Arecibo Radar Observations of 23 High-Priority Near-Earth Asteroids During CY2017

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Introduction

Radar is arguably the most powerful Earth-based technique for post-discovery physical and dynamical characterization of near-Earth asteroids (NEAs). Arecibo radar observations routinely provide sequences of images of NEAs with resolution as fine as 7.5 m revealing surface features, such as boulders, concavities, and ridges, that our SHAPE software [Hudson, 1994; Magri et al., 2007] inverts to obtain spin-state estimates and three-dimensional shape models limited only by echo strength and orientational coverage. Over the long term, our observations will help answer fundamental questions regarding the origin of the diversity in asteroid morphologies, the importance of spin-up mechanisms and collisional influences, the interior structure and thermal properties of asteroids, and the variety of dynamical states.

Observing Program

NASA's Near-Earth Object Observations program supports the Arecibo planetary radar to observe NEAs for at least 600 hours per year. We propose radar imaging, detailed physical characterization, and orbit refinement of our 23 highest-priority NEAs for calendar year 2017 using 454.50 hours of telescope time. A companion proposal (Virkki et al.) with a more survey-oriented approach requests at least 241 hours to concentrates on basic characterization and precise astrometry for many more objects bringing the total proposed telescope time to $\sim$700 hours.

The previous year's proposal (project R3037) requested 312 hours of telescope time to observe 18 objects visible from January 2016 through January 2017. However, the targets are strongly weighted to the latter part of the year following this proposal deadline. Through August, only 7 objects were visible, accounting for 118.75 hours of our time request. Due to the maintenance shutdown of the telescope, the S-band system was unavailable for roughly three months such that only 4 objects from R3037 have been observed so far this year. For these, 67.5 hours were requested and 40.75 hours were scheduled. Noteworthy results include observations of (441987) 2010 NY65 suggesting a non-gravitational acceleration modifying its orbit [Giorgini et al., 2016] and high-resolution images of (154244) 2002 KL6 resulting in a press release describing this elongated body, roughly 1.5 by 2.7 km, that rotates in less than 5 hours. The remaining 4 months of the calendar year, plus early January 2018, include 11 high-priority targets and almost 200 hours of telescope time requested.

The time request for each target is dictated by the science goals and the estimated signal-to-noise ratio (SNR). Past experience demonstrates that the key factor in our ability to secure shapes

and spin-state estimates is good sky and rotational coverage over several days of observation, especially when very little is known about the target beforehand. For all targets we will measure the circular polarization ratio and radar albedo, which are gauges of near-surface roughness and surface density, provide precise astrometry, and constrain the size, shape, and spin state, which when combined with photometric measurements constrain the optical albedo and composition.

Table 1 describes our targets and lists synergistic observations. The objects requested at the Goldstone radar (more maneuverable, but less sensitive than Arecibo) will have greater coverage from longer daily tracks and observations outside the Arecibo declination window, which may lead to tighter constraints on physical parameters. Overlapping tracks with Goldstone allows for bistatic X- or C-band experiments with resolutions of 3.75 or 1.875 m. Seven targets are part of a coordinated program with the NASA InfraRed Telescope Facility (IRTF) for spectral characterization and to apply radar-derived shape information to thermophysical modeling. Speckle tracking [Busch et al., 2010] with the Very Long Baseline Array (VLBA) will be used to resolve the prograde/retrograde-rotation ambiguity of at least 5 targets. Table 2 lists specific track requests for each target.

Student Participation

Graduate student Sean Marshall (Cornell; Advisor: Don Campbell) has worked with radar for several years and is shape and thermal modeling several asteroids observed with both radar and the IRTF for his thesis project. Graduate student Adam Greenberg (UCLA; Advisor: Jean-Luc Margot) observed asteroid 2010 NY65 in 2015 (project R2960) and 2016 (project R3037) and will lead observations of this same object in June/July 2017. Undergraduate Benjamin Sharkey (University of Minnesota; Advisor: Chick Woodward) was part of the Research Experience for Undergraduates (REU) program sponsored by the National Science Foundation in 2015 and returned as a summer research assistant in 2016 to continue work on shape modeling asteroid (52760) 1998 ML14 (projects R1172 and R2831) and participate in radar observations (projects R3035 and R3037). Other undergraduate and graduate students are welcome to gain observing experience through this proposed work.

