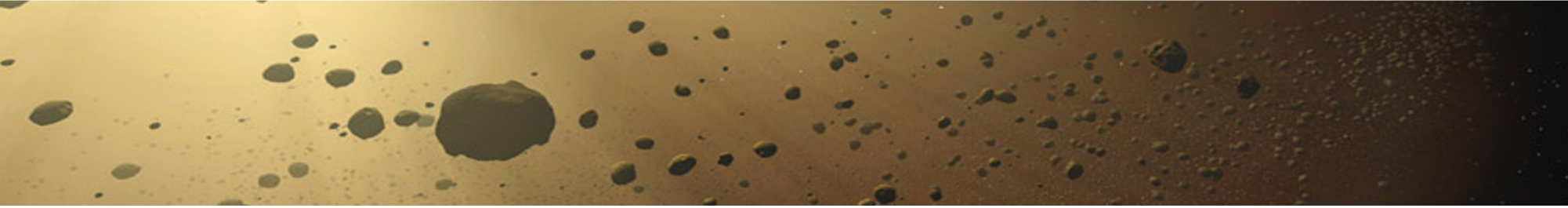

Physical models of asteroids from photometric surveys:
preparation of Gaia data exploitation

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Science from the Gaia Data Releases, Barcelona (Catalonia)

December 2nd, 2014

How much is/will be known

Property	today	Gaia
rotation periods	$\sim 5,000$ ($\sim 1\%$)	$\sim 50,000$ ($\sim 10\%$)
shapes, poles	~ 400 ($\sim 0.1\%$)	$\sim 50,000$ ($\sim 10\%$)

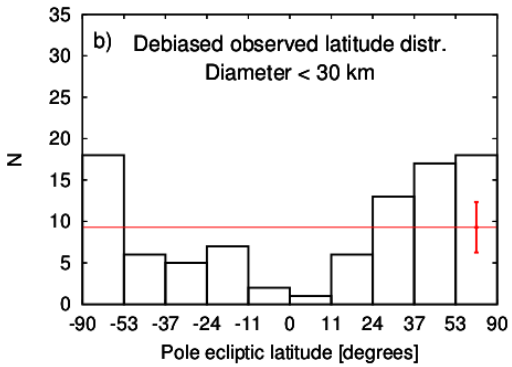


Figure: Observed latitude distribution of main-belt asteroids, Hanus et al. 2013

As an important application, we mention that the constraint for the value of cYORP can be used in simulations of the long-term dynamical evolution of asteroid families. "..." Constraining cYORP therefore removes one free parameter from the simulations and should thus lead to a better determination of the ages of asteroid families.

Non-gravitational forces

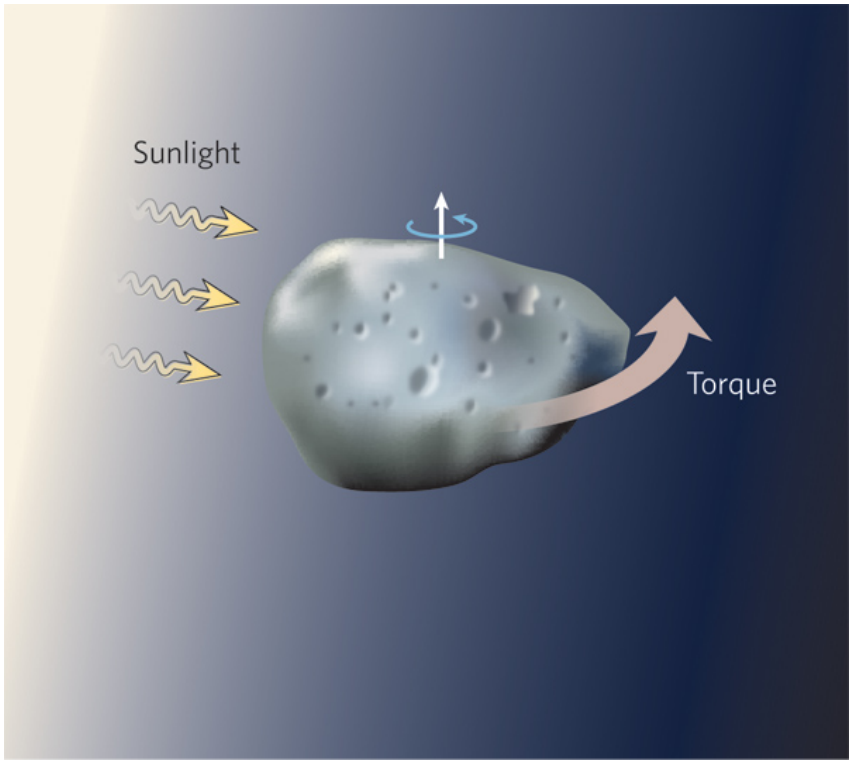


Figure: An unevenly shaped asteroid heating up in sunlight re-radiates the energy away at right angles to its surface. The resultant net torque can change the asteroid's spin rate, Bottke W.F., 2007

Can we predict if...

