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Fermi Calibration Data in the *HEASARC* Calibration Database

Michael F. Corcoran
Code 662,
NASA/GSFC,
Greenbelt,
MD 20771

Jerry Bonnell
Code 662,
NASA/GSFC,
Greenbelt,
MD 20771

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SUMMARY

This document describes the structure of the *Fermi* calibration database (CALDB) at the *HEASARC*. It includes brief descriptions of the data files, update plans, and retrieval information.

LOG OF SIGNIFICANT CHANGES

Release Date	**Sections Changed**	**Brief Notes**
2007 Jan 01	All	First (internal) Draft
2007 Mar 21	§2, table 1, fig. 1	included cal data files from **?**
2009 Apr 21	(throughout)	Changed GLAST to *Fermi*
2011 May 10	Table 1	revised LAT caldb file names
2012 Feb 22	Table 1	added GBM leaf files

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1 Introduction

1.1 *Fermi*

The *Fermi* Gamma-Ray Space Telescope is a joint NASA/DOE mission to survey the gamma-ray sky in the energy range from 10 keV to 300 GeV. *Fermi* was successfully launched aboard a Delta II rocket from Cape Canaveral Air Force Station in Florida at 12:05 p.m. EDT, June 11, 2008. *Fermi* consists of 2 instruments, the Large Area Telescope (LAT) and the Gamma-Ray Burst Monitor (GBM). The GBM is an all-sky monitor similar to the BATSE instrument on the Compton Gamma-Ray Observatory (CGRO) and is designed to detect and coarsely localize gamma-ray bursts and other high energy transient events. The GBM includes 12 Sodium Iodide (NaI) scintillation detectors and 2 Bismuth Germanate (BGO) scintillation detectors. The NaI detectors cover the lower part of the energy range, from a few keV to about 1 MeV and provide burst triggers and locations. The BGO detectors cover the energy range of 150 keV to 30 MeV, providing a good overlap with the NaI at the lower end, and with the LAT at the high end. Together the NaI and BGO detectors have similar characteristics to the combination of the BATSE large area and spectroscopy detectors but cover a wider energy range and have a smaller collection area.

The LAT detector is designed to provide high-sensitivity detection of gamma-ray sources in the 20 MeV – 300 GeV range, with fine position resolution. The LAT consists of a four-by-four array of 16 tower modules. Each tower module consists of interleaved planes of silicon-strip detectors and tracker lead converter sheets. Silicon-strip detectors (SSDs) are able to more precisely track the electron or positron produced from the initial gamma-ray than previous types of detectors. The SSDs will give the LAT the ability to determine the location of a cosmic gammay-ray source to within 0.5 to 5 arc minutes. More details on the *Fermi* mission and the LAT and GBM instruments are available from the *Fermi* website, `http://fermi.gsfc.nasa.gov`.

Fermi calibration data is any data obtained on ground or in orbit which is used to characterize the properties of the spacecraft and/or instruments for the analysis of *Fermi* science data. Calibration data may vary with time, but usually such variations are on timescales long compared to relevant observational timescales (for example, the orbital period or the slewing timescale). Calibration data may also vary with instrumental, environmental or observing conditions. Calibration data includes such things as instrumental response matrices, instrumental effective areas, sensitivities, gains, etc., but generally excludes ancillary engineering or housekeeping data like pointing histories or livetimes which might vary with each observing scan.

During the mission the *Fermi* Science Support Center (*FSSC*) is tasked with making *Fermi* calibration data available to the astrophysical community in a manner consistent with the *Fermi* analysis software. The *FSSC* will produce and provide all *Fermi* calibration data necessary for analysis of *Fermi* science data in a format consistent with the specifications of the "Calibration Database" (CALDB) at the High Energy Astrophysics Science Archive Research Center (the *HEASARC*).

1.2 The HEASARC Calibration Database

The HEASARC's calibration database (CALDB) system stores and indexes datasets associated with the calibration of high energy astronomical instrumentation. The system can be accessed by users and software to determine which calibration datasets are available, and which are appropriate for data reduction and analysis. Data in the CALDB which is to be used in analysis must be stored in FITS format, and must include specific FITS header keywords as described in "Required and Recommended FITS keywords for Calibration Files" (CAL/GEN/92-011), available online from the *HEASARC* CALDB document library. The HEASARC also distributes a set of access routines, called the `caltools`, as part of the HEASoft multi-mission analysis system. The *HEASARC* CALDB access software is supported on every operating system that is supported by the HEASoft software suite. This includes almost all flavors of Unix (including linux and Mac OS X). There is currently no support for versions of the Microsoft Windows operating system.

