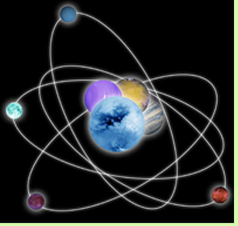
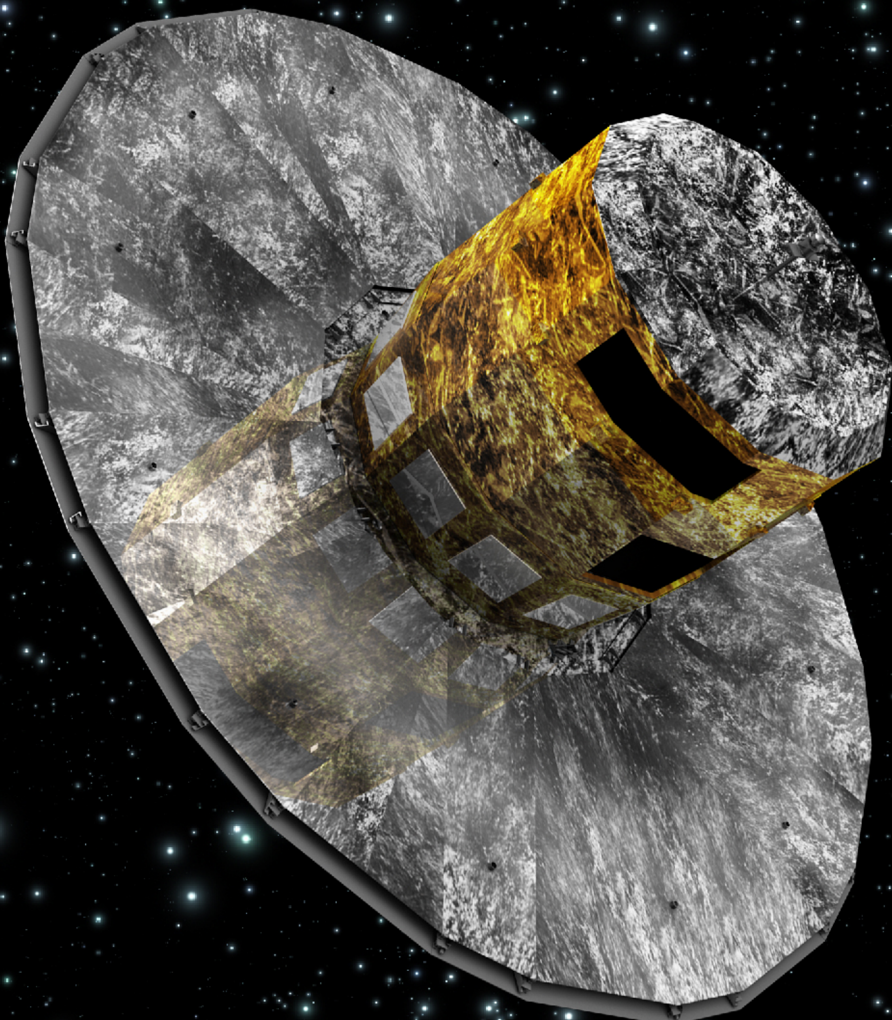


Gaia as a Tool for EChO Target Selection and Characterization

A. Sozzetti

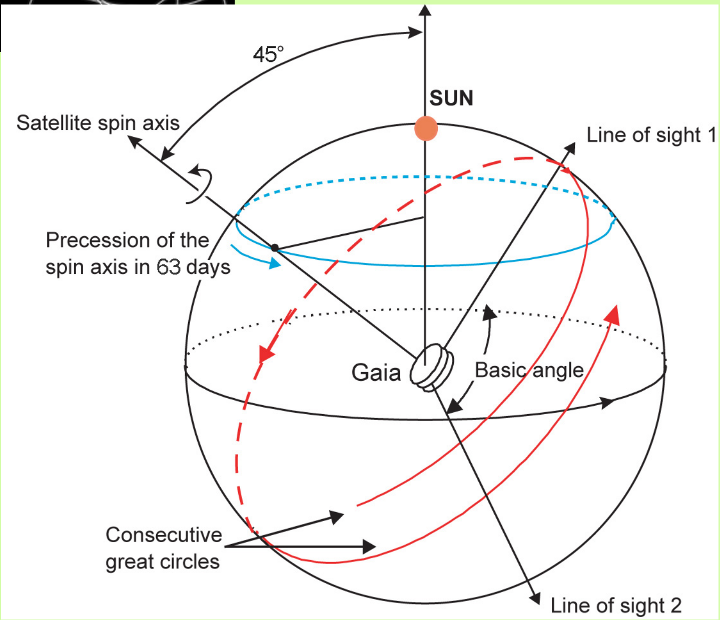
INAF – Osservatorio Astrofisico di Torino

