UNIVERSITY OF HELSINKI

OBSERVATORY

SMART-1-XSM

To Planetary Science Archive Interface Control Document

S1-CIX-HY-ICD-001

Issue 1.16

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Distribution List

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Change Log

Date	Sections Changed	Reasons for Change
18.11.2003		Up grading
20.01.2004		Up grading
02.04.2004		Up grading
09.07.2004		Up grading
05.10.2004	S/W description	Changes in reduction process
14.10.2004		Minor corrections
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11.01-2007	Extended Phase info, lower energy threshold 2 keV and PDS-label update	Up grading
22.01.2008	New description of the data table structure with PDS labels	Up grading
26.02.2008	Minor corrections	

TBD ITEMS

Section	Description

TABLE OF CONTENTS

1 Introduction

1.1 Purpose and Scope

The purpose of this EAICD (Experimenter to (Science) Archive Interface Control Document) is two fold. First it provides users of the XSM instrument with detailed description of the product and a description of how it was generated, including data sources and destinations. Secondly, it is the official interface between XSM instrument team and the archiving authority.

1.2 Archiving Authorities

ESA's Planetary Science Archive (PSA)

ESA implements an online science archive, the PSA,

- to support and ease data ingestion
- to offer additional services to the scientific user community and science operations teams as e.g.
  - search queries that allow searches across instruments, missions and scientific disciplines
  - several data delivery options as
    - direct download of data products, linked files and data sets
    - ftp download of data products, linked files and data sets

The PSA aims for online ingestion of logical archive volumes and will offer the creation of physical archive volumes on request.

1.3 Contents

This document describes the data flow of the XSM instrument on SMART-1from the S/C until the insertion into the PSA for ESA. It includes information on how data were processed, formatted, labeled and uniquely identified. The document discusses general naming schemes for data volumes, data sets, data and label files. Standards used to generate the product are explained. Software that may be used to access the product is explained further on.

The design of the data set structure and the data product is given. Examples of these are given in the appendix.

1.4 Intended Readership

The staff of the archiving authority (Planetary Science Archive, ESA, RSSD, design team) and any potential user of the XSM data.

1.5 Scientific Objectives

The XSM spectrometer is tailored to measure solar X-ray emission at the energy range 1.0 – 20 keV. Its main goal is to be a calibration instrument for the D-CIXS instrument. D-CIXS is also an X-ray spectrometer, whose main scientific objective is to determine the elemental abundances in the Moon soil by fluerencence analysis. Due to the variations in the solar X-ray output, the direct solar spectra measured by XSM are required to calibrate the fluorescence data obtained by D-CIXS.

During the cruise phase XSM is able to do independent science by monitoring the solar coronal X-ray emission.

1.6 Applicable Documents [AD]

1. Planetary Data System Standards Reference, August 2003, Version 3.6, JPL, D-7669, Part 2
2. SMART-1 Archive Generation, Validation and Transfer Plan
3. D-CIXS Instrument Data Handling Interface Control Document. S1-CIX-ICD-3002, version 12.
4. D-CIXS/XSM User Manual, S1-CIX-UM-3002, version 7
5. Planetary Science Archive Experiment Data release Concept Technical Proposal, RSSD-SOP-TN-015, version 1.16
6. Experiment Interface Document - Part A (EID-A), Issue 4 Doc.: S1-EST-EID-3 001, 17-April-2001

1.7 Relationships to Other Interfaces

XSM is an auxiliary detector of D-CIXS and the read out electronics is located in the D-CIXS e-box.This means that all XSM operation is controlled by D-CIXS instrument. RAL has the responsibility on D-CIXS operation, hence all XSM related ITLs etc. goes via RAL team. All the interface documentation [AD n. 4] is archived by RAL.

Changes in this document shall affect on XSM data production pipeline and archive volume production and delivery system.

1.8 Acronyms and Abbreviations

ARF	Ancillary Response File
cps	counts per second
D-CIXS	Demonstration of a Compact Imaging X-ray Spectrometer
EDR	Experiment Data Record
EEP	Earth Escape Phase
EUV	Extreme Ultra Violet
FITS	Flexible Image Transfer System
FOV	Field Of View
HK	House Keeping
HP	High Purity
IDL	Interactive Data Language
JPL	Jet Propulsion Laboratory
keV	kilo-electron-Volt
LP	Lunar Phase
NASA	National Aeronautics and Space Administration
PIN	Positive Intrinsic Negative
PSA	Planetary Science Archive
QE	Quantum Efficiency
RAL	Rutherford Appleton Laboratory
RMF	Redistribution Matrix File
SCET	Spacecraft Event Time
SOHO	Solar Heliospheric Observatory
S/W	Soft Ware
TBW	To Be Written

UH	University of Helsinki
XSM	X-ray Solar Monitor

1.9 Contact Names and Addresses

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2 Overview of Instrument Design, Data Handling Process and Product Generation

2.1 Scientific Objectives

2.1.1 Calibration of D-CIXS Data

The strength and spectral distribution of the fluorescence spectrum measured by D-CIXS is strongly dependent on the solar X-ray irradiance at the surface of the Moon, and the primary task for the XSM is to provide solar X-ray spectra for the calibration of the fluorescence lines. For the derivation of the expected fluorescence, the incident solar spectrum shape and intensity at energies higher than the absorption edges of relevant elements are necessary. XSM will observe the solar input at 2-20 keV, which includes all important absorption edges, and a broad enough energy range above them.

2.1.2 Studies of Solar Corona

Being a part of the D-CIXS measuring system, the XSM will provide significant independent information about the solar corona.

The XSM spectral range is very sensitive to solar flare activity. During a flare the measured total spectrum will be largely dominated by the flux from the event, especially at higher energies above 2-3 keV. For example, XSM energy range (1-20 keV) covers 97% of the total flux emitted by an X1 flare. Following the total evolution of a large number of various flare events during the long observing period will yield a very useful database for general studies of flare physics and flare evolution. On the other hand, XSM is sensitive enough to see the 2-10 keV tail of the quiescent Sun spectrum at solar minimum with 10 ksec integration times.

2.1.3 Monitoring of Solar Corona in Short Time Scales

The mean coronal temperature and non-thermal tails can be followed with the time resolution of 16 seconds applied in the XSM. Earlier studies of solar corona suggest 1/f - type power spectral density, which may be characteristic to magnetic systems (like Tokamaks). This flickering behavior is also characteristic to the black hole candidate Cyg X-1. This indicates that magnetic flares on the disc may cause the variability and serve also as sites for the Comptonization process and soft-hard time lags. In this way, the data provided by XSM may have a much broader significance.

XSM can trace the evolution of the X-ray spectrum of solar flares during the declining phase, and for the strongest flares also along the rise of the flare. From the spectrum evolution it is possible to track the temperature evolution, and also much of the whole physical process during the flare.

2.1.4 Combining with Simultaneous Observations of Solar Corona by Other Satellites

Adding independent knowledge about the spatial extent and morphology of the flares from e.g. observations obtained by SOHO will provide a possibility for significant improvements of flare modeling studies. It is also important to note that XSM will extend the spectral range of SOHO data up to 20 keV, being thus a valuable complement for these data.

2.1.5 Long Term Monitoring of Solar Corona and Study of Solar-stellar Connection

Long term monitoring of the X-ray spectral variability of the Sun has also significance, especially in comparison with similar studies of other stars. The coronal emission is known to have a strong connection with the magnetic activity of stars, and following the behavior of the solar coronal emission together with other types of solar monitoring programs (magnetograms, radio emission monitoring, Extreme Ultra Violet –

EUV – observations) will help in building a more complete picture about the connection between different aspects of the magnetic activity.

2.1.6 Testing Stellar X-ray emission Models

Since XSM will observe the "Sun as a star", the interpretation of the resulting data will be similar to that obtained from distant point objects by large X-ray observatories. In addition, the spectral range of XSM overlaps partly with many of the modern astronomical X-ray satellites (e.g., BeppoSAX, ASCA, XMM-Newton, Chandra), and also the spectral resolution is closely similar. Therefore it will be possible to make direct comparisons of the X-ray emission models of the Sun, which are based on the XSM observations, with the observations of other stars and astronomical objects.

2.2 Instrument Overview

2.2.1 Instrument Design

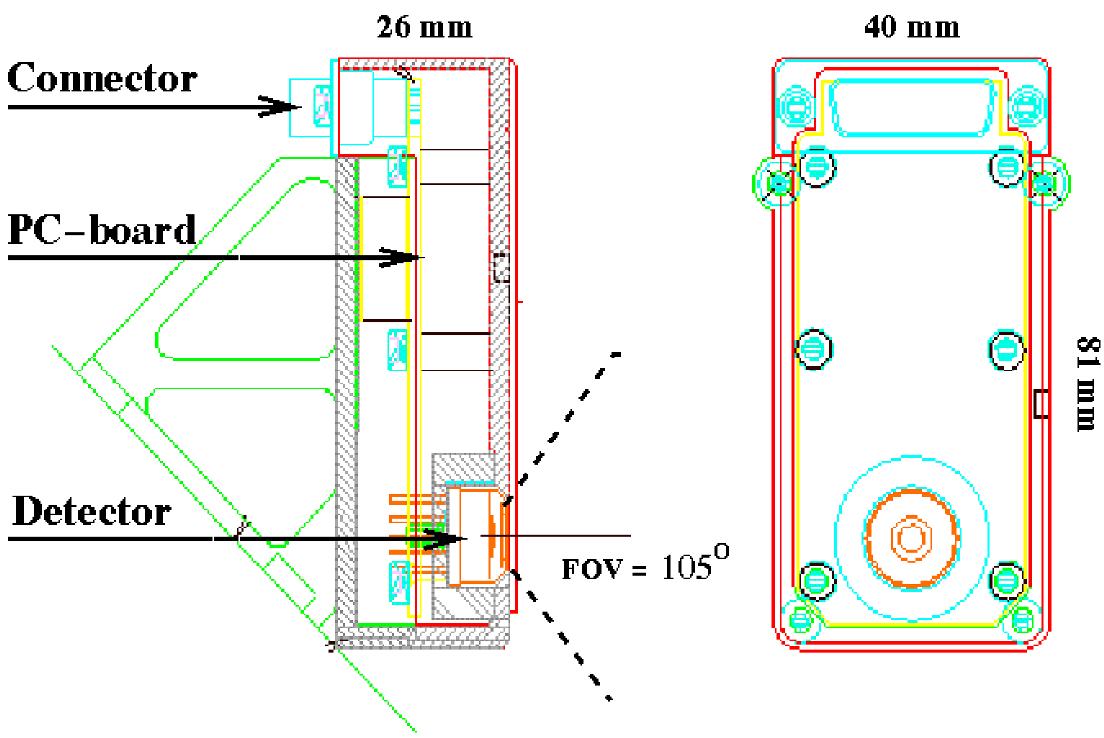

Figure 1. Illustration of Structural Layout of the XSM detector box.

The flux of the Sun in the energy range 0.1-20 keV, is very high (several hundred million photons/cm^2/s) and variable. The spectrum has a very steeply declining slope with increasing energy, which means that most of the photons are concentrated in the lower energies below 1 keV.

The variability, on the other hand, is concentrated in the higher energies because it is mainly caused by the changes in the high temperature components of the solar spectrum (originated in active regions and flares). This means that tuning the low energy limit for the XSM is very important to achieve reasonable count rates.

Nevertheless, even by removing the mostly invariable low energy part of the flux below 1 keV, the detector will receive high photon fluxes requiring a very small active detector area.

The lower energy limit of the band pass is determined by the filter layers in front of the detector PIN. The optimal energy band-pass is acquired with a 27 micron Beryllium window. The standard design includes an Aluminium contact of 590 nm thickness, and the estimated Silicon dead layer is 200 nm. The co-added effects of these lead to a band pass with 10% efficiency at about 1 keV.

The upper limit of the energy range for the High Purity Silicon (HPSi) PIN-detector depends on the thickness of the detector, which dominates the upper energy limit via the QE. The detector thickness of 0.5 mm suits well in this purpose. The range extends to about 20 keV with well sufficient QE for our purpose.

