Newsletter 24

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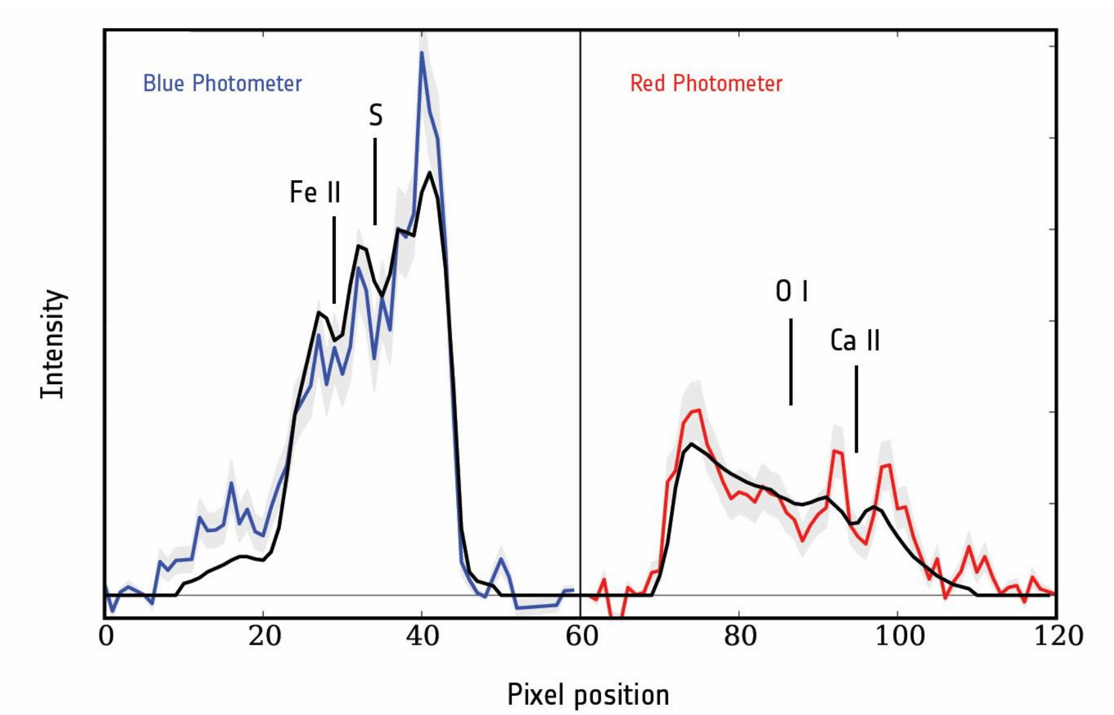


The Photometric Alert system of Gaia detected its first supernova on 30 August 2014. The nature of the source has been subsequently confirmed by ground-based spectroscopy at the Isaac Newton Telescope, before it was imaged by the Liverpool Robotic telescope on La Palma. The figure shows the low-resolution spectrum obtained by Gaia photometry. The blue (from 330 to 680 nm) and red (640 to 1050 nm) curves are Gaia spectra and the black smoother lines come from a model fitting. Gaia is expected to discover many more transient phenomena with its photometric alert mode.

More: http://www.cosmos.esa.int/web/gaia/iow_20140912 and http://sci.esa.int/gaia/54630-gaia-discovers-its-first-supernova/ credits : ESA/Gaia/DPAC/N. Blagorodnova, M. Fraser, H. Campbell, A. Hall (Institute of Astronomy, Cambridge)

IN THIS ISSUE:

Editorial by DPAC chair, Anthony Brown

The publication of the last Newsletter took place in the middle of the intense period of commissioning Gaia and its instruments. We have since closed these activities at the in-orbit commissioning review, which took place on July 18 and also marked the official handover of Gaia by the ESA Gaia Project team and Airbus D&S to the Gaia mission manager and DPAC. An update on the status of Gaia can be found elsewhere in this Newsletter.

On July 25 Gaia started its nominal observing campaign with a special scanning mode designed to enable bootstrapping of the data calibrations. On September 25 the spin axis orientation of Gaia was optimized to catch future occasions when Gaia can observe stars close to the limb of Jupiter and thus carry out precise light bending measurements.

