The PLANCK Newsletter

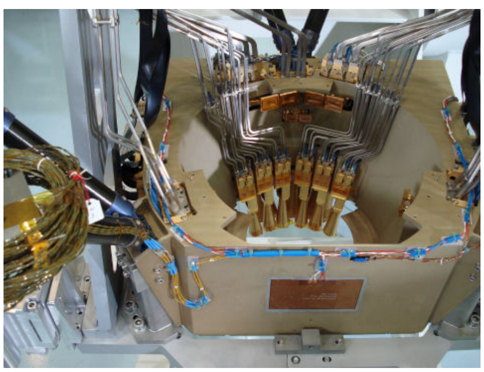
Issue 9 *Information and news for the Planck community* July 2007

Finally together !

B. Guillaume, A. Arts, T. Passvogel, G. Crone

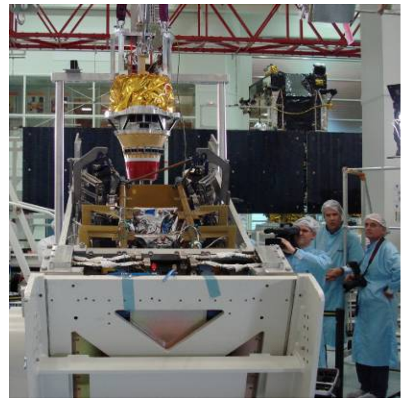
In Cannes media events are not unusual. This time, however, the show was not in the Palais des Festivals, but instead in the M01 clean room of Thales Alenia Space. And the stars were the LFI and HFI, which were mated together in a precisely synchronized ballet of people and hardware.

Last November, the flight model (FM) of both LFI and HFI were ready for integration at Thales in Cannes. First they had to be mated together, and then the common assembly had to be integrated onto the satellite. Meeting the requirements was a real challenge, demanding very tight tolerances, as tight as 10 micrometres for some parts. The activity went extremely smoothly, with an impressive Swiss-watch-like high precision assembly performed by Thales Alenia Space and the instrument teams. The result was a success: the HFI FM was mated with the LFI FM on 20 November.

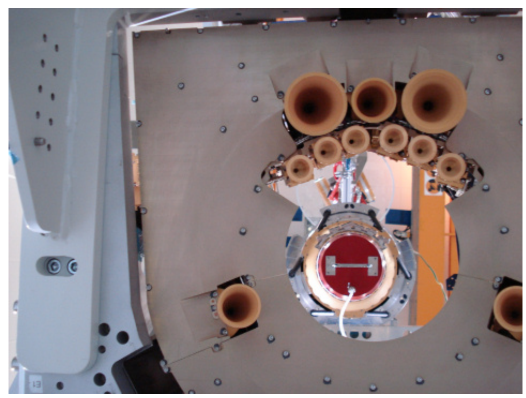


The LFI FPU before integration. One can clearly see the six 70 GHz horns with their wave-guides attached and the hole in the centre in which the HFI should be fitted.

The handling of the HFI FPU integrated on dedicated equipment supporting the dilution cooler and 4K cooler pipes.



The HFI FM is carefully lowered into the LFI FM during one of the most critical phasse of the instrument integration at Alcatel Cannes.



The HFI visible through the LFI as it is lowered down.

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The Planck Newsletter is published by the Planck Science Office, Research and Scientific Support Department of ESA, ESTEC, Noordwijk, The Netherlands. See also http://www.rssd.esa.int/Planck .

Planck Spacecraft Development:

Entering the Final Lap

G. Crone and T. Passvogel

The end of the year 2006 has seen quite a number of achievements. The final integration of the flight spacecraft was nearly achieved with both instruments now mounted and just the telescope integration remaining. With the completion of this instrument integration, the rest of the testing of the spacecraft leads to a target launch date of 31 July 2008.

Significant progress has been made since the last Newsletter. The main project milestones have been passed, many of which are reported in more detail elsewhere in this Newsletter.

A first assembly of the flight model of the Planck Service Module (SVM) with the sorption coolers and a representative thermal setup of the payload was achieved in early 2006. The LFI and HFI were replaced by thermal dummies simulating the thermal loads at the sorption cooler cold-end. This assembly underwent the first of the two cryogenic tests of the flight model in the CSL facility in Liege. The main objective of this test is to verify that the SVM thermal control system is ready for flight, and that the sorption cooler works as expected in the integrated system configuration. The test was a full success and the spacecraft can be declared ready for flight with respect to these objectives.

On the instrument side, the main achievements as seen from the spacecraft side were the completion of the instrument calibration tests and the delivery of the flight instruments to Alcatel for integration to the spacecraft. This major milestone was achieved first by HFI in summer followed by LFI later in autumn 2006. The integration of the two instrument focal plane units, a quite delicate integration task, went smoothly and the assembled instrument package could be released for the integration to the spacecraft.

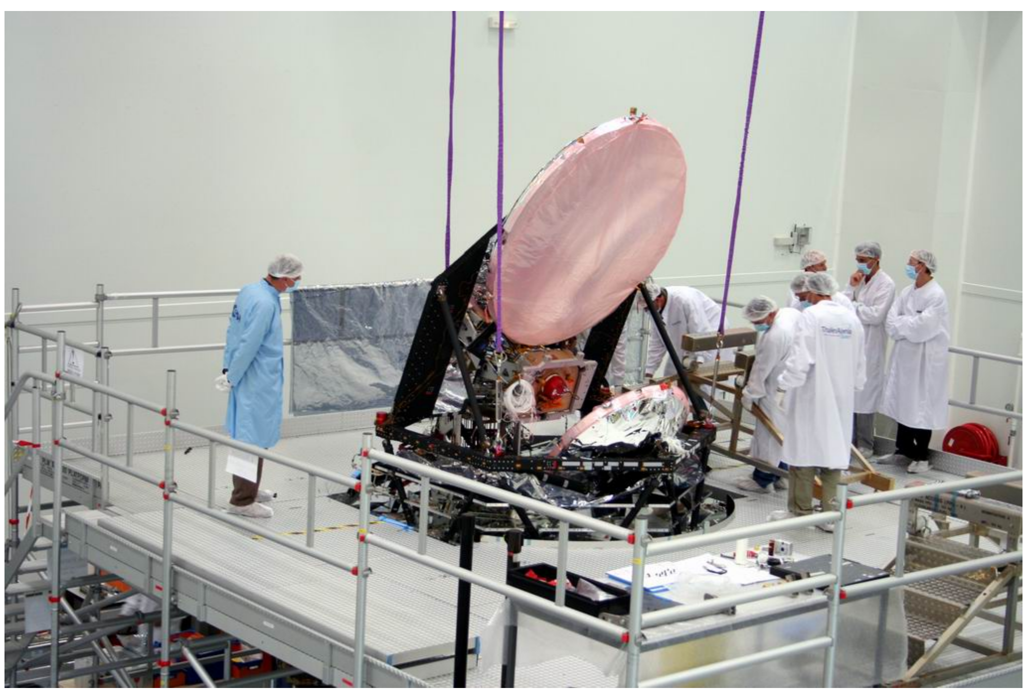
The Planck telescope has by now seen its final cryo-optical testing. After completion of the reflector testing earlier, the two reflectors were integrated to the telescope structure. The mechanical bahavior of the whole telescope assembly was verified down to 100 K in the large space simulation facility at ESTEC. The large amount of test data have been reduced and analysed to determine the best possible position of the instrument focal plane units. The two reflectors have been shimmed into their final positions on the telescope structure, following which the telescope has been integrated onto the satellite.