- the resulting modelling sample is going to be affected by a selection bias?
- the inversion is better performing for given values of the asteroids' physical parameters?

If bias do exist...

- what can we do to improve the results?

Gaia photometry simulations

- Sample of 10.359 asteroids with...
  - Triaxial elipsoid/non-convex
  - Different scattering laws
  - Period sample: Maxwellian distribution
  - Poles uniformly distributed in space
  - Orbits: Mainly main-belt

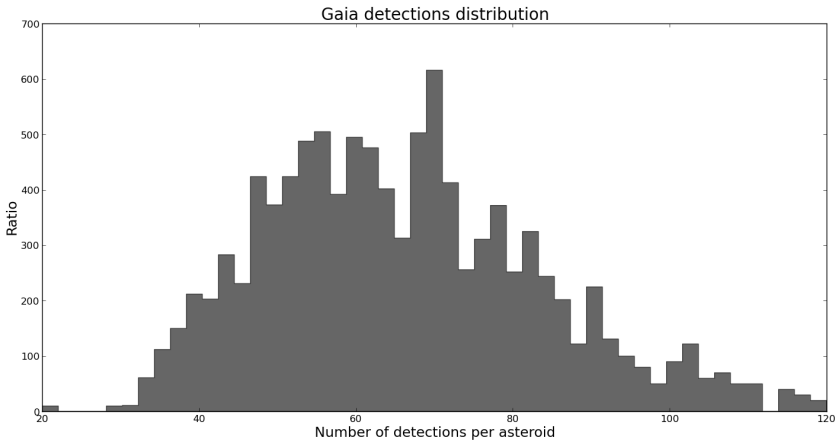


Figure: Histogram shows the distribution of total detections per asteroid from the Gaia simulations for 5 years.

Results for the 'ideal' case: sample already biased!

