Latest Developments with Multistation Deployments

19 April 2016

Lucky Star Meeting

Paris Observatory (remote)

David W. & Joan B. Dunham

John Broughton

Outline

- Basics of Multi-Station Deployments – “Pre-pointing”
- (Very) brief history of multi-station deployments – first attempts
- (almost) a year in Australia, N.Z., and Indonesia
  - Design and test new occultation observation equipment & techniques
  - Major observational results
- 25cm “Suitcase” Telescope (2 fit in standard airline suitcase)
- Paver Mounts Allow Previous-Night Pre-pointing for early evening events – Pre-point on a 30cm paver stone that is left in the bush
- New light-weight design for Paver Mounts
- Many more occultations will be accurately predicted following the first release of Gaia data later this year, giving many more opportunities for you to use the techniques that we have pioneered

Diagram explaining the geometry of a lunar occultation, and of grazes visible near the limits

Figure 2-1a

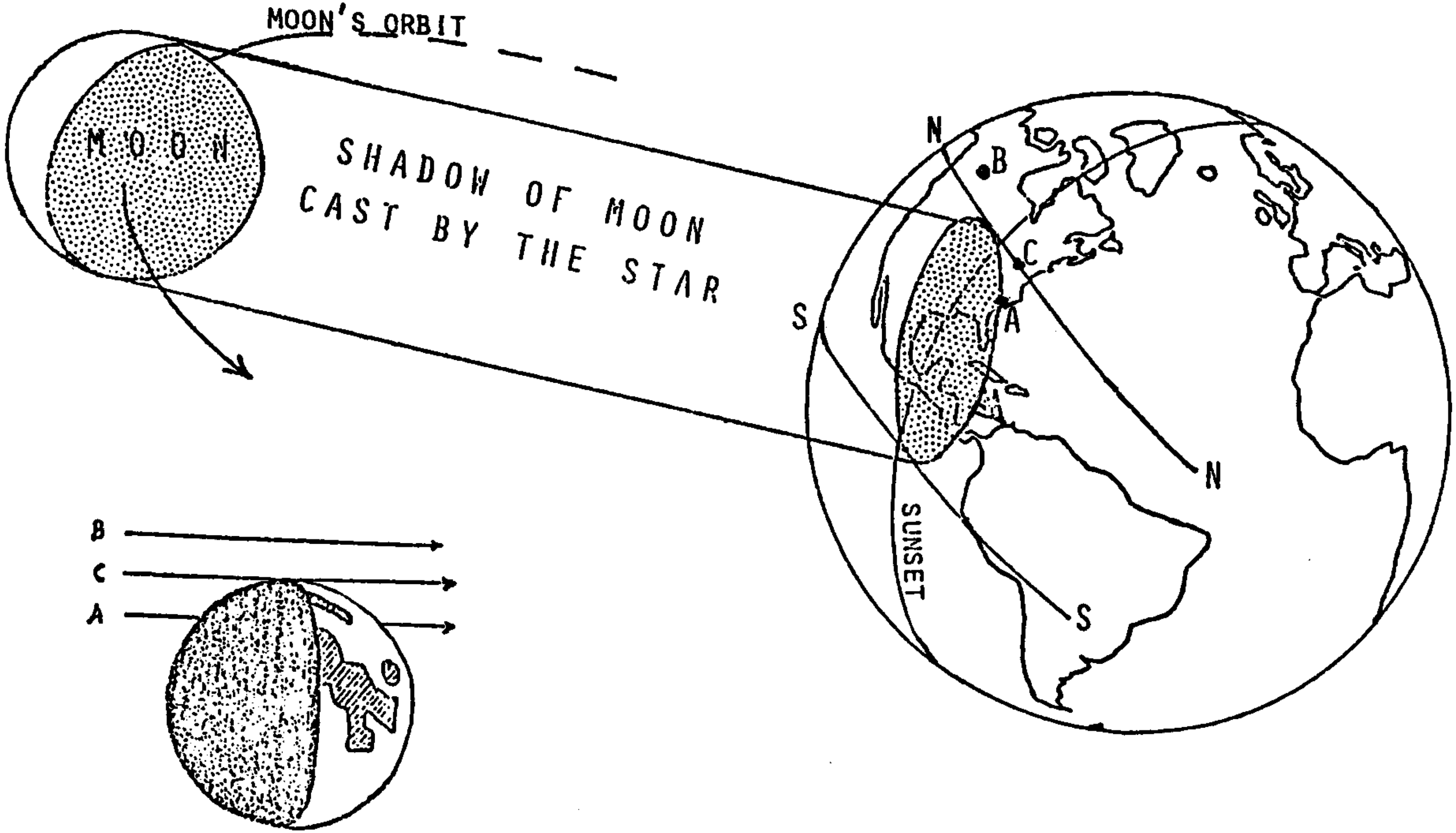
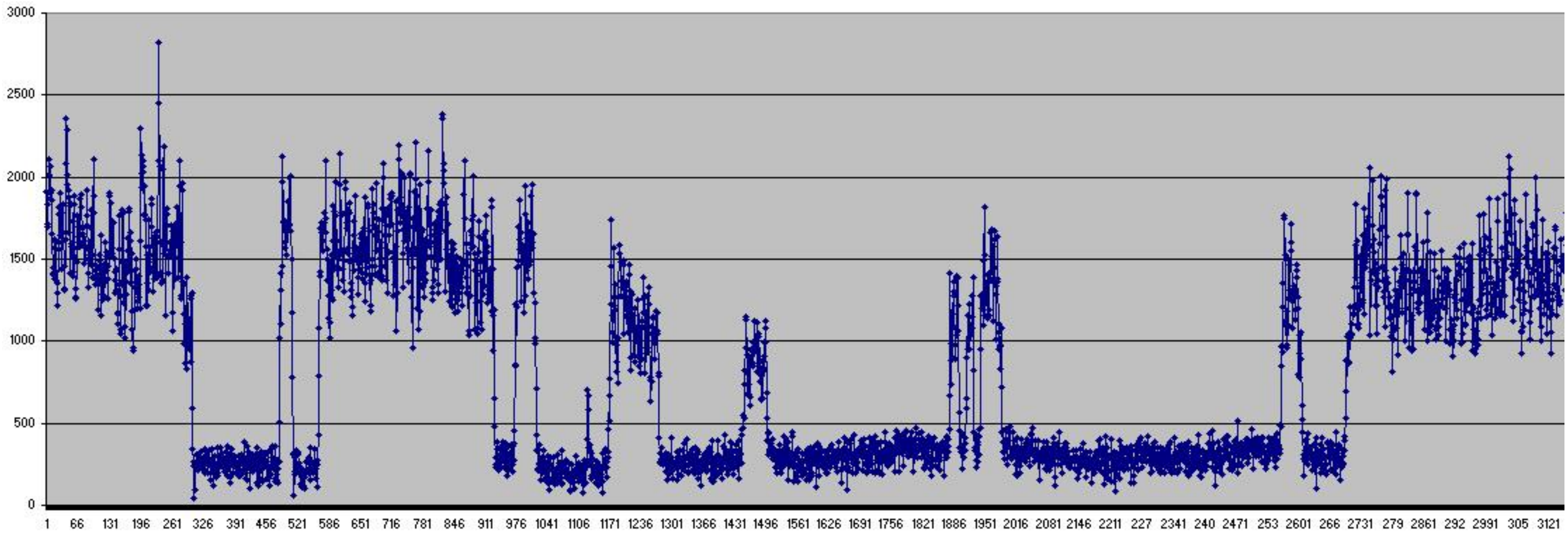


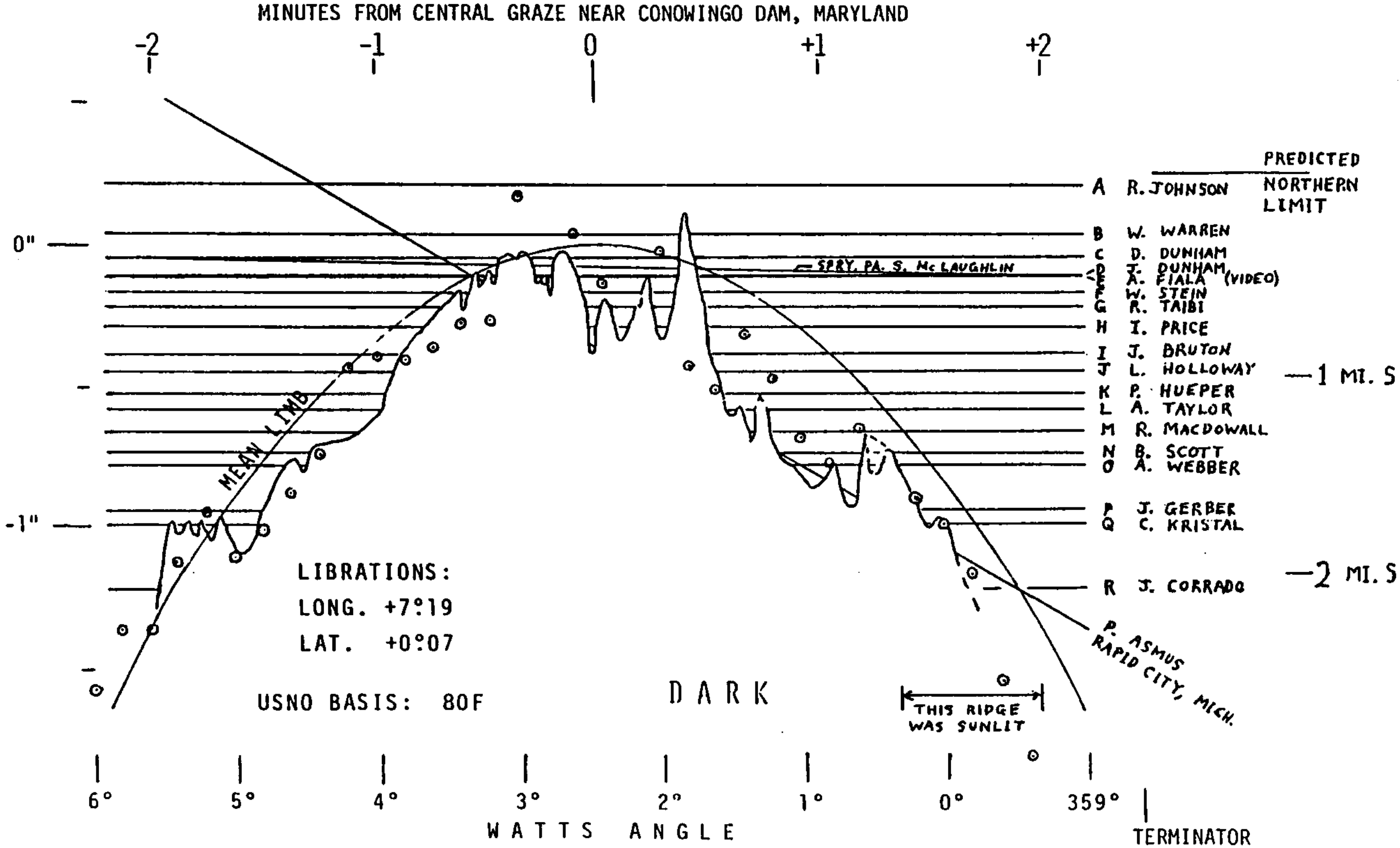
Figure 2-1b

Light curve from Bob Sandy's video recording of the 2007 June 12th grazing occultation of μ Arietis



This is a very close double star, but it was near periastron with separation about 0.01″ so the duplicity was resolved only with a few events (such as the first D on the left, & "faint flash" in center

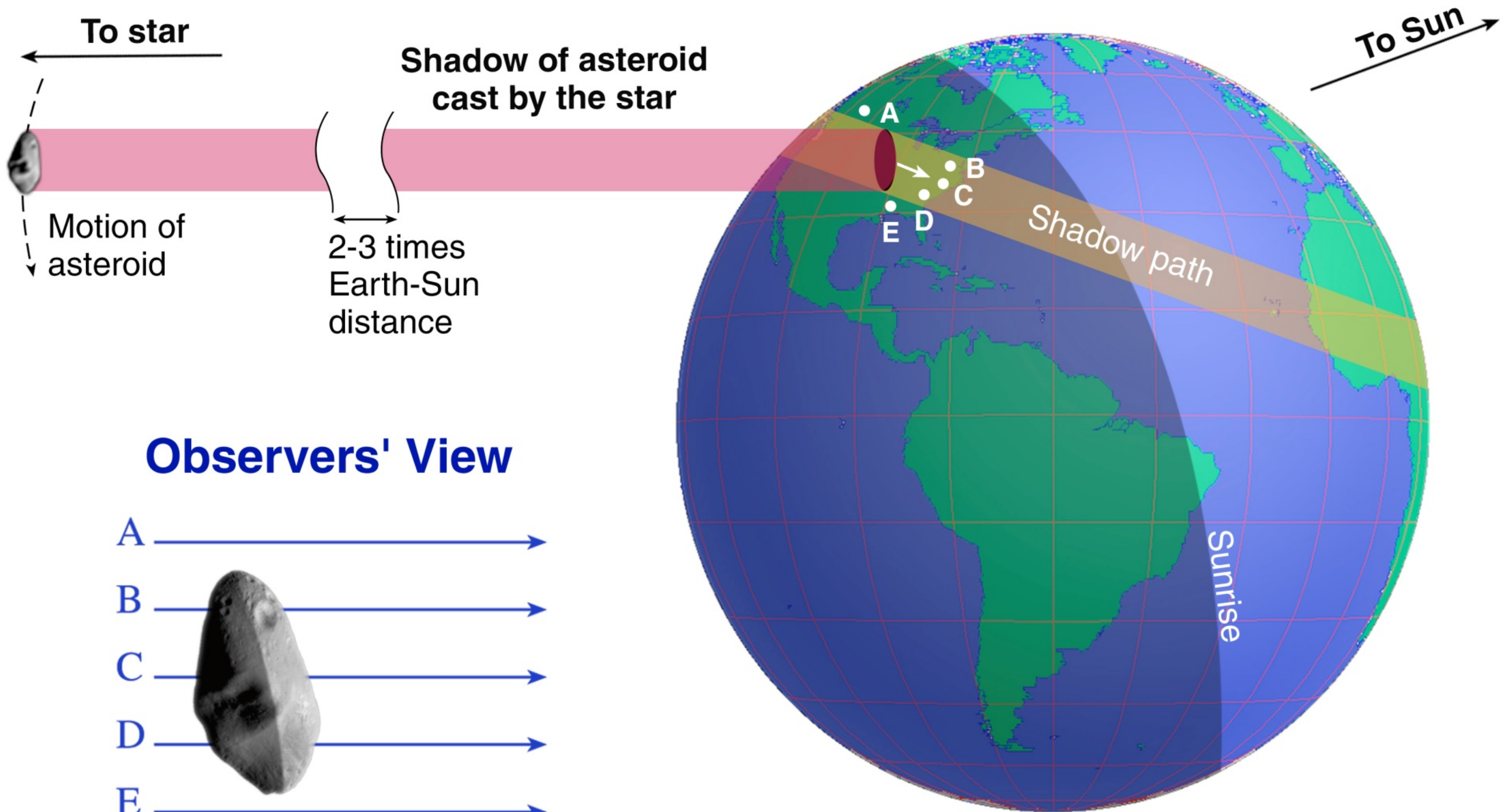
Lunar Profile from the well-observed Grazing Occultation of delta Cancri – 1981 May 9-10