The measurement of the radio frequency properties of the Planck telescope and detectors have been meanwhile completed with the Radio Frequency Qualification Model at the Compact Antenna Test Range facility in Thales Alenia Space. Measurements have been carried out in both polarization directions at frequencies of 30 GHz, 70 GHz, 100 GHz and finally at 320 GHz. The obtained data is of high quality and will serve as one of the inputs for the prediction of the in-flight optical behaviour of Planck.

The Planck flight hardware is now mechanically assembled with the spacecraft built up. The next and final steps will be the completion of the functional and performance testing. This is the final check-out programme before the launch.

Some specific major events in the coming months are:
- Final alignment of the focal plane units.
- First full integrated system testing on the flight hardware as a performance reference prior to the major environmental tests.
- System mechanical testing with sine vibration and acoustic noise testing.
- Final Thermal vacuum and thermal balance testing in the cryo-facility in Liege. The test will be used to finally verify the service module under near orbital conditions

With the level of pressure and exciting steadily rising, it is clear that we have now entered the final lap of the race to the launch of Planck!



The Planck telescope being integrated onto the satellite.

Integration

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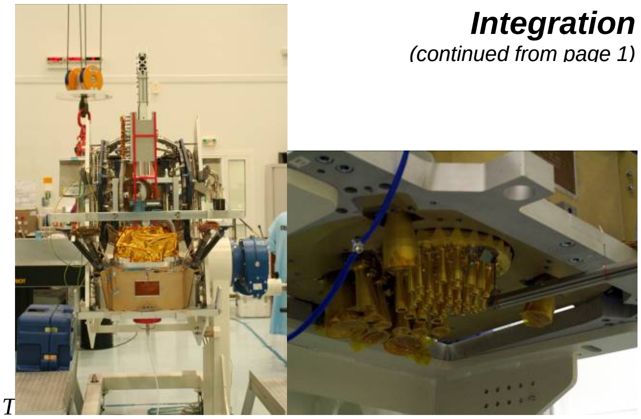
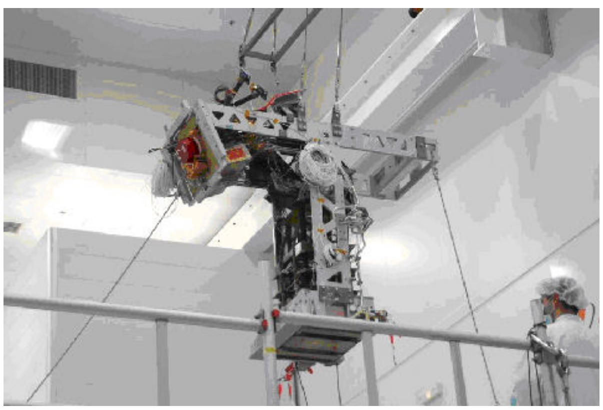
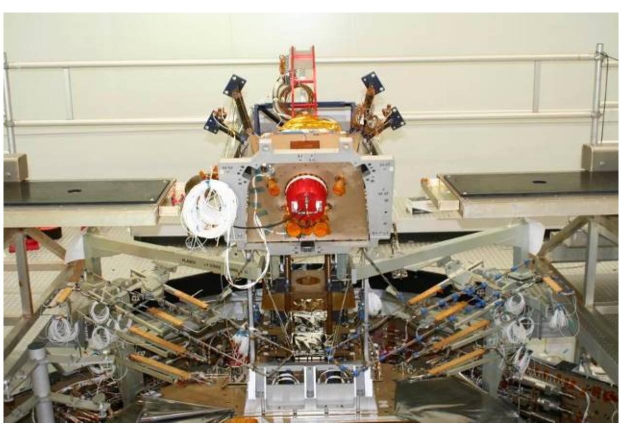


Truly and finally together !

After completion of the mating and subsequent measurements on the focal plane assembly, its integration onto the Service Module sub-platform was performed on 19 December.



The RAA hanging on the crane with the MGSE supporting structure. The RAA was then slowly lifted down to the sub-platform.



The integrated focal plane assembly in its final place on the Planck satellite.

Congratulations to all the members of the many engineering teams who contributed to this impressive achievement!

LFI Activities

R. Mandolesi, C. Butler, M. Bersanelli, A. Mennella, and the LFI teams

Important Steps Achieved in the development of LFI

The Test Results Review of the LFI Flight Model (FM) was held successfully on November 3, 2006, at the end of the instrument acceptance and calibration test campaign that commenced in early June. This was followed directly by the shipment of the instrument to AAS(F) at Cannes and consignment to ESA, where in parallel HFI was being prepared for integration into LFI to complete the Planck Payload.

The integration of HFI into LFI, which required the application of a highly complex procedure, given the very tight tolerances imposed on both instruments, was achieved successfully in late November. The preliminary activities prior to the integration of the entire payload in to the satellite were performed. The integration of the entire Planck payload commenced in December 2006 and will be completed by the first electrical tests of both instruments on the satellite in January /February 2007

In parallel, all the documentation associated to LFI for its future integration and satellite level testing has been completed. Detailed procedures for the satellite level verification have been reviewed with ESA and the prime contractor for all foreseeable activities over the next 6 months. Also the LFI team worked on the instrument section of the Planck Satellite Avionic Model (AVM) test campaign, in which LFI participated with the LFI AVM. The campaign was held at AAS(I) Torino in January 2007.

Calendar of (some) Events

Meetings

Planck Science Team meetings

ST34: 15-17 October, 2007 (Varenna TBC)

ST35: 21- 23 January 2008 (Paris or ESAC)

ST36: 21- 23 April 2008 (ESTEC)

Working Group Meetings

HFI Core Team: 13-14 September 2007 (Paris)

LFI Activities: Instrument-level Calibration

M. Bersanelli, A. Mennella, and the LFI teams

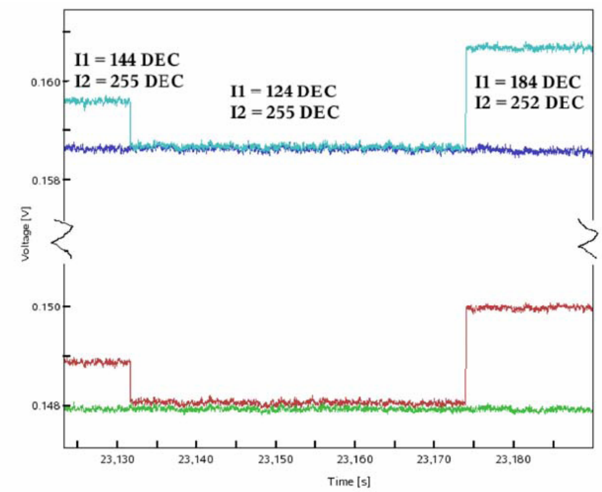
The LFI Instrument Team has been deeply involved in the Instrument level test and calibration campaign, carried out during the summer at AAS-I (Alcatel Alenia Space, Milano, Italy). The most critical cryo-testing phase started on August 12 and ended on August 26. During the cryo campaign the instrument was operated with flight-like interface temperatures (typical values were: front-end unit 25 K, V-groove 1: 184 K, V-groove 2: 106 K, V-groove 3: 59 K, back-end unit: 308 K), while the sky and reference loads could be adjusted in the range 18-25 K.

