

Gaia Mission: Solar System Dynamics

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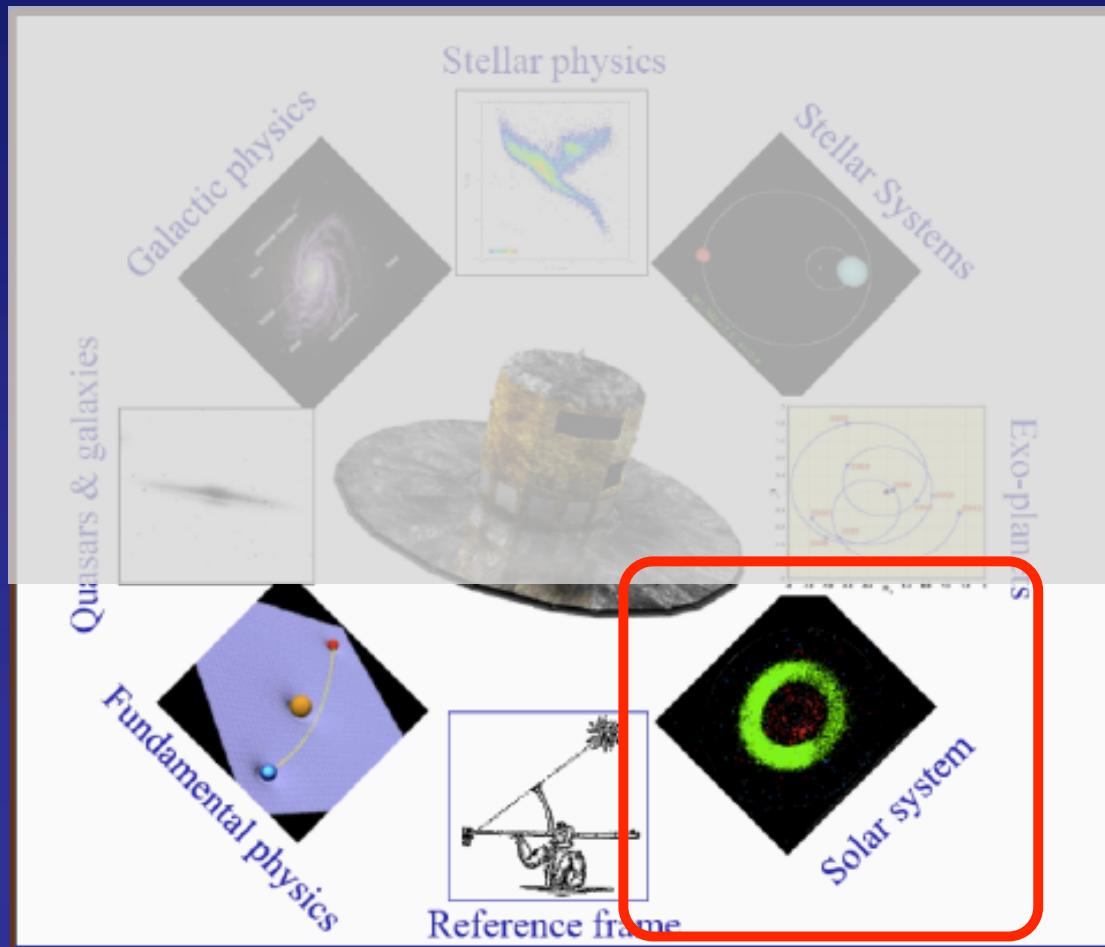
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JSR, Sep. 2013 – Observatoire, Paris

From F. Mignard's talk

gaia

Driven by Astrometry, designed for astrophysics



yet SSO & and dynamics
are included

Gaia – observations of SSOs



- Asteroids ($\approx 300,000$ – mostly known)
 - ▶ Main Belt Asteroids (MBA)
 - ▶ ~ 1600 Near Earth Objects (NEO)
 - ▶ Other populations (Trojans, Centaurs, Pluto/Charon, binaries, ...)
- Comets
 - ▶ ~ 200 Jupiter family JFC, a few long period LPC
- « Small » planetary satellites
 - ▶ about 20 objects in total - M, J, S, U, N
 - ▶ « regular » and « irregular » (retrograde orbits)
- Also exoplanets but NO “large” extended bodies
 - ▶ Major planets, large satellites, (Ceres marginally)

