Transient Absorption Module for HPD-TA

Ta-Absorption

User Manual version 8.1

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Contents

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Preface

Transient Absorption with a streak camera system is a powerful measurement technique that allows very rapid measurement. The TA-Absorption Module is an optional software module for the HPD-TA Streak Camera Control Software. It allows the streak user to do transient absorption measurements in a convenient way.

By using the TA-Absorption module you can:

- ***Drive external shutters*** controlling optical beam paths
- Do the ***image acquisitions*** for recording the various needed data
- Perform the necessary inter-image ***calculations*** to obtain absorbance data in logarithmic scales

TA-Absorption offers to perform such measurement sequences fully automatically, allowing very rapid data recording. Under suitable conditions, complete measurements can be done within one second!

By using TA-Absorption transient absorption measurements become

- Convenient
- Safe
- Fast

What this document contains:

The topic **Introduction** gives a rough background of the method itself.

The topic **Overview** explains the principle of Transient Absorption with a streak camera and defines the various terms used throughout the software and this manual.

The topic **Setup** lists the hardware typically required for performing transient absorption measurements. It also gives a rough outline how to connect the required interfaces and cables correctly and how to setup the HPD-TA software.

The topic **Operation Instruction** explains in detail how to actually perform the measurements by using the Transient Absorption Measurement window.

A few relevant publications are listed in the topic **Literature**

Introduction

In the realm of time-resolved spectroscopy in chemical and physical sciences, streak camera systems have traditionally been mainly used for measuring luminous events, particularly fluorescence emission

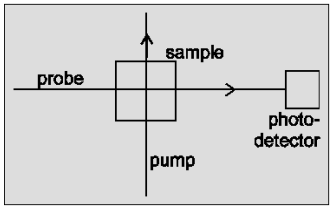
radiation (also to a lesser degree others like time-resolved Raman spectra etc.). The streak method has proven to be a very powerful one in these domains, especially due to its capability of recording temporal and spectral data truly simultaneously (by combining the streak camera with a multichannel spectrograph), and due to the superb temporal resolution and high sensitivity of streak camera systems.

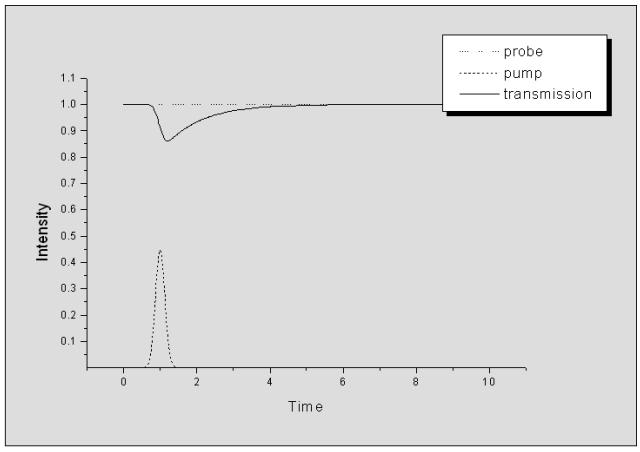
Depart of emission methods, however, absorption methods are of – at least – equal importance in the standard arsenal of the researcher doing analysis of chemical compounds, mainly in the areas of physical chemistry, photochemistry, biochemistry and related life sciences.

While there are some scientific questions that can – in principle – be answered by doing experiments of either sort, some kind of studies can much better – or exclusively – be done only in the absorption domain. For instance, molecular or atomic energy level transitions that decay radiationless cannot reveal themselves by fluorescence emission but can be studied by measuring their absorption behavior.

The basic principle of an absorption measurement is as follows. So-called probe light is sent through the sample and measured by a photodetector. Hence the detector is measuring the absorption of the probe light by the sample. If the detector is a multi-wavelength recording device (such as a spectrograph with a multichannel detector), the absorption of the sample can be measured at many wavelengths simultaneously if the probe light is generated by a broad-band source. (This broad-band source - also called "white light source" or "continuum source" - can be realized by a lamp such as a halogen or Xenon lamp or by other methods such as nonlinear interaction of a high-power laser with a transparent medium and others.)

In case of transient absorption, the time-resolved absorption of the sample is studied in dependence on a short-pulse excitation of some selected energy levels in the sample. In order to realize this, an additional light source (typically a short-pulsed wavelength-tunable laser) is used. This is called the pump light. The aim is to detect the temporal variation of the absorption in dependence on this excitation.





The transient absorption of the sample is determined by the ratio of the probe light transmitted through the sample with and without excitation and is defined as the logarithm of that ratio. (The logarithm is a convenient way to cope with the fact that, if the absorption coefficient – the differential absorption per unit thickness of the sample - is constant, the transmitted light falls exponentially with the sample thickness.) Further, a minus sign is applied to reflect the decrease of light during its passage through the sample and in order to obtain positive numerical values for the absorption.

So, we have the following definition:

$$Absorption(\lambda,t) \;=\; -\log\left(\frac{transmitted\ light\ with\ excitation\ (\lambda,t)}{transmitted\ light\ without\ excitation\ (\lambda,t)}\right) \qquad (eq.1)$$

One well-known method of measuring transient absorption spectra is the traditional so-called pump & probe scheme. In this case the probe light is by itself a short pulse (frequently generated by the same laser as the excitation pulse by means of special optical methods). So the probe pulse reveals the absorption of the sample at one given instant. In order to obtain the temporal trace of the dynamic absorption behavior the temporal delay between the excitation pulse and the probe pulse needs to be varied. So, the time profile of the absorption is scanned by doing repetitive measurements and assembling the time profile of the absorption from the results. The advantage of this method is that the optical detector can be a simple steady-state detector with no time resolving abilities (such as a CCD detector for instance). The basic disadvantage, however, lies in the need of the scanning process, i.e. many pulses are needed to construct the temporal profile of the absorption. In contrast, absorption measurements with a streak camera can be much faster. This is more detailed in the next chapter.

