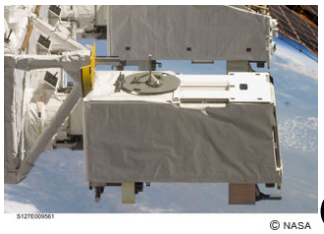

CALET

CALET Gamma Ray Burst Monitor Analysis Guide

Version 1.0

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Prepared by: Jesse Allen, James Runge, and Lorella Angelini (HEASARC/NASA)

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1 CALET Overview

The CALorimetric Electron Telescope (CALET) is a Japan-led international mission funded by the Japanese Space Agency (JAXA) in collaboration with the Italian Space Agency (ASI) and NASA. The CALET payload consists of two main experiments: a) Calorimeter (CAL) is the primary instrument dedicated to the high–precision measurement of the cosmic-ray total electron spectrum in the GeV to TeV region; b) CALET Gamma Ray Burst Monitor (CGBM) dedicated to the detection of gamma-ray bursts and gamma-ray transients

This software guide enable the data analysis of the data collected with CGBM experiment that comprises of two different detectors: the Soft Gamma-ray Monitor (SGM ~100 keV – 20 MeV) and the Hard X-ray Monitor (two identical units HXM1 and HXM2, 7 keV-1000 keV).

Section 2 shows an example to how run the software on CGBM event data, section 3 instead includes the help on individual tasks.

2 CALET CGBM data and software tasks

The CALET CGBM archive contains for each observation: a) the monitor PH data which are binned spectra every 4 sec, b) the monitor TH data which are counts in 4 bins integrated 0.125s, and c) if a burst is triggered on board an event file is also included. The PH, TH and event are collected in High and Low gain which effectively cover different energies range. The CALET CGBM software package within HEASoft includes tasks to generate products from the CGBM event data. It would be possible to use these tools with the monitoring data after summing the energy channels into one channel, however the 4 sec binning would made the burst search only useful for longer burst. Therefore, this guide shows a full example using only the event data.
The CALET CGBM software package includes the following tasks :

burstbkgevt - Generate simulated background events based on input background lightcurve and spectra.
burstfinder - Search for burst(s) and calculate the time intervals using as input a binned lightcurve.
burstt90t50 - Calculate the T90 and T50 intervals and write results to GTI output file.
cgbm_bstgti - Search for burst(s) and calculate the time intervals using as input an event file from a specific CALET GBM detector (script that run **burstfinder**).
cgbm_speclc - Extract spectra and/or lightcurves from a CGBM event file within a time interval (script the run the **extractor** tuned to CALET GCBM data).
cgbm_findrmf - Select and retrieve the appropriate response from the CGBM CALDB for a given time, sky location, detector, and gain.

2.1 Example how to run the tasks on event data

The first step is to search the data for the burst. **cgbm_bstgti** takes an input event file , binned the data and searches for time intervals with significantly higher rates. **cgbm_bstgti**, calls **extractor** for binning the event and **burstfinder** for detecting the intervals with the bursts. It outputs binned lightcurves, with and without modeled background and net rate values, GTI associated with the burst(s), and summary information.

```
cgbm_bstgti infile=cgbm_sgm.evt outroot=cgbm_sgm_025h timebin=0.25
pirange=155:4031 ecol=PI_HIGH timewin=10.0 numsdv=3.0 numsdv2=3.0
timewin2=0.25 mufactor=0.2 min_int=30 chatter=1 history=yes
```

which produces the following terminal output:

```
INFO   ::cgbm_bstgti 1.26b (29 Jul 2025)
INFO   ::-------------------------------------------------------
INFO   ::
INFO   ::
```

```
INFO   ::FTOOLS CMD: extractor 'filename=../input/cgbm_sgm.evt[PI_HIGH=155:4031]'
'fitsbinlc=cgbm_sgm_025h.lc' 'lcthresh=0.99' 'binlc=0.25' 'tcol=TIME' 'ecol=PI_HIGH'
'events=EVENTS' 'eventsout=NONE' 'regionfile=NONE' 'qdpfile=NONE' 'lctzero=yes'
'xronwn=NONE' 'unbinlc=NONE' 'phafile=NONE' 'imgfile=NONE' 'timefile=NONE'
'adjustgti=no' 'gstring=NONE' 'usetpixrsel=no' 'timeorder=no' 'xcolf=NONE'
'ycolf=NONE' 'xcolh=NONE' 'ycolh=NONE' 'xfkey=TLMAX' 'yfkey=TLMAX' 'xhkey=TLMAX'
'yhkey=TLMAX' 'phamax=TLMAX' 'specbin=1' 'binh=1' 'binf=1' 'ccol=NONE' 'gcol=NONE'
'polwcol=NONE' 'gti="GTI"' 'gtitxt=NONE' 'timeref=40000.00' 'wtmapb=no' 'stokes=NONE'
'gtinam="GTI"' 'exitnow=no' 'clobber=yes'
INFO   ::extractor v6.18    23 Apr 2025
INFO   :: Getting FITS WCS Keywords
INFO   :: Doing file: ../input/cgbm_sgm.evt
INFO   :: 10% completed
 20% completed
 30% completed
 40% completed
 50% completed
 60% completed
 70% completed
 80% completed
 90% completed
100% completed
INFO   ::          Total      Good    Bad: Time     Phase     Grade       Cut
INFO   ::         826266    592059            0         0         0    234207
INFO
::================================================================================
INFO   ::    Grand Total      Good    Bad: Time     Phase     Grade       Cut
INFO   ::         826266    592059            0         0         0    234207
INFO   ::   in  633.58     seconds
INFO   :: Fits light curve has  5.9206E+05 counts for   934.5     counts/sec
INFO   ::
INFO   ::
INFO   ::FTOOLS CMD: burstfinder 'infile=cgbm_sgm_025h.lc' 'outroot=cgbm_sgm_025h'
'leapfile=REFDATA' 'timewin=10.0' 'gap_interval=100.0' 'numsdv=3.0' 'fraction=0.01'
'polyorder=3' 'fill=yes' 'refit=yes' 'use_covar=yes' 'maxiter=10' 'pdiff=0.1'
'numsdv2=3.0' 'timewin2=0.25' 'mufactor=0.2' 'time_min=NONE' 'time_max=NONE'
'trigtime=' 'tcol=TIME' 'rcol=RATE' 'min_int=30' 'clobber=yes' 'chatter=1' 'debug=no'
'history=no'
INFO   ::burstfinder: INFO: burstfinder 1.951b (10 Jan 2025)
INFO   ::--------------------------
INFO   ::burstfinder: Writing light curve file
INFO   ::burstfinder: Total burst time start: 612648619.298257
INFO   ::burstfinder: T90 burst time start:   612648626.798257
INFO   ::burstfinder: TRIGTIME in input FITS: 612648625.034470
INFO   ::burstfinder: Writing GTI files
INFO   ::
```

In this example, the input event file `cgbm_sgm.evt` is from the Soft Gamma Ray Monitor (SGM). The event data are searched in the high gain subset of SGM in the 10-1000 keV range (*ecol* set to be PI_HIGH and *pirange* set to 155:4031), binning the data into 0.25 s bins (*timebin*=0.25). To find intervals where the event is significantly higher than average, the parameter *numsdv* is set to 3.0. In the first pass the algorithm sets a time window with the parameter *timewin* to 10.0 s. for averaging the rate and make an initial estimate of the background rate.

In the second pass, the background derived in the first pass is subtracted and the code searches for statistically significant event rates as defined by the parameter *numdv2* set to 3.0, smoothing data with a 0.25 s window (*timewin2*). The start and stop of the burst interval is found by searching around the peak time until the rate fall below a multiple of the standard deviation set in the example to 0.2 using the parameter *mufactor*. If more than one burst candidate is found, the task merges into a single burst if the peaks are less than 30.0 s apart (set with the parameter *min_int*). If it fails to find any bursts, it will exit with a binned lightcurve with the raw binned rates and a second which includes the background model and background-subtracted rates.

The example run of **cgbm_bstgti** has several parameters left to their default. Some are : a) *polyorder* has a default value of 3 indicating that the background is modeled using a third order polynomial to fit the data; b) *use_covar* has a default value of 'yes', indicating the use of a covariance method for fitting the background model which considers both rate and error when fitting; c) *gap_interval* has a default of 100.0 s indicating that if the data have a large gap greater than 100.0s, the background is modelled independently on each side of the gap rather than trying to fit the model across the empty interval.

The output from this command is two lightcurves, `cgbm_sgm_025h.lc` and `cgbm_sgm_025h_user.lc`, a GTI file `cgbm_sgm_025h_dur.gti` containing up to six GTI extensions, and two summary files `cgbm_sgm_025h_summary.fits` and `cgbm_sgm_025h_summary.txt`.

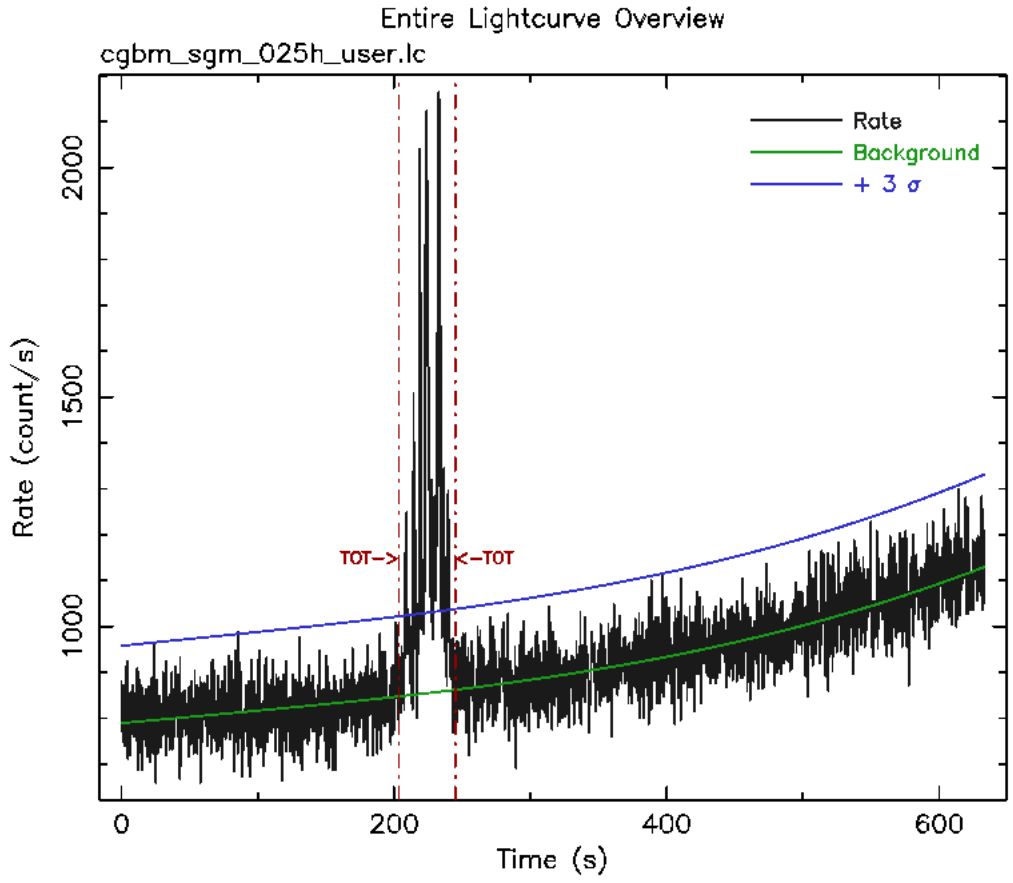
The plot shows the output of this example run; a single burst interval is found in this example between t = 203.5 and 245.0s. To create a plot that mark in the lightcurve the burst interval, the following commands are used:

```
ftcalc ../input/cgbm_sgm_025h_user.lc tmpplot.fits THREESIG
"BKGRATE+(3*BKGRATE_ERROR)" clobber=yes

fplot infile=tmpplot.fits xparm=TIME yparm="TOTRATE[TOTRATE_ERROR] BKGRATE
THREESIG" rows=- device='/xw' pltcmd=@mylc.pco
```

where the plot command file mylc.pco is

```
label t "Entire Lightcurve Overview"
label x "Time (s)"
label y "Rate (count/s)"
label f "cgbm_sgm_025h_user.lc"
LABEL 1 P 203.500000 509 LINE 90 2315 COLOR 5 LS 3
LABEL 2 P 245.000000 509 LINE 90 2315 COLOR 5 LS 3
LABEL 3 Justify Right P 203.500000 1150 CSIZE 0.8 COLOR 5 "TOT->"
LABEL 4 Justify Left P 245.000000 1150 CSIZE 0.8 COLOR 5 "<-TOT"
LABEL 5 VP 0.65 0.85 LI 0 CS 1.0 COLOR 2 " Rate"
LABEL 6 VP 0.65 0.815 LI 0 CS 1.0 COLOR 3 " Background"
LABEL 7 VP 0.65 0.78  LI 0 CS 1.0 COLOR 4 " + 3 \gs"
plot overlay
```



Find the T90 and T50 intervals

The task **burstt90t50** calculates T90 and T50 write the values in a GTI file. The example is run using the `cgbm_sgm_025h_user.lc`, a GTI file `cgbm_sgm_025h_dur.gti` output of the task **cgbm_bstgti.** The GTI interval required by the task is the total interval that includes the entire burst which is the extension 4 in the GTI file output of the task **cgbm_bstgti**.

```
burstt90t50 lcfile=cgbm_sgm_025h_user.lc gtifile=cgbm_sgm_025h_dur.gti+4
outfile=NONE
```

which produces the following screen output:

```
INFO    ::burstt90t50 0.7b (23 Jul 2025)
INFO    ::-----------------------------------------------------------
INFO    ::
INFO    ::FTOOLS CMD: fstruct 'infile=cgbm_sgm_025h_dur.gti'
INFO    ::  No. Type     EXTNAME      BITPIX Dimensions(columns)      PCOUNT  GCOUNT
INFO    ::
INFO    ::   0  PRIMARY                 16     0                          0    1
INFO    ::   1  BINTABLE GTI             8     16(2) 0                    0    1
INFO    ::
INFO    ::      Column Name               Format     Dims       Units     TLMIN  TLMAX
INFO    ::      1 START                     D                  s
INFO    ::      2 STOP                      D                  s
INFO    ::
INFO    ::   2  BINTABLE GTI             8     16(2) 0                    0    1
```

```
INFO   ::
INFO   ::      Column Name                Format     Dims       Units     TLMIN  TLMAX
INFO   ::      1 START                      D                  s
INFO   ::      2 STOP                       D                  s
INFO   ::
INFO   ::   3  BINTABLE GTI             8     16(2) 1                    0    1
INFO   ::
INFO   ::      Column Name                Format     Dims       Units     TLMIN  TLMAX
INFO   ::      1 START                      D                  s
INFO   ::      2 STOP                       D                  s
INFO   ::
INFO   ::   4  BINTABLE GTI             8     16(2) 1                    0    1
INFO   ::
INFO   ::      Column Name                Format     Dims       Units     TLMIN  TLMAX
INFO   ::      1 START                      D                  s
INFO   ::      2 STOP                       D                  s
INFO   ::
INFO   ::   5  BINTABLE GTI             8     16(2) 1                    0    1
INFO   ::
INFO   ::      Column Name                Format     Dims       Units     TLMIN  TLMAX
INFO   ::      1 START                      D                  s
INFO   ::      2 STOP                       D                  s
INFO   ::
INFO   ::   6  BINTABLE GTI             8     16(2) 1                    0    1
INFO   ::
INFO   ::      Column Name                Format     Dims       Units     TLMIN  TLMAX
INFO   ::      1 START                      D                  s
INFO   ::      2 STOP                       D                  s
INFO   ::
INFO   ::
INFO   ::FTOOLS CMD: ftappend 'infile=cgbm_sgm_025h_dur.gti+3' 'outfile=tempfile.gti'
'history=yes'
INFO   ::
INFO   ::FTOOLS CMD: ftappend 'infile=cgbm_sgm_025h_dur.gti+4' 'outfile=tempfile.gti'
'history=yes'
INFO   ::
INFO   ::FTOOLS CMD: ftappend 'infile=cgbm_sgm_025h_dur.gti+5' 'outfile=tempfile.gti'
'history=yes'
INFO   ::
INFO   ::FTOOLS CMD: ftappend 'infile=cgbm_sgm_025h_dur.gti+6' 'outfile=tempfile.gti'
'history=yes'
INFO   ::
INFO   ::FTOOLS CMD: ftchecksum 'infile=tempfile.gti' 'update=yes' 'datasum=yes'
INFO   ::File: tempfile.gti
INFO   ::  HDU CHECKSUM  DATASUM
INFO   ::    1:  updated  updated
INFO   ::    2:  updated  updated
INFO   ::    3:  updated  updated
INFO   ::    4:  updated  correct
INFO   ::    5:  updated  correct
INFO   ::    6:  updated  correct
INFO   ::    7:  updated  correct
INFO   ::   OK, all checksums are valid.
INFO   ::
INFO   ::
INFO   ::Moving temporary GTI file to cgbm_sgm_025h_dur.gti
INFO   ::
```

