

Stellar Spectroscopy with Virtual Observatory

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Astronomical Institute
of the Czech Academy of Sciences



**RESEARCH
CENTER FOR
INFORMATICS**

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



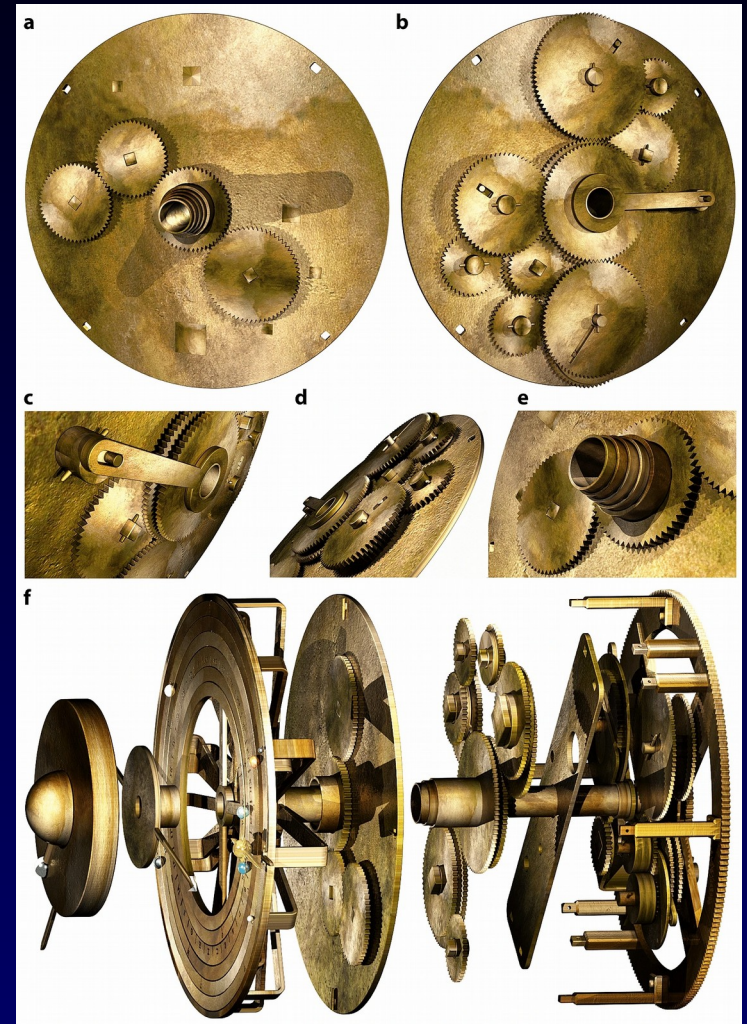
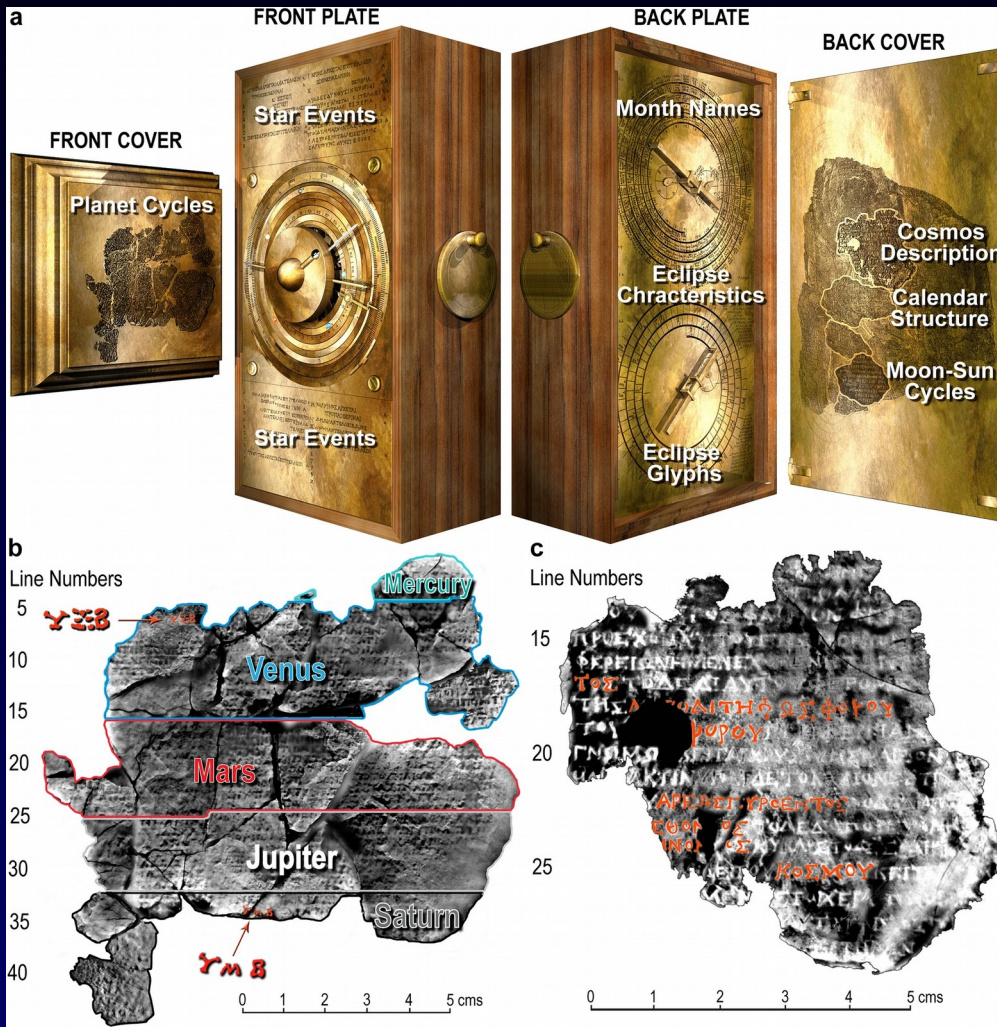
MINISTRY OF EDUCATION,
YOUTH AND SPORTS

Lecture at workshop on observational techniques,
AI Ondřejov, 8th September 2022

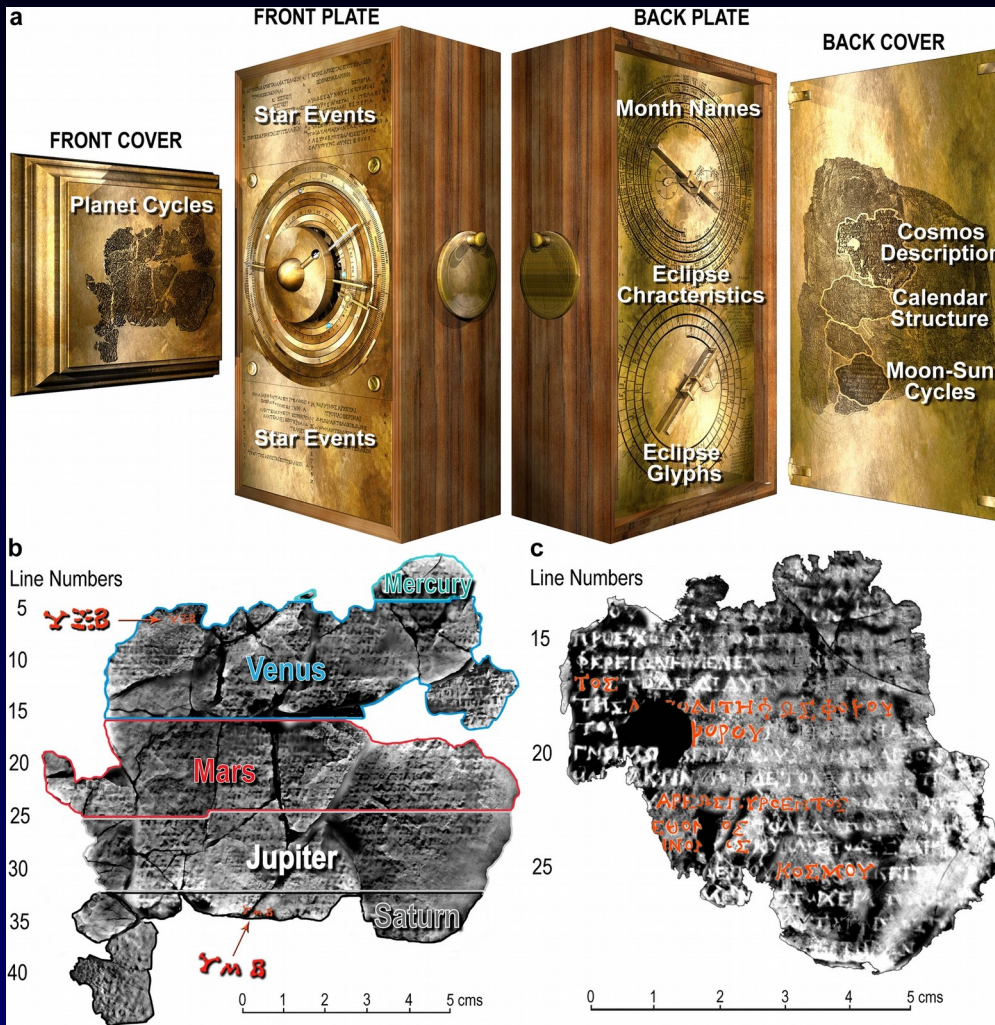
Credits

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.

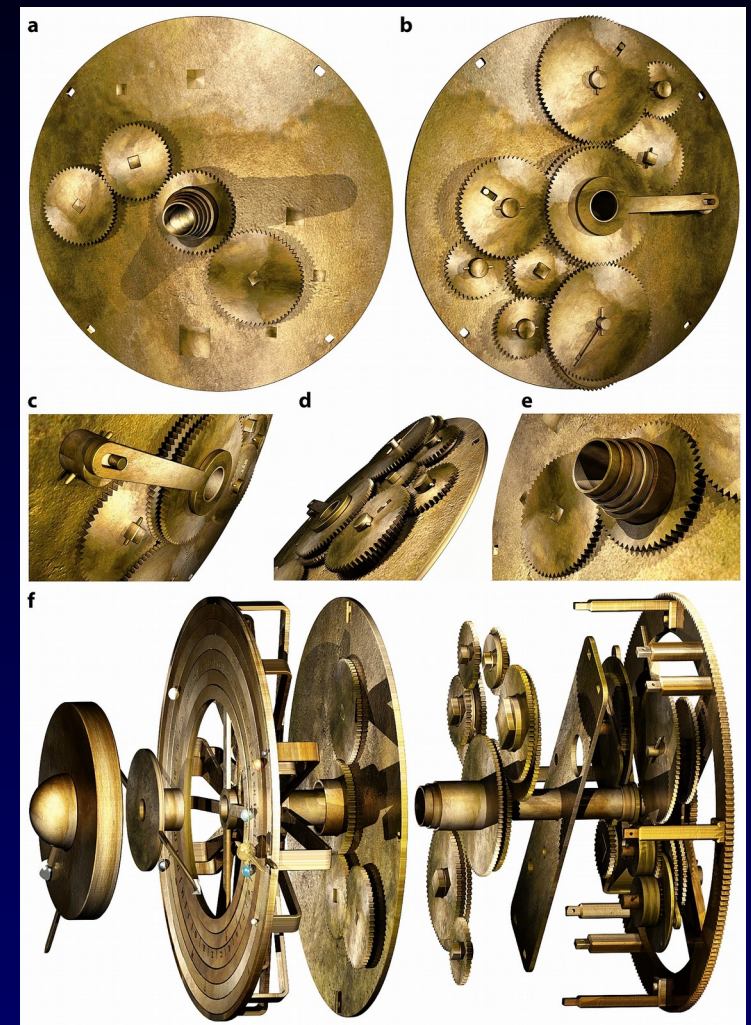
Astronomy - the leader of technology



Astronomy - the leader of technology



Antikythera mechanism 150-100 BC



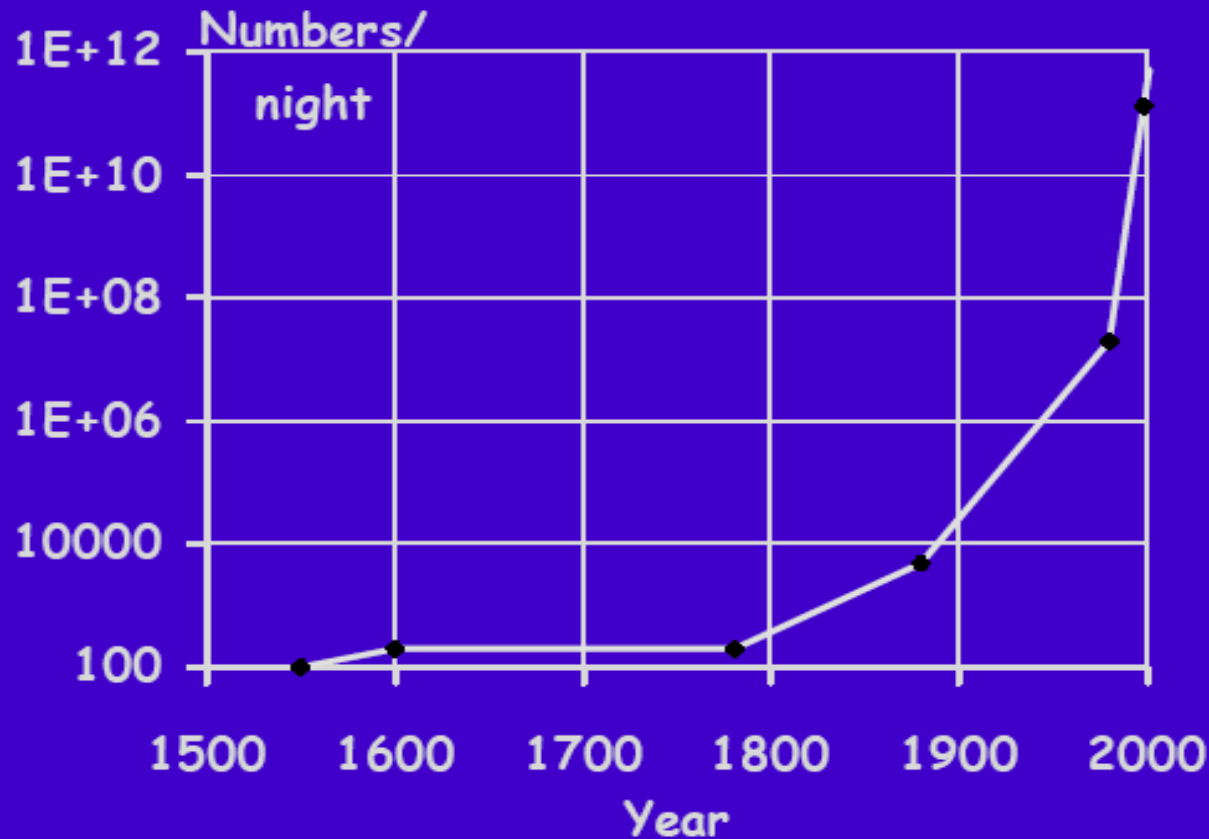
Freth et al. Nature Sci. Rep. 11, 5821 (2021)

