Gaia DPAC Newsletter n°4

N° 4 — April 30, 2009

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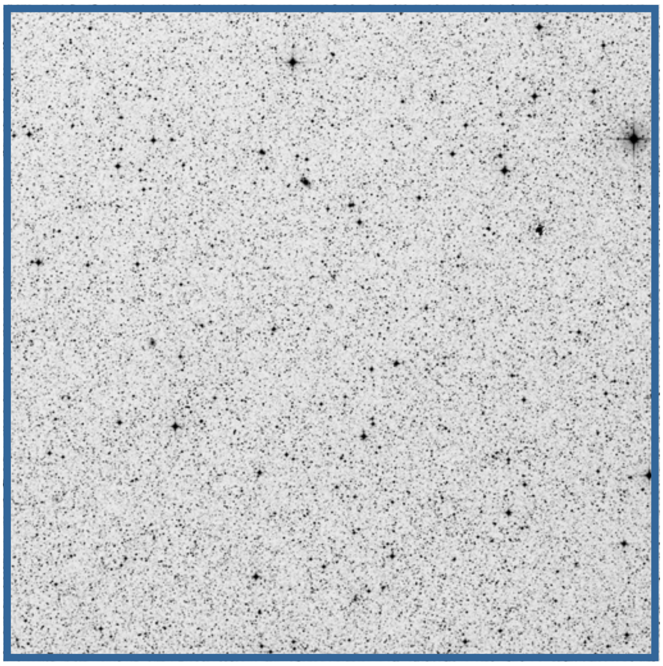
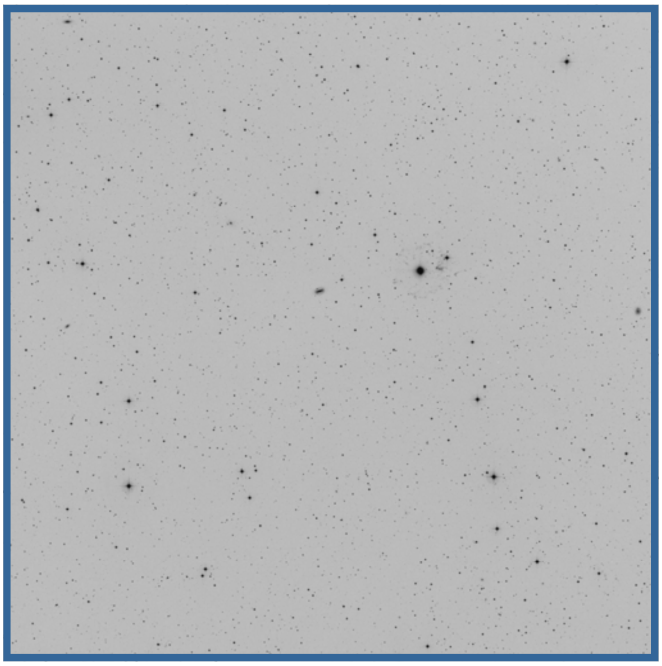
SEP (South Ecliptic pole)



NEP (North Ecliptic pole)



The two sky areas around the ecliptic poles (south on the left and north on the right) will be used during the Gaia commissioning to test the spacecraft performance just after launch. The scan will be in a special mode for about two weeks, with the fields of view going repeatedly through the ecliptic poles every six hours. We will check the actual sensitivity of the detectors, the on-board detection software, the windowing procedure and the level of completeness around the Gaia detection limit. To meet this goal, special observations led by M. Altmann from the CU3 and coordinated by the GBOG group are under way to improve our knowledge of these sky regions both in astrometry and photometry, so that it can be used as reference for calibration purposes. In the above images the fields are 67' x 67' with the faintest stars around 20 mag in the red. Courtesy M. Altmann.

Editorial *by DPAC chair, François Mignard*

From recent presentations at the project level one thing emerges clearly: the construction of Gaia (the C/D phase) is there. Gaia is no longer just these beautiful CAD artworks produced by Astrium, as real pieces of hardware are being produced and qualified.