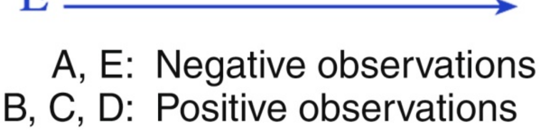
Circled dots are Watts' predicted limb corrections

The first remote stations were run for lunar grazing occultations starting in 1998, with tracking mounts and stations a few hundred meters apart

Geometry of an Asteroid Occultation



Observers' View



01-0417-5

The more stations that can be deployed, The better the resolution of the asteroid's shape

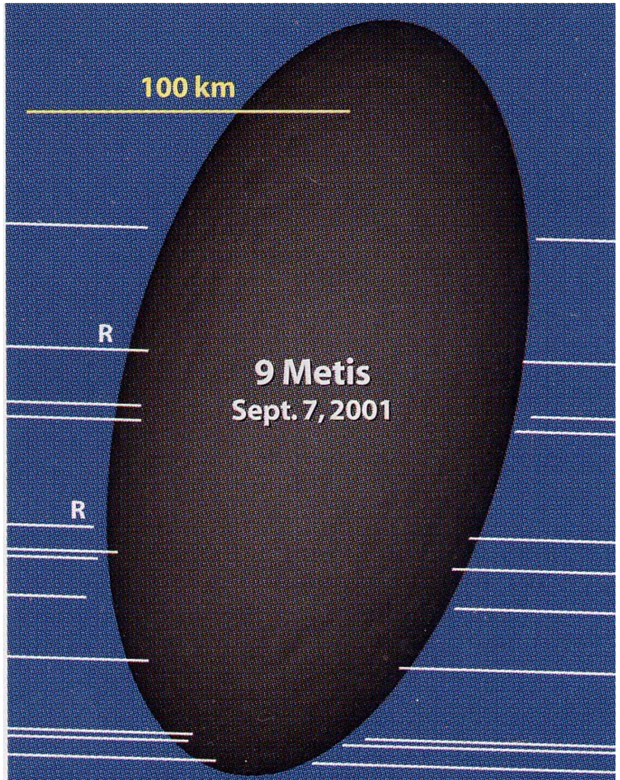
Remote Stations for Asteroidal Occultations

- 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; these factors are all taken into account with current Guide 8, and the Occult 4 pre-point star lists.
- Can usually find "pre-point stars" that are much easier to find than the target
- Find a safe but accessible place for both the attended & remote scopes

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.; it occurred 2 nights before the Titania occultation, on which other observers concentrated their efforts
- I made the first REMOTE recording of an asteroidal occultation during this event, in the Sacramento Valley of northern California, using a telephoto lens
- 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, Calif.

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.


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

Complete portable occultation timing setup (air carryon)

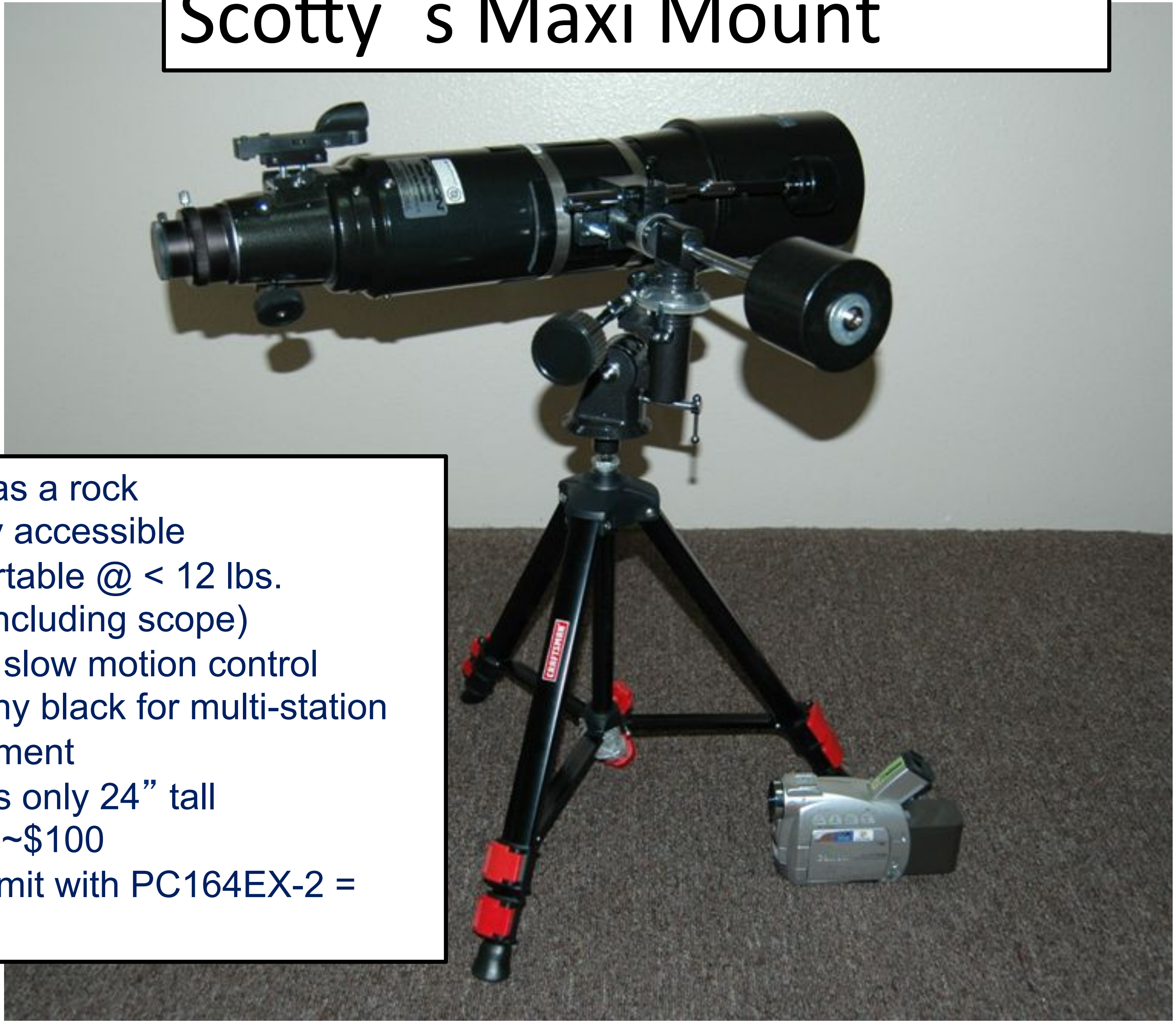
Success depends on availability of inexpensive sensitive easy-to-use video cameras and high-fidelity recorders, such as the PC164C-EX2 (discontinued about a year ago) and Canon mini-DV tape camcorders (ZR models, last made in 2004). It is becoming harder to find suitable equipment; a new inexpensive digital system is needed.

Mighty Midi – Orion 80mm short tube

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

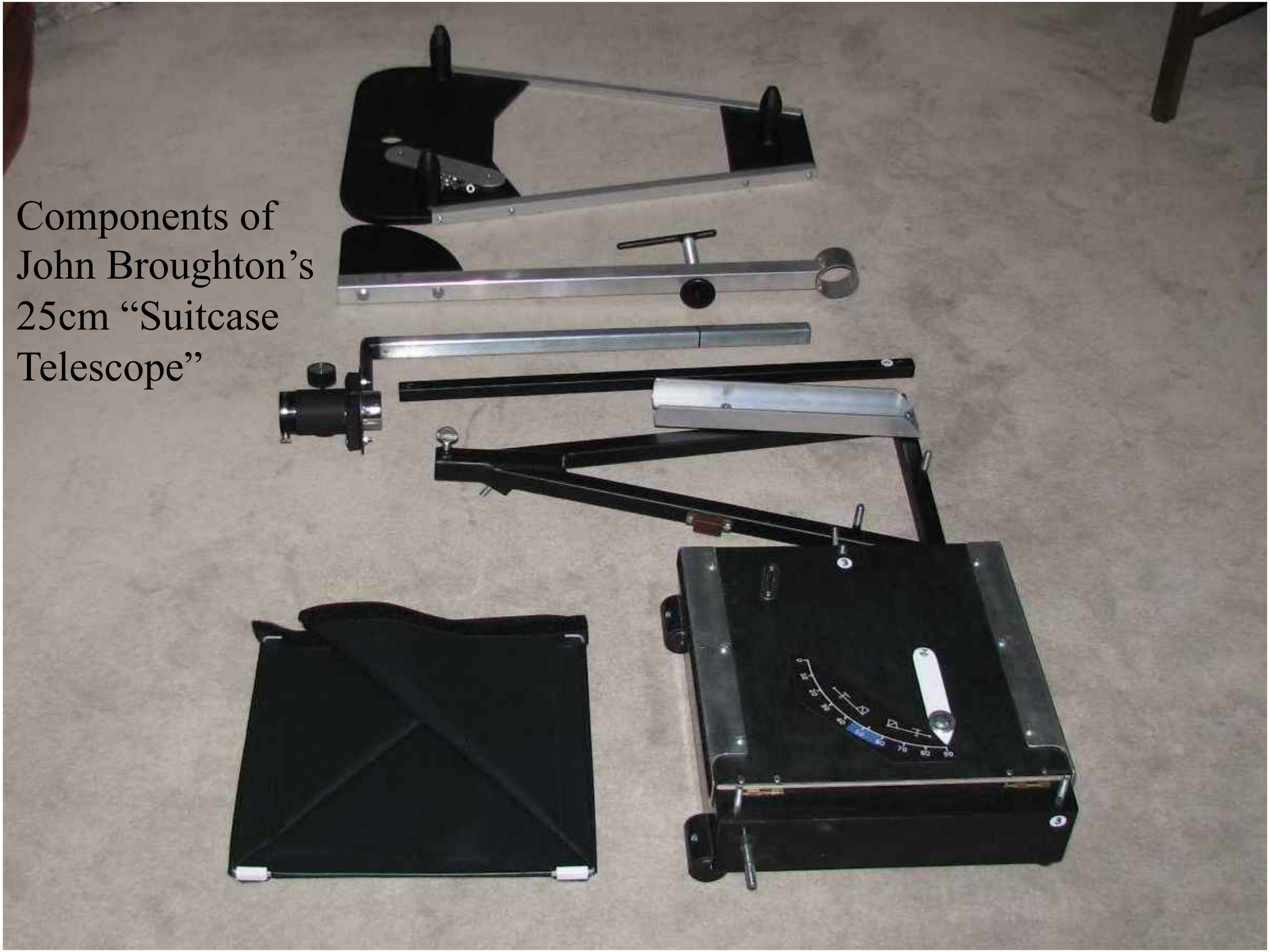
I use visual finder scope and $60 Quantanray tripod while Scotty uses a mighty mini video as the finder and MX-350 tripod (not as sturdy as the Quantanray)

