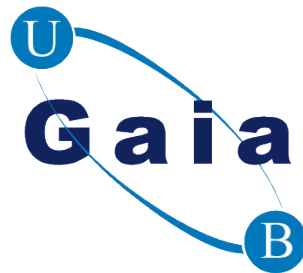


Gaia

*Status, upcoming data releases and
the mission archive*



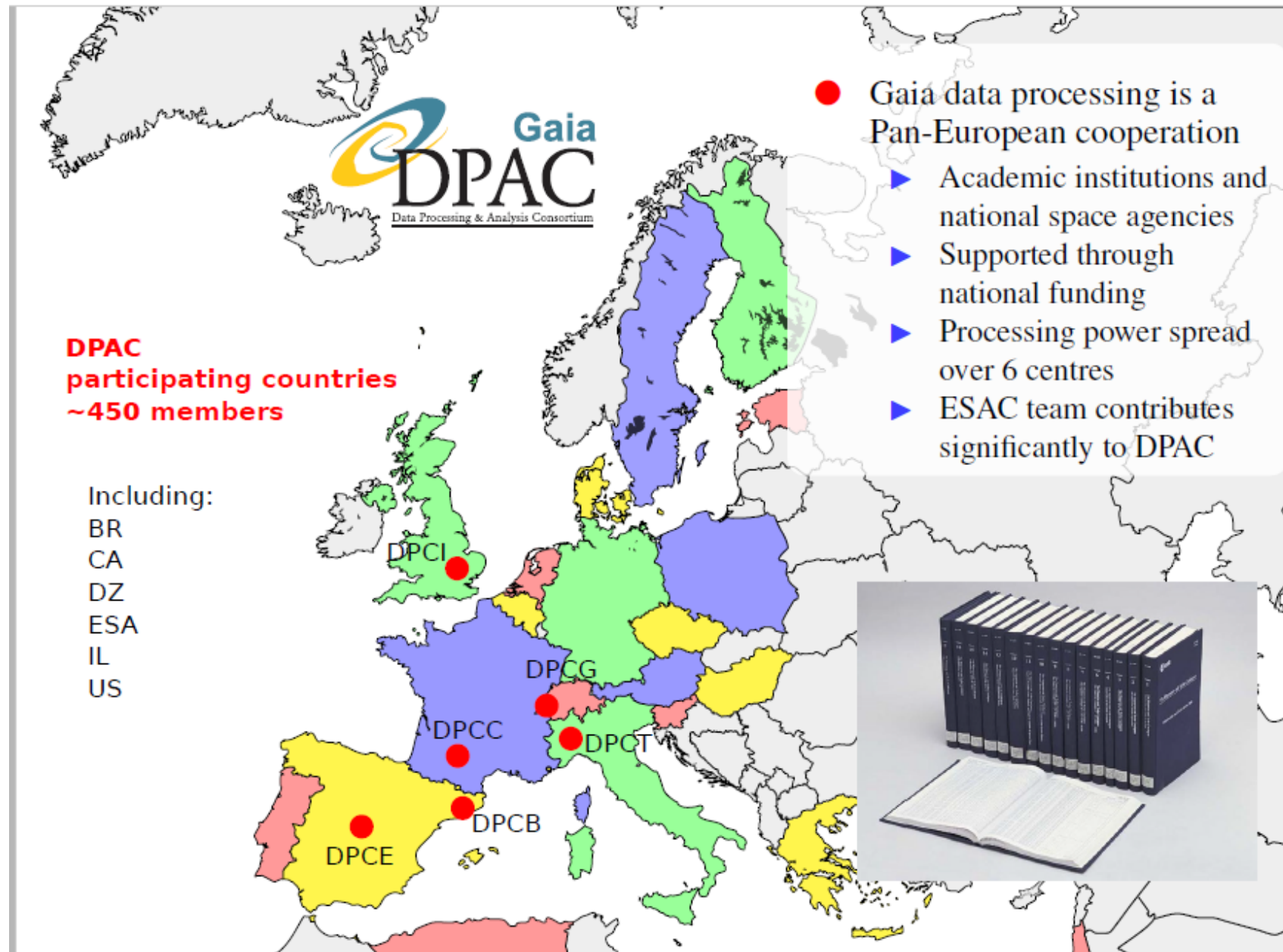
May 2015



X. Luri, ICCUB/IEEC

Gaia: a (mainly) astrometric mission

- $>10^9$ objects (~1% Milky Way + others)
- Complete up to >20 th magnitude
- ➔ • Positions, velocities and parallaxes
 - Nominal precision (15^{th} mag): $\sim 25\mu\text{as}$
- ➔ • Spectrophotometry
- ➔ • Spectroscopy and radial velocities ($G < 16$)
- No input catalogue → unbiased survey



