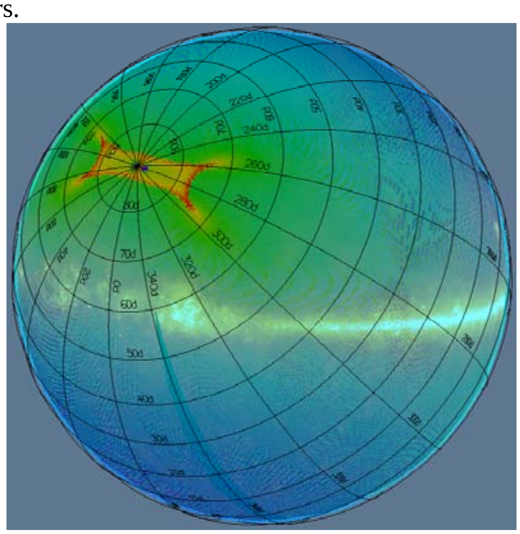
The PLANCK Newsletter

Issue 8 — *Information and news for the Planck community* — March 2006

Defining the Planck Baseline Scanning Strategy

J.-Ph. Bernard, C. Burigana, R. Paladini, X. Dupac, B. Cappellini and the Planck WG9 team

Over the past 9 months, WG9 (scanning strategy working group) has been working towards defining a new baseline scanning strategy for Planck, as requested by the Science Ground Segment Design Review of January 2005. We have considered the generic strategies described in Dupac & Tauber 2005 (A&A 430, 363) and based the analysis on hit count maps and angle distribution maps provided by these authors.



Map of the hit counts for the baseline scanning strategy, superimposed on the IR sky (here IRAS 100 micron). The grid shows ecliptic coordinates.

Methodology

The respective merits of each possible strategy were evaluated with respect to operational constraints imposed by satellite operations, and instrumental constraints imposed to obtain the best possible data quality. The considered operational constraints can be summarized as follows:

•Sun constraint: The spin axis of the satellite must remain within 10° from the satellite-Sun direction in order to keep the Planck payload in the shadow cone of the solar array.

•Telemetry constraint: The spin axis of the satellite must remain within 15° from the satellite-Earth direction, to ensure a good telemetry rate through the medium gain antenna.

•Limit on microslews: Except for exceptional gap recovery operations, systematic use of dwell time shorter than 30 minutes should be avoided in order to save fuel.

•Survey margin: handling small gap recoveries requires a

>>> *Continues on page 2*

All the flight hardware has been built

J. Tauber

2005 has been such a busy year that 2006 has come upon us almost unnoticed. Not too long ago, this would have meant that the Project was barely one year from launch. However, a number of development problems have caused unavoidable delay in the launch date. Recently it has become clear that Herschel and Planck cannot launch before February of 2008. This is anyway very, *very* soon !

Since the last Newsletter a number of important events have taken place (many of which are reported in more detail elsewhere in this Newsletter):

- The Planck qualification model satellite was assembled, and underwent cryogenic testing at a facility in the Centre Spatial de Liège. This model was almost fully representative of flight (the only significant pieces missing being the LFI, the sorption cooler compressors, and the reflectors). The tests validated crucial design aspects of Planck, in particular the passive thermal cooling; and were the first time the whole cryo-chain was operated. I am glad to say that the campaign was a resounding success, in spite of initial major problems, and thanks to the herculean efforts of many individuals in industry and instrument teams. This was a major milestone in our development programme.
- In parallel, the LFI QM instrument-level test campaign was being carried out on the premises of Laben in

>>> *Continues on page 2*

INSIDE THIS ISSUE

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All the flight hardware has been built

-continued from page 1

Italy. This was successfully completed and provided a solid basis for the upcoming tests of the flight model.

- In the last half-year, both the LFI & HFI flight detector chains were fully characterized and subsequently delivered for assembly into the flight instruments. Many problems were resolved along the way, and both instrument teams have made huge efforts to provide the best possible performances.
- The telescope reflector characterisation is now almost finished. This activity has faced serious technical issues and the whole verification approach has had to be significantly adapted.
- More lately testing of the Radio Frequency Qualification Model has started at a Compact Antenna Test Range facility in Alcatel Space. This model consists of an RF-representative payload module including feedhorns, focal plane, telescope, and large reflecting structures, and will allow us to understand the fidelity with which we can predict the in-flight optical behavior of Planck.
- The flight Service Module of Planck has been assembled, tested, and has been delivered by Alenia Spazio to Alcatel.

As you can see from the above highlights, all of the flight hardware now exists, major modules of the flight satellite have been assembled, and all qualification campaigns have been completed.

In the next year, the completely assembled flight satellite will materialize and be tested. Specific milestones that you can look forward to in the near future are:

- A “PFM1” model will be tested in March-April at the Centre Spatial de Liège. This model includes the complete sorption cooler unit and in this test its operation in flight conditions will be validated.
- The behavior of the complete flight telescope at cryogenic temperatures will be characterized using videogrammetry around June at Estec.
- The instrument flight models are expected to be delivered to ESA in the June-July timeframe. They will then be mated to each other, integrated into the satellite, leading to final functional, environmental and cryogenic testing. The major cryogenic test campaign is planned to start around May 2007.

As we come closer to launch, the Ground Segment will also start to figure more prominently in the development; currently all interfaces are well defined, and test plans are under elaboration.

In parallel to all the infrastructure developments, we must also think in more detail of the scientific exploitation of the Planck data during the proprietary period. The Baseline Core Programme established in 2001, and which formed the basis for the “Bluebook”, will have to be revisited and updated as needed. For this purpose a proposal process similar to the one of 2001 will be started by the Science Team probably in the autumn of 2006, aiming to the establishment of the Core Programme by early 2007.

More information on all of these topics will be available at the Joint Consortium meeting to be held in Ischia between
Clearly an exciting year ahead of us with a lot of work in all areas !

The Baseline Scanning Strategy

- continued from page 1

margin in the trailing direction of the Sun constraint. The selected strategy should therefore stay away from the Sun constraint limit on this side.

•Orbit manoeuvres: The spin axis of the satellite should be within about 6° from the satellite-Sun direction at the time of orbit correction manoeuvres which will take place about once a month, in order to correct for accumulated perturbations. Unlike the others, this constraint is a soft one, since it can be overcome at the expense of additional slews before and after orbit manoeuvres if necessary.

The merits of each scanning strategy were also evaluated with respect to the possible influence of external straylight, thermal stability of the spacecraft and instruments, availability of the largest possible dipole signal for calibration purpose, and the availability of over integrated Deep-Fields. The analysis were performed assuming an Aug 2007 launch, but robustness against changes in launch date was checked.

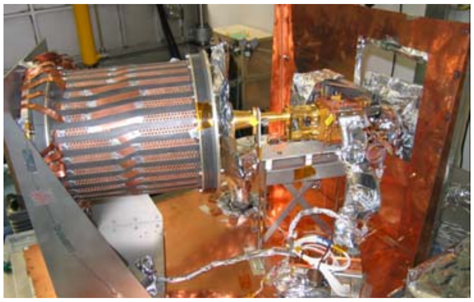
Selected scanning strategy baseline

In order to minimize solar aspect angle variations during the mission, a cycloidal precession has been selected. The Planck spin axis slowly rotates on a circle around the anti-Sun direction, which travels along the ecliptic plane. This scanning pattern produces Deep Fields (DFs) near the ecliptic poles, see figure. Very short precession periods of the cycloid violate the limit on microslews. We have chosen a period of 6 months, because shorter periods violate telemetry constraints for some launch dates. The selected amplitude of the precession is 7.5°, which is the minimum amplitude allowing full sky coverage at all Planck frequencies. The precession direction was chosen in such a way as to remain within telemetry constraints at all times. Finally, the phase of the cycloidal motion (defining where on the circle is the spin axis at any given date) is a compromise between several instrumental constraints, in particular the need for sufficient dipole calibration signal at all time during the mission, the impact on the accuracy of the anisotropy power spectrum and the availability of regions as clean as possible from foreground contamination in the DF regions.