DPAC is now well into its nominal operations phase, processing tens of millions of Gaia observations every day. Scientific result has already been achieved, the first discovery of a supernova by Gaia! This exciting result is testament to the work done by DPAC, in particular its Initial Data Treatment chain, the quick assessment of the outputs by the Science Alerts team, and the observatories around Europe that have provided time to collect follow-up observations to confirm the supernova nature of Gaia's discovery.

Finally, I would like to take this opportunity to thank the ESA Gaia Project team and the Airbus Defence & Space industrial team for all the fantastic work they put into building, launching, and commissioning Gaia.

DPAC News

Anthony Brown

Since the last Newsletter DPAC has been very busy with many aspects of the data processing (the times of working on simulated data seem very long ago!), and also continued to develop its processing systems, in particular those that are planned to come online later in the DPAC life cycle. I highlight a few developments below.

Throughout the Gaia commissioning period the data processing and analysis by DPAC was essential. You can read about the contributions by the Payload Experts elsewhere in this Newsletter. The work of the First Look team and the Payload Experts in assessing the space craft and instrument health continues even though we are in nominal operations. The results of the analyses are published in the First Look Scientist and Payload Experts weekly report which forms an important input to the weekly planning of the spacecraft operations.

The DPAC front line systems IDT, First Look, and AVU/BAM and AVU/AIM have continued the daily processing of the data stream flowing down from Gaia. In general there has been no issue in keeping up with the large amount of observations but of course many bugs and little problems have been uncovered which are typically addressed quickly and lead to improved data processing and calibrations. In this context it should be noted that the processing software for all Gaia instruments has been adapted to deal with the stray light, which is modelled and then subtracted before further processing. Of course this aspect continues to evolve as our knowledge of the stray light evolution is refined.

The advanced treatment of the photometric and spectroscopic data is close to becoming fully operational. The first calibrations of the prism spectra have been derived and are being validated, while a first demonstration of results from the automated spectroscopic processing were recently posted on the Gaia website. Also the daily treatment of data related to solar system objects (with the aim of generating alerts on newly discovered asteroids) is on the way to becoming operational.

During commissioning a request was made for DPAC to try and verify the observed basic angle variations through astrometric measurements by Gaia. The One-Day Astrometric Solution (ODAS) which is derived daily as part of the First Look is from its mathematical design not capable of seeing 6 hour variations in the basic angle. However, the CU3 team came up with the very clever trick of combining two ODAS solutions that were constructed 3 months apart. The different way in which the basic angle variations project into the astrometric measurements leads to a clearly defined signature in the differences between the two ODAS solutions, where the signature can be predicted from the Basic Angle Monitor measurements. This experiment confirmed the reality of the basic angle variations and the high precision with which the monitor measures these variations. Not only does this strengthen our confidence to account for the basic angle variations in the data processing, but the experiment also demonstrated the very high quality of Gaia's astrometric measurements. Namely, over the course of the three months the projection of the parallactic and proper motions of the observed stars into the measurements also changes and leads to a signal (dependent on Galactic kinematics and the stellar distance distribution) similar to that caused by the basic angle variations. This effect was accounted for in the experiment to verify the reality of the basic angle variations and demonstrates how incredibly sensitive Gaia is, being able to discern galactic rotation with only three months of stellar position measurements. In fact it was already shown by the First Look team that the one-day astrometric solution residuals are already better than 1 milliarcsecond (even at this early stage with an unstable instrument and non-optimal instrument calibrations).

Lastly, DPAC has started on the fifth operations rehearsal which is focused on the cyclic (iterative) data processing which will not be operational until later next year. For this rehearsal the special ecliptic pole scanning data set will be pushed as far as possible through all DPAC systems, from the initial data treatment to the astrophysical characterization of sources buy CUs 4, 7, and 8. Although the rehearsal is conducted with real data the results will obviously not be of science grade quality at this stage. The main purpose of the exercise will be to gain experience with the complex iterative processing cycles, and to uncover well ahead of time any problems DPAC may encounter in the cyclic part of its operations.