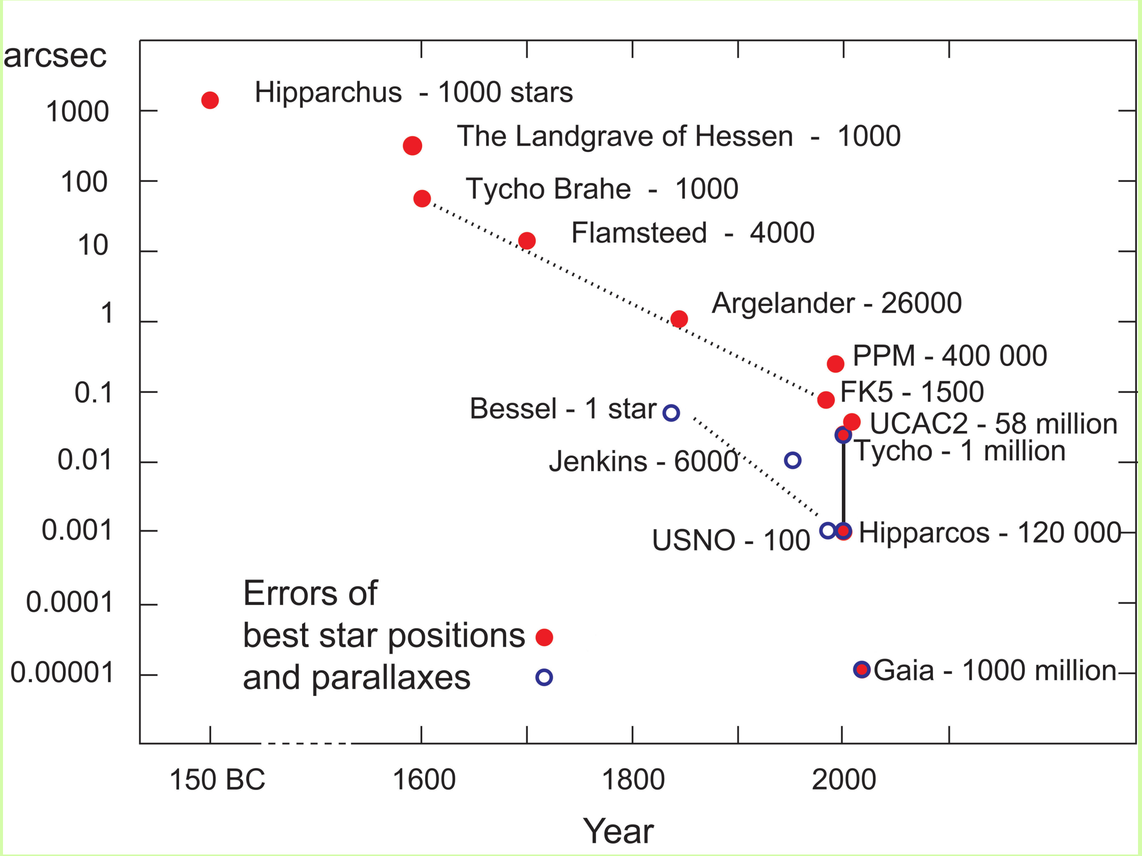
Gaia



First launch opportunity starts on October 20th, 2013!

Gaia: a 10 µas machine!

