CENTRE NATIONAL D'ÉTUDES SPATIALES

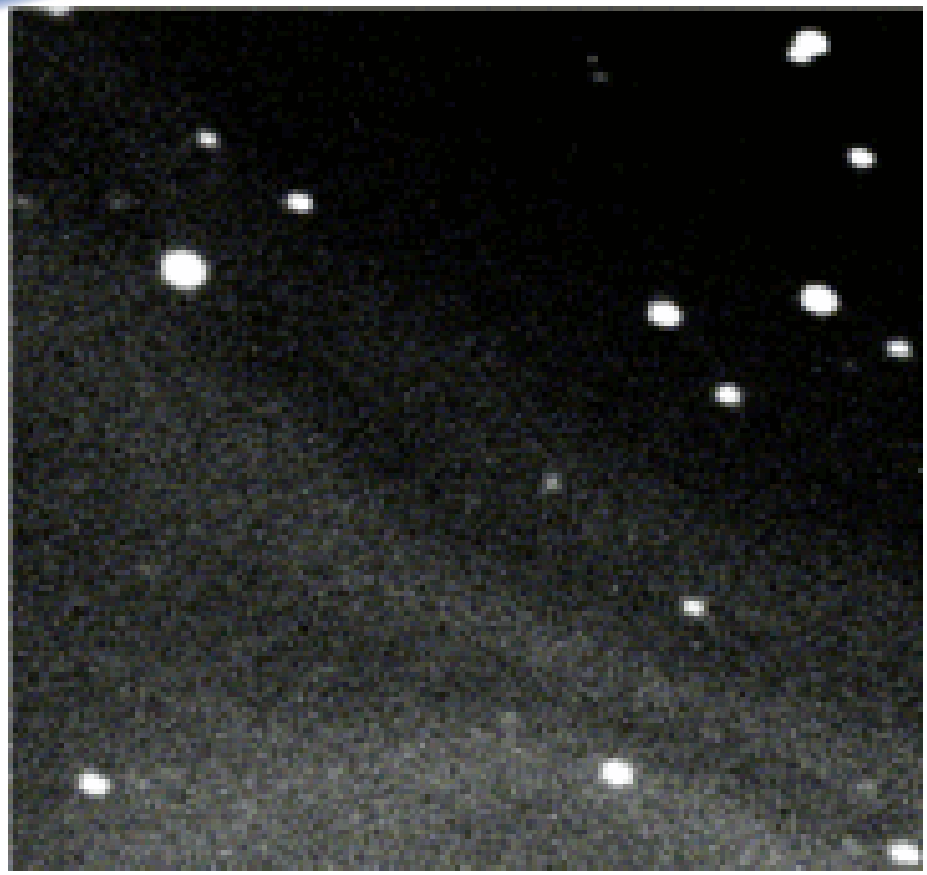
French activities related to Apophis

Jean-Yves Prado CNES Toulouse France

Presentation Overview

- APOPHIS reminder
- Ephemeris Improvement Opportunities
- APOPHIS 2029 first thoughts
- IMCCE Contribution

