



*Not Only*  
**Stellar Spectroscopy with  
Virtual Observatory**

**Petr Škoda**

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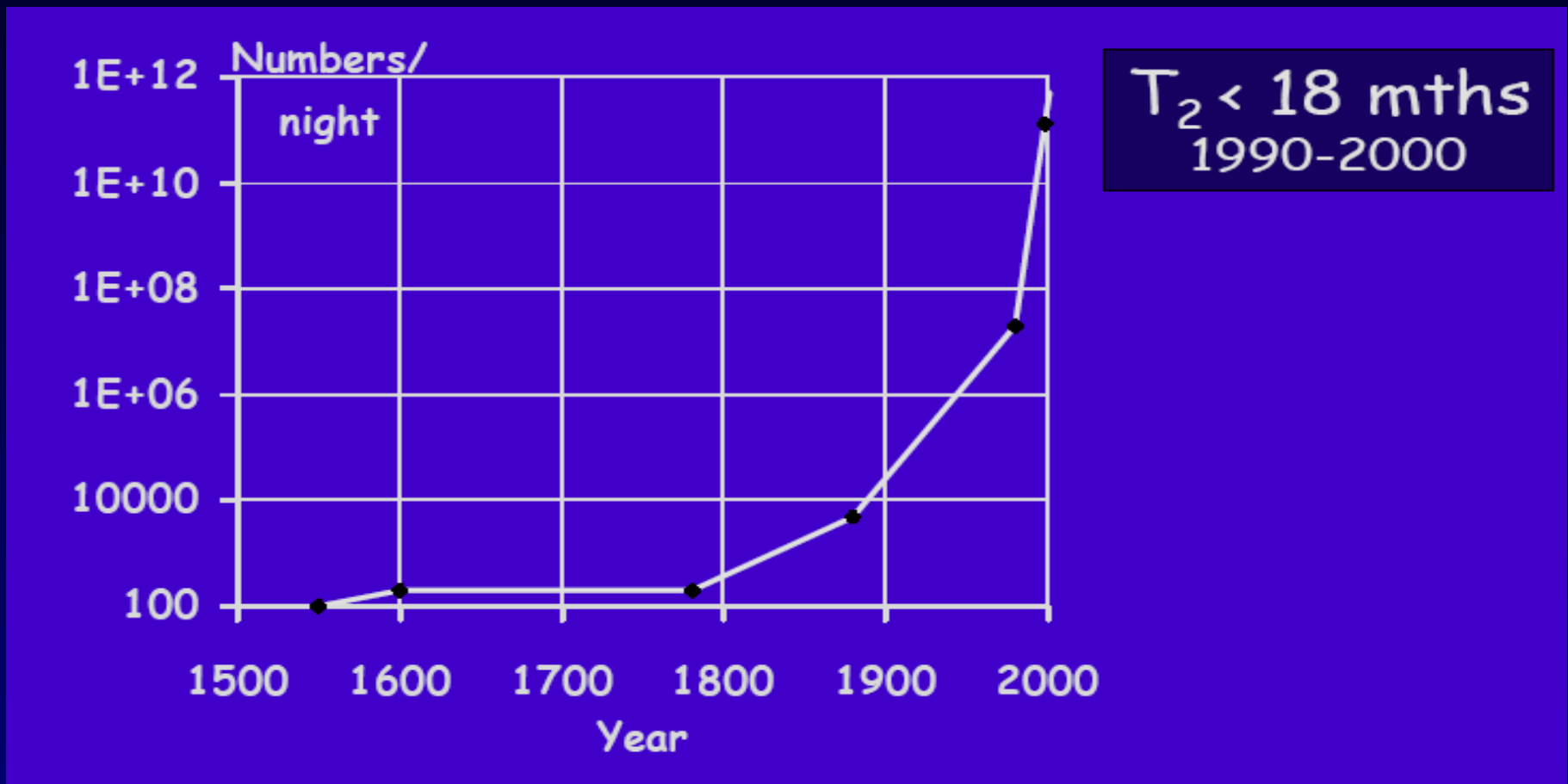
Lecture at workshop on observational techniques,  
AI Ondřejov, 5<sup>th</sup> Sep 2024

