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GBT SOFTWARE PROJECT NOTE 5.0

GBT Spectral Processor FITS File Specification

HTML version Available¹

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Abstract

The FITS format structure is presented for the GBT SpectralProcessor 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 scan data FITS files contain both 1) a complete description of the spectral processor setup for the observation and 2) measurement data with a FITS keyword description of the data organization. The `STATE` and `PORT` tables describe the setup and the `DATA` table contains measured values.

¹<http://www.gb.nrao.edu/GBT/MC/doc/dataproc/gbtSPFits/gbtSPFits.html>

1 Background

All GBT scan data FITS files should conform to the standards specified in the GBT Software Project Note 4.0, “Device and Log FITS Files for the GBT.” The SpectralProcessor consists of two identical Banks (A and B) which are setup in tandem and whose output are combined into a single FITS file. Three GBT SpectralProcessor binary table extensions will be produced: PORT, STATE and DATA, and these tables will be placed in a single scan data FITS file for each scan.

2 Primary HDU keywords

The SpectralProcessor FITS keywords for the primary HDU conforms to the definition for common FITS headers. Only the keyword MODE is added to identify the overall state. Possible values are:

- DedispTimeSamples
- TimeSyncSpectra
- SigAvgDedisp
- SpectraBurst
- FreqTimeAvg
- VoltageTimeSamples
- StdSpectLine
- PowerTimeSamples
- PulsePhaseSpectra
- SyncFreqTime

The primary header keywords are as follows:

```

SIMPLE = T / file does conform to FITS standard
BITPIX = 8 / number of bits per pixel
NAXIS = 0 / number of data axes
EXTEND = T / FITS dataset may contain extensions
ORIGIN = 'NRAO Green Bank' /
DATE-OBS='2000-10-25T13:57:17' / Scan Coordinator parameter startTime
TIMESYS = 'UTC' / time scale specification for DATE-OBS
INSTRUME='SpectralProcessor' / device or program of origin
GBTCVER= '3.3.0' / telescope control software release
FITSVER = '1.1' / FITS definition version for this device
DATEBLD= 'Thu Jun 7 20:15:13 GMT 2001' / time program was linked
SIMULATE= 0 / Is the instrument in simulate mode?
TELESCOP= 'NRAO_GBT' / Green Bank Telescope (Robert C. Byrd 100m)
OBJECT = '0013+1527' / Scan Coordinator parameter source
PROJID = 'RMP_DCR' / Scan Coordinator parameter projectId
OBSID = 'test' / Scan Coordinator parameter scanId
SCAN = 3 / Scan Coordinator parameter scanNumber
MODE = 'StdSpectLine' / Set of quadrants and associated input ports
END

```

As for all GBT scan data FITS files, the DATE-OBS keyword takes the value of the Manager parameter `startTime`. This is the scheduled start time for the scan as a whole. The actual time at which integrations are taken is recorded in the DATA table; it is possible that there may be some delay between the start of the scan (as recorded in DATE-OBS) and the actual time of the first integration.

3 PORT Binary Table Extension

The PORT table describes the SpectralProcessor set up and which IF inputs (samplers) have been used. An example header, plus ascii listing of typical table data, is given below:

