Occultation Systems: Portable Telescopes & Detectors

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The Basic Requirements

- For most distant objects (like Jupiter, Titan, Pluto, Eris...), the apparent speed of the occulter on the sky plane is due to the Earth's parallactic motion (i.e., between 0 and ~29 km/sec at quadrature or opposition).
- A FRESNEL SCALE is sqrt(λD/2), about 1.2 km for an object at 40 AU, observed at 5000 Å.
- This means that observations near 20 Hz are needed to characterize most diffraction light curves. Slower rates may be acceptable to sample differential refraction due to atmospheres with scale heights of tens of km.
- Short exposures => low counts. MINIMIZE READ NOISE!

Basic Requirements, 2

- Aperture & detector sensitivity need to be sufficient (SNR > 10) for Mv = 17 events at 1 to 20 Hz.
- The desired pixel resolution and physical pixel size constrain the telescope's focal length. (Example: if we want each 15 μm pixel to subtend 1" or less, then the telescope's focal length needs to be at least 206265 * 15 μm / 1" = 3093 mm.)
- Detectors need to have (a) low read noise, (b) fast read-out, (c) virtually no dead-time, and (d) high QE.
- Try frame-transfer CCDs, possibly EMCCDs (electron multiplication CCDs provide gain during the serial readout). EMCCDs add ~40% to Poisson noise sources.

Which Events to Pursue?

- If the occulter is brighter than the occulted star, then the PHOTON SHOT NOISE due to the occulter's counts is probably the dominant noise source. (Example: suppose a star gives you 10 e-/s and the occulter gives you 1000 e-/s. The Poisson noise is sqrt(1000), which overwhelms the light curve drop of 10 e-.)

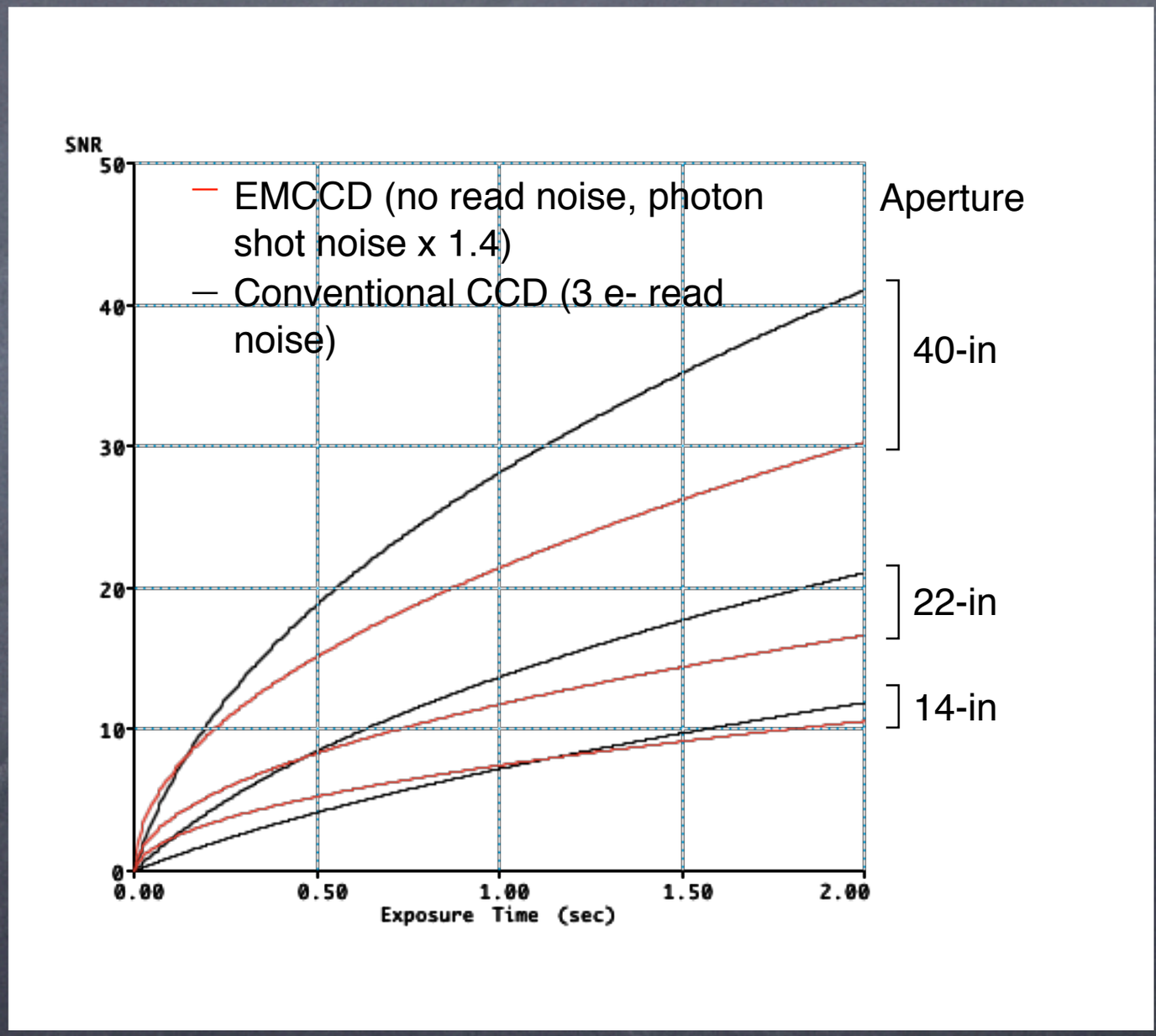
- For EXTENDED OBJECTS, the brightness of a resolution element is the key, not total brightness. Adaptive Optics systems would be enormously helpful. Are these available for portable systems?

