Asteroids and Comets in the coming decade

Alan Fitzsimmons
Astrophysics Research Centre
Queen's University Belfast

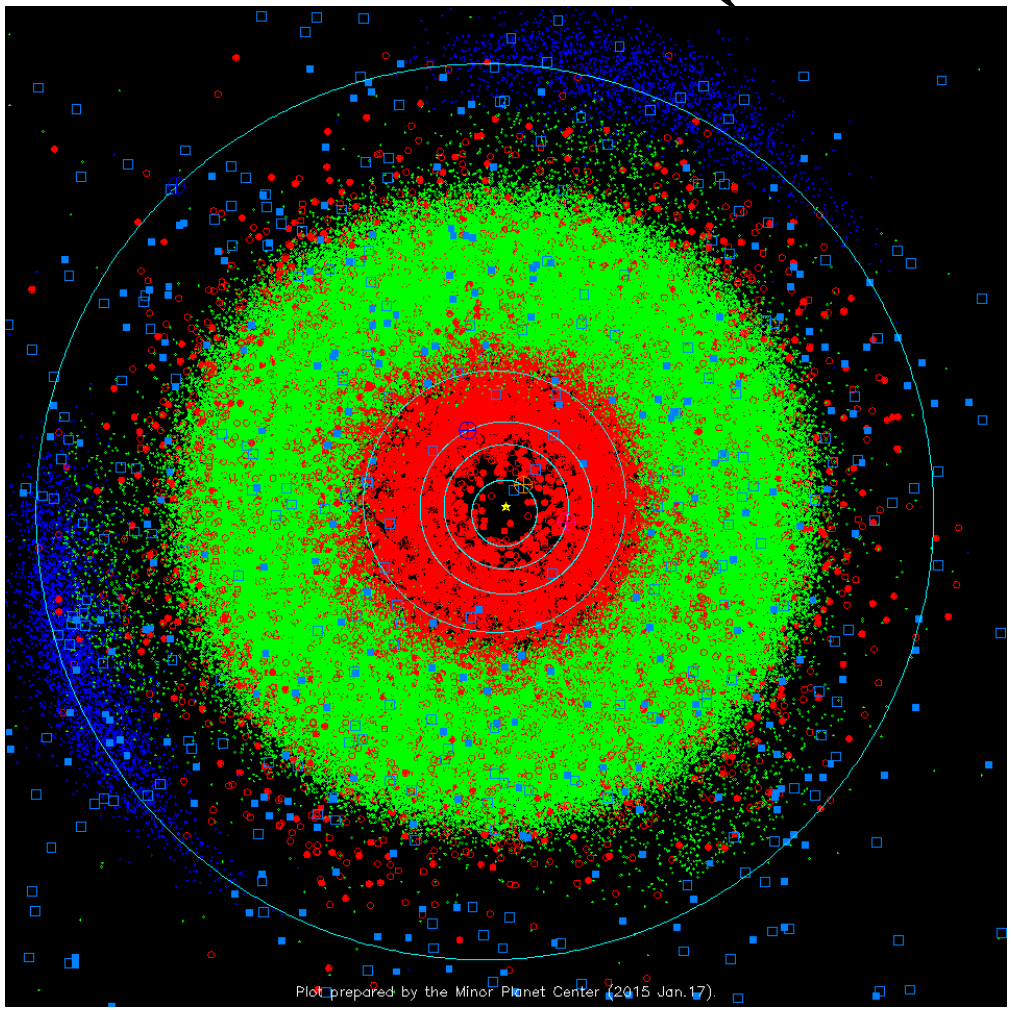
(with input from Colin Snodgrass and other members of the community)

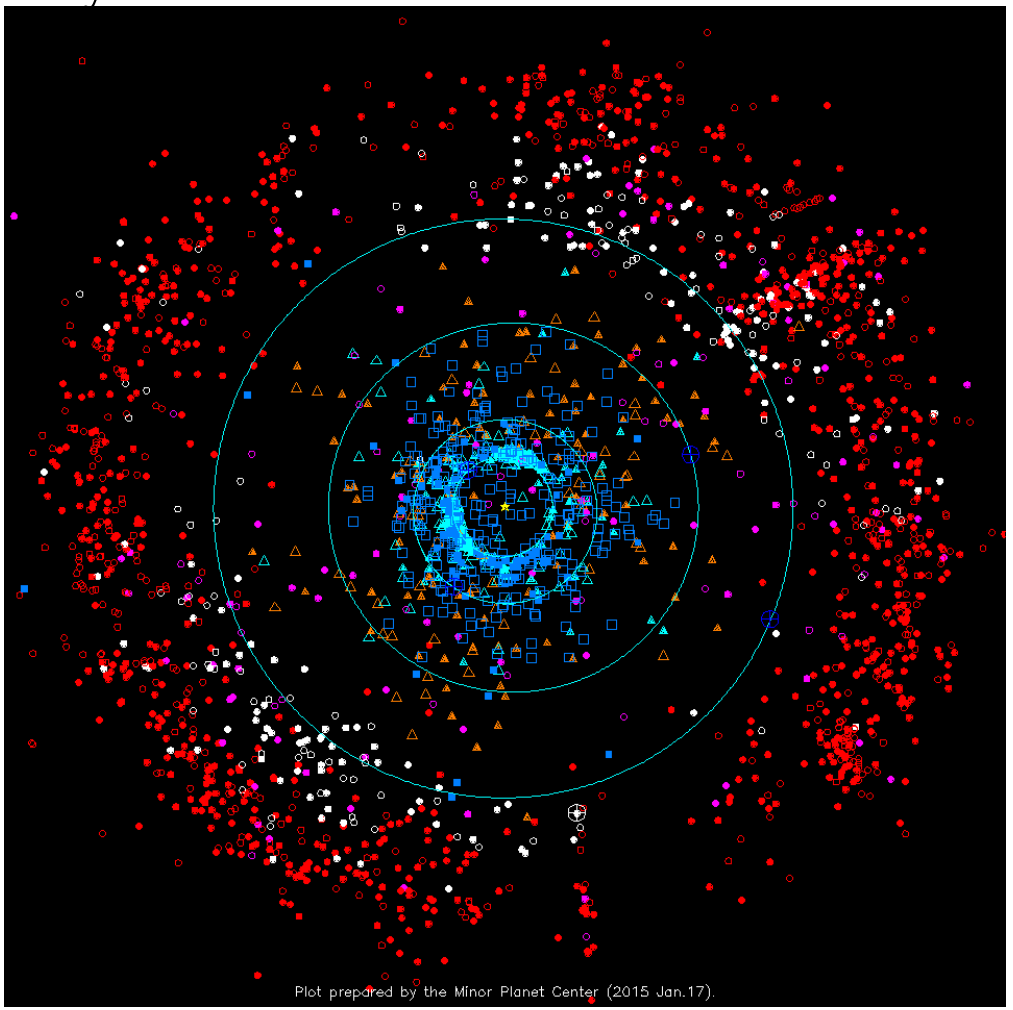
- Recent highlights*
- Current/future facilities
- Some important science drivers**
- What's needed at ESO for these?