Data Avalanche

Moore law for chips –doubling 1.5 year

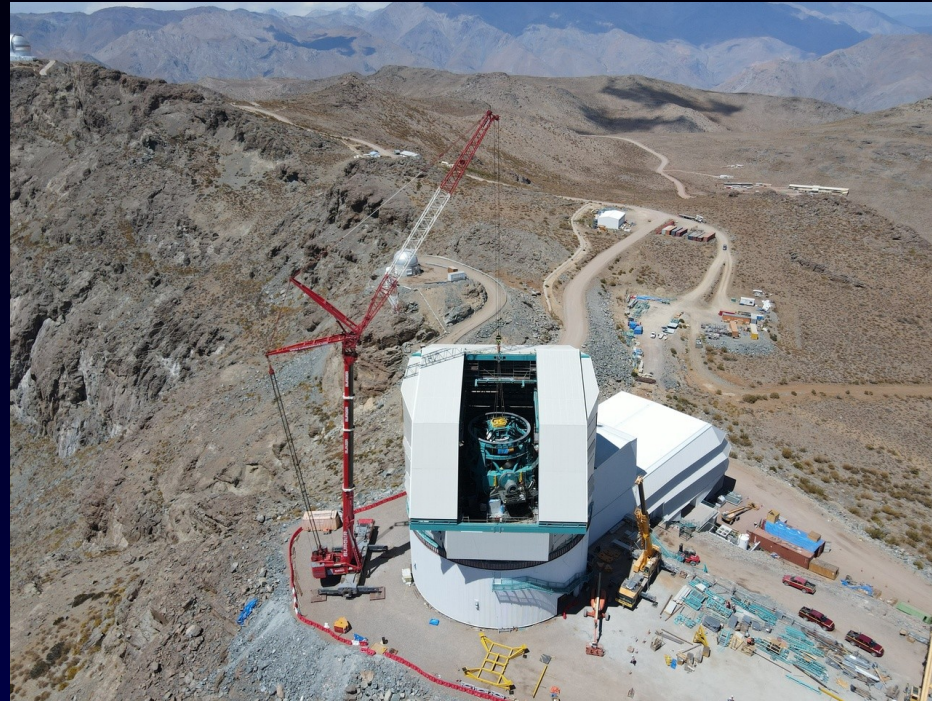
Data in astronomy – doubling < 1 yr ! (9 month current)

100 PB today, 100 TB/night



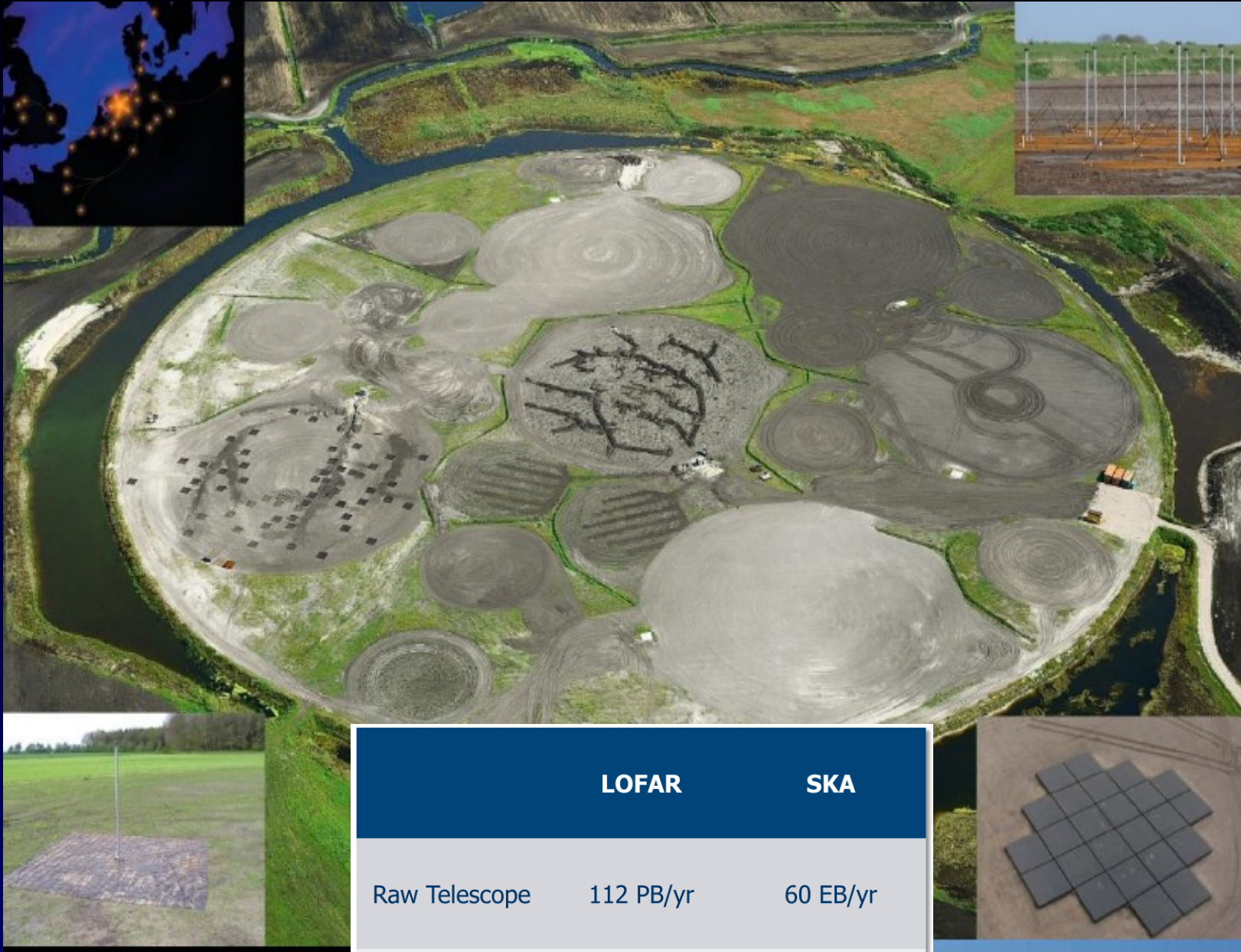
$T_2 < 18$ mths
1990-2000

LSST – Vera C. Rubin Observatory



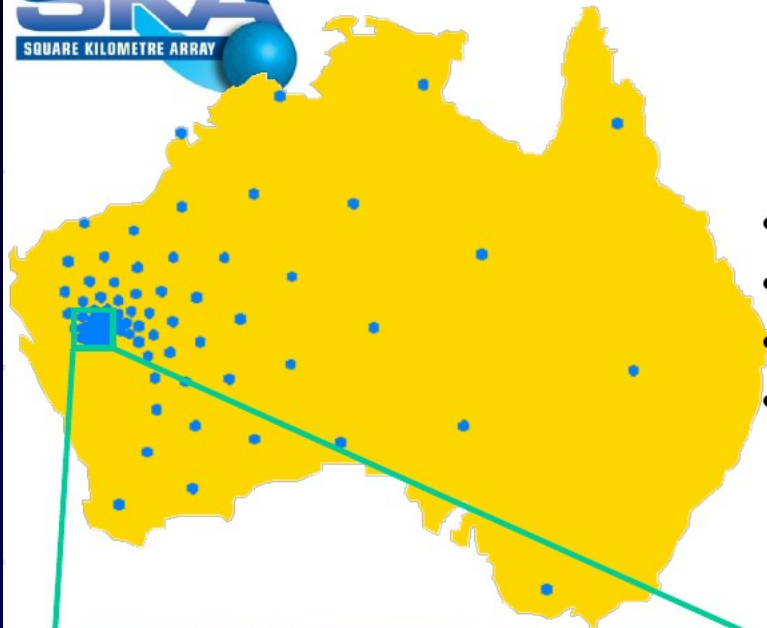
201 CCD 4kx4k,
3.2 Gpix every 15 sec
3.5 deg FOV (64cm)
20 TB/day=6 PB/yr RAW
1.5 PB catalogue !!!
detection of changes 60s!
10 million alerts/night !
38 billion objects x 1000
32 tril. meas. -5 PB table

LOFAR network



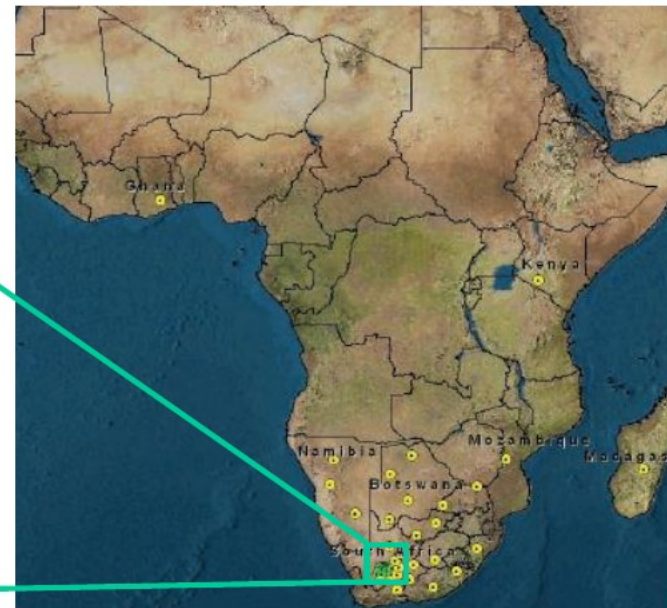
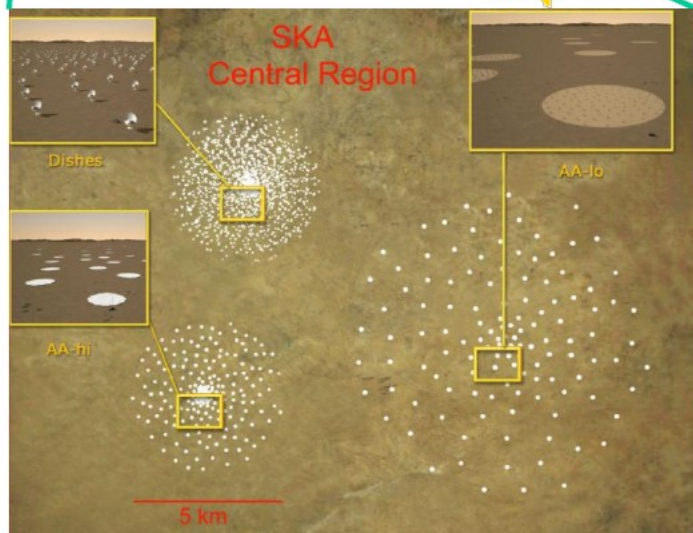
	LOFAR	SKA
Raw Telescope	112 PB/yr	60 EB/yr
Archive Rate	6 PB/yr	100 PB/yr

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



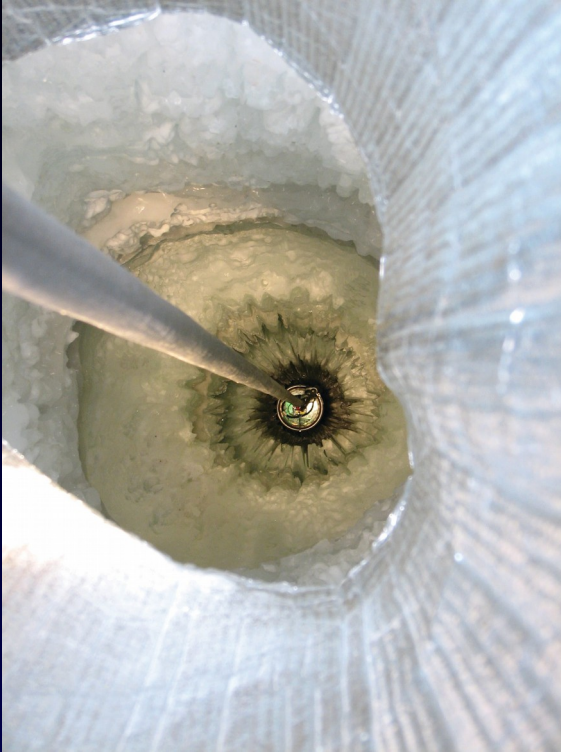
Dishes

SKA 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**

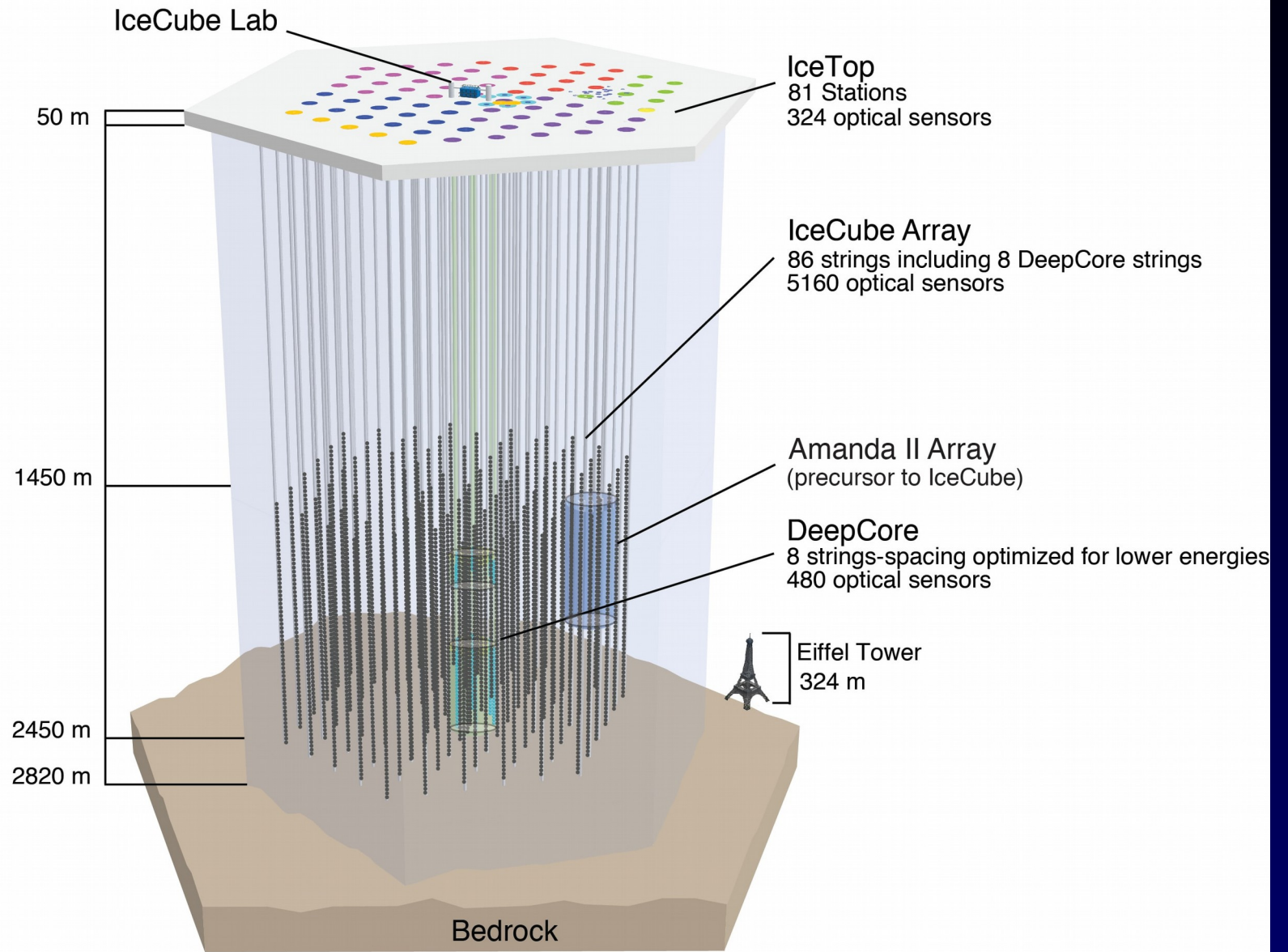
100 Pbytes – 3 EBytes / year of fully processed data

