Multi-wavelength Astronomy
Your World in a Different Light

Khadija EL Bouchefry

email: **khadija@hartrao.ac.za**

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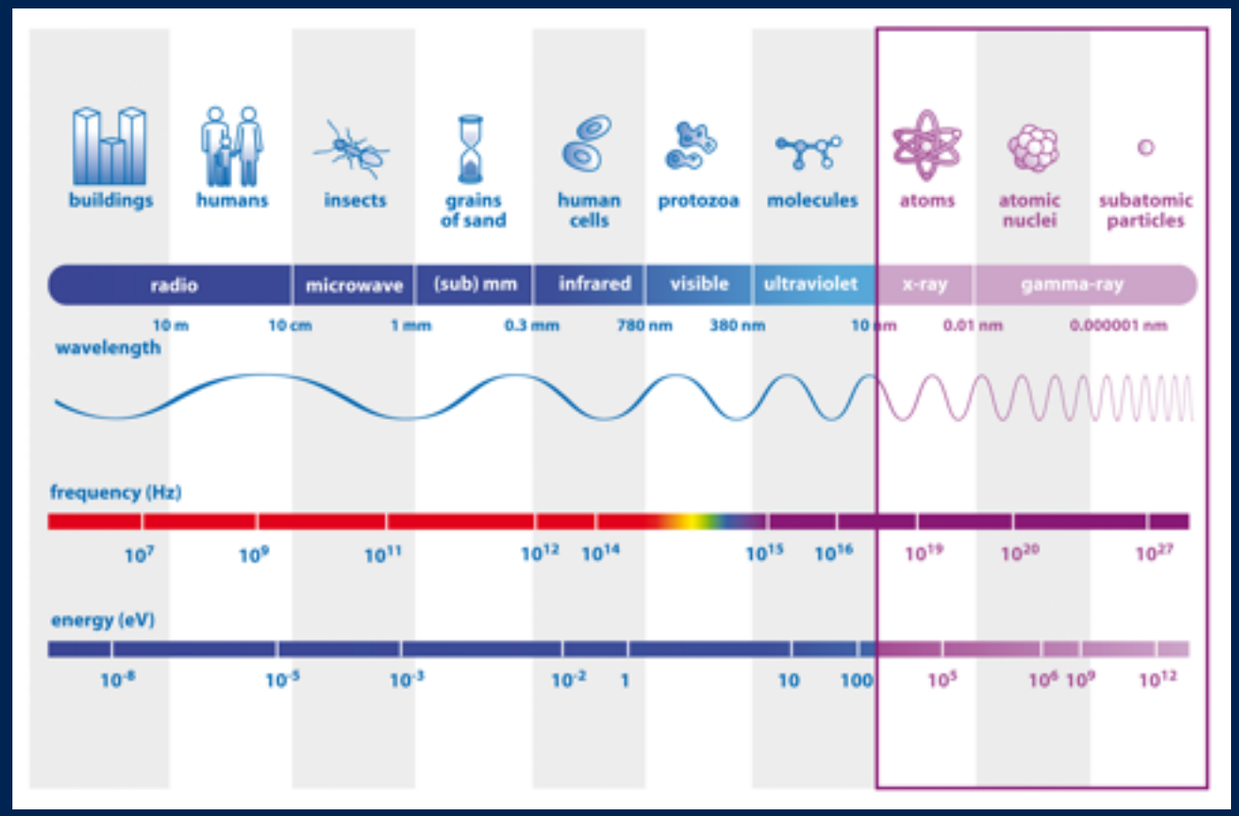
Types of EM Radiation

Ranges: Radio, Millimeter, Microwave, Infrared, Visible, Ultraviolet, X-rays, Gamma rays

Types of EM Radiation



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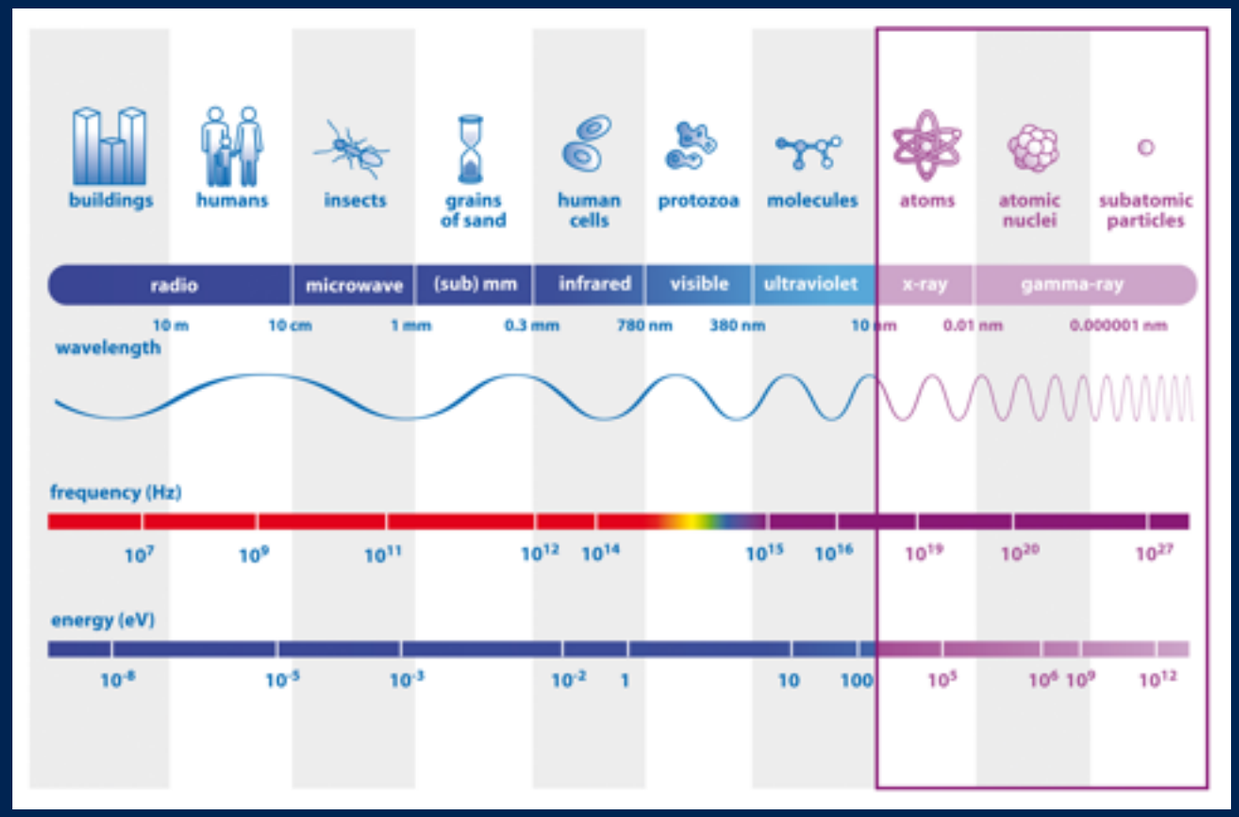
Types of EM Radiation

Astronomers have constructed telescopes that have detected all forms of EM radiation, both visible and non-visible, emitted by objects in space.



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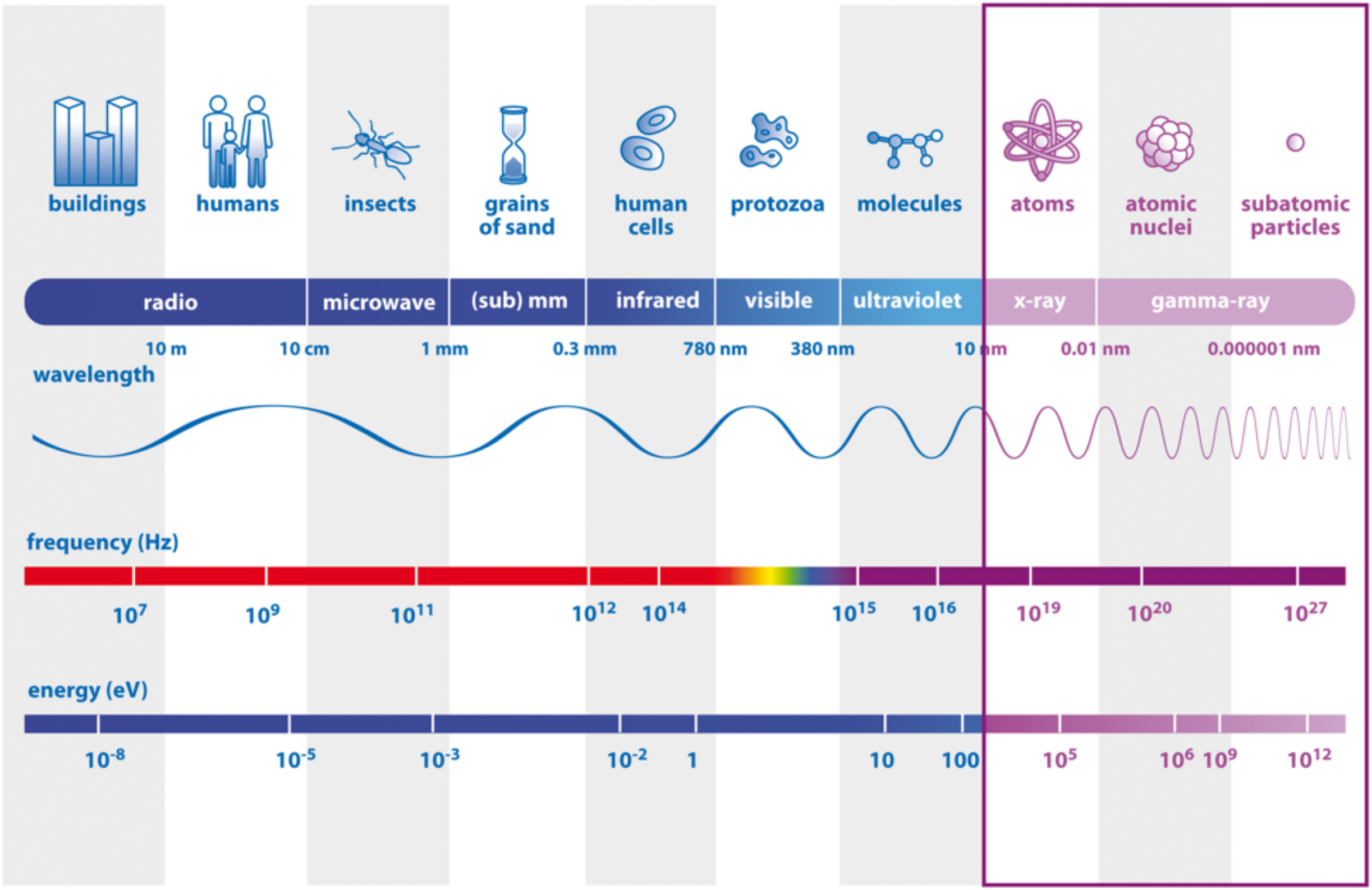
buildings
humans
insects
grains of sand
human cells
protozoa
molecules
atoms
atomic nuclei
subatomic particles
radio
microwave
(sub) mm
infrared
visible
ultraviolet
x-ray
gamma-ray
10 m
10 cm
1 mm
0.3 mm
780 nm
380 nm
10 nm
0.01 nm
0.000001 nm
wavelength
frequency (Hz)
10^{7}
10^{9}
10^{11}
10^{12}
10^{14}
10^{15}
10^{16}
10^{19}
10^{20}
10^{27}
energy (eV)
10^{-8}
10^{-5}
10^{-3}
10^{-2}
1
10
100
10^{5}
10^{6}
10^{9}
10^{12}

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- **Different physical processes** can be studied at **different wavelengths**
- Xray, gamma ray and radio astronomers need to identify their sources with **optical counterparts**

