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BEPICOLOMBO SGS

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APPROVAL

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CHANGE LOG

CHANGE LOG

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Initial version	D.1	22-12-2017	All	All
Updated version: • Instrument description included • FITS product format changed to CDF format • Calibration first description included • References included • Annexes included	D.2	28.12.2022		
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• Section 3.3.3.4 Frontend, Backend, Triggering test data description updated				

DISTRIBUTION LIST

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1. Introduction

1.1 Purpose and Scope

This document describes the BERM science data processing pipeline. It details the data flow, the processing steps, and its implementation and operation, including any configuration and interface details needed for the integration and operation of the pipeline within the context of the BepiColombo Science Operations Control System (BSCS).This document does not contain detailed descriptions of the data products resulting from the pipeline; details of the format and structure of the data products can be found in the BERM EAICD [RD.06].The development schedule for the data processing pipeline and quick-look analysis functionalities is maintained by the SGSe as part of the overall SGS schedule [AD.05].

1.2 Applicable Documents

The following documents, of the issue given hereunder, are pertinent to the extent specified herein. If no issue given, the most recent issue should be used. They are referenced in the form [AD.XX]:

[AD.01] BC-SGS-PL-014, BepiColombo Science Data Generation, Validation and Archiving Plan
[AD.02] BC-SGS-TN-026, BepiColombo Archiving Guide
[AD.03] BC-SGS-TN-023, BepiColombo SGS Software Engineering Guidelines (SEGU)
[AD.04] BC-SGS-ICD-026, SGS-PI ICD
[AD.05] BC-SGS-SP-006, Data Processing Subsystem Architectural Design
[AD.06] BC-SGS-TN-055, BSCS Virtualization Infrastructure
[AD.07] BC-SGS-SCH-012, SGS Schedule
[AD.08] PDS4 Standards Reference (SR)
[AD.09] PDS4 Data Dictionary (DDDB)
[AD.010] PDS4 Information Model Specification (IM)
[AD.011] BC-SGS-ICD-024, BERM Experiment-to-Archive ICD (EAICD)

1.3 Reference Documents

The following documents, of the issue given hereunder, although not part of this document, amplify or clarify its contents. If no issue given, the most recent issue should be used. They are referenced in the form [RD.XX]:

[RD.01] BC-SGS-LI-014, SGS Glossary
[RD.02] BC-EFA-UM-00001 05G BERM - Equipment User Manual & Handling Procedures
[RD.03] BARD-LIP-TR 0001 02 Analysis-Industrial-BERM-Data, Industrial Data Calibration Report
[RD.04] Pinto M., et al. 2022, The BepiColombo Environment Radiation Monitor, BERM, Space Science Reviews (2022) 218:54, https://doi.org/10.1007/s11214-022-00922-2
[RD.05] BC-SGS-TN-056, BepiColombo Science Overview & Quick-look Analysis Description
[RD.06] BC-SGS-ICD-024, BERM Experiment-to-Archive ICD (EAICD)
[RD.07] BARD-LIP-TR 0001 02 Analysis-Industrial-BERM-Data, Industrial Data Calibration Report

1.4 Acronyms and Definitions

See BepiColombo online Glossary [RD.01].

2. Instrument Overview

2.1 Science Objectives

The primary objective of BERM onboard the Mercury Planetary Orbiter (MPO) is to provide continuous measurements of the radiation environment of the spacecraft in order to collect regular data on the amount of highly energetic particles, discriminating by type (electrons, protons, heavy ions) and energy level. These measurements will provide information on the radiation doses that the spacecraft and its electronics encounter over the course of the mission. The radiation levels and characteristics derived from BERM data will allow the impact of the radiation environment on the scientific payloads to be derived. In addition, the data from BERM will be used to augment and extend the in-situ particle measurements of the SIXS-P sensor, by extending the measurement range for electrons, protons and heavy ions. Also, the radiation data collected by BERM provides a valuable reference measurement for the MGNS instrument, allowing for a better discrimination of radiation sources in the MGNS data.

2.2 Instrument Description

The BERM instrument (Fig 1a) is an adaptation of the MFS (Multi-Functional Spectrometer) unit flown on Alphasat, from which it has inherited most of its functional features. A noteworthy difference is a re-designed circuit board and an updated ASIC chip which performs the particle recognition and energy reconstruction process.

The so-called Frontend (the actual detector) of the instrument consists of a stack of 11 separate thin (300µm) silicon detector layers with variable absorber layers of aluminium and tantalum between the individual detector layers (see Fig 1b for schematic). The effective FOV is ~40deg around the -Y axis, pointing out of the radiator panel, close to the baffle of the PHEBUS instrument (Fig.2) of the Mercury Planetary Orbiter (MPO/Bepi).

The instrument is designed to discriminate between electrons, protons and heavy ions (mostly alpha particles) and record them in three different particle type channels. It can detect electrons in the range of 0.3-10 MeV, separated into 5 spectral bins; protons between 1-205 MeV, separated into 8 spectral bins and heavy ions in the range of 1-50 MeV/mg/cm2, separated into 5 spectral bins. Table 1 displays the BERM expected energy bins per particle type. These values were revisited in the analysis of the industrial data performed in the context of the BARD contract, that can be found in [RD.04] and [RD.07]. The revaluated proton and electron energy bins, including the cross contaminations of electrons to proton channels and of protons to electrons channels are shown in Table 2. The Heavy ion energy bins are still to be verified in the context of the ongoing work.

