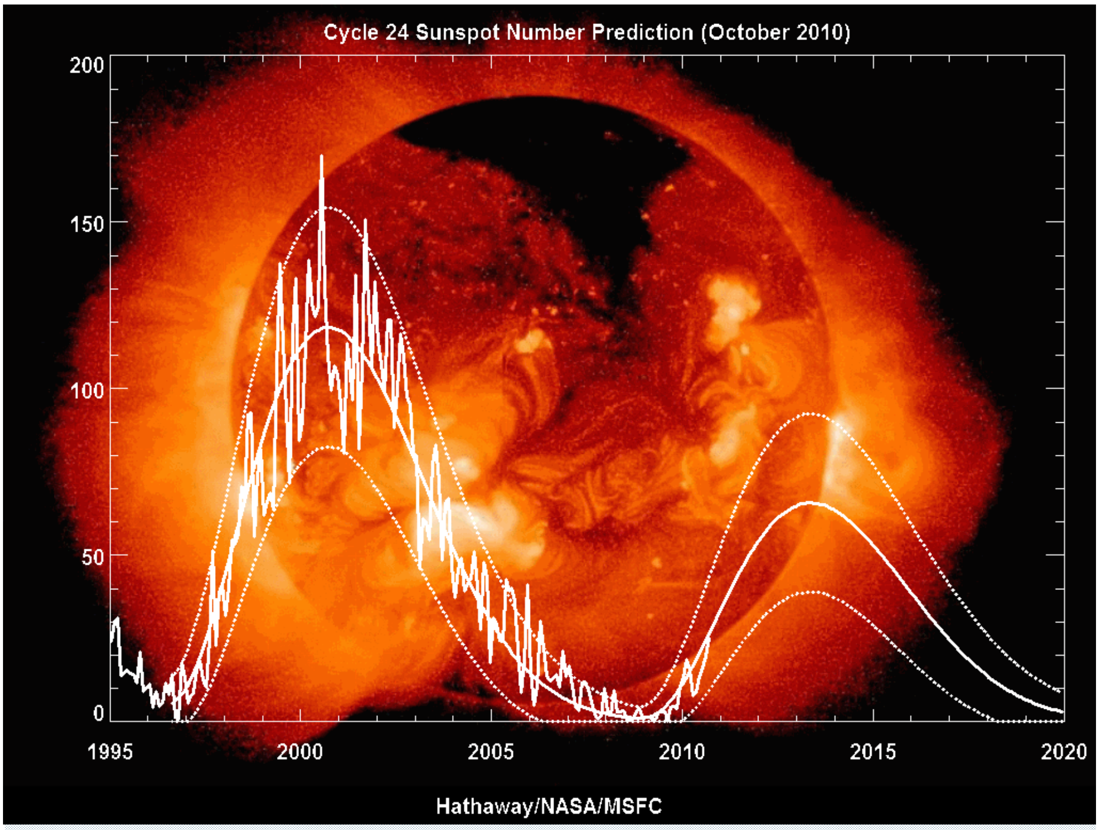
Gaia DPAC Newsletter 10

N° 10 - October 29, 2010



Prediction of the cycle 24 sunspot number superimposed on a full-disk view of the X-ray Sun produced by the Yohkoh solar observatory. The figure shows that the present solar cycle (number 24) started in late 2008 (see http://www.solarcycle24.com/ for more detailed information).

See impact for Gaia on p.4.

Counting the number of dark spots on the solar disk is one of the indicators of the solar activity during its ~ 11yr-cycle.

The left part of the plot shows the recorded sunspot number until 2011, while the right part gives the prediction for the next cycle, happily with a small maximum.

Predictions use primarily indicators of geomagnetic activity at the start of the cycle, which correlate fairly well with later solar activity

Editorial *by DPAC chair, François Mignard*

The satellite CDR (Design Review) has been successfully passed and the delivery and integrations of sub-systems continue: all the 106 CCDs of the focal plane have safely arrived at EADS Astrium in Toulouse, several mirrors, including one of the two primaries, are also there and the folding optics structure has been integrated on the SiC Torus. The Service Module flight model has been in Toulouse since July and numerous tests are being performed. Schedule is still very tight, but could it be different ? It will be tight until the very end, and DPAC is no exception to the rule.

