

# Stellar Spectroscopy with Virtual Observatory

**Petr Škoda**

Astronomical Institute of the Czech Academy of Sciences, Ondřejov

Faculty of Information Technology, Czech Technical University in Prague



**Astronomical Institute**  
of the Czech Academy of Sciences



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INFORMATICS**

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EUROPEAN UNION  
European Structural and Investment Funds  
Operational Programme Research,  
Development and Education



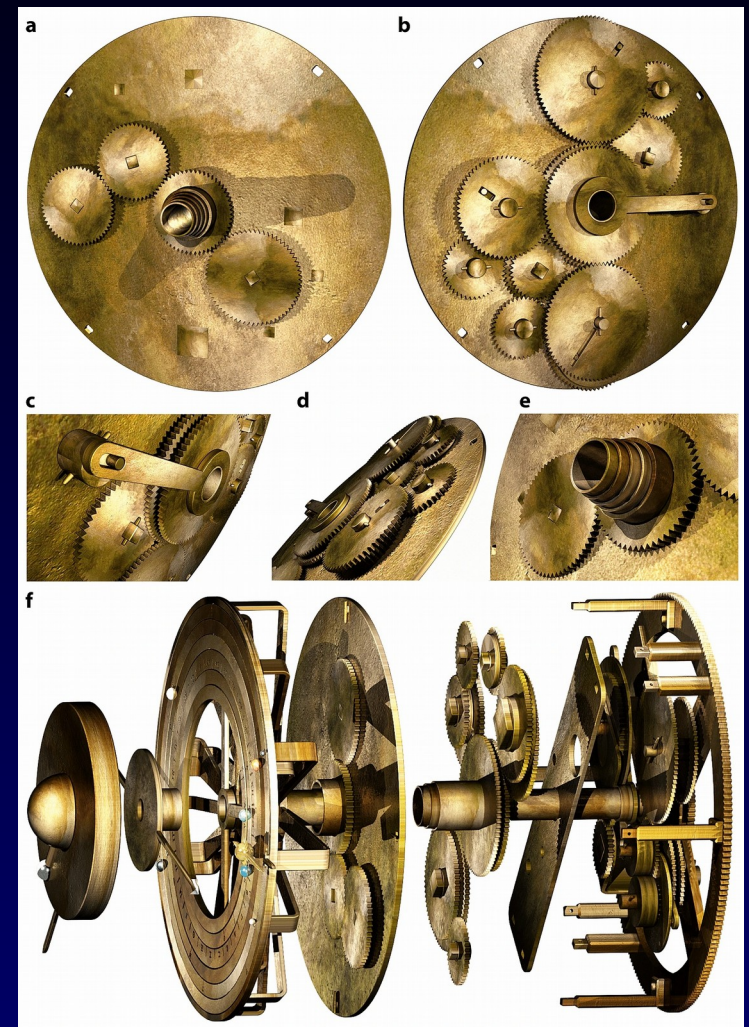
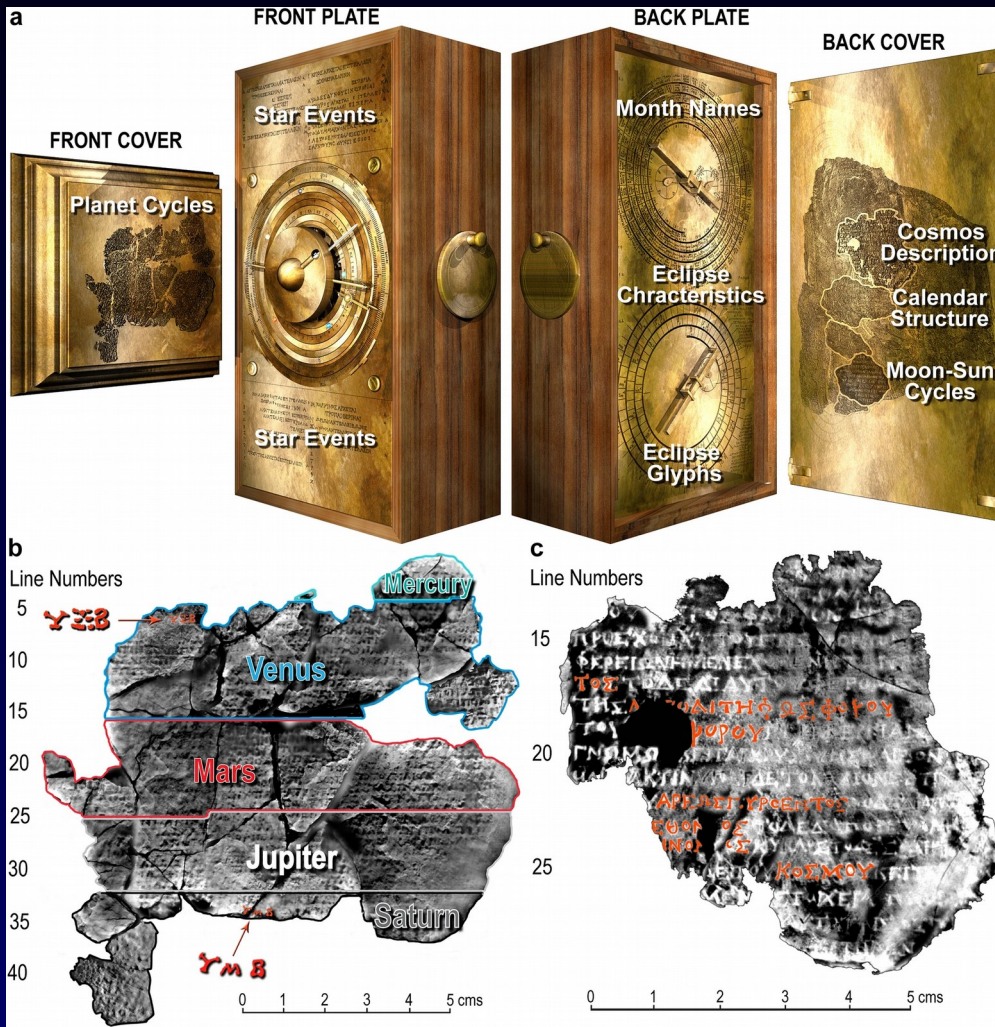
MINISTRY OF EDUCATION,  
YOUTH AND SPORTS

Lecture at workshop on observational techniques,  
AI Ondřejov, 16<sup>st</sup> September 2021

# Credits

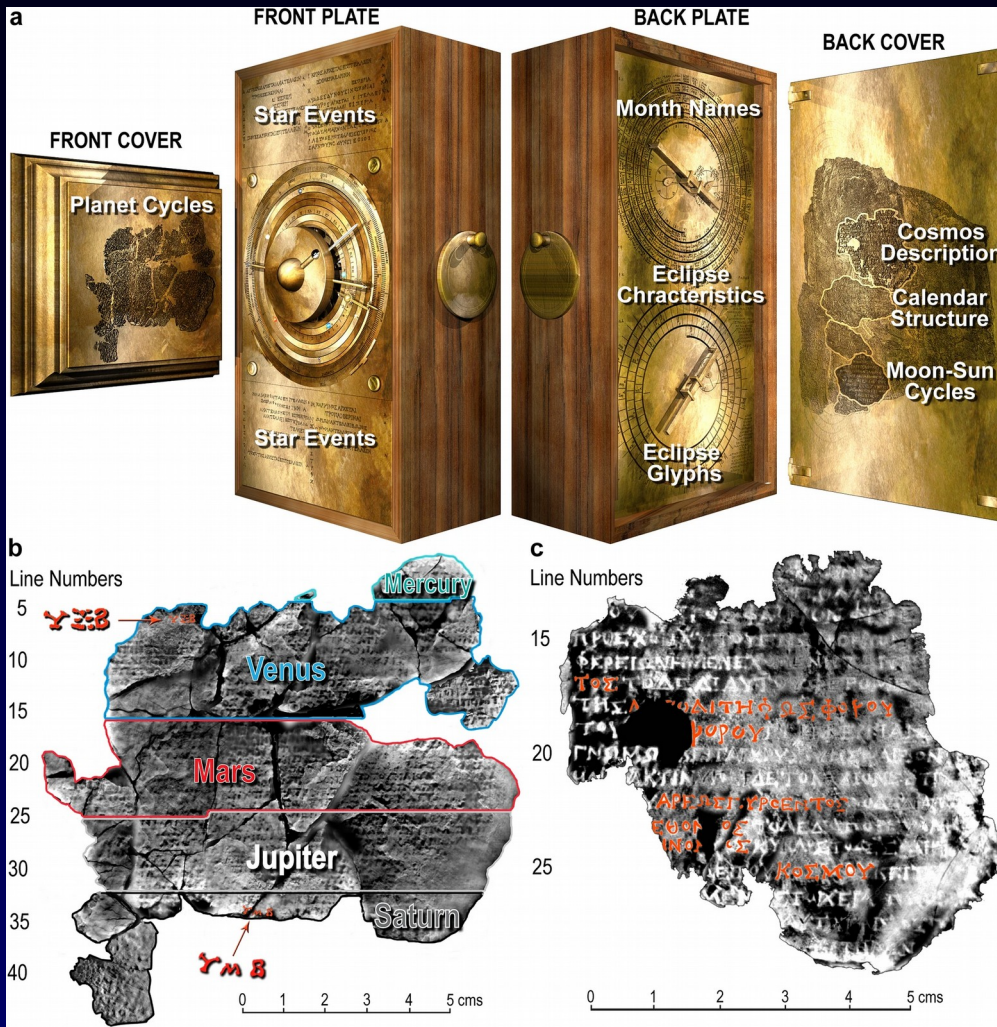
The presentation is based on many different sources – mainly the on-line published slides from IVOA meetings, slides from Astrominformatics and COST meetings or pictures found on Internet.

# Astronomy - the leader of technology

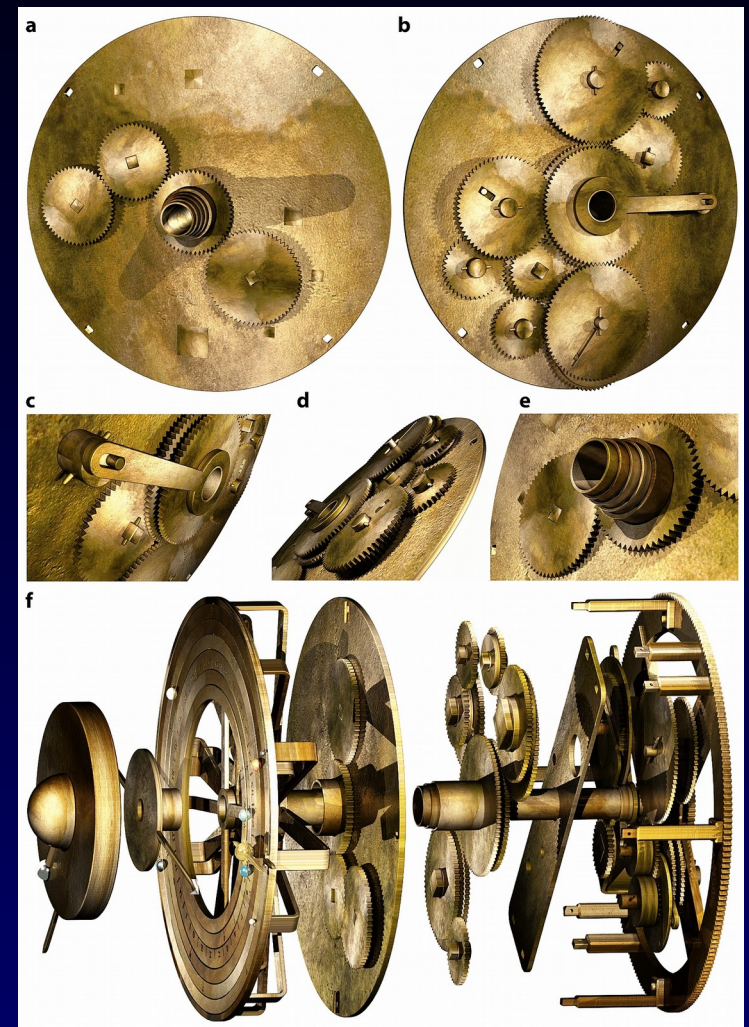




# Astronomy - the leader of technology



Antikythera mechanism 150-100 BC



Freth et al. Nature Sci. Rep. 11, 5821 (2021)