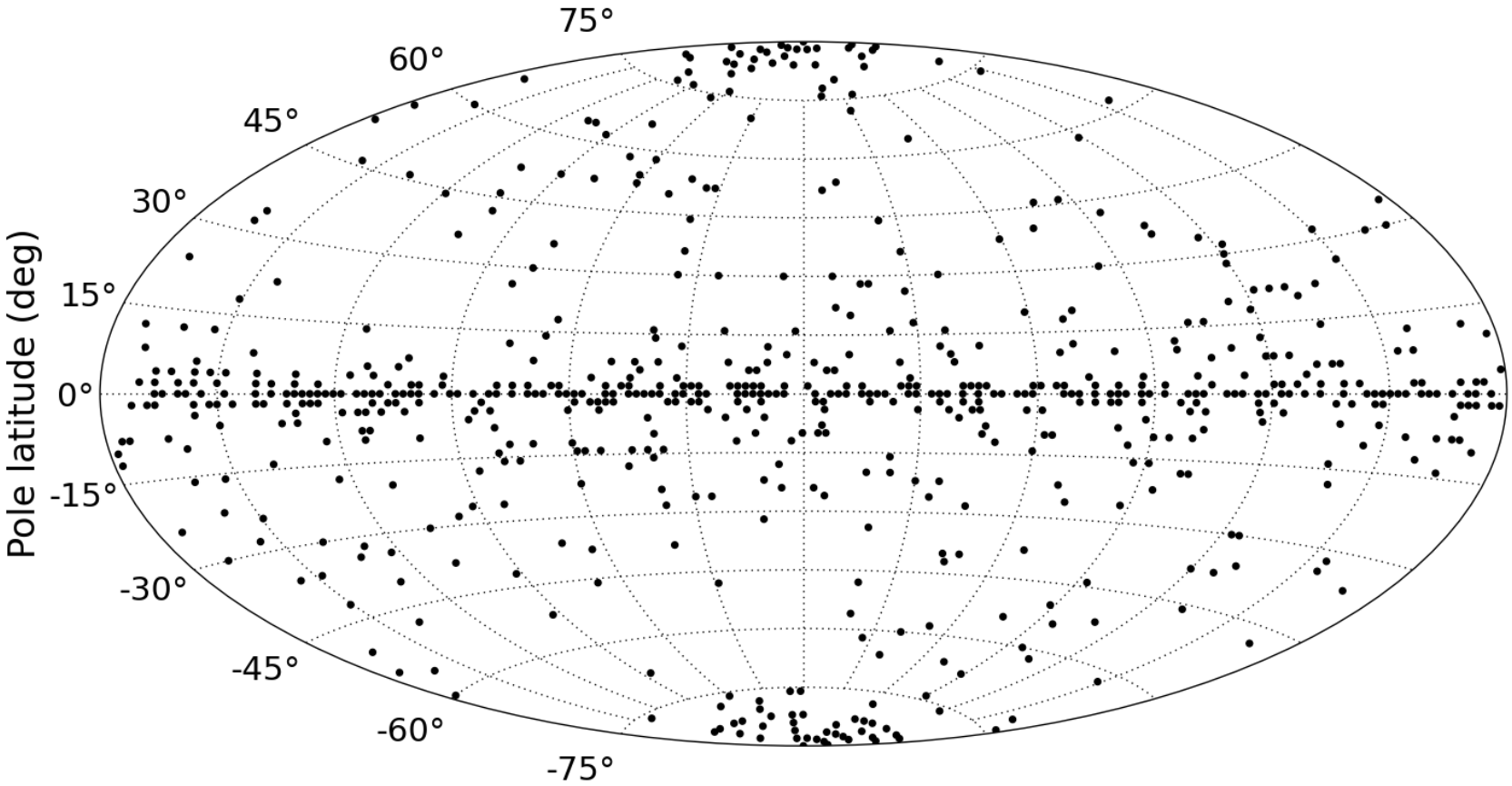
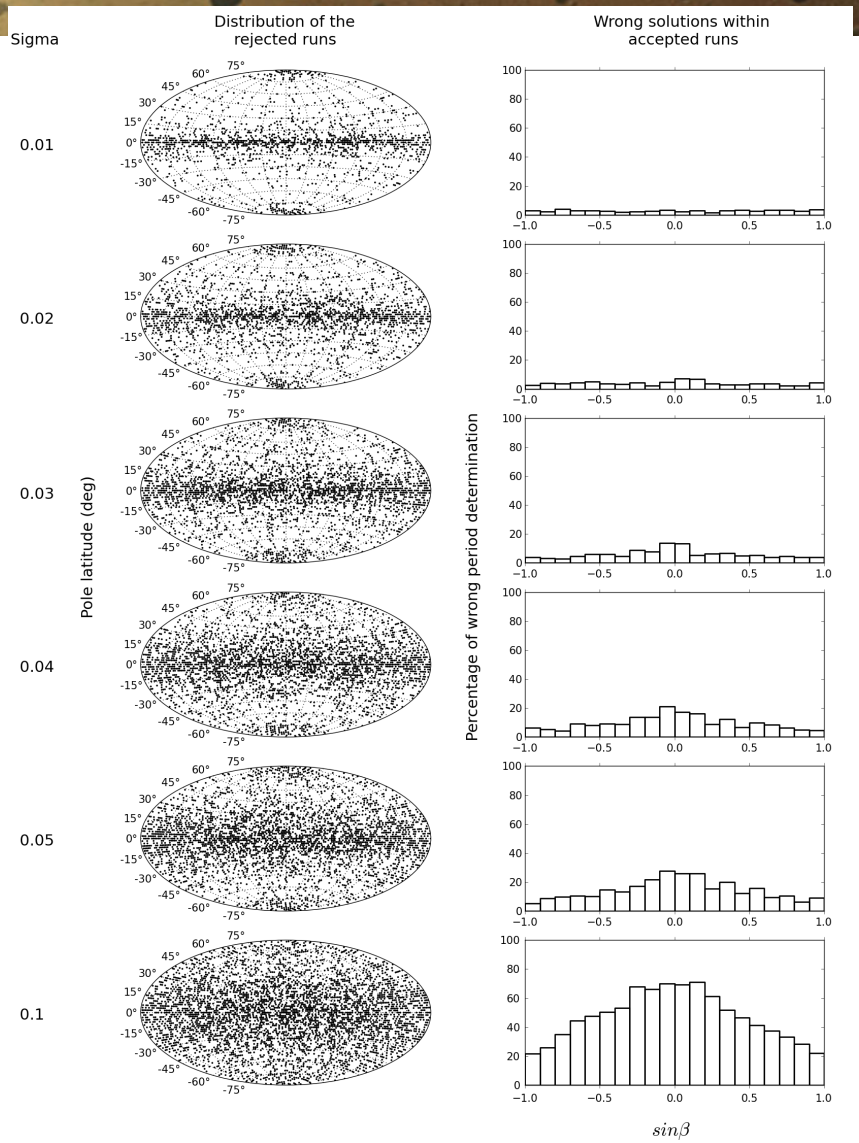
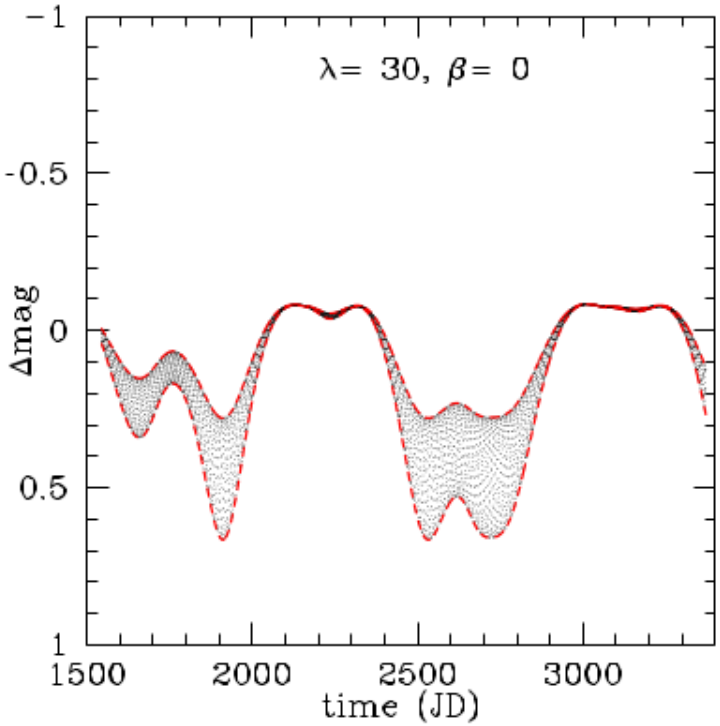


