Alt-Az Initiative

Efforts to Improve the Signal-to-Noise Ratio of Occultation Measures

Bruce Holenstein and Russ Genet

2010 ANNUAL IOTA MEETING

Agenda

- Alt-Az Initiative Research Interests
- Occulted Object Science Potential
- Signal-to-Noise-Ratio Dependencies

Alt-Az Initiative Research Interests

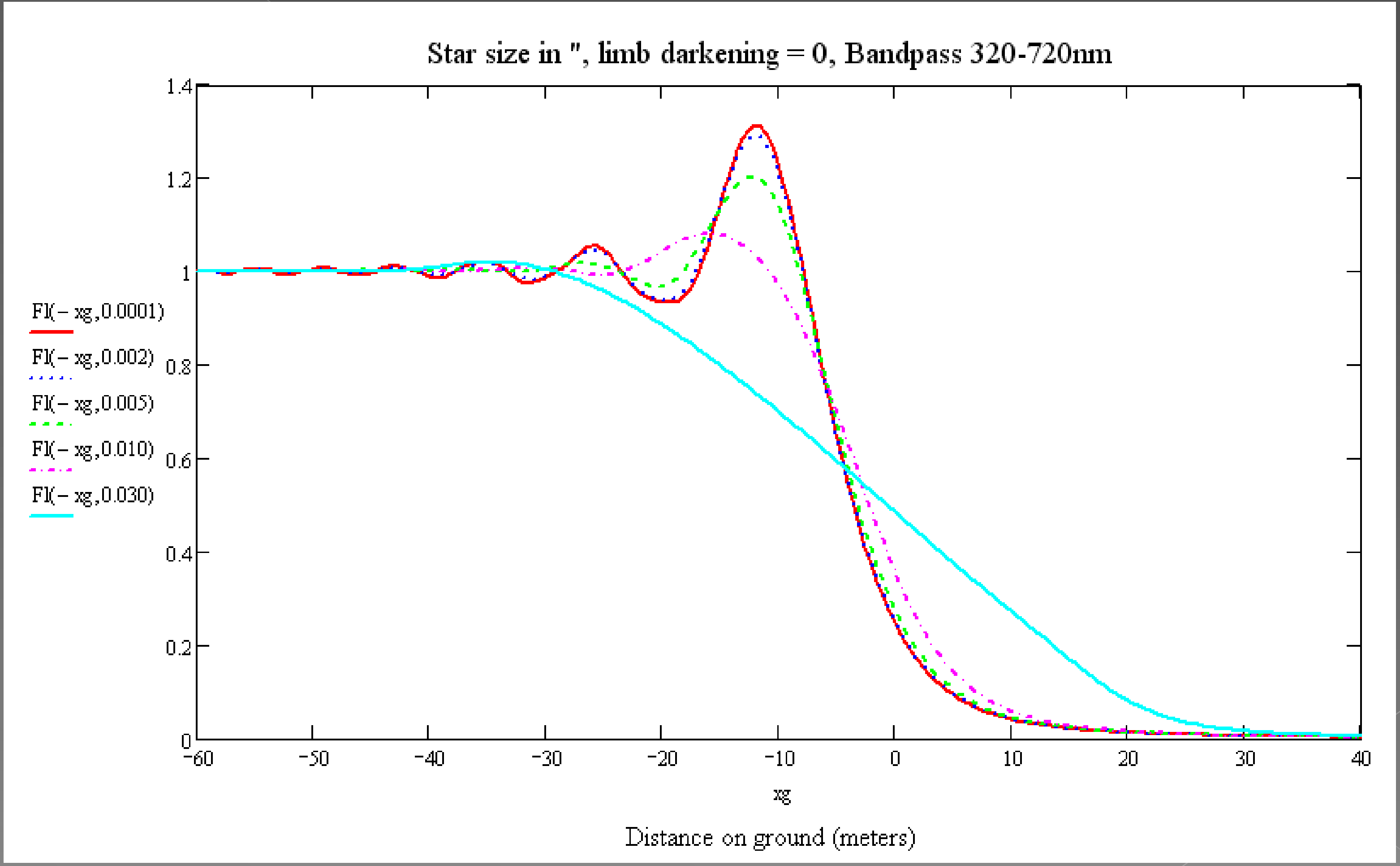
- Occultations
- Intensity Interferometry
- High-precision photometry
- Spectroscopy
- Polarimetry
- And many other astronomical areas…