The CALDB for any and all supported missions can be downloaded and installed on a user's machine for any analysis task. Alternatively, users can access the HEASARC CALDB remotely without having to download, install or maintain a local copy of the CALDB (which can be rather large, and which can be updated rather frequently). Analysis software included in the HEASoft package includes CALDB access support. This simplifies the identification and use of calibration data appropriate to the observation being analyzed.

2 Structure of the *Fermi* CALDB

The top-level CALDB directory is stored in the Unix environment variable `$CALDB`. For the *HEASARC* CALDB, the environment variable `$CALDB` may be defined as `http://heasarc.gsfc.nasa.gov/FTP/caldb`, which is useful for users to remotely access CALDB data via the internet without having to install a version of the CALDB on a local disk. Remote access to the CALDB is described on the "CALDB Remote Access" document at `http://heasarc.gsfc.nasa.gov/docs/heasarc/caldb/caldb_remote_access.html`. Users may copy the *Fermi* CALDB to their own machines for easier access by downloading a single tar file, in which case a local `$CALDB` environment variable needs to be defined, as described in "How to Install a Calibration Database" (cal/gen/94-004).

Subdirectories of the `$CALDB` directory include `data`, `docs` and `software` subdirectories.

2.1 The `docs` subdirectory

The `docs` subdirectory contains documentation describing the calibration data for given missions. *Fermi*-specific calibration documentation describing types of calibration data, uncertainties in the calibrations, applications of the calibrations, and other descriptive matter (including this document) will be located in the `docs/fermi` subdirectory. Documents describing the structure and use of the CALDB as instituted at the *HEASARC* will be stored in the `docs/memos` subdirectory.

2.2 The `software` subdirectory

The `software` subdirectory contains various scripts and procedures used for CALDB maintenance. The `software/tools/` subdirectory contains setup and initialization files used by the CALDB, in particular:

- `caldbinit.csh`, `caldbinit.sh`, `caldbinit.vms` and `caldbinit.iraf`: these files define necessary CALDB environment variables for c-shell, bash shell, VMS (no longer supported) and IRAF users, respectively.
- `caldb.config`: this is an ASCII text file which provides necessary information regarding the configuration of individual mission CALDBs.
- `alias_config.fits`: this FITS file provides the list of "aliases" for the names of particular instruments on particular missions.

2.3 The `data` subdirectory

The *Fermi* CALDB follows the general CALDB structure in which calibration data are divided, for largely historical reasons, into two types, "basic calibration files" (bcf), consisting of FITS-formatted calibration data primitives, and "calibration product files" (cpf), FITS-formatted calibration data usually derived from the "basic calibration" primitives. A discussion of the differences between "bcf" and "cpf" data is given in CAL/GEN/92-003, "BCF & CPF Calibration File Guidelines". For a given mission and instrument, the calibration data are stored in CALDB subdirectories whose directory path is specified by the mission and instrument name, according to the "type" of data (basic calibration or calibration product). Data for the LAT instrument will be stored in `$CALDB/data/glast/lat/<type>`, where `<type>` is either `bcf` or `cpf`, depending, respectively, on whether the file is assigned to the basic calibration file or calibration product file type. Similarly, GBM data will be stored in `$CALDB/data/glast/gbm/<type>`.

3 *Fermi* CALDB Codenames Values: the CCNM0001 keyword list

Calibration data in the calibration database can be identified by codenames given by the CALDB keyword `CCNM0001` in the header of the calibration file extension. Table 1 lists the values of the CCNM0001 keywords, with brief descriptions, in use by the *Fermi* mission to describe *Fermi* CALDB data. For all tabulated entries, the keyword `TELESCOP='GLAST'` (for Gamma-ray Large Area Space Telescope, which was the name of the telescope prior to launch).