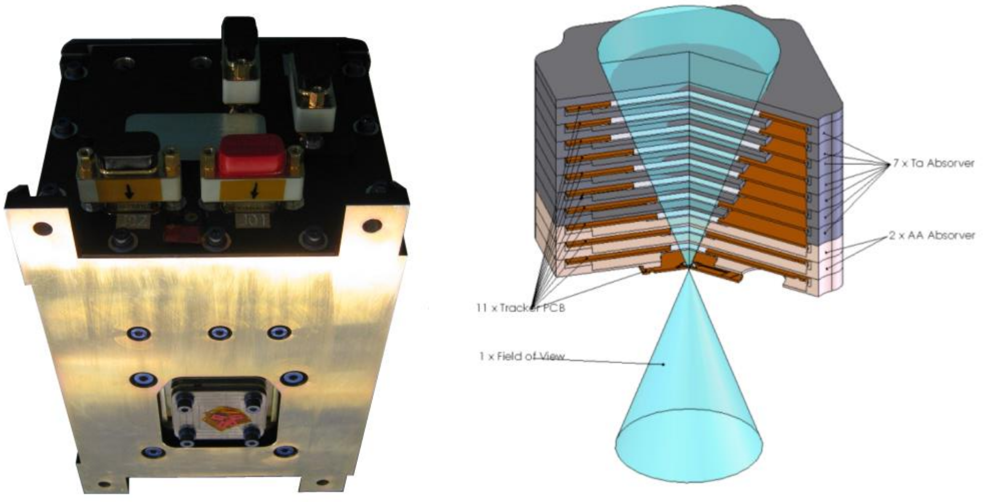

Figure 1: (a) BERM flight unit and (b) Frontend/Detector stack schematic overview

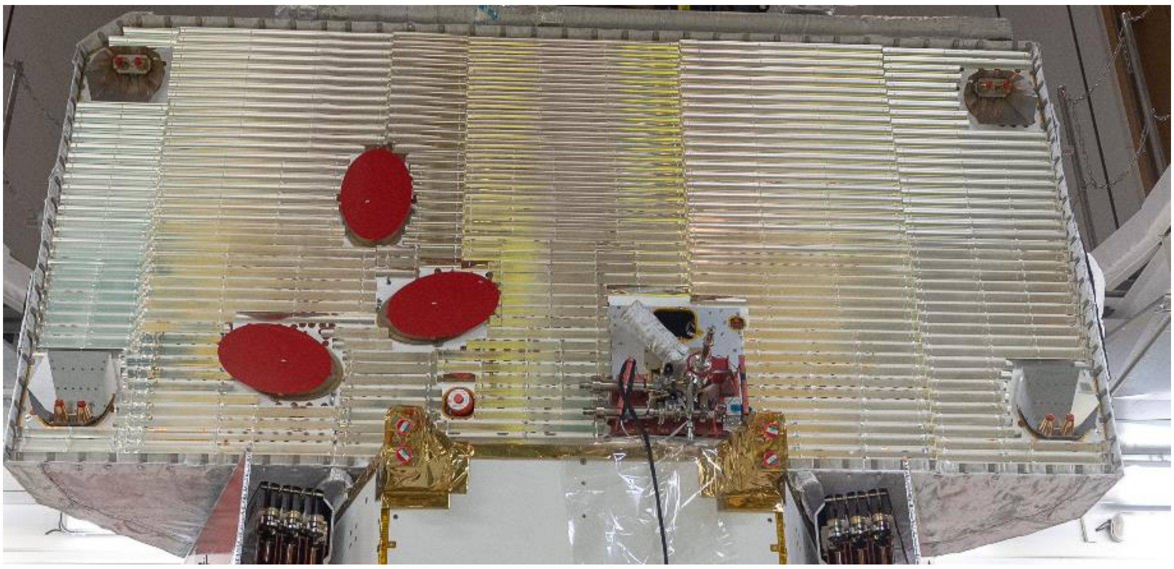

Figure 2: Location of the BERM aperture on the spacecraft radiator panel

Table 1: BERM Energy bins per particle type, prior to the review of BERM calibration.

Channel/Bin	1	2	3	4	5	6	7	8
Electrons [Mev]	0.3-0.62	0.62- 1.26	1.26- 2.54	2.54- 5.1	5.1- 10.22			
Protons [Mev]	1- 1.8	1.8- 3.4	3.4- 6.6	6.6- 13.0	13.0- 25.8	25.8- 51.4	51.4- 102.6	102.6- 205
Heavy Ions [Mev/mg/cm²]	1- 2.2	2.2- 4.8	4.8- 10.5	10.5- 22.9	22.9- 50			

Table 2: BERM energy bins per particle type both for the Electron and Proton signal bins obtained after the analysis of the calibration data (described in [RD.07]. including the expected cross-contamination of electrons to proton channels and protons to electron channels.

