



Astronomical Institute
of the Czech Academy of Sciences



Not Only **Stellar Spectroscopy with Virtual Observatory**

Petr Škoda

Astronomical Institute of the Czech Academy of Sciences, Ondřejov

Lecture at workshop on observational techniques,
AI Ondřejov, 11th Sep 2025

About Myself

Petr Škoda

Charles University in Prague – Master Thesis 1987 (title RNDr.)

A Simple model of HII regions

Astronomical Institute Ondřejov PhD study 1987-1989

Staff member since 1989, PhD thesis 1996 (title CSc.)

Study of Physical Processes in Sparse Envelopes of Hot Stars

Theory, Non-LTE models, RTE , b-factor , Gaunt factor (symbolic)

Computers in astronomy, ADASS, start of Internet in CZ (EARN)

Reduction of spectra , TCS, CCD detectors, Echelle unblazing

About Myself

Virtual Observatory (2003) , IAU Prague (2006)

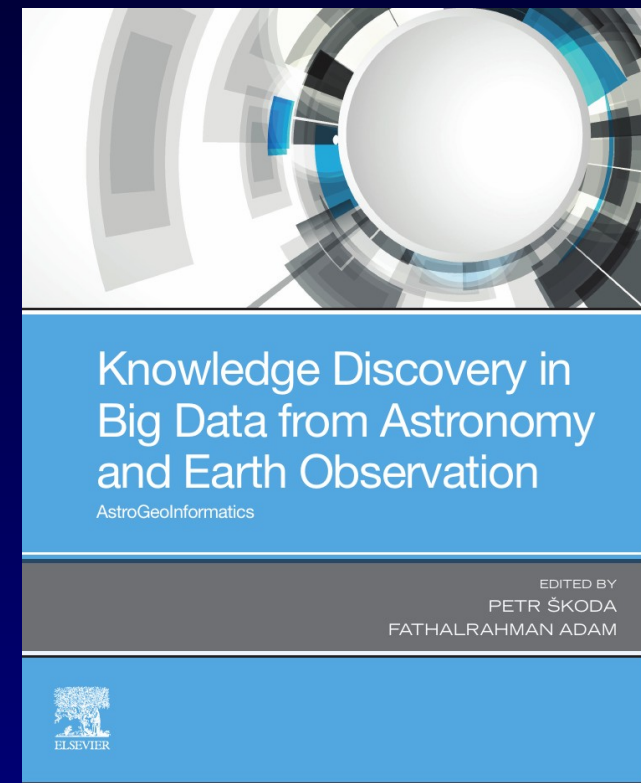
Astroinformatics (2010)

ML, AI (Technical universities Prague, Brno Ostrava)

FIT CTU Prague – grant RCI 4 years,

Bc, Master and 2 PhD students (Expert Supervisor)

COST Action Big Sky Earth, Editor of Book

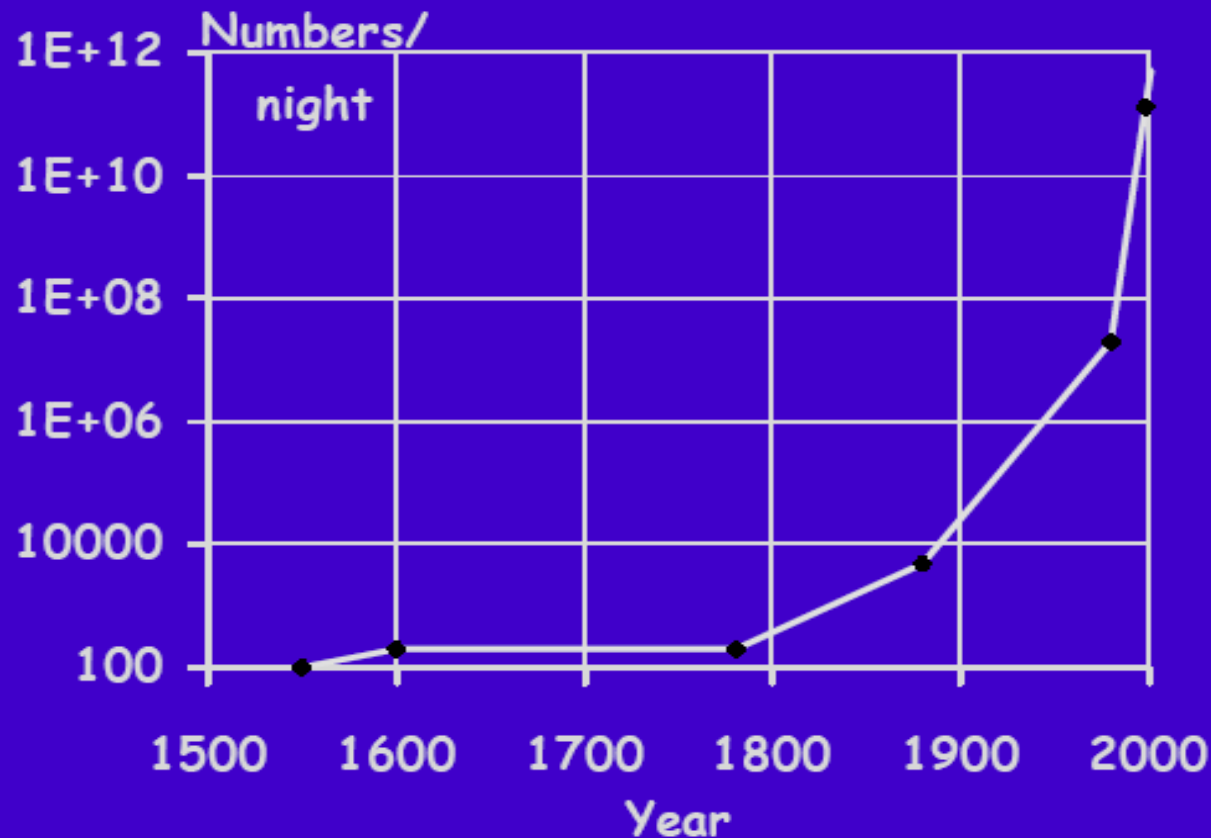


Data Avalanche

Moore law for chips –doubling 1.5 year

Data in astronomy – doubling < 1 yr ! (9 month current)

100 PB today, 100 TB/night



$T_2 < 18$ mths
1990-2000

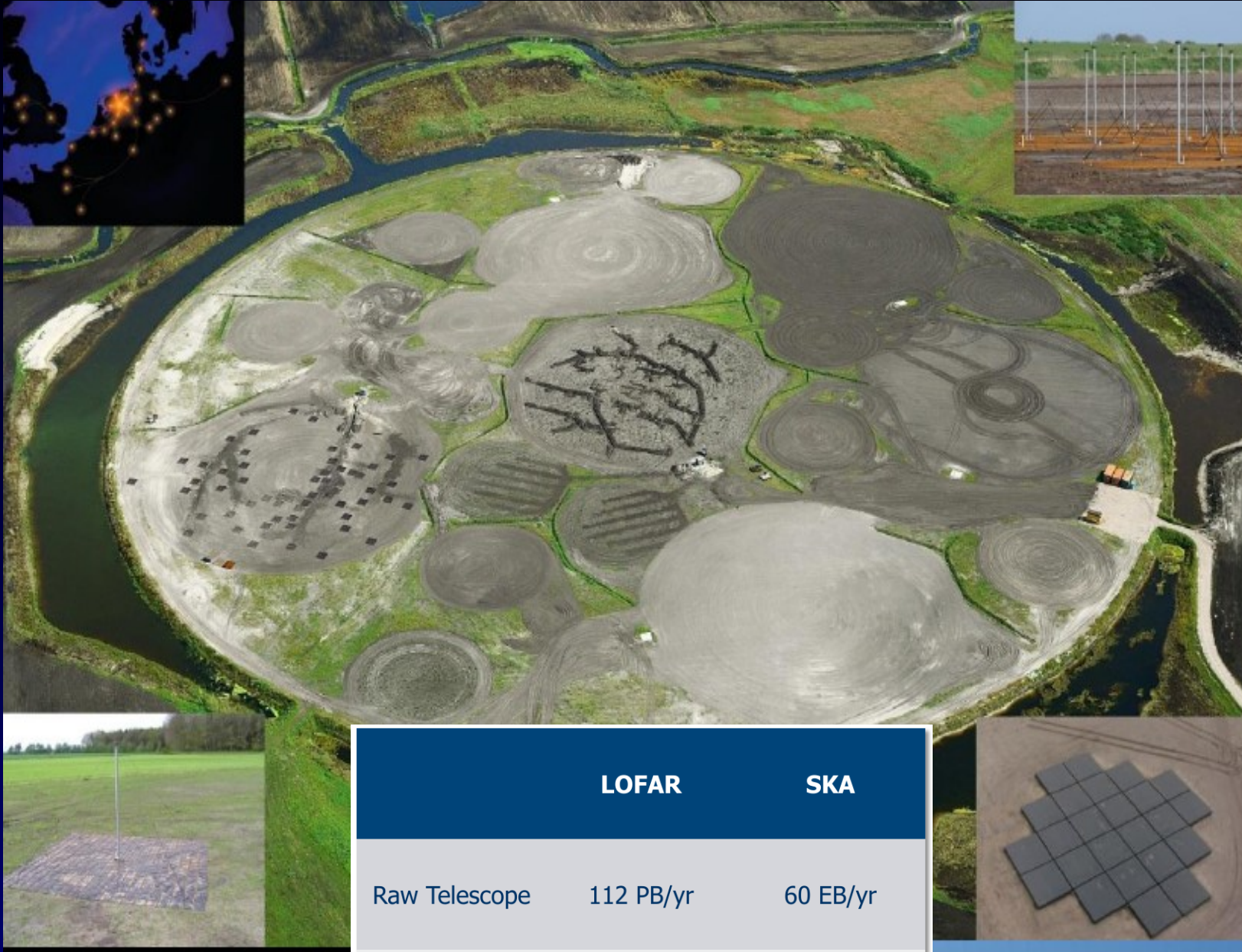
LSST – Vera C. Rubin Observatory



201 CCD 4kx4k,
3.2 Gpix every 15 sec
3.5 deg FOV (64cm)
20 TB/day=6 PB/yr RAW
1.5 PB catalogue !!!
detection of changes 60s!
10 million alerts/night !
38 billion objects x 1000
32 tril. meas. -5 PB table



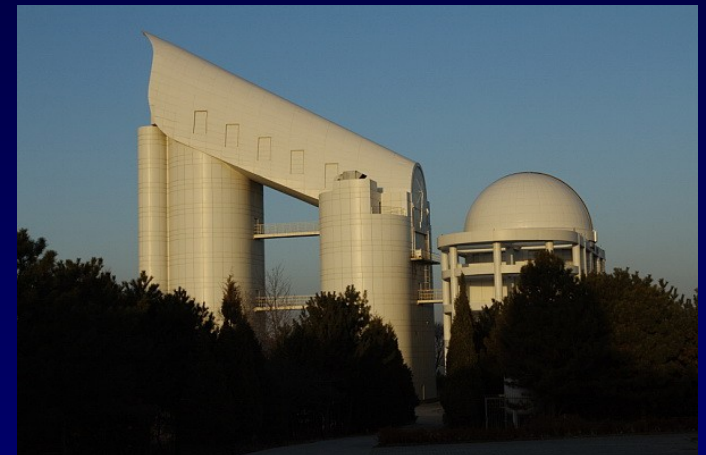
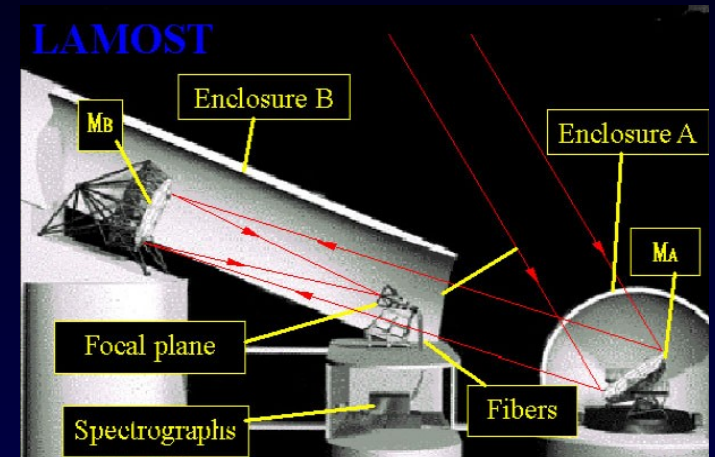
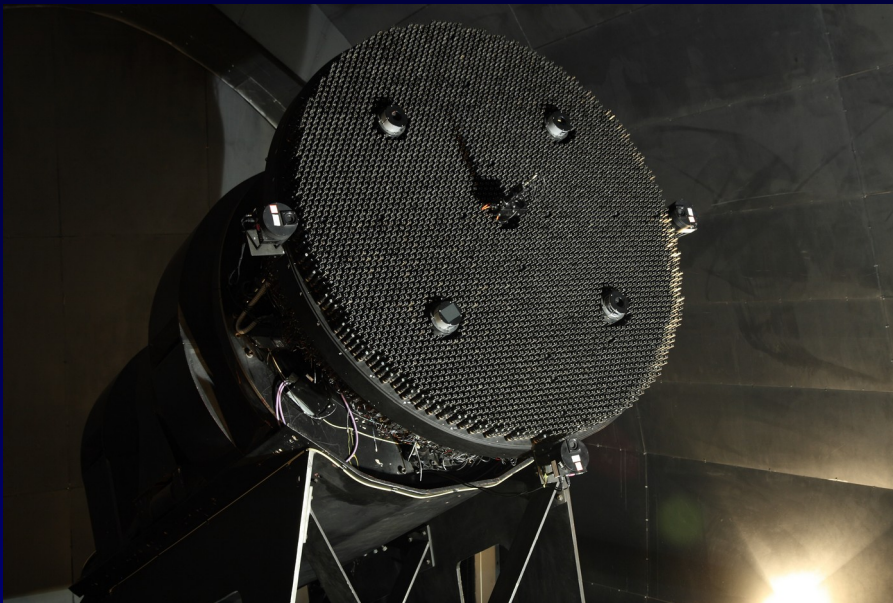
LOFAR network



	LOFAR	SKA
Raw Telescope	112 PB/yr	60 EB/yr
Archive Rate	6 PB/yr	100 PB/yr

LAMOST (Guoshoujing)

- Xinglong, China
- 4 m mirror (30 deg meridian)
- 4000 fibres



LAMOST Spectral Surveys

DR1 (end 2013) **2 204 860** spectra
 1 085 404 stars classified by pipeline

DR2 (beg 2015) **4 132 782** spectra
 3 779 674 stars
 307 000 unknown!