Some Occulted Object Science Potentials with a Sufficient SNR

- Presence/absence of stellar companions
  - Separations, PA, relative luminosity
- Stellar sizes
- Limb darkening laws
- Presence of plages and spots
- Circumstellar disks
- Detection of hot Jupiters

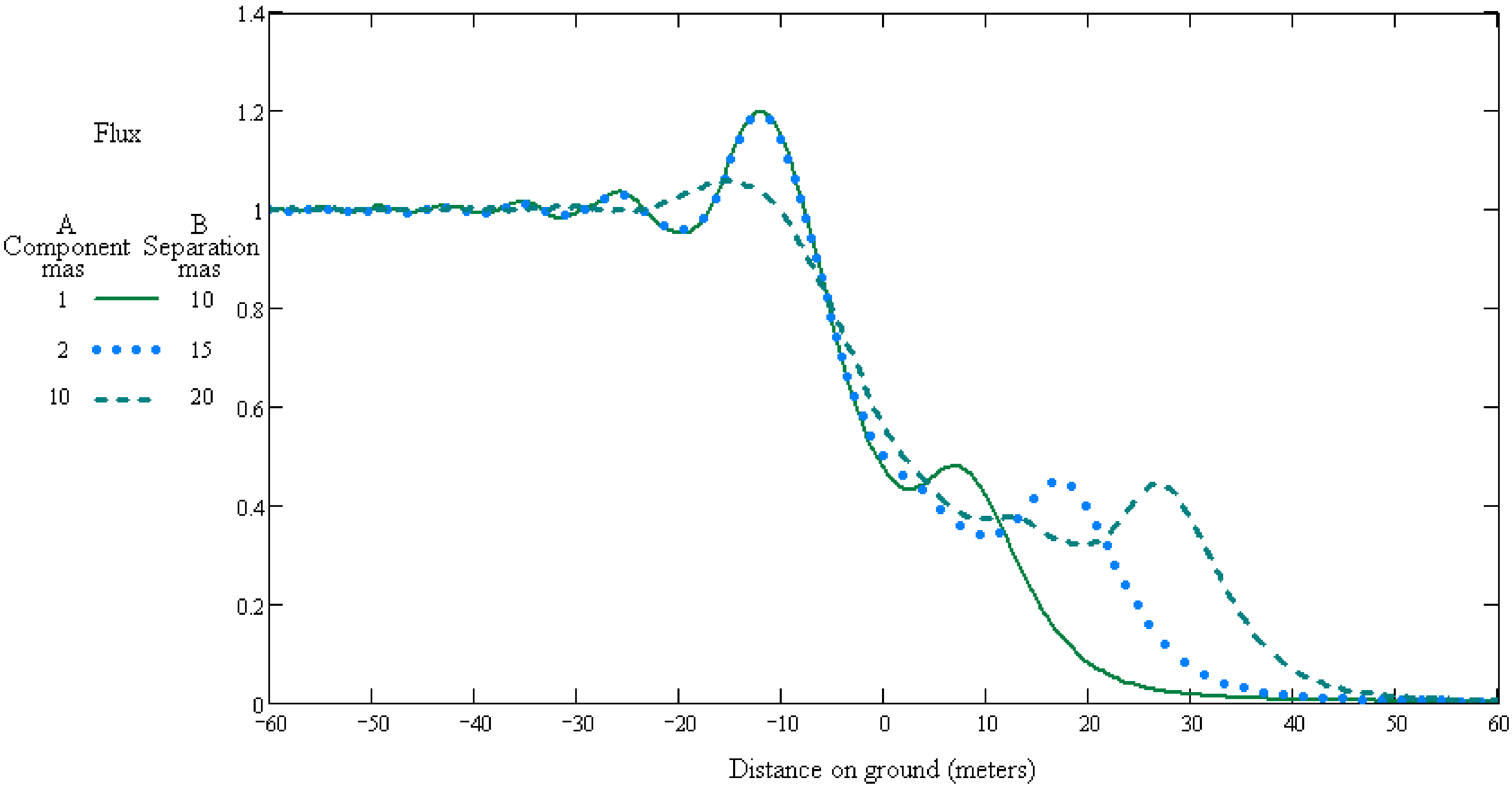
Lunar Occultations Examples

Theoretical diffraction light curves for different sized stars (0.1 to 30-mas)



