Simulating the Planck Mission on a Distributed Computing Architecture.

The DEISA and EGEE experiences.

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ADASS XVI, October 2006

Planck in a nutshell

- ESA mission, due to be launched in early 2008 (with Herschel)
- Mapping the microwave sky with an unprecedented combination of sky coverage, frequency range, calibration accuracy, independence from systematic errors, stability and sensitivity
- Two Consortia, each in charge of building an instrument and perform data processing :
  - **LFI**, tuned radiometers working at 3 frequencies (30 to 70 GHz) PI: N.Mandolesi - INAF/IASF Bologna
  - **HFI**, array of bolometers working at 6 frequencies (100 to 850 GHz), PI: J.L.Puget - IAS Orsay
- Nominal lifetime: 14 months $\Rightarrow$ two full sky surveys
- Main scientific goals:
  - temperature and polarization of anisotropies of the Cosmic Microwave Background
  - all-sky maps of all the major sources of microwave to far-infrared emission,
  - evaluation of main cosmological parameters

Simulations

Predicting the data is fundamental to understand them.

Simulations are used:

* to assess likely science outcomes.
* to set requirements on instruments in order to achieve the expected scientific results.
* to test the performance of data analysis algorithms and infrastructure
* to help understanding the instrument and its noise properties.
* to analyze known and unforeseen systematic effects.
* to deal with known physics and new physics.

Simulation pipeline: Level S/1/2

Generate CMB sky

Add foregrounds

reference sky maps

"Observe" sky with LFI

instrument parameters

Time-Ordered Data

Data reduction

frequency sky maps

Freq. merge Comp. sep.

component maps

C(l) evaluation

C(l)

Parameter evaluation

cosmological parameters

cosmological parameters

Knowledge and details increase over time, therefore the whole computational chain must be iterated many times

NEED OF HUGE COMPUTATIONAL RESOURCES

GRID can be a solution!!!

GRID Resources

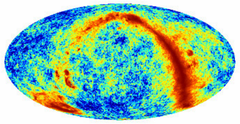
Coordinating computing resources to get the best from them and to provide the maximum “computing power” to users in an “unexpensive” way

Now (FINALLY), moving **from infrastrcture to science**

In FP6, the European Commission funded two outstanding projects for development of a European GRID infrastructure:

- **EGEE** (Enabling Grids for E-science) – bottom-up approach
- **DEISA** (Distributed European Infrastructure for Super-computing Applications) – top-down apprach

Both are being exploited for the Planck mission



EGEE (in a nutshell)

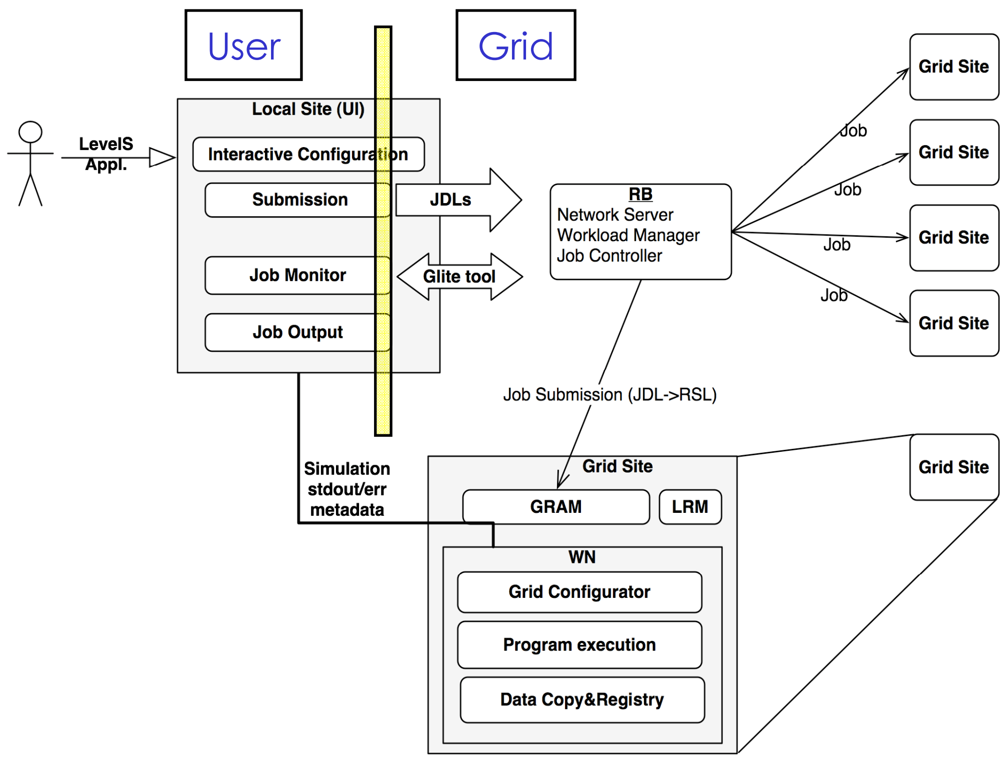
- The Enabling GRIDs for E-sciencE (EGEE) project aims at providing researchers in academia and industry with fast and effective access to distributed computing resources, independent of their geographic location.