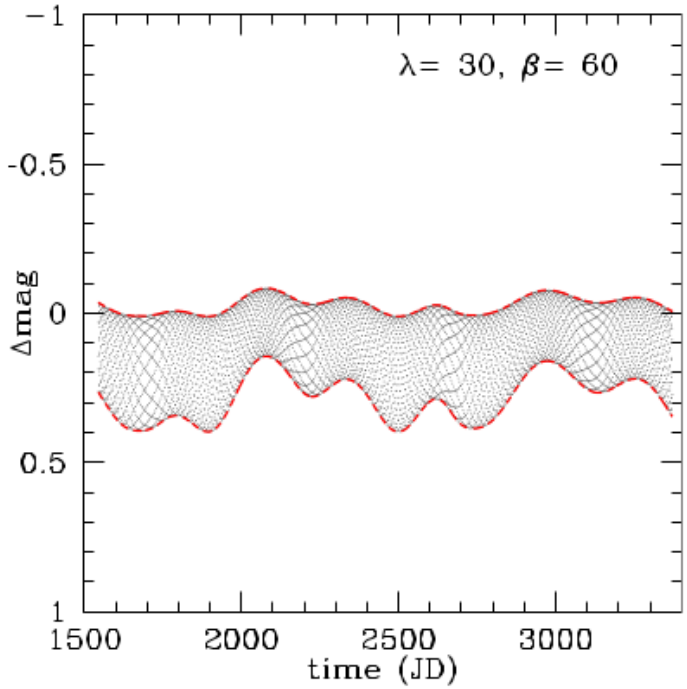
Figure: Distribution of the warnings received from the inversion algorithm (Santana-Ros et al. submitted)

