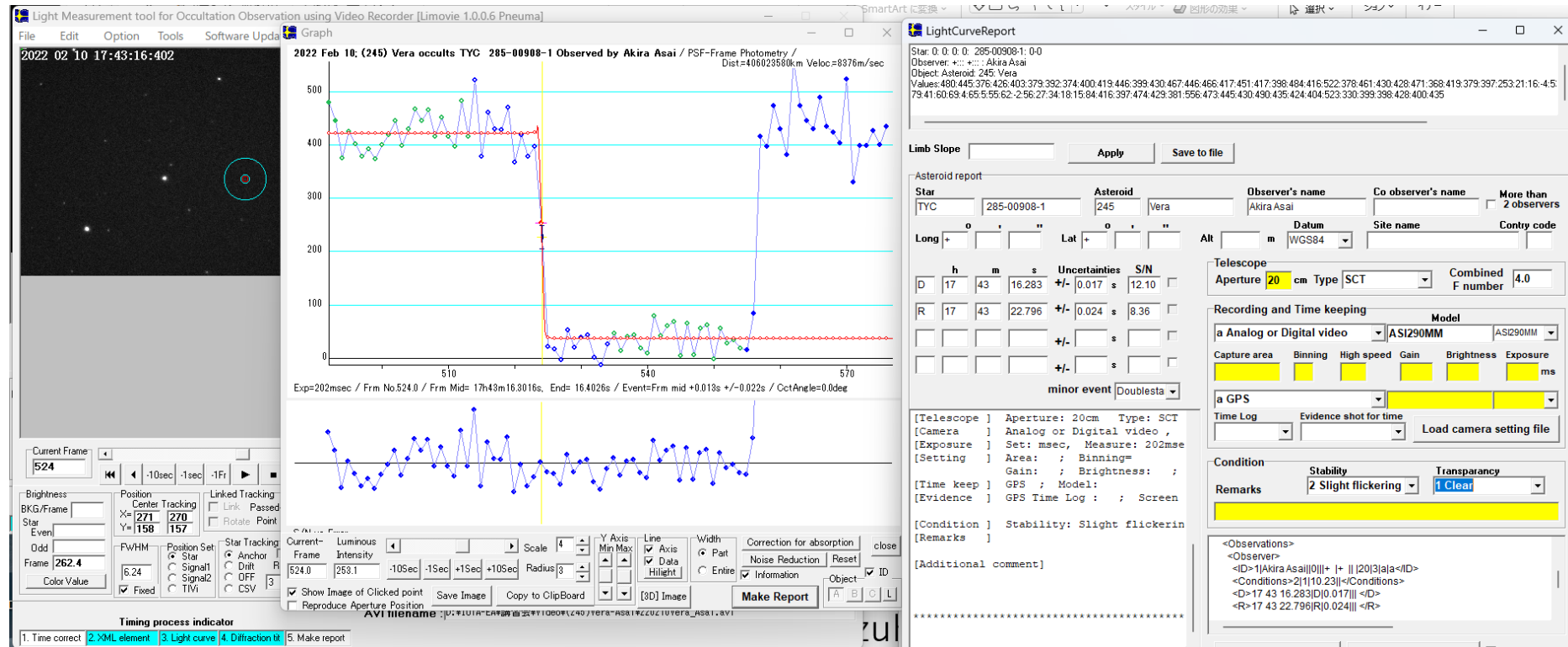


The functions on Limovie to improve the accuracy of occultation observation using a CMOS camera and the methods on observation.



In this talk ...

- Can Irradiated light length be converted to pixel brightness?
 - > IPPS LED can be used to time correction.
 - > Mechanism for obtaining event time.
- Time keeping software HACSTIP-GPS.
- Deciding frame exposure length from preparation video records with xml prediction file.
- Limovie's reporting function.

Analog video camera with video time inserter



- With the analog camera used until about 2018, the time inserter provided accurate time with an error of less than 1 millisecond.
- In 2019, Japanese observers began to use “non-GPS” CMOS cameras, and the first challenge was how to obtain the time base.

ZWO 290MM (rolling shutter type) has high sensitivity and high speed exposure, additionally it is not expensive.

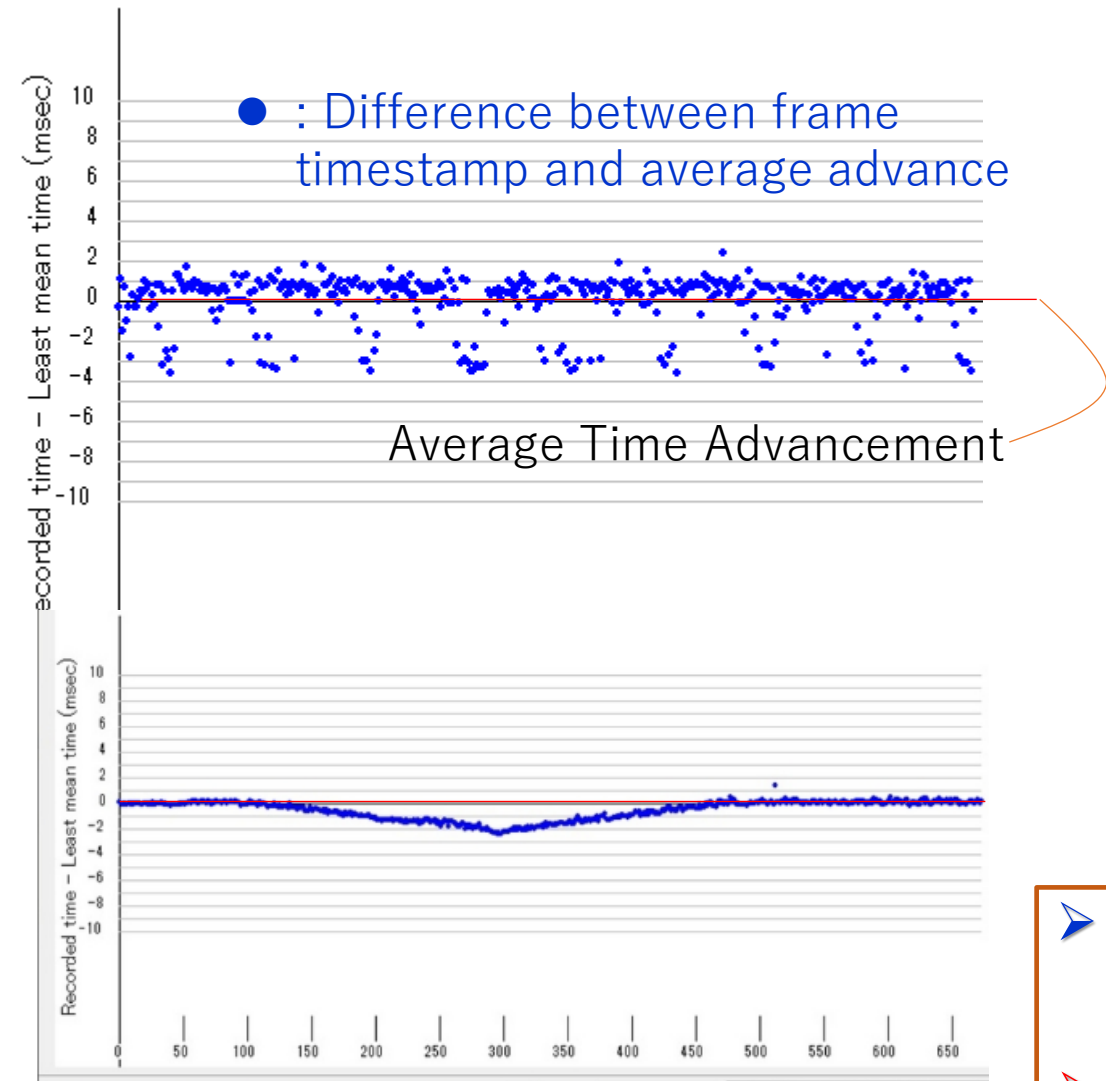
2024 08 10 11:17:58:917

Time stamp on CMOS camera recorded

Except for the camera with built-in GPS...

(e.g. ZWO non-GPS camera etc.)

- If there were no “delay” as described next, the timestamp would indicate the time when the frame exposure ended (or started, depending on the software version)...
- In fact, the time stamp indicates the time that the end of processing on capture software.
- We often see some fluttering or temporary delay and recovery.



