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IMAGING CHARACTERISTICS OF THE PROPOSED NRAO MMA, WITH AND WITHOUT A SINGLE LARGE ELEMENT, AND A POINTING CORRECTION ALGORITHM

D. T. EMERSON
National Radio Astronomy Observatory,* 949 N. Cherry Ave., Tucson, AZ 85721, U.S.A.

ABSTRACT This is a continuation of earlier imaging studies for the MMA. Earlier work is confirmed, and the differences in imaging quality resulting from small and larger central antennas used for short-spacing information are investigated. An algorithm is presented which uses interferometer data to correct for an important component of central element pointing errors.

INTRODUCTION

An independent study has been made of imaging characteristics of a Millimeter Array (MMA) consisting of a large number of 8m antennas, in which short spacing information is obtained either from the 8m array elements operating independently in single dish mode, or from a separate 20m dish. This study partially overlaps with earlier work (see references below), giving independent confirmation of some aspects of that work. The current study examines in more detail the relative importance of different components of the pointing error model, and presents an algorithm (PHFIT) which may lead to a relaxation of pointing requirements of the individual antennas.

POINTING CORRECTION ALGORITHM (PHFIT)

This algorithm uses the area of overlap in the UV plane between single dish and interferometer data. Interferometric phase data are largely unaffected by pointing errors, while a global pointing error in single dish data appears as an unwanted phase gradient. A linear phase gradient is searched for in the phase difference map (single dish - interferometer data), and used to correct the single dish pointing. This technique is equivalent to performing a cross-correlation between the two data sets, but with some pre-weighting of spatial frequency terms in order to optimize the resultant signal-to-noise ratio.

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THE SIMULATIONS

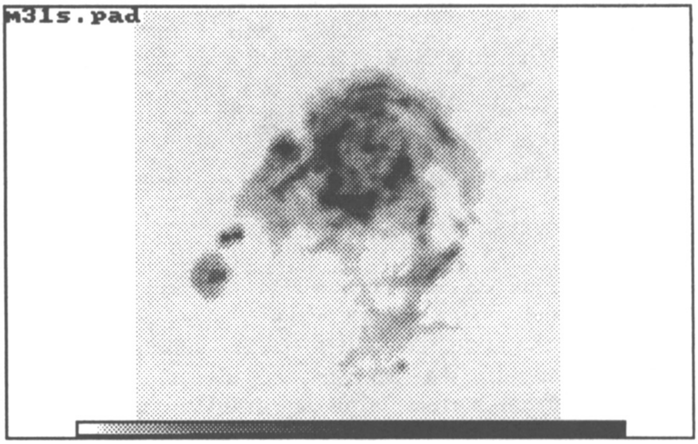

Fig. 1. The raw data used for these simulations. The total extent of the field is 2.1′

The simulations used the same model source (Fig. 1) as earlier studies. Observations were simulated at a wavelength of 1.3mm, using a MMA with 8m antennas (primary beam 40″) and baselines ranging from 9m to 70m. Within these radii, the UV plane has been assumed to be well sampled. Short spacing information is provided either by the 8m elements operating in total power mode, or by a separate 20m dish (beam 16″). The success of imaging was measured by a dynamic range parameter, defined as the ratio of peak temperature on the model source divided by the rms of the difference between the simulated observation and the original model. The pointing model consisted of 5 independent terms. For the single dish data, components were (a) a global pointing offset for the entire single dish map, and (b) a random tracking error. For interferometer data the components were (c) a systematic global pointing error for the entire mosaic, (d) a random tracking error, and (e) a systematic pointing error of the entire interferometric array which is randomly different for each element of the mosaic. The simulations investigated the relative effect on dynamic range of these different pointing error components, in the presence of varying degrees of random noise, with and without application of the PHFIT algorithm.

Relative importance of different pointing errors terms

The relative importance of different components of the pointing error model was investigated. Figures 2 and 3 show, respectively, the dynamic range achieved as a function of components (a) and (e) of the pointing model. These two terms are by far the most critical. In neither case has the PHFIT

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algorithm been applied. It is seen that the single dish pointing errors (a) are about 5 times more serious than array errors (e).

