EXOPLANET TRANSIT OBSERVATION

Bart Billard & Jerry Hubbell

Outline

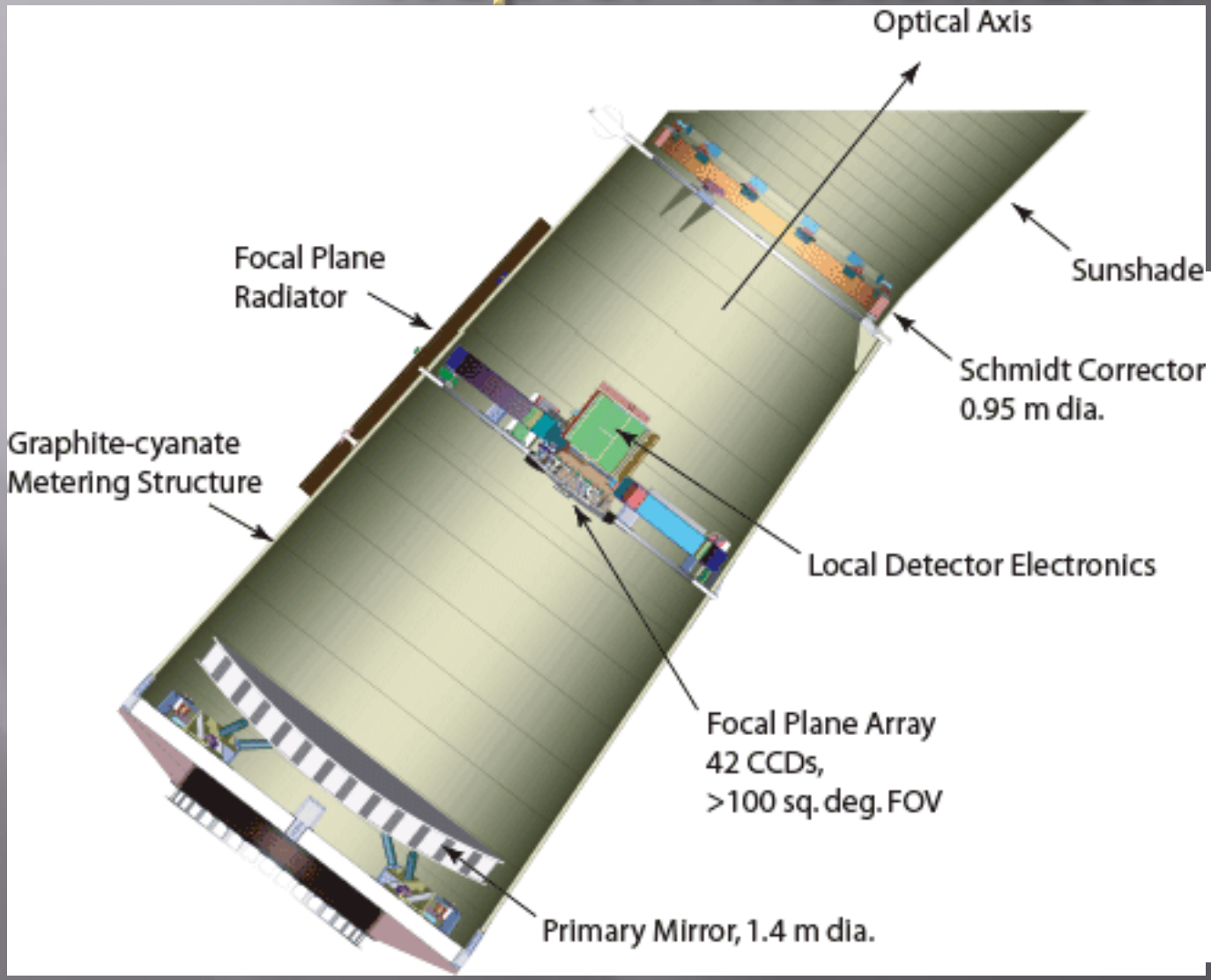
- Introduction and background
  - Basics
  - Bruce Gary's book
  - AAVSO Exoplanet Course and CHOICE program
  - Dennis Conti's book
- First observation attempt—GJ436
  - Looking at predictions to find observing opportunities
  - Translating identifiers to locate the star
  - Checking field of view (FOV) for its suitability for an observation
  - Locating the FOV with the telescope and taking the data
  - Results
- Lessons learned and next step
- Resources

The Kepler Mission

NASA Discovery Mission # 10 "Are there other planets, orbiting other stars, with characteristics similar to Earth?"

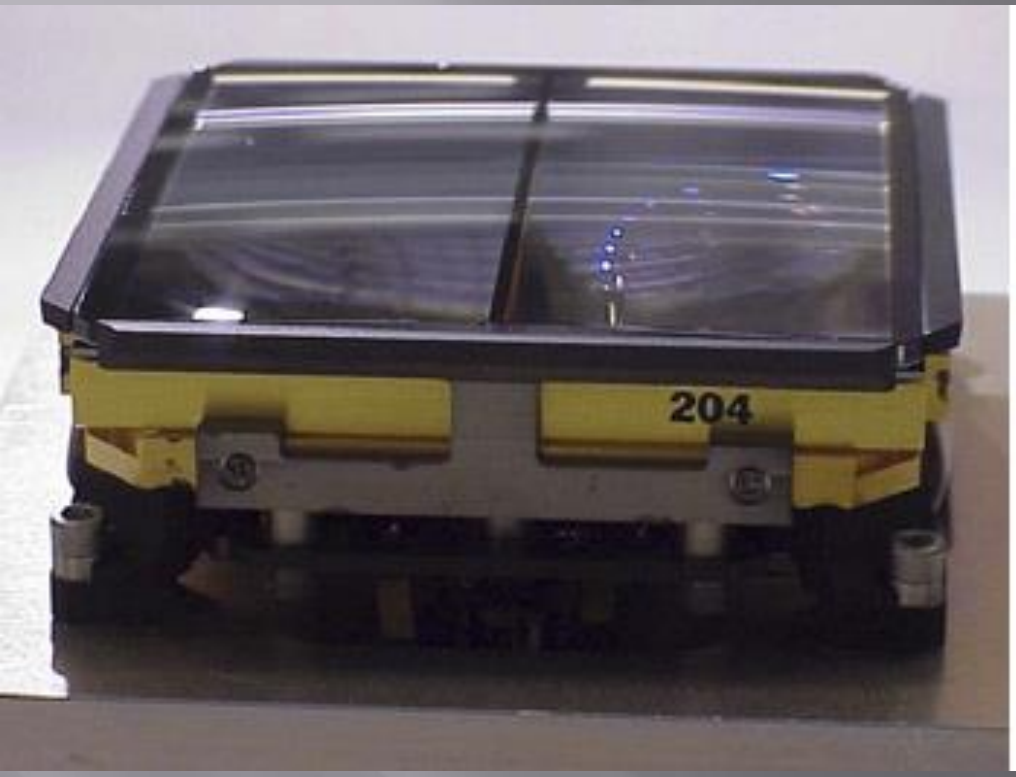
"The Kepler mission will challenge thousands of stars to a staring contest, you know, like the ones you used to have with your siblings when you were younger, and that you have with the cat every once in awhile?"
— Davin Flateau, 365 Days of Astronomy podcast, March 1, 2009