Bin	Electron energy (MeV)	Proton energy (MeV)
Electron Bin 1	0.17	100–∞
Electron Bin 2	0.3	1.35–1.55; 100–∞
Electron Bin 3	0.5–∞	100–∞
Electron Bin 4	1.1–∞	100–∞
Electron Bin 5	2.6–∞	100–∞
Proton Bin 1	0.44–∞	1.5–5.9; 103–∞
Proton Bin 2	0.33–∞	9.1–13; 103–∞
Proton Bin 3	NA	5.9–9.1
Proton Bin 4	1.1–∞	13–20.7
Proton Bin 5	1.3–∞	20.7–31.4; 95.6–109.2
Proton Bin 6	6.5–∞	31.4–59.1; 100–117
Proton Bin 7	NA	59.1–130
Proton Bin 8	NA	80.1–160

In order to maintain a low data volume, the flight unit cannot report individual particle detection signatures, but has been limited to identifying the three measured particle types and their approximate energy ranges on-board and group them into the pre-defined bins, generating a science frame which integrates the measured particle statistics over a fixed interval of 30 seconds. A more in-depth technical description of BERM can be found in [RD.03].

2.3 Operational Modes

The operational modes of BERM are defined as follows (Modes are identified in the BERM data with a corresponding mode number):

- IDLE (Mode number = 0)
- SCIENCE (Mode number = 2)
- TEST_BACKEND (Mode number = 3)
- TEST_FRONTEND (Mode number = 4)

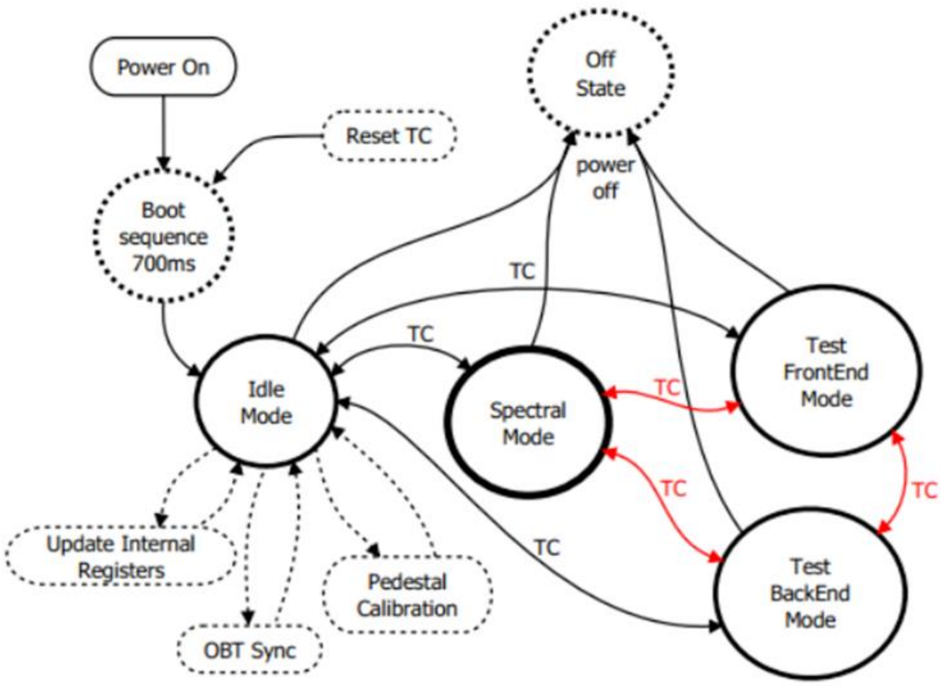

Figure 3 BERM Mode Transition Diagram

In its role as spacecraft infrastructure, BERM Is supposed to continuously operate in the "SCIENCE" mode (also referred to as "Spectral" mode in some documents), in which every 30s the total number of counts in each pre-defined particle/energy range bin is reported as a histogram. In case of maintenance activities, the instrument can be cycled through an "IDLE" mode (equivalent to an instrument standby mode) to either "Test Frontend" or "Test Backend" modes, which allow for the insertion of pre-defined test signals into different parts of the signal processing chain, allowing diagnosis of the health status of the unit. The "Test FrontEnd" (TFE) mode is designed to check the detector stack of BERM by applying pre-defined bursts of voltages at specific frequencies and of variable energy levels. Data from the TFE mode are reported in dedicated frames with different contend than the normal science data and are thus archived separately from these. The "Test

BackEnd” (TBE) mode feeds a set of artificial detector readings into the signal processing chain, in order to check for the proper functioning of the particle recognition and energy reconstruction algorithm as described in the BERM user manual [RD.02]. Data from the TBE mode is currently not archived in a dedicated product, as the mode was not foreseen to be used during flight. Therefore, the mode number should be consulted to identify the data collected in the TBE mode.