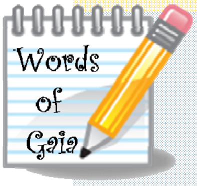
On the DPAC side, progress is more difficult to assess. For sure, we see that hardware procurement is moving fast in the various Processing Centres to meet the requirement at launch time. But software development status and complexity have always been hard to quantify, let alone the fact one cannot prove that a software produces correct results. With about 2.5 million lines of code in the DPAC repository, we have at least a first measurement and a reference for further comparisons. Each CU applies strict quality controls for the design and conformance and, at a global level, the Project Office is using Internet available tools to better monitor the advancement. More will come from the DPAC testing campaigns under way.

In this issue of the NewsLetter you will find the presentation of two of the largest DPAC teams, both having a wide involvement in our activities. You will learn why we care so much about the solar activity during the mission and hope the Sun to stay quiet to keep the Gaia CCDs healthy and discover why the solar system community is expecting so much from Gaia.

DPAC news

The DPAC system has entered into the first stage of integration testing, with the validation and production of a huge volume of simulated data during summer. Then several pieces among the critical software (those activated daily as soon as real data are available) have been integrated at ESAC, with already fruitful lessons drawn from the exercise. The first stage of the testing for the early processing chains started on September 29 and is progressing as expected. In parallel the testing of the numerous interfaces, including data transfer, between ESAC and each of the other processing centres is scheduled for a start on 12 November 2010.

A new DPACE level working group named GAP, standing for Gaia Archive Preparation, has been put in place by the Executive Committee to provide advice on the needs and organisation of the archive and start polling in the community for interested groups with relevant expertise, in anticipation of the future CU9. This WG is chaired by William O'Mullane and will be in function until CU9 is formally activated, following the answers to a dedicated AO to be released by ESA.



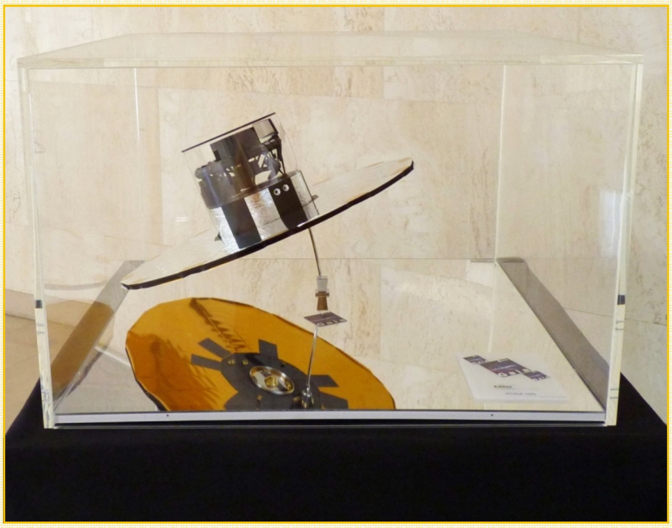
Java

Java story starts in 1991, when a small group of Sun Microsystem employees conducted by James Gosling was chosen to work on a project called *Green* dedicated to commercial electronic applications. A specific language, *Oak* was created for managing these electronic equipments. This name originated from an oak tree that stood outside Gosling's office. But the name *Oak* being too similar with another trademark name, it was renamed Java in 1995. No particular reason for the choice of *Java* and the name was chosen from a list of random words. But Americans using also *java* as a colloquial word for coffee, from the Arabica coffee beans produced in Java island's plantation, the famous Java logo figuring a smoking cup of coffee was born.

The most important advantage of the Java language is probably its portability, as it can be run on every kind of machine with a java interpreter. That portability is fundamental for Internet applications, where an important number of machines and operating systems can be found. This was also one of the reasons it was selected for the processing software in the DPAC.

