



**Robert C. Byrd Green Bank Telescope  
NRAO Green Bank**

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4th December 2001

GBT SOFTWARE PROJECT NOTE 16.0

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## **Berkeley Caltech Pulsar Machine FITS File Specification**

HTML version Available<sup>1</sup>

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### **Abstract**

The FITS format structure is presented for the Berkeley Caltech Pulsar Machine (BCPM) scan data files. The scan data FITS files are permanently archived after each observation, together with the scan data files from other devices selected for the scan.

The scan data FITS files contain a complete description of the BCPM setup for the observation. Measurement data is written via independent software running locally on the BCPM workstations in separate data files; the format of the measurement data files does not conform to the FITS specification.

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

## **History**

**4th December 2001** Initial version (Amy Shelton).

## 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.” There are two identical Berkeley Caltech Pulsar Machines (BCPM) available for use with the GBT. An observer may use one or both of these machines, which are referred to as BCPM1 and BCPM2. Each BCPM generates its own FITS file. These FITS files only contain header information, which is useful for recording the set-up of the machine during an observation. The data taken during an observation is saved in a non-FITS file by a software package developed by the Penn State Pulsar Group and later modified by the Berkeley-Caltech team for use with the BCPM.

## 2 Primary HDU keywords

The BCPM FITS keywords for the primary HDU 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 keywords included in the Primary HDU are dependent on the mode of operation of the BCPM. Four modes of operation are defined for the BCPM: monitor, search, timing, and voltage sampling.

### 2.1 Monitor Mode PHDU

The primary header keywords for monitor 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' /
INSTRUME= 'Berkeley Caltech Pulsar Machine' / device or program of origin
GBTMCVER= '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?
DATE-OBS= '2000-10-25T13:57:17' / Manager parameter startTime
TIMESYS = 'UTC' / time scale specification for DATE-OBS
TELESCOP= 'NRAO_GBT' / Green Bank Telescope (Robert C. Byrd 100m)
OBJECT = '0013+1527' / Manager parameter source
PROJID = 'RMP_DCR' / Manager parameter projectId
OBSID = 'test' / Manager parameter scanId
SCAN = 3 / Manager parameter scanNumber
MANAGER = 'BCPM1' / GBT Device Manager
CALFLAG = 0 / Flag whether cal signal was used
MODE = 'monitor' / BCPM operating mode
SUMPOL = 0 / Flag whether polarizations are summed
BANDWDTH= 1.740000E+06 / SSB channel bandwidth in Hz
SAMPTIME= '4x' / Sample time
ELAPTIME= 1.5E+01 / elapsed time of the observation
END

```

There are four non-standard GBT keywords. A value of 0 for the CALFLAG keyword indicates that a calibration signal was not present for the observation; a value of 1 indicates the presence of a calibration signal. The MODE keyword indicates the operating mode of the BCPM; this keyword is always set to “monitor” while the BCPM is in monitoring mode. The SUMPOL keyword is set to a value of 1 when polarization summing is in effect during

an observation and it is 0 otherwise. The data sample time is expressed in terms of decimation factors in the SAMPTIME keyword; possible values for this keyword are “1x”, “2x”, “4x”, and “8x.”

## 2.2 Search Mode PHDU

The primary header keywords for search are as follows:

```

SIMPLE      =          T / file does conform to FITS standard
BITPIX     =          8 / number of bits per data pixel
NAXIS      =          0 / number of data axes
EXTEND     =          T / FITS dataset may contain extensions
ORIGIN     = 'NRAO Green Bank' /
INSTRUME= 'Berkeley Caltech Pulsar Machine' / device or program of origin
GBTMCVER= '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=          F / Is the instrument in simulate mode?
DATE-OBS= '2000-10-25T13:57:17' / Manager parameter startTime
TIMESYS   = 'UTC' / time scale specification for DATE-OBS
TELESCOP= 'NRAO_GBT' / Green Bank Telescope (Robert C. Byrd 100m)
OBJECT    = '0013+1527' / Manager parameter source
PROJID    = 'RMP_DCR' / Manager parameter projectId
OBSID     = 'test' / Manager parameter scanId
SCAN      =          3 / Manager parameter scanNumber
MANAGER   = 'BCPM1' / GBT Device Manager
CALFLAG   =          0 / Flag whether cal signal was used
MODE      = 'search' / BCPM operating mode
SUMPOL    =          0 / Flag whether polarizations are summed
BANDWIDTH=          1.740000E+06 / SSB channel bandwidth in Hz
SAMPTIME= '4x' / Sample time
RA        = '00:00:00.0' / R. A. of the observation
DEC       = '00:00:00.0' / declination of the observed object
ELAPTIME=          1.5E+01 / elapsed time of the observation
STORAGE   = 'Tape' / The data storage device
FILESIZE=          100 / The size of the data file
TARGET    = '0013+1527' / Keyword in BCPM data file header
BASENAME= '0013+1527' / Basis for the data filename
END

```

There are eight non-standard GBT keywords. A value of 0 for the CALFLAG keyword indicates that a calibration signal was not present for the observation; a value of 1 indicates the presence of a calibration signal. The MODE keyword indicates the operating mode of the BCPM; this keyword is always set to “search” while the BCPM is in search mode. The SUMPOL keyword is set to a value of 1 when polarization summing is in effect during an observation and it is 0 otherwise. The data sample time is expressed in terms of decimation factors in the SAMPTIME keyword; possible values for this keyword are “1x”, “2x”, “4x”, and “8x.” The STORAGE keyword indicates whether the observation data are saved to “Disk”, which refers to the workstation’s hard drive, or to “Tape”, which refers to either DLT tape or a networked directory. If STORAGE is “Tape”, the BCPM software will partition the data into multiple files rather than one large file. The partition size is specified via the FILESIZE keyword, which only appears if STORAGE is “Tape”, and is in units of seconds. TARGET is a keyword that represents a string that identifies the observation, which is in the BCPM data file. The BASENAME is a string that forms part of the data file name. Both TARGET and BASENAME are user specified at the time of the observation.

## 2.3 Timing Mode PHDU

The primary header keywords for timing are as follows:

```

SIMPLE = T / file does conform to FITS standard
BITPIX = 8 / number of bits per data pixel
NAXIS = 0 / number of data axes
EXTEND = T / FITS dataset may contain extensions
ORIGIN = 'NRAO Green Bank' /
INSTRUME= 'Berkeley Caltech Pulsar Machine' / device or program of origin
GBTMCVER= '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= F / Is the instrument in simulate mode?
DATE-OBS= '2000-10-25T13:57:17' / Manager parameter startTime
TIMESYS = 'UTC' / time scale specification for DATE-OBS
TELESCOP= 'NRAO_GBT' / Green Bank Telescope (Robert C. Byrd 100m)
OBJECT = '0013+1527' / Manager parameter source
PROJID = 'RMP_DCR' / Manager parameter projectId
OBSID = 'test' / Manager parameter scanId
SCAN = 3 / Manager parameter scanNumber
MANAGER = 'BCPM1' / GBT Device Manager
CALFLAG = 0 / Flag whether cal signal was used
MODE = 'timing' / BCPM operating mode
PERIOD = 1.0E-03 / Period of the pulsar in seconds
PHASEBIN= 128 / The number of phase bins (power of 2)
DM = 3E-02 / Dispersion measure (parsecs per cm^3)
CENTFREQ= 1.4E+09 / Sky frequency for center of the band in Hz
BANDWDTH= 1.740000E+06 / SSB channel bandwidth in Hz
SUMPOL = 0 / Flag whether polarizations are summed
ELAPTIME= 1.5E+01 / elapsed time of the observation
STORAGE = 'Disk' / The data storage device
END

```

There are eight non-standard GBT keywords. A value of 0 for the CALFLAG keyword indicates that a calibration signal was not present for the observation; a value of 1 indicates the presence of a calibration signal. The MODE keyword indicates the operating mode of the BCPM; this keyword is always set to “timing” while the BCPM is in timing mode. The PERIOD keyword indicates the period of the pulsar to be timed; if the pulsar already has an entry in the polyco.dat file, this keyword is omitted. The PHASEBIN keyword indicates the number of phase bins used for the observation. The number of phase bins is a power of two and must be between 1 and 8192. If the pulsar under observation already has an entry in the polyco.dat file, the PHASEBIN keyword is omitted. The DM keyword indicates the dispersion measure of the pulsar under observation; dispersion measure is related in units of parsecs per cubic centimeter. If the pulsar under observation already has an entry in the polyco.dat file, the DM keyword is omitted. The CENTFREQ keyword indicates the sky center frequency of the observation in Hertz. The SUMPOL keyword is set to a value of 1 when polarization summing is in effect during an observation and it is 0 otherwise. The STORAGE keyword is always set to “Disk” in timing mode, indicating that the data files are saved to the hard drive of the BCPM computer.

## 2.4 Voltage Sampling Mode PHDU

The primary header keywords for voltage sampling are as follows:

```

SIMPLE = T / file does conform to FITS standard

```

```

BITPIX = 8 / number of bits per data pixel
NAXIS = 0 / number of data axes
EXTEND = T / FITS dataset may contain extensions
ORIGIN = 'NRAO Green Bank' /
INSTRUME= 'Berkeley Caltech Pulsar Machine' / device or program of origin
GBTMCVER= '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= F / Is the instrument in simulate mode?
DATE-OBS= '2000-10-25T13:57:17' / Manager parameter startTime
TIMESYS = 'UTC' / time scale specification for DATE-OBS
TELESCOP= 'NRAO_GBT' / Green Bank Telescope (Robert C. Byrd 100m)
OBJECT = '0013+1527' / Manager parameter source
PROJID = 'RMP_DCR' / Manager parameter projectId
OBSID = 'test' / Manager parameter scanId
SCAN = 3 / Manager parameter scanNumber
MANAGER = 'BCPM1' / GBT Device Manager
CALFLAG = 0 / Flag whether cal signal was used
MODE = 'voltage sampling' / BCPM operating mode
BANDWDTH= 1.740000E+06 / DSB channel bandwidth in Hz
SAMPTIME= '4x' / Sample time
REGISTER= 'POLA0' / Register from which the voltage is sampled
RA = '00:00:00.0' / R. A. of the observation
DEC = '00:00:00.0' / declination of the observed object
ELAPTIME= 1.5E+01 / elapsed time of the observation
STORAGE = 'Tape' / The data storage device
FILESIZE= 100 / The size of the data file
TARGET = '0013+1527' / Keyword in BCPM data file header
BASENAME= '0013+1527' / Basis for the data filename
END

```

There are eight non-standard GBT keywords. A value of 0 for the CALFLAG keyword indicates that a calibration signal was not present for the observation; a value of 1 indicates the presence of a calibration signal. The MODE keyword indicates the operating mode of the BCPM; this keyword is always set to “voltage sampling” while the BCPM is in voltage sampling mode. The data sample time is expressed in terms of decimation factors in the SAMPTIME keyword; possible values for this keyword are “1x”, “2x”, “4x”, and “8x.” The REGISTER keyword indicates the register name from which the voltage is being sampled. Possible values for REGISTER are “POLA0”, “POLA1”, “POLA2”, “POLA3”, “POLB4”, “POLB5”, “POLB6”, and “POLB7”. The STORAGE keyword indicates whether the observation data are saved to “Disk”, which refers to the workstation’s hard drive, or to “Tape”, which refers to either DLT tape or a networked directory. If STORAGE is “Tape”, the BCPM software will partition the data into multiple files rather than one large file. The partition size is specified via the FILESIZE keyword, which only appears if STORAGE is “Tape”, and is in units of seconds. TARGET is a keyword that represents a string that identifies the observation, which is in the BCPM data file. The BASENAME is a string that forms part of the data file name. Both TARGET and BASENAME are user specified at the time of the observation.

### 3 SUMMARY

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

In conclusion it is important to emphasize that the scan data FITS files contain only a Primary HDU, which lists keywords to describe the BCPM setup for the observation. Measurement data is written via independent software

running locally on the BCPM workstations in separate data files; the format of the measurement data files does not conform to the FITS specification.