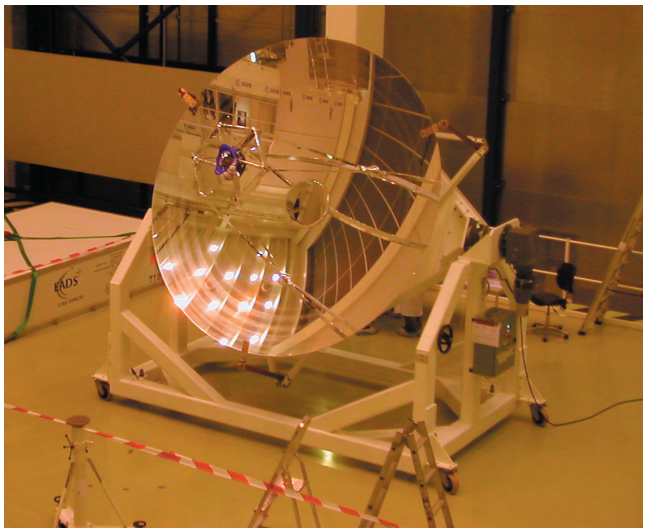
Planck for the Nordic Countries

Trough the system for Principal Investigator teams Nordic institutes will play an important role in using the Planck data for further research around the birth of the and the evolution to this day. Without disparagement for the other countries, Denmark has played a major role in the development, and will possibly make the most use of the incoming data.



The Planck mirror during tast at ESTEC. Photo credit: Nordicspace

Denmark - Developing the Mirrors and Critical Software

Among the Planck's many subcontractors spread throughout Europe and the USA, ESA and the Danish National Space Centre are responsible for the provision of Planck's telescope mirrors. The Danish National Space Institute (NSI) has also contributed to the Planck reflector system by ensuring that the system can endure very low temperatures. The Danish National Space Centre and NSI, funded by the Danish Natural Science Research Council, have participated in the preparation of the Planck mission since the very beginning.

NSI has thus made an agreement with ESA assuring full access for Danish astrophysicists to the Planck database. To completely exploit these scientific possibilities the NSI formed a consortium called DK-Planck together with Niels Bohr Institute and the Theoretical Astrophysics Center in 1998. Danish astronomers were thus involved in mission preparations in all scientific areas related to Planck.

Baard Kringen Nordicspace

Not only have the space-related institutes been involved in Planck. The Danish company Terma is also supplier for both Herschel and Planck, as well as supplier for the two space telescopes, thus, Tema constitute the largest contribution to scientific ESA missions. Terma's supply to the two scientific ESA missions are developed at and delivered from their company's departments in the Netherlands, Germany, and Denmark.

From Denmark, Terma has developed and delivered the central and critical on-board software which ensures that the satellite manoeuvres correctly in space. This is the so-called Attitude Orbit and Control Software.
Further, Terma in Denmark has supplied the Software Validation Facility, which ensures and checks that all on-board software performs as intended and that no errors occur which could lead to mission failure.
Terma is also responsible for the implementation of a system test and an independent validation of the software which ensures the collection of data from the on-board instruments and the communication with earth.
Terma's department in Darmstadt/ Germany has supplied the Mission Control System which the control centre uses for the post-launch monitoring and control of the satellites.
From Leiden/The Netherlands, Terma has supplied the Central Check-Out System. This is the main test system for the collection, integration, and validation of the satellites' functionality prior to launch.

Finland - Developing and Building Scientific Components

The Finnish involvement, originally initiated by the Finnish institute MilliLab, is very significant both in the areas of instrument building and cosmology and astronomy. All the critical parts of the 70 GHz receivers have been built by a Finnish instrument team formed by MilliLab, VTT and DA-Design Ltd. Finland is leading in some fields of building scientific instruments and this competence have given Finland possibilities to participate in using data from Planck.

Based on this involvement, data processing, cosmology and astronomy work associated with the Planck mission was performed by several Finnish Institutes. The Finnish researchers have particular responsibility for the measurement of the 70-gigahertz frequency area, which is part of the tasks of the Low Frequency Instrument (LFI). The measuring devices have been manufactured in Finland, and the measuring data been analyzed by physicists from the University of Helsinki. A software application called Madam, developed at the University of Helsinki, is used to analyze the LFI's data in the LFI computing centre (LFI DPC) based in Trieste, Italy.

