Using Sharpcap Sequencing to Automate Nightly Occultation Observations with any ASCOM GoTo Telescope

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Disclaimer!

- There are many ways to address the scheduling automated observation of a full night of occultations.

  - Many of you already do so!

  - This presentation is about sharing one approach that has worked well for me and that is straightforward to implement.

What Led Me Here

- I was impressed with multi-telescope prepointed "Mighty Mini"-type video capture observations and wanted to extend that automated capability to frame-based sCMOS imagers.

    – Particularly the QHY174-GPS running with SharpCap

How SharpCap "Sequencing" Can Help

- SharpCap is a "free" Windows application that provides for adept use of integrating cameras.

  – You need to pay the ~$15 annual "Pro" fee to unlock the features exploited here.

- The Sequencer is a simple scripting language that includes commands such as:

  – MOUNT GOTO "19 53 49.8   -18 07 14"

  – MOUNT SOLVESYNCONLY

  – SET EXPOSURE TO 1.000

  – CAPTURE 1200 LIVE FRAMES

  – AUTOFOCUS OFFSET -2400 to 2400 STEP COUNT 14 BACKLASH 0

- And most importantly for occultations

  – WAIT UNTIL LOCALTIME 08:42

    •

SharpCap Sequence Editor

Basic Recipe

- Roughly align telescope to a fiducial position and turn on power.
  - Skywatchers, for example, power on with due north horizon coordinates (north and level)
  - Alternatively use park position (even with a portable telscope, for example Alt =55 Az=180)
- Slew to target
  - The pointing will be a degree or two off. No big deal.
- Platesolve and sync (zeros out the initial pointing error)
- Iterate pointing: Slew to target, again (1-2 deg). Platesolve and Sync. Slew.
- Autofocus
- Wait until event time
- Set integration time
- Capture required number of frames
- Next target...

Required Hardware/Software Components

- All hardware should be ASCOM compatible (most every driver is)
  - GoTo Telescope mount
  - ASCOM Focuser

- Platesolving software and associated stellar databases
  - All Sky Platesolver (ASPS)
  - Astrometric STAcking Program (ASTAP)

- Sharpcap compatible camera (the all are…)

- Ride along data acquisition and control computer
  - Remote desktop software
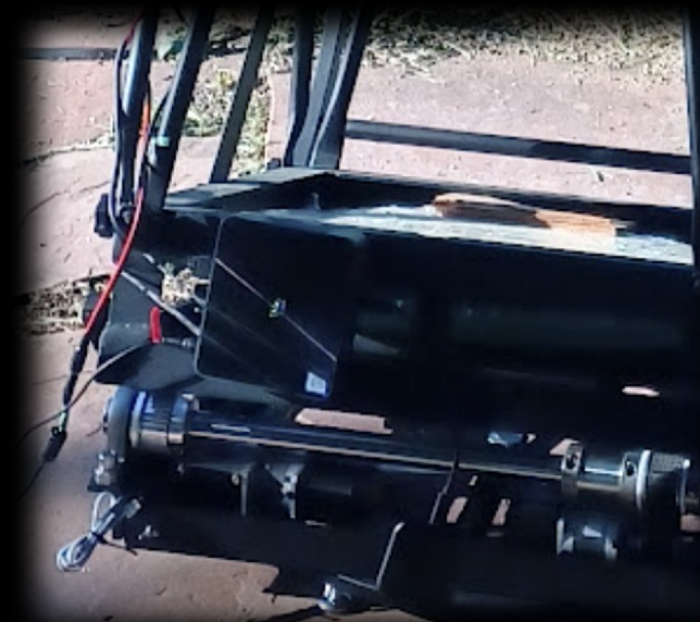
A DIY ASCOM Focuser – MyFP2 Project

- Extremely well documented

- Arduino Nano based.

- All drivers provided

- Runs NEMA-14 or NEMA-17 stepper motor

- Up to you to produce a drive train to turn your focuser knob – not hard.

- SharpCap has an autofocus routine that steps through focus positions and does a parabolic fit to the focus curve, returning to best focus at the end.

A Few Words About Platesolving

- You'll never star-align again. Your finder, if you can still find it, will collect dust.

