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86 GHz VLBI surveys of compact radio sources.

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Abstract. We present here our ongoing VLBI survey of compact radio sources at 86 GHz, and compare it with earlier VLBI surveys made at this frequency. The ongoing survey will increase the total number of objects imaged at 86 GHz by a factor of 3–5 (with a baseline sensitivity of ≈ 0.1 Jy and image sensitivity of better than 10 mJy/beam). Such an expanded 86 GHz database will be essential for implementation of the VLBI technique in space and at shorter wavelengths. The survey data will also advance both observational and theoretical studies of extragalactic jets, since it probes those regions of extragalactic jets where radio emission reflects the dynamics and physics of the central engine of AGN.

1. Introduction

Continuum VLBI observations at 86 GHz have been made since 1981 (Readhead et al. 1983), and have enabled probing the most compact regions in AGN. However, the number of objects detected and imaged at 86 GHz has remained small, compared with the number of objects imaged with VLBI at lower frequencies. Four detection and imaging surveys have been undertaken to date, with a total of 125 extragalactic radio sources observed at 86 GHz. Fringes have been detected in 36 objects, and only 17 radio sources have been successfully imaged. An overview of the VLBI surveys at 86 GHz is given in Table 1.

The low detection and imaging rates of the existing 86 GHz surveys have been caused by the relatively poor baseline sensitivities, small numbers of telescopes and short observing times. At present, up to 12 antennas can be made available for VLBI observations at 86 GHz, and the baseline sensitivity can be improved by a factor of ≈ 4 ($\Delta S = 0.1$ Jy, for the Effelsberg – Pico Veleta baseline, 128 MHz bandwidth and 30 sec integration time). Likewise, the image sensitivity of snapshot observations with 12 antennas can be made better by a factor of ≈ 3, compared to the existing surveys (a typical *uv*–coverage of such an observation is shown in Figure 1). Such an improvement in baseline and image sensitivity can bring the 86 GHz VLBI database to a state comparable with the VLBI imaging surveys at lower frequencies (e.g. the VLBA survey at 15 GHz which contains about 120 objects; Kellermann et al. 1998). In October 2001 we started a new, large VLBI survey at 86 GHz aimed at obtaining snapshot images of more than 100 compact radio sources. The source selection for the survey is based on the results from the VLBI surveys at 22 GHz (Moellenbrock et al. 1996), 15 GHz (Kellermann et al. 1998), and on the multi-frequency monitoring data from Metsahovi at 22, 37, and 86 GHz (Teräsranta et al. 1998) and from Pico Veleta at 90, 150, and 230 GHz (Ungerechts, priv. comm.). Using these databases, we have selected the sources with expected flux density above ∼ 0.3 Jy at 86 GHz.

Table 1. VLBI surveys at 86 GHz.

Ref. (1)	$N_{\rm ant}$ (2)	ΔS (3)	$\Delta I_{\rm m}$ (4)	$D_{\rm img}$ (5)	$N_{\rm obs}$ (6)	$N_{\rm det}$ (7)	$N_{\rm img}$ (8)
1	3	∼ 0.5	...	...	51	12	...
2	2–5	∼ 0.7	...	...	79	14	...
3	6–9	∼ 0.5	∼ 30	70	68	16	12
4	3–5	∼ 0.4	∼ 20	100	28	26	14
Total number of unique objects:					127	36	17
Estimated properties of the ongoing survey:							
	12	∼ 0.2	≤ 10	300	100	90	90

Columns: 1 – reference; 2 – number of participating antennae; 3 – average baseline sensitivity [Jy]; 4 – average image sensitivity [mJy/beam]; 5 – typical dynamic range of images; 6 – number of objects observed; 7 – number of objects detected; 8 – number of objects imaged. **References:** 1 – Beasley et al. (1996); 2 – Lonsdale et al. (1998); 3 – Rantakyrö et al. (1998); 4 – Lobanov et al. (2000).

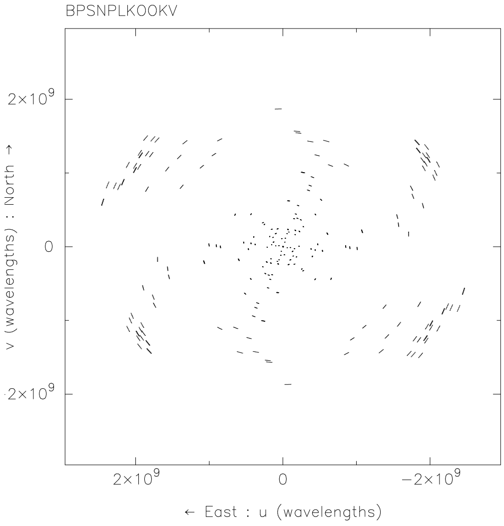

Fig. 1. A typical *uv*–coverage expected to be obtained in the survey observations (the declination is 60° in this example).

