Progress and Future Plans for emCCD Testing

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16-18 October July 2015

Cheyenne Campus of the College of Southern Nevada

North Las Vegas, Nevada

Agenda

- Testing performed this past year
- New hardware acquired and access to new facilities
- Plans for testing in the coming year

emCCD Cameras

- Described in our 2014 IOTA talk: “**Specialized Software and Equipment for High Speed Cameras**”

Photometrics Cascade 512B emCCD

CCD read noise is reduced from 10’s of electrons per pixel to under 0.1 per pixel. Back illumination increases QE to over 90%.

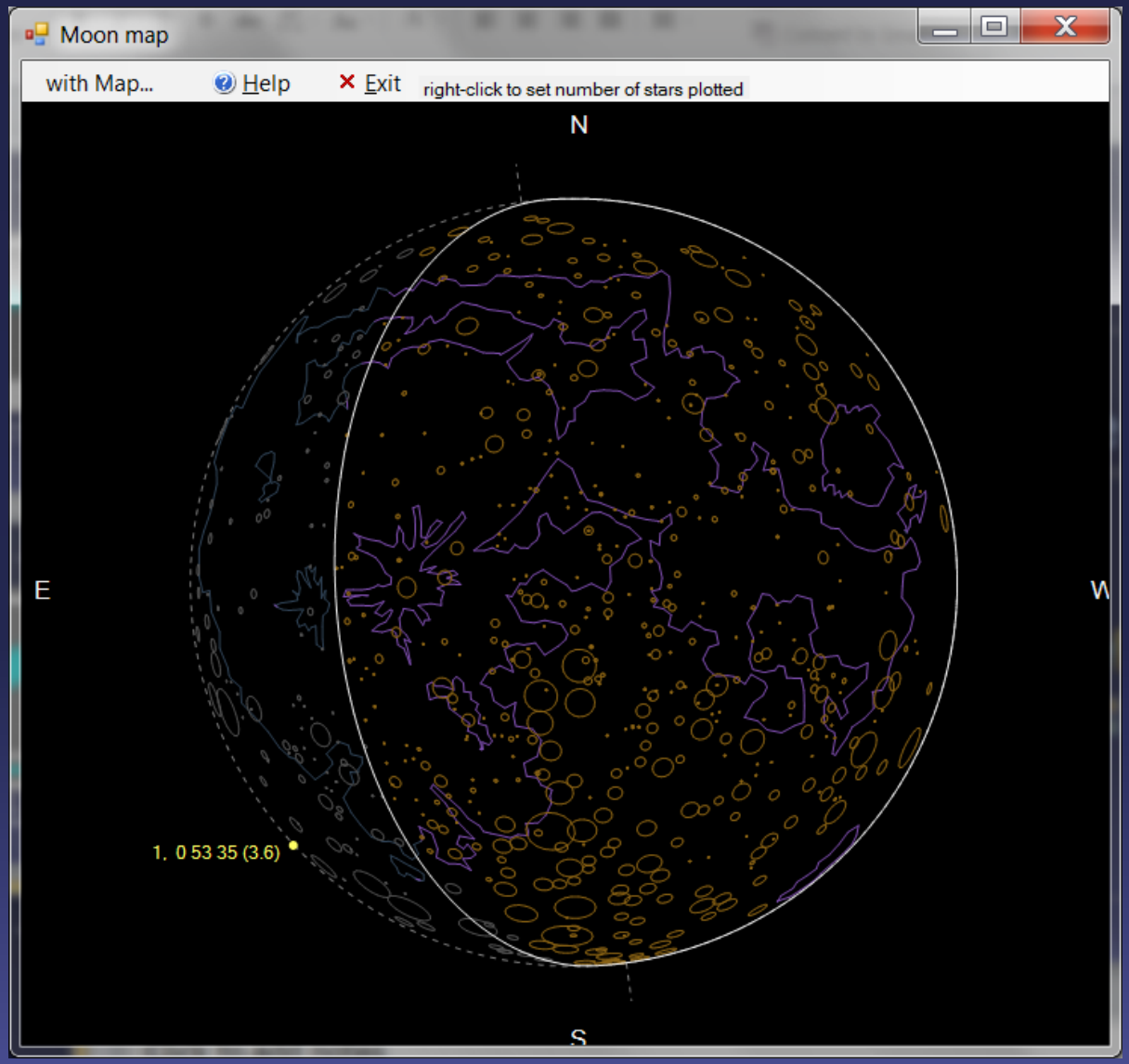
2015 Testing to Date

- Due to work commitments, only a very limited amount of testing was performed
- A few lunar occultations were attempted
  - Lambda Gemini is the only one we'll address today
- No appropriate asteroid events were tried
  - On high probability events, we tend to be risk adverse, and avoid losing a potential positive by using traditional equipment
  - New equipment and access to new facilities should help with this in the coming year