- For the five largest TNOs, stars at 17 mag occur often (roughly once per year). Mv = 17 is a reasonable goal.

A Signal-to-Noise Survey

SNR as a function of...

- Aperture
- Read Noise
- Magnitude of Sources
- QE of detector



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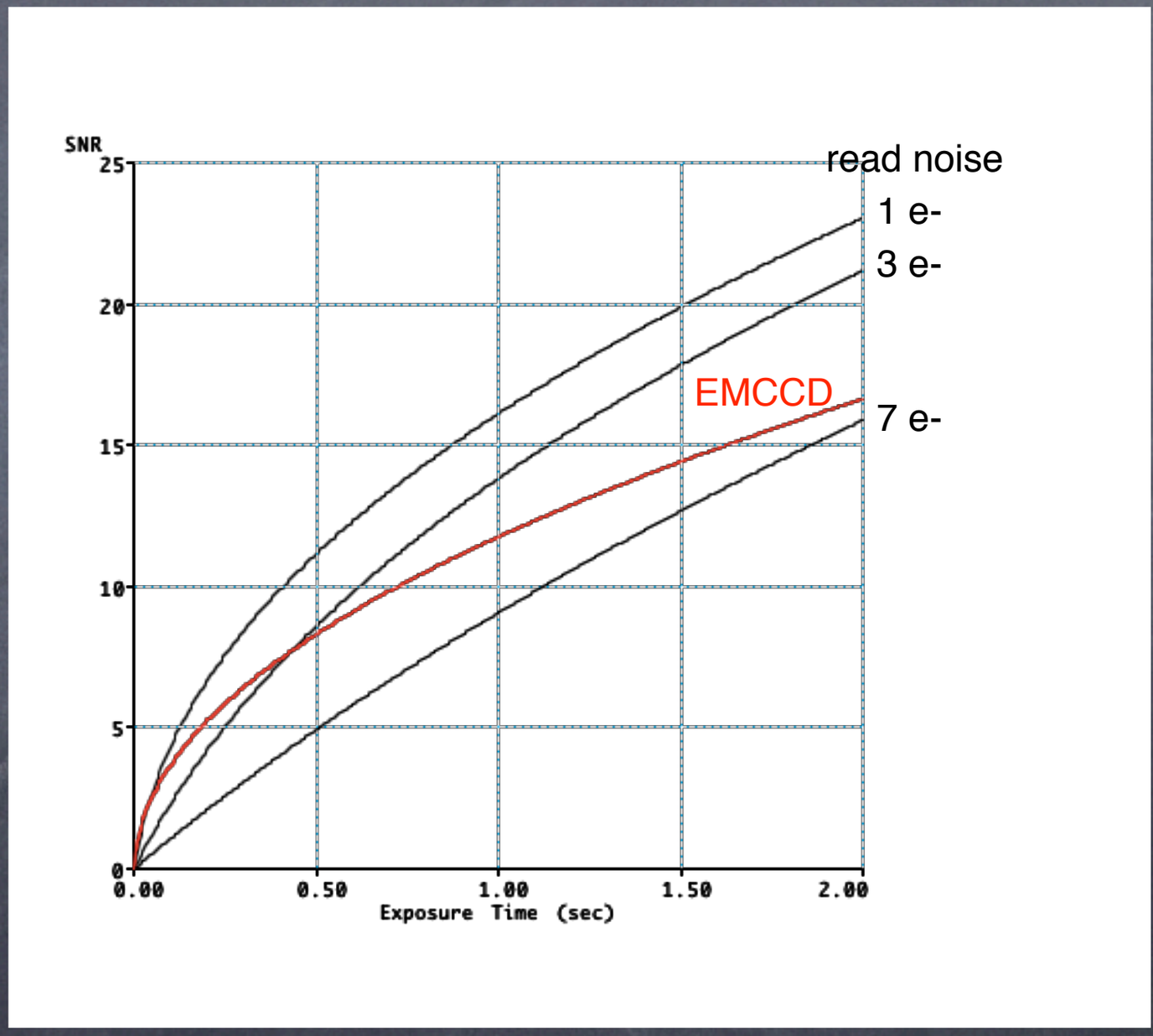

