

Solar System Simulations

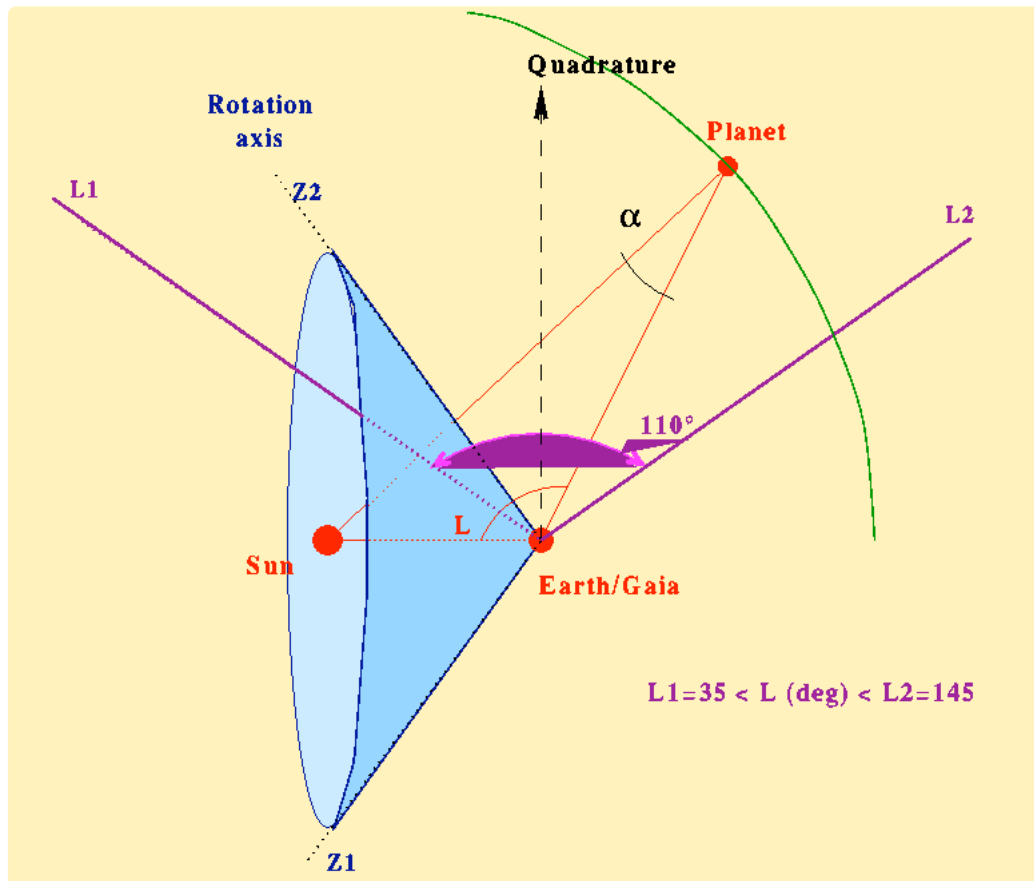
D. Hestroffer (IMCCE, Paris)
& F. Mignard (CERGA, Grasse)

Observable objects

- **Asteroids, Satellites, Comets, (Planets, debris, ...)**
- **Limitation :**
 - ♦ **magnitude, faint and bright**
 - ♦ **motion, no detection if too fast**
 - ♦ **angular size if too large**
- **After detection \Rightarrow `same' treatment as for a star**