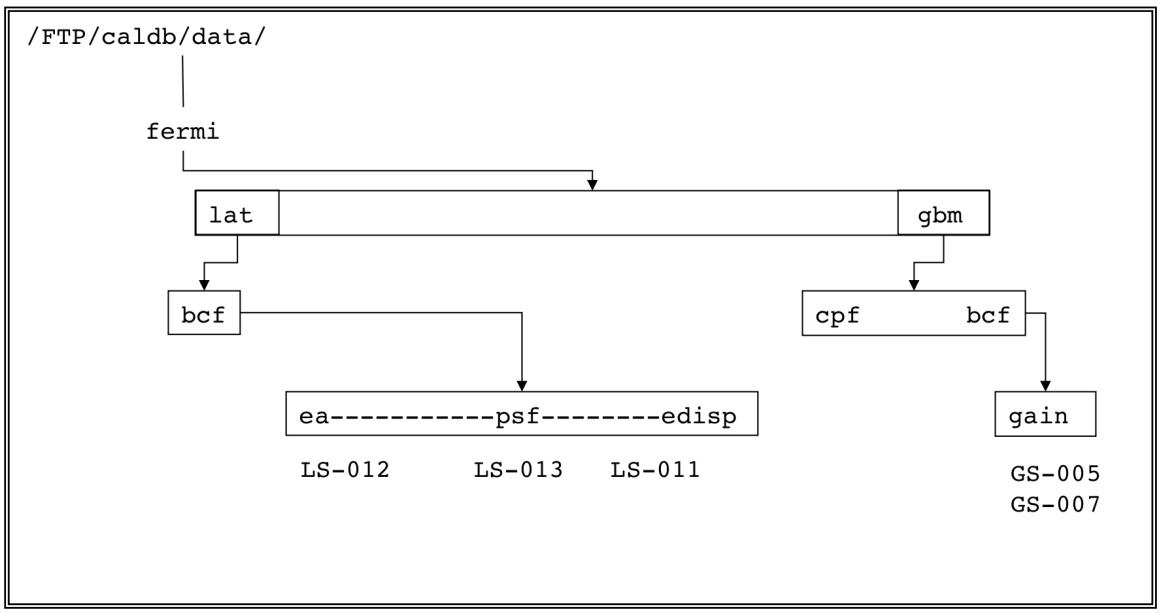

Figure 1: Map of the *Fermi* CALDB data directory.

Table 1: Values of the CCNM0001 keyword in *Fermi* CALDB calibration files.

CCNM0001 Value	INSTRUME	*FSSC* Des.[1]	Sample File	CAL_DESC	Comment
DET_GAIN	GBM	GS-005	glg_spechist_<wx> _<yymmdd>_v<zz>.fit+	`Spectral Gain History for Detector NAI_00`	Spectral Gain History for GBM Detector XXX_YY. w=N or B for NaI or BGO; x=HEX detector number; yymmdd = date covered by the file; zz = version number
DET_BIN	GBM	GS-007	glg_lut<ww>_<zzz> _<yymmddfff>_v<xx>.fit	`GBM PHA LUT`	GBM PHA Look up table; ww = (ct for ctime,cs for cspec); zzz = nai or bgo; yymmdd=date of start of table validity; fff = fraction of day; xx= version number

Table 1: Values of the CCNM0001 keyword in *Fermi* CALDB calibration files.

CCNM0001 Value	INSTRUME	*FSSC* Des.[1]	Sample File	CAL_DESC	Comment
ECOMPRESS	GBM	GS-008	glg_leaf_<nt>_z<wwwwww> _az<yyyyyy>_v<xx>.rsp	`LEAF files for GBM response generator`	n='n' or 'b' for detector type; t=0 to b for detector HEX number; wwwwww = zenith angle, millidegrees; yyyyyy = azimuth angle, millidegrees; xx=version number
EDISP	LAT	LS-011	`edisp_PN_vM_<class>.<side>.fits`[2]	`(BLANK)`	Constants for parameterization of the LATs energy redistribution
EFF_AREA	LAT	LS-012	`ea_PN_vM_<class>.<side>.fits`[2]+	`(BLANK)`	Constants for parameterization of the LATs effective area
RPSF	LAT	LS-013	`psf_PN_vM_<class>.<side>.fits`[2]	(BLANK)	Constants for parameterization of the LATs radial point spread function

[1]see GLAST FITS Format Document (GLAST-GS-DOC-0001), **?**

[2]`class` is either `diff`, `source` or `trans`; `side` is either `front` or `back`

4 CALDB Updates

Updates to the *Fermi* CALDB will follow the procedure described in "Automated Delivery of Calibration Data to the CALDB" (cal/gen/2003-001). Ingest data scripts are located in `$CALDB/local/scripts/DATA_DELIVERIES` at the *HEASARC*. Data to be ingested can be placed in appropriate subdirectories in `$CALDB/staging/data/glast`. Each update to the *Fermi* CALDB will be listed on the CALDB "What's New" webpage, and also announced via the CALDB RSS NewsFeed.