Gaia Status

Anthony Brown

Following the in orbit commissioning review a summary of the Gaia commissioning period was posted on the Gaia website (http://www.cosmos.esa.int/web/gaia/news_20140729). You can read the details on those pages. Below I give a short update on the current status of Gaia and its instruments.

Since September 25 Gaia is scanning the skies according to the nominal scanning law which has been optimized to enable the collection of highly precise measurements of light bending at Jupiter's limb. This requires that Gaia observes Jupiter at times when our giant neighbour is crossing fields on the sky containing sufficiently bright stars. This scanning law will be followed throughout the mission. Over the period July 25 to September 25 Gaia followed a special scanning law which was designed to facilitate the bootstrapping of the calibrations. For example the photometric and PSF/LSF calibrations are greatly facilitated by the repeated scans over the ecliptic poles which took place in the first four weeks after July 25 allowing up to 8 observations per day of the same sources.

Meanwhile the out-gassing of water vapour that condenses onto Gaia's mirror has continued and this necessitated two further ‘decontamination campaigns’, the most recent of which took place on September 23 and 24. The Gaia mirrors are clean at the moment and the telescope throughput and image quality are as they should be. Obviously the situation is closely monitored by the Payload Experts in order to decide if and when a next decontamination is needed, and whether a further focusing of the telescopes is needed to ensure optimal image quality (the continued thermo-mechanical settling of the Gaia telescopes will slowly change the image quality).

The well-known stray light cannot be removed by on-board measures so Airbus D&S, ESA, and DPAC are working closely together on the optimization of the observing strategy so as to minimize the impact of the stray light. In particular the RVS experts and Airbus have already put a lot of effort into tuning the on-board software such that the RVS data collection is adapted to the stray light levels which vary on a six hour timescale. It is expected that the optimizations will be implemented on-board by the end of the year.

In parallel the detection thresholds for Gaia are being tuned. For RVS the threshold has been set to a brighter magnitude (16.2) in order to avoid collecting data containing only noise. For AF and XP the detection threshold has been lowered to study the possibility of extending the Gaia survey limit to G=21. Decisions on the final thresholds for all instruments will be taken later this year.

Finally, a working group with ESA and Airbus D&S participants is re-examining all the commissioning findings with respect to the variations of the basic angle between the two lines of sight of Gaia's telescopes. The aim is to understand the root cause of the variations in order to identify mitigation measures, or to provide a more solid basis for the interpretation of the Basic Angle Monitor measurements and the calibration of the basic angle variations in the astrometric data processing. In parallel this group is also taking a fresh look at the stray light issue with the aim of understanding the root cause.

Gaia Data: Estimated volumes on 15 October 2014 (*)	
9×10^9 astro transits 1×10^9 RVS transits	90×10^9 astro images, 18×10^9 photometric images 3×10^9 spectra
7.6 TB of science data on ground	IDT/FL DB ~ 60 TB

(*) since the start of the mission Jan 2014

CU7: Variability Processing and Analysis

L. Eyer, N. Mowlavi, B. Holl & D. Ordonez

Gaia will reveal variable phenomena of celestial objects in a unique and unprecedented way. Indeed, Gaia is performing an unbiased multi-epoch whole sky survey down to magnitude 20 with photometric, spectro-photometric and astrometric information. In addition spectroscopic information is gathered down to magnitude 16.

The purpose of CU7 is to populate the Gaia catalogue with information on variable objects. The figure shows a schematic view of the top-level variability tasks. The core activities of CU7 include four major tasks: variability detection, characterization, classification and specific object studies.

Variability detections

Special Variability Detection consists of specific algorithms that use the *a priori* knowledge of particular classes of variable stars, such as short time scale variables (down to seconds thanks to per- CCD data), planetary transits, and solar-like (magnetic) variable stars. Such variable stars often have a low level of variability that may escape the selection done in General Variability Detection (including the constancy level provided by CU5).