To date 87 of the 106 flight model CCDs are available while all mirrors are in various phases in the production line like grinding, polishing, ion-beam figuring, final coating, with the small mirrors done first and primary mirrors due in one year. The 17 elements of the SiC (*Silicon Carbide*) torus have been successfully tested and a critical phase is under way with the brazing of the whole torus next June or July. Smaller artefacts gradually fill the shelves like the gyroscope, the engineering model of the clock, the video processing unit (VPU), the conical structure of the service module (SM).

You will see in this issue how the satellite operations are being actively prepared by the ESOC team at Darmstadt, another indication that the Gaia flight is nearing.

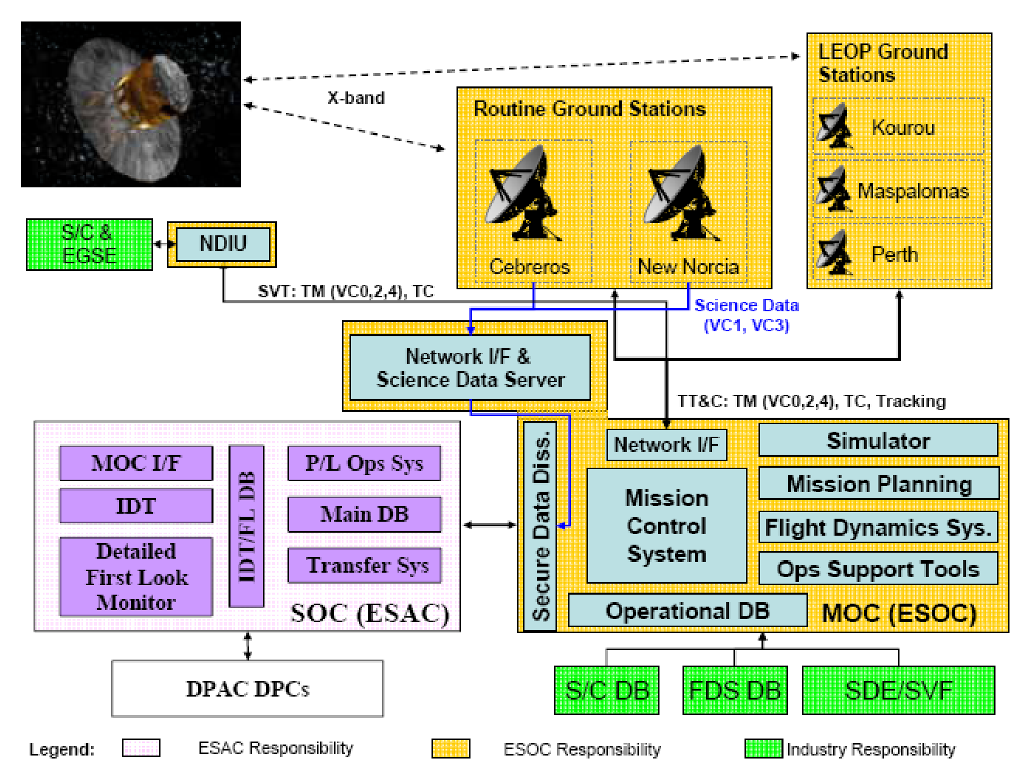
The DPAC is also having its share of significant advances with concrete integration of many pieces of software in the DPCs, although we are still far from digesting from the start-to-end a sizeable amount of telemetry data. This should happen next year with the early phases of the end-to-end testing.

The Design Review which starts in a few days will critically look at the DPAC activities, focussing on the part of our work which are the most critical for the mission, like the IDT (Initial Data Treatment) and First Look or our ability to receive the data from ESOC on a regular basis and to transfer large volumes of data within the DPAC centres. The first conclusions of this review will be reported in the next issue of this Newsletter.

