

How to beat the photon noise limit
In your WFS&C system

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LGS and ExAO

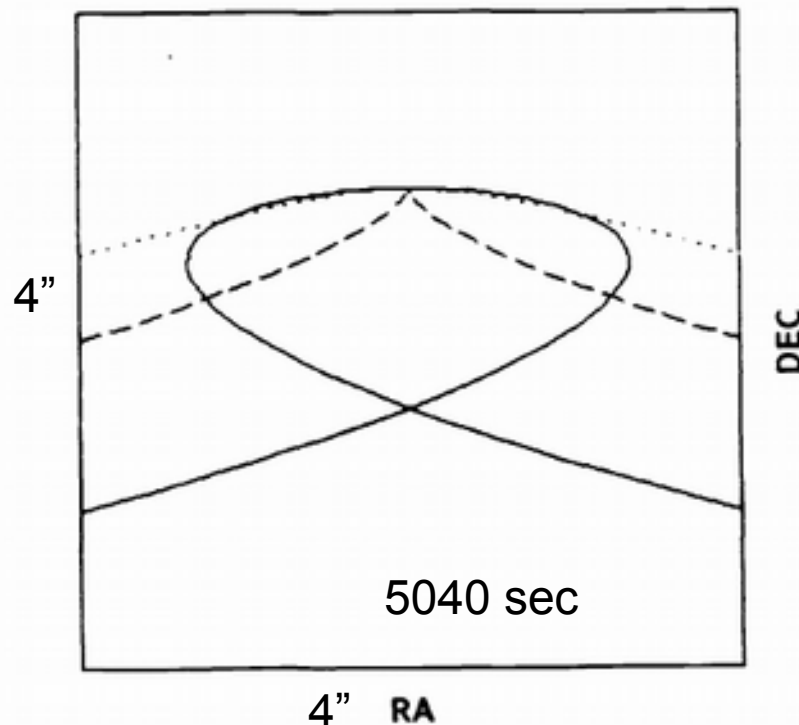
- LGS has done great things
- Not perfect (especially for ExAO)
 - Cone effect (much much worse on ELTs)
 - Spot size limits WFS sensitivity
 - Limited brightness (requires high power lasers)
 - Requires T/T star – still not 100% sky coverage
- There are solutions proposed/under development for most of these

A 25 year old Idea

Satellite borne laser for adaptive optics reference

A.H. Greenaway.

Royal Signals and Radar Establishment,
St. Andrews Rd., MALVERN, WR14 3PS, U.K.



