

# Support for EPICS Time Stamps in areaDetector

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## Overview

There have been several requests to support EPICS time stamps in areaDetector. This will be used by setting the TSE field in the EPICS records to -2. The record support then directly uses the TIME field in the record as the timestamp. Device support must have properly set the TIME field in the record.

Setting the timestamp when the driver processes, rather than later on when the record processes can be desirable because the timestamp then reflects more accurately the actual time that the I/O operation was performed. It is also desirable to allow for a user-defined function to provide the timestamp, rather than being restricted to simply calling `epicsTimeGetCurrent()`. For example, the driver may be associated with a particular EPICS event, and the user-defined function would then call `epicsTimeGetEvent()` with that event ID. This can return a site-specific time format. For example at LCLS `epicsTimeGetEvent()` returns a timestamp where the low-order bits encode the pulse ID. They want the areaDetector drivers to read that timestamp as soon as possible after the I/O is complete. In areaDetector these timestamps should also be written to data files by the standard file-writing plugins whenever possible.

A previous document described the changes to support timestamps that have recently been added to `asynManager` and `asynPortDriver` in the `asyn` module. These will be officially released in `asyn` R4-22, but are available in the SVN trunk now. This document describes the changes that have been made to `areaDetector` to support timestamps. These will be officially releases in `areaDetector` R1-10, but are available in the SVN trunk now.

## **NDArray changes**

A new field has been added to the NDArray class. This is the definition of that field.

```
epicsTimeStamp epicsTS; /**< The epicsTimeStamp; this is set with
    * pasynManager->updateTimeStamp(),
    * and can come from a user-defined timestamp source. */
```

## **asynNDArrayDriver changes**

Two new parameters have been added to the asynNDArrayDriver class.

NDEpicsTS\_Sec, asynInt32 parameter, contains NDArray.epicsTS.secPastEpoch

NDEpicsTS\_Nsec, asynInt32 parameters, contains NDArray.epicsTS.nsec

Added 2 new records to NDPluginBase.template that use these parameters, \$(P)\$ (R)EpicsTS\_Sec\_RBv, and \$(P)\$ (R)EpicsTS\_Nsec\_RBv. These contain the secPastEpoch and nsec fields of the current NDArray.epicsTS timestamp respectively.

## Detector driver changes

All detector drivers required a single-line addition of a call to `updateTimeStamp`, like the following:

```
pImage->timeStamp = startTime.secPastEpoch + startTime.nsec / 1.e9;
```

```
updateTimeStamp(&pImage->epicsTS);
```

The drivers were already setting the double `NDArray.timeStamp` field, typically with the time from a call to `epicsTimeGetCurrent`. The call to `asynPortDriver::updateTimeStamp` calls `pasynManager->updateTimeStamp()`, which gets the current time either from its internal time stamp source function, or from a user-defined timestamp source function.

This line has been added to all detector drivers in `areaDetector`. Any detector drivers that are not part of the `areaDetector` module will also need this line to be added.

## NDPluginDriver changes

NDPluginDriver, which is the base class from which all plugins derive has had the following additions to the NDPluginDriver::processCallbacks() method:

```
    setIntegerParam(NDColorMode, colorMode);
    setIntegerParam(NDBayerPattern, bayerPattern);
    setIntegerParam(NDUniqueId, pArray->uniqueId);
+   setTimeStamp(&pArray->epicsTS);
    setDoubleParam(NDTimeStamp, pArray->timeStamp);
+   setIntegerParam(NDEpicsTSSTSec, pArray->epicsTS.secPastEpoch);
+   setIntegerParam(NDEpicsTSNsec, pArray->epicsTS.nsec);
    /* See if the array dimensions have changed.  If so then do callbacks on them. */
```

It calls setTimeStamp with the epicsTimeStamp from NDArrary that was passed to the plugin. setTimeStamp sets the internal timestamp in pasynManager. This is the timestamp that will be used for all callbacks to device support and read() operations in this plugin asynPortDriver. Thus, the record timestamps will come from the NDArrary passed to the plugin if the record TSE field is -2.

It also sets the new asynNDArraryDriver NDEpicsTSSTSec and NDEpicsTSNsec parameters to the fields from the NDArrary.epicsTS. These records can then be used to monitor the EPICS timestamp in the NDArrary even if TSE is not -2.

## NDPluginStdArrays changes

The pasynUser->timestamp field is now set from the NDArrary.epicsTS field for both array callbacks and array read operations. The waveform records holding the NDArrary data thus have the timestamps from the NDArrary if TSE=-2.

## NDFileNetCDF changes

The netCDF file writing plugin was changed to write 2 new variables to every netCDF file for each NDArrary.

epicsTSSTSec contains NDArrary.epicsTS.secPastEpoch.

epicsTSNsec contains NDArrary.epicsTS.nsec.

Note that these variables are arrays of length numArrays, where numArrays is the number of NDArraries (images) in the file.

It was not possible to write the timestamp as a single 64-bit value because the classic netCDF file format does not support 64-bit integers.

