

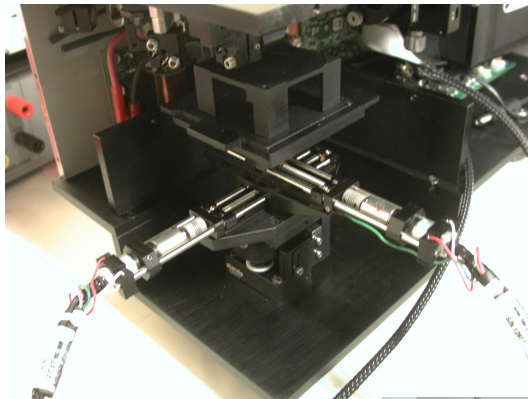
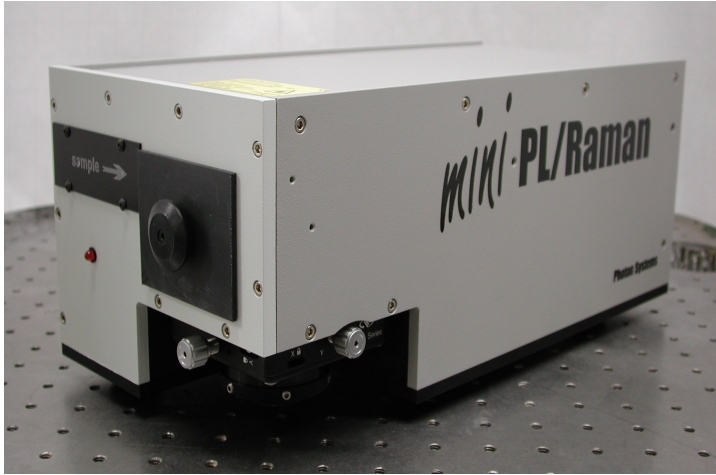
***Technology and Applications Overview
For Photoluminescence, Fluorescence Detection***

Photon Systems, Inc.

***William F. Hug, Ph.D.
Ray D. Reid, M.S.***

Mini PL/Raman Spectrometer

Features:



- Deep UV resonance Raman or wide bandgap semiconductor PL
- Fully integrated, self contained, system
- 5.5(224nm) or 5.0 eV(248.6nm) laser excitation
- 1/8 m Czerny-Turner spectrograph with two computer controlled gratings. Specs with 125um entrance slit:
 - 1200g/mm grating 0.7 nm resolution (FWHM)
 - 3600g/mm grating 0.2 nm or 35 cm^{-1} resolution (FWHM)
- Digital PMT controller with gated box car integrator & averager for low noise digital emission measurement
- Measurement of excitation and emission energy
- X-Y-Z stage manual sample control 50mm standard
- 50mm X-Y motorized stage including mapping software optional.
- Up to 50 mm diameter sample size
- LabView interface and control of laser, spectrograph, PMT, spectral data
- Analysis software included, FWHM, Peak, Side lobe identification, spectral subtract, normalize etc.
- Highly portable 15 x 18 x 36cm, <8Kg
- < 20Watts (90-240VAC) input
- < \$33,000