3. Science Data Processing Pipeline

3.1 Overview

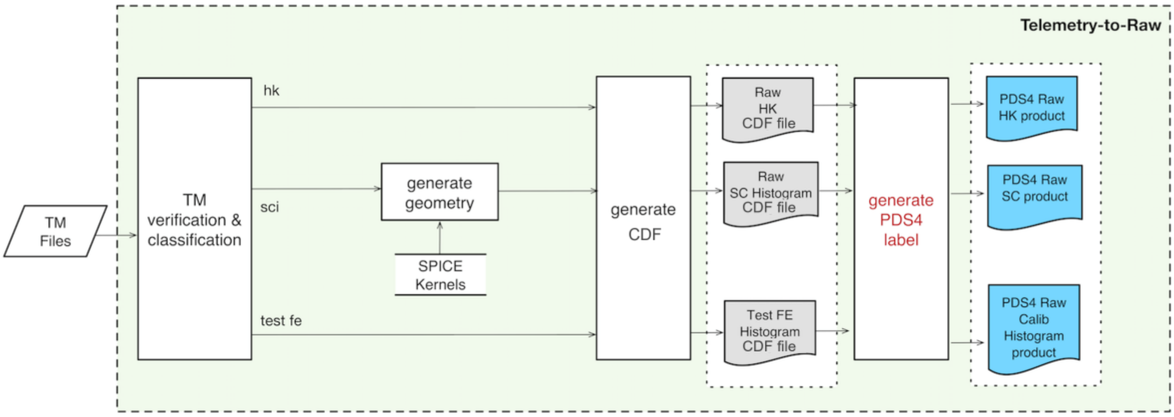

Figure 4: BERM science data processing workflow

Table 3: Science Data Processing Pipeline steps

Classification	***Operation***	***Processing Steps***	***Type***	***Developed by***
Telemetry-to-Raw (tm2raw)	SGS	Telemetry to CDF conversion	Automatic	IT
		Time correlation and geometry computation	Automatic	IT
		HK information to SC products	Automatic	IT
		PDS4 label generation	Automatic	IT
BERM Calibration	SGS	calibration inputs: Response functions, background (TBD)	Automatic	IT
		HK conversion to physical units	Automatic	IT
		Conversion of Channel particle counts per 30s to particle fluxes per channel	Automatic	IT
		CDFto PDS conversion	Automatic	IT

3.2 Telemetry-to-Raw

The telemetry-to-raw (tm2raw) processor accepts BERM TM packet files, and decodes housekeeping and science packets into PDS-formatted raw data products (CDF with the corresponding label). This processor also implements classification of measurements based on: data type, mission phase and time coverage (daily products), for which separate PDS products are produced. The tm2raw processor is composed of a set of tasks executed in sequence (*), outlined in Figure 4 and described in the following sub-sections.

- Telemetry decoder
- Data type classification
- Time correlation & geometry computation
- CDF product generation
- PDS4 label generation

(*) Set of common data processing components developed by the SGS in Java. Code available under LGPL open-source license. Used by several instrument data processing pipelines including all tm2raw implementations developed by the SGS.

3.2.1 Processing Tasks

3.2.1.1 Telemetry decoder

This task performs the following activities:

- Reads all TM files in the input processing folder, and checks that the files are not empty. Input TM files are in the form of an EDDS PktTmRaw response. See additional details in section 3.2.2.
- Decodes TM headers (SCOS-2000 and CCSDS headers)
- Selects relevant TM packets and decodes the data field (instrument and packet type specific) in those packets based on a configuration file that defines the TM packet structures (this is the so-called MIB+).

The MIB+ are XML files describing the structure of the CCSDS TM packets. The BERM TM packet structure descriptions can be found in the MIB, from which the MIB+ file can be generated automatically. The list of relevant BERM TM packet types can be found in Table 4; the selection is done based on the APID, Service Type and Subtype, and SID. The associated TM structure definitions can be found in the following MIB+ file: telemetry_ber_mib.xml, maintained under version control in the BSCS Git repository: mibplus.git). This task can be automatically triggered every time new files are received in the input-processing folder. It can be also triggered manually.

3.2.1.2 Data Type Classification

Classifies the TM packet input stream according to the data type (based on the APID, Service Type, Service Subtype and SID), as follows:

- BERM housekeeping (SPID = 30451)
- BERM science acquisition report (SPID = 30401)
- BERM test front-end (TFE) data (SPID = 95106 - 95107)

See TM packet details in Table 4 below:

Table 4: BERM Telemetry Packet Types

SPID	APID	TYPE	STYPE	SID	Description	Reference
30451	164	3	25	86	BERM Housekeeping	
30401	213	169	20	0	BERM Science Acquisition Report	
95106	166	2	129	58591	BERM Test Front-End Data Part I	
95107	166	2	129	58592	BERM Test Front-End Data Part II	

BERM TM structure definitions can be found in the MIB+ file: telemetry_ber_mib.xml, maintained under version control in the Git repository: bepi.if.telemetry.git.

3.2.1.3 Test Front-End Histogram (TFE)

This TFE product is generated by combining data from two TM packets with SPID = 95106 - 95107. To identify matching pairs of SPID 95106 and 95107 TM packets, the following algorithm should be applied (i.e. pair the two parts of the TFE data by their proximity in time):

- Check that there are no TM gaps for SPIDs 95106 - 95107 by using the Source Sequence Counter (SSC)
  - < Richard to document what to do when there are TM gaps >
- Record which is the first TFE packet with SPID 95106
- The next packet with SPID number 95107 is the matching packet

There are some rare cases (i.e. internal clock rollover during the TFE sequence) in which this might fail for an individual pair of packets. To safeguard we might add a consistency check with the S/C OBT value. I think I can work that out in a brainstorming session with Fran. Richard to specify better what this means. Note: The "Science Packet Counter" is a regular sequence counter and does get updated when the S/C has requested an even number of HK data frames, therefore, matching OBT and the Science Packet Counter values fails whenever there are two HK packets being requested inside one TFE interval (consistent with the observed frequency and all occurrences).

