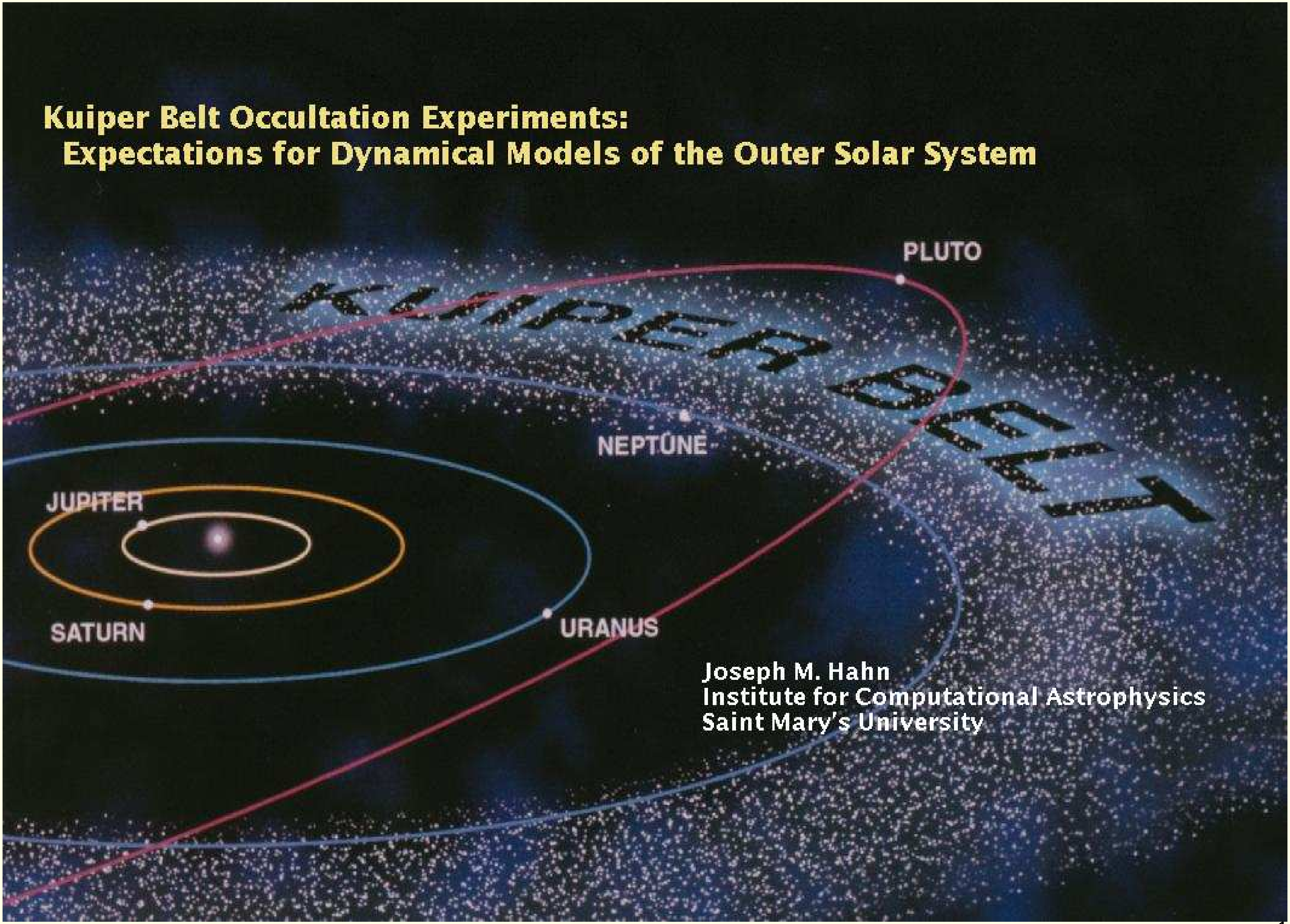
Kuiper Belt Occultation Experiments:
Expectations for Dynamical Models of the Outer Solar System