Scanning Law

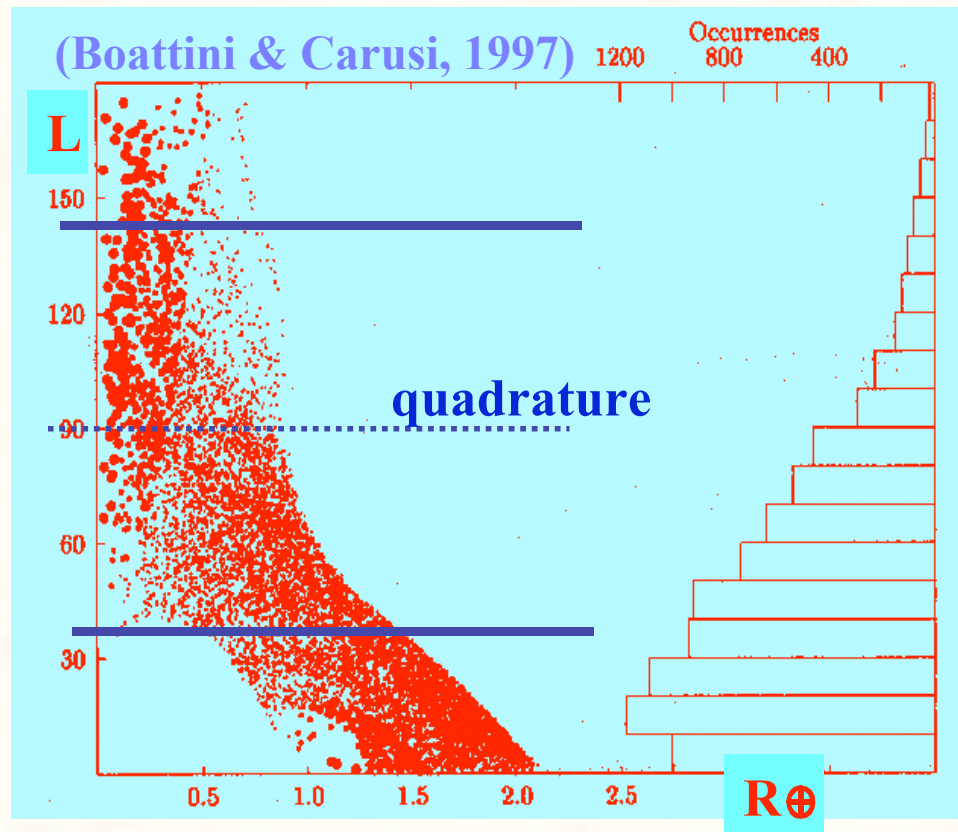
- **Observations near quadratures and to small elongations L (angle Sun-planet)**



- **Moderate to large phase angle α (fraction of illum. Disk)**
- **Asteroid motion preferably in cross-scan direction**

KBOs & NEOs

- Whole sky scanned and at small elongations
21 Atens $V < 20$



- Other Plutos
- NEOs
- Atens et IEOs

Identification and Imaging

- **Peculiarities**
 - ◆ **Spectra ~ G star**
 - ◆ **Angular size (≤ 1 arcsec)**
 - ◆ **Solar phase angle, Irregular shape**
 - ◆ **Moving objects (when not stationary)**
 - > **Along/Cross-scan motion**
 - > **Date of FOV crossing**
- **Use, or to Consider in**
 - ◆ **Detection and FOVs crossing history**
 - ◆ **Imaging**

Asteroid General

- **Known population $\sim 10^5$ objects, increasing**
 - ◆ 44,000 entries in Jan. 1999 (astorb.dat)
 - ◆ 108,000 entries in Jan. 2001
 - ◆ **174,000** entries in Mar. 2002 \leq (today)
 - **Simulated population of NEOs (20,000 objects)**
 - **Observing Log from scanning law (FM)**
 - ◆ Provide sequence of observation for several 10^4 ast.
 - ◆ Crossing time during 4 years, over the 3FOVs
 - ◆ Output: for each object
 - > **date; magnitude; phase; velocities; ...**
 - > **can be completed: angular size; distance; ...**
- GAIA SimWG - Cambridge March 2002*

Observing Log

★	1	Ceres	193				
	0	1	-1	0	0	1	-1
15.8667	15.9108	15.9479	15.9920	38.7440	38.7881	38.8250	
8.0	8.0	8.0	8.0	7.6	7.6	7.6	
21.40	21.40	21.39	21.39	17.31	17.31	17.28	
2.66	2.66	2.61	2.61	-2.44	-2.44	-2.40	
5.80	5.80	5.79	5.79	-2.48	-2.48	-2.53	

★ 2 Pallas 208

etc ...

Planet ID, N_obs (1 obs = 1 FOV)

Fields (0 : spectro, 1: astro leading, -1 : astro trailing)

Crossing time (days)

Apparent magnitude V

Phase angle α [deg.]

Along-scan inertial speed[mas/s]

Cross-scan inertial speed [mas/s]