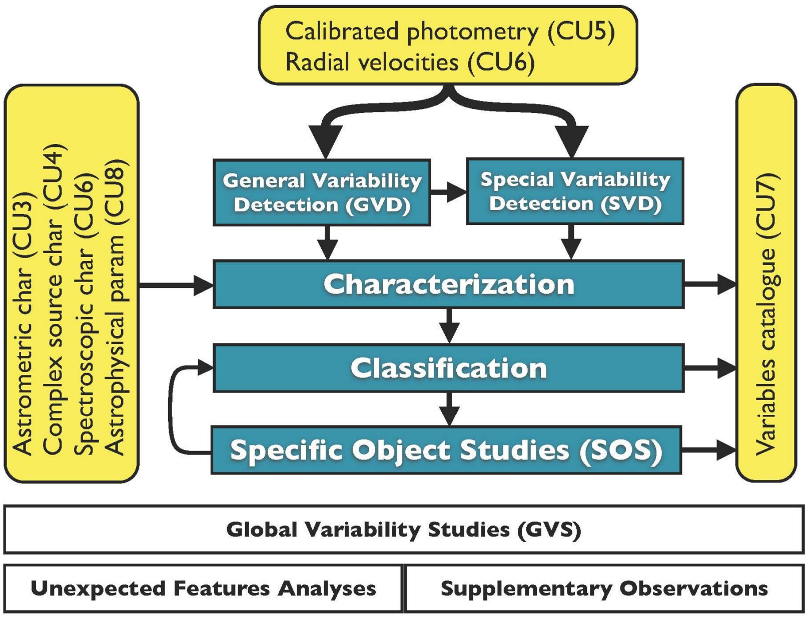
Once variable objects are spotted, their variability behaviour is characterized. The goal is to find general descriptions of the observed variations, through statistical parameters and basic models. Once they are identified and characterized, variables go through different classification methods. Three different classification approaches are being developed: supervised methods, unsupervised methods, and extractors. The extractors are applied to transients, microlensing events, and some specific binaries.

The result is a number of variability types containing objects with similar variability behaviours, and most probably, similar physical properties.

Variability classes

Up to classification the data is generally processed in a generic way. In Specific Object Studies, objects of different variability types are further analyzed with algorithms tuned to their specific properties. For example, the processing of the periodic Cepheid stars is different from the one required for the usually rather erratic distant Active Galactic Nuclei.

Finally, special care is taken to check the quality of the data and to validate some aspects of the photometric and spectroscopic calibrations provided by CU5 and CU6. Some results from the CU7 variability processing are used as inputs for further processing by CU4 and CU8.



CU7 plans to release the results of its full analysis during the 4th release (currently planned for 2018/2019). However, tests done on Hipparcos data showed that the current methodology leads to satisfactory classification for certain variability types even with small amount of data (e.g. RR Lyrae stars). If this is confirmed with Gaia data, the identification of these variability types will be delivered in earlier releases with estimations of completeness and contaminations.

CU7 comprises 72 active and 23 affiliate people, spread in 20 countries. The variability processing pipeline provided by CU7 is operated in the DPCG, the associated data processing center hosted at the University of Geneva.