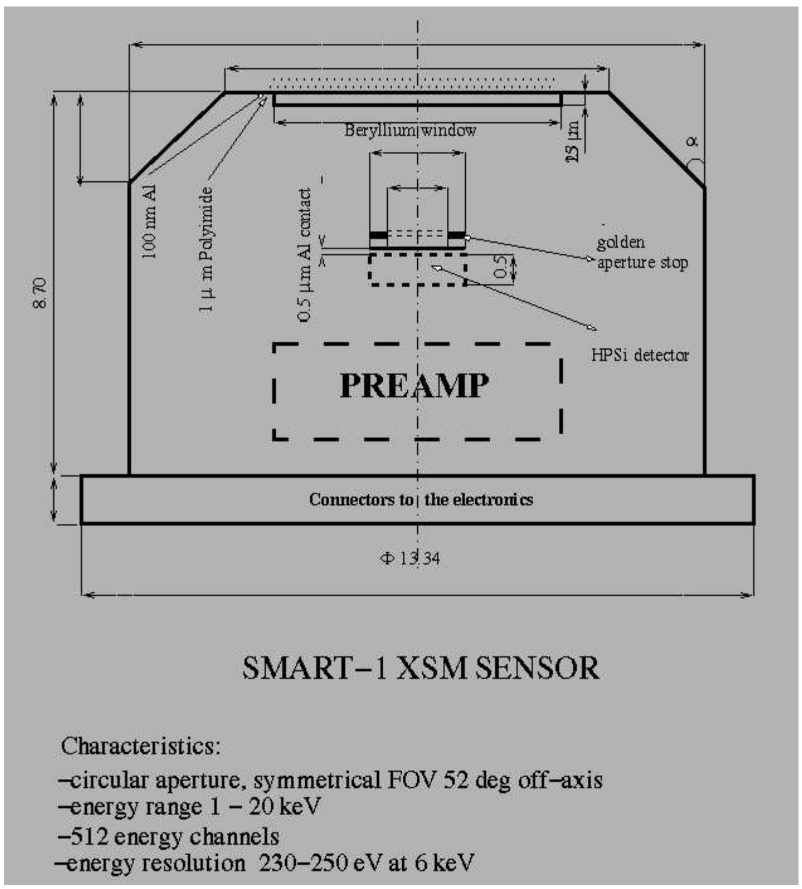

Figure 2: Simplified assembly of the XSM sensor

2.2.2 Electronics

The electronics of the XSM consists of pre-amplifier stages and shaping amplifier, which are in the sensor unit box, and an electronics board in the main D-CIXS instrument box, which includes further stages of the signal processing electronics. The electrical and data interfaces connect the XSM with the D-CIXS. There will be no direct electrical or data interfaces from the XSM to the spacecraft.

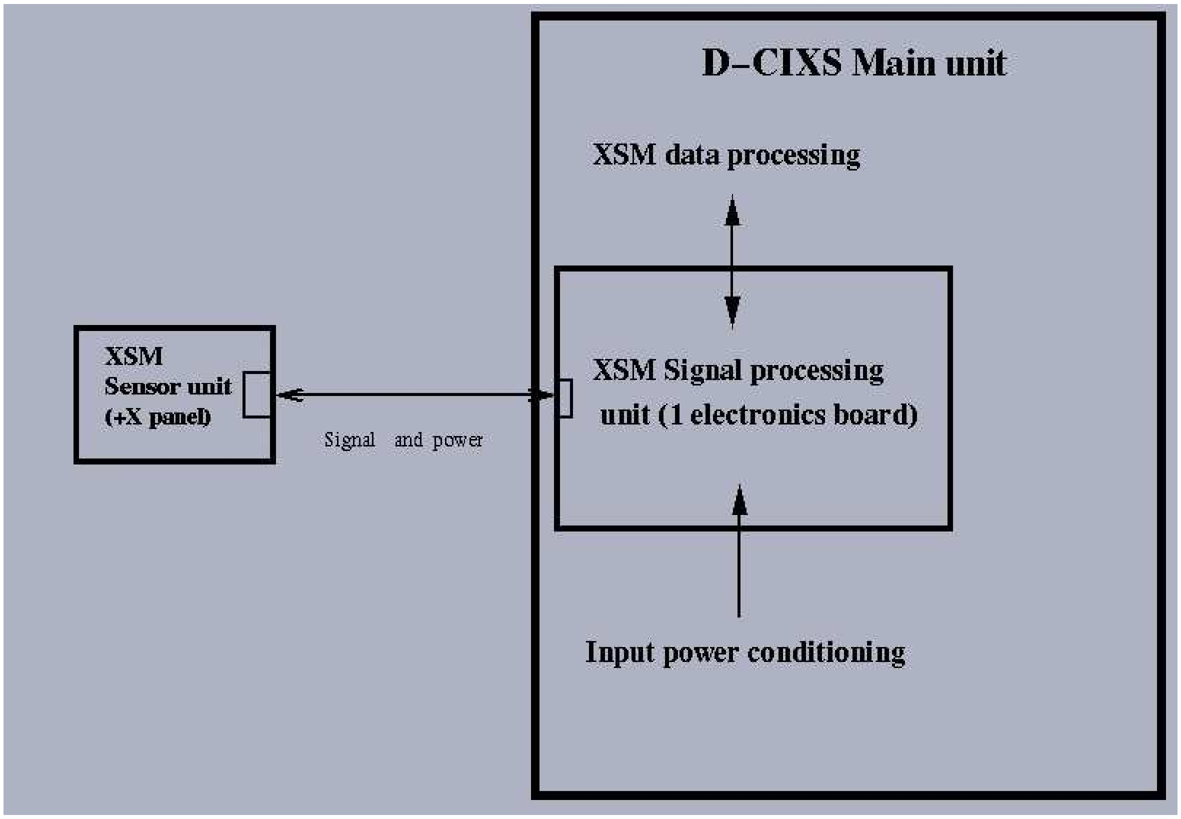

Figure 3: Electrical Interface between XSM and D-CIXS instruments

2.2.3 Performance and Field Of View

The detector features will, according to simulations, yield about 1 count per second (cps) in the solar activity minimum (i.e., sunspot cycle minimum), about 200 cps in the solar maximum (i.e., average sunspot cycle maximum), and about 7000 cps during an X1 flare (a strong flare). Class X10 flares have been detected, and photon count rates above 10000 cps are therefore not ruled out, albeit very rare. From these we can set the requirement for the dynamic range of the detector. The optimisation of that range should, however, be done simultaneously with that of the energy resolution, which is equally important for our science goals.

The XSM efficiency when the Sun is in the middle of the FOV is shown in the following plot. The efficiency is defined by the filters in front of the detector PIN and the S/C attitude i.e. the position of the Sun in the XSM FOV. The further the Sun is with respect to the optical axis, the worse is the efficiency.

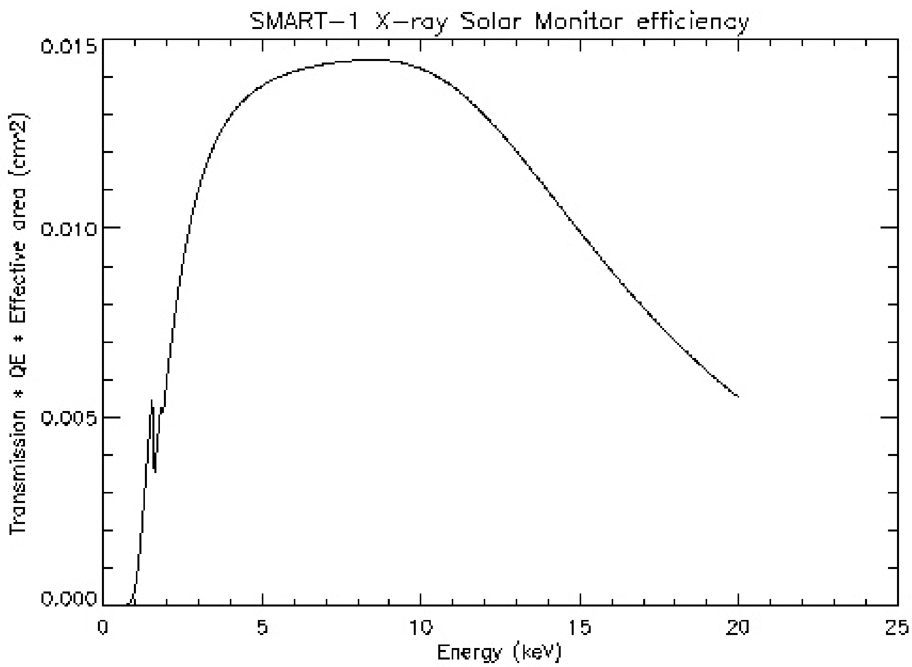

Figure 4. Sensitivity of XSM when the Sun is in the middle of the FOV.

Technically, there is a clear trade off between these goals, since high dynamic range, and capability to handle very high count rates will inevitably lead to a loss of energy resolution, and to an intolerable event pile-up. Therefore, we set the requirement for the energy resolution to be about 230 eV at 6 keV. This is quite sufficient for a good spectral analysis, with the capability of resolving the major spectral lines expected in the lower energy part of the spectrum (thin thermal plasma spectrum). The resolution will also be comparable to those of the instruments on the other X-ray missions (XMM-Newton, Chandra, SRG). The suitable number of equally spaced energy channels in the range 0-20 keV is 512, leading to at least 3-4 channels per resolution element.

The dynamic range is optimized by a hardware technique to compensate the detector dead time losses. This will also lead to significantly decreased amount of signal pile-up. The estimated fraction of piled up events will be about 1% at the signal level of 20000 cps.

The X-ray flux from the Sun will overwhelmingly dominate the signal in the energy range of the instrument over the sky background or any other possible source simultaneously in the FOV. In fact, the open aperture of the detector should be maximized in order to observe the Sun at different attitudes of the S/C. Thus, the instrument requires no collimation or a focusing system (telescope), and the full aperture of the detector will be used.

The XSM detector is a PIN-diode made of High Purity Silicon. Its initial energy resolution will be about 250 eV at 5.9 keV at the beginning of the SMART-1 mission. Bombardment of solar protons and cosmic particles will deteriorate the operation of the PIN-diode by degrading the energy resolution. These radiation damages will cause higher leakage current across the PIN-diode, which will be the dominant noise source in the system. The noise caused by a leakage current can be decreased by frequent annealing periods of 5 hours when required. The leakage current level will be controlled autonomously by an onboard logic. This feature enables also an autonomous annealing procedure to start the annealing during an observation. This logic includes 3 parameters, which can be changed i.e. down load via up link.

2.3 Data Handling Process

The Observatory of University of Helsinki is responsible for data processing, preparation and archiving within the PSA the XSM data products. The relevant contact information is provided in **Error! Reference source not found.**.

The following table provides the XSM data processing level:

Processing Level	Description
1A	XSM data that have been cleaned and merged, time ordered, and in packet format. Cleaned and merged means that duplicate data have been deleted, missing packets are padded out, and the data are organized by days. The data format is the same as the XSM telemetry packets. These raw data have APID 1006 and 1007 codes in the DDS. [**This data will not be archived in the PSA**]
1B	XSM PDS formatted data, in scientifically useful from, as data tables including science and calibration spectra, housekeeping values and attitude related information. These data are still uncalibrated.
3	High level data products generated using XSPEC fitting software tools. [**This data will not be archived in the PSA**]

XSM obtains the data required to generate the level 1b data products from:

- Raw Telemetry data (Level 1a): RAL or DDS via FTP – RAL has developed an automated application that fetches the telemetry data for D-CIXS and XSM from the DDS and pushes the packets to UH FTP server.
- Attitude information: ESTEC via FTP – STOC produces regularly Geometry Files containing the required attitude information. SPICE kernels are also obtained from ESTEC FTP server.