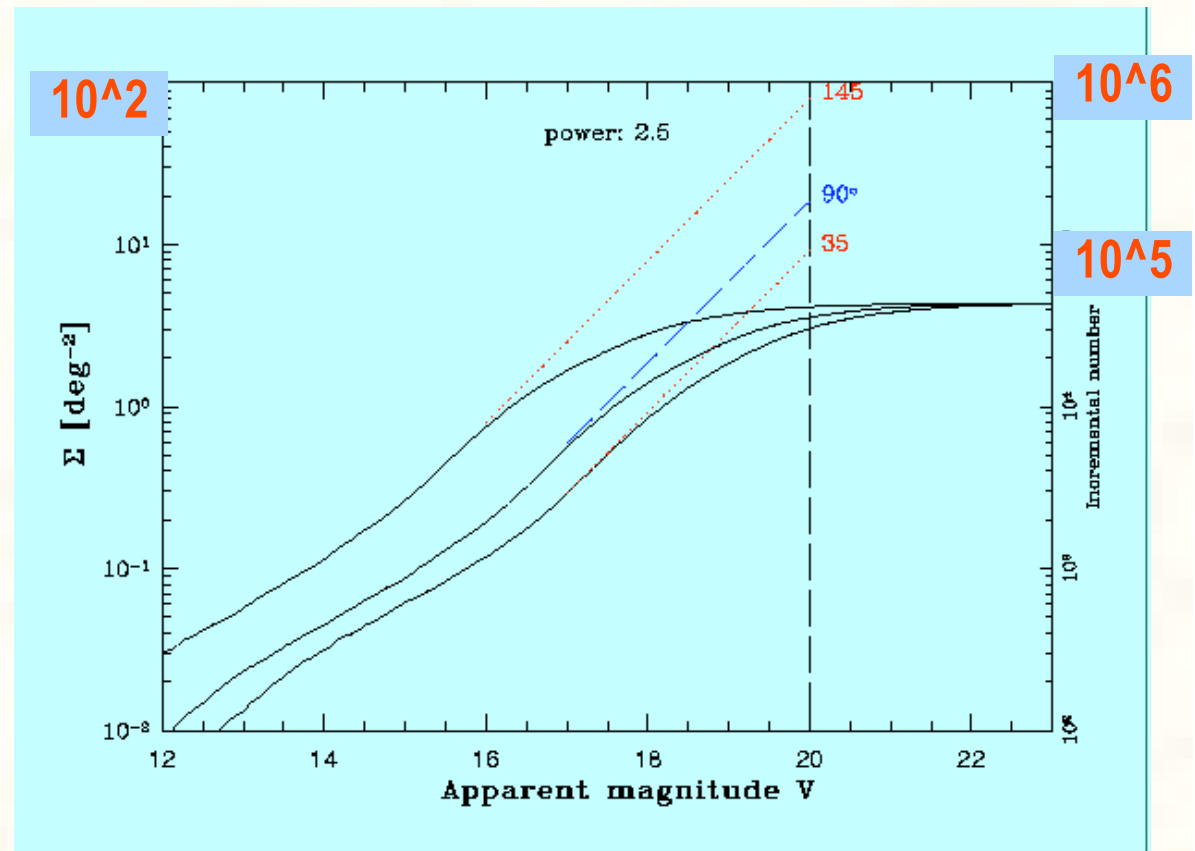
Asteroids - Main belt (MBA)