## **NDFileTIFF changes**

The TIFF file writing plugin previously had one user-defined TIFF tag that contained the double `NDArray.timeStamp` field.

Tag=65000, field name=`NDTimeStamp`, field\_type=`TIFF_DOUBLE`, value=`NDArray.timeStamp`.

3 new TIFF tags have been added to each TIFF file:

Tag=65001, field name=`NDUniqueId`, field\_type=`TIFF_LONG`, value=`NDArray.uniqueId`.

Tag=65002, field name=`EPICSTSSec`, field\_type=`TIFF_LONG`, value=`NDArray.epicsTS.secPastEpoch`.

Tag=65003, field name=`EPICSTSNsec`, field\_type=`TIFF_LONG`, value=`NDArray.epicsTS.nsec`.

It was not possible to write the timestamp as a single 64-bit value because TIFF does not support 64-bit integer tags. It does have a type called `TIFF_RATIONAL` which is a pair of 32-bit integers. However, when reading such a tag what is returned is the quotient of the two numbers, which is not what is desired.

## Testing

ADApp/ADSrc/myTimeStampSource.cpp is a new file that contains an example of a user-defined timestamp source. The timestamp source in that file simply calls `epicsTimeGetCurrent(&timeStamp)` and then sets `timeStamp.nsec=0`, so the time stamp is always an integer number of seconds. This makes it easy to tell that the user-defined timestamp source is being used. That function is loaded and unloaded with the new commands that were recently added to asyn:

```
registerTimeStampSource("port", "myTimeStampSource")
```

and

```
unregisterTimeStampSource("port")
```

A new shell script for testing has been added in `areaDetector/iocBoot/timeStampMonitor.sh`. This script takes 2 arguments: `$1=PV prefix`, `$2=TSE value for records being monitored`. The script first sets the TSE field of all records being monitored to `$2`, and then runs `camonitor` on all of the PVs. It monitors some PVs from the detector database (`ADBase.template`), some PVs from the `NDPluginStdArrays` plugin (`image1`), some PVs from the `NDPluginROI` plugin (`ROI1`), and some PVs from the `NDPluginStats` plugin (`Stats1`). The plugins are arranged with `Prosilica driver->ROI1->Stats1`. Thus, monitoring timestamps on the `Stats1` plugin tests whether the timestamps are passed correctly through a plugin chain.

The timestamp tests were done with the Prosilica camera running at a fixed rate of 2 frames/sec. Tests were done with `TSE=0` (normal operation), `TSE=-2` with default timestamp source, and `TSE=-2` with the user-defined timestamp source.

## Timestamp test 1. TSE=0

```
corvette:~/devel/areaDetector/iocBoot>./timeStampMonitor.sh 13PS1 0
Old : 13PS1:cam1:ArrayCounter_RBV.TSE 0
New : 13PS1:cam1:ArrayCounter_RBV.TSE 0
Old : 13PS1:imager:ArrayCounter_RBV.TSE 0
New : 13PS1:imager:ArrayCounter_RBV.TSE 0
Old : 13PS1:imager:UniqueId_RBV.TSE 0
New : 13PS1:imager:UniqueId_RBV.TSE 0
Old : 13PS1:imager:ArrayData.TSE 0
New : 13PS1:imager:ArrayData.TSE 0
Old : 13PS1:imager:EpicstSSec_RBV.TSE 0
New : 13PS1:imager:EpicstSSec_RBV.TSE 0
Old : 13PS1:imager:EpicstSNsec_RBV.TSE 0
New : 13PS1:imager:EpicstSNsec_RBV.TSE 0
Old : 13PS1:ROI1:ArrayCounter_RBV.TSE 0
New : 13PS1:ROI1:ArrayCounter_RBV.TSE 0
Old : 13PS1:ROI1:UniqueId_RBV.TSE 0
New : 13PS1:ROI1:UniqueId_RBV.TSE 0
Old : 13PS1:Stats1:ArrayCounter_RBV.TSE 0
New : 13PS1:Stats1:ArrayCounter_RBV.TSE 0
Old : 13PS1:Stats1:UniqueId_RBV.TSE 0
New : 13PS1:Stats1:UniqueId_RBV.TSE 0
Old : 13PS1:Stats1:MeanValue_RBV.TSE 0
New : 13PS1:Stats1:MeanValue_RBV.TSE 0
13PS1:cam1:ArrayCounter_RBV 2013-09-15 12:00:19.230659 1 20529
13PS1:imager:ArrayCounter_RBV 2013-09-15 12:00:19.231246 1 20529
13PS1:imager:UniqueId_RBV 2013-09-15 12:00:19.231249 1 20529
13PS1:imager:ArrayData 2013-09-15 12:00:19.231243 1 33
13PS1:imager:EpicstSSec_RBV 2013-09-15 12:00:19.231253 1 748112419
13PS1:imager:EpicstSNsec_RBV 2013-09-15 12:00:19.231255 1 230464364
13PS1:ROI1:ArrayCounter_RBV 2013-09-15 12:00:19.230632 1 20455
13PS1:ROI1:UniqueId_RBV 2013-09-15 12:00:19.230635 1 20529
13PS1:Stats1:ArrayCounter_RBV 2013-09-15 12:00:19.237740 1 20455
13PS1:Stats1:UniqueId_RBV 2013-09-15 12:00:19.237743 1 20529
13PS1:Stats1:MeanValue_RBV 2013-09-15 12:00:19.237758 1 73.3657
13PS1:ROI1:ArrayCounter_RBV 2013-09-15 12:00:19.730675 1 20456
13PS1:ROI1:UniqueId_RBV 2013-09-15 12:00:19.730739 1 20530
13PS1:cam1:ArrayCounter_RBV 2013-09-15 12:00:19.730760 1 20530
13PS1:imager:ArrayData 2013-09-15 12:00:19.731286 1 33
13PS1:imager:ArrayCounter_RBV 2013-09-15 12:00:19.731348 1 20530
13PS1:imager:UniqueId_RBV 2013-09-15 12:00:19.731352 1 20530
13PS1:imager:EpicstSNsec_RBV 2013-09-15 12:00:19.731357 1 730472829
13PS1:Stats1:ArrayCounter_RBV 2013-09-15 12:00:19.737856 1 20456
13PS1:Stats1:UniqueId_RBV 2013-09-15 12:00:19.737866 1 20530
13PS1:Stats1:MeanValue_RBV 2013-09-15 12:00:19.737889 1 73.6318
13PS1:ROI1:ArrayCounter_RBV 2013-09-15 12:00:20.230544 1 20457
13PS1:ROI1:UniqueId_RBV 2013-09-15 12:00:20.230604 1 20531
13PS1:cam1:ArrayCounter_RBV 2013-09-15 12:00:20.230650 1 20531
13PS1:imager:ArrayData 2013-09-15 12:00:20.231253 1 33
13PS1:imager:ArrayCounter_RBV 2013-09-15 12:00:20.231316 1 20531
```