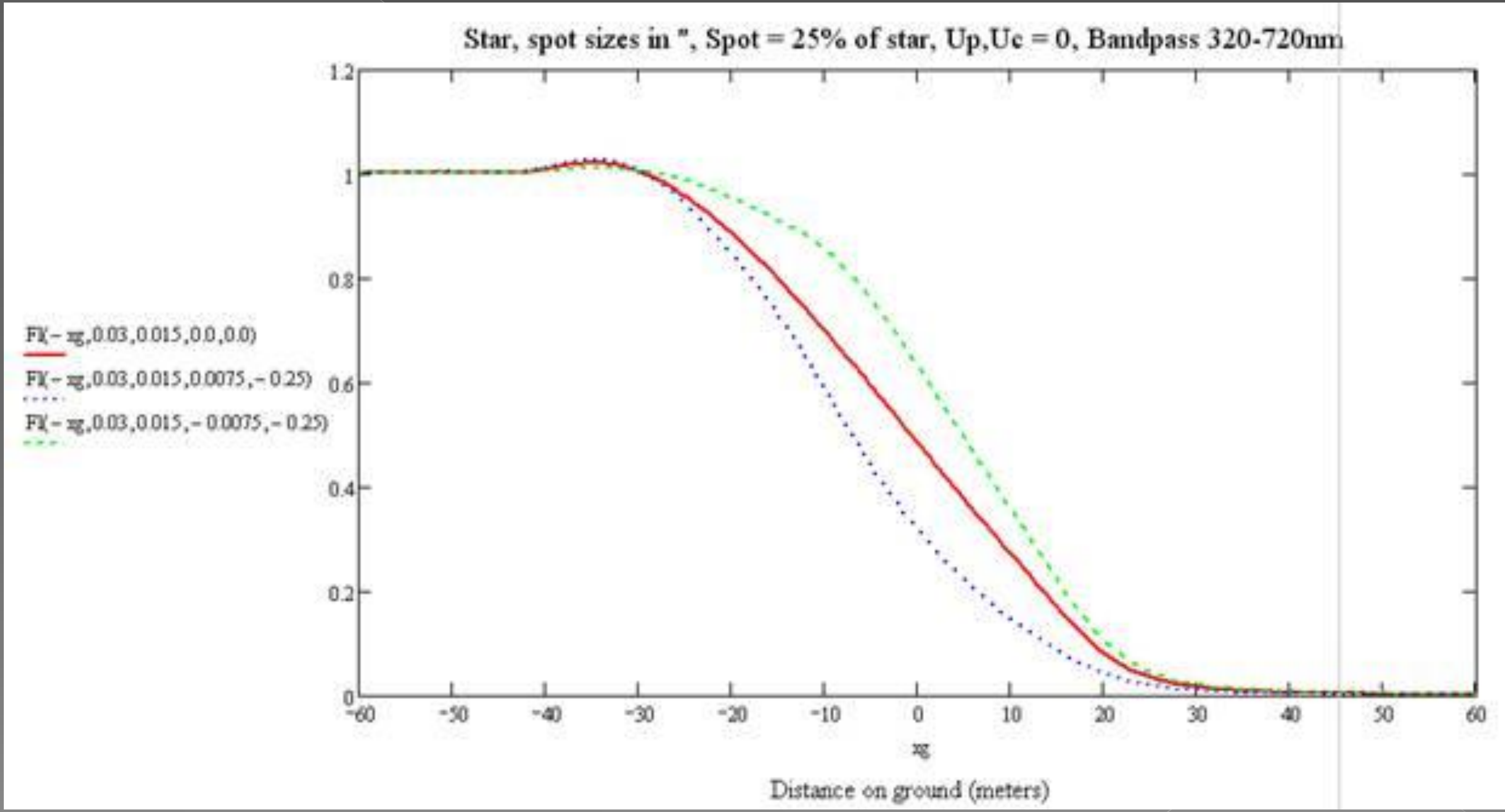
Lunar Occultations - Binaries

Theoretical diffraction light curves for three different binary systems



Lunar Occultations - Spots

Theoretical diffraction light curves for a 30-mas star lacking spots(red), and a dark spot (25%) leading (blue) and trailing (green) by 7.5-mas.