*Apologies for missing your favourite paper
**Apologies for missing your favourite science

Asteroids and Comets in the coming decade

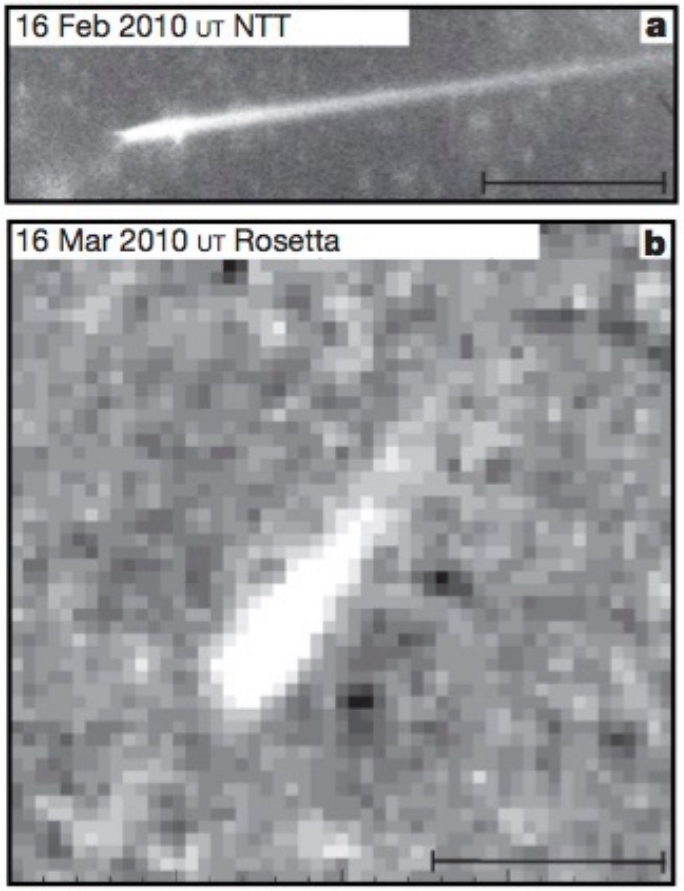
Alan Fitzsimmons
Astrophysics Research Centre
Queen's University Belfast





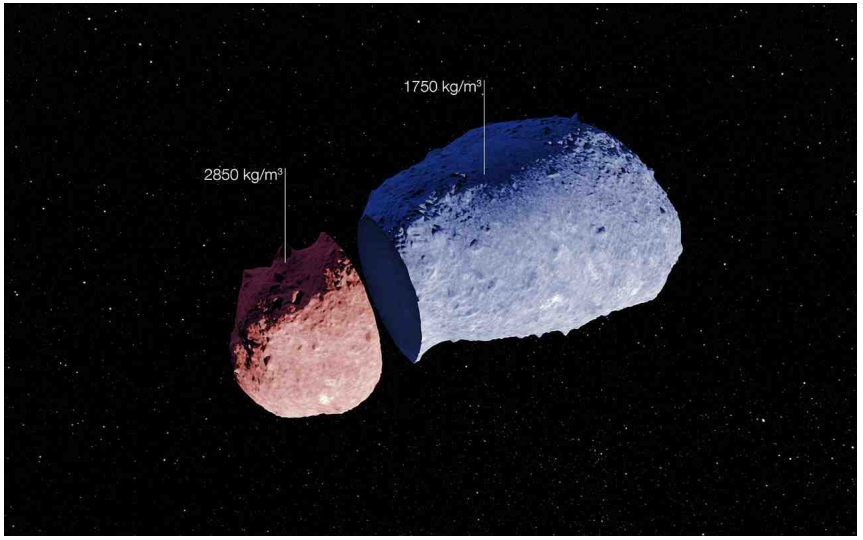
Some ESO Highlights in 2010-2015

P/2010 A2 - First potential asteroid collision



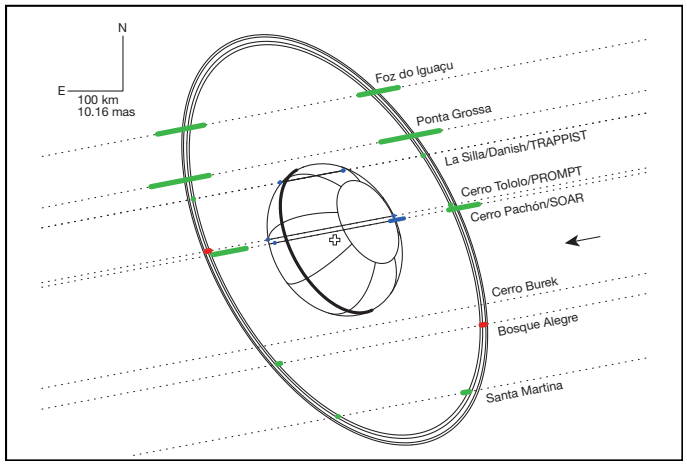
Snodgrass et al. 2010

Itokawa - NEO internal structure from YORP spin-up



Lowry et al. 2014

Ring system around centaur Chariklo



Braga-Ribas et al. 2014

The status in 2020+?