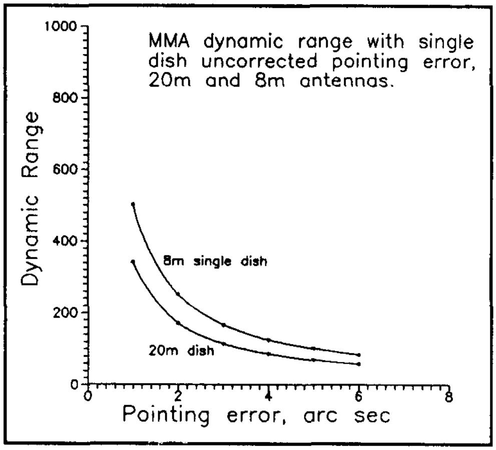

Fig. 2. Dynamic range of simulated observations, as a function of single dish global pointing error, for 8m and 20m antennas. No errors in MMA interferometer observations

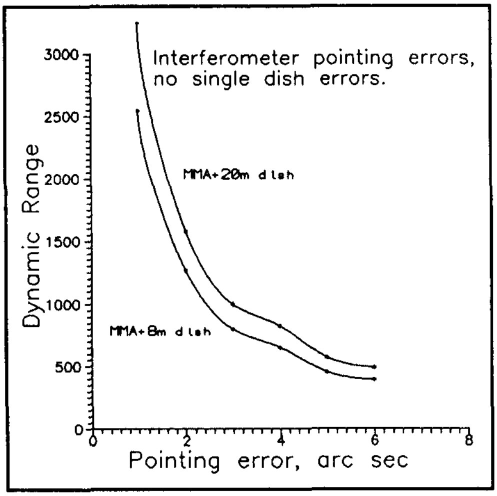

Fig. 3. Dynamic range vs MMA interferometer pointing errors, with no single dish errors

In Fig. 4 pointing errors have been simulated in both the single dish and interferometer data, but the PHFIT algorithm has been applied to compensate for the single dish global pointing offset. The components of pointing errors include (a) 6″, (b) 1″, (c) 6″and (d) 1″. The dynamic range has been plotted as a function of the additional systematic interferometer pointing error (e). If the

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PHFIT algorithm is applied, this latter term is by far the dominant cause of imaging errors. Comparing with Figure 2, it is seen that, within the bounds of these simulations, the dynamic range attainable for a given magnitude of pointing error has been extended considerably by use of the PHFIT algorithm. The dynamic range using a 20m dish for short spacing data is now slightly better than that achieved with an 8m dish, for the same pointing inaccuracies.

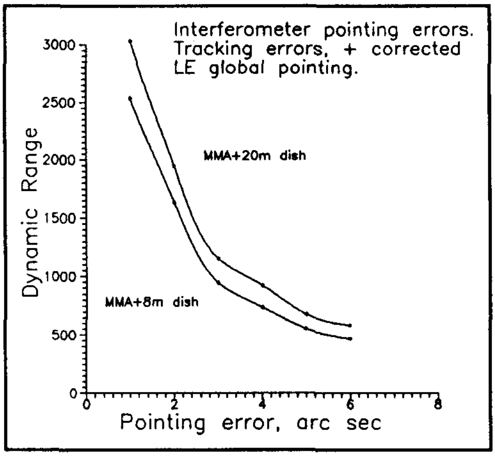

Fig. 4. Dynamic range vs MMA interferometer pointing errors, in the presence of single dish pointing errors (see text) but after applying the PHFIT algorithm

CONCLUSIONS

1. Where similar noise and pointing error parameters have been used, this study is in good agreement with the earlier studies, giving independent confirmation of that work.
2. The most serious pointing errors are (i) any global pointing offset in the single dish data, and (ii) for interferometer data any systematic pointing error of individual elements of the mosaic away from the mean mosaic grid positions. (i) is typically several times more serious than (ii), for a given magnitude of pointing error.
3. The PHFIT algorithm is very successful at correcting for the single dish global pointing error, with either 8m or 20m dishes providing the short-spacing data.
4. Provided the PHFIT algorithm is applied, a 20m central element gives slightly better imaging quality than an 8m dish used for short spacing data.

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