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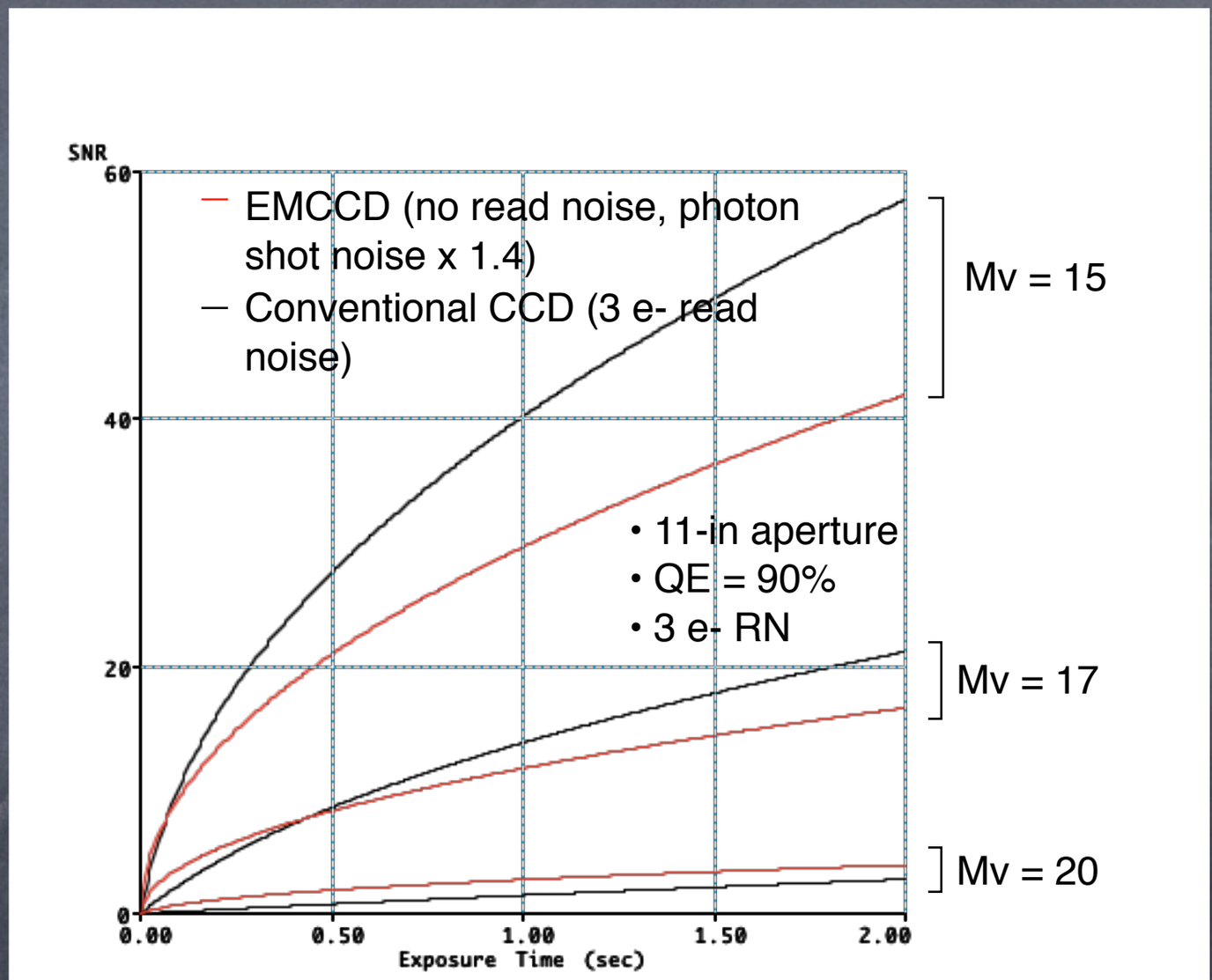

