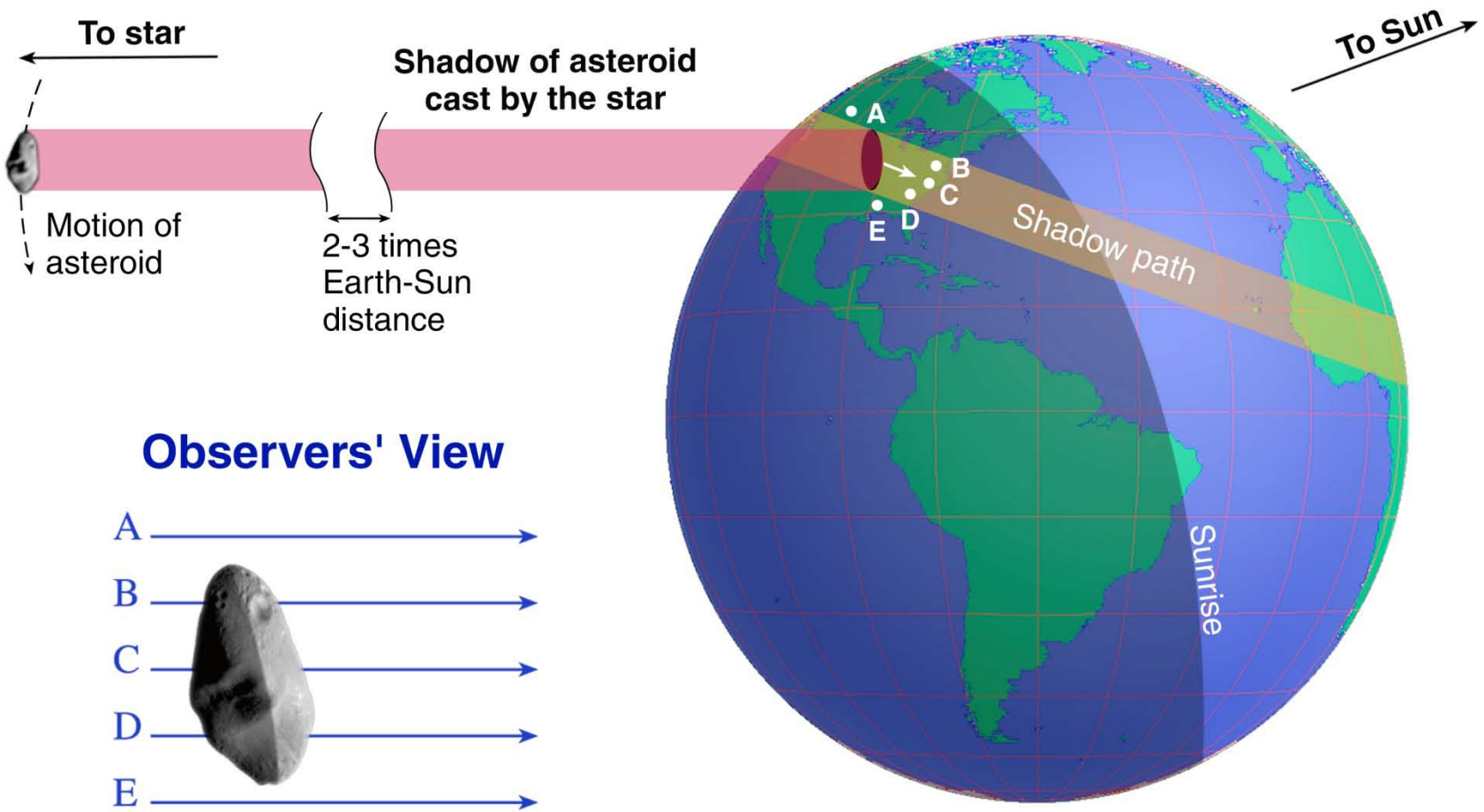
Observing Asteroidal Occultations from Multiple Stations

2012 August 26

ESOP-31, Pescara, Italy

David W. Dunham, IOTA

Geometry of an Asteroid Occultation



Observers' View

A, E: Negative observations
B, C, D: Positive observations

01-0417-5

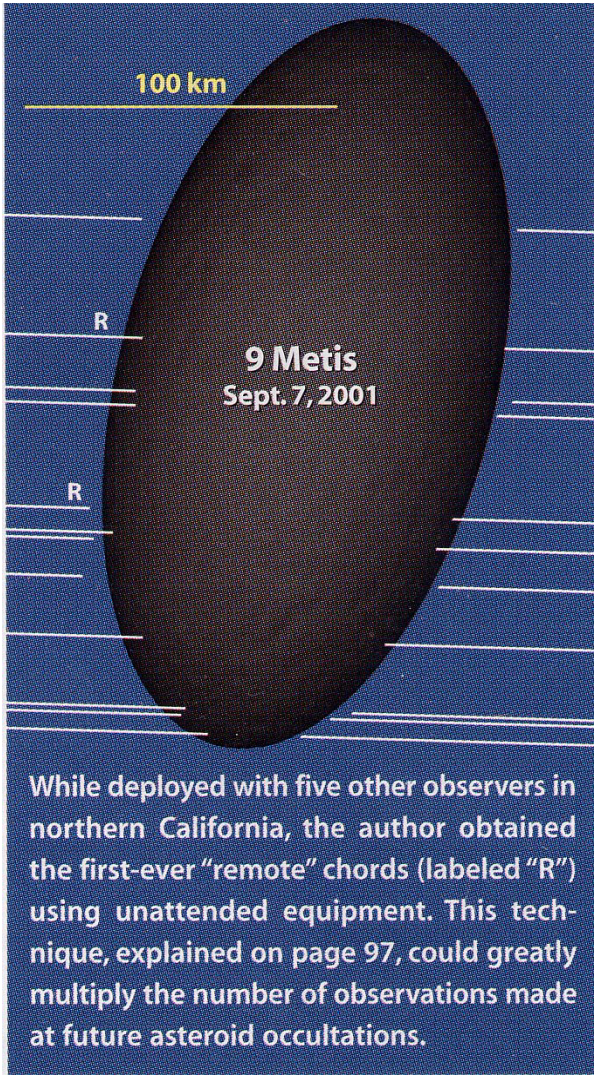
Remote Stations for Asteroidal Occultations

- Separation should be many km, much larger than for grazes, so tracking times & errors are too large
- Unguided is possible since the prediction times are accurate enough, to less that 1 min. = ¼°
- Point telescope beforehand to same altitude and azimuth that the target star will have at event time and keep it fixed in that direction
- Plot line of target star's declination on a detailed star atlas; I used the Millennium Atlas, but now use Guide 8 to produce the charts
- From the RA difference and event time for the area of observation, calculate times along the declination line
- Adjust the above for sidereal rate that is faster than solar rate, add 10 seconds for each hour before the event
- Can usually find "guide stars" that are easier to find than the target
- Find a safe but accessible place for both the attended & remote scopes
- Separation distance limited by travel time & tape to start tapes, but we have had some success with programmable remote control devices to turn on the recordings; then the only limit is battery life, which can be several hours
- Roger Venable uses VCR's with timed starts, allows larger separation
- Sometimes it is better to have remote sites attended for starting equipment later (allows larger separations) and security

Occultation of the 6.0-mag. Close Double Star SAO 78349 by (9) Metis on 2001 September 7

- The star was known to be a close double, sep. about 0.08” with 6.5 and 6.9-mag. Components, from a photoelectric lunar occultation recording at McDonald Obs., Texas, on 1973 April 9
- Best asteroidal occultation of 2001 in the U.S.A.
- Unfortunately, 1 night before the occultation of a 7th-mag. Star by Uranus’ satellite Titania in Europe & n. S. America
- I made the first REMOTE recording of an asteroidal occultation during this event, in the Sacramento Valley of northern California
- Kent Okasaki tried a remote observation of this event, but he tried to track with a 20cm SCT, and the tracking wasn’t accurate enough

Sky-plane plot of Metis occ'n from March 2002 S&T



While deployed with five other observers in northern California, the author obtained the first-ever "remote" chords (labeled "R") using unattended equipment. This technique, explained on page 97, could greatly multiply the number of observations made at future asteroid occultations.

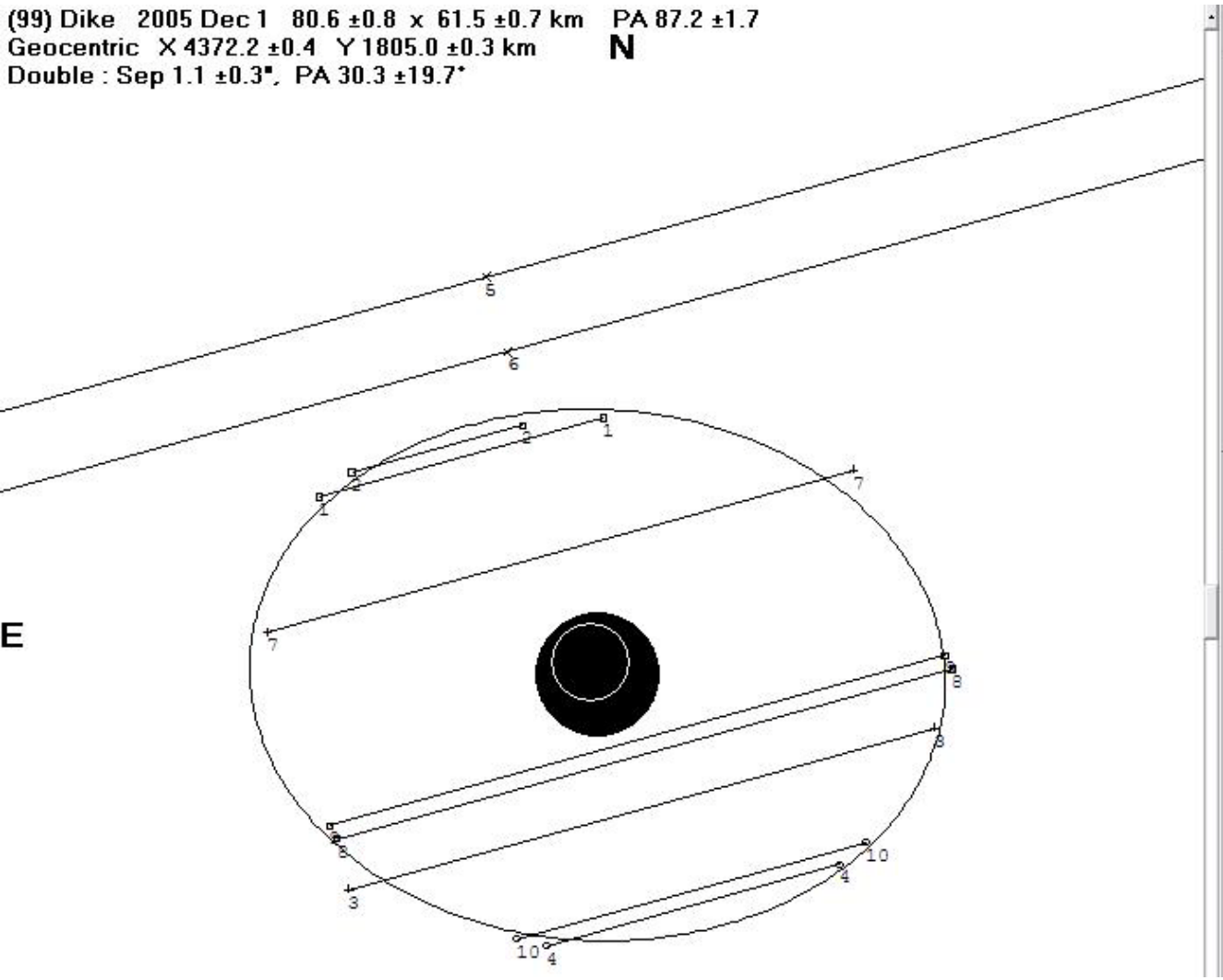
Remote equipment at Orland, CA

Another view

This used my image intensifier and a 50mm Nikon lens, but similar results (with a narrower, about 3 , field of view) are possible with the PC164C.

Successful Remote + Attended Positive Observations from 2 or more stations, 2001 to 2008

- 2001 Sept. 7, 9 Metis, northern California, D. Dunham
- 2002 April 21, Oriola, Washington, S. Preston
- 2003 Jan. 17, Bathilde, Georgia, R. Venable
- 2004 July 1, Nanon, s. Calif., D. Dunham, but D. Stockbauer was at “remote” site, turned on recorder without changing pointing
- 2004 Oct. 6, Ute, North Carolina, D. Dunham
- 2004 Oct. 29, Flora, New Mexico, D. Dunham
- 2005 Mar. 12, Bathseba, Georgia, R. Venable
- 2005 May 13, Dufour, New South Wales (AU), D. Gault (home “remote” & mobile)
- 2005 Dec. 1, Laurentia, Georgia, R. Venable **(first time, two successful multiple deployments in one night)**
- 2005 Dec. 1, Dike, Maryland & Virginia, D. Dunham **(3 positives, star close double)**
- 2005 Dec. 3, Europa, California, D. Dunham
- 2006 Jan. 28, Veritas, North Carolina, D. Dunham
- 2006 Feb. 24, Turandot, Indiana, D. Dunham
- 2006 Feb. 26, Abnoba, Florida, R. Venable
- 2006 June 12, Pallas, Georgia, R. Venable **(4 positives! Widest separation)**
- 2007 Jan. 10, Nysa, Georgia, R. Venable
- 2007 Feb. 21, Thisbe, Florida, D. Dunham
- 2007 Feb. 28, Nemausa, California, D. Dunham
- 2007 Apr. 13, Fortuna, Virginia and N. Carolina, D. Dunham (2 +, 1 miss, my widest separation)
- 2007 Apr. 22, Dike, Florida, R. Venable
- 2007 May 24, Papagena, Maryland and Pennsylvania, D. Dunham (3 positives)
- 2007 Sept. 11, Senta, New South Wales (AU), D. Gault **(first outside USA)**
- 2007 Nov. 20, Amalia, Georgia, R. Venable
- 2007 Dec. 18, Thusnelda, Florida, D. Dunham
- 2008 Jan. 14, Sicilia, Alabama, R. Venable (star close double)
- 2008 Feb. 10, Dynamene, North Carolina, R. Venable
- Many other cases where 2 stations were run and 1 had an occ’n & the other a miss, especially by Roger Venable; example was my observation of Rhodope occulting Regulus on 2005 October 19



Center X	-1.4	0.0
Center Y	-7.0	0.0
Major Axis (km)	80.6	0.0
Minor Axis (km)	61.5	0.0
Orientation	87.2	0.0
Sepn (masec)	1.1	0.0
PA of 2nd star	30.3	-0.1

Include Miss events

Circular Quality Good

Plot Scale

rms Fit: 0.2 ±1.4km

- (•) Plot both stars
- ( ) Primary star only
- ( ) Secondary star only

1	David & Joan Dunham, Greenbelt, MD
2	David & Joan Dunham, Greenbelt, MD
3	Joe Sedlack, La Plata, MD
4	David Dunham (mobile), Dahlgren, VA
5(M)	Wayne Warren,Goddard Optical Site,MD
6(M)	Gary Fishkorn, Dayton, MD
7	John Wetmore, Bethesda, MD
8	David Dunham (remote), La Plata, MD
9	David Dunham (remote), La Plata, MD
10	David Dunham (mobile), Dahlgren, VA


Multi-Station Occultation
Observing with Galileo Sized
Optical Systems
Scott Degenhardt, IOTA
Galileo's Legacy 2009
Waianae, Hawaii

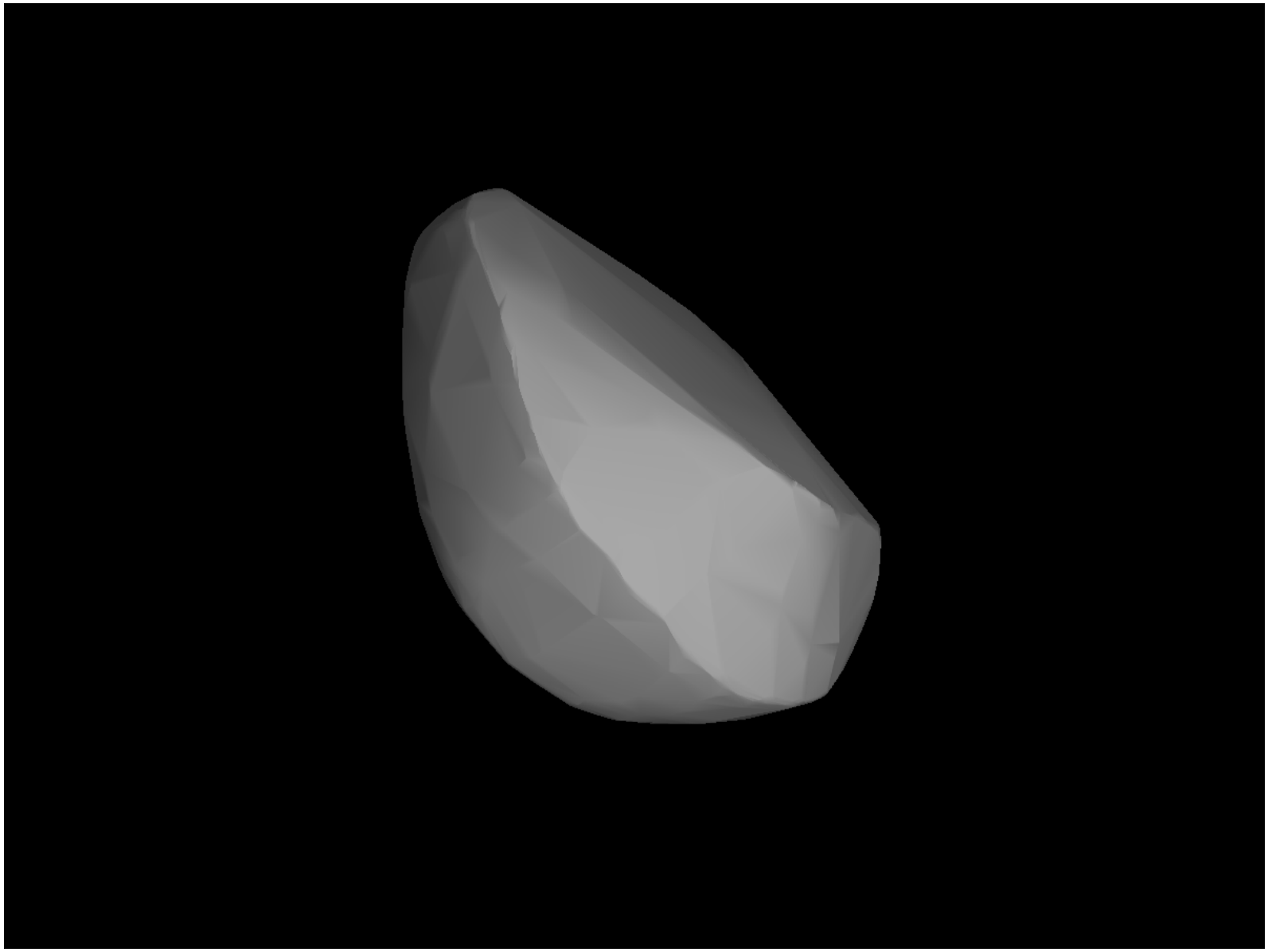
The Mighty Mini
Introduced to IOTA Aug 21st, 2008

50mm objective, f/2 effective f/ratio (with Owl focal reducer)

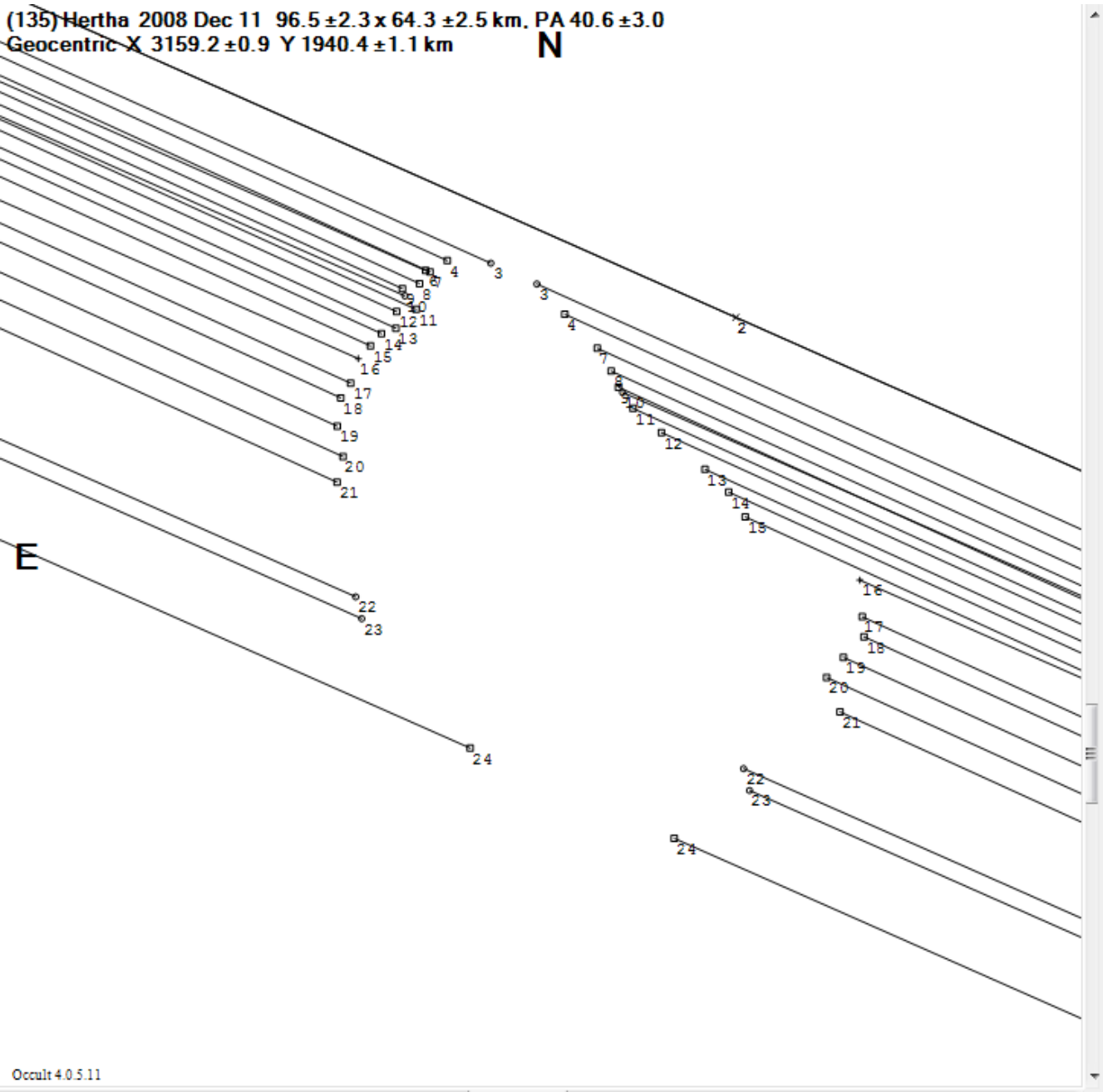
Complete portable occultation timing setup (air carryon)

Taken before boarding my plane for (343) Ostara, 7 complete stations as a carryon!

