Acquiring Luminescence Spectra using the ARC –NCL Spectral Measurement System + Lock-in Amplifier

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 :

<u>**Chemoluminescence**</u>, 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

<u>**Photoluminescence**</u> (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

<u>**Electroluminescence**</u> (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 Luminescence spectra using ARC –NCL Spectral System

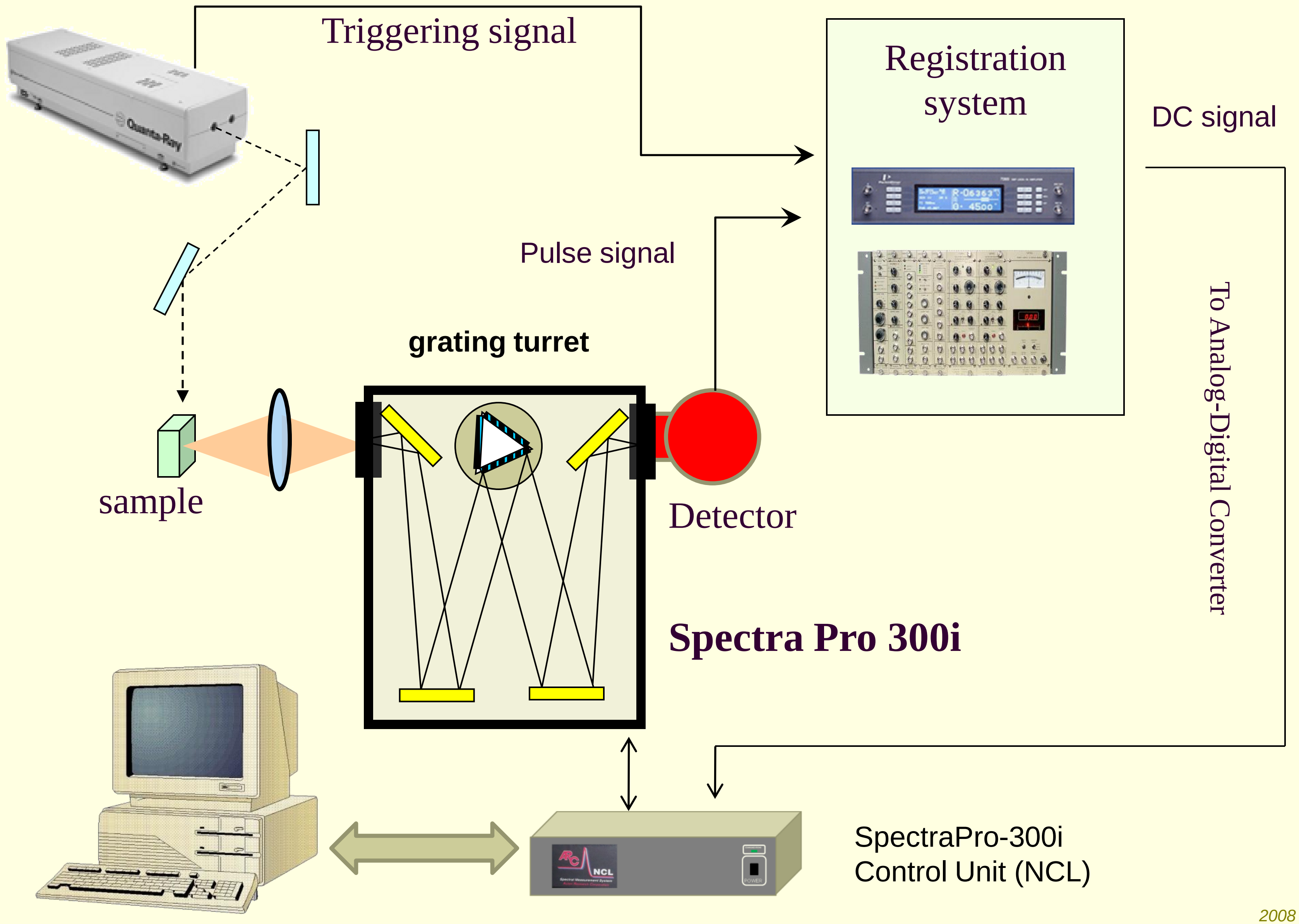
Experiment Background

1. First of all, we need excitation source to transfer our sample into excited (high energy) state. Here we will consider only optical excitation. It means that we will use optical radiation to excite sample

2. Second, we need optical system to collect the luminescence and direct it to detector. Also we need select luminescence from the excitation radiation. For these proposes we can use optical filter or monochromator which can help select radiation only at required wavelength.

3. We need detect optical signal (convert intensity of the optical radiation into electrical signals) and then convert signal into digital format

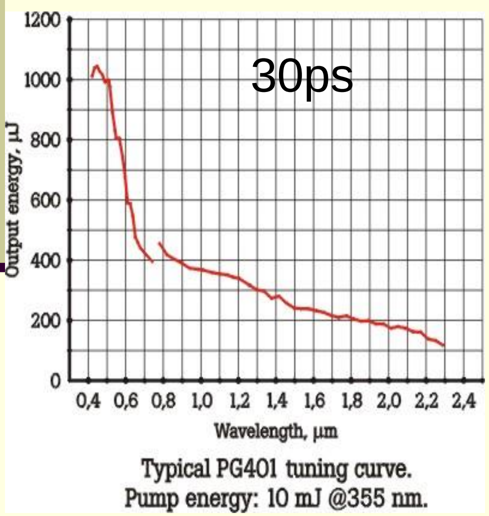
Experimental setup (Principal Schema)



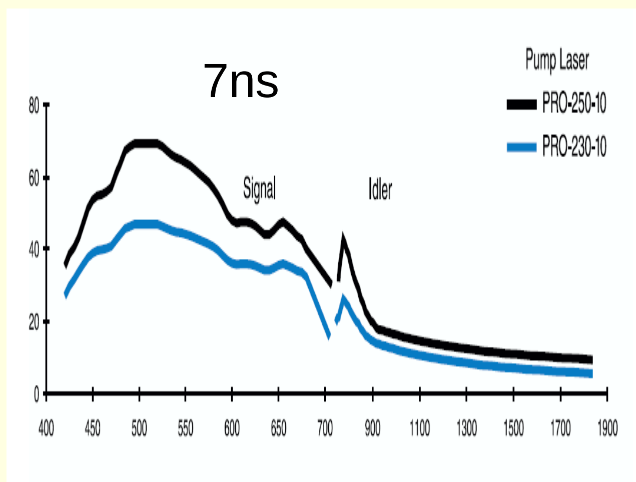
Requirements to optical excitation

A wavelength of the optical excitation pulses should be within absorption band of the studied samples !!!

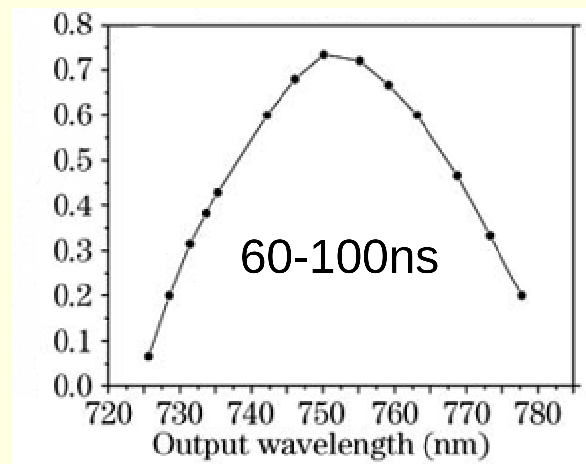
Available commercial tunable solid-state lasers



