GENIUS
Final Report
for WP5

gaia

Gaia
DPAC
Data Processing & Analysis Consortium

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On behalf of WP5/DPAC940 contributors

The Catalogue validation

- ✓ The preparation of the Gaia archive before its publication requires a careful, detailed and in-depth validation of its contents.
- ✓ The scientific and statistical challenge of this task on a one-billion data set containing a wide variety of data (astrometric, photometric, spectrophotometric, spectroscopic…) is daunting, and would be impossible without tools adapted to work on such a massive and data-diverse archive.
- ✓ This work package aims at producing such tools, based on the actual validation needs and on the characteristics of the archive system, thus making them as efficient as possible.
- ✓ Furthermore, the validation process will rely on methods and tools that can also be used, with little or no adaptation, for the scientific analysis of the catalogue. Therefore, this work package will also produce tools for the use of the scientific community in its analysis of the Gaia data.

Validation Work

Work done thanks to GENIUS support:

1. Validation Test Specification (VTS) document
   - Description of all tests : objective, release, test data
2. Implement these validation tests
   - Development of a S/W environment
   - 130 000 Source Lines Of Codes within GENIUS duration
3. Run them at ESAC
   - Initially using simulated data then the true data
4. Generate a Validation Test Report (VTR)
   - Proposal of filtering stars for DR1
   - Reviewed by a Test Review Board/DPACE/GST
   - Validation of the DR1 data, documentation, publication

Work breakdown

GENIUS/CU9 work breakdown

- ✓ T5.2 – Looking for trouble
  - F.A./K. Findeisen (CNRS/GEPI)
- ✓ T5.3 – Simulation vs reality
  - A. Robin/H. Ziaeepour (CNRS/Utinam)
- ✓ T5.4 - External catalogues
  - C. Babusiaux, L. Ruiz (CNRS/GEPI)+CSIC+KU
- ✓ T5.5 - Statistical & graphical
  - CNRS/OP-GEPI+FFCUL
- ✓ Transversal (special objects):
  - T5.6.1- Solar system objects
    - D.Hestroffer/M.Kudryashova(CNRS/IMCCE)
  - T5.6.2 - Multiple stars
    - D. Pourbaix (ULB)
  - T5.6.3 – Variability
    - S. Blanco, L. Eyer (UG)

- ❑ 942 – Internal tests
  - ❑ C. Fabricius (Univ. Barcelona)
- ❑ 943 - Comparison to models
  - ❑ A. Robin (Utinam, Besançon)
- ❑ 944 - External catalogues
  - ❑ C. Babusiaux (CNRS/OPM)
- ❑ 945 - Statistical & graphical
  - ❑ A. Helmi (Groningen), M. Manteiga
- ❑ Special objects:
  - ❑ 948 - Solar system objects
    P. Tanga (OCA)+D. Hestroffer
  - ❑ 947 - Clusters as tools
    A. Vallenari (INAF)
  - ❑ 946 – Variability
    L. Eyer (U.Geneva)

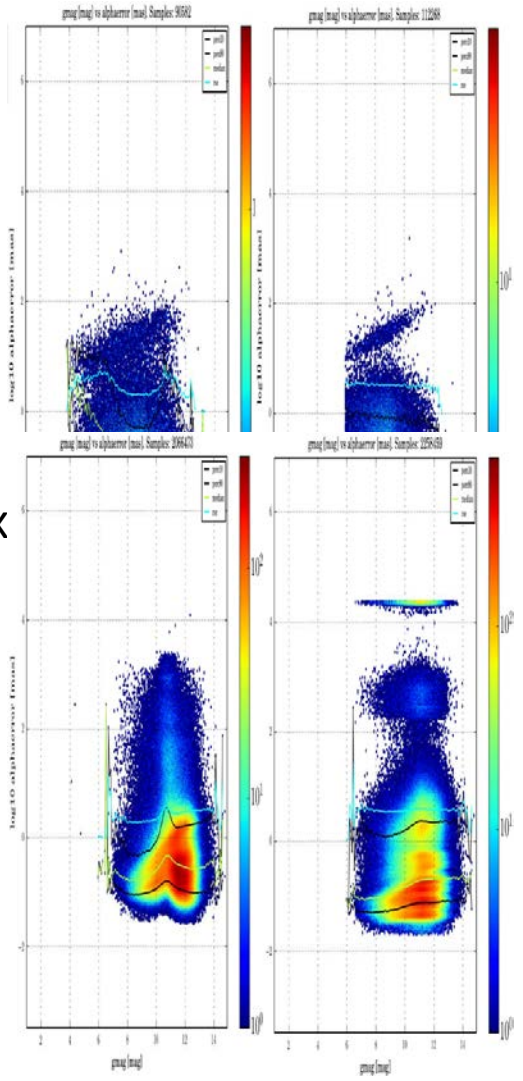
Task 5.1: technical coordination

- ✓ Work summary
  - Design + R&D + implementation of tests
    - Validation Test Specification (VTS) reference document (100+ tests)
    - TGAS solutions availability changed completely our schedule
  - Creation of simulated Catalogues
    - Based on AGISlab simulation added to astronomical data
  - Setting a validation environment S/W
    - Running at ESAC, sending back results
  - Performed 3 TGAS validation rehearsals, then DR1 validation
    - Validation Tests Report on TGAS_00.01, sent to Test Review Board

- ✓ Meetings
  - 5 plenary meetings
    - Vienna 2014, Meudon 2015, Barcelona 2015, Paris 2016, Sitges 2017
  - Telecon meetings with WP managers every 1.5 month (22 up to now)
    - Once every 2 weeks within WP942/T5.2

T5.2: Internal consistency

- ✓ Basic checking: formal validation
  - Parameter content (check NaN, field types, etc.)
  - All fields are within valid ranges
  - Check for outliers or poor solutions
- ✓ Internal consistency
  - Eg. Photometry between bands, coordinate conversions
  - Use assumed parameters properties (e.g. true parallax is positive)
  - Exploit intrinsic redundancy between instrument data (colours)
- ✓ Build scenarios based on what is known to produce errors, e.g
  - Duplicate sources or sourceIds
  - Check for calibration problems, e.g. gate transitions
  - Environment of bright stars



T5.3 : Model-based tests

1. Make statistics on Gaia *simulated* data
   - Extract statistical properties + conf. interval for all observables: distribution, correlations
2. Compare this to actual Gaia data
   - Checking whether the large, expected structures are present (not going into details)
   - Can help to understand and explain the main structures (see e.g. Hipp. Vol 1)
   - Complement where external data is incomplete

✓ Implement tests as func(mag, latitude)
   - Stellar density
   - Mean p.m. and standard deviations
   - Mean parallax and standard deviations

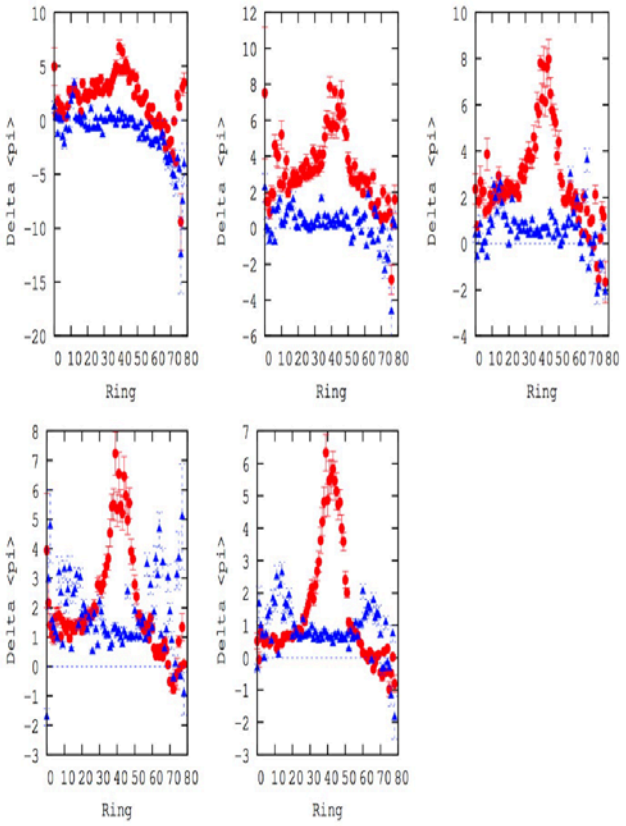


FIGURE 4: WP943-040-010: Differences between model and data in the mean parallax as a function of latitude (healpix rings of different latitudes). In blue: TGAS, in red: AGI