SPIE 1991

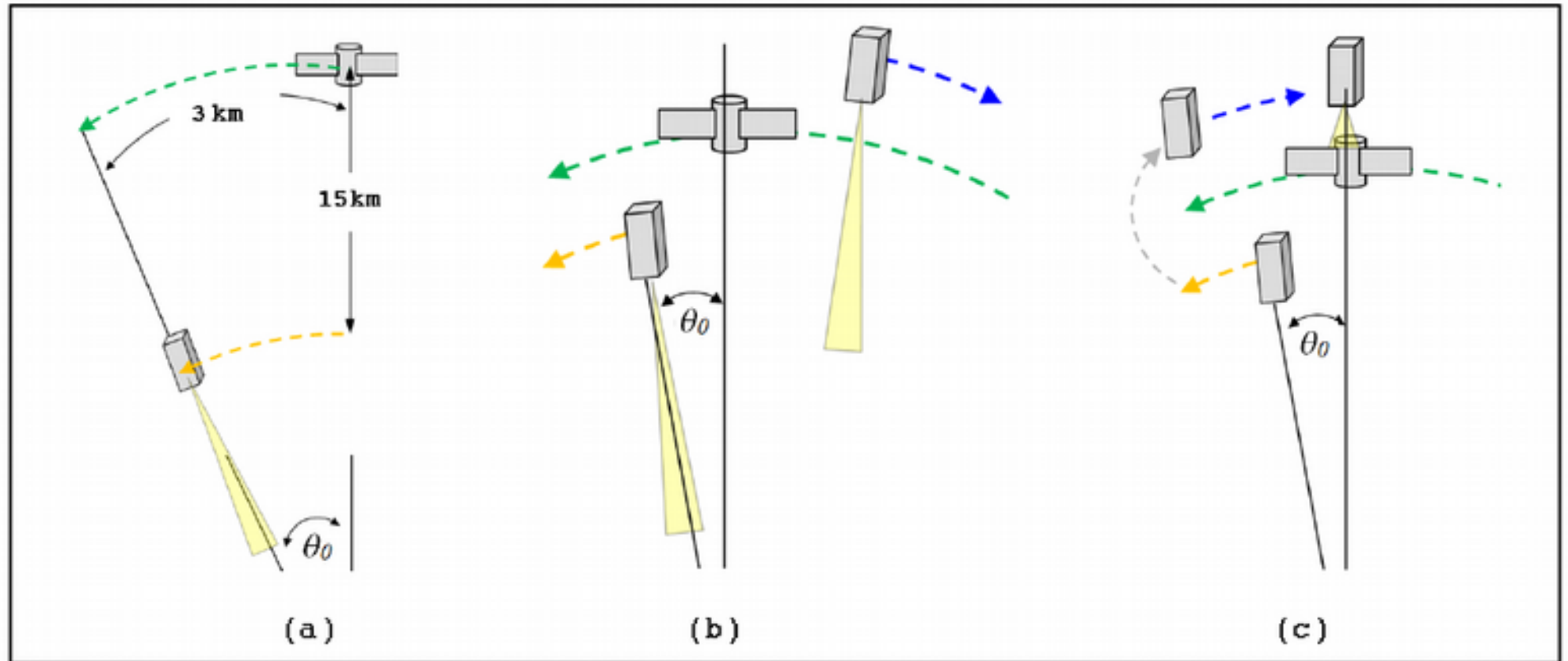
Photon flux from laser pointer
(few mW) is order of -10 mags
over 8 m aperture

Easy to get < 5 mag with
reasonable assumptions on
pointing, projection, etc.

Satellite Guide Star Study

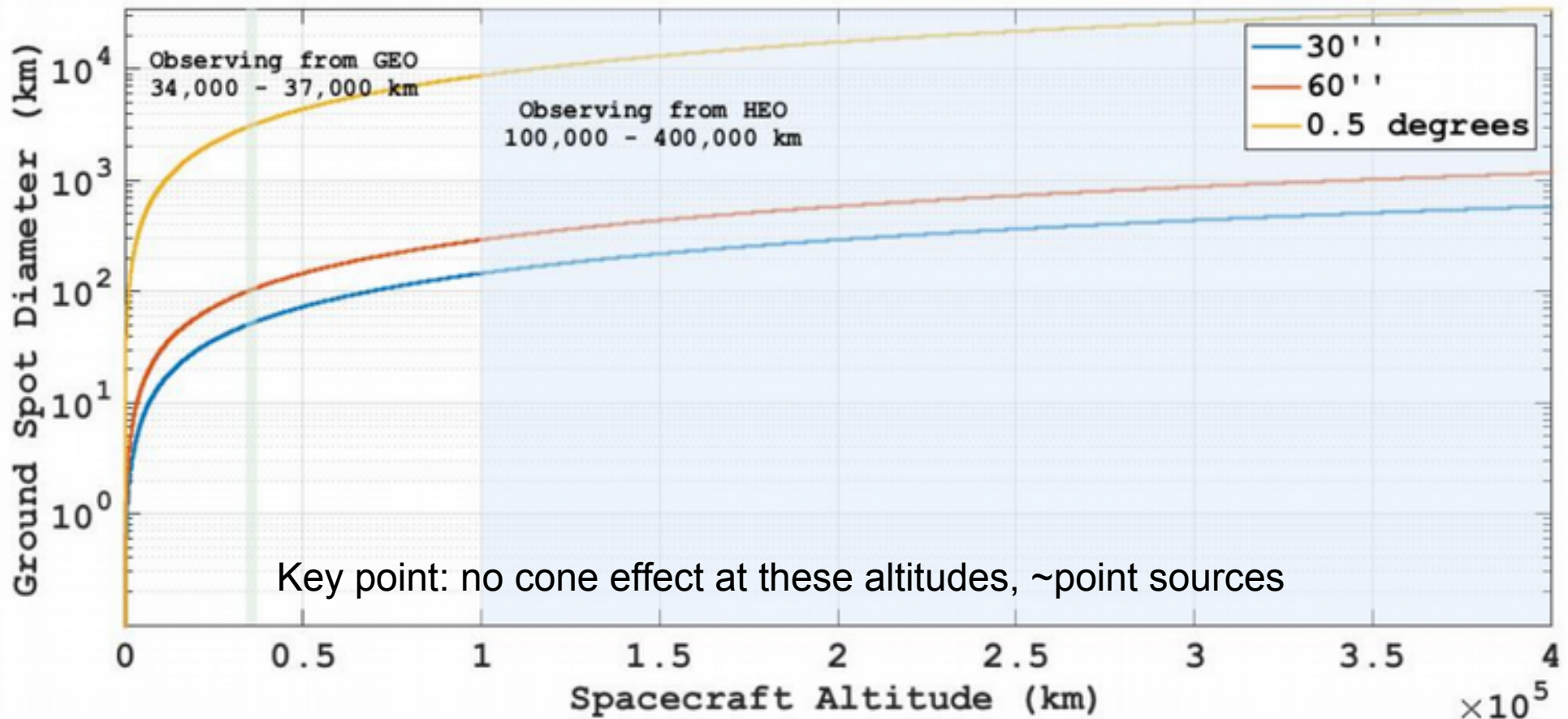
- With Kerri Cahoy's students @ MIT
 - Weston Marlow
 - Ashley Carlton
 - Hyosang Yoon
- Cube Sat revolution
 - In 1991 this was a major satellite
- Began as class project, now submitted paper
 - Design study of an SGS system
 - This was focused on ground based telescopes