MOC at ESOC *by David Milligan*

The Gaia spacecraft will be operated by the Mission Operations Centre (MOC) from ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany. ESOC is responsible for operating most of ESA's scientific and Earth Observation missions (e.g. GOCE, ERS2, Envisat, Cluster II, Mars Express, Venus Express, Rosetta, Integral, XMM, Herschel and Planck) and holds the development responsibilities for ESA ground stations, and ground segment systems such as the SCOS Mission Control System (MCS). ESOC also performs mission analysis and provides Flight Dynamics operational services.

The Gaia MOC functional breakdown is shown within the overall ground segment in the following figure:



The MOC is in charge of mission operations planning, execution, monitoring and control, including Ground Station control. The Deep Space antennas at new Norcia and Cebreros will be used throughout the mission, complimented by a set of 15m antennas for Launch and Early Orbit Phase (LEOP) and critical operations.

At the heart of the MOC systems is the real-time spacecraft monitoring and control functions provided by the Mission Control System (MCS). The MOC also includes: the On-Board Software Maintenance system, which will provide the functions related to configuration control of the On-Board Software packages; the Mission Planning System, which will plan and schedule the mission operations for the space and ground segment; the Spacecraft Simulator, which is used for MOC validation and team training; the Science Data Server, which stores science data from VCs 1 and 3 before transfer to the SOC; and the Flight Dynamics System, which provides functions related to orbit determination and prediction, manoeuvre planning, AOCS command generation, and attitude monitoring.

The Gaia MOC team structure is split into four main sections: Flight Control Team (overall responsible for spacecraft operations), Software Support (responsible for mission data systems tailoring and maintenance), Stations and Facilities (responsible for ground stations and facilities tailoring), and Flight Dynamics (responsible for orbit and attitude). During LEOP these teams work together as part of the Mission Control Team (MCT), which will additionally contain the Project support team made up of Project and Industry specialists. The MCT is led by the Operations Director (OD) and during LEOP works around the clock until the spacecraft is confirmed in a stable and safe configuration, ready for commissioning to start.

Following this the payload is commissioned with the help of payload specialists, until the routine phase of the mission begins.

Before the launch, the MOC coordinates ground segment development with the ESTEC Project, SOC/DPAC, and industry through such forums as the Ground Segment Systems Engineering Working Group (GSSEWG) and Gaia Science Team meetings. The MOC recently passed into the implementation phase, which mainly involves tailoring of ground segment infrastructure systems for Gaia, after performing the Ground Segment Design Review at the beginning of this year.

SIM - U. of Lisbon *by André Moitinho de Almeida*

SIM (http://sim.fc.ul.pt/sim_en/Main_Page) is the abbreviation for a Centre with a very long name, the "Laboratory of Systems, Instrumentation and Modelling for Environment and Space Sciences and Technologies" which belongs to the University of Lisbon.

The Centre is composed of 2 groups. One dedicated to "Climate Change. Impacts, Adaptation and Mitigation" (CC-IAM). And one dedicated to "Instrumentation and Computing for Space and Earth Observations" (ICSEO), which is the group participating in the DPAC. ICSEO has 3 senior scientists, 2 post-docs, 1 engineer and 7 students (BSc, MSc). The ICCSEO group has led the design and construction of the first Portuguese instrument for ESO - CAMCAO - a near infrared camera for multi-conjugate adaptive optics and is responsible for mechanic and cryogenic systems of other instruments under development for large telescopes (VLT, VLTi and GTC). The team's astronomical expertise comprises Galactic Structure and young low mass stars and brown dwarfs.

Within the DPAC, our activity is focused on CU1 and CU7. Building on experience gained in preparation of the CERN LHC ATLAS experiment, A. Amorim manages the CU1 Database Test Work Package (WP). He and C. Jesus (student) address the Gaia database infrastructure, covering database implementation, testing, validation and performance evaluation.