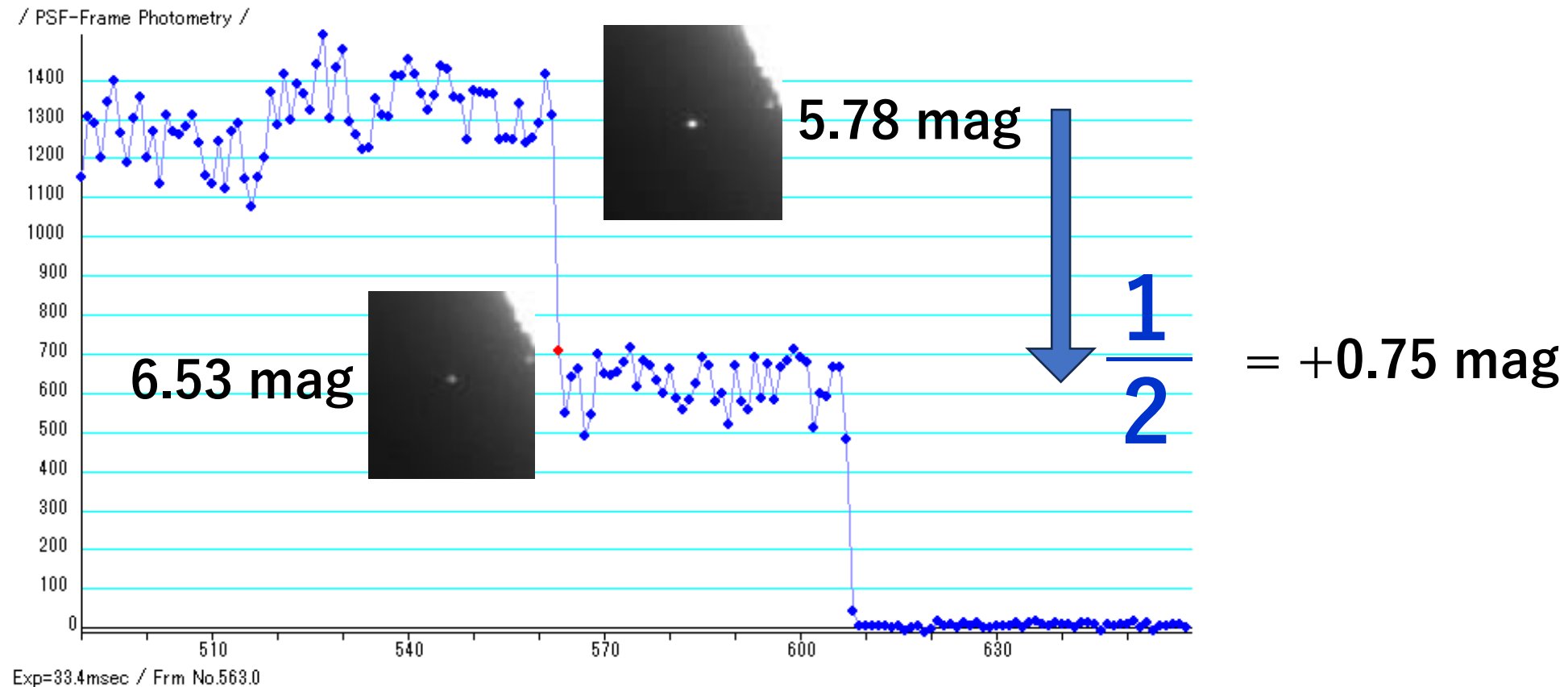
➤ **Correction with another accurate signal is necessary.**



➤ **1PPS LED was expected to be a solution...**

Thinking about how to use the 1PPS LED for time correction.

On CMOS camera, when received light flux changed to half...



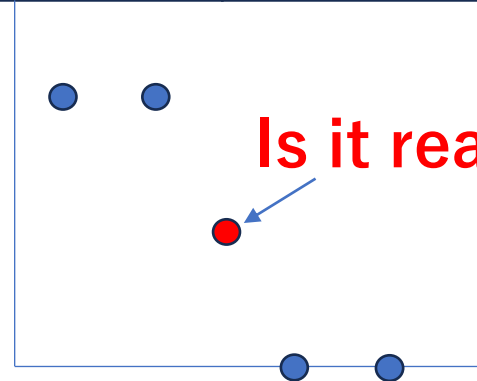
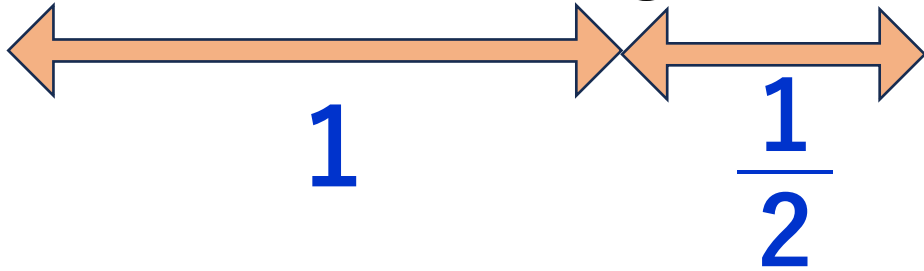
Star's pixel value will be half.

Then, if received light LENGTH will be half...



	frame	frame	frame	frame
--	-------	-------	-------	-------

irradiate length is

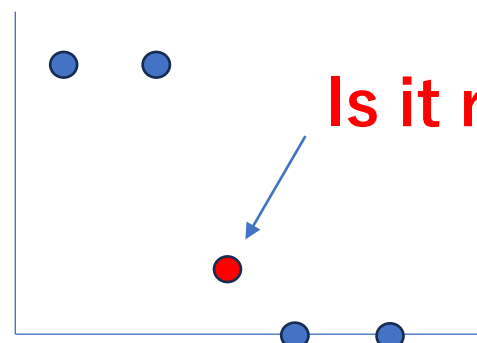
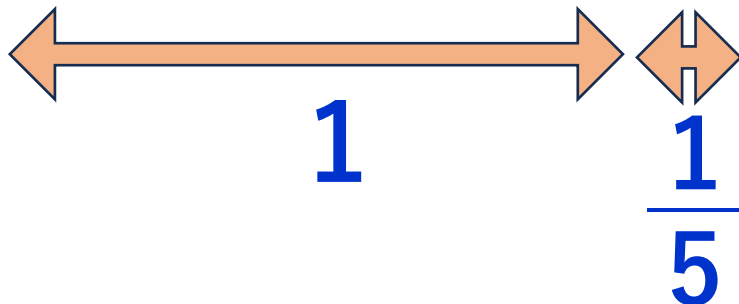


Is it really recorded at $\frac{1}{2}$ value?

5.03 mag



	frame	frame	frame	frame
--	-------	-------	-------	-------

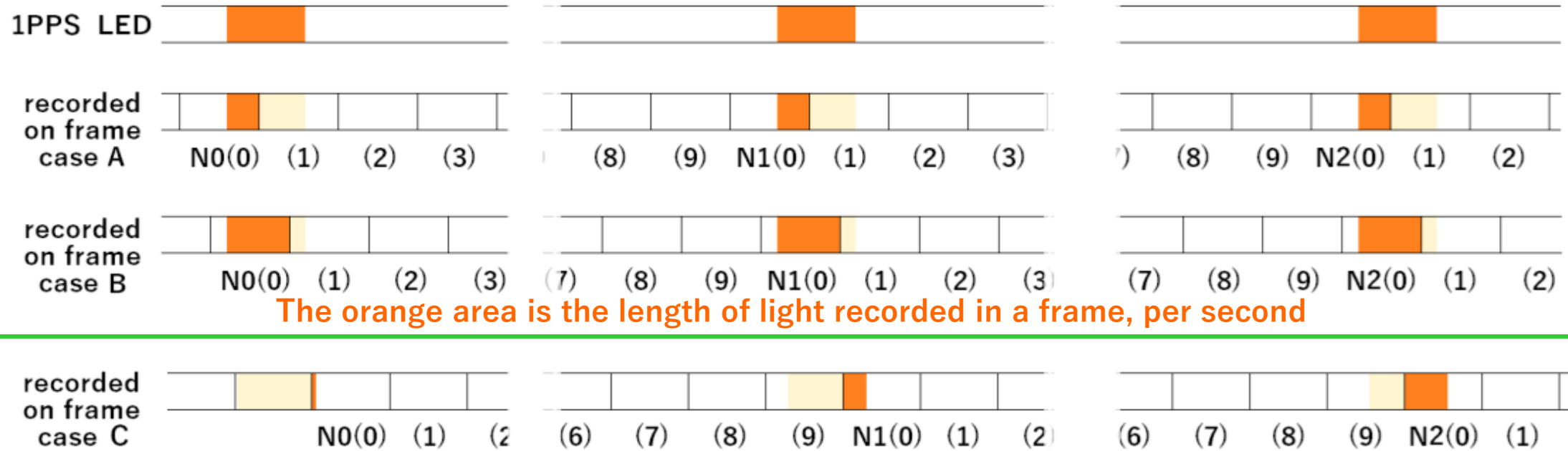


Is it really recorded at $\frac{1}{5}$ value?

➤ Can length be converted to star image's brightness?