Towards the LFI Flight Model

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

The LFI Instrument-level Qualification Model testing was completed in the summer 2005. The results are summarised in Mennella et al (PL-LFI-PST-AN-005) after a detailed analysis of the data. The LFI QM included four of the eleven radiometer chain assemblies (RCAs) foreseen for the flight instrument. Two of them, at 30 and 44 GHz, were integrated and tested at Alcatel Alenia Spazio (AAS), Milano, and two, both at 70 GHz, in Elektrobit/Millilab, Finland. The instrument-level QM campaign was carried out at AAS-Milano in the LFI cryofacility. The facility contains single-stage coolers at 25 K and 12 K producing a 40 K radiative environment, 20 K front-end units and reference loads, three intermediate stages simulating the three V-grooves and the 300 K back-end and warm electronics. The radiometric performance verification of the QM covered the bulk of the tests foreseen for the flight model, and included functionality tests of the radiometers and cryochamber, RCA tuning verification, performance tests and characterisation of thermal and electrical susceptibilities. The QM calibration campaign turned out to be a challenge, as for the first time a number of hardware and software sub-systems were interfaced in a complex cryogenic environment. In spite of some difficulties and limitations, the QM campaign led to a higher level of confidence in the various subsystems and in the definition of a consolidated test procedure, which is essential in view of the FM. A further major achievement was the agreement obtained for the radiometric properties as measured at instrument level and at RCA level.



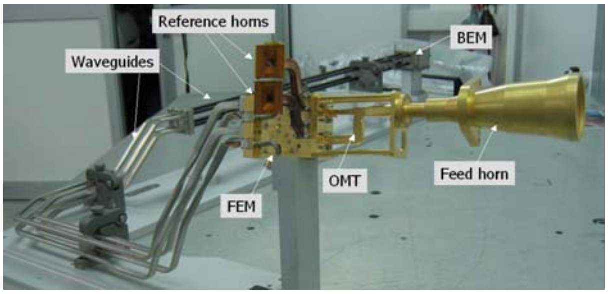
A detail of the AAS test setup for the FM cryo testing of the 30 and 44 GHz radiometers. On the left is the new sky load that will be used for the RCA flight campaign. In the center the radiometer front-end is visible (including feedhorn, OMT and Front-end receiver) of the radiometer under test.

The development, integration and testing of the FM radiometers have been done in parallel. Four of the six FM 70 GHz RCAs (complete with feed-horns, OMTs, front-end modules, waveguides, back-end modules) have been integrated and fully tested in the Elektrobit RCA cryofacility. The RCA test setup and sequence were only slightly modified taking into account the lessons learnt during the RCA QM campaign. Both at Elektrobit (70 GHz) and at AAS-Milano (30 and 44 GHz), the FM RCA setup uses as control and acquisition system a flight-like data acquisition electronics unit, ("DAE Breadboard") produced by AAS: this allows to test RCA-DAE interfaces in advance, before integration in the FM instrument. For two of the 70 GHz FM radiometer chains the calibration data have been analysed, showing performances close to the requirement. These two RCAs were already delivered to AAS for integration in the FM model. Performance testing of the remaining 70 GHz RCAs is underway and completion is foreseen in March.

In parallel, all the FM radiometer units at 30 and 44 GHz have been produced and tested at unit level. Early testing of the 30 GHz back-end modules showed evidence of instabilities in the measured output voltages: this triggered a dedicated investigation which led to the successful identification and fix of the problem. The first 44 GHz and 30 GHz RCAs have been integrated at AAS-Milano. The RCA cryofacility has been improved after the QM campaign, in particular by changing the orientation of the 4K cryocooler in order to optimise low-temperature and stability performance. In parallel, activity is already ongoing at AAS for the integration and testing of the LFI FM at instrument level. Both the DAE and the REBA hardware are nearly ready for integration in the FM. The in-flight software has also been qualified.

An upgrade of the LFI "large" (instrument-level) cryofacility is foreseen in view of the FM testing, to better support scientific performance tests. In particular, improvements in the thermal link to the LFI focal plane unit combined with an increase of cooling power of the 20K stage are expected to yield the nominal 20K in the front end (which was not reached in the QM). In addition, it is foreseen to implement a better control of the sky and reference load temperature stages with the aim of allowing intermediate measurement points between 20 and 40K. The LFI FM will commence its full test campaign in early April and is expected to be ready for consignment and then integration with HFI in July.

Finally, the LFI scientific team is currently working on a new version of the instrument-level calibration analysis software ("LAMA"), more powerful and flexible than the version realized for the QM. The improvements are designed to cope with the much larger number of radiometer channels of the FM instrument (a total of 44) and with the need to efficiently correlate inter-channel science data and housekeeping parameters in near-real time.



Picture of the 30 GHz FM radiometer chain assembly after integration (BEM: back-end mmodule; FEM: front-end module; OMT: ortho-mode transducer).

LFI Level 1 software end-to-end tests started for the FM

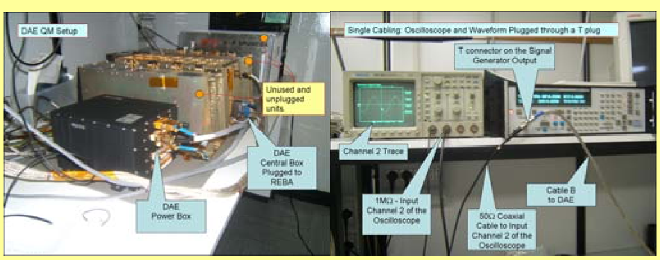
M. Frailis, M. Maris, N. Morisset, R. Rohlfs, C. Franceschet, M. Miccolis, P.Leutenegger, M. Turler, A. Zacchei et al.

To assess the proper operation of the Planck/LFI Level 1 software, and specifically of the Telemetry Handler System and the Telemetry Quick Look system (TMH/TQL), a set of dedicated tests have been performed at AAS-Milano with the support of the LFI DPC Team and the Geneva group in December 2005.

The TMH/TQL is the software dedicated to the handling of the scientific and housekeeping (HK) Planck/LFI telemetry data. The TMH performs the following tasks: acquisition and storage of the TM packets from SCOS 2000, time un-scrambling operations, TM packet decoding, conversion of packet content into physical units and the creation of Time Ordered Information (TOIs). The TQL performs a graphical display of the scientific and HK parameters and includes simple on-the-fly analysis tools.

The scope of the end to end test was to assess the proper coverage of the requirements by the TMH/TQL and validate TMH/TQL operations. The main testing scheme used was a *forward comparison* between the input data provided by the hardware and the output provided the Level 1 software. Input signals of known properties were injected in the hardware chain in order to test the behavior of the software system.

The tests were ordered according to the *functional classification* of requirements: handling of raw packets (communication with SCOS, storing of raw packets, proper commutation of packets according to their purpose, source, service, size and time stamp); handling of time information; decompression, decoding and reconstruction of scientific packets content; decoding and reconstruction of HK packets content; TOIs generation; graphical display.