References

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Object	H mag	Diam [km]	P_{spin} [h]	Prev Obs?	RTT [s]	AST Window	SNR /run	Notes	Next Opp
2015 BN509	20.6	*0.37*	*2.1*		42	Feb 01-13	200	P G	2018
(443103) 2013 WT67	18.0	*1.22*	135	Y	114	Feb 03-24	300	P G	2034
(215588) 2003 HF2	19.4	0.49	*2.1*		43	Mar 22 - Apr 03	280	P G	2027
(143404) 2003 BD44	16.8	*2.10*	*2.1*		60	Mar 31 - May 07	780	P G I	2050
2014 JO25	18.1	*1.22*	*2.1*		13	Apr 12-20	11000	P G X S I A	–
2007 LE	19.0	0.50	2.60	Y	82	May 23-28	35	B P	2154
(418094) 2007 WV4	19.3	*0.89*	*2.1*		23	May 31	5700	P G X S	2151
(6063) Jason	15.9	1.40	51.7	Y	126	Jun 02-10	160	G I	2159
(441987) 2010 NY65	21.5	0.23	4.98	Y	28	Jun 13 - Jul 05	580	P G Y	2018
2010 VB1	23.4	*0.10*	*0.5*		26	Jun 16-22	70	N G	2057
(190166) 2005 UP156	17.1	1.03	40.5		134	Jun 06 - Aug 11	70	G I	2057
(153415) 2001 QP153	17.0	*1.95*	*2.1*		97	Aug 02-07	130	G	2070
(310560) 2001 QL142	17.8	*1.34*	*2.1*		90	Sep 03-08	100	P G	2060
(3122) Florence	14.1	*4.35*	2.36		47	Sep 02-05	5700	P G X S I	2057
(171576) 1999 VP11	18.5	*0.97*	*2.1*		37	Oct 12-19	1300	P G X	2086
2003 UV11	19.5	0.20	16.3	Y	41	Oct 26-30	240	P G I	2166
1989 VB	19.7	*0.40*	16.0		37	Oct 08-31	940	P G X S	2078
1989 UP	20.5	*0.30*	6.98		55	Oct 25 - Nov 19	100	P G	2050
(444584) 2006 UK	20.1	*0.49*	*2.1*		22	Nov 07-18	2700	P G X S	2059
(163696) 2003 EB50	16.5	2.45	62.4	Y	95	Nov 21-27	7300	G X	2078
(3200) Phaethon	14.6	5.10	3.60	Y	69	Dec 15-19	2400	P G X I	2050
(418849) 2008 WM64	20.6	*0.37*	*2.1*	Y	39	Dec 21-23	250	P G I	2018
2007 AG	20.1	*0.47*	*2.1*		58	Dec 13 - Jan 08	90	P G	2048

Table 1: We propose to observe our 23 highest-priority NEAs in a combined 454.50 hours (including transmitter warm-up time; see Table 2 for detailed time requests). Absolute magnitudes H are from the JPL Small-Body Database. Rotation periods P_{spin} are taken from the asteroid Lightcurve Database [Warner et al., 2009] when available. Previously observed objects ("Prev Obs?" column) have radar-estimated spin periods consistent with the listed value of P_{spin}. Italicized periods are assumed very rapid at 2.1 h for $H < 22$, which gives a more conservative signal-to-noise ratio (SNR), and 0.5 h for $H > 22$. Diameters are taken from previous radar observations or space-based infrared observations [Mainzer et al., 2011, 2012, 2014; Nugent et al., 2015] if available. Italicized diameters are estimates taken from the NEODyS database. The closest approach is given by the round-trip time, RTT, for light to reach the target and return. Notes include binary asteroids (B), potentially hazardous asteroids (P), NHATS objects (N), Goldstone radar targets (G), possible bistatic X-band targets (X), VLBA speckle-tracking targets (S), proposed IRTF near- and thermal-infrared targets (I), Yarkovsky-drift candidates (Y), and objects requiring optical astrometry prior to radar observations (A). Next Opp indicates when the next comparable close approach to Earth occurs, where comparable means less than 1.2 times the RTT of the 2017 apparition. Many are not re-observable at the same strength for several decades meaning this is our best chance to characterize them, while, on the other hand, observing 2015 BN509, 2010 NY65, and 2008 WM64 now will help us prepare for their close approaches in the next few years and possibly allow for detections of Yarkovsky orbital drift.

