GBT Memo No. 15

Notes from the GBT Design Workshop

George Seielstad
September 29, 1989

The Workshop was held in Green Bank on September 25 and 26, 1989. The eighty-eight people who attended are listed in Appendix 1. Herein we attempt to record those recommendations put forward.

I. Needs for Various Scientific Disciplines

Appendix 2, the Agenda, lists the speakers addressing the "Scientific Requirements Affecting the GBT's Design" and their topics. We summarize below the needs each perceived for the discipline he represented. To make this input most valuable to the GBT Design Team, we have reorganized it into the framework of our organization: we lump comments about the GBT's structure, its optics, and its active surface and pointing into one category called The Antenna; other categories are Electronics, Monitor & Control, Site, and Operations. To identify the sources of the advice presented within each of these categories, we code as follows:

Type of Observation	Code
Meter-Wave	mλ
Survey	Surv
VLBI/Geodetic	VLB
Spectroscopic	Line
High-Frequency	CO

A. The Antenna

Largest Possible Collecting Area (dia.≈140m)	mλ, Surv
Surface Accuracy permitting equivalent of 70m antenna at λ3mm	CO,VLB
Good point-source polarization characteristics (≤-20 db cross-pol)	mλ
(≤-35 db in power)	VLB
Minimize Beam Squint to Maximize Off-Axis Polarization Purity	Line
Interference Rejection = Low Sidelobes = Clear Aperture	mλ
All-sky coverage; in particular, low Southern Horizon; El ≥3°	mλ,Surv,VLB,Line
Min. Standing Waves; Max. Dynamic Range (≥10^3); = Clear Aperture	Surv, Line
Slew Rate ≥ $1° s^{-1}$; Acceleration Rate ≥ $0.2° s^{-2}$	VLB
Over-the-top Observing	VLB
Provide easy access to Prime Focus	mλ,Surv,Line

B. Electronics

Simultaneous multi-frequency capability	mλ,Line
At least S and X band	VLB
Frequency Coverage	
Lowest frequency requested, <100 MHz	mλ
Highest VLBA frequency, 90 GHz	VLB
Highest frequency requested, 115 GHz	CO
Multi-beams; Focal-Plane Arrays; Imaging Receivers	mλ,Surv,Line,CO
Beams rotatable and targetable	
Rapid Instrumentation Changeovers (minutes, at any time)	Surv,Line,VLB,CO
Wide Bandwidth Receivers ($\geq$hundreds of MHz)	mλ,Surv,Line,CO
All receivers Dual Polarization	mλ,Surv,VLB,Line
Signal Processors	
Provide for > 1 frontend	Surv,Line,CO
Wide instantaneous bandwidths ($\geq$200 MHz)	mλ,Surv,Line,CO
Flexibility in placing portions of bandwidth	Surv,Line
High frequency resolution = 10^4 - 10^6 channels	mλ,Surv,Line,CO
High time resolution ($\approx$1000 time bins per sample)	mλ
Interference Excision	mλ,Surv,Line
Beam switching/chopping capability (at $\approx$10 Hz for λ3mm)	Surv,Line,CO
Compatibility with VLBA	VLB
10 frontends	
H maser frequency standard	
VLBA Recording Terminal	
Constant signal path lengths (to $\leq$1mm)	

C. Monitor & Control

Provide offsite observers the same information available on site	Surv,Line,CO
Use commercial, standardized components	All
Provide separate storage mechanism for backends sampling highest rates	mλ

D. Site

Green Bank superb at meter wavelengths	mλ
Green Bank ideally located for large-antenna VLBI	VLB
Green Bank "quite acceptable" CO site	CO
GBT should be invisible from Highway 28/92	

E. Operations

Flexible scheduling	All
Permit piggybacking whenever a multi-beam receiver is in use	mλ
Develop policies for public availability of data	Surv
Schedule long-term, large-effort programs	Surv
Improve telephone lines to data-transfer quality	All

II. Tradeoffs/Compromises

Several conflicting requirements emerged from the invited talks, as well as from the open discussions. Not every argument can be reconstructed here. We attempt only to record the areas of conflict and the main compromises involved in resolving them.

A. Diameter *vs.* Maximum Operational Frequency

Money not spent on actuators, sensors, metrology systems, precision subreflectors, and the like can instead be spent to maximize collecting area, if that area is only to be useful at wavelengths ≥ a centimeter or two.

Arguments for cm-λ only	Arguments for <1 cm capability
Optimizes use of NRQZ	λ3mm performance and dia ≥70m unequalled
GB not an ideal mm site	Arecibo >> GBT for 0°-40°,0.1-10 GHz
Mature disciplines require up to 80% of time in large projects	GBT's biggest contribution to VLB is sensitivity and resolution at 43 and 90 GHz
Size = Speed ($S \sim dia^4$)	CO more sensitive per nucleon than HI

B. Shaped Reflectors *vs.* Field of View

This is a continuation of the high/low frequency debate. Receivers for frequencies < 1 GHz will need to be mounted at the prime focus, but dish illumination from prime focus will be poor if the primary mirror is shaped. But shaping increases the efficiency of high-frequency observations conducted from a secondary focus. These observations suffer from reduced field of view, however, and the loss in gain as feeds are moved off axis appears as unwanted coma lobes for these feeds. Shaping probably also increases the number of different panels required = higher cost.

C. Diameter *vs.* Interference Protection

The low frequency observations (<10 GHz) that benefit most from raw collecting area also suffer the most interference (presently). Interference is reduced if sidelobes are minimized by constructing a clear-aperture antenna, but the extra cost of this design is at the expense of area.

