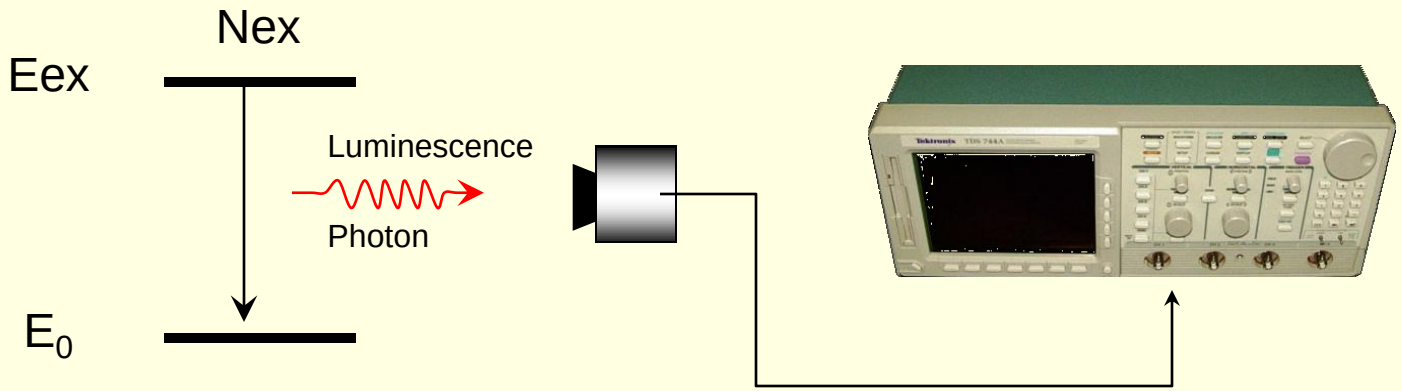
Measuring Kinetics of Luminescence with TDS 744 oscilloscope



Disclaimer

- Safety –the first !!! This presentation is not manual. It is just brief set of rule to remind procedure for simple measurements. You should read manual first.

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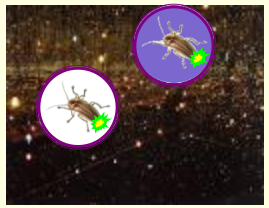
Luminescence

is a process in which a excited material emits light (electromagnetic radiation)

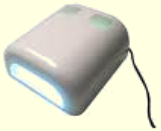
For example, the following types of luminescence caused by different excitation process could be classify :

Chemoluminescence, is the emission of light as the result of a chemical reaction



Light production in fireflies is due to a type of chemical reaction called bioluminescence

Photoluminescence (PL) is a process in which a material absorbs photons (electromagnetic radiation) and then re-radiates photons



Banknote photoluminescence after excitation by UV light from flash lamp

Electroluminescence (EL) is an process in which a material emits light in response to an electric current passed through it, or to a strong electric field.

Infrared electroluminescence of photodiode in the remote is stimulated by electrical current

Parameters of the Luminescence

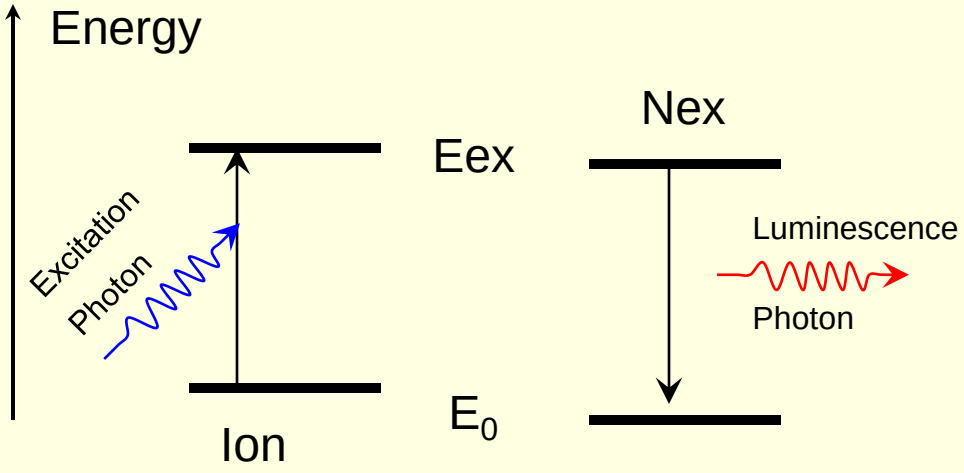
- Luminescence **spectra** shows how intensity of the luminescence depends on wavelength