PORT Binary Tables Extension: Header

```
-----
XTENSION= 'BINTABLE'           / binary table extension
BITPIX   =                      8 / 8-bit bytes
NAXIS    =                      2 / 2-dimensional binary table
NAXIS1   =                    118 / width of table in bytes
NAXIS2   =                      2 / number of rows in table
PCOUNT   =                      0 / size of special data area
GCOUNT   =                      1 / one data group (required keyword)
TFIELDS  =                      5 / number of fields in each row
TTYPE1   = 'BANK_A'             / label for field 1
TFORM1   = '1A'                 / data format of field: 1-byte CHAR
TUNIT1   = 'none'               / physical unit of field
TTYPE2   = 'PORT_A'             / label for field 1
TFORM2   = '1I'                 / data format of field: 2-byte INTEGER
TUNIT2   = 'INDEX'              / physical unit of field
TTYPE3   = 'BANK_B'             / label for field 1
TFORM3   = '1A'                 / data format of field: 1-byte CHAR
TUNIT3   = 'none'               / physical unit of field
TTYPE4   = 'PORT_B'             / label for field 2
TFORM4   = '1I'                 / data format of field: 2-byte INTEGER
TUNIT4   = 'INDEX'              / physical unit of field
TTYPE5   = 'TAPER'              /
TFORM5   = '8A'                 /
TUNIT5   = 'none'               / physical unit of field
TTYPE6   = 'FREQRES'            /
TUNIT6   = 'HZ'                 /
TFORM6   = '1D'                 /
TTYPE7   = 'BANDWIDTH'          /
TUNIT7   = 'HZ'                 /
TFORM7   = '1E'                 /
TTYPE8   = 'ATTENUAT'           /
TFORM8   = '1E'                 /
TUNIT8   = 'dBm'                /
TTYPE9   = 'FASTTIME'           /
TUNIT9   = 'SECONDS'            /
TFORM9   = '1E'                 /
TTYPE10  = 'SLOWTIME'           /
TUNIT10  = 'none'               /
TFORM10  = '1E'                 /
TTYPE11  = 'CLIP'               /
```

```

TUNIT11 = 'none' /
TFORM11 = '1E' /
TTYPER12 = 'THRESH' /
TUNIT12 = 'SECONDS' /
TFORM12 = '1E' /
TTYPER13 = 'SYNTHL' /
TUNIT13 = 'CODE' /
TFORM13 = '1B' /
TTYPER14 = 'OVERL' /
TUNIT14 = 'CODE' /
TFORM14 = '1B' /
TTYPER15 = 'IMODF' /
TUNIT15 = 'CODE' /
TFORM15 = '1B' /
TTYPER16 = 'IFSYNTH' /
TUNIT16 = 'CODE' /
TFORM16 = '1B' /
TTYPER17 = 'TAPEROFF' /
TUNIT17 = 'CODE' /
TFORM17 = '1B' /
TTYPER18 = 'RFIEXC' /
TUNIT18 = 'CODE' /
TFORM18 = '1B' /
TTYPER19 = 'CLKSRC' /
TUNIT19 = 'CODE' /
TFORM19 = '1B' /
TTYPER20 = 'IFLO' /
TUNIT20 = 'CODE' /
TFORM20 = '1B' /
TTYPER21 = 'IFSIDE' /
TUNIT21 = 'CODE' /
TFORM21 = '1B' /
MULTMODE= 'SqrCross' / Square, Cross, or SqrCross
EXTNAME = 'PORT' / name of this binary table extension
END

```

PORT Binary Tables Extension: Data (complete)

(This will have to wait until we have actual data!!)

Each row of the PORT table describes one complex spectrum produced by the SpectralProcessor. The total number of rows therefore defines the size of the third dimension (CYTPE3 = 'PORT') of the seventh column (TTYPER7 = 'DATA') of the DATA table described below, and the row number provides the index into this dimension.

Each row contains the value of two ports which are identified by BANK and PORT (BANK_A, PORT_A, BANK_B, and PORT_B). For non-cross multiplier mode, i.e., Square, the A and B ports are the same. For example, using two samplers per rack yields:

BANK_A	PORT_A	BANK_B	PORT_B
A	1	A	1
A	2	A	2

B	1	B	1
B	2	B	2

For cross multiplier modes, i.e., `Cross` and `SqrCross`, the ports will have all combinations. For example, using one sampler per rack yields:

BANK_A	PORT_A	BANK_B	PORT_B
-----	-----	-----	-----
A	1	A	1
A	1	B	1
B	1	B	1
B	1	A	1

The `MULTMODE` keyword specifies whether the scan was intended to be cross and/or squared.

The definitions of the columns in the binary table are as follows:

BANK_A Identifier for the first bank containing the A/D sampler for the spectrum.

PORT_A Index to the A/D sampler in `BANK_A` for the spectrum.

BANK_B Identifier for the second bank containing the A/D sampler for the spectrum. This will be identical to `BANK_A` in `Square` mode.

PORT_B Index to the A/D sampler in `BANK_B` for the spectrum. This will be identical to `PORT_A` in `Square` mode.

TAPER Describes the weighting function used on the A/D amplitude-vs-time series before its transformation. Possible values are `Box`, `Halfbox`, and `Cosine`.

FREQRES Specifies the frequency resolution, i.e., Hz per channel.

BANDWIDTH Specifies the port bandwidth.

ATTENUAT Specifies the port attenuator setting.

FASTTIME Specifies the response time of the total power pulsed RFI threshold detector.

SLOWTIME Specifies the response time of the baseline comparison level for the total power pulsed RFI threshold detector.

CLIP Specifies the maximum instantaneous level applied to the slow baseline integrator. It is specified in fraction of the total IF power plus noise peak level with the given bandwidth.

THRESH Specifies the level difference between the outputs of the fast and slow integrators that will flag an RFI pulse. Specified in fraction of total IF peak noise excursions from the average DC detected level with the given bandwidth.

SYNTHL Designates whether the IF's synthesizer is out of lock, i.e., 1 if out of lock.

OVERL Designates whether the total power is overloaded, i.e., 1 if overloaded.

IMODF Designates whether the InterMode filter is is, i.e., 1 if in.