T5.4: External data

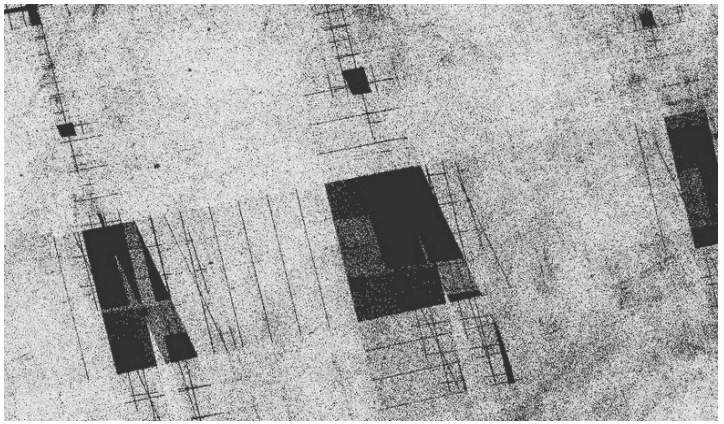
- ✓ A difficult recipe
  - Get external data
  - Make cross-matching
  - Compare to Gaia data
- ✓ Completeness
  - search for duplicate or missing entries
  - homogeneity of the sky distribution, with mag., colour or p.m. ranges
  - small scale completeness of the catalogue
  - performance of visual double stars observations
  - Tycho-2 + 2MASS + UCAC4 + HST (HSC+ACS) + OGLE + WDS

- ❑ Parallaxes
  - ❑ Astrometry: VLBI + HST + RECONS + Hipparcos
  - ❑ Galactic stars distant enough: Cepheids+RRLyrae+APOKASC + APOGEE + LAMOST
  - ❑ Extragalactic: LMC + SMC
- ❑ Proper motions
  - ❑ Accuracy+precision
  - ❑ Tycho-2 + Hipparcos + VLBI
  - ❑ High-proper motions stars
- ❑ Photometry
  - ❑ Hipparcos + SDSS strip 82 + CFHT SNLS + Hubble Caspec
- ❑ Other
  - ❑ QSOs ICRF2
  - ❑ double stars WDS

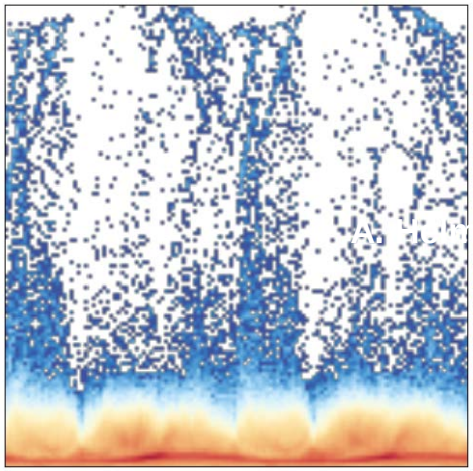
T5.5 : Statistics & Visualisation

- ✓ Goal: define statistical tools for:
  - Clustering and sub-population statistical characterisation tools
  - Study of correlations between observables
  - Find outlying substructures
  - Comparisons to simulations

- ✓ Currently implemented
  - FFCUL visualisation input for the
    - statistical analysis of the data content.
    - Spatial structure discovery
  - the Kullback-Leibler divergence (KLD)
    - degree of clustering from comparisons to simulations for all two-dimensional subspaces. Input from external centers
  - Work on a visualisation prototype
    - Vaex, also used in WP970
    - Used to analyse correlations.



FFCUL T5.5 visualisation near galactic center



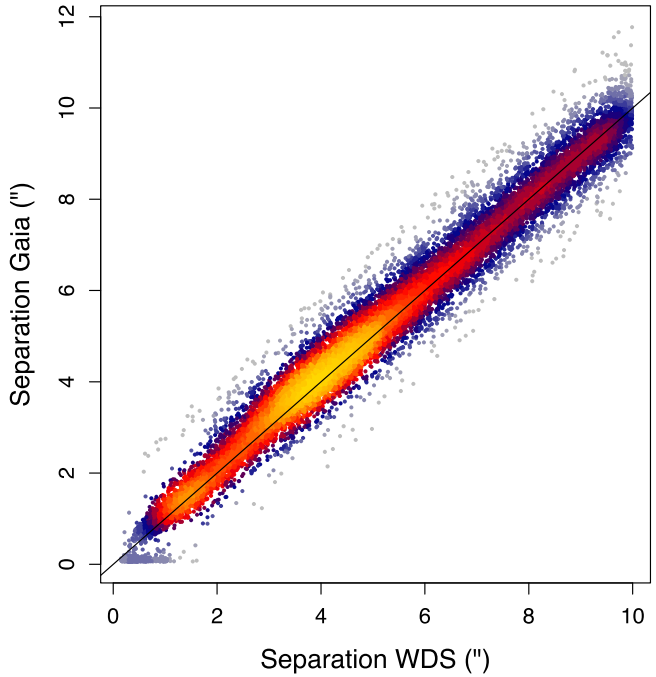
alpha-muAlphaStarError

T5.6.1: solar system objects

- ✓ Motivation
  - Avoid spurious detections of new SSO
  - Avoid corruption of data due to close approach to stars
  - This requires special competence different from stellar validation mainstream
- ✓ Tests
  - Backward occultation verification
  - Detection of anomalous stellar signals due to asteroid proximity
  - RP-BP spectra vs expected SED, fluxes vs G mag.
  - Photometric outliers (may indicate peculiar shape/binarity effects)
- ✓ Tests on individual astrometry
  - Shows good quality on the identified transits
  - Uncertainty is dominated by IDT

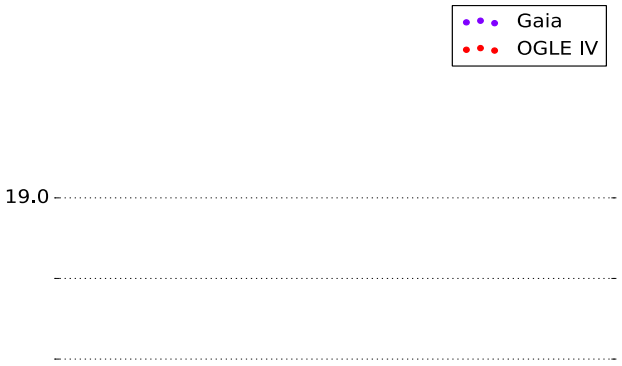
T5.6.2: non-single stars (ULB)

- ✓ See Dimitri Pourbaix presentation



T5.6.3: Time series,variability(UG)

- ✓ See Nami Mowlavi's presentation



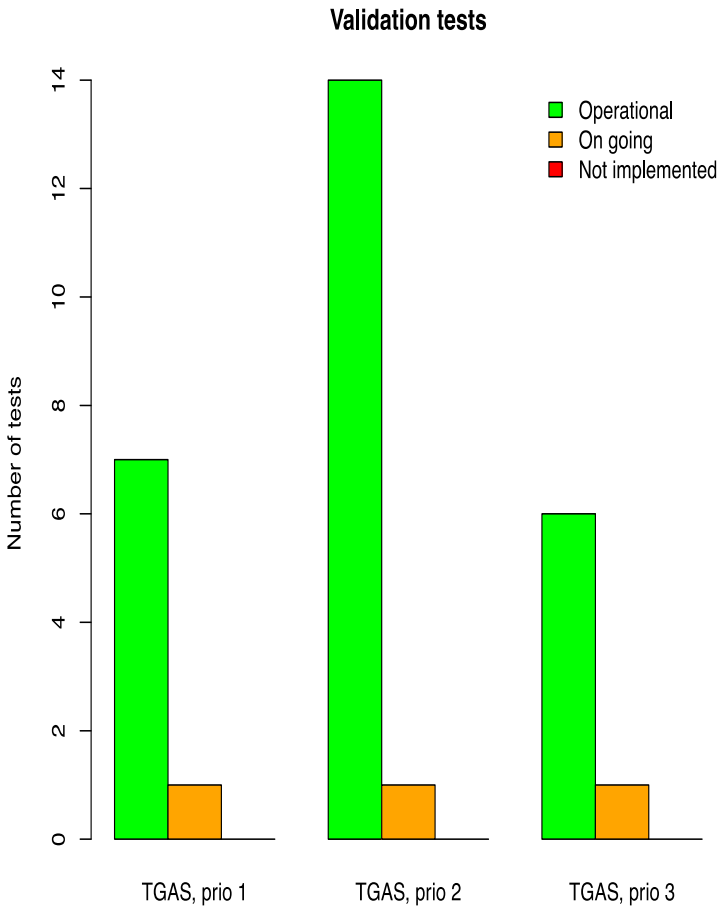
Software development of validation tests