IceCube Neutrino Lab

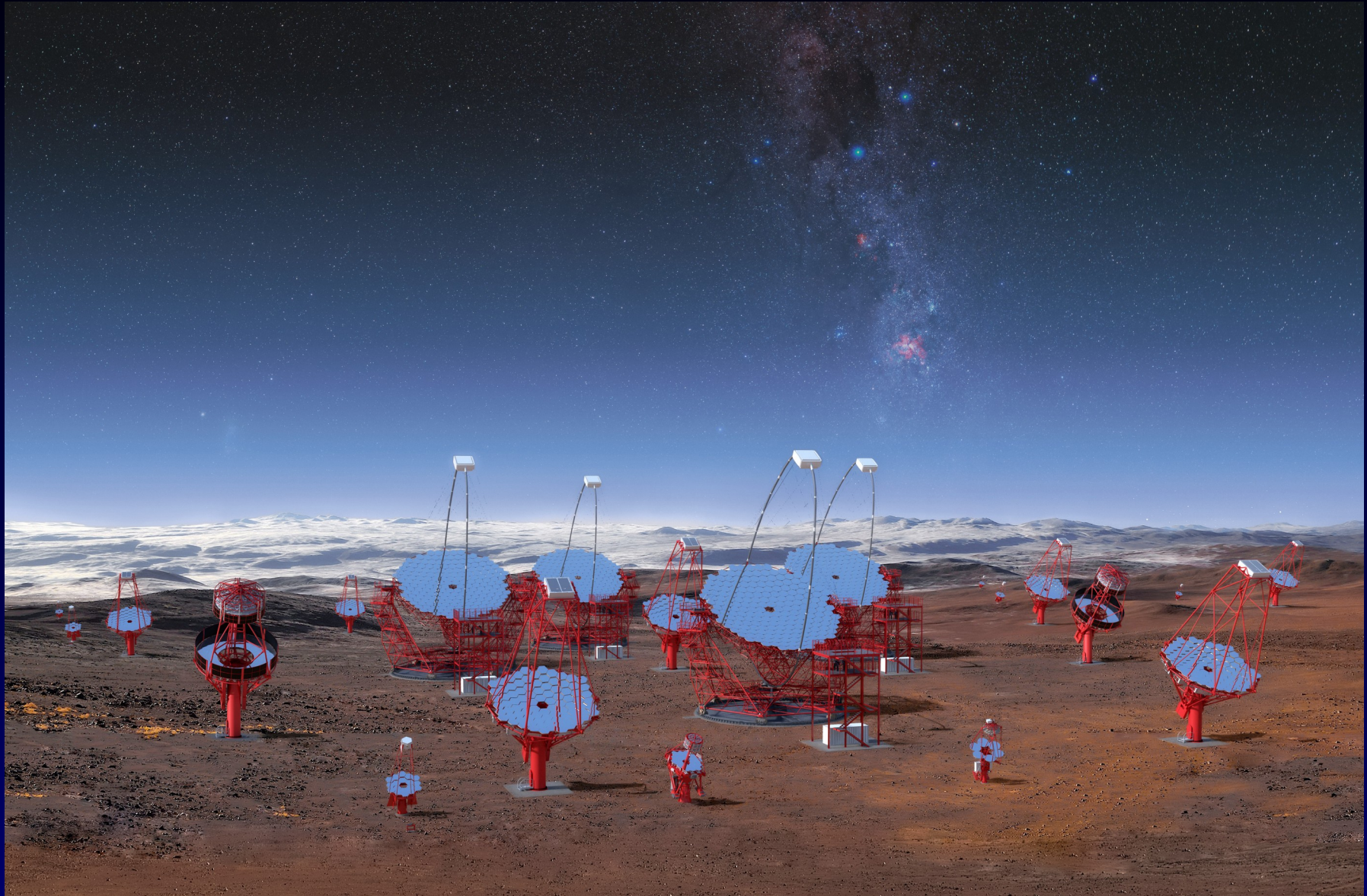


South Pole
Amundsen-Scott station

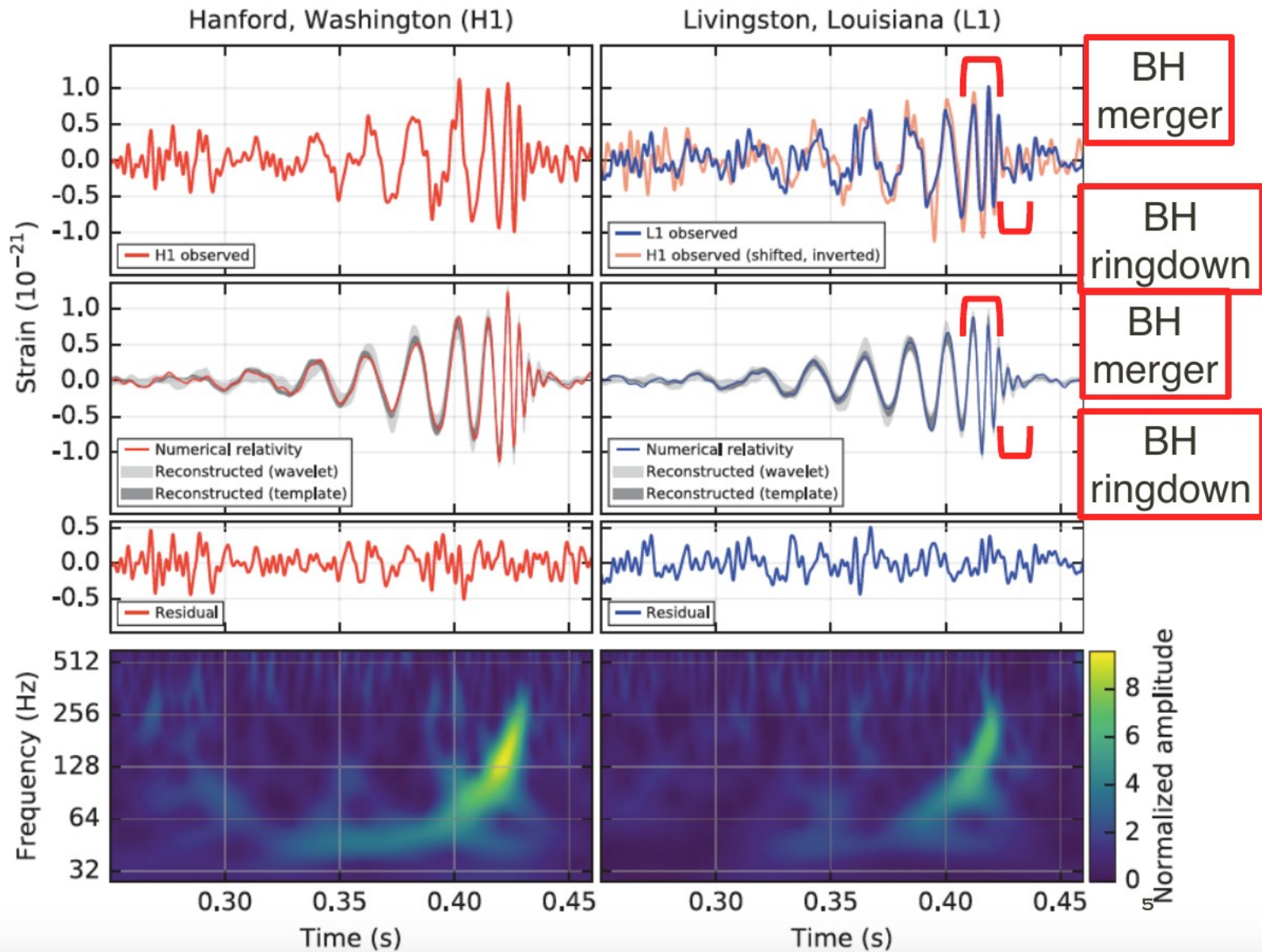
IceCube Neutrino Lab



Cherenkov Telescope Array



Gravity Wave First Detection



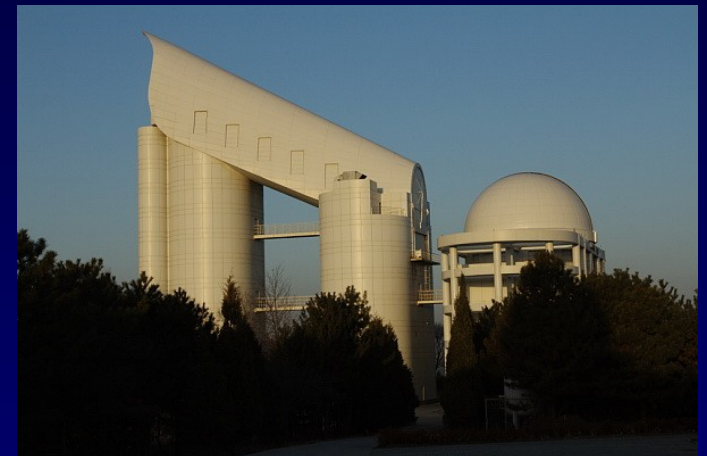
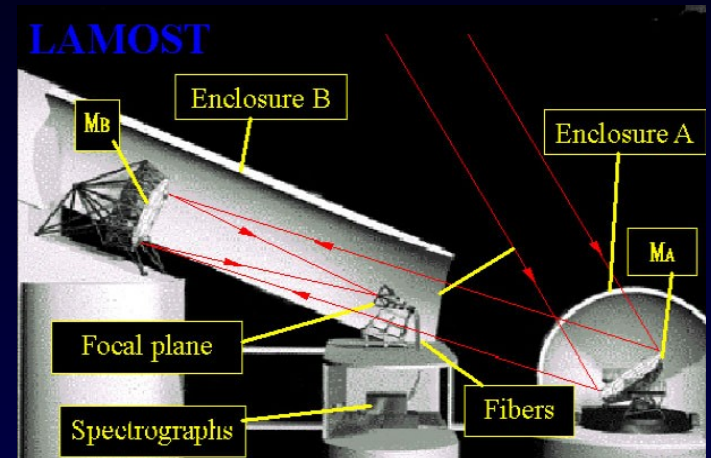
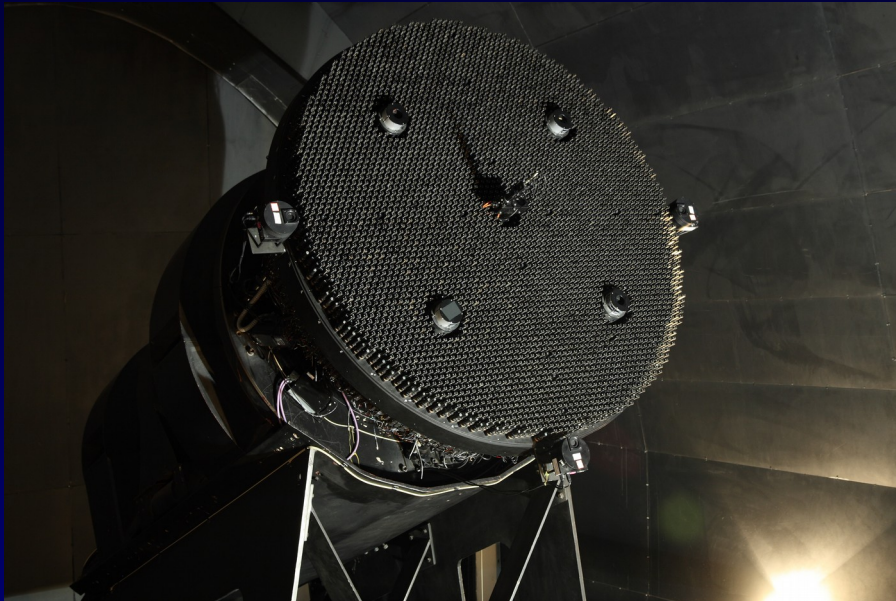
Gravitation Wave Detection Network

Expanded IFO network 2020+



LAMOST (Guoshoujing)