- Luminescence **lifetime** refers to the average time the molecule/ion stays in its excited state before emitting a photon (or how long luminescence could be observed)

- The luminescence **quantum yield** gives the efficiency of the luminescence. It is defined as the ratio of the number of photons emitted to the number of photons absorbed.

Goal of the Lab: Measuring of the kinetics of the photoluminescence signal and luminescence lifetime

Decay kinetics of the Luminescence



$$\frac{dN_{ex}}{dt} = -\frac{N_{ex}}{\tau}$$

$$N_{ex}(t) = N_0 e^{-t/\tau}$$

$$I_{Lum} \sim \frac{dN_{ex}}{dt} \sim e^{-t/\tau}$$

Excitation: Absorption of the excitation photon result in transition of the molecule/ion from the ground state (E_0) to the excite state (Eex) and create population at higher energy state (Nex)

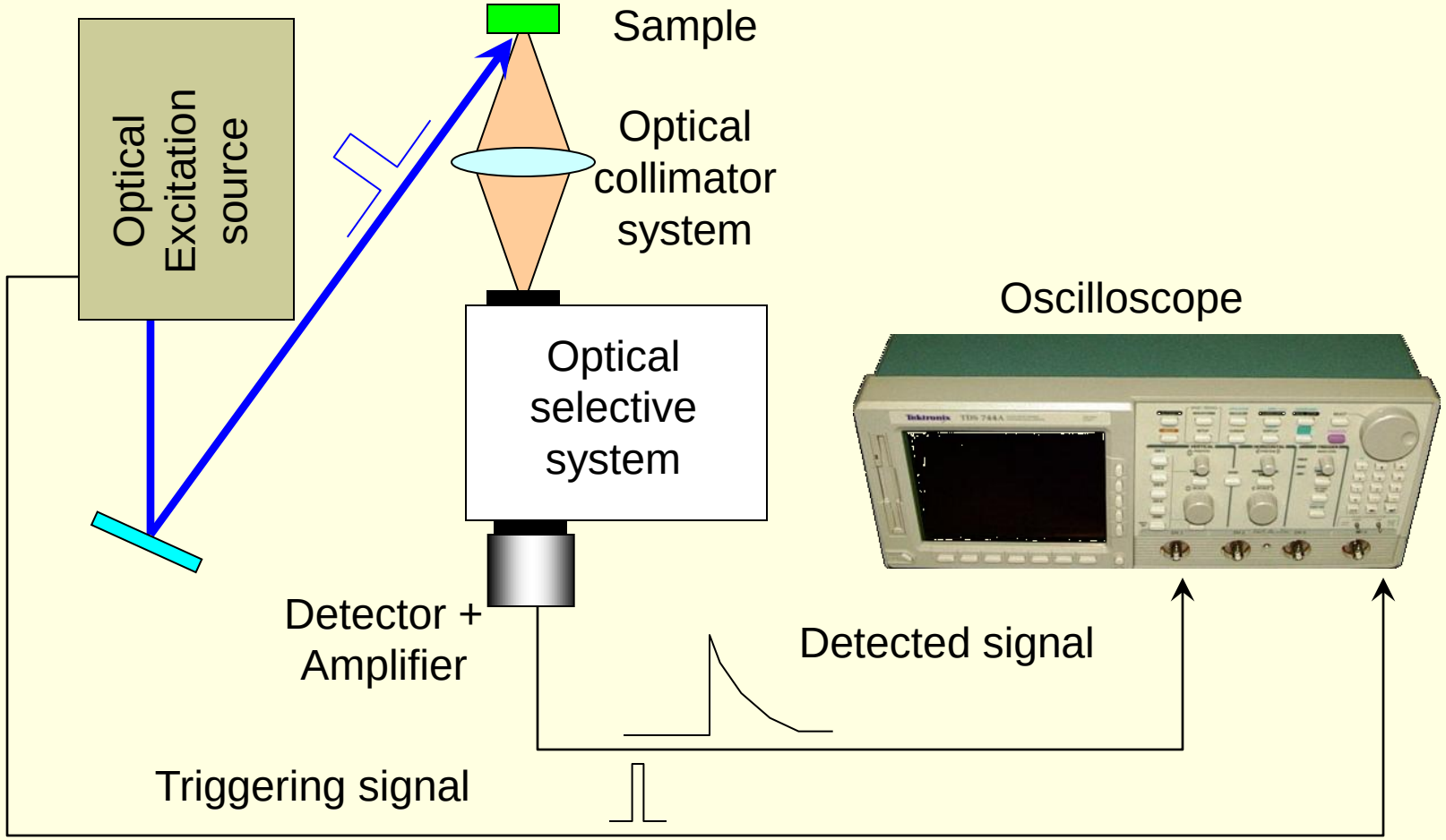
Relaxation: Followed relaxation of the molecule/ion to the ground state could result either emission luminescence photon or energy transfer to the crystal (heating the crystal)