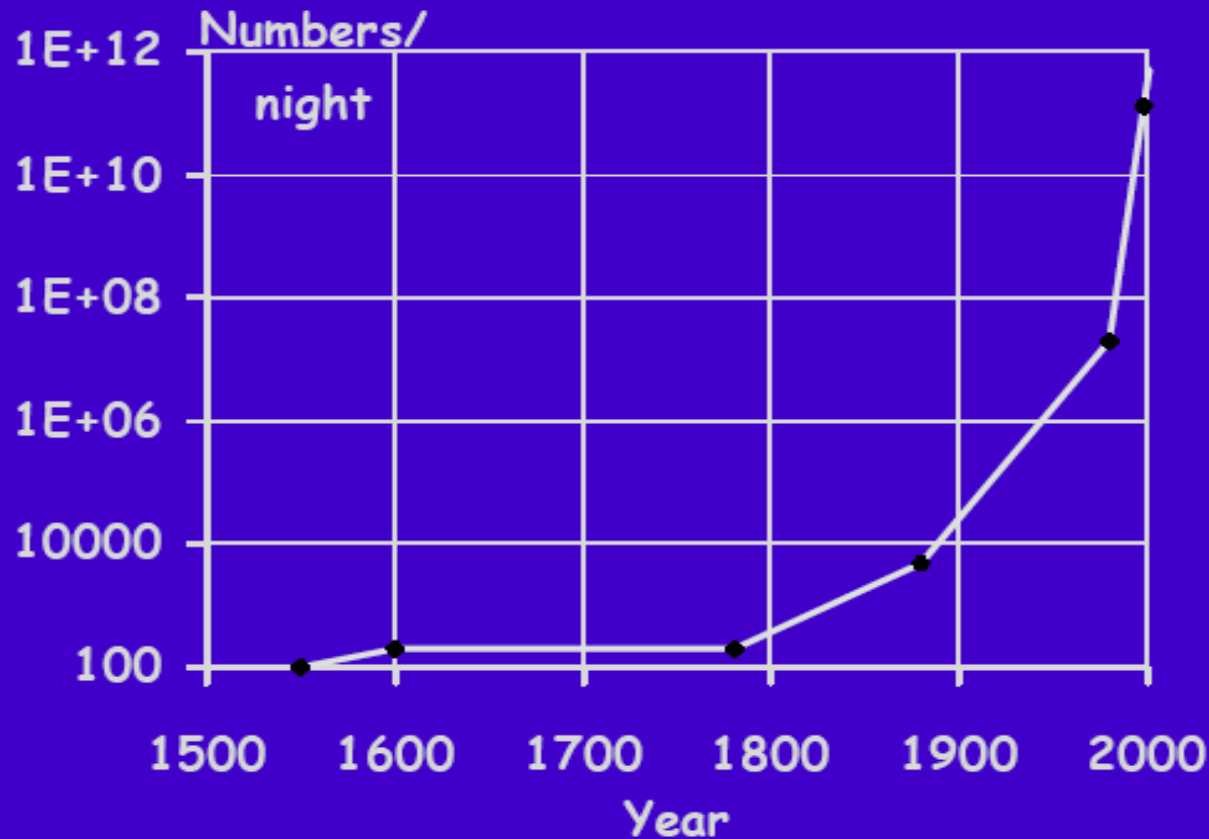


# Data Avalanche

Moore law for chips –doubling 1.5 year

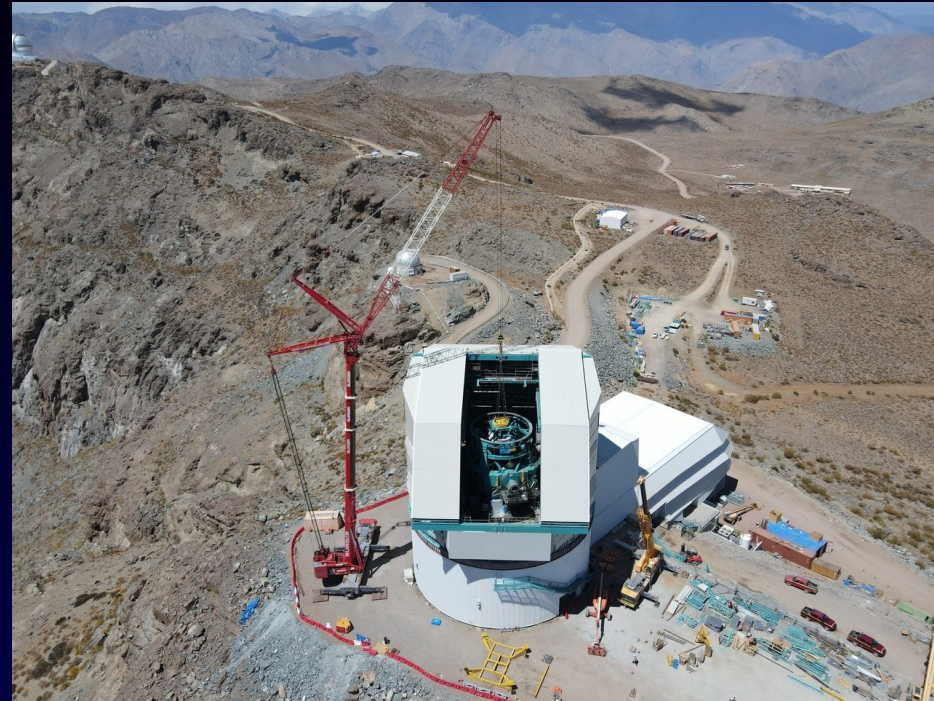
Data in astronomy – doubling < 1 yr ! (9 month current)

100 PB today, 100 TB/night



$T_2 < 18$  mths  
1990-2000

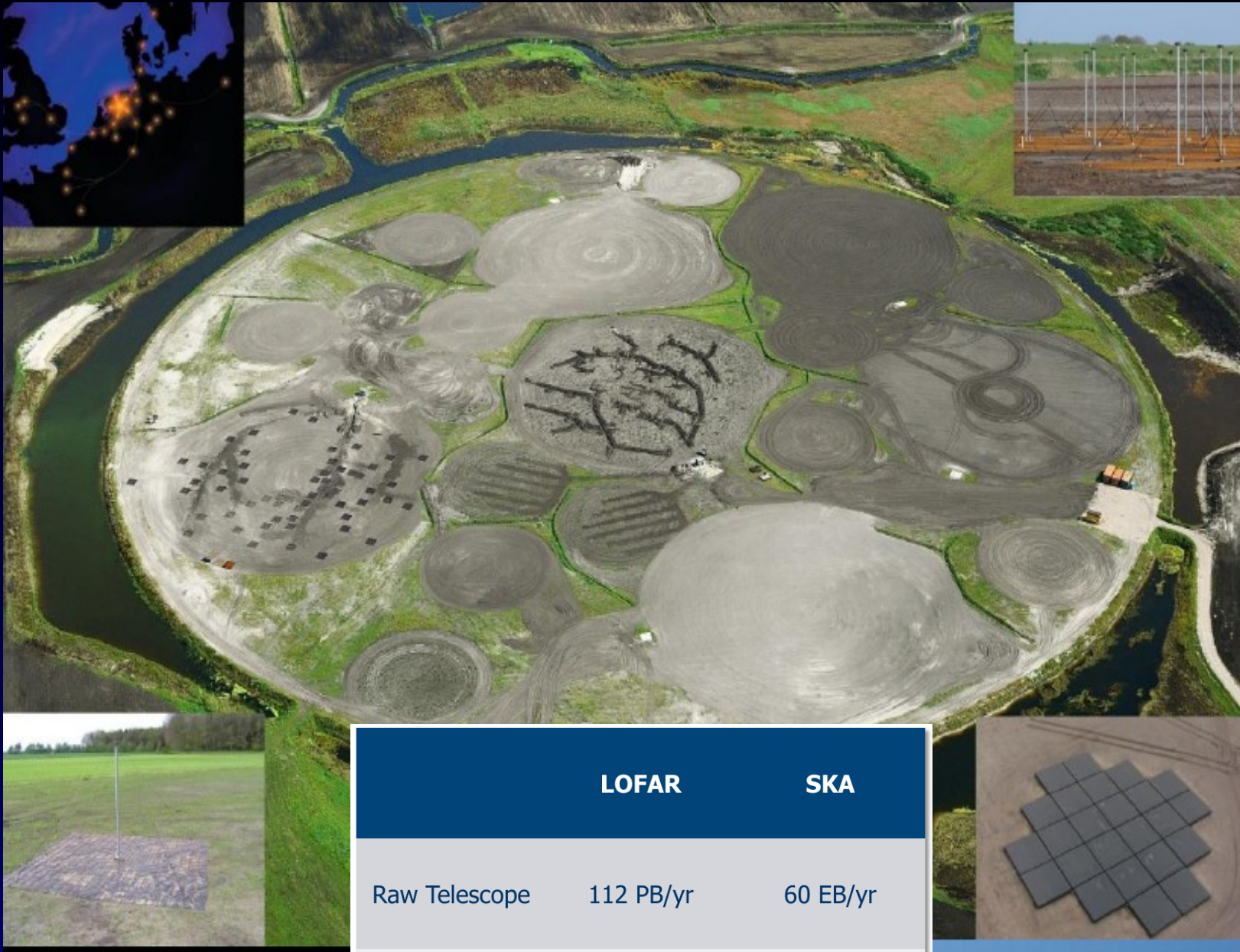
# LSST – Vera C. Rubin Observatory



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

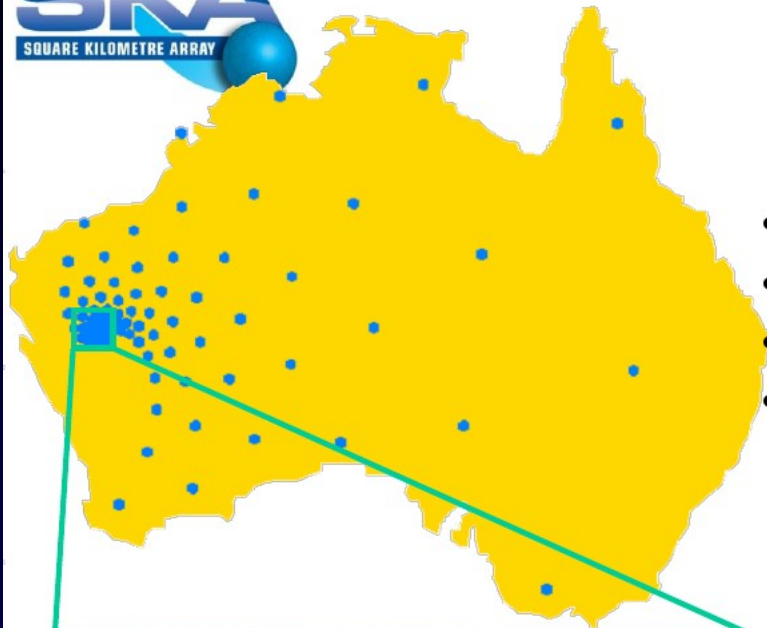


# LOFAR network



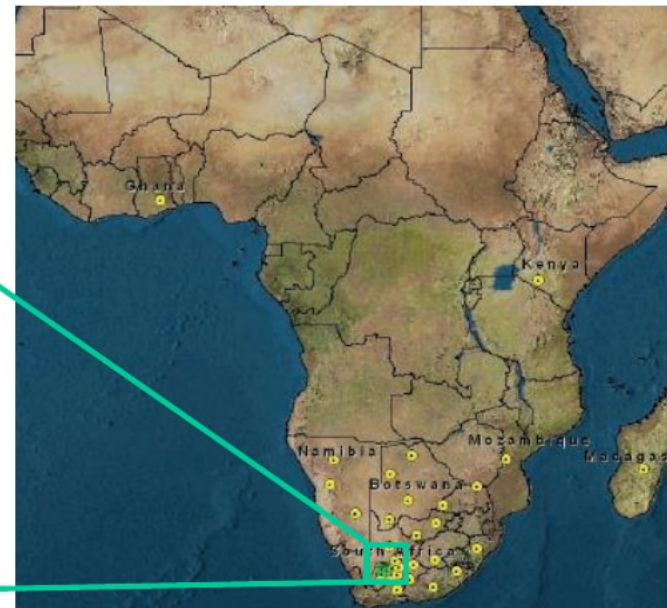
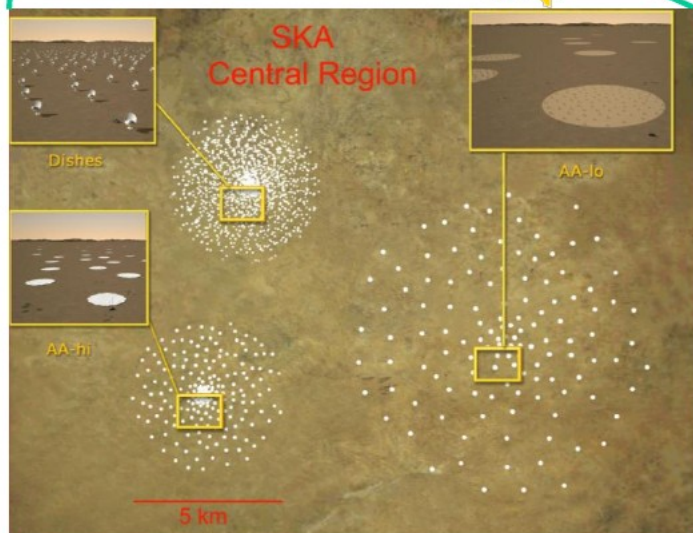
	LOFAR	SKA
Raw Telescope	112 PB/yr	60 EB/yr
Archive Rate	6 PB/yr	100 PB/yr

# SKA



## also a Continental sized Radio Telescope

- Need a radio-quiet site
- Very low population density
- Large amount of space
- Possible sites (decision 2012)
  - Western Australia
  - Karoo Desert RSA





