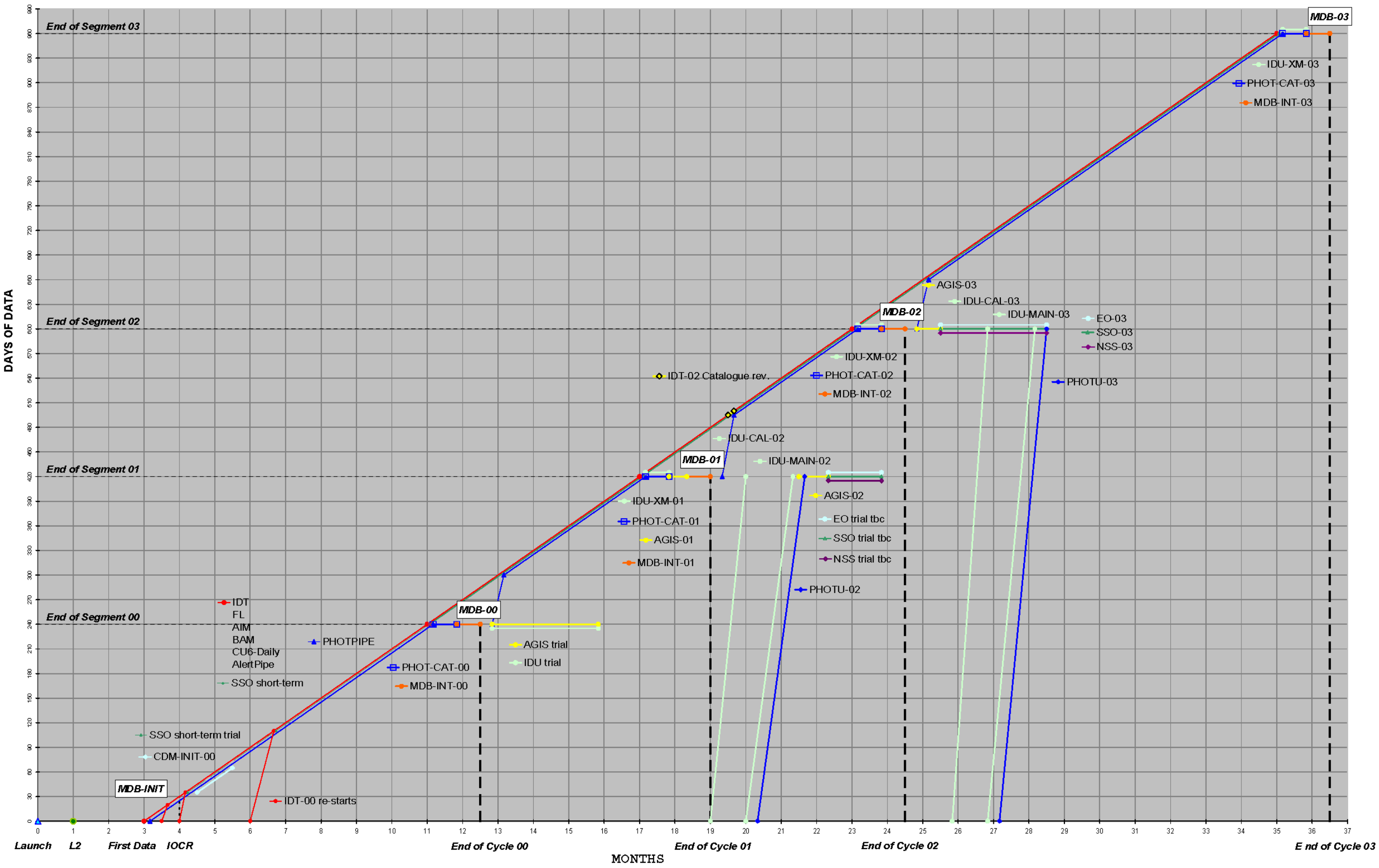
Newsletter 16

N° 16 - APRIL 27, 2012

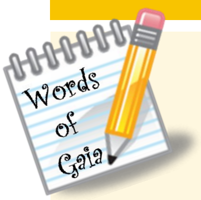


A creative chart designed by Floor van Leeuwen to gather in a single diagram the main steps of the DPAC operations presented in this issue. The operations cycles (processing steps) are given in abscissa while the data segments (data flow received every day from the satellite) are in ordinate. The different versions of the Main Data Base (current results of the processing) are released at each cycle closure. The continuous lines of slope ~1 represent the daily processing (primarily Initial Data Treatment, First Look and daily photometry). The cyclic and/or iterative systems are activated and repeated around the end of cycles using one or several data segments. Systems that are initiated late during the processing appear on the right of the diagram, even though they may run on early data segments.

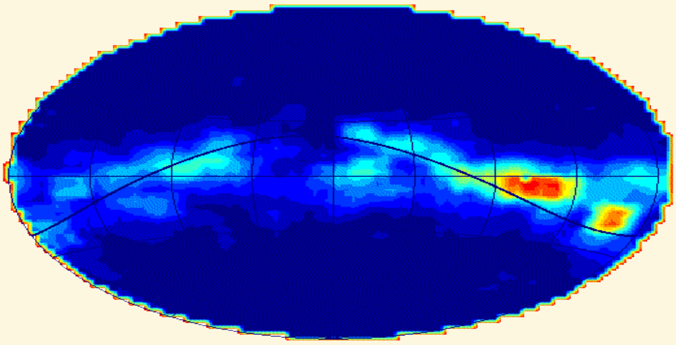
Editorial *by DPAC chair, François Mignard*

We are now within 18 months of the scheduled launch and DPAC is focusing more and more on the integration and tests of the pieces of software absolutely needed at the start of the mission for the instrument commissioning. The Project, EADS-Astrium and the DPAC are working in close cooperation to be ready for this early mission phase. Most of the required