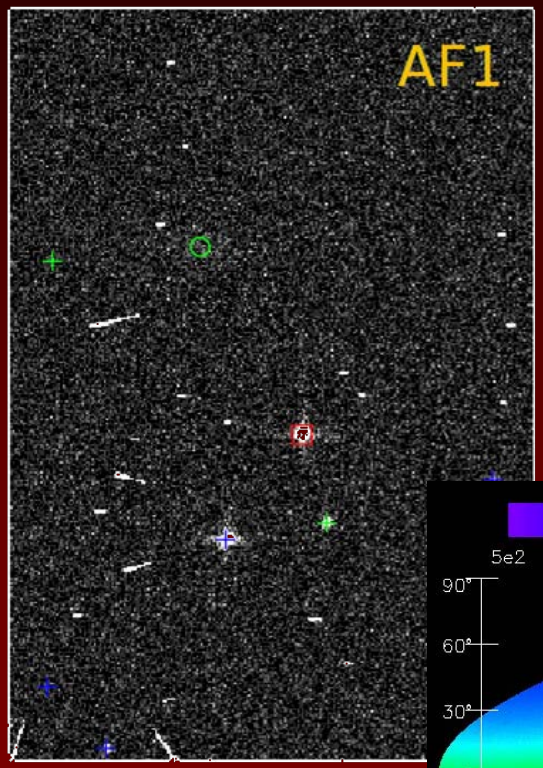
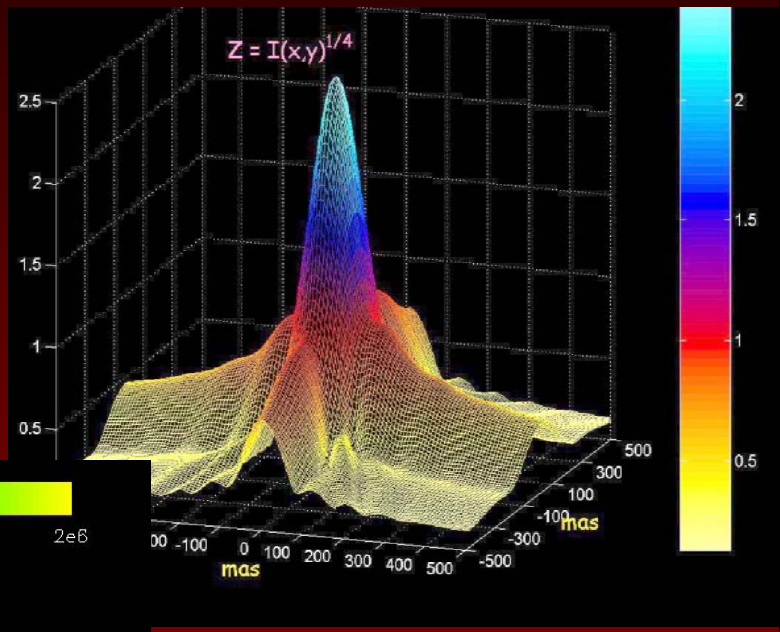
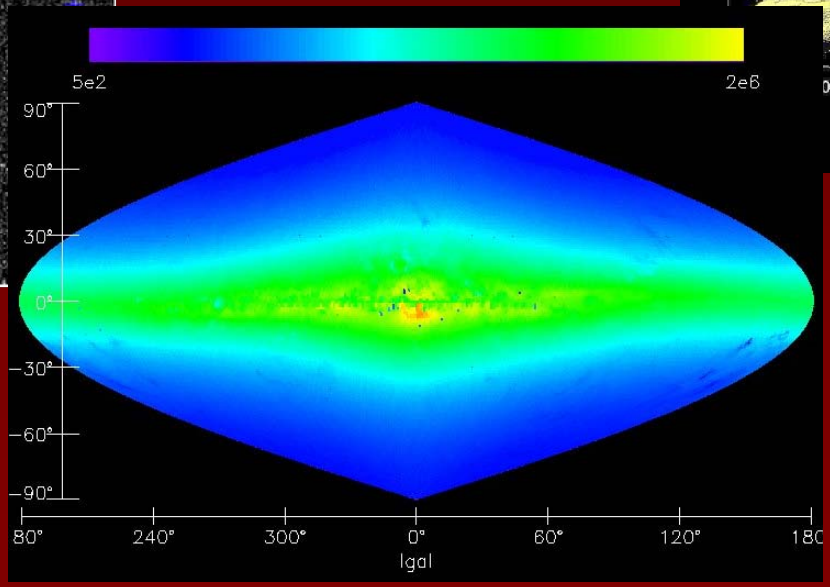
GOG: the Gaia Object Simulator

X. Luri, ICCUB/IEEC

The Gaia simulator







The CU2

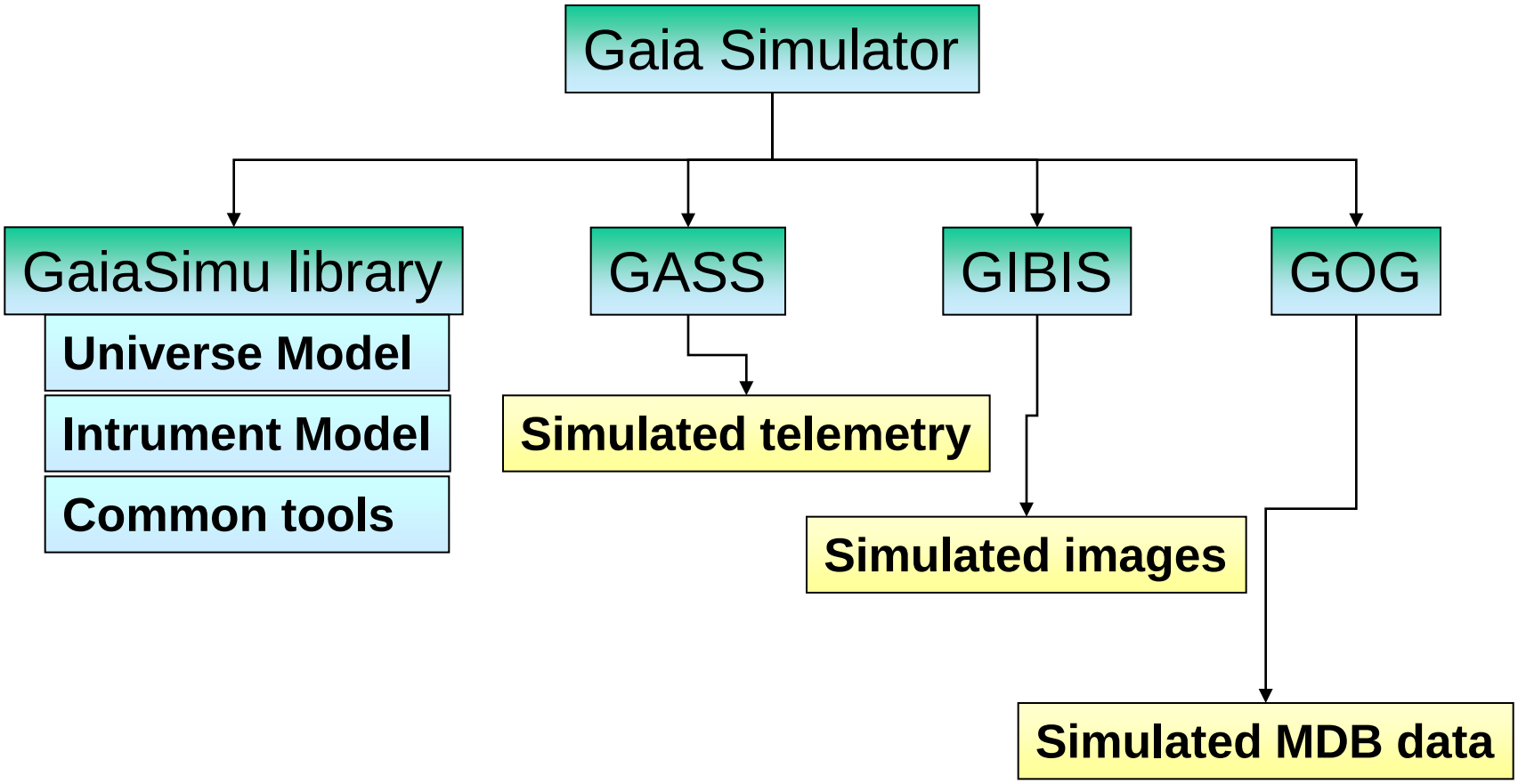
The CU2 task is to cover the simulation needs for the work of other CUs, ensuring that **reliable data simulations** are available for the **development and testing of the various stages of the data processing development.**