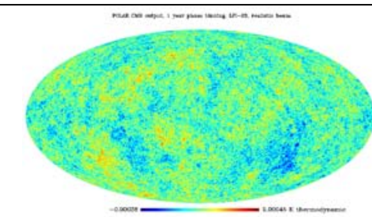
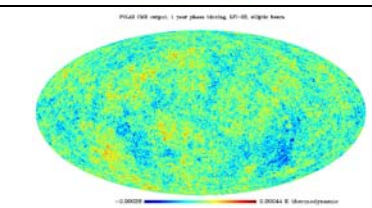
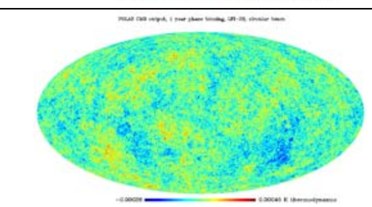
The proper operation of the TQL system was verified on-site. Due to limits in the time which could be allocated for end-to-end testing at the testing site, part of the data analysis for the tests was performed off-line at the DPC. For the end-to-end tests the QM hardware, consisting of the REBA, the power boxes and the DAE central box, was used with known simulated input data.

LFI-DPC pipeline tests in Trieste

C. Baccigalupi, D. Maino, C. Burigana, G. De Gasperis, M. Sandri, F.Villa, A. Zacchei, S. Leach, X. Dupac

The LFI-DPC at Trieste has begun a systematic series of tests of its scientific pipeline after the kick-off meeting held in the Trieste Astronomical Observatory on February 14, 2005. The group, open to the Trieste DPC members and all the code developers within the Planck community, holds teleconferences every two weeks.

By choice, in the past year, all inputs and results have been produced exploiting hardware resources internal to the DPC. The database, largely composed of simulated Time Ordered Data (TOD) and output maps, occupies about 1 Tb. The computer used is a Beowulf machine, with 8 nodes and double Pentium III processors, 1.1 GHz per processor, 2 GB RAM per node, with a front-end double Xeon processor at 2.8 GHz, 1 GB RAM per processor. These machines are now being replaced by those which will be used during the mission operations.

Beam	result
Realistic	
Gaussian elliptic	
Gaussian Circular	

Pipeline outputs for 1 year LFI 23 phase binned data: output maps for Gaussian circular, Gaussian elliptic, and realistic beams.

Four LFI detectors at 70 GHz have been simulated with ideal, elliptical, realistic beams, with and without 1/*f* noise, for a sky with CMB only. The output maps have been obtained by running the POLAR destriping code, for total intensity only. Due to the constraints of the current hardware resources, the input data have been phase binned, the data

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LFI-DPC pipeline tests in Trieste

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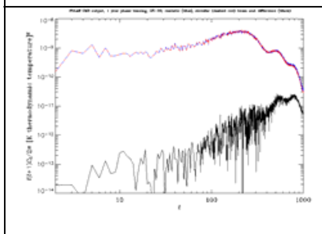
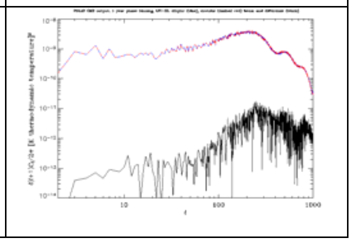
within each bin having been simply co-added. The output, for 48 days of data without binning, has also been produced. The figure shows example output maps.

Realistic vs. Gaussian circular beam and difference	Gaussian elliptic vs. circular beam and difference
	

Output power spectra for the Gaussian elliptic and realistic beam cases, compared with the Gaussian circular one. The power spectra difference is also plotted. Note: according to the Planck reference sky the power on the large scale is identical to that of the first year WMAP data.

The most important results so far are the quantification of the effect of a realistic beam by comparison, resolution of several software bugs in the Planck level S, and of course the expertise which the group is accumulating towards the launch of Planck. The group will have a second meeting in Trieste, in the first half of March 2006. The entire group activity and results are open and visible at a provisional web page .

Planck – Herschel Key Projects: an update

L. Valenziano, K. Ganga, G. Lagache

The preparations for Planck-related proposals to be presented as Herschel Open Time Key Programmes are ongoing, with the proposed topics having been discussed in WG6 and WG7 meetings. The status was reported to the Planck Science Team (ST) in its November meeting. The main recommendation by the ST to the Planck community is to work together to merge proposals on similar topics into common, stronger ones. This will also help to avoid duplication and 'internal' competition.

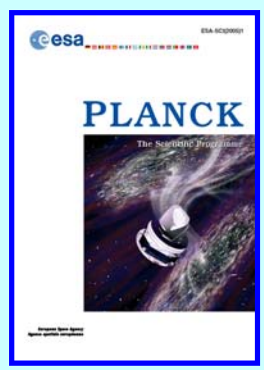
In addition, it was felt needed to improve the interaction between teams from the HFI and the LFI. The coordinators of the WG 6.4 and 7.5 will help this process, since their main task is now to organise the work of Planck people to use the Herschel potential.

In the meantime, as communicated in October 2005, the AO for the Herschel Key Project has been delayed until the "late summer" of 2006. The deadline for the presentation of the Planck-related proposals to the coordinators has been consequently postponed to 3 April, 2006. The coordinators have asked the PIs of the proposals to send their contributions using a template provided by email. The proposals will be submitted to the ST for approval in April.

More information on the Herschel Announcement of Opportunity process is available from the Herschel web pages. For information on the Planck process, please contact the authors of this update.

The Planck Bluebook

is now officially published. The electronic version can be downloaded from http://www.rssd.esa.int/Planck .



The Qualification Model which was tested in the cryogenic chamber at CSL between June and October 2005. Note that the reflectors are (obviously) not present).

The HFI flight detectors perform superbly

J. L. Puget and the HFI teams

The HFI Cryogenic Qualification Model was delivered to ESA in several parts between the end of 2004 and early 2005, as described in the previous Newsletter, and was then integrated into the satellite Cryo-Qualification Model (CQM). The CQM was transported to the Centre Spatial de Liège in June 2005 where it underwent the first major cryogenic test of the satellite, and of the whole cryogenic chain (including the passive cooling the V-grooves, the cold head of the Sorption Cooler and the 4K cooler). The first critical achievement of the test was the demonstration of the passive cooling stages, achieved at the end of August when the 3rd V-groove temperature dropped below 60 K. It subsequently went on to even lower temperatures. The cryogenic chain proved more recalcitrant, and for a period of close to one month the 100 mK stage refused to cool below about 1 K. After many investigations and tests, success was achieved on 26 September when it finally reached the correct temperature. It was then possible to carry out most of the tests originally planned. In particular the detectors were operated in these flight-representative conditions.

Besides the very important step of demonstrating that the efficiency of the passive cooling is within expectations, the CQM test has allowed to verify some untested yet critical aspects of the focal plane thermal model, namely the interactions between the HFI and LFI and the two Sorption Cooler cold heads. The analysis of the test results has confirmed that the heat input through the LFI gives an acceptable load on the HFI 4K box. The fluctuations induced through the LFI on the HFI 4K feed horns and on the LFI 4K loads (both critical for performances) nevertheless dominates over the fluctuations transmitted directly through HFI if no active control is applied on the LFI Sorption Cooler 18K cold head. This active control was not implemented on the CQM but is implemented on the FM and has been tested in JPL. This active regulation should reduce the fluctuations of the 4K box to levels well within specification for the HFI feed horns and the high frequency LFI 4K loads. The HFI 4K PID situated above the low frequency LFI 4K loads is not very efficient to stabilise these and the performances will have to be assessed during the CSL FM tests.

An Instrument Working Group meeting to review the instrument status was held in early January. The excellent performances of the flight bolometers measured at JPL have been confirmed by the measurements at Cardiff of the full integrated pixels (bolometer, filters, lenses and feed horns). The total optical efficiencies of the selected channels are larger than 25% for all CMB channels (including the Polarisation-Sensitive Bolometers, or PSBs) with values of cross polarization leakage always well within specifications (and often less than half of it). The measured beam patterns of the 4K feed horns are in very good agreement with the predicted ones. The readout chain is also well within expected performances with flat noise throughout the whole critical frequency range (0.016 to 100 Hz). Thus, if the thermal stability is confirmed in the next set of tests, we expect the performances of the HFI to be on average very close to or better than the goals. The flight Focal Plane Unit has now been fully integrated and the whole readout electronic chain tested at the subsystem level.

