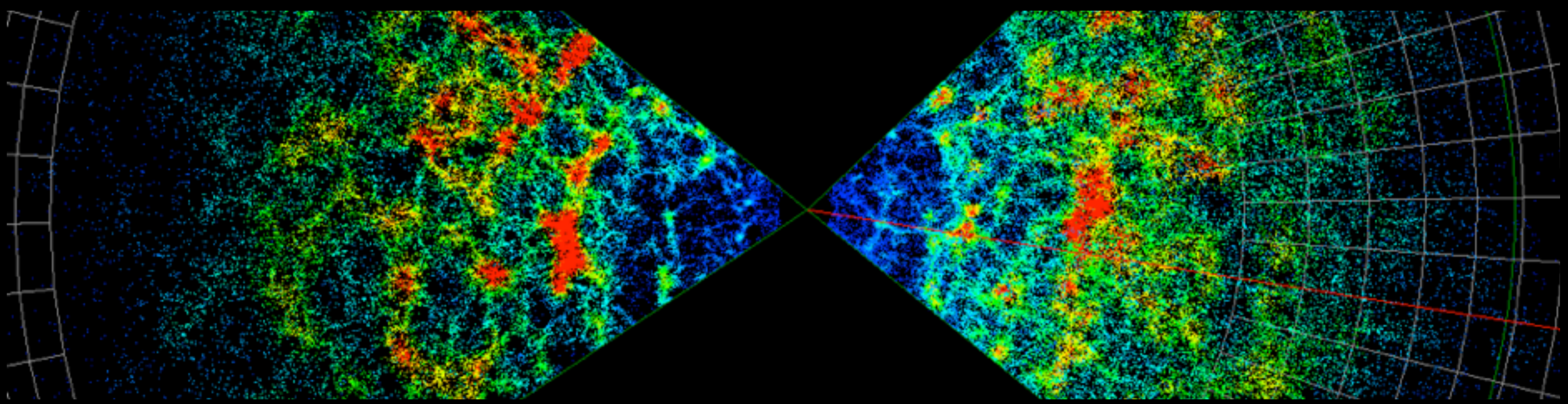
Surveys and Databases

Eduardo González-Solares (IoA, Cambridge, UK)



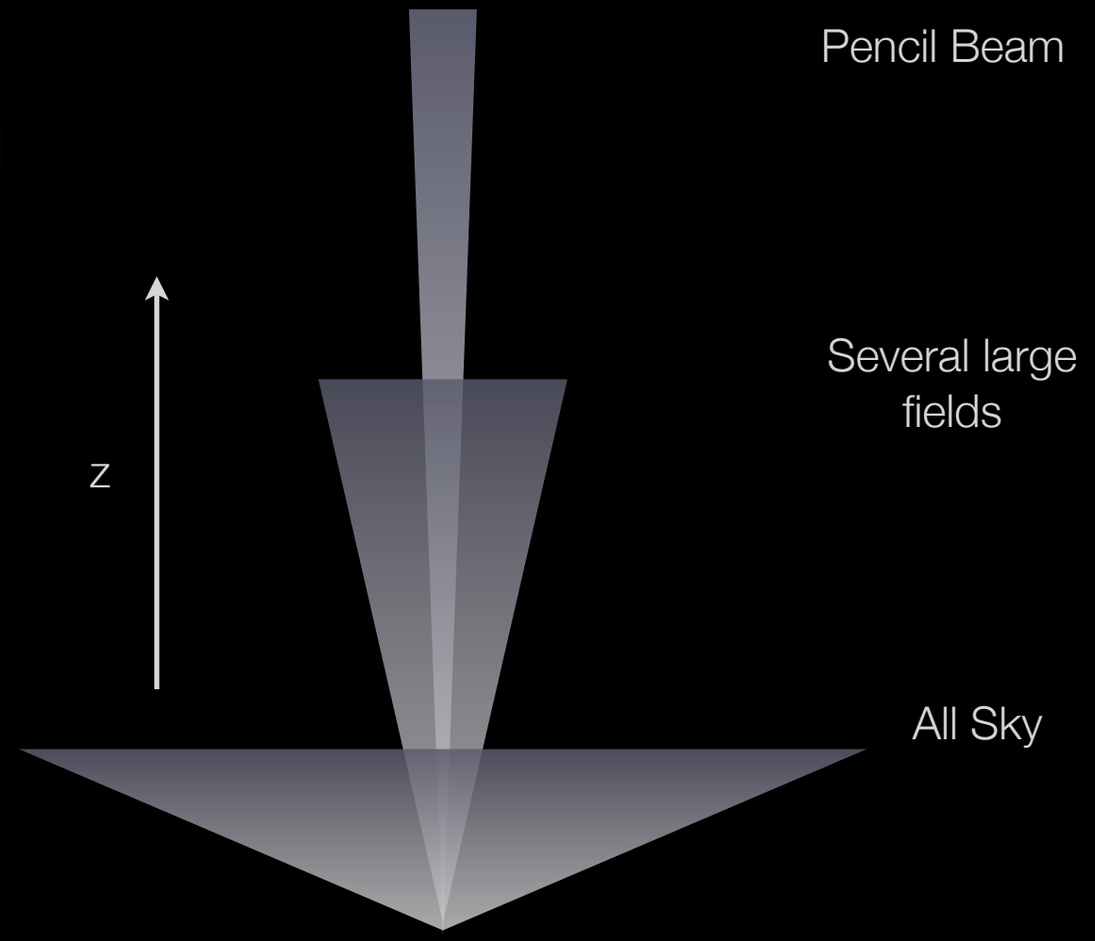
Challenges in Modern Astrophysics, Sofia 13 -14 October 2009

Why Survey The Sky?

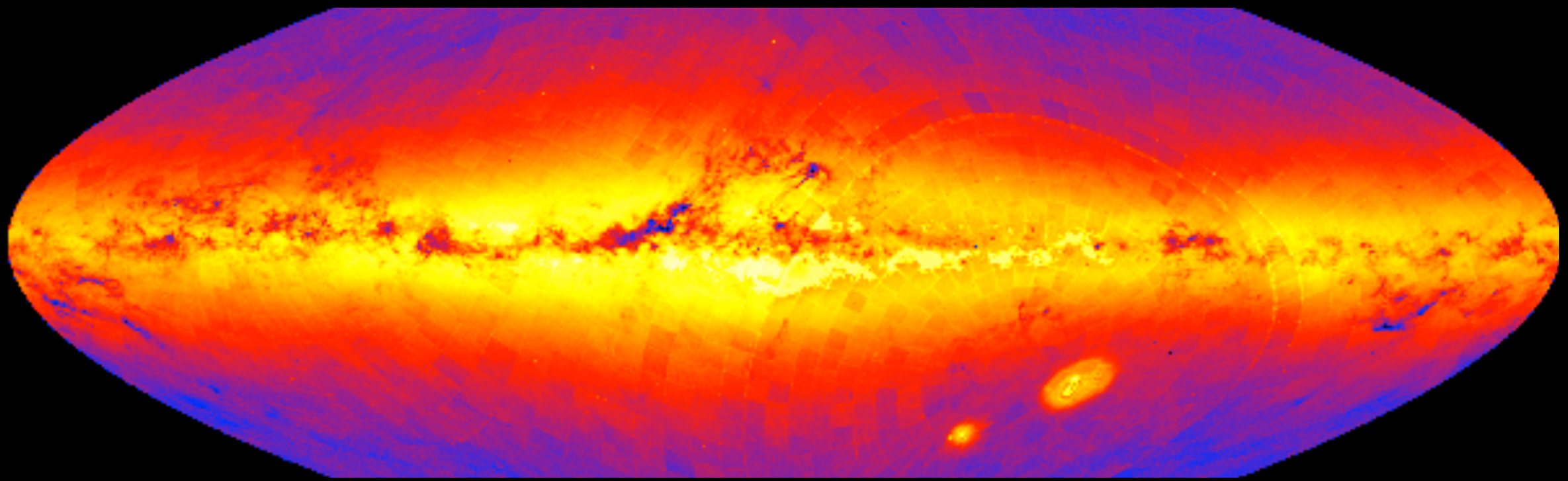
- A survey is the observation of large volumes of the universe in order to gather representative samples of objects, to discover new types of objects and/or to find the most rare objects

- Scientific aims of surveys are very broad

- Wide versus Deep

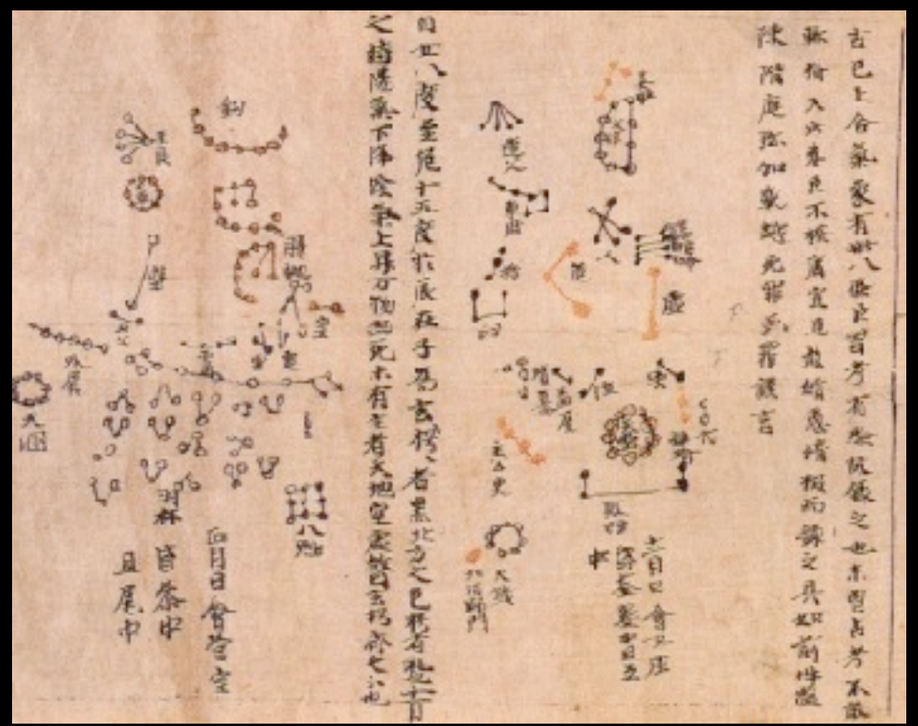


Surveys : A brief history



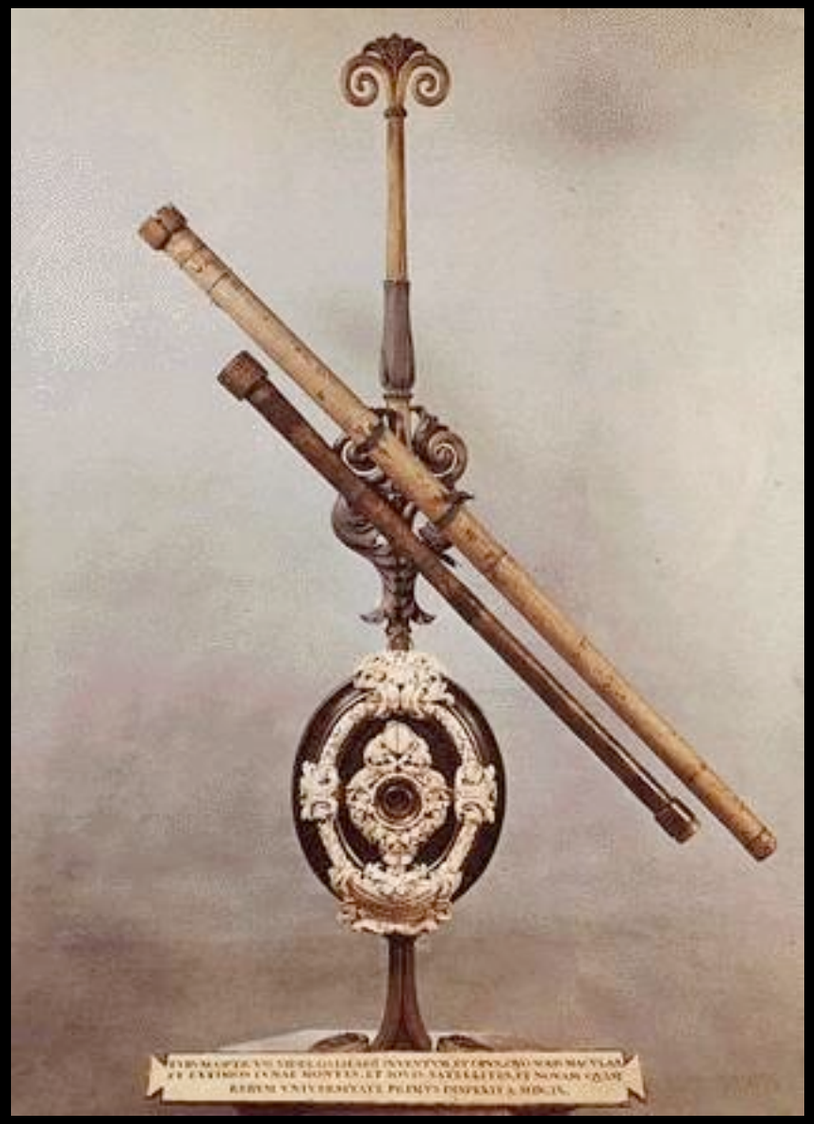
Ancient Surveys

- At night one can see about ~1000 stars
- First sky surveys were records of positions and motions of stars and planets over 5,000 years ago (Egypt, China, Central America, Mesopotamia)
- First star catalogue (800 stars) created in China in 350 B.C.
- Greek philosophers (600 B.C to 400 A.D):
  - Movement and distance of planets
  - Size of Earth, Sun and Moon



Modern Astronomy

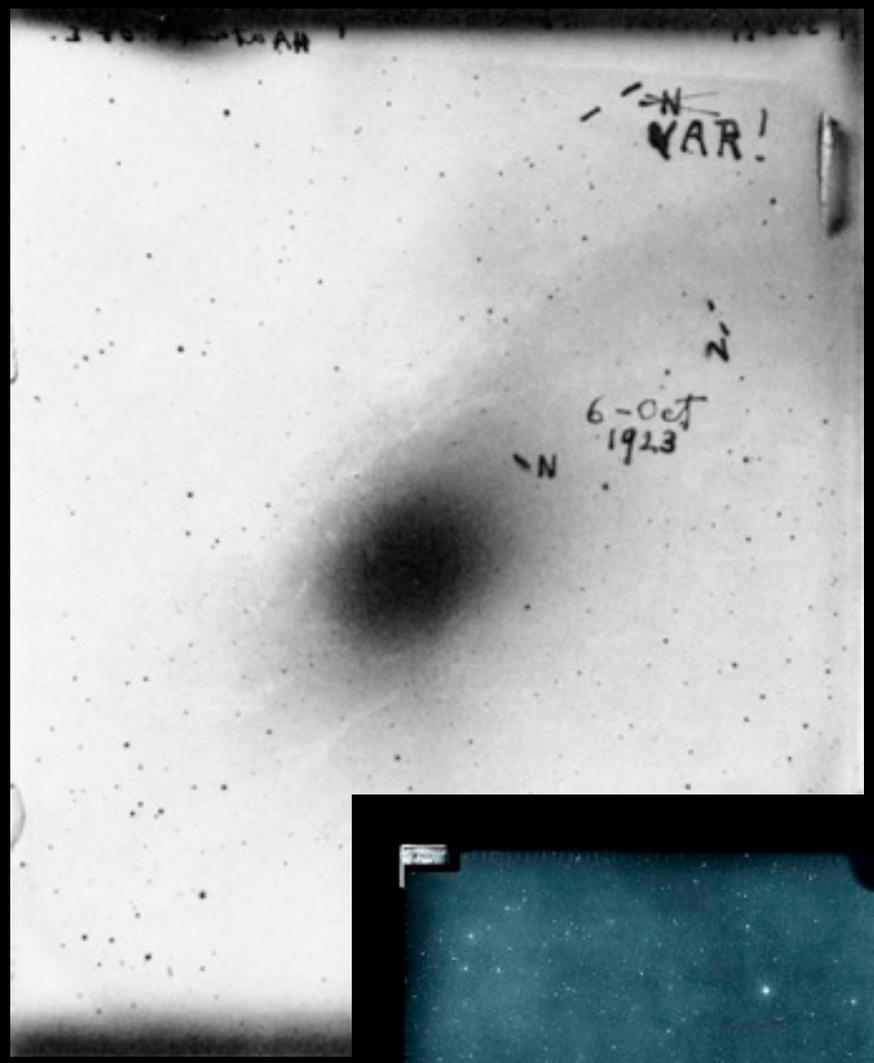
- Nicholas Copernicus (1543) solar system movement
- 1600s movement of planets
    - Tycho Brahe & Kepler compiled accurate astronomical catalogue of 700 stars
    - Galileo Galilei invents the telescope -> we can see further than our eye
    - Isaac Newton gravitation theory

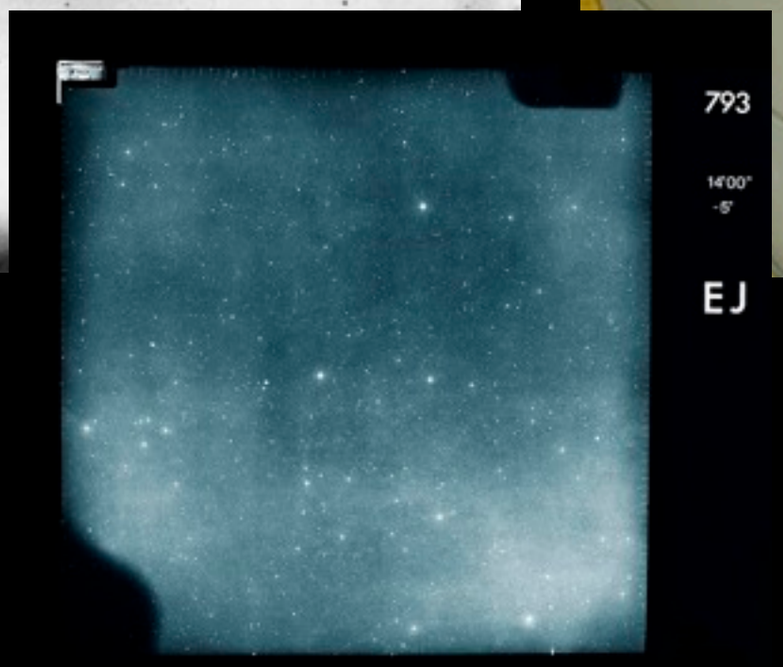


20th Century Surveys

- Invention of camera and spectrograph (late 1800s)
- Schmidt telescope (46 cm) in Mount Palomar (1936)
- Palomar Sky Survey I (1950-57) using a 1.2 meter telescope in Palomar, followed by Palomar Sky Survey II (1980-99)
- Development of observatories and surveys at other wavelengths (radio: FIRST, X-ray: RASS, Infrared: 2MASS, Far-IR: IRAS)

