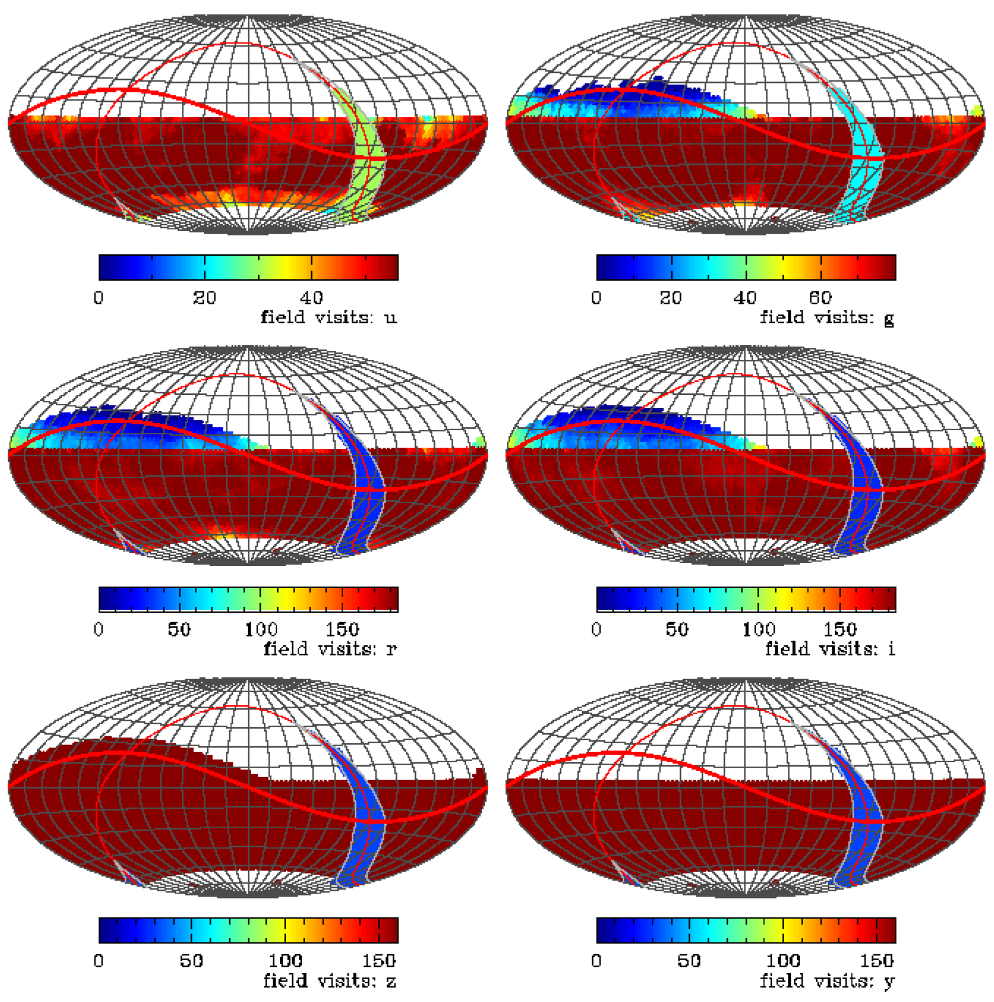
Large Synoptic Survey Telescope

Solar System Science with LSST

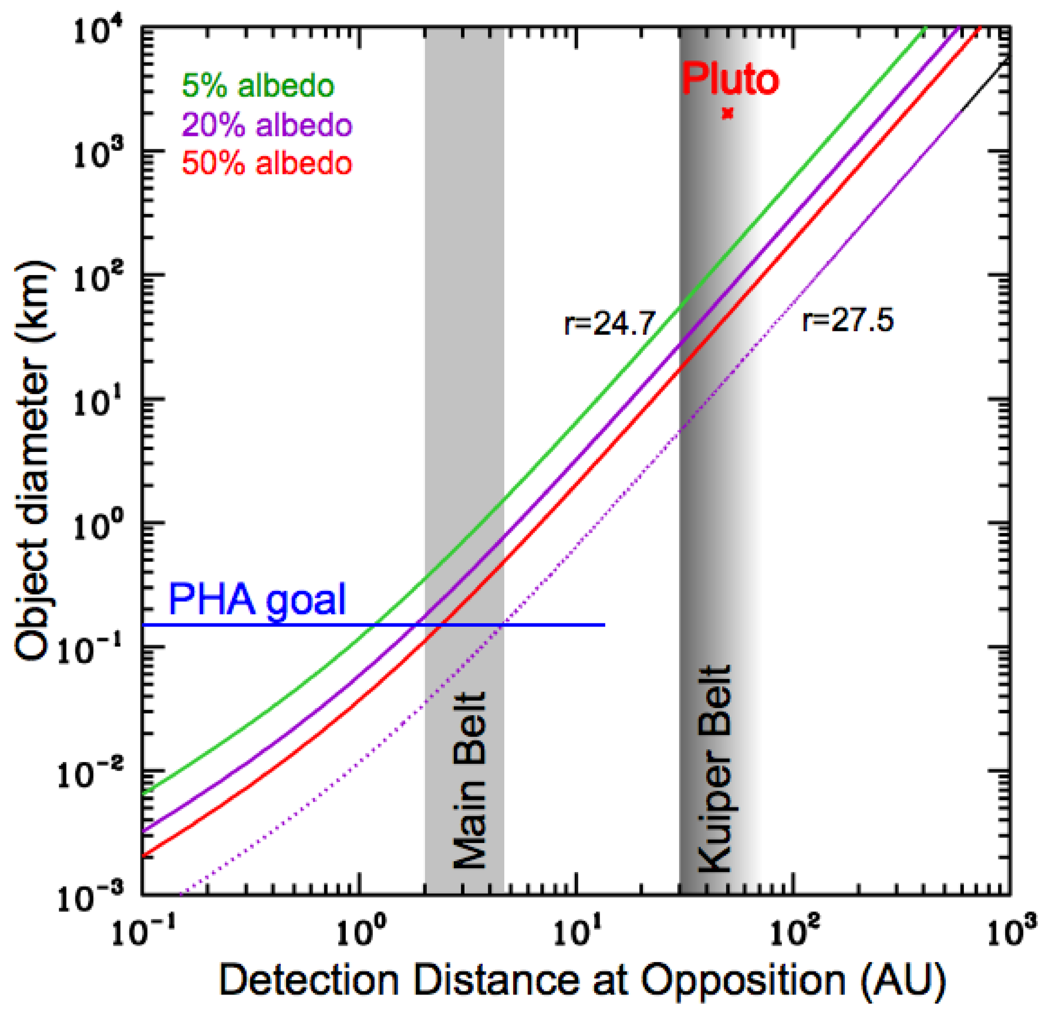
R.L. Jones (UW), S.R. Chesley (JPL/Caltech), A.J. Connolly (UW), A.W. Harris (SSI), Z. Ivezic (UW),
Z. Knezevic (AO Belgrade, Serbia and Montenegro), J. Kubica (Google), A. Milani (U. Pisa), D.E. Trilling (Steward),
and the LSST Solar System Objects Science Collaboration