Gaia Fact Sheet



Launch	Nov. 20, 2013
Duration	5 years (+1yr extension)
Observing mode	CCD, TDI, scanning
Orbit	L2 Earth–Sun
Solar elongation	$45^\circ \leq L \leq 135^\circ$
# observations	≈ 60 obs/target in 5years
Limiting magnitude ; size	$V \leq 20$; $\emptyset \leq 700\text{--}900$ mas
Astrometric precision /CCD	$AL \approx 0.2\text{--}2$ milli-arcsec (mas)
Photometric precision	≈ 0.001 mag
Catalogue release	$\approx 2020 +$ intermediate (TBD)

Identified science



RP/BP
spectrophot.

- Snapshot photometry over 5 years :
rotation, pole, shape
- Photometric data in several bands :
taxonomic classification

- Diameter *for over 1000 asteroids*
 - *(with mass => density ; with H => albedo)*
- Binary asteroids *(sep >100 mas)*

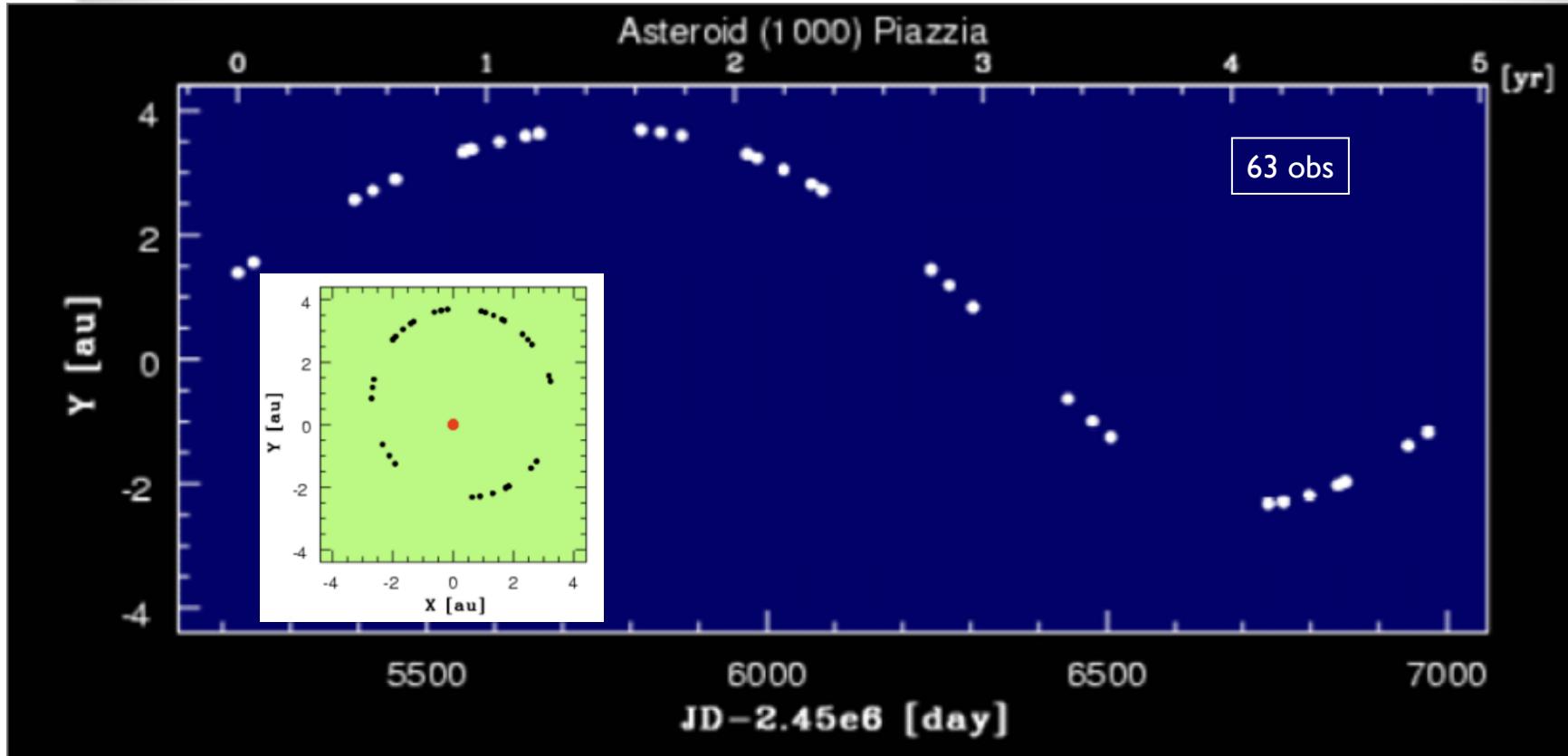
CCD signal

Astrometry
AL centroing

- Systematic survey - *discoveries possible*
- Orbits : X 50 improvement ; or preliminary
- Masses from close encounters *for ≈100 asteroids*
- Local test of GR ; non grav. effects

direct - from Gaia data

Orbit coverage

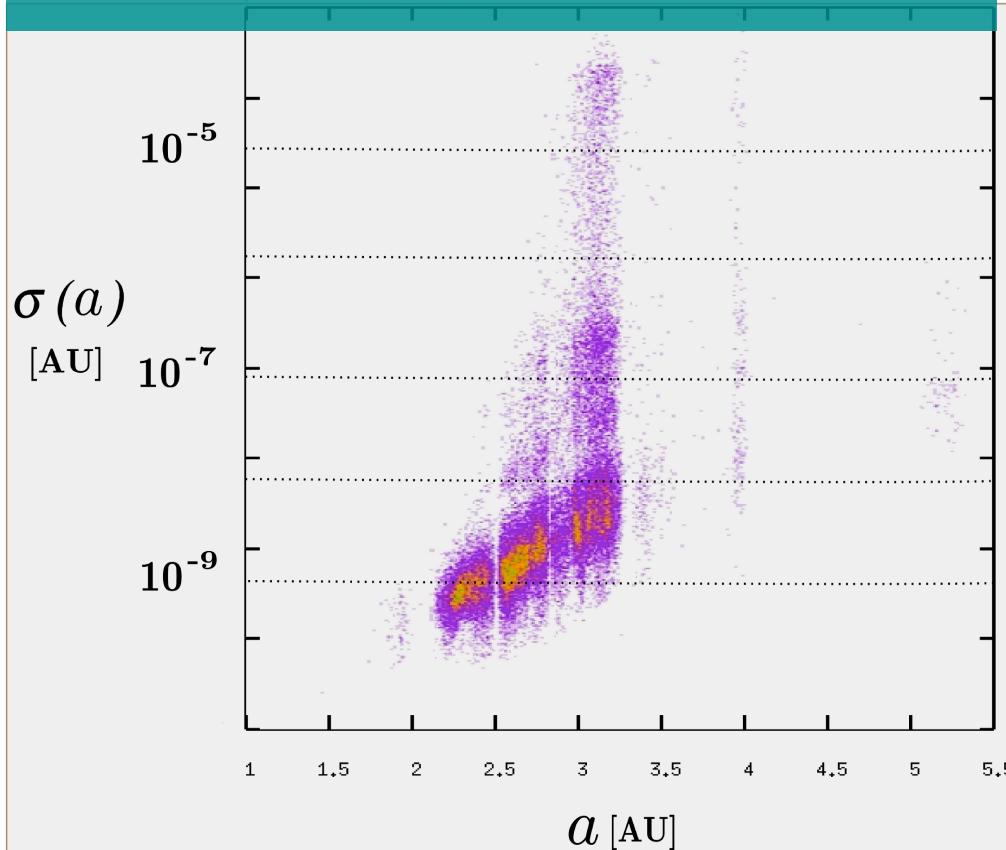


- A typical MBA, orbital period ≈ 5 years
- Different for NEA, Centaur, faint objects, ...

