Starshade concepts

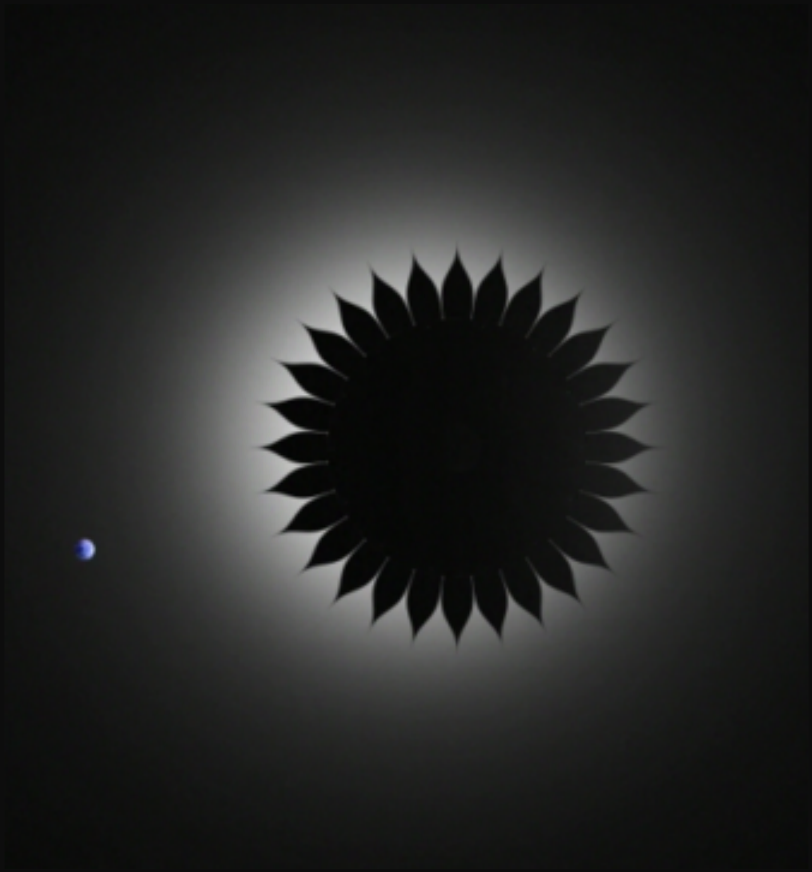

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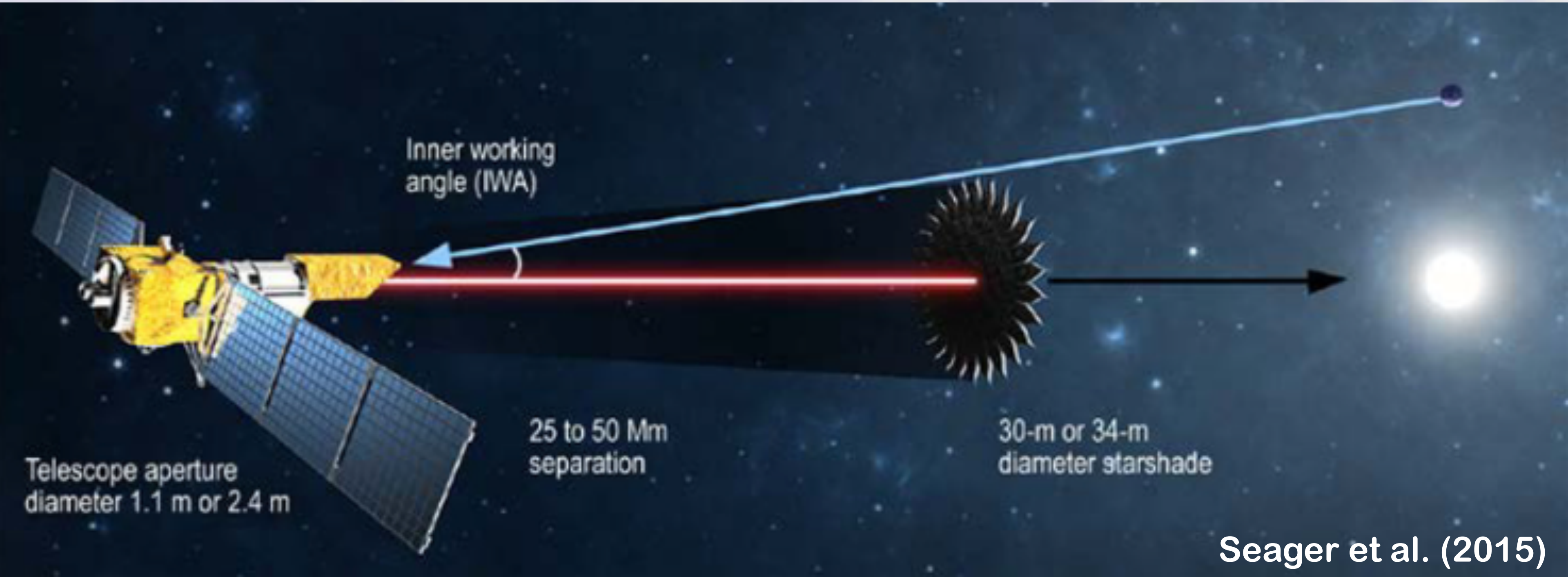
Image credit: NASA

