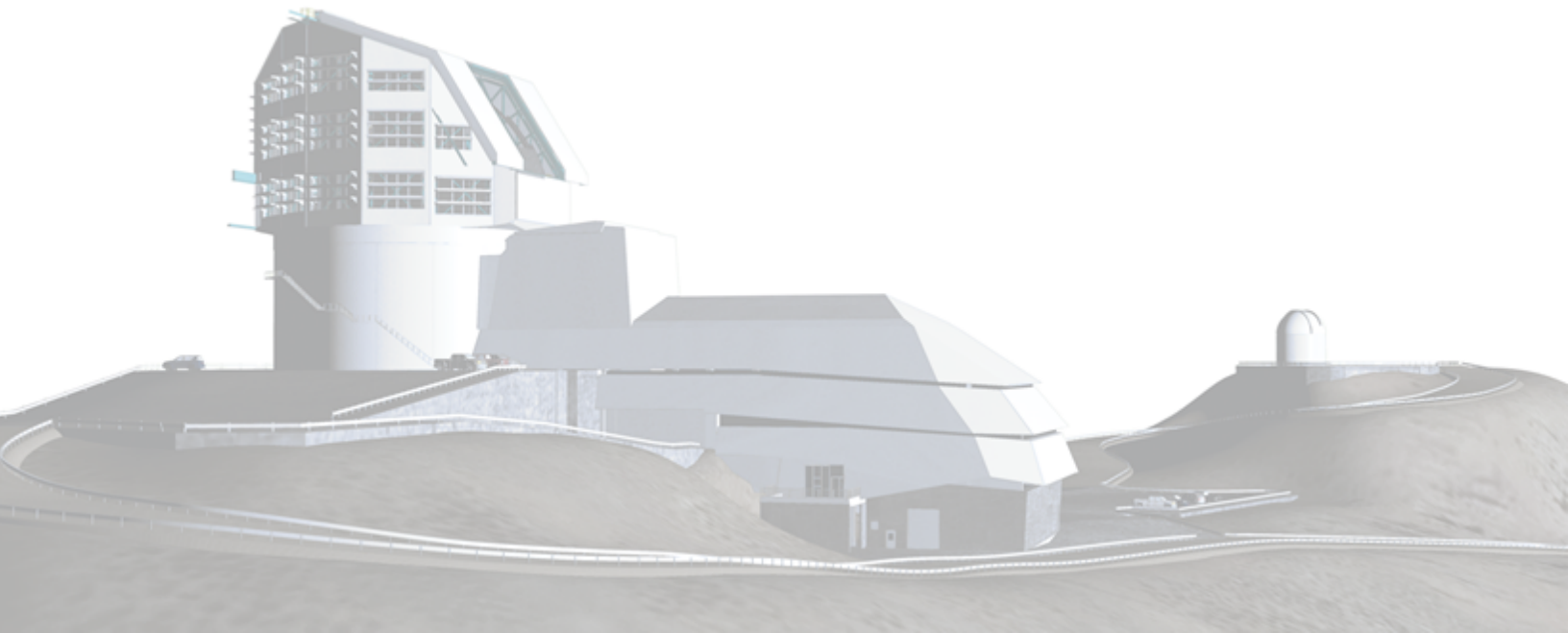

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Working with Rubin EFD timestamps.

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Abstract

There are some subtleties to working with the timestamps in the EFD, and how they relate to the FITS file header keywords. This technote attempts to capture my learning on this topic.

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Working with Rubin EFD timestamps.

1 Introduction

I have been working with the timestamps in the Rubin EFD (Engineering Facilities Database), and have generated some notebooks and learning that is captured in this technote. This also relates to the timestamps in the generated FITS file headers. This work is with the Auxiliary Telescope, but it is believed that it will translate to ComCam and LSSTCam files as well.

2 UTC vs TAI

There are two important time scales to remember, UTC and TAI. A simple introduction to these can be found at the following Wikipedia pages:

1. `https://en.wikipedia.org/wiki/Coordinated_Universal_Time`
2. `https://en.wikipedia.org/wiki/International_Atomic_Time`

From the point of view of this technote, the following things are important to remember:

1. UTC is the time reported by any Unix computer, and is typically what is used as a time-base in any commercially available software.
2. UTC has one second discontinuties in the past whenever a "leap-second" was applied to keep the UTC timebase in sync with the Earth's rotation. There may be further discontinuties in the future if a leap second is added or subtracted.
3. TAI is a continuous time base without these discontinuties.
4. Because of the accumulated leap seconds, TAI is currently exactly 37 seconds ahead of UTC.

