LIGHT BUCKET ASTRONOMY

Efforts to Improve the Signal-to-Noise Ratio of Program Object Measures

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Agenda

- Regions of Excellence for Light Buckets
- Signal-to-Noise-Ratio Dependencies
- Light Buckets Comparisons to Conventional Scopes
- Light Bucket Arrays
- Impact of Tracking Errors

Regions of Excellence for Light Buckets

- Light bucket astronomy is advantageous where the sky background is a small or nearly negligible source of noise.
  - The object being observed is very bright
  - The integration times are very short
  - Scintillation dominates
  - The bandwidth is very narrow or the light is spread out as in spectroscopy
  - Noise from the detector is dominant (as it can be in the near infrared).

Signal-to-Noise-Ratio Dependencies

- How do the factors affect the Signal-to-Noise-Ratio (SNR) of program measures?

$$SNR = \frac{N_{Star+Sky} - N_{Sky}}{\sqrt{N_{Star+Sky} + N_{Sky} + N_{Detector} + S^2}},$$

where *Ns* are counts and *S* models atmospheric scintillation

- Various Alt-Az Initiative members are focused on improving each part of the SNR equation

Dependency: Sky and Star

- Objective: Increase program object signal, decrease sky
  - Need large, affordable, and portable scopes
- New mirror making technologies
  - Balance needs, e.g. light bucket diaphragm size vs. aberrations
- Mounts & Controllers
  - Alt, az, fov rotation

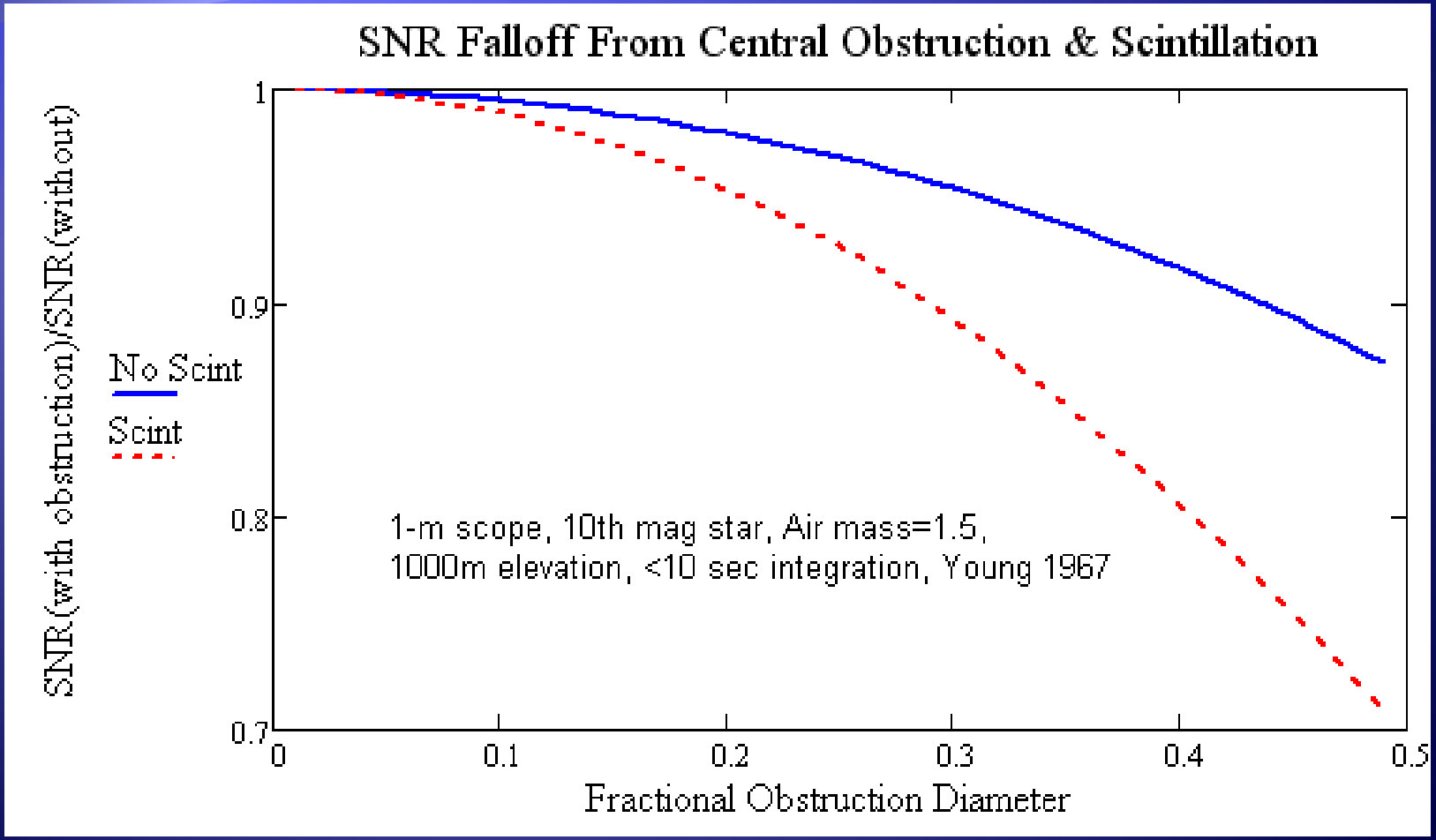
42-inch pneumatic mirror prototype at Gravic Labs

