

# Determination of radio spectra from catalogues and identification of Gigahertz peaked sources (GPS) from the Virtual Observatory

Bernd Vollmer, S. Derriere, T. Krichbaum, T. Boch, B.  
Gassmann, E. Davoust, P. Dubois, F. Genova, F.  
Ochsenbein, W. van Driel

CDS, Observatoire de Strasbourg, France  
MPIfR, Bonn, Germany  
Observatoire Midi-Pyrénées, Toulouse, France  
Observatoire de Paris, France

# The project

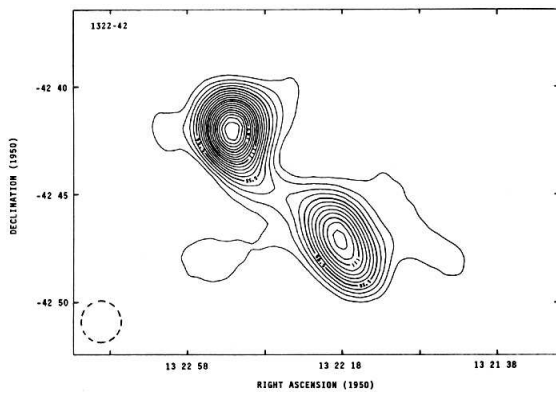
- Aim: extract radio cross-ids / spectra from a homogeneous set of catalogues
- Scientific goal: datamining to search for peculiar sources (e.g. GPS sources = young radio loud AGNs not well understood) + the role of variability in a multi-epoch database
- Results: (i) catalogue of radio spectra ([VizieR](#)) = added value data for the **VO**
  - (ii) follow-up simultaneous observations at 3 frequencies: assess source variability; search for new GPS sources
  - (ii) prototype of a **VO** tool for intelligent data discovery

# Radio surveys

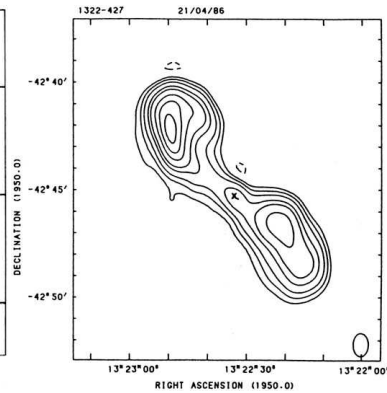
- Single dish ↔ Interferometer
- Systematic / pointed (finder) surveys
- Main characteristics:
  - Sky coverage
  - Frequency → *m/cm wavelength range*
  - Angular resolution (beamsize)
  - Sensitivity

# Cross-identification of radio sources – the influence of frequency

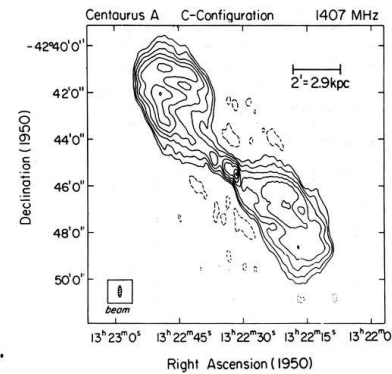
Example: Cen A



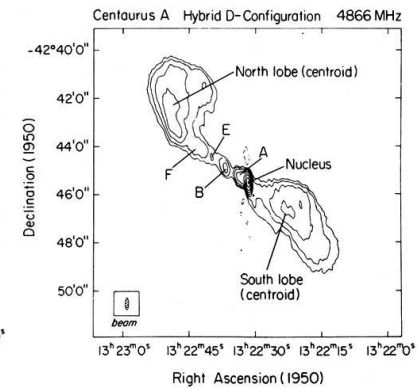
1.9m  
(Slee 1977)



35cm  
(Paul et al. 1992)