- The EGEE community has developed G-Lite middleware, starting from the experience of EDG and LCG.

- Standard homogeneous configuration for G-Lite:
  - Globus Toolkit
  - A Storage Element (**SE**) takes care of storage services, a Computing Element (**CE**) is in charge of the computing resources and distributes jobs among the Worker Nodes (**WN**), the application execution machines.
  - The Resource Broker (**RB**) allows users to submit jobs to the GRID without an "a priori" knowledge of the resources and of their location
  - The GRID site is a cluster with its own queue system (Torque-Maui or LSF)
  - The cluster operating system is Scientific Linux 3 CERN version

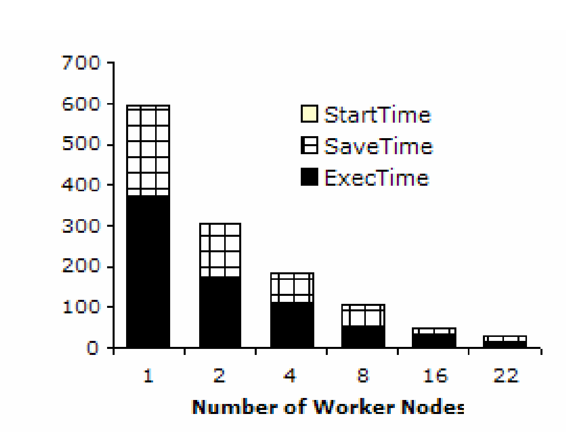
EGEE usage

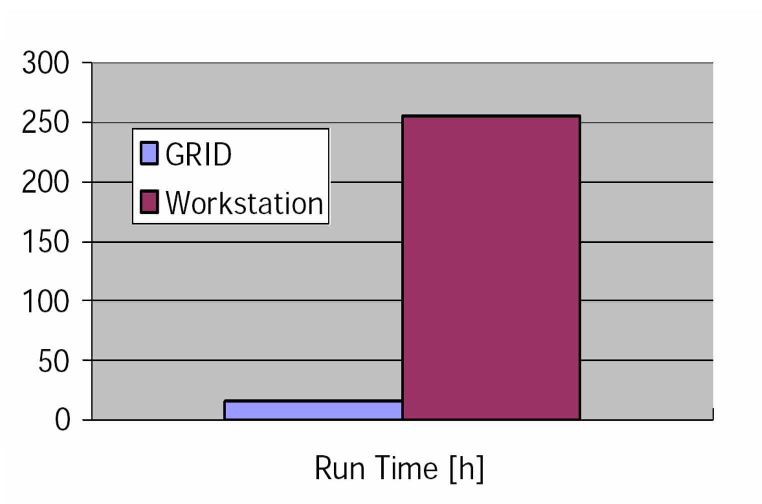
- Planck Mission Simulation (Level S) and some data reduction code (map-making, destriping) was **successfully ported on EGEE** (**EGEE Generic Application – EGAAP**)
- Application Specific Environment on top of G-Lite services that **mimics** the behavior of the standard UNIX applications and **hides the GRID complexity**
- A **metadata schema** is used to describe the output (parameters, date, size, etc.) and make data access and reduction easy for Planck Users.