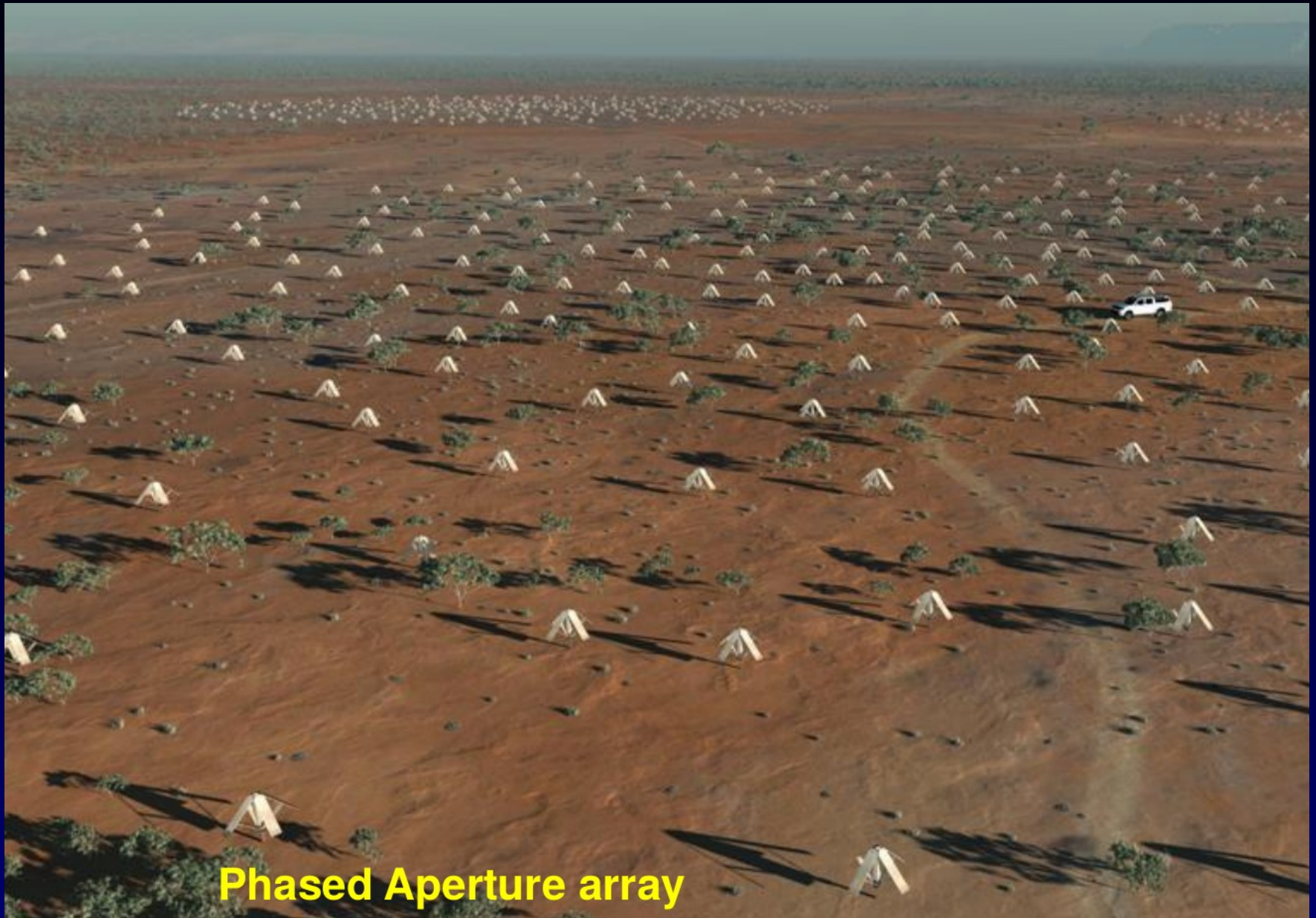
# SKA



Dishes



# SKA



**Phased Aperture array**

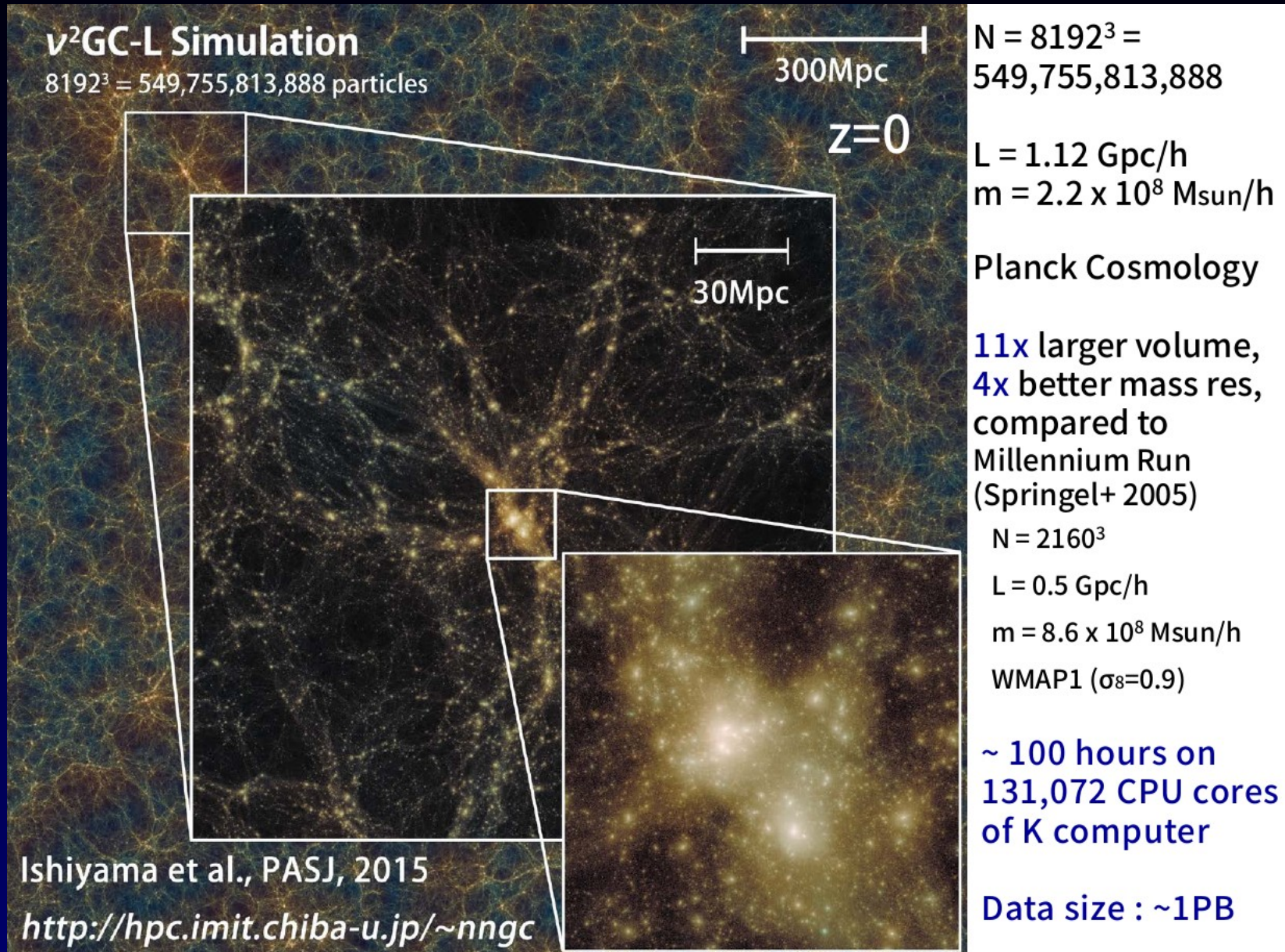


# SKA Archive Volumes

- ~0.5 – 10 PB/day of image data
- Source count  $\sim 10^6$  sources per square degree
- $\sim 10^{10}$  sources in the accessible SKA sky,  $10^4$  numbers/record
- **~1 PB for the catalogued data**

**100 Pbytes – 3 EBytes / year of fully processed data**

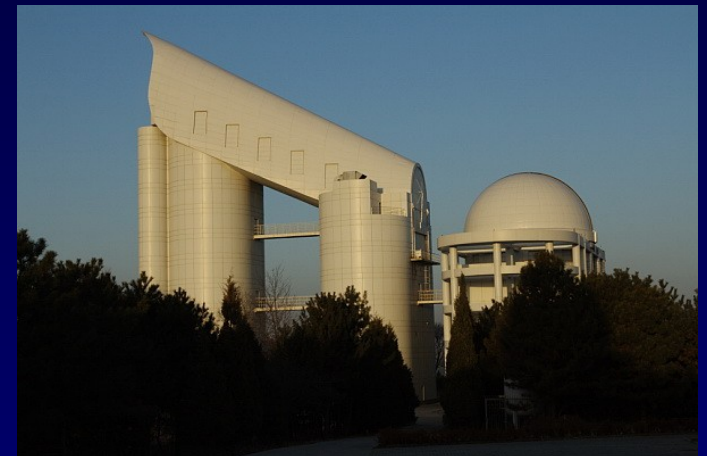
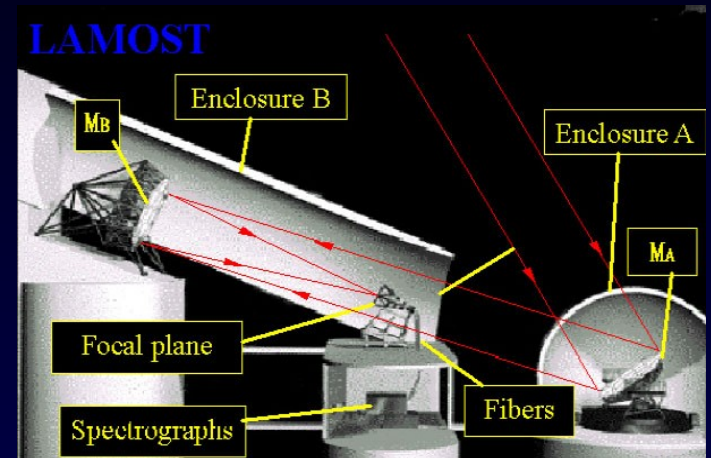
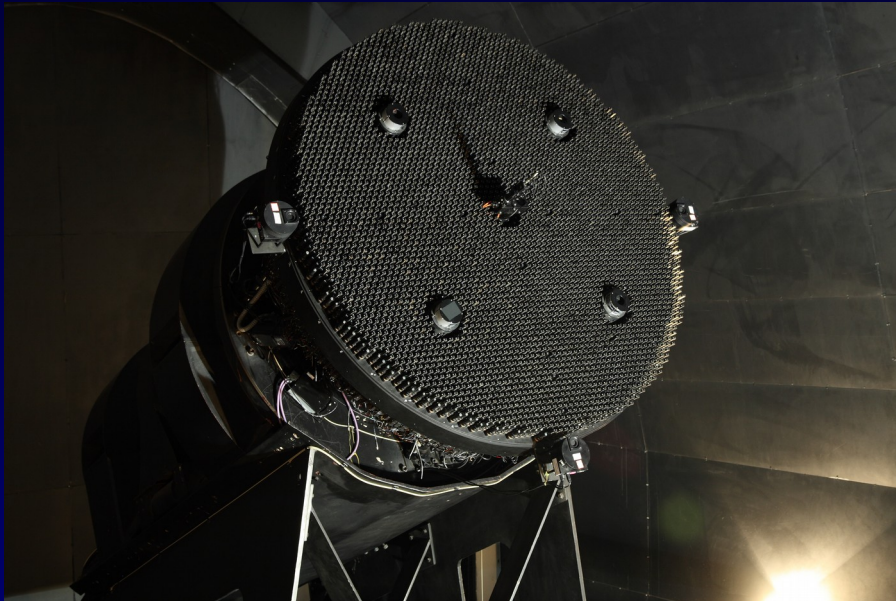
# Simulation of Universe





# LAMOST (Guoshoujing)

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

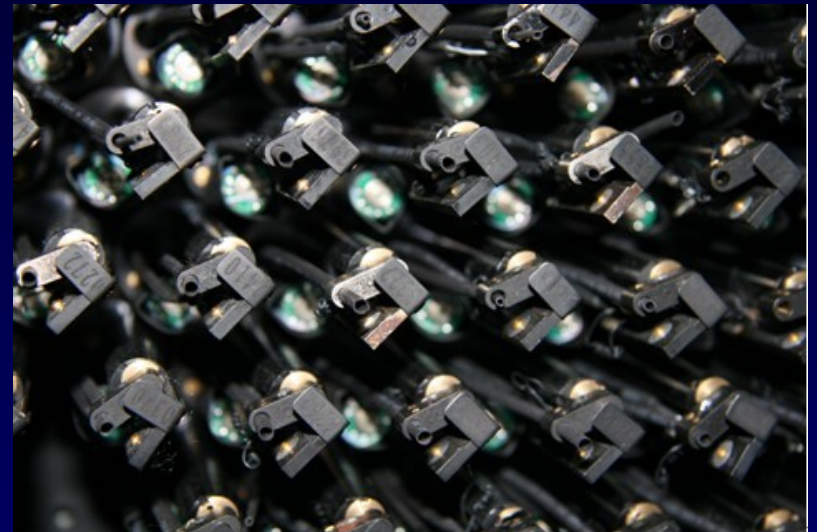


# LAMOST Spectral Surveys

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	
DR6 (half 2018)	<b>+ 739 006</b> <b>+ 249 591 low res.</b> <b>+ 3 508 695 mid res.</b>	

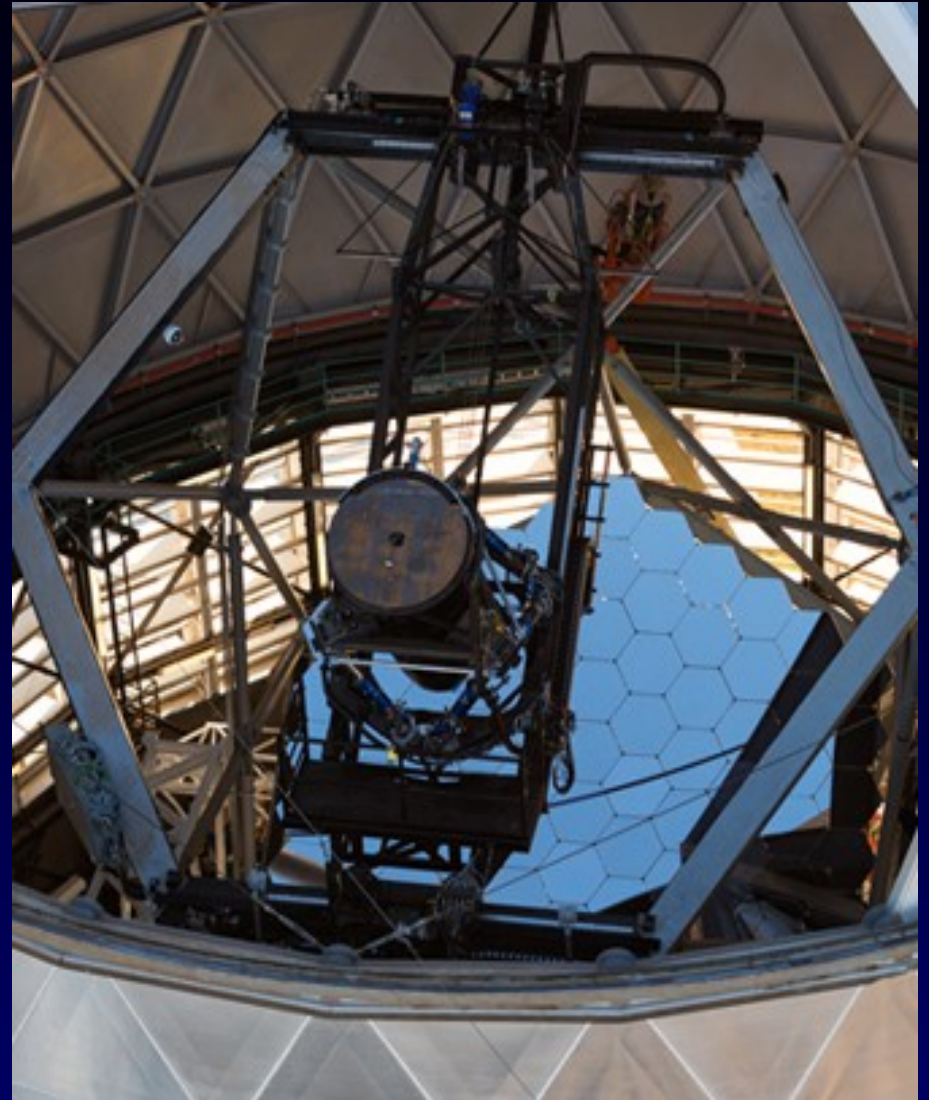
Each fibre – 2 motors  
double arm 33mm circle