# Data Avalanche

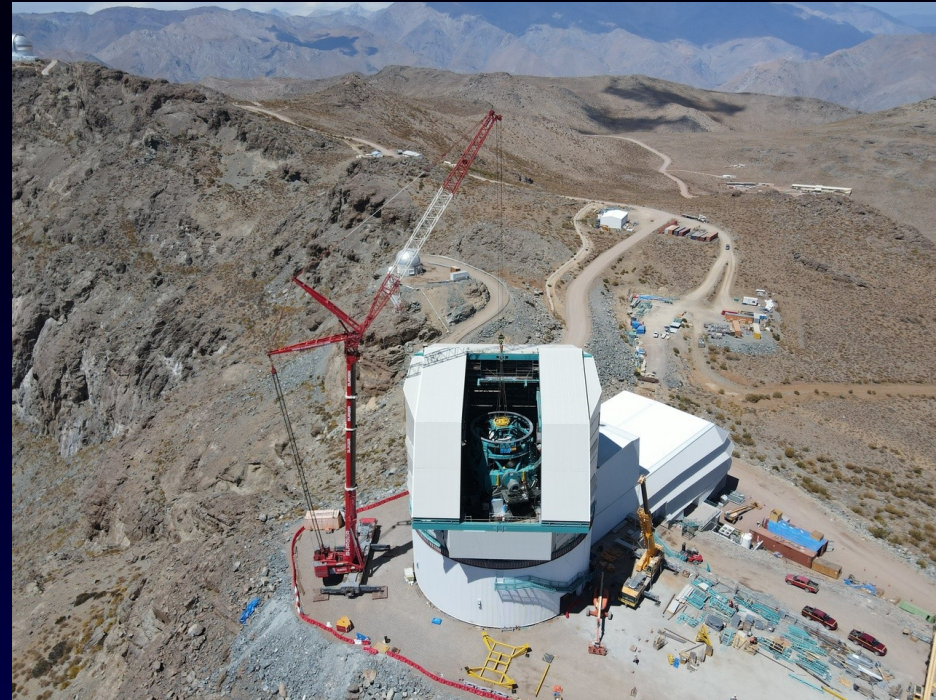
Moore law for chips –doubling 1.5 year

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

100 PB today, 100 TB/night



# LSST – Vera C. Rubin Observatory

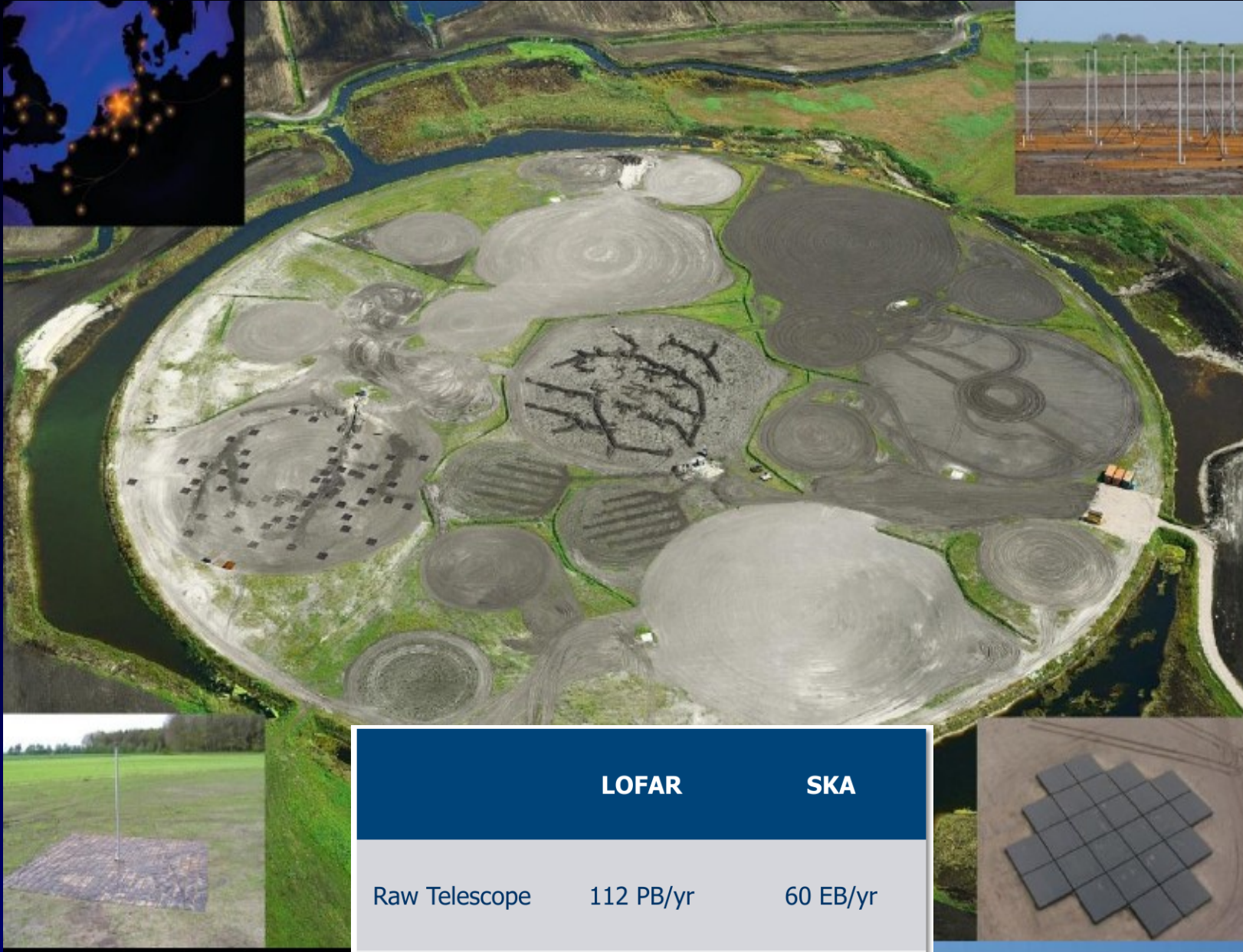


201 CCD 4kx4k,  
3.2 Gpix every 15 sec  
3.5 deg FOV (64cm)  
20 TB/day=6 PB/yr RAW  
1.5 PB catalogue !!!  
detection of changes 60s!  
10 million alerts/night !  
38 billion objects x 1000  
32 tril. meas. -5 PB table





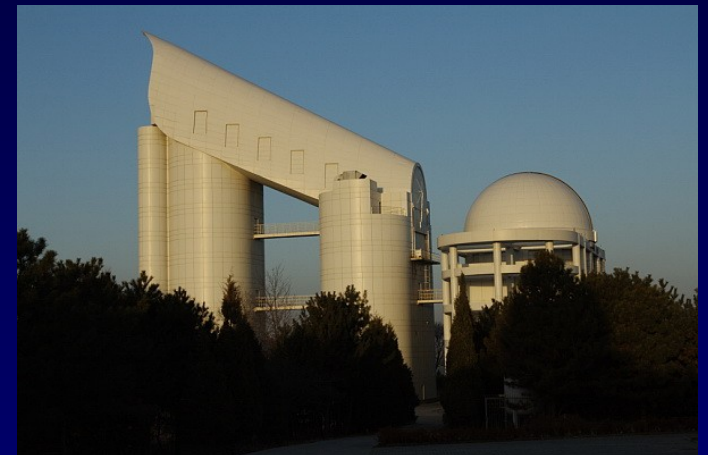
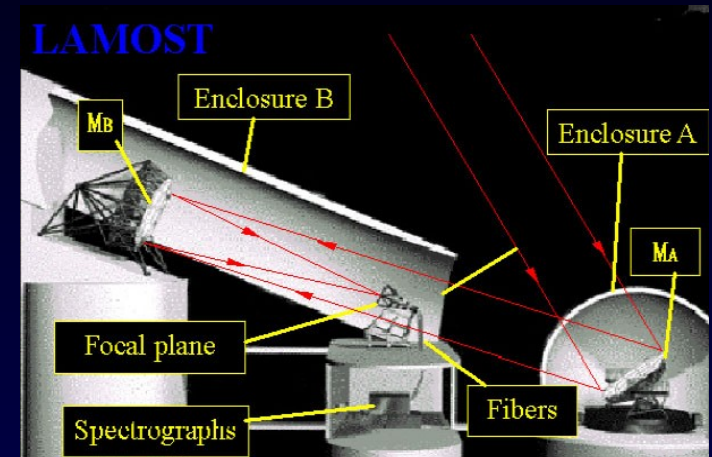
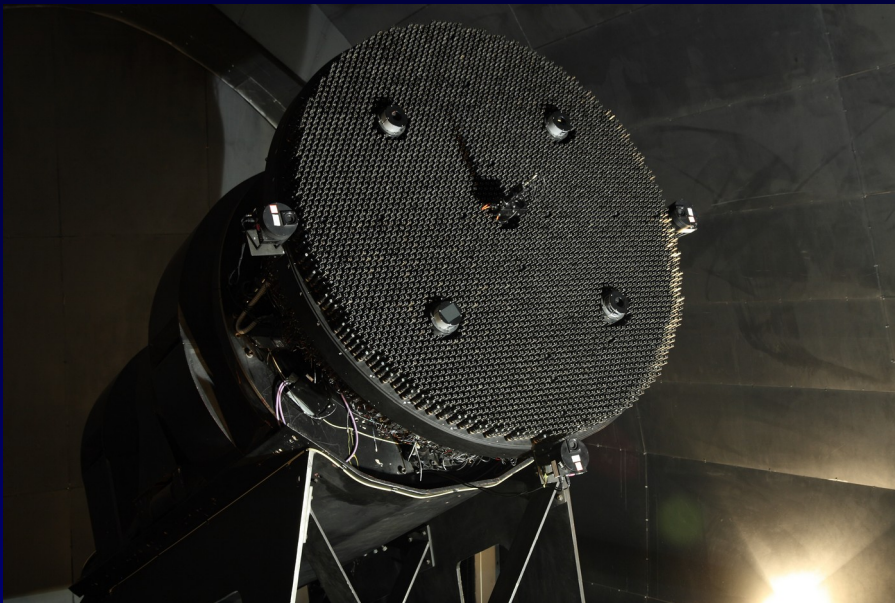
# LOFAR network



	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)	<b>2 204 860</b> spectra	1 085 404 stars classified by pipeline
DR2 (beg 2015)	<b>4 132 782</b> spectra	3 779 674 stars 307 000 unknown!
DR5 (half 2017)	<b>9 017 844</b> spectra	
...		
DR8 (Feb 2022)	<b>10 927 525</b> low res <b>+ 5 975 982</b> 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)