General concept

External opaque mask casts a shadow on the telescope, providing high contrast with good IWA.

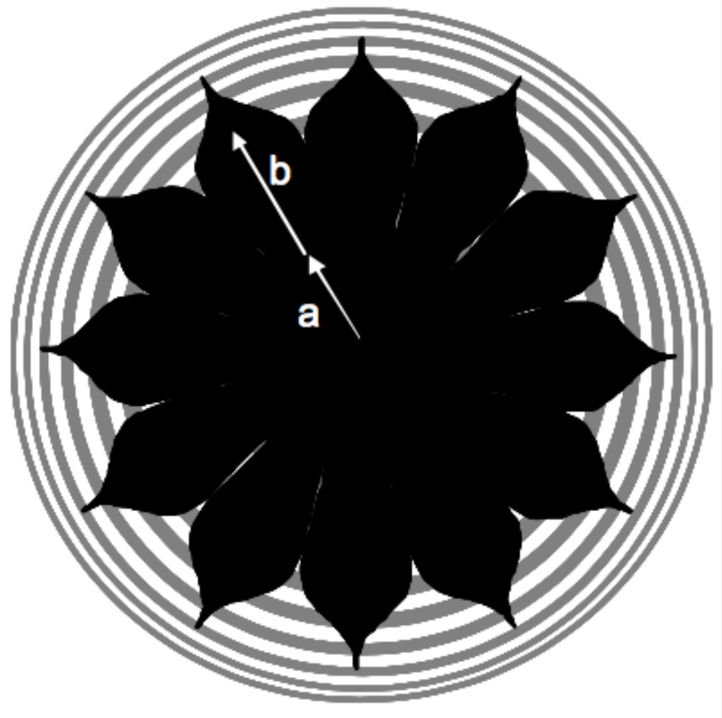
Pros: Easier than coronagraphy to reach very high contrasts

Cons: Limited directability; lack of "stepping stones"



Some basic parameters

Design from Cash (2006)



Larger separation between telescope and starshade is better, but more expensive.

Short wavelengths are easier than long wavelengths.

=> UV is easy, while mid-infrared is essentially hopeless.