- Extrapolation of distribution law

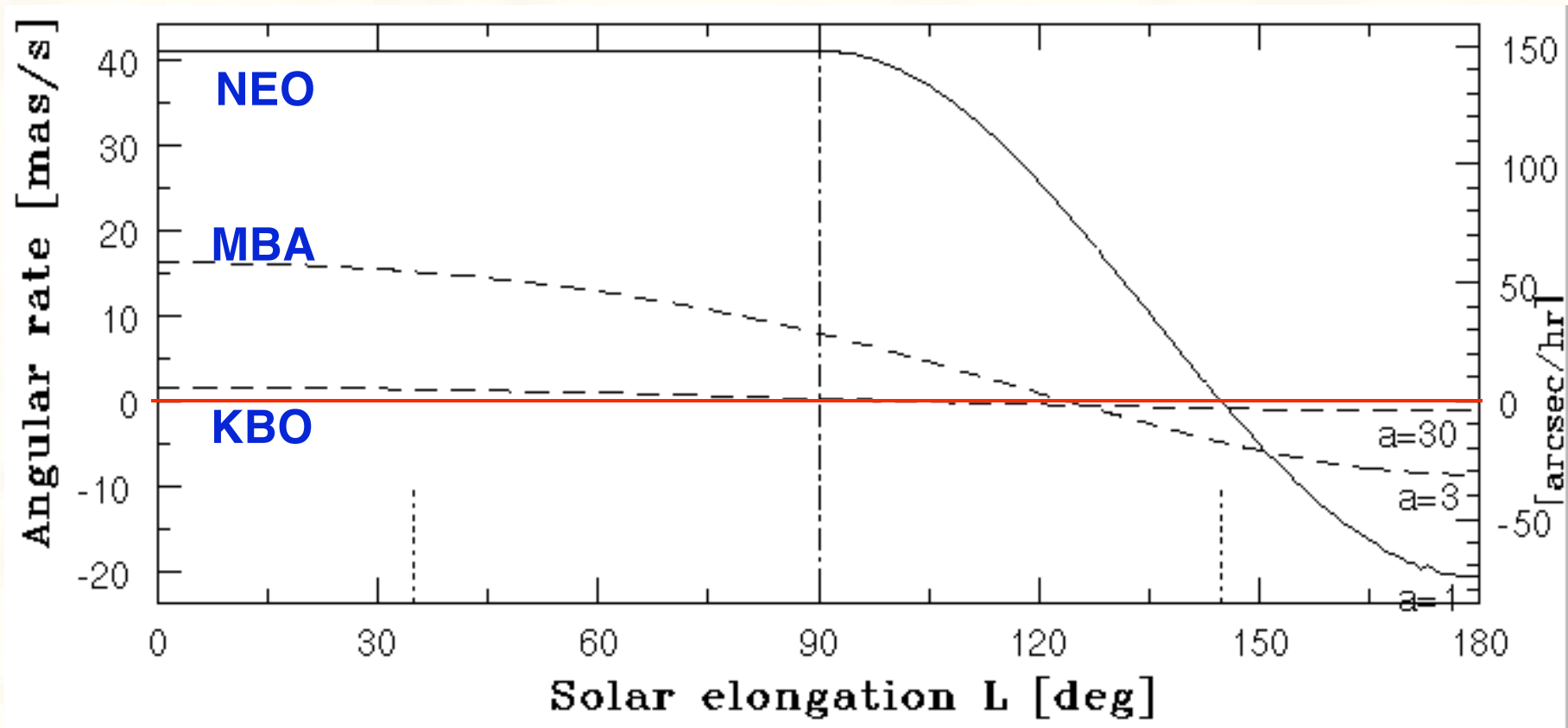
- $N \sim 5 \times 10^5$

- Most known
in 10 years time

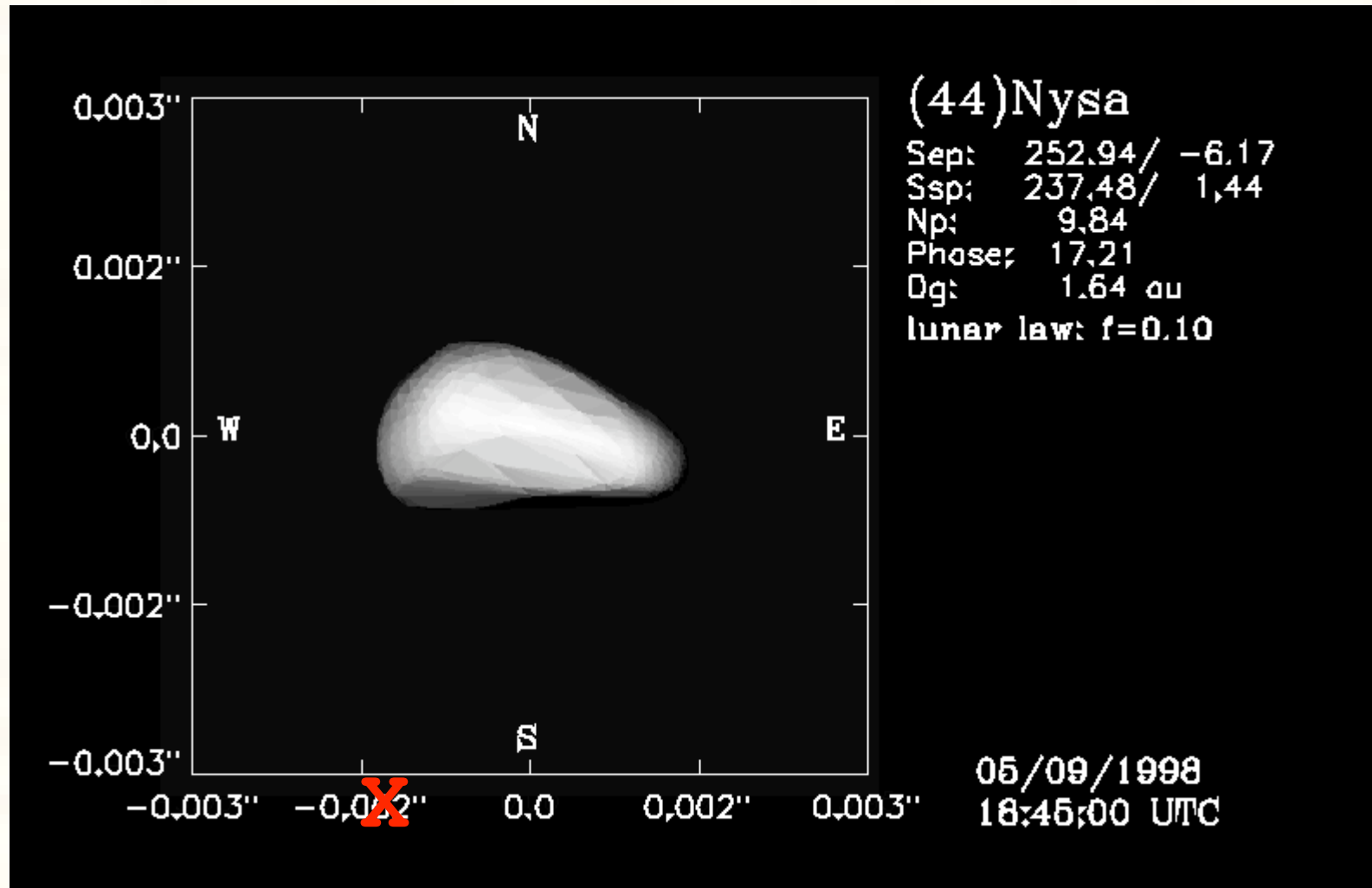
$\Rightarrow \Sigma \Rightarrow 10^2/\text{deg}^2$