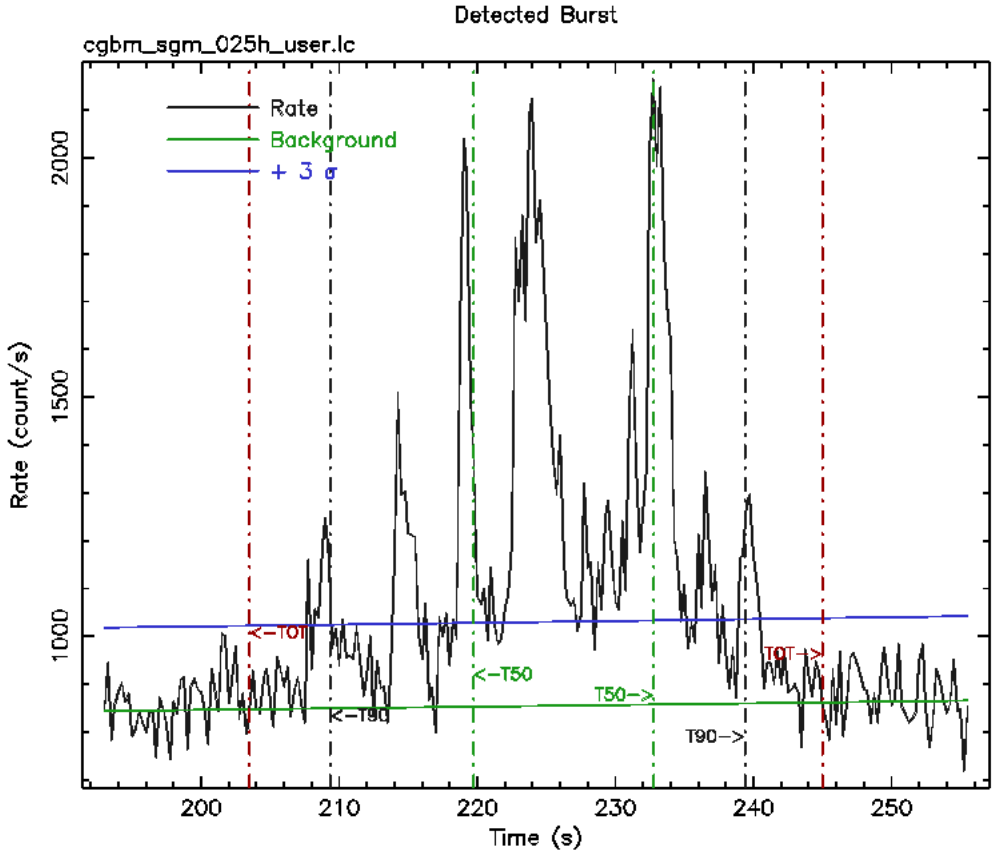
The T90 interval is found between 209.351 and 239.388 s and the T50 between 219.713 and 232.90 s.

To create a plot that mark in the lightcurve the burst interval and T90, the following commands are used:

```
fplot infile=tmpplot.fits xparm=TIME yparm="TOTRATE[TOTRATE_ERROR] BKGRATE
THREESIG" rows=- device='/xw' pltcmd=@myburst.pco
```

where the plot command file myburst.pco is

```
label t "Detected Burst"
label x "Time (s)"
label y "Rate (count/s)"
label f "cgbm_sgm_025h_user.lc"
LABEL 1 P 209.351234 575 LINE 90 2309 COLOR 2 LS 3
LABEL 2 P 239.387853 575 LINE 90 2309 COLOR 2 LS 3
LABEL 3 Justify Right P 239.387853 792 CSIZE 0.8 COLOR 2 "T90-> "
LABEL 4 Justify Left P 209.351234 836 CSIZE 0.8 COLOR 2 "<-T90"
LABEL 5 P 219.713359 575 LINE 90 2309 COLOR 3 LS 3
LABEL 6 P 232.789964 575 LINE 90 2309 COLOR 3 LS 3
LABEL 7 Justify Right P 232.789964 879 CSIZE 0.8 COLOR 3 "T50-> "
LABEL 8 Justify Left P 219.713359 922 CSIZE 0.8 COLOR 3 "<-T50"
LABEL 9 P 203.500000 575 LINE 90 2309 COLOR 5 LS 3
LABEL 10 P 245.000000 575 LINE 90 2309 COLOR 5 LS 3
LABEL 11 Justify Right P 245.000000 965 CSIZE 0.8 COLOR 5 "TOT-> "
LABEL 12 Justify Left P 203.500000 1009 CSIZE 0.8 COLOR 5 "<-TOT"
LABEL 13 VP 0.35 0.85 LI 0 CS 1.0 COLOR 2 " Rate"
LABEL 14 VP 0.35 0.815 LI 0 CS 1.0 COLOR 3 " Background"
LABEL 15 VP 0.35 0.78  LI 0 CS 1.0 COLOR 4 " + 3 \gs"
r x 193 255.5
plot overlay
```



Extract spectra

Spectra are extracted using the tool **cgbm_speclc**. This task can generate binned lightcurves from specific energy bands with up to three different energy bands (plus a total lightcurve) as well as spectra. The spectra are generated in the original PI (or PHA) bins of the input event data but may also be generated using a rebinning format to match the CALDB instrument response binning structure.

In this example, the task will obtain spectra for the intervals before and after the burst (which are needed for inputs for **burstbkgevt** later), and during the burst. For the burst interval spectra only, the spectra are also made with both the original and the CALET-specific rebinning (*binfile* set to default REFDATA; for the pre- and post-burst interval, *binfile* was set to NONE to skip this). The high gain data from the SGM event file is read (*ecol*=PI_HIGH). To skip the generation of lightcurves, *timebin1* is set to NONE.

```
cgbm_speclc infile=cgbm_sgm.evt outroot=cgbm_sgm_preburst
gtifile=cgbm_sgm_025h_dur.gti+5 timebin1=NONE ecol=PI_HIGH binfile=NONE

cgbm_speclc infile=cgbm_sgm.evt outroot=cgbm_sgm_postburst
gtifile=cgbm_sgm_025h_dur.gti+6 timebin1=NONE ecol=PI_HIGH binfile=NONE

cgbm_speclc infile=cgbm_sgm.evt outroot=cgbm_sgm_burst
gtifile=cgbm_sgm_025h_dur.gti+4 timebin1=NONE ecol=PI_HIGH
```

which produces the following terminal output for the last of these three commands:

```
INFO   ::cgbm_speclc 1.302b (13 Nov 2024)
INFO   ::-----------------------------------------------------
INFO   ::No timebin1 provided. Skipping light curve creation.
INFO   ::
INFO   ::Extracting GTI from ../input/cgbm_sgm_025h_dur.gti+4
INFO   ::
INFO   ::FTOOLS CMD: fextract 'infile=../input/cgbm_sgm_025h_dur.gti+4'
'outfile=temp.gti'
INFO   ::
INFO   ::FTOOLS CMD: extractor 'filename=../input/cgbm_sgm.evt[PI_HIGH=0:4095]'
'eventsout=NONE' 'regionfile=NONE' 'qdpfile=NONE' 'fitsbinlc=NONE' 'unbinlc=NONE'
'imgfile=NONE' 'phafile=cgbm_sgm_burst.pi' 'lcthresh=0' 'lctzero=YES'
'timefile=temp.gti' 'adjustgti=no' 'gstring=NONE' 'usetpixrsel=no' 'timeorder=no'
'xcolf=NONE' 'ycolf=NONE' 'xcolh=NONE' 'ycolh=NONE' 'xfkey=TLMAX' 'yfkey=TLMAX'
'xhkey=TLMAX' 'yhkey=TLMAX' 'phamax=TLMA' 'specbin=1' 'binh=1' 'binf=1' 'binlc=1'
'tcol=TIME' 'ecol=PI_HIGH' 'ccol=NONE' 'gcol=NONE' 'polwcol=NONE' 'events=EVENTS'
'gtitxt=NONE' 'timeref=40000.00' 'wtmapb=no' 'stokes=NONE' 'exitnow=no' 'clobber=no'
INFO   ::extractor v6.18    23 Apr 2025
INFO   :: Getting FITS WCS Keywords
INFO   :: Doing file: ../input/cgbm_sgm.evt
INFO   :: 10% completed
 20% completed
 30% completed
 40% completed
 50% completed
 60% completed
 70% completed
 80% completed
 90% completed
100% completed
INFO   ::          Total      Good    Bad: Time     Phase     Grade       Cut
INFO   ::         826266     61462       764804         0         0         0
INFO
::=============================================================================
INFO   ::    Grand Total      Good    Bad: Time     Phase     Grade       Cut
```

```
INFO   ::         826266     61462       764804         0         0         0
INFO   ::   in  41.500     seconds
INFO   :: Spectrum         has    61462 counts for   1481.     counts/sec
INFO   :: ... wrote the PHA data Extension
INFO   ::
INFO   ::
INFO   ::FTOOLS CMD: fdump 'infile=cgbm_sgm_burst.pi+0' 'outfile=primary_header.tmp'
'columns=-' 'rows=-' 'prhead=yes' 'prdata=no'
INFO   ::
INFO   ::FTOOLS CMD: fthedit 'cgbm_sgm_burst.pi+0' '@primary_header_edit.tmp'
INFO   ::
INFO   ::FTOOLS CMD: fthedit 'cgbm_sgm_burst.pi+1' '@ext_header_edit.tmp'
INFO   ::
INFO   ::FTOOLS CMD: fthedit 'cgbm_sgm_burst.pi+2' '@ext_header_edit.tmp'
INFO   ::
INFO   ::FTOOLS CMD: fthedit 'infile=cgbm_sgm_burst.pi+1' 'keyword=GAIN' 'value=HIGH'
'operation=add' 'comment=Gain setting'
INFO   ::
INFO   ::FTOOLS CMD: fthedit 'infile=cgbm_sgm_burst.pi+1' 'keyword=CHANTYPE'
'value=PI' 'operation=add' 'comment=Channel type'
INFO   ::
INFO   ::FTOOLS CMD: ftchecksum 'infile=cgbm_sgm_burst.pi' 'update=yes' 'datasum=yes'
INFO   ::File: cgbm_sgm_burst.pi
INFO   ::  HDU CHECKSUM  DATASUM
INFO   ::   1:  updated  correct
INFO   ::   2:  updated  correct
INFO   ::   3:  updated  correct
INFO   ::   OK, all checksums are valid.
INFO   ::
INFO   ::
INFO   ::Raw spectra saved as cgbm_sgm_burst.pi
INFO   ::
INFO   ::FTOOLS CMD: ftrbnpha 'infile=cgbm_sgm_burst.pi'
'outfile=cgbm_sgm_burst_rebin.pi'
'binfile=/processing/heasoft_version/develop/heasoft/x86_64-pc-linux-gnu-
libc2.28/refdata/cgbm_evtbin_pihigh.txt' 'properr=no' 'error=poiss-0' 'clobber=no'
INFO   ::
INFO   ::FTOOLS CMD: ftchecksum 'infile=cgbm_sgm_burst_rebin.pi' 'update=yes'
'datasum=yes'
INFO   ::File: cgbm_sgm_burst_rebin.pi
INFO   ::  HDU CHECKSUM  DATASUM
INFO   ::   1:  correct  correct
INFO   ::   2:  correct  correct
INFO   ::   3:  correct  correct
INFO   ::   OK, all checksums are valid.
INFO   ::
INFO   ::
INFO   ::Rebinned spectra saved as cgbm_sgm_burst_rebin.pi
INFO   ::  Removing temporary file temp.gti
INFO   ::
```

The combination of these three commands is five files: a pre-burst and a post-burst spectra file (`cgbm_sgm_preburst.pi` and `cgbm_sgm_postburst.pi`), a burst spectra in the original 4096 PI channels for the high gain, and a second one which uses the rebining structure from CALDB (`cgbm_sgm_burst.pi` and `cgbm_sgm_burst_rebin.pi` respectively) and a log of the task run named `cgbm_specl c.log`.

Select the best spectra response function

The tool **cgbm_findrmf** takes an ISS attitude file, the time and sky coordinates of the burst and computes the polar angles θ and ϕ orientation of the instrument to the source. The tool queries CALDB searching for both high and low gain in both HXMs and SGM responses and returns the best-matching filename if the parameter *closest_only* is set to yes and download the file is the parameter is set to *download* is set to yes .

For this example, the best RMF is found and downloaded from CALDB for SGM high gain only.

```
cgbm_findrmf datetime=2019-05-31T20:10:20.034 ra=24.2962 dec=41.9584
attfile="cgbm_20190531.iat.gz" detector=SGM download=yes gain=HIGH chatter=1
```

which produces the following terminal output:

```
INFO   ::cgbm_findrmf 1.501b (12 Mar 2025)
INFO   ::-----------------------------------------------------
INFO   ::
INFO   ::
INFO   ::FTOOLS CMD: time2sec 'date=2019-05-31' 'time=20:10:20.034' 'datezero=2000-01-
01' 'timezero=00:00:00' 'leapfile=FTOOLS'
INFO   :: offset in seconds (including leapseconds) from 2000-01-01   00:00:00     is
INFO   ::  6.126486250340004E+08
INFO   ::
INFO   ::
INFO   ::FTOOLS CMD: time2sec 'date=2019-05-30' 'time=23:59:50' 'datezero=2000-01-01'
'timezero=00:00:00' 'leapfile=FTOOLS'
INFO   :: offset in seconds (including leapseconds) from 2000-01-01   00:00:00     is
INFO   ::  6.125759950000000E+08
INFO   ::
INFO   ::
INFO   ::FTOOLS CMD: time2sec 'date=2019-05-31' 'time=23:59:52' 'datezero=2000-01-01'
'timezero=00:00:00' 'leapfile=FTOOLS'
INFO   :: offset in seconds (including leapseconds) from 2000-01-01   00:00:00     is
INFO   ::  6.126623970000000E+08
INFO   ::
INFO   ::Retrieving quaternion from attitude file
INFO   ::Performing rotations
INFO   ::Finding theta and phi
INFO   ::R.A., Dec:  24.2962 , 41.9584
INFO   ::Time: 2019-05-31T20:10:20.034
INFO   ::Theta,Phi: 114.8981 , 356.5097
INFO   ::Detector: SGM
INFO   ::Gain: HIGH
INFO.  ::Nearest RMF file:
/processing/calet/caldb/data/calet/cgbm/cpf/responses/sgm_hg/cgbm_sgm_th115_ph355_hg_2
0000101v002.rsp
INFO   ::Separation (degrees): 1.3726
INFO   ::
```

When this runs, the task computes the polar angles between the source at 24.2962, 41.9584 (in J2000 degrees) to be at a θ=114.8981˚ and ϕ=356.5097˚. CALDB contains an SGM high gain response matrix file for θ=155, ϕ=335 which is the closest file with an angular separation of 1.37˚.