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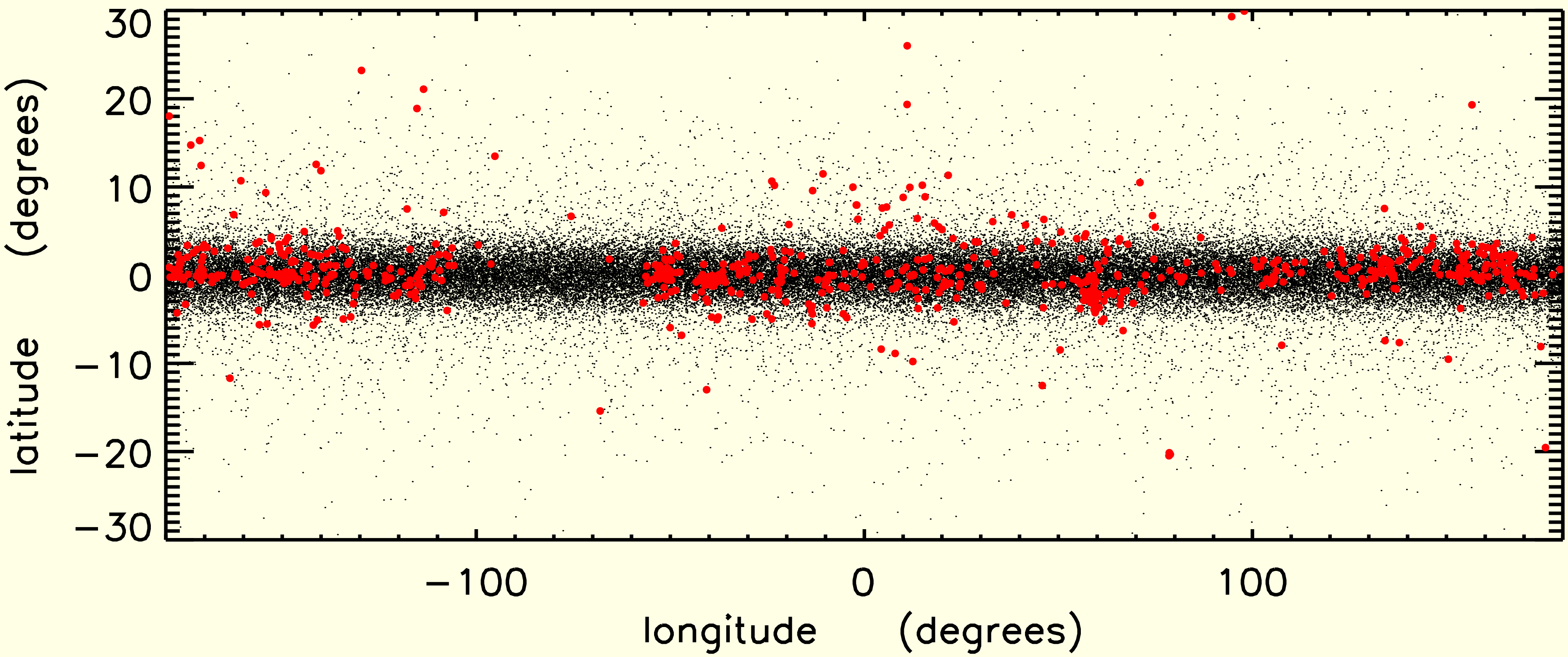
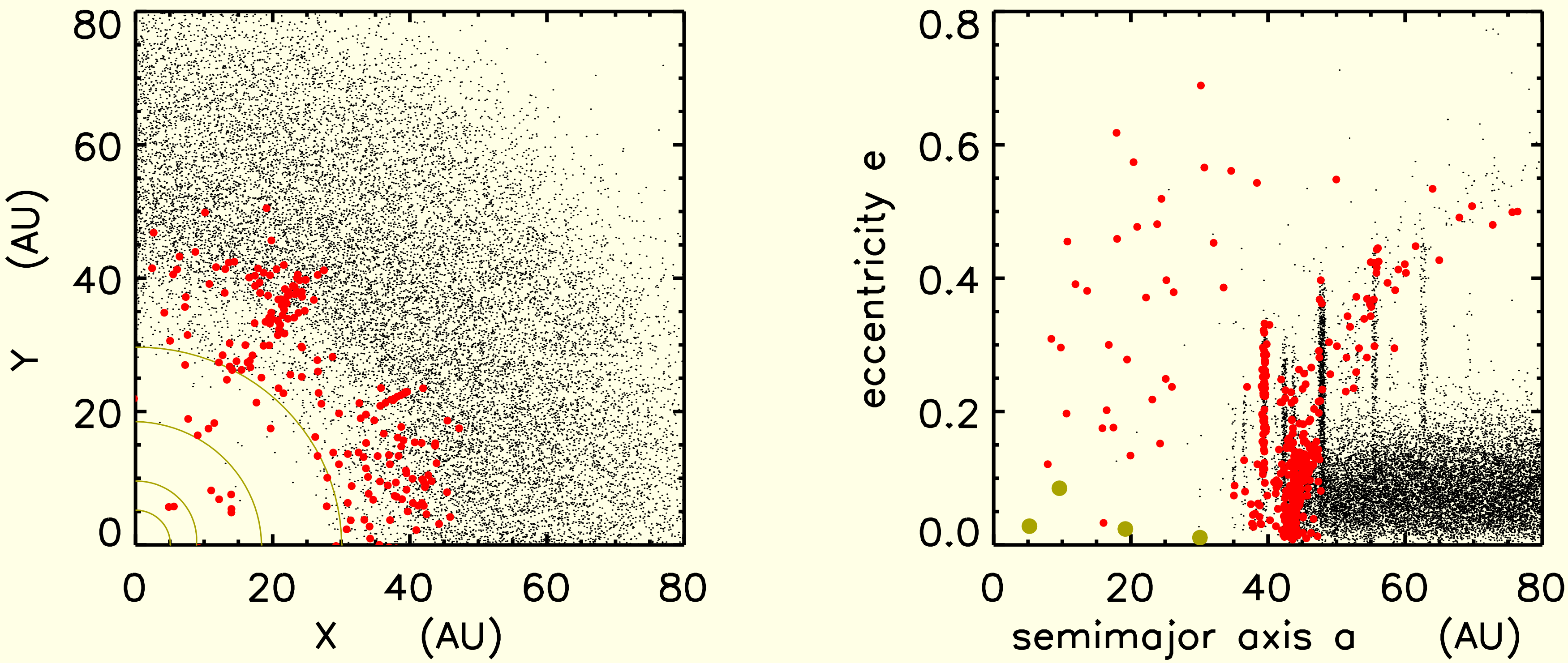
How KB occultations might constrain models of the KB's dynamical evolution