DR5 (half 2017) **9 017 844** spectra

...

DR12 (Mar 2025) **12 602 390** low res
 + **15 475 985** mid res

Each fibre – 2 motors
double arm 33mm circle

Fibre collects light from
3.3 arcsec circle on sky



Virtual Observatory : Key Definitions

- “The Virtual Observatory will be a system that allows astronomers to *interrogate multiple data centers* in a seamless and transparent way, which provides new *powerful analysis and visualization* tools within that system, and which gives data centers a *standard framework for publishing* and delivering services using their data”.
- **Standardization** of data and metadata, and of data exchange methods.
- **Registry**, listing available services and what can be done with them.

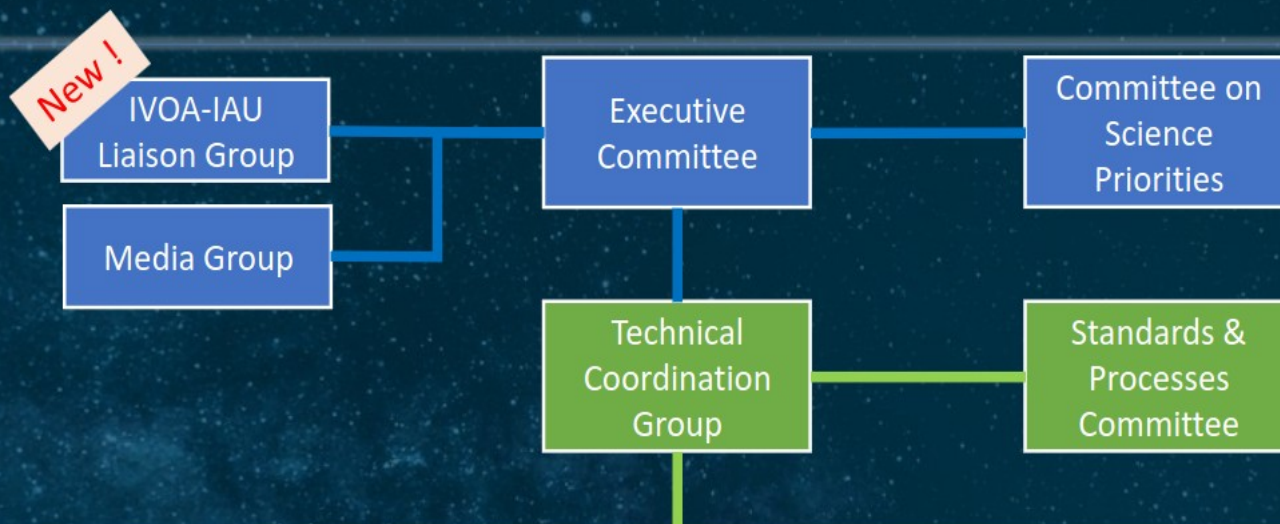
R.J.Hanisch, P.J.Quinn, in “IVOA – Guidelines for participation”

IVOA (established 2002)



IVOA Structure

IVOA Organization



Working Groups

Applications

Data Access
Layer

Data Models

Grid and Web
Services

Registry

Semantics

Interest Groups

Data Curation &
Preservation

Operations

Theory

Radio
Astronomy

Solar System

Time Domain

Education

Knowledge
Discovery

Ecosystem of VO – level 0

LEVEL 0

USERS



COMPUTERS

USER LAYER

USING

F
I
N
D
I
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G

VO
CORE

G
E
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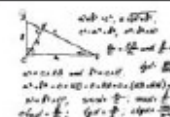
SHARING