Scotty's Maxi Mount

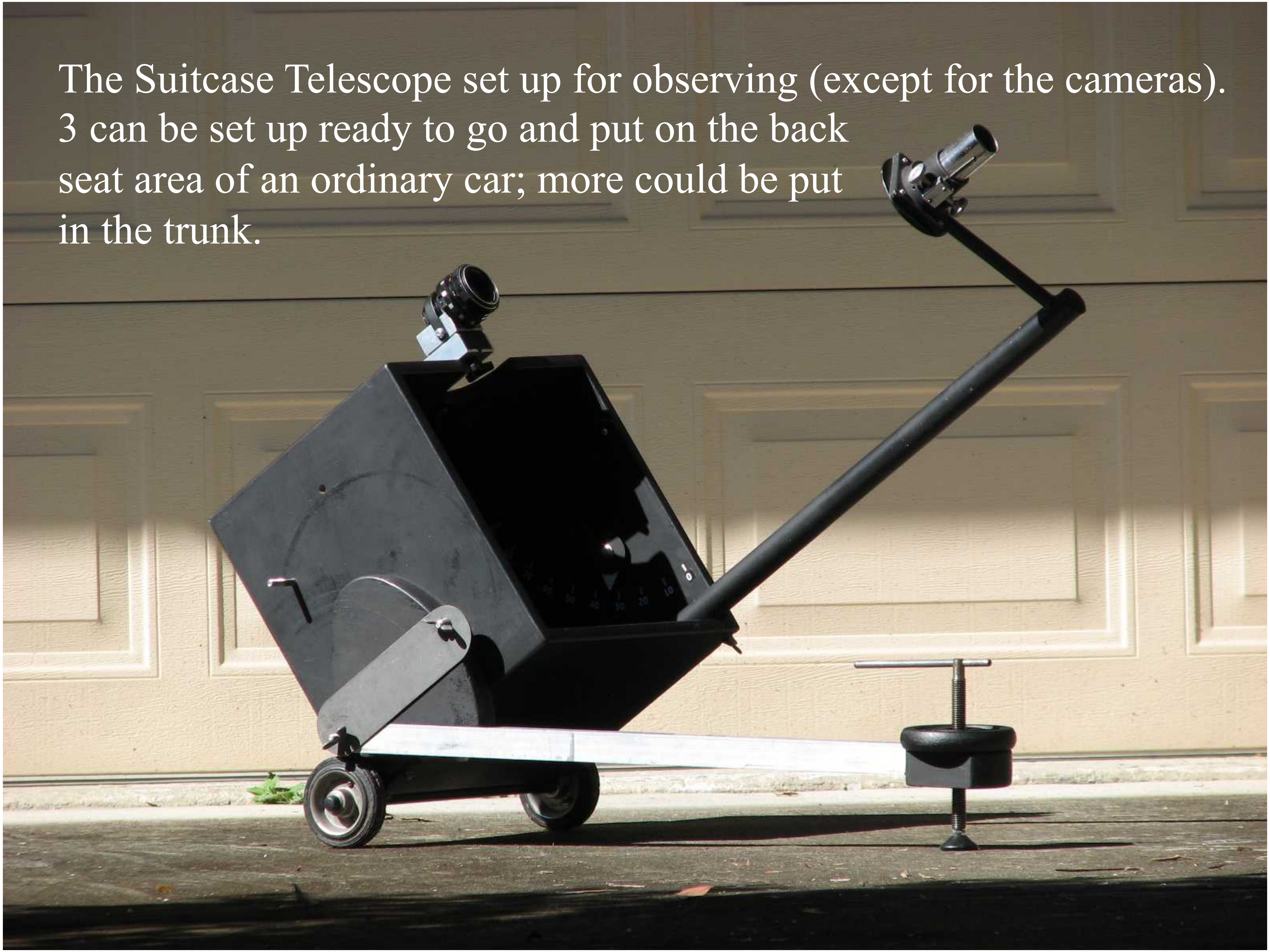


- Solid as a rock
- All sky accessible
- Air portable @ < 12 lbs.
- (<20 including scope)
- 2 axis slow motion control
- Stealthy black for multi-station deployment
- Stands only 24" tall
- Costs ~$100
- Mag limit with PC164EX-2 = **12.5**

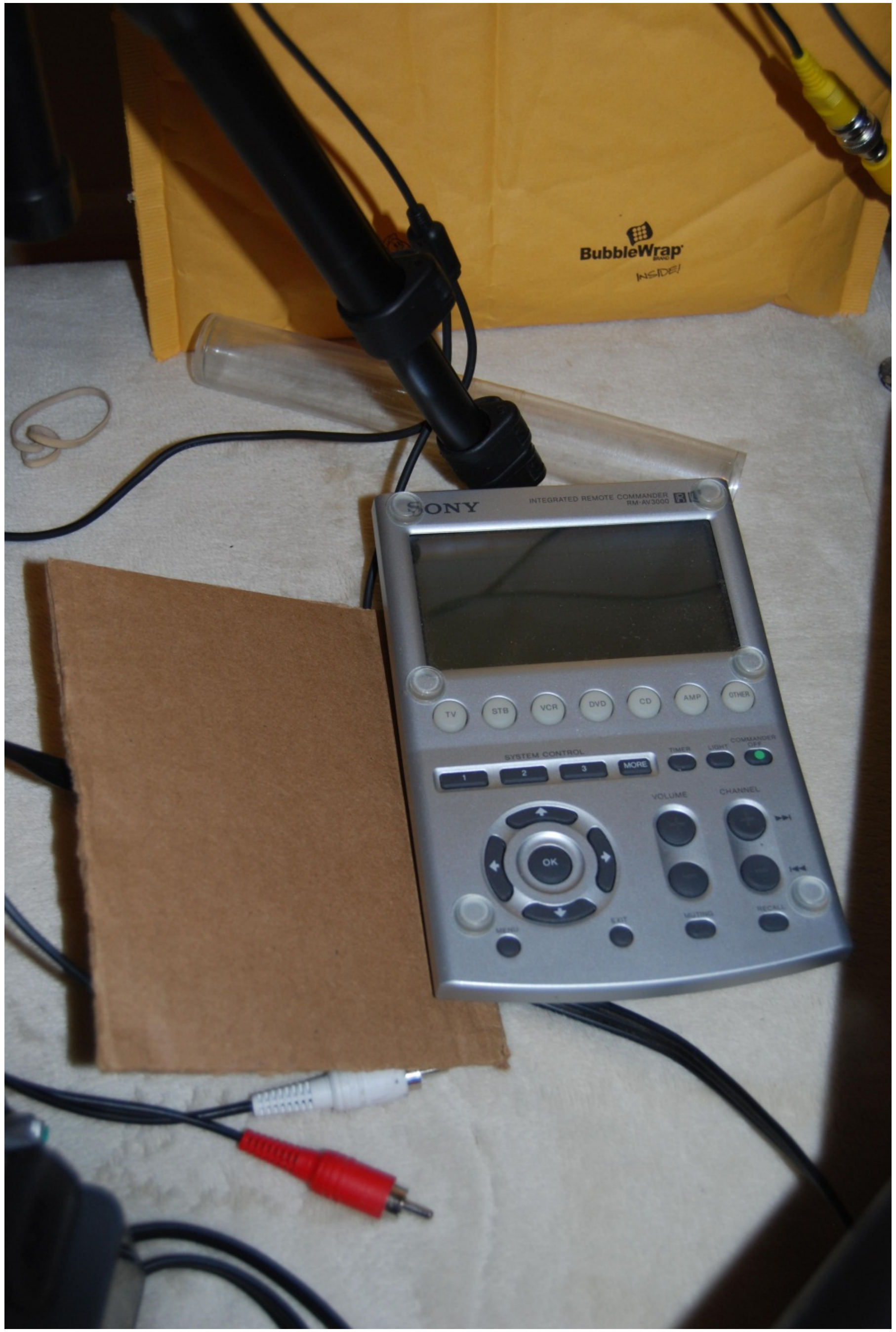
Components of John Broughton's 25cm "Suitcase Telescope"



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

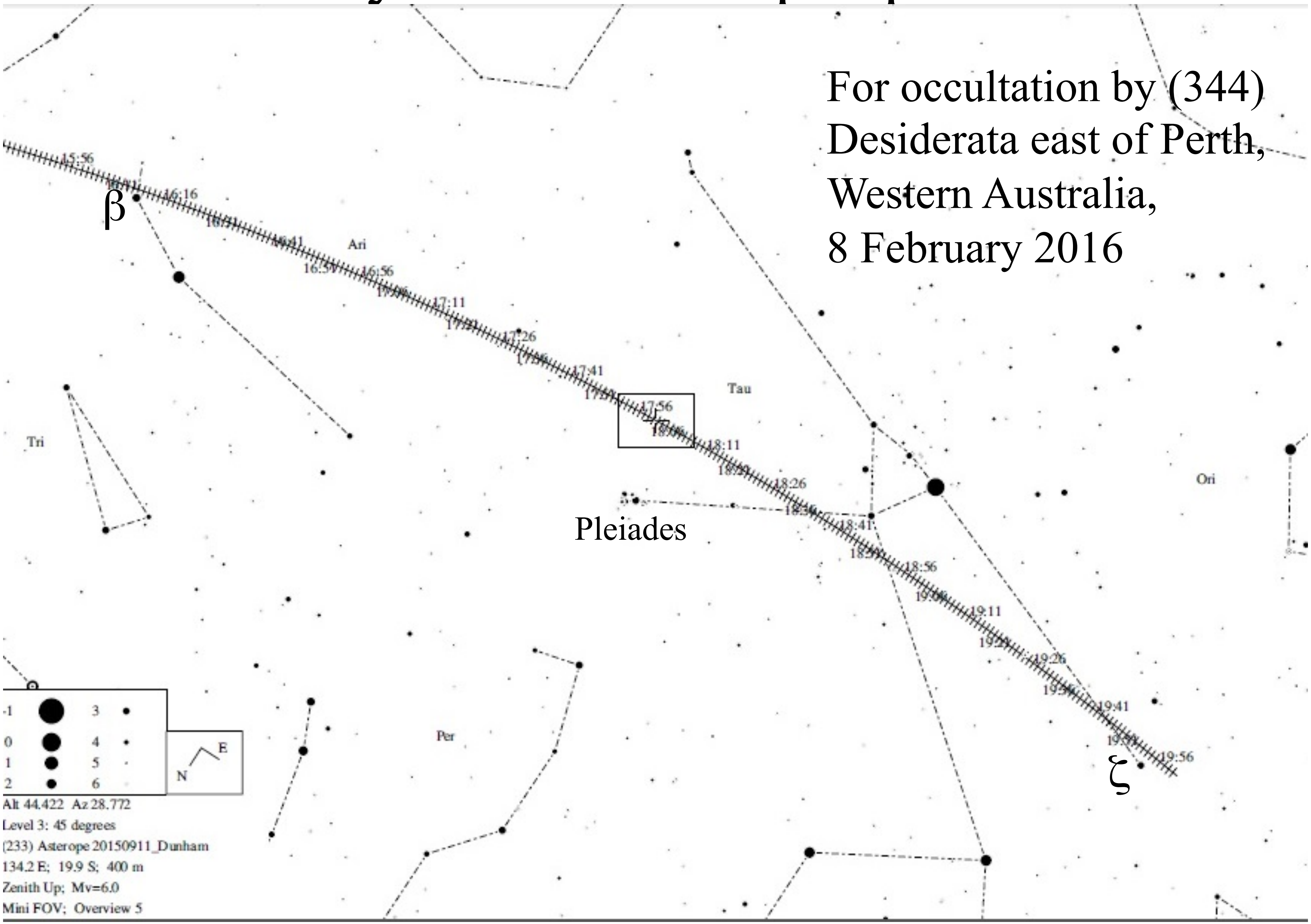

The Suitcase Telescope set up for observing (except for the cameras). 3 can be set up ready to go and put on the back seat area of an ordinary car; more could be put in the trunk.

Programmable Remote for Timed Recordings

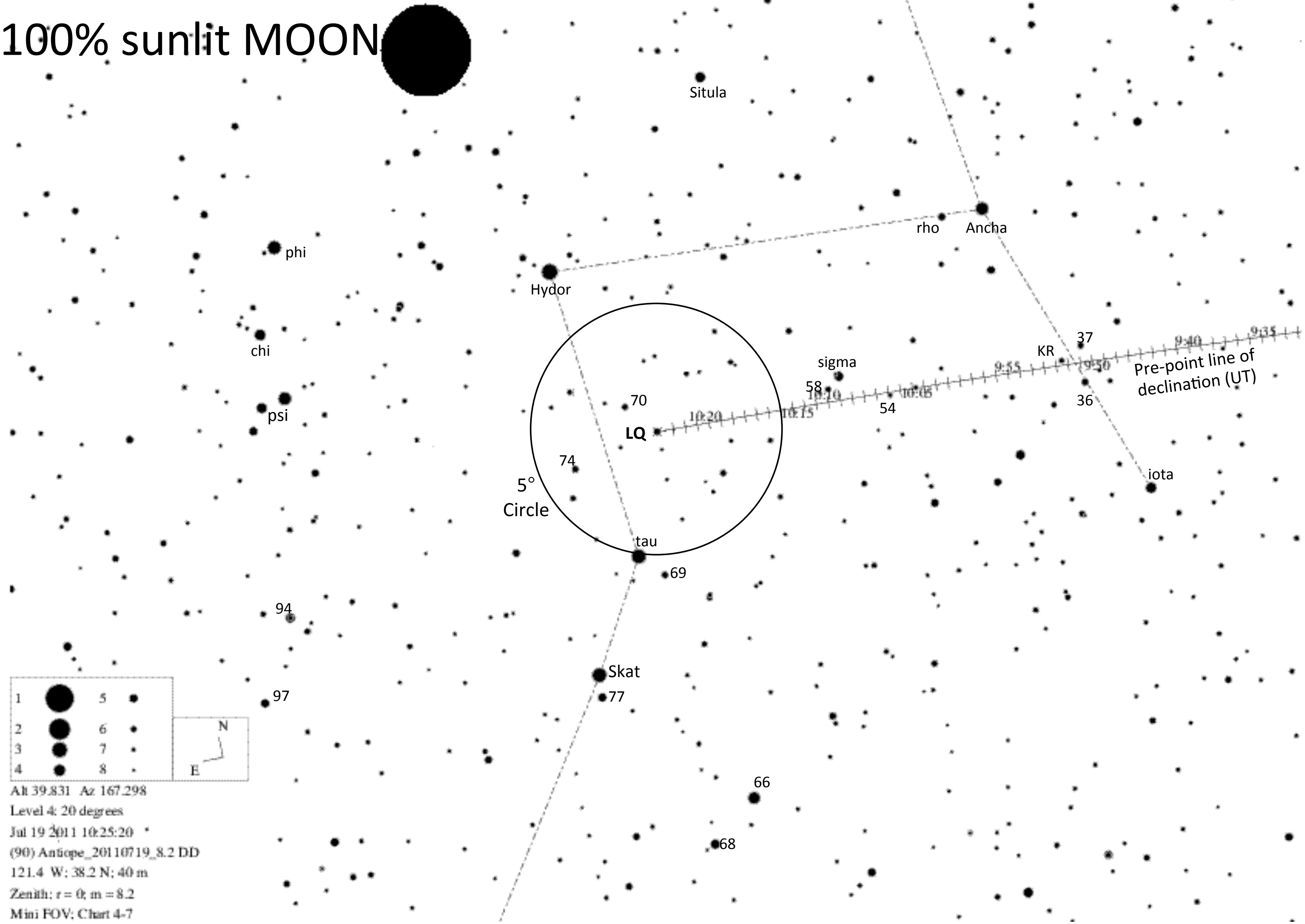


Suggested by Steve Conard. Scotty found a “100% effective” system. Place transparent plastic tube (I believe made from 2 coin holders fastened together with Scotch tape; shown at foot of tripod) at bottom of the brown mailing bag in the background. After setting the programmable remote, place it pointing 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.