Observing Requests

Table 2. We request 130 tracks and 454.50 hours to observe 23 asteroids. Requested tracks are marked with a +; unmarked tracks are acceptable alternatives. The rise/set imes do NOT include one hour of transmitter warm-up time prior to the source rising. Several days of observations spread over the observing window allow for complete rotational coverage (assuming typical rotation periods) and better constraints on the spin state. Calculations assume the physical parameters from Table 1 and a radar albedo of 0.1. When unknown, the sizes and spin rates used tend to give conservative estimates of the SNR. Nominal system parameters are assumed: transmitter power = 900 kW, sensitivity = 10 K/Jy, and system temperature = 24 K.

Request: 6 tracks, 23.50 h

UT Date **2015 BN509**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Feb-01	84	12.4	12	53	18	130	06:45-09:23
2017-Feb-02	75	12.7	13	60	27	206	06:57-09:38
2017-Feb-03	66	13.0	14	69	41	344	07:14-09:58
2017-Feb-04	57	13.5	15	81	68	616	07:39-10:25
+ 2017-Feb-05	50	14.2	16	93	107	1040	08:13-11:02
+ 2017-Feb-06	45	15.1	16	103	154	1570	09:00-11:51
+ 2017-Feb-07	42	16.1	16	110	196	2060	09:58-12:49
+ 2017-Feb-08	42	17.2	14	108	196	2040	11:01-13:49
+ 2017-Feb-09	46	18.2	12	96	143	1410	12:00-14:40
+ 2017-Feb-10	51	19.0	09	81	100	903	12:49-15:17
2017-Feb-11	59	19.6	07	65	61	489	13:27-15:42
2017-Feb-12	67	20.0	05	51	39	282	13:57-15:58
2017-Feb-13	77	20.3	03	38	24	149	14:20-16:08

Request: 8 tracks, 29.25 h

UT Date **2013 WT67**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Feb-03	160	23.6	35	15	92	365	18:26-19:48
2017-Feb-04	155	23.8	35	16	102	410	18:30-19:58
2017-Feb-05	149	23.9	34	19	118	512	18:34-20:09
2017-Feb-06	144	0.2	34	20	132	592	18:39-20:21
2017-Feb-07	139	0.4	33	22	150	715	18:44-20:35
2017-Feb-08	135	0.6	32	25	166	829	18:49-20:49
+ 2017-Feb-09	130	0.8	31	28	189	1000	18:54-21:03
2017-Feb-10	127	1.1	30	30	205	1120	19:01-21:18
2017-Feb-11	123	1.3	29	32	229	1300	19:07-21:33
+ 2017-Feb-12	120	1.6	27	35	250	1480	19:15-21:48
2017-Feb-13	118	1.8	25	37	265	1630	19:23-22:02
2017-Feb-14	116	2.1	23	39	281	1770	19:32-22:16
+ 2017-Feb-15	115	2.3	21	41	290	1850	19:42-22:28
+ 2017-Feb-16	114	2.6	19	41	299	1920	19:52-22:40
+ 2017-Feb-17	114	2.8	16	41	299	1910	20:03-22:50
+ 2017-Feb-18	114	3.1	14	40	299	1900	20:16-22:58
+ 2017-Feb-19	115	3.3	12	39	290	1810	20:28-23:04
+ 2017-Feb-20	116	3.5	09	36	281	1690	20:42-23:09
2017-Feb-21	118	3.7	07	32	265	1520	20:57-23:11
2017-Feb-22	121	3.9	04	26	243	1260	21:13-23:11
2017-Feb-23	124	4.1	02	21	223	1020	21:30-23:08
2017-Feb-24	127	4.3	00	13	205	747	21:52-23:00

Request: 7 tracks, 26.75 h

UT Date **(215588) 2003 HF2**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Mar-22	91	1.2	02	29	21	111	16:52-18:25
2017-Mar-23	80	1.5	03	37	32	196	16:57-18:46
2017-Mar-24	69	1.9	05	50	54	381	17:08-19:14
+ 2017-Mar-25	59	2.4	08	68	93	763	17:28-19:50
+ 2017-Mar-26	50	3.1	11	87	164	1530	18:00-20:38
+ 2017-Mar-27	45	4.1	14	101	235	2370	18:50-21:40
+ 2017-Mar-28	43	5.4	17	108	275	2870	19:58-22:52
+ 2017-Mar-29	45	6.6	19	104	235	2400	21:10-00:03
+ 2017-Mar-30	51	7.7	18	92	153	1470	22:08-01:00
+ 2017-Mar-31	60	8.4	17	78	87	771	22:51-01:40
2017-Apr-01	70	9.0	16	67	51	419	23:21-02:08
2017-Apr-02	81	9.3	15	57	31	234	23:42-02:26
2017-Apr-03	93	9.7	14	49	19	135	23:57-02:39

