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DESIGN OF VLBI ARRAY IN SOUTH AMERICA

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RESUMEN. Estudiamos la localización óptima de estaciones de VLBI futuras en territorio brasileño. Con una red VLBI de estaciones reales y ficticias simulamos observaciones. Se usan los datos generados de estos experimentos para obtener la distribución de brillo de radiofuentes ficticias por medio de técnicas de mapeo híbrido. Se concluye que la mejor localización de estaciones VLBI futuras, tomando en cuenta las estaciones de EUA y de Europa, se encuentra en el Norte-Noreste de Brazil. El análisis de los datos se hizo con los programas de CALTECH, los cuales están instalados en una computadora VAX del Departamento de Astronomía del Instituto Astronómico y Geofísico de la Universidad de São Paulo.

ABSTRACT: In this work we study the optimum localization for future VLBI stations in the Brazilian territory. With a VLBI network of real and fictitious stations we make simulations of observations. The data generated in these experiments are used to obtain brightness distribution of a fictitious radio source by the hybrid mapping techniques. We conclude that the best localization of a future VLBI station taking into account the addition of US and European Stations, is roughly in North-Northeast sites in Brazil. The analysis of the data is made with the software of CALTECH, which is installed in the VAX computer of the Astronomy Department of Instituto Astronômico e Geofísico - USP.

Key words: INSTRUMENTS — INTERFEROMETRY

. INTRODUCTION

In Very Long Baseline Interferometry (VLBI), the signal received at individual ntennae is converted to the video frequency band and recorded in magnetic tapes. The data btained are cross-correlated to find the interference fringes. In designing VLBI arrays, he principal aim is to obtain the more complete and uniformly spaced uv-plane coverage, so hat the array geometry is fundamental in performing VLBI observations. The arrays used in his work are listed in table 1. The antenna with (*) are fictitious.

TABLE 1

STATION	CODE	LATITUDE (DEG)	LONGITUDE (DEG)
Itapetinga	X	-23.20	46.55
La Silla	L	-29.15	70.44
Leoncito*	L	-31.00	68.00
São Paulo*	S	-22.00	47.40
RS*	R	-30.00	51.17
Brasilia*	B	-15.73	47.86
Natal*	N	-05.79	35.21
Bonn	B	50.34	-06.88
Bologna	L	44.50	-11.30
HSTK	K	42.43	71.49
NRAO	G	38.25	79.84
OVRO	O	37.05	118.28

II. SIMULATION OF THE EXPERIMENTS. MAPPING

We want to obtain the brightness distribution of a source from the observed visibility function. These quantities are related by the Fourier Transform pairs (Clark, 1989; Sramek and Schwab, 1989), that is

$$I'(\ell,m) = \sum_{j=1}^{M} V(u_j,v_j)\, W_j \; e^{2\pi i(u_j\ell+v_j m)} \qquad (1)$$

where: $I'(\ell,m)$ is the preliminar brightness distribution or the dirty map. $V(u_j,v_j)$ is the visibility function related to the j^{th} point in the uv-plane, ℓ and m are the u and v director cosines in the source frame. W_j is the statistical weight related to the j^{th} point.

The dirty beam, that is the equivalent beam of the array is given by (1) making $V(u_j,v_j) = 1$.

$$B'(\ell,m) = \sum_{j=1}^{M} W_j \; e^{2\pi i(u_j\ell+v_j m)} \qquad (2)$$

It is clear from (1) and (2) that the success of a VLBI experiment depends strongly on the array geometry.

The locii of uv-tracks as the Earth rotates are ellipses given by (Clark, 1989)

$$u^2 + \left[\frac{V - (\frac{Lz}{\lambda})\cos\delta_o}{\sin\delta_o}\right]^2 = \frac{L_x^2 + L_y^2}{\lambda^2} \qquad (3)$$

where δ_o is the declination of the phase reference position, L_x, L_y and L_z are the coordinate differences for each baseline.

The generation and analysis of the data were made with the California Institute of Technology (CALTECH) VLBI programs (Pearson, 1987). The FAKE program simulates the observations, introducting some noise in them and the output is a data file of complex visibilities. This program gives the uv-plane coverage, also. The data generated by FAKE are used in the hybrid mapping procedure. This is an iterative technique in which one tries to estimate the fringe phases and amplitude calibration errors (Cornwell and Wilkinson, 1981). Figure (1) gives the complete sequence of the experiment. The cleaned map (CLEAN program output) can be displayed by using the MAPPLOT program, which produces the contour maps.