➤ We can confirm the question on this experiment.

LED light exposed to the frame and its change



Frame rate and recorded 1 PPS of LED light.

When the frame rate is an integer (case A, case B), there is no change in light intensity, but ...

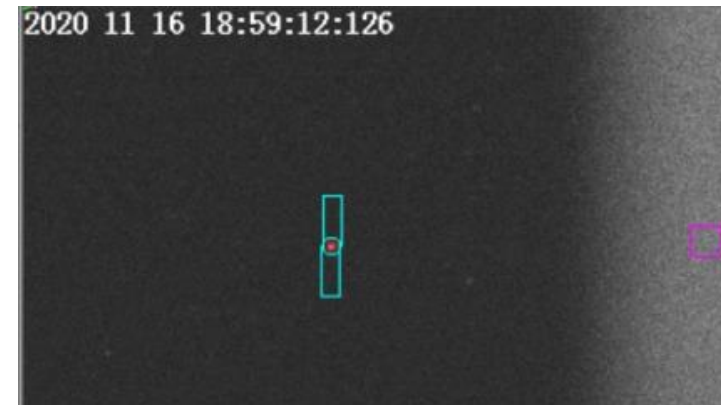
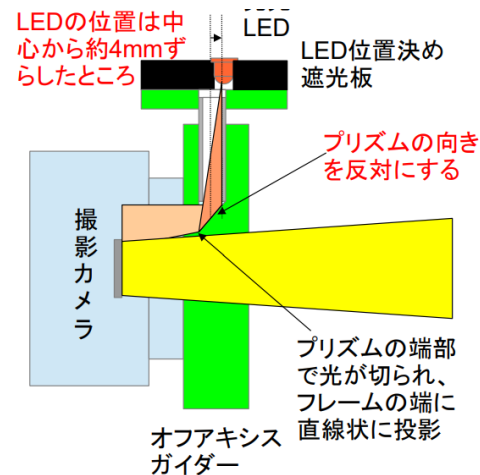
When the frame rate is not an integer, the irradiate length increase/decrease at a constant rate.

➤ 1PPS LED light irradiates from telescope aperture.



The camera receives light almost entirely pixels on the sensor

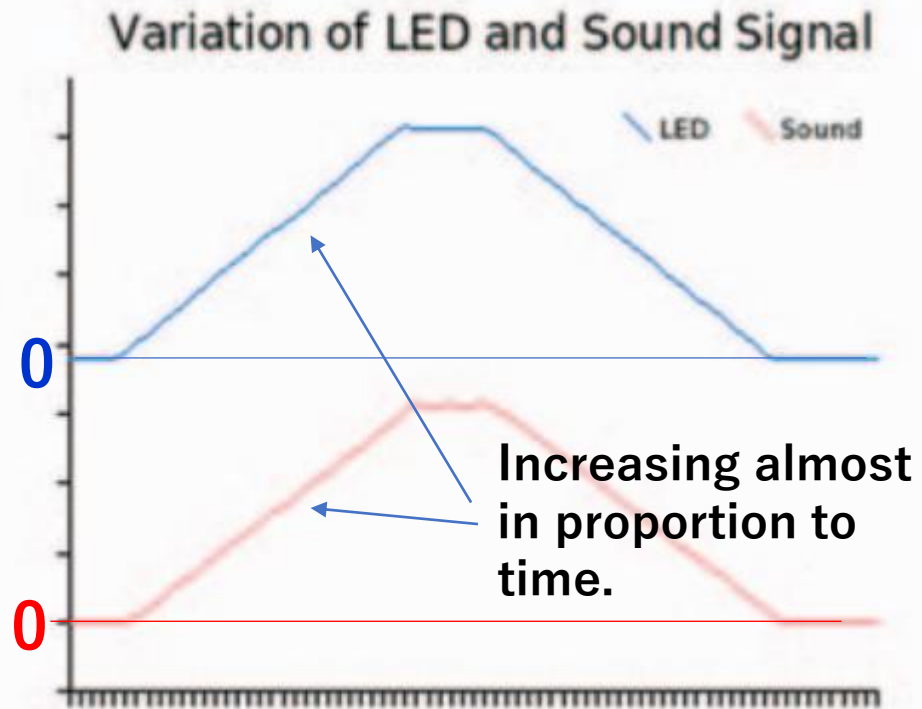
➤ This time equipment can irradiate the side of sensor.



Can length be converted to LED image's brightness?

We had that answer in 2005.

LED : Intensity of light accu-
mulated in the frame
Sound : Signal-frame rate



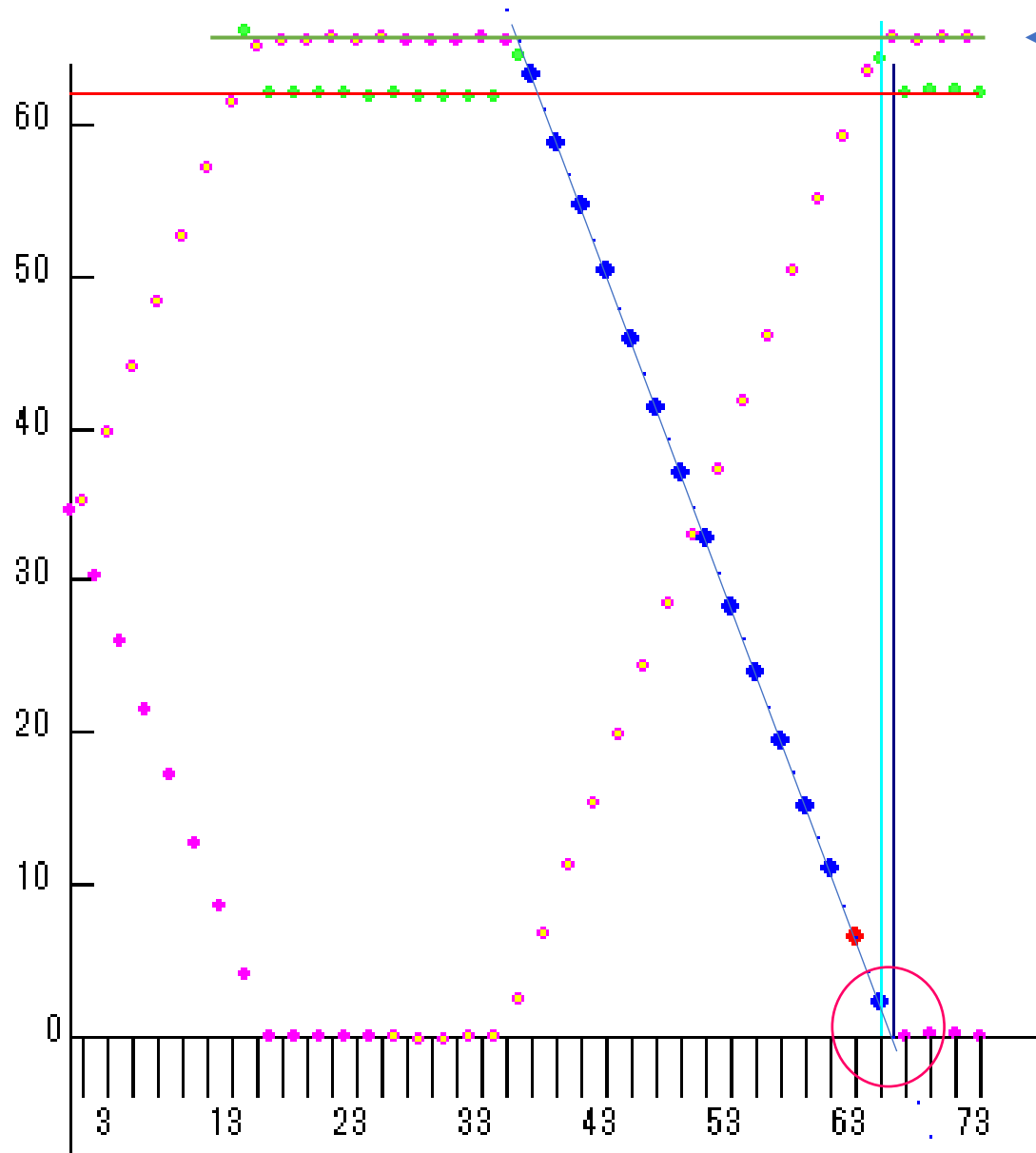
Frame extracted every 30 frames

IPPS LED and Sound intensity
recorded on analog video frame.

Miyashita et. al. (2005)

The sound signal gradually enters the frame. Intensity of LED has increased.