Request: 10 tracks, 32.25 h

UT Date **(143404) 2003 BD44**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Mar-31	164	11.6	05	21	24	108	02:30-04:27
2017-Apr-01	156	11.5	05	22	28	132	02:19-04:23
2017-Apr-02	148	11.4	06	25	34	169	02:09-04:18
2017-Apr-03	140	11.4	07	27	41	215	01:58-04:12
2017-Apr-04	132	11.3	08	30	50	277	01:47-04:07
2017-Apr-05	124	11.2	09	33	63	362	01:35-04:00
2017-Apr-06	117	11.1	11	37	76	468	01:23-03:53
+ 2017-Apr-07	110	11.0	12	40	95	606	01:10-03:45
2017-Apr-08	103	10.9	14	45	119	799	00:57-03:36
2017-Apr-09	96	10.8	15	48	152	1060	00:43-03:25
2017-Apr-10	89	10.6	17	53	198	1440	00:28-03:12
+ 2017-Apr-11	83	10.4	20	56	252	1900	00:12-02:57
+ 2017-Apr-11	77	10.2	22	60	327	2530	23:56-02:38
+ 2017-Apr-12	72	9.9	25	61	412	3240	23:39-02:14
+ 2017-Apr-13	67	9.6	28	61	529	4130	23:21-01:44
+ 2017-Apr-14	63	9.2	32	54	654	4810	23:04-01:06
+ 2017-Apr-15	60	8.7	35	41	775	5020	22:50-00:14
...	Target is north of the Arecibo declination window						
+ 2017-Apr-24	75	3.3	36	27	358	1890	17:00-18:08
+ 2017-Apr-25	81	3.0	34	35	274	1620	16:21-18:01
2017-Apr-26	87	2.7	32	39	214	1340	15:52-17:51
2017-Apr-27	94	2.5	30	40	164	1040	15:28-17:41
2017-Apr-28	101	2.3	29	39	127	797	15:09-17:31
+ 2017-Apr-29	108	2.1	27	39	101	631	14:52-17:22
2017-Apr-30	116	2.0	26	37	79	483	14:38-17:12
2017-May-01	124	1.9	25	36	63	380	14:26-17:04
2017-May-02	131	1.8	24	34	51	300	14:15-16:55
2017-May-03	140	1.7	23	33	41	238	14:05-16:47
2017-May-04	148	1.7	22	31	34	190	13:56-16:40
2017-May-05	156	1.6	21	30	28	153	13:48-16:33
2017-May-06	165	1.6	20	28	23	124	13:41-16:26
2017-May-07	174	1.6	20	27	19	101	13:34-16:19

Request: 6 tracks, 18.50 h

NOTE: 2014 JO_{25} will require optical recovery prior to radar observations.

UT Date **2014 JO25**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Apr-12	128	23.8	19	37	25	150	13:31-16:16
2017-Apr-13	109	23.8	20	43	43	284	13:23-16:09
2017-Apr-14	90	23.7	20	52	84	607	13:15-15:59
+ 2017-Apr-15	71	23.6	22	65	191	1540	13:04-15:47
+ 2017-Apr-16	52	23.3	24	86	561	5220	12:49-15:28
+ 2017-Apr-17	34	22.9	28	119	2410	26300	12:25-14:47
+ 2017-Apr-18	19	21.4	37	76	17200	150000	11:48-12:17
+ 2017-Apr-19	13	16.7	34	207	59300	855000	06:48-08:05
+ 2017-Apr-20	22	13.8	06	162	10500	134000	03:22-05:22

Request: 6 tracks, 20.75 h

UT Date **2007 LE**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
+ 2017-May-23	103	21.1	33	30	15	85	08:34-10:23
+ 2017-May-24	97	21.0	28	42	19	123	08:06-10:31
+ 2017-May-25	92	20.9	23	50	23	161	07:48-10:30
+ 2017-May-26	87	20.8	17	54	28	203	07:37-10:21
+ 2017-May-27	84	20.7	10	51	31	223	07:33-10:03
+ 2017-May-28	82	20.6	03	36	34	204	07:43-09:33

