High Speed Photometry and Scintillation

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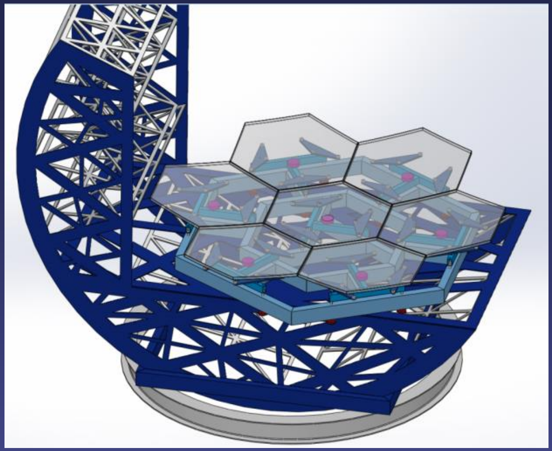
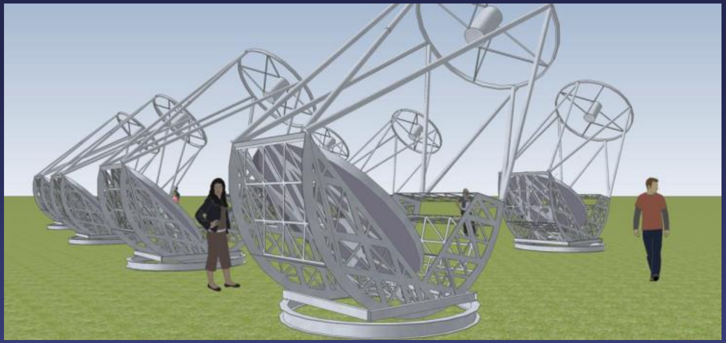
Alt-Az Initiative Portland VIII Workshop
August 1-3, 2014

Motivation

- High Time Resolution Observations of Transient & High Cadence Events
- Scintillation minimization

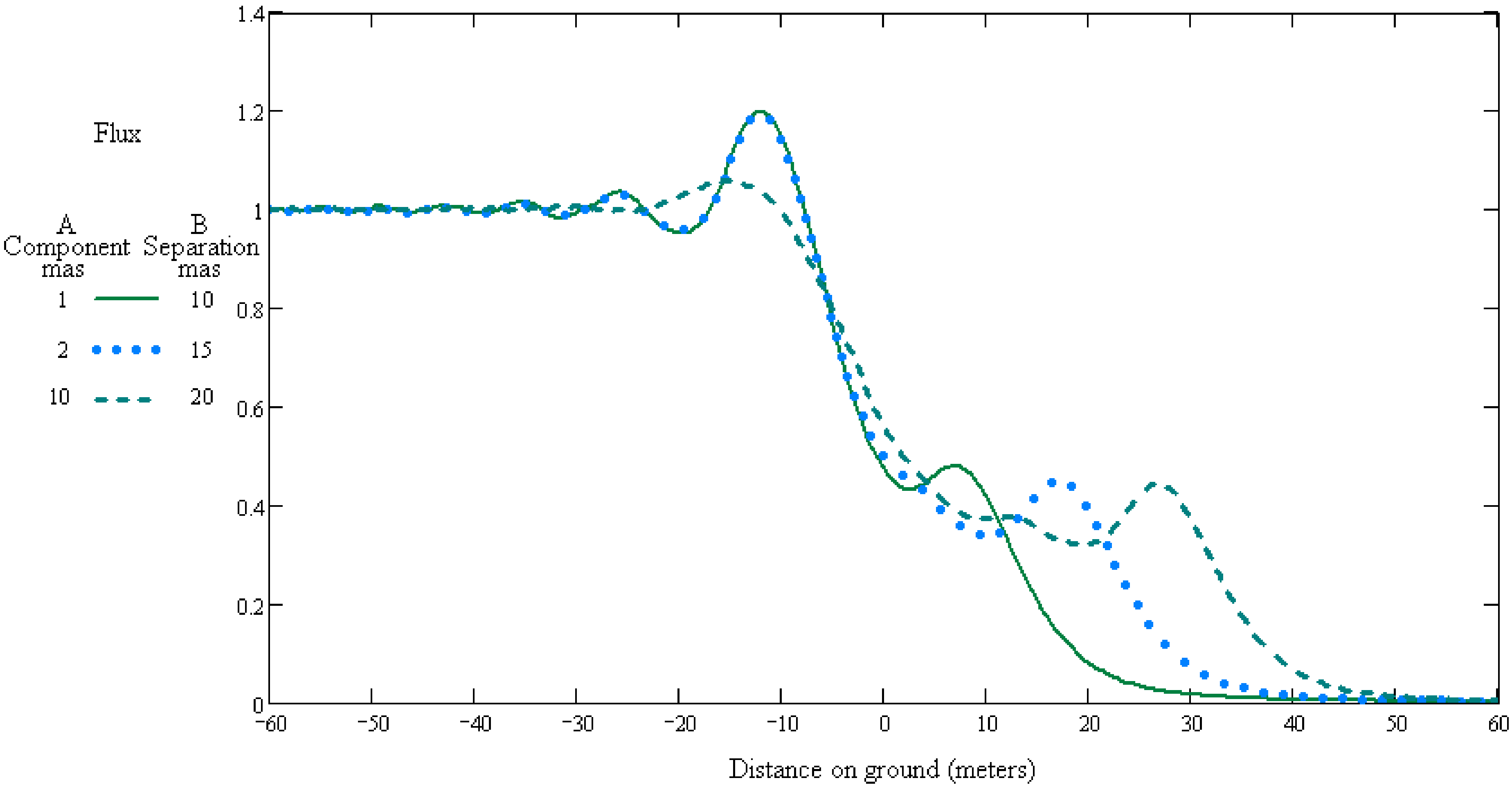




Scaled up design to 2.4-m

HTRA Theory – Binary Occultations[3]

Theoretical diffraction light curves for lunar occultation of three different binary systems