The Gaia model

The pictures show two views of a Gaia scale model hand-made by J.F. Tapia in Toulouse. He owns and operates a small business specialised in the design and realisation of models at various scales, primarily directed to space and aeronautical industry. The models are all made individually, by hand out of resin, acrylic glass, brass and kapton and have sharp details.



The views correspond to the 1/20 scale which is made up of 219 components and seen on display in its case. Gaia models have been ordered by, and delivered to, EADS-Astrium, CNES and the observatories of Paris, Côte d'Azur and Geneva.

Models at 1/50 or 1/10 scale are also available.

Contact: jftapia31@orange.fr

Focus on partners

Gaia at ARI Heidelberg *by U. Bastian*

The acronym ARI stands for Astronomisches Rechen-Institut, which means institute for astronomical computations. ARI's participation in the Gaia project has grown out of its 300-year history in positional astronomy, and more specifically out of the contributions to Gaia's predecessor, Hipparcos. At the time of its foundation, and during its first two centuries, ARI was mainly occupied with the computation of calendars, ephemerides and orbits of minor planets. The 20th century saw a gradual shift of emphasis towards astrometry, reference systems definition and research on galactic structure and evolution. In recent years, strong extragalactic research and cosmology groups have extended the institute's scope. Since 2003 ARI is one of the three institutes comprising Heidelberg University's Zentrum für Astronomie (Centre for Astronomy, ZAH).

Left to right, top row first:

U. Bastian, M. Biermann, S. Jordan, E. Mercier, W. Löffler, T. Brüsemeister, U. Stampa, S. Aguduri, M. Altmann, H. Lenhardt, H. Bernstein, W. Hofmann

The Gaia group at ARI consists of twelve people, eight of which are funded by the German Space Agency DLR, with four of them being software engineers (Shilpa Aguduri, Ulrike Stampa, Thomas Brüsemeister, Wolfgang Löffler). One of us (Emmanuel Mercier) is doing project management at ESAC, Villafranca, where he is leading the DPAC Project Office. The other seven are astronomers and are located at Heidelberg.

ARI is mainly active in CU3, DPAC's large "Core Processing" coordination unit. The biggest contribution is the preparation of concepts, data and manpower for the First Look task aiming at a daily in-depth assessment of instrument health and scientific data quality during all of Gaia's 5-year operations. This task is one of those few DPAC activities which in the agreements with ESA have been classified as "schedule-critical items". The First Look task keeps the majority of us very busy. In addition, the DPAC group at ARI contributes to CU3 by providing the scientific CU leader, the coordination of the planned ground-based optical tracking of the Gaia spacecraft, the preparation of the ecliptic-poles catalogue, and a few other smaller work packages.

It should be noted that the topic "Gaia at ARI" goes well beyond the DPAC contributions. A significant part of the institute's 96 heads - namely the galactic and near-field extragalactic researchers - are actively preparing for the scientific exploitation of the Gaia results.

ESAC team in DPAC *by W. O'Mullane*

The Gaia team started at the European Space Astronomy Centre near Madrid in August 2005. The first arrivals to the baking heat were myself and Uwe Lammers. Neither of us were of course newcomers to Gaia even at that stage but we had the new task of setting up the Science Operations Centre (SOC) for Gaia. SOCs tend to vary in their composition and purpose. Gaia SOC was to be a technical resource for the Gaia mission in collaboration with the, yet to be officially formed, processing consortium. Clear goals and guidelines were set by Michael Perryman (Project Scientist at the time) and plans and manpower profiles were drawn up.

The ESAC team (like MOC) is funded by ESA as part of the Satellite Cost at Completion and envelope for SOC was negotiated in 2005 covering the full mission-duration up to the final catalogue production in 2020.

The technical role of CU1 in the processing architecture was firmed up and tools such as Subversion were quickly put in place and used for building the response to the AO. The team grew quickly from year to year and will reach its maximum of 23 people next year most of whom are full time dedicated to Gaia.

