The Gaia simulator: scientific contents

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and CU2, DPAC consortium

The Gaia data generators

- GIBIS (C. Babusiaux): images, simulation at the pixel level
- GASS (E. Masana): raw telemetry data, simulation of CCD readout
- GOG (Y. Isasi): simulation of intermediate and final database

GaiaSimu on top of the generators

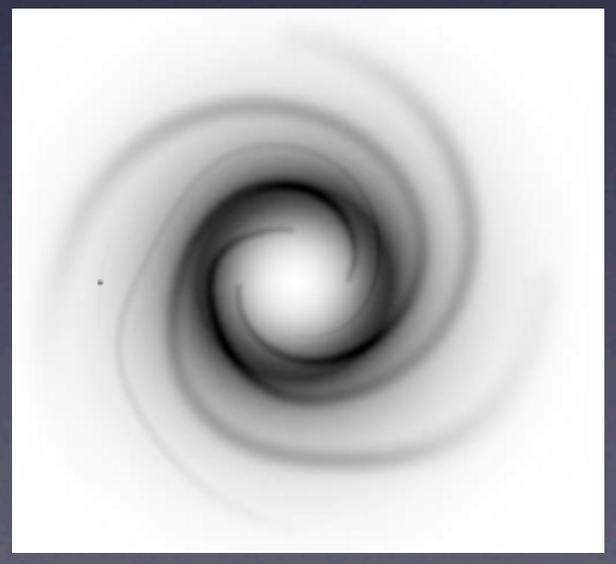
- Universe model (A. Robin): astronomical sources observed by Gaia and their characteristics
- Instrument model (D. Gardiol) : spacecraft and instrument characteristics (attitude, instrument response, optics, scanning law...)

The Universe model: aims

- Produce objects with their observational properties and physical characteristics in given regions of the sky and at a given time
- Distributions and statistics of observables of these objects should be as realistic as possible but compatible with computation capabilities (Mare Nostrum)
- Provides data for estimating telemetry, simulating images, testing detection/reduction/analysis algos

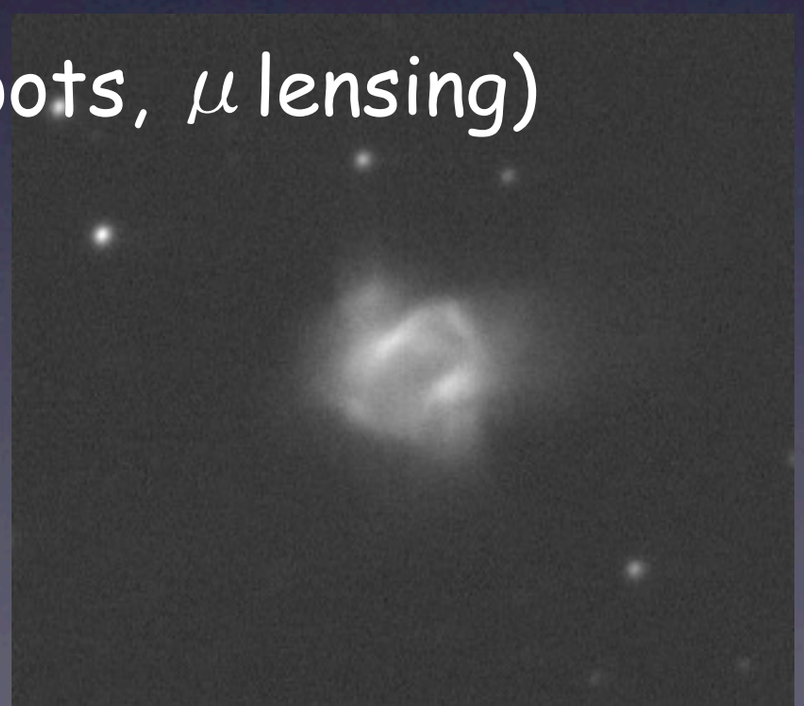
The Universe model: ingredients

- Solar sytem objects: planets, asteroids, comets
- Galactic objects : stars, star systems, exoplanets, star clusters, nebulae, HII regions, LMC & SMC
- Extragalactic objects: (resolved and unresolved galaxies, quasars, SN)
- Relativity model (S. Klioner et al.)
- Backgrounds (zodiacal light, extended nebulae, ...)
- Radiation environment (A. Short)
- Interstellar extinction (R. Drimmel et al.)



The Universe model: requirements

- 3D spatial distribution and motion (+ orbits) to compute astrometry
- spectral characteristics to compute photometry and spectroscopy
- variability (intrinsic, eclipses, spots, μ lensing)
- images for extended objects



Solar system objects

Catalogue with orbital elements of ~10^5 objets (P. Tanga & F. Mignard)

id	a	e	i	gomeg	pomeg	M	H	radius	mass	name
2456000.50										
1	2.76880953	0.077790	10.5879	80.3507	72.1462	242.4432	3.34	424.20	0.45E-09	Ceres
2	2.77102015	0.231348	34.8426	173.1252	310.0381	224.4806	4.13	249.05	0.16E-09	Pallas
3	2.67126481	0.255219	12.9794	169.9034	248.2262	167.4183	5.33	116.95	0.80E-11	Juno
4	2.36190937	0.088221	7.1343	103.8952	150.0888	110.5315	3.20	234.15	0.17E-09	Vesta

Computation of ephemerides + confrontation with scanning law => list of transiting SSOs during the mission with transit time, astrometric data, apparent magnitude

LMC & SMC

Catalogues of stars of LMC and SMC and their characteristics (magnitudes B, V, I, Teff, logg, spectral type) obtained from the literature (Belcheva et al., private communication).