Reality – Omega Leonis 0910Apr14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Occult4 prediction for Malvern-Gravic patio
E. Longitude - 75 32 21.1,  Latitude  40  4 30.2,  Alt.  108m;  Telescope dia 50cm;  dMag 0.0

       day  Time    P   Star  Sp  Mag  Mag    % Elon Sun  Moon   CA   PA  VA  AA Libration   A   B   RV    Cct   durn R.A. (J2000)  Dec    Mdist   SV
y   m  d  h  m  s       No  D      v    r V  ill     Alt Alt Az   o    o   o   o   L     B  m/o m/o "/s    o   sec  h  m   s    o  m  s   Mm    m/s
14 Apr 10  6  4 49 D    1397cF9  5.5          76+ 121     20 265  88S 107  56  88 -2.1 +7.0 +0.4-1.7 .451    4.8       9 28 27.4   9  3 24 400.7 884.1
   R1397 = omega Leonis
      1397 is double: AB 5.69 7.28 0.88" 114.0, dT = +1.9sec
      1397 is a close double. Observations are highly desired
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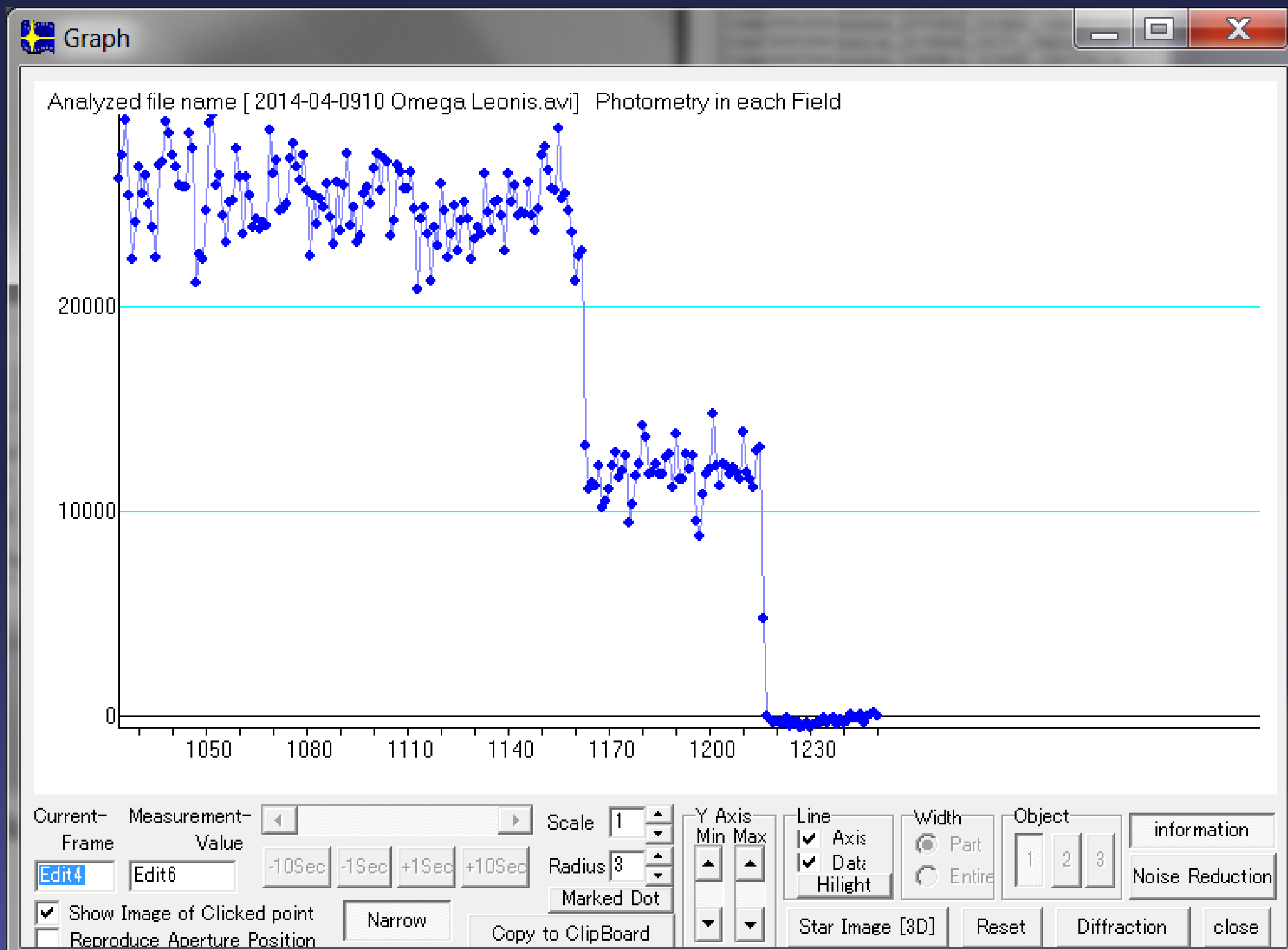
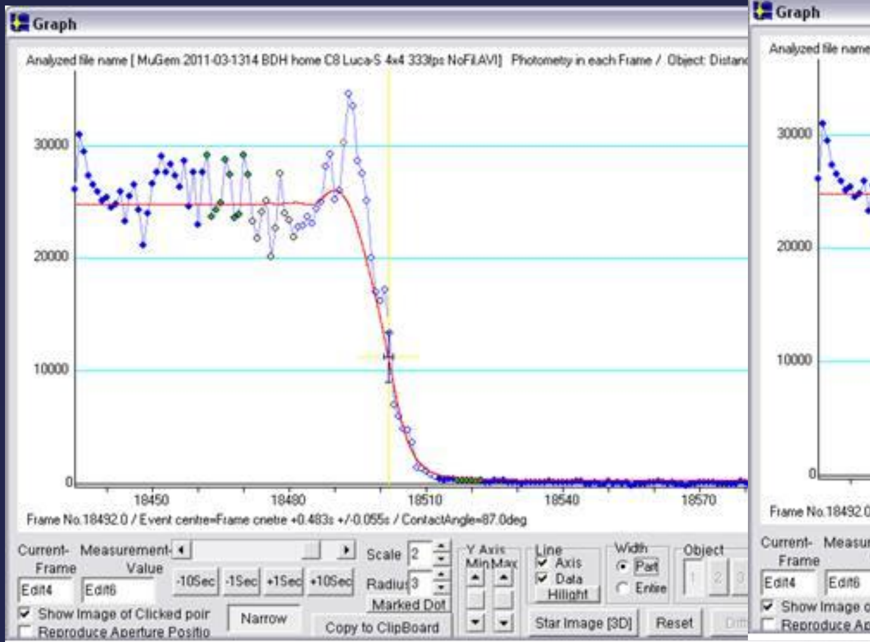
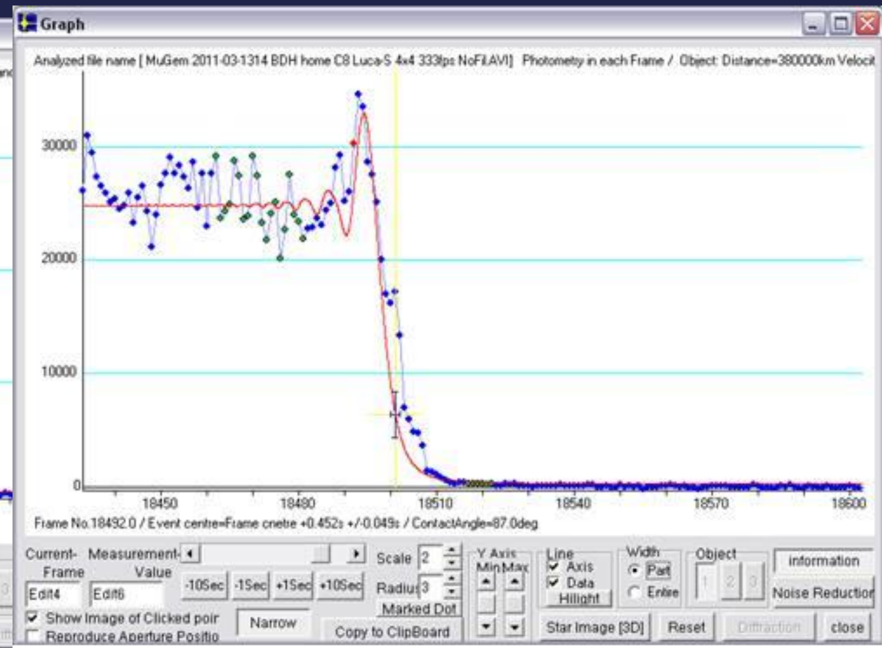
- Hubble Optics UL20 30fps video capture with VTI