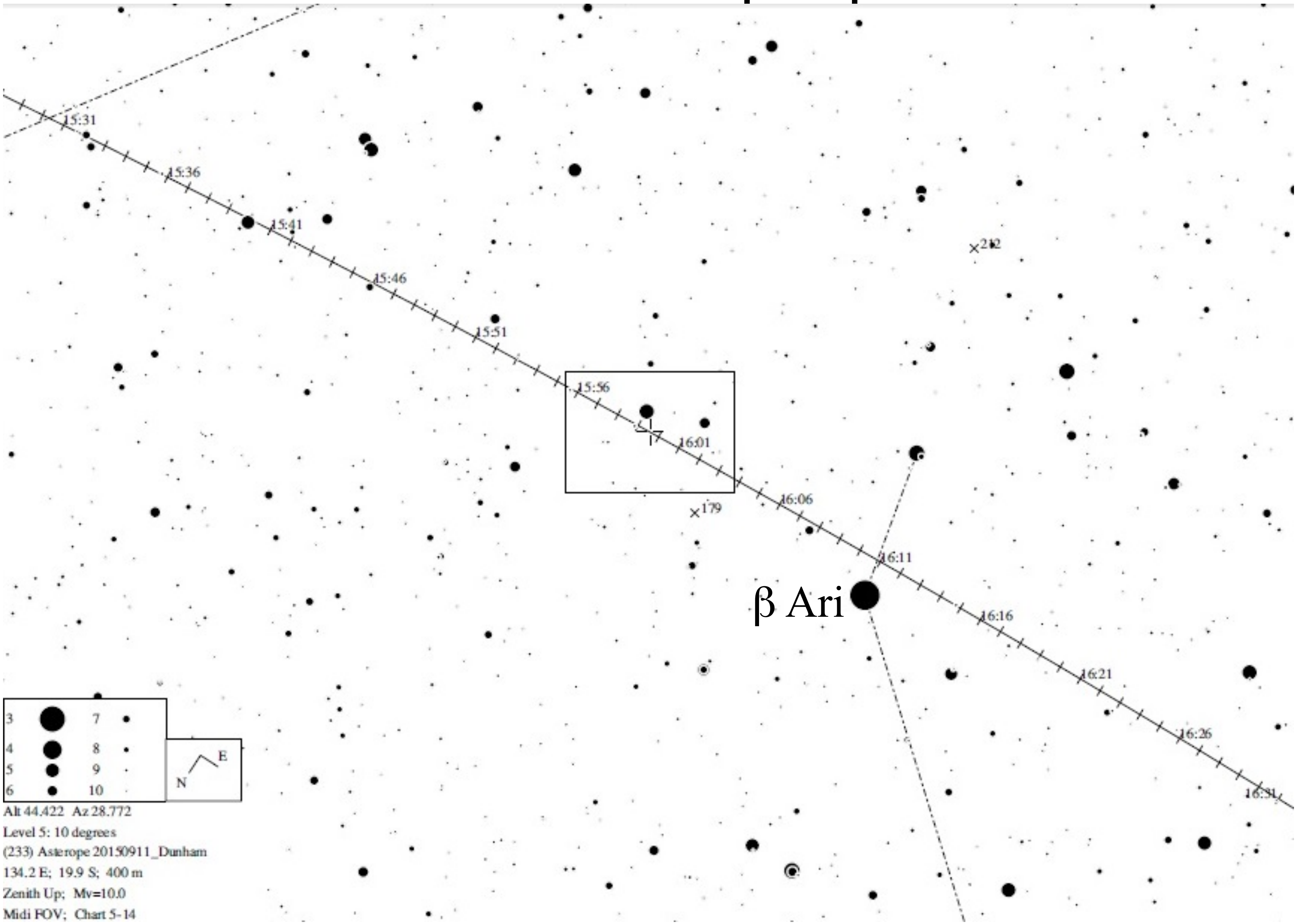
Naked-eye "overview" pre-point chart



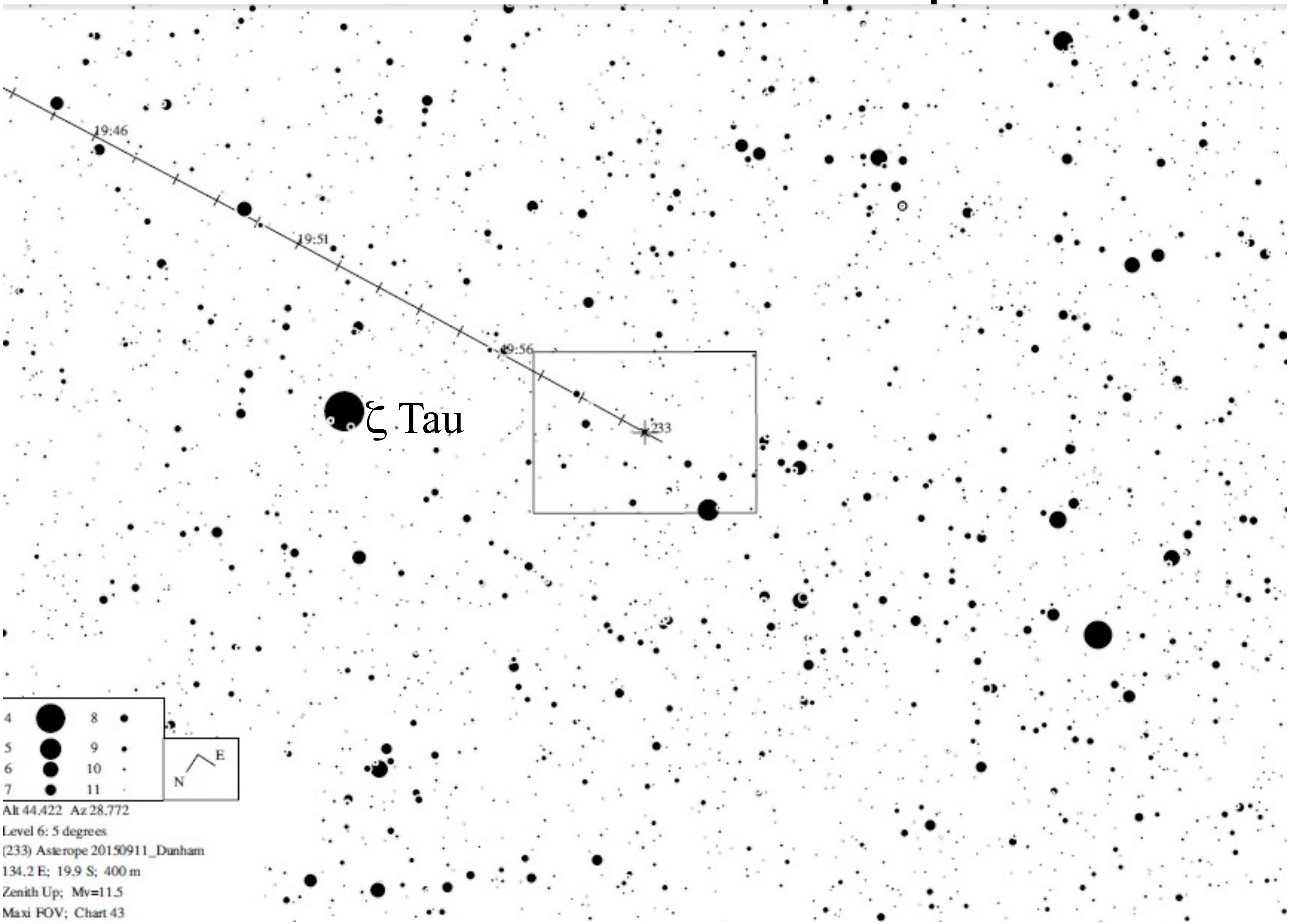
Last level 4 (for finder scope or mighty mini) pre-point chart for the 19 July 2011 Antiope occultation



80mm “midi” level 5 pre-point chart

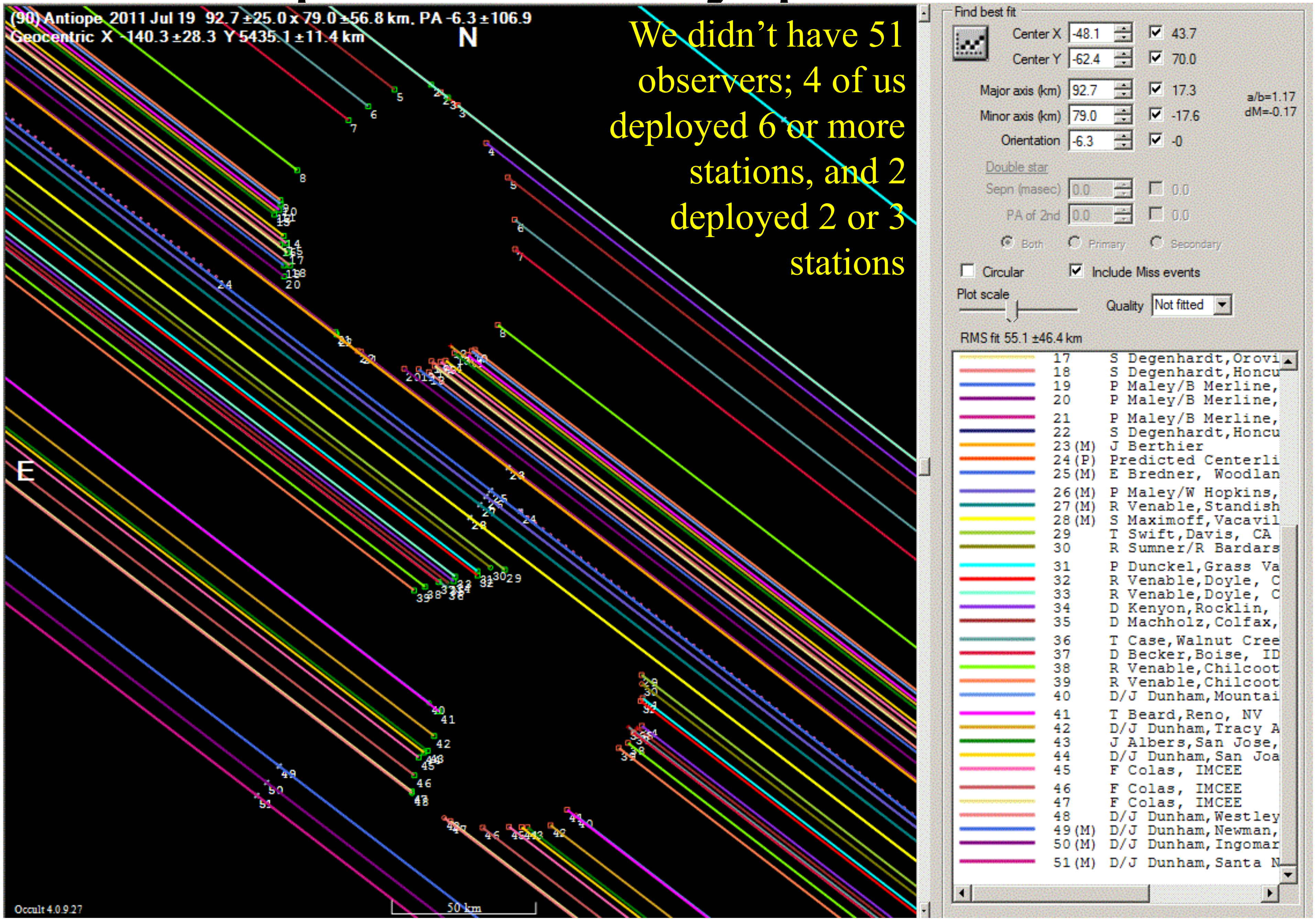


120mm "maxi" level 6 final pre-point chart



Antiope Occ'n Sky-plane Profile

We didn't have 51 observers; 4 of us deployed 6 or more stations, and 2 deployed 2 or 3 stations