- ASPS and ASTAP are fast (a few seconds typically, 20-30 seconds for ASPS worst case) and reliable as long as the platesolver detects enough stars
  - ASPS: 6-8 stars
  - ASTAP: 20-30 stars   (but in return it's much faster – less than a second)

- I've used both at different times but have gradually defaulted to ASPS because it is robust to having a limited number of stars.
  - Aside: Platesolving makes prepointing trivial. You point to/center on the appropriate coordinate for the current time and *don't need prepoint stars.*

A Real Sequencer Script - Setup

- Define subroutines to make the main script less wordy

  - Platesolving, focus, pointing

  - Errors kick you out of the sequence unless you explicitly ignore them.

  - One pointing subroutine for each occultation, again in the name of brevity later on.

```
SEQUENCE
#
  DEF SUB PLATESOLV
    IGNORE ERRORS FROM
      RETRY ERRORS UP TO 2 TIMES
        MOUNT SOLVESYNCONLY
      END RETRY ERRORS
    END IGNORE ERRORS
  END SUB
#
  DEF SUB POINT1
    IGNORE ERRORS FROM ONERROR RUN ""
      MOUNT GOTO "19 27 31.0 -15 24 58"
    END IGNORE ERRORS
    DELAY 10
  END SUB
#
  DEF SUB POINT2
    IGNORE ERRORS FROM ONERROR RUN ""
      MOUNT GOTO "18 36 06.1 -23 06 14"
    END IGNORE ERRORS
    DELAY 10
  END SUB
  ....
```

A Real Sequencer Script – First Occultation

- Largely consists of calling the subroutines set up previously.

- "UNLOCK CONTROLS" allows you to manipulate most SharpCap controls during the step. Otherwise you are locked out.

```
#
# Wait until 10 minutes before data recording time
#
    MOUNT TRACKING None
    UNLOCK CONTROLS
        WAIT UNTIL LOCALTIME 04:19
    END UNLOCK
    GOSUB TRACKSID
#
    GOSUB POINT1
    GOSUB PLATESOLV
#
    GOSUB AFOCUS
#
    GOSUB POINT1
    GOSUB PLATESOLV
# --1--
    UNLOCK CONTROLS
        WAIT UNTIL LOCALTIME 04:29
    END UNLOCK
# --1--
#
    GOSUB PLATESOLV
    SET COOLER TARGET TO -15
    DELAY 1
```

A Real Sequencer Script – Occultation 1

- Largely consists of calling the subroutines set up previously.

- "UNLOCK CONTROLS" allows you to manipulate most SharpCap controls during the step. Otherwise you are locked out.

- Repeat as needed

```
GOSUB AFOCUS
#
GOSUB POINT1
GOSUB PLATESOLV
# --1--
UNLOCK CONTROLS
    WAIT UNTIL LOCALTIME 04:29
END UNLOCK
# --1--
#
GOSUB PLATESOLV
SET COOLER TARGET TO -15
DELAY 1
SET EXPOSURE TO 0.250
DELAY 3
DISPLAY STRETCH AUTO
GOSUB POINT1
UNLOCK CONTROLS
  CAPTURE 1000 LIVE FRAMES
END UNLOCK
```

A Script Will Run Any ASCOM Scope Without Modification

- You do have to change the SharpCap Hardware settings but otherwise, every configuration below works transparently.

Hubble

ZWO AM5 + C11

Skywatcher

Celestron

IOptron AzPro

A Script Will Run Any ASCOM Scope Without Modification

- You do h̲̲̲ings but
  otherwise̲̲̲ently

SharpCap Settings ✕

Plate Solving	Polar Alignment	Guiding	Logging	Startup Scripts
General	Saving	**Hardware**	Cameras	Filenames	Memory

General

☑ Connect Hardware automatically when opening a camera

Mount

Select Hardware : SkyWatcher Telescope ⌄   [Properties]

☐ Reverse direction of SharpCap's Horizontal movement buttons

☐ Reverse direction of SharpCap's Vertical movement buttons

Focuser

Select Hardware : myFP2ASCOM ⌄   [Properties]

Backlash Compensation : ⚫ None
⚫ Handled by ASCOM Driver
⚫ Handled by SharpCap   Amount : [0 ⇕] steps
⚫ Overshoot (always approach from a single direction)
approach in [Positive ⌄] direction, overshoot [10 ⇕] steps

Filter Wheel

Select Hardware : None ⌄   [Properties]

☐ Use Focus Offset information to adjust focus on filter change

Rotator

Note there is a SharpCap Settings Screen for Platesolving

Is Scheduling 10 Occs a Night at Home Possible or Useful In Practice??