Key point:

we are presently serving the **simulation needs of a data reduction consortium**. We are not doing simulations for instrument design (although we did in the past) and **we are just now starting to provide simulations to prepare the science exploitation** (simulated Gaia catalogue to be released in 2012).

This has set our priorities and design choices up to now.

CU2 product tree



The GaiaSimu library

GaiaSimu library: this library is the basis for the development of the Gaia simulator. It contains the common models used by the data generators to produce simulations of the Gaia observations. It is composed of three parts:

1. The instrument model: models of the Gaia instruments and elements of the spacecraft
2. The universe model: model of the objects in the sky that Gaia will observe, with all its physical characteristics
3. Common tools: a toolbox for use throughout the simulator

Gaia modelling with a Gaia mock catalogue

The Universe Model

See A. Robin presentation

Solar System

- Sun, Earth, Moon
  (not for observation)
- Planets and satellites
- Minor bodies
  - Asteroids
  - Comets
  - Kuiper belt
- Other components
  - Zodiacal light
  - Solar wind
  - Etc.

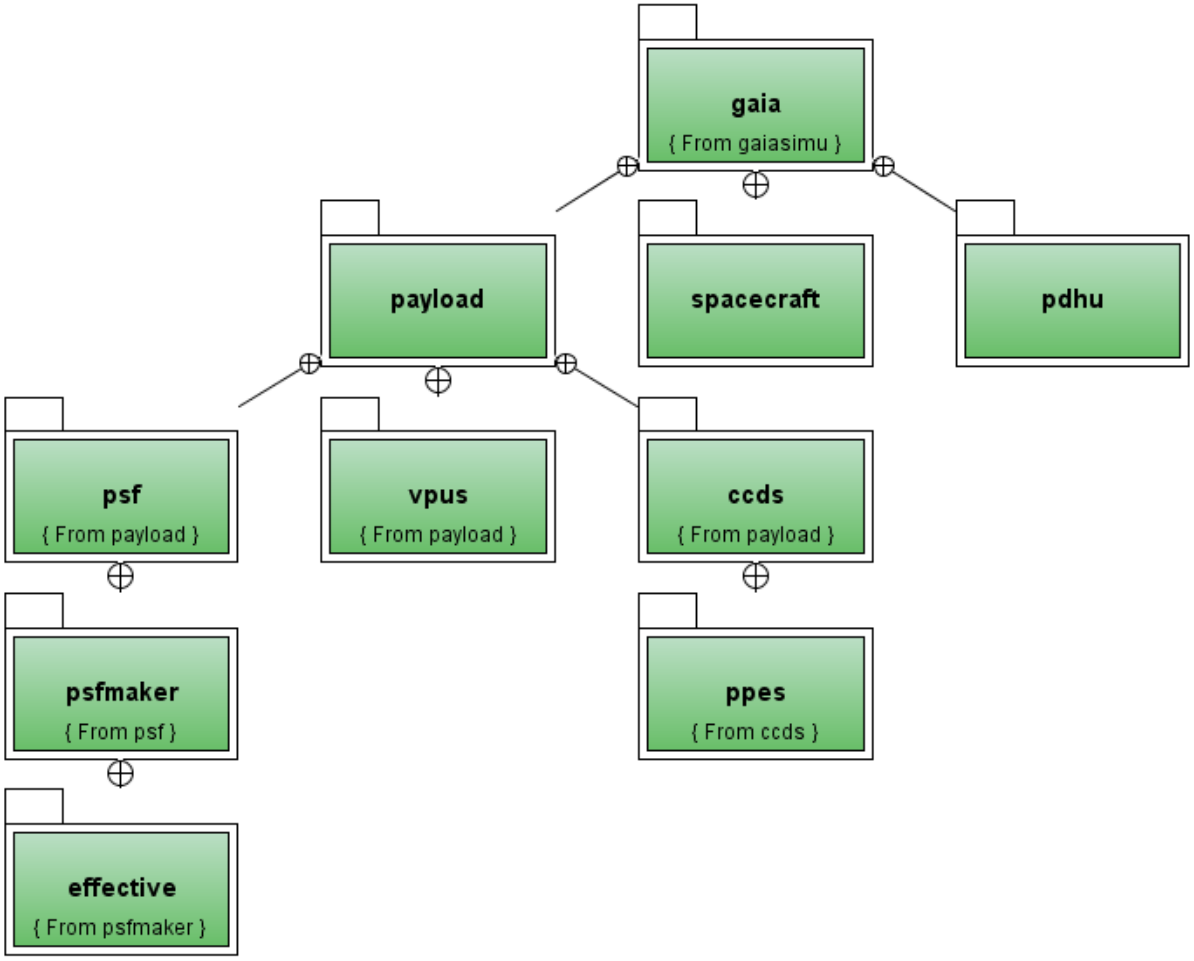
Our Galaxy

- Field stars
  - **"Normal"**
  - **Multiple systems**
  - **Variable stars**
- Stellar clusters
  - Open clusters
  - Globular clusters
  - OB associations
  - Stellar streams
- Extended objects
  - Planetary nebula
  - HII regions
  - Reflection nebula
- Other components
  - Galactic diffuse light
  - Extrasolar planets

Extragalactic objects

- Galaxies with resolved structure (LMC/SMC)
  - Field stars
  - Stellar clusters
  - Surface brightness
  - Supernovae
- Galaxies with unresolved structure
  - Surface brightness
  - Supernovae
- QSO
- Other components
  - Diffuse extragalactic light

The Instrument Model



The Data Generators

The simulator comprises three *data generators*, software components that use the GaiaSimu library to produce specific types of data for the DPAC. The three data generators are:

- The GAia System Simulator (GASS)
- The Gaia Instrument and Basic Image Simulator (GIBIS)
- The Gaia Object Generator (GOG)

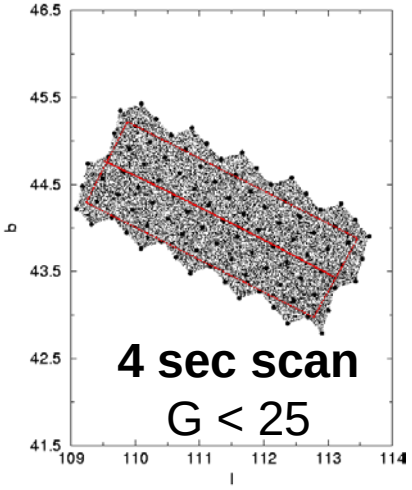
GASS

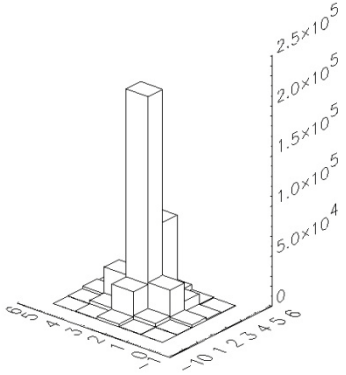
This data generator provides simulations of the telemetry stream of the mission based on some simplications of the instrument and Universe models allowing a large amount of data to be simulated over a signicant period of time.