Intensity of the Luminescence (I_{Lum}) typically follows exponential decay law (where parameter τ is excited-state lifetime)

Basic Components of the experimental setup

1. First of all, for photoluminescence measurements we need source of the optical pulses for excitation our sample (*usually it is pulse laser*)
2. We need optical collimator to collect maximum of the emitted photons and to direct luminescence to the detector *(usually it is single lens or lens system)*
3. Next we need optical selective system to block optical excitation pulses and measure only selective luminescence *(usually it is optical selective filter or spectrometer)*
4. Detector is a type of sensor capable of converting light into either current or voltage
5. Electrical signal from the detector (+amplifier) is measured by oscilloscope

Experimental setup

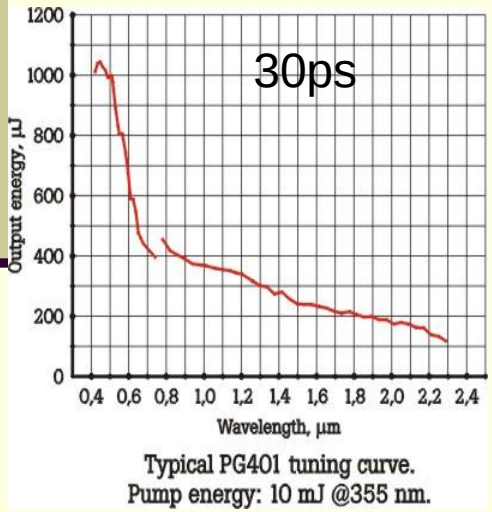


Requirements to optical excitation

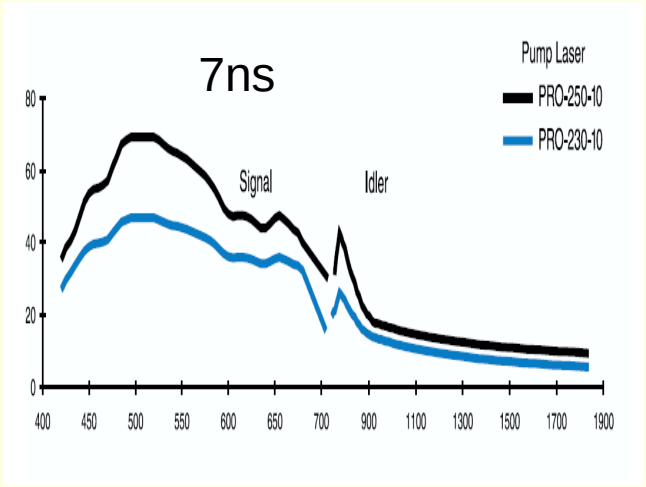
First of all, a wavelength of the optical excitation pulses should be within absorption band of the studied samples

Second, excitation pulse duration should be shorter than studied kinetics of luminescence. Otherwise, measurements will demonstrate excitation-pulse temporal-profile.