From the outset CU3 and ESAC were closely related. All daily processing was targeted to be at ESAC while the software would be developed in different CU3 institutes. From ESAC, data will be shipped to the other Data Processing Centres after IDT processing. This is the job of the Main Database (covered in a previous issue) and Gaia Transfer System. A first key task of the team was to show that the Astrometric Global Iterative Solution (AGIS) is feasible, a clear demonstration of the technology was required and provided early in 2006 with the collaboration of Lund Observatory, ARI and UB.

ESAC continues leading the testing effort for DPAC and is looking forward to launch!

Gaia SOC team taken September 2009 on then old IUE Satan Antenna hill at ESAC Madrid.

The role of solar activities on the Gaia mission flow *by George Seabroke (MSSL, University College London), Thibaut Prod'homme (Leiden Observatory)*

The Sun both helps and hinders the Gaia mission. It will help by powering the satellite via the solar panels but it will also hinder: solar radiation will damage Gaia's CCDs.

Gaia will travel through trapped electrons and protons around the Earth and then encounter Galactic cosmic-ray protons and ions and solar protons and ions at L2. The flux level of solar protons at L2 dominates over the other radiation particles and so models of this space environment only consider solar protons. Ground-based CCDs encounter the same Galactic cosmic rays but, unlike Gaia, they are protected from the solar protons from the Earth's magnetic field.

Solar protons are produced in solar flares and coronal mass ejections and therefore the solar proton flux depends on the level of solar activity, governed by the solar cycle. Predicting the behaviour of a solar cycle is relatively reliable after its start as illustrated in the cover picture of this Letter.

These protons will cause displacement damage in the light-sensitive areas of Gaia's CCDs by knocking silicon atoms out of the lattice. The resulting vacancies move around the lattice and can bond with other vacancies or atoms: phosphorous (implanted dopant used to make the buried channel within the CCD) or oxygen or carbon (present in Gaia CCDs due to the e2v manufacturing processes). The different bonds are different radiation traps, so called because they trap electrons from passing charge packets and then release them again stochastically with different characteristic timescales. In TDI, this means that electrons are captured from the leading edge of images with some, but not all, deposited in the trailing edge. In AF images, this causes a positional centroid shift and charge loss. In RVS spectra, this causes a radial velocity shift and loss of detail in the shape of the absorption lines.

In order to investigate how radiation damage effects Gaia's CCDs, Engineering Model (EM) CCDs were irradiated on the ground. Increasingly realistic "observations" have been made in a series of tests, called the Astrium Radiation Campaign (RC). This data is analysed by ESA and DPAC and discussed at regular DPAC Radiation Task Force (RTF) meetings.

As the RC needed to start before the onset of the new cycle, the EM CCDs were irradiated with a proton flux based on a solar proton model that used the best prediction of cycle 24 at the time (see table).

The RC values in the table are based on cycle 24 starting around early 2007 with Gaia launching in December 2011, at the peak of solar activity, and observing 3.5 years in solar maximum and 3 years in solar minimum.

