

Digital Video Cameras:

**SharpCap Timestamps**

AND

**TANGRA**

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2020 May 07

There is a growing number of occultation observations with digital video cameras, some of them with integrated GPS.

The QHY174GPS (<https://www.qhyccd.com>) camera is the first CMOS camera with built-in GPS timing and in this aspect a real alternative to the usual analogue video technology. Various worldwide occultation results are known gotten with this camera. However, because of the complex system QHY174GPS – SharpCap (currently for occultation work the only suitable control software, <https://www.sharpcap.co.uk>) – data reduction / photometry software, there is a deep learning curve that must be gone by the users. In a workshop at the Archenhold-Sternwarte Berlin the basics and the advanced use of this camera have been studied ([http://www.iota-es.de/qhy174gps\\_workshop.html](http://www.iota-es.de/qhy174gps_workshop.html)).

The swiss DVTI Camera, a second camera with integrated GPS, is under development (<https://groups.io/g/d-vti-cam/>).

In the meantime, questions about timestamping came up. Some tests with a SEXTA device (<https://www.kuriwaobservatory.com/SEXTA/SEXTA.html>) I made in preparation for the Berlin Workshop, some further ones in the last time.

Just now we also have a new Tangra version 3.7.2 (<http://www.hristopavlov.net/Tangra3/>) with greatly improved support for digital video cameras.

In this tutorial I'll give some instructions how the QHY174GPS SC timestamps work together with Tangra.

The test system used was mainly a notebook with Intel i7 2.2GHz, RAM 16GB, W7 Home Premium - 64bit, SSD; SharpCap 3.2.6248.0, 32bit, Pro, the SEXTA device and a camera QHY174GPS (mono, cooled). The times are usually UT.

SharpCap processes various high-precision time information provided by the QHY174GPS camera (or, in case of no GPS, basing on the system time) and timestamps the output files accordingly. So far ADV is not yet available, there are FITS sequences and SER format records possible. The latter is not a dedicated occultation work format.

To fully utilize the potential of the QHY174GPS camera, LED calibration is strongly recommended. To avoid dropped frames see the Berlin Workshop files. The GPS antenna needs an unobstructed view to the sky.

It is recommended to activate the SC GPS-logging to check whether the GPS data was valid for particular frames.

## QHY174GPS in GPS locked state:

The SC timestamp is the GPS **\*start exposure\***

In GPS locked and calibrated state, with suitable hardware and appropriate SC settings you will get an overall timing accuracy of 1...2ms.

There are no camera delays to be considered.

## Digital video cameras without GPS and QHY174GPS without/lost GPS lock:

The SC timestamp is the frame **\*end time\*** (the time, the frame is received by SC). However, for FITS sequences, SC provides with the header DATE-OBS an *estimated* frame **\*start time\***

The time reference is the system time (with all it's inaccuracies).



QHY174GPS



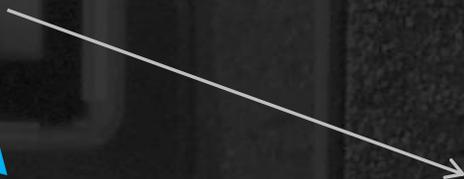
SharpCap



FITS Sequ.



SER



ADV  
(To develop)

UTC synchronized  
time signals

UTC synchronized  
SC timestamps

GPS \*start  
exposure\*  
(DATE-OBS)

Page 6

GPS \*start  
frame\*

Page 9



~~UTC synchronized time signals~~

QHY174GPS

SharpCap

FITS Sequ.

SER

ADV  
(To develop)

System time synchronized SC timestamps

System clock *estimated*  
\*frame start\*  
(DATE-OBS)

\*Frame received\* system time

In the following, a sample workflow for a QHY174GPS (locked) 100ms FITS sequence is shown. The pictures refer to the first frame of the sequence.

**Fits-Header First frame FITS header**

```

SIMPLE = T / C# FITS: 02/23/2020 17:02:34
BITPIX = 16
NAXIS = 2 / Dimensionality
NAXIS1 = 480
NAXIS2 = 300
GPS_Long= 13.427605 / Longitude
GPS_SFlg= 51 / StartFlag
GPS_ST = '2020-02-23T16:02:34.000000Z' / StartShutterTime
GPS_SU = 811872 / StartShutterMicroSecond
GPS_EFlg= 51 / EndFlag
GPS_ET = '2020-02-23T16:02:34.000000Z' / EndShutterTime
GPS_EU = 911807.2 / EndShutterMicroSeconds
GPS_NFlg= 51 / NowFlag
GPS_NU = 911807.1 / NowShutterMicroSeconds
GPS_Lat = 52.5161616666667 / Latitude
GPS_PPSC= 1000000 / PPSCounter
GPS_Stat= 'Locked ' / GPS Status
GPS_ExpU= 99935.2 / Exposure (microseconds)
GPS_DSYS= -0.002689 / System clock - GPS clock
GPS_DSTB= 562 / Time offset stable for
GAIN = 100 /
GPS_NT = '2020-02-23T16:02:34.000000Z' / NowShutterTime
GPS_H = 256 / Height
GPS_Tmp#= 2 / TempSequenceNum
BLKLEVEL= 20 /
EXTEND = T / Extensions are permitted
BZERO = 32768 /
BSCALE = 1 /
EXPTIME = 0.1 /
XPIXSZ = 5.8600001335144 /
YPIXSZ = 5.8600001335144 /
XBINNING= 1 /
GPS_W = 496 / Width
YBINNING= 1 /
SWCREATE= 'SharpCap' / v3.2.6232.0, 32 bit
DATE-OBS= '2020-02-23T16:02:34.8118720' / GPS:Start Exposure
DATE-END= '2020-02-23T16:02:34.9091182' / System Clock:Frame Received
    
```