Dependency: Scintillation

- Can't increase integration duration
  - Need about 300 fps in visible for lunar occultation diffraction patterns
- Mitigate it
  - Increase objective diameter to a point
    - About 2-meters max.
  - Move to a higher altitude
  - Watch central obstruction size
- Arrays of light bucket scopes (future)

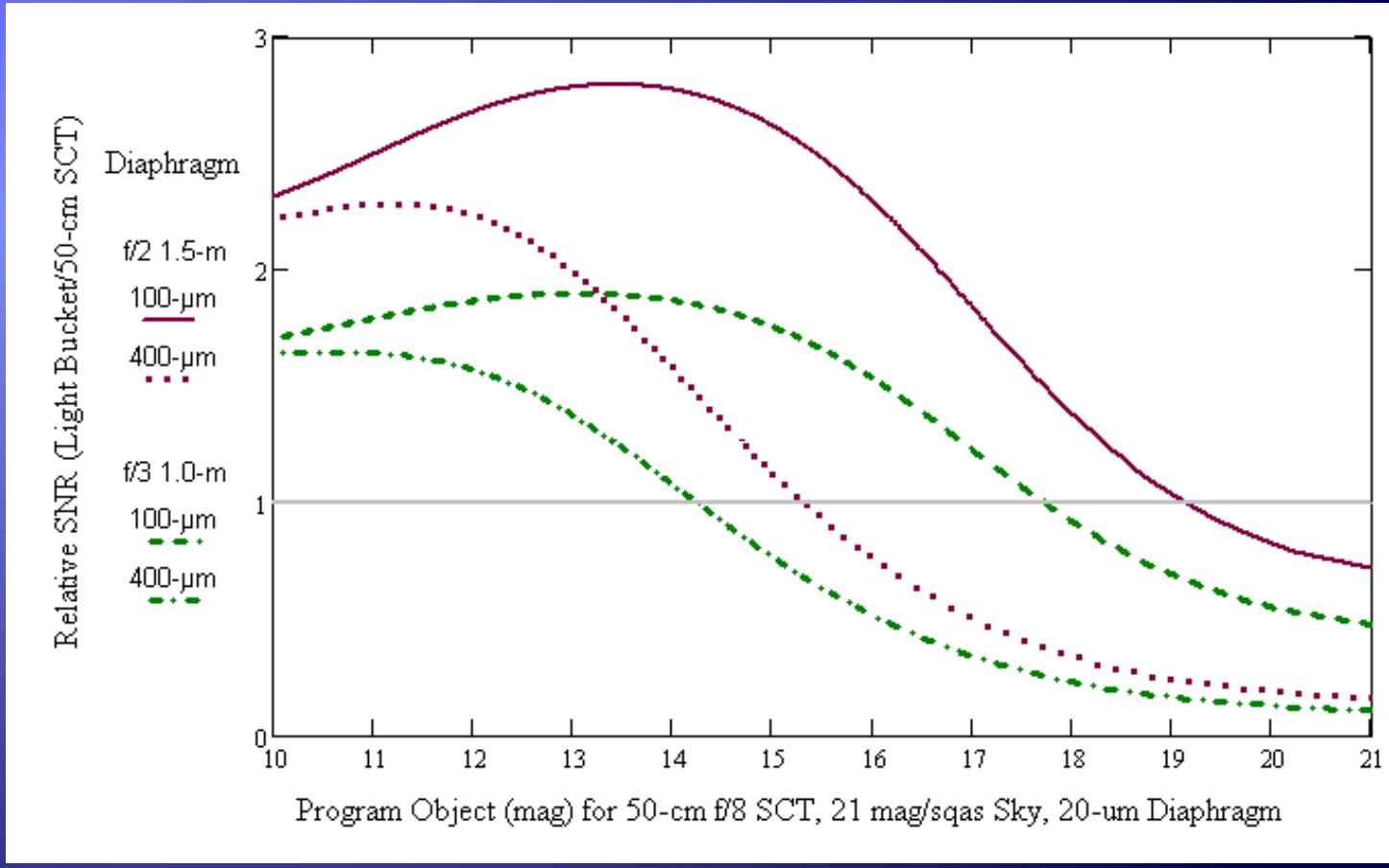
Central Obstruction SNR Falloff

Shot noise only (blue), plus extra scintillation due to obstruction (red).



Light Bucket vs. SCT

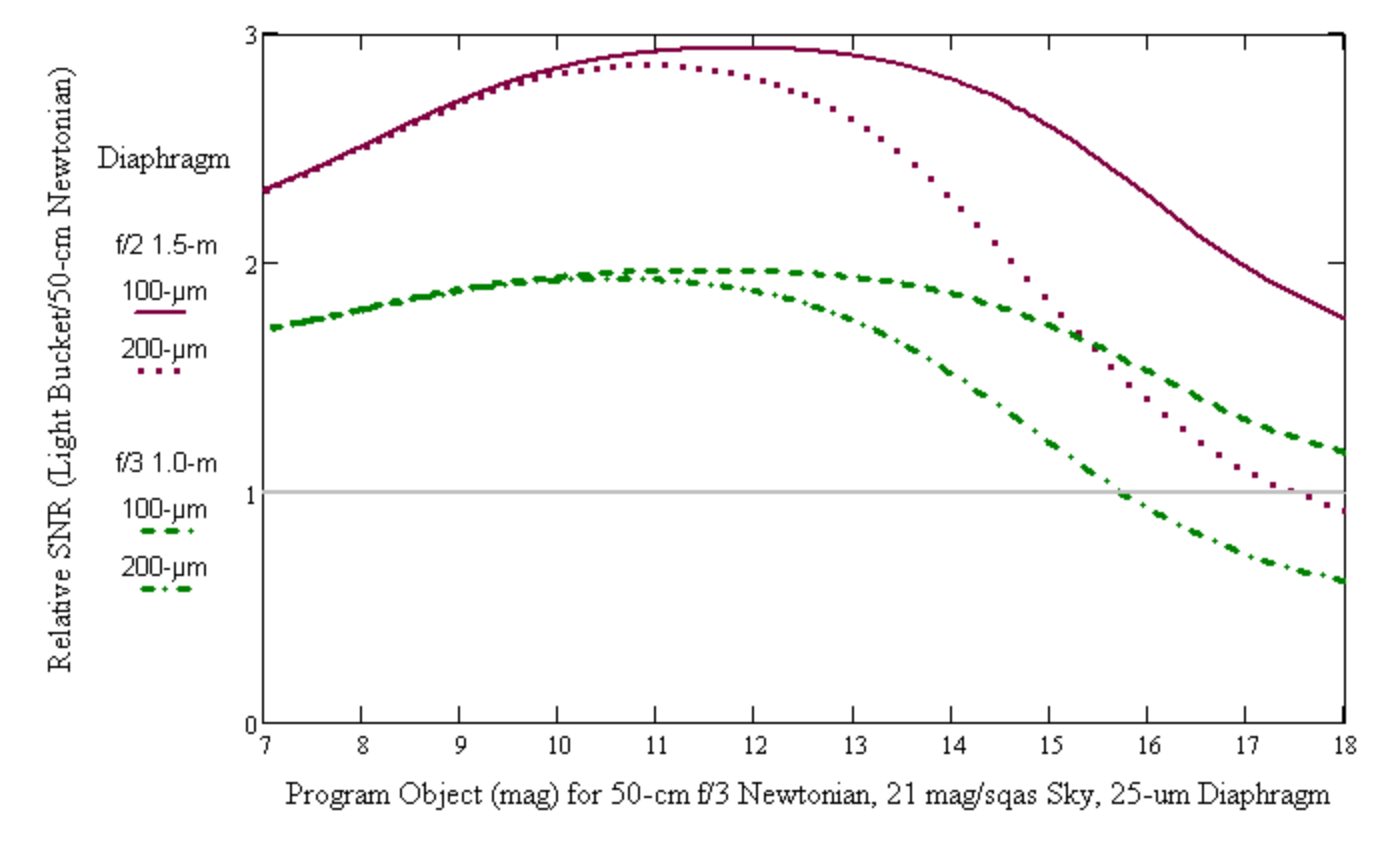
- Traditional f/8 SCT, 0.50-m mirror
- Light bucket f/2, 1.5-m & f/3 , 1.0-m
- Diaphragms - 28"&7" vs. 1" on SCT
- Scintillation at 1000-m, air-mass 1.5