CU7 work is done in team with the Uninova/CA3 artificial intelligence group of the New University of Lisbon.

A. Moitinho manages the Bias Estimation WP. The goal is to assess and correct biases in the final Variability Catalogue. Work on code parallelisation and performance assessment is done together with our own CU1 people and tested in our cluster of 160 cores. We also participate in the Unsupervised Classification WP. B. Miranda (student, shared between SIM and Uninova) is our Software Engineer who implements it all and also writes the SDDs. Gaia funding for SIM and the other six Portuguese centres is provided by a national project (PI A. Moitinho).

From left to right: B. Miranda, A. Amorim, A. Moitinho, C. Jesus.

Observatoire de Besançon *by Céline Reylé*

The Astronomical Observatory of Besançon, France (http://www.obs-besancon.fr/) hosts 45 researchers, PhD students, technicians and support personnel. The main research areas are small bodies in the Solar System, stellar populations in the Milky Way, fundamental physics and the reference frame, and time transfer.

6 people are involved in the preparation of Gaia, in CU2, CU3, CU4 and CU7.

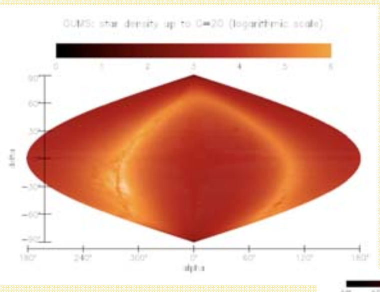
In CU2 (data simulations) A. Robin, C. Reylé and E. Grux have the responsibility of the Universe model and of the development of the Galaxy model (based on a model developed over many several years in Besançon, http://modele.obs-besancon.fr/). This simulator, or at least part of it, is used by the generators GASS (telemetry), GIBIS (images) and GOG (objects) and by other CUs to test their algorithms.

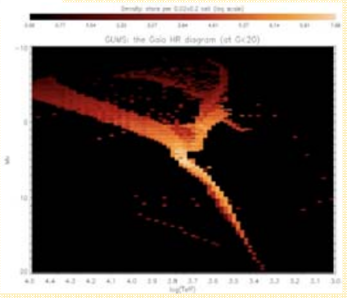
In CU3 (core processing), A. Fienga, together with the IMCCE in Paris, develops and delivers to DPAC the 4-D planetary ephemerides INPOP (http://www.imcce.fr/fr/presentation/equipes/ASD/inpop/). INPOP will be used for the data processing as well as for the navigation activities at ESOC.

In CU4 (object processing), J.-M. Petit is responsible for the threading of Solar System Objects that links all the observations of a same object during the mission. This work is necessary to determine the orbit and the physical parameters of asteroids.

In CU7 (variability processing), M. Schultheis is involved in the processing of long period variables.

The Gaia group is primarily state funded for the salaries of the staff and by the French space agency (CNES http://www.cnes.fr/) that supports temporary appointments of one engineer and other expenses.

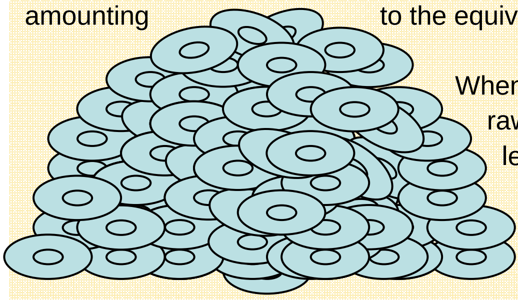




Figures: GUMS: Gaia Universe Model Simulations (collaboration with Y. Isasi, F. Figueras, X. Luri, University of Barcelona). Density of stars and HR diagram up to Gaia magnitude G=20.

Gaia data volume in perspective *by François Mignard & Sophie Rousset*

The Gaia mission is impressive on many counts including the final data volume to be stored in the raw and science data bases. Every day about 100 Gigabits of compressed data will be channelled to the ground station, amounting to the equivalent of 30,000 standard CD-ROM by the end of the mission.