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



LAMOST Spectral Surveys

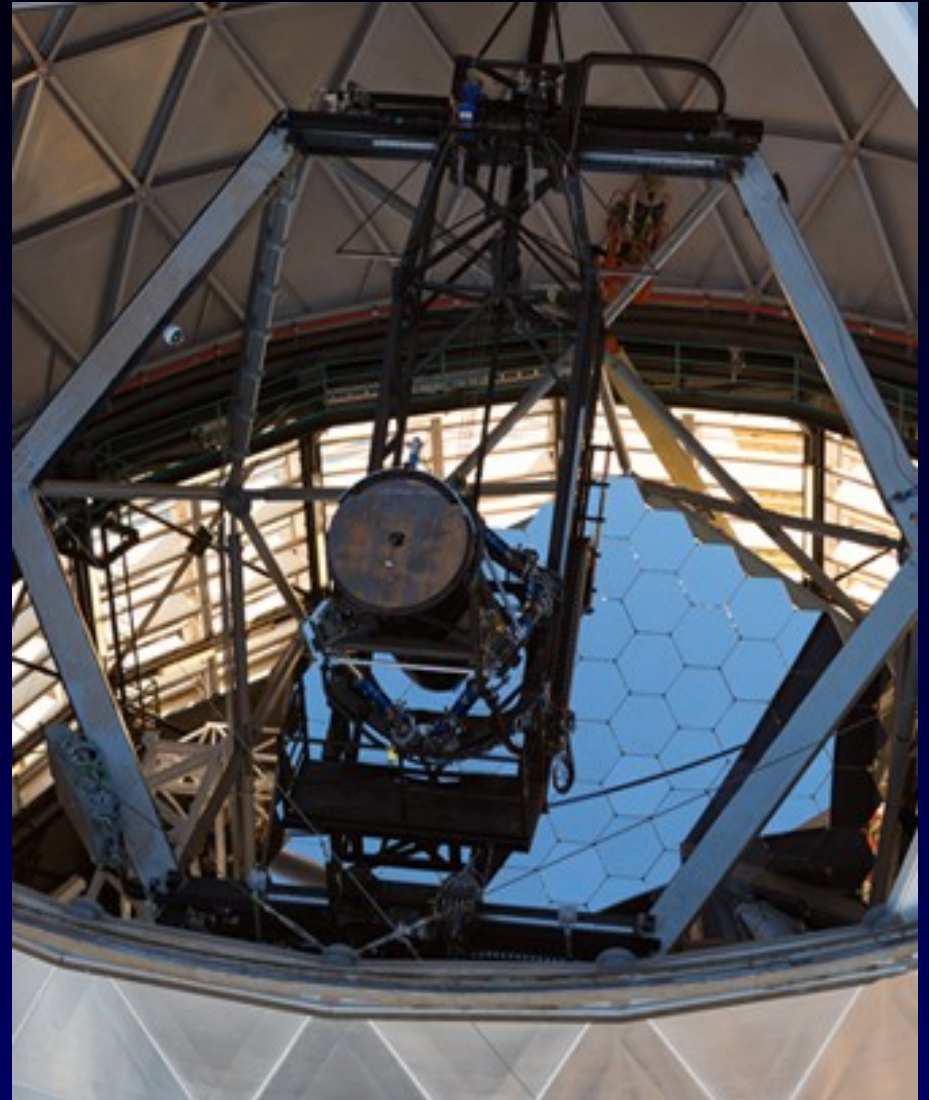
DR1 (end 2013)	2 204 860 spectra	1 085 404 stars classified by pipeline
DR2 (beg 2015)	4 132 782 spectra	3 779 674 stars 307 000 unknown!
DR5 (half 2017)	9 017 844 spectra	
...		
DR8 (Feb 2022)	10 927 525 low res + 5 975 982 mid res	

Each fibre – 2 motors
double arm 33mm circle

Fibre collects light from
3.3 arcsec circle on sky



Hobby Eberly Telescope (HET)



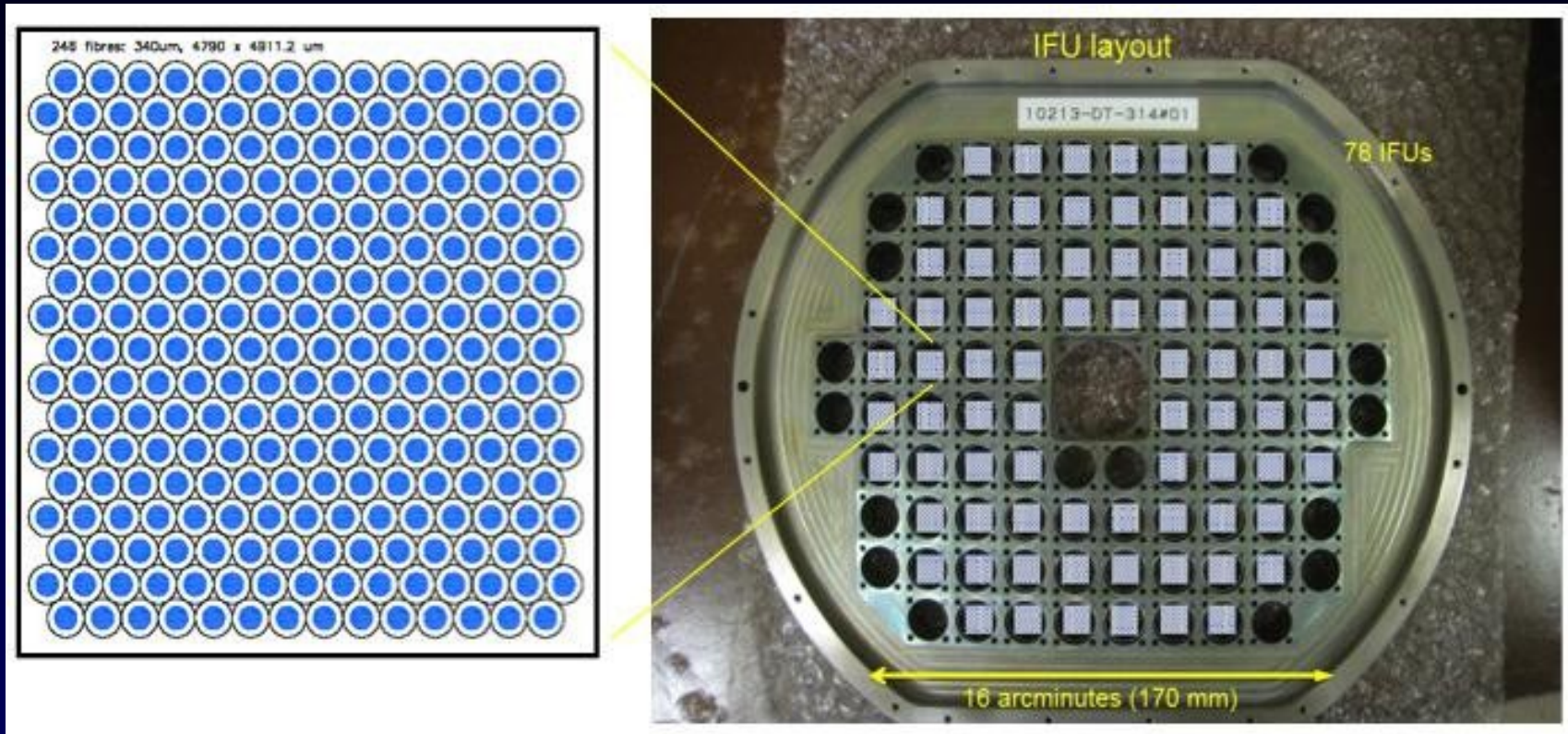
Mc Donald Observatory Texas

Equiv diameter 9.5m (11m)

Fixed in position during observation -
only primary tracker

HETDEX Survey

In theory 34944 spectra every 20min !



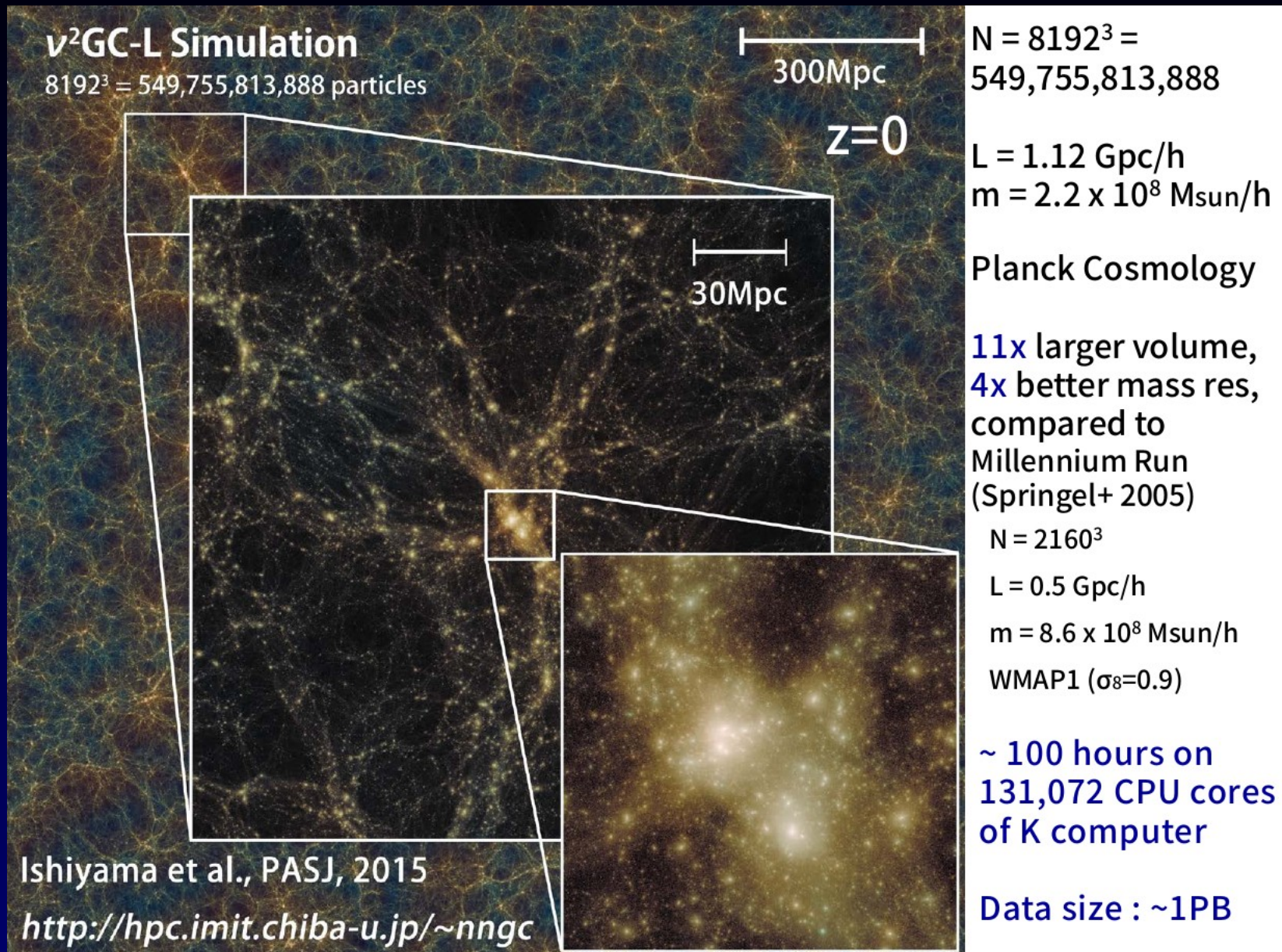
VIRUS 78 IFU = 156 spectrographs

IFU= 448 fibers

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

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

Simulation of Universe

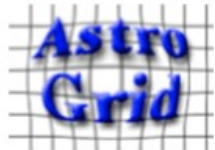


Virtual Observatory : Key Definitions

- “*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)