Fibre collects light from  
**3.3 arcsec** circle on sky





# Hobby Eberly Telescope (HET)



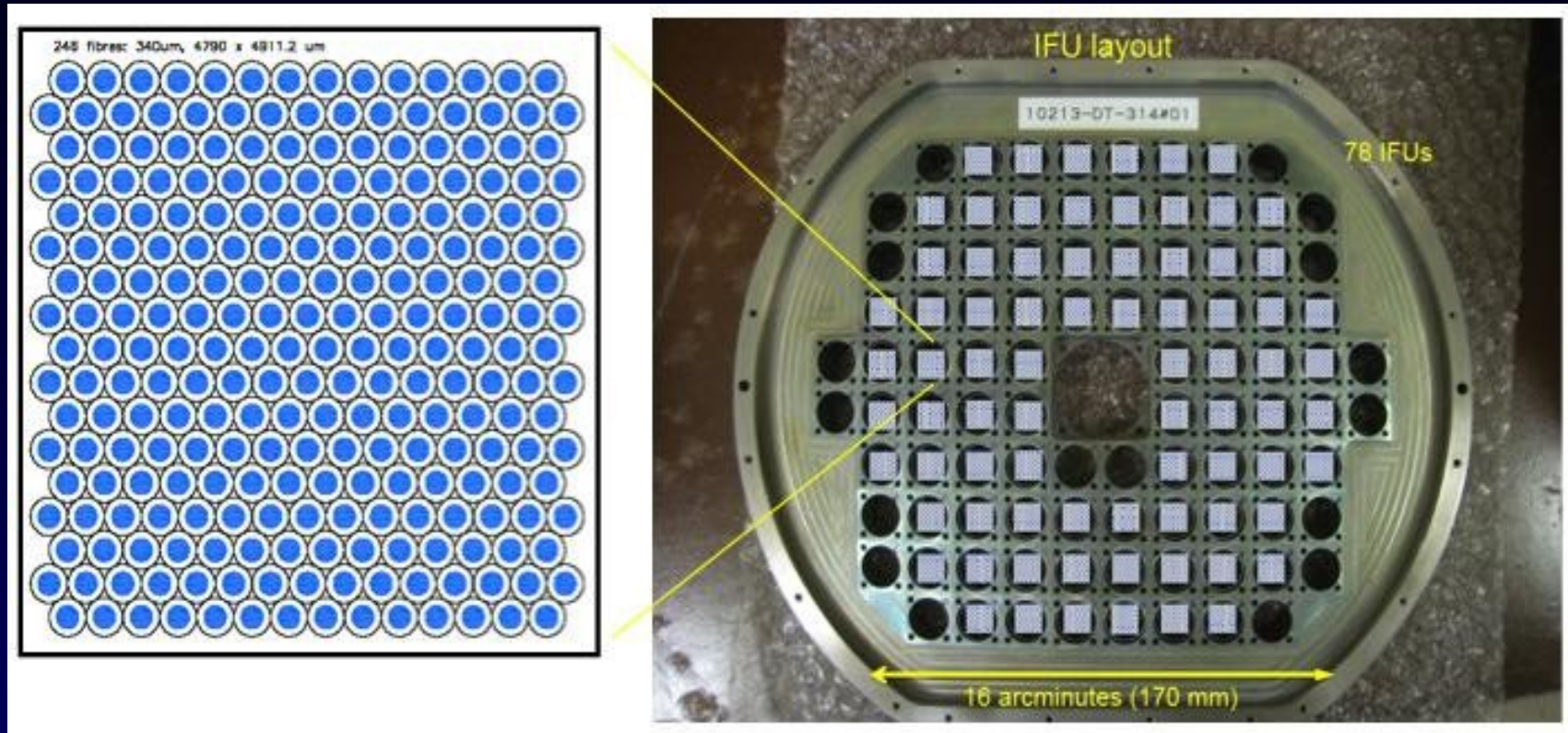
Mc Donald Observatory Texas

Equiv diameter 9.5m (11m)

Fixed in position during observation -  
only primary tracker

# HETDEX Survey

In theory 34944 spectra every 20min !



VIRUS 78 IFU = 156 spectrographs

IFU= 448 fibers

34944 fibers , FOV 22 arcmin, 3500-5500 A, R=800

1 million spectra of galaxies (only part - statistic hits)



# 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)





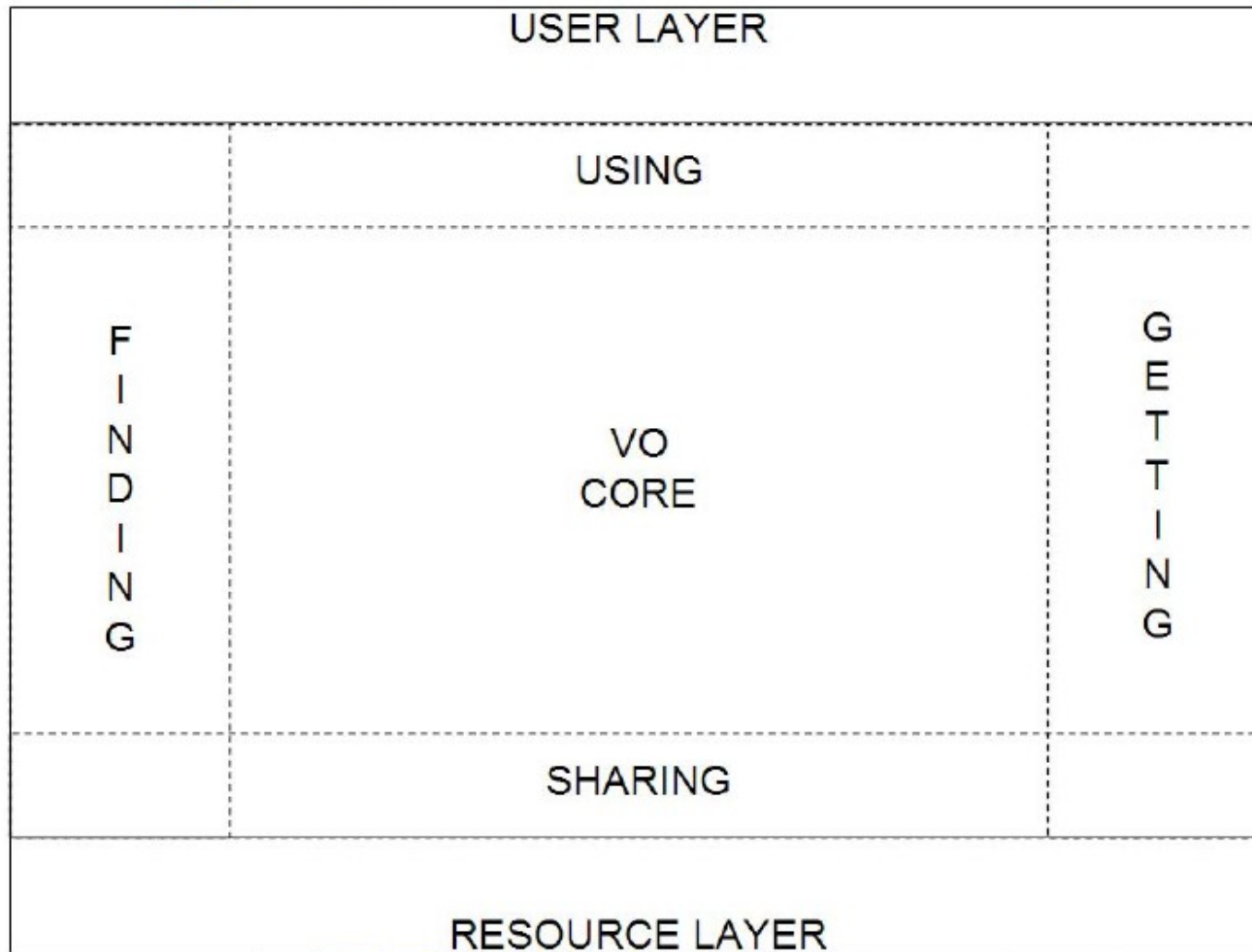
# Ecosystem of VO – level 0

LEVEL 0

USERS



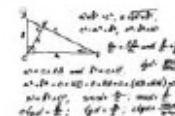
COMPUTERS



20101004  
IVOA Architecture



PROVIDERS



# Ecosystem of VO – level 1

LEVEL 1  
empty

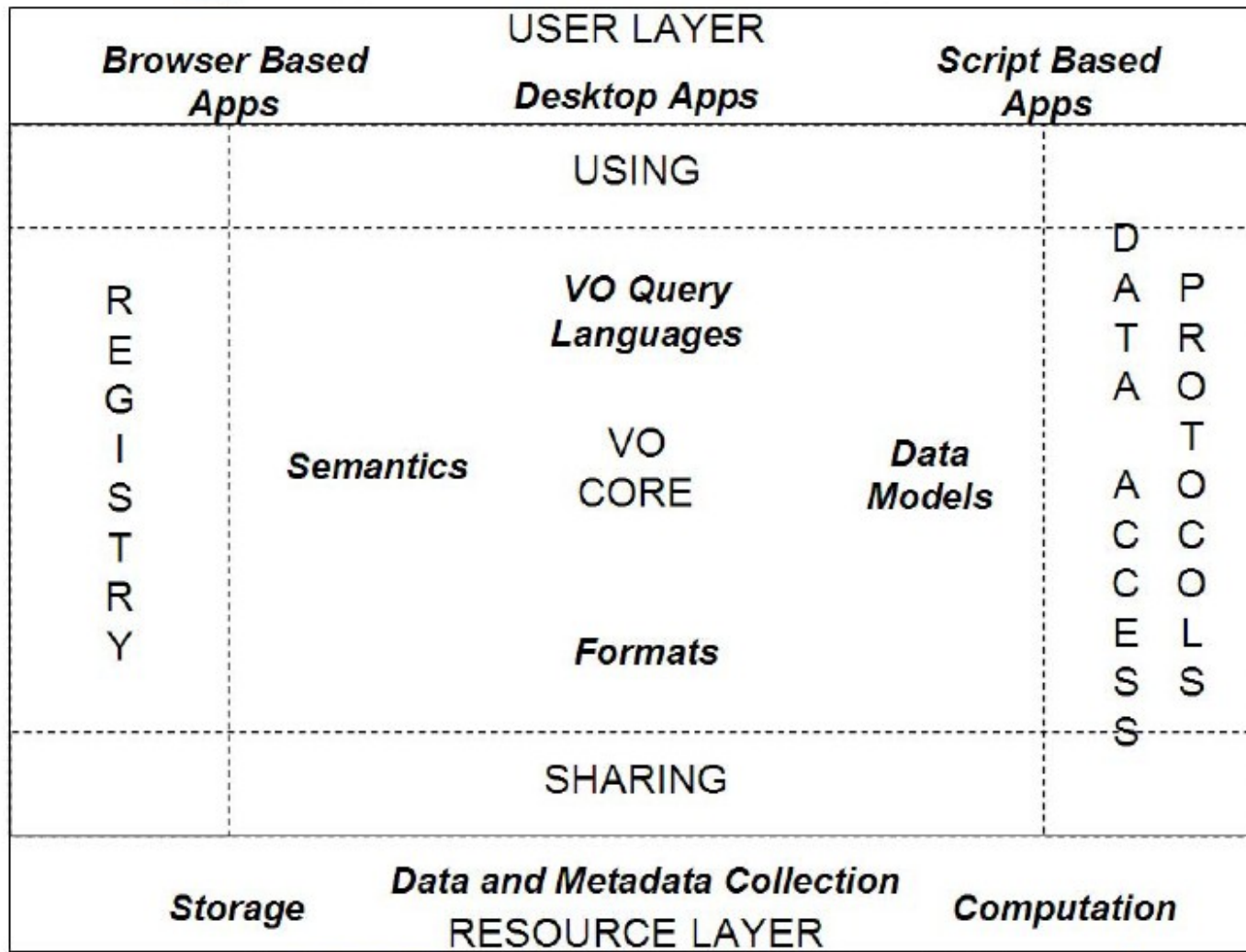
USERS



COMPUTERS

REC

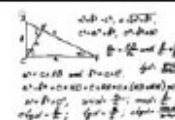
InProgress



20101004  
IVOA Architecture

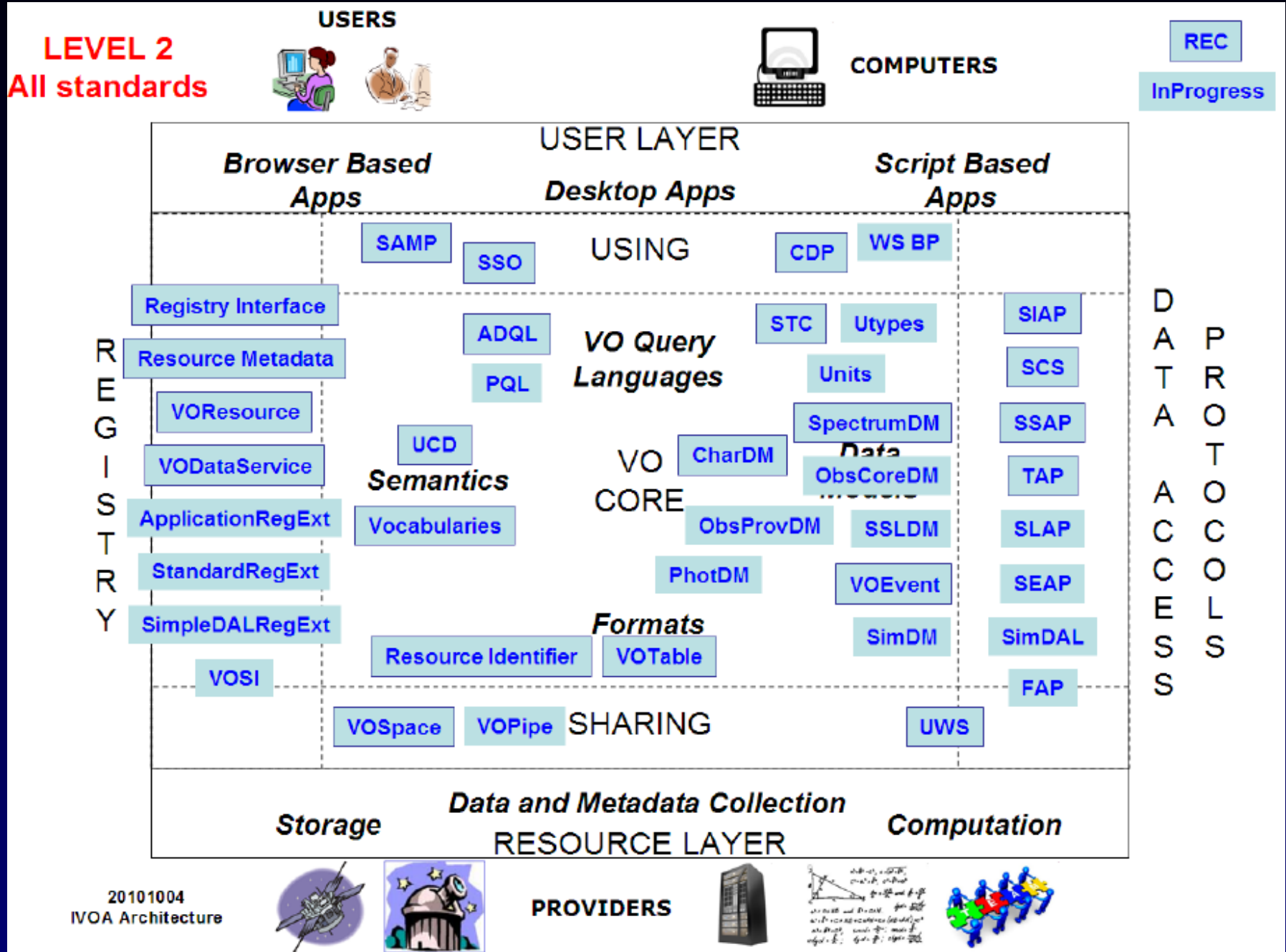


PROVIDERS





# Ecosystem of VO – level 2



# 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



# Technology of VO

Unified data format– VOTable, UCD (Vizier)