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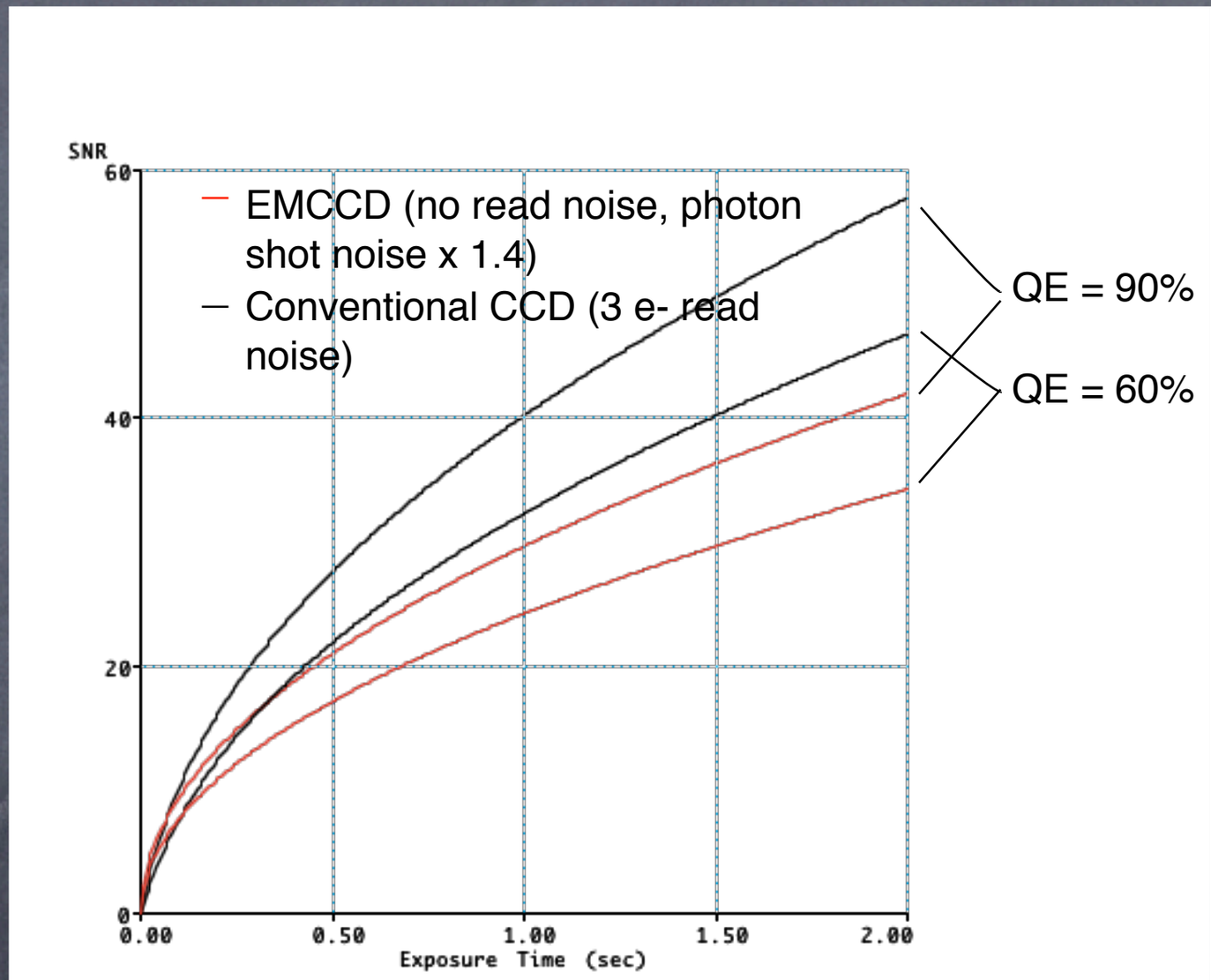


