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VLA PROGRAM
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VLA TEST MEMORANDUM NO. 137

MEASUREMENTS OF BANDWIDTH SMEARING OF THE SYNTHESIZED BEAM

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I. INTRODUCTION

The deletorious effects of bandwidth on the peak response of the synthesized beam were first calculated by A.R. Thompson (VLA Electronics Memo No. 183). This work was later extended to include beam broadening by R.A. Perley (VLA Scientific Memo No. 138). Briefly reviewed, the results of these studies are that under very general assumptions, the bandwidth effect broadens the response to a point source along a line joining the position of the source to the phase center. Since the distortion is one-dimensional, no loss of generality occurs if the coordinate system is defined so the x-axis coincides with this line. The distorted profile can be calculated thus: if B(x) is the undistorted profile, and $G(\nu)$ is an appropriate average correlator pass-band shape (the definition of "appropriate average" being purposely left undefined), then the response to a point source observed at x_o radians from the phase center is:

$$B'(x'-x_o) = \frac{\nu_o}{x_o} G(\frac{\nu_o}{x_o} \cdot x) * B(x) \quad , \tag{1}$$

where the asterisk represents one-dimensional convolution, and ν_o is the observing frequency. This relationship is correct for the calculation of the point source response, but is not for an extended source since the broadening is a function of the position.

Examples of the expected loss of central amplitude and profile shapes for various simple cases are given in VLA Scientific Memo No. 138. Here we show the results of measurements made to test these calculations.

II. OBSERVATIONS

The data were taken over a 3^h period on 22 April, 1982. They consisted of short ($\sim 4^m$) observations at 20 cm of the strong point source 1928+738 at positions from 0" to 300", in steps of 20", off the source. Observations were made at both 50 and 6 MHz bandwidths. Every 20^m, the source was observed at 0" offset for calibration purposes. The data were calibrated and exported to the VAX. All subsequent processing was done on the VAX. Maps were made of every position at each bandwidth.

III. RESULTS

The results for the peak degraded response are in Fig. 1. Plotted are the observed peak and center amplitudes, plus the expected response taken from VLA Scientific Memo No. 138 vs offset in arcseconds. The abscissa also shows the parameter $\beta = \Delta\nu x_o/\nu_o b$, where b is the undistorted beamwidth. In all cases the profile was centered on the expected cell, although the profile becomes distinctly asymmetric as the offset increases. This effect necessitated the plotting of both peak and central intensities. The narrow bandwidth data showed no asymmetries and no deviation of position from the expected location.

The measured halfwidths divided by the undistorted half-width are plotted in Fig. 2, along with representative calculated values. In both plots there is excellent agreement between calculation and observation, the discrepancies easily being covered by the measurement uncertainties, and the non-symmetric bandpass.

IV. DISCUSSION

An interesting consequence of equation (1) is that the broadened profile will eventually give the mean system bandpass. This can be understood by taking the limit of equation (1) as $x_o \to \infty$. Then $B(x) \to \delta(x)$, and $B'(x-x_o) \to \nu_o/x_o\, G\,(\nu_o/x_o\, x)$. In Fig. 3 is shown the profile taken at r = 300" (β = 6.3). The shape is indeed representative of the observed bandpass as measured by the spectrum analyzer of a number of IF channels. Because the distorted beam shape approaches the bandpass shape, the measured width will eventually be proportional to the offset x_o - this is observed in Fig. 2 for offsets greater than ~160". Thus, the distorted beam shapes found at large offsets are simply a consequence of the asymmetric system bandpass.