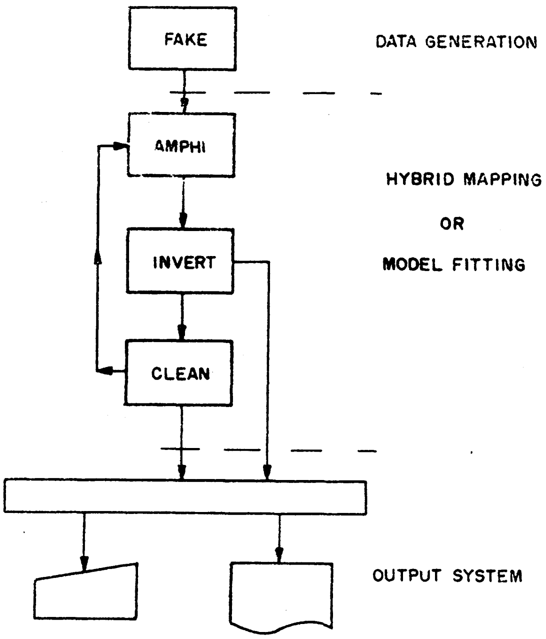

Fig. 1 - Sequence for data analysis

In all experiments we used a model with four point source components, with total flux of 15 Jy. This model represents the fictitious source named 300-5, whose coordinates are AR = 03:00:00 and DEC = -05:00:00 (fig.2).

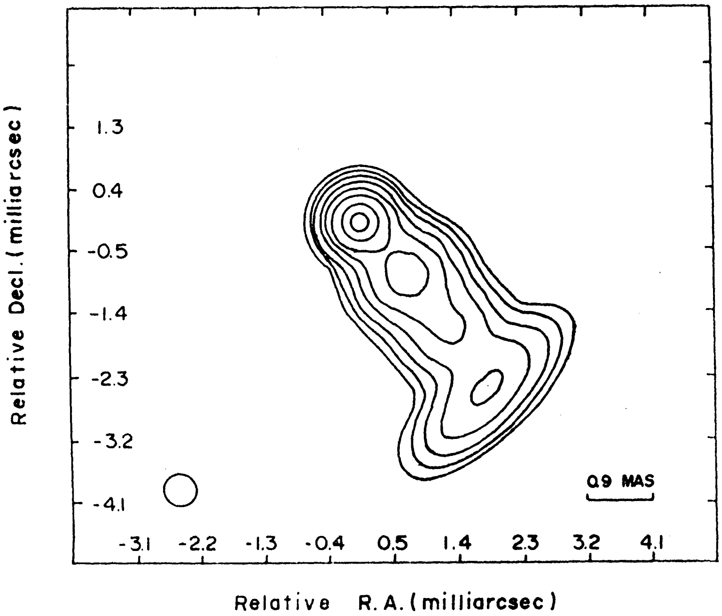

Fig. 2. Four point source components model used for mapping. Contours are -1, 1, 2, 4, 8, 16, 32, 64, 90% of the peak brightness. Total flux is 15 Jy.

III. RESULTS

We made seven simulations with the arrays listed in table 2.

TABLE 2

ARRAY NUMBER	STATION CODE
1	XLNBLKGO
2	XLSBLKGO
3	XLBBLKGO
4	XLRBLKGO
5	XLLBLKGO
6	XLLSN
7	BLKGO

The arrays 6 and 7 are southern-hemisphere and northen-hemisphere stations respectively, and were used only to analyze the effect of beam shape on the maps. In both cases the North-South resolution was very bad.

Fig. 3 represents the results using the array 1 and gives the best reproduction of the model. Fig. 3(a) is the corresponding uv-track; fig. 3(b) is the dirty-beam and fig. 3(c) is the final map after two iterations.

In fig. 4 we include the results obtained with array 2 that gives worse results. Note the gap in uv-plane. The resolution is the same as in fig. 3 because the longest baselines are mantained, but the clean-map is much noisier due to the lack of visibilities. The number of iterations and the figure sequence are the same as in fig. 3.