More accurate confirmation with CMOS video camera



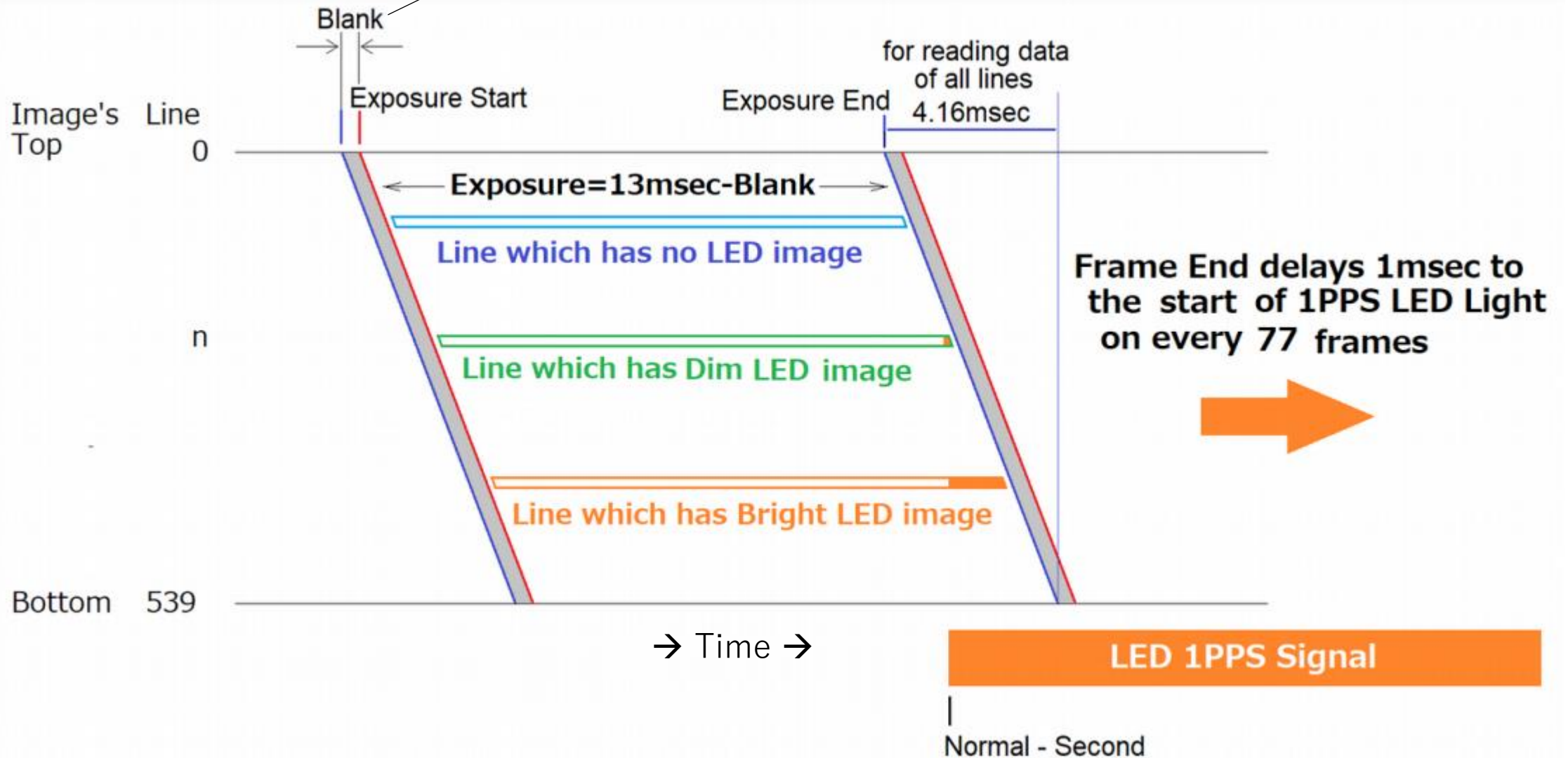
LED light irradiates entire of frame exposure.

- Figure is the case of 490msec frame exposure.
- When there is not any saturate pixel, brightness value decreases or increases **in proportion to irradiation length**.
- The cross point of calibration line and X axis is the time that the end of frame exposure is coincide to accurate UTC second.

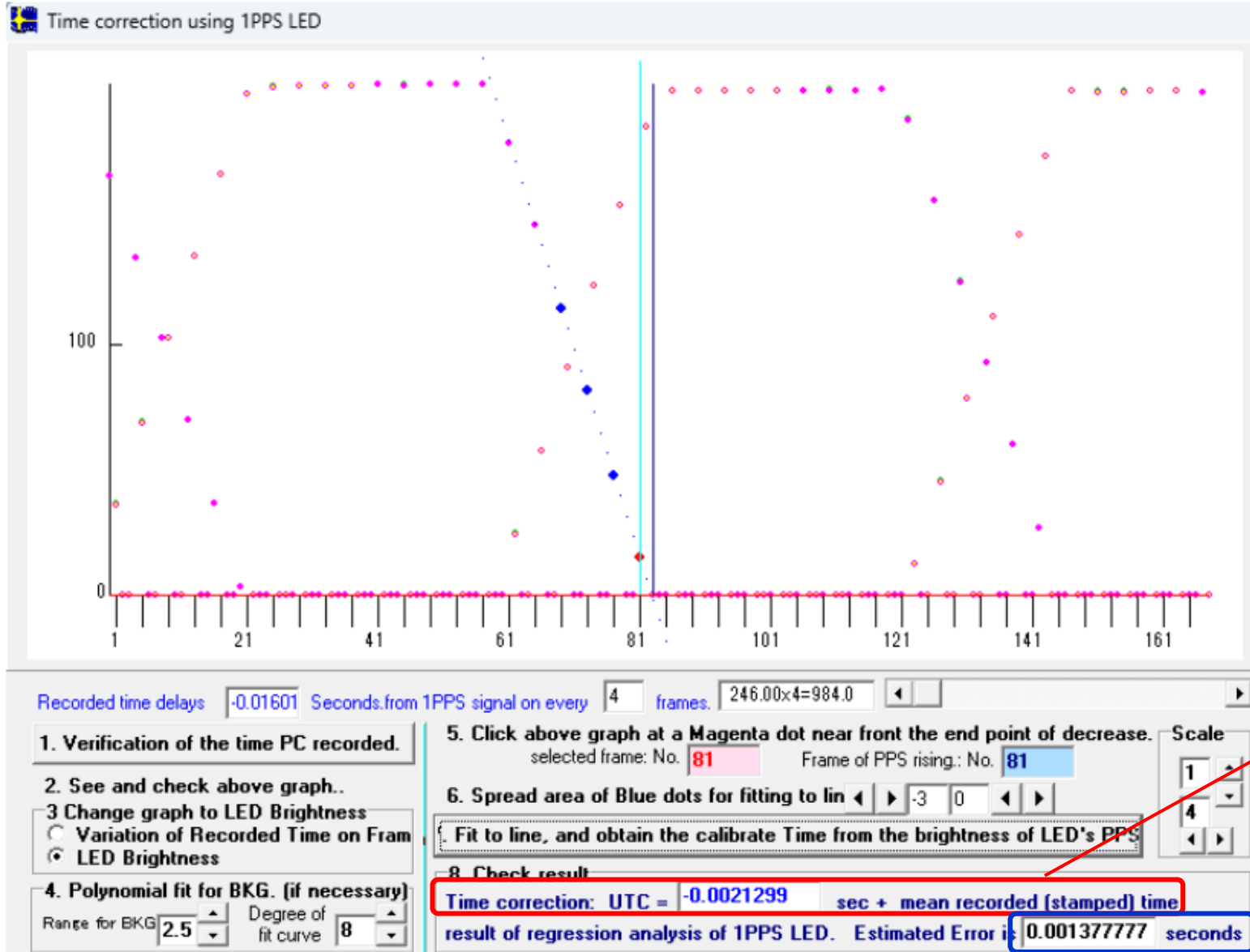
➤ **Length (event time) can be converted to LED/star image's brightness.**

Rolling Shutter Camera (ZWO290MM) records 1PPS LED

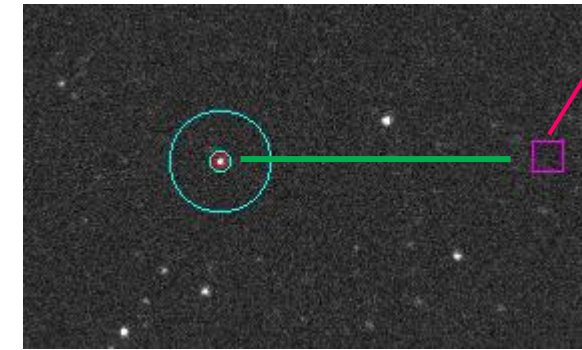
Blank: Rolling shutter camera ... very short (1msec or shorter).
Global shutter camera ... rather long (a few milli seconds)



Application for time correction of observation video



Aperture for LED should be set on same height as target star.