Data release scenario

Five incremental releases are planned with increasing volume of data, data types and precisions:

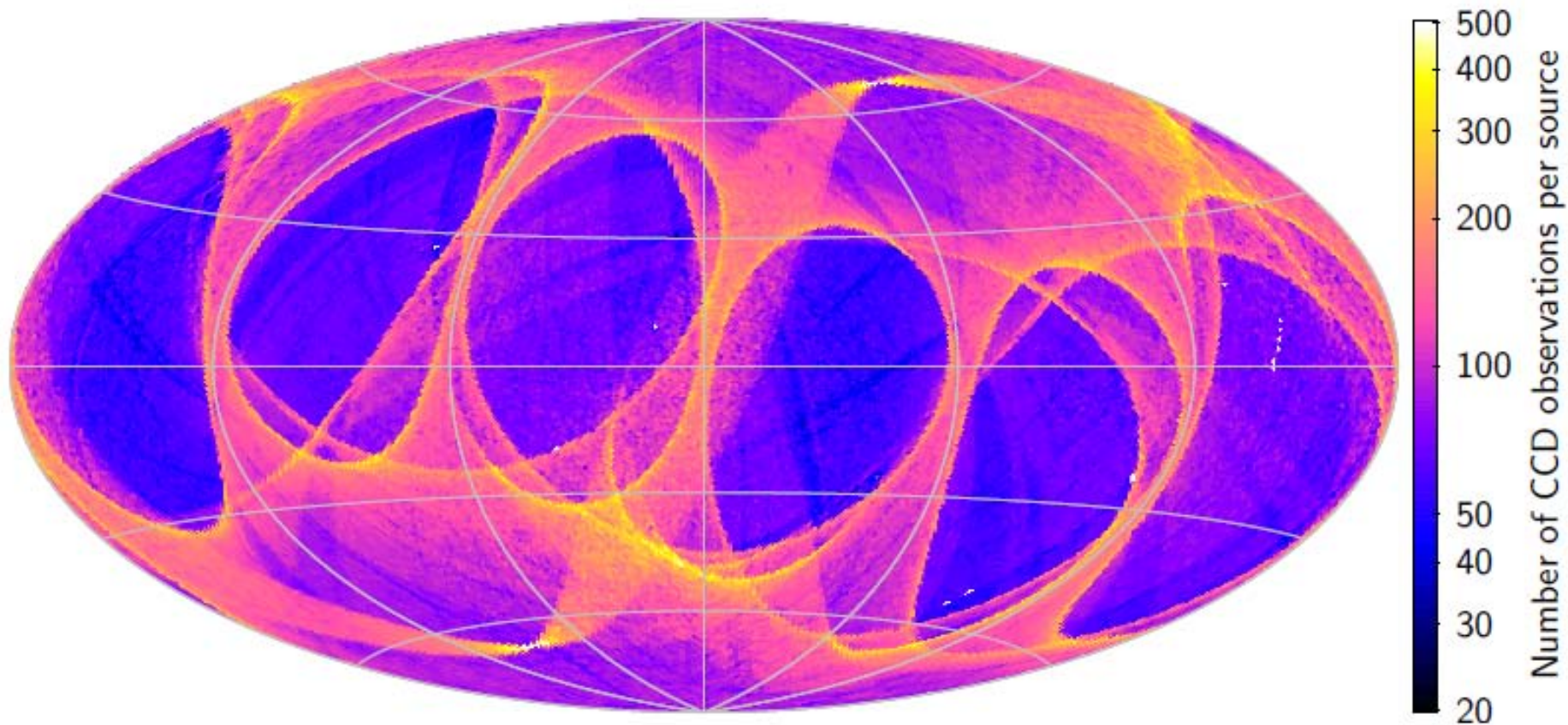
- **DR1: September 2016**
- **DR2: autumn 2017 (updated after the XMM workshop)**
- **DR3: 2018 (TBC)**
- **DR4: 2019 (TBC)**
- **Final release: end of mission + 3 years (2022-2023)**