functionalities of the relevant DPAC software are implemented, but in several cases the targeted performances are not yet achieved, although the trend shows steady progress. A DPAC Rehearsal for these systems in near operational conditions will take place in June. The key people should be ready to work round the clock during this early summer event!

In this issue, The GEPI in the Observatory of Paris, a major DPAC contributor, appears in our partner column together with a smaller institute from Hungary which joined the project more recently. An important topic is covered by R. Drimmel, the DPACE Deputy Chair, with the introduction of our operation scheme showing a processing timeline compatible with the mutual dependencies and the iterative nature of many systems. I am confident that all our readers will be happy to see the progress made in the AGIS system (Astrometric Global Solution) since it was introduced in a past issue of NewsLetter.



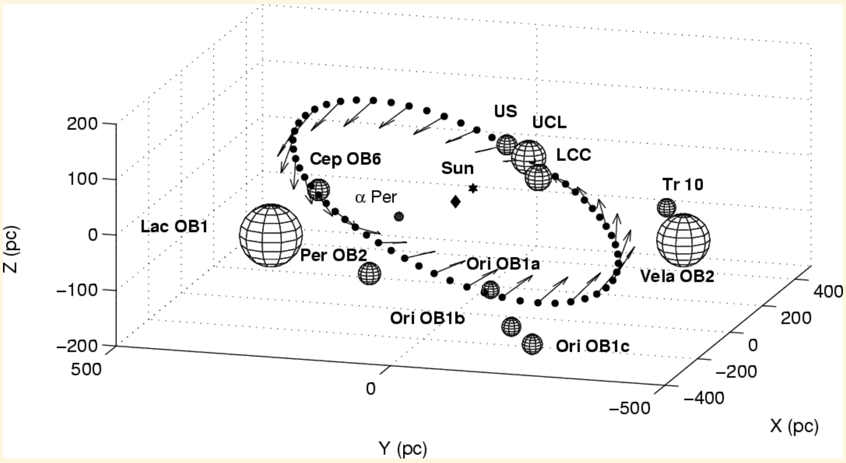
It was surmised in the 19th century that our Milky-Way is organised in arc-like structures, known today, thanks to reliable photometric catalogues, to be the spiral arms.



During his stay at the Cape Observatory J.F.W. Herschel, the son of William Herschel, noticed a partial ring structure of bright stars around the Sun tilted by 20 degrees to the Galactic plane (1847).