Transparent transport (unit conversion)

Web services (WS)

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)

datacubes, DATALINK on-the-fly data processing

# 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)



# Science Portals

ESASky

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

ESO Archive Science Portal

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

IRSA IPAC archive (Firefly)

<https://irsa.ipac.caltech.edu/irsaviewer/>

# 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

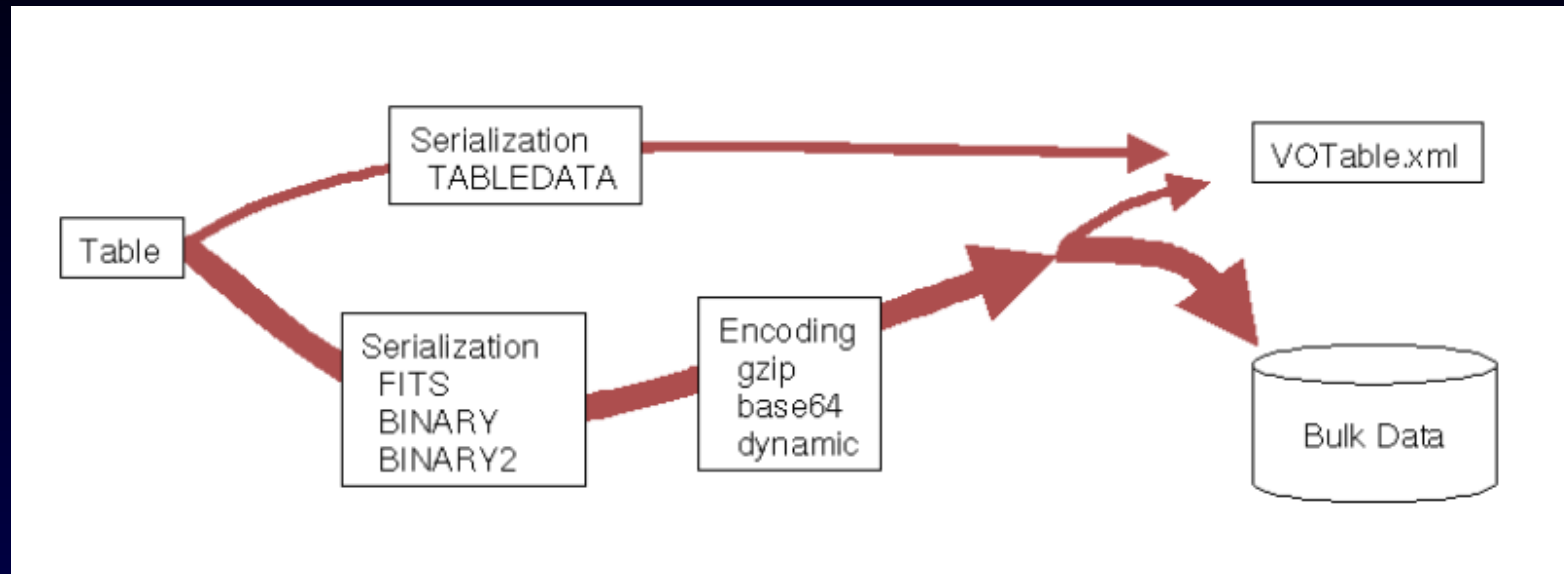
BIG DATA transfer

Links to streams...

Live pre-processing URLs

On-the-fly creation of data

# VOTable Serialization



```
<RESOURCE>
  <PARAM name="EPOCH" datatype="float" value="1999.987">
    <DESCRIPTION> Original Epoch of the coordinates</DESCRIPTION>
  </PARAM>
  <PARAM name="TELESCOP" datatype="char" arraysize="*" value="VTel" />
  <INFO name="HISTORY">
    The very first Virtual Telescope observation made in 2002
  </INFO>
  <TABLE>
    <FIELD (insert field metadata here) />
    <DATA><FITS extnum="2">
      <STREAM encoding="gzip" href="ftp://archive.cacr.caltech.edu/myfile.fit.gz"/>
    </FITS></DATA>
  </TABLE>
</RESOURCE>
```



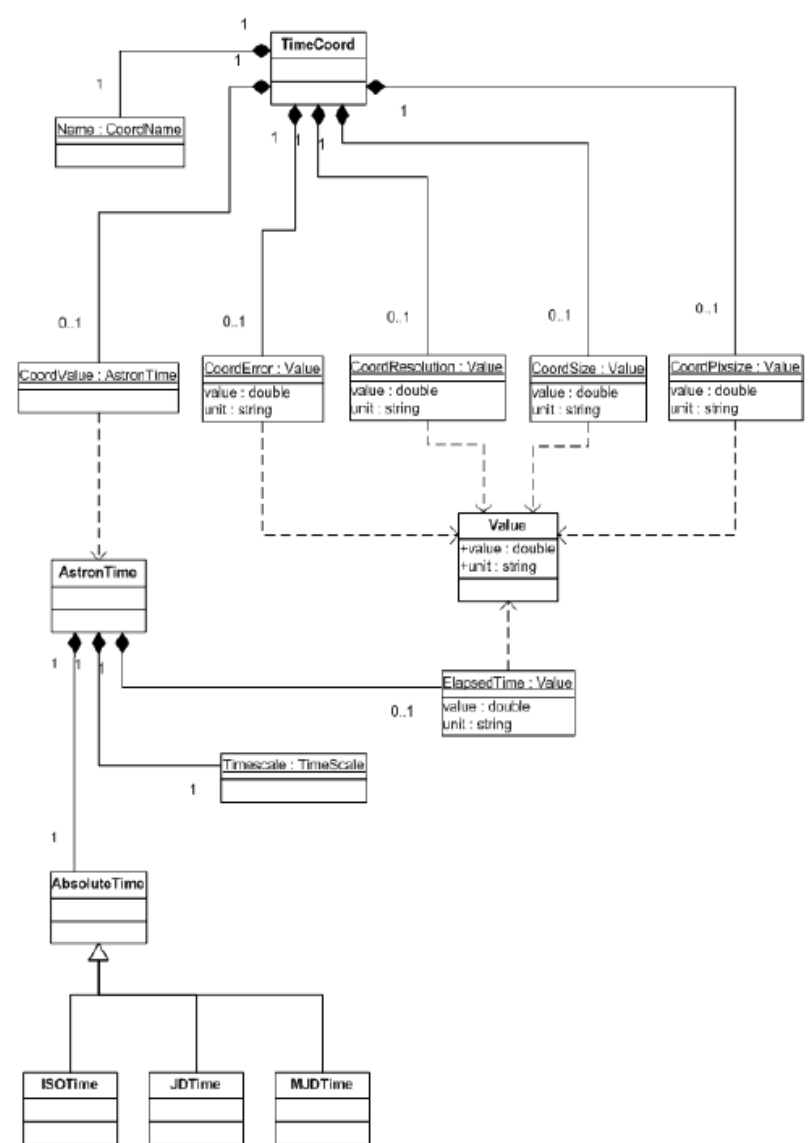
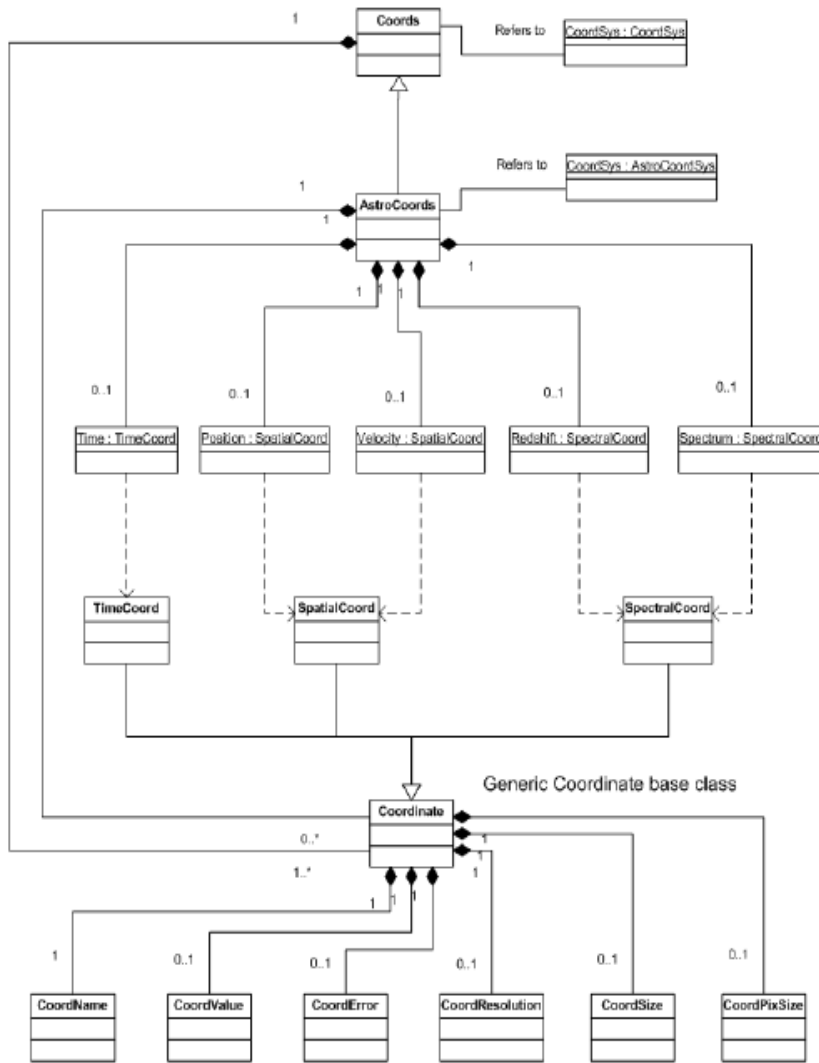
# Universal Content Descriptors

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

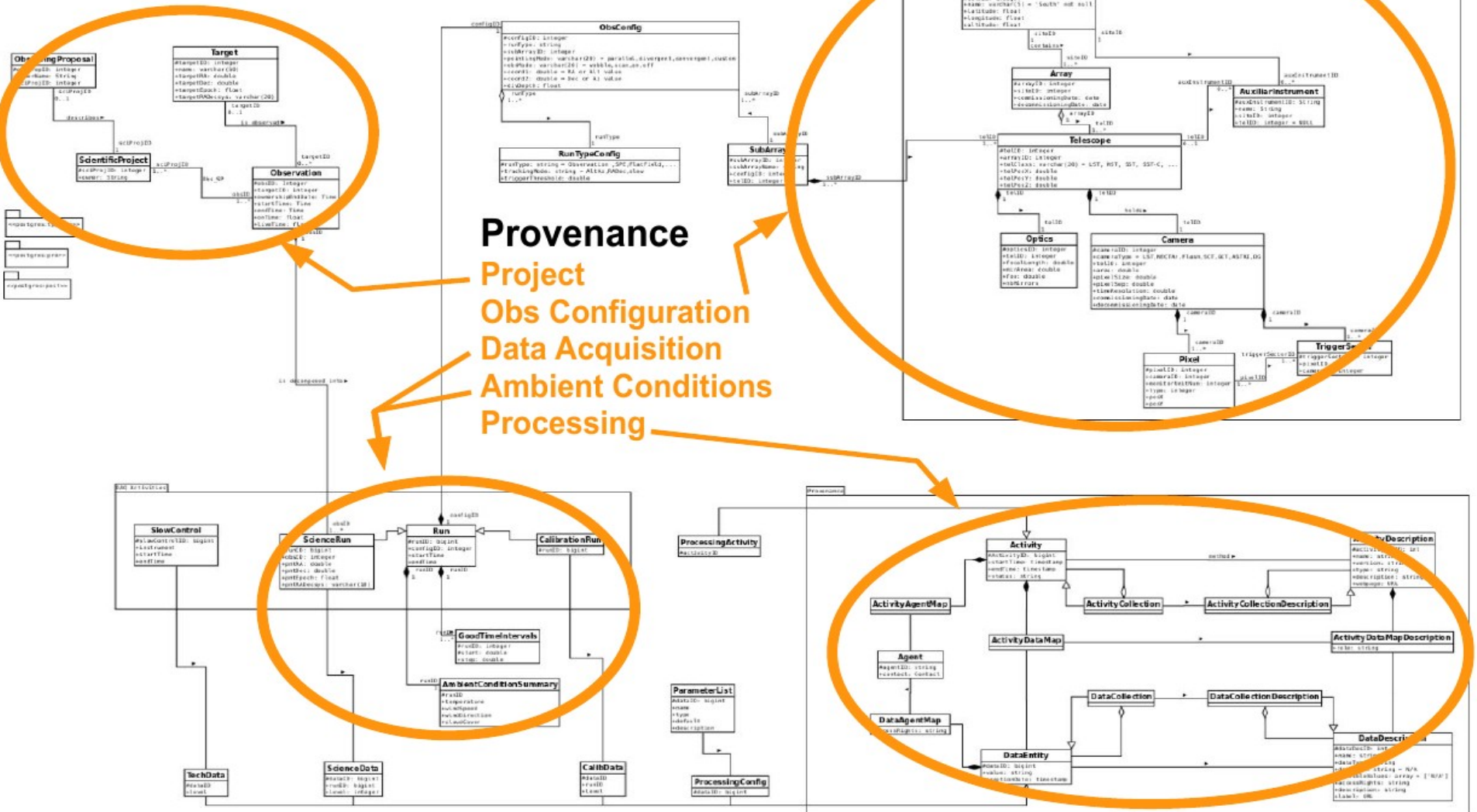
# Space-Time-Coordinate Data Model





# Cherenkov Telescope Array Data Model

## CTA data model



# 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  
Virtual  
Observatory  
Alliance*

## Simple Spectral Access Protocol

Version 1.04

IVOA Recommendation Feb 01, 2008

**This version:**

<http://www.ivoa.net/Documents/REC/DAI/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:**

D.Tody, M. Dolensky

**Authors:**

D.Tody, M. Dolensky, J. McDowell, F. Bonnarel, T. Budavari, I. Busko, A. Micol, P. Osuna, J. Salgado, P. Skoda, R. Thompson, F. Valdes, and the data access layer working group.