3.2.1.4 Time correlation & Geometry computation

Computes a set of time and geometry information for the input packet streams, using the SPICE toolkit. The list of SPICE kernels to be used is provided in the form of a SPICE meta-kernel file. This task performs the following activities:

- Reads a SPICE meta-kernel and loads all SPICE kernels. By default, the latest version of the BERM SPICE meta-kernel file in the Data Store is used (see section 4.6.1 To Be Written); a specific meta-kernel file can be provided as an optional input to this task if necessary.
- Converts the S/C clock counter string for each time stamp (SCET) in the packets to UTC
- Computes a pre-defined set of geometry metadata

3.2.1.5 CDF product generation

3.2.1.6 CDF-to-PDS4 label generation

3.2.2 Inputs

This section describes the inputs required by the telemetry-to-raw processor. The main input is TM files. The telemetry-to-raw processor accepts TM files containing multiple types of TM packets. Independently of the content of the input TM files, data are classified and split into separate PDS raw products as defined in the processing tasks described in previous sections (i.e. by data type, data rate, sensor and divided according to a time-based criteria). The table below specifies the configuration of the inputs for an operational session scenario.

Table 5: telemetry-to-raw inputs

DIT	Identifier	Description	Content
TM	hk	HK TM file	SPID = 30451
TM	sc	SC TM file	SPID = 30401
TM	test_fe	Test FE TM file	SPID = 95106 - 95107
SPICE	spice	SPICE kernels	SPICE kernels and associated metakernel
TBD	TBD	Mission Phases file	Information on mission phases
TBD	TBD	Observation Context file	Observation context information

Input TM files contain packets sorted by on-board generation time, do not contain corrupted or duplicated packets, and are split based on the following criteria:

- During the NEC and Cruise phases: 1 Earth-day
- During the Mercury phase: 10 orbits

The format of the TM files is EDDS PktTmRaw response (XML file containing a stream of packets in ASCII hexadecimal format; each packet has the SCOS-2000 common and TM headers attached to the CCSDS space packet). Details of the SCOS-2000 packet structure can be found in the DDID [RD.05].

The file naming convention for the input TM files is as follows:

- bcber_TM_<identifier>_<YYYYMMDD>.xml (during the NEC and Cruise phases)
- bcber_TM_<identifier>_<MMMMM>_<NNNNN>.xml (during the Mercury phase)

Where:

- <YYYYMMDD>: date of the measurements in the file, in UTC format
- <MMMMM>, <NNNNN>: start and stop orbits of the measurements in the file

The observation context file will be used as an input to write a set of observation context metadata in the PDS product label.

3.2.3 Outputs

The section describes the outputs generated by the telemetry-to-raw processor.

- One PDS 4 raw HK product with the housekeeping parameters, in CDF format
- One PDS4 raw Science Histogram product with the science acquisition report information, in CDF format
- One PDS raw Calibration Histogram product with the test front-end data, in CDF format

Table 3 Telemetry-to-raw outputs

DIT	Identifier	Description	Format	Content
PDSRAW	ber_raw_hk	Raw HK (SPID = 51000)	PDS Observational (Table_Character)	See PDS Template and file naming convention below (1).
PDSRAW	ber_raw_sc_histogram	Raw Science Acquisition Report (SPID = 51001)	PDS Observational (Table_Character)	

The corresponding PDS4 templates are listed below (see also Annex E):

1) ber_raw_hk_template.xml
2) ber_raw_sc_histogram_template.xml

The file naming convention for the PDS4 raw products is as follows:

1) ber_raw_hk_<YYYYMMDD | NNNNN>.xml/.cdf
2) ber_raw_sc_histogram_< YYYYMMDD | NNNNN >.xml/.cdf

3

Where:s

<YYYYMMDD>: date of the measurements in the product (only used during NEC and Cruise)

<NNNN>: orbit number of the first measurement in the product (only used at Mercury)

3.3 BERM Calibration

This section will describe in detail the generation, calibration and analysis of the BERM data, with focus on the calibration, and including:

- A detailed description of the calibration inputs (and how these were/are derived) including:
  - Calibration data from ground test and simulation
  - Statistical data on the noise to correct from background noise identified in the analysis of AR-18.
- Recommended software to calibrate and analyse the data.

The BERM calibration chain is composed of a set of tasks executed in sequence:

- Conversion of particle counts per 30s to particle flux per unit area for all BERM channels
- Conversion of particle counts per 30s to particle spectra, which correspond to particle fluxes per unit energy and per unit area, for all BERM channels
- CDF to PDS4 conversion (*)

(*) This task is a common task used by the telemetry-to-raw and calibration chains.

Each processing task can be executed as a stand-alone routine. A wrapper is used to execute the processing tasks in sequence and to connect their inputs-outputs; the output of one task feeds the input of the next. All tasks produce intermediate products, mostly in CDF format, except the CDF to PDS4 conversion task that generates the PDS4 data products to be archived.

3.3.1 Processing Tasks

3.3.1.1 Conversion of HK data to Physical Units (bermhk)

Converts BERM housekeeping raw data, as recorded by the instrument in raw digitally encoded numbers (DN) without units to housekeeping data converted into physical units.