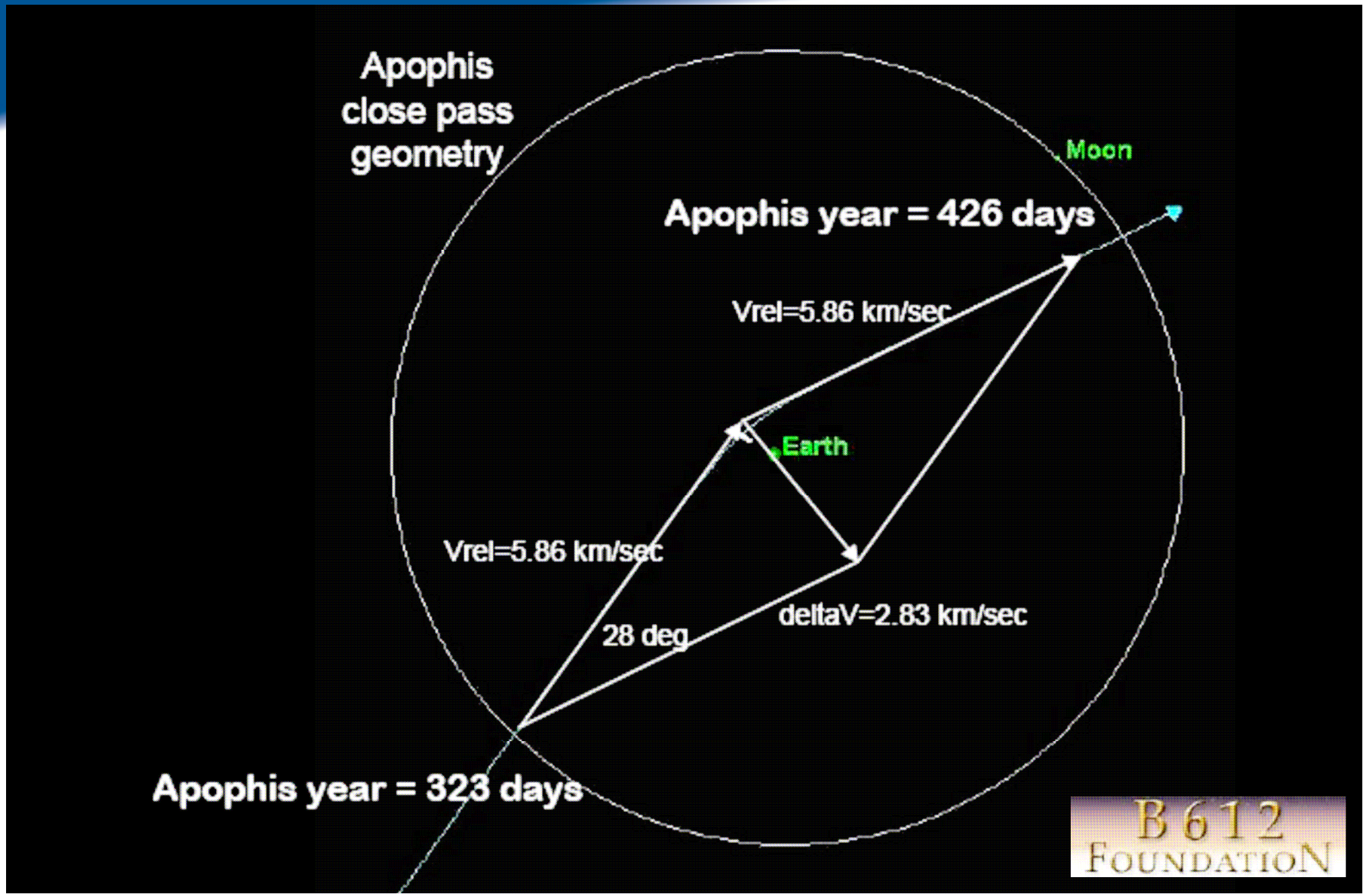
APOPHIS



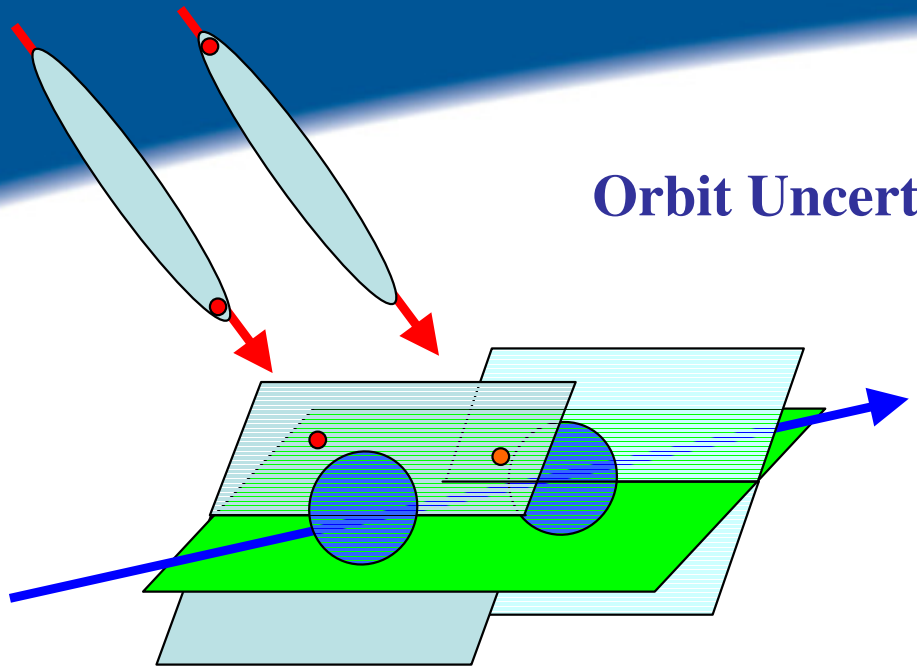
Discovery	
Discovered by:	Roy A. Tucker, David J. Tholen, Fabrizio Bernardi
Discovery date:	June 19, 2004
Orbital characteristics	
Aphelion distance:	1.099 AU
Perihelion distance:	0.746 AU
Orbital period:	323.6 d (0.89 year)
Inclination:	3.331°
Physical characteristics	
Dimensions:	~250 m (estimated)
Mass:	2×10^{10} kg (estimated)