- The answer depends on your level of patience and available time.

  - With an 8" telescope I had been producing about one positive a week on average, never leaving the house – 50 positives a year.

  - Today, with a 16" aperture, it's looking like I can double that pace.

- Most of these events don't appear in Occult Watcher because they are not of high rank

  - But that low rank is interesting in its own right.

A Typical High Rank (OW) Event

- Uncertainty is small relative to object size.

- It's worth making a trip to the shadow and you will likely succeed.

- Great campaign target to determine a shape.

A Typical "Stay at Home" Low Rank Event

- Large uncertainty relative to shadow size.

- No point in traveling
  - Typical probability 5-10% almost independent of location.

- A positive result improves the orbit.
  - Next time around the prediction will be more precise.

Running Personal Predictions with Occult4 is Essential

- OW shows a limited number of filtered high rank events.

- Occult4 lets you see "all" potential events with even modest probability and low rank (but those are the juicy ones).

- For the 16" I currently filter for all events brighter than 16 mag with greater than 5% probability for local observation.

Running Personal Predictions with Occult4 is Essential
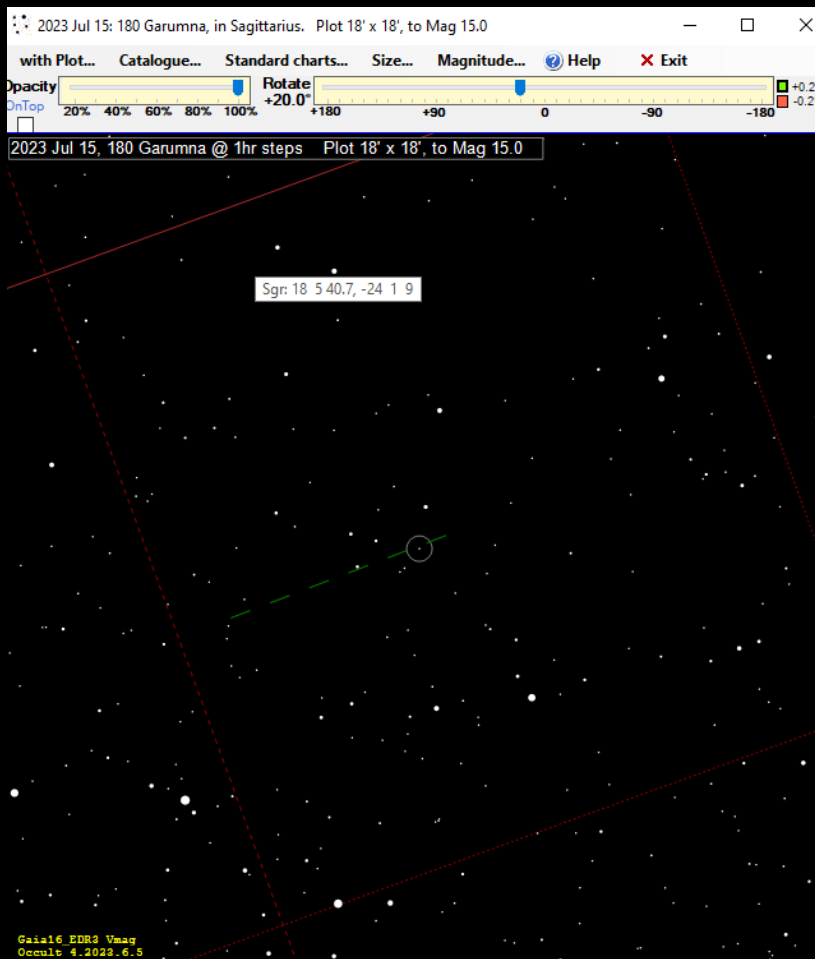
- Occult4 steps:
  - Cast a wide net with default downloaded elements.
    - 3 km object size limit searches 150,000 objects
  - Download Horizons elements from pass1 events and run a second pass for final (accurate predictions).
  - Yields about 25 potential events per night with >5% probability at or better than the limit of my 16" system.