IFSYNTH Designates whether synthesizer doubler is on, i.e., 1 if doubling.

TAPEROFF Designates whether synthesizer taper offset between racks is on.

RFIEXC Designates whether RFI excision is on.

CLKSRC Designates whether clock source is external, i.e., 1 if external.

IFLO Designates whether the IF's LO is external, i.e., 1 if external.

IFSIDE Designates whether the IF's sideband selection if upper or lower, i.e., 1 if lower.

4 STATE Binary Table Extension

The SpectralProcessor FITS keywords for the STATE table conforms to the definition for common FITS headers as described in GBT Software Project Note 4.0 “Device and Log FITS Files for the GBT.” The row number provides the index into the STATE dimension of the seventh column (DATA) in the DATA table. The order of the states in this table is that of the STATE dimension in the DATA cube.

Note that the SpectralProcessor cannot act as a slave to switching signals generated from an external source, i.e., it must be the master. An example STATE header, plus ASCII listing of typical table data, is given below:

STATE Binary Tables Extension: Header

this will wait for actual data

STATE Binary Tables Extension: Data (complete)

wait for real data

Note that this table describes the SpectralProcessor’s internal configuration of switching signals, it is name STATE in accordance with common M&C usage and convention in the other GBT backend FITS files.

5 DATA Binary Table Extension

The DATA table contains a (large) DATA column containing counts from both banks of the Spectral Processor.

An example extension header, and a subset of the data is given below:

DATA Binary Tables Extension: Header

XTENSION= 'BINTABLE' / FITS binary table.
BITPIX = 8 / Binary data.
NAXIS = 2 / Table is a Matrix.
NAXIS1 = 32792 / Width of table in bytes.
NAXIS2 = 1 / Number of entries (rows) in Table.
PCOUNT = 0 / Pointer Count
GCOUNT = 1 / Only one group.
TFIELDS = 7 / Number of fields in each row.
TTYPE1 = 'DMJD' /
TFORM1 = '1D' /
TUNIT1 = 's' /
TTYPE2 = 'UTDTSTR' /
TUNIT2 = 'MJD' /
TFORM2 = '1J' /
TTYPE3 = 'UTCSTR' /
TUNIT3 = 'SECONDS' /
TFORM3 = '1D' /
TTYPE4 = 'PSRPER' /
TUNIT4 = 'PULSAR PERIOD' /
TFORM4 = '1D' /
TTYPE5 = 'FFTS' /

```

TUNIT5  = 'none'      /
TDIM5   = '(1,4,2)'   / Structure of 3D item (1, STATE, PORT)
TFORM5  = '8J'        /
TTYPER6 = 'DELETED'   /
TUNIT6  = 'none'      /
TFORM6  = '8J'        /
TDIM6   = '(1,4,2)'   / Structure of 3D item (1, STATE, PORT)
TTYPER7 = 'DATA'      /
TUNIT7  = 'COUNTS'   /
TFORM7  = '8192E'     /
TDIM7   = '(1024,4,2)' / Structure of 3D item (FREQUENCY, STATE, PORT)
CTYPE1  = 'FREQUENCY' / First data axis is Frequency
CTYPE2  = 'STATE'     / Second data axis is State
CTYPE3  = 'PORT'      / Third data axis is Port
EXTNAME = 'DATA'      / extension name
END

```

The DATA table contains rows describing each integration obtained during the scan.

The DMJD column specifies the center of the integration, as does UTDSTRT and UTCSTRT (but more accurately to nail down pulsar work). The PSRPER gives the actual integration time which can vary from integration to integration in pulsar mode. The FFTS and DELETED columns contain the number of Fourier transforms used and the number deleted as the result of RFI excision. They are three-dimensional entries with variable size axes between scans, but constant within a scan, i.e., STATE*PORT. The structure of these 3 dimensional elements are specified by the keywords TDIM5 and TDIM6. The first dimension always has only one element. The structure of the 3 dimensional element DATA is specified by the keyword TDIM7. Its dimensions are defined by the keywords:

CTYPE1 Type of data along the first axis of the DATA's 3 dimensional table element. Normally this FITS keyword entry has the form CTYPE1 = 'FREQUENCY'.

CTYPE2 Type of data along the second axis of the 3 dimensional table element. Normally this FITS keyword entry has the form CTYPE2 = 'STATE'.

CTYPE3 Type of data along the third axis of the 3 dimensional table element. Normally this FITS keyword entry has the form CTYPE3 = 'PORT'.

6 SUMMARY

The definition of FITS file keywords and table columns conforms to the standard for the GBT project as a whole.

A Example FITS file

Examples from each of the three Spectral Processor modes.