Request: 1 track, 4.00 h

UT Date **(418094) 2007 WV4**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
+ 2017-May-31	23	6.1	18	199	5660	80100	16:31-19:21

Request: 4 tracks, 14.50 h

UT Date **(6063) Jason**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
+ 2017-Jun-02	126	14.7	33	25	160	798	01:31-03:27
+ 2017-Jun-03	135	14.8	28	30	125	693	01:20-03:47
+ 2017-Jun-04	146	15.0	24	31	96	532	01:17-03:57
+ 2017-Jun-05	157	15.1	21	30	74	406	01:16-04:02
2017-Jun-06	168	15.2	18	28	59	310	01:17-04:03
2017-Jun-07	180	15.2	16	26	46	235	01:18-04:02
2017-Jun-08	193	15.3	13	23	36	176	01:20-03:59
2017-Jun-09	205	15.3	11	21	29	135	01:22-03:56
2017-Jun-10	218	15.4	09	19	24	103	01:24-03:51

Request: 8 tracks, 28.00 h

UT Date **(441987) 2010 NY65**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Jun-13	81	5.9	08	49	15	106	15:43-18:06
2017-Jun-14	74	6.0	10	57	21	157	15:40-18:07
2017-Jun-15	66	6.0	11	66	31	249	15:37-18:10
2017-Jun-16	59	6.1	13	77	45	397	15:35-18:14
2017-Jun-17	52	6.2	15	89	70	660	15:35-18:18
+ 2017-Jun-18	46	6.3	18	102	107	1080	15:37-18:24
+ 2017-Jun-19	39	6.5	22	117	188	2040	15:45-18:31
+ 2017-Jun-20	33	6.8	28	123	333	3690	16:05-18:36
+ 2017-Jun-21	28	7.3	35	88	582	5460	17:00-18:26
...	Target is north of the Arecibo declination window						
+ 2017-Jun-28	34	15.9	33	91	300	2870	01:04-02:58
+ 2017-Jun-29	41	16.2	28	99	158	1580	01:00-03:28
+ 2017-Jun-30	47	16.4	24	95	99	968	01:02-03:42
+ 2017-Jul-01	54	16.6	22	85	61	568	01:04-03:49
2017-Jul-02	61	16.7	19	77	40	354	01:06-03:52
2017-Jul-03	68	16.8	18	69	28	230	01:07-03:53
2017-Jul-04	75	16.8	16	62	20	156	01:08-03:52
2017-Jul-05	82	16.9	15	57	15	109	01:08-03:51

Request: 4 tracks, 14.75 h

UT Date **2010 VB1**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Jun-16	26	13.5	37	56	70	526	00:02-00:43
+ 2017-Jun-16	26	14.1	30	143	70	835	23:46-02:06
+ 2017-Jun-18	28	14.7	23	160	54	689	00:00-02:46
+ 2017-Jun-19	30	15.1	16	153	43	533	00:21-03:07
+ 2017-Jun-20	32	15.4	10	131	35	396	00:45-03:14
2017-Jun-21	35	15.7	05	98	25	252	01:12-03:12
2017-Jun-22	39	15.9	00	43	18	115	01:44-02:59

Request: 7 tracks, 25.75 h

UT Date **2005 UP156**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Jun-06	180	16.2	03	16	26	104	02:49-04:37
...	Target remains in sky at similar times						
+ 2017-Jun-20	150	16.8	10	28	49	260	02:10-04:37
...	Target remains in sky at similar times						
2017-Jul-01	137	17.5	13	33	67	383	02:03-04:42
2017-Jul-02	136	17.6	13	33	68	395	02:03-04:43
2017-Jul-03	136	17.7	13	33	68	395	02:04-04:44
2017-Jul-04	135	17.8	14	34	70	409	02:04-04:44
2017-Jul-05	135	17.8	14	34	70	409	02:05-04:45
2017-Jul-06	134	17.9	14	34	72	422	02:06-04:46
2017-Jul-07	134	18.0	14	34	72	422	02:06-04:47
+ 2017-Jul-08	134	18.1	14	34	72	422	02:07-04:49
+ 2017-Jul-09	134	18.1	14	34	72	422	02:08-04:50
+ 2017-Jul-10	134	18.2	14	34	72	422	02:09-04:51
+ 2017-Jul-11	134	18.3	14	34	72	422	02:10-04:52
+ 2017-Jul-12	134	18.4	14	34	72	422	02:12-04:53
2017-Jul-13	134	18.5	14	34	72	422	02:13-04:54
2017-Jul-14	134	18.6	14	34	72	422	02:14-04:55
2017-Jul-15	135	18.7	14	34	70	409	02:15-04:56
2017-Jul-16	135	18.8	14	34	70	409	02:17-04:57
2017-Jul-17	136	18.8	14	34	68	398	02:18-04:58
2017-Jul-18	136	18.9	13	33	68	395	02:19-04:59
2017-Jul-19	137	19.0	13	33	67	383	02:21-05:00
...	Target remains in sky at similar times						
+ 2017-Jul-29	150	19.8	10	28	49	260	02:33-05:03
...	Target remains in sky at similar times						
2017-Aug-11	183	20.6	05	19	24	106	02:44-04:45