The XSM level 1b data products are generated using the following procedure:

1. Convert Raw Telemetry data (level 1a) into FITS formatted data files. The application used to perform this conversion is **smart1convert**. This software requires as input the binary raw telemetry packages (APID 1006 and 1007). The application removes the D-CIXS data contained in the packages and sorts out XSM data times into housekeeping and spectral data (both calibration and scientific data are considered as spectral data). smart1convert associates type 0 to housekeeping data and type 4 for spectral data for future use in the data reduction pipeline.
2. Generate FITS formatted data table containing spectral data, HK values, relevant attitude information and additional parameters required in further analysis. This is the final level 1b data table. The application used to generate these products is **DT.PRO**. This application takes as inputs the type 0 and type 4 data files generated by smart1convert and also a tailored geometric file containing attitude information.
3. Finally, generate the PDS label for each of the data tables generated by DT.PRO. This is the final level 1b data product that is archived in PSA. The application used to generate PDS labels from the FITS table header keywords is F2P – FITS to PDS conversion tool. The data table remains unchanged in this conversion, and the result is a PDS formatted label of the data file.

Level 3 data precuts can be generated using XSPEC software. This software is freely available from:

http://heasarc.gsfc.nasa.gov/docs/xanadu/xspec/.

Although level 3 data products will not be archived in PSA, the software tools required to generate the XSPEC compliant inputs files are archived within the data sets. The process to generate these input files is the following:

1. Use **RA.PRO** to generate the redistribution matrix file (RMF) and the ancillary redistribution files (ARF). ARF files contain information on the sensitivity of the detector. The RMF contains information about the energy resolution and energy scale of the detector.

ATTENTION! THE LOWEST RELIABLE ENERGY CHANNEL IN ALL XSM DATA FILES EQUALS TO ABOUT 2.0 keV. HENCE, WHEN DOING SPECTRAL ANALYSIS IGNORE ALL CHANNELS LESS THAN THE CORRESPONDING LOWER TRESSHOLD ENERGY (2 keV)! EFFECTIVE AREAS MUST BE NULLED ALSO FROM 0 keV UP TO THE LOWER TRESSHOLD LIMIT! IF YOU DO SPECTRAL ANALYSIS WITH XSPEC AND YOU WILL USE THE ATTACHED RA.PRO, THEN THIS REDUCTION WILL BE PERFORMED AUTOMATICALLY.

2. Generate XSPEC compliant data files using **DG.PRO**.

The figure 5 describes the XSM data flow. The boxes filled with yellow color will be archived within the level 1b data set.

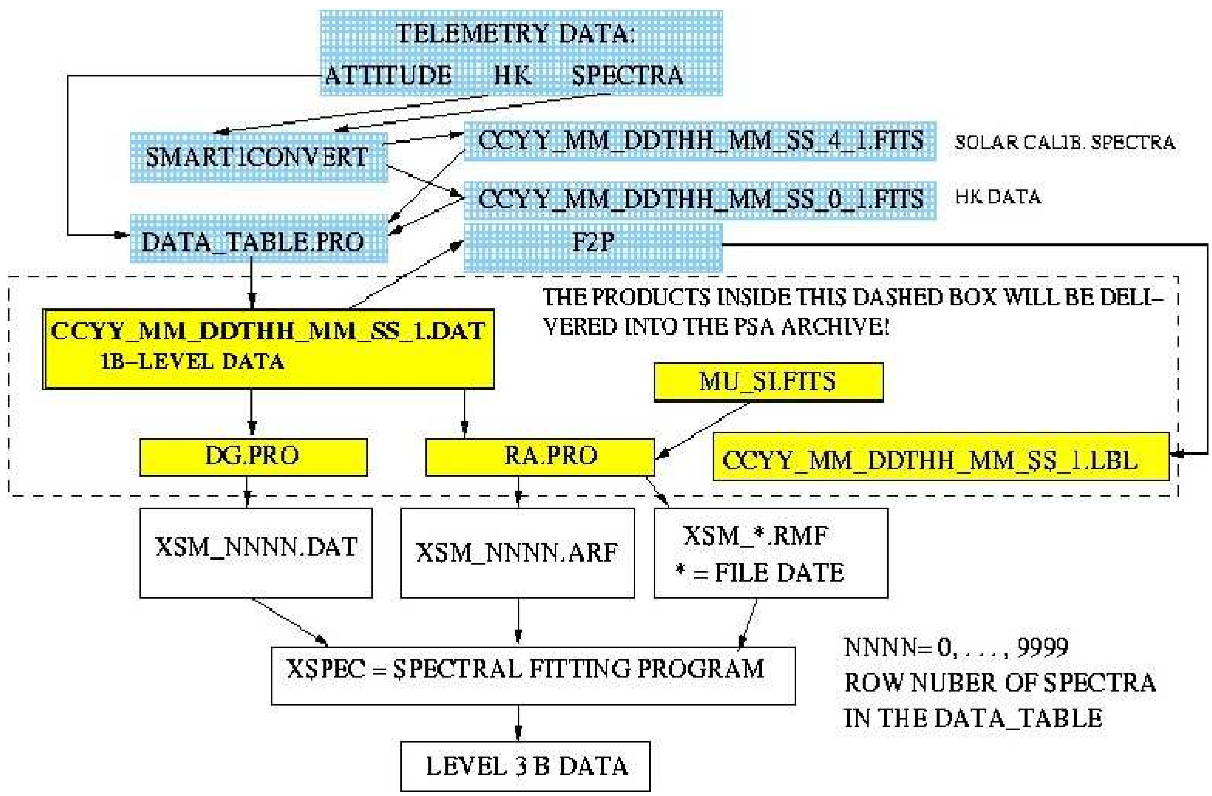

Figure 5: XSM data reduction pipeline.

2.4 Overview of Data Products

2.4.1 Pre-Flight Data Products

Neither ground calibration information nor documents will be made available on the archive. The XSM team will provide and update relevant information so that the processing pipeline is up to date to reflect current situation of the XSM instrument.

2.4.2 Instrument Calibrations

Two different products are required to perform the spectral calibration:

- Calibration data, which is provided for each data product within the level 1b data table. Nominally, the 20 first and 20 last spectra in the data table correspond to calibration data.
- Auxiliary Calibration table, called **MU_SI.FITS**, which contains Silicon mass attenuation factors as a function of photon energy for the nominal range of XSM. This file is archived together with the **RA.PRO** software, since this file is a crucial input for the application.

The calibration required previous to the generation of level 3 data products is perform by **RA.PRO.**

2.4.3 In-Flight Data Products

Raw data (at ESOC and UH)

ESOC will archive the telemetry data downloaded from SMART-1, sorted by APID. University of Helsinki will archive all XSM telemetry data in DDS format.

Level 1b data (at UH and PSA)

University of Helsinki and PSA will archive the XSM level 1b data products in PDS format. These data products will be separated into two different data sets, one covering the Earth Escape Phase (EEP) and the other covering the Lunar Phase (LP). These data products contain calibration data for each observation, the scientific data obtained in the observation, relevant attitude information, housekeeping data and some additional parameter required in the data analysis. The reason to keep all information in one table is to facilitate the usage of the data, since all the information contained in each data product is required to analyze the data product itself.

Reduced data (at UH)

Level 3 data products will be generated at UH for private usage. These data could be used in cross-instrument calibration and scientific analysis.

2.4.4 Software

2.4.4.1 Pipeline analysis software

The following software applications are used in the level 1b data generation pipeline:

1. **smart1convert**: This program converts the raw telemetry data into FITS format files. There are 2 different data types for XSM that are needed for the PDS level 1b data set generation. Those are type 0, associated to HK, and type 4 for spectral data (be aware that both calibration and scientific data are covered by this type). The application will generate two different types of FITS files, one for housekeeping data and another for spectral data. Both files include a FITS formatted table, a primary header and an extension header.

   This application will not be archived in any of the XSM data sets. It is intended to be used locally at UH to generate the data products.

   The file naming scheme used for the output files is as follows:

   CCYY_MM_DDThh_mm_ss_t_1.FITS

   where:

Token	Description
CC	Century, two digits
YY	Year, two digits
MM	Month, two digits
DD	Day, two digits
T	**Separator**
hh	Hours, two digits – 24 hour format

mm	Minutes, two digits
ss	Seconds, two digits
t	Data type: 0 – Housekeeping data; 4 – Spectral data

2. **DT.PRO**: Data Table Generator. This program generates a table containing spectral, HK, attitude data and some additional parameters related to one particular observation. The table is a FITS array made of 27 columns and variable number of rows and together with its associated label forms the level 1b data product. The total number of rows depends on the observation time. Each row represents one calibration or solar spectrum. Integration time of 16 seconds is used to acquire each single spectrum. In addition to the spectrum, each row also contains the related HK, attitude information and descriptive data quality and type parameters such as a flag indicating how the data should be used. A detailed description of the table contents and format is available in the section 4.3 Data Product Design.

   This application will not be archived in any of the XSM data sets. It is intended to be used locally at UH to generate the data products.

   The input file name shall follow the smart1convert output file naming scheme.

   The output file name follows exactly the same file naming scheme with the exception of the token 't', which is removed, i.e. CCYY_MM_DDThh_mm_ss_1.DAT

3. **f2p**: FITS to PDS label generator. This program generates the PDS detached data product label files to be archived in PSA. The fits table remains intact after this conversion. The software creates a PDS compliant label file from the information contained in the FITS header keywords.

   This application will not be archived in any of the XSM data sets. It is intended to be used locally at UH to generate the data products.

   The input file name shall follow the DT.PRO output file naming scheme.

   The output file name is exactly the same as the input file name with the exception of the extension which is changed to .LBL, i.e. CCYY_MM_DDThh_mm_ss_1.LBL

2.4.4.2 Calibration Software:

Although there is no specific calibration software, **RA.PRO** performs calibration of the spectral data using as inputs the MU_SI.FITS file and the calibration data contained in the level 1b data products. For further description of this application, please check the next section: Scientific Analysis Software.

2.4.4.3 Scientific Analysis Software:

The software applications used to visualize and analyze the data are non-commercial FTOOLS S/W package. None of these tools will be archived in any of the XSM data sets and can be freely download from:

http://heasarc.gsfc.nasa.gov/docs/software/ftools/ftools_menu.html

Before using refine data analysis tools, i.e. XSPEC spectra fitting program, the user shall run the following applications to obtain the required inputs:

1. **DG.PRO**: Data Generator. This program generates the final data files to be used in XSPEC fitting program.

   This application will be archived in all the XSM data sets. It is intended to be used by the XSM data user before refining the data with XSPEC.

   The input file names shall follow the level 1b data product file naming scheme.

   The application will generate a set of files, named XSM_nnnn.DAT, where nnnn denotes the row number, i.e. the corresponding spectrum, in the input file (nnnn = 0000, 0001, … ,9999)

When generating the XSPEC compliant data files with the DG.PRO application, both of the program and the input data must be located under the same subdirectory. The output of this process will be kept in the same directory.

2. **RA.PRO**: RMF and ARF Files Generator. This program generates the final redistribution and ancillary response files to be used in XPESC fitting program.

   This application will be archived in all the XSM data sets. It is intended to be used by the XSM data user before refining the data with XSPEC.

   When running this application, the in-flight calibration is done automatically i.e. the energy versus energy channel relation is defined and the energy resolution as a function of photon energy is also determined.

   The inputs to this application are the calibration spectra contained in the data products plus the MU_SI.FITS file. The application selects the calibration spectra by checking the additional parameters included in the data product not taking into account the background noise and solar spectra.

   The information of channel vs. photon energy and energy resolution i.e. FWHM (Full Width at Half Maximum) are included in the corresponding RMF.

   Only one RMF-file is generated for each observation as default. This IDL program generates also an extra log file for validity check, i.e. it records the channel vs. energy scale shift during the observation. The user can insert a specific spectrum number on program line 529. As a default the spectrum number is the mean value of the total number of the spectra in the data file. The log file gives a signal if the shift is greater than 20 eV between the start and the end of the observation. One can minimize the scale shift by generating several RMF's for spectra at specific intervals if required. Each science spectra of 16 sec requires its own ARF file, hence the number of ARF files generated is equal to the number of spectra, i.e. rows, in the data table. Each ARF is a function of spacecraft attitude.

