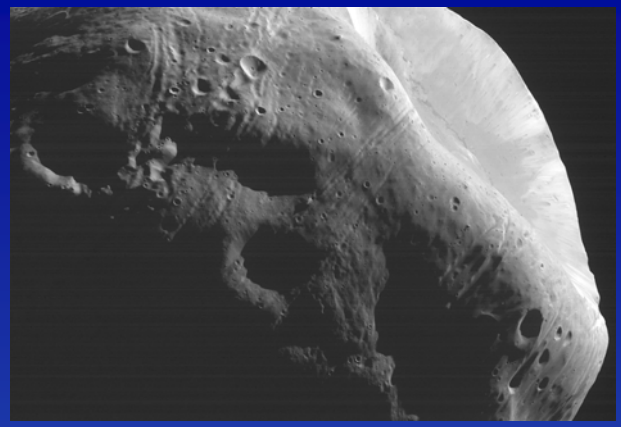
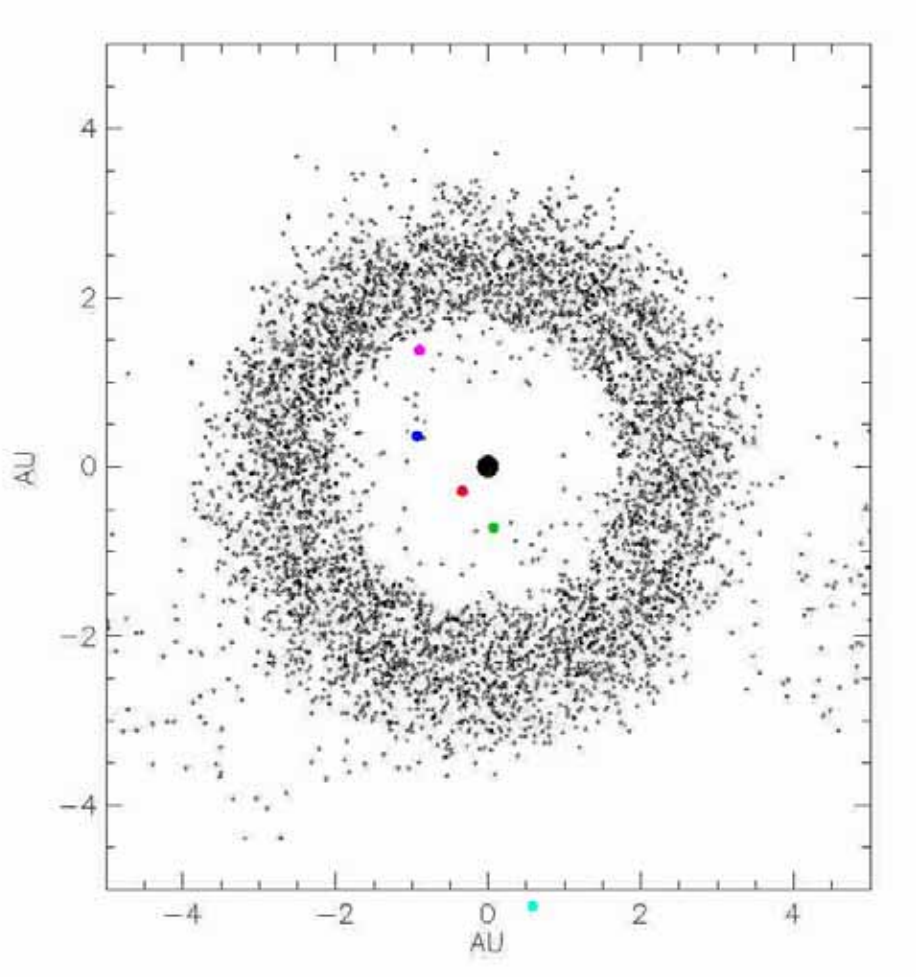


