VLBI survey of the most compact AGNs: core properties

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Outline

- Introduction

  - mm VLBI, Previous Surveys

- Observation

  - Sample selection, Data Processing

- Results

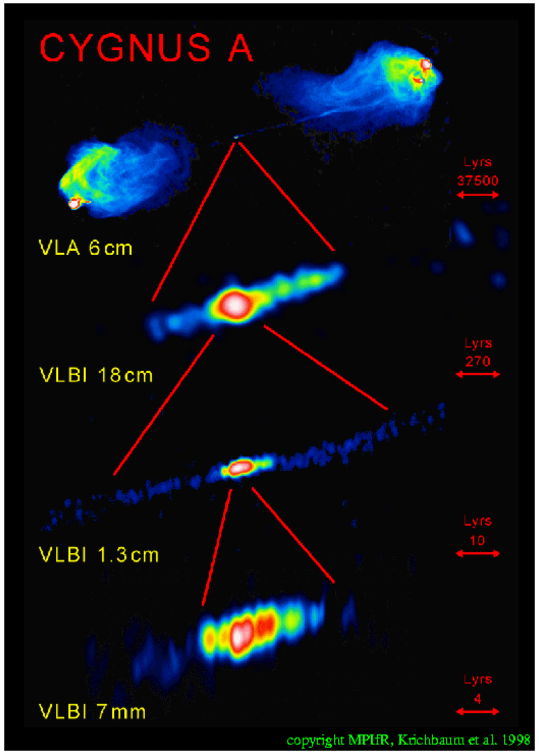
  - correlated visibility and cleaned maps, Morphology

- Discussion

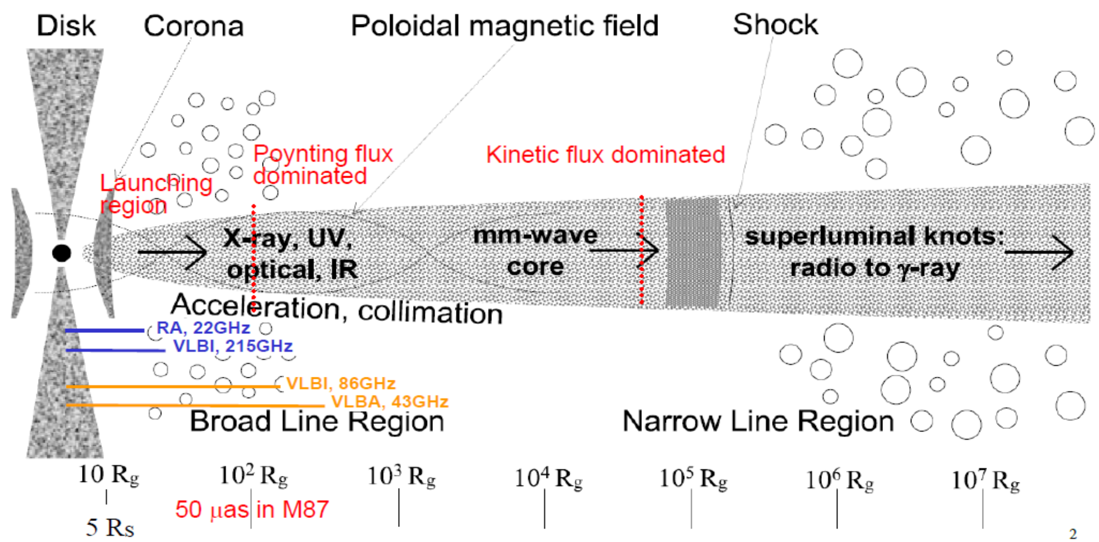
  - compactness of cores, Brightness temperature (T_B), correlation between γ-ray and radio bands

- Summary

Why mm VLBI?



From Krichbaum et al. 1998



From Lobanov et al. 2015

- High angular resolution

  0.3 mas resolution at 43 GHz (EAVN)

  0.2 mas resolution at 43 GHz (VLBA);

  0.1 mas resolution at 86 GHz (VLBA);

  0.04 – 0.1 mas resolution at 86 GHz (GMVA)

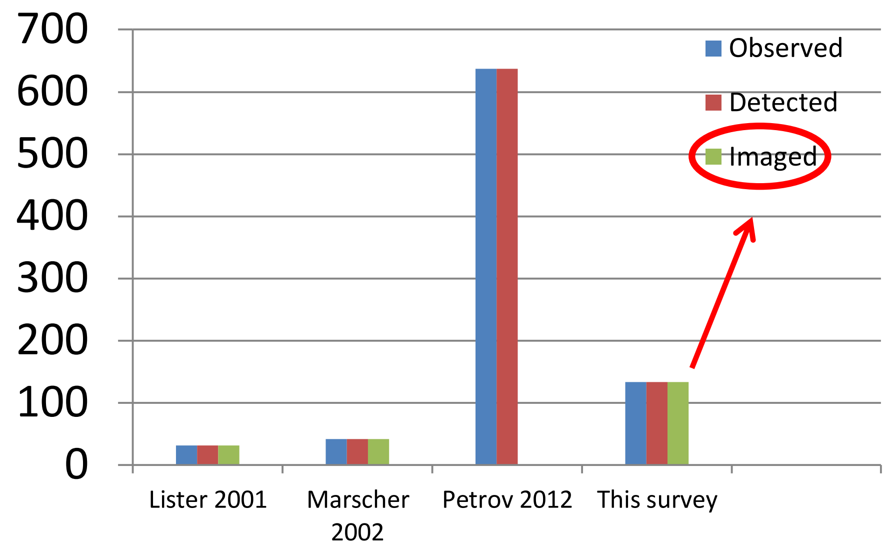
- Weak opacity effect

Improving our understanding of the jet launching, acceleration and collimation !