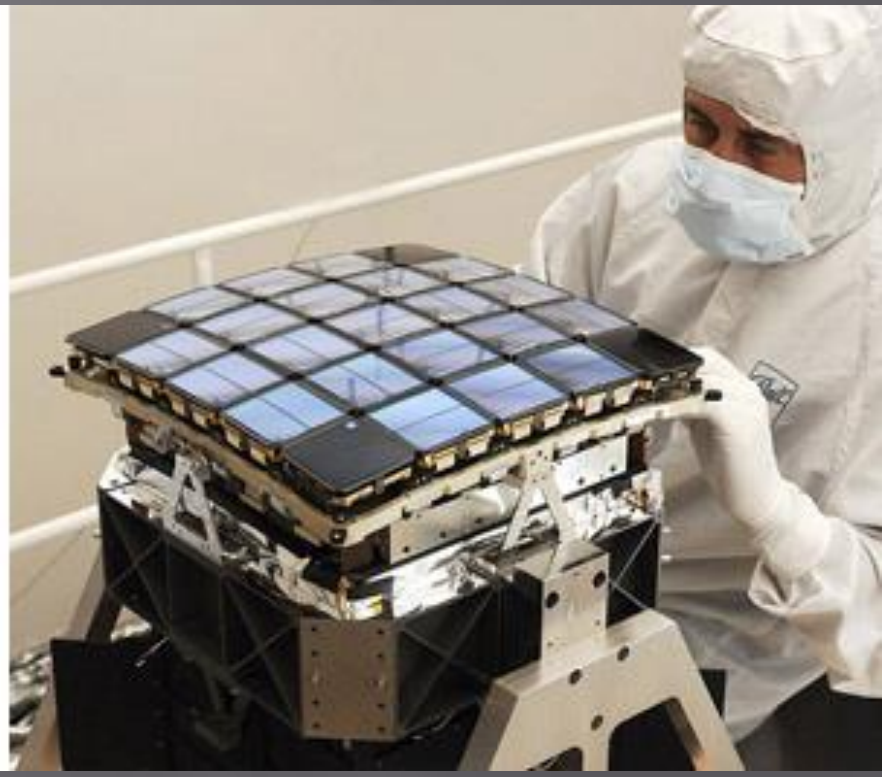
Kepler Photometer



http://kepler.nasa.gov/multimedia/Images/

Kepler CCD Array





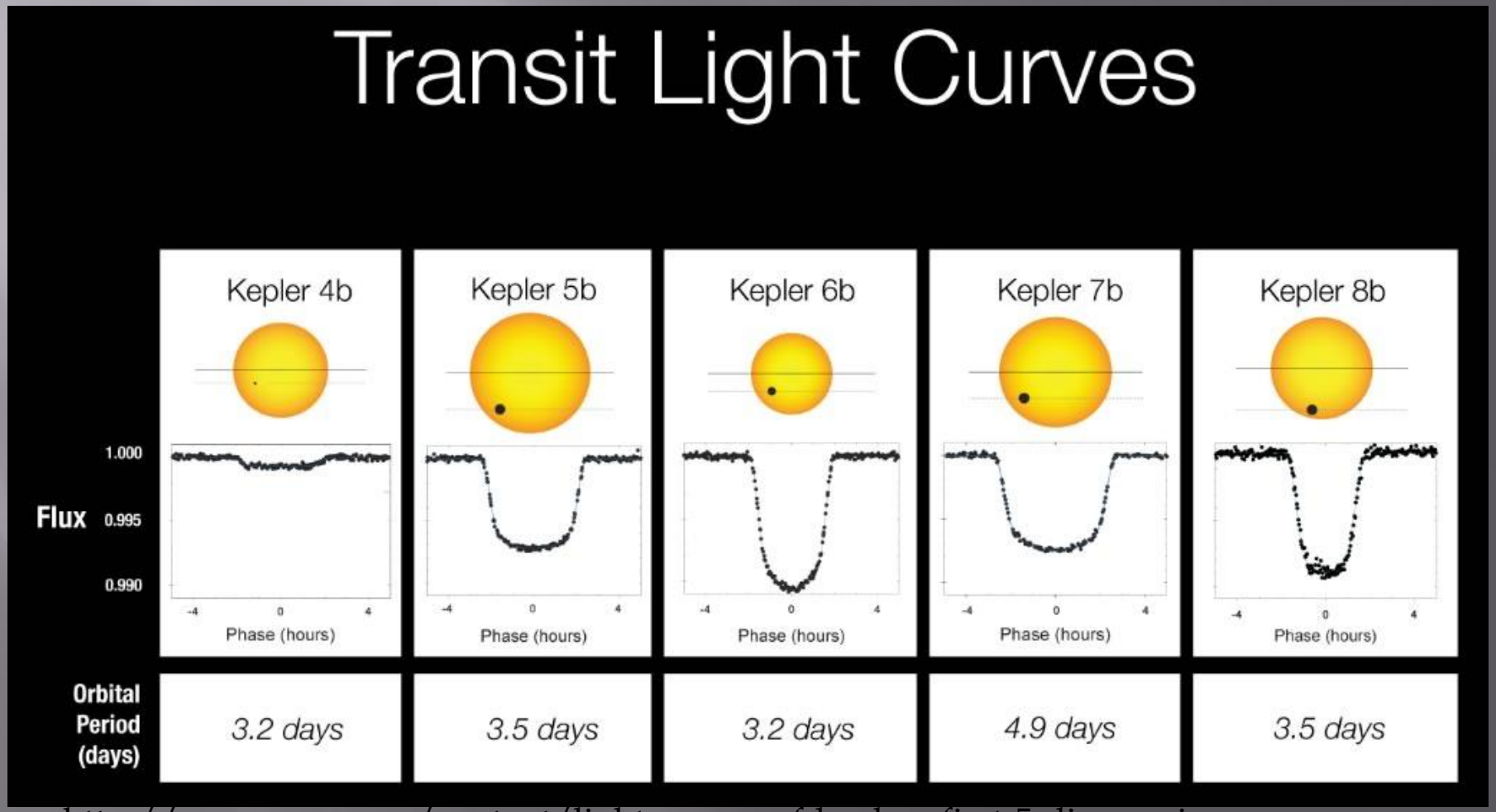
24 pairs of CCD elements, each 2,200 By 1,024 pixels, for 95 megapixels total —30 pixels for each target star

Covers 15-degree wide field of view in Cygnus and Lyra

Square arrangement can turn 90 degrees each quarter

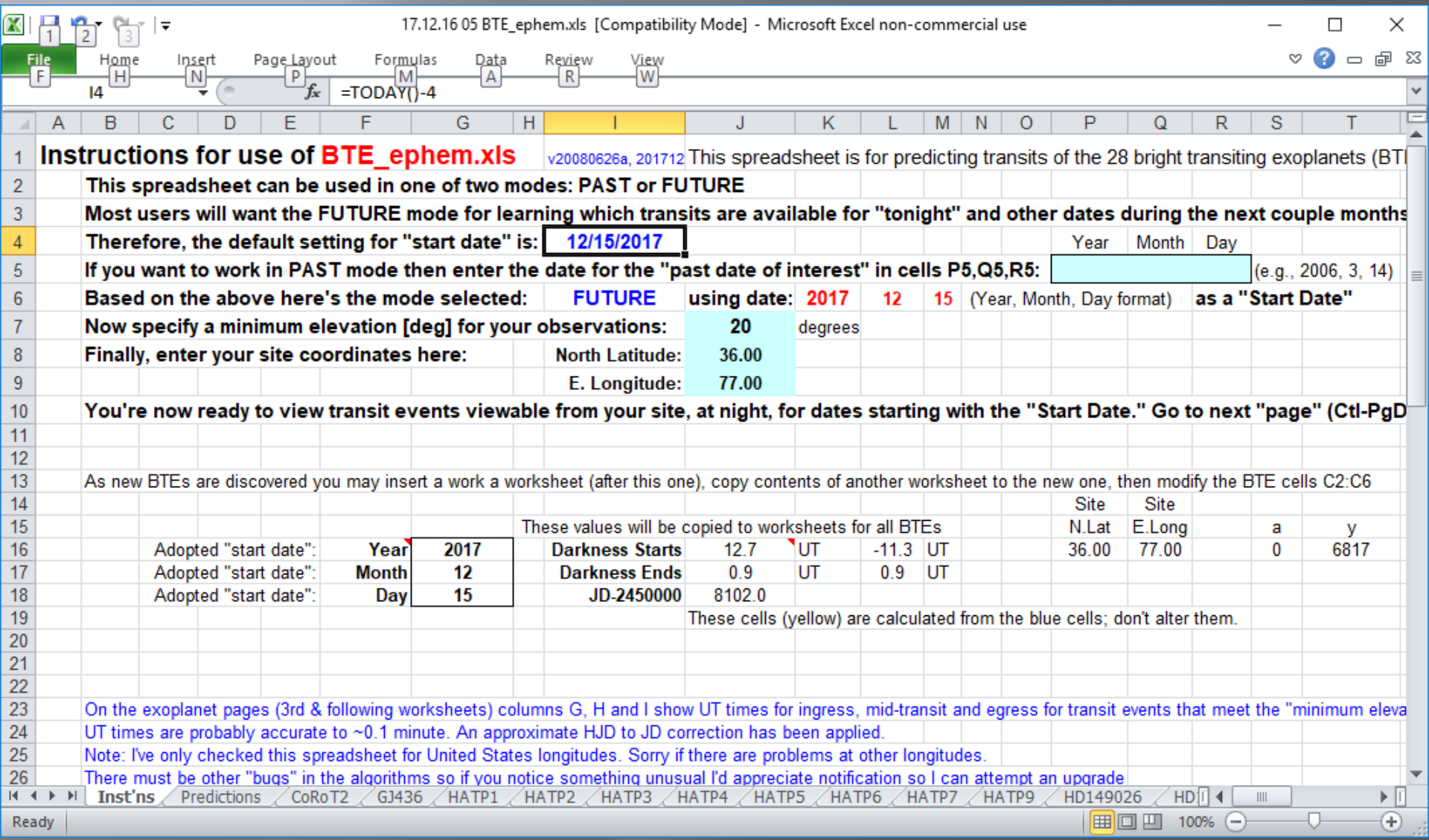
http://kepler.nasa.gov/multimedia/Images/

Detecting Transits with Photometry



http://www.nasa.gov/content/light-curves-of-keplers-first-5-discoveries

Using Bruce Gary's BTE_ephemeris spreadsheet to find out what's happening



17.12.16 05 BTE_ephem.xls [Compatibility Mode] - Microsoft Excel non-commercial use

File Home Insert Page Layout Formulas Data Review View

I4 =TODAY()-4

Instructions for use of BTE_ephem.xls v20080626a, 201712 This spreadsheet is for predicting transits of the 28 bright transiting exoplanets (BTI

This spreadsheet can be used in one of two modes: PAST or FUTURE

Most users will want the FUTURE mode for learning which transits are available for "tonight" and other dates during the next couple months

Therefore, the default setting for "start date" is: 12/15/2017 (Year, Month, Day)

If you want to work in PAST mode then enter the date for the "past date of interest" in cells P5,Q5,R5: (e.g., 2006, 3, 14)

Based on the above here's the mode selected: FUTURE **using date:** 2017 12 15 (Year, Month, Day format) **as a "Start Date"**

Now specify a minimum elevation [deg] for your observations: 20 degrees

Finally, enter your site coordinates here: North Latitude: 36.00

E. Longitude: 77.00

You're now ready to view transit events viewable from your site, at night, for dates starting with the "Start Date." Go to next "page" (Ctl-PgD

As new BTEs are discovered you may insert a work a worksheet (after this one), copy contents of another worksheet to the new one, then modify the BTE cells C2:C6

These values will be copied to worksheets for all BTEs

								Site N.Lat	Site E.Long	a	y
Adopted "start date":	Year	2017	Darkness Starts	12.7	UT	-11.3	UT	36.00	77.00	0	6817
Adopted "start date":	Month	12	Darkness Ends	0.9	UT	0.9	UT				
Adopted "start date":	Day	15	JD-2450000	8102.0							

These cells (yellow) are calculated from the blue cells; don't alter them.