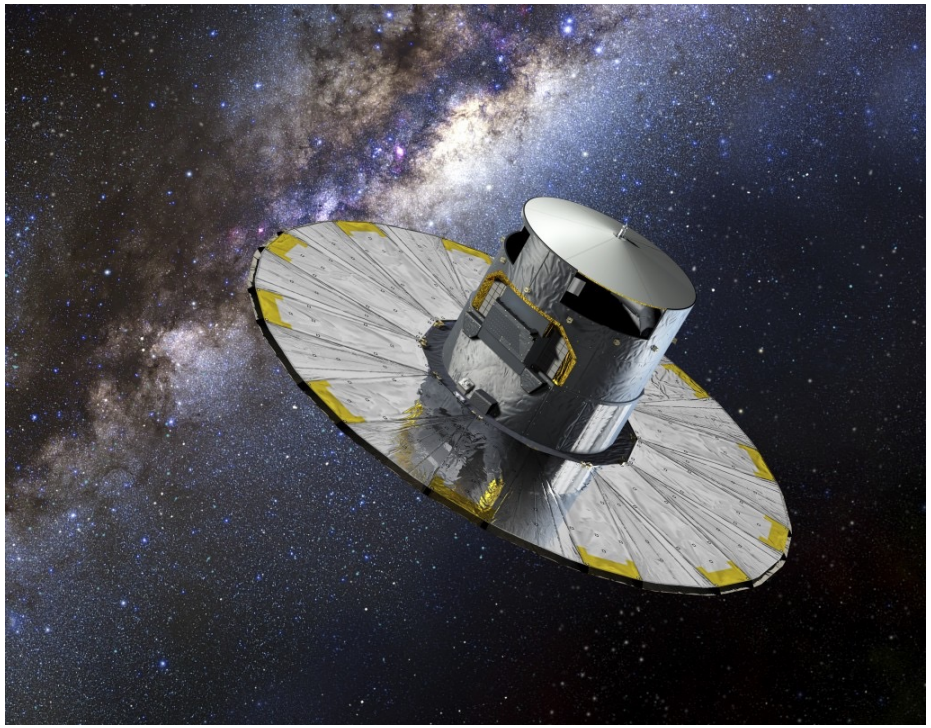
Pan-STARRS/Catalina/DECam - Main-belt complete to V=21 (D~4km), TNOs 80% complete to V=21 (D~600km), NEOs 90% complete to D~0.8km

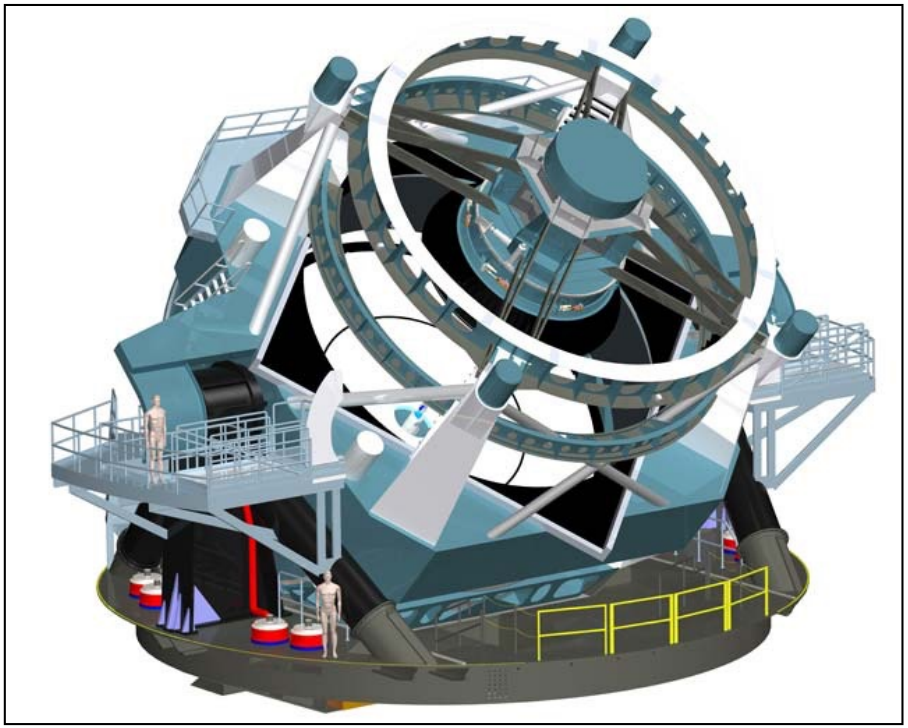
GAIA - Precise orbits for all objects during mission with V=20 and brighter

JWST - High-resolution opt/NIR studies of individual objects

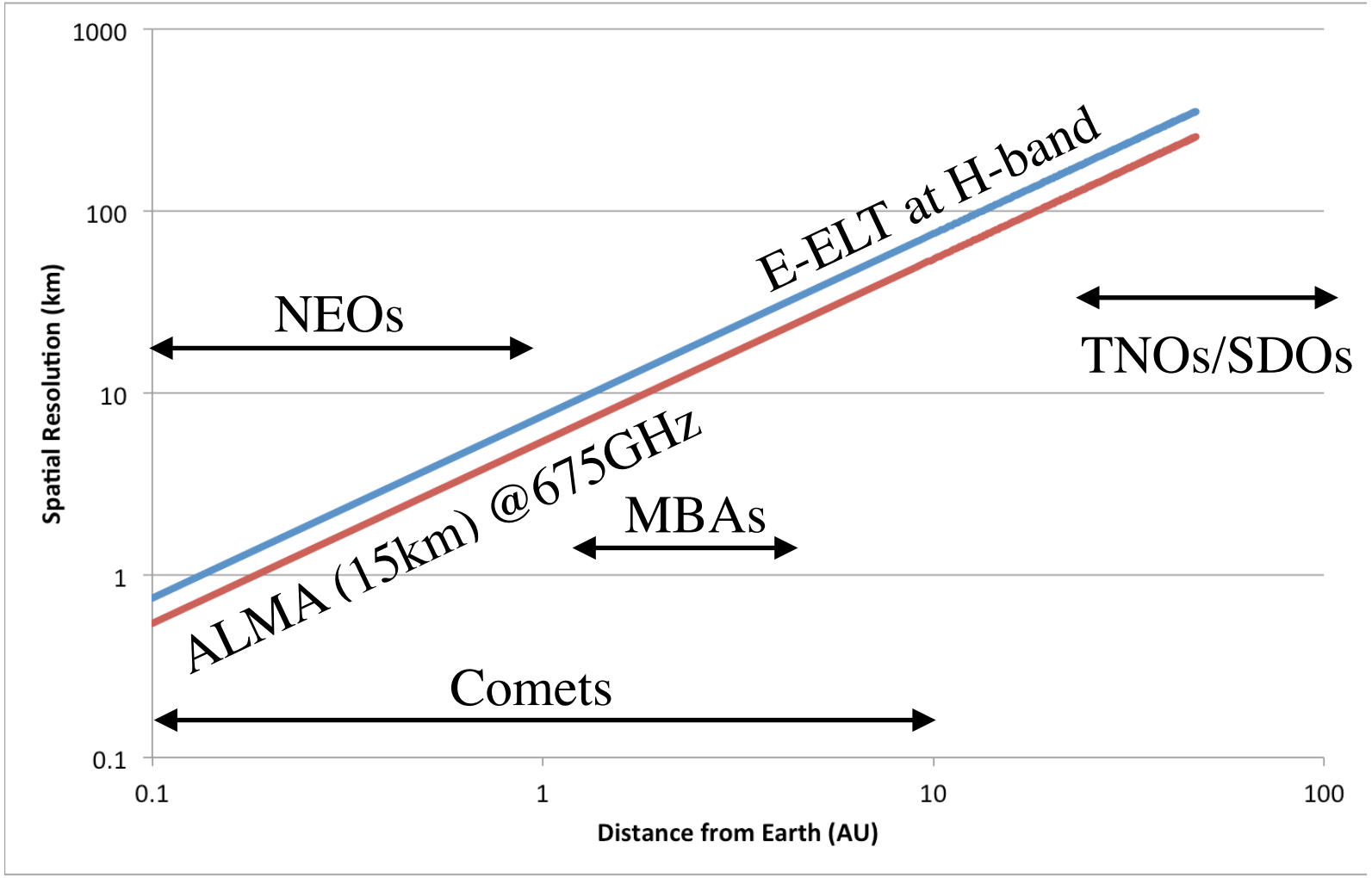
LSST - 3-day cadence to V~24, increasing all populations by factor ~10