OPO Ekspla



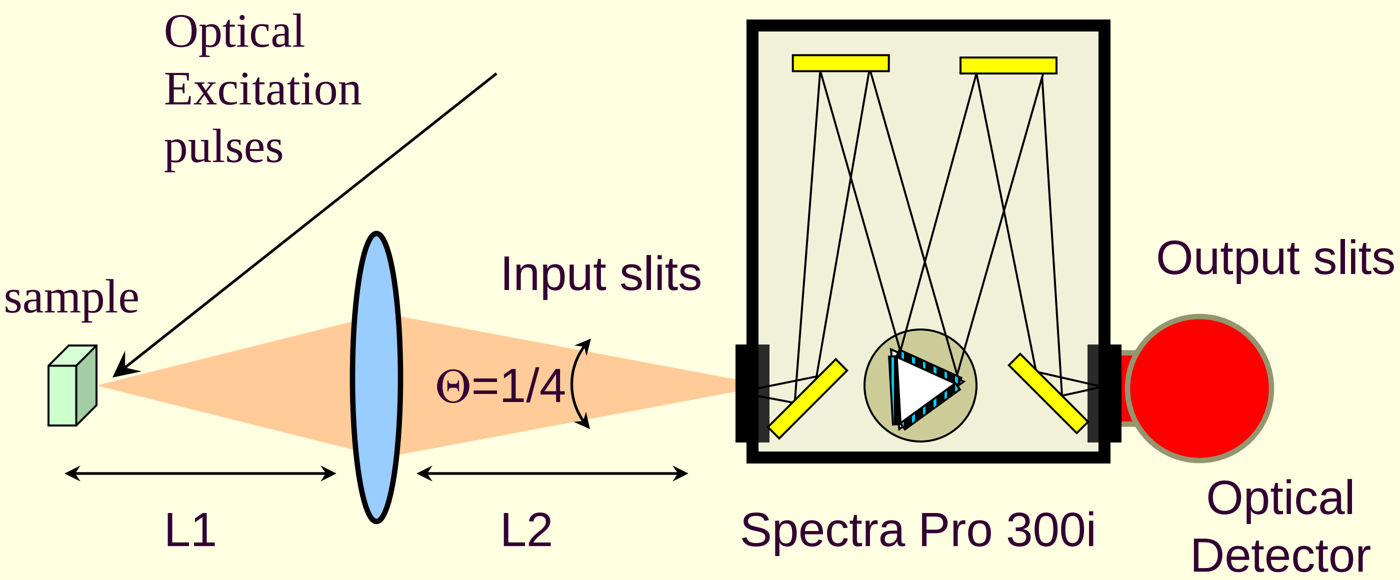
OPO Spectra Physics



Typical curve of the Alexandrite laser

Optical Setup

1) Avoid reflection of the excitation radiation to the measurement system!!!



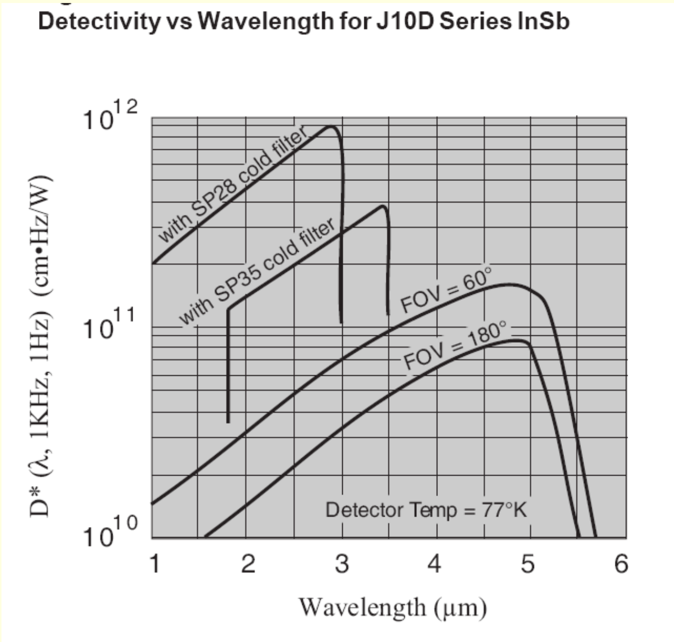
2) Acceptance angle of Spectra Pro300i is Θ=1/4. Therefore lens diameter should be D>LΘ (for L2=L1=2F configuration D>F/2)

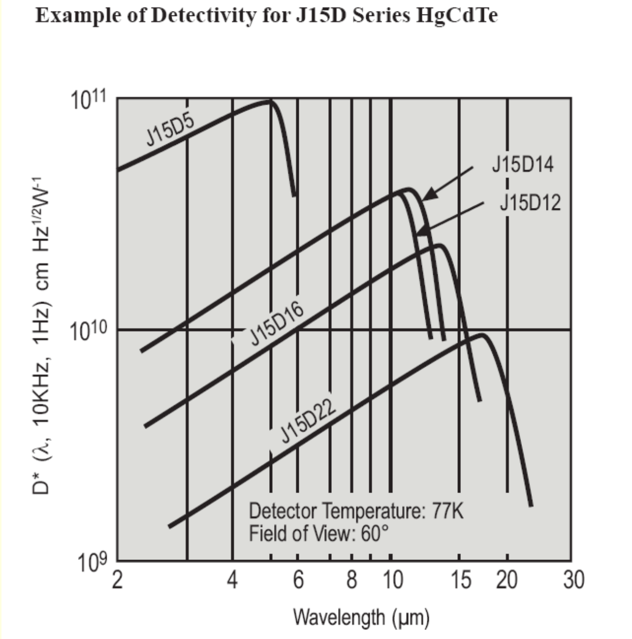
How to Choose a Detector ?

A **optical detector should** convert luminescence of the sample into a electrical signal.

Therefore the major requirement to the optical detector : to be sensitive at the wavelength of the to the luminescence photons

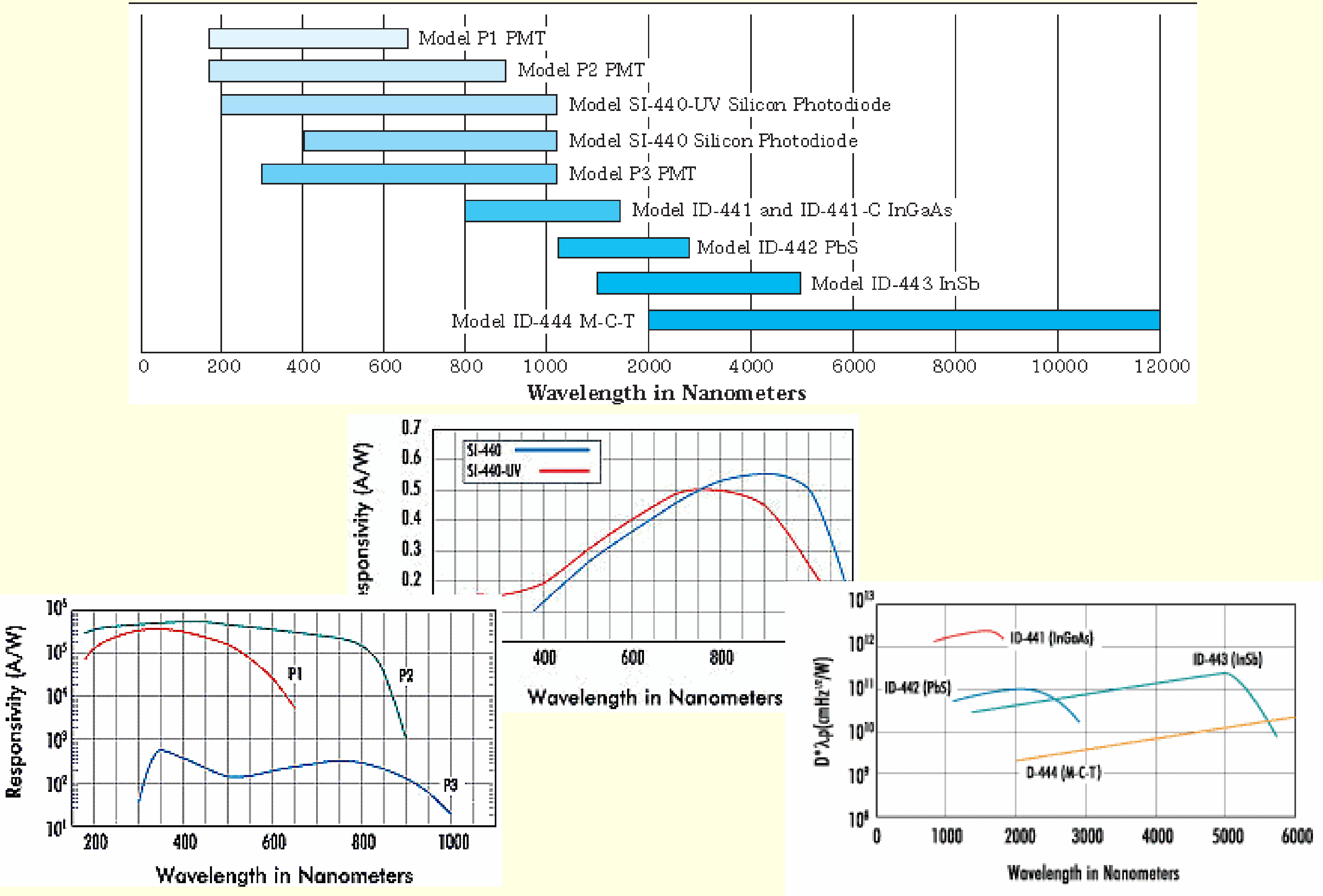
Operating Ranges for Judson Technologies detectors