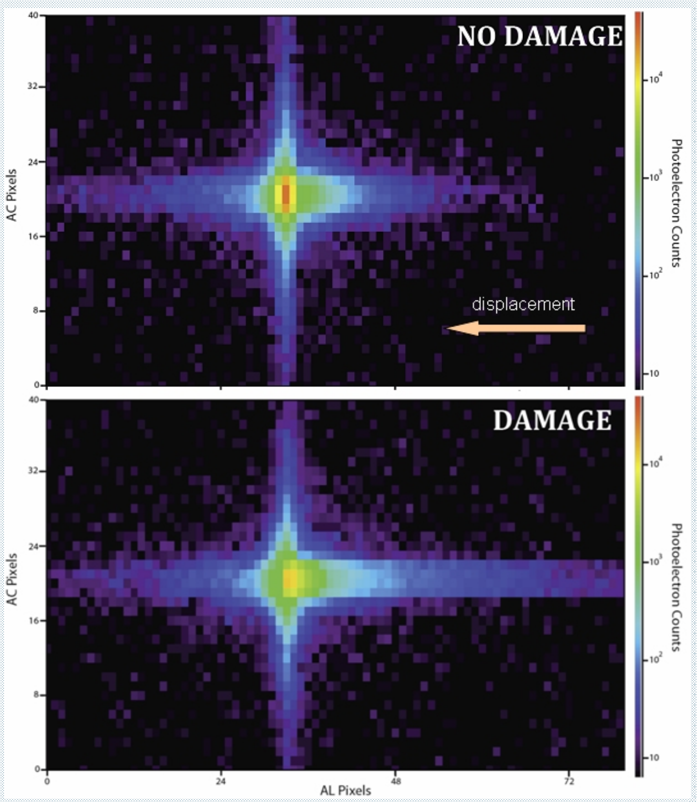
Table comparing the end-of-mission fluence (10 MeV equivalence) of protons per cm^2

CCD	RC	New prediction
AF	4.0×10^9	1.7×10^9
BP	2.0×10^9*	8.3×10^8
RP	2.0×10^9	8.6×10^8
RVS	2.0×10^9	1.0×10^9

**predicted value, no BP CCDs irradiated in RC*

However, we know now that cycle 24 actually started later than predicted (see cover picture). The RC values were also based on the assumption that cycle 24 was going to have the same level of activity as the previous cycle but the figure shows that the now more reliable prediction is for a lower level of activity than expected. Astrium's new predicted values reflect this as well as Gaia's later launch date of 2012 and better shielding around the CCDs.

The table shows that the RC values are a factor of two higher than what can now be expected at the end of mission, which is good news! Having calibrated radiation damage correction models, including the Charge Distortion Model that will run in the DPAC data processing pipelines, against the RC data, the RTF can now use these models to update Gaia's science performance predictions in light of its now less harsh radiation environment at L2.



Effect of radiations on the Gaia CCDs, showing in the radiated image the loss of flux at the centre and the extended trail in the image of a point-like source.

credit: CEMGA simulations, Thibaut Prod'homme

Gaia Observations of Asteroids: waiting for the Revolution *by Alberto Cellino and Aldo Dell'Oro (INAF - Osservatorio Astronomico di Torino)*

The population of minor bodies mainly located in the main asteroid belt between Mars and Jupiter, including also the dwarf-planet (1) Ceres, is thought to have experienced a limited physical evolution since the early epochs of planetary accretion. Due to the non-negligible radial extent of the main belt, the asteroids can provide information about the gradient of mineralogical composition of the early planetesimals as a function of heliocentric distance.

Available spectroscopic data and the recent discoveries of so-called main-belt comets, suggest a large variety of compositions among the asteroid population, confirming the expectations that bodies in the asteroid belt should exhibit a gradual transition from mostly rocky planetesimals typical of the inner Solar System to volatile-rich, comet-like planetesimals more common in the outer regions. The inventory and size distribution of the asteroid population should also be a tracer of the main collisional and dynamical evolution experienced by the population since the early epoch of formation.

Unfortunately, however, our knowledge of the physical properties of asteroids is still severely limited, due to the fact that these bodies are mostly faint, point-like sources when observed from the ground. Two key problems, in particular, are very annoying:

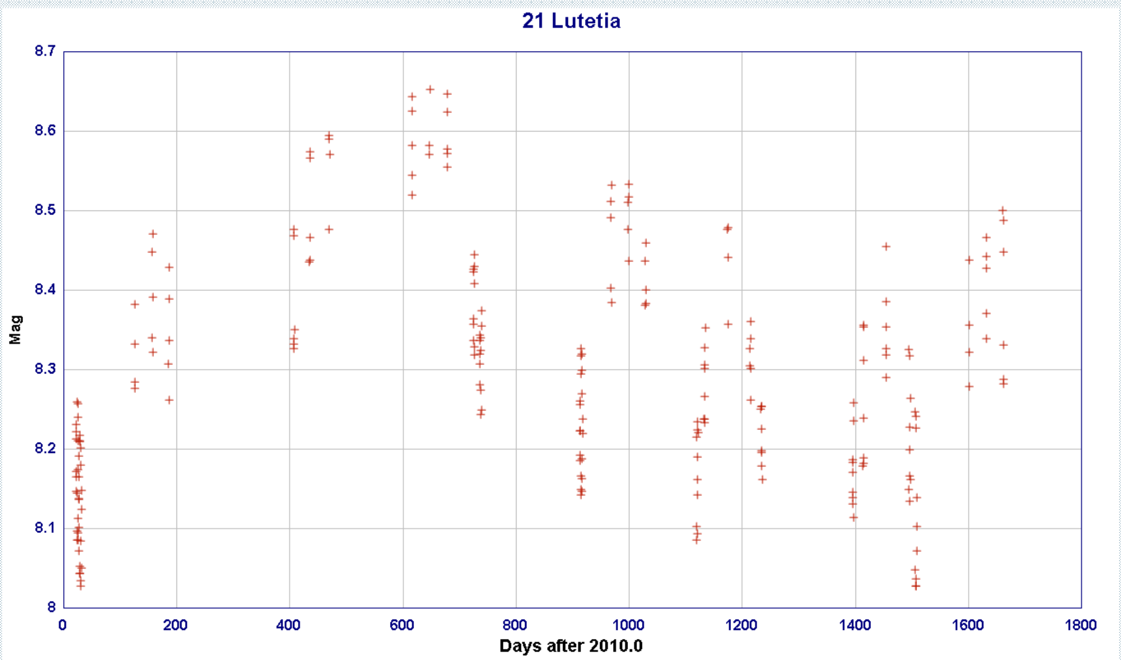
- We do not know the *masses* of the asteroids, but in a very few cases.
- As a consequence, we do not know asteroid *densities*. In this respect, we stress that the present knowledge of asteroid *sizes* is also limited, being mostly based on indirect measurements and model-dependent inferences.

Other problems are also currently open. We have a limited knowledge of the distribution of the spin periods and orientation of the rotation axes. These parameters are important because they are produced by the interplay of collisions and subtle thermal radiation mechanisms. Moreover, currently available spectrophotometric data, which sign the surface mineralogical composition, are biased in favour of brighter (and thus larger and/or less distant) objects.

Fortunately the exquisite astrometry and photometry of Gaia will cast new light on these issues. Thanks to its repeated observations of more than 200 000 asteroids down to magnitude 20, we expect to directly measure the sizes of about 1000 and obtain masses for at least 100 of them, through the tiny orbital deflections experienced during mutual close approaches. For the same objects, we will derive also the average density. Moreover, we expect to be able to derive spin properties and overall shapes of more than 10 000 objects, and obtain much improved orbits and spectrophotometric data that will be used to derive a new taxonomic classification for most of the observed sources.

Several teams are now involved in producing innovative algorithms to process Gaia asteroid data. As an example, a genetic algorithm has been developed to carry out the inversion of sparse photometric data, in order to obtain spin properties and overall shapes of the objects.

Gaia will open up a completely new era. By working to prepare data reduction algorithms specially designed for Gaia asteroid observations, we are aware that we are preparing a big revolution in asteroid science.