S/W development environment

- ✓ Developing a common framework
  - Rationale: automatize most tests
    - Software and configurations
    - Input, output, results of the tests (email/ftp ?)
  - Access standardized
    - TAP interface + VO tools
    - Gbins for all “serial” tests
      - when large fraction of rows returned
- ✓ Software environment
  - Using all tools what DPAC has put in place
    - Under svn
    - Jira, Hudson, Nexus, etc.
  - language: most developments in Java
  - Software has to run at ESAC

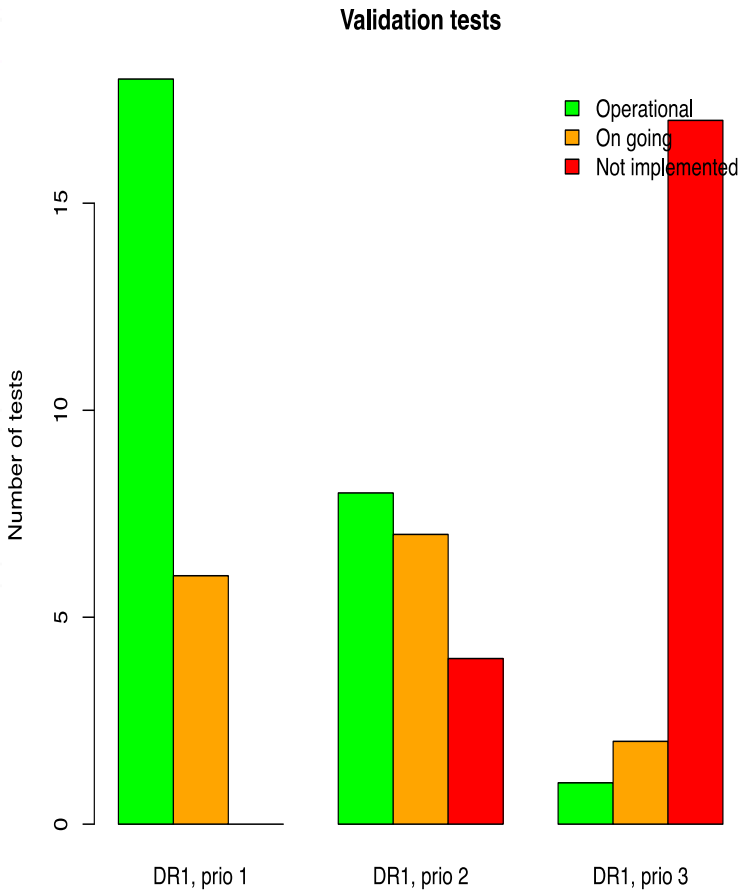
VTS: tests for TGAS subset

Summary of tests starting at Release TGAS			
Test reference link	Description	P	S
WP941-VAL-020-100	Generate global statistics of the Catalogue	1	O
WP941-VAL-020-110	Generate MPA statistics and graphs	1	O
WP942-VAL-310-040	Check of parameter continuity at gate transitions	1	O
WP942-VAL-340-010	Accurate formal parallax errors	1	O
WP943-VAL-040-020	Parallaxes distribution as a function of color vs GOG	1	I
WP944-VAL-030-003	Comparison to Hipparcos astrometry	1	O
WP944-VAL-030-006	Parallax zero-point and precision using very distant stars	1	O
WP947-VAL-010-030	Spatial variations and precision of parallaxes in clusters	1	O
WP942-VAL-120-020	Verify that the errors are consistent between each other.	2	O
WP942-VAL-210-010	Verify that there are no duplicate sourceIds.	2	O
WP942-VAL-210-020	Verify that there are no duplicates based on the object location.	2	O
WP942-VAL-310-080	Detection of groups of proper motion (PM) outliers	2	O
WP942-VAL-310-090	Detection of isolated proper motion (PM) outliers	2	O
WP942-VAL-310-100	Check consistency in proper motions (PM) and parallax	2	O
WP942-VAL-310-110	Testing Negative Parallaxes (NP)	2	O
WP942-VAL-310-120	Check consistency of TGAS astrometric error distributions	2	O
WP943-VAL-030-010	Mean and higher moments of proper motion components in magnitude bins	2	O
WP943-VAL-030-020	Histogram of proper motion components versus color	2	O
WP943-VAL-040-010	Parallaxes distribution in magnitude vs GUMS and GOG	2	I
WP944-VAL-030-002	External proper motions	2	O
WP944-VAL-030-004	Known high proper motion stars	2	O
WP944-VAL-070-001	Unbiasedness and consistency of fit properties for non-single stars	2	O
WP947-VAL-010-010	Proper motion accuracy for distant clusters	2	O
WP942-VAL-110-010	No fields equal NaN or infinity.	3	O
WP942-VAL-110-030	All values fall within the specified range.	3	O
WP942-VAL-110-050	Check that the astrometric correlation matrix is a valid correlation matrix	3	O
WP944-VAL-010-003	Known issues for specific stars	3	O
WP944-VAL-030-001	External parallaxes (and proper motions)	3	O
WP944-VAL-030-005	Parallax zero-point and precision using external distances	3	O
WP944-VAL-060-003	QSO parallax and proper motions	3	I



VTS: tests for the rest of DR1

Summary of tests starting at Release I			
Test reference link	Description	P	S
WP942-VAL-310-150	Check that flux error, flux, and observation count are correctly related.		
WP941-VAL-000-100	Check the distribution of solutionId in TAP tables	1	O
WP941-VAL-000-200	Check the distribution of solutionId in gbin files	1	O
WP941-VAL-000-210	Check number of objects in all the gbin files	1	O
WP941-VAL-030-100	Generate global statistic of stars inside flagged pixels	1	O
WP942-VAL-110-021	Few entries are null.	1	O
WP942-VAL-110-070	Check that astrometric data quality is not excessively poor.	1	O
WP942-VAL-120-011	Source brightness inconsistent with Tycho ID.	1	O
WP942-VAL-130-010	GACS and gbins have the same data (GaiaSource)	1	O
WP942-VAL-130-011	GACS and gbins have the same data (TgasSource)	1	O
WP944-VAL-010-001	Sky homogeneity	1	O
WP944-VAL-010-002	Catalogue detailed completeness	1	O
WP944-VAL-010-005	Visual binaries completeness	1	I
WP944-VAL-050-001	Colour relations	1	O
WP944-VAL-060-001	QSOs identification from cross-identification; sky distribution	1	I
WP944-VAL-060-002	QSOs detailed completeness	1	I
WP944-VAL-060-004	ICRF2	1	I
WP946-VAL-010-001	Validate classification of Cepheids using the external catalogue OGLE IV SEP	1	O
WP946-VAL-010-002	Validate classification of RR-Lyrae using the external catalogue OGLE IV SEP	1	O
WP946-VAL-010-003	Validate light curves of Cepheids using the external catalogue OGLE IV SEP	1	O
WP946-VAL-010-004	Validate light curves of RR-Lyrae using the external catalogue OGLE IV SEP	1	O
WP946-VAL-020-001	Coherence check: Cross-matching sources between variability tables	1	O
WP946-VAL-020-002	Coherence check: reported mean/max/min values actually corresponds to the mean/max/min value for time series	1	O
WP946-VAL-020-003	Coherence check: verify there is no value above/below the min/max value reported in the data model	1	O
WP946-VAL-040-001	Variability effects using Hipparcos catalogue and X-matching by Tycho ID	1	O
WP946-VAL-040-002	Variability effects using Hipparcos cat. and X-matching by sky coordinates	1	O
WP942-VAL-110-060	Check that there are more observations than astrometric parameters.	2	O
WP942-VAL-110-080	Check that no data are provided where there are no observations.	2	O
WP942-VAL-120-100	Astrometric parameters should be provided if and only if solved for	2	O
WP942-VAL-220-020	Verify that there are no stars below contrast limits close to bright stars	2	I
WP942-VAL-220-040	Verify that astrometric quality is unchanged close to bright stars	2	
WP942-VAL-310-050	Verification of the ra and dec distributions	2	I
WP942-VAL-310-060	Spatial variations of parallax (and other) zero point	2	I
WP942-VAL-310-130	Consistency of median astrometric error distributions in pixels	2	O
WP942-VAL-310-140	Check astrometric error distribution ratio in different magnitude ranges	2	O
WP942-VAL-320-020	Verification of completeness in magnitude.	2	I
WP942-VAL-320-021	Verification of completeness of bright magnitudes.	2	O
WP942-VAL-320-040	Faint star completeness	2	I
WP942-VAL-330-020	Angular correlation function	2	-
WP942-VAL-330-021	Basic angle correlations	2	-
WP942-VAL-340-020	Correlations consistent with formal covariance	2	-
WP944-VAL-010-004	Problematic areas	2	O
WP947-VAL-010-050	Photometric tests	2	I