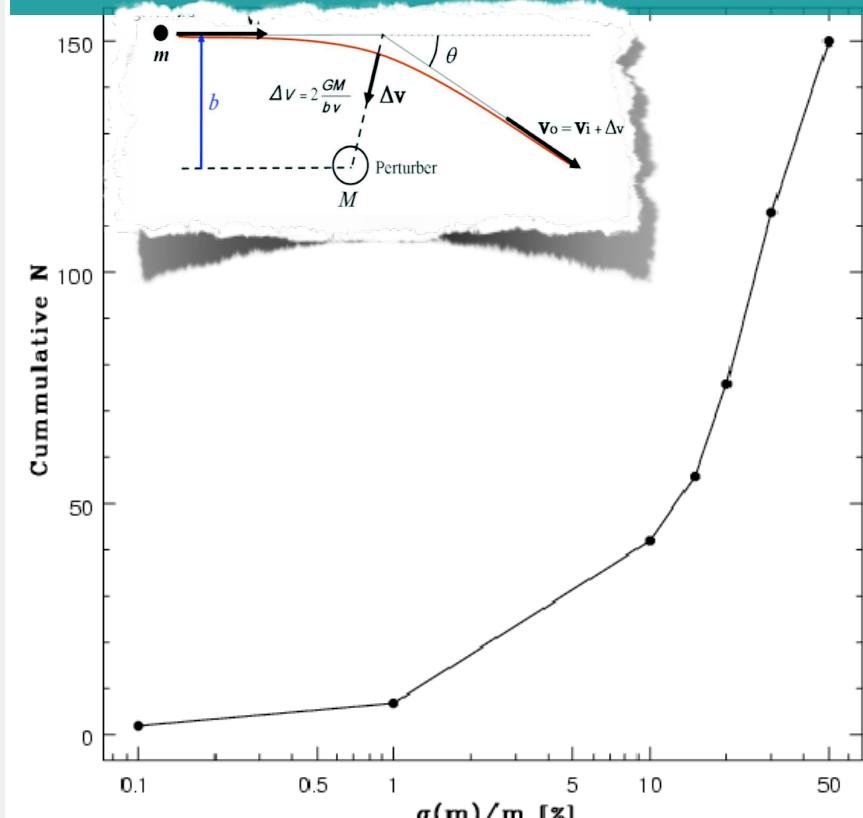
Orbits and mass



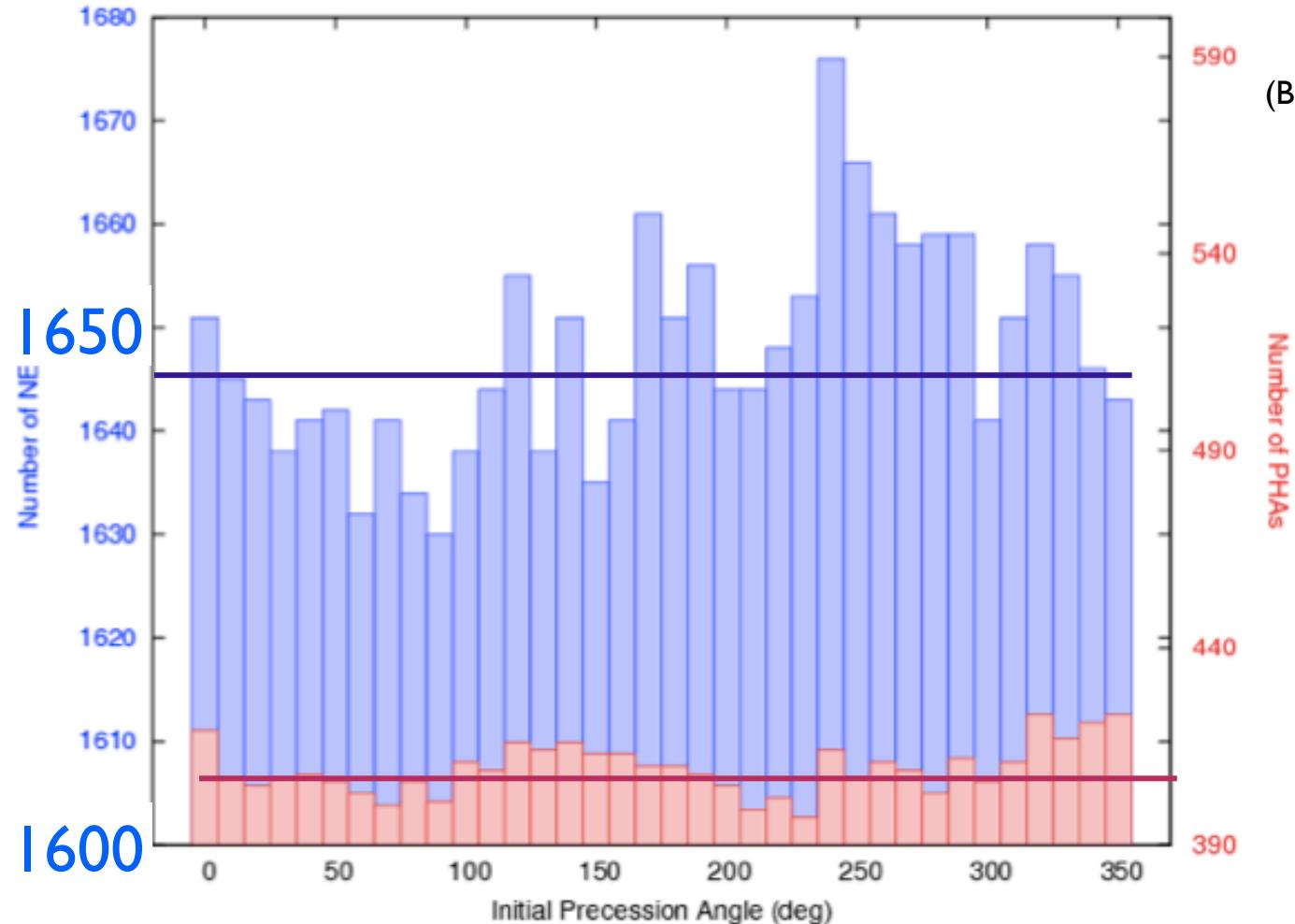
- Orbit improvement $\approx 50\times$
- Gaia data alone
- Robust LLS (no partic. cases)