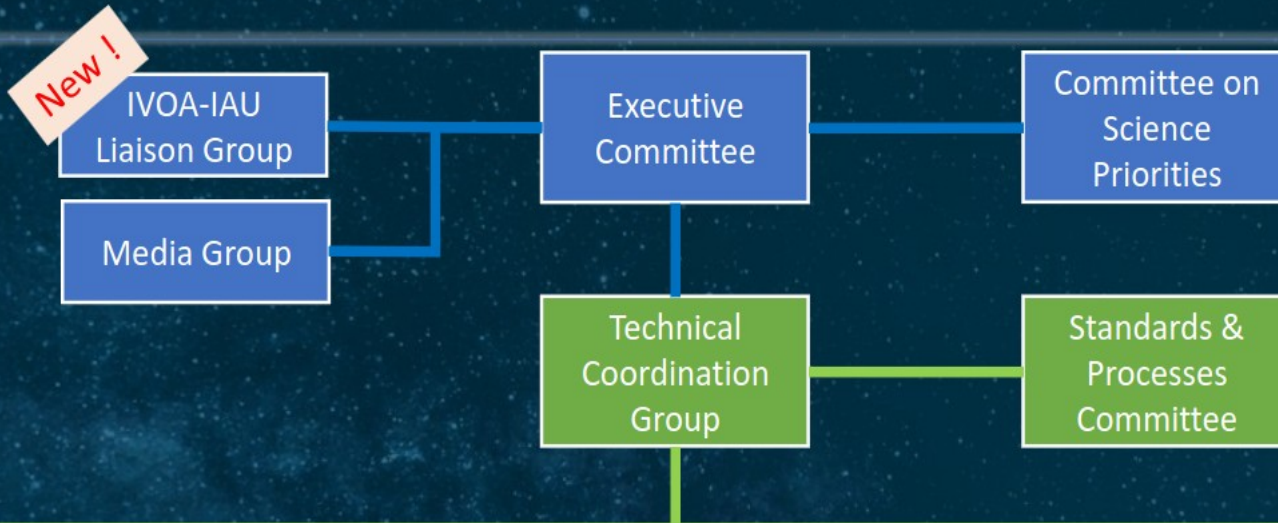




# IVOA Structure



## IVOA Organization



### Working Groups



### Interest Groups



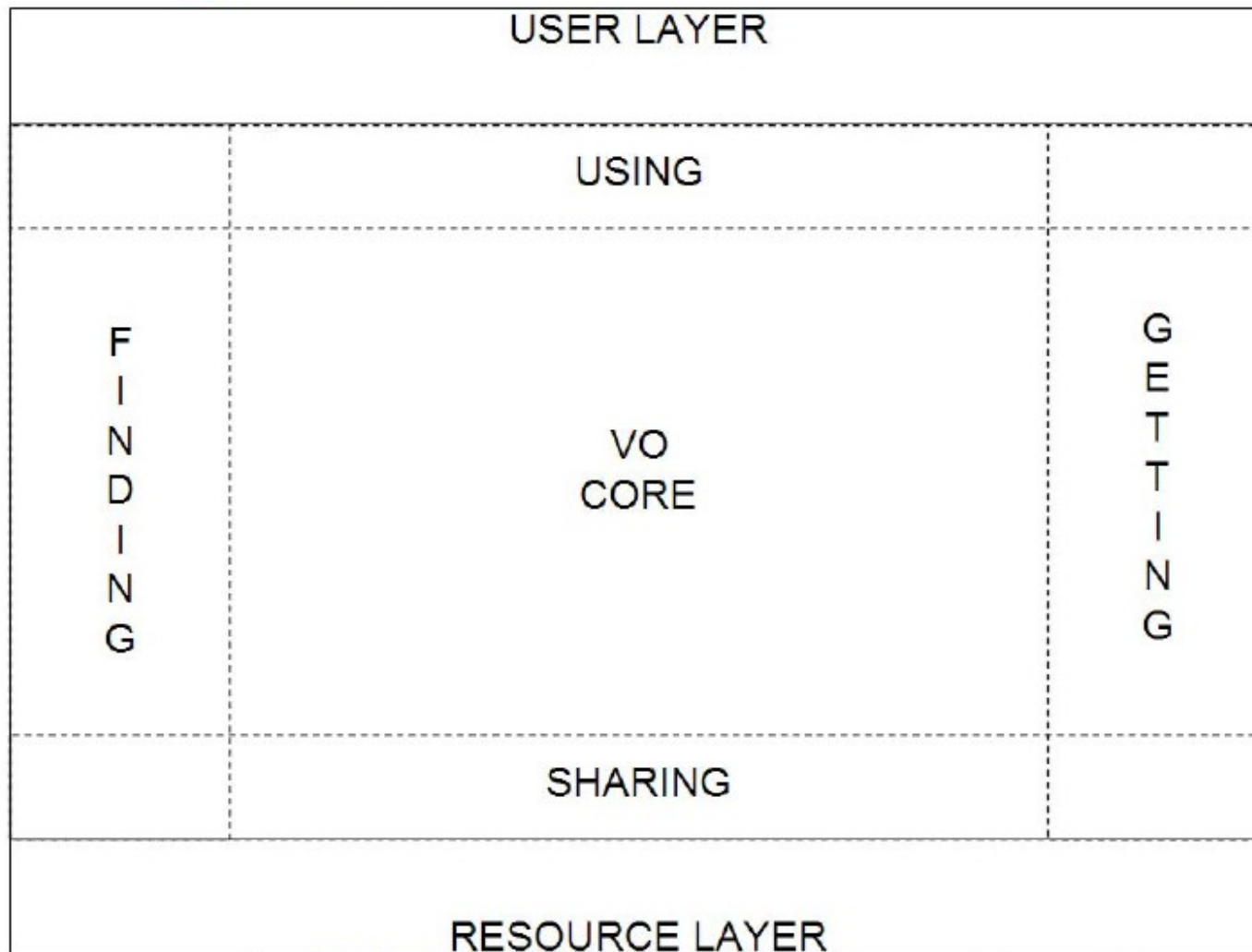
# Ecosystem of VO – level 0

LEVEL 0

USERS



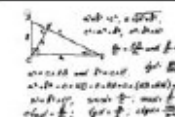
COMPUTERS



20101004  
IVOA Architecture



PROVIDERS



# Ecosystem of VO – level 1

LEVEL 1  
empty

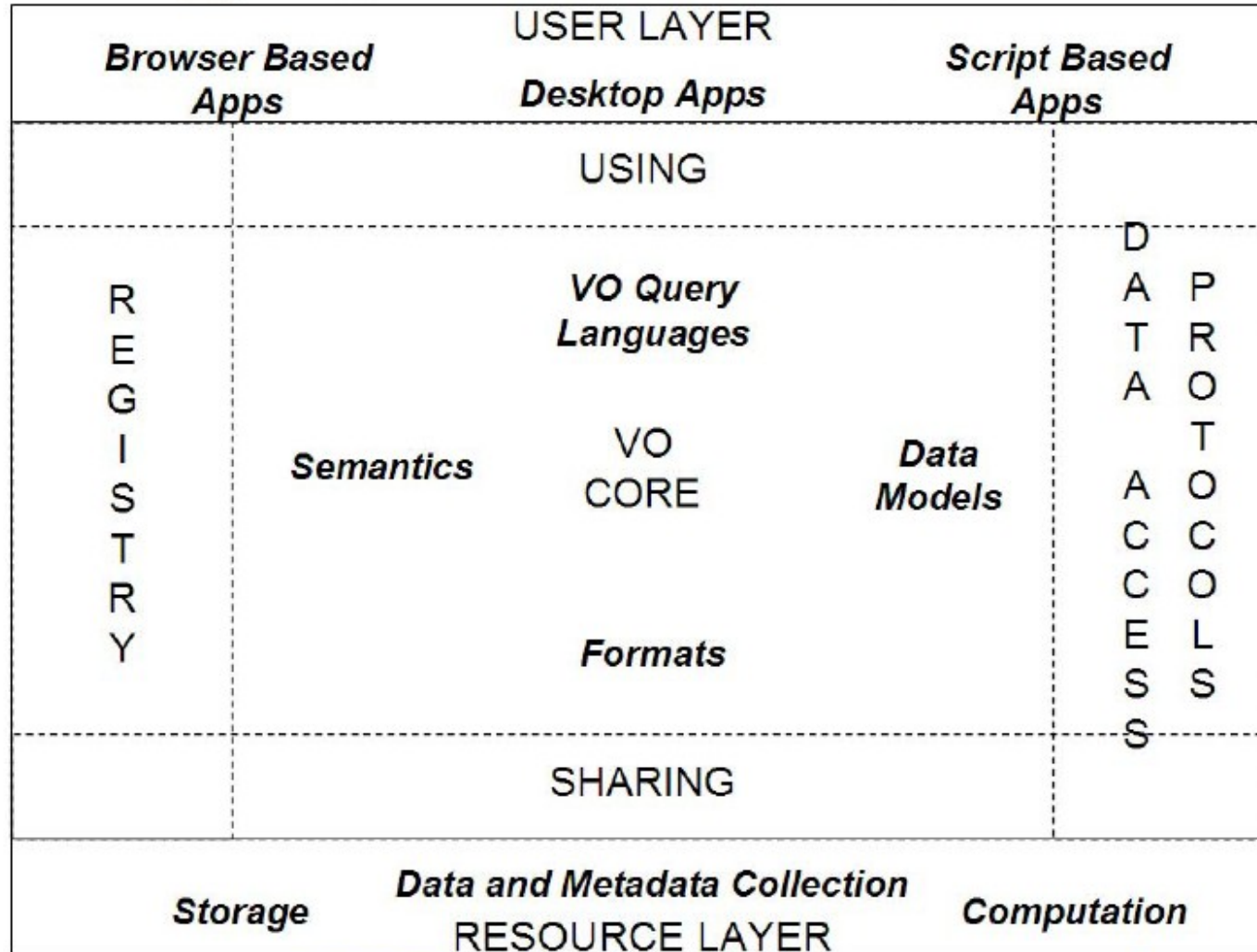
USERS



COMPUTERS

REC

InProgress



20101004  
IVOA Architecture

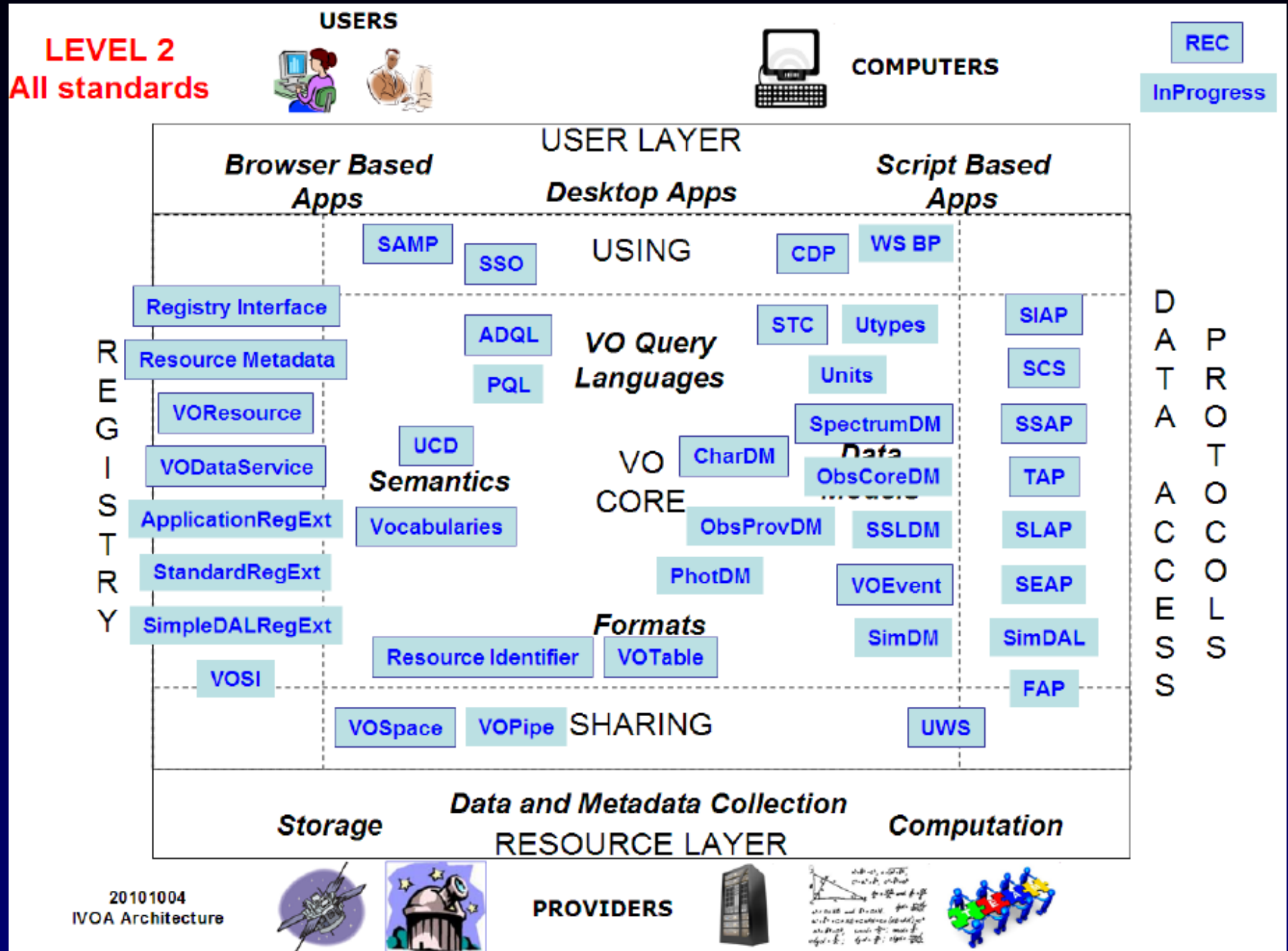


PROVIDERS





# Ecosystem of VO – level 2



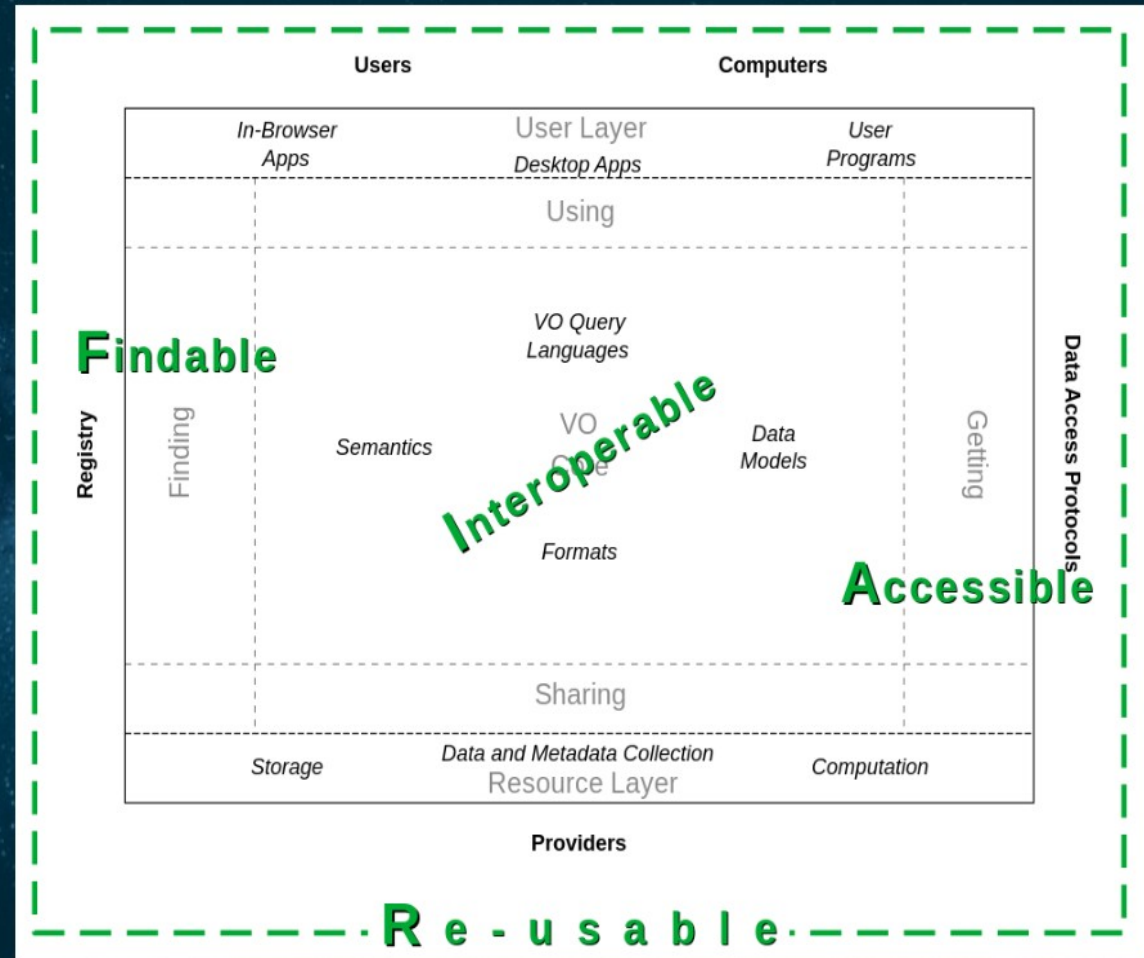
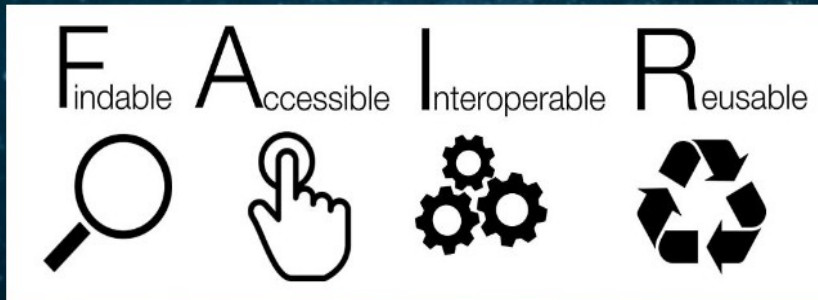
# Open Science – EOSC

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

## IVOA Architecture – FAIR data management



VO has been FAIR from the beginning!



# 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)*

# TOPCAT

The screenshot displays the TOPCAT software interface with several windows open:

- Table Access Protocol (TAP) Query:** Shows query details for 'GAIADR1' with columns like 'ra', 'dec', 'pmra', and 'pmra\_err'.
- Match Tables:** Displays 'CDS Upload X-Match' results with columns for 'Name', 'RA column', and 'Dec column'.
- Plane Plot (1):** A scatter plot showing the distribution of stars in a 2D plane.
- Plane Plot (2):** A scatter plot showing a different view of the star distribution.
- Plane Plot (3):** A scatter plot showing a third view of the star distribution.
- Plane Plot (4):** A scatter plot showing a fourth view of the star distribution.
- Plane Plot (5):** A scatter plot showing a fifth view of the star distribution.
- Plane Plot (6):** A scatter plot showing a sixth view of the star distribution.
- Plane Plot (7):** A scatter plot showing a seventh view of the star distribution.
- Plane Plot (8):** A scatter plot showing an eighth view of the star distribution.
- Plane Plot (9):** A scatter plot showing a ninth view of the star distribution.
- Plane Plot (10):** A scatter plot showing a tenth view of the star distribution.
- Plane Plot (11):** A scatter plot showing an eleventh view of the star distribution.
- Plane Plot (12):** A scatter plot showing a twelfth view of the star distribution.
- Plane Plot (13):** A scatter plot showing a thirteenth view of the star distribution.
- Plane Plot (14):** A scatter plot showing a fourteenth view of the star distribution.
- Plane Plot (15):** A scatter plot showing a fifteenth view of the star distribution.
- Plane Plot (16):** A scatter plot showing a sixteenth view of the star distribution.
- Plane Plot (17):** A scatter plot showing a seventeenth view of the star distribution.
- Plane Plot (18):** A scatter plot showing an eighteenth view of the star distribution.
- Plane Plot (19):** A scatter plot showing a nineteenth view of the star distribution.