Binaries and multiples added, no variables.

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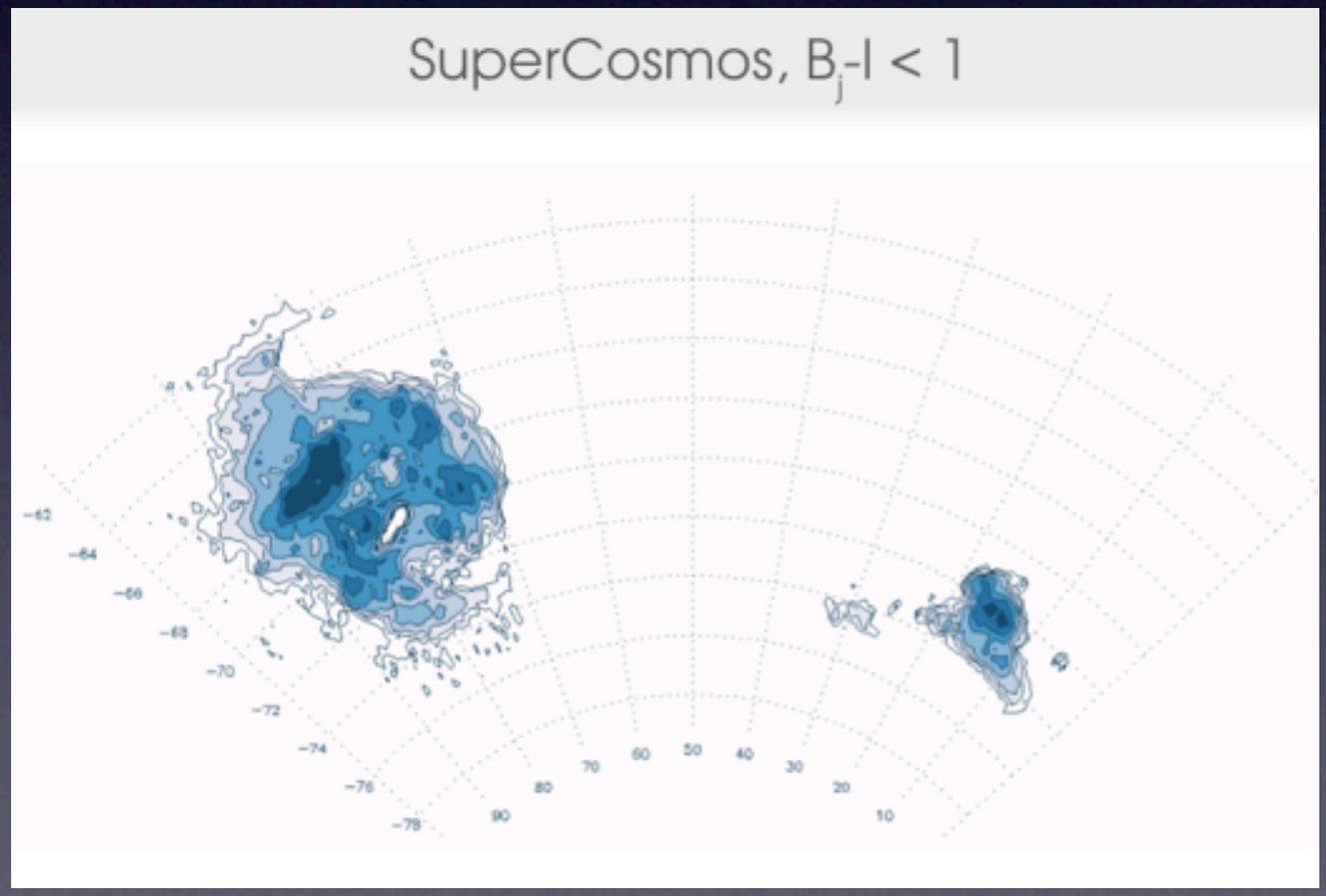


Unresolved galaxies

Stuff (catalogue generation) and Skymaker (shape/image simulation) codes from E. Bertin translated by A. Krone-Martins. Assembled as a sum of a disc and a bulge.

Type	Phi* Mpc^{-3}	M* mag	alpha	Bulge/Total
E2	1.91e-3	-20.02	-1.	1.0
E-SO	1.91e-3	-20.02	-1.	0.9
Sa	2.18e-3	-19.62	-1.	0.57
Sb	2.18e-3	-19.62	-1.	0.32
Sbc	2.18e-3	-19.62	-1.	0.32
Sc	4.82e-3	-18.86	-1.	0.016
Sd	9.65e-3	-18.86	-1.	0.049
Im	9.65e-3	-18.86	-1.	0.
QSFG	1.03e-2	-16.99	-1.73	0.

Spectral library established from PEGASE2 software (B. Rocca)

Library of images from the HST, rescaled and resampled at the correct distance

Extragalactic objects

★QSO

Catalogue of 10^6 quasars (E. Slezak, F. Mignard, J.C. Mauduit)