1

**Choose FITS Time Headers Tangra timing selection**

Timestamp + Exposure   
  Start + End Timestamps   
  None (Sort by Filename)

Composition:  Single Timestamp   
  Separate Date and Time

Date / Time	Format	Type
DATE-OBS	yyyy-MM-ddTHH:mm:ss.ffffff	Start Exposure
DATE-OBS= '2020-02-23T16:02:34.8118720' / GPS:Start Exposure		

Exposure    Units  
 EXPTIME    Seconds  
 EXPTIME = 0.1 /

Flip Vertically   
  Flip Horizontally

Pixel Value Mapping    OK    Cancel

Because of GPS-locked state we choose \*Start Exposure\* given with DATE-OBS

2

Tangra v3.7 - data, FITS.16::SEQ

File Frame Actions Reduction Tools Settings Help

3

2020 02 23 16:02:34:8118720

First frame SEXTA

16.02.34 9

Configuring Frame: 1 Display Mode (0,0)=0

Camera and Timing Corrections

Enter information about used video camera and timing

Camera/System QHY174-GPS <https://www.qhyccd.com>

The QHY174M-GPS and QHY174C-GPS cameras will record the global shutter exposure starting and ending time with microsecond precision.

Tangra camera and timing selection

Timestamping UTC Timestamp by the Camera

The camera has access to UTC, typically via a GPS receiver. It associates accurate time with the exposures and sends this with each frame as metadata or via the driver.

? OK

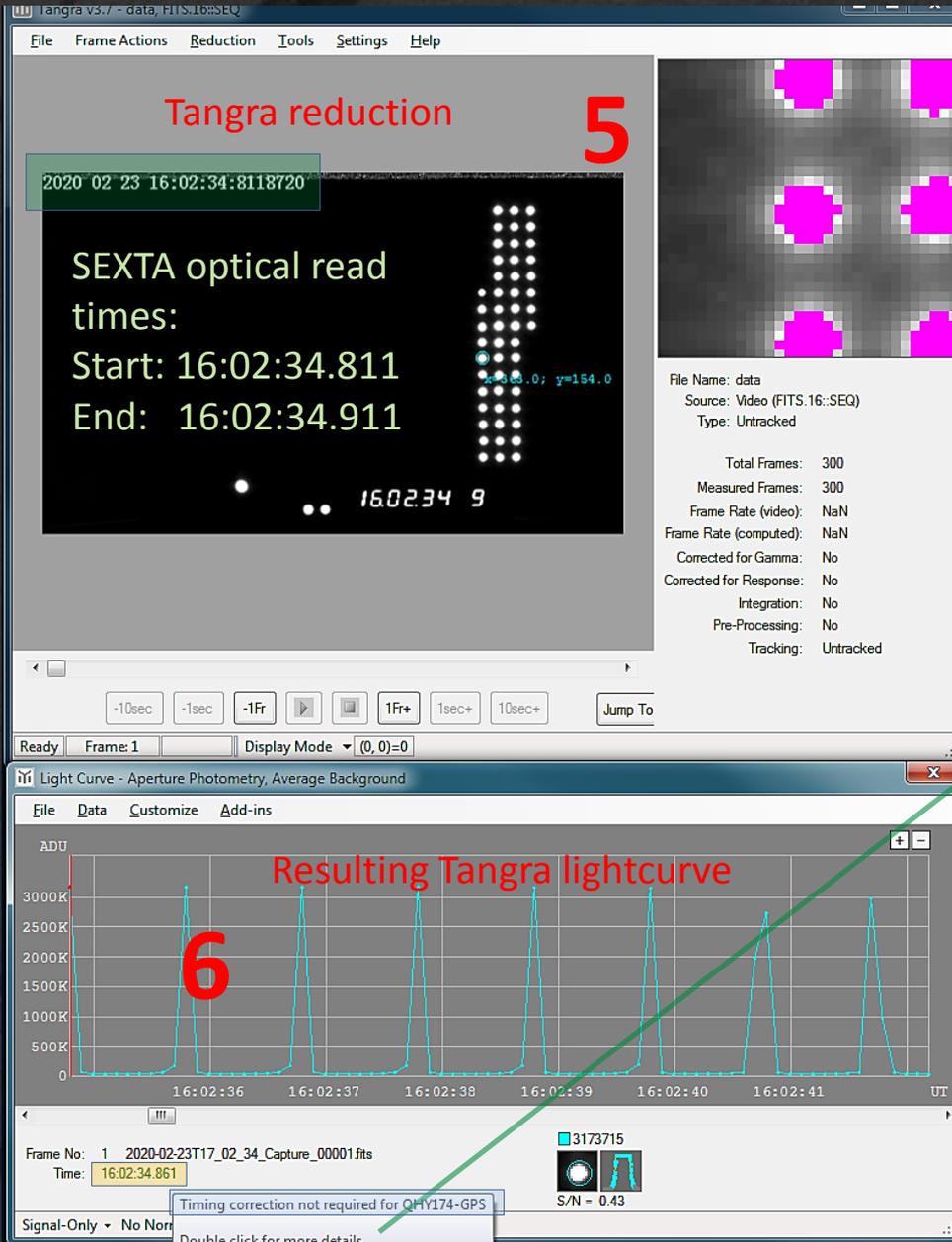
4

Measuring: 0 targets

- Move to the first frame you want to measure
- Select your first target
- Press the 'Add Object' button