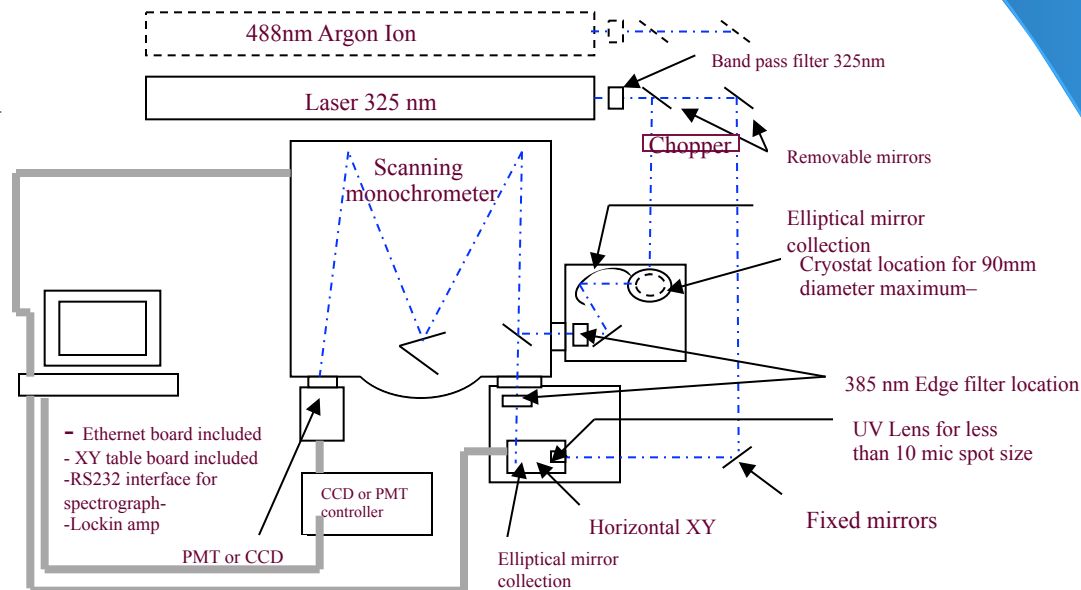
Wide Band Gap Laser excited Photoluminescence Instrument

- Wide Band Gap Photoluminescence Need
- New Deep UV laser sources
- Gated Box Car integration PMT controller
- 1/8 meter dual grating monochrometer
- Integrated Solution
- Instrument demonstration

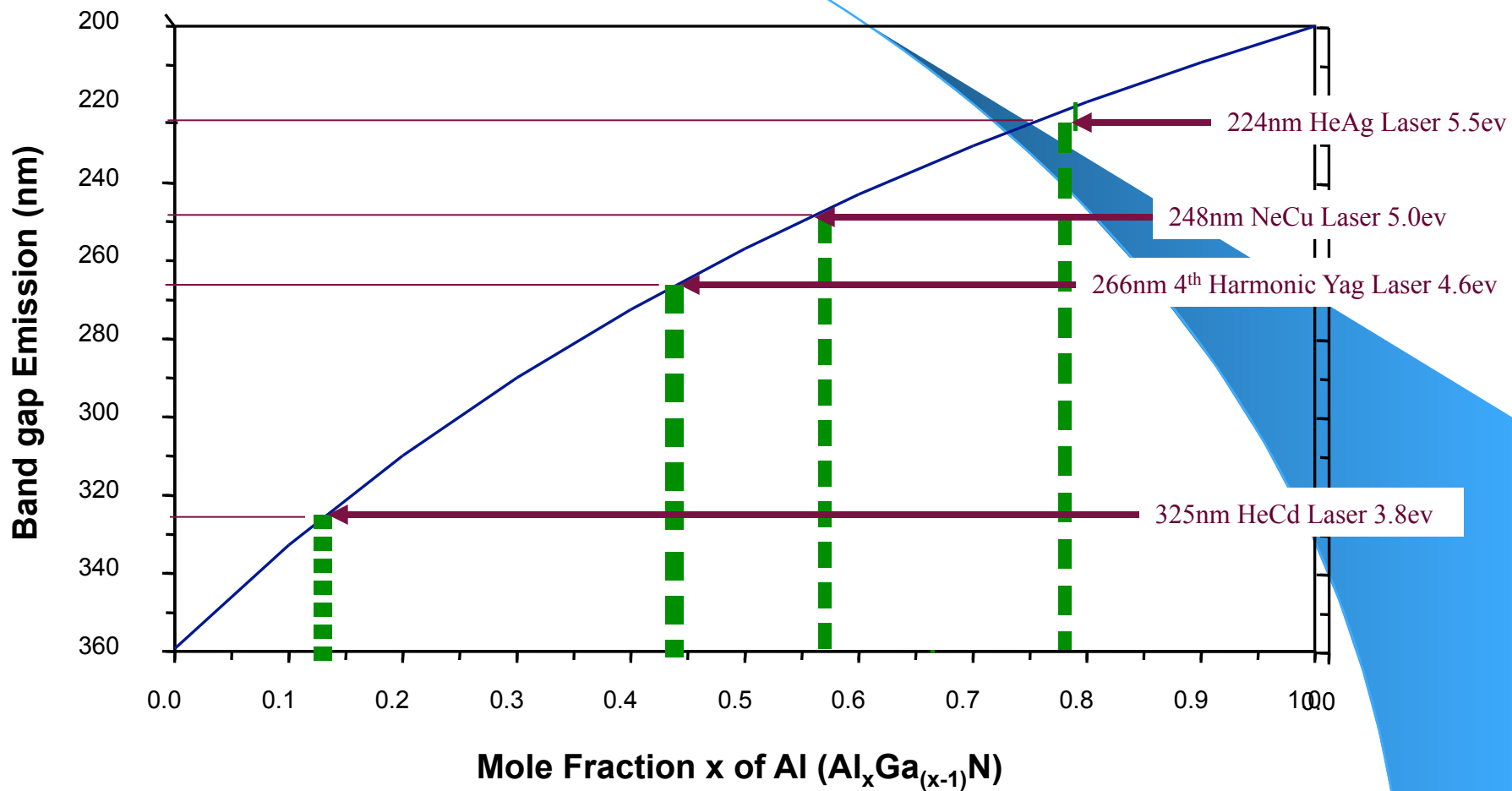
Wide Band Gap Laser Induced Photoluminescence