Correlation between radio and -ray emissions

Previous Surveys

Surveys	Frequency	N_{obs}	N_{img}
Lister et al.2001	43	32	32
Marscher et al.2002	43	42	42
Petrov et al.2012	43	637	0
This survey	**43**	**134**	**134**



Surveys	Frequency	N_{obs}	N_{img}
Beasley et al. 1997	86	45	…
Lonsdale et al.1998	86	79	…
Rantakyro et al.1998	86	67	12
Lobanov et al.2000	86	28	14
Lee et al.2008	86	127	109
This survey	**86**	**20**	**20**

Detection Surveys

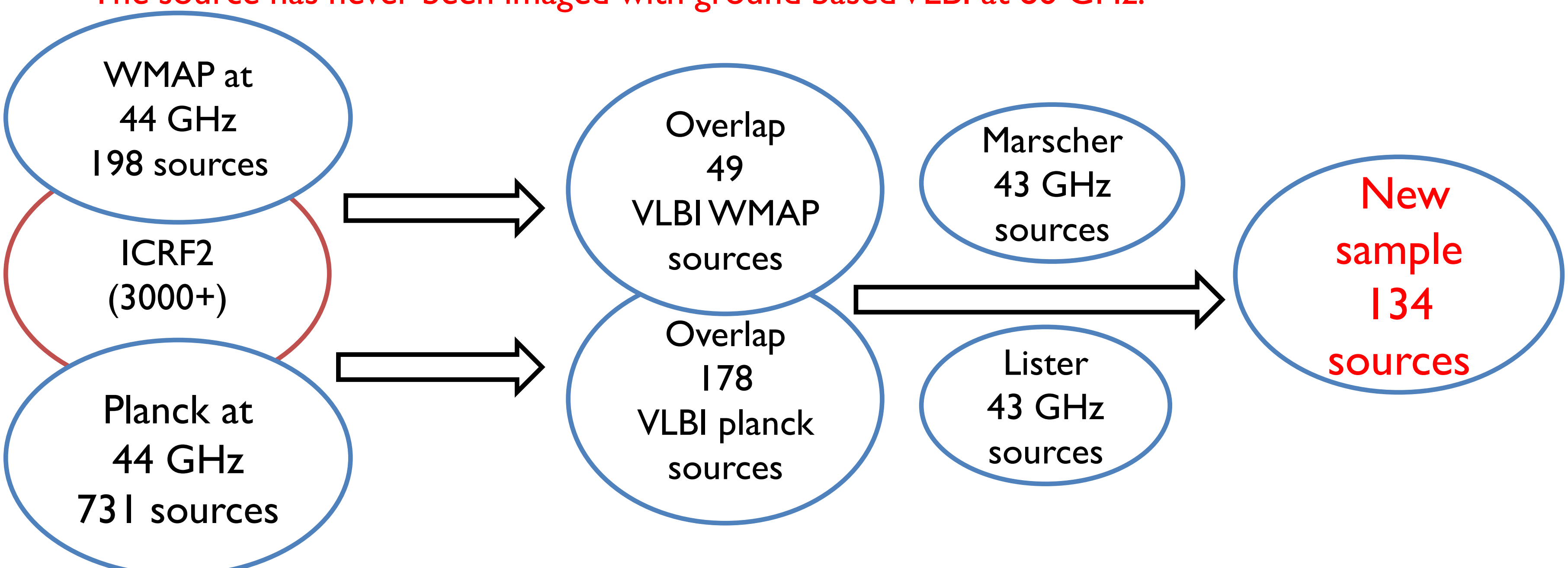
20 sources – 100% Imaged

Imaging Surveys

Sample selection

From the WMAP and PCCS catalogue(Chen et al.2013) and the ICRF2 (Fey et al.2015):

- a flat radio spectrum($\alpha \geq -0.5$) between 33 and 94 GHz.
- The flux density at 44 GHz is higher than 1 Jy
- The declination is at least -40°
- The source has never been imaged with ground based VLBI at 86 GHz.



Observation

- session I (deep imaging)

10 sources; on source time 80 minutes ; 43 and 86 GHz

Antennas – VLBA stations; 2014 November 21 to 2016 May 6

- session II (snapshot imaging survey)

40 sources; on source time 28 minutes; 43 GHz

Antennas – All VLBA stations; 2015 Jun 30 to 2016 May 2

84 sources; on source time 14 minutes; 43 GHz

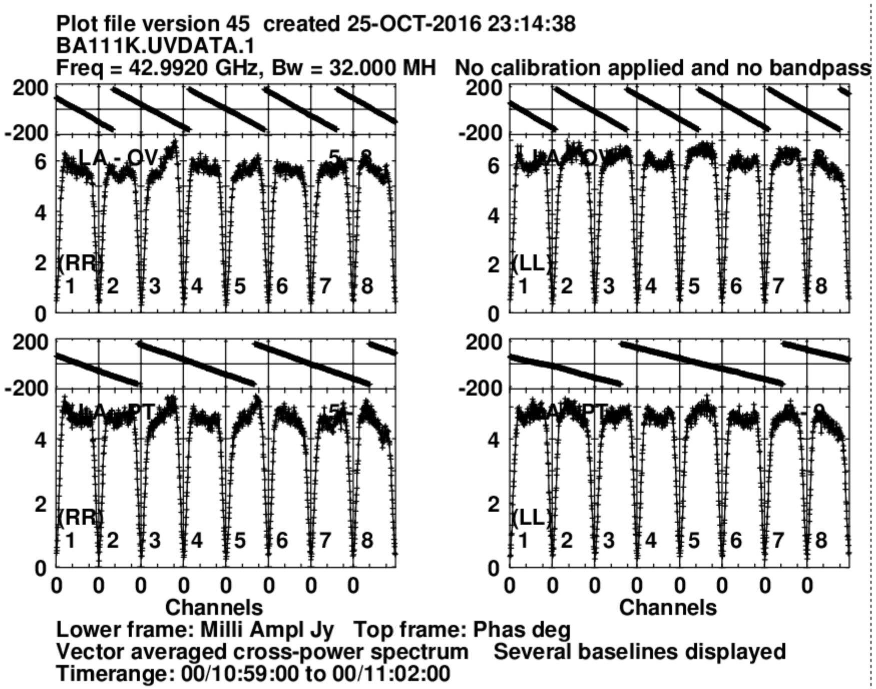
Antennas – All VLBA stations; 2015 Oct 20 to 2016 May 16

