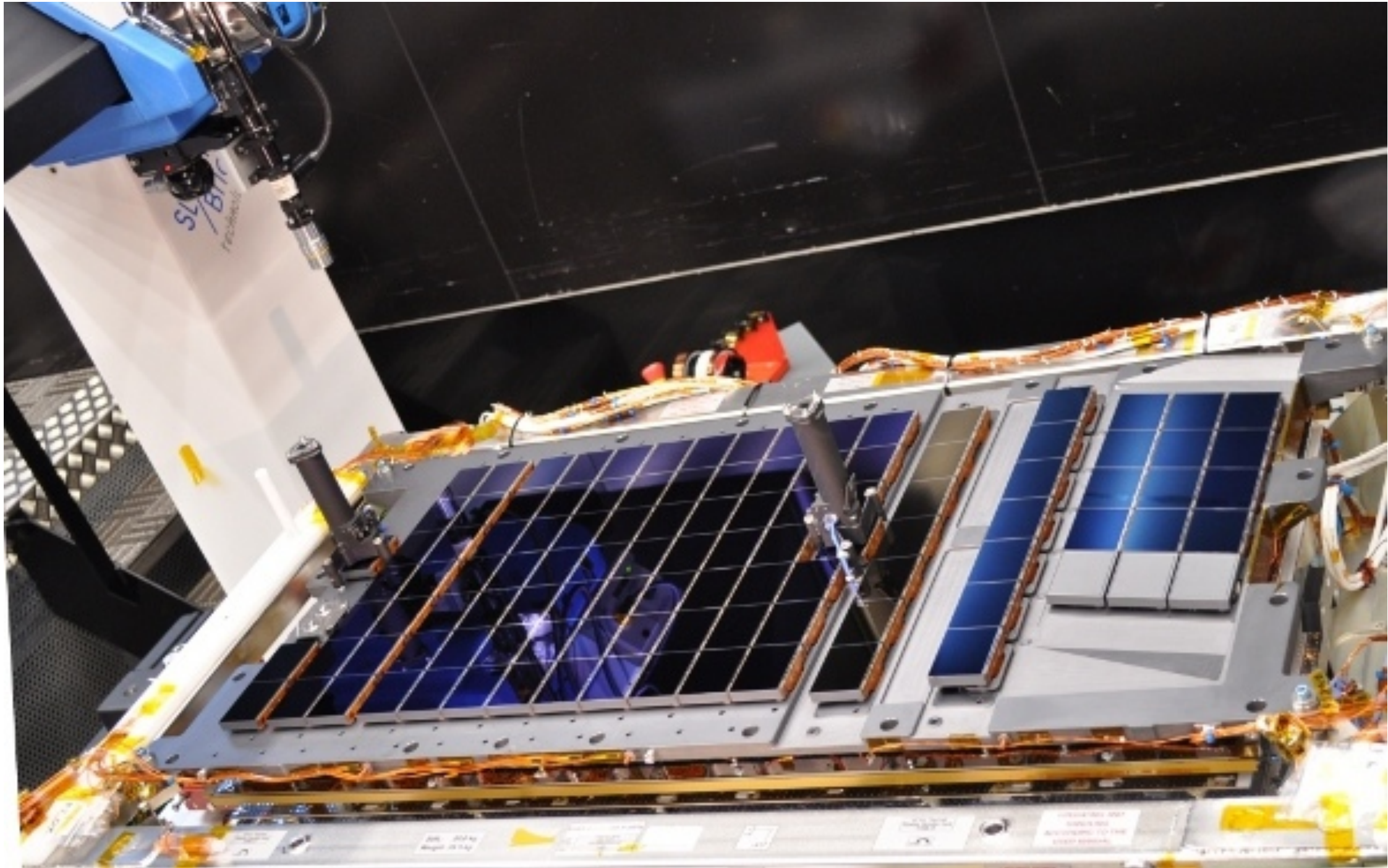


Gaia: Science and Data Products

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CAA Meeting, Washington (4-5 Nov 2013)