Hertha model from light curve data



Still the record, Scotty observed from 14 stations in Oklahoma



Find best fit

Center X	-22.4	☑ -6.7	
Center Y	-81.6	☑ 3.4	
Major axis (km)	96.5	☑ 4.3	a/b=1.50
Minor axis (km)	64.3	☑ -6.7	dM=-0.44
Orientation	40.6	☑ 5.0	

Double star

Sepn (masec)	0.0	☐ 0.0
PA of 2nd	0.0	☐ 0.0

(•) Both ( ) Primary ( ) Secondary

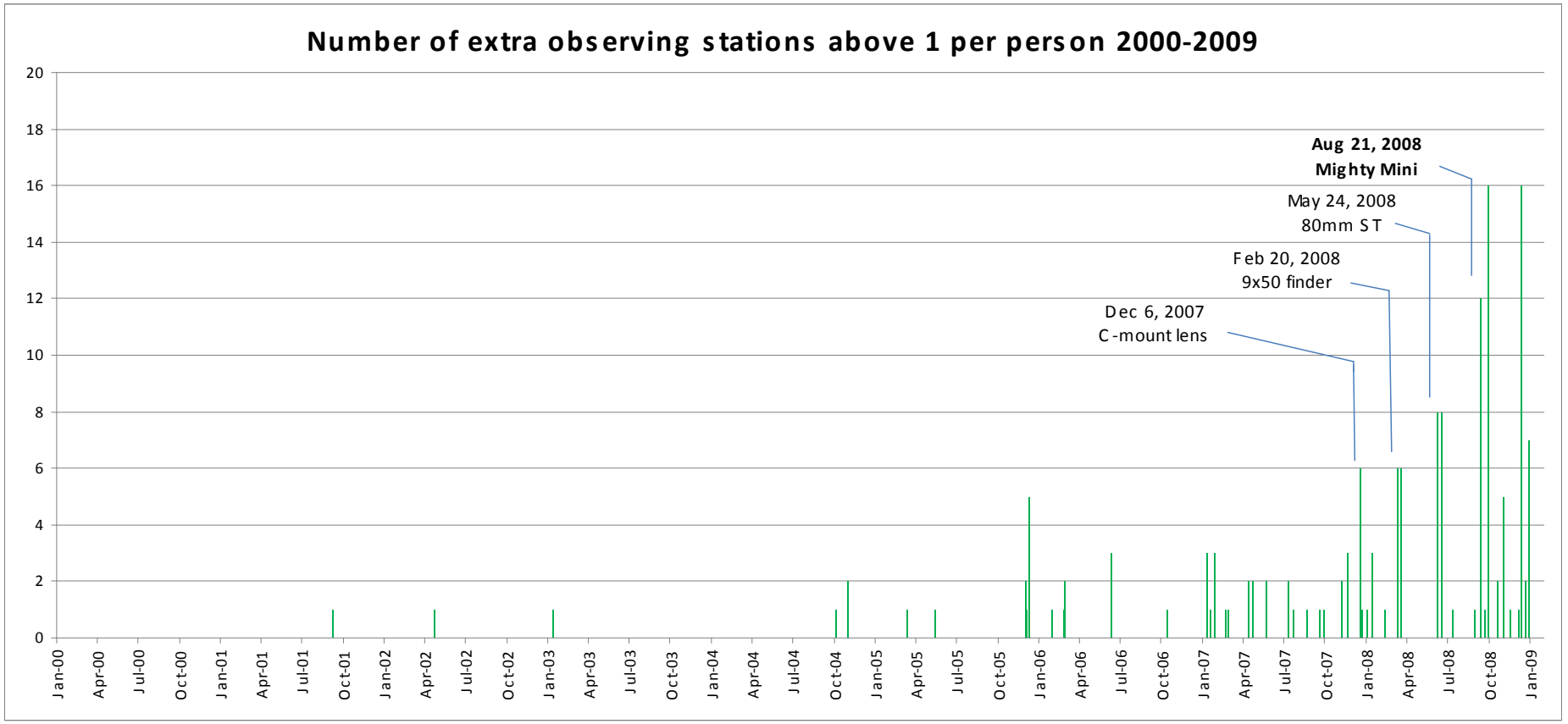
☐ Circular ☐ Include Miss events

Plot scale

Quality: Not fitted

RMS fit 1.8 ±7.5 km

1	(M)	R Stanton,Three Rivers, CA
2	(M)	P Maley,Baker CA
3		G Mroz,Santa Fe, NM
4		S Degenhardt01,Okarche, OK
6		D Dunham,Harvard, CA
7		S Degenhardt02,Okarche, OK
8		S Degenhardt03,Okarche, OK
9		S Degenhardt04,Okarche, OK
10		R Wasson,Barstow, CA
11		S Degenhardt05,El Reno, OK
12		S Degenhardt06,El Reno, OK
13		S Degenhardt07,El Reno, OK
14		S Degenhardt08,El Reno, OK
15		S Degenhardt09,El Reno, OK
16		A Holmes, Goleta, CA
17		S Degenhardt10,El Reno, OK
18		S Degenhardt11,El Reno, OK
19		S Degenhardt12,Union City, OK
20		S Degenhardt15,Union City, OK
21		S Degenhardt14,Minco, OK
22		B Owen/J Young,Wrightwood, CA
23		K Young,Wrightwood, CA
24		G Lyzenga,Altadena, CA


Number of extra observing stations above 1 per person 2000-2009
Aug 21, 2008
Mighty Mini
May 24, 2008
80mm ST
Feb 20, 2008
9x50 finder
Dec 6, 2007
C-mount lens
0
2
4
6
8
10
12
14
16
18
20
Jan-00
Apr-00
Jul-00
Oct-00
Jan-01
Apr-01
Jul-01
Oct-01
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
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Apr-08
Jul-08
Oct-08
Jan-09

Mighty Mini

Can record occultations of stars to mag. 9.5, even mag. 10.0 under good conditions

Mighty Midi – Orion 80mm short tube

Can record occultations of stars to mag. 11.0, even mag. 11.3 under good conditions

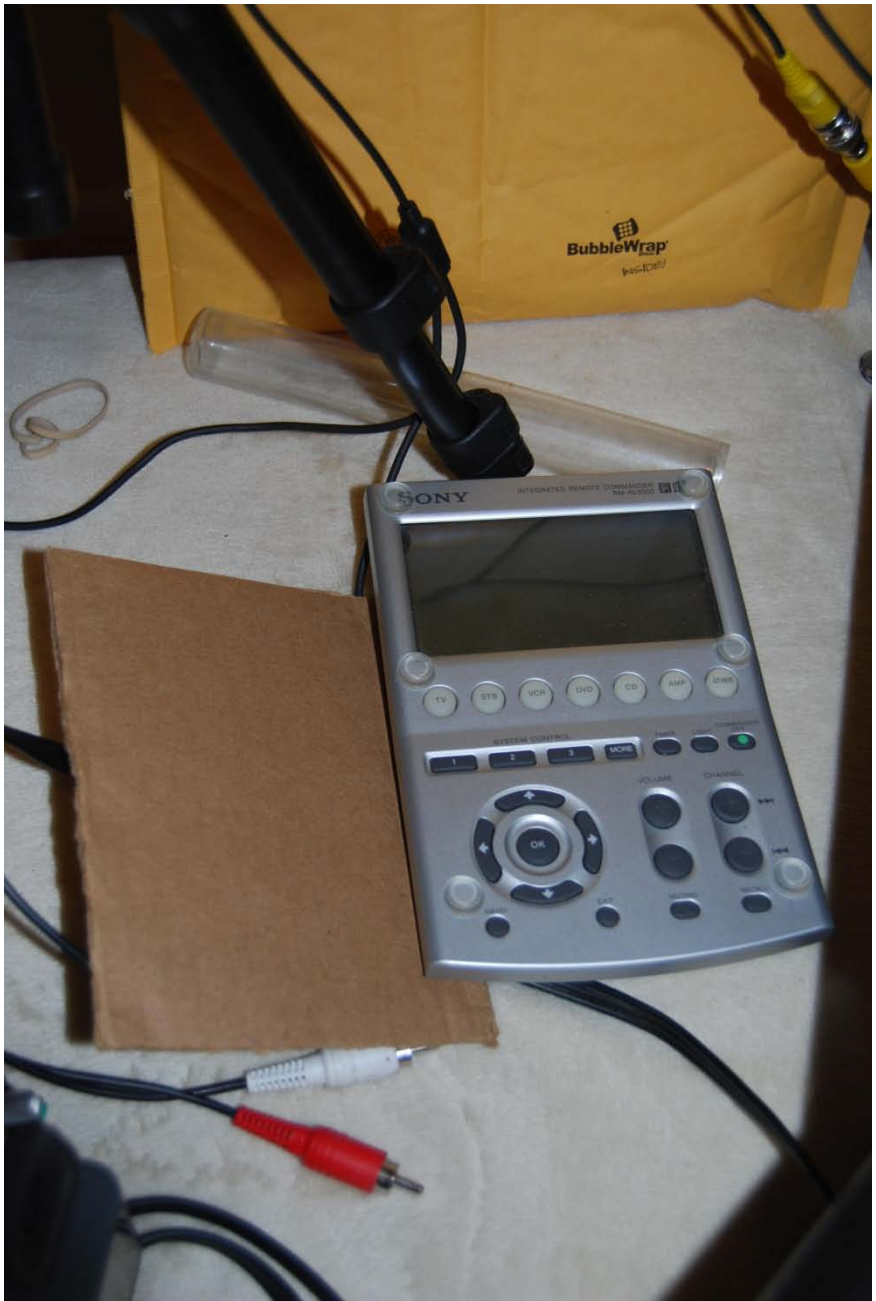
I use visual finder scope and $60 Quantanray tripod while Scotty uses a mighty mini video as the finder and MX-350 tripod (not as sturdy as the Quantanray)

Mighty Maxi – Orion 120mm short tube

Can record occultations of stars to mag. 12.0, even mag. 12.5 under good conditions

I use visual finder scope and an alt-az mount built from PVC pipe, bolts, wing nuts, velcro straps, 2 “clam shells” made from large-diameter PVC pipe, and a rectangular piece of wood that Scotty sold me for $50. The 2-pt. support for the heavy scope make balance and altitude adjustment tricky; placing an MX-350 tripod under the end of the camera with crumpled paper between adds a 3rd point and stability, but re-pointing is often needed when put in place. Scotty has a better mount design for about $100 in parts that he will present at the IOTA meeting in Oct. Commercial mounts that can hold this weight cost hundreds of $, more than twice the $300 cost of the 120mm OTA.

Programmable Remote for Timed Recordings



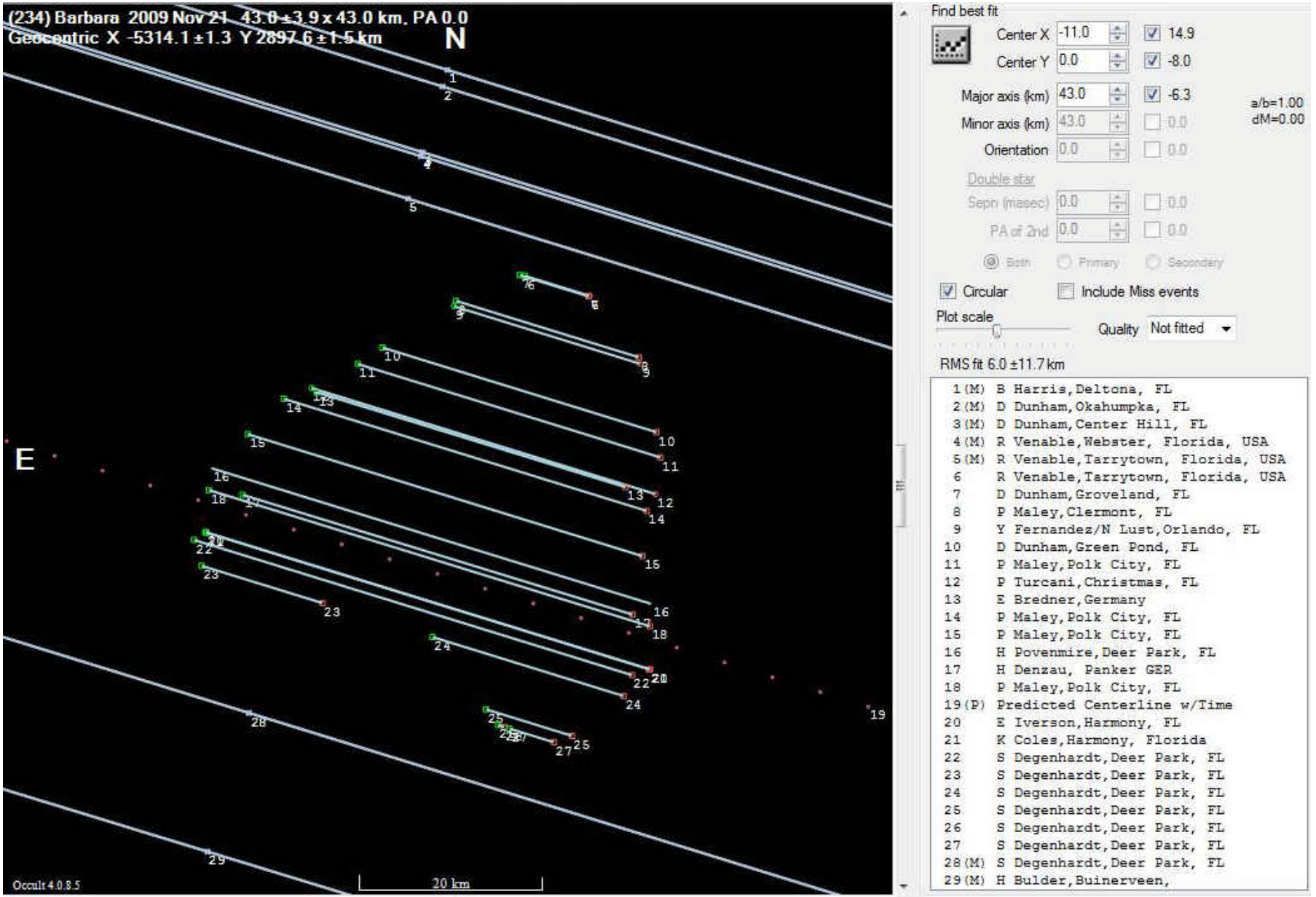
Suggested by Steve Conard. Scotty found a “100% effective” system. Place transparent plastic tube (I believe made from 2 coin holders fastened together with Scotch tape; shown at foot of tripod) at bottom of the brown mailing bag in the background. After setting the programmable remote, place it pointing down at the tube at the bottom. Turn the Canon ZR camcorder to the VCR position with front end down facing the tube. If cold, add some hand warmers. 6 plastic tabs glued to the edges of the front of the remote, and the piece of cardboard held on with the rubber band, prevent the programmable remote from turning on, which happens whenever the screen is touched.

Components of John Broughton's 25cm "Suitcase Telescope"

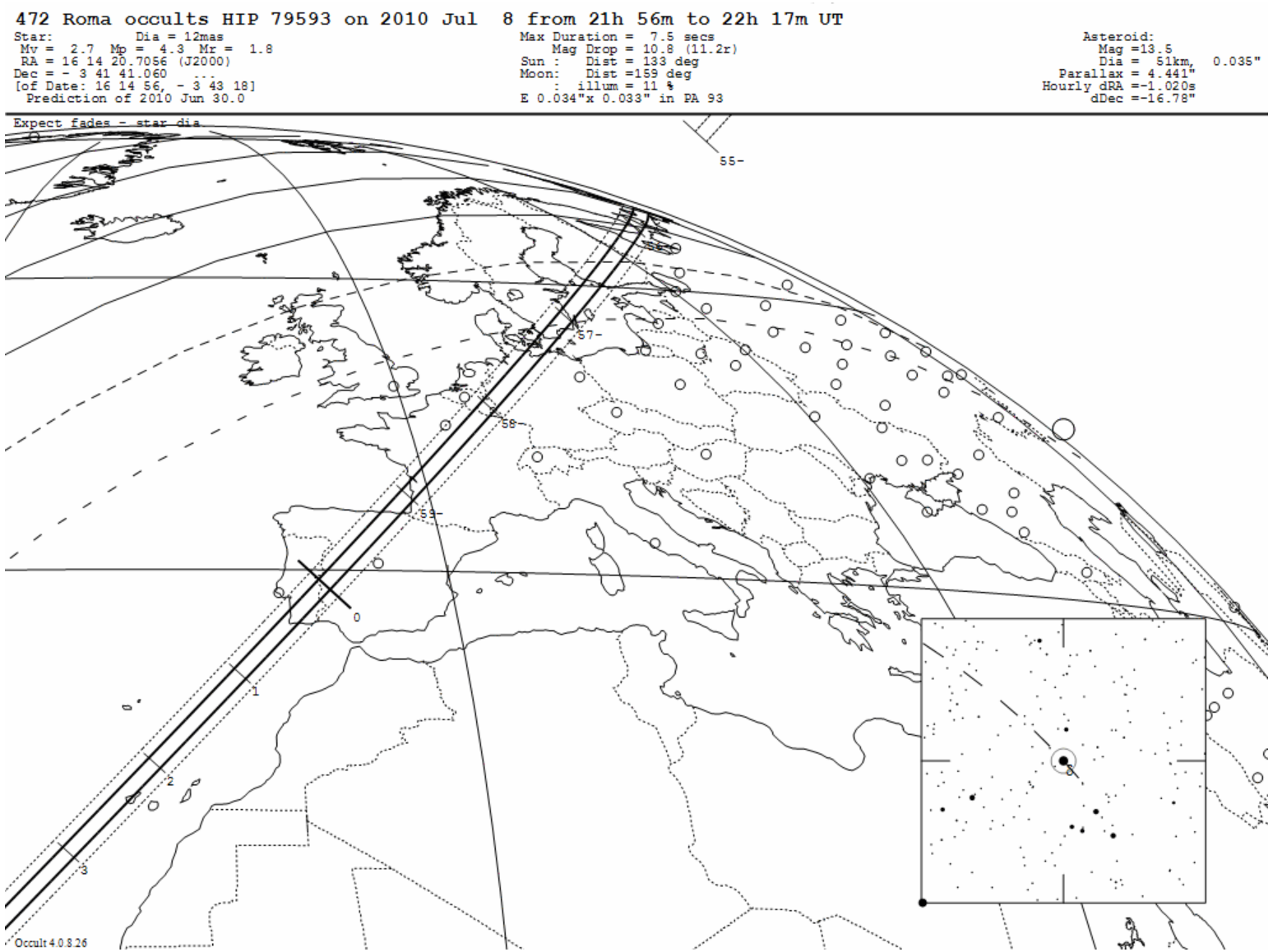
Goal:
Fit 2 of them within the 22-kg per suitcase weight limit of most airlines


The Suitcase Telescope set up for observing (except for the cameras).
3 can be set up ready to go and put on the back
seat area of an ordinary car; more could be put
in the trunk.