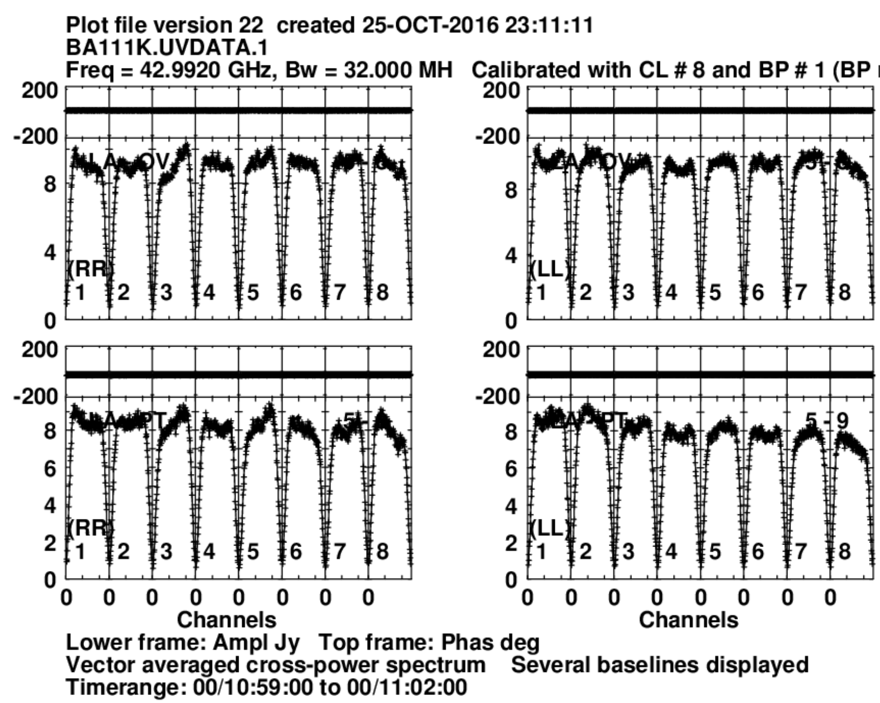
10 brightest and most compact sources at 86 GHz

- 256 MHz bandwidth; 2-bit sampling; 2 Gbps

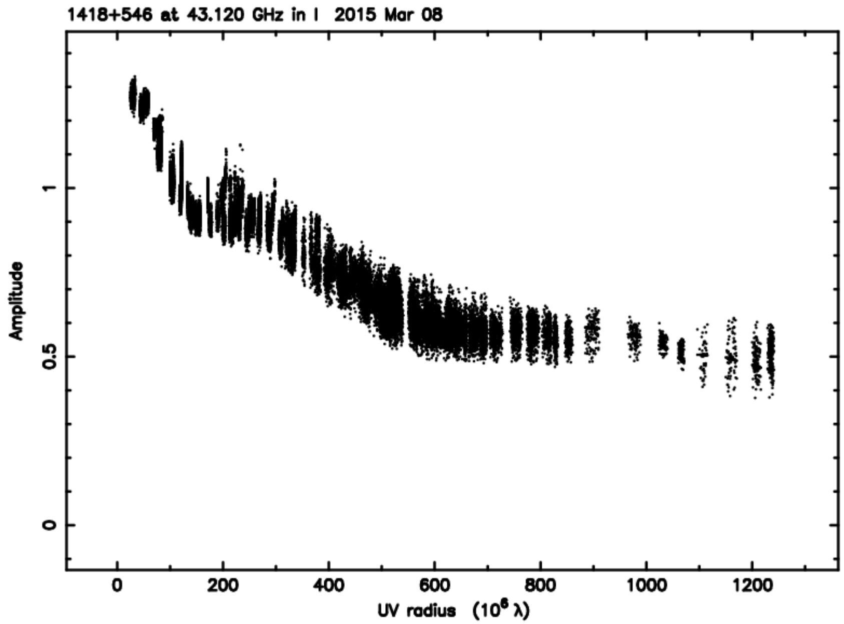
Data Processing

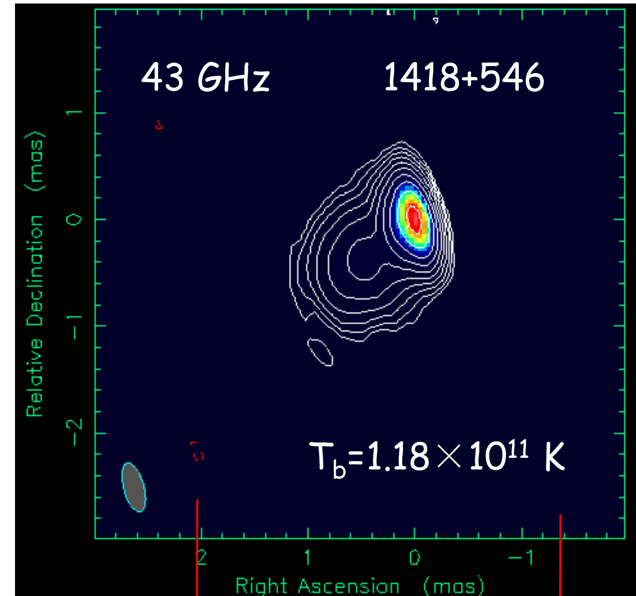
Correlation using the DIFX software correlator at Socorro → Amplitude & Fringe Calibration AIPS → Self-calibration & Imaging DIFMAP