The closest matching RMF file in CALDB is `cgbm_sgm_th115_ph355_hg_20000101v002.rsp.`

Generate a simulated background event file

The task **burstbkgevt** simulates background events using the background model found with **cgbm_bstgti** and the pre- and post-background spectra derived with **cgbm_speclc**. The inputs are : a) the `cgbm_sgm_025h_user.lc` output from **cgbm_bstgti;** b) the `cgbm_sgm_preburst pi cgbm_sgm_postburst pi` pre and post burst spectra output of **cgbm_speclc**

```
burstbkgevt infile="cgbm_sgm_025h_user.lc" prespec="cgbm_sgm_preburst.pi"
postspec="cgbm_sgm_postburst.pi" outroot="cgbm_sgm_025h" ratecol="BKGRATE"
destcol="PI_HIGH" errcol="ERROR" chatter=1 history=yes
logfile="\!burstbkgevt_sgm_025h.log"
```

which produces the following terminal output:

```
burstbkgevt: INFO: burstbkgevt 0.6b (29 Oct 2024)
--------------------------
burstbkgevt: INFO: Opening FITS file ../input/cgbm_sgm_025h_user.lc
burstbkgevt: INFO: Opening FITS file ../input/cgbm_sgm_preburst.pi
burstbkgevt: INFO: Opening FITS file ../input/cgbm_sgm_postburst.pi
burstbkgevt: INFO: GAIN of HIGH found in header.
burstbkgevt: INFO: ALERT! Spectral range is channels 0 to 4095
burstbkgevt: INFO: Sampling spectra from channels 155 to 4031
burstbkgevt: INFO: Initialized background and time arrays with 580439 elements
burstbkgevt: INFO: Creating event file cgbm_sgm_025h_simback.evt...
burstbkgevt: INFO: Opening FITS file ../input/cgbm_sgm_025h_user.lc to copy keywords
burstbkgevt: INFO: ...Reading GTI from ../input/cgbm_sgm_025h_user.lc
```

Note, the following alert:

```
burstbkgevt: INFO: ALERT! Spectral range is channels 0 to 4095
burstbkgevt: INFO: Sampling spectra from channels 155 to 4031
```

means that the spectra contains bins for all possible values (0-4095), but that the spectral range considered when computing the background model is limited to the range between channels 155 and 4031 that match the channel range over which the lightcurve is calculated (see channel range inputs in **cgbm_bstgti)**. The output simulated background event file contains channels between 155-4031.

3 Help for individual tasks

3.1 cgbm_bststi

cgbm_bstgti identifies time intervals associated with bursts detected by a CALET CGBM detector (HXM1, HXM2, or SGM) for a specific gain. The task uses a single input event file and uses the columns TIME, PI_LOW or PI_HIGH which report the time, the low gain energy channel and the high gain energy channel. The *ecol* parameter specifies which gain column to use. The task first generates a binned lightcurve from the input event file using the **extractor** task and then uses **burstfinder** to search the lightcurve for bursts and calculates the time intervals in four steps (see help of **burstfinder**).
The task outputs a Good Time Interval file, two lightcurves and a summary file. The GTI file contains up to 6 extensions that are:

- first and second extensions which are reserved for the time intervals corresponding to the 90% and 50% of the burst respectively but are not populated (see task **burstt90t50**);
- the third extension is populated with the time interval for the peak of the burst;
- the fourth extension is populated with the time interval for the total burst;
- the fifth and sixth extension is populated with the pre and/or post background interval if both intervals exist else only with the one that exists.

Each extension contains a header keyword GTITYPE with value of GTI_90, GTI_50, GTI_PEAK, GTI_TOT, GTI_BKG1, GTI_BKG2 to identify the extension content.
The output files are:

- the output of **extractor** where the rate corresponds to the binned rate of events;
- a lightcurve that contains the original rates taken from the **extractor** lightcurve (in columns TOTRATE and TOTRATE_ERROR), the background rates (BKGRATE and BKGRATE_ERROR) and the background subtracted rates (RATE and ERROR);
- The summary file (suffix ‘summary’ in filename) which contains a single line for each burst with summary information and is provided as FITS file and ASCII file.

If no bursts are found, the GTI and summary files are not created, but light curve files are always generated

Many of the input parameters are either for **extractor** or for **burstfinder**. The recommended default bin time is either 1 sec or .25 sec (paramter *timebin*) and channel range (parameter *pirange*) for the CGBM for each of the detectors and gain are:

- SGM high gain energy 40- 1000 keV pirange=155:4031
- SGM low gain energy 550-28000 keV pirange=78:3999
- HXM1/HXM2 high gain energy 4- 100 keV pirange=166:4095
- HXM1/HXM2 low gain energy 60- 3000 keV pirange=80:4000

PARAMETERS

infile [filename]
Input event file.

outroot [filename]
Root name for the output files.

(leapfile = "REFDATA") [string]
Name of the leap second file. If set to REFDATA (default), the leap second file in FTOOLS reference data directory is used.

timebin [real] (seconds)
The time bin (in seconds) used to generate the binned lightcurve from *infile*.

(lcthresh = 0.99) [real]
Minimum fractional exposure to retain bins in the lightcurves. Allowed values ranges from 0 (keep all bins) to 1 (keep the bin only if fully exposed). The default is 0.99.

pirange [integer:integer] (chan)
Specifies the minimum and maximum channels to include in the lightcurve. Provide the range as a string in the format "min:max", where both min and max are integers. For example, *pirange*="80:140" selects channels 80 through 140.

(extension = "EVENTS") [string]
Extension name to find events in the input FITS event file. Default is EVENTS.

ecol [string]
Column name in the FITS event file containing the channel information. For CGBM, these would be "PI_LOW" for low gain, or "PI_HIGH" for high gain data.

timewin [real] (seconds)
Time window (in seconds) to calculate the average in the first step. The value should be larger of the original binning.

(gap_interval=100.0) [real] (seconds)
If the lightcurve has large gap, this parameter allows restarting the sliding window average from the first valid point after the gap. The default is 100 s.

numsdv [real]
Number of standard deviations used in the first step to calculate the threshold between the current value and moving average.

(fill=yes) [boolean]
If set to "no", exclude values that are above the standard deviation defined by *numsdv* in the average caculation. If set to "yes" (default), the points above the standard deviation are replaced by

```
average*(1-frac)
```

where the `average` is the value of the rate average calculated for the *timewin* interval including the preceding point and `frac` is defined by the parameter *fraction*

(fraction=0.01) [real]
Fraction used to calculate the rate to be replaced in the original lightcurve if *fill*=yes. Value range between 0 and 1, default is 0.01.

(polyorder=3) [integer]
The order of the polynomial used to fit data to model background. Default is 3 (i.e. cubic fit).

(use_covar=yes) [boolean]
If set to "yes" (default), the polynomial fit model takes error in rate into account when fitting. If set to "no", error in rates are not used when computing the fitted model.

timewin2 [reF
Time window (in seconds) to calculate the average in the third step. The value should be larger than the original binning.

numsdv2 [real]
Number of standard deviations used in the third step to calculate the threshold between the polynomial fit and the smooth rates. Rates above *numsdv2* are considered a burst.

mufactor [real]
Multiplicative factor to the standard deviation obtained from the polynomial fit and the smoothed rate. This factor is used to determine the start and stop of a burst.

(min_int = 30.0) [real] (seconds)
The minimum time between adjacent bursts. If two bursts are detected within *min_int* seconds of each other, they are merged and consider a single burst. Default is 30.0 seconds

(refit=yes) [boolean]
Execute the fourth step (iterative refitting) if set to "yes" (default), where burst intervals found in the third step are excluded from the lightcurve and the data are refit. If set to "no", the fourth step is not executed and there is no refitting.

(maxiter=10) [integer]
If set (default is 10), the maximum number of times to iterate to potentially improve the polynomial fit solution. Ignored if *refit* is set to no.

(pdiff=0.1) [real]
Define the minimum difference in sigma between two subsequent polynomial fits. This is valid only if the parameter *refit* is set to yes. If the fit has improved sigma by more than *pdiff* times sigma, the new polynomial fit has improved and steps two and three are repeated.

(time_min = "NONE") [string]
The earliest time in the lightcurve to consider when searching for bursts. The time values may be provided as:
- Mission Elapsed Time (MET), the number of seconds from the start of the mission time, defined by keywords MJDREF (or MJDREFI and MJDREF) in the input lightcurve; OR
- UTC date in the form "YYYY-MM-DDThh:mm:ss.ff"

If set to NONE (or blank: default), the input lightcurve search starts with the first data point.

(time_max = "NONE") [string]
The latest time in the lightcurve file to consider when searching for bursts. The time values may be provided as:
- Mission Elapsed Time (MET), the number of seconds from the start of the mission time, defined by keywords MJDREF (or MJDREFI and MJDREF) in the input lightcurve; OR
- UTC date in the form "YYYY-MM-DDThh:mm:ss.ff"

If set to NONE (or blank: default), the input lightcurve search ends at the last data point.

(trigtime = "NONE") [string]
Trigger time. The value is informative only and written in the output files but not used in computations. The default setting is NONE (i.e. do not set TRIGTIME).

(tcol = TIME) [string]
Column name in the input file containing the time information. Default is TIME.

(clobber = no) [Boolean]
Overwrites the existing output files if set to yes (yes/[no]).

(chatter = 1) [integer, 0 - 3]
Chatter level for output. Set to 0 to suppress output, or to 1 (default), 2, or 3 for increasing the chatter of the output.

(debug = no) [boolean]

Diagnostic output is printed out on the screen if set to yes (yes/[no]). Also creates a diagnostic *outroot*_fit.lc file.

(logfile = !DEFAULT) [string]
Log filename. If set to DEFAULT uses the name of the task (i.e. cgbm_bstgti.log) and, if preceded by "!" overwrite the file if it exists. If set to NONE (or blank), no log file is created.

(history = no [boolean])
If set to yes, add HISTORY keywords to the output files record parameter settings. Default is NO.

(mode = ql) [string ql|hl|q]
Mode to query the parameter file. Acceptable values include:

- "ql" (query and learn/remember; DEFAULT),
- "hl" (hidden and learn/remember),
- "q" (query but don't remember),
- "h" (hidden).

EXAMPLE

Run **cgbm_bstgti** on a CGBM SGM event file using the low gain channels in the range 384-4079, a lightcurve time binning of 64 ms and search for the burst using a sliding window width of 10 s in the initial first pass, flagging any interval more than 3 standard deviations from this average as an outlier. Use the fill model to estimate background for any outlier using 0.99 times the sliding average plus 0.01 times the data value. Fit this background model with a cubic polynomial using the default covariance fitting algorithm. In the second pass, use an averaging time window of 1 s, setting the burst detection threshold for rates higher than 3 standard deviations above the background model, and set begin and end time bins for burst(s) when the rate first falls below 0.2 standard deviations. The output files have root names starting with "sgm112700". Do not attempt to iterate or refit after making an initial estimate of the burst interval(s).

```
cgbm_bstgti infile=cgbm_sgm_112700.evt.gz outroot=sgm112700 timebin=0.064
pirange="384:4079" ecol=PI_LOW numsdv=3.0 fraction=0.01 timewin=10
polyorder=3 numsdv2=3.0 timewin2=1.0  mufactor=0.2 fill=yes refit=no
```

3.2 cgbm_speclc

cgbm_speclc extracts binned lightcurves and/or spectra from a CALET CGBM detector (HXM1, HXM2, or SGM) event file and a GTI file. The task uses a single input event file either for the SGM or HXM1 or HXM2 and uses the columns TIME, PI_LOW or PI_HIGH which reports the time, the low gain energy channel and the high gain energy channel. The *ecol* parameter allows to specify with PI columns to use. The task uses **extractor** to generate the following files:

- Up to two lightcurves containing up to four energy bands with two different time binning. Up to three channels boundaries may be specified by the parameters *pirangel*, *pirangem*, and *pirangeh* and the task calculates a total rate that spans all three. The output lights each have up to three extensions: one for each time binning and a GTI extension. Each of the extensions contains a TIME column, RATE and ERROR for the total rate and up to 3 columns named RATE1, RATE2, RATE3 with the rate or any energy bands specified, and up to three columns for their errors (respectively columns ERROR1, ERROR2 and ERROR3). For the CGBM here are the standard three channel ranges for each of the detectors and gain:

High Gain		
PI	HXM (keV)	SGM (keV)
155- 410	4-10	40-100

411-2026	10-50	100-450
2027-4031	50-100	450-1000
Low Gain		
PI	HXM (keV)	SGM (keV)
80-119	60-100	550-830
120-383	100-300	830-2600
384-4079	300-3000	2600-28000

- Up to two spectra: one in the original channels and the second in rebinned channels. The rebinned spectrum is calculated with **ftrbnpha** and uses a CGBM-specific predefined rebinning (see parameter *binfile* with the default setting "REFDATA"). The channels in the rebin spectrum matches the channel over which the responses in CALDB are calculated.

If the parameter *lc_only* is set to "yes", spectral products are not generated. If *timebin1* is set to NONE (or left blank), the lightcurves are not generated.

PARAMETERS

infile [filename]
The input event file for the CGM SGM, HXM1, or HXM2 .

outroot [string]
Rootname for the output files.

gtifile [filename]
The input GTI file. If the parameter is set to NONE or blank, spectra and lightcurves are extracted using the GTI in the input event file.

timebin1 [real] (seconds)
The first of up to two time bins used to construct the lightcurve. If *timebin1* is set to NONE or blank, the task will not generate the lightcurve.

timebin2 [real] (seconds)
The second time bin for the lightcurve. If *timebin2* is set to NONE or blank, the lightcurve is generated only if the *timebin1* is set. This parameter is ignored if *timebin1* is NONE or blank.

pirangel [integer:integer] (chan)
Minimum and maximum channels to include in the low band lightcurve. The range is a string in the format "min:max", where both min and max are integers. For example, *pirangel*="80:119" selects channels 80 through 119.

pirangem [integer:integer] (chan)
Minimum and maximum channels to include in the medium band lightcurve. The range is a string in the format "min:max", where both min and max are integers. For example, *pirange*m="120:383" selects channels 120 through 383.

pirangeh [integer:integer] (chan)
Minimum and maximum channels to include in the high band lightcurve. The range is a string in the format "min:max", where both min and max are integers. For example, *pirangeh*="384:4079" selects channels 384 through 4079.

(lcthresh = 0.99) [real]

Minimum fractional exposure in the lightcurve. Allowed values ranges from 0 (keep all time bins) to 1 (keep only fully exposed bins). Default is 0.99.

(events = "EVENTS") [string]
Name of the extension containing events in the input file. Default is EVENTS.

ecol [string]
Column name in the input file containing the channel information. For CGBM, this should be one of PHA_HIGH, PHA_LOW, PH_HIGH, or PI_LOW.

(tcol = "TIME") [string]
Column name in the input file containing the time information. Default is TIME.

(binfile = "REFDATA") [string]
The name of file containing the channel grouping to rebin the spectra. If set to REFDATA, use the standard grouping provided with HEASoft. If set to NONE, no rebinning is performed. Ignored if *lconly* is set to yes.

(lconly = no) [boolean]
If set to yes, no spectra are made. Default is no.

(cleanup = yes) [boolean]
Remove all temporary files on completion if set to yes (default).

(clobber = no) [boolean]
Overwrites pre-existing output files if set to yes. Default is no.

(chatter = 1) [integer, 0 - 3]
Chatter level for output. Set to 0 to suppress output, or to 1 (default), 2, or 3 for increasing the chatter of the output.

(debug = no) [boolean]
Diagnostic output is printed out on the screen if set to yes (yes/[no]).

(logfile = !DEFAULT) [string]
Log filename. If set to DEFAULT, uses the name of the task (i.e. cgbm_speclc.log) and, if preceded by "!" clobber any pre-existing log file. If set to NONE, no log file is created. Default is "!DEFAULT"

(history = yes) [boolean]
If set to yes, record the task parameters run in the header of the output file in the HISTORY keywords.

(mode = ql) [string ql|hl|q]
Mode to query the parameter file. Acceptable values include:

- "ql" (query and learn/remember; DEFAULT),
- "hl" (hidden and learn/remember),
- "q" (query but don't remember),
- "h" (hidden).