Quick Aside: Best Finder Charts I Have Ever Used

Tonight's (Jul 16 UT) Raw List from Occult4

```
Event Summary for Longitude -105.4454°, Latitude 39.9872°  - sorted by Date

Date      U.T.      Diameter   Durn  Star  Mag-Drop Elon  Star              Rely    Planet          Alt  Proba-        R.A. (J2000)  Dec.

Jul 16    3 37.1     13 0.008  1.09s 15.0  3.3   3.7† UCAC4 292-184550      0.90  10444 de Hevesy   11 150    11%    18 29   2.321 -31 41 54.77
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Jul 16    4 26.2    6.2 0.004  0.51s 15.9  3.6   3.7  UCAC4 381-065645      1.10  21696 Ermalmquis  21 229     7%    13 49 29.283 -13 56 56.88
Jul 16    4 52.0    8.5 0.006  0.66s 15.7  1.5   1.7  UCAC4 424-060430      1.00   6898 Saint-Mary  31 230    20%    14 41 12.826 -  5 18 27.33
Jul 16    4 57.8   3.41 0.004  0.44s 14.7  3.7   4.2† UCAC4 313-244252      1.20 118631 2000 HB48   19 157     5%    19  9 58.363 -27 35  8.35

Jul 16    5  8.3   3.81 0.004  0.46s 14.9  3.6   3.9  UCAC4 383-116063      0.85 206668 2003 YE85   35 163     6%    18 35 32.136 -13 28 36.84
Jul 16    5  8.2   3.71 0.005  0.53s 15.2  2.3   2.5† UCAC4 327-155258      1.10  18773 Bredehoft   24 168     8%    18 30  6.989 -24 42 58.56
Jul 16    5 21.1    4.7 0.003  0.34s 14.5  6.2   5.8  UCAC4 390-059321      1.15  41684 2000 UL15   11 243     9%    13 38 14.406 -12  9 26.82
Jul 16    5 27.0    8.8 0.007  0.81s 13.8  4.1   4.3  UCAC4 278-213583      1.00  13775 Thebault    14 167     7%    19  0 23.396 -34 31  5.00
Jul 16    5 33.5   3.61 0.003  0.61s 15.4  3.4   3.9  UCAC4 347-093316      1.00  20420 Marashwhit  28 193     6%    17 16 55.396 -20 37 34.29

Jul 16    5 49.2     18 0.012  1.56s 15.8  0.7   0.8† UCAC4 367-123735      2.70   2802 Weisell     33 178    19%    18 27  4.057 -16 44 42.08
Jul 16    5 55.5    8.4 0.005  0.82s 13.5  5.6   6.3  UCAC4 275-150018 s    1.60  83451 2001 SR60   15 186     6%    18  1 16.643 -35  0  6.59
Jul 16    5 55.1   3.51 0.004  0.42s 14.5  4.2   4.3  UCAC4 454-120392      1.00  15121 2000 EN14    7  95     7%    23 52  9.990   0 47 50.69
Jul 16    6 14.6     19 0.014  1.67s 15.0  1.9   2.0  UCAC4 374-175175      0.90   4808 Ballaero    26 142    36%    21  4 58.129 -15 12 20.09
Jul 16    6 33.3   3.91 0.005  0.58s 14.8  1.9   2.4† UCAC4 310-208220      0.90  52839 1998 RZ55   21 190    13%    18 22  0.391 -28  2 56.41