13PS1:image1:UniqueId_RBV	2013-09-15	12:00:20.231320	1	20531
13PS1:image1:EpicstSSec_RBV	2013-09-15	12:00:20.231327	1	748112420
13PS1:image1:EpicstSNsec_RBV	2013-09-15	12:00:20.231332	1	230366264
13PS1:Stats1:ArrayCounter_RBV	2013-09-15	12:00:20.237810	1	20457
13PS1:Stats1:UniqueId_RBV	2013-09-15	12:00:20.237885	1	20531
13PS1:Stats1:MeanValue_RBV	2013-09-15	12:00:20.237911	1	74.2664
13PS1:ROI1:ArrayCounter_RBV	2013-09-15	12:00:20.730565	1	20458
13PS1:ROI1:UniqueId_RBV	2013-09-15	12:00:20.730625	1	20532
13PS1:cam1:ArrayCounter_RBV	2013-09-15	12:00:20.730644	1	20532
13PS1:image1:ArrayData	2013-09-15	12:00:20.731285	1	32
13PS1:image1:ArrayCounter_RBV	2013-09-15	12:00:20.731325	1	20532
13PS1:image1:UniqueId_RBV	2013-09-15	12:00:20.731330	1	20532
13PS1:image1:EpicstSNsec_RBV	2013-09-15	12:00:20.731376	1	730415475
13PS1:Stats1:ArrayCounter_RBV	2013-09-15	12:00:20.738065	1	20458
13PS1:Stats1:UniqueId_RBV	2013-09-15	12:00:20.738103	1	20532
13PS1:Stats1:MeanValue_RBV	2013-09-15	12:00:20.738127	1	74.8682
13PS1:ROI1:ArrayCounter_RBV	2013-09-15	12:00:21.230629	1	20459
13PS1:ROI1:UniqueId_RBV	2013-09-15	12:00:21.230648	1	20533
13PS1:cam1:ArrayCounter_RBV	2013-09-15	12:00:21.230678	1	20533
13PS1:image1:ArrayData	2013-09-15	12:00:21.231301	1	32
13PS1:image1:ArrayCounter_RBV	2013-09-15	12:00:21.231341	1	20533
13PS1:image1:UniqueId_RBV	2013-09-15	12:00:21.231345	1	20533
13PS1:image1:EpicstSSec_RBV	2013-09-15	12:00:21.231352	1	748112421
13PS1:image1:EpicstSNsec_RBV	2013-09-15	12:00:21.231355	1	230466245
13PS1:Stats1:ArrayCounter_RBV	2013-09-15	12:00:21.237705	1	20459
13PS1:Stats1:UniqueId_RBV	2013-09-15	12:00:21.237716	1	20533
13PS1:Stats1:MeanValue_RBV	2013-09-15	12:00:21.237734	1	75.4404

This test shows the expected normal behavior. Each record is processing every 0.5 seconds. The timestamps for each record in the group are slightly different because the timestamp is generated when the record processes.