On the exoplanet pages (3rd & following worksheets) columns G, H and I show UT times for ingress, mid-transit and egress for transit events that meet the "minimum eleva

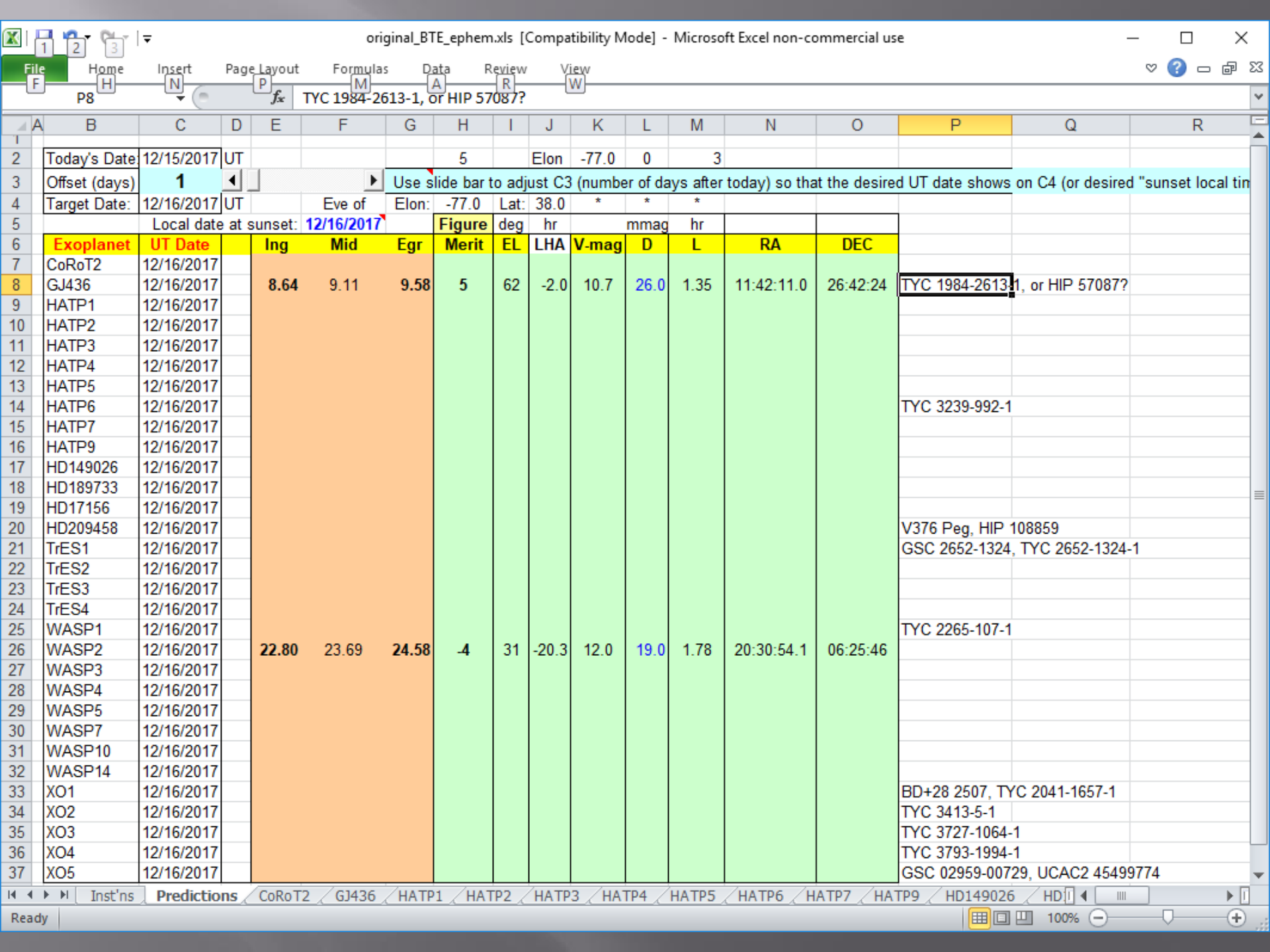
UT times are probably accurate to ~0.1 minute. An approximate HJD to JD correction has been applied.

Note: I've only checked this spreadsheet for United States longitudes. Sorry if there are problems at other longitudes.

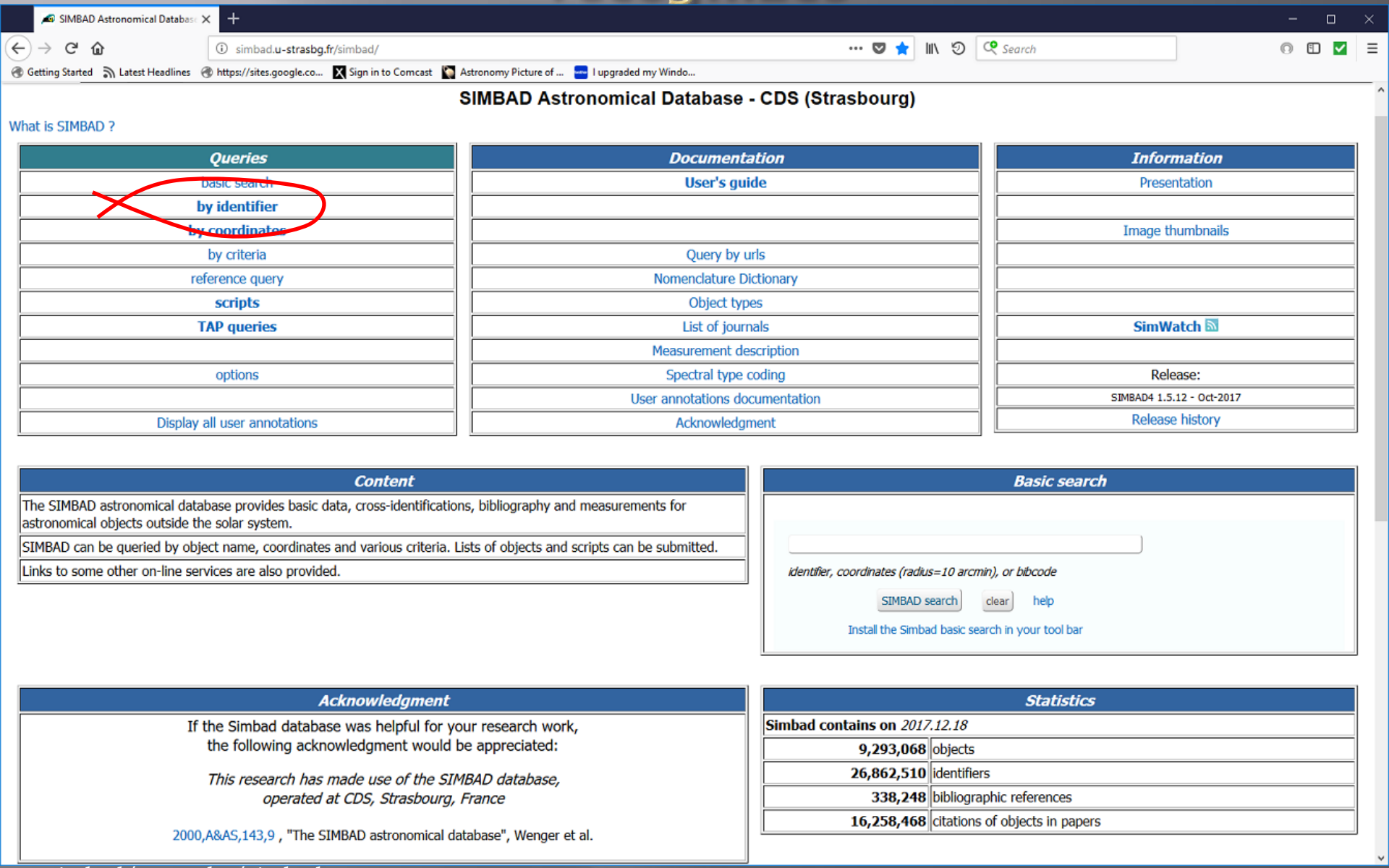
There must be other "bugs" in the algorithms so if you notice something unusual I'd appreciate notification so I can attempt an upgrade

Inst'ns Predictions CoRoT2 GJ436 HATP1 HATP2 HATP3 HATP4 HATP5 HATP6 HATP7 HATP9 HD149026 HD