E-ELT - High sensitivity, high spatial resolution in opt+NIR.





Impact of ELT spatial resolution

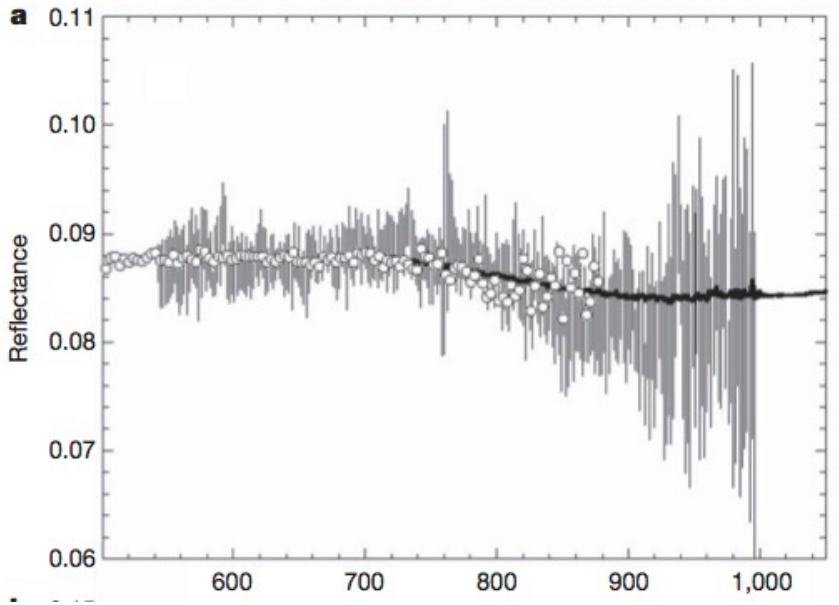


Resolved NEO and Main-Belt binaries.
Accurate shapes/sizes + GAIA masses -> densities.
Mineralogy/compositional mapping of larger objects.

Near-Earth Objects

- Small impactors from ATLAS/LSST. Trajectories and physical characterisation from astrometry, photometry and opt/NIR spectroscopy.
- Requires observations within 24 hours of discovery i.e. before they hit! High-speed guiding of >1 arcsec/sec required.