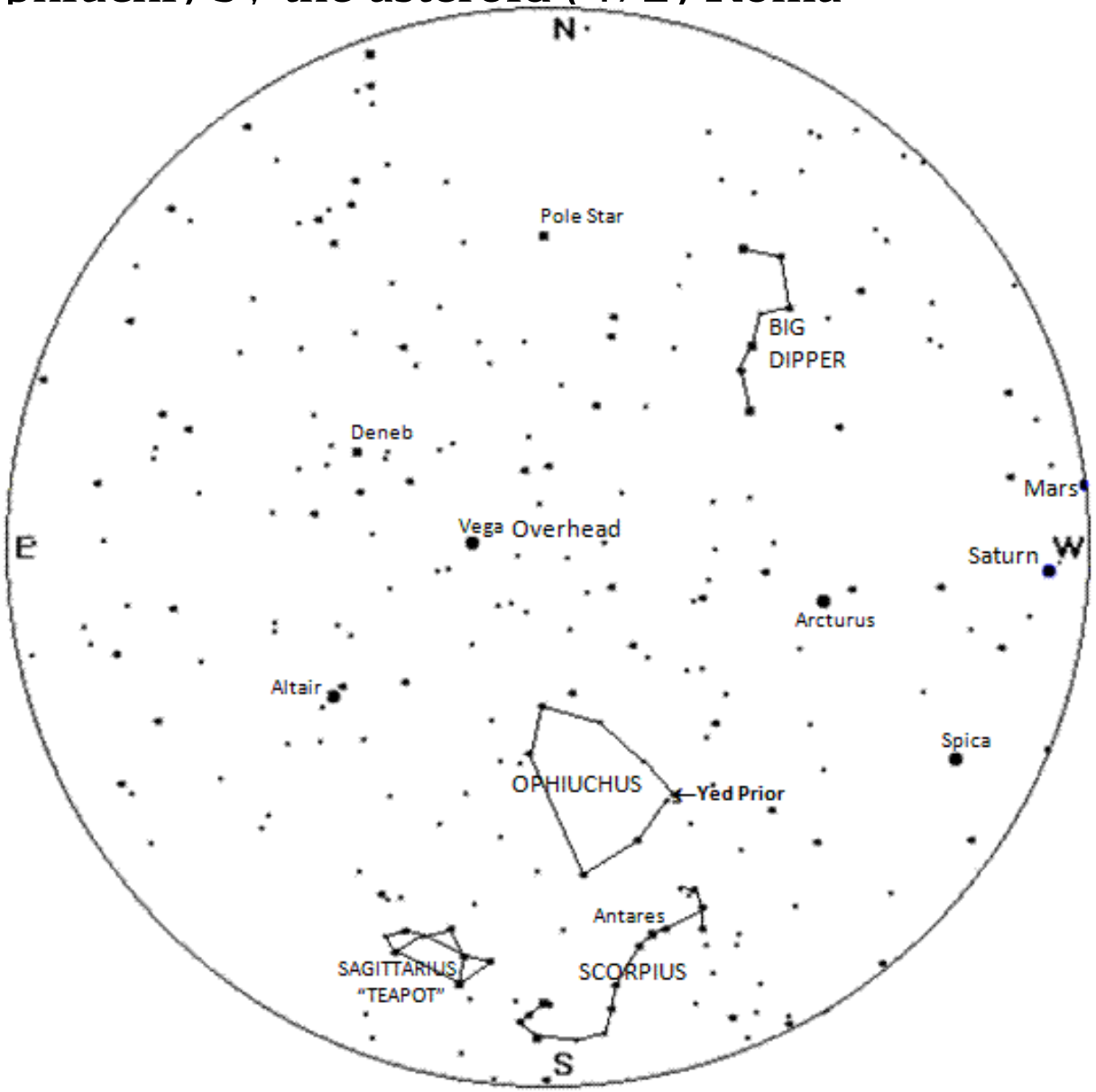
Occultation of 7th-mag. Star by (234) Barbara, 2009 Nov. 21



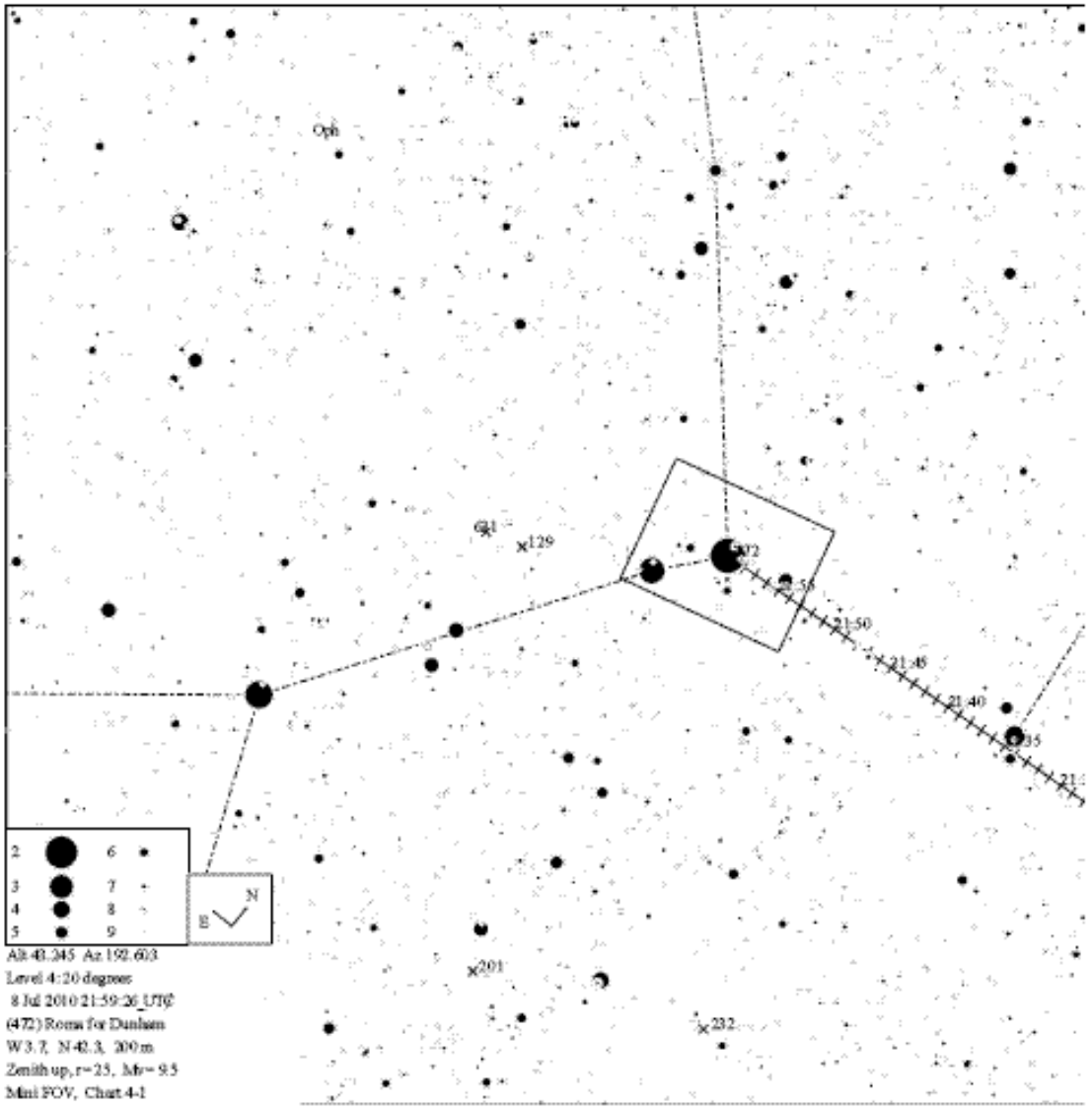
Path of the 2010 July 8th occultation of 2.5-mag. Yed Prior (delta Ophiuchi) by the asteroid (472) Roma



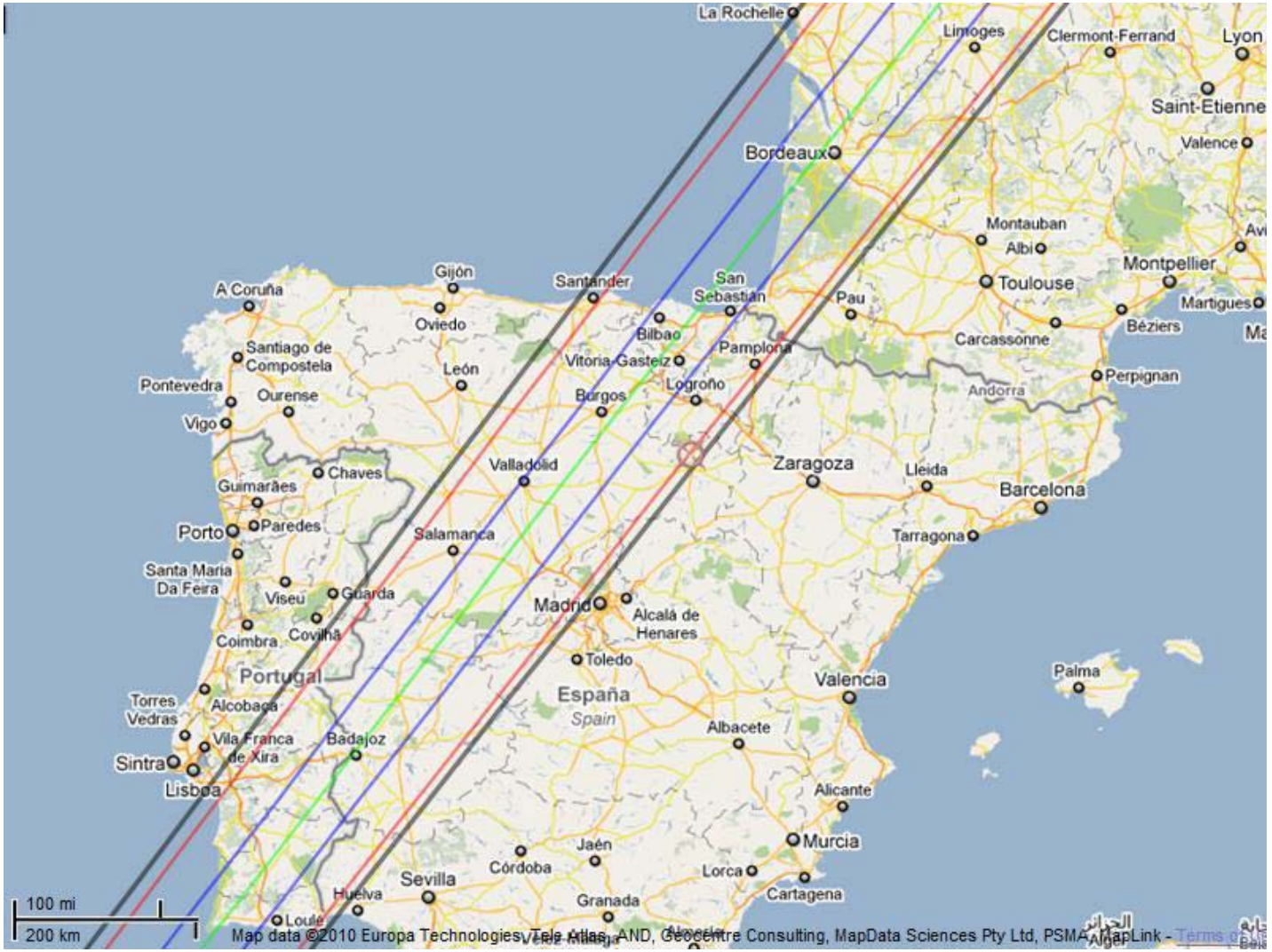
Sky chart for the 2010 July 8th occultation of 2.5-mag. Yed Prior (delta Ophiuchi) by the asteroid (472) Roma



Pre-Point chart for the 2010 July 8th occultation of 2.5-mag. Yed Prior (delta Ophiuchi) by the asteroid (472) Roma

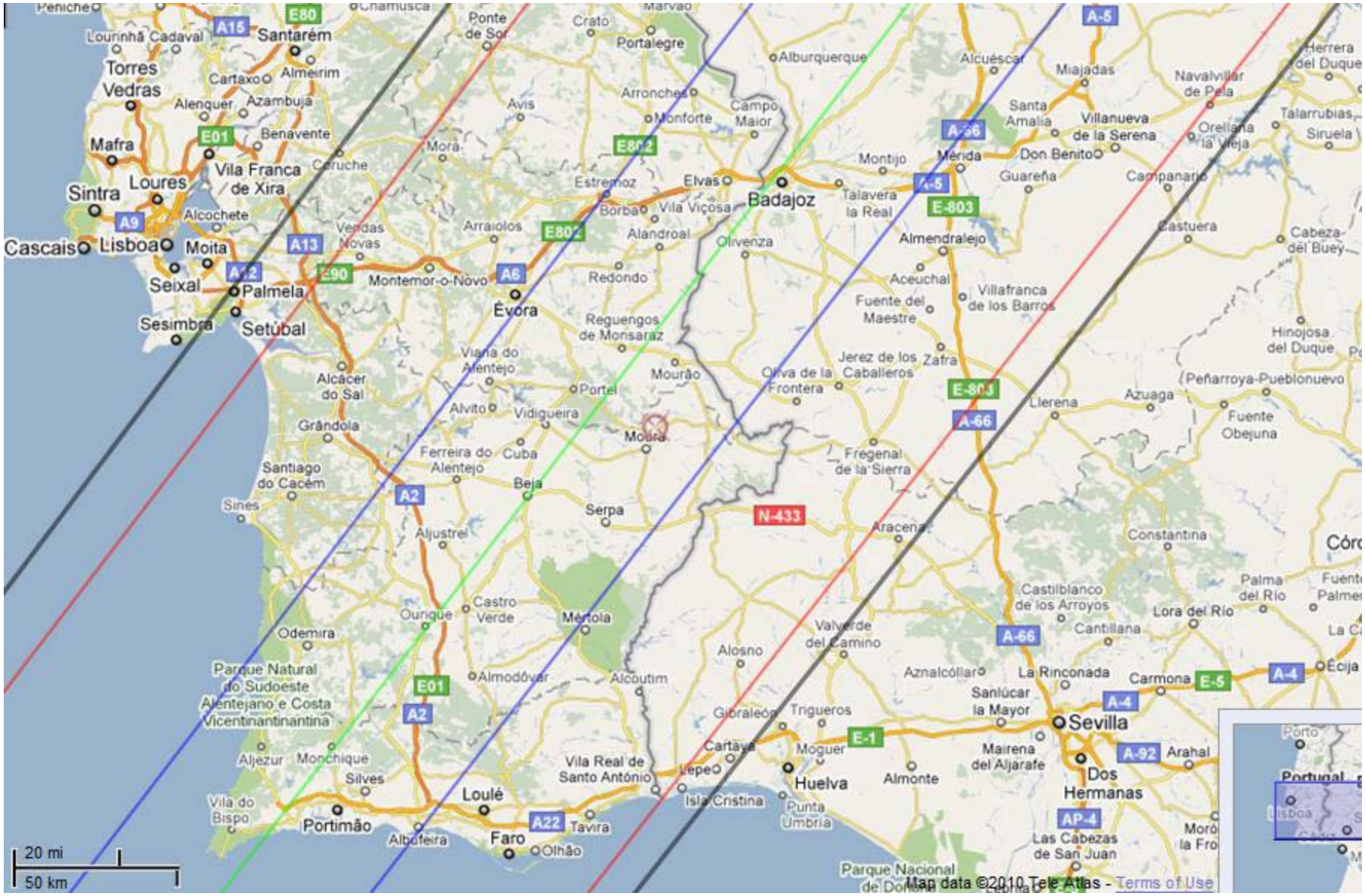


Path of the 2010 July 8th occultation of 2.5-mag. Yed Prior (delta Ophiuchi) by the asteroid (472) Roma over Iberia

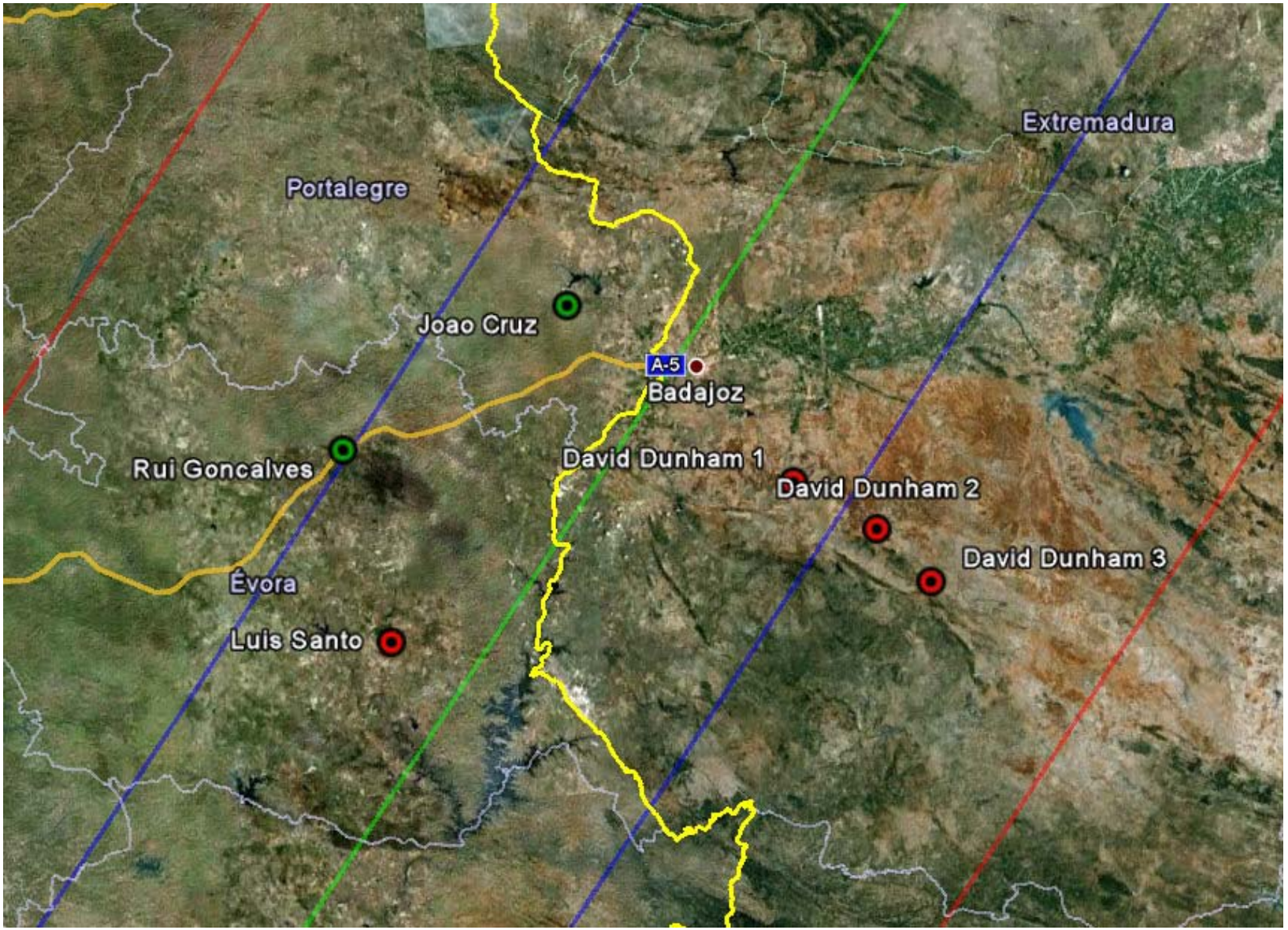


Mighty Mini Training at Sabadell

Path of the 2010 July 8th occultation of 2.5-mag. Yed Prior (delta Ophiuchi) by the asteroid (472) Roma over s.w. Iberia

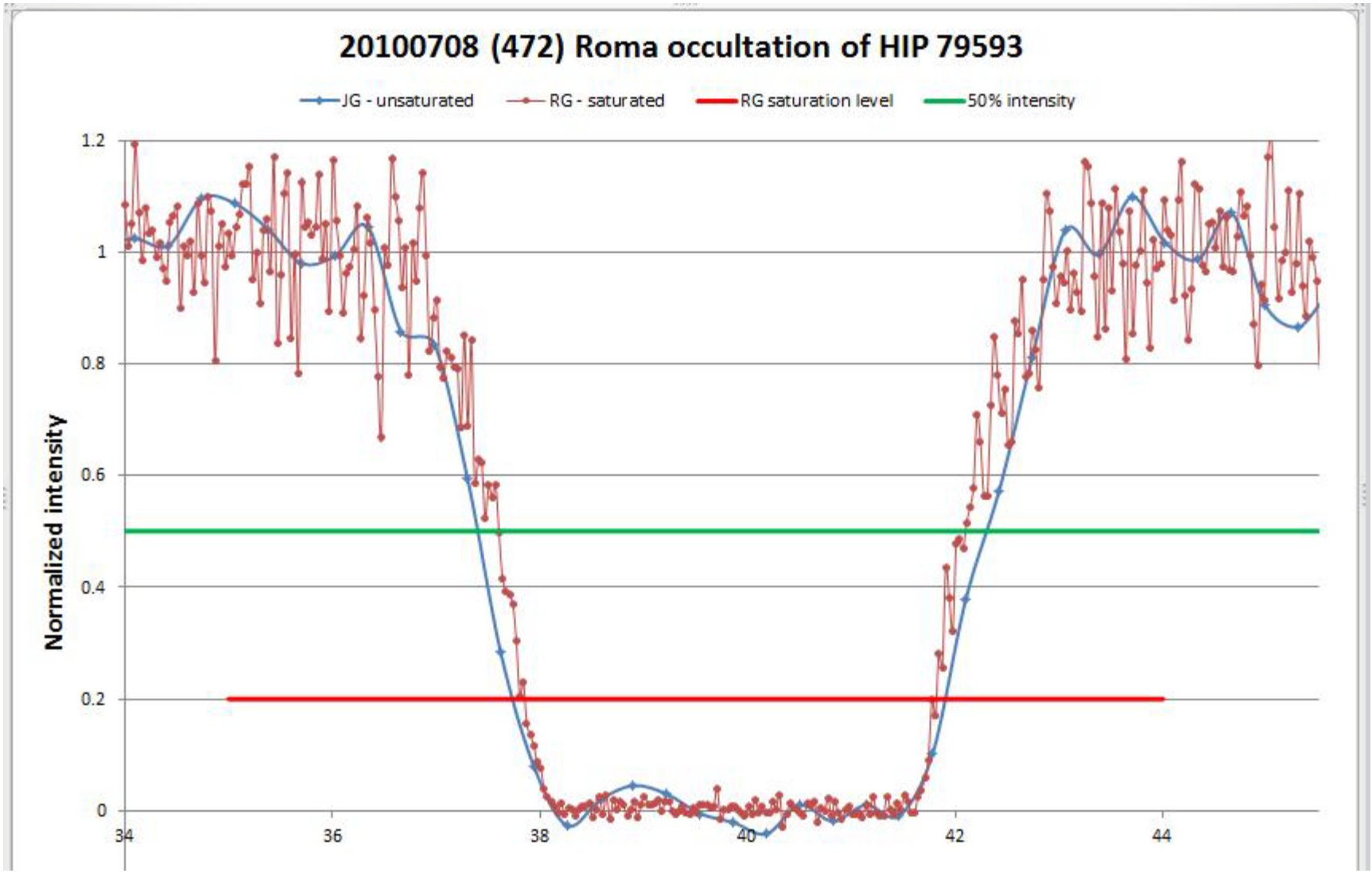


Locations of Mighty Minis deployed for the 2010 July 8th occultation of Yed Prior by Roma in s.w. Iberia