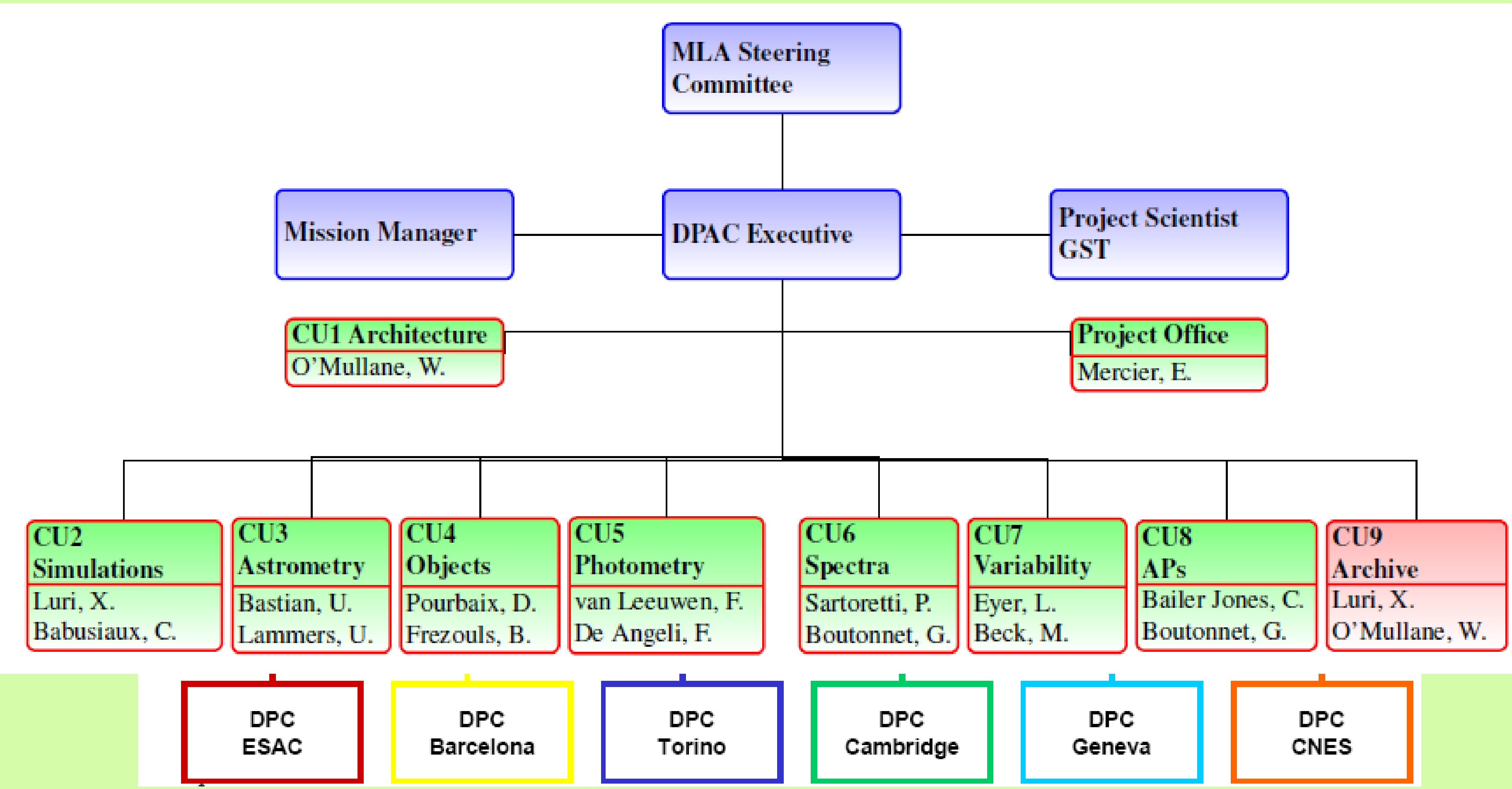




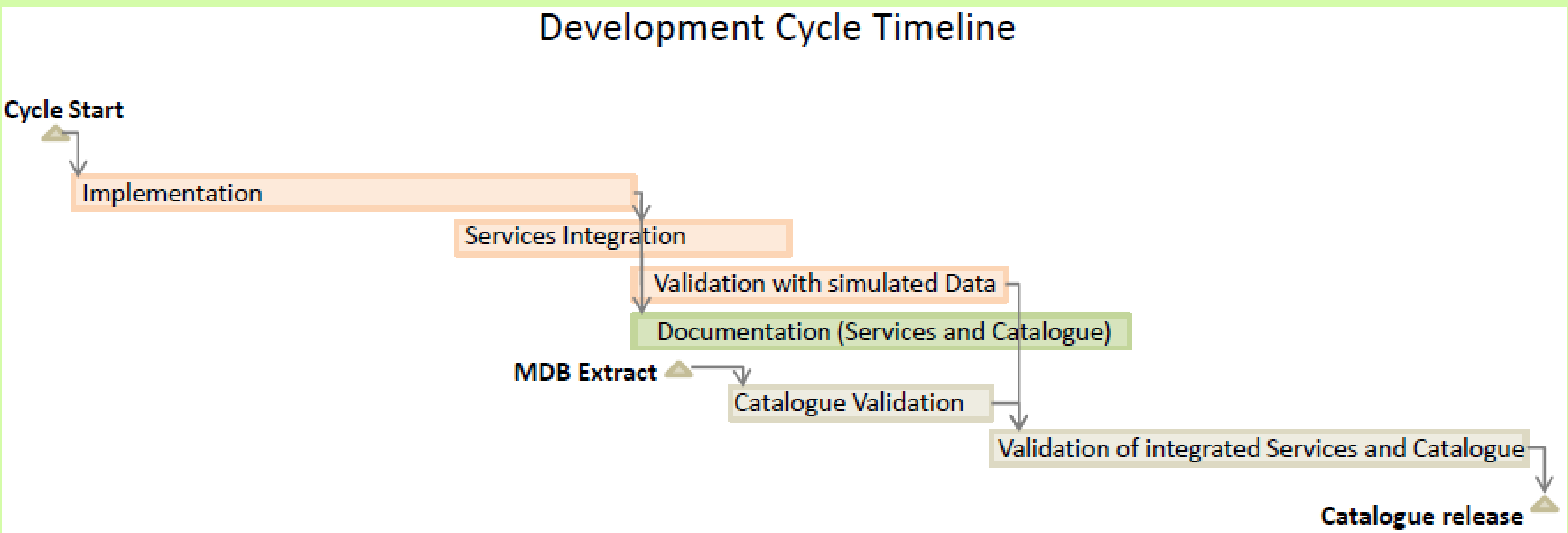
At the V=20 survey limit: 1 billion stars observed!

Intermediate Data Releases

- Intermediate Data Release Scenario agreed with inputs from Data Release Policy and DPAC Operations Plan
  - Science Alerts as soon as possible
  - L+22m positions, G-magnitudes, proper motions to Hipparcos stars, ecliptic pole data
  - L+28m + first 5 parameter astrometric results, bright star radial velocities, integrated BP/RP photometry
  - L+40m + BP/RP data, some RVS spectra, astrophysical parameters, orbital solutions for short period binaries
  - L+65m + variability, solar system objects

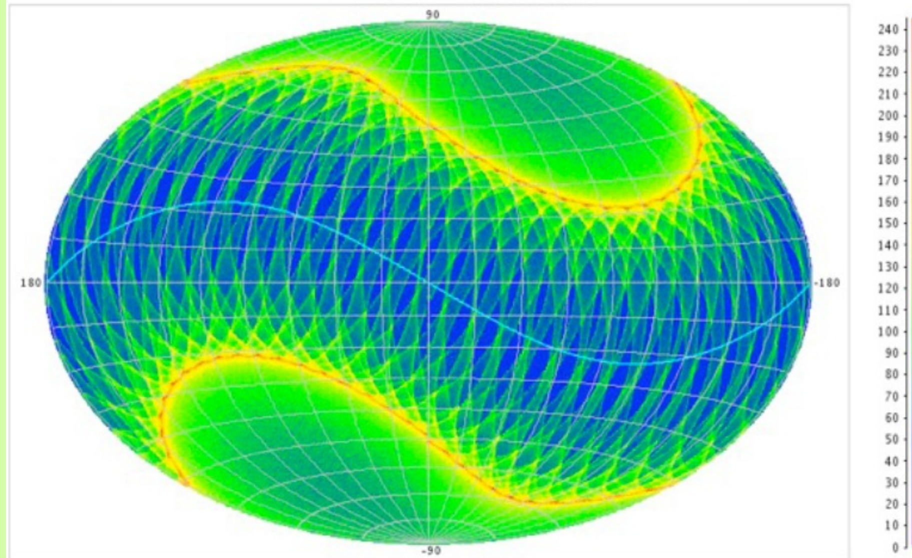

MLA Steering Committee
Mission Manager
DPAC Executive
Project Scientist GST
CU1 Architecture
O'Mullane, W.
Project Office
Mercier, E.
CU2 Simulations
Luri, X.
Babusiaux, C.
CU3 Astrometry
Bastian, U.
Lammers, U.
CU4 Objects
Pourbaix, D.
Frezouls, B.
CU5 Photometry
van Leeuwen, F.
De Angeli, F.
CU6 Spectra
Sartoretti, P.
Boutonnet, G.
CU7 Variability
Eyer, L.
Beck, M.
CU8 APs
Bailer Jones, C.
Boutonnet, G.
CU9 Archive
Luri, X.
O'Mullane, W.
DPC ESAC
DPC Barcelona
DPC Torino
DPC Cambridge
DPC Geneva
DPC CNES

Name	Duration	Time Frame
Data Processing Cycle 00	$\sim$ 10m	2014
Data Processing Cycle 01	$\sim$ 6m	2014-2015
Data Processing Cycle 02	$\sim$ 6m	2015
Data Processing Cycle 03	$\sim$ 12m	2015-2016
Data Processing Cycle 04	$\sim$ 12m	2016-2017
Data Processing Cycle 05	$\sim$ 15m	2017-2019