***Left panel**: the very moment in which the cryo-facility was opened after cryogenic campaign on August 26. **Right panel**: side view of the LFI instrument mounted within the cryo-facility.*

The principal goals of the instrument-level testing were to verify the overall system functionality and to confirm, within measurement accuracy, the parameters obtained in the calibration campaigns carried out at the radiometer chain assembly (RCA) level, see also Planck Newsletter 8, p.3. In fact, the LFI FM performance verification started much earlier, when the 70 GHz RCAs were calibrated at Elektrobit, Finland, and the 30-44 GHz receivers at AAS-I, Milano, Italy. In the RCA cryo-facilities the loads could be cooled down to (nominally) 4K with high accuracy monitoring of the absolute temperatures. This allowed a more accurate estimation of those radiometer properties which are derived through temperature steps in one of the loads (such as noise temperature, isolation, gain). On the other hand, the radiometer noise properties (power spectrum, knee frequency, white noise, noise effective bandwidth) were better characterised at instrument level thanks to the excellent stability of the large sky load used at instrument level (Figure 3) and to the ability to run long-duration tests.

View of the LFI horns at the top facing down the large sky-load at the bottom of the set-up.

After a set of functional tests carried out before and after cooldown, the first fundamental step in the radiometric calibration was to determine the phase switches and low noise amplifiers optimal bias parameters in the front-end modules, in order to achieve the best noise performance and internal balance. These complex tuning procedures were prepared after the experience of the RCA testing and of the LFI QM campaign was applied. The resulting biases turned out to be in general agreement with those expected from lower level tests, with a spread mostly due to the different cryo-harness and thermal conditions.



An example of the tuning of the bias currents of a phase switch.. In this case the objective was to find the optimal currents I1 and I2 driving the two switch diodes in order to maximise their amplitude.

After completion of the bias tuning phase, the gain and offset parameters in the data acquisition electronics (DAE) and the compression parameters in the radiometer electronics box assembly (REBA) were optimised. Testing then proceeded with the evaluation of basic radiometer parameters through a number of temperature steps in the sky target (typically 18 K, 25 K, 32 K) for comparison with the more accurate measurements performed at RCA level. In particular, noise temperature measurements are highly sensitive to the knowledge of the absolute effective temperature, front-end operation temperature, and radiometer linearity properties which were more accurately determined only at RCA level. While the detailed analysis of the instrument-level tests is still ongoing, our preliminary results indicate good match, within measurement uncertainty, with the RCA values for both noise temperature and isolation. The radiometer bandwidth was measured in three different ways: direct swept source tests at RCA level, from the noise spectra, and LFI modelling. Preliminary results show good consistency both in bandwidth and band shape. Taking into account the results of the noise temperature measurement, we arrive at a high degree of internal consistency and an expected sensitivity performance near the requirement level.

Then noise properties were evaluated through a series of integration tests, typically performed with sky and reference loads near 20 K. These tests were carried out with the full flight configuration (“Mode 5”), including quantisation,

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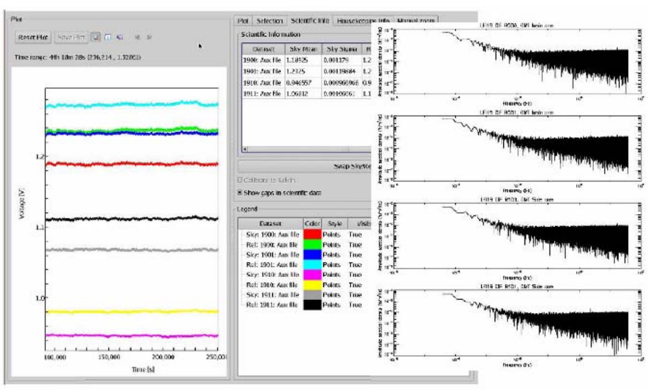
LFI Calibration *(continued from page 4)*

compression and decompression. Some of these tests used different phase switch configurations, and their comparison showed no measurable effect due to different phase switch choices. The most powerful noise stability verification came from an extended test comprising 71 hours of uninterrupted and undisturbed acquisition in nominal conditions. In Figure 5 we show an example of raw data and power spectra for a 42-hours subset of such test for a particular RCA. Note that the 8 data streams are the undifferenced “sky” and “reference” signals of each RCA diode, while the power spectra refer to the differenced “sky-reference” signals as will be used in-flight. The measured knee frequency is at the 10 mHz level, and is typical of all LFI channels. This excellent radiometer stability confirms our understanding developed in the past several months that the knee frequencies measured in the 70 GHz RCA setup (typically at 100-150 mHz level) were actually upper limits mainly dominated by thermal instability of the input loads. The measured radiometer stability, at a level surpassing the scientific requirement, has important beneficial scientific impact.



Screenshots of the LFI processing software, showing the detector timelines and the related noise frequency analysis plots.

The last set of tests before warm up was dedicated to thermal/electrical susceptibility tests and to the characterisation of the focal plane unit thermal damping. This test, in particular, aimed at the verification of the dynamic thermal model which was used in the past to derive the main temperature stability requirements of the LFI 20K stage. Results confirm model predictions and indicate, moreover, a slightly larger-then-predicted thermal damping (which is beneficial from the point of view of thermal stability) likely to be determined by contact resistances not accounted for in the model. Soon after cooldown, we identified an anomalous behaviour in two of the twenty-two LFI radiometers: one at 70 GHz and one at 44 GHz. A series of diagnostic tests, carried out with the essential participation of our colleagues in the Finnish and UK teams, allowed us to precisely identify the origin of the problem and to fix them just after warm-up in record short-time (<1.5 days). The expected performance recovery for the affected 70 GHz radiometer is 90% and for the 44 GHz radiometer 100%. The final tests performed before delivery confirmed full instrument functionality.

HFI Activities

J.L. Puget

Most of the HFI instrument was delivered to Thales-Alenia Space (formerly Alcatel Space) in Cannes at the end of 2006, following the ground calibration campaign at IAS in June and July 2006. The performances of the instrument are excellent, for more details see the contribution by J.-M. Lamarre, F. Pajot, and coworkers in this Newsletter. The cryogenic chain of the HFI is one of the most critical items. Only one of the 3 active coolers, the ^{3}He-^{4}He dilution cooler, was used during the calibration in the Saturne 2K chamber at IAS. The Saturne chamber provided a 1m diameter optical plate and a fully representative HFI environment in terms of background radiation and Focal Plane unit interfaces.

The Sorption Cooler, providing the 20K stage and built by the Jet Propulsion Laboratory in California, was delivered and integrated with the satellite early this year.

The 4K cooler flight model was also delivered to Cannes, but the Drive Electronics as well parts of the 4K cooler piping needed to be modified or rebuilt. Some of the elements delivered in Cannes and used for the system tests are not the final ones.

A potentially serious problem was identified during the additional tests of the 4K cooler at RAL on the spare compressors. A very thorough analysis of this problem was conducted by the UK teams (RAL and Astrium) and a recovery plan agreed by the Herschel Planck project and HFI management. The concerned 4K elements will be replaced by modified ones in the unit presently integrated into Planck, without introducing a significant delay in the program.