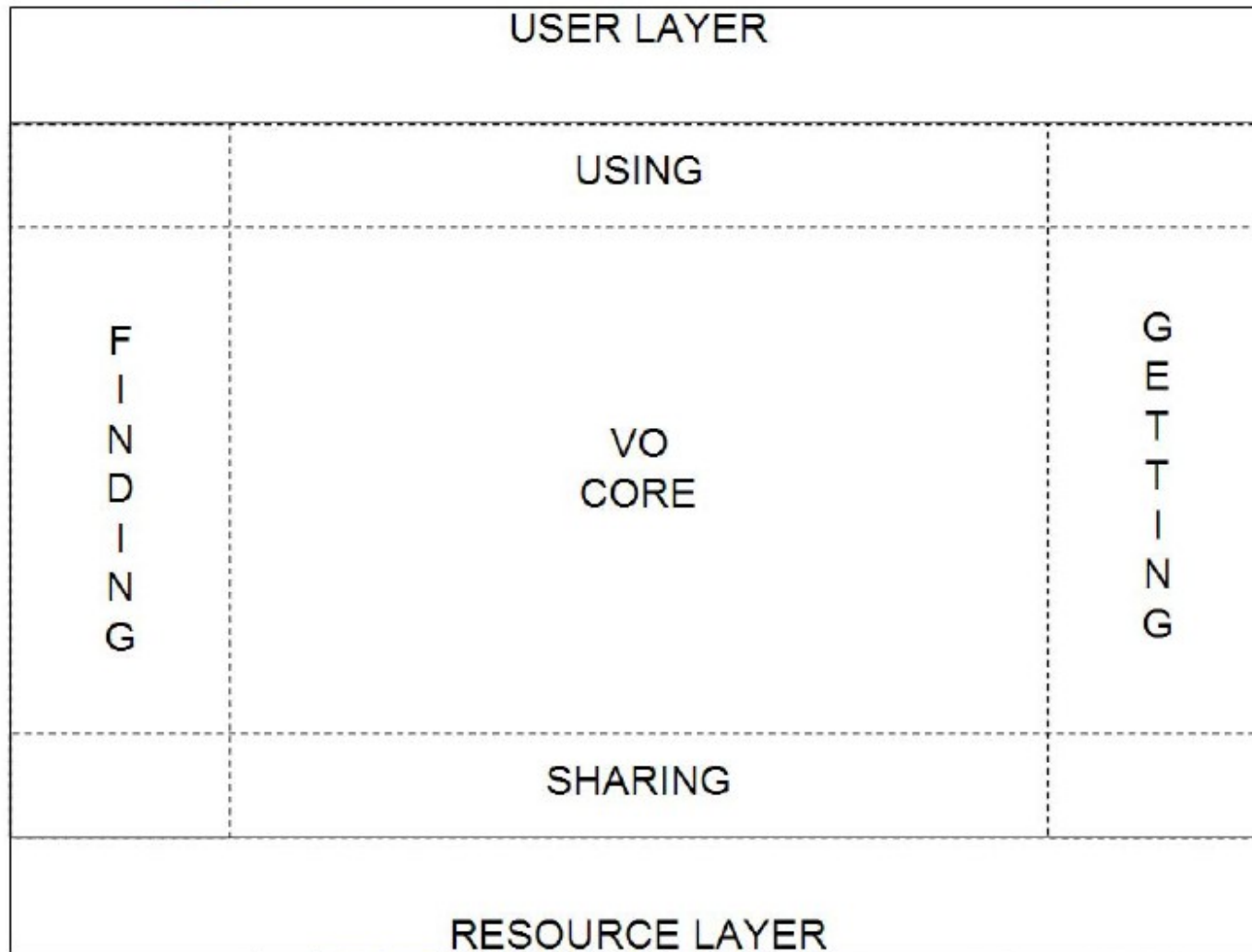
Ecosystem of VO – level 0

LEVEL 0

USERS



COMPUTERS



20101004
IVOA Architecture



PROVIDERS



Ecosystem of VO – level 1

LEVEL 1
empty

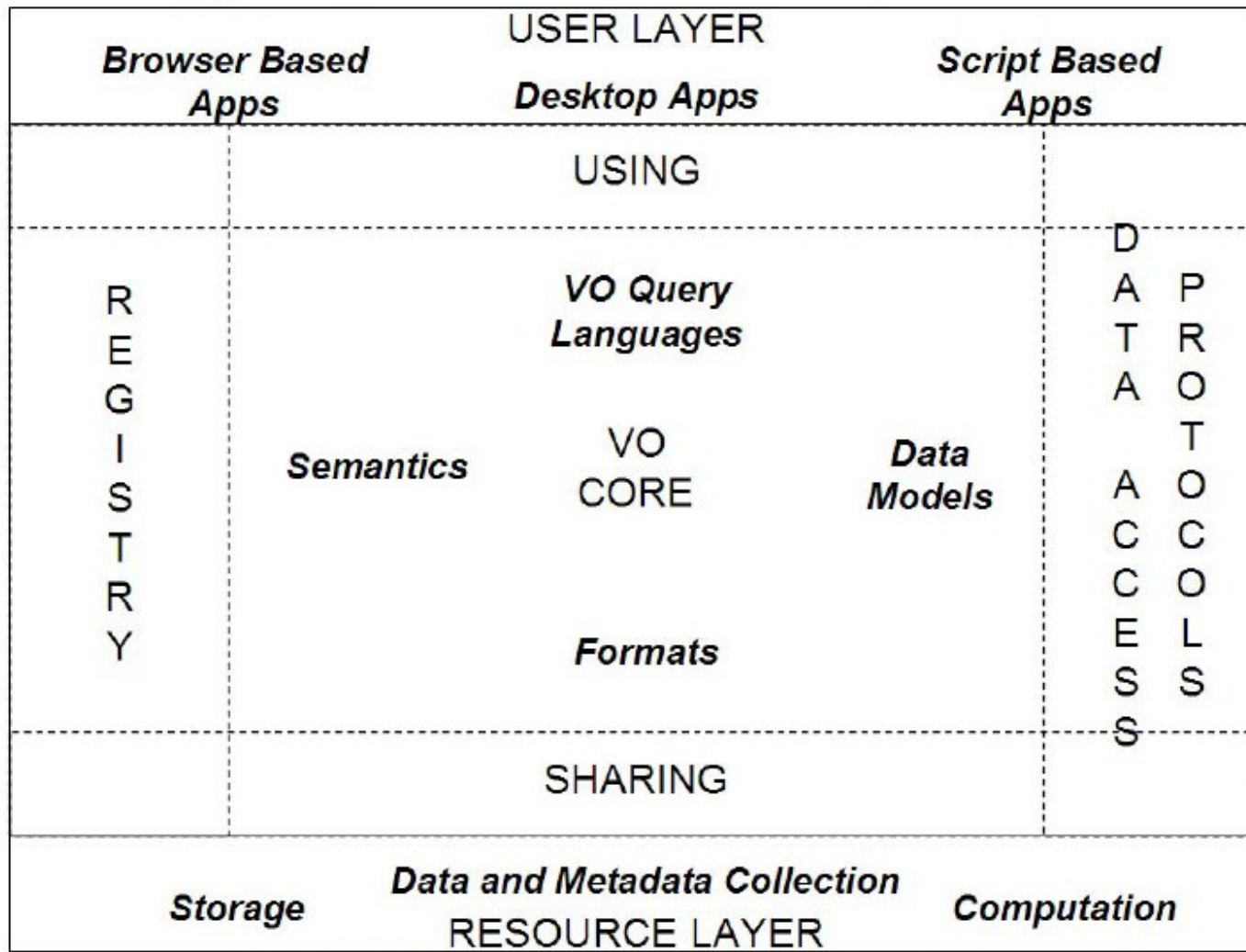
USERS



COMPUTERS

REC

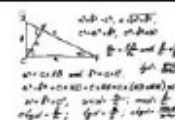
InProgress



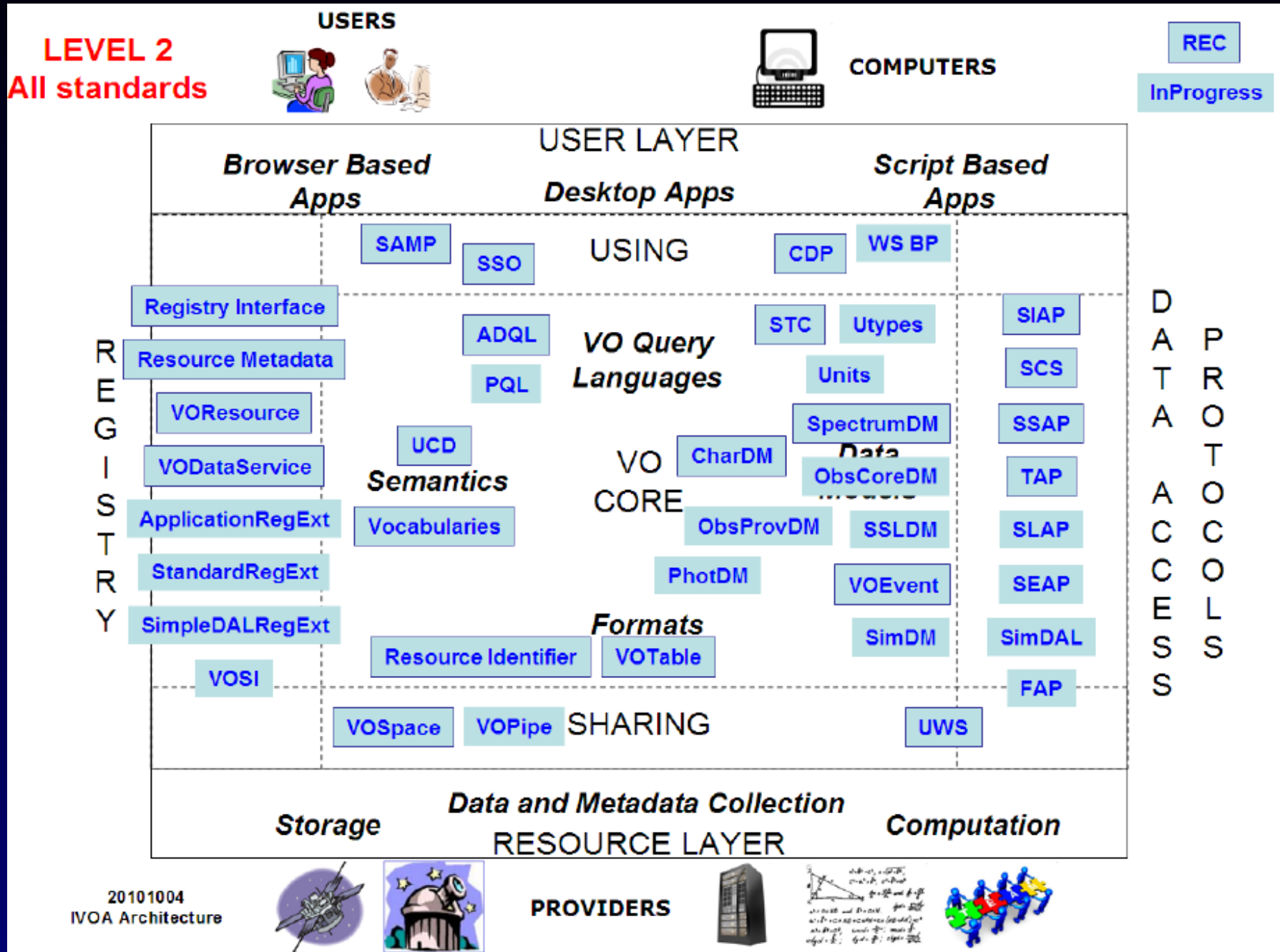
20101004
IVOA Architecture



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
- Science platforms (SciServer JHU) <https://scidrive.org/scidrive/>

Technology of VO

Unified data format– VOTable, UCD (Vizier)

Transparent transport (**VOunits**)

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)

Gaia archive!

Application interoperability – SAMP

Allows develop applications as bricks

sending VOTABLES (catalogue-spectra-images)

