Data Archives and Radio Surveys

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Multiwavelength Summer School

Layout

- Surveys and Radio Surveys
  - What is available – blind and targeted surveys
- Data Archives
  - How do you use them?
  - Virtual Observatory
  - Example case

Surveys

- Survey (noun): *1. a detailed examination or investigation, e.g., to find out public opinion or customer preference*

- For us: Astronomical Survey: *Study of regions of the sky using telescopes for imaging or mapping those* ⇨ **Astronomical Catalogs**

Surveys

- High-Energies
  - RASS
- Optical
  - Palomar
  - Digitized Sky Survey
  - Sloan Digital Sky Survey
  - …
- Infra-Red
  - IRAS
  - 2-micron All-Sky Survey
  - Akari Survey
- Radio
  - NVSS
  - WENSS
  - CLASS
  - Ohio Sky Survey
  - …
- Multi-Wavelength
  - GOODS
  - COSMOS
  - …

Radio Surveys: History

- Optical astronomers have their catalogs since ages
  - Uranometria, Johann Bayer (1603)
  - Star Atlas, Flamsteed (1725)
  - Messier Catalog (1781): Mnnn
  - Bonner Durchmusterung ()
  - New General Catalogue (1880s): NGCnnnn
  - Henry Draper Catalogue (1918-1924): HDnnnnnn
  - Uppsala General Catalogue (1973), UGCnnnnn
  - Hipparcos Catalogue (1997) …
- Radio Astronomy was born in the 1930s
- First images were performed by Grote Reber
- Construction of the first large telescopes. First surveys performed:
  - Cambridge (2C, 3C, 4C)
  - Parkes Telescope (PKSnnnn−nnn)
  - NRAO 300-ft Telescope (NRAOnnn)
- Advances in sensitivity, data acquisition, more specifical surveys

Ingredients of the radio sky

- Galactic continuum radiation
  - Magnetic field and cosmic rays: synchrotron ($\alpha = -0.55$)
- Interstellar medium
  - Spectral lines: Neutral H (HI) at $\lambda 21$ cm, ionized H (HII), rotational and vibrational lines for another molecules (O_2, N_2, CH_4, CO_2, etc.)
  - Supernova remnants: synchrotron
- Stars
  - Circumstellar masers (SiO, H_2O, OH)
  - Novae
  - Binaries and flare stars (recurrent novae, X-ray binaries): non-thermal
- Pulsars
  - Neutron stars emitting coherent radiation with $\alpha = -2 \pm 1$
- Radio galaxies and quasars
  - Radio galaxy lobes: synchrotron
  - AGN cores: synchrotron, flat spectrum (parts self-absorbed)
- Cosmic microwave background
  - Thermal radiation from the Big Bang

The sky at 1.4 GHz at 45" resolution

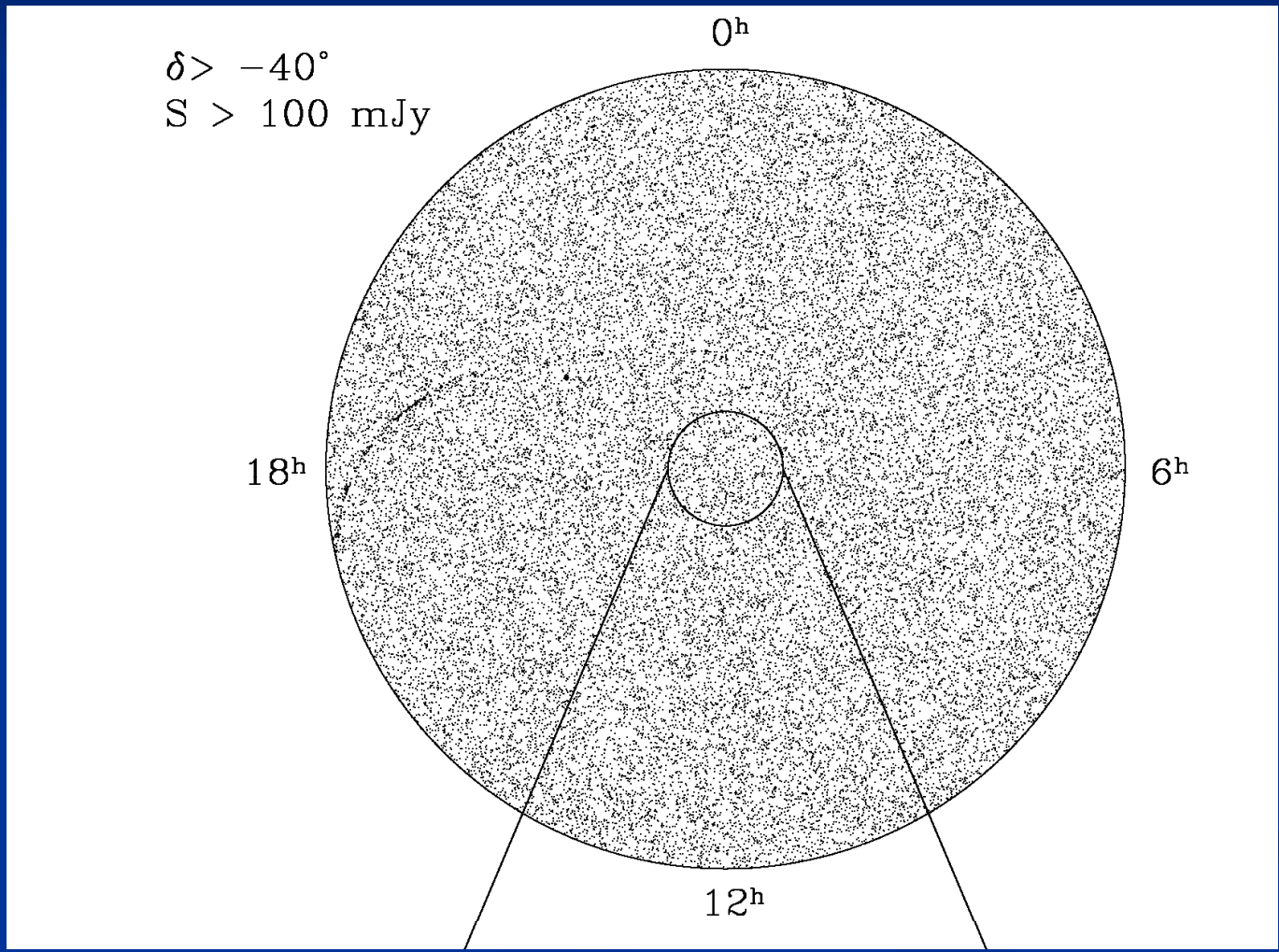


Image: Condon et al.

The sky at 1.4 GHz at 45” resolution

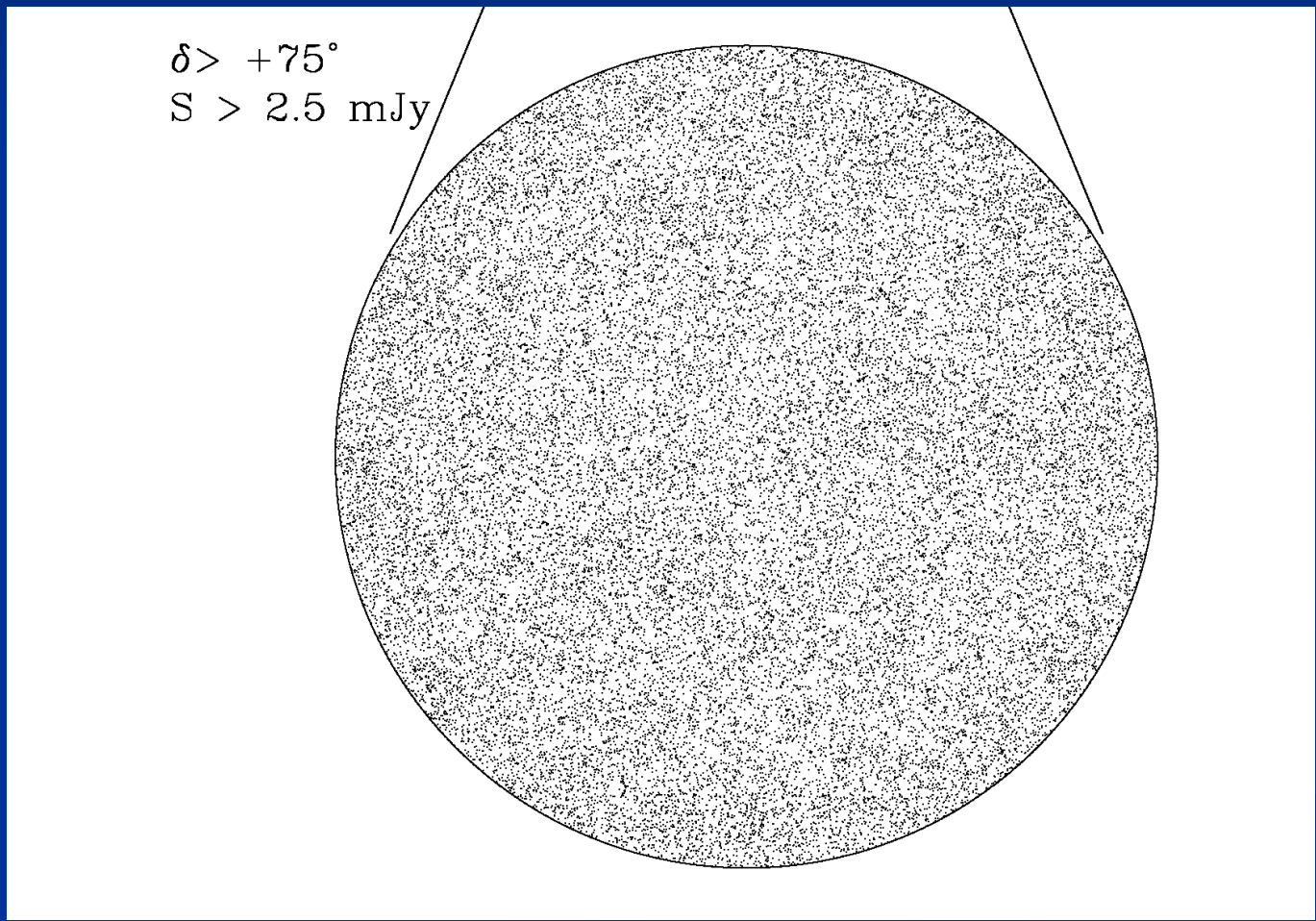
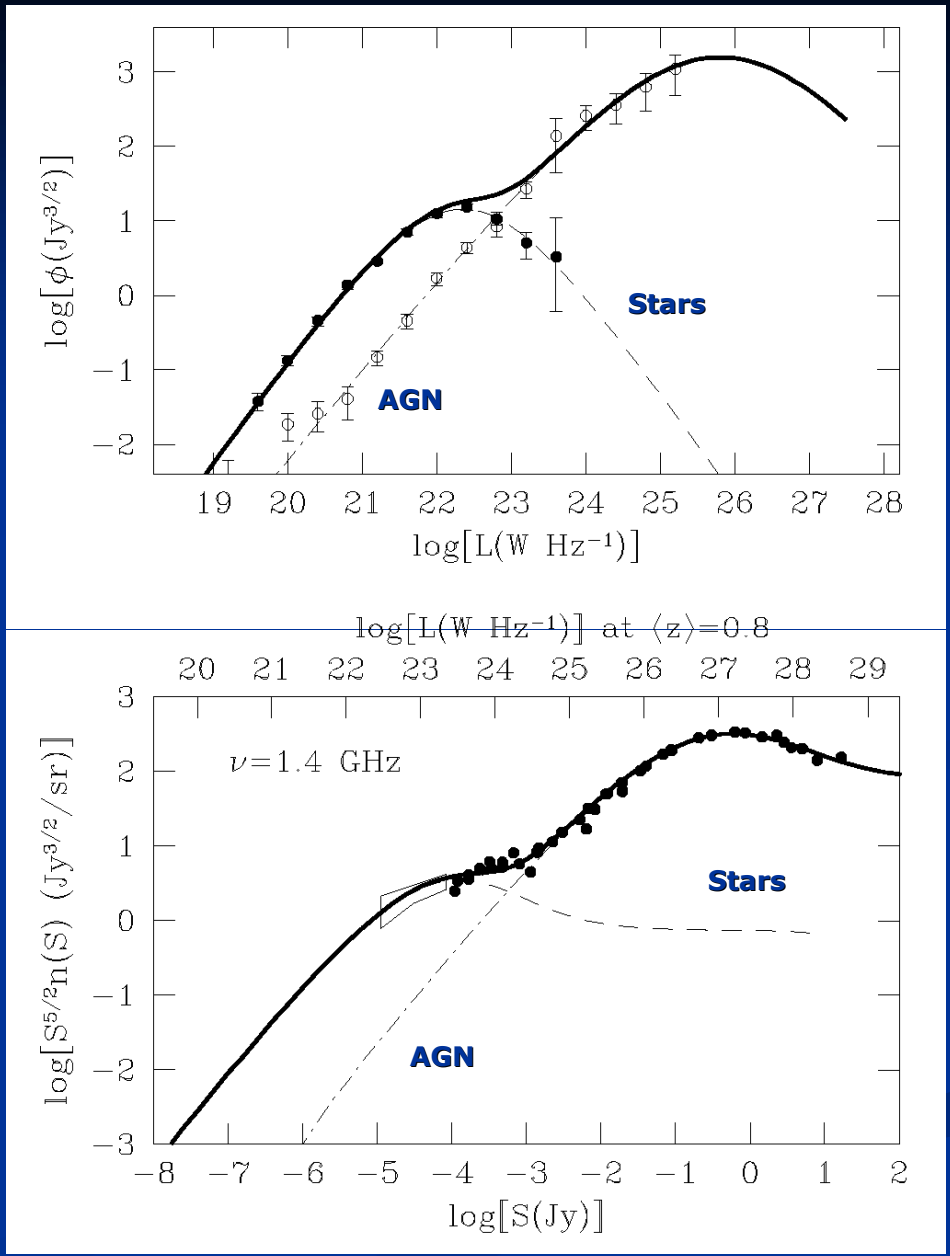