Overview

In this chapter we explain the basic principle of transient absorption measurements with a streak camera. In the course of this, we also define and explain the nomenclature used by the TA-Absorption module (what we mean when we speak of "Data", "Monitor", "Emission1", etc.), which is essential for using the software correctly. Finally, we document and explain the involved mathematical calculations.

1. Principle of Transient Absorption with a Streak Camera

The principle of transient absorption measurements *with a streak camera* is the same as outlined in chapter B, however, there is a big difference compared to the traditional pump & probe method. That is that the streak camera can do the desired temporal resolution by itself *without the need to sample* the time axis by a short-pulsed probe pulse (while the advantage of the multi-wavelength recording is preserved).

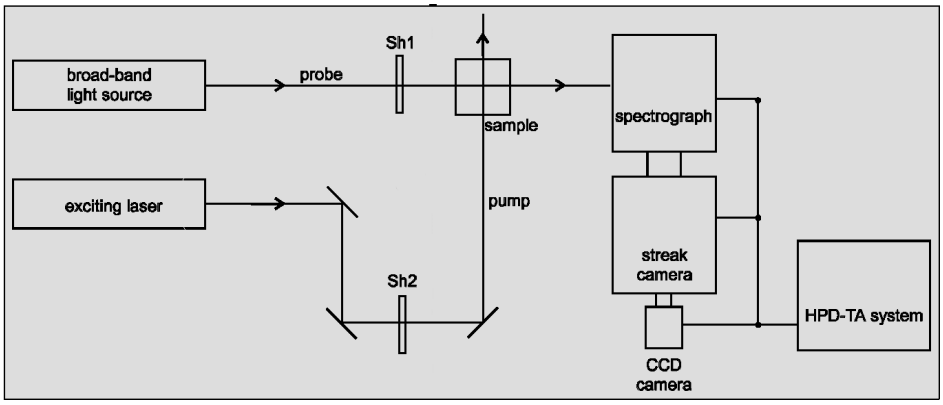
As a result, full transient absorption spectra can be recorded by using *single laser shots* without the need to record many shots for a sampling procedure.

Of course, even with the streak method it may sometimes be desirable to integrate over several laser shots in order to improve the signal-to-noise ratio of the measurement results. But nevertheless the streak method will typically be much more rapid and require far less laser shots than any sampling method.

Obviously, one big difference in the experimental setup of a streak-based transient absorption experiment compared to a pump & probe method is that in the former case the probe light source must deliver cw light (as opposed to a short-pulsed one) or at least a pulse that is long enough to cover the length of the streak camera's time window that shall be used for the experiment. But we don't detail such matter further in this software manual; the reader should refer to the literature.

2. Schematics of Optical Setup

The below sketch shows the basic principle of a streak-based transient absorption setup.



As mentioned above, the exciting light source should preferably be a laser that is wavelength-tunable (so that the desired energy levels to be excited can be picked) and short-pulsed (short enough for the required temporal resolution in the given case). The probe light source should be broad-band and cw or long-pulsed. (The spectral and temporal profile should be broad enough to cover the whole range of the time-resolved absorption spectrum to be measured. In other words, it is desirable that the time-resolved spectrum would fill the streak camera image completely and as uniformly as possible). In addition, the intensity of the probe light must be high enough to give a good signal so that the signal-to-noise ratio of the measurement will be sufficient.

The two mechanical shutters Sh1 and Sh2 are used to arbitrate the various beam paths required for a complete measurement. This matter is further detailed in the next section.

3. The Various Types of Image Data

Considering data and Monitor signal

As eq. (1) showed, the absorption is defined via the ratio of light transmitted through the sample with and without excitation. So, in order to determine the absorption, shutter Sh2 must be used.

In the easiest case, two streak images have to be recorded, which are called **Data** and **Monitor** in this software:

Data = transmitted light intensity with excitation, both shutters open

Monitor = transmitted light intensity without excitation, shutter Sh2 closed

As we call the result of such a measurement **Absorption**, we can write:

$$Absorption \quad = \quad -\log\left(\frac{Data}{Monitor}\right) \qquad (eq.\,2)$$

Please note that all these data (incl. Monitor) are *variable* (not constant) in *both* time and spectrum. (So, strictly speaking, we had to write Data(λ,t), Monitor(λ,t) and so on, but we omit the parameters throughout this manual.) In chapter B we assumed the simplifying idealization that the probe light is completely flat in time (and in spectrum), but in reality of course this condition is never met, as the temporal and spectral characteristics of this light depends on the physics of its generation. Further, eq. (2) refers to signals measured by the detection system, not to the "light as is". This means especially that the spectral measurement signal depends also on the spectral response of the detection system

(including the spectral efficiency of the spectrograph, the streak camera's photocathode, etc.) that are usually far from uniform.

But it is important to understand that all these (temporal and spectral) non-uniformities are *cancelled out* during the calculation of eq. (2) because the measured absorption depends only on the *ratio* of the two measured signals.

Nevertheless, the following factors must be considered for obtaining good results:

Even though only the ratio of Data and Monitor is involved in eq. (2), the relative noise of Absorption1 will be high at those parts (λ,t) of the streak image where Monitor(λ,t) is low. This means, although non-uniformities of the probe light are basically cancelled out during the calculation, it is nevertheless desirable to have a Monitor signal *as uniform as possible* if you want to obtain a uniform signal-to-noise ratio over the whole time-resolved absorption spectrum.

Opening and closing the shutter Sh2 should have no optical side-effects other than blocking the excitation. This must be ensured by a proper design of the experimental setup. Some types of unwanted "side-effects" cannot be eliminated in principle, however, such as fluorescence emission from the sample. This point is further detailed below.

All *conditions must be exactly the same* at the times when Data and Monitor are recorded. This means especially that the sample itself must not have changed in between. In most cases, this simply means that data and Monitor shall be recorded *in rapid succession*. The fact that this is more easily possible with the streak-based method (see section 1 above) is one of the main advantages of the method.

