GBT Memo No. 42

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, VA

MEMORANDUM March 13, 1990

To: GBT Memo Series

From: John M. Payne

Subject: **Fine Pointing for the GBT**

Introduction

We have some basic decisions to make regarding the fine pointing system for the GBT. Some decisions have been made already; the most important are:

1. We will not be able to provide a tower at the center of the structure reaching to the intersection of the axes.

2. We will not ask the prime contractor to attempt to meet our pointing specifications. We will specify a pointing tolerance looser than required for precision operation and NRAO will be responsible for implementing additional equipment for realizing the fine pointing.

3. We will, however, specify the drive system so that the tracking smoothness will be sufficient to implement the fine pointing.

Pointing Specifications

Manufacturer's specification	7 arcseconds (0.1 BW at 11 GHz)
For 43 GHz	2 arcsecs.
For operation above 43 GHz	< 2 arcsecs.

Fine Pointing Options

1) An Inertial System

Sperry, of Charlottesville, has completed a study of the feasibility of using an inertial reference system for the fine pointing of the GBT. The report is available for anyone who wishes to read it.

The study concludes that it is possible to build a self-contained "box" that may be placed anywhere on the antenna that will read out azimuth and elevation to an accuracy of one arcsecond. One of the ground rules was that calibration on a radio source was permitted every three hours. A complete "off the shelf" system is not available but the individual components are. This leads to a fairly high development cost and the three configurations investigated by Sperry have price tags varying from 2 M$ to 4 M$ for a single unit. The price would come down considerably in quantity, but this would involve a joint venture with other interested organizations. It should be pointed out that these prices result from estimating procedures that are substantially different from those in use at NRAO. Larry has looked at the Sperry estimates and believes the development cost estimates may be too high and the 2 M$ price could be reduced to perhaps 1.3 M$.

One advantage of this system is that it may be placed anywhere on the antenna, and it is almost certainly true that some locations will more accurately track the antenna beam than others.

2) <u>An Autocollimator System</u>

Experience with other telescopes suggests that significant pointing errors result from distortions in the structure supporting the elevation axle. Measurements of these distortions and compensation for them will certainly result in an improvement in the pointing performance. The magnitude of the improvement is unknown at the present but, presumably, future analysis of the structure will clarify this.

It may be possible, using commercially-available components, to measure the tilt of the elevation axle in two orthogonal planes with respect to gravity and also the rotation of the axle with respect to the azimuth encoder. In this way the angular position of the axle may be defined, with respect to the azimuth encoder reading and with respect to local gravity to about one arcsecond. This system is described in GBT Memo #38.

A preliminary cost estimate for this system is 400 k$.

3) <u>The Ranging System</u>

A limitation of both of the above schemes is that the pointing is established with respect to a particular point on the structure. What ideally is required is a knowledge of the direction of the axis of the best-fit surface with respect to the ground.

A proposed method of completely solving the pointing problem, involving surface measurement and referencing this measurement to the ground, is outlined in GBT Memo #36.

The cost of the system comes in two parts: (1) The cost of the surface measuring system, which will be needed to realize the closed-loop active surface and (2) the additional cost of a ground-based reference system.

(1) Cost of surface measurement .... 660 k$

(2) Additional cost for pointing .... 250 k$

These cost estimates are preliminary and need refining. In any of the above schemes, the subreflector position must be either measured with respect to the surface or held in a constant position with respect to the surface. Either system is difficult but possible.

<u>Recommendations</u>

I would like to suggest the following course of action:

1. For the present, we do not pursue the inertial reference system. Sperry has done a really great job on evaluating this kind of system for our use; their study is tremendous value for money. The result is, in my opinion, that this solution does not offer benefits over the alternatives that justify the additional expense. This alone is sufficient to reject the system. I am also uneasy on the questions of spares and service. I believe we should not invest any more money or effort in this approach unless the other approaches appear not to be viable.

2. We proceed with the system outlined in Memo #38. This system will, hopefully, enable us to approach our goal of 2 arcsec pointing and will also provide valuable information on the behavior of the telescope structure. This is an important point. Every large radio telescope seems to have been equipped with instrumentation to investigate pointing problems as an add-on. If we implement the scheme in Memo #38, fundamental instrumentation will be built in from the start. A significant additional advantage of this scheme is that, unlike the ranging system, it will be unaffected by atmospheric conditions.

3. If we decide to implement the closed-loop active surface for operation above 43 GHz, it would seem ill advised not to spend the extra 250 k$ for the ground-based targets to implement the fine pointing system. I would not like to see us rely on this scheme alone for the fine pointing system; it's too risky.