Gaia and the Ecliptic

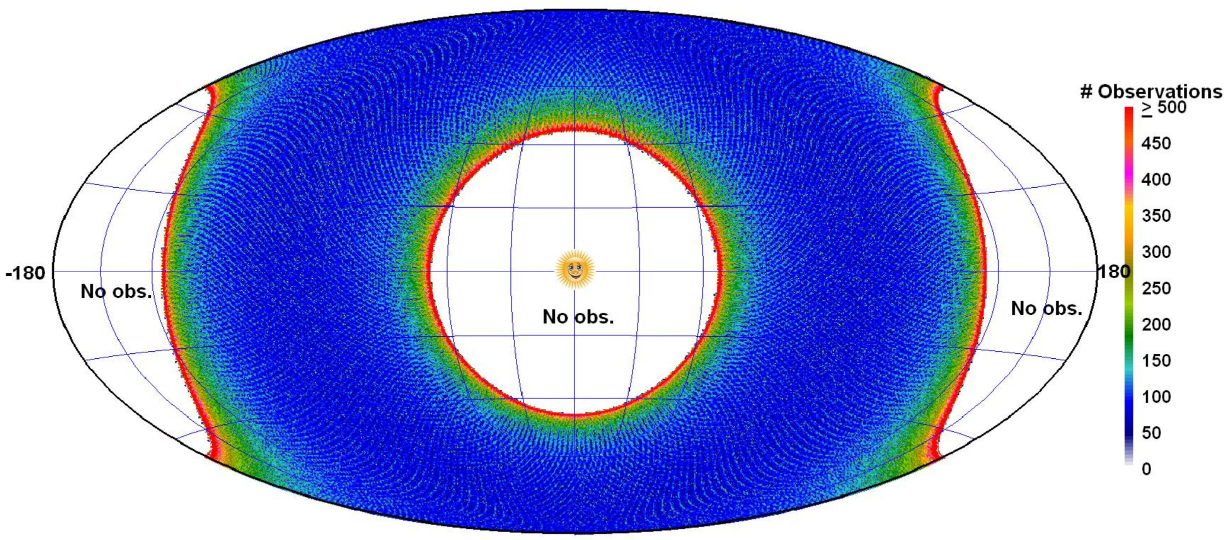
F. Mignard

The Ptolemy's Star Catalogue, a distant cousin of the forthcoming Gaia Catalogue, marked the star positions with their ecliptic longitude and latitude. On the other hand the earliest Chinese Catalogues and celestial maps, more or less contemporary to Ptolemy's, were in keeping with the mainstay of Chinese astronomy relying on the Pole star and the celestial equator. Since the Renaissance and Tycho systematic observations, European astronomers have switched to a system of coordinates based on the celestial equator, a compelling choice when using mural quadrants or transit instruments.

Although Gaia reference frame will ultimately be constructed with a set of extragalactic sources with a reference plane very close to the celestial equator, the mission retains some association, albeit very loose, with the apparent yearly Sun path. Nothing with high metrological meaning in this particular relationship unlike in the old days (not so old in fact) of the Celestial Frame before the advent of the ICRF (International Celestial Reference Frame), when the FK5 ruled astrometry.

The Gaia ecliptic has no very accurate definition and is in practice realised by a small computer function nested in the scanning law package giving the longitude of the Gaia-Sun, a point on the sky used as the center of the precession cone of Gaia spin axis. It is a good approximation of the solar location although it must be regarded as conventional and should not be employed for any other purpose requiring an accurate position of the Sun. The tie with ICRF is realised by the appearance somewhere in the program of an obliquity to express the quaternions of the nominal scanning law with reference to the ICRF. By definition the nominal attitude expressed with this normalised quaternion describes to full accuracy the nominal orientation of the spacecraft with respect to the ICRF coordinates.

In the process the Gaia ecliptic has vanished, however it will not forget to signal itself in most of our all-sky plots, like the ones appearing in Daniel Michalik contribution in this issue. Actually the appearance of the ecliptic in Gaia is conspicuous in any plots displaying all-sky astrometric feature, like the accuracy, whatever the parameter selected, or the observations distribution, and even more in the plot below when this is plotted as a function of the solar elongation revealing also a tie to the Sun.



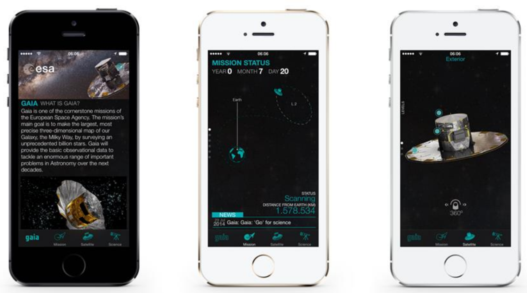
The plots gives the number of times, over the 5-year mission, one of the Gaia FOV is directed in a particular direction on the sky in a rotating frame with the x-axis constantly aligned with the Sun. The plot must be read exactly in the same way as our classical representation of the number of observations in different part of the sky in a fixed frame. In the standard case, the number of pointings in a particular direction happens to be the same as 'the number of time a source is observed' since the sources, except from solar system objects, have essentially fixed coordinates in the non-rotating frame. In this plot we have also the number of pointings, or the observation density, but in a particular direction in a frame rotating with the Sun. For solar system objects this represents, at low ecliptic latitude, the observation distributions as a function of the solar elongation, a very significant parameter for these sources. For stars this shows that the ~ 80 observations are fairly unevenly distributed in position with respect to the sun, with a large concentration near the lower and upper limits. The all-sky average of the pointing in this plot is around 80 as expected, but a source, if it existed, at fixed elongation of 135 deg would be seen ~ 500 times.