VO Science Portals

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/>

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

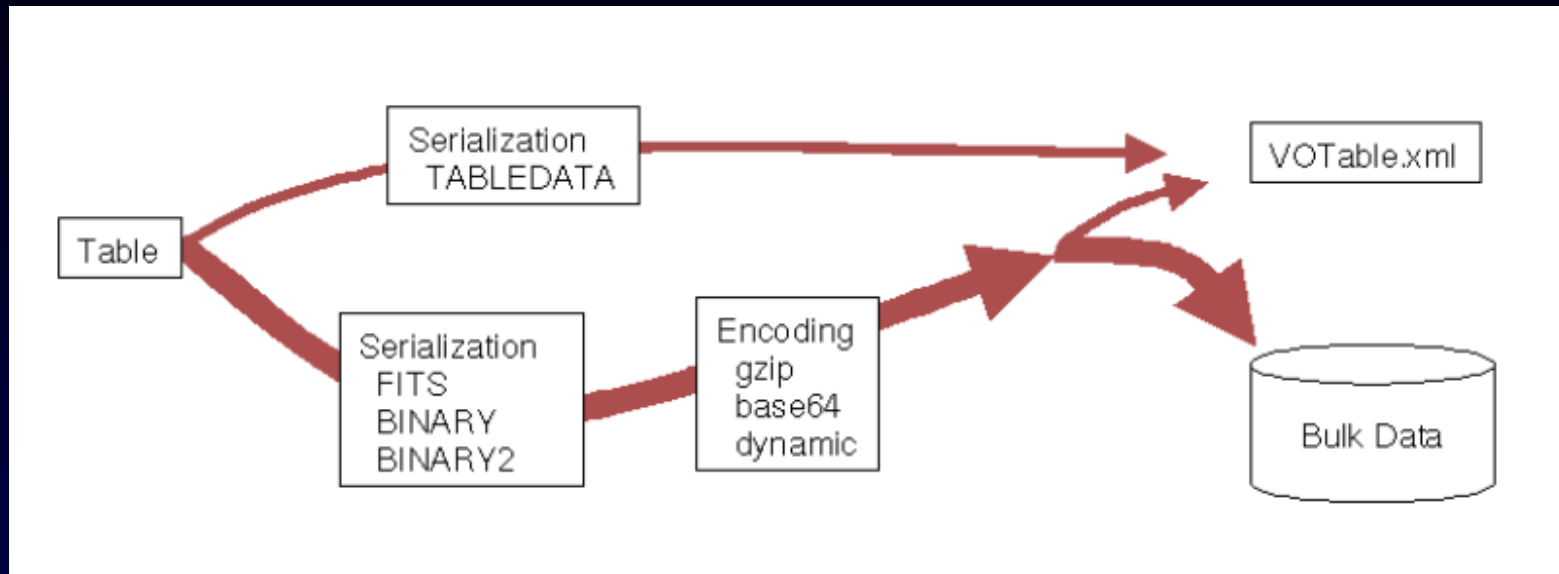
BIG DATA transfer

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>
```

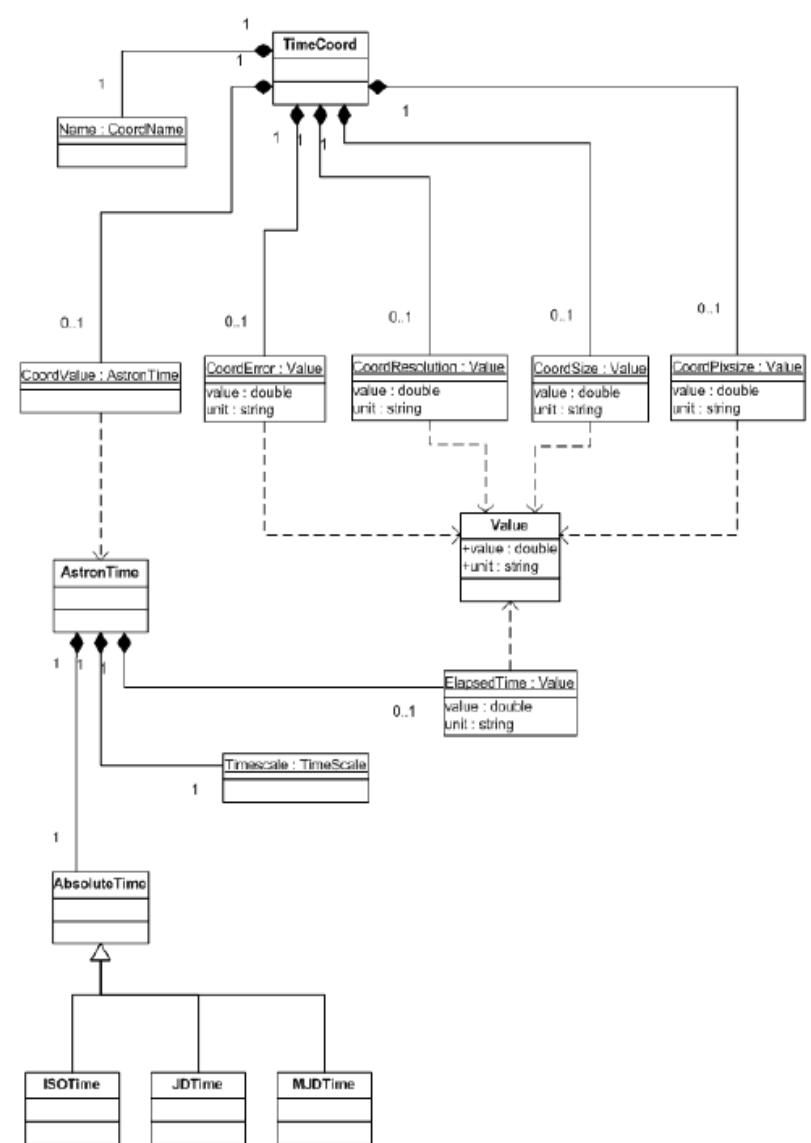
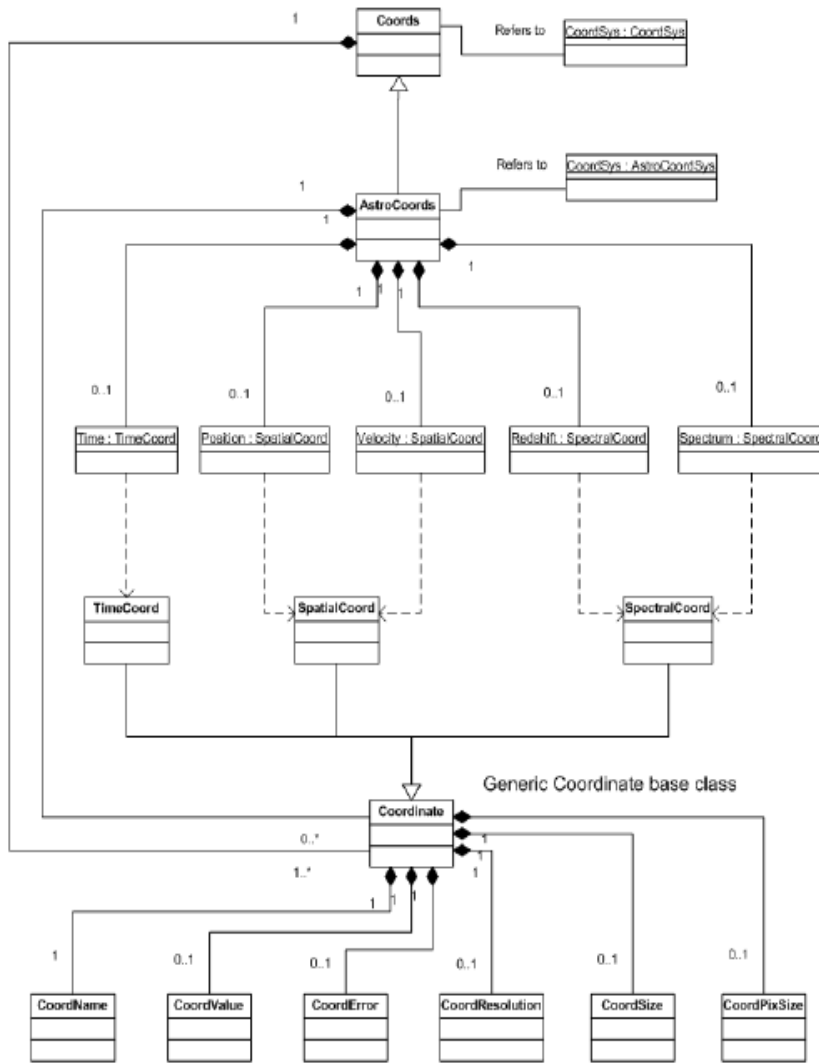

Universal Content Descriptors

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

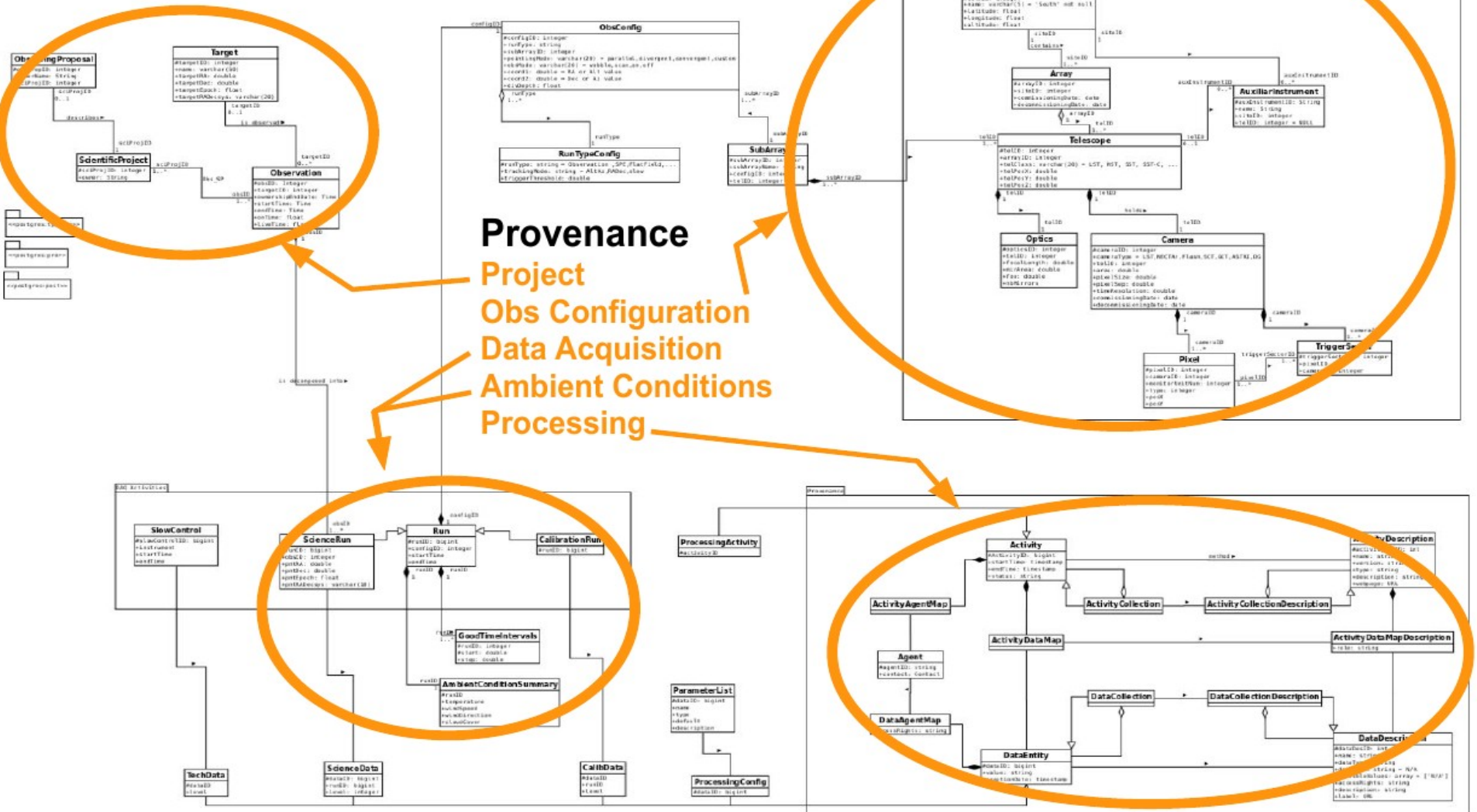
P	stat.stdev	Standard deviation
S	stat.uncalib	Qualifier of a generic incalibrated quantity
Q	stat.value	Miscellaneous statistical value
P	stat.variance	Variance
P	stat.weight	Statistical weight
Q	time	Time, generic quantity in units of time or date
Q	time.age	Age
Q	time.creation	Creation time/date (of 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:

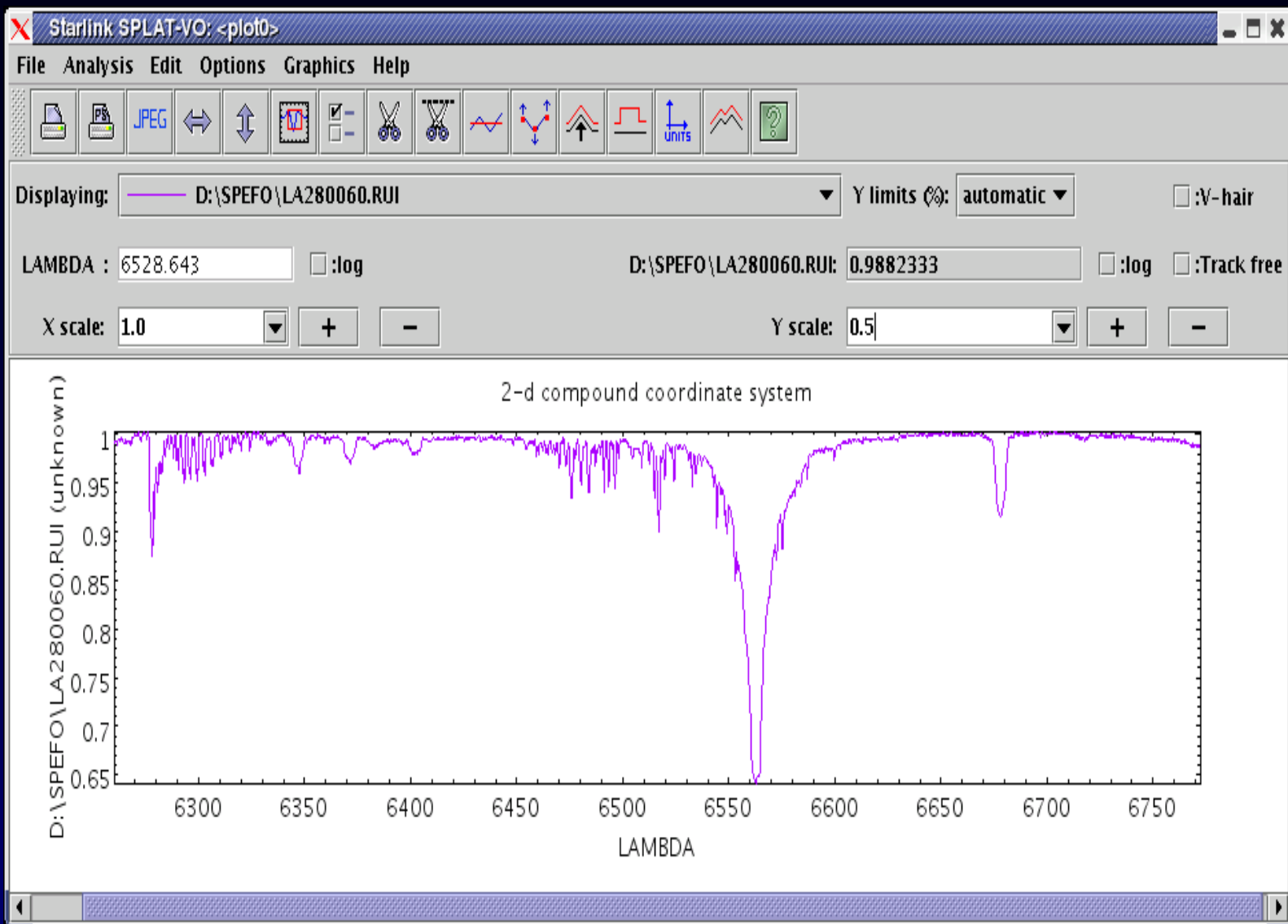
<i>Parameter</i>	<i>Sample value</i>	<i>Physical unit</i>	<i>Datatype</i>
POS	52, -27.8	degrees; defaults to ICRS	string
SIZE	0.05	degrees	double
BAND	2.7E-7/0.13	meters	string
TIME	1998-05-21/1999	ISO 8601 UTC	string
FORMAT	votable	-	string

4.1.2 Recommended and Optional Query Parameters

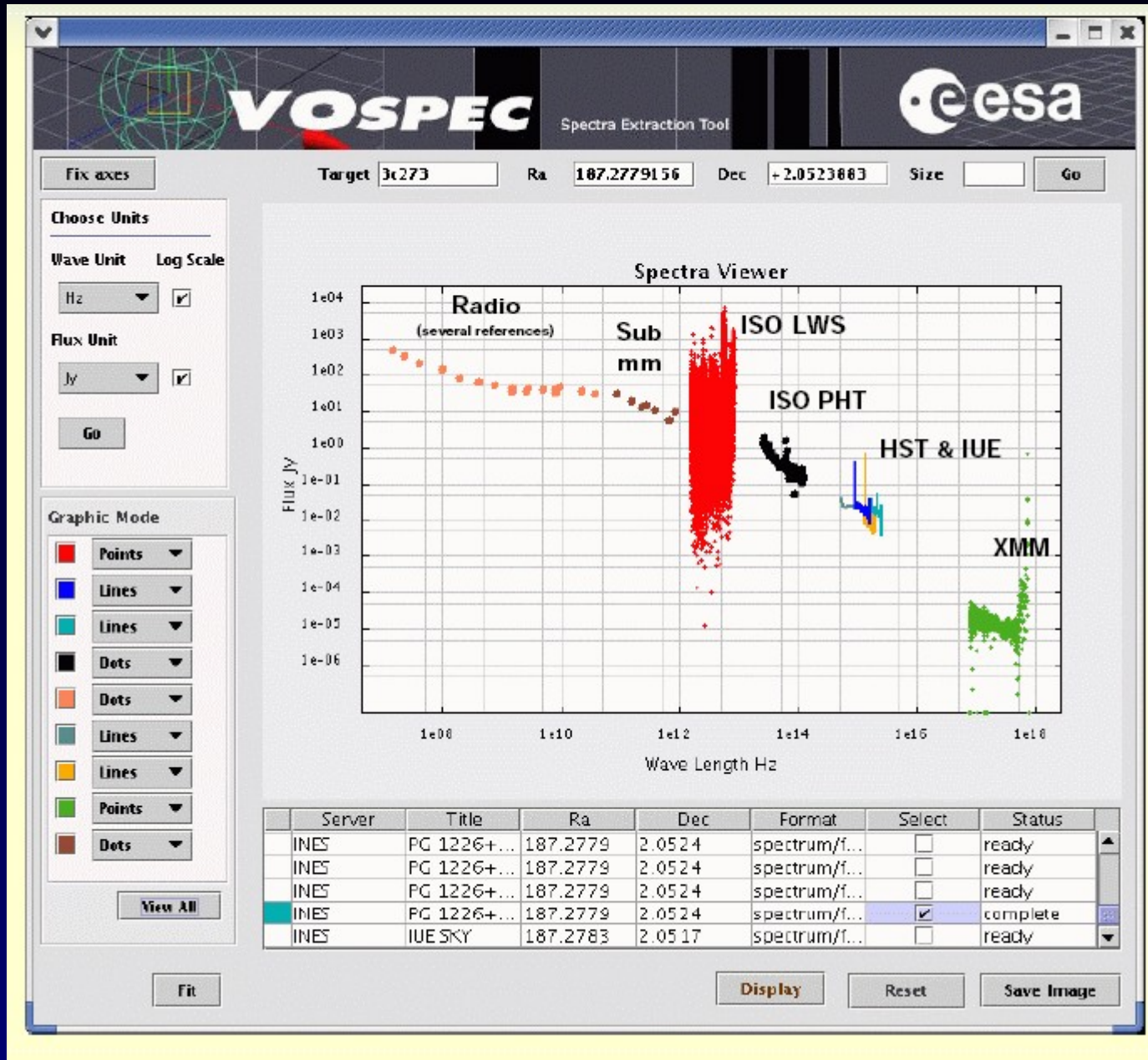
Parameter	Sample value	Unit	Req	Datatype
APERTURE	0.00028 (=1")	degrees	OPT	double
SPECRP	2000	$\lambda/d\lambda$	REC	double
SPATRES	0.05	degrees	REC	double
TIMERES	31536000 (=1yr)	seconds	OPT	double
SNR	5.0	dimensionless	OPT	double
REDSHIFT	1.3/3.0	dimensionless	OPT	string
VARAMPL	0.77	dimensionless	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

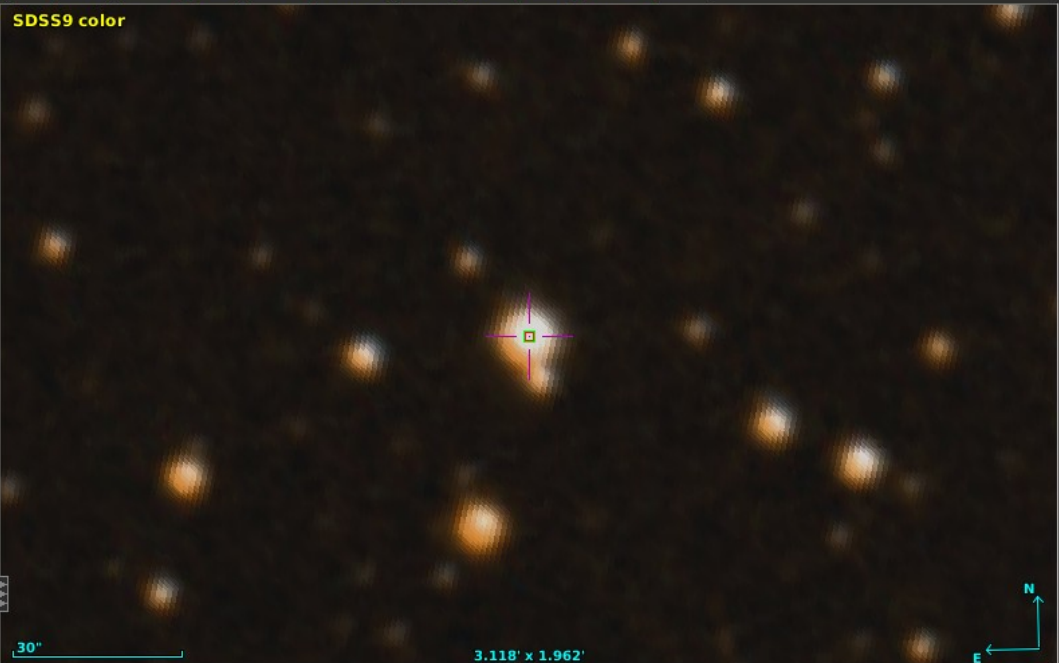
Aladin v10.1 *** BETA VERSION (based on v10.117) ***

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

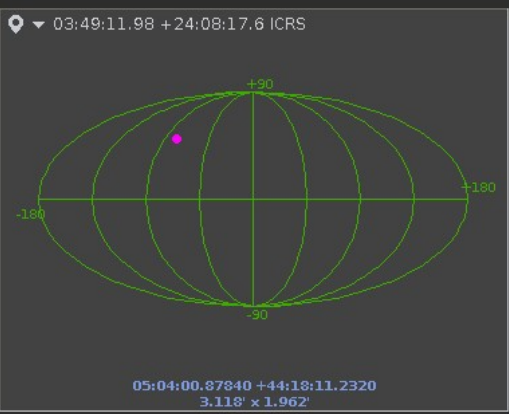
CDS/Simbad
CDS/P/SDSS9/color
CDS/P/DSS2/color

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

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	

Search

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



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

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

1 sel / 4370 src 429Mb

TOPCAT

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

- Table Access Protocol (TAP) Query:** Shows a query in ADQL-2.0 language: `SELECT TOP 10000 ...`
- Match Tables:** Displays details for a match between two tables, including RA, Dec, and distance columns.
- Plane Plot (1):** A scatter plot showing data points in a 2D space.
- Plane Plot (2):** A scatter plot showing data points in a 2D space, possibly a different projection.
- Plane Plot (3):** A scatter plot showing data points in a 2D space.
- Plane Plot (4):** A scatter plot showing data points in a 2D space.
- Plane Plot (5):** A scatter plot showing data points in a 2D space.
- Plane Plot (6):** A scatter plot showing data points in a 2D space.
- Plane Plot (7):** A scatter plot showing data points in a 2D space.
- Plane Plot (8):** A scatter plot showing data points in a 2D space.
- Plane Plot (9):** A scatter plot showing data points in a 2D space.
- Plane Plot (10):** A scatter plot showing data points in a 2D space.
- Plane Plot (11):** A scatter plot showing data points in a 2D space.
- Plane Plot (12):** A scatter plot showing data points in a 2D space.
- Plane Plot (13):** A scatter plot showing data points in a 2D space.
- Plane Plot (14):** A scatter plot showing data points in a 2D space.
- Plane Plot (15):** A scatter plot showing data points in a 2D space.
- Plane Plot (16):** A scatter plot showing data points in a 2D space.
- Plane Plot (17):** A scatter plot showing data points in a 2D space.
- Plane Plot (18):** A scatter plot showing data points in a 2D space.
- Plane Plot (19):** A scatter plot showing data points in a 2D space.
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- Plane Plot (21):** A scatter plot showing data points in a 2D space.
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- Plane Plot (40):** A scatter plot showing data points in a 2D space.
- Plane Plot (41):** A scatter plot showing data points in a 2D space.
- Plane Plot (42):** A scatter plot showing data points in a 2D space.
- Plane Plot (43):** A scatter plot showing data points in a 2D space.
- Plane Plot (44):** A scatter plot showing data points in a 2D space.
- Plane Plot (45):** A scatter plot showing data points in a 2D space.
- Plane Plot (46):** A scatter plot showing data points in a 2D space.
- Plane Plot (47):** A scatter plot showing data points in a 2D space.
- Plane Plot (48):** A scatter plot showing data points in a 2D space.
- Plane Plot (49):** A scatter plot showing data points in a 2D space.
- Plane Plot (50):** A scatter plot showing data points in a 2D space.

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 FKeys Hints

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

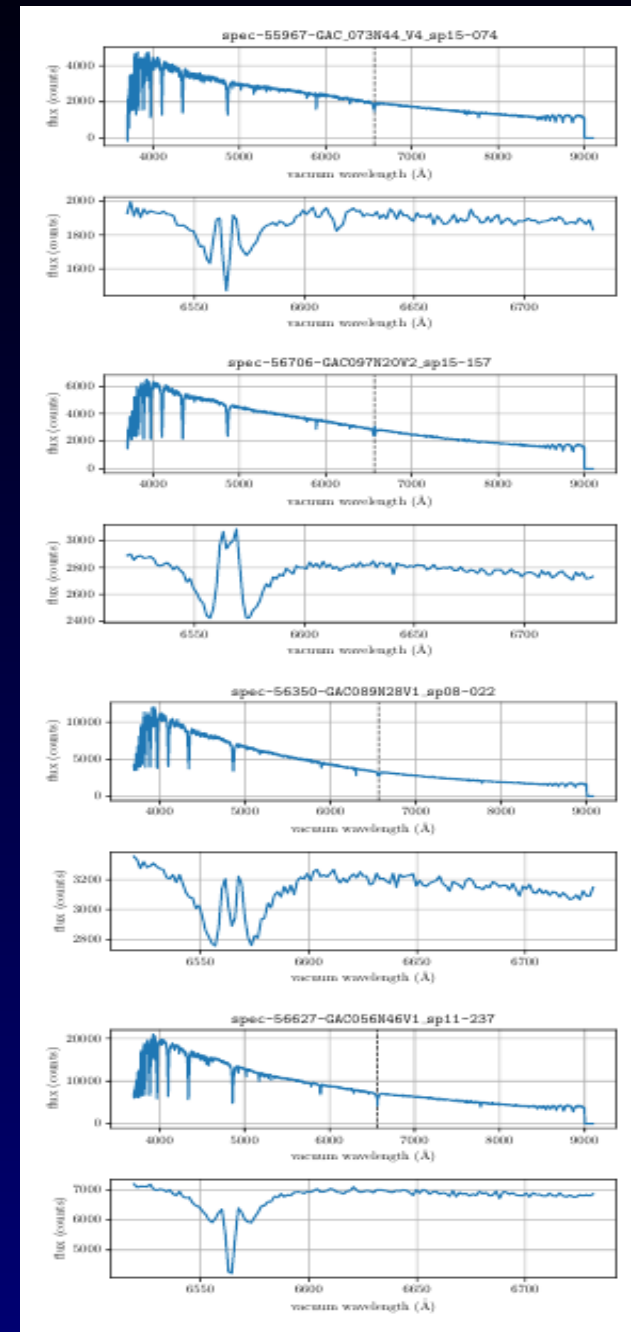
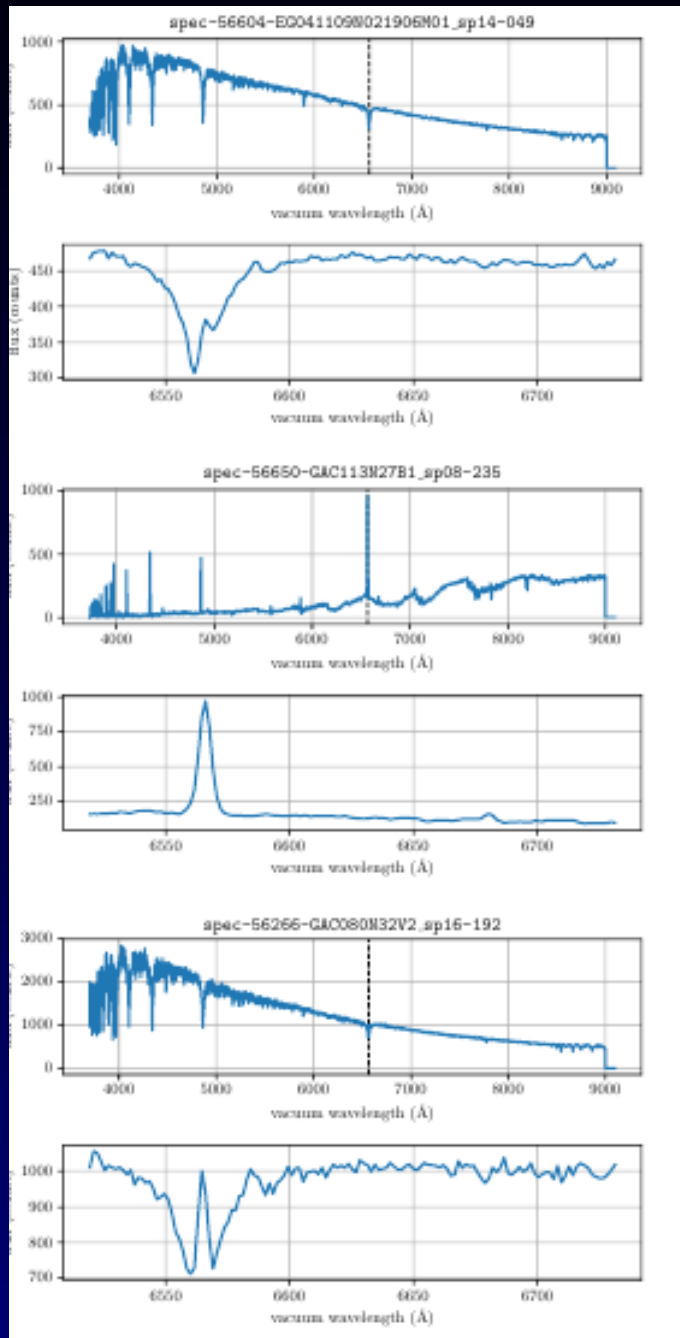
Mode: Synchronous