Solar System science: Gaia in the 2015→2020 context

P. Tanga, F. Mignard

Observatoire de la Côte d'Azur



M. Delbo’

- Peculiar properties of SSOs
- Expected Gaia science
- Role of Gaia data

Asteroid Science

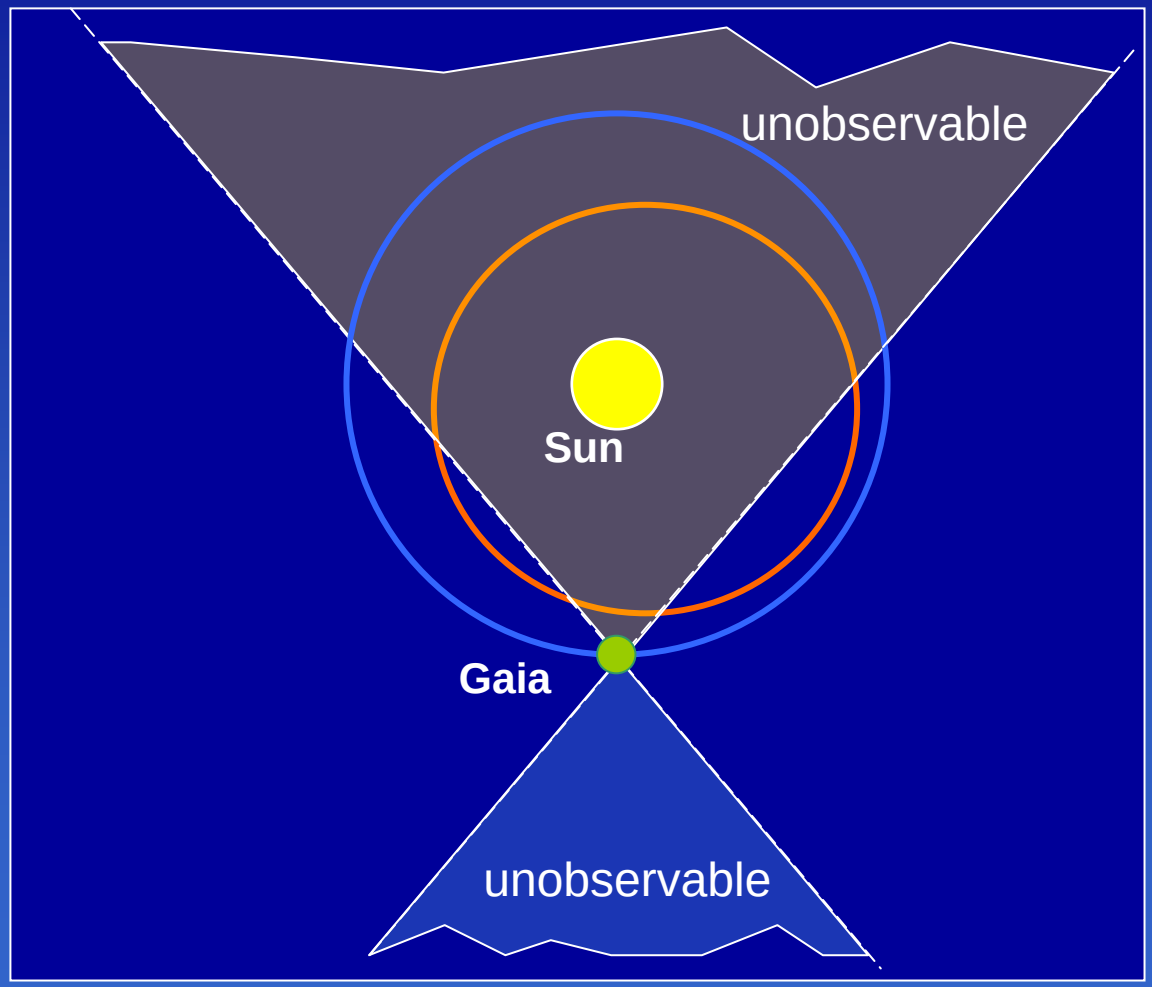
- Main issues:
  - Origin: collisional life, related physics
  - Dynamical processes:
    - transport, mixing in the primitive nebula, origin of meteorites
  - Impact risks and mitigation strategy
- Main problems: lack of basic data
  - density, porosity…
  - Spectral types and connection to composition
  - Shapes, satellites
  - Size distribution

How much is / will be known

Property	today	Gaia
astrometry	~ 0"5	0"005
rotation periods	1000	~100,000
shapes, poles	100	~100,000
spectral type	~ 1800	~200,000
masses, $\sigma < 60\%$	~ 40	150
size , $\sigma < 10\%$	~ 500	1000
satellites	~ 20 (MBA)	?

Discovery potential and follow-up

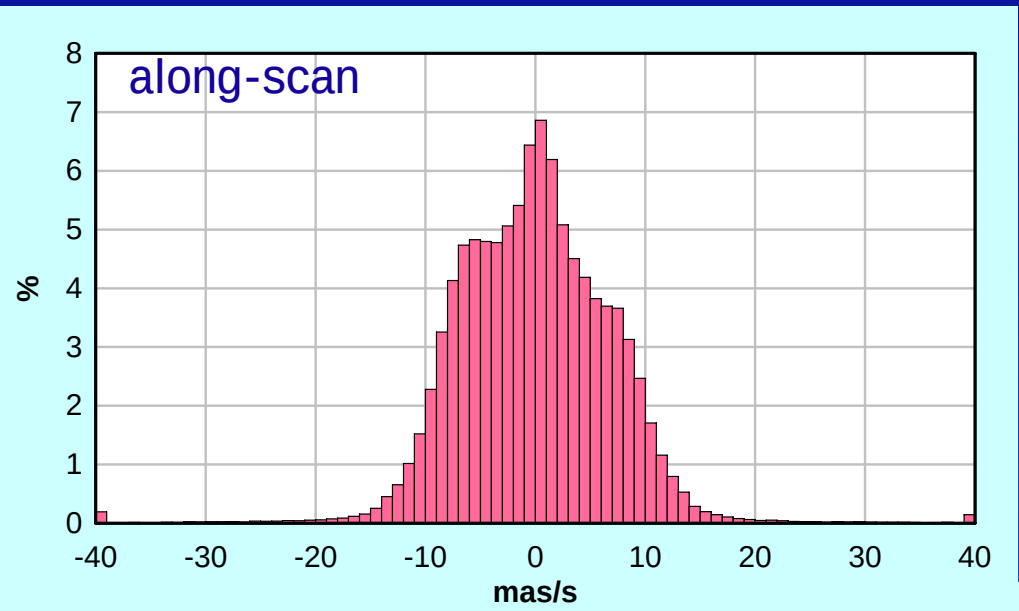
Observable region on the ecliptic plane



~ 70 detections/ 5 years for Main Belt asteroids

- Discovery space:
  - Low elongations (~45-60°)
  - Inner Earth Objects (~unknown)
  - Other NEOs