Gaia focal plane: astrometric, photometric and radial velocity CCDs



Astrium, January 2012

Gaia: sunshield and solar array deployed



Gaia: mission products

- astrometry:
 - 10^9 stars to 20 mag
 - complete: on-board detection
 - represents $\sim 1\%$ of the Galaxy stellar population
 - accuracy at 15 mag: 25 microarcsec
 - accuracy at 20 mag: 300 microarcsec
 - applies to positions, parallaxes, annual proper motions
- photometry (from low-res spectroscopy):
 - multi-colour, in about 10 bands (cf 2 for Tycho)
 - optimised for T_{eff} , metallicity, reddening
- radial velocities (from 860nm CaII triplet):
 - $V < 17$: radial velocities, 1-10 km/s (~ 150 million objects)
 - $V < 13$: multi-epoch (5 million objects)
 - $V < 13$: rotational velocities, atmospheric parameters, reddening
 - $V < 12$: abundances (2 million₄ objects)

Gaia compared with Hipparcos

	Hipparcos	Gaia
Magnitude limit	12	20 mag
Completeness	7.3 – 9.0	~20 mag
Bright limit	~0	~3-7 mag
Number of objects	120 000	26 million to V = 15 250 million to V = 18 1000 million to V = 20
Effective distance limit	1 kpc	1 Mpc
Quasars	None	$\sim 5 \times 10^5$
Galaxies	None	$10^6 - 10^7$
Accuracy	~1 milliarcsec	7 μ arcsec at V = 10 25 μ arcsec at V = 15 300 μ arcsec at V = 20
Photometry	2-colour (B and V)	Spectrum to V = 20
Radial velocity	None	1-10 km/s to V = 16 -17
Observing programme	Pre-selected	Complete and unbiased

Stellar astrophysics

- Comprehensive luminosity calibration, for example:
 - distances to 1% for ~ 10 million stars to 2.5 kpc
 - distances to 10% for ~ 100 million stars to 25 kpc
 - rare stellar types and rapid evolutionary phases in large numbers
 - parallax calibration of all distance indicators
 - e.g., Cepheids and RR Lyrae to LMC/SMC
- Physical properties, for example:
 - clean Hertzsprung–Russell diagrams throughout the Galaxy
 - Solar-neighbourhood mass and luminosity function
 - e.g., white dwarfs ($\sim 400,000$) and brown dwarfs ($\sim 50,000$)
 - initial mass and luminosity functions in star-forming regions
 - luminosity function for pre-main-sequence stars
 - detection and dating of all spectral types and Galactic populations
 - detection and characterisation of variability for all spectral types

One billion stars in 3-d will provide ...