Jul 16    6 35.6    6.2 0.006  0.70s 15.9  0.6  0.49‡ UCAC4 279-185107      0.85  31487 Parthchopr  15 189     9%    18 23 47.982 -34 16 51.26
Jul 16    6 36.3    8.3 0.004  0.57s 13.5  5.5   5.8† UCAC4 336-186099      2.50  47108 1999 CM37   27 180     8%    19  9 16.365 -22 51 59.84
Jul 16    6 53.0    8.3 0.005  0.74s 15.9  3.5   4.1  UCAC4 356-109172      1.00  74400 Streaky     26 208     8%    17 40 34.873 -18 54 16.09
Jul 16    6 59.9    8.0 0.006  0.88s 14.6  0.9   0.8† G180042.3-272011 s   0.95  25261 1998 VX5    20 202     8%    18  0 42.259 -27 20 10.69
Jul 16    7  6.8    8.0 0.006  0.85s 15.6 0.30  0.11‡ UCAC4 314-126147      1.15  25261 1998 VX5    19 203     9%    18  0 42.035 -27 20 10.65

Jul 16    6 50.4    4.8 0.007  1.29s 15.5  2.6   3.2  UCAC4 327-102480      1.25  77981 2002 JK24   20 209     6%    17 24 20.026 -24 40 17.84
Jul 16    7 31.4    4.7 0.006  0.54s 15.5  1.4   1.7  UCAC4 304-252072      0.95  25546 1999 XL164  20 194    13%    19  4  3.327 -29 13 56.94
Jul 16    8 12.7     10 0.008  1.49s 13.2  4.8   5.8  UCAC4 345-103661 s    0.80   4108 Rakos       15 225    16%    17 34 51.728 -21  5 46.51
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Jul 16    8 27.8     10 0.008  1.24s 12.8  5.1   6.0† UCAC4 296-167073 s    0.80  14077 Volfango     9 216    14%    18 11 11.099 -30 50  2.98

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Jul 16    9 36.8     82 0.107   7.3s 12.8 0.33  0.33  UCAC4 549-127153      0.90    914 Palisana    61 233    50%    20 33  7.475  19 44 39.75
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```

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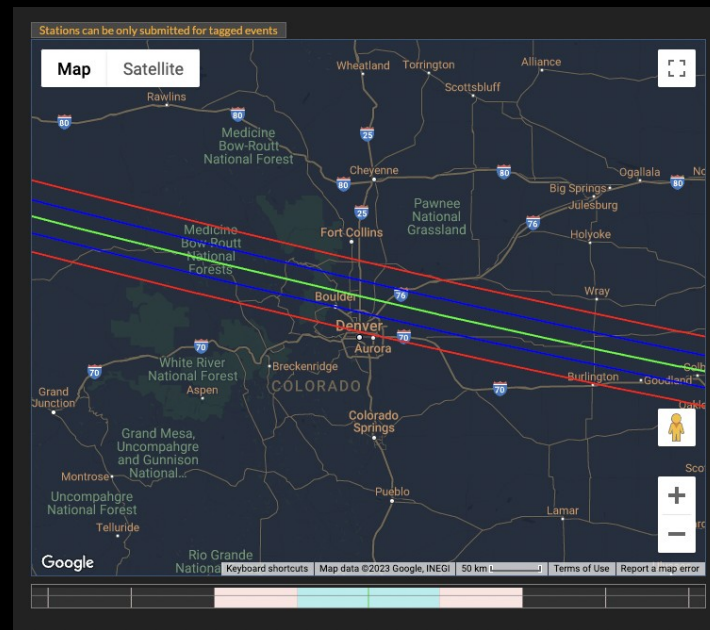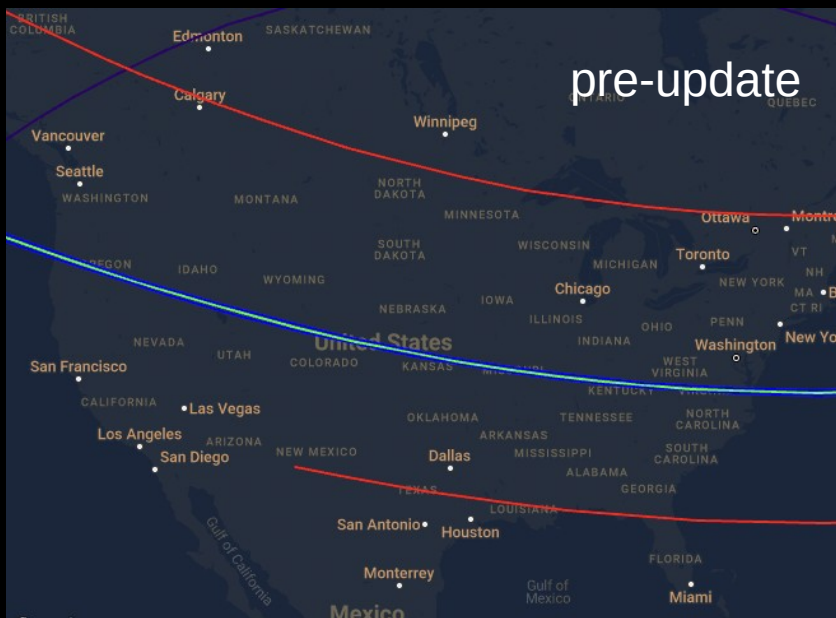
Another Aside: 4808 Ballaero Tonight

- Prior to requesting an update at Occult Watcher Cloud this event was Rank 2 with huge uncertainty.

- Following a request for update at OWC the Rank is now 86 and the uncertainty is tight as suggested by the Occult4 prediction.

pre-update

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Jul 16   5 33.5   3.61 0.003   0.61s 15.4   3.4   3.9  UCAC4 347-093316   1.00   20420 Marashwhit  28 193     6%     17 16 55.396 −20 37 34.29

Jul 16   5 49.2     18 0.012   1.56s 15.8   0.7   0.8† UCAC4 367-123735   2.70    2802 Weisell     33 178    19%     18 27  4.057 −16 44 42.08