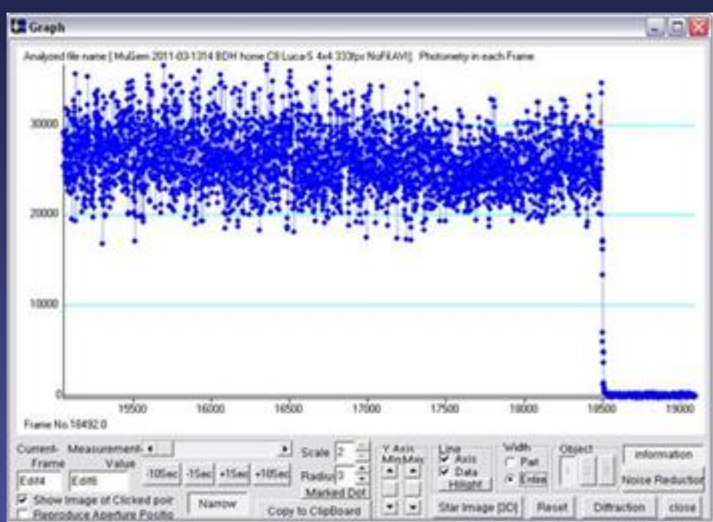
mu Gem Lunar Occ. 1314Mar11



16.5 mas fit (red)



0.1 mas fit (red)



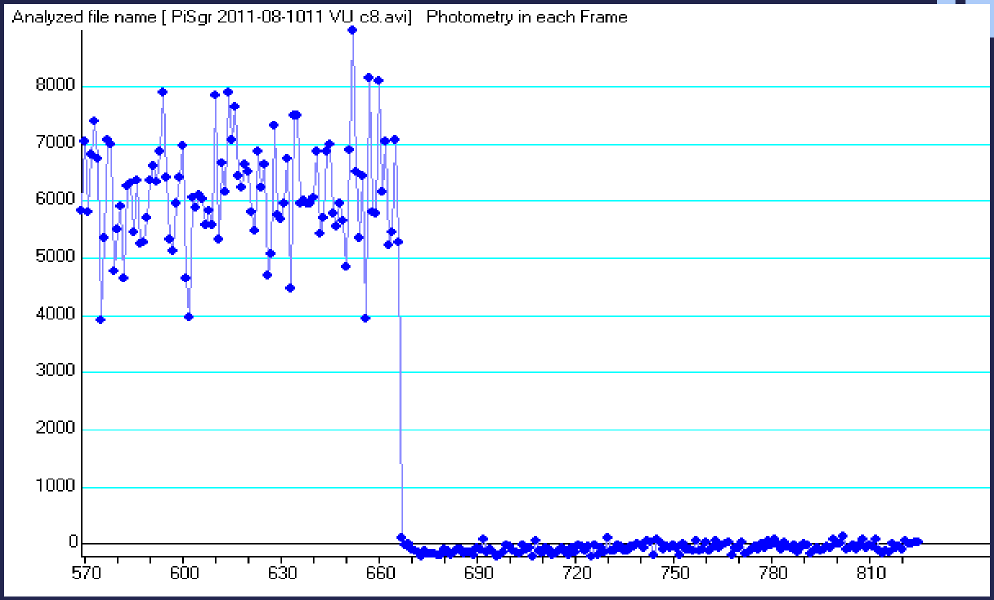
Media, PA C8, Luca-S at 333fps, unfiltered, LiMovie

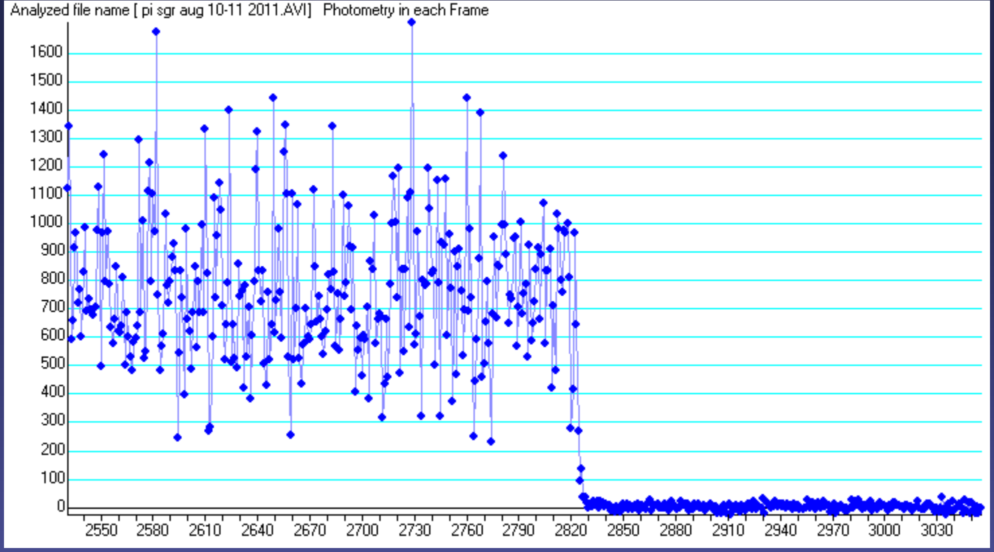
Scintillation limited SNR!