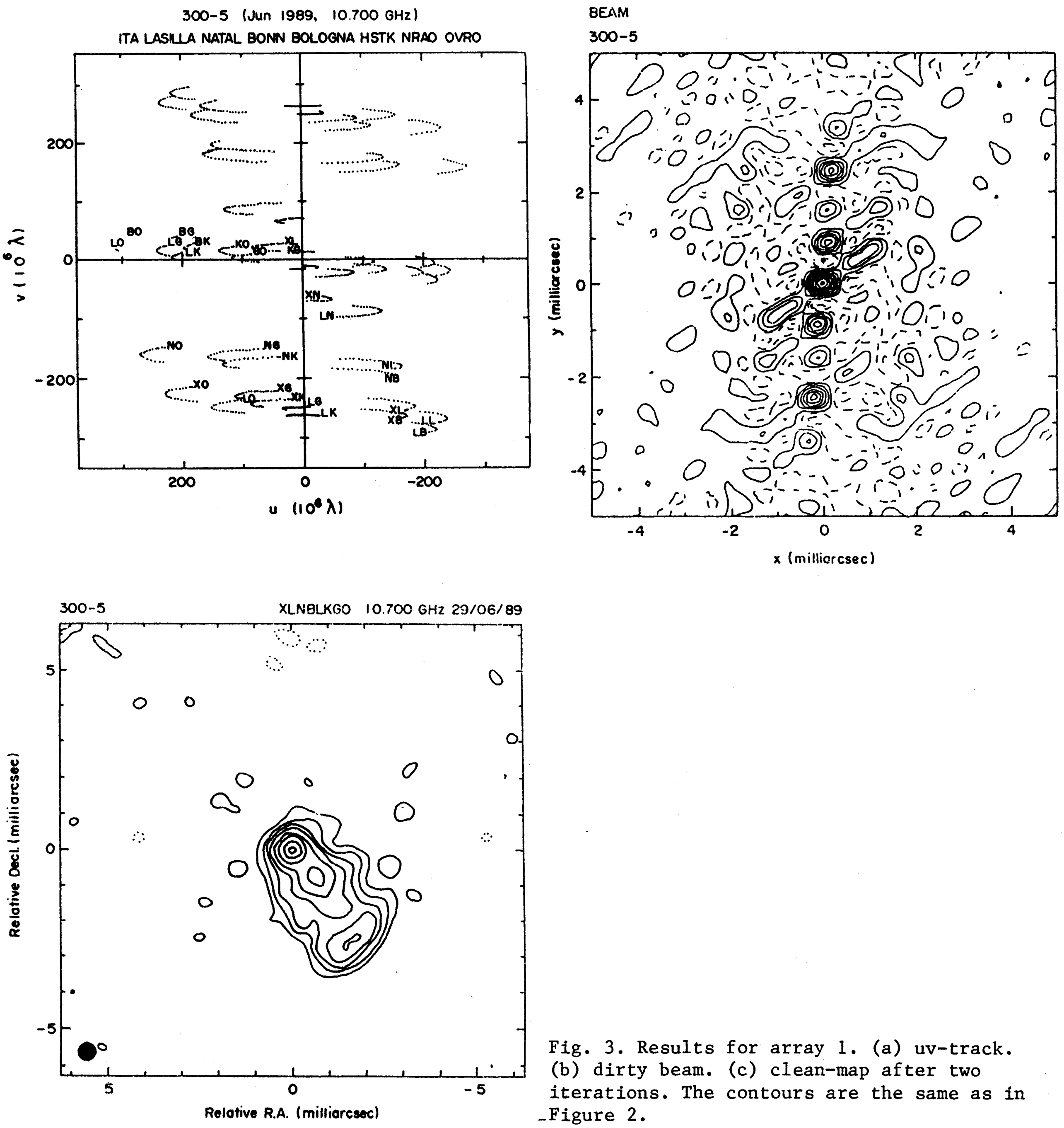

Fig. 3. Results for array 1. (a) uv-track. (b) dirty beam. (c) clean-map after two iterations. The contours are the same as in Figure 2.

We conclude that the optimum localization for a future VLBI station in Brazil using a global VLBI array is roughly in North-Northeast regions.

