Design
Results
myExperiment
Service panel
Filter:
Clear
Import new services
Biomoby @ http://moby.ucalgary.ca/moby/MOBY-Central.pl
Soaplab @ http://www.ebi.ac.uk/soaplab/services/
WSDL @ http://soap.bind.ca/wsdl/bind.wsdl
WSDL @ http://soap.genome.jp/KEGG.wsdl
WSDL @ http://www.ebi.ac.uk/ws/services/urn:Dbfetch?wsdl
Found 1537 services [Biomoby service http://moby.ucalgary.ca/moby/MOBY-Central.pl]
Workflow explorer
Details
Validation report
Workflow1
Workflow input ports
Workflow output ports
Services
Data links
Control links
Merges
Workflow diagram


Taverna Workbench 2.2.0
File Edit Insert View Workflows Advanced Help
Design
Results
myExperiment
Service panel
Filter:
Clear
Import new services
Biomoby @ http://moby.ucalgary.ca/moby/MOBY-Central.pl
Soaplab @ http://www.ebi.ac.uk/soaplab/services/
WSDL @ http://soap.bind.ca/wsdl/bind.wsdl
WSDL @ http://soap.genome.jp/KEGG.wsdl
WSDL @ http://www.ebi.ac.uk/ws/services/urn:Dbfetch?wsdl
fetchBatch - Get a set of database entries (see http://www.ebi.ac.uk/Tools/webservices/servi
fetchData - Get a database entry (see http://www.ebi.ac.uk/Tools/webservices/services/dbfet
getDbFormats - Get a list of formats for a given database (see http://www.ebi.ac.uk/Tools/we
getFormatStyles - Get a list of available styles for a format of a database (see http://www.ebi
Workflow explorer
Details
Validation report
Workflow1
Workflow input ports
Workflow output ports
Services
fetchBatch
db
format
ids
style
attachmentList
fetchBatchReturn
Data links
Control links
Merges
Workflow diagram
db
format
ids
style
fetchBatch
attachmentList
fetchBatchReturn


Taverna Workbench 2.2.0
File Edit Insert View Workflows Advanced Help
Design
Results
myExperiment
Workflow runs
Remove
Click on a run to see its values
Click on a service in the diagram
to see intermediate values (if available)
Workflow1 2010-10-16 23:09:15
Graph
Progress report
Name
Status
Queued iterations
Iterations done
Iterations w/errors
Average time/iterat...
First iteration started
Last iteration ended
Workflow1
Finished
-
-
-
924 ms
23:09:15
23:09:16
fetchBatch
Finished
0
1
1
72 ms
23:09:16
23:09:16
Finished
Pause
Cancel
Refresh intermediate values
Show workflow results
Workflow results
Save all values


Taverna Workbench 2.2.0
File Edit Insert View Workflows Advanced Help
Design
Results
myExperiment
Service panel
Filter:
Clear
Import new services
Biomart @ http://www.biomart.org/biomart/martservice
Biomoby @ http://moby.ucalgary.ca/moby/MOBY-Central.pl
Soaplab @ http://www.ebi.ac.uk/soaplab/services/
WSDL @ http://soap.bind.ca/wsdl/bind.wsdl
WSDL @ http://soap.genome.jp/KEGG.wsdl
WSDL @ http://www.ebi.ac.uk/ws/services/urn:Dbfetch?wsdl
fetchBatch - Get a set of database entries (see http://www.ebi.ac.uk/Tools/webservices/servi
fetchData - Get a database entry (see http://www.ebi.ac.uk/Tools/webservices/services/dbfet
getDbFormats - Get a list of formats for a given database (see http://www.ebi.ac.uk/Tools/we
Workflow explorer
Details
Validation report
Workflow1
Workflow input ports
fetchmine
Workflow output ports
storeResults
Services
fetchBatch
db
format
ids
style
attachmentList
fetchBatchReturn
Data links
fetchmine -> fetchBatch:db
fetchBatch:fetchBatchReturn -> storeResults
Control links
Merges
Workflow diagram
Workflow input ports
fetchmine
db
format
ids
style
fetchBatch
attachmentList
fetchBatchReturn
Workflow output ports
storeResults


Taverna Workbench 2.2.0
File Edit Insert View Workflows Advanced Help
Design
Results
myExperiment
Service panel
Filter:
Clear
Import new services
Concatenate Files
Execute Command Line App
Get Environment Variables as XML
List Files by Extension
List Files By Regex
Read Text File
Write Text File
jdbc
list
Workflow explorer
Details
Validation report
Execute_SQL_Query
driver
params
password
provideXml
sql
url
userid
resultList
xmlresults
fetchBatch
db
format
ids
style
attachmentList
fetchBatchReturn
Read_Text_File
fileurl
filecontents
Workflow diagram
fileurl
Read_Text_File
file contents
driver
params
password
provideXml
sql
url
userid
Execute_SQL_Query
resultList
xmlresults
db
format
ids
style
fetchBatch
attachmentList
fetchBatchReturn
Workflow output ports
storeResults