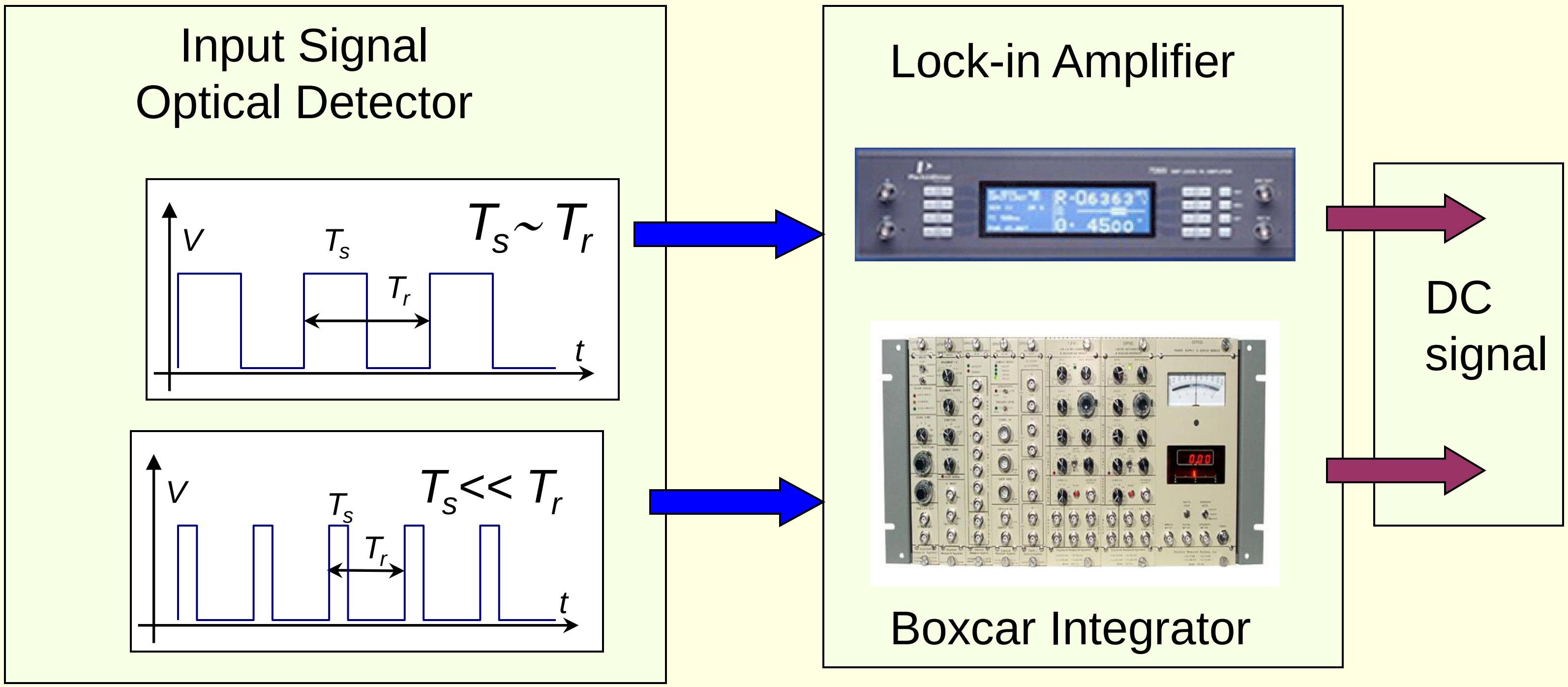
Attention, these detectors should cooled by liquid Nitrogen !!!

Operating Ranges for ARC detectors



Two type of the electronic registration system

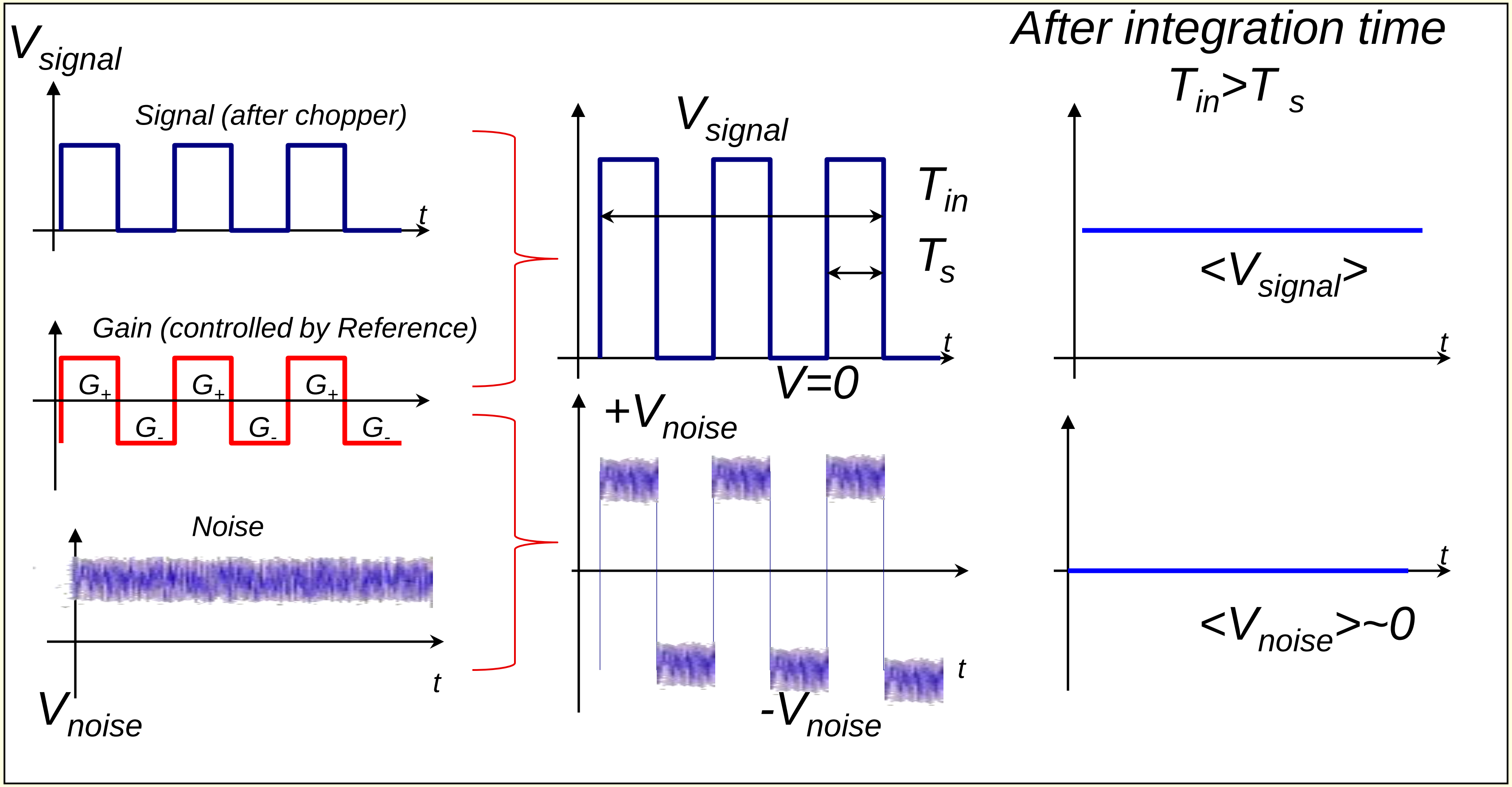
depends on the ratio of the signal duration (Ts) and period between pulses (T_r); **duty cycle**



- Lock-in Amplifier for signals when $T_s \sim T_r$
- Boxcar Integrator for signals when $T_s << T_r$