A bit of history

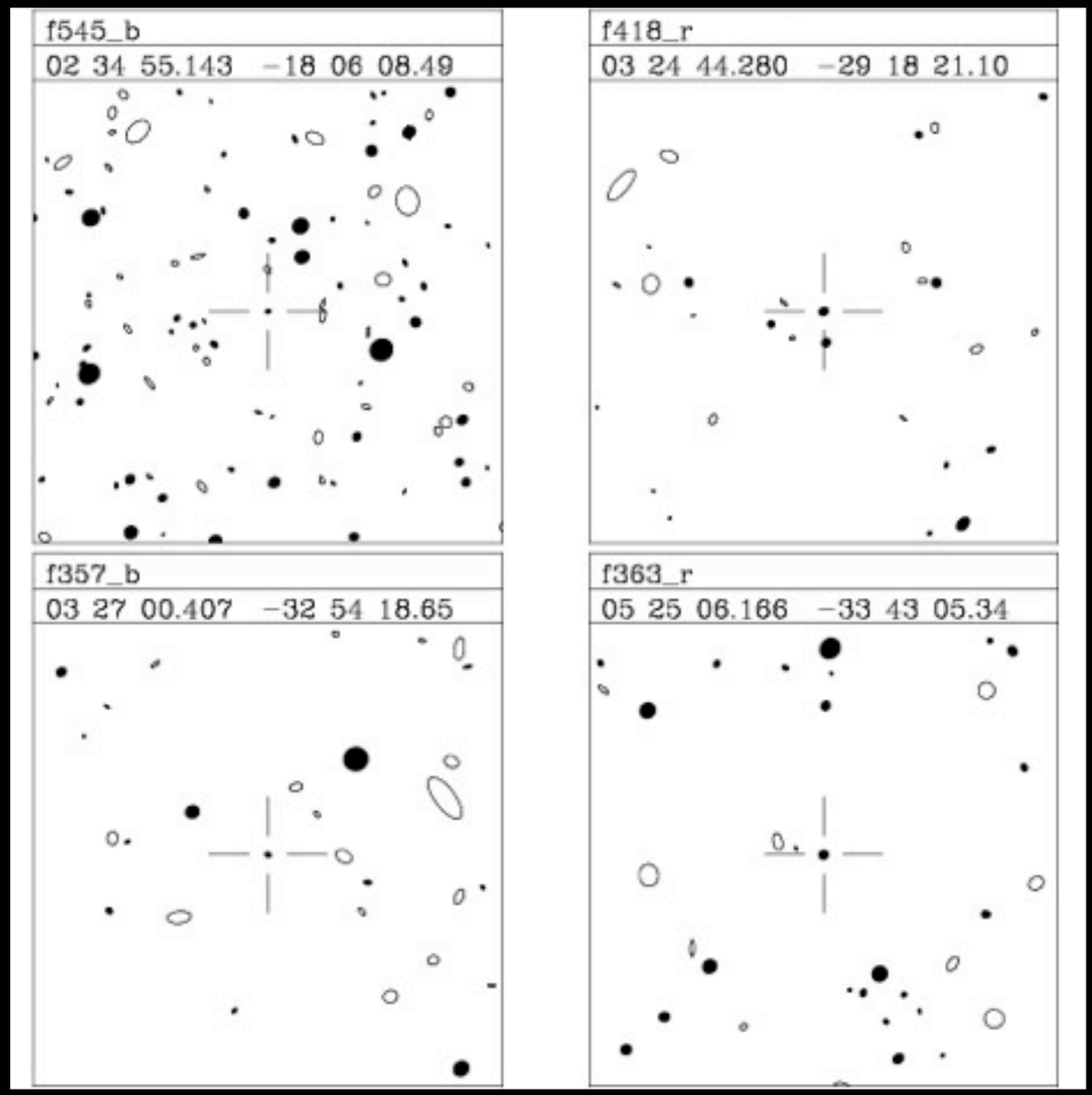




Automate Plate Measurement machine,
IoA, Cambridge

The APM photographic sky survey

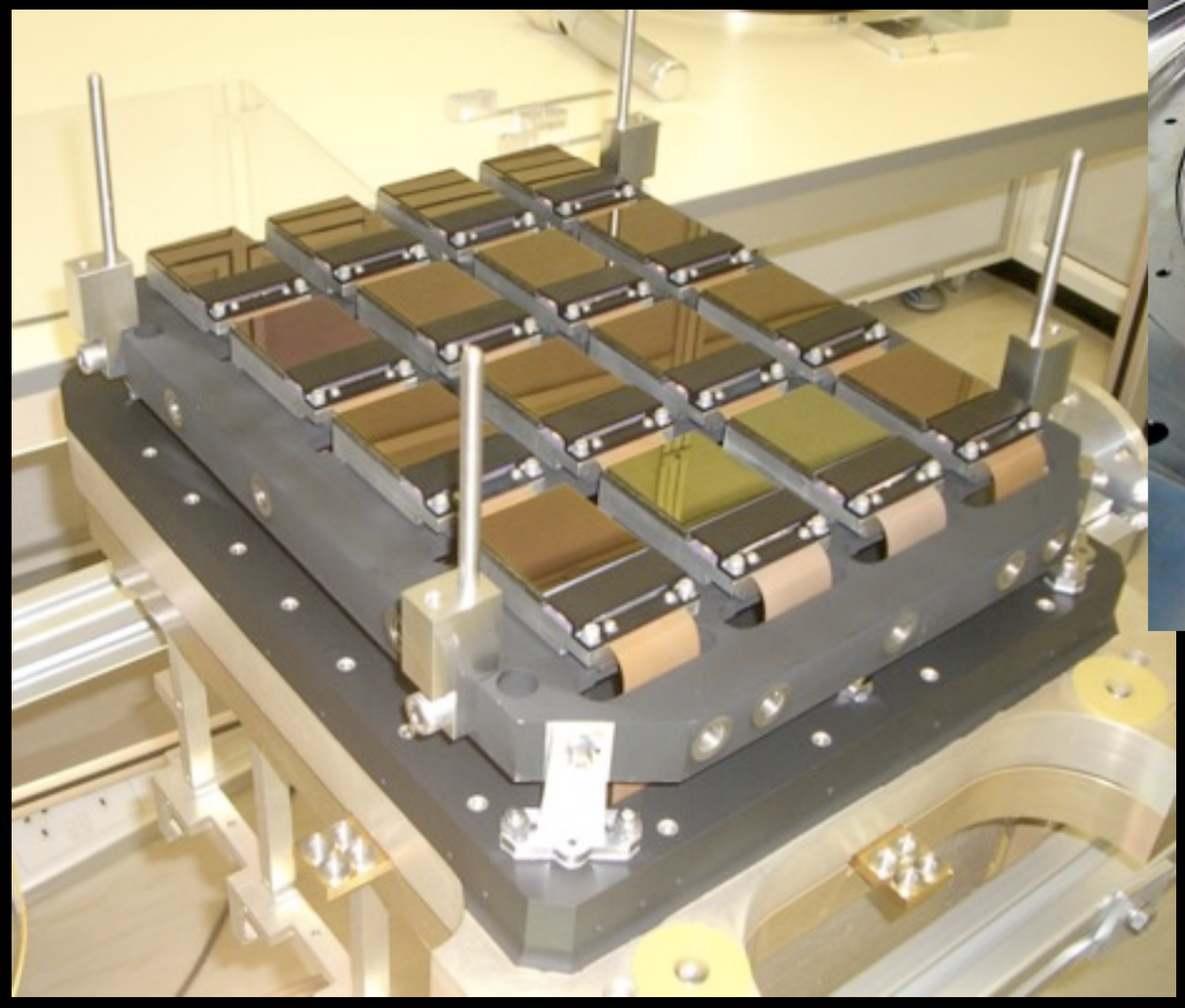
- ~10GB/day
- ~1000 plates/year
- UKST, AAT, KPNO, CFHT, CTIO
- Object extraction and parameterization
- ~4h/plate scanning and processing (UKST)



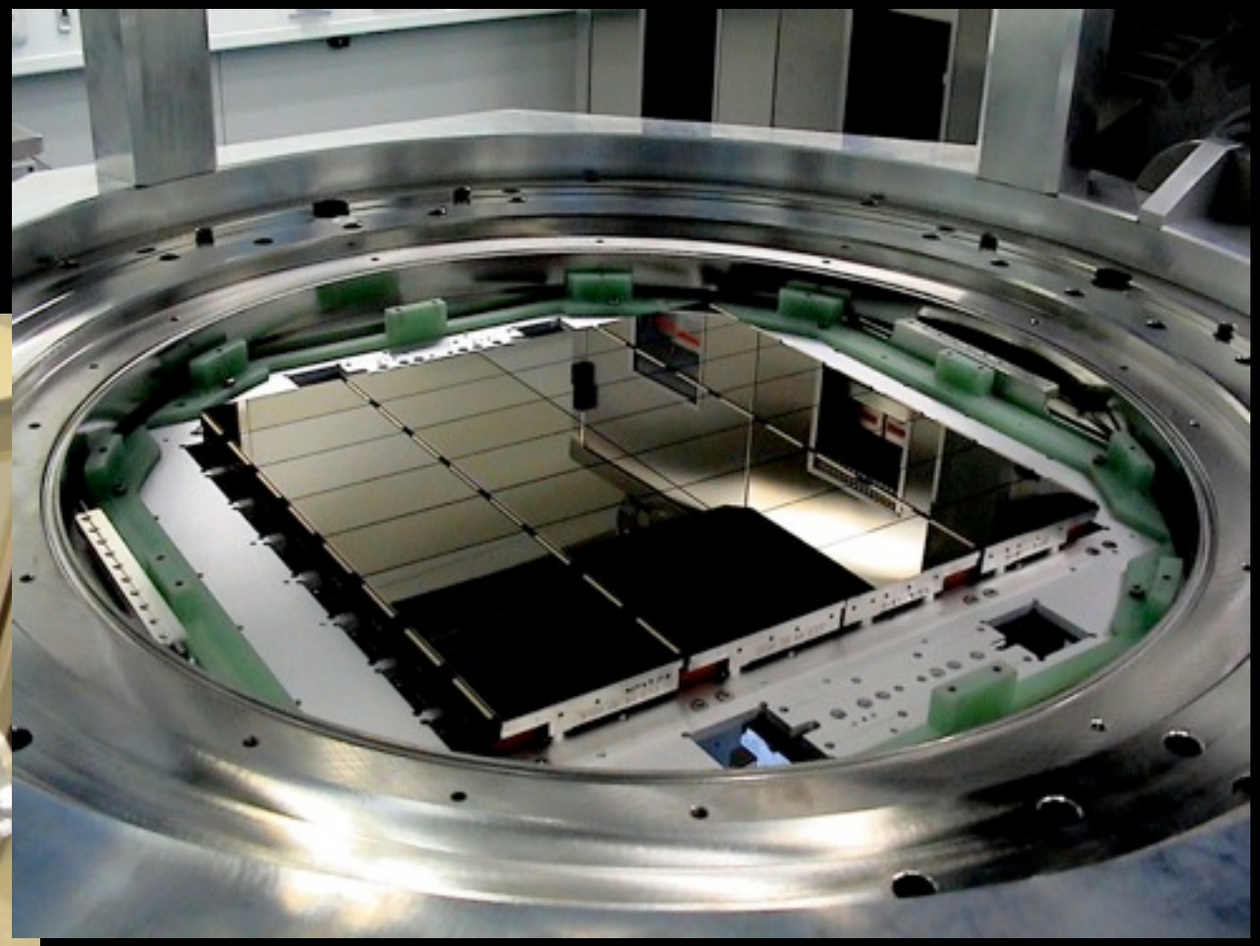
Irwin 1985
McMahon & Irwin 1992
Irwin 1994
McMahon et al 2001

Modern day technology

1st light CCD on 1m telescope in KPNO (1979)



VIRCAM@VISTA



Omegacam@VST

Modern Day Surveys

Optical: The Sloan Digital Sky Survey

- SDSS 2.5m telescope at Apache Point Observatory (New Mexico)
- Optical multiband (ugriz) imaging and spectroscopic survey of 1/4 of the sky
- Imaging catalogue: 357M / Spectroscopic catalogue: 1.6M
- Archive > 100 TB

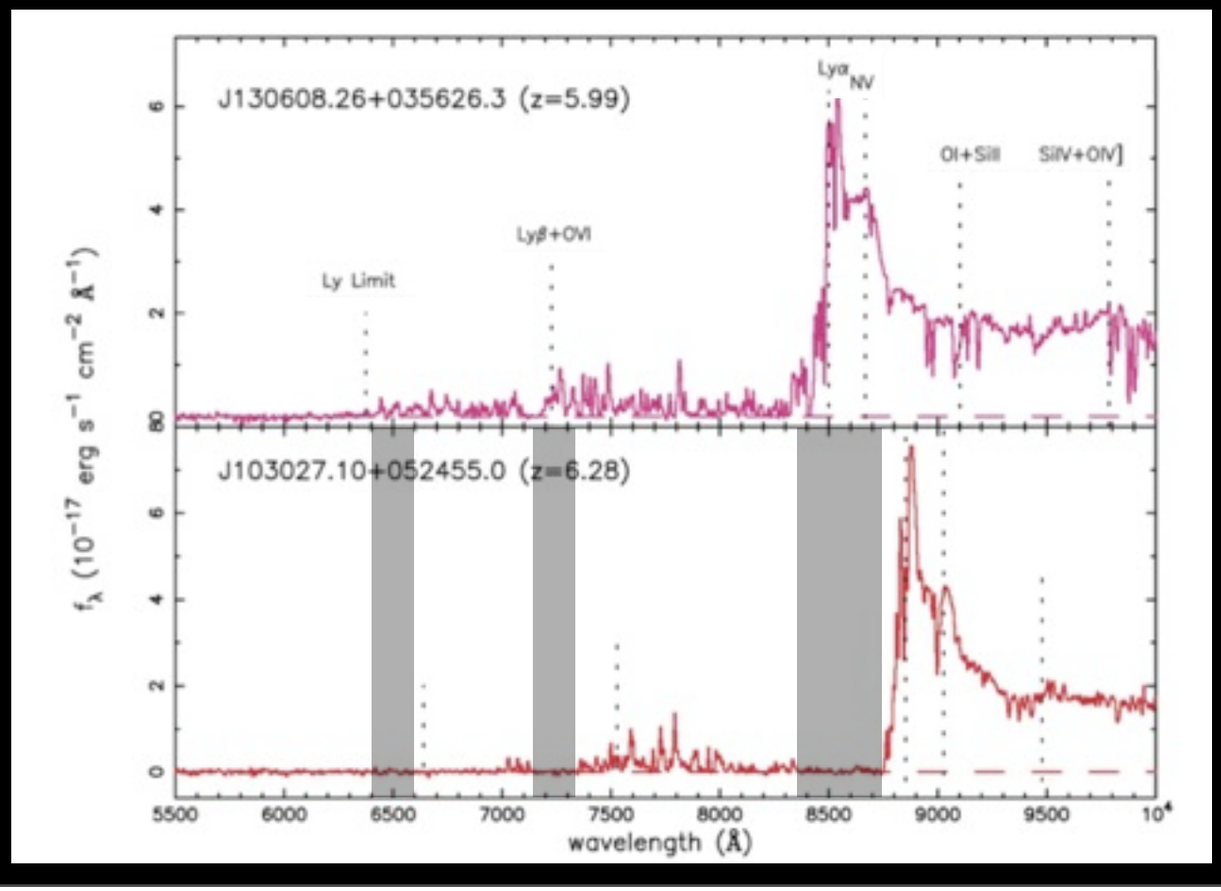
SDSS-I: 2000-5
SDSS-II: 2005-8
SDSS-III: 2008-14

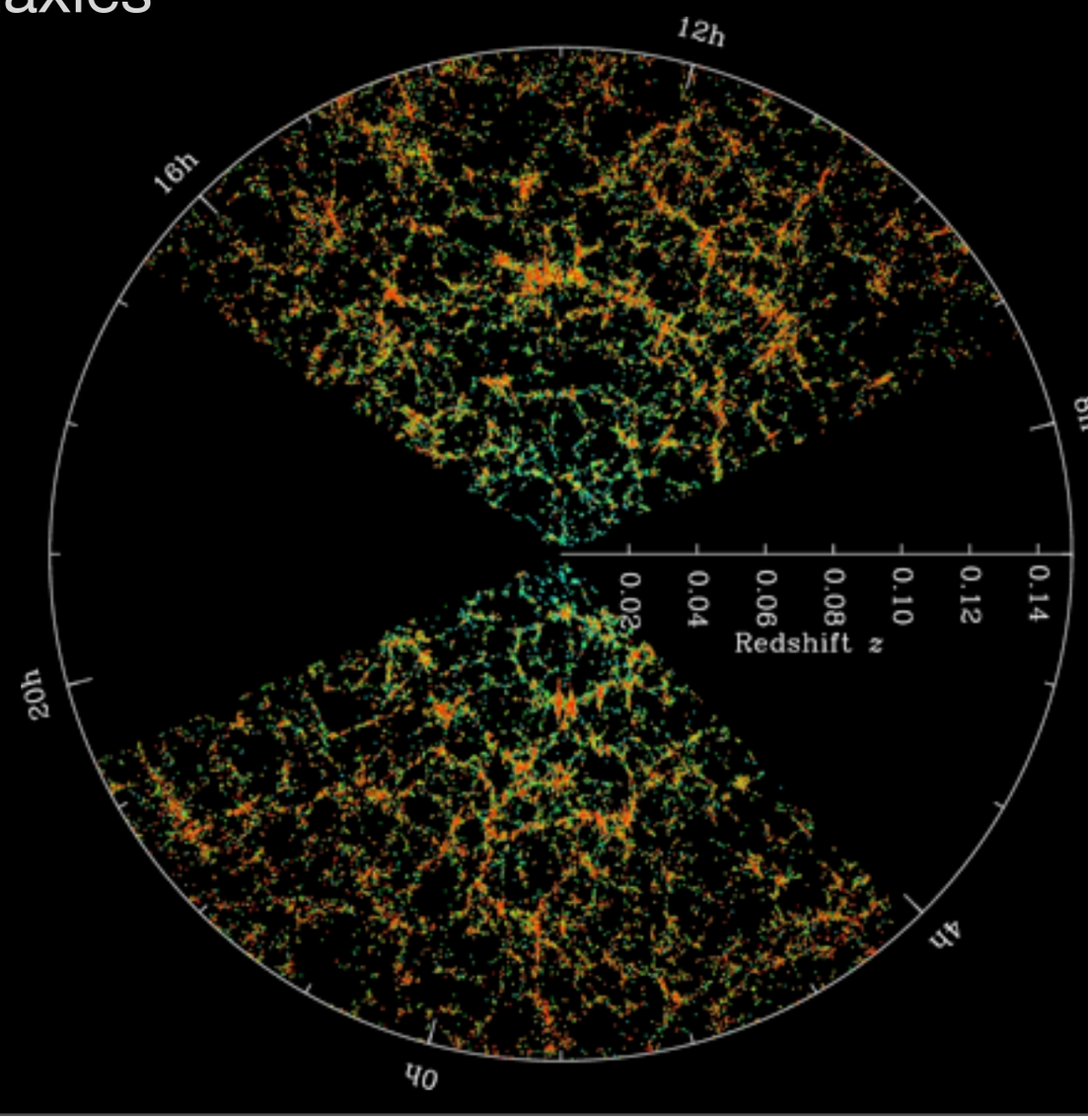
Optical: The Sloan Digital Sky Survey

- Discovery of most distant quasars seen when the Universe was just 900 million years old

- Measurement of large scale structure of galaxies

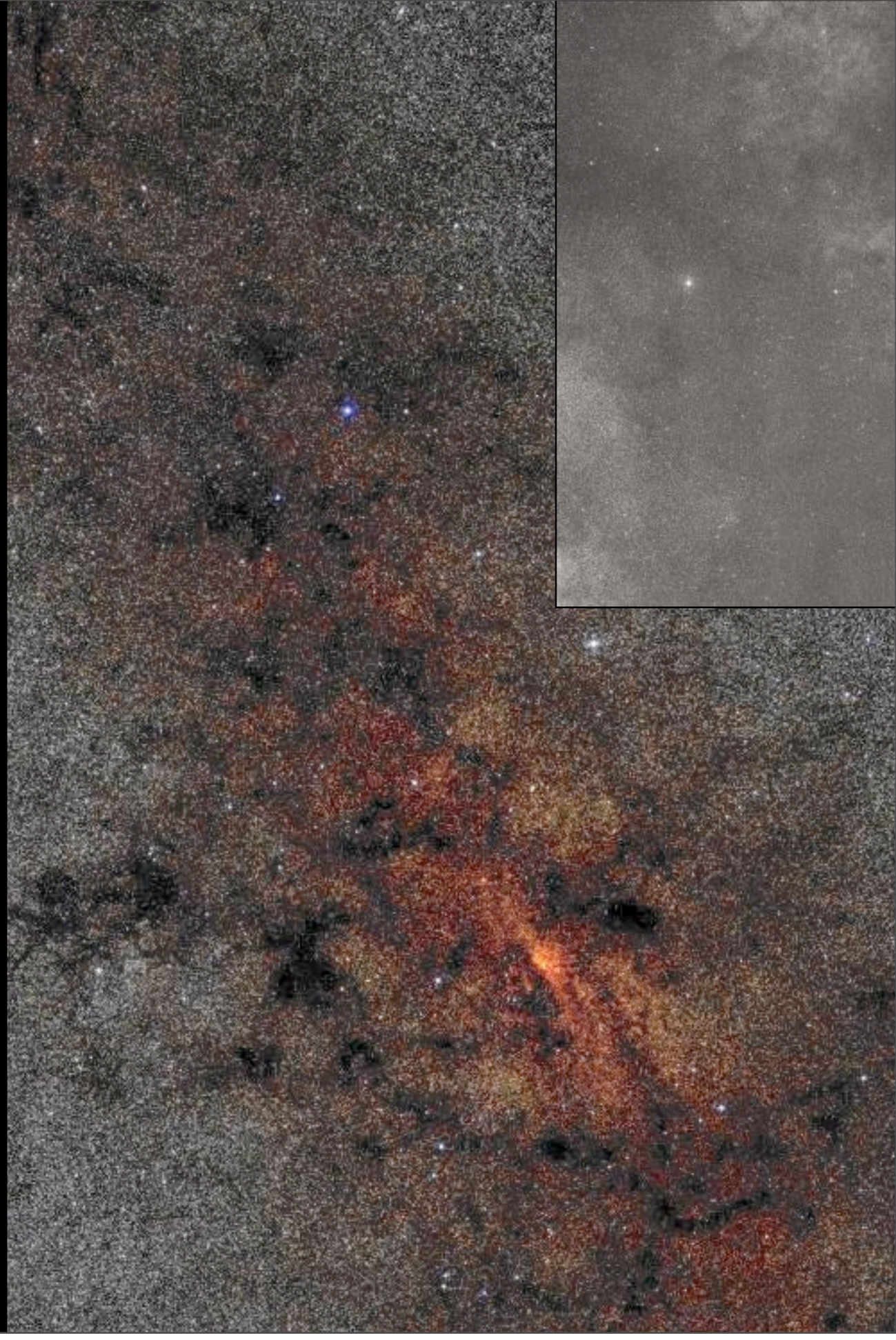
- Origin and structure of the Milky Way





Near-IR: From 2MASS to VISTA

- Near-IR is more sensitive to cooler, redder stars than optical
- Can view through dust regions
- Probe red, obscured galaxies
- 2MASS covers all sky
- 4M images, 472M objects
- 10TB of images