## Timestamp test 2. TSE=-2, default timestamp source

```
corvette:~/devel/areaDetector/iocBoot>./timeStampMonitor.sh 13PS1 -2
Old : 13PS1:cam1:ArrayCounter_RBV.TSE -2
New : 13PS1:cam1:ArrayCounter_RBV.TSE -2
Old : 13PS1:imager:ArrayCounter_RBV.TSE -2
New : 13PS1:imager:ArrayCounter_RBV.TSE -2
Old : 13PS1:imager:UniqueId_RBV.TSE -2
New : 13PS1:imager:UniqueId_RBV.TSE -2
Old : 13PS1:imager:ArrayData.TSE -2
New : 13PS1:imager:ArrayData.TSE -2
Old : 13PS1:imager:EpicsTSSec_RBV.TSE -2
New : 13PS1:imager:EpicsTSSec_RBV.TSE -2
Old : 13PS1:imager:EpicsTSNsec_RBV.TSE -2
New : 13PS1:imager:EpicsTSNsec_RBV.TSE -2
Old : 13PS1:ROI1:ArrayCounter_RBV.TSE -2
New : 13PS1:ROI1:ArrayCounter_RBV.TSE -2
Old : 13PS1:ROI1:UniqueId_RBV.TSE -2
New : 13PS1:ROI1:UniqueId_RBV.TSE -2
Old : 13PS1:Stats1:ArrayCounter_RBV.TSE -2
New : 13PS1:Stats1:ArrayCounter_RBV.TSE -2
Old : 13PS1:Stats1:UniqueId_RBV.TSE -2
New : 13PS1:Stats1:UniqueId_RBV.TSE -2
Old : 13PS1:Stats1:MeanValue_RBV.TSE -2
New : 13PS1:Stats1:MeanValue_RBV.TSE -2
13PS1:cam1:ArrayCounter_RBV 2013-09-15 12:03:55.228895 1 20961
13PS1:imager:ArrayCounter_RBV 2013-09-15 12:03:55.228895 1 20961
13PS1:imager:UniqueId_RBV 2013-09-15 12:03:55.228895 1 20961
13PS1:imager:ArrayData 2013-09-15 12:03:55.228895 1 40
13PS1:imager:EpicsTSSec_RBV 2013-09-15 12:03:55.228895 1 748112635
13PS1:imager:EpicsTSNsec_RBV 2013-09-15 12:03:55.228895 1 228895370
13PS1:ROI1:ArrayCounter_RBV 2013-09-15 12:03:55.228895 1 20887
13PS1:ROI1:UniqueId_RBV 2013-09-15 12:03:55.228895 1 20961
13PS1:Stats1:ArrayCounter_RBV 2013-09-15 12:03:55.228895 1 20887
13PS1:Stats1:UniqueId_RBV 2013-09-15 12:03:55.228895 1 20961
13PS1:Stats1:MeanValue_RBV 2013-09-15 12:03:55.228895 1 85.0236
13PS1:ROI1:ArrayCounter_RBV 2013-09-15 12:03:55.728924 1 20888
13PS1:ROI1:UniqueId_RBV 2013-09-15 12:03:55.728924 1 20962
13PS1:cam1:ArrayCounter_RBV 2013-09-15 12:03:55.728924 1 20962
13PS1:imager:ArrayData 2013-09-15 12:03:55.728924 1 38
13PS1:imager:ArrayCounter_RBV 2013-09-15 12:03:55.728924 1 20962
13PS1:imager:UniqueId_RBV 2013-09-15 12:03:55.728924 1 20962
13PS1:imager:EpicsTSNsec_RBV 2013-09-15 12:03:55.728924 1 728923543
13PS1:Stats1:ArrayCounter_RBV 2013-09-15 12:03:55.728924 1 20888
13PS1:Stats1:UniqueId_RBV 2013-09-15 12:03:55.728924 1 20962
13PS1:Stats1:MeanValue_RBV 2013-09-15 12:03:55.728924 1 84.8537
13PS1:ROI1:ArrayCounter_RBV 2013-09-15 12:03:56.229066 1 20889
13PS1:ROI1:UniqueId_RBV 2013-09-15 12:03:56.229066 1 20963
13PS1:cam1:ArrayCounter_RBV 2013-09-15 12:03:56.229066 1 20963
```