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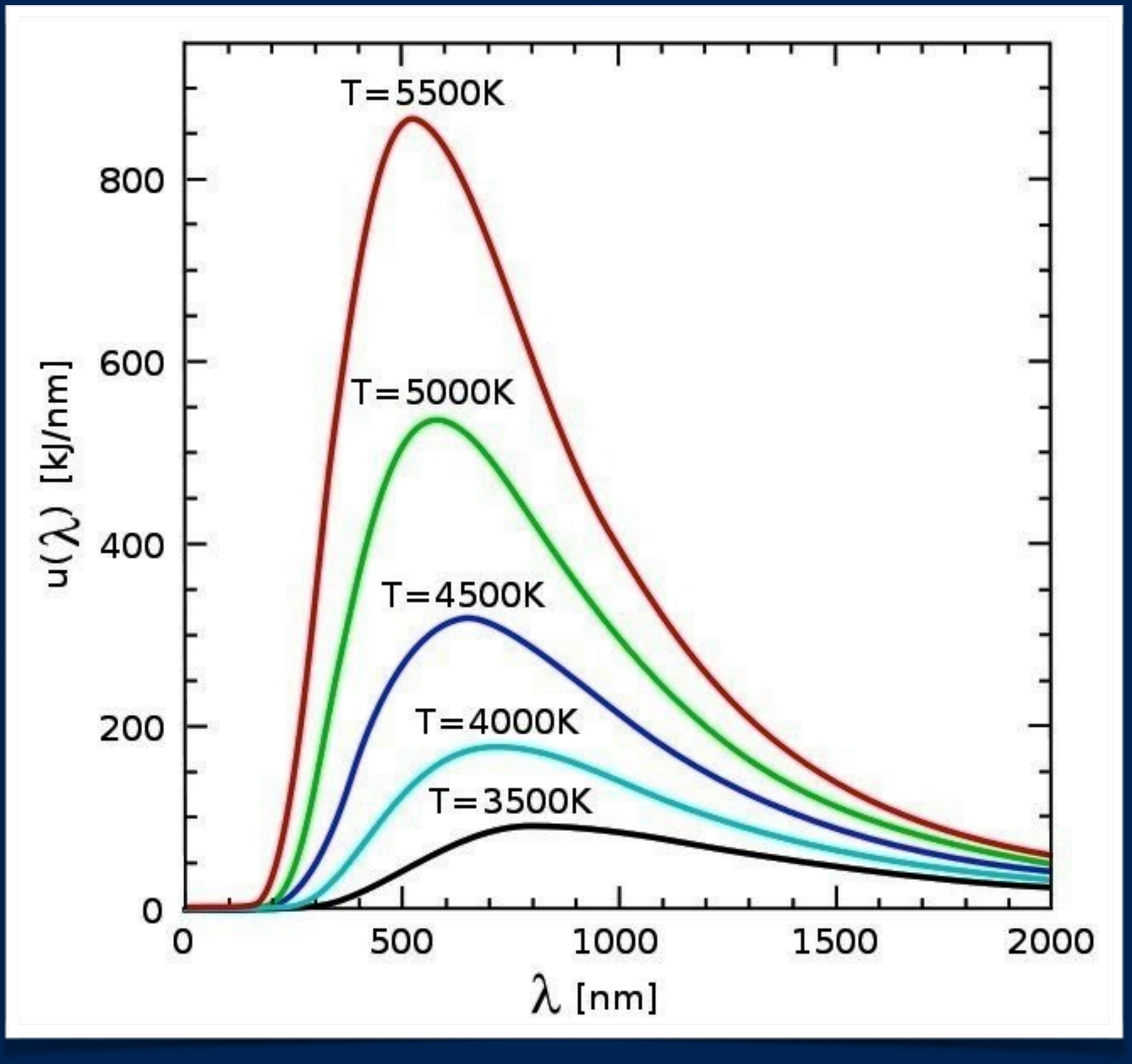
- **Optical** and **UV** astronomers use **Angstroms** or **Nano-meters**
- **X-ray** and **gamma ray** observers switch to an energy scale, i.e. in **electron-Volts**

Wien's Law



$$T = \frac{2.9 \times 10^{-3}}{\lambda_{max}}$$

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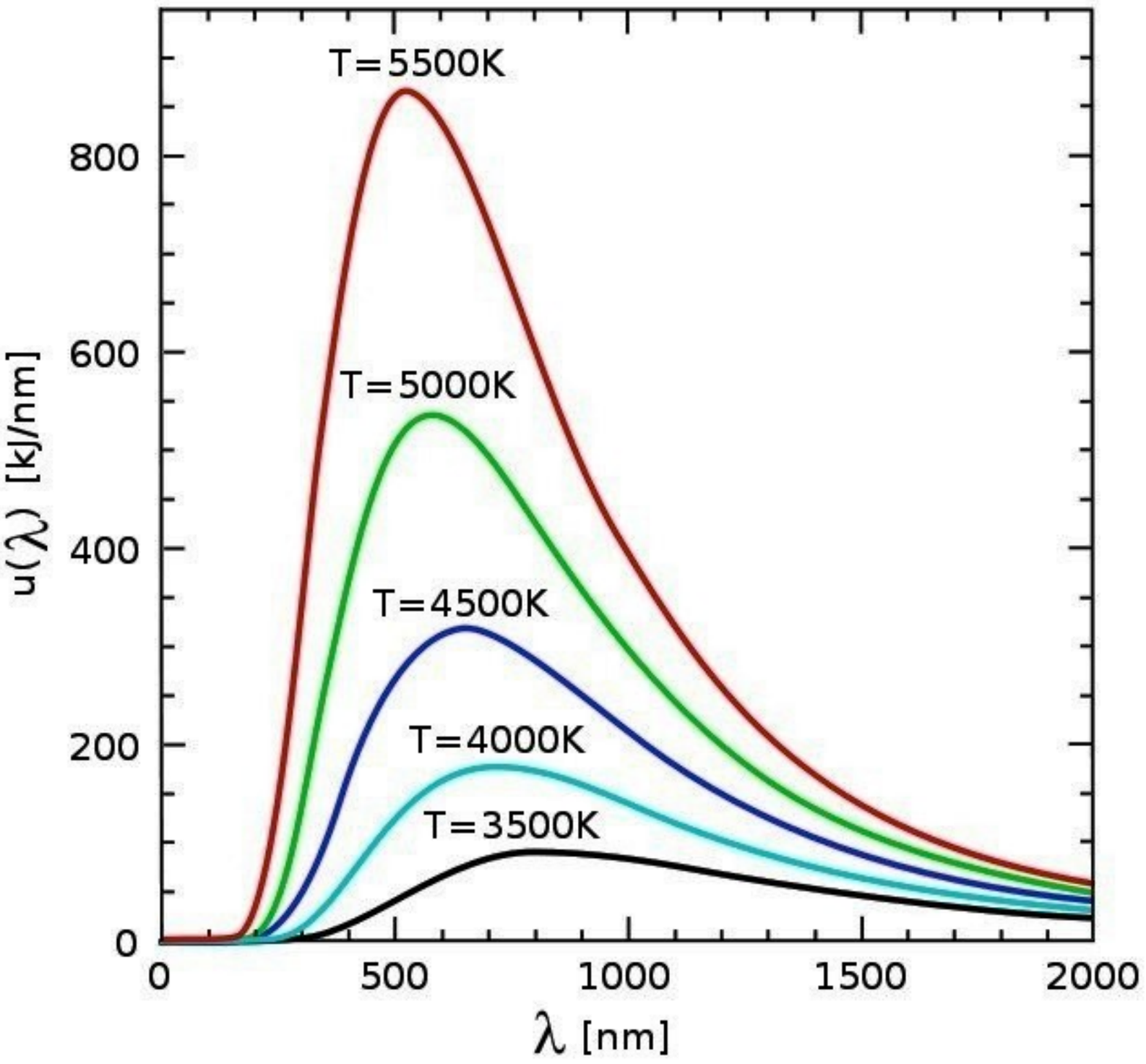

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How Does All of this Relate to Galactic Astronomy?

Multi-wavelength Astronomy

Waveband	Wavelength /Energy	Temperature	What can be studied ?
Gamma rays	100keV-100MeV	$>10^8$K	accretion disks, gamma-ray bursts
X-rays	<1-100keV	10^6-10^8K	Hot gas in clusters of galaxies, stellar coronae, accretion disks
Ultra-violet	900-3000A	10^4-10^6K	Hot stars, white dwarfs, instellar gas
Optical	3000-10,000A	10^3-10^4K	Sun-like stars
Infra-red	1-100 micron	10-10^3K	Dust, planets, brown dwarfs
Microwave	1cm	<10K	Background radiation of the Universe (remnant of Big Bang)
Radio	>1m	<10K	Radiation from electrons moving in a magnetic field: pulsars

radio continuum (408 MHz)

atomic hydrogen

radio continuum (2.5 GHz)

molecular hydrogen

infrared

mid-infrared

near infrared

optical

x-ray

gamma ray

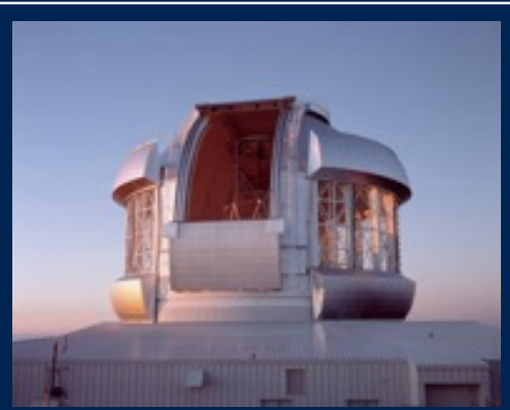
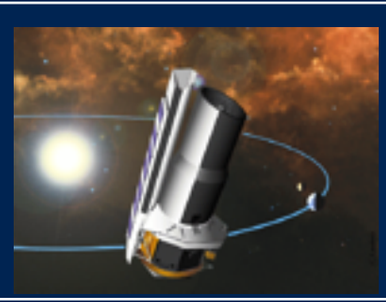
Multiwavelength Milky Way

http://adc.gsfc.nasa.gov/mw

Effect of atmosphere

Band	Stopped by	Observe from	Example
Gamma rays	Ionisation, Compton scattering	Balloon, space	
Xrays	Ionisation O2, N2	Space	
UV	O2, N2, O3 disassociation	Space	
Optical	Clear!	Ground	

Effect of atmosphere

Band	Stopped by	Observe from	Example
Infra-red <10microns	CO_2, H_2O but clear bands	mountain	
Infra-red >20 microns	Molecular absorption	Space, aircraft	
Sub mm	Molecular absorption	Mountain	
Radio	Clear!	Ground	

Astronomical Surveys

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Survey (noun): a detailed examination or investigation, e.g., to find out public opinion or customer preference

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For us: Astronomical Survey: study of regions of the sky using telescopes for Imaging or mapping those Astronomical catalogs

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  - Reductions, data volume, dissemination?

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WARNING - acronym soup!

Surveys

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- X-ray
  - XMM-Newton: X-ray Multi-Mirror mission
  - EXOSAT
  - CLASXS: Chandra Large Area Synoptic X-Ray Survey
  - ROSAT:
  - ……

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  - **SDSS**: Sloan Digital Sky Survey
  - **Tycho-2**:
  - **USNO**: US Naval Observatory
  - **DSS**: Digitized Sky Survey
  - **APM**: Cambridge Automated Plate Measurement
  - **MAPS**: Minnesota Automated Plate Scanner
  - **PDSSS**: Palomer Distant Solar System Survey
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  - **2MASS**: The 2-micron All Sky Survey
  - **DENIS**: Deep Near Infrared Survey
  - **WISE**: Wide-field Infrared Survey Explorer
  - **IRAS**: InfraRed Astronomical Satellite
  - **SST**: Spitzer Space Telescope
  - **UKIDSS**: UKIRT Infrared Deep Sky Survey
  - **VISTA**: Visible and Infrared Survey Telescope for Astronomy
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  - NVSS: NRAO VLA Sky Survey
  - SUMSS: Sydney University Molonglo Sky Survey
  - WENSS: Westerbork Northern Sky Survey
  - ASKAP: The Australian Square Kilometre Array Pathfinder
  - HIPASS: HI Parkes All Sky Survey
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  - WENSS: We
  - ASKAP: The Pathfinder
  - HIPASS: HI
- Multi-wavelength
  - GAMA: the Galaxy And Mass Assembly survey
  - GOODS: The Great Observatories Origins Deep Survey
  - COSMOS: Cosmic Evolution Survey

The Optical Surveys:

SDSS

SDSS

The Sloan Digital Sky Survey

- Special 2.5m telescope, located at Apache Point, NM
- Two surveys in one:
  - Photometric survey in 5 bands
  - Spectroscopic redshift survey
- Huge CCD Mosaic
- Two high resolution spectrographs
  - 2 x 320 fibers, with 3 arcsec diameter
  - Spectral coverage from 3900Å to 9200Å

- Automated data reduction
- Very high data volume
  - Expect over 40 TB of raw data.
  - About 1 TB processed catalogs.
  - Data made available to the public.