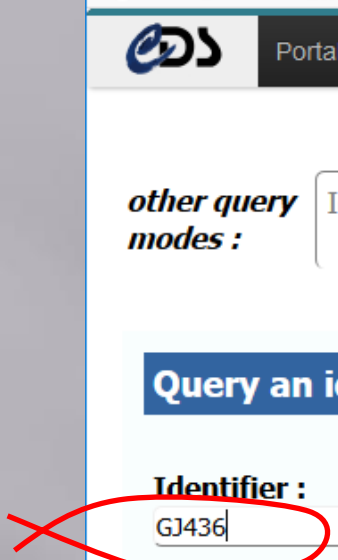
Ready 100%


original_BTE_ephem.xls [Compatibility Mode] - Microsoft Excel non-commercial use
File Home Insert Page Layout Formulas Data Review View
P8
TYC 1984-2613-1, or HIP 57087?
Today's Date 12/15/2017 UT
Offset (days) 1
Use slide bar to adjust C3 (number of days after today) so that the desired UT date shows on C4 (or desired "sunset local tim
Target Date: 12/16/2017 UT
Eve of
Elon: -77.0 Lat: 38.0
Local date at sunset: 12/16/2017
Figure Merit
deg
hr
mmag
hr
Exoplanet UT Date Ing Mid Egr EL LHA V-mag D L RA DEC
CoRoT2 12/16/2017
GJ436 12/16/2017 8.64 9.11 9.58 5 62 -2.0 10.7 26.0 1.35 11:42:11.0 26:42:24
HATP1 12/16/2017
HATP2 12/16/2017
HATP3 12/16/2017
HATP4 12/16/2017
HATP5 12/16/2017
HATP6 12/16/2017
HATP7 12/16/2017
HATP9 12/16/2017
HD149026 12/16/2017
HD189733 12/16/2017
HD17156 12/16/2017
HD209458 12/16/2017
TrES1 12/16/2017
TrES2 12/16/2017
TrES3 12/16/2017
TrES4 12/16/2017
WASP1 12/16/2017
WASP2 12/16/2017 22.80 23.69 24.58 -4 31 -20.3 12.0 19.0 1.78 20:30:54.1 06:25:46
WASP3 12/16/2017
WASP4 12/16/2017
WASP5 12/16/2017
WASP7 12/16/2017
WASP10 12/16/2017
WASP14 12/16/2017
XO1 12/16/2017
XO2 12/16/2017
XO3 12/16/2017
XO4 12/16/2017
XO5 12/16/2017
TYC 1984-2613-1, or HIP 57087?
TYC 3239-992-1
V376 Peg, HIP 108859
GSC 2652-1324, TYC 2652-1324-1
TYC 2265-107-1
BD+28 2507, TYC 2041-1657-1
TYC 3413-5-1
TYC 3727-1064-1
TYC 3793-1994-1
GSC 02959-00729, UCAC2 45499774
Inst'ns Predictions CoRoT2 GJ436 HATP1 HATP2 HATP3 HATP4 HATP5 HATP6 HATP7 HATP9 HD149026 HD
Ready
100%

Finding a star identifier that Cartes du Ciel recognizes



simbad/u-strasbg/simbad



SIMBAD: Query by identifiers

simbad.u-strasbg.fr/simbad/sim-fid

Search

Getting Started | Latest Headlines | https://sites.google.co... | Sign in to Comcast | Astronomy Picture of ... | I upgraded my Windo...

Portal | Simbad | VizieR | Aladin | X-Match | Other | Help

SIMBAD: Query by identifiers

other query modes : Identifier query | Coordinate query | Criteria query | Reference query | Basic query | Script submission | TAP | Output options | Help

Query an identifier

Identifier :

GJ436

Examples
sirius, M31, MCG+02-60-010
How to write an identifier can be found in the dictionary of nomenclature
IAU format can also be used, with the following format:
`iau [J|B]1230+08 [* enlarging-factor ] [= Object-type ]`

you can choose to query : only this object

around the object, define a radius : 2 arc min

submit id | clear

Query a list of identifiers

Enter the name of an ASCII file produced by a text editor containing one identifier per line:

Browse... No file selected.

◉ list display ○ full display

submit file | clear

☐ query around the objects with radius : 2 arc min *Only the list display applies here*

GJ436

other query modes : Identifier query | Coordinate query | Criteria query | Reference query | Basic query | Script submission | TAP | Output options | Help

Query : GJ436 submit id

C.D.S. - SIMBAD4 rel 1.5.12 - 2017.12.18CET23:52:28

Available data : Basic data • Identifiers • Plot & images • Bibliography • Measurements • External archives • Notes • Annotations

Basic data :

Ross 905 -- High proper-motion Star

Other object types:	* (Ref,AC,...), PM* (Ref,LHS,...), IR (2MASS), X (1RXS)
ICRS coord. *(ep=J2000) :*	11 42 11.0932 +26 42 23.653 (Optical) [0.245 0.223 90] A 2016A&A...595A...2G
FK5 coord. *(ep=J2000 eq=2000) :*	11 42 11.093 +26 42 23.65 [0.245 0.223 90]
FK4 coord. *(ep=B1950 eq=1950) :*	11 39 31.17 +26 59 42.9 [10.003 6.204 90]
Gal coord. *(ep=J2000) :*	210.5419 +74.5689 [0.245 0.223 90]
Proper motions *mas/yr* :	895.196 -813.717 [0.200 0.124 90] A 2016A&A...595A...2G
Radial velocity / Redshift / cz :	V(km/s) 9.61 [0.1] / z(~) 0.000032 [0.000000] / cz 9.61 [0.10] A 2002ApJS..141..503N
Parallaxes *(mas)*:	102.58 [0.31] A 2016A&A...595A...2G
Spectral type:	M3V B 1991ApJS...77..417K
Fluxes (11) :	B 12.06 [0.28] D 2000A&A...355L..27H V 10.613 [0.01] D 2012yCat.1322....0Z R 10.272 [0.01] D 2012yCat.1322....0Z I 8.24 [~] D 2004AJ....128..463R G 9.411 [0.001] C 2016A&A...595A...2G J 6.900 [0.024] C 2003yCat.2246....0C H 6.319 [0.023] C 2003yCat.2246....0C K 6.073 [0.016] C 2003yCat.2246....0C g 11.373 [0.02] D 2012yCat.1322....0Z r 10.101 [0.01] D 2012yCat.1322....0Z i 9.668 [0.3] E 2012yCat.1322....0Z

SIMBAD query around with radius 2 arcmin

Interactive AladinLite view

2MASS DSS SDSS

VizieR photometry viewer

Search within radius Max 30 arcsec

notes:

- Hosts a giant planet candidate GJ 436 b and possibly two others less massive, of which GJ 436 c, see also GJ 436 in the Extrasolar Planets Encyclopaedia.

Hierarchy : number of linked objects
whatever the membership probability is (see description here) :

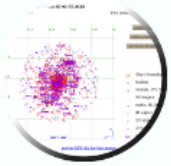
children : 3

Display criteria : All

Identifiers (37) :

LHS 310
AC +27 28217
ASCC 683818
BPS BS 15625-0002
CSI+26-11395
CSI+27-11395
CSI+27-11394
Gaia DR1 4017861056947245696
GCRV 7104
GEN# +9.80120068
G 120-68
G 147-68
G 121-7
GJ 436
HIC 57087
HIP 57087
LFT 838
LP 319-75
LSPM J1142+2642
LTT 13213
2MASS J11421096+2642251
MCC 616
NLTT 28288
PLX 2704.1
PLX 2704.10
PM J11421+2642
PM 11395+2700
Ross 905
1RXS J114211.9+264328
StKM 2-754
TYC 1984-2613-1
UCAC2 41198281
UCAC4 584-046777
USNO-B1.0 1167-00204205
VVO 171
Zkh 164
[RHG95] 1830