   The output file naming schemes are as follows:

   > RMF file: dd_mm_yy.RMF, where dd is days, mm months and yy year (Recommended file naming scheme – THE NAME OF THIS REDISTRIBUTION MATRIX FILE CAN BE TAYLORED BY THE USER!)
   >
   > ARF files: XSM_nnnn.ARF, where nnnn denotes the row number, i.e. the corresponding spectrum, in the input file (nnnn = 0000, 0001, … ,9999)

   When generating the ARFs and RMF with the RA.PRO application, both of the program and the input data must be located under the same subdirectory. The output of this process will be kept in the same directory.

3. **XSPEC**: Refine Analysis Tools. This is a noncommercial S/W tool dedicated for analysis of high energy astrophysical data. Details can be found e.g. at the web address:

   > http://heasarc.gsfc.nasa.gov/docs/xanadu/xspec/

   The input files required for this application, i.e. XSPEC compliant data files, ARFs and RMF shall be stored in the same directory.

   The output of this application is refined level 3 data of solar X-ray spectra with physical units**.**

   XSM team will not deliver this Level 3 data to the archive. The level 3 data are a final scientific result. Those researchers outside XSM team willing to do refined analysis of the XSM data shall manage to do this by themselves using the delivered S/W and data described in this document.

All these above described deliverable programs and the ancillary data table – MU_SI.FITS – are archived under the software directory in the delivered data sets. All the programs can be operated under **LINUX/UNIX** stations. No source codes will be delivered.

2.4.5 Documentation

All the XSM related documents are located under the DOCUMENT subdirectory. This directory contains all the XSM documentation required to understand and analyze the archived data. The main document provided in the DOCUMENT directory is this EAICD, which contains all the relevant information on the content of the level 1b science and calibration data. This document will be archived in PDF, ASCII and DOC formats. Images and figures will be archived in this directory as JPEG files. Additional documents might be provided in any of the already mentioned formats.
Further description of the contents of the DOCUMENT directory can be found in xxxx.

2.4.6 Derived and other Data Products

XSM team will not deliver any derived data (Level 3) data to the archive. The level 3 data are a final scientific result. Those researchers outside XSM team willing to do refined analysis of the XSM data shall manage to do this by themselves using the delivered S/W and data described in this document.

Any kind of separate in-flight calibration files will not be delivered. In nominal operation, the calibration spectra are taken at the beginning and in the end of each observation. These nominal 40 spectra consist of the 20 first and 20 last spectra in the data table, which will be used to generate calibrated data by running the RA.PRO.

2.4.7 Ancillary Data Usage

The efficiency of the XSM detector is dependent on the Sun's position in the FOV, hence XSM needs the information of the satellite attitude at least at every 16 seconds for deriving Sun's position in the wide circular FOV with radius of 52 deg. The accuracy of the attitude data should be less or equal to 1 degree. Two angles, OFF_AXIS and ROLL are derived from this attitude data, either from the geometric file generated by the STOC at ESTEC or by using SPICE. These angles are needed to calculate the efficiency of the instrument during each observation. Since this information is required to analyze the data, it will be kept in the data products. These two angles are calculated by running the DT.PRO, which generates the deliverable FITS formatted data table. The time resolution in the geometric files is 5 minute, therefore when using this input the attitude data is interpolated to achieve the required time resolution of 16 sec – note that no interpolation is required if using SPICE to retrieve attitude information.

No separate attitude files will be delivered within the data set and for that reason there is no GEOMETRY directory in the data sets. All the attitude related information is included in the data products as additional columns of the data table CCYY_MM_DDTHH_MM_SS_1.DAT.

PSA will archive separated data sets containing all the required ancillary information for the SMART-1 mission in both SPICE and ESOC formats. Should you require additional auxiliary data for SMART-1 or XSM, please refer to the PSA auxiliary data sets.

3 Archive Format and Content

3.1 Format and Conventions

3.1.1 Deliveries and Archive Volume Format

XSM data is delivered according to the "release" concept [AD n. 5] procedure, i.e. there will be three data sets, one for the Earth Escape Phase, second for the Lunar Phase and third one for the Extended Phase.

3.1.2 Data Set ID Information

The Data Set ID is formed according to the following scheme:

<instrument host>-<target>-<instrument>-<level>-<type>-<description>-<version>

The names of the data sets are:

Earth Escape Phase: S1-X-XSM-2-EDR-EEP-V1.0

Lunar Phase: S1-X-XSM-2-EDR-LP-V1.0

Extended Phase: S1-X-XSM-2-EDR-EP-V1.0

The first data set includes all data obtained during the cruise phase, also called Earth Escape Phase (EEP), i.e. the period from launch to Moon capture. The second data set will include the data obtained during the lunar phase (LP). The last data set includes the data obtained during the rest of the mission called as extended phase (EP).

3.1.3 Data Directory Naming Convention

The data products will be archived under the DATA directory. There will be no subdirectories under the data directory.

3.1.4 File Naming Convention

The naming of the data files, stored under the DATA directory, is based on the date and time of the observation. The file naming scheme is as follows:

CCYY_MM_DDThh_mm_ss_n.DAT

Token	**Description**
CC	Century, two digits
YY	Year, two digits
MM	Month, two digits
DD	Day, two digits
T	**Separator**
Hh	Hours, two digits – 24 hour format
Mm	Minutes, two digits
Ss	Seconds, two digits
N	Data level Identifier: 1 – Level 1B Data –

Each of the data products contains both calibration and scientific data plus additional information required to process and analyze the data. Associated to the data files, there is a detached PDS compliant label file, with the same filename and .LBL extension.

3.2 Standards Used in Data Product Generation

3.2.1 PDS Standards

PDS standard for the EEP and LP datasets is version is v3.6 as described in document [AD. 1]

3.2.2 Time Standards

Three time standards are used in the XSM data products:

UTC: Coordinated Universal Time. The format used for UTC is the **ISOC** format:

YYYY-MM-DDThh:mm:ss.ddd

JD: Julian Date. JD represents continuous counts of days and fractions of a day starting from January 1st, 4173 BC (-4173 in the Astronomical Calendar) at Greenwich Mean Noon (12 hours UT). JD is determined from UTC.

Onboard Time (also called SCET): seconds and fractions of a second since last reset or discontinuity in the Spacecraft Clock Time Correlation. The format followed for this time standard is the following:

p/x.y

where p is the partition number, x is the number of seconds elapsed from the last reset of the onboard clock and y is the number of fractions of a seconds. The SMART-1 clock has a granularity of 1/ 65536th a second (corresponding to an approximate precision of 15 microseconds).

3.2.3 Reference Systems

Inertial Reference Frame: The Earth Mean Equator and Equinox of Julian Date 2451545.0 (corresponding to January, 1st 2000 – Frame also referred as the J2000 system) is the standard reference frame.

Spacecraft Reference Frame: This frame, used to define the position of the Sun with respect to the Spacecraft is defined in document [AD. 6] as:

- +Z axis is perpendicular to the launcher interface plane, directed positively through the S/C body;
- +X axis is perpendicular to the Z-axis and the solar array drive axis, directed positively through the side of the S/C containing the Medium Gain Antenna;
- +Y axis completes the right-handed system.
- The origin of this frame is the launch vehicle interface point.

Instrument Reference Frame: This frame, used to define the position of the Sun with respect to the XSM FOV is defined in document [AD. 4] as follows:

- +Z axis points in the Optical Axis direction; and it is nominally rotated by -45 degrees from the s/c -Z axis about the s/c +Y axis;
- +Y axis is nominally co-aligned with the s/c +Y axis;
- +X axis completes the right hand frame;
- The origin of the frame is located at the detector geometrical centre.

3.2.4 Other Applicable Standards

FITS: Flexible Image Transport System standard. It is developed mainly for astrophysical data analysis purposes within NASA. See more details e.g. http://fits.gsfc.nasa.gov/. Fits files can be manipulated with FTOOLS S/W. See section **Error! Reference source not found.**.

3.3 Data Validation

3.3.1 PDS Label and Data Set Validation

- PDS Label Verifier – PVV – program can be used to verify the syntax of a PDS label, including labels attached to their data file, insuring the *language* of the label is correct.
- PDS Table Browser – program can be used to interactively examine binary SPECTRUM data objects through the PDS label that describes the data format.
- READPDS SBN software – the program has been used to read the PDS formatted label to plot the spectral data and to read the additional information contained in the table files.

3.3.2 Scientific Validity of XSM Data Validation

- XSM team has done cross-calibration between XSM data and data obtained from RHESSI and GOES missions. The data from these two spacecraft are X-ray spectra and flux level measurements respectively. With that cross-calibration a first validity check of the solar spectral data is performed.

3.4 Content

3.4.1 Volume Set

XSM data will be split into three data sets. Since XSM data are delivered electronically to PSA, there is no need to bundle several data sets into one volume set, and therefore, each data set will be contained in a volume. The three data sets to be provided to PSA are those for the Earth Escape Phase, the Lunar Phase and Extended Phase.

3.4.2 Data Set

As mentioned in the previous section, each volume contains a single data set. Therefore three data sets will be delivered to PSA, by using the release and revision concept [AD. 5]. The first data set contains data for the Earth Escape Phase, from launch until Moon capture. The data set ID will be named S1-X-XSM-2-EDR-EEP-V1.0.

In the same way, the data for the lunar phase will be stored in the data set ID will be named S1-X-XSM-2-EDR-LP-V1.0 Respectively the data set for extended phase will be named S1-X-XSM-2-EDR-EP-V1.0.

The data set names will be the same for both data sets, with the only difference of the description. The scheme followed to create this filename is: Instrument Host / Target Name / Instrument / Data level / Data Set type / Description / Version

The data set names are:

EEP: "SMART1 SOLAR XSM 2 EDR EARTH ESCAPE PHASE DATA"

LP: "SMART1 SOLAR XSM 2 EDR LUNAR PHASE DATA"

EP: "SMART1 SOLAR XSM 2 EDR EXTENDED MISSION PHASE DATA"

3.4.3 Directories

3.4.3.1 Root Directory

Files in the ROOT directory include an overview of the archive, a description of the volume for the PDS catalogue, and a list of comments about the archive. The following files are included in the ROOT directory:

File Name	File Contents
AAREADME.TXT	Contains an overview of the contents and organization of the associated volume,

	general instructions for its use, and contact information.
VOLDESC.CAT	Contains the VOLUME object, which gives a high level description of the contents of the volume.

3.4.3.2 Calibration Directory

There will not be CALIB directory in any of the data sets since the calibration data – calibration spectra and Silicon Mass attenuation coefficients data – are located in the data products and in the software directory respectively.

3.4.3.3 Catalog Directory

The files in the CATALOG directory provide top level understanding of the mission, spacecraft, instrument and data set. The files in this directory are created by the XSM team in cooperation with the PSA team. The following files are located in the CATALOG directory:

File Name	File Contents
CATINFO.TXT	A description of the contents of this directory
DATASET.CAT	Data set information in PDS format. This file describes the data and peculiarities of the data set.
INSTHOST.CAT	Instrument host (spacecraft) information in PDS format. This file is generated by the PSA team to guarantee consistency between the different SMART-1 data sets.
INST.CAT	XSM Instrument description and additional information about the experiment.
MISSION.CAT	Mission information in PDS format. This file is generated by the PSA team to guarantee consistency between the different SMART-1 data sets.
SOFTWARE.CAT	Software information in PDS format. This catalogue file describes the software delivered with the data set in the SOFTWARE directory.
RELEASE.CAT	Description, through DATA_SET_RELEASE objects, of the data products delivered to the PSA with each Release or Revision of the data set. This file is not PDS compliant.

3.4.3.4 Index Directory

Files in the INDEX Directory are provided to help the user to locate products on the archive volume. These files might be used also in a database to help to the ingestion or retrieval of the data in the system. The following files are contained in the INDEX directory:

File Name	File Contents
INDXINFO.TXT	A description of the contents of this directory
INDEX.TAB	A table listing all data products on this volume. This file is generated using the PSA PVV software application.
INDEX.LBL	A PDS detached label that describes the INDEX.TAB file. This file is generated using the PSA PVV software application.