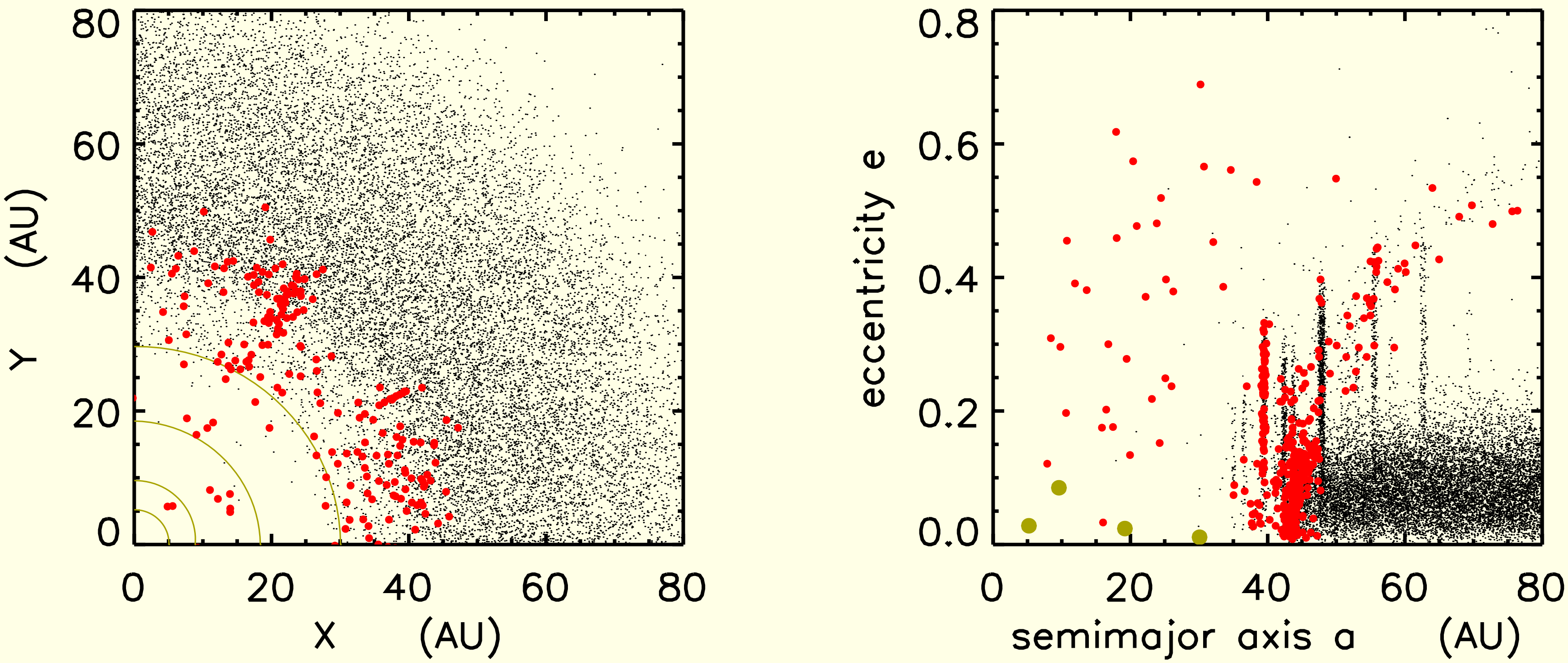
- first you need a model
  - eg., develop a KB scenario, evolve it, & compare model endstate (black dots) to the observed endstate (red)