FPS (speed) - Pi Sgr at Villanova, 1011Aug11

- Villanova C8, 164CEX-2 CCD, no filter, 30fps
- 9.4mas per datum

- Gravic C8, Andor Luca-S emCCD, Sloan r filter, 120fps
- 2.4 mas per datum
- **Again Scintillation limited SNR**





Young 1967 on Scintillation

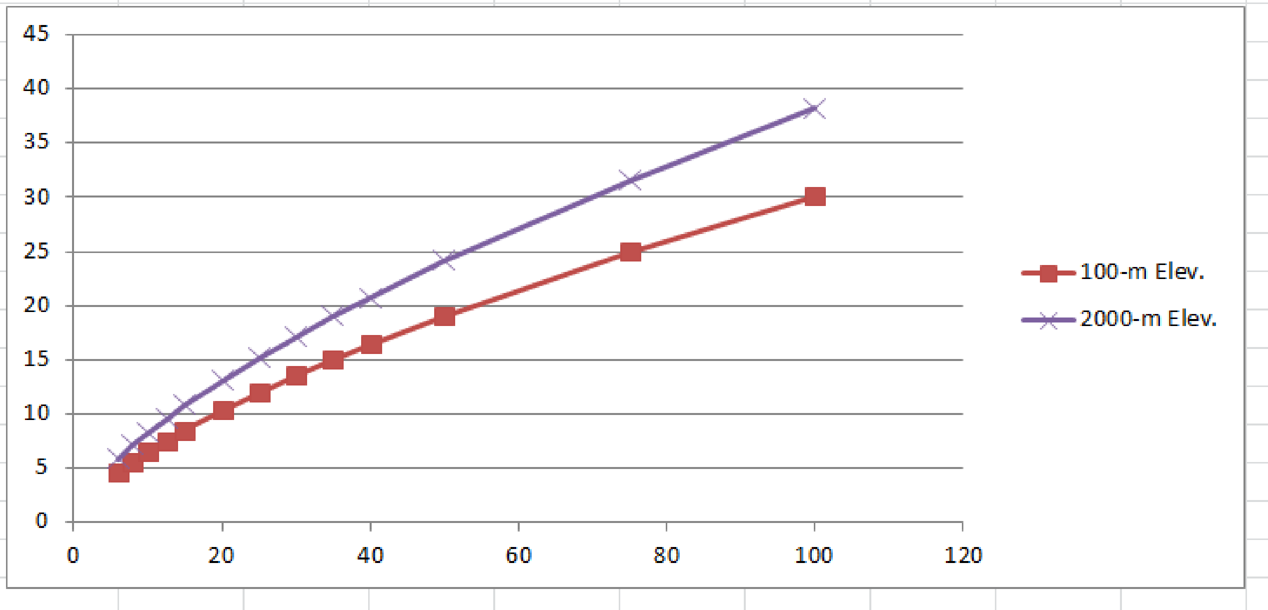
$$S = \frac{I_{rms}}{I_{DC}} = S_o d^{-2/3} X^{3/2} e^{-h/h_o} (\Delta f)^{1/2}$$

where S_o is 0.05 if aperture d is in inches, X is the air mass, scale height $h_o \sim 8000$m

Young, A. 1967, *AJ* **72**, 6

Scintillation SNR Theory

- Limit Scintillation imposes on SNR vs. aperture

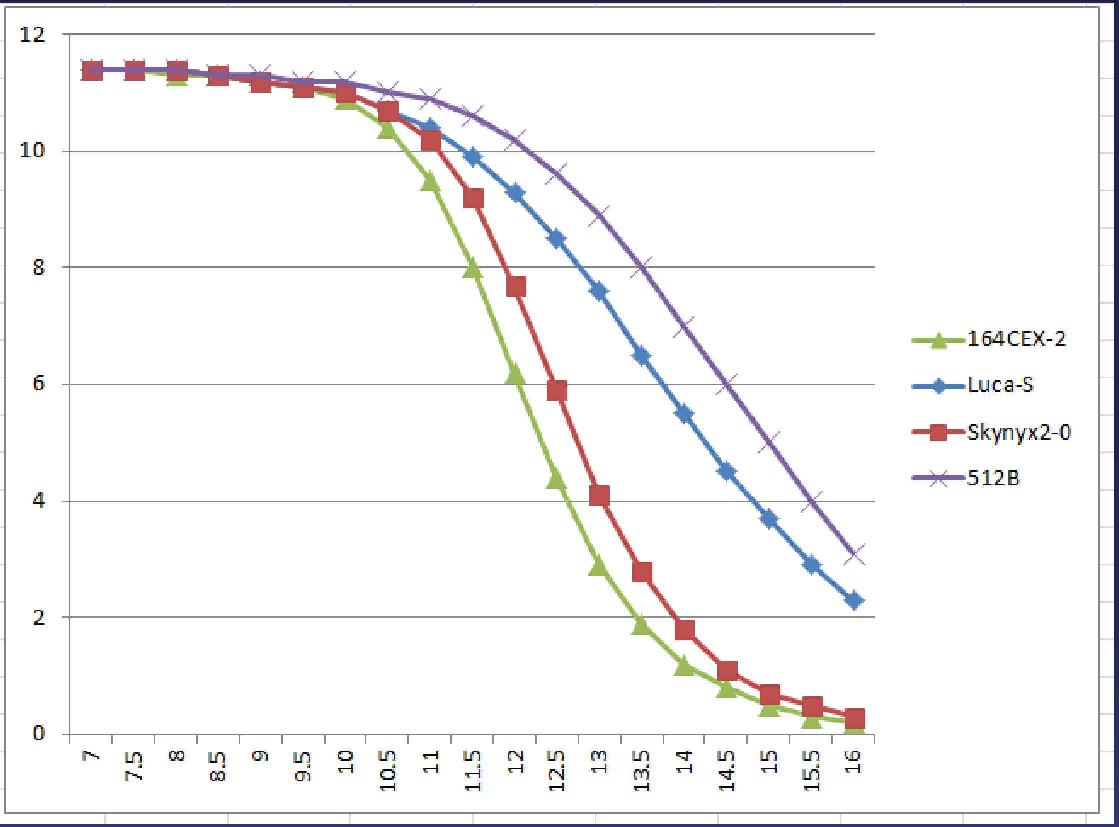


Scintillation limit on SNR vs. Aperture (cm)

30-fps, two elevations, 1.2 airmass, 20-mag./sq.as.