LSST will provide a unique tool to study moving objects in the solar system. In the baseline LSST observing plan, back-to-back 15-second images will reach a limiting magnitude as faint as r=24.7 in each 9.6 square degree field twice per night; approximately 15,000 square degrees will be imaged in multiple filters every 3 nights. This time sampling will continue throughout each lunation, creating a massive catalog of solar system objects with accurately measured orbits, as well as colors and light curves accurate to 0.005 magnitudes for the brightest objects. The catalog will include more than 80% of the potentially hazardous asteroids larger than 140m diameter within 10 years, millions of main-belt asteroids and perhaps 20,000 Trans-Neptunian Objects. By observing fields over a wide range of ecliptic longitudes and latitudes, including large separations from the ecliptic plane, not only will these catalogs greatly increase the numbers of known objects, the characterization of the inclination distributions of these populations will be much improved. Derivation of proper elements for main belt and Trojan asteroids will allow ever more resolution of asteroid families and their size-frequency distribution, as well as the study of the long-term dynamics of the individual asteroids and the asteroid belt as a whole. By obtaining multi-color ugrizy data for a substantial fraction of objects, relationships between color and dynamical history can be established. With the addition of light-curve information, rotation periods and phase curves can be measured for large fractions of each population, leading to new insight on physical characteristics. In addition, long-period comets will be discovered at much larger distances than previously possible, enabling testing of Oort cloud population models.

Discovering Solar System Objects



Observing Footprint - LSST will detect solar system objects over a wide range of ecliptic latitudes and through all ecliptic longitudes.



Detection Limits - Moving objects with diameters as small as 100m in the Main Belt and < 100km in the Kuiper Belt can be detected in individual images. Specialized 'deep drilling' observing sequences will detect KBOs only 10s of kilometers in diameter

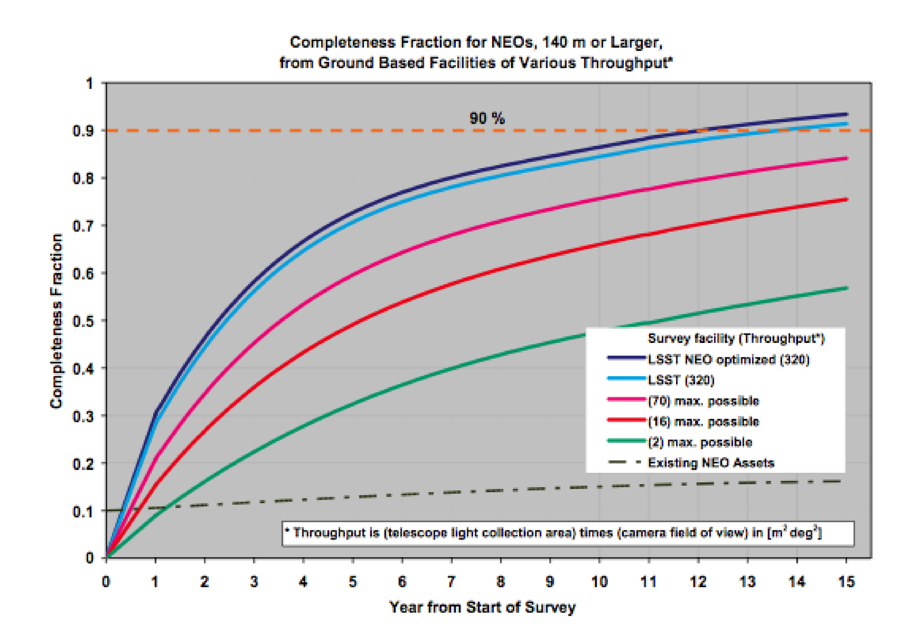
From Detections to Orbits

The Moving Object Processing System (MOPS) is part of a collaborative development effort with the Pan-STARRS project. The tremendous increase in data volume anticipated from LSST will pose numerous significant technical challenges in extracting moving object detections and linking them across nights, months and years to form reliable orbits. Tree-based algorithms for multi-hypothesis testing of asteroid tracks can help solve these challenges by providing the necessary 1000 fold speed-up over current approaches while recovering 95% of the underlying objects.

Using MOPS, doubtless we will detect many objects on exotic and unusual orbits, in addition to the thousands on more familiar orbits.