Request: 4 tracks, 13.75 h

UT Date **(153415) 2001 QP153**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Aug-02	134	5.9	03	22	43	200	12:45-14:34
2017-Aug-03	124	6.0	08	32	56	318	12:28-14:49
+ 2017-Aug-04	115	6.0	14	40	73	459	12:19-14:59
+ 2017-Aug-05	107	6.1	20	44	93	619	12:17-15:03
+ 2017-Aug-06	101	6.2	27	42	114	739	12:26-14:58
+ 2017-Aug-07	97	6.4	35	26	131	669	13:01-14:31

Request: 4 tracks, 14.25 h

UT Date **(310560) 2001 QL142**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Sep-03	144	11.9	20	33	19	109	16:06-18:52
2017-Sep-04	133	11.9	18	35	25	149	16:05-18:51
+ 2017-Sep-05	121	12.0	15	38	35	216	16:05-18:48
+ 2017-Sep-06	110	12.0	12	40	48	309	16:07-18:44
+ 2017-Sep-07	100	12.1	08	40	67	426	16:14-18:36
+ 2017-Sep-08	90	12.2	04	36	97	583	16:29-18:22

Request: 4 tracks, 14.00 h

UT Date **(3122) Florence**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
+ 2017-Sep-02	47	20.9	07	81	5680	51300	01:29-03:45
+ 2017-Sep-03	49	20.7	16	95	4920	48000	01:01-03:44
+ 2017-Sep-04	51	20.6	24	88	4290	40200	00:49-03:28
+ 2017-Sep-05	55	20.4	31	65	3300	26700	00:52-02:57

Request: 5 tracks, 17.00 h

UT Date **(171576) 1999 VP11**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Oct-12	121	13.7	11	36	21	129	15:28-18:00
2017-Oct-13	109	13.7	10	39	31	193	15:28-17:58
2017-Oct-14	97	13.8	10	44	46	307	15:28-17:58
+ 2017-Oct-15	84	13.9	10	51	76	544	15:30-17:57
+ 2017-Oct-16	72	14.0	09	57	130	988	15:34-17:58
+ 2017-Oct-17	60	14.1	08	66	244	2000	15:41-18:00
+ 2017-Oct-18	48	14.3	06	76	527	4600	15:54-18:04
+ 2017-Oct-19	37	14.7	03	79	1290	11500	16:22-18:11

Request: 4 tracks, 11.75 h

UT Date **2003 UV11**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Oct-26	80	1.5	09	52	23	169	02:27-04:50
+ 2017-Oct-27	68	1.1	08	59	41	316	02:03-04:21
+ 2017-Oct-28	58	0.6	06	63	71	566	01:33-03:41
+ 2017-Oct-29	48	23.9	04	67	137	1120	00:55-02:45
+ 2017-Oct-30	41	22.9	00	41	235	1510	00:12-01:22