Experiments with 7235 Lock-in Amplifier

Basic principals of the Lock-in Amplifier



$V_{noise} \sim V_{signal}$

$V_{noise} <<< V_{signal}$

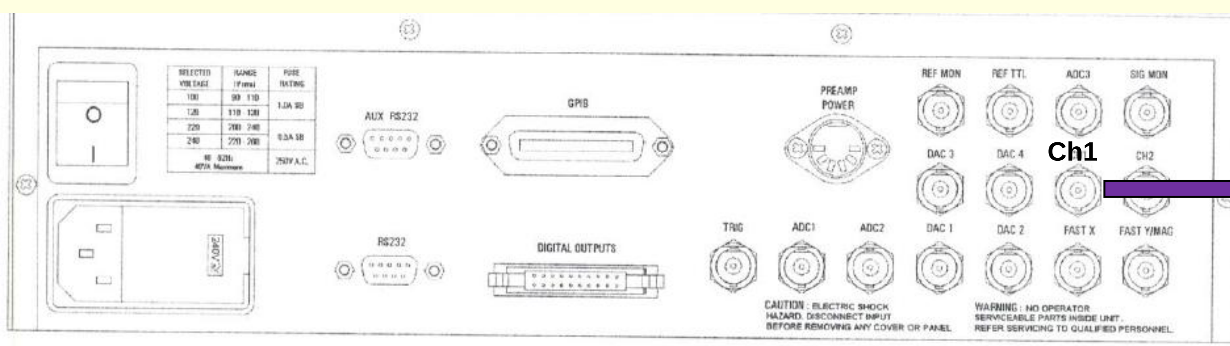
Lock-in Amplifier Connections

A lock-in amplifier can extract a signal amplitude at frequency of the reference signal and phase shift with respect to reference signal.

Output signal (from the BNC connector "Ch1" on the rear panel) should be directed to the Analog-Digital Convector in the *Spectral Measurement System* ,ARC

Input Signal from Optical Detector

Reference Input



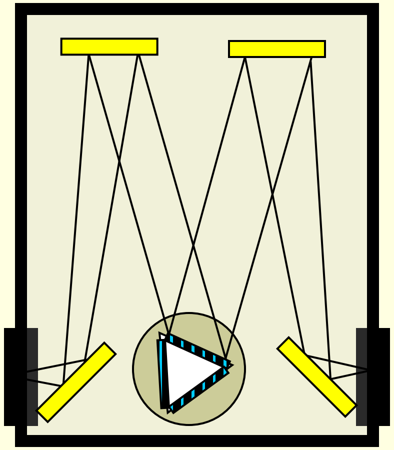
Ch1

Signal output

To Analog-Digital Converter (Ch1 in SpectraPro-300i CONTROL unit)

Spectra Pro 300i

Optical design: Czerny – Turner

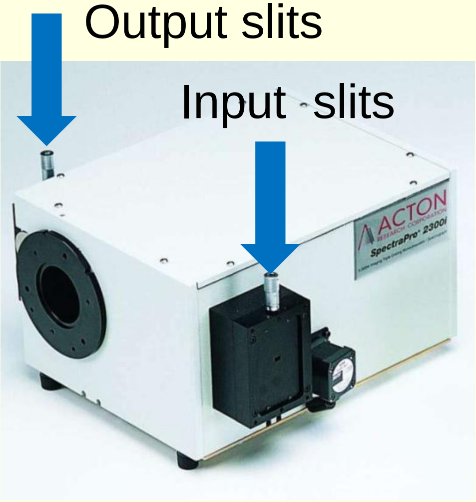


Focal length: 300 mm
Aperture ratio: f / 4

Grating size: 68 x 68 mm

Grating mount: triple-grating turre
Grating #1 300gr/mm (λ_{blaze}=) (λ_{max}=5.6)
Grating #2 600 gr/mm (λ_{blaze}=) (λ_{max}=2.8)
Grating #3 150 gr/mm (λ_{blaze}=) (λ_{max}=11.2)

Standard slits: adjustable
from 10 µm to 3 mm wide;



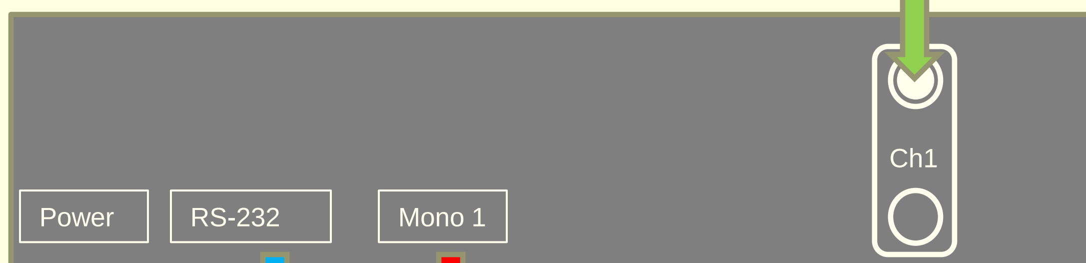
Linear dispersion (nm/mm)@500 nm :
11- Grating #1 300gr/mm
5- Grating #2 600 gr/mm
21- Grating #3 150 gr/mm

Spectra Pro 300i Connections

To Power Supply unit

To Control Unit (NCL)