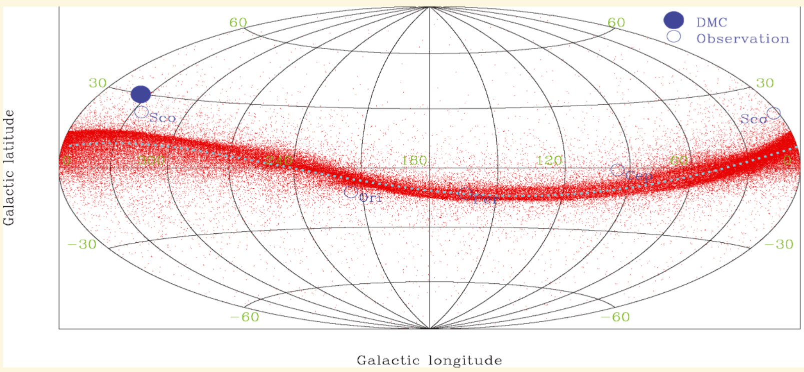
Two decades latter, B.A. Gould (the founder of the Astronomical Journal) visiting Argentina to establish the observatory of Cordoba, discovered the entire ring (1874) which was later named after him. This discovery came as a by-product of a much larger survey in photographic astrometry and photometry (1400 plates in total) of the southern sky.

One century later, J. Rountree Lesh (1970) established the detailed structure and evolution of the belt in a seminal paper, giving the ages, distances, proper motions and the internal evolution of its components. The importance of the belt has been recognized because our Sun is situated in the empty ring of 900 pc of diameter at 200 pc from the centre. The Sun looks like a star in an empty gaseous ring surrounded by lots of very young star formation regions: Perseus, Cygnus, Serpens, rho-oph, Lupus, Orion, etc. with ages ranging between 40 and 70 Myrs.



Recent numerical simulations by Bekki (2009) offer a clue to understand its origin, from the collision of an oblate sphere onto the galactic plane; adjusting the impact parameter allows to reproduce the observed structures with compatible ages around 45 Myrs (see last figure very similar to the one on the top of the page following from Rosat X-ray observations). This is a very important simulation and the Gould's belt proves that there are unconventional possibilities to form stars in the Galaxy. Quoting from Bekki (2009): "This new mode of star formation is in a striking contrast to those resulting from small-scale turbulence within clouds (e.g. Larson 1981) and from global galaxy-scale dynamical instability".

How many structures like that do exist today in the Galaxy? No doubt that Gaia will help in discovering such unrecognized structures resulting of dark matter impacts. How frequent are they? Surely not rare. On one hand, the number of gas clouds evolving around the Galaxy is large and radio astronomy demonstrates that the phenomenon is surely frequent; on the other hand, incoming gas is mandatory to provide the fuel of the star formation. Chemical evolution models of the Galaxy have already demonstrated the need to accrete metal poor gas clouds to explain the chemical distribution in stars. The Milky-Way is not a closed box. The best example of such future accretion is the Smith's cloud that is suspected not to survive to the next encounter with the Galaxy, but we will not know that before …27 Myr. But waiting for that future event I have to go back to other work.



Your Affectionate Friend and very Humble Servant,

Frédéric Thévenin

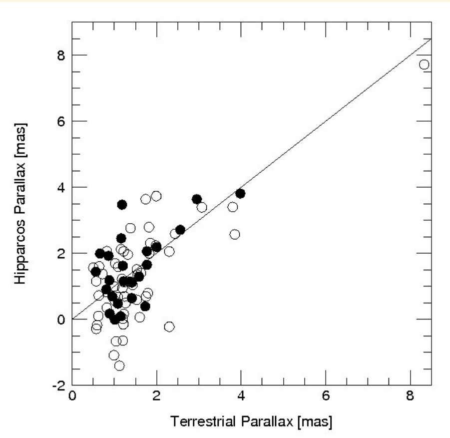
Bekki, K, 2009, MNRAS, 398, 36

The Gaia team at the Konkoly Observatory *by László Szabados*

The Konkoly Observatory was founded in 1899 when Miklós Konkoly Thege donated his private observatory (in Ó-Gyalla) to the Hungarian State. After World War I the observatory was relocated in Budapest and now it is a research institute of the Hungarian Academy of Sciences. It is a known centre for the study of pulsating stars. A recent research direction has appeared with infrared astronomy, involving studies of infrared variability of young stars. Exoplanets and minor bodies of the Solar System are also investigated.