GASS provides realistic data for:

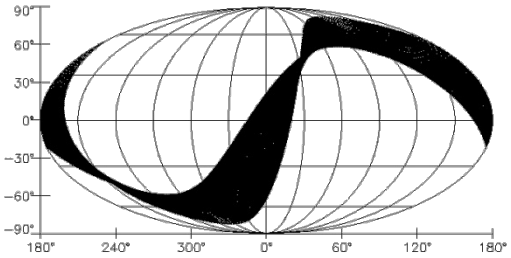
- Predictions to be used for mission design.
- Filling of test databases
- Testing of core reduction algorithms
- Evaluation of mission performances, in particular for peculiar objects (binary stars, NEO's, extrasolar planets,...)

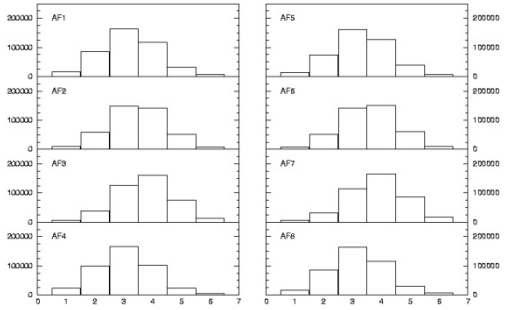
GASS is run in large computer clusters and specially at the **Mare Nostrum supercomputer**.





ASM





ASTRO patches

GIBIS

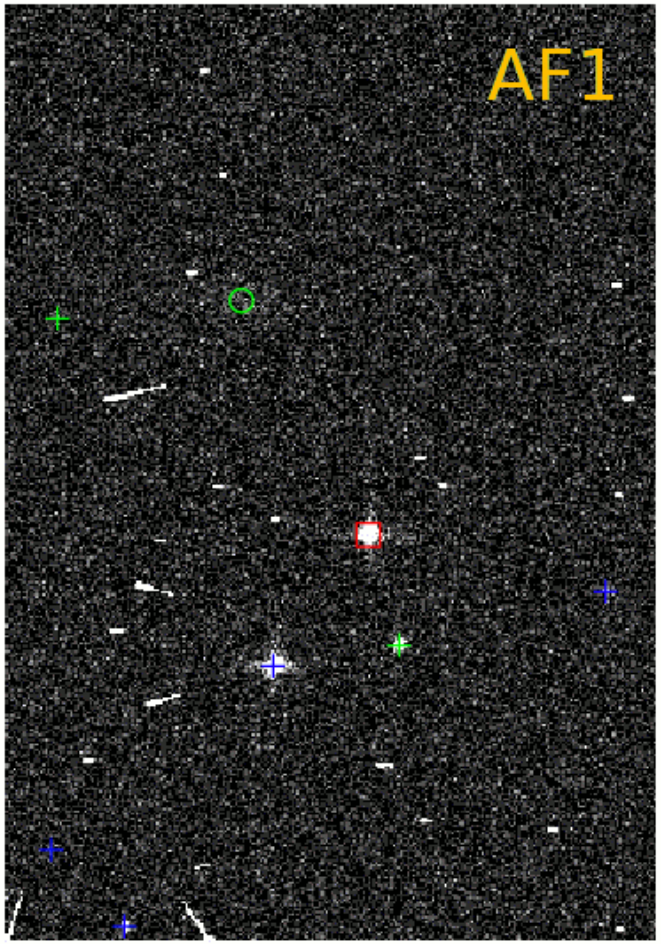
This data generator provides simulations of the data at the pixel level. The resulting simulations are as realistic as possible and restricted, due to computing time limitations, to a region of a sky over a short period of time (~1 hour).

GIBIS provides realistic CCD images for:

- Instrument design
- PDHE design
- Detection & selection algorithm development
- Scientific mission design (e.g. RVS)
- Detailed analysis of reduction algorithms

Gaia modelling with a Gaia mock catalogue

GIBIS is available as a web service and is also run in batch mode in computer clusters.



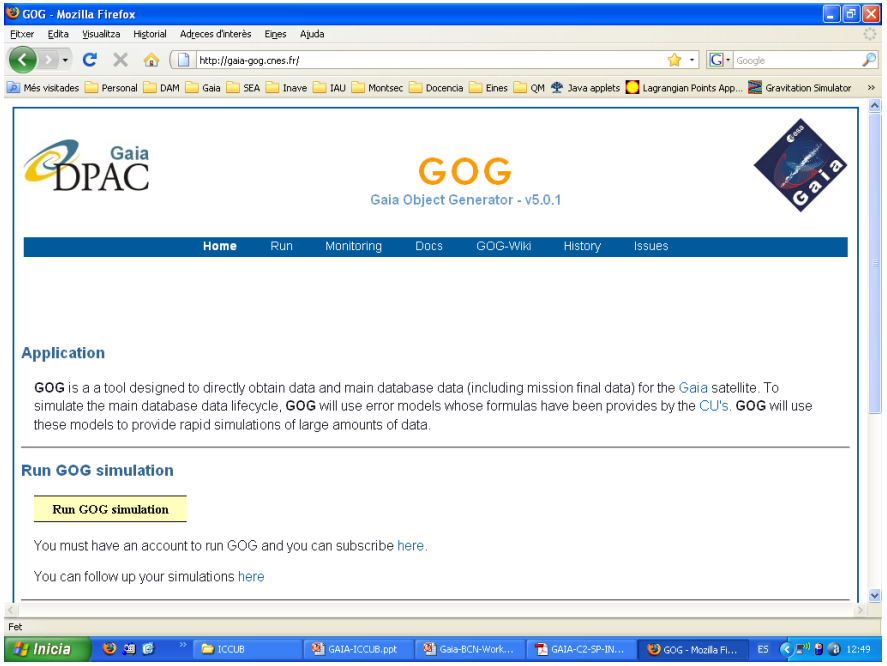
GOG

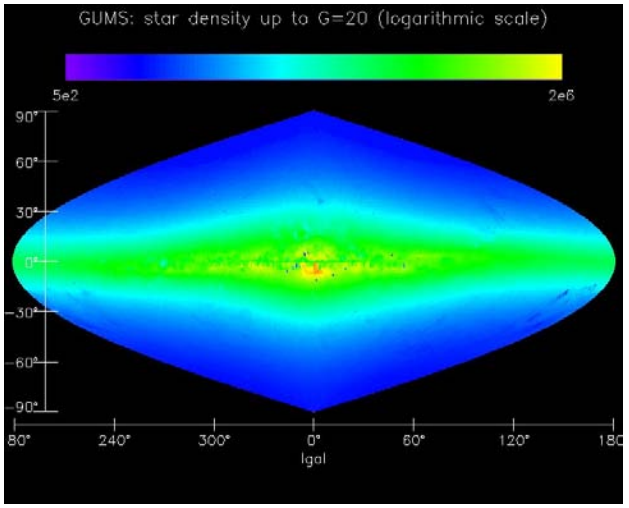
This data generator provides simulations of number counts and lists of observable objects from the Universe model and, for a given source or a collection of sources, **simulations of intermediate and end-of-mission Gaia data**.

