Solar System Science: Small Bodies

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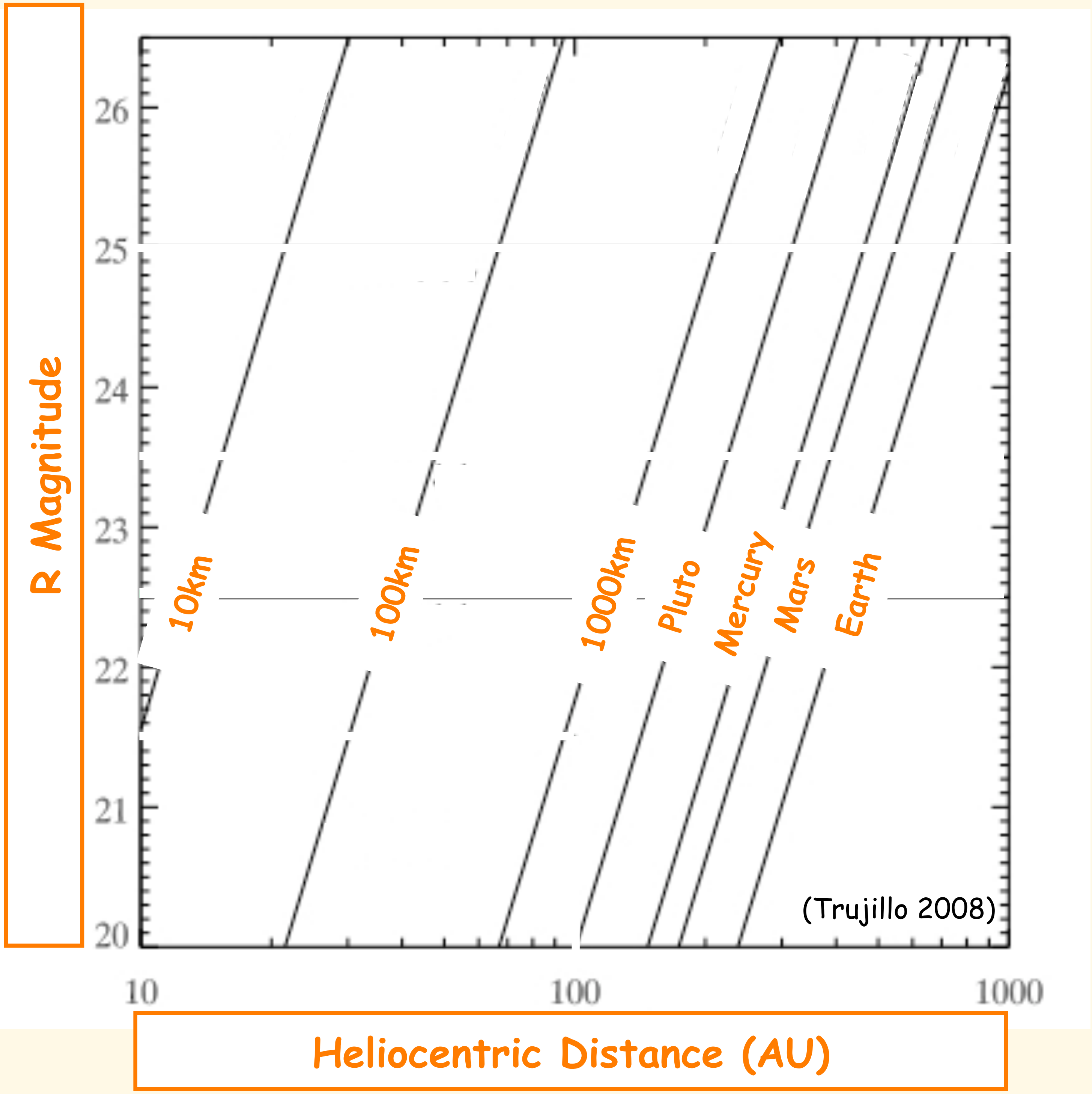
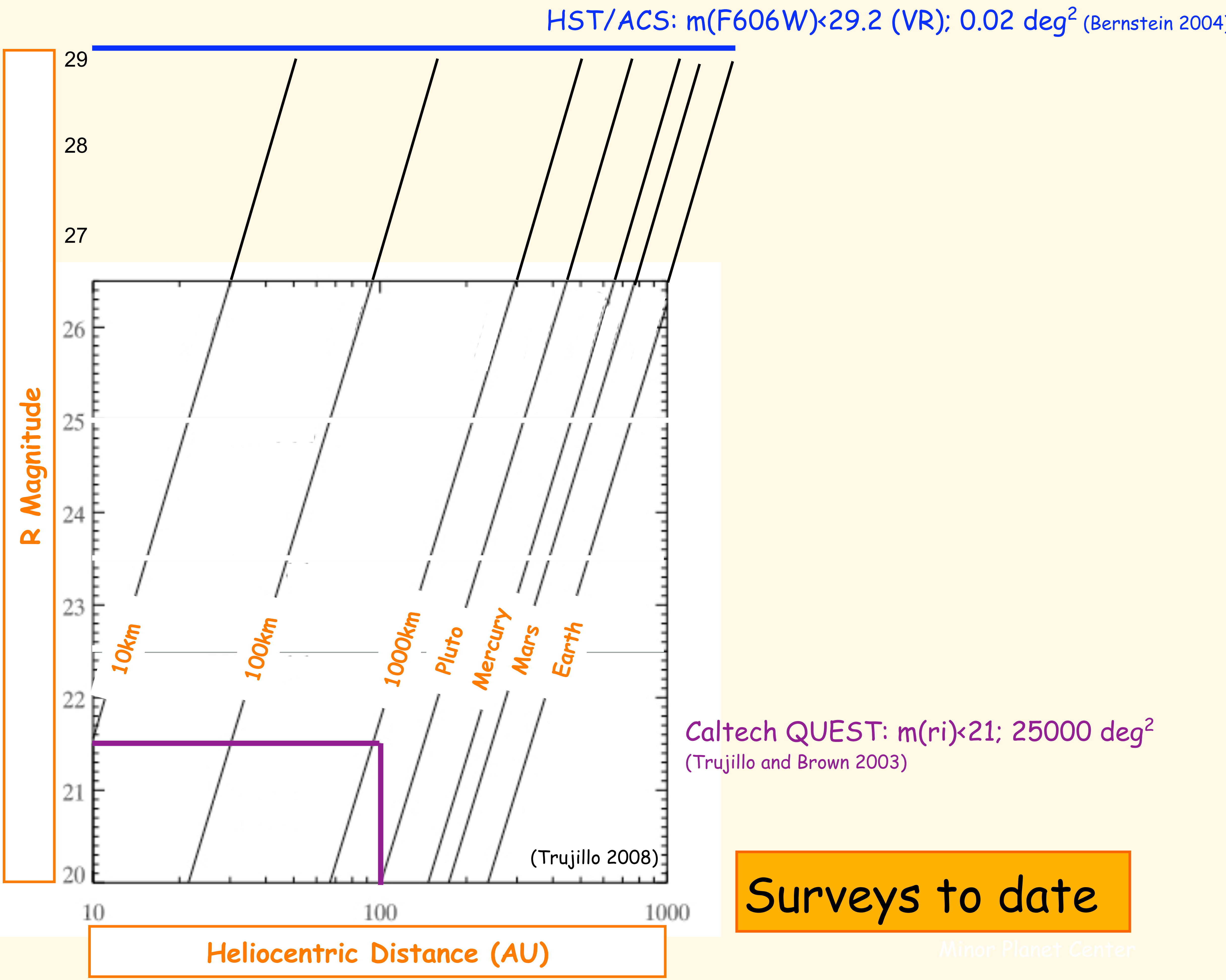
Detectable sizes for a given magnitude depth and heliocentric distance