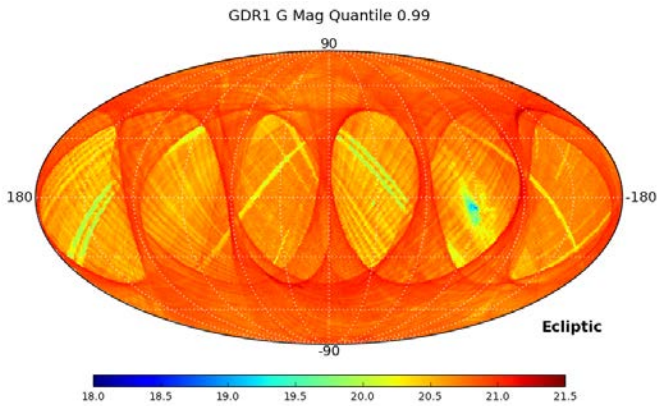


Summary of DR1 results

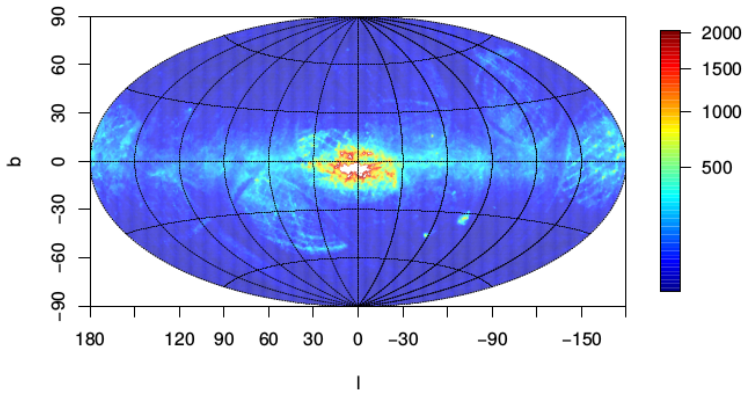
Published in A&A A&A 599, A50 (2017), see D5.9