Mass of APOPHIS ~ 200 x

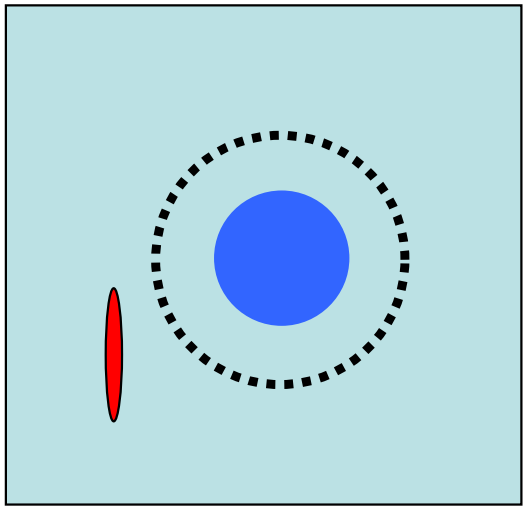
APOPHIS Fly by of the Earth on April 13, 2029



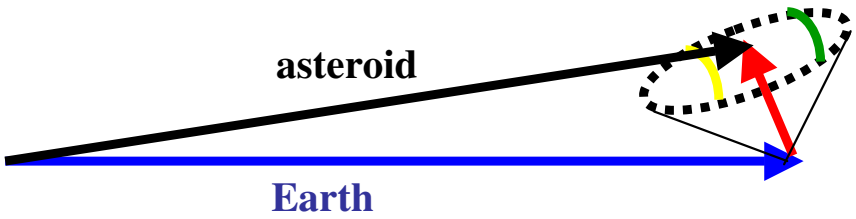