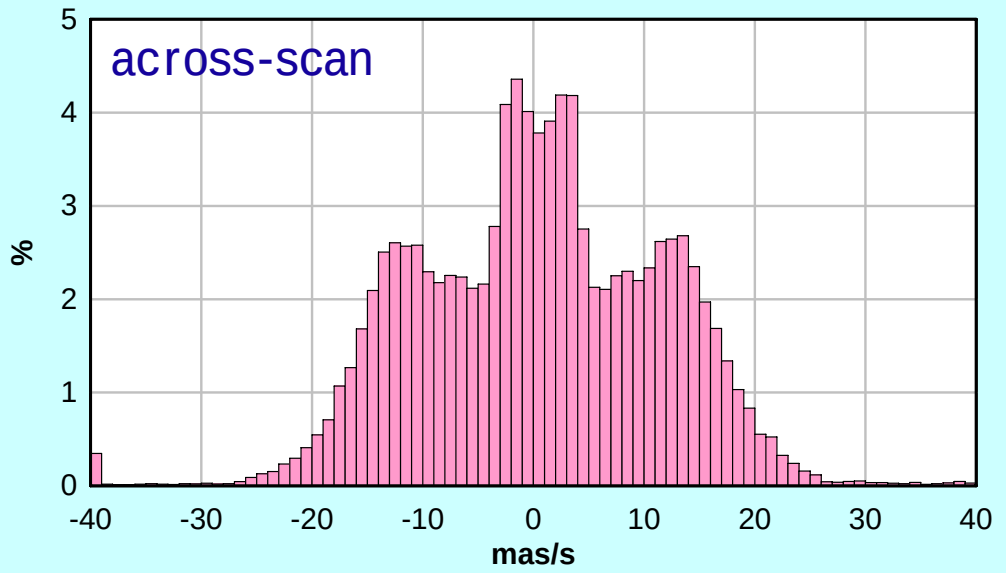
Velocity distribution



- simulation on 5,000 objects
  - main-belt, NEOs
- motion detectable over 1 transit

$\sigma \sim 7$ mas/s

$\sigma \sim 12$ mas/s



CU4 : two pipelines for SSO

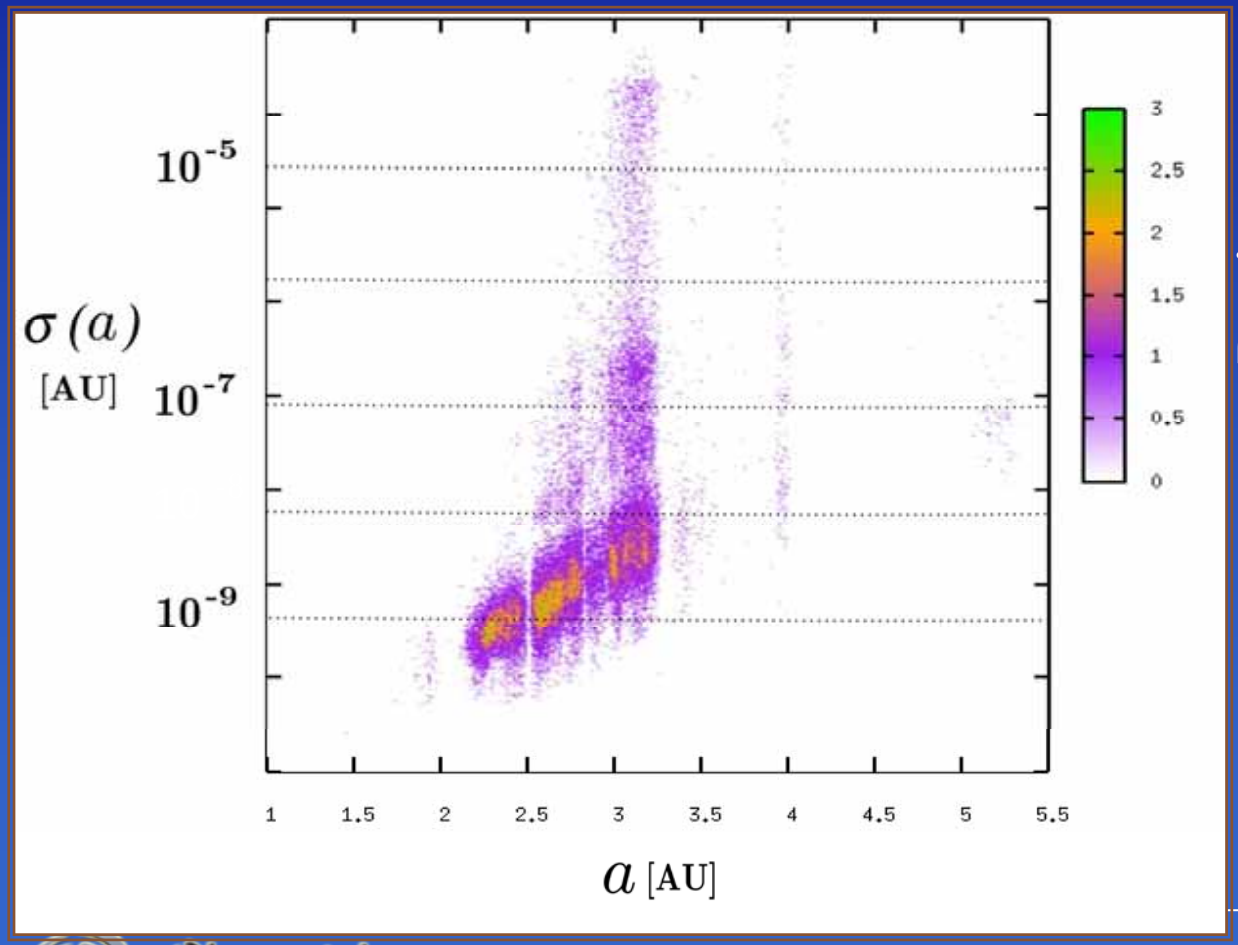
- **Input data: sources not matched by IDT**