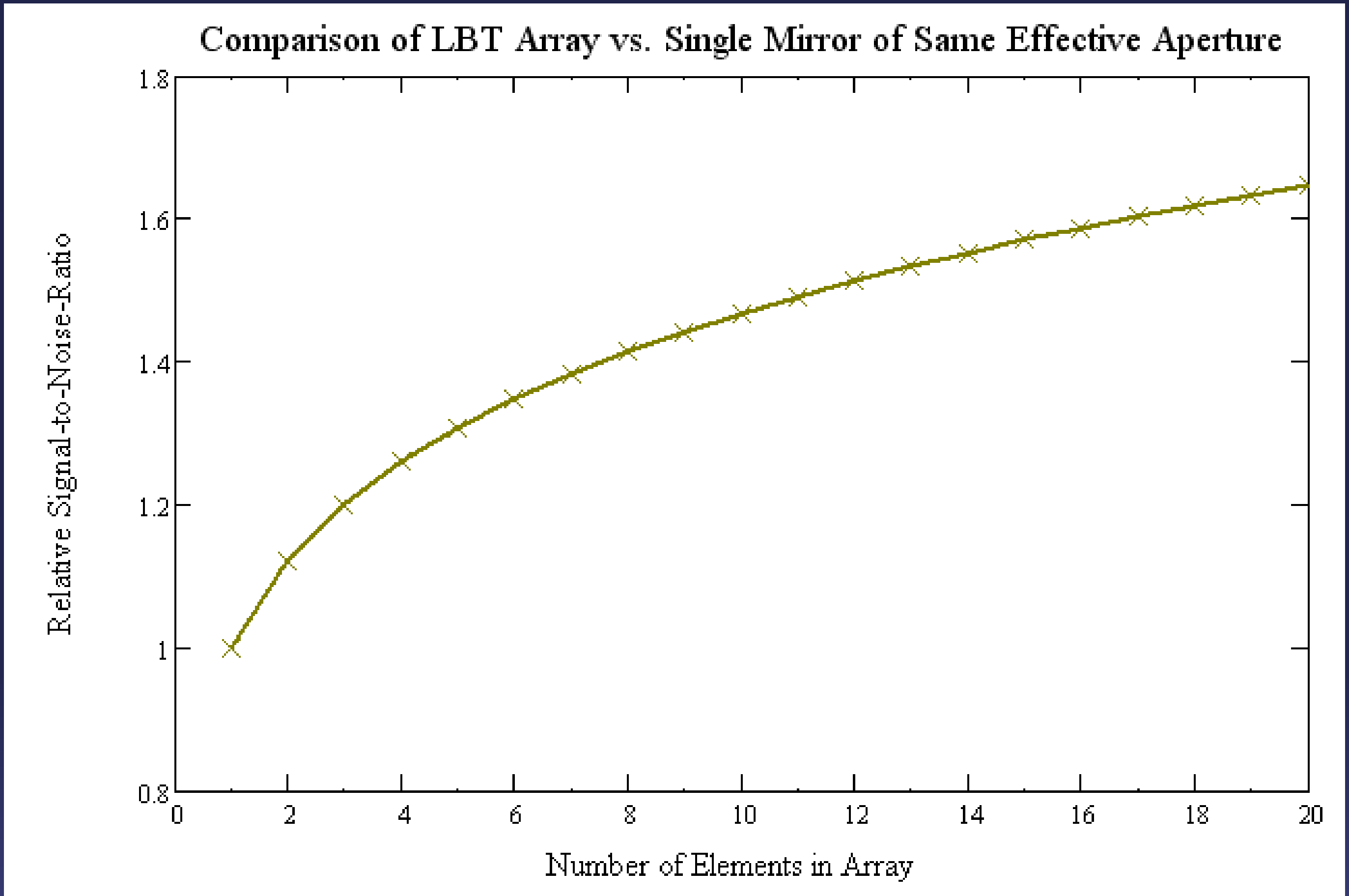
SNR Theory for 14" f/4 SCT

- SNR for four cameras vs object mag.
- 30-fps, 100-m elevation, 1.2 airmass, Sky: 20th mag./sq.as.
- Each magnitude fainter worked is about 300% more targets (2.5 mag. is ~30x more)