RESOURCE LAYER

20101004
IVOA Architecture



PROVIDERS



Ecosystem of VO – level 1

LEVEL 1
empty

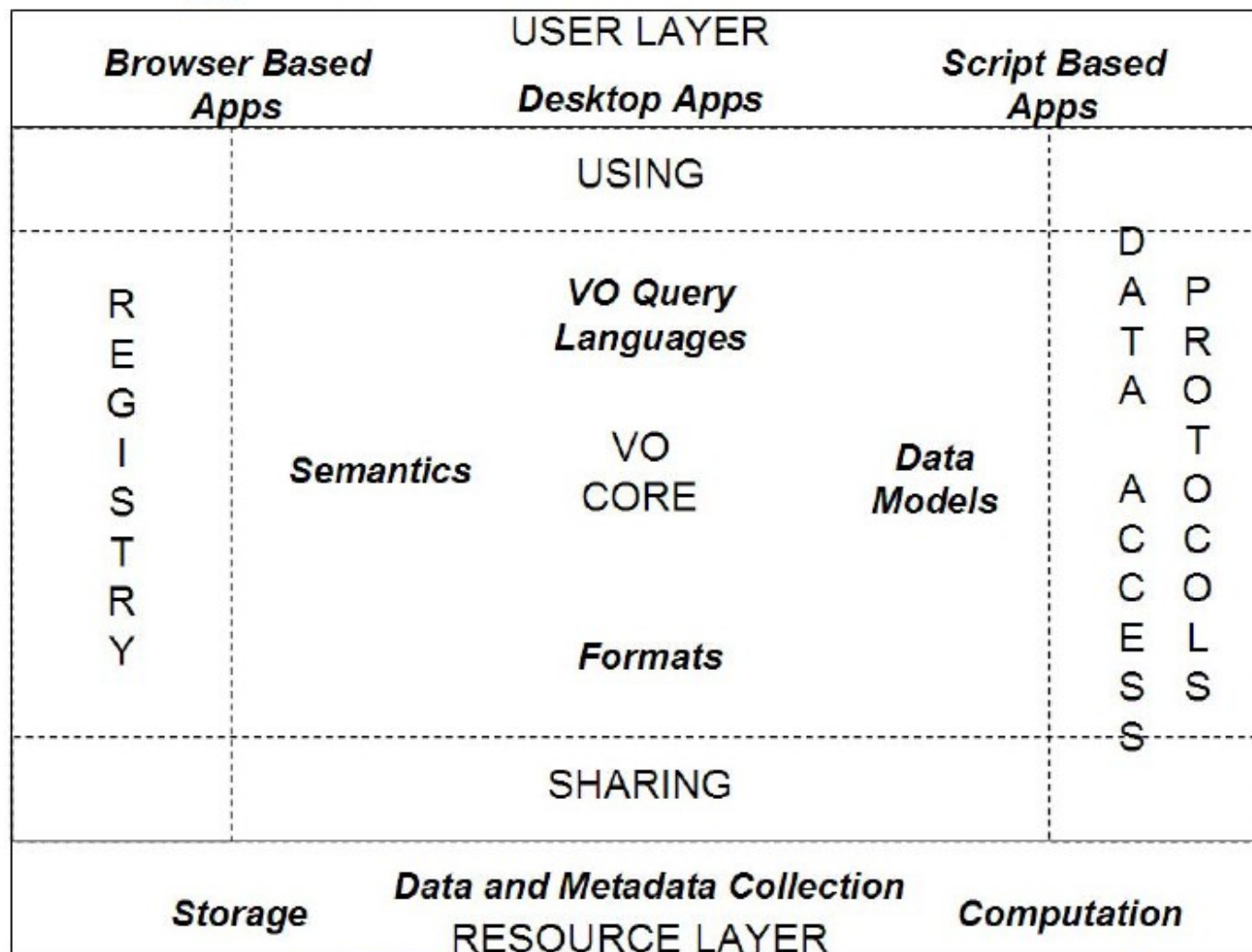
USERS



COMPUTERS

REC

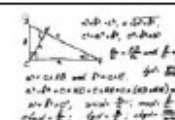
InProgress



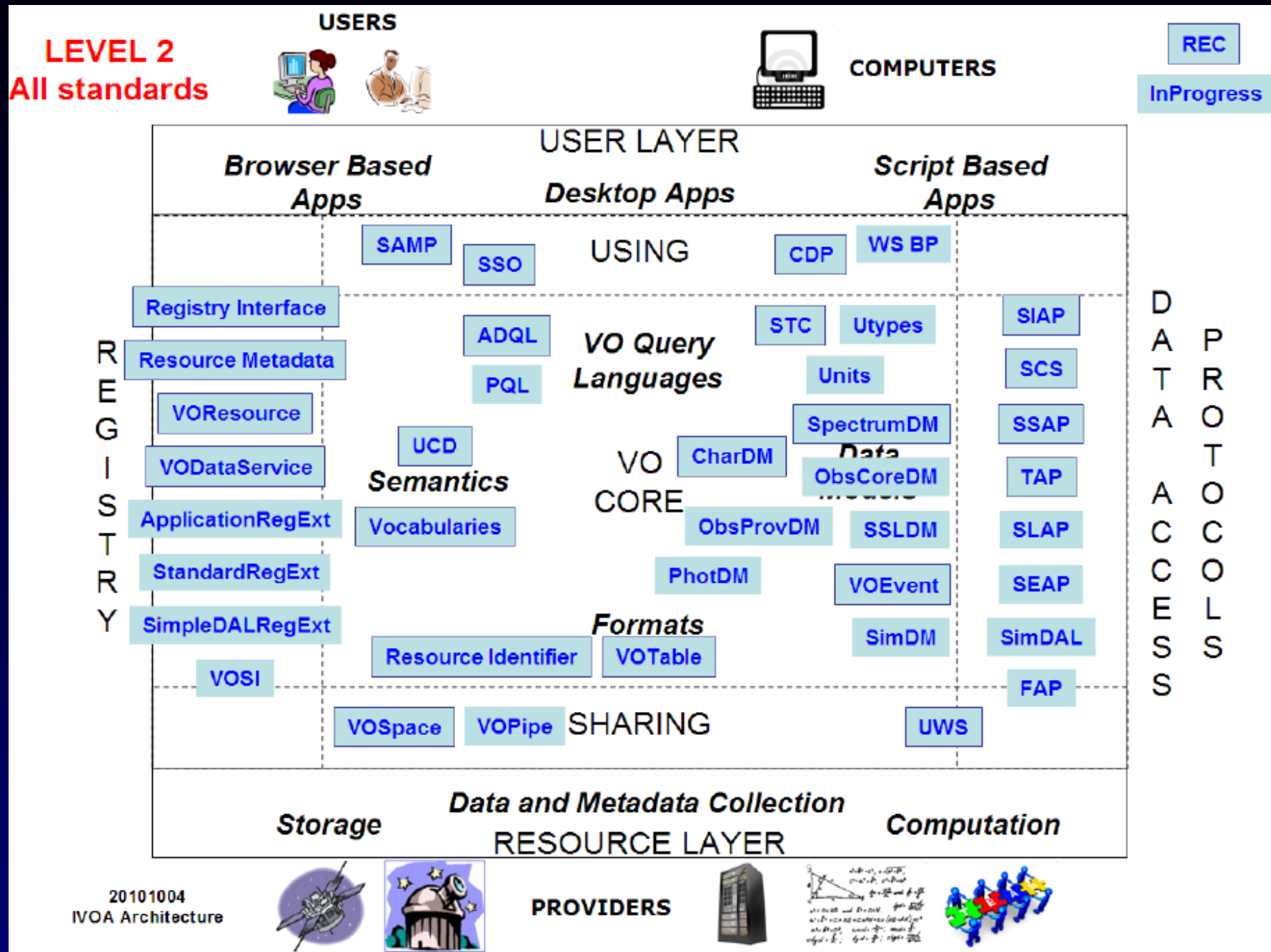
20101004
IVOA Architecture



PROVIDERS



Ecosystem of VO – level 2



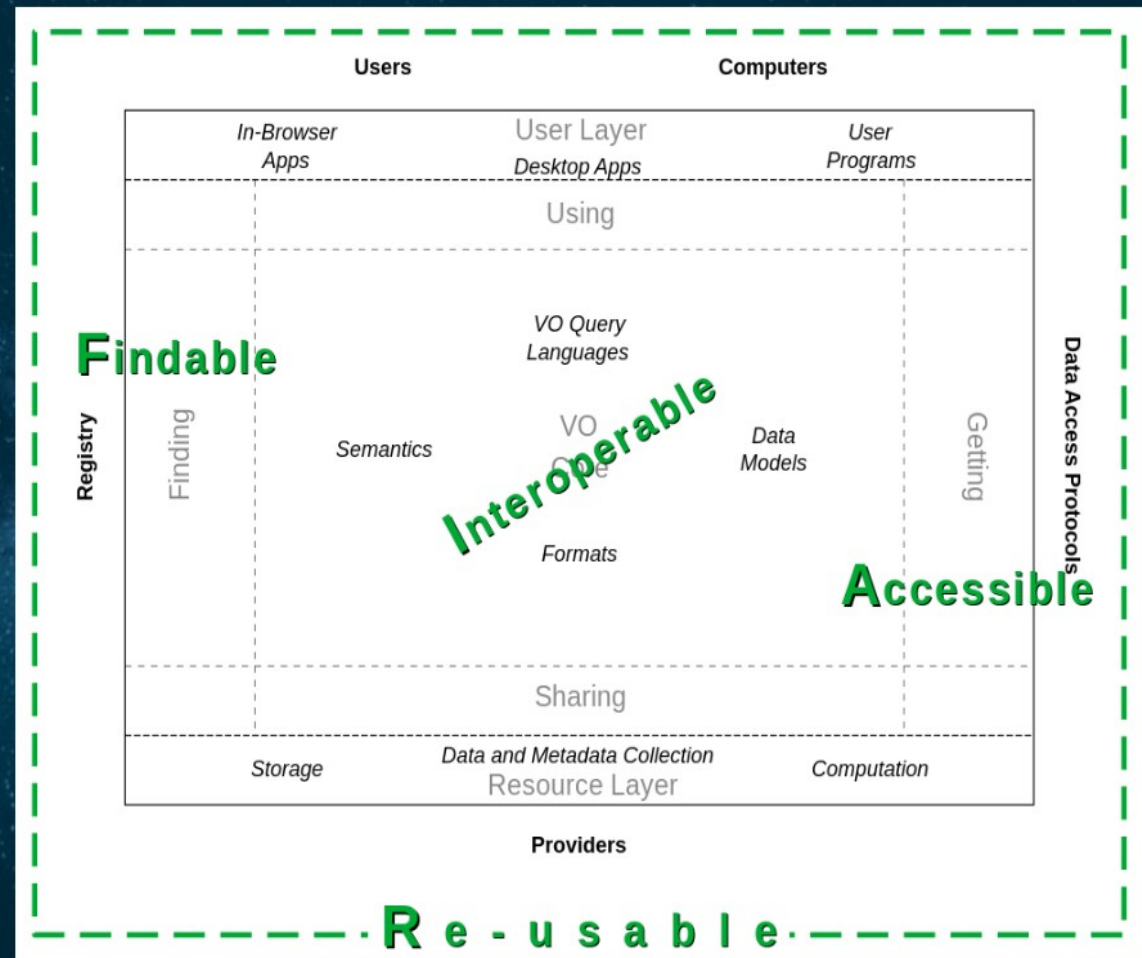
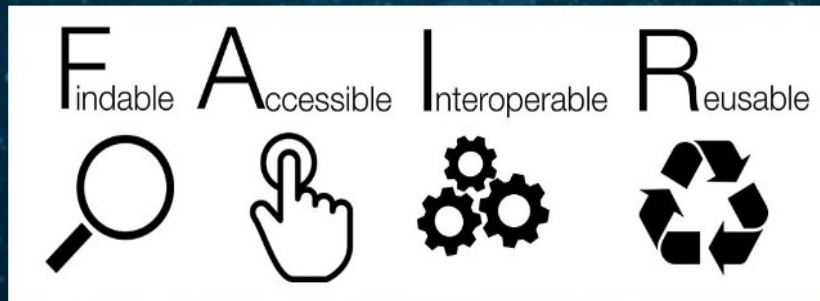
Open Science – EOSC

EURO-VO DCA, ICE, CoSADIE, ASTERICS, ESCAPE - Astroparticles

IVOA Architecture – FAIR data management



VO has been FAIR from the beginning!



TOPCAT

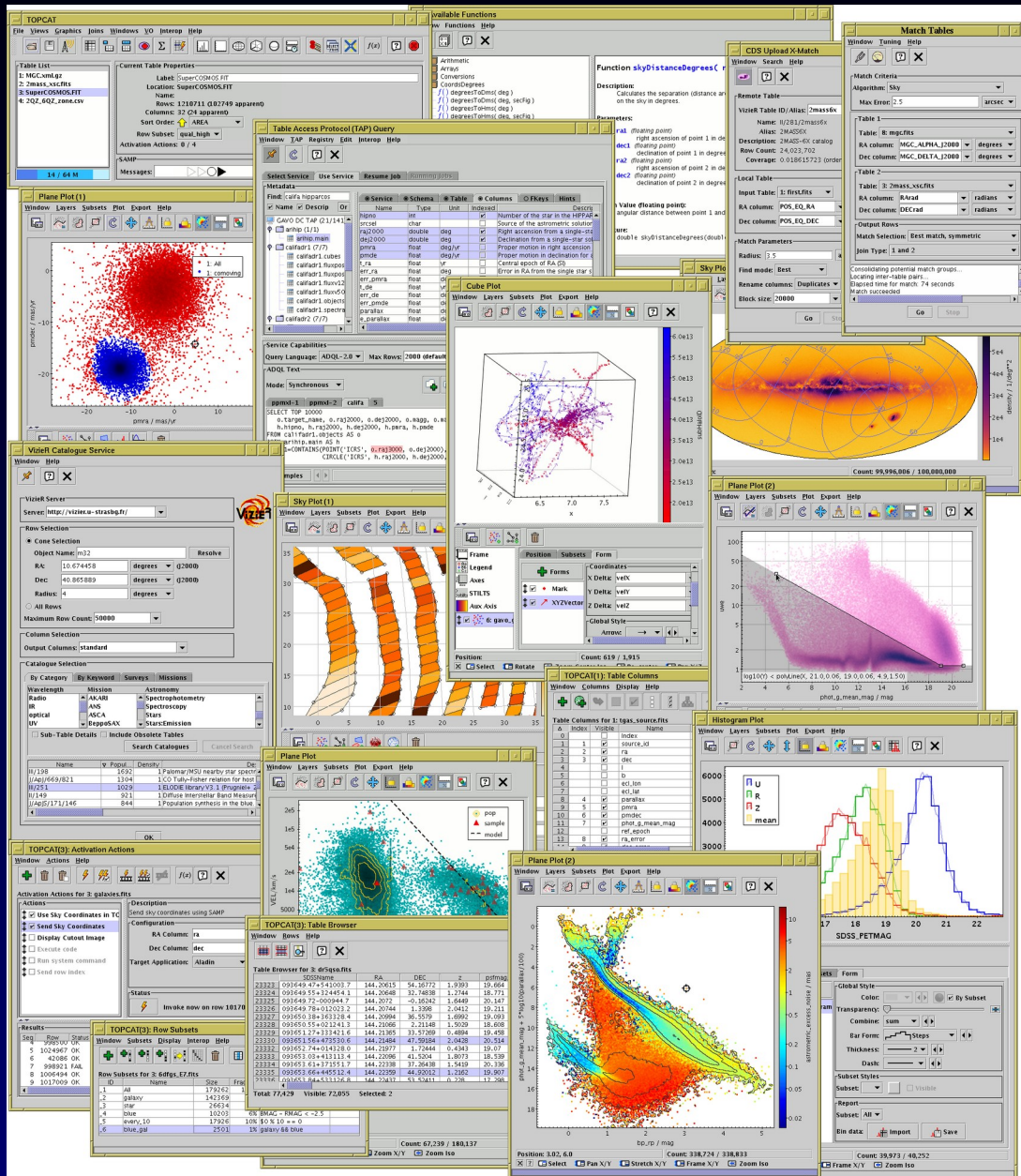


Table Access Protocol (TAP) Query

Window TAP Registry Edit Interop Help

Select Service Use Service Resume Job Running Jobs

Metadata

Find:

☒ Name ☐ Descrip Or ☐ Columns ☐ FKeys ☐ Hints

Service	Schema	Table
gaiadr1 (8)		
gaiadr1.aux_qso_icrf2_r		
gaiadr1.cephheid		
gaiadr1.gaia_source		
gaiadr1.phot_variable_t		
gaiadr1.phot_variable_t		
gaiadr1.rhyrae		
gaiadr1.tgas_source		
gaiadr1.variable_summa		

Service Capabilities

Query Language: ADQL-2.0 Max Rows: 100000 (default) Uploads: 1000krow/

ADQL Text

Mode: Synchronous

```

1
SELECT TOP 50000
  gaia.source_id,
  gaia.hip,
  gaia.phot_g_mean_mag*5*log10(gaia.parallax)-10 AS g_mag_abs_gaia,
  gaia.phot_g_mean_mag*5*log10(hip.plx)-10 AS g_mag_abs_hip,
  hip.b_v,
  gaia.parallax, gaia.b, gaia.r
FROM gaiadr1.tgas_source AS gaia
INNER JOIN extcat.hipparcos AS hip ON gaia.hip = hip.hip
  
```

Run Query

Aladin

Aladin v9.6 *** PROTOTYPE VERSION (based on v9.623) ***

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Data access → 24 / 19697 Location 05:43:27.24 -01:54:27.1 Frame ICRS Projection Aitoff

Collections → 24 / 19697
 Data base → 1 / 2
 SIMBAD Astronomical Database
 Catalog → 23 / 17224
 IX-High-Energy data → 1 / 69
 ROSAT All-Sky Bright Source
 IRIX Correlation to
 Journal table → 22 / 15736
 A+A → 11 / 4151
 Field star positions (f
 Cluster positions and
 X-ray sources detect
 X-ray sources detect
 NGC 6192 star posit
 Catalog of objects fo
 Star positions (from
 The cross-identificat
 Simbad position for s
 Sources extracted w
 Additional compact s
 A+AS → 2 / 723
 Source positions (fro
 Summary of stars wi
 AJ → 2 / 2615
 EBs that appear in e
 Cluster positions (fro
 ApJ → 1 / 3206
 Simbad positions for
 ApJS → 4 / 1429
 The CVs and WDs an
 RASS/SIMBAD class
 SIMBAD stars with A
 She positions from S
 MNRAS → 1 / 2549
 Cluster positions (fro
 PASP → 1 / 141

CDSP/DSS2/color

Stack controls:

- the icon: show/hide a plane
- size: change object size
- zoom: adjust field size.
- Opacity: adjust transparency.

The view is drawn according to the projection of a reference plane.

For changing the reference, click on its check box.

select
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 dens.
 opac.
 zoom
 crop
 eont
 pixel
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 del

CDSP/Simbad

☒ CDSP/DSS2/color

epoch -

size -

rgb -

dens. -

opac. -

zoom -

Search

MAIN_ID	OTYPE	RA	DEC	C00	C00	C...	PMR
NAME Flame Nebula	MoICld	05 41 42.7	-01 54 44				
* zet Ori A	**	05 40 45.527	-01 56 33.26	1	1	90	4
NGC 2023	RINeb	05 41 37.9	-02 15 52	3200...	7000...	51	
* zet Ori	**	05 40 45.52...	-01 56 33.2...	5.189	2.289	90	3
HD 37903	Ew*	05 41 38.38...	-02 15 32.4...	7.651	3.437	90	-1
* zet Ori B	Star	05 40 45.571	-01 56 35.59	8	5	90	4
HD 38087	**	05 43 00.57...	-02 18 45.3...	11.084	5.986	90	
[MCKP81] NGC 2024 FIR 5	dens	05 41 44.6	-01 55 38				

filter
 coll
 inside
 zoom

OSPS Image coverage (footprints)

The screenshot displays the Aladin software interface, which is used for visualizing astronomical data. The main window shows a deep-field image of a galaxy cluster with numerous red rectangular footprints overlaid, representing the coverage of the OSPS (Ondrejov Sky Project Survey) survey. The footprints are concentrated in a central region, with some scattered elsewhere.

Left Panel: Target and Filter Settings

Target (ICRS, name): 05 15 53 -69 25 57
Radius: 10 deg
Filter: R - Filter R
Format: image/png
Obs min date:
Obs max date:
Grab

Left Panel: Catalog servers

All
VizieR
Surveys
Missions
Simbad
NED
MOC
SkyBot
Others..

Left Panel: Image servers

Aladin images
SkyView
UKIDSS
Sloan
DSS...
DK154
VLA...
Archives...
Others...