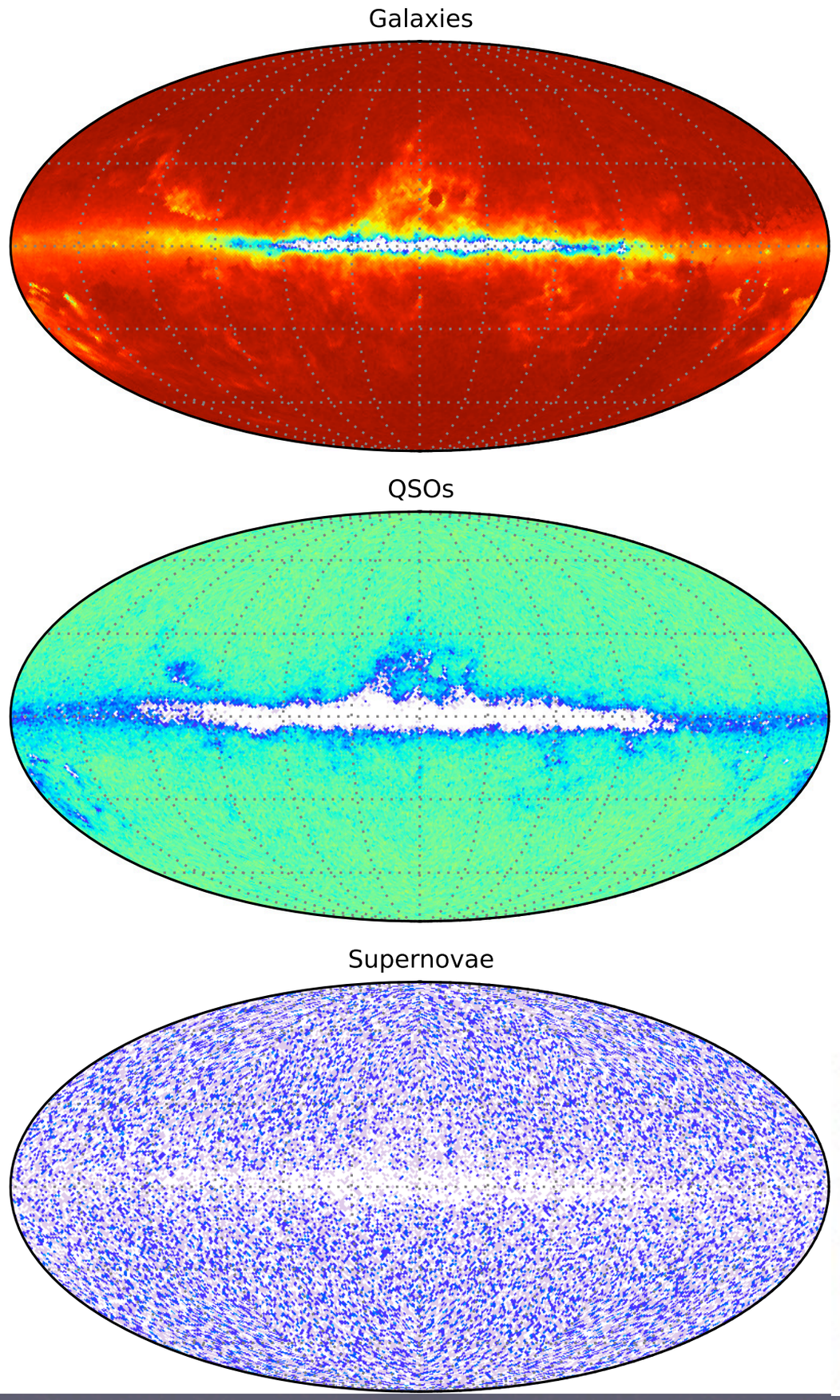
Distribution on the sky (vs mag and z) similar to SDSS

Variability and spectral library

★SN I & SN II

A set associated with galaxies, with a proportion for each Hubble type

A set generated randomly on the sky (host galaxy too faint).



Color scale: $\log_{10}$ of number of objects per sq. deg.

Stars	G < 20 mag	Grvs < 17 mag	Grvs < 12 mag
Stars in LMC	7,550,000	1,039,000	5,600
Stars in SMC	1,250,000	161,000	950
Unresolved galaxies	38,000,000	3,000,000	4,320
QSO	1,000,000	5,200	11
Supernovae	50,000	-	-

Stars in the Milky Way

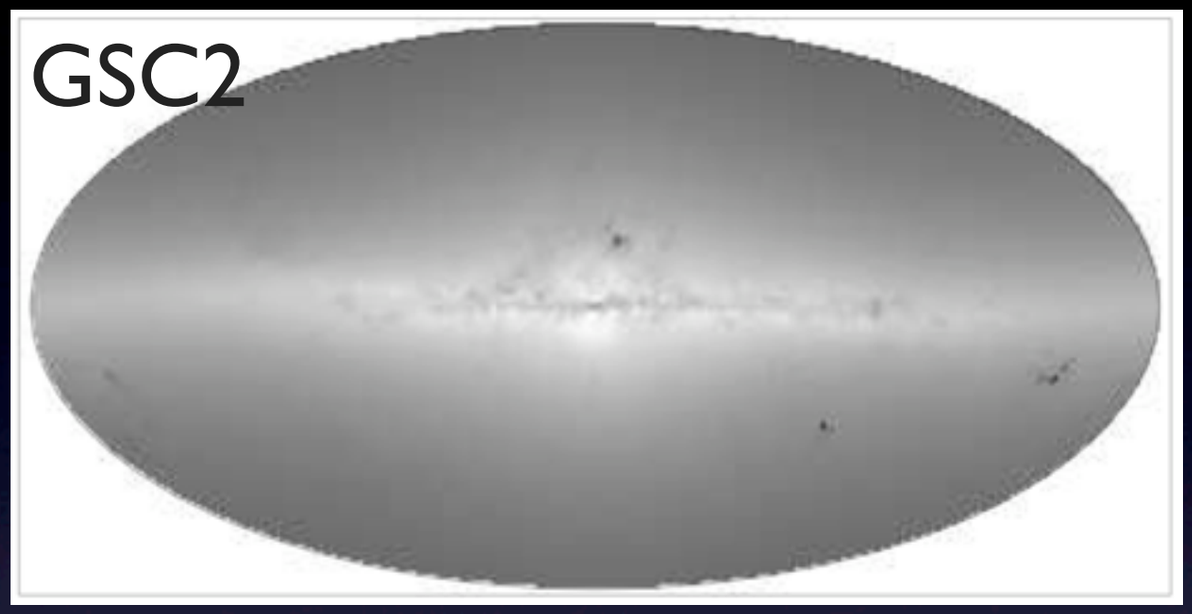
- based on the Besançon Galaxy model (2003)