The LFI 70 GHz Instrument

The measuring devices for the three lowest frequencies (30, 44 and 70 GHz) are radio receivers, constituting the Low Frequency Instrument (LFI). The 70-gigahertz frequency measuring devices of Planck have been designed and built in Finland and utilize, like the HFI instrument, the common 1.5 meter aperture off-axis reflector antenna.

Simplifying, a Planck receiver resembles a good old crystal radio. In the crystal radio, the wanted signal is detected using a single crystal and a suitable tuning network. In the Planck receiver, extremely weak signal has to be amplified (amplification factor 500 000) before the 70 GHz signal is detected using a diode, the modern version of the crystal. The sensitivity of the receiver is so good that even radiation emitted by human body can be measured. Because the observed signal is very weak special emphasis is placed on the noise performance and the stability of the receiver. As in all space equipment, size and power consumption of the device are also minimized.

Planck LFI 70 GHz Front-End Module (FEM, in front)) and Back End Module (BEM, in back) developed by the Finnish Planck team. The FEM component houses four InP semiconductor low noise amplifiers and two phase shifters, and the BEM additional four low noise amplifiers.

The data analysis involves computationally demanding Monte Carlo simulations and carried out using CSC's Louhi supercomputer (Cray XT4) with resources granted mainly by the Distributed European Infrastructure for Supercomputing Applications (DEISA). Planck has been selected as one of DEISA's virtual communities, meaning it has been granted computing time for its supercomputers.

In the Planck project, Department of Physics is part of the LFI Consortium and Working Group 3, also known as the CTP Working Group. They has contribute especially to the study of map-making methods. With specializing on a class of map-making methods called destriping . The department has developed two map-making codes, Polar and Madam. The difference between them is that Madam utilizes prior knowledge on the detector noise properties, whereas Polar does not.

The analysis of Planck observations has many phases, and involves an international chain of cooperation, participated by Finnish researchers from the Department of Physics and the Department of Astronomy at the University of Helsinki, from the Helsinki Institute of Physics (HIP), the Metsähovi Radio Observatory of the Helsinki University of Technology, and from the Tuorla Observatory of the University of Turku. A research team operating at the University of Helsinki in the Department of Physics and the Helsinki Institute of Physics is responsible for compiling the frequency maps for the Low Frequency Instrument. The first frequency maps were published in September 2009.

Norway - Developing Methods for Analyzing Data

Institute for Theoretical Astrophysics, University of Oslo, is the Norwegian door-opener for access to data from the Planck satellite. The Institute has contributed to developing essential methods for analyzing data from the satellite and is in the core team that has the main responsibility for analyzing the data.

The Planck work in Norway is led by the Co-Investigator for the LFI-instrument. In addition, four other persons within the institute are included in the team, three of whom are so-called Planck Scientists having rights to be co-authors for all scientific articles based on the LFI Instrument. All five participate in the Core Team that gets ready the software for the data analyzing and will carry out the analysis.

Most of the Norwegian participation takes place through direct contract with ESA and includes substrate for the solar arrays, simulation equipment for ground tests and the Electrical Ground Support Equipment.

Preliminary results from the European Space Agency ESA's research satellite Planck shows that the data quality is outstanding. This shows again that the involved institutions have much to look forward to, now that the observation of the whole sky has just begun. Planck, in which researchers from the Institute of Theoretical Astrophysics at the University of Oslo has an essential role, began to investigate the whole sky 13 August last year. The instruments were tweaked to provide optimum performance in the weeks before.

With support from the Norwegian Research Council, scientists at the Institute of Theoretical Astrophysics at the University of Oslo have contributed to developing very important methods for analyzing data from Planck, and are now with the core team that has primary responsibility for the analysis of the data. In collaboration with the Institute for Theoretical Astrophysics, Spacetec AS Kongsberg has delivered a substantial portion of ground equipment to LFI.

The Norwegian Co-Investigator for the LFI-instrument Professor Per Barth Lilje tells to us that much of the time now is used to calibrate the instrument and compare the data previously collected before the real research begins. He further tells us that the members of the investigating teams make individual plans for their research, but most of the research is coordinated both on a national and international level to prevent exaggerated research in some fields.

The University of Oslo is very interested in re-examining one of the theories about the expansion of the universe. One of the theories is that the expansion is similar in all directions. However, some observations indicate that the theory not is fully correct, and that is one of the questions Planck can provide answers to.

The final results from the research will not be published until 2012-2013.