VLBA PROPOSAL COVERSHEET

DEADLINES: 1st of Feb., June, Oct.

rcvd:

(1) Date Prepared: October 3, 2005

(2) Title of Proposal: Northern Polar Cap VLBA Survey

(3) AUTHORS (Add * for new location)	INSTITUTION	E-mail	Students Only G/U	For Thesis?	Ph.D. Year
Y.Y. Kovalev	NRAO, GB	ykovalev@nrao.edu			
L. Petrov	NVI, Inc./NASA GSFC	Leonid.Petrov@lpetrov.net			
E. B. Fomalont	NRAO, CV	efomalon@nrao.edu			
D. Gordon	Raytheon/NASA GSFC	dgg@leo.gsfc.nasa.gov			

(4) Related previous or current VLBI proposal(s): BB023, BF071, BP110, BP118, BK124 ◯ Resubmission

(5) Contact author for scheduling: Ed Fomalont
Address: NRAO, 520 Edgemont Road,
Charlottesville, VA 22903–2475
email: efomalon@nrao.edu

(6) Telephone: +1-434-296-0232
Fax: +1-434-296-0278

(7) Scientific Category: ◯ astrometry & geodesy ◯ galactic ⊗ extragalactic ◯ other:

Rapid Response Science: ◯ Known Transient ◯ Exploratory ◯ Target of Opportunity

(8) Wavelength(s) requested (those not available on the global network are indicated with a small circle):
◯ 90cm ◯ 50cm ◯ 30cm ◯ 21cm ◯ 18cm ◯ 13cm ◯ 6cm ◯ 5cm ◯ 3.6cm ⊗ 3.6/13cm
◯ 2cm ◯ 1.3cm ◯ 7mm ◯ 3mm
◯ Global Network standard bands ◯ Special frequencies:__________

(9) Recording format: ⊗ Default continuum setup (VLBA only), ◯ VLBA/MkIV, ◯ MkIII: Mode______
Bandwidth per BaseBand channel: ______
Aggregate bit rate: ______ (______ BB channels at ______ MSamples/sec of ◯ 1 bit, ◯ 2 bit)

(10) ◯ Multi-epoch observation: ______ epochs of ______ hours each, separated by ______

(11) Network	Requested antennas	Total time requested
EVN & MERLIN		
VLBA	ALL	3×24 hours
other NRAO		
Non-VLBI Instruments		

(12) ABSTRACT (Do not write outside this space. Please type)

We request three 24 hour sessions with the VLBA for S/X observing *a complete sample* of 500 sources in the zone with $\delta > +75°$ with flux density > 200 mJy at 1.4 GHz regardless their spectral index value. Almost all previous VLBI surveys selectively observed flat spectrum sources and this limits the statistical studies to the classes of sources with relatively dominant cores. We expect to detect compact steep spectrum sources, FR I and FR II sources with radio cores, as well as core-dominated sources. With S/X observations, we will also obtain spectral information of the structure. The statistical studies will determine an unbiased estimate of the role of compact emission in all sources. The VLBA data will be supplemented by total instantaneous 2–22 GHz broad-band spectra measured at RATAN–600 in 2005. This will allow direct comparison of the parsec scale structure and compactness versus the continuum spectra.

Scheduler use only
(8/03)

(13) Observation type: ⊗ Interferometry, ◯ Spectroscopy, ◯ Pulsar, ◯ Phase referencing

(14) Proposal is ⊗ Suitable for dynamic scheduling.

(15) Polarization: ⊗ Single Polarization ◯ Dual Circular Polarization
Global network standard for single polarization is LCP for all λs except 13cm (RCP) and 3.6cm (RCP).