SAS 2010 LBA paper

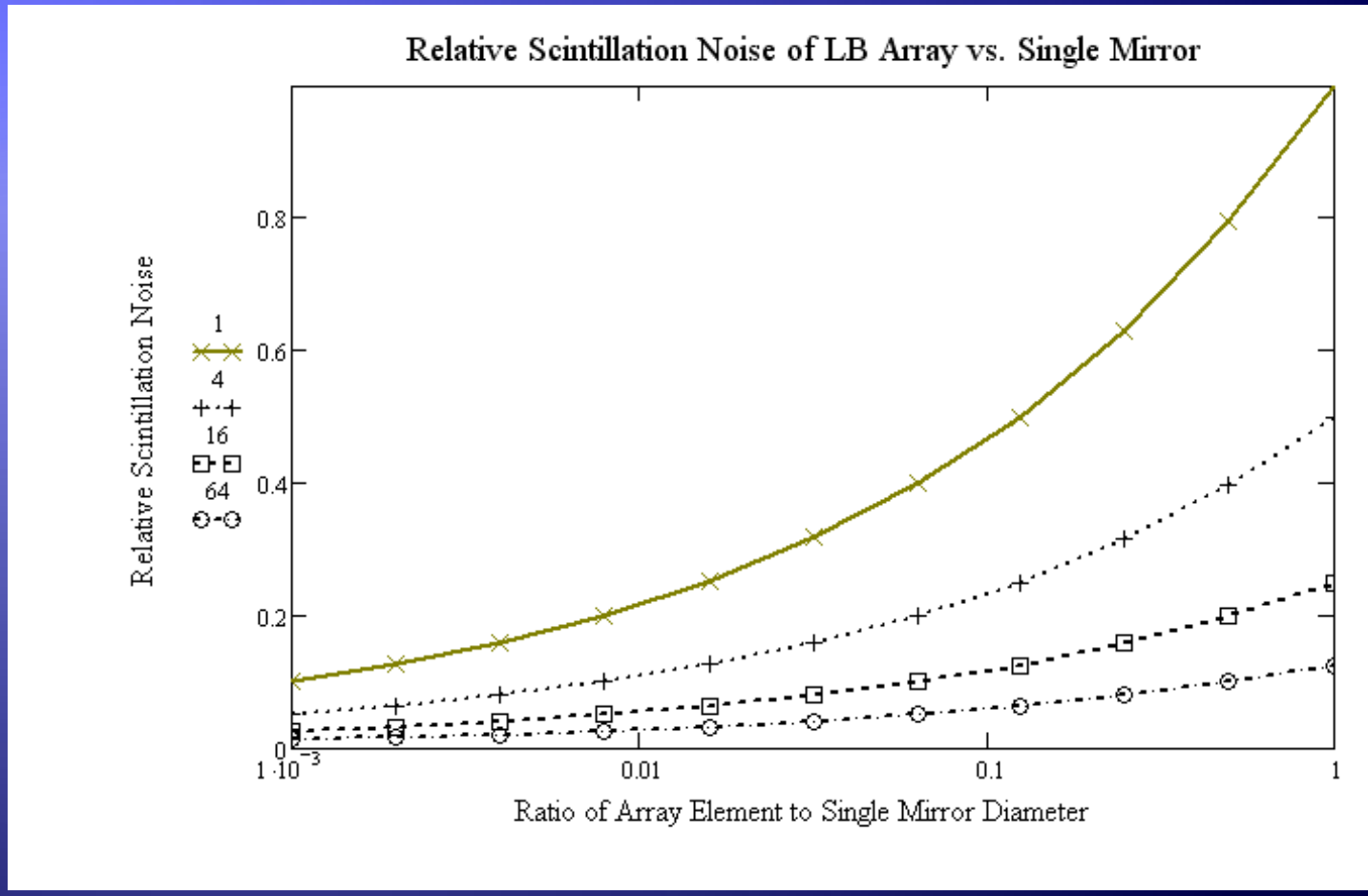
Light Bucket vs. Newtonian

- Traditional f/3 Newt., 0.50-m mirror
- Light bucket f/2, 1.5-m & f/3 , 1.0-m
- Diaphragms - 28"&7" vs. 7" on Newtonian