Table 2. Session log of the survey.

Part	Date	Status	$N^{\dagger}_{\rm obs}$	$N^{\ddagger}_{\rm det}$	$S^{\S}_{\rm noise}$
A	Oct 2001	correlated	49	46	58 ± 9
B	Apr 2002	observed	44	*>40*	*∼60*
C	Oct 2002	to be scheduled	*∼30*	*>26*	*∼60*

Notes: Italics denote expected values. Symbols are:† – observed sources; ‡ – sources with fringes detected; § – average noise level of fringe detections [mJy].

2. Current status of the survey observations

The survey observations consist of three parts. Part A and Part B of the survey have been done during the CMVA[1] observing sessions in October 2001 and April 2002, respectively. The third part should be observed in October 2002. A total of 71 different sources have been observed so far (for several objects two observations were made). The parameters of the observing sessions are listed in Table 2. In Part A, 46 out of 49 sources observed have yielded fringe detections with SNR> 6. Figure 2 shows a histogram of the distribution of fringe SNR in the Part A data.

3. Physics of compact extragalactic radio sources

One of the prime goals of the survey is to study in detail the distribution of observed brightness temperatures, $T_{\rm b}$, and compare it with the $T_{\rm b}$ distributions measured at lower frequencies. Such studies help constrain the bulk Lorentz factor of the jet plasma and the intrinsic brightness temperature, T_0, of the radio emission, using different types of population models of the jets (Lobanov et al. 2000, Medici & Lobanov, *these proceedings*).

The existing sample of sources with $T_{\rm b}$ measured at 86 GHz (Lobanov et al. 2000) yields estimates of $T_0 \leq 5\times10^{10}$K in the moving jet features, and $T_0 \sim 1$–4×10^{11}K in the VLBI cores (Figure 3). The same analysis applied to brightness temperatures measured in a larger database of 132 objects observed with VLBI at 15 GHz (Kellermann et al. 1998) gives $T_0 = (5.3 \pm 0.6) \times 10^{11}$K for the VLBI cores (Lobanov et al. 2000). If the difference between the T_0 determined at 15 and 86 GHz is real, this may have strong implications for the physics of jets. If T_0 decreases at $\nu_{\rm obs} \geq 86$ GHz, there will be only a few sources suitable for VLBI at 215 GHz and higher frequencies. Such a decrease of T_0 will also provide an argument in favor of the decelerating jet model or particle–cascade models as discussed by Marscher (1995). With improved population models (see Medici & Lobanov, *these proceedings*), it should ultimately become possible to distinguish between accelerating and decelerating jet models.

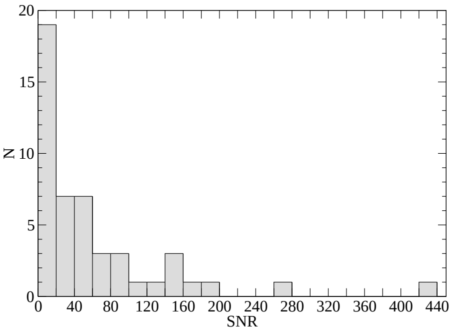

Fig. 2. Histogram of the fringe SNR distribution in the data from Part A of the survey.

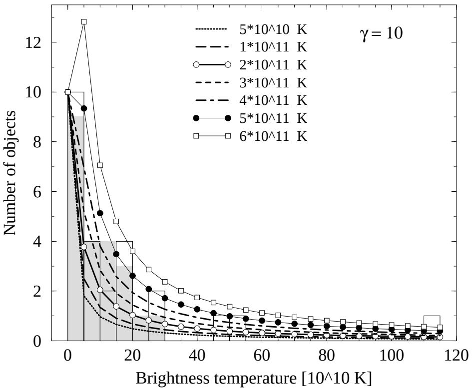

Fig. 3. Distribution of the brightness temperatures measured in the VLBI cores at 86 GHz. Curved lines show the predicted distributions in a sample of randomly oriented jets with a given intrinsic brightness temperature, T_0. The best fit of the observed distribution is given by a population of jets with intrinsic brightness temperatures $T_0 \sim 1$–4×10^{11}K. (Lobanov et al. 2000)

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[1] The Coordinated Millimeter VLBI Array administered by the MIT Haystack Observatory