EXAMPLES

1. Extract lightcurves and spectra using the high gain data (PI_HIGH) from a CGBM SGM event file. Generate lightcurves for bands 155-410, 411-2026, 2027-4031, and a TOTAL channel band 155-4031 using each of 1.0 s and 64 ms time bins. Limit the events used to make products to those contained within GTIs defined by the file bssgm12700.gti. Use the HEASoft reference data to define the CGBM rebin grouping when making

rebinned spectra. Create a log file of this named cgbm_speclc.log, overwritting any previous log file with that name.

```
cgbm_speclc infile="cgbm_sgm_112700.evt.gz" outfile="sgm12700"
gtifile="bssgm12700.gti" timebin1=1 timebin2=0.064 pirangel="155:410"
pirangem="411:2026" pirangeh="2027:4031" ecol="PI_HIGH" binfile=REFDATA
lconly=no
```

2. Extract a lightcurve from a CGBM SGM instrument event file, but no spectra. The lightcurve contains three channel ranges: 155-410, 411-2026, and a TOTAL channel band 155-2026 using a 0.5 s binning. Use only events within the GTI specified by `bssgm12700.gti`.

```
cgbm_speclc infile="cgbm_sgm_112700.evt.gz" outfile="sgm12700"
gtifile="bssgm12700.gti" timebin1=0.5 timebin2=NONE pirangel="155:410"
pirangem="411:2026" ecol="PI_HIGH" lconly=yes
```

3. Extract a spectra, but no lightcurve, from the CGBM SGM instrument using the low gain data in the event file. Do not create a rebinned spectra.

```
cgbm_speclc infile="cgbm_sgm_112700.evt.gz" outfile="sgm12700"
gtifile="bssgm12700.gti" timebin1=1 timebin2=0.064 pirangel="155:410"
pirangem="411:2026" pirangeh="2027:4031" ecol="PI_HIGH" binfile=REFDATA
lconly=no
```

3.3 cgbm_findrmf

The CALET Gamma Ray Burst Monitor (CGBM) consists in three detectors SGM, HXM1 and HXM2 with a wide field of view of ~ 60 deg for the HXM and ~ 120 deg for the SGM. The HXM and SGM detectors have the difference of 10 degrees in their boresight directions. The CGBM spectral responses have been generated for each the individual detector (SGM, HXM1 and HXM2), gain (LOW and HIGH), and direction expressed in term of the angles THETA and PHI relative to the instrument with a sampling of 5 deg. All responses are stored in in the calibration database (CALDB).

This task selects from CALDB the appropriate response and requires as input the following information: sky coordinates of the source, the ISS attitude, and the time of interest. The time is used to derive from the attitude the closest pointing quaternion. That, combined with the sky position, determines the angles THETA and PHI of the incident direction. Using the THETA and PHI values together with the detector and gain, the task queries CALDB and the task works out the appropriate response within 5 degrees of the incident direction. The HXM and SGM detectors have the difference of 10 degree in their boresight directions therefore the THETA and PHI for the SGM and HXM may be different. The task by default only retrieves the name of the closest responses from the incident angle (parameter *closest* set to 'yes') for all instruments and gains which names are written in the parameter file of the task. To download the responses to the local disk, the parameter *download* must be set to 'yes'. The task allows also to retrieve responses for single detector and/or gain using the parameters detector and gain respectively. The task requires that the CALET CALDB is set.

PARAMETERS

datetime [string]
The UTC input time of the event/observation in the format YYYY-MM-DDTHH:mm:ss.

ra [real] (degrees; J2000)
Right ascension of the source position.

dec [real] (degrees; J2000)
Declination of the source position.

attfile [filename]
Name of input ISS attitude file (*.iat). This file is located in the CGBM archive in the directory auxil/ of the observation that include the source of interest.

detector [string]
Name of CGBM detector. Allowed values are SGM, HXM1, HXM2, or ALL. If set to ALL, the RMFs are found for all three detectors.

gain [string]
Gain value. Valid inputs are HIGH, LOW, or ALL If set to ALL, the RMFs are found for both gains.

(timetoler=15) [integer] (s)
Specifies the time tolerance for matching the input *datetime* parameter with the time entries in the ISS attitude file. The default value is 15 seconds. If no time stamp in the attitude file falls within *timetoler* of the requested datetime, the orientation of the CALET instruments is considered undetermined.

(download=no) [boolean]
Download the RMFs from CALDB (yes/[no]).

(closest_only=yes) [boolean]
If *download*=yes, setting *closest_only*=yes (default) downloads only the best matching RMF. If *closest_only*=no, all RMFs found within a 5 degree area around the sky coordinates are downloaded. Ignored if *download*=no.

(chatter=1) [integer]
Control the screen output from the code. The default value of 1 provides moderate levels of output. Increasing the value increases the level of detail. Valid values run from 0 and 3.

(thetahxm) [real, output] (degrees, output)
Populated with the calculated theta angle value for the co-aligned HXM1 and HXM2 detectors.

(phihxm) [real, output] (degrees, output)
Populated with calculated phi angle value for the HXM1 and HXM2 detectors.

(thetasgm) [real, output] (degrees, output)
Populated with the calculated theta angle value for the SGM detector.

(phisgm) [real, output] (degrees, output)
Populated with the calculated phi angle value for the SGM detector.

(rmfhx1h) [filename, output]
Populated with the best matching HXM1 high gain RMF filename.

(rmfhx2h) [filename, output]
Populated with the best matching HXM2 high gain RMF filename.

(rmfhx1l) [filename, output]
Populated with the best matching HXM1 low gain RMF filename.

(rmfhx2l) [filename, output]
Populated with the best matching HXM2 low gain RMF filename.

(rmfsgmh) [filename, output]
Best matching SGM high gain RMF filename.

(rmfsgml) [filename, output]
Populated with the best matching SGM low gain RMF filename.

(clobber = no) [boolean]
Not implimented with this tool.

(history = no) [boolean]
Not implimented in this tool.

(mode = ql) [string ql|hl|q]
Mode to query the parameter file. Acceptable values include:

- "ql" (query and learn/remember; DEFAULT),
- "hl" (hidden and learn/remember),
- "q" (query but don't remember),
- "h" (hidden).

EXAMPLES

1. Find the RMFs for all detectors and gains for the input time, ra, dec and attitude. Write results to terminal screen and also the logfile `cgbm_findrmf.log`. The RMFs found are all within 5 deg of the incident direction, but are not downloaded (*download*=no by default).

```
cgbm_findrmf datetime=2015-10-06T09:54:45 ra=147.4256 dec=70.5036
attfile=cgbm_20151006.iat.gz detector=ALL gain=ALL closest_only=no
```

2. Find the RMF for the low gain SGM detector and download the closest matching file found. Also record results to a logfile named `cgbm_20160821_findrmf.log`, overwriting any existing log file with the same name. The default value for *closest_only* is set to yes, so there is no need to specify this when invoking the command.

```
cgbm_findrmf datetime=2016-08-21T20:36:21.911 ra=171.248 dec=42.343
attfile=cgbm_20160821.iat.gz detector=SGM gain=LOW download=yes
logfile="\!cgbm_20160821_findrmf.log"
```

3.4 burstfinder

burstfinder searches in an equally binned lightcurve in FITS format for bursts and outputs files with the burst time interval as well as other diagnostic files. By default, the task expects an input lightcurve with columns named TIME and RATE, containing the time in seconds and rate as count/s, otherwise the parameters *tcol* and *rcol* maybe used to specify the names of the columns.

The task searches for the burst in the lightcurve with four steps.

In the first step the lightcurve is scanned with a sliding window technique to detect major deviation from an average. The average of the RATE values within a time window (parameter *timewin*) is calculated by sliding the window by one point. If the difference of the previous average with current RATE value is greater than a threshold (parameter *numsdv)*, the rate of the current point is substituted with the average multiple by factor (see parameter *fraction*) and the following average uses the latter value if the parameter *fill* is set to yes else it is ignored.

The second step uses the rates calculated from the first step and fits a polynomial with the order is defined by parameter *polyorder*. By default, the polynomial fitting also uses the errors on the rates (parameter *use_covar* set to yes).

At the third step, the original rate in the lightcurve is compared to the polynomial. The lightcurve is first smoothed (see parameter *timewin2*) and each bin is compared with the polynomial searching for deviations larger than a threshold (see parameter *numsdv2*). If the deviation larger than the threshold, it assumes that there is a burst and starts a search for the start and stop of the burst by looking backward and forward for points that are below a threshold defined by the parameter *mufactor*. If there are multiple bursts detected, and their time intervals are significantly close to each other (see parameter *min_int*), they are combined into a single interval.

The fourth step is executed if the parameter *refit* is set to yes where the rates of the original lightcurve are clipped for the time interval associated to the burst found in step three and a new polynomial fit is executed and step three is repeated with the new fit only if there is a significant difference in the sigma of the two fits (see parameter *pdiff*).

The task outputs a Good Time Interval file, a lightcurve file, and a summary file. The GTI file (suffix 'dur' in filename) contains upto 6 extensions that are: first and second extensions are reserved for the time intervals corresponding to the 90% and 50% of the burst respectively but are not populated (see task **burstt90t50**); the third extension is populated with the time interval for the peak of the burst; the fourth extension is populated with the time interval for the total burst; the fifth and sixth extensions are populated with the pre- and/or post-background interval if both intervals exist else only with the one that exists. Each extension has a header keyword GTITYPE with value of ‘GTI_90’, ‘GTI_50’, ‘GTI_PEAK’, ‘GTI_TOT’, ‘GTI_BKG1’, ‘GTI_BKG’) to identify the extension it contains. The lightcurve (suffix 'user' in filename) contains the original total non-background subtracted rate taken from the input lightcurve (TOTRATE and TOTRATE_ERROR), the background rates (BKGRATE and BKGRATE_ERROR) and the background subtracted rates (RATE and ERROR). The summary file (suffix 'summary' in filename) contains for each burst one line with summary information and is provided as FITS file and ASCII file If no bursts are found, the GTI and summary files are not output, but lightcurve file is always output.

PARAMETERS

infile [filename]
: Input lightcurve. The lightcurve is expected to be equally binned containing the columns RATE and TIME.

outroot [filename]
: Root name for the output files. The filenames for the lightcurve, gti and summary are made by adding to the root "user.lc", "dur.gti" "summary.fits" or "summary.txt” respectively.

(leapfile = "REFDATA") [string]

Name of the leap second file. If set to REFDATA (default), the leap second file in FTOOLS reference data directory is used.

timewin [real] (seconds)
Time window (in seconds) to calculate the average in the first step. The value should be larger of the original binning.

(gap_interval=100.0) [real] (seconds)
If the lightcurve has a large gap, this parameter allows to restart the sliding window average from the first valid point after the gap. The default is 100 s.

numsdv [real]
Number of standard deviations used in the first step to calculate the threshold between the current value and moving average.

(fill=yes) [boolean]
If set to "no", exclude values that are above the standard deviation defined by *numsdv* in the average caculation. If set to "yes" (default), the points above the standard deviation are replaced by the

```
average*(1-frac)
```

where the average is the value of the rate average calculated for the *timewin* interval including the preceding point and frac is defined by the parameter *fraction.*

(fraction=0.01) [real]
Fraction used to calculate the rate to be replaced in the original lightcurve if *fill*=yes. Value range between 0 and 1, default is 0.01.

(polyorder=3) [integer]
The order of the polynomial used to fit data to model background. Default is 3 (i.e. cubic fit).

(use_covar=yes) [boolean]
If set to "yes" (default), the polynomial fit model takes error in rate into account when fitting. If set to "no", error on rates are not used in the fitting.

timewin2 [real]
Time window (in seconds) to calculate the average in the third step. The value should be larger of the original binning.

numsdv2 [real]
Number of standard deviations used in the third step to calculate the threshold between the polynomial fit and the smooth rates. Values found above *numsdv2* indicate a burst.

mufactor [real]
Multiplicative factor to the standard deviation obtained from the polynomial fit and the smoothed rate. This factor is used to search the start and stop of a burst.

(min_int = 30.0) [real] (seconds)
The minimum time between adjacent bursts. If two bursts are detected within *min_int* seconds of each other, they are merged and consider a single burst. Default is 30.0 seconds

(refit=yes) [boolean]
Execute the fourth step if set to "yes" (default), where burst intervals found in the third step are excluded from the lightcurve and the data are refit. If set to "no", the fourth step is not executed no refitting.

(maxiter=10) [integer]

If set (default is 10), the maximum number of times to iterate to potentially improve the polynomial fit solution. Ignored if *refit* is set to no.

(pdiff=0.1) [real]
Define the minimum difference in sigma between two subsequent polynomial fits and is valid only if the parameter *refit* is set to yes. If the fit has improved sigma by more than *pdiff* times sigma, the new polynomial fit has improved and step two and three are redone.

(time_min = "NONE") [string]
The earliest time in the lightcurve to consider when searching for bursts. The time values may be provided as:

- Mission Elapsed Time (MET), the number of seconds from the start of the mission time, defined by keywords MJDREF (or MJDREFI and MJDREFF) in the input lightcurve; or
- UTC date in the form "YYYY-MM-DDThh:mm:ss.ff"

If set to NONE (or blank: default), the input lightcurve search starts with the first data point.

(time_max = "NONE") [string]
The latest time in the lightcurve to consider when searching for bursts. The time values may be provided as:

- Mission Elapsed Time (MET), the number of seconds from the start of the mission time, defined by keywords MJDREF (or MJDREFI and MJDREF) in the input lightcurve; or
- UTC date in the form "YYYY-MM-DDThh:mm:ss.ff"

If set to NONE (or blank: default), the input lightcurve search ends at the last data point.

(trigtime = "NONE") [string]
Trigger time. The value is informative only and written in the output files but not used in computations. The default setting is NONE (i.e. do not set TRIGTIME).

(tcol = TIME) [string]
Column name in the input lightcurve containing the time information. Default is TIME.

(rcol = RATE) [string])
Column name in the input lightcurve containing the count or rate information. Default is RATE.

(clobber = no) [boolean]
Overwrites the existing output file if set to yes (yes/[no]).

(chatter = 1) [integer, 0 - 3]
Chatter level for output. Set to 0 to suppress output, or to 1 (default), 2, or 3 for increasing the chatter of the output.

(debug = no) [boolean]
Diagnostic output is printed out on the screen if set to yes. Also, a diagnostic FITS file with polynomial fitting is written out. (yes/[no]).

(logfile = NONE) [string]
Log filename. If set to DEFAULT, use the name of this task (i.e. burstfinder.log). If preceded by "!" overwrite the file if it exists. If set to NONE (default), no log file is created.

(history = no) [boolean]
If set to yes, add HISTORY keywords to the output files that record the parameters used to create them. Default is NO.

(mode = ql) [string ql|hl|q]
Mode to query the parameter file. Acceptable values include:

- "ql" (query and learn/remember; DEFAULT),
- "hl" (hidden and learn/remember),
- "q" (query but don't remember),
- "h" (hidden).