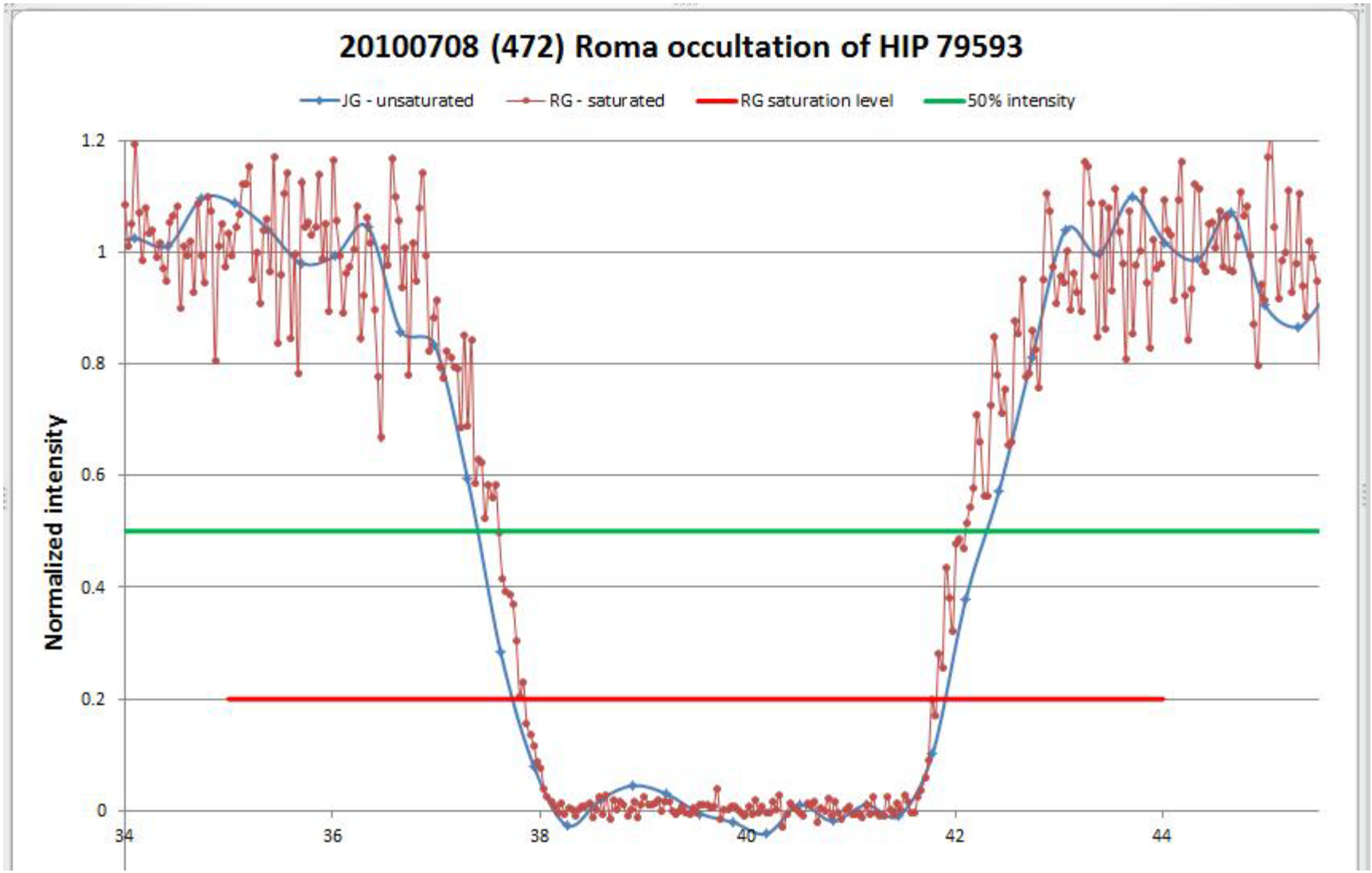


Our First Station, Setup in a ditch at La Albuera, Spain, s.e. of Badajoz

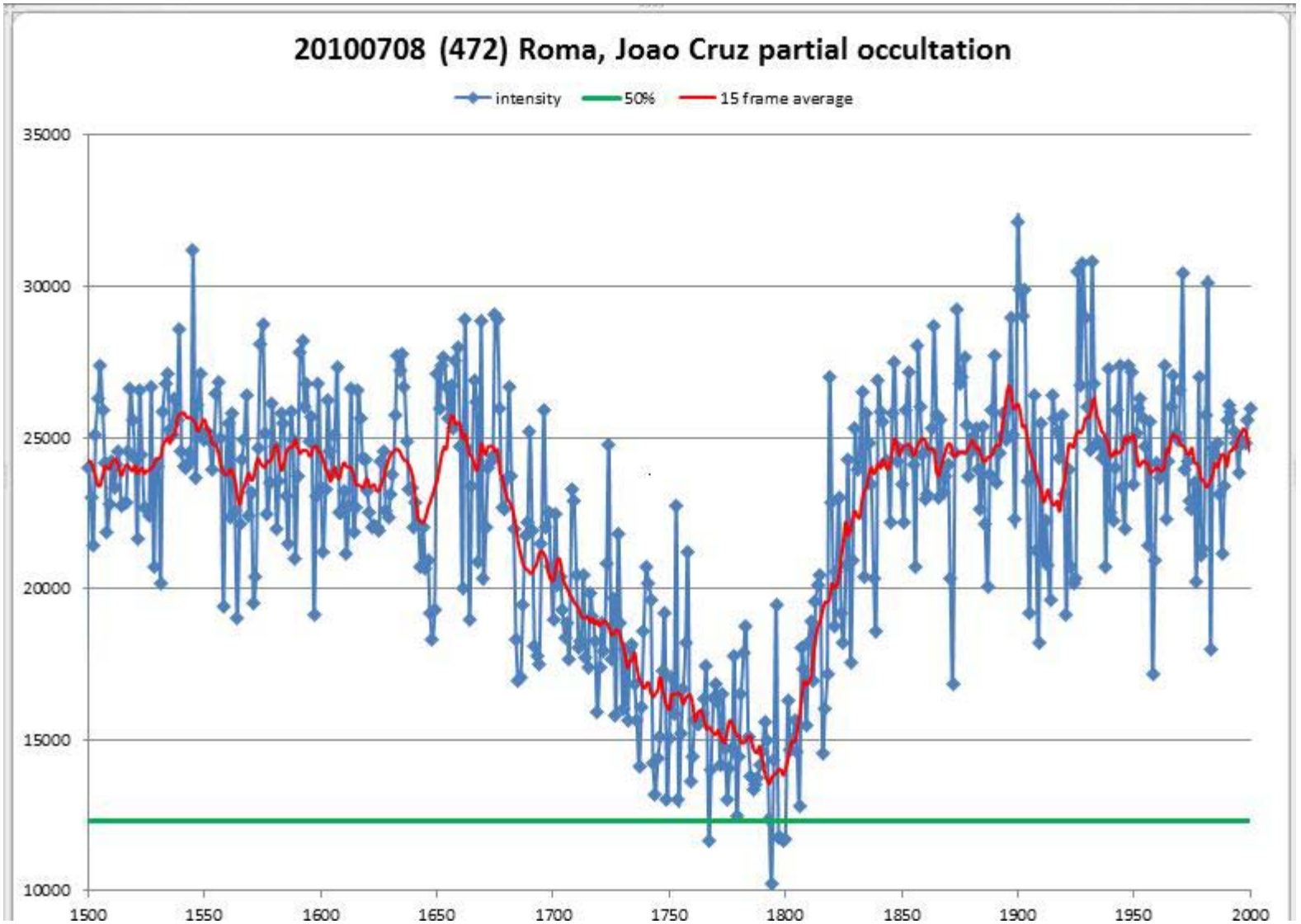
Saturation study of Portuguese mighty mini light curves



Saturation study of Goncalves' mighty mini light curve



Joao Cruz' unsaturated partial occultation light curve

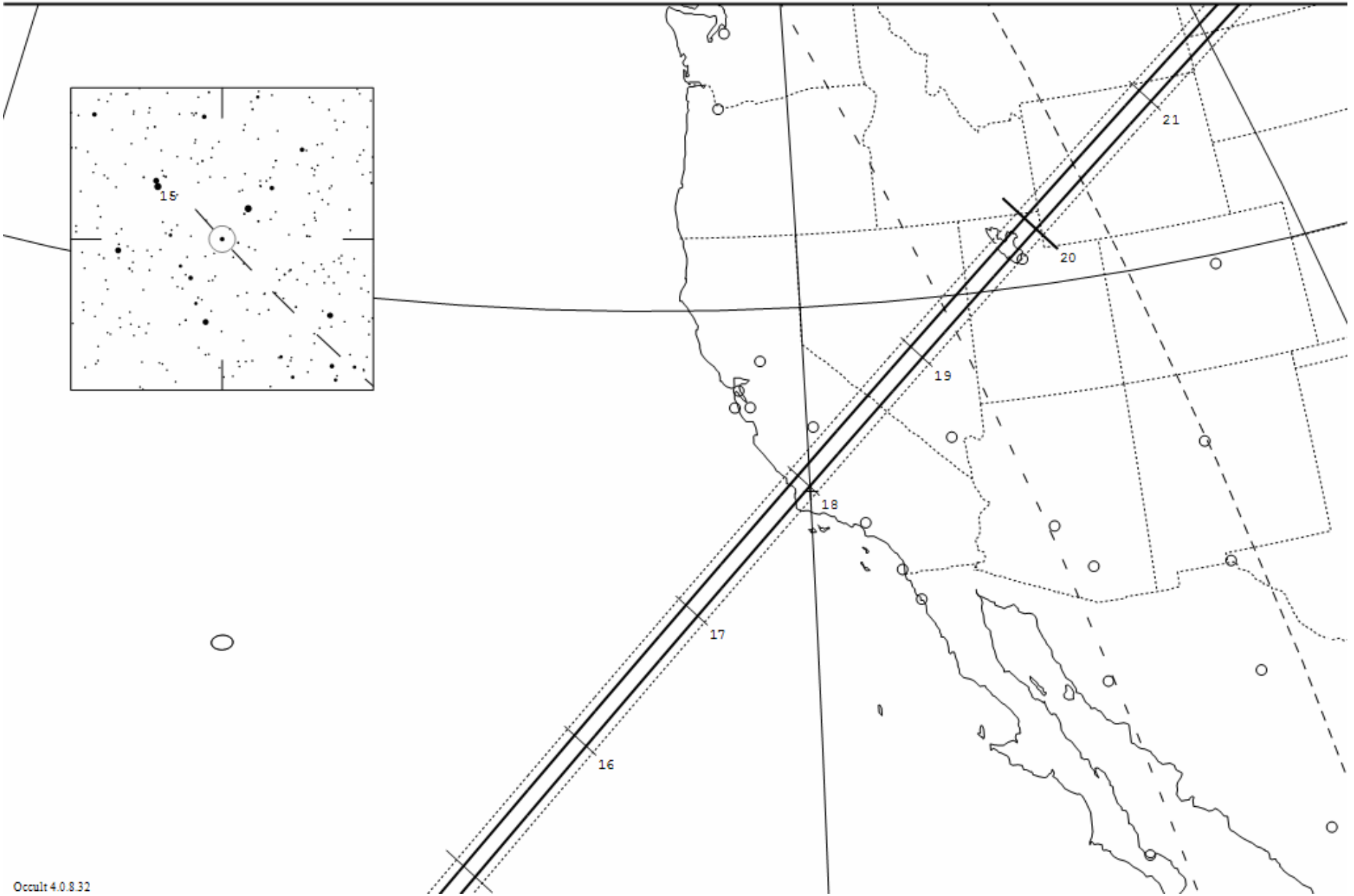


695 Bella occults TYC 2332-01054-1 on 2010 Aug 31 from 12h 5m to 12h 29m UT

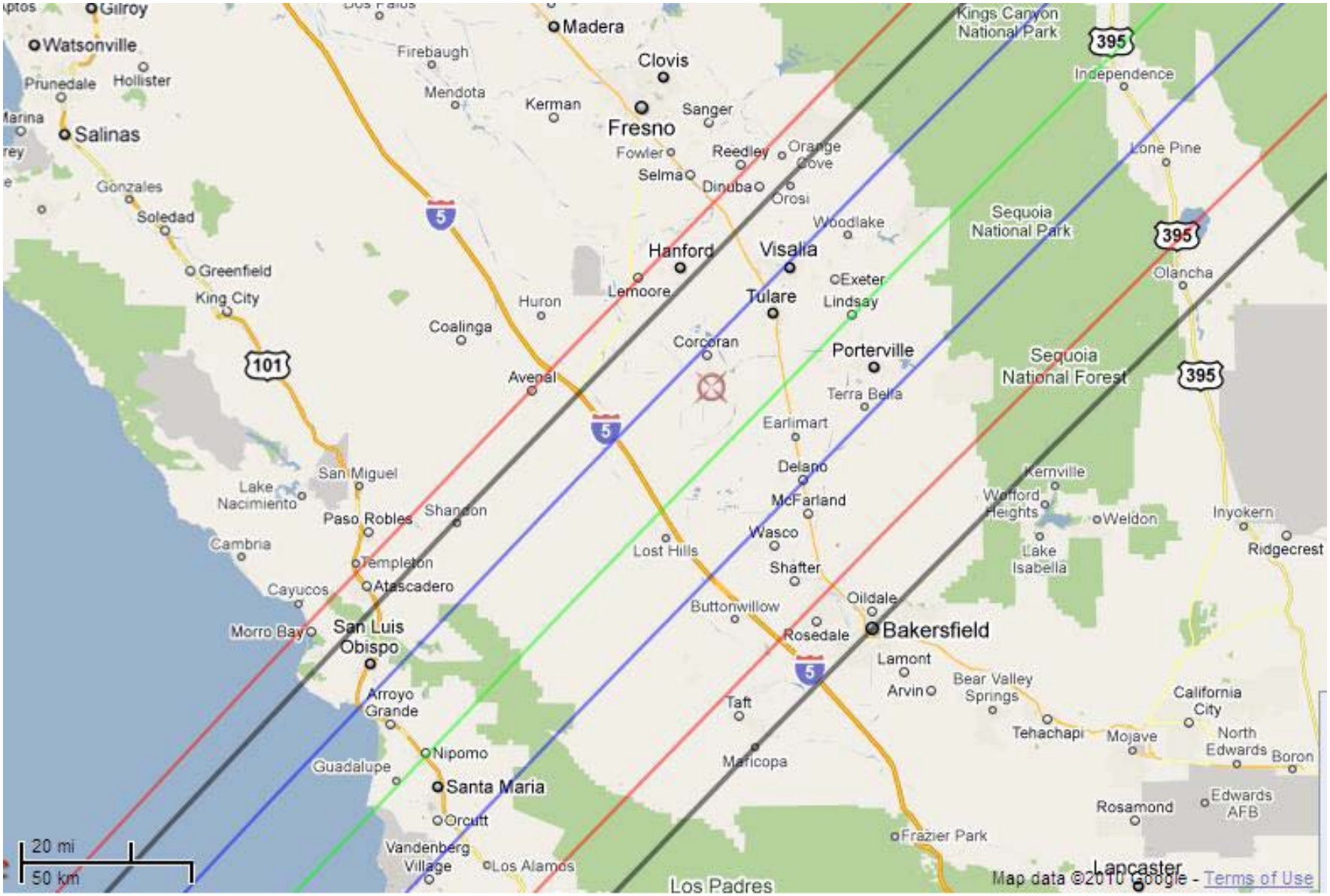
Star:
Mv = 7.7 Mp = 7.8 Mr = 7.6
RA = 2 33 42.7562 (J2000)
Dec = 34 20 28.608 ...
[of Date: 2 34 24, 34 23 19]
Prediction of 2010 Jul 21.0

Max Duration = 5.4 secs
Mag Drop = 5.5 (5.1r)
Sun : Dist = 110 deg
Moon: Dist = 16 deg
: illum = 62 %
E 0.028"x 0.019" in PA 87

Asteroid:
Mag =13.2
Dia = 48km, 0.041"
Parallax = 5.500"
Hourly dRA = 1.504s
dDec = 20.23"