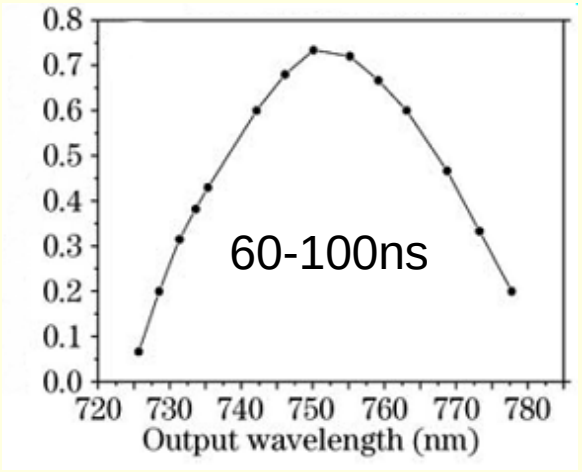
Available commercial tunable solid-state lasers



OPO Ekspla



OPO Spectra Physics

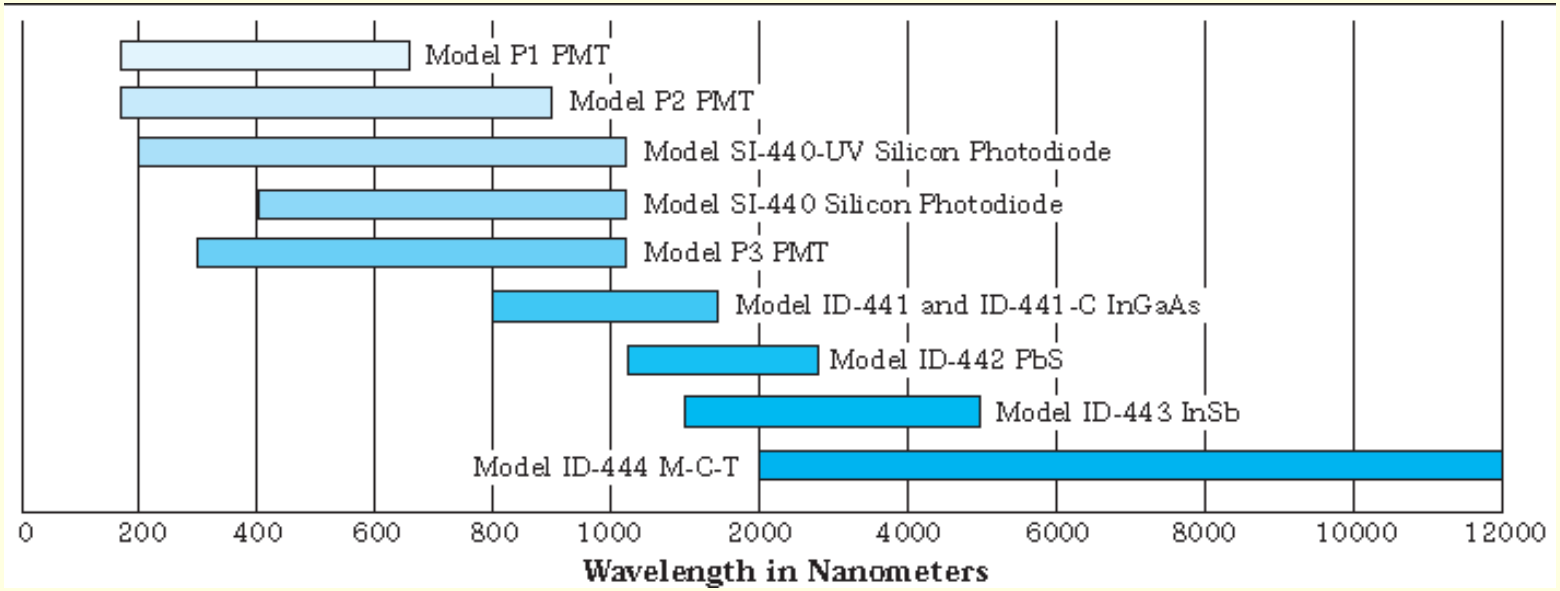


Typical curve of the Alexandrite laser

Requirements to detector

1. Detection spectral range:

Detector should be sensitive in the spectral range of the luminescence



Operating Ranges for ARC detectors

2. Respond time :

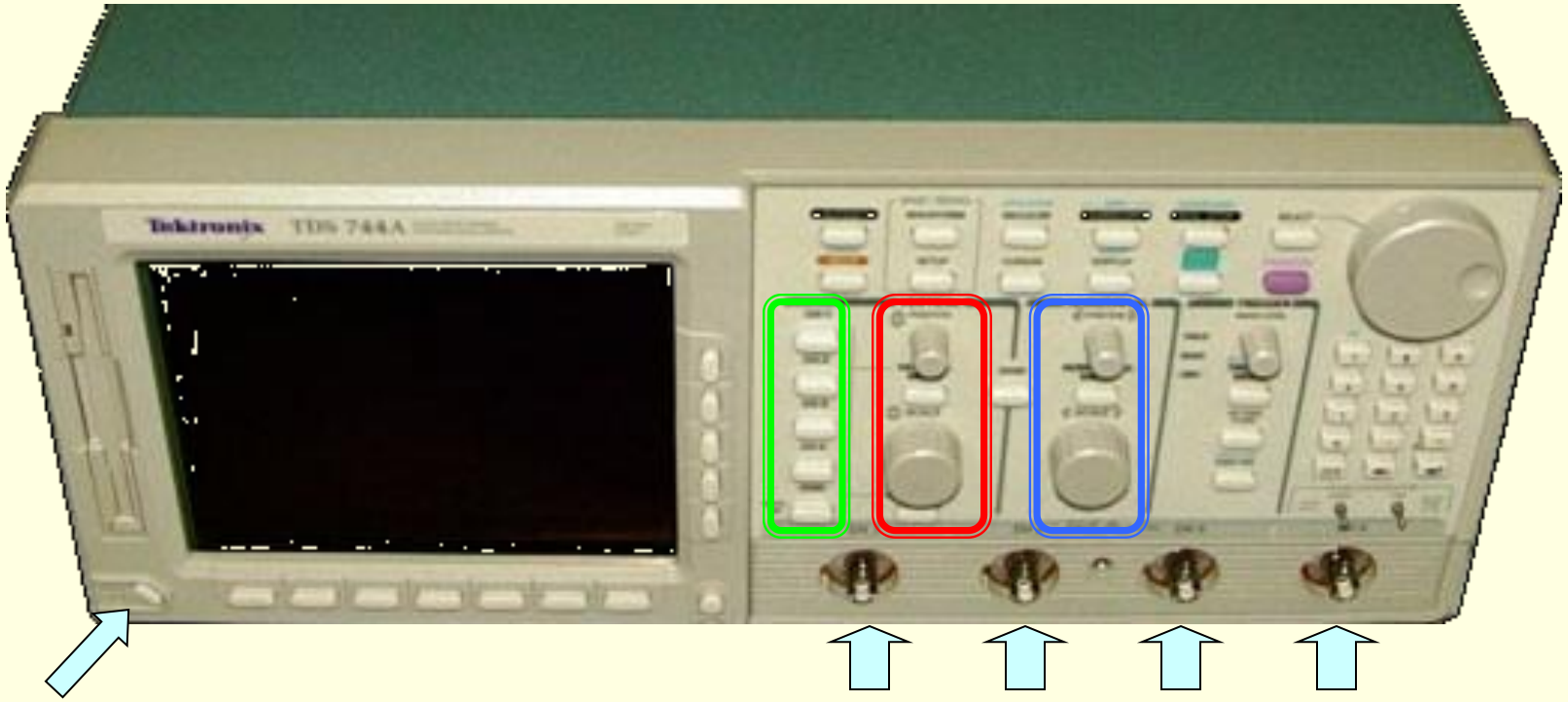
Detector (+Amplifier) respond time should be shorter than studied kinetics of luminescence