The input to this task are the raw HK values recorded onboard as numeric readouts of digital encoders in unitless numbers, referred to as DN (Digital Number) values **in intervals of 2 minutes**.

All voltages used by individual components of the circuit board and electronics, as well as the temperatures for the RADFET and the ASIC, are being recorded along with several error flags and counters that allow the instrument health status to be checked.

The task converts the raw housekeeping data to data with appropriate physical units, by applying the transfer functions described in [RD.02]. The software module used to perform this task is **bermhk** (?).

Inputs			
Description	Naming convention	Content	Format
BERM HK raw data	ber_raw_hk.cdf	BERM housekeeping data (raw), Include geometry, UTC timestamps.	CDF file
Outputs			
Description	Naming convention	Content	Format
BERM HK calibrated data	ber_cal_hk.cdf	BERM housekeeping data (cal), Include geometry, UTC timestamps.	CDF file

3.3.1.2 Conversion to particle event counts per unit area (bermparflux)

Converts BERM particle counts per 30s per channel - channels correspond to particle types and energy bins as described Table 1 and Table 2 - to channel particle fluxes per unit area, which correspond to the 'partially processed science' data, to be used for data quality verification.

The inputs to this task are the particle event counts per 30s interval integration interval per channel contained in the BERM RAW SC data products.

This task converts the particle counts per 30s for BERM channels to particle counts per unit area, based on the active areas of the corresponding BERM channels, derived from ground calibrations and instrument simulations. The software module used to perform this task is **bermparflux** (TBD)

Inputs			
Description	Naming convention	Content	Format

Inputs			
BERM SC particle count per channel per 30s (raw)	ber_raw_sc_histogram.cdf	BERM Particle event counts per 30s interval (raw), Include geometry, UTC timestamps and relevant HK	CDF file
Outputs			
Description	Naming convention	Content	Format
BERM SC particle flux per channel unit area (par)	ber_par_sc_histogram.cdf	BERM Particle flux per unit area per channel (par), Include geometry, UTC timestamps and relevant HK.	CDF file

3.3.1.3 Conversion to Particle Fluxes (bermspectra)

Converts BERM channel particle counts per 30s to particle spectra, i.e. particle fluxes per unit energy and per unit area. The input to this task is the particle event counts per 30s interval integration interval of measurements, sorted by particle types and energy bins contained in the BERM RAW SC data products.

The conversion performed in this task is based on the Response Functions of the BERM channels derived from ground calibrations and instrument simulations. The software module used to perform this task is **bermspectra** (TBD).

Inputs			
Description	Naming convention	Content	Format
BERM SC particle count per channel per 30s (raw)	ber_raw_sc_histogram.cdf	BERM Particle event counts per 30s interval per channel (raw), Include geometry, UTC timestamps and relevant HK	CDF file
Outputs			
Description	Naming convention	Content	Format
BERM SC particle spectral data per channel (cal)	ber_cal_sc_histogram.cdf	BERM Particle spectra per channel, Include geometry, UTC timestamps and relevant HK.	CDF file

3.3.1.4 Processing of Frontend, backend and triggering test data

BERM has defined three internal tests that shall be used during in-flight operations to access its health an optimise its performance, by adjusting its tuneable parameters:

- Pedestal
- Test backend
- Test frontend

Pedestal

Pedestal test evaluates the drift of the electronic noise floor and shall be run periodically, once per month, to eliminate its drift.

It shall be highlighted that the noise level, as well as, all electronics performance depends on BERM temperature, and if there are large temperature variations during a short period of time, they will have impact on the instrument performance.

However, if periods at low delta temperature are long, we shall perform a pedestal calibration whenever we enter that temperature, to have the right value of the noise level and then check it every month.

Inputs			
Description	Naming convention	Content	Format
BERM HK raw data	ber_raw_hk_YYYYMMDD.cdf	BERM housekeeping data (raw), Include geometry, UTC timestamps.	CDF file
Outputs			
Description	Naming convention	Content	Format
BERM HK calibrated data	ber_cal_hk_YYYYMMDD.cdf	BERM housekeeping data (cal), Include geometry, UTC timestamps.	CDF file

Test Frontend

Test frontend evaluates the drift of the BERM through all its analogue chain, i.e., Si detector, ASIC and conditional electronics.

While pedestal only looks to the noise level drift and defines its new threshold, test frontend uses a defined and precise step amplitude as emulator of an input charge and then uses all the BERM analogue electronics to acquire and measure it.

With this measure we can evaluate the drift of the overall analogue chain gain, since the input is always the same. This value shall be considered in the transfer functions to the energy levels conversion.

Once again, as similarly to the pedestal, test frontend also suffers from the same temperature effects, and its run shall be performed, ideally, under similar temperature conditions to have the measure of the real drift.

Since test frontend reports the analogue chain readout of the step amplitude applied, it uses the pedestal value set on the run time. So, to evaluate properly the drift and quantify it, we shall also take into consideration if there was a drift or change in the pedestal value between its run and take them into account.

Test frontend is proposed to be run every 3 months or 6 months, pending on previous drifts significance.