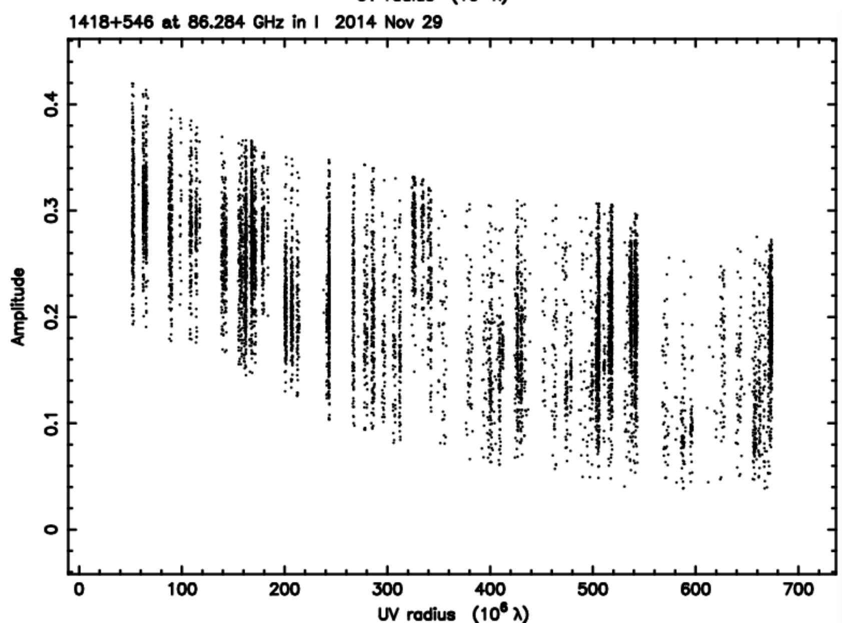


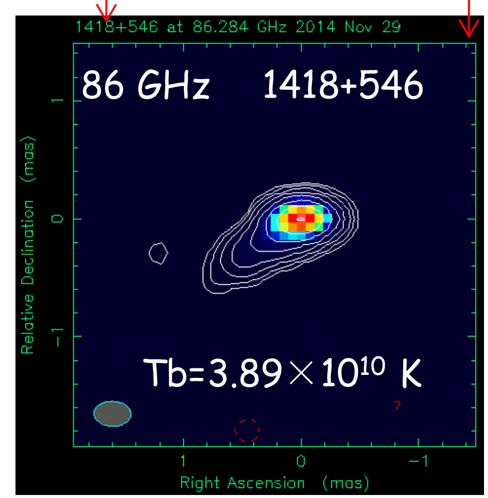


Correlated visibility and cleaned maps

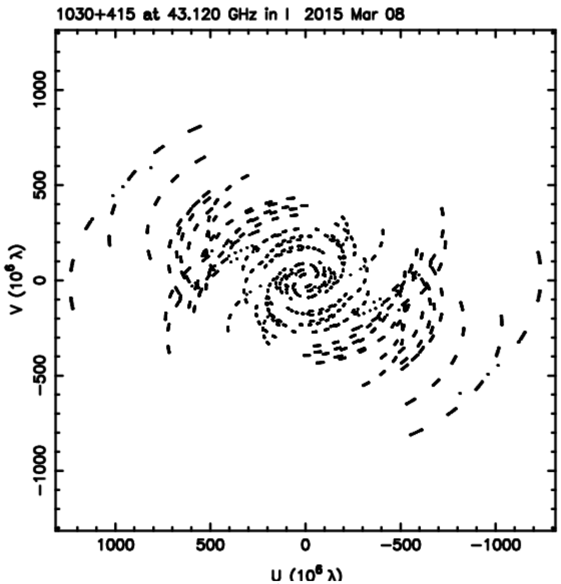


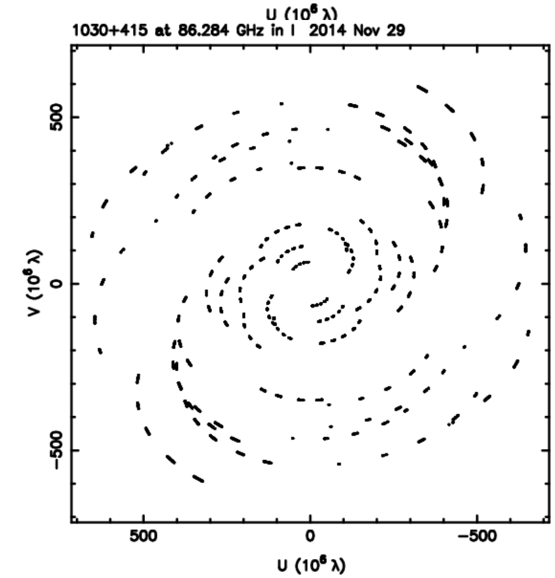


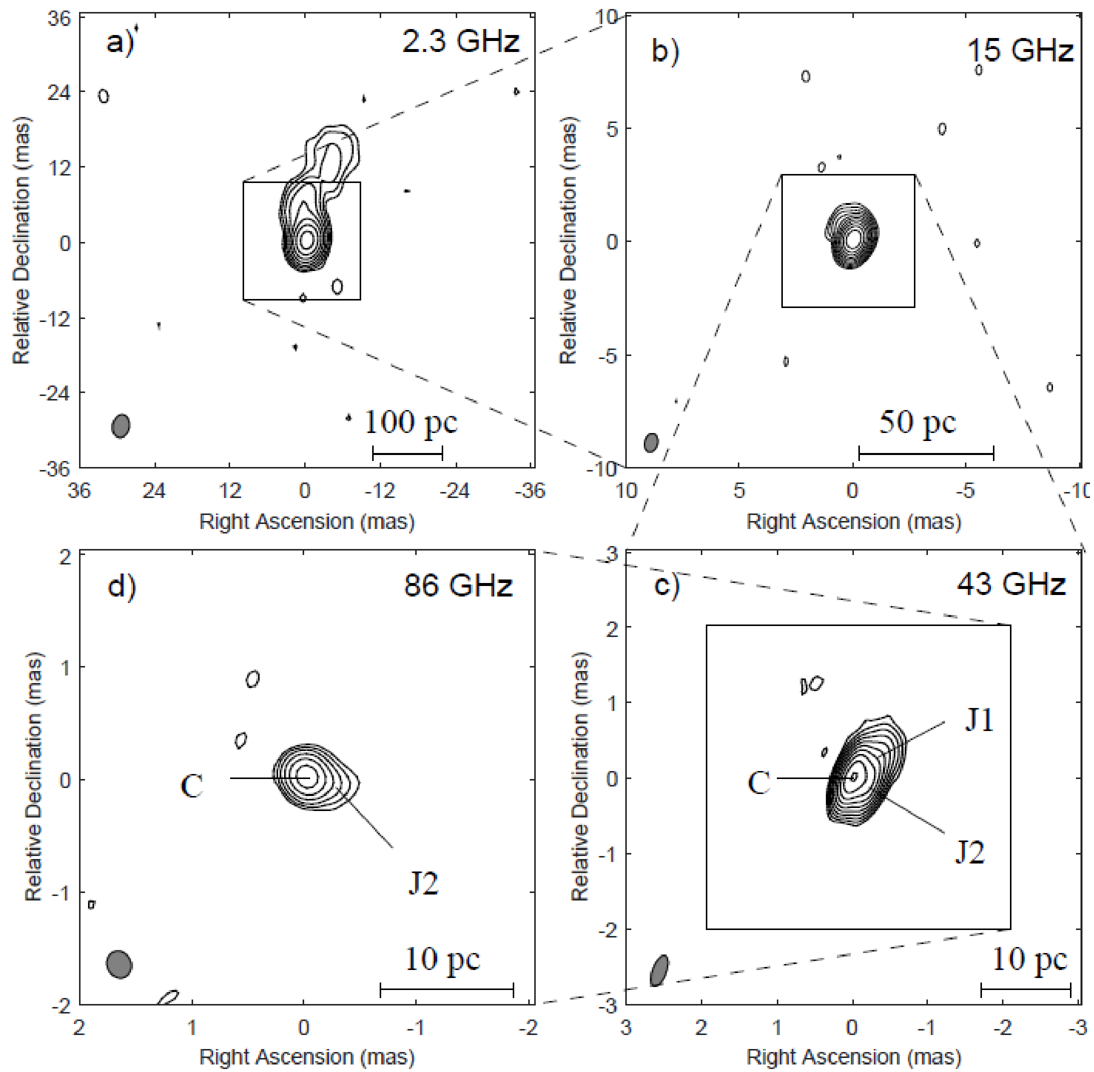




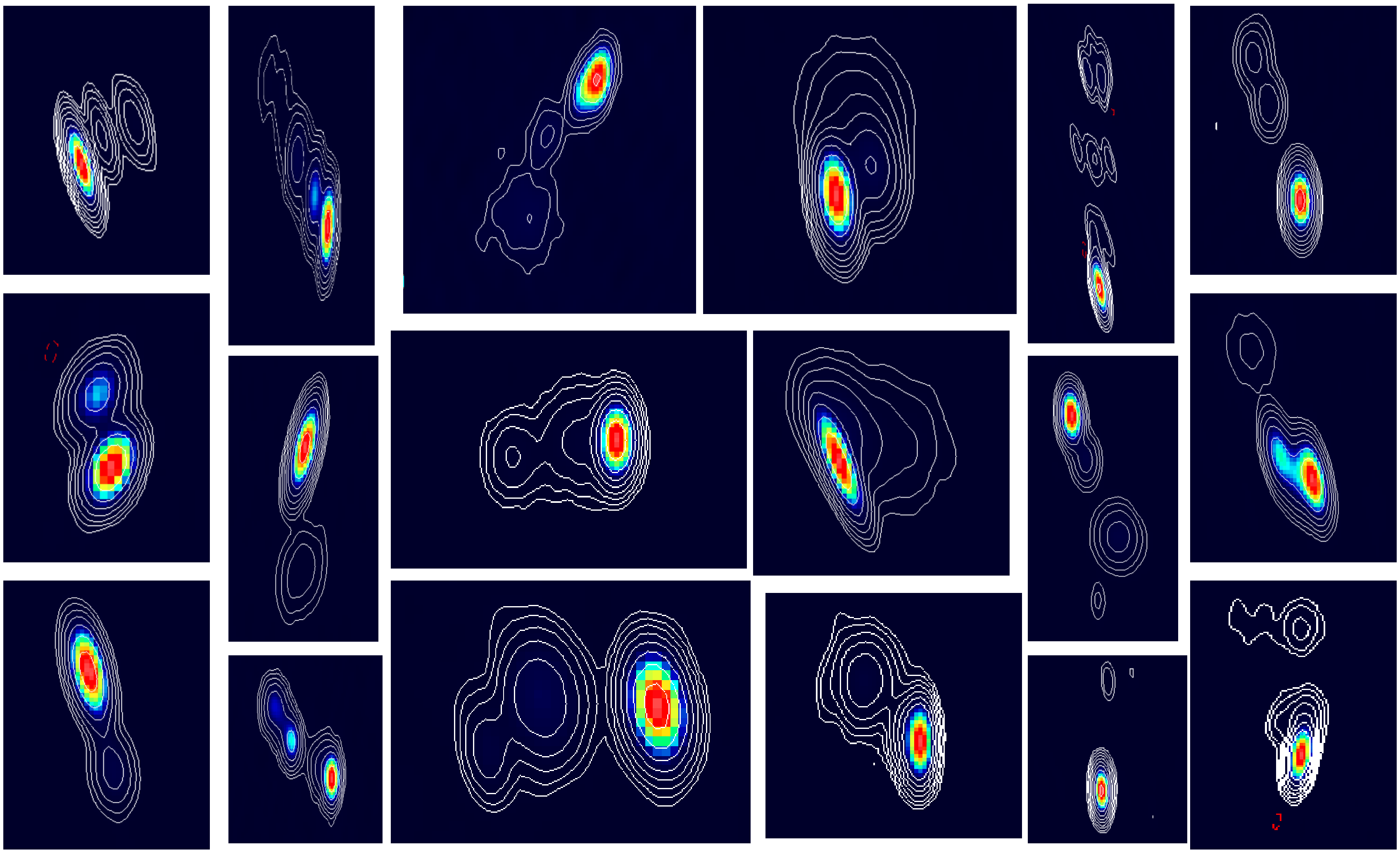
Notes on individual sources



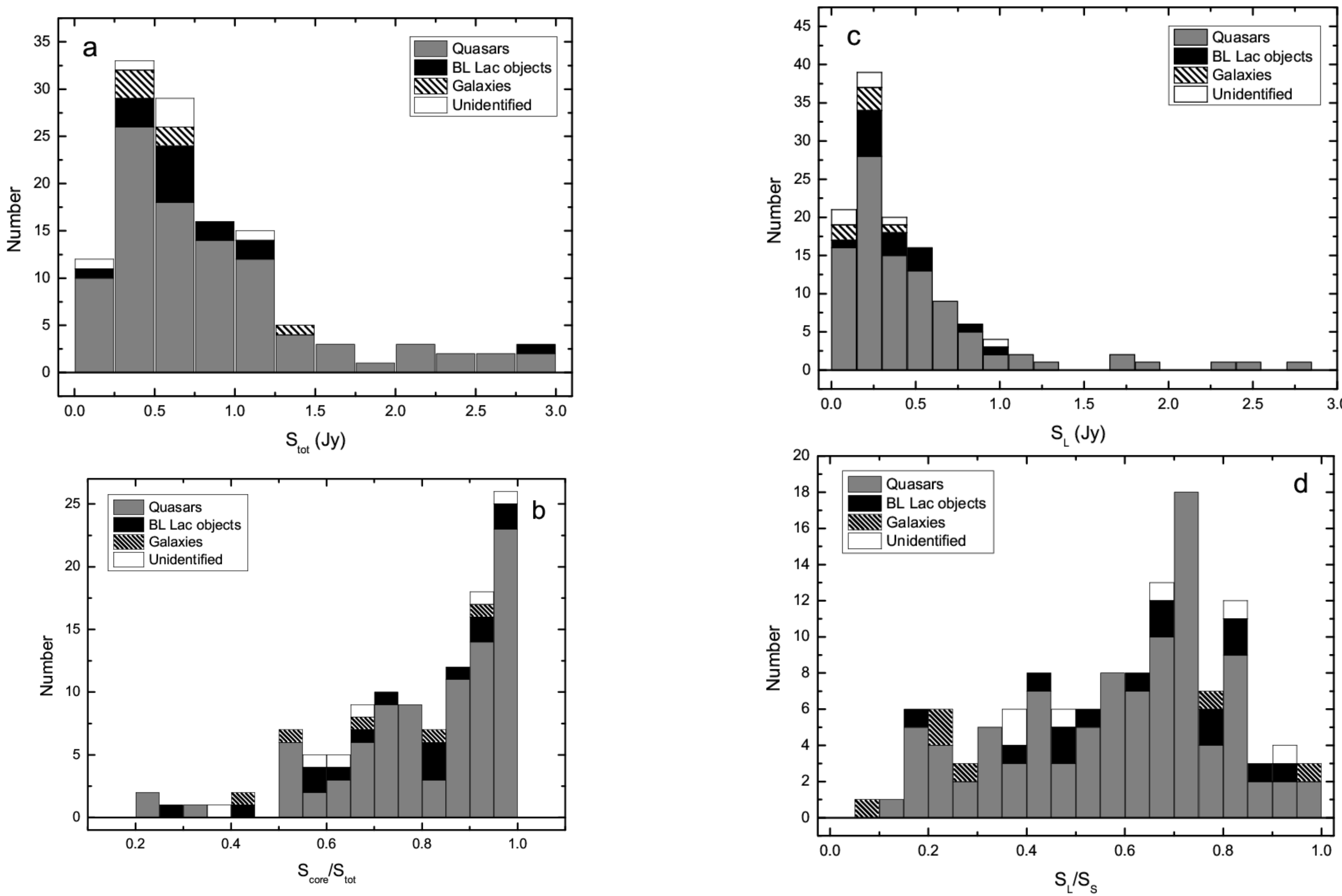




Classification of source structure



Compactness of cores