EXAMPLES

1. Search the lightcurve `testfile.lc` for bursts using for the first step *timewin*=10 s, with replace points (*fill*=yes) that have a standard deviation > 3 (*numsdv*=3) with an average decrease by 0.01 (*fraction*=0.01). Fit the lightcurve from the first step with a cubic polynomial model (*polyorder*=3) using the error on rate (*use_covar*=yes). For the third step use a *timewin2*=1 s and a threshold of 2 (numsdv=2) when comparing the lightcurve with the polynomial fit and a value of *mufactor*=0.2 when fine searching the start and stop of the burst. The output files have root names starting with `burst_test`. Do not attempt to refit after making an initial estimate of the burst interval (*refit*=no)).

```
burstfinder infile=testfile.lc outroot=burst_test timewin=10.0 numsdv=3
fraction=0.01 polyorder=3 numsdv2=3.0 timewin2=1.0 mufactor=0.2 fill=yes
refit=no use_covar=yes
```

2. Same as the example 1) but the lightcurve is only searched in the time interval defined by *time_min* and *time_max* provided in mission elapsed time MET and record terminal output to a logfile `burst_test2.log`.

```
burstfinder infile='testfile.lc' outroot='burst_test' timewin=10.0 numsdv=3.0
fraction=0.01 polyorder=3 numsdv2=3.0 timewin2=1.0 mufactor=0.2
time_min=6.80012E+08 time_max=6.80018E+08 logfile=burst_test2.log fill=yes
refit=no use_covar=yes
```

3. Same as the example 1) but after step 3 refit (*refit*=yes) the polynomial on the lightcurve clipped by the burst intervals and iterate up to 10 times (*maxiter*=10) to find the best solution. Exit if the fit improves by less than 10% between iterations (*pdiff*=0.1). Write to a log file `burst_test3.log` and clobber any previous logfile of the same name.

```
burstfinder infile='testfile.lc' outroot='burst_test' timewin=10.0 numsdv=3.0
fraction=0.01 polyorder=3 numsdv2=3.0 timewin2=1.0 mufactor=0.2 fill=no
refit=yes maxiter=10 pdiff=0.1 logfile="\!burst_test3.log"
```

3.5 burstt90t50

Read a lightcurve and GTI which defines burst intervals. Calculate the 90% and 50% total accumulated rate intervals (T90 and T50) within the burst. The input lightcurve needs columns defining time and rate (or counts) set by parameters *tcol* and *rcol* respectively. If the input parameter *gtifile* does not specific which extension contains the GTI, it is assumed to be in the 4th extension (as is expected for burstfinder-type GTI files): the parameter must explicitly specify the extension if this is not desired.

The task computes the cumulative total intensity at each binned interval and estimates the T90 and T50 times by finding those intervals where the 5% and 95% total (for T90) and 25% and 75% (for T50) occur and interpolating within those intervals. In computing the cumulative total, only positive values are considered unless told otherwise (parameter *usenegative* is set to yes)

The resulting intervals are written to an output GTI with two extensions, one for each of T90 and T50. In the special case of a burstfinder-type input gtifile, T90 is written to the first extension and T50 to the second, filling in these extensions with the values found.

PARAMETERS

lcfile [filename]
The input lightcurve file.

gtifile [filename]
The input GTI file. If no extension is specified, and gtifile is a burstfinder-type file with six extensions, the total interval is read from the 4th extension automatically; otherwise, it reads the first extension.

outfile [filename]
The output GTI file. If set to NONE or left blank, the new GTI information will overwrite the input GTI file (This requires *clobber* to be 'yes'). If the input *gtifile* is a burstfinder-type file (6 extensions with total interval in the 4th), *outfile* will contain T90 in the first extension, T50 in the second, and all other extensions will be copied from the input *gtifile*. Otherwise *outfile* will contain two extensions with T90 and T50 respectively.

(rcol = "RATE") [string]
Column in the input lightcurve containing count or rate information. Default is "RATE".

(tcol = "TIME") [string]
Column in the input lightcurve containing time information. Default is "TIME".

(usenegative = no) [boolean]
When computing T90 and T50 intervals, whether to include negative values in computing accumulated totals. Default is "no".

(uselast = no) [boolean]
If including negative values in computing accumulated totals, it is possible to cross a T90 or T50 threshold more than once. If more than one starting time solution is found, the earliest (first) is always considered. If *uselast* is set to "yes", define the interval end by the latest of all possible intervals. If set to "no" (default), use the earliest. Ignored if *usenegative* is "no".

(cleanup = yes) [boolean]
Remove all temporary files on completion if set to yes (default). Not used in this tool.

(clobber = no) [boolean]
Overwrites pre-existing output files if set to yes. Default is no.

(chatter = 1) [integer, 0 - 3]
Chatter level for output. Set to 0 to suppress output, or to 1 (default), 2, or 3 for increasing the chatter of the output.

(debug = no) [boolean]
Diagnostic output is printed out on the screen if set to yes (yes/[no]).

(logfile = !DEFAULT) [string]
Log filename. If set to DEFAULT, uses the name of the task (i.e. burstcalc.log) and, if preceded by "!" clobber any pre-existing log file. If set to NONE, no log file is created. Default is "!DEFAULT"

(history = yes) [boolean]

If set to yes, record the task parameters run in the header of the output file in the HISTORY keywords. Not enabled in this current version.

(mode = ql) [string ql|hl|q|h]

Mode to query the parameter file. Acceptable values include:

- "ql" (query and learn/remember; DEFAULT),
- "hl" (hidden and learn/remember),
- "q" (query but don't remember),
- "h" (hidden).

EXAMPLES

1. Define the T90 and T50 intervals for a burst use the total burst interval contained in the GTI file `cgbm_20180411_sgm_083733_1h_dur.gti` and the input lightcurve file `cgbm_20180411_sgm_083733_1h_user.lc`. The GTI has six extensions, with the total burst interval defined by the 4th extension. Read the column TIME for time and RATE for rates in the input lightcurve. Replace the first and second extensions of the input GTI file with the computed T90 and T50 intervals respectively.

```
burstt90t50 lcfile=cgbm_20180411_sgm_083733_1h_user.lc
gtifile=cgbm_20180411_sgm_083733_1h_dur.gti outfile=NONE rcol=RATE tcol=TIME
clobber=yes
```

2. Define the T90 and T50 intervals using the columns TIME and RATE in the first extension of `example.lc` and the total burst interval defined by the first extension of `example_burst.gti`. Write the T90 and T50 GTIs to a new file `example_t90t50.gti`.

```
burstt90t50 lcfile=example.lc+1 gtifile=example_burst.gti+1
outfile=example_t90t50.gti rcol=RATE tcol=TIME  clobber=no
```

3.6 burstbkgevt

burstbkgevt reads the background rate from a lightcurve and background spectra and generates a simulated background where the energy channels to each event are assigned based on the background spectra and the rate of events is determined by the background model.

The input lightcurve needs to have a time column, a background rate, and an error column. By default, the task searches for columns named TIME, BKGRATE and ERROR, otherwise the parameters *timecol*, *ratecol* and *errcol* maybe used to specify the names of the columns. The lightcurve header must contain the keywords PHALCUT and PHAHCUT to specify the minimum and maximum channels over which the background rates were derived. If they are not found, the tasks assumes that the rates are derived from all the channels in the input spectra. The output lightcurve from **burstfinder** is compatible to the input lightcurve of **burstbkgevt**.

The spectral files are used to derive the channel number associated to an event. The task accepts up to two spectra that are input using parameters *prespec* and *postspec*. They may represent the pre-burst and post-burst background spectra and they are averaged together within the task. A single spectrum may be input by setting either parameter to NONE (or blank). The spectral file must have two columns with integer values corresponding to CHANNEL and COUNTS (or be set to other values with parameters *chancol* and *cntcol* respectively) and must contain the full original channel range for a given detector.

The task assigns the number of events based on the bin rate and its error of the input lightcurve. If the user provides a positive value for the parameter *stdv,* this fixed value replaces the error column and can be used if there is no error column. The default error column is ERROR and can be set to a different value with the parameter *errcol*. The error

is also scaled by a multiplying factor *stdv_mult*. The time of each event is assigned randomly within the time bin. The channel for each event is assigned by randomly choosing from the weighted spectra and weight and the channel corresponding to that weight.

The output is an event file with the name *outroot*_simback.evt. If the input light curve has a GTI extension, this is copied to the output event file.

PARAMETERS

infile [filename]
Input lightcurve with columns for time and background rate.

prespec [filename]
Input for 1st spectral file, typically a pre-burst spectra. May be set to NONE (or blank) if no spectra file is defined. However, at least one of *prespec* or *postspec* must be set. If both are set, the task makes an average of the two.

postspec [filename]
Input for 2nd spectral file, typically a post-burst spectra. May be set to NONE (or blank).

outroot [string]
The root name of the output event file *outroot*_simback.evt.

(timecol = "TIME") [string]
The name of the column containing time intervals in *infile*. Default is TIME.

(ratecol = "BKGRATE") [string]
The name of the column containing the background rate in *infile*. Default is BKGRATE.

(errcol = "ERROR") [string]
The name of the column containing the background subtracted rate error in *infile*. Default is ERROR. Ignored if *stdv* is set to a positive value.

(chancol = "CHANNEL") [string]
The name of the column containing the channel number in the input spectra. Default is CHANNEL.

(cntcol = "COUNTS") [string]
The name of the column containing the counts in each spectral channel in the input spectra. Default is COUNTS.

(destcol = "PI") [string]
The name of the destination column for events, corresponding to the *chancol* input. Typical values might be PI (default) or PHA. Set to match *chancol* if left blank or set to NONE.

(stdv=-999) [real]
Set to a negative value (default is -999) to ignore and use scatter defined by *errcol*. If set to a positive value, this fixed value is used to define scatter in the background subtracted rate when generating simulated events.

(stdv_mult=1) [real]
A multiplicative factor to apply to the error when determining the amount of scatter. The default value is 1.

(clobber = no) [boolean]
Overwrites the existing output file if set to yes (yes/[no]).

(chatter = 1) [integer, 0 - 3]
Chatter level for output. Set to 0 to suppress output, or to 1 (default), 2, or 3 for increasing the chatter of the output.

(debug = no) [boolean]
Diagnostic output is printed out on the screen if set to yes (yes/[no]).

(logfile = !DEFAULT [string])
Log filename. If set to DEFAULT, it uses the name of this task (i.e. burstbkgevt.log) and, if preceded by "!" will overwrite the file if it already exists. If set to NONE, no log file is created.

(history = no) [boolean]
If set to yes, add HISTORY keywords to the output FITS files that record the parameters used to create these files. Default is NO.

(mode = ql) [string ql|hl|q]
Mode to query the parameter file. Acceptable values include:

- "ql" (query and learn/remember; DEFAULT),
- "hl" (hidden and learn/remember),
- "q" (query but don't remember),
- "h" (hidden).

EXAMPLE

Use a lightcurve which contains columns TIME, BKGRATE, and ERROR to define the time-dependent component of modelled events. Use a pre- and post-burst spectra files to define the spectral shape of the modelled background events. These spectra files contain columns CHANNEL and COUNTS. Record the results in a simulated background event file which has columns TIME and PI (*destcol*=PI, the default) and include HISTORY keywords to record the parameters used to generate the output FITS file. The GTI are also copied to the output event file. Record a log file and if the log file exists, clobber it.

```
burstbkgevt infile="cgbm_20180411_sgm_083733_1h_user.lc"
prespec="cgbm_20180411_sgm_083733_1h_pre.pi"
postspec="cgbm_20180411_sgm_083733_1h_post.pi"
outroot="cgbm_20180411_sgm_083733_1h" ratecol="BKGRATE" errcol="ERROR"
chancol="CHANNEL" cntcol="COUNTS" chatter=3 history=yes
logfile="\!cgbmbackevt_20180411_sgm_083733_1h.log"
```

4 Output Files

4.1 cgbm_bstgti

lightcurve with suffix *_user. lc

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                   16 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   72 / width of table in bytes
NAXIS2  =                 2534 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    9 / number of fields in each row
TTYPE1  = 'TIME    '           / Time
TFORM1  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'TOTRATE '           / Total source rate
TFORM2  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT2  = 'count/s '           / physical unit of field
TTYPE3  = 'TOTRATE_ERROR'      / Total source rate error
TFORM3  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT3  = 'count/s '           / physical unit of field
TTYPE4  = 'FRACEXP '           / Fractional exposure
TFORM4  = 'D       '           / data format of field: 8-byte DOUBLE
TTYPE5  = 'BKGRATE '           / Background rate
TFORM5  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT5  = 'count/s '           / physical unit of field
TTYPE6  = 'BKGRATE_ERROR'      / Background rate error
TFORM6  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT6  = 'count/s '           / physical unit of field
TTYPE7  = 'BACKCALCE'          / Background fitting error
TFORM7  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT7  = 'count/s '           / physical unit of field
TTYPE8  = 'RATE    '           / Background subtracted rate
TFORM8  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT8  = 'count/s '           / physical unit of field
TTYPE9  = 'ERROR   '           / Background subtracted rate error
TFORM9  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT9  = 'count/s '           / physical unit of field
EXTNAME = 'RATE    '           / name of this binary table extension
TELESCOP= 'CALET   '           / Telescope (mission) name
INSTRUME= 'CGBM    '           / Instrument name
DETNAM  = 'SGM     '           / Detector
DATAMODE= 'EVENT   '           / Datamode
OBS_ID  = 'YYYYMMDD'           / Observation ID
OBJECT  = '1243368627'         / Name of observed object
RA_PNT  =               273.35 / R.A. pointing of the CALET z-axis [deg]
DEC_PNT =               -14.13 / Dec. pointing of the CALET z-axis [deg]
RA_INS  =               273.35 / R.A. pointing of the detector z-axis [deg]
DEC_INS =               -14.13 / Dec. pointing of the detector z-axis [deg]
RA_SC   =               272.81 / R.A. from the geocenter at TRIGTIME [deg]
```

```
DEC_SC  =               -13.15 / Dec. from the geocenter at TRIGTIME [deg]
DIST_SC =              6798.48 / Distance from the geocenter at TRIGTIME [km]
LON_SC  =                81.48 / Longitude at TRIGTIME [deg]
LAT_SC  =               -13.15 / Latitude at TRIGTIME [deg]
MJDREFI =                51544 / MJD reference day
MJDREFF = 7.428703703703700E-04 / MJD reference (fraction of day)
TIMEREF = 'LOCAL   '            / reference time
TASSIGN = 'SATELLITE'           / Time assigned on satellite
TIMESYS = 'TT      '            / time measured from
TIMEUNIT= 's       '            / unit for time keywords
CLOCKAPP=                    T / Is clock correction applied
DATE-OBS= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
DATE-END= 'YYYY-MM-DDThh:mm:ss.ffff' / End date of observations
TSTART  =     xxxxxxxxx.xxxxxx / Start time of first observation
TSTOP   =     yyyyyyyyy.yyyyyy / End time of last observation
TIMEDEL = 2.500000000000000E-01 / Binning factor
TELAPSE = 6.335839565992355E+02 / elapsed time
ONTIME  =                633.5 / End time of last observation
EXPOSURE=                633.5 / Exposure time
DEADAPP =                    F / Is dead-time correction applied
TRIGGER = '######  '            / Trigger number
TRIGTIME=     xxxxxxxxx.xxxxxx / Trigger time in MET
TRIGUTC = '2019-05-31T20:10:20.034470' / Trigger time in UTC
TRIGMDC =    1243368627.679125 / Trigger time in MDC time
TRIGEBOX=           244.762125 / Trigger time in EBOX time
TRIGPAT = '1111    '            / Trigger pattern: 4, 1, 1/2, 1/4 s scales
SRCHDU  =                    1 / HDU number in the source L2 data file
HDUCLASS= 'ogip    '            / Format conforms to OGIP/GSFC conventions
HDUCLAS1= 'LIGHTCURVE'          / Extension contains a light curve
HDUCLAS2= 'TOTAL   '
ORIGIN  = 'NASA/GSFC'           / origin of fits file
CREATOR = 'extractor v6.18'     / Extractor
PROCVER = '4.1.3.2 '            / Major.Minor.Tool.CALDB
CALDBVER= 'hxm151005_sgm151005' / CALDB version
SEQPNUM =                    1 / sequence in procver
DATE    = '2025-07-30T14:51:53' / file creation date (YYYY-MM-DDThh:mm:ss UT)
HISTORY File modified by user 'cgbm' with fv  on 2022-10-07T21:46:13
HISTORY Corrected by evtgain_recorr.py at 2024-05-20 10:02:39
HDUCLAS3= 'RATE    '
LIVETIME= 6.335839565992355E+02 / On-source time
DATE-BEG= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
MJD-BEG = 5.863483888723677E+04 / MJD of data start time
MJD-END = 5.863484622038442E+04 / MJD of data start time
MJD-OBS = 5.863483888723677E+04 / MJD of data start time
EQUINOX =            0.000E+00 / Equinox of celestial coord system
RADECSYS= '        '            / celestial coord system
USER    = 'jsallen1'            / User name of creator
FILIN001= 'cgbm_sgm.evt'        / Input file name
TIMEZERO= 6.126484157982572E+08 / Time Zero
TIMEPIXR= 5.000000000000000E-01 / Timestamps give center of bin
PHALCUT =                  155 / Minimum PI_HIGH channel
PHAHCUT =                 4031 / Maximum PI_HIGH channel
NPIXSOU =     0.0000000000E+00 / Numbers of Pixels
MINFREXP=     9.9000000000E-01 / Minimum value of FRACEXP included
HISTORY extractor v6.18
HISTORY
HISTORY START PARAMETER list for cgbm_bstgti_1.26b at 2025-07-30T14:51:53
HISTORY
HISTORY P1 infile = ../input/cgbm_sgm.evt
HISTORY P2 outroot = cgbm_sgm_025h
HISTORY P3 leapfile = REFDATA
HISTORY P4 timebin = 0.25
```