To be updated: a mission extension will be proposed to ESA end 2016

<http://www.cosmos.esa.int/web/gaia/release>

Gaia DR1 status

Gaia observation coverage



Mean no. observations per pixel ($\sim 1 \text{ deg}^2$)

Credits: DPAC-AGIS team

- 14 months of input data used
- $\sim 2.3 \times 10^{10}$ transits across focal plane
- All sources treated as single
- Processing and preliminary validation of astrometry and photometry completed
- Reference frame aligned to ICRS, astrometry at epoch J2015.0

Gaia-DR1 contents

Astrometry

α , δ for all sources (> 1 billion)

ϖ , μ_{α^*} , μ_{δ} for TGAS sources (~ 2 million)

Covariance matrices (standard errors and correlations)

→ formal errors ‘inflated’ to realistic values

Statistical information to judge astrometry quality

Photometry

Mean G -band fluxes and errors for all sources

G magnitudes in VEGAMAG system

Photometric zero-points for VEGAMAG and AB

No pass-band calibration, transformation to other systems will be provided

Statistical information to judge photometry quality

Variable star data

G -band light curves for selected RR-Lyrae and Cepheids

Classification information for these variables

Statistical information on G -band time series

Gaia-DR1 contents

Filtering before release

- Contents of Gaia-DR1 are not a 1-to-1 copy of main data base contents
- Filtering of results will be done based on validation at the AGIS, PhotPipe and VariPipe level, and at global level (CU9)
- YOUR FAVOURITE SOURCE(S) MAY THUS NOT APPEAR IN Gaia-DR1

Examples

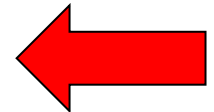
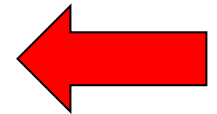
- ◆ Omit sources with too few observations
- ◆ Omit sources without astrometry and/or photometry
- ◆ Upper limit on errors in parallax, position, photometry
- ◆ Omit sources suffering from specific problems in the data processing (e.g., data gaps)
- ◆ No high proper motion stars ($\mu > 3.5 \text{ arcsec yr}^{-1}$) due to technical issue
- ◆ ...

The archive

The screenshot shows the Gaia Archive Core Systems web interface. The browser address bar displays `gaia.esac.esa.int/archive/`. The page header includes the Gaia Archive logo and the ESA logo. A navigation menu contains links for HOME, SEARCH, STATISTICS, VISUALIZATION, HELP, and DOCUMENTATION. Below the menu, there are tabs for Simple Form, ADQL Form, and Query Results. The main content area features a search form with a "Job name:" label and a text input field containing the number "1". To the right of the input field is a "Query examples" link. Below the input field are two buttons: "Reset Form" and "Submit Query". The search results section displays "No results found" above a table with the following columns: Status, Job, Creation date, Num. rows, and Size. The table is currently empty. At the bottom of the table, there are navigation controls showing "1-1 of 0" and buttons for "Apply jobs filter", "Filter this session" (checked), "Select all jobs", and "Delete selected jobs". The footer of the page contains the text "COPYRIGHT 2000 - 2016 © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED. (v0.7)".