compactness on milliarcsecond scales , R = S_{core}/S_{clean}

compactness on sub-milliarcsecond scales, r = S_{long}/S_{short}

Compactness of cores

S_{core}/S_{tot} is a better indicator of the source compactness

S_L is still useful and can be used to evaluate the correlated flux density on long baseline.

S_{tot} contain a bright, compact component

$S_L > 150$ mJy
$S_{tot} > 300$ mJy
$R > 0.5$

→

Choose **95** candidates for space Very Long Baseline Interferometry (VLBI) observations at mm wavelengths !

Brightness temperature (T_B)

$$T_b = \frac{2\ln 2}{\pi K_B} \cdot \frac{S_{tot}\lambda^2(1+z)}{d^2}$$

If $d < d_{min}$, then the lower limit of Tb is obtained with $d = d_{min}$.

minimum resolvable size of a gaussian model component in an image is given →

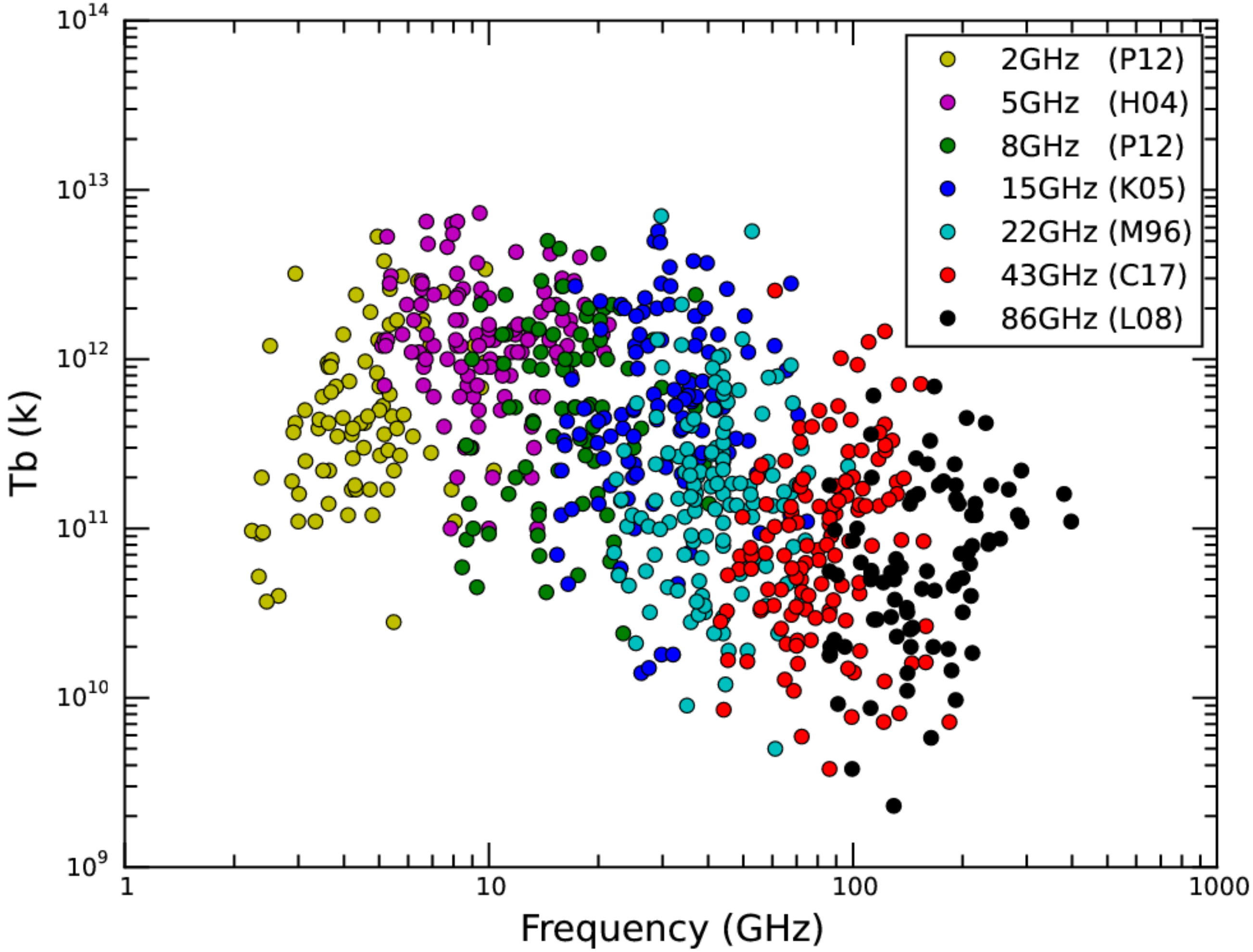
$$d_{min} = \frac{2^{1+\beta/2}}{\pi}\left[\pi ab \ln 2 \ln \frac{(S/N)}{(S/N - 1)}\right]^{1/2}$$