Major Focus: GEO Imaging

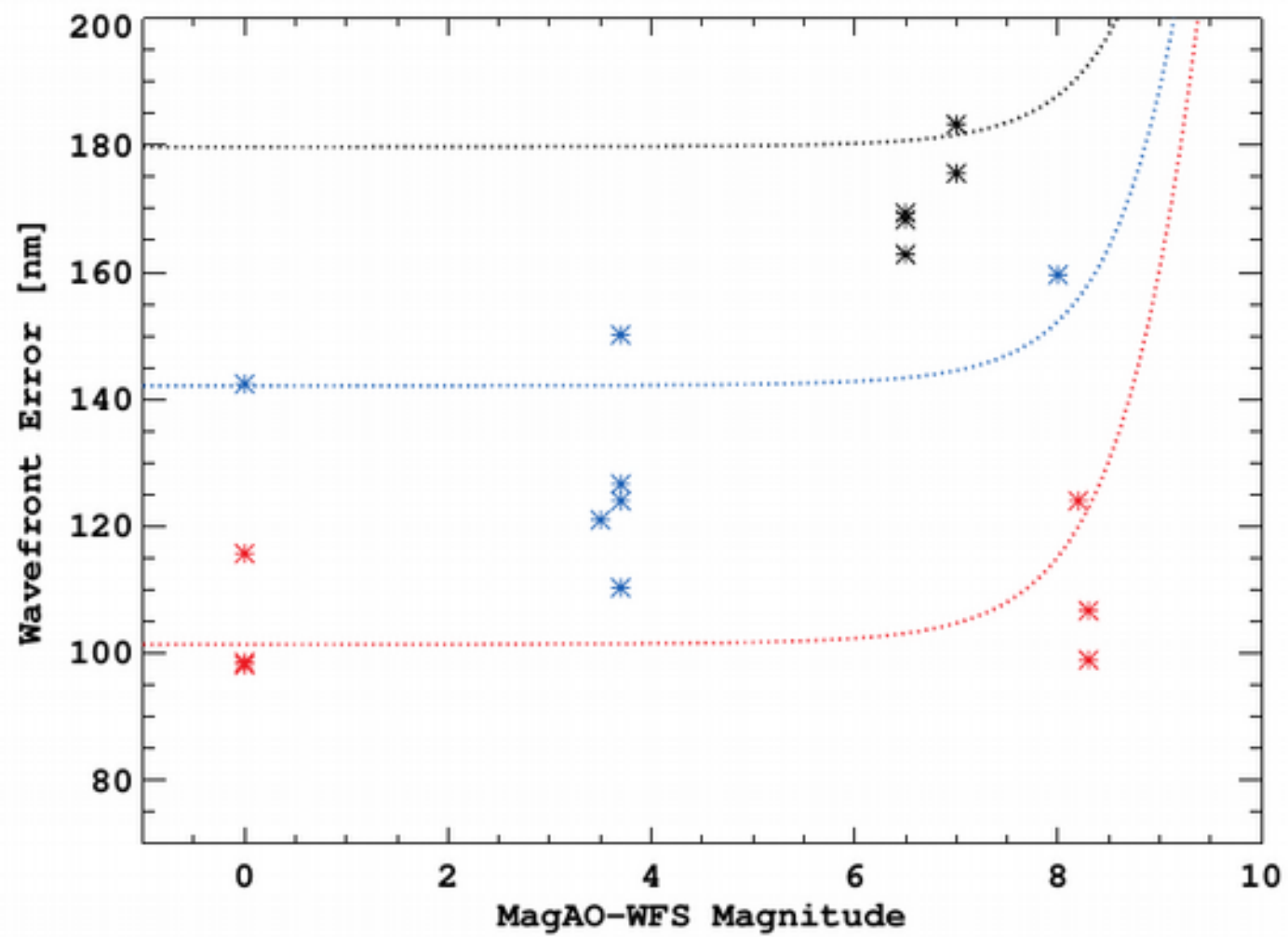


- DARPA challenge: 10 cm in GEO (36,000 km)
- More tractable problem (easier than sidereal)