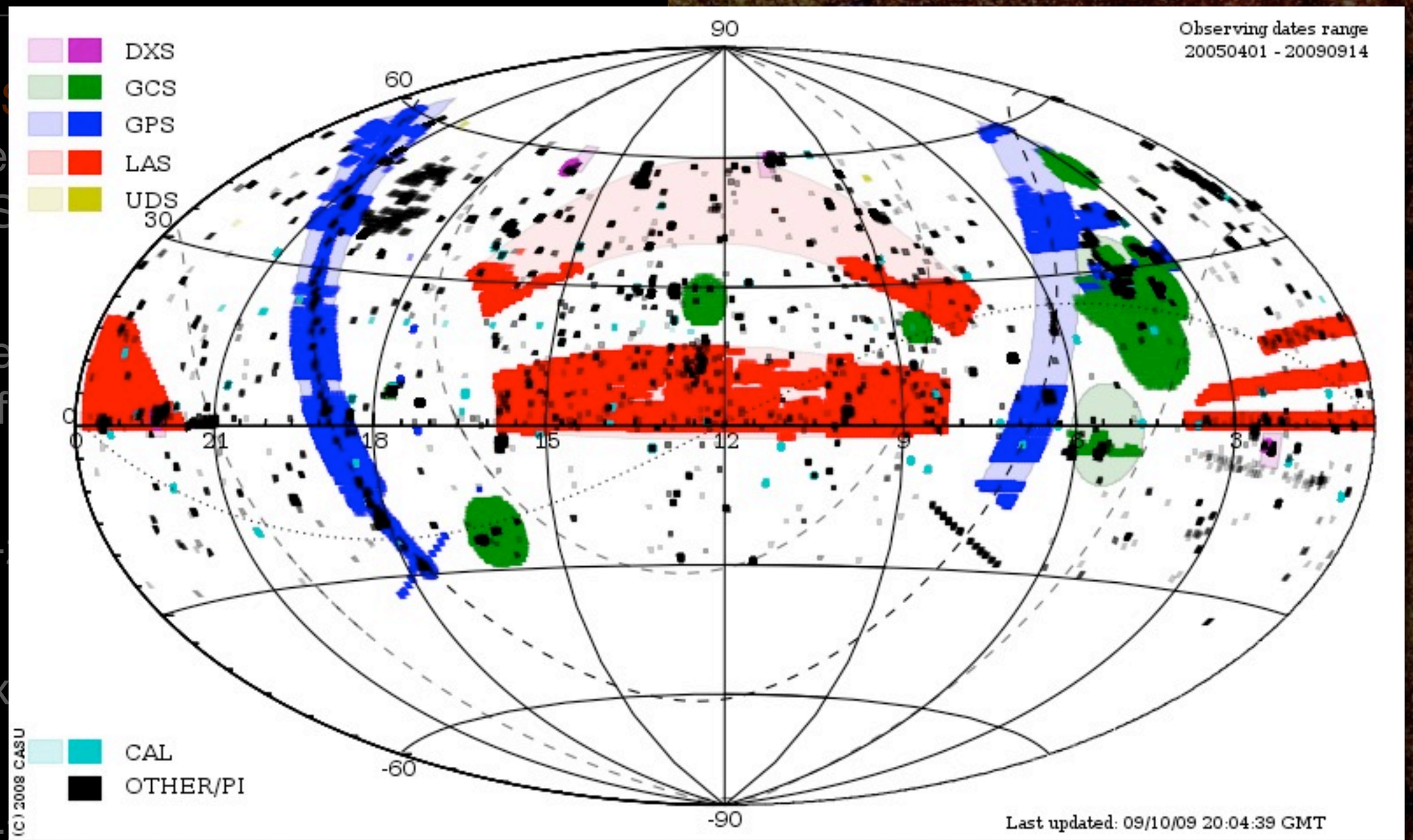


Near-IR: From 2MASS to VISTA

- UKIDSS now observing 7,500 sq deg - 3 mag deeper than 2MASS
- Coolest and nearest brown dwarfs
- High-z starburst galaxies
- Galaxy clusters at z~2
- High-z quasars at z~7

Near-IR: From 2MASS to VISTA

- UKIDS
  sq de
  2MAS
- Coole
  dwarf
- High-
- Galax
- High-



Near-IR: From 2MASS to VISTA

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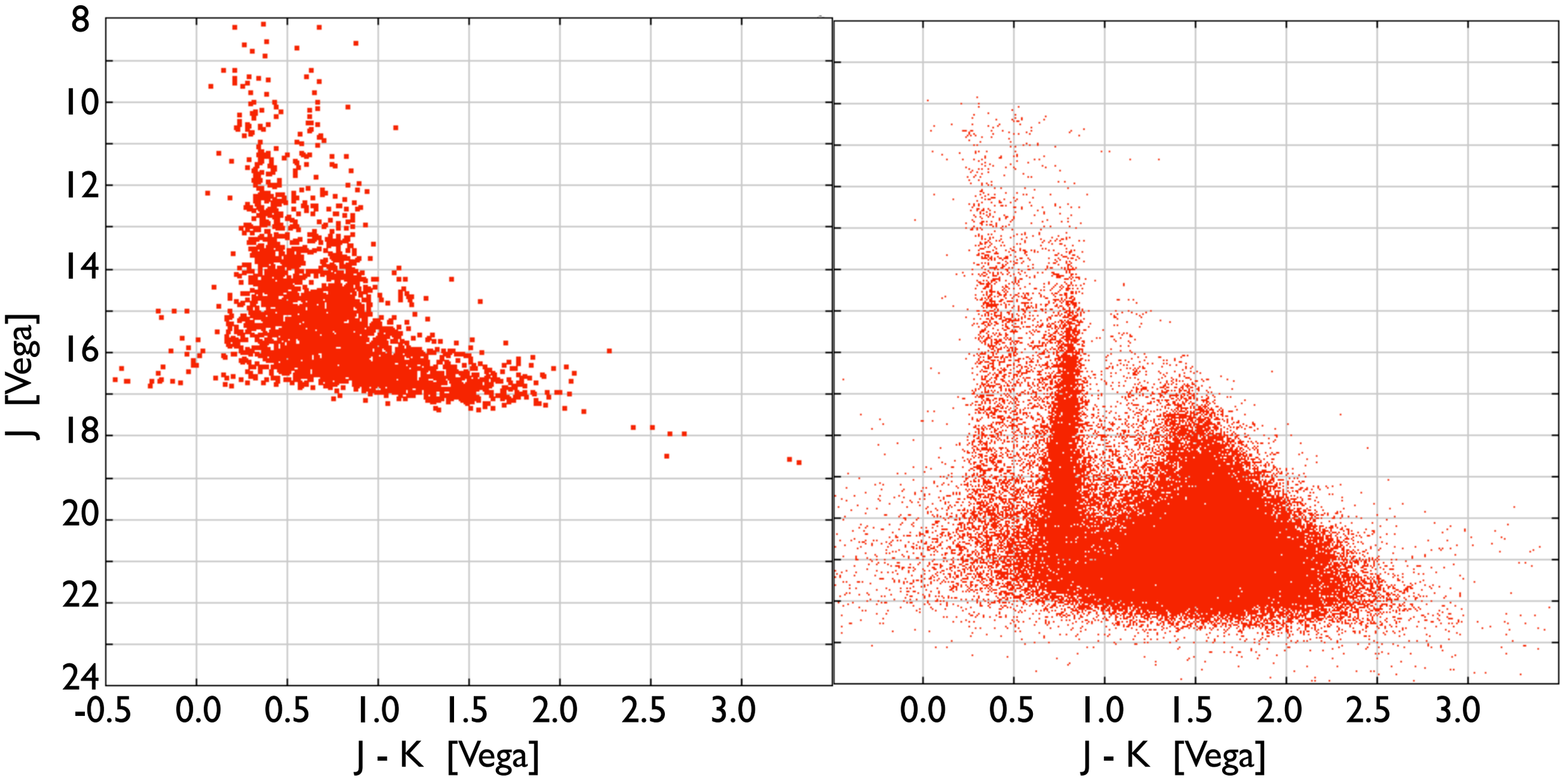
2.5 sq. deg. 2MASS vs UKIDSS-DXS



Near-IR: From 2MASS to VISTA

- VISTA will survey the southern hemisphere in the near-IR
- Nearest and lowest mass stars
- Nature and evolution of Dark Energy
- Physics of the epoch or reionization; the discovery of the first z>7 QSOs
- 100 times the volume of 2MASS
- Support of ESA missions: XMM-Newton, Herschel, Plank, GAIA

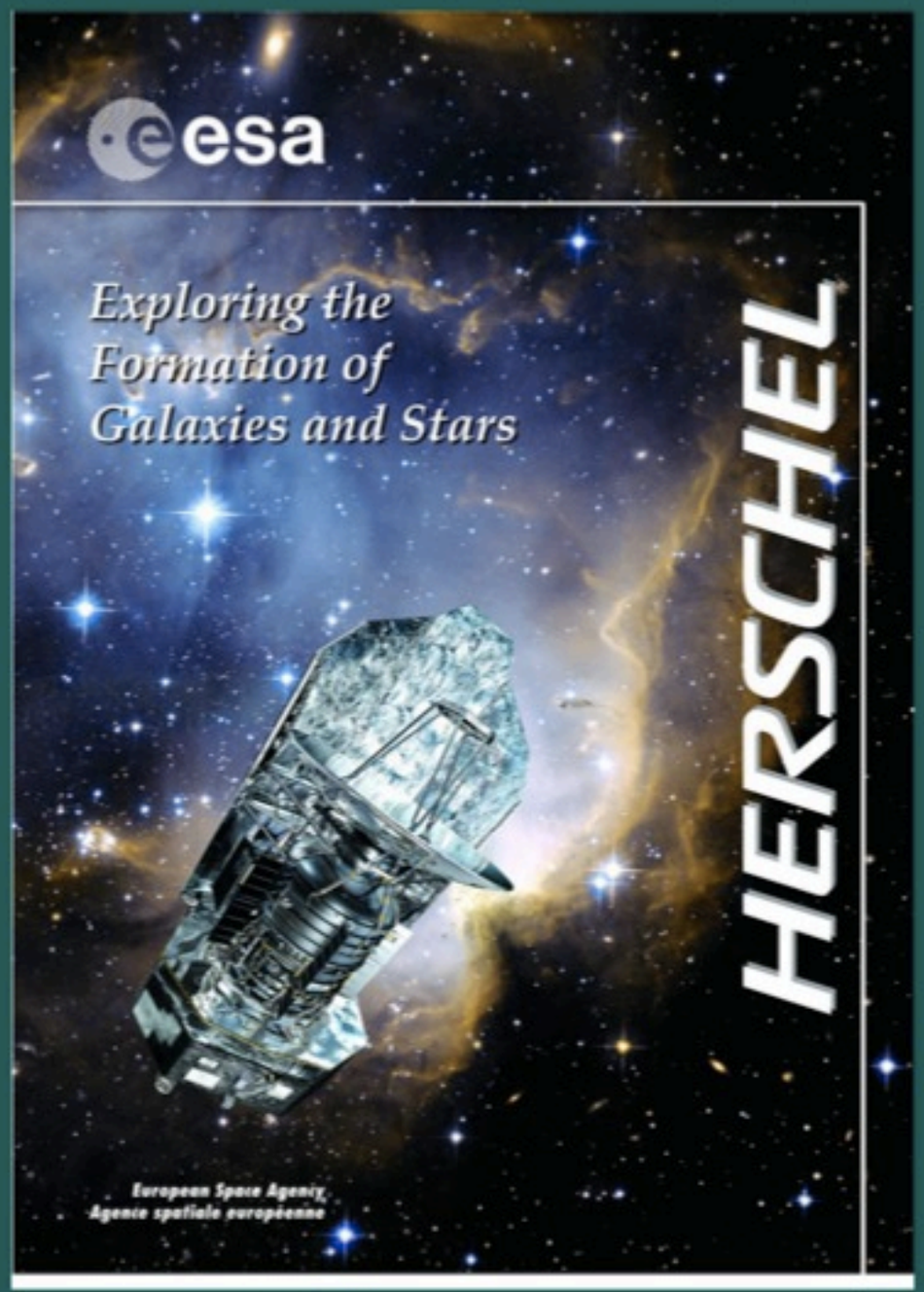
Mid- and Far-IR: IRAS, Spitzer and Herschel

- IRAS (1983) full sky survey at 12, 25, 60 and 100 um - 350,000 sources
  - Infrared cirrus (dust clouds in our galaxy)
  - Starburst galaxies - galaxies emit most of the bolometric luminosity in the IR
  - Strong IR emission from interacting galaxies
  - Most luminous object in the Universe (F10214+4724)

Mid- and Far-IR: IRAS, Spitzer and Herschel

- Spitzer (2003, still operating) and Herschel (2009) are observatory type missions but much time is dedicated so surveys.
- Very cool stars
- History of Star Formation and energy production
- Galaxy structure formation, evolution of clustering
- AGN/Starburst Connection

Herschel Key Projects



Herschel Multi-tiered Extragalactic Survey (HerMES, 900hrs)

PACS Evolutionary Probe (PEP, 650hrs)

The Herschel Thousand Degree Survey (600hrs)

The Great Observatories Origins Deep Survey: far-infrared imaging with Herschel (363hrs)

The Herschel Lensing Survey (292h)

X-Ray, Radio, Sub-mm, ...

- X-Ray: RASS, XMM and Chandra Surveys, ...
- Radio: FIRST VLA Survey, ...
- CMB: COBE, WMAP, Planck, ...

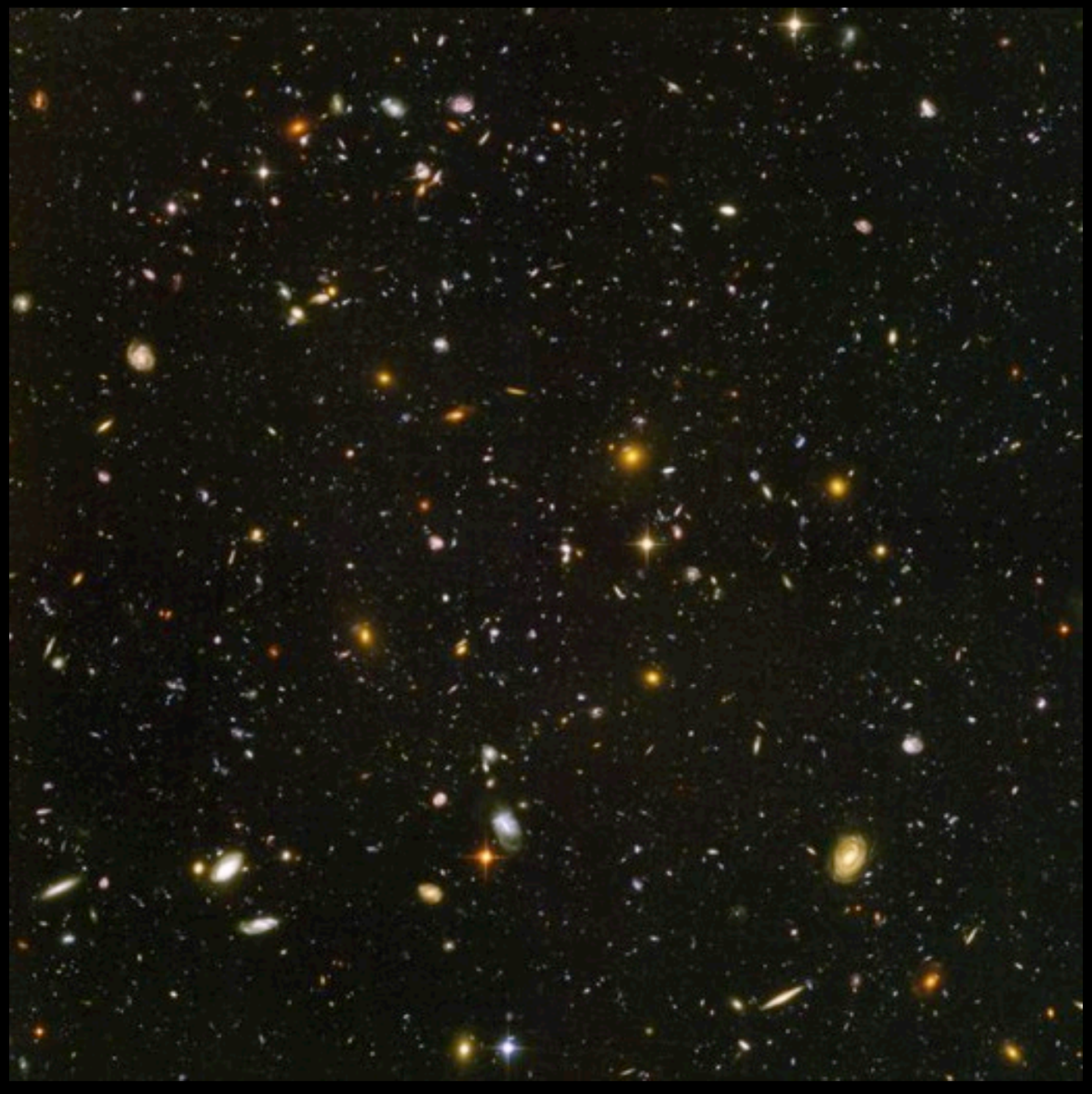
- GAIA will produce the most accurate 3D map of our Galaxy

Every telescope or space mission
has been used to carry out surveys

... and also pushed to their limits to
reach the most distant Universe ...

Deep Surveys : Hubble Ultra Deep Field

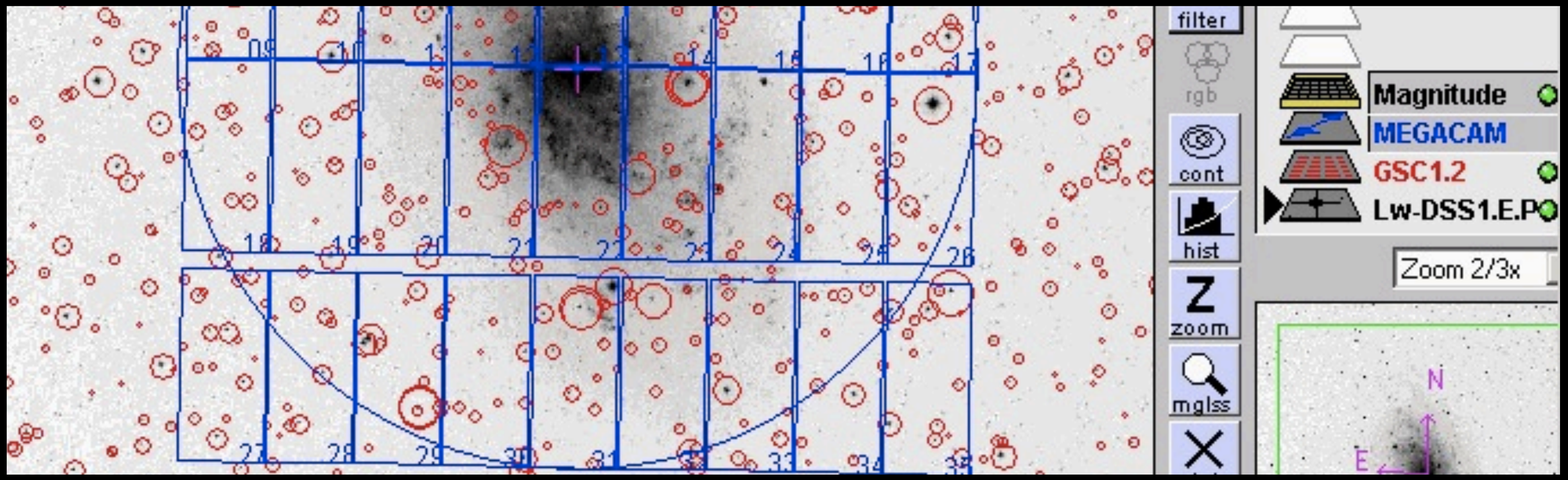
- 1 million seconds
- 11 sq arcmin / 38M pixels
- 10,000 galaxies many at z>3
- To observe the entire sky would take 1 million years
- Target of all major observatories: Chandra, XMM, Spitzer, VLA, ...