3 Timestamps in the EFD

There are two types of time information in the EFD:

1. Event time stamps that are updated once per second. An example of one of these is "lsst.sal.ATMCS.logevent_allAxesInPosition"
2. Events that need to be sampled more often, such as the position of the mount. An example of one of these is "lsst.sal.ATMCS.mount_AzEl_Encoders". For these events, every second 100 values are entered into the EFD, indicating the position of the mount every 10 milliseconds for the preceding second. These are indexed from 0-99, and are called "packed time series". These is software (lsst_efd_client.select_packed_time_series) that parses these packed time series and returns a pandas dataframe with the sequential measurements.

Prior to mid-October 2021, the time stamps in the EFD were in TAI, but after this date, all of the timestamps in the EFD are being reported in UTC.

4 Example notebook to query these times.

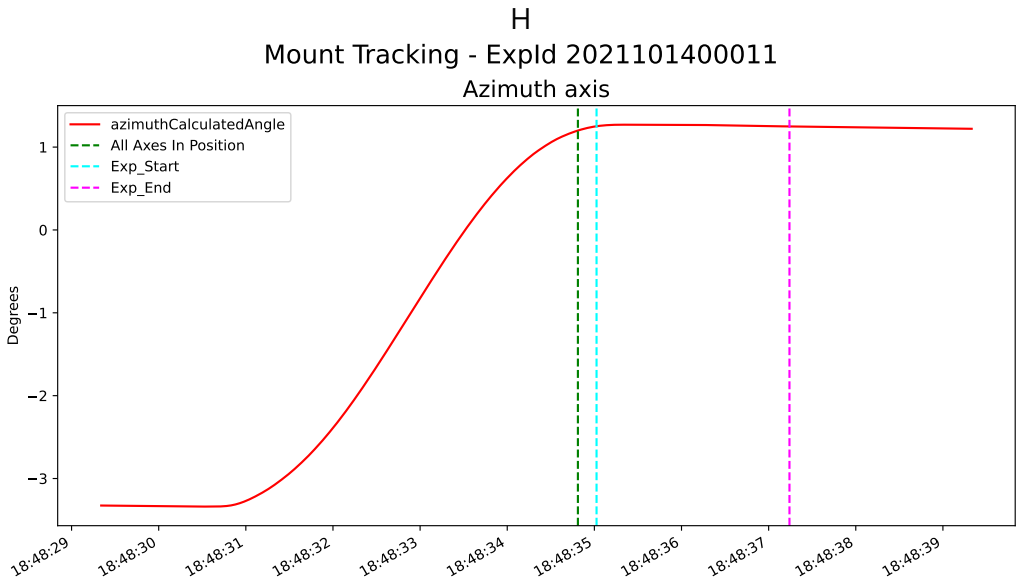
I have generated a simple notebook to illustrate accessing these times from the FITS headers and from the EFD. It has one plot for a single exposure on the AuxTel on 20211014 and one plot for a set of 10 exposures on the same data. I will attempt to keep this notebook (and this document) up to date as things change. The notebook can be accessed in two places:

1. `https://github.com/craiglagegit/ScratchStuff/blob/master/notebooks/Plot_Tracking_UTC_29Oct21.ipynb`
2. At NCSA at /project/cslage/AuxTel/notebooks/Plot_Tracking_UTC_29Oct21.ipynb

In order for the notebook to work properly, the efd_client version must be at least v0.9.1. Presumably this will soon be part of the base build, but as of this writing, it is necessary to install the latest version as folllows:

1. In a terminal, type: pip install –user lsst_efd_client==0.9.1
2. Restart the LSST kernel in the notebook to pick the new version
3. You can check in the notebook that you have the correct version with:
   (a) import lsst_efd_client
   (b) print(lsst_efd_client.__version__)
   (c) This should give: __version__ ’0.9.0’

The graph generated by this notebook is shown below. It shows the mount tracking, then a small slew is made (at about 18:48:31), then the “allAxesInPosition” time stamp is received at about 18:48:35, then the exposure is taken between about 18:48:35 and 18:48:37.



5 Important things to remember

There are several pieces of learning that came out of this exercise:

1. In the FITS headers, The DATE-BEG and DATE-END keywords represent the time of shutter open and close, and are in TAI, as specified by the TIMESYS keyword. The DATE

keyword is the time the file was written, and is in UTC, as specified by the FITS specification. To use the DATE-BEG and DATE-END times to query the EFD, these need to be converted to UTC. The notebook shows how to do this in a way that should remain valid even if additional leap-seconds are added.