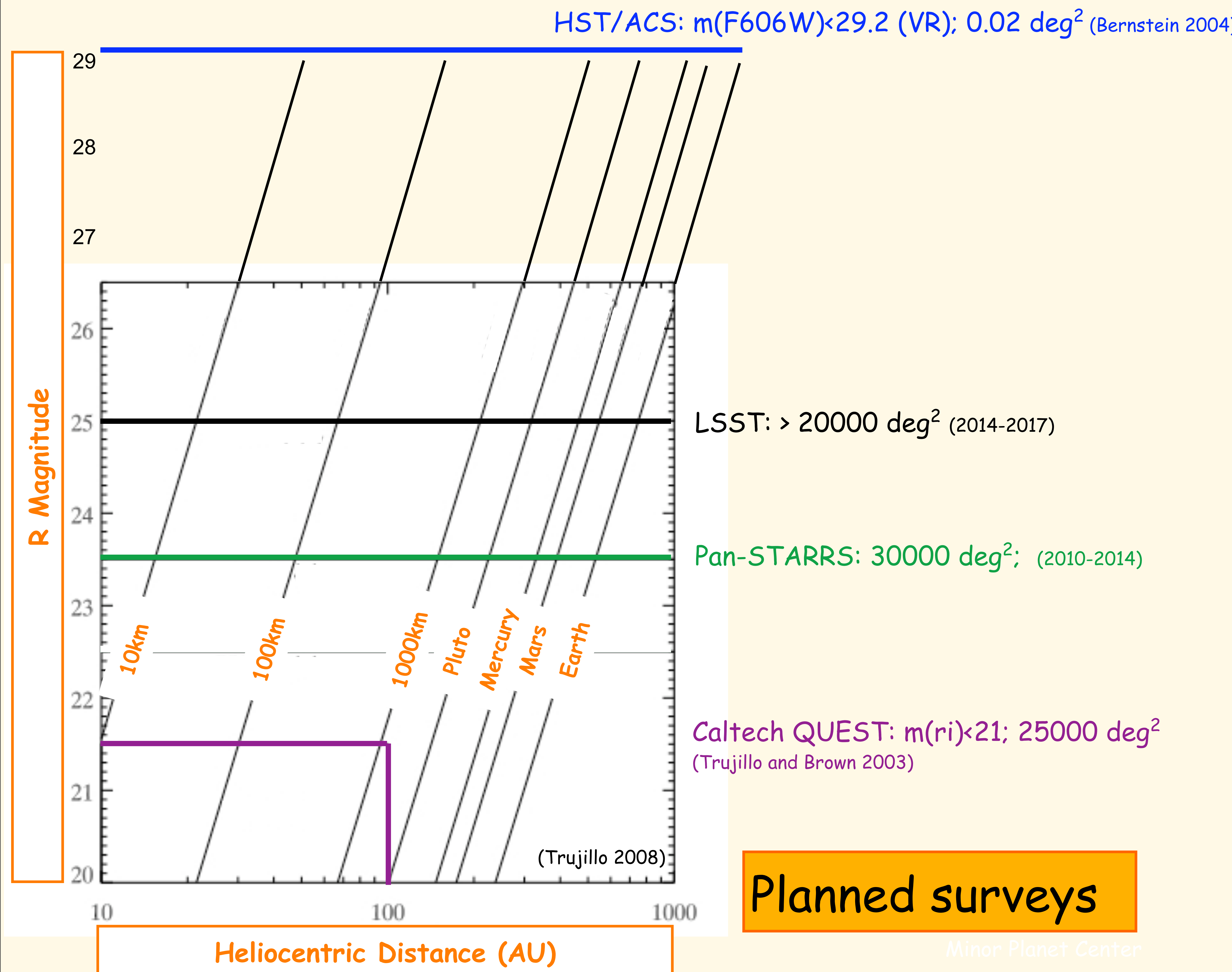


Magnitude → Size

- Requires modeling of dynamical and surface properties.
- Assumes 25% albedo. Additional complications due to varying albedos with size: albedo independent of size for objects < 200-300 km but high albedo for objects > 1000 km (Stansberry et al. 1999).