SDSS Sky Coverage

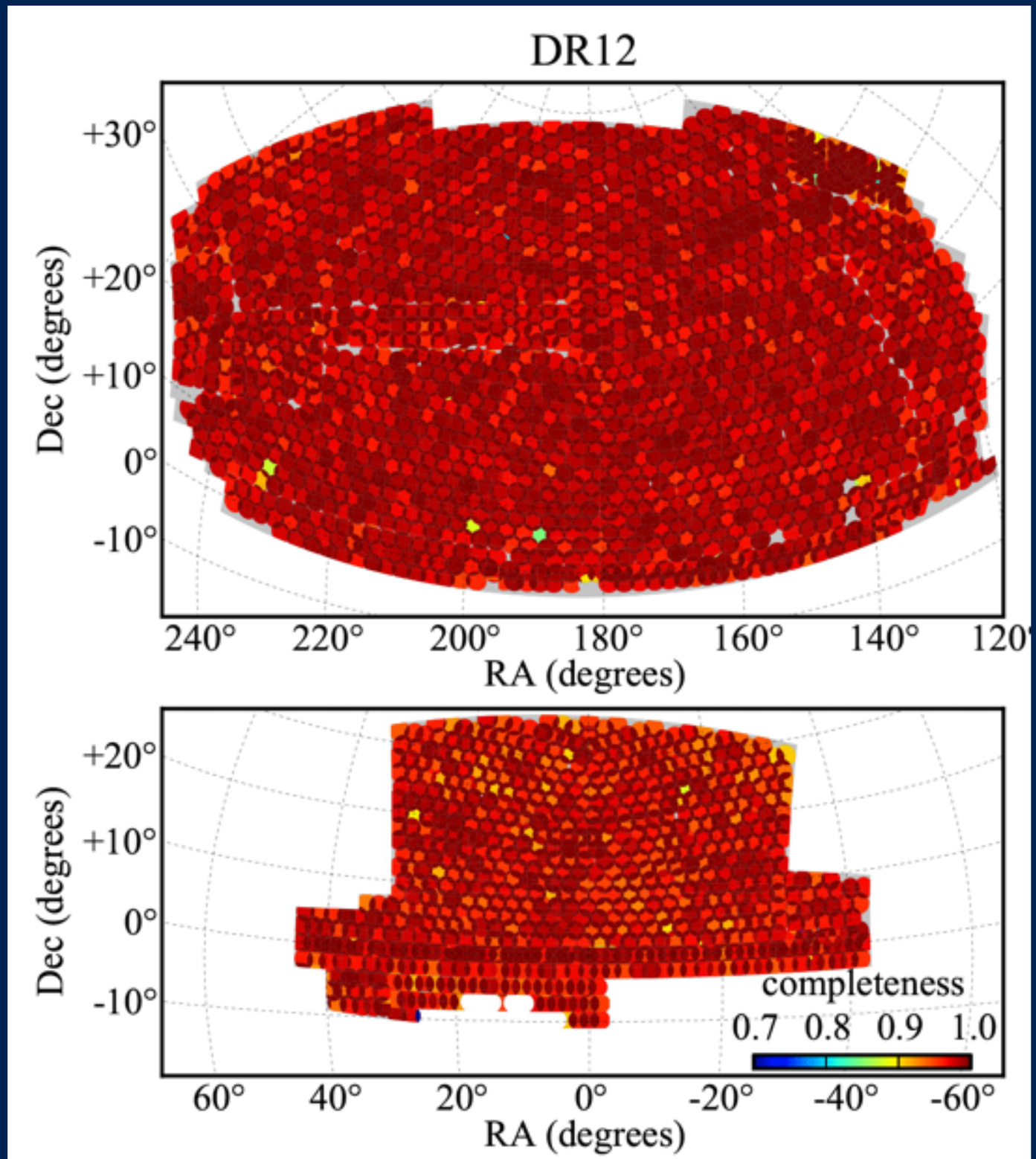
http://www.sdss.org/dr12/

Imaging

- Area covered: **14,555** square degrees
- Total area imaged: **31,637** square degrees
- Objects: **1,231,051,050**
- Global astrometric precision
  - 0.1 arcsec rms (absolute)

Spectroscopic

- Total spectra: **4,355,200**
- Useful spectra: **4,266,444**
- Galaxies: **2,401,952**
- Quasars: **477,161**
- Stars: **851,968**

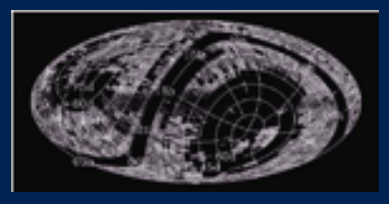


The Infrared Surveys:

2MASS

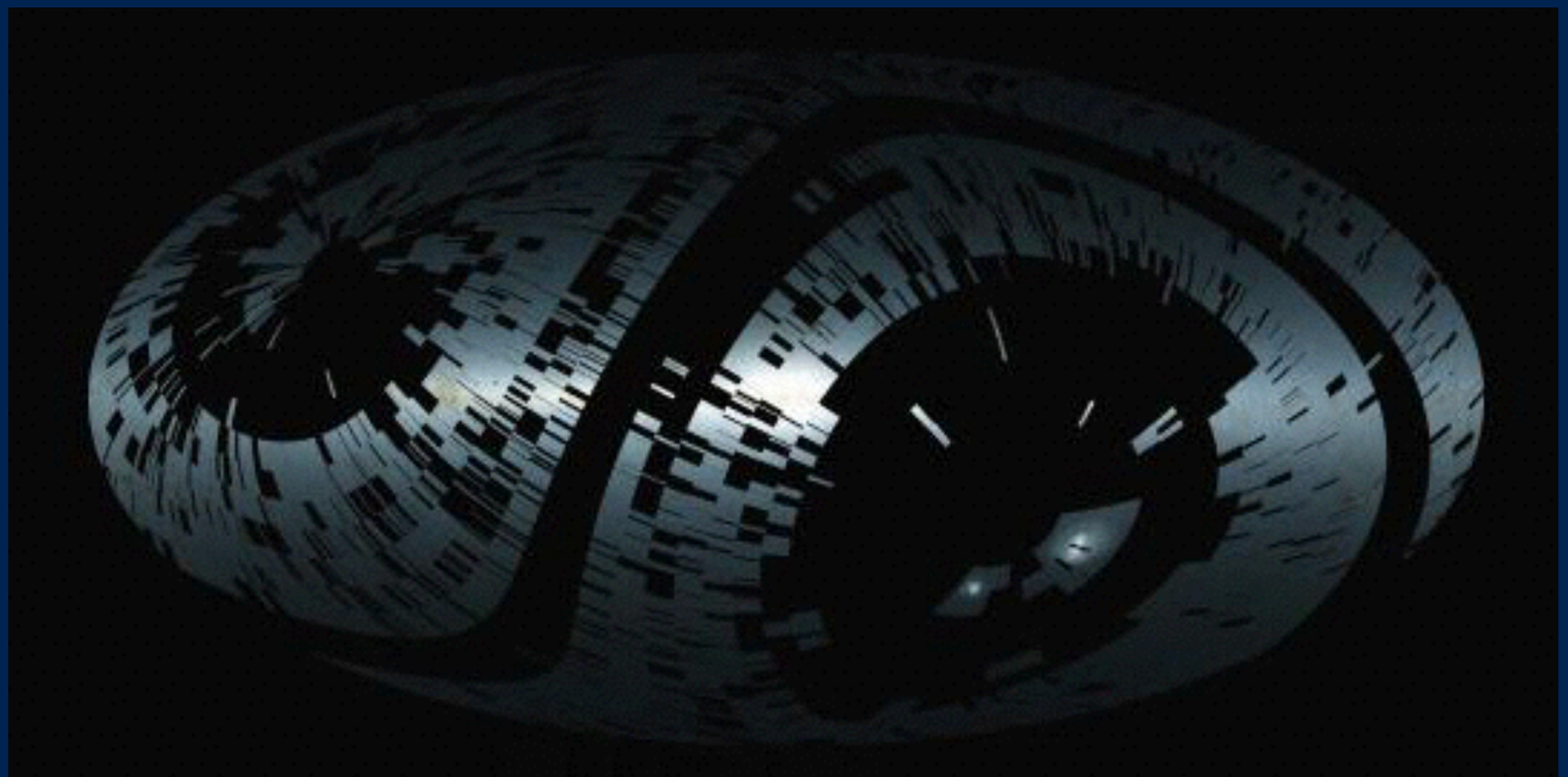
2MASS

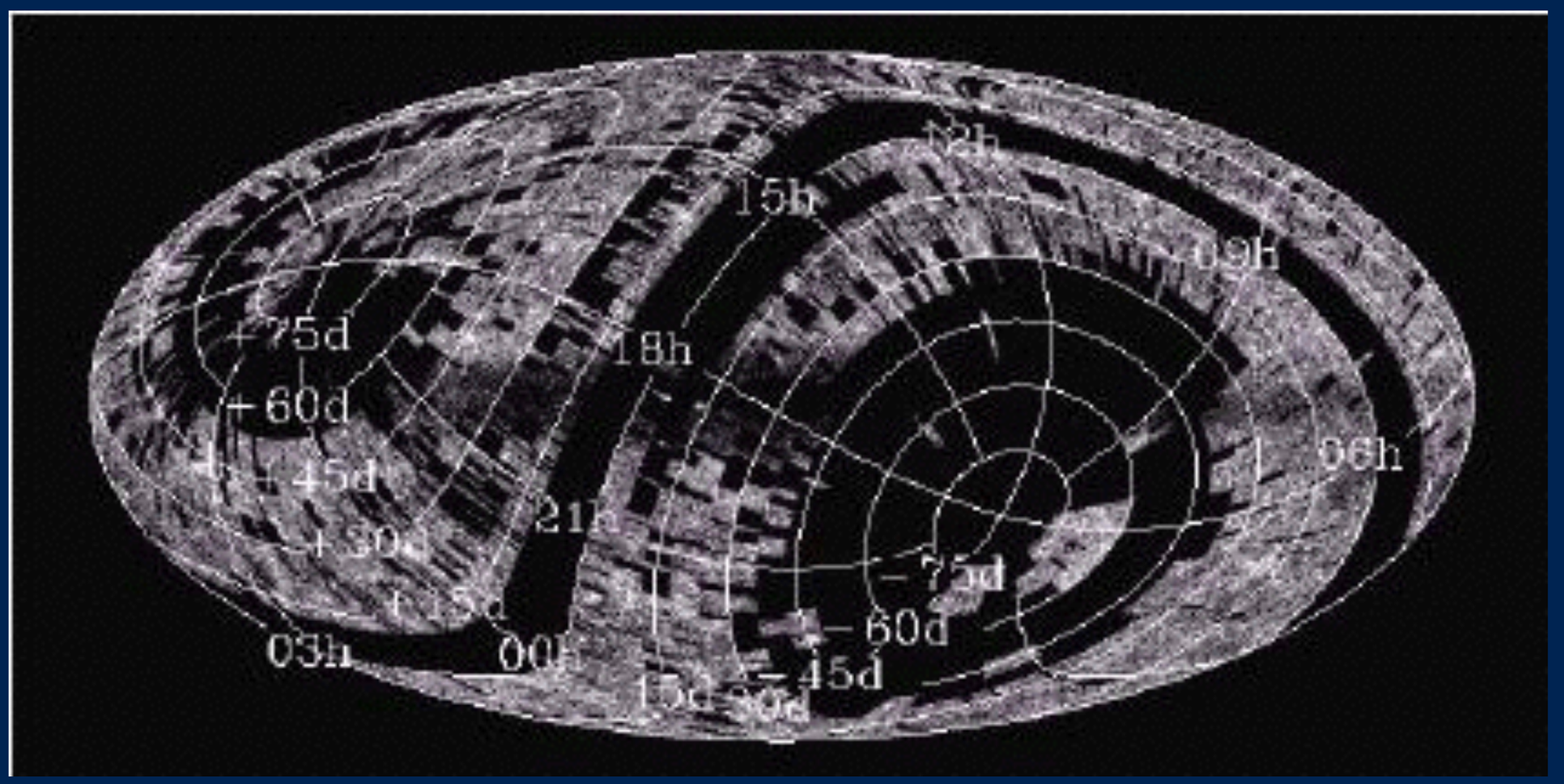
The Two Micron Sky Survey



- ✓ Scanned 70% of the sky
- ✓ Used two highly-automated 1.3-m telescopes, one at Mt. Hopkins, AZ, and one at CTIO , Chile
- ✓ Capable of observing the sky simultaneously at J (1.25 microns), H (1.65 microns), and K_s (2.17 microns)
- ✓ **Point source catalog (300 million stars and other unresolved objects)**
- ✓ **Extended source catalog** (more than 1,000,000 galaxies and other nebulae