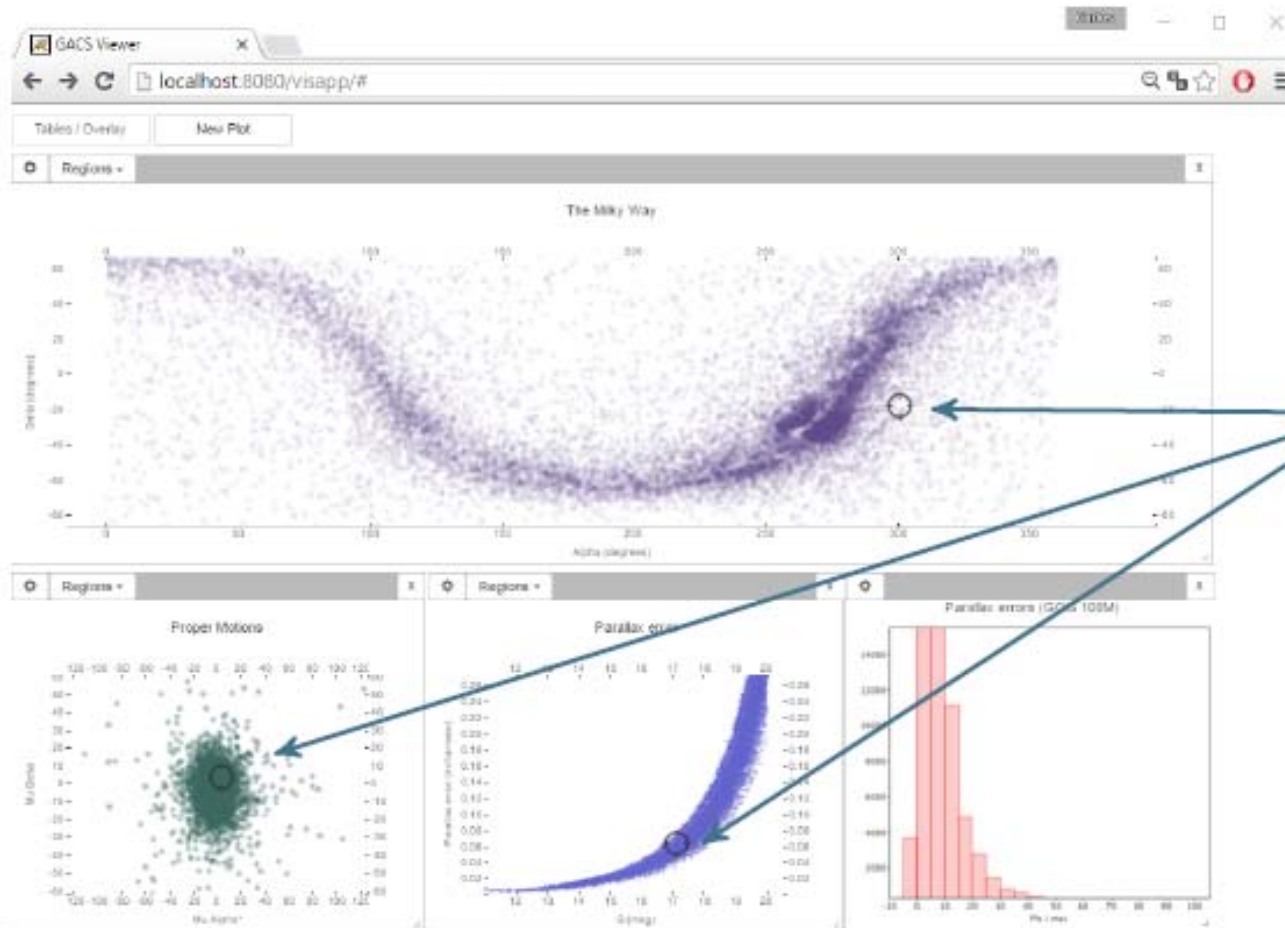
Gaia-DR1: facilities

- Online archive @ ESDC (ESAC Science Data Centre)
 - ▶ catalogue mirrored at CDS, ASDC, ARI, AIP, as well as STScI, USNO, NAOJ, SAAO, ObsPM
 - ▶ these data centres may layer their own services on top of Gaia catalogue
- Online (interactive) and offline documentation
 - ▶ archive contents and the meaning of the tables
 - ▶ how was the processing done
 - ▶ how were the results validated
 - ▶ A&A papers providing ‘condensed documentation’
 - ▶ science verification papers on open clusters and Cepheids
- Query tools for the archive (ADQL, TAP)
- Visualization tools
 - ▶ pre-computed views of large data sets
 - ▶ web-client with linked views, option to visually generate catalogue queries
- Pre-computed and validated cross-match with:
 - ▶ Hipparcos-2, Tycho-2, 2MASS PSC, GSC2.3, PPMXL, UCAC4, SDSS DR10/DR12, AllWISE, URAT-1, RAVE