Reset Start

Type: Untracked  
Signal Method: Aperture Photometry  
Background Method: Average Background

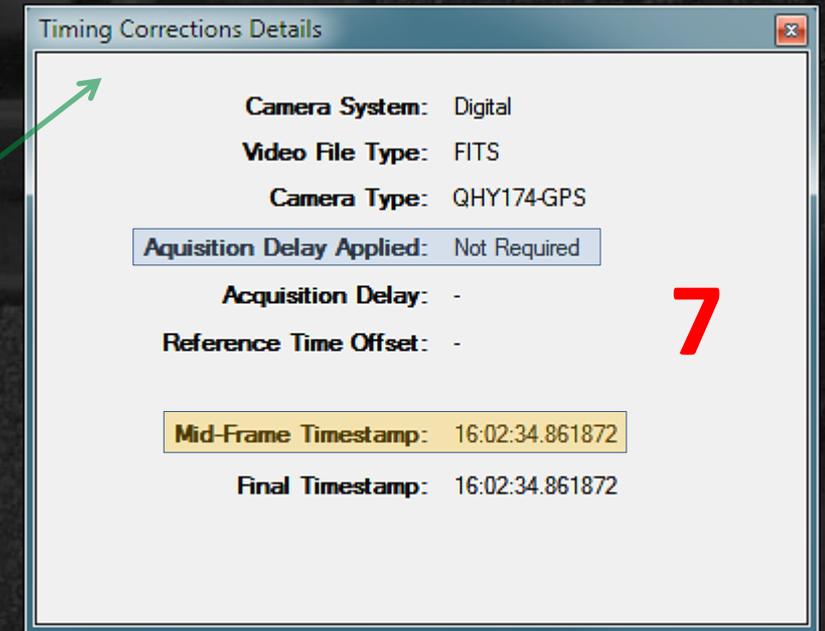


Because of GPS-locked state we selected \*Start Exposure\* given with DATE-OBS.

Tangra light curves show \*Mid-frame\* timestamps:  
 $(\text{Start Exp. } .811\text{s}) + \frac{1}{2} (0.1\text{s}) = (\text{Mid-fr. } .861)$

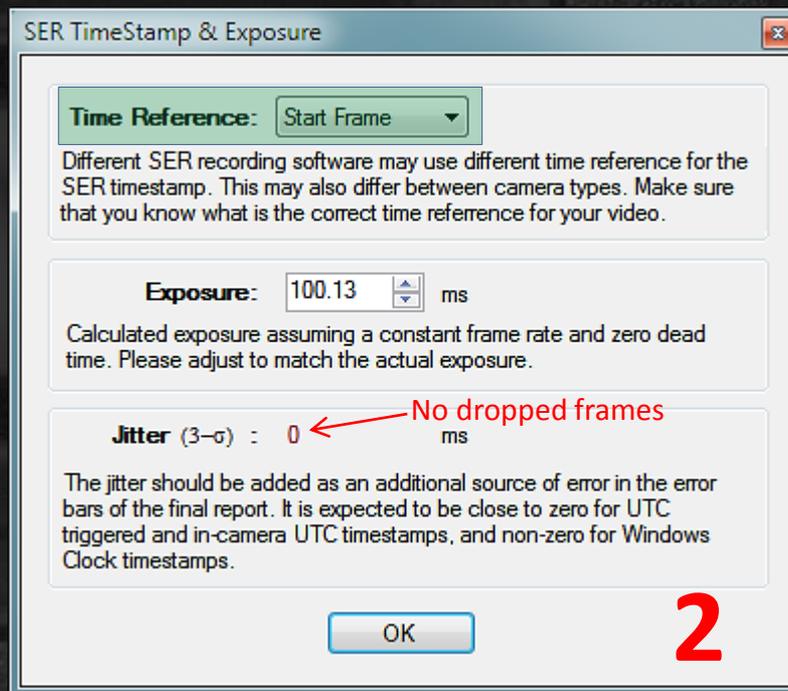
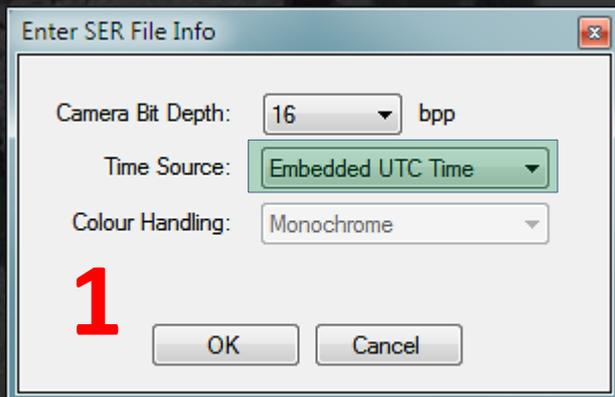
Timing corrections are not required.