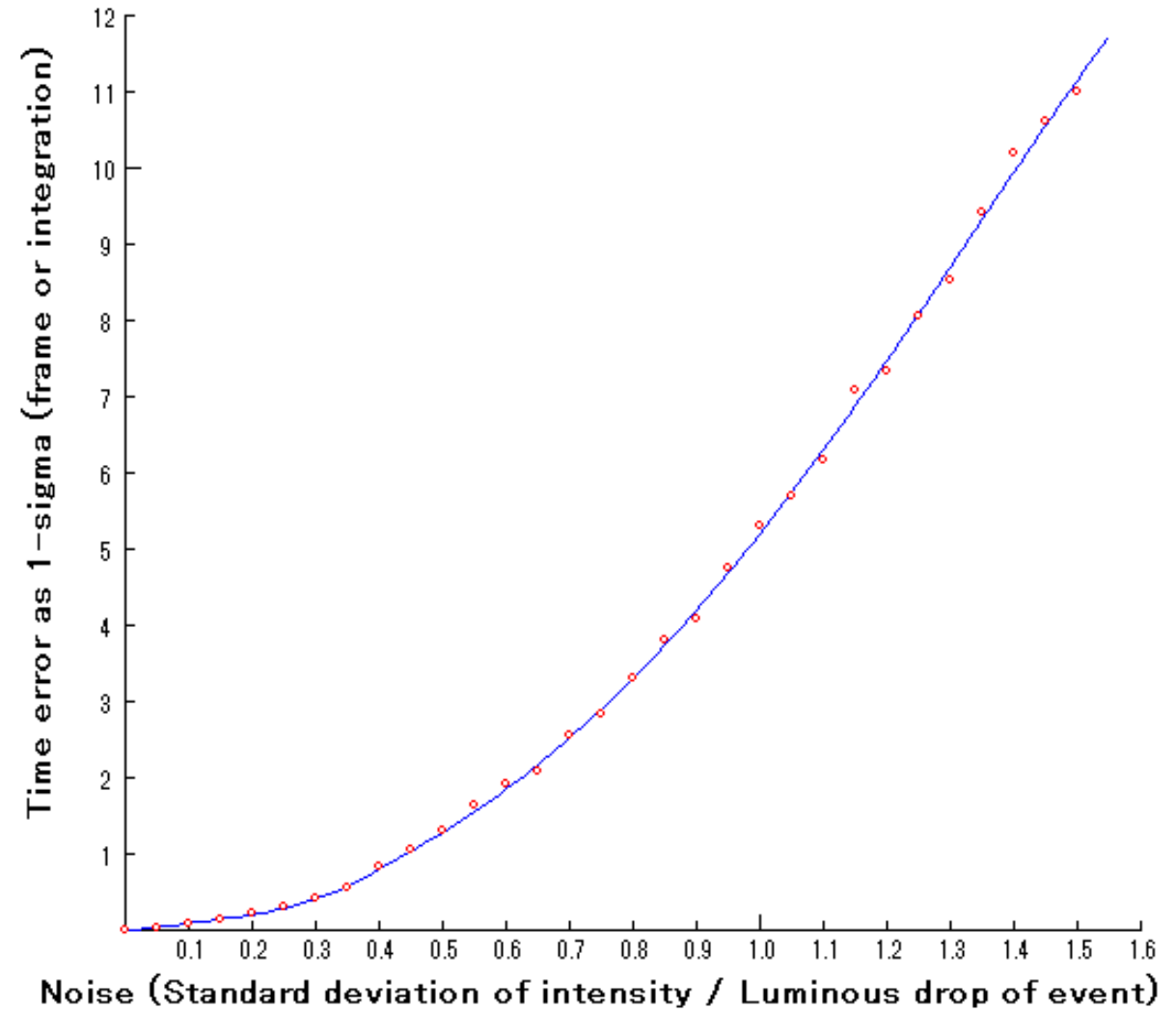
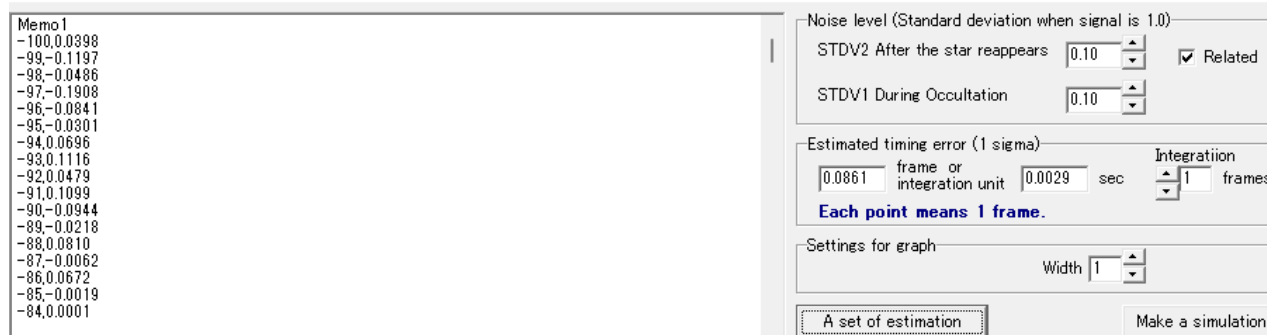
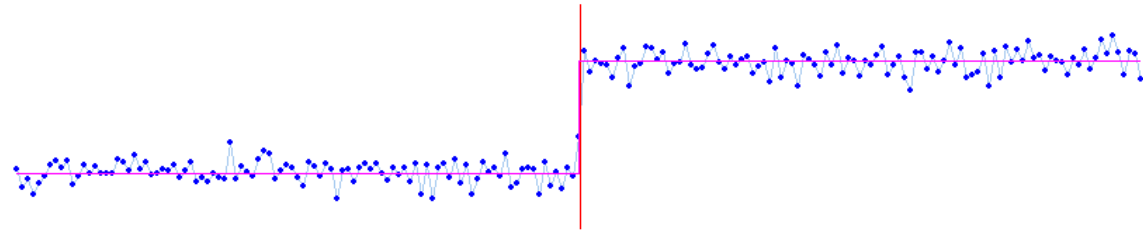


- Figure is the case of 490msec frame exposure.

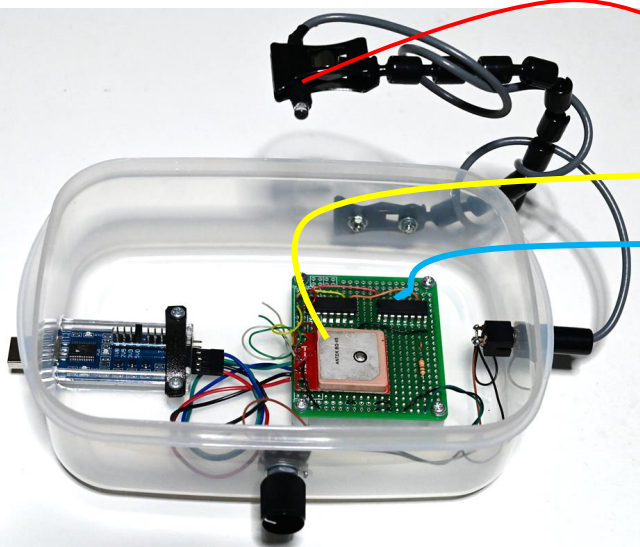
Calculated time adjustment from calibration line.

Correction error from one calibration line.

Time error estimation obtained from experiment on PC.



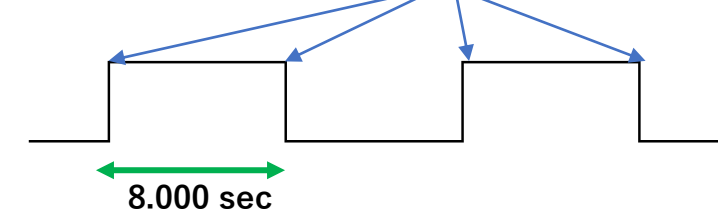
The relation of N/S ratio and estimated time error had been obtained from one thousand number of experiments(on each N/S) were done on PC.