KEYHOLES

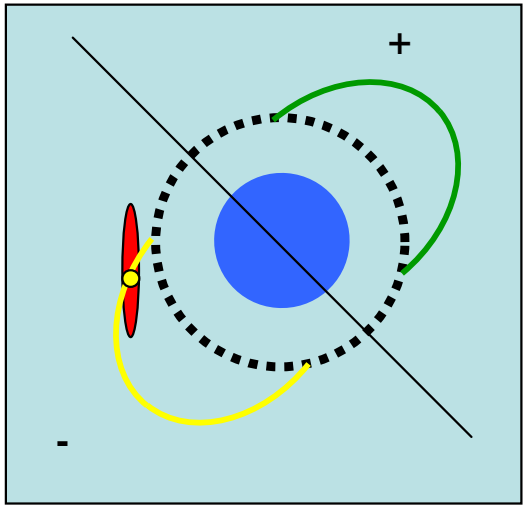


Orbit Uncertainty

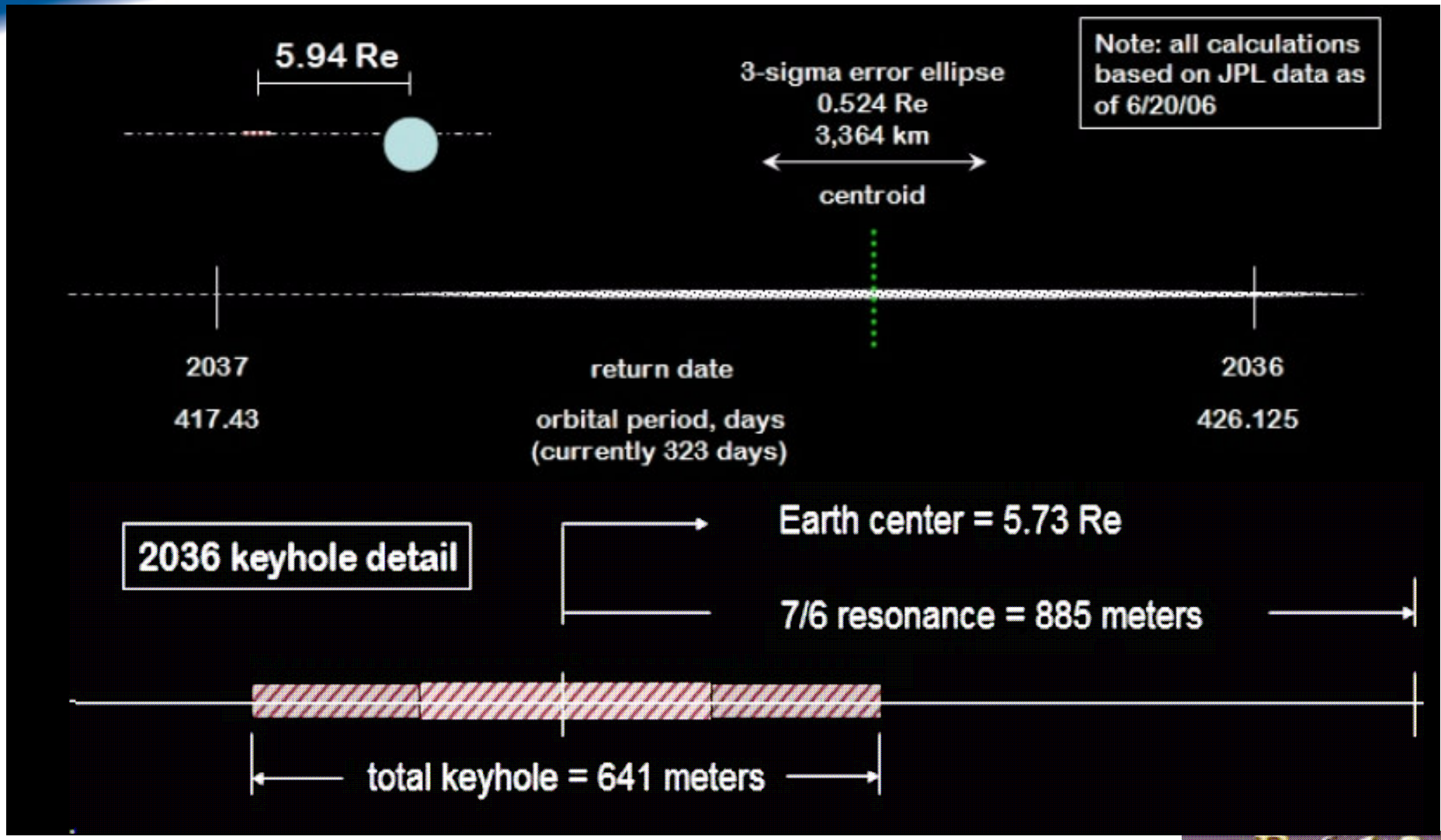


+ Earth Gravity Assist