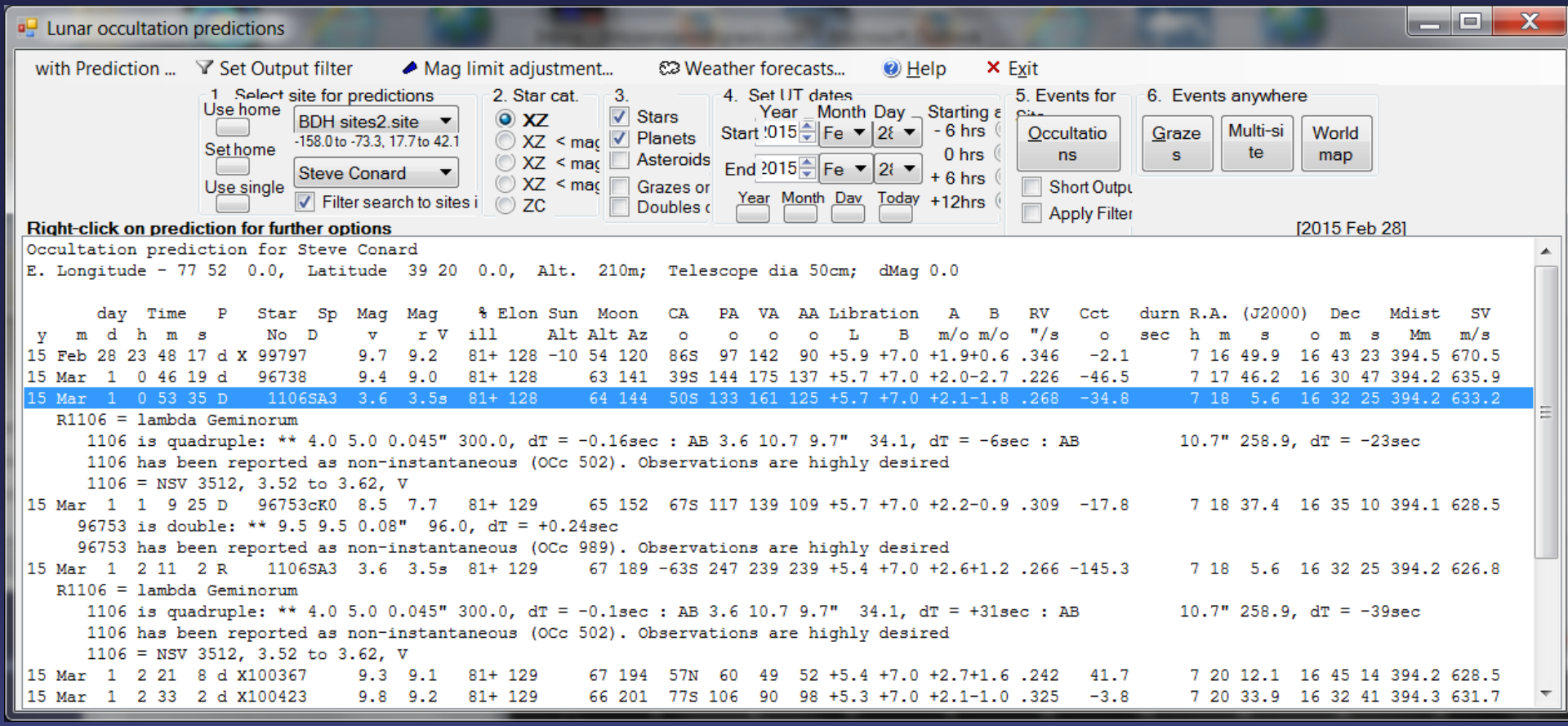
Lambda Gemini

- On Feb 28th, the waxing gibbous moon occulted λ-Gemini over North America
  - This is (quaduple) star, with non-instantaneous transitions reported
- Conard used a Photometrics 512B, on a C-14 operating at its native f:11 to attempt to record this event
  - The camera was windowed at 32 x 32, and binned by 2, in order to achieve a frame rate of 200 Hz
  - Dylan's software (PVCAMTest and Bin2ADV) was used to record & convert the data, and Tangra used for the analysis

Lambda Gem Moon Map at Willow Oak Observatory



Lambda Gem Occultation at Willow Oak Observatory



Lambda Gem – The System

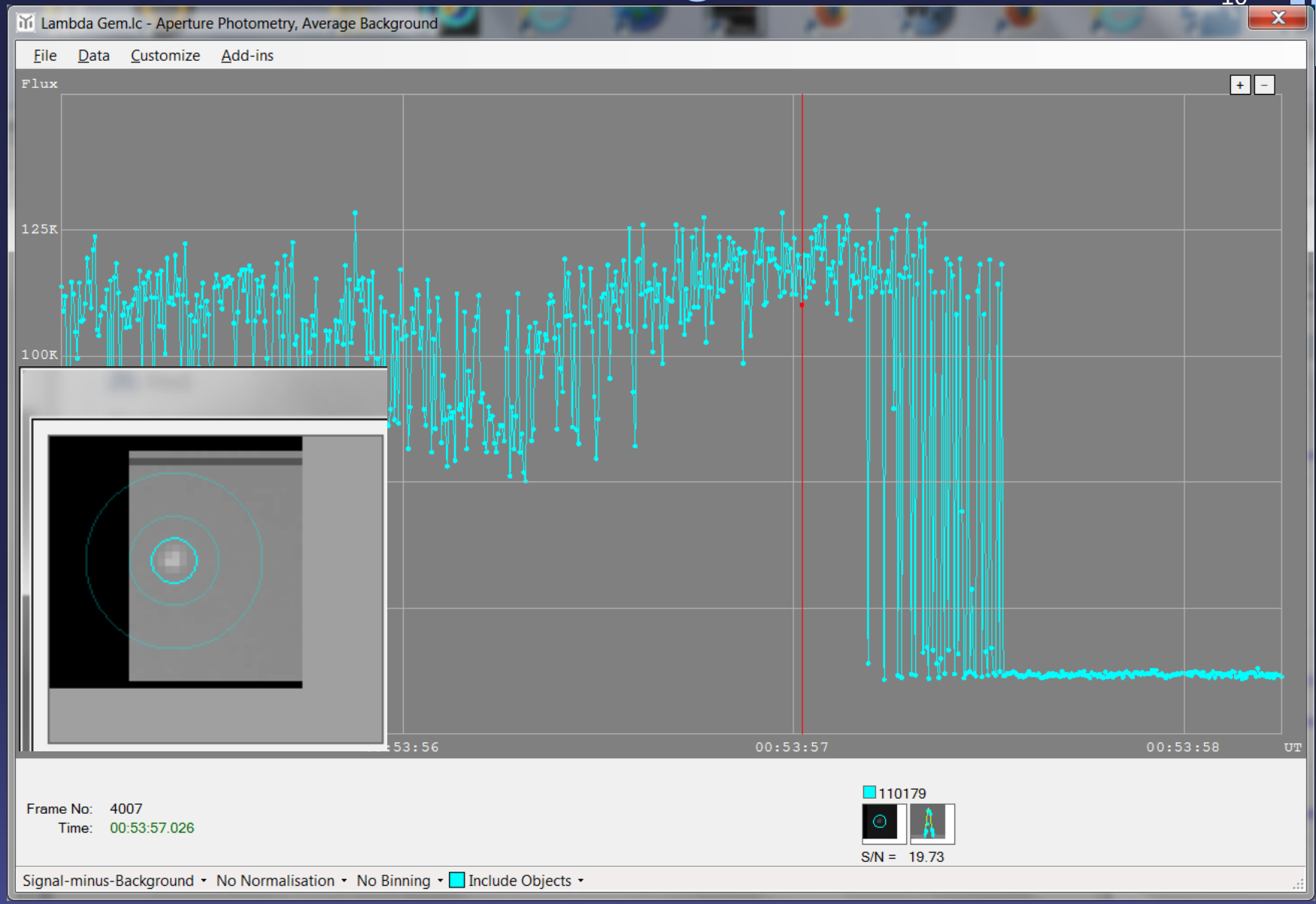
Right ascension	07h 18m 05.6s
Declination	+16° 32′ 25.4″
Apparent magnitude (V)	3.571[2]
Radius	2.7773 ± 0.0469 R⊙
Distance	30.9 ± 0.2 pc