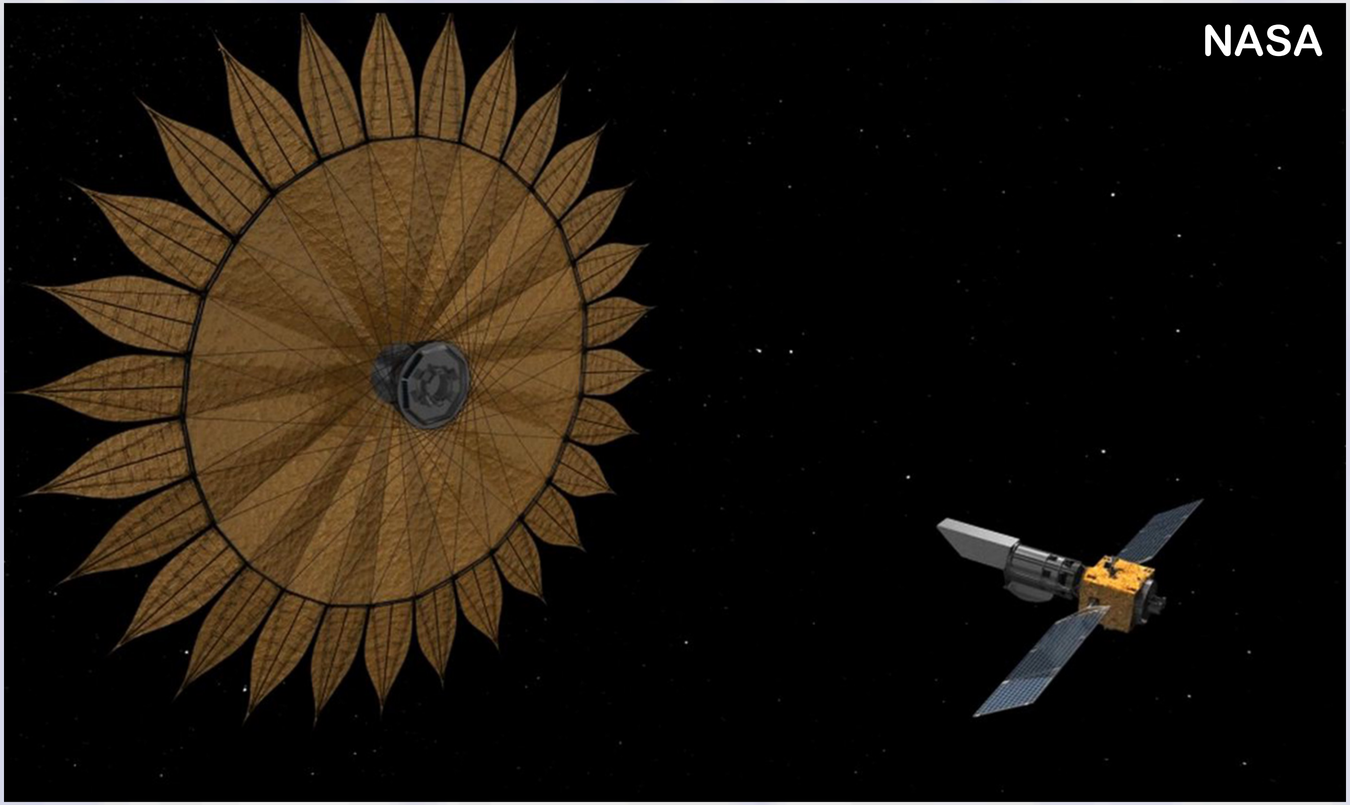
There is partially a trade-off between contrast and bandwidth.

$$\mathcal{R} = \left[\frac{n!}{r^{2n}}\left(\frac{s\lambda}{2\pi}\right)^n\right]^2$$

(Not optimal, but conceptually useful)

Examples of concepts

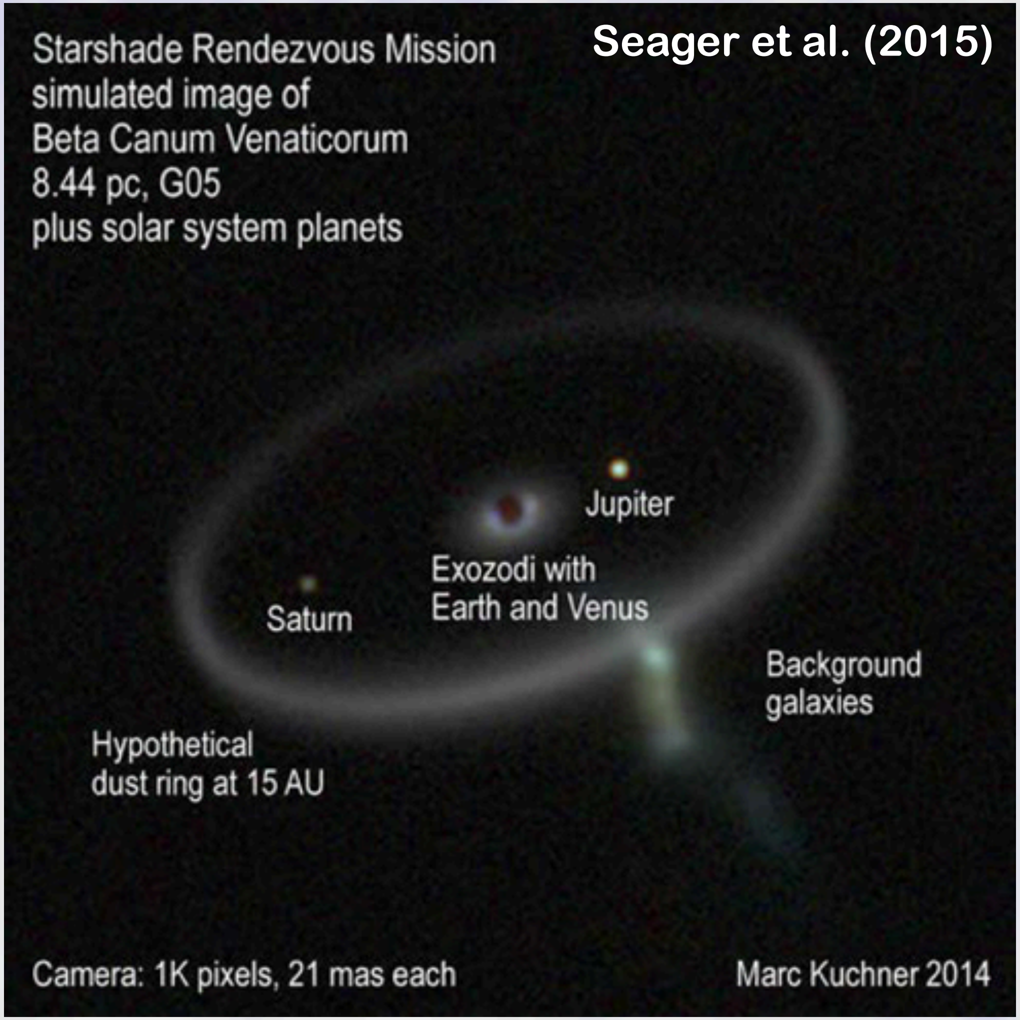
Path 1: Design mission with a telescope-occulter pair