http://www.ipac.caltech.edu/2mass/index.html




12h
15h
09h
+75d
18h
+60d
+45d
06h
21h
+30d
+15d
03h
00h
-75d
-60d
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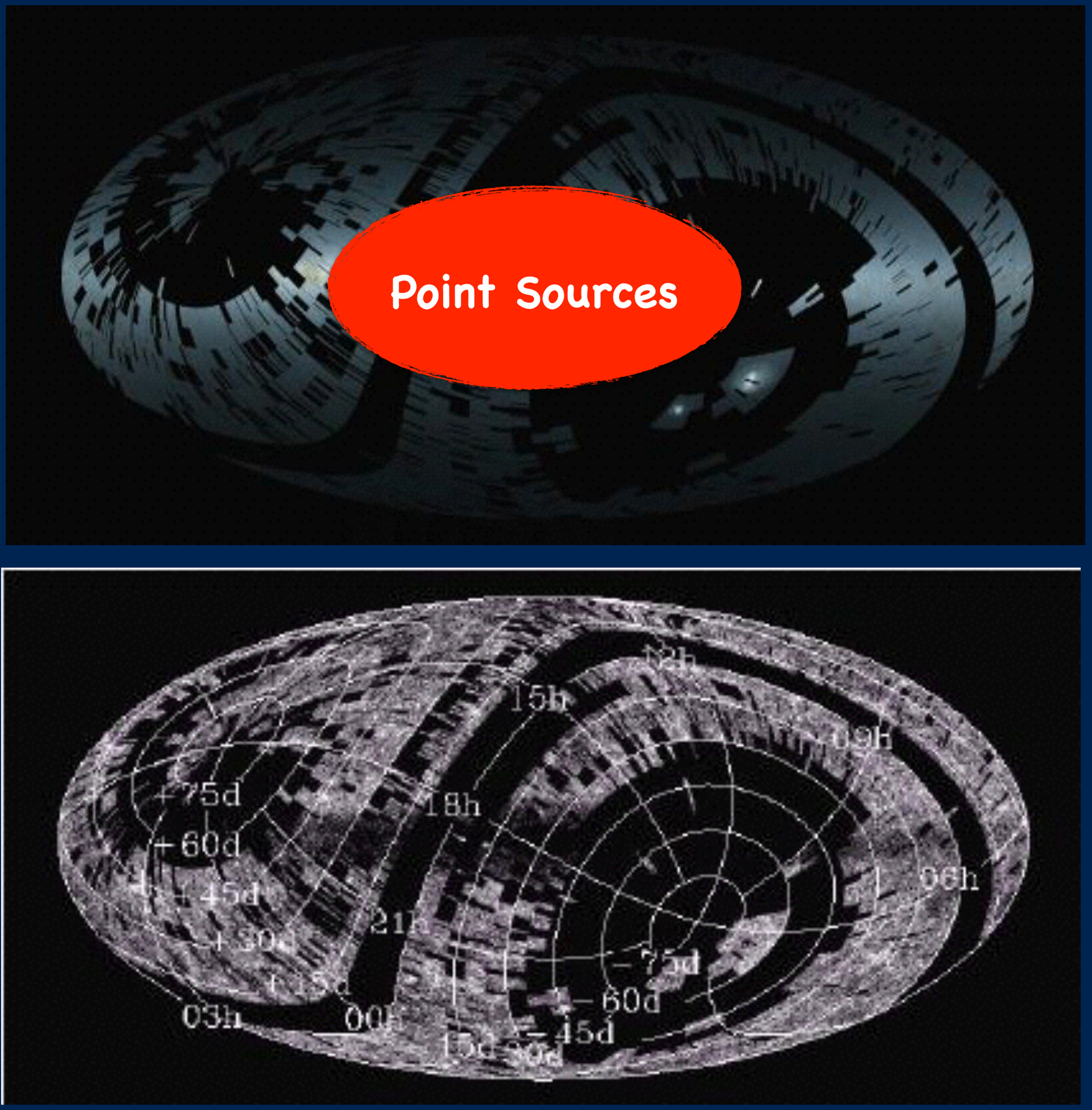
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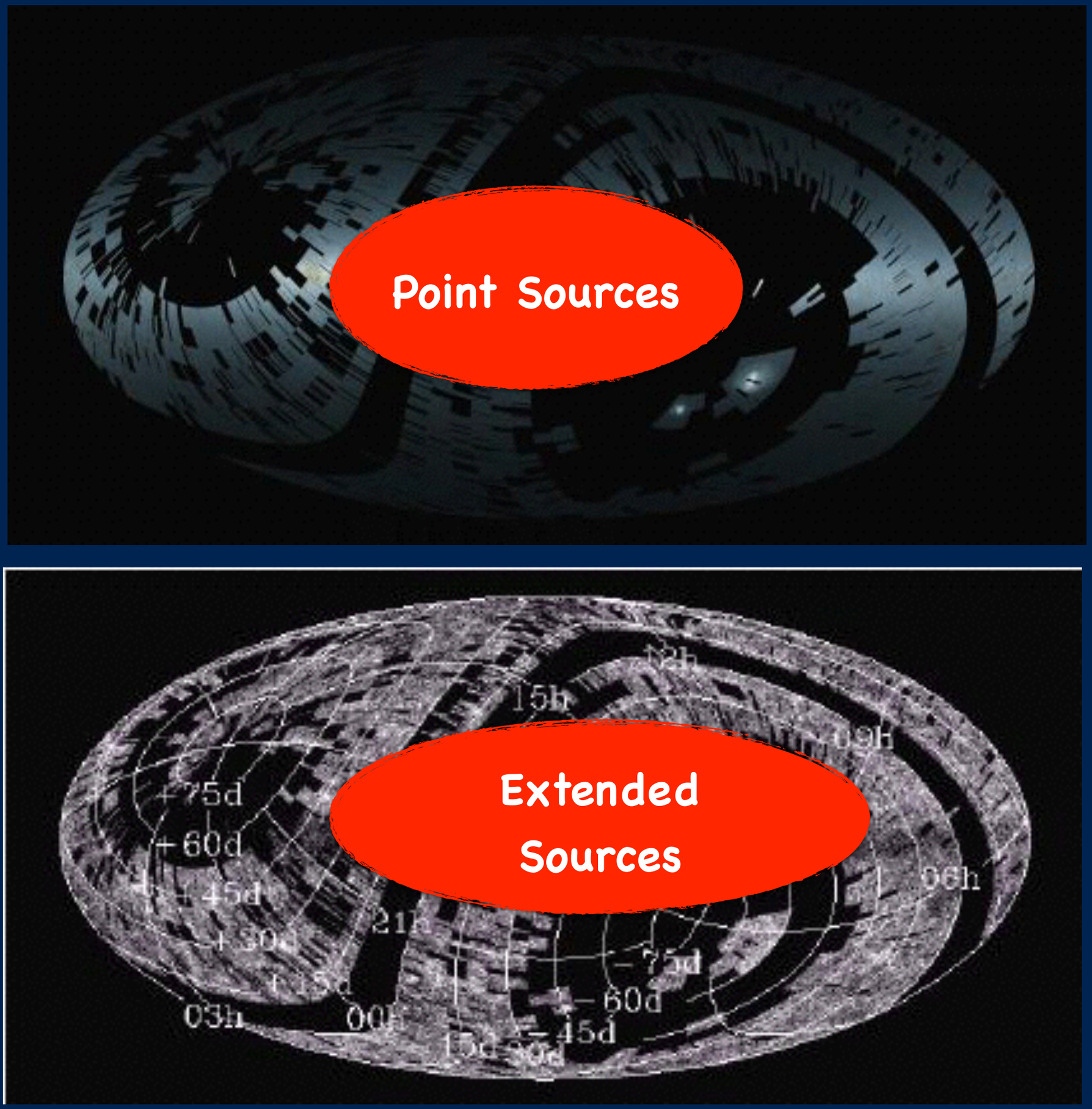
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Classes of radio surveys

- **Blind Surveys:**
  - (Parts of) all-sky Surveys like FIRST, NVSS, WENSS, etc.

- **Targeted surveys:**
  - Deep surveys (ATLAS, CDF)
  - Most VLBI survey (CJF, 2cm S/MOJAVE, TANAMI)

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- **Interstellar medium**
  - Spectral lines: Neutral H (HI) at lambda21 cm, ionized H (HII), Rotational and vibrational lines for another molecules (O_2, N_2, CH_4, CO_2, etc.)
  - Supernova remnant: synchrotron

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- **Galactic continuum radiation Pulsars**
  - Magnetic field and cosmic
  - rays: synchroton (α = -0.55)

- **Interstellar medium**
  - Spectral lines: Neutral H (HI) at lambda21 cm, ionized H (HII), Rotational and vibrational lines for another molecules (O_2, N_2, CH_4, CO_2, etc.)
  - Supernova remnant: synchrotron

- **Pulsars**
  - Neutron stars emitting
  - Coherent radiation with α =-2+-1

Ingredients of the radio sky

- **Galactic continuum radiation Pulsa**
  - Magnetic field and cosmic
  - rays: synchroton (α = -0.55)

- **Interstellar medium**
  - Spectral lines: Neutral H (HI) at lambda21 cm, ionized H (HII), Rotational and vibrational lines for another molecules (O_2, N_2, CH_4, CO_2, etc.)
  - Supernova remnant: synchrotron

- **Radio galaxies and quasars**
  - Radio galaxy robes:
  - Syncrothron
  - AGN cores:syncrothron,
  - flat spectrum(parts self absorbed)

- **Pulsars**
  - Neutron stars emitting
  - Coherent radiation with α =-2+-1

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Stars

- Circumstellar maser (SiO), H_2O, OH)
- Novae
- Binaries and flare stars
- (recurrent novae), X-ray binaries):Non-thermal

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Stars

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- Binaries and flare stars
- (recurrent novae), X-ray binaries):Non-thermal

Cosmic microwave background

- Thermal radiation from the big bang

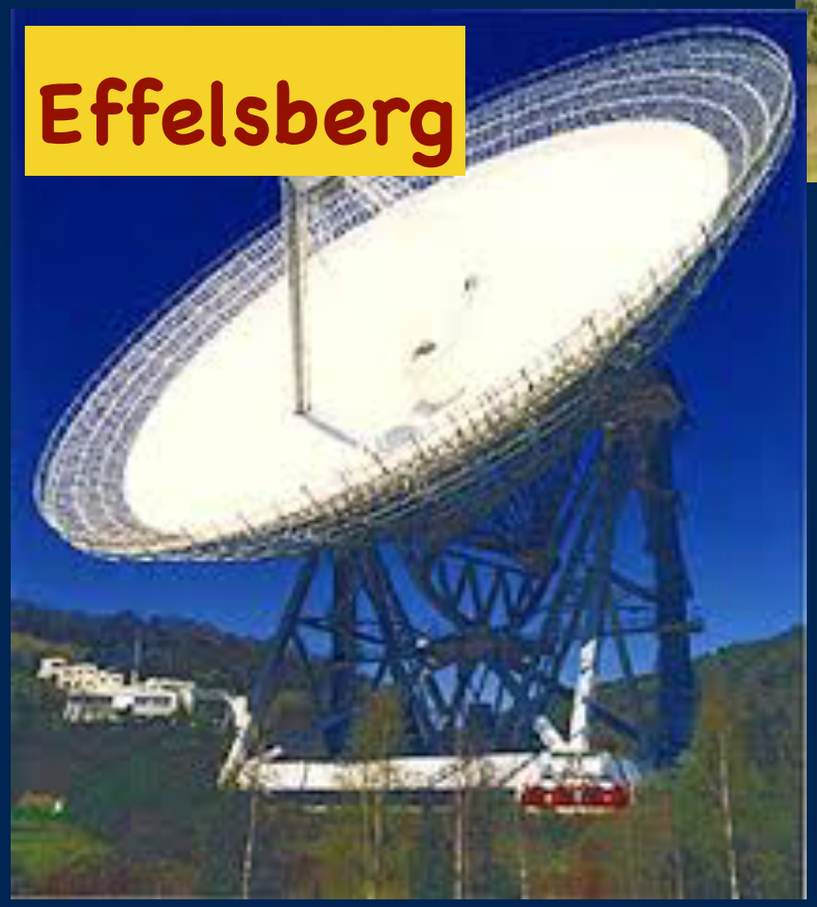
Toys

Toys


VLA


WSRT


VLBA


Effelsberg


Merlin
Jodrell Bank Lovell
Jodrell Bank Mk2
Darnhall
Cambridge
Knockin
Oulton


GMRT


MOST

Blind Surveys

- Covering almost the entire sky below **1.4 GHz**
- Typical resolution of **50″**
- Root-mean-square noise of the order of **mJy**
- Provide **post stamps** (**JPG/FITS** files)