The Konkoly Observatory Gaia Team formed in 2009 is funded by an ESA PECS (Plan for European Cooperating States) Arrangement. Its current members are Péter Klagyivik and László Szabados.

In cooperation with the DPAC CU7 (Variability Processing), our contribution to the Specific Object Studies is the study of the observational behaviour of Cepheid variable stars, the accurate description of their light variations, period changes, and the determination of their physical properties. One of our main research tasks was the selection of binaries among Cepheids. We pointed out that the border separating short and long period Cepheids is at 10.47 days instead of the widely used 10 days which has to be taken into account in calibrating the period-luminosity relation.



Hipparcos parallax vs. ground-based parallax of nearest Cepheids. Empty and filled circles denote Cepheids with and without known companions, respectively. All negative Hipparcos parallax values correspond to Cepheids with known physical companion(s). This finding warns that disregarded binarity has an adverse effect on the trigonometric parallax, thus may falsify the period-luminosity relationship of Cepheids. This Figure was the Picture of the Week on the Gaia web-page (2010/07/09).

Our contributions to the Supplementary Observations work package include photometric observations of Cepheids. Imaging faint Cepheids for studying photometric contamination by optical companions utilizes an EMCCD camera and 'lucky imaging' techniques. These observations are obtained with the 1 m RCC, 60/90/180 cm Schmidt, 50 cm Cassegrain and the new, remotely controlled 40 cm telescopes in the Piszkéstető Mountain Station. We joined the Ground-Based Observations for Gaia (GBOG) group, the Gaia Follow-Up Network (FUN), and the Gaia Science Alerts Working Group.

The Gaia team at GEPI *by Frédéric Arenou*

GEPI (http://gepi.obspm.fr) is one of the Departments of the Paris Observatory, which was founded in 1667 and merged with the Meudon Observatory in 1926. GEPI is also a laboratory of the CNRS (the French National Center for Scientific Research http://www.cnrs.fr) and an associated laboratory of the Denis Diderot (Paris VII) university.

The roots of GEPI (at that time the DASGAL Department) in space astrometry come from the large involvement in the Hipparcos mission, in particular as the centre of the Input Catalogue Consortium. And just like the IMCCE and SYRTE, other Departments of the Paris Observatory, the GEPI is deeply involved in the Gaia preparation.

Beside the scientific preparation from the very beginning of Gaia, our technical involvement started in 1998 with data simulations and in 1999 with the prototype of a detection algorithm for the on-board Gaia processing. From 1999 on, the GEPI was also involved in the spectro instrument, with the optimization of the RVS design with respect to the Gaia science goals. The activity within the scientific working groups was then recentred to the data processing activities when DPAC was created.

Within CU2, the GEPI maintains the Gibis pixel simulator (first opened to the Gaia community ten years ago!) and manages the simulation of spectra for GaiaSimu and GOG. Due to our prior involvement in the Hipparcos mission, we are also active in the Non-Single Star (NSS) part of CU4, with the responsibility of the simulation of multiple objects and the NSS solution combiner. Many activities are handled within CU6, from the CU management to the data model, detailed first look, calibration tests, RV ground-based standards and Single Transit Analysis. GEPI members are also involved in the FLAME workpackage of CU8

The GEPI has several responsibilities at CU top level coordination, with the manager of the CU6 (D. Katz 2006-2012 and now P. Sartoretti), the deputy manager of the CU2 (C. Babusiaux) and members of CU4 and CU6 steering committees. The staff represents more than 10 FTE, on either permanent positions from the Ministry of Higher Education and Research and CNRS or on support contracts from CNES which also funds most of the DPAC related activities.