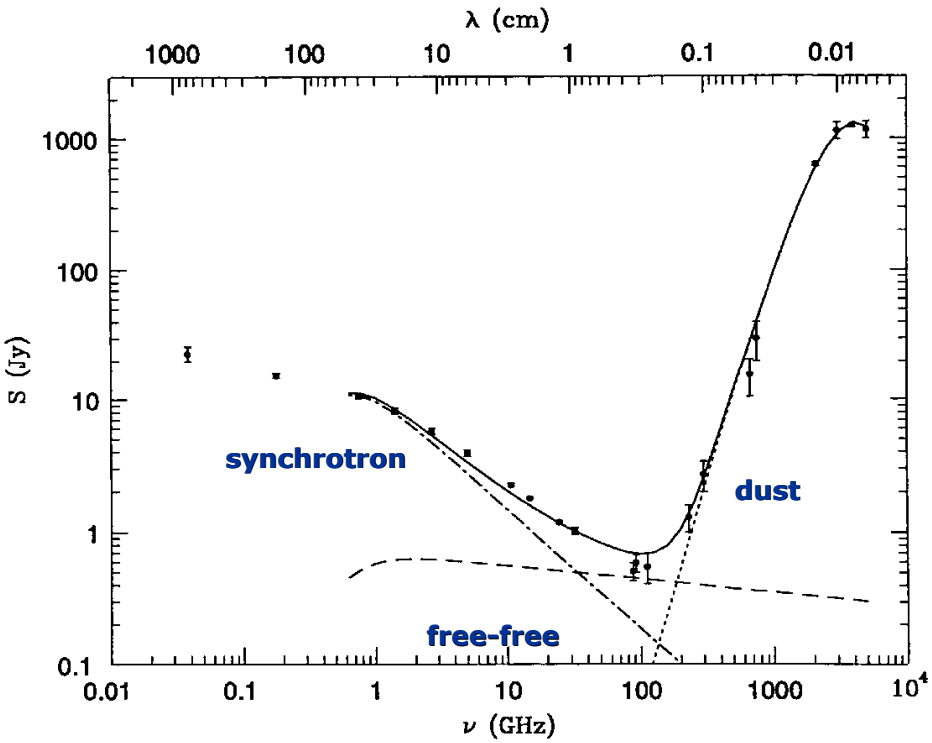
Image: Condon et al.

Flux density versus luminosity of radio sources

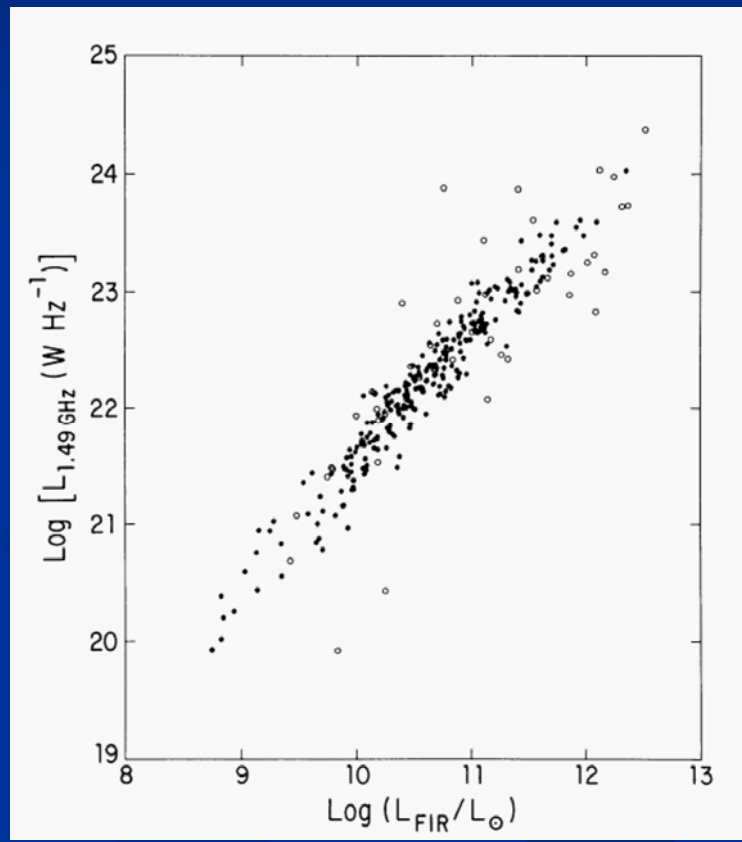
- Evolution 10× in luminosity → few nearby sources, <z> ~ 1 (cosmic downsizing)
- "shell" → $L \propto S$
- AGNs at high L, S
- Star-forming galaxies at low L, S



Low Luminosity: Star-forming Galaxies



M 82 spectrum



Condon et al.

FIR/Radio Correlation for Starburst Galaxies

Classes of Radio Surveys

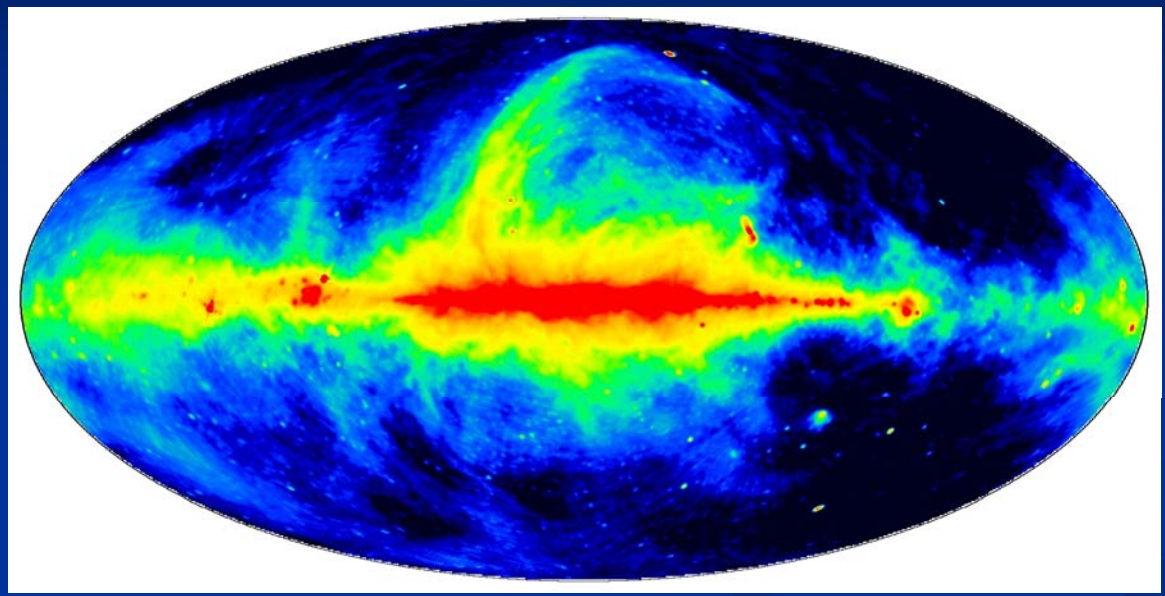
- Blind Surveys:
  - (parts of) all-sky surveys like NVSS, WENSS, etc.
- Targeted surveys:
  - deep surveys (ATLAS, CDF)
  - imaging of celestial fauna (HI)
  - most VLBI surveys (CJF, 2cmS/MOJAVE, TANAMI)

Toys

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)

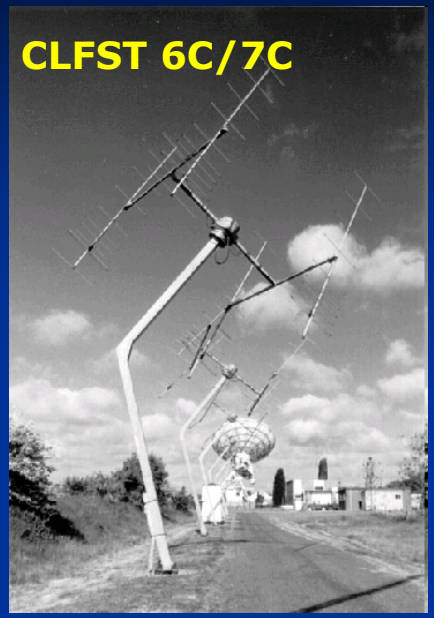
Bonn 408 MHz Survey

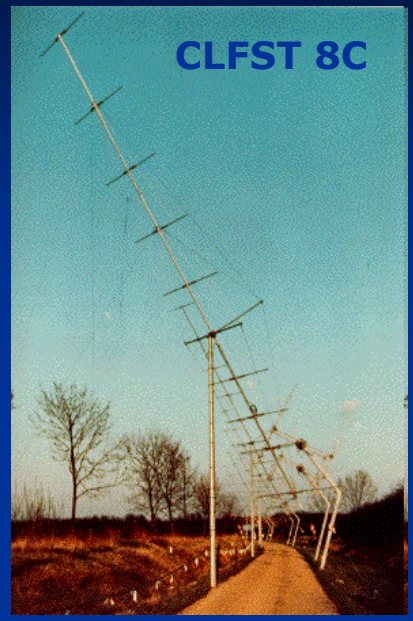


- Haslam et al. 1974; Jodrell Bank 250-ft + Effelsberg 100-m + Parkes 64-m
- "Classical" picture

http://www.mpifr-bonn.mpg.de/survey.html

The newer Cambridge Surveys





6C	151 MHz	0.3 Jy	4.2′ ×4.2′ cosec δ	2.8 Sr	Hales et al. 1993
7C	151 MHz	0.15 Jy	70″ × 70″ cosec δ	4 Sr	Visser et al. 1996
8C	38 MHz	1 Jy	4.5′ ×4.5′ cosec δ	0.8 Sr	Rees 1990
9C	15 GHz	0.01 Jy		0.15 Sr	Waldram et al. 2003

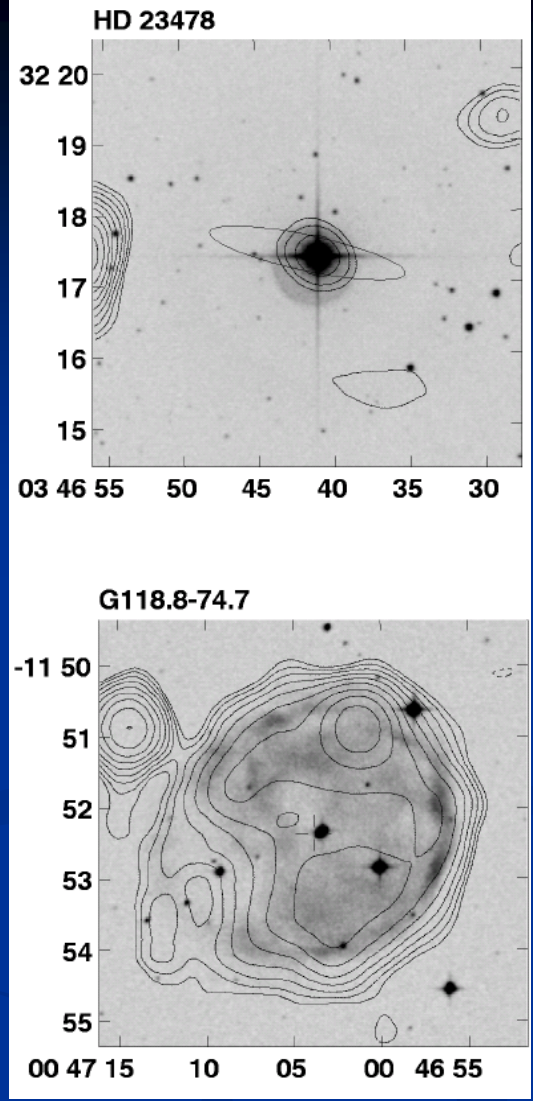
Main Blind Surveys of the Nearby Universe

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

- Low redshift surveys
- For distant sources, new instruments are needed to get the whole sky population (EVLA, SKA)
- Low freq. observations are biased towards

NVSS
NRAO VLA Sky Survey

- Entire sky north of −40°, at 45” resolution and 2.5 mJy/beam limit.
- 2326 4° × 4° continuum cubes (Stokes I, Q, V) and 1.8 Mio discrete sources
- Most used and complete sky survey



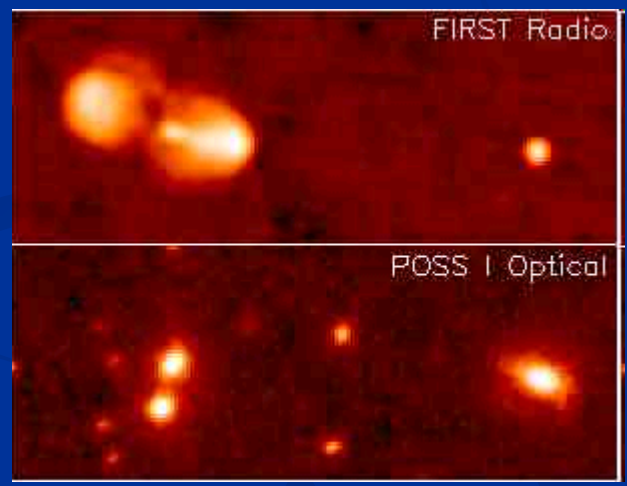
Example of postage-stamp images (NVSS contour, DSS grey) Condon et al. 1998