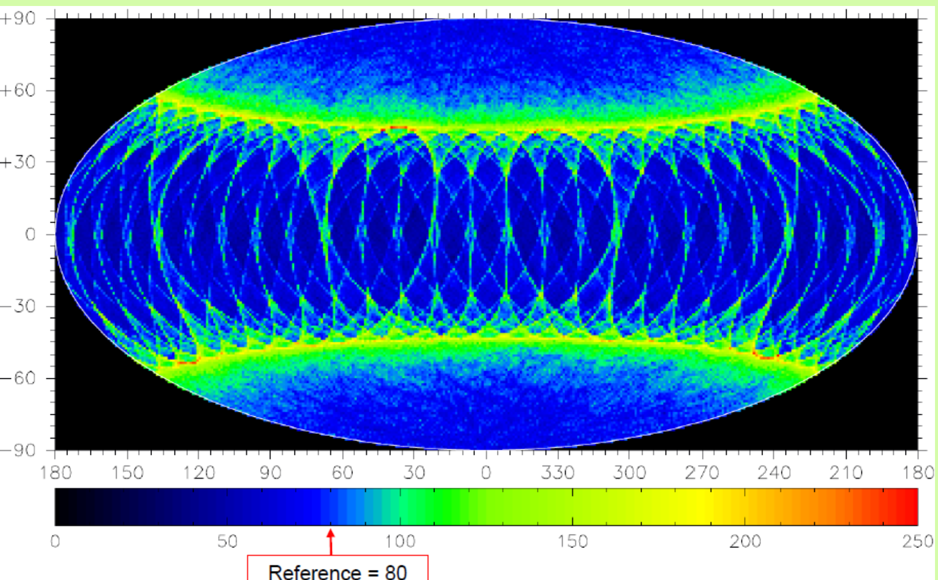


Gaia Scanning Law

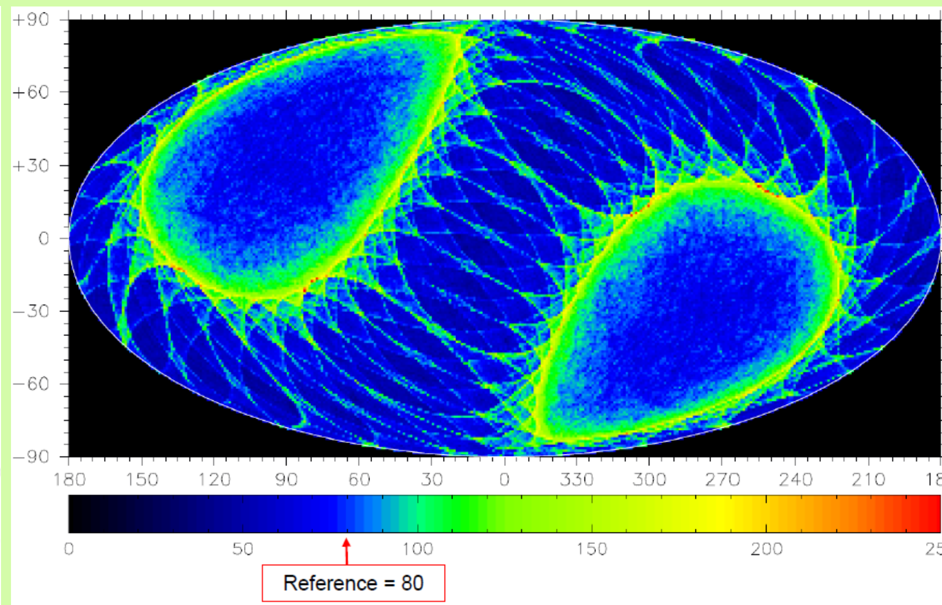
Number of FoV crossings per star (5 yr)