The currently most active DPAC members in Meudon, from left to right: R. Haigron, F. Royer, I. Jégouzo, N. Leclerc, D. Katz, C. Delle Luche, O. Martins (admin.), F. Crifo, P. Sartoretti, C. Turon, P. Di Matteo, A. Gueguen, Y. Viala, C. Babusiaux, A. Oger (admin), P. Gavras, F. Arenou

The DPAC processing system

By Ronald Drimmel (INAF, Torino, Italy)

“The whole is more than the sum of its parts.” **Aristotle, *Metaphysics***

Through its various CUs, DPAC is building many software systems and subsystems. Those that interact with the Main DataBase (MDB) as individual systems are about 21 in number, and this does not count the DPC infrastructure SW that hosts these systems. Taken together they make up the “DPAC system”. Years of effort and thought have gone into designing and implementing the individual parts of this system, but putting all these parts together has already proved to be a non-trivial task. The problem is not only the need to map the many cross-dependencies between DPAC sub-systems, but to decide how to “start the ball rolling”. Of course, first there’s Initial Data Treatment (IDT) and First Look (FL) at ESAC, then the other daily processing systems, then...

...it gets complicated.

“Complicated” because the DPAC system is not a simple pipeline with one system following on another. Fundamental to processing the Gaia data is the need for self-calibration, which imposes the need for iterations between the DPAC sub-systems. (Thus after launch the now familiar Development Cycles will be replaced by Processing Cycles, even if development may continue in parallel) As a result there are three kinds of processing in DPAC: daily “pipeline” processing, end-of-cycle processing and cyclic processing. While the daily processing treats the segment of the Gaia data stream associated with the cycle (called a *mission segment*), the cyclic processes are treating the data from the previous processing cycles derived from the earlier mission segments. The results from these two types of processes are then brought together (i.e. “integrated”) with the end-of-cycle processing to produce a consistent data set, represented by a MDB release, ready for the next processing cycle.

Here’s how it starts:

Processing begins during the initial Commissioning phase of the Gaia mission, just a few months after launch, with the first reception at ESAC of satellite telemetry: this starts all the daily processing systems, as IDT and FL results will be immediately distributed to all the other daily processing systems. It is also the start of the DPAC Initialization phase, which must be completed by the end of the first Processing Cycle, nominated Cycle00, nominally lasting about 8 months.

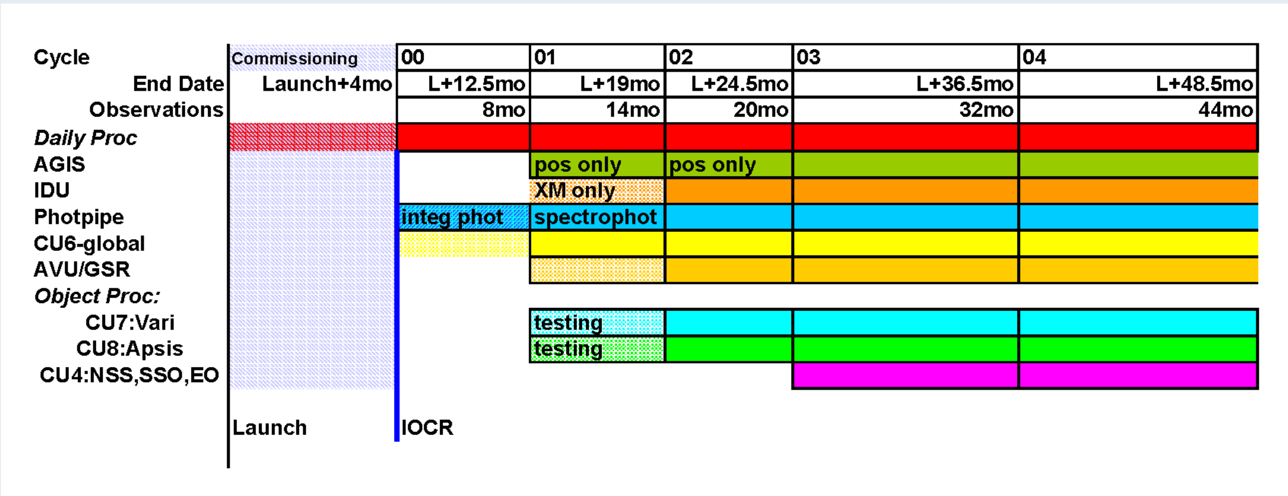
With Cycle01 we begin to see activity from some of the cyclic processes. Initially this will only be in the form of system testing using real data, but by the end of this cycle (lasting 6 months), we hope to have the first astrometric results from AGIS, including new proper motions for those sources also found in the Hipparcos Catalogue, as well as calibrated photometry. Ideally these first astrometric results will already be independently verified by comparisons to Gaia Sphere Reconstruction (GSR) solutions.