Jul 16   5 55.5    8.4 0.005   0.82s 13.5   5.6   6.3  UCAC4 275-150018 s 1.60   83451 2001 SR60   15 186     6%     18  1 16.643 −35  0  6.59
Jul 16   5 55.1   3.51 0.004   0.42s 14.5   4.2   4.3  UCAC4 454-120392   1.00   15121 2000 EN14    7  95     7%     23 52  9.990   0 47 50.69
Jul 16   6 14.6     19 0.014   1.67s 15.0   1.9   2.0  UCAC4 374-175175   0.90    4808 Ballaero    26 142    36%     21  4 58.129 −15 12 20.09
Jul 16   6 33.3   3.91 0.005   0.58s 14.8   1.9   2.4† UCAC4 310-208220   0.90   52839 1998 RZ55   21 190    13%     18 22  0.391 −28  2 56.41

Jul 16   6 35.6    6.2 0.006   0.70s 15.9   0.6  0.49‡ UCAC4 279-185107   0.85   31487 Parthchopr  15 189     9%     18 23 47.982 −34 16 51.26
Jul 16   6 36.3    8.3 0.004   0.57s 13.5   5.5   5.8† UCAC4 336-186099   2.50   47108 1999 CM37   27 180     8%     19  9 16.365 −22 51 59.84
Jul 16   6 53.0    8.3 0.005   0.74s 15.9   3.5   4.1  UCAC4 356-109172   1.00   74400 Streaky     26 208     8%     17 40 34.873 −18 54 16.09
Jul 16   6 59.9    8.0 0.006   0.88s 14.6   0.9   0.8‡ G180042.3-272011 s 0.95   25261 1998 VX5   20 202     8%     18  0 42.259 −27 20 10.69
Jul 16   7  6.8    8.0 0.006   0.85s 15.6  0.30  0.11‡ UCAC4 314-126147   1.15   25261 1998 VX5   19 203     9%     18  0 42.035 −27 20 10.65

Jul 16   6 50.4    4.8 0.007   1.29s 15.5   2.6   3.2  UCAC4 327-102480   1.25   77981 2002 JK24   20 209     6%     17 24 20.026 −24 40 17.84
Jul 16   7 31.4    4.7 0.006   0.54s 15.5   1.4   1.7  UCAC4 304-252072   0.95   25546 1999 XL164  20 194    13%     19  4  3.327 −29 13 56.94
Jul 16   8 12.7     10 0.008   1.49s 13.2   4.8   5.8  UCAC4 345-103661 s 0.80    4108 Rakos       15 225    16%     17 34 51.728 −21  5 46.51
Jul 16   8 18.3    4.4 0.003   0.42s 15.3   4.7   5.3† UCAC4 287-136437   0.95  146543 2001 SC277   7 216     7%     17 55 31.941 −32 47 46.80
Jul 16   8 27.8     10 0.008   1.24s 12.8   5.1   6.0† UCAC4 296-167073 s 0.80   14077 Volfango     9 216    14%     18 11 11.099 −30 50  2.98

Jul 16   8 45.4     13 0.007   0.84s 15.4   3.7   3.8  UCAC4 567-000122   0.95  109582 2001 QL275  52 103     5%      0  3 42.527  23 18 45.82
Jul 16   9  4.5    6.2 0.004   0.70s 15.4   4.5   4.9  UCAC4 366-089969   1.00   69967 1998 VS49    9 239     6%     17 28 13.815 −16 52  5.72
Jul 16   8 52.2    7.9 0.004   1.56s 14.0   5.9   6.0  UCAC4 461-059518   0.90  104540 2000 GF57   11 264     6%     16 14 57.448   2 10  6.11