- the simplest occultation experiment will provide KBO column density, but no depth information
  - this will yield only a very mild constraint on the Belt's latitude distribution

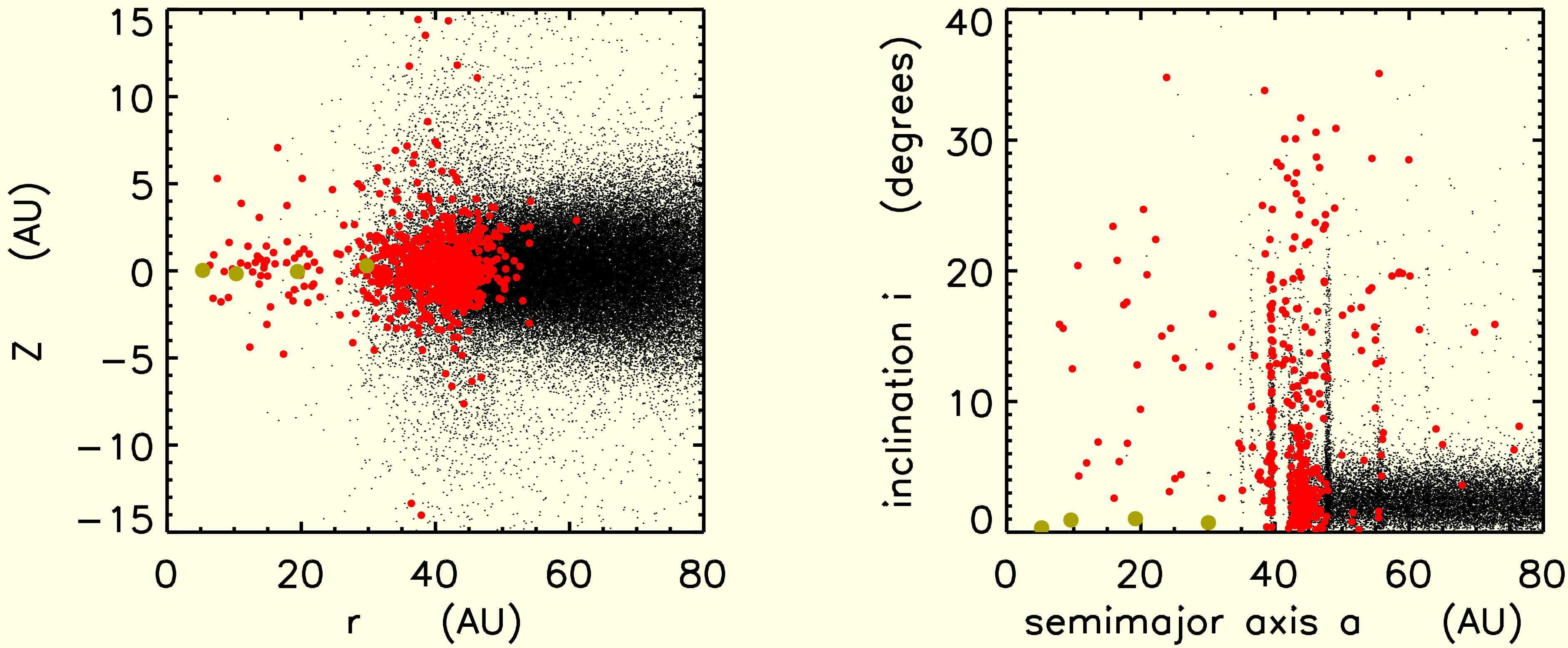
Depth information is desirable



- measuring distance r to a KB occultation event requires observing diffraction fringes, or tracking the KBO's shadow with a telescope array (e.g, Cooray 2003).
- although more difficult, such observations will be far more useful & will provide KB's gross characteristics
  - unlike telescopic observations which view only the Belt's inner edge, occultation observations can peer across the entire Belt
  - this should yield surface density $\sigma(r)$ of small KBOs
  - determine the Belt's outer edge r_{edge}