  4 populations: disc, thick disc, halo, bulge

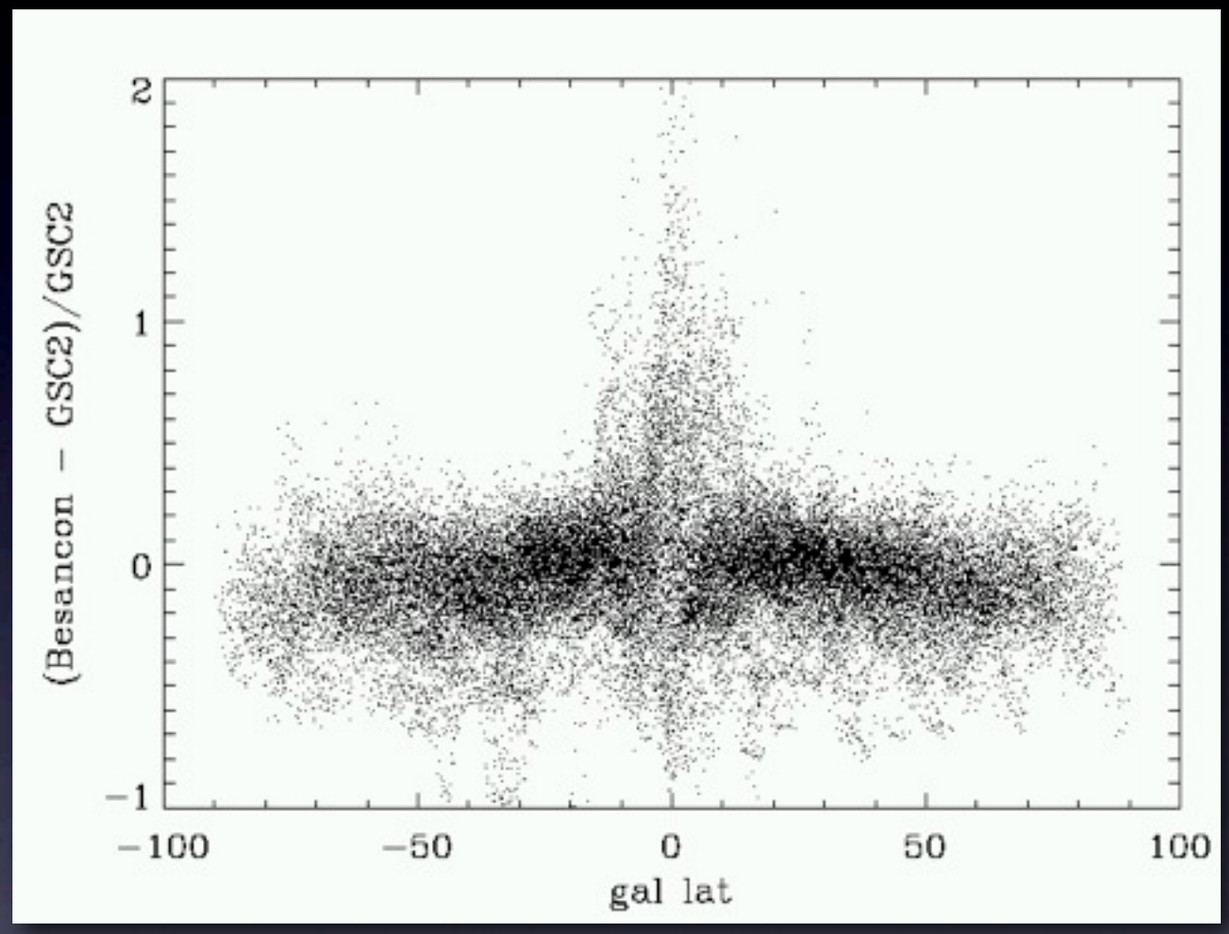
  luminosity function + density law => stars with Mv, Tsp, Age, Masse, Teff, log g, [Fe/H], [α/H]

- multiplicity (F. Arenou): secondary is drawn following mass ratio and separation distributions
- variability
- exoplanets (A. Sozetti)
- star clusters, planetary nebulae, HII regions