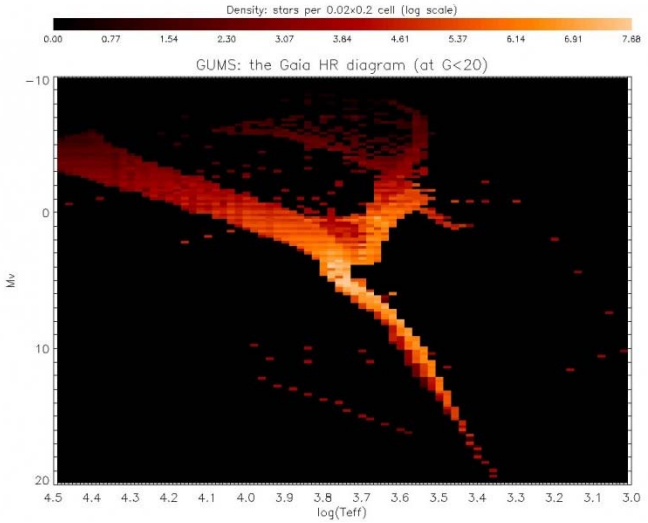
GOG aims to simulating the contents of the MDB at any stage of the data processing.

Gaia modelling with a Gaia mock catalogue

GOG is available as a web service and is also run in batch mode in desktops computers or clusters.







Towards a Gaia mock-up catalogue

First step: GUMS

The Gaia Universe Model Snapshot (GUMS) is a full G<20 simulation of the contents of the universe model at T=0 used for validation and testing.

Several versions of GUMS have been generated at various stages of the development. We are currently at GUMS-10.

GUMS-10 Overview

The model has generated ~1,000,000,000 galactic objects:

~49% single stars

~51% stellar systems formed by multiple stars and stars with planets

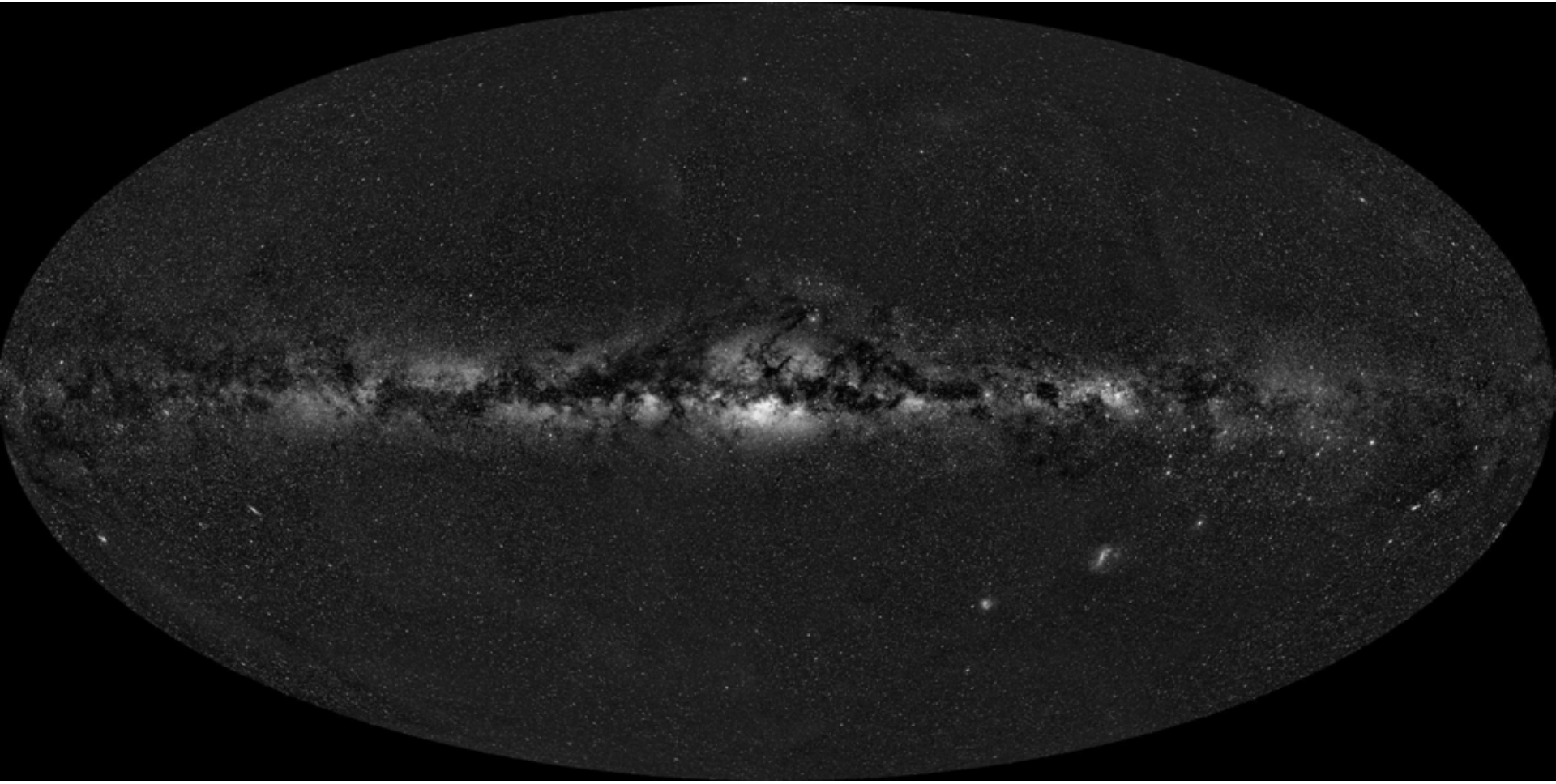
Grand total of 1,600,000,000 individual stars