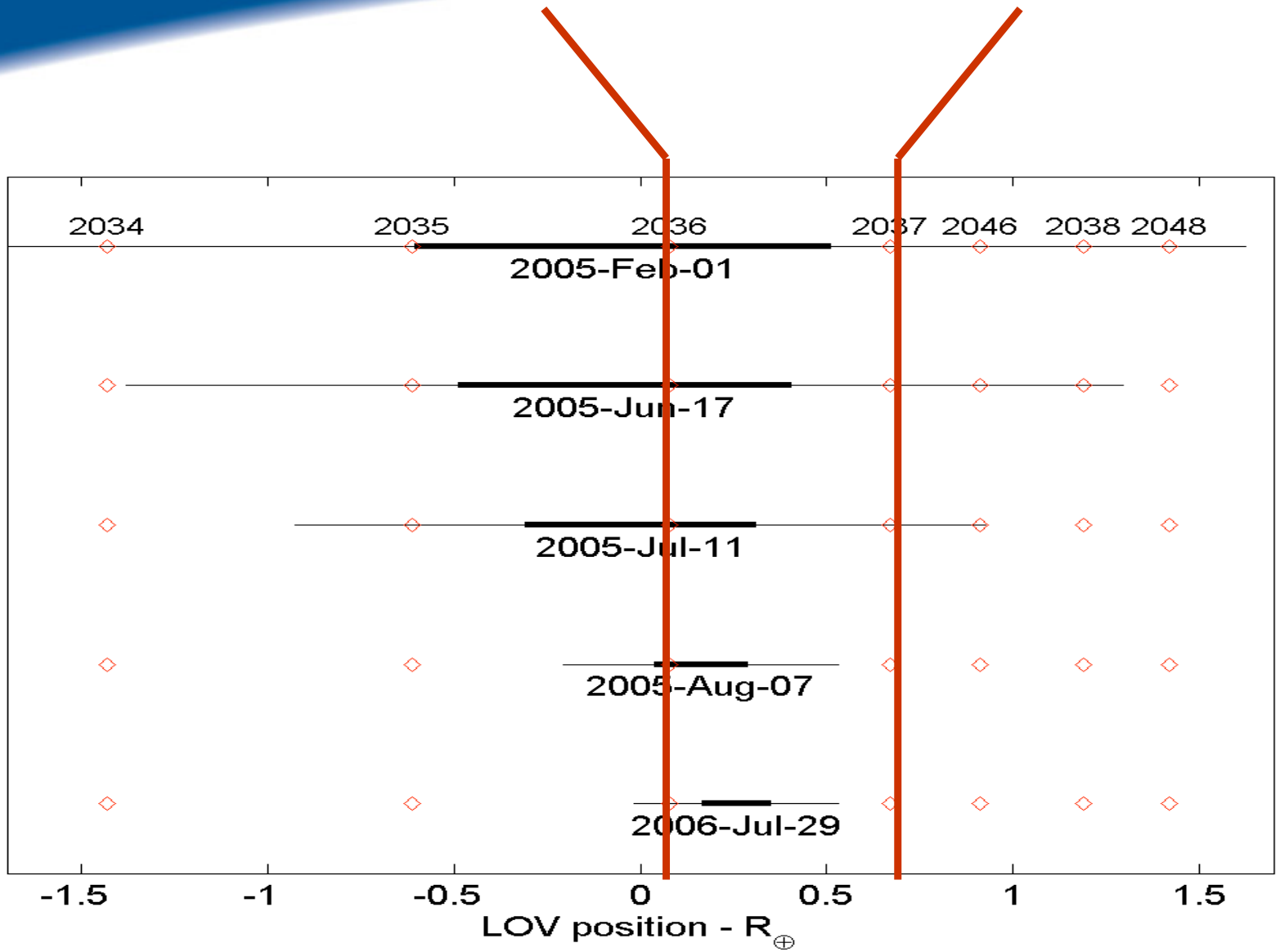




APOPHIS Flyby of the Earth in 2029

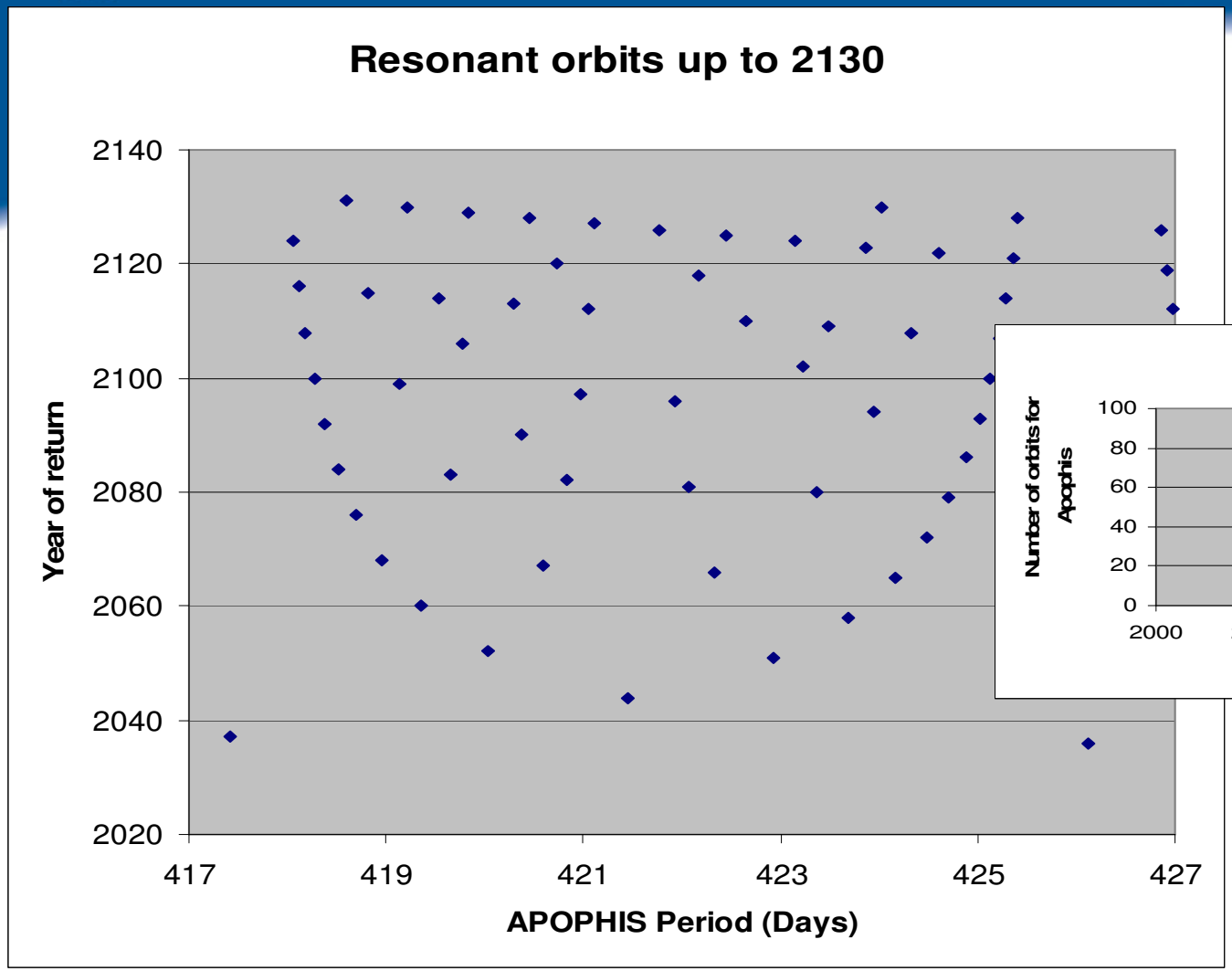


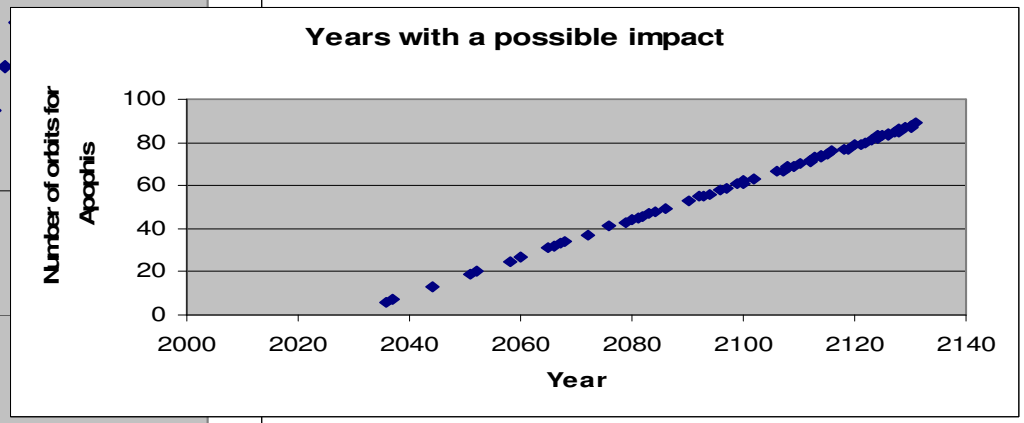
Key Holes location evolution



Ref: Steven R. Chesley (JPL) Potential Impact Detection for Near Earth Asteroids: the case of 99942 Apophis (2004 MN4)