Scintillation limits photometric SNR for bright objects

Array Scintillation Noise Reduction

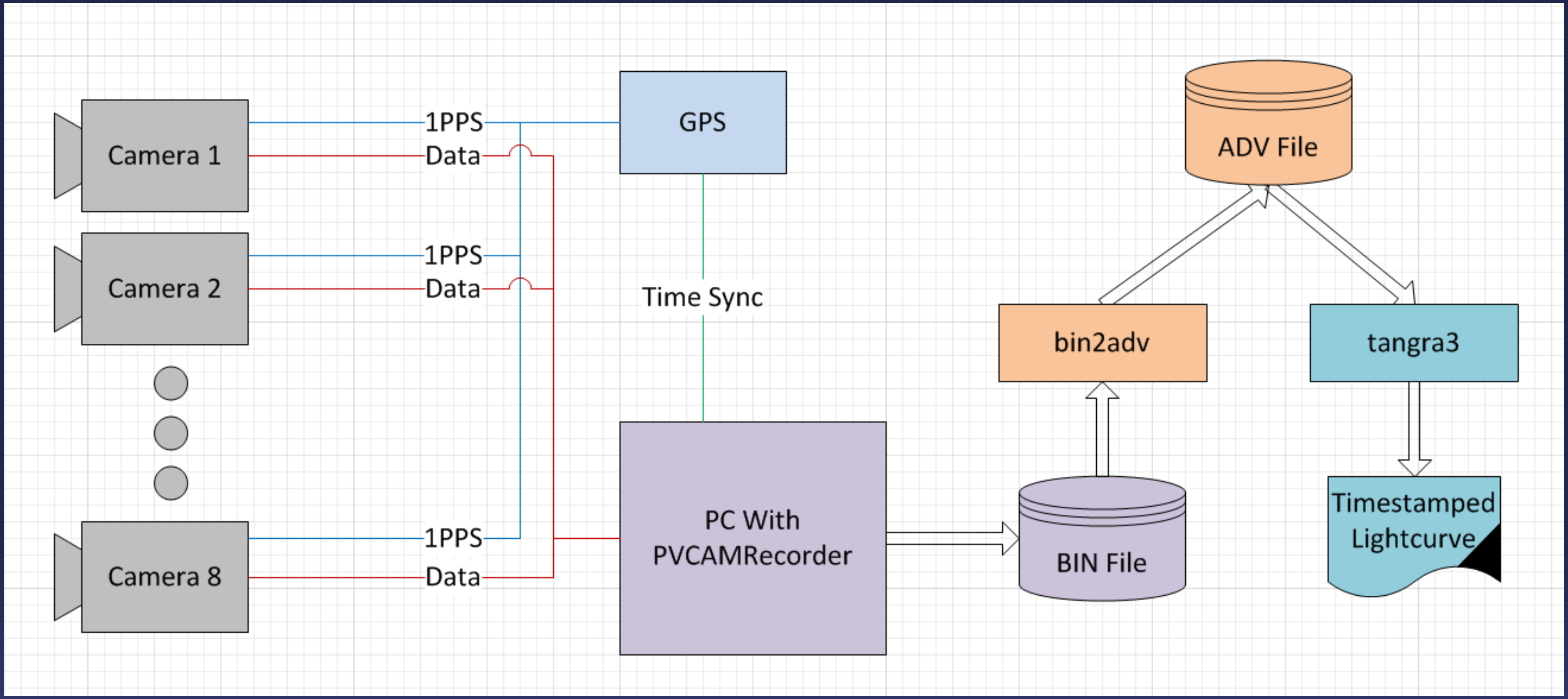


Only Scintillation per Young (1967) counted in noise.

Desired Capabilities for HTRA Capture Software

- Ability to drive multiple cameras for an array
- Full emCCD camera feature control
- Live-view of the star while recording
- Ability to record for long periods with precise timing and no data loss
- Recover gracefully from equipment failures