E.g. HabEx: ~4m telescope, ~72m starshade

Examples of concepts

Path 2: Design occulter for an ‘existing’ telescope



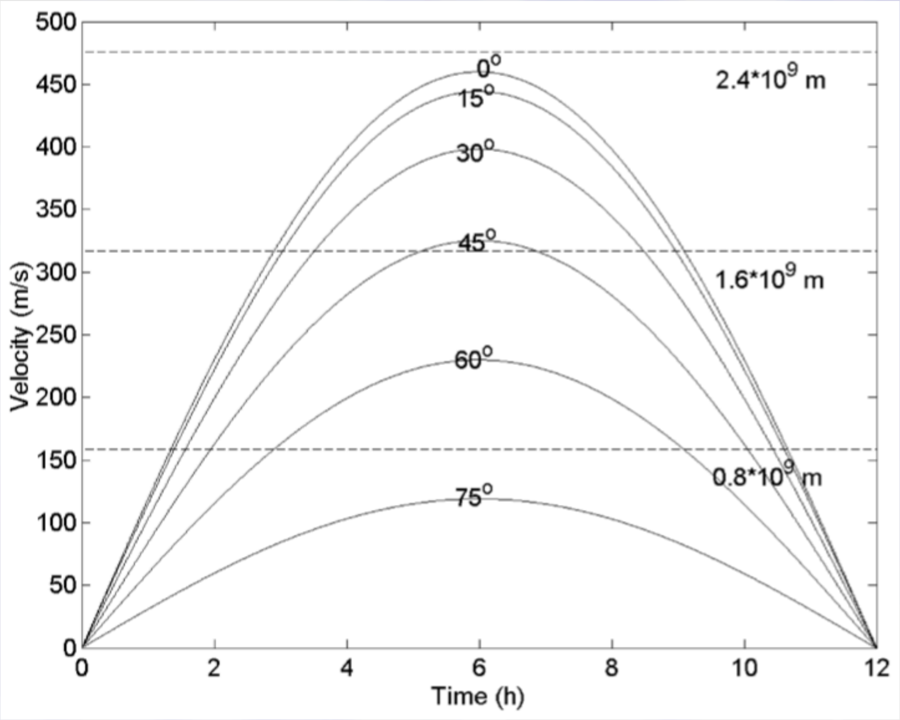
E.g. Starshade rendezvous: WFIRST telescope, ~20m starshade