- Mass determination ≈ 100
- Gaia data alone
- + Densities

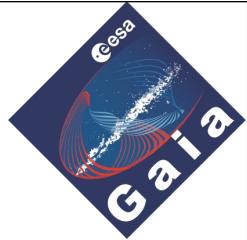


NEOs - PHAs



(Bancelin et al. 2010)

Local test of GR



also indirect - with Gaia data

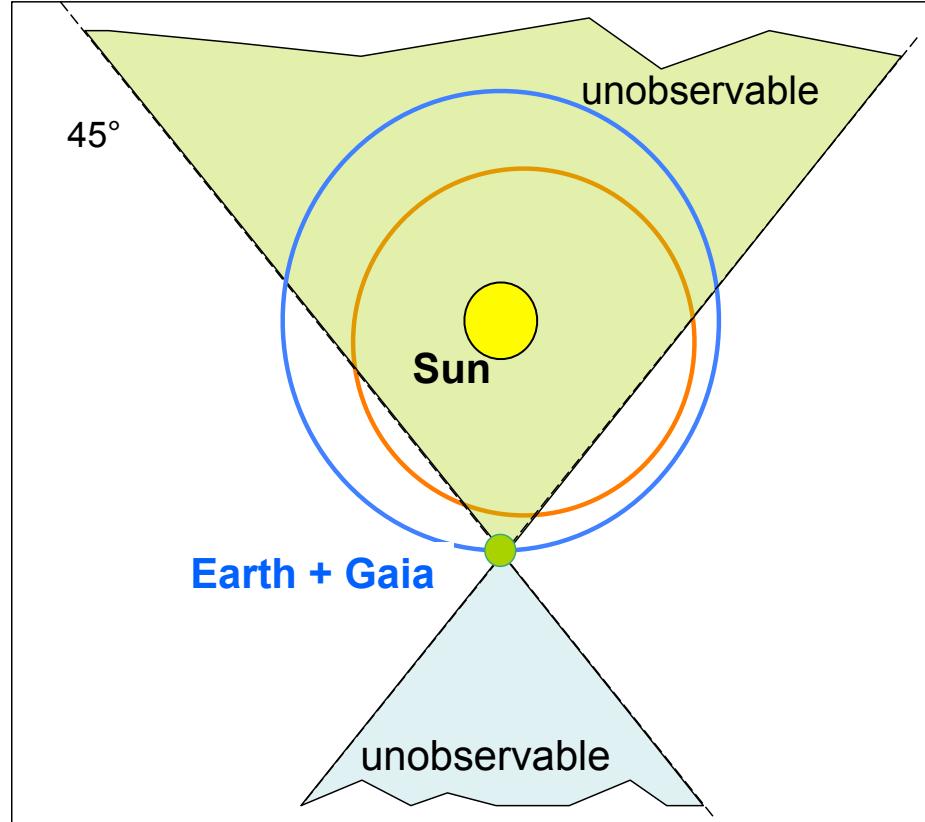
- PPN formalism
 - $\beta (10^{-4})$, $J_2 (10^{-8})$ simultaneously (NB: γ from stars)
 - independant of η Nordtvedt
 - gravitational constant $d(GM)/dt (10^{-12})$
- Reference frame
 - kinematical vs. dynamical non-rotating frame
 - rotation rate wrt to QSO in absolute frame
- Non gravitational forces
 - comets only one apparition (A_1, A_2, A_3)
 - Yarkovsky - simple A_4 parameter (Chesley)
- Any other
 - 1 year extension?
 - combine with ground-based data
 - e.g. SEP Nordtvedt η , anomalous acceleration κ (Wallin et al.), post-Einsteinian grav. (Jaeckel et al.), Lense-Thirring