D. Dish Illumination *vs.* Polarization Purity

It may prove difficult to construct feeds that simultaneously permit wide bandwidths, illuminate the dish well, and solve the polarization peculiarities of clear-aperture antennas.

III. Comments, Suggestions, and Opinions

The following statements were made at various times throughout the Workshop. They are summarized here strictly for the record. No evaluation of their applicability has yet been attempted.

Homology: The starting model is a symmetric antenna whereas the final product is asymmetric. Design instead to the whole.

Homology: Designing only to acceptable performance at $\lambda 2$ cm seems exceptionally cautious. Both the $\lambda/16$ parameter and the 14" pointing error budget should be tightened.

Conventional Apertures: Can scattering off feedlegs, hence far-out sidelobes, be reduced by wrapping the legs with absorber?

Dimensions: The clear, unprojected aperture of 100m x 112m is larger than for a circularly symmetric aperture, but the amount of steel (i.e., cost) may not be significantly greater because the curvatures differ.

Dimensions: The collecting area of the GBT could be increased for low frequencies by adding a ring of lightweight mesh panels around the outer edge.

Signal Processors: The VLBA correlator could constitute the basis for a next-generation backend.

Data Analysis: ANALYZE is a suitable, existing software package for single dishes. A new one need not be developed.

Data Analysis: The effort of a new software package could be spread over several observatories.

Pointing: An optical or IR telescope could serve as a guide telescope.

Appendix 1

Attending September GBT Workshop

Aller, Hugh
Baars, Jaap
Backer, Don
Bagri, D.
Balister, Mike
Ball, John
Bania, Tom
Bartel, Norbert
Blitz, Leo
Burke, Bernard
Bremenkamp, Victor
Briggs, Frank
Broderick, John
Brown, Robert
Churchwell, Ed
Claussen, Mark
Condon, Jim
Cordes, James
Crane, Pat
D'Addario, Larry
Davis, Michael
Dent, William
Dickey, John
Emerson, Darrell
Findlay, John
Fisher, Rick
Heiles, Carl
Hall, Bob
Heeschen, Dave
Hills, Richard
Hogg, Dave
Hollis, Jan
Imbriale, Bill
Irvine, William
Jahoda, Keith
Jewell, Philip
Kellermann, Ken
Kerr, Frank
King, Lee
Kulkarni, S.R.
Levy, Roy
Liszt, Harvey
Lo, K. Y.
Lobb, Verl
Lockman, Jay
Maddalena, Ron
Martin, Robert
Matsakis, Demetrios
Matlick, Tom
Moran, Jim
Mundy, Lee
Mutel, Robert
Napier, Peter
Oster, Ludwig
Palmer, Pat
Payne, John
Price, Mark
Rickard, Lee J.
Roberts, Mort
Rocci, S. A.
Rood, Bob
Romney, Jonathan
Schwab, Fred
Scoville, Nick
Sebring, Paul
Snyder, Lewis
Sramek, Dick
Srikanth, S.
Stinebring, Dan
Thaddeus, Patrick
Turner, Kenneth
vanden Bout, Paul
Verschuur, Gerrit
Wolszczan, Alex
Wootten, Al

75 - Total

Green Bank Attendees

G. Behrens
C. Chestnut
M. Clark
J. Coe
F. Crews
R. Fleming
F. Ghigo
S. Heatherly
R. Lacasse
R. Norrod
G. Seielstad
W. Sizemore
S. White

13 - Total

Appendix 2

GREEN BANK TELESCOPE DESIGN WORKSHOP

AGENDA

MONDAY, SEPTEMBER 25, 1989

Introduction

08:00	The GBT Proposal	Vanden Bout
08:30	The Design of Large Antennas	D'Addario

Scientific Requirements Affecting GBT's Design

09:00	Special Needs of Meter-Wave Observations	Stinebring
09:30	Special Needs of Survey Observations	Heiles
10:00	*Coffee*	
10:30	Special Needs of VLBI/Geodetic Observations	Bartel
11:00	Special Needs of Spectroscopic Observations	Bania
11:30	Special Needs of High Frequency Observations	Scoville
12:30	*Lunch*	

Report from the GBT Specifications Working Group

13:30	Overview	Seielstad
13:45	Structural Aspects of the GBT	King
14:15	Astronomical Consequences of Aperture Blockage	Lockman
15:00	Electromagnetic Performance of a Clear Aperture	Fisher
15:30	*Coffee*	
16:00	Optics of the GBT	Norrod
16:30	Options to Achieve Precision Pointing	D'Addario
17:00	Operation of an Active Surface	Payne
18:00	*Cocktails*	
18:30	*Dinner*	

Evening Round Table Discussion

20:30	State-of-the-Art Advances of the GBT	Chair: Seielstad

GREEN BANK TELESCOPE DESIGN WORKSHOP

AGENDA

TUESDAY, SEPTEMBER 26, 1989

Report from the GBT Specifications Working Group, Continued

08:00	Electronics	Norrod
08:30	Philosophy of GBT's Control System	Emerson
09:00	Data Analysis	Maddalena
09:30	The Green Bank Site	Hogg
10:00	Summary	Seielstad
10:30	*Coffee*	

Discussion

11:00	Tradeoffs, Compromises, Priorities	Chair: Seielstad
12:30	*Lunch*	
13:30	Management and Review of the GBT Project	Vanden Bout
14:00	Discussion	
16:30	*Adjourn*	