Model vs observations

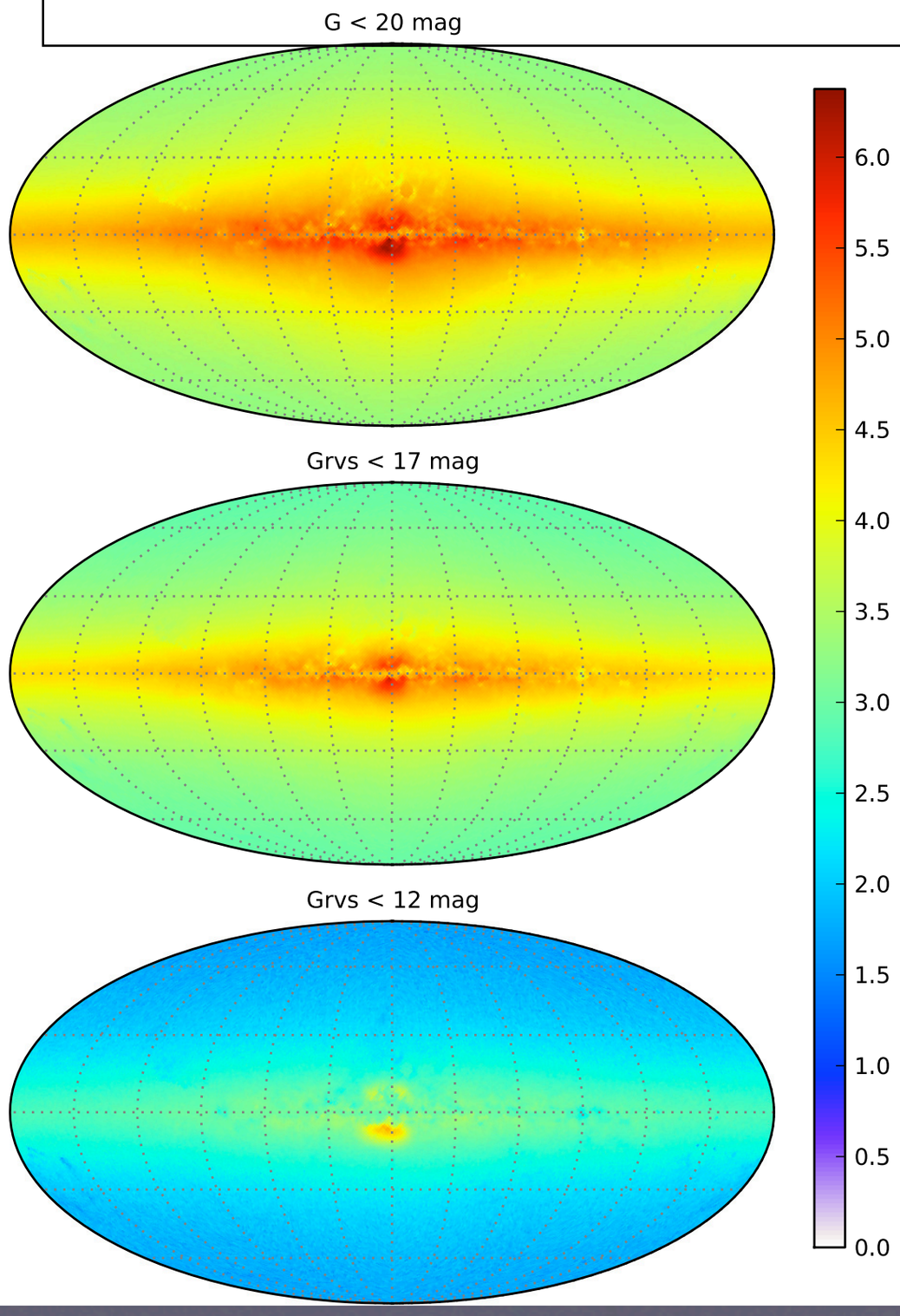


comparaison model/GSC2, G<20



Agreement < 30 %
except in plane

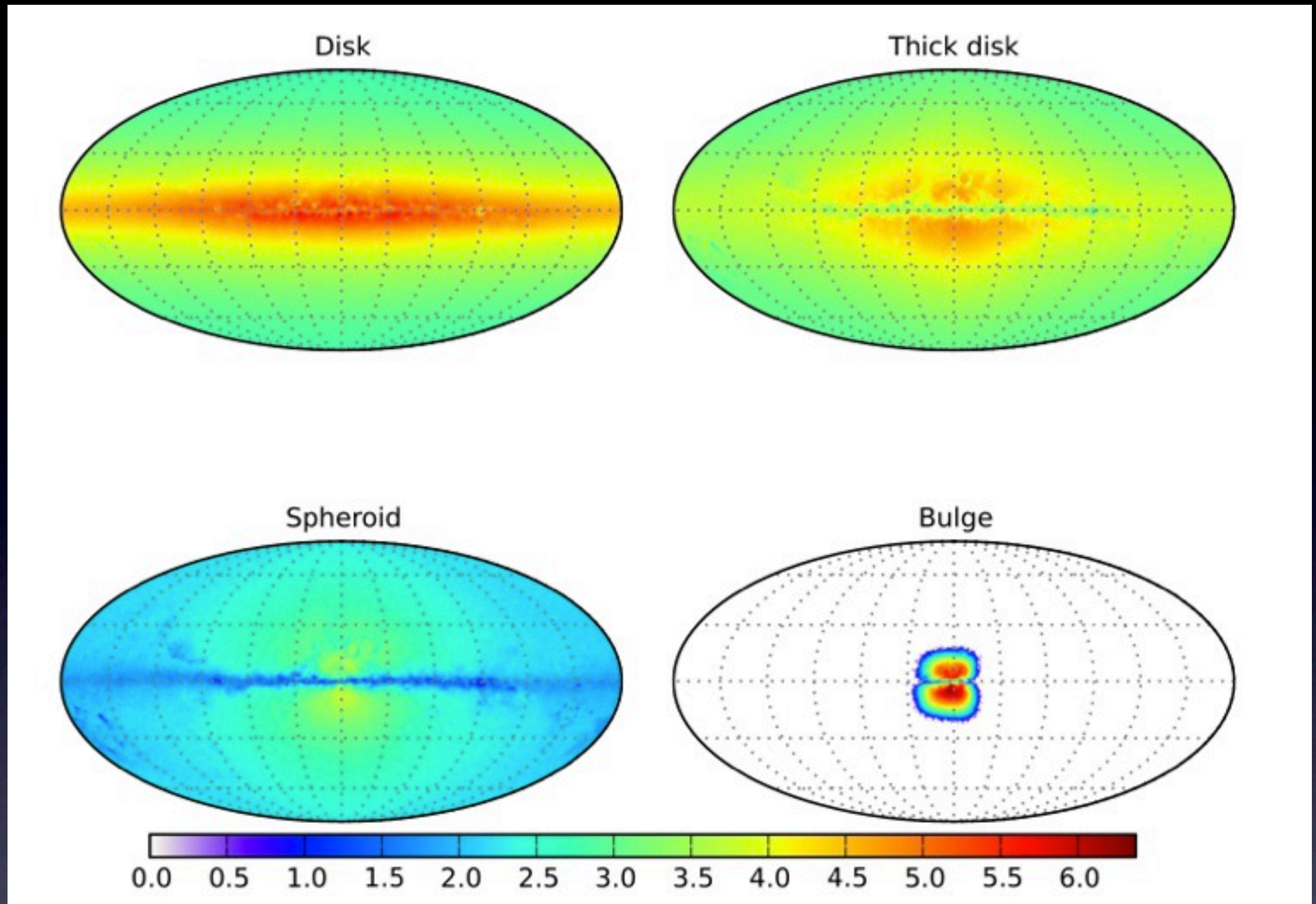
GUMS: Gaia Universe Model Snapshot



Spectral type	G < 20 mag	Grvs < 17 mag	Grvs < 12 mag
O	<0.01%	<0.01%	<0.01%
B	0.26%	0.50%	0.88%
A	1.85%	3.30%	4.84%
F	23.13%	22.94%	13.83%
G	38.28%	31.58%	15.46%
K	27.68%	32.23%	41.75%
M	7.75%	6.78%	11.38%
L	<0.01%	<0.01%	<0.01%
WR	<0.01%	<0.01%	0.01%