The calibration facility of the HFI Focal Plane Unit has been tested and the flight FPU has been integrated into it, despite a major mishap at the last minute due to the rupture of a water pipe in the University campus, which caused flooding in the basement of the IAS clean room. The calibration activities have nonetheless started on schedule in the first days of March. After environmental tests in April and beginning of May, the final calibration of the HFI will take place, ending by mid-June. The HFI should be delivered in the first days of July to ESA and Alcatel for integration into the spacecraft.

The HFI Core Team is a structure bringing together instrument people, calibration teams and DPC people, which will be active throughout the life of the project. It provides a place where all topics of general interest and importance within HFI are discussed, and where direct exchange of information will take place via regular meetings. Its activities will start with meetings where the test and calibration data analysis relevant to the performances of HFI are presented and discussed. The HFI Core Team has held its kick-off meeting in January, and the next meeting is planned in late March.

The flight model of the HFI flight focal plane being integrated into the Saturne chamber in Orsay. The inset shows the assembled 4K plate with the feedhorns mounted.

Component separation activities in WG2

J. Delabrouille, G. de Zotti, and the WG2 team

The Planck "Component Separation" working group, WG2, focuses its activity on the identification and separation of the signatures of all the distinct astrophysical emissions. Mapping the Cosmic Microwave Background is the primary scientific objective of Planck. Additional components however, among which Sunyaev Zel'dovich (SZ) signals, Galactic emission components and extra-galactic radio sources and galaxies, are of great scientific interest as well.

The WG2 activities are split into three main lines of investigation: (1) the collection of ancillary data, (2) the modeling of the sky, and (3) the development of component separation methods and software, to be provided to the Planck DPCs and used for the scientific analysis of Planck observations.

The component separation problem

One of the main goals of the Planck mission is to provide a CMB map as clean as possible. The instrument, however, observes the total sky emissions in various channels, which comprise CMB anisotropies, as well as contributions from a number of foregrounds. In addition, observations are polluted by instrumental noise (Fig. 1).

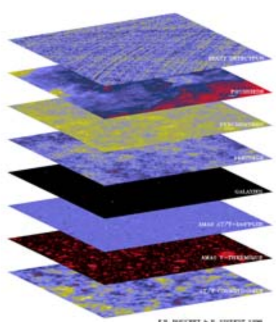


Fig. 1: The component separation problem. Instead of observing the CMB only, each Planck channel observes a mixture of astrophysical emissions and noise. Component separation consists in isolating, as well as possible, each individual emission from the others (Figure prepared by François Bouchet & Richard Gispert).

For each channel, the total observed emission is then: *observation(channel) = beam(channel) * (CMB + foreground1(channel) + foreground2(channel)) + ... + noise(channel)* where * denotes convolution. When observations are calibrated and provided in units of temperature anisotropies, the CMB signal in all channels is the same (apart from the channel dependent effect of the beam), whereas the contribution of foregrounds is expected to vary from channel to channel.

The objective of component separation is to separate the emission from each individual astrophysical source using all Planck observations and additional external information.

Clearly, an efficient component separation requires:

- Collecting all possible additional information, relevant for better characterising the foregrounds, such as, for instance, catalogues of known point sources emitting in the Planck frequency range, maps obtained at other frequencies by other instruments, and any prior knowledge on parameters describing the various astrophysical emissions;
- Modeling the emission of the sky, properly taking into account all the available observational constraints. In addition, modeling activities are necessary to simulate plausible sky emissions, for developing and testing component separation methods;
- The build up of component separation algorithms, which consists in devising methods and writing software packages to estimate from Planck and ancillary data the parameters describing each of the emissions, and in particular to obtain maps of the emission of each astrophysical process in the frequency bands of the Planck channels.

Collection of ancillary data sets

Observations relevant to the activities of WG2 have been made already by many instruments. On the diffuse emission side, data from COBE (the FIRAS and DIRBE instruments) and from IRAS provide important information on Galactic dust emissions at frequencies on the higher range of Planck spectral coverage. Observations at 408 MHz trace synchrotron emission, observations of the H-alpha emission trace the free-free. Maps of CO and HI emissions provide additional information about the interstellar medium, relevant to the so-called "anomalous" emission of dust. In addition, catalogues of point sources have been collected by several instruments, at high frequencies (IRAS) and at low frequencies (GB6 + PMN observations at 5 GHz, NVSS catalogue at 1.4 GHz and the SUMSS catalogue at 843 MHz). Last but not least, the WMAP observations provide sky maps from 22 GHz to 94 GHz, as well as a catalogue of detected point sources.
Other ongoing surveys (both shallow surveys over large areas, in particular of polarised synchrotron emission and of radio sources at high frequencies, or deep surveys in limited regions of the sky) will provide additional ancillary data, to be collected by WG2.

Modelling sky emission

To test component separation algorithms we need models describing what we think Planck may observe. A typical model comprises the distinct components sought (currently we consider 9 components) and a set of parameters describing their emission, which may be known, partially known, or unknown, but still identified as part of the relevant physical representation of that component.
For each component, several distinct models are plausible and of interest for the scientific programme of Planck. For instance, the CMB emission may be Gaussian or non-gaussian, and there may be several distinct reasons for it to be non-gaussian. Dust emission may be described, to first order, by an intensity at some frequency in each sky pixel (which depends essentially on the optical depth in the corresponding direction), and by a spectral emission law in each pixel (which depends on dust temperature and physical properties along the line of sight).

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Component separation activities in WG2

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WG2 has put a lot of effort in assembling a reference sky model for Planck. The objectives of this activity are twofold. First, it aims at predicting as accurately as possible what Planck is expected to see from each type of known emission processes. In some cases this prediction can be quite poor, as, e.g., for polarised dust emission, for which very little data is available to make a reasonable model. Second, it aims at providing a tool which permits to simulate, as accurately as possible, “plausible” sets of Planck observations, with the appropriate statistical properties (power spectra of foregrounds for temperature and polarisation, distribution, number counts of sources, etc...), for various models. These simulations permit to check the accuracy of component separation in as realistic cases as possible, as well as to check the impact of component separation methods on the extraction of parameters of interest on the recovered component maps as, for instance, on the estimation of the CMB power spectrum, or of source number counts, or of the gaussianity of CMB emission. This modelling and simulation activity is thus of prime importance for the scientific analysis and interpretation of the future Planck data sets (Fig.2).

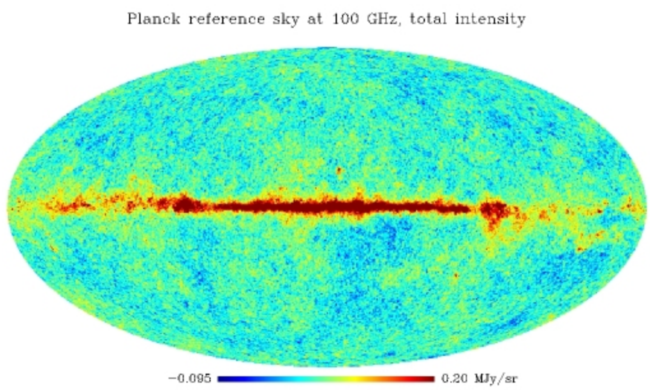


Fig. 2: Sky emission models. Sky models for Planck are used in level S simulations, which are used for testing and validating the various component separation methods. In this figure are displayed the modelled sky intensity I at 100 GHz (Figure prepared by Carlo Baccigalupi).