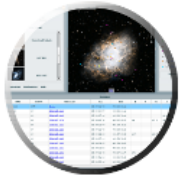
Plots and Images



plot

radius 10 arcmin

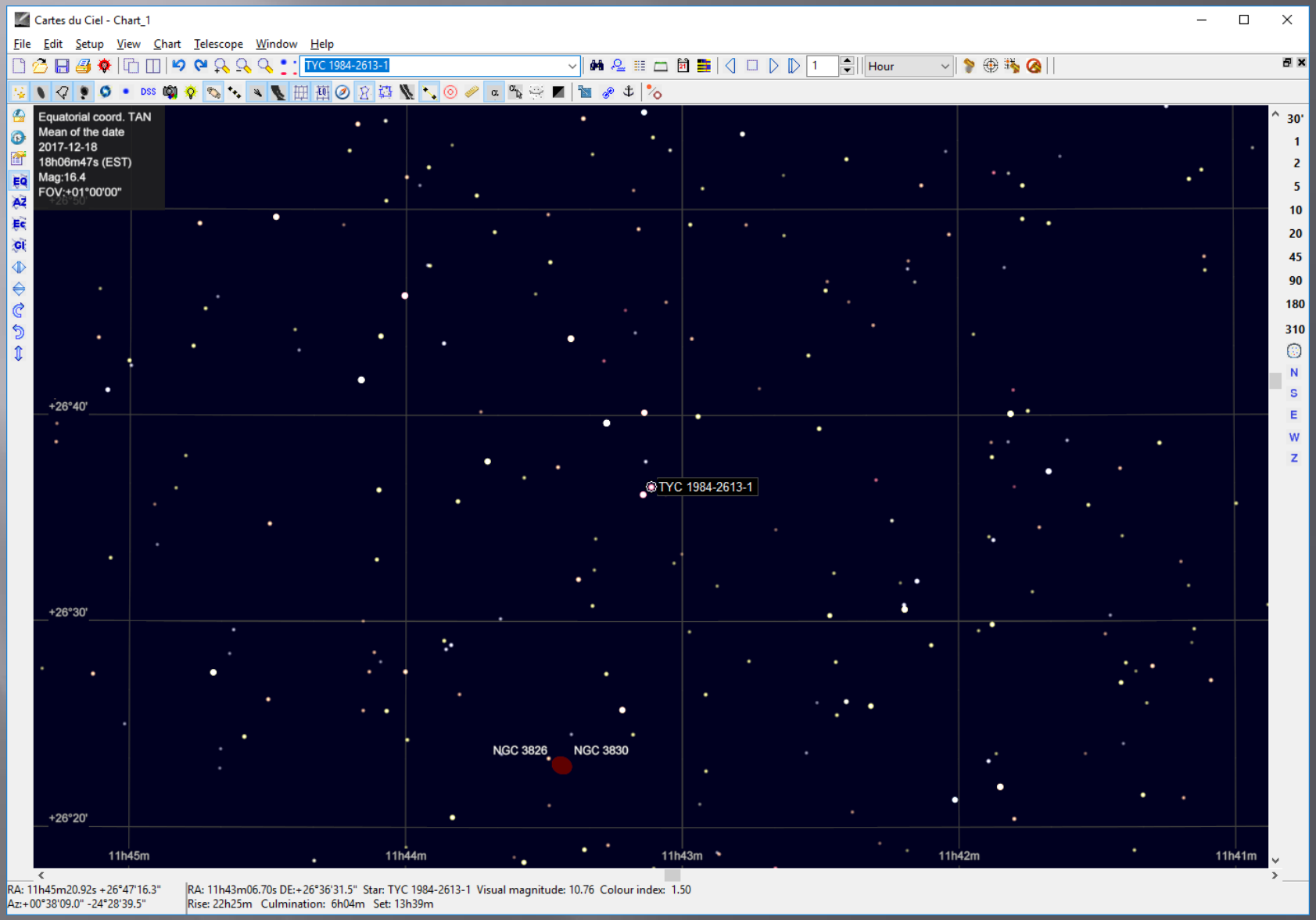
CDS portal



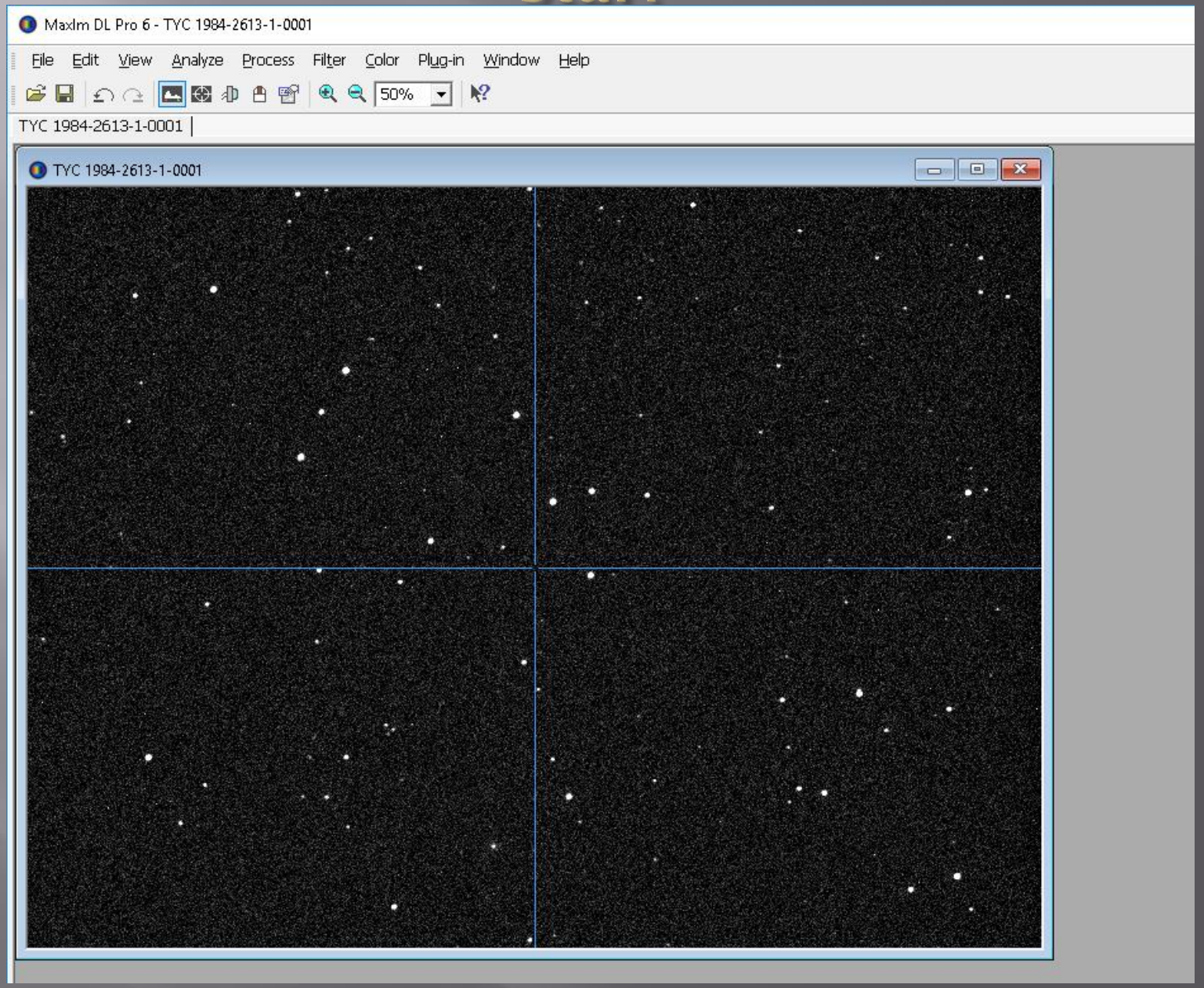
CDS Simplay
(requires flash)

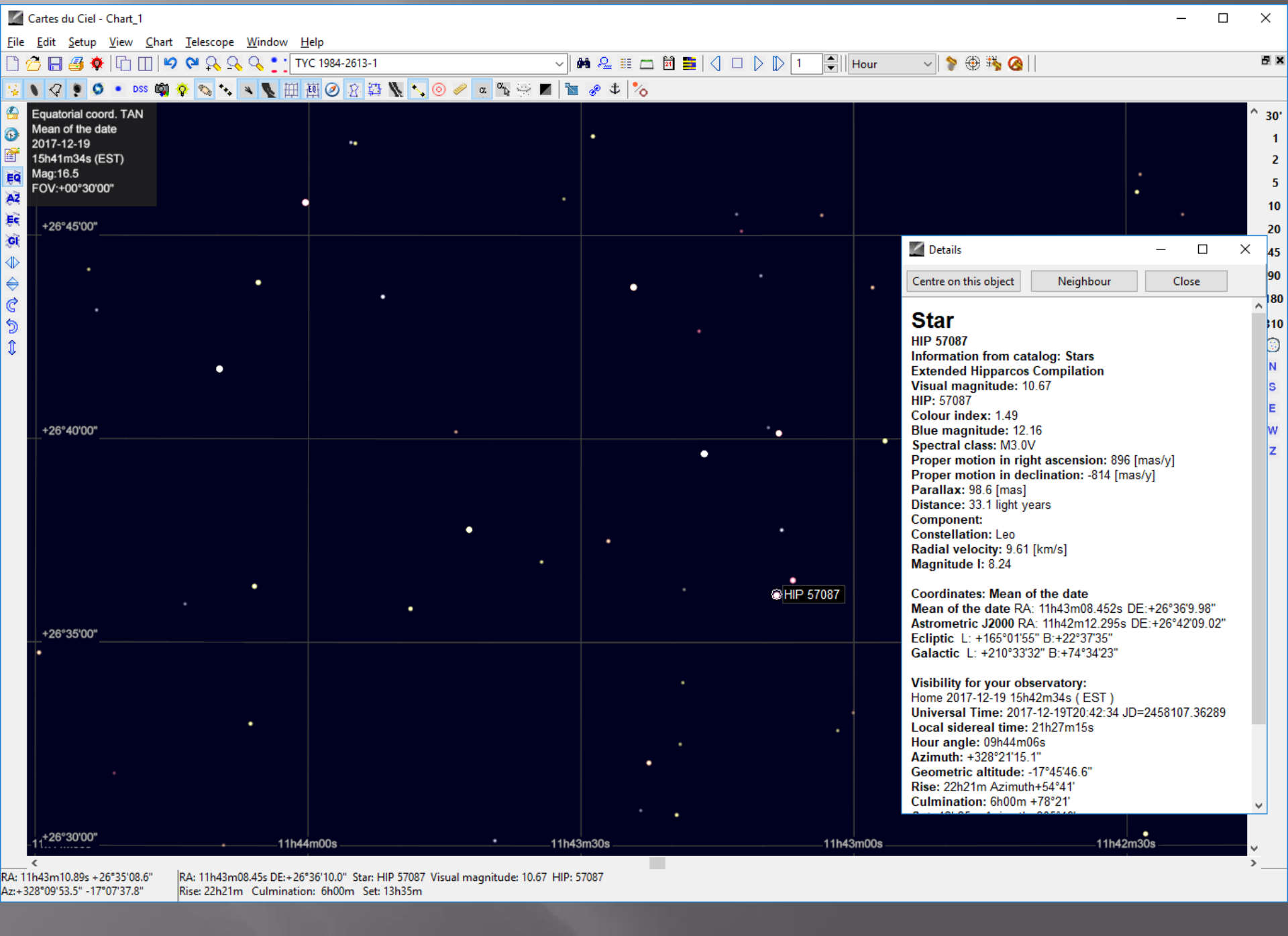
Aladin applet

Found GJ436/Ross 905 in Cartes du Ciel



Located field—but where's the companion star?