- Quadruple

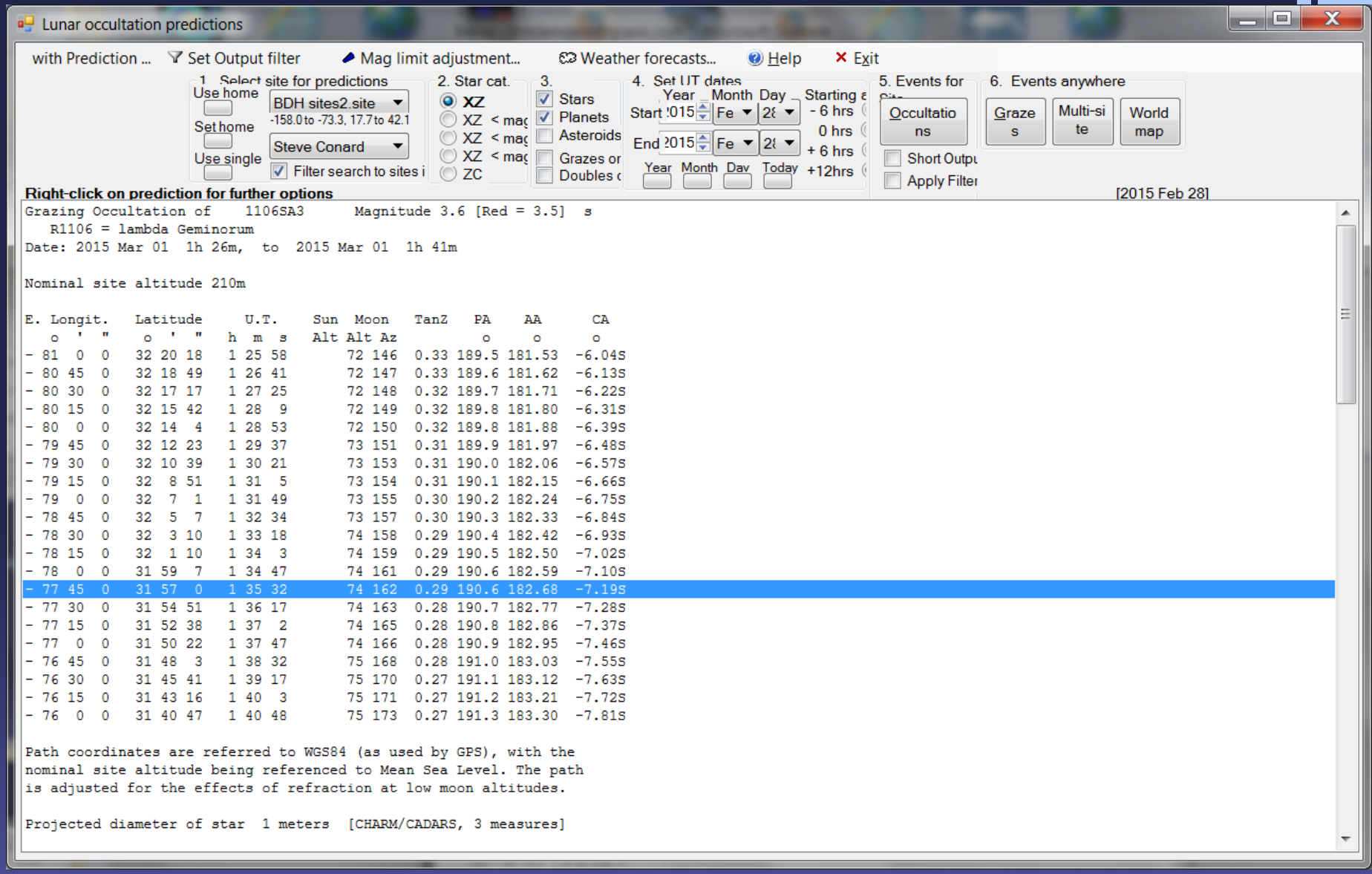
Source: Wikipedia

Lambda Gem Video
Using Media Player Classic

Lambda Gem – Tangra LC



Computed Graze

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Grazing Occultation of    1106SA3      Magnitude 3.6 [Red = 3.5]  s
   R1106 = lambda Geminorum
Date: 2015 Mar 01  1h 26m,  to  2015 Mar 01  1h 41m