Adding gaussian noise



A reasonable explanation





From Cellino et al. 2006

Irregular shapes: putting Gaia inversion to test

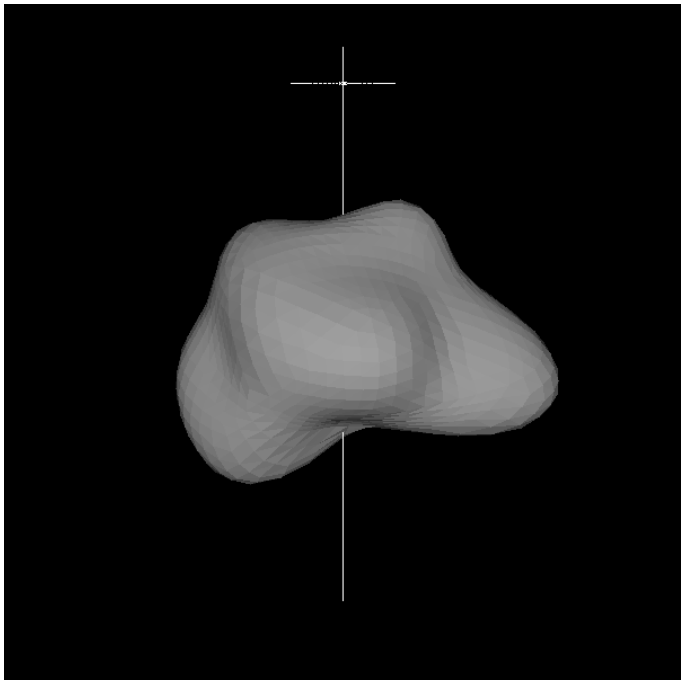


Figure: Example of a random non-convex shape used for generating the photometric simulations.

Simulations with non-convex shapes: asteroid elongation

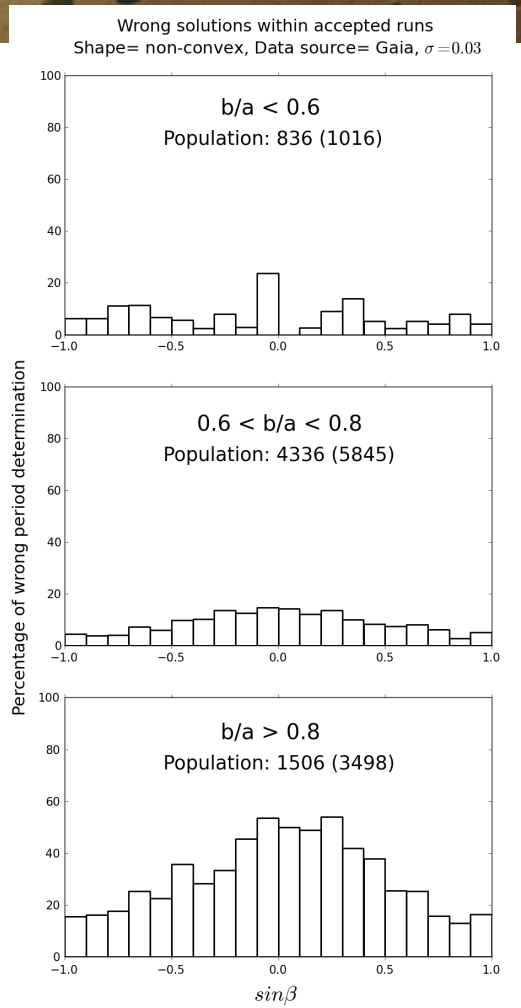


Figure: Histograms showing the inversion results obtained for three different groups of asteroids as a function of their equivalent b/a axis ratio. The population numbers are indicating the amount of generated solutions and the total of inversion runs executed (in brackets)

Simulations with non-convex shapes: number of measurements

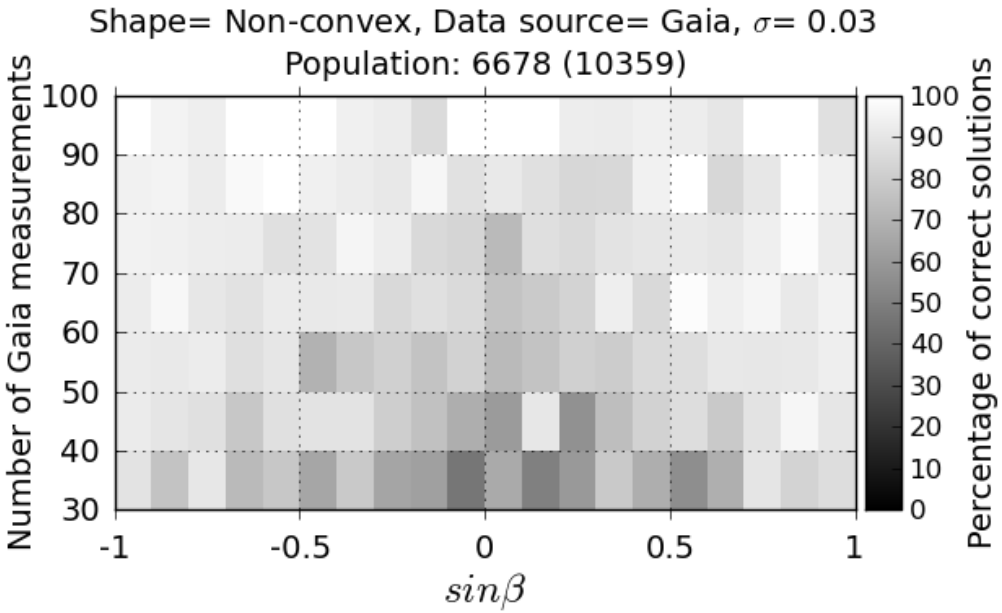


Figure: Histogram showing the results obtained for the inversion of the simulated set of irregular body shapes. The percentage of correct solutions is plotted as a function of the number of Gaia detections for each bin of asteroid's pole latitude. The population number is indicating the amount of generated solutions and the total of inversion runs executed (in brackets).

