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Planck/LFI Ground Tests: data management and analysis

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Abstract. Ground Tests are a fundamental milestone within the development of the Low Frequency Instrument (LFI) which will fly onboard the ESA satellite Planck. They allow the collection of information which can not be supplied by monitoring onboard activity of the satellite during operations. Here methods and principles driving the management and elaboration of data collected during the Ground Tests campaign for the Planck/LFI are synthetically presented. Ground Tests take place in LABEN (Milano) and will last for about one year.

Key words. PLANCK/LFI – Methods: Data Analysis – Ground Tests

1. Introduction

The ESA satellite Planck [1], is the 3rd generation of CMB space missions (after COBE and WMAP) designed to produce measurements of temperature anisotropy over full sky (Burigana et al. 1998). Planck will operate as a surveyor equipped with a 1.5 m Gregorian aplanatic telescope, carryng in the focal surface two instruments covering the frequency bands 30, 44, and 70 GHz (Low Frequency Instrument, LFI, Mandolesi et al. 1998, Pasian 2003) and 100, 143, 217, 353, 545, and 857 GHz (High Frequency Instrument, HFI). Planned to be launched in February 2007 together with Herschel, its main target is to produce CMB maps of sky at different frequencies and to derive from them the cosmological parameters with an unprecedented resolution (FWHM

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[1] http://astro.estec.esa.nl/Planck/

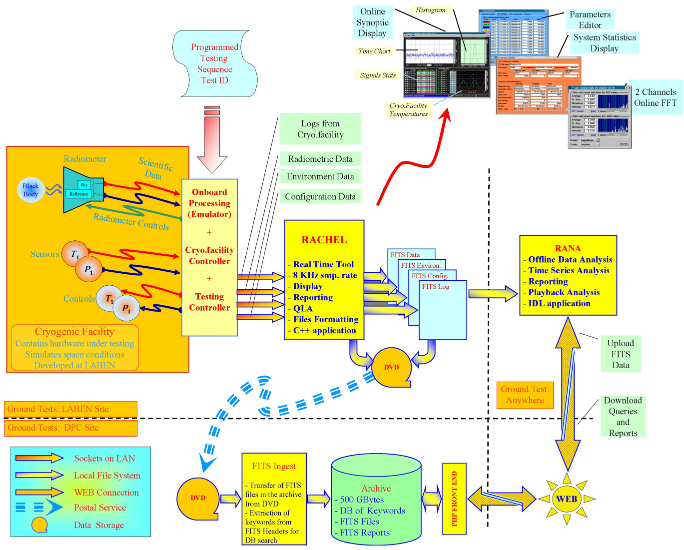

Fig. 1. Data handling scheme for Planck/LFI ground tests.

from $\simeq 33'$ to $\simeq 5'$) and sensitivity (in the range of $\simeq 10-40$ mJy on a FWHM resolution element). The Planck satellite will be placed in an orbit around the libration L2 point for the Earth-Sun system, so it will be visible from the ground station for a short time each day (2 hours).

Ground Tests campaign is a fundamental step of LFI instrument development. During Ground Tests, quantitative information are collected and made available to the community through LFI Data Processing Center (DPC, Zacchei et al. 2003a). Ground Tests data are fundamental for the instrument characterization, setup and calibration (Bersanelli et al. 2003; Fogliani et al. 2002; Maris et al. 2001) as well as for the data quality assessment of the LFI DPC pipeline scientific products. In fact, likewise any instrument to be hosted by a space mission, in flight instrument calibration and tuning will be possible only for some parameters, such as the photometric calibration or the measurement of the detectors main beams. LFI Ground testing is a multi-site activity involving Scientific Institutions and Industry. Major Planck/LFI Industry partners are LABEN (Milano, Italy), which is responsible for integration and testing of the instrument; SPACETECH (Tromso, Norway) in charge of the development of Electric Ground Segment Equipment (EGSE). Scientific Institutes are IASF/Milano (Italy) responsible for the development of the RANA [2] package, off-line analysis and scientific support; INAF/OAT (Trieste, Italy) for the LFI DPC, the Test Data Archive and scientific support and IASF/Bologna (Italy) for development of the RACHEL [3] software. The LFI Ground Tests campaign is planned to take place in LABEN in middle 2004 and will last for about one year.