Thanks to the first astrometric and photometric products from Cycle01, in Cycle02 many other cyclic processes will start, including Intermediate Data Update (IDU), and the systems of CU6, CU7 and CU8, responsible for spectroscopic, variability and source characterization.

Finally, in Cycle03, the last of the DPAC sub-systems will come on-line with the start of the CU4 cyclic processes, responsible for astrometric solutions of non-single stars as well as results for solar system and extragalactic objects. This processing cycle will last one year in duration and will be a “normal” cycle, in the sense that the following cycles will be like it, at least to the end of satellite operations. *

So far I’ve only written about how the DPAC system will start but, as in any iterative process, it is also important to define how to stop the iterations. That is a task that still awaits us.

**Further details can be found in the Gaia Science Ground Segment Operations Plan (JSH-033).*



Sequence of DPAC processes for the first data processing cycles.

Where do we stand with AGIS in the year before launch?

By Uwe Lammers (ESAC, Spain) on behalf of the AGIS development team.

It has been a while since the Astrometric Global Iterative Solution (AGIS) was featured in a DPAC NL, so it is time for an update on where we are and what remains to be done.

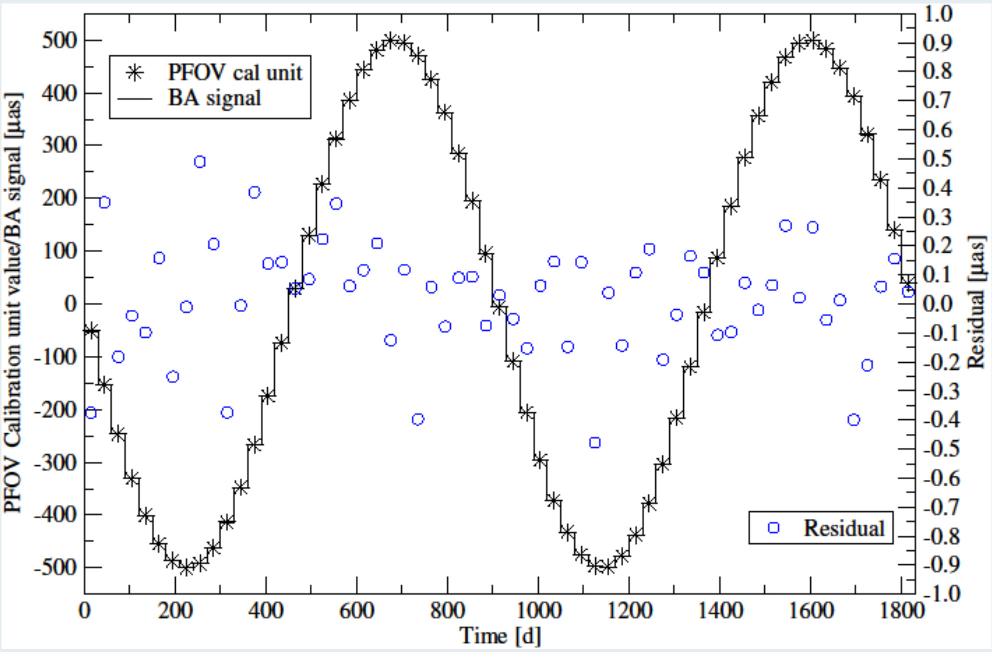
With AGIS we aim to construct the astrometric part of the catalogue by seeking in a global, least-square sense the best possible match between *predicted* observations calculated through models and all *actual* measurements. The unknowns of the four relevant models for Source (S: ~ $5x10^8$), Attitude (A: ~ 10^7), Calibration (C: ~ 10^4), and Global (G: ~ 10^2) are adjusted iteratively from given initial values until the updates in the current iteration become sufficiently small and other measures indicate that the system can be considered converged.