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

FIRST

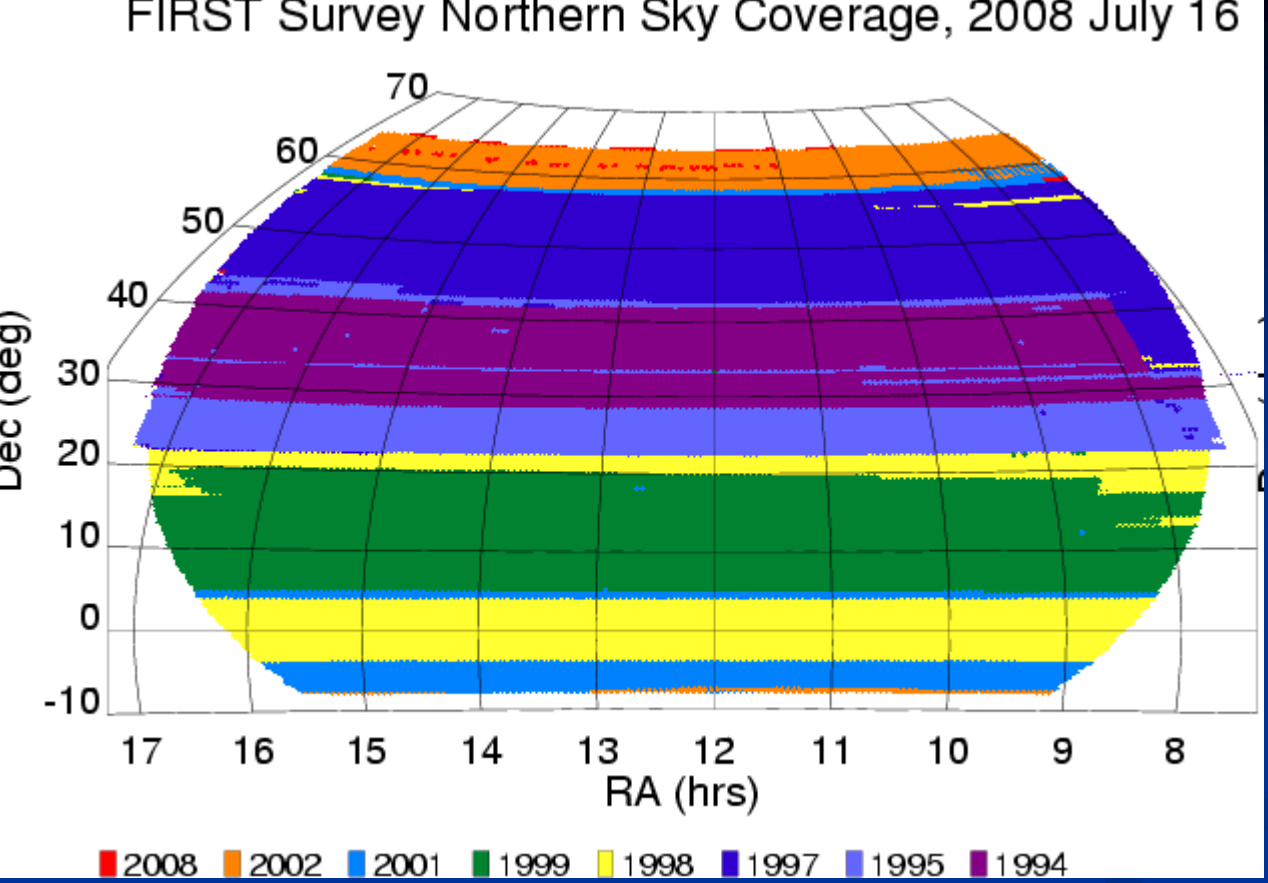
Faint Images of the Radio Sky at Twenty-cm

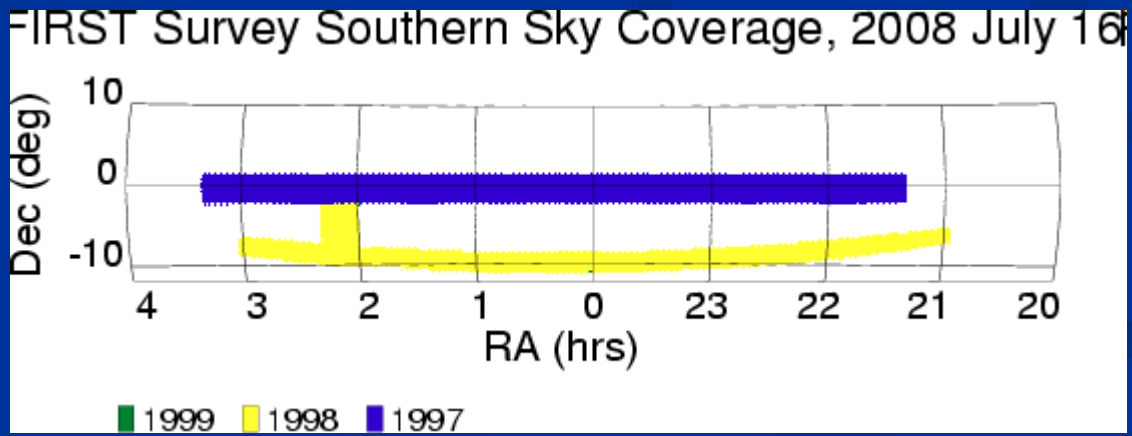
- High resolution (5”) of the north Galactic cap at 1400 MHz, above 1 mJy/beam
- 816000 sources
- Extension to South



http://sundog.stsci.edu/top.html

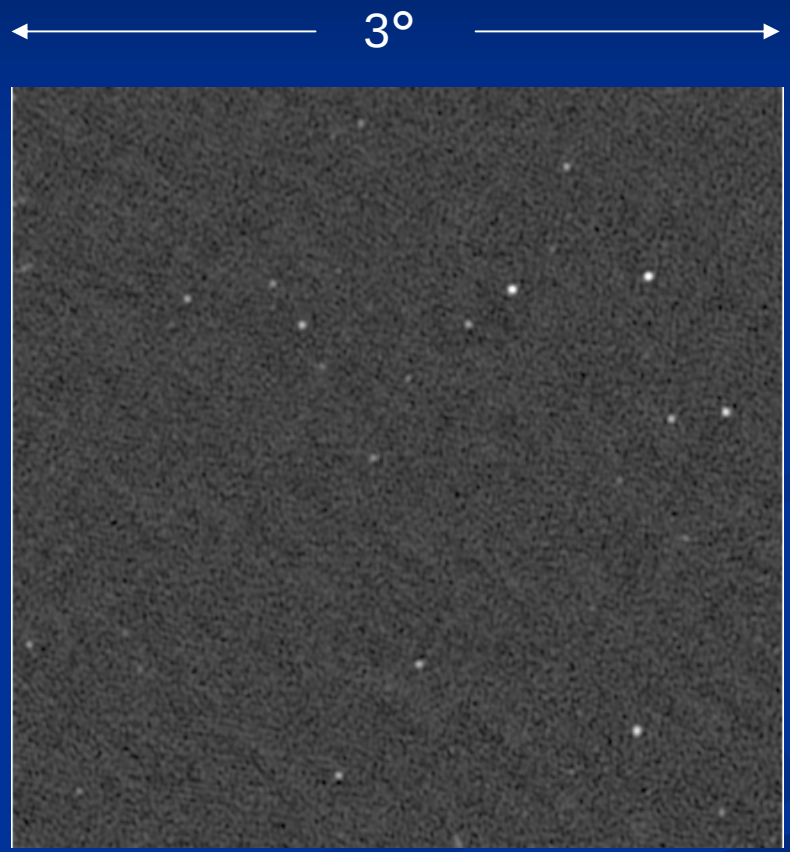
FIRST Sky Coverage





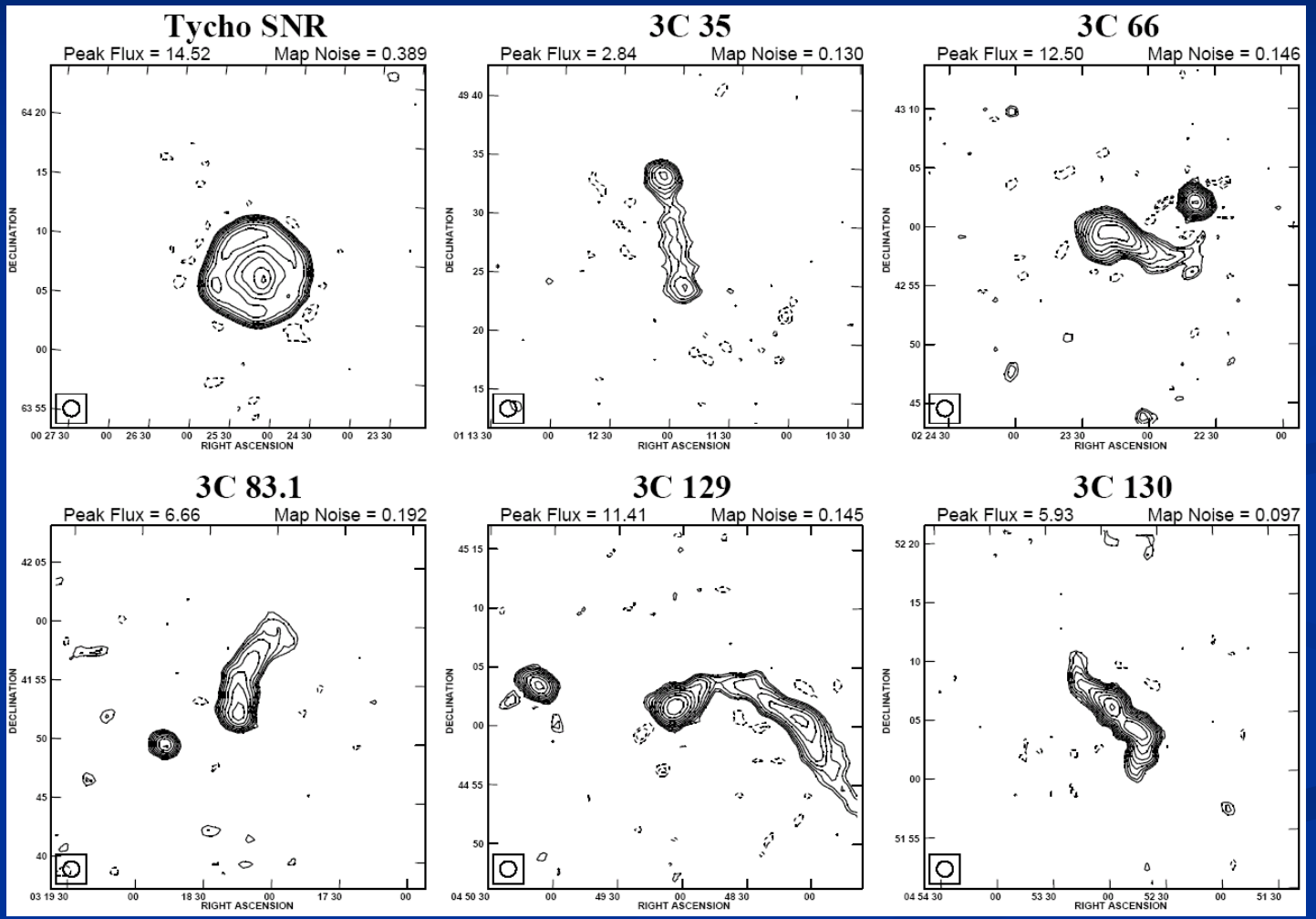
VLSS
VLA Low-Frequency Sky Survey

- Formerly known as 4MASS
- 74 MHz (λ4m), 80″ resolution, 0.1 Jy/beam noise
- 70000 sources
- Special analysis needed due to ionosphere; sidelobe confusion



http://lwa.nrl.navy.mil/VLSS/

VLSS Sample Images

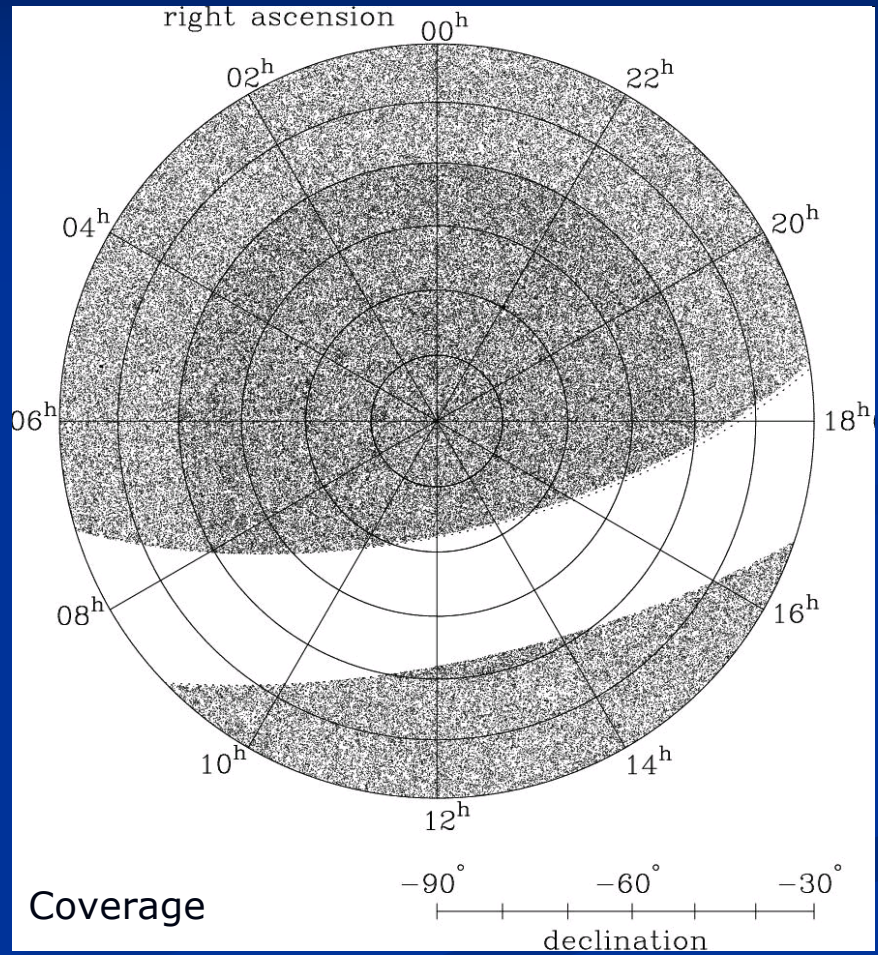


Cohen et al. 2007, AJ, 134, 1245-1262

SUMSS

Sidney University Molonglo Sky Survey

- Southern sky below −30° and |b|>10°, 843 MHz
  - complemented by MGPS-2 at the galactic plane (Murphy et al. 2007, MNRAS, 382, 382)
- Similar to NVSS in resolution and sensitivity
- 211000 sources