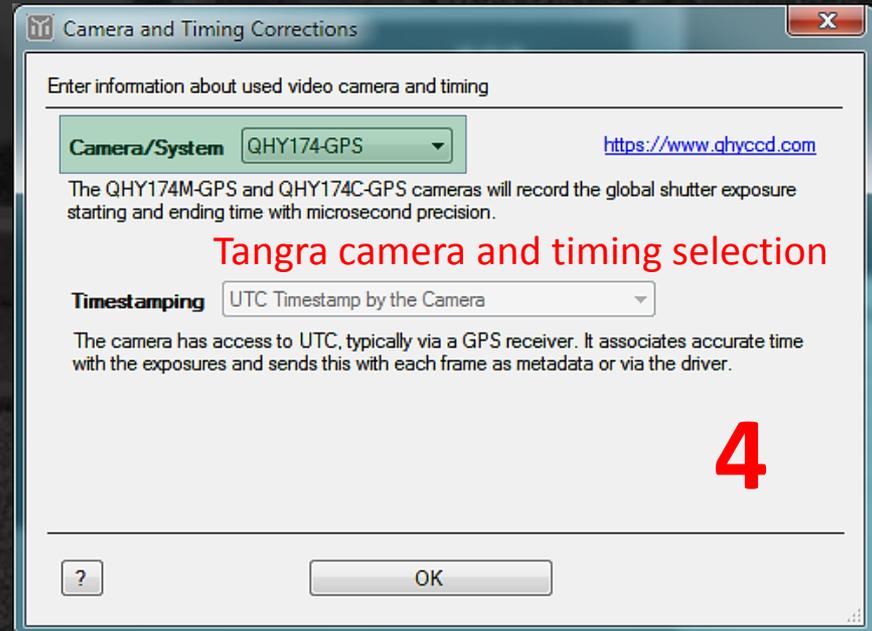
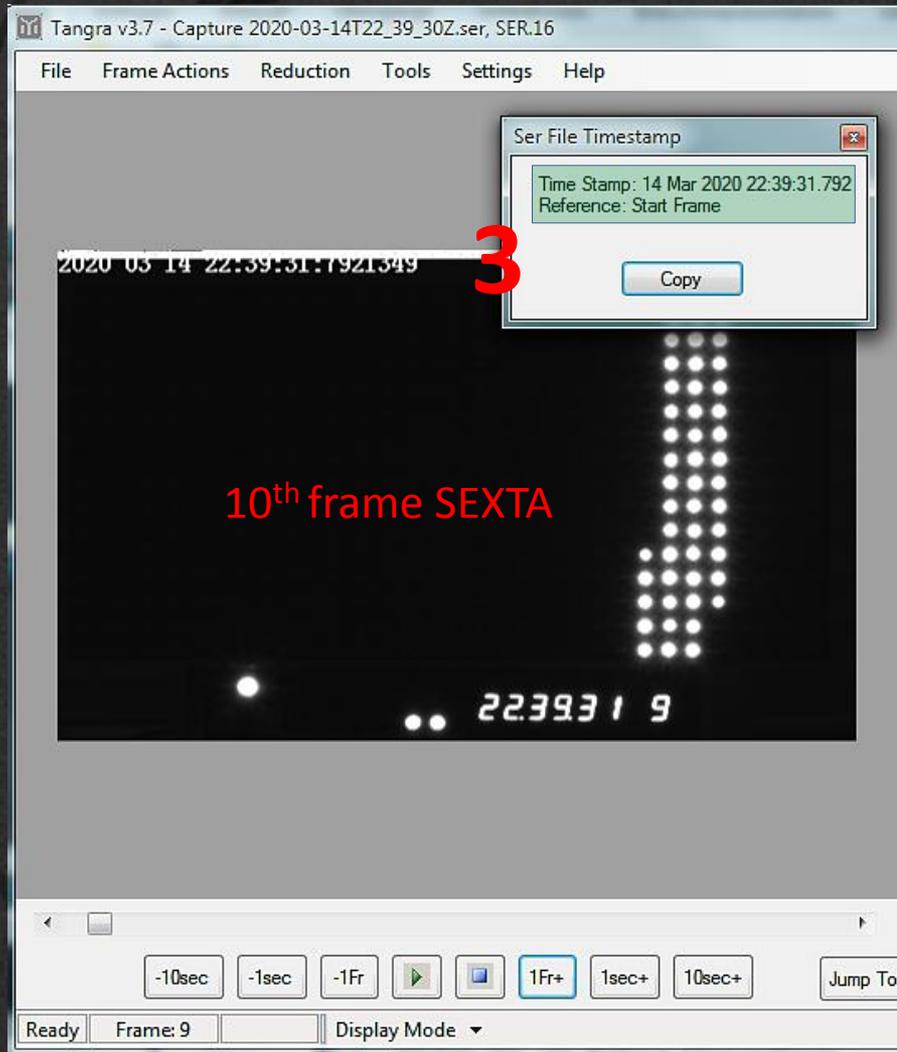
The SEXTA optical read times agree with the times from camera/SC.



In the following, a sample workflow for a QHY174GPS (locked) 100ms SER video is shown. The pictures refer to the 10<sup>th</sup> frame of the sequence.

Because of GPS-locked state we choose \*Start Frame\*





Tangra v3.7 - Capture 2020-03-14T22\_39\_30Z.ser, SER.16

Tangra reduction 5

2020-03-14 22:39:31.7921349

SEXTA optical read times:  
Start: 22:39:31.791  
End: 22:39:31.891

Time Stamp: 14 Mar 2020 22:39:31.792  
Reference: Start Frame

Copy

File Name: Capture 2020-03-14T22\_39\_30Z.ser  
Source: Video (SER.16)  
Type: Untracked

Total Frames: 300  
Measured Frames: 300  
Frame Rate (video): 9.987  
Frame Rate (computed): NaN  
Corrected for Gamma: No  
Corrected for Response: No  
Integration: No  
Pre-Processing: No  
Tracking: Untracked

Because of GPS-locked state we selected \*Start Frame\*

Tangra light curves show \*Mid-frame\* timestamps:  
 $(\text{Start Exp. } .792\text{s}) + \frac{1}{2} (0.1\text{s}) = (\text{Mid-fr. } .842)$

Timing corrections are not required.