NOTE: No geometry index files are to be provided within the data sets.

3.4.3.5 Geometry Directory

There will not be a GEOMETRY directory in any of the data sets since the geometry information required to analyze the data is contained in the data products.

PSA will archive separated data sets containing all the required ancillary information for the SMART-1 mission in both SPICE and ESOC formats. Should you require additional auxiliary data for SMART-1 or XSM, please refer to the PSA auxiliary data sets. The list below includes all the SPICE kernels used in generating the attitude and pointing related information, i.e. the columns between 23 and 42 in the data tables.

ATNS_P030929010023_00188.BC

ATNS_P050930150947_00220.BC

ATNS_P060301004212_00233.BC

DE405S.BSP

NAIF0008.TLS

ORES________________00125.BSP

ORMS________________00233.BSP

KERPATH/ORMS__041111020517_00206.BSP

PCK00008.TPC

SMART1_V1.TF

SMART1_XSM_V02.TI

SMART1_070227_STEP.TSC

3.4.3.6 Software Directory

The SOFTWARE directory contains the software applications required to generate the required compliant input files for XSPEC spectral fitting software. The software packages are made of IDL programs and a data table in FITS format used by one of the applications to perform data calibration. A detailed description of the software applications and the data file is provided in sections 2.4.4.2 and 2.4.4.3. The packages are compressed with the extension of *.ZIP for the delivery. Before using the software, these files shall be uncompressed. The contents of the SOFTWARE directory are listed in the following table:

File Name	File Contents
SOFTINFO.TXT	A description of the contents of this directory
XSM_SOFT.ZIP	ZIP compressed file containing the IDL programs DG.PRO and RA.PRO. This file includes also the MU_SI.FITS auxiliary table file. This file has been compressed under LINUX by using the command **tar –czvf. To uncompress the file under LINUX, please use the tar –xzvf XSM_SOFT.ZIP.**
XSM_SOFT.LBL	A PDS detached label that describes the XSM_SOFT.ZIP file.

3.4.3.7 Document Directory

The DOCUMENT directory contains the required documentation to understand the data contained in the data set. XSM encourages the reading of this documentation before starting to use the data. The following files are stored in the DOCUMENT directory:

File Name	File Contents
DOCINFO.TXT	A description of the contents of this directory
XSM_EAICD.ASC	XSM Experiment to Archive interface control document in ASCII format.
XSM_EAICD.DOC	XSM Experiment to Archive interface control document in Microsoft Word format.
XSM_EAICD.PDF	XSM Experiment to Archive interface control document in PDF format.
XSM_EAICD_FIG01.JPG	Figure 1 of the XSM EAICD for the ASCII version of the document.
XSM_EAICD_FIG02.JPG	Figure 2 of the XSM EAICD for the ASCII version of the document.
XSM_EAICD_FIG03.JPG	Figure 3 of the XSM EAICD for the ASCII version of the document.

XSM_EAICD_FIG04.JPG	Figure 4 of the XSM EAICD for the ASCII version of the document.
XSM_EAICD_FIG05.JPG	Figure 5 of the XSM EAICD for the ASCII version of the document.
XSM_EAICD_FIG06.JPG	Figure 6 of the XSM EAICD for the ASCII version of the document.
XSM_EAICD.LBL	A combined PDS detached label describing the XSM_EAICD documents – All the files above this line except the DOCINFO.TXT.
XSM_PAPER001.PDF	``The SMART-1 X-ray Solar Monitor (XSM): Calibrations for D-CIXS and independent coronal science'', Houvelin et al., Planetary and Space Science, Vol 50/14-15, p. 1345-1353.
XSM_PAPER001.LBL	A PDS detached label describing the XSM_PAPER001.PDF document.

All future publications related to XSM and their label files will be archived in the document directory, after updating this document.

3.4.3.8 Data Directory

The DATA directory contains the XSM Level 1B data products. These data products are made of scientific data, calibration data to be used together with the scientific data, attitude information and some additional parameters.

There is a reference to the mission phase in the data set name. There are no subdirectories in the data directory. The data will be separated in three different data sets, EEP, LP and EP, and only level 1B data products will be archived in the PSA.

4 Detailed Interface Specifications

This chapter provides the XSM user with detailed information on the dataset, directory filenaming and archive design that have not been mentioned already or that are of exteme importance for the final usage of the data.

4.1 Structure and Organizational Overview

XSM data are archived in two different data sets, depending on the mission phase. In each data set, the data is stored under the DATA directory in subdirectories containing data for a single month. The subdirectory naming scheme used in both data sets is: yymm, where yy corresponds to the year and mm to the month when the data was acquired.

Each subdirectory contains all the data obtained during that month, archived in data products containing all the data acquired in a single observation. XSM observations start with a calibration procedure during which 20 spectra are obtained – with integration times of 16 seconds –. Once the calibration procedure is done, the instrument operates nominally, acquiring solar spectral data. Before finalizing the observation, XSM starts a second calibration period acquiring once again 20 spectra.

It has been noticed that due to XSM internal malfunctioning, the first spectra data might be corrupted. An additional column has been included in the data table to indicate the validity and type of the data.

All these spectral data – calibration and scientific spectra – are archived in a single file in FITS format together with additional parameters required to analyze the data.

The filename scheme is described in detail in section 3.1.4.

4.2 Data Sets, Definition and Content

Two data sets will be produced as part of the archive of XSM Level 1B data, one for the Earth Escape Phase and another for the Lunar Phase. The Data Set IDs for all three data sets are:

EEP: S1-X-XSM-2-EDR-EEP-V1.0

LP: S1-X-XSM-2-EDR-LP-V.0

EP: S1-X-XSM-2-EDR-EP-V1.0

Each release will contain data for a period covering the whole mission phase – and will be delivered after three months of the reception of the raw telemetry data by the XSM team.

For further information about the data set IDs and data set names please refer to sections 3.1.2 and 3.4.2

4.3 Data Product Design

The final and archived data table containing the level 1B data is generated by the IDL program DT.PRO. Inputs for this program is spectral data (type 4) and HK data (type 0) files and a specially tailored attitude data (geometry file containing solar angles given with respect to the spacecraft frame). The content of the data table is described below. The number of rows is variable and depends on the total observation time. The total number of columns in this data table is always constant and equal to 37.

COLUMN NUMBER:

1. SPECTRUM, SOLAR, CALIBRATION OR BACKGROUND/NOISE

In nominal operation 20 first and 20 last rows contain the calibration spectra. All rows between those contain solar spectra, sky background or noise depending on the current offset angle and detector performance. Each element in this column can be extended to show the counts of each 512 channel of XSM. The number of counts in the first channel is reset, because those are just generated by the instrumental noise.

2. FLAG

This column includes the flags indicating the type of spectral data. 1 equals to calibration, 0 equals to solar spectrum and .1 equals to noise or background.

3. OBSERVATION_START_TIME, SCET [s]

This column contains the integration start time of each spectrum represented in UTC.

4. OBSERVATION_START_TIME, SCET [s]

This column contains the integration start times of all spectra of 16 sec obtained during this particular observation. This time is expressed in Spacecraft Event Counts.

5. INEGRATION_TIME, [s]

This column contains a constant value of 16 s. Integration time is always 16 seconds.

6. TOTAL_COUNTS, NUMBER OF PHOTONS MEASURED IN 16 SECONDS

There are 512 energy channels forming the final spectra in readout electronics. The counts of the first channel (# 0) are reset to zero. This column includes the total number of counts of a single spectrum integrated for 16 seconds.

7. A_EFF, EFFECTIVE AREA

This column includes effective area. It is a function of photon energy, off axis and roll angle. Effective area changes every time the S/C attitude varies. Each element can be expanded into a vector of 512 elements.

8. PIN_TEMP, DETECTOR TEMPERATURE [C]

This HK value represents the current detector temperature in Celsius scale at each time.

9. BOX_TEMP, DETECTOR BOX TEMPERATURE [C]

This HK value represents the current detector box temperature in Celsius scale at each time.

10. BIAS_HV, BIAS HIGH VOLTAGE [VDC]

This column includes the bias high voltage values. It should be about 100 VDC during normal operation.

11. LEAKAGE_CURRENT [pA]

This column includes the leakage current in pico amps. This value depends on the count rate, temperature and lattice defects caused by particle radiation. Leakage current indicates the performance of XSM with respect to the energy resolution. XSM will be autonomously starting to anneal, when the leakage current level exceeds a certain level. This tripping level is an adjustable parameter in the flight S/W.

12. POS_5_V, +5 VDC POWER

This column includes the power supply voltage of +5 VDC.

13. POS_12_V, +12 VDC POWER

This column includes the power supply voltage of +12 VDC.

14. NEG_12_V, -12 VDC POWER

This column includes the power supply voltage of -12 VDC.

15. PELTIER_VOLTAGE, [VDC]

This column includes the Peltier power supply voltage. Nominally it is about 1.65 VDC.

16. PELTIER_STAGE

This column includes the information of the Peltier stage. Peltier off equals to 0 and Peltier on equals to 1.

17. FIFO_STATE, ON/OFF, 0/1

This column includes the FIFO status. When XSM has acquisition on, this value is 1 and otherwise it is 0.

18. DET_OVER_TEMP, 0/1

This column includes the status of detector PIN over temperature. Nominally it is 0. When the temperature is greater than +0, the status value is 1 one XSM is switched off.

19. DAC_0, 0/1

This column includes the status of digital to analog conversion related to the DAC_0. Nominal value is 0.

20. DAC_1, 0/1

This column includes the status of digital to analog conversion related to the DAC_1. Nominal value is 0.

21. XSM_STATE

This column includes the XSM state value, which is a constant value of 1536 after the operation has been stabilized.

22. SECOND_COUNTER

This column includes the second counter value, which is a constant value of 62 after the operation has been stabilized.

23. RA_PNTG

This column includes the RA of the pointing in degrees.

24. DEC_PNTG

This column includes the declination of the pointing.

25. SUN_FOV

This column includes the flag indicating the Sun position in the FoV.. (Inside =1 and Outside=0)

26. RANGE_SUN

This column contains the distance to the Sun center in kilometers.

27. RA_SUN

This column includes the RA of the Sun in degrees.

28. DEC_SUN

This column includes the declination of the Sun in degrees.

29. OFF_AXIS

This column includes the off axis angle in degrees. This angle is the angular separation between the optical axis of XSM and the Sun.

30. ROLL

This column includes the values for the Sun roll angle. It is calculated clockwise starting from the S/C +Z-axis (+Y = 90 deg etc.).

31. MOON_FOV

This column includes the flag indicating the Moon position in the FoV. (Inside =1 and Outside=0)

32. RANGE_MOON

This column contains the distance to the Moon center in kilometers.

33. RA_MOON

This column includes the Moon RA in degrees.

34. DEC_MOON

This column includes the Moon declination in degrees.

35. OFF_MOON

This column includes the Moon off axis angle in degrees. This angle is the angular separation between the optical axis of XSM and the Moon.

36. ROLL_MOON

This column includes the values for the roll angle. It is calculated clockwise starting from the S/C +Z-axis (+Y = 90 deg etc.).

37. EARTH_FOV

This column includes the flag indicating the Earth position in the FoV. (Inside =1 and Outside=0)

38. RANGE_EARTH

This column contains the distance to the Earth center in kilometers.

39. RA_EARTH

This column includes the Earth RA in degrees.

40. DEC_EARTH

This column includes the Earth declination in degrees.

41. OFF_EARTH

This column includes the Earth off axis angle in degrees. This angle is the angular separation between the optical axis of XSM and the Earth.

42. ROLL_EARTH

This column includes the values for the roll angle. It is calculated clockwise starting from the S/C +Z-axis (+Y = 90 deg etc.).

This fits-formatted data table is converted into PDS-format. This conversion is carried out by running a fits2pds (=f2p) conversion program. The data table remains untouched in this conversion, but the conversion creates a PDS label file of the data file according to archiving requirements. The data table is composed of **1b** level data. It includes list of spectra in a binary table according to ascending integration time. NOTE! The first 20 and the last 20 spectra in the data table are calibration spectra requiring that the operation has been nominal. This is the deliverable 1b level data file. Each of the delivered data file has a corresponding PDS compliant label file. These label files are also delivered among the spectral data files.