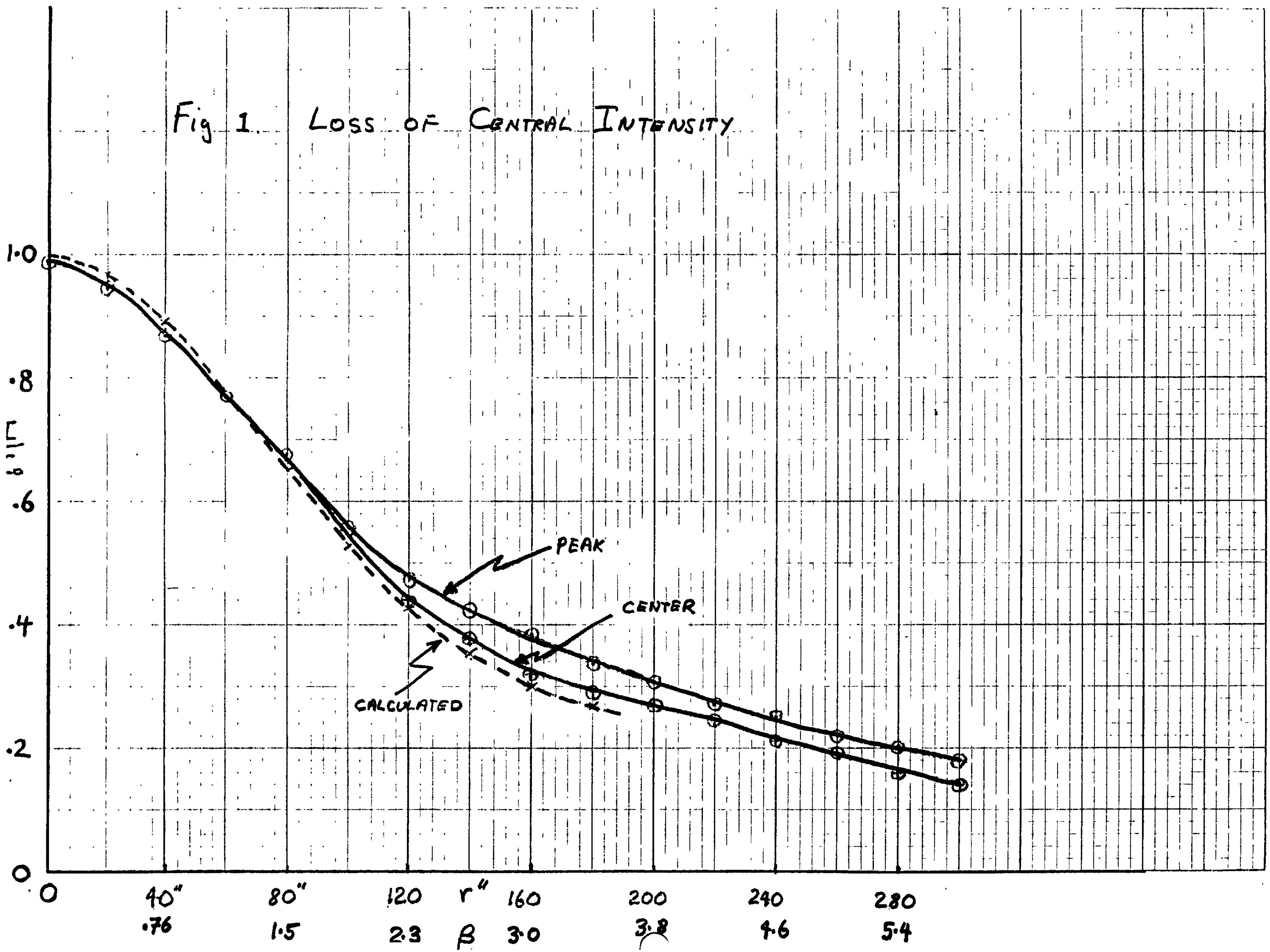


Fig 1. Loss of Central Intensity

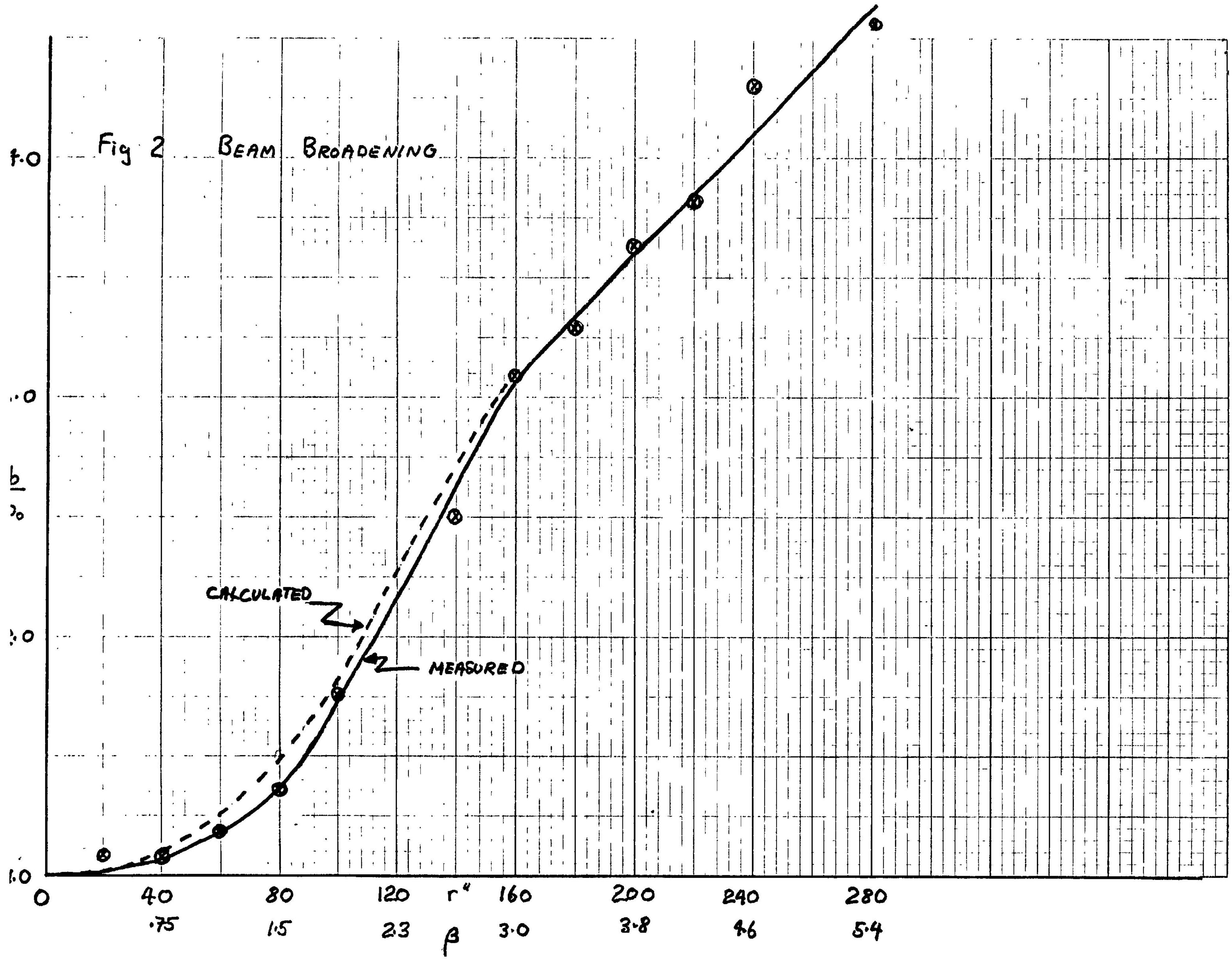