In the past years we have made steady progress in maturing the processing framework in terms of performance and robustness, but, also in improving the core algorithms and developing a rigorous understanding of the mathematical and numerical foundations of AGIS. In parallel we continued to test and validate the system through numerous simulations runs that increased in complexity and size of the CU2-generated input data. Through these runs we have gained a good understanding of the convergence properties and the factors that govern the quality of the solution. All this work nicely culminated in a comprehensive publication (Lindegren et al., A&A 538, A78 (2012)) that we now regard as reference documentation for AGIS.

We started in 2006 with a small core system that allowed "Simple Iterations" (SI) between basic S, A, and C blocks and this was used for a first converging run using a 1 Million star/18-month input set. Today, AGIS comprises well over 100.000 lines of code. All four blocks are distributed, multi-threaded and rich in functionality and versatility. We have a generic Calibration scheme that gives large flexibility in defining the calibration model at runtime. At the moment a similar scheme is being conceived for the Global block. In addition to SI, a "Conjugate Gradient" (CG) solver with much improved convergence properties is available and both schemes can be used together in a hybrid mode that will be needed in operations. The reliable identification and rejection of outlier observations turned out to be a much more difficult problem than initially thought. A robust scheme is in place now that, however, must still be validated and optimized through corresponding test runs. Concerning data volumes we have successfully executed several 10 iterations of 50 Million star/5 yr simulation sets with good run times giving full confidence that the final AGIS solution in a few years can be done on timescales of weeks (rather than months or years) on adequate processing hardware.

So, what is still missing? It is clear that testing and validation will remain a key issue until and well beyond the launch. We are implementing now a Generic Globals Update (GGU) block which will greatly help in exploiting Gaia's scientific potential in the area of Fundamental Physics. The principles of the Primary star selection scheme have been designed but little is implemented yet. Almost all simulation runs until now have used smooth, well-behaved NSL attitude data. The real, dynamical attitude of the satellite, however, is much more complex and efforts are underway to increase the realism of the validation runs in this regard.

Like all other DPAC systems, AGIS is not finished, but we have no reason to doubt that we will get a system in time able to compute a reliable and accurate astrometric solution consistent with the ambitious goals of the mission.

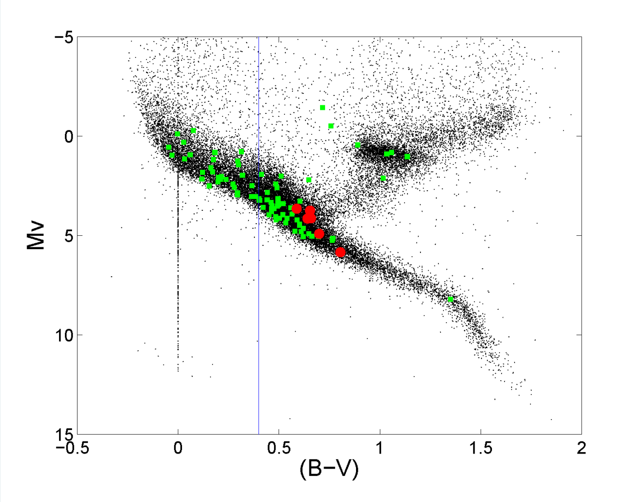


A simulated, step-sinusoidal (A=0.5 mas, P=2.5yr) basic angle variation (solid line) is recovered with an expected µas accuracy (blue circles, right ordinate axis) as part of the calibration in a 2.2 Million star run. See A&A paper for details.