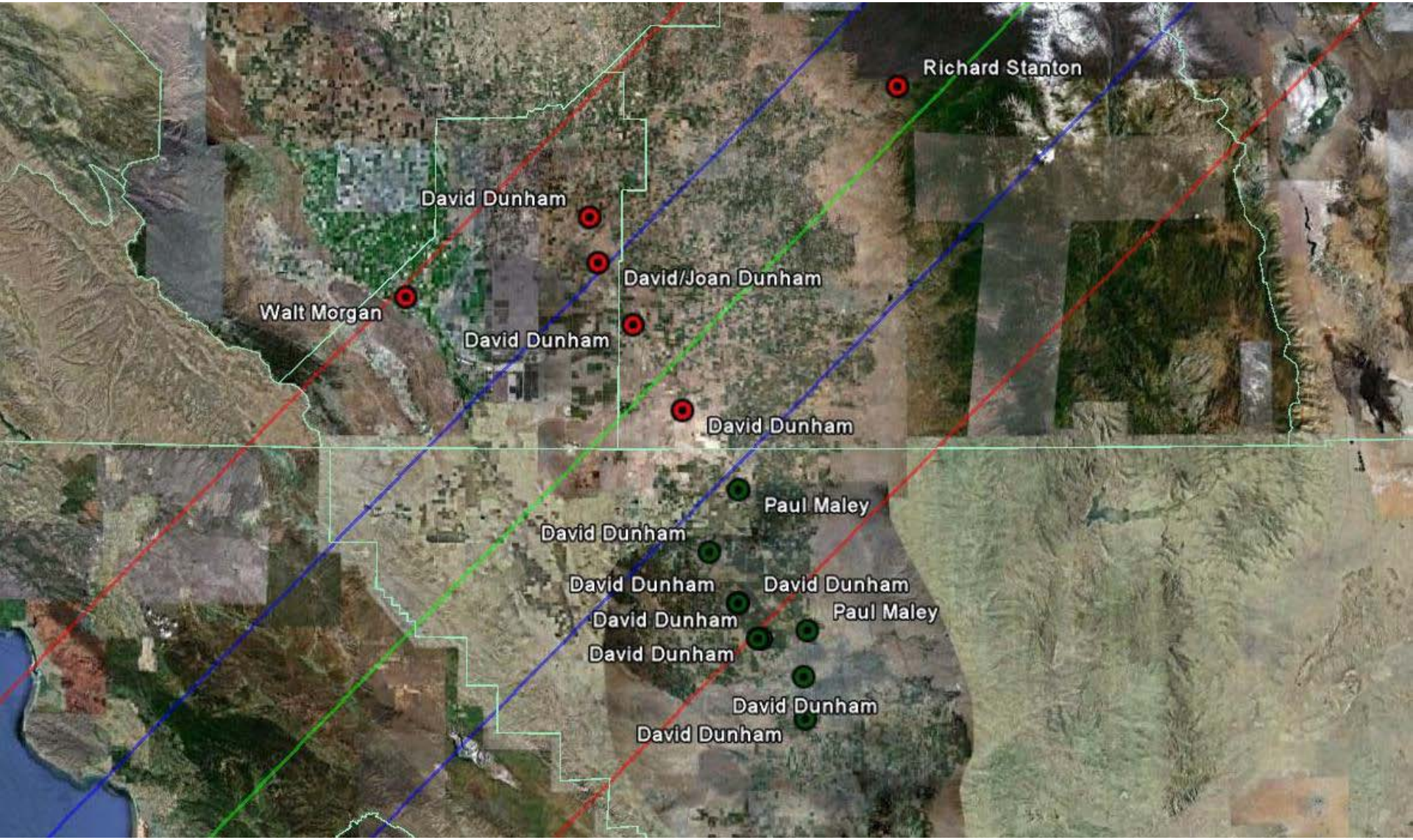


Occult 4.0.8.32

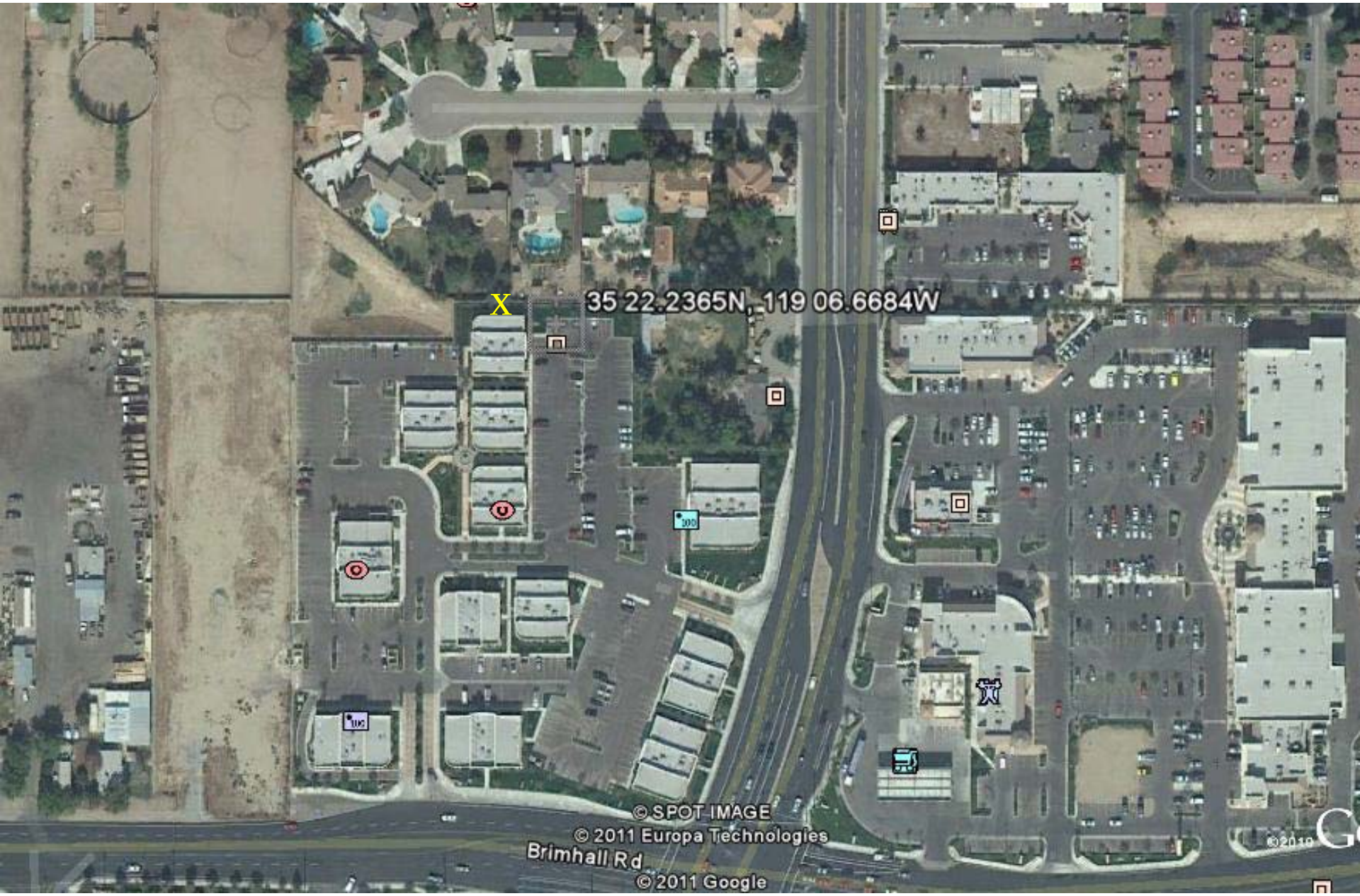

Gilroy
Watsonville
Prunedale
Hollister
Salinas
Gonzales
Soledad
Greenfield
King City
Madera
Firebaugh
Mendota
Kerman
Clovis
Fresno
Sanger
Fowler
Reedley
Orange Cove
Selma
Dinuba
Orosi
Woodlake
Hanford
Visalia
Lemoore
Tulare
Exeter
Lindsay
Huron
Coalinga
Corcoran
Porterville
Terra Bella
Avenal
Earlimart
Delano
McFarland
Wasco
Lost Hills
Shafter
Oildale
Bakersfield
Buttonwillow
Rosedale
Lamont
Arvin
Taft
Maricopa
Bear Valley Springs
Tehachapi
Mojave
California City
North Edwards
Boron
Rosamond
Edwards AFB
Frazier Park
Lancaster
Kings Canyon National Park
Independence
Lone Pine
Sequoia National Park
Olancha
Sequoia National Forest
Kernville
Wofford Heights
Weldon
Lake Isabella
Inyokern
Ridgecrest
San Miguel
Lake Nacimiento
Paso Robles
Shandon
Cambria
Templeton
Atascadero
Cayucos
Morro Bay
San Luis Obispo
Arroyo Grande
Nipomo
Guadalupe
Santa Maria
Orcutt
Vandenberg Village
Los Alamos
Los Padres
101
5
395
20 mi
50 km
Map data ©2010 Google - Terms of Use

Occult Watcher Stations for the Bella Occultation

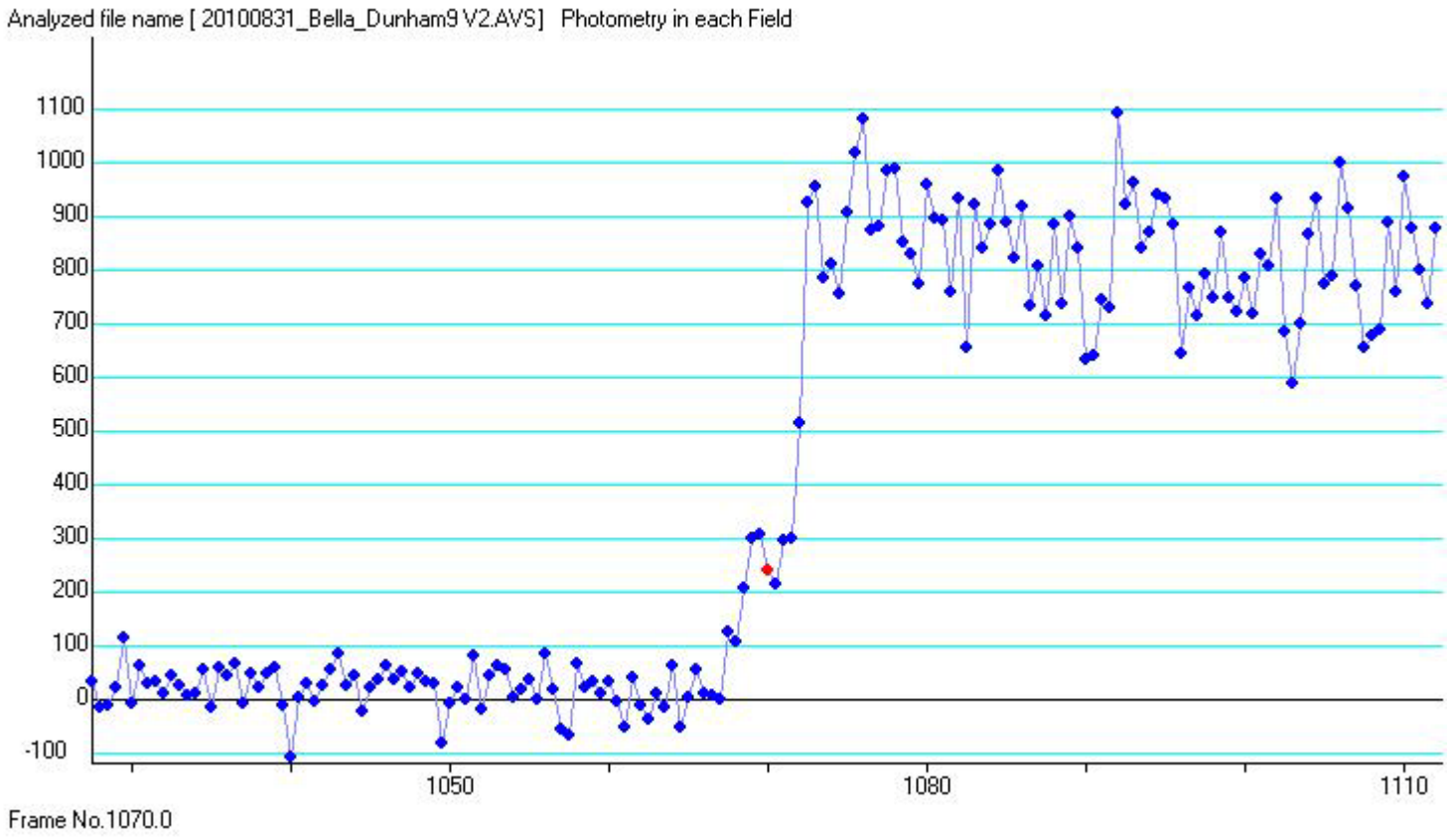
Successful Stations for the Bella Occultation



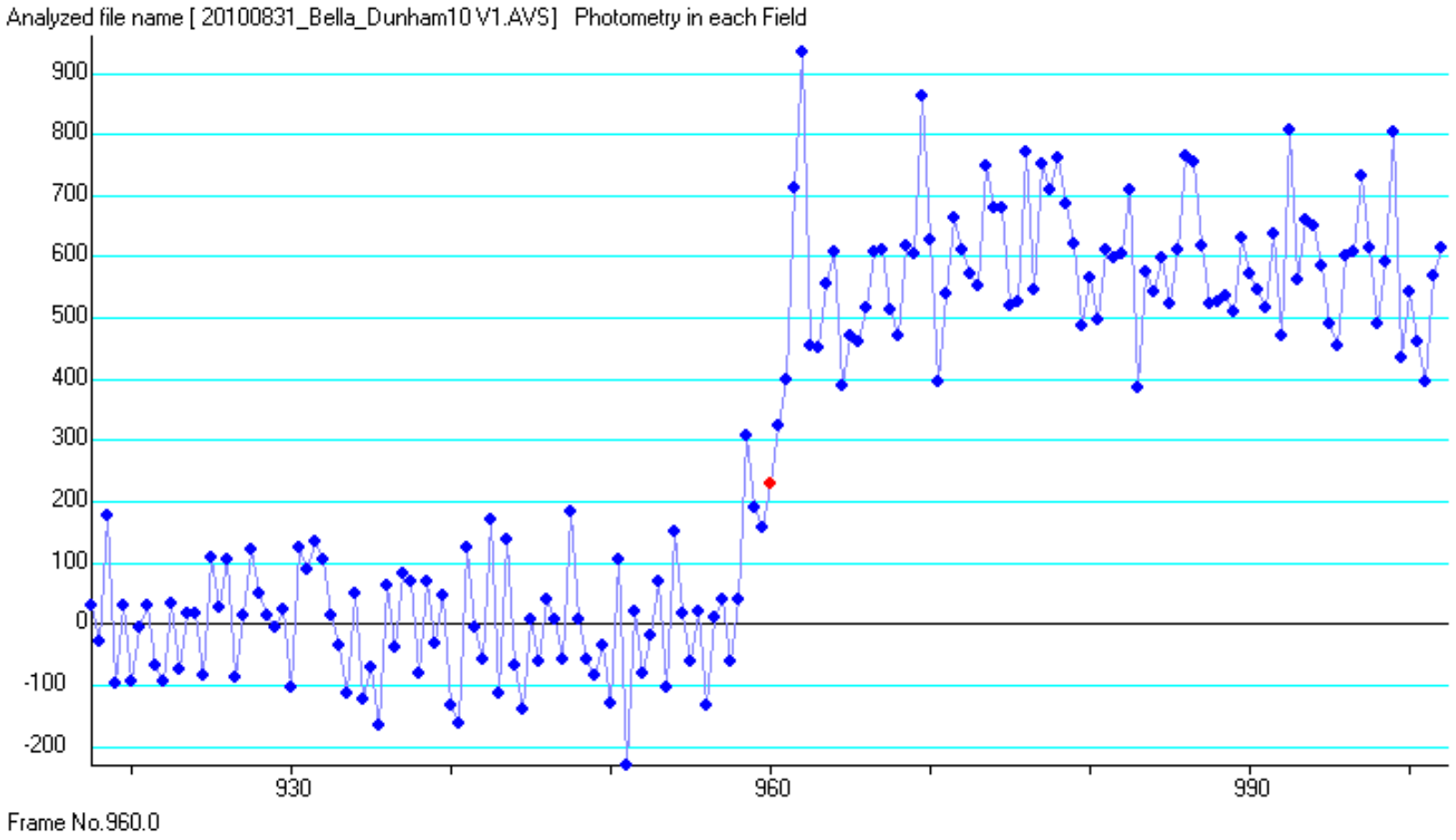
Bella Occultation Station 11 site, Greenacres, Calif.



Bella Station 9 reappearance shows that the star is likely a close binary

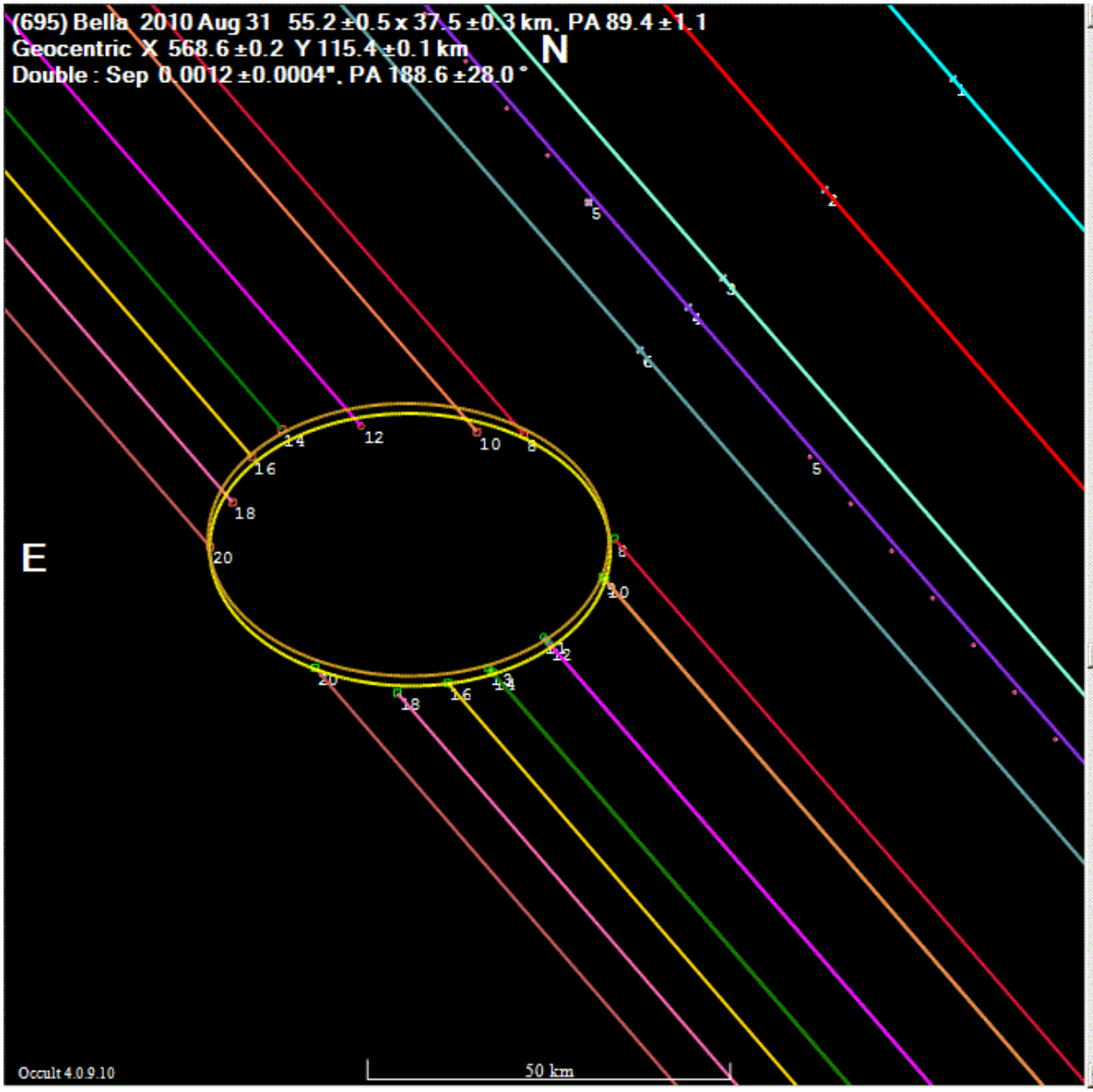


Bella Station 10, shows a step reappearance like Station 9



Profile of Bella from the Aug. 31st Observations

Stations mostly set up s. of predicted center due to expected PPMXL star catalog shift



Find best fit

Center X	-23.7	0.0	
Center Y	-22.6	0.0	
Major axis (km)	55.2	0.0	a/b=1.47
Minor axis (km)	37.5	0.0	dM=-0.42
Orientation	89.4	0.0	
Double star			
Sepn (masec)	1.2	0.0	
PA of 2nd	188.6	0.0	

Both / Primary / Secondary

Circular — Include Miss events

Plot scale — Quality: Not fitted

RMS fit 0.0 ±0.9 km

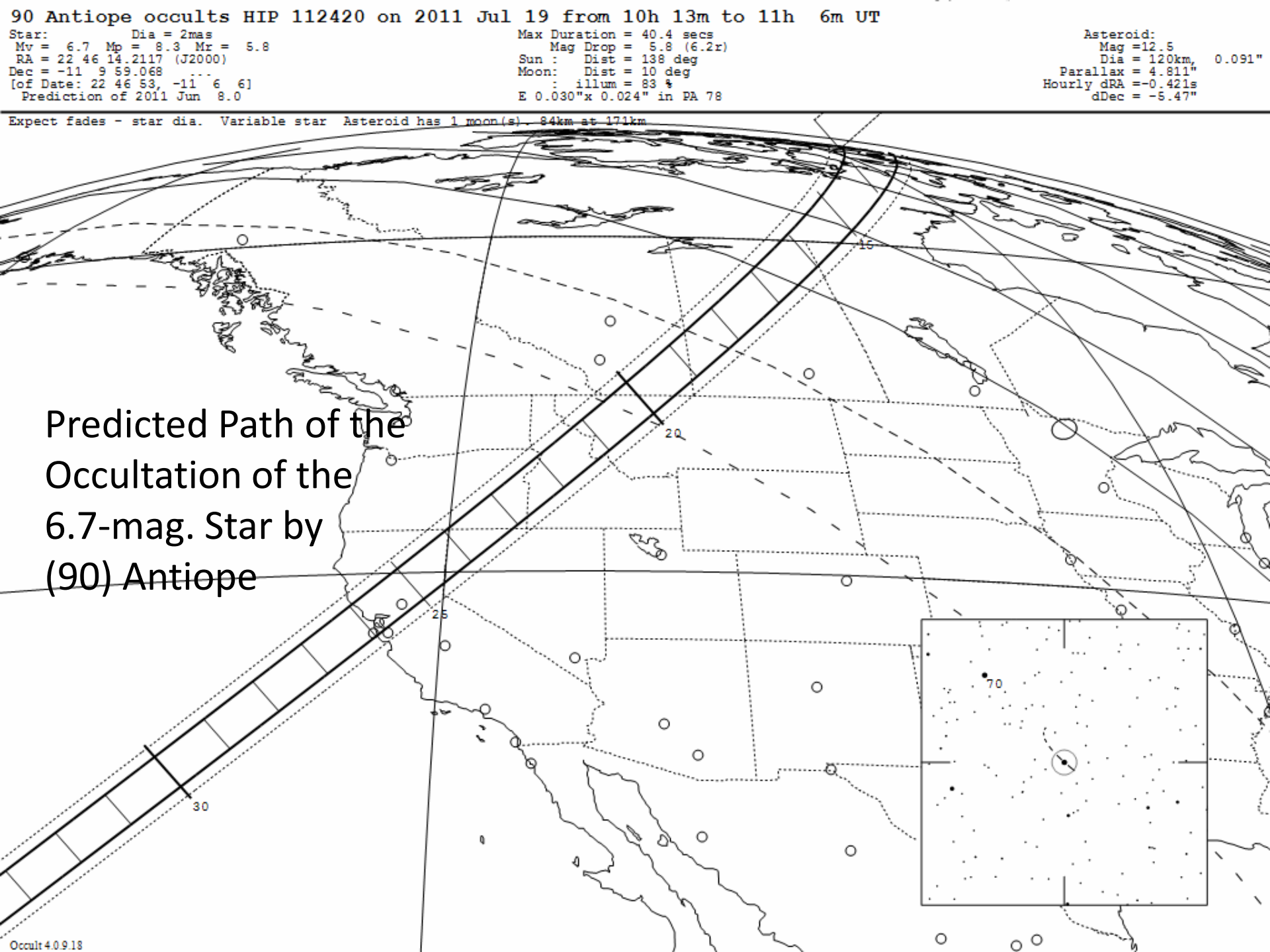
1	(M)	W Morgan,Kettleman C
2	(M)	D Dunham,Corcoran, C
3	(M)	R Stanton,Three Rive
4	(M)	T Beard,Tonopah, NV
5	(P)	Predicted Centerline
6	(M)	D Dunham,Alpaugh, CA
8		P Maley,Delano, CA
9		D Dunham,Wasco, CA
10		D Dunham,Wasco, CA
11		D Dunham,Shafter, CA
12		D Dunham,Shafter, CA
13		D Dunham,Shafter, CA
14		D Dunham,Shafter, CA
16		P Maley,Bakersfield,
18		D Dunham,Greenacres,
20		D Dunham,Bakersfield

Bella Occultation my best success, but . .

- It was extremely exhausting, made me ill
- As I drove back to Fresno, my nose started running
- At hotel, 2 hours to pack, then go to airport – no rest
- Ear infection evident as plane landed in Baltimore
- Next week, very weak, flu symptoms for 3 days
- Didn’t recover; after 2 weeks, I saw doctor
- Diagnosis: Thyroiditis; main recovery took 6 weeks
- Full recovery took several months
- Now, I insist on 4h+ sleep after an all-nighter
- Need younger people to take up this extreme sport!