Oscilloscope Overview

Select Channel

Vertical control (sensitivity, V)

Horizontal control (time, sec)

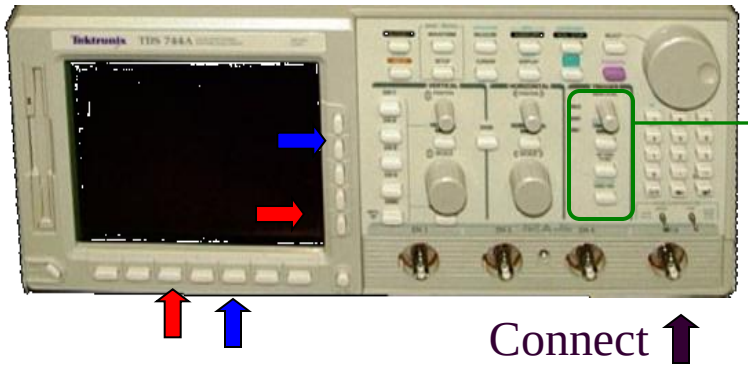


On/Off Button

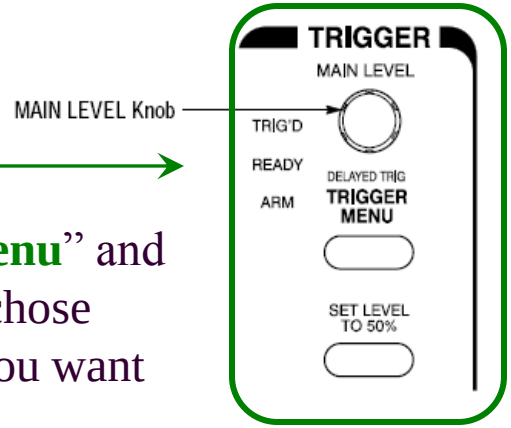
Channel inputs

Oscilloscope triggering

To measure kinetic of the Luminescence you need to trigger oscilloscope when optical pulse hit the sample. Trigger determine when the oscilloscope starts acquiring and displaying a waveform. Trigger signal could be either electrical logic signal from the pump-laser power-supply or electrical signal from the external photodiode detecting pump optical pulse .You could connect **any** of four oscilloscope inputs to connect trigger signal.



Connect triggering signal



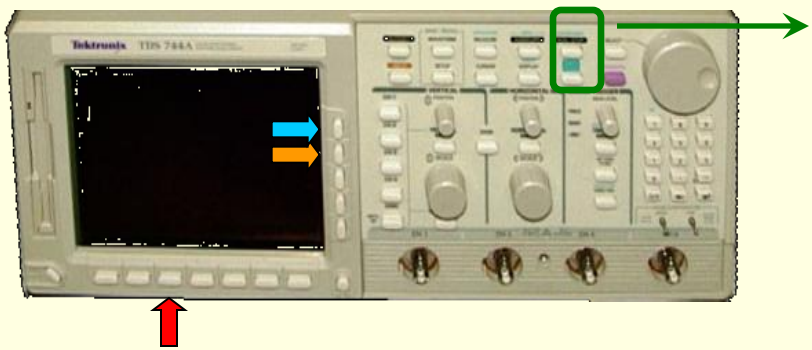
1. Press "**Trigger Menu**" and "**Select #**" knobs to chose channel from what you want trigger oscilloscope

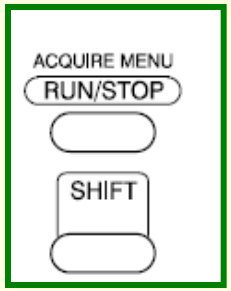
2. Press "**Trigger Menu** " and "**Slope**" knobs to chose triggering edge-slope.