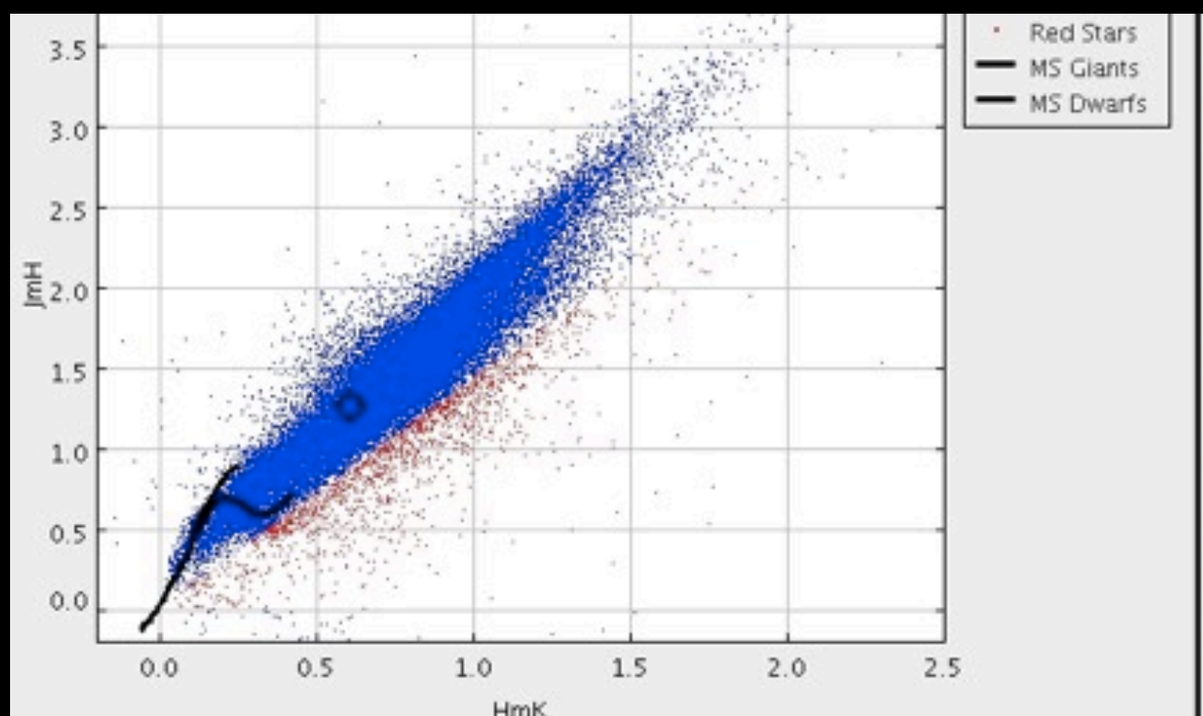
200 arcsec / 6200 pix

There are many fields with a lot of observations...

- GOODS North & HDFN
- GOODS South & CDFS
- Lockman Hole
- Extended Groth Strip
- XMM-LSS
- ELAIS N1, N2, S1
- First Look Survey
- Bootes (NOAO Deep Wide)
- VVDS
- ...and many more...



Astronomy In The Internet Age



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8282	16.9186	0.03424	16.1881	1.5098	0.730505	0.483843
8283	13.8458	0.002594	12.8409	2.12918	1.00488	0.471955
8284	13.9156	0.00273	13.6383	0.623055	0.277364	0.445167
8285	16.7164	0.028553	15.7788	1.82902	0.937608	0.512628
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8288	17.2891	0.047938	16.3794	1.30627	0.909657	0.696377
8289	14.9812	0.006302	14.541	0.987638	0.440269	0.445779
8290	15.6616	0.011224	13.9998	2.97237	1.6618	0.559082
8291	16.7246	0.028755	15.5558	2.1776	1.1688	0.536735
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8293	17.2259	0.045246	16.3878	1.57188	0.838041	0.533146
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8299	12.104	0.000851	11.9174	0.348541	0.186615	0.535417
8300	10.2197	0.000324	9.61589	-0.190254	0.603826	-3.17378
8301	17.3531	0.050744	16.3772	1.40084	0.975897	0.696652
8302	15.2676	0.00801	14.4939	1.60517	0.772716	0.482015

Astronomy Trends

CMB Surveys (pixels)

- 1990 COBE 1,000
- 2000 Boomerang 10,000
- 2003 WMAP 1M
- 2009 Planck 10M

Angular Galaxy Surveys (obj)

- 1970 Lick 1M
- 1990 APM 2M
- 2005 SDSS 200M
- 2009 PanStarrs 1200M
- 2015 LSST 3000M

Galaxy Redshift Sources (obj)

- 1986 CfA 3,500
- 1996 LCRS 23,000
- 2003 2dF 250,000
- 2005 SDSS 750,000

Astronomy data

- 1 pixel (byte) per sq arc second -> 4 TB to cover the whole sky
- Multi wavelength, different epochs, different depths, ... -> 1 PB
- Data doubles every 2 years

What is a Petabyte

- A Petabyte is a lot of data (10^{15} bytes)
- 1PB 13.3 years of HD video
- 50PB is the entire written works of mankind from the beginning of recorded history in all languages
- Get ready for the next revolution: Exabytes (10^{18}), Zettabytes (10^{21}) and Yotabytes (10^{24})

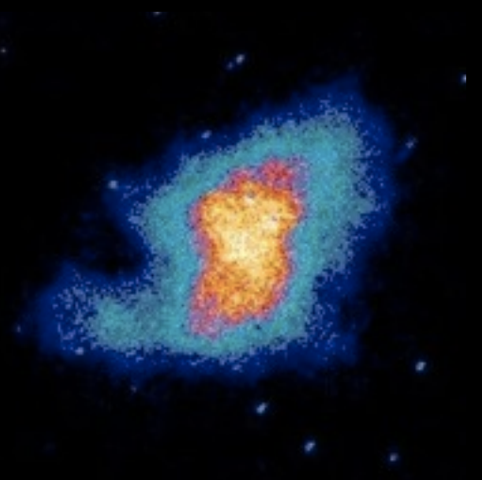
Some future facilities

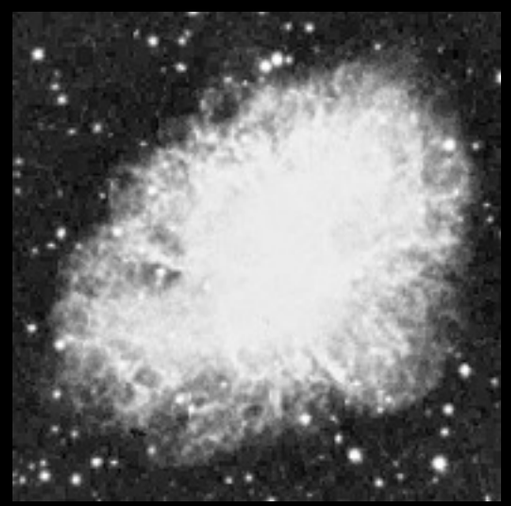
- PanStarrs 1 (1.8m) produces in 1PB / year. 80TB database server (largest astronomy database in the world)
- PanStarrs 4 (2012) will generate 4 PB/year
- LSST (2015) is a 8.4m telescope which will produce 30TB per night
- SKA (2020) 1EB / day (i.e. more data in 6 hours than all radio astronomy ever)

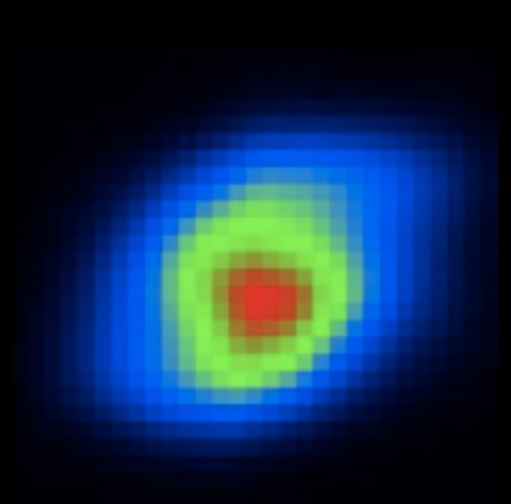
Astronomy data

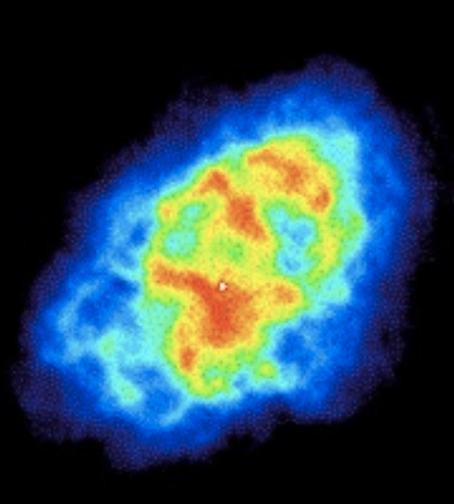
- 1 pixel (byte) per sq arc second -> 4 TB to cover the whole sky
- Multi wavelength, different epochs, different depths, ... -> 1 PB
- Data doubles every 2 years
- Discoveries are done in the boundaries, need to cross match different wavelengths

The multiwavelength Crab Nebula









http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m1.html
http://imagine.gsfc.nasa.gov/docs/science/know_l2/multiwavelength.html

Need for databases

- Traditional data search and transfer are not adequate
- You can do a grep of 1TB in 2 days, transfer it by internet in 2 days for 1K$
- You can do a grep of 1PB in 3 years, transfer it by internet in 3 years for 1M$
- Need indices to limit search, parallel data search, i.e. databases
- Do not move the data, do all data manipulations at the database

Sloan Digital Sky Survey / SkyServer

Welcome to the **DR7 Catalog Archive Server** site providing public access to SDSS data for professional astronomers.

The following databases are available	
BestDR7	[Default] The best version photo (imaging), spectro and tiling data
TargDR7	The version of the data from which spectroscopic targets were chosen

News

This site contains data from **Data Release 7 (DR7)**. Please see the **Site News** page, **What's New in DR7** page and the **Known Problems** page for more information.

To run a query on one of the DR7 DBs other than BESTDR7, name the database explicitly in the query:

```
SELECT TOP 100 * FROM TARGDR7..PhotoObj
WHERE r<17 and r-i>2
```

SDSS is supported by

Search Tools

- Radial Search
- Rectangular Search
- SQL Search
- Imaging Query
- Spectro Query
- Object Cross-ID
- Get images
- Emacs Interface
- sqlcl

Advanced Tools

- Finding Chart
- Navigate
- Image List
- Explore
- CasJobs
- CasJobs CL tool
- VO Services
- Open SkyQuery
- Spectrum Services

Links

- About the SDSS
- About the SkyServer
- SDSS Project Website
- Data Archive Server
- Public SkyServer
- Famous places
- Images of RC3 Galaxies
- Educational Projects
- NVO Website

Help and Tutorials

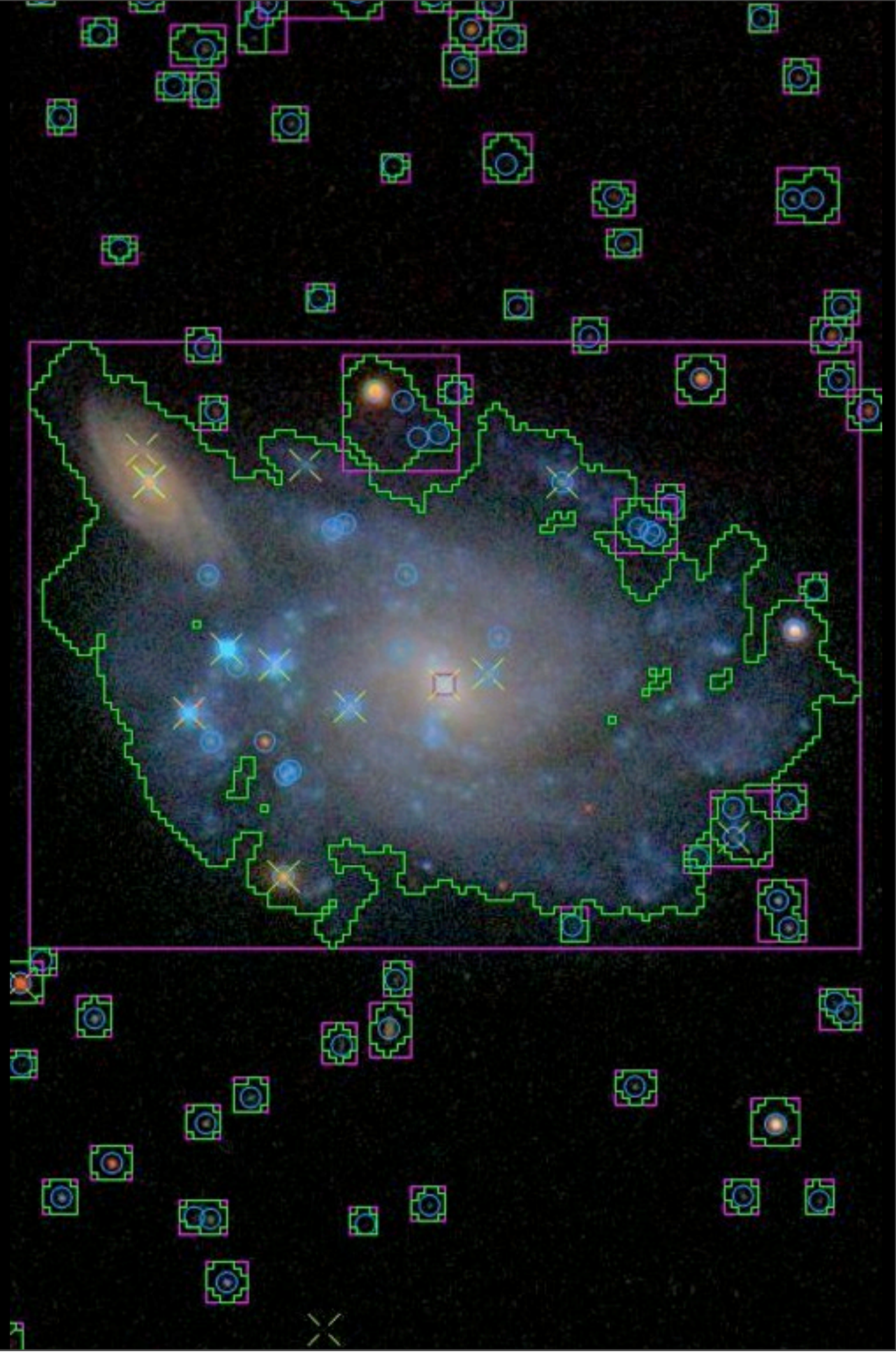
- Archive Intro
- FAQ
- Glossary
- Algorithms
- Table Descriptions
- Schema Browser
- Sample SQL Queries
- Details of SDSS Data
- Skyserver.org

Powered by Microsoft

Site Traffic
Privacy Policy

SDSS SkyServer

- Radial / Rectangular Search
- Image Query
- Spectra Query
- Image List
- Object Cross ID
- CasJobs / SQL Search
- Command Line Access

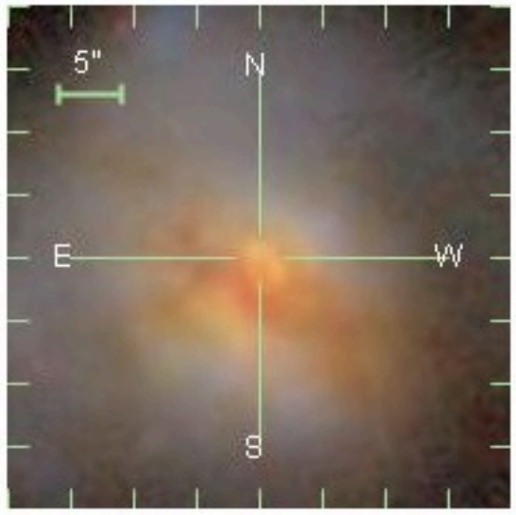


SDSS J153457.20+233013.2

GALAXY ra=233.73836418, dec=23.50368353, ObjId = 587739815850606701

Column names link to glossary entries. Move mouse over a column name to get its units.

mode	PRIMARY
status	TARGET PRIMARY OK_STRIPE OK_SCANLINE PSEGMENT RESOLVED OK_RUN GOOD SET
flags	DEBLEND_DEGENERATE PSF_FLUX_INTERP INTERP_CENTER BAD_MOVING_FIT MOVED BINNED1 INTERP COSMIC_RAY NODEBLEND CHILD BLENDED
PrimTarget	TARGET_GALAXY TARGET_GALAXY_RED
SecTarget	



u	g	r	i	z
15.75	14.02	13.15	12.68	12.37

err_u	err_g	err_r	err_i	err_z
0.01	0.00	0.00	0.00	0.00

run	rerun	camcol	field	obj	rowc	colc
4671	40	5	33	109	227.4	290.1

fiberMag_r	petroMag_r	devMag_r	expMag_r	psfMag_r	modelMag_r
17.27	13.10	12.99	13.15	17.68	13.15

extinction_r	petroRad_r	parentId	nChild
0.14	26.258	587739815850606700	0

SpecObjID = 6090615428931911 68

plate	mjd	fiberId	z	zErr	zConf	specClass	ra	dec	fiberMag_r	objId
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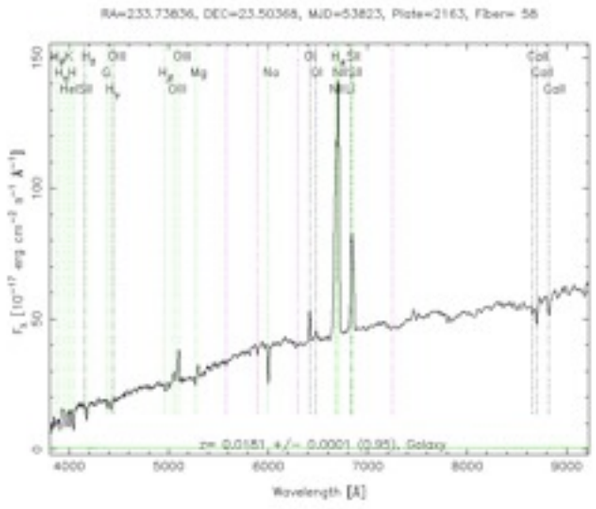

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zWarning	AB_INC
PrimTarget	TARGET_GALAXY TARGET_GALAXY_RED
SecTarget	
eClass	-0.25141
emZ	0.018
emConf	0.860575
xcZ	0.018
xcConf	0.954553

DR7

|Home |Help |Chart |Navi |Explore |

Use query to fill form

```
99-582 255.537 64.206
03-328 255.737 60.563
03-365 256.157 60.585
88-167 258.984 57.238
88-563 260.121 58.797
```