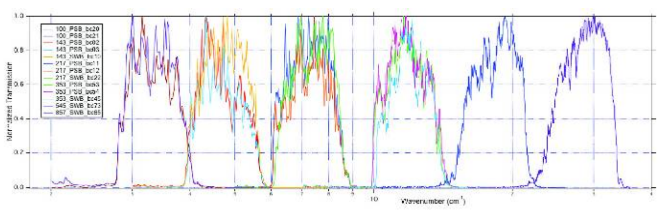
The full cryogenic chain has been tested at CSL in Liege with the CQM. The FM will test the Planck cryogenic chain with the flight elements. The performances measured on the HFI focal plane unit and the in the subsystem tests for the 20K and 4K coolers show that the cooling chain has very good margins and that we will probably be using the minimum flow of ^{3}He and ^{4}He for the dilution cooler allowing four sky surveys to be carried out (the nominal mission is 2 surveys). this will improve the signal to noise but will increase the redundancy, which is excellent for the Planck data analysis.

All systematic effects identified during the various tests campaigns are now being included in a major simulation of one year of HFI data with all detectors which will be ready in September and will be used extensively in the coming year to test the FM pipelines which will be the one used at the beginning of the mission one year from now. We will then improve the pipeline following the in flight performance verification phase and during the surveys.

HFI meets the goal performances

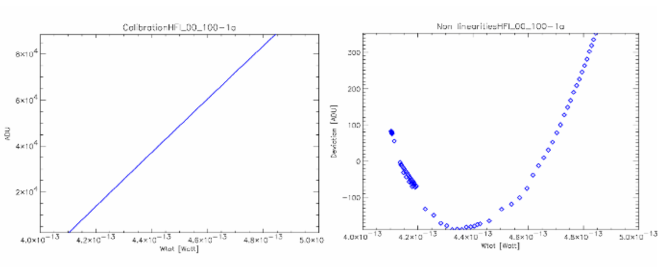
J.-M. Lamarre, F. Pajot, and the HFI teams

Characterizing and calibrating the integrated HFI was both a challenging and exciting experience for the Instrument Development Team. They had to operate the proto-flight model with its 52 bolometers mounted in the “Saturne” calibration system, which was complemented with the external spectrometer and light sources. A complex architecture of computers controlled both the HFI and the calibration setup, and acquired synchronized data from the two systems. The Real Time and Quick Look Analysis software were used extensively for the assessment of the data. With this set-up, the performances of the HFI as a system could be verified for the first time. The IDT was able not only to measure the responses of all channels, but also to test the interactions between critical subsystems, such as the dilution cooler, the active temperature control loops, and the bolometers. An impressive number of measurements were performed in a few weeks of nearly continuous operation. The picture emerges of HFI with excellent performances.



Spectral transmission measured for one channel (SWB and PSB) of every HFI band.

The dilution cooler performed according to the best expectations. It produced well-stabilized temperatures below 100 mK with gas flows that guarantee at least three full sky surveys. The required temperature stability was achieved for this stage as well as for the 1.6 K and 4 K stages. This means that the impact of temperature fluctuations will remain well below the detector noise at all frequencies higher than the satellite spin frequency. This is an excellent example of our learning process: we learned how to use most efficiently the complex subsystems; we demonstrated that the system meets our expectations, and we came out with accurate and sophisticated models of the instrument performances. This is also true for other aspects of the HFI performances, e.g. for the linearity determination of the measurement chain.

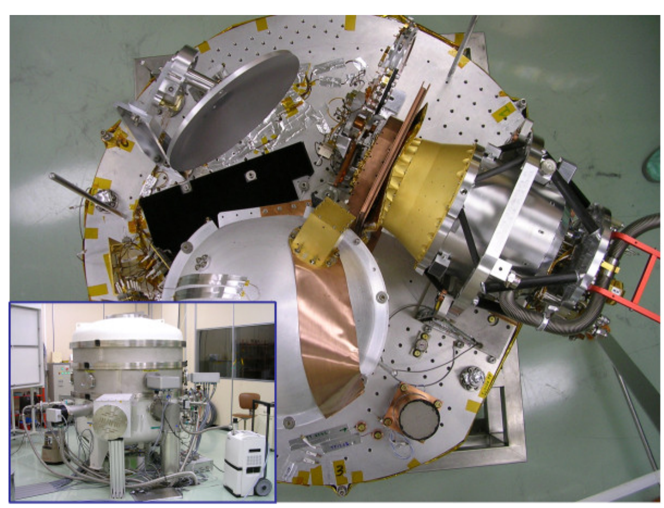


Response of a 100Ghz bolometer (left). Deviation from linearity (right) is less than 1% for a change of 20% of the optical power.

The measured sensitivities of the 52 detection chains are fully consistent with the goal performances announced in the “Bluebook”. The in-flight sensitivities depend also on some unspecified parameters, such as the temperature and the emissivity of the telescope, or unknown systematics. In any case, presently everything indicates that the goal sensitivities or better will be reached in most channels. The performances are stable for a wide range of settings of the readout electronics. This stability will facilitate the tuning procedures during the CPV phase at the beginning of the mission.

Among all calibration parameters measured for each channel and detailed in the 27 sections of the calibration report, two important parameters showed unexpected behaviour. The time response was found to be more complex than initially expected, in particular the low frequency response (LFR). A detailed complementary measurement of the LFR will be made during the thermal test at CSL in Liège. The orientation of the polarisation sensitive bolometers (PSBs) was difficult to measure due to internal multiple reflections, which could not be suppressed. The uncertainty of this measurement is above the maximum required value, despite important and talented efforts in the processing of the data. Checking these polarisation parameters and improving their accuracy will be an important task of the in-flight calibration. All other parameters were well inside the expectations and the requirements.

The delivered HFI instrument is a collection of many new devices and principles in an innovative architecture. Its sensitivity will be limited mainly by the statistical fluctuations of the measured radiation itself, as projected 14 years ago from audacious extrapolations. The teams that have operated the instrument and reduced the data have learned how to do so and how to work together. They now form an essential part of the HFI core team. They have also developed an instructed set of models that represent the process in which the instrument transforms photons into data. This provides essential support to the operation and data processing teams.



The Saturne tank at IAS provided the environment needed for the operation of HFI and calibration sources.

Planck work in Grenoble

Daniel Santos (LPSC)

The contribution of the "Laboratoire de Physique Subatomique et de Cosmologie" (LPSC), a CNRS/ IN2P3/ UJF/ ENSPG laboratory in Grenoble, to Planck covers development of on-board hardware and software tools for data analysis. The LPSC has developed two electronics that are used to control the 20K Sorption Cooler (JPL/NASA) and the 0.1K Dilution Cooler (CRTBT/CNRS - Air Liquide).

The Sorption Cooler Electronics (SCE) has been designed by the LPSC, with the final development and manufacturing done in cooperation with CRISA/ASTRIUM. The electronics, based around a space qualified DSP, is directly connected to the spacecraft processing unit through a MIL-STD-1553 communication bus. It contains the sequencing of the Sorption cooler compressors, the power distribution system (Sorption Cooler power consumption can be up to 550W), high precision temperature (up to 10mK resolution) and pressure measurement, defrosting and temperature regulation of the cold end. The Sorption Cooler is used by both HFI and LFI instruments. To avoid a major single point failure of the system, it has been decided to install two sorption coolers and two SCE on the Planck satellite.