see poster

Science alert



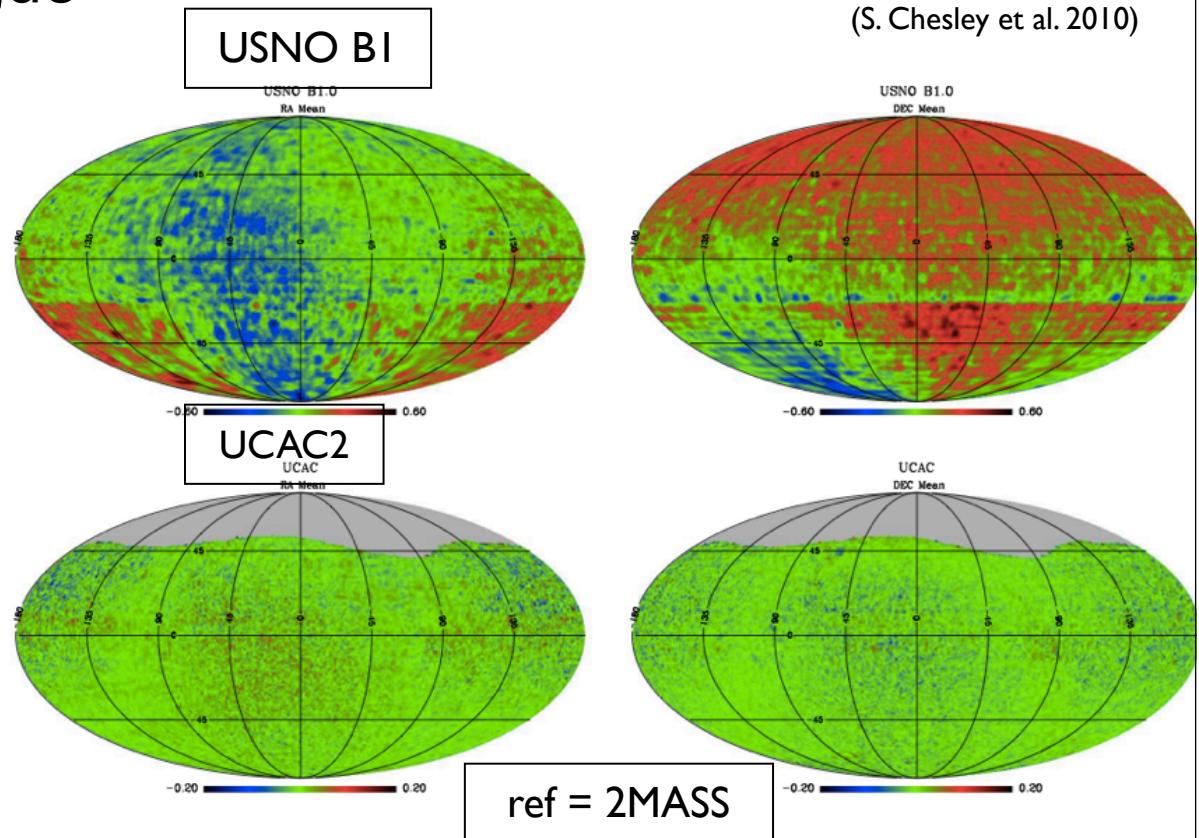
- All sky survey
Low elongation
- Possibility to discover
IEOs, sub-Atens, Attiras,
quasi-satellites, ...
- Science alert
 - 50 mas precision
 - ground-based support Gaia-FUN-SSO
 - <https://www.imcce.fr/gaia-fun-sso/>