The CESO concept

A starshade in space casts a shadow on a telescope on Earth

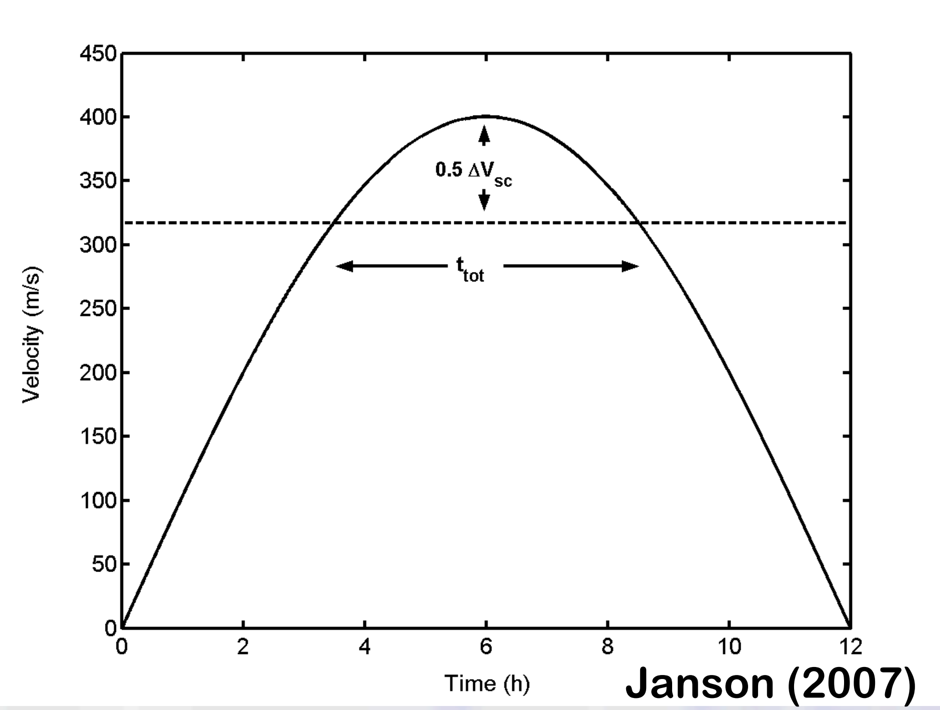
Janson (2007) examines an orbital configuration to accomplish a fixed shadow at minimal delta-V constraints

The CESO concept



A co-rotating orbit at appropriate distance will give a shadow motion that instantaneously matches Earth's rotation at some latitude.

=> Minimal delta-V required to maintain shadow fixed on a telescope around that time.

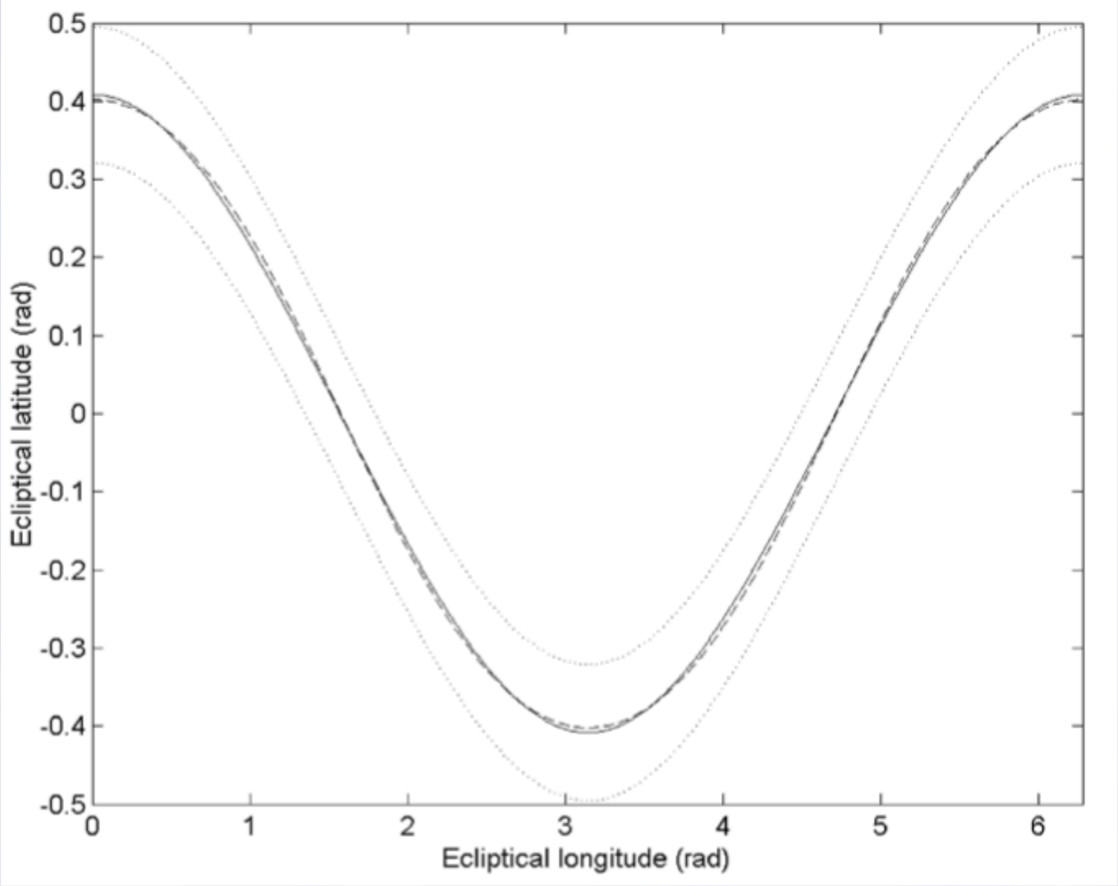


Janson (2007)