Blind Surveys of the Nearby Universe

NVSS	1.4 GHZ	2.5 mJy	10.3	Condon et al. 1998
FIRST	1.4 GHz	1 mJy	2.6	Becker et al. 1995
SUMSS	843 MHz	5 mJy	6	Bock et al. 1999
WENSS	330 MHz	18 mJy	3.1	Rengelink et al. 1997
WISH	352 MHz	18 mJy	1.6	De Breuck et al. 2002
VLSS	74 MHz	500 mJy	9.4	Cohen et al. 2006

NVSS

NRAO VLA SKY Survey

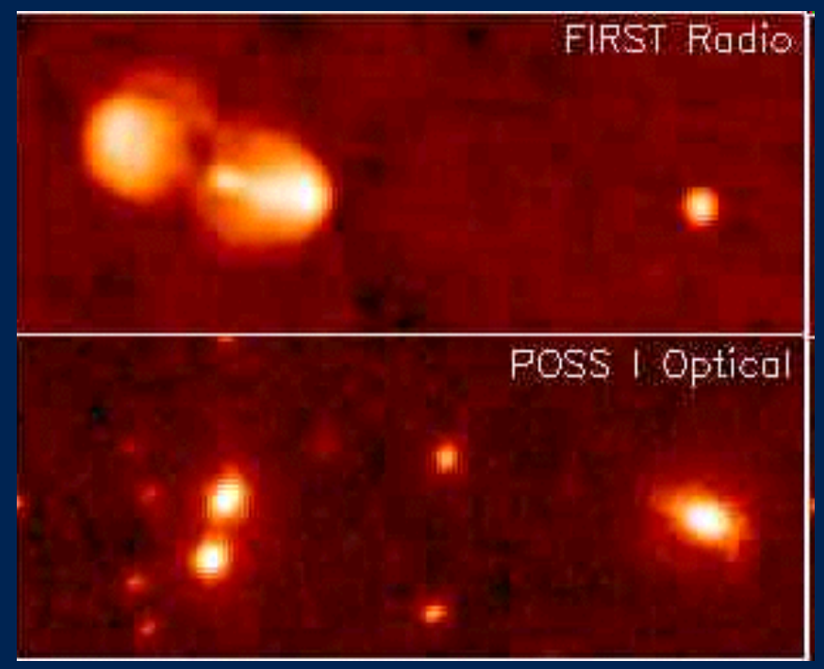
- Entire sky north of **-40°**, at 45 ″ resolution and 2.5 mJy/beam limit.
- Most used and complete sky survey

http://www.cv.nrao.edu/nvss/

FIRST

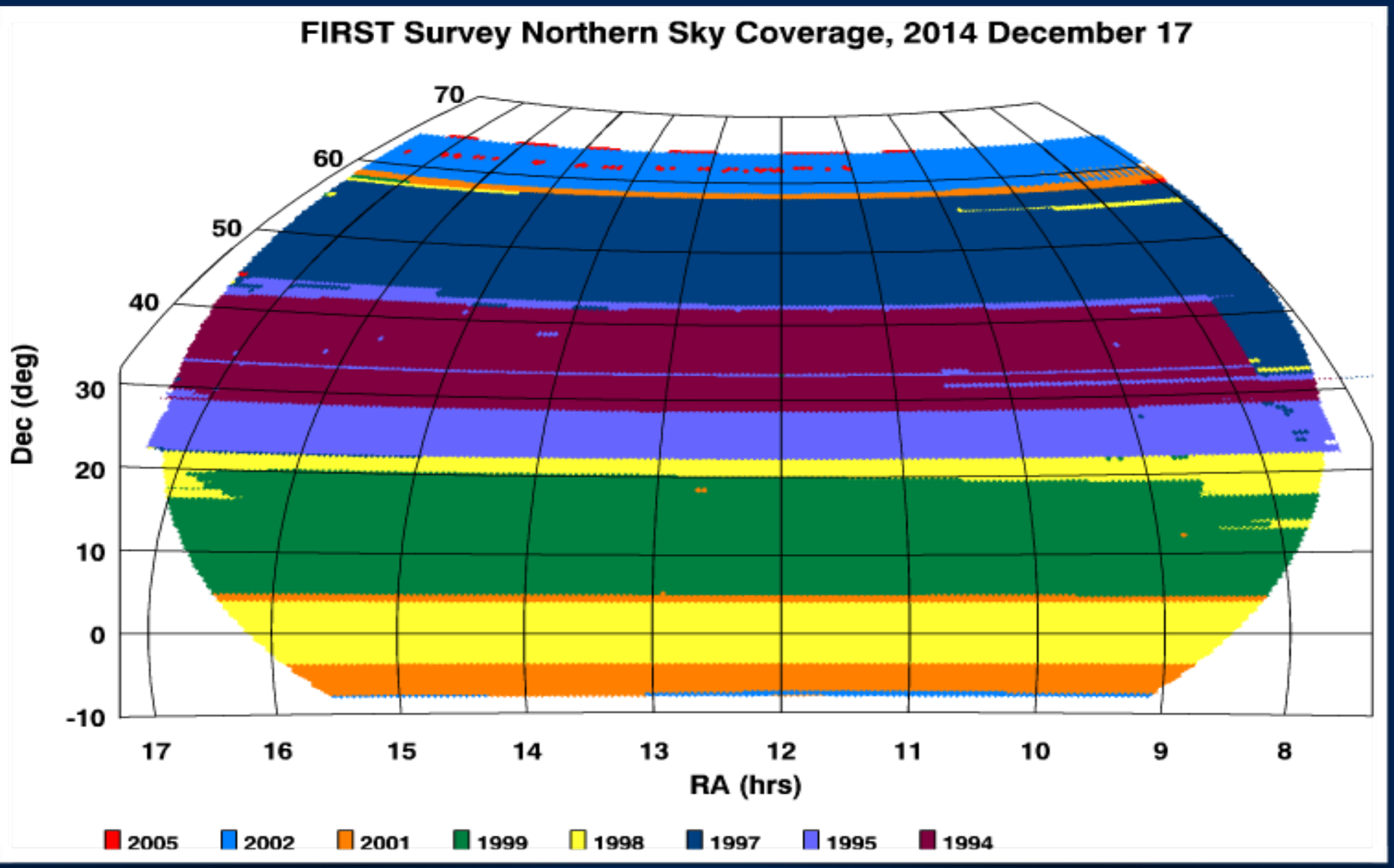
Faint Images of the Radio Sky at Twenty-cm

- High resolution (**5"**) of the north Galactic cap at 1.4 GHz, above 1 mJy/beam
- 10,575 square degrees of sky
  - 8,444 square degrees in the north
  - 2,131 square degrees in the south
- 946,432 sources

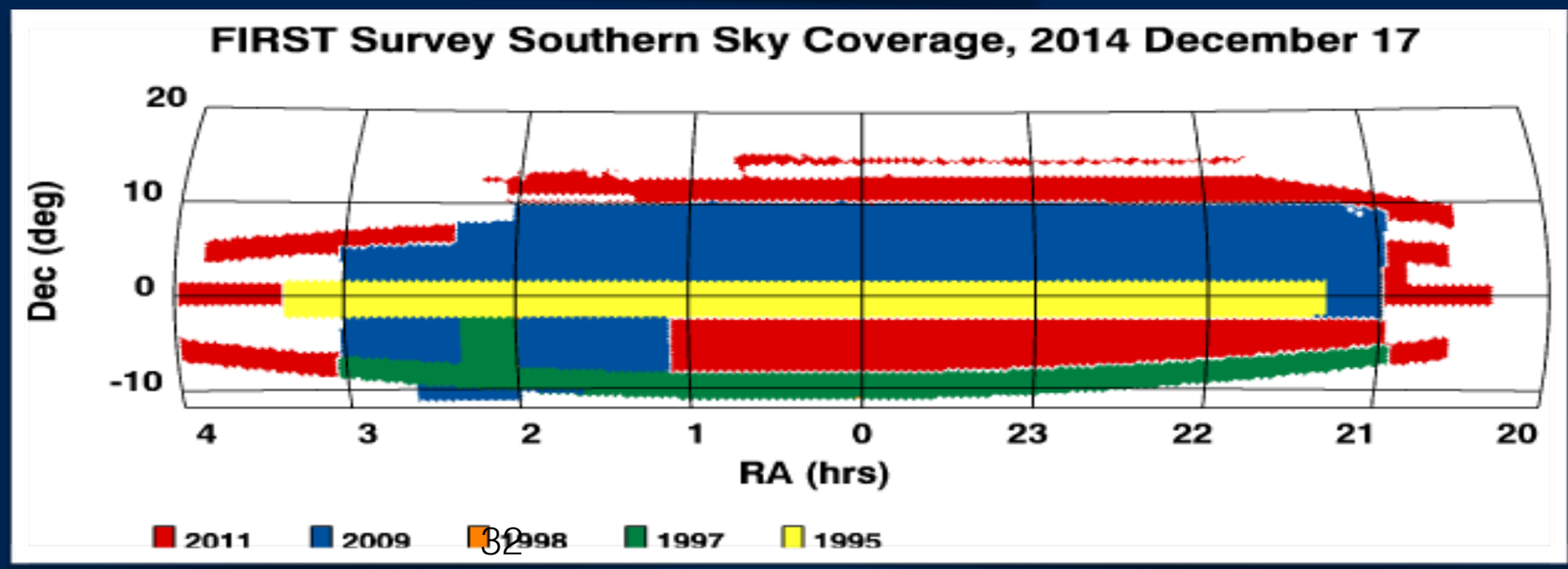


- Both the northern and southern areas were chosen to coincide approximately with the area covered by the Sloan Digital Sky Survey (SDSS)

http://sundog.stsci.edu/first/catalogs.html



FIRST SKY Coverage



The FIRST Catalog

The catalog is sorted by decreasing declination and has the following format:

RA	Dec	P(S)	Fpeak	Fint	RMS	Maj	Min	PA	fMaj	fMin	fPA	Field	SDSS #	SDSS Sep	SDSS i	SDSS Cl	2MASS #	2MASS Sep	2MASS K	Epoch Mean-yr
07 27 34.289	+64 40 59.80	0.197	1.00	1.12	0.139	2.13	1.58	0.2	5.80	5.63	0.2	07300+64243J	-1	99.00	99.00	-	1	6.76	14.62	2002.687
07 38 39.304	+64 40 16.28	0.014	2.39	5.73	0.139	9.31	3.58	136.6	10.76	6.48	136.6	07360+64243J	-1	99.00	99.00	-	0	99.00	99.00	2002.687
07 50 24.019	+64 40 01.21	0.014	22.09	24.00	0.140	1.96	1.13	6.8	5.74	5.52	6.8	07480+64243J	-1	99.00	99.00	-	0	99.00	99.00	2002.687
07 38 45.622	+64 39 50.12	0.014	2.39	4.33	0.140	6.43	3.27	13.5	8.40	6.31	13.5	07360+64243J	-1	99.00	99.00	-	0	99.00	99.00	2002.687
07 39 32.799	+64 39 18.03	0.082	1.41	1.25	0.139	2.63	0.00	37.5	6.01	4.30	37.5	07420+64243J	-1	99.00	99.00	-	0	99.00	99.00	2002.687

The catalog is sorted by decreasing declination and has the following format:

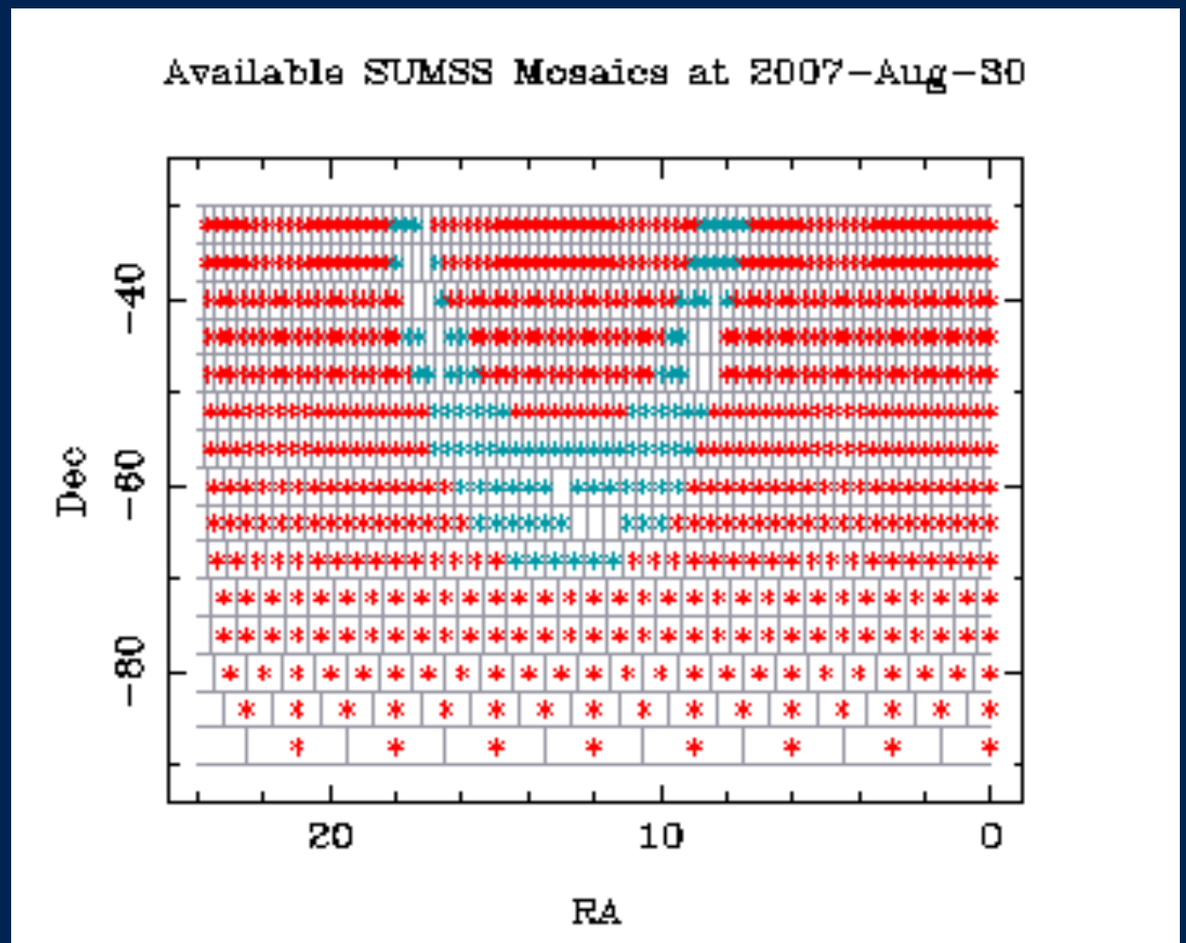
RA	Dec	P(S)	Fpeak	Fint	RMS	Maj	Min	PA	fMaj
07 27 34.289	+64 40 59.80	0.197	1.00	1.12	0.139	2.13	1.58	0.2	5.80
07 38 39.304	+64 40 16.28	0.014	2.39	5.73	0.139	9.31	3.58	136.6	10.76
07 50 24.019	+64 40 01.21	0.014	22.09	24.00	0.140	1.96	1.13	6.8	5.74
07 38 45.622	+64 39 50.12	0.014	2.39	4.33	0.140	6.43	3.27	13.5	8.40
07 39 32.799	+64 39 18.03	0.082	1.41	1.25	0.139	2.63	0.00	37.5	6.01

fMaj	fMin	fPA	Field	SDSS #	SDSS Sep	SDSS i	SDSS Cl	2MASS #	2MASS Sep	2MASS K	Epoch Mean-yr
5.80	5.63	0.2	07300+64243J	-1	99.00	99.00	-	1	6.76	14.62	2002.687
10.76	6.48	136.6	07360+64243J	-1	99.00	99.00	-	0	99.00	99.00	2002.687
5.74	5.52	6.8	07480+64243J	-1	99.00	99.00	-	0	99.00	99.00	2002.687
8.40	6.31	13.5	07360+64243J	-1	99.00	99.00	-	0	99.00	99.00	2002.687
6.01	4.30	37.5	07420+64243J	-1	99.00	99.00	-	0	99.00	99.00	2002.687

SUMSS

Sidney University Molongolo Sky Survey

- Southern sky below -30 deg and |b|> 10 deg, 843 MHz
- Similar to NVSS in resolution and sensitivity
- 211000 sources



http://www.physics.usyd.edu.au/sifa/Main/SUMSS

WENSS

Westerbork Northern Sky Survey

- Northern Sky, δ >+30°, 326 MHz, (54′ ′ x 54′ ′)/sin δ resolution
- 230000 sources stronger than 18 mJy
- Extended to the south (WISH)

http://www.astron.nl/wow/testcode.php?survey=1

WISH

Westerbork In the Southern Hemisphere

- Southern Sky, $-26° < \delta < -9°$
- 352 MHz, (54′ ′ x 54′ ′)/sin δ resolution
- Flux density limit at 18 mJy

http://www.astron.nl/wow/testcode.php?survey=1

Targeted Surveys

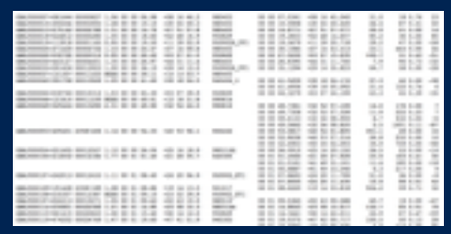
- **Deep field surveys**: commonly with a multi-band approach
- Stamp collection (and movie making): **VLBI** monitoring surveys, **HI images**, polarisation

- Examples ……

CLASS

The cosmic Lens All-Sky Survey

- 11000 VLA snapshots at 8.4 GHz of sources with flat radio spectra (spectral index of >-0.5 between 1.4 and 5GHz) and flux density (>30mJy at 5GHz).
- Resolution of 0.2"
- Sources checked for evidence of gravitationally lensed compact radio sources. Lensing (22 were found)



http://www.jb.man.ac.uk/research/gravlens/class/class.html

CLASS

The cosmic Lens All-Sky Survey

GB6J000007+081644	00000827	1.06	00	00	06.98	+08	16	46.2	980403	00	00	07.0341	+08	16	45.040	31.0	18	0.76	23
GB6J000010+305556	00003093	1.28	00	00	10.10	+30	55	59.3	980403	00	00	10.0908	+30	55	59.420	26.4	87	0.31	50
GB6J000013+275142	00002786	1.31	00	00	14.76	+27	51	57.8	980403	00	00	14.8771	+27	51	57.577	29.9	21	0.00	14
GB6J000018+024812	00000280	1.05	00	00	18.60	+02	48	16.9	950829	00	00	19.2833	+02	48	14.657	85.2	36	0.00	85
GB6J000019+113918	00001165	0.95	00	00	19.50	+11	39	02.9	950902A_FF1	00	00	19.5679	+11	39	20.718	29.2	47	0.00	-58
GB6J000029+471629	00004726	1.33	00	00	24.47	+47	16	09.8	980403	00	00	30.1085	+47	16	43.313	23.1	263	0.00	56
GB6J000026+030706	00000312	0.95	00	00	26.20	+03	07	21.0	950829	00	00	27.0230	+03	07	15.635	100.7	31	0.43	-51
GB6J000030+443127	00004451	1.35	00	00	26.97	+44	31	11.4	980403	00	00	26.8395	+44	31	11.700	7.9	90	0.73	-32
GB6J000035+291424	00012923	1.00	00	00	36.10	+29	14	12.0	950902A_FF1	00	00	35.1294	+29	14	35.823	64.7	58	0.00	-28
GB6J000037+121357	00011223	NOSH	00	00	39.11	+12	13	53.7	980403										
GB6J000040+391758	00013929	1.05	00	00	41.20	+39	18	04.5	940404_1	00	00	41.5259	+39	18	04.172	97.3	42	0.00	-38
										00	00	41.4936	+39	18	05.092	21.4	122	0.74	6
GB6J000044+030744	00010312	1.03	00	00	45.30	+03	07	39.9	950829	00	00	44.3279	+03	07	54.199	63.3	45	0.39	-35
GB6J000048+121810	00011230	NOSH	00	00	49.41	+12	18	31.8	990816										
GB6J000049+325424	00013290	2.31	00	00	49.90	+32	54	24.0	990816	00	00	49.7361	+32	52	57.109	14.0	176	0.00	7
										00	00	49.7358	+32	52	57.328	11.9	222	0.23	7
										00	00	49.6133	+32	56	08.944	6.7	432	0.05	-6
										00	00	49.5662	+32	56	08.820	5.5	1491	0.11	-87
GB6J000053+405401	2358+406	1.14	00	00	54.33	+40	53	56.1	900222	00	00	53.0817	+40	54	01.805	351.1	49	0.00	16
										00	00	52.8036	+40	53	57.314	26.8	232	0.00	10
										00	00	52.6903	+40	54	02.093	34.9	759	0.00	-48
GB6J000054+251605	00012527	1.12	00	00	56.04	+25	16	18.9	980314A	00	00	56.0910	+25	16	20.152	26.5	23	0.00	-14
GB6J000100+414932	00014182	1.77	00	01	01.40	+41	49	35.7	940305	00	01	01.4560	+41	49	27.929	23.9	163	0.41	30
										00	01	01.5161	+41	49	31.101	11.4	185	0.00	-18
										00	01	00.8887	+41	49	33.546	0.3	217	0.00	9
GB6J000107+242013	00012433	1.11	00	01	08.40	+24	20	06.9	950902_FF1	00	01	07.8693	+24	20	11.799	51.0	36	0.00	-9
										00	01	07.8555	+24	20	11.435	10.9	99	0.51	52
GB6J000109+191428	2358+189	1.08	00	01	08.86	+19	14	13.5	921017	00	01	08.6225	+19	14	33.818	504.2	59	0.71	32
GB6J000108+235307	00012387	NOSH	00	01	09.10	+23	52	39.9	950902_FF1										
GB6J000107+024313	00010271	1.05	00	01	09.63	+02	43	10.0	980510	00	01	09.5365	+02	43	09.588	60.7	19	0.00	-47
GB6J000114+235801	00022396	1.21	00	01	14.85	+23	58	10.3	980314A	00	01	14.8643	+23	58	10.617	132.7	65	0.51	79
GB6J000115+061415	00020623	1.06	00	01	15.40	+06	14	12.0	950829	00	01	14.3441	+06	14	22.011	22.9	67	0.47	-59
GB6J000119+474202	00024769	1.47	00	01	19.60	+47	41	51.9	940305	00	01	19.0375	+47	42	00.717	100.5	50	0.13	28
										00	01	19.5903	+47	42	00.525	3.8	113	0.00	-85