3. Tune "MAIN LEVEL" knob to select trigger voltage-level

Run/Stop acquisition measurements

If you need to stop after single acquisition measurements then :





1. Press switch to additional knobs menu by press "SHIFT" (blue) and "Acquire Menu" knobs

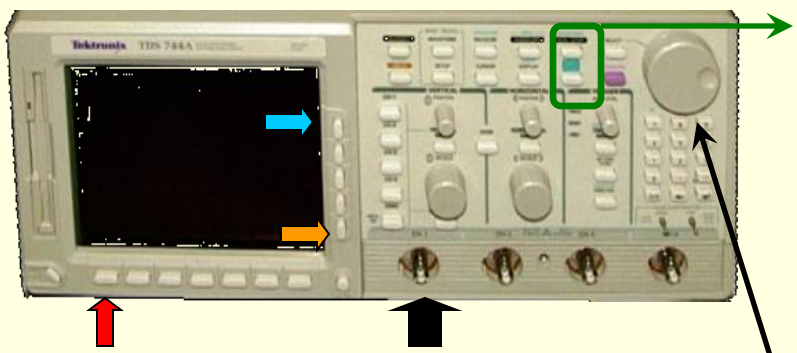
2. Select "**Stop After Average**"

2A. To stop after single acquisition measurements select "**Single acquisition measurements**"

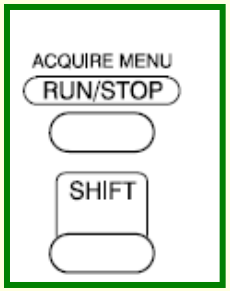
2B. To select non-stop measurements select " **Run/Stop button only**"

3. To start or stop measurements press " "**Run/Stop**" knob

Averaging of the measurements



Measured signal



1. Press switch to additional knobs menu by press “SHIFT” (blue) and “Acquire Menu” knobs

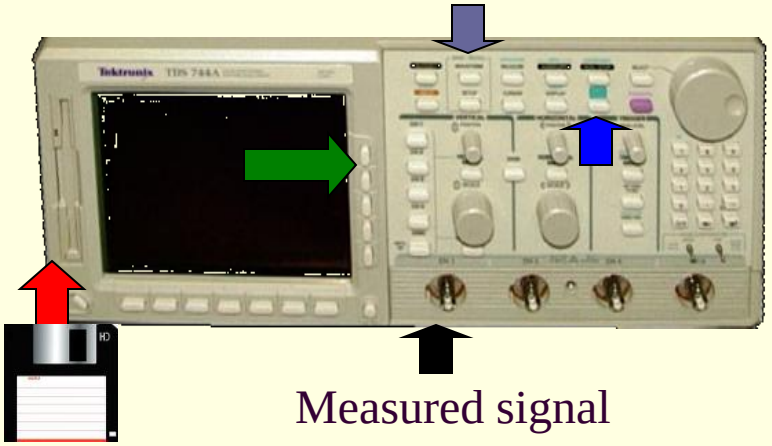
2. Select file format by press “**Mode Average**” and “**Sample**” for operation without averaging

3A. Select file format by press “**Mode Average**” and “**Averaging**” for averaging operation

3B. Use scrollbar to select number of the averaging

Save measurements to file

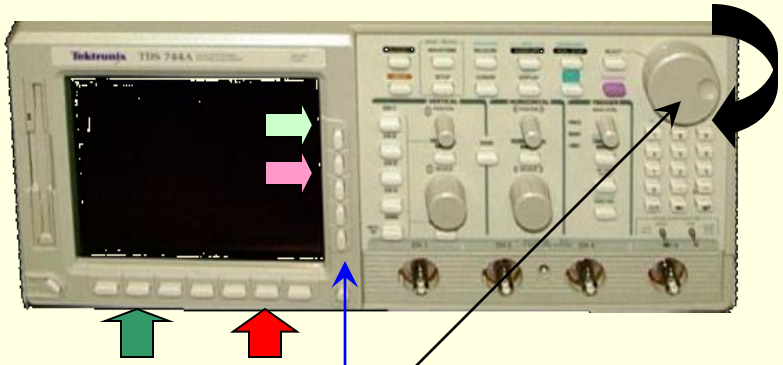
(procedure for oscilloscope TDS 744A)