The SEXTA optical read times agree with the times from camera/SC.

Light Curve - Aperture Photometry, Average Background

Resulting Tangra lightcurve 6

ADU

2000K  
1500K  
1000K  
500K  
0

22:39:35 22:39:40 22:39:45 22:39:50 22:39:55 UT

Frame No: 9  
Time: 22:39:31.842

Timing correction not required for QHY174-GPS

Signal-Only No ND

Double click for more details.

Timing Corrections Details

Camera System: Digital  
Video File Type: SER  
Camera Type: QHY174-GPS  
Acquisition Delay Applied: Not Required  
Acquisition Delay: -  
Reference Time Offset: -

Mid-Frame Timestamp: 22:39:31.842134  
Final Timestamp: 22:39:31.842134

7

In the following, a sample workflow for a QHY174GPS with GPS off for a 100ms FITS sequence is shown. The pictures refer to the first frame of the sequence.

### Fits-Header First frame FITS header

```
SIMPLE = T / C# FITS: 05/03/2020 23:48:21
BITPIX = 16
NAXIS = 2 / Dimensionality
NAXIS1 = 480
NAXIS2 = 300
GAIN = 40 /
DATE-OBS= '2020-05-03T21:48:20.9717277' / System Clock:Est. Frame Start
SWCREATE= 'SharpCap' / v3.2.6248.0, 32 bit
CCD-TEMP= 29.7 /
YBINNING= 1 /
XBINNING= 1 /
XPIXSZ = 5.8600001335144 /
BLKLEVEL= 20 /
EXPTIME = 0.1 /
BSCALE = 1 /
BZERO = 32768 /
EXTEND = T / Extensions are permitted
YPIXSZ = 5.8600001335144 /
INSTRUME= 'QHY174M ' /
END
```

**1**

### Choose FITS Time Headers Tangra timing selection

Timestamp + Exposure     Start + End Timestamps     None (Sort by Filename)

Composition:  Single Timestamp     Separate Date and Time

Date / Time	Format	Type
DATE-OBS	yyyy-MM-ddTHH:mm:ss.ffffff	Start Exposure
DATE-OBS= '2020-05-03T21:48:20.9717277' / System Clock:Est. Frame Start		

Exposure Units

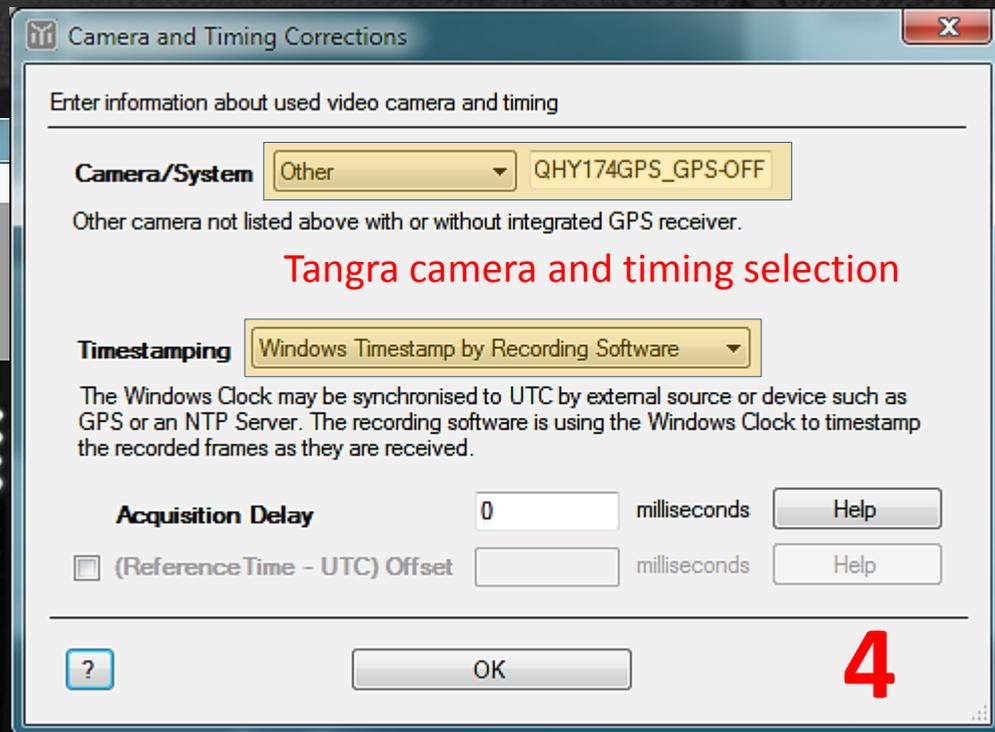
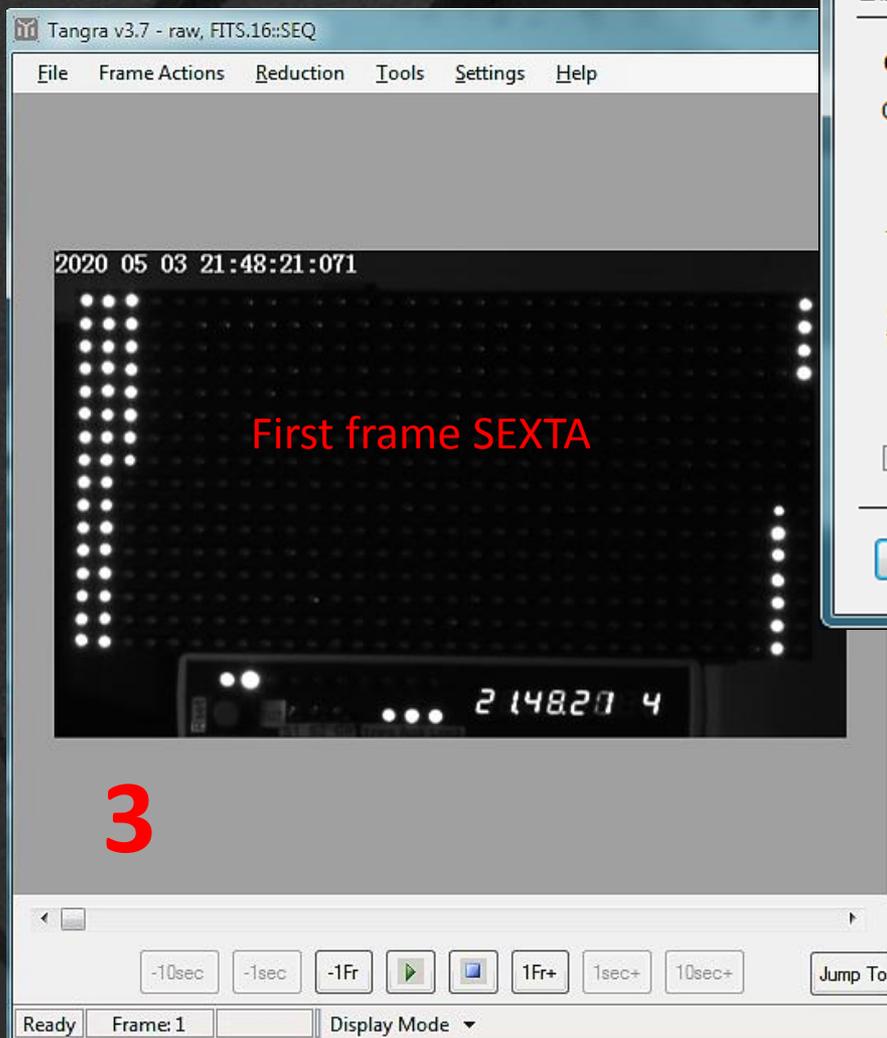
EXPTIME	Seconds
EXPTIME = 0.1 /	