13PS1:image1:ArrayData	2013-09-15	12:03:56.229066	1	39
13PS1:image1:ArrayCounter_RBV	2013-09-15	12:03:56.229066	1	20963
13PS1:image1:UniqueId_RBV	2013-09-15	12:03:56.229066	1	20963
13PS1:image1:EpicsTSNsec_RBV	2013-09-15	12:03:56.229066	1	748112636
13PS1:image1:EpicsTSNsec_RBV	2013-09-15	12:03:56.229066	1	229065628
13PS1:Stats1:ArrayCounter_RBV	2013-09-15	12:03:56.229066	1	20889
13PS1:Stats1:UniqueId_RBV	2013-09-15	12:03:56.229066	1	20963
13PS1:Stats1:MeanValue_RBV	2013-09-15	12:03:56.229066	1	84.968
13PS1:ROI1:ArrayCounter_RBV	2013-09-15	12:03:56.728913	1	20890
13PS1:ROI1:UniqueId_RBV	2013-09-15	12:03:56.728913	1	20964
13PS1:cam1:ArrayCounter_RBV	2013-09-15	12:03:56.728913	1	20964
13PS1:image1:ArrayData	2013-09-15	12:03:56.728913	1	38
13PS1:image1:ArrayCounter_RBV	2013-09-15	12:03:56.728913	1	20964
13PS1:image1:UniqueId_RBV	2013-09-15	12:03:56.728913	1	20964
13PS1:image1:EpicsTSNsec_RBV	2013-09-15	12:03:56.728913	1	728913237
13PS1:Stats1:ArrayCounter_RBV	2013-09-15	12:03:56.728913	1	20890
13PS1:Stats1:UniqueId_RBV	2013-09-15	12:03:56.728913	1	20964
13PS1:Stats1:MeanValue_RBV	2013-09-15	12:03:56.728913	1	85.035
13PS1:ROI1:ArrayCounter_RBV	2013-09-15	12:03:57.228957	1	20891
13PS1:ROI1:UniqueId_RBV	2013-09-15	12:03:57.228957	1	20965
13PS1:cam1:ArrayCounter_RBV	2013-09-15	12:03:57.228957	1	20965
13PS1:image1:ArrayData	2013-09-15	12:03:57.228957	1	38
13PS1:image1:ArrayCounter_RBV	2013-09-15	12:03:57.228957	1	20965
13PS1:image1:UniqueId_RBV	2013-09-15	12:03:57.228957	1	20965
13PS1:image1:EpicsTSNsec_RBV	2013-09-15	12:03:57.228957	1	748112637
13PS1:image1:EpicsTSNsec_RBV	2013-09-15	12:03:57.228957	1	228957340
13PS1:Stats1:ArrayCounter_RBV	2013-09-15	12:03:57.228957	1	20891
13PS1:Stats1:UniqueId_RBV	2013-09-15	12:03:57.228957	1	20965
13PS1:Stats1:MeanValue_RBV	2013-09-15	12:03:57.228957	1	84.9281

This test shows the expected result. The timestamps within a single 0.5 second group are identical, which is different from test 1. Timestamps for the Prosilica driver records (13PS1:cam1:ArrayCounter\_RBV) are coming from the most recent call by the driver to updateTimeStamp(). Timestamps for all of the plugin records are coming from the NDAarray.epicsTS field, which is used in the call to setTimeStamp() in the plugin driver. The default timestamp source is clearly being used because the fractional seconds are non-zero. This has the desired result that all records associated with a particular image have the timestamp at the time the Prosilica driver received that image.

### Timestamp test 3. TSE=-2, user timestamp source

```
corvette:~/devel/areaDetector/iocBoot>./timeStampMonitor.sh 13PS1 -2
Old : 13PS1:cam1:ArrayCounter_RBV.TSE -2
New : 13PS1:cam1:ArrayCounter_RBV.TSE -2
Old : 13PS1:imager:ArrayCounter_RBV.TSE -2
New : 13PS1:imager:ArrayCounter_RBV.TSE -2
Old : 13PS1:imager:UniqueId_RBV.TSE -2
New : 13PS1:imager:UniqueId_RBV.TSE -2
Old : 13PS1:imager:ArrayData.TSE -2
New : 13PS1:imager:ArrayData.TSE -2
Old : 13PS1:imager:EpicsTSSec_RBV.TSE -2
New : 13PS1:imager:EpicsTSSec_RBV.TSE -2
Old : 13PS1:imager:EpicsTSNsec_RBV.TSE -2
New : 13PS1:imager:EpicsTSNsec_RBV.TSE -2
Old : 13PS1:ROI1:ArrayCounter_RBV.TSE -2
New : 13PS1:ROI1:ArrayCounter_RBV.TSE -2
Old : 13PS1:ROI1:UniqueId_RBV.TSE -2
New : 13PS1:ROI1:UniqueId_RBV.TSE -2
Old : 13PS1:Stats1:ArrayCounter_RBV.TSE -2
New : 13PS1:Stats1:ArrayCounter_RBV.TSE -2
Old : 13PS1:Stats1:UniqueId_RBV.TSE -2
New : 13PS1:Stats1:UniqueId_RBV.TSE -2
Old : 13PS1:Stats1:MeanValue_RBV.TSE -2
New : 13PS1:Stats1:MeanValue_RBV.TSE -2
13PS1:cam1:ArrayCounter_RBV 2013-09-15 12:13:25.000000 1 22102
13PS1:imager:ArrayCounter_RBV 2013-09-15 12:13:25.000000 1 22102
13PS1:imager:UniqueId_RBV 2013-09-15 12:13:25.000000 1 22102
13PS1:imager:ArrayData 2013-09-15 12:13:25.000000 1 27
13PS1:imager:EpicsTSSec_RBV 2013-09-15 12:13:25.000000 1 748113205
13PS1:imager:EpicsTSNsec_RBV 2013-09-15 12:13:22.000000 1 0
13PS1:ROI1:ArrayCounter_RBV 2013-09-15 12:13:25.000000 1 22028
13PS1:ROI1:UniqueId_RBV 2013-09-15 12:13:25.000000 1 22102
13PS1:Stats1:ArrayCounter_RBV 2013-09-15 12:13:25.000000 1 22028
13PS1:Stats1:UniqueId_RBV 2013-09-15 12:13:25.000000 1 22102
13PS1:Stats1:MeanValue_RBV 2013-09-15 12:13:25.000000 1 59.7119
13PS1:ROI1:ArrayCounter_RBV 2013-09-15 12:13:26.000000 1 22029
13PS1:ROI1:UniqueId_RBV 2013-09-15 12:13:26.000000 1 22103
13PS1:cam1:ArrayCounter_RBV 2013-09-15 12:13:26.000000 1 22103
13PS1:imager:ArrayData 2013-09-15 12:13:26.000000 1 28
13PS1:imager:ArrayCounter_RBV 2013-09-15 12:13:26.000000 1 22103
13PS1:imager:UniqueId_RBV 2013-09-15 12:13:26.000000 1 22103
13PS1:imager:EpicsTSSec_RBV 2013-09-15 12:13:26.000000 1 748113206
13PS1:Stats1:ArrayCounter_RBV 2013-09-15 12:13:26.000000 1 22029
13PS1:Stats1:UniqueId_RBV 2013-09-15 12:13:26.000000 1 22103
13PS1:Stats1:MeanValue_RBV 2013-09-15 12:13:26.000000 1 60.5082
13PS1:ROI1:ArrayCounter_RBV 2013-09-15 12:13:26.000000 1 22030
13PS1:ROI1:UniqueId_RBV 2013-09-15 12:13:26.000000 1 22104
13PS1:cam1:ArrayCounter_RBV 2013-09-15 12:13:26.000000 1 22104
```