Combining Gaia data with lightcurves: asteroid elongation

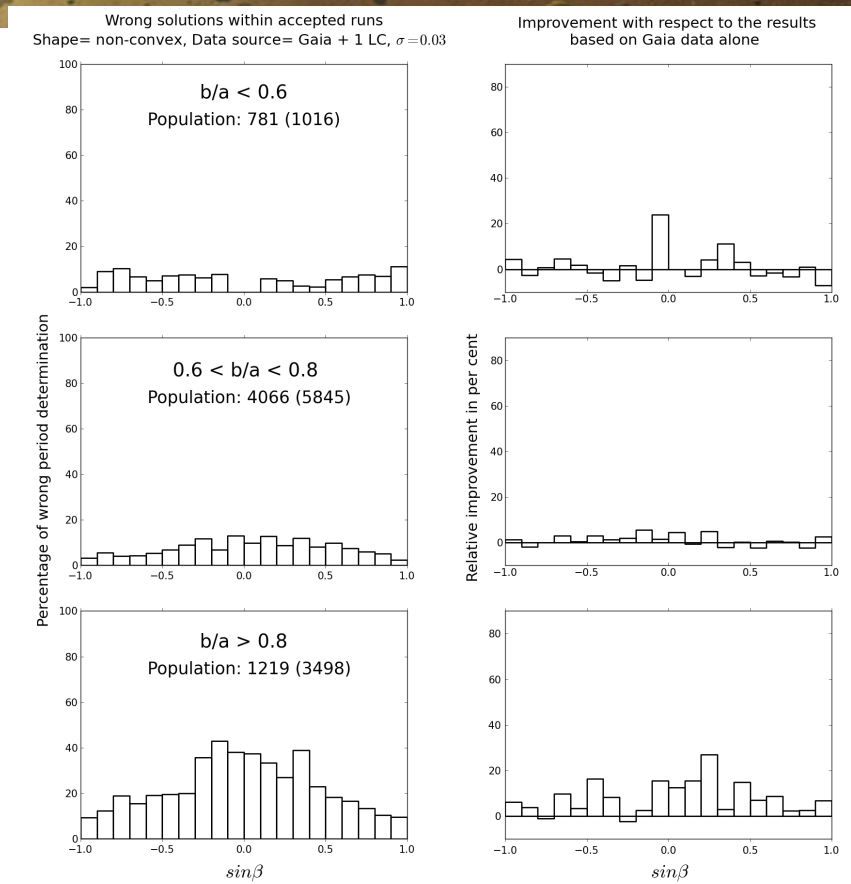


Figure: Histograms on the left show the inversion results obtained for a data set combining Gaia photometry and one full lightcurve. The results are divided into three groups as a function of the asteroids' equivalent b/a axis ratio and are plotted as a function of the asteroids' pole latitude. Histograms on the right show the relative improvement comparing with the inversion results obtained for Gaia data alone.