- Direct Room temperature or Cryo-temperature PL
 - III-Nitrides and SiC Materials for:
LEDs, Laser Diodes, and Photodiodes
 - High breakdown fields and High saturation velocity characteristics
High Temperature and High Power transistors

Typical System



Typical AlGa_xN Band gap vs PL laser excitation



Mini PL 5.5ev PL System from Photon Systems Inc.

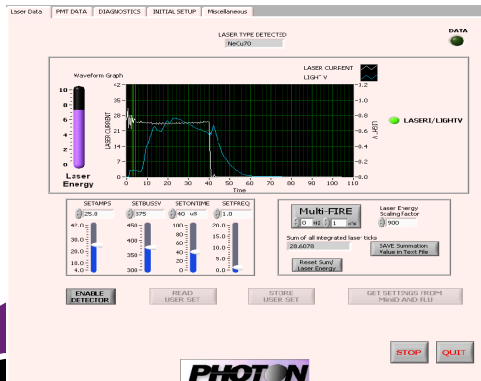
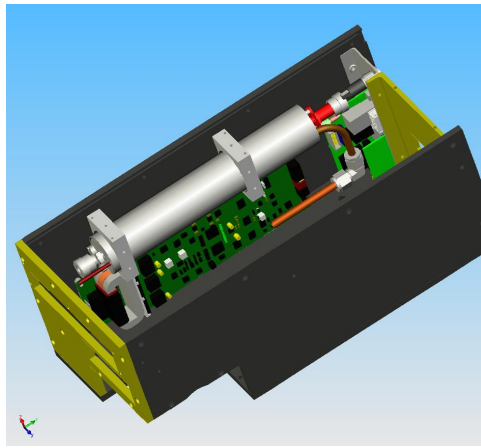
Laser excitation source

Based on the Photon Systems family of Series 30 Deep UV electronically chopped laser products @ 224nm and 248nm

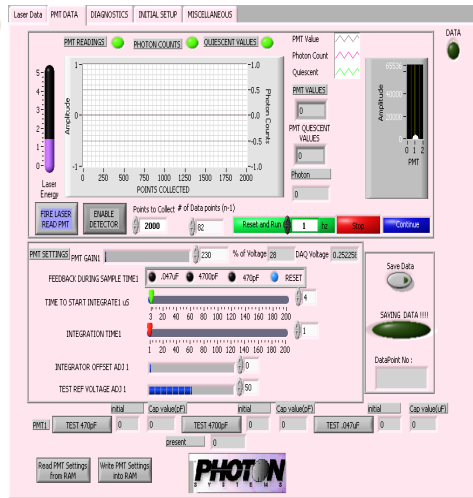
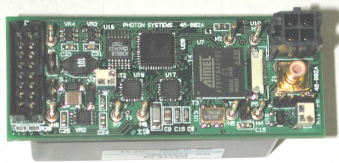
Specifications:

	NeCu 30(5.0ev)	HeAg 30(5.5ev)
Wavelength	248.6nm	224.3nm
Photon energy	5.0ev	5.5ev
Energy(data point)	15uJ	5uJ
Pulse width	35us	70us
Data sample rate	5Hz	5Hz
Line width	3GHz	3GHz

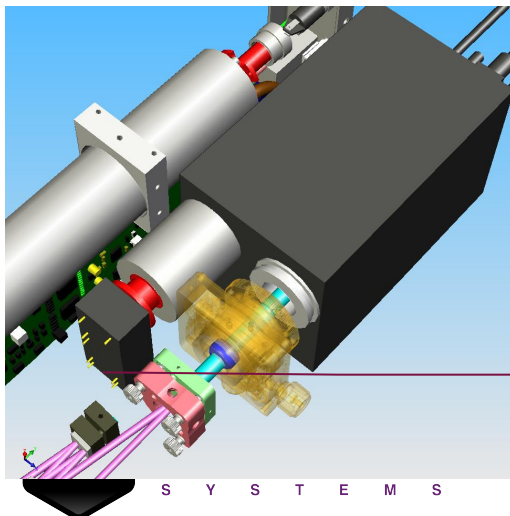
LabView controlled with open architecture



Gated Box Car Integration PMT Controller

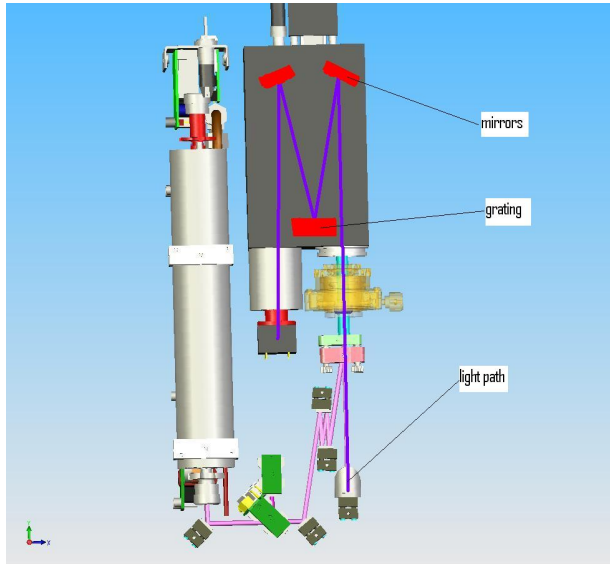


- **Digital PMT or photodiode controller with boxcar integrator, digitizer, and averager**
- **9 decades of detection range (5 with PMT gain and 4 with Electronic Gain)**
- **32 bit, 75 Mips processor with 2M RAM and 256K flash**
- **16 bit A/D with 16 bit resolution**
- **Fully adjustable start/finish signal integration, 2 μ s resolution**
- **Built in test and Electronic Calibration**
- **RS422 interface/control by LabView**



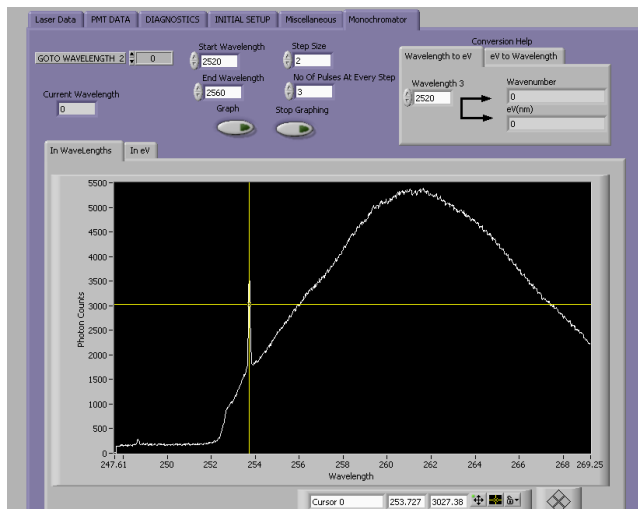
Gated Box Car PMT controller and Hamamatsu PMT module