(16) Tape usage (Show <recording time>/<total time>): ________

(17) Assistance required:
Observation Setup: ◯ Consultation, ◯ Extensive help, ◯ Observe file preparation
Postprocessing: ◯ Consultation, ◯ Extensive help, ◯ Calibration service

(18) Processor: ⊗ Socorro, ◯ JIVE, ◯ Haystack, ◯ Bonn, ◯ Washington, ◯ Other______________
Special processing: ◯ XPol, ◯ Pulsar gate, ◯ Multiple Fields: ________
Averaging time: 1 sec Spectral channels per baseband channel: 64
◯ Other special processing: ____

(19) Postprocessing Location: NRAO-CV, NRAO-GB, GSFC

(20) Source list: ◯ J2000 ◯ B1950
If more than 4 sources, please attach list. If more than 30, give only selection criteria and GST range(s)

	Source 1	Source 2	Source 3	Source 4
Name(s)	ALL SKY			
RA (hh mm)	0–24h			
Dec (dd.d)	+75d to +90d			
GST range (Europe)				
GST range (US)	0–24h			
GST range (Other)				
Band(s)	S/X			
Flux density (Total, Jy)	>40 mJy			
Flux density (correlated, mJy)	>20 mJy			
RMS needed (mJy/beam)	3–5 mJy			
Peak/RMS needed	>100:1			

(21) Preferred VLBI session or range of dates for scheduling, and why:
Three 24 hour sessions.

(22) Dates which are NOT acceptable, and why:

(23) Attach a self-contained scientific justification, not in excess of 1000 words.
Preprints or reprints will not be forwarded to the referees.

Information about the capabilities of the VLBA may be found on the World Wide Web by starting at the NRAO home page, http://www.nrao.edu, and selecting the VLBA from "Sites and Telescopes."

A brief summary of the capabilities of the EVN antennas is given in the EVN STATUS TABLE in the EVN USER GUIDE, which may be found at http://www.evlbi.org/user_guide/user_guide.html.

Please include the full postal addresses for first-time users or for those that have moved (if not contact author).

Northern Polar Cap VLBA Survey

1 Summary

The focus of this proposal is to make a statistical study of the compact emission of *all* sources down to a relatively low level of flux density. All previous large VLBI surveys selectively observed flat spectrum sources that are nearly all core-dominated. We expect to image an unbiased sample of compact steep spectrum sources (CSS) and extended FR I and FR II sources with radio core.

In order to achieve the proper sample for study, we request three 24 hour sessions for observing with the VLBA at S/X bands of *a complete sample* of 500 sources in the zone $\delta > +75°$ with NVSS flux density > 200 mJy at 1.4 GHz *regardless their spectral indexes*. The VLBA results will be supplemented by instantaneous broad-band spectra measured in 2005 at RATAN–600 in the 2–22 GHz frequency range including S and X bands. This will allow direct comparison of the parsec scale structure and compactness versus the total flux density continuum spectra. We will propose VLBA follow-up observations for identified CSS at a later date in order to produce and analyze higher dynamic range mas-scale images than the once resulting from this search experiment.

2 Previous Observations

From the previous 1994–2005 VLBA observations in the framework of the VLBA Calibrator survey (projects BB 023, BF 071, BP 110, BP 118, BK 124) and 53 RDV observing sessions, positions of 3331 sources were determined and images of more than 2400 objects were produced (Beasley et al. 2002; Fomalont et al. 2003, Petrov et al. 2005a, Petrov et al. 2005b, Kovalev et al, in preparation). Among them, a subset of ∼2000 objects with $\delta > -30°$ forms a homogeneous, reasonably complete (>95%) sample of flat-spectrum sources with correlated flux density greater than 200 mJy at 8 GHz.

Completeness of the sample and uniformity of the data reduction permits robust statistical analysis of this population of bright compact flat spectrum sources, such as: population modeling of the observed core brightness temperature in order to estimate distributions of the intrinsic core brightness temperature, the viewing angle, and Doppler brightening; expanding the cosmological significance of core-jet angular size versus redshift distribution, comparing the compactness of radio structures with IDV properties; correlating the radio core properties with optical class; etc.

However, the selection of candidates for the VLBA Calibrator surveys and the RDV programs was focused on observing the sources with a spectrum flatter than −0.5 ($S \sim \nu^{+\alpha}$), which comprise approximately 15% of the entire population of radio sources at centimeter wavelengths. This spectral criterion guarantees that a large proportion of sources will be detected with mas-resolution. This spectral selectiveness is common for almost all previous VLBI surveys and future large VLBA surveys (e.g., VIPS, Taylor et al. 2005, to start in 2006). There are two exceptions, the PR+CJ1 and the Bologna samples.