Incompleteness: large scale

S. Soria/T5.2

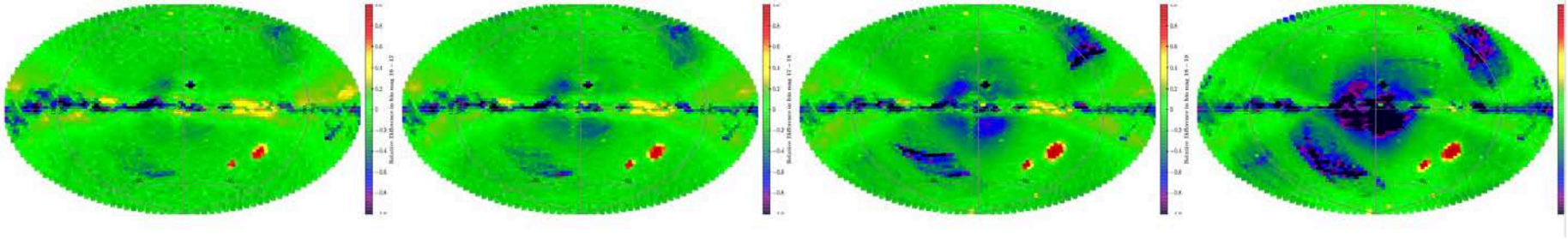


C. Babusiaux / T5.4



UCAC4 sources not in DR1

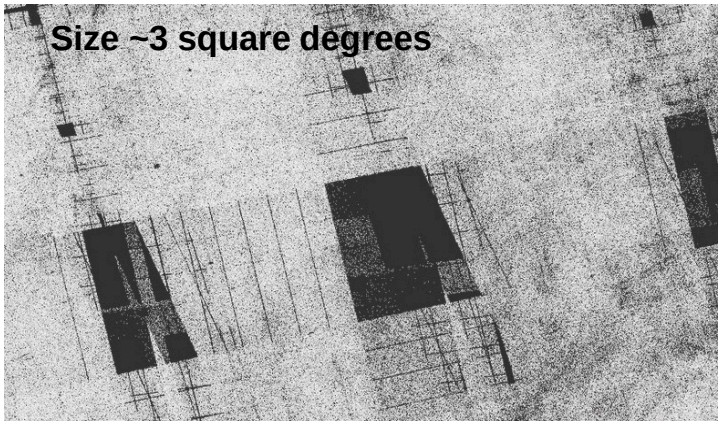
A. Robin/T5.3

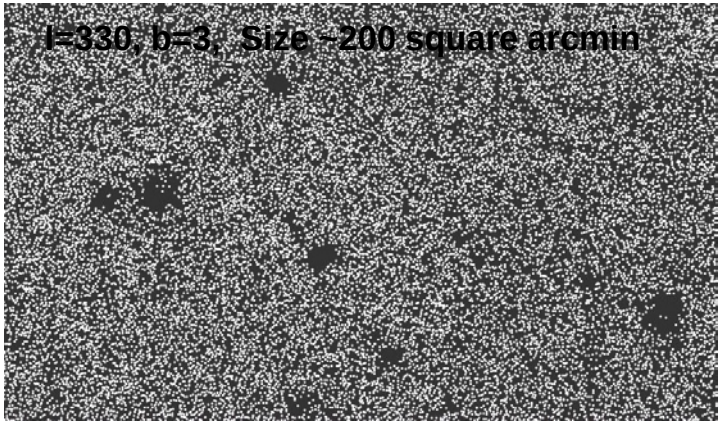


16<G<17 | 17<G<18 | 18<G<19 | 19<G<20

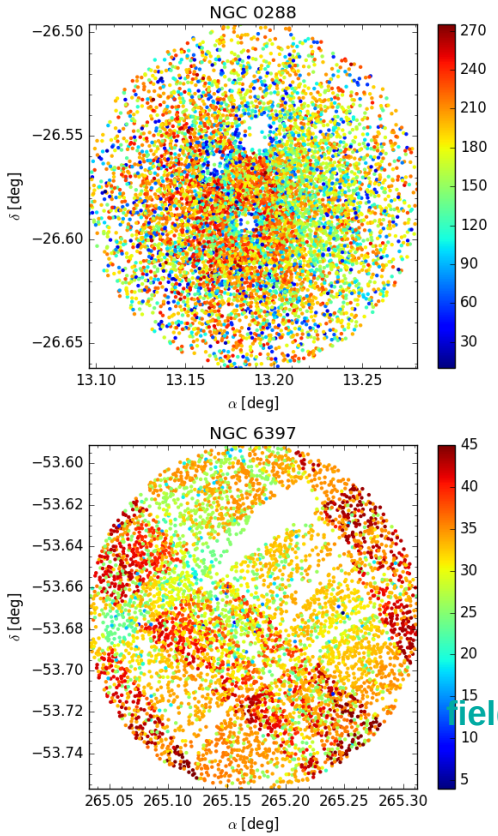
Completeness: intermediate scale

F.A./ T5.2

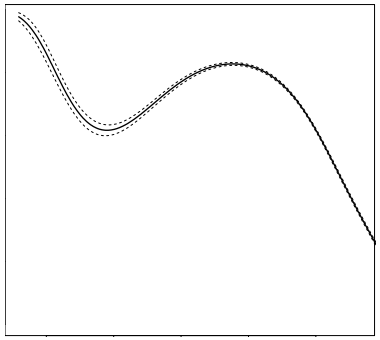




A. Vallenari / WP947



C. Babusiaux / T5.4

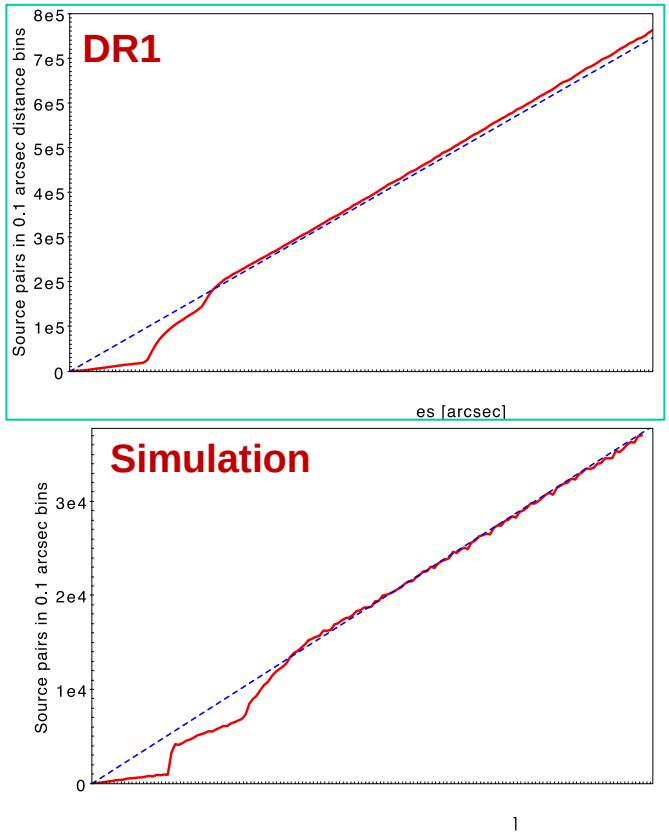


Completeness vs G, OGLE bulge field

Work done thanks to FFCUL visualization tool, T5.5

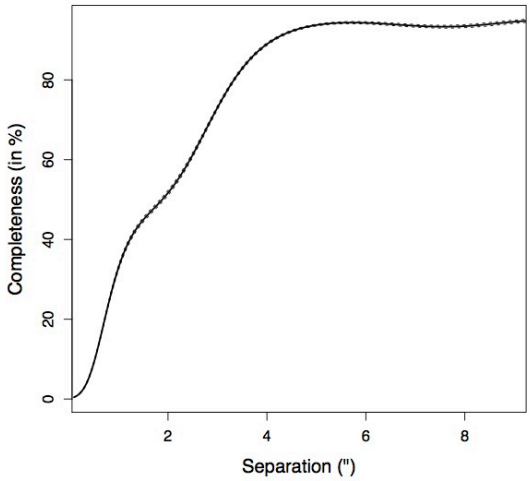
Completeness: small scale

C. Fabricius / T5.2



Distance between sources (”) in high density field

C. Babusiaux / T5.4

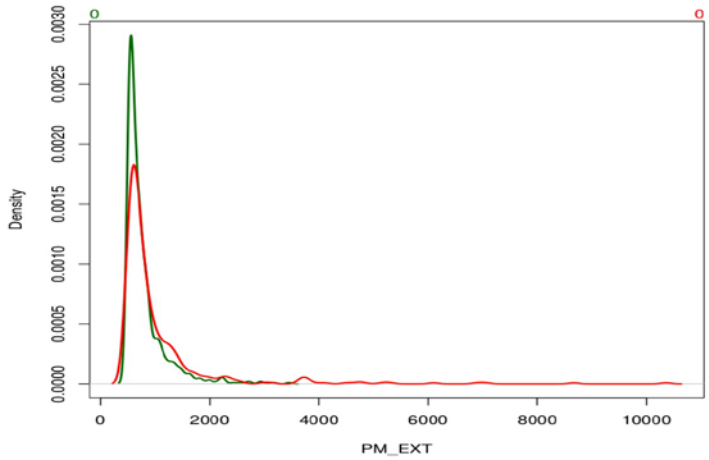


Completeness vs separation for double stars in WDS

Other selection effects

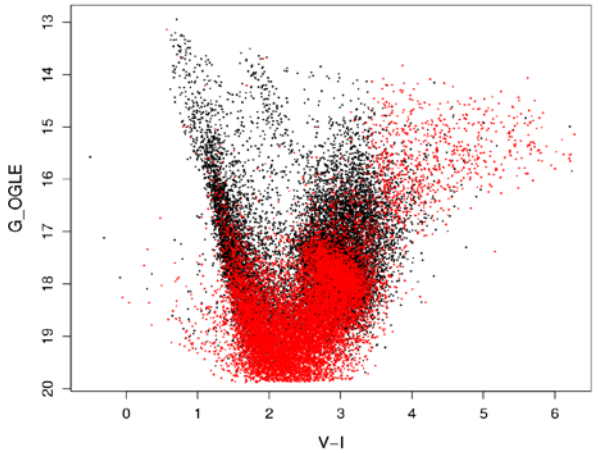
- ✓ As a function of color or magnitude
  - Very bright, very red stars missing
- ✓ Missing high proper motion stars

C. Babusiaux/T5.4



Missing high proper motion stars

C. Babusiaux / T5.4



OGLE bulge CMD: stars in red are missing in DR1.

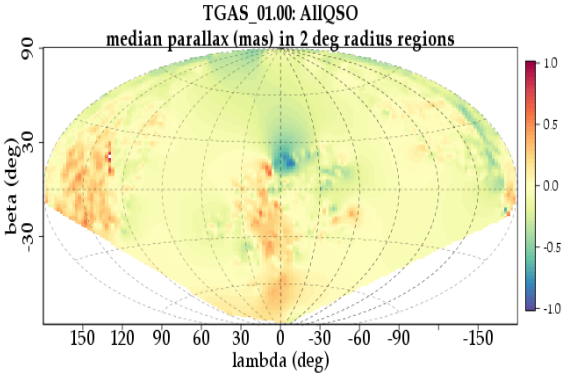
Parallax accuracy

C. Babusiaux / T5.4

Catalogue	Outliers	ϖ bias
Hipparcos	0.09%	-0.094 ± 0.004
VLBI	0 / 9	0.083 ± 0.12
HST	2 / 19	-0.11 ± 0.19
RECONS	0 / 13	-1.04 ± 0.58
VLBI & HST & RECONS	2 / 41	-0.08 ± 0.12
Cepheids	0 / 207	-0.014 ± 0.014
RRLyrae	0 / 130	-0.07 ± 0.02
Cepheids & RRLyrae	0 / 337	-0.034 ± 0.012
RAVE	47 / 5144	0.07 ± 0.005
APOGEE	0 / 2505	-0.06 ± 0.006
LAMOST	6 / 317	-0.01 ± 0.02
PASTEL (J-K>0.3)	1 / 218	0.05 ± 0.02
APOKASC	0 / 969	-0.07 ± 0.009
LMC	2 / 142	0.11 ± 0.02
SMC	0 / 58	-0.12 ± 0.05
ICRF2 QSO auxiliary solution	1 / 2060	-0.046 ± 0.01

Fully consistent with internal results: −0.036 ± 0.002 mas (weighted)

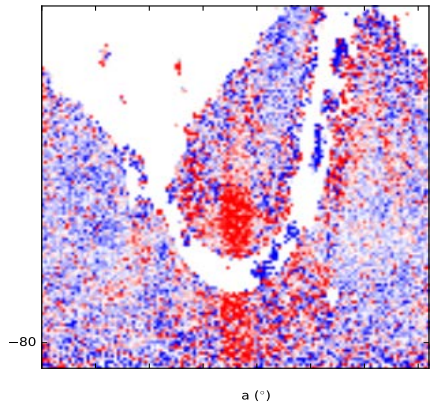
F.A. / T5.2



QSO parallaxes

RAVE (ϖ ratio -1)