When one comes to the processed data the numbers are skyrocketing. The raw data is first uncompressed and followed by numerous processing steps leading to a final storage **in the range of the PB**, (a million GBytes).

Nothing comparable exists already in astronomy and the only way to grasp the challenge is by reference to existing data or other big projects !

☞ **The size of the CDS database used by every astronomer is dwarfed by Gaia:**

- ***VizieR*** (Astronomical catalogues server) **0.5 TB**
- ***Aladin*** (multi wavelengths images of the sky) **6 TB**
- Daily flux of data to the users **4 GB/days**

Note: Important to know that despite its unimpressive volume, the CDS service needs about 10 staff for its maintenance, operation and technological monitoring. Good to know for us: size is not the last word, complexity and reliability matter quite as much, if not more!

- The SDSS (Sloan Digital Sky Survey) has produced 20 TB of raw images, leaving at the end a scientific database of about 1 TB.

- ***Planck*** database at mission completion **about 1TB**
- Human Genome Database **25 TB**

- The World Data Center for Climate is believed to host the largest science data base in the world with **220 TB** of web data and an additional **6 PB** stored on magnetic tape.

- Larger volumes of science data are routinely found in particle physic experiments, with the recently dedicated LHC in CERN expected to generate **15 PB** of data per year (for the 4 experiments).

However, the radio-astronomical facility SKA (Square Kilometer Array) will generate **250 PB/day** of raw data when in full operation in 2020.

☞ *For comparison, hereafter are listed some well-known usual database volumes:*

the text of all the books published in the world every year = **1 TB**

Text of the books of the Library of Congress (largest in the world) = **20 TB**

amazon.fr database accessible on the web has a volume of ~ **40 TB**.

The popular videoserver ***YouTube*** has 45 TB of video readily available, but a traffic of **30 PB/months**.

Facebook hosts more than 10 billion photos amounting to **1 PB** of volume storage.

...in conclusion you should have a better idea of what 1PB of accessible data means!

Managing stellar multiplicity or the art of recycling *by Frédéric Arenou*

My respected Coordination Unit Manager often describes CU4 as the garbage collector of all ill-behaved objects. Far be it from me to introduce any competition between CUs, but the fact is that CU4 is the only ecological CU. Indeed, we recycle all bad solutions that no one else wants, and this on a large scale: dozens of millions of Non-Single Stars (NSS) are expected.

Accordingly, the NSS data handling has been organised as a vast selective waste collection. Not less than 12 different kind of solutions will be produced for binaries only, not mentioning the handling of multiple stars. However, not all garbage dumps have been created equals.

On the top rank (based on the scientific outcome, and the number of people struggling to work on the subject, not on the number of objects), one may find the rich man's dump of the extrasolar planets. Then, because they allow to obtain radii and masses, eclipsing binaries follow, then come the astrometric orbital solutions and the spectroscopic binaries. Various poorer VIM solutions (double stars where one component is variable and the astrometric position thus oscillates) come next, together with the acceleration solutions, and the numerous, mostly long period, resolved binaries. Finally, and as a last resort, the poor's man stochastic solution dump will deal with (read: do nothing else than down-weight) those outliers that no one knows how to manage. Still, I would like to stand up for their case: after all, *today's outliers are sometimes tomorrow's science...* Then, the various solutions may in some cases be combined to improve the results (think e.g. of spectroscopic eclipsing binaries) or to exhibit stellar multiplicity.