Considering background data

Next, we need to eliminate one simplification on which eq. (2) is based. In the above discussion, we implicitly assumed that the data were not affected by "dark signal". By the term "**Dark**" we refer to any offset signal that is present in the streak image even if no light from the sample enters the streak camera's photocathode. The presence of such signal is unavoidable. It is mainly the dark current of the CCD camera and the offset of its A/D converter we are concerned with, although the term **Dark** generally includes *any* offset signal - even stray room light that may enter the cathode for instance. (But nevertheless it is advisable to prevent such extra offset signal by eliminating its cause of course.)

The measured signal for both Data and Monitor contain an additive component, where Data* and Monitor* are the real Data and Monitor signals as we need them in our absorption formula.

$$Data = Data^* + Dark \qquad (eq.\ 3)$$

$$Monitor = Monitor^* + Dark \qquad (eq.\ 4)$$

Substituting eq. (2) by the above formulas we get

$$Absorption1 \quad = \quad -\log\left(\frac{Data^*}{Monitor^*}\right) \qquad (eq.\ 5)$$

And finally:

$$Absorption1 \quad = \quad -\log\left(\frac{Data - Dark}{Monitor - Dark}\right) \qquad (eq.\ 6)$$

How is Dark obtained? Simply by doing a third measurement where both shutters, Sh2 and Sh1, are closed.

Considering emission data

Finally, we need to consider those cases where the excitation of the sample leads to (unwanted) fluorescence emission from the sample. This value is called **Emission** and is obtained by exciting the sample without probe light, i.e. shutter Sh2 is closed while shutter Sh1 is open. Like Data and Monitor Emission contains an additive component, where Emission*is the real signal and Emission the measured one.

$$Emission = Emission* + Dark \qquad (eq.7)$$

The measured Data in these cases contains now the dark and the emission component:

$$Data = Data* + Dark + Emission* \qquad (eq.8)$$

using eq. (5), (8) and (9) we can write:

$$Absorption2 = -\log\left(\frac{Data - Emission}{Monitor - Dark}\right) \qquad (eq.9)$$

Absorption data calculated by this method are called **Absorption2** in this software.

Considering “Tsukinuke” data

In some cases data and monitor contain an addition signal which we call Tsukinuke (This term derives from the Japanese word Tsukinukeru written as つきぬける or 突き抜ける which means to pierce). The Tsukinuke signal is light which passes the photocathode and reaches the CCD sensor directly

$$Data = Data* + Dark1 + Tsukinuke* \qquad (eq.10)$$

$$Monitor = Monitor* + Dark1 + Tsukinuke* \qquad (eq.11)$$

To eliminate this component we measure a different type of dark signal which contains the Tsukinuke component as well (This is done by opening shutter 1 and opening the streak camera gate):

$$Dark2 = Dark1 + Tsukinuke* \qquad (eq.12)$$

Thus we get:

$$Absorption3 = -\log\left(\frac{Data - Dark2}{Monitor - Dark2}\right) \qquad (eq.13)$$

If we additionally consider the emission component we get:

$$Data = Data* + Dark1 + Emission* + Tsukinuke* \qquad (eq.14)$$

and finally:

$$Absorption4 \quad = \quad -\log\left(\frac{Data - Emission - Dark2 + Dark1}{Monitor - Dark2}\right) \qquad (eq.15)$$

Summary

In the simplest case - when we can assume that there is no fluorescence emission from the sample – the absorption is given by:

$$Absorption1 \quad = \quad -\log\left(\frac{Data - Dark}{Monitor - Dark}\right) \qquad (eq.6)$$

while in the more general case – where fluorescence has to be expected – the absorption is given by:

$$Absorption2 \quad = \quad -\log\left(\frac{Data - Emission}{Monitor - Dark}\right) \qquad (eq.9)$$

Considering Tsukinuke without emission we get:

$$Absorption3 \quad = \quad -\log\left(\frac{Data - Dark2}{Monitor - Dark2}\right) \qquad (eq.13)$$

Considering Tsukinuke with emission we get:

$$Absorption4 \quad = \quad -\log\left(\frac{Data - Emission - Dark2 + Dark1}{Monitor - Dark2}\right) \qquad (eq.15)$$

Finally, we repeat the definitions of the five types of acquisition data together with their associated shutter conditions including the gate signal

Image data name	Contents	Shutter 1	Shutter 2	Gate
Data	Probe signal with pump (and fluorescence)	open	open	Low
Monitor	Probe signal w/o pump	open	closed	Low
Dark (also called Dark1)	Only dark signal	closed	closed	Low
Dark2)	Dark signal with Tsukinuke	open	closed	High
Emission	Only fluorescence	closed	open	Low

All above image data is the data directly measured by the camera systems. They contain dark and eventually emission and tsukinuke components.

4. Calculations

The above mentioned three, four or five different image data types are contained in separate image buffers in the software (for details see chapter E). These are images that contain acquisition data. In addition, the *absorption data* are also placed and *visualized in image buffers*, even though they don't contain data obtained by acquisitions from the CCD camera but the *results of the absorption calculations*.

As explained in section 3 above, there are four different types of such absorption data, Absorption1, Absorption2, Absorption3 and Absorption4 and all are calculated individually. The formula for their calculation is basically given by eqs. (6), (9, (13)) and (15), but we need two modifications:

1. Scaling factor

The values for Absorption1-4 given by eqs. (6), (9, (13)) and (15) are typically very small numbers in the range between 0 and 1. It would obviously be pointless to construct the image buffers directly from these numbers, since images in HPD-TA always contain integer values in their pixels. So, before filling the associated image buffers, the values obtained by eqs. (6), (9, (13)) and (15) are multiplied with an *arbitrary fixed factor* called C.

$$Absorption1 = -\log\left(\frac{Data - Dark}{Monitor - Dark}\right) * C \quad (eq.16)$$

$$Absorption2 = -\log\left(\frac{Data - Emission}{Monitor - Dark}\right) * C \quad (eq.17)$$

$$Absorption3 = -\log\left(\frac{Data - Dark2}{Monitor - Dark2}\right) * C \quad (eq.18)$$

$$Absorption4 = -\log\left(\frac{Data - Emission - Dark2 + Dark1}{Monitor - Dark2}\right) * C \quad (eq.19)$$

Depending on the output data type which can be either 16 bit or 32 bit this factor is 1.000 (for 16 bit output) or 1.000.000 (for 32 bit).