Nominal site altitude 210m

E. Longit.    Latitude      U.T.     Sun  Moon   TanZ   PA     AA      CA
   o  '  "     o  '  "    h  m  s   Alt Alt Az          o      o       o
- 81  0  0    32 20 18    1 25 58       72 146  0.33 189.5 181.53  -6.04S
- 80 45  0    32 18 49    1 26 41       72 147  0.33 189.6 181.62  -6.13S
- 80 30  0    32 17 17    1 27 25       72 148  0.32 189.7 181.71  -6.22S
- 80 15  0    32 15 42    1 28  9       72 149  0.32 189.8 181.80  -6.31S
- 80  0  0    32 14  4    1 28 53       72 150  0.32 189.8 181.88  -6.39S
- 79 45  0    32 12 23    1 29 37       73 151  0.31 189.9 181.97  -6.48S
- 79 30  0    32 10 39    1 30 21       73 153  0.31 190.0 182.06  -6.57S
- 79 15  0    32  8 51    1 31  5       73 154  0.31 190.1 182.15  -6.66S
- 79  0  0    32  7  1    1 31 49       73 155  0.30 190.2 182.24  -6.75S
- 78 45  0    32  5  7    1 32 34       73 157  0.30 190.3 182.33  -6.84S
- 78 30  0    32  3 10    1 33 18       74 158  0.29 190.4 182.42  -6.93S
- 78 15  0    32  1 10    1 34  3       74 159  0.29 190.5 182.50  -7.02S
- 78  0  0    31 59  7    1 34 47       74 161  0.29 190.6 182.59  -7.10S
- 77 45  0    31 57  0    1 35 32       74 162  0.29 190.6 182.68  -7.19S
- 77 30  0    31 54 51    1 36 17       74 163  0.28 190.7 182.77  -7.28S
- 77 15  0    31 52 38    1 37  2       74 165  0.28 190.8 182.86  -7.37S
- 77  0  0    31 50 22    1 37 47       74 166  0.28 190.9 182.95  -7.46S
- 76 45  0    31 48  3    1 38 32       75 168  0.28 191.0 183.03  -7.55S
- 76 30  0    31 45 41    1 39 17       75 170  0.27 191.1 183.12  -7.63S
- 76 15  0    31 43 16    1 40  3       75 171  0.27 191.2 183.21  -7.72S
- 76  0  0    31 40 47    1 40 48       75 173  0.27 191.3 183.30  -7.81S

Path coordinates are referred to WGS84 (as used by GPS), with the
nominal site altitude being referenced to Mean Sea Level. The path
is adjusted for the effects of refraction at low moon altitudes.