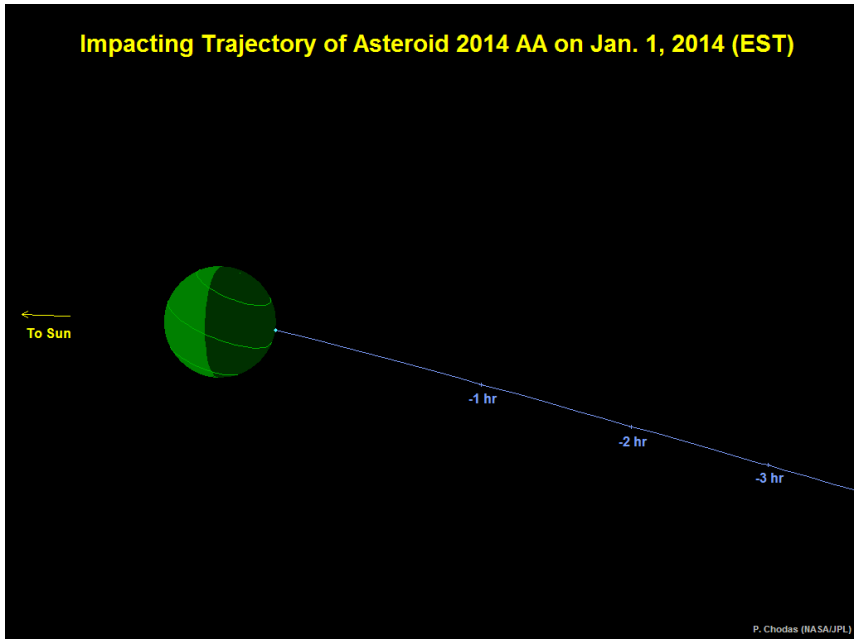
2008 TC3



Jenniskens et al. 2009

Chelyabinsk 2013

2014 AA

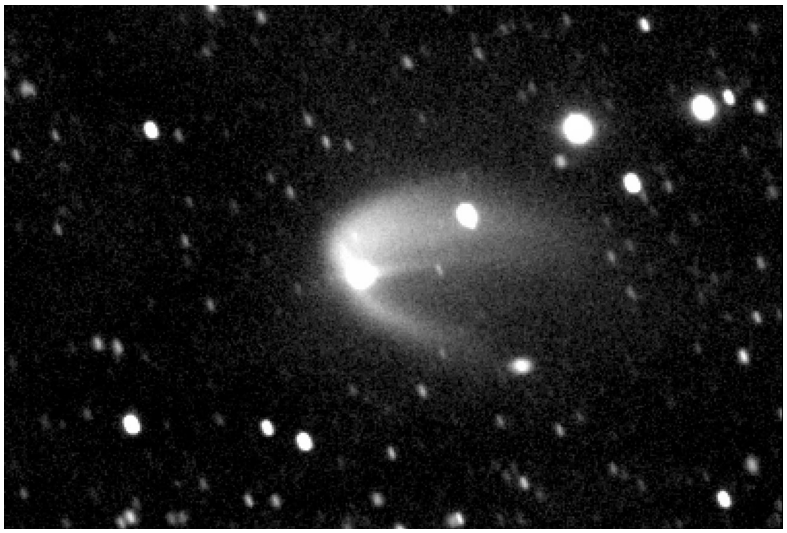


Chodas 2014

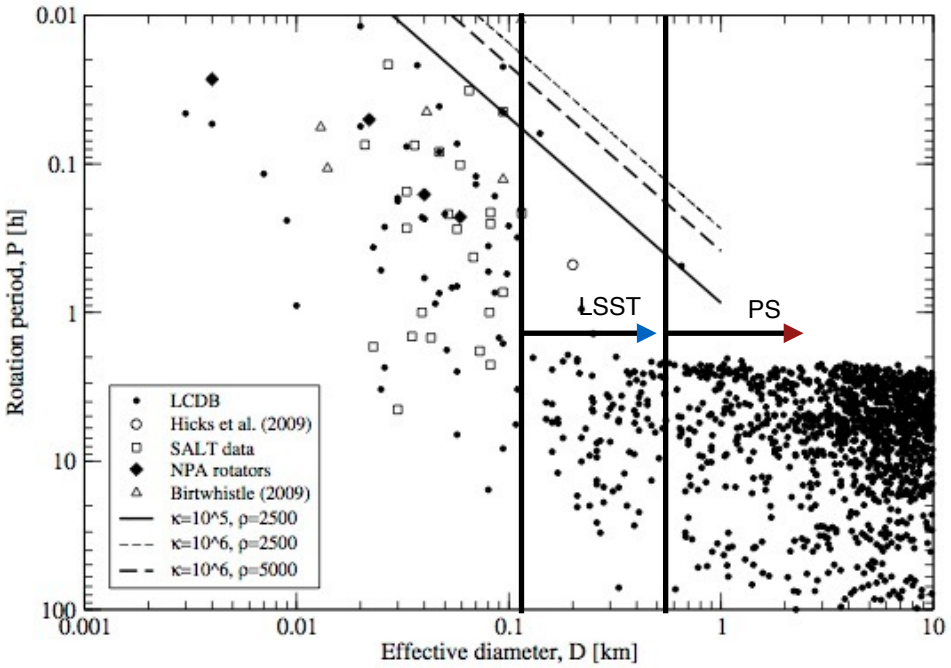
Main-Belt Asteroids

- ~1 collision/disruption found per year - LSST should significantly increase this due to sensitivity+cadence.
- Current observations imply YORP spin-up disruptions more important than collisions.
- Requires early detection and monitoring.