AGB	0.91%	2.50%	11.37%
Other	0.09%	0.07%	0.33%
Total	1,100,000,000	390,000,000	13,000,000

Luminosity class	G < 20 mag	Grvs < 17 mag	Grvs < 12 mag
supergiant	0.00%	0.01%	0.07%
Bright giant	0.81%	2.18%	11.01%
Giant	14.47%	28.38%	62.71%
Sub-giant	15.08%	14.38%	10.32%
Main sequence	69.40%	54.82%	15.76%
Pre-main sequence	0.18%	0.20%	0.08%
White dwarf	0.05%	0.01%	0.03%
Others	0.01%	0.02%	0.02%
Total	1,100,000,000	390,000,000	13,000,000

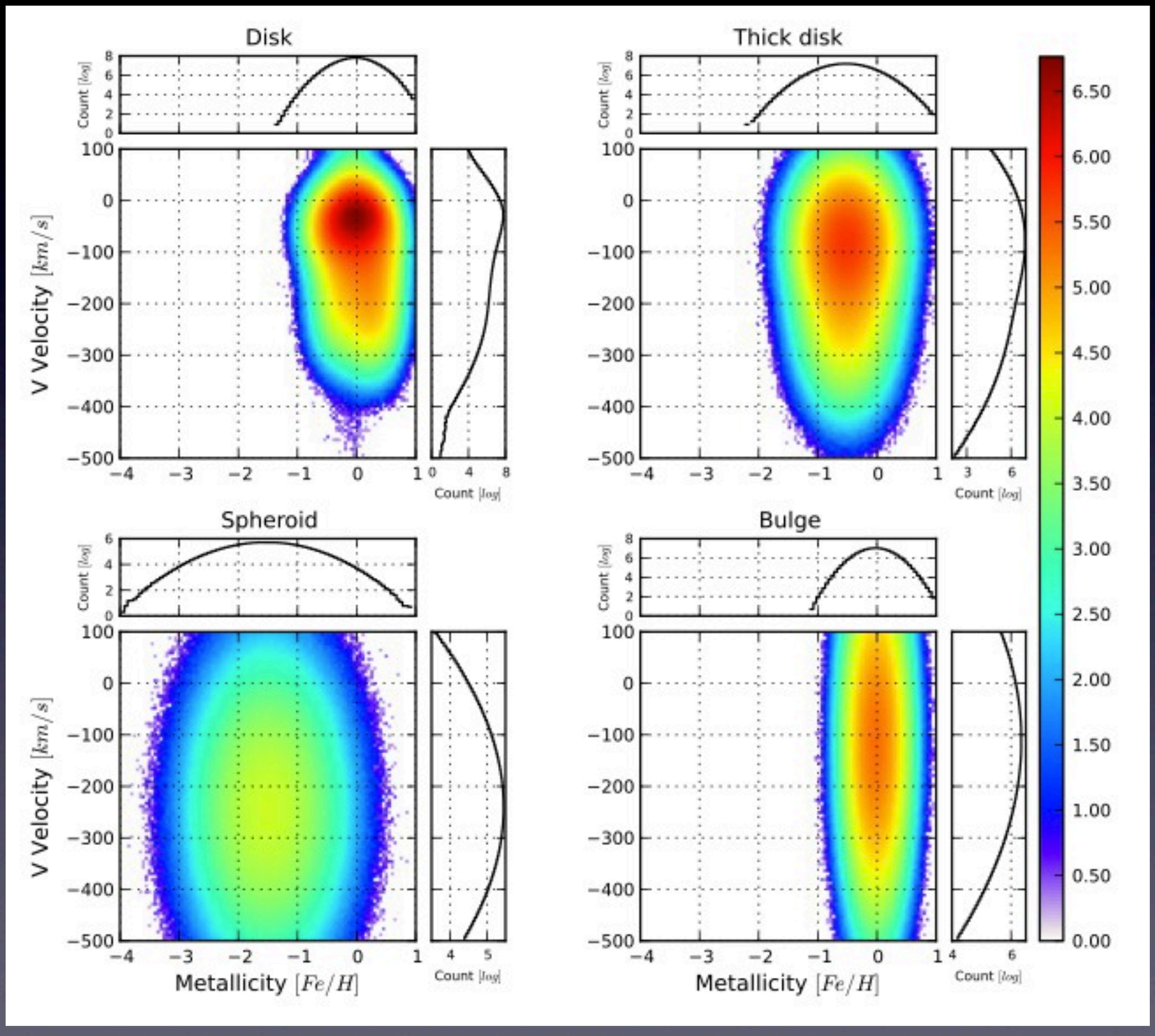
GUMS:



Population	G < 20 mag	Grvs < 17 mag	Grvs < 12 mag
disc	66.59%	76.82%	76.21%
Thick disc	21.88%	14.39%	8.75%
Spheroid	1.25%	0.58%	0.19%
Bulge	10.28%	8.22%	14.85%
Total	1,100,000,000	390,000,000	13,000,000

GUMS: Gaia Universe Model Snapshot

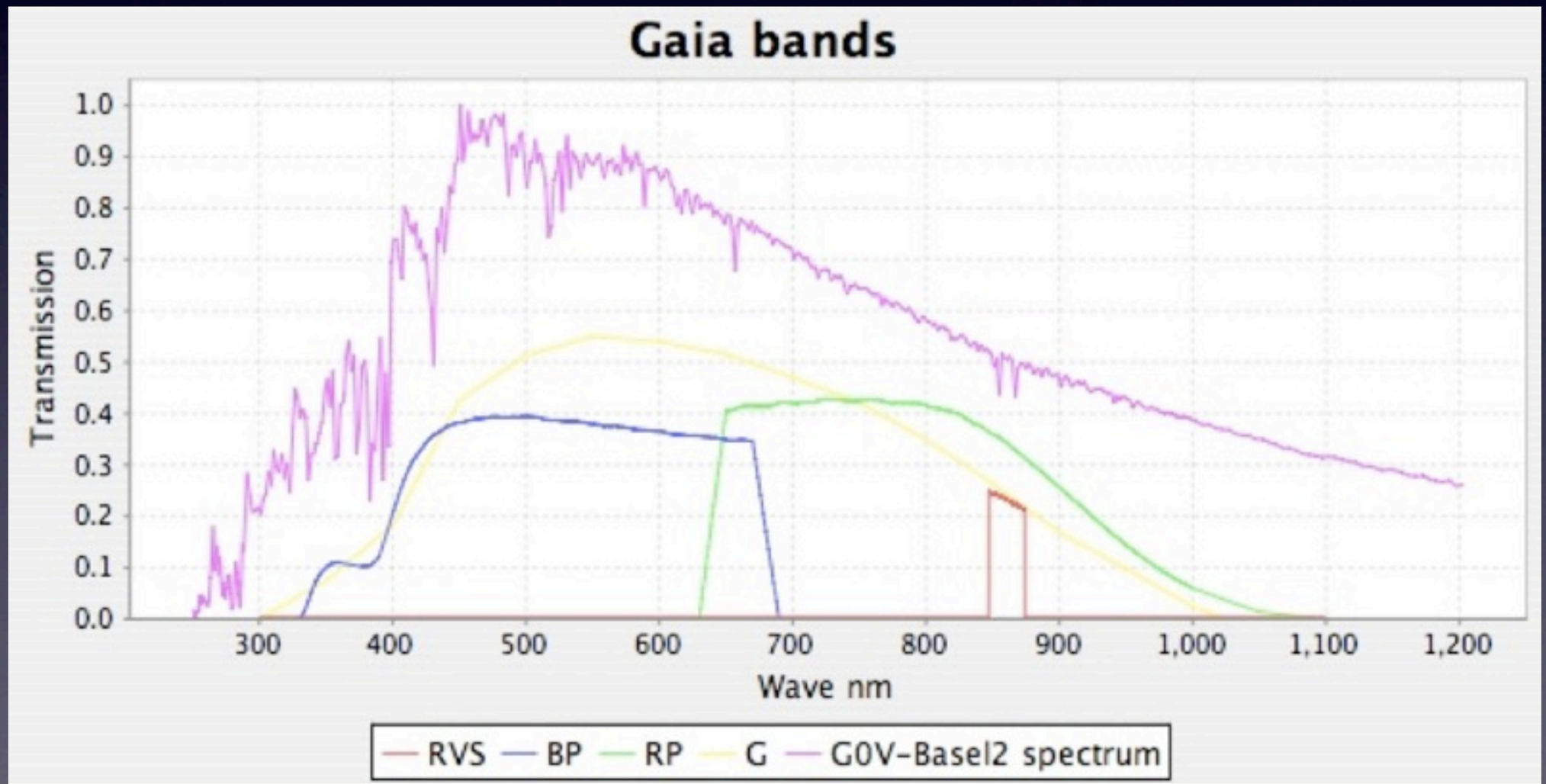
Kinematics and metallicity



Stars in the Milky Way

- Spectral libraries: (P. Sartoretti)