The Impact Hazard

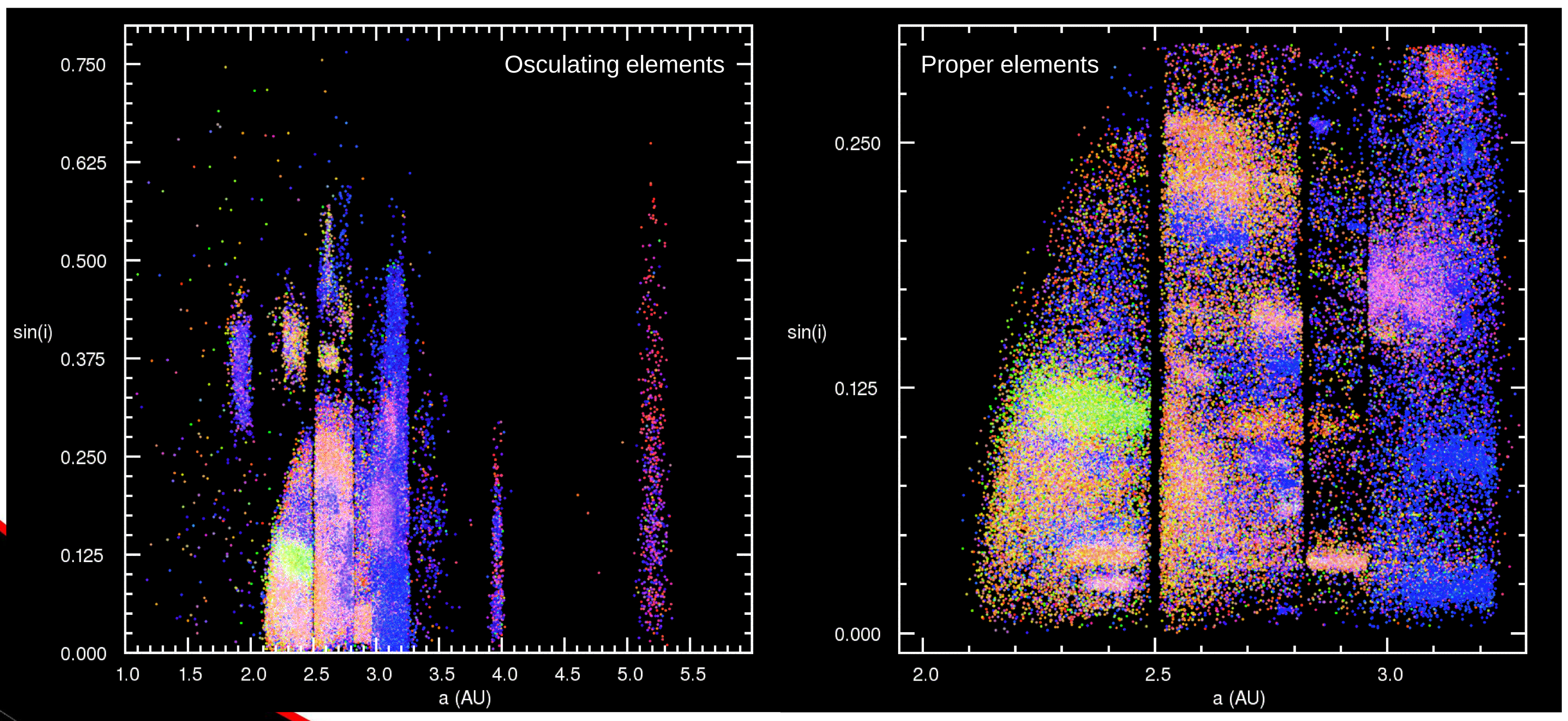
In December 2005 Congress directed NASA to implement a near-Earth object survey that would catalogue 90% of NEOs larger than 140m. LSST will discover 80-90% of potentially hazardous asteroids (PHA's) larger than 140m, thus approaching the NASA goal in ten years of surveying, and thereby reducing the impact threat posed by undiscovered objects by more than an order of magnitude. In the process, LSST will assess the hazard to Earth from asteroid impacts by constraining the orbital and size distribution of the near-Earth population, allowing concrete estimates of the impact frequency as a function of size.