Table of OSPS Observations

OSPS	2013-02-25T04:55:50.713	R	HV2274	14.2"	x 13.6"
OSPS	2013-02-25T03:23:04.800	R <th>HV982</th> <th>14.2"</th> <th>x 13.6"</th>	HV982	14.2"	x 13.6"
OSPS	2015-01-05T01:09:44.372	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T01:58:30.900	R <th>LMC01</th> <th>14.2"</th> <th>x 13.6"</th>	LMC01	14.2"	x 13.6"
OSPS	2015-01-05T08:16:30.688	R <th>LMC52</th> <th>14.2"</th> <th>x 13.6"</th>	LMC52	14.2"	x 13.6"
OSPS	2015-01-05T06:46:14.164	R <th>LMC01</th> <th>14.2"</th> <th>x 13.6"</th>	LMC01	14.2"	x 13.6"
OSPS	2015-01-05T04:26:44.012	R <th>LMC33</th> <th>14.2"</th> <th>x 13.6"</th>	LMC33	14.2"	x 13.6"
OSPS	2015-01-05T08:50:50.510	R <th>LMC52</th> <th>14.2"</th> <th>x 13.6"</th>	LMC52	14.2"	x 13.6"
OSPS	2015-01-05T02:37:13.832	R <th>LMC01</th> <th>14.2"</th> <th>x 13.6"</th>	LMC01	14.2"	x 13.6"
OSPS	2015-01-05T00:47:50.584	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T00:49:50.776	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T05:37:36.244	R <th>LMC33</th> <th>14.2"</th> <th>x 13.6"</th>	LMC33	14.2"	x 13.6"
OSPS	2015-01-05T07:31:12.104	R <th>LMC52</th> <th>14.2"</th> <th>x 13.6"</th>	LMC52	14.2"	x 13.6"
OSPS	2015-01-05T03:32:56.160	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T05:31:36.388	R <th>LMC01</th> <th>14.2"</th> <th>x 13.6"</th>	LMC01	14.2"	x 13.6"
OSPS	2015-01-05T04:52:58.112	R <th>LMC52</th> <th>14.2"</th> <th>x 13.6"</th>	LMC52	14.2"	x 13.6"
OSPS	2015-01-05T04:59:18.207	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T07:55:26.440	R <th>LMC33</th> <th>14.2"</th> <th>x 13.6"</th>	LMC33	14.2"	x 13.6"
OSPS	2015-01-05T05:01:19.872	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T01:56:30.956	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T03:42:57.456	R <th>LMC33</th> <th>14.2"</th> <th>x 13.6"</th>	LMC33	14.2"	x 13.6"
OSPS	2015-01-05T06:16:03.988	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T06:14:03.732	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T06:10:03.804	R <th>LMC52</th> <th>14.2"</th> <th>x 13.6"</th>	LMC52	14.2"	x 13.6"
OSPS	2015-01-05T04:20:44.316	R <th>LMC01</th> <th>14.2"</th> <th>x 13.6"</th>	LMC01	14.2"	x 13.6"
OSPS	2015-01-05T03:20:55.868	R <th>LMC01</th> <th>14.2"</th> <th>x 13.6"</th>	LMC01	14.2"	x 13.6"
OSPS	2015-01-05T02:51:37.240	R <th>LMC33</th> <th>14.2"</th> <th>x 13.6"</th>	LMC33	14.2"	x 13.6"
OSPS	2015-01-05T02:33:15.952	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T02:41:13.124	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T08:44:45.780	R <th>LMC33</th> <th>14.2"</th> <th>x 13.6"</th>	LMC33	14.2"	x 13.6"
OSPS	2015-01-05T08:54:55.836	R <th>LMC52</th> <th>14.2"</th> <th>x 13.6"</th>	LMC52	14.2"	x 13.6"
OSPS	2015-01-05T00:43:50.628	R <th>LMC03</th> <th>14.2"</th> <th>x 13.6"</th>	LMC03	14.2"	x 13.6"
OSPS	2015-01-05T02:45:36.976	R <th>LMC01</th> <th>14.2"</th> <th>x 13.6"</th>	LMC01	14.2"	x 13.6"
OSPS	2015-01-05T07:14:51.916	R <th>LMC52</th> <th>14.2"</th> <th>x 13.6"</th>	LMC52	14.2"	x 13.6"
OSPS	2015-01-05T06:00:06.644	R <th>LMC33</th> <th>14.2"</th> <th>x 13.6"</th>	LMC33	14.2"	x 13.6"
OSPS	2015-01-05T02:02:31.648	R <th>LMC01</th> <th>14.2"</th> <th>x 13.6"</th>	LMC01	14.2"	x 13.6"
OSPS	2015-01-05T04:30:43.492	R <th>LMC33</th> <th>14.2"</th> <th>x 13.6"</th>	LMC33	14.2"	x 13.6"
OSPS	2015-01-05T08:05:31.448	R <th>LMC52</th> <th>14.2"</th> <th>x 13.6"</th>	LMC52	14.2"	x 13.6"
OSPS	2015-01-05T06:06:05.956	R <th>LMC52</th> <th>14.2"</th> <th>x 13.6"</th>	LMC52	14.2"	x 13.6"

Right Panel: Stack controls

select
pan
zoom
dist
phot
draw
tag
filter
rgb
crop
cont
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prop
del

Stack controls:
the icon: show/hide a plane
size: change object size
zoom: adjust field size.
Opacity: adjust transparency.
The view is drawn according to the projection of a reference plane.
For changing the reference, click on its check box.

Bottom Right: R. OSPS 2015-01-05T08:05:31.448 R LMC52 14.2" x 13.6"

epoch:
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opac:
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Frame: ICRS
+180
+90
-90
-180
05:13:33.99 -69:22:41.7
4.882" x 4.644"

Bottom: Search

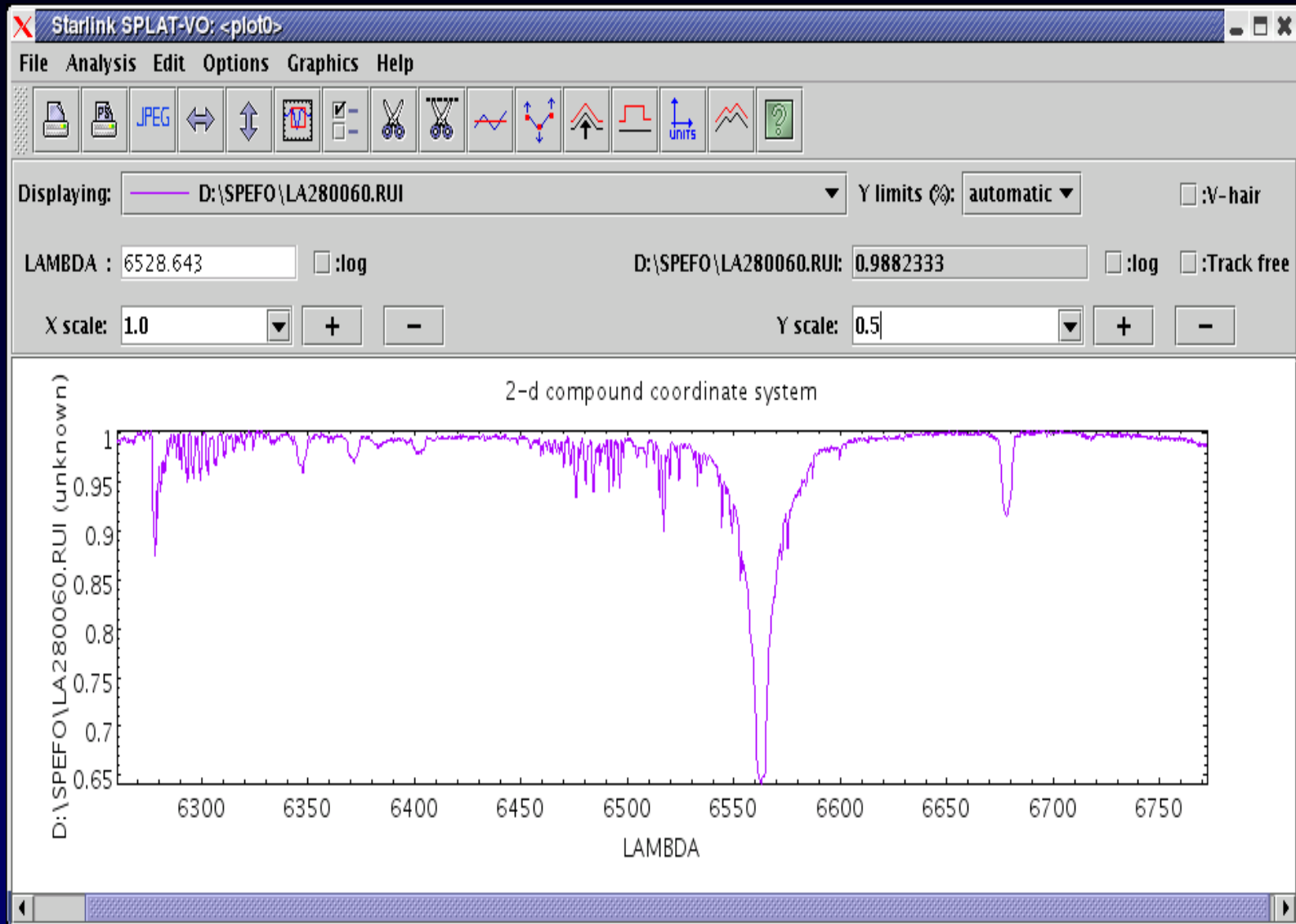
Search:
grid wink north hdr multiview match

Footer:

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0 sel / 0 src 67fps / 184Mb

SPLAT-VO

(Starlink, Heidelberg, Ondrejov)



Spectra in SPLAT-VO - query

Starlink SPLAT-VO: Query VO for Spectra

File Options Resolver Interop Help

Service selection options
Data Source
☒ Observed data ☐ Theoretical data

Wave Band
☐ Radio ☐ Millimeter ☐ Infrared
☐ Optical ☐ UV ☐ EUV
☐ X-ray ☐ Gamma-ray ☒ ALL

Tags
+ -

Search parameters:
Simple Query
Object: psi per Lookup Clear
RA: 03:36:29.38 Dec: +48:11:33.48
Radius: 10.0 MAXREC:
Band: 6530e-10 / 6580e-10
Time:
Query Format: votable
Wavelength calibration: None
Flux calibration: None

Optional Parameters
Use Name Value UCD
☐ REDSHIFT src.redshift
☐ TARGETCLASS src.class
☐ MTIME
☐ SPECPR spect.resolution;em.wl
☐ SPATRES pos.angResolution
☐ PUDDID
☐ CREATORDID meta.id
Select all Deselect all Update

SSAP Servers
short name title
BeSS Be Stars Spectra
califa ssa CALIFA DR2
castor Espadons/Narval leg...
castor+ Espadons/NARVAL le...
ccd700-voarchive ccd700 OND
ccd700-vos2
CDFSS SSAP Optical Spectroscop...
CENCOS-VVDS_DEEP CENCOS-VVDS_DEEP...
CENCOS-VVDS_DEEP+ CENCOS-VVDS_DEEP...
Cfa Hectospec Cfa Hectospec Spec...
dk154
dk154-extr15
dk154-extr15jan dk154
dk154-extr16jan dk154
DK154-SSA DK154 SSA
ELODIE ELODIE archive
ELODIEInterp Spectrum interpolat...
ESO SAF SSA ESO Science Archive...
EUVE Extreme Ultraviolet ...
extract_jul16 DK154
F/H Orders SSAP Flash/Heros Split-Or...
FEROS SSAP FEROS Public Spectra
Flash/Heros SSAP Flash/Heros SSAP
FUSE Far Ultraviolet Spect...
GALEX Galaxy Evolution Exp...
GIRAFFE GIRAFFE archive of r...
H.E.S.S. High Energy Stereos...
HEAVENS @ ISDC Mining the HEAVENS...
HEROS OND HEROS archive of On...
HEROS OND CUTOUT cutout server of HE...

Query: <SERVER>?REQUEST=queryData&POS=54.122416666666666,48.192633333333333&FORMAT=votable&SIZE=0.166666666666666&BAND=6530e-10/6580e-10