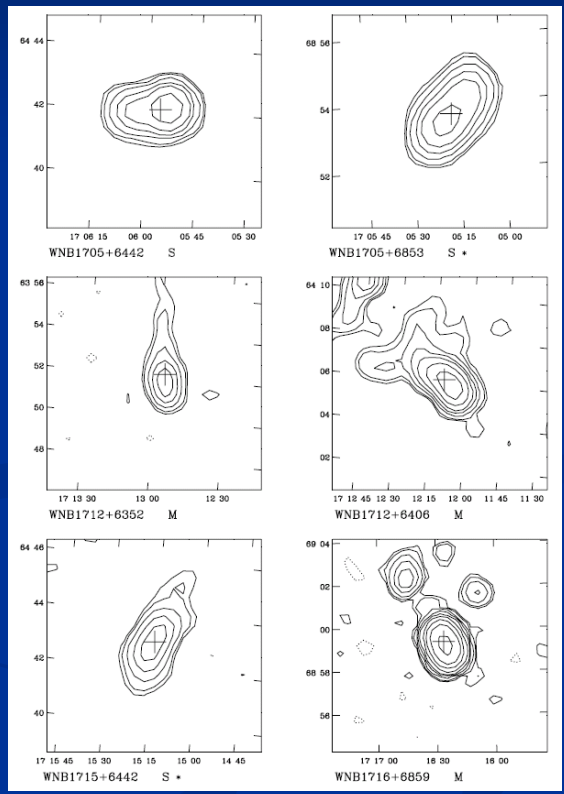


Updated from Mauch et al. 2003, MNRAS, 342, 1117

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

WENSS
Westerbork Northern Sky Survey

- Northern sky, δ > +30°, 326 MHz, (54” × 54” / sin δ) resolution, 230000 sources stronger than 18 mJy
- Extended to the South (WISH)



Extended sources
Rengelink et al. 1997

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

WISH

Westerbork in the Southern Hemisphere survey

- Extension of WENSS to the South, $-26° < \delta < -9°$, $|b| > 10°$, resolution of $(54'' \times 54''/ \sin \delta)$, flux density limit at 18 mJy

http://www.astron.nl/wow/testcode.php?survey=2

Targeted Surveys

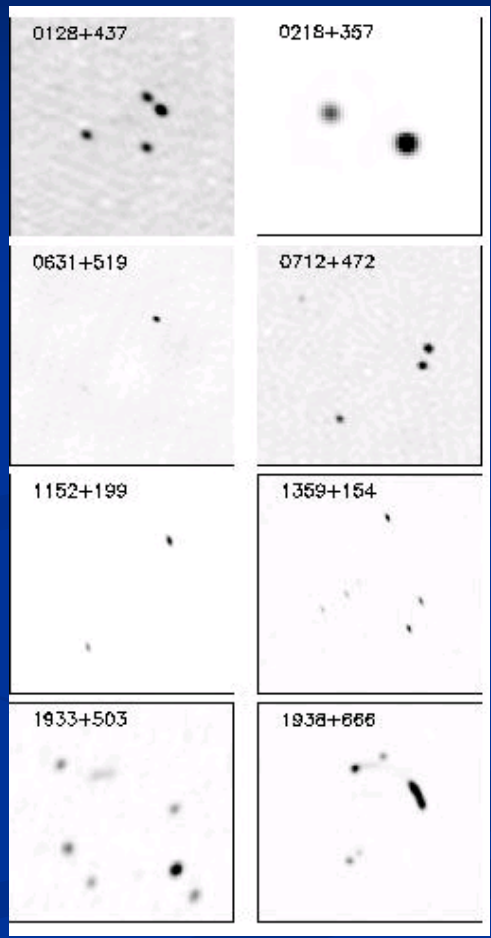
- Deep field surveys: commonly with a multi-band approach
- Stamp collection (and movie making): VLBI monitoring surveys, HI images, polarisation

- Examples…

CLASS

Cosmic Lens All-Sky Survey

- 11000 VLA snapshots at 8.4 GHz of sources with flat radio spectra ($\alpha_{(1.4\text{-}5)\ GHz} > -0.5$) and S > 30 mJy at 5 GHz; resolution of 0.2”
- Sources checked for evidence of grav. lensing (22 were found)
- Extension of JVAS (1992)
- Follow-up observations with MERLIN and the VLBA

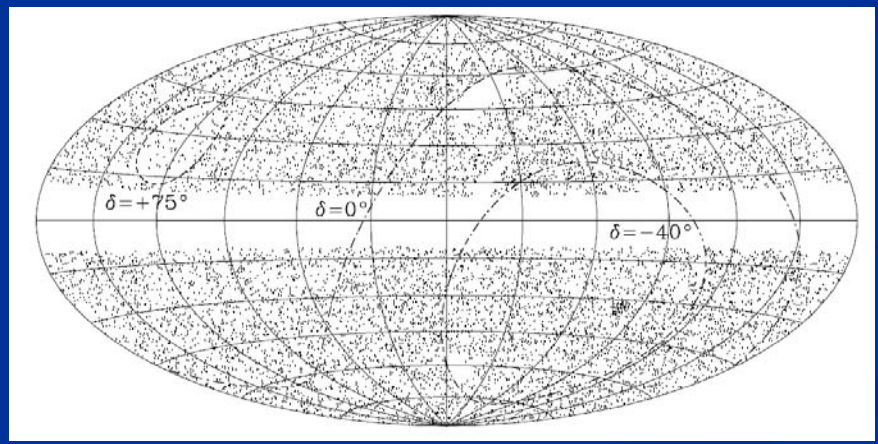


MERLIN images of CLASS sources

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

CRATES
Flat Spectrum Radio Source Catalog

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



Healey et al. 2007

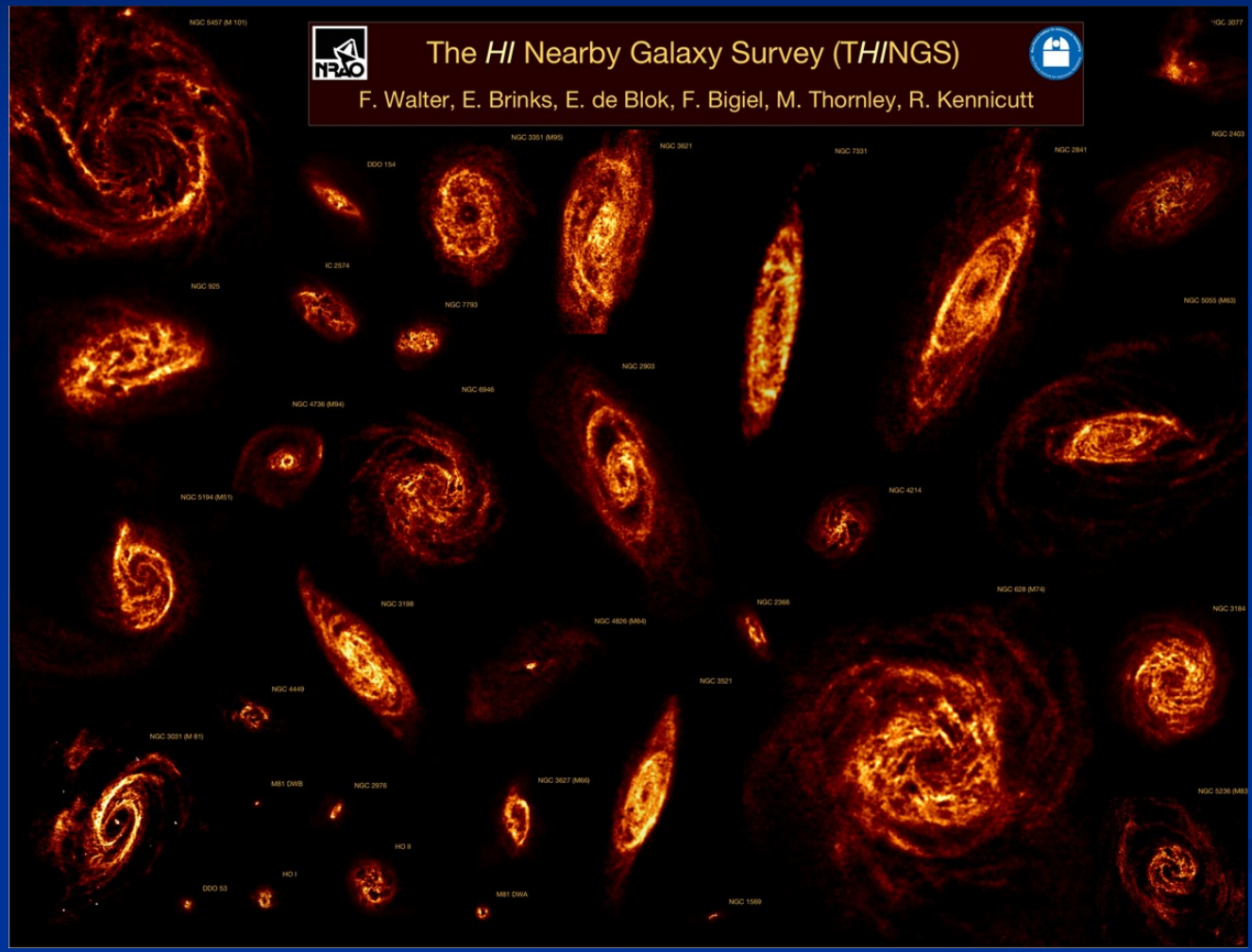
http://astro.stanford.edu/CRATES/

VLA-COSMOS
Cosmic Evolution Survey with the HST

- COSMOS field: X-ray to mm survey including VLA observations:
  - 1.5” resolution, 10 μJy, 1.4 GHz
  - 2 square degree deep field
  - 3500 sources