SNR: Conclusions

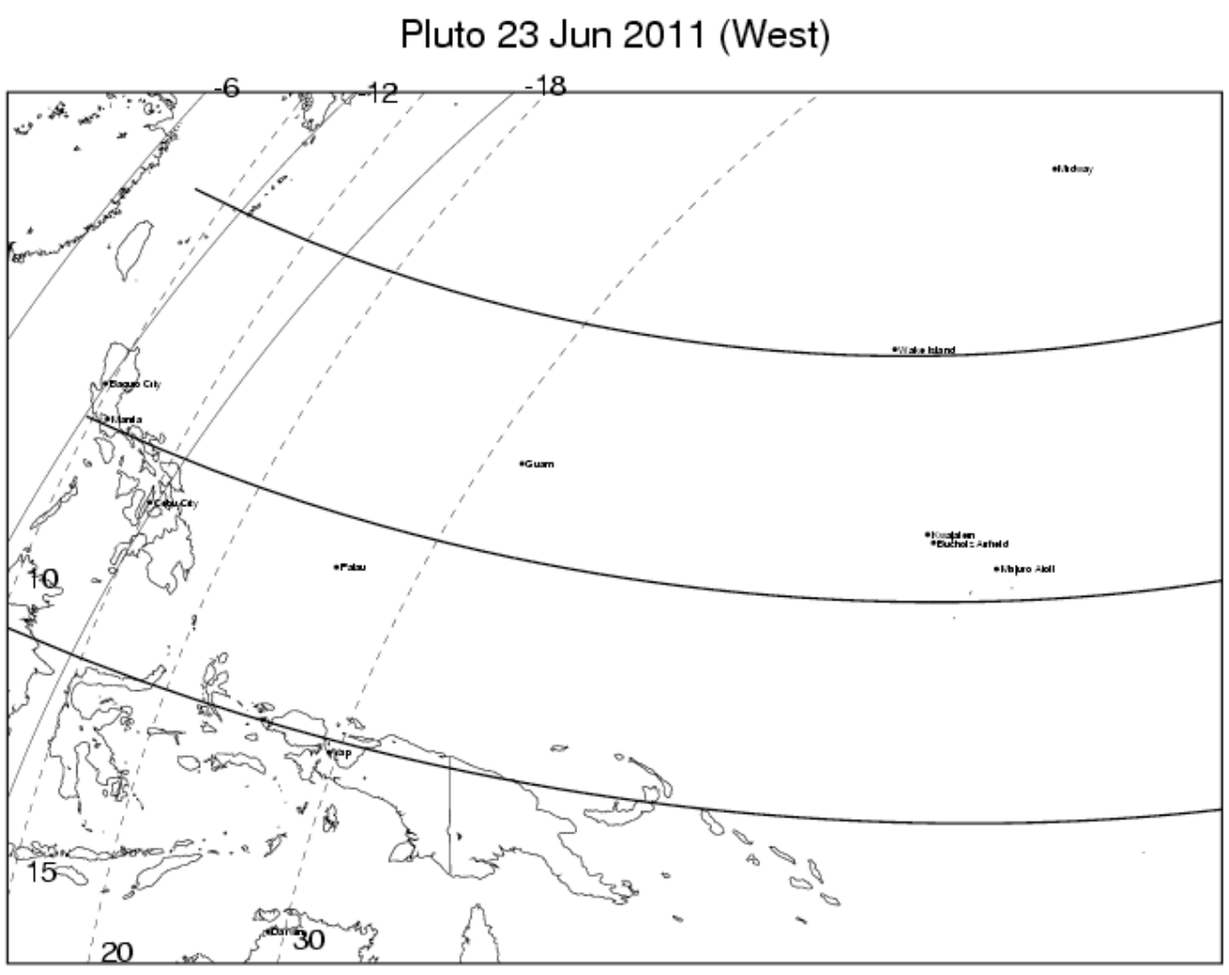
- For faint events (e.g., Mv = 17), 14-inch apertures are only useful to help establish the geometric position of the shadow path or crude length of the chord. Bigger aperture is important.

- For faint events, EMCCDs are better - the near-zero read noise outweighs the increase in noise from the source counts. (NOTE: investigate HgCdTe avalanche detectors, with virtually no amplification of photon shot noise.) EMCCDs - with fast readouts - or frame-transfer CCDs are needed to minimize deadtime between frames.

- For brighter events (e.g., large apertures, longer integration times, bright stars), conventional (non-EMCCDs) are preferred.

Portable Telescopes for Upcoming Events

- Two bright (RED!) stars will be occulted on June 23 and 27.



- Portables for coverage over Hawaii & Marshall islands.