Gaia at your fingertips

Marcial Clotet (on behalf of the Gaia UB Team)

Would you like to know in near real time how many transits have been already observed by Gaia? Do you want to be always up to date with the latest news about the mission? Are you curious about the current status of the satellite? You can have all that and even more available in your mobile device!

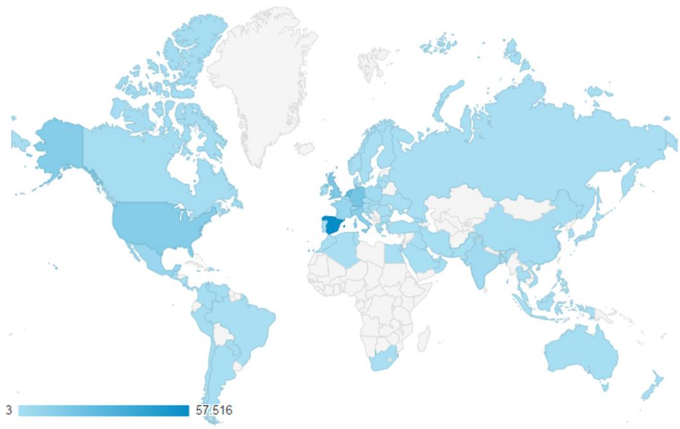
As some of you might already know, the team at the University of Barcelona (UB) has developed a mobile app about Gaia. The Gaia Mission app aims to provide information about the mission in an interactive, user-friendly and engaging way. We hope that many of you already have it on your phone and use it frequently.



Gaia Mission App Screenshots

The Gaia Mission app is conveniently divided into four different sections. Each section includes interactive demos that help to understand complex concepts, like trigonometric parallax, as well as videos, images and diagrams that enrich the text. Information is organized into several levels to allow users to have just an overview or an in-depth explanation. There is also an interactive 3D model of the satellite exterior, interior and focal plane.

Since the first version of the app was published in November 2013, there have been almost 2 000 downloads from 85 different countries. In this period there have been almost 200 000 screen views. The Figure shows the distribution of total screen views per country. The application has proven to be an effective way to do outreach about the mission.



Distribution of screen views per country

There is an entry in Gaia's blog about the app (http://blogs.esa.int/gaia/2014/09/01/) as well as on the corresponding Twitter™ and Facebook™ accounts. There has been media coverage at local and European level both after the initial release of the application and after the post on the blog of Gaia. This has helped to reach out and increase the number of users. Our goal is to increase that number even more.

To that end, the UB team is now working on the Android version, which will be available later this year together with versions for iPad and Android tablets. We hope these versions will also be successful.

Currently the app is available for free from the iTunes store in English, Spanish and Catalan, and it is ready to include additional languages. If you would like to have it in any other language and you can provide the translation, please contact our team. Additional languages will help to reach even more users.

This project was co-financed by the Spanish Foundation for Science and Technology - Ministry of Economy and Competitiveness.

PAYLOAD Experts

Sebastian ELS

Approximately two years prior to the launch of Gaia, DPAC started to develop and compile a number of tests and calibration activities which would be conducted on-board Gaia during its commissioning and science performance verification phase. The DPAC members working on the definition of these activities formed the Initial In-Orbit and Calibration group (IIOC).