Projected diameter of star  1 meters  [CHARM/CADARS, 3 measures]
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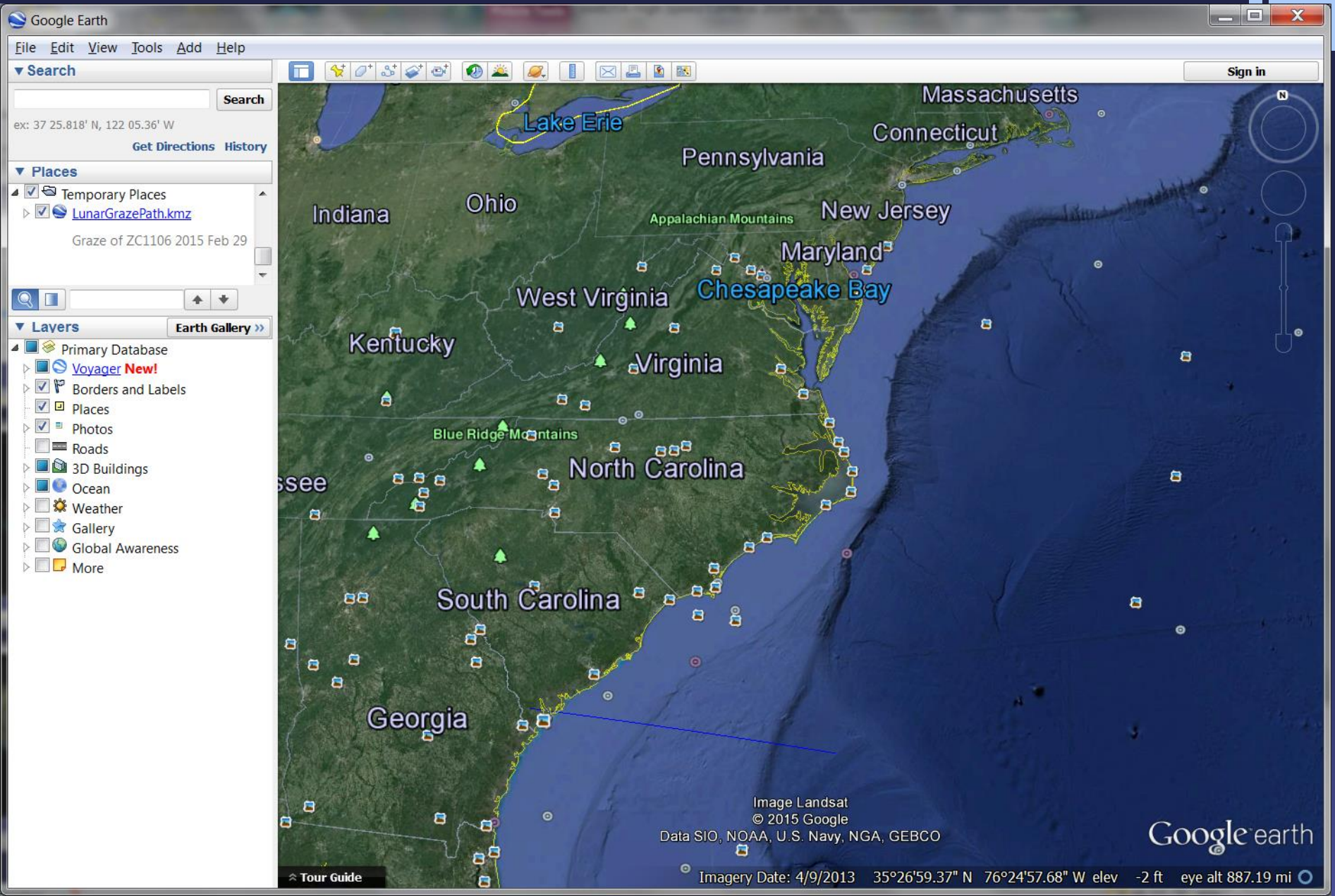
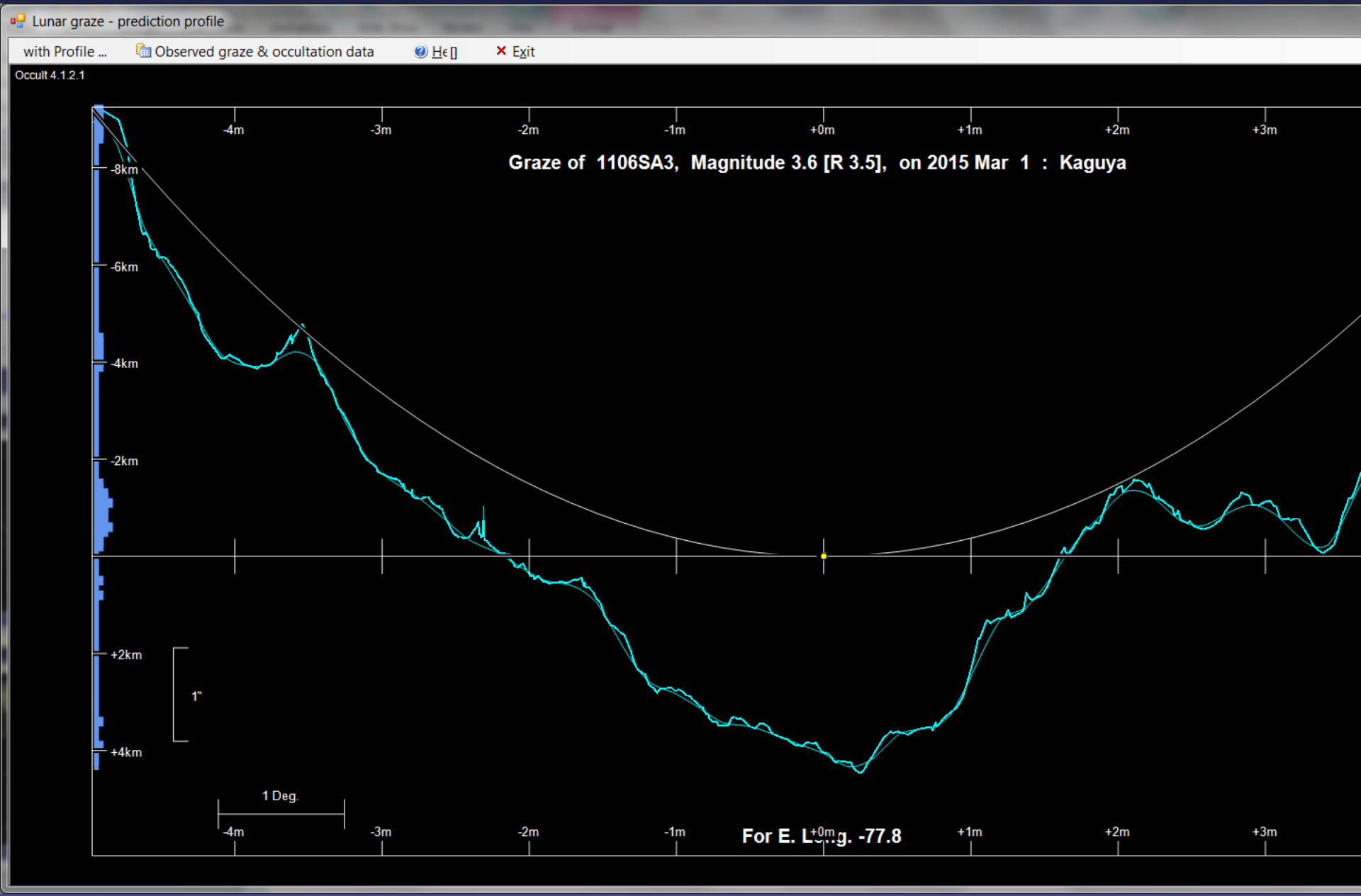
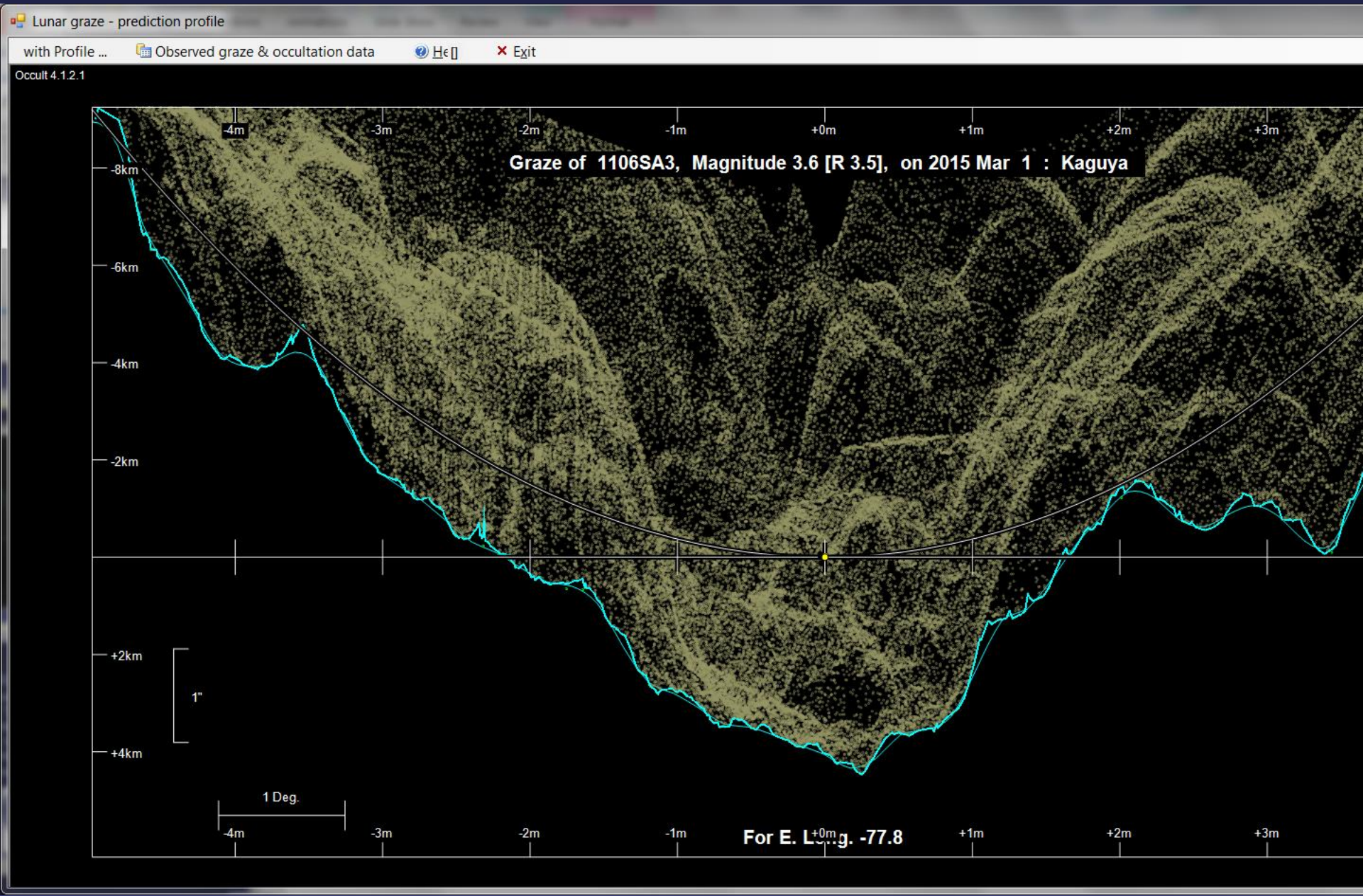
Computed Graze was in Georgia