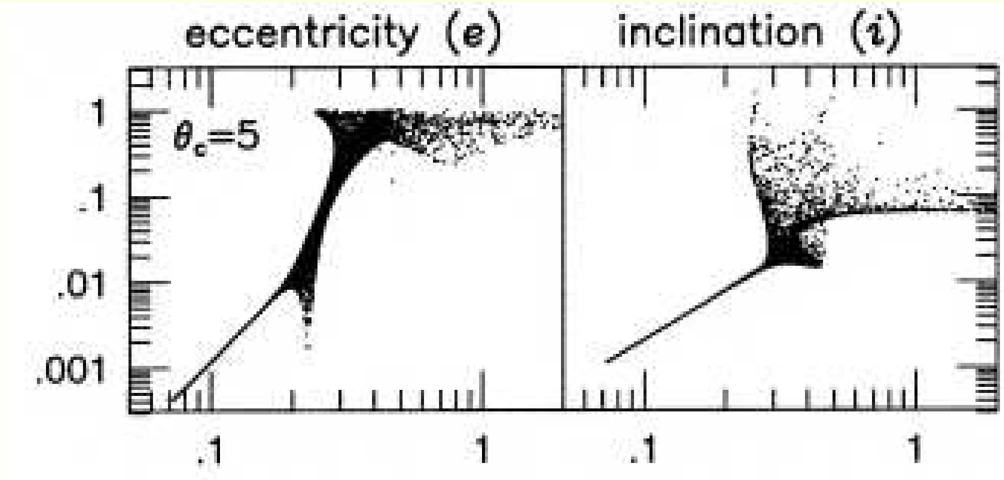


- however occultation observations will not reveal the Belt's fine–structure that is preserved in its orbit elements (a, e, i)
  - no follow-up observations→no orbits
- consequently, occultation observations will say little about the Belt's resonant populations, and thus will say little about dynamical scenarios that invoke Neptune's outward migration.
- nonetheless, some occultation data will be better than nothing, which is our current understanding of small/distant KBOs



- provided r is measured, occultation obs' can probe the Belt's 3D structure
- such observations can address other issues:
  - is the Belt's inner edge puffed up?
  - is there an outer Belt beyond $r > 50$ AU?
    - if so, is it flat (as expected from accretion theory)?
    - or is it fat (suggesting some post-formation disturbance)?

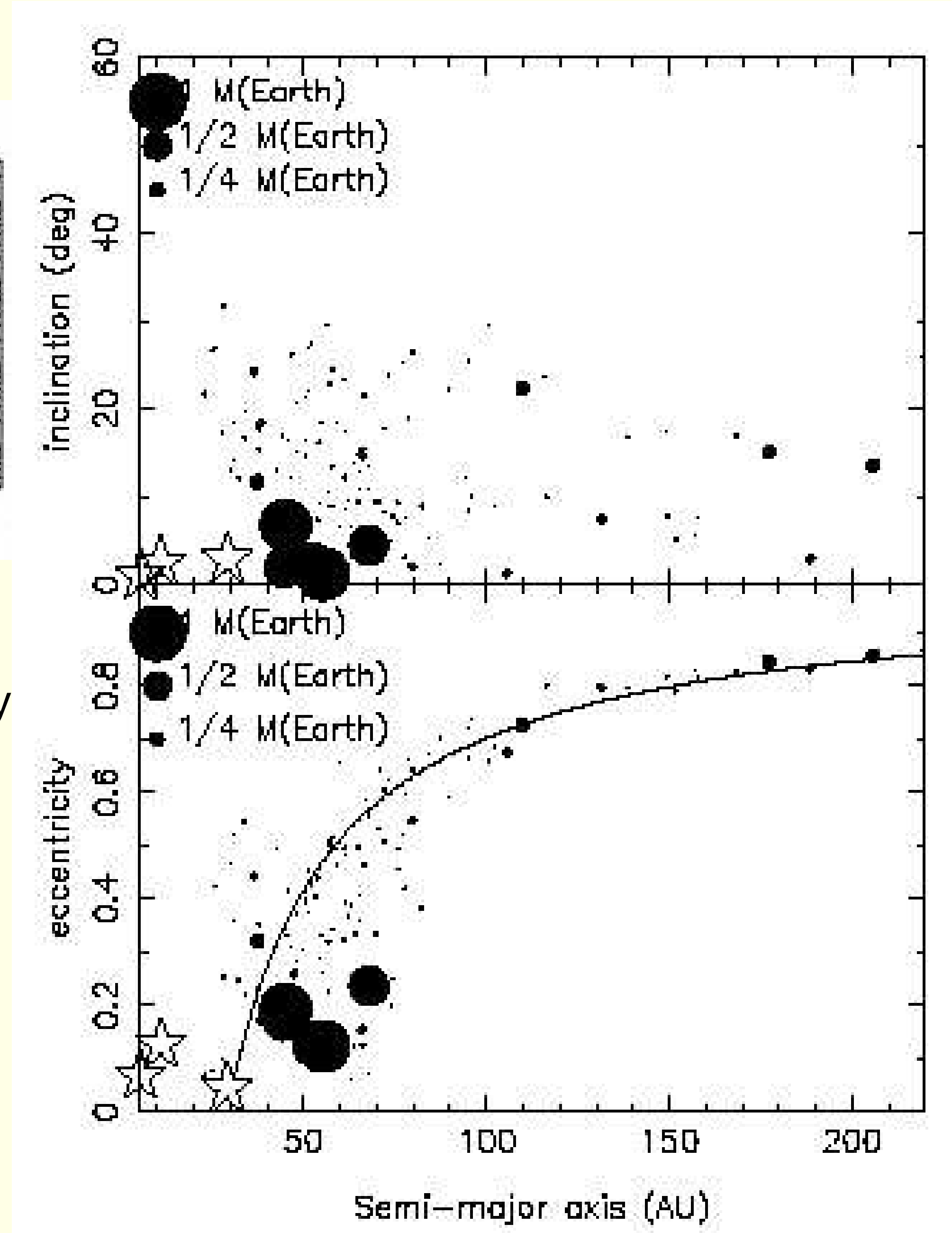
Possible 'post–formation disturbances'