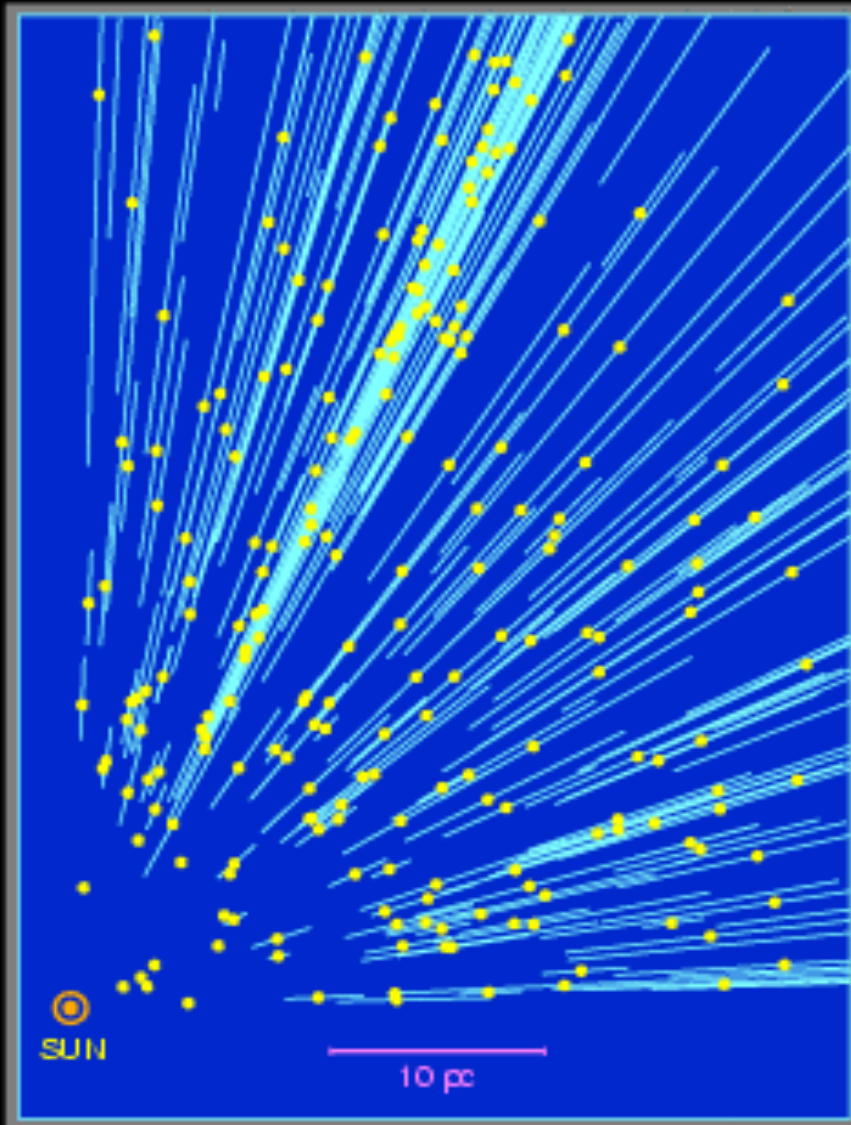
- in our Galaxy ...
 - the distance and velocity distributions of all stellar populations
 - the spatial and dynamic structure of the disk and halo
 - its formation history
 - a detailed mapping of the Galactic dark-matter distribution
 - a rigorous framework for stellar-structure and evolution theories
 - a large-scale survey of extra-solar planets ($\sim 10,000$)
 - a large-scale survey of Solar-system bodies ($\sim 250,000$)
- ... and beyond
 - definitive distance standards out to the LMC/SMC
 - rapid reaction alerts for supernovae and burst sources ($\sim 20,000$)
 - quasar detection, redshifts, microlensing structure ($\sim 500,000$)
 - fundamental quantities: γ to 2×10^{-6} (2×10^{-5} present)

Why a Survey to 20 mag?