Gaia-DR1: facilities

Visualization client



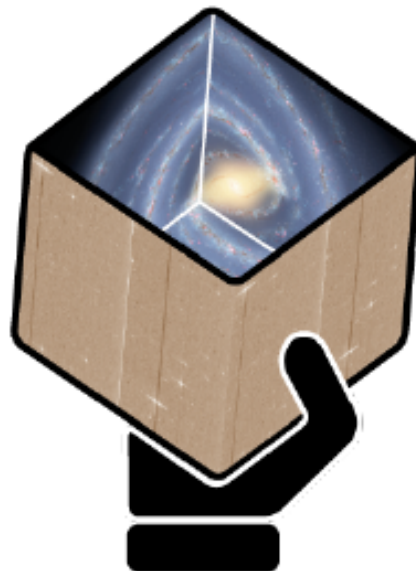
- Web app: displays in browser; PC, tablets, mobile phones
- Multiple panels; resizable and movable
- Interactive (zoom, pan, etc)
- Linked views

Known weaknesses of Gaia-DR1

- Limited input data compared to end-of-mission
- TGAS limited to the brightest and most difficult to calibrate stars
- Cyclic processing loop not closed
 - ▶ strong chromaticity and effects of other unmodelled PSF variations
- Cross-matching suffers from crude attitude, IGSL, and spurious source problems
 - ▶ real sources at $G < 20$ may be missing
- Attitude modelling inaccurate and incomplete
 - ▶ longer than ideal knot intervals for spline models
 - ▶ no treatment of μ -meteoroid hits and μ -clanks
- All sources treated as single stars
- Incomplete geometric calibration model
- No self-consistent basic angle variation calibration
- Several of the above weaknesses will lead to spatially correlated systematics
 - ▶ do not blindly average astrometric quantities

However!

- ◆ Gaia-DR1 results will be immensely valuable in spite of problems
 - ▶ most accurate sky-map to date at HST-like resolution
 - ▶ large increase in parallax information
 - ▶ much more accurate proper motions for Hipparcos stars
- ◆ Experience from scientific use of the data will benefit future improvements of the Gaia data processing
- ◆ ALL of the weaknesses mentioned on previous slide will be addressed in upcoming data releases!



Plans for Gaia-DR2

- Astrometry and photometry based on roughly 22 months of data
 - ▶ Gaia stand-alone astrometric solution (not priors needs as for TGAS)
 - ▶ 5-parameter astrometry for all sources
- Broad band colours ($G_{BP} - G_{RP}$)
 - ▶ improved photometric calibrations
 - ▶ proper pass-band calibrations
- Median radial velocities for bright ($G_{RVS} < 12$) stars
- More variable star results
 - ▶ Cepheids, RR Lyrae all sky, LPV, short time scale variables, exercise exo-planet transit algorithms, QSO variability
- Astrophysical parameters
 - ▶ attempt determination T_{eff} and A_0 from ($G_{BP} - G_{RP}$) or publish relation between T_{eff} and ($G_{BP} - G_{RP}$)
 - ▶ from BP/RP spectra: T_{eff} , A_0 , $[\text{Fe}/\text{H}]$, $\log g$ ($[\text{Fe}/\text{H}]$, $\log g$ only for brighter stars)
 - ▶ for TGAS stars release M_G
 - ▶ attempt radius and luminosity determination for TGAS sources

Synergies with XMM?

Synergies will come from the combination of Gaia and XMM data. For this:

- Exploitation of VO resources combining Gaia and XMM archive.
- Cross-match of Gaia and XMM data. Planned as part of the archive for future Gaia data releases.
- Partner data centres planning for combined databases (particularly INAF-ASI in Rome)
- Data mining combining XMM and Gaia data

Some ideas (thanks to Fred Jansen for the help):

- Gaia science alerts: transients for X-Ray follow-up
- Distances of known optical counterparts of X-Ray sources: look at the intervening absorption from the X-ray data and use the derived density/distribution to make distance estimates for other X-ray sources by extrapolating these densities/distribution models
- Gaia data on specific globular clusters to tie-up with the observed density of X-ray sources