```
HISTORY P5 lcthresh = 0.99
HISTORY P6 pirange = 155:4031
HISTORY P7 extension = EVENTS
HISTORY P8 ecol = PI_HIGH
HISTORY P9 timewin = 10.0
HISTORY P10 gap_interval = 100.0
HISTORY P11 numsdv = 3.0
HISTORY P12 fraction = 0.01
HISTORY P13 polyorder = 3
HISTORY P14 fill = yes
HISTORY P15 refit = yes
HISTORY P16 use_covar = yes
HISTORY P17 maxiter = 10
HISTORY P18 pdiff = 0.1
HISTORY P19 numsdv2 = 3.0
HISTORY P20 timewin2 = 1.0
HISTORY P21 mufactor = 0.2
HISTORY P22 time_min = NONE
HISTORY P23 time_max = NONE
HISTORY P24 trigtime = NONE
HISTORY P25 tcol = TIME
HISTORY P26 min_int = 30
HISTORY P27 clobber = yes
HISTORY P28 cleanup = yes
HISTORY P29 chatter = 3
HISTORY P30 debug = no
HISTORY P31 history = yes
HISTORY P32 logfile = !DEFAULT
HISTORY P33 mode = ql
HISTORY END PARAMETER list for cgbm_bstgti_1.26b
HISTORY
POLYCO00=     789.290012506009 / Constant polynomial coefficient
POLYCO01=    0.279232486191104 / 1st polynomial order coefficient
POLYCO02= -0.000140319499423915 / 2nd polynomial order coefficient
POLYCO03= 8.66387275580377E-07 / 3rd polynomial order coefficient
POLYXOFF=                   0. / TIME at x = 0 in fit
BACKCALC= 'ITERATIVE_COVAR'    / Background model calculation method
PKSIGMA =     17.3521634093193 / Maximum std dev from background
NBURSTS =                    1 / Number of bursts detected
PK01    =     22.3049631517077 / 1st peak deviation from background (std devs)
CHECKSUM= 'AAhaD6eVAAeaA5eU'   / HDU checksum updated 2025-07-30T14:51:54
DATASUM = '260819738'          / data unit checksum updated 2025-07-30T14:51:54
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   16 / width of table in bytes
NAXIS2  =                    1 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'START   '           / GTI start time
TFORM1  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / Physical unit of field
TTYPE2  = 'STOP    '           / GTI stop  time
TFORM2  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT2  = 's       '           / Physical unit of field
EXTNAME = 'STDGTI  '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / Conforms to OGIP/GSFC standards
HDUCLAS1= 'GTI     '           / Contains good time intervals
HDUCLAS2= 'STANDARD'           / Contains standard good time intervals
```

```
HDUVERS = '1.0.0   '           / Version of GTI header
TIMEZERO=                   0. / Zero-point offset for TIME column
MJDREF  =    51544.00074287037 / MJD Epoch of Time = 0
TSTART  =    612648415.6732572 / Start time of GTI
TSTOP   =    612649049.2572138 / Stop  time of GTI
DATE    = '2025-07-30T14:51:54' / file creation date (YYYY-MM-DDThh:mm:ss UT)
CHECKSUM= '0TT32SS10SS10SS1'   / HDU checksum updated 2025-07-30T14:51:54
DATASUM = '2684067316'         / data unit checksum updated 2025-07-30T14:51:54
END
```

cgbm_bstgti GTI output file

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                   16 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   16 / width of table in bytes
NAXIS2  =                    0 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'START   '           / GTI start time
TFORM1  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / Physical unit of field
TTYPE2  = 'STOP    '           / GTI stop  time
TFORM2  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT2  = 's       '           / Physical unit of field
EXTNAME = 'GTI     '           / name of this binary table extension
HDUVERS = '1.0.0   '           / Version of GTI header
TELESCOP= 'CALET   '           / Telescope (mission) name
INSTRUME= 'CGBM    '           / Instrument name
DETNAM  = 'SGM     '           / Detector
DATAMODE= 'EVENT   '           / Datamode
OBS_ID  = '20190531'           / Observation ID
OBJECT  = '1243368627'         / Name of observed object
RA_PNT  =               273.35 / R.A. pointing of the CALET z-axis [deg]
DEC_PNT =               -14.13 / Dec. pointing of the CALET z-axis [deg]
RA_INS  =               273.35 / R.A. pointing of the detector z-axis [deg]
DEC_INS =               -14.13 / Dec. pointing of the detector z-axis [deg]
RA_SC   =               272.81 / R.A. from the geocenter at TRIGTIME [deg]
DEC_SC  =               -13.15 / Dec. from the geocenter at TRIGTIME [deg]
DIST_SC =              6798.48 / Distance from the geocenter at TRIGTIME [km]
LON_SC  =                81.48 / Longitude at TRIGTIME [deg]
LAT_SC  =               -13.15 / Latitude at TRIGTIME [deg]
MJDREFI =                51544 / MJD reference day
MJDREFF = 7.428703703703700E-04 / MJD reference (fraction of day)
TIMEREF = 'LOCAL   '           / reference time
TASSIGN = 'SATELLITE'          / Time assigned on satellite
TIMESYS = 'TT      '           / time measured from
TIMEUNIT= 's       '           / unit for time keywords
CLOCKAPP=                    T / Is clock correction applied
DATE-OBS= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
DATE-END= 'YYYY-MM-DDThh:mm:ss.ffff' / End date of observations
TRIGGER = '201020  '           / Trigger number
```

```
TRIGTIME=     612648625.034470 / Trigger time in MET
TRIGUTC = '2019-05-31T20:10:20.034470' / Trigger time in UTC
TRIGMDC =    1243368627.679125 / Trigger time in MDC time
TRIGEBOX=           244.762125 / Trigger time in EBOX time
TRIGPAT = '1111    '           / Trigger pattern: 4, 1, 1/2, 1/4 s scales
SRCHDU  =                    1 / HDU number in the source L2 data file
HDUCLASS= 'OGIP    '           / Conforms to OGIP/GSFC standards
HDUCLAS1= 'GTI     '           / Contains good time intervals
HDUCLAS2= 'STANDARD'           / Contains standard good time intervals
ORIGIN  = 'NASA/GSFC'          / origin of fits file
CREATOR = 'extractor v6.18'    / Extractor
PROCVER = '4.1.3.2 '           / Major.Minor.Tool.CALDB
CALDBVER= 'hxm151005_sgm151005' / CALDB version
SEQPNUM =                    1 / sequence in procver
DATE    = '2025-07-30T14:51:54' / file creation date (YYYY-MM-DDThh:mm:ss UT)
HISTORY File modified by user 'cgbm' with fv  on 2022-10-07T21:46:13
HISTORY Corrected by evtgain_recorr.py at 2024-05-20 10:02:39
LIVETIME= 6.335839565992355E+02 / On-source time
DATE-BEG= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
MJD-BEG = 5.863483888723677E+04 / MJD of data start time
MJD-END = 5.863484622038442E+04 / MJD of data start time
MJD-OBS = 5.863483888723677E+04 / MJD of data start time
EQUINOX =            0.000E+00 / Equinox of celestial coord system
RADECSYS= '        '           / celestial coord system
USER    = 'jsallen1'           / User name of creator
FILIN001= 'cgbm_sgm.evt'       / Input file name
TIMEZERO=     612648415.798257 / Zero-point offset for TIME
PHALCUT =                  155 / Minimum PI_HIGH channel
PHAHCUT =                 4031 / Maximum PI_HIGH channel
MINFREXP=     9.9000000000E-01 / Minimum value of FRACEXP included
HISTORY extractor v6.18
HISTORY
HISTORY START PARAMETER list for cgbm_bstgti_1.26b at 2025-07-30T14:51:53
HISTORY
HISTORY P1 infile = ../input/cgbm_sgm.evt
HISTORY P2 outroot = cgbm_sgm_025h
HISTORY P3 leapfile = REFDATA
HISTORY P4 timebin = 0.25
HISTORY P5 lcthresh = 0.99
HISTORY P6 pirange = 155:4031
HISTORY P7 extension = EVENTS
HISTORY P8 ecol = PI_HIGH
HISTORY P9 timewin = 10.0
HISTORY P10 gap_interval = 100.0
HISTORY P11 numsdv = 3.0
HISTORY P12 fraction = 0.01
HISTORY P13 polyorder = 3
HISTORY P14 fill = yes
HISTORY P15 refit = yes
HISTORY P16 use_covar = yes
HISTORY P17 maxiter = 10
HISTORY P18 pdiff = 0.1
HISTORY P19 numsdv2 = 3.0
HISTORY P20 timewin2 = 1.0
HISTORY P21 mufactor = 0.2
HISTORY P22 time_min = NONE
HISTORY P23 time_max = NONE
HISTORY P24 trigtime = NONE
HISTORY P25 tcol = TIME
HISTORY P26 min_int = 30
HISTORY P27 clobber = yes
HISTORY P28 cleanup = yes
```

```
HISTORY P29 chatter = 3
HISTORY P30 debug = no
HISTORY P31 history = yes
HISTORY P32 logfile = !DEFAULT
HISTORY P33 mode = ql
HISTORY END PARAMETER list for cgbm_bstgti_1.26b
HISTORY
GTITYPE = 'GTI_T90 '           / GTI type
CHECKSUM= 'bAMIe4K9b9KGb9K9'   / HDU checksum updated 2025-07-30T14:51:54
DATASUM = '2161674240'         / data unit checksum updated 2025-07-30T14:51:54
END
```

There are five more extensions with the same keywords as above for each of (in order) T50, Peak, Total, Pre-burst, and Post-burst intervals. The only keywords that vary between extensions will be the relevant time settings and

```
GTITYPE = 'GTI_T50 '           / GTI type

GTITYPE = 'GTI_PEAK'           / GTI type

GTITYPE = 'GTI_TOT '           / GTI type

GTITYPE = 'GTI_BKG1'           / GTI type

GTITYPE = 'GTI_BKG2'           / GTI type
```

cgbm_bstgti summary ASCII file

```
      START        STOP  PEAK START   PEAK STOP  BKG1 START   BKG1 STOP   AVG BKG1
  203.50000   245.00000   232.75000   233.00000     0.00000   203.25000    816.432
 BKG2 START   BKG2 STOP   AVG BKG2   RANK TOTAL RATE
  245.25000   633.25000    972.829      1  50045.751
```

4.2 burstt90t50

The GTI output from burstt90t50 is the same as the output from cgbm_bstgti (above) save that the empty rows in the T90 and T50 are populated and relevant time-related keywords set.

4.3 cgbm_speclc

Spectra file

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                  -32 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
TELESCOP= 'CALET   '           / Telescope (mission) name
INSTRUME= 'CGBM    '           / Instrument name
DETNAM  = 'SGM     '           / Detector
DATE-OBS= 'YYYY-MM-DDThh:mm:ss.ffff'' / Start date of observations
DATE-END= 'YYYY-MM-DDThh:mm:ss.ffff'' / End date of observations
ORIGIN  = 'NASA/GSFC'          / origin of fits file
DATE    = '2025-07-30T16:06:49' / file creation date (YYYY-MM-DDThh:mm:ss UT)
OBJECT  = '1243368627'         / Name of observed object
HISTORY File modified by user 'cgbm' with fv  on 2022-10-07T21:46:13
```

```
HISTORY Corrected by evtgain_recorr.py at 2024-05-20 10:02:39
DATE-BEG= '2019-05-31T20:10:56.4823' / Start date of observations
MJD-BEG = 5.863484124400760E+04 / MJD of data start time
MJD-END = 5.863484172433168E+04 / MJD of data start time
MJD-OBS = 5.863484124400760E+04 / MJD of data start time
HISTORY extractor v6.18
CHECKSUM= 'BdG9CbF7BbF7BbF7'   / HDU checksum updated 2025-07-30T16:06:50
DATASUM = '         0'         / data unit checksum updated 2025-07-30T16:06:49
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                    8 / width of table in bytes
NAXIS2  =                 4096 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'CHANNEL '           / Detector channel (type unknown)
TFORM1  = 'J       '           / data format of field: 4-byte INTEGER
TTYPE2  = 'COUNTS  '           / Counts per channel
TFORM2  = 'J       '           / data format of field: 4-byte INTEGER
TUNIT2  = 'count   '           / physical unit of field
EXTNAME = 'SPECTRUM'           / name of this binary table extension
HDUCLASS= 'OGIP    '           / format conforms to OGIP standard
HDUVERS1= '1.2.0   '           / Obsolete - included for backwards compatibility
HDUVERS = '1.2.0   '           / Version of format (OGIP memo OGIP-92-007)
HDUCLAS3= 'COUNT   '           / PHA data stored as Counts (not count/s)
TLMIN1  =                    0 / Lowest legal channel number
TLMAX1  =                 4095 / Highest legal channel number
TELESCOP= 'CALET   '           / Telescope (mission) name
INSTRUME= 'CGBM    '           / Instrument name
FILTER  = 'NONE    '           / no filter in use
AREASCAL=         1.000000E+00 / area scaling factor
BACKFILE= 'none    '           / associated background filename
BACKSCAL=         1.000000E+00 / background file scaling factor
CORRFILE= 'none    '           / associated correction filename
CORRSCAL=         1.000000E+00 / correction file scaling factor
RESPFILE= 'none    '           / associated redistrib matrix filename
ANCRFILE= 'none    '           / associated ancillary response filename
PHAVERSN= '1992a   '           / obsolete
DETCHANS=                 4096 / total number possible channels
POISSERR=                    T / Poissonian errors to be assumed
STAT_ERR=                    0 / no statistical error specified
SYS_ERR =                    0 / no systematic error specified
GROUPING=                    0 / no grouping of the data has been defined
QUALITY =                    0 / no data quality information specified
HISTORY  FITS SPECTRUM extension written by WTPHA2 1.0.1
DETNAM  = 'SGM     '           / Detector
DATAMODE= 'EVENT   '           / Datamode
OBS_ID  = '20190531'           / Observation ID
OBJECT  = '1243368627'         / Name of observed object
RA_PNT  = 2.733500000000000E+02 / File average of RA(degrees)
DEC_PNT = -1.413000000000000E+01 / File average of DEC(degrees)
RA_INS  =               273.35 / R.A. pointing of the detector z-axis [deg]
DEC_INS =               -14.13 / Dec. pointing of the detector z-axis [deg]
RA_SC   =               272.81 / R.A. from the geocenter at TRIGTIME [deg]
DEC_SC  =               -13.15 / Dec. from the geocenter at TRIGTIME [deg]
DIST_SC =              6798.48 / Distance from the geocenter at TRIGTIME [km]
LON_SC  =                81.48 / Longitude at TRIGTIME [deg]
LAT_SC  =               -13.15 / Latitude at TRIGTIME [deg]
MJDREFI =                51544 / MJD reference day
```