(A.P. Lobanov 2005)

β is 0 for natural weight or 2 for uniform weight;

a × b - Beam size; S/N is signal-to-noise ratio

Core brightness temperature distribution



1、Large scattering

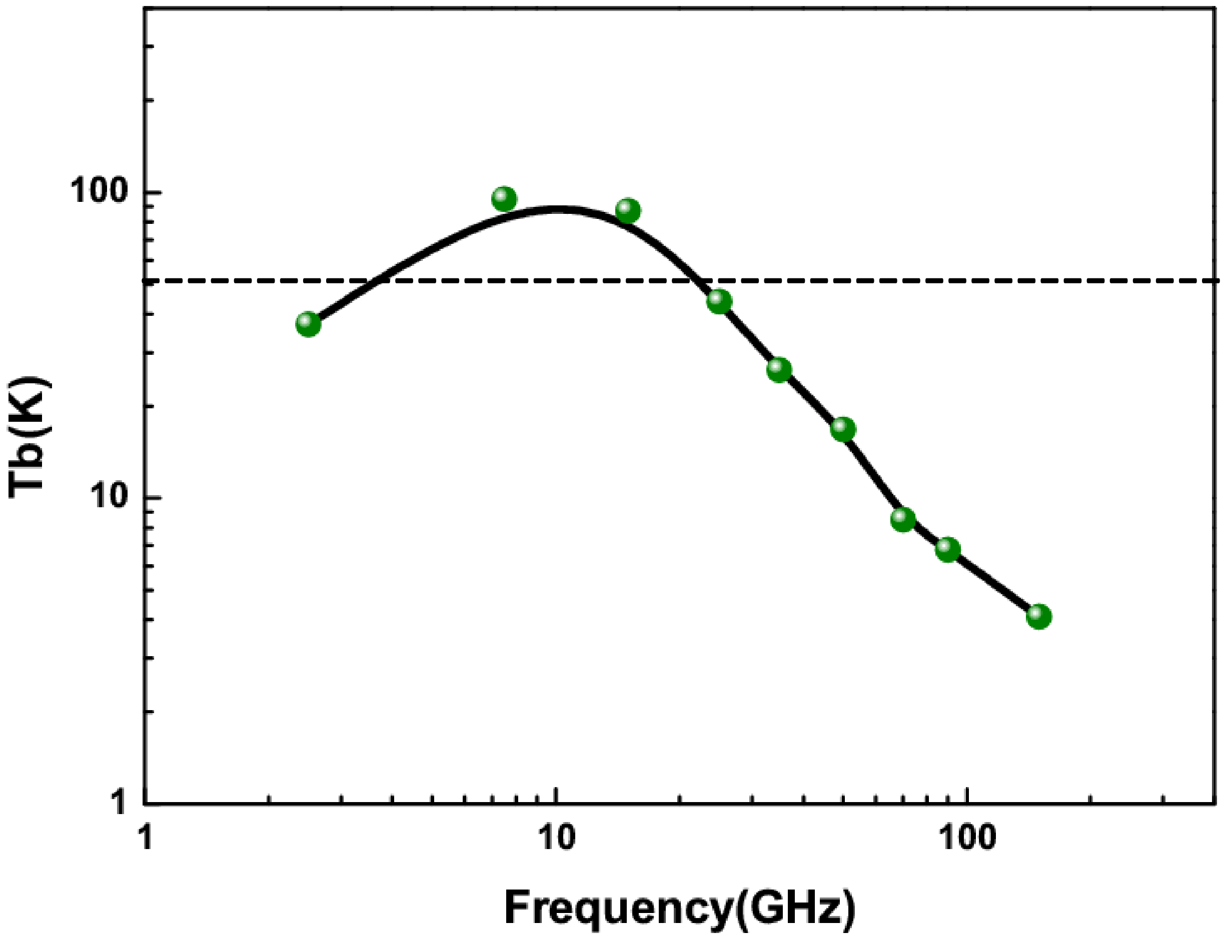
2、5 GHz VSOP data

3、flat distribution until 40 GHz

4、decreasing from 40 GHz to 200 GHz

5、need more higher frequency data

Core brightness temperature distribution



Freq.	Tb
2.5	37
7.5	97
15	87
25	44
35	26.3
50	16.8
70	8.5
90	6.8
150	4.1

smoothly broken power-law function:

$$T_0(\nu) = T_{0,\mathrm{j}} \left[\left(\frac{\nu}{\nu_\mathrm{j}} \right)^{\alpha_1 n} + \left(\frac{\nu}{\nu_\mathrm{j}} \right)^{\alpha_2 n} \right]^{-1/n}$$