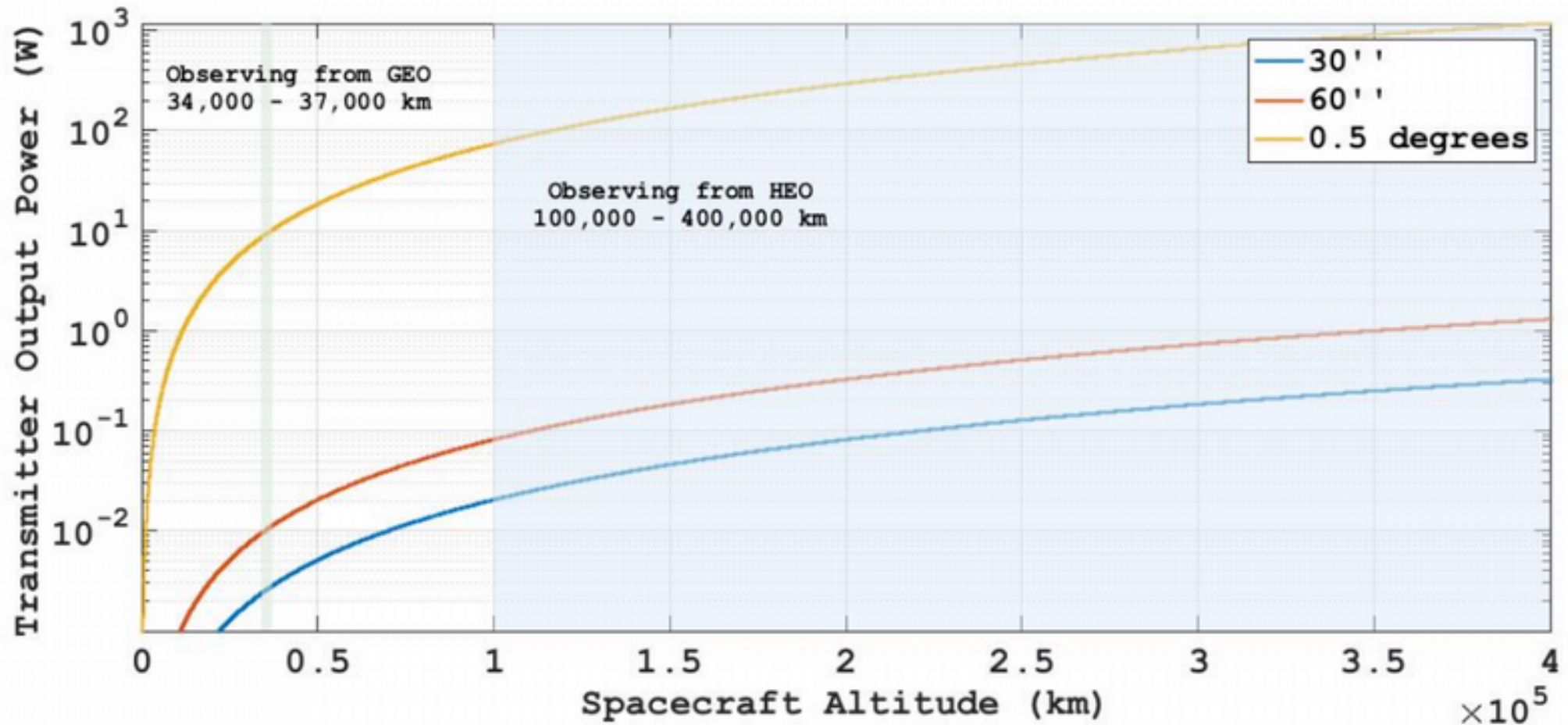
Pointing vs. Beam Size



- Pointing dominates beam size, so projection optics might as well be small