- Plane Plot (20):** A scatter plot showing a twentieth view of the star distribution.
- Plane Plot (21):** A scatter plot showing a twenty-first view of the star distribution.
- Plane Plot (22):** A scatter plot showing a twenty-second view of the star distribution.
- Plane Plot (23):** A scatter plot showing a twenty-third view of the star distribution.
- Plane Plot (24):** A scatter plot showing a twenty-fourth view of the star distribution.
- Plane Plot (25):** A scatter plot showing a twenty-fifth view of the star distribution.
- Plane Plot (26):** A scatter plot showing a twenty-sixth view of the star distribution.
- Plane Plot (27):** A scatter plot showing a twenty-seventh view of the star distribution.
- Plane Plot (28):** A scatter plot showing a twenty-eighth view of the star distribution.
- Plane Plot (29):** A scatter plot showing a twenty-ninth view of the star distribution.
- Plane Plot (30):** A scatter plot showing a thirtieth view of the star distribution.
- Plane Plot (31):** A scatter plot showing a thirty-first view of the star distribution.
- Plane Plot (32):** A scatter plot showing a thirty-second view of the star distribution.
- Plane Plot (33):** A scatter plot showing a thirty-third view of the star distribution.
- Plane Plot (34):** A scatter plot showing a thirty-fourth view of the star distribution.
- Plane Plot (35):** A scatter plot showing a thirty-fifth view of the star distribution.
- Plane Plot (36):** A scatter plot showing a thirty-sixth view of the star distribution.
- Plane Plot (37):** A scatter plot showing a thirty-seventh view of the star distribution.
- Plane Plot (38):** A scatter plot showing a thirty-eighth view of the star distribution.
- Plane Plot (39):** A scatter plot showing a thirty-ninth view of the star distribution.
- Plane Plot (40):** A scatter plot showing a fortieth view of the star distribution.
- Plane Plot (41):** A scatter plot showing a forty-first view of the star distribution.
- Plane Plot (42):** A scatter plot showing a forty-second view of the star distribution.
- Plane Plot (43):** A scatter plot showing a forty-third view of the star distribution.
- Plane Plot (44):** A scatter plot showing a forty-fourth view of the star distribution.
- Plane Plot (45):** A scatter plot showing a forty-fifth view of the star distribution.
- Plane Plot (46):** A scatter plot showing a forty-sixth view of the star distribution.
- Plane Plot (47):** A scatter plot showing a forty-seventh view of the star distribution.
- Plane Plot (48):** A scatter plot showing a forty-eighth view of the star distribution.
- Plane Plot (49):** A scatter plot showing a forty-ninth view of the star distribution.
- Plane Plot (50):** A scatter plot showing a fiftieth view of the star distribution.