Signal-to-Noise-Ratio Dependencies

- What 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: Detectors

- High QE, visible and NIR (J, K &L) photometers
- Area detectors
  - CCD, emCCD evaluations
- High-speed, high gain, low noise amplifiers
- Dynamic range
  - Linearity and overload control

High-speed Si detector/trans impedance amp at Gravic

Dependency: Detectors II

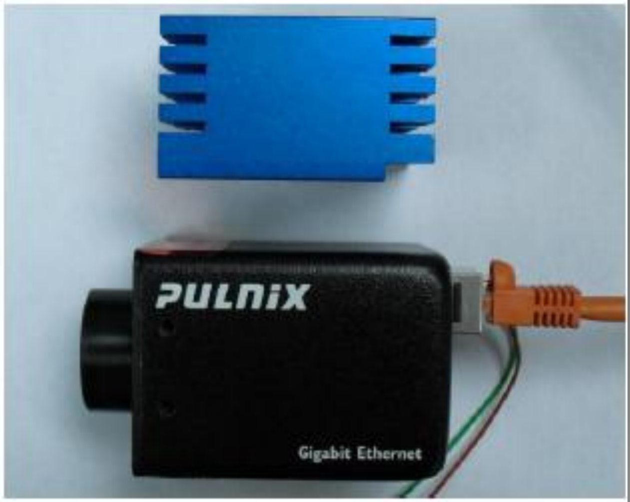
- Greg Jones NIR K’-band photometer

Parts - Bit-whacker controller, VCO, vacuum chamber, custom detector boards

Dependency: Fast Cameras

- Area detectors
  - Fast CCD, CMOS, and emCCD
- Evaluation of industrial and commercial units (JAI, Andor, and others)

Andor LUCA-S emCCD



JAI 6470GE

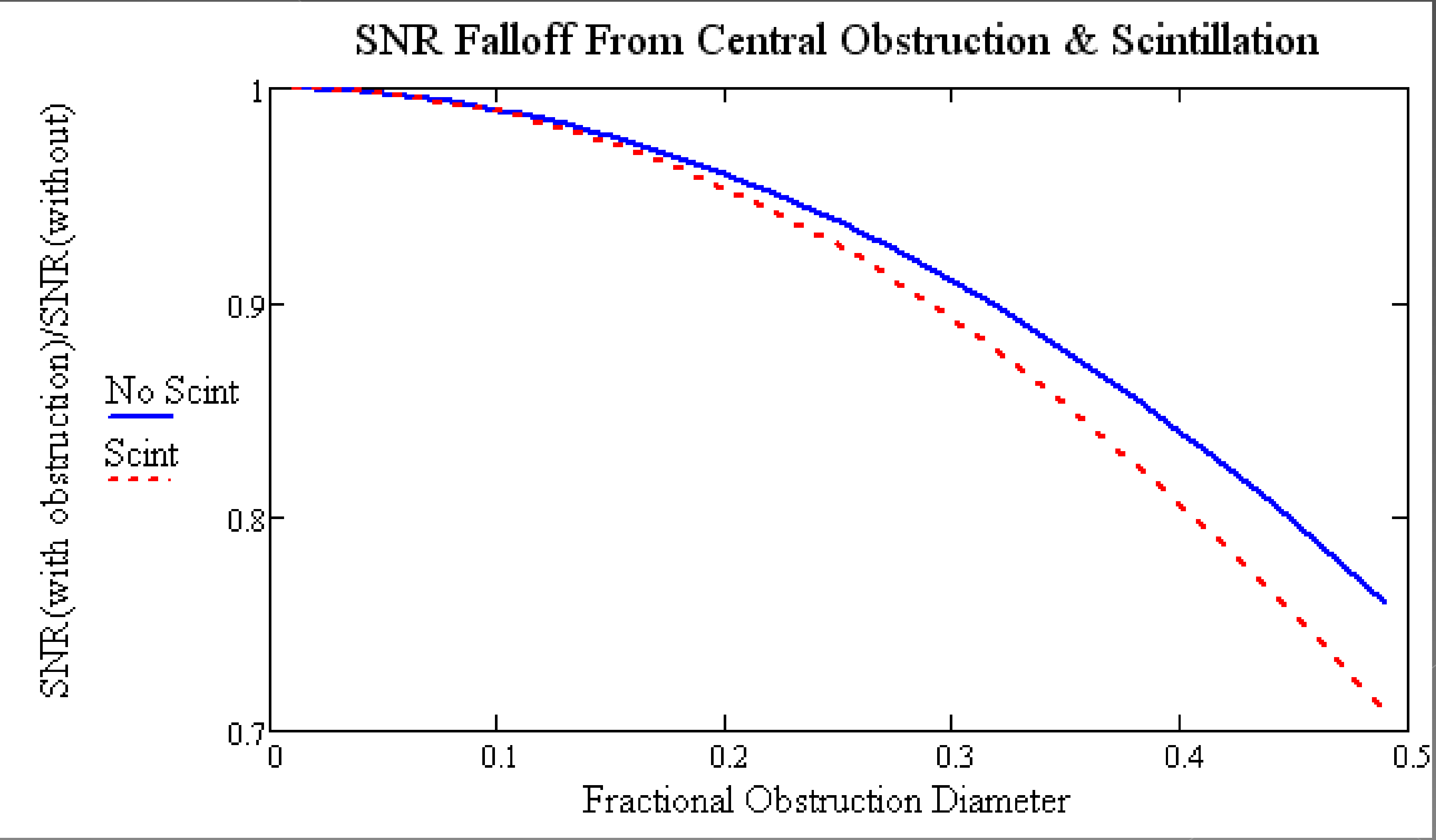
Frank Suites, Bruce Holenstein, Russ Genet collaboration