13PS1:image1:ArrayData	2013-09-15	12:13:26.000000	1	28
13PS1:image1:ArrayCounter_RBV	2013-09-15	12:13:26.000000	1	22104
13PS1:image1:UniqueId_RBV	2013-09-15	12:13:26.000000	1	22104
13PS1:Stats1:ArrayCounter_RBV	2013-09-15	12:13:26.000000	1	22030
13PS1:Stats1:UniqueId_RBV	2013-09-15	12:13:26.000000	1	22104
13PS1:Stats1:MeanValue_RBV	2013-09-15	12:13:26.000000	1	61.1341
13PS1:ROI1:ArrayCounter_RBV	2013-09-15	12:13:27.000000	1	22031
13PS1:ROI1:UniqueId_RBV	2013-09-15	12:13:27.000000	1	22105
13PS1:cam1:ArrayCounter_RBV	2013-09-15	12:13:27.000000	1	22105
13PS1:image1:ArrayData	2013-09-15	12:13:27.000000	1	29
13PS1:image1:ArrayCounter_RBV	2013-09-15	12:13:27.000000	1	22105
13PS1:image1:UniqueId_RBV	2013-09-15	12:13:27.000000	1	22105
13PS1:image1:EpicsTSSec_RBV	2013-09-15	12:13:27.000000	1	748113207
13PS1:Stats1:ArrayCounter_RBV	2013-09-15	12:13:27.000000	1	22031
13PS1:Stats1:UniqueId_RBV	2013-09-15	12:13:27.000000	1	22105
13PS1:Stats1:MeanValue_RBV	2013-09-15	12:13:27.000000	1	62.0059
13PS1:ROI1:ArrayCounter_RBV	2013-09-15	12:13:27.000000	1	22032
13PS1:ROI1:UniqueId_RBV	2013-09-15	12:13:27.000000	1	22106
13PS1:cam1:ArrayCounter_RBV	2013-09-15	12:13:27.000000	1	22106
13PS1:image1:ArrayData	2013-09-15	12:13:27.000000	1	30
13PS1:image1:ArrayCounter_RBV	2013-09-15	12:13:27.000000	1	22106
13PS1:image1:UniqueId_RBV	2013-09-15	12:13:27.000000	1	22106
13PS1:Stats1:ArrayCounter_RBV	2013-09-15	12:13:27.000000	1	22032
13PS1:Stats1:UniqueId_RBV	2013-09-15	12:13:27.000000	1	22106
13PS1:Stats1:MeanValue_RBV	2013-09-15	12:13:27.000000	1	62.6052

This test shows the expected result. The timestamps within a single 0.5 second group are identical, the same as test 2. The user timestamp source is clearly being used because the fractional seconds are all zero. This has the desired result that all records associated with a particular image have the timestamp at the time the Prosilica driver received that image, and the user-defined timestamp source is being used.

## netCDF file test

The netCDF files should now contain the NDArray.epicsTS data in two arrays. The values do not depend on TSE, since that only affects the record timestamps. The values do depend on whether the default timestamp source or the user-defined timestamp source is being used. For these tests 10 images were collected in each netCDF file in “stream” mode.