Occultation maker

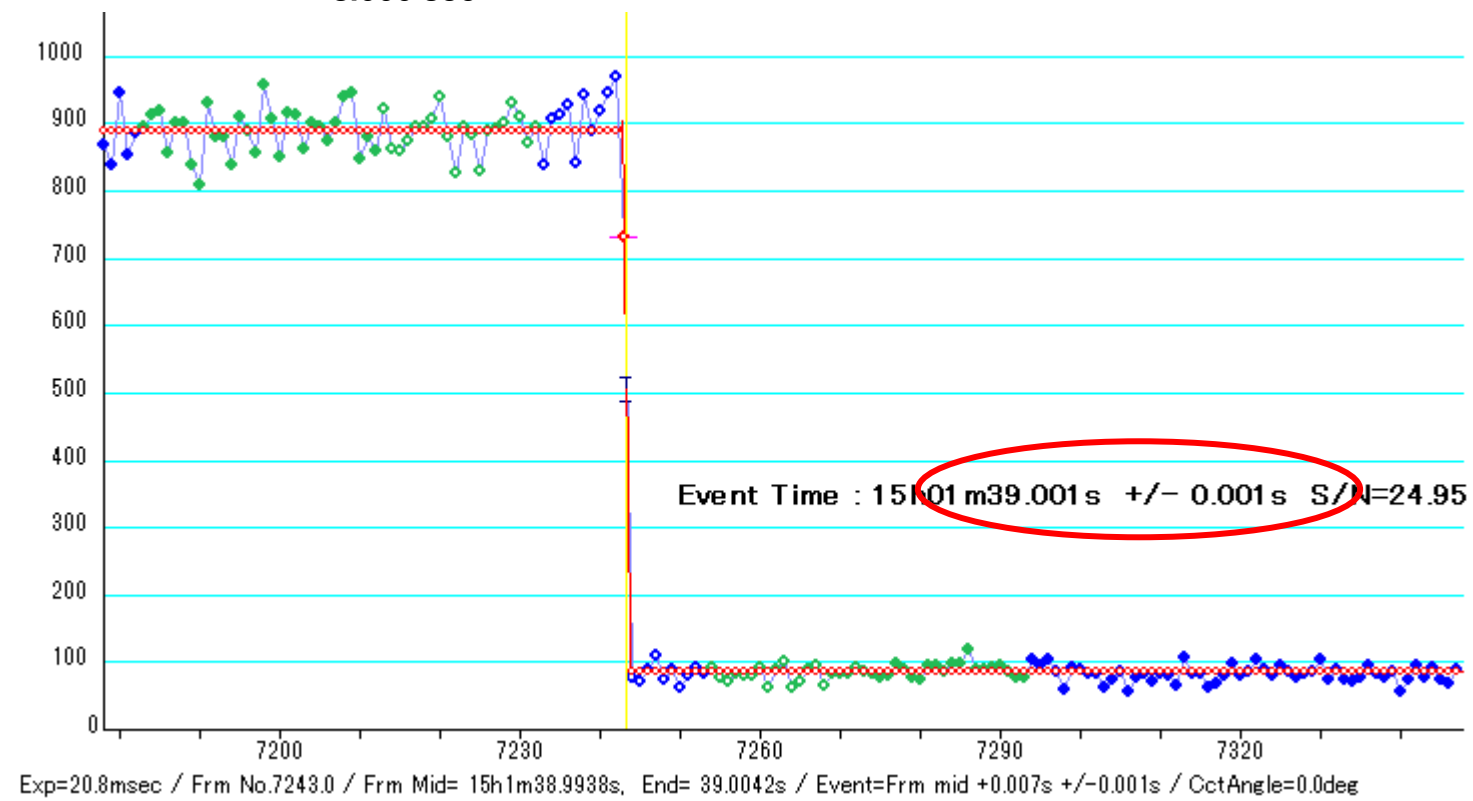
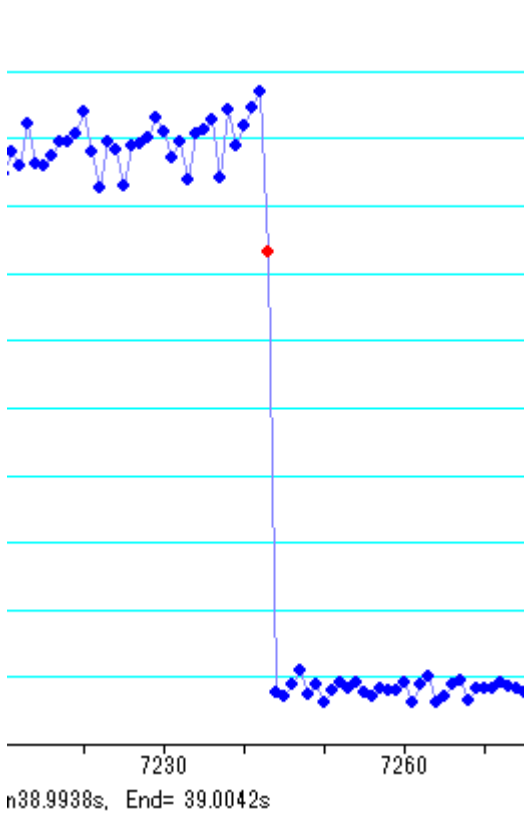
using 1PPS signal of GPS receiver & Binary Counter.

It makes “occultation event” that occurs on accurate UTC second.



Characteristics	Symbol	Test Condition	Ta = 25°C			Unit	
			VCC (V)	Min	Typ.		Max
Propagation delay time (CK -Q1)	tpLH tpHL		2.0	—	70	145	ns
			4.5	—	20	29	
			6.0	—	17	25	
Propagation delay time (Qn-Q + 1)	Δtpd		2.0	—	20	75	ns
			4.5	—	6	15	
			6.0	—	4	13	

➤ Counter makes time delay on binary counting. This 74H4020 counter's delay is nano second order. -> It is accurate enough for this analysis.



➤ Time values are obtained almost within the margin of error.

➤ I'm planning to do this experiment in various noise (especially large noise) situation.

➤ Time keeping

Corrector for PC Time ... HACSTIP-GPS

How Accurately Can we Set Time on PC with GPS?

✓ In past (up to the beginning this year) quite a few observations had GPS leap second problems.

HACSTIP (How Accurately Can we Set Time on Pc using GPS?)

Files Properties Version

Time Zone of this PC: Localtime-UTC= hour Global position Now

Date (UTC) 2024. 08. 24 Long. 137° ' .692" E

GPS Tme (UTC) 06:54:07 GPS Tme (Local) 15:54:07 Lat. 36° ' .224" N

Antenna Altitude 562.5m Sat. Num 12

DSR(1PPS) signal available (Type: Falling Edge) Geoidal Height 36.5m HDO 0.67

Fix Type for Google Maps

DGPS fix, using local DGPS or WAAS etc. 36.3667253,137.8965843

0.05	2024-08-24 15:54:03.000	2024-08-24 15:54:03.000	Set_PC_Time
-0.02	2024-08-24 15:54:03.999	2024-08-24 15:54:04.000	Set_PC_Tim
-0.01	2024-08-24 15:54:04.999	2024-08-24 15:54:05.000	Set_PC_Tim
0.02	2024-08-24 15:54:06.000	2024-08-24 15:54:06.000	Set_PC_Time
0.14	2024-08-24 15:54:07.000	2024-08-24 15:54:07.000	Set_PC_Time

Log

Compare PC/GPS Digits of PC-GPS 2 Estimate calibration for this receiver 0 Satellite information ☒

COM port Properties

☐ Auto Port Search

port COM4

baud rate 19200

Synchronization parameter 980

Set Time on PC

☐ One time correction

☒ ON ☐ OFF

Time when a set of NMEA is completed 390 msec

GPS receiver gives Stable Time now.

LED Length for MT3333 , ublox M8 ☒ 100msec ☐ 400msec ☐ 700msec

PMTK for setting Baud rate at connection

G: GPS M: MITCHIBIKI R: GLONASS
E: GALILEO B: BEIDOU

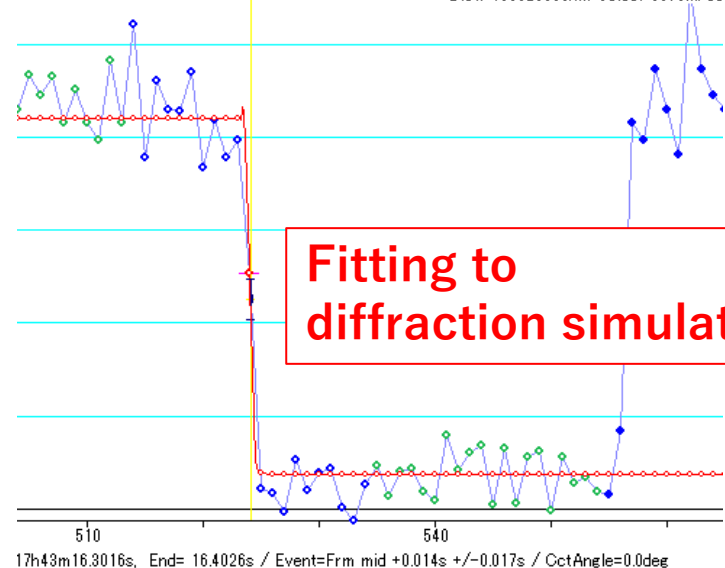
No.	Az	Alt	C/N				
G 05	145	12	27		o	o	o
G 10	318	25	21		o	o	o
G 12	155	29	26		o	o	o
G 15	77	49	32		o	o	o
G 18	226	26	44		o	o	o
G 22	43	14	28		o	o	o
G 23	307	63	35		o	o	o
R 65	317	23	28		o	o	o
R 72	27	60	31		o	o	o
R 73	34	24	24		o	o	o
R 74	67	63	28		o	o	o
R 75	179	44	28		o	o	o
R 81	339	4	20		o	o	o
R 87	237	7	22		o	o	o
R 88	290	15	31		o	o	o

This software corrects PC's system time with 0.2 msec (or smaller) accuracy. It is realized by using 1PPS signal via DSR line.