A. Helmi / T5.5



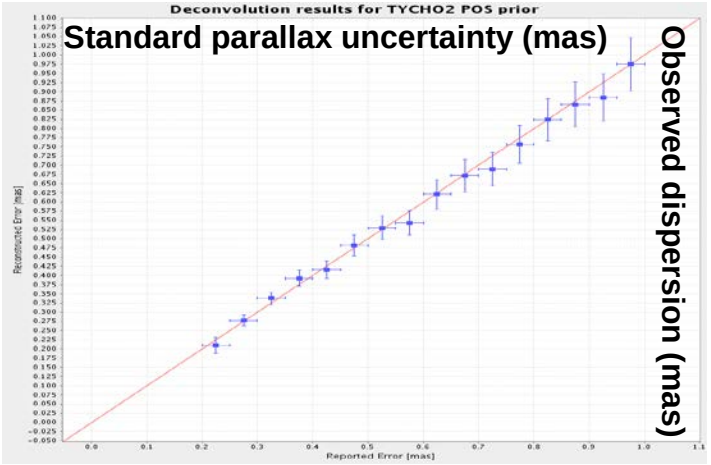
Parallax precision

C. Babusiaux / T5.4

Catalogue	ϖ extra standard dev
Hipparcos	0.58 ± 0.005
VLBI	-
HST	0.6 ± 0.2
RECONS	-0.9 ± 0.5
VLBI & HST & RECONS	0.42 ± 0.13
Cepheids	-0.18 ± 0.01
RRLyrae	-0.16 ± 0.02
Cepheids & RRLyrae	-0.17 ± 0.01
RAVE	-0.06 ± 0.02
APOGEE	-0.12 ± 0.01
LAMOST	-0.17 ± 0.02
PASTEL (J-K>0.3)	0.1 ± 0.05
APOKASC	-0.15 ± 0.01
LMC	-0.14 ± 0.03
SMC	-0.09 ± 0.09
ICRF2 QSO auxiliary solution	-0.17 ± 0.01

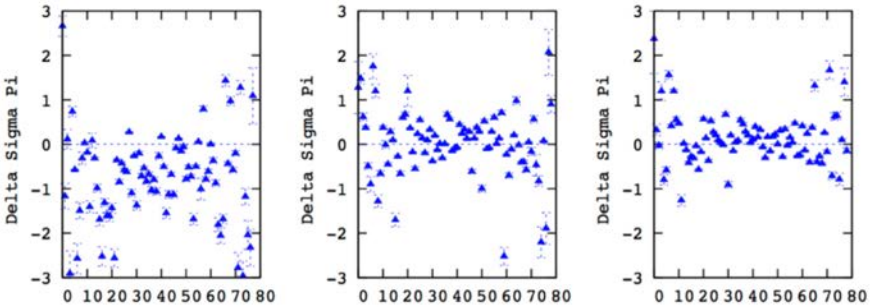
Extra std. dev on parallax uncertainties (mas)

K.Findeisen / T5.2



Deconvolution of the negative parallax tail for Tycho stars
extra dispersion: −0.11 ± 0.01 mas

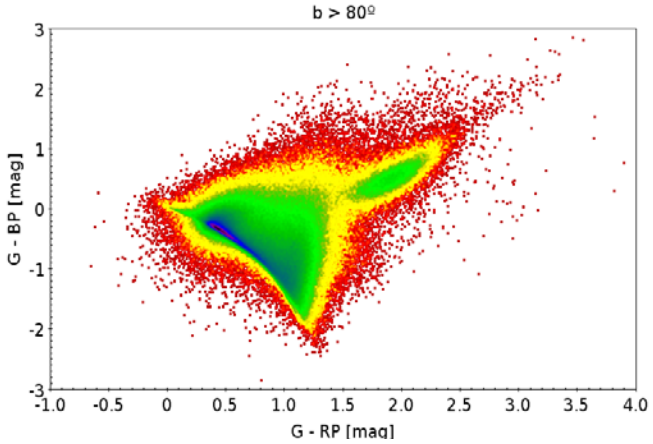
Comparison of parallaxes uncertainties f(b) for mag V_T=9, 9.5, 10



A. Robin / T5.3

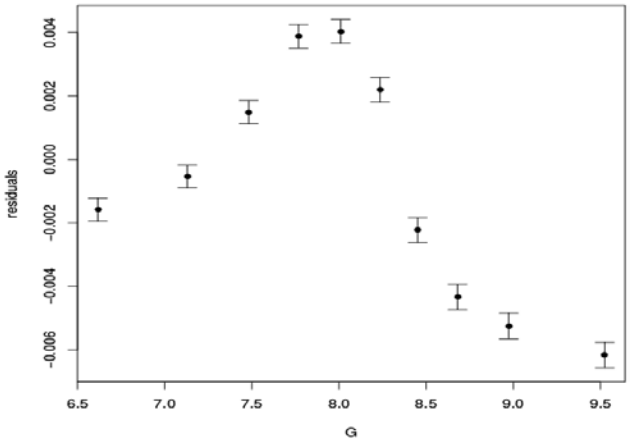
Photometry

C. Fabricius / T5.2



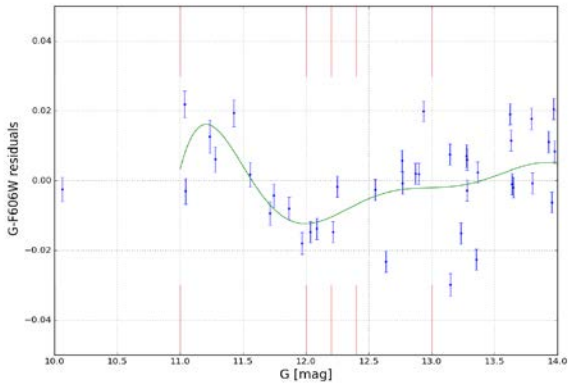
G-BP vs G-RP

C. Babusiaux / T5.4



Hipparcos, residuals vs G

M4 using *G* minus HST *F606W* *vs G*



A. Vallenari / WP947

Folded light curve of an RR Lyrae

S. Blanco / T5.63

Tests overlap between WPs

✓ For DR1

GENIUS DPAC	T5.2 WP942	WT5.3 P943	T5.4 WP944	T5.5 WP945	T5.63 WP946	WP947
Completeness, large scale	✘	✘	✘			
Completeness, small scale	✘		✘			✘
Astrometric accuracy		✘	✘	✘		✘
Astrometric precision	✘		✘	✘	✘	✘
Photometric data	✘		✘	✘	✘	✘
Variability data					✘	

Summary of work done within GENIUS

Livelink documents

• Minutes of CU9 validation telecons 1-2	28-dec-14	GAIA-C9-MN-OPM-FA-063
• Minutes of CU9 validation telecons 3-8	28-dec-14	GAIA-C9-MN-OPM-FA-064
• Statistical validation of Gaia Archive	18-fev15	GAIA-C9-TN-UB-ELA-017
• Besancon Galaxy Model Simulation for CU9-WP943	11-mai-15	GAIA-C9-TN-UB-RMC-001
• Simulated TGAS data used for validation Interface Control	13-mai-15	GAIA-C9-SP-OPM-FA-066
• WP943 validation code, Software Release Notes	19-mai-15	GAIA-C9-TN-IUOB-HZ-001
• GWP-947 Cluster selection requirements for the first Gaia data release	5-juin-15	GAIA-C9-SP-OAPD-AV-014
• WP-947 Cluster Validation, Auxiliary data description for TGAS validation	7-sept-15	GAIA-C9-SP-OAPD-AV-016
• TGAS Test description WP947-010-030, Spatial variation and precision	8-sept-15	GAIA-C9-TN-OAPD-TCG-001
• Calibration of Parallax Deconvolution Parameters for WP942-VAL-340-010	14-sept-15	GAIA-C9-TN-OPM-KF-002
• Software User Manual for CU9 ValidationTools	17-sept-15	GAIA-C9-UG-OPM-IS-001
• Validation Tests Specification (WP940)	18-sept-15	GAIA-C9-SP-OPM-FA-061
• CU9 Validation Procedure Specification	18-sept-15	GAIA-C9-SP-OPM-IS-004
• CU9 ValidationTools Software Release Note	30-sept-15	GAIA-C9-SP-OPM-IS-005
• WP944 v18.1 Validation with external catalogues; Detailed Description	25-nov-15	GAIA-C9-SP-OPM-LRD-001
• StatisticalTools 18.2 Software Release Note	3-mars-16	GAIA-CU9-SP-UB-ELA-025
• StatisticalTools Software User Manual	4-mai-16	GAIA-C9-UG-UB-ELA-026-1
• StatisticalTools 18.4 Software Release Note	4-mai-16	GAIA-C9-SP-OPM-KF-004-1
• SSO Short Term processing, validation of the short arc	13-juil-16	GAIA-C9-TN-OCA-FSP-001
• CU9 Validation Tests Report, preliminary TGAS 00.01 data	16-nov-16	GAIA-C9-SP-OPM-FA-067
• Validation Tests Report, preliminary TGAS 01.00 data	14-mars-16	GAIA-C9-SP-OPM-FA-070
• SSO Short Term processing, validation of the short arc Functions	13-JUL-16	GAIA-C9-TN-OCA-FSP-001
• Validation Tests Report, GDR1 (pre- and post-filtering)	03-aou-16	GAIA-C9-TN-OPM-FA-073
• Cookbook of CU9 Scientific Validation for DR1 Functions	10-jan-17	GAIA-C9-TN-OPM-IS-006