This is the output of the “ncdump” utility on a netCDF file collected with the default timestamp source:

```
corvette:~/scratch>ncdump -v uniqueId,timeStamp,epicsTSSec,epicsTSNsec
~/scratch/test_DefaultSource_001.nc
netcdf test_DefaultSource_001 {
dimensions:
    numArrays = UNLIMITED ; // (10 currently)
    dim0 = 512 ;
    dim1 = 680 ;
    attrStringSize = 256 ;
variables:
    int uniqueId(numArrays) ;
    double timeStamp(numArrays) ;
    int epicsTSSec(numArrays) ;
    int epicsTSNsec(numArrays) ;
    byte array_data(numArrays, dim0, dim1) ;
    int Attr_BayerPattern(numArrays) ;
    int Attr_ColorMode(numArrays) ;
    double Attr_AcquireTime(numArrays) ;
    char Attr_CameraModel(numArrays, attrStringSize) ;
    int Attr_FramesDropped(numArrays) ;

// global attributes:
    :dataType = 1 ;
    :NDNetCDFFileVersion = 3. ;
    :numArrayDims = 2 ;
    :dimSize = 680, 512 ;
    :dimOffset = 0, 0 ;
    :dimBinning = 2, 2 ;
    :dimReverse = 0, 0 ;
    :Attr_BayerPattern_DataType = "Int32" ;
    :Attr_BayerPattern_Description = "Bayer Pattern" ;
    :Attr_BayerPattern_Source = ;
    :Attr_BayerPattern_SourceType = "Driver" ;
    :Attr_ColorMode_DataType = "Int32" ;
    :Attr_ColorMode_Description = "Color Mode" ;
    :Attr_ColorMode_Source = ;
    :Attr_ColorMode_SourceType = "Driver" ;
    :Attr_AcquireTime_DataType = "Float64" ;
    :Attr_AcquireTime_Description = "Camera acquire time" ;
    :Attr_AcquireTime_Source = "13PS1:cam1:AcquireTime" ;
    :Attr_AcquireTime_SourceType = "EPICS_PV" ;
```

```

:Attr_CameraModel_DataType = "String" ;
:Attr_CameraModel_Description = "CameraModel" ;
:Attr_CameraModel_Source = "MODEL" ;
:Attr_CameraModel_SourceType = "Param" ;
:Attr_FramesDropped_DataType = "Int32" ;
:Attr_FramesDropped_Description = "FramesDropped" ;
:Attr_FramesDropped_Source = "PS_FRAMES_DROPPED" ;
:Attr_FramesDropped_SourceType = "Param" ;

data:

uniqueId = 23569, 23570, 23571, 23572, 23573, 23574, 23575, 23576, 23577,
          23578 ;

timeStamp = 748113951.240688, 748113951.740688, 748113952.240688,
            748113952.740688, 748113953.240688, 748113953.740688, 748113954.240688,
            748113954.740688, 748113955.240688, 748113955.740688 ;

epicsTSSec = 748113951, 748113951, 748113952, 748113952, 748113953,
             748113953, 748113954, 748113954, 748113955, 748113955 ;

epicsTSNsec = 259958854, 759958117, 259985340, 759984911, 259874142,
              760020860, 259933342, 759950117, 259764554, 759964413 ;
}

```

This shows the expected result. The epicsTSNsec values are non-zero, because the default timestamp source is being used. The epicsTSSec values are the same as the integer part of the timeStamp values.

This is the output of the “ncdump” utility on a netCDF file collected with the user-defined timestamp source:

```
corvette:~/scratch>ncdump -v uniqueId,timeStamp,epicsTSSTSec,epicsTSNsec
~/scratch/test_UserSource_001.nc
netcdf test_UserSource_001 {
dimensions:
    numArrays = UNLIMITED ; // (10 currently)
    dim0 = 512 ;
    dim1 = 680 ;
    attrStringSize = 256 ;
variables:
    int uniqueId(numArrays) ;
    double timeStamp(numArrays) ;
    int epicsTSSTSec(numArrays) ;
    int epicsTSNsec(numArrays) ;
    byte array_data(numArrays, dim0, dim1) ;
    int Attr_BayerPattern(numArrays) ;
    int Attr_ColorMode(numArrays) ;
    double Attr_AcquireTime(numArrays) ;
    char Attr_CameraModel(numArrays, attrStringSize) ;
    int Attr_FramesDropped(numArrays) ;

// global attributes:
    :dataType = 1 ;
    :NDNetCDFFileVersion = 3. ;
    :numArrayDims = 2 ;
    :dimSize = 680, 512 ;
    :dimOffset = 0, 0 ;
    :dimBinning = 2, 2 ;
    :dimReverse = 0, 0 ;
    :Attr_BayerPattern_DataType = "Int32" ;
    :Attr_BayerPattern_Description = "Bayer Pattern" ;
    :Attr_BayerPattern_Source = ;
    :Attr_BayerPattern_SourceType = "Driver" ;
    :Attr_ColorMode_DataType = "Int32" ;
    :Attr_ColorMode_Description = "Color Mode" ;
    :Attr_ColorMode_Source = ;
    :Attr_ColorMode_SourceType = "Driver" ;
    :Attr_AcquireTime_DataType = "Float64" ;
    :Attr_AcquireTime_Description = "Camera acquire time" ;
    :Attr_AcquireTime_Source = "13PS1:cam1:AcquireTime" ;
    :Attr_AcquireTime_SourceType = "EPICS_PV" ;
    :Attr_CameraModel_DataType = "String" ;
    :Attr_CameraModel_Description = "CameraModel" ;
    :Attr_CameraModel_Source = "MODEL" ;
    :Attr_CameraModel_SourceType = "Param" ;
    :Attr_FramesDropped_DataType = "Int32" ;
    :Attr_FramesDropped_Description = "FramesDropped" ;
    :Attr_FramesDropped_Source = "PS_FRAMES_DROPPED" ;
    :Attr_FramesDropped_SourceType = "Param" ;
```