```
MJDREFF = 7.428703703703700E-04 / MJD reference (fraction of day)
TIMEREF = 'LOCAL   '           / reference time
TASSIGN = 'SATELLITE'          / Time assigned on satellite
TIMESYS = 'TT      '           / time measured from
TIMEUNIT= 's       '           / unit for time keywords
CLOCKAPP=                    T / Is clock correction applied
DATE-OBS= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
DATE-END= 'YYYY-MM-DDThh:mm:ss.ffff' / End date of observations
TSTART  = 6.126486192982570E+08 / time start
TSTOP   = 6.126486607982570E+08 / time stop
TELAPSE = 4.150000000000000E+01 / elapsed time
ONTIME  = 4.150000000000000E+01 / On-source time
EXPOSURE= 4.150000000000000E+01 / Exposure time
DEADAPP =                    F / Is dead-time correction applied
TRIGGER = '201020  '           / Trigger number
TRIGTIME=     612648625.034470 / Trigger time in MET
TRIGUTC = '2019-05-31T20:10:20.034470' / Trigger time in UTC
TRIGMDC =    1243368627.679125 / Trigger time in MDC time
TRIGEBOX=           244.762125 / Trigger time in EBOX time
TRIGPAT = '1111    '           / Trigger pattern: 4, 1, 1/2, 1/4 s scales
SRCHDU  =                    1 / HDU number in the source L2 data file
HDUCLAS1= 'SPECTRUM'           / PHA dataset (OGIP memo OGIP-92-007)
HDUCLAS2= 'TOTAL   '           / Gross PHA Spectrum (source + bkgd)
ORIGIN  = 'NASA/GSFC'          / origin of fits file
CREATOR = 'extractor v6.18'    / Extractor
PROCVER = '4.1.3.2 '           / Major.Minor.Tool.CALDB
CALDBVER= 'hxm151005_sgm151005' / CALDB version
SEQPNUM =                    1 / sequence in procver
DATE    = '2025-07-30T16:06:49' / file creation date (YYYY-MM-DDThh:mm:ss UT)
HISTORY File modified by user 'cgbm' with fv  on 2022-10-07T21:46:13
HISTORY Corrected by evtgain_recorr.py at 2024-05-20 10:02:39
LIVETIME= 4.150000000000000E+01 / On-source time
DATE-BEG= '2019-05-31T20:10:56.4823' / Start date of observations
MJD-BEG = 5.863484124400760E+04 / MJD of data start time
MJD-END = 5.863484172433168E+04 / MJD of data start time
MJD-OBS = 5.863484124400760E+04 / MJD of data start time
EQUINOX =               2000.0 / Epoch of celestial coord system
RADECSYS= 'FK5     '           / Celestial coord system
FILIN001= 'cgbm_sgm.evt'       / Input file name
TOTCTS  =                    0 / Total counts in spectrum
SPECDELT=                    1 / Binning factor for spectrum
SPECPIX =                    0 / The rebinned channel corresponding to SPECVAL
SPECVAL = 0.000000000000000E+00 / Original channel value at center of SPECPIX
HISTORY extractor v6.18
CHECKSUM= '9GcWC9cU9EcUC9cU'   / HDU checksum updated 2025-07-30T16:06:50
DATASUM = '8448022 '           / data unit checksum updated 2025-07-30T16:06:49
GAIN    = 'HIGH    '           / Gain setting
CHANTYPE= 'PI      '           / Channel type
HISTORY
HISTORY START PARAMETER list for cgbm_speclc_1.302b (13 Nov 2024) at 2025-07-30T
HISTORY 16:06:50
HISTORY
HISTORY P1 infile = ../input/cgbm_sgm.evt
HISTORY P2 outroot = cgbm_sgm_burst
HISTORY P3 gtifile = ../input/cgbm_sgm_025h_dur.gti+4
HISTORY P4 timebin1 = NONE
HISTORY P5 timebin2 = NONE
HISTORY P6 pirangel = 155:410
HISTORY P7 pirangem = 411:2026
HISTORY P8 pirangeh = 2027:4031
HISTORY P9 lcthresh = 0.9
HISTORY P10 events = EVENTS
```

```
HISTORY P11 ecol = PI_HIGH
HISTORY P12 tcol = TIME
HISTORY P13 binfile = REFDATA
HISTORY P14 lconly = no
HISTORY P15 cleanup = yes
HISTORY P16 clobber = no
HISTORY P17 chatter = 1
HISTORY P18 logfile = !DEFAULT
HISTORY P19 debug = no
HISTORY P20 history = yes
HISTORY P21 mode = ql
HISTORY END PARAMETER list for cgbm_speclc_1.302b (13 Nov 2024)
HISTORY
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   16 / width of table in bytes
NAXIS2  =                    1 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'START   '           / label for field   1
TFORM1  = '1D      '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'STOP    '           / label for field   2
TFORM2  = '1D      '           / data format of field: 8-byte DOUBLE
TUNIT2  = 's       '           / physical unit of field
EXTNAME = 'GTI     '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / File conforms to OGIP/GSFC conventions
HDUCLAS1= 'GTI     '           / File contains Good Time Intervals
HDUCLAS2= 'STANDARD'           / File contains Good Time Intervals
TELESCOP= 'CALET   '           / Telescope (mission) name
DATAMODE= 'EVENT   '           / Datamode
DETNAM  = 'SGM     '           / Detector
INSTRUME= 'CGBM    '           / Instrument name
OBJECT  = '1243368627'         / Name of observed object
ONTIME  = 4.150000000000000E+01 / On-source time
EXPOSURE= 4.150000000000000E+01 / Exposure time
LIVETIME= 4.150000000000000E+01 / On-source time
DATE-BEG= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
DATE-END= 'YYYY-MM-DDThh:mm:ss.ffff' / End date of observations
TSTART  = 6.126486192982570E+08 / time start
TSTOP   = 6.126486607982570E+08 / time stop
TELAPSE = 4.150000000000000E+01 / elapsed time
MJD-BEG = 5.863484124400760E+04 / MJD of data start time
MJD-END = 5.863484172433168E+04 / MJD of data start time
MJDREFI =                 51544 / MJD reference day
MJDREFF = 7.428703703703700E-04 / MJD reference (fraction of day)
DATE-OBS= '2019-05-31T20:10:56.4823' / Start date of observations
MJD-OBS = 5.863484124400760E+04 / MJD of data start time
TIMEREF = 'LOCAL   '           / reference time
TIMESYS = 'TT      '           / time measured from
TIMEUNIT= 's       '           / unit for time keywords
FILIN001= 'cgbm_sgm.evt'       / Input file name
CREATOR = 'extractor v6.18'    / Extractor
DATE    = '2025-07-30T16:06:49' / file creation date (YYYY-MM-DDThh:mm:ss UT)
ORIGIN  = 'NASA/GSFC'          / origin of fits file
HDUNAME = 'STDGTI  '           / ASCDM block name
MTYPE1  = 'TIME    '           / Data type
MFORM1  = 'START,STOP'         / names of the start and stop columns
```

```
METYP1  = 'R       '           / data descriptor type: Range, binned data
CHECKSUM= 'lXGUoUETlUETlUET'   / HDU checksum updated 2025-07-30T16:06:50
DATASUM = '1133567705'         / data unit checksum updated 2025-07-30T16:06:49
END
```

Lightcurve file

```
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
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
CHECKSUM= '3fI74d953dG53d95'   / HDU checksum updated 2024-10-25T13:00:37
DATASUM = '         0'         / data unit checksum updated 2024-10-25T13:00:37
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   56 / width of table in bytes
NAXIS2  =                   19 / Number of bins
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                   13 / number of fields in each row
TTYPE1  = 'TIME    '           / label for field   1
TFORM1  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'RATE    '           / label for field   2
TFORM2  = 'E       '           / data format of field: 4-byte REAL
TUNIT2  = 'count/s '           / physical unit of field
TTYPE3  = 'ERROR   '           / label for field   3
TFORM3  = 'E       '           / data format of field: 4-byte REAL
TUNIT3  = 'count/s '           / physical unit of field
TTYPE4  = 'FRACEXP '           / label for field   4
TFORM4  = 'E       '           / data format of field: 4-byte REAL
EXTNAME = 'RATE    '           / name of this binary table extension
TELESCOP= 'CALET   '           / Telescope (mission) name
INSTRUME= 'CGBM    '           / Instrument name
DETNAM  = 'SGM     '           / Detector
DATAMODE= 'EVENT   '           / Datamode
OBS_ID  = '20181028'           / Observation ID
OBJECT  = '1224770954'         / Name of observed object
RA_PNT  =                99.25 / R.A. pointing of the CALET z-axis [deg]
DEC_PNT =                28.89 / Dec. pointing of the CALET z-axis [deg]
RA_INS  =                99.25 / R.A. pointing of the detector z-axis [deg]
DEC_INS =                28.89 / Dec. pointing of the detector z-axis [deg]
RA_SC   =                97.95 / R.A. from the geocenter at TRIGTIME [deg]
DEC_SC  =                27.48 / Dec. from the geocenter at TRIGTIME [deg]
DIST_SC =              6778.56 / Distance from the geocenter at TRIGTIME [km]
LON_SC  =               208.95 / Longitude at TRIGTIME [deg]
LAT_SC  =                27.46 / Latitude at TRIGTIME [deg]
MJDREFI =                51544 / MJD reference day
MJDREFF = 7.428703703703700E-04 / MJD reference (fraction of day)
TIMEREF = 'LOCAL   '           / reference time
TASSIGN = 'SATELLITE'          / Time assigned on satellite
TIMESYS = 'TT      '           / time measured from
TIMEUNIT= 's       '           / unit for time keywords
CLOCKAPP=                    T / Is clock correction applied
DATE-OBS= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
DATE-END= 'YYYY-MM-DDThh:mm:ss.ffff' / End date of observations
```

```
TSTART  = 5.940509880336860E+08 / time start
TSTOP   = 5.940510080336860E+08 / time stop
TIMEDEL = 1.000000000000000E+00 / Binning factor
TELAPSE = 2.000000000000000E+01 / elapsed time
ONTIME  = 2.000000000000000E+01 / On-source time
EXPOSURE= 2.000000000000000E+01 / Exposure time
DEADAPP =                    F / Is dead-time correction applied
TRIGGER = '140943  '           / Trigger number
TRIGTIME=     594050988.795514 / Trigger time in MET
TRIGUTC = '2018-10-28T14:09:43.795514' / Trigger time in UTC
TRIGMDC =    1224770954.101250 / Trigger time in MDC time
TRIGEBOX=           256.270125 / Trigger time in EBOX time
TRIGPAT = '1101    '           / Trigger pattern: 4, 1, 1/2, 1/4 s scales
SRCHDU  =                    1 / HDU number in the source L2 data file
HDUCLASS= 'ogip    '           / Format conforms to OGIP/GSFC conventions
HDUCLAS1= 'LIGHTCURVE'         / Extension contains a light curve
HDUCLAS2= 'TOTAL   '
ORIGIN  = 'NASA/GSFC'          / origin of fits file
CREATOR = 'extractor v6.12'    / Extractor
PROCVER = '4.1.3.2 '           / Major.Minor.Tool.CALDB
CALDBVER= 'hxm151005_sgm151005' / CALDB version
SEQPNUM =                    1 / sequence in procver
DATE    = '2024-10-25T13:00:33' / file creation date (YYYY-MM-DDThh:mm:ss UT)
HISTORY File modified by user 'cgbm' with fv  on 2022-10-07T21:46:13
HDUCLAS3= 'RATE    '
LIVETIME= 2.000000000000000E+01 / On-source time
DATE-BEG= '2018-10-28T14:10:25.2177' / Start date of observations
MJD-BEG = 5.841959088214914E+04 / MJD of data start time
MJD-END = 5.841959111363062E+04 / MJD of data start time
MJD-OBS = 5.841959088214914E+04 / MJD of data start time
EQUINOX =               2000.0 / Epoch of celestial coord system
RADECSYS= 'FK5     '           / Celestial coord system
FILIN001= 'cgbm_20181028_sgm_140943.evt' / Input file name
TIMEZERO= 5.940505060336856E+08 / Time Zero
TIMEPIXR= 5.000000000000000E-01 / Timestamps give center of bin
NPIXSOU =     0.0000000000E+00 / Numbers of Pixels
MINFREXP=     9.0000000000E-01 / Minimum value of FRACEXP included
HISTORY extractor v6.12
CHECKSUM= '9AAlI19j98AjG89j'   / HDU checksum updated 2024-10-25T13:00:37
DATASUM = '1064112056'         / data unit checksum updated 2024-10-25T13:00:37
TTYPE5  = 'RATE1   '           / Label for field 5
TFORM5  = 'E       '           / data format of field: 4-byte REAL
TUNIT5  = 'count/s '           / physical unit of field
TTYPE6  = 'ERROR1  '           / Label for field 6
TFORM6  = 'E       '           / data format of field: 4-byte REAL
TUNIT6  = 'count/s '           / physical unit of field
TTYPE7  = 'FRACEXP1'           / Label for field 7
TFORM7  = 'E       '           / data format of field: 4-byte REAL
TTYPE8  = 'RATE2   '           / Label for field 8
TFORM8  = 'E       '           / data format of field: 4-byte REAL
TUNIT8  = 'count/s '           / physical unit of field
TTYPE9  = 'ERROR2  '           / Label for field 9
TFORM9  = 'E       '           / data format of field: 4-byte REAL
TUNIT9  = 'count/s '           / physical unit of field
TTYPE10 = 'FRACEXP2'           / Label for field 10
TFORM10 = 'E       '           / data format of field: 4-byte REAL
TTYPE11 = 'RATE3   '           / Label for field 11
TFORM11 = 'E       '           / data format of field: 4-byte REAL
TUNIT11 = 'count/s '           / physical unit of field
TTYPE12 = 'ERROR3  '           / Label for field 12
TFORM12 = 'E       '           / data format of field: 4-byte REAL
TUNIT12 = 'count/s '           / physical unit of field
```

```
TTYPE13 = 'FRACEXP3'           / Label for field 13
TFORM13 = 'E       '           / data format of field: 4-byte REAL
GAIN    = 'HIGH    '           / Gain setting
CHANTYPE= 'PI      '           / Channel type
CHRATE  = '155:4031'           / Channel boundaries for RATE
CHRATE1 = '155:410 '           / Channel boundaries for RATE1
CHRATE2 = '411:2026'           / Channel boundaries for RATE2
CHRATE3 = '2027:4031'          / Channel boundaries for RATE3
HISTORY
HISTORY START PARAMETER list for cgbm_speclc_1.301b (25 Oct 2024) at 2024-10-25T
HISTORY 13:00:37
HISTORY
HISTORY P1 infile = ../input/cgbm_20181028_sgm_140943.evt
HISTORY P2 outroot = cgbm_20181028_sgm_140943
HISTORY P3 gtifile = ../input/cgbm_20181028_sgm_140943_1h_t90.gti+1
HISTORY P4 timebin1 = 1
HISTORY P5 timebin2 = 0.064
HISTORY P6 pirangel = 155:410
HISTORY P7 pirangem = 411:2026
HISTORY P8 pirangeh = 2027:4031
HISTORY P9 lcthresh = 0.9
HISTORY P10 events = EVENTS
HISTORY P11 ecol = PI_HIGH
HISTORY P12 tcol = TIME
HISTORY P13 binfile = REFDATA
HISTORY P14 lconly = no
HISTORY P15 cleanup = yes
HISTORY P16 clobber = yes
HISTORY P17 chatter = 1
HISTORY P18 logfile = !DEFAULT
HISTORY P19 debug = no
HISTORY P20 history = yes
HISTORY P21 mode = ql
HISTORY END PARAMETER list for cgbm_speclc_1.301b (25 Oct 2024)
HISTORY
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   56 / width of table in bytes
NAXIS2  =                  312 / Number of bins
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                   13 / number of fields in each row
TTYPE1  = 'TIME    '           / label for field   1
TFORM1  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'RATE    '           / label for field   2
TFORM2  = 'E       '           / data format of field: 4-byte REAL
TUNIT2  = 'count/s '           / physical unit of field
TTYPE3  = 'ERROR   '           / label for field   3
TFORM3  = 'E       '           / data format of field: 4-byte REAL
TUNIT3  = 'count/s '           / physical unit of field
TTYPE4  = 'FRACEXP '           / label for field   4
TFORM4  = 'E       '           / data format of field: 4-byte REAL
EXTNAME = 'RATE    '           / name of this binary table extension
TELESCOP= 'CALET   '           / Telescope (mission) name
INSTRUME= 'CGBM    '           / Instrument name
DETNAM  = 'SGM     '           / Detector
DATAMODE= 'EVENT   '           / Datamode
OBS_ID  = '20181028'           / Observation ID
```