*International  
Virtual  
Observatory  
Alliance*

## 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:**

Jonathan McDowell, Doug Tody

**Contributors:**

Jonathan McDowell, Doug Tody, Tamas Budavari, Markus Dolensky, Inga Kamp, Kelly McCusker, Pavlos Protopapas, Arnold Rots, Randy Thompson, Frank Valdes, Petr Skoda, and the IVOA Data Access Layer and Data Model Working Groups.



# SSAP Parameters

## 4.1.1 Mandatory Query Parameters

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

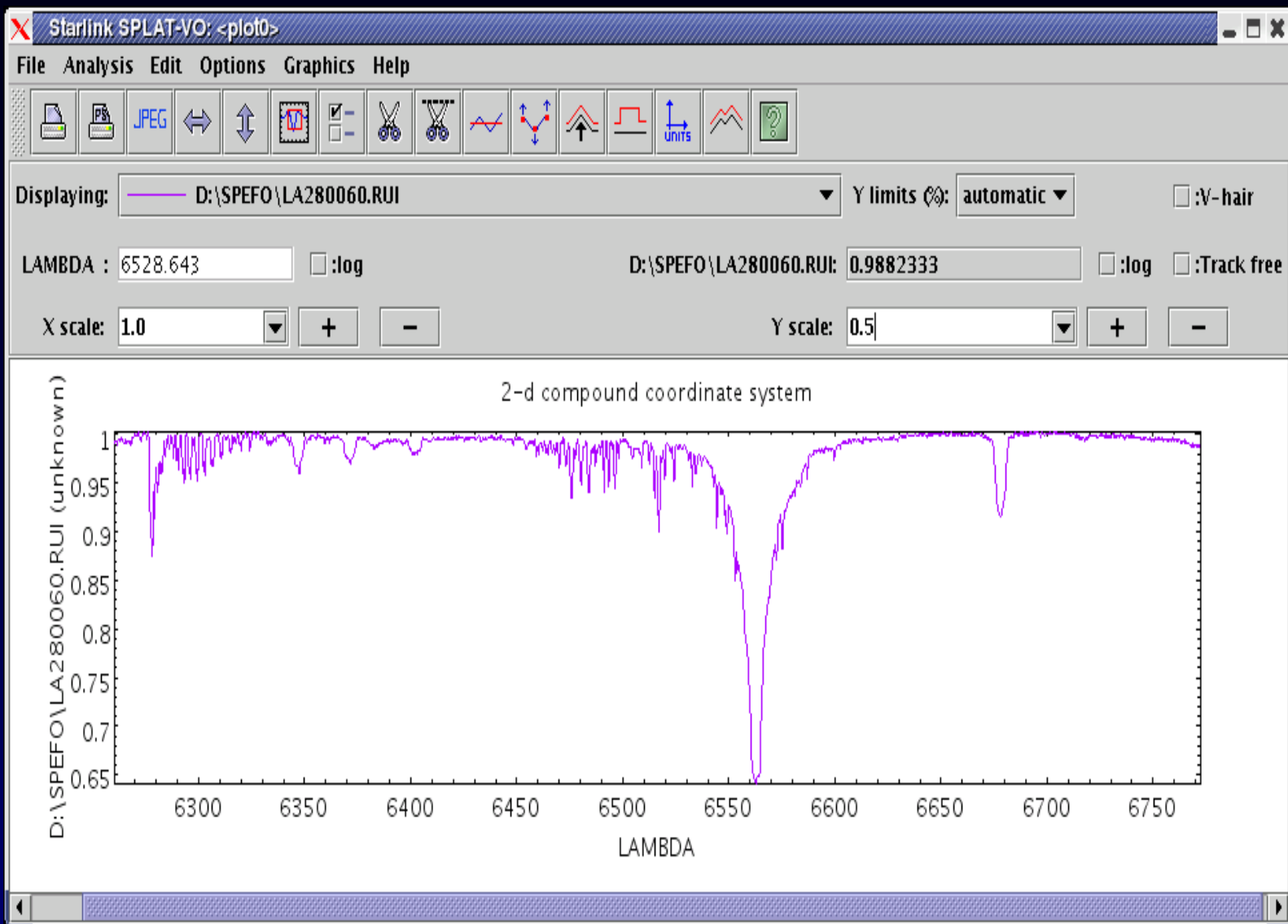
<i>Parameter</i>	<i>Sample value</i>	<i>Physical unit</i>	<i>Datatype</i>
POS	52, -27.8	degrees; defaults to ICRS	string
SIZE	0.05	degrees	double
BAND	2.7E-7/0.13	meters	string
TIME	1998-05-21/1999	ISO 8601 UTC	string
FORMAT	votable	-	string

## 4.1.2 Recommended and Optional Query Parameters

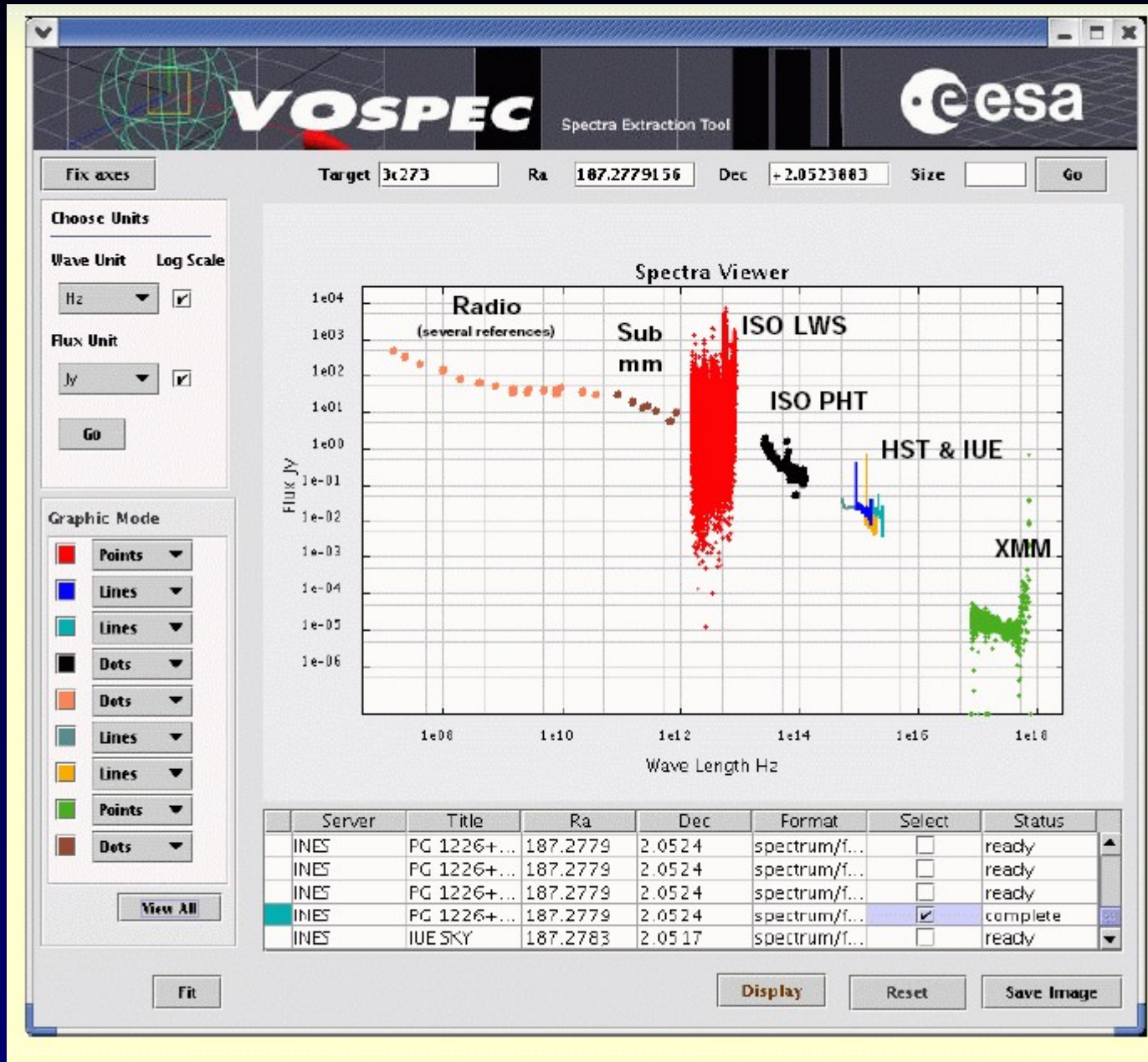
Parameter	Sample value	Unit	Req	Datatype
APERTURE	0.00028 (=1")	degrees	OPT	double
SPECRP	2000	$\lambda/d\lambda$	REC	double
SPATRES	0.05	degrees	REC	double
TIMERES	31536000 (=1yr)	seconds	OPT	double
SNR	5.0	dimensionless	OPT	double
REDSHIFT	1.3/3.0	dimensionless	OPT	string
VARAMPL	0.77	dimensionless	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, spectral, and time resolution of the data are all the usual astronomical units.

# SPLAT-VO (Starlink, Heidelberg, Ondrejov)



# VOSpec (ESAC)





# Aladin- HIPS

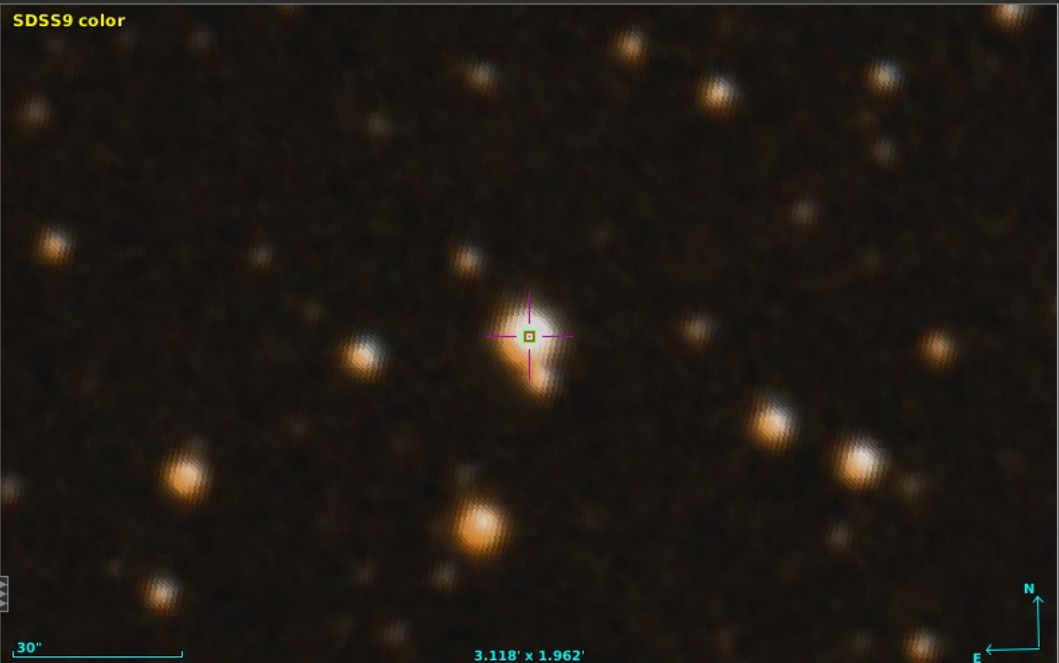
Aladin v10.1 \*\*\* BETA VERSION (based on v10.117) \*\*\*

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Command 05:03:57.48 +44:17:43.4 Frame ICRS Projection Aitoff

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

**SDSS9 color**




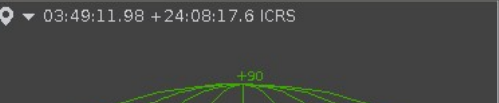


Imagine your eye looking through a stack of planes (below). Each plane contains its own data set: image, catalog, graphical overlays... You see the combination of them in the main panel. For accessing to other data, use the discovery tree in the left panel, or clic & drag your own local files.