Query results:
CCD700-voarchive

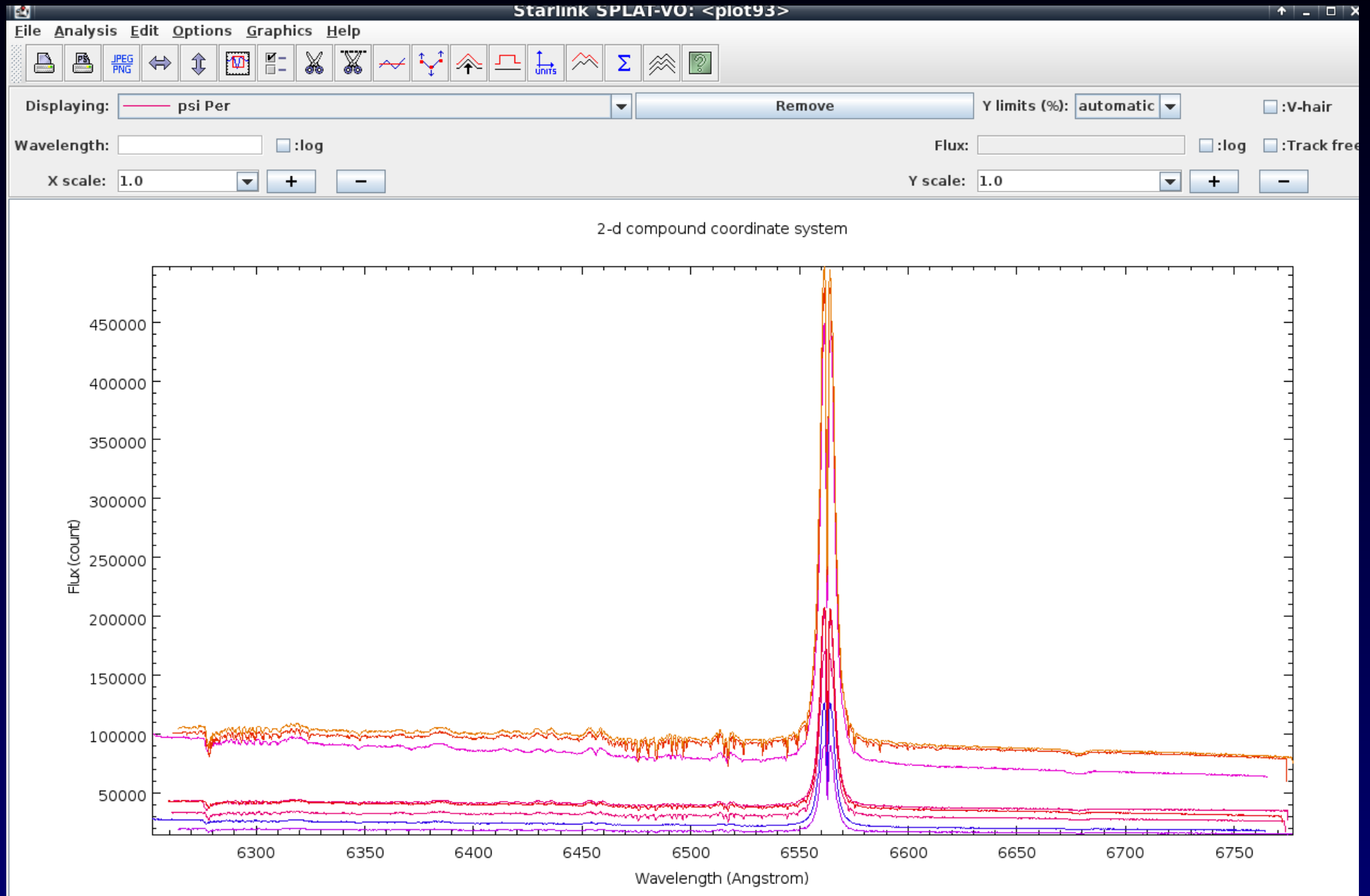
l...	ssa_specstart	ssa_specend	ssa_dstitle	ssa_targname	ssa_dateObs	ssa_timeExt	ssa_snr	ssa_length	accref	
12	6.26183E-7	6.77426E-7	ccd700/data/psiper/6255-676...	Psi Per	53216.0049	1800.		1997	http://voarchive.asu.cas.cz/ge...	appli
27	6.24978E-7	6.76217E-7	ccd700/data/psiper/6255-676...	psi Per	54701.97209	1333.19		1997	http://voarchive.asu.cas.cz/ge...	appli
13	6.25854E-7	6.77081E-7	ccd700/data/psiper/6255-676...	psi Per	52982.77964	1300.		1997	http://voarchive.asu.cas.cz/ge...	appli
31	6.26359E-7	6.73614E-7	ccd700/data/psiper/6260-673...	psi Per	56884.01015	1201.		2047	http://voarchive.asu.cas.cz/ge...	appli
30	6.26359E-7	6.73614E-7	ccd700/data/psiper/6260-673...	psi Per	56884.02565	901.		2047	http://voarchive.asu.cas.cz/ge...	appli
2	6.26234E-7	6.77466E-7	ccd700/data/psiper/6255-676...	psi Per	53451.88616	899.564		1997	http://voarchive.asu.cas.cz/ge...	appli
28	6.26587E-7	6.77822E-7	ccd700/data/psiper/6255-676...	psi Per	54209.80019	899.214		1997	http://voarchive.asu.cas.cz/ge...	appli
3	6.25267E-7	6.76496E-7	ccd700/data/psiper/6255-676...	Psi Per	55902.84843	800.		1997	http://voarchive.asu.cas.cz/ge...	appli
10	6.25163E-7	6.76402E-7	ccd700/data/psiper/6255-676...	psi Per	54757.88729	730.		1997	http://voarchive.asu.cas.cz/ge...	appli
6	6.26183E-7	6.77426E-7	ccd700/data/psiper/6255-676...	Psi Per	53216.02811	600.		1997	http://voarchive.asu.cas.cz/ge...	appli
14	6.24978E-7	6.76217E-7	ccd700/data/psiper/6255-676...	psi Per	54701.96266	600.		1997	http://voarchive.asu.cas.cz/ge...	appli
9	6.25809E-7	6.77051E-7	ccd700/data/psiper/6255-676...	psi Per	52897.07116	556.599		1997	http://voarchive.asu.cas.cz/ge...	appli
18	6.26587E-7	6.77822E-7	ccd700/data/psiper/6255-676...	psi Per	54209.81274	450.		1997	http://voarchive.asu.cas.cz/ge...	appli
20	6.25854E-7	6.77081E-7	ccd700/data/psiper/6255-676...	psi Per	52982.79788	350.		1997	http://voarchive.asu.cas.cz/ge...	appli
16	6.26235E-7	6.77492E-7	ccd700/data/psiper/6255-676...	psi Per	53475.85182	300.043		1997	http://voarchive.asu.cas.cz/ge...	appli
19	6.26401E-7	6.77677E-7	ccd700/data/psiper/6255-676...	psi Per	53249.01697	300.		1997	http://voarchive.asu.cas.cz/ge...	appli
23	6.25161E-7	6.76378E-7	ccd700/data/psiper/6255-676...	psi Per	54519.80405	300.		1997	http://voarchive.asu.cas.cz/ge...	appli
24	6.25161E-7	6.76378E-7	ccd700/data/psiper/6255-676...	psi Per	54519.7984	300.		1997	http://voarchive.asu.cas.cz/ge...	appli
7	6.26434E-7	6.77677E-7	ccd700/data/psiper/6255-676...	psi Per	53228.0436	218.373		1997	http://voarchive.asu.cas.cz/ge...	appli
11	6.25641E-7	6.76875E-7	ccd700/data/psiper/6255-676...	psi Per	55443.86444	200.		1997	http://voarchive.asu.cas.cz/ge...	appli
22	6.25161E-7	6.76378E-7	ccd700/data/psiper/6255-676...	psi Per	54519.81162	200.		1997	http://voarchive.asu.cas.cz/ge...	appli
25	6.25908E-7	6.77147E-7	ccd700/data/psiper/6255-676...	psi Per	52901.91749	194.574		1997	http://voarchive.asu.cas.cz/ge...	appli
15	6.25937E-7	6.77178E-7	ccd700/data/psiper/6255-676...	psi Per	52904.03609	180.		1997	http://voarchive.asu.cas.cz/ge...	appli
1	6.26100E-7	6.77340E-7	ccd700/data/psiper/6255-676...	psi Per	55396.07196	150.		1997	http://voarchive.asu.cas.cz/ge...	appli
6	6.25908E-7	6.77147E-7	ccd700/data/psiper/6255-676...	psi Per	55956.73346	120.		1997	http://voarchive.asu.cas.cz/ge...	appli

Display selected Display all Download selected Download all Deselect table Deselect all DataLink Services

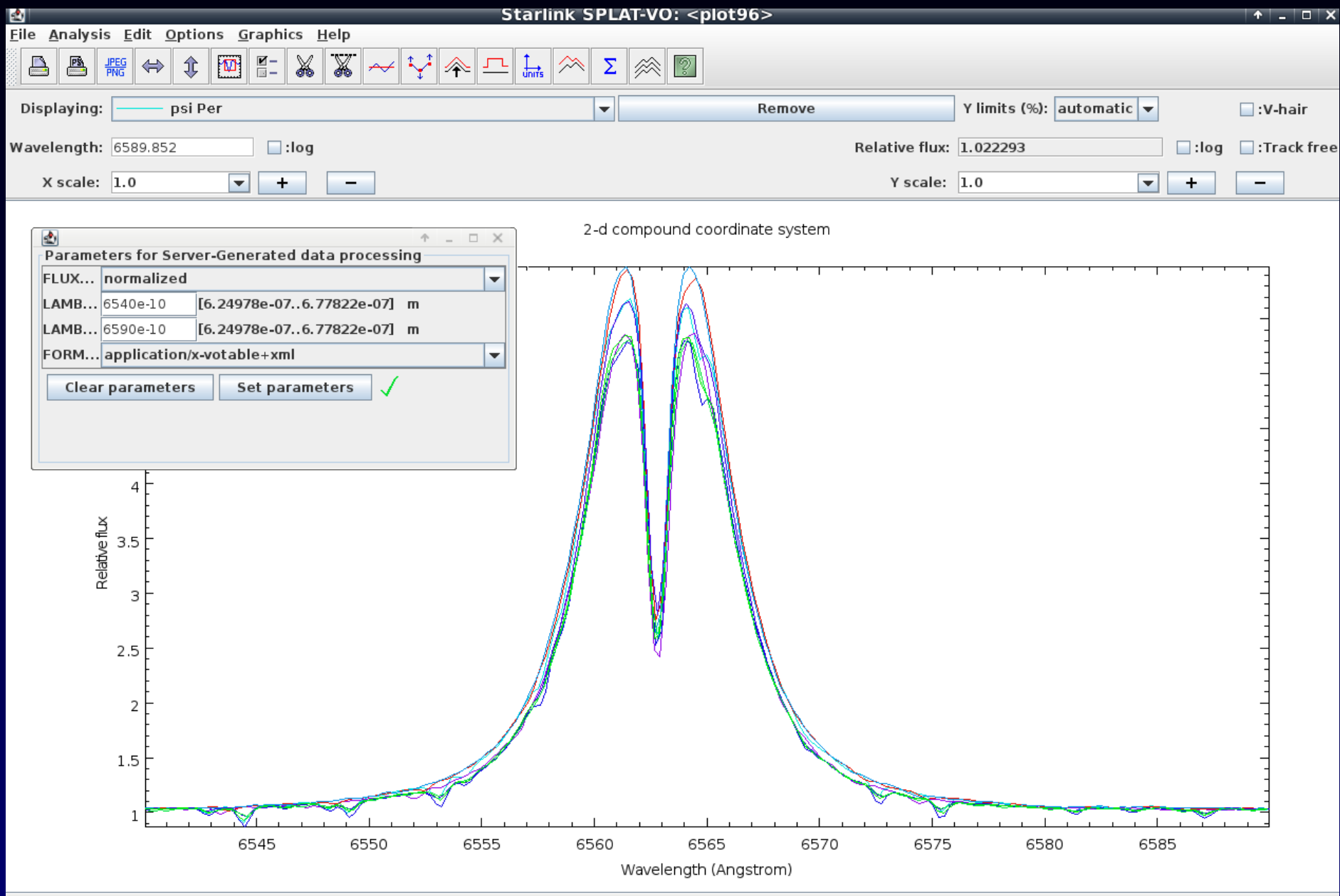
Select all Deselect all Query registry Add New Server