Request: 8 tracks, 27.00 h

UT Date **1989 VB**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
+ 2017-Oct-08	37	6.1	01	59	937	7240	08:46-10:10
+ 2017-Oct-09	40	6.2	04	80	718	6420	08:28-10:22
+ 2017-Oct-10	43	6.2	06	85	560	5160	08:17-10:28
+ 2017-Oct-11	46	6.2	08	86	444	4140	08:09-10:31
+ 2017-Oct-12	49	6.2	10	86	357	3330	08:02-10:32
+ 2017-Oct-13	53	6.2	12	84	273	2500	07:56-10:31
2017-Oct-14	56	6.2	13	81	226	2030	07:51-10:30
2017-Oct-15	59	6.2	15	78	188	1670	07:46-10:28
2017-Oct-16	62	6.2	16	75	159	1380	07:42-10:25
+ 2017-Oct-17	66	6.2	17	71	128	1080	07:37-10:22
2017-Oct-18	69	6.2	18	68	110	905	07:33-10:19
2017-Oct-19	72	6.2	18	65	95	766	07:29-10:15
2017-Oct-20	76	6.2	19	62	78	618	07:25-10:11
2017-Oct-21	79	6.2	20	59	69	529	07:21-10:07
2017-Oct-22	82	6.2	21	57	60	455	07:18-10:03
2017-Oct-23	86	6.2	21	54	51	377	07:14-09:58
+ 2017-Oct-24	89	6.2	22	52	45	327	07:10-09:54
2017-Oct-25	92	6.2	22	50	40	287	07:06-09:49
2017-Oct-26	96	6.2	23	48	35	242	07:02-09:45
2017-Oct-27	99	6.2	23	46	31	213	06:58-09:40
2017-Oct-28	102	6.2	24	44	28	188	06:54-09:35
2017-Oct-29	106	6.2	24	42	25	162	06:50-09:30
2017-Oct-30	109	6.2	24	41	22	145	06:45-09:25
2017-Oct-31	112	6.2	25	40	20	129	06:41-09:20

Request: 7 tracks, 24.25 h

UT Date **1989 UP**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Oct-25	69	4.1	00	24	47	234	05:49-06:55
2017-Oct-26	66	4.4	01	33	55	319	05:51-07:12
2017-Oct-27	63	4.6	02	41	64	416	05:56-07:29
2017-Oct-28	61	4.9	03	48	72	499	06:01-07:47
+ 2017-Oct-29	59	5.2	04	54	81	597	06:09-08:06
+ 2017-Oct-30	57	5.5	05	60	91	709	06:18-08:24
2017-Oct-31	56	5.8	07	68	97	802	06:29-08:43
2017-Nov-01	55	6.1	08	72	103	879	06:41-09:03
+ 2017-Nov-02	55	6.4	09	75	103	892	06:55-09:22
+ 2017-Nov-03	55	6.8	10	77	103	905	07:09-09:41
+ 2017-Nov-04	56	7.1	11	78	97	854	07:23-09:59
2017-Nov-05	56	7.5	12	79	97	862	07:37-10:16
2017-Nov-06	58	7.8	13	78	86	757	07:51-10:32
2017-Nov-07	59	8.1	14	78	81	714	08:05-10:47
+ 2017-Nov-08	61	8.3	15	76	72	628	08:17-11:01
+ 2017-Nov-09	64	8.6	15	72	61	520	08:29-11:13
2017-Nov-10	66	8.9	16	71	55	462	08:39-11:24
2017-Nov-11	69	9.1	16	68	47	388	08:49-11:34
2017-Nov-12	72	9.3	16	65	41	327	08:58-11:43
2017-Nov-13	75	9.5	16	62	35	278	09:05-11:51
2017-Nov-14	78	9.7	16	60	31	238	09:12-11:57
2017-Nov-15	82	9.8	16	57	26	200	09:18-12:03
2017-Nov-16	85	10.0	17	55	23	171	09:23-12:08
2017-Nov-17	89	10.2	17	53	20	145	09:27-12:13
2017-Nov-18	92	10.2	17	51	17	123	09:31-12:16
2017-Nov-19	96	10.4	17	49	15	106	09:34-12:19

Request: 8 tracks, 23.75 h

UT Date **(444584) 2006 UK**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Nov-07	95	2.0	32	36	18	108	02:24-04:26
2017-Nov-08	87	1.9	32	39	24	152	02:16-04:14
2017-Nov-09	78	1.8	33	40	36	226	02:06-04:01
2017-Nov-10	70	1.6	33	45	52	348	01:55-03:45
2017-Nov-11	62	1.4	34	46	79	535	01:42-03:26
+ 2017-Nov-12	54	1.2	34	52	127	924	01:26-03:04
+ 2017-Nov-13	47	0.8	35	53	205	1490	01:05-02:36
+ 2017-Nov-14	40	0.4	35	62	357	2810	00:35-02:01
+ 2017-Nov-14	33	23.7	34	85	689	6360	23:49-01:19
+ 2017-Nov-15	28	22.8	33	110	1200	12600	22:41-00:30
+ 2017-Nov-16	24	21.6	28	167	2030	26200	21:11-23:30
+ 2017-Nov-17	22	20.3	19	208	2720	39200	19:40-22:16
+ 2017-Nov-18	24	19.1	08	163	2030	25900	18:36-20:51