Flip Vertically     Flip Horizontally

Pixel Value Mapping    OK    Cancel

**2**

We have no GPS, but SC provides a system time *estimated* \*Frame start\* timestamp. Using it, we have to choose \*Start Exposure\*.



Within this example, acquisition delay and time offset are not considered. For information see Tangra help. Acquisition delay is set to be 0.

Tangra v3.7 - raw, FITS.16:SEQ

File Frame Actions Reduction Tools Settings Help

**Tangra reduction 5**

2020 05 03 21:48:21.071

SEXTA optical read times:  
Start: 21:48:20.981  
End: 21:48:21.079

File Name: raw  
Source: Video (FITS.16:SEQ)  
Type: Untracked

Total Frames: 303  
Measured Frames: 303  
Frame Rate (video): NaN  
Frame Rate (computed): NaN  
Corrected for Gamma: No  
Corrected for Response: No  
Integration: No  
Pre-Processing: No  
Tracking: Untracked

Ready Frame: 1 Display Mode (56,123)=1472

Without GPS, the in-frame timestamp refers to the system time frame received.

From DATE-OBS, the *estimated* \*frame start\* time is 21:48:20.971

Tangra light curves show \*Mid-frame\* timestamps.

Timing corrections are not considered.

The system time based SC timestamps are ~10ms behind the SEXTA optical read times .

Light Curve - Aperture Photometry, Average Background

File Data Customize Add-ins

**Resulting Tangra lightcurve**

ADU

1500K  
1000K  
500K  
0

21:48:25 21:48:30 21:48:35 21:48:40 21:48:45 UT

Frame No: 1 Capture 2020-05-03T21\_48\_21Z\_00001.fits  
Time: 21:48:21.021

1849784  
S/N = 0.41

Acquisition delay has been applied to the times

Signal-minus-Backg Double click for more details.