The CESO concept

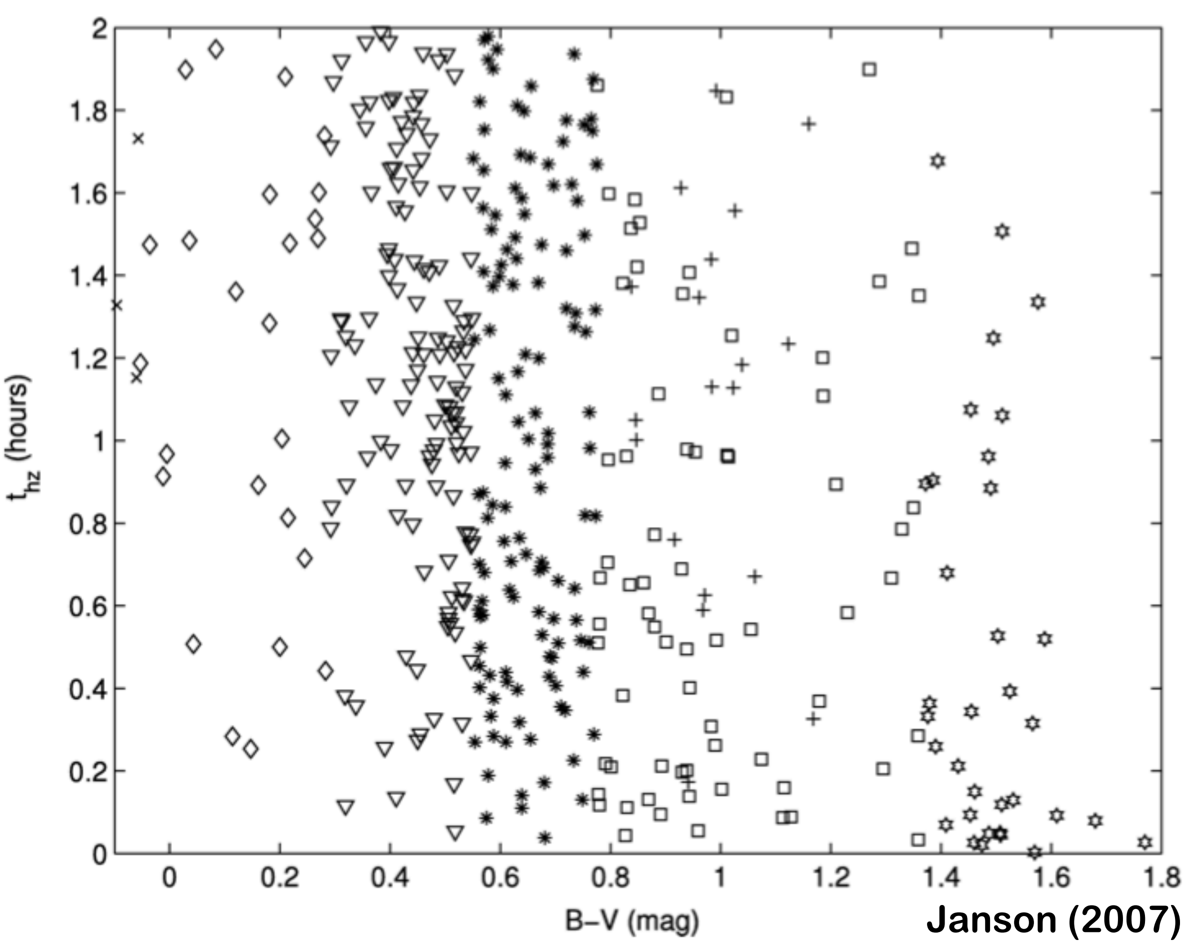
An orbital solution exists that matches the celestial equator across the year (well enough)

Target-to-target motion very cheap, though restricted within +/-5 deg latitude



Janson (2007)