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

CDS/Simbad  
CDS/P/SDSS9/color  
CDS/P/DSS2/color

epoch -  
size -  
dens. -  
cont. -  
opac. -  
zoom -

03:49:11.98 +24:08:17.6 ICRS



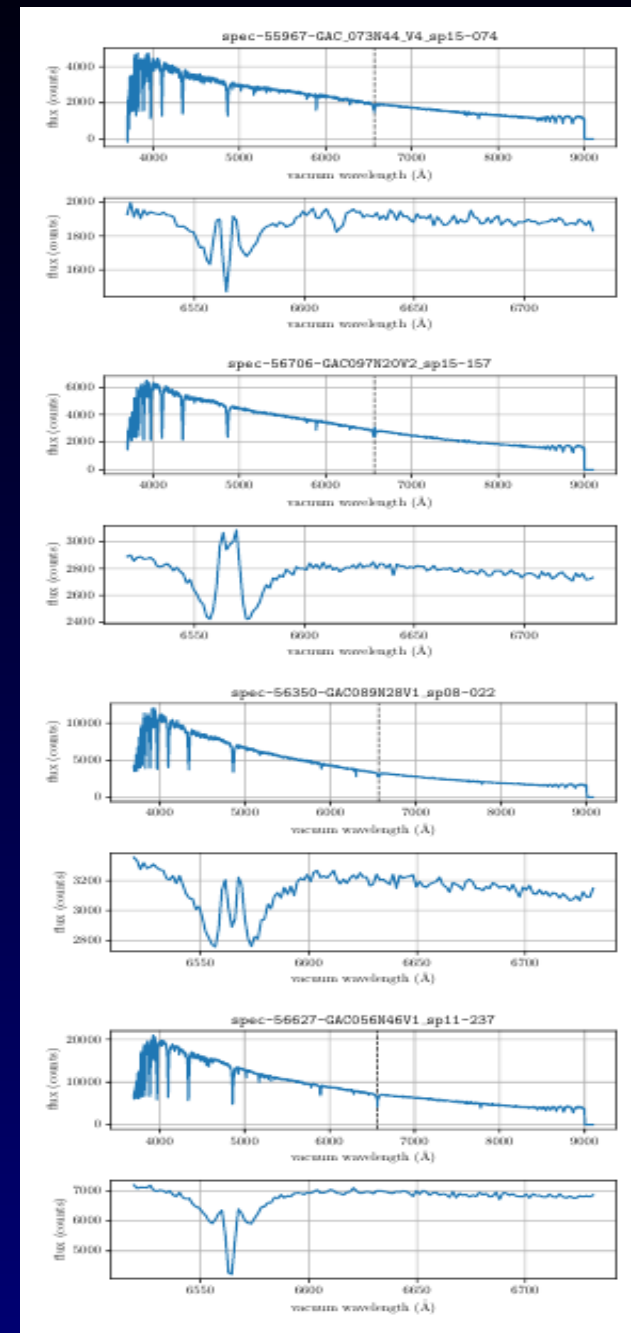
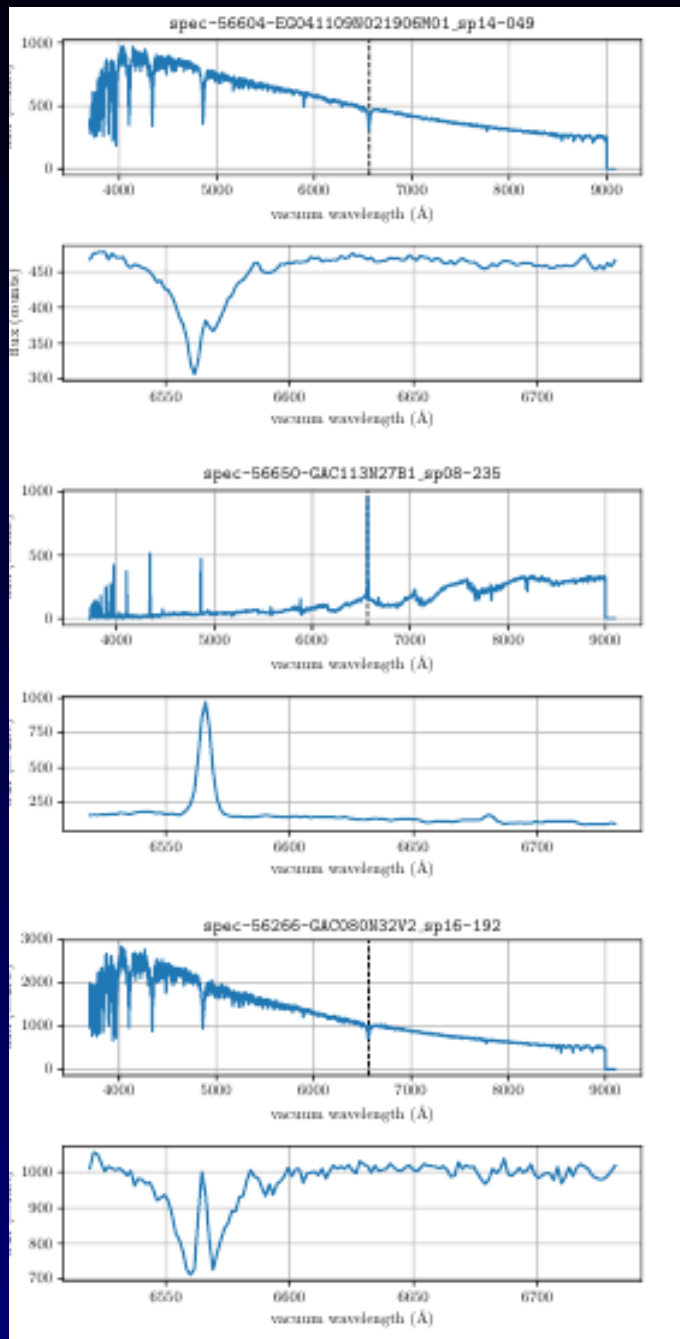
05:04:00.87840 +44:18:11.2320  
3.118' x 1.962'

main_id	nbref	ra_sesa	dec_sesa	main_type	other_ty...	radvel
EM* VES 867	6	05 04 00.88182	+44 18 11.2916	Em*	Em*   *   IR	

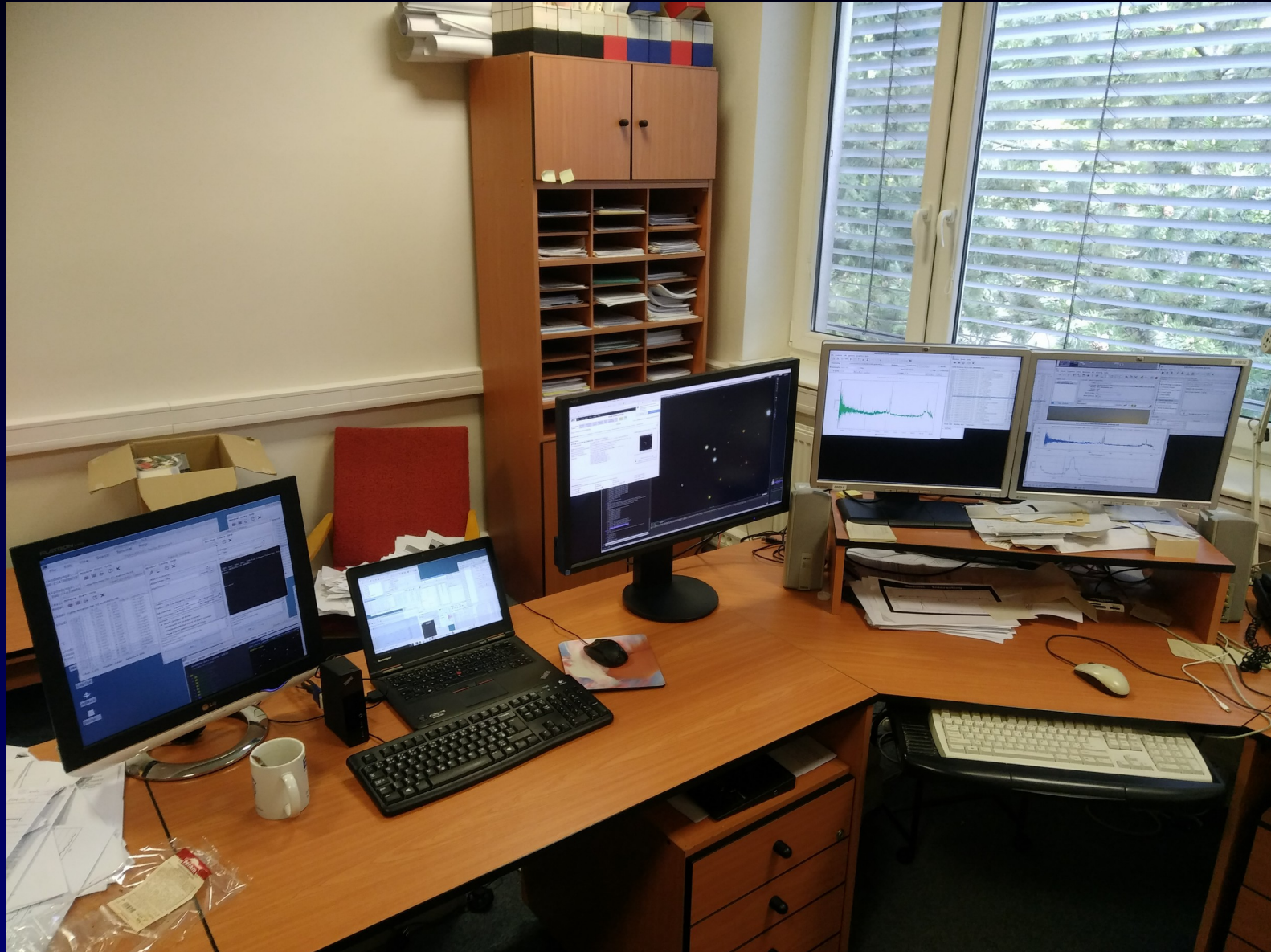
grid study wink north hdr multiview match Search

(c) 2018 Université de Strasbourg/CNRS - developed by CDS, distributed under GPLv3 1 sel / 4370 src 429Mb

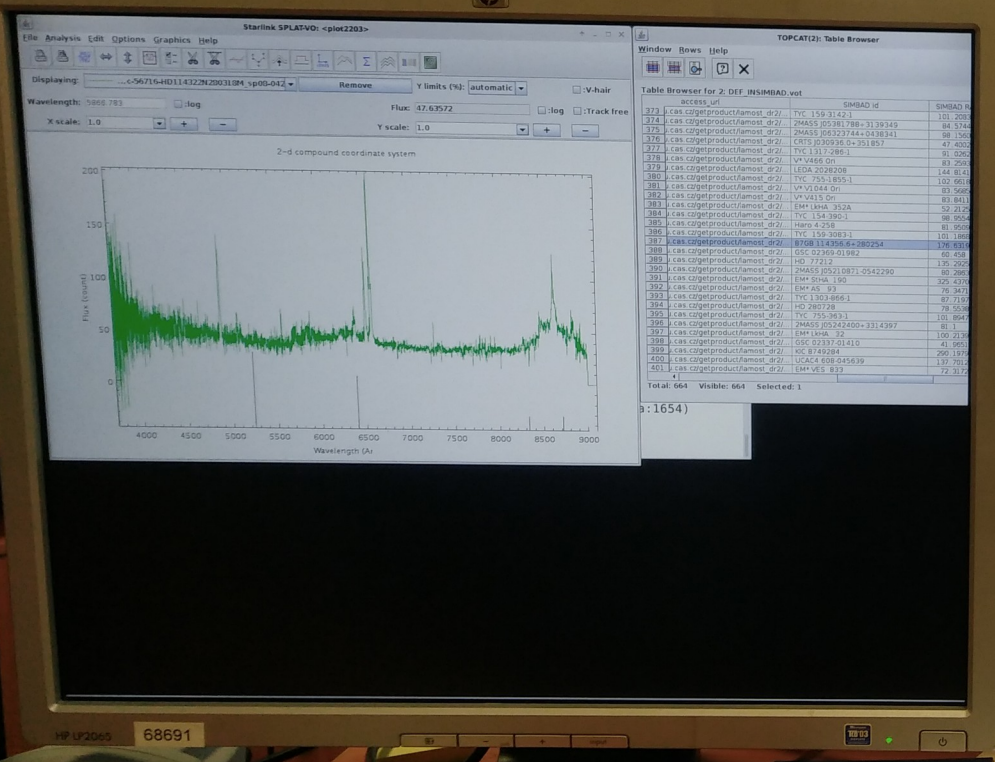
# Single-peak & Double-peak Candidates



# Analysis





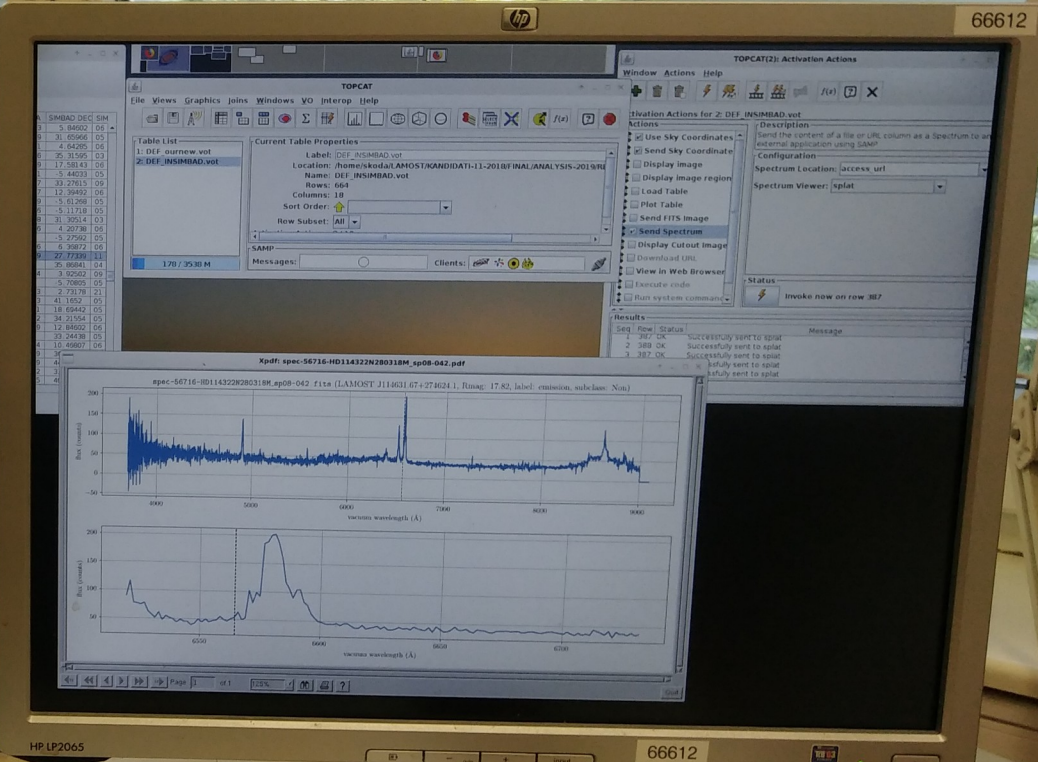


TOPCAT2: Table Browser

Table browser for 2: DEF\_INSMBAD.vot

access_url	SIMBAD ID	SIMBAD R
373   cas.cageproduct/famost-dr2   TYC 13231121   101.2708		
374   cas.cageproduct/famost-dr2   2MASX J05391788+3139349   84.1364		
375   cas.cageproduct/famost-dr2   2MASX J06327744+0418341   98.1560		
376   cas.cageproduct/famost-dr2   CR3 025935.0+331837   47.4008		
377   cas.cageproduct/famost-dr2   TYC 1317285   91.2360		
378   cas.cageproduct/famost-dr2   VV V4691.01   83.2708		
379   cas.cageproduct/famost-dr2   LEDA 2028208   144.8141		
380   cas.cageproduct/famost-dr2   TYC 7531859-1   102.6616		
381   cas.cageproduct/famost-dr2   VV V1044.01   93.5688		
382   cas.cageproduct/famost-dr2   VV V415.01   83.8413		
383   cas.cageproduct/famost-dr2   EM 1484_332A   88.9564		
384   cas.cageproduct/famost-dr2   TYC 154390-1   52.2125		
385   cas.cageproduct/famost-dr2   NAME 4258   81.9508		
386   cas.cageproduct/famost-dr2   TYC 1593983-1   101.1488		
387   cas.cageproduct/famost-dr2   8708 114356.6+282254   176.8119		
388   cas.cageproduct/famost-dr2   GSC 02193.0182   60.4818		
389   cas.cageproduct/famost-dr2   HD 77212   135.2025		
390   cas.cageproduct/famost-dr2   2MASX J052108710542290   100.2055		
391   cas.cageproduct/famost-dr2   EM 504A_150   329.4118		
392   cas.cageproduct/famost-dr2   EM X5_V3   76.3471		
393   cas.cageproduct/famost-dr2   TYC 1303866-1   87.1189		
394   cas.cageproduct/famost-dr2   HD 280728   78.5038		
395   cas.cageproduct/famost-dr2   TYC 7253983-1   101.8645		
396   cas.cageproduct/famost-dr2   2MASX J0242400+3314397   81.1111		
397   cas.cageproduct/famost-dr2   EM 1484_33   100.2118		
398   cas.cageproduct/famost-dr2   GSC 02337-01410   41.9915		
399   cas.cageproduct/famost-dr2   GSC 0749284   260.1378		
400   cas.cageproduct/famost-dr2   USAC 609045639   117.7614		
401   cas.cageproduct/famost-dr2   EM VES 833   72.3172		

Total: 664 Visible: 664 Selected: 1



Handwritten notes and printed documents on the desk. Visible text includes:

- MIRASTROLOGER
- CHAO H 11010
- Handwritten notes on lined paper, including "program" and "output" sections.