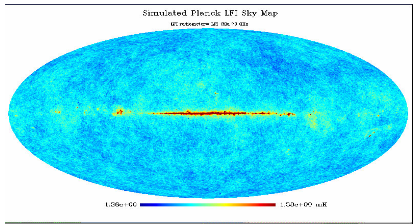


EGEE usage - Results

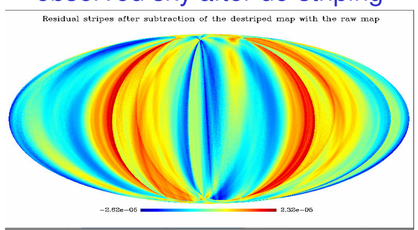
- Full mission simulated on Grid.it and EGEE, at full resolution for LFI (TOD ~ 1.3 TB) – plan to extend to HFI channels (74 total, 5.4 TB of TOD size)







observed sky after de-striping

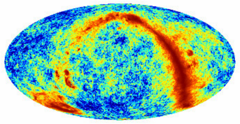


map of de-striping residuals

This approach is not effective for applications which require:

- Parallel computing (intensive communication, coupled processes)
- Large memories
- High network bandwidth
- Shared filesystems

Or for intensive exploration of phase spaces



DEISA (in a nutshell - 1)

Distributed European Infrastructure for Supercomputing Applications

GOALS:

- To enable Europe's terascale science by the **integration** of Europe's **most powerful supercomputing systems**.
- To enable **scientific discovery** across a broad spectrum of science and technology
- To **better exploit the resources** both at site level and European level and to promote openness and usage of standards

In summary:

DEISA is an European Supercomputing Service built on top of existing national services. This service is based on the deployment and operation of a persistent, production quality, distributed supercomputing environment with continental scope. **The Main focus is High Performance Computing (HPC).**

DEISA (in a nutshell - 2)