In physical units this means that the numerical value in the absorption image is either:

mOD (16 bit output images) or

µOD (32 bit images)

2. Numerical exceptions

As can be seen from eqs. (16) to (19), the calculation may lead to infinities for some pixels, which may especially happen in case of very weak and noisy data. Such infinities will occur when either the denominator is zero or when the argument of the logarithm is zero or negative. In both of these cases, the corresponding pixel in the Absorption1 or Absorption2 image will be *set to zero.*

Note: The mathematical inclined reader may wonder why we set these exceptional pixels to zero instead of to positive and negative infinity resp. the corresponding largest integer numbers available. The reason is that in most cases this would completely forbid to extract any intensity profiles from the absorption images without very gross distortions caused by these pixels even if they are only a few. Even if – mathematically speaking – the error made by replacing an infinite value by zero is maximal, you should not forget that the physical reason for the occurrence of these exceptional pixels is always very weak signal. This means, the statistical significance of these pixels is very low in any case.

Setup

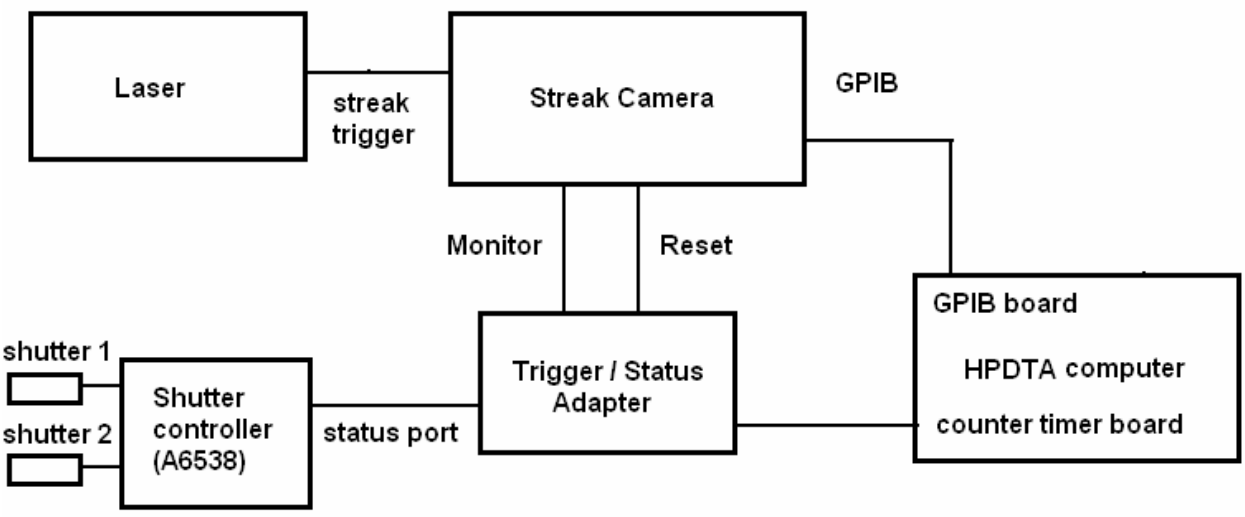
This chapter explains the setup that has to be done prior to using TA-Absorption. It is divided into a hardware and a software section.

1. Hardware Setup

Since there are many ways to realize the necessary setup of the light sources and their synchronization, optical beam paths, light sampling from the sample, and so on, in this software manual we cannot give any useful hints concerning these subjects that will vary widely from one lab to the other. For novice users, some hints may be obtained via the literature (also see chapter F), and in any case we encourage you to contact your nearest Hamamatsu office for advice in case of difficulties.
So, here we only refer to the streak system itself.
In order to use the TA-Absorption module you need the following parts:

- a CTR 05 (computer boards) counter timer board installed in your computer
- a "trigger/status adapter" (also known as T/S adapter)
- a A6538 shutter system, consisting of the shutter controller and two shutters
- a special cable for the connection between the A6538 and the T/S adapter

The following diagram shows the correct cable connections.