87GB 114356.6+280254

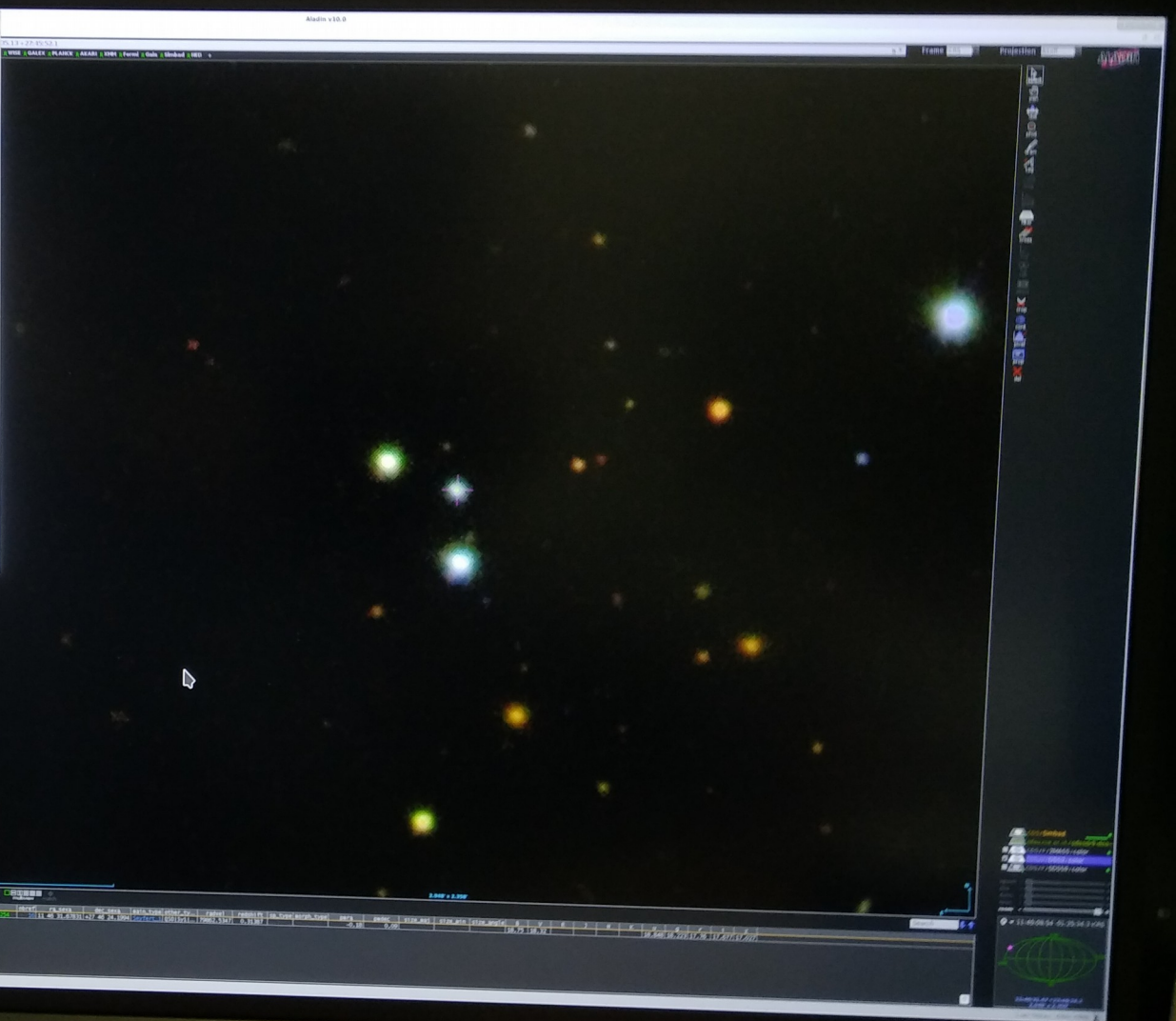
Query: 87GB 114356.6+280254 CDS: SIMBAD4 rev 1.7 2019.05.10CEST15:13:18

Available data: Basic data • Identifiers • Plot & images • Bibliography • Measurements • External archives • Notes • Annotations

Basic data:  
**87GB 114356.6+280254 -- Seyfert 1 Galaxy**  
 Other object types:  
 ICRS coord. (epo=J2000):  
 FK4 coord. (epo=J1950):  
 Gal coord. (epo=J2000):  
 Proper motions mas/yr:  
 Radial velocity / Redshift / cz:  
 Fluxes (B):

Identifiers (20):  
 An access of full data is available using the icon Viner near the identifier of the catalogue

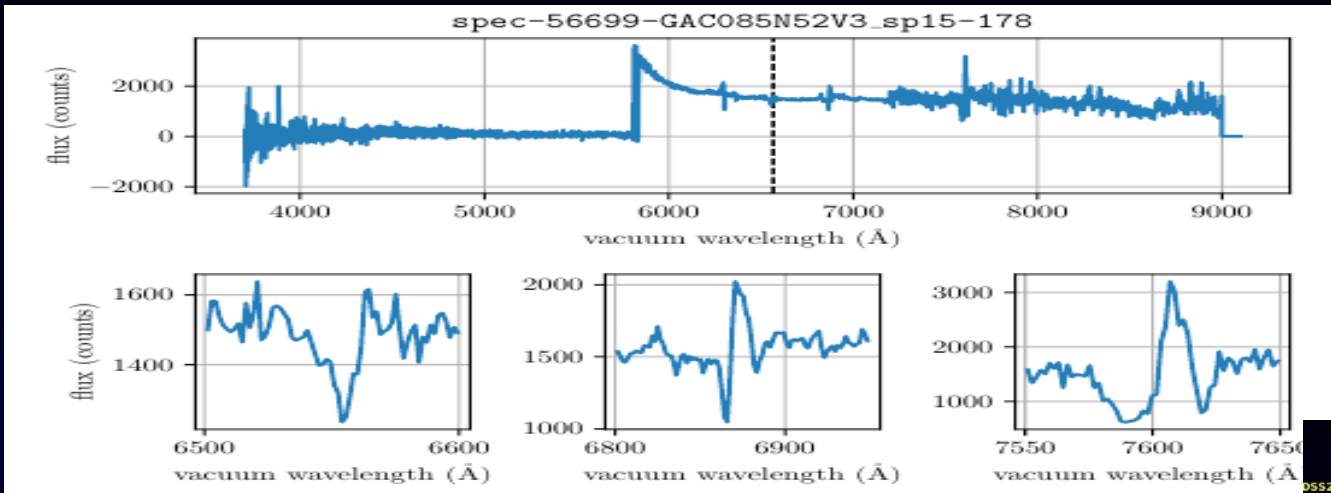
ID	NAME	RA (J2000)	DEC (J2000)	MAG	CLASS
87GB 114356.6+280254	87GB 114356.6+280254	31 46 31.470382371	+27 46 24.193356448	16.80	Galaxy
...	...	...	...	...	...



- Data release 6 of Sloan Digital Sky Survey Catalogs
- Data release 7 of Sloan Digital Sky Survey Catalogs
- Data release 7 of Sloan Digital Sky Survey Catalogs
- Data release 7 of Sloan Digital Sky Survey Catalogs
- Data release 7 of Sloan Digital Sky Survey Catalogs
- Data release 7 of Sloan Digital Sky Survey Catalogs
- Data release 7 of Sloan Digital Sky Survey Catalogs
- The SDSS data release of SDSS
- The SDSS data release of SDSS
- SDSS DR12 white dwarfs catalog
- SDSS DR12 white dwarfs catalog
- Laurotic et al 2011 Catalog of wide photometric redshifts for SDSS candidate quasars
- Laurotic et al 2011 Catalog of wide photometric redshifts (optical-NV) for SDSS candidate quasars
- IRVIZO Database et al 2006 Catalog of SDSS Quasar candidates
- Sloan Digital Sky Survey Core Search (Latest Release)
- Sloan Digital Sky Survey (DR1)
- Sloan Digital Sky Survey (DR2)
- Sloan Digital Sky Survey (DR3)
- Sloan Digital Sky Survey (DR4)
- Sloan Digital Sky Survey (DR5)
- Sloan Digital Sky Survey (DR6)
- Sloan Digital Sky Survey (DR7)
- Sloan Digital Sky Survey (DR8)
- Sloan Digital Sky Survey (DR9)
- Sloan Digital Sky Survey Data Release 3
- Sloan Digital Sky Survey Data Release 5
- Sloan Digital Sky Survey Data Release 6
- Sloan Digital Sky Survey Data Release 7
- Sloan Digital Sky Survey Data Release 8
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- Sloan Digital Sky Survey Data Release 99
- Sloan Digital Sky Survey Data Release 100



# Visual Verification of Object with Disk



Aladin v10.0

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Available data → 2314

Command

Frame ICRS Projection Aitoff

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

select

pan

dist

phot

draw

tag

mos

spec

filter

cross

copy

rgb

epoch

size

crop

spec

cont

zoom

pixel

prop

del

select

from

exp. sort view scan filter

grid study work north hd

multiview match

Last news

Aladin is now available in Tur May 2019)

New HIPs available:

- DECaPS DR5 g, DECaLS DR5 (Jun 2019-CD5)
- IPHAS DR2 r and alpha (Feb 2019-CD3)
- HIPASS cube (Feb 2019-CD5)

cds/r / DSS2/color

05:39:44.81 +53:18:25.7 ICRS

05:39:44.81 +53:18:25.7 1.000" x 51.01"

1.000" x 51.01"



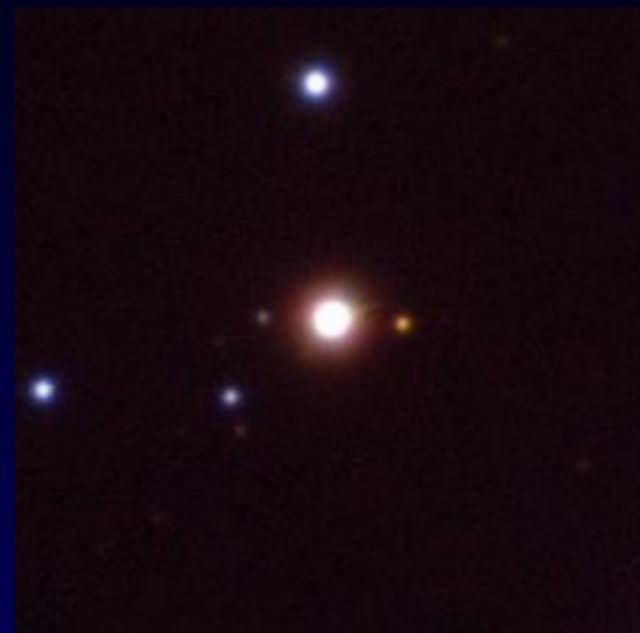
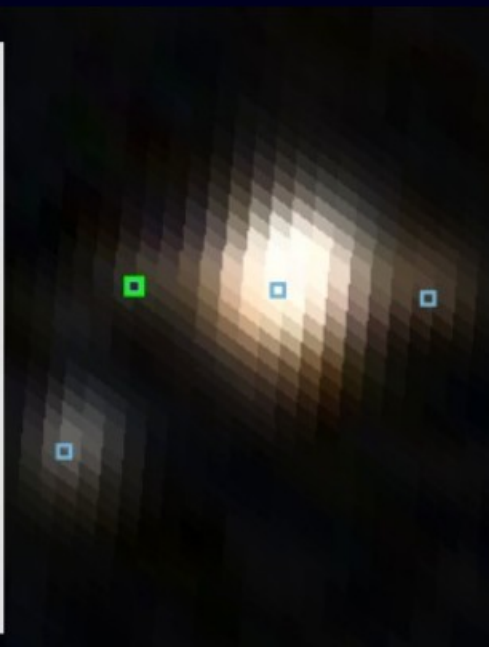


# Gravitational lensing ???

6.7 arcsec from center star – absolute symmetry, no time evolution

PanSTARRS-1 Archive  
2011-2014

Gaia DR2 source	
ra_epoch2000	84.93979285120
dec_epoch2000	53.30720574190
errHalfMaj	0.013
errHalfMin	0.013
errPosAng	90
source_id	263908015009666176
ra	84.93980026419
ra_error	0.4277
dec	53.30720143583
dec_error	0.4478
parallax	-0.2022
parallax_error	0.4712
pmra	1.029



1<sup>st</sup> lens – Twin QSO 0957+561 A+B  
1979 2.1m Kitt Peak

6 arcsec distance

# Tutorial of VO

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

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

*Thank You*