Velocity

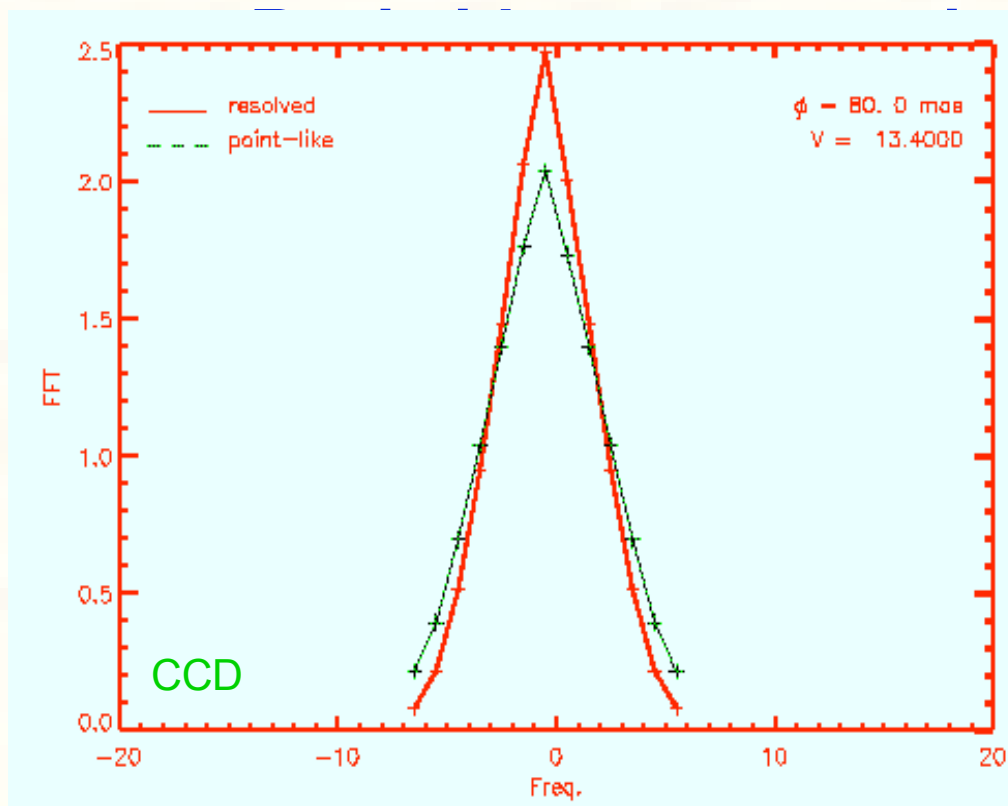


Physical Ephemeris



Asteroid Sizes & Duplicity

- **Image reconstruction: not adapted** (2 pix at most)



age to PSF from FFT

- **PSF of a star**
- **convolution with a disk**
- **angular diam. 80 mas**
- **$V = 13.4$**

Detection - Centroiding - Imaging

- **Realistic simulation of data from CCD**
 - ✦ moving image/stars: cross/along-scan velocities
 - ✦ extended source: angular size
- **Identification from Astro & Spectro SM**
 - ✦ accuracy of position and relative speed
- **Imaging**
 - ✦ detect binaries and measure sizes/shapes