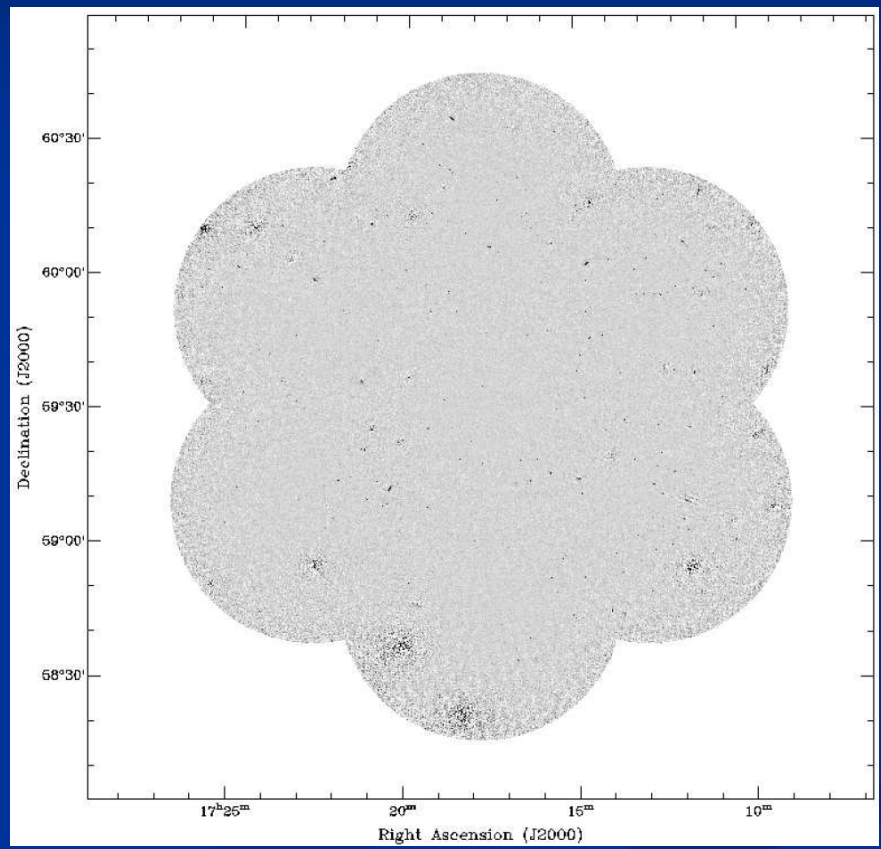
http://www.mpia-hd.mpg.de/COSMOS/

THINGS
The HI Nearby Galaxy Survey



Spitzer Extragalactic first-look Survey

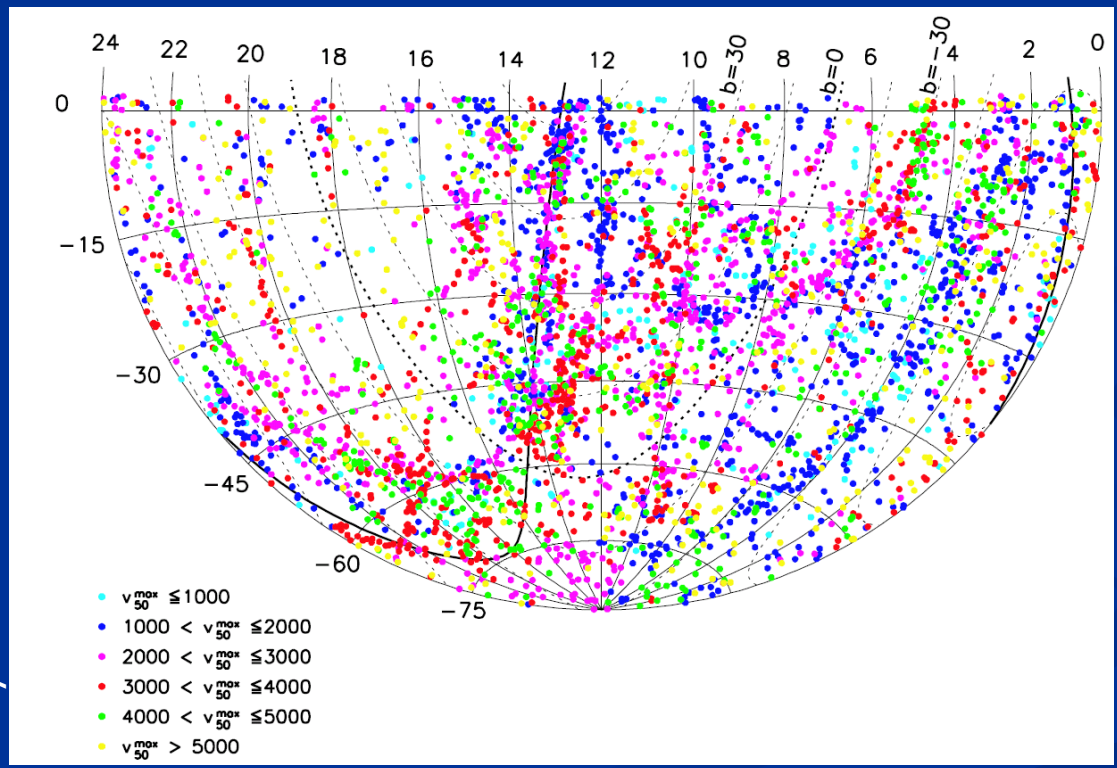
- GMRT 610-MHz observations
- 4 sq. deg, 5.8″ × 4.7″ resolution at P.A. 60°, 30 μJy rms noise
- 3944 sources



http://www.mrao.cam.ac.uk/surveys/GMRT/FLS/

HIPASS
HI Parkes Archive Sky Survey

- Neutral Hidrogen survey in the South



Meyer et al. 2002

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

VLBI Surveys

- Designed to provide milliarcsecond 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)

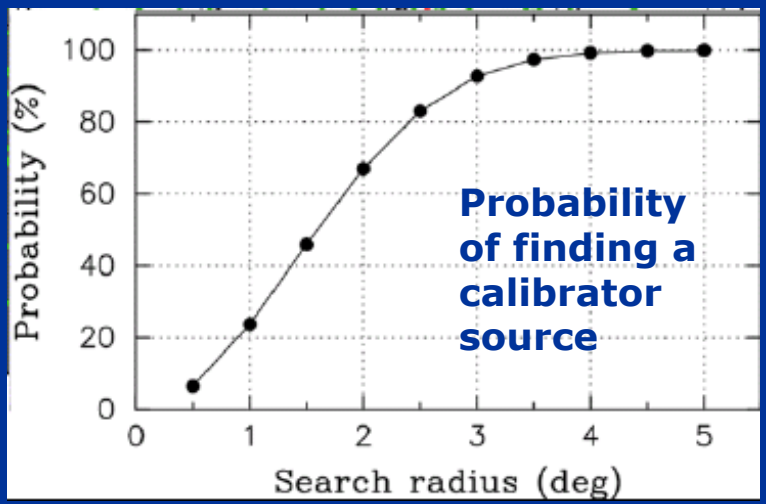
VLBI Surveys

CJF	18/6 cm	293	Complete	Pollack et al. 2003
ICRF/RDV	13/3.6 cm	~500		Ojha et al. 2004
VLBA Cal. Surv.	13/3.6 cm	>3400	Open, complete	Kovalev et al. 2007
VSOP/VLBA	6 cm	374		Fomalont et al. 2000
VSOP Survey	6 cm	~300		Dodson et al. 2008
VIPS	6 cm	1127	Open	Helmboldt et al. 2007
2 cm Survey	2 cm	250	Open, complete	Kellermann et al. 1998
MOJAVE	2 cm	≥133	Open, complete	Lister et al. 2009
VERA FSS / GaPS	1.35 cm	>500		Petrov et al. 2007
ICRFext	1.35 / 0.7 cm	~100		Lanyi et al. 2005
GMVA	3 mm	123		Lee et al. 2008

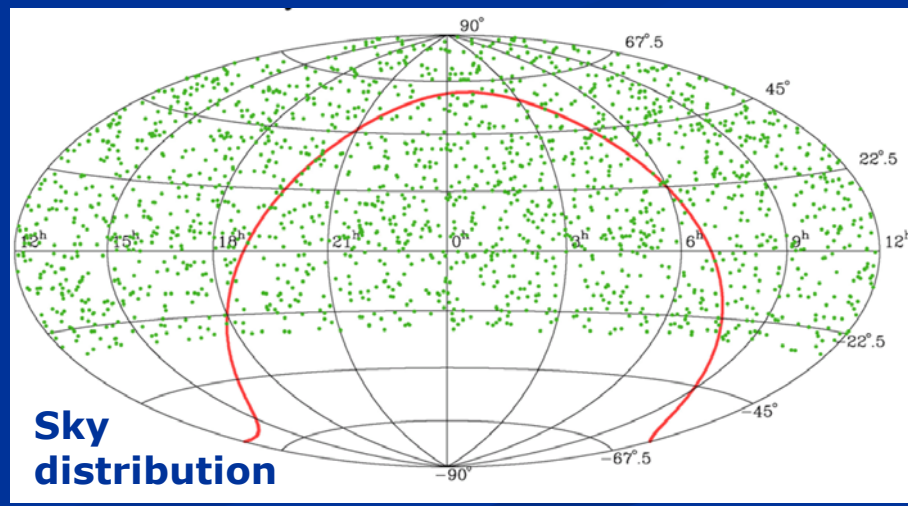
List compiled by Y.Y.Kovalev (2008)

VCS
NRAO VLBA Calibrator Source Survey

- Sample of compact radio sources in the Northern sky
- Needed for astrometrical, geodetical and astrophysical applications



Kovalev et al.



http://astrogeo.org/vcs/

VIPS

The VLBA Imaging and Polarimetry Survey

- 5 GHz and 15 GHz imaging of 1100 AGN with the VLBA
- Parent sample: CLASS crossed with SDSS
- One-epoch survey, paving the way to Fermi observations

(Taylor et al. 2007, ApJ 658, 203)

http://www.phys.unm.edu/~gbtaylor/VIPS/

2cm Survey / MOJAVE

- Study of over 200 sources at 15 GHz with the VLBA at 1-mas resolution
- Database collected since 1994
- Data on the brightest radio AGN in the Northern sky available in the web
  - Images, visibility data, movies
  - Radio flux densities and spectra
  - Kinematics plots

See Lister et al. 2009

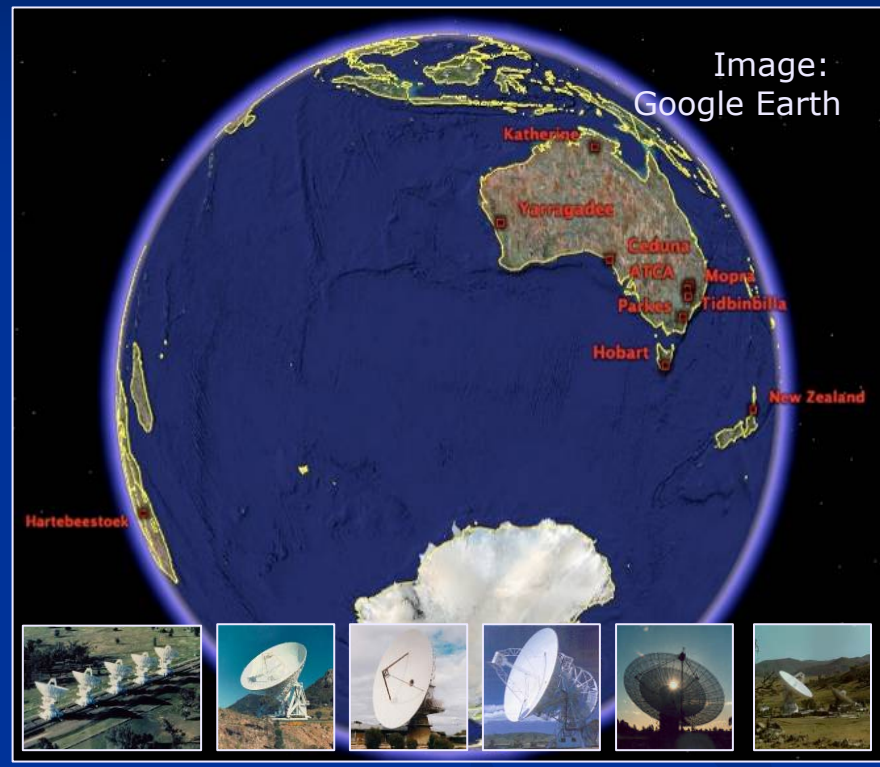
http://www.physics.purdue.edu/MOJAVE/

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

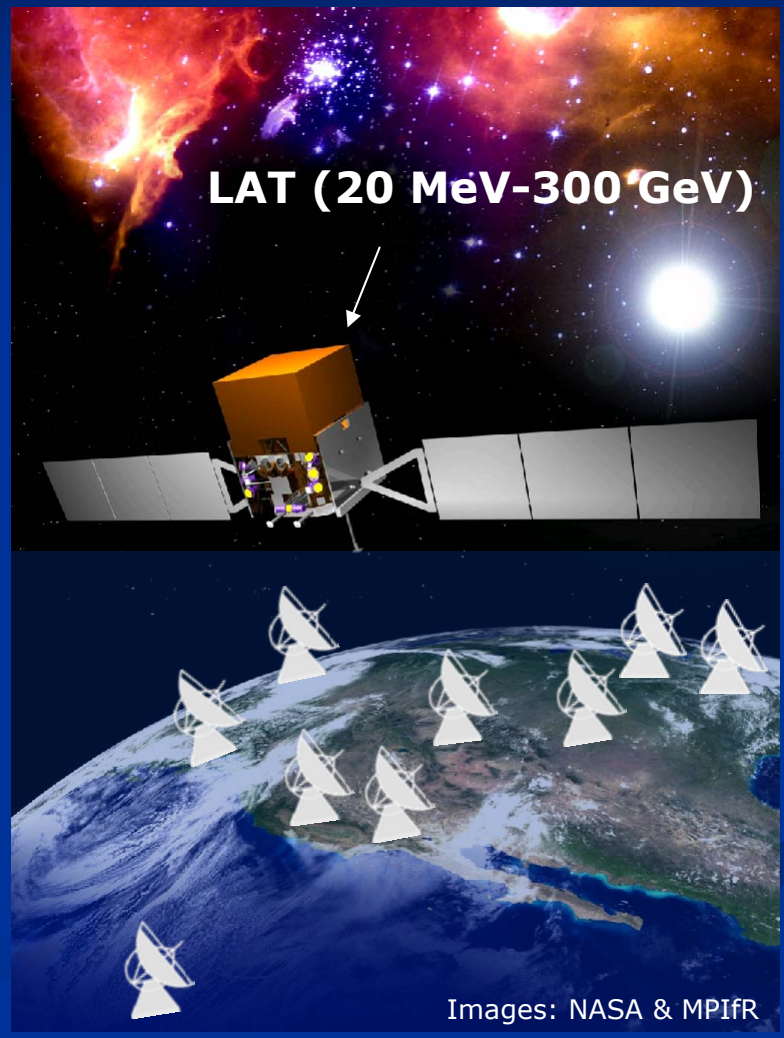
(Ojha et al. 2009, A&A submitted)



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

VLBI Surveys in the Fermi era

- AGN nature, compact jet emission
- Cross-correlation: compactness/ variability/ viewing angle vs. γ-ray emission
- Relating the γ-ray flares (detection, light curves) with the feature ejection in AGN jets
- See Lister et al. (2009), Kovalev et al. (2009), Savolainen et al. (in preparation)



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

Direct data archives

- EVN
  - http://archive.jive.nl/scripts/listarch.php
  - http://db.ira.inaf.it/evn/
- VLBA
  - http://vlba.nrao.edu/astro/archive
- MERLIN
  - http://www.merlin.ac.uk/archive
- VLA
  - http://www.vla.nrao.edu/astro/#D9
- GMRT
  - http://neptune.gmrt.ncra.tifr.res.in/obsastro/
- WSRT
  - http://www.astron.nl/p/WSRT4.htm
- ATCA
  - http://atoa.atnf.csiro.au/
- IRAM
  - http://iram.fr/IRAMFR/PDB/arch.html

SIMBAD

- Astronomical database providing
  - Basic data
  - Cross-identifications
  - Bibliography
  - Measurements
- Web interface and batch mode possible
- Linked to VizieR (Catalogue Service) and Aladin (Sky Atlas Viewer)
- All objects outside the Solar System

http://simbad.u-strasbg.fr/

SIMBAD

SIMBAD Astronomical Database

Queries
basic search
by identifier
by coordinates
by criteria
reference query
scripts

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

Information
Presentation
Release history
Acknowledgment
Release:
SIMBAD4 1.123 - 25-May-2009

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.