**6**

Timing Corrections Details

Camera System: Digital  
Video File Type: FITS  
Camera Type: QHY174GPS\_GPS-OFF

Acquisition Delay Applied: Yes  
Acquisition Delay: 0 sec

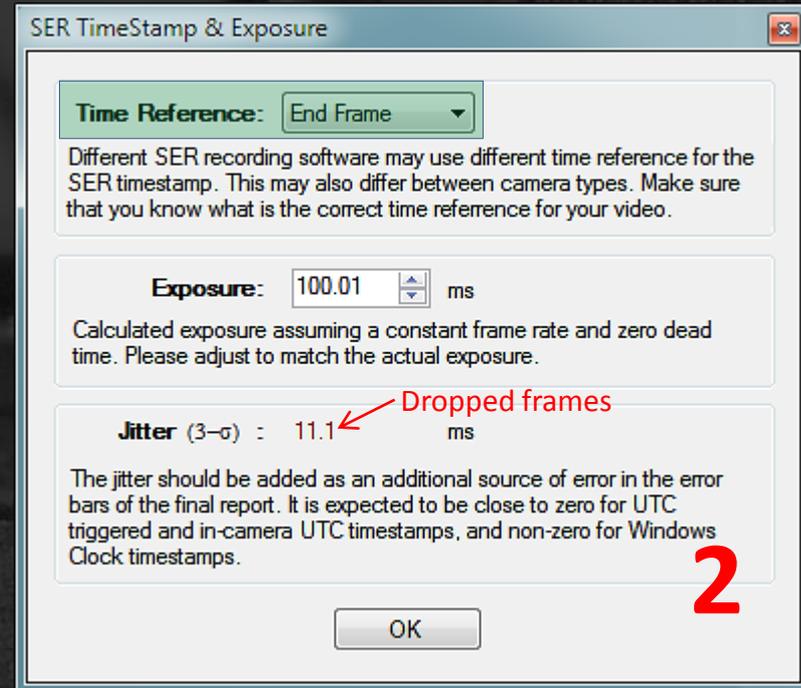
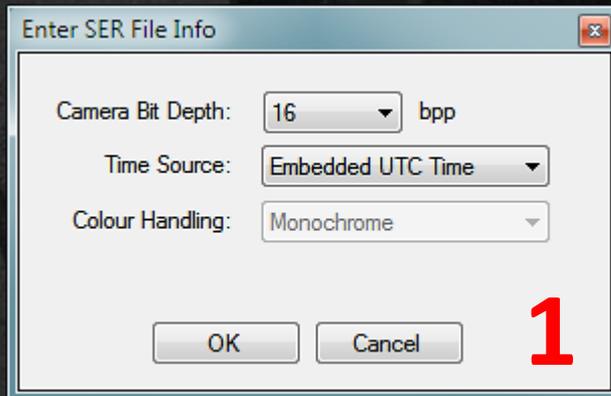
Reference Time Offset: -

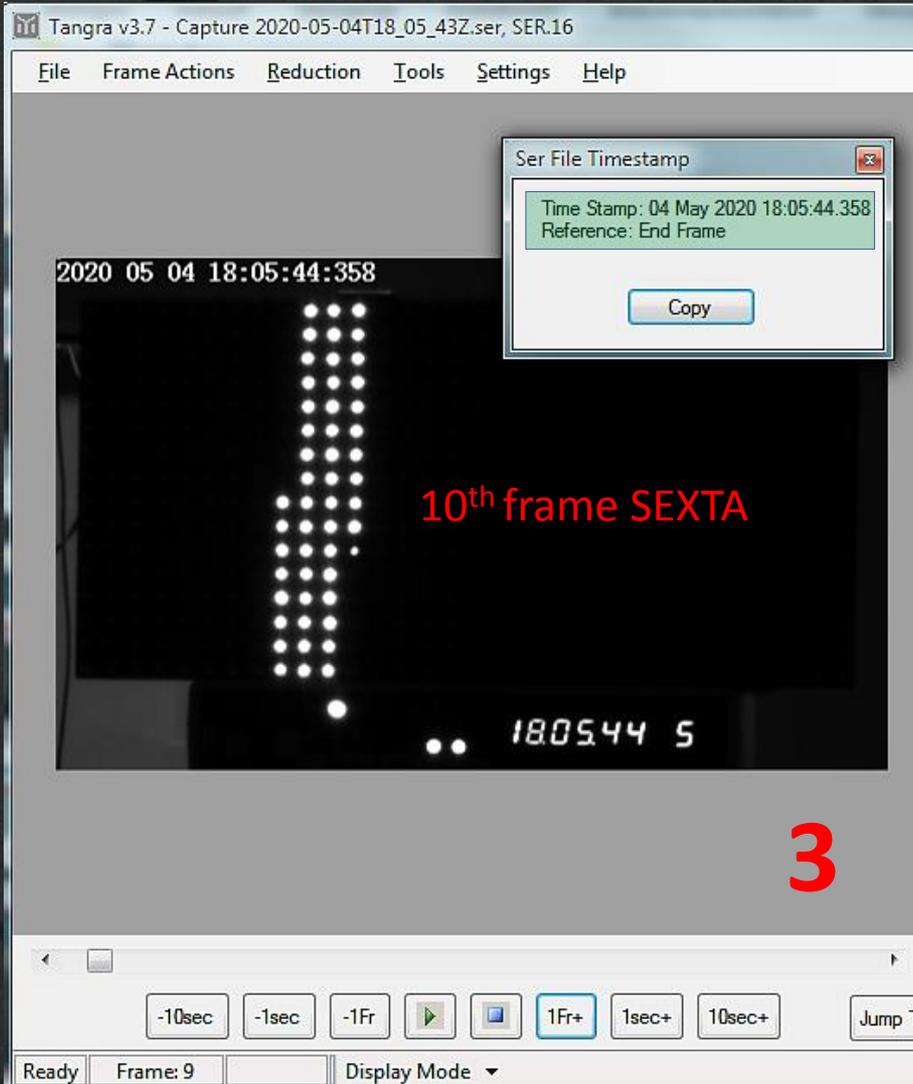
Mid-Frame Timestamp: 21:48:21.021727  
Final Timestamp: 21:48:21.021727

**7**

In the following, a sample workflow for a QHY174GPS with GPS off for a 100ms SER video is shown. The pictures refer to the 10<sup>th</sup> frame of the sequence.