Component separation methods

The component separation methods activity aims at developing the best (as measured by a set of factors of merit) possible solutions for separating the different emissions, in view of the various scientific objectives of Planck.
The first obvious objectives are:
- obtain CMB maps of temperature and polarisation with minimum variance of residual noise and foregrounds
- obtain maps of other diffuse emission components at all Planck frequencies, with minimum variance of residues
- obtain catalogues of sources observed by Planck with positions and fluxes (or upper limits) for all Planck channels.

Other criteria may be set for evaluating the component separation (e.g. minimising non-gaussian residuals in maps).

Currently, the methods implemented by the WG2 include:
- diffuse component separation methods as Wiener filtering or Maximum Entropy, which separate emissions assuming their statistical properties (power spectrum of components and noise maps) known
- blind methods to separate independent components (the so-called Independent Component Analysis, or ICA), among which the Spectral Matching ICA (SMICA) and its wavelet-based version wSMICA, and FastICA (fig. 3).
- Maximum likelihood estimators of sets of parameters describing foreground emission (subsequently used for the separation)
- compact source extraction using matched filters, wavelets, or likelihood-based methods with and MCMC algorithm.

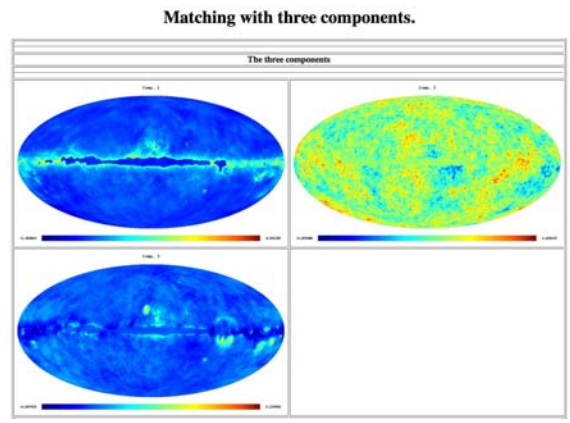


Fig. 3: Component separation in WMAP data. Methods and sky models are being tested against WMAP observations. Here a blind component separation extracts CMB and two galactic foregrounds in WMAP data. (Figure prepared by Jean-François Cardoso).

Future plans

Although a lot of activity has taken place in WG2, the products have not been completely integrated yet into a logical and structured sequence. As a next step in this direction, the WG2 is currently focusing its activities on
- Putting together a reference Planck sky model, which summarizes at its best the present knowledge, (and various plausible theories) about CMB and foreground emissions including polarisation;
- Developing the corresponding simulation tools, which permit to generate statistically meaningful sets of fake Planck observations, compatible with existing observations and present models and theories
- Comparing the various existing methods on sets of well understood fake data.

In the longer term, WG2 has to develop its activity towards preparing the optimised use of external data sets in component separation, and to devise and test component separation methods specifically designed for separating polarised sky emissions.

Contacts: People interested in knowing more about WG2 activities are welcome to browse the WG2 Livelink web page.

Goodbye to Planck hardware at NASA's JPL

C. Lawrence and the Planck JPL teams

With shipment of the last set of bolometers in October 2005, JPL completed its hardware deliveries for Planck. In all, 47 spider-web bolometers (SWBs), 56 polarization-sensitive bolometers (PSBs), two complete 20 K hydrogen sorption coolers, and one additional cooler "cold end" have been delivered. Twenty SWBs, 32 PSBs, and both complete coolers will fly on Planck. The other components are for tests or are spares.

Both the bolometers and the coolers represent state-of-the-art advances. SWBs are the first bolometers to combine ultra-low noise, stability, and insensitivity to cosmic rays. PSBs are the first bolometers capable of measuring CMB polarization. And while coolers based on a thermally driven sorption/desorption cycle have been around for a long time, the Planck coolers will be the first such ever used to cool scientific instruments in flight. It took many innovations and a lot of work to make this possible, but in the end the 20 K sorption coolers turn out to be nearly ideal for cooling LFI to 20 K and precooling the HFI 4 K cooler at about 18 K.

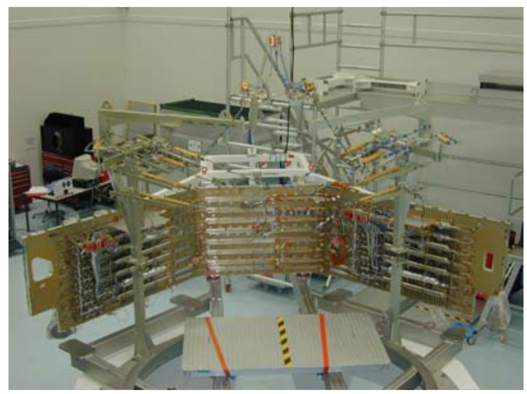
The bolometers were delivered to Cardiff University for integration into the HFI focal plane. Measurements at JPL and at Cardiff show that the ambitious performance goals set out years ago have been reached or exceeded, with only a few minor exceptions. Brendan Crill (IPAC), Warren Holmes (JPL), and Bill Jones (Caltech) have made numerous trips to Cardiff and Paris in support of I&T activities.

The cooler in solitary glory during transport to Alcatel.

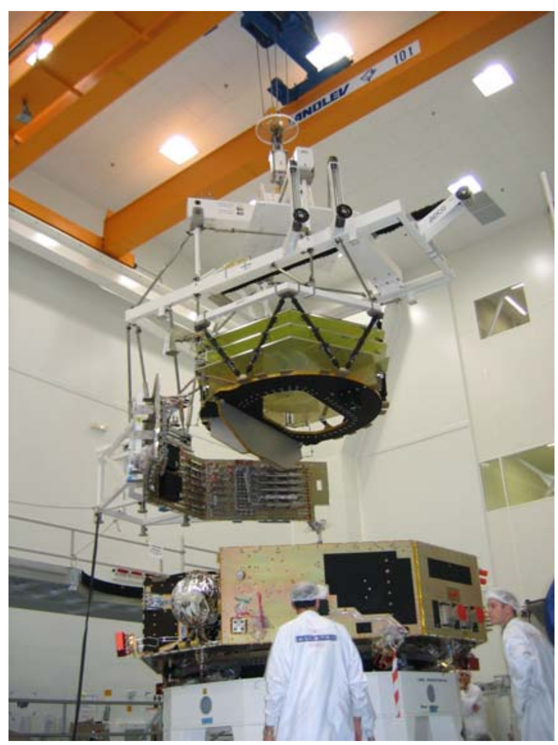
Shipment of the bolometers was routine enough; however, the second cooler, which left JPL last August, had an interesting ride. The Cargo Lux 747 lost an engine due to a compressor stall over the Atlantic, and landed in Scotland rather than Luxembourg as planned. Phil Wilson and Joe Mora from JPL, who were waiting in Luxembourg, were informed by Cargo Lux that the cooler would be transferred to another plane. Phil said that if they were going to do that, he and Joe had to be there to supervise the off- and on-loading. Cargo Lux said there wasn't time for that. But when Phil informed Cargo Lux of the sensitive nature of the cargo, and said "if anything happens it would not be good", it was decided to remove all the other cargo from the plane, and fly the cooler along to Luxembourg on three engines (see photo of the cooler alone in the cargo hold). Everything worked out just fine, including the long truck ride to Alcatel in Cannes.

As with the bolometers, JPL will continue strong support for cooler integration and test activities. Dave Pearson, Phil Wilson, and Joe Mora, for example, have had extended visits to Alcatel in Cannes or to CSL in Liège over the last nine months.

It is both gratifying and exciting for the large teams at JPL who worked for many years to see their hardware integrated into Planck, and to know that it enables measurements that will advance our understanding of the Universe in fundamental ways.



Above, both sorption coolers integrated into their satellite panels; and below, their integration into the satellite's Service Module.