2. All of the time stamps in the EFD should now be returned in UTC.
3. There still appears to be a slight shift in the timestamps between the packed time series and the non-packed time series. This is why the allAxesInPosition" timestamp appears while the mount is still moving. This shift is of the order of 1-2 seconds. This appears to require changes to the cRIO_timestamp data which is being entered into the EFD, but the exact fix is not clear at present. There is a Jira ticket `https://jira.lsstcorp.org/browse/CAP-816` to address this.

6 Future plans

There is still ongoing discussion of how to fix the above-mentioned timestamp shift, including discussion of whether the packed time series are necessary. Ultimately, this shift needs to be eliminated, since we need to know the stability of the mount during the actual exposures.

7 Situation prior to mid-October, 2021. EFD timestamps were in TAI.

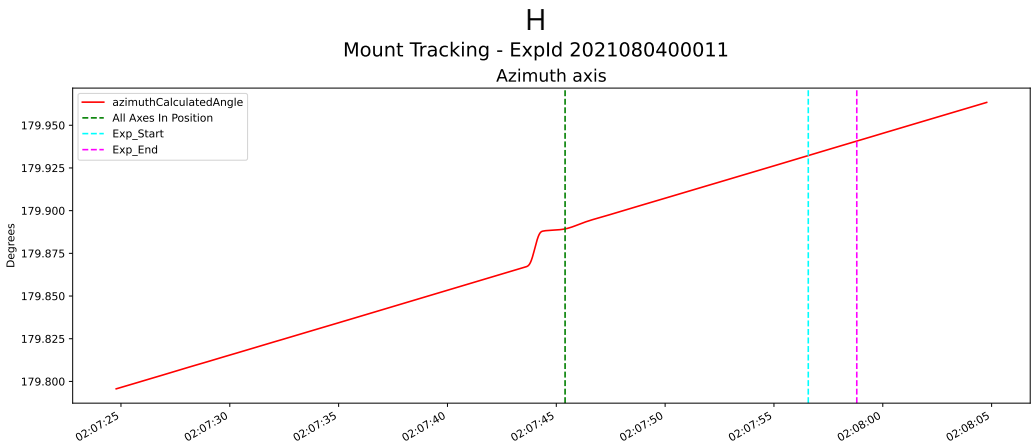
Prior to mid-October, 2021, the timestamps in the EFD were in TAI. Below is a summary of the situation at that time. This is included for historical reasons, and if there is a need to query EFD data from these earlier times.

7.1 Example notebook to query these times.

I have generated a simple notebook to illustrate accessing these times from the FITS headers and from the EFD. It is for a single exposure on the AuxTel on 04-Aug-2021. I will attempt to keep this notebook (and this document) up to date as things change. The notebook can be accessed in two places:

1. https://github.com/craiglagegit/ScratchStuff/blob/master/notebooks/Plot_Tracking_3_13Aug21.ipynb
2. At NCSA at /project/cslage/AuxTel/notebooks/Plot_Tracking_3_13Aug21.ipynb

The graph generated by this notebook is shown below. It shows the mount tracking, then a small adjustment was made to center the image (at about 02:07:44), then the "allAxesInPosition" time stamp is received at about 02:07:46, then the exposure is taken between about 02:07:56 and 02:07:58.



7.2 Important things to remember

There are several pieces of learning that came out of this exercise:

1. In the FITS headers, The DATE-BEG and DATE-END keywords represent the time of shutter open and close, and are in TAI, as specified by the TIMESYS keyword. The DATE keyword is the time the file was written, and is in UTC, as specified by the FITS specification.
2. Pandas indicates that the timestamps in the EFD are in UTC, but this is not correct. All of the timestamps in the EFD should be in TAI.
3. When using lsst_efd_client.merge_packed_time_series, you currently need to override the default (internal_time_scale="tai"), and specify (internal_time_scale="utc"). I am unclear as to the resolution of this, but it has been reported that this is an astropy bug that is being worked on.

A References

B Acronyms

Acronym	Description
ComCam	The commissioning camera is a single-raft, 9-CCD camera that will be installed in LSST during commissioning, before the final camera is ready.
EFD	Engineering and Facility Database
FITS	Flexible Image Transport System
LSST	Legacy Survey of Space and Time (formerly Large Synoptic Survey Telescope)
NCSA	National Center for Supercomputing Applications
SE	System Engineering
TAI	International Atomic Time
UTC	Coordinated Universal Time