Some Actions of the SSWG

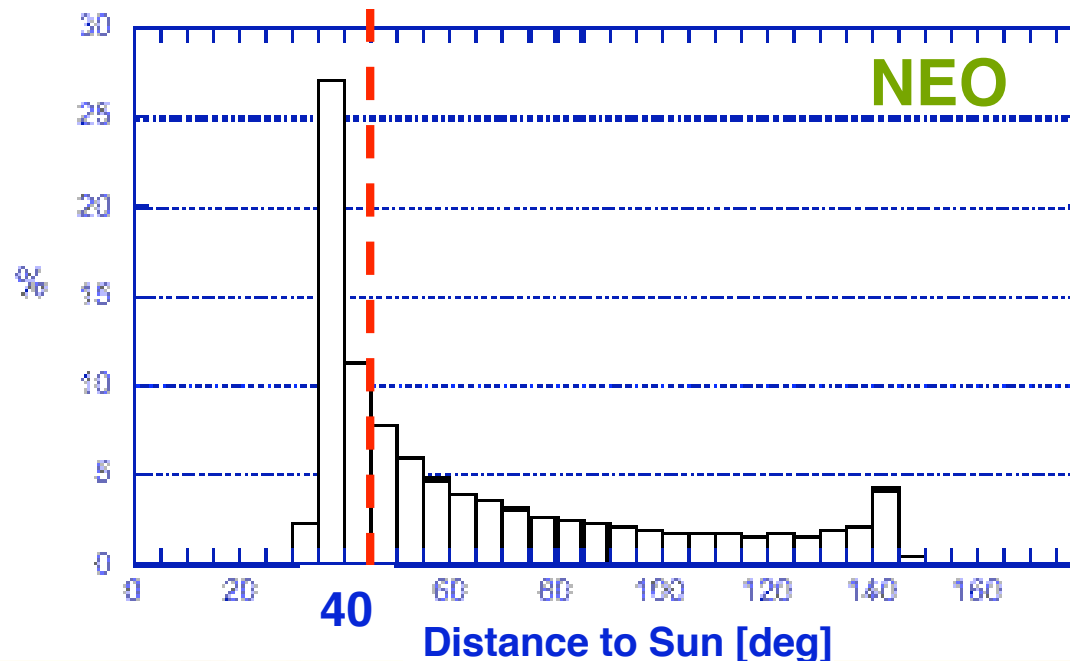
- Reference orbit for GAIA about L2 (F. Mignard)
- Possibility to obtain radial velocities, taxonomy (E. Dotto)
- How many objects and orbits by 2010 ? (V. Zappalà)
- Follow-up observations, quick alert (W. Thuillot)