Organization of the Systematic Effects WG

Marco Bersanelli, Jean-Michel Lamarre

Since the very beginning of the Planck (then "Cobras/Samba") development, the necessity of strict requirements on potential systematics has been recognized, to ensure that the final results actually conform to the instrument sensitivity and not limited by unwanted environmental or instrumental effects. Control of systematics is an important driver of several features of the mission, including instrument and spacecraft design, orbit choice, scanning strategy, and data analysis. Since its start in January 2001, the Planck Systematic Effects Working Group (SEWG, or WG1) has carried out a broad range of activities in this area, supporting both instruments through the various stages of their development. The SEWG was subdivided in nine Working Teams addressing specific areas, such as main beam and side lobes effects, pointing errors, instrument-intrinsic issues, effects from thermal instabilities and temperature interfaces, polarisation-specific effects, calibration issues. The teams provided inputs useful for instruments optimisation, for the on-ground testing and calibration approach, and algorithms to model specific effects or to enable their removal, thus contributing to the DPCs activity.

Most of the key people in SEWG play a central role in the instrument teams. Recently these people have been deeply committed in the instruments QM campaigns and related data analysis, and are starting to be heavily involved in the FM campaigns. Now the QM analysis is nearly completed, and the Flight Model is being built and tested at subsystem levels. In the meantime the DPCs pipelines are being consolidated, and it is essential that the SEWG expertise is injected in the data processing development. The SEWG should now support these new phases of the project, taking into account a realistic assessment of availability of resources - note that no specific resources are dedicated to the SEWG. This requires some change in the *content* and *organisation* of the Working Group. This reorganisation was discussed within the SEWG Coordinators in October 2005, and then presented and discussed at the Planck Science Team meeting, held in Milano on Nov. 2-4.

Content

We propose to concentrate future SEWG activities in three main areas, addressing issues related to systematics that are crucial for the overall Planck data analysis.

The first area covers *Optics and beams properties*. The optical design is frozen and fabrication and test of optical parts (telescope, feeds, focal plane arrangement) is well advanced, so we are now in a position to explore in detail expected residual non-idealities. Both main beam and side lobe properties play a crucial role in the data calibration and analysis. Beam characterisation requires a combination of ground and in-flight measurements, as well as model predictions. A review of the requirements on optical parameters and the limitations on their knowledge through all Planck frequencies will help the data analysis. Analysis of residual uncertainties in measured optical parameters also involves receiver effects (such as readout electronics effects, non-linearity) that may be introduced during testing, both in flight and on-ground.

The second work area is *Systematics induced by thermal effects*. Previous activity within SEWG produced examples of detailed analysis of the impact of thermal fluctuations generated within the satellite, mostly based on models. Now the thermal design of the instruments and spacecraft is completed, and thermal transfer functions have been measured or verified. Laboratory data from the 20K Sorption Cooler are available, and data from the 4K cooler will be gathered soon. In addition, the CQM campaign in Alcatel has provided key information on the passive cooling properties of the system. Clearly the issues related to the Planck thermal system cover a much wider range than what is under SEWG scope: our specific task will be to study the propagation of thermal effects in the instrument performances.

Unique to Planck is the simultaneous measurement of the microwave background with two instruments that are based on different technologies. They are generally affected by systematics of different nature and amplitude. This can be exploited to search for anomalous features in the data. Our third SEWG activity addresses the *Inter-Instrument cross-check and systematics diagnostics*, with the objective of developing a strategy for comparing of LFI and HFI data that optimises analysis robustness. How can we use combined data streams to identify, and possibly remove, a systematic effect? Can we suggest strategies to track the sources of systematics? Conversely: how would a given instability (or other anomalous behaviour) affect the two instruments during the survey? What are the data sets that need to be compared to optimise the crosscheck? This activity should provide a direct support to the DPCs in the area of inter-instrument information and cross-calibration.

Organisation

The above main objectives imply a simplification of the Working Group structure. Initially, it was necessary to identify, model, and analyse **"**all**"** potential sources of systematics, requiring several small Working Teams with relatively narrow tasks. Now we need to pull together the information to support data analysis and, possibly, in-flight calibration.

We foresee that three groups, corresponding to the three topics above mentioned, will be organised. Each group will identify priority questions to be answered. As a result of this activity, we intend to promote workshops with the goal of developing mutual understanding between theoreticians and experimentalists of the Planck community to prepare the data reduction in the best conditions. We plan to hold the first such conference in October 2006 on optical issues, with a tentative title: "*Beams in CMB experiments: modelling, measurements and induced systematic effects. The case of Planck*", This is planned to be followed by workshops on thermal effects and on systematics diagnostics.

The impact of GRID technology on the Planck community

Giuliano Taffoni, Claudio Vuerli, Fabio Pasian and Andrea Zacchei

Towards the end of the last century, there was a revolution in the way people use computers. This revolution involved the expansion of Internet as well as the availability of powerful computers and high-speed network technologies as low-cost commodity components. These technological opportunities led to the possibility of developing low cost high-performance computing (HPC) resources, commonly called clusters, that can be used to solve computational-intensive problems in a number of scientific and technological application domains.

However, there are a number of problems that due to their size and complexity cannot be faced using the current generation of HPC clusters. They are commonly computational and data intensive applications that require working collaboratively with distributed heterogeneous environments and institutions.

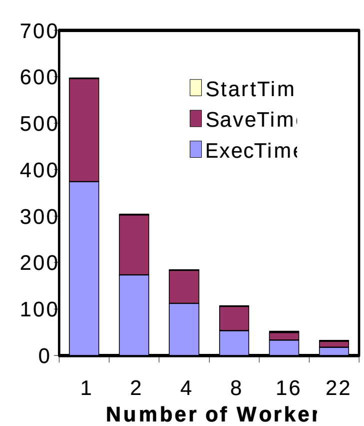
To handle this particular kind of scientific (but also engineering and business) problems, a new approach has been proposed in the use of distributed computing: the GRID. The term "GRID" is chosen in analogy with the electrical power grid, which provides consistent and transparent access to electrical power irrespective to its source. Similarly, a computational and data GRID enables the aggregation and sharing of a wide variety of resources (clusters, supercomputers, storage systems, data services, etc.) that appear to the user as a single unified system image. Therefore a GRID is not only an integrated computational tool but also a collaborative environment to share and exchange information and data. Organizations and institutes coming together to share resources but also skill and competencies in other to face a particular scientific (but also engineering and business) problem, create a GRID Virtual Organization. Any user identified by a digital certificate deal with one or more Virtual Organizations and can access computational power and data related to his Organizations. This guarantees an extremely secure authentication and authorization mechanism. From the user point of view once connected to a GRID user interface (a Linux desktop that is the entry point to the GRID), or to a GRID portal, a user finds the same environment and data wherever he connects to the GRID.

There are a number of different national and continental GRID initiatives but the pioneer project in this field is the CERN LCG computational GRID that builds a huge computational and data infrastructure distributed in Europe and USA to store and process data produced by the Large Hadron Collider experiment. The other main GRID project that involves the European Countries is the EGEE (Enabling Grids for E-sciencE) project. EGEE project was funded by the European Commission and aims to build on recent advances in grid technology and develop a service grid infrastructure, which is available to scientists 24 hours-a-day. EGEE infrastructure involves 20.000 CPU and nearly 20PB of storage. It is distributed in all European countries and it is developing interactions with extra-European GRID initiatives. In a few months the LCG and EGEE infrastructures are planned to be merged.

Since November 2004 the Planck "community" is a supported Virtual Organization of the EGEE GRID: this implies that the Planck community can access the EGEE GRID computational and data resources. Planck applications are particularly interesting from the GRID point of view, both as they are computational and data intensive and because of the nature of the Planck consortium: a collaboration of different institutes distributed throughout Europe. For these reasons the use of GRID can be an added value to the community.