GENIUS deliverables (delivered)

Delivery	Name	Month after K.O.	Document name
D5.1	Prototype of internal checking tools (WP 520)	12	GAIA-CO-TN-OPM-FA-062
D5.2	Prototype model-based validation tools (WP 530)	18	GAIA-C9-TN-IUOB-HZ-001
D5.3	Internal checking tools (WP 520)	24	GAIA-CO-TN-OPM-FA-069
D5.6	prototype comp. with external catalogues (WP 540)	24	GAIA-C9-SP-OPM-LRD-001
D5.4	Statistical tools (WP 550)	36	D5.4
D5.5	Model-based validation tools (WP 530)	36	D5.5
D5.7	External validation tools (WP 540)	36	GAIA-C9-SP-OPM-LRD-002
D5.8	Special objects: clusters + variable stars	36	GDR1_master_WP-560
D5.8	Special objects: non-single stars	36	GAIA-C4-TN-ULB-DP-055
D5.8	Special objects: SRS for Solar System Objects	36	SRS-WP-560-SSO
D5.9	Deployment of validation on the archive	42	D5.9

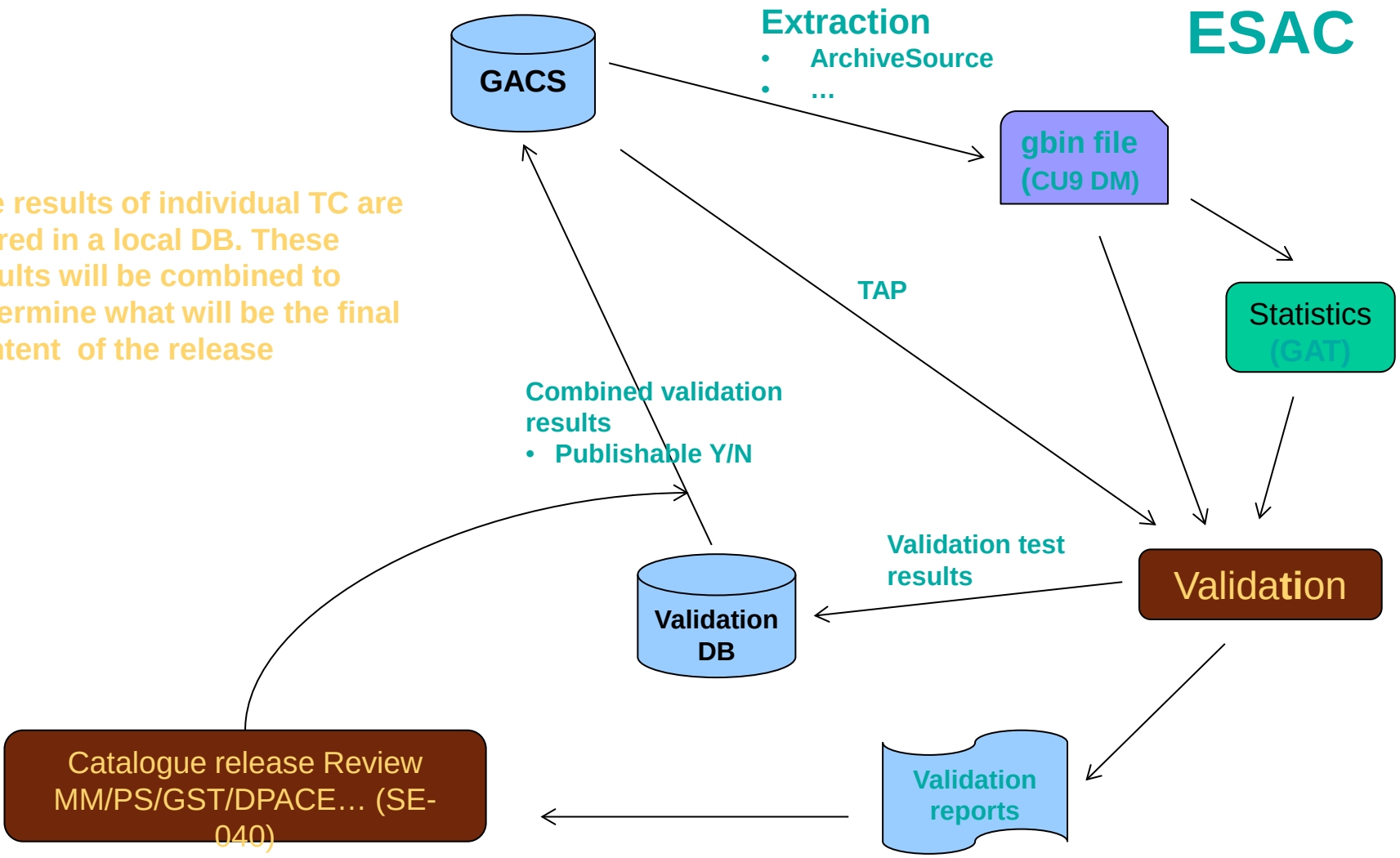
Note: the last document is mostly the A&A paper about the DR1 validation

GENIUS legacy from WP5

- ✓ The development of a full validation code
  - 130 000 source lines of code
  - Plus the infrastructure for the code execution
  - Now being used for DR2 and following data releases
- ✓ Tools trained on validation then scientific exploitation
  - E.g. Kullback-Leibler divergence→ 2017ApJ...836..234S
- ✓ A published paper (A&A 599, A50):
  - Full validation of DR1, about 35p.
- ✓ Training of new developers
  - in an ESA project environment

Thank you
for your attention

Validation process

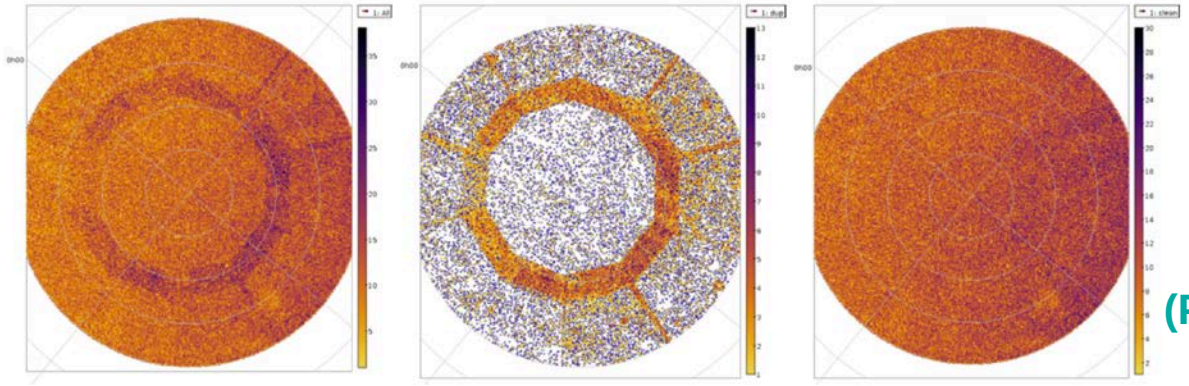


Pre-DR1 filtering

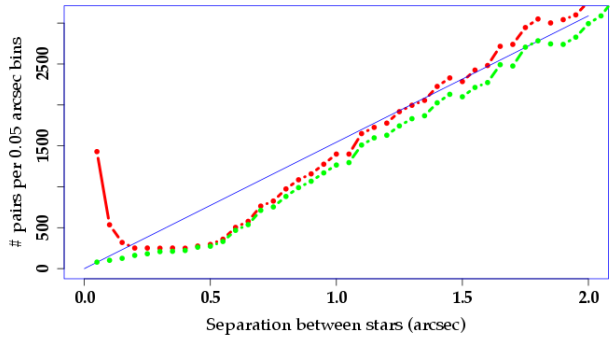
Improvements brought to the DR1 catalogue before publication