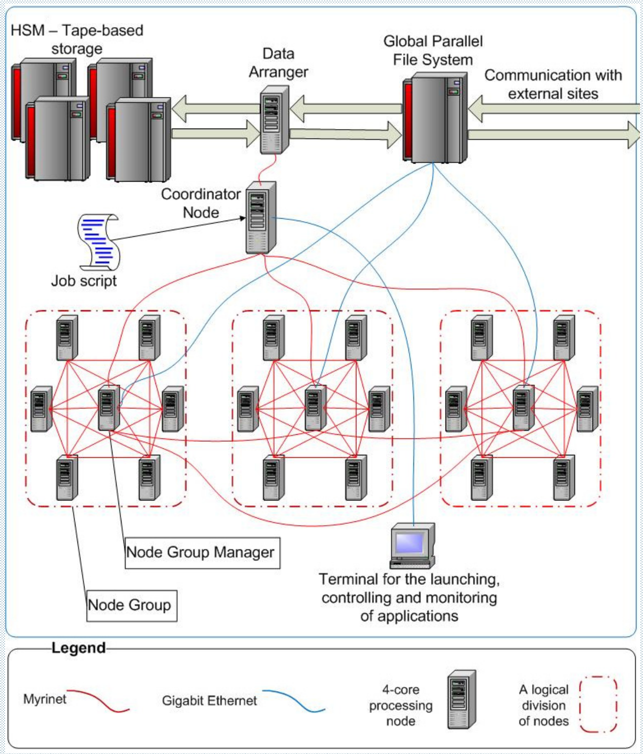


Simulation of Gaia photometric observations of the asteroid (21) Lutetia over five years. The plot shows the visual magnitude referred to a constant distance of 1 au (the so-called absolute magnitude for solar system objects), so that the remaining variations follow just from the phase and the rotation of an irregularly shaped body. From data like this, it will be possible to derive information on the asteroid spin period, spin axis direction, and overall shape assuming a triaxial ellipsoid approximation.

ELSA: Aidan Fries, *University of Barcelona*

Aidan Fries is a Ph.D. student at the University of Barcelona. He is based in the Department of Astronomy and Meteorology (ICC, Institute for Cosmos Sciences) and is one of the members of the Data Processing Centre of Barcelona (DPCB).

The general focus of his work is on the use of Java-based software in a High Performance Computing (HPC) environment. Java is one of the most widely used computer programming languages; however, its use in HPC is not widespread. Therefore, the Gaia data reduction chain, which is almost entirely written in Java, represents an opportunity to showcase the capabilities of Java in HPC.



A number of topics have been identified as crucial to the efficient design and operation of the Gaia software. These include: optimisation (both of the code and of the Java Virtual Machine - *JVM* -), efficient data transfers (at several levels), and the monitoring and controlling of the software while it is running. Another important issue is the management of the Gaia data reduction chain during an upgrade of the available hardware.

Aidan has developed a Java Management Extension (JMX) based application to allow the monitoring of remote JVMs. He has also collaborated with researchers at the Barcelona Supercomputing Centre on the profiling of Gaia software and on the optimization of the IBM JVM. Currently he is working on the management of the data transfers within the MareNostrum supercomputer.

To that end, he is collaborating with researchers at the University of A Coruña, building upon a Java-based implementation of Message Passing Interface (MPI) which was developed there, to provide fast data transfers between computing nodes.

Proposed scheme for data communication between computing nodes and the central disk within MareNostrum.

Calendar of next DPAC related meetings

Date	Place	Who	Type	Resp.
04-05/11/2010	Nice		GBOG	C. Soubiran
10-12/11	Cambridge	CU7	Plenary	L. Eyer / D. W. Evans
16-18/11	CNES	CU4	Plenary	D. Pourbaix
25-26/11	Lund	CU3	AGIS14	U. Lammers
29/11-01/12	Bordeaux	CU6	Plenary	C. Soubiran / D. Katz
16-17/12	Dresden	CU3	REMAT08	S. Klioner
20/01/2011	Toulouse	Steering	SC #07	W. Boland
18-20/01	ESAC	CU1	SOC/MIT/IDT/FL	J. Hoar
27-28/01	ESTEC		DPACE #12/GST #33	F. Mignard / T. Prusti

Gaia and related science meetings

Date	Place	Title	Type
02-04/11	Nice	Gaia Chemo Dynamical Survey	Workshop
29/11-01/12	Paris	Gaia FUN-SSOs	Workshop

More information on calendar of Gaia : http://www.rssd.esa.int/index.php?project=Gaia&page=Calendar_of_meetings

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