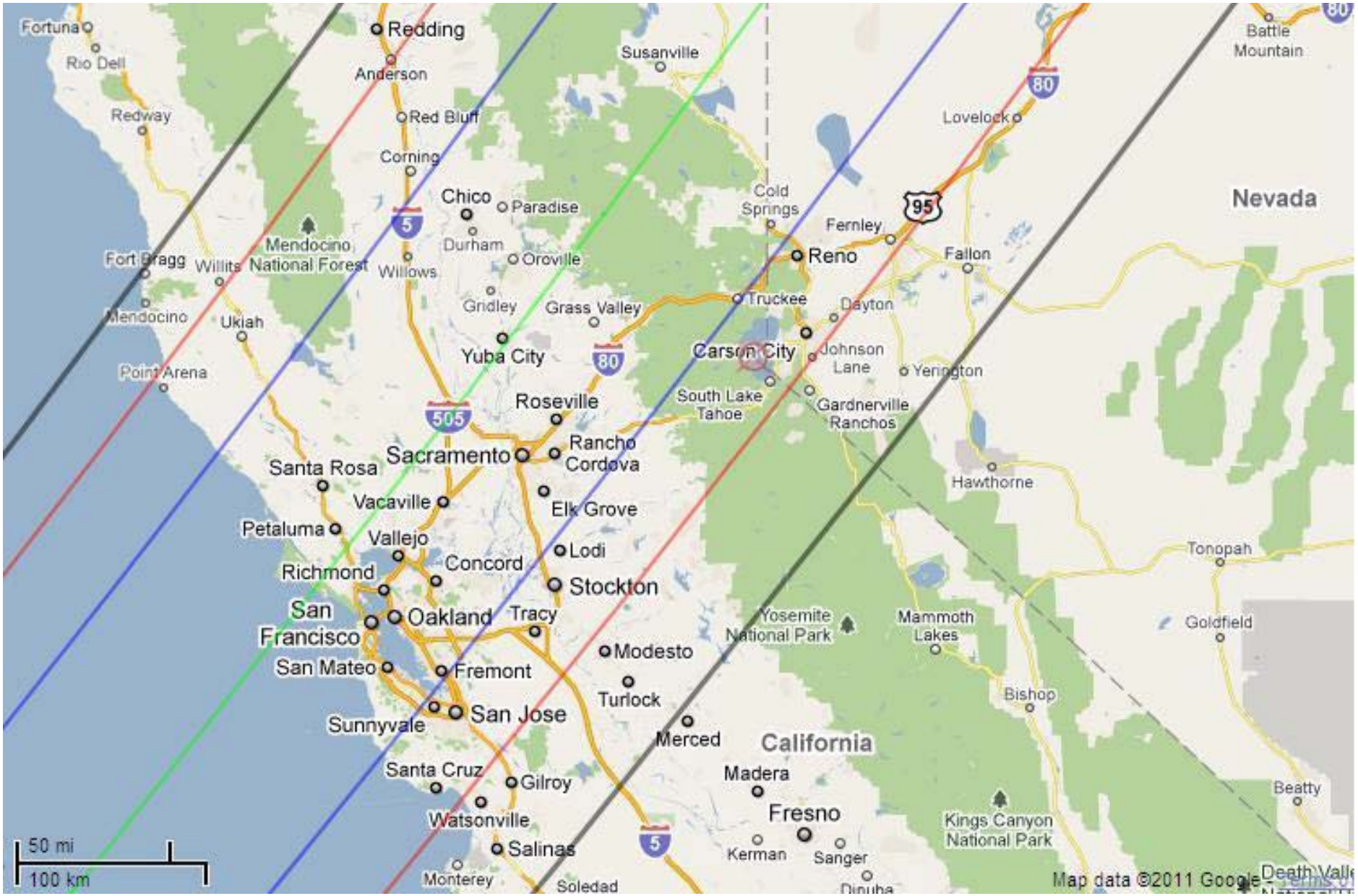
Occultation of LQ Aquarii on 2011 July 19 mapped the profile of the binary asteroid (90) Antiope

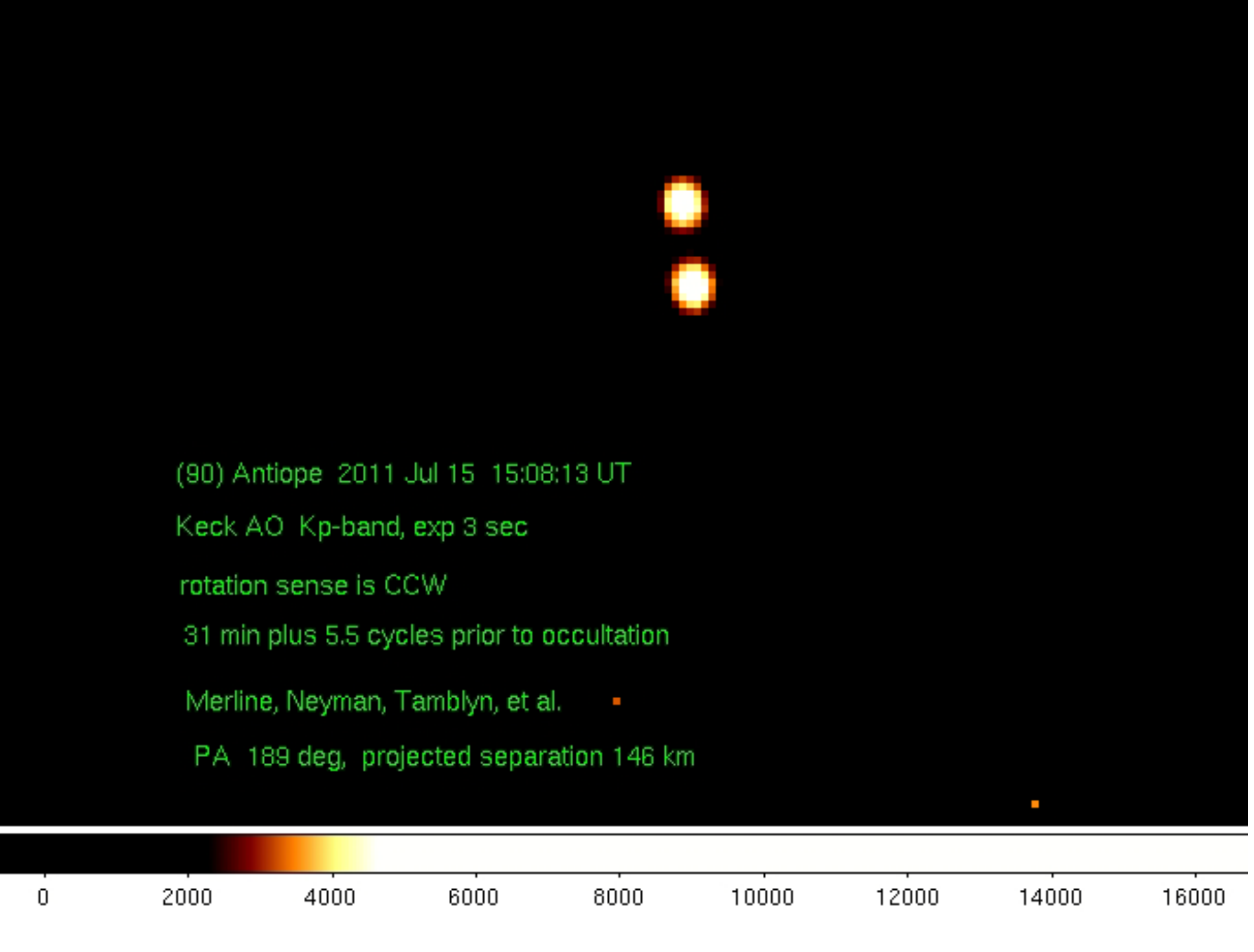
David W. Dunham,
International Occultation Timing Association
and KinetX, and many others, from IOTA,
IMCCE (Paris Observatory), the SETI Institute,
Southwest Research Institute, JPL, Sierra College,
etc.



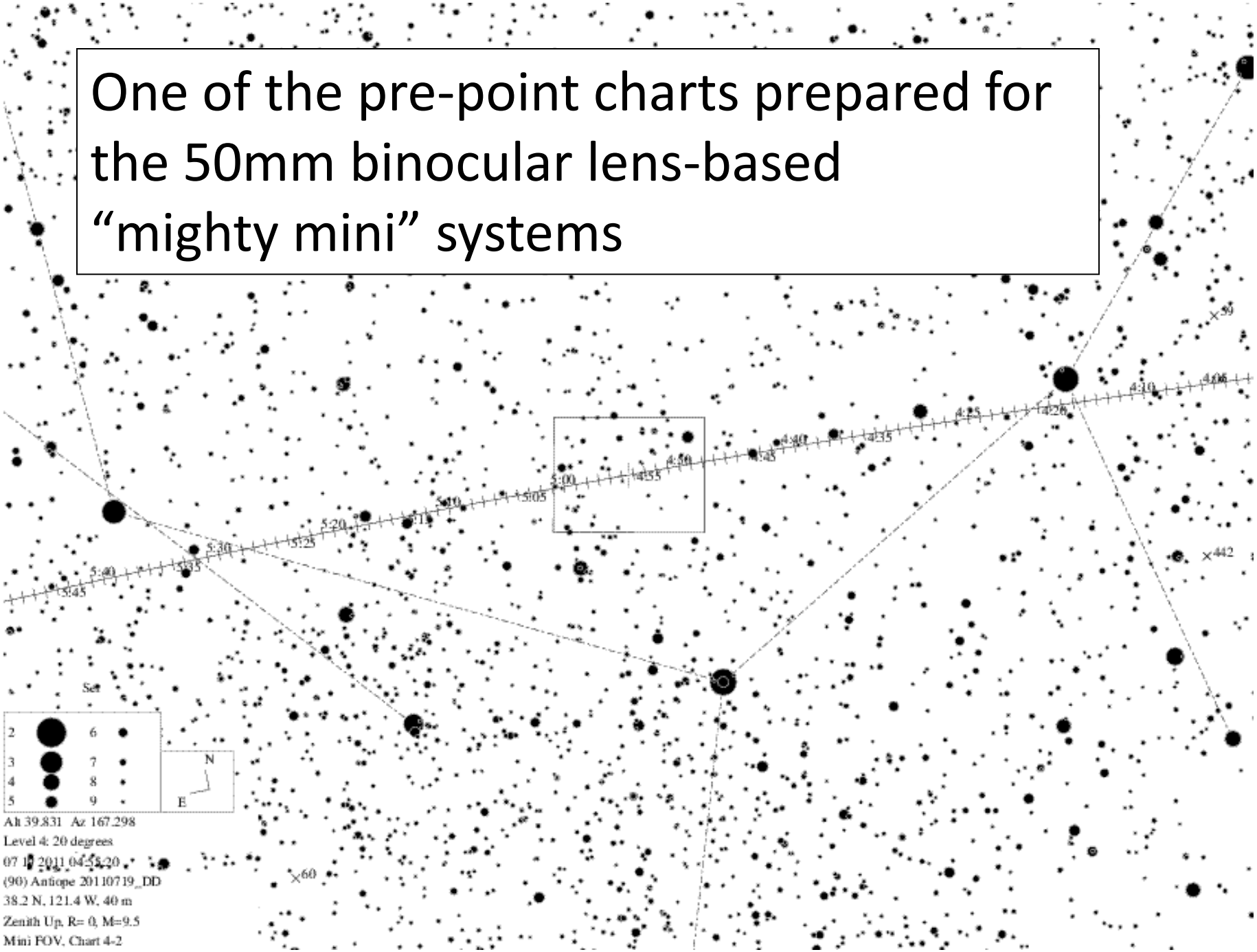
Predicted Path of the Occultation of the 6.7-mag. Star by (90) Antiope

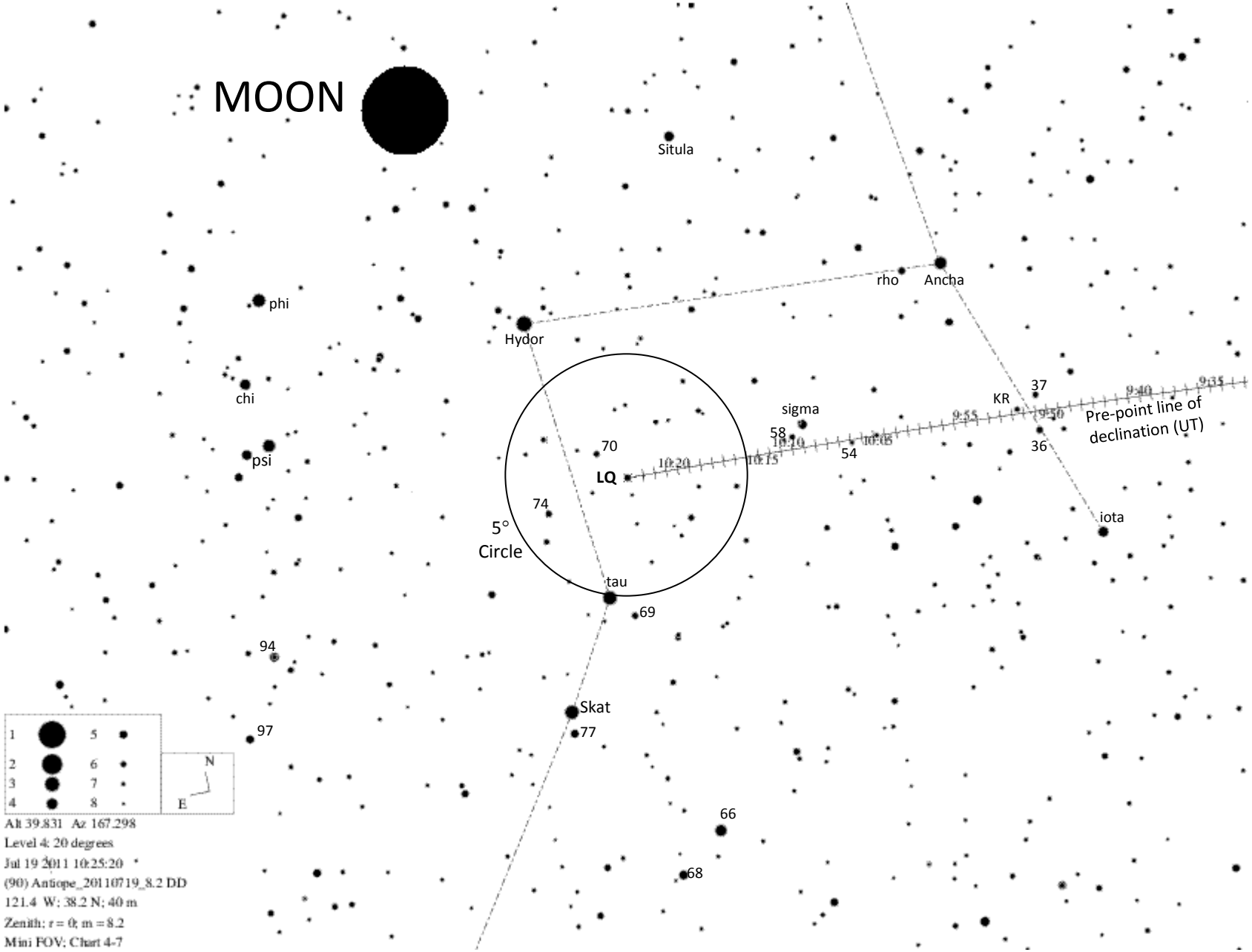
The path over northern Calif. & Nevada




(90) Antiope 2011 Jul 15 15:08:13 UT
Keck AO Kp-band, exp 3 sec
rotation sense is CCW
31 min plus 5.5 cycles prior to occultation
Merline, Neyman, Tamblyn, et al.
PA 189 deg, projected separation 146 km
0
2000
4000
6000
8000
10000
12000
14000
16000

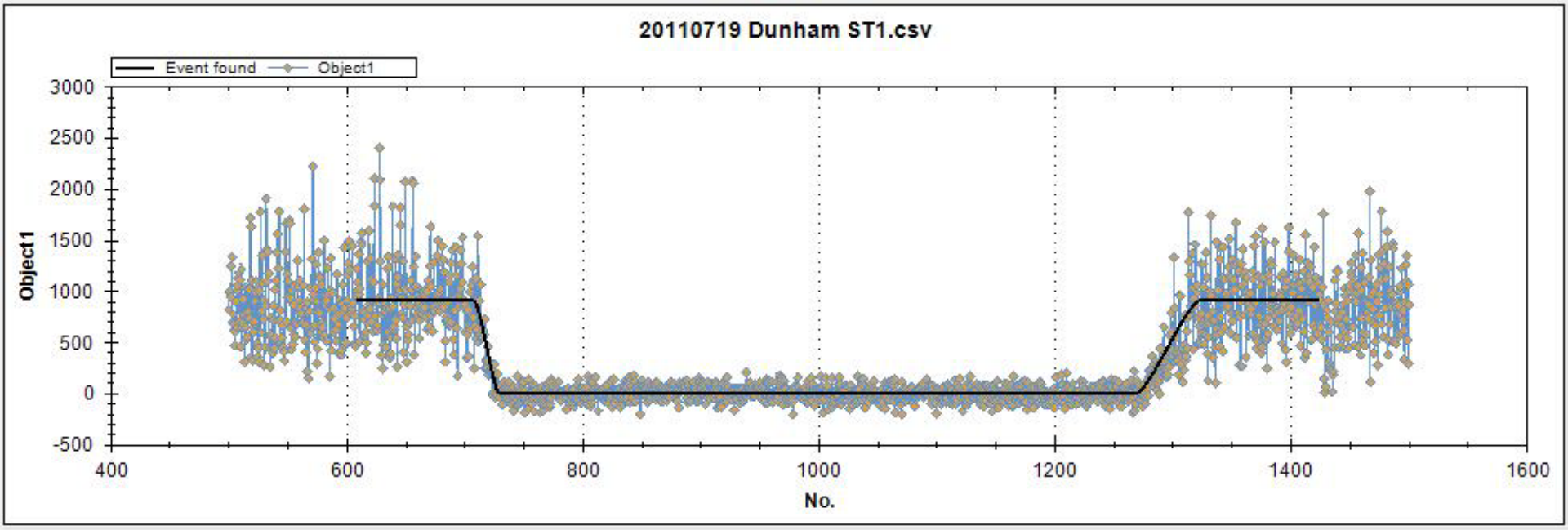
IOTA meeting at Sierra College, Rocklin, CA


One of the pre-point charts prepared for the 50mm binocular lens-based "mighty mini" systems
Set
2
3
4
5
6
7
8
9
N
E
Alt 39.831 Az 167.298
Level 4: 20 degrees
07 19 2011 04:58:20
(90) Antiope 20110719_DD
38.2 N, 121.4 W, 40 m
Zenith Up, R= 0, M=9.5
Mini FOV, Chart 4-2


MOON
Situla
rho
Ancha
Hydor
phi
chi
psi
sigma
KR
37
36
58
54
70
74
LQ
5°
Circle
tau
69
iota
Pre-point line of
declination (UT)
9:35
9:40
9:45
9:50
9:55
10:05
10:10
10:15
10:20
94
97
77
Skat
66
68
1
2
3
4
5
6
7
8
N
E
Alt 39.831 Az 167.298
Level 4: 20 degrees
Jul 19 2011 10:25:20
(90) Antiope_20110719_8.2 DD
121.4 W; 38.2 N; 40 m
Zenith: r = 0; m = 8.2
Mini FOV; Chart 4-7

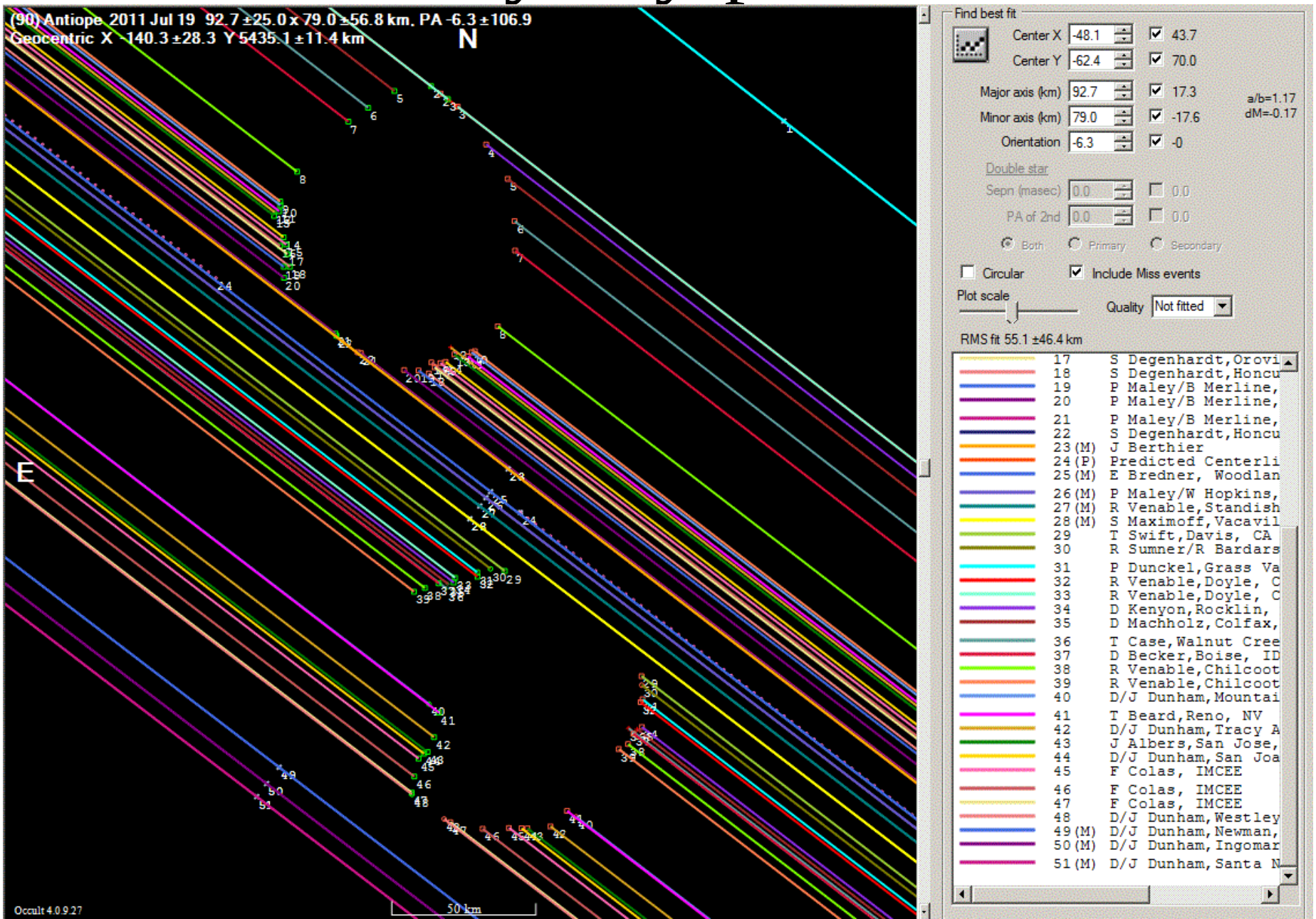
Setting up a mighty mini at my station #5 in Newman, Calif.