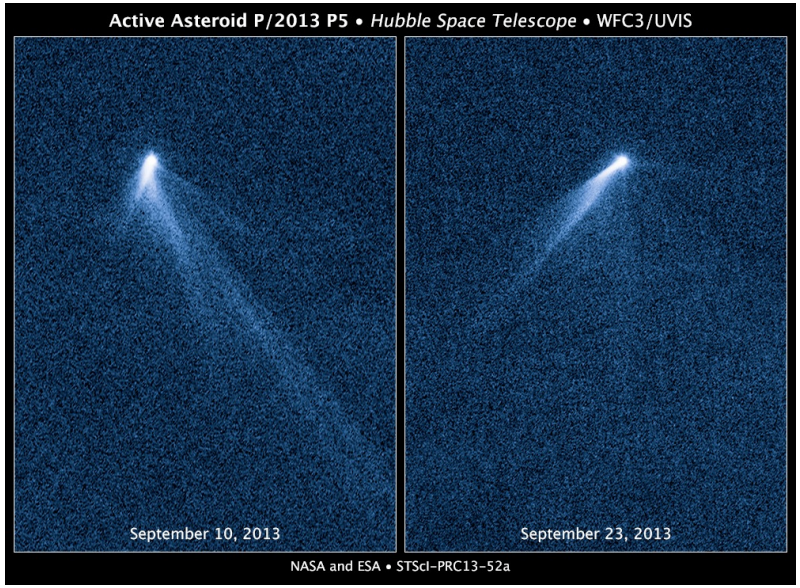
596 Sheila



Rotational studies



P/2013 P5

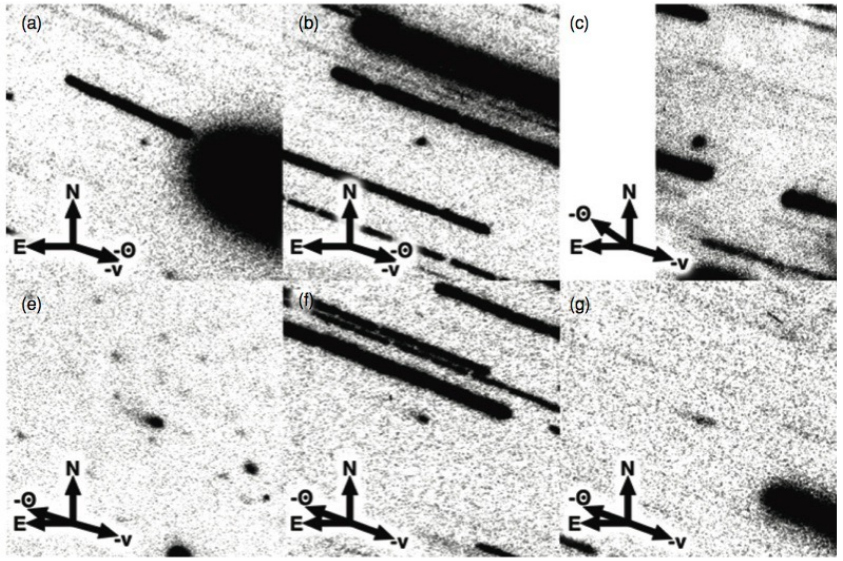


Jewitt et al. 2014

Main-Belt Comets

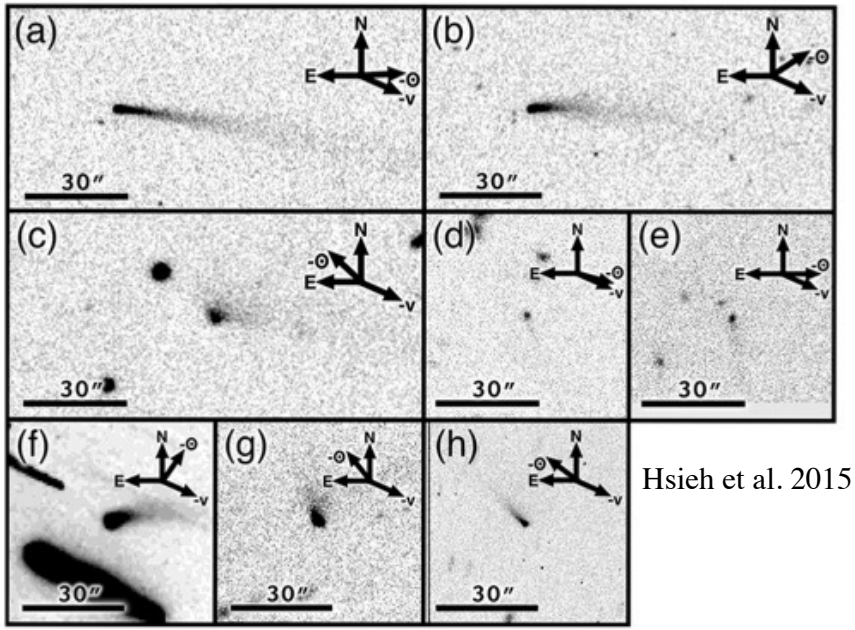
- 3 now confirmed, probable instantaneous population of ~100.
- Collisional activation likely origin, but lifetimes and sublimation rates unmeasured.
- Requires deep imaging for all objects, sensitive spectroscopy for gas emission (UV/blue > 370nm) and model testing.
- Subject of several ESA/NASA proposals due to possible H2O origins and D/H.