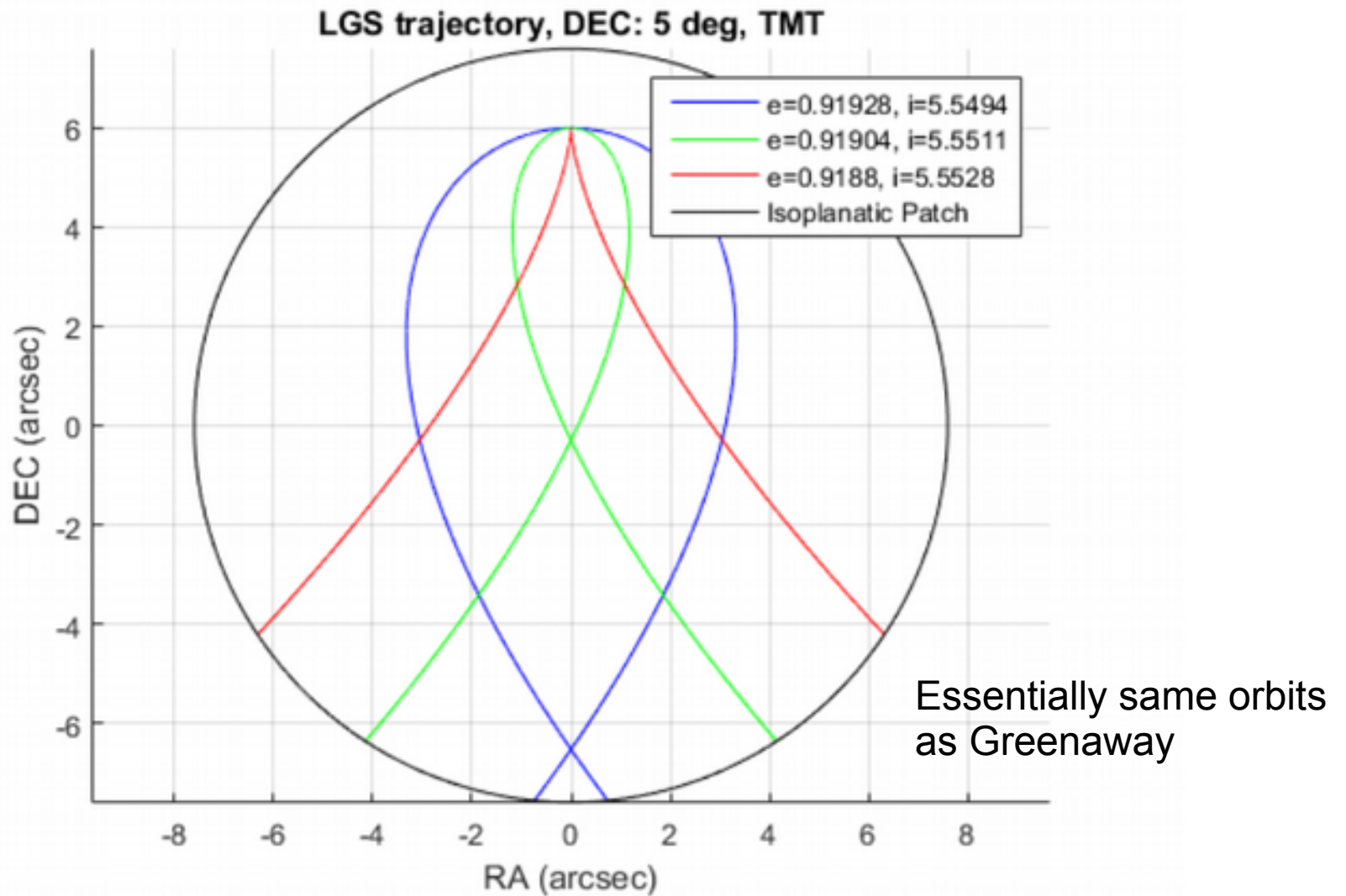


Low Power Lasers



To be an 8th mag guide star
Goes as pointing²

Sidereal Motion



- How to match S.M. without going to infinity?