### Table Access Protocol (TAP) Query

Window TAP Registry Edit Interop Help

Select Service Use Service Resume Job Running Jobs

Metadata

Find:

Name  Descrip Or  Service  Schema  Table

Name	Data type	Indexed
source_id	BIGINT	<input checked="" type="checkbox"/>
ra	DOUBLE	<input checked="" type="checkbox"/>
dec	DOUBLE	<input checked="" type="checkbox"/>
l	DOUBLE	<input checked="" type="checkbox"/>
b	DOUBLE	<input checked="" type="checkbox"/>
ecl_lon	DOUBLE	<input checked="" type="checkbox"/>
ecl_lat	DOUBLE	<input checked="" type="checkbox"/>
parallax	DOUBLE	<input checked="" type="checkbox"/>
pmra	DOUBLE	<input checked="" type="checkbox"/>

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.b
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

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

CDS/P/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.

filter filter CDS/Simbad  CDS/P/DSS2/color

epoch size dens. opac. zoom

grid study wink north bdr multiview match

MAIN_ID	OTYPE	RA	DEC	C00	C00	C...	PMR
NAME Flame Nebula	NoICld	05 41 42.7	-01 54 44				
* zet Ori A	**	05 40 45.527	-01 56 33.26	1	1	90	4
NGC 2023	RfNeb	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	E*	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	
[MCP91] NGC 2024 FIR 5	dens	05 41 44.6	-01 55 38				

select simbad

from -- All collections --

filter tool inside scan



# OSPS Image coverage (footprints)

Others File all VO Watch Fov... Tools...

Image servers

- Aladin Images
- SkyView
- UKIDSS
- Sloan
- DSS...
- DK154
- VLA...
- Archives...
- Others...

Target (ICRS, name) 05 15 53 -69 25 57 Grab

Radius 10 deg

Filter R - Filter R

Format image/png

Obs min date

Obs max date

R  
 OSPS 2013-02-25T04:55:50.713 R HV2274 14.2' x 13.6'  
 OSPS 2013-02-25T03:23:04.800 R HV982 14.2' x 13.6'  
 OSPS 2015-01-05T01:09:44.372 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T01:58:30.980 R LMC01 14.2' x 13.6'  
 OSPS 2015-01-05T08:16:30.688 R LMC52 14.2' x 13.6'  
 OSPS 2015-01-05T06:46:14.164 R LMC01 14.2' x 13.6'  
 OSPS 2015-01-05T04:26:44.012 R LMC33 14.2' x 13.6'  
 OSPS 2015-01-05T08:50:50.510 R LMC52 14.2' x 13.6'  
 OSPS 2015-01-05T02:37:13.832 R LMC01 14.2' x 13.6'  
 OSPS 2015-01-05T00:47:50.584 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T09:49:50.776 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T05:37:36.244 R LMC33 14.2' x 13.6'  
 OSPS 2015-01-05T07:31:12.104 R LMC52 14.2' x 13.6'  
 OSPS 2015-01-05T03:32:56.160 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T05:31:36.388 R LMC01 14.2' x 13.6'  
 OSPS 2015-01-05T04:52:58.112 R LMC52 14.2' x 13.6'  
 OSPS 2015-01-05T04:59:18.207 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T07:55:26.440 R LMC33 14.2' x 13.6'  
 OSPS 2015-01-05T05:01:19.872 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T01:56:30.956 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T03:42:57.456 R LMC33 14.2' x 13.6'  
 OSPS 2015-01-05T06:16:03.988 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T06:14:03.732 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T06:10:03.804 R LMC52 14.2' x 13.6'  
 OSPS 2015-01-05T04:20:44.316 R LMC01 14.2' x 13.6'  
 OSPS 2015-01-05T03:20:55.868 R LMC01 14.2' x 13.6'  
 OSPS 2015-01-05T02:51:37.240 R LMC33 14.2' x 13.6'  
 OSPS 2015-01-05T02:33:15.952 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T02:41:13.124 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T08:44:45.780 R LMC33 14.2' x 13.6'  
 OSPS 2015-01-05T08:54:55.836 R LMC52 14.2' x 13.6'  
 OSPS 2015-01-05T00:43:50.628 R LMC03 14.2' x 13.6'  
 OSPS 2015-01-05T02:45:36.976 R LMC01 14.2' x 13.6'  
 OSPS 2015-01-05T07:14:51.916 R LMC52 14.2' x 13.6'  
 OSPS 2015-01-05T06:00:06.644 R LMC33 14.2' x 13.6'  
 OSPS 2015-01-05T02:02:31.648 R LMC01 14.2' x 13.6'  
 OSPS 2015-01-05T04:30:43.492 R LMC33 14.2' x 13.6'  
 OSPS 2015-01-05T08:05:31.448 R LMC52 14.2' x 13.6'  
 OSPS 2015-01-05T06:06:05.956 R LMC52 14.2' x 13.6'

INFO on this ...

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Location Frame ICRS

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

DSS Colored

select  
 pan  
 zoom  
 dist  
 phot  
 draw  
 tag  
 filter  
 crop  
 cont  
 pixel  
 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.