- Scintillation at 1000-m, air-mass 1.5



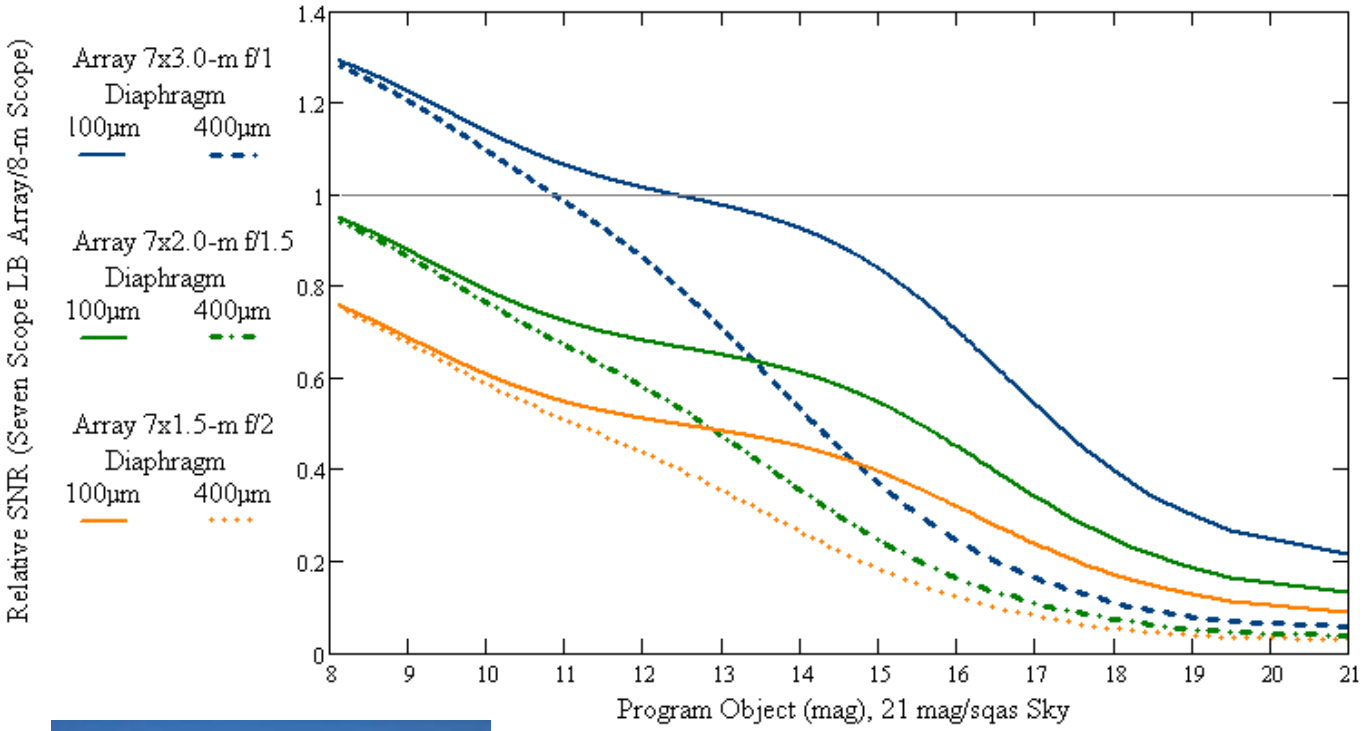
Arrays – Scintillation Reduction

- Top curve: same effective aperture of single mirror and array
- Array elements spread out