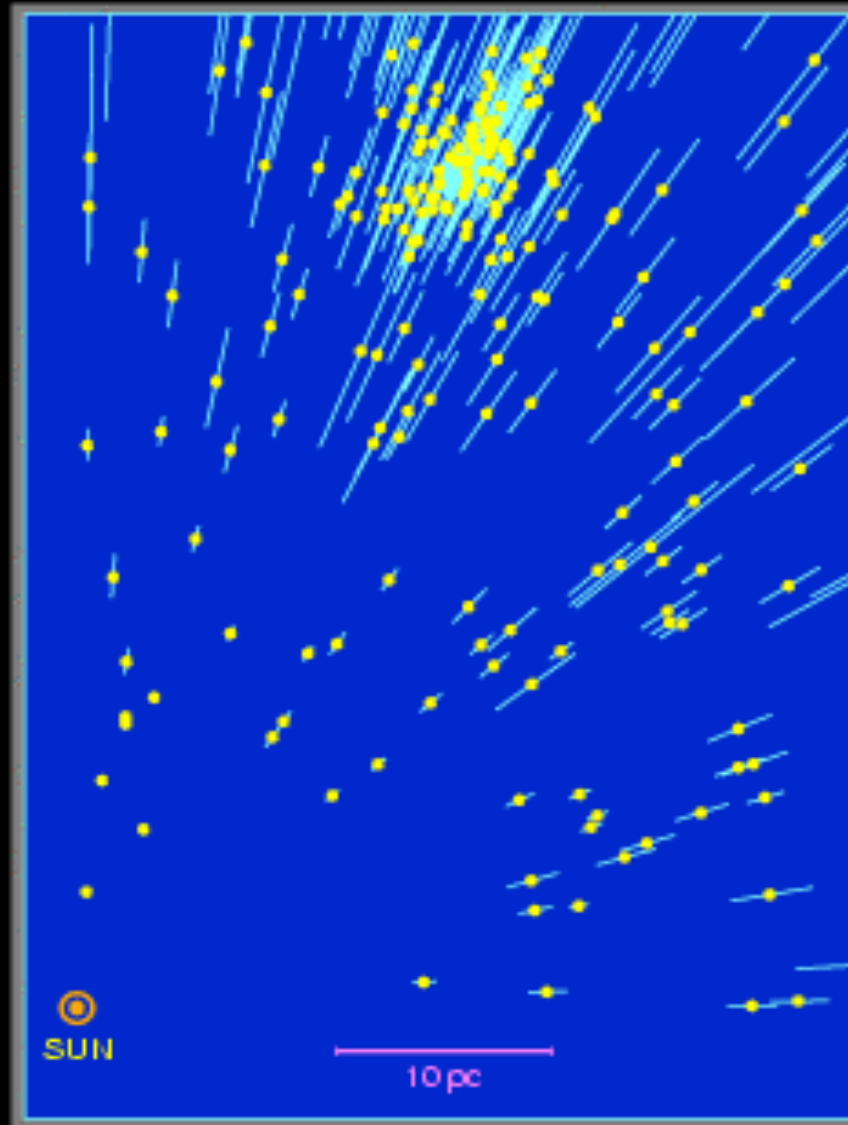
Population	Tracer	M _v	l	b	d	A _v	V ₁	V ₂	ε _T	σ _{μ₁}	σ _{μ₁}	σ _{π₁}
		mag	deg	deg	kpc	mag	mag	mag	km/s	μ _{as/yr}	-	-
Bulge	gM	-1	0	<20	8	2-10	15	20	100	10	0.01	0.10
	HB	+0.5	0	<20	8	2-10	17	20	100	20	0.01	0.20
	MS	+4.5	1	-4	8	0-2	19	21	100	60	0.02	0.60
Spiral arms	Cepheids	-4	All	<10	10	3-7	14	18	7	5	0.03	0.06
	B-M supergiants	-5	All	<10	10	3-7	13	17	7	4	0.03	0.05
	Perseus Arm (B)	-2	140	<10	2	2-6	12	16	10	3	0.01	0.01
Thin disk	gK	-1	0	<15	8	1-5	14	18	40	6	0.01	0.06
	GK	-1	180	<15	10	1-5	15	19	10	8	0.04	0.10
Disk warp	gM	-1	All	<20	10	1-5	15	19	10	8	0.04	0.10
Thick disk	Miras, gK	-1	0	<30	8	2	15	19	50	10	0.01	0.10
	HB	+0.5	0	<30	8	2	15	19	50	20	0.02	0.20
	Miras, gK	-1	180	<30	20	2	15	21	30	25	0.08	0.65
	HB	+0.5	180	<30	20	2	15	19	30	60	0.20	1.50
Halo	gG	-1	All	<20	8	2-3	13	21	100	10	0.01	0.10
	HB	+0.5	All	>20	30	0	13	21	100	35	0.05	1.40
Gravity, K-z	dK	+7-8	All	All	2	0	12	20	20	60	0.01	0.16
	dF8-dG2	+5-6	All	All	2	0	12	20	20	20	0.01	0.05
Globular clusters	gK	+1	All	All	50	0	12	21	100	10	0.01	0.10
Satellite orbits	gM	-1	All	All	100	0	13	20	100	60	0.30	8.00

Example:
distances from ground, Hipparcos, and Gaia
in the region of the Hyades open cluster