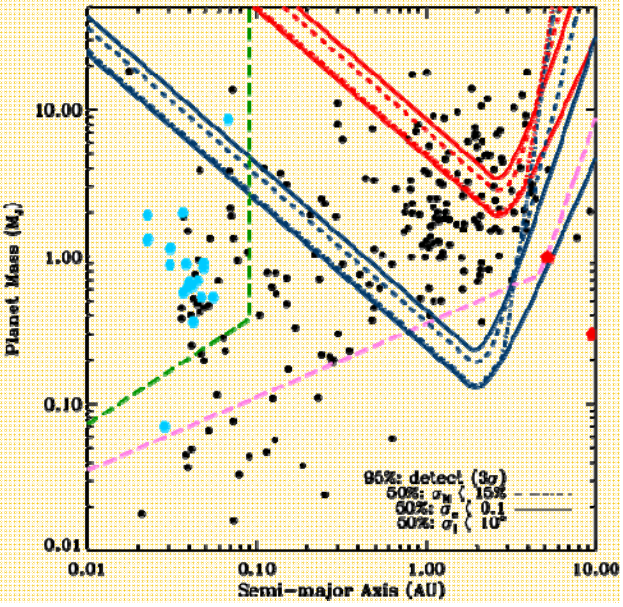
Clearly, dealing with multiple stars will be complex, not that Gaia would be too easy a mission with well-behaved, single stars only. But that's not new, multiplicity has been complex since the beginning of time. Gaia, the Goddess, became, with some difficulties, the first mother of a multiple system. Still, it is worth noting that Gaia used the starry sky (Ouranos) to conceive a titanic outcome, which is probably a good presage for the Gaia mission... (and well, for the scoffing persons, the "titanic" adjective refers to the huge size of the Titans, not to the fateful ship).

Sober artist impression of sunsets on a distant planet unveiled by Gaia.

Mass of planets *by Frédéric Arenou*

One of the most significant contributions of the Gaia mission will be the unbiased census of thousands of giant extrasolar planets. They will be detected by the stars' wobbles in response to the gravitational pulls of the planets they host, characterised by the astrometric signature $\alpha \sim (M_p/M_*)\, a_p\, \varpi$ where the masses of star and planet are in solar mass, the planet orbital semi-major axis in A.U. , the signature and parallax in µas (see Figure). Besides, one advantage of astrometry is also to provide the inclinations and position angles for the lines of nodes of the orbital planes and thus successfully test the coplanarity in about 150 cases for the ~1000 multiple-planet systems detected as estimated thanks to extensive double-blind test campaigns (see Casertano et al., 2008A&A...482..699C).

Gaia potential discoveries compared to spectroscopy (in pink, σ=3m/s, 3σ detection level for a 1M$_o$ star and a 10yr Survey) and transit methods (in green, dense sampling, S/N=9, for a 1M$_o$, 1R$_o$ star). Black dots are exoplanets as of Sept. 2007, transits as blue dots, Jupiter and Saturn as red pentagons. Gaia detection curves in red for a 1M$_o$ at 200pc, in blue for a 0.5M$_o$ at 25pc.. From Sozzetti A. et al., 2008IAUS..248..256S.



Focus on ELSA programme: Dagmara Oszkiewicz, U. of Helsinki Observatory

Dagmara Oszkiewicz is a postgraduate student in the Planetary-System Research-group (PSR) led by prof. Karri Muinonen at the University of Helsinki Observatory. Primarily she is working on asteroid orbital inversion methods using astronomical astrometric observations from ground-based observatories and simulated observations from Gaia. In the DPAC, the PSR group has responsibilites in the CU4: Object Processing: Solar System Objects.

Recently, she has successfully developed a Markov-Chain Monte-Carlo (MCMC) ranging method (Oszkiewicz et al., 2008), applicable for poorly-observed, single-apparition asteroids, having two or more observations and short observational arcs. Distributions of orbital elements and observed-minus-computed residuals obtained by this method, serve as a base in problems such as: computing collision probabilities for Near-Earth objects, asteroid dynamical classification, recovery of lost objects and outlier detection. Lately she has applied the new method to Gaia simulated data, in order to see the evolution of orbital-element probability density functions (p.d.f.) as a function of accuracy of the astrometric observations. Example of a collapse of selected marginal orbital-element distributions with improving accuracy obtained for asteroid (4) Vesta, is presented on Fig. 1.