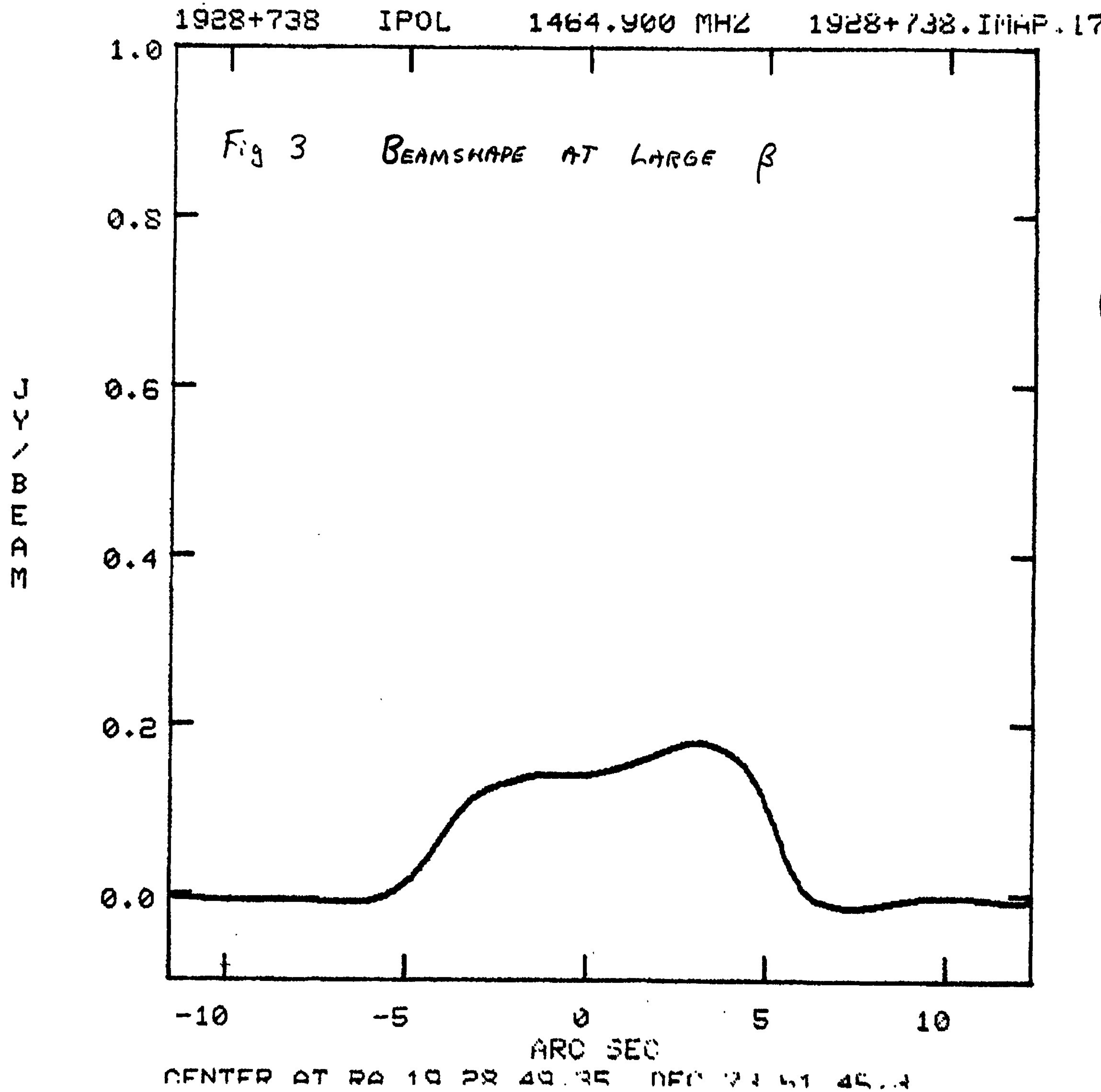


Fig 2 BEAM BROADENING
CALCULATED
MEASURED
0
40
80
120
r"
160
200
240
280
·75
1·5
2·3
β
3·0
3·8
4·6
5·4



r = 300"

β = 6.30

341

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