During the first months of tests we were able to port on the GRID environment the Level S simulation software, providing a number of simulations with different cosmological and instrumental parameters. The data produced has been stored in the GRID. The advantage of using a GRID infrastructure in this case regards not only the possibility of running a large number of simulations with a clear gain in performances (see the figure below) but also the use of a native collaboration tool to share data between institutes in order to produce, modify, analyze and store data. For example the TODs produced by our simulations and saved in the GRID were used to test de-striping algorithms. This is a typical example in which a scientist produces data for another scientist in a different institute who needs to post-process those data in some way. This exercise is easily solved in a GRID environment while it requires setting up a complex infrastructure if faced on a "standard" way.

The success of our first tests and the possibility to have full support by the EGEE community suggest that a more massive and pervasive use of this technology can certainly help to solve some complex numerical problems related to Planck simulations. Moreover, the GRID can support Planck scientists in the data analysis and in the comparison of the detection results with their theoretical models.

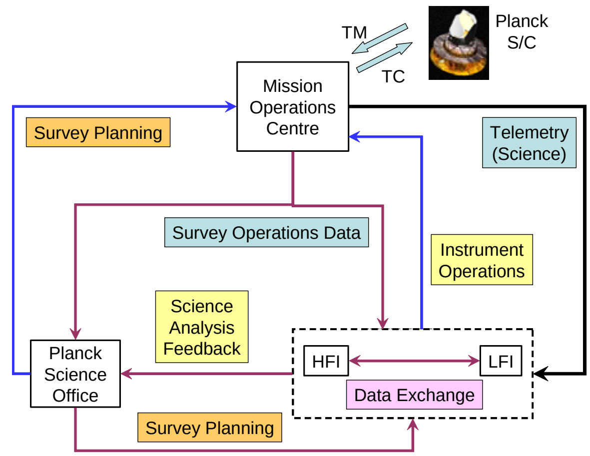


Scalability of Level S on a GRID distributed environment. We run full mission simulations for LFI incrementing the degree of granularity. We start from simulating the whole mission on one node and we progresssively increase the degree of "parallelization" up to assigning each radiometer to a different computing node.

Getting ready to test the Science Ground Segment

M. McKinnell, R. Laureijs

A critical component of the Planck mission is the "science ground segment" (SGS), comprising the HFI and LFI Data Processing Centres (DPCs) and Instrument Operations Teams (IOTs), the Planck Science Office (PSO), and their links to the Mission Operations Centre (MOC). The Planck SGS enables survey operations planning and monitoring, instrument commanding and operations, downlink and distribution of spacecraft and science telemetry, processing of scientific data, and generation and delivery of final data and products to the scientific community. The main SGS components are located in four different cities across Europe (Paris, Trieste, Darmstadt and Madrid).



An overview of the major flows of information in the Planck Science Ground Segment .

The overall coordination of the SGS development falls to the Planck Ground Segment System Engineering Group (PGSSG), with representatives from the entire SGS. The PGSSG is the forum for coordinating the development of individual ground segment components, and for the integration and testing of the science ground segment as we approach launch. In the last few years the group worked on the design aspects of the SGS, which for a large part included definition of the system interfaces.

The ground segment system development has progressed well over the past year. We have passed the design phase, and are at the stage where system and software components are being delivered. An important activity throughout most of 2005 has been the definition and development of the interfaces required to link these SGS elements and provide the critical flow of operational data throughout the Planck system. This activity has also been an important step in the development of key tools assessing the science data and providing time-critical data quality analysis for the overall survey coverage. The MOC mission control system design was reviewed in October 2005.

In 2006, Planck ground segment engineers and scientists will be turning their attention to the all important issues of integration and testing for this complex system. The basic testing philosophy will begin with localised component and acceptance testing within each SGS element, building up to interface level testing and integration of the various elements. Finally, operational verification tests and end-to-end system tests will be undertaken, coordinated with satellite verification testing. There are two such system verification test campaigns planned, one in early 2007 and one in late 2007. This overall test scheme will ensure operational readiness for Planck launch, in-orbit testing and commencement of survey operations.

Data Access Procedures

J. Tauber

High-level policies for data rights and guidelines to manage the scientific exploitation have existed for some time and are embedded in "official" documents. However, as we come closer to launch, these policies and guidelines need to be implemented in an infrastructure which can be practically managed by the two Data Processing Centres, since they will contain the scientific data repositories, both for raw and processed data, which will be used for scientific exploitation during the operational and proprietary periods (i.e. from launch up to 2 years after the end of the last sky survey performed by the mission). It therefore becomes necessary to define in detail the procedures which will be put in place for the availability and distribution of Planck data to the members of the Planck Consortia during these periods, and even beyond.

The two DPC Managers have jointly produced a document describing these procedures, which has been endorsed by the Planck Science Team. Among other items it contains:

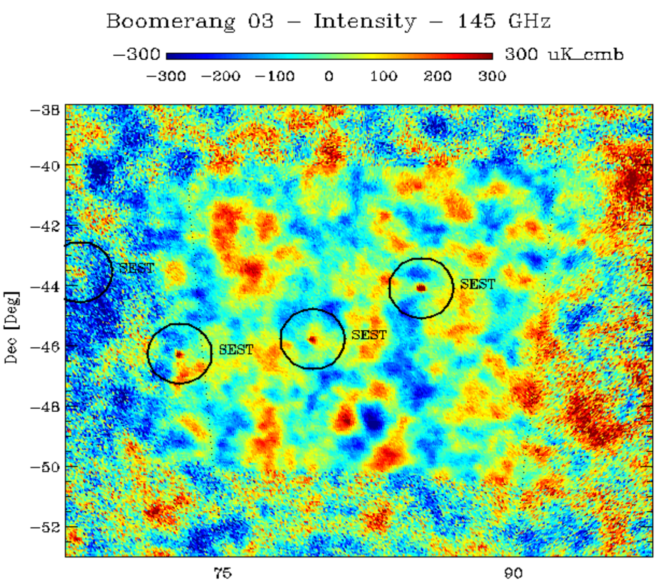
- Descriptions of the different types of data which will be processed and made available during the proprietary period.
- Descriptions of the roles of individuals within the Consortia, and the associated data access rights. In particular it describes the Core Teams which will become active already before launch.
- Descriptions of access mechanisms and the periodicities at which processed data products will be made available.

This document can be found in Livelink. You are encouraged to read it carefully as it has important implications for the way in which the scientific exploitation of the Planck data will be carried out.

BOOMERanG strikes back

Francesco Piacentini, Silvia Masi, and the BOOMERanG collaboration.

Last July the BOOMERanG team submitted five papers presenting the result of the January 2003 Antarctic balloon flight. The papers describe the instrument and the maps of temperature and polarization (Masi et al.), presents the angular power spectra (Jones at al., Piacentini et al., Montroy et al.) and the resultant cosmological parameters (MacTavish et al.). Maps and power spectra of temperature and polarization of the CMB have been obtained. Without any other dataset, these measurements constrain the parameters of the standard Lambda-CDM model remarkably well, proving that the “concordance” model properly describes CMB anisotropy, and also polarization.



BOOMERanG-03 map of the deep region in the 145 GHz band. Stokes parameter I. The circles indicate known extragalactic sources, which are masked for the CMB analysis.

BOOMERanG-03 shares several technical solutions with Planck-HFI. In particular it employs Polarization Sensitive Bolometers (four pairs, eight channels at 145 GHz) and Spider Web Bolometers (four detectors at 245 GHz and four at 345 GHz); the band-pass filters and corrugated feeds are made with the same Planck technology and sky modulation is obtained by means of slow sky scans, and readout with an AC filtered total power system.