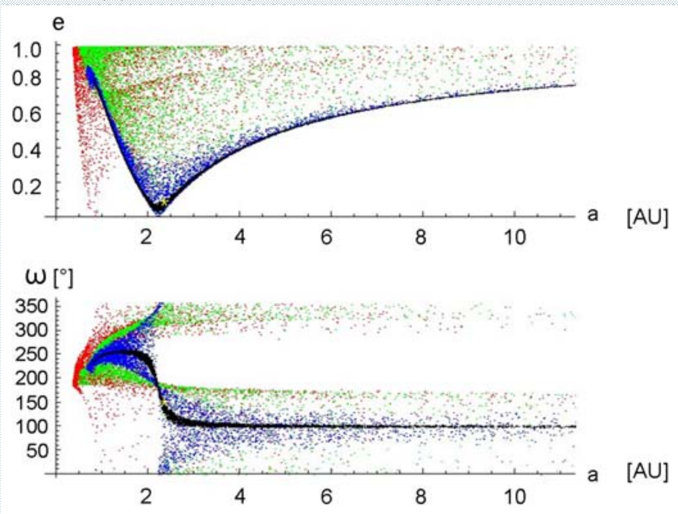


Fig. 1. Collapse of orbital-element p.d.f.s with improving accuracy of observations. Sets of distributions each composed of 5000 possible orbit solutions for (4) Vesta obtained from Gaia simulated data for epoch 2010 Aug 5.0 TDT.

The distributions were obtained using 4 observations from a single scan (0.32 days observational time interval). Different colors correspond to different assumptions about the observational astrometric error (red $\sigma_{\alpha,\delta}$= 1:0 arcsec, green $\sigma_{\alpha,\delta}$ =0.1 arcsec, blue $\sigma_{\alpha,\delta}$ =0.01 arcsec and black $\sigma_{\alpha,\delta}$ =0.001 arcsec). Yellow star indicates the end-of-mission least square solution. The distributions were obtained using MCMC ranging method.

Gaia at IAU (International Astronomical Union) *by Carmen Blasco*

The IAU General Assembly takes place every three years and joins people working in all fields of astronomy. The next event, the XXVII General Assembly, will be held in Rio de Janeiro (Brazil), August 3 – 14, 2009. It comprises 6 Symposia, 16 Joint Discussions and 10 Special Sessions. Gaia will be present in most of the scientific programme with a special emphasis on:

* Joint Discussion 5: “Modelling the Milky way in the Era of Gaia”
* Special Session 8: “The Galactic Plane – in Depth and Across the Spectrum”
* Special Session 6: “Planetary Systems as Potential Sites for Life”
* Special Session 10: “Next Generation Large Astronomical Facilities”

The scientific programme relevant to Gaia and the corresponding dates are compiled in our webpage (http://www.rssd.esa.int/index.php?project=Gaia&page=General_Assembly)

For more information about the XXVII General Assembly, you can visit http://www.astronomy2009.com.br/index.html

Calendar of next DPAC related meetings

Date	Place	Who	Type	Resp.
05-07 May	Vienna	CU7	Plenary meeting	Eyer
19-20 May	ESTEC		GST #27	Prusti
28-29 May	Torino	CU4	Plenary meeting	Pourbaix
02-04 June	Postdam	CU6	Plenary meeting	Ocvirk/Veltz/Steinmetz
04-05 June	Heidelberg	CU3	AGIS #11	Lammers/Bastian
08-10 June	Toulouse	CU8	Plenary meeting	Janotto/Chastel/Passot
16-17 June	ESA/HQ	Steering Comittee	SC#04	
18-19 June	Nice	CU3	REMAT#05	Mignard

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

This newsletter is published by DPAC Chair
To publish news or articles please contact: sophie.rousset@oca.eu