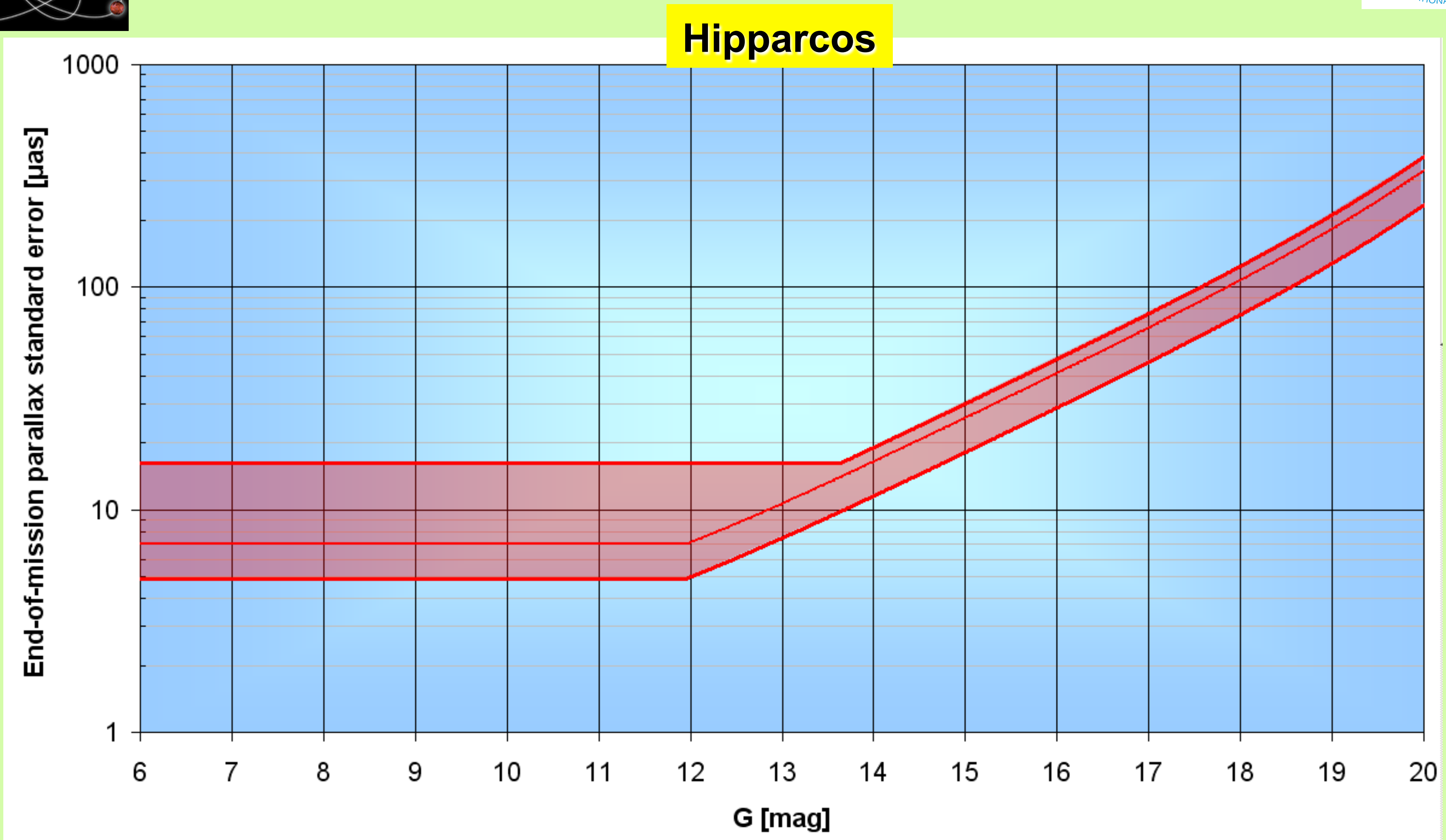
Equatorial projection



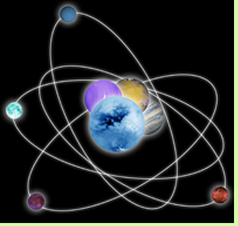
Number of astrometric transits over 5 years in ecliptic coordinates



Number of astrometric transits over 5 years in galactic coordinates



1. 6 < G < 12: bright-star regime (calibration errors, CCD saturation)
2. 12 < G < 20: photon-noise regime (sky-background and electronic noise at G ~ 20 mag)



Hosts of Transiting Planets

- **Parallaxes of virtually ALL known planet-hosting stars released formally around mid-2016**
- **For a typical target with V~15 at d~ 20(500) pc, expect σ(π)/π<0.1(2-3)%**
- **Re-calibrate absolute luminosities (particularly at the bottom of the main sequence)**
- **Derive trigonometric gravities to ~0.03(0.05) dex**
- **Re-determine the stellar radii to <3(5)% 'accuracy'**
- **A first obvious synergy element with the EChO target sample**

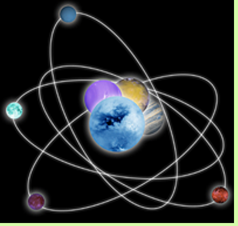


TABLE I

Stellar parameters derivable from the GAIA data. SED=spectral energy distribution (15 photometric measures in medium and broad band filters); nSED=normalized SED (absolute flux information removed); RVS=radial velocity spectrum; BC=bolometric correction; π=parallax; A_λ=interstellar extinction function; **v**(t) & **r**(t)=point source velocity and position as a function of time (from c. 70 observations over four years)

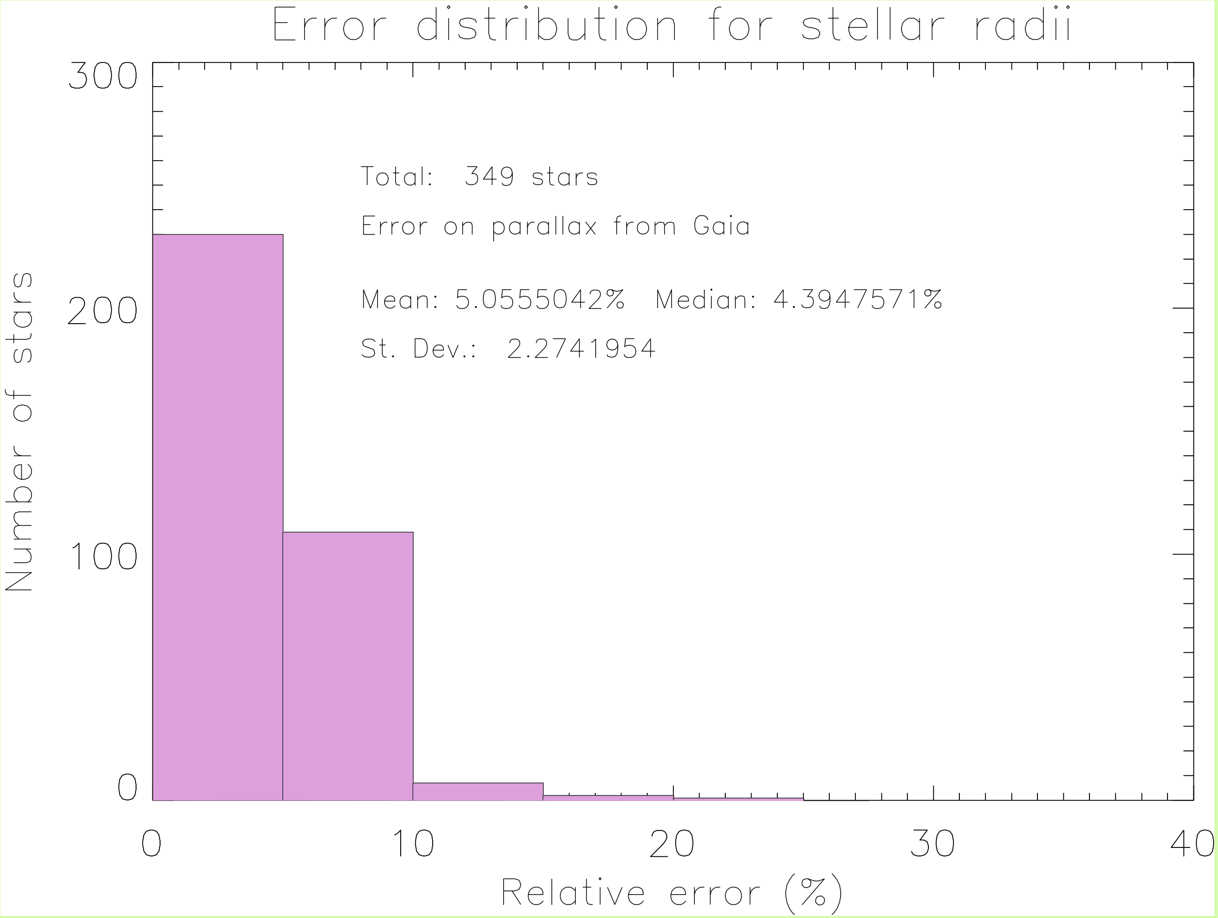
non-astrometric parametrizer:			
nSED, (RVS)	$\Rightarrow$	$T_{\rm eff}$, log g, [Fe/H],	
		A_λ, BC, [α/Fe]?	atmospheric model
additional use of astrometry gives:			
SED, BC, π, A_λ	$\Rightarrow$	L	$2.5 \log L - f(\mathrm{SED}, \mathrm{BC})$
			$= A - 5 \log \pi$
L, $T_{\rm eff}$	$\Rightarrow$	R	$L = 4\pi R^2 \sigma T_{\rm eff}^4$
log g, R	$\Rightarrow$	M	$g = GM/R^2$