CLASS

The cosmic Lens All-Sky Survey

GB6J000007+081644	00000827	1.06	00	00	06.98	+08	16	46.2	980403	00	00	07.0341	+08	16	45.040	31.0	18	0.76	23
GB6J000010+305556	[illegible]3093	1.28	00	00	10.10	+30	55	59.3	980403	00	00	10.0908	+30	55	59.420	26.4	87	0.31	50
GB6J000013+275142	[illegible]	1.31	00	00	14.76	+27	51	57.8	980403	00	00	14.8771	+27	51	57.577	29.9	21	0.00	14
GB6J000018+024812	[illegible]	[illegible]	00	00	18.60	+02	48	16.9	950829	00	00	19.2833	+02	48	14.657	85.2	36	0.00	85
GB6J000019+113918	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+11	39	02.9	950902A_FF1	00	00	19.5679	+11	39	20.718	29.2	47	0.00	-58
GB6J000029+471629	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	09.8	980403	00	00	30.1085	+47	16	43.313	23.1	263	0.00	56
GB6J000026+03070	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	950829	00	00	27.0230	+03	07	15.635	100.7	31	0.43	-51
GB6J000030+44311	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	00	00	26.8395	+44	31	11.700	7.9	90	0.73	-32
GB6J000035+2914	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	00	00	35.1294	+29	14	35.823	64.7	58	0.00	-28
GB6J000037+121357	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GB6J000040+391758	00013929	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+39	18	04.172	97.3	42	0.00	-38
															.092	21.4	122	0.74	6
GB6J000044+030744	00010312	1.03	00	00	45.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63.3	45	0.39	-35
GB6J000048+121810	00011230	NOSH	00	00	49.41	+12	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GB6J000049+325424	00013290	2.31	00	00	49.90	+32	54	24.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14.0	176	0.00	7
																11.9	222	0.23	7
																6.7	432	0.05	-6
										00	00	49.[illegible]				5.5	1491	0.11	-87
GB6J000053+405401	2358+406	1.14	00	00	54.33	+40	53	56.1	900222	00	00	53.0817	[illegible]	[illegible]	[illegible]	351.1	49	0.00	16
										00	00	52.8036	+40	53	57.[illegible]	26.8	232	0.00	10
										00	00	52.6903	+40	54	02.093	34.9	759	0.00	-48
GB6J000054+251605	00012527	1.12	00	00	56.04	+25	16	18.9	980314A	00	00	56.0910	+25	16	20.152	26.5	23	0.00	-14
GB6J000100+414932	00014182	1.77	00	01	01.40	+41	49	35.7	940305	00	01	01.4560	+41	49	27.929	23.9	163	0.41	30
										00	01	01.5161	+41	49	31.101	11.4	185	0.00	-18
										00	01	00.8887	+41	49	33.546	0.3	217	0.00	9
GB6J000107+242013	00012433	1.11	00	01	08.40	+24	20	06.9	950902_FF1	00	01	07.8693	+24	20	11.799	51.0	36	0.00	-9
										00	01	07.8555	+24	20	11.435	10.9	99	0.51	52
GB6J000109+191428	2358+189	1.08	00	01	08.86	+19	14	13.5	921017	00	01	08.6225	+19	14	33.818	504.2	59	0.71	32
GB6J000108+235307	00012387	NOSH	00	01	09.10	+23	52	39.9	950902_FF1										
GB6J000107+024313	00010271	1.05	00	01	09.63	+02	43	10.0	980510	00	01	09.5365	+02	43	09.588	60.7	19	0.00	-47
GB6J000114+235801	00022396	1.21	00	01	14.85	+23	58	10.3	980314A	00	01	14.8643	+23	58	10.617	132.7	65	0.51	79
GB6J000115+061415	00020623	1.06	00	01	15.40	+06	14	12.0	950829	00	01	14.3441	+06	14	22.011	22.9	67	0.47	-59
GB6J000119+474202	00024769	1.47	00	01	19.60	+47	41	51.9	940305	00	01	19.0375	+47	42	00.717	100.5	50	0.13	28
										00	01	19.5903	+47	42	00.525	3.8	113	0.00	-85

Catalogue sample

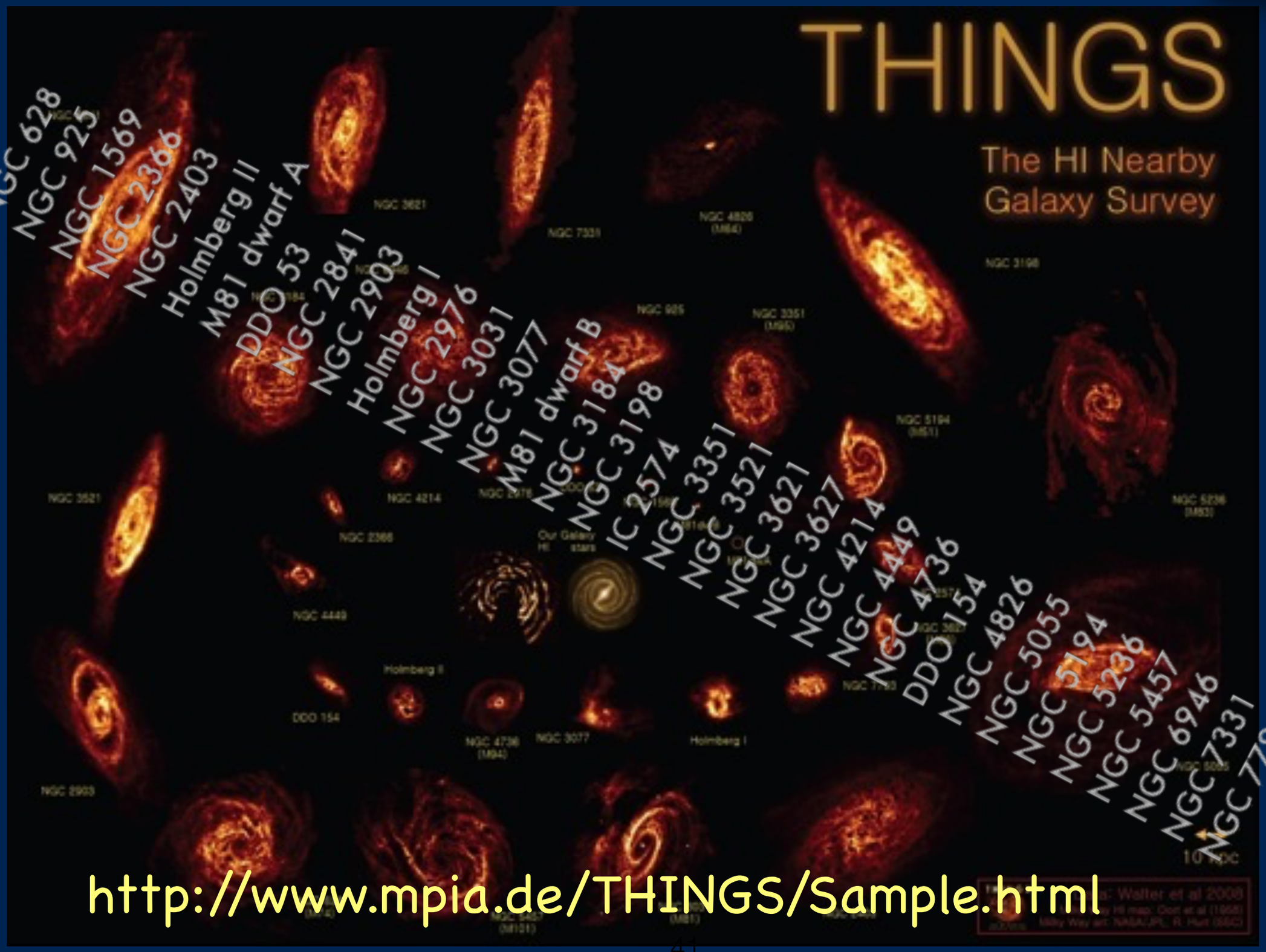
CRATES

The Combined Radio All-Sky Targeted Eight GHz Survey

- 8.4 GHz survey of 11000 bright flat-spectrum sources above 65 mJy (4.8 GHz)
- With VLA & ATCA
- Positions, sub-arcsecond structures and spectral indices

http://astro.stanford.edu/CRATES/

The HI Nearby Galaxy Survey



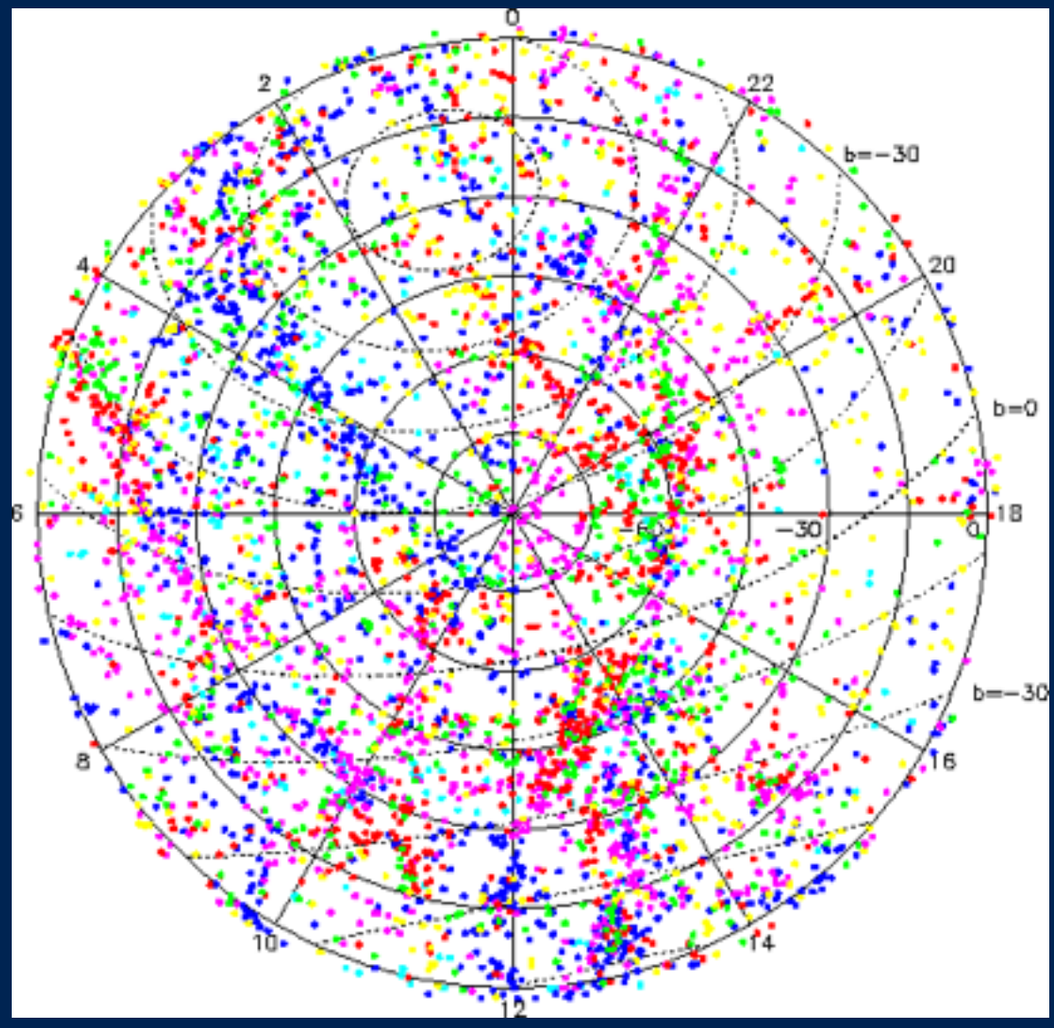
HIPASS

HI Parkes Archive Sky Survey

Caption: CSIRO's Parkes radio telescope. Credit: David McClenaghan, CSIRO

- ✓ Covers the whole southern sky
- ✓ Northern declinations up to +25 degrees
- ✓ Carried out with parkes telescope (64m)
- ✓ Neutral Hidrogen survey in the South

http://www.atnf.csiro.au/research/multibeam/release/

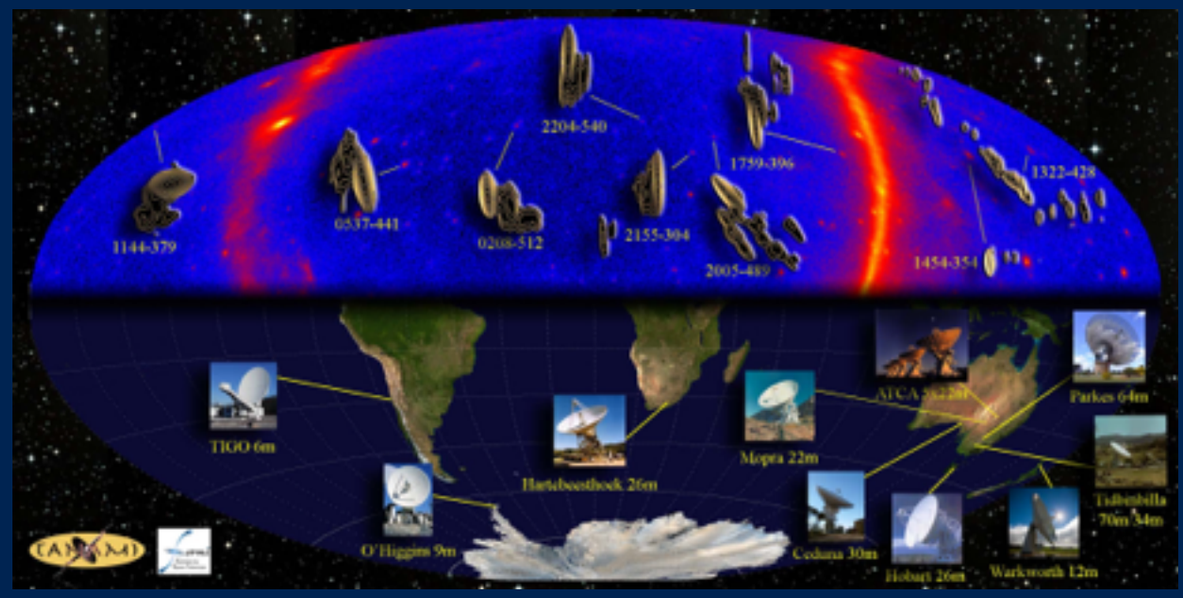


VLBI Surveys

- Designed to provide milliarsecond resolution images of compact sources (usually AGN)
- Extensive surveys to get one image of a large sample of sources (**ICRF**, VIPS, VCS)
- Intensive surveys to monitor the structural evolution of selected sources (CJF, MOJAVE, TANAMI)

TANAMI

Tracking AGN with Austral Milliarcsecond Interferometry



- ★ Monitoring of Southern Sources at 8.4 GHz and 22 GHz
- ★ 40 initial sources observed, adding up to 80 new ones
- ★ Observations started in November 2007 with the Australian Long Baseline Array and some additional antennas
- ★ TANAMI is monitoring about 90 jets including many sources found by Fermi to be flaring at gamma-rays

http://pulsar.sternwarte.uni-erlangen.de/tanami/

Using Data Archives

- Categories:
  - Publication archive (ADS, Arxiv)
  - Data interface (Simbad , NED)
  - DATA archives (Observatories, Virtual Observatory)

- If you know which data you need, go directly to the facility portal (see next slide)

- One step above: use the **Virtual Observatory**

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Portal | Simbad | VizieR | Aladin | X-Match | Other | Help

VizieR Result Page

Send to VO tools

Show the target form
Show constraint information

The 1 column in *color* are computed by VizieR, and are *not part of the original data*.