Post-Gaia era



- Gaia Astrometric Catalogue
 - Stochastic/Systematic
 - high precision
 - proper motion
 - Little zonal errors
 - Homogeneous, dense



Post-Gaia era



- Gaia Astrometric Catalogo
 - Stochastic/Systematic
 - high precision
 - proper motion
 - Little zonal errors
 - Homogeneous, dense
- Reduction of obs.
 - future CCD images
 - old plates
 - NAROO project

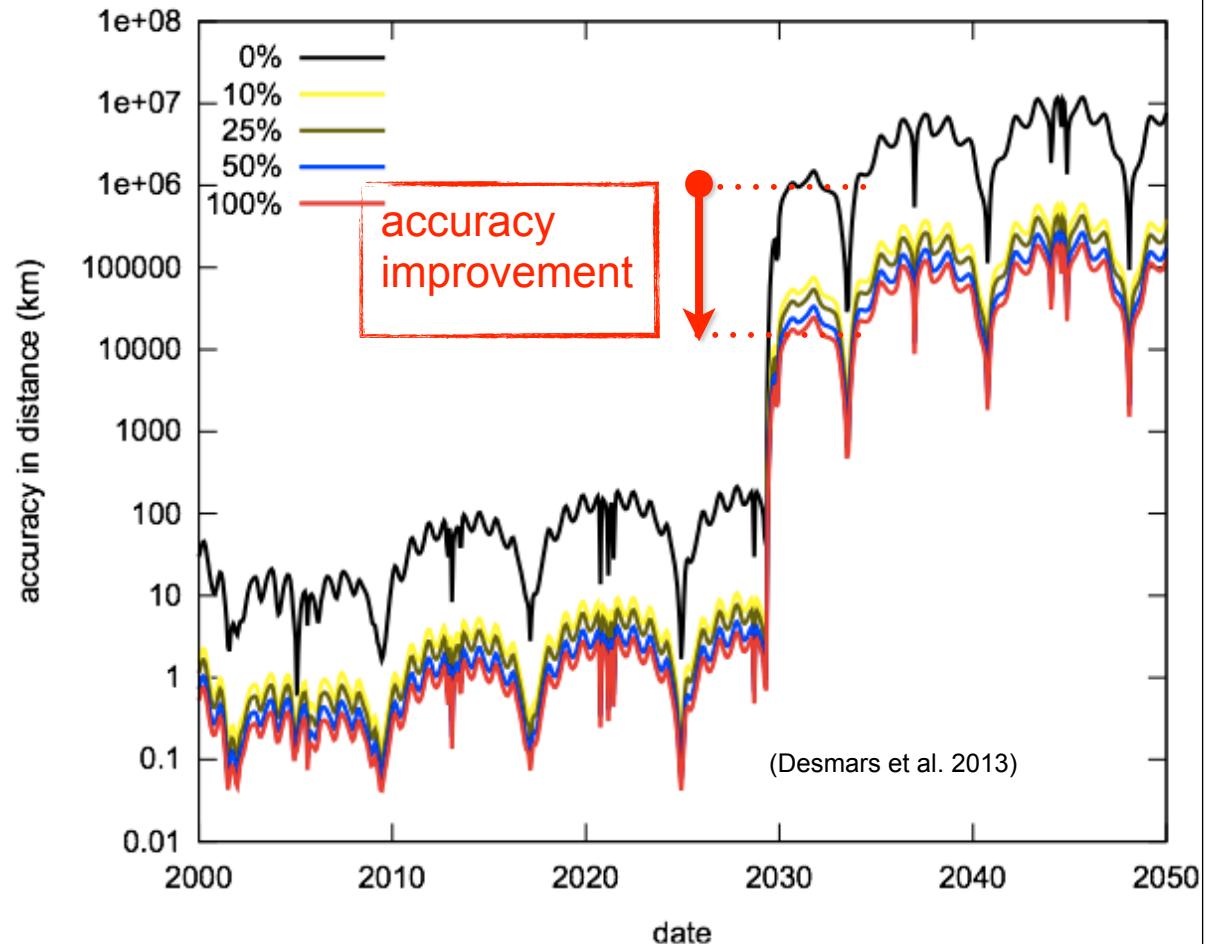