```

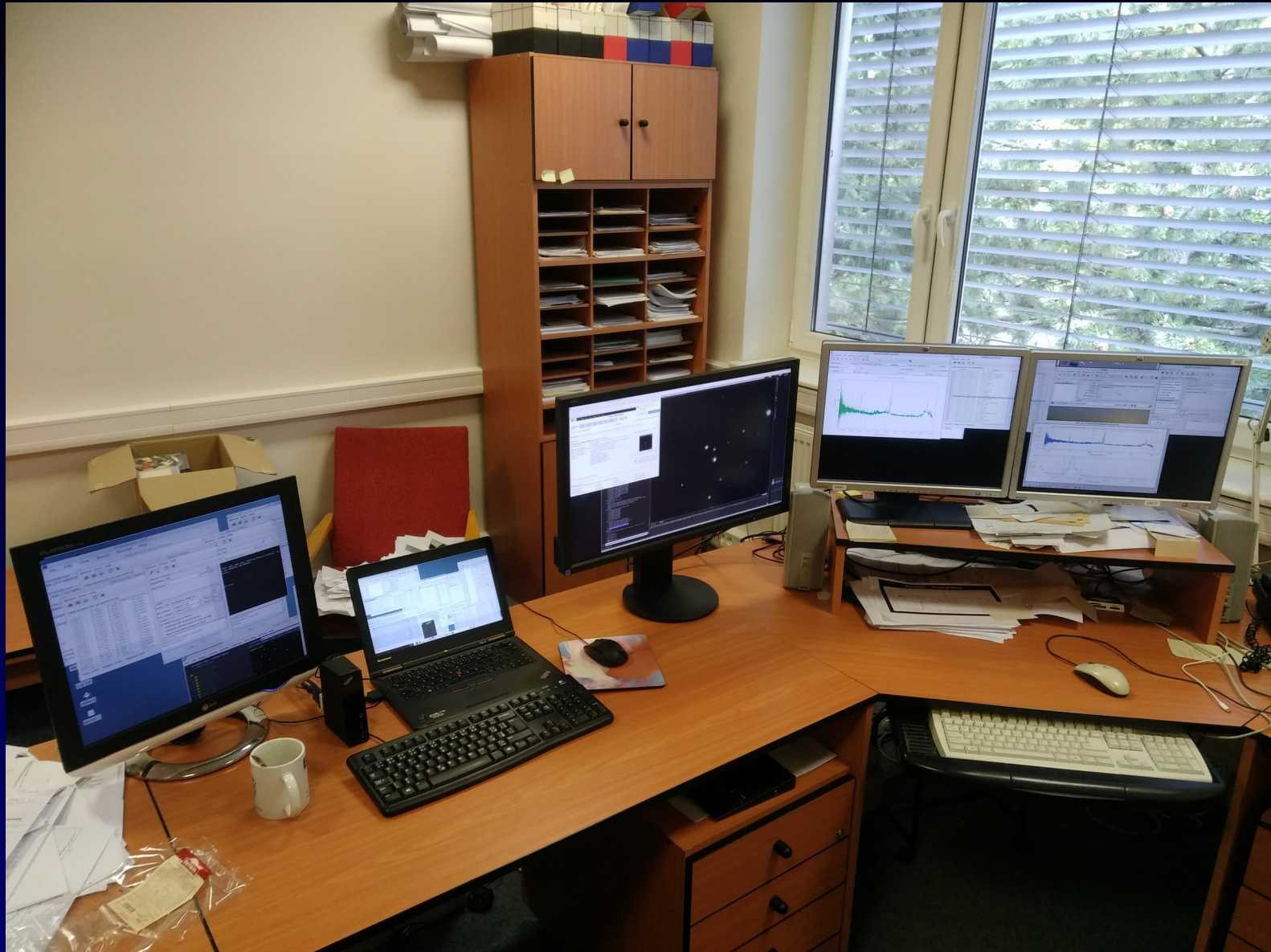
1
SELECT TOP 50000
  gaia.source_id,
  gaia.hip,
  gaia.phot_g_mean_mag+5*log10(gaia.parallax)-10 AS g_mag_abs_gaia,
  gaia.phot_g_mean_mag+5*log10(hip.plx)-10 AS g_mag_abs_hip,
  hip.b_v,
  gaia.parallax, gaia.b, gaia.b
FROM gaiadr1.tgas_source AS gaia
INNER JOIN extcat.hipparcos AS hip ON gaia.hip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