238P/Read



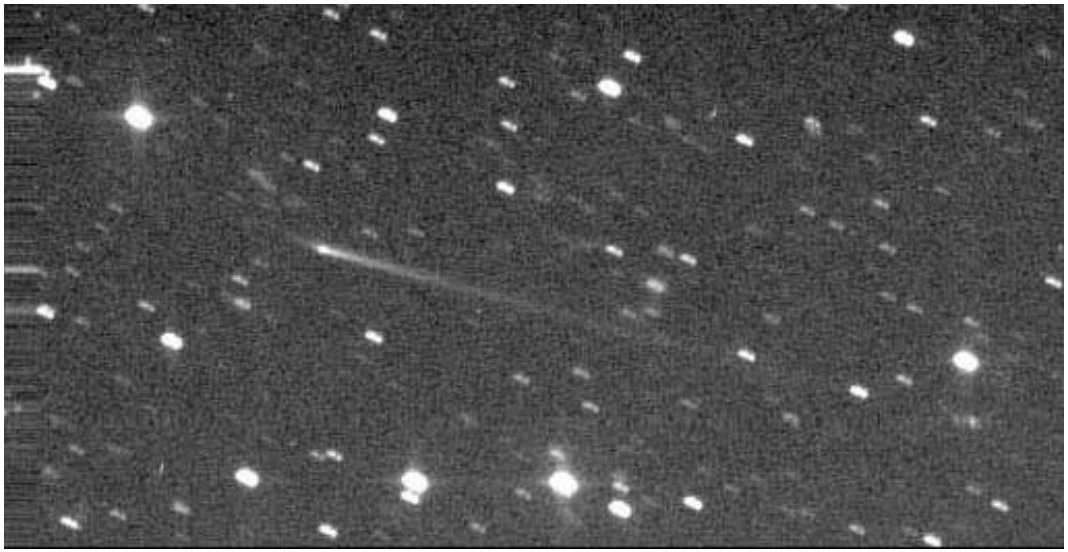
Hsieh et al. 2011

313P/Gibbs



Hsieh et al. 2015

133P/Elst-Pizarro

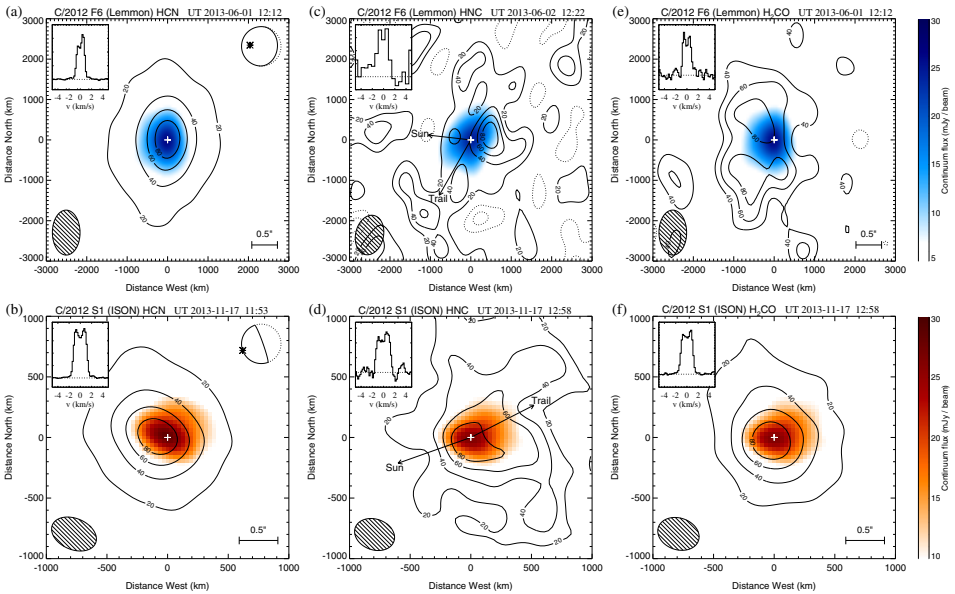


Boehnhardt 1998

Bright Comets

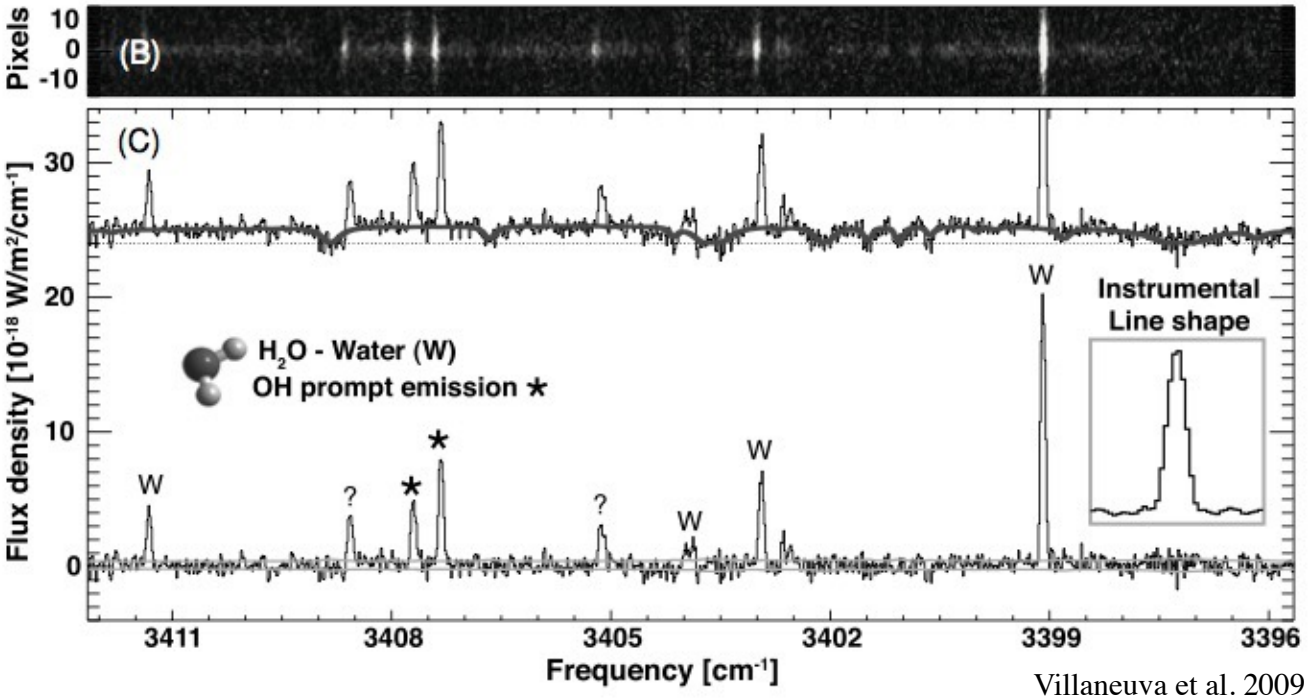
- Near-nuclear gas-phase distributions now being obtained from ALMA.
- VLT + ESPRESSO, VLT+CRIRES, ELT-HIRES can allow C,N isotopic ratios and even D/H from close Kuiper-belt comets.

Comets Lemmon & ISON



Cordiner et al. 2014

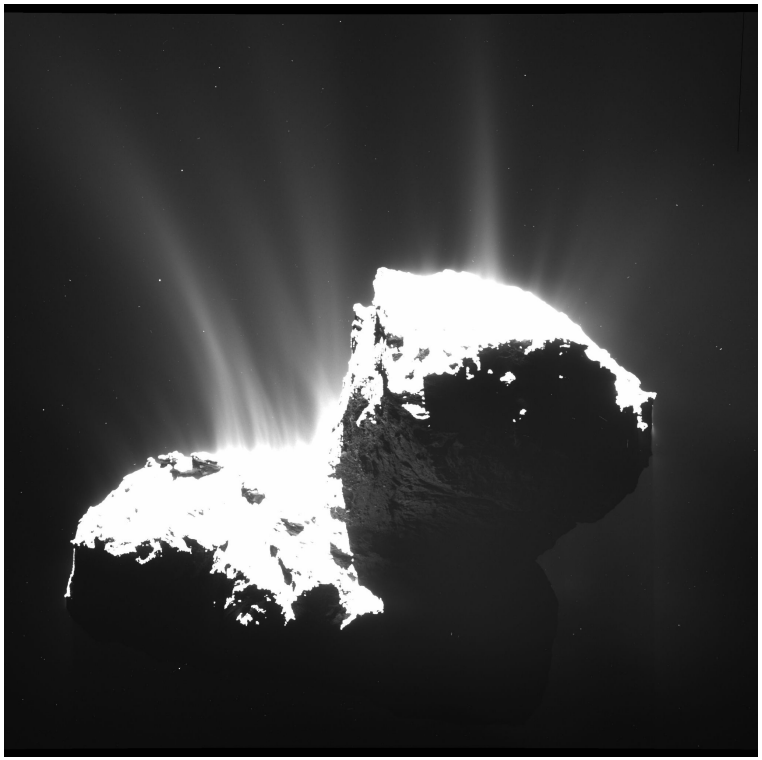
D/H in Comet 8P/Tuttle



Villaneuva et al. 2009

Comets

- Distant activity at > 3AU is poorly studied - 67P results agree with significant activity at large distances. Requires 4m/8m monitoring.
- Inner coma chemistry and dust dynamics from ALMA/E-ELT extremely important for understanding classically observed species and dust/gas interactions.