Because of no GPS  
we choose \*End Frame\*





10<sup>th</sup> frame SEXTA

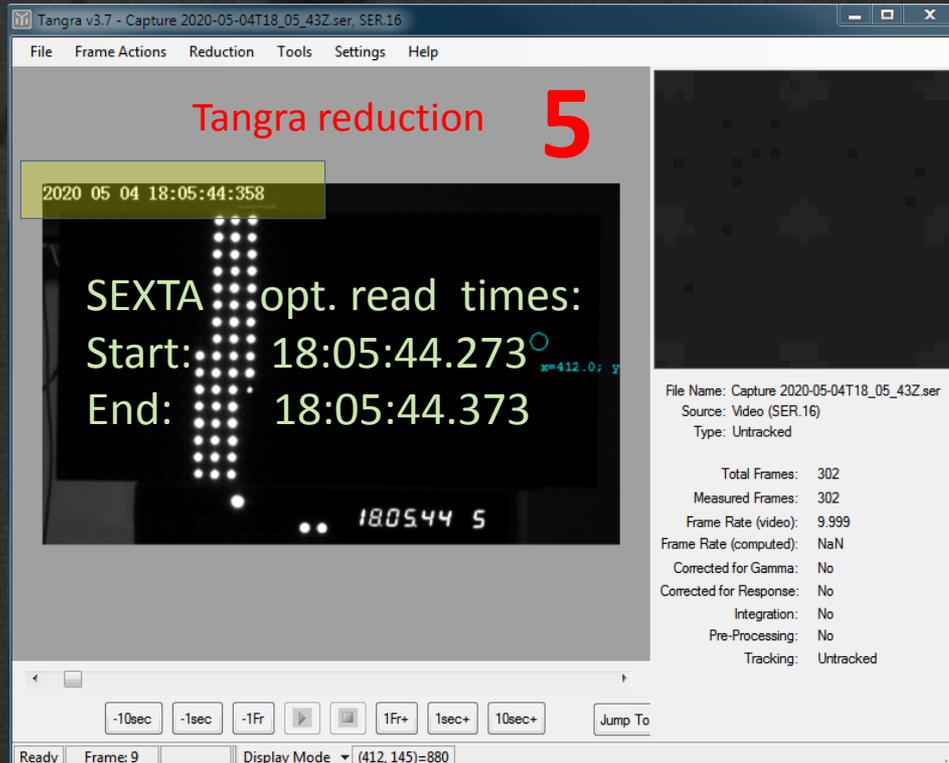
3

Within this example, acquisition delay and time offset are not considered. For information see Tangra help. Acquisition delay is set to be 0.



Tangra camera and timing selection

4

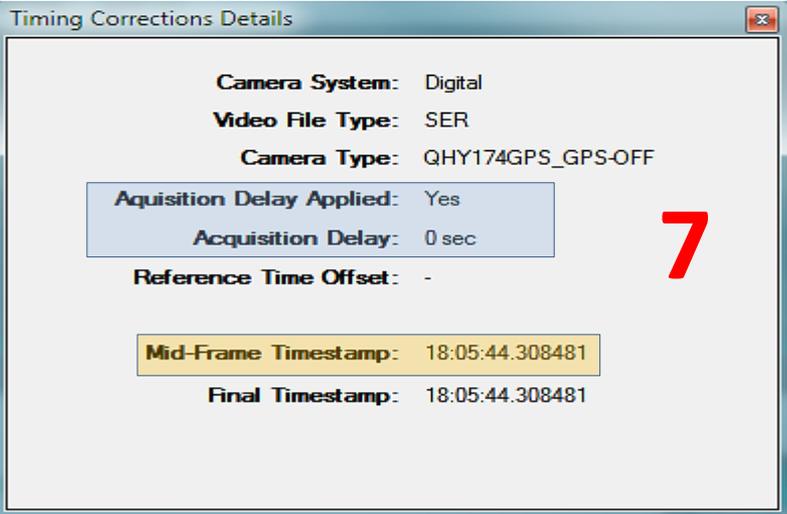
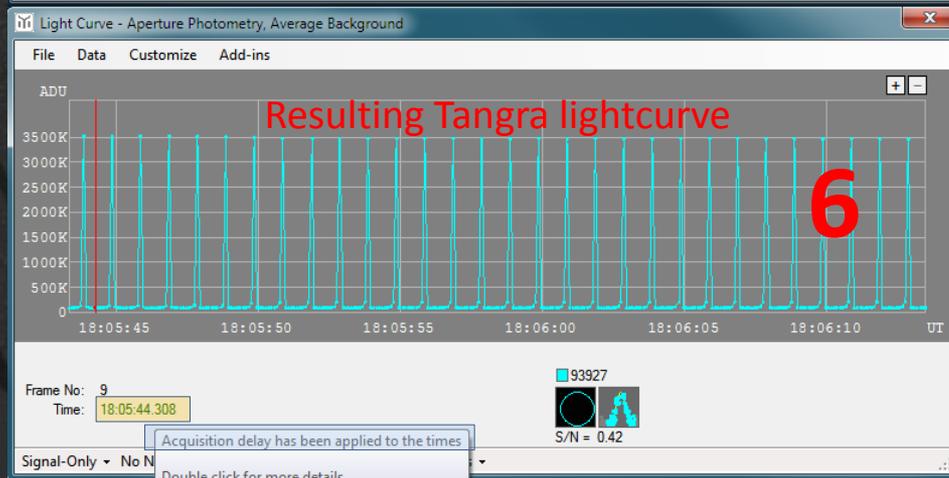


Without GPS, the in-frame timestamp refers to the system time frame received.

Tangra light curves show \*Mid-frame\* timestamps.

Timing corrections are not considered.

The system time based SC timestamps are ~15ms behind the SEXTA optical read times .



Many thanks to:

Robin Glover      SharpCap developer

Hristo Pavlov      Developer of TANGRA

Th. Midavaine      For providing a SEXTA device (developed by  
Tony Barry and Dave Gault)

Colleagues of the worldwide community for suggestions  
and valuable discussions.

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