data:

```
uniqueId = 24063, 24064, 24065, 24066, 24067, 24068, 24069, 24070, 24071,  
          24072 ;
```

```
timeStamp = 748114198.240688, 748114198.740688, 748114199.240688,  
            748114199.740688, 748114200.240688, 748114200.740688, 748114201.240688,  
            748114201.740688, 748114202.240688, 748114202.740688 ;
```

```
epicsTSSec = 748114198, 748114198, 748114199, 748114199, 748114200,  
            748114200, 748114201, 748114201, 748114202, 748114202 ;
```

```
epicsTSNsec = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 ;
```

```
}
```

This shows the expected result. The epicsTSNsec values are zero, because the user-defined timestamp source is being used. The epicsTSSec values are the same as the integer part of the timeStamp values.



## TIFF file test

The netCDF files should now contain the NDArray.epicsTS data in two tags, 65002 and 65003. The values do not depend on TSE, since that only affects the record timestamps. The values do depend on whether the default timestamp source or the user-defined timestamp source is being used.

This is the output of the “tiffinfo” utility on a TIFF file collected with the default timestamp source:

```
corvette:~/scratch>tiffinfo tiff_DefaultTS_001.tif
TIFFReadDirectory: Warning, tiff_DefaultTS_001.tif: unknown field with tag 65000 (0xfde8)
encountered.
TIFFReadDirectory: Warning, tiff_DefaultTS_001.tif: unknown field with tag 65001 (0xfde9)
encountered.
TIFFReadDirectory: Warning, tiff_DefaultTS_001.tif: unknown field with tag 65002 (0xfdea)
encountered.
TIFFReadDirectory: Warning, tiff_DefaultTS_001.tif: unknown field with tag 65003 (0xfdeb)
encountered.
TIFF Directory at offset 0x55008 (348168)
  Image Width: 680 Image Length: 512
  Bits/Sample: 8
  Sample Format: unsigned integer
  Compression Scheme: None
  Photometric Interpretation: min-is-black
  Samples/Pixel: 1
  Rows/Strip: 512
  Planar Configuration: single image plane
  Make: Unknown
  Model: Unknown
  Tag 65000: 748114737.240688
  Tag 65001: 25141
  Tag 65002: 748114737
  Tag 65003: 254905820
```

This shows the expected result. The epicsTSNsec (tag 65003) values are non-zero, because the default timestamp source is being used. The epicsTSSec values are the same as the integer part of the timeStamp values.

This is the output of the “tiffinfo” utility on a TIFF file collected with the used-defined timestamp source:

```
corvette:~/scratch>tiffinfo tiff_UserTS_001.tif
TIFFReadDirectory: Warning, tiff_UserTS_001.tif: unknown field with tag 65000 (0xfde8)
encountered.
TIFFReadDirectory: Warning, tiff_UserTS_001.tif: unknown field with tag 65001 (0xfde9)
encountered.
TIFFReadDirectory: Warning, tiff_UserTS_001.tif: unknown field with tag 65002 (0xfdea)
encountered.
TIFFReadDirectory: Warning, tiff_UserTS_001.tif: unknown field with tag 65003 (0xfdeb)
encountered.
TIFF Directory at offset 0x55008 (348168)
  Image Width: 680 Image Length: 512
  Bits/Sample: 8
  Sample Format: unsigned integer
  Compression Scheme: None
  Photometric Interpretation: min-is-black
  Samples/Pixel: 1
  Rows/Strip: 512
  Planar Configuration: single image plane
  Make: Unknown
  Model: Unknown
  Tag 65000: 748114762.240688
  Tag 65001: 25191
  Tag 65002: 748114762
  Tag 65003: 0
```

This shows the expected result. The epicsTSNsec (tag 65003) values are zero, because the user-defined timestamp source is being used. The epicsTSsec values are the same as the integer part of the timeStamp values.

## **Future plans**

While making these changes I found that the NDFileNexus and NDFileHDF5 plugins, which write Nexus-HDF5 and native HDF5 files respectively, do not currently store the NDArrary.timeStamp information at all in the files. This is an oversight that should be fixed, and they should of course be extended to also store NDArrary.epicsTS. I did not write these plugins, so I am hoping that the original authors can make these changes.

An additional request from the SLAC group was to provide a means for adding user-defined attribute functions to set attribute values in NDArrarys. I am currently looking at how best to do this.