XSM main data product is solar X-ray spectra obtained at the energy range of 2-20 keV with 16 sec time resolution. Calibration spectra are composed of four distinct X-ray lines. Two lines are obtained from the Fe55-source (radio active iron isotope). It emits Mn K-alpha- and Mn K-beta-lines. There is a titanium foil attached on the Fe55 source, which emits titanium K-alpha- and K-beta fluorescence lines. Calibration spectra are applied in characterization of the operation of XSM. All this data is delivered for archiving at the level of 1B in PDS-format. Data may also contain background when the Sun has been outside of the FOV during an observation. At the beginning of each observation, the first three calibration spectra are usually noisy

4.4 Data Product Design

XSM data consists of one data table, which includes spectral data, HK-data and attitude data attached in the same FITS-formatted data table. The data file name is composed of the observation start time i.e. the integration start time of the first spectrum acquired. The capital T in the file name is just a separator. If there has been an interruption extending over 16 seconds within an observation e.g. acquisition has switched off, then a new data file is generated and the file name of this new file is determined by the start time of the first acquired spectrum succeeding the acquisition interruption.
The following sections provide the description of the PDS product labels that are used in describing XSM data sets that will be supplied to the PSA. These example labels are generated from the data file having a name 2004_10_18T14_56_19_1.DAT.

```
PDS_VERSION_ID                 = PDS3
LABEL_REVISION_NOTE            = "2006-04-28 L.ALHA SPECTRAL LABEL V1.6"

/***  FILE CHARACTERISTIC DATA ELEMENTS   ***/
FILE_NAME                      = "2004_10_18T14_56_19_1.DAT"
FILE_RECORDS                   = 37
RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 4264
RELEASE_ID                     = 0003
REVISION_ID                    = 0000

/***  DATA OBJECT POINTERS                ***/
^HEADER                        = "2004_10_18T14_56_19_1.DAT"
^EXTENSION_HEADER              = ("2004_10_18T14_56_19_1.DAT", 2881<BYTES>)
^TABLE                         = ("2004_10_18T14_56_19_1.DAT", 14401<BYTES>)
```

```
/***  IDENTIFICATION DATA ELEMENTS        ***/
DATA_SET_ID                   = "S1-X-XSM-2-EDR-EEP-V1.0"
DATA_SET_NAME                 = "SMART1 SOLAR XSM 2 EDR EARTH ESCAPE PHASE DATA"
PRODUCT_ID                    = "2004_10_18T14_56_19_1"
PRODUCT_CREATION_TIME         = 2007-10-19T14:53:09
PRODUCT_TYPE                  = EDR
START_TIME                    = 2004-10-18T14:56:19.588
STOP_TIME                     = 2004-10-18T15:04:35.588
SPACECRAFT_CLOCK_START_COUNT  = "8/0020396096.00000"
SPACECRAFT_CLOCK_STOP_COUNT   = "8/0020396592.00000"
TARGET_NAME                   = SUN
TARGET_TYPE                   = SUN
MISSION_ID                    = SMART1
MISSION_NAME                  = "
  SMALL MISSIONS FOR ADVANCED RESEARCH AND TECHNOLOGY
"
INSTRUMENT_HOST_ID            = S1
INSTRUMENT_HOST_NAME          = "
  SMALL MISSIONS FOR ADVANCED RESEARCH AND TECHNOLOGY
"
MISSION_PHASE_NAME            = "EARTH ESCAPE PHASE"
ORBIT_NUMBER                  = "N/A"
PRODUCER_ID                   = "XSM_TEAM"
PRODUCER_FULL_NAME            = "LAURI ALHA"
PRODUCER_INSTITUTION_NAME     = "OBSERVATORY, UNIVERSITY OF HELSINKI"

/***  DESCRIPTIVE DATA ELEMENTS           ***/
INSTRUMENT_ID                 = XSM
INSTRUMENT_NAME               = "X-RAY SOLAR MONITOR"
DATA_QUALITY_ID               = 1
DATA_QUALITY_DESC             = "
  1 CORRESPONDS TO NOMINAL DATA AND 0 TO CORRUPTED DATA
"
INSTRUMENT_MODE_ID            = "CALIB/OBS"
INSTRUMENT_MODE_DESC          = "
  XSM HAS 2 MODES: CALIBRATION AND OBSERVATION. THE DATA PRODUCT
  CONTAINS BOTH SOLAR AND CALIBRATION SPECTRA
"
INSTRUMENT_TYPE               = SPECTROMETER
PROCESSING_LEVEL_ID           = 2
PROCESSING_LEVEL_DESC         = "
  EDITED DATA: CORRECTED FOR TELEMETRY ERRORS. CORRESPONDS TO EDR -
  EXPERIMENTAL DATA RECORDS -. THE DATA ARE TAGGED WITH TIME AND
  LOCATION OF ACQUISITION. CORRESPONDS TO THE PROCESSING LEVEL FOR
  SCIENCE DATA SETS OF THE PSA DATA PROCESSING AND ARCHIVE PLAN OF
  SMART-1 LEVEL-1B
"

/***  DATA OBJECT DEFINITIONS             ***/
OBJECT                        = HEADER
  BYTES                         = 2880
  HEADER_TYPE                   = FITS
  INTERCHANGE_FORMAT            = BINARY
  RECORDS                       = 1
  DESCRIPTION                   = "
    THIS PRIMARY HEADER CONTAINS THE
    STANDARD KEYWORDS TO DESCRIBE A FITS-
    FORMATTED DATA TABLE.
  "
END_OBJECT                    = HEADER
```

```
OBJECT                        = EXTENSION_HEADER
  BYTES                         = 11520
  HEADER_TYPE                   = FITS
  INTERCHANGE_FORMAT            = BINARY
  RECORDS                       = 4
  DESCRIPTION                   = "
    THIS SECONDARY EXTENSION HEADER CONTAINS THE
    KEYWORDS REQUIRED TO DESCRIBE THE INTERNAL
    STRUCTURE OF A FITS-FORMATTED DATA TABLE AND
    THE AUXILIARY INFORMATION NEEDED IN THE FURTHER
    ANALYSIS.
  "
END_OBJECT                    = EXTENSION_HEADER

OBJECT                        = TABLE
  COLUMNS                       = 42
  INTERCHANGE_FORMAT            = BINARY
  ROW_BYTES                     = 4264
  ROWS                          = 32
  DESCRIPTION                   = "
    THIS TABLE IS A FITS-FORMATTED BINARY ARRAY
    CONTAINING THE ARCHIVED LEVEL 2 DATA OF XSM.
  "


  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 1
    NAME                          = SPECTRUM
    BYTES                         = 2048
    START_BYTE                    = 1
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE RAW DATA OF THE 512
      CHANNEL X-RAY SPECTRUM OF THE XSM.
    "
    ITEMS                         = 512
    ITEM_BYTES                    = 4
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 2
    NAME                          = FLAG
    BYTES                         = 2
    START_BYTE                    = 2049
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE FLAG INDICATING THE SPECTRAL
      TYPE. 1 MEANS CALIBRATION, 0 SOLAR SPECTRUM AND -1
      BACKGROUND OR NOISE.
    "
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 3
    NAME                          = T_UTC
    BYTES                         = 26
    START_BYTE                    = 2051
    DATA_TYPE                     = CHARACTER
    DESCRIPTION                   = "
```

```
  "
  UNIT                          = DATE
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 4
  NAME                          = START_OBS
  BYTES                         = 8
  START_BYTE                    = 2077
  DATA_TYPE                     = IEEE_REAL
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS THE START TIME OF THE INTEGRATION
    OF EACH SPECTRUM OBTAINED DURING THE OBSERVATION.
    THE START TIME IS REPRESENTED IN SCET (SPACECRAFT EVENT
    TIME).
  "
  UNIT                          = S
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 5
  NAME                          = INTEGRATION_TIME
  BYTES                         = 4
  START_BYTE                    = 2085
  DATA_TYPE                     = MSB_INTEGER
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS THE INTEGRATION TIME OF EACH SPECTRUM.
  "
  UNIT                          = S
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 6
  NAME                          = TOTAL_COUNTS
  BYTES                         = 8
  START_BYTE                    = 2089
  DATA_TYPE                     = IEEE_REAL
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS THE TOTAL COUNTS OF EACH SPECTRUM.
  "
  UNIT                          = COUNTS
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 7
  NAME                          = A_EFF
  BYTES                         = 2048
  START_BYTE                    = 2097
  DATA_TYPE                     = IEEE_REAL
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS THE EFFECTIVE AREA IN CM^2 FOR EACH OF
    THE 512 CHANNELS OF THE XSM CORRESPONDING TO THE CURRENT
    INTEGRATION.
  "
  ITEMS                         = 512
  ITEM_BYTES                    = 4
  UNIT                          = CM^2
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 8
```

```
    NAME                          = PIN_TEMP
    BYTES                         = 8
    START_BYTE                    = 4145
    DATA_TYPE                     = IEEE_REAL
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE TEMPERATURE OF THE DETECTOR PIN IN
      CELSIUS. IF THE TEMPERATURE IS GREATER THAN 0 DEGREES CELSIUS,
      XSM IS SWITCHED OFF.
    "
    UNIT                          = DEG / C
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 9
    NAME                          = BOX_TEMP
    BYTES                         = 8
    START_BYTE                    = 4153
    DATA_TYPE                     = IEEE_REAL
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS TEMPERATURE OF THE XSM SENSOR BOX IN
      CELSIUS. THIS TEMPERATURE VALUE DEPENDS ON THE POINTING OF
      THE XSM. DURING NORMAL OPERATION THIS VALUE IS AROUND 40
      DEGREES CELSIUS OR MORE.
    "
    UNIT                          = DEG / C
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 10
    NAME                          = BIAS_HV
    BYTES                         = 8
    START_BYTE                    = 4161
    DATA_TYPE                     = IEEE_REAL
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE BIAS HIGH VOLTAGE. NOMINAL
      VALUE IS AROUND 100 VDC WHEN XSM IS OBSERVING.
    "
    UNIT                          = VDC
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 11
    NAME                          = LEAKAGE_CURRENT
    BYTES                         = 8
    START_BYTE                    = 4169
    DATA_TYPE                     = IEEE_REAL
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE LEAKAGE CURRENT IN PICO AMPS.
      THIS VALUE DEPENDS ON THE CURRENT COUNT RATE,
      PIN TEMPERATURE AND LATTICE DEFECTS CAUSED BY PARTICLE
      RADIATION. LEAKAGE CURRENT CAN BE DECREASED BY ANNEALING.
      THE AUTONOMOUS ANNEALING WILL START, WHEN A SPECIFIC TRIPPING
      VALUE IS EXCEEDED.THIS VALUE IS AN ADJUSTABLE S/W PARAMETER
      AND ITS VALUE WILL INCREASE AS A FUNCTION OF TIME. THE LEAKAGE
      CURRENT REPRESENTS THE NOISE LEVEL OF THE XSM, WHICH
      HAS A GREAT IMPACT ON THE XSM ENERGY RESOLUTION.
    "
    UNIT                          = PA
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
```

```
    COLUMN_NUMBER                = 12
    NAME                         = POS_5_V
    BYTES                        = 8
    START_BYTE                   = 4177
    DATA_TYPE                    = IEEE_REAL
    DESCRIPTION                  = "
      THIS COLUMN CONTAINS THE VOLTAGE OF THE POWER SUPPLY
      +5 V LINE. NOMINAL VALUE IS +5 VDC
    "
    UNIT                         = VDC
  END_OBJECT                   = COLUMN

  OBJECT                       = COLUMN
    COLUMN_NUMBER                = 13
    NAME                         = POS_12_V
    BYTES                        = 8
    START_BYTE                   = 4185
    DATA_TYPE                    = IEEE_REAL
    DESCRIPTION                  = "
      THIS COLUMN CONTAINS THE VOLTAGE OF THE POWER SUPPLY
      +12 V LINE. NOMINAL VALUE IS +12 VDC
    "
    UNIT                         = VDC
  END_OBJECT                   = COLUMN

  OBJECT                       = COLUMN
    COLUMN_NUMBER                = 14
    NAME                         = NEG_12_V
    BYTES                        = 8
    START_BYTE                   = 4193
    DATA_TYPE                    = IEEE_REAL
    DESCRIPTION                  = "
      THIS COLUMN CONTAINS THE VOLTAGE OF THE POWER SUPPLY
      -12 V LINE. NOMINAL VALUE IS -12 VDC.
    "
    UNIT                         = VDC
  END_OBJECT                   = COLUMN

  OBJECT                       = COLUMN
    COLUMN_NUMBER                = 15
    NAME                         = PELTIER_VOLTAGE
    BYTES                        = 8
    START_BYTE                   = 4201
    DATA_TYPE                    = IEEE_REAL
    DESCRIPTION                  = "
      THIS COLUMN CONTAINS THE PELTIER VOLTAGE.
      NOMINAL VALUE DURING COOLING IS AROUND 1.65 VDC.
    "
    UNIT                         = VDC
  END_OBJECT                   = COLUMN

  OBJECT                       = COLUMN
    COLUMN_NUMBER                = 16