Bailer-Jones 2002

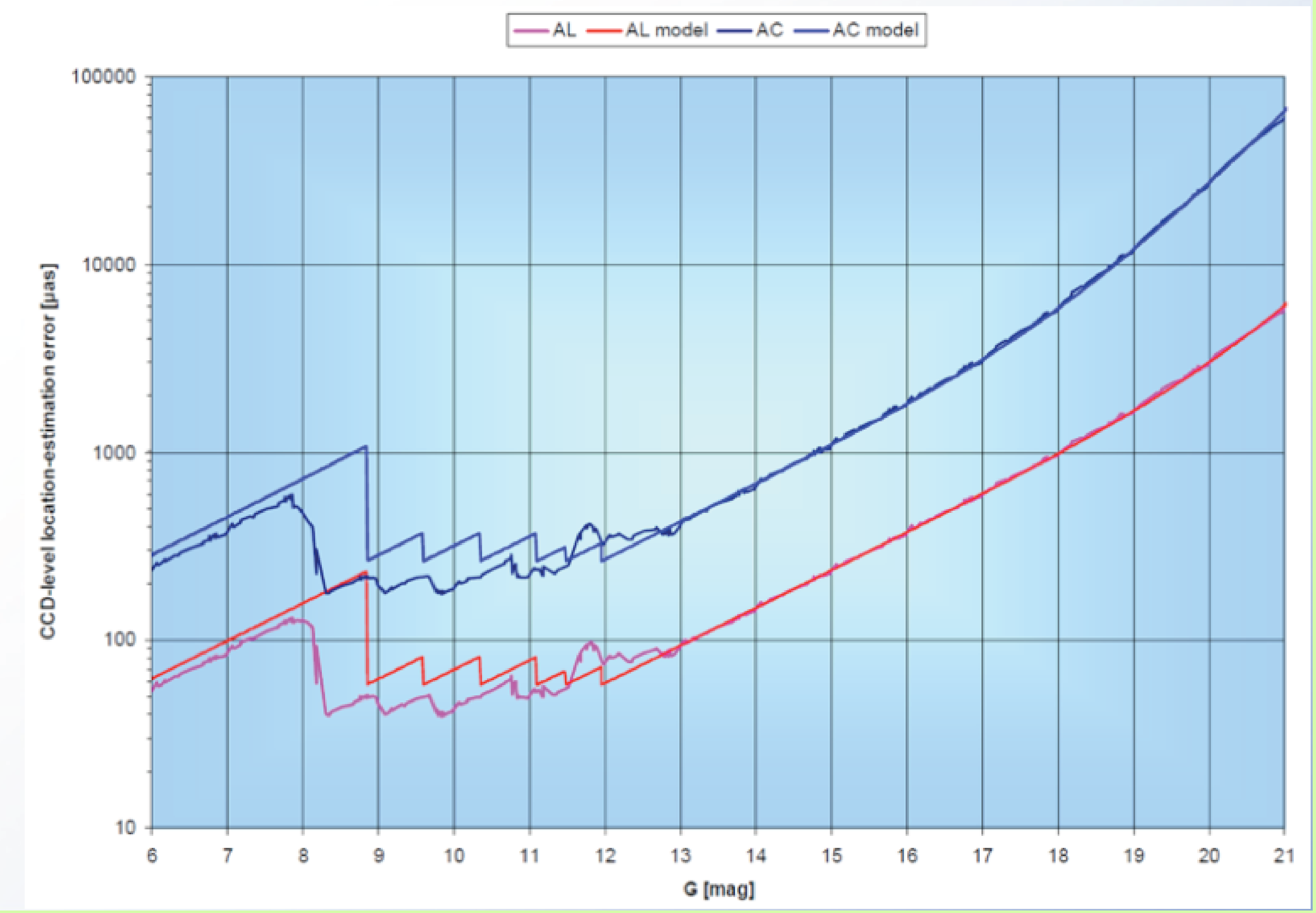
$$\log \frac{g}{g_\odot} = \log \frac{M}{M_\odot} + 4 \log \frac{T_{\rm eff}}{T_{\rm eff\odot}} + 2 \log \pi + 0.4(V_0 + \mathrm{BC}) + 0.11$$