Duplicate stars removed

✓ A significant fraction of pairs (or +) of stars with same position



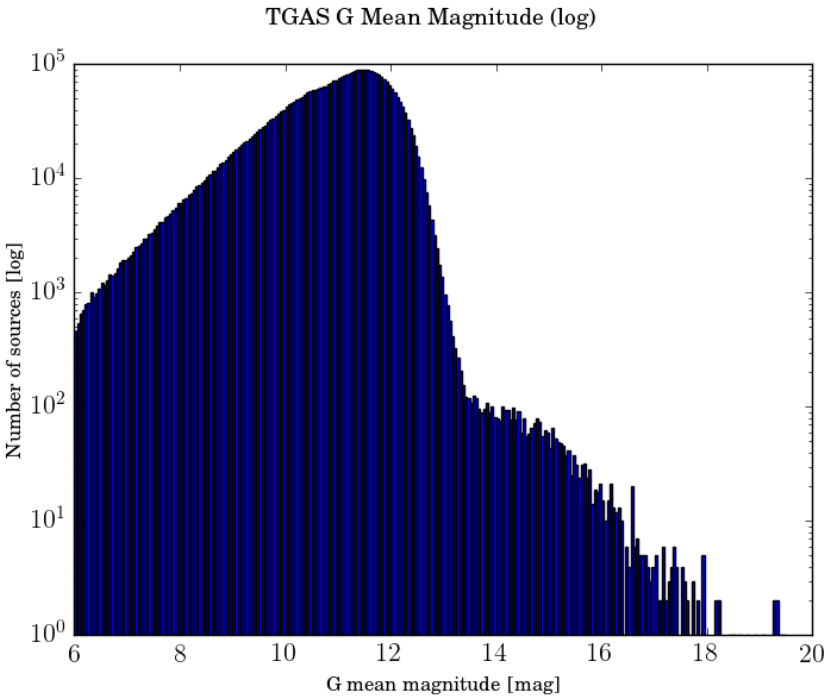
Near the south pole: overdensities found before filtering, duplicates found, and after filtering (Plots: FFCUL T5.5)

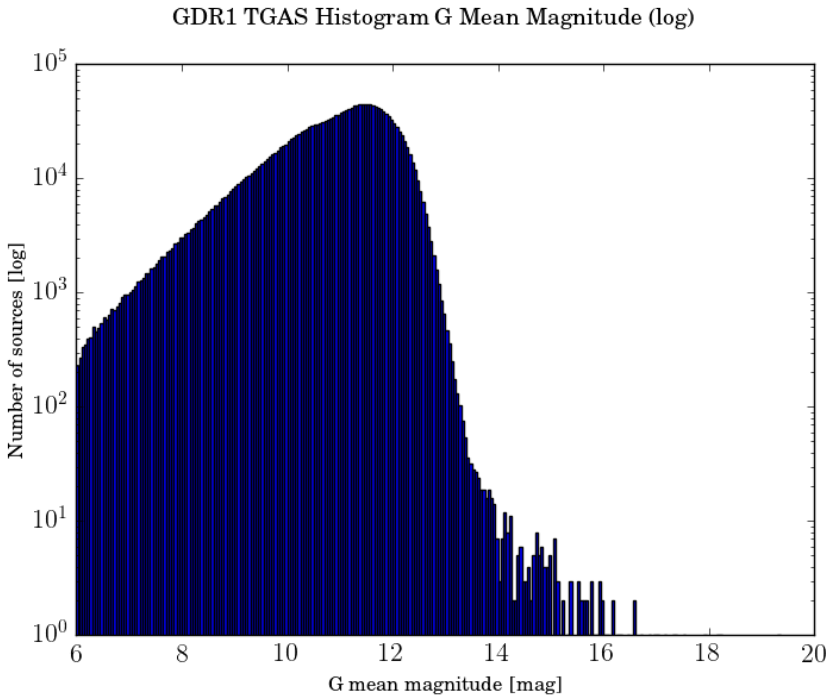


Number of pairs in field *l* = 350◦, *b* = 0◦ before and after filtering

Faint spurious TGAS stars removed

- ✓ Before / after filtering

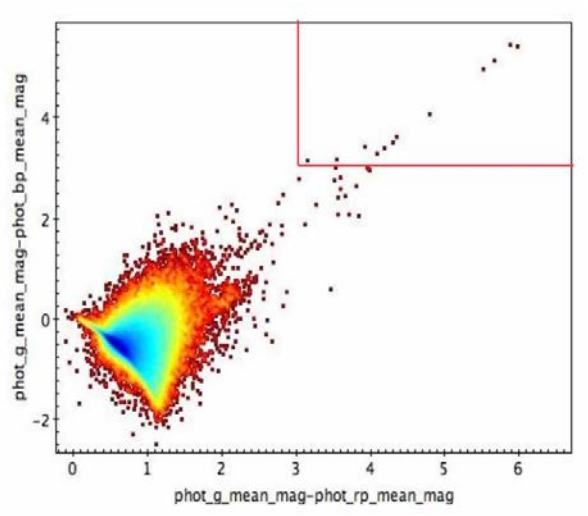


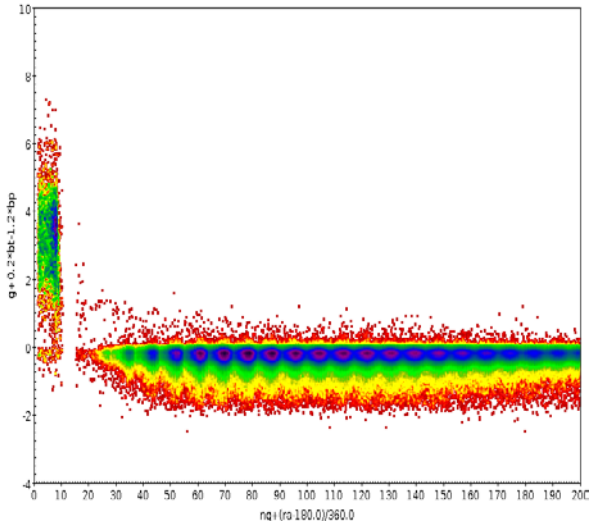


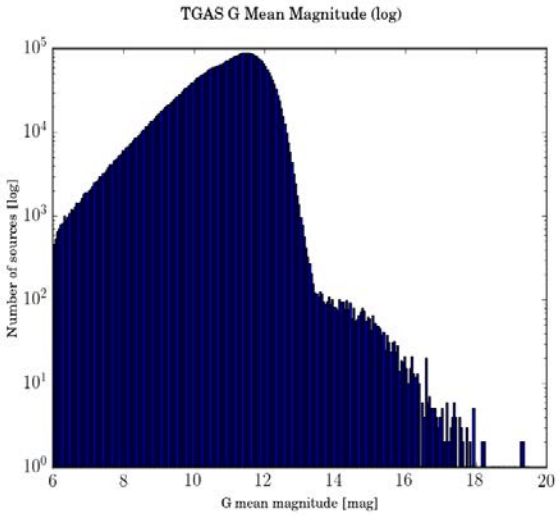
for the 60 faintest: 1/3 may be
wrong Tycho-2 stars, 2/5 may be
wrong x-match in the TGAS solution

Photometric filtering of outliers

- ✓ Categories of sources being clear outliers were also filtered
  - Sources both very blue and very red
  - Sources with less than 10 observations
  - Contributing to the faint tail of TGAS, suspecting problems with G







T5.6.3: Time series,variability(UG)

- ✓ Motivations:
  - Is variability behaviour due to the instrument or the reduction ?
  - Periodicities linked to sampling law, stars with identical periods
  - Variability trends and correlations with astrophysical parameters
- ✓ Tests done or foreseen
  - MPA for variability/constancy, periodicity or linked to scanning law
  - Compare variability types numbers to external surveys
  - Effect from bright contamination source creating fake variability
  - Distribution of outlying values in time series
  - Detection of trends and correlations with astrometric parameters
  - Correlation between variability and duplicity (such as separation).

- ✓ For DR1
  - independent cross-check of fields in the variable star annex
  - Verification of parallaxes and proper motions Gaia vs Hipparcos