Distributed European Infrastructure for Supercomputing Applications

SITES

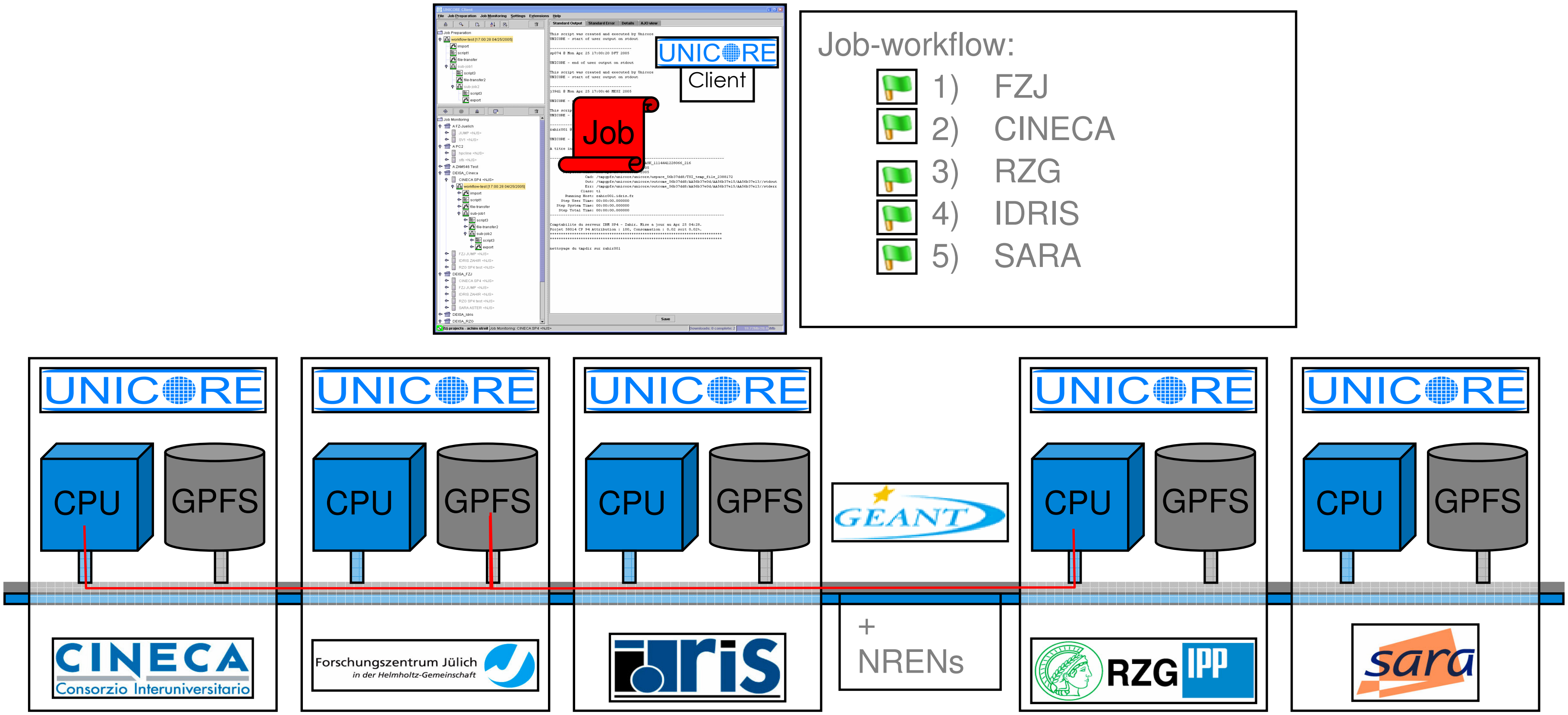
BSC	*Barcelona Supercomputing Centre*	Spain
CINECA	*Consortio Interuniversitario per il Calcolo Automatico*	Italy
CSC	*Finnish Information Technology Centre for Science*	Finland
EPCC/HPCx	*University of Edinburgh and CCLRC*	UK
ECMWF	*European Centre for Medium-Range Weather Forecast*	UK (int)
FZJ	*Research Centre Juelich*	Germany
HLRS	*High Performance Computing Centre Stuttgart*	Germany
IDRIS	*Institut du Développement et des Ressources en Informatique Scientifique - CNRS*	France
LRZ	*Leibniz Rechenzentrum Munich*	Germany
RZG	*Rechenzentrum Garching of the Max Planck Society*	Germany
SARA	*Dutch National High Performance Computing*	The Netherland

HPC RESOURCES

- IBM AIX Super-cluster
  - FZJ-Julich, 1312 processors, *8,9 teraflops peak*
  - RZG – Garching, 748 processors, *3,8 teraflops peak*
  - IDRIS, 1024 processors, *6.7 teraflops peak*
  - CINECA, 512 processors, *3,8 teraflops peak*
  - CSC, 512 processors, *2,6 teraflops peak*
  - ECMWF, 2 systems of 2276 processors each, *33 teraflops peak*
  - HPCx, 1600 processors, *12 teraflops peak*
- BSC, IBM PowerPC Linux system, 4864 processors, *40 teraflops peak*
- SARA, SGI ALTIX Linux system, 416 processors, *2,2 teraflops peak*
- LRZ, Linux cluster (2.7 teraflops) moving to SGI ALTIX system HLRS, NEC SX8 vector system, 646 processors, *12,7 teraflops peak*.
- *Systems interconnected with dedicated 1Gb/s network – currently upgrading to 10 Gb/s – provided by GEANT and NRENs*