Basel, Kurucz, Marcs, Phoenix, Balmer emission lines

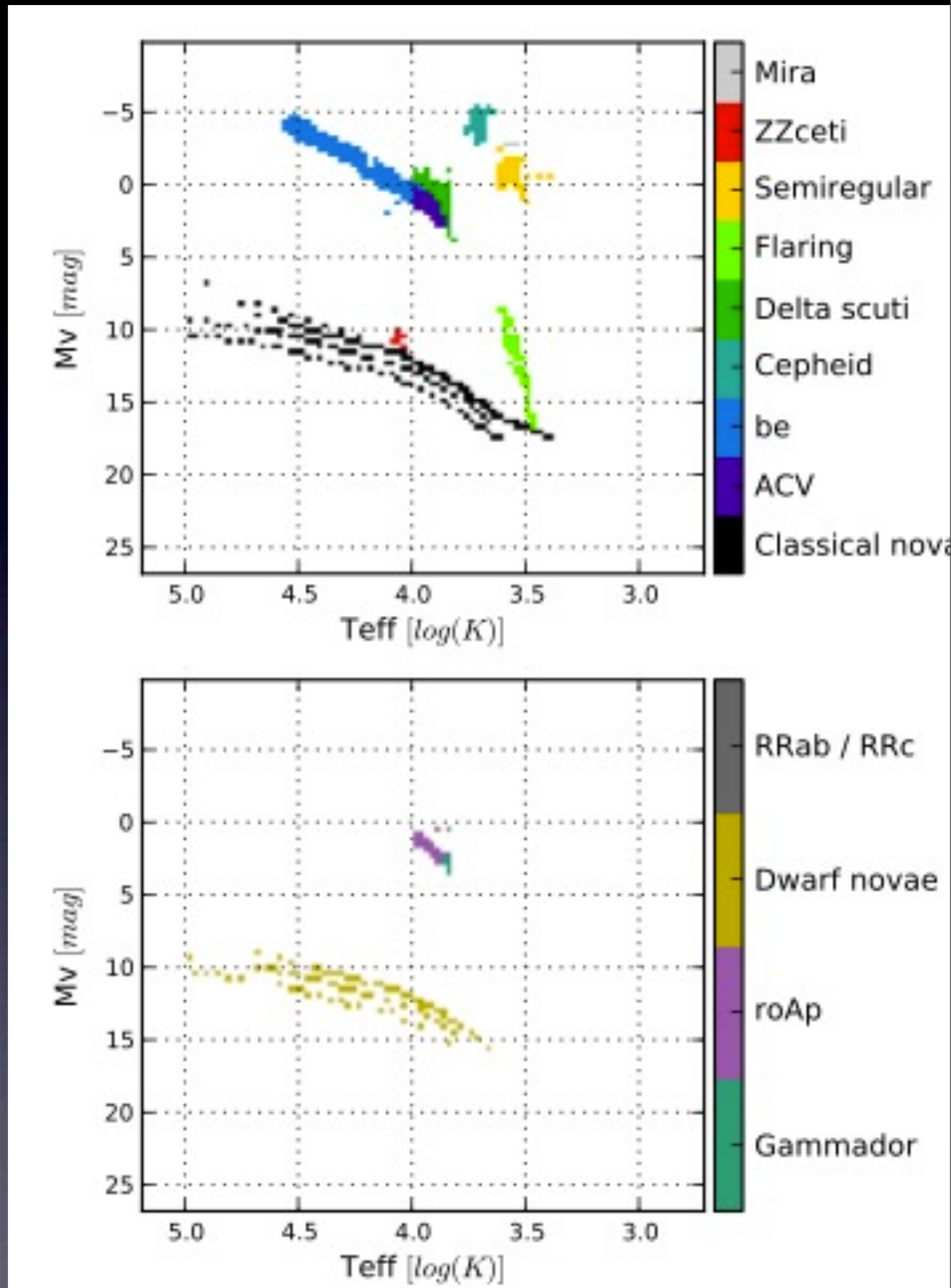


Stars in the MW

- Variability:
  (N. Mowlavi, L. Eyer)

  21 x 10^6 variable stars

Variability type	G < 20 mag	Grvs < 17 mag	Grvs < 12 mag
ACV	0.61%	0.52%	0.18%
Flaring	1.46%	0.49%	0.01%
RRab	0.37%	0.34%	0.02%
RRc	0.09%	0.09%	0.01%
ZZceti	0.12%	<0.01%	<0.01%
Be	2.15%	2.02%	0.87%
Cepheids	0.03%	0.04%	0.11%
Classical novae	0.05%	0.06%	0.19%
δ scuti	48.57%	41.01%	14.11%
Dwarf novae	<0.01%	<0.01%	0.00%
Gammador	0.09%	0.01%	<0.01%
Microlens	4.27%	1.87%	0.91%
Mira	0.19%	0.24%	0.91%
ρ Ap	0.05%	0.04%	0.01%
Semiregular	41.94%	53.27%	82.6%
Total	21,500,000	16,000,000	2,000,000



Stars in the Milky Way

- Multiplicity and exoplanets: (F. Arenou)

  410 x 10^6 binary systems

67% of primary stars are main sequence
62% of systems are a double main sequence system
30 % of systems are subgiants and giants as primary with a main sequence star

- Exoplanets: (A. Sozetti)

  34 x 10^6 exoplanets

Stars	G < 20 mag	Grvs < 17 mag	Grvs < 12 mag
Total stars with planets	27,500,000	9,000,000	182,000
⇒ *Stars with one planet*	*75.00%*	*74.99%*	*74.93%*
⇒ *Stars with two planets*	*25.00%*	*25.01%*	*25.07%*
Total number of planets	34,000,000	11,000,000	228,000

Reference

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

Robin A. C, Luri X., Reylé et al, 2012

A&A, 2012 (in press)
arXiv.1202.0132