- **Short-term (daily) processing**
  - Shortest timescale available
  - Fast processing of astrometry
  - Aims: **identification** of new of poorly known objects → diffusion of predictions to a network (DU459) and positions to the Minor Planet Center

- **Long term processing**
  - Best accuracy
  - Complex object model (shapes, motion,…), best astrometric solution, all effects taken into account
  - Aims: intermediate → final data releases

Astrometry → orbit refinement

- Orbit reconstruction from simulated data
  - point sources & gravitational interaction
  - solar system perturbations

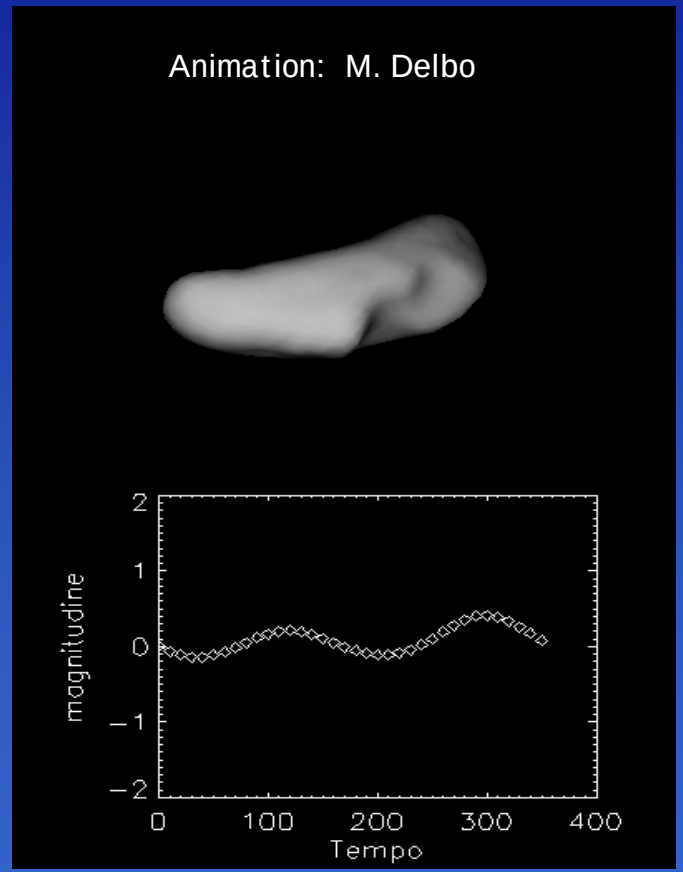


> 10^2 better than current accuracy!