Visibility based on the integrated magnitude G < 20

Ignoring the real spatial resolution of Gaia

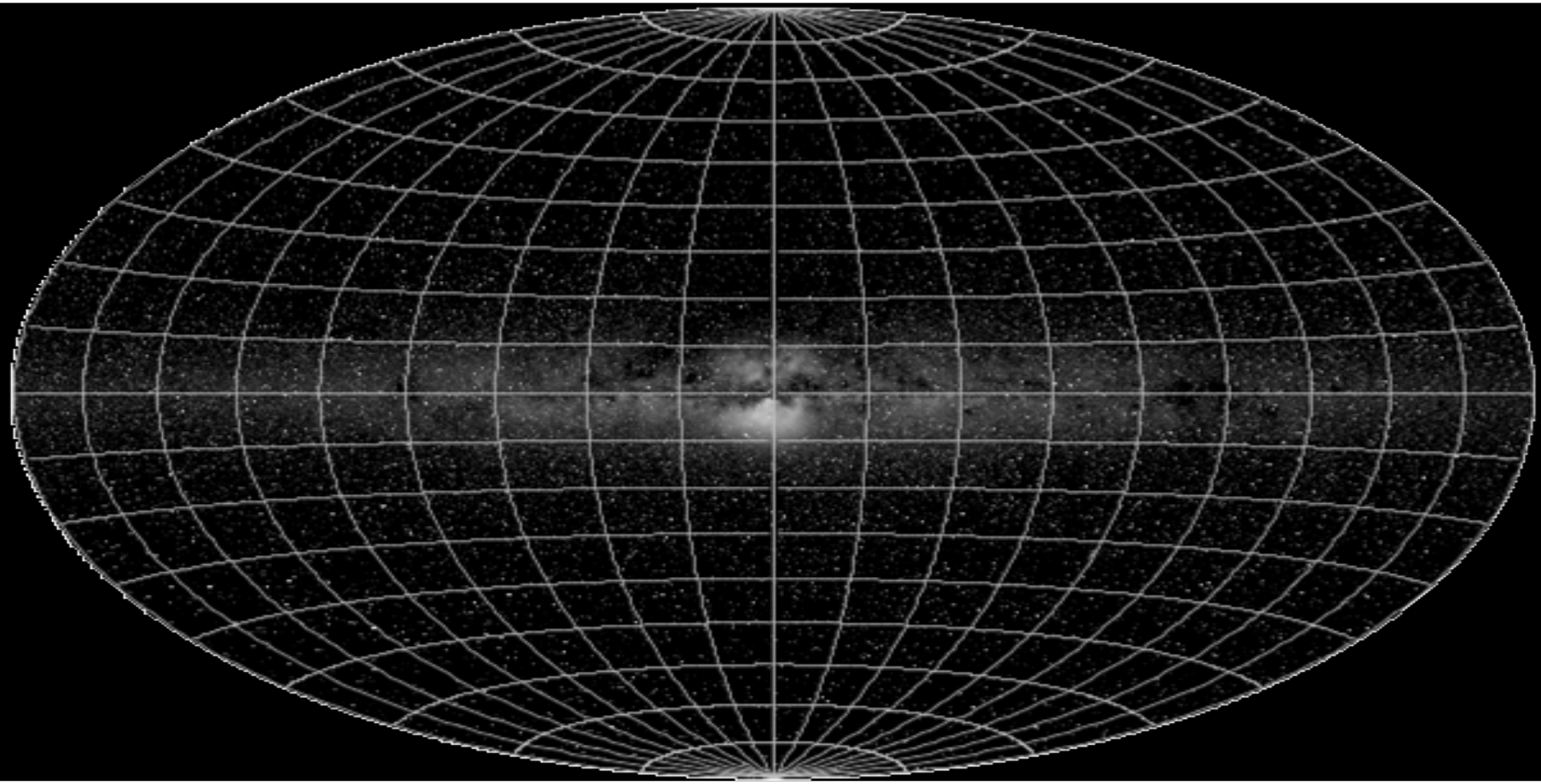
Real sky

https://www.cfa.harvard.edu/~rkirshner/MilkyWay.jpg

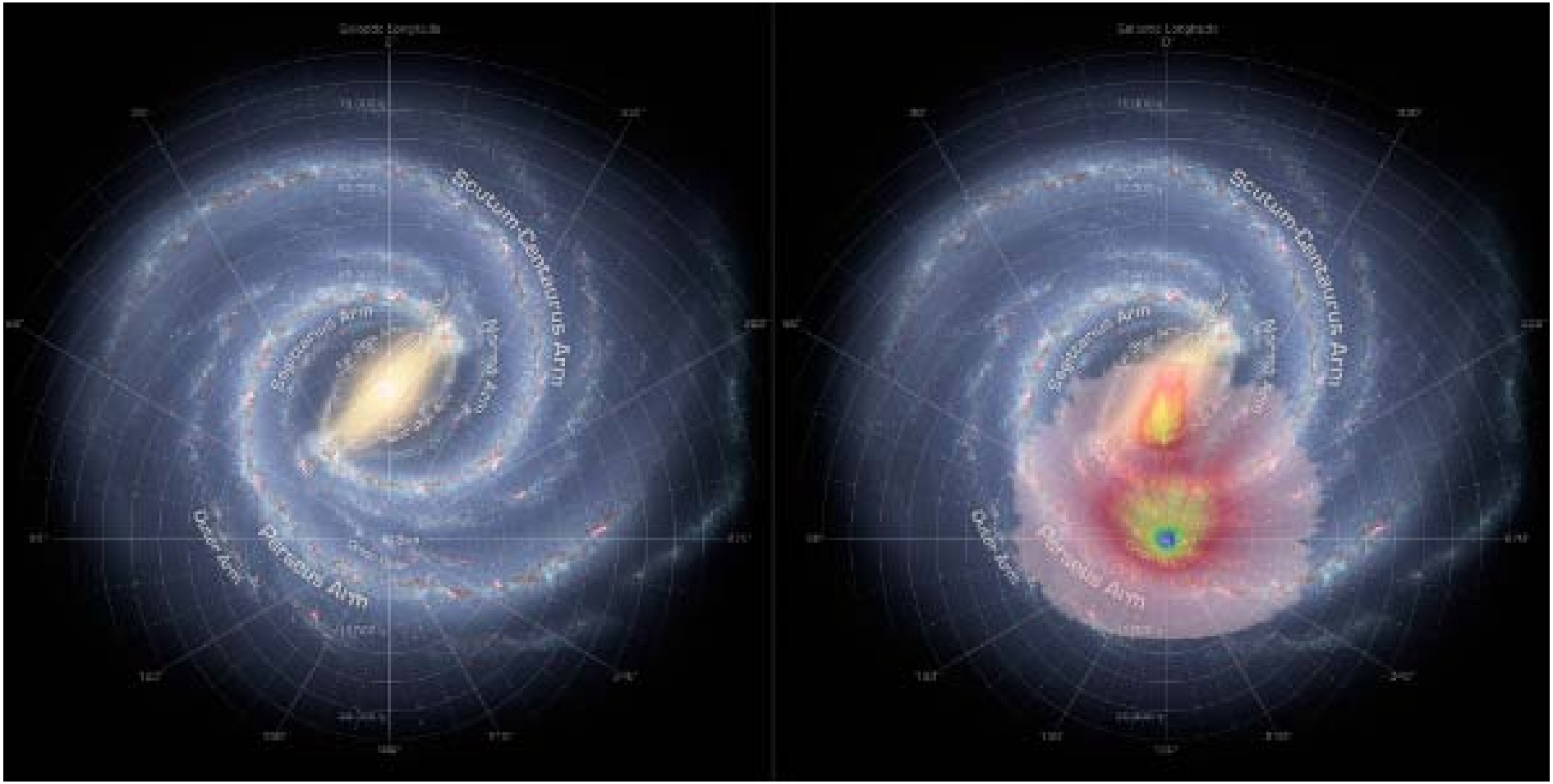


Simulated sky

The sky in G magnitude



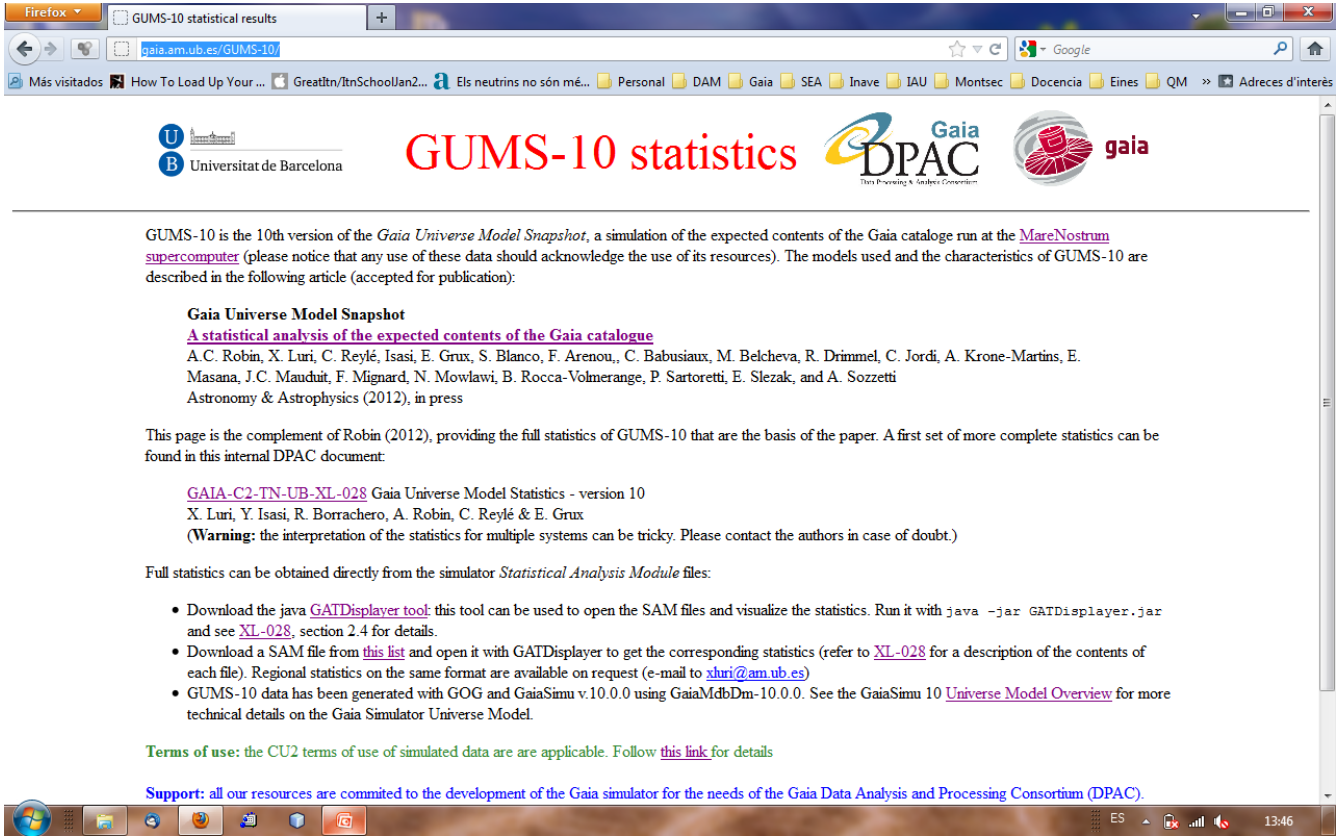
Gaia modelling with a Gaia mock catalogue



Gaia modelling with a Gaia mock catalogue

Details can be found at:

http://gaia.am.ub.es/GUMS-10/



GUMS-10 statistical results

gaia.am.ub.es/GUMS-10/

Universitat de Barcelona

GUMS-10 statistics

GUMS-10 is the 10th version of the *Gaia Universe Model Snapshot*, a simulation of the expected contents of the Gaia cataloge run at the MareNostrum supercomputer (please notice that any use of these data should acknowledge the use of its resources). The models used and the characteristics of GUMS-10 are described in the following article (accepted for publication):

Gaia Universe Model Snapshot
A statistical analysis of the expected contents of the Gaia catalogue
A.C. Robin, X. Luri, C. Reylé, Isasi, E. Grux, S. Blanco, F. Arenou,, C. Babusiaux, M. Belcheva, R. Drimmel, C. Jordi, A. Krone-Martins, E. Masana, J.C. Mauduit, F. Mignard, N. Mowlawi, B. Rocca-Volmerange, P. Sartoretti, E. Slezak, and A. Sozzetti