correlation between radio and γ-ray emissions

- 73 sources have included in the third Fermi catalog

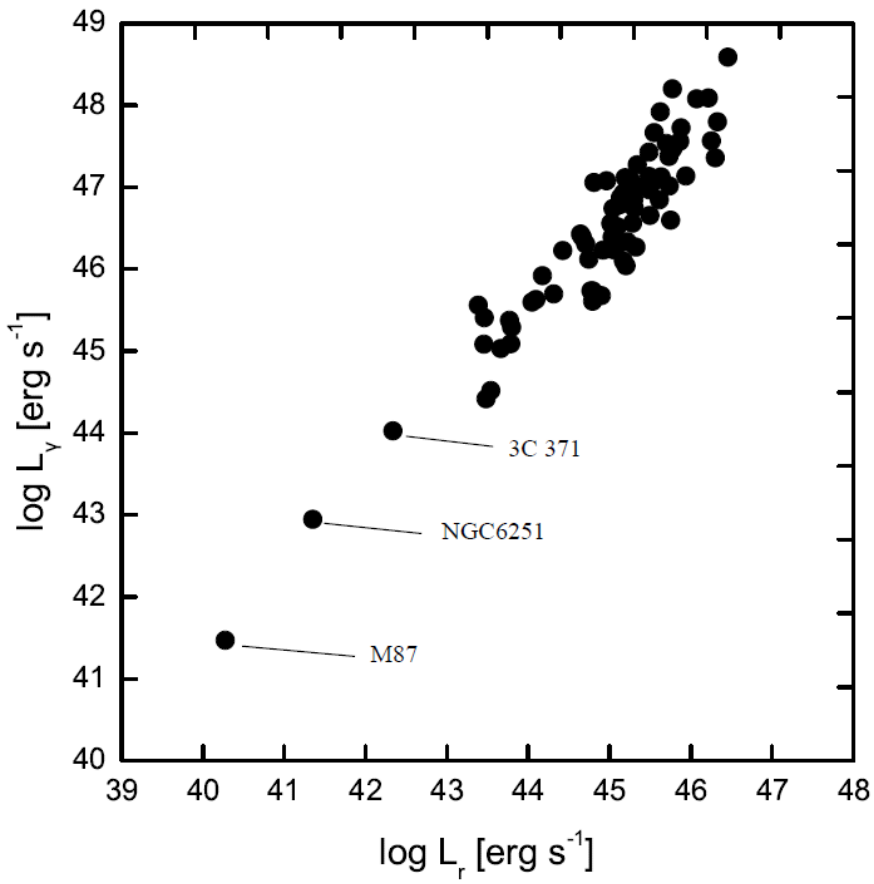
- Previous study reveal the correlation existing (Fan et al.2016, Ackermann et al.2011, Ghirlanda et al. 2010, Nieppola et al. 2011)

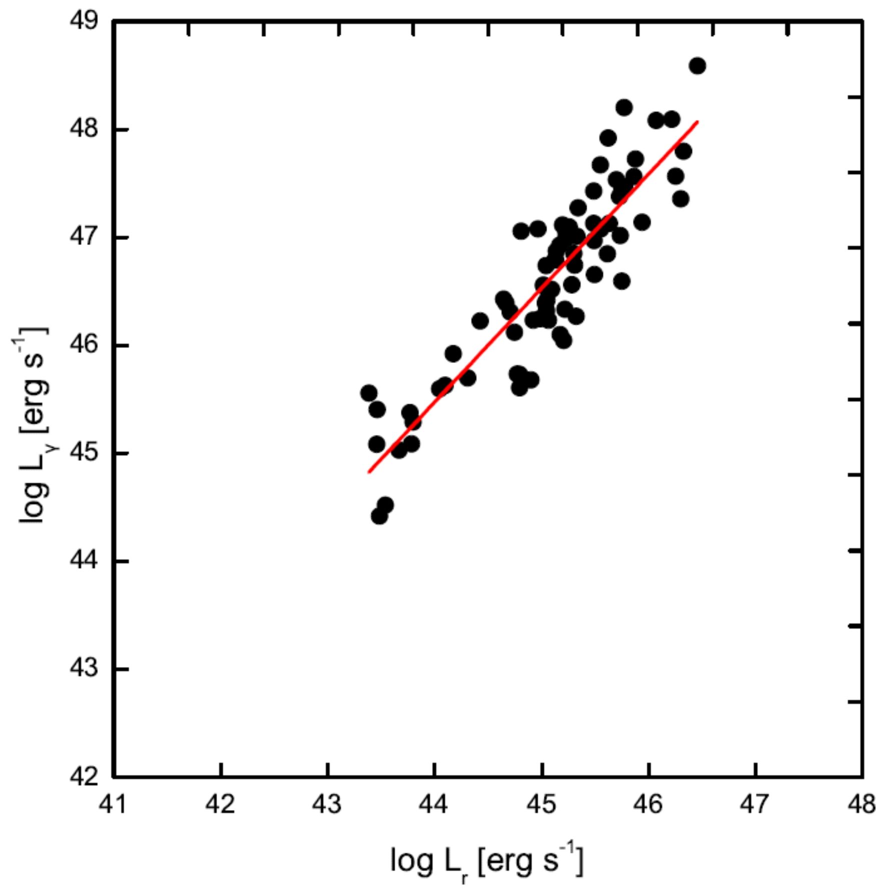
- Formula:

$$L_{radio} = 4\pi d_L^2 \, \nu S_\nu$$

$$L_\gamma = 4\pi d_L^2 \, F_\gamma(\nu_1, \nu_2)/(1+z)^{2-\Gamma}$$

correlation between radio and -ray emissions





Summary

1. This survey is detected and imaged 100% of the 134 sources at 43 GHz and 20 sources at 86 GHz.

2. From the distribution of source compactness on milliarcsecond scales (R) and sub-milliarcsecond (r) scales, 95 sources are suitable for the future space VLBI array.

3. We estimated brightness temperature (T_b) using the parameters of the components.

4. Our luminosity correlation is consistent with the previous work but shows the stronger correlation coefficient.

Outlook

Choose some suitable sources from our sample for new observations with the EAVN