From Lock-in- Amplifier

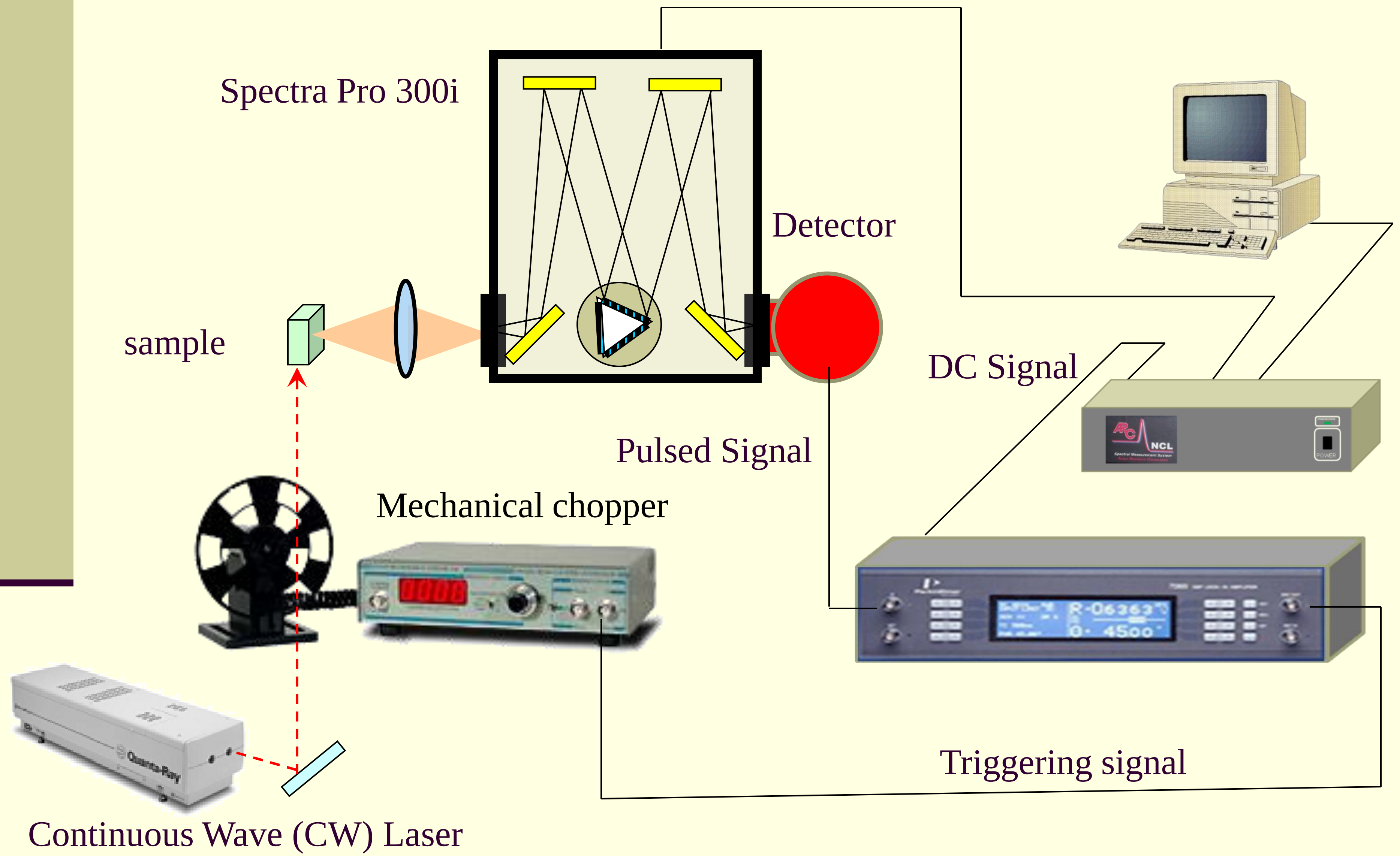


To Power Supply unit

To Computer

To Spectrometer

Experimental setup



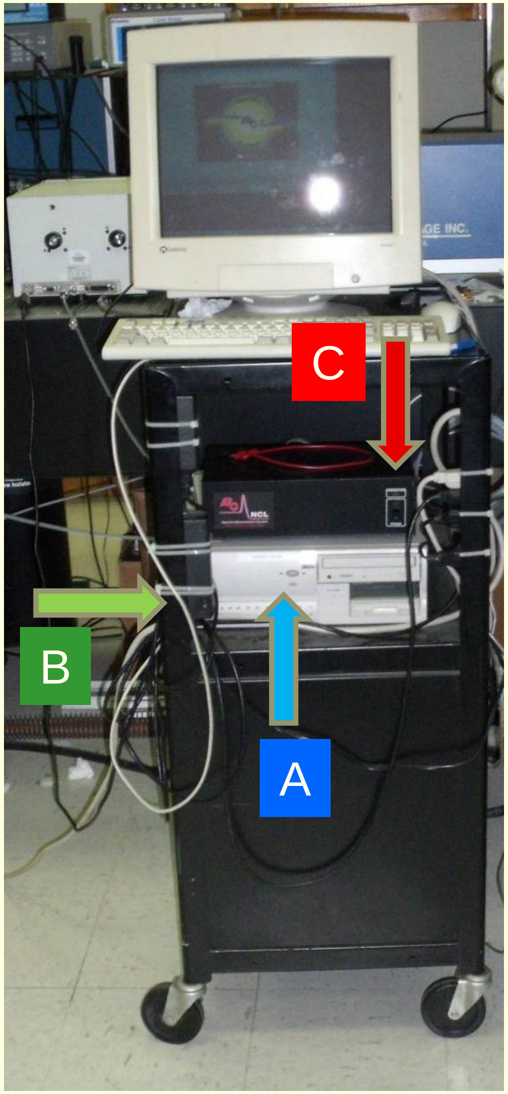
Operation Procedure

1.Switch on :

Mechanical chopper (see manual)
Detector Power Supply (see manual)
Lock-in-Amplifier (see manual)

2. Switch on Spectra Pro 300i :

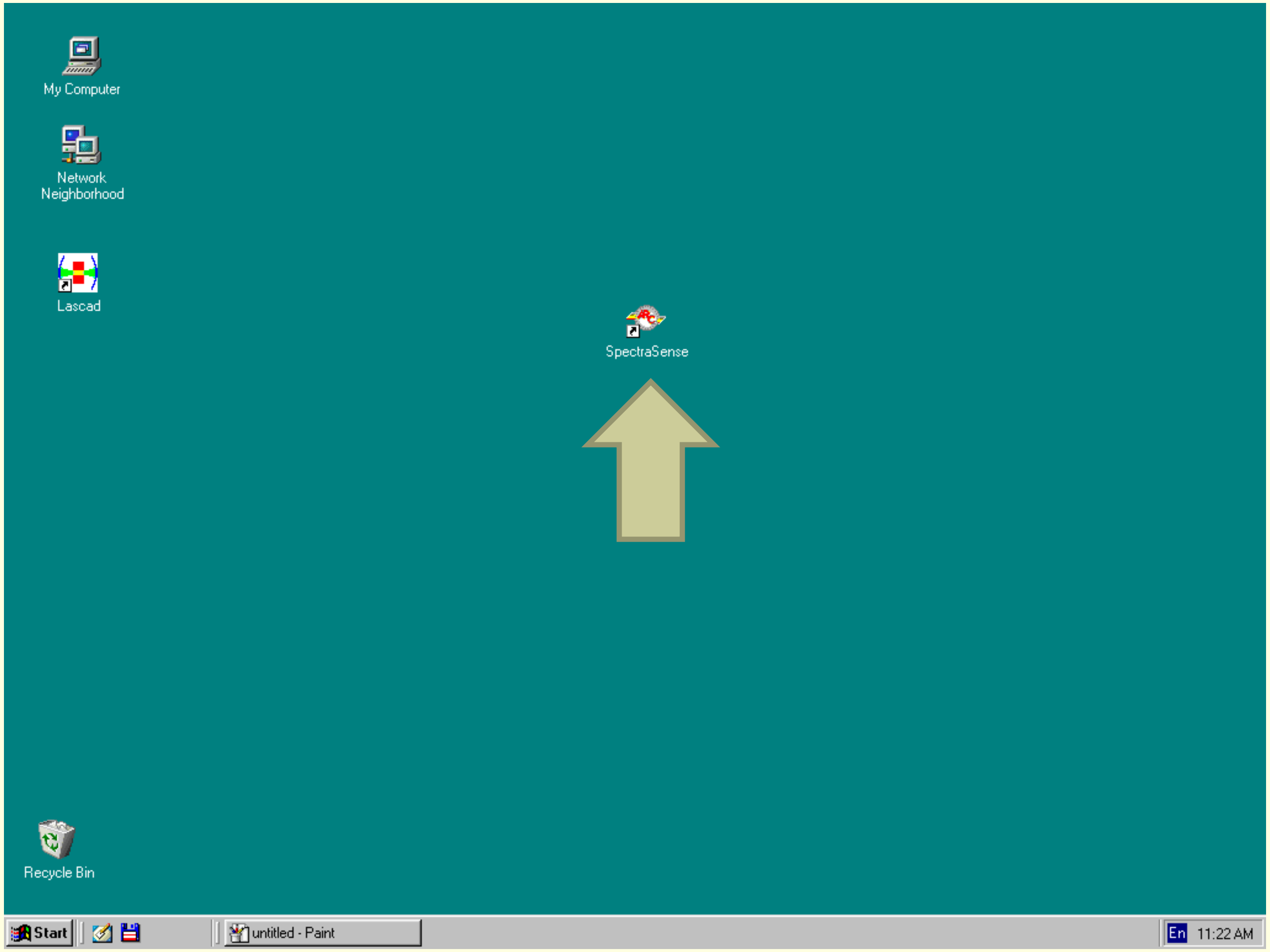
A-Switch on PC
B-Switch on Spectrometer power supply
C- Switch on Controller Unit (NCL)



Do not switch Laser on !!!

