The 100-meter Robert C. Byrd Green Bank Telescope

VLBI usage:

About 15% of GBT time goes to VLBI projects.

Including Large projects:
  - Megamaser cosmology
  - Pleiades distance
  - Radio Astron

Development:

- 68-92 GHz receiver
- “Vegas” spectrometer
- RadioAstron ground station

Frank Ghigo  National Radio Astronomy Observatory – Green Bank

VLBI Technology Workshop, Haystack, Oct 2012
Subreflector and receiver room

Prime Focus receivers:
• 290-1200 MHz
• 9-feed array (planned)
• phased-array feed (planned)

Gregorian focus receivers
• 8 slots
• 1-2; 2-3; 4-6; 8-10 GHz
• 12-18; 18-26 7-beam;
• 26-40; 40-50; 68-92 GHz
• 80-100 GHz bolometer
On the receiver turret
Inside the receiver room
GBT active surface system

- Surface has 2004 panels
  - average panel rms: 68 \( \mu \)
- 2209 precision actuators
“Traditional Holography”
Reduction of the small-scale surface features:

January 4, 2009  February 2009  March 2009

May 3, 2009  August 3, 2009  September 11, 2009
OOF: out of focus “holography”

Fig. 3.— Top row: A sample set of out-of-focus maps taken on 11th April 2005 (scan numbers 114ff). The left-most map is in-focus, the other two are both 35 mm out of focus, with the sense of the defocus such that in the centre map the subreflector is further away from the primary than the optimal focus and in the right-most map the subreflector is closer to the primary than optimal. Middle row: simulated beam maps for the GBT with no wavefront errors. Bottom row: simulated beam maps of the best-fitting model (using Zernike polynomials up to fifth radial order inclusive) to the observed maps in the top row. Angular scale is indicated in the units of radians and contours in all maps are at $(\text{min, max}) \times 0.5^i$. 

Zernike polynomials
Plan C
VLBA backend runs independently

Key file
sched
Vex file
vex2script

GBT Managers
Scan Coordinator
Receiver
LO/IF system
Antenna

Message MUX

Weather,
Clock, etc

GBT Status
Database

Status demon

Monitor msgs
and alerts

Multicast
Land

Astrid runs
Python script

Script translator

Python station control file
BB123.GB.py

Station computer
Executor

VLBA Devices
4x4
RDBE boards
Mark5 recorders

A status demon collects the monitor data from
the GBT system and multicasts it out to the
VLBA monitor system. It may also collect
messages and alerts from the VLBA devices
and send them to the message MUX.
4mm Receiver to be re-installed Nov 1

- 68-92 GHz
- performance optimized at 86 GHz
- dual beam;
- dual linear polarizations
- phase shifter to convert dual linear to dual circular

- Absolution calibration with on-board cold and ambient loads.
4mm receiver block diagram

Figure 3-1
Front-end Simplified Block Diagram
4mm Receiver Project Book
$\frac{1}{4}$ wave plate: linear to circular polarizations
4mm receiver Tsys measurements January 2012

![Graph showing temperature vs frequency for GBT 4mm T(sys) 2012.01.06]
RadioAstron Space Telescope

Launched July 2011

Elongated orbit up to 380,000 km

receivers:
  1.3 cm
  6 cm
  18 cm
  1 m

Fringe size ~ 10uas at 1.3 cm
Radio Astron ground station at Green Bank

Refurbishing the old 140-foot (43-meter)

Data downlink  15.0 GHz
Timing downlink  8.4 GHz
Timing uplink  7.2 GHz

Receivers and decoder provided by Russia.

To be operational in about 1 year.
GBT/RadioAstron VLBI astronomy

Observe compact components in AGNs
Measure flux density, angular size, brightness temperature.
Test inverse Compton limit, Doppler boosting.

Recording at the GBT with the “legacy” VLBA system:
256 Mbps bit rate; 2-bit sampling
(spacecraft: 128 Mbps/ 1-bit sampling)

4 channels 16 MHz each

Data copied from Mark5A to external disk;
then transferred via internet to ASC.
VEGAS: Versatile GBT Astronomical Spectrometer

- FPGA technology using CASPAR tools
  - Roach-2 boards

- 8 or 9 spectrometers
  - 1 MHz to 1.25 GHz bandwidth each.

- up to 32768 spectral channels

- 1 or 8 sub bands per spectrometer
VEGAS Block Diagram
### Modes

<table>
<thead>
<tr>
<th>Obs. Mode</th>
<th>Number of sub-band per pol</th>
<th>Bandwidth of a sub-band Window (MHz)</th>
<th>Number of channels per sub-band per pol</th>
<th>Spectral resolution (KHz)</th>
<th>Velocity range at 90 GHz (km s(^{-1}))</th>
<th>Velocity resolution at 90 GHz (km s(^{-1}))</th>
<th>Integration time minimum (unsec)</th>
<th>Integration time maximum (sec)</th>
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Figure 2: The reconfigurable hardware of VEGAS will be used to support 17 observing modes as shown in the table above. Each of the 8 spectrometers, which processes signals from a dual polarized beam, can be configured in these 17 observing modes. The usable bandwidth for Mode 1 is 1250 MHz.