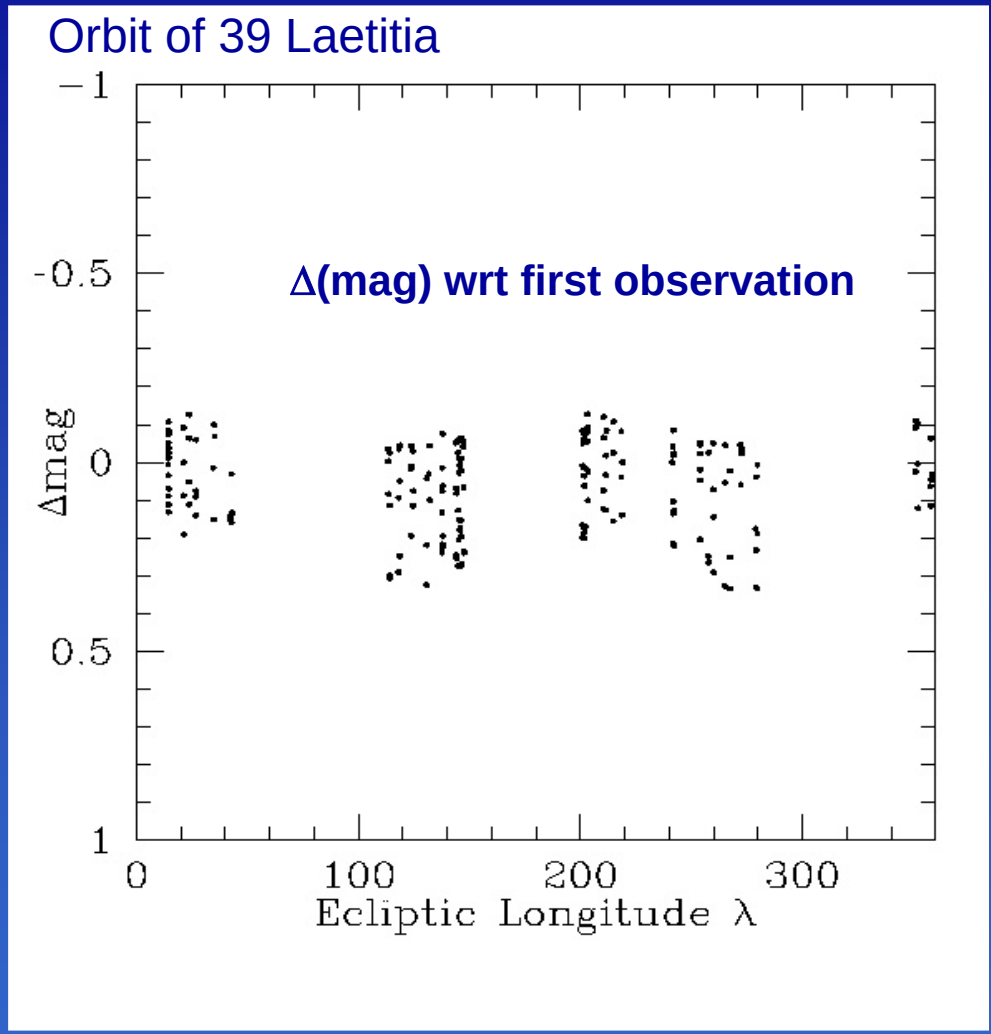
Mouret at al.

Photometry → Shapes

- Asteroid's magnitude function of:
  - shape, rotation period, direction of spin axis
- Direct problem:
  - model of light curves for different shapes and rotation
- Inverse problem:
  - find the rotation parameters from photometric data
  - strongly non linear
- Choice for Gaia:
  - Three-axial ellipsoids