Paver mount for previous night pre-pointing

By John Broughton

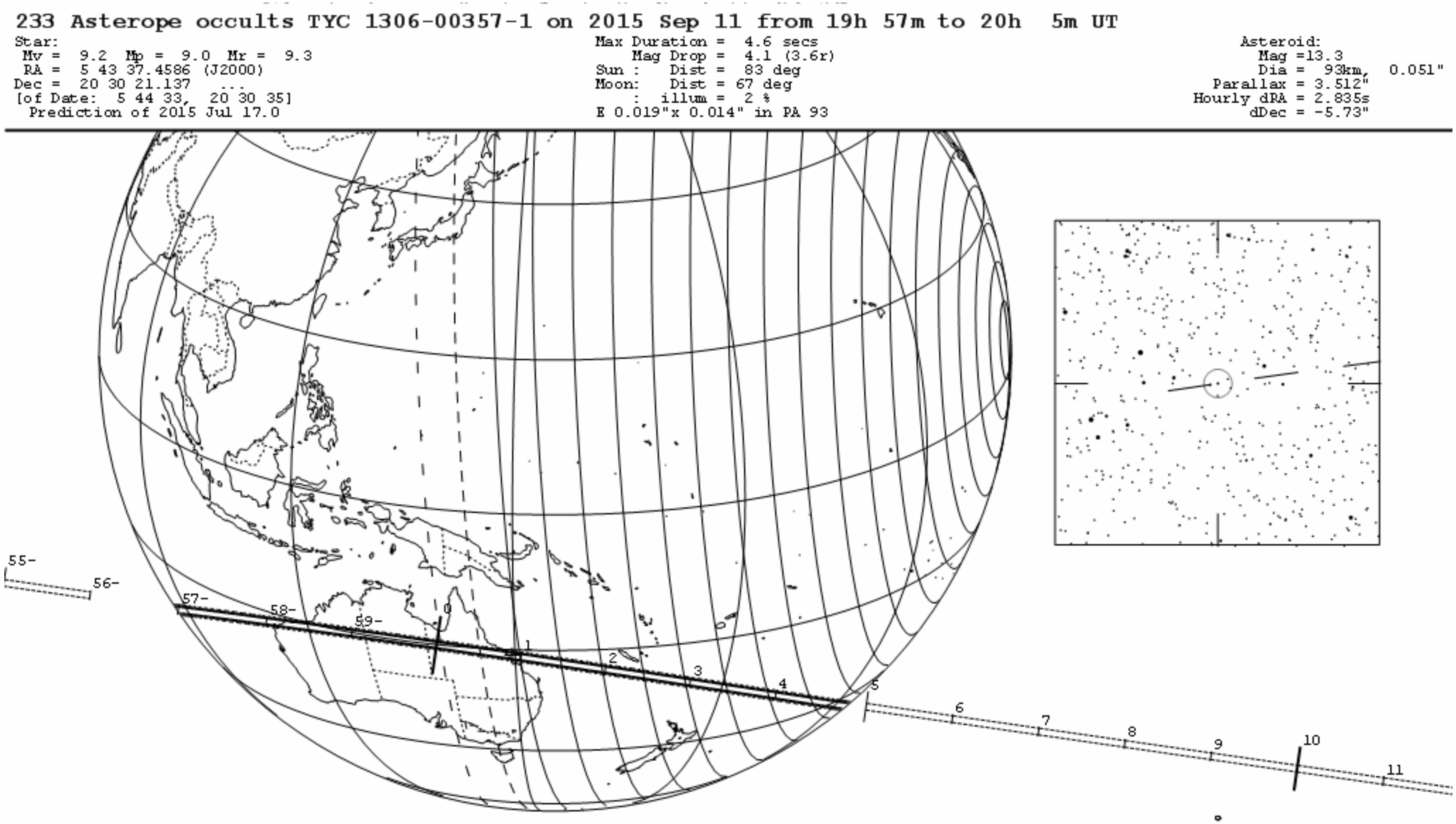
These were specialized rugged mounts with a low profile, good for hiding in the bush, that we used extensively while in Australia, built to carry 80mm (for stars to mag. 11.0) and 120mm (for stars to 12^{th} mag.) short-tube refractors that we used for many of our observations. More about these will be in a TTSO10 talk tomorrow.

Equipment setups at Dunham Adeona observing sites

David with 10" suitcase telescope (John Broughton designed and built; he presented this design remotely at the 2011 IOTA meeting)

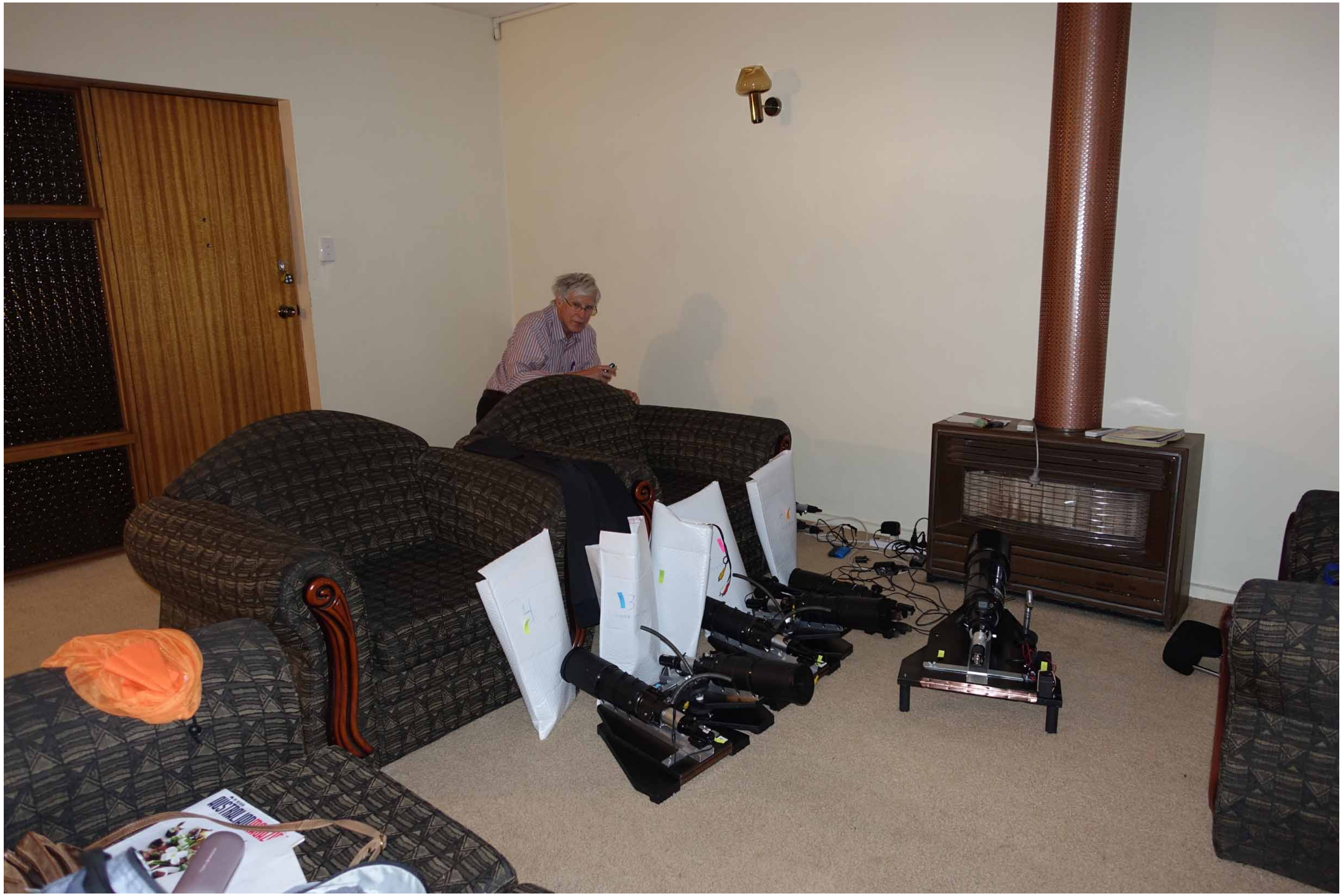
Midi scope on paver stone (John Broughton designed and built mount; for another event, since the Adeona star was too faint for midi's)

Sept. 11, 19:59 UT, occultation of 9.2-mag. star by Asterope



This was an ideal event for remote stations, with over 10h of dark time to deploy and pre-point telescopes, so we devoted all our resources to this high-rank event. Although most stations were picked up after sunrise, the small systems were hidden well enough for that.

Preparing for the Asterope Occultation

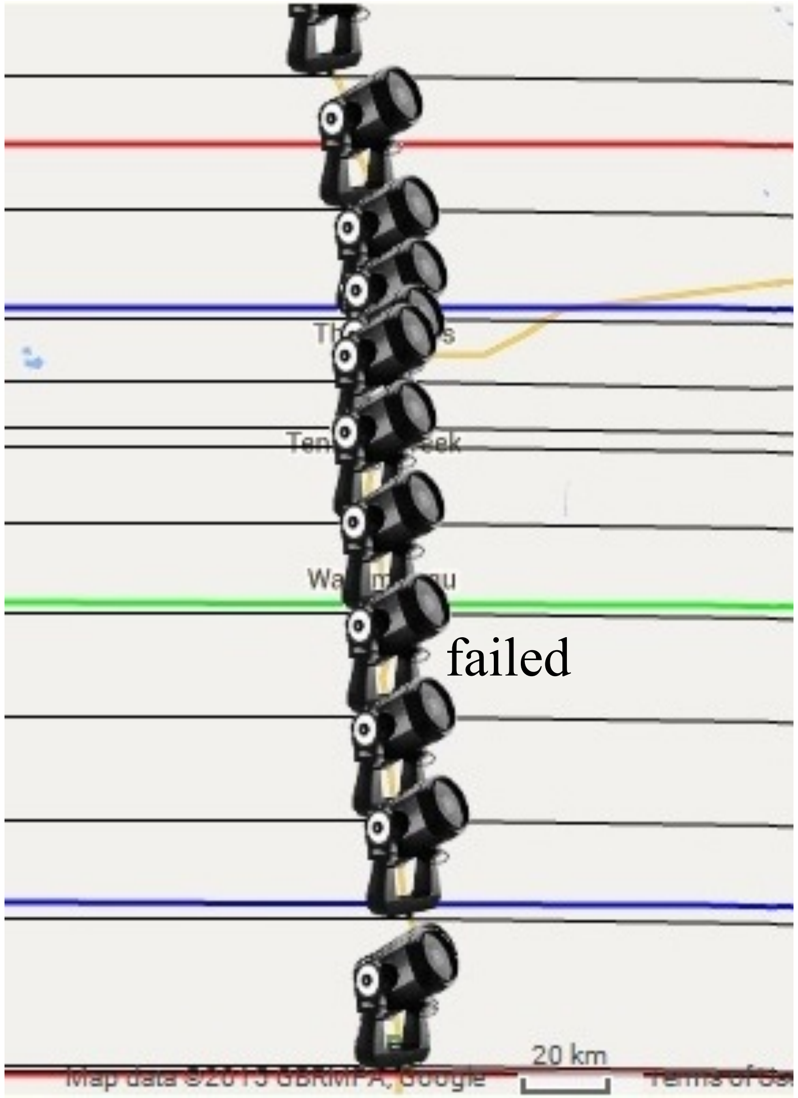


Scopes ready to travel

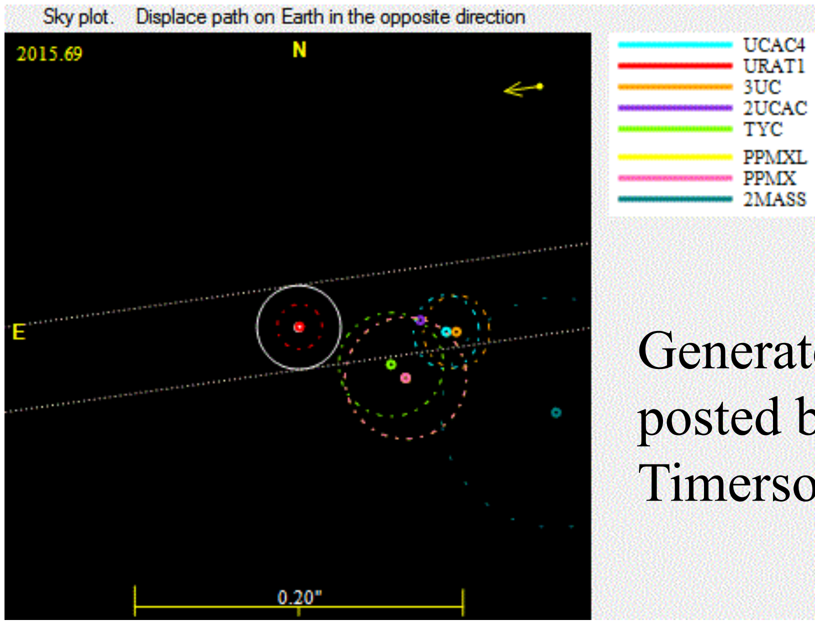
Wycliffe Well, "the UFO capital of Australia", was at the south 1σ limit, so we stayed there for 3 nights