Measured signal

1. **Insert floppy disk.**
Select channel you want to save by press knob "**Channel #**" and

2. Press switch to additional knobs menu by press "**Shift**" (blue) and "Save/Recall" knobs



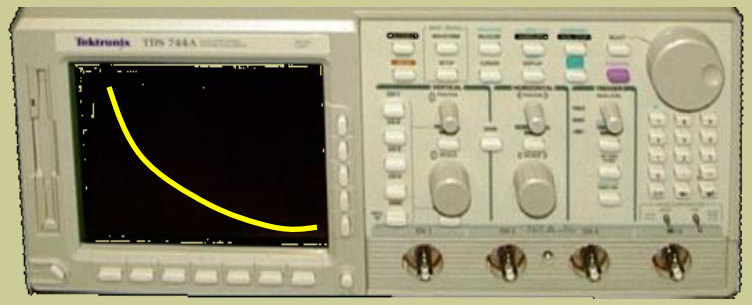
3. Select file format by press "**File Format**" ant then "**Spreadsheet**" knobs

4.Press "**Save wfm** (waveform) #" and then " **To file**"

5. Use **scrollbar** to select Tek??? for new file-name in sequence, or select already exist file to overwrite data. Then press "Save to selected file"

Experimental protocol

1- Measure and save luminance signal



2- Measure and save electrical background when luminescence is blocked

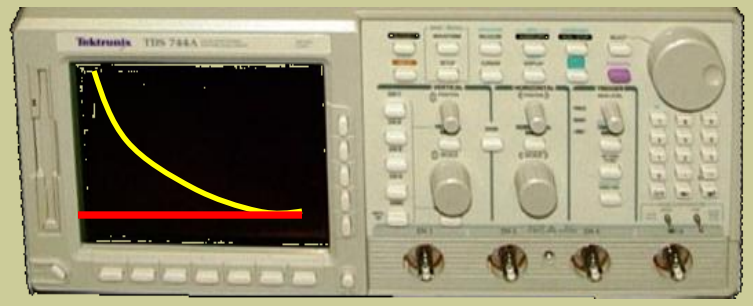
3- Measure and save setup respond time

Experimental protocol

1- Measure and save luminance signal

2- Measure and save electrical background when luminescence is blocked

Do not change any experimental setting, keep all setting the same as during luminescence measurements, only block excitation pulses before samples !!!!



3- Measure and save setup respond time

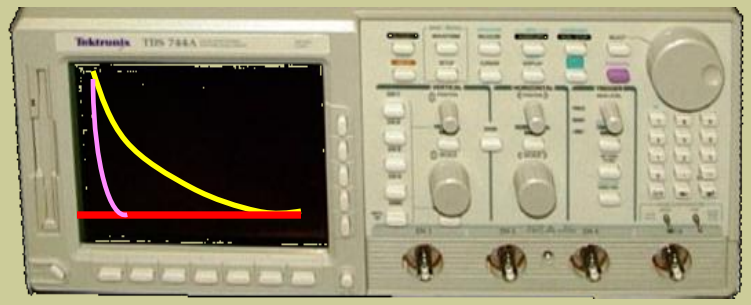
Experimental protocol

1- Measure and save luminance signal

2- Measure and save electrical background when luminescence is blocked

3- Measure and save setup respond time

Be careful, usually scattering of the excitation pulse much bigger than luminescence signal. Try to avoid saturation of the detector. Try to measure temporal respond time at the same level of the signal like in luminescence measurements



Troubleshooting

(Long Kinetics)

AC oscilloscope coupling shows only the alternating components of an input signal. The oscilloscope does not accurately display “long kinetic” with AC coupling is selected.