Finding the lost siblings of the Sun *by CHENG LIU, LUND Observatory, Sweden*

I am a Ph.D. student at the Lund Observatory and a member of WP4 within GREAT ITN. My supervisor is Prof. Sofia Feltzing. We focus on the search for the Sun's siblings which can be identified by combining the kinematic approach with the chemical tagging technique and stellar ages from high resolution spectra.

Revealing solar siblings will enable us to trace the history of the Sun and the (now dissolved) cluster where it was born, and thus better understand the chemical evolution of the Milky Way. Based on the predicted kinematics (Brown et al. 2010) of solar siblings, 57 candidates were selected from Hipparcos Catalogue (van Leeuwen 2007) with $(B-V) \geq 0.4$. Combining with the updated age and metallicity calibrations for the Geneva-Copenhagen Survey (GCS, Casagrande et al. (2011)), we found six candidate siblings of which three are in common with the Brown et al. study. We will find more potential candidates with many objects that Gaia will detect in the solar neighbourhood. The Gaia-ESO survey data could also be very useful for our work.



Colour-magnitude diagram showing the absolute magnitude Mv versus (B-V). The green squares are the candidate siblings selected according to predicted kinematic and the ages of six candidate siblings (red dots) are consistent with 4.6 Gyr within errors. The blue line is the colour index of (B-V) =0.4. Stars located to left of the line are too young to be solar siblings.

The accurate abundances can be determined from the high resolution spectra using Spectroscopy Made "Easy" (SME) code while ages are derived for given metallicity from theoretical isochrones. This will be used to separate potential siblings from the field star population. The accurate abundances could also be used to test for potential Earth-hosting stars having the same abundance pattern as the Sun (Ramirez et al. 2010).

Calendar of next DPAC related meetings

3 - 4 May 12	Coruña, Spain	**CU8: Astrophysical Parameters #10**	Bailer-Jones / Manteiga
10 - 11 May 12	ESTEC	**GST meeting #38**	Prusti
14 - 16 May 12	Torino	**GBOT meeting #4**	Altmann / Smart
29 - 31 May 12	Helsinki	**CU4: Object Processing #13**	Pourbaix / Muinonen
29 - 31 May 12	Menorca (Spain)	**CU7: Variability Processing #14**	Eyer / Sarro
11 - 12 June 12	Gaia, Portugal	**AGIS #17**	Lammers / Osorio
11 - 13 June 12	Ljubljana	**CU6: Spectroscopic Processing #13**	Sartoretti / Zwitter
13 - 15 June 12	Gaia (Portugal)	**CU3: Core Processing #7**	Bastian / Osorio
25 June - 4 July	ESAC and other	**DPAC/SOC Operations Rehearsal #1**	Brown / Hoar / others
11 - 12 July 12	Observatory of Paris	**DPACE #15**	Mignard / Katz

Gaia and related science meetings

14 - 18 May	Cargese, Corsica	**Astronomical Data Analysis Conference (ADA VII)**	http://ada7.cosmostat.org/
21 - 24 May	Medana, Slovenia	**Stars without borders, radial migration in spiral galaxies**	http://www.itp.uzh.ch/~roskar/migration_workshop/
20 May- 9 June	Aspen	**A window to the formation of the Milky Way: Dynamics, (…)**	http://www.aei.mpg.de/~pau/Aspen2012/
29 - 31 May	Bologna	**The metallicity distribution in the Milky Way discs**	http://www.bo.astro.it/great-esf-gradient/
11 - 15 June	Teramo	**Fundamental Cosmic Distance Ladder and Transient Sky**	http://isa2012.oa-teramo.inaf.it/
18 - 20 June	Heidelberg	**The Milky Way: Stars, Gas, Dust and Magnetic Fields in 3D**	http://www.astra-gaia.eu/meetings/MWin3D/
20 - 22 June	Paris Observatory	**A new reduction of old observations in the Gaia era**	http://www.imcce.fr/hosted_sites/naroo/index.html
1 - 6 July 2012	Amsterdam	**SPIE Astronomical Telescopes & Instrumentation**	http://spie.org/astronomical-instrumentation.xml?
4 - 6 July 2012	Roma	**GREAT Network Science Symposium**	http://aramis.obspm.fr/EWASS12/

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