The Dilution Cooler Electronics (DCE) unit has been entirely designed by the LPSC electronics department, which was also responsible for the manufacturing of this unit. The DCE is part of the Dilution Cooler, a sub-system of the HFI instrument. The DCE is used to control the He^3 and He^4 flow by operating 12 latch valves, to inform the instrument on the status of the system (valve status, readout of 6 pressure transducers and 14 temperature sensors) and to defrost He lines if needed (8 heaters, thermo-regulated by the DCE). The HFI processing unit communicates with the DCE core (an Actel FPGA) by means of a RS422 type serial link in order to send commands (valve opening/closing, line defrost) and to receive housekeeping data.

The on-board software in the SCE controls the sequencing of the sorption cooler compressors and takes care of the safety of the cooler. The software includes a complex fault detection and recovery process module and handles the communication with ground by receiving tele-commands and sending sorption cooler parameters in the form of housekeeping telemetry. At the receiving end, we are involved in the Real Time Analysis of the SCE data and the building of the data files compatible with SCOS2K (MIB)

The Sorption Cooler has many different functioning modes and mode transitions are managed by the software. This software has been developed in collaboration with the JPL team. We are involved in the HFI Core Team and Level2. We take advantage from the expertise from Archeops – which was a balloon experiment with detectors, cryogenics, electronics and pointing strategy close to the HFI characteristics. In particular, we are in charge of most of data handling issues at the TOI level: from the raw time-stamped to time-ordered data, cleaned, as much as possible from instrumental systematic effects. Therefore, we provide the detector signal after gain correction, glitch flagging, time constant deconvolution, filtering of parasitic signal induced by the 4K cooler and other useful processing steps. As a continuity of the development of the hardware of the 20 K and 100 mK stages, we also work on de-correlation of thermal effects induced by small variations in the temperature of different parts of the instrument. These sources of systematic effects are all in the time-domain and not linked to the sky. They act at very different time scales: ranging from milliseconds for a short glitch, to perhaps months for a gain drift. Special care must also be taken of the PSB, as any systematic effect residuals on only one of the two bolometers would appear as a polarized signal.

The pre-processing pipeline has been successfully applied to Level-S data within the HFI Development Model. One year of data for one bolometer is processed on a bi-processor in about half a day wall-clock time (cumulated input/output and CPU times). The Instrument Model Database (IMO) is partly developed in Grenoble. This file contains few thousand parameters describing in detail a simplified representation of the instrument needed for data processing.

Naturally, we participate in the Planck scientific working groups, allowing easy and efficient communication between studies of systematic effects and effective data handling.

CNRS: Centre National de la Recherche Scientifique
IN2P3: Inst. Nat. de Phys. Nucléaire et Phys. de Particules, Paris
UJF: Université Joseph Fourier, Grenoble
ENSPG: Ecole Nationale Supérieure de Physique de Grenoble
CRTBT: Centre de Recherche de Très Basses Témperatures. (Grenoble)
JPL: Jet Propulsion Laboratory (Pasadena, CA -USA)

The Planck Legacy Archive

Jan Tauber

The final data products of Planck will be delivered by the LFI and HFI DPCs to ESA about 43 months after launch. These products will then be distributed to the scientific community via an online Archive developed by ESA along the lines of its existing and planned archive infrastructure (see the e.g. ESAC Archives). This Archive is referred to as the Planck Legacy Archive, or PLA for short. The development of the PLA will start at around the time of launch of Planck, and will offer the same range of functionnalities to its users as other astronomical archives at ESA.

Recently it has been agreed between ESA and the DPCs that a prototype of the PLA will be used to deliver intermediate DPC products to the Planck Collaboration during the proprietary period. For this purpose, the PLA will start as a simple "glorified ftp server", and gradually grow in functionalities throughout the operations and post-operations period.

Map Making Status

Charles Lawrence, and the CTP group

Starting in 2003, Planck Working Group 3 (the "CTP" group) undertook a comparison of mapmaking codes in increasingly realistic situations. We tested mapmaking codes of two basic types, "destripers", and "optimal" codes (sometimes called generalized least squares or GLS codes), written by various members of the Planck Consortia.

With the latest and most realistic round of simulations, called the "Trieste round" because the working meeting of the group for this round was held at the LFI DPC in Trieste, we come to the end of the period during which mapmaking code evaluation dominated the work of the CTP WG. For this round we used the Level-S simulations pipeline to generate 1-year intervals of simulated detector observations (time-ordered data streams, or TODs, the relevant sky emission (CMB, dipole, diffuse galactic foreground emissions, and the strongest extragalactic point sources) in both temperature and polarisation, plus a number of instrumental effects: correlated (1/f) and non-correlated (white) noise, symmetric/asymmetric detector beams, noise from sorption cooler temperature fluctuations, realistic nutation of the satellite spin axis, and fluctuations of the satellite spin rate.

Two characteristics of mapmaking codes are important. One is the *accuracy*, that is, how close a given code comes to recovering the input sky signal in the presence of noise and other mission and instrumental effects. The other is the *resources required*, that is, how much processor time, input-/output time, memory, disk space are required to produce the map.

It would be nice if accuracy could be maximized and resource requirements minimized in one and the same code. Unsurprisingly, this turns out not to be the case. The optimal methods, and the destripers that calculate offsets for the shortest intervals, produce slightly more accurate maps, while taking substantially greater computer resources. However, it is easy to imagine different regimes of mapmaking, with different requirements. On the one hand, for the Planck legacy maps, high-accuracy will be of paramount importance. Because such maps need be produced infrequently, the code can be quite demanding of resources if necessary. On the other hand, in the intermediate steps of the Planck data analysis (e.g, in systematics detection, understanding, and removal), we will switch frequently between TOD, map, and power spectrum domains. We also may need or benefit from Monte Carlo simulations to characterize the noise. For these purposes, speed and minimum resource use will be paramount.

Along the way, many problems with mapmaking codes were identified and fixed, and the machinery for performing simulations expanded greatly in capability. Even aside from the specific knowledge gathered on mapmaking, this legacy of the CTP WG will last a long time.

SGS Review

Damien Texier and René Laureijs

An Implementation Review of the Planck Science Ground Segment (SGS) took place in the November 2006 to March 2007 timeframe. The calling authority is the ESA Science Directorate and the outcome of the review will be used at higher-level reviews. This review follows the SGS Requirements Review and the SGS Design Review.

The objectives of the review were to assess the status of the implementation of the whole SGS at the present stage of the project. The SGS includes: the LFI and HFI Data Processing Centres (DPCs) including the Instrument Operations Teams (IOTs), the Planck Science Office (PSO), and their interfaces with the Mission Operations Centre (MOC). The main focus was on the activities related to the preparation for operations, e.g. Interfaces, Operations Plans, Integrations and Tests and implementation of the scientific pipelines.

Two panels reviewed the documents of the data package starting from November 2006 (about 60 documents to review plus of order 100 documents for reference). Following the findings raised by the panels, conclusions from the Board were made in a report available on Livelink. One of the conclusions was the need for a delta-review focusing on HFI and IDIS. This was held in May of 2007, and the resulting report is also available on Livelink.