Light Bucket Arrays

- 7 LBT arrays vs 8-m f/1 scope
- 2 relative diaphragm diameters (400, 100 vs 40 micron on 8-m)
- Scintillation at 3000-m, air-mass 1.5

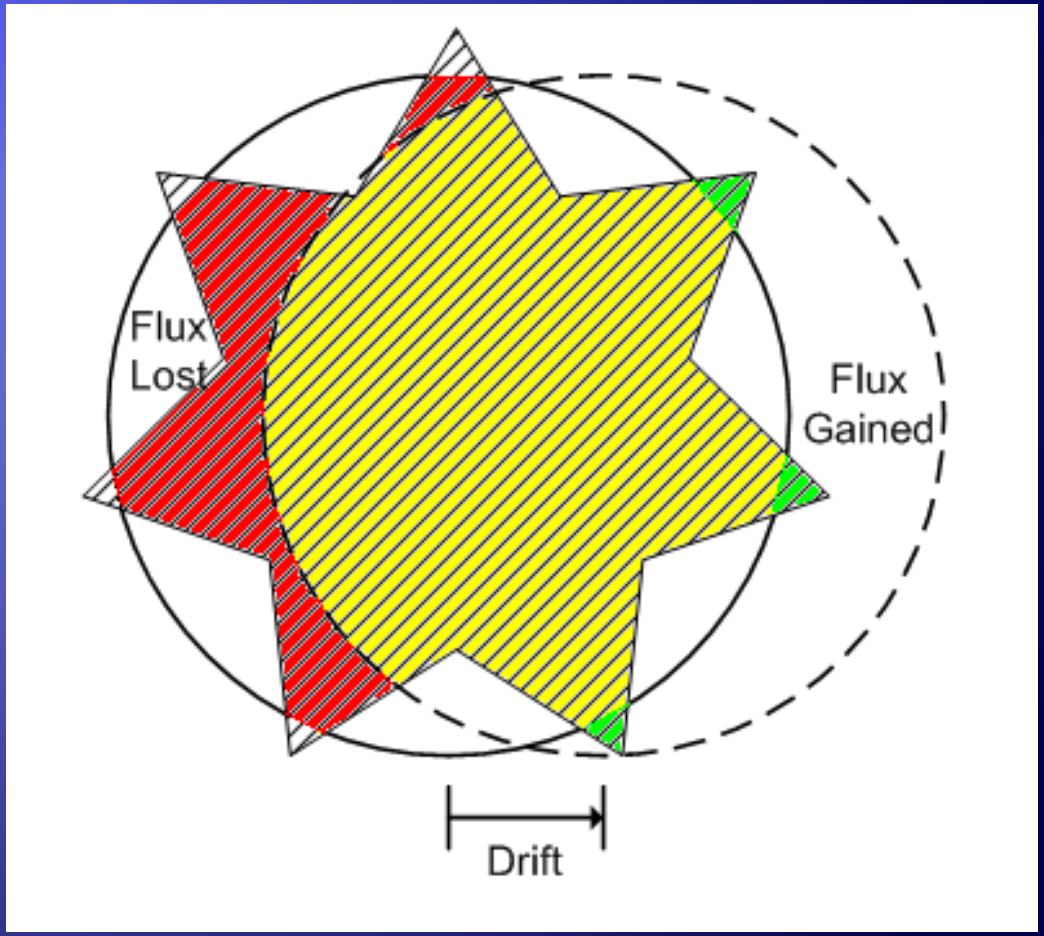


Light Bucket Array Features

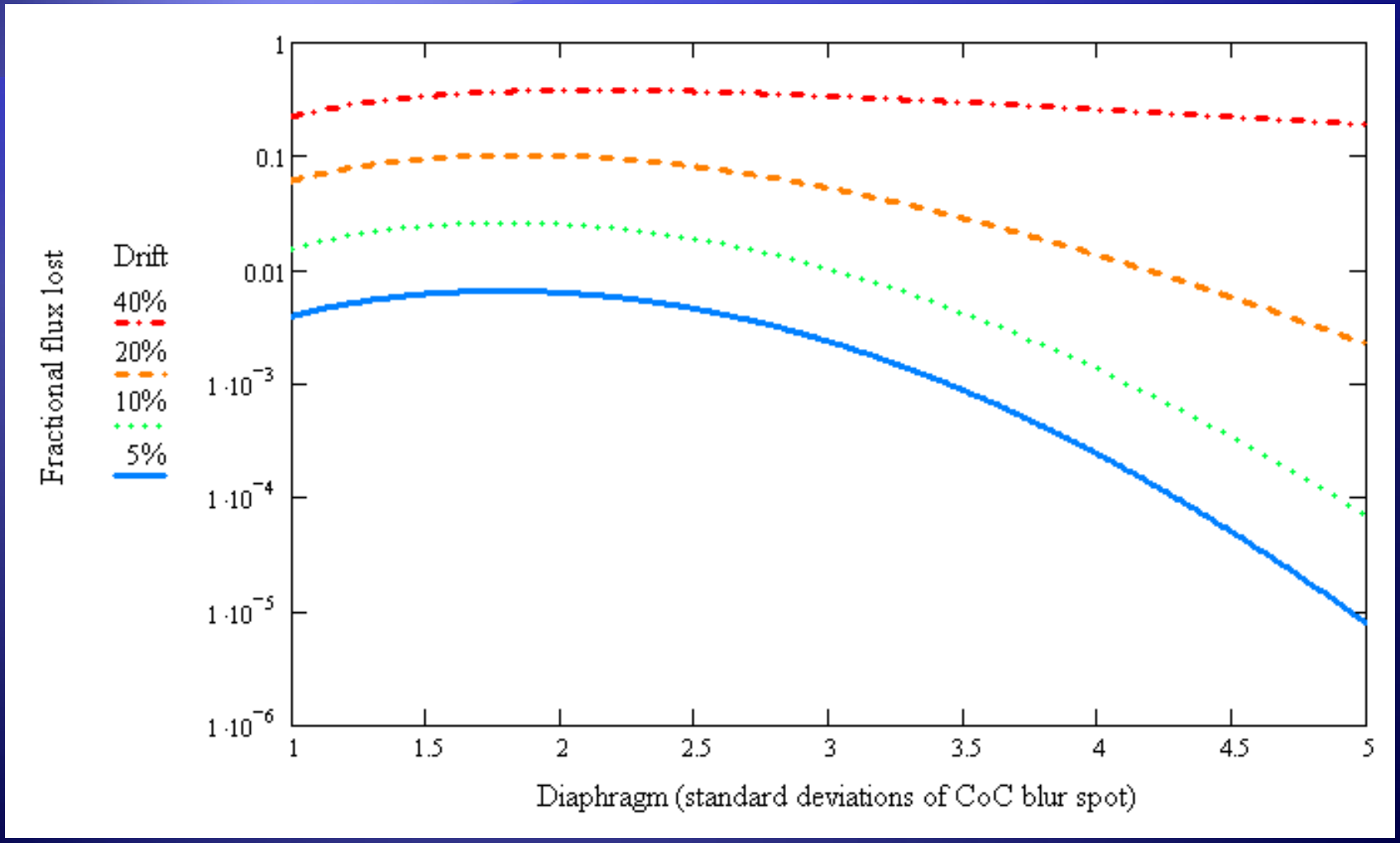
- *Reliability. Immediate and independent confirmation of rare, transient events*
- *Availability. Graceful failure rather than all at once*
- *Independence. Geographic area avoids clouding out the array*
- *Transportability. Moveable elements to avoid bad weather or seek advantageous observing locations*
- *Expandability. Add more array elements later as funds allow.*

Tracking Errors

- Drifting circular detector diaphragm
  - **Red** – flux lost
  - **Green** – flux gained
- Causes a systematic, non-random error



Tracking Errors – Flux Lost



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- Yahoo Discussion Group - http://groups.yahoo.com/group/AltAzInitiative

More details:
The Alt-Az Initiative: Telescope, Mirror, & Instrument Developments, eds. Genet, Johnson, & Wallen, (Payson, AZ: Collins Foundation Press) 2010