Save query results Restore query results Close

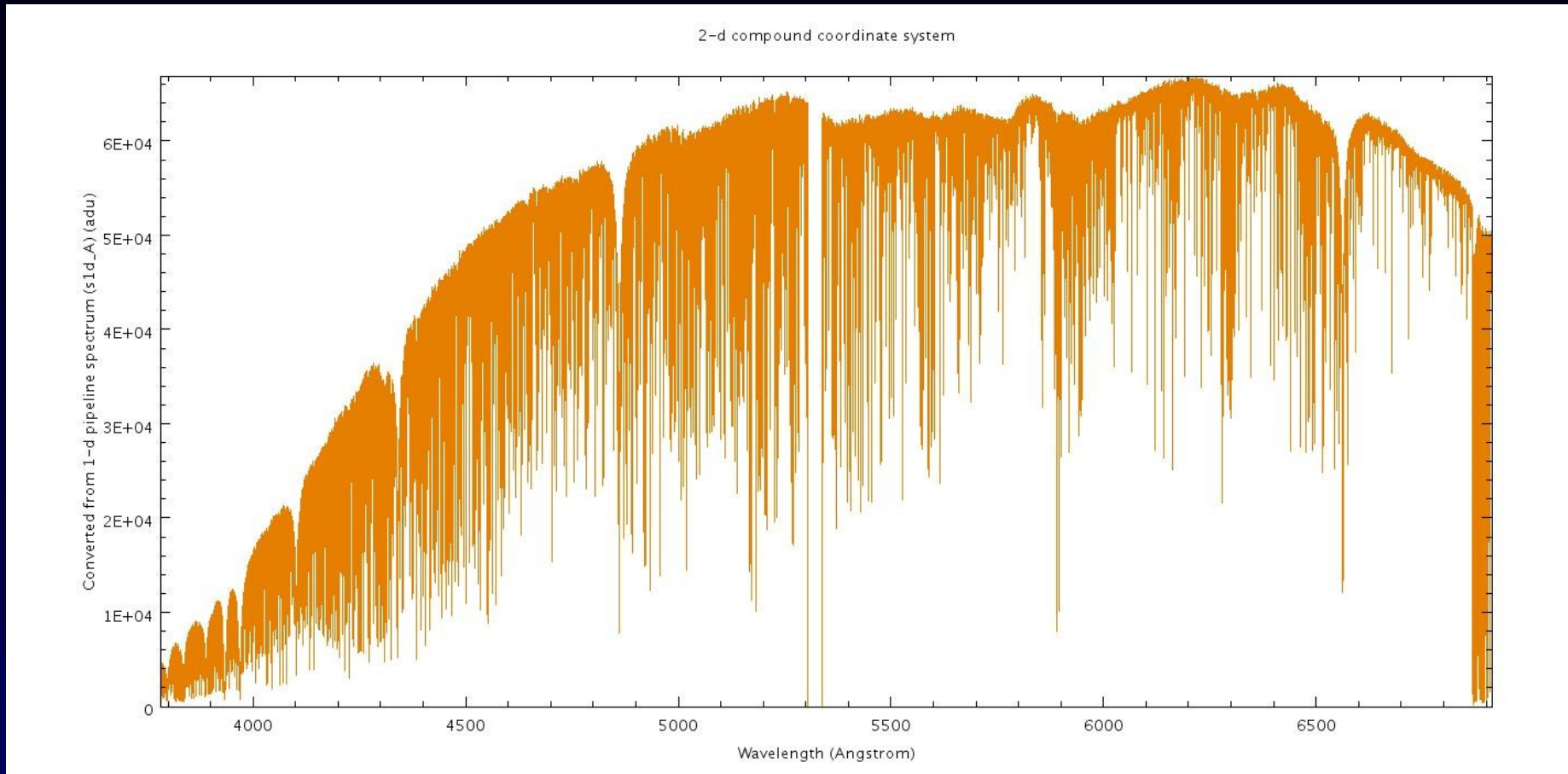
Spectra in SPLAT-VO direct access



Spectra in SPLAT-VO - DataLink



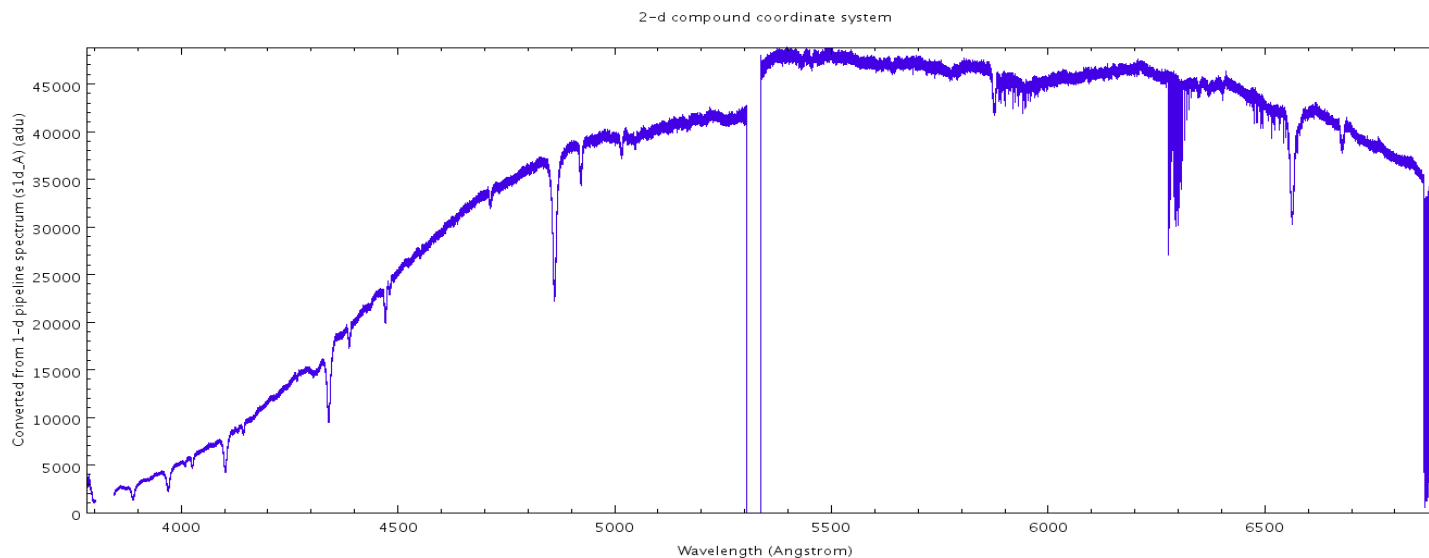
HARPS-S in SPLAT



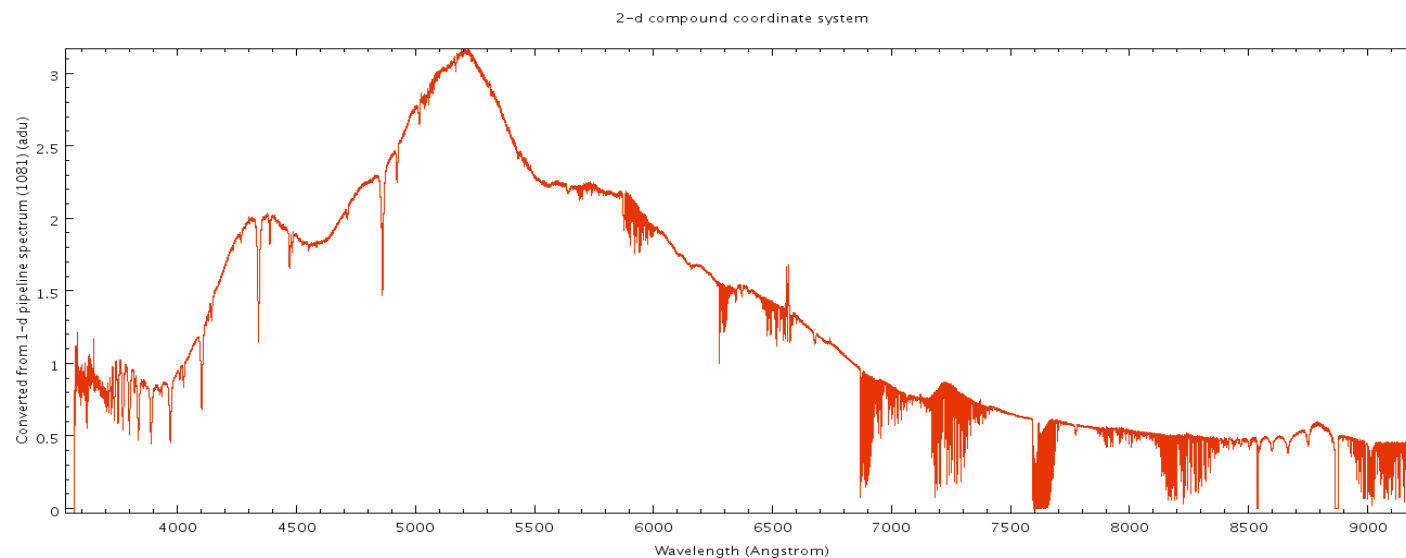
313138 points

Procyon

1D Merges in SPLAT-VO

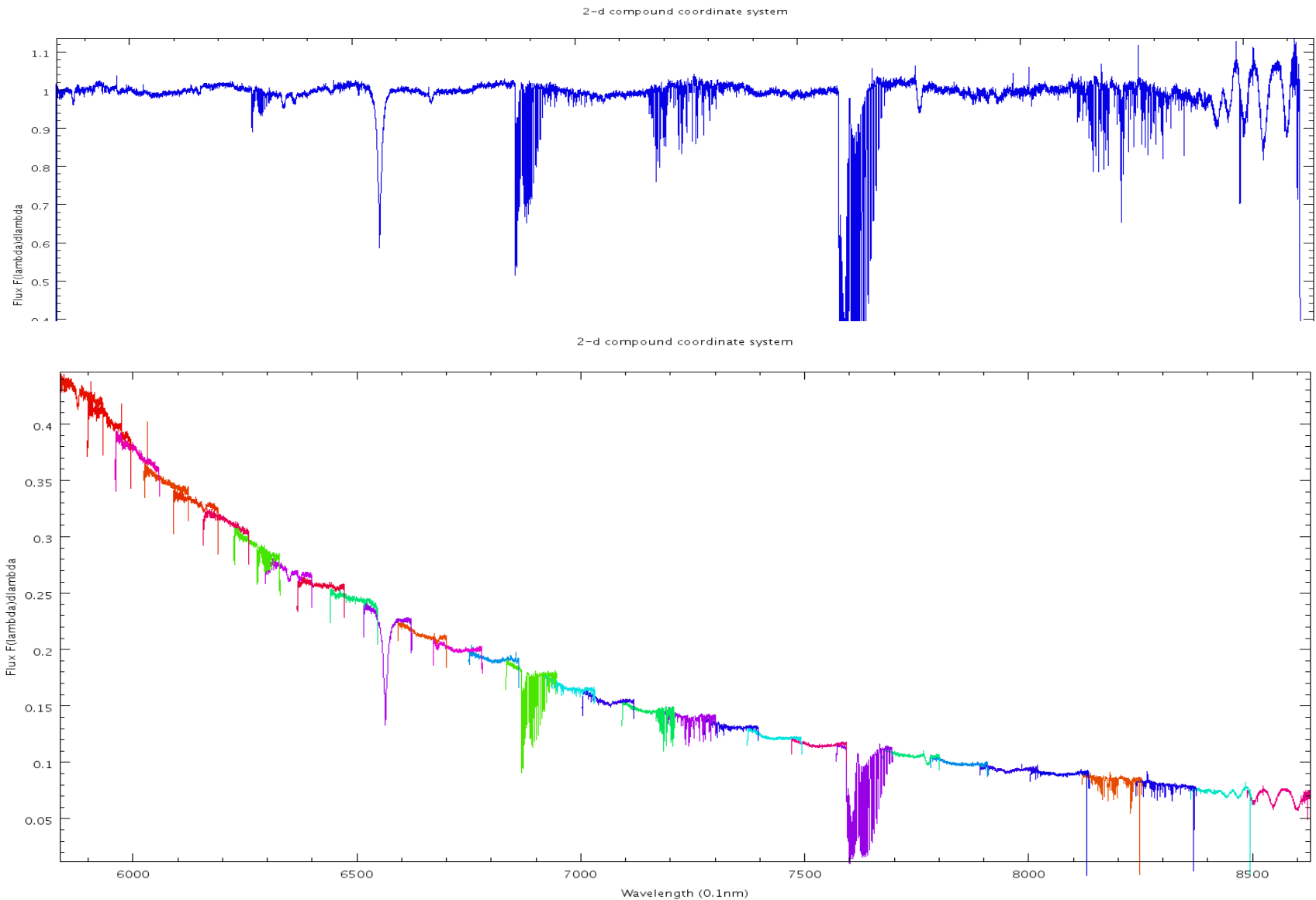


HARPS
unblazed



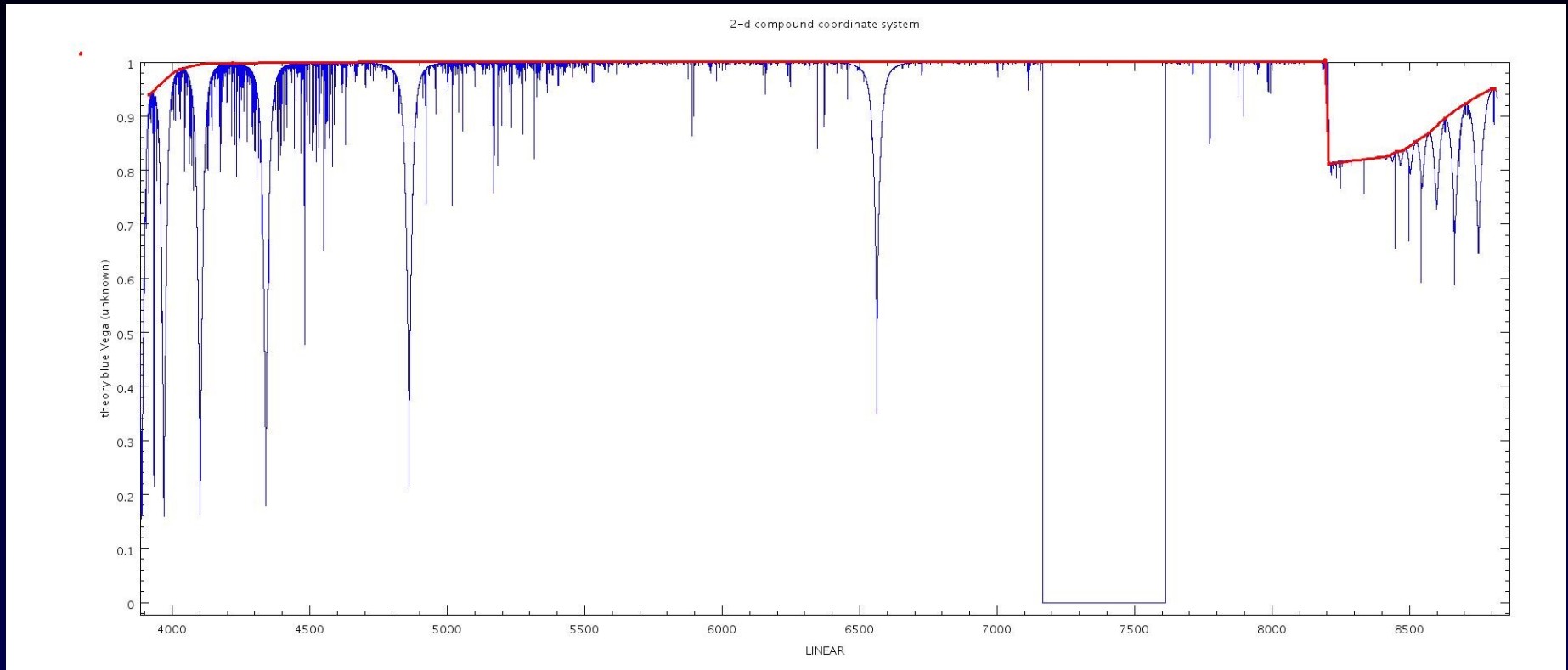
FEROS
pseudonormalized

DaCHS Testbed Split-Order SSAP



nu Pup HEROS red

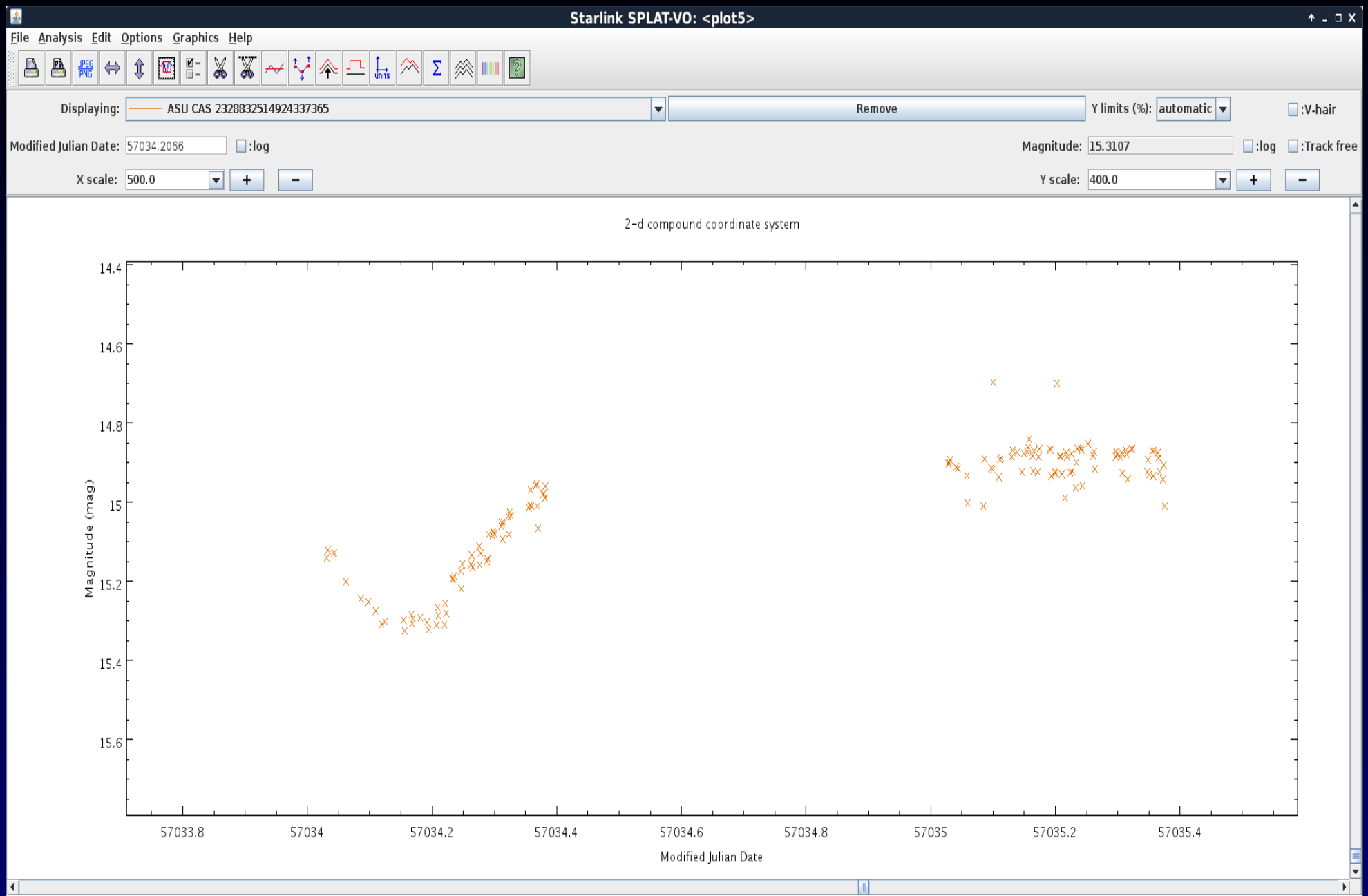
Continuum Normalisation



Theoretical spectrum of Vega

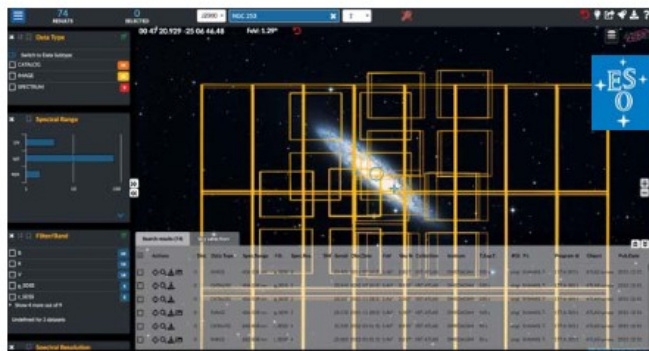
The continuum is NOT ALWAYS at 1.0 !

Light Curve in SPLAT-VO (zoom)

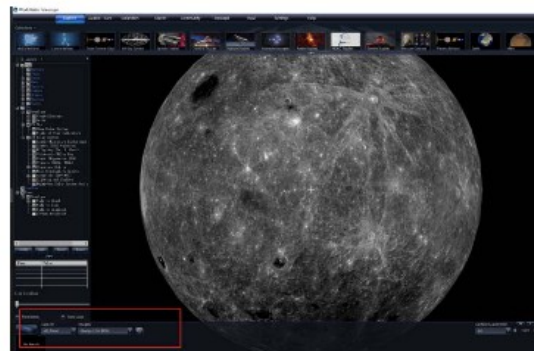


VO Science Portals

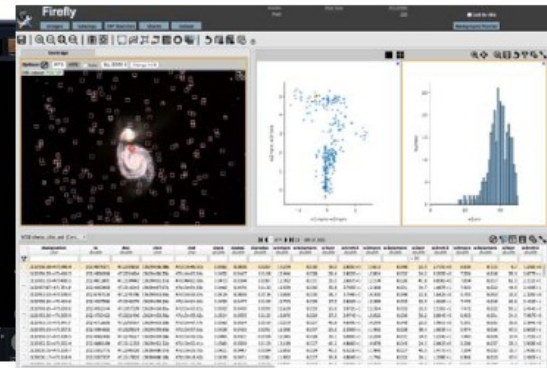
VO embedded in astronomy services



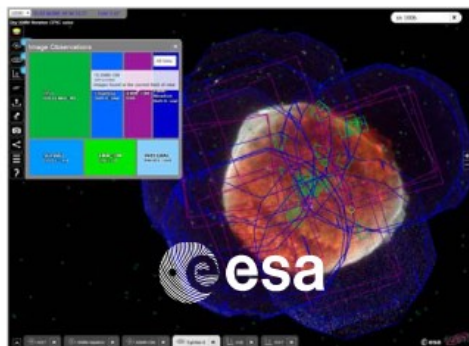
ESO Science Portal



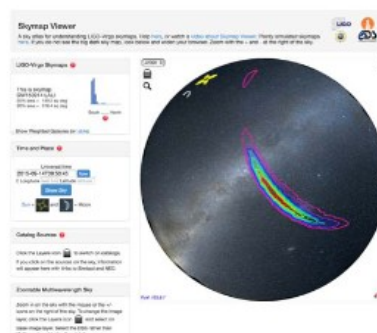
WWT



Firefly
Caltech-IPAC



ESA Sky



Grav.waves



CDS reference data service

SVO Filter Profile service



Galaxy Science Cloud Workshop, Nov. 3-4, 2020

VO Science Portals

Stellarium + VirGo (ESO, unsupported)

ESASky

<https://sky.esa.int/>

ESO Archive Science Portal

<https://archive.eso.org/scienceportal/home>

IRSA IPAC archive (Firefly)

<http://worldwidetelescope.org/webclient/>

WWT (original MS, now AAS, web client)

<http://worldwidetelescope.org/webclient>

GoogleSky

<https://www.google.com/sky/>

Science Portals using VO standards

- CDS (Vizier, Simbad), NASA (MAST)
- SKAO (SKA)
- DataCentral Science Platform (Australia)
- CfA Nexus (Harvard)
- Rubin Science Platform (LSST)
- CTA
- Astro-COLIBRI (real time alerts GW, Neutrinos, Gamma, Xray),
LIGO VIRGO..
- CAESAR Space weather
- NEORocks
- Theory:
 - Simulations ILUSTRIS ...
 - Spectra (Kurucz, TLUSTY...)
 - SED builders ,fitters – IRIS, VOSA

EUROPLANET VESPA (EPN-TAP)

Aladin v10.0 *** BETA VERSION (based on v10.041) ***

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Command: 16:12:32.01 -50:02:48.5

Frame: ICRS Projection: Spheric

Available data:

- ↳ idc...idc... → 2
- ↳ lap → 1
- ↳ irsa.ipac → 1
- ↳ jacobsoni → 4
- ↳ CRISM
- ↳ Mars_craters
- ↳ epn1 TAP service
- ↳ USGS_WMS
- ↳ jvo → 13
- ↳ latmos.ipd → 3
- ↳ lmd.jussieu → 3
- ↳ madrigal.haystack.mit.edu → 1
- ↳ mssl.ud.ac.uk → 30
- ↳ nasa.heasarc → 31
- ↳ nd.org.au → 3
- ↳ oca → 1
- ↳ org.gavo.dc → 31
- ↳ purx → 2
- ↳ spectrum.iaa → 3
- ↳ swinburne → 1
- ↳ tohoku.univ.jp → 12
- ↳ uni-heidelberg.de → 1
- ↳ vo-plasma.oaw.ac.at → 1
- ↳ vopdc.obspm → 14
- ↳ voxastro.org → 2
- ↳ wfau.roe.ac.uk → 2
- ↳ xaovo → 1
- ↳ xcatdb → 2
- ↳ Problematic → 1
- ↳ Planet → 11
- ↳ Earth → 1
- ↳ Blue Marble next generation
- ↳ Mars → 5
- ↳ Mars MGS MOLA Elevation Model -463m (M)
- ↳ Mars MOLA Shaded Relief / Coloured E
- ↳ Mars THEMIS Day IR Global Mosaic 100
- ↳ Mars Viking-MDIM21-color
- ↳ Panorama → 1
- ↳ Mars Stinson panorama
- ↳ Venus → 5
- ↳ Venus Magellan C3-MDIR-2025m
- ↳ Venus Magellan C3-MDIR-CkTopo-6600m
- ↳ Venus Magellan MeterScaleSlope-4641m
- ↳ Venus Magellan Microwave-Emissivity-464
- ↳ Venus Magellan Topography-4641m

Command: 16:12:32.01 -50:02:48.5

Frame: ICRS Projection: Spheric

25-000004 - Click on it to get details

granule...	granule...	obs_id	dataprod...	target_n...	target_c...	time_min	time_max	time_sap	time...
25-000004	25	000004	c1	Mars	planet				
25-000007	25	000007	c1	Mars	planet				
25-000010	25	000010	c1	Mars	planet				
25-000012	25	000012	c1	Mars	planet				
25-000028	25	000028	c1	Mars	planet				
25-000031	25	000031	c1	Mars	planet				
25-000034	25	000034	c1	Mars	planet				
25-000039	25	000039	c1	Mars	planet				

select

from -- all collections --

coll. view scan filter

17 sep / 2001 str 437Mb

EUROPLANET VESPA (EPN-TAP)

Aladin v10.0 *** BETA VERSION (based on v10.075) ***

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Command $4^{\circ}23'42.46''$ S, $137^{\circ}8'54.65''$ E Frame Planet Projection Spheric