GLONASS system provides "historical leap second information" every seconds. Ublox M8 or later, and MediaTek 33xx GPS engine can use GLONASS, and they don't have any LEAP SECOND PROBLEM.

Making report automatically

285-00908-1 Observed by Akira Asai / PSF-Frame Photometry /
Dist=406023580km Veloc=8376m/se



Fitting to
diffraction simulation



Text out to Graph
☒ OFF
☐ Text with transparency BKG
☐ Text with opaque background

Mode
☒ Time
☐ Info. Right
☐ Info. Left

Font size
Edit16
10
Edit25

1 17 43 16.283 +/- 0.017s, S/N= 12.10 D Main change
2 17 43 22.796 +/- 0.024s, S/N= 8.36 R Main change

Analyzed event time

Miss Disappearance [approx. time] Miss Reappearance [approx. time]

Main light change Delete Sort Add to report Apply & Close

LightCurveReport

376:379:424:457:376:381:372:436:456:472:476:429:429:451:444:397:440:450:437:414:432:373:376:474:447:397:491:401:495:427:377:462:424:427:423:402:392:346:462:464:456:461:396:321:420:480:445:376:426:403:379:392:374:400:419:446:399:430:467:446:466:417:451:417:398:484:416:522:378:461:430:428:471:368:26:46:13:40:43:18:9:79:41:60:69:4:65:5:55:62:-2:56:27:34:18:15:84:416:397:474:429:381:556:473:445:430:490:435:424:404:523:330:399:398:428:400:435:442:42:416:468:516:441:420:515:473:388:441:378:437:498:405:377:416:473:431:418:447:500:457:420:445:383:448:403:431:474:507:494:446:510:446:420:405:369:403:502:415:411:505:445:473:398:455:529:439:403:427:468:515:462:433:415:420:426:434:486:426:460:548:413:338:481:435:378:477:460:482:478:469:480:436:437:

Light curve data in .dat text format

Reducing the burden on the collection business is one of its goals.

Limb Slope Apply

Asteroid report

Star TYC 285-00908-1 Asteroid 245 Vera Observer's name Akira Asai Co observer's name More than 2 observers

Long + Lat + Alt m Datum WGS84 Site name Contry code

Telescope Aperture 28 cm Type SCT Combined F number 4.0

Recording and Time keeping Model a Analog or Digital video ASI290MM ASI290MM

Capture area 968x548 Binning 2 High speed Off Gain 351 Brightness 0 Exposure 202 ms

a GPS GT902MGG GT902MG

Time Log Recorded Evidence shot for time Recorded Load camera setting file

Condition Stability 2 Slight flickering Transparency 1 Clear

Remarks

<Observations>
<Observer>
<ID>1|Akira Asai||0||+ |+ || 28|3|a|a</ID>
<Conditions>2|1|10.23||</Conditions>
<D>17 43 16.283|D|0.017||| </D>
<R>17 43 22.796|R|0.024||| </R>

xml report

Save XML Report File Copy for Text Report Add Lightcurve

for regional community

For planning an observation...

Created a function to estimate the error of an observation.

1. Load from XML file

or

Paste

Clear

Back

Forward

2. Select (click) observed Event

2024 May 24 2.0h UT , (623)Chimaera occults UCAC4 263-180282

2024 May 24 3.1h UT , (623)Chimaera occults UCAC4 263-180265

2024 May 24 13.9h UT , (623)Chimaera occults UCAC4 263-180133

2024 May 24 14.9h UT , (623)Chimaera occults UCAC4 263-180118

2024 May 24 16.0h UT , (623)Chimaera occults UCAC4 262-174781

2024 May 24 16.6h UT , (623)Chimaera occults UCAC4 262-174775

3. Occultation Elements of observed Event

Source JPL#102+Ephem:2024-Jun-03

Date / Time

2024 May 24

16.0

UT

Combined(Asteroid + Star) Mag.

12.31

Mag drop

2.7

Object

(623)Chimaera

Mag

15.05

Contact angle

0.0

deg.

Target star

UCAC4 262-174781

B

13.07

V

12.40

R

11.62

B-V

0.67

Spectrum Type

--

Diameter

0.0

mas

Shadow's Vwlocity

7850.0

m/sec

Uncertainty (Asteroid + Star)

0.0013

arcsec

1743

m

5.6

sec

2896

Fresnel number

Distance of Object

276576543.4

km

Diameter of Object

43.8

km

RUWE

1.05

Error ellipse

0.0013

0.0003

0.222

sec

Observation simulation

5. Check and Edit : Date / Time on video recorded

2024

5

24

16

05

02.0

4. Check and Edit : Camera

ZWO ASI290

Save camera to ini file

6. Check and Edit : Observer and Site location

Longitude

Latitude

Altitude

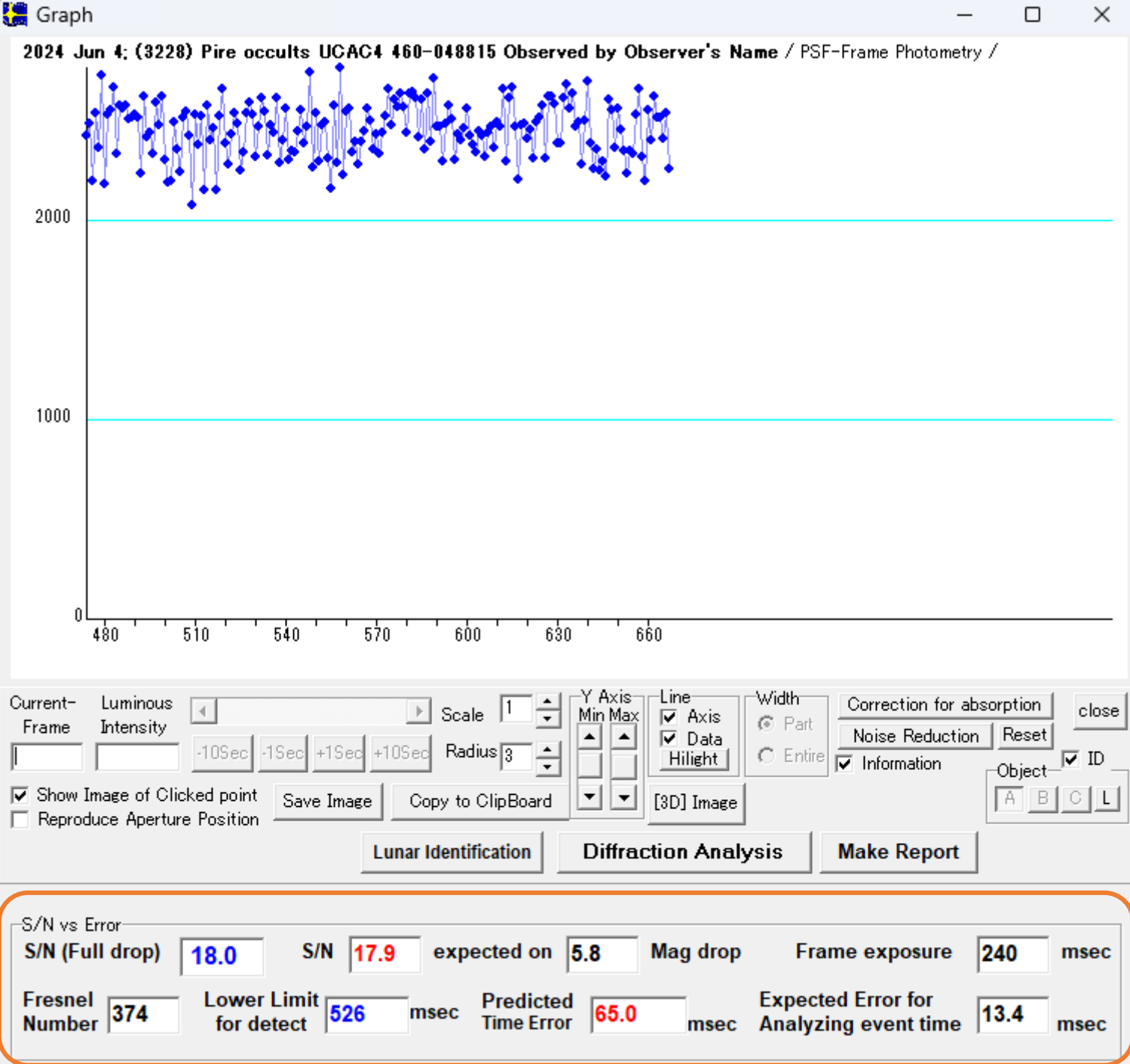
observation Site

Error consideration

Assuming (S/N on no occultation should be given to below)