5 General Calibration Data

The *Fermi* mission may use general calibration data which may be used by many various missions.

Table 2: General Calibration Files Available for Use by *Fermi*

Type of File	CCNM0001 Value	CAL_DIR	CAL_DESC	Sample
Leap Seconds Table	LEAPSECS	$CALDB/data/gen/bcf	Table of times at which Leap seconds occurred	leapsec_010905.fits

6 CALDB Data Access

Fermi data in the CALDB can be retrieved by a number of mechanisms. Users can directly access files via anonymous ftp from `ftp://legacy.gsfc.nasa.gov/caldb/data/glast`, or via the WWW from `http://heasarc.gsfc.nasa.gov/FTP/caldb/data/glast`, if the user knows the name and location of the file. This is not very convenient when a user needs to choose from a number of versions of the same file, since it may not be clear which version is applicable to the analysis task at hand. The tool `quzcif`, distributed as part of the HEASoft `caltools` package, allows users to determine which calibration file (or files) are appropriate for a given analysis task after the user specifies a given set of observing parameters (date and time of observation, instrument, and other relevant parameters). After the relevant observing parameters are specified, `quzcif` returns the names of the appropriate files from the CALDB. The HEASoft calibration software library (`callib`) FORTRAN subroutine `gtcalf` can be used by individual software tasks to retrieve relevant calibration data from the CALDB with little or no user input. A description of `gtcalf` is given in "HEASARC CALDB Access Subroutines" (cal/sw/95-002).

This subroutine may evolve as new capabilities are required; users should check the latest distribution of the HEASoft package for the latest version of the `gtcalf.f` subroutine.

Users of the HEASoft software (or any software that supports virtual file input using `urls`[1] (like software based on the CFITSIO library) and an internet connection can also access the HEASARC CALDB remotely (i.e. without having to install the CALDB locally).

The CALDB website has more information on installing and managing the CALDB, and information on accessing the CALDB remotely.

7 CALDB Websites

The CALDB homepage is `http://heasarc.gsfc.nasa.gov/docs/heasarc/caldb/`. General information regarding the *Fermi* CALDB, including links to tarfiles of *Fermi* calibration data and dates of updates, will be made available on the CALDB supported missions webpage and announced on the CALDB rss feed, and included on the CALDB "What's New" web page. For each *Fermi* CALDB release for the LAT and the GBM, a summary of the current calibration files will be available from the *Fermi* LAT and *Fermi* GBM CALDB summary pages.

[1] Uniform Resource Locator

8 Relevant *Fermi* Documents

- GLAST Project Management Data Plan (433-PLAN-009) (**?**)
- GSSC-Functional Requirements Document (Rev. A) (433-RQMT-0002) (**?**)
- GLAST-HEASARC Memorandum of Understanding (GSSC-0008) (**?**)
- Science Data Products File Format Document GLAST-GS-DOC-0001, (**?**)
- Ingest System Detailed Design Document (GSSC-0009)(**?**)
- Science Data Products ICD (GLAST-GS-ICD-0006) (**?**)

9 Relevant *HEASARC* Documents

- "The HEASARC Calibration Database (a brief overview)" (cal/gen/91-001)
- "The Organization of the HEASARC CALDB" (cal/gen/93-006)
- "Automated Delivery of Calibration Data to the CALDB" (cal/gen/2003-001)

10 Other Useful Webpages

- Other OFWG FITS Format Documentation:
  `http://heasarc.gsfc.nasa.gov/docs/heasarc/ofwg/ofwg_recomm.html`
- The CALDB Documentation Library:
  `http://heasarc.gsfc.nasa.gov/docs/heasarc/caldb/caldb_doc.html`
  (contains descriptions of other FITS data file conventions and standards)
- The HEASARC FITS Resource Page:
  `http://heasarc.gsfc.nasa.gov/docs/heasarc/fits.html`