Request: 7 tracks, 23.50 h

UT Date **(163696) 2003 EB50**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
+ 2017-Nov-21	94	7.8	05	37	1120	6830	07:13-09:16
+ 2017-Nov-22	95	7.6	11	46	1080	7340	06:41-09:13
+ 2017-Nov-23	97	7.3	17	48	1010	7030	06:18-09:02
+ 2017-Nov-24	101	7.1	23	45	875	5900	06:02-08:44
+ 2017-Nov-25	106	6.9	27	40	740	4680	05:51-08:19
+ 2017-Nov-26	111	6.7	32	30	631	3500	05:47-07:49
+ 2017-Nov-27	118	6.5	36	17	510	2140	05:53-07:09

Request: 5 tracks, 16.00 h

UT Date **(3200) Phaethon**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
+ 2017-Dec-15	71	1.4	35	35	2150	12700	23:34-00:56
+ 2017-Dec-16	69	0.5	27	61	2370	18500	22:02-00:27
+ 2017-Dec-17	71	23.7	18	66	2150	17500	21:02-23:42
+ 2017-Dec-18	78	23.0	09	53	1550	11300	20:29-22:49
+ 2017-Dec-19	87	22.5	01	25	1060	5370	20:23-21:47

Request: 3 tracks, 10.00 h

UT Date **(418849) 2008 WM64**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
+ 2017-Dec-21	41	8.1	05	84	213	1950	05:40-07:37
+ 2017-Dec-22	39	8.0	18	120	252	2760	05:00-07:44
+ 2017-Dec-23	40	7.7	32	84	231	2120	05:05-07:01

Request: 6 tracks, 21.25 h

UT Date **2007 AG**	RTT [s]	RA [h]	Dec [deg]	Runs	SNR /run	SNR /day	UT rise-set
2017-Dec-13	95	17.7	26	46	17	113	15:23-17:59
2017-Dec-14	91	17.9	27	47	20	134	15:30-18:04
2017-Dec-15	86	18.1	27	49	23	163	15:38-18:09
2017-Dec-16	82	18.2	28	50	27	194	15:48-18:15
+ 2017-Dec-17	78	18.5	29	51	33	232	15:59-18:23
2017-Dec-18	75	18.7	30	50	37	266	16:12-18:32
2017-Dec-19	71	19.0	30	53	45	330	16:27-18:43
2017-Dec-20	68	19.3	31	53	52	381	16:44-18:56
2017-Dec-21	65	19.6	31	55	61	456	17:01-19:11
2017-Dec-22	63	20.0	31	57	68	515	17:20-19:29
+ 2017-Dec-23	61	20.4	31	59	76	585	17:39-19:49
2017-Dec-24	60	20.8	31	60	81	625	17:58-20:11
2017-Dec-25	59	21.2	30	64	86	684	18:17-20:35
2017-Dec-26	58	21.7	29	68	91	748	18:35-21:00
+ 2017-Dec-27	59	22.1	27	71	86	724	18:52-21:24
+ 2017-Dec-28	59	22.5	26	73	86	733	19:09-21:47
+ 2017-Dec-29	61	22.9	24	74	76	656	19:24-22:07
2017-Dec-30	62	23.2	22	74	72	623	19:39-22:25
2017-Dec-31	64	23.5	20	73	65	552	19:53-22:40
2018-Jan-01	67	23.8	18	70	55	462	20:06-22:53
2018-Jan-02	70	0.0	16	67	47	388	20:18-23:03
2018-Jan-03	73	0.2	14	63	41	325	20:29-23:11
+ 2018-Jan-04	76	0.5	13	60	36	276	20:39-23:17
2018-Jan-05	80	0.6	11	55	30	221	20:48-23:22
2018-Jan-06	84	0.8	10	51	25	180	20:56-23:25
2018-Jan-07	88	0.9	08	45	21	145	21:04-23:27
2018-Jan-08	92	1.1	07	42	19	121	21:21-23:28