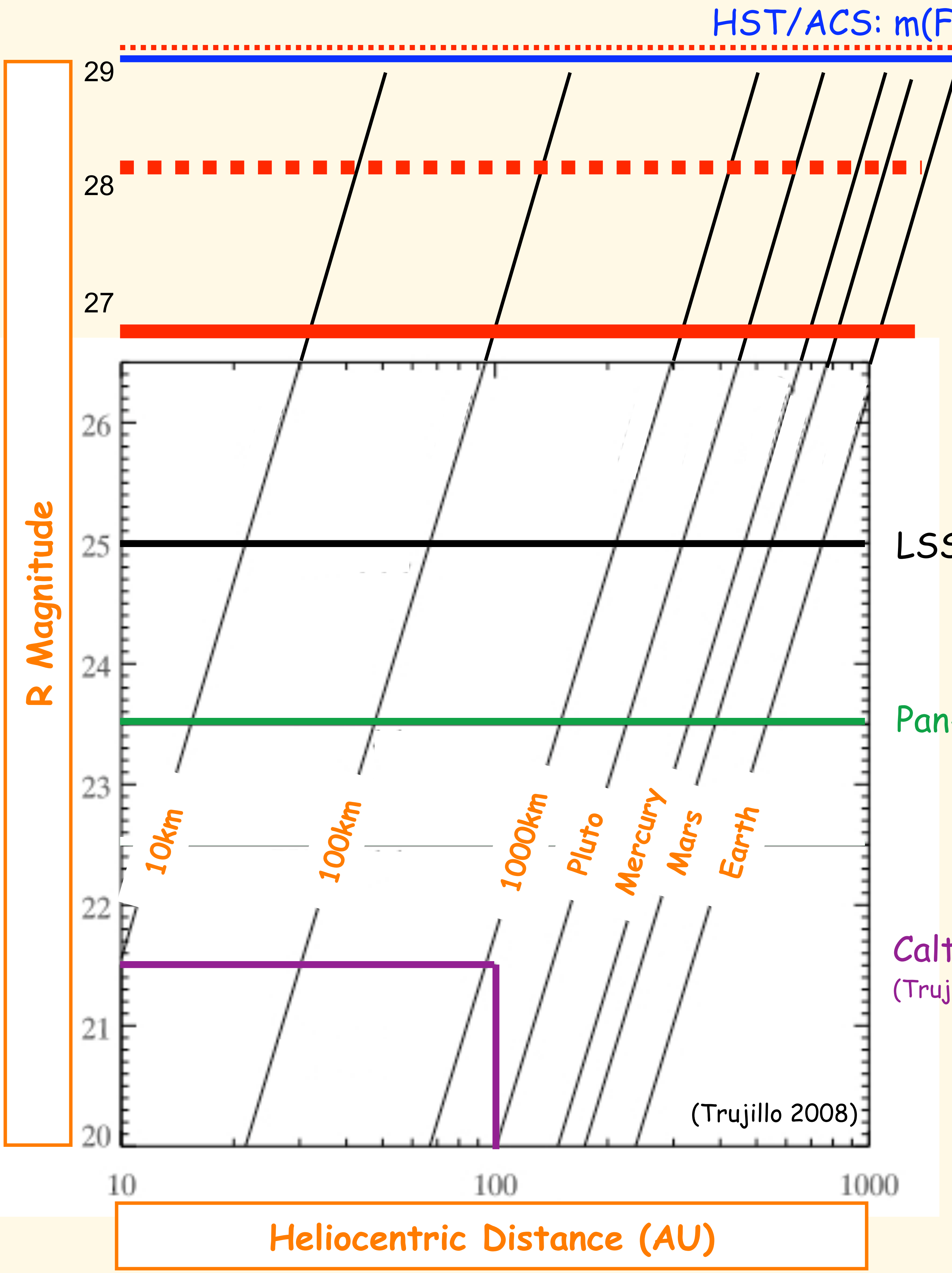
Surveys to date





Planned surveys

The HSC Survey



HSC: m(r)<29.3; 5 deg^2

HSC: m(r)<28.1; 20 deg^2

HSC: m(r)<26.8; 300 deg^2

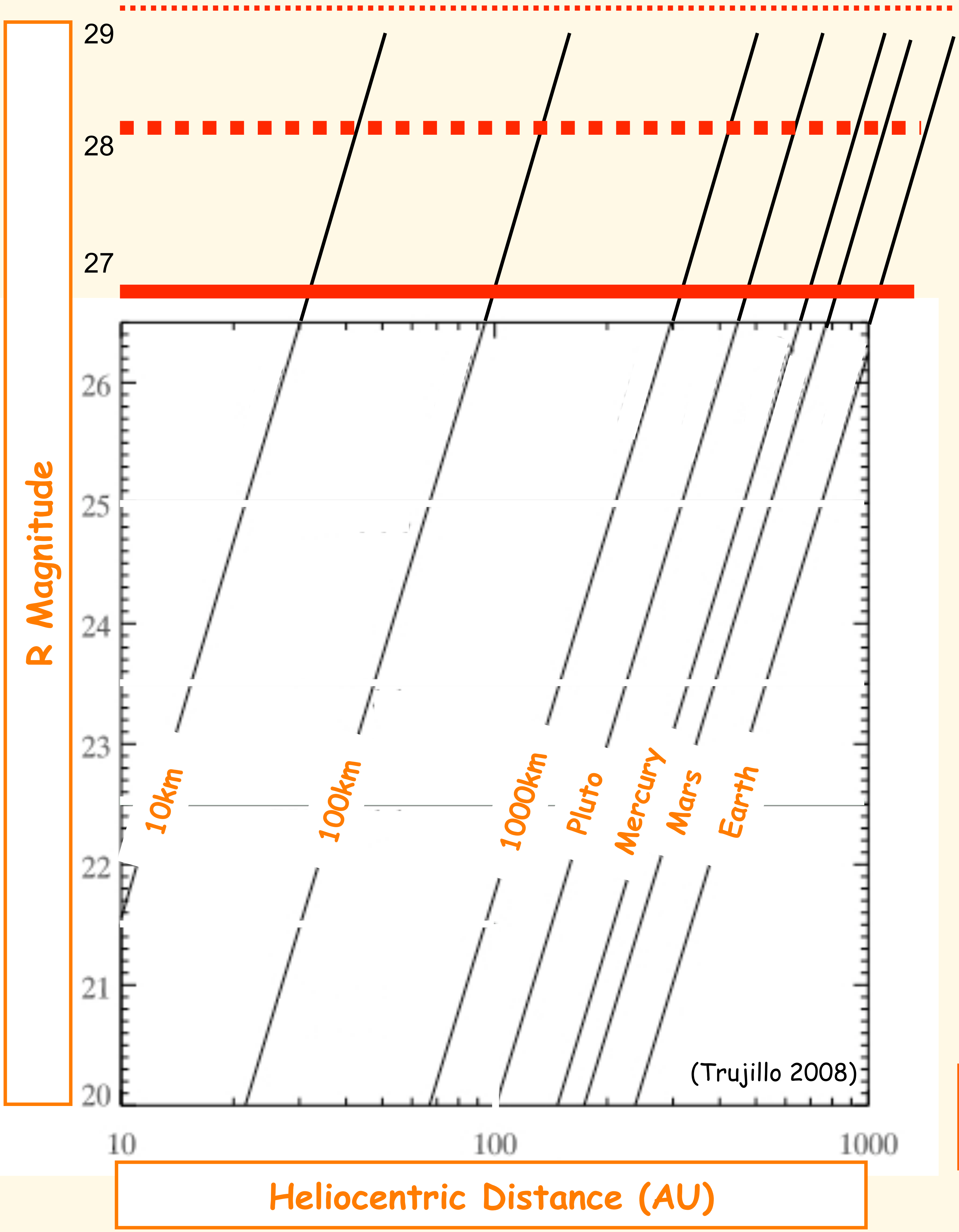
Reaching this depth for KBO dependents on cadence strategy; need to add separate observations for moving targets

r & i filters are the most sensitive for KBO observations

LSST: > 20000 deg^2 (2014-2017)

Pan-STARRS: 30000 deg^2; (2010-2014)

Caltech QUEST: m(ri)<21; 25000 deg^2
(Trujillo and Brown 2003)