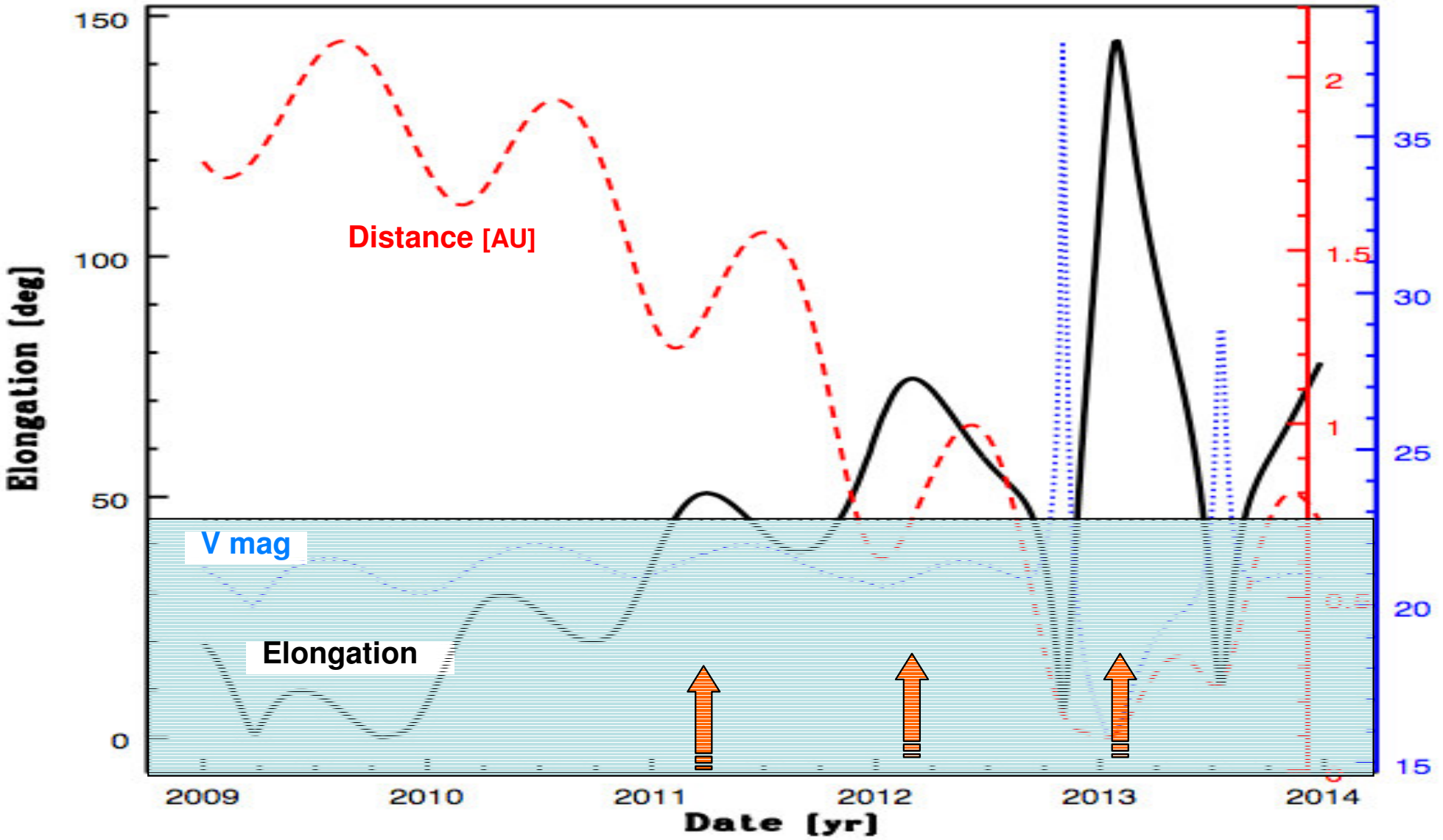
KH for the 21st century





- Increasing number of resonant orbit with time
- About 1 / Year from '90s
- 100 KH ~0.7 km in diameter split over a 3 σ uncertainty 3500 km wide
- **~ 1 in 50 chances for an impact with the Earth between 2036 and 2130**