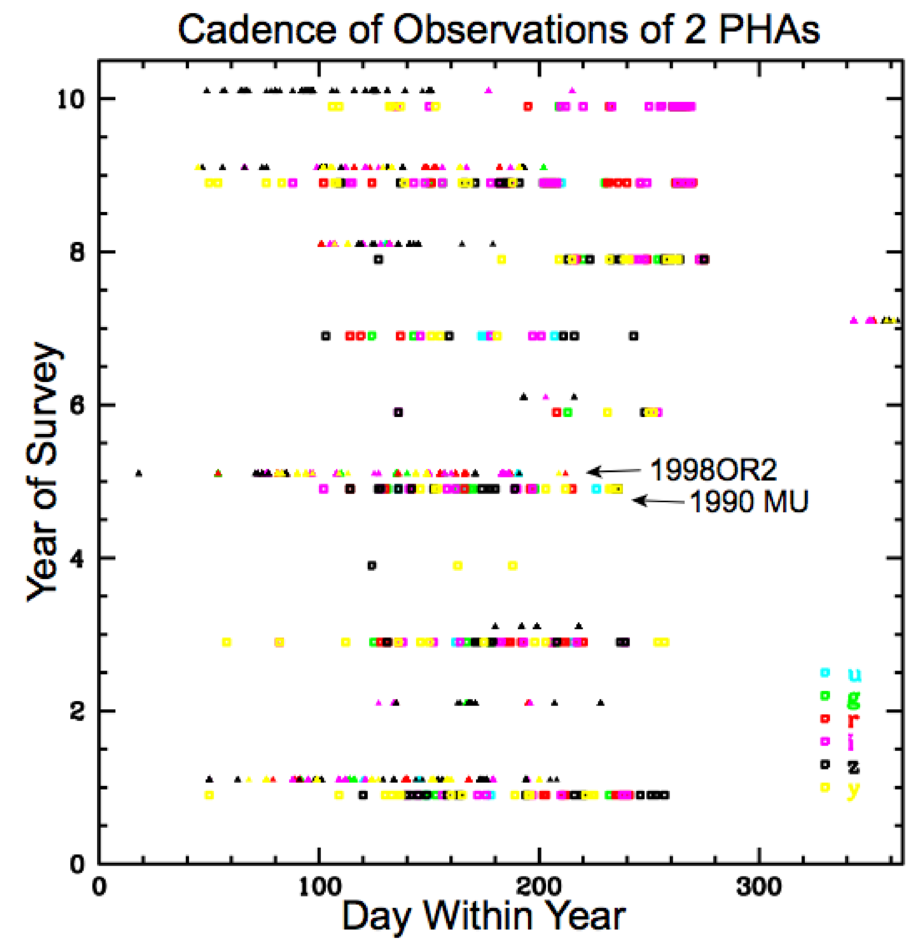
Recent survey simulations reveal that LSST will have excellent efficiency in detecting moving objects. The figure above estimates PHA population completeness levels for 140m and larger objects, for various facilities. Optimizing LSST for NEO detection would reduce the amount of telescope time available for other science, but decrease the amount of time necessary to reach the 90% completeness goal.

Photometric Colors

LSST will measure ugrizy colors for a substantial fraction of objects. This will enable taxonomic classification of asteroids, may provide further links between diverse populations such as irregular satellites and KBOs or planetary Trojans, and enable estimates of asteroid diameter with an rms uncertainty of 30%.