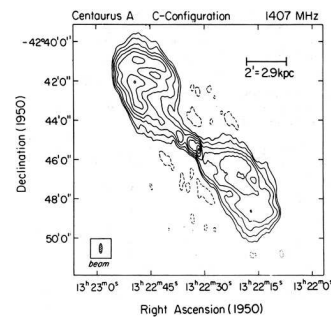
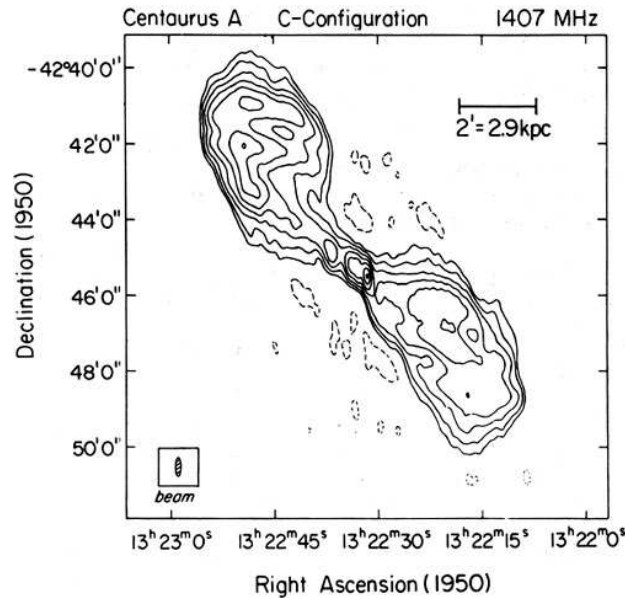
20cm  
(Burns et al. 1983)



6cm  
(Burns et al. 1983)

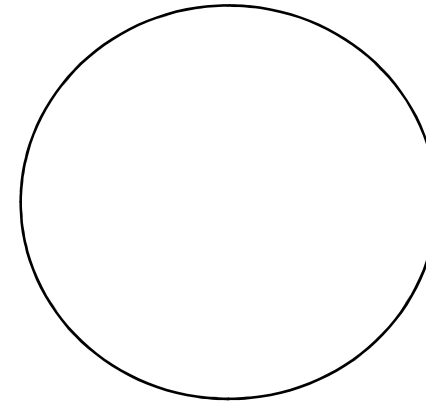
→  
Increasing frequency

# Cross-identification of radio sources- the influence of resolution

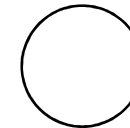


at a larger distance:

VLA, 20cm (Burns et al. 1983)



Green Bank  
20cm  
10'



Green Bank  
6cm  
3.5'



VLA, NVSS  
20cm  
45''



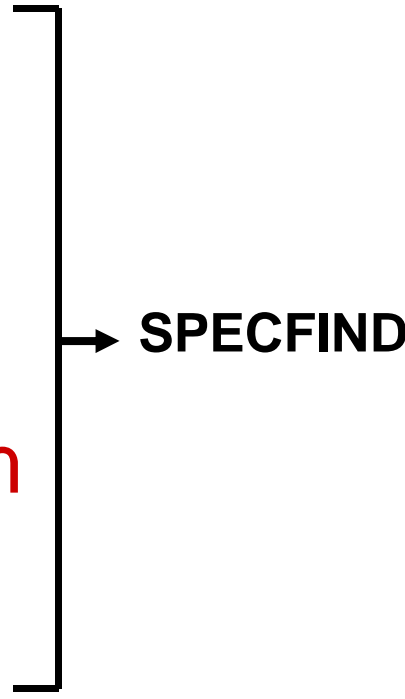
VLA, FIRST  
20cm  
5''