Scanning Monochromator Detection system

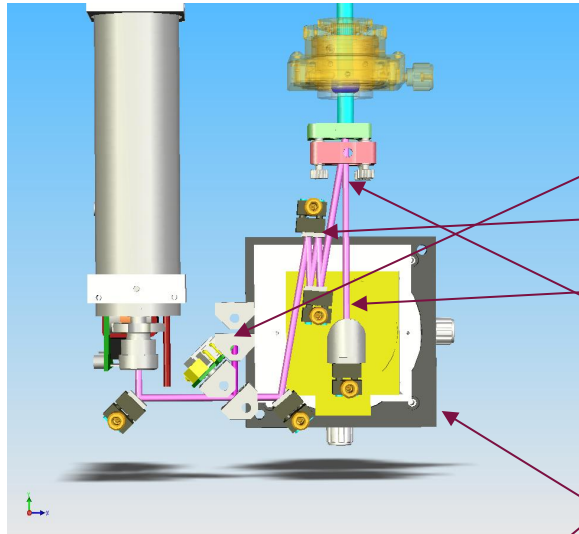


Monochromator Specifications:

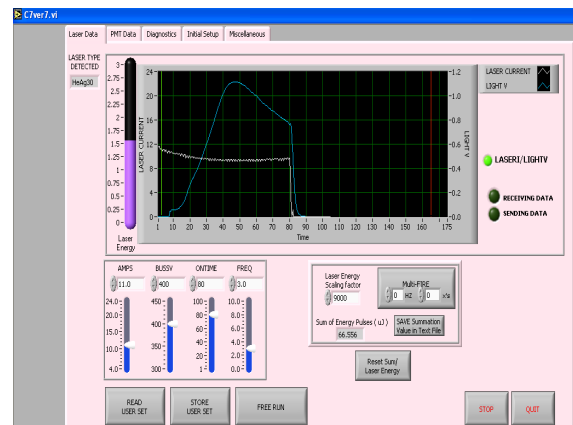
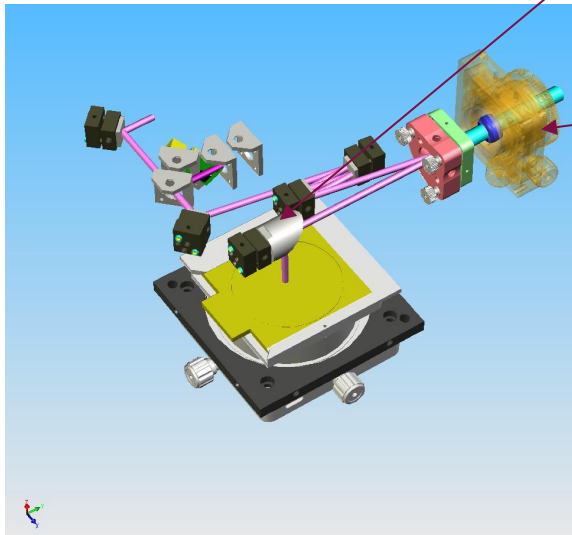
- 1/8th meter Czery-Turner
- Dual Grating program selectable
- F # 3.9
- Wavelength Precision: 0.2nm
- Wavelength Accuracy: ± 0.2 nm
- Slewing Speed: >100nm/second
- Max Resolution:
 - <1nm w/1200G/mm grating (included)
 - <0.25nm w/3600nm grating (optional 2nd)
- Software: Demonstration control program and LabView driver included.
- Serial and USB control provided