    NAME                         = PELTIER_STATE
    BYTES                        = 1
    START_BYTE                   = 4209
    DATA_TYPE                    = MSB_INTEGER
    DESCRIPTION                  = "
      THIS COLUMN CONTAINS THE PELTIER STATE.
      OFF = 0 AND COOLING = 1.
    "
```

```
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 17
  NAME                          = FIFO_STATE
  BYTES                         = 1
  START_BYTE                    = 4210
  DATA_TYPE                     = MSB_INTEGER
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS THE FIFO STATE.
    FIFO EQUALS TO 1, WHEN ACQUISITION IS ON AND TO 0,
    WHEN ACQUISITION IS OFF.
  "
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 18
  NAME                          = DET_OVER_TEMP
  BYTES                         = 1
  START_BYTE                    = 4211
  DATA_TYPE                     = MSB_INTEGER
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS THE DETECTOR OVER TEMPERATURE FLAG.
    NOMINAL VALUE IS 0. IF THE PIN TEMPERATURE EXCEEDS +0
    DEGREES CELSIUS, THIS VALUE IS 1 AND XSM IS SWITCHED OFF.
  "
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 19
  NAME                          = DAC_0
  BYTES                         = 1
  START_BYTE                    = 4212
  DATA_TYPE                     = MSB_INTEGER
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS INFORMATION OF DIGITAL TO ANALOG
    CONVERSION RELATED TO THE READ OUT ELECTRONICS (DAC0).
    NOMINAL VALUE IS 0.
  "
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 20
  NAME                          = DAC_1
  BYTES                         = 1
  START_BYTE                    = 4213
  DATA_TYPE                     = MSB_INTEGER
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS INFORMATION OF DIGITAL TO ANALOG
    CONVERSION RELATED TO THE READ OUT ELECTRONICS (DAC1).
    NOMINAL VALUE IS 0
  "
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 21
  NAME                          = XSM_STATE
  BYTES                         = 4
  START_BYTE                    = 4214
  DATA_TYPE                     = MSB_INTEGER
  DESCRIPTION                   = "
```

```
    THIS COLUMN CONTAINS THE XSM STATE. THE VALUES ARE GIVEN
    IN DECIMAL AND HEXADECIMAL AND ARE FOLLOWED BY THE
    CORRESPONDING STATE NUMBERS AND NAMES.
    DEC   HEX  STATE NUMBER  STATE NAME
    0     0    0             OFF
    256   100  1             STARTING
    512   200  2             COOLING
    768   300  3             COOL
    1024  400  4             CALIBRATE
    1280  500  5             OPENING SHUTTER
    1536  600  6             OPERATING
    1792  700  7             CLOSING SHUTTER
    2048  800  8             PRE-ANNEAL1
    2304  900  9             PRE-ANNEAL2
    2560  A00  10            ANNEAL
    2816  B00  11            CLOSING SHUTTER FOR CALIBRATION
  "
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 22
  NAME                          = SECOND_COUNTER
  BYTES                         = 4
  START_BYTE                    = 4218
  DATA_TYPE                     = MSB_INTEGER
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS THE SECOND COUNTER. THE VALUE IS THE
    NUMBER OF SECONDS THE XSM HAS BEEN IN THE STATE GIVEN IN
    THE XSM STATE COLUMN.
  "
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 23
  NAME                          = RA_PNTG
  BYTES                         = 2
  START_BYTE                    = 4222
  DATA_TYPE                     = MSB_INTEGER
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS THE RIGHT ASCENSION OF THE XSM
    POINTING IN DEGREES.
  "
  UNIT                          = DEG
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 24
  NAME                          = DEC_PNTG
  BYTES                         = 2
  START_BYTE                    = 4224
  DATA_TYPE                     = MSB_INTEGER
  DESCRIPTION                   = "
    THIS COLUMN CONTAINS THE DECLINATION OF THE XSM
    POINTING IN DEGREES.
  "
  UNIT                          = DEG
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER                 = 25
  NAME                          = SUN_FOV
```

```
    BYTES                          = 1
    START_BYTE                     = 4226
    DATA_TYPE                      = MSB_INTEGER
    DESCRIPTION                    = "
      THIS COLUMN CONTAINS THE FLAG INDICATING THE POSITION OF THE SUN
      IN RESPECT TO THE XSM FIELD OF VIEW. 1 MEANS THAT THE SUN IS INSIDE
      THE FOV, I.E. OFF-AXIS ANGLE OF THE SUN IS LESS THAN OR EQUAL TO
      52 DEGREES, 0 MEANS THAT THE SUN IS OUTSIDE OF FOV, I.E. IT'S
      OFF-AXIS ANGLE IS GREATER THAN 52 DEGREES.
    "
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    COLUMN_NUMBER                  = 26
    NAME                           = RANGE_SUN
    BYTES                          = 4
    START_BYTE                     = 4227
    DATA_TYPE                      = MSB_INTEGER
    DESCRIPTION                    = "
      THIS COLUMN CONTAINS THE DISTANCE TO THE CENTER OF THE SUN IN
      KILOMETERS.
    "
    UNIT                           = KM
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    COLUMN_NUMBER                  = 27
    NAME                           = RA_SUN
    BYTES                          = 2
    START_BYTE                     = 4231
    DATA_TYPE                      = MSB_INTEGER
    DESCRIPTION                    = "
        THIS COLUMN CONTAINS THE RIGHT ASCENSION OF THE SUN
        IN DEGREES.
    "
    UNIT                           = DEG
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    COLUMN_NUMBER                  = 28
    NAME                           = DEC_SUN
    BYTES                          = 2
    START_BYTE                     = 4233
    DATA_TYPE                      = MSB_INTEGER
    DESCRIPTION                    = "
        THIS COLUMN CONTAINS THE DECLINATION OF THE SUN
        IN DEGREES.
    "
    UNIT                           = DEG
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    COLUMN_NUMBER                  = 29
    NAME                           = OFF_AXIS
    BYTES                          = 2
    START_BYTE                     = 4235
    DATA_TYPE                      = MSB_INTEGER
    DESCRIPTION                    = "
      THIS COLUMN CONTAINS THE OFF-AXIS ANGLE OF THE SUN IN DEGREES IN
      RESPECT TO THE OPTICAL AXIS OF THE XSM. THE SUN IS OUTSIDE OF THE
      FOV OF XSM WHEN THE OFF-AXIS ANGLE IS GREATER THAN 52 DEGREES.
```

```
    "
    UNIT                          = DEG
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 30
    NAME                          = ROLL
    BYTES                         = 2
    START_BYTE                    = 4237
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE ROLL ANGLE OF THE SUN IN DEGREES.
      ROLL 0 DEGREES LIES ON THE PLANE DEFINED BY S/C +Z- AND +X-AXIS.
      ROLL ANGLE INCREASES CLOCK WISE SEEN FROM THE SUN DIRECTION.
      HENCE ROLL ANGLE OF +90 DEGREES EQUALS THE DIRECTION 0F +Y AXIS ETC.
    "
    UNIT                          = DEG
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 31
    NAME                          = MOON_FOV
    BYTES                         = 1
    START_BYTE                    = 4239
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE FLAG INDICATING THE POSITION OF THE MOON
      IN RESPECT TO THE XSM FIELD OF VIEW. 1 MEANS THAT THE MOON IS INSIDE
      THE FOV, I.E. OFF-AXIS ANGLE OF THE MOON IS LESS THAN OR EQUAL TO
      52 DEGREES, 0 MEANS THAT THE MOON IS OUTSIDE OF FOV, I.E. IT'S
      OFF-AXIS ANGLE IS GREATER THAN 52 DEGREES.
    "
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 32
    NAME                          = RANGE_MOON
    BYTES                         = 4
    START_BYTE                    = 4240
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE DISTANCE TO THE CENTER OF THE MOON IN
      KILOMETERS.
    "
    UNIT                          = KM
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 33
    NAME                          = RA_MOON
    BYTES                         = 2
    START_BYTE                    = 4244
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
        THIS COLUMN CONTAINS THE RIGHT ASCENSION OF THE MOON
        IN DEGREES.
    "
    UNIT                          = DEG
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
```

```
    COLUMN_NUMBER                 = 34
    NAME                          = DEC_MOON
    BYTES                         = 2
    START_BYTE                    = 4246
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
        THIS COLUMN CONTAINS THE DECLINATION OF THE MOON
        IN DEGREES.
    "
    UNIT                          = DEG
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 35
    NAME                          = OFF_MOON
    BYTES                         = 2
    START_BYTE                    = 4248
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE OFF-AXIS ANGLE OF THE MOON IN DEGREES IN
      RESPECT TO THE OPTICAL AXIS OF THE XSM. THE MOON IS OUTSIDE OF THE
      FOV OF XSM WHEN THE OFF-AXIS ANGLE IS GREATER THAN 52 DEGREES.
    "
    UNIT                          = DEG
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 36
    NAME                          = ROLL_MOON
    BYTES                         = 2
    START_BYTE                    = 4250
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE ROLL ANGLE OF THE MOON IN DEGREES.
      ROLL 0 DEGREES LIES ON THE PLANE DEFINED BY S/C +Z- AND +X-AXIS.
      ROLL ANGLE INCREASES CLOCK WISE SEEN FROM THE SUN DIRECTION.
      HENCE ROLL ANGLE OF +90 DEGREES EQUALS THE DIRECTION 0F +Y AXIS ETC.
    "
    UNIT                          = DEG
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 37
    NAME                          = EARTH_FOV
    BYTES                         = 1
    START_BYTE                    = 4252
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE FLAG INDICATING THE POSITION OF THE EARTH
      IN RESPECT TO THE XSM FIELD OF VIEW. 1 MEANS THAT THE EARTH IS INSIDE
      THE FOV, I.E. OFF-AXIS ANGLE OF THE EARTH IS LESS THAN OR EQUAL TO
      52 DEGREES, 0 MEANS THAT THE EARTH IS OUTSIDE OF FOV, I.E. IT'S
      OFF-AXIS ANGLE IS GREATER THAN 52 DEGREES.
    "
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 38
    NAME                          = RANGE_EARTH
    BYTES                         = 4
    START_BYTE                    = 4253
```

```
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE DISTANCE TO THE CENTER OF THE EARTH IN
      KILOMETERS.
    "
    UNIT                          = KM
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 39
    NAME                          = RA_EARTH
    BYTES                         = 2
    START_BYTE                    = 4257
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
        THIS COLUMN CONTAINS THE RIGHT ASCENSION OF THE EARTH
        IN DEGREES.
    "
    UNIT                          = DEG
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 40
    NAME                          = DEC_EARTH
    BYTES                         = 2
    START_BYTE                    = 4259
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
        THIS COLUMN CONTAINS THE DECLINATION OF THE EARTH
        IN DEGREES.
    "
    UNIT                          = DEG
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 41
    NAME                          = OFF_EARTH
    BYTES                         = 2
    START_BYTE                    = 4261
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE OFF-AXIS ANGLE OF THE EARTH IN DEGREES IN
      RESPECT TO THE OPTICAL AXIS OF THE XSM. THE EARTH IS OUTSIDE OF THE
      FOV WHEN THE OFF-AXIS ANGLE IS GREATER THAN 52 DEGREES.
    "
    UNIT                          = DEG
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    COLUMN_NUMBER                 = 42
    NAME                          = ROLL_EARTH
    BYTES                         = 2
    START_BYTE                    = 4263
    DATA_TYPE                     = MSB_INTEGER
    DESCRIPTION                   = "
      THIS COLUMN CONTAINS THE ROLL ANGLE OF THE EARTH IN DEGREES.
      ROLL 0 DEGREES LIES ON THE PLANE DEFINED BY S/C +Z- AND +X-AXIS.
      ROLL ANGLE INCREASES CLOCK WISE SEEN FROM THE SUN DIRECTION.
      HENCE ROLL ANGLE OF +90 DEGREES EQUALS THE DIRECTION 0F +Y AXIS ETC.
    "
    UNIT                          = DEG
```

```
  END_OBJECT                  = COLUMN
END_OBJECT                  = TABLE
END
```