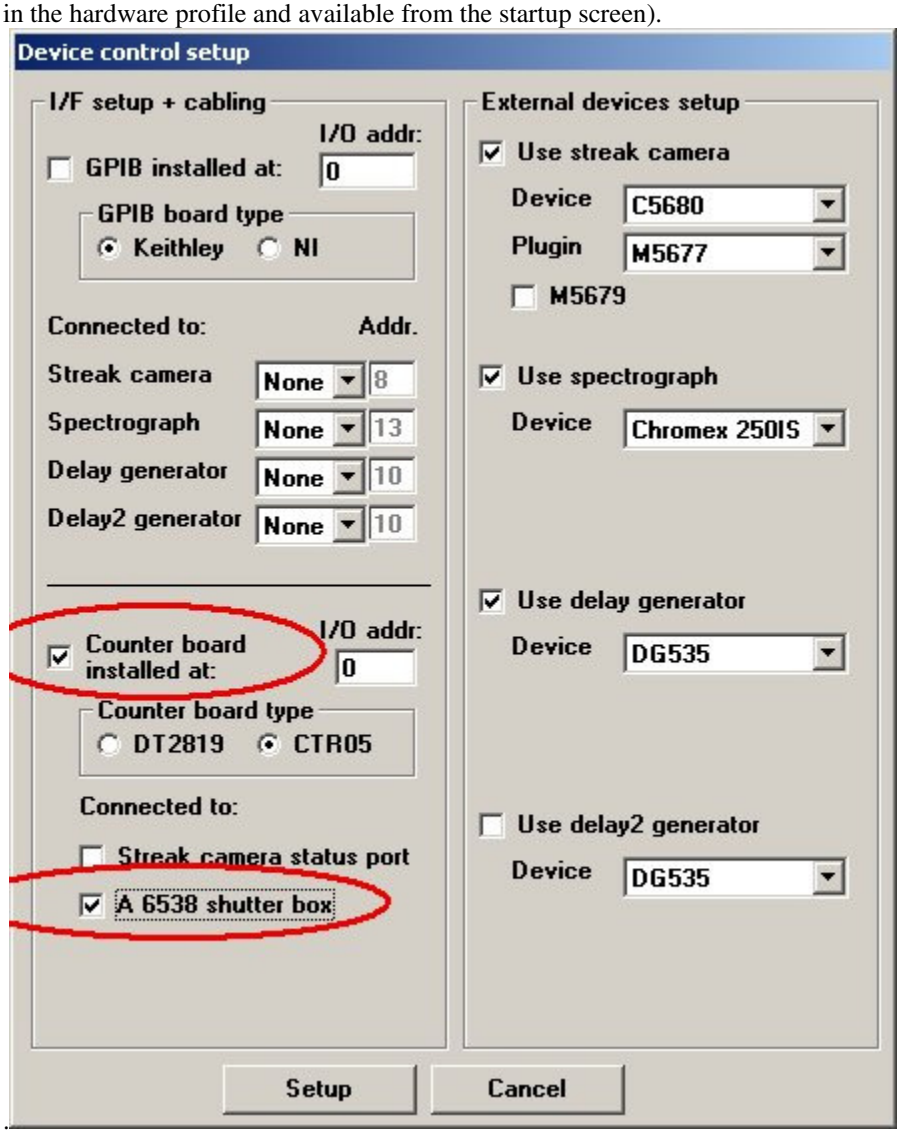


Notes:
1. The monitor/reset trigger handshake can only be used with digital versions of the CCD camera. If the streak camera has GPIB, it is not necessary to use monitor/reset handshake but can be advantageous in some cases.
2. The GPIB connection is only valid if the streak camera is a model equipped with GPIB, of course. Additional peripherals may also be 2. FG trigger is used only with video versions of the CCD camera.
3. The exact way of triggering and synchronization with the laser depends on the details of the experimental setup, including the type of laser and others. Also, some extra parts may be involved (like pulse/delay generators) that are not included in the above diagram.

4. Other types of shutters/controllers may also be driven if they are compatible. For checking compatibility of shutters you wish to use please consult Hamamatsu.

2. Software Setup

There is no special setup required to use the TA-Absorption module in general. If you want to control your shutters through the TA-Absorption module, however, you need to enable the feature in the "Device Control Setup" (stored in the hardware profile and available from the startup screen).



Please make sure that both “Counter board installed” and "A6538 shutter box" are checked and that the correct I/O address is specified for the Counter board (for the latter, please refer to the HPD-TA manual). Also be sure to *turn off* "Streak camera status port". (The usage of the status port and of the shutter control are *exclusive*, as mentioned in note 5 in section 1 above.)

> Please note that you use the same checkbox "A6538 shutter box" even if your actual shutters are not made by Hamamatsu but are compatible with the A6538 (see note 6 in section 1 above).

Operation Instructions

General

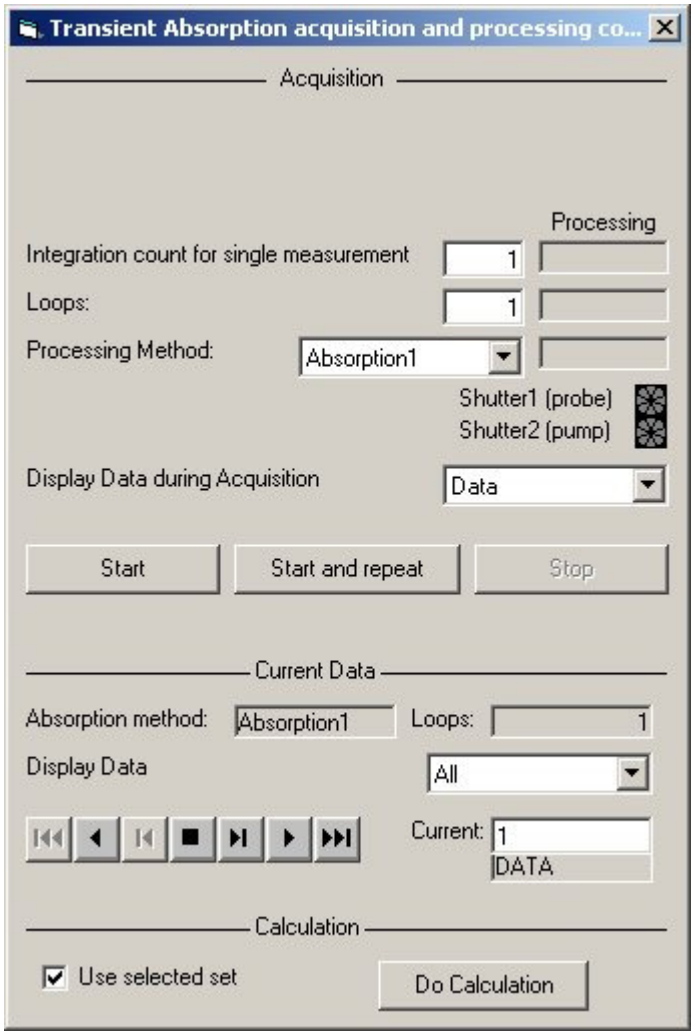
The Transient Absorption software module allows to perform the following actions.

- Select the parameters which control the measurement. The main parameters of the Transient Absorption measurement can be selected in the Transient Absorption options dialog and in the Transient Absorption main dialog. Besides these parameters in the Trigger Options, the Camera Options and the Acquisition Options may be of interest.
- Perform a complete measurement consisting of individual measurement (like Data), sets (like Absorption1) and loops (repeats the set n times). An individual measurement can consist of one or more camera images, a set consist of three to five individual measurements The set itself can be repeated n times to increase precision. The shortest measurement consists of three camera images which build up one single set. Depending on the readout time of the camera and other parameters this can take place in less then one second. On the other hand a measurement can consist of n sets where every set contains several individual measurements, every individual measurement consisting of m integrated camera images.
- Perform the same measurement repeatedly to improve parameters and adjust optics and other hardware components.
- Save and load complete measurements as a sequence of images.
- Evaluate the data by using the DoCalculation function. If more than one set has been recorded individual sets can be excluded in the evaluation process.