Note: *The column **FIRST** provides a link to the FIRST cutout image server (see also the original FIRST search engine)*

VIII/92/first14 The FIRST Survey Catalog, Version 2014Dec17 (Helfand+ 2015) 2015ApJ...801...26H ReadMe+ftp
Post annotation The FIRST survey catalog, 14Dec17 Version *(946432 rows)*

start AladinLite | plot the output | query using TAP/SQL

Search Criteria
Save in CDSportal
Keywords: Back
VIII/92
Tables: Add
VIII/92
..first14
Choose
Constraints
Modify Query

Preferences
max: 100
HTML Table
All columns
Compute
Submit

Mirrors
CDS, France

Full	FIRST	FITS	RAJ2000 "h:m:s"	DEJ2000 "d:m:s"	p(S)	Epeak mJy	Fint mJy	Rms mJy	Maj arcsec	Min arcsec	PA deg	N1	c1	N2	Ep yr	Ep(JD) d	s_ d
1	J072734.2+644059	FITS	07 27 34.289	+64 40 59.80	0.197	1.00	1.12	0.139	2.13	1.58	0.2			1	2002.687	2452526.1	0.002
2	J073839.3+644016	FITS	07 38 39.304	+64 40 16.28	0.014	2.39	5.73	0.139	9.31	3.58	136.6			0	2002.687	2452526.1	0.001
3	J075024.0+644001	FITS	07 50 24.019	+64 40 01.21	0.014	22.09	24.00	0.140	1.96	1.13	6.8			0	2002.687	2452526.1	0.002
4	J073845.6+643950	FITS	07 38 45.622	+64 39 50.12	0.014	2.39	4.33	0.140	6.43	3.27	13.5			0	2002.687	2452526.1	0.000
5	J073932.7+643918	FITS	07 39 32.799	+64 39 18.03	0.082	1.41	1.25	0.139	2.63	0.00	37.5			0	2002.687	2452526.1	0.002
6	J075135.5+643856	FITS	07 51 35.553	+64 38 56.29	0.016	2.24	2.01	0.138	0.00	0.00	27.5			0	2002.687	2452526.1	0.002
7	J075032.2+643847	FITS	07 50 32.291	+64 38 47.49	0.016	1.36	1.07	0.137	1.50	0.00	19.2			0	2002.687	2452526.1	0.002
8	J071958.3+643836	FITS	07 19 58.390	+64 38 36.15	0.014	2.94	3.17	0.148	3.08	0.00	147.8			0	2002.687	2452526.1	0.005
9	J070143.5+643833	FITS	07 01 43.536	+64 38 33.30	0.014	1.69	1.57	0.149	1.45	0.00	133.8	1	g	0	2002.687	2452526.1	0.005
10	J074347.7+643814	FITS	07 43 47.715	+64 38 14.61	0.014	7.85	7.40	0.146	0.00	0.00	14.0			0	2002.687	2452526.1	0.003
11	J065619.9+643811	FITS	06 56 19.957	+64 38 11.32	0.014	4.33	5.45	0.137	3.31	2.08	50.1	1	g	0	2002.687	2452526.1	0.004
12	J074420.8+643748	FITS	07 44 20.828	+64 37 48.16	0.014	5.17	6.08	0.135	2.36	2.19	87.8			0	2002.687	2452526.1	0.002
13	J074419.7+643744	FITS	07 44 19.743	+64 37 44.66	0.014	9.83	10.29	0.135	1.78	0.00	26.5			0	2002.687	2452526.1	0.002
14	J071929.0+643742	FITS	07 19 29.010	+64 37 42.70	0.014	2.53	5.26	0.160	6.86	4.36	31.4			0	2002.687	2452526.1	0.006
15	J070239.6+643740	FITS	07 02 39.698	+64 37 40.12	0.072	1.03	1.51	0.134	4.83	2.38	14.2	0		0	2002.687	2452526.1	0.003
16	J071926.3+643731	FITS	07 19 26.377	+64 37 31.88	0.014	2.12	3.88	0.160	7.40	2.19	16.4			0	2002.687	2452526.1	0.007
17	J071926.3+643723	FITS	07 19 26.339	+64 37 23.64	0.014	1.88	2.50	0.160	4.60	0.76	28.6			0	2002.687	2452526.1	0.007
18	J074354.5+643722	FITS	07 43 54.567	+64 37 22.54	0.190	1.08	1.22	0.142	3.44	0.00	148.8			0	2002.687	2452526.1	0.003
19	J073144.1+643715	FITS	07 31 44.119	+64 37 15.48	0.014	1.99	1.78	0.146	0.00	0.00	125.3			0	2002.687	2452526.1	0.006
20	J074023.0+643702	FITS	07 40 23.029	+64 37 02.10	0.014	8.97	13.19	0.152	5.59	1.13	16.3			0	2002.687	2452526.1	0.004
21	J074022.9+643650	FITS	07 40 22.990	+64 36 50.99	0.014	2.91	3.87	0.151	4.28	1.55	155.5			0	2002.687	2452526.1	0.004
22	J071508.3+643642	FITS	07 15 08.357	+64 36 42.87	0.014	1.32	2.96	0.140	6.85	5.20	52.0			0	2002.687	2452526.1	0.002
23	J071426.9+643603	FITS	07 14 26.966	+64 36 03.19	0.014	1.95	2.92	0.141	6.35	0.00	161.7			0	2002.687	2452526.1	0.004

SIMBAD Astronomical Database

15-Oct-2015: CDS is releasing SimWatch, a tool allowing you to follow changes on SIMBAD objects.
Register to SimWatch to be notified when new papers are attached to your favourite SIMBAD objects.

Queries
basic search
by identifier
by coordinates
by criteria
reference query
scripts
TAP queries
options
Display all user annotations

Documentation
User's guide
Query by urls
Nomenclature Dictionary
Object types
List of journals
Measurement description
Spectral type coding
User annotations documentation

Information
Presentation
Acknowledgment
SimWatch
Release:
SIMBAD4 1.4 - Dec-2015
Release history

Content
The SIMBAD astronomical database provides basic data, cross-identifications, bibliography and measurements for astronomical objects outside the solar system.
SIMBAD can be queried by object name, coordinates and various criteria. Lists of objects and scripts can be submitted.
Links to some other on-line services are also provided.

Basic search

identifier, coordinates (radius=10 arcmin), or bibcode

SIMBAD search | clear | help

Install the Simbad basic search in your tool bar

NED

News & Featured Updates - February 2016

- 43,411 new object links to 1,207 references
- NED-D surpasses 100,000 redshift-independent distances
- Hundreds of new images and spectra
- Latest articles in Level 5

Try our next-generation user interface, which features a Simple Search box on the main screen. Results from searching Objects and Unprocessed Catalog Sources and Source Nomenclature now have improved table formatting, with options to change the number of rows per page, to sort on selected columns, and to search all columns.

OBJECTS	DATA	LITERATURE	TOOLS	INFO
By Name	Images by Object Name Region	References by Object Name	Coordinate Transformation & Extinction Calculator	Introduction Latest News/Updates
Near Name	Photometry & SEDs	References by Author Name	Velocity Calculator	Features FAQ
Near Position	Spectra	Text Search	Cosmology Calculators	Brochure (pdf) Best Practices (pdf)
IAU Format	Redshifts	Knowledgebase LEVEL 5	Extinction-Law Calculators	Source Nomenclature
By Parameters	Redshift-Independent Distances	Galaxy Distance Tabulations (NED-D)	Galaxy Environment by Precomputed Parameters Radial Velocity Constraint	Web Links New Interface
By Classifications *Types, Attributes*	Classifications by Object Name	Abstracts	X/Y offset to RA/DEC	Glossary & Lexicon
By Refcode	Positions	Thesis Abstracts	Batch Help	Team
Object Notes	Diameters		Build Data Table from Input List By Name Near Name/Position (Cross-Matching)	Contact Us or Comment

NASA JPL Caltech ipac

Surveys Cross Identification

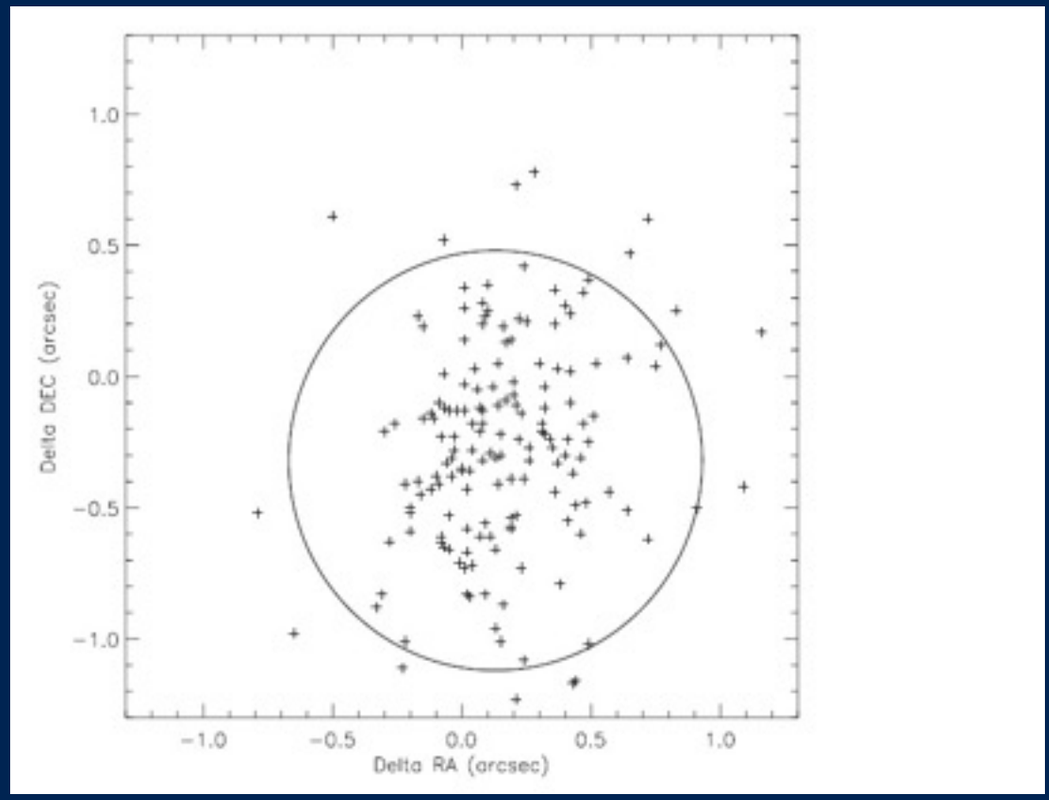
- Matching radio sources to other wavelength is key to understanding the radio population. Optical observations can provide redshifts and reveal crucial properties of the host galaxy

But

- How to determine which sources are associated with one another and which are unrelated?

Two popular method to match radio sources:

- Simple Nearest Neighbour
- The Likelihood Ratio



Oops forget one more Survey !

SETI: The Search for extraterrestrial Intelligent Life

- Proposed ~ 1960: use radio/microwave frequencies to listen for signals from extraterrestrial civilisations, or send signals for them to receive!

- Jury's still out...

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