Cartes du Ciel - Chart_1
File Edit Setup View Chart Telescope Window Help
TYC 1984-2613-1
Hour
Equatorial coord. TAN
Mean of the date
2017-12-19
15h41m34s (EST)
Mag:16.5
FOV:+00°30'00"
+26°45'00"
+26°40'00"
+26°35'00"
+26°30'00"
11h44m00s
11h43m30s
11h43m00s
11h42m30s
HIP 57087
Details
Centre on this object
Neighbour
Close
Star
HIP 57087
Information from catalog: Stars
Extended Hipparcos Compilation
Visual magnitude: 10.67
HIP: 57087
Colour index: 1.49
Blue magnitude: 12.16
Spectral class: M3.0V
Proper motion in right ascension: 896 [mas/y]
Proper motion in declination: -814 [mas/y]
Parallax: 98.6 [mas]
Distance: 33.1 light years
Component:
Constellation: Leo
Radial velocity: 9.61 [km/s]
Magnitude I: 8.24
Coordinates: Mean of the date
Mean of the date RA: 11h43m08.452s DE:+26°36'9.98"
Astrometric J2000 RA: 11h42m12.295s DE:+26°42'09.02"
Ecliptic L: +165°01'55" B:+22°37'35"
Galactic L: +210°33'32" B:+74°34'23"
Visibility for your observatory:
Home 2017-12-19 15h42m34s (EST)
Universal Time: 2017-12-19T20:42:34 JD=2458107.36289
Local sidereal time: 21h27m15s
Hour angle: 09h44m06s
Azimuth: +328°21'15.1"
Geometric altitude: -17°45'46.6"
Rise: 22h21m Azimuth+54°41'
Culmination: 6h00m +78°21'
RA: 11h43m10.89s +26°35'08.6"
Az:+328°09'53.5" -17°07'37.8"
RA: 11h43m08.45s DE:+26°36'10.0" Star: HIP 57087 Visual magnitude: 10.67 HIP: 57087
Rise: 22h21m Culmination: 6h00m Set: 13h35m

notes:

- Hosts a giant planet candidate GJ 436 b and possibly two others less massive, of which GJ 436 c, see also GJ 436 in the Extrasolar Planets Encyclopaedia.

Hierarchy : number of linked objects
whatever the membership probability is (see description here) :

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LHS 310
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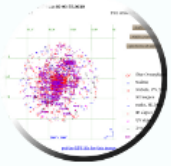
CSI+27-11394
Gaia DR1 4017861056947245696
GCRV 7104
GEN# +9.80120068
G 120-68
G 147-68
G 121-7
GJ 436
HIC 57087
HIP 57087
LFT 838
LP 319-75
LSPM J1142+2642
LTT 13213
2MASS J11421096+2642251
MCC 616
NLTT 28288
PLX 2704.1
PLX 2704.10
PM J11421+2642
PM 11395+2700
Ross 905
1RXS J114211.9+264328
StKM 2-754
TYC 1984-2613-1
UCAC2 41198281
UCAC4 584-046777
USNO-B1.0 1167-00204205
VVO 171
Zkh 164
[RHG95] 1830

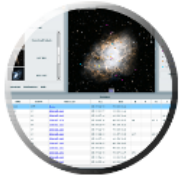
Plots and Images



plot

radius 10 arcmin

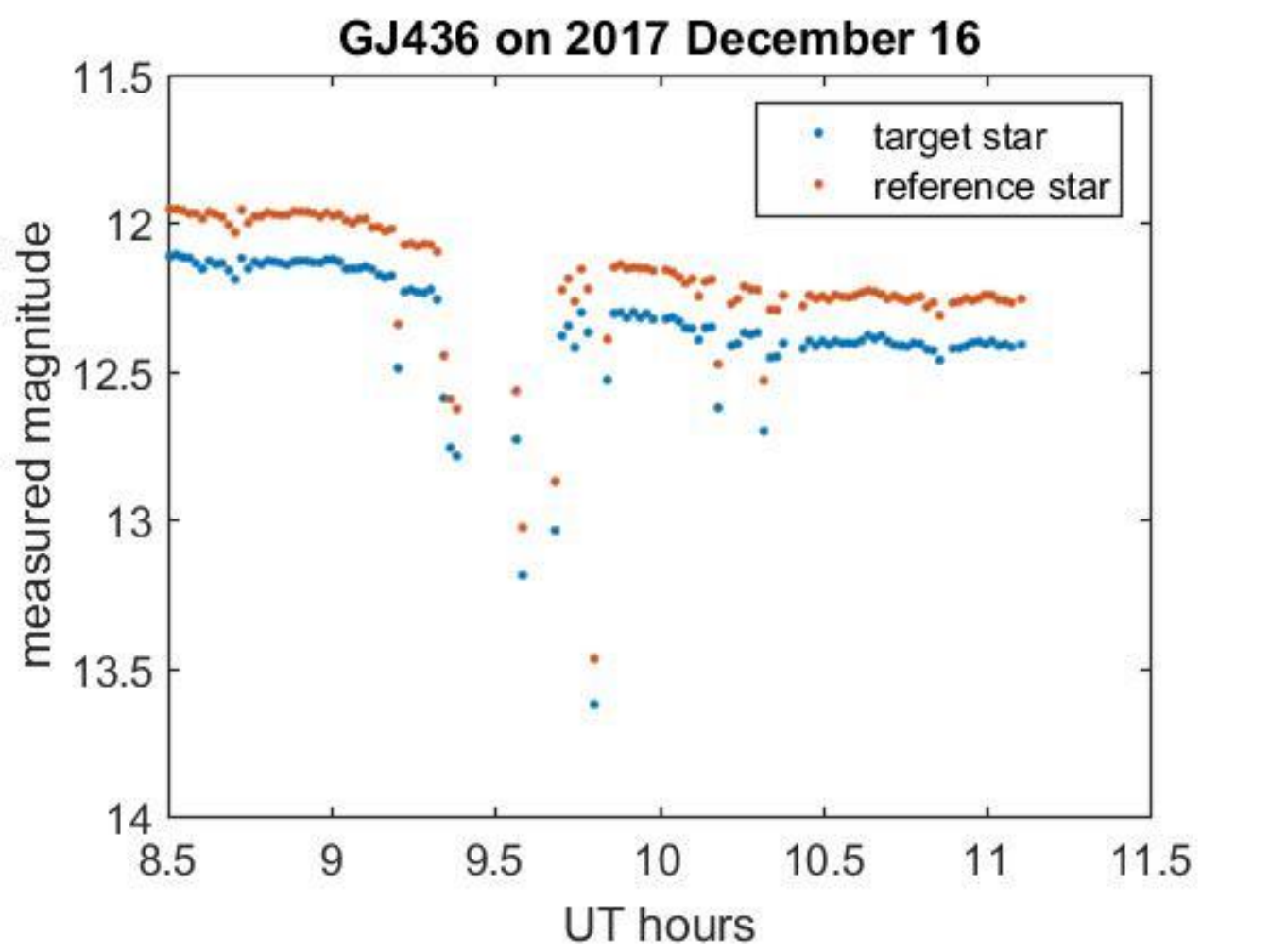
CDS portal



CDS Simplay
(requires flash)