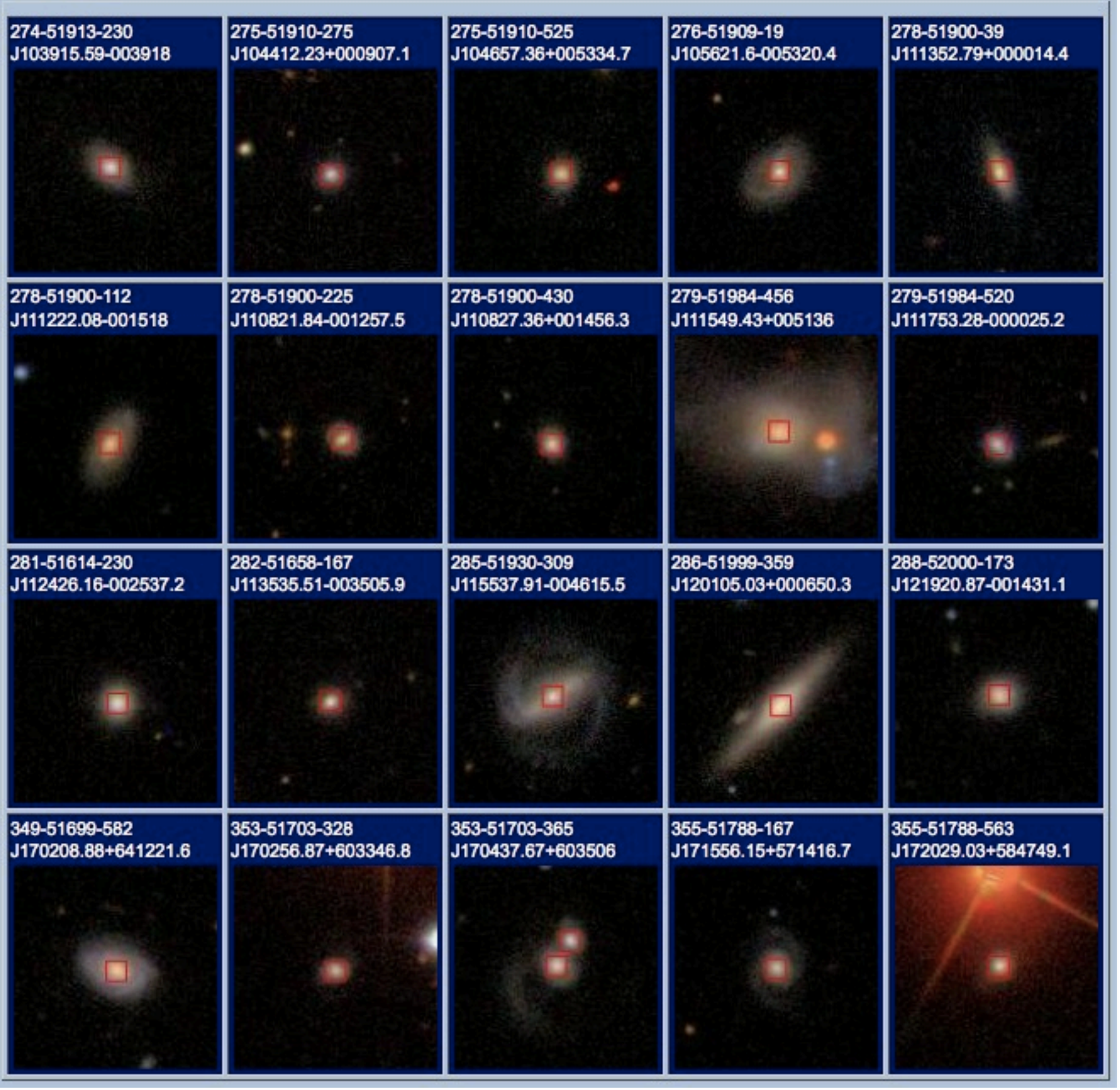
Cut and paste ra/dec list

Parameters		
scale	0.40	"/pix
opt	S	

Get Image

- Drawing options
  - [ ] Grid
  - [ ] Label
  - [ ] Photometric objects
  - [x] Objects with spectra
  - [ ] Invert Image
- Advanced options
  - [ ] Spectroscopic Targets
  - [ ] Outlines
  - [ ] Bounding Boxes
  - [ ] Fields
  - [ ] Masks
  - [ ] Plates

obj list page 1



CasJobs: Advanced Search using SQL

SDSS Query / CasJobs

Help Tools Query History MyDB Import Groups Output Profile Queues SkyServer Logout eddie0uk

Context **Table** (optional) **Task Name**

DR7 | MyTable | My Query

Samples Recent Clear Line 1, Col 1 [2 s] Query complete! Syntax Plan Quick Submit

```
SELECT TOP 100 s.objid,s.ra,s.dec,u.modelmag_r as umagr, s.modelmag_r as smagr
FROM PhotoPrimary s
JOIN Ubercal u on (s.objID=u.objID)
WHERE
    ra BETWEEN 257 and 262 AND dec BETWEEN 58.2 and 60.8
    AND s.objID=u.objID  AND  u.calibStatus_r & dbo.fUberCalibStatus('PHOTOMETRIC') > 0
```

100 row(s)

objid	ra	dec	umagr	smagr
587725503410405638	257.00106032	58.21833946	20.52997	20.52884
587725490525307697	257.00031051	58.72180179	20.98223	20.98217
587725503410340769	257.00032749	58.37866251	21.2412	21.24036
587725491061654307	257.00086382	59.9224984	20.4928	20.49268
587725503410405637	257.00029804	58.22087488	15.51977	15.51864
587725503946818623	257.00028905	59.38704185	21.83955	21.83828
587725503946818571	257.00043863	59.43112964	22.50306	22.50259

Plot Save As HTML Query Results Both

CasJobs: Advanced Search using SQL

- Basic SELECT-FROM-WHERE
- Galaxies with two criteria
- Unclassified spectra
- Galaxies with multiple criteria
- Spatial unit vectors
- CVs using colors
- Data subsample
- Low z QSOs by colors
- Velocities and errors
- Using BETWEEN
- Moving asteroids
- Quasars in imaging
- Selected neighbors in run
- Multiple OUTER JOINs
- Repeat spectra
- Special program targets
- Uniform Quasar Sample
- Combining UberCal mags
- Checking SDSS footprint

- Repeated high-z objects
- Object counts and logic
- Galaxies blended with stars
- Stars in specific fields
- Using three tables
- Objects close pairs
- QSOs in spectroscopy
- Errors using flags
- Elliptical galaxies
- Galaxies with blue centers
- Diameter limited sample
- Extremely red galaxies
- LRG sample
- Brightness of closest source
- Multiple spectral lines
- Special program data
- Merging Galaxy Pairs
- Using sppLines table
- Splitting 64-bit values

- Galaxies by spectra
- Clean photometry
- Binary stars colors
- QSO broadlines near galaxy
- Galaxies unsaturated
- Ellipticals with odd lines
- Broadest spectral lines
- Gridded galaxy counts
- Galaxy counts on HTM grid
- Stars multiply measured
- White Dwarf candidates
- More quasar queries
- Using LEFT OUTER JOIN
- Galaxy counts in North
- Counts by type and program
- Spatial Queries using HTM
- Using sppParams table
- Spectroscopy Completeness
- Variability Queries

NASA/IPAC Extragalactic Database (NED)

- World's largest database of cross-identified extragalactic objects
- 163M objects, 170M cross IDs
- Queries by name, near name or position, by reference, author.
- Constraints on redshift, type, flux, sky area

NASA/IPAC Extragalactic Database (NED)

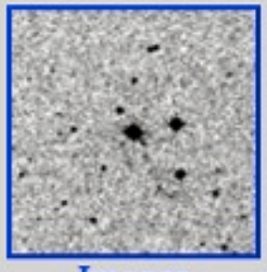
- Available data: positions, redshifts, photometry, images, spectra, diameters, associations, references to literature

INDEX for 3C 273

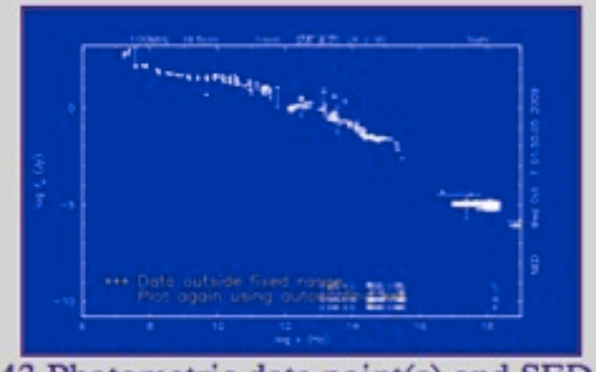
Essential Data (jump to sub-section of this query report):

Essential Note
Cross-IDs
Coordinates
Basic Data
Quantities Derived from Redshift
Redshift-Independent Distances NEW
Foreground Galactic Extinction
External Services

Detailed Data (NED queries):



Images

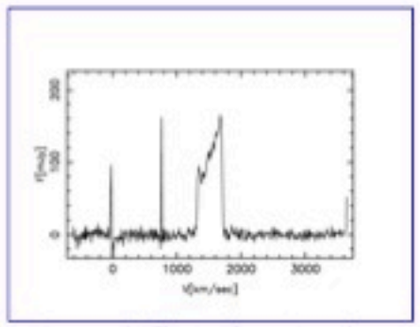
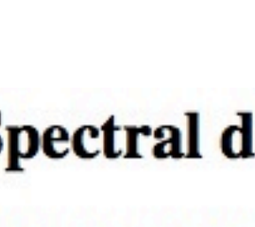
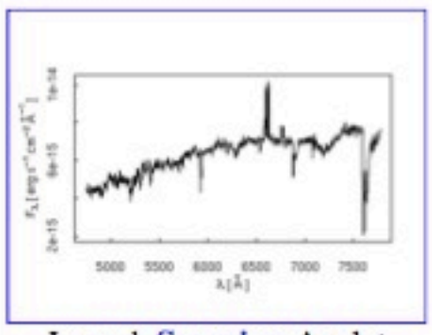
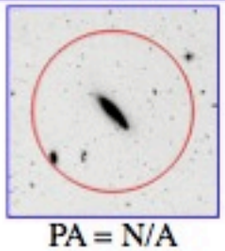
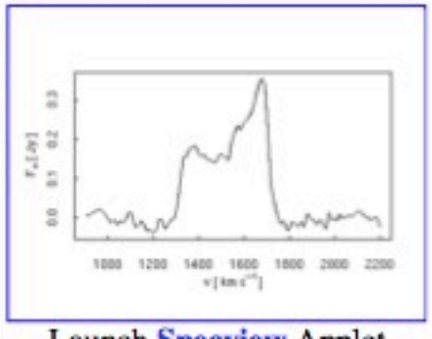


443 Photometric data point(s) and SED

Spectra
Redshift-Independent Distances
1957 Reference(s)
11 Position data point(s)
2 Redshift data point(s)
6 diameter data point(s)
31 Note(s)
PKS data
HB89 data

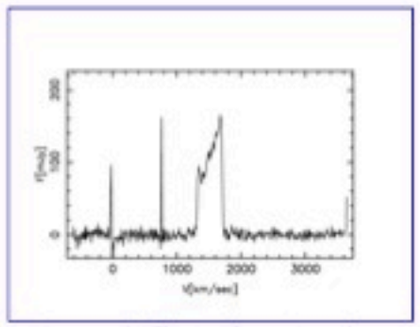
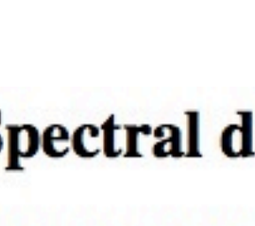
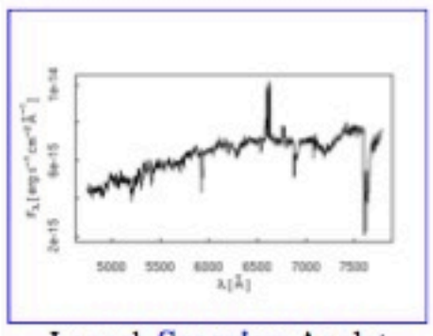
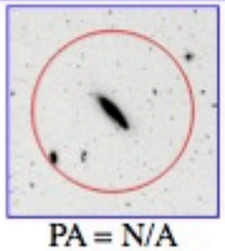
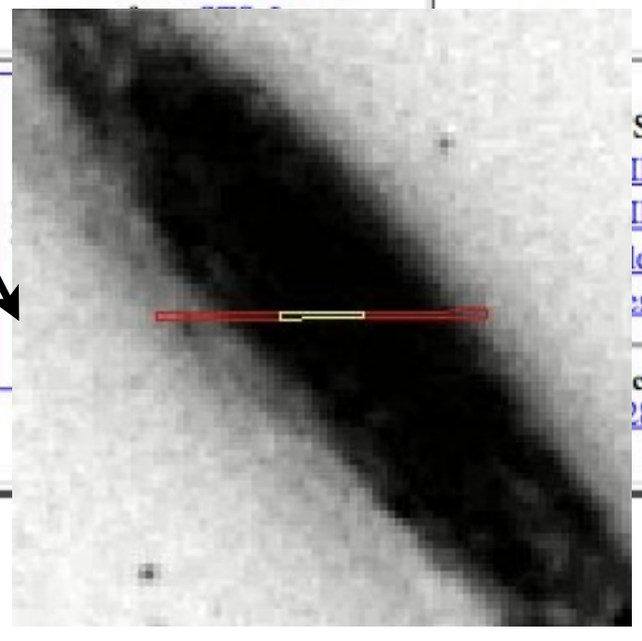
Spectral data in NED archive for object NGC 4666

AND Bandpass(s): Xray **OR** Ultraviolet **OR** Optical **OR** Infrared **OR** mm **OR** Radio

Aperture/Beam	Spectrum Previews	Retrieve Data	Observational Information	Spectral Coverage & Resolution
UGC 07926 PA = N/A	 Launch Specview Applet from STScI	FITS N/A Author-ASCII 23.5kb NED-ASCII 65.9kb VOTable 61.9kb External Resource **Reference:** 2005ApJS..160..149S	**Name:** UGC 07926 **Region:** Integrated **Telescope:** Arecibo 305m **Instrument:** Line-feed system **Abs-Cal:** Yes **Ref-Frame:** Observed Full description	**Line:** HI **From:** -608.4 km s^{-1} **To:** 3647.2 km s^{-1} **Step:** 8.3 km s^{-1} **Resolution:** 11.0 km s^{-1}
NGC 4666  PA = 90 deg	 Launch Specview Applet from STScI	FITS 4.7kb Author-ASCII 25.7kb NED-ASCII 131.6kb VOTable 122.7kb **Reference:** 1995ApJS...98..129K	**Name:** NGC 4666 **Region:** Nucleus **Telescope:** MKO 2.2m **Instrument:** Faint Object Spectrograph **Abs-Cal:** Yes **Ref-Frame:** Observed Full description	**Band:** Optical **From:** 4747.7 Å **To:** 7770.0 Å **Step:** 2.9 Å **Resolution:** 7.0 Å
HIPASS J1245-00  PA = N/A	 Launch Specview Applet from STScI	FITS N/A Author-ASCII 4.4kb NED-ASCII 12.9kb VOTable 12.5kb External Resource **Reference:** 2004AJ....128...16K	**Name:** HIPASS J1245-00 **Region:** Integrated **Telescope:** Parkes **Instrument:** 21 cm Multibeam Receiver **Abs-Cal:** Yes **Ref-Frame:** Observed Full description	**Line:** HI **From:** 906.2 km s^{-1} **To:** 2199.1 km s^{-1} **Step:** 13.2 km s^{-1} **Resolution:** 18.0 km s^{-1}

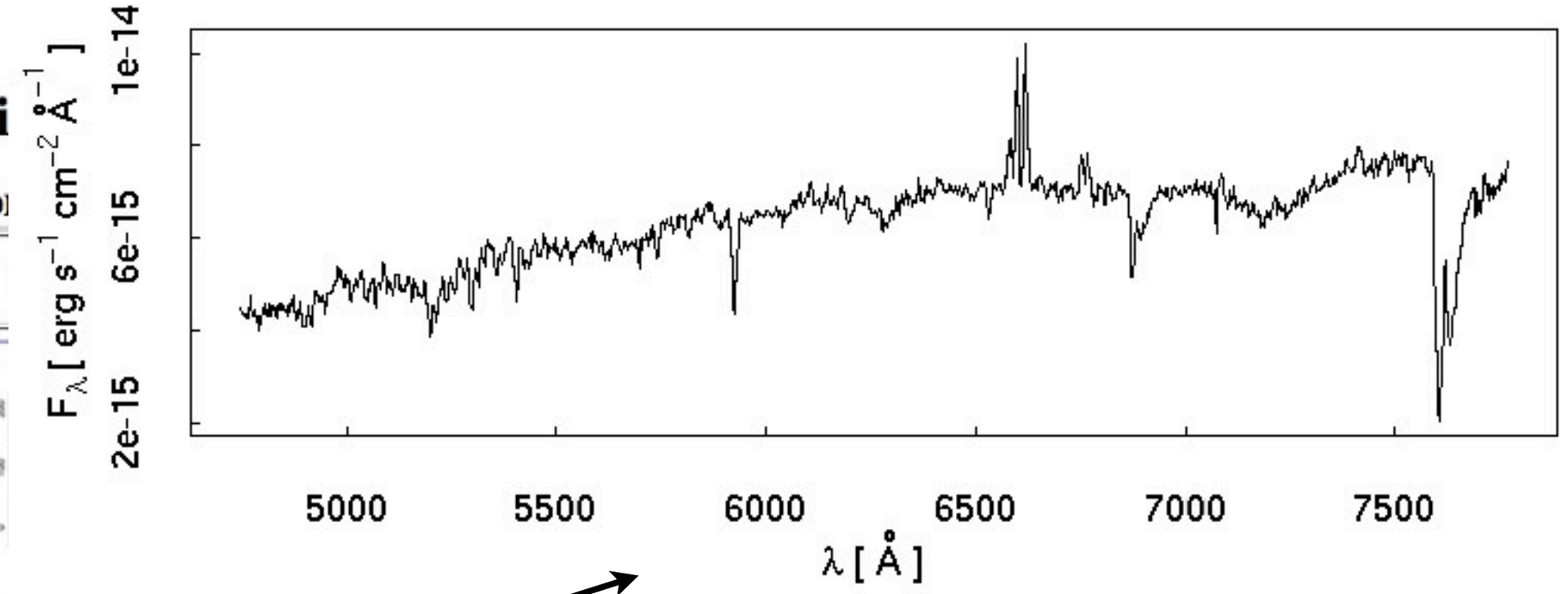
Spectral data in NED archive for object NGC 4666

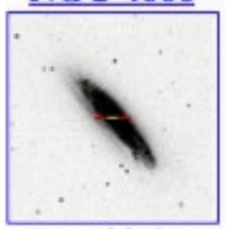
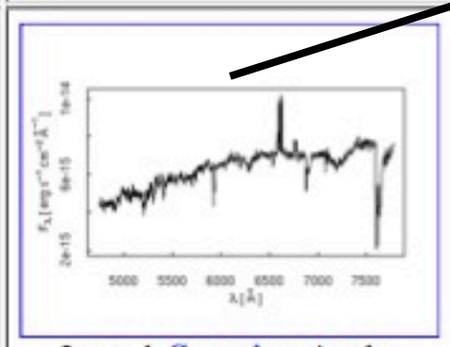
AND Bandpass(s): Xray **OR** Ultraviolet **OR** Optical **OR** Infrared **OR** mm **OR** Radio

Aperture/Beam	Spectrum Previews	Retrieve Data	Observational Information	Spectral Coverage & Resolution
UGC 07926 PA = N/A	 Launch Specview Applet from STScI	FITS N/A Author-ASCII 23.5kb NED-ASCII 65.9kb VOTable 61.9kb External Resource **Reference:** 2005ApJS..160..149S	**Name:** UGC 07926 **Region:** Integrated **Telescope:** Arecibo 305m **Instrument:** Line-feed system **Abs-Cal:** Yes **Ref-Frame:** Observed Full description	**Line:** HI **From:** -608.4 km s^{-1} **To:** 3647.2 km s^{-1} **Step:** 8.3 km s^{-1} **Resolution:** 11.0 km s^{-1}
NGC 4666  PA = 90 deg	 Launch Specview Applet	FITS 4.7kb Author-ASCII 25.7kb NED-ASCII 131.6kb VOTable 122.7kb **Reference:** 1995ApJS...98..129K	**Name:** NGC 4666 **Region:** Nucleus **Telescope:** MKO 2.2m **Instrument:** Faint Object Spectrograph **Abs-Cal:** Yes **Ref-Frame:** Observed Full description	**Band:** Optical **From:** 4747.7 Å **To:** 7770.0 Å **Step:** 2.9 Å **Resolution:** 7.0 Å
HIPASS J1245-00  PA = N/A		SN/A II 4.4kb II 12.9kb le 12.5kb :source ce: 28...16K	**Name:** HIPASS J1245-00 **Region:** Integrated **Telescope:** Parkes **Instrument:** 21 cm Multibeam Receiver **Abs-Cal:** Yes **Ref-Frame:** Observed Full description	**Line:** HI **From:** 906.2 km s^{-1} **To:** 2199.1 km s^{-1} **Step:** 13.2 km s^{-1} **Resolution:** 18.0 km s^{-1}