Astronomy & Astrophysics (2012), in press

This page is the complement of Robin (2012), providing the full statistics of GUMS-10 that are the basis of the paper. A first set of more complete statistics can be found in this internal DPAC document:

GAIA-C2-TN-UB-XL-028 Gaia Universe Model Statistics - version 10
X. Luri, Y. Isasi, R. Borrachero, A. Robin, C. Reylé & E. Grux
(**Warning:** the interpretation of the statistics for multiple systems can be tricky. Please contact the authors in case of doubt.)

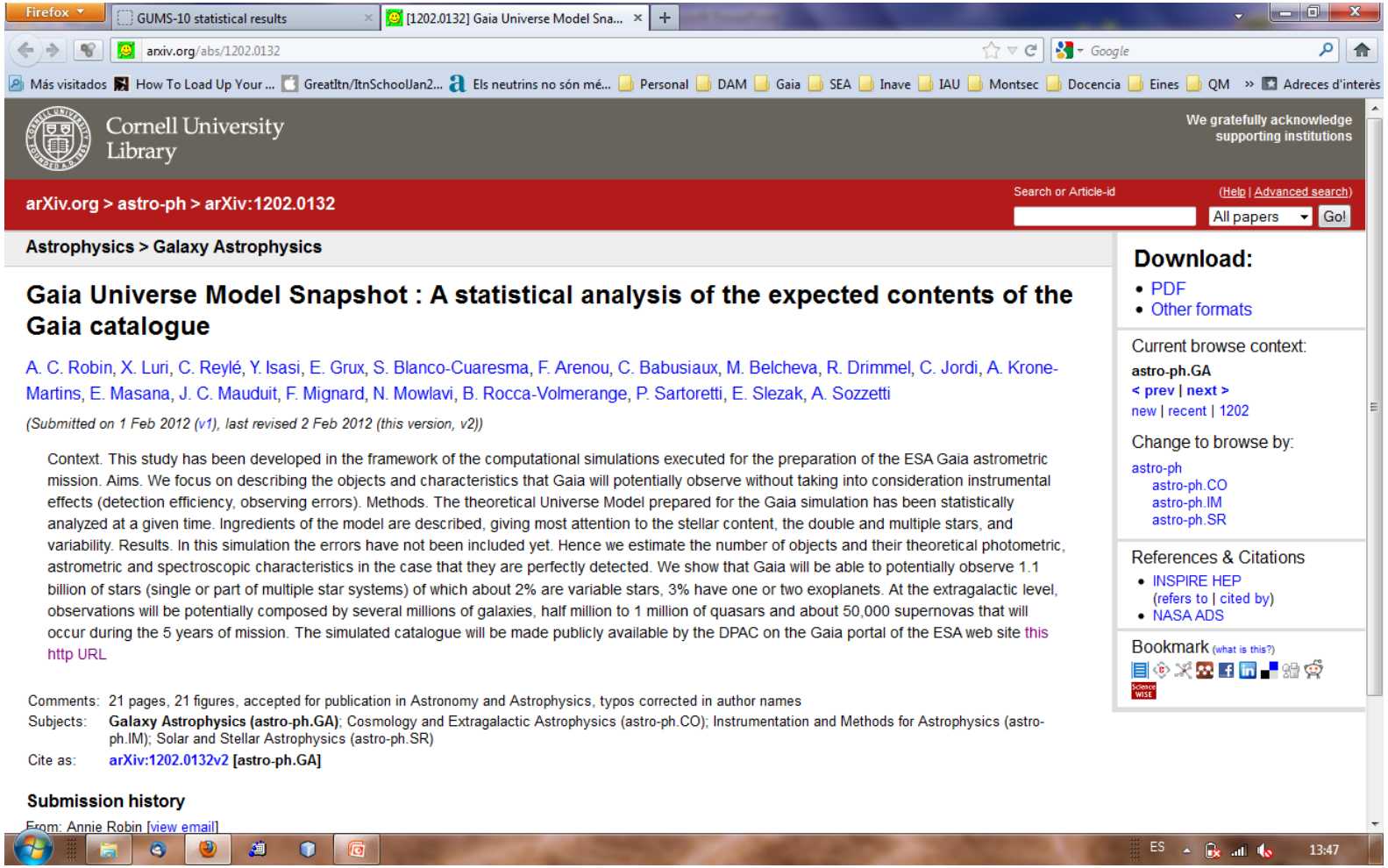
Full statistics can be obtained directly from the simulator *Statistical Analysis Module* files:

- Download the java GATDisplayer tool: this tool can be used to open the SAM files and visualize the statistics. Run it with `java -jar GATDisplayer.jar` and see XL-028, section 2.4 for details.
- Download a SAM file from this list and open it with GATDisplayer to get the corresponding statistics (refer to XL-028 for a description of the contents of each file). Regional statistics on the same format are available on request (e-mail to xluri@am.ub.es)
- GUMS-10 data has been generated with GOG and GaiaSimu v.10.0.0 using GaiaMdbDm-10.0.0. See the GaiaSimu 10 Universe Model Overview for more technical details on the Gaia Simulator Universe Model.