R.OSPS 2015-01-05T  
 DSS colored

epoch   
 size   
 opac.   
 zoom

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

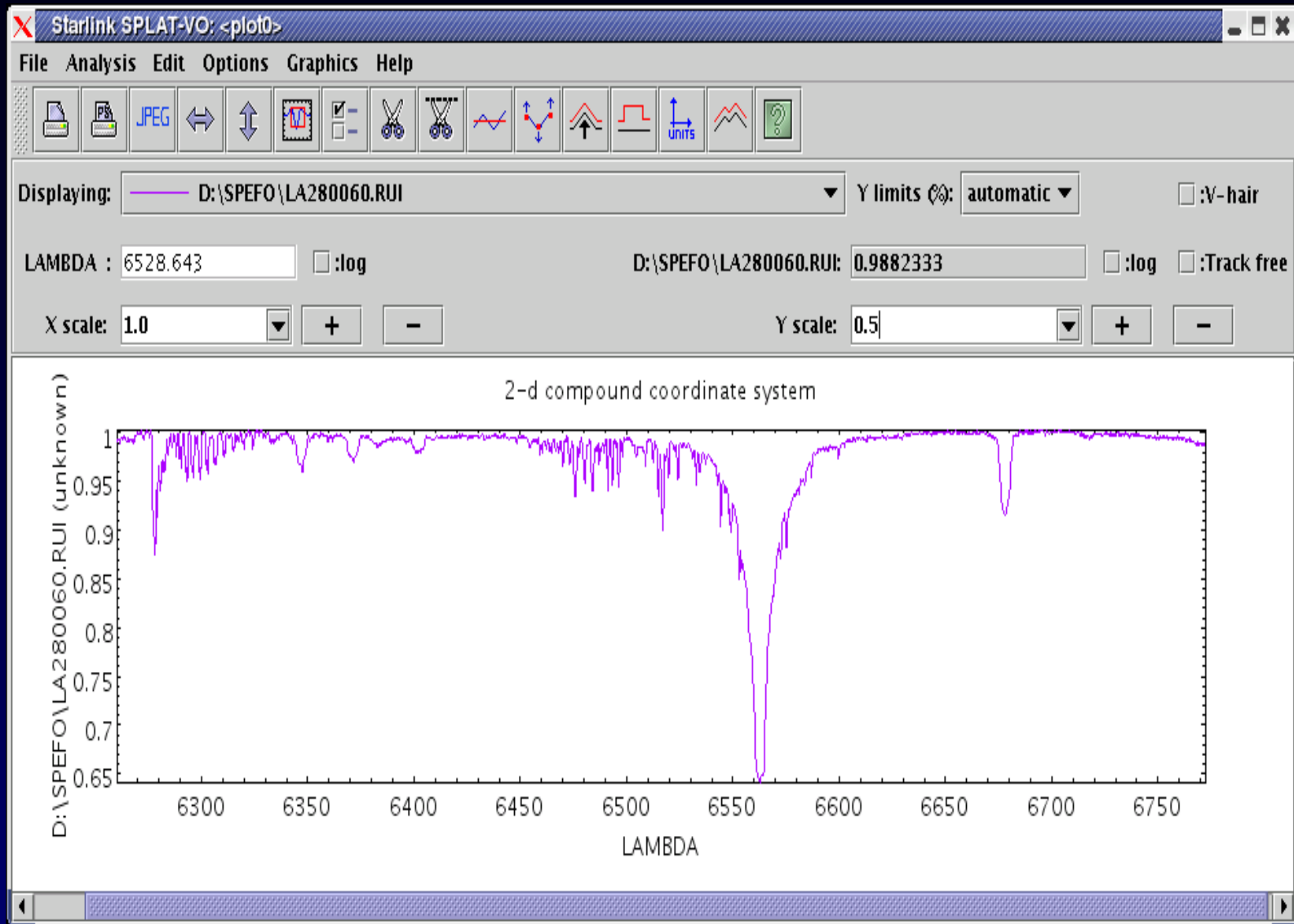
grid wink north hdr multiview match

4.882" x 4.644"

Search

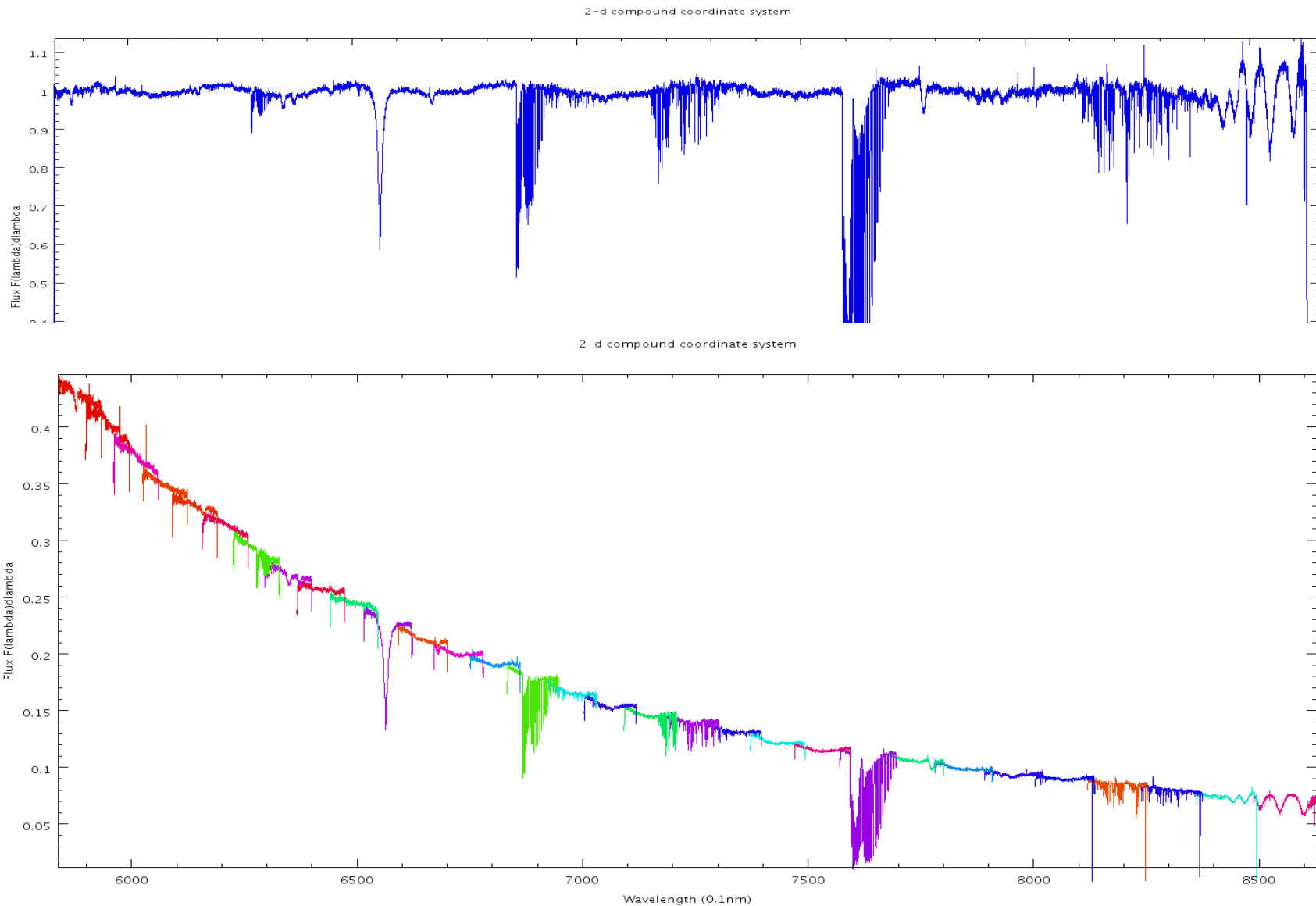
© 2016 Unistra/CNRS - by CDS - Distributed under GNU GPL v3 0 sel / 0 src 67fps / 184Mb