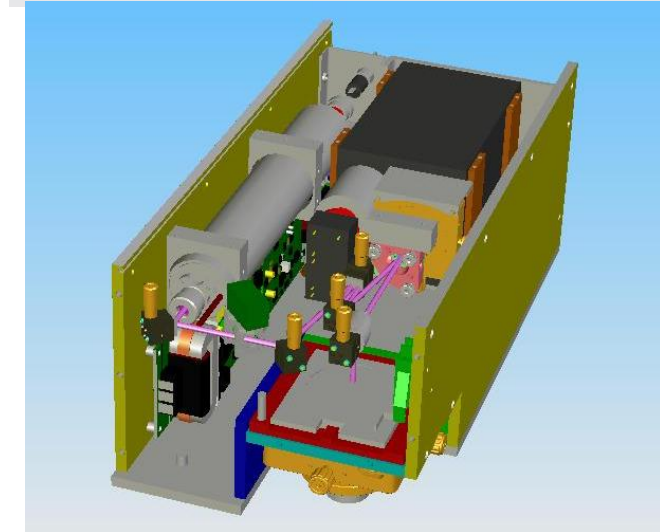
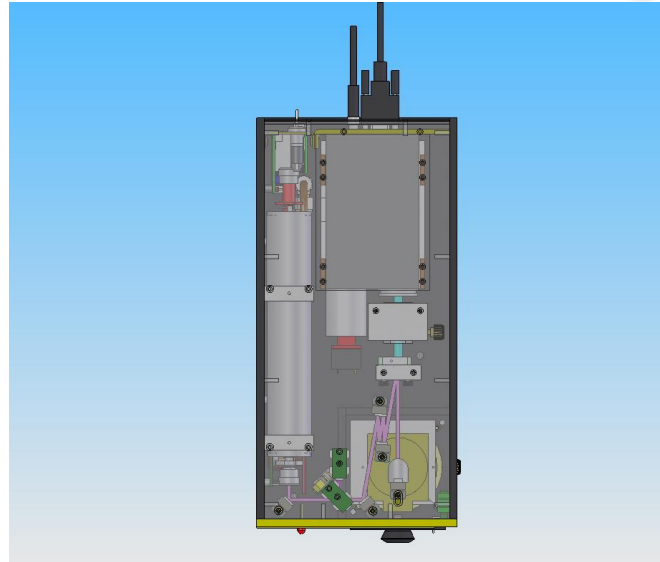
Optical Path



- Beam sample scope output
- Laser line filter system
- 180° Backscatter detection
- Shallow angle Injection
- Off axis Parabola collection (achromatic)
- X – Y – Z sample manipulation
- X – Y – Z focus adjustment on Monochromator injection lens