# Cross-identification of radio sources

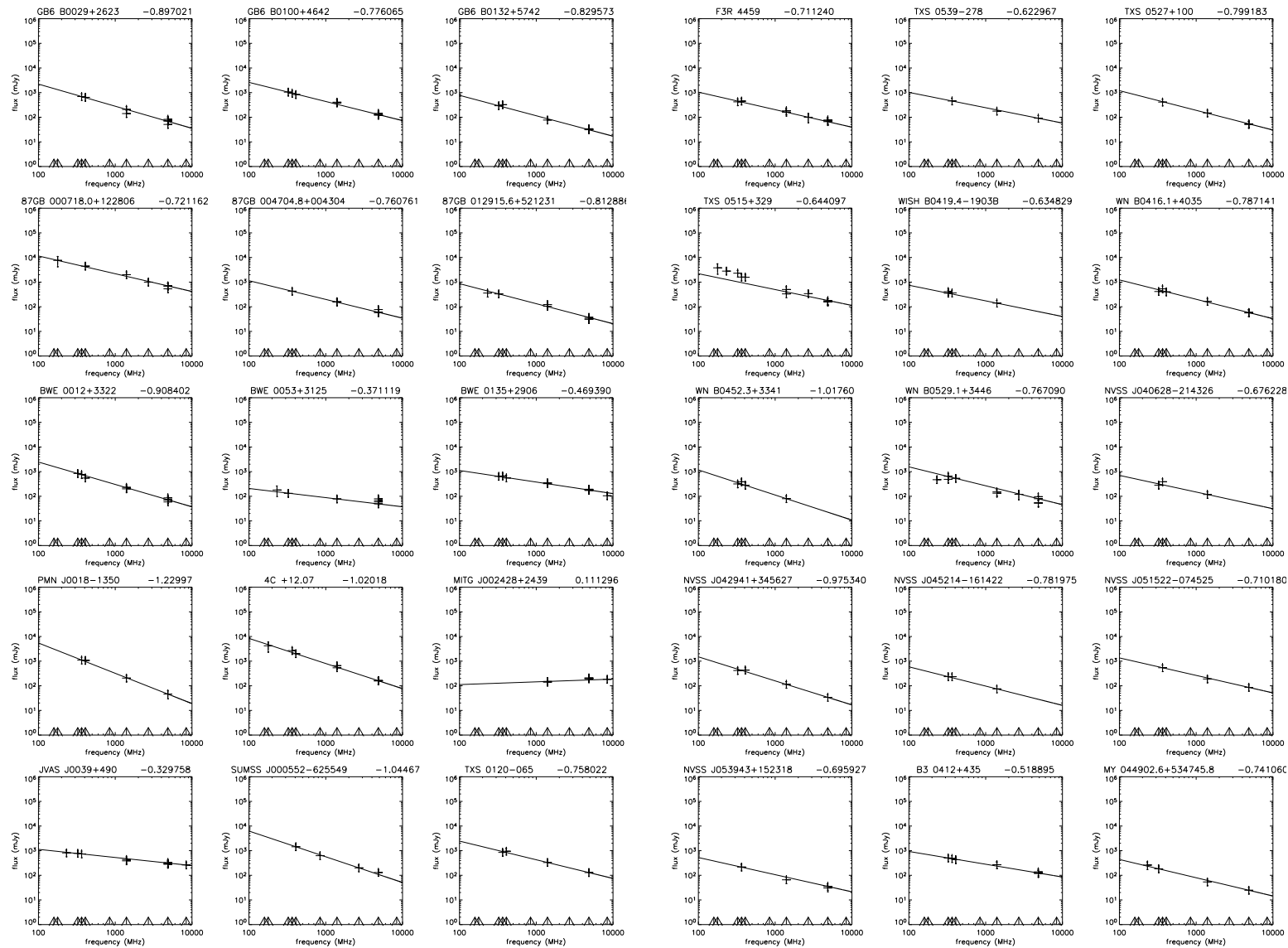
Based on

- on proximity / resolution / source extent
- comparison of fluxes at the same frequency
- radio spectrum (radio SED)
- physical characteristics (e.g. galaxies, SN remnants, AGNs)

# Steps for cross-identification

- Search for, preparation of and uniformization of radio catalogues → VO tool
  - Definition of code standards
  - Proximity search
  - Selection based on fluxes at the same frequency
  - Selection based on radio spectrum
  - Self-consistency of the final catalogue
- 
- A large right-facing curly bracket groups the last four steps of the list. An arrow points from the middle of this bracket to the text 'SPECFIND'.