Sidereal Motion

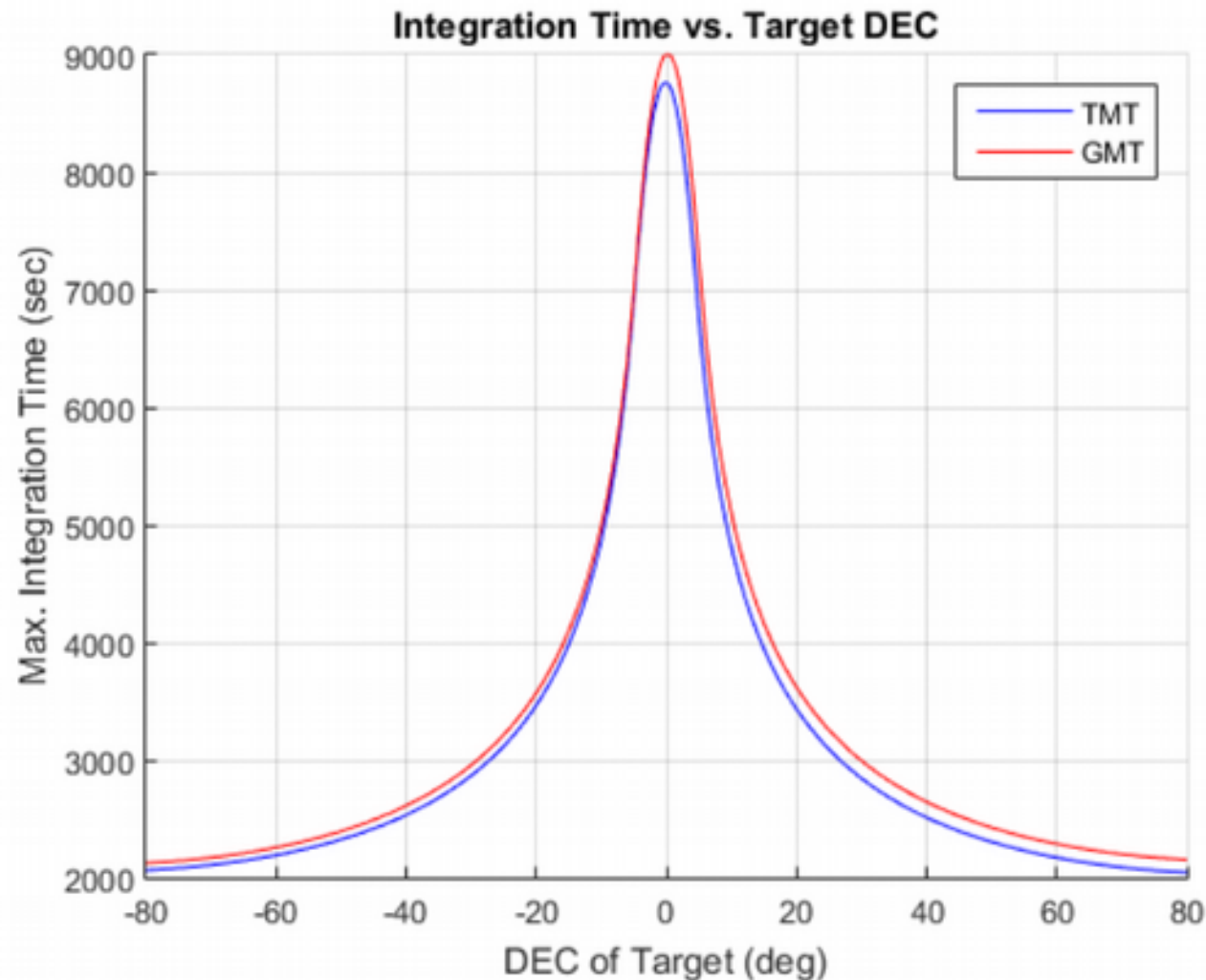


Figure 9 Maximum integration time depending on declination of targets for 5-day-period orbits