The User I/F

The Main Dialog

The transient absorption measurement software has two dialogs: the main dialog and the options dialog.



Transient absorption main dialog

The main dialog contains three parts:

Acquisition (Acquire data as a set of individual data)

Current Data (Display and handling of measured data)

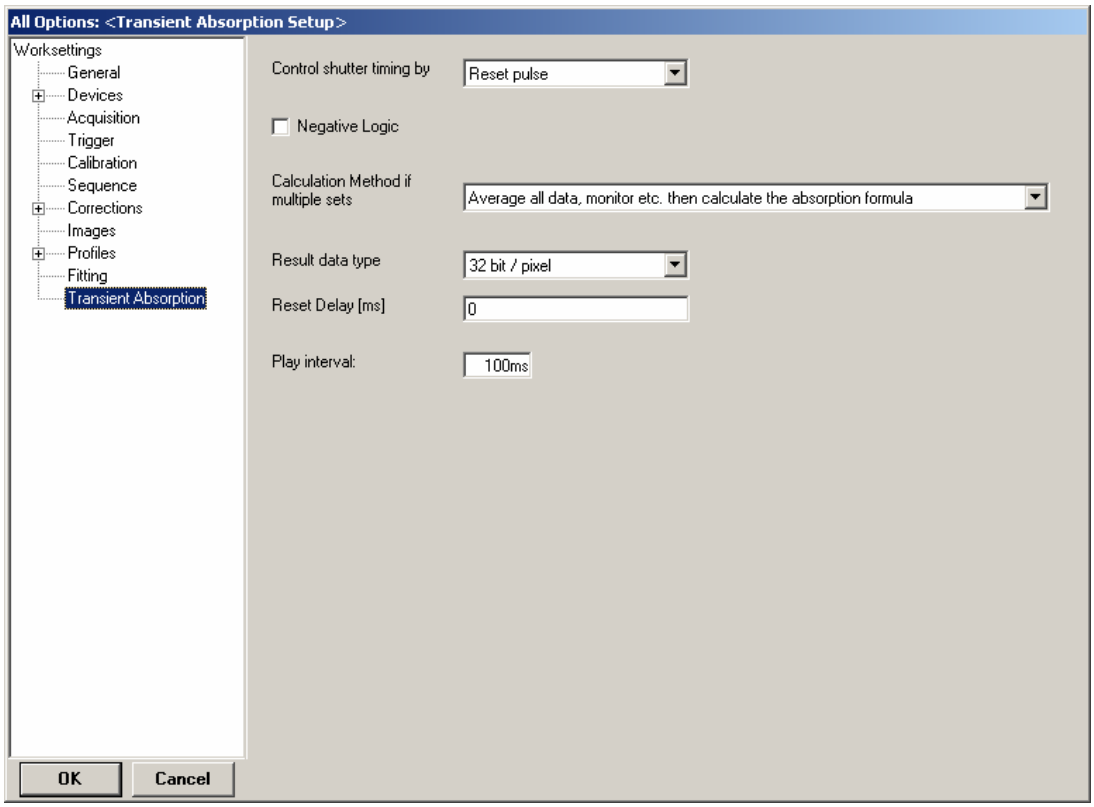
Calculation (Processing of the current data)

The dialog contains the following controls:

Integration count for single measurement	If this control is set to 1 LIVE mode is used, if this control is set to >1 Analog Integration mode is used with the integration count set to this value.
Loops	Number of sets acquired inside a loop
Processing method	Defines which individual measurements are performed within one set. Possible values are Absorption1, Absorption2 etc
Shutter 1 (probe)	Displays the state of shutter 1 (open or closed) graphically (white is open, grey is closed). By clicking on the icon the state can be changed manually. This state is kept until the acquisition sequence requires a different state.
Shutter 2 (pump)	Displays the state of shutter 2 (open or closed)

	graphically (white is open, grey is closed). By clicking on the icon the state can be changed manually. This state is kept until the acquisition sequence requires a different state.
Display data during acquisition	This control determines which data will be displayed during the acquisition. Either all data can be displayed or only one single data type (like Data).
Start	Start the measurement
Start and repeat	Starts the measurement repeatedly
Stop	Stops the measurement
Exposure time	This control is only visible in not synchronized mode (especially for synchroscan mode). It defines the exposure time of the CCD camera.
Acquisition interval	This control is only visible in not synchronized mode (especially for synchroscan mode). It defines the timing of individual images. As there is no trigger handshake in not synchronized mode this value needs to be specified. It should be larger then exposure time and readout time.
Current data	Indicates the acquisition type of the currently loaded Absorption data. This can be either data which has just been recorded or data which has been saved to disk and reloaded later.
Display data	Defines which part of the absorption data should be displayed. Either all data can be displayed or only one single data type (like Data)
	These controls serve to select and display desired individual measurements. They are: First, Play Backward, Previous, Stop, Next, Play Forward, Last
Current	Number of current set, Below this control the data type of the currently selected measurement is displayed
Use Selected Set	Indicates whether the currently select set will be included in the evaluation or not.

The Options Dialog



Transient absorption options dialog

With the Transient absorption options dialog one can select the following options

Control shutter timing by	Reset pulse: The shutter positions for the next individual measurement are programmed when the reset pulse is sent. This is useful especially for fast shutters. Monitor pulse: The shutter positions for the next individual measurement are programmed when the monitor pulse is detected. This is useful especially for slow shutter.
Negative Logic	TTL pulses for the shutters are active High. If this option is selected they are active low.
Calculation method	If Loop count is > 1 there are two methods of calculation the result image: Calculate the absorption formula for every set then average. Average all data, monitor etc. then calculate the absorption formula.
Result data type	Can be either 16 or 32 bit. For 16 bit data the calculation constant is 1000 for 32 bit data it is 1000000.
Reset delay	Before sending the reset pulse the program waits a user specified delay time (in [ms]). If this value is zero the program does not wait.
Play Interval	When the acquired data is played the speed can be influenced by the Play Interval (works same as the

	play interval option for sequences)

Data Acquisition

Acquisition takes place at three levels

Individual measurement

An individual measurement is a collection of image data with a well defined position of shutters (and gate control status). An individual measurement can be a single acquisition in live mode or an image taken in analog integration. The “Integration count for single measurement” defines whether image data is acquired in Live mode (=1) or analog integration (>1).

