Robert C. Byrd Green Bank Telescope
NRAO Green Bank

M. H. Clark

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GBT SOFTWARE PROJECT NOTE 11.2

GBT Calibration FITS File Specification

HTML version Available[1]

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Abstract

The FITS format structure is presented for the GBT Calibration (Receiver) scan data files. The scan data FITS files are permanently archived after each observation, and will usually be input to the aips++ filler, which has the task of combining all scan data FITS files into an aips++ Measurement Set. This data may then either be processed further in aips++, or written out in an aips++ supported FITS format (one of which is single dish FITS).

The Calibration FITS file produced for each receiver contains binary tables of the smoothed, interpolated calibration temperatures for each receptor. In addition, the primary header contains default values of various efficiencies and atmospheric opacity, which may be used for subsequent data processing.

[1] http://www.gb.nrao.edu/GBT/MC/doc/dataproc/gbtMeasFits/gbtMeasFits/gbtMeasFits.html

History

8th November 2001 Penultimate definition of FITSVER 1.1; released for general comment (Richard Prestage).

16th November 2001 Final version agreed for implementation of FITSVER 1.1. Added history. Subsequent changes to the content of this document should increment the document version number (Richard Prestage).

31st July 2007 Updated to reflect FITSVER 2.2, added linear polarization angle keywords. (Mike McCarty).

1 Background

All GBT scan Calibration FITS files should conform to the standards specified in the GBT Software Project Note 4.0, "Device and Log FITS Files for the GBT." All receiver calibration data from bench tests are stored in a relational data base. These data will in general be stored in raw form, in sanitized form (obvious spurious values rejected) and in a smooth or interpolated form. The Measurements Manager, given the receiver to be used in a scan, extracts from the data base the most recent smoothed results for that receiver and generates a FITS file containing the calibration data. If no smoothed values are available, no FITS file will be produced.

In addition to the calibration temperatures, the most recent values for the atmospheric zenith optical depth τ_o, rear spillover efficiency η_l, aperture efficiency η_A and beam efficiency η_M will be read from the database, and written to the primary HDU. In version 1.1 of the Calibration FITS files, simple scalar values for each of these quantities will be provided. Subsequent versions of the FITS file may contain a more complex parameterisation of these quantities (for example tables of gain dependence on azimuth, elevation and frequency).

The FITS file is regenerated if new results are available or a new project or receiver is selected. The number of receiver calibration binary tables in a FITS file is wholly dependent on the number of independent tests run by the engineers.

2 Primary HDU

The Calibration FITS keywords for the primary HDU conforms to the definition for common FITS headers with caveats pertaining to the keywords DATE-OBS, OBJECT, OBSID, and SCAN. The caveats reflect the fact that the FITS file is not the result of an actual observation, but rather a bench test. Therefore, DATE-OBS's value is the day but not the time of the most recent test, OBJECT's value is "NOISE DIODE," OBSID's value is "calibration," and SCAN is 0.

In addition to the standard primary HDU keywords, the following additional keywords will be present:

RECEIVER The name of the receiver whose calibration values are in the tables.

MIN_FREQ The minimum operating frequency of the receiver and associated feedhorn for this set of calibrations.

MAX_FREQ The maximum operating frequency of the receiver and associated feedhorn for this set of calibrations.

NBEAM The number of spatially separate RF signals the receiver is able to accept.

TAUZENIT The opacity per unit air mass (for some receivers, this may simply be a sensible default to be used until a skydip has been performed).

ETAL The rear spillover and scattering efficiency.

APEREFF The aperture efficiency.

BEAMEFF The main beam efficiency.

XANGLE1 The linear polarization angle (optional depending on recievers database).

XANGLE2 The linear polarization angle (optional depending on recievers database).

YANGLE1 The linear polarization angle (optional depending on recievers database).

YANGLE2 The linear polarization angle (optional depending on recievers database).

In version 2.2, all of the above quantities are assumed to be independent of receptor, azimuth, elevation or frequency within a given receiver's passband.

3 Receiver Calibration Binary Table Extension

Each row of the RX_CAL_INFO binary table holds the receiver and calibration temperatures at the indicated frequency under the conditions described by the header keyword values. The EXTVER keyword distinguishes this extension from other RX_CAL_INFO binary tables in the file as described in section 2.1 General (item 4) in the GBT Software Project Note 4.0, "Device and Log FITS Files for the GBT."

```
XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   16 / width of table in bytes
NAXIS2  =                  175 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    4 / number of fields in each row
TTYPE1  = 'FREQUENCY'          / label for field   1
TFORM1  = '1E      '           / data format of field: 4-byte REAL
TUNIT1  = 'Hz      '           / physical unit of field
TTYPE2  = 'RX_TEMP '           / label for field   2
TFORM2  = '1E      '           / data format of field: 4-byte REAL
TUNIT2  = 'K       '           / physical unit of field
TTYPE3  = 'LOW_CAL_TEMP'       / label for field   3
TFORM3  = '1E      '           / data format of field: 4-byte REAL
TUNIT3  = 'K       '           / physical unit of field
TTYPE4  = 'HIGH_CAL_TEMP'      / label for field   4
TFORM4  = '1E      '           / data format of field: 4-byte REAL
TUNIT4  = 'K       '           / physical unit of field
EXTNAME = 'RX_CAL_INFO'        / name of this binary table extension
EXTVER  =                    3 / extension version
TESTDATE= '2001-06-20'         / date test data acquired
RECEPTOR= 'XL      '           / source of IF signal
FEED    =                    1 / feed identifier
POLARIZE= 'X       '           / channel's polarization
BANDWDTH=             2.00E+06 / frequency width in which test was taken (Hz)
ENGINEER= 'M. Stennes'         / receiver engineer
TECH    = 'T. Dunbrack'        / responsible technician
COMMENT   low_cal and high_cal indicate selectable calibration levels
END
```

The header keywords describe what part of the receiver was tested, how the test was run, when, and by whom. In the above example, the XL path (RECEPTOR) from beam (FEED) 1 was tested at 175 frequencies using linear ('X') polarization (POLARIZE) with a 20 MHZ bandwidth (BANDWDTH) on June 20th 2001 (TESTDATE) by Mike Stennes (ENGINEER) and Tom Dunbrack (TECH). Also comments by the testing engineer are included.