Simulations with non-convex shapes: number of measurements

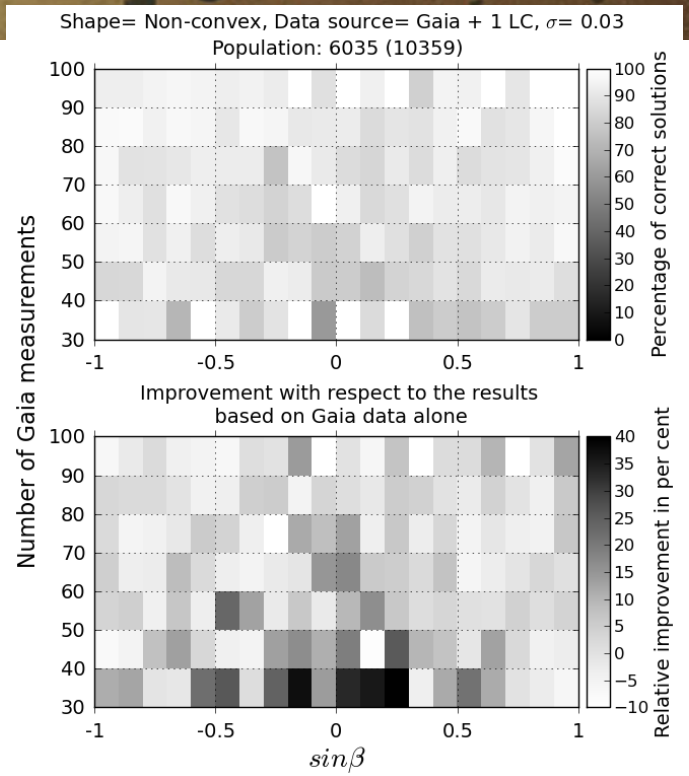


Figure: The histogram on the top shows the results obtained for the combined data set. The percentage of correct solutions is plotted as a function of the number of Gaia detections for each bin of asteroids' pole latitude. The population number is indicating the amount of generated solutions and the total of inversion runs executed (in brackets). The histogram on the bottom shows the relative improvement compared to the inversion results obtained for Gaia data alone.

Ground-based Observation Service for Asteroids

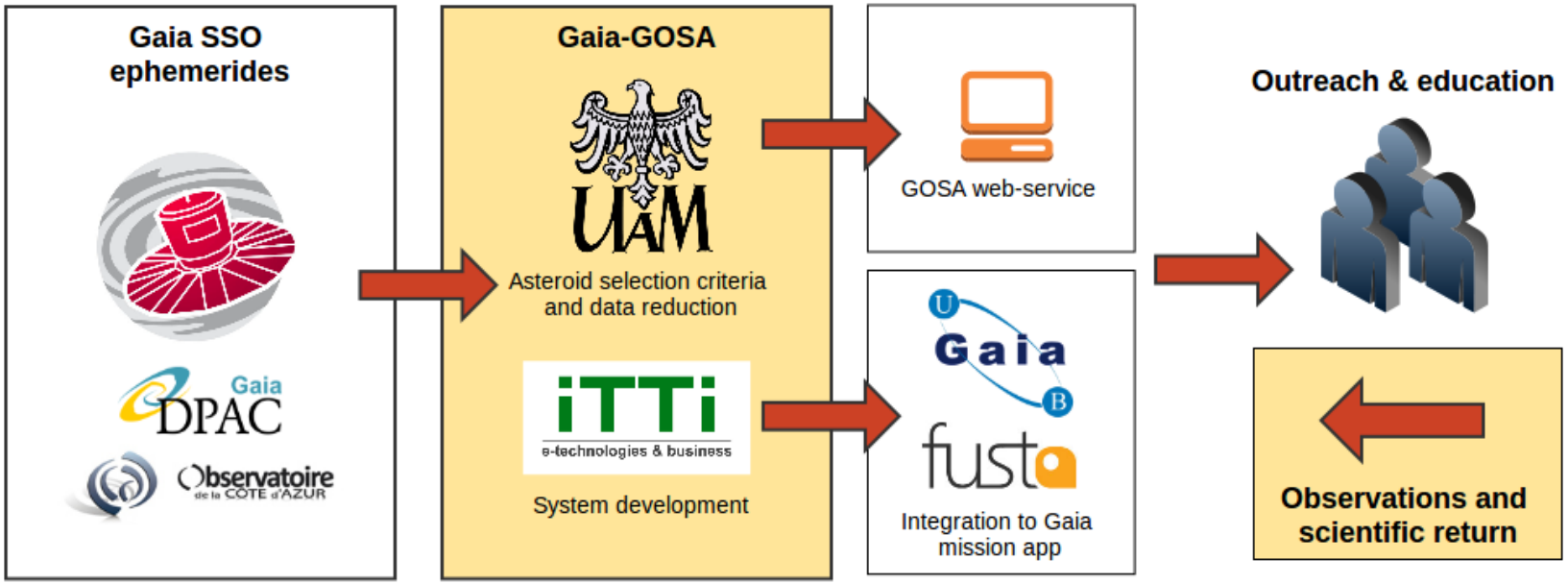


Figure: Gaia-GOSA service plans to support observers in planning asteroids photometry observations, so they can generate valuable scientific data which will be used for enhancing the final Gaia SSO release