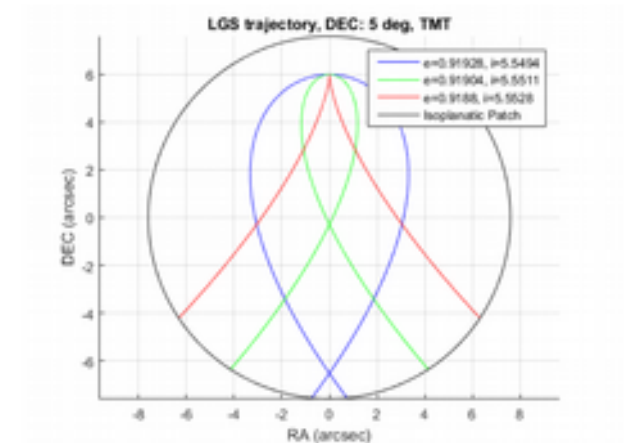
- How to match S.M. without going to infinity?

For Space Telescopes

- You always run out of photons, eventually
- Related team working on applying this to space telescopes (LUVOIR/HabEx)
 - Cahoy, Feinberg, Guyon, Males, (et al)
 - For segment control, want $\sim 400\text{Hz}$ sampling, $\sim 100\text{Hz}$ bandwidth
- Questions we need to answer:
 - On-axis? How far off?
 - Far field? How out of focus can you be?
 - Formation flyer, or on a boom?
 - (We've done very little real work – any ideas?)

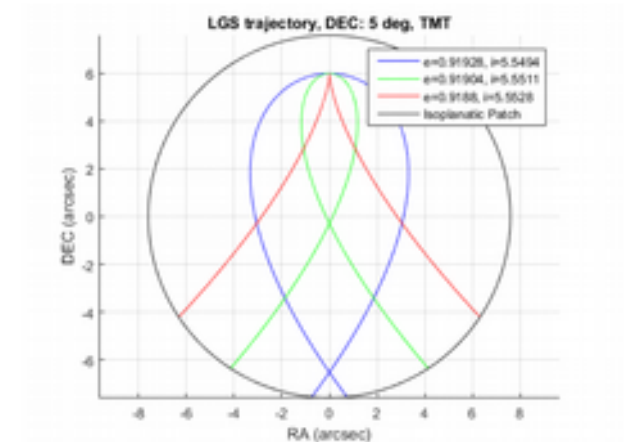
For Ground

- Could potentially deliver ~ 0 mag guide star anywhere in the sky.
 - Game changing for ExAO.
- Need clever orbital mechanics



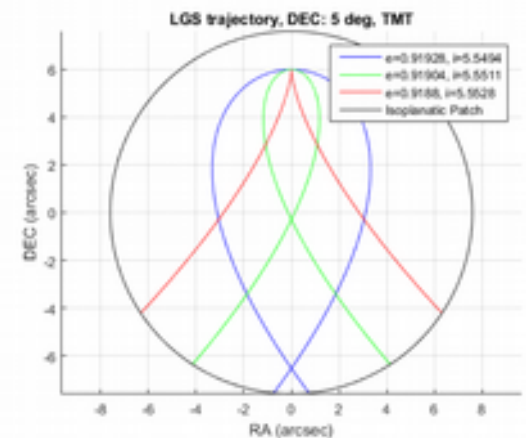
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 - or-
- Revolutionary propulsion system



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 - Game changing for ExAO.
- Need clever orbital mechanics
 - or-
- Revolutionary propulsion system
 - What some might call a "breakthrough"



Need a Breakthrough

- If you had the propulsion system, and it took N days to maneuver between targets, then you just need (a few $\times N$) to always have one available for observations.