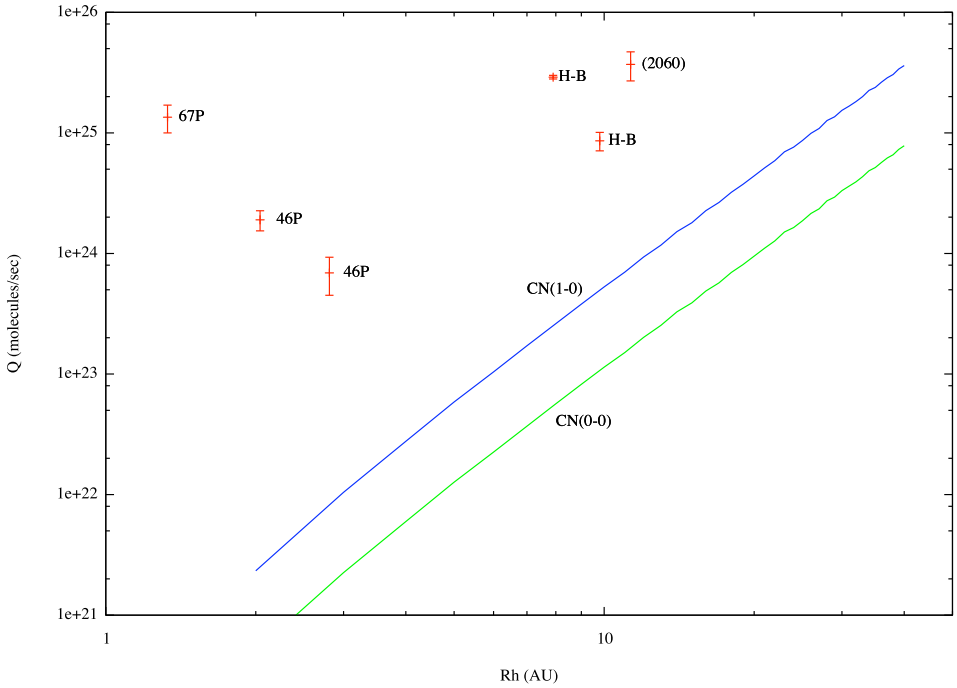
4km

ESA/MPS/OSIRIS

= E-ELT H-band spatial resolution @ 0.5AU

100,000km

Snodgrass/ESO 2014

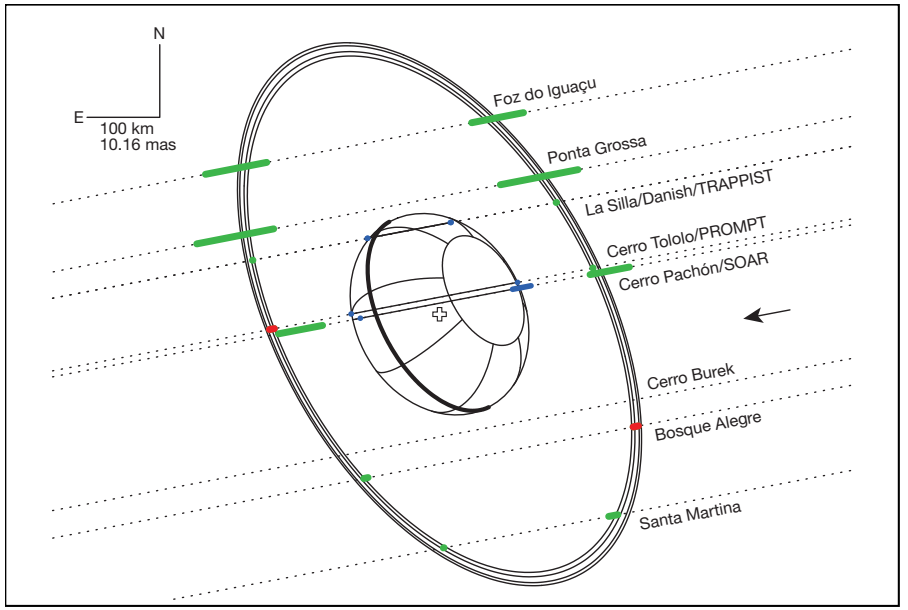


Centaurs and Trans-Neptunian Objects

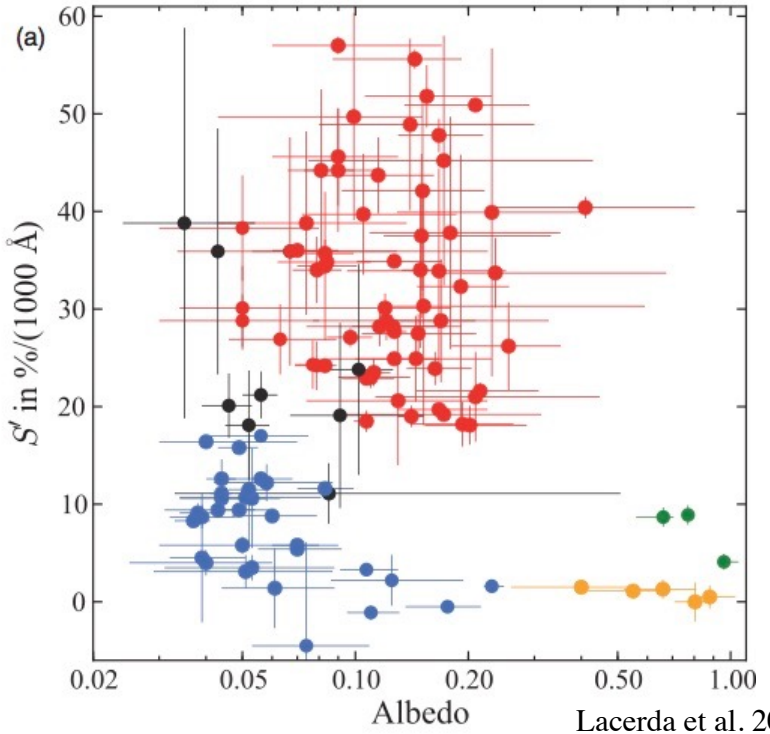
- Resolved imaging/spectroscopy of large TNOs/Centaurs.
- Occultations of bright and faint TNOs using GAIA orbits and stellar positions.
- Photometry and spectroscopy of populations - why so different?

Haumea's Dark Red Spot

Chariklo's Rings



Braga-Ribas et al. 2014



Lacerda et al. 2014

ESO support of Science Drivers for asteroids/comets in 2020+

- Accurate non-sidereal guiding for E-ELT - required for high spatial resolution imaging/spectroscopy of all solar system targets.
- Rapid response availability very important for transients on 8-m and 4-m (TOOs and DDTs) - collisions/disruptions/outbursts.
- Multi-colour monitoring should be available - LSST will only provide one bandpass at 3-day cadence.
- Low-res opt+NIR spectroscopy will remain central to asteroid/comet studies - requires high-throughput instruments on NTT/VLT/E-ELT.
- Sensitive high-cadence capability for occultation studies.
- Blue spectroscopy (<400nm) necessary for cometary studies.