The PR+CJ1 sample (e.g., Person & Readhead 1988, Xu et al. 1995) includes all sources with flux density > 0.7 Jy at 5 GHz. Unfortunately, only 128 out of 200 were observed with VLBI, so the sample of observed sources is complete only at the 64% level.

Another complete sample of sources, regardless of spectral index value, is the Bologna sample of 95 objects (Giovanni et al. 2004). However this sample, first, limits the objects with redshift $z < 0.1$, secondly, only a fraction of these objects has been observed with VLBI. Nevertheless, even preliminary results showed that statistics based on flat-spectrum samples may not give a valid role of compact emission in galaxies and quasars since they "found a dramatically higher fraction of two-sided sources in comparison with that of previous flux-limited VLBI survey."

We analyzed statistics of 3989 sources observed in 21 VLBA Calibrator survey experiments, 53 VLBA RDV experiments and 3941 Mark3/Mark4 experiments for geodesy and astrometry and compared it with the complete NVSS catalog (Condon et al. 1998). According to Table 1, only 20–30% of sources were observed even among the strong objects with the total flux density > 1 Jy at 1.4 GHz.

Table 1: Statistics of observed sources in geodesy and astrometry programs

S at 1.4 GHz, Jy	# total in NVSS	# observed	# detected
>5.0	167	50	44
>2.0	727	198	179
>1.0	2206	485	446

3 Scientific Goals

The scientific goal of the proposed campaign is to perform a statistical study of the complete sample of all 500 objects with NVSS flux density at 1.4 GHz > 200 mJy in the area of 0.21 srad around the northern celestial pole. This sample was chosen because it has been observed with the Russian transit mode radio telescope RATAN–600 in 2005, and simultaneous measurements of total flux density at 2, 5, 8, 11, and 22 GHz are available (Mingaliev et al. 2001, 2005, in preparation).

The proposed observations will identify those sources from this sample which have compact details at the level of 20 mJy or higher at X and/or S bands. We expect that between 100 and 200 sources will be detected (this proportion is really unknown); images and positions at mas level will be obtained. Precise positions will enable performing reliable optical identification and follow-up VLBA studies which are planned for detected sources with mas-scale components.

Analysis of this sample should provide insight into the following questions:

- What is the share of CSS in the entire population of AGN? What percentage of compact sources are missed in flat-spectrum surveys? What proportion of the detected sources are radio cores of FR I and FR II sources?
- Do these CSS that have an overall steeper spectrum have different morphological properties from their flatter-spectrum cousins?
- Do CSS counts and properties change to fainter flux density / luminosity level (e.g., a higher portion of compact sources at low flux density level is suggested by the VLA MASIV survey results, Lovell et al. 2003)?
- What is the relationship between the total spectrum of CSS from the RATAN supporting observations and the spectrum of compact components? Are differences related to ageing?
- What is the probability that a source with a given spectral index and total flux density will have a given compactness?

Finally, results of this campaign will allow us to determine the true distribution of compact emission and its spectral properties for an unbiased complete sample of sources. This knowledge will allow us to assess whether conclusions drawn from VLBI surveys of flat-spectrum sources can be extended to the whole population of extragalactic objects regardless their continuum spectrum.

4 Proposed Observations

We request three 24 hour observing sessions. Each source will be observed in one scan for 7 minutes. Eight IF channels, four in S-band and four in X-band are proposed, with a total bandwidth of 64 MHz at 1 bit sampling, 128 Mbps. We will reach the 20 mJy detection level and even with the relatively poor *uv* coverage, images will be made at both frequencies. We will determine the group delays of the detected sources and obtain better positions of the compact emission. We request the same correlator setup as in the BP 118 proposal: 64 spectral channels in each IF and integration time 1 sec. This will give us an extra-wide search window needed for fringing sources with poorly known a priori positions. Analysis of BP 118 observations showed that the a priori position errors for 20% of detected sources were greater than 1 arcsec and for 8% — greater than 5 arcsec. The observations scheme will be identical to the recent VLBA Calibrator survey experiments. The calibration and imaging will be made by using standard packages AIPS and difmap. Positions will be determined with Calc/Solve.

References

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