Lunar graze - prediction profile
with Profile ...
Observed graze & occultation data
Help
Exit
Occult 4.1.2.1
Graze of 1106SA3, Magnitude 3.6 [R 3.5], on 2015 Mar 1 : Kaguya
-4m
-3m
-2m
-1m
+0m
+1m
+2m
+3m
-8km
-6km
-4km
-2km
+2km
+4km
1"
1 Deg.
For E. Long. -77.8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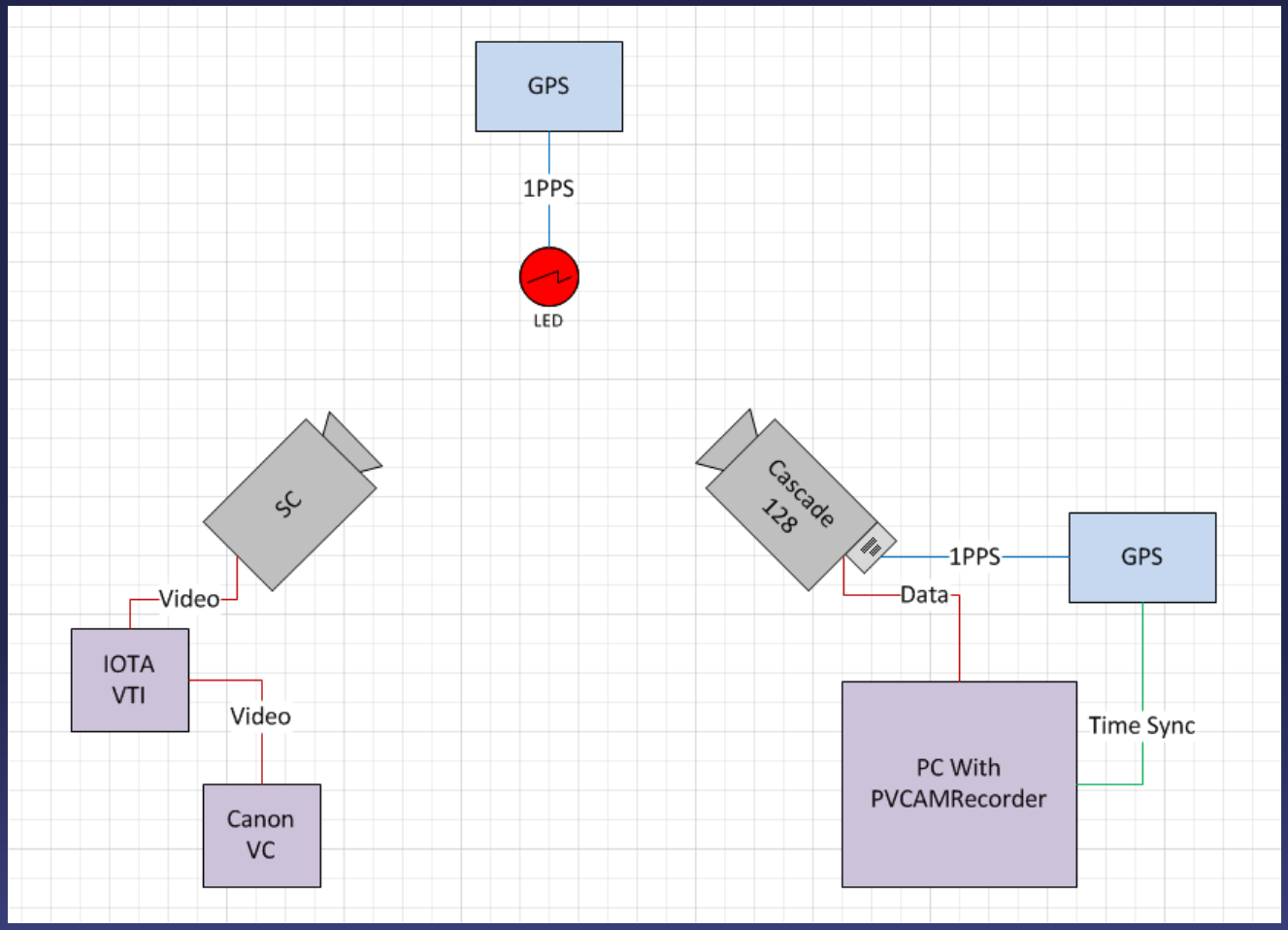
Occult 4.1.2.1
Graze of 1106SA3, Magnitude 3.6 [R 3.5], on 2015 Mar 1 : Kaguya
-4m
-3m
-2m
-1m
+0m
+1m
+2m
+3m
-8km
-6km
-4km
-2km
+2km
+4km
1"
1 Deg.
For E. Long. -77.8