Inputs			
Description	Naming convention	Content	Format
BERM Frontend test raw data	ber_raw_hk_calib_test_fe_YYYYMMDD.cdf	BERM calibration data after a frontend test (raw), UTC timestamps.	CDF file
Outputs			
Description	Naming convention	Content	Format
BERM Frontend test calibrated data	ber_cal_hk_calib_test_fe_YYYYMMDD.cdf	BERM calibration data after a frontend test (cal), UTC timestamps.	CDF file

Test Backend

Test backend of BERM only evaluates its digital part performance, i.e., the FPGA and memories integrity, algorithms and processes.

Test backend switches the input of the data through a multiplexer inside the FPGA, to a known and defined "hit signature" instead of the acquired by the Si detectors and all analogue chain. In this way, we can confirm if there are any "stacked" bit on the digital parts and / or evaluate the correctness performance of the processes and algorithms inside the FPGA.

We have simulators of the FPGA code, that allows us to know in advance the expected result of the test backend.

This test is implemented as backup in case something is criticality wrong. It is not scheduled to be performed periodically. It shall be performed only by special request.

Inputs			
Description	Naming convention	Content	Format
BERM Backend test raw data	ber_raw_hk_calib_test_be_YYYYMMDD.cdf	BERM calibration data after a backend test (raw), UTC timestamps.	CDF file
Outputs			
Description	Naming convention	Content	Format

Inputs			
BERM Backend test calibrated data	ber_cal_hk_calib_test_be_YYYYMMDD.cdf	BERM calibration data after a backend test (cal), UTC timestamps.	CDF file

3.3.1.5 CDF to PDS4 Label Generator (bermlbl)

At this stage, a PDS4 compliant XML label for each of the CDF final product that are to be archived is generated. It generates the PDS label by extracting the relevant metadata from the CDF. The CDF file remains unchanged in this conversion. The result is a PDS product composed of a PDS label and a CDF file.

The software module used to perform this task is **bermlbl (TBC)**.

Inputs			
Description	Naming convention	Content	Format
BERM SC particle flux data per channel (cal)	ber_cal_sc_histogram.cdf	Output of berm spectra; see 3.3.1.3	CDF format table
Outputs			
Description	Naming convention	Content	Format
BERM SC particle flux data per channel (cal)	See section 3.3.3	BERM Particle spectra per channel, Include geometry, UTC timestamps and relevant HK.	PDS (Table_Binary); CDF compliant

3.3.2 Input

The telemetry-to-raw chain produces the inputs to the BERM calibration; see telemetry-to-raw outputs in section 3.2.3.

Table 4: BERM calibration inputs

DIT	Identifier	Description	Format	Content
PDSRAW	ber_raw_hk	BERM housekeeping data in raw digitally encoded numbers (DN) (raw) ; Include geometry, UTC timestamps	PDS Observational (Table_Binary); CDF compliant	
PDSRAW	ber_raw_sc_histogram	BERM Particle event counts per 30s	PDS Observational (Table_Binary); CDF compliant	See section 3.2.3

DIT	Identifier	Description	Format	Content
		interval per channel (raw)		

3.3.3 Outputs

The section describes the outputs generated by the telemetry-to-raw processor.

- PDS calibrated BERM SC flux per channel data product, with relevant HK and geometry information

Table 5: BERM calibration outputs

DIT	Identifier	Description	Format	Content
PDSCAL	ber_cal_hk	BERM housekeeping data in physical units(cal); Include geometry, UTC timestamps	PDS Observational (Table_Binary); CDF compliant	See PDS Template and file naming convention below (1).
PDSCAL	ber_cal_sc_histogram	BERM particle spectra per channel (cal); Include geometry, UTC timestamps and relevant HK	PDS Observational (Table_Binary); CDF compliant	See PDS Template and file naming convention below (2).

The corresponding PDS templates are listed below (see also Annex A):

ber_cal_hk_template.xml

ber_cal_sc_template.xml

The file naming convention for the PDS raw products is as follows:

ber_cal_hk_<YYYYMMDD>.xml/.cdf

ber_cal_sc_histogram_<YYYYMMDD>.xml/.cdf

Where:

<YYYYMMDD>: date of the measurements in the product (only used during NEC and Cruise)

<NNNN>: orbit number of the first measurement in the product (only used at Mercury)

4. Science Overview and Quick-Look Analysis

The science overview and quick-look analysis functionalities are temporarily described in a separate document (see [RD.04]). The following sub-sections are placeholders for future versions of this document.

The requirements for the BERM Quick-look analysis to be developed in the Context of the BARD [ref] contract are an input to this section.

4.1 Instrument Data Quality Criteria

TBW

4.2 Science Overview & Quick-look Analysis Products

TBW

5. Operational Scenario

This section describes the operational scenario for the systematic generation of BERM science data and associated science overview and quick-look analysis products.

The SGS data processing, quick-look analysis and archiving activities are aligned with the concept of an “operational session", as described in the SODPL <REF>.

During an operational session, the data processing pipelines are automatically triggered after the data acquisition from the OGS (via the EDDS) is completed and the corresponding SPICE kernels and auxiliary products have been generated by the ADCS.

This means that, prior to the execution of the pipeline, all necessary telemetry data, parameters and auxiliary files are available in the SGS internal repository (composed of a database and a Data Store) and in the archive (BOA+PSA).