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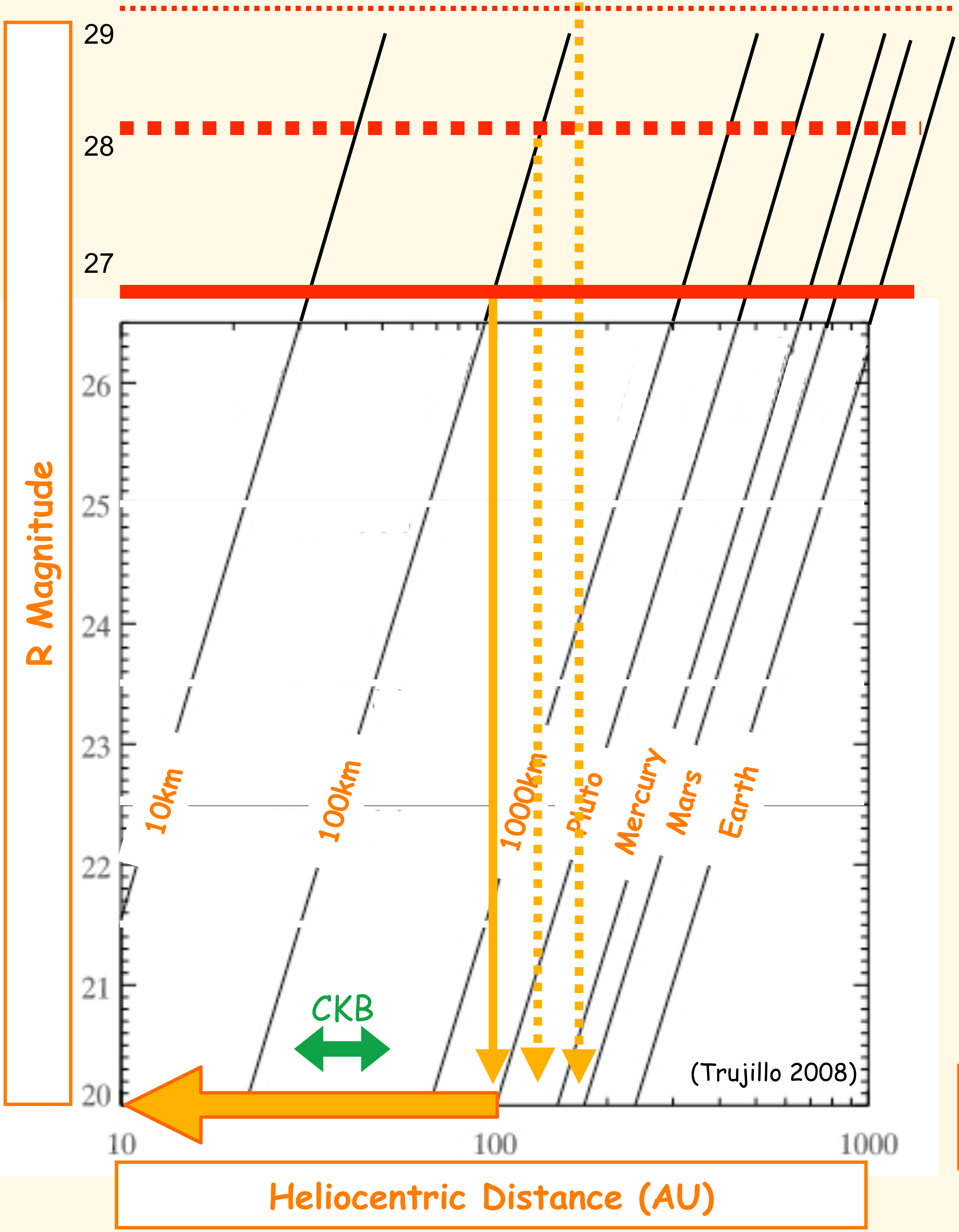
The HSC Survey

Minor Planet Center

The HSC Survey



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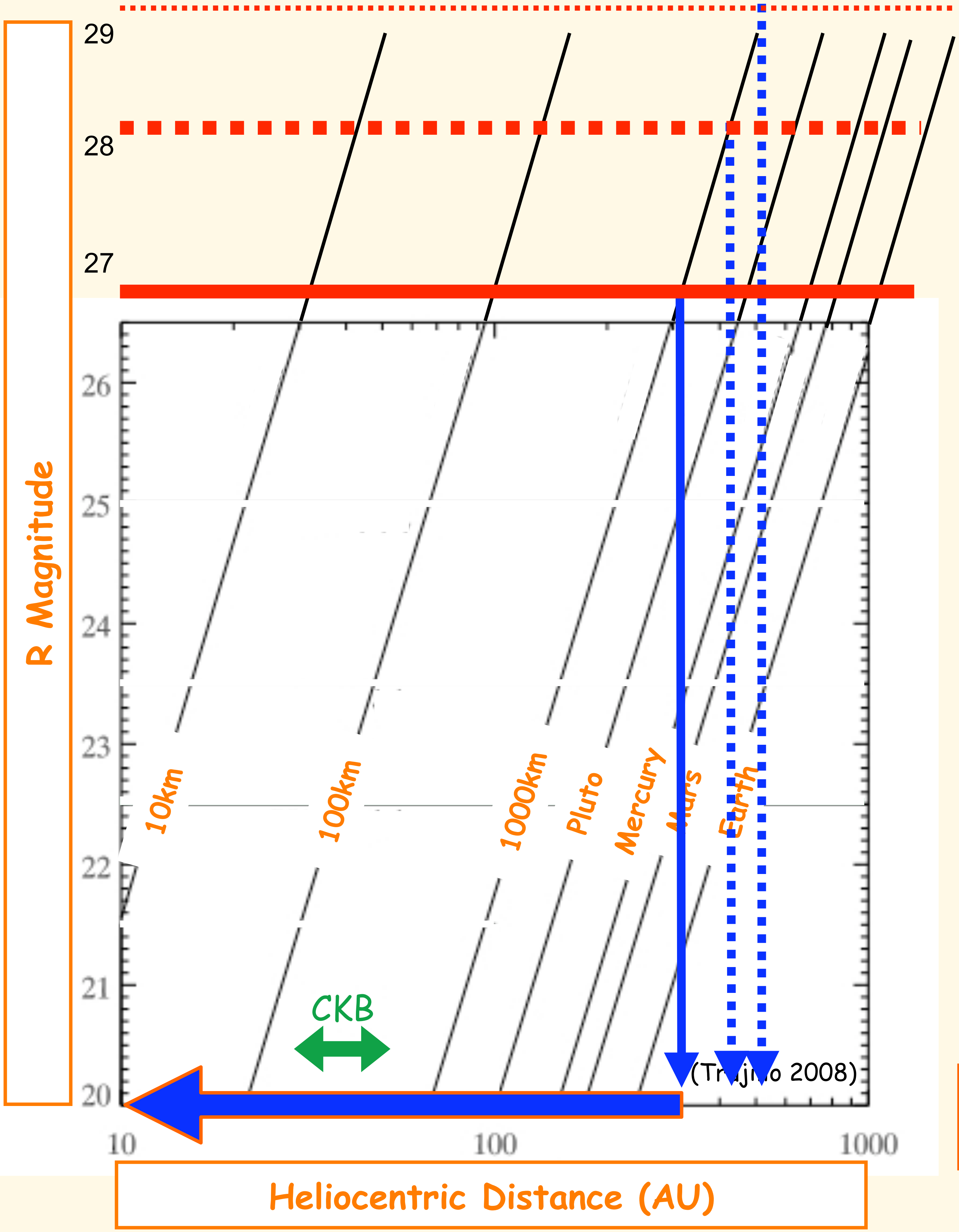
Could detect(*) 100 km diameter KBOs at:

$\lesssim$ 100 AU: shallow survey

($\lesssim$ 170 AU: deep survey)

(*) given that multi-year observations can be added.



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r & i filters are the most sensitive for KBO observations

Could detect(*) 1000 km diameter KBOs at:

≲ 300 AU: shallow survey

(≲ 500 AU: deep survey)

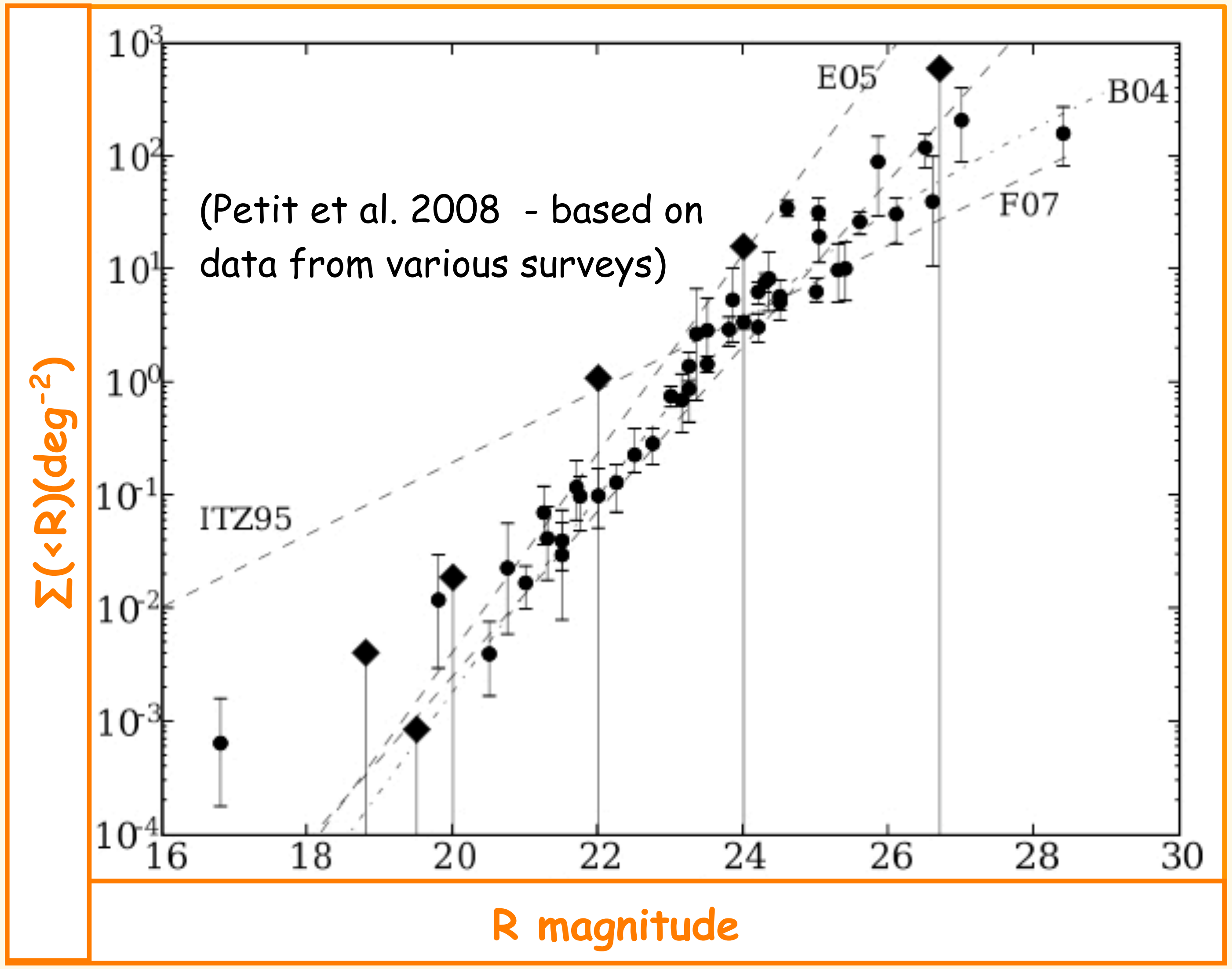
(*) given that multi-year observations can be added.