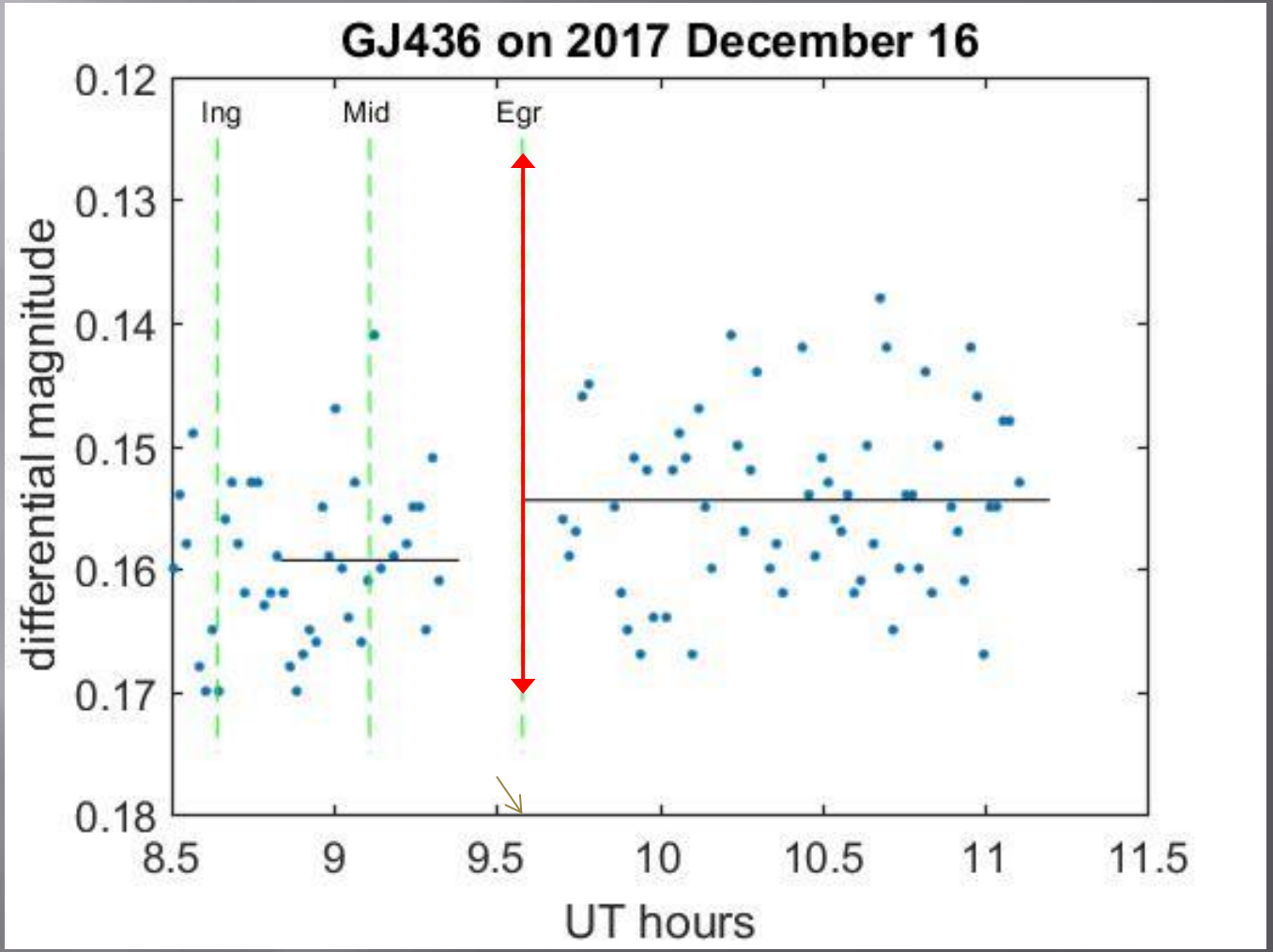
Aladin applet

First observation, 12/16/2017



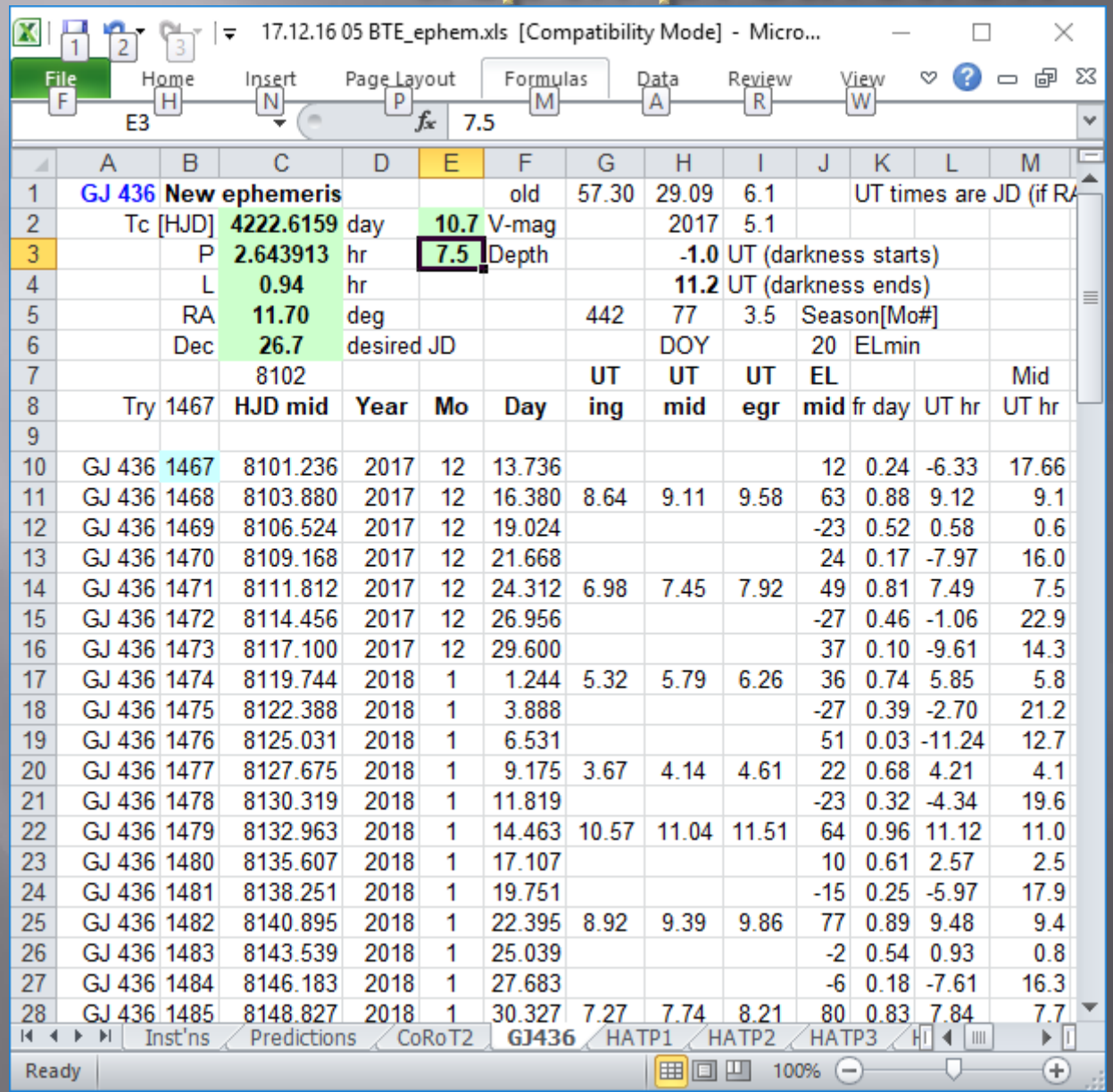
Clouds and deteriorating transparency?

First light curve



We should have easily seen the expected 26 mmag increase in brightness after egress (at 9.58 hours) compared with mid transit at about 9.11 hours. The average changes from around mid transit to after egress by only 4.9 mmag. What happened?

The BTE_ephemeris had the wrong depth prediction



17.12.16 05 BTE_ephem.xls [Compatibility Mode] - Micro...

File Home Insert Page Layout Formulas Data Review View

E3 = 7.5

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	GJ 436	New ephemeris				old	57.30	29.09	6.1		UT times are JD (if RA		
2	Tc [HJD]		4222.6159	day	10.7	V-mag		2017	5.1				
3		P	2.643913	hr	7.5	Depth		-1.0	UT (darkness starts)				
4		L	0.94	hr				11.2	UT (darkness ends)				
5		RA	11.70	deg			442	77	3.5	Season[Mo#]			
6		Dec	26.7	desired JD				DOY		20	ELmin		
7			8102				UT	UT	UT	EL			Mid
8	Try	1467	HJD mid	Year	Mo	Day	ing	mid	egr	mid	fr day	UT hr	UT hr
9													
10	GJ 436	1467	8101.236	2017	12	13.736				12	0.24	-6.33	17.66
11	GJ 436	1468	8103.880	2017	12	16.380	8.64	9.11	9.58	63	0.88	9.12	9.1
12	GJ 436	1469	8106.524	2017	12	19.024				-23	0.52	0.58	0.6
13	GJ 436	1470	8109.168	2017	12	21.668				24	0.17	-7.97	16.0
14	GJ 436	1471	8111.812	2017	12	24.312	6.98	7.45	7.92	49	0.81	7.49	7.5
15	GJ 436	1472	8114.456	2017	12	26.956				-27	0.46	-1.06	22.9
16	GJ 436	1473	8117.100	2017	12	29.600				37	0.10	-9.61	14.3
17	GJ 436	1474	8119.744	2018	1	1.244	5.32	5.79	6.26	36	0.74	5.85	5.8
18	GJ 436	1475	8122.388	2018	1	3.888				-27	0.39	-2.70	21.2
19	GJ 436	1476	8125.031	2018	1	6.531				51	0.03	-11.24	12.7
20	GJ 436	1477	8127.675	2018	1	9.175	3.67	4.14	4.61	22	0.68	4.21	4.1
21	GJ 436	1478	8130.319	2018	1	11.819				-23	0.32	-4.34	19.6
22	GJ 436	1479	8132.963	2018	1	14.463	10.57	11.04	11.51	64	0.96	11.12	11.0
23	GJ 436	1480	8135.607	2018	1	17.107				10	0.61	2.57	2.5
24	GJ 436	1481	8138.251	2018	1	19.751				-15	0.25	-5.97	17.9
25	GJ 436	1482	8140.895	2018	1	22.395	8.92	9.39	9.86	77	0.89	9.48	9.4
26	GJ 436	1483	8143.539	2018	1	25.039				-2	0.54	0.93	0.8
27	GJ 436	1484	8146.183	2018	1	27.683				-6	0.18	-7.61	16.3
28	GJ 436	1485	8148.827	2018	1	30.327	7.27	7.74	8.21	80	0.83	7.84	7.7

Inst'ns | Predictions | CoRoT2 | GJ436 | HATP1 | HATP2 | HATP3

Ready 100%

The predictions tab of the spreadsheet did not have the depth prediction from this tab for GJ436. Instead it was showing the depth (and length of transit) from the tab for TrES3.