Statistics	
Simbad contains on *2009.06.18*	
4,602,519	objects
13,124,663	identifiers
232,322	bibliographic references
6,538,203	citations of objects in papers

Acknowledgment
If the Simbad database was helpful for your research work, the following acknowledgment would be appreciated:
This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France

Basic search
identifier, coordinates (radius=10 arcmin), or bibcode
SIMBAD search clear help
Install the Simbad basic search in your tool bar

SIMBAD query

Simbad | VizieR | Aladin | Catalogs | Dictionary | Biblio | Tutorials | Developers

SIMBAD: Query by identifiers

other query modes : Identifier query | Coordinate query | Criteria query | Bibliography query | Basic query | Script submission | Output options | Help

Query an identifier

Identifier :

Examples
sirius, M31, MCG+02-60-010
How to write an identifier can be found in the dictionary of nomenclature
IAU format can also be used, with the following format:
`iau [J|B]1230+08 [* enlarging-factor ] [= Object-type ]`

you can choose to query : only this object

around the object, define a radius : 2 arc min

submit id | clear

Query a list of identifiers

Enter the name of an ASCII file produced by a text editor containing one identifier per line:

Choose File No file chosen

list display | full display

submit file | clear

query around the objects with radius : 2 arc min

Only the list display applies here

Query by identifiers can be done by

- full identifiers
- partial identifiers using wildcards ('?' = one char, '*' = any string, including an empty one (no char), '[xyz]' = one char among the list.
  Examples:
  `HD *0000` returns all HD objects having the HD identifier ending with 4 zeros
  `HD 10?` returns HD 100, 101, ..., 109.
- query around an object, with a radius definition
- a whole catalogue.
- Query by lists of objects

SIMBAD

Source Query: M 87

Basic data

Identifiers

Plots and images

Bibliographical references

Measurements

External archives

NED
NASA/IPAC Extragalactic Database

- Database of extragalactic objects including:
  - Cross-identifications of names
  - Positions, redshifts
  - Basic data
  - Bibliographical references
  - Images from 2MASS, DSS, etc.
- Web interface, batch mode

http://ned.ipac.caltech.edu/

NASA/IPAC Extragalactic Database

- Latest Updates to NED and Level 5 Knowledgebase
- NEW Query Redshift-Independent Distances by Object Name
- NEW Redshift-Independent Distances in query reports
- NEW Query volumes of space around objects in query reports
- NEW Improved query reports including Index and SED preview
- NEW 450,000 object Associations between SDSS and other surveys

Notice: Ongoing upgrades to the user interface include changes to the HTML query reports. Automated queries should use XML (VOTable) output. Details

OBJECTS	DATA	LITERATURE	TOOLS	INFO
By Name	Images By Object Name or By Region	References by Object Name	Coordinate Transformation & Extinction Calculator Velocity Calculator	FAQ Introduction
Near Name	Photometry & SEDs	References by Author Name	Cosmology Calculators Extinction-Law Calculators	Features Graphical Overview
Near Position	Spectra	Text Search	FTP	NED Source List
Advanced All-Sky	Redshifts	Knowledgebase CRITICAL LEVEL 5	X/Y offset to RA/DEC	NED Team
IAU Format	Redshift-Independent Distances NEW	Galaxy Distance Tabulations (NED-D)	Batch Job Submission	Comment
By Refcode	Positions	Abstracts	Pick Up Batch Job Results	Web Links
Object Notes	Diameters	Thesis Abstracts	Skyplot	Glossary & Lexicon

Interface last updated: 2 June 2009

- 163 million objects
- 170 million multiwavelength object cross-IDs
- 638 thousand associations (candidate cross-IDs)
- 1.5 million redshifts
- 1.7 billion photometric measurements
- 609 million diameter measurements

Database last updated: 2 June 2009

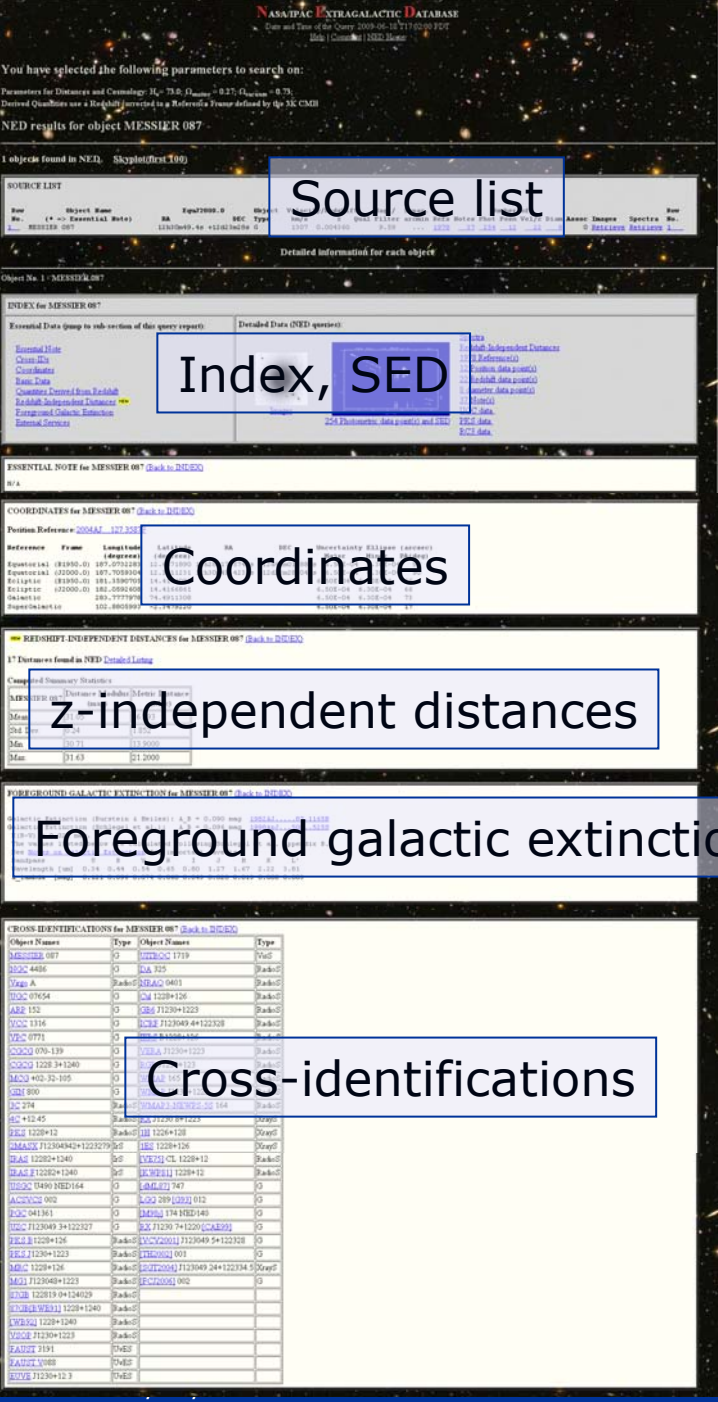
- 5.1 million objects linked to 71,596 journal articles
- 2.3 million images, maps and external links
- 56,405 spectra
- 18,150 redshift-independent distances for 5,049 galaxies
- 64,956 object notes
- 48,661 journal article abstracts

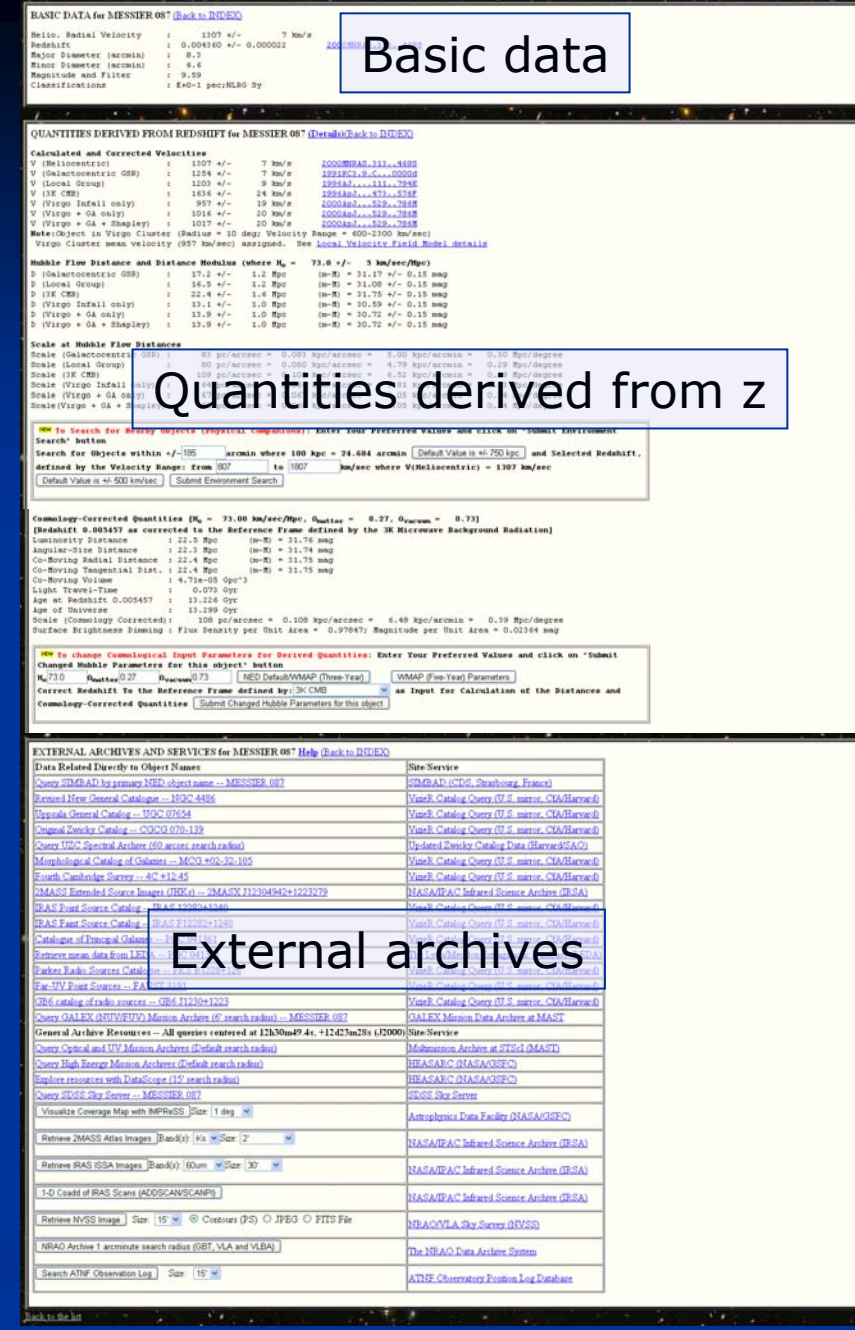
If your research benefits from the use of NED, we would appreciate the following acknowledgement in your paper: *This research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.*