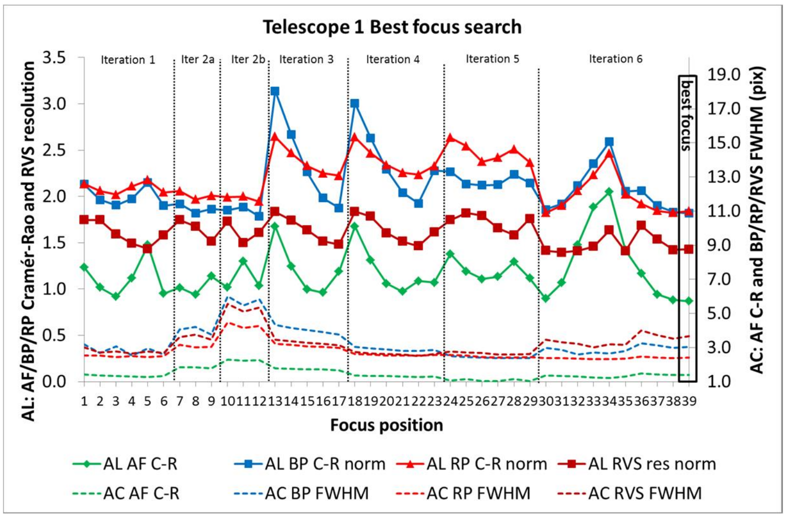
During the pre-launch tests of DPAC's daily systems, the commissioning activities were seen as the main early operation tasks and it quickly became clear that a number of people with expertise and practical knowledge of the various components and sub-systems of Gaia would be needed to assess the Gaia data. Therefore, the IIOC grew and finally resulted in the Payload Expert (PE) group. The term "Payload" refers to the telescopes and scientific instruments within the Gaia spacecraft. Thus the PEs are assessing and working on improving the science performance of Gaia. This group comprises almost 40 scientists now, mostly from CUs handling the raw Gaia data. But membership is handled flexibly, and persons with expertise in a specific field can be called in as needed.

Commissioning and aftermath

During the very intense commissioning phase the PEs were the ones who would have to provide quick feedback on the findings about the features of Gaia. This group has turned out to work very well and did an excellent job, in particular during the early mission when not all daily pipelines were functioning yet. This caused in fact a double load on a number of the PEs: while on the one hand the PEs needed to trouble shoot their parts of the daily pipelines they had been developing, they also had to perform analyses with their offline tools. To help the PEs perform their work, the DPAC Data Processing Centres provide quick access to the Gaia data and support the technical needs of the PEs. As known by now, the Gaia commissioning turned out to be more complicated than initially thought. Several spacecraft issues required a number of analyses to be developed on the fly and a very quick turn around was often needed.

Also a number of tasks thought to be performed only once by the Gaia manufacturer have to be performed more frequently and need to be supervised by DPAC. For example, the needs for decontamination and subsequent refocusing are being defined by DPAC. The monitoring and triggering of those activities are now up to DPAC and the PEs is the group in charge for these tasks. It was particularly encouraging to see that during commissioning also downstream CU members joined the PE group to contribute with their particular expertise to analyze the readings of a wealth of sensors of the Gaia service module to look for frequencies of tiny temperature fluctuations. Finally, also the contribution by our colleagues at the mission operations centre at ESOC in Darmstadt is appreciated. Also they participate occasionally in the regular PE telecons in which findings are shared and recommendations for conducting on-board activities are defined.

The PE group, which crosses all CU and DPC boundaries, has established itself as an effective team which is on the front line of assessing and maintaining the scientific performance of Gaia. It will continue its work over the years to come, keeping a close eye on Gaia's performance, assuring that the DPAC processing pipelines receive the best possible data.



Search of the Gaia best focus position for FOV1 (similar plot for FOV2). The best focus is assessed by the image quality (e.g. small and symmetric PSF) through the three instruments of Gaia. Quantitatively in the AL direction this is expressed by the near achievement of the Cramer-Rao limit in the extraction of astrometric, photometric (BP/RP) or spectroscopic information, while the PSF width is used in AC. The plot shows the results over the six search campaigns for the AL (solid lines, left scale) and AC (dashed lines, right scale) directions. The best focus selected is the 30th in this series.
Credit : Payload Expert Group. See more in AB-047.