The HSC Survey

The HSC survey can set constraints on the size distribution of KBOs from their luminosity distribution

Small planetesimals (50-100km):

- Is there a “knee” in the size distribution? (like HST/ACS survey suggests)
- HSC survey could provide good statistics.
- Determined by the physical properties and the dynamical and collisional evolution.
- Constraints on fragmentation parameters and bulk properties.
- Serves as a test of KBO formation models.



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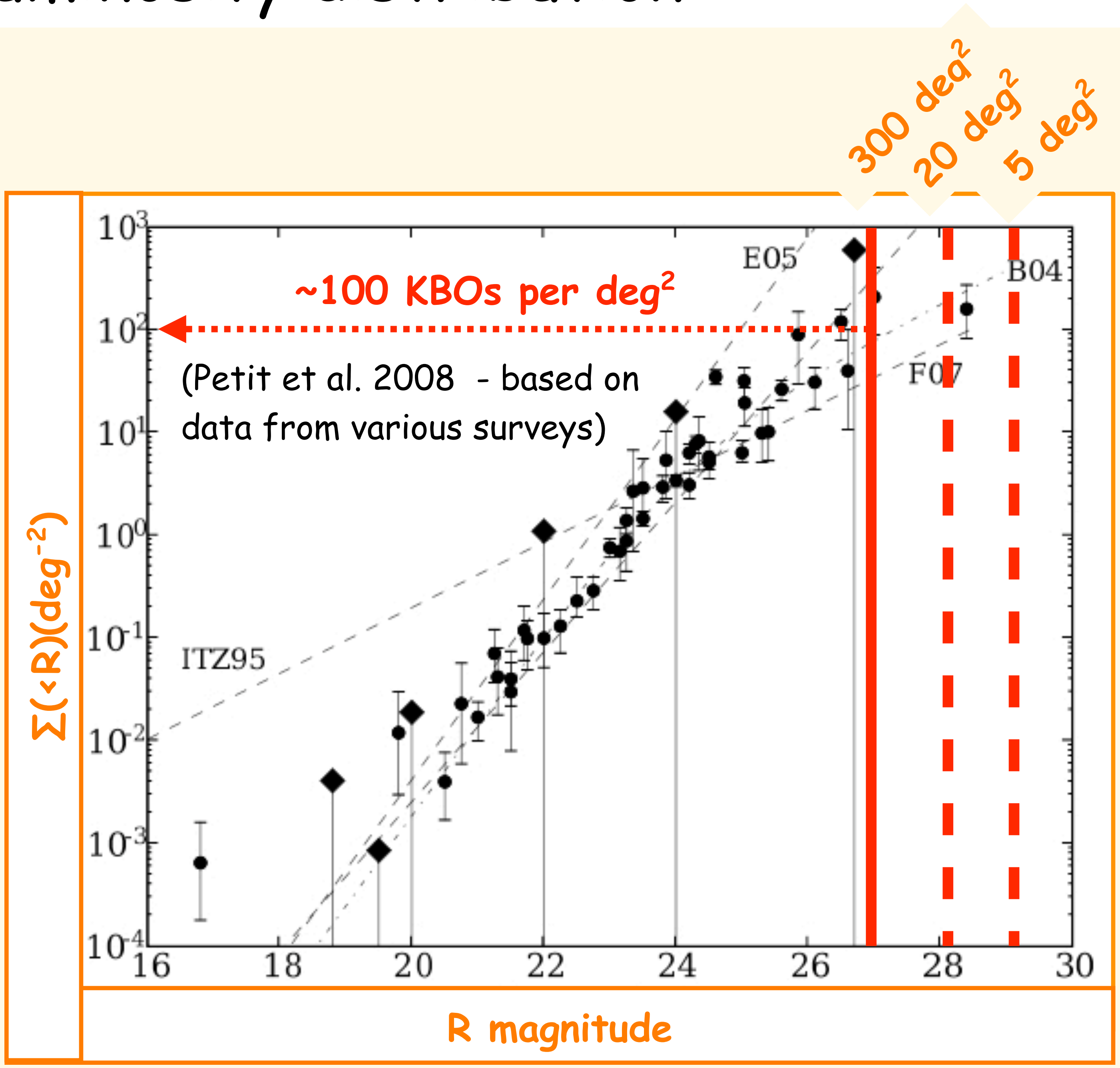