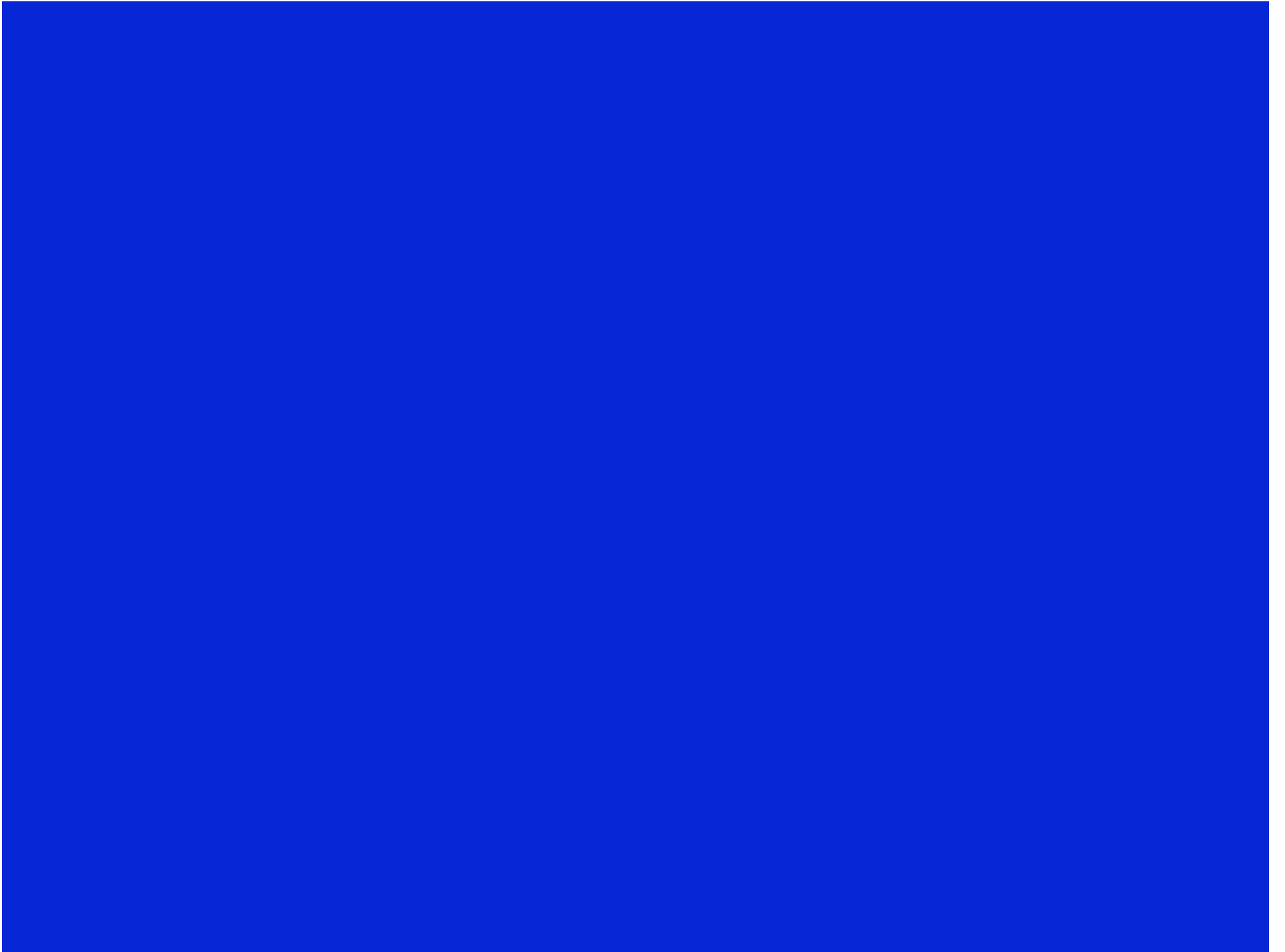
Solar System and Stars

- **Ephemeris of the planets**
- **Can saturate CCDs (blooming)**
- **Can corrupt data for stars**
- **Light deflection**
- **...**

New Design for GAIA

- **Detection to $V < 22$**
- **Combined fields: identification**
- **Spin rate ω : less observations/object**
- **Spin angle ξ : obs. at larger elongation**





Useful Numbers

D : diameter - H : abs. mag. - θ : angular diameter - V : apparent mag.