More information (restrictive access): http://wiki.cosmos.esa.int/gaia-dpac/index.php/Payload_Experts and the PE handbook http://www.rssd.esa.int/cs/livelink/fetch/-2433/29744/3219842

PhD Corner: Daniel Michalik, Lund University (Sweden)

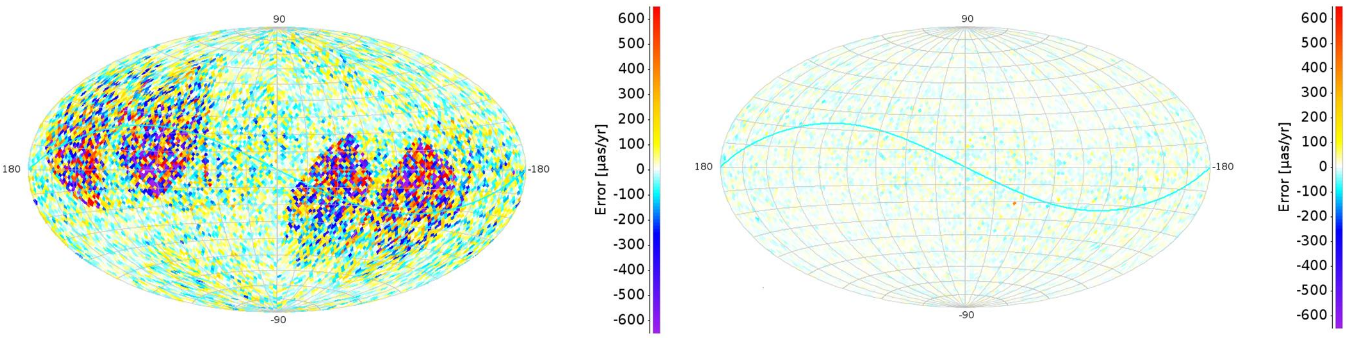
Gaia astrometry for stars with too few observations

I am working with Lennart Lindegren, David Hobbs (Lund), and Uwe Lammers (ESA/ESAC) on the astrometric core solution. Gaia needs to determine at least five astrometric parameters per star, requiring at least five distinct observations. In early data reductions many stars will be under-observed, and even after the full mission there will be some (e.g. variables, supernovae) with insufficient observations. My research focusses on how to deal with such stars. I am exploring ways to incorporate prior information in the solution through Bayes' rule, and methods to derive such priors.

One application is the joint solution of Hipparcos and Gaia in the Hundred Thousand Proper Motions (HTPM) project, which delivers proper motions accurate to tens of µas/yr (see figure) and can be used to detect long-period companions (Michalik et al. 2014, A&A, in print).

Recently we have studied a scheme to include also Tycho-2 positions (Michalik, Lindegren, Hobbs 2014, A&A, in preparation). This would allow us to perform the first full-sky five parameter astrometric solution much earlier than previously thought.

In the final results no prior should be used for the primary stars to avoid biases. For secondary stars with insufficient observations we are utilizing probability distributions from a Galactic model as additional constraints. This ensures that a solution with realistic error estimates can be obtained for all stars.



All-sky map of the R.A. proper motion errors.
Left: One year of Gaia-only data leads to some poorly-observed regions. Right: HTPM gives a more homogeneous distribution at an overall lower level.

DPAC meetings

Please note: Attendance at these meetings is restricted to members of the Gaia Coordination Units

Date	Title	Place	Local Organiser
21-22 October 2014	GBOT #9	Torino	M. Altmann, R. Smart
23-24 October 2014	GST #46	ESA	T. Prusti
28-29 October 2014	DPAC #20	ESAC	A. Brown
6-7 November 204	CU8 : plenary meeting	Torino	R. Drimmel
12-14 November 2014	CU7 : plenary meeting	Geneva	L. Eyer
19-21 November 2014	Operations Workshop #2	Tenerife	S. Els
24-26 November 2014	AGIS #21	Nice	F. Mignard
9-11 December 2014	CU6 : plenary meeting	Paris	P. Sartoretti

More information at http://www.cosmos.esa.int/web/gaia/calendars

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