2. Ground Tests Operations and Handling of Ground Tests Information

The data handling scheme is represented in Figure 1. The hardware to be tested is hosted inside a cryostatic facility where the flight environment (vacuum, thermal and electrical conditions) will be simulated. LFI radiometric chains will be tested one-by-one before and after their integration in the instrument. The

[2] Radiometer ANAlyzer
[3] RAdiometer CHains EvaLuator

cryostatic facility allows programmed variations of the parameters defining the environmental conditions. Each test, aimed at assessing a specific feature of the instrument, is characterized by:

– hardware/software configuration;
– set of constant parameters and the laws by which variable parameters are changed;
– test results;
– assessment of proper telecommands execution for specific operations;
– synthetic test report (e.g.: good, bad, failed, etc.).

Functionalities for real time data integration and formatting as quick-look and real-time data analysis are provided by the RACHEL facility, running at the testing site. RACHEL receives data produced by the controllers of the testing facility and from the data acquisition electronics through TCP/IP sockets. The bulk of data is represented by radiometric chains output which are tested in groups of four and are sampled at a frequency of about 8 KHz with a 14 bits acquisition electronics. The other sources of information (sensors, asynchronous events, comments from the operators and soon) are sampled at a much lower rates. RACHEL performs quick-look display and real-time analysis of data through a system of panels and strip-charts displaying acquired data and/or the tests results. RACHEL allows simple statistical analysis (real-time determination of statistical moments, histogramming, FFT, time-series correlations). At last RACHEL integrates the various sources of real time information and store them in a local data store. Information from RACHEL are stored as FITS files, according to a simple predefined standard. Four kinds of FITS files are generated from each test according to the four classes of raw data generated by the test:

– radiometric data;
– radiometric chain set-up;
– cryostat status;
– log files.

No permanent archival facility is planned at the testing site, but the FITS files of each day of test are permanently stored in couples of twin DVDs (about one couple of DVD each day) a copy of which are delivered by postal service to the LFI/DPC for the final storage (one delivery per week) while the other will be hold at the testing site till the end of the testing campaign. In this way the activities at the testing site are decoupled from the activities at LFI/DPC which will have not to provide a real-time archival service of tests data through internet. At DPC the collection of DVD will represents the bulk of testing data backup, reducing the effort for the preparation of a backup archive. At testing site the DVD collection will represent a data repository whose access is automatically limited to authorized people. The volume of data expected to be gathered during the Ground Test campaign is about 2 Terabyte. LFI Instrument fine-tuning and calibration parameters table will be the result of more refined ground test data streams analysis performed through the RANA tool. This tool consists of an interactive IDL application built on the top of an interface to read RACHEL FITS files, a digital signal analysis methods library tailor-made for LFI Instrument characterization and calibration purposes and finally a report generator. The library is expected to grow during Ground Tests as experience will suggest new and interesting analysis to be integrated in RANA in addition to the basic procedures already provided. In addition the RANA library will represent a prototype for the Quick-Look and Trend Analysis development to be applied to satellite data during the mission at LFI/DPC. At the opposite of RACHEL, which will be installed only at the testing site and maintained only up to the end of the test champaign, RANA will be installed and operated at any site interested to off-line analysis of Ground Test information and likely will be maintained all over the mission.

The Data Archive operated by the LFI/DPC will provide services for Ground Tests data ingestion and retrieval by keyword search (Zacchei et al. 2003b). The archive will be automatically feed through a FITS Ingestor with the data produced by RACHEL and stored in DVD. The FITS Ingestor will extract from FITS files all the needed keywords required to prepare tables for a fast retrieval of test products. Once consolidated, the results of RANA as the connected documentation are delivered through Internet and ingested in the LFI/DPC archive through a PHP WEB interface. Storage of RANA output follow rules similar to those used for the RACHEL products. The path leading to each result will have to be fully traceable and linked to the specific version of RANA which has been used to obtain it, the same for the site from which the contribution has been originated. It is important to note that the permanent archival of testing data is fundamental in order to exploit the full potential of ground test information along the mission. Archived data will be helpful not only to characterize the instrument but also for calibration and diagnostic during the flight. The archive is placed at the LFI/DPC since it will be the most important consumer of such information during operations. Permanent use of archived data requires to keep information self consistent in time, as to assure full traceability of the physical conditions, of the procedures and of the data analysis algorithm leading to a particular result. For this reason the archive will be ingested both with raw data from the testing facility, metadata including the history of tests and data analysis modules which contributed to the generation of a particular data product. In addition it has to be taken in account that tests will evolve as experience will be gained on the behaviour and analysis of the real instrument. Flexibility in the data model assumed for the archive and the exchange data format is then an asset.

3. Conclusions

The entire Ground Tests data processing chain is under test at LABEN with good results from the analysis and performance point of view. The design used to develop the Ground Tests data management for PLANCK/LFI can be easily exported to different kinds of instrument.

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