stellar encounter (Ida et al 2000)

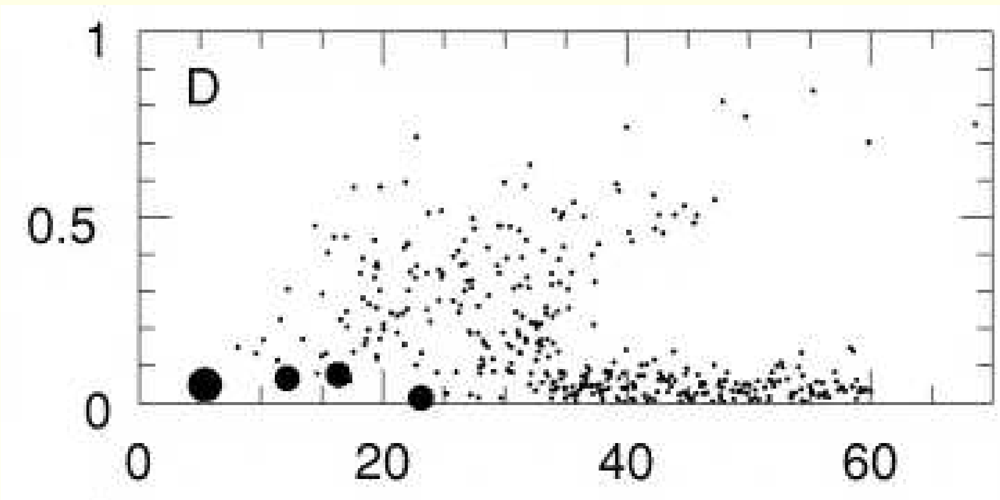
intriguing idea, but no longer supported by observations.

from "Planetary Embryos Never Formed in the Kuiper Belt"

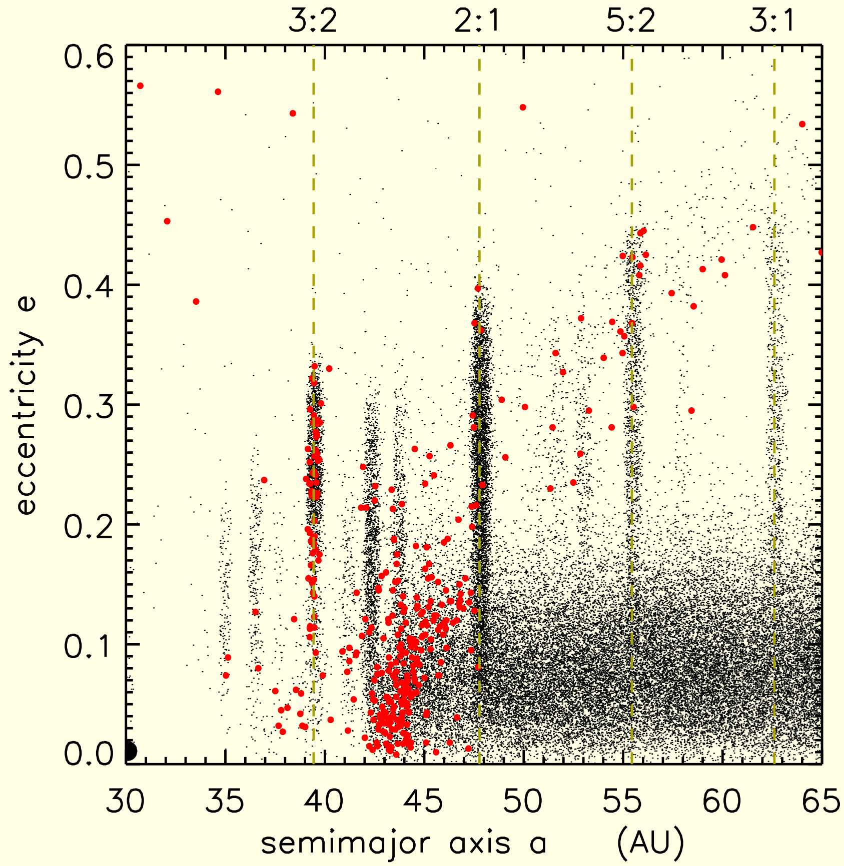


scattering by embryos (Morbidelli et al 2002)

more likely 'post–formation disturbances'?



