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Software for Testing and Commissioning the GBT

J. Braatz, J. McMullin, R. Garwood, R. Maddalena, R. Norrod & T. Cornwell

National Radio Astronomy Observatory

Abstract. The Green Bank Telescope is a 100-m diameter radio antenna located in the National Radio Quiet Zone in West Virginia. The telescope has a number of advanced design features including an unblocked aperture, an active surface and a laser metrology system. It is designed to observe at frequencies from 300 MHz to 100 GHz. Construction of the telescope is expected to be completed in early 2000. The electronics systems for the telescope have been under development and testing in a "Mock-up" which includes the receivers, LO systems, analog filters, and backends. The computer control systems and the data analysis software tools are being developed simultaneously and are used with the mock-up hardware to simulate the data acquisition process.

After construction, the telescope will undergo a series of commissioning procedures to prepare for general astronomical observing. Software which handles the commissioning tasks, engineering analysis, and data processing are being developed in the AIPS++ system. Most of the code development is done in *Glish* and uses the extensive library of mathematical functions, plotting tools, and GUI routines available in AIPS++. Here we give some examples of the software being developed and we show some of the tools available in the AIPS++ programming and analysis environment.

1. Engineering Tools

The hardware, software control systems, and communications mechanisms for GBT electronics have been under testing in a mock-up. The components can be tested individually or as a complete system. Data from the backends are filled into an AIPS++-readable format and then AIPS++ tools and custom *Glish* routines are used to perform the analysis. Figure 1 shows an example of a GUI developed in *Glish* for processing data from the Digital Continuum Receiver (DCR). The data are normalized, scaled, and fit to a baseline (if necessary), and finally sent to the AIPS++ *pgplotter* tool for display. In the figure, the total power seen by two different channels in the DCR is plotted against time.

Data for a large group of GBT-related devices (including receivers, electronic filters, antenna motors, weather stations, and a tipper) are monitored and recorded. These data can be accessed with a flexible GUI-based program, *gbtlogview*. The GUI is used to select data for a given time range and for the devices of interest. These data are then filled from the native FITS format into

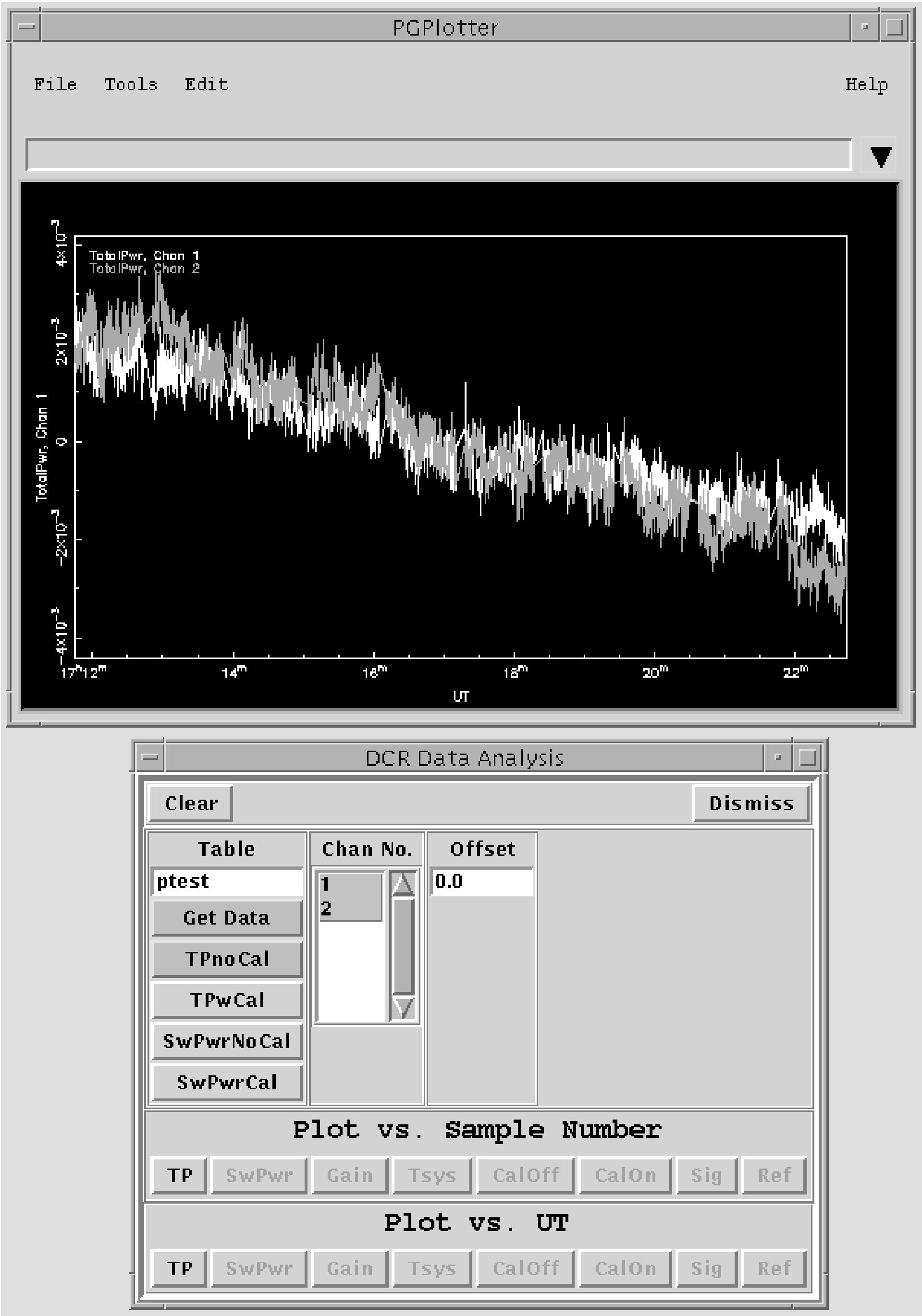

Figure 1. An example of a GUI used for tests of the GBT electronics systems. This GUI is used to process and display data from the Digital Continuum Receiver. The line plot shows a comparison of total power seen in two channels as a function of time.