Light curve of the occultation at Dunham Station #1 west of Tracy, Calif.



The angular diameter of the red giant star caused the disappearance and reappearance to be gradual over several tenths of a second, with different durations at the two events due to different slopes of the asteroid's surface

Preliminary Sky-plane Profile



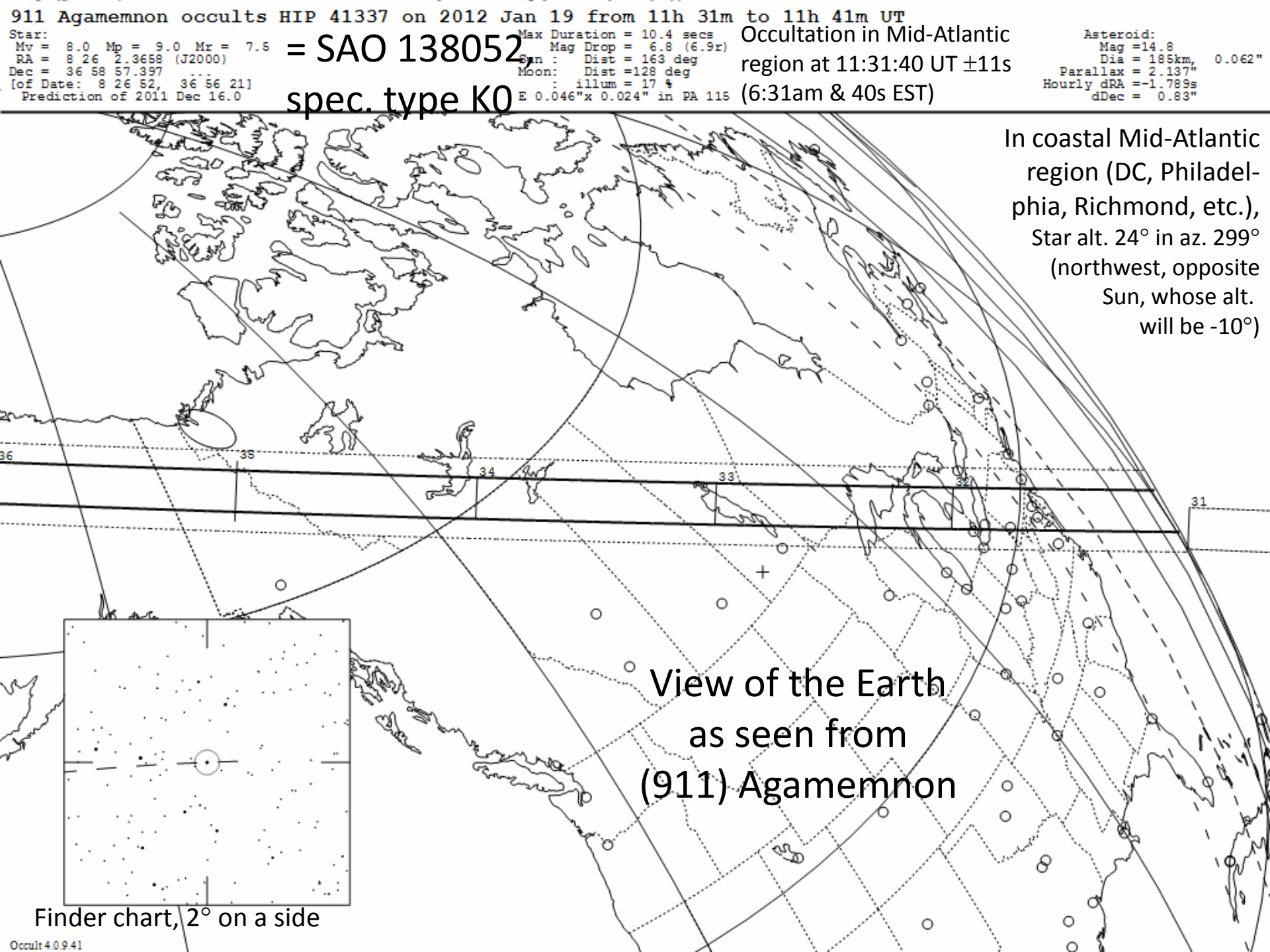
Occultation of SAO 60804, mag. 8.0, by the Trojan Asteroid (911) Agamemnon Thurs. morning, 2012 January 19

This is the best, most valuable asteroidal occultation over the MD/greater Washington, DC region this year

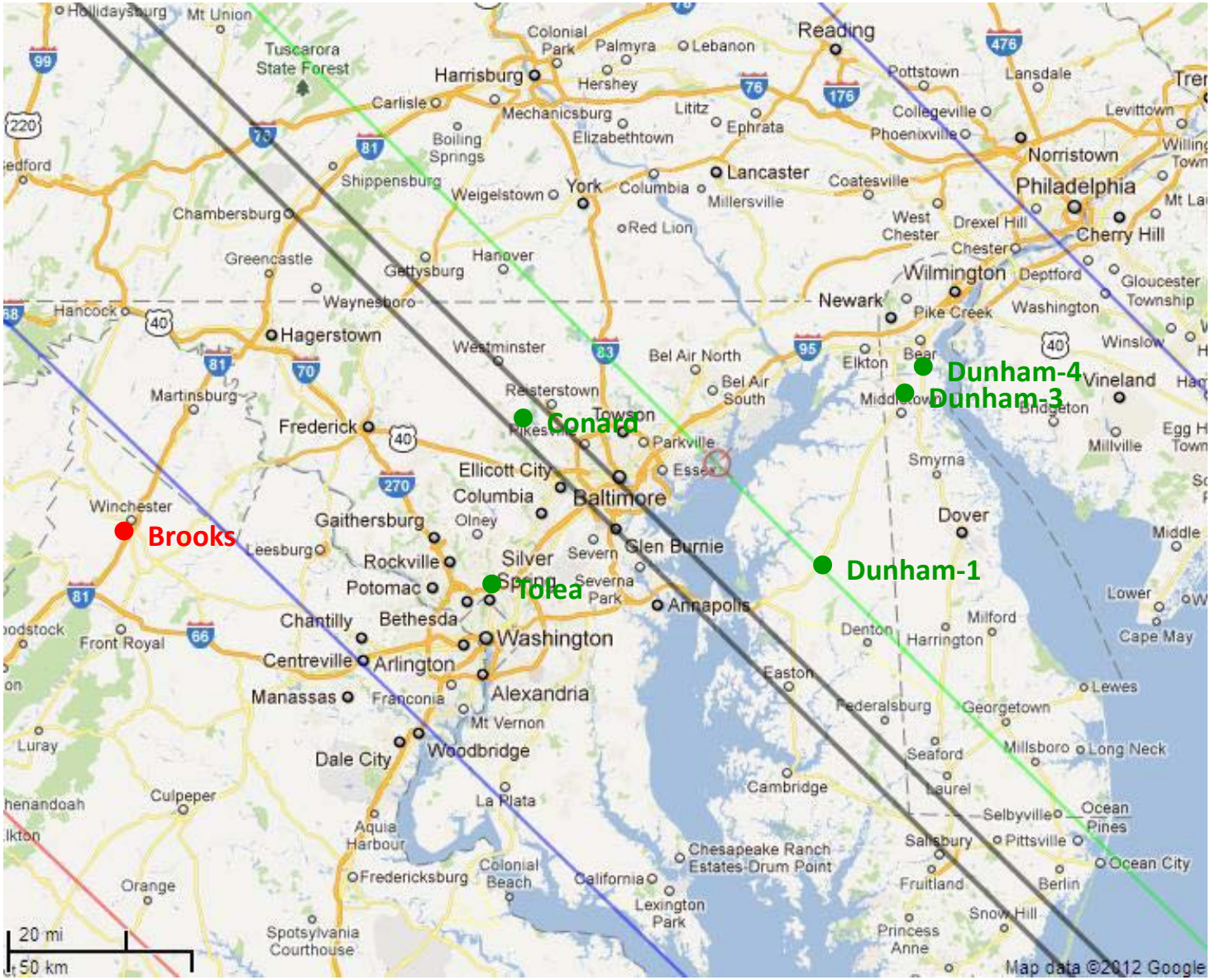
We need your help to observe it

Following are maps of the path, and several star charts to locate the star in obscure Lynx;

Pre-pointing may be needed by most to find the star


911 Agamemnon occults HIP 41337 on 2012 Jan 19 from 11h 31m to 11h 41m UT
Star:
Mv = 8.0 Mp = 9.0 Mr = 7.5
RA = 8 26 2.3658 (J2000)
Dec = 36 58 57.397
[of Date: 8 26 52, 36 56 21]
Prediction of 2011 Dec 16.0
Max Duration = 10.4 secs
Mag Drop = 6.8 (6.9r)
Sun : Dist = 163 deg
Moon: Dist =128 deg
: illum = 17 %
E 0.046"x 0.024" in PA 115
Asteroid:
Mag =14.8
Dia = 185km, 0.062"
Parallax = 2.137"
Hourly dRA =-1.789s
dDec = 0.83"
= SAO 138052,
spec. type K0
Occultation in Mid-Atlantic region at 11:31:40 UT ±11s (6:31am & 40s EST)
In coastal Mid-Atlantic region (DC, Philadelphia, Richmond, etc.), Star alt. 24° in az. 299° (northwest, opposite Sun, whose alt. will be -10°)
36
35
34
33
32
31
View of the Earth as seen from (911) Agamemnon
Finder chart, 2° on a side
Occult 4.0.9.41

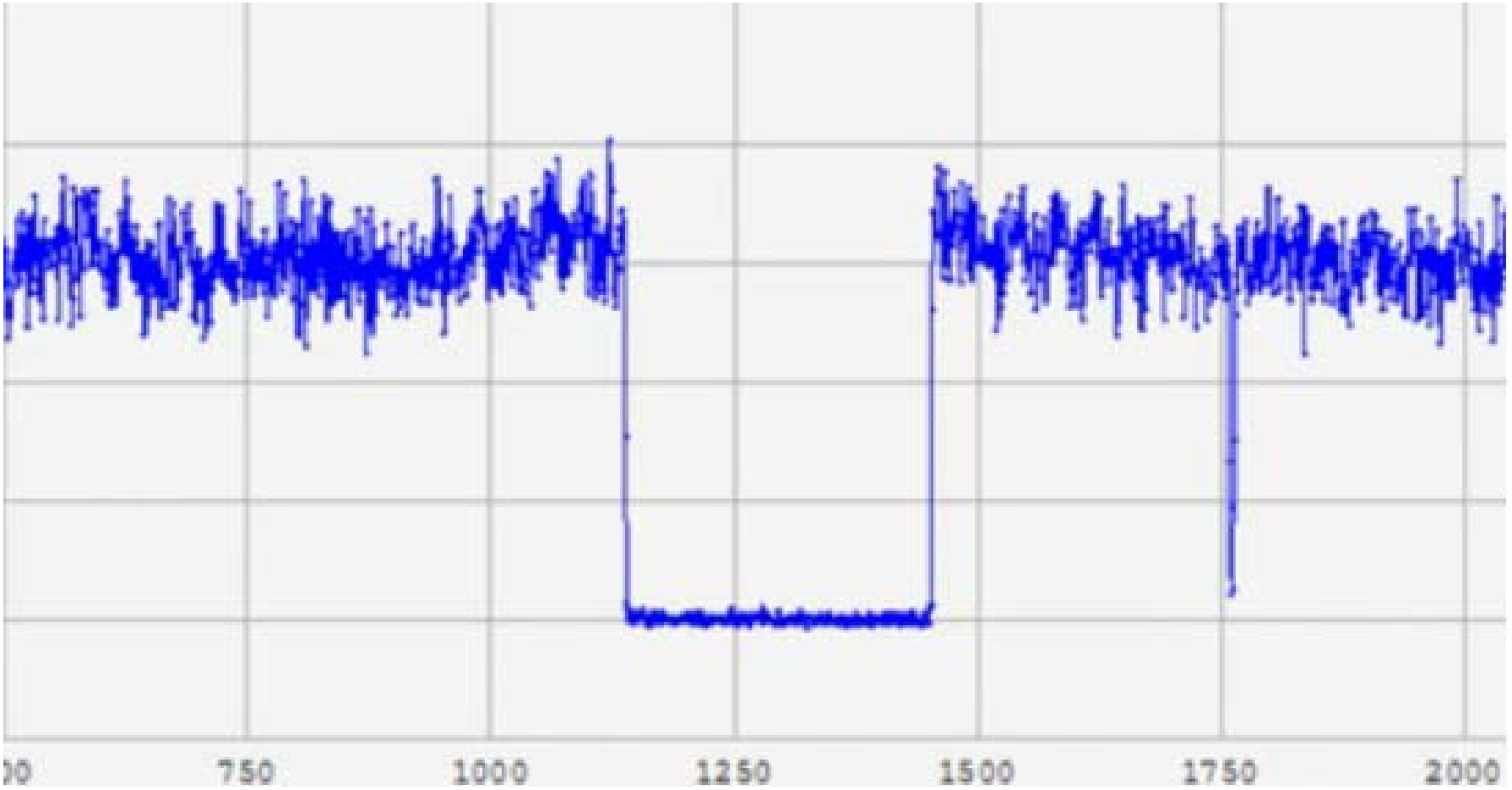
Map of 2012 Jan. 19th Agamemnon occ'n observers



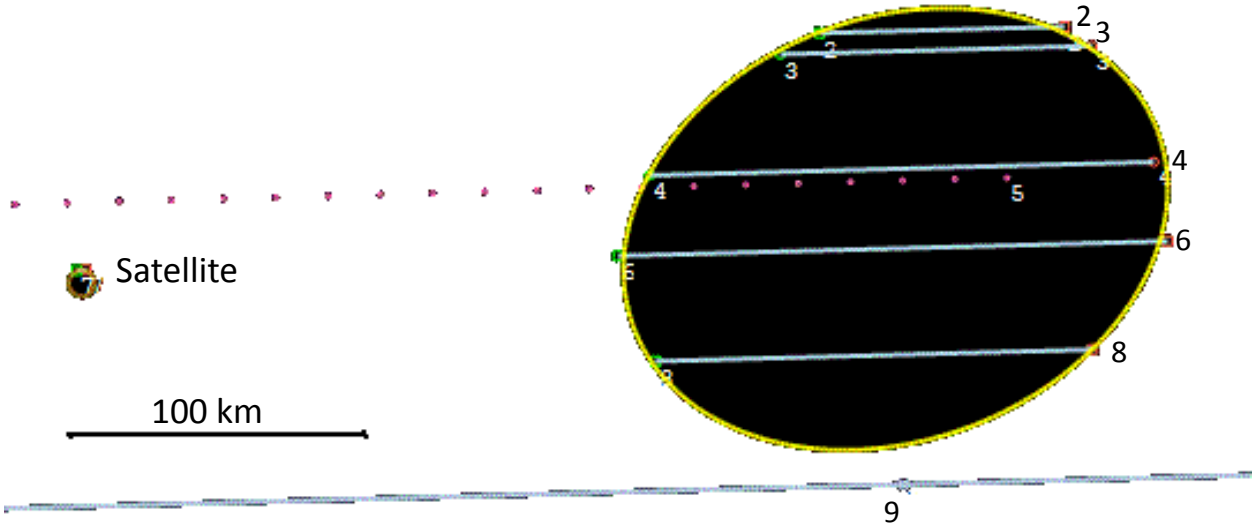
Dunham ran a 2nd station between #1 and #3 but the video recorder at #2 failed.

Green dots mark positive observations, while red (Brooks) indicates a miss (negative, no occ'n).
The green line is the predicted central line while the blue lines are the predicted path limits.
The gray lines mark a 10-km zone bracketing Conard's location where the satellite occ'n occurred.

Steve Conard's light curve of the Jan. 19th Agamemnon occultation



Sky-plane plot, 2012 Jan. 19th
(911) Agamemnon occultation



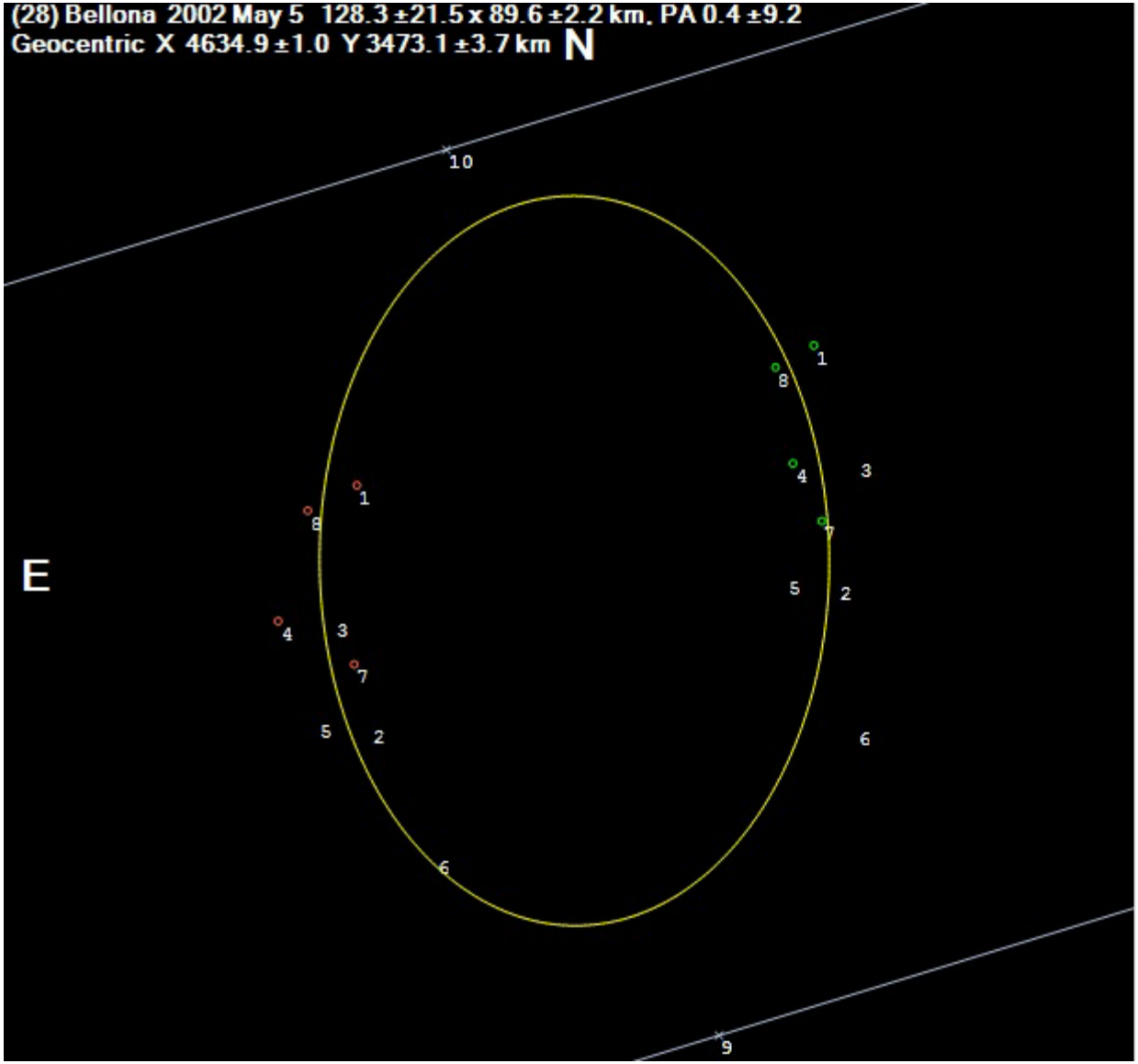
Agamemnon: Axes 190.6 ±0.9 by 143.8 ±1.5 km, PA minor axis -69.3° ±1.3°,
center X 4661.6 ±0.4 km, Y 3113.7 ±0.6 km; disappearances on right side
Satellite plotted as 9-km circle (but it's more likely about 4 km across)
0.0931″ (278 km in the plane) from Agamemnon's center in PA 93.8°

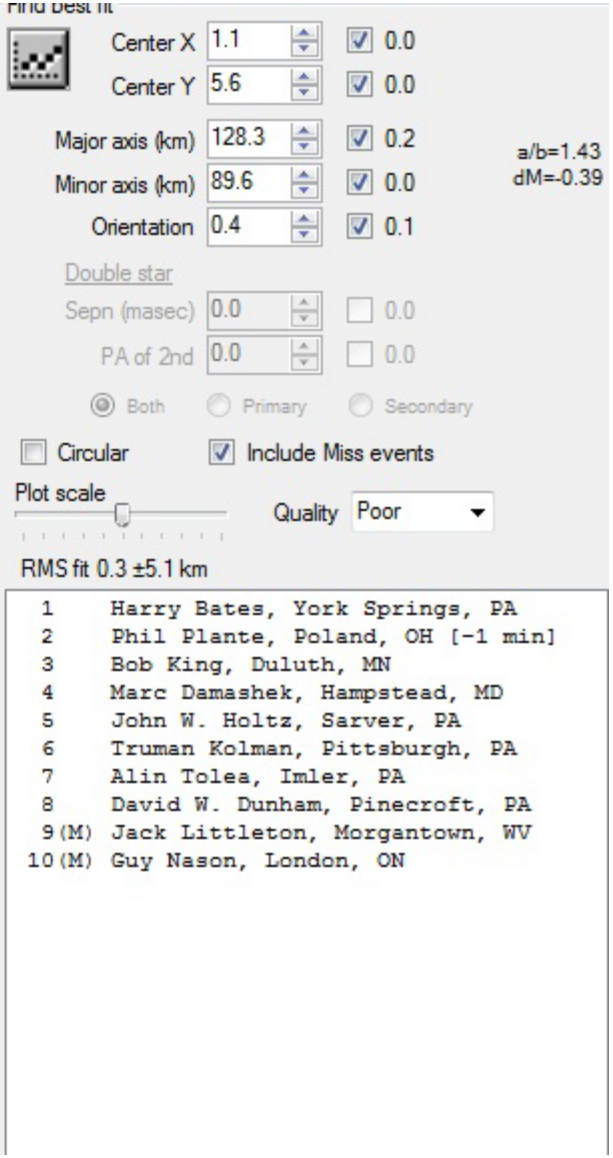
Occultation of 6.5-mag. SAO 140947 (HIP 78870) by asteroid (28) Bellona in the Khabarovsk area, 11 May 2012 evening