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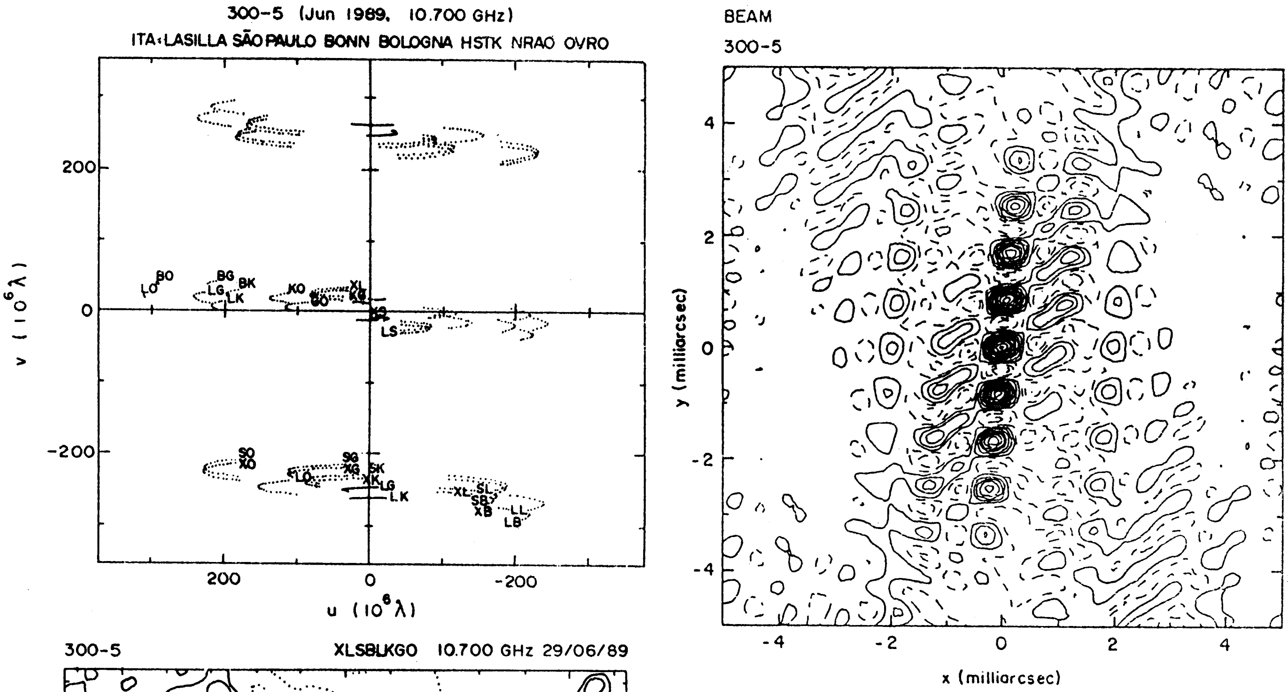

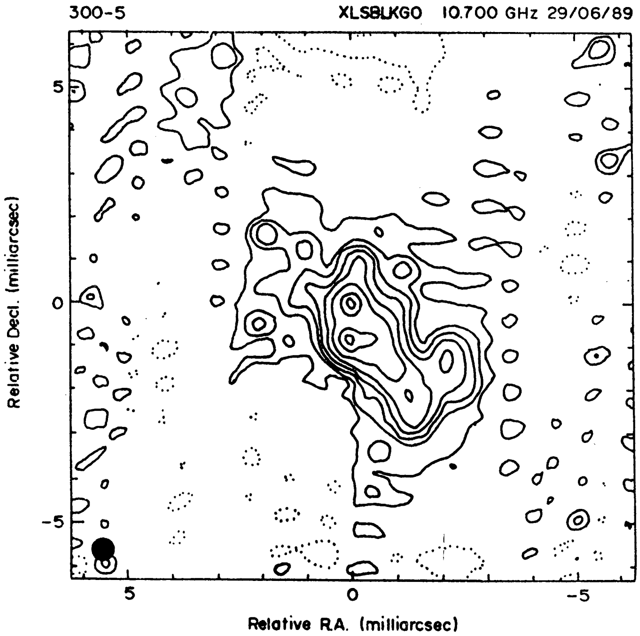

Fig. 4. Results for array 2. The sequence is that of Figure 3. The contours are the same as in Figure 2.

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