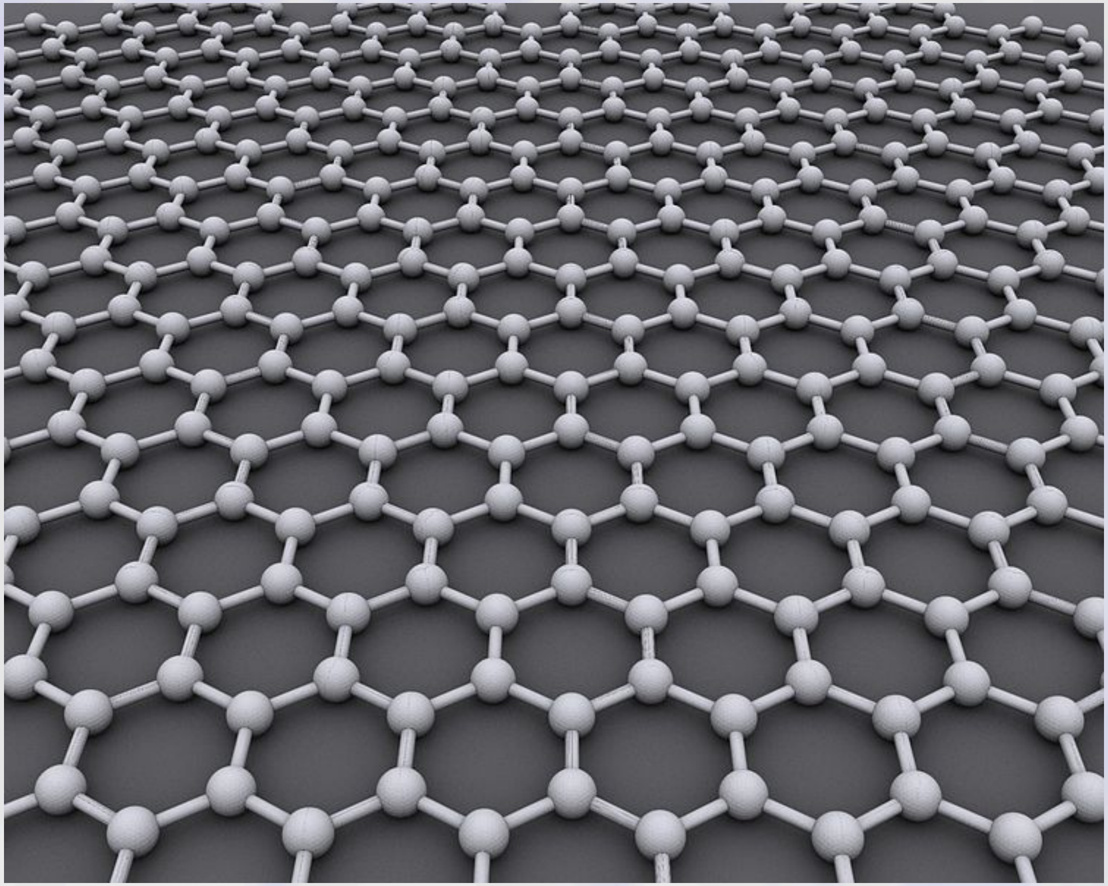
The CESO concept



Janson (2007)