The review board recognizes the fact that the Planck mission will lay down a legacy of observations of central importance for the whole of science. The board was impressed by the progress made since the Design Review where the implementation of the main recommendation – the separation of the SGS development into an SGS1 and SGS2 component – has been fully implemented. After the delta-review it became clear that the current status, plans, resources and schedule of all parties (PSO, LFI, and HFI) are compatible with SGS launch readiness.

One important concern of the board was the status of the preparations for the Planck Commissioning Phase (CP) and Calibration and Performance Verification (CPV) Phase. The board called for a clear coordination of these mission phases together with the construction of a "roadmap" outlining the activities leading to a complete and validated CP and CPV plan and timeline.

The board reinforces the importance of performing extensive End-to-End (EE) tests using realistic CMB simulations. The board recommended reviewing and agreeing on a prioritized list of functionalities to be implemented in the Level-S software, which should be in time for the upcoming Phase-2 EE tests. The SGS2 EE tests should have the highest priority among all SGS2 items.

It was also decided during the delta-review to bring forward the development of the Planck Archive at ESAC in order to be used during operations by the Planck Consortium.

LFI DPC Pipeline Operation Model and Test

F. Perrotta, D. Maino, A. Zacchei

In order to guarantee the best performance of the OM (Operation Model) software integrated at the LFI-DPC, it is necessary to perform a number of tests aimed to scientifically validate the pipeline. Some of these tests have been already performed with the Demonstration Model pipeline using a set of simulated data for all the 70 GHz LFI detectors. However, due to limitation in size of the machine available at that time, data were compressed. For the OM 0 we expect to run tests at full resolution for all the frequency channels starting from the 30 GHz which fits into the current available machine.

Here we will present the planning for these test with the scope to be compliant with the proposed end-to-end test.

The main scientific pipelines correspond to the SGS2 or, more in detail, to the operation level 2 (from raw TOI to calibrated frequency maps) and level 3 (from calibrated sky maps to component maps and CMB power spectrum estimation). We organize the software in the way the pipelines can be, in turn, divided into (almost) independent blocks, called "sub-pipelines", each dealing with a specific task. While each software module being part of a sub-pipeline has been tested as a single unit during its integration into the DPC framework, we are now in the process of testing the whole sub-pipelines. Members of the LFI-DPC have now started the pipeline testing process. Our approach proceeds in a "parallel" way: each sub-pipeline is, as a first step, tested individually, assuming the knowledge of necessary parameters, instead then using the parameter values coming from different sub-pipelines. The LFI-DPC members agreed on the institution of four main working groups, one for each branch of the pipeline, lead by DPC test responsible (F. Perrotta, INAF-OATS). They established the following tasks division for the testing process of the Operation Model version 0.

Instrument parameter reconstruction: this part of the pipeline is devoted to the computation of the "R" gain modulation factor for each detector and the most important parameters of the instrumental noise: the knee frequency and associated errors for each detector, the Noise Equivalent Temperature and associated errors for each detector. Coordinator of this working group is S. Leach (SISSA,Trieste).

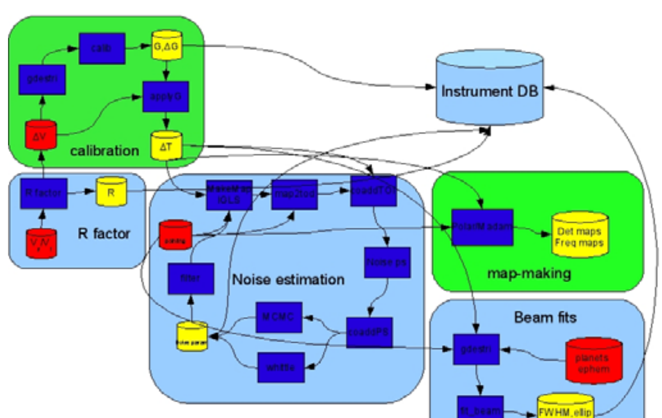
Pointing and beam reconstruction: the main objective of this sub-pipeline is to reconstruct the pointing of each detector given the pointing of the spacecraft. This is needed to get main beam patterns maps for each feed-horn. Furthermore, this allows to reconstruct the beam shape, observation of bright point-like sources. C. Burigana (INAF-IASF, Bologna) is responsible of the optical working group.

Calibration: the test has to demonstrate the ability of the DPC to carry out the photometric calibration of a detector. Given input sky data including total dipole variation, one has to determine the gain and offset in the conversion from instrument units to thermodynamics temperature. These tests are being performed under the direction of D. Maino (UNIMI, Milano).

Map Making: this part of the pipeline produces single channel and frequency maps, both for temperature and polarization. For each calibrated detector, individual maps can be obtained with the use of destriping algorithms. Maps are then coadded together with inverse noise weights. Map making algorithms are being tested under the direction of P. Natoli (Tor Vergata University, Rome).

The tests have to demonstrate the capability of the DPC software to produce scientifically meaningful sky maps. For this purpose, each subpipeline is characterized by key parameters, which are the quantities to be evaluated and which will undergo the pass/fail criteria of the test.

Input data for those tests are the results of simulations performed in the framework of the Level-S team: TODs have been produced for 12 months data (8784 rings) for the 30 GHz channel. Simulations concerning the others LFI channels will be produced according to the test group requests. The map making MADAM algorithm is now being tested, with diffuse signal plus noise, and assuming the dipole has been exactly subtracted. The results will be compared soon with runs of MADAM on noiseless maps. The optimal map-making code ROMA is being installed on CINECA and first results of the tests will soon be available, as for the other subpipelines. After so many years of team work, from the start of the development of the instrument until its delivery to ESA, it is nearly impossible to acknowledge, thank, and congratulate all the talented and dedicated people in the Consortium and our industrial partners. The LFI agenda is now already crowded with activities to complete the FM analysis and to prepare for the Planck System Level Tests, the CPV phase, and to support to data analysis.



The Planck-LFI DPC OM-0 pipeline

Participants waving at the photographer before the consortium meeting dinner at the palace Hotel d'Assezat in Toulouse.

The Planck Joint Consortium Meeting 2007

R. Laureijs

The Centre de Congrès Pierre Baudis in Toulouse served as the ideal setting of the Planck Consortium Meeting 2007. More than 200 scientists of the Planck consortia convened to hear about the status of the Planck mission, the instruments, and the progress made by the scientific Working Groups. The congress centre provided excellent accommodation for both the plenary and the splinter sessions as well as restaurant facilities for lunch.

The focus of this year's meeting was the preparation of the Planck core proposals. Versions of the proposals have been sent to the Planck Science Team before the meeting. Besides the status reports, the plenary sessions included reports on the proposals lead by each working group as well as the proposals led by the Planck Science Team. During the meeting, details of many proposals were displayed in posters. A glimpse of the full scope of the Planck scientific output was provided, and many key papers are envisaged. Of equal importance is the growing awareness of the amount of work to be carried out in the upcoming period before and after launch before the science can be published. The discussion how to prepare for this in terms of organisation and guidance from the Planck Science Team was kicked-off during the last plenary session of the meeting. See also the related contribution by Jan Tauber on this page.

Special attention was given to the polarisation calibration for both instruments. It became clear that envisaged the in-flight calibrations supported by ground campaigns still need serious considerations to ensure that the accuracies are obtained required for a successful analysis of the data.