NED

NED

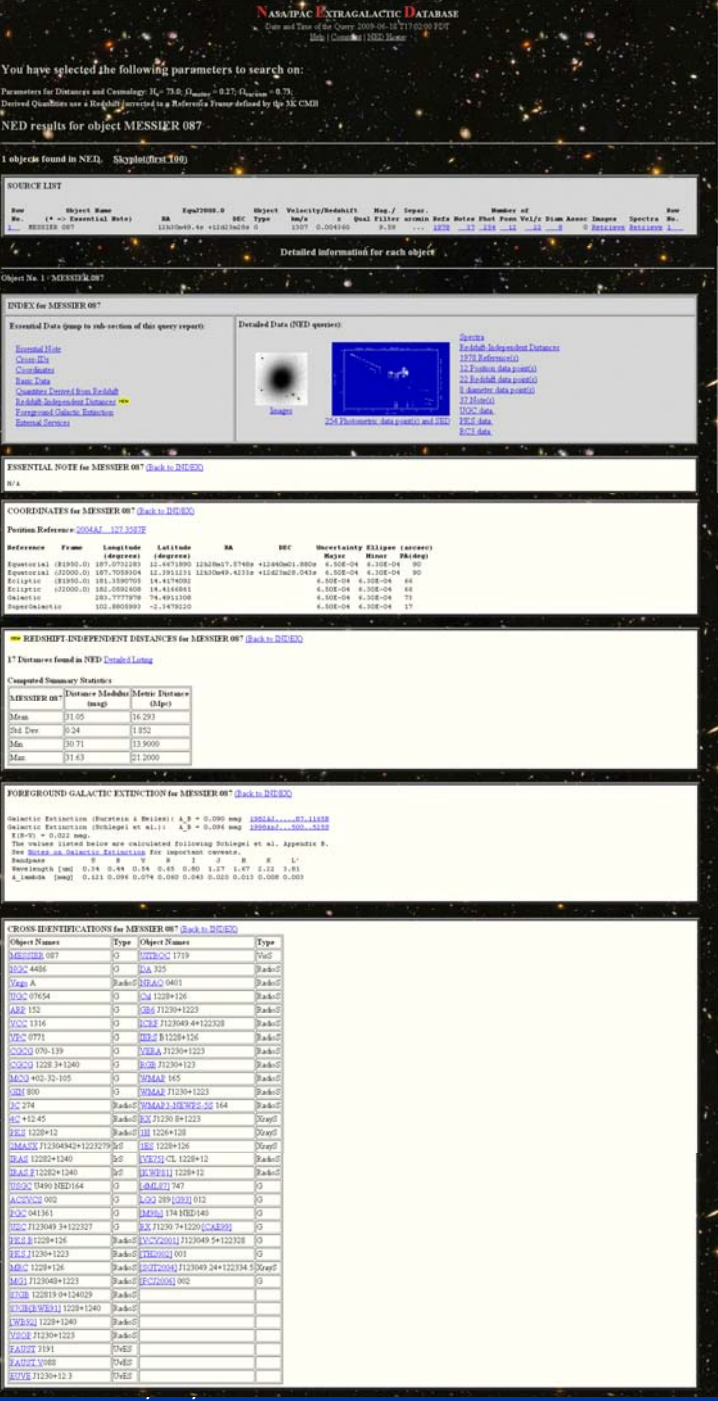
Source Query: M 87

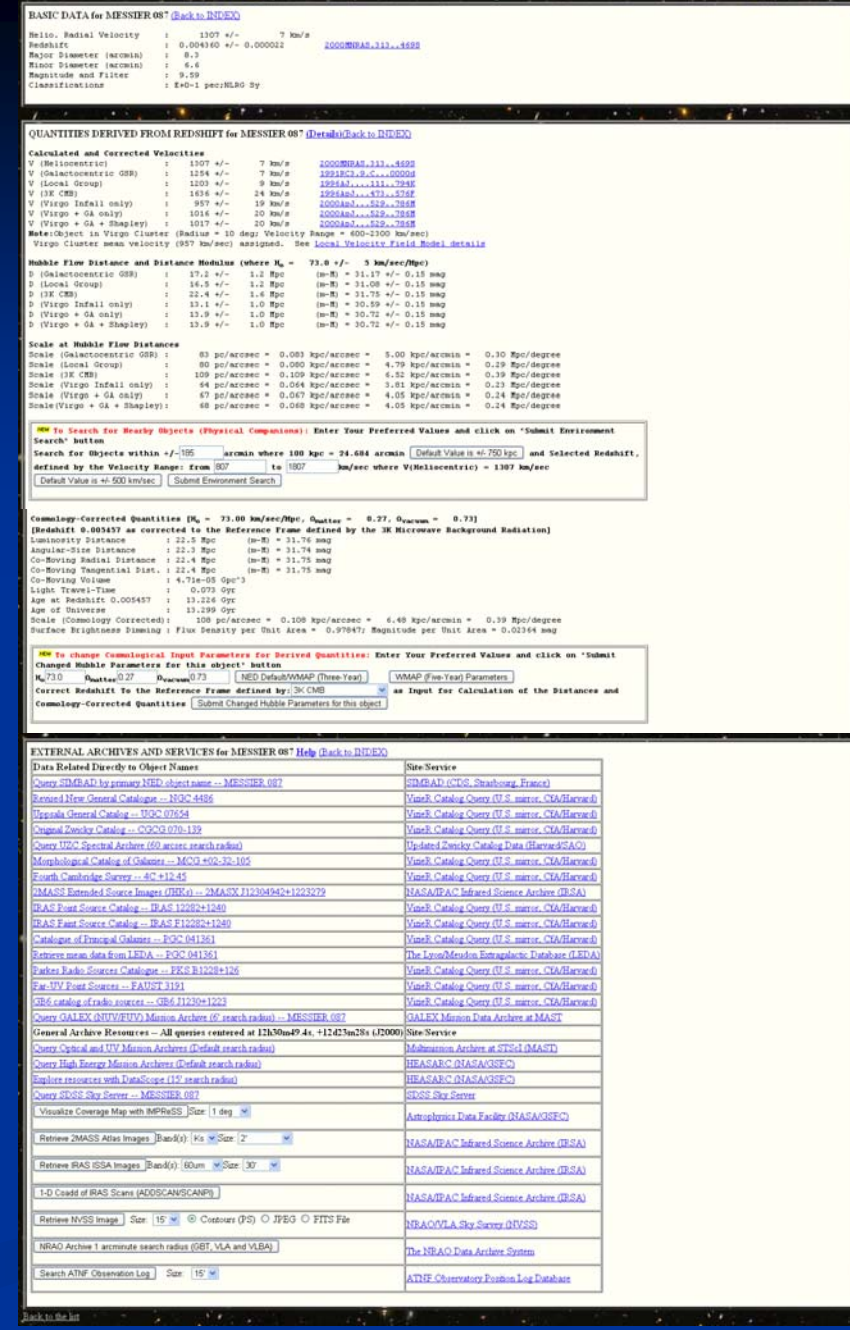




NED

Source Query: M 87





Virtual Observatory

- Idea: all the World's astronomical data are transparently useable as the WWW
- Metadata standards needed (VOTables replacing FITS)
- Coordinated by the International Virtual Observatory Alliance
- European Virtual Observatory: Euro-VO
- National Sites:
  - German Astron. VO (GAVO: http://www.g-vo.org)
  - Australian VO (AVO: http://aus-vo.org/)
  - USA Natnl. VO (NVO: http://www.virtualobservatory.net/)
  - …

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  - …VO: http://aus-vo.org/)
  - … (NVO: …virtualobservatory.net/)
  -

See M. Allen Lecture on July 9th

AstroGrid

- Portal to the Virtual Observatory
- Desktop Applications Suite
- TOPCAT
- AstroGrid Python available, so you can create your own applications

http://www.astrogrid.org

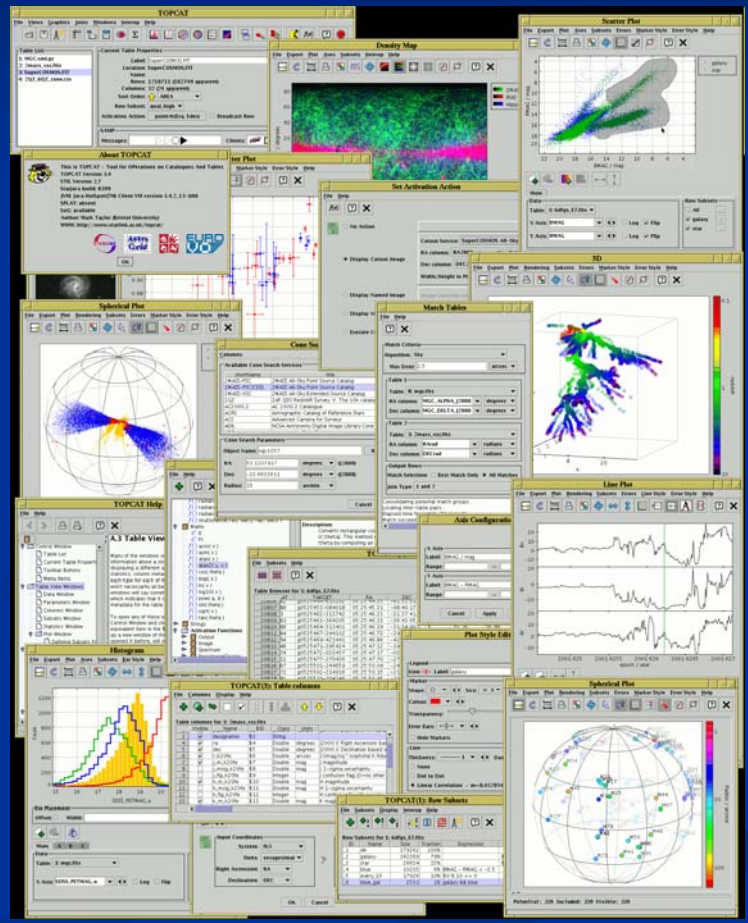
Virtual Observatory: Viewers

TOPCAT	http://www.star.bris.ac.uk/~mbt/topcat/
Aladin	http://aladin.u-strasbg.fr/
VOSpec	http://esavo.esa.int/vospec/
SkyView	http://skyview.gsfc.nasa.gov/
DataScope	http://heasarc.gsfc.nasa.gov/cgi-bin/vo/datascope/init.pl

TOPCAT

Tool for OPerations on Catalogues And Tables

- Interactive graphical viewer and editor for tabular data
- JAVA script as part of AstroGrid
- Fast access to large data sets, manipulation, plotting features, statistical tools, interface with other applications (SAMP, PLASTIC)



http://www.star.bris.ac.uk/~mbt/topcat/

Things you can do

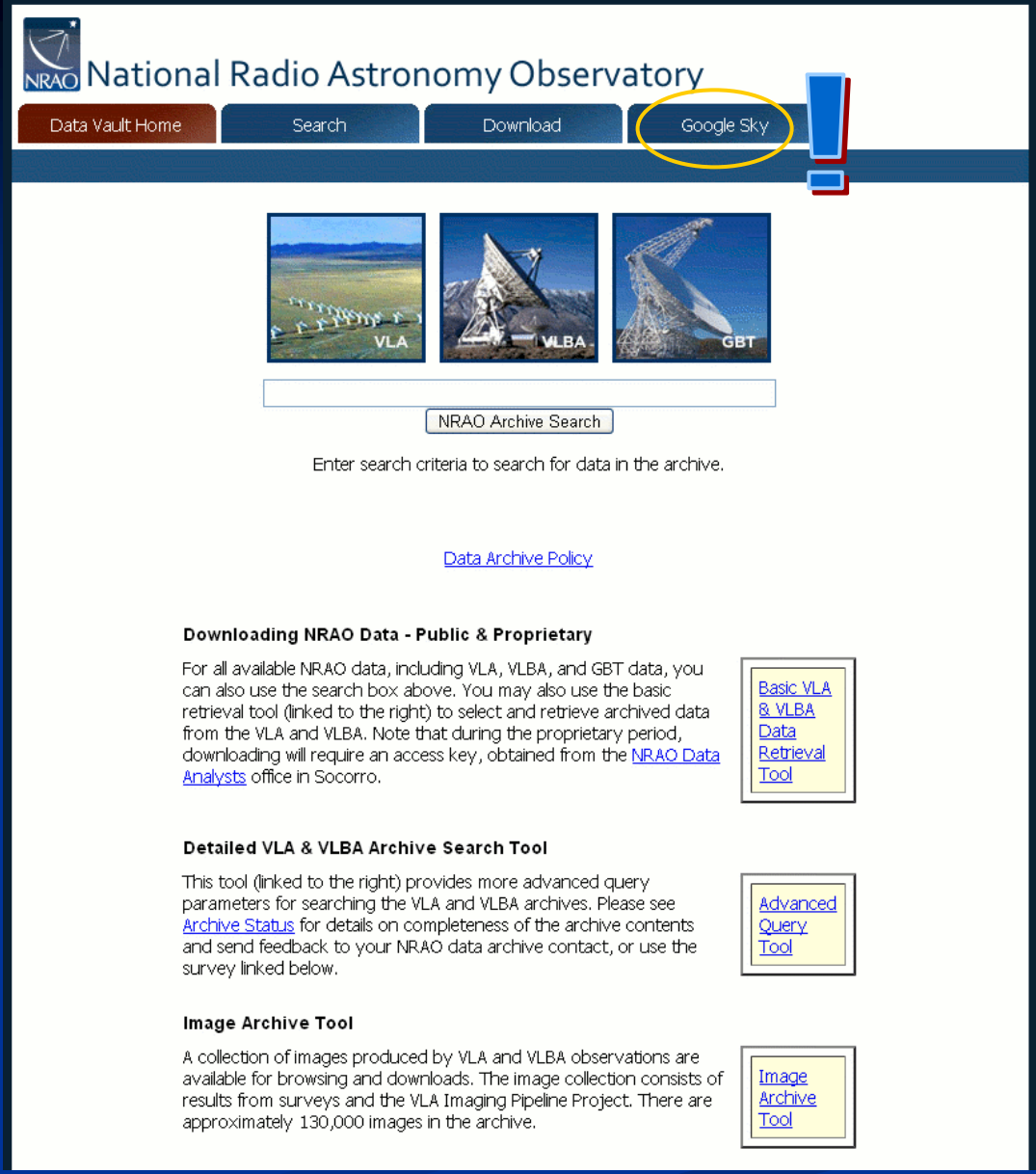
- Finding data for a new source
- Checking all available data in all wavelength and resolution available observations
- Cross correlating catalogs
- Visualizing a catalog

Finding radio data: choosing the telescope

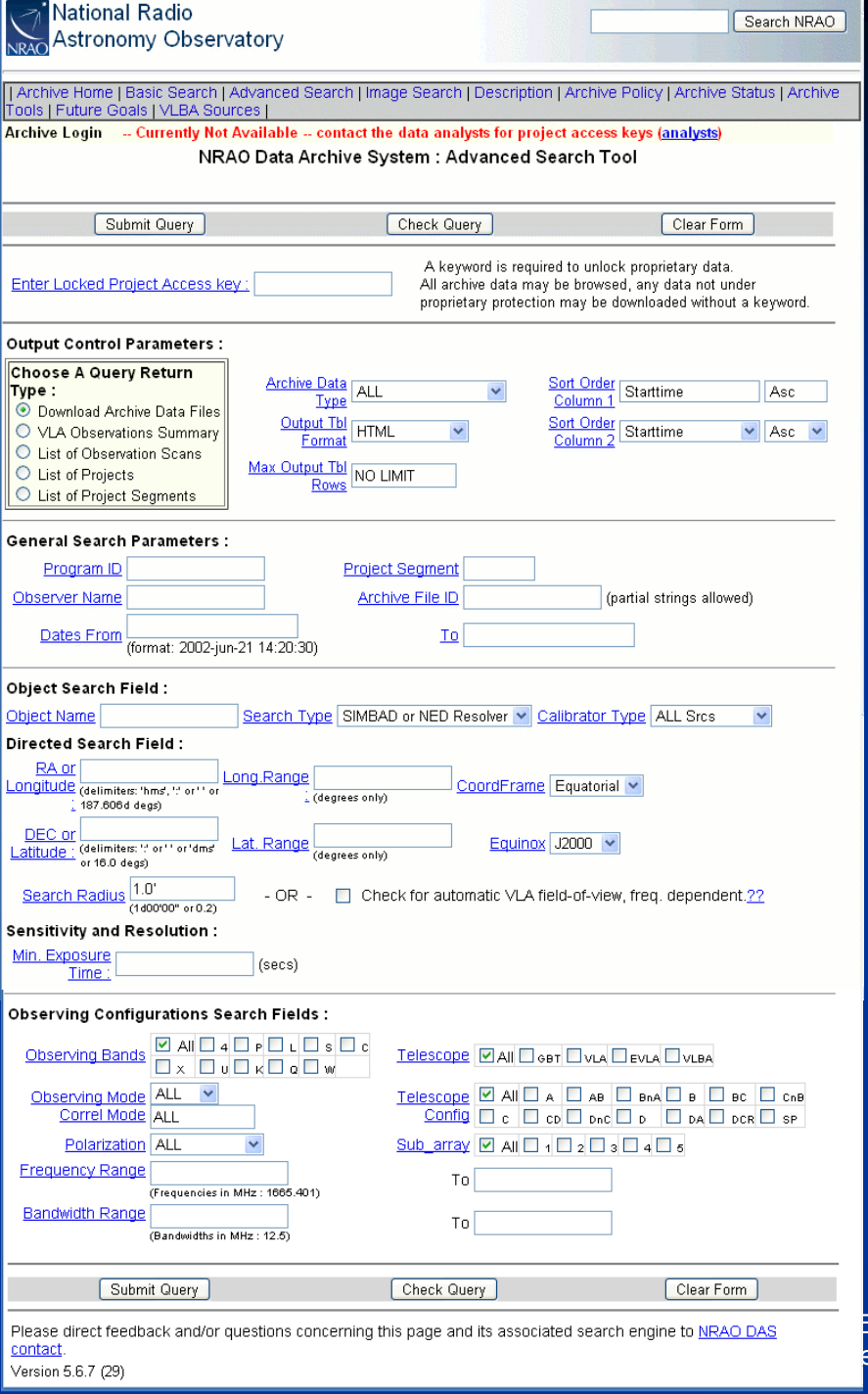
- North or south?
  - Dec >-40 → VLA/VLBA
    - Dec> 0 → MERLIN
  - Dec <-30 → ATCA
- Desired resolution & source size?
  - VLA/ATCA: arcsecond to arcmin resolution over few to 10s of arcminutes
  - MERLIN: 10s of milliarcseconds resolution over arcmin
  - VLBA: milliarcsecond resolution over arcseconds