A plan to observe the occultation with five “mighty mini”s
set up across the path to measure the size and shape of Bellona

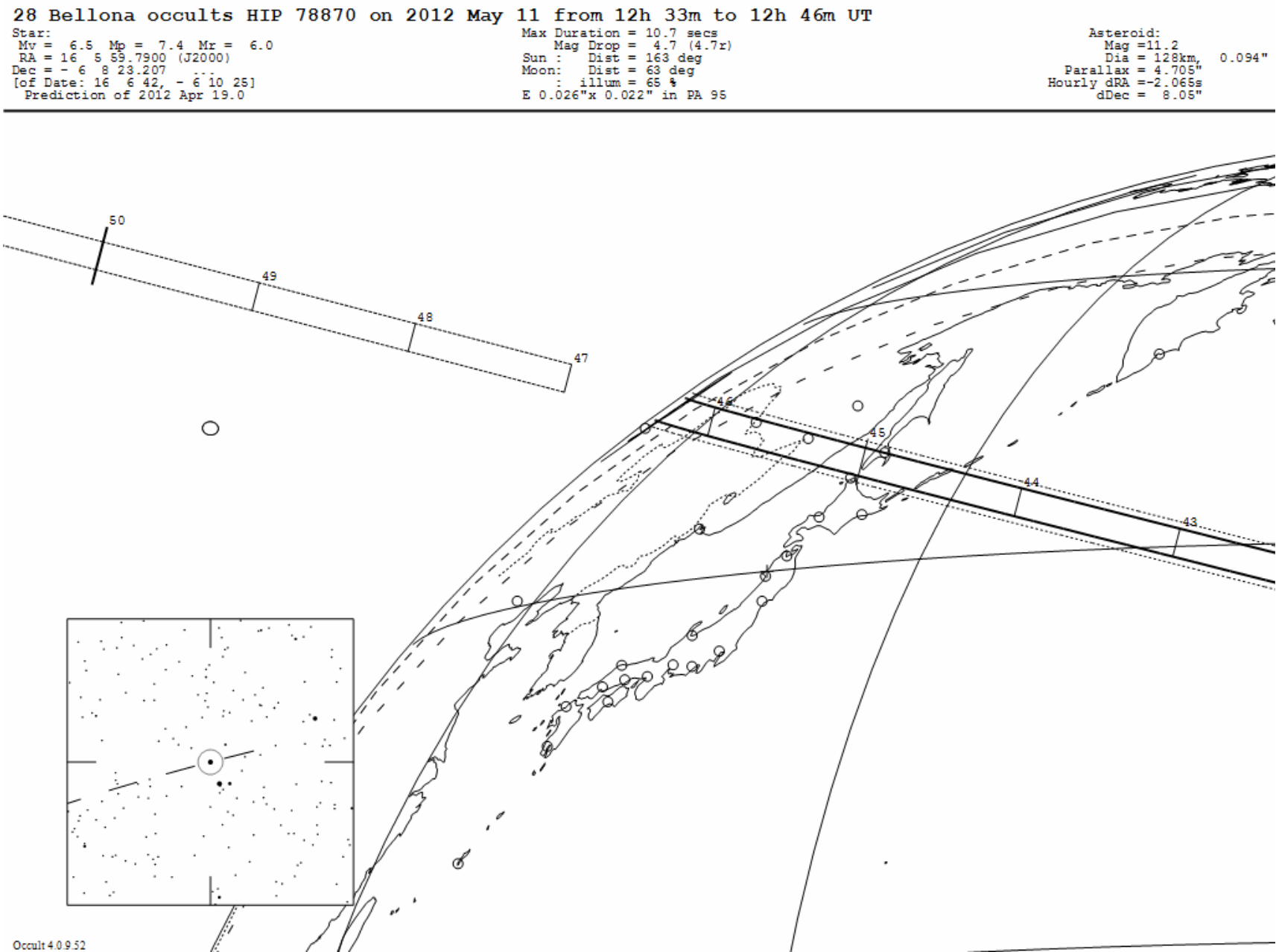
David W. Dunham, KinetX, Inc.,
Moscow Inst. of Electronics & Mathematics (MIEM),
and
International Occultation Timing Association (IOTA)

The best previously-observed Bellona occultation was observed in the northeastern U.S.A. almost 10 years before

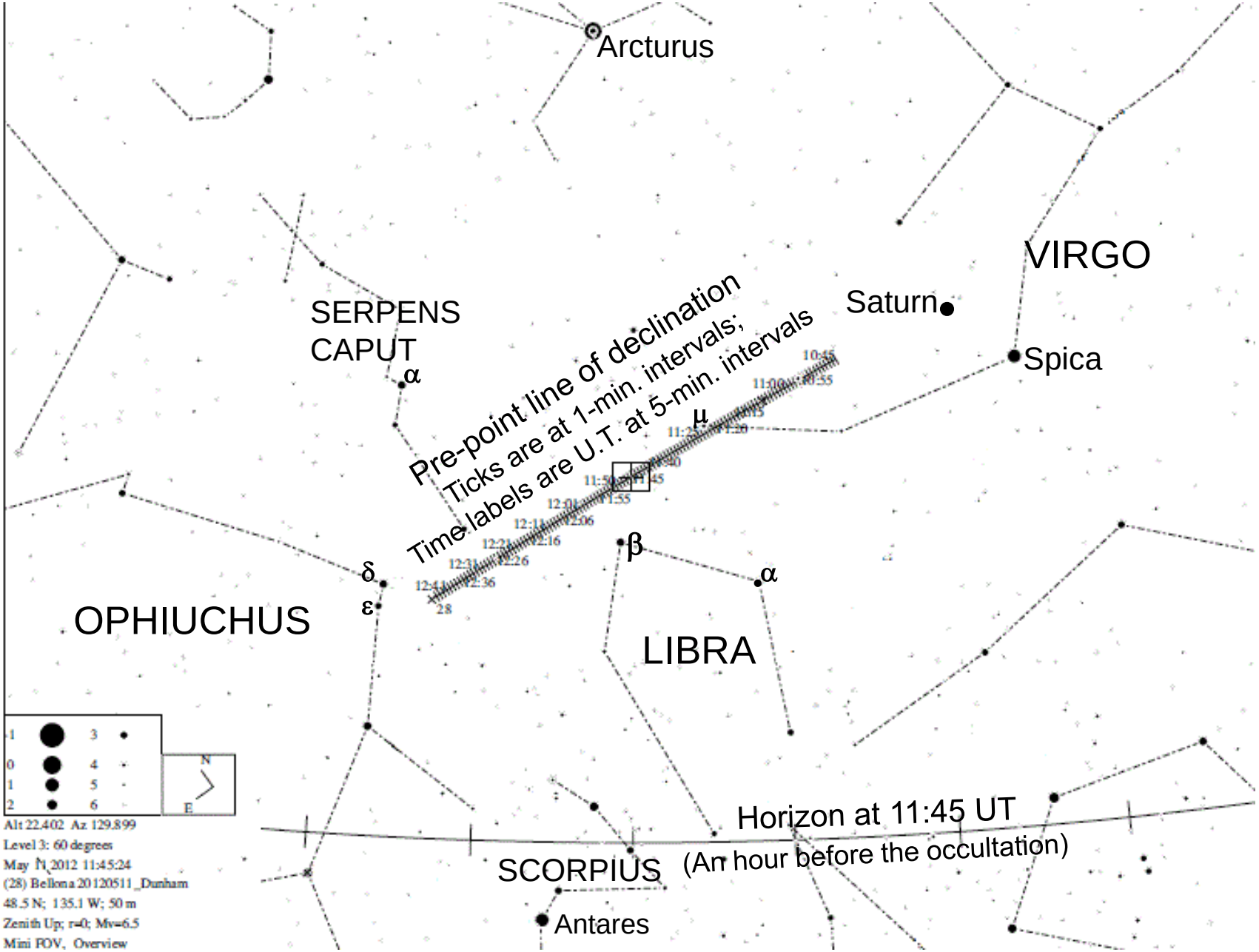




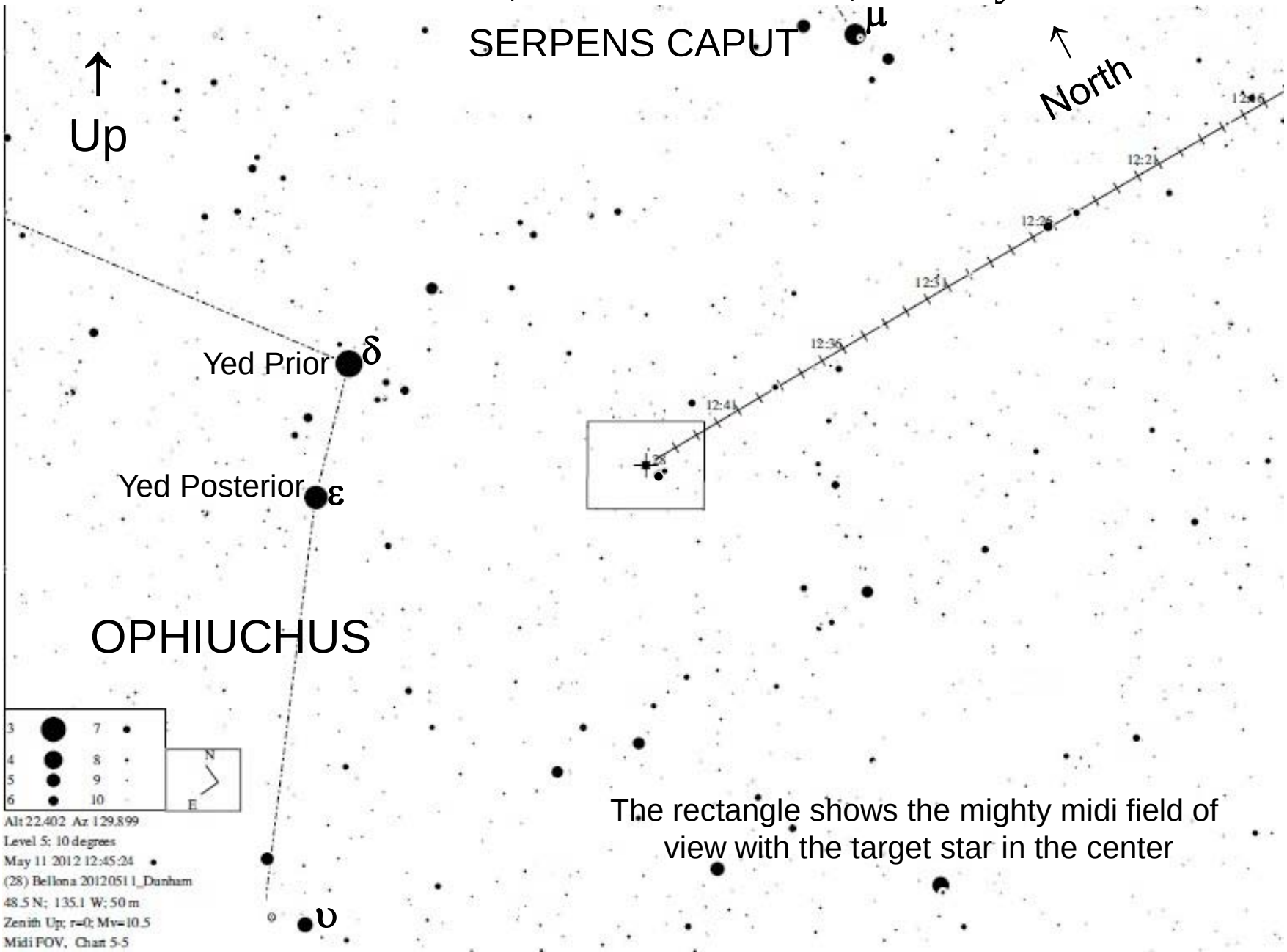
Next good Russian asteroidal occultation, Khabarovsk area, 11 May 2012



Naked Eye View, towards the southeast

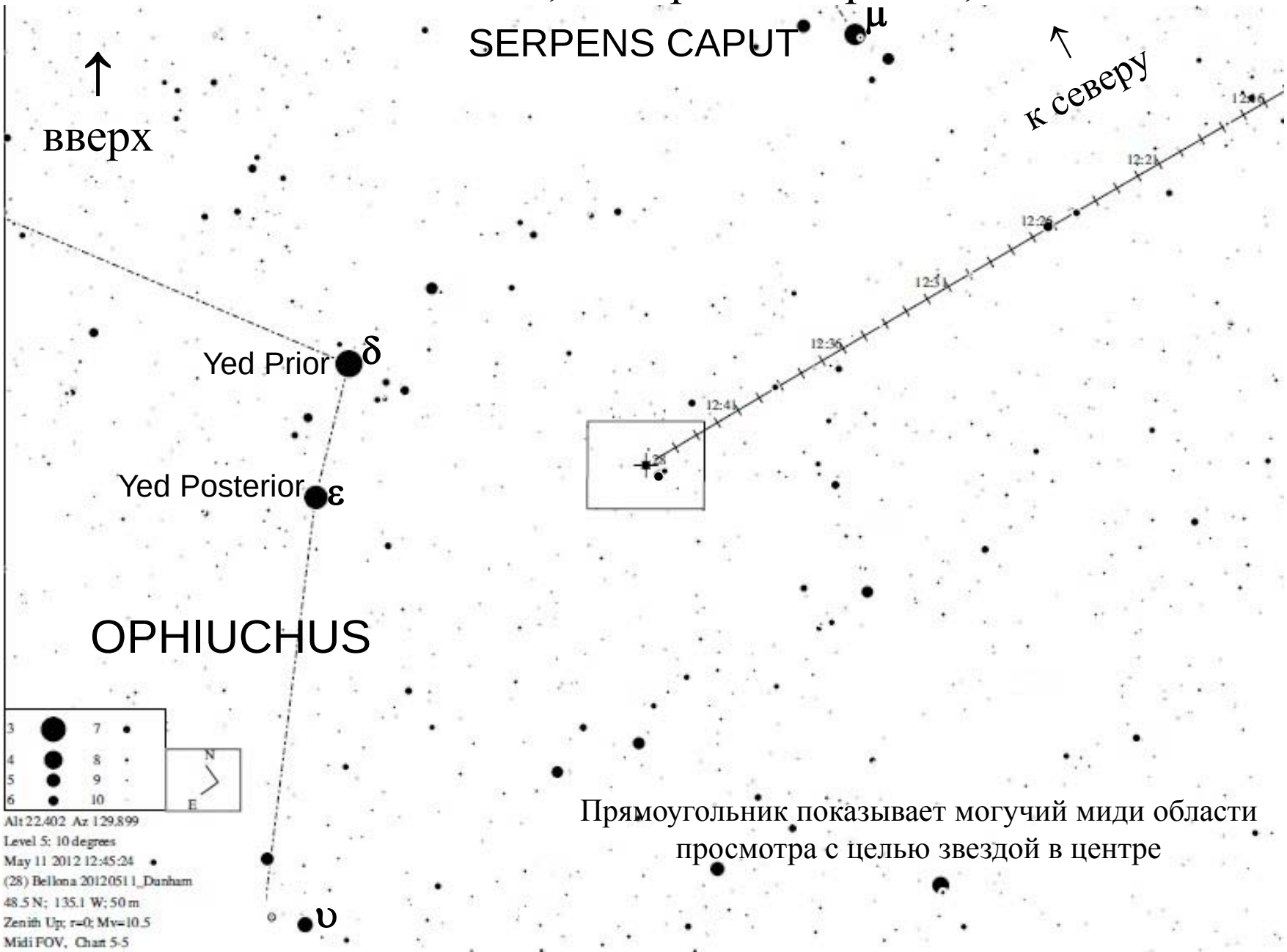


80mm Short-Tube Refractor or “Mighty Midi” view, (28) Bellona and SAO 140947, Khabarovsk area, 11 May 2012



The rectangle shows the mighty midi field of view with the target star in the center

80 коротких труб рефрактор или â € € œMighty Мидия зрения (28), Беллона и CAO 140947, Хабаровский район, 11 мая 2012

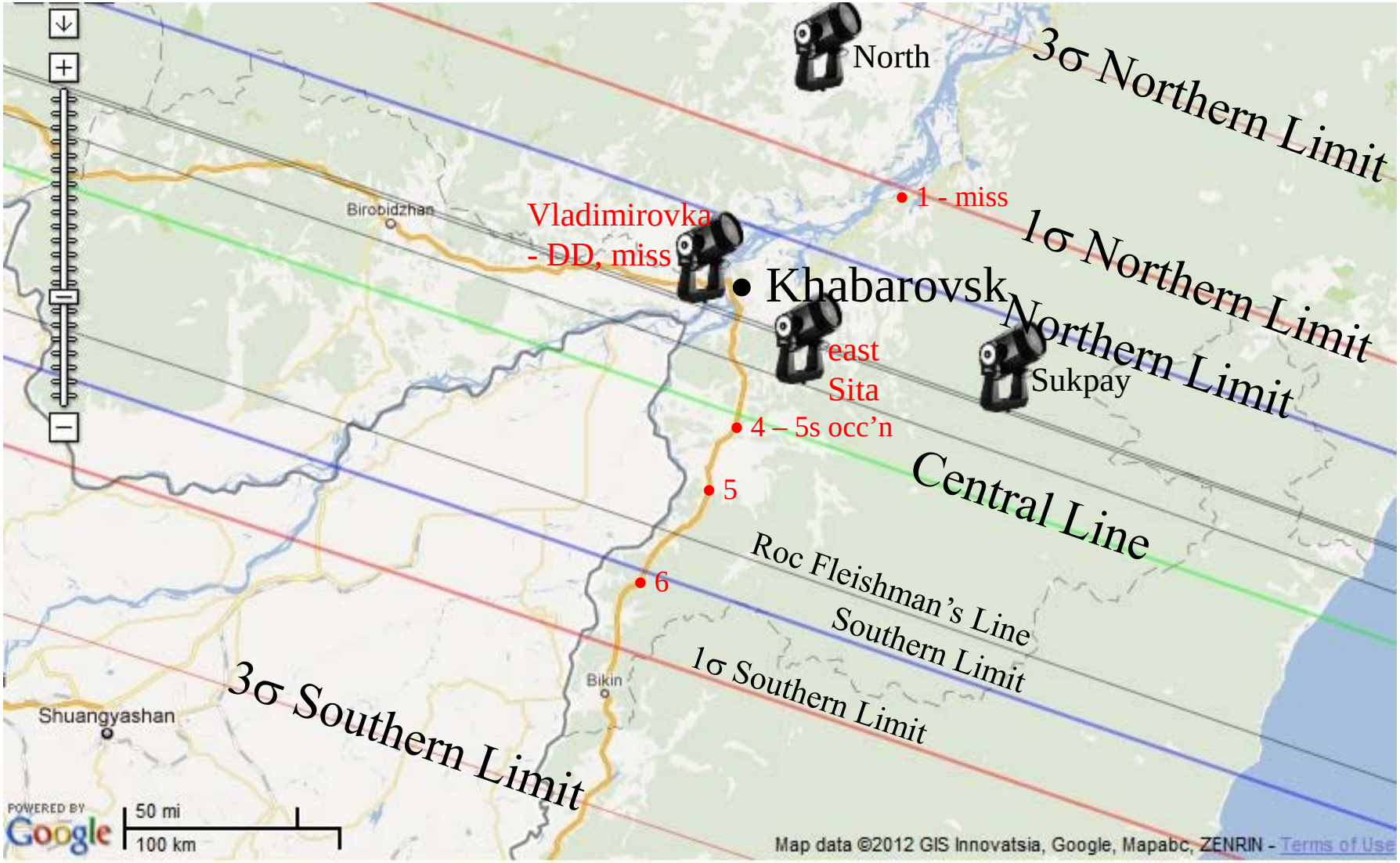


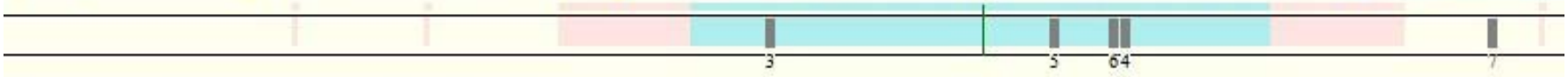
Прямоугольник показывает могучий миди области просмотра с целью звездой в центре


ГРАФУ
МУРАВЬЕВУ-АМУРСКОМУ
1891


9 мая
РОСНЕФТЬ

Stations around Khabarovsk for the 2011 May 11 (28) Bellona Occultation





Observing locations currently announced by other observers:

3 = Fleishman R Home; 4 = Vladimirovka Igor dacha; 5 = 7km e. Sita, RU; 6 = Sukpay, RU ; 7 = David Dunham (100km nne KHV friend dacha)