Large sample available even within +/-5 deg, thanks to the small IWA

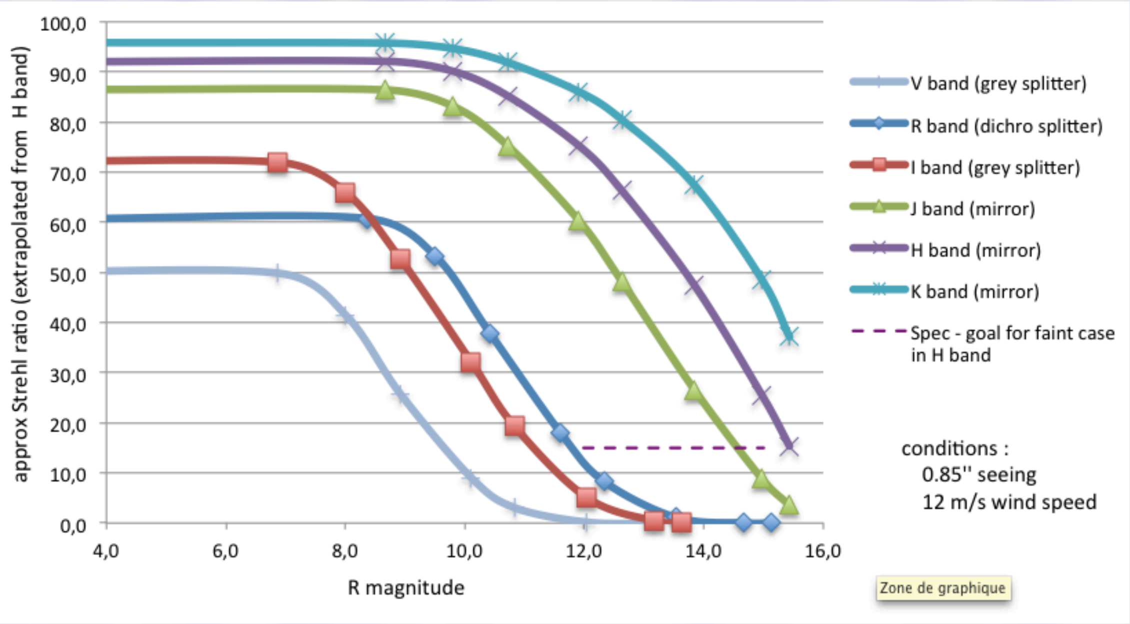
Notable developments



Thin, opaque materials are becoming increasingly manufacturable

Notable developments

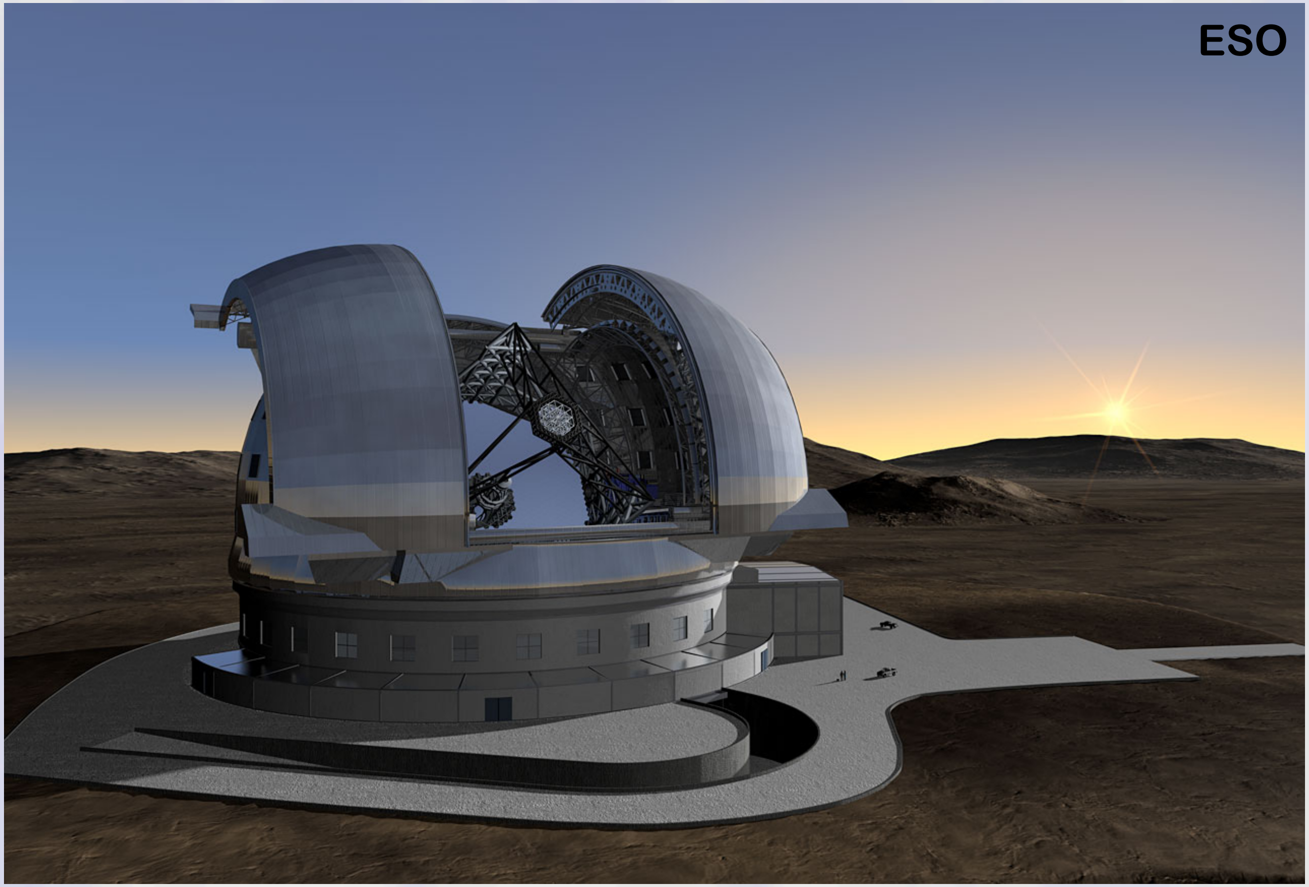
Extreme adaptive optics: >50% Strehl at visible wavelengths! (e.g. ZIMPOL)



ESO

Requires bright guide star

Notable developments



Telescopes of increasingly larger sizes are becoming available from the ground