We saw no aliens, but did see mice in our room

Sept. 11, 19:59 UT, occultation of 9.2-mag. star by Asterope

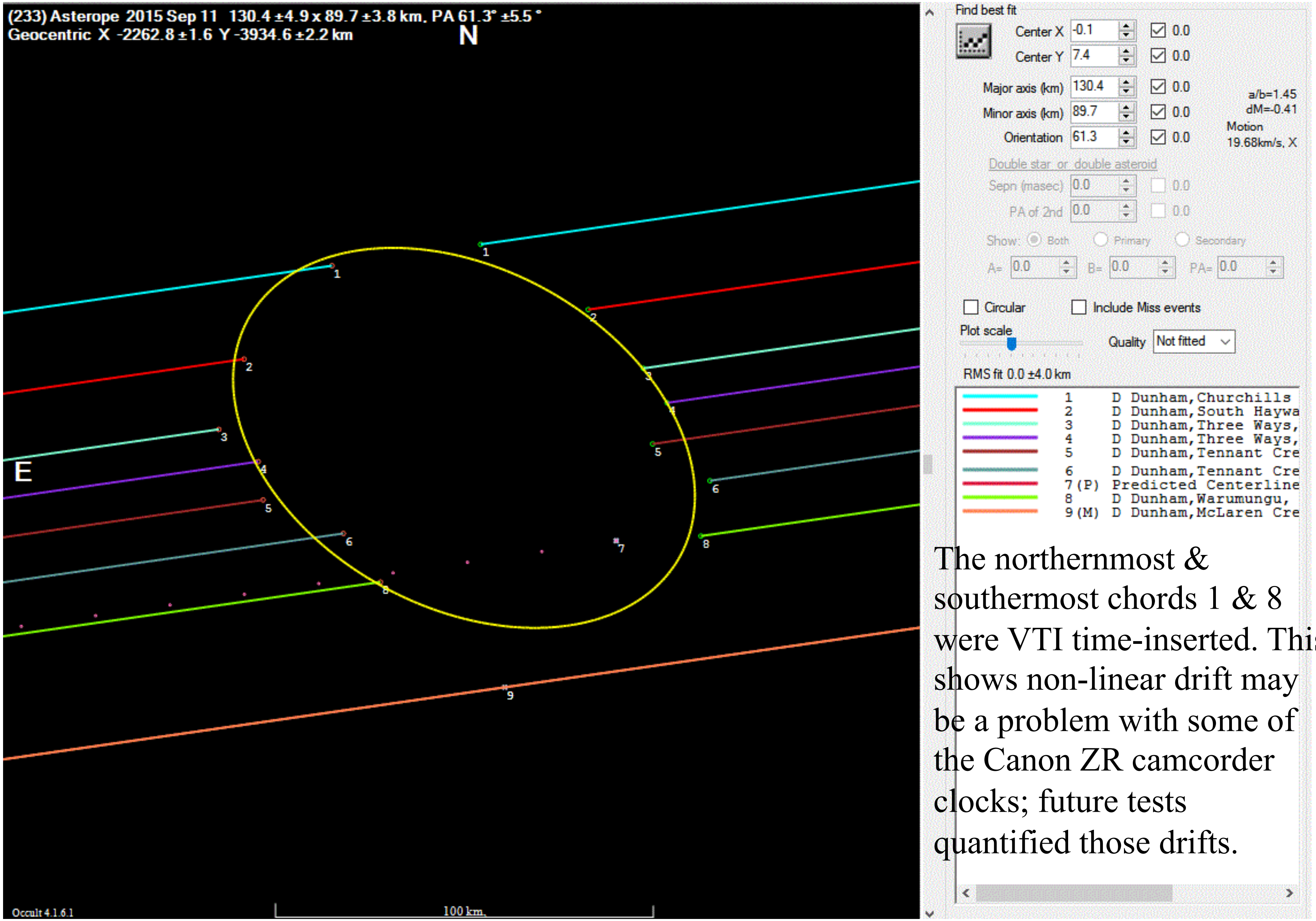


Joan and I ran 11 stations along the Stuart Hwy from Wycliffe Well to Churchills Head (northern attended station), 3 120mm maxi's, 6 80mm midi's, a mini with an integrating camera, & the 10in. scope. The 3 southern stations had no occultation, station 4 camera battery was too low, and the 7 others were all positive, a record for us. The PPMX catalog showed a large north shift (see below) which is why we set up as far north as Churchills Head (good thing we did) & later work by S. Preson confirmed a north shift likely.



Generated and posted by Brad Timerson

Sept. 11, 19:59 UT, occultation of 9.2-mag. star by Asterope



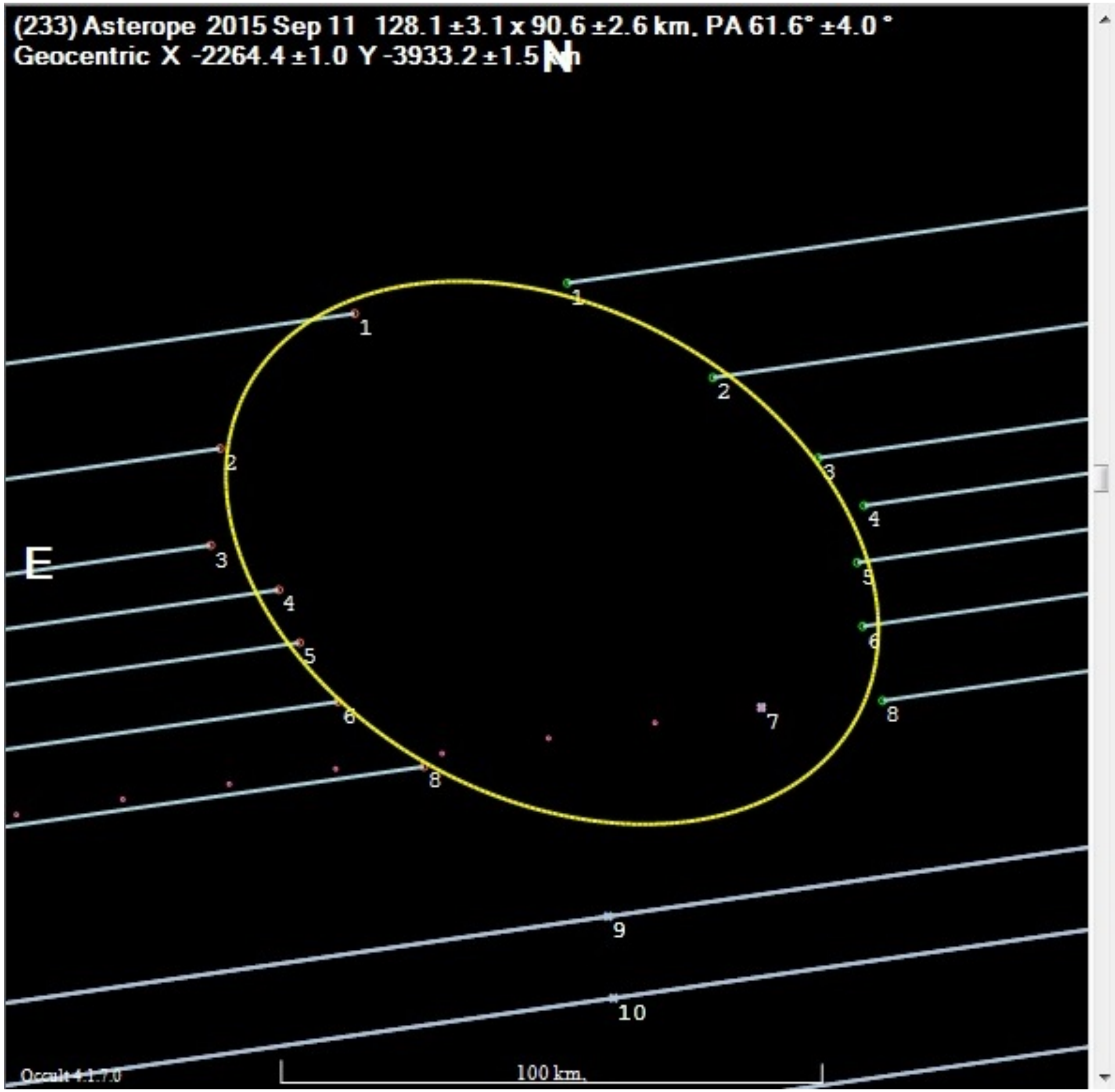
The northernmost & southermost chords 1 & 8 were VTI time-inserted. This shows non-linear drift may be a problem with some of the Canon ZR camcorder clocks; future tests quantified those drifts.

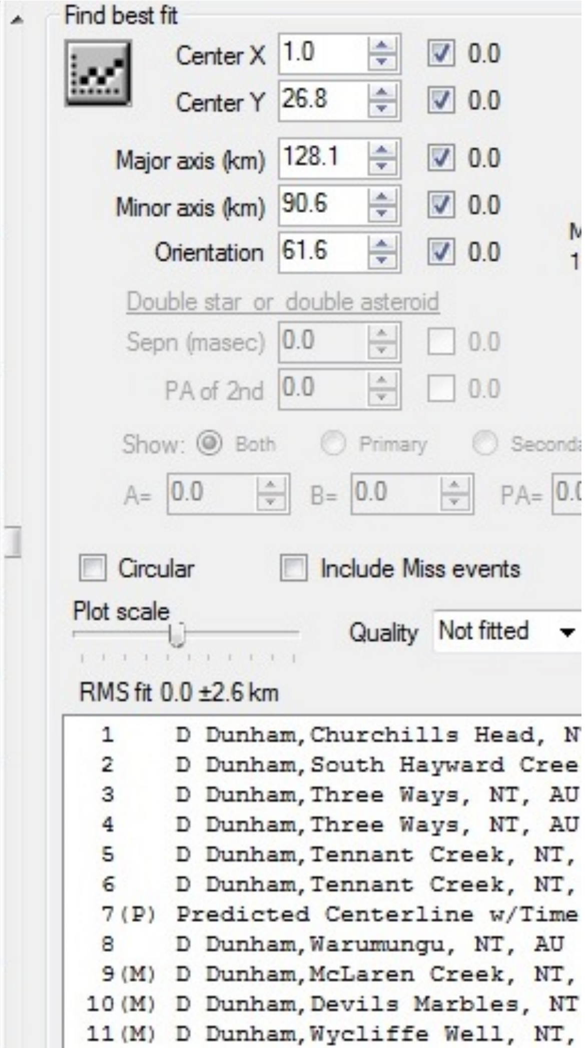
The ZR camcorders and MiniDVR's that didn't have real-time IOTA-VTI time insertion were tested on 3 nights, with similar times (relative to sunrise) & temperatures that occurred for the 2015 Sept. 11 Asterope & 2016 Feb. 8 Desiderata occ'ns

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Results of tests for Canon ZRs and MiniDVRs whose clocks were used as reference for timing asteroidal occultations														
2	233 Asterope	video			Results are: UTC - ZR time from 2016 Feb. Test 1 (12th), 2 (20th), & 3 (21st) in sec.										
3	Date 2015Sep11	recorder	pre hrs	post hrs	Test 1	Test 2	Test 3	average	est. error	D	**D corr.**	R	**R corr.**	sigma	new sigma
4	Sta10-Prof2	ZR34	-1.1	0.5		-0.07	-0.083	-0.0765	0.02	26	25.9235	30.63	30.5535	0.03	0.036056
5	Sta9-Prof3	MDVR4	-2.1	0.95	0.173	0.197	0.149	0.173	0.03	25.95	26.123	31.66	31.833	0.03	0.042426
6	Sta8Prof4	MDVR3	-4	1.3	0.275	0.276	0.304	0.2825	0.03	26.66	26.9425	32.16	32.4425	0.08	0.08544
7	Sta7Prof5	MDVR2	-4.7	1.8	0.423	0.396	0.386	0.407	0.03	26.7	27.107	31.94	32.347	0.05	0.05831
8	Sta6Prof6	ZR31	-5.3	2.25	-0.192	-0.414	-0.446	-0.311	0.13	27.88	27.569	32.81	32.499	0.03	0.133417
9															
10	344 Desiderata														
11	Date 2016Feb08														
12	Sta1Prof6	ZR28	-6.5	3.2		-0.628	-0.56	-0.594	0.13	11.875	11.281	14.916	14.322	0.04	0.136015
13	Sta6Prof2	ZR35	-1.1	0.6		-0.098	-0.111	-0.1045	0.02	0.611	0.5065	3.471	3.3665	0.04	0.044721
14															
15	Note, for Asterope, - the "average" is weighted, (2*test1 + test2 + test3)/4 since test1 had a more similar temp. profile														

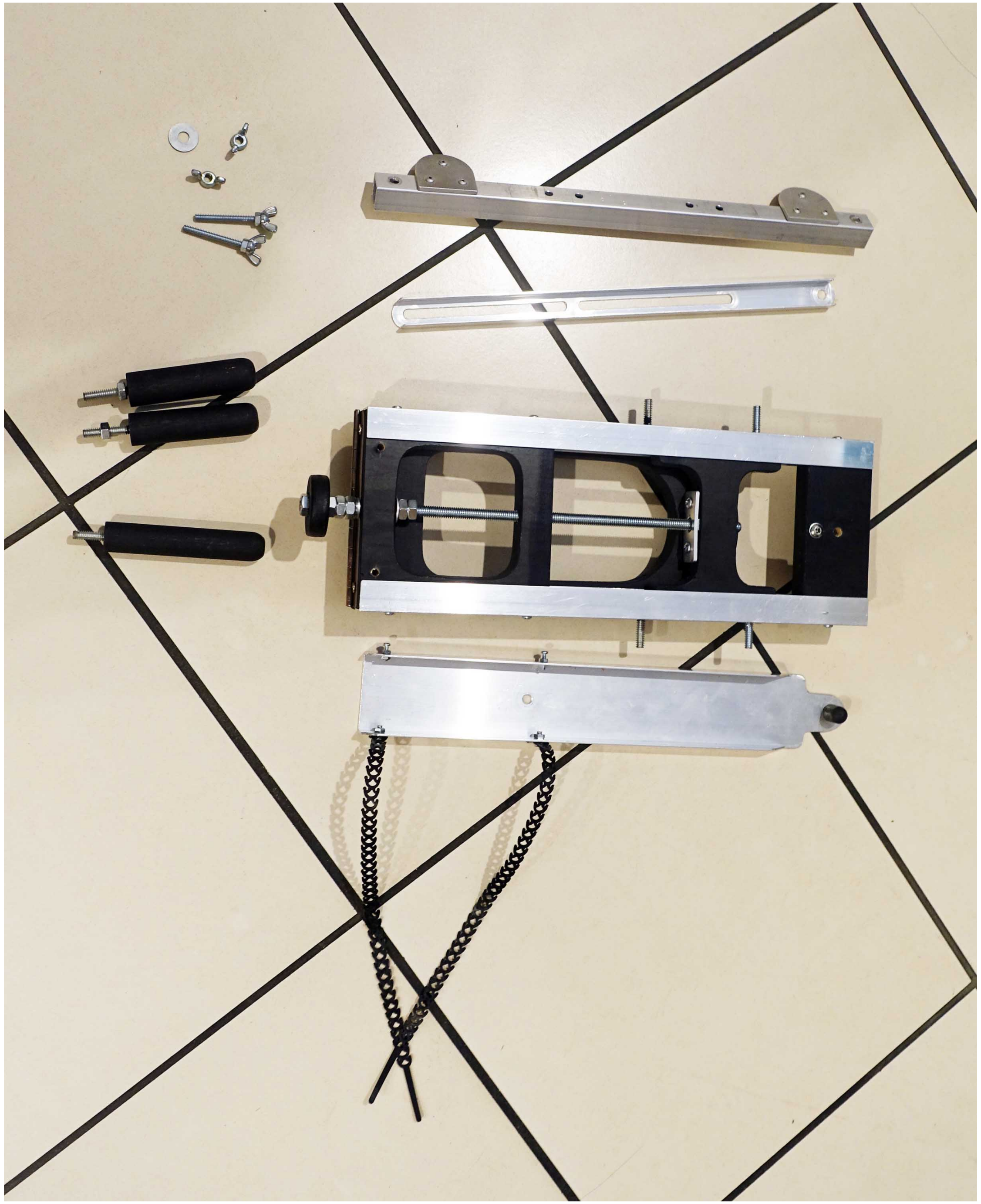
The deviations from a constant rate were similar for the 3 tests, so the times were improved by applying an average of the test corrections, resulting in smaller residuals for the fits, shown in the next slide. Without tests like these, the results show that errors of a few tenths of a second are likely for past occultations where the recorder clock was used for timing, and errors >1s can occur if the IOTA-VTI calibrations are half a day or more from the event.