S/N= 10 when 100 msec exposure

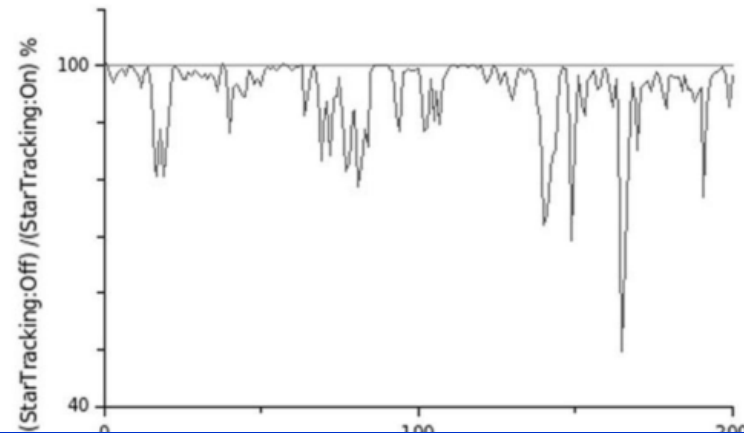
When S/N>=2.3, accuracy can be expected on the right side of the RED LINE.
Occultation can be detected on the right side of the BLUE LINE.

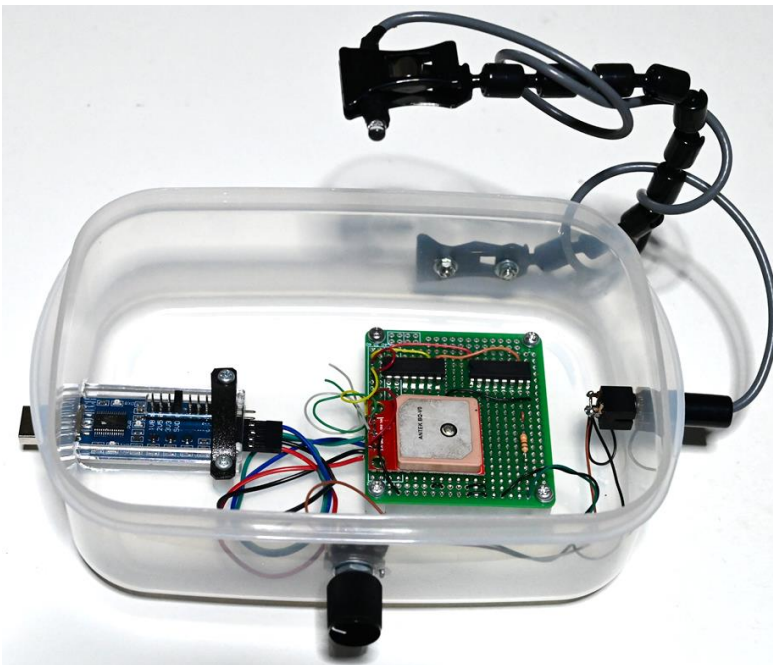


- Using the information in the xml forecast file, the value of the frame exposure time can be determined by comparing the estimated time error calculated from the S/N of the preliminary observation with the orbit forecast error.

One other thing..

When many downward pointing points like this appear, there is a high possibility of a tracking error. The error will be even higher than the error calculated by the analysis software. It is better to perform photometry again to ensure good tracking.





HACSTIP (How Accurately Can we Set Time on Pc using GPS?)

Files Properties Version

Time Zone of this PC: Localtime-UTC= hour Global position Now

Date (UTC) 2024. 08. 24 Long. 137° ' .692" E

GPS Tme (UTC) GPS Tme (Local) Lat. 36° ' .224" N

06:54:07 15:54:07

Antenna Altitude 562.5m Sat. Num 12

Geoidal Height 36.5m HDO 0.67

DSR(1PPS) signal available (Type: Falling Edge)

Fix Type for Google Maps

DGPS fix, using local DGPS or WAAS etc. 36.3667253,137.8965843 Copy

0.05 2024-08-24 15:54:03.000 2024-08-24 15:54:03.000 Set_PC_Time

-0.02 2024-08-24 15:54:03.999 2024-08-24 15:54:04.000 Set_PC_Time

-0.01 2024-08-24 15:54:04.999 2024-08-24 15:54:05.000 Set_PC_Time

0.02 2024-08-24 15:54:06.000 2024-08-24 15:54:06.000 Set_PC_Time

0.14 2024-08-24 15:54:07.000 2024-08-24 15:54:07.000 Set_PC_Time

Log

Compare PC/GPS Digits of PC-GPS 2

Synchronization parameter 980

Set Time on PC

One time correction ☐ ON ☐ OFF

Estimate calibration for this receiver 0

Time when a set of NMEA is completed 390 msec

Connect Disconnect Exit

GPS receiver gives Stable Time now.

LED Length for MT3333 , ublox M8

100msec 400msec 700msec

PMTK for setting Baud rate at connection

Satellites information

No.	Az	Alt	C/N					
G 05	145	12	27	00000				
G 10	318	25	21	0000				
G 12	155	29	26	00000				
G 15	77	49	32	000000				
G 18	226	26	44	00000000				
G 22	43	14	28	000000				
G 23	307	63	35	0000000				
R 65	317	23	28	000000				
R 72	27	60	31	000000				
R 73	34	24	24	00000				

Light Measurement tool for Occultation Observation using Video Recorder [Limovie 1.0.0.6 Pneuma]

File Edit Option Tools Software Update

2024 08 10 11:17:58.917

6728.0,52.1,11,18,01,8502276,-0.6,

6729.0,52.1,11,18,01,8818871,-21.3

6730.0,51.6,11,18,01,9128262,-7.4,

6731.0,51.9,11,18,01,9453107,-3.9,

6732.0,52.1,11,18,01,9757297,-2.0,

6733.0,51.7,11,18,02,0046484,12.7,

6734.0,51.9,11,18,02,0372548,18.7,

6735.0,51.9,11,18,02,0694216,-1.1,

6736.0,52.0,11,18,02,1003077,-8.1,

6737.0,52.0,11,18,02,1310865,20.0,

6738.0,51.9,11,18,02,1623386,33.1,

6739.0,51.6,11,18,02,1938762,-8.4,

6740.0,51.9,11,18,02,2243869,8.1,

6741.0,52.0,11,18,02,2558686,8.2,

6742.0,52.1,11,18,02,2865006,-16.6

6743.0,51.7,11,18,02,3178574,-15.8

6744.0,52.0,11,18,02,3484277,1.2,

6745.0,51.7,11,18,02,3805519,0.6,

6746.0,51.7,11,18,02,4120839,-7.3,

6747.0,51.7,11,18,02,4439285,-3.2,

6748.0,51.9,11,18,02,4753796,-15.2

6749.0,52.0,11,18,02,5055019,-9.2,

6750.0,52.0,11,18,02,5366476,6.2,

6751.0,51.6,11,18,02,5683261,-20.5

6752.0,51.5,11,18,02,5984581,-16.8

6753.0,51.6,11,18,02,6318863,2.1,

Asteroid timing guide Operation Guide

SharpCap Timing Analysis More

Frame time Date Threshold

Sharp4.1 24 08 10 80

h m s [Start] [Mid] [End] S1 S2

11 17 58.89568 58.901458 58.9170567

Current Frame 6634

Measurement

Brightness BKG/Frame

Star Even

Odd

Frame 1377.3

Color Value

Position Center Tracking

X= 326 Y= 344

Star Tracking

Star

Signal1

Signal2

TVI

Fixed

Linked Tracking

Link Passed

Frame1 Frame2

Rotate Point

Star Tracking

Anchor

Drift

OFF

CSV

Estimated track

Radius Threshold

Frame1 Frame2

Passed Point (Frame)

Set Cl Set Cl

PSF

Tracking

Photometry

Form of BKG-Area

Standard

Avoid Sunlit Face

Meteor/Lunar Limb

Direction Setting

Width Gap

Radius Inner Outer

Set radius to recorded

Star Image [3D] Update Setting Items

Measurement / View Option

Show Field

Field Measure

Field Order

Even first

Odd first

Current Object

A B C

AVI filename F:\Occultation-Video\20240810_Spica\UnoW20_14_31.avi

Timing process indicator

1. Time correct 2. XML element 3. Light curve 4. Diffraction tilt 5. Make report

- I will investigate the error estimation issue, and improve Limovie / HACSTIP-GPS