Terms of use: the CU2 terms of use of simulated data are are applicable. Follow this link for details

Support: all our resources are commited to the development of the Gaia simulator for the needs of the Gaia Data Analysis and Processing Consortium (DPAC).

Published A&A paper



Firefox | GUMS-10 statistical results | [1202.0132] Gaia Universe Model Sna...

arxiv.org/abs/1202.0132

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arXiv.org > astro-ph > arXiv:1202.0132

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Astrophysics > Galaxy Astrophysics

Gaia Universe Model Snapshot : A statistical analysis of the expected contents of the Gaia catalogue

A. C. Robin, X. Luri, C. Reylé, Y. Isasi, E. Grux, S. Blanco-Cuaresma, F. Arenou, C. Babusiaux, M. Belcheva, R. Drimmel, C. Jordi, A. Krone-Martins, E. Masana, J. C. Mauduit, F. Mignard, N. Mowlavi, B. Rocca-Volmerange, P. Sartoretti, E. Slezak, A. Sozzetti

(Submitted on 1 Feb 2012 (v1), last revised 2 Feb 2012 (this version, v2))

Context. This study has been developed in the framework of the computational simulations executed for the preparation of the ESA Gaia astrometric mission. Aims. We focus on describing the objects and characteristics that Gaia will potentially observe without taking into consideration instrumental effects (detection efficiency, observing errors). Methods. The theoretical Universe Model prepared for the Gaia simulation has been statistically analyzed at a given time. Ingredients of the model are described, giving most attention to the stellar content, the double and multiple stars, and variability. Results. In this simulation the errors have not been included yet. Hence we estimate the number of objects and their theoretical photometric, astrometric and spectroscopic characteristics in the case that they are perfectly detected. We show that Gaia will be able to potentially observe 1.1 billion of stars (single or part of multiple star systems) of which about 2% are variable stars, 3% have one or two exoplanets. At the extragalactic level, observations will be potentially composed by several millions of galaxies, half million to 1 million of quasars and about 50,000 supernovas that will occur during the 5 years of mission. The simulated catalogue will be made publicly available by the DPAC on the Gaia portal of the ESA web site this http URL

Comments: 21 pages, 21 figures, accepted for publication in Astronomy and Astrophysics, typos corrected in author names

Subjects: **Galaxy Astrophysics (astro-ph.GA)**; Cosmology and Extragalactic Astrophysics (astro-ph.CO); Instrumentation and Methods for Astrophysics (astro-ph.IM); Solar and Stellar Astrophysics (astro-ph.SR)

Cite as: **arXiv:1202.0132v2 [astro-ph.GA]**

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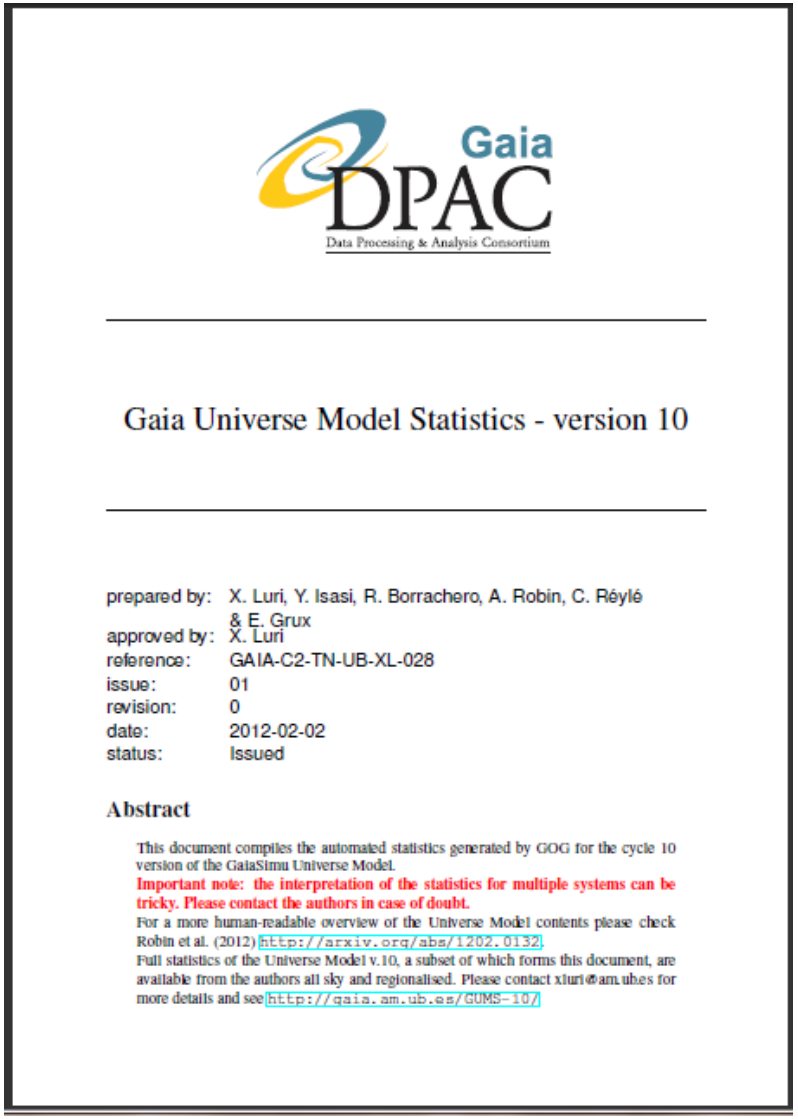
700 page report with statistics