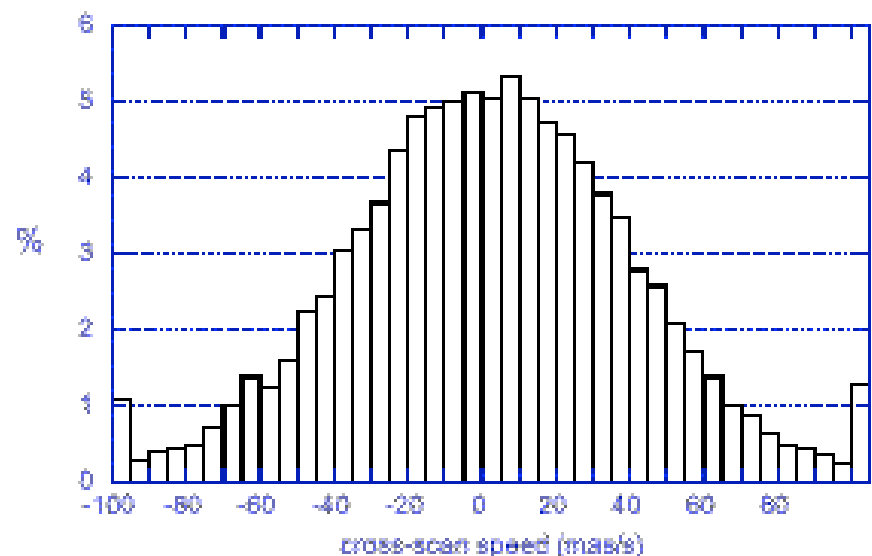
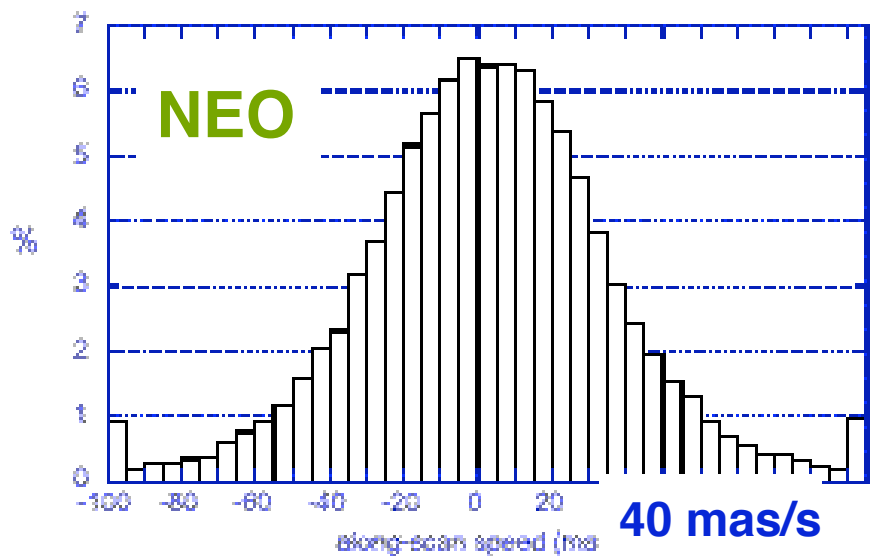
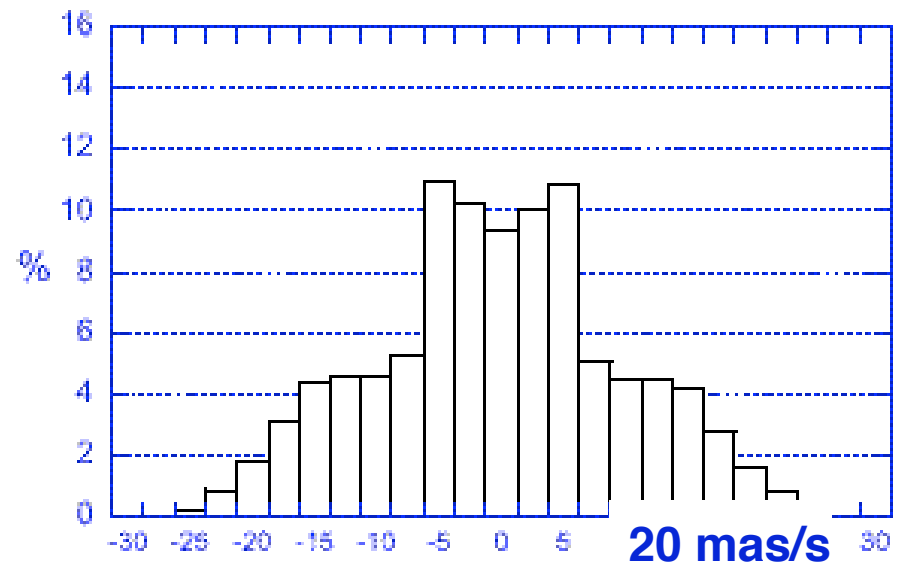
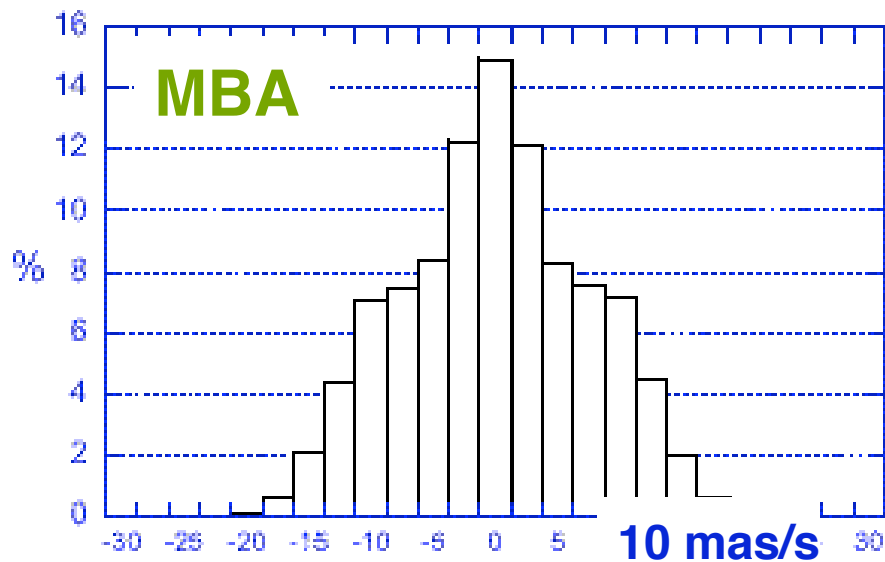
$= 1.7 \text{ au}$	$= 3.7 \text{ au}$	D	km	H	mag	θ	A	mag	V	mag	V	mag	2507.3520
						θ					θ		

Albedo = 0.05

Along-scan

Velocity [mas/s]

Cross-scan



Other tools (FM)

- Scanning law of GAIA as a callable subroutine

- ◆ call scanlaw(XMJD,XLSUN, PSI, TETA,PSIP,TETAP, SUN, EPS)

```
! input
!
!   xmjd  : date in modified julian days
!
! output
!
!   xlsun : longitude of the sun in degrees
!   psi   : ascending node/sun of the scanning circle in deg
!   teta  : inclination of the scanning circle in deg
!   psip  : dpsi/dt in "/s
!   tetap : dteta/dt in "/s
!   sun   : heliotropic abscissa of the node
!   eps   : latitude of the sun /scanning circle (pi/2-xi)
```

KBOs