APOPHIS visibility



Credit D. Hestroffer IMCCE

Ground based observations

Observation criteria

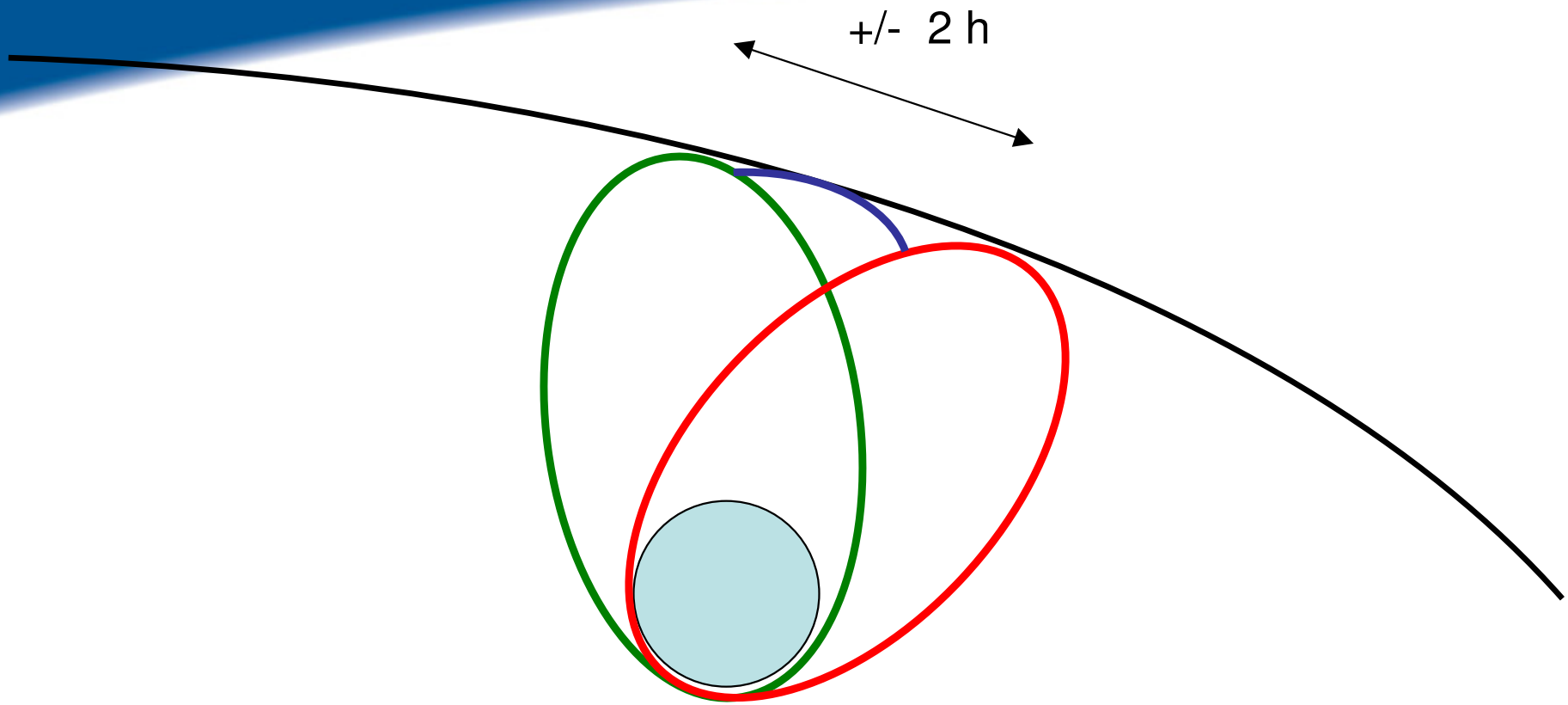
Visual Magnitude <23

Elongation > 50°

periods	PdM 1m	ESO 8m
A: Feb. — May 2011	2h	1h
B: Nov 2011 Sep 2012	3h	2h
C: Dec 2012 June 2013	4h	7h

From visible and IR observations, expected improved knowledge in 2013 about rotation parameters, size, inertia, thermal inertia, preliminary 3D model

APOPHIS 2029 First thoughts



Single launch on a GTO like orbit @ i=40° a few weeks before APOPHIS pass
Impactor + impact imager @ tp-1 h
Data reception system prepositioned after the perihelion
Interior sounding under investigation (MEX Marsis, Rosetta Consert heritage)

IMCCE Contribution

- IMCCE (Institute for Celestial Mechanics and Ephemerides Computation) is part of Paris Observatory

- Uses its own model INPOP (Intégration Numérique Planétaire de l'Observatoire de Paris) for the computation of the solar system ephemerides

- The results are totally independant from the ones produced by MPC or Pisa University who both use DE405 ephemerides from JPL

- High interest from this institute to be involved in the APOPHIS data processing

- Support from CNES can be envisioned as a contribution to the ESA's SSA Programme

- see http://www.imcce.fr/