Gaia DPAC
Data Processing & Analysis Consortium

Gaia Universe Model Statistics - version 10

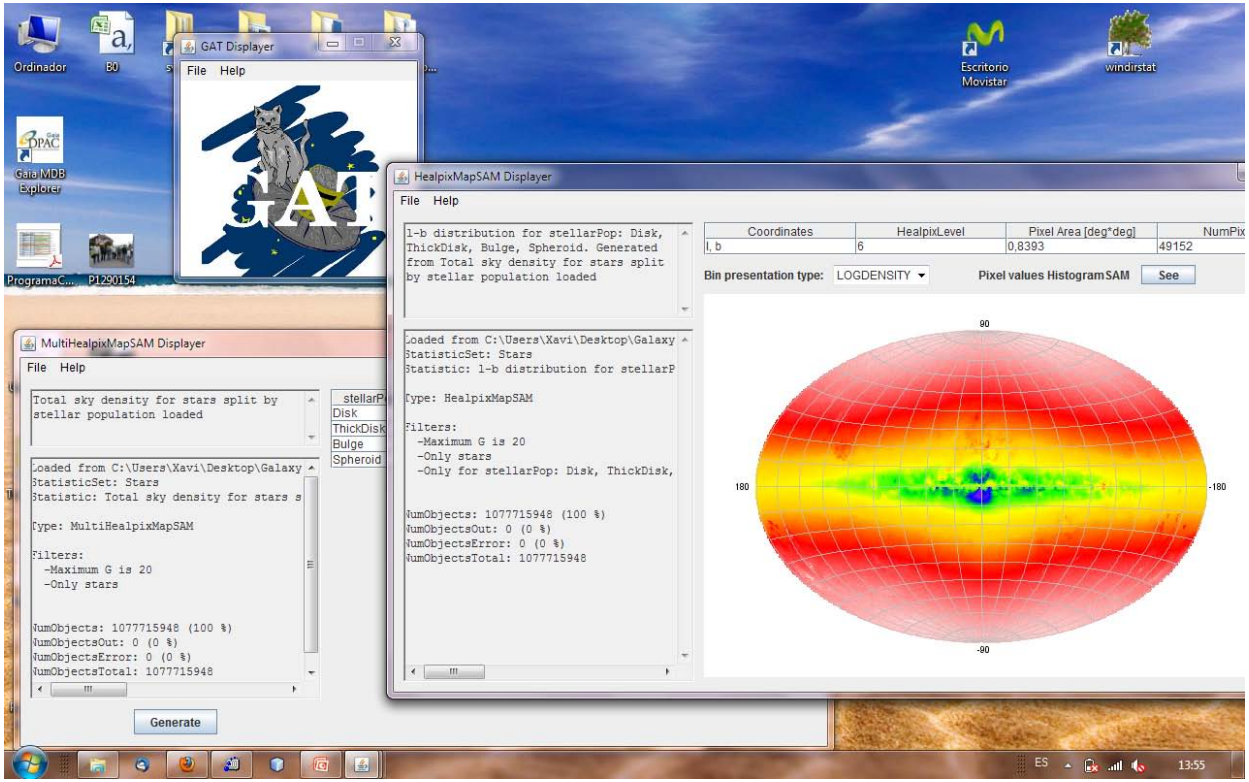
prepared by: X. Luri, Y. Isasi, R. Borrachero, A. Robin, C. Réylé & E. Grux
approved by: X. Luri
reference: GAIA-C2-TN-UB-XL-028
issue: 01
revision: 0
date: 2012-02-02
status: Issued

Abstract

This document compiles the automated statistics generated by GOG for the cycle 10 version of the GaiaSimu Universe Model.
Important note: the interpretation of the statistics for multiple systems can be tricky. Please contact the authors in case of doubt.
For a more human-readable overview of the Universe Model contents please check Robin et al. (2012) http://arxiv.org/abs/1202.0132.
Full statistics of the Universe Model v.10, a subset of which forms this document, are available from the authors all sky and regionalised. Please contact xluri@am.ub.es for more details and see http://gaia.am.ub.es/GUMS-10/

Packaged statistics: GAT files

- 254 files with pre-computed statistics
- Tool for tailored visualization (including export in ASCII): GATDisplayer

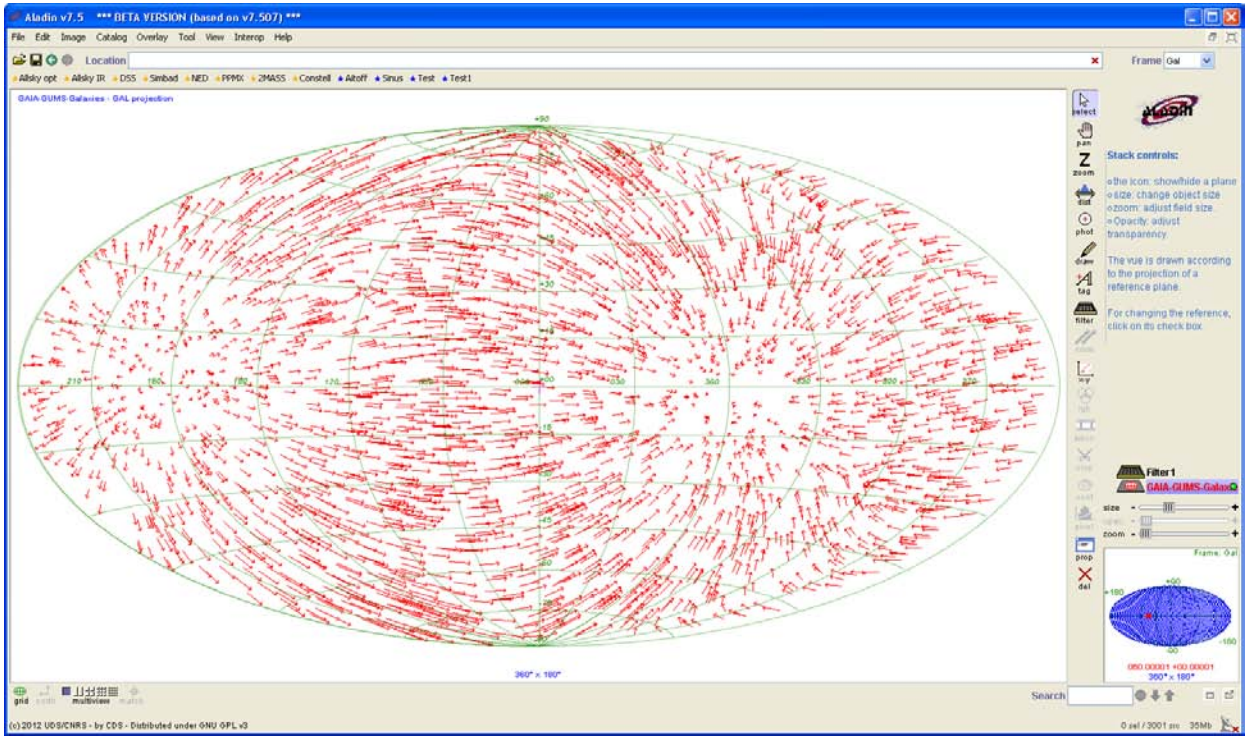


GUMS-10 also available for download from ESAC

- Link details in Gaia portal
- Contact W. O'Mullane for access permission
- In form of gbin files (requires some work in Java to use), some 350GB

GUMS-10 just been uploaded to a database at CDS (Strasbourg) and can be made available on request

- Region queries (QueryCat)
- Aladdin visualization (in preparation)



Second step: GOG MDB simulations

All the products (intermediate and final) of the Gaia data reduction will be stored in the Main Data Base (MDB). **The actual Gaia catalogue will be obtained by extraction of selected data from this database.**

GOG is designed to simulate the contents of the MDB, and therefore **relevant mock-up data can be extracted from its outputs.**

Status:

GOG MDB simulations are still work in progress *(not all the outputs are simulated and the validation of the products is still not complete).*

However, ***the main Gaia products (astrometry and photometry) are already available*** *in GOG simulations.*

A dataset containing simulated GOG MDB ***mock-up data for objects up to G=17 has been produced for this workshop*** *and will be used in tomorrow's session to illustrate* ***how data mining can be done in a very large dataset,***

Coming in the near future

We expect to produce a full G<20 mock-up catalogue in the coming months

Plans to make it available during 2012-2013, maybe in a similar way than the GUMS-10 data (TBD):

- Pre-packaged statistics
- Gbin files
- Maybe access through CDS or a similar query system

Already available

GOG accepts user provided sources for its simulations. Gaia-like observations can be generated with your own list of sources.

- *GOG can be installed in your own computer*
- *GOG can be run through GOG-web at CNES*

  http://gaia-gog.cnes.fr

- *We would be happy to discuss how to cooperate to do large scale processing of your models' data*

Caveats:

- *Input has to be provided in gbin format*
- *Requires some learning about the DPAC systems*

Thank you