Santos et al. 2004

Work in Progress…



CCD-level Location Estimation



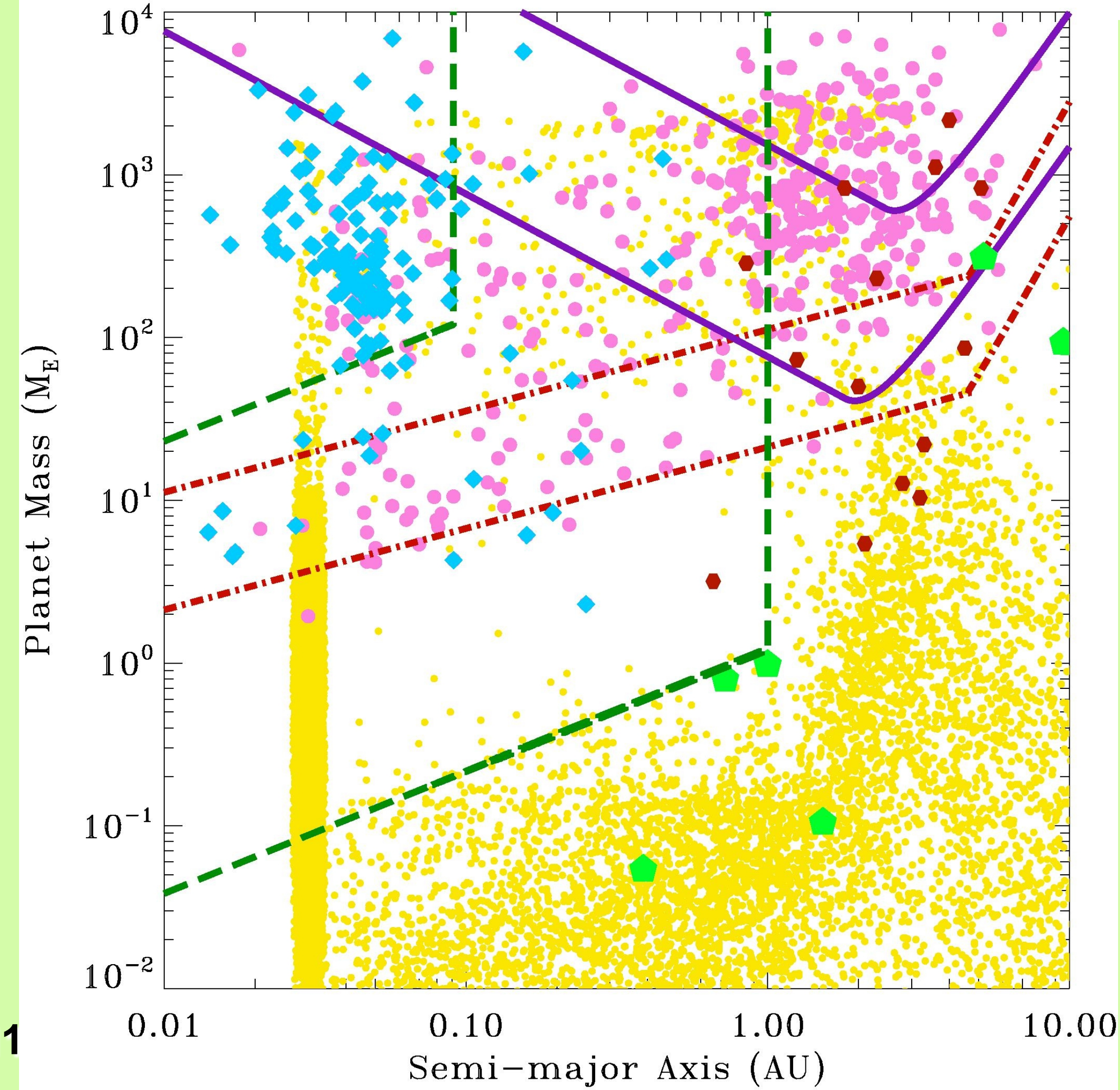
Gaia Discovery Space

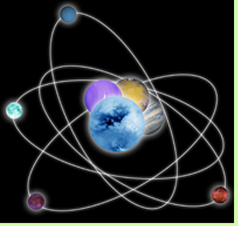
1) 2-3 M_J planets at 2<a<4 AU are detectable out to~200 pc around solar analogs

2) Saturn-mass planets with 1<a<4 AU are measurable around nearby (<25 pc) M dwarfs

For Gaia: σ_A ~ 15-20 μas

Sozzetti 2011





How Many Planets will Gaia find?

Star counts (V<13), $F_p(M_p,P)$, Gaia completeness limit →

Δd (pc)	$N_\star$	Δa (AU)	ΔM_p (M_J)	N_d	N_m
0-50	~10 000	1.0 - 4.0	1.0 - 13.0	~ 1400	~ 700
50-100	~51 000	1.0 - 4.0	1.5 - 13.0	~ 2500	~ 1750
100-150	~114 000	1.5 - 3.8	2.0 - 13.0	~ 2600	~ 1300
150-200	~295 000	1.4 - 3.4	3.0 - 13.0	~ 2150	~ 1050

Casertano, Lattanzi, Sozzetti et al. 2008

How Many Multiple-Planet Systems will Gaia find?

Star counts (V<13), $F_{p,mult}$, Gaia detection limit →

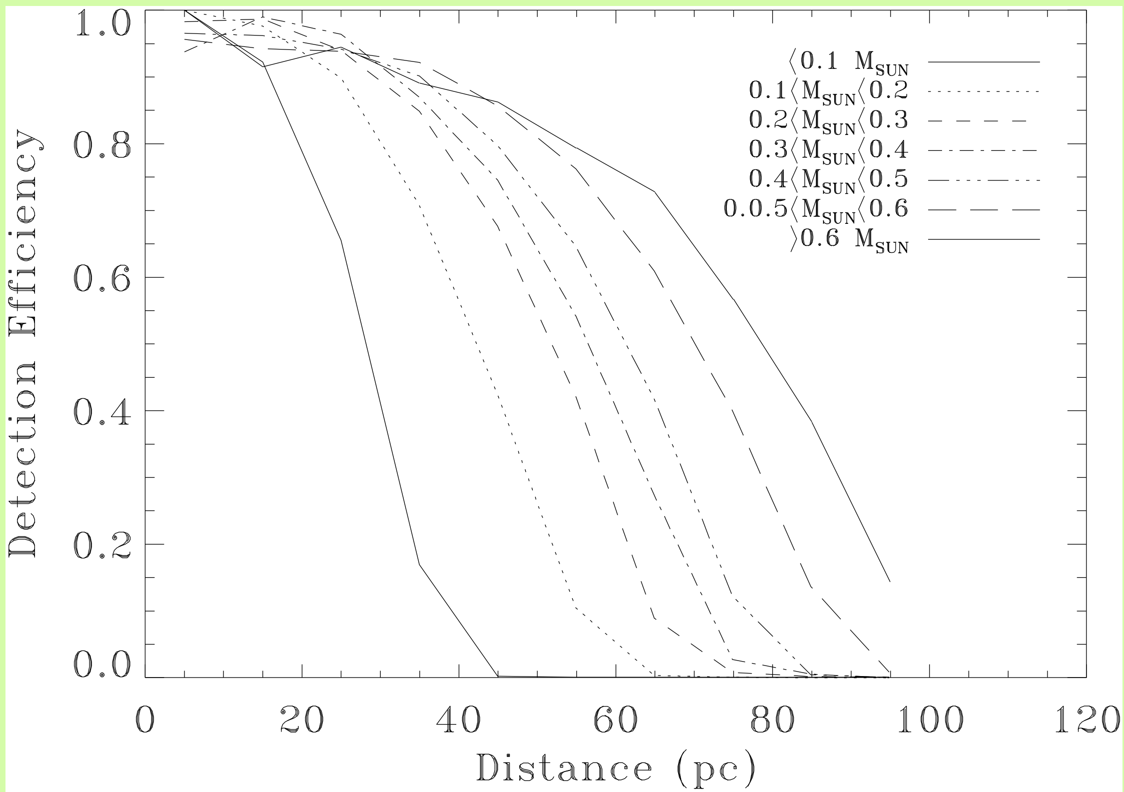
Case	Number of Systems
Detection	~ 1000
Orbits and masses to better than 15-20% accuracy	~ 400 – 500
Successfull coplanarity tests	~ 150