# SPECFIND: some example spectra





# SPECFIND

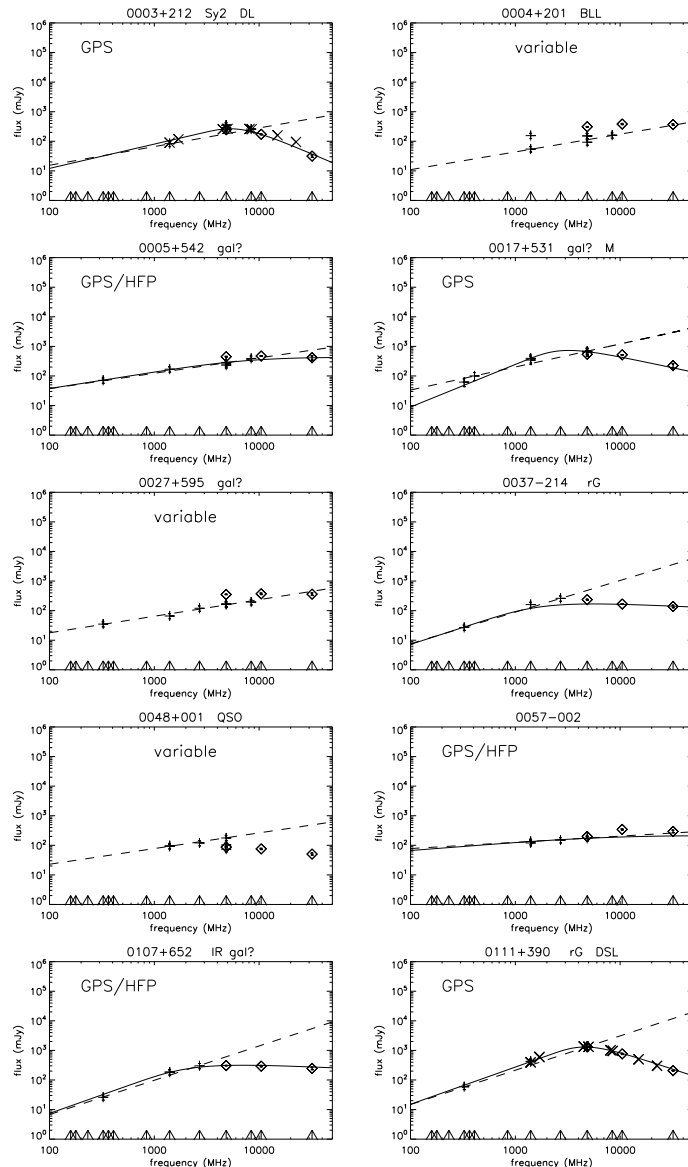
(Vollmer et al., 2005a, 2005b)

- 22 radio catalogues included
- 11 different frequencies
- 3.5 million sources (half of them are from the NVSS)
- **Results: ~760,000 independent associations**  
**~67,000 independent radio spectra with**  
**more than 2 independent points**  
-> more than an order of magnitude more than previous works  
(e.g. Vigotti et al. 1989, Kulkarni et al. 1990)
- **Cross-ids and spectra available in**  
**VizieR at CDS**

# Scientific follow-up project

- Datamining of the SPECFIND database
- Search for sources with *inverted radio spectrum* => variability; possible *Gigahertz peaked sources (GPS: young radio loud AGN's not well understood)* or futur mm-VLBI targets
- Quasi-simultaneous observations of these sources at three frequencies (4.8 GHz, 10.4 GHz, 32 GHz) with the Effelsberg 100m telescope
- Comparison of spectra from data at different epochs with data at the same epoch => *source variability* => potential candidates for intraday variable (IDV) sources

# GPS source observations: results



- more than 50% of the sources show a peak at  $\nu > 1$  GHz
- ~50% of the sources are variable
- ~20% of the sources have flat spectra up to 9 mm
- <10% uncertain classification