Dependency: Scintillation

- Can't increase integration duration
  - Need about 300 fps in visible for diff. pattern
- 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)

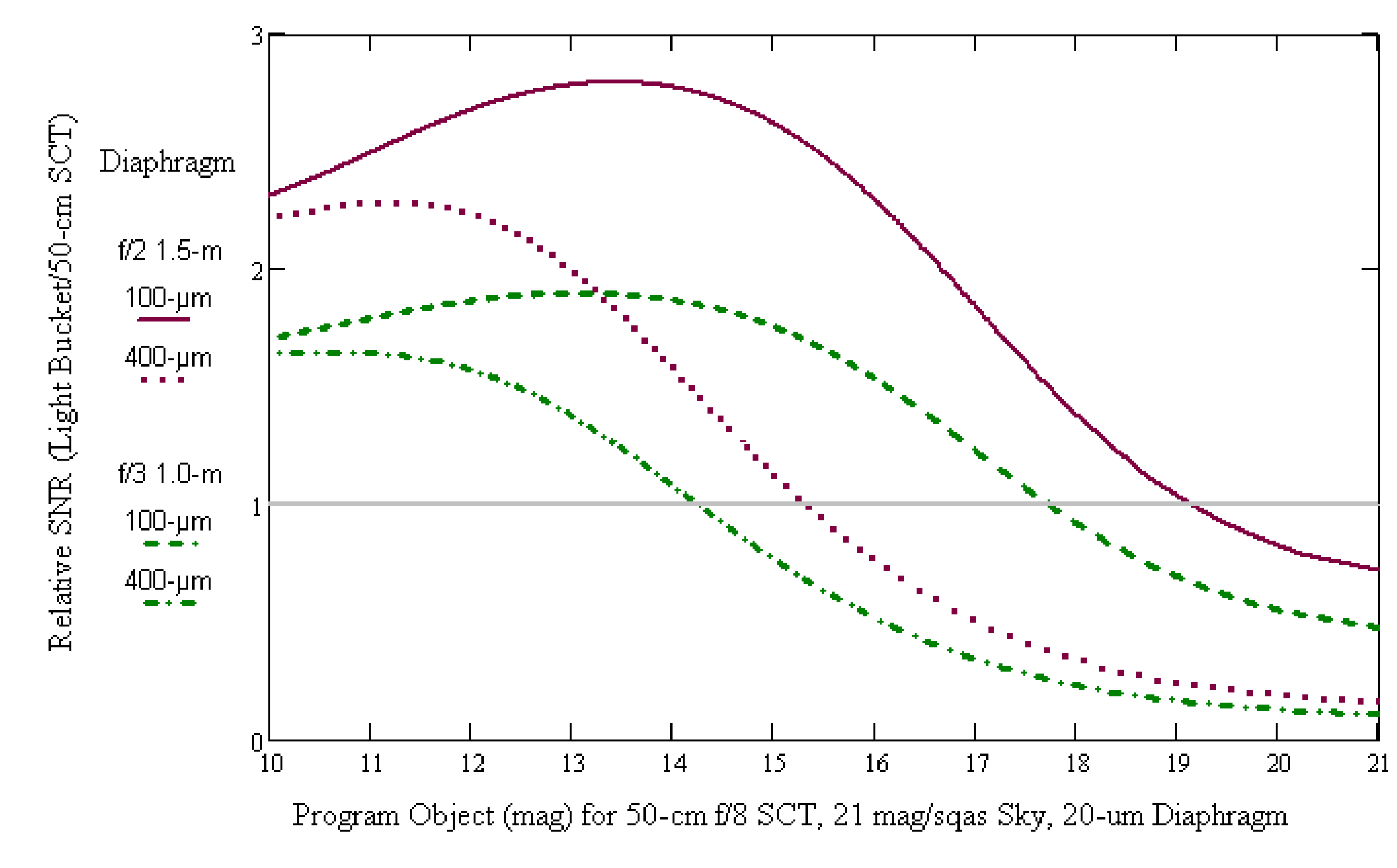
Central Obstruction SNR Falloff