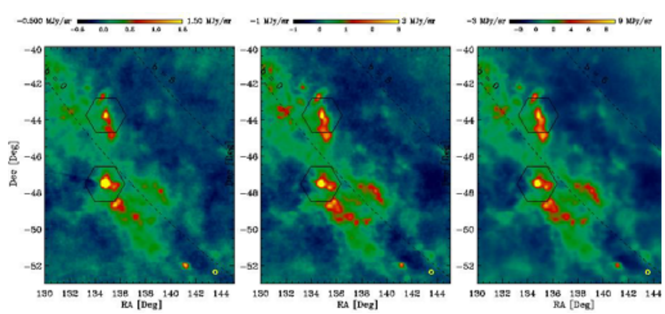
The observation strategy is designed to obtain three results: a map of the Galactic plane in the galactic longitude range from 260 to 280; a shallow map covering 1.8% of the sky, and a deep map covering 0.22% of the sky: these two maps are at galactic latitudes around -40 degrees. The galactic plane map is useful for investigating polarized foregrounds. The shallow map reduces cosmic variance in the CMB power spectra <TT> and <TE>, while the deep map has lower instrumental noise and is optimized for <EE> polarization measurements.

In the deep region, at 145 GHz, the BOOMERanG-03 map has a sensitivity of 16 microK per 3.5' pixel, and covers 28000 pixels. At the same frequency and with the same pixelization, Planck is expected to reach an average sensitivity of 6 microK. Also, HFI will have slightly better resolution and wider frequency coverage.

Nevertheless the high S/N of the 145 GHz map from BOOMERanG-03 represents an exciting preview of what we expect on the full sky from Planck. Even with this high sensitivity, the maps of Q and U Stokes parameters are completely noise dominated and remarkably featureless. In the portion of the Galactic plane that was observed many diffuse dust clouds and a few compact sources are evident, see the intensity map below. However, only a few sources are clearly detected in the Q and U maps.

BOOMERanG may also be considered a precursor for the Planck-HFI data analysis. Two independent pipelines have been developed, along the following main steps: data cleaning and deconvolution, pointing solution, iterative map-making, calibration, beam estimation, noise estimation, Monte-Carlo simulation and power spectra extraction. The full process passed several consistency tests. Data were split in two subsets, either by observation time or by channel. The resulting maps were differenced and the power spectra compared to zero.

We learned many lessons from the BOOMERanG data analysis. First, none of the data analysis steps above is straightforward. For example, to pass consistency tests it was necessary to properly take into account noise correlation between channels, particularly pairs of PSBs. Second, the propagation of calibration uncertainties (on responsivity, time constants, cross-polarization, beam shape etc...) can be particularly severe. Carrying out extensive simulations, we proved that this is not a problem at the level of the BOOMERanG-03 sensitivity. But we also were confirmed that an extremely accurate characterization of the integrated instrument is necessary in the case of Planck.



Galactic region observed with BOOMERanG-03. From left to right, 145, 254 and 345 GHz maps. Brightness units are MJy/sr. The hexagons locate RCW38 (dec~-47.5°), and IRAS08576 (dec~-43.8°). The dashed line is the galactic equator. The maps are convolved with a 6' FWHM Gaussian filter. The yellow circle on the bottom right of each panel indicates the equivalent

Some of the people from ESA and industry who manage the vast engineering efforts that make the Planck satellite a reality, during a break in one of the innumerable progress meetings on the premises of the prime contractor Alcatel Space (Cannes).

Recent Planck-related Publications

◊ F. Atrio-Barandela, J.P. Muecket "Contribution of the Intergalactic Medium to Cosmic Microwave Background Anisotropies" astro-ph/0601424

◊ F. R. Bouchet, A. Benoit, Ph. Camus, F. X. Desert, M. Piat, N. Ponthieu "Charting the New Frontier of the Cosmic Microwave Background Polarization" astro-ph/0510423

◊ Efststhiou, G. Janaury 2006 "Hybrid Estimation of CMb Polarization Power Spectra", astro-ph/0601107

◊ M. R. Francis, R. Bean, A. Kosowsky "Impact of Systematic Errors in Sunyaev-Zel'dovich Surveys of Galaxy Clusters" astro-ph/0511161

◊ T. A. Ensslin, C. Vogt, A. Waelkens, Alexander A. Schekochihin "Future magnetic fields studies using the Planck Surveyor experiment" astro-ph/0511488

◊ H. K. Eriksen, C. Dickinson, C. R. Lawrence, et al. "CMB component separation by parameter estimation" astro-ph/0508268

◊ D. L. Harrison, F. van Leeuwen "The Geometric Calibration of the Planck satellite using Solar System Objects" astro-ph/0510559

◊ D. L. Harrison, F. van Leeuwen "The Geometric Calibration of the Planck satellite using point-source observations" astro-ph/0510345

◊ J.B. Juin, D. Yvon, A. Refregier, C. Yeche "Cosmology with wide-field SZ cluster surveys: Selection and Systematic Effects" astro-ph/0512378

◊ J. Lesgourgues, L. Perotto, S. Pastor, M. Piat "Probing neutrino masses with CMB lensing extraction" astro-ph/0511735

◊ M. Liguori, F. K. Hansen, E. Komatsu, S. Matarrese, A. Riotto "Testing Primordial Non-Gaussianity in CMB Anisotropies" astro-ph/0509098

◊ 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

◊ L.A. Popa "History of stellar evolution at high redshifts: Implications for the CMB E-mode polarization" astro-ph/0510805

◊ Poutanen, T. "Map-making and Power Spectrum Estimation for Cosmic Microwave Background Temperature Anisotropies" 2005 PhD Thesis, Helsinki Institute of Physics

◊ M. Reinecke, K. Dolag, R. Hell, M. Bartelmann, T. Ensslin "A simulation pipeline for the Planck mission" astro-ph/0508522

◊ B. M. Schaefer, M. Bartelmann "Detecting Sunyaev-Zel'dovich clusters with PLANCK: III. Properties of the expected SZ-cluster sample" astro-ph/0602406

◊ Sinigaglia, A. "Analisi della Strategia Osservativa dell'Esperimento Planck", 2005, Tesi de Laurea in Fisica, Università degli Studi di Trieste

◊ J.A. Tauber, D. de Chambure, G. Crone, R.J. Daddato, J. Martí Canales, R. Hills, T. Banos, D. Dubruel, P. Martin, J.B. Riti, H.U. Norgaard-Nielsen, T. Stute, , "Optical Design and Testing of the Planck Satellite", in Proceedings of the XXVIIIth General Assembly of URSI, New Delhi, October 2005

CALENDAR OF (SOME) EVENTS

MEETINGS

JOINT HFI/LFI CONSORTIUM MEETING, 18-20 APRIL, 2006; ISCHIA

CMB AND PHYSICS OF THE EARLY UNIVERSE, 20-22 APRIL, 2006; ISCHIA

"*BEAMS IN CMB EXPERIMENTS: MODELLING, MEASUREMENTS AND INDUCED SYSTEMATIC EFFECTS. THE CASE OF PLANCK*", OCTOBER 2006 (SEE PAGE 10)

PLANCK SCIENCE TEAM MEETINGS

ST23: 10 -11 APRIL, 2006 (ESTEC)

ST24: 10 - 12 JULY, 2006 (ROME)

ST25: 9 – 11 OCTOBER, 2006 (COPENHAGEN)

WORKING GROUP MEETINGS

HFI CORE TEAM: 30-31 MARCH, PARIS (TBC)

The Radio Frequency Qualification Model being readied for measurements in the Alcatel Compact Antenna Test Range.

The Planck Joint Consortium Meeting 2006

It has now become a tradition that the meetings of the LFI and HFI Consortia are held yearly and jointly. The next one will take place on the island of Ischia between the dates of 18 and 20 April. This year, the meeting will be short, but it will be followed between 20 and 22 April by the International Conference "CMB and Physics of the Early Universe". Information and registration procedures can be found on the web at www.iasfbo.inaf.it/cmb .

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