Spectral data i

AND Bandpass(s): Xray O



Aperture/Beam				
UGC 07926 PA = N/A	 Launch Specview Applet from STScI	2005ApJS...160..149S	Full description	
NGC 4666  PA = 90 deg	 Launch Specview Applet	FITS 4.7kb Author-ASCII 25.7kb NED-ASCII 131.6kb VOTable 122.7kb **Reference:** 1995ApJS...98..129K	**Name:** NGC 4666 **Region:** Nucleus **Telescope:** MKO 2.2m **Instrument:** Faint Object Spectrograph **Abs-Cal:** Yes **Ref-Frame:** Observed Full description	**Band:** Optical **From:** 4747.7 Å **To:** 7770.0 Å **Step:** 2.9 Å **Resolution:** 7.0 Å
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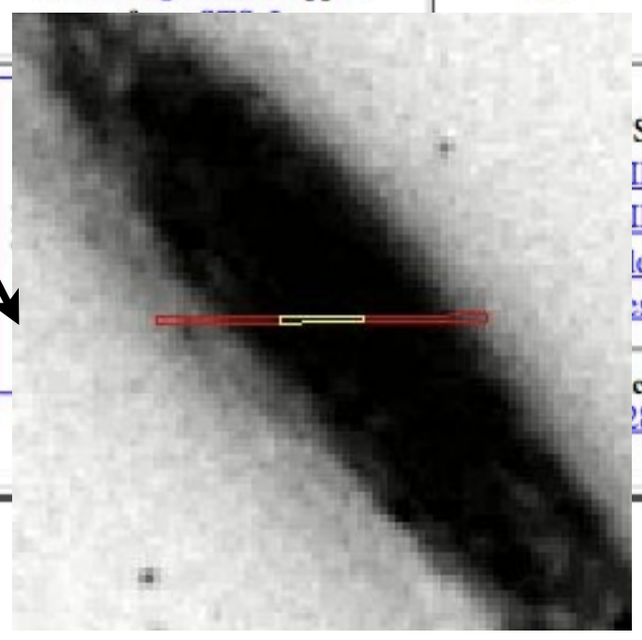
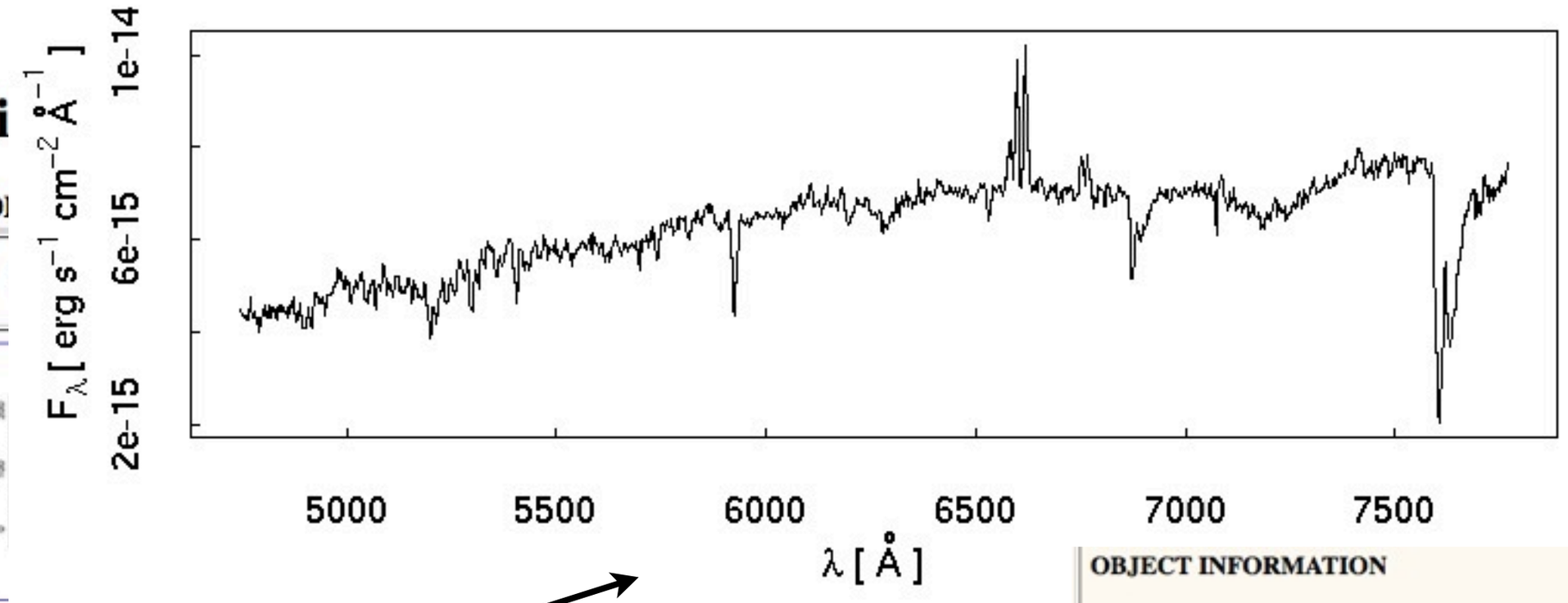
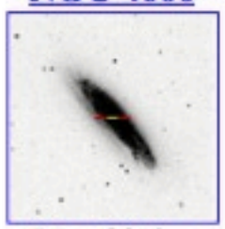
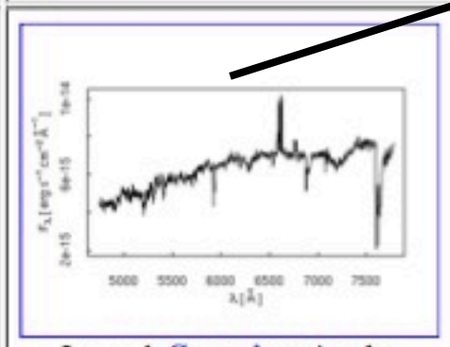


Spectral data i

AND Bandpass(s): Xray O



Aperture/Beam			
UGC 07926 PA = N/A		Launch Specview Applet from STScI	2005ApJS..160..149S Full description
NGC 4666  PA = 90 deg	 Launch Specview Applet	FITS 4.7kb Author-ASCII 25.7kb NED-ASCII 131.6kb VOTable 122.7kb **Reference:** 1995ApJS...98..129K	**Name:** NGC 4666 **Region:** Nucleus **Telescope:** MKO 2.2m **Instrument:** Faint Object Spectrograph **Abs-Cal:** Yes **Ref-Frame:** Observed Full description
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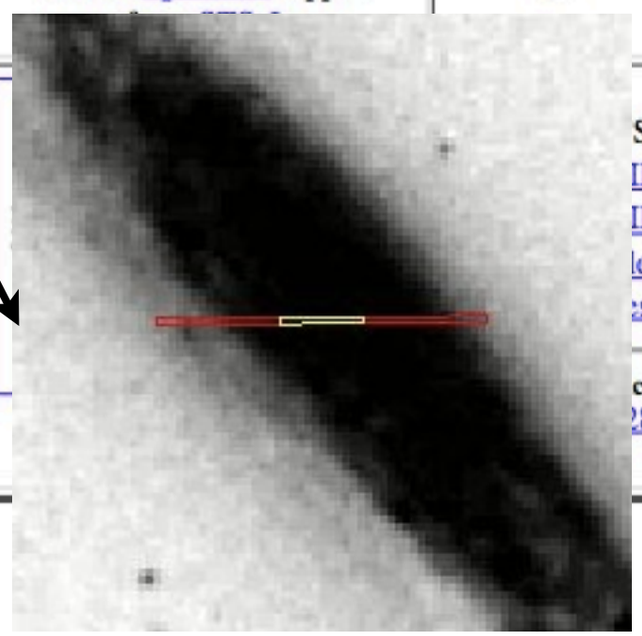
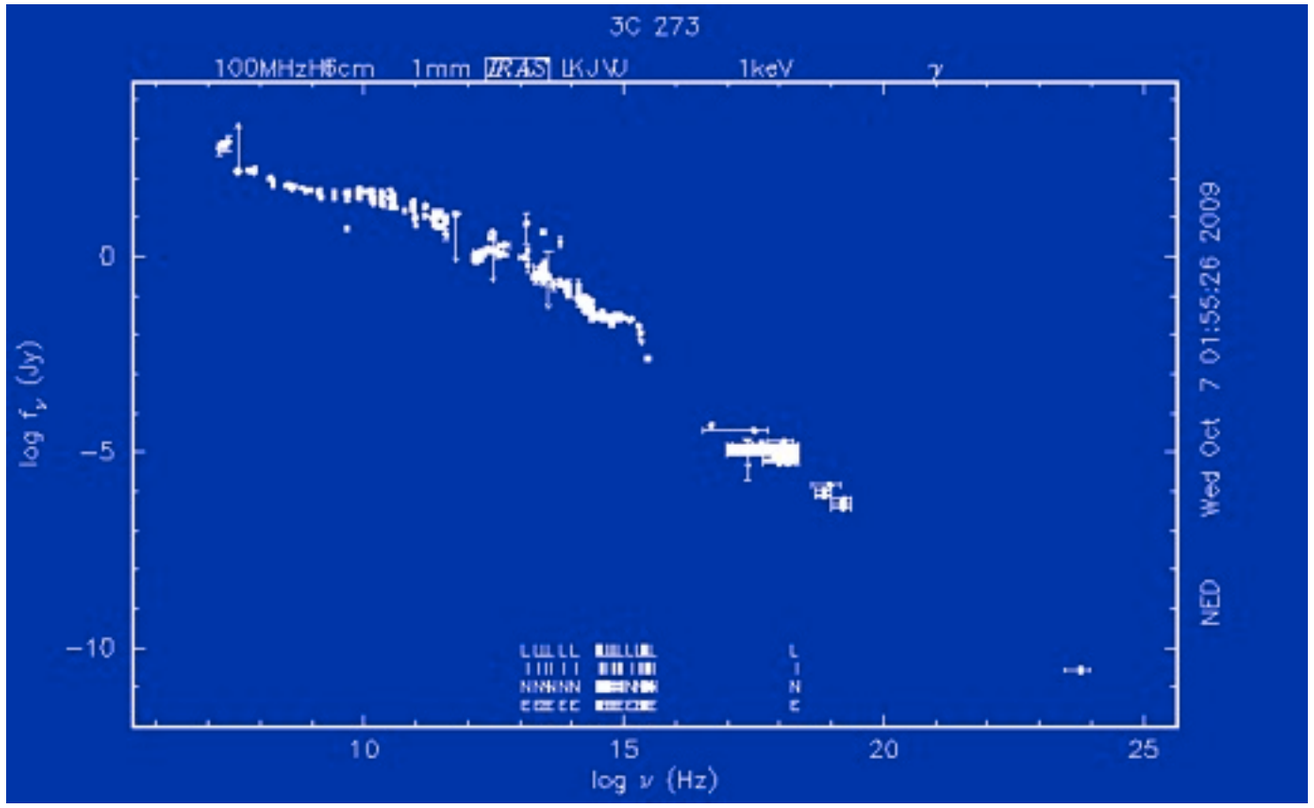


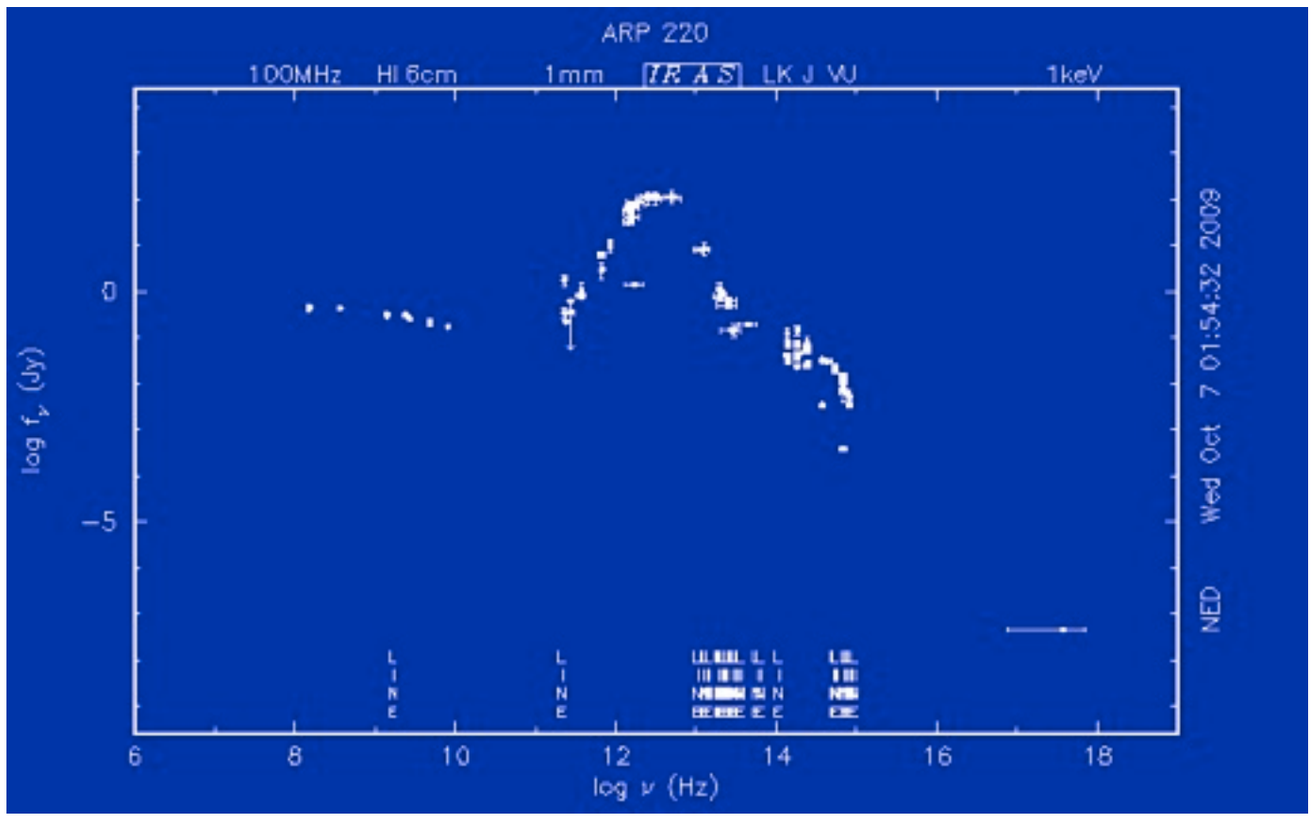
OBJECT INFORMATION

	Published Values
Name:	NGC 4666
Position (J2000):	12h45m08.43s
Origin:	**Published-Value**
System:	**Equatorial**
Type:	**Sexagesimal**
Equinox:	**B1950** 12h42m34.6s

OBSERVATIONAL DETAILS

Observed Region:	Nucleus
Band:	Optical
Start Channel:	4747.7 Å
End Channel:	7770.0 Å
Channel Step:	2.9 Å
Spectral Resolution:	7.0 Å
Mean Resolving Power:	894.1
Seeing:	1.00 arcsec
Airmass:	1.90
Integration Time:	400 sec
Flux Units:	erg s^{-1} cm^{-2} Å^{-1}
Flux Calibration:	Yes





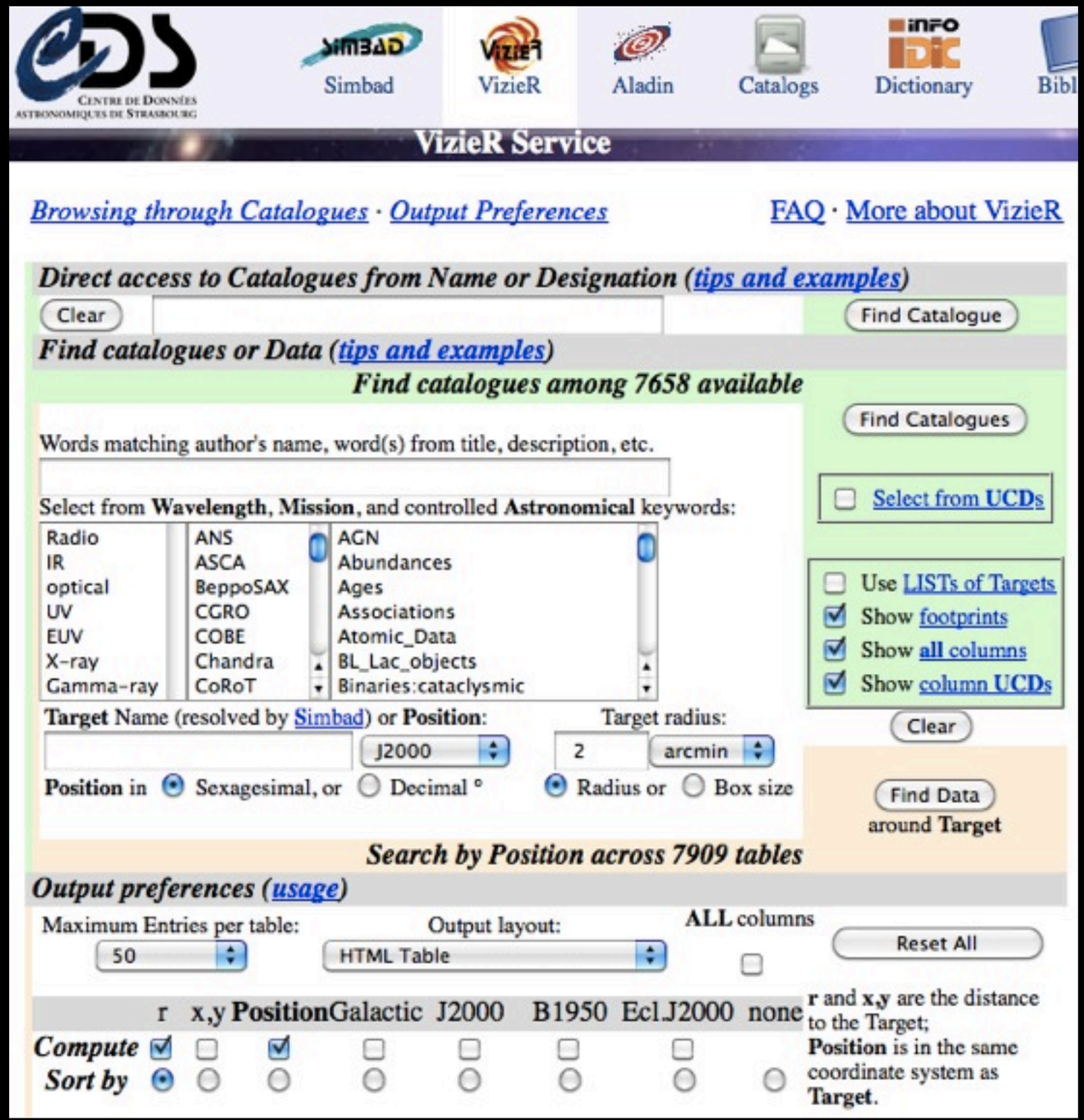
	Published Units			
No.	**Observed Passband**	**Measurement**	**Uncertainty**	**Units**
1	EO IPC (0.1-4.5 keV)	45.69	...	nJy
2	U (U_T)	14.27	+/- 0.15	mag
3	U (U_T^0)	13.87	...	mag
4	U_T (VATT)	14.341	+/- 0.023	mag
5	[O II] 3727 (Bok)	116.0E-15	+/- 21.0E-15	erg s^-1^ cm^-2^
6	103a-O (POSS-I O)	14.43	...	mag
7	H{delta} (Bok)	6.60E-15	+/- 3.60E-15	erg s^-1^ cm^-2^
8	H{gamma} (Bok)	4.40E-15	+/- 3.10E-15	erg s^-1^ cm^-2^
9	B (B_T)	13.94	+/- 0.14	mag
10	B (m_B)	13.90	+/- 0.20	mag
11	B (B_T^0)	13.61	...	mag
12	m_p	14.4	+/- 0.4	mag
13	B_T (VATT)	14.011	+/- 0.011	mag
14	B (UH)	14.00	+/- 0.07	mag
15	B (UH)	17.6	+/- 0.1	mag
16	H{beta} (Bok)	11.20E-15	+/- 2.50E-15	erg s^-1^ cm^-2^

No. 1
Reference Code : 1996MNRAS.278.1049R
Freq. targeted : EO IPC (0.1-4.5 keV)
Measurement : 45.69 nJy = 4.57E-34 W m^-2^ Hz^-1^
Uncertainty : nJy = 0.00E+00
Significance : no uncertainty reported
Freq or Vel. : 1.6 keV (OBS)= 3.87E+17 Hz
Frequency mode : Broad-band measurement; broad-band flux derived by integration over spectrum; synthetic band
Coord. targeted: 153457.22 +233011.40 (J2000)
Spatial mode : Integrated from scans
Notes : Homogenized from previously published data
Qualifiers :

No. 2
Reference Code : 1991RC3.9.C...0000d
Freq. targeted : U (U_T)
Measurement : 14.27 mag = 3.55E-29 W m^-2^ Hz^-1^
Uncertainty : 0.15 mag = 5.09E-30
Significance : rms uncertainty
Freq or Vel. : 3660 A (OBS)= 8.19E+14 Hz
Frequency mode : Broad-band measurement
Coord. targeted: 153247.3 +234006 (B1950)
Spatial mode : From multi-aperture data
Notes : Homogenized from new and previously published data; Standard Johnson UBVRI filters assumed
Qualifiers :