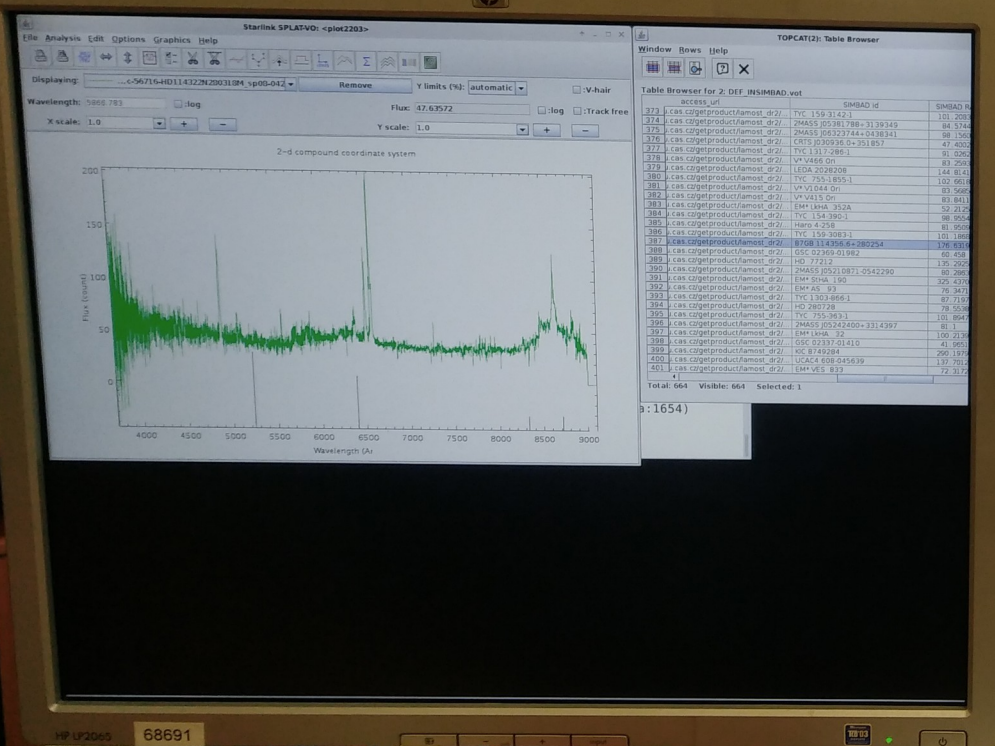
Run Query

Single-peak & Double-peak Candidates



Analysis



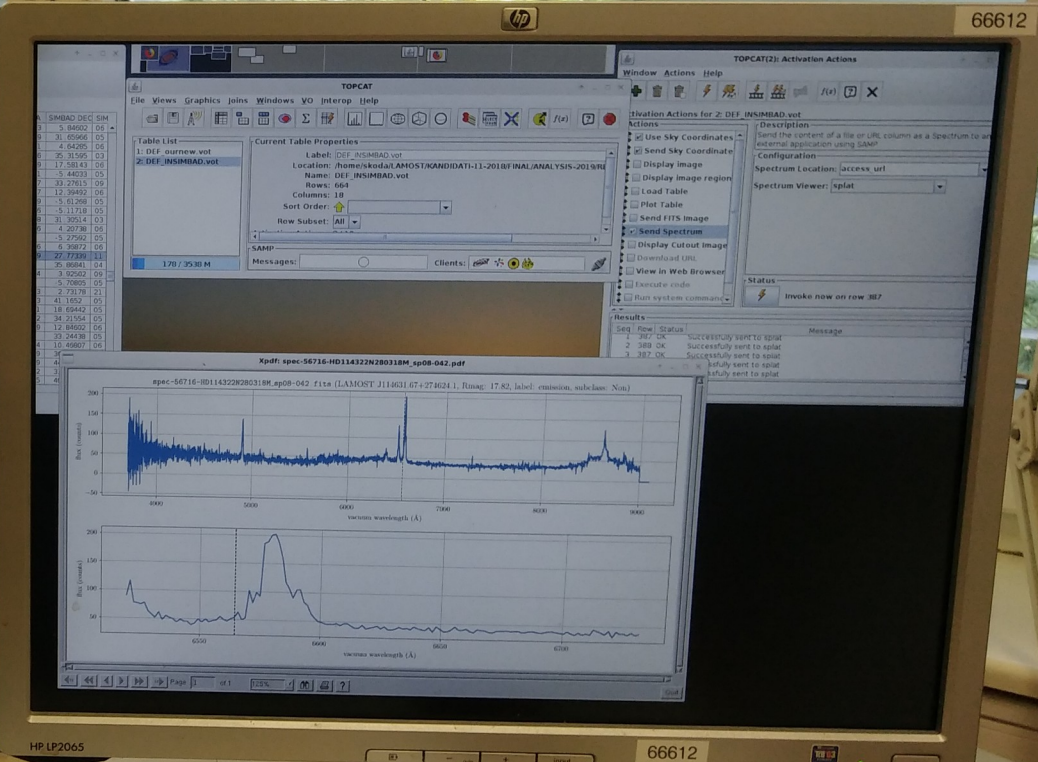


TOPCAT(2): Table Browser

Table browser for 2: DEF_INSMIBAD.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+0419341 98.1560		
376 cas.cageproduct/famost-dr2 CR3 0259395.0+3318937 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 Mero 4258 81.9508		
386 cas.cageproduct/famost-dr2 TYC 1593983-1 101.1468		
387 cas.cageproduct/famost-dr2 8708 114396.6+280254 176.8119		
388 cas.cageproduct/famost-dr2 GSC 02193.0182 60.488		
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_73 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 698045639 117.7614		
401 cas.cageproduct/famost-dr2 EM VES 833 72.3172		

Total: 664 Visible: 664 Selected: 1



68691

66612

Handwritten notes and printed documents on the desk, including a note with the name 'MILAN KALOUSEK' and other illegible text.

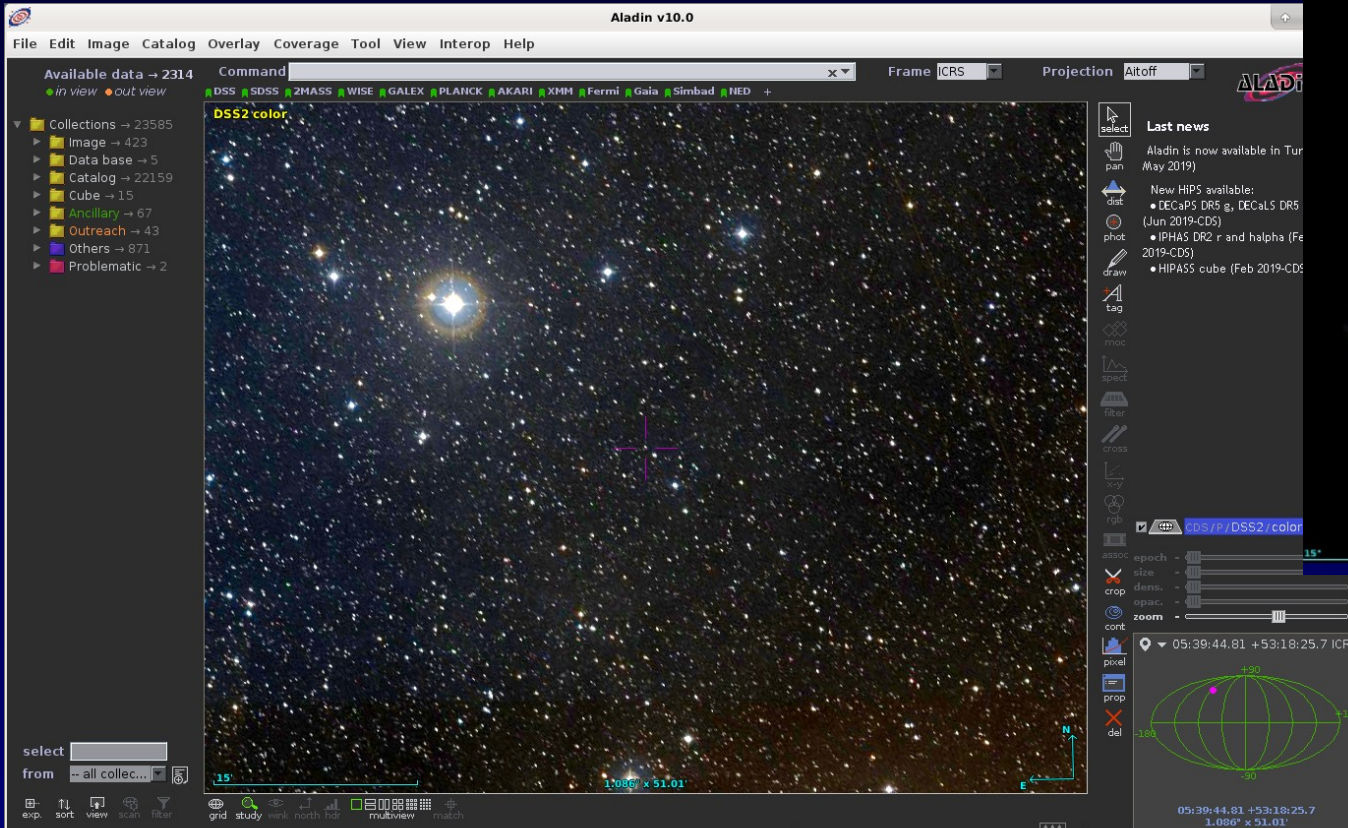
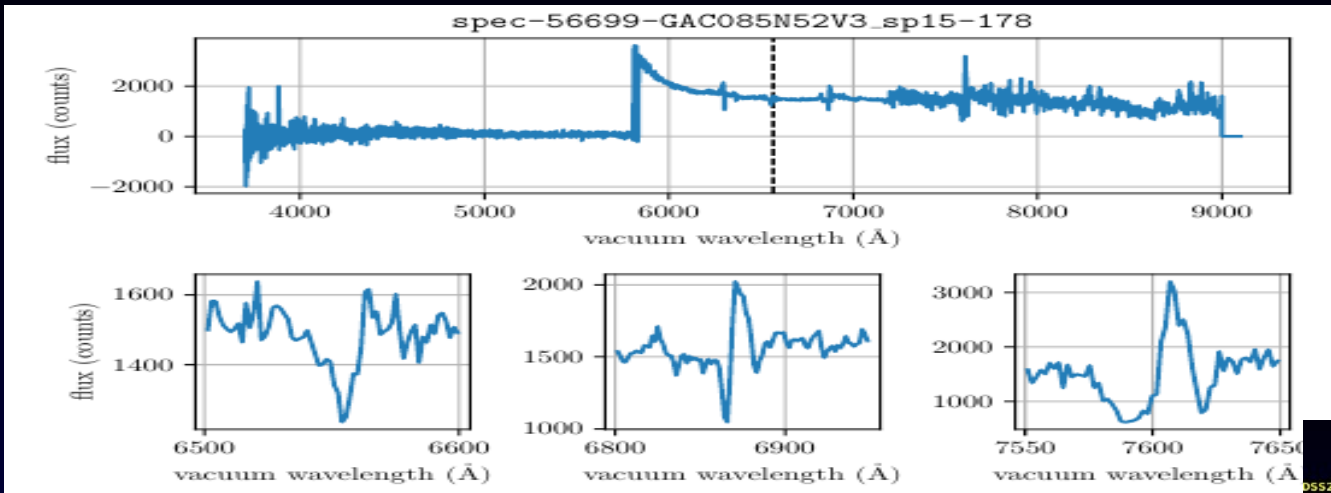
NEC

MultiSync EA2700B

Firefox browser window showing the SIMBAD database entry for 87GB 114356.6+280254. The page includes navigation tabs (Identifier, Coordinate, Criteria, Reference, Basic, Script, TAP, Output, Help) and a 'Query: 87GB 114356.6+280254' section. The 'Basic data' section is expanded to show details for '87GB 114356.6+280254 -- Seyfert 1 Galaxy'. It lists various coordinates (ICRS, FK4, Gal), proper motions, radial velocity, fluxes, and SIMBAD query options. A small image of the galaxy is visible on the right. Below the main content, an 'Identifiers (20)' section lists various astronomical catalogs and their corresponding identifiers.

A large astronomical image of the galaxy 87GB 114356.6+280254, showing a bright central nucleus surrounded by a complex, multi-lobed structure of ionized gas and dust. The image is displayed in a window titled 'Astrin v10.0'. The right side of the window features a vertical toolbar with various icons for zooming, panning, and other image manipulation functions. At the bottom, there is a status bar with technical information, including a '2.9W x 1.10W' label and other coordinates.

Visual Verification of Object with Disk

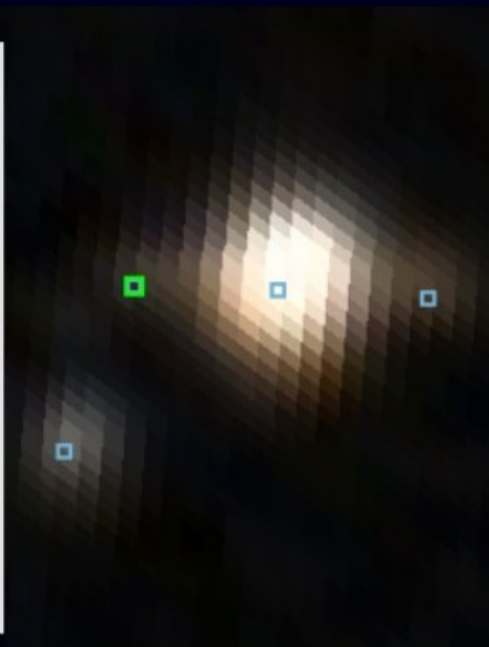


Gravitational lensing ???

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



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

6 arcsec distance

Thank You



Astronomical Institute
of the Czech Academy of Sciences



**RESEARCH
CENTER FOR
INFORMATICS**

rci.cvut.cz



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



MINISTRY OF EDUCATION,
YOUTH AND SPORTS

Tutorials of VO

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

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

IVOA Interoperability meeting 17-20 October 2022

Newcomers Intro 17 Oct 20:30 UTC !!!

Watch the link

<https://wiki.ivoa.net/twiki/bin/view/IVOA/InterOpOct2022>