# SPLAT-VO (Starlink, Heidelberg, Ondrejov)



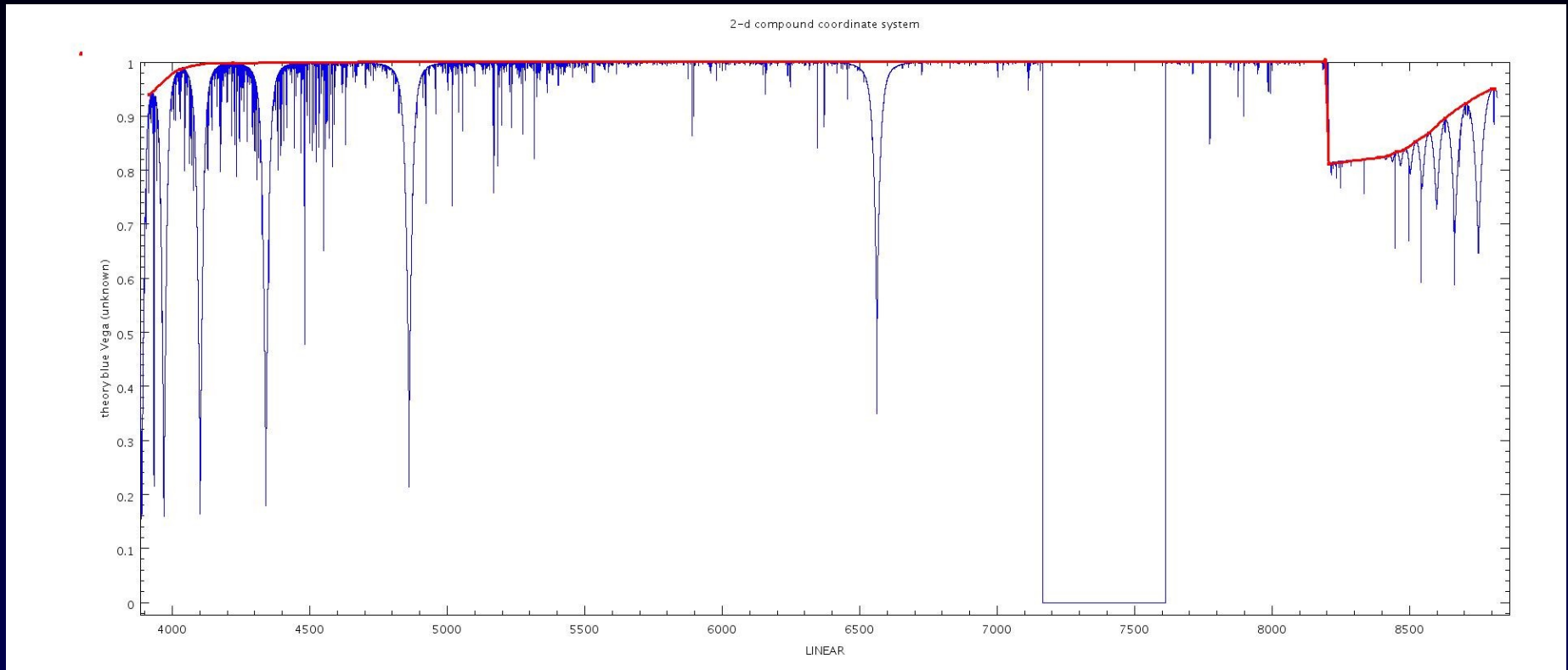


# DaCHS Testbed Split-Order SSAP



nu Pup HEROS red

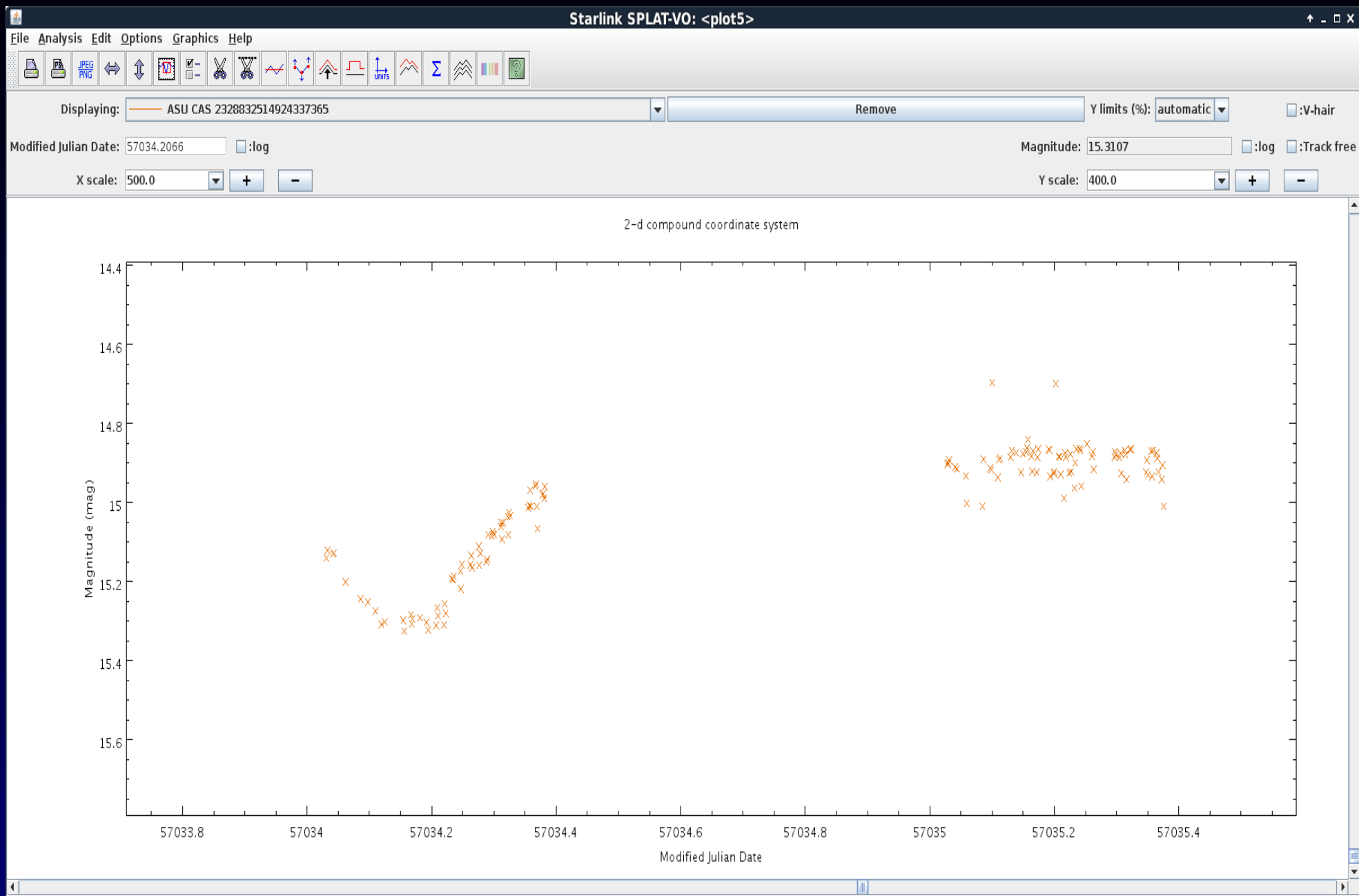
# Continuum Normalisation



Theoretical spectrum of Vega

The continuum is NOT ALWAYS at 1.0 !

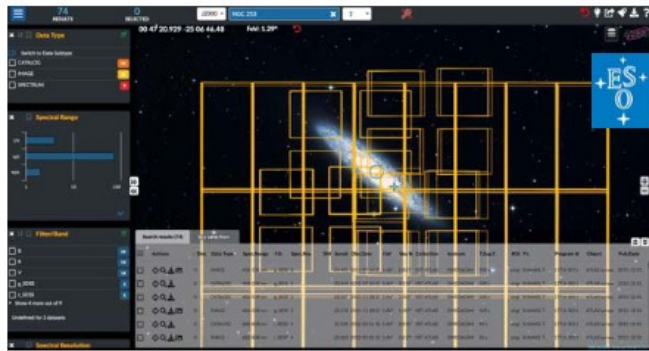
# Light Curve in SPLAT-VO (zoom)



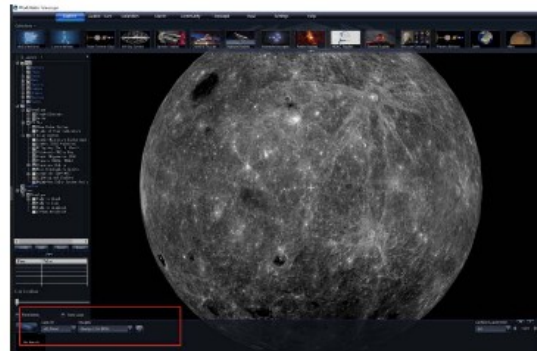


# VO Science Portals

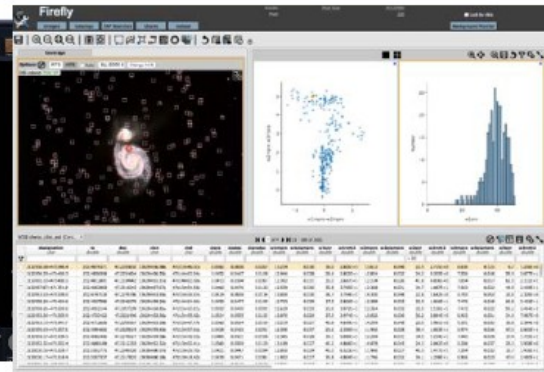
## VO embedded in astronomy services



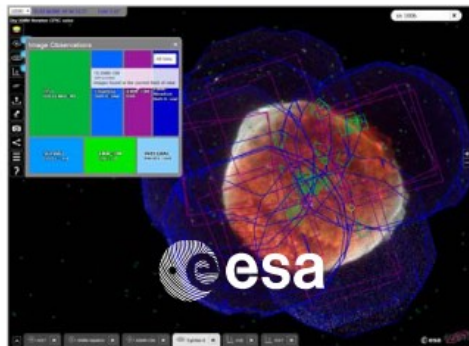
ESO Science Portal



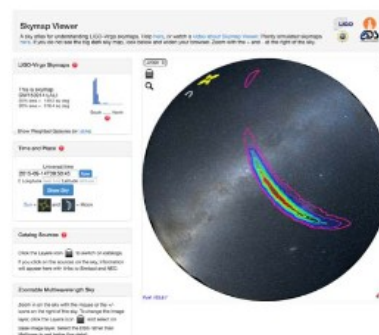
WWT



Firefly  
Caltech-IPAC



ESA Sky



Grav.waves



CDS reference data service

SVO Filter Profile service



# 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

- lap → 1
- irsa.ipac → 1
- jacobsuni → 4
  - CRISM
  - Mars\_craters
  - epn I 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.oew.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

select

from -- all collections --

coll. view scan filter

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				

106.4° x 180°

10.80° x 84.2°

epoch - size - dens - opac - zoom

358.91954 +49.37469 ICRS

16:03:23.95 -48:43:06.0  
14.86° x 24.41°

ALADIN

Welcome to Aladin,  
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- Prepare your observation missions.

To start, type any object name, such as M1, and press ENTER...