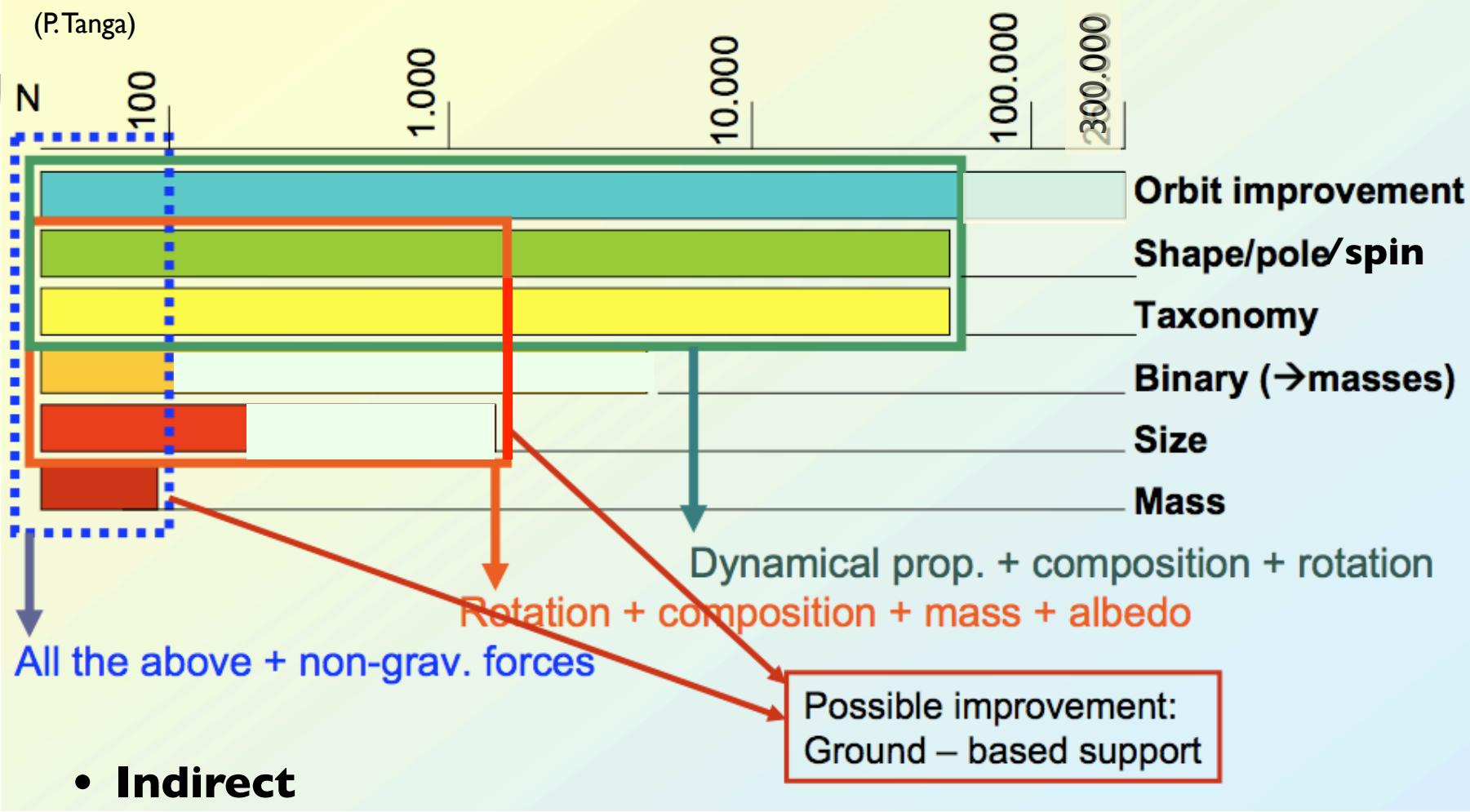


Fig. 9. Evolution of the position uncertainty of asteroid Apophis by considering that a certain percentage of optical observations could be reduced with Gaia stellar catalogue, i.e. with an accu-

Science Summary



- **Indirect**

- space/ground complement
- occultation prediction
- Gaia catalogue for SSO astrometry (future & past)
- satellites, planets
- refined analysis