Simulated Gaia photometry



$\lambda_p = 30$

$\beta_p = 60$

b/a = 0.7

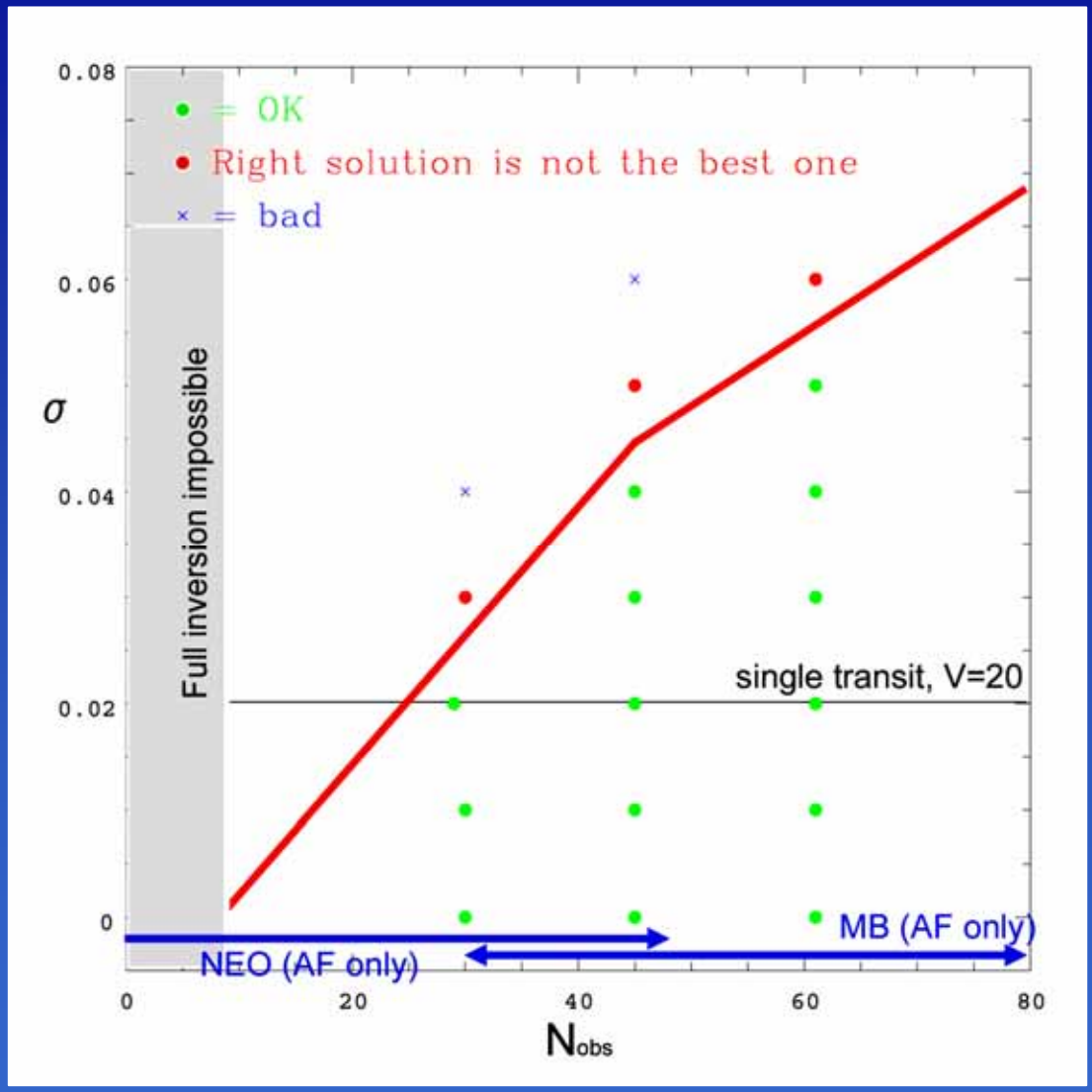
c/a = 0.5

$P = 7^h.527$

$\phi_0 = 0.4$

A. Cellino, P. Tanga, M. Delbo

Inversion limits

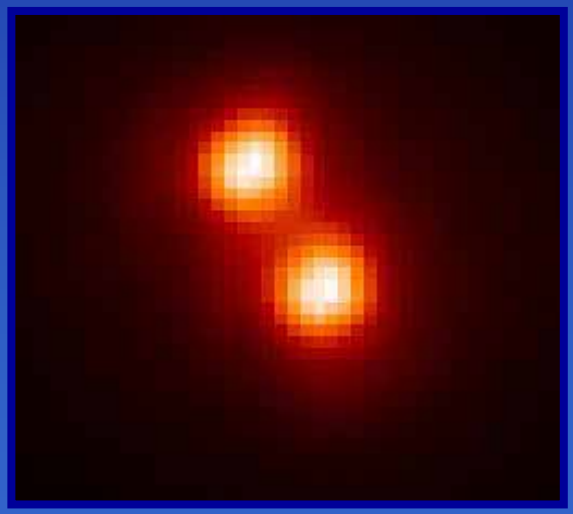


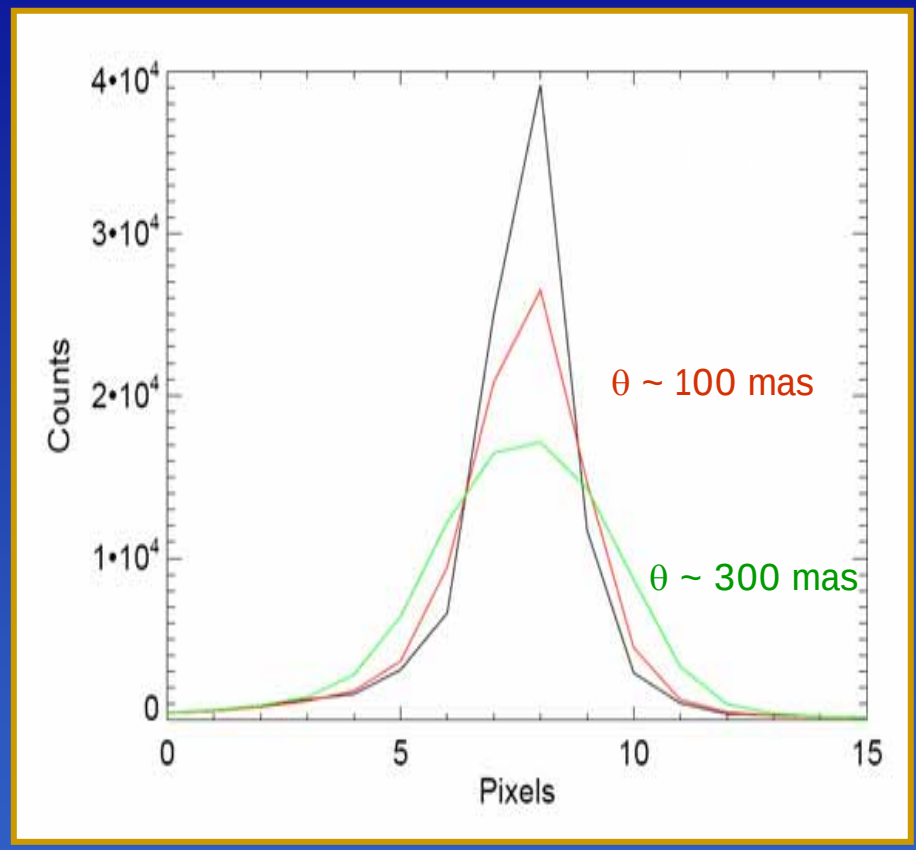
Ellipsoidal model inversion

A. Cellino, P. Tanga

Size of the asteroids

- Direct size determination for over 1000 asteroids
- Good quality sizes for D>40km
- Object's size at different epochs
  → overall shape
- Binarity