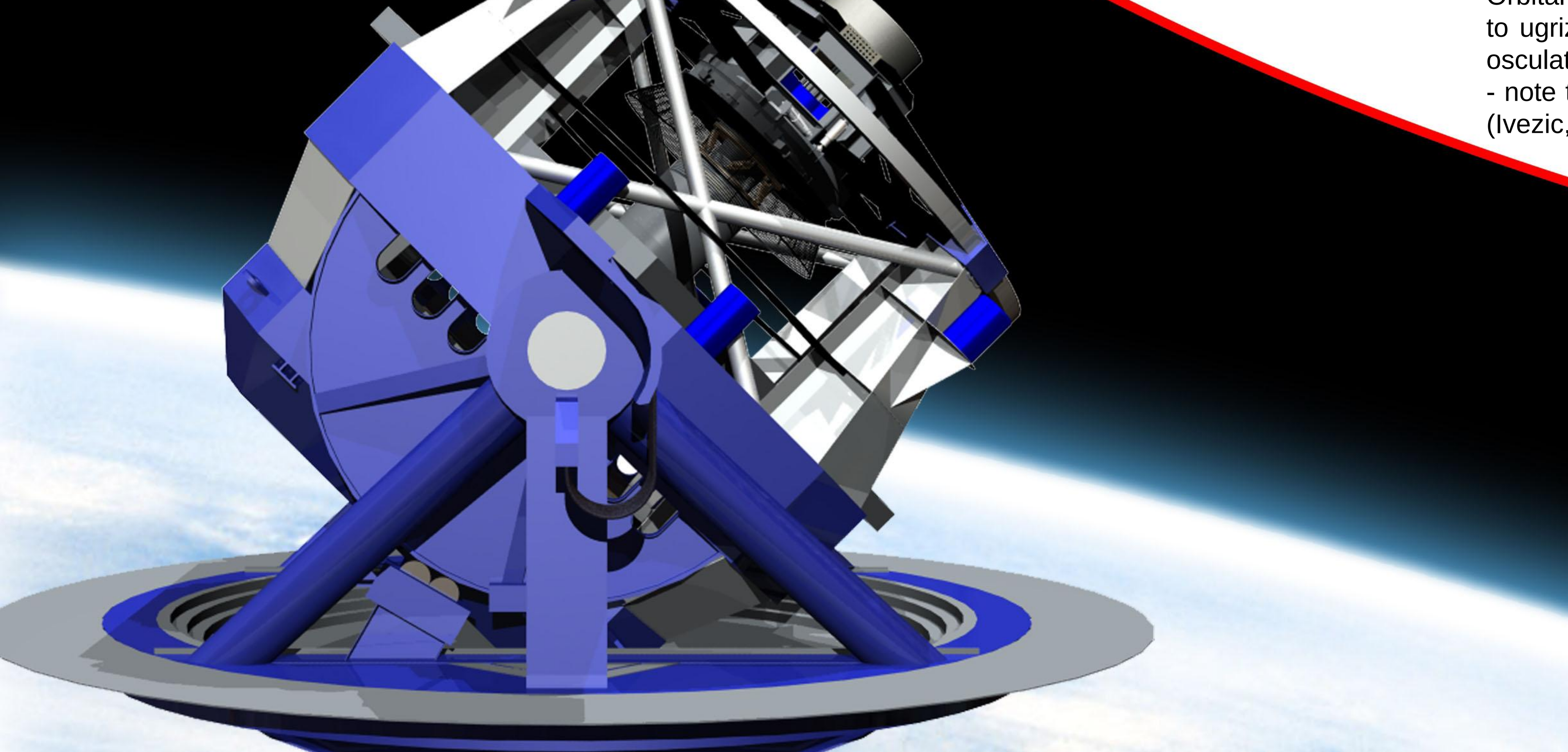


Orbital parameters of Main Belt Asteroids, color-coded according to ugriz colors measured by SDSS. The figure to the left shows osculating elements, the figure to the right shows proper elements - note the asteroid families visible as clumps in parameter space. (Ivezic, Juric & Lupton, 2007)



Photometric variability

Photometric variability information will allow **spin state and shape estimation for up to two orders of magnitude more objects than presently known**. This will leverage physical studies of asteroids, constraining the size-strength relationship, which has important implications for the internal structure (solid, fractured, rubble pile) and in turn the collisional evolution of the asteroid belt.



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