VizieR : Archive of Catalogues

- Find and search published catalogues
- Coverage, documentation



VizieR : Archive of Catalogues

- Find and search published catalogues
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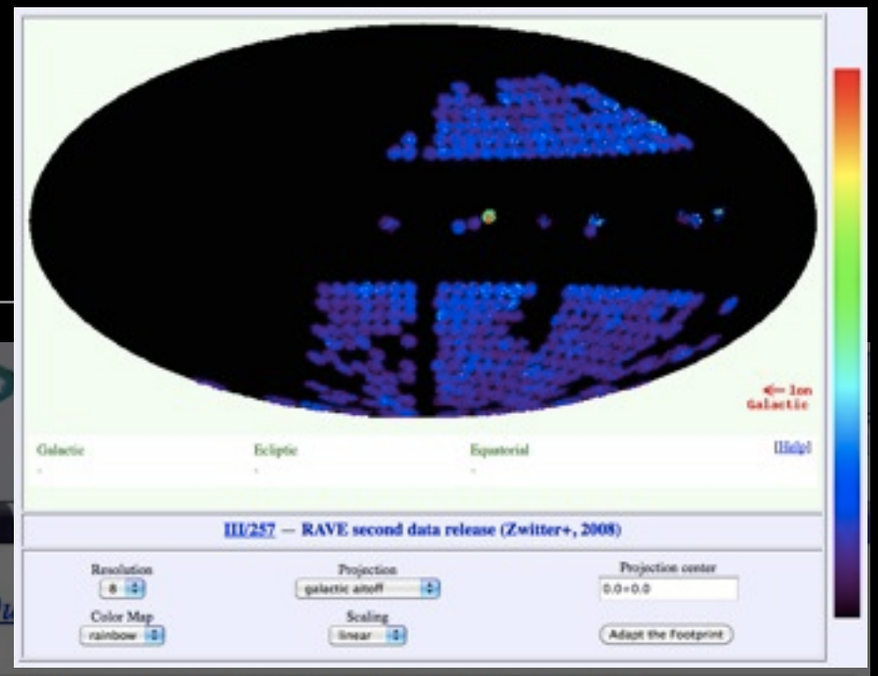
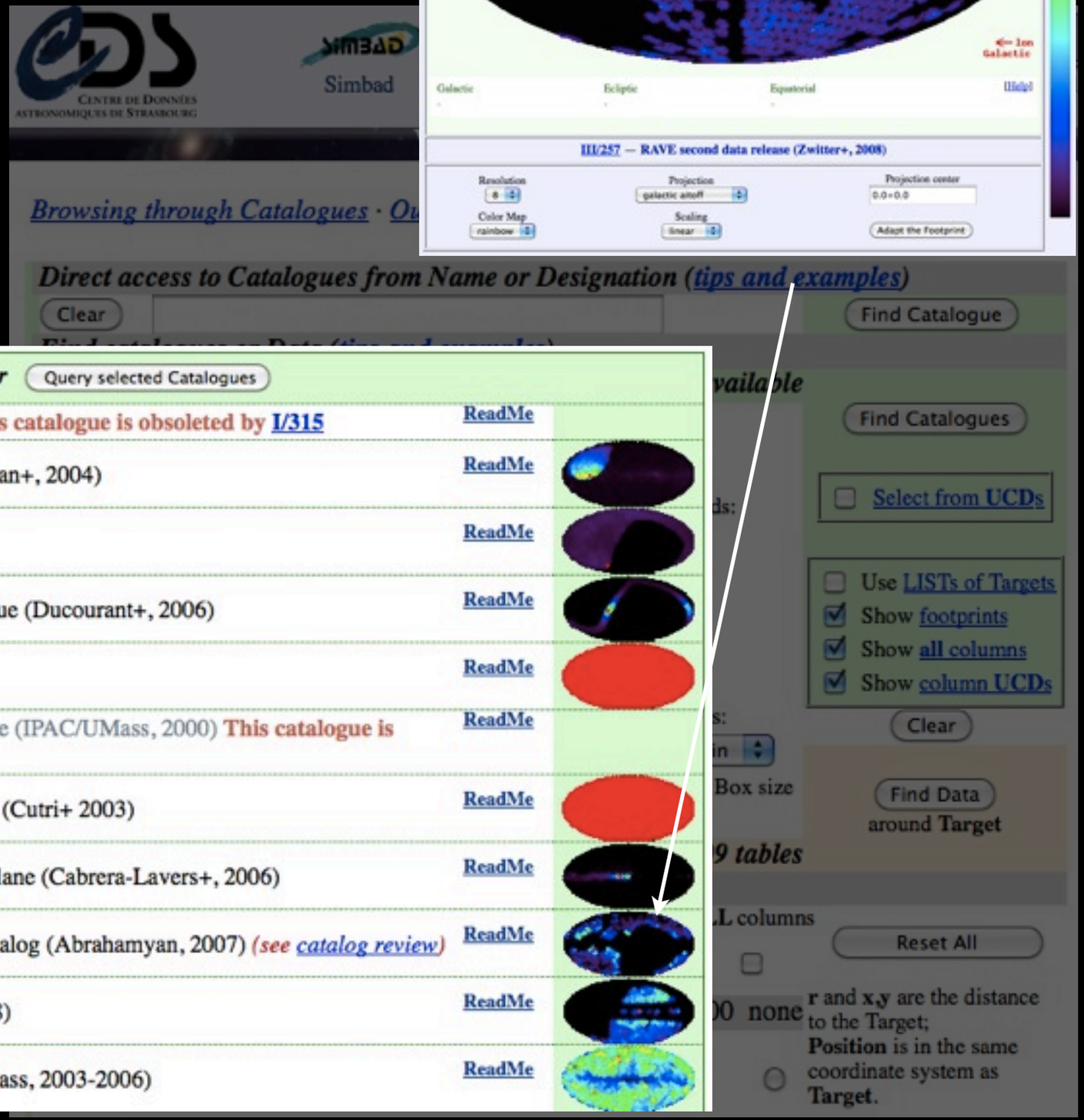




Many more data services

- IRSA
- MAST
- WSA
- Telescope Archives: ING, ESO, CFHT, NOAJ, ...
- **Lots of data already available to download from the Internet**

The Virtual Observatory

The Virtual Observatory

- Premise: most data is (or could be) online
- So the Internet is the world's best telescope
  - It has data on every part of the sky
  - In many spectral bands: optical, radio, x-ray, ...
  - As deep as the best instruments (2 years ago)
  - It is up when you are up. Seeing is always great, no working at night, ...
  - It is a smart telescope: links objects and data to literature on them.

Slide from A. Szalay

The Virtual Observatory

- Data distribution is not homogeneous at the moment: different archives, different data formats, data description, tools to interact, ...

- IVOA: International Virtual Observatory Alliance (about 20 countries and growing up)

- Provide content (data, metadata) services, standards, analysis services

- Federate existing and forthcoming large sky surveys and archives, facilitate data distribution

- Develop and provide data exploration and discovery tools

The Virtual Observatory

- Need for new data mining techniques, data understanding technologies, hyperdimensional visualisation, machine assisted discovery, ...
- Facilitate science with massive data sets
- Optimise use of expensive resources (e.g. space missions)
- Enable and stimulate new science

http://www.ivoa.net
http://www.euro-vo.org

NVO DataScope : Finding Data

National Virtual Observatory

NVO Portal: DataScope Response

NVO Home | New Query | Help | Contact Us

Hosted by: HEASARC NASA/GSFC

Data found(503) No data (5310) Errors(46) Waiting(0) 100% complete

Summary | Resources | Data Table | No Data | Still Processing | Errors | Help

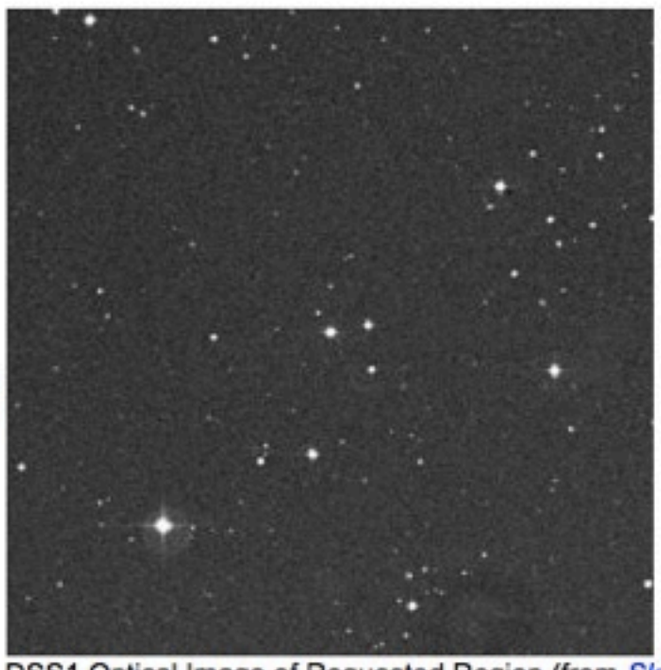
Summary of Request and Selections

Request parameters	
Target: 3c273	
12 29 06.70	02 03 08.6
187.277916	2.052388
Size:	0.25

No resources currently selected.
When you check tables and individual data files, you can download them in a single tar file or send them to Aladin from here.

Analysis Options

Aladin Applet | Aladin script | Save as tar



DSS1 Optical Image of Requested Region (from *SkyView*)

Developed with the support of the National Science Foundation under Cooperative Agreement AST0122449 with the Johns Hopkins University

The NVO is a member of the International Virtual Observatory Alliance

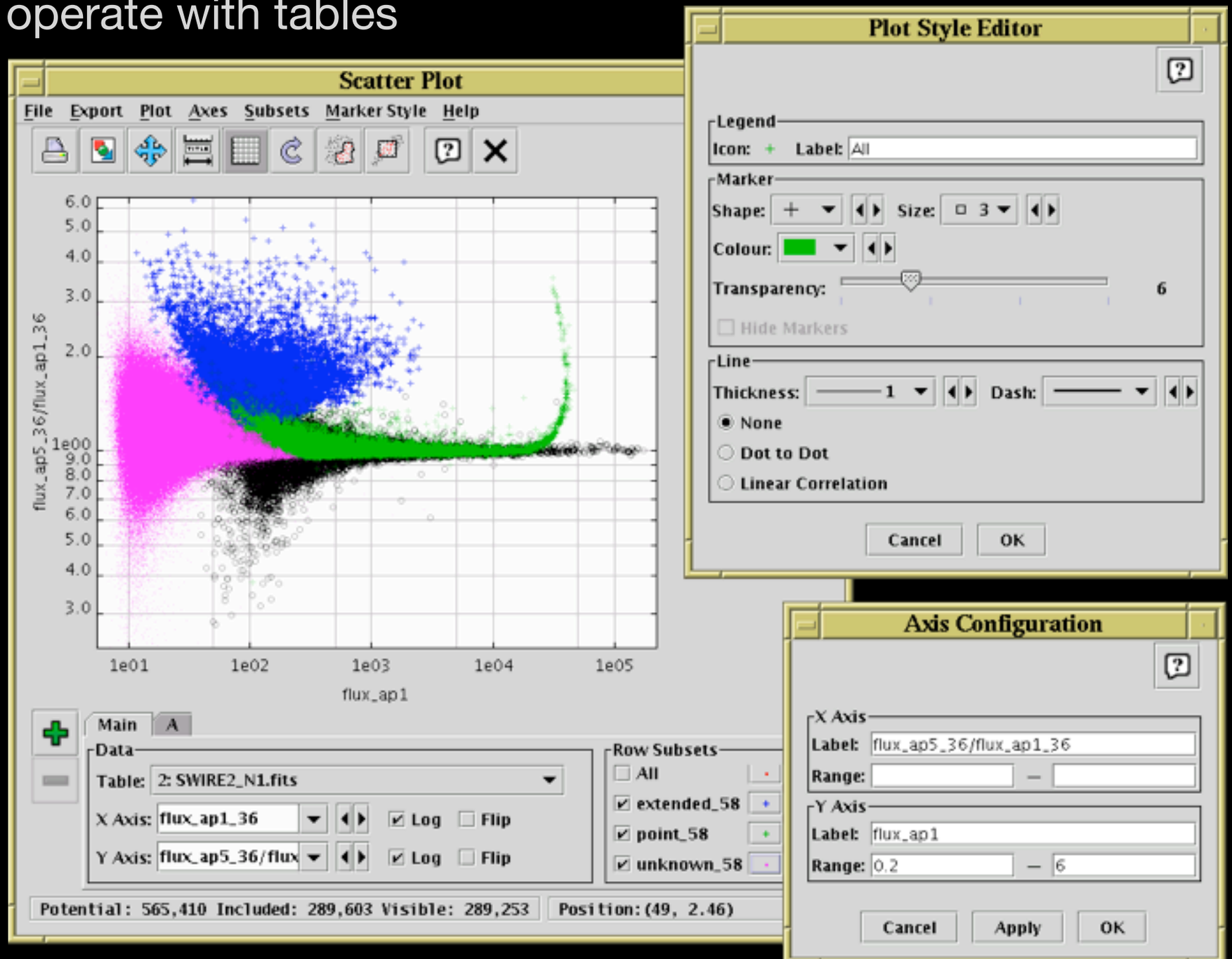
Meet the

NVO DataScope : Finding Data

Major Multiwavelength Services					
	Simbad (266) ?	ADS (200) ?	SkyView (0/48) ?	NED(images) (0/51) ?	
(68) Images (Data in one or more FITS files)					
(46) Lists of Observations (Data in one VOTable)					
Catalogs of Objects (Data in one VOTable)					
Surveys	CGRABS (1) ?	Einstein (3) ?	GSC23 (1350) ?	IBISCAT3 (1) ?	SDSS-DR2 (1000) ?
	USNO-A2.0 (203) ?	USNO-SA2.0 (203) ?	NVSS (45) ?	RASS/Soft (1) ?	NVSS Catalog (55) ?
	North20cm (1) ?	VLSS (3) ?	EUVE/2 (1) ?	WMAPPTSRC (1) ?	MRC (2) ?
	FERMILBSL (1) ?	ROSAT/REP (4) ?	BHROSATOpt. (1) ?	RASS/HRC (1) ?	XMMOMSUSS (856) ?
	ASCA (3) ?	INTIBISASS (1) ?	RASS/BSC (1) ?	IRASSSC (6) ?	2MASS-PSC (676) ?
	EGRET (49) ?	PMN (3) ?	SDSSNBCKDE (18) ?	CHESSCAT (1) ?	Chan/XAssist (215) ?
	FIRST (35) ?	RASS/RBS (1) ?	EUVE/RAP2 (1) ?	ROSAT/HRI (978) ?	IRAS (1) ?
	RASS/FSC (1) ?	2MASS-XSC (9) ?	XMM/SSC (1068) ?	ROXA (1) ?	Parkes (1) ?
	XMMBSS (2) ?	IRAS (1) ?	ROSAT/PSPC (63) ?	Texas (1) ?	ROSAT/PSPC (185) ?
	EXOSAT/Slew (1) ?	North-6cm (2) ?	SAXWFCCAT (1) ?	WGACAT (80) ?	INTEGRAL/BSC (1) ?
	EGRCAT (24) ?	SDSS-DR5 (5000) ?	BMW-HRI (120) ?	Einstein/HRI (1) ?	Dixon (18) ?
	ROSAT/HRI (55) ?	SDSS-DR3 (4849) ?	Einstein/ETS (2) ?	GB6 (1) ?	INTEGRAL (25) ?
	CRATES (1) ?	MIT-GB (6) ?	SDSS(QSO) (2) ?	XMM/XAssist (83) ?	ChaMPPS (26) ?
	Einstein/IPC (3) ?	UIT (2) ?	PG (1) ?	SDSS-DR4 (5000) ?	
Galaxies	GALEX (3590) ?	digitalHIarchive (1) ?	J/ApJ/599/886 (1) ?	J/MNRAS/229/589 (1) ?	J/ApJS/155/257 (5) ?
	J/A+A/386/97 (1) ?	J/A+A/423/469 (1) ?	J/AJ/126/2237 (1) ?	J/ApJS/148/97 (1) ?	J/MNRAS/380/1608 (36) ?
	J/ApJ/522/113 (1) ?	CFAZ (20) ?	J/A+AS/132/305 (1) ?	J/MNRAS/329/700 (1) ?	J/PASJ/52/997 (1) ?
	J/A+AS/120/201 (1) ?	J/MNRAS/385/1270 (1) ?	VII/54 (4) ?	VIII/85A (4) ?	VIII/77 (1) ?
	J/A+A/440/409 (1) ?	J/A+AS/127/521 (1) ?	J/AN/327/365 (4) ?	J/AJ/131/1942 (1) ?	J/ApJS/143/257 (1) ?
	J/ApJS/143/277 (1) ?	J/MNRAS/216/173 (1) ?	J/MNRAS/375/68 (35) ?	III/157 (1) ?	J/A+A/363/141 (1) ?

Tools : Catalogue Operations with TOPCAT

- TOPCAT is a tool to operate with tables
- Table browse
- Subset selection
- 2D/3D plots
- Histograms
- User Interaction



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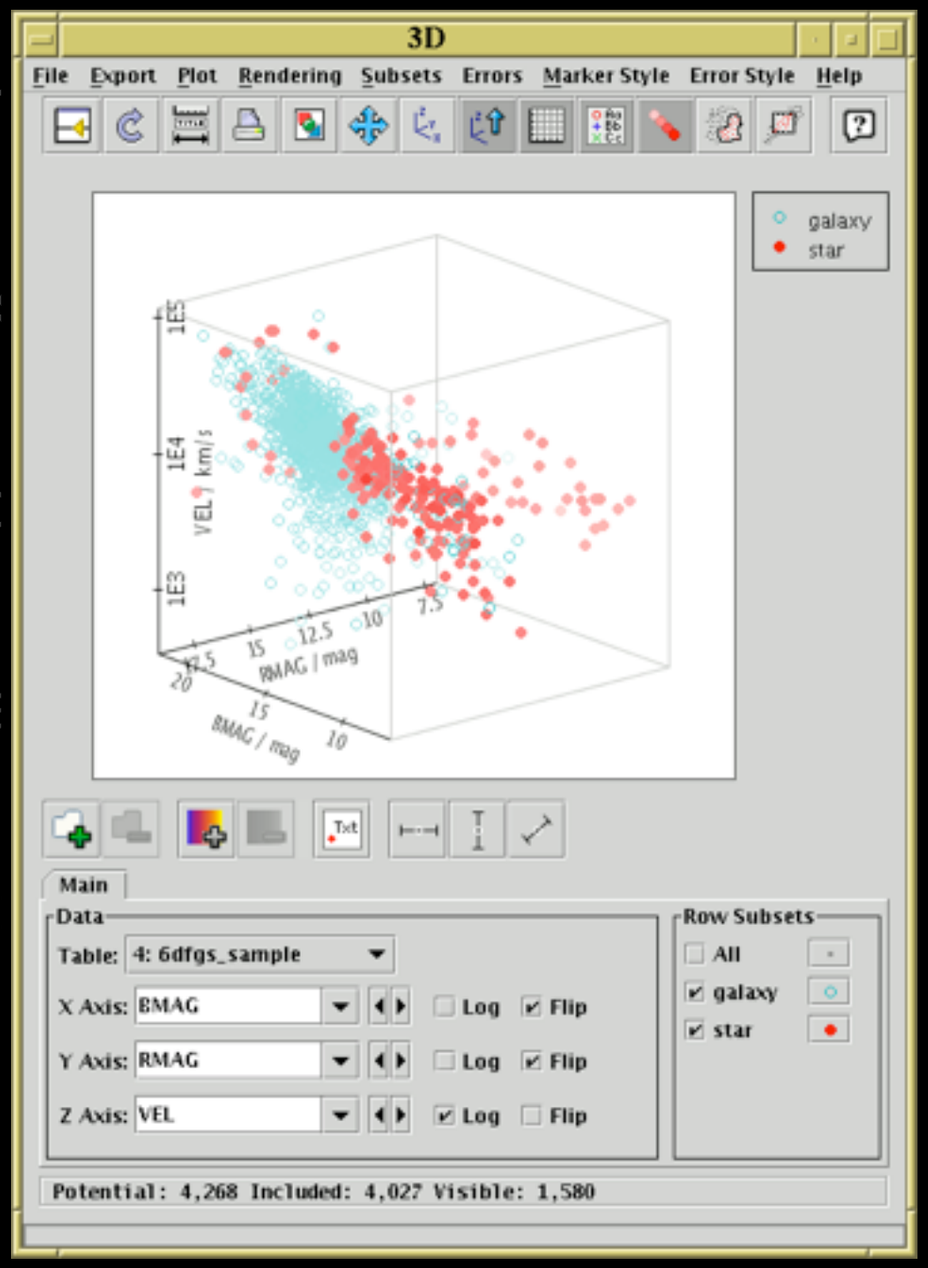