Jul 16   9 36.8     82 0.107    7.3s 12.8  0.33  0.33  UCAC4 549-127153   0.90     914 Palisana    61 233    50%     20 33  7.475  19 44 39.75
Jul 16   9 30.1   3.91 0.004   0.42s 15.6   1.9   2.2  UCAC4 347-165280   1.10   19596 Spegorlars  16 224     6%     18 59 55.905 −20 38  9.65
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Last Night's (Jul 15 UT) Selected List – Ten Events, All Observed

2023 Jul 15	4 31.0	12 0.009	1.03s 15.0	1.5	1.7	173	UCAC4 373-171209	0.95	9711 Zeletava	25 140	0.0	17%	150	6	19 27 31.0 -15 24 58.81
2023 Jul 15	4 44.9	6.6 0.005	0.70s 14.0	4.8	5.3	166	UCAC4 335-177058	1.25	73622 3418 T-3	24 159	0.0	6%	165	6	18 36 06.1 -23 06 14.22
2023 Jul 15	4 55.0	25 0.016	2.2s 14.8	0.8	1.2	159	UCAC4 330-126165	1.10	180 Garumna	25 169	0.0	26%	172	6 §	18 05 35.6 -24 08 21.16
2023 Jul 15	5 4.6	9.7 0.006	0.69s 13.1	5.0	5.1	167	UCAC4 356-161667	0.85	15243 1989 TU1	29 160	0.0	28%	161	6	18 44 39.1 -18 56 19.84
2023 Jul 15	5 13.7	12 0.009	0.98s 15.9	1.8	2.3†	164	UCAC4 329-155593	1.35	25467 1999 XV32	25 168	0.0	23%	167	6	18 30 21.9 -24 12 11.29
2023 Jul 15	5 42.5	4.0 0.003	0.35s 14.5	4.7	4.8	164	UCAC4 419-135018	1.00	46060 2001 DL88	37 145	0.0	5%	139	6	20 00 55.3 -06 22 01.91
2023 Jul 15	6 18.6	6.6 0.004	0.56s 15.3	4.8	5.0	136	UCAC4 490-068931	0.90	162971 2001 QU256	53 215	0.0	5%	145	6	17 26 19.2 07 55 52.12
2023 Jul 15	6 43.1	186 0.104	15.7s 13.6 0.36		0.5‡	154	UCAC4 278-151607	6.10	94 Aurora	14 196	0.0	90%	172	6 §	17 56 53.8 -34 30 07.86
2023 Jul 15	6 53.5	7.1 0.005	0.70s 13.3	5.1	5.3	154	UCAC4 340-108576	0.85	45635 2000 EY11	24 205	0.0	7%	175	6	17 43 35.4 -22 10 28.51
2023 Jul 15	8 0.3	22 0.013	1.64s 15.1	2.0	2.6	161	UCAC4 408-086141	0.85	24388 2000 AB175	36 213	0.0	17%	156	6	18 42 20.6 -08 33 55.50

- Typically 6 to 12 events survive selection for a given night
- Star is dead center in every automated observation (very rarely platesolve will fail)
- Autofocus still needs work. Worst case it returns to the previous focus after failing a parabolic fit.
  - Windshake, tracking glitches will confuse the algorithm.

Contact Info – Queries Always Welcome

- Questions about
  - SharpCap sequencing
  - Mount interfacing
  - MyFP2 focuser
    - I had a bunch of boards made and can mail you one.
  - Etc...

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