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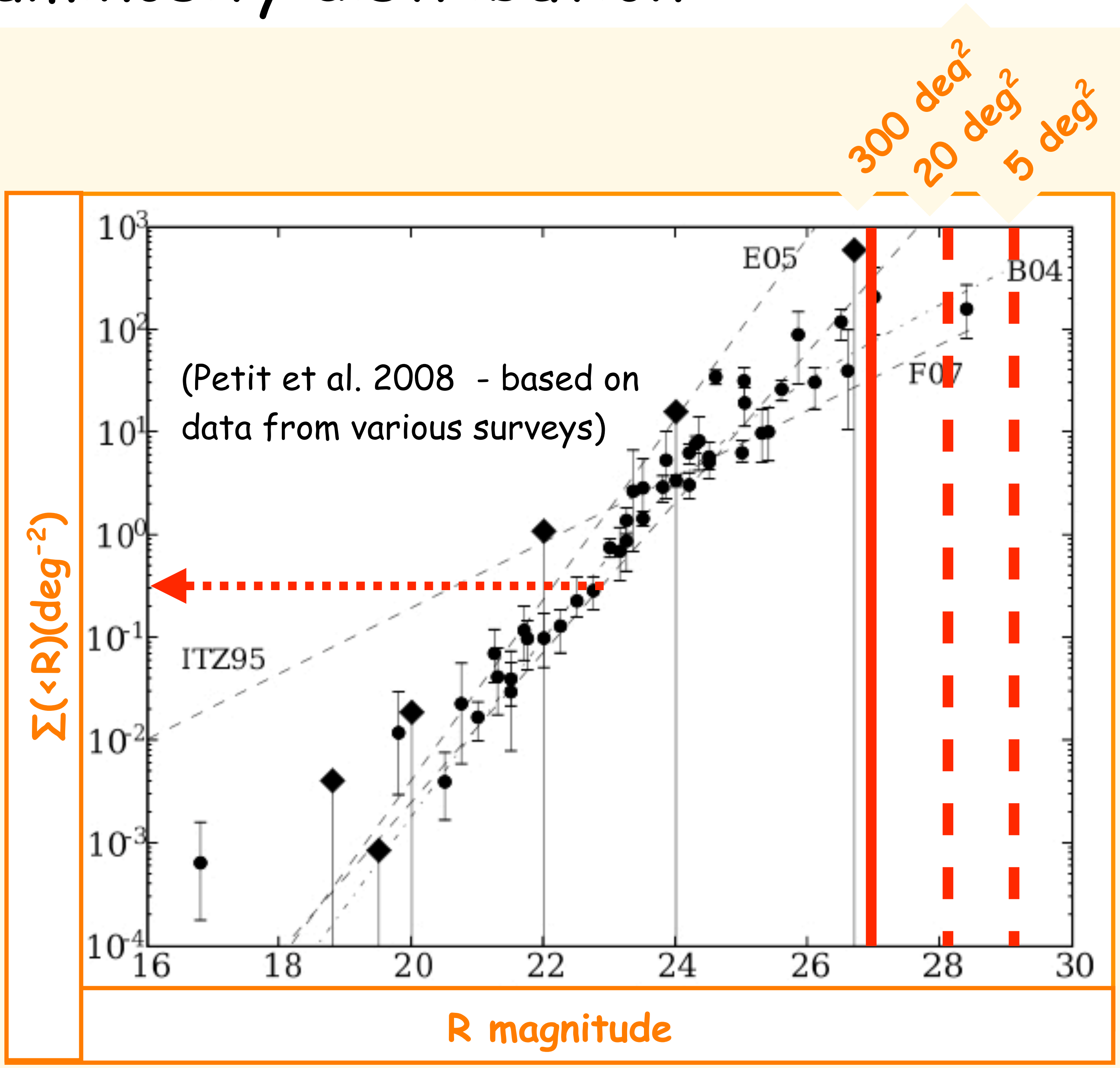
Large planetesimals:

- Determined by accretion processes (not affected by collisions)
- Help constrain accretion models (relevant for planet formation).
- Because of scarcity of large objects, need large survey in ecliptic plane (~1500 deg^2).
- Potential to detect more Sedna-like objects (q=76AU; a=976AU,e=0.85, D=1100-1800km, albedo~0.2) out to 300-400 AU (they spend most of their time near aphelion and their flux is proportional to R^{-4}, so they must be more common at larger distances).

Radial distribution at large distances helps constrain dynamical models.

[Mean motion is 0.3 arcsec/hour -> 1 arcmin/yr; 10 arcsec/day].



The HSC survey can set constraints on dynamical evolution models

- Inclination distribution: current observations indicate $i_{1/2}$~5° (Jewitt et al. 96) but biased against high inclinations (could be > 20° - Trujillo et al. 2001 and SDSS). Important to know because at formation $i_{1/2}$~1° and changed due to scattering by massive planetesimals, sweeping resonances, mutual scattering and/or perturbation by passing star.

- Constraining Neptune migration history from the study of the Towtino population at +75° vs. -75° (Chiang et al. 2002)

- Test the Nice model (explains LHB, giant planets and KB orbits, - Levison et al., Gomes et al., Tsiganis et al. 2005). Prediction: The KB was initially nearly empty at > 50 AU. Test: if correct, KBOs at > 50 AU should have collisional and dynamical signatures from the scattered population. If not correct and formed in situ, the size distribution is different (determined by collisional growth, self stirring and stirring by 30 M_{Earth} of planetesimals at 20-30 AU scattered through the KB).

Other possible HSC survey results

Studying KBOs surface properties from colors: currently ~200 known. Very diverse, from neutral (V_R~0.35) to very red (V_R~0.75). Due in part to irradiated organics. Is the variation due to intrinsic differences in composition or is it due to competition between irradiation and impact resurfacing? HSC can significantly increase the sample of KBOs with color information.

Summary

The study of the small body population with HSC, together with theoretical models, can shed light on the physical and chemical conditions of the Solar System, the formation of planets and planetesimals and their collisional and dynamical evolution.