Sept. 11, 19:59 UT, occultation of 9.2-mag. star by Asterope





With 7 chords recorded across the length of the asteroid, this was our most successful effort ever to observe an asteroidal occultation. With the corrections applied, the residuals of the fit are smaller than for the uncorrected fit.



John Broughton's new light-weight design for the paver mounts.

All the pieces for the mount for an 80mm short-tube f5 refractor are shown

Less wood than the old design, lighter weight alumninum pieces, no hard-to-make quarter-circle screw

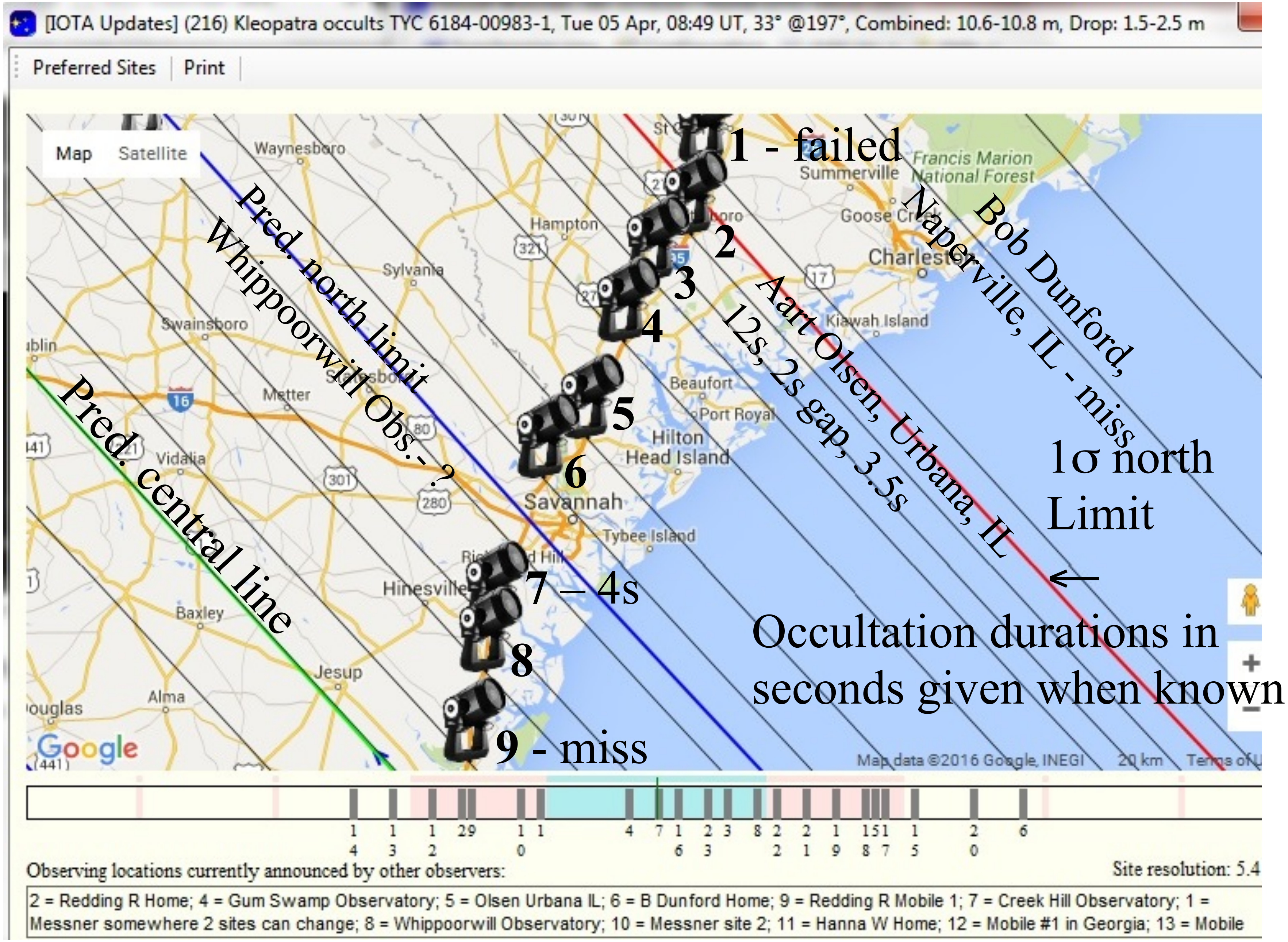
Attach the side rail with two thumb screws. The bottom is held with a screw through a single hole, the top is in one of two ranges. This is the coarse altitude adjustment. Fine adjustment is made by turning the knob on the back end.

Assembled paver mount, without the telescope

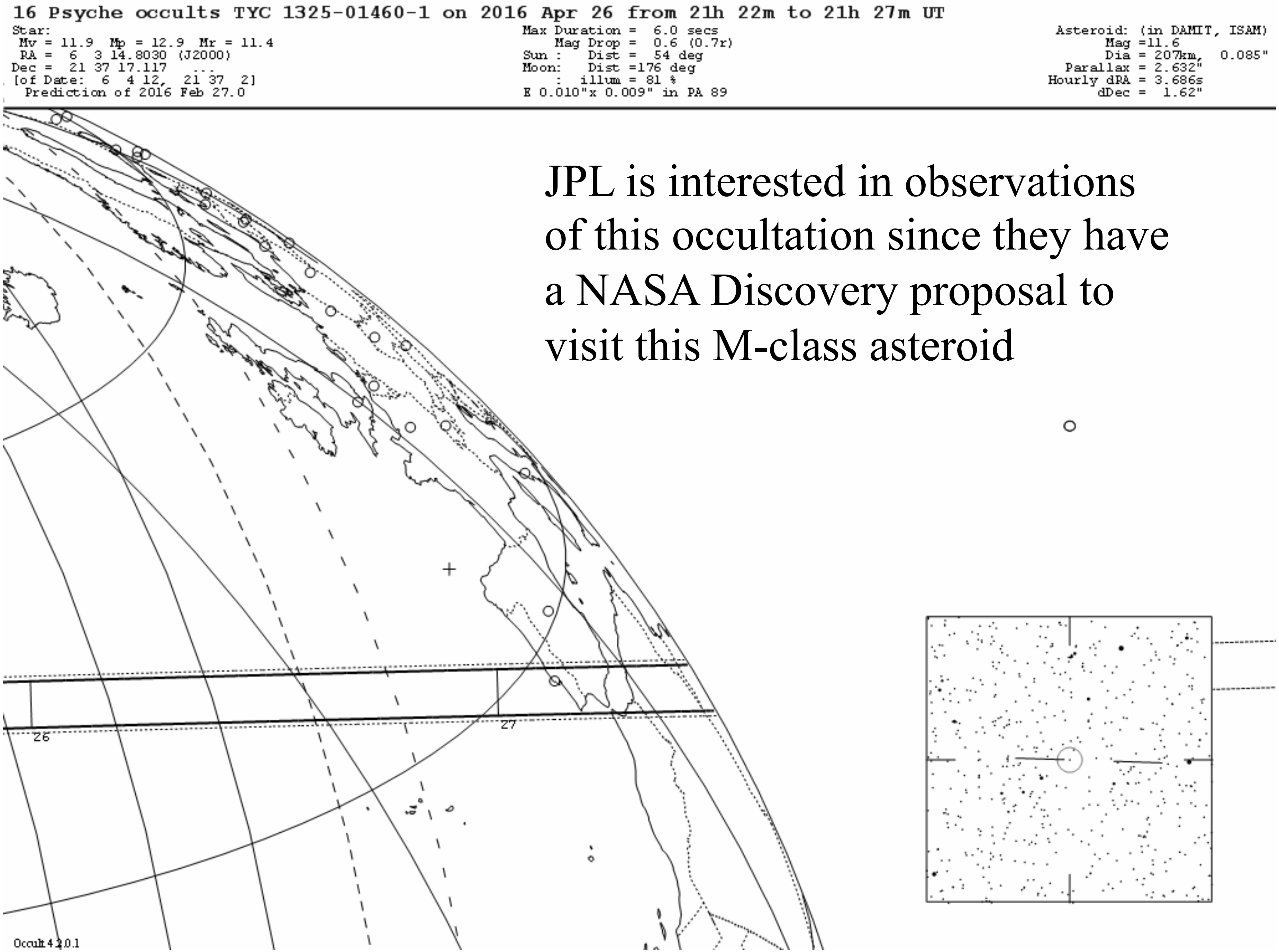
New Paver Mount (by John Broughton) in use

The telescope is attached with the 2 black straps and the camera inserted in the eyepiece holder. This shows a ZWO ASI120MC on the telescope, controlled with a computer which is in the brown box.

Occult Watcher – Dunham Stations for 2016 April 5th Occultation by (216) Kleopatra (our latest success)