DSS PanSTARRS SDSS 2MASS GALEX Gaia Simbad NED +

Mars THEMIS-Day-100m

Mars Pan-Stimson

15° 1.039° x 28.95° 5° 25.6° x 9.643°

[View A1] - CDS/P/Mars/THEMIS-Day-100m

(c) 2018 Université de Strasbourg/CNRS - developed by CDS, distributed under GPLv3

0 sel / 0 src 106fps / 1513Mb

The screenshot shows the Aladin v10.0 software interface. At the top, the title bar reads 'Aladin v10.0 *** BETA VERSION (based on v10.075) ***'. Below it is a menu bar with 'File', 'Edit', 'Image', 'Catalog', 'Overlay', 'Coverage', 'Tool', 'View', 'Interop', and 'Help'. A command line shows the coordinates '4°23'42.46" S, 137°8'54.65" E'. Below the command line is a toolbar with icons for 'DSS', 'PanSTARRS', 'SDSS', '2MASS', 'GALEX', 'Gaia', 'Simbad', and 'NED'. The main window is divided into two panels. The top panel, titled 'Mars THEMIS-Day-100m', shows a grayscale image of Mars with a 15-degree scale bar and a 1.039 x 28.95 degree field of view. The bottom panel, titled 'Mars Pan-Stimson', shows a color image of Mars with a 5-degree scale bar and a 25.6 x 9.643 degree field of view. On the right side, there is a vertical toolbar with icons for 'select', 'pan', 'dist', 'phot', 'draw', 'tag', 'moc', 'spect', 'filter', 'cross', 'xy', 'rgb', 'epoch', 'size', 'dens.', 'opac.', 'crop', 'cont', 'pixel', 'prop', and 'del'. Below the toolbar is a 'Drawing' section with a list of layers: 'CDS/P/Mars/Pan-Stimson', 'MarsSL_TraverseMap_Sol1809', 'peace', 'msl_hirise_gale1-de-vrr-%C3%', and 'CDS/P/Mars/THEMIS-Day-100'. The bottom right corner shows a coordinate system diagram with axes labeled +90, -90, +180, and -180, and a timestamp '09:08:34.42 -04:19:24.2' and a field of view '1.039° x 28.95°'.

VO in IAU



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Division B WG Virtual Observatory — Functional

Description

This functional Working Group is intended to provide the liaison between the International Virtual Observatory Alliance (IVOA) and the International Astronomical Union (IAU). The IVOA is an organization, composed of 22 international member initiatives, that develops and maintains the technical standards needed to find, access, interoperate and re-use astronomy data (according to the FAIR principles), thus realizing the Virtual Observatory (VO). IVOA also acts as a framework for discussing and sharing VO ideas and technology, for engaging astronomy projects, missions and researchers, and as a body for promoting and publicizing the VO. The IVOA processes for the development of interoperability standards includes the possibility for IAU endorsement. Since its beginnings in 2002 the VO is now a mature framework for the interoperability of astronomy data, with IVOA compliant services operated by astronomy data centers worldwide. This functional working group will provide a communication channel between the IVOA and the IAU on topics of FAIR-compliant standards, use of the VO for scientific research, and for promoting best practices for interoperability of data and services in Astronomy.

Links:

- [WG Annual Report \(2022\) - Virtual Observatory](#)

Search [www.iau.org](#)

Search Scientific Bodies

Search...

Search

Follow the IAU on social media



Tutorials of VO

https://hendhd.github.io/ivoa_newcomers/

<https://www.canfar.net/storage/list/pdowler/ivoa/virtual2021a> (video)

IVOA Interoperability meetings (May + November)

Newcomers Intro

Watch the link <https://www.ivoa.net>

Number of VO Schools:

EURO-VO DCA, AIDA, ICE
CoSADIE, ASTERICS, ESCAPE

Technology of VO

Unified data format– VOTable, UCD (Vizier)

Transparent transport (VOunits)

VOregistry (DNS like) Google for data+WS

Protocols

ConeSearch (searching in circle on sky)

SIAP (Simple Image Access Protocol)

SSAP(Simple Spectral Access Protocol)

SLAP(Simple Line Access Protocol) - VAMDC

TAP (Table Access Protocol) – query e.g. whole SDSS

VOEVENT (transients, robotic telescopes, Sun

DATALINK (related data products, e.g. raw, mosaics..)