Operation Procedure

3. Run "SepctraSense" Program



Operation Procedure

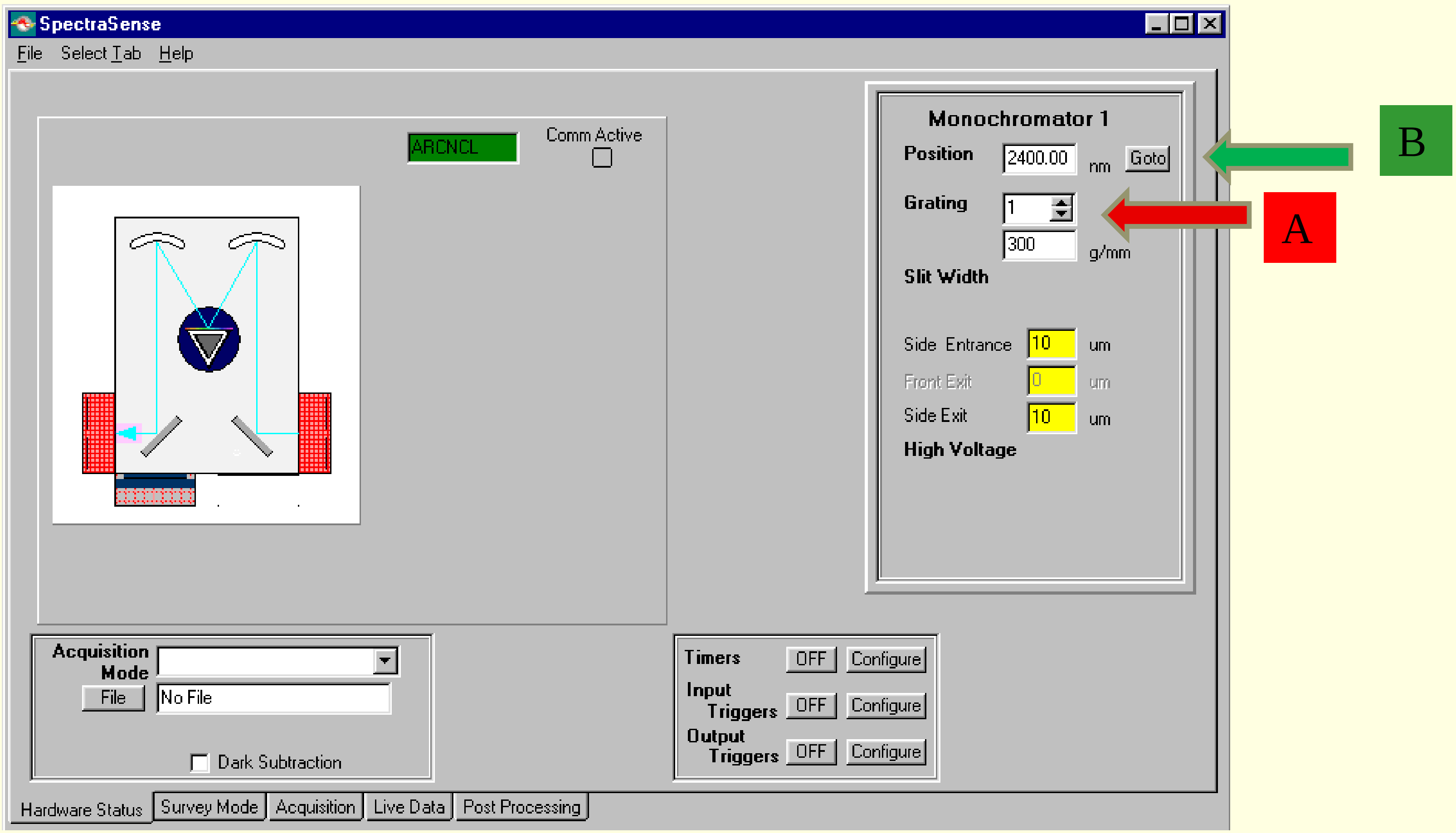
4. Select Hardware Status Menu

Here

Or Here

Operation Procedure

4. Select grating (#1,#2, or #3) –A
5. To Select required wavelength : input wavelength, in nm and press “GOTO” -B

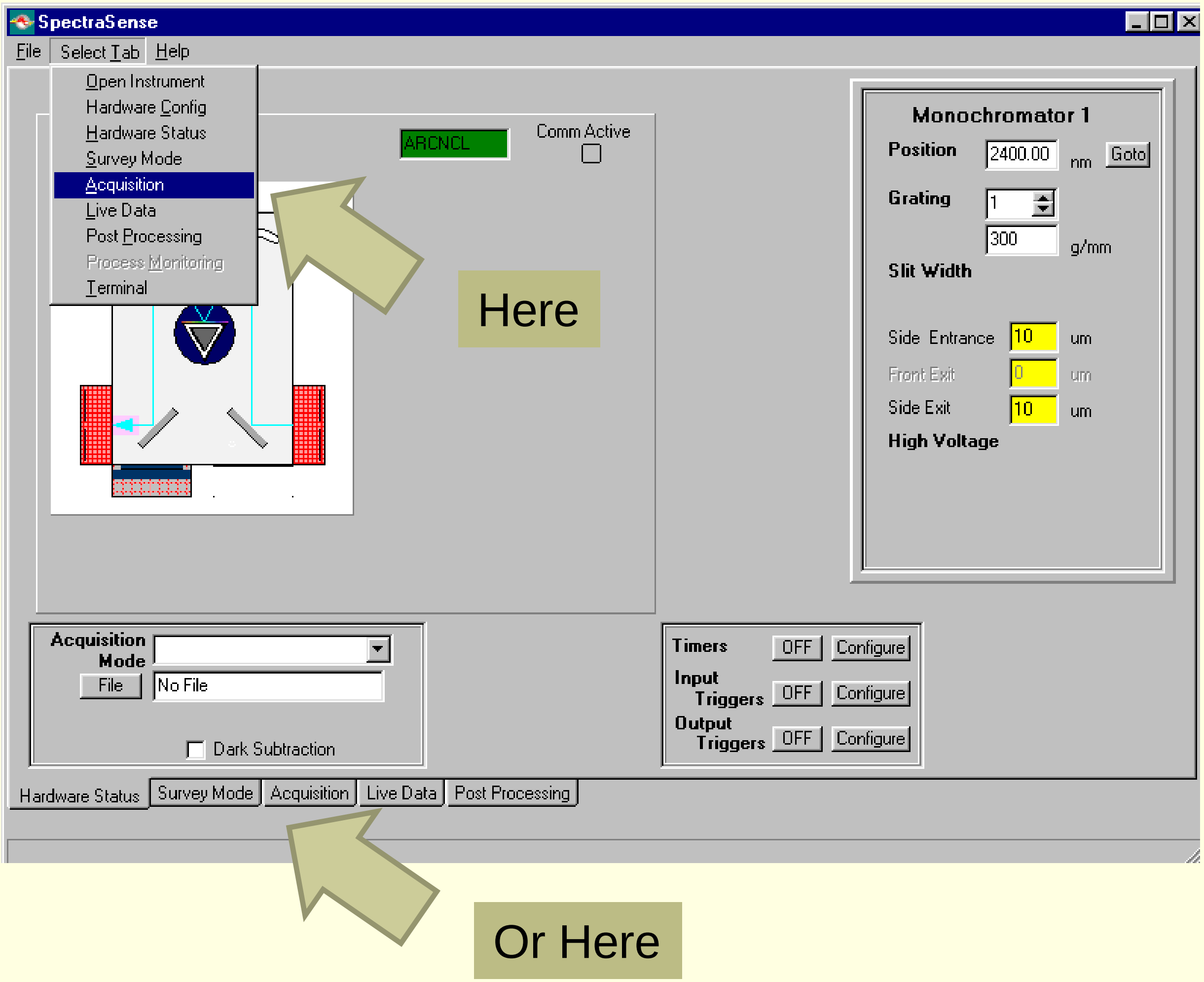


6 . Switch laser on according to the laser manual (see safety instruction !!!)