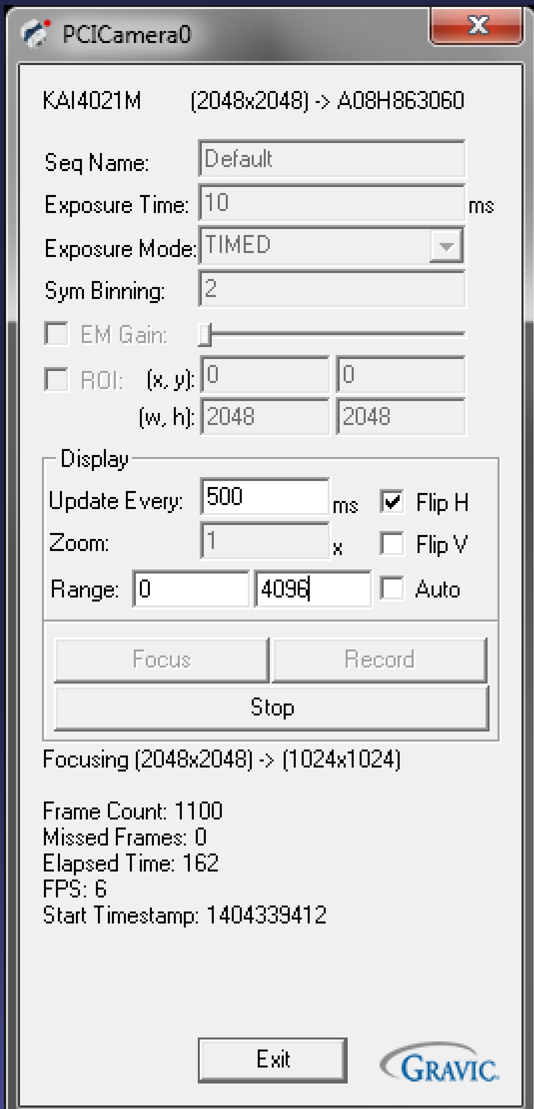
Architecture



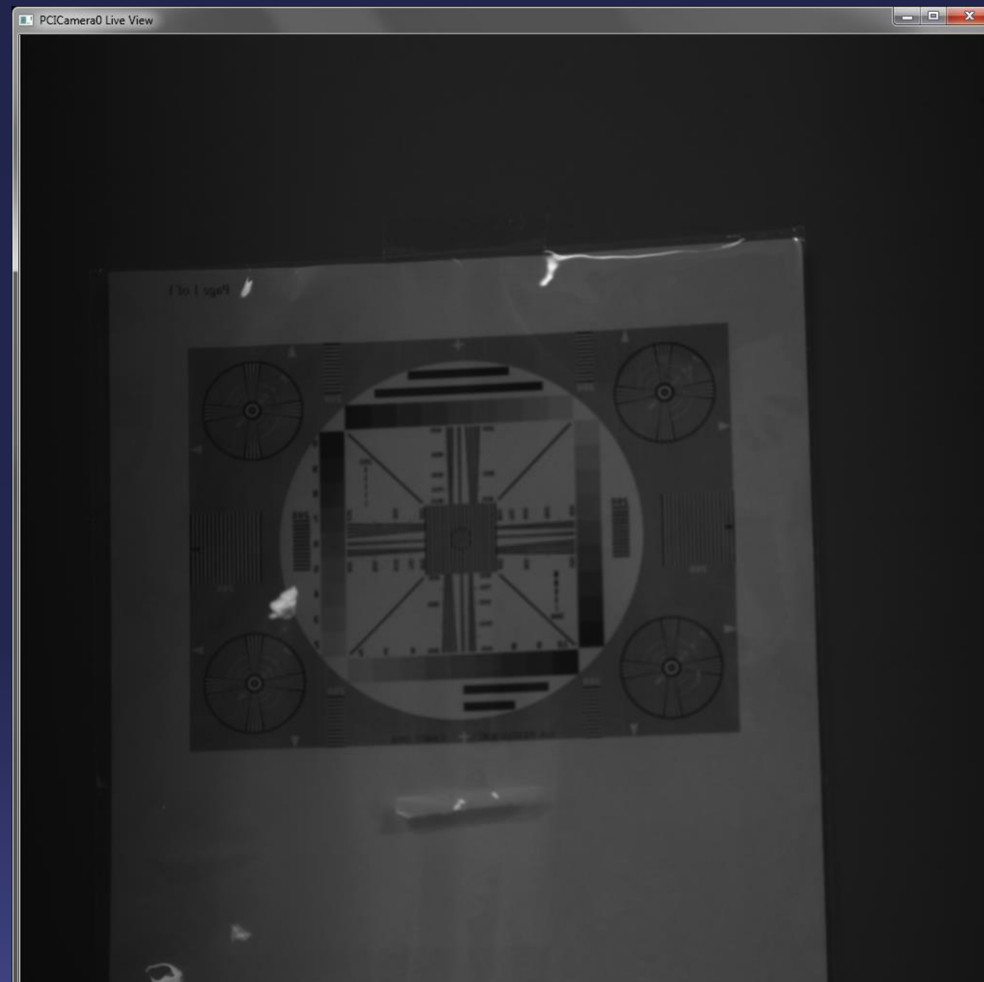
Triggering

- Two solutions developed
- Arduino-based
- Camera clock-based

User interface

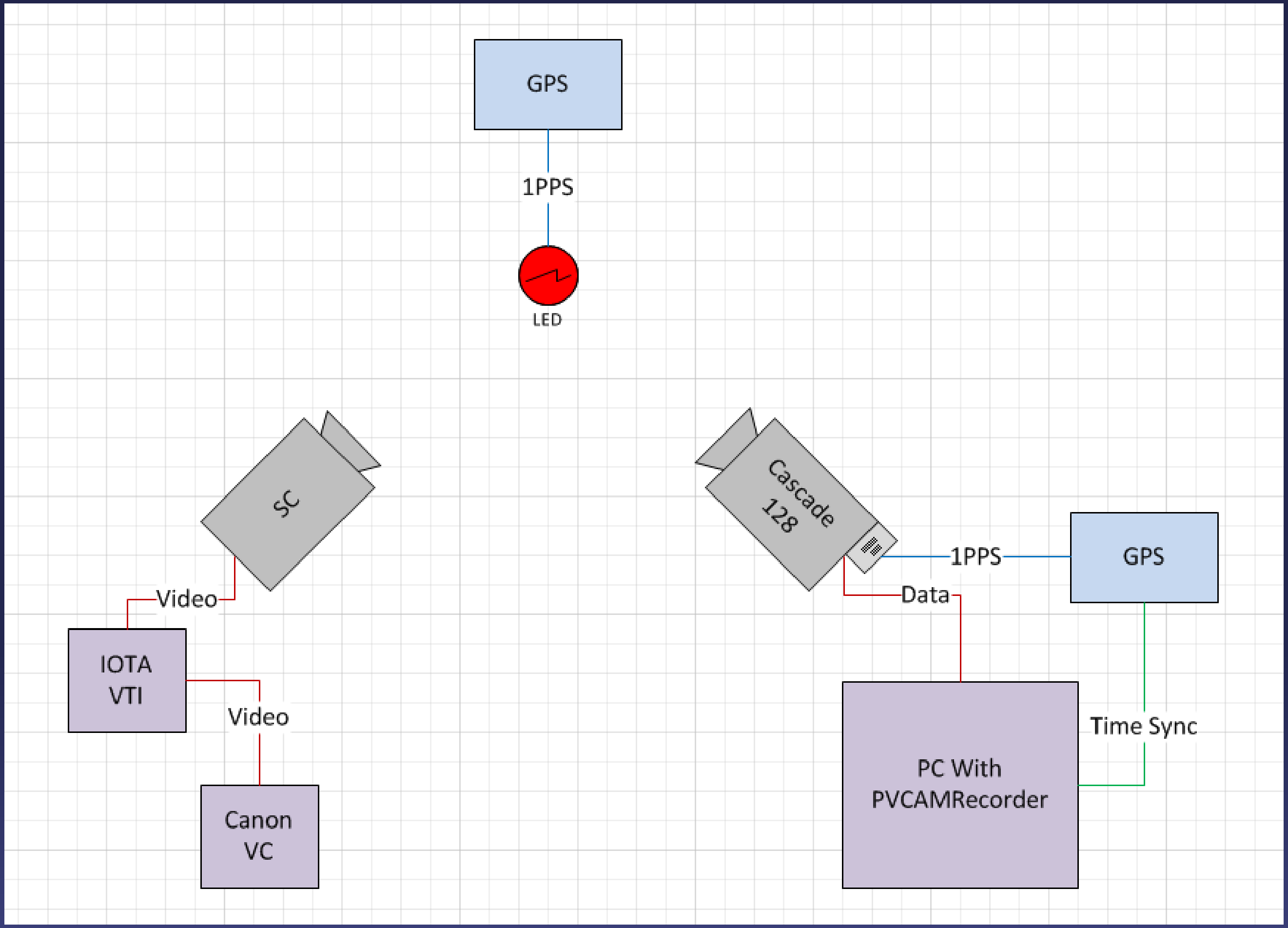


Main camera control



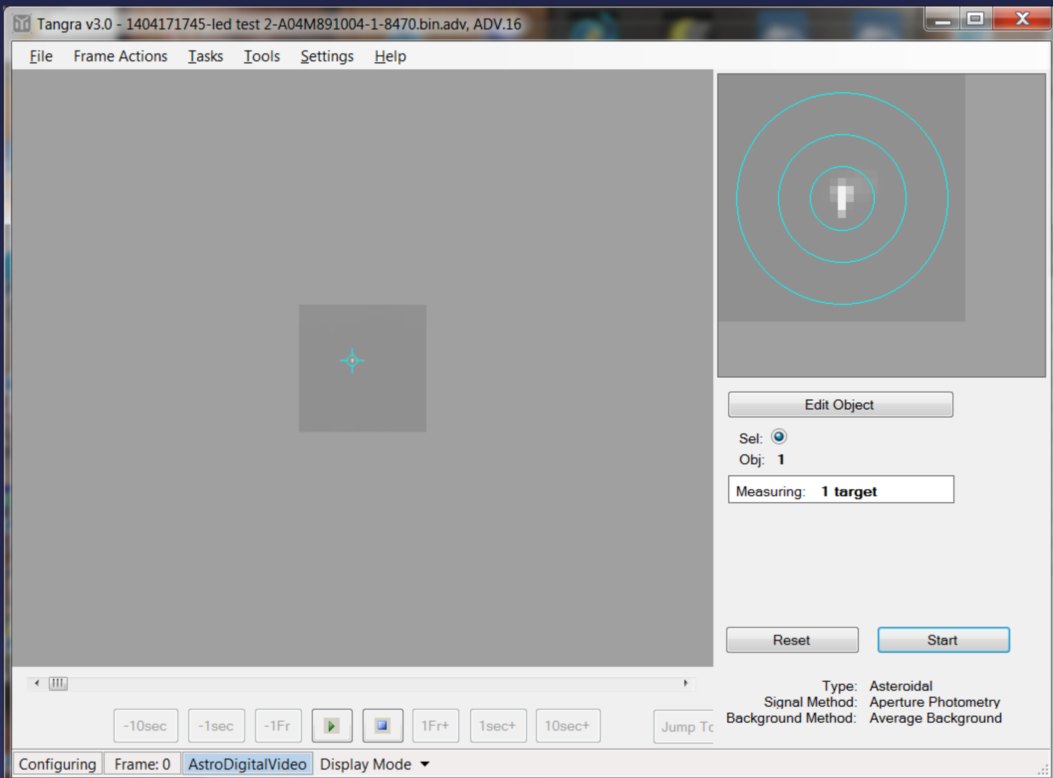
Live View

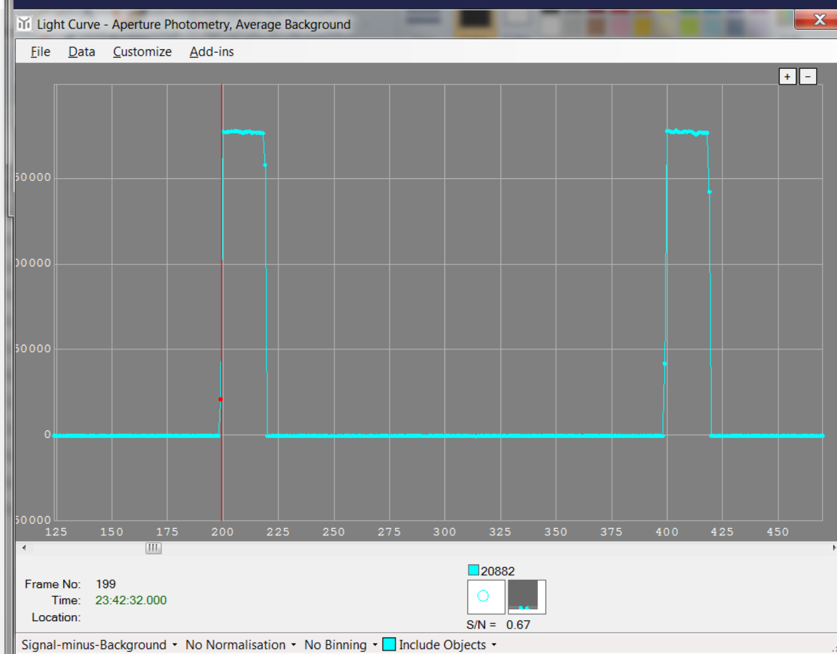
Verification – Lab Comparison



164CEX-2 & emCCD capturing LED blinking with 1pps GPS signal,

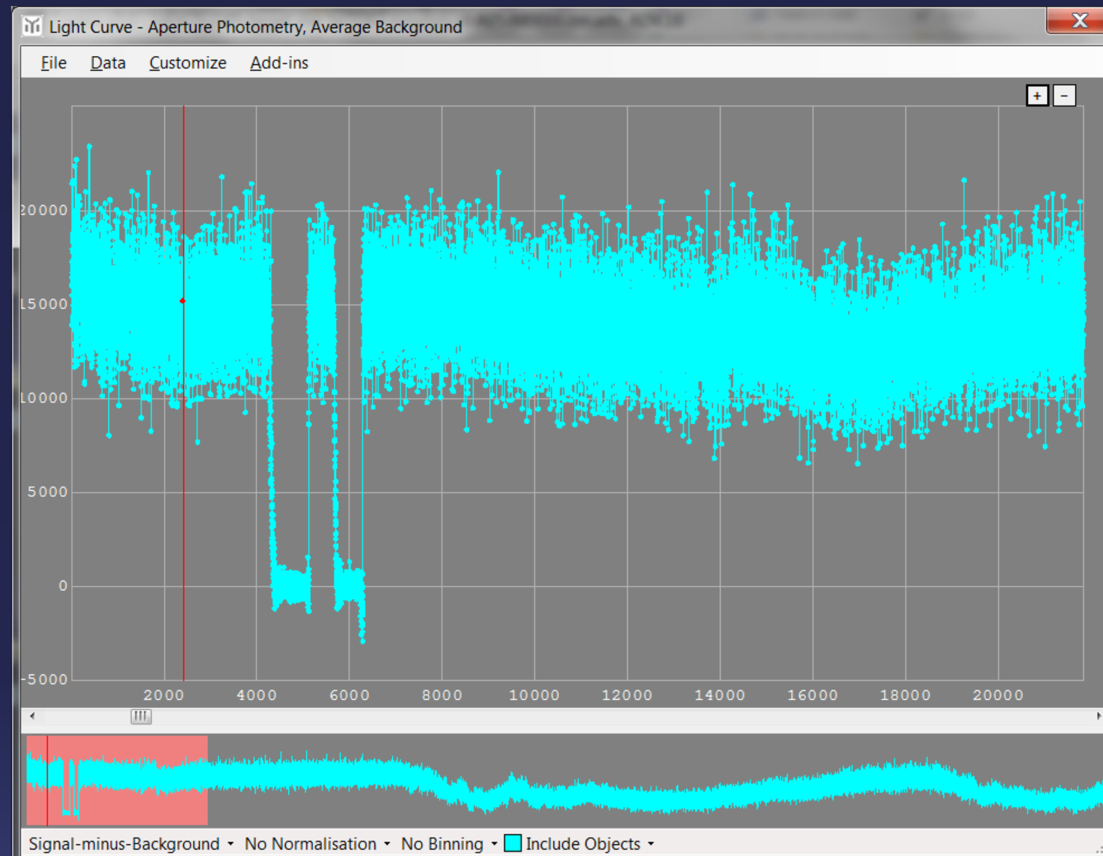
Verification – New Capture Software





Photometrics Cascade 128 emCCD capturing LED blinking with 1pps GPS signal at 200fps, Tangra light curve with timings also captured.

Some Results - Hohenstenia



- Hohenstenia (12.8-mag.) on left & TYC5083-00898-1 (10.7-mag.) on right. Occultation miss 2014-07-0708 512B emCCD 250ms 12" LX200
- Tangra 3 Light curve made from 128x128 RoI video @ 96fps. We covered the aperture twice at start, clouds came in later.

Contact and further information

- Email: d2holenstein@gravic.com, bholenstein@gravic.com

- Gravic Labs Papers (source for some slide pictures):

http://www.gravic.com/graviclabs/rd/astronomy/papers.html

- Alt-Az Telescope Initiative Website: www.AltAzInitiative.org