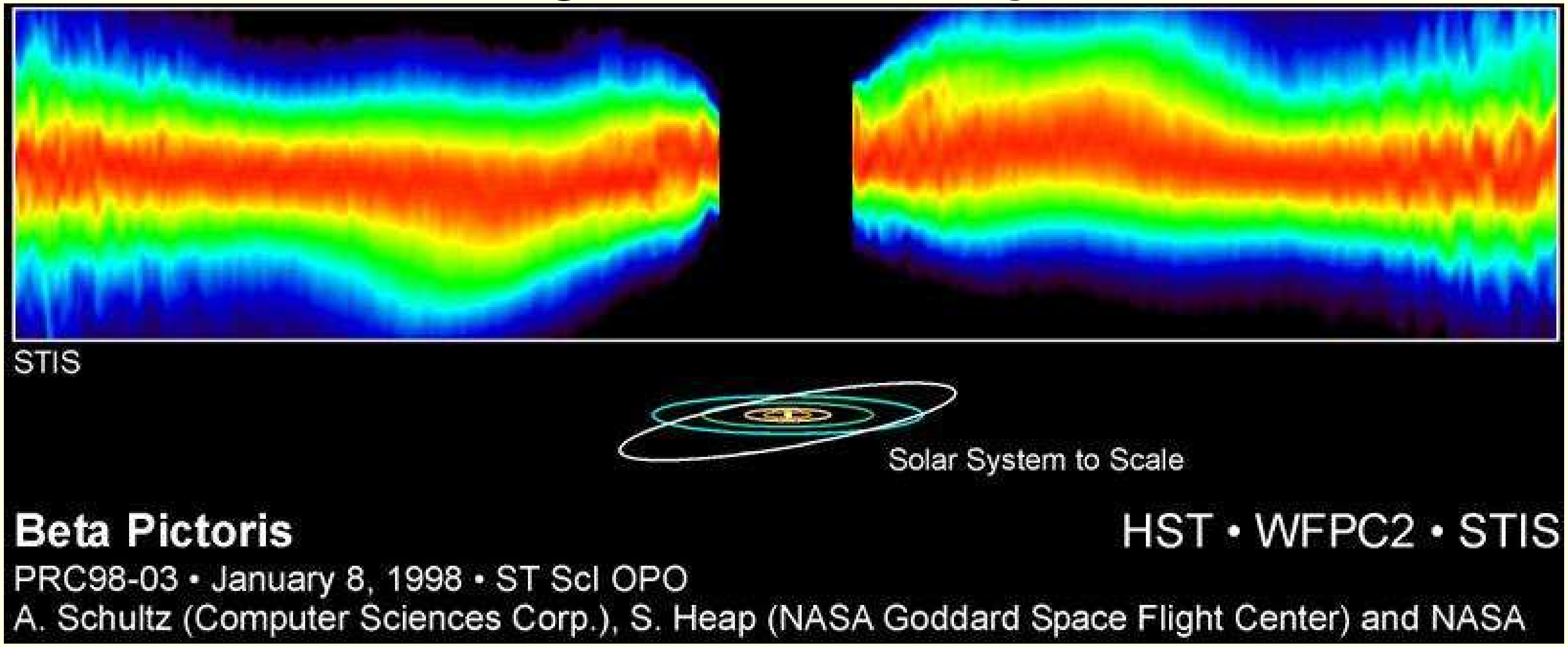
scattering U & N out into Kuiper Belt
(Thommes et al 2002)



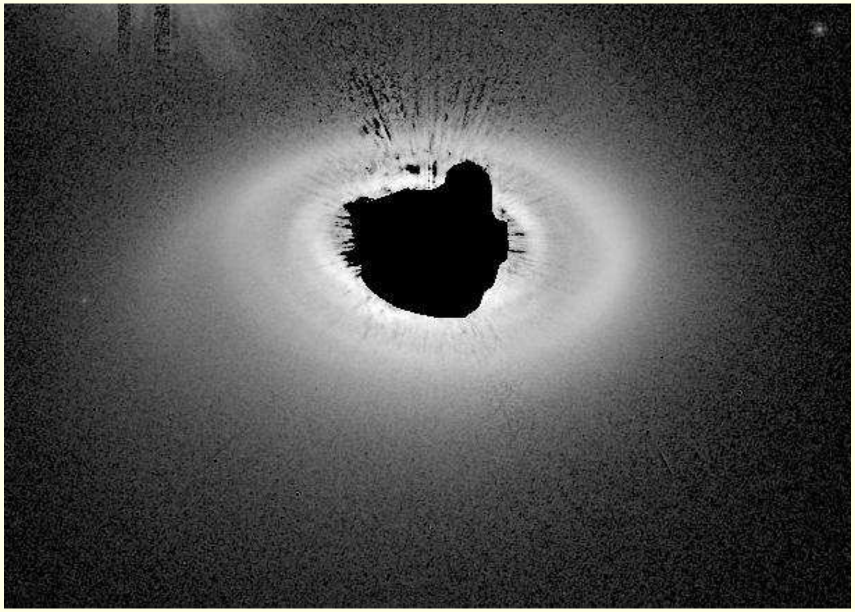
Neptune's migration
(Malhotra 1993, Hahn and Malhotra 2003)