Description

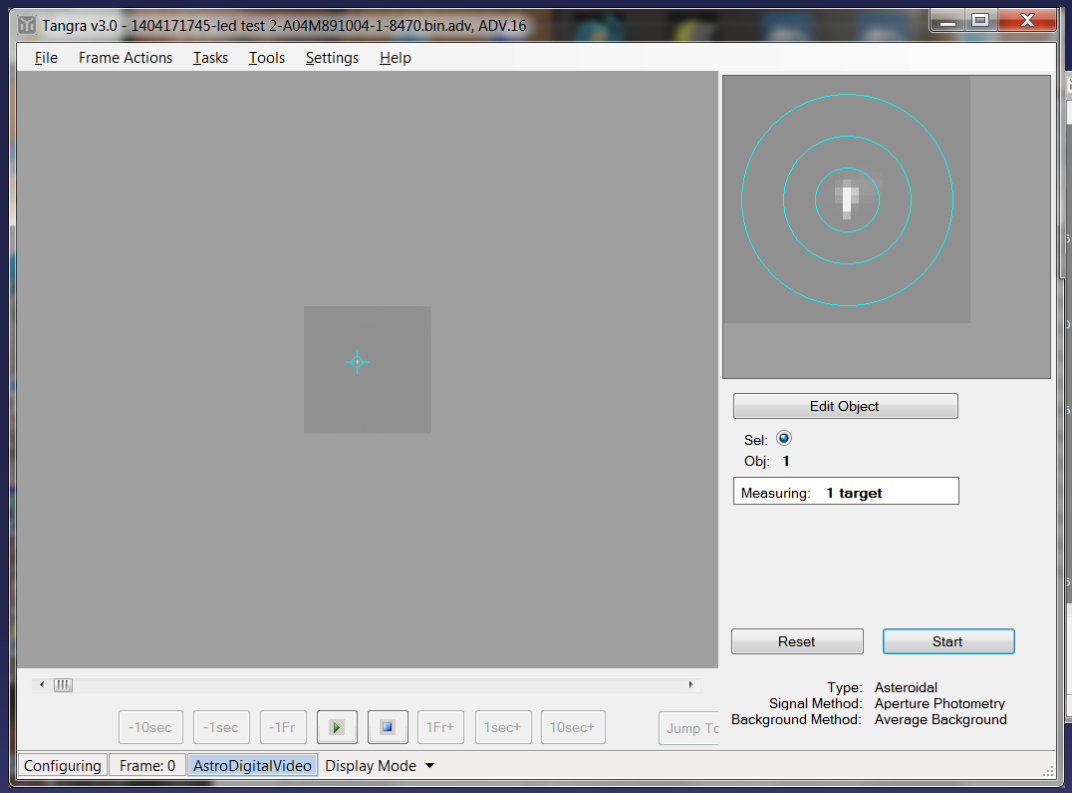
- The light curve shows ~13 transitions prior to the star completely disappearing, over a total time of about 0.3 seconds
  - Equates to about 200 meters on the moon
  - Most of these are between completely on to completely off, only about 3 partial signal levels
- It is exceedingly unlikely that the occultation geometry could support such an event, and the 200 Hz sampling would have to produce many more partial levels than we are seeing
  - The actual exposure time would have to be a small fraction of the 5 msec cadence to support this result, we believe the duty cycle is about 80%
- ***Our provisional conclusion is that this must be an instrumentally produced result***