Operation Procedure

6. For Spectra Measuring:

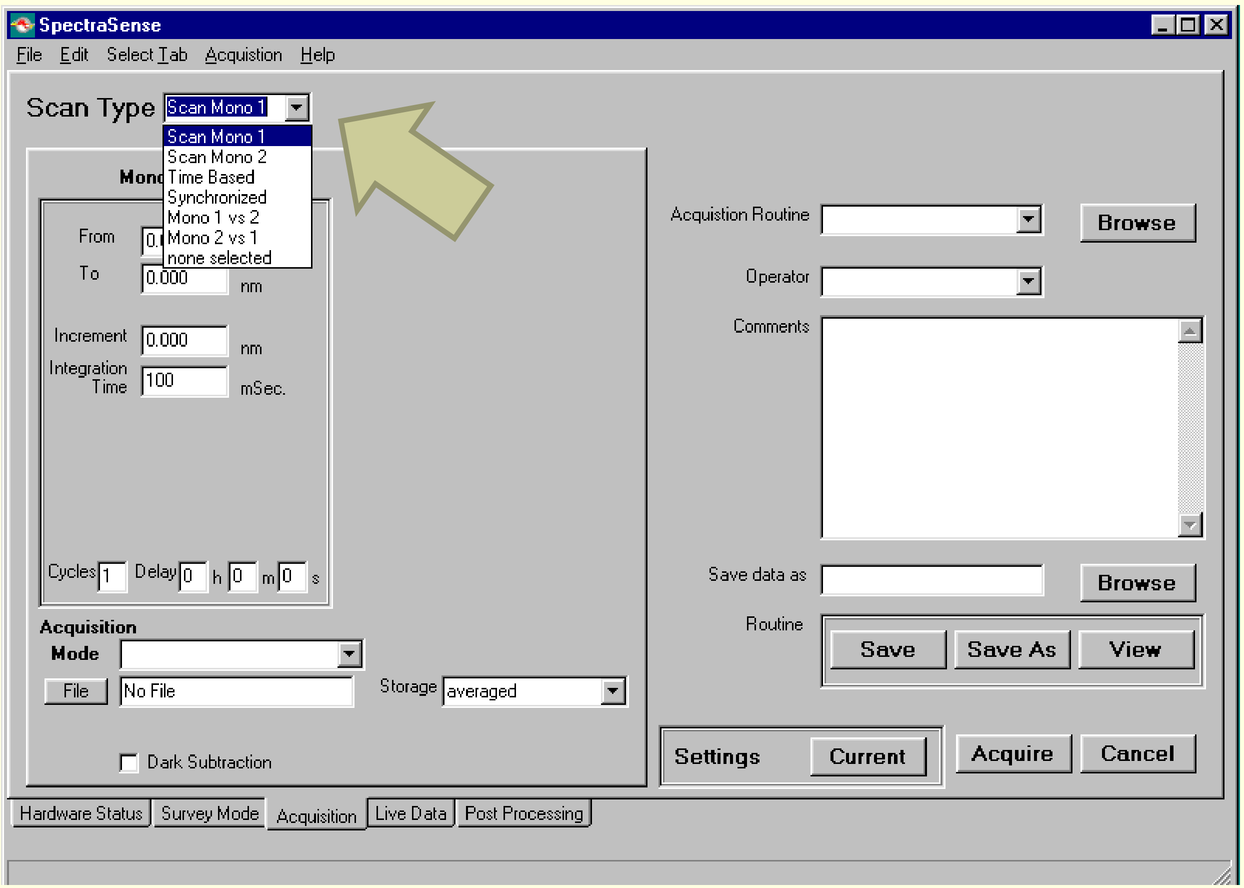
6.A- Select Accusation mode



Operation Procedure

6. For Spectra Measuring:

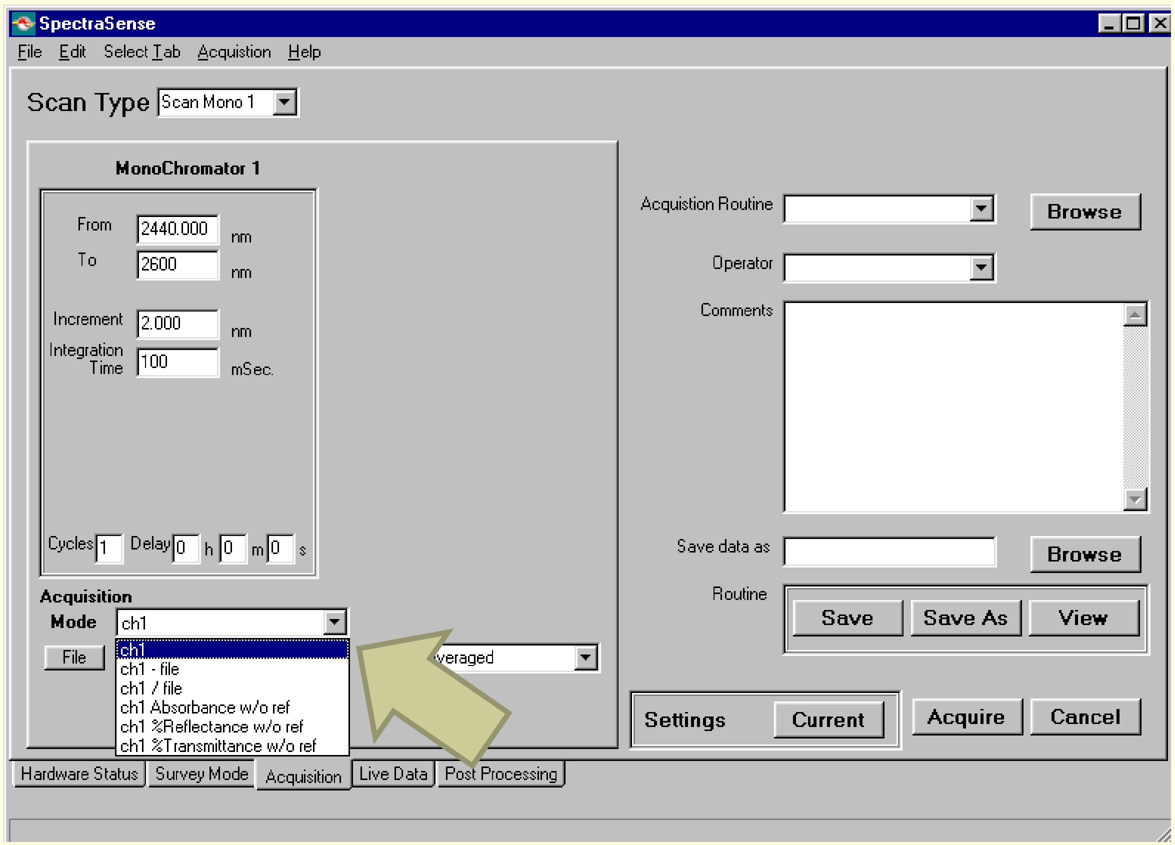
6.B- Select Scan of the Monochromator #1



Operation Procedure

6. For Spectra Measuring:

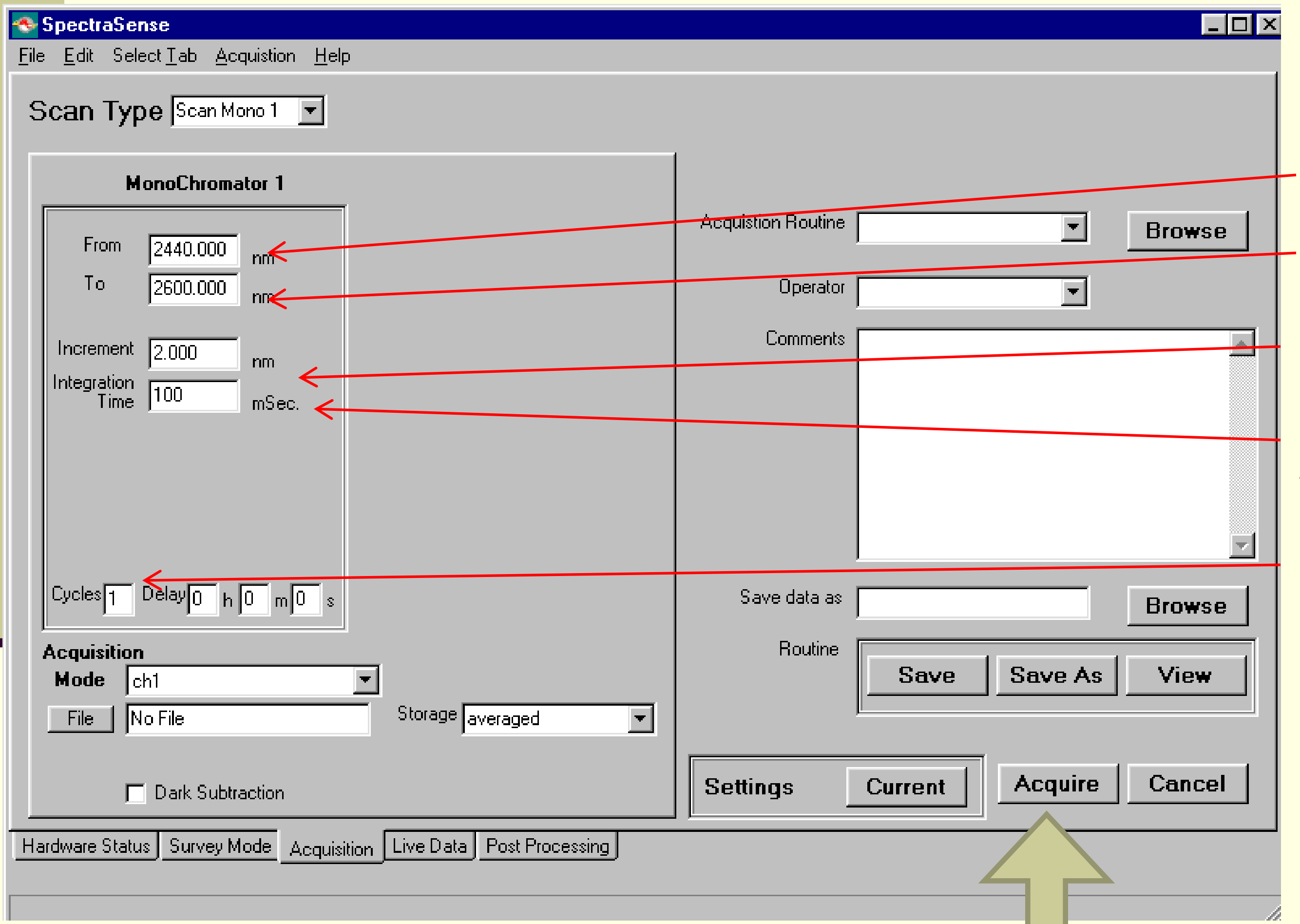
6.D- Select Acquisition Mode – Chanel #1