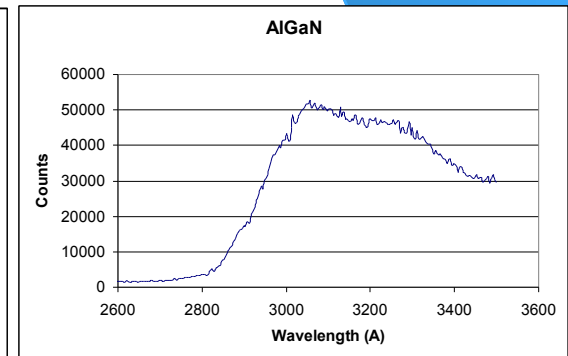
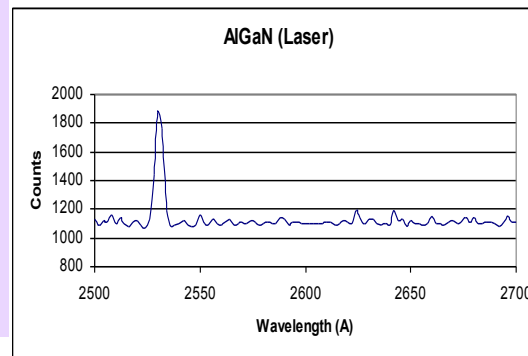
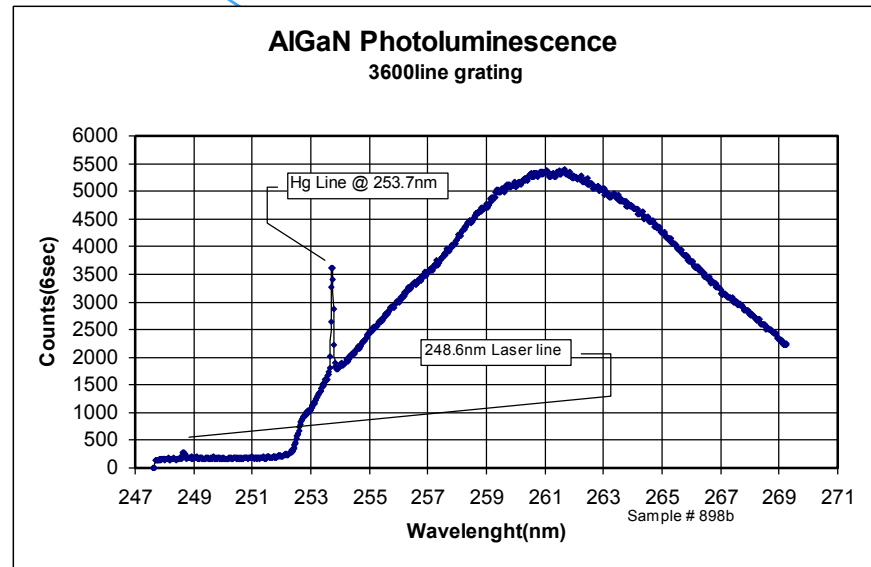
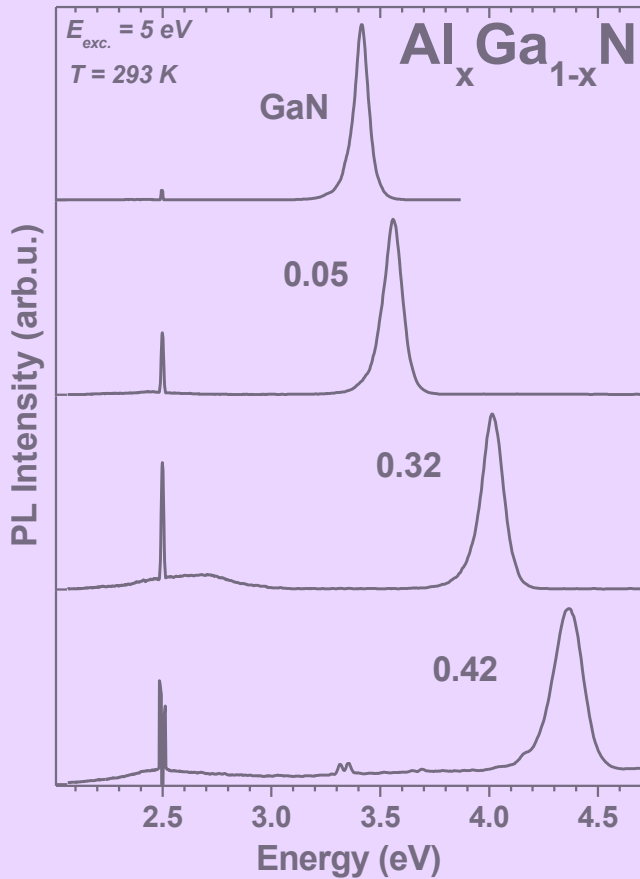


Integrated Solution



- Fully integrated Deep UV PL instrument
- Rugged Reliable and Portable PL solution
- < 15 Watts input, can be Battery operated, no circulating air
- > 15,000 sample lifetime
- Warrantee 1 year
- 5.0 and 5.5ev PL solutions
- LabView interface
- Sample size up to 2" wafer
- 90-240VAC input, 50/60Hz
- CE