Release plan

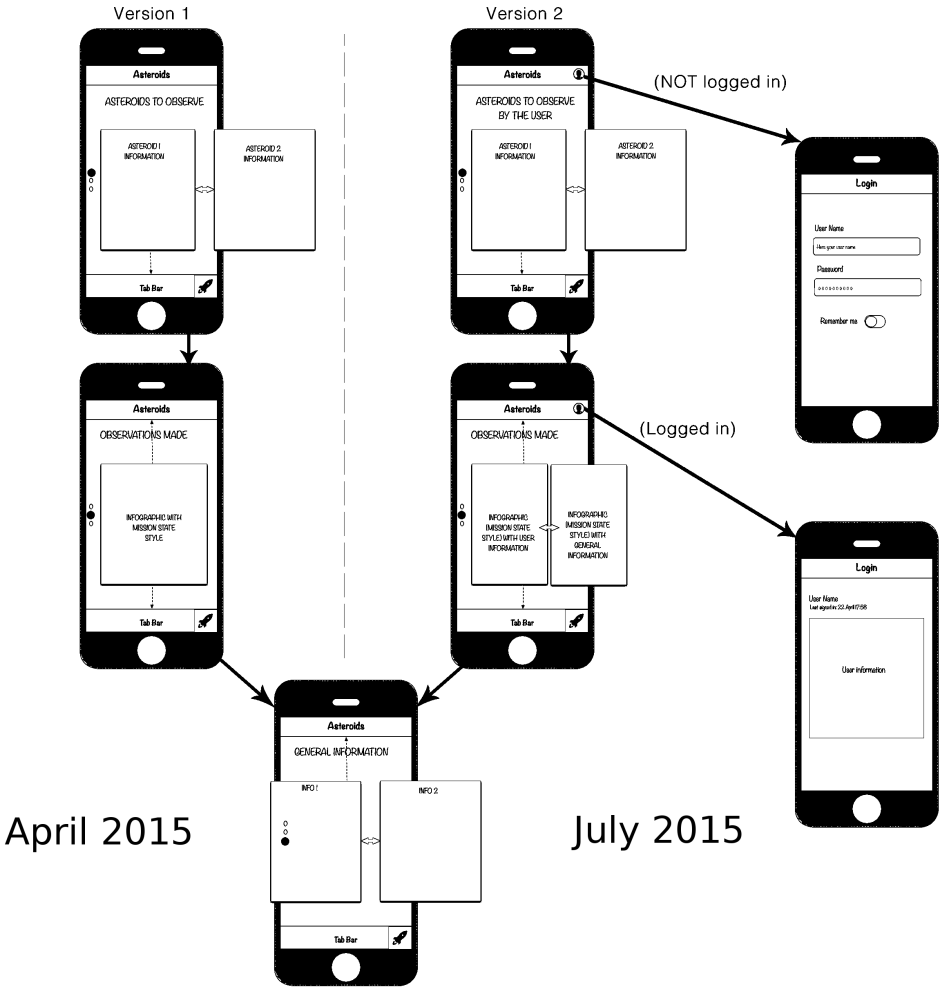
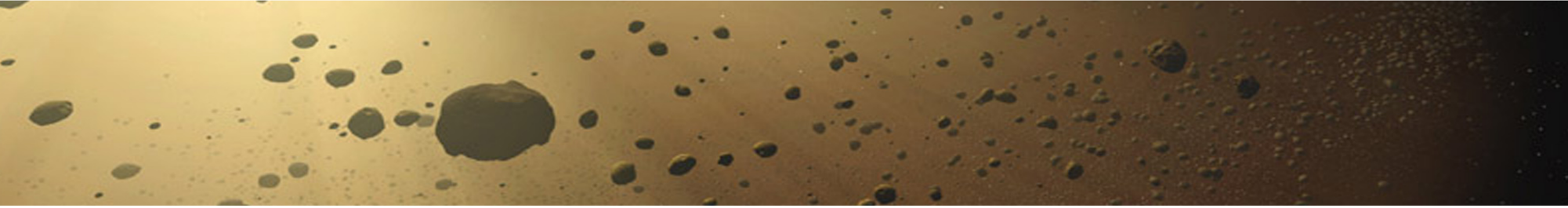


Figure: Mockup of the Gaia-GOSA app (Credits: Marcial Clotet)

Summary

- Good news! Even for realistic simulations with non-convex shapes and additional gaussian noise, the Gaia inversion has a validity greater than 70%
- Asteroids' sample derived from Gaia modelling might be slightly biased (against pole latitudes)
- The validity of the modelling is correlated with the asteroid's ...
  - Pole latitude
  - Elongation
  - Number of photometric measurements
- Ground-based lightcurves can be used to enhance the "tricky cases" – Gaia-GOSA is the tool needed!



Thank you!

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