Hopefully occultation observations will test these and other scenarios.

How big is the Solar System?



- circumstellar disks are big!
  - $r \sim 1000$ AU at β Pictoris
  - $r \sim 400$ AU at HD 141569



Clampin et al (2003)

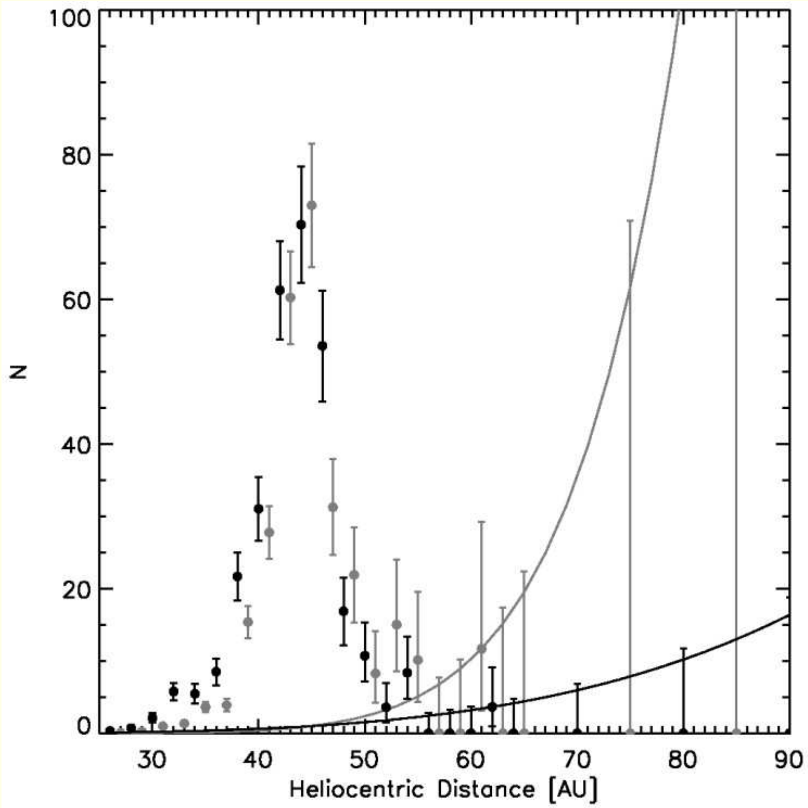
However a Big Belt is looking unlikely...

- Trujillo & Brown (2001) analysis of KBO observations suggests an edge at $r \sim 45$ AU

- Allen et al (2002) null result:
  surveyed $\Omega = 2.3$ deg^2 to $m = 25.5$
  could detect $D \sim 100$ km KBOs at $r = 50$ AU
  $\Sigma(r > 50$ AU, $m > 25.5) < 0.4$ KBOs/deg^2

- Holman et al (2003) null result:
  surveyed $\Omega = 0.02$ deg^2 to $m = 29.2$
  could detect $D \sim 20$ km KBOs at $r = 42$ AU
  $\Sigma(r > 42$ AU, $m > 29.2) < 50$ KBOs/deg^2

- is there an edge at $r \sim 45$ AU?
  or a gradient in the KBO size distribution
  (ie, smaller KBOs live at larger r)?



Occultation observations, which are not biased towards large & nearby KBOs, are very well–suited for measuring the size of the Solar System.

Summary

- when observing KBO occultations, take the time to measure distance r
  - this is costly since it requires
    - an array of telescopes to detect the KBO's moving shadow
    - or high–speed photometry to detect the KBO's diffraction fringes
  - but will provide interesting results
    - can provide density$(r,$ latitude$)$ of small, distant, hard–to–see KBOs
    - can provide the KB's scale height $h(r)$
    - tell us how big/small the Solar System really is
  - these finding will also place important constraints on dynamical models of the outer Solar System's early history
    - will test planet–migration & planet–scattering scenarios
    - or may lead to the invention of new scenarios to explain the new data