Example: data extraction

- Use the VLA (NRAO's workhorse, with 3 Tb data)



http://archive.cv.nrao.edu/



Finding radio data

- Checking the VLA archive
- Search by
  - Source name (SIMBAD) or position & radius
  - VLA configuration
  - Observing frequency
- Check Summary Table…

The VLA Archive

- Returns:
  - **Date**
  - **Obs. Frequency**
  - **Configuration**
  - Field of View
  - Resolution
  - Largest angular scale
  - Time on source
  - Theor. rms noise
  - No of channels
  - Bandwidth
  - Stokes

NRAO Archive - Observing Summary

Show Query Parameters
Displaying nrows : 1279

Transfer uv file for that table row to the Download Page - click the UV button
Search for archived image files for a table row - click the I button
Return a list of observing scans for a table row - click the S button

UV Data	Image Search	Scan List	Source	Project	Frequency MHz	Distance arcmin	TOS sec	rms mJy/b	resolution arcsec	FOV arcmin	Tele:config :sub:nants	Chans #	BW MHz	Polar	First Time	Last Time	RA(J2000)	DEC(J2000)
UV	none	S	C274	AD0094-public	4835.100	0.008	410	0.117	0.4	9.0	VLA:A:1:26	1	50.000	RR,LL,RL,L	83-Sep-17 21:37:10	83-Sep-17 21:43:49	12h30m49.397s	+12d23'27.78"
			C274	AD0094-public	4885.100	0.008	410	0.117	0.4	9.0	VLA:A:1:26	1	50.000	RR,LL,RL,L	83-Sep-17 21:37:10	83-Sep-17 21:43:49	12h30m49.397s	+12d23'27.78"
UV	none	S	C274	AD0094-public	14914.900	0.008	400	0.3	0.14	3.0	VLA:A:1:26	1	50.000	RR,LL,RL,L	83-Sep-17 21:44:20	83-Sep-17 21:50:50	12h30m49.397s	+12d23'27.78"
			C274	AD0094-public	14964.900	0.008	400	0.3	0.14	3.0	VLA:A:1:26	1	50.000	RR,LL,RL,L	83-Sep-17 21:44:20	83-Sep-17 21:50:50	12h30m49.397s	+12d23'27.78"
UV	none	S	C274	AD0094-public	1464.900	0.008	280	0.194	1.4	30.0	VLA:A:1:26	1	50.000	RR,LL,RL,L	83-Sep-17 21:51:20	83-Sep-17 21:55:50	12h30m49.397s	+12d23'27.78"
			C274	AD0094-public	1514.900	0.008	280	0.194	1.4	30.0	VLA:A:1:26	1	50.000	RR,LL,RL,L	83-Sep-17 21:51:20	83-Sep-17 21:55:50	12h30m49.397s	+12d23'27.78"
UV	none	S	1228+126	AW0087-public	4885.100	0.005	310	0.28	0.4	9.0	VLA:A:3:6	1	50.000	RR,LL,RL,L	83-Oct-10 15:56:10	83-Oct-10 20:04:49	12h30m49.407s	+12d23'28.18"
			1228+126	AW0087-public	4835.100	0.005	310	0.28	0.4	9.0	VLA:A:3:6	1	50.000	RR,LL,RL,L	83-Oct-10 15:56:10	83-Oct-10 20:04:49	12h30m49.407s	+12d23'28.18"

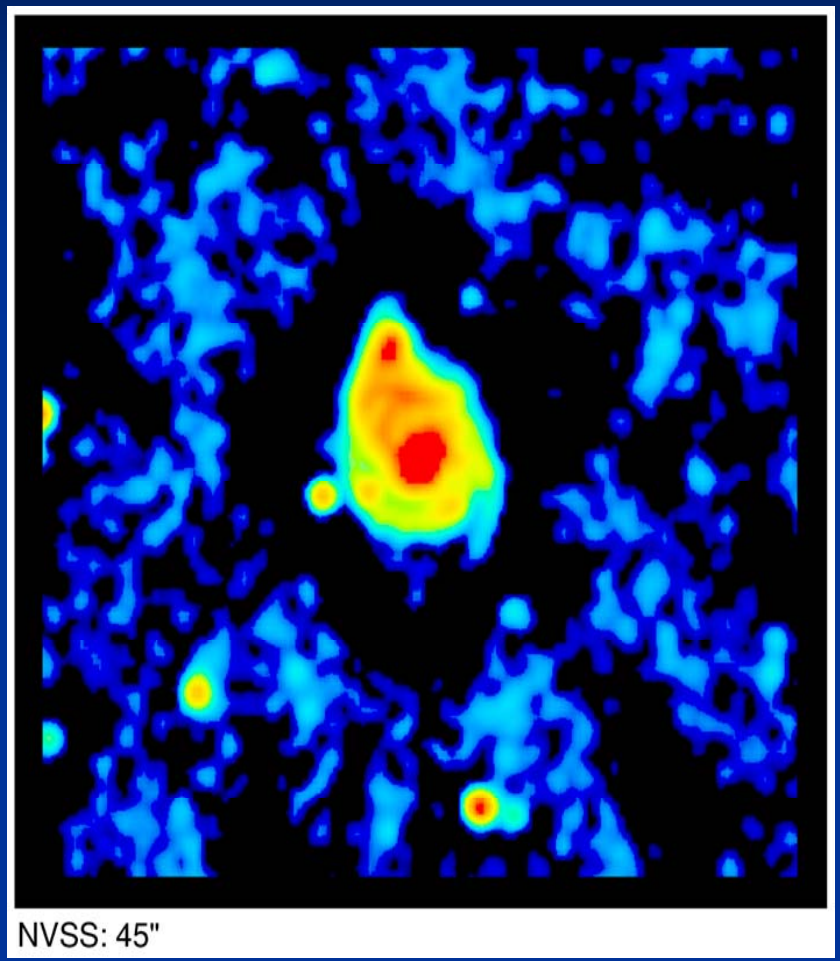
Dealing with data: a first look

- The archives send raw uv-data, not images
- Quick & dirty processing: VLARUN, VLBARUN
  - can get reasonable quick-look images in a few minutes, with no special black-belt qualification
- Steps:
  - AIPS
  - Load in data (FILLM)
  - Set array configuration; image size; depth of deconvolution
  - VLARUN → calibrated data & images
  - Write them out (FITTP)

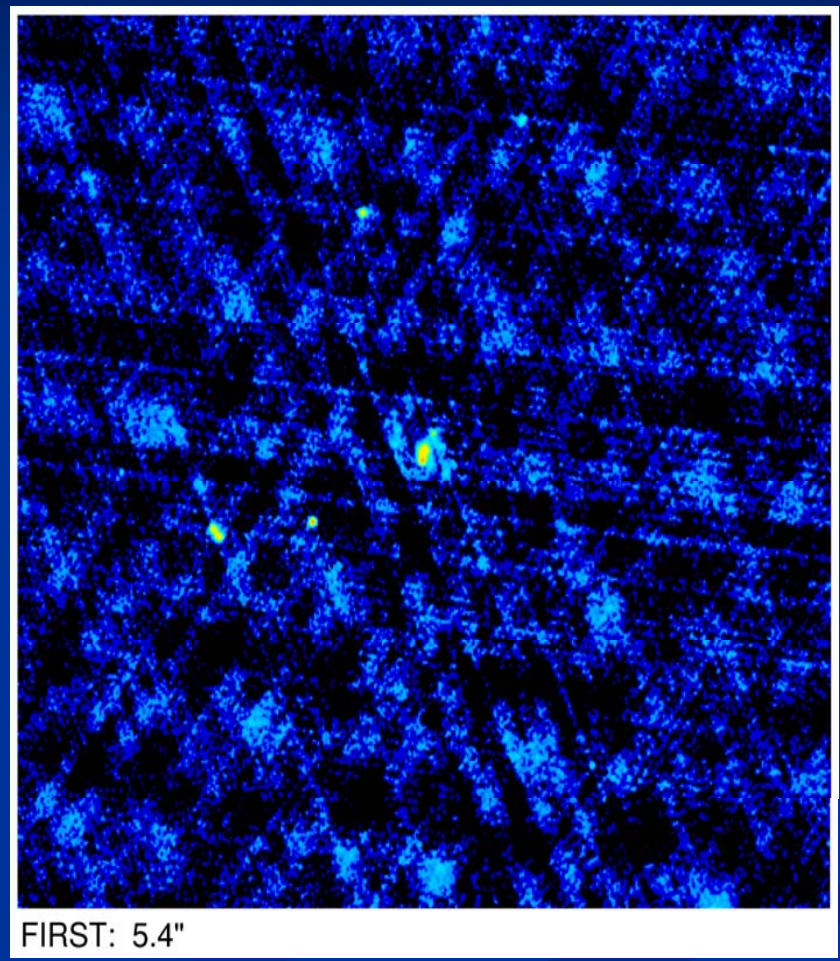
Checking which data

- Resolution vs missing structure
  - VLA array configuration choice to be made carefully (A to D)
- Sensitivity
  - Longer observations are better (interferometers!)
  - More bandwidth is better
  - Some frequency bands are more sensitive (5, 8 GHz)
- Special purposes
  - Spectroscopy: total bandwidth covers entire line
  - Polarization: Stokes field carefully checked, long runs needed
- Make your life easier
  - Continuum is easier than spectral line
  - "Center" frequencies (1-15 GHz) are easier than edges
  - VLBI is more challenging than VLA/ATCA
  - New data are better than old

M51: Surveys…

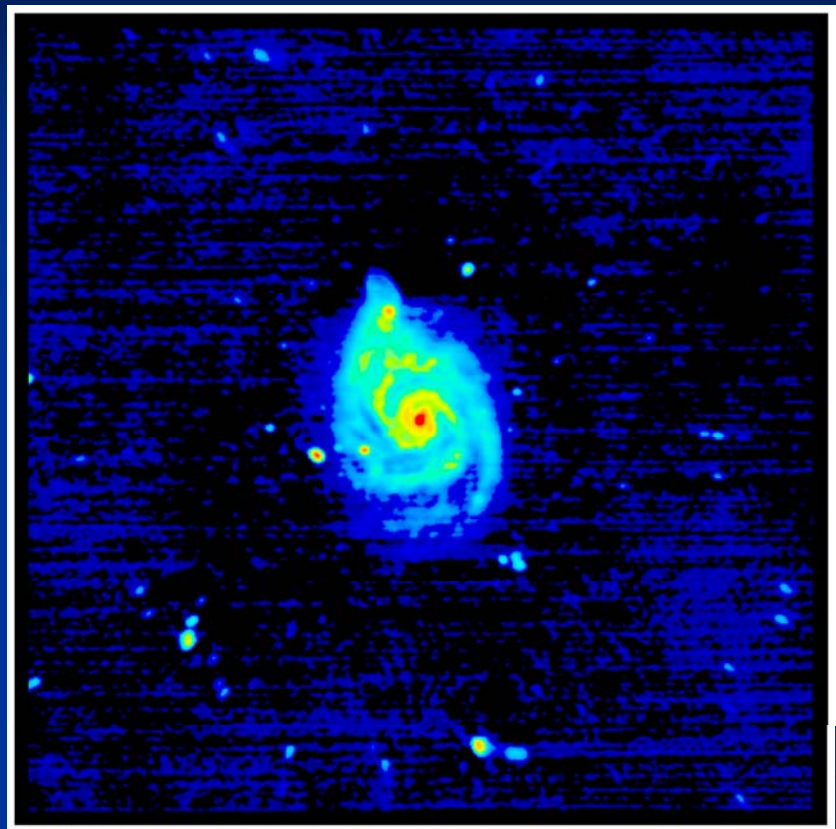


NVSS: 45” resolution



FIRST: 5.4” resolution

...and the archive



VLA/C @ 20cm:
15” resolution

Some remarks

- Please refer to the original publications and not to databases in your publications
- Use requested acknowledgments for open, unpublished data
- Please give credit to the people who put hard work on it
- If doing survey work, design it to become a public data base and put it online as soon as possible

The future

- The archives are growing, getting better, merging into the VO…
- Lots of new radio telescopes coming this decade: SMA, EVLA, ALMA, eMERLIN, …

  → great times to be an astronomer!