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select pan dist phot draw tag filter cross xy rgb zoom del

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17 sep / 2001 str 437Mb

# EUROPLANET VESPA (EPN-TAP)

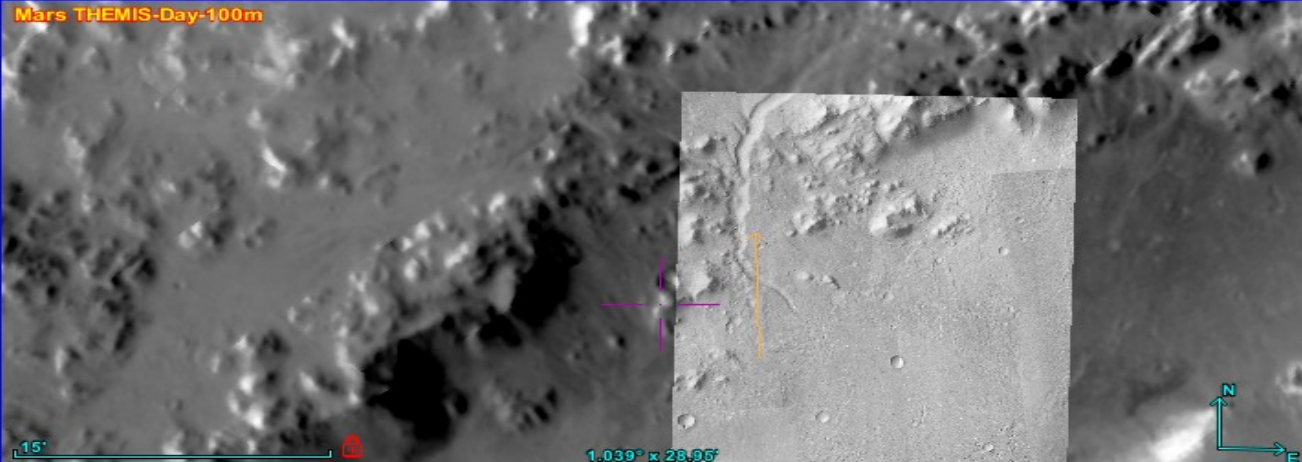
Aladin v10.0 \*\*\* BETA VERSION (based on v10.075) \*\*\*

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

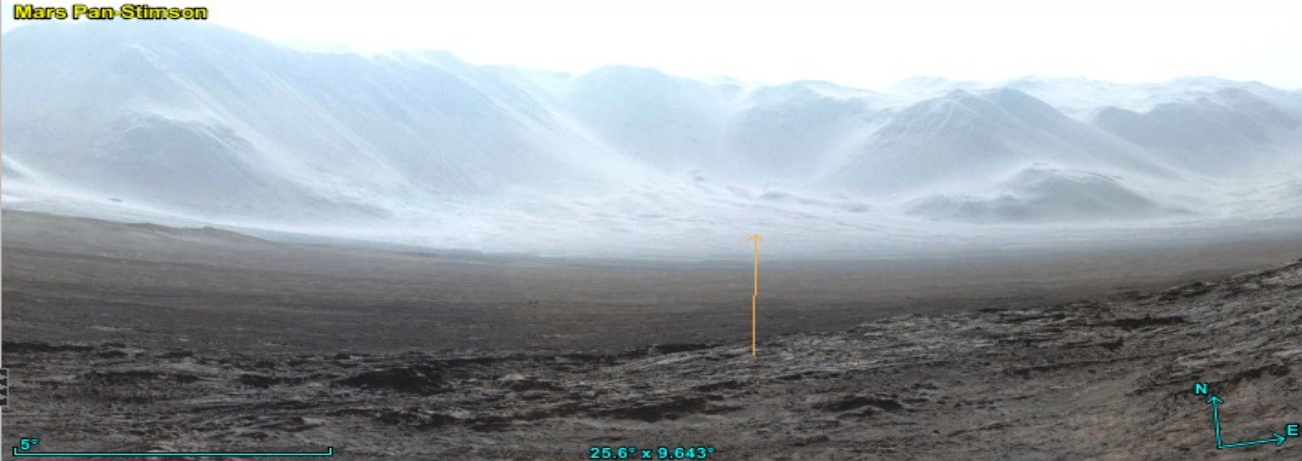
DSS PanSTARRS SDSS 2MASS GALEX Gaia Simbad NED +

**Mars THEMIS-Day-100m**



15° 1.039° x 28.95°

**Mars Pan Stimson**



5° 25.6° x 9.643°

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

select pan dist phot draw tag moc spect filter Drawing CDS/P/Mars/Pan-Stimson MarsSL\_TraverseMap\_Sol1809 peace msl\_hirise\_gale1-de-vrr-%C3% CDS/P/Mars/THEMIS-Day-100 epoch size dens. opac. zoom 137.21561 -04.24684 pixel prop del 09:08:34.42 -04:19:24.2 1.039° x 28.95°

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# 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 Scientific Bodies

Follow the IAU on social media





# Tutorials of VO

[https://hendhd.github.io/ivoa\\_newcomers/](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**

# 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 uncalibrated 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.edu/ssap/hst</identifier>
▼<curator>
  <publisher>MAST</publisher>
  ▼<creator>
    <name>MAST</name>
  </creator>
  <version>1.0</version>
  ▼<contact>
    <name>Archive Branch, STScI</name>
    <email>archive@stsci.edu</email>
  </contact>
</curator>
▼<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

**Editors:**

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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>

**Editors:**

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**Contributors:**

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# SSAP Parameters

## 4.1.1 Mandatory Query Parameters

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

<i>Parameter</i>	<i>Sample value</i>	<i>Physical unit</i>	<i>Datatype</i>
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

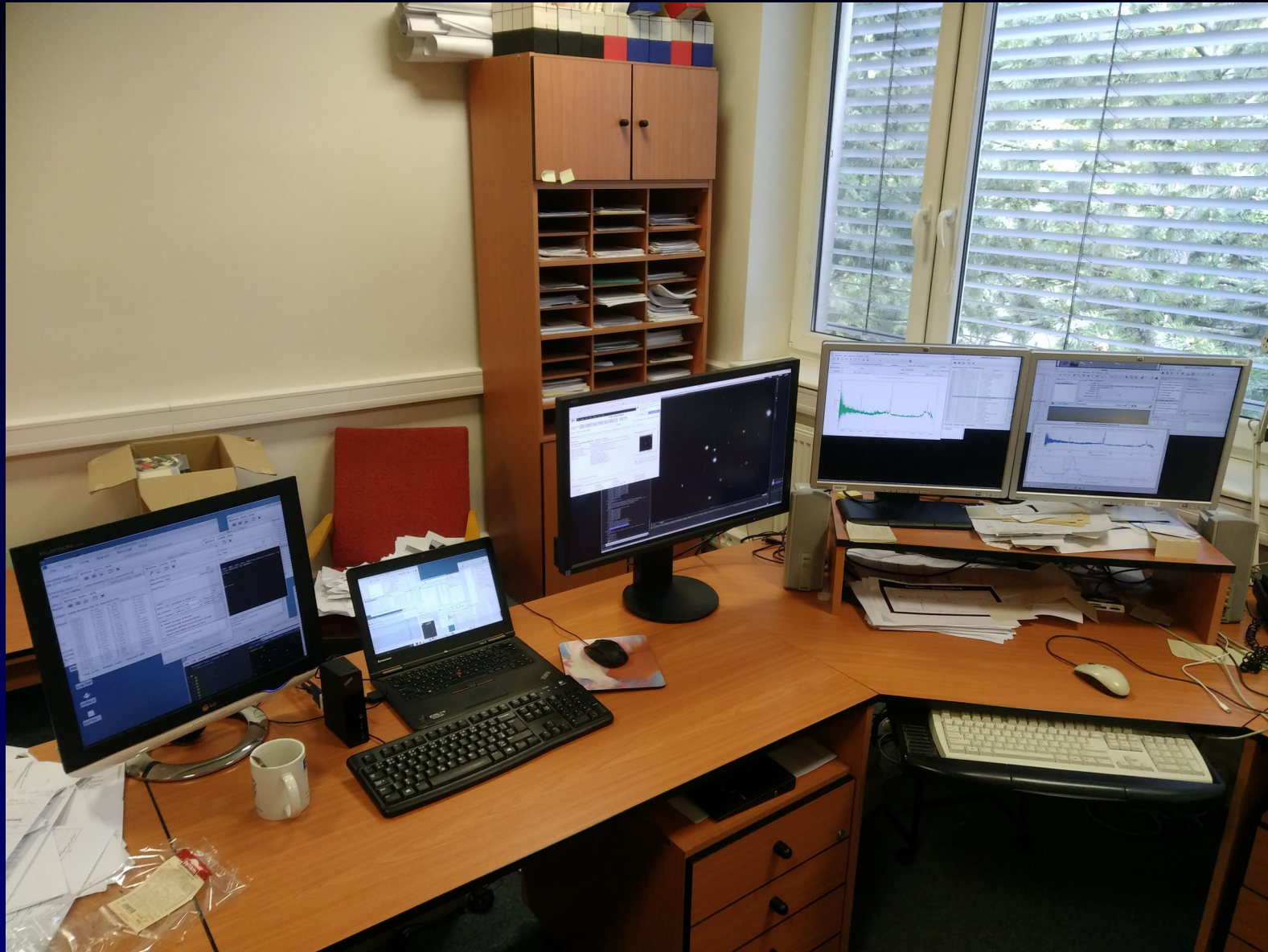
## 4.1.2 Recommended and Optional Query Parameters

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 resolution and time resolution of the data are all the same as the resolution of the query.



# Analysis



*Live Demo...*