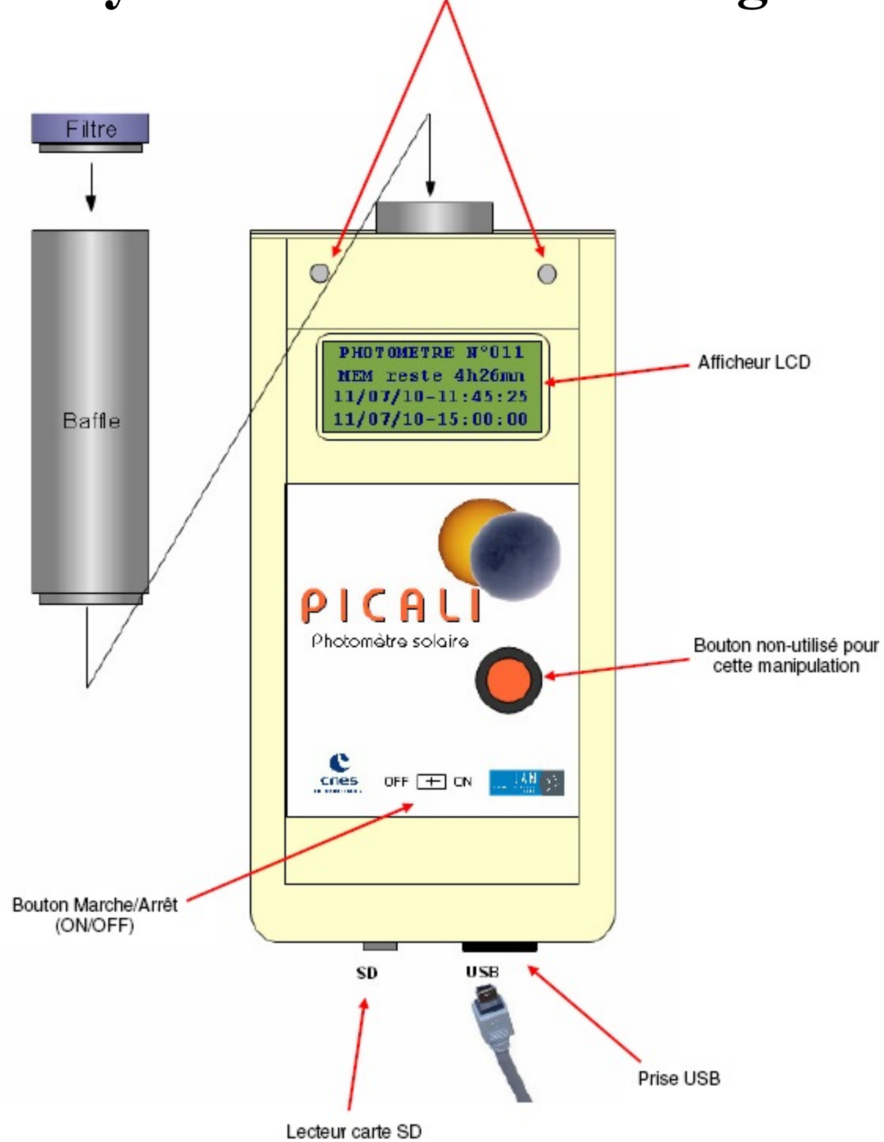


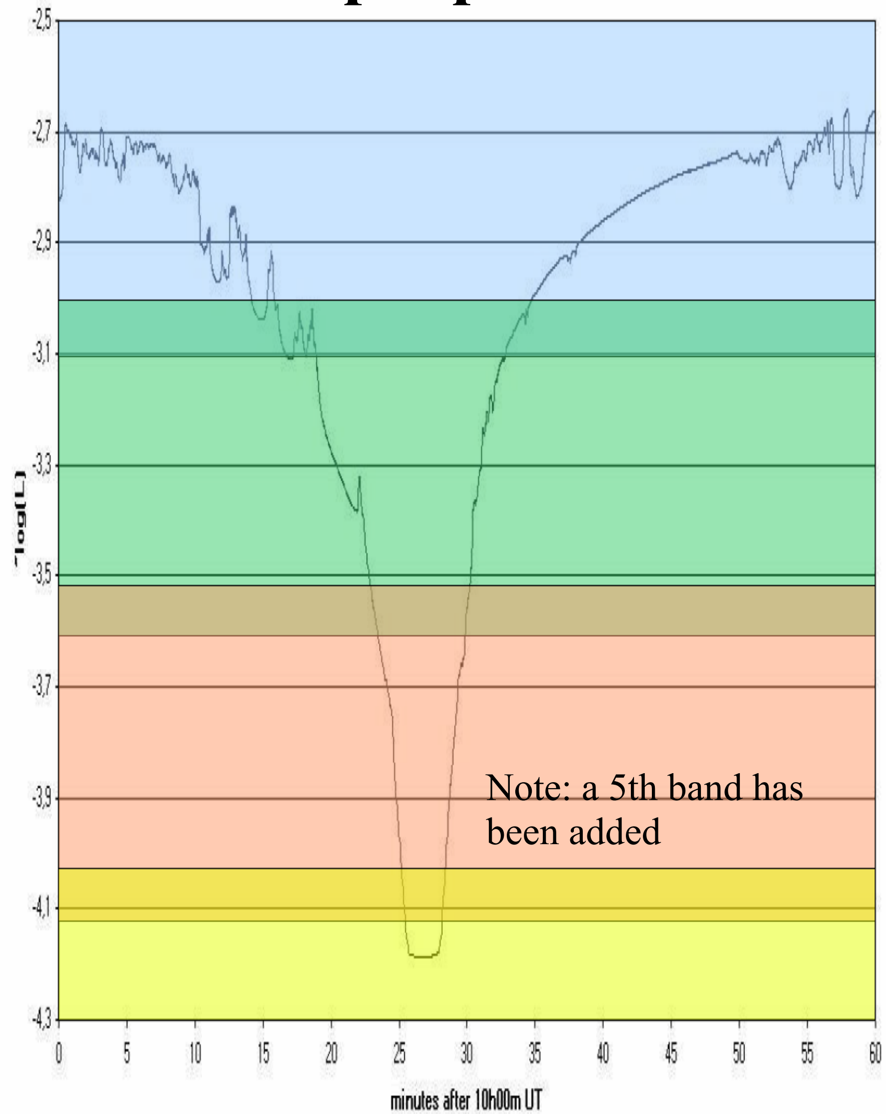
April 26th, occultation of 11.9-mag. star by (16) Psyche



JPL is interested in observations of this occultation since they have a NASA Discovery proposal to visit this M-class asteroid

Simple Photometers for measuring sunlight in a 10° FOV from Many locations near the edges of total solar eclipse paths

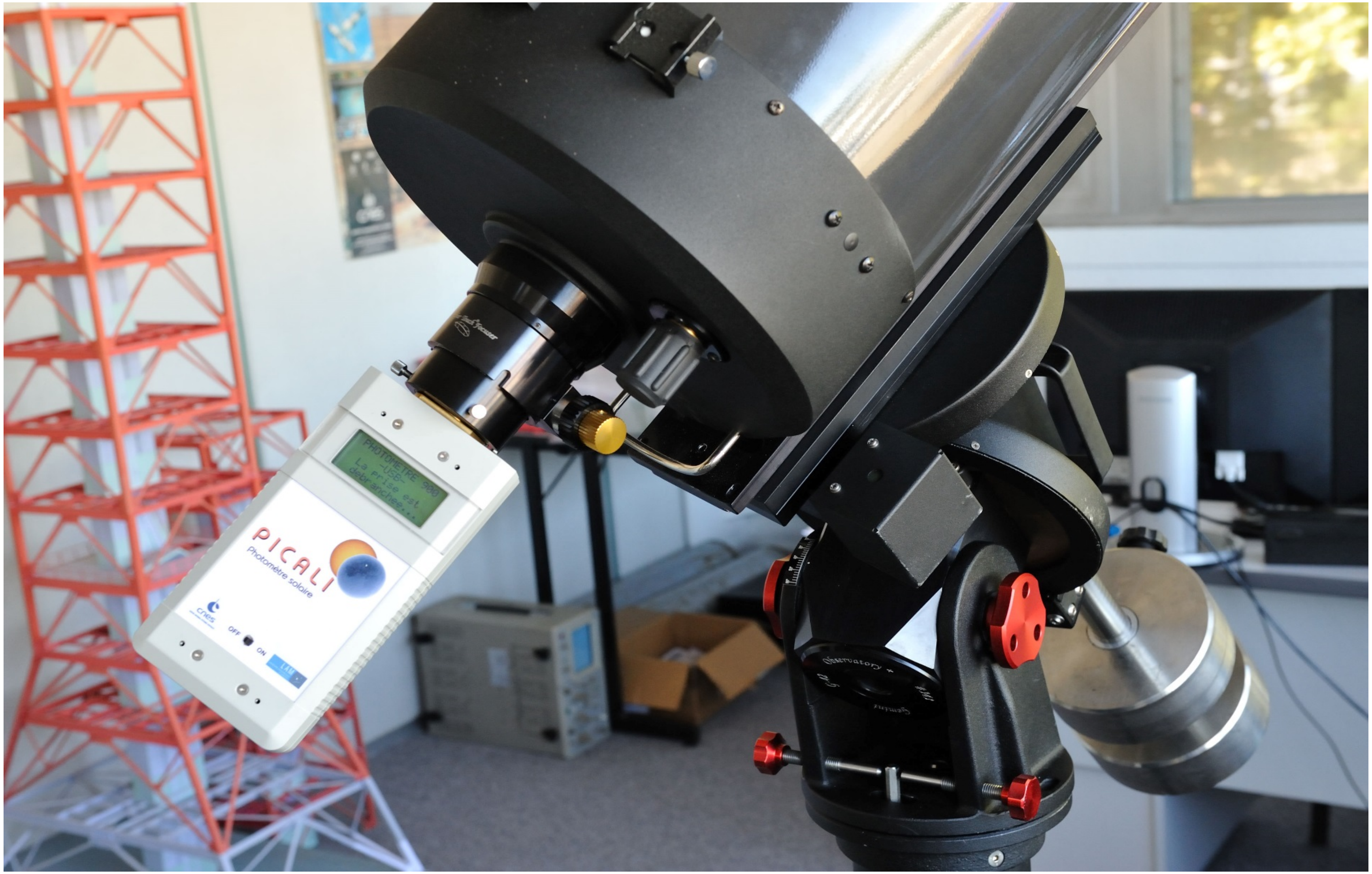




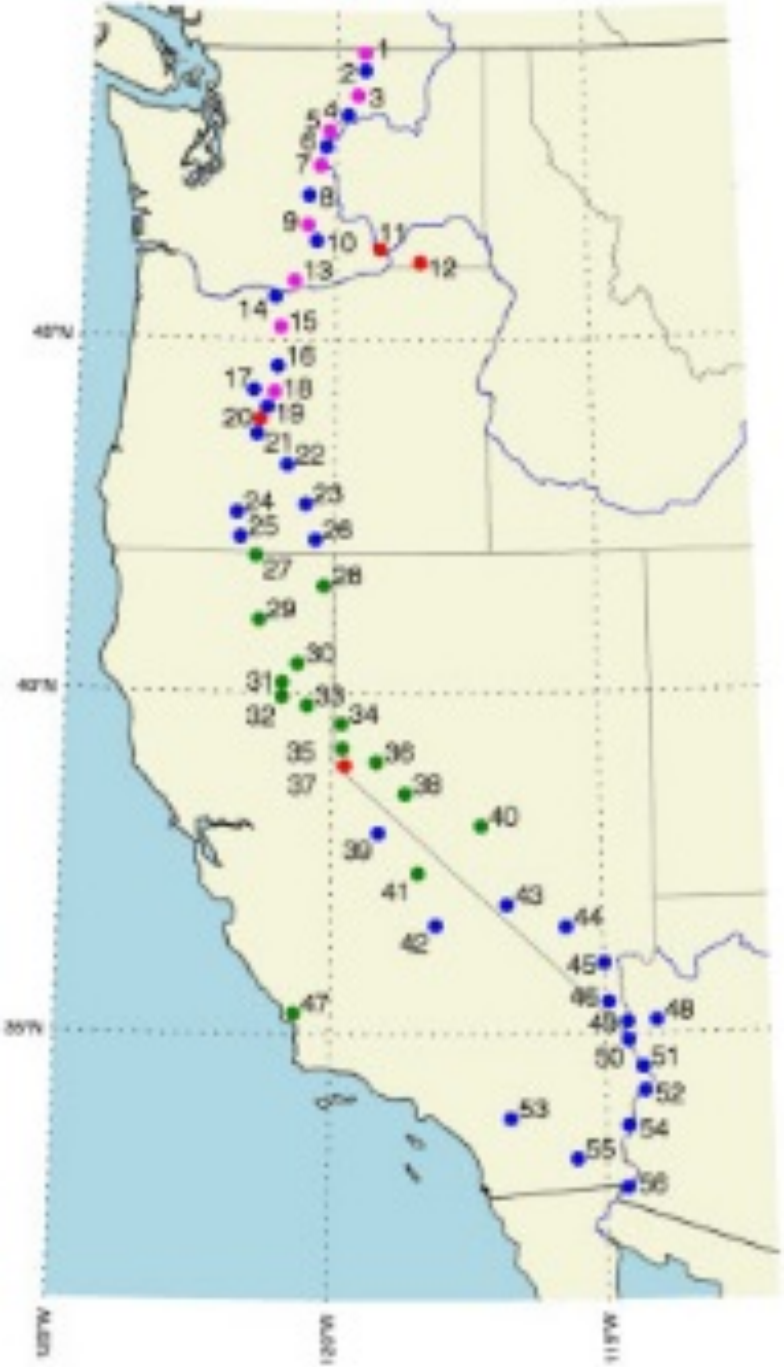
Developed by Jean-Yves Prado, Philippe Lamy, & others at CNES; manufactured in France (I think, company near Toulouse)

Fonctionnement en mode 'assisté'

Other plans to use the photometers:
- Aerosols monitoring through an educative project
- Asteroid survey



RECON network for TNO occultations



56 observatories with 11-in. SCT or larger scopes set up at schools and small colleges in small towns in the rain shadow of the Cascade mountains across the w. USA.

Funded by NSF largely as a public outreach/educational effort. Marc Buie at SWRI is the principal investigator.

Could something similar be set up along the Stewart Hwy across central Australia? Since the roadhouses are smaller than US towns, may need students from larger cities to run them.

With Gaia, the current “low probabily” events list will no longer have low probabilities (almost always a miss currently), but can either be observed from your observatory, or nearby with portable equipment like the small scopes that I described earlier. A dramatic improvement will occur for some asteroids, and a good improvement for others, later this year, but a much better improvement will come in 2019 with the first planned release of Gaia’s Solar System objects observations. Dave Herald has quantified what is likely to happen in his earlier talks.

Occult Watcher, ver. 3.7.0.13 - Home (UTC -05:00)

Synchronise now | Configuration | Add-ins ▾ | Help ▾

Asteroid Name	Event Date, UT	Magn.	Rank	Travel Dist.	Last Updated
North America Extras					
(53088) 1998 YF5	Sun 13 Mar, 02:09 UT	10.3	2	150 km @191°	27 Feb, 18:28 *
(3894) Williamcooke	Mon 14 Mar, 03:42 UT	9.4	2	433 km @152°	27 Feb, 18:28 *
(71595) 2000 DW77	Wed 16 Mar, 02:42 UT	10.3	1	73 km @7°	27 Feb, 18:28 *
(97432) 2000 AG227	Thu 17 Mar, 01:58 UT	9.4	1	31 km @243°	27 Feb, 18:29 *
(8273) Apatheia	Thu 17 Mar, 08:42 UT	8.5	2	349 km @343°	27 Feb, 18:29
(165717) 2001 QR45	Sun 20 Mar, 04:23 UT	9.3	1	228 km @184°	27 Feb, 18:30
(47744) 2000 DJ75	Thu 24 Mar, 02:27 UT	9.3	1	421 km @208°	27 Feb, 18:31
(7153) Vladzakharov	Thu 24 Mar, 02:51 UT	10.4	2	212 km @79°	27 Feb, 18:31
(17463) 1990 UO5	Thu 24 Mar, 05:35 UT	10.0	2	444 km @222°	27 Feb, 18:31
(2291) Kevo	Thu 24 Mar, 09:45 UT	8.5	30	320 km @292°	02 Feb, 20:15
(7630) 1979 MR2	Sun 27 Mar, 03:10 UT	8.0	1	121 km @205°	27 Feb, 18:32
(44557) 1999 CZ23	Mon 28 Mar, 01:38 UT	10.1	0	1461 km @193°	27 Feb, 18:32
(119946) 2002 JD53	Mon 28 Mar, 03:05 UT	9.5	1	614 km @228°	27 Feb, 18:32
(43568) 2001 FV134	Mon 28 Mar, 04:31 UT	9.5	1	399 km @197°	27 Feb, 18:32
(34723) 2001 QV14	Mon 28 Mar, 07:23 UT	10.3	2	398 km @194°	27 Feb, 18:32
(26719) 2001 HQ5	Wed 30 Mar, 01:45 UT	9.8	2	377 km @200°	27 Feb, 18:33
(41394) 2000 AW162	Thu 31 Mar, 01:28 UT	8.9	2	132 km @6°	27 Feb, 18:33
(43024) 1999 VU12	Fri 01 Apr, 09:10 UT	9.1	1	873 km @32°	27 Feb, 18:33