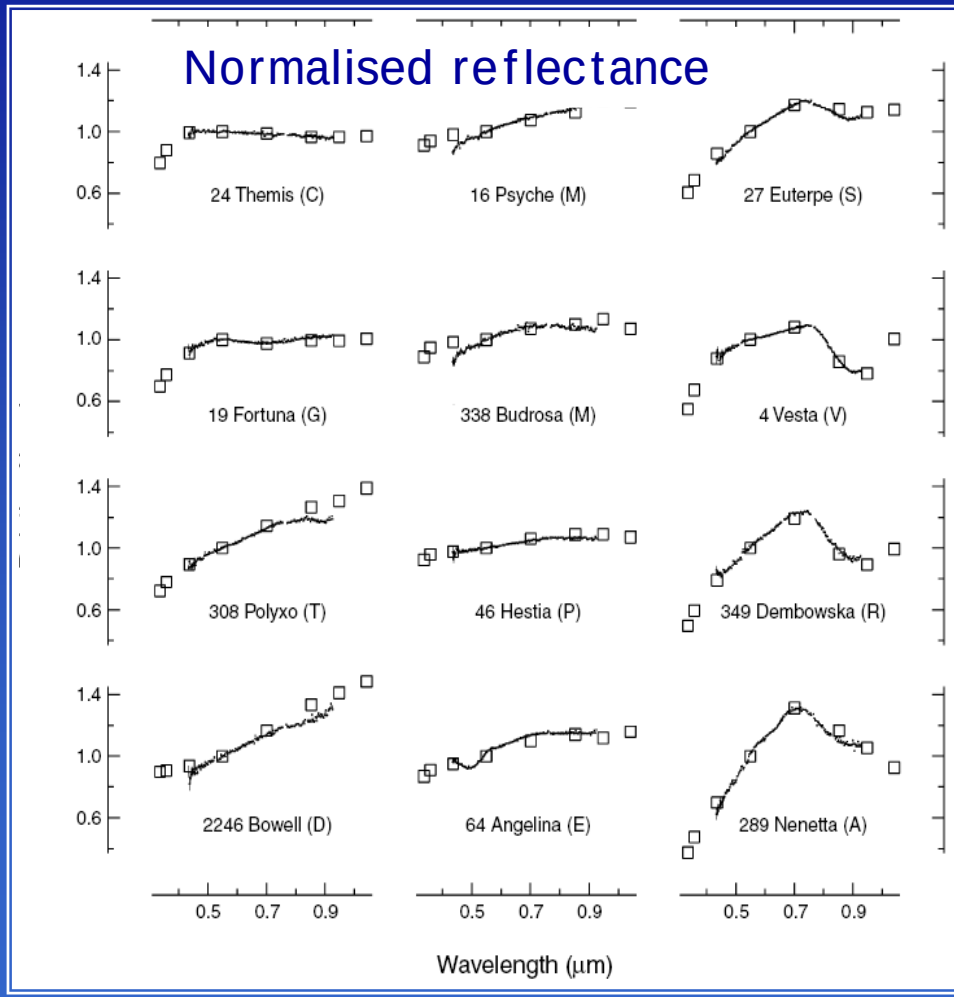




Basic images for different source diameter

RP/BP → Taxonomic classification

- Taxonomy classifies asteroids on the basis of visible *and* near-IR reflectance spectroscopy
  - Based on ~1000 objects today
- Gaia special features:
  - High solar elongation
  - Blue spectrum coverage
  - Several "bands"
  - → Preliminary investigation on earth-based observations
- Limitations
  - …no albedo → ambiguity E,M,P…
- automatic classifier developed for Gaia
  - → *Gaia taxonomy*



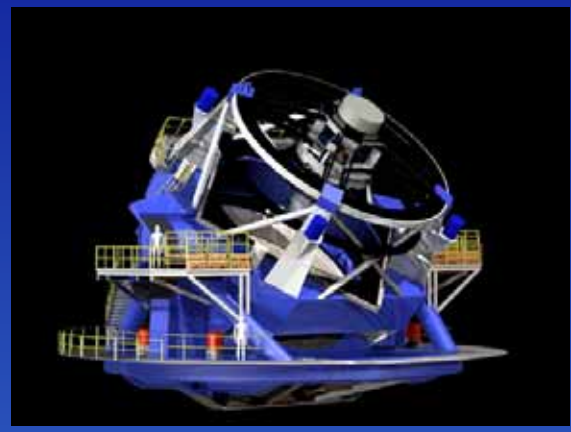
Science goals : summary

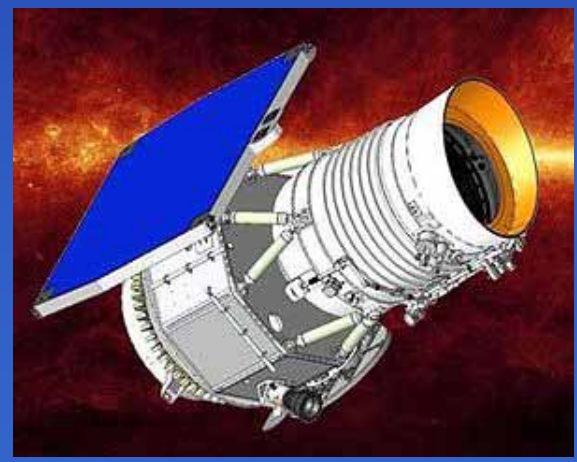
- Systematic survey down to 20 mag ~ $3x10^5$ objects
  - Main belt
  - NEOs
- Orbits : virtually all object observed - x30 better than now
  higher resolution of dynamical families
- Masses from close encounters ~ 100 masses expected