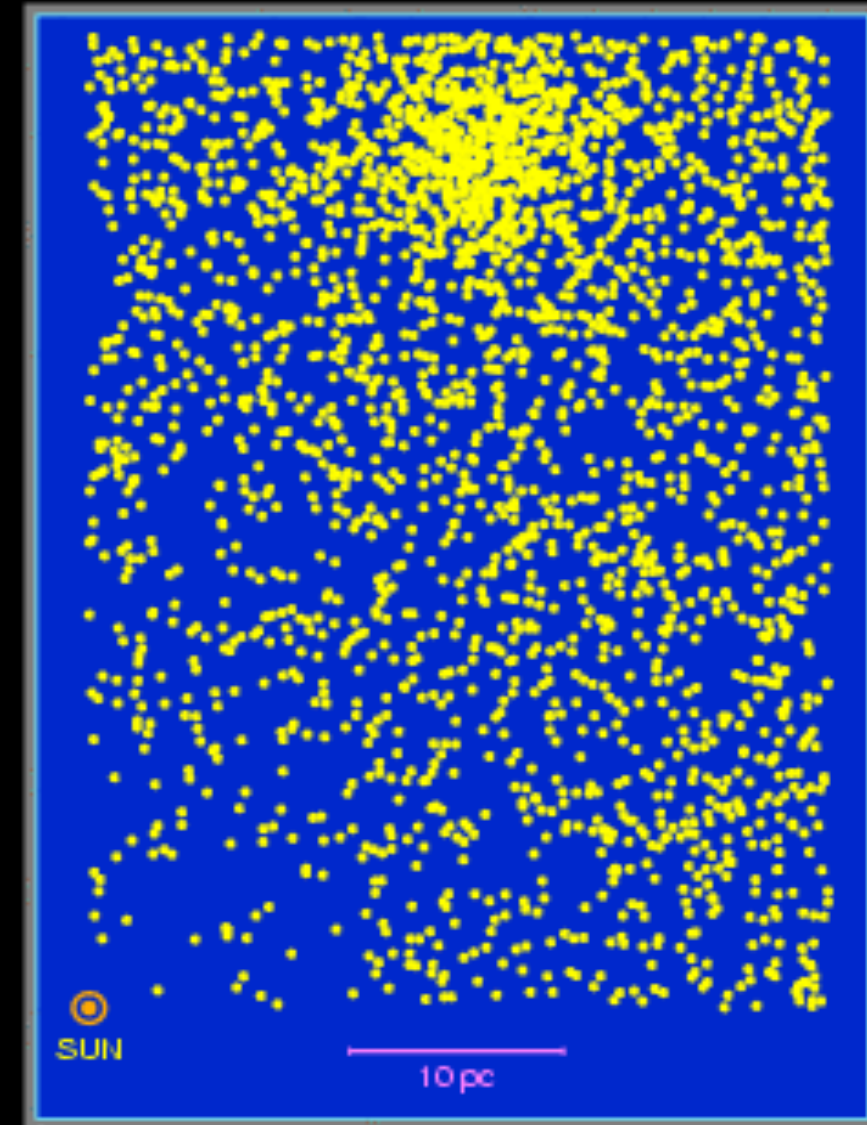
Ground



Hipparcos

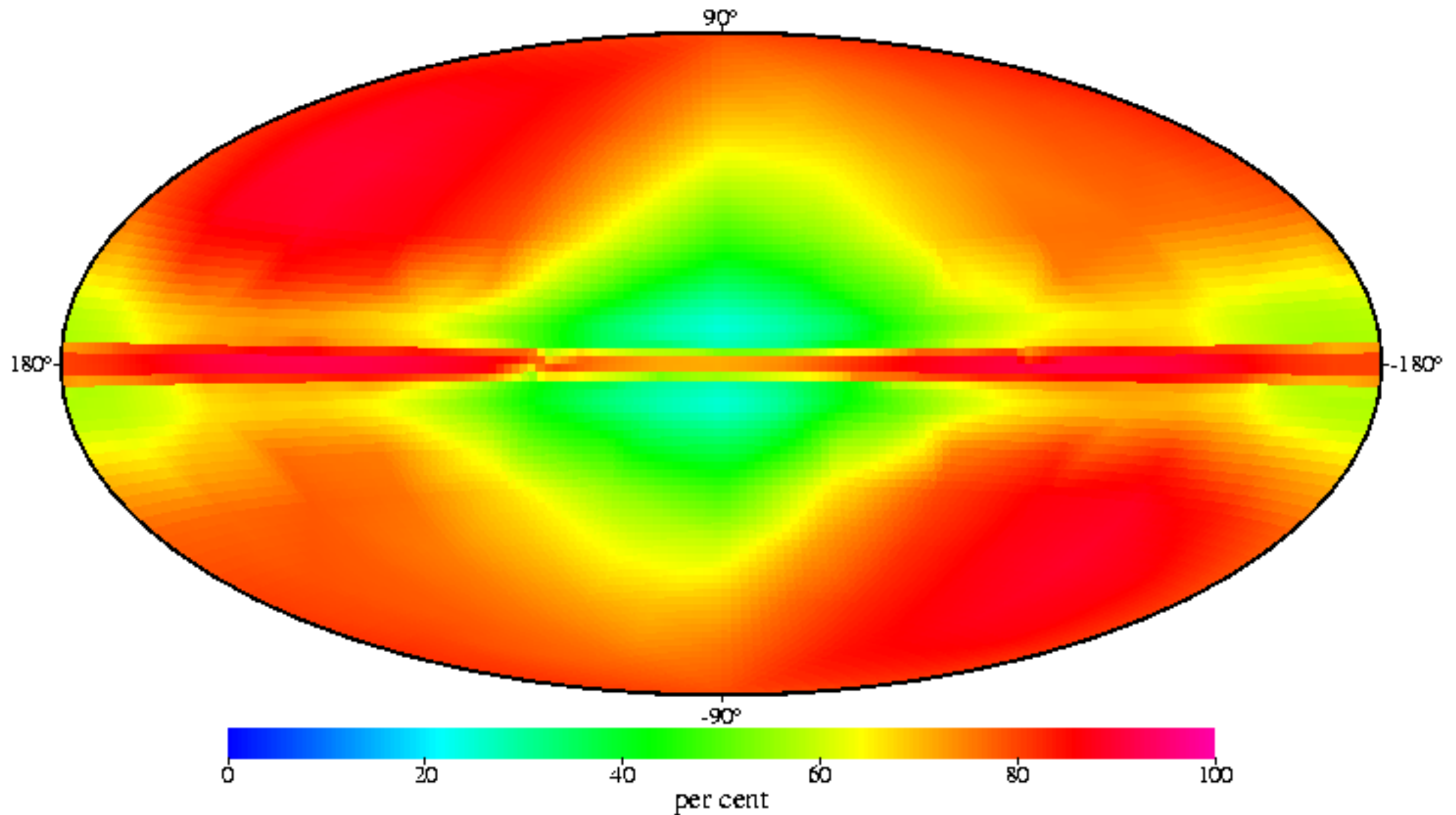


GAIA

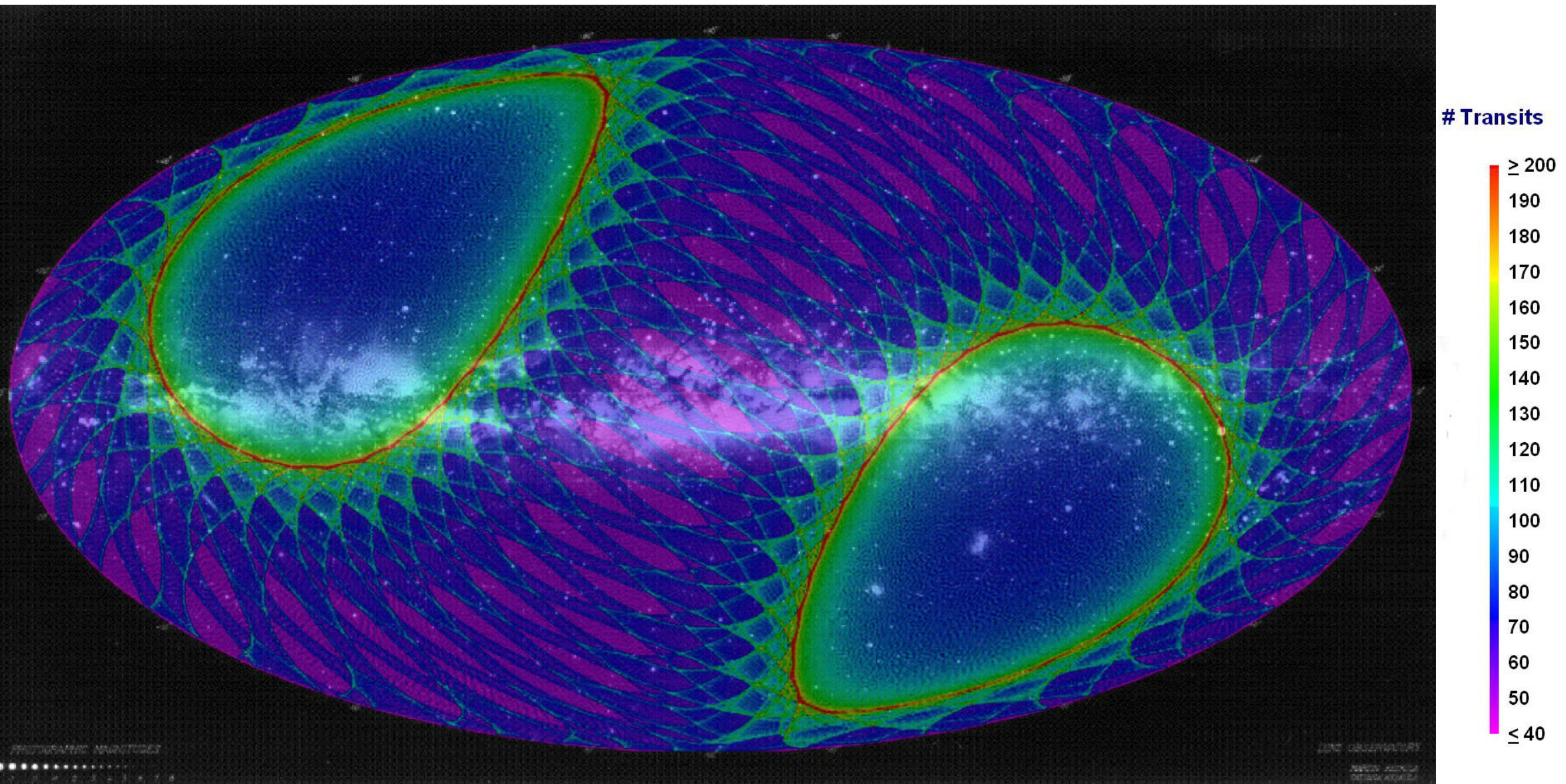


Accuracy example: stars at 15 mag with $\sigma_{\pi}/\pi \leq 0.02$

Galactic coordinates



Number of field of view transits



Gaia data release: open to all

Logistics:

- L+6 months: positioning at L2, commissioning
- L+12m: first full sky scan completed
- L+24m (18 months data): parallaxes and proper motions separable
- internal database to public archive (validation): ~3 months

Products:

- L+22m: positions + G mag (all sky, single stars, alerts, NEOs)
+ 10^5 proper motions (Hipparcos + Gaia) at 50 micro-arcsec/yr
- L+28m: full astrometry, radial velocities for brighter stars
- L+40m: orbital solutions, some red/blue photometry, radial velocities, RVS spectra, some astrophysical parameters
- L+65m: updates on previous, more sources, classification, variable star solutions, epoch photometry
- end(5yr)+36m (~2021): everything

End