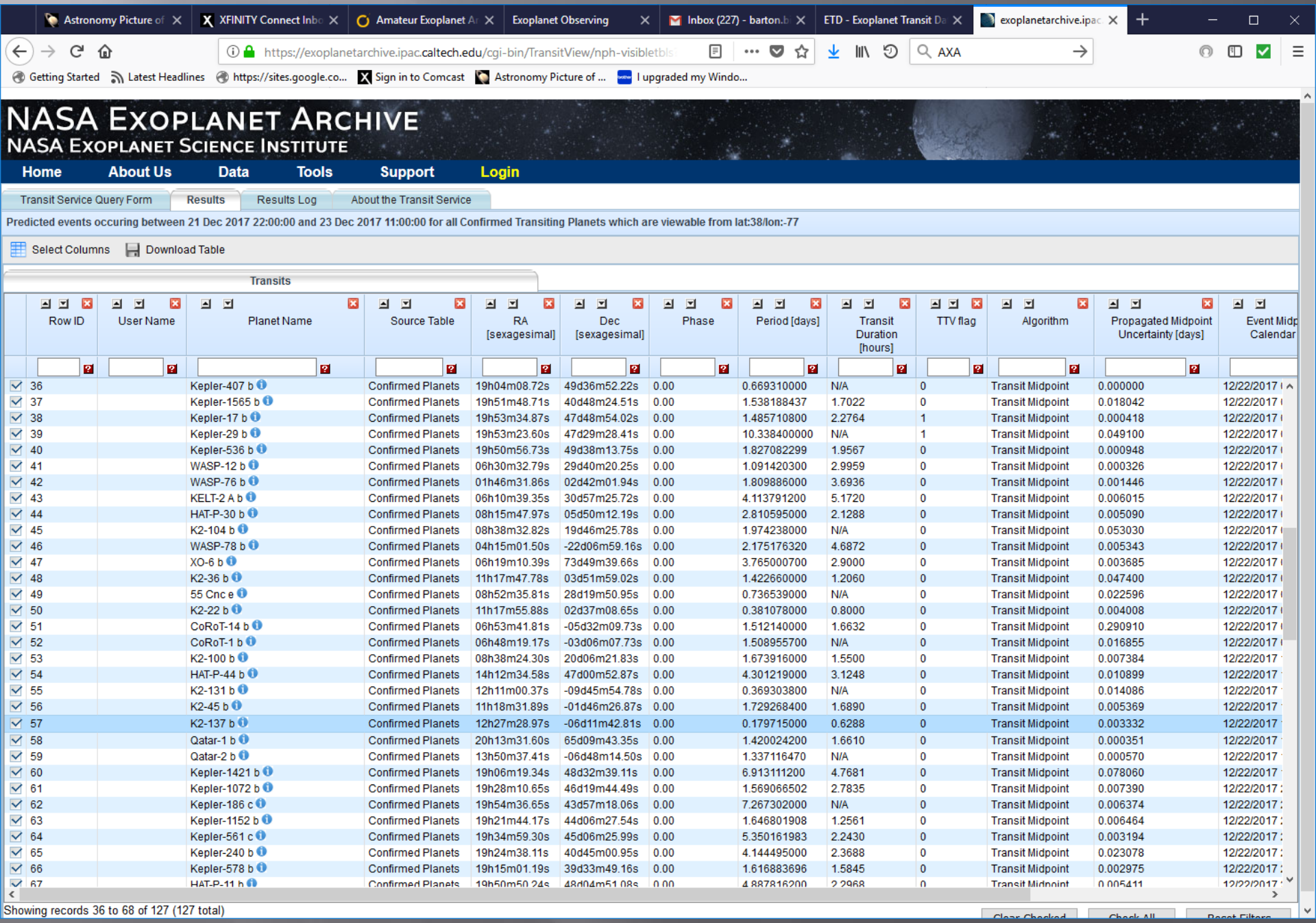
Lessons learned and next steps

- Even with the deteriorating transparency and interference from clouds, our observation would have detected the transit depth we originally expected
- More preparation is always a good idea
- We should also use the newer prediction resources with more choices of transits we can choose

"Hmm… That was pretty cool. When is the next one?"

Resources

- Bruce Gary's Amateur Exoplanet Archive: has his book, Exoplanet Observing for Amateurs, analyzed transit data, and some tools such as the BTE_ephemeris
- Dennis Conti's Exoplanet Observing by Amateur Astronomers website: has his book, *A Practical Guide to Exoplanet Observing*, a planning worksheet tool, and links to AstroImageJ, along with sample data and configuration file for working through an AstroImageJ example
- EDT (Exoplanet Transit Database) and NASA Exoplanet Archive—online alternatives to BTE_ephemeris that have larger selection s of stars to observe. Also ETD has a tool for fitting transit models.
- AAVSO—Variable Star Plotter to check comparison stars for suitability & CHOICE courses including exoplanet observing and photometry



Astronomy Picture of | XFINITY Connect Inbo | Amateur Exoplanet Ar | Exoplanet Observing | Inbox (227) - barton.b | ETD - Exoplanet Transit Da | exoplanetarchive.ipac

https://exoplanetarchive.ipac.caltech.edu/cgi-bin/TransitView/nph-visibletbls

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Predicted events occuring between 21 Dec 2017 22:00:00 and 23 Dec 2017 11:00:00 for all Confirmed Transiting Planets which are viewable from lat:38/lon:-77

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Transits

Row ID	User Name	Planet Name	Source Table	RA [sexagesimal]	Dec [sexagesimal]	Phase	Period [days]	Transit Duration [hours]	TTV flag	Algorithm	Propagated Midpoint Uncertainty [days]	Event Midp Calendar
36		Kepler-407 b	Confirmed Planets	19h04m08.72s	49d36m52.22s	0.00	0.669310000	N/A	0	Transit Midpoint	0.000000	12/22/2017
37		Kepler-1565 b	Confirmed Planets	19h51m48.71s	40d48m24.51s	0.00	1.538188437	1.7022	0	Transit Midpoint	0.018042	12/22/2017
38		Kepler-17 b	Confirmed Planets	19h53m34.87s	47d48m54.02s	0.00	1.485710800	2.2764	1	Transit Midpoint	0.000418	12/22/2017
39		Kepler-29 b	Confirmed Planets	19h53m23.60s	47d29m28.41s	0.00	10.338400000	N/A	1	Transit Midpoint	0.049100	12/22/2017
40		Kepler-536 b	Confirmed Planets	19h50m56.73s	49d38m13.75s	0.00	1.827082299	1.9567	0	Transit Midpoint	0.000948	12/22/2017
41		WASP-12 b	Confirmed Planets	06h30m32.79s	29d40m20.25s	0.00	1.091420300	2.9959	0	Transit Midpoint	0.000326	12/22/2017
42		WASP-76 b	Confirmed Planets	01h46m31.86s	02d42m01.94s	0.00	1.809886000	3.6936	0	Transit Midpoint	0.001446	12/22/2017
43		KELT-2 A b	Confirmed Planets	06h10m39.35s	30d57m25.72s	0.00	4.113791200	5.1720	0	Transit Midpoint	0.006015	12/22/2017
44		HAT-P-30 b	Confirmed Planets	08h15m47.97s	05d50m12.19s	0.00	2.810595000	2.1288	0	Transit Midpoint	0.005090	12/22/2017
45		K2-104 b	Confirmed Planets	08h38m32.82s	19d46m25.78s	0.00	1.974238000	N/A	0	Transit Midpoint	0.053030	12/22/2017
46		WASP-78 b	Confirmed Planets	04h15m01.50s	-22d06m59.16s	0.00	2.175176320	4.6872	0	Transit Midpoint	0.005343	12/22/2017
47		XO-6 b	Confirmed Planets	06h19m10.39s	73d49m39.66s	0.00	3.765000700	2.9000	0	Transit Midpoint	0.003685	12/22/2017
48		K2-36 b	Confirmed Planets	11h17m47.78s	03d51m59.02s	0.00	1.422660000	1.2060	0	Transit Midpoint	0.047400	12/22/2017
49		55 Cnc e	Confirmed Planets	08h52m35.81s	28d19m50.95s	0.00	0.736539000	N/A	0	Transit Midpoint	0.022596	12/22/2017
50		K2-22 b	Confirmed Planets	11h17m55.88s	02d37m08.65s	0.00	0.381078000	0.8000	0	Transit Midpoint	0.004008	12/22/2017
51		CoRoT-14 b	Confirmed Planets	06h53m41.81s	-05d32m09.73s	0.00	1.512140000	1.6632	0	Transit Midpoint	0.290910	12/22/2017
52		CoRoT-1 b	Confirmed Planets	06h48m19.17s	-03d06m07.73s	0.00	1.508955700	N/A	0	Transit Midpoint	0.016855	12/22/2017
53		K2-100 b	Confirmed Planets	08h38m24.30s	20d06m21.83s	0.00	1.673916000	1.5500	0	Transit Midpoint	0.007384	12/22/2017
54		HAT-P-44 b	Confirmed Planets	14h12m34.58s	47d00m52.87s	0.00	4.301219000	3.1248	0	Transit Midpoint	0.010899	12/22/2017
55		K2-131 b	Confirmed Planets	12h11m00.37s	-09d45m54.78s	0.00	0.369303800	N/A	0	Transit Midpoint	0.014086	12/22/2017
56		K2-45 b	Confirmed Planets	11h18m31.89s	-01d46m26.87s	0.00	1.729268400	1.6890	0	Transit Midpoint	0.005369	12/22/2017
57		K2-137 b	Confirmed Planets	12h27m28.97s	-06d11m42.81s	0.00	0.179715000	0.6288	0	Transit Midpoint	0.003332	12/22/2017
58		Qatar-1 b	Confirmed Planets	20h13m31.60s	65d09m43.35s	0.00	1.420024200	1.6610	0	Transit Midpoint	0.000351	12/22/2017
59		Qatar-2 b	Confirmed Planets	13h50m37.41s	-06d48m14.50s	0.00	1.337116470	N/A	0	Transit Midpoint	0.000570	12/22/2017
60		Kepler-1421 b	Confirmed Planets	19h06m19.34s	48d32m39.11s	0.00	6.913111200	4.7681	0	Transit Midpoint	0.078060	12/22/2017
61		Kepler-1072 b	Confirmed Planets	19h28m10.65s	46d19m44.49s	0.00	1.569066502	2.7835	0	Transit Midpoint	0.007390	12/22/2017
62		Kepler-186 c	Confirmed Planets	19h54m36.65s	43d57m18.06s	0.00	7.267302000	N/A	0	Transit Midpoint	0.006374	12/22/2017
63		Kepler-1152 b	Confirmed Planets	19h21m44.17s	44d06m27.54s	0.00	1.646801908	1.2561	0	Transit Midpoint	0.006464	12/22/2017
64		Kepler-561 c	Confirmed Planets	19h34m59.30s	45d06m25.99s	0.00	5.350161983	2.2430	0	Transit Midpoint	0.003194	12/22/2017
65		Kepler-240 b	Confirmed Planets	19h24m38.11s	40d45m00.95s	0.00	4.144495000	2.3688	0	Transit Midpoint	0.023078	12/22/2017
66		Kepler-578 b	Confirmed Planets	19h15m01.19s	39d33m49.16s	0.00	1.616883696	1.5845	0	Transit Midpoint	0.002975	12/22/2017
67		HAT-P-11 b	Confirmed Planets	19h50m50.24s	48d04m51.08s	0.00	4.887816200	2.2968	0	Transit Midpoint	0.005411	12/22/2017

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