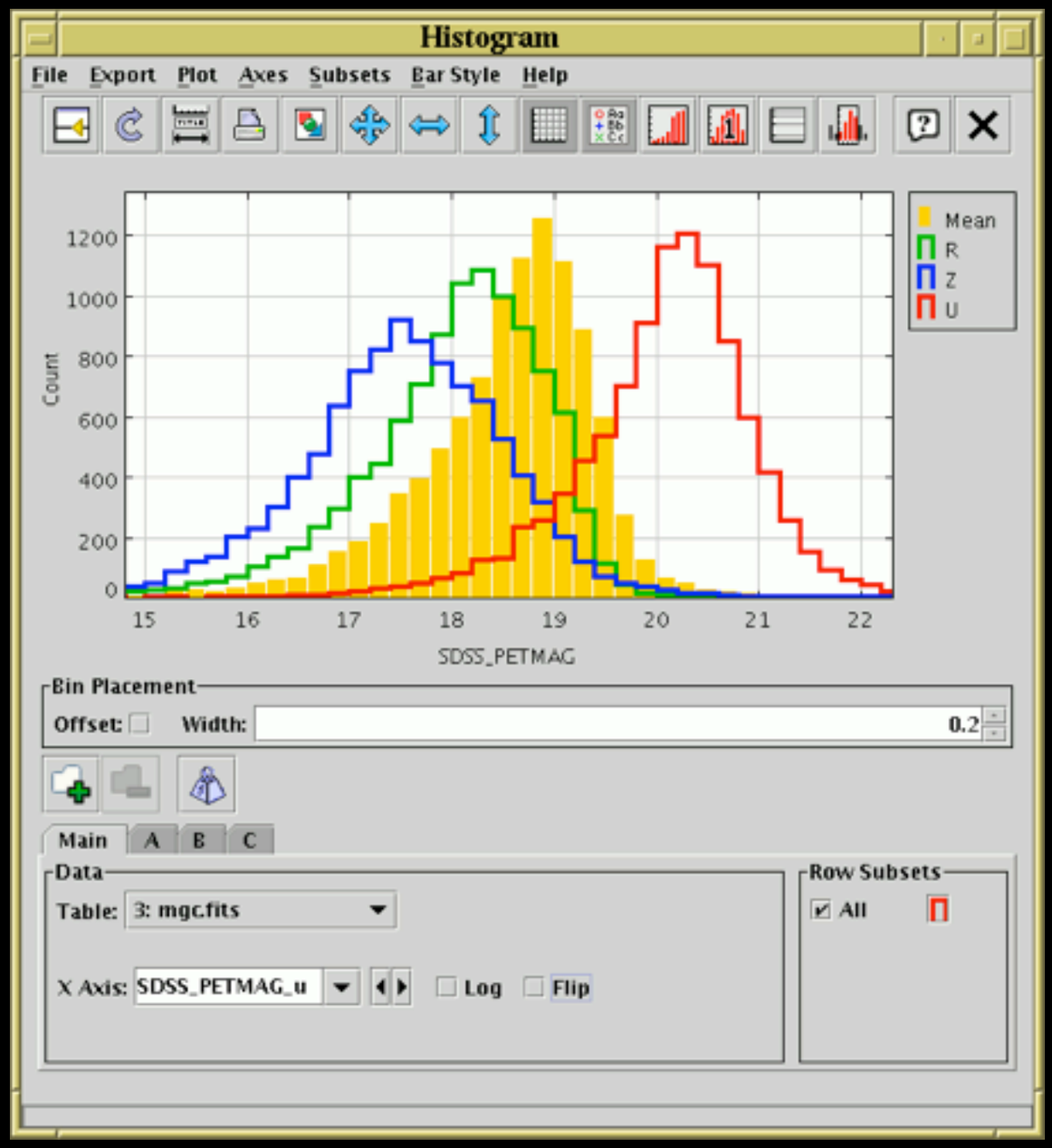

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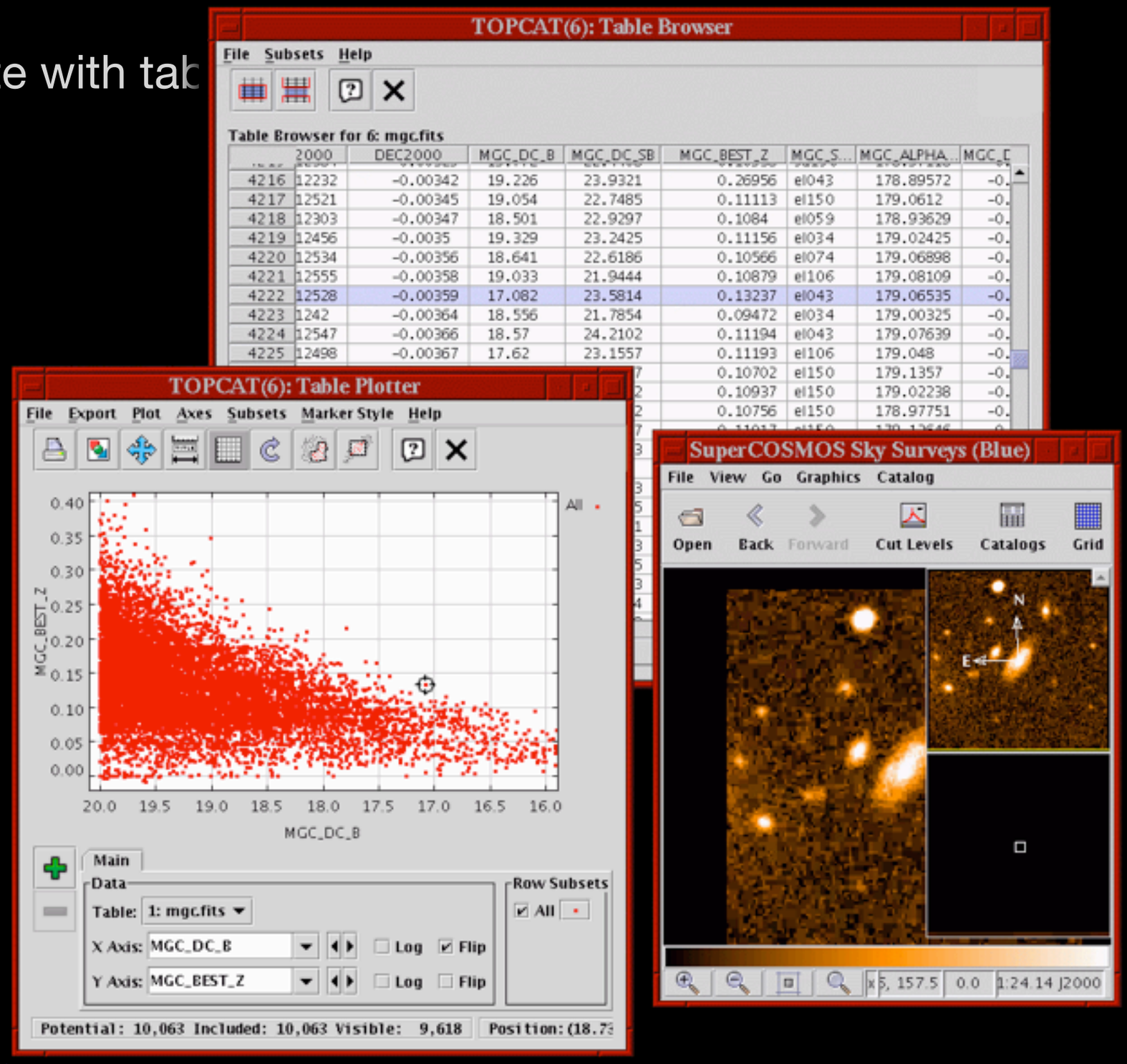
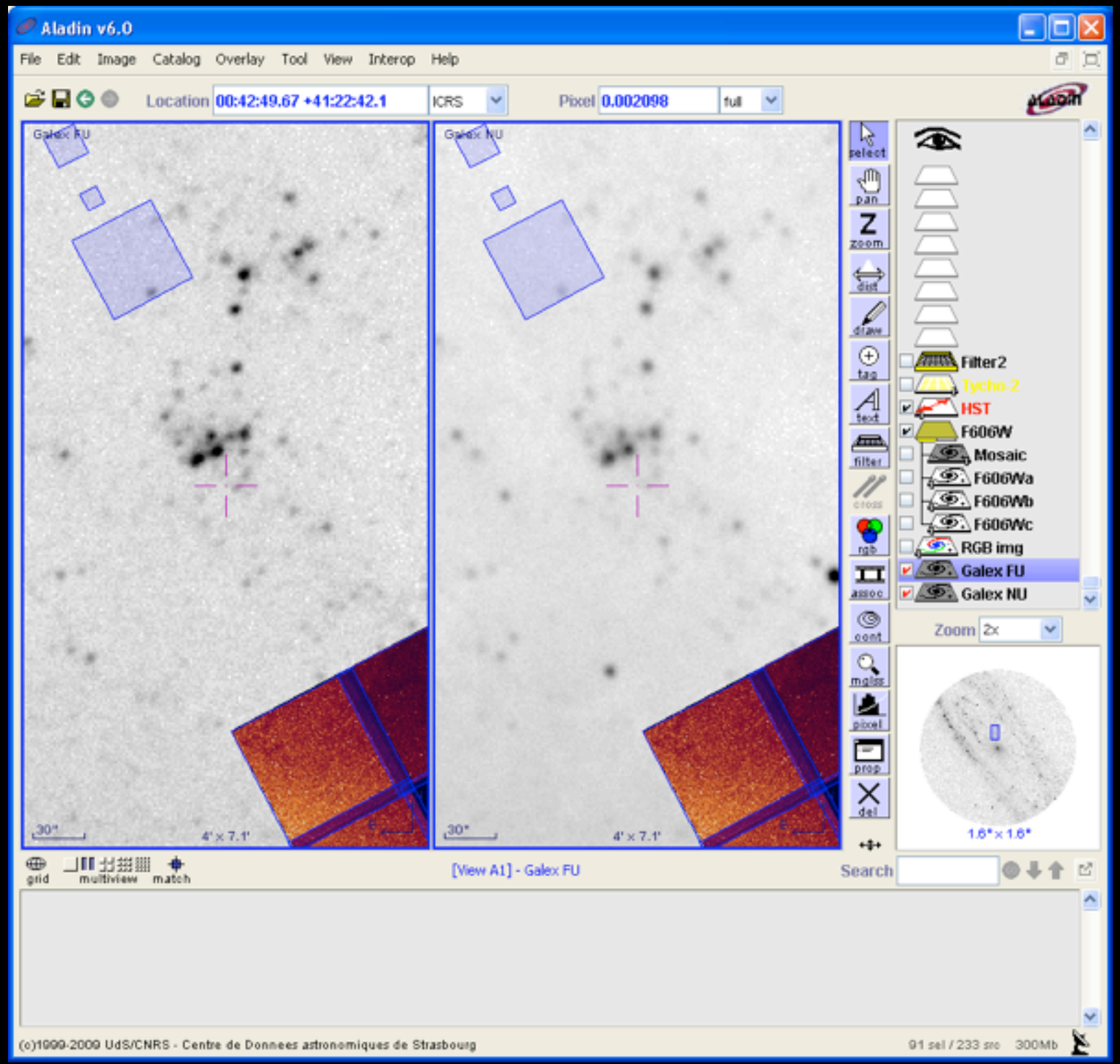


Tools : Image Visualisation with Aladin

- Search and view images
- Display footprints
- Display Catalogues
- Measure quantities
- VO Tools share standards and are interoperable



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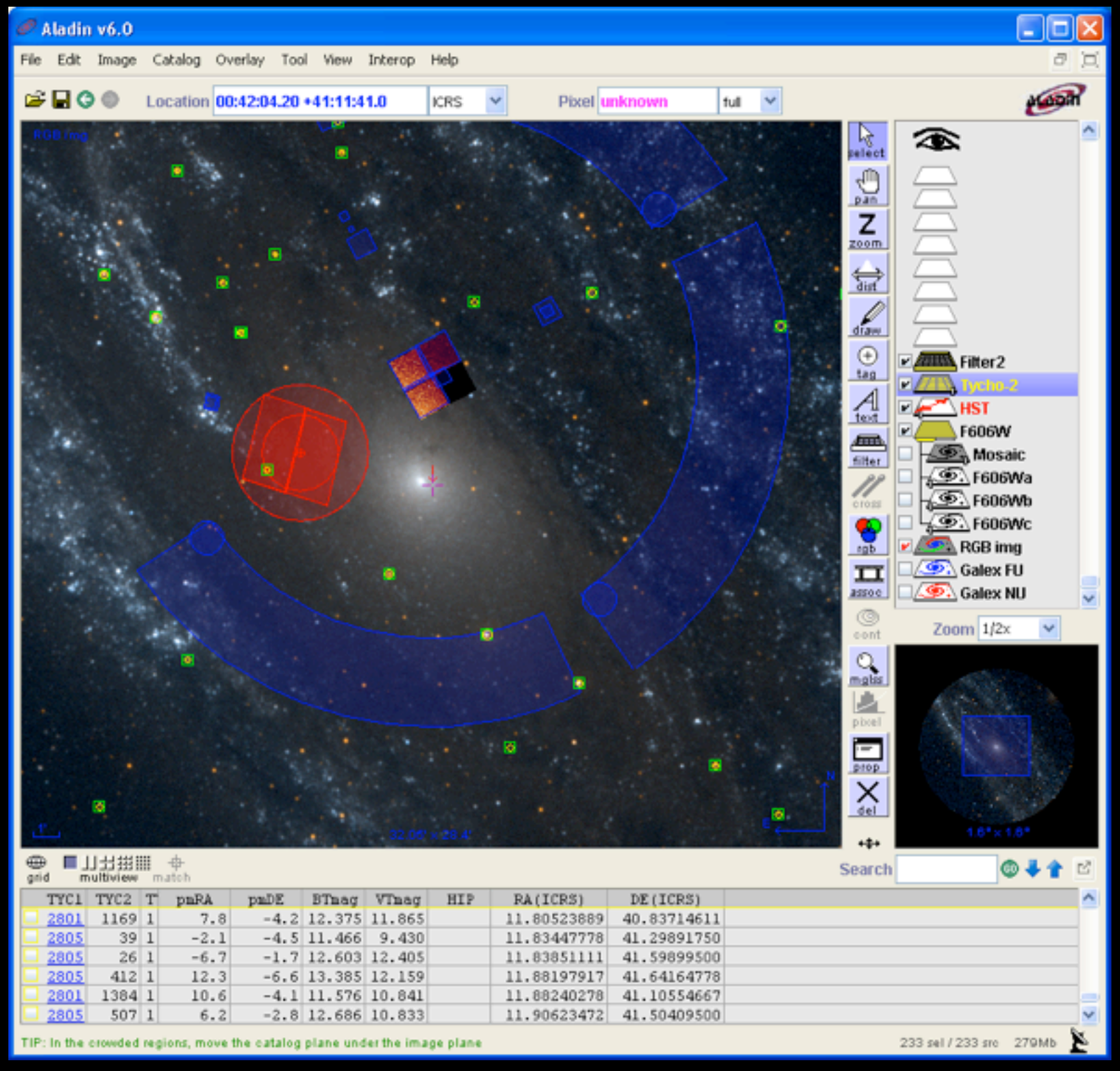

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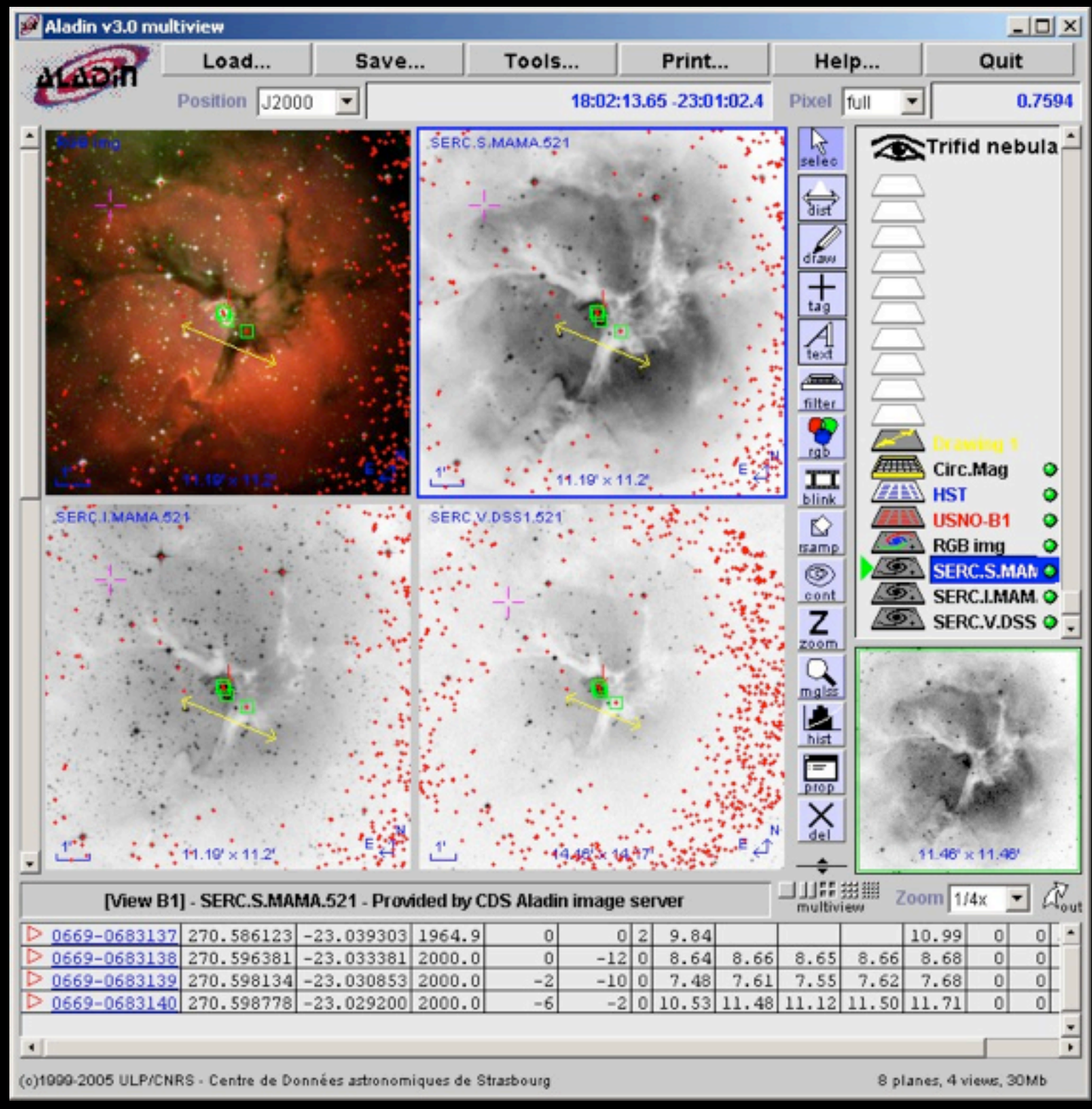

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0669-0683138	270.596381	-23.033381	2000.0	0	-12	0	8.64	8.66	8.65	8.66	8.68	0	0
0669-0683139	270.598134	-23.030853	2000.0	-2	-10	0	7.48	7.61	7.55	7.62	7.68	0	0
0669-0683140	270.598778	-23.029200	2000.0	-6	-2	0	10.53	11.48	11.12	11.50	11.71	0	0

Challenges

- **Large amounts of data** - Need of databases, efficient search. Move analysis to the data

- **Make efficient use of existing data from archives** - every part of sky has been observed at least once, many areas with multiwavelength coverage

- **Data exploration** - an emerging new branch of science - computational methods, algorithm thinking, visualisation, new HPC architectures

The End

"Challenges in modern Astrophysics"

OPTICON awareness conference

Sofia, 13-14 October 2009

Scientific organisers:

Michel Dennefeld
Martin Ward

Invited lecturers:

A. LeCavelier (France)
F. Hammer (France)
B. Nordstroem (Denmark)
X. Barcons (Spain)
M. Ward (UK)
St. Wagner (Germany)
B. Leibundgut (ESO)
Z. Tsvetanov (NASA)
E. Gonzalez (UK)
E. Semkov (Bulgaria)
T. Bonev (Bulgaria)

LOC:

K. Panov (Chair)
R. Konstantinova-Antova
M. Dechev
V. Popov

OPTICON

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National Science Fund
Project DO 02-85