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



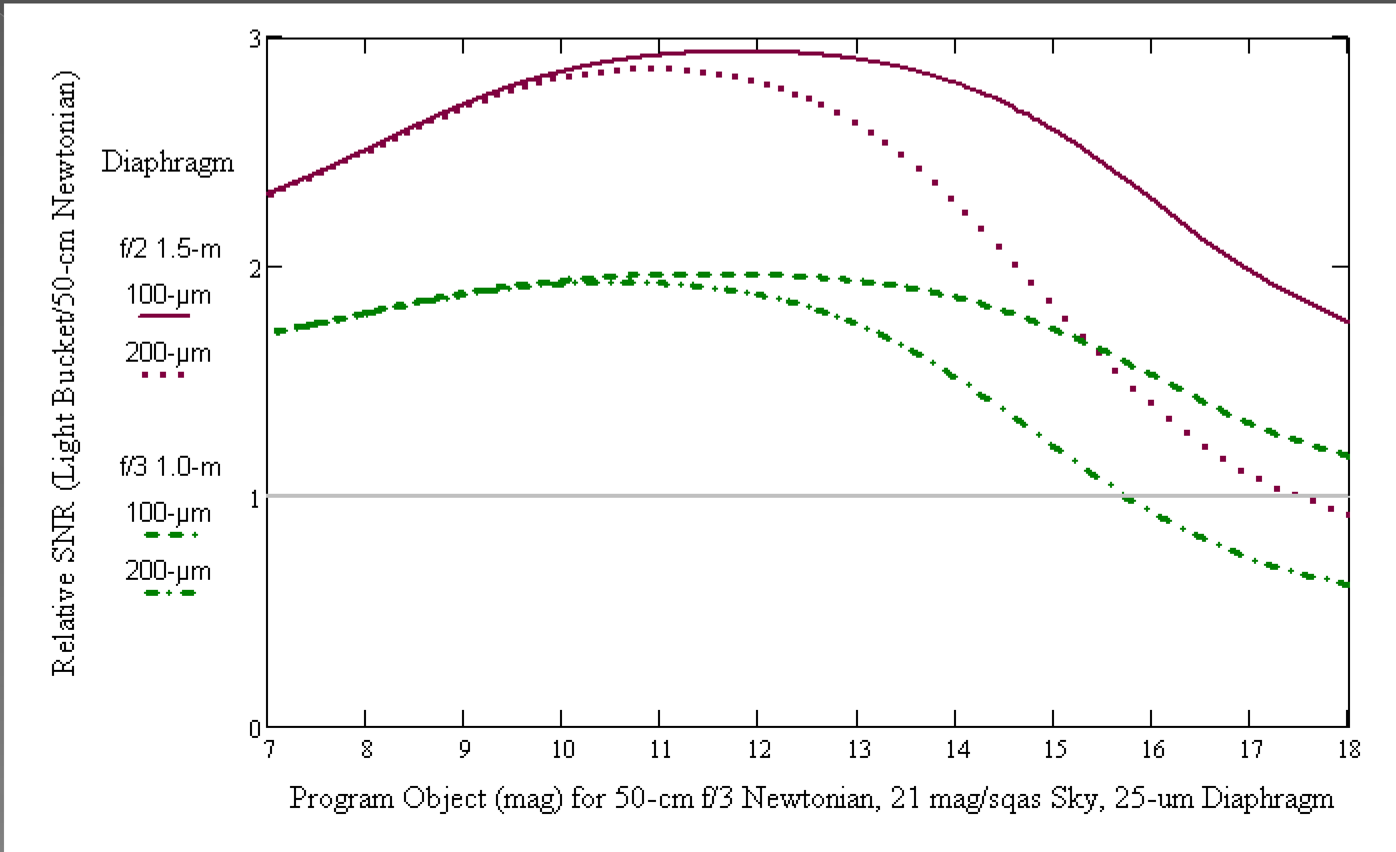
Light Bucket vs. SCT

- 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



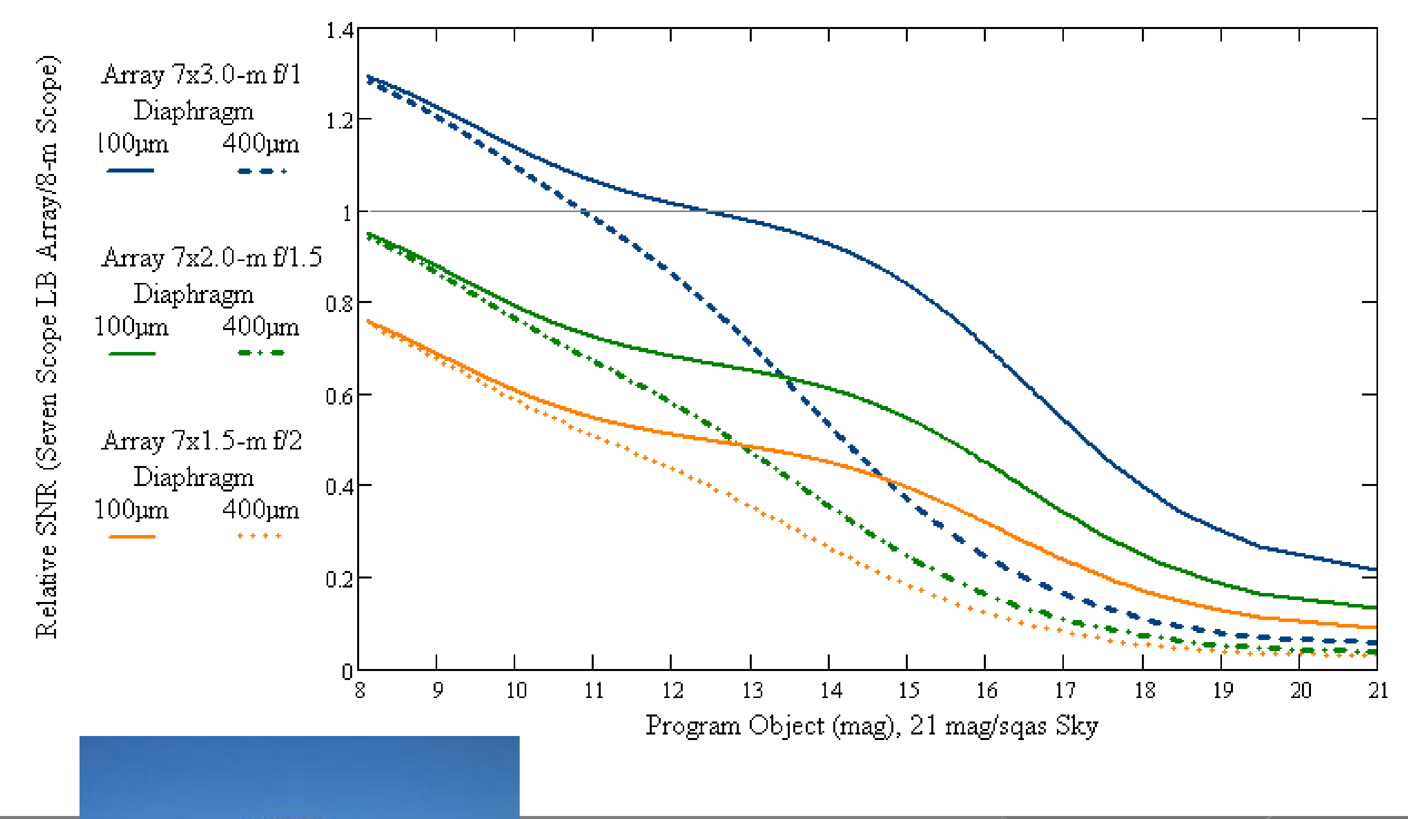
Light Bucket vs. Newtonian

- 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



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



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

More details:
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