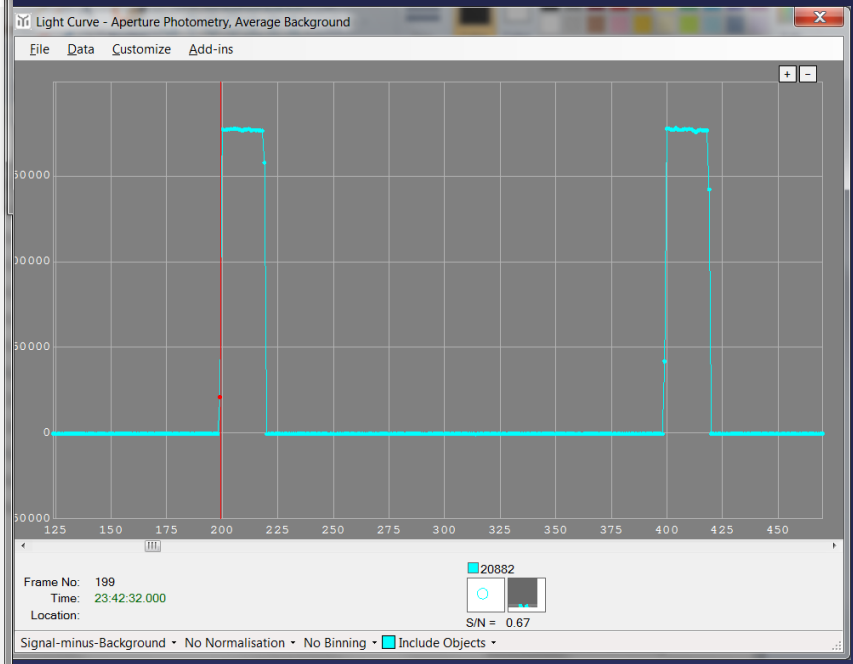
Diagnostic Testing (2014-2015)



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

Verification – New Capture Software

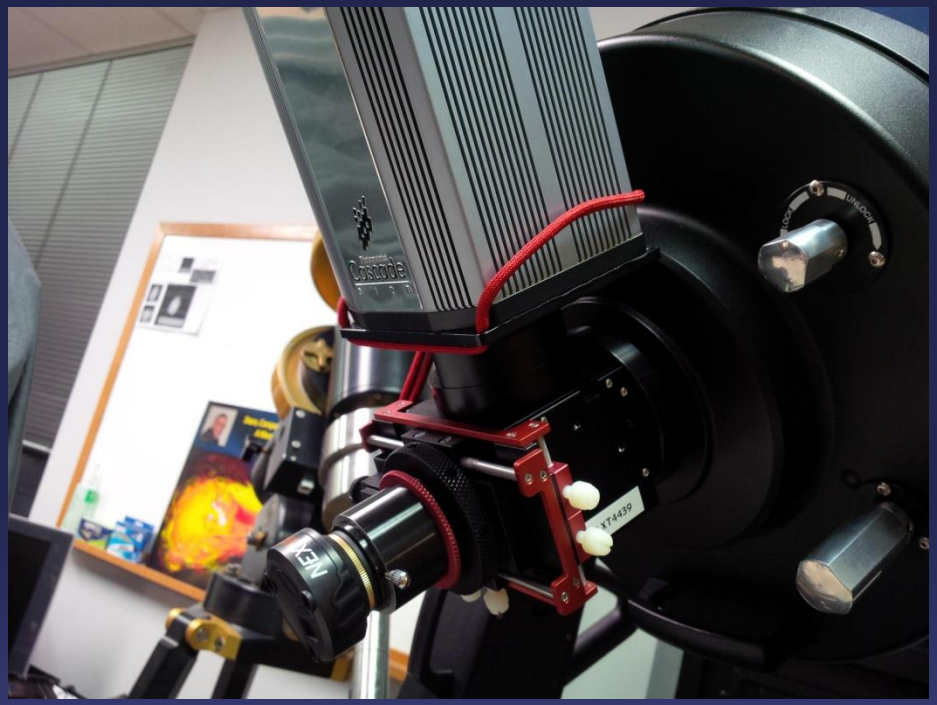




Photometrics Cascade 128 emCCD capturing LED blinking with 1pps GPS signal at 200fps, Tangra light curve with timings also captured.

New Equipment

- Two Innovation Foresight ONAG-XT's have been acquired, with adjustable focal reducers
  - These are designed for "On Axis Guiding", and contain a dichroic beam splitter
    - Passes >780 nm (induces slight astigmatism in this leg)
    - Reflects 350 to 750 nm
  - We have one here for you to look at, and we hope to use it on tonight's asteroid event



New Equipment - ONAGs

- We intend to use these in two ways
  - To begin to look for wavelength dependence in the fast-frame rate data collected
  - To allow us to directly compare timing data collected with traditional RS-170 sensors to the emCCDs, without adding significant risk of data loss for high probability events

New Equipment-AS212 Camera

- We have also acquired a ZW Optical ASI224MC camera for testing
  - This is in response to Russ Genet's request that we test one for Lunar Occultation work
  - These are very low noise color CMOS sensors, 1/3" format, USB 3.0 (0.75 to 1.5 e read noise)
  - Rolling shutter
  - Small and lightweight
  - Interestingly, they have very good sensitivity in the NIR, well matched to the ONAG transmitted path

Access to Existing Hardware/Facilities

- Conard is observatory director for the new Roelke Observatory near Westminster, MD
  - This has a 14” SCT on a heavier mount than Conard’s own Willow Oak Observatory, and should allow heavier payloads
- Conard likely will soon have access to a 0.6 m R-C at his place of employment
- We are trying to obtain access to a 0.8 m R-C at a Baltimore area university as well
- All these potential assets should allow us to test these heavy cameras on relatively larger apertures
  - Continue to look to try faint TNO events

Plans for the Next Year

- Begin regularly performing dual camera measurements on both lunar and asteroid events
  - Some of these will include the ZWO camera
- Use high speed cameras to look for diffraction phenomena
- Use the emCCDs on larger university-based for very faint events
  - Actual TNO events or very faint asteroid events

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