5 Appendix: Example of Directory Listing

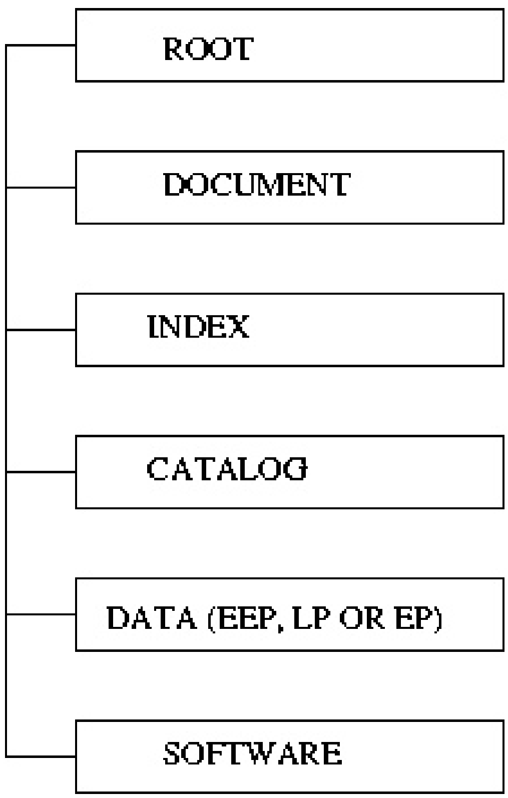

Figure 6. Data set directory structure.

6 Appendix: Example of Spectral Data Types

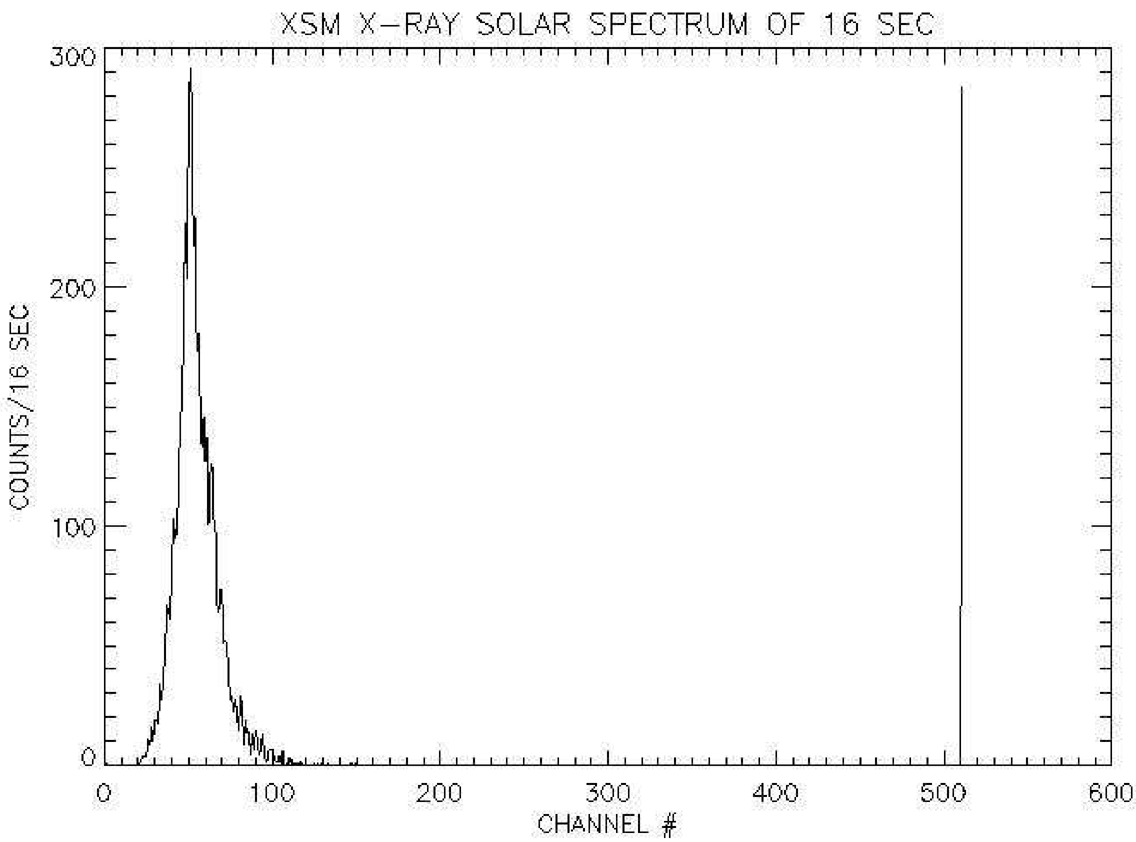

Figure 7. XSM raw data solar spectrum.

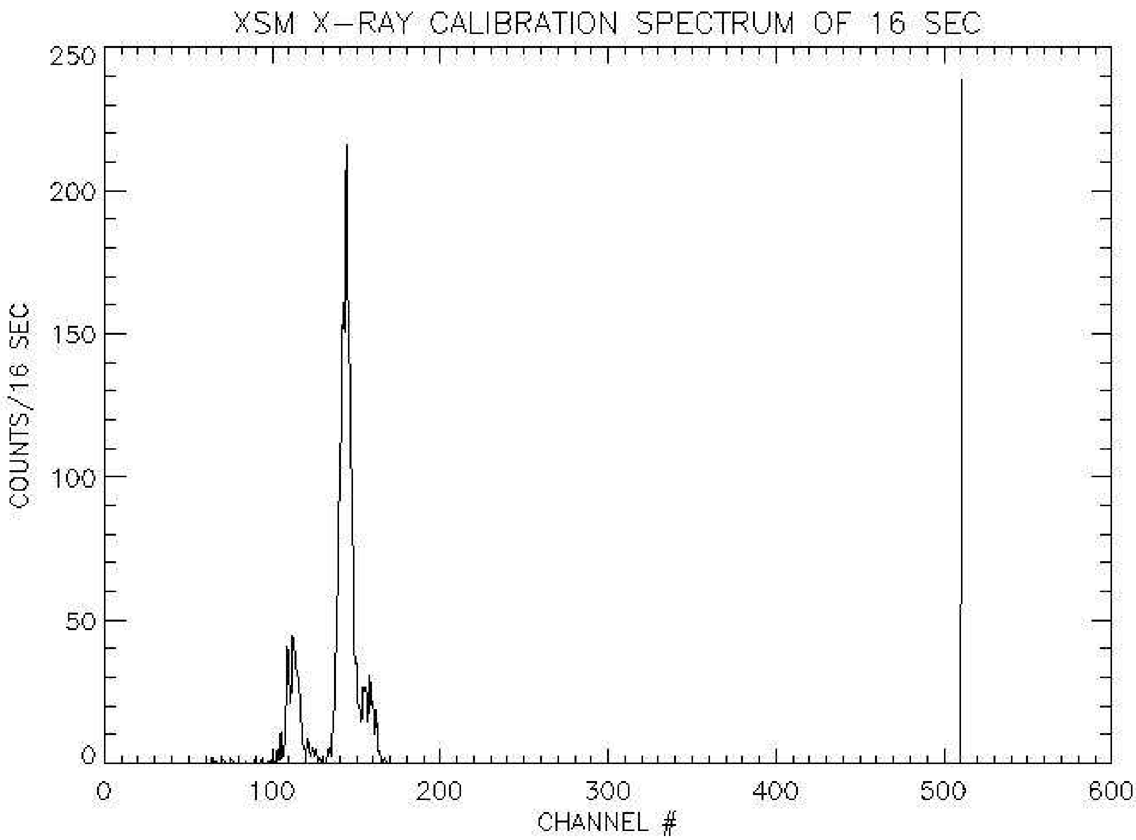

Figure 8. XSM calibration spectrum.

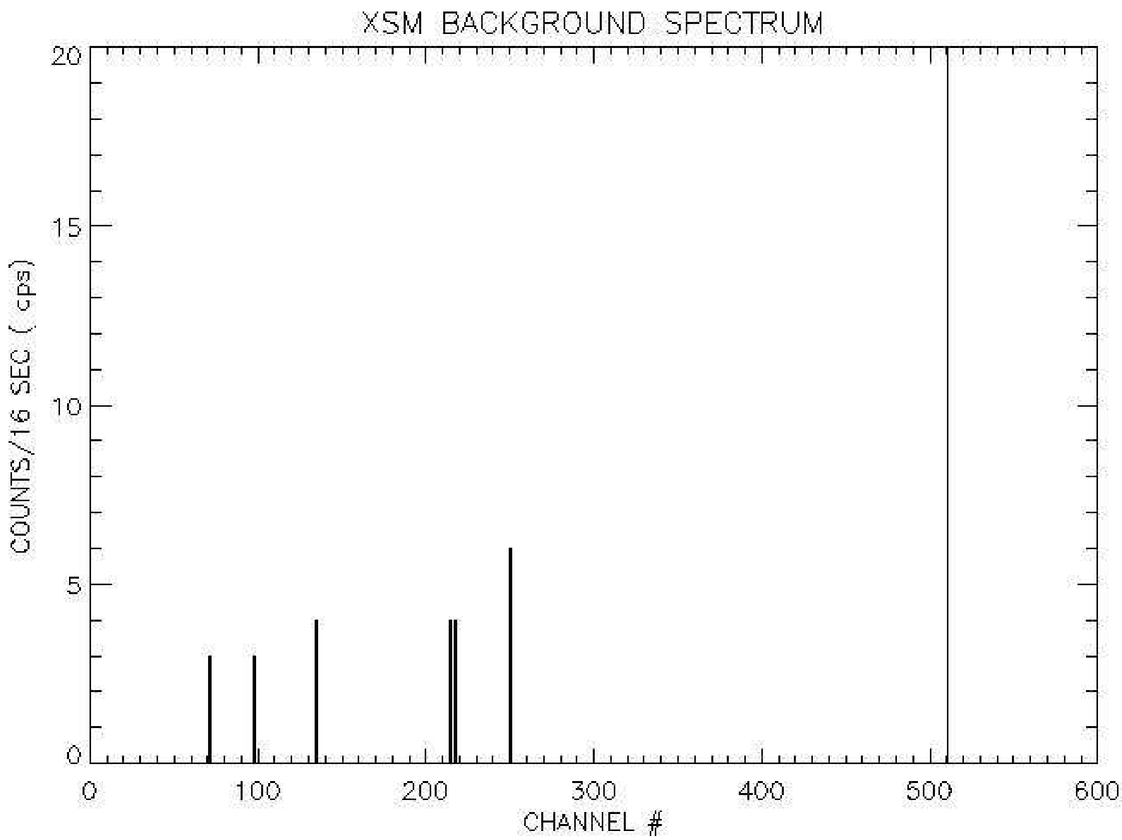

Figure 9. XSM background spectrum.