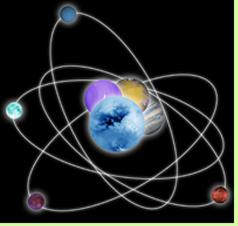
Unbiased, magnitude-limited planet census of $>10^5$ F-G-K dwarfs

Gaia & Low-Mass Stars

- M dwarfs starcounts to G=20 within 100 pc: ~500k stars
- Expect >2500 giants detected, ~1000 accurate orbits

Sozzetti et al. 2013





Gaia transiting candidates?

- Low-cadence of the observations a serious limitation
- It's not hopeless if you have the right tools! (Dzigan & Zucker 2012)
- It can work for early detections of (1000?) short-period transiting Jupiters, BUT:

A) It will depend upon the actual content of Gaia early data releases

B) It will require the definition of transit candidates as Science Alerts (TBD)

C) It will require a dedicated follow-up network

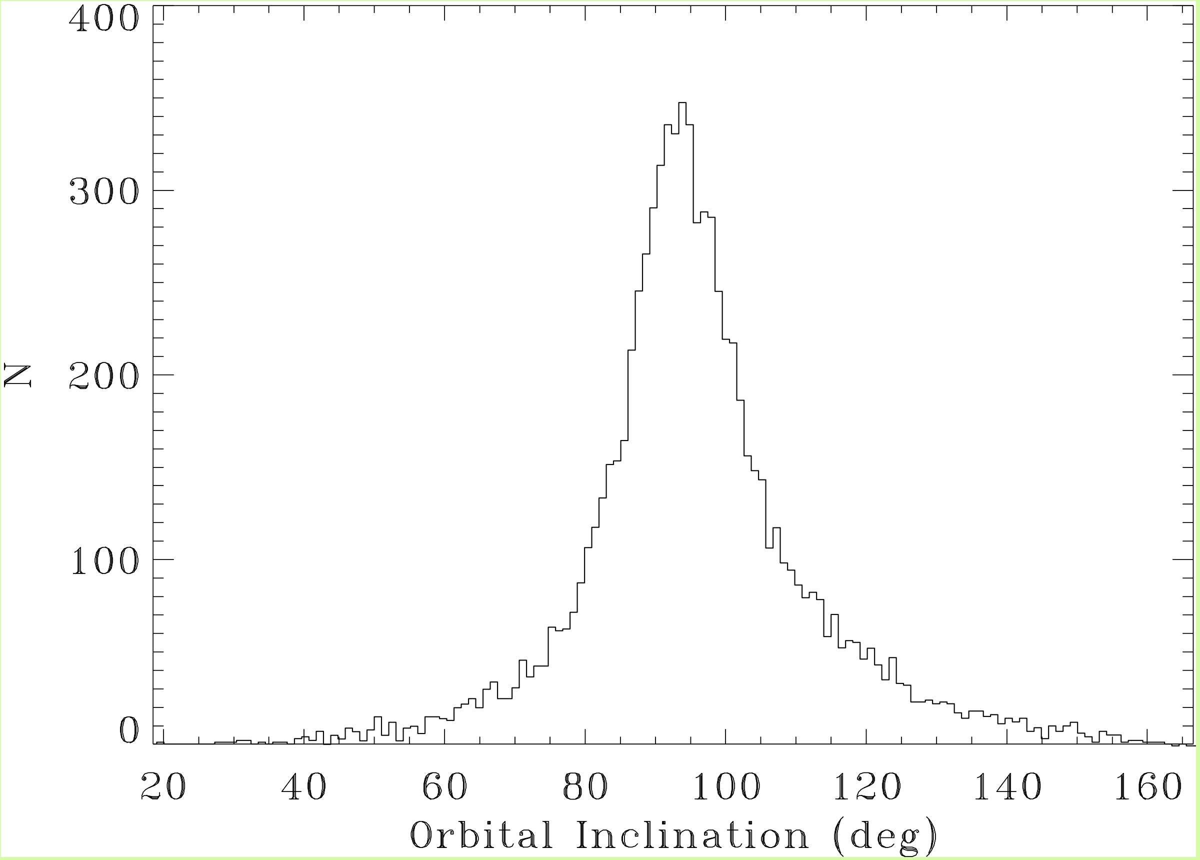
D) Confirmation efforts will be limited by V mag (typically, V > 14 mag)

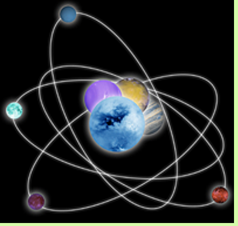
‘Astrometric’ Transiting Wide Separation Giants

20k stars
$0.4<M_{SUN}<1.2$ primaries
d<50pc, one M_J companion
0.1<P<2.5 yr period
edge-on orbits within one deg
e < 0.7

1 in 2 objects detected
1 in 3 of these with *i* measured to within 3%

Extrapolating from Kepler results, <u>there WILL be</u> Gaia detections of such systems!





Gaia Contribution

- > Saturn-mass planets at P>60 d or so (Cold)
- Some maybe transiting, some maybe very eccentric
- Hosts with all spectral types, metallicities, ages (bright-ish, V<14)
- (Possibly) transiting Hot Jupiters (faint-ish, V>14)
- <u>ALL</u> EChO targets re-calibration