- Diameter for over 1000 asteroids : shape, density
- Binary asteroids
- Photometric data in several bands : albedo, taxonomic classification
- Light curves over 5 years : rotation, pole, shape
- Space distribution vs. physical properties
- Perihelion precession for 300 planets : GR testing, solar J2

Next generation Earth-based surveys for dynamical and physical characterization

- Panoramic Survey Telescope & Rapid Response System (Pan-STARRS)
- Large Synoptic Survey Telescope (LSST)
- Wide-Infrared Survey Explorer (& Spitzer)





Home | Science Goals | Asteroid Threat | Design Features | Project Status | Internal Pages

Pan-STARRS
UNIVERSITY OF HAWAI'I

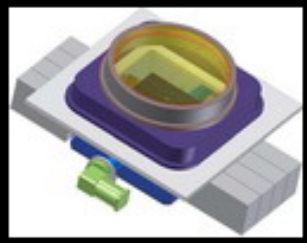
Dangers from space

Learn about the threat to Earth from asteroids & comets and how the Pan-STARRS project is designed to help detect these NEOs. Learn more...

1,400,000,000 pixels

Pan-STARRS has the world's largest digital cameras.

Read about them here...



The PS1 Prototype

PS1 discovers its first supernova!

PS1 consortium formed...

More about PS1 here...

Zoomable images from PS1

Survey details

- Pan-STARRS (PS1 – 2010 ??...)*
  - V = 24, 5 Sloan bands - σ~63 mas + parallaxes - whole sky 4 /month
  - 100,000 Jupiter Trojans (2900 now), 20,000 Kuiper belt objects (800)
  - PS1 operated from March to September 2009: 4000 asteroids, 7 new
  - Automated analysis and extraction of transient sources
  - Plans for **photometric inversion → « complex » shapes**

- LSST (2015…)*
  - V=24, 6 bands σ~9 mas + parallaxes whole sky 8 /month
  - 30 TB each night, immediately public
  - **Plans for NEO search – not yet clear for other aims**

- WISE (under way)
  - 4 bands (3.3 – 23 μm), 1000 x IRAS sensitivity (1983)
  - <10 observations for 100,000 asteroids

  ….also SPITZER (more objects, lower precision)

  → albedos

Gaia and the others…

Gaia

SSO orbit accuracy
coverage at small elongation
spectro-photometry resolution
photometric accuracy

Pan-STARRS, LSST

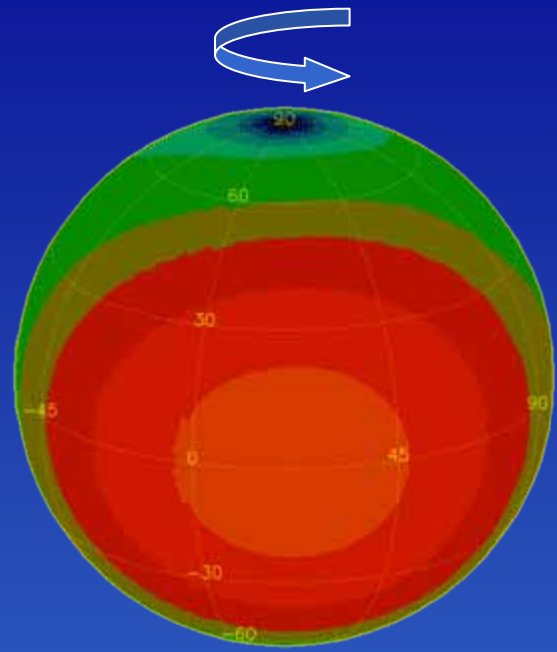
Higher number of observations
→ Complex shapes
Smaller objects accessible
Longer operation

Gaia is not said to save mankind from extinction…

…but could give a contribution on specific asteroids!

Gaia & WISE

- Thermal observations → surface temperature of a SSO
  - Thermo physical model are based on a knowledge of shape
  - No shape model → larger size uncertainty (30% common)



- Complementarity:
  - Gaia asteroid sample about the same size
  - Gaia shapes parameters can be used for thermal modeling

→ Size inventory in a “global” solution

Conclusions

- Gaia is an impressive tool for Solar System science
- Complementary in several aspects of other surveys
  - Better astrometric accuracy
  - Smaller solar elongation
  - Great support to WISE observations of about the same population of objects
- Open problems in photometry inversion
  - Space – based data more accurate (?)
  - Which difference in practical use of different shape models (ellipsoid vs compex) ?

The End…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