The local organising committees is thanked for their excellent organisation of the consortium meeting providing the right atmosphere for the many discussions and interactions among the scientists. The invitation by the mayor of Toulouse to visit to the Toulouse City Hall formed the highlight in the social programme. The outstanding web site (and web-cast) dedicated to this meeting provided all necessary information and enabled a smooth handling of all possible organisational issues.

The Scientific Core Programme

J. Tauber

As Planck comes closer to launch, it becomes necessary to organise in detail the plans for the scientific exploitation of the Planck data during the proprietary period. The body of science that will be carried out during this period is referred to as the Scientific Core Programme of Planck.

To start the process of organising this work, a Call for Proposals was issued to the Planck Collaboration in late March, soliciting science cases and work plans to be submitted by 15 May. The proposals, which can be downloaded from Livelink, describe the work leading to papers in three categories:

- Those describing the official Planck data products
- Those dedicated to CMB-based cosmology
- Those dedicated to non-CMB-based science.

In total 51 submissions were received, proposing an imposing number (>100) of scientific papers to be written during the proprietary period. This is an impressive but very ambitious plan, which will require careful organisation to optimise the resources available and to ensure that all the papers are of consistently high quality. The first look at the complete set of proposals took place at the recent Joint Consortium meeting in Toulouse. It is clear that all of the work areas are closely linked.

The big task which lies ahead is to create from all the proposals a coherent system of interrelated projects and associated working teams, which is able to gather efficiently all the data needed (both Planck and non-Planck) for each area, analyse it thoroughly, and feed back the results to the DPCs (which are responsible to produce the official products) and to the other working teams. This system will have to work under high pressure as the proprietary period is limited, and so are the resources available !

The Planck Science Team expects that by the end of 2007, it can propose to the whole Planck collaboration such a structure, which needs to be a solid starting point, even though it will certainly evolve through the life of the mission

Recent Planck-related Publications

- ◊ F. Atrio-Barandela, J.P. Muecket "Contribution of the Intergalactic Medium to Cosmic Microwave Background Anisotropies" astro-ph/0601424
- ◊ Efststhiou, G. Janaury 2006 "Hybrid Estimation of CMb Polarization Power Spectra", astro-ph/0601107
- ◊ M. Maris, C. Burigana, S. Fogliani "Zodiacal Light Emission in the PLANCK mission" astro-ph/0603048
- ◊ J.-B. Melin, J. G. Bartlett, J. Delabrouille "Catalog Extraction in SZ Cluster Surveys: a matched filter approach" astro-ph/0602424
- ◊ M.-A. Miville-Deschenes, F. Boulanger, P. G. Martin, F. J. Lockman, W. T. Reach, A. Noriega-Crespo "Dust in High-Velocity Clouds : relevance for Planck" astro-ph/0608655
- ◊ Michele Maris, Carlo Burigana, Sandro Fogliani. "Simulating the Zody Emission in the Planck Mission" Proceedings of International Conference on CMB and Physics of the Early Universe, Ischia, Italy, 20-22 Apr 2006 astro-ph/0607439
- ◊ Martin White "cosmological science enabled by Planck" Proceedings of the UC Irvine conference on cosmic microwave background temperature and polarization anisotropies astro-ph/0606643
- ◊ M. A. J. Ashdown, C. Baccigalupi, A. Balbi, J. G. Bartlett, J. Borrill, C. Cantalupo, G. de Gasperis, K. M. Gorski, E. Hivon, E. Keihanen, H Kurki- Suonio, C. R. Lawrence, P. Natoli, T. Poutanen, S. Prunet, M. Reinecke, R. Stompor, B. Wandelt Making sky maps from Planck data Submitted to A&A astro-ph/0606348
- ◊ M. Lopez-Caniego, D. Herranz, J. Gonzalez-Nuevo, J. L. Sanz, R. Barreiro, P. Vielva, F. Argueso, L. Toffolatti "Comparison of filters for the detection of point sources in Planck simulations"Mon.Not.Roy.Astron.Soc. 370 (2006) 2047-2063
- ◊ Fabio Noviello, Vladimir Yurchenko, Jean-Michel Lamarre, John Anthony Murphy "PTD vs. PO effects in power and polarisation of PLANCK HFI 100 beams" Accepted for publication in PoS, CMB and Physics of the Early Universe, International Conference, Ischia, Italy, April 2006 astro-ph/0606122
- ◊ Cédric Pahud, Andrew R Liddle, Pia Mukherjee, David Parkinson "Model selection forecasts for the spectral index from the Planck satellite" Phys.Rev. D73 (2006) 123524
- ◊ The Planck Collaboration "The Scientific Programme of Planck" astro-ph/0604069
- ◊ M. Maris, C. Burigana, S. Fogliani "Zodiacal Light Emission in the PLANCK mission" Submitted to A&A astro-ph/0603047
- ◊ Bjoern Malte Schaefer; Matthias Bartelmann "Detecting Sunyae Zel'dovich clusters with PLANCK: III. Properties of the expected SZ cluster sample" submitted to MNRAS, 16.Feb.2006 astro-ph/0602406
- ◊ Amedeo Balbi "Cosmology from Planck" Proceedings of the Francesco Melchiorri Memorial Conference (Rome, Italy, April 12-14 2006). To appear in New Astron. Rev astro-ph/0612720
- ◊ X. Dupac "Cosmology from Cosmic Microwave Background fluctuations with Planck" "Challenges in particle astrophysics" conf. held in Hanoi, Aug. 2006 astro-ph/0701523
- ◊ Amit P. S. Yadav, Eiichiro Komatsu, Benjamin D. Wandelt "Fast Estimator of Primordial Non-Gaussianity from Temperature and Polarization Anisotropies in the Cosmic Microwave Background" astro-ph/0701921
- ◊ M.A.J. Ashdown, C. Baccigalupi, A. Balbi, J.G. Bartlett, J. Borrill, C. et al. " Making Maps from Planck LFI 30GHz Data" astro-ph/0702483
- ◊ E.M. Waldram, R.C. Bolton, G.G. Pooley, J.M. Riley "Some estimates of the source counts at Planck Surveyor frequencies, using the 9C survey at 15 GHz" astro-ph/07061182
- ◊ Erik Elfgren, Francois-Xavier Desert, Bruno Guiderdoni "Dust Distribution during Reionization" astro-ph/07053403
- ◊ Steven Gratton, Antony Lewis, George Efstathiou "Prospects for Constraining Neutrino Mass Using Planck and Lyman-Alpha Forest Data" astro-ph/07053100
- ◊ A.R. Taylor et al: "Radio Polarimetry of the ELAIS N1 Field: Polarized Compact Sources" astro-ph/07052736
- ◊ A. Friedland, K.M. Zurek, S. Bashinsky "Constraining Models of Neutrino Mass and Neutrino Interactions with the Planck Satellite" astro-ph/07043271
- ◊ A. Amblard, A. Cooray "Anisotropy studies of the unresolved far-infrared background" astro-ph/0703592
- ◊ J. Aumont "Blind MC-MC component separation for polarized observations of the CMB with the EM algorithm" astro-ph/0703260
- ◊ M. Negrello et al. "Astrophysical and Cosmological Information from Large-scale sub-mm Surveys of Extragalactic Sources" astro-ph/0703210
- ◊ A.P.S. Yadav, E. Komatsu, B.D. Wandelt "Fast Estimator of Primordial Non-Gaussianity from Temperature and Polarization Anisotropies in the Cosmic Microwave Background" astro-ph/070192

Planck Scientists 2007

Below is the list of Planck Scientists updated to include all contributions up to the end of 2006.