Operation Procedure

7. For Spectra Measuring:

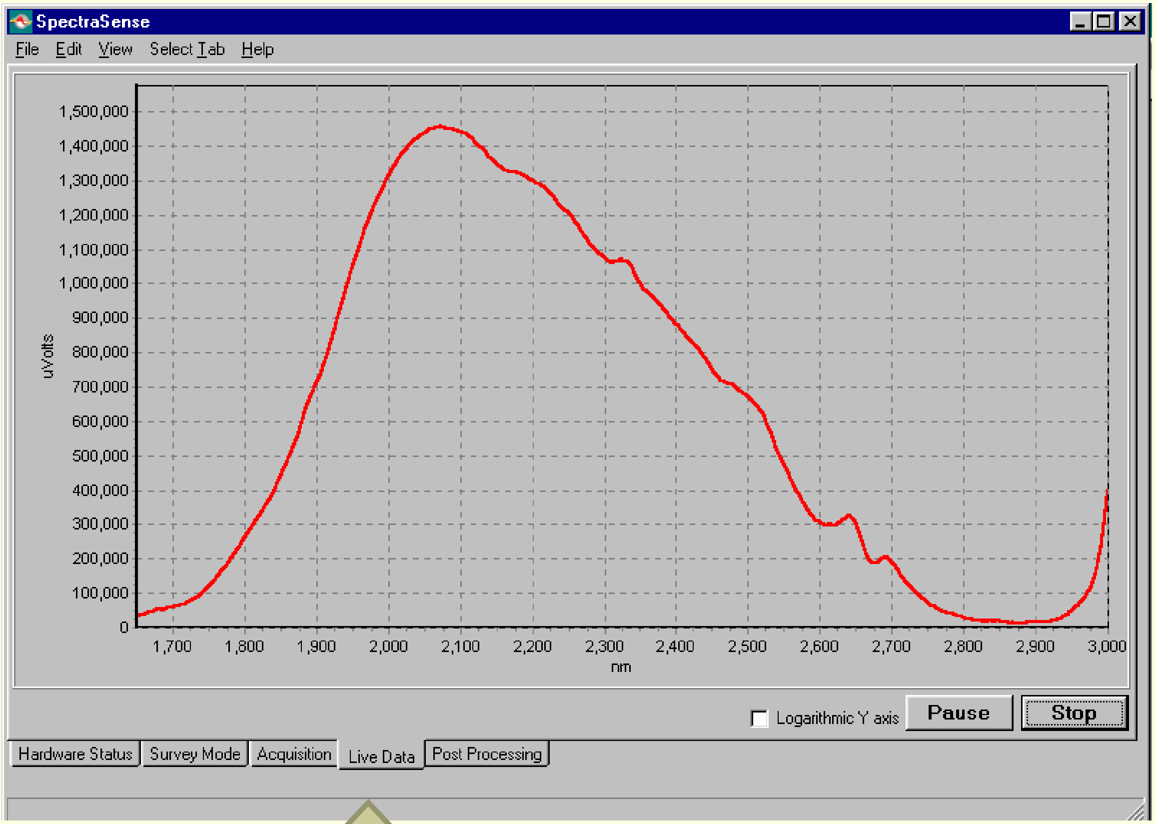
7.E- Select Scan Parameters



- E1-Initinal Wavelength
- E2- Final Wavelength
- E3 –Increment
- E4- Integration Time at each wavelength
- E5- Number of scanning cycles

8. Press Acquire to start measurements

Results will be shown in the “Live Data’ window



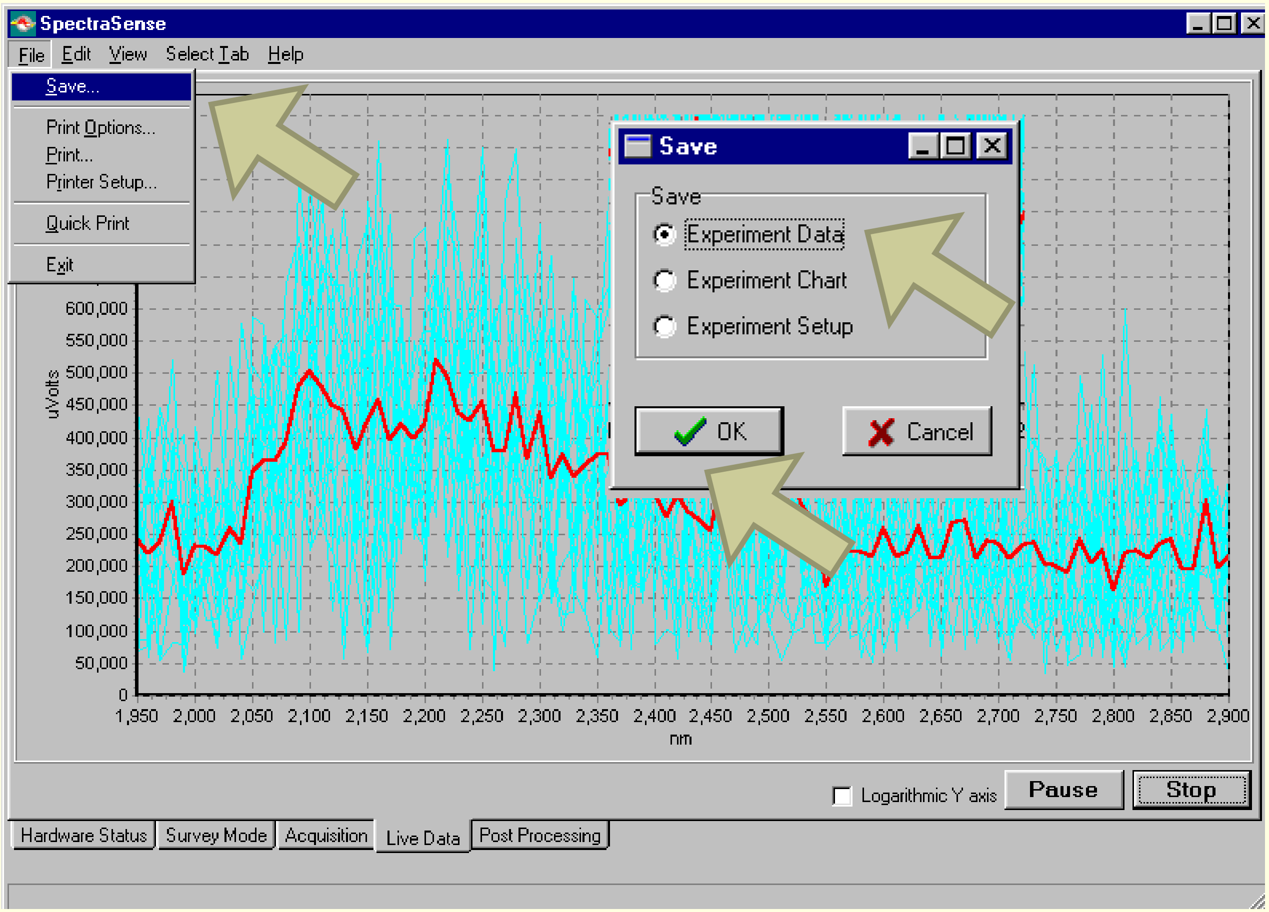
9. To save Spectra in the ASCII code (Text File)

9.1 Select File>Save

9.2 Select “Experiment Data”

9.3 Press “OK”

9.4 Select Directory and File Name



Operation Procedure

10. After work done, shutdown :

- Laser (according manual)
- Detector Power Supply Unit
- Chopper
- Lock-in –Amplifier
- NCL controller
- Monochromator power supply unite