SODA Server-side Operations for Data Acces

Technology of VO

ADQL (Astronomical Data Query Language)

XMATCH, REGION (2 catalogues – shifted)

Application interoperability – **SAMP**

Allows develop applications as bricks

sending **VOTABLES** (catalogue-spectra-images)

Surveys visualization

HIPS (Hierarchical Progressive Survey) - allsky zoom

MOC (Multi order coverages) time, space, spectral (FoV)

Big Data handling

VO Space Moving big tables across (load only results)

SSO Authentication, authorization, groups and consortia

UWS Universal worker service (job synch, asynch)

PDL Parameter Description Language

SIM-DB Simulations, theory data

Science platforms for BD analysis and ML

(SciServer JHU, NOAO DataLab, CANFAR, Gaia, Jupyterhub, Docker, ASTROpy)

FITS standard

>30 years, separation of metadata (human readable and data)

```
SIMPLE = T / file does conform to FITS standard
BITPIX = 16 / number of bits per data pixel
NAXIS = 2 / number of data axes
NAXIS1 = 2048 / length of data axis 1
NAXIS2 = 2048 / length of data axis 2
EXTEND = T / FITS dataset may contain extensions
COMMENT FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
BZERO = 32768
BSCALE = 1 / REAL=TAPE*BSCALE+BZERO
ORIGIN = 'PESO' / AsU AV CR Ondrejov
OBSERVAT= 'ONDREJOV' / Name of observatory (IRAF style)
LATITUDE= 49.91056 / Telescope latitude (degrees), +49:54:38.0
LONGITUD= 14.78361 / Telescope longitud (degrees), +14:47:01.0
HEIGHT = 528 / Height above sea level [m].
TELESCOP= 'ZEISS-2m' / 2m Ondrejov observatory telescope
GAIN = 2 / Electrons per ADU
READNOIS= 10 / Readout noise in electrons per pix
TELSYST = 'COUDE' / Telescope setup - COUDE or CASSEgrain
INSTRUME= 'OES' / Coude echelle spectrograph
CAMERA = 'VERSARRAY 2048B' / Camera head name
DETECTOR= 'EEV 2048x2048' / Name of the detector
CHIPID = 'EEV 42-40-1-368' / Name of CCD chip
```

VOTable Example

```
<?xml version="1.0"?>
<VOTABLE version="1.3" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="http://www.ivoa.net/xml/VOTable/v1.3"
  xmlns:stc="http://www.ivoa.net/xml/STC/v1.30" >
  <RESOURCE name="myFavouriteGalaxies">
    <TABLE name="results">
      <DESCRIPTION>Velocities and Distance estimations</DESCRIPTION>
      <GROUP utype="stc:CatalogEntryLocation">
        <PARAM name="href" datatype="char" arraysize="*"
          utype="stc:AstroCoordSystem.href" value="ivo://STClib/CoordSys#UTC-ICRS-TOP0"/>
        <PARAM name="URI" datatype="char" arraysize="*"
          utype="stc:DataModel.URI" value="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"/>
        <FIELDref utype="stc:AstroCoords.Position2D.Value2.C1" ref="col1"/>
        <FIELDref utype="stc:AstroCoords.Position2D.Value2.C2" 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"
        datatype="float" width="6" precision="2" unit="deg"/>
      <FIELD name="Dec" ID="col2" ucd="pos.eq.dec;meta.main"
        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>
```

Header with metadata first

Unknown end

BIG DATA transfer

Links to streams...

Live pre-processing URLs

On-the-fly creation of data

Universal Content Descriptors

S	em.IR	Infrared part of the spectrum
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	pos.eq	Equatorial coordinates
Q	pos.eq.dec	Declination in equatorial coordinates
Q	pos.eq.ha	Hour-angle
Q	pos.eq.ra	Right ascension in equatorial coordinates
Q	pos.eq.spd	South polar distance in equatorial coordinates
S	pos.errorEllipse	Positional error ellipse
Q	pos.frame	Reference frame used for positions (FK5, ICRS,...)
S	pos.galactic	Galactic coordinates
Q	pos.galactic.lat	Latitude in galactic coordinates
Q	pos.galactic.lon	Longitude in galactic coordinates

P	stat.stdev	Standard deviation
S	stat.uncalib	Qualifier of a generic incalibrated quantity
Q	stat.value	Miscellaneous statistical value
P	stat.variance	Variance
P	stat.weight	Statistical weight
Q	time	Time, generic quantity in units of time or date
Q	time.age	Age
Q	time.creation	Creation time/date (of dataset, file, catalogue,...)
Q	time.crossing	Crossing time
Q	time.duration	Interval of time describing the duration of a generic event or phenomenon
Q	time.end	End time/date of a generic event

VO Registry – XML

```
<validationLevel validatedBy="ivo://archive.stsci.edu/nvoregistry">2</validationLevel>
<title>Hubble Space Telescope Spectra</title>
<shortName>HST Spectra</shortName>
<identifier>ivo://mast.stsci/ssap/hst</identifier>
▼<curation>
  <publisher>MAST</publisher>
  ▼<creator>
    <name>MAST</name>
  </creator>
  <version>1.0</version>
  ▼<contact>
    <name>Archive Branch, STScI</name>
    <email>archive@stsci.edu</email>
  </contact>
</curation>
▼<content>
  <subject>UV</subject>
  <subject>Optical</subject>
  <subject>and Infrared Astronomy</subject>
  ▼<description>
    Spectra from the following HST instruments are available: GHRS (processed by CADC), FOS (processed by ECF), and STIS (1st
    order). Service is still under development. Links point to new (but incomplete) VO-compatible FITS files created by MAST staff.
  </description>
  <referenceURL>http://archive.stsci.edu/</referenceURL>
  <type>Archive</type>
  <contentLevel>Research</contentLevel>
</content>
▼<capability standardID="ivo://ivoa.net/std/SSA" xsi:type="ssa:SimpleSpectralAccess">
  ▼<interface role="std" version="0.5" xsi:type="vs:ParamHTTP">
    <accessURL use="base">http://archive.stsci.edu/ssap/search.php?id=HST</accessURL>
    <queryType>GET</queryType>
  </interface>
  <complianceLevel>query</complianceLevel>
  <dataSource>pointed</dataSource>
  <creationType>archival</creationType>
  <maxSearchRadius>360.0</maxSearchRadius>
  <maxRecords>10000</maxRecords>
  <defaultMaxRecords>10000</defaultMaxRecords>
  <maxAperture>180.0</maxAperture>
  <maxFileSize>10000000000</maxFileSize>
</capability>
▼<coverage>
  ▼<STCResourceProfile xmlns="http://www.ivoa.net/xml/STC/stc-v1.30.xsd">
    <AstroCoordSystem id="mast.stsci_ssap_hstUTC-FK5-TOPO" xlink:href="ivo://STClib/CoordSys#UTC-FK5-TOPO" xlink:type="simple" />
    ▼<AstroCoords coord_system_id="mast.stsci_ssap_hstUTC-FK5-TOPO">
      ▼<PositionID>
        <Size pos_unit="arcsec">0.0500000007450581</Size>
      </PositionID>
    </AstroCoords>
  </STCResourceProfile>
  <waveband>UV</waveband>
  <waveband>Optical</waveband>
</coverage>
</ri:Resource>
```

Simple Spectra Access Protocol Spectral Data Model

Simple Spectral Access Protocol V1.04



*International
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Simple Spectral Access Protocol

Version 1.04

IVOA Recommendation Feb 01, 2008

This version:

<http://www.ivoa.net/Documents/REC/DAL/SSA-20080201.html>

Latest version:

<http://www.ivoa.net/Documents/latest/SSA.html>

Previous version(s):

Version 1.03, December 2007
Version 1.02, September 2007
Version 1.01, June 2007
Version 1.00, May 2007
Version 0.97, November 2006
Version 0.96, September 2006
Version 0.95 May 2006
Version 0.91 October 2005
Version 0.90 May 2005

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IVOA Spectral Data Model

Version 1.03

IVOA Recommendation 2007-10-29

This version (Recommendation Rev 1)

<http://www.ivoa.net/Documents/REC/DM/SpectrumDM-20071029.pdf>

Latest version:

<http://www.ivoa.net/Documents/latest/SpectrumDM.html>

Previous versions:

<http://www.ivoa.net/Documents/PR/DM/SpectrumDM-20070913.html>

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SSAP Parameters

4.1.1 Mandatory Query Parameters

The following parameters **must** be implemented by a compliant service:

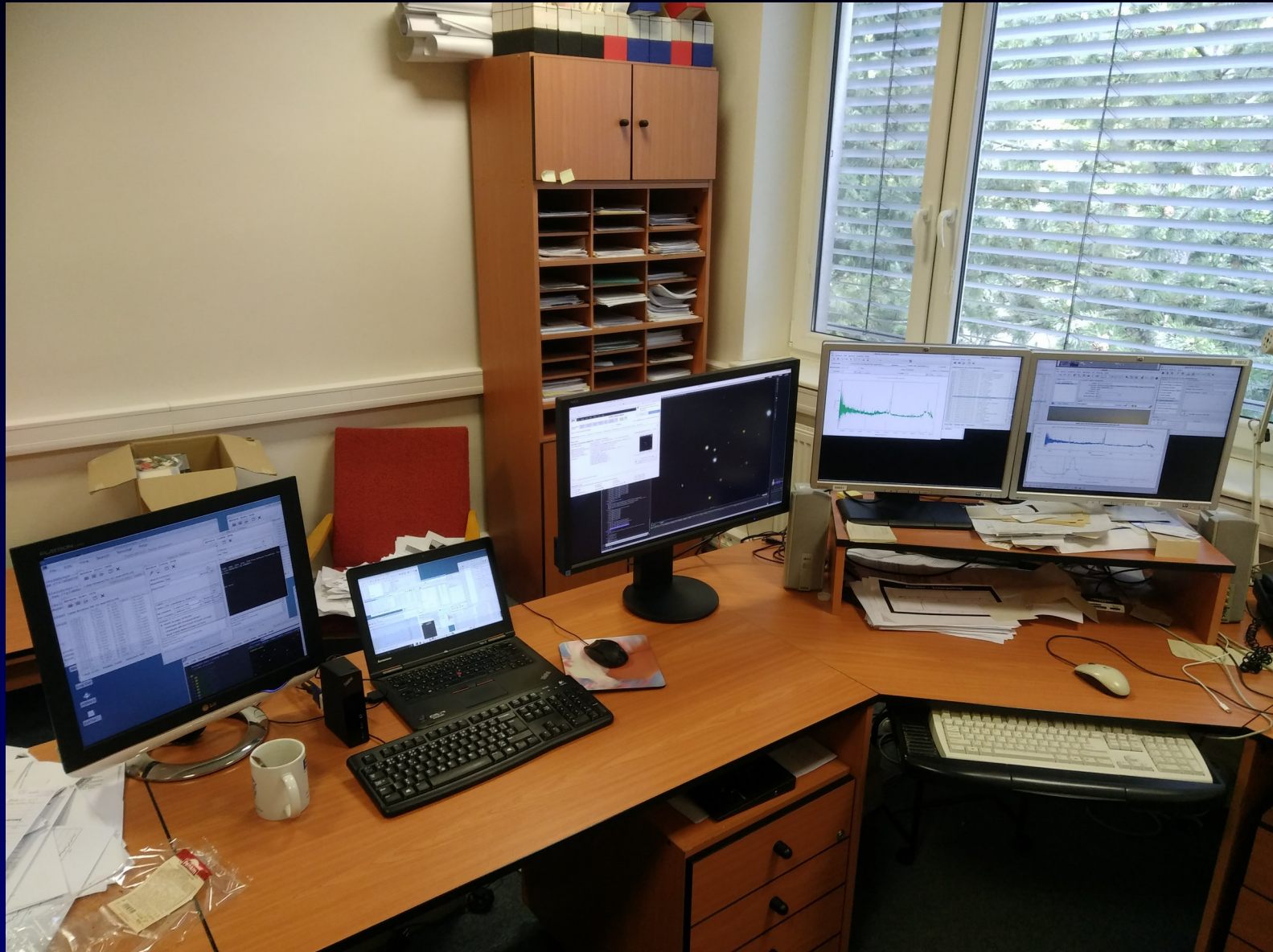
Parameter	Sample value	Physical unit	Datatype
POS	52, -27.8	degrees; defaults to ICRS	string
SIZE	0.05	degrees	double
BAND	2.7E-7/0.13	meters	string
TIME	1998-05-21/1999	ISO 8601 UTC	string
FORMAT	votable	-	string

4.1.2 Recommended and Optional Query Parameters

Parameter	Sample value	Unit	Req	Datatype
APERTURE	0.00028 (=1")	degrees	OPT	double
SPECRP	2000	$\lambda/d\lambda$	REC	double
SPATRES	0.05	degrees	REC	double
TIMERES	31536000 (=1yr)	seconds	OPT	double
SNR	5.0	dimensionless	OPT	double
REDSHIFT	1.3/3.0	dimensionless	OPT	string
VARAMPL	0.77	dimensionless	OPT	string
TARGETNAME	mars		OPT	string
TARGETCLASS	star		OPT	string
FLUXCALIB	relative		OPT	string
WAVECALIB	absolute		OPT	string
PUBDID	ADS/col#R5983		REC	string
CREATORID	ivo://auth/col#R1234		REC	string
COLLECTION	SDSS-DR5		REC	string
TOP	20	dimensionless	REC	int
MAXREC	5000		REC	string
MTIME	2005-01-01/2006-01-01	ISO 8601	REC	string
COMPRESS	true		REC	boolean
RUNID			REC	string

The spatial, spectral and time resolution of the data may all be used as query constraints.

Analysis



Live Demo...