There are the following individual measurements:

Measurement	Shutter1 (probe)	Shutter2 (pump)	Gate
Data	Open	Open	Low
Monitor	Open	Close	Low
Emission	Close	Open	Low
Dark1	Close	Close	Low
Dark2	Open	Close	High

Sets

Several of theses individual measurements define a set. According to the parameter “processing method” the following sets are produced:

Absorption1: Data, Monitor, Dark1
Absorption2: Data, Emission, Monitor, Dark1
Absorption3: Data, Monitor, Dark2
Absorption4: Data, Monitor, Emission, Dark1, Dark2

Loops

Several sets can be acquired in a loop. The number of sets is defined in the parameter loop count

Acquiring measurement

To perform a complete measurement please proceed as follows:

- Select the desired parameters especially the parameters in the trigger setup, the Transient Absorption Options and all settings of the Acquisition section of the Transient Absorption main dialog.
- Start acquisition by clicking to Start
- Once the complete loop has been finished the data can be evaluated with the DoCalculation pushbutton.

Repeat for adjustment and maintenance purposes

If the pushbutton “Start and Repeat” is selected the same measurement is repeated continuously and the result is calculated. For display an image window is used which already contains a transient absorption result image. This is to avoid that with every measurement a new window will be opened.

To use this feature effectively proceed as follows:

1. Acquire measurement data with the desired or needed parameters with the “Start” button.
2. Manually execute DoCalculation.
3. Select Window position and LUT settings of the result image to be able to observe the data correctly.
4. Start the measurement with the “Start and Repeat” button. The result image will be displayed in the window which is already on screen.
5. Adjust your experiment condition while viewing at the screen.
6. Stop the measurement and start acquiring real data with the Start button.

Synchroscan operation

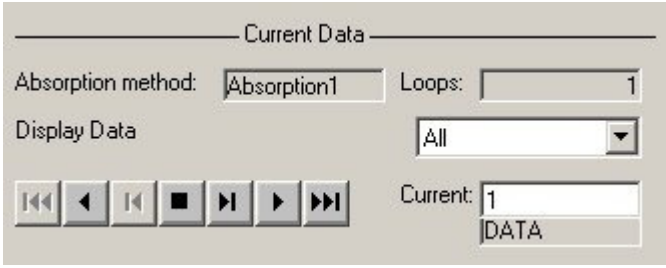
A special case is the acquisition of Transient Absorption data in not synchronized mode especially for synchroscan operation.

I such case one can specify the exposure time and the timing interval for individual images. All controls related to trigger handshake are meaningless. The evaluation is, however, identical to cases where trigger handshake takes place.

Data Display

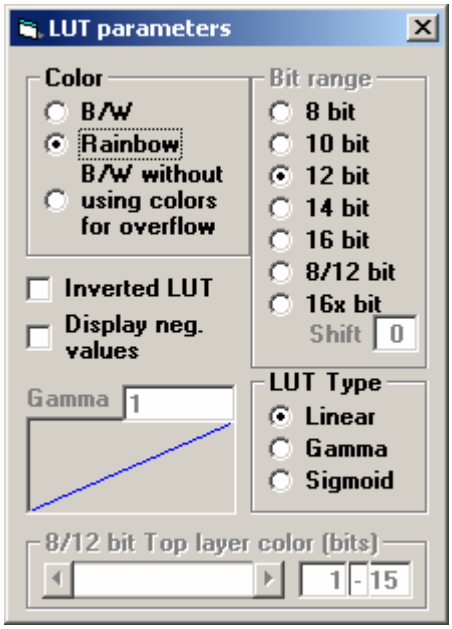
Accessing Individual Measurements

Once the data is acquired it can be displayed. The user can either look at all the data, or only at the images taken under specified shutter positions like Data or Monitor. This choice is selectable with the parameter Display data. Pushbuttons are available to navigate between the individual measurements (first, previous, next and last). The data can also be played backward or forward.



LUT for negative values

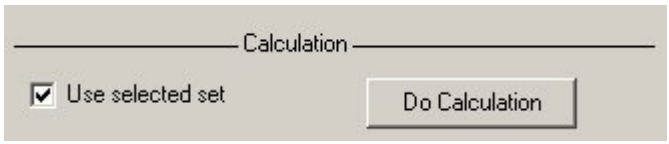
Normally the LUT is set in a way the negative values are not displayed. They appear black. A setting allows to program the LUT to display negative values. In this case negative values of data are displayed like the same positive value. This can be done by setting the checkbox “Display neg. values”.



Data Evaluation

Select Sets

To process the data the user simply has to press the Do Calculation pushbutton. Individual sets can be excluded by deselecting the selected set with the “Use selected set” checkbox.



Result image calculation

The calculation of the result image is as follows

Absorption1: Result = $\log_{10}$((Data-Dark1)/(Monitor-Dark1)) * const

Absorption2: Result = $\log_{10}$ ((Data-Emission)/(Monitor-Dark1)) * const

Absorption3: Result = $\log_{10}$ ((Data-Dark2)/(Monitor-Dark2)) * const

Absorption4: Result = $\log_{10}$ ((Data-Emission-Dark2+Dark1)/(Monitor-Dark2)) * const

Where const = 1.000 for 16 bit result images and 1.000.000 for 32 bit result images.

Technical information

Data storage and memory usage

This chapter explains some inside information which is not needed in everyday live but could be interesting to understand the functioning of this module better.

The complete data is stored in a sequence which resides in RAM (see the HPDTA manual for details about sequences). A set of individual measurements is stored in 3 to 5 consecutive images (depending of the type) of the sequence (let's call this number M). If several sets (lets say n sets) are acquired the sequence contains n x m images. The sequence can be stored to hard disk and loaded later for evaluating.

The header of the sequence contains important information about the type of data, the number of loops and the order in which the individual measurement of the set is acquired.