```
OBJECT  = '1224770954'         / Name of observed object
RA_PNT  =                99.25 / R.A. pointing of the CALET z-axis [deg]
DEC_PNT =                28.89 / Dec. pointing of the CALET z-axis [deg]
RA_INS  =                99.25 / R.A. pointing of the detector z-axis [deg]
DEC_INS =                28.89 / Dec. pointing of the detector z-axis [deg]
RA_SC   =                97.95 / R.A. from the geocenter at TRIGTIME [deg]
DEC_SC  =                27.48 / Dec. from the geocenter at TRIGTIME [deg]
DIST_SC =              6778.56 / Distance from the geocenter at TRIGTIME [km]
LON_SC  =               208.95 / Longitude at TRIGTIME [deg]
LAT_SC  =                27.46 / Latitude at TRIGTIME [deg]
MJDREFI =                51544 / MJD reference day
MJDREFF = 7.428703703703700E-04 / MJD reference (fraction of day)
TIMEREF = 'LOCAL   '           / reference time
TASSIGN = 'SATELLITE'          / Time assigned on satellite
TIMESYS = 'TT      '           / time measured from
TIMEUNIT= 's       '           / unit for time keywords
CLOCKAPP=                    T / Is clock correction applied
DATE-OBS= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
DATE-END= 'YYYY-MM-DDThh:mm:ss.ffff' / End date of observations
TSTART  = 5.940509880336860E+08 / time start
TSTOP   = 5.940510080336860E+08 / time stop
TIMEDEL = 6.400000000000000E-02 / Binning factor
TELAPSE = 2.000000000000000E+01 / elapsed time
ONTIME  = 2.000000000000000E+01 / On-source time
EXPOSURE= 2.000000000000000E+01 / Exposure time
DEADAPP =                    F / Is dead-time correction applied
TRIGGER = '140943  '           / Trigger number
TRIGTIME=     594050988.795514 / Trigger time in MET
TRIGUTC = '2018-10-28T14:09:43.795514' / Trigger time in UTC
TRIGMDC =    1224770954.101250 / Trigger time in MDC time
TRIGEBOX=           256.270125 / Trigger time in EBOX time
TRIGPAT = '1101    '           / Trigger pattern: 4, 1, 1/2, 1/4 s scales
SRCHDU  =                    1 / HDU number in the source L2 data file
HDUCLASS= 'ogip    '           / Format conforms to OGIP/GSFC conventions
HDUCLAS1= 'LIGHTCURVE'         / Extension contains a light curve
HDUCLAS2= 'TOTAL   '
ORIGIN  = 'NASA/GSFC'          / origin of fits file
CREATOR = 'extractor v6.12'    / Extractor
PROCVER = '4.1.3.2 '           / Major.Minor.Tool.CALDB
CALDBVER= 'hxm151005_sgm151005' / CALDB version
SEQPNUM =                    1 / sequence in procver
DATE    = '2024-10-25T13:00:33' / file creation date (YYYY-MM-DDThh:mm:ss UT)
HISTORY File modified by user 'cgbm' with fv  on 2022-10-07T21:46:13
HDUCLAS3= 'RATE    '
LIVETIME= 2.000000000000000E+01 / On-source time
DATE-BEG= '2018-10-28T14:10:25.2177' / Start date of observations
MJD-BEG = 5.841959088214914E+04 / MJD of data start time
MJD-END = 5.841959111363062E+04 / MJD of data start time
MJD-OBS = 5.841959088214914E+04 / MJD of data start time
EQUINOX =               2000.0 / Epoch of celestial coord system
RADECSYS= 'FK5     '           / Celestial coord system
FILIN001= 'cgbm_20181028_sgm_140943.evt' / Input file name
TIMEZERO= 5.940505055656855E+08 / Time Zero
TIMEPIXR= 5.000000000000000E-01 / Timestamps give center of bin
NPIXSOU =     0.0000000000E+00 / Numbers of Pixels
MINFREXP=     9.0000000000E-01 / Minimum value of FRACEXP included
HISTORY extractor v6.12
CHECKSUM= 'oUKapUIUoUIaoUIU'   / HDU checksum updated 2024-10-25T13:00:37
DATASUM = '3225435624'         / data unit checksum updated 2024-10-25T13:00:37
TTYPE5  = 'RATE1   '           / Label for field 5
TFORM5  = 'E       '           / data format of field: 4-byte REAL
TUNIT5  = 'count/s '           / physical unit of field
```

```
TTYPE6  = 'ERROR1  '           / Label for field 6
TFORM6  = 'E       '           / data format of field: 4-byte REAL
TUNIT6  = 'count/s '           / physical unit of field
TTYPE7  = 'FRACEXP1'           / Label for field 7
TFORM7  = 'E       '           / data format of field: 4-byte REAL
TTYPE8  = 'RATE2   '           / Label for field 8
TFORM8  = 'E       '           / data format of field: 4-byte REAL
TUNIT8  = 'count/s '           / physical unit of field
TTYPE9  = 'ERROR2  '           / Label for field 9
TFORM9  = 'E       '           / data format of field: 4-byte REAL
TUNIT9  = 'count/s '           / physical unit of field
TTYPE10 = 'FRACEXP2'           / Label for field 10
TFORM10 = 'E       '           / data format of field: 4-byte REAL
TTYPE11 = 'RATE3   '           / Label for field 11
TFORM11 = 'E       '           / data format of field: 4-byte REAL
TUNIT11 = 'count/s '           / physical unit of field
TTYPE12 = 'ERROR3  '           / Label for field 12
TFORM12 = 'E       '           / data format of field: 4-byte REAL
TUNIT12 = 'count/s '           / physical unit of field
TTYPE13 = 'FRACEXP3'           / Label for field 13
TFORM13 = 'E       '           / data format of field: 4-byte REAL
GAIN    = 'HIGH    '           / Gain setting
CHANTYPE= 'PI      '           / Channel type
CHRATE  = '155:4031'           / Channel boundaries for RATE
CHRATE1 = '155:410 '           / Channel boundaries for RATE1
CHRATE2 = '411:2026'           / Channel boundaries for RATE2
CHRATE3 = '2027:4031'          / Channel boundaries for RATE3
HISTORY
HISTORY START PARAMETER list for cgbm_speclc_1.301b (25 Oct 2024) at 2024-10-25T
HISTORY 13:00:37
HISTORY
HISTORY P1 infile = ../input/cgbm_20181028_sgm_140943.evt
HISTORY P2 outroot = cgbm_20181028_sgm_140943
HISTORY P3 gtifile = ../input/cgbm_20181028_sgm_140943_1h_t90.gti+1
HISTORY P4 timebin1 = 1
HISTORY P5 timebin2 = 0.064
HISTORY P6 pirangel = 155:410
HISTORY P7 pirangem = 411:2026
HISTORY P8 pirangeh = 2027:4031
HISTORY P9 lcthresh = 0.9
HISTORY P10 events = EVENTS
HISTORY P11 ecol = PI_HIGH
HISTORY P12 tcol = TIME
HISTORY P13 binfile = REFDATA
HISTORY P14 lconly = no
HISTORY P15 cleanup = yes
HISTORY P16 clobber = yes
HISTORY P17 chatter = 1
HISTORY P18 logfile = !DEFAULT
HISTORY P19 debug = no
HISTORY P20 history = yes
HISTORY P21 mode = ql
HISTORY END PARAMETER list for cgbm_speclc_1.301b (25 Oct 2024)
HISTORY
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   16 / width of table in bytes
NAXIS2  =                    1 / number of rows in table
PCOUNT  =                    0 / size of special data area
```

```
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'START   '           / label for field   1
TFORM1  = '1D      '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'STOP    '           / label for field   2
TFORM2  = '1D      '           / data format of field: 8-byte DOUBLE
TUNIT2  = 's       '           / physical unit of field
EXTNAME = 'GTI     '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / File conforms to OGIP/GSFC conventions
HDUCLAS1= 'GTI     '           / File contains Good Time Intervals
HDUCLAS2= 'STANDARD'           / File contains Good Time Intervals
TELESCOP= 'CALET   '           / Telescope (mission) name
DATAMODE= 'EVENT   '           / Datamode
DETNAM  = 'SGM     '           / Detector
INSTRUME= 'CGBM    '           / Instrument name
OBJECT  = '1224770954'         / Name of observed object
ONTIME  = 2.000000000000000E+01 / On-source time
EXPOSURE= 2.000000000000000E+01 / Exposure time
LIVETIME= 2.000000000000000E+01 / On-source time
DATE-BEG= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
DATE-END= 'YYYY-MM-DDThh:mm:ss.ffff' / End date of observations
TSTART  = 5.940509880336860E+08 / time start
TSTOP   = 5.940510080336860E+08 / time stop
TELAPSE = 2.000000000000000E+01 / elapsed time
MJD-BEG = 5.841959088214914E+04 / MJD of data start time
MJD-END = 5.841959111363062E+04 / MJD of data start time
MJDREFI =                51544 / MJD reference day
MJDREFF = 7.428703703703700E-04 / MJD reference (fraction of day)
DATE-OBS= '2018-10-28T14:10:52.2177' / Start date of observations
MJD-OBS = 5.841959088214914E+04 / MJD of data start time
TIMEREF = 'LOCAL   '           / reference time
TIMESYS = 'TT      '           / time measured from
TIMEUNIT= 's       '           / unit for time keywords
FILIN001= 'cgbm_20181028_sgm_140943.evt' / Input file name
CREATOR = 'extractor v6.12'    / Extractor
DATE    = '2024-10-25T13:00:33' / file creation date (YYYY-MM-DDThh:mm:ss UT)
ORIGIN  = 'NASA/GSFC'          / origin of fits file
HDUNAME = 'GTI     '           / ASCDM block name
MTYPE1  = 'TIME    '           / Data type
MFORM1  = 'START,STOP'         / names of the start and stop columns
METYP1  = 'R       '           / data descriptor type: Range, binned data
CHECKSUM= 'nQPNqNPKnNPKnNPK'   / HDU checksum updated 2024-10-25T13:00:37
DATASUM = '965478438'          / data unit checksum updated 2024-10-25T13:00:33
END
```

4.4 burstbkgevt

Simulated background event file

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                   16 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
```

```
NAXIS1  =                   10 / width of table in bytes
NAXIS2  =               580439 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'TIME    '           / label for field   1
TFORM1  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'PI_HIGH '           / label for field   2
TFORM2  = 'I       '           / data format of field: 2-byte INTEGER
TUNIT2  = 'chan    '           / physical unit of field
EXTNAME = 'EVENTS  '           / name of this binary table extension
TLMIN2  =                    0 / Minimum value in column PI
TLMAX2  =                 4095 / Maximum value in column PI
HDUCLASS= 'OGIP    '           / Conforms to OGIP/GSFC standards
HDUCLAS1= 'EVENT   '           / Contains event data
HDUCLAS2= 'ALL     '           / Photon event list without screening
HDUVERS = '1.2.0   '           / Version of format (OGIP memo-92-007)
TELESCOP= 'CALET   '           / Telescope (mission) name
INSTRUME= 'CGBM    '           / Instrument name
DETNAM  = 'SGM     '           / Detector
DATAMODE= 'EVENT   '           / Datamode
OBS_ID  = '20190531'           / Observation ID
OBJECT  = '1243368627'         / Name of observed object
RA_PNT  =               273.35 / R.A. pointing of the CALET z-axis [deg]
DEC_PNT =               -14.13 / Dec. pointing of the CALET z-axis [deg]
RA_INS  =               273.35 / R.A. pointing of the detector z-axis [deg]
DEC_INS =               -14.13 / Dec. pointing of the detector z-axis [deg]
RA_SC   =               272.81 / R.A. from the geocenter at TRIGTIME [deg]
DEC_SC  =               -13.15 / Dec. from the geocenter at TRIGTIME [deg]
DIST_SC =              6798.48 / Distance from the geocenter at TRIGTIME [km]
LON_SC  =                81.48 / Longitude at TRIGTIME [deg]
LAT_SC  =               -13.15 / Latitude at TRIGTIME [deg]
MJDREFI =                51544 / MJD reference day
MJDREFF =  0.00074287037037037 / MJD reference (fraction of day)
TIMEREF = 'LOCAL   '           / reference time
TASSIGN = 'SATELLITE'          / Time assigned on satellite
TIMESYS = 'TT      '           / time measured from
TIMEUNIT= 's       '           / unit for time keywords
CLOCKAPP=                    T / Is clock correction applied
DATE-OBS= 'YYYY-MM-DDThh:mm:ss.ffff' / Start date of observations
DATE-END= 'YYYY-MM-DDThh:mm:ss.ffff' / End date of observations
TSTART  =     612648415.673257 / Start time of first observation
TSTOP   =     612649049.173257 / End time of last observation
TELAPSE =     633.583956599236 / elapsed time
ONTIME  =                633.5 / End time of last observation
EXPOSURE=                633.5 / Exposure time
DEADAPP =                    F / Is dead-time correction applied
TRIGGER = '201020  '           / Trigger number
TRIGTIME=      612648625.03447 / Trigger time in MET
TRIGUTC = '2019-05-31T20:10:20.034470' / Trigger time in UTC
TRIGMDC =     1243368627.67913 / Trigger time in MDC time
TRIGEBOX=           244.762125 / Trigger time in EBOX time
TRIGPAT = '1111    '           / Trigger pattern: 4, 1, 1/2, 1/4 s scales
SRCHDU  =                    1 / HDU number in the source L2 data file
GAIN    = 'HIGH    '           / Gain setting
ORIGIN  = 'NASA/GSFC'          / origin of fits file
CREATOR = 'burstbkgevt'        / Software that created this file
PROCVER = '4.1.3.2 '           / Major.Minor.Tool.CALDB
CALDBVER= 'hxm151005_sgm151005' / CALDB version
SEQPNUM =                    1 / sequence in procver
HISTORY
```

```
HISTORY START PARAMETER list for burstbkgevt_0.6b at 2025-07-30T16:52:12
HISTORY
HISTORY P1 infile = ../input/cgbm_sgm_025h_user.lc
HISTORY P2 prespec = ../input/cgbm_sgm_preburst.pi
HISTORY P3 postspec = ../input/cgbm_sgm_postburst.pi
HISTORY P4 outroot = cgbm_sgm_025h
HISTORY P5 timecol = TIME
HISTORY P6 ratecol = BKGRATE
HISTORY P7 errcol = ERROR
HISTORY P8 chancol = CHANNEL
HISTORY P9 cntcol = COUNTS
HISTORY P10 destcol = PI
HISTORY P11 stdv = -999
HISTORY P12 stdv_mult = 1
HISTORY P13 clobber = yes
HISTORY P14 chatter = 1
HISTORY P15 debug = no
HISTORY P16 logfile = !burstbkgevt_sgm_025h.log
HISTORY P17 history = yes
HISTORY P18 mode = ql
HISTORY END PARAMETER list for burstbkgevt_0.6b
HISTORY
DATE    = '2025-07-30T16:52:12' / file creation date (YYYY-MM-DDThh:mm:ss UT)
CHECKSUM= 'aAoAd1m4a8m9a8m9'   / HDU checksum updated 2025-07-30T16:52:12
DATASUM = '4200500604'         / data unit checksum updated 2025-07-30T16:52:12
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   16 / width of table in bytes
NAXIS2  =                    1 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'START   '           / GTI start time
TFORM1  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / Physical unit of field
TTYPE2  = 'STOP    '           / GTI stop  time
TFORM2  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT2  = 's       '           / Physical unit of field
EXTNAME = 'STDGTI  '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / Conforms to OGIP/GSFC standards
HDUCLAS1= 'GTI     '           / Contains good time intervals
HDUCLAS2= 'STANDARD'           / Contains standard good time intervals
HDUVERS = '1.0.0   '           / Version of GTI header
TIMEZERO=                   0. / Zero-point offset for TIME column
MJDREF  =    51544.00074287037 / MJD Epoch of Time = 0
TSTART  =    612648415.6732572 / Start time of GTI
TSTOP   =    612649049.2572138 / Stop  time of GTI
END
```