How to beat the photon noise limit
In your WFS&C system
How to beat the photon noise limit
In your WFS&C system
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
Satellite borne laser for adaptive optics reference

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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

Key point: no cone effect at these altitudes, ~point sources
Low Power Lasers

To be an 8\textsuperscript{th} mag guide star
Goes as pointing\(^2\)
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 ~400Hz sampling, ~100 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
For Ground

- Could potentially deliver ~0 mag guide star anywhere in the sky.
  - Game changing for ExAO.
- Need clever orbital mechanics
  -or-
- Revolutionary propulsion system
For Ground

- Could potentially deliver ~0 mag guide star anywhere in the sky.
  - 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 $X N$) to always have one available for observations.