DEISA technology

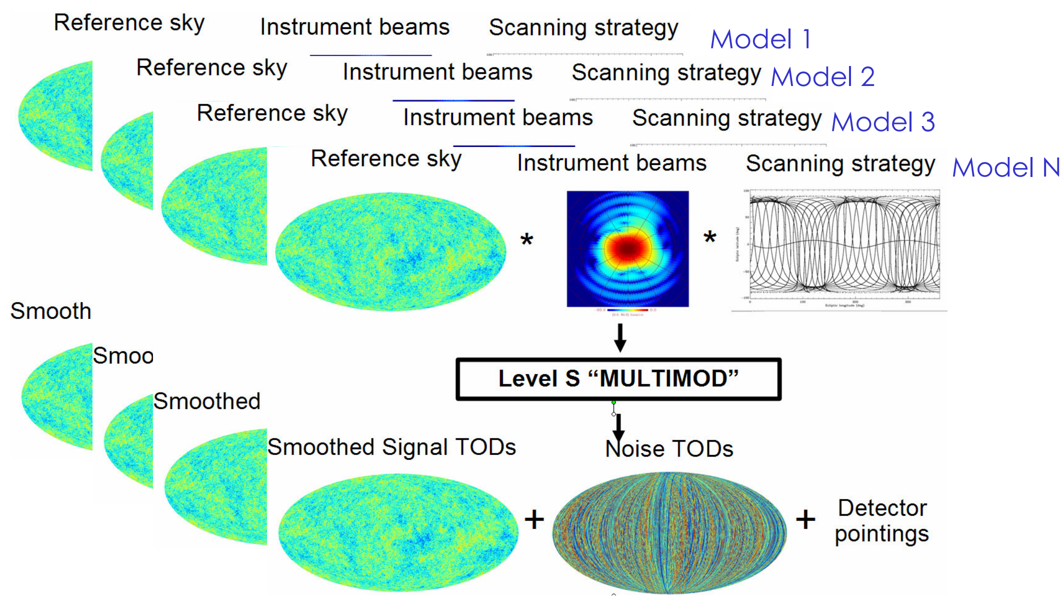
- UNICORE metascheduling system
- Load Leveler, LSF schedulers
- GPFS MC filesystem technology



DEISA usage

The supercomputing framework provided by DEISA is being used

- to simulate many times the whole mission of Planck's LFI instrument, on the basis of different scientific and instrumental hypotheses;
- to reduce, calibrate and analyse the simulated data down to the production of the final products of the mission, in order to evaluate the impact of possible LFI instrumental effects on the quality of the scientific results, and consequently to refine appropriately the data processing algorithms.



Approved as DEISA application – DECI

(DEISA Extreme Computing Initiative,

see http://www.deisa.org/applications)

Simulations in action

- **3 core sites:** CINECA (Italy), FZJ Juelich, RZG Garching (Germany) – 2572 processors available, 64 to 320 used for single run (memory bounded)
- Data stored on a **distributed filesystem** based on GPFS MC technology – approx 2 TB of resident data
- **Homogeneous** DEISA environment
- **500000** CPU hours available for the project
- Job management based on **Load Leveler MC** technology. Series of scripts to submit and control the workflow:

COMPARISON	DEISA	EGEE
Number of processors	O(1000), but HPC (fast processors, high performance networks…)	O(10000), distributed but NOT parallel computing
Available time	500000 hours	No limits
Data	Shared	Distributed
Network	High bandwidth – dedicated	Standard (large downloads difficult
Wait time	Possibly long	Usually short

COMPLEMENTARY

Summary

- Planck simulations are essential to get the best possible understanding of the mission and to have a “conscious expectation of the unexpected”
- They also allow to properly plan Data Processing Center resources

- Simulations on the EGEE grid are very useful to check (~ fast) the impact of a specific systematic effect on the scientific result of the mission
- DEISA grid allows to produce massive sets of simulated data and to perform and test data processing steps which requires supercomputing resources (lots of coupled processors, large memories, large bandwidth…)

- Interoperation between the two grid infrastructures (possibly based on the G-Lite middleware) is expected in the next years
- Planck represents an effective example of a SCIENTIFIC GRID APPLICATION