AIPS++ tables. A set of parameters for each device is then made available for selection (e.g. for the weather station, the user can select temperature, humidity, wind speed, etc.). The data are then plotted using the *pgplotter* tool.

2. Holography

One of the first tests to be conducted on the GBT will be a measurement of the surface shape via holography. The procedure involves measuring the complex beam pattern of the antenna towards a strong artificial or natural radio source, and then Fourier transforming the pattern to obtain the phase variations across the surface of the dish. After correcting for a number of geometrical effects relating to the signal path, these phases can be converted into displacement errors and used to tune the dish surface for better aperture efficiency. The holographic measurements to be conducted on the GBT have an expected accuracy of less than 0.1 mm RMS.

Figure 2 shows an AIPS++ session in which holography data are being reduced and analyzed. This data, used for testing the software, was taken in 1986 with the 140-ft telescope in Green Bank. The top left panel shows the amplitude of the holographic measurement, reflecting essentially the illumination pattern seen by the antenna feed. The image below that shows the surface accuracy of the dish, taken from the phase of the holographic measurement. A test panel about 2 mm in thickness can be seen on this image directly above the center of the dish, about half of a radius out. These images are displayed with the AIPS++ *viewer* tool. The line plot shows cuts through the surface anomalies image, taken directly North-South and East-West. The 140-ft dish is seen to have deviations of about 2 mm RMS from this plot.

3. Commissioning Software

An AIPS++ tool has been developed to handle the software requirements of the GBT commissioning procedure. The tool encompasses routine procedures for the analysis of continuum data including the derivation of pointing offsets from scans across a radio source, measurement of focus, determination of the atmospheric opacity through a tip scan, derivation of a power spectrum, and the calculation of system temperature and antenna temperature towards a given source. The tool also includes some system performance tasks, such as measuring the precision to which a source is tracked over a period of time. Procedures for cataloging the pointing, focus, and calibration results will be incorporated in the tool. The commissioning tool can be accessed either through the AIPS++ tool manager GUI or directly with the *Glish* CLI.

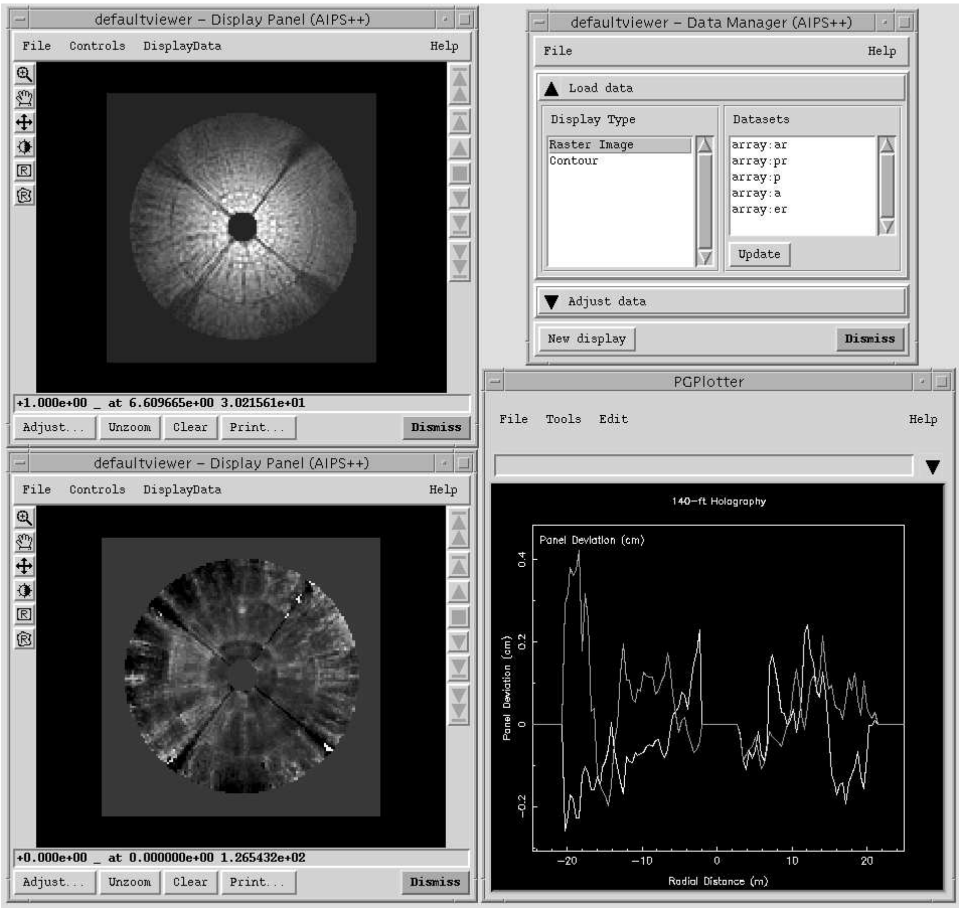

Figure 2. An example screen showing the display of holography data. The top left panel shows the illumination pattern seen by the feed and below it is an image of the surface anomalies. The line plot shows two cuts in the vertical and horizontal directions through the surface anomalies image. Above the line plot is one of the AIPS++ *viewer* panels.