Do **not** save the sequence as a display2Tiff sequence and do not modify the header (except for the comment). You may no longer be able to evaluate this sequence if you do so.

When acquiring transient absorption data you should take care that the data can really fit into the computers physical RAM, otherwise the system may not be able to perform the measurement in real time. To find out how many images can be recorded in RAM you can easily try to store a sequence to RAM with a high number of required frames. The system will then try to get as many Ram as possible and acquire the number of images fitting into RAM. If this number is N do not specify more then N/m for the number of Loops. Please also take into account that the system requires some RAM for other purposes and allow the system to keep some RAM as a security.

Window handling

The sequence is managed with the sequence control and kept in the sequence buffer of the system. However to avoid confusion the sequence control window disappears as long as the transient absorption main window is visible. If you want to use the sequence control independently please close the transient absorption main window. The same is true for the camera acquisition dialog. It disappears once the transient absorption main window is visible. If for some reason or other you want to access the camera acquisition window please close the transient absorption main window.

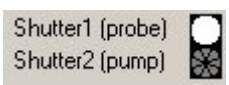
Previous version of the Transient absorption module used several image buffers to store different individual measurements. This is no longer true. This version displays the complete measurement inside one window. Only the calculation result is written and displayed in a separate window

Direct shutter control

The shutters can be directly controlled by clicking on the respective icons.

This could be useful if other acquisition modes should be combined with the shutter control provided by this module.

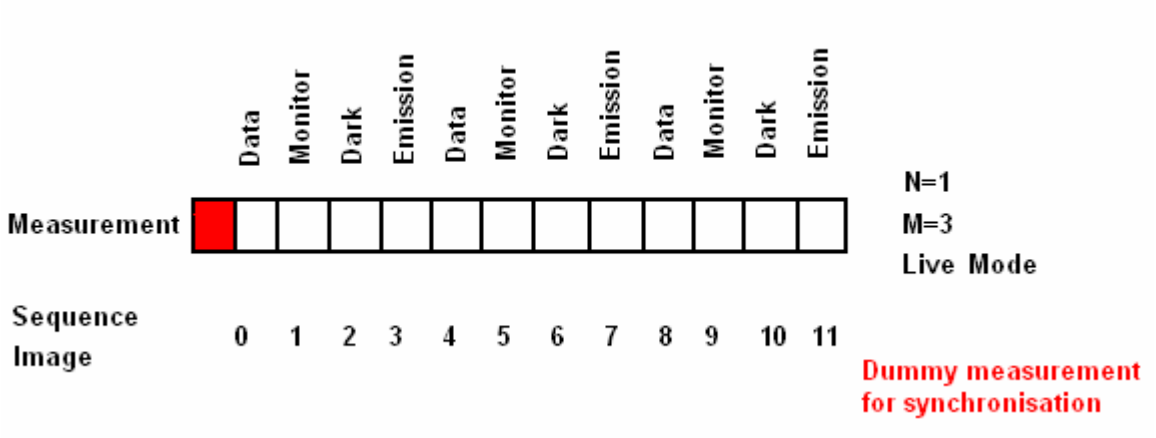
The shutter states are overwritten if during transient absorption measurement acquisitions the states of the shutters have to be changed. Please note that due to some considerations the sequence and camera acquisition dialog are invisible once the transient absorption main window is visible. To combine the manual shutter control with a manual camera acquisition you eventually have to show and hide the transient absorption main window.



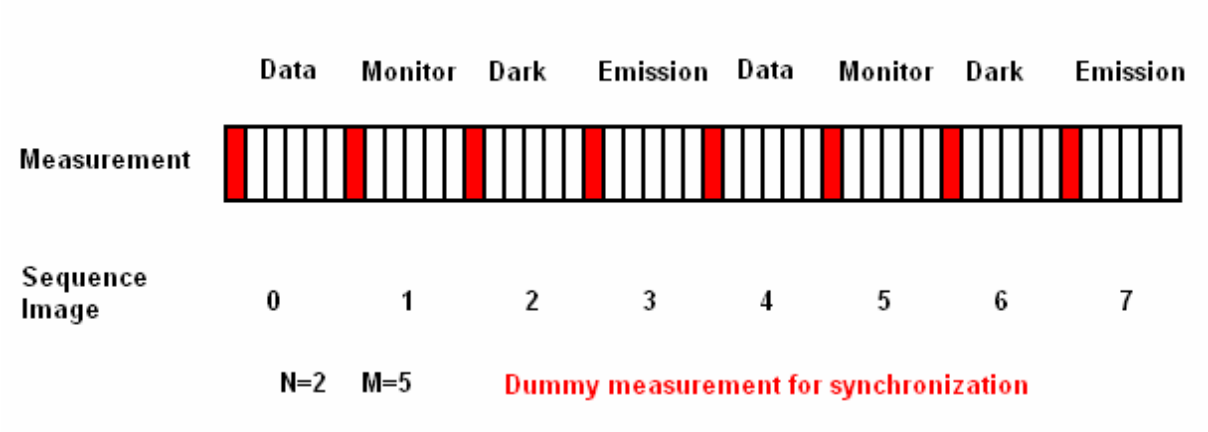
Timing

If the Number of Loops is set to 1 the measurement takes place in live mode.

The timing is then as follows:



If the Number of loops is larger than 1 the timing is as follows:



Literature

Below are some publications reporting about the experimental aspects of transient absorption with a streak camera.

Ito, T; Hiramatsu, M.; Hirano, I.; Ohtani, H., *Macromolecules*, **23**, 4528 (1990)
("Photoisomerization of spirobenzopyran in polystyrene film")

Ito, T.; Hiramatsu, M.; Hosoda, M.; Tsuchiya, Y., *Rev. Sci. Instrum.* **62 (6)**, 1415 (1991)
("Picosecond time-resolved absorption spectrometer using a streak camera")

Trzinski, T., Diplomarbeit, Institut für Physikalische und Theoretische Chemie der TU München, 1994
("Fluoreszenz- und Differenzabsorptionsmessungen an künstlichen und biologischen
Elektrontransfersystemen mit Hilfe eines Streakkamerasystems")

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