When the SIXS pipeline is triggered, the following processing chains are executed in sequence (upon completion of the previous chain):

- BERM telemetry-to-raw processing chain:
  - The Pipeline Feeder is triggered with the configuration specified in section 3.2.2
  - Upon reception of an input data package, the package is unpacked, and if successful, the input files are moved to the pipeline processing area
  - The tm2raw processor is executed
  - The Product Delivery Packager is triggered; configured to read the output folder of the pipeline processing area. This stores a delivery package in the /from_ber area of the SGS repository.
  - Upon reception of the package in the /from_ber area, the Pipeline Delivery Handler is automatically triggered.
- BERM calibration chain:
  - The Pipeline Feeder is triggered with the configuration specified in section **Error! Reference source not found.**
  - Upon reception of an input data package, the package is unpacked, and if successful, the input files are moved to the pipeline processing area
  - The BERM calibration processor is executed
  - The Product Delivery Packager is triggered; configured to read the output folder of the pipeline processing area. This stores a delivery package in the /from_ber area of the SGS repository.
  - Upon reception of the package in the /from_ber area, the Pipeline Delivery Handler is automatically triggered.
- Upon successful execution of the previous chain, all inputs are pushed to the “Instrument Team Centre”:
  - The Pipeline Feeder is triggered to push all generated raw, calibrated and auxiliary products

The Pipeline Delivery Handler is triggered automatically every time a new delivery package is received from the BERM team. Delivery packages are unpacked, validated against the applicable PDS4 schemas, and upon successful validation moved to the SGS Data Store area and delivered to the archive (PSA). These deliveries can contain:

- Derived data products (sporadic deliveries, as available)
- Supplementary products e.g. calibration, geometry, documents... (one delivery prior to Launch; sporadic deliveries whenever new / updated products are available)

6. Integration, Deployment and Execution environment

The integration, deployment and execution environment of the BERM pipeline within the SGS infrastructure is described in a separate document (see [AD.06]).

ANNEX A INVOLVED PARTIES AND KEY PERSONNEL

To be completed in a future version of the document

ANNEX B ESTIMATED VOLUME OF INPUTS AND OUTPUTS

To be completed in a future version of the document.

ANNEX C PIPELINE PROCESSING AREA

(to be confirmed by reviewers)

<PipelineStageArea>/berm/

- input/
- output/

<PipelineProcessingArea>/berm/

- <$pipeline_chain>/
  - input/
  - output/
  - processing/
  - failed/

ANNEX D DATA STORE

The Data Store is part of the file system located in the SGS internal repository (RHS), and it contains the following areas:

<DataStore>/

- tm/
- pds/
- spice/
- aux/

Telemetry Area

Stores TM files with same filename, format and split as used by the pipeline.

The structure of the telemetry folder is as follows:

<DataStore>/tm/

- berm/

PDS Area

Stores PDS products generated by the pipelines.

The structure of the PDS folder is as follows:

<DataStore>/pds/

- berm/
  - data_raw/
    - hk/
    - sc/
  - data_calibrated/
    - hk/
    - sc/
  - calibration/

SPICE Area

Stores SPICE kernels. This is a mirror of the BepiColombo area of the SPICE FTP repository (see below) plus the meta-kernels (mk).

SPICE FTP repository: ftp://ssols01.esac.esa.int/pub/data/SPICE/BEPI/

The structure of the SPICE folder is as follows:

- <DataStore>/spice/
    - kernels/
        - ck/
        - fk/
        - ik/
        - lsk/
        - mk/
        - orbnum/
        - pck/
        - sclk/
        - spk/
    - misc/kernels/

ANNEX E SOFTWARE REPOSITORY

(To be checked and completed)
The BERM data processing software is maintained under version control in a SGS Git repository. (?)

Git repo: gitolite@scigit02.esac.esa.int:bepi.dps.ber.git ?

<repo>

- src/
  - bermhk ?
  - bermparflux
  - bermspectra
- test/
- doc/

ANNEX F PDS4 SCHEMAS AND TEMPLATES

BERM PDS4 templates follow the PDS4 Information Model, and are therefore compliant with the PDS4 XML Schemas and schematron files listed below.

- pds/PDS4_PDS_<version>.xsd|sch
- psa/PDS4_PSA_LDD_<version>.xsd sch
- bepicolombo/PDS4__BC_MPO_BER_1F00_1001<version>.xsd|sch

All PDS4 Schemas and templates are maintained under version control in SGS Git repository.

gitolite@scigit02.esac.esa.int:<repo>

Where:

<repo> is

- psa.pds4.git (R permission to IT; R to SGS) – *PDS / PSA PDS4 schemas*
- bepi.pds4.git (R permission to IT; RW to SGS) – *BepiColombo PDS4 schemas*
- bepi.pds4.ber.git (RW permission to IT) – *BERM PDS4 templates (to be confirmed)*

The following SIXS PDS4 product label templates are used:

- For BERM SC data: raw and calibrated (*label templates/format of derived products to be discussed at a later stage*).
  - ber_cal_sc_template.xml (?)
  - ber_cal_hk_template.xml

- For BERM calibration products (i.e. response functions, background noise…) (TBD)
  - ber_calib_rf_template.xml
  - ber_calib_bkg_template.xml

Additional details on the PDS4 Schemas and templates can be found in the BepiColombo Archiving Guide [AD.02].