Ade
Aghanim
Ashdown
Baccigalupi
Balbi
Banday
Banday
Barreiro
Bartelmann
Battaner
Benabed
Bennett
Benoit
Bernard
Bersanelli
Bhatia
Bock
Bond
Borrill
Bouchet
Bradshaw
Burigana
Butler
Cabella
Cantalupo
Cappellini
Cayon
Challinor
Chiang
Christensen
Church
Clements
Couchot
Crill
Cuttaia
Danese
D'Arcangelo
Davies
Davis
De
Bernardis
de Gasperis
De Zotti
Delabrouille
Desert
Doerl
Dolag
Dupac
Efstathiou
Ensslin
Finelli
Fogliani
Fosalba
Franceschi
Gaier
Ganga
Giard
Giardino
Giraud-
Heraud
Gorski
Gregorio
Gruppuso
Haissinski
Hansen
Harrison
Hazell
Hell
Henrot-
Versille
Hivon
Hobson
Holmes
Hovest
Hoyland
Hughes
Jewell
Jukkala
Keihanen
Knox
Kurki-Suonio
Laaninen
Lagache
Lahteenmaki
Lamarre
Lange
Lasenby
Laureijs
Lawrence
Leahy
Leroy
Levin
Lilje
Linden Vornle
Lubin
Maffei
Maino
Mandolesi
Maris
Martinez
Gonzalez
Masi
Matarrese
Matthai
Mazzotta
Meinhold
Mendes
Mennella
Miville-
Deschenes
Moneti
Montier
Morgante
Morisset
Mortlock
Munshi
Murphy
Nartallo
Naselsky
Nati
Natoli
Norgaard-
Nielsen
Novikov
Paine
Pajot
Paladini
Partridge
Pasian
Perdereau
Piacentini
Piat
Pierpaoli
Platania
Popa
Poutanen
Prunet
Puget
Rebolo
Rees
Reinecke
Renault
Riller
Ristorcelli
Rocha
Rohlfs
Rosset
Rubino Martin
Salerno
Sandri
Santos
Sanz
Scott
Seiffert
Sjöman
Smareglia
Smoot
Stolyarov
Stompor
Stringhetti
Sudiwala
Sygnet
Tauber
Terenzi
Toffolatti
Tonazzini
Torre
Tuovinen
Valenziano
van
Leeuwen
Varis
Vielva
Villa
Vittorio
Vuerli
Wade
Wandelt
White S
White M
Wilkinson
Woodcraft
Yurchenko
Yvon
Zacchei

Press Event

At a press event organised by ESA and Thales Alenia Space in January 2007, George Smoot, one of the two 2006 Physics Nobel Prize winners and a long-standing member of the Planck Collaboration, had the opportunity to inspect the Planck hardware. Congratulations George for a well deserved prize !

About the Authors

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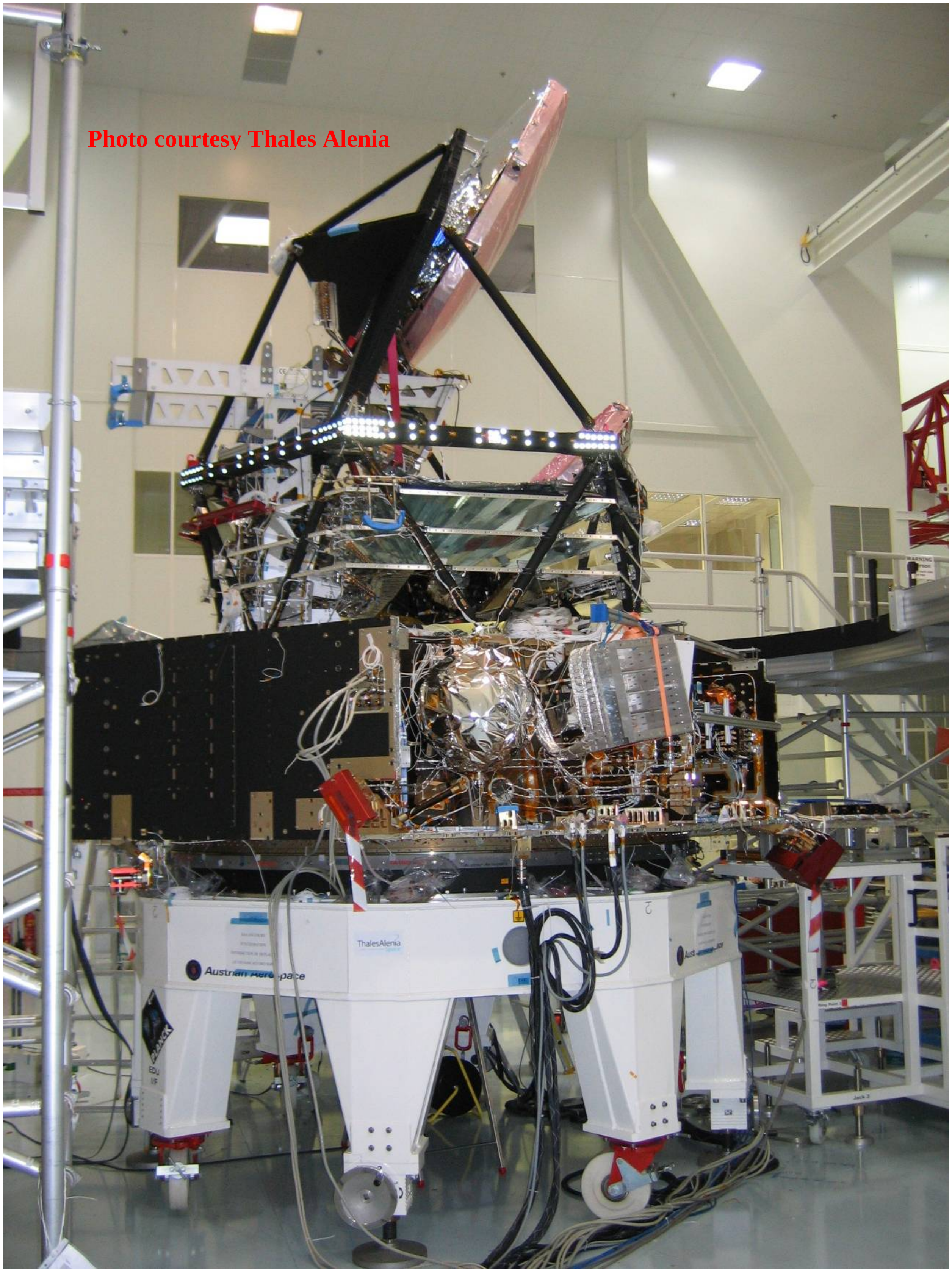
Editor: R.J. Laureijs, J. Tauber (PSO/ESA)
As usual, if you have any feedback on this issue, or would like to propose contributions for forthcoming issues, please contact us directly at jtauber@rssd.esa.int.



On 27 June 2007, the integration scaffolding was temporarily opened and the Thales team took this opportunity to take the first photographs of the Planck Flight Model in the integrated configuration.