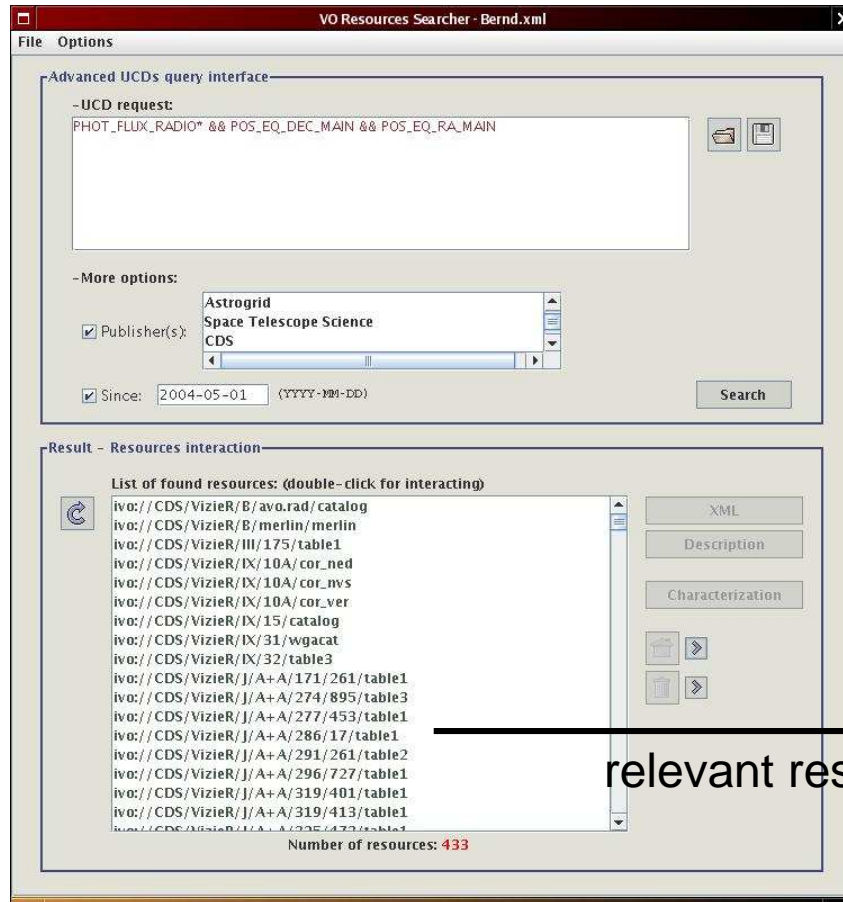
# Going further with VO capabilities

## Towards a new VO tool

- Preparation and uniformization of radio catalogues very time consuming
- Aim: include a maximum of available radio catalogues (>100)
- Within the framework of VOTECH at CDS: development of
  - (i) a tool to search for useful catalogues in the Virtual Observatory
  - (ii) a tool to extract relevant information and to uniformise the catalogue information
  - (iii) a tool to characterise the data

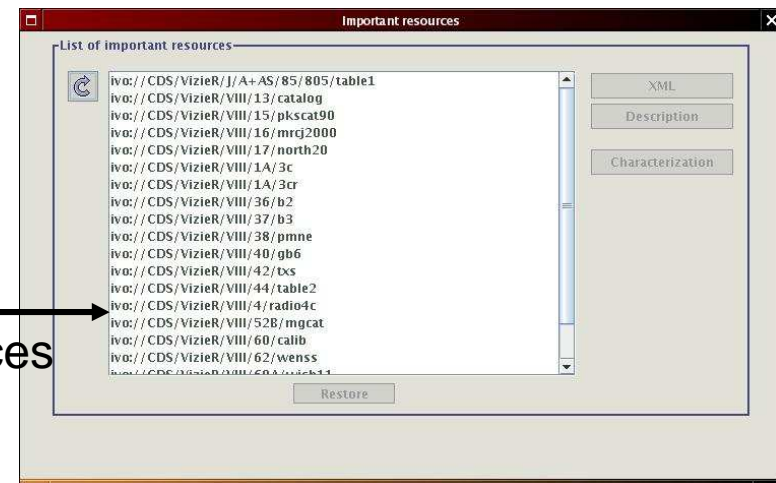
# I. Registry query tool

- Finding VO resources based on Unified Content Descriptors (UCDs) matching a query (written in Java; uses XMLDV API to get data from an XML registry)



UCD examples:

Radio flux: PHOT\_FLUX\_RADIO\*  
Right ascension: POS\_EQ\_RA  
Declination: POS\_EQ\_DEC



relevant resources

# II. Data homogenisation tool

- Aim: extraction of homogenized data from a heterogeneous set of catalogues (Java; works on XML tables)
- Output: VOTable or ASCII

homogenization interface

The image displays two windows from the SED Construction tool. The left window, titled 'SED Construction tool - Bernd.xml', shows a list of resources to process and a list of output columns. The right window, titled 'Uniformisation form', shows a table with columns for Catalogs, RA(2000), RA\_error, DEC(2000), DEC\_error, and Flux. Each row represents a different catalogue with its corresponding parameters and units.

Catalogs	RA(2000) (POS_EQ_RA_MAIN) Unit: s	RA_error (*ERROR*) Unit: s	DEC(2000) (POS_EQ_DEC_MAIN) Unit: arcsec	DEC_error (*ERROR*) Unit: arcsec	Flux (PHOT_FLUX_RADIO*) Unit: mJy
ivo://CDS/VizieR/VIII/13/catalog	RAB1950	8	DEB1950	20	Flux
ivo://CDS/VizieR/VIII/14/j2000	RAJ2000	e_RAs	DEJ2000	e_DEs	Flux
ivo://CDS/VizieR/VIII/37/b3	RA1950	60	DE1950	60	Flux
ivo://CDS/VizieR/VIII/38/pmne	RAJ2000	(24/60)...	DEJ2000	sqrt(1...	\$(GFlux...
ivo://CDS/VizieR/VIII/4/radio4c	RA1950	138	DE1950	138	FluxDen
ivo://CDS/VizieR/VIII/40/gb6	RAJ2000	e_RAs	DEJ2000	e_DEs	\$(MajA...
ivo://CDS/VizieR/VIII/42/txs	RA1950	\$(e_RA...	DE1950	e_DEs	S365

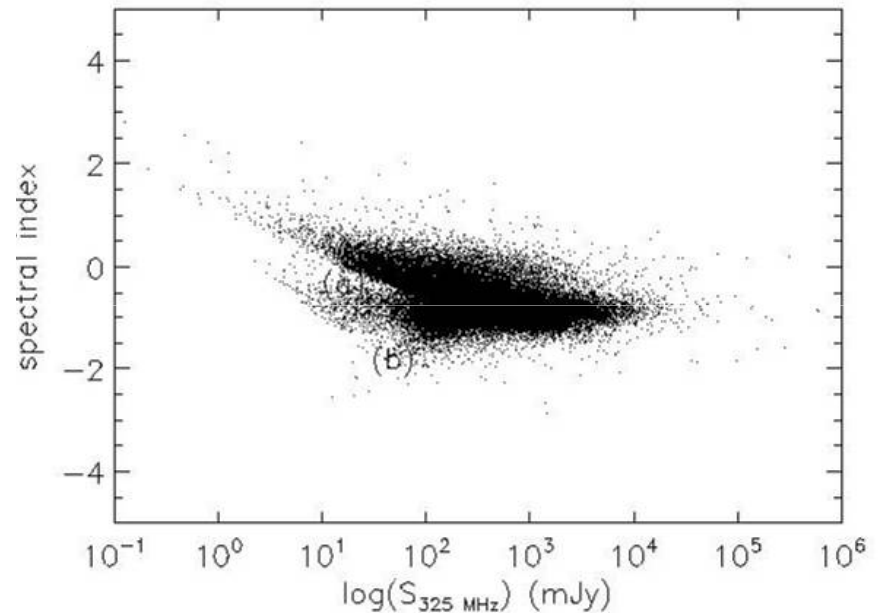
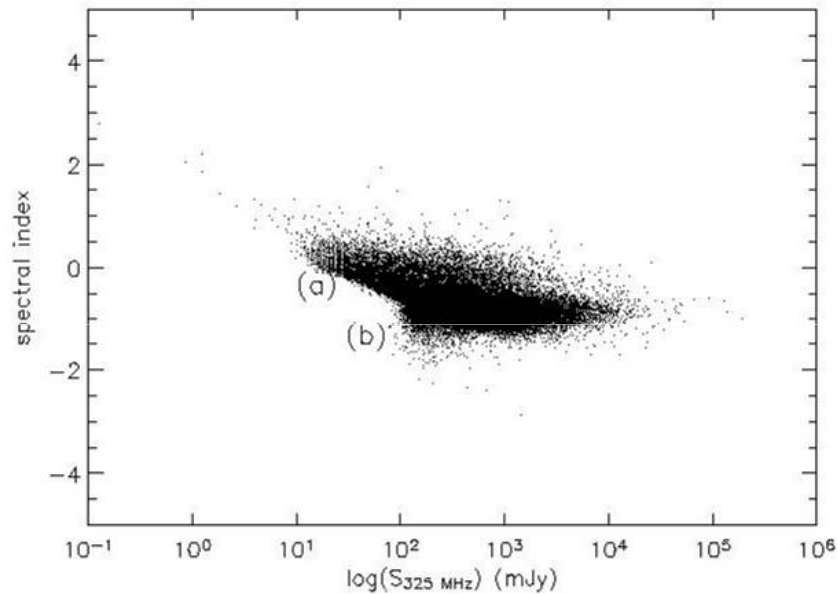
# III. Characterisation tool

- Implementation of the VO « characterization » data model
- Serves as input for the homogenisation tool

The screenshot shows a web-based interface titled "Characterization Editor - MPFS.xml". It features a menu bar with "File" and "Axis", and a set of tabs: "spatial", "time", "spectral", and "flux". The "spatial" tab is active, displaying the "Axis frame" configuration. The form includes the following fields and options:

- Axis type:** spatial (dropdown)
- Name:** spatial (text input)
- Calibration status:** CALIBRATED (dropdown)
- UCD:** pos (text input)
- Unit:** deg (text input)
- Observatory location:** (text input)
- Coordinate system:**
  - Id:** TT-ICRS-WAVELENGTH-TOPO (text input)
  - Ref:** (text input)
  - Link HREF:** ivo://STClib/CoordSys#TT-ICRS-TOPO (text input)
- Number of bins:** (16,15) (text input)
- Quality:** (text input)
- Statistical error:**
  - Flavor:** statistical (text input)
  - value:** (0.00055,0.00055) (text input)
  - bounds:** (text input)
  - map:** (text input)
- Systematic error:**
  - Flavor:** (text input)
  - value:** (text input)
  - bounds:** (text input)
  - map:** (text input)
- Independent axis:**  true  false
- Undersampling:**   true  false
- Regular sampling:**   true  false

# SPECFIND: next release



## VizieR catalogue VIII/74A

22 radio catalogues

3.49 million sources

67000 objects



## new release

105 radio catalogues

3.76 million sources

84000 objects



# Summary

- A tool to extract radio spectra from a large set of radio catalogues is available (SPECFIND)
- Results for 22 radio catalogues are published and available in [VizieR](#) at CDS (Vollmer et al. 2005a,b)
- Scientific follow-up projet based on the datamining of the SPECFIND spectra is in progress (submitted to A&A)
- Within the framework of VOTECH at CDS:  
development of
  - (i) a tool to search for useful radio catalogues in the Virtual Observatory
  - (ii) a tool to extract relevant information from these catalogues and to uniformise the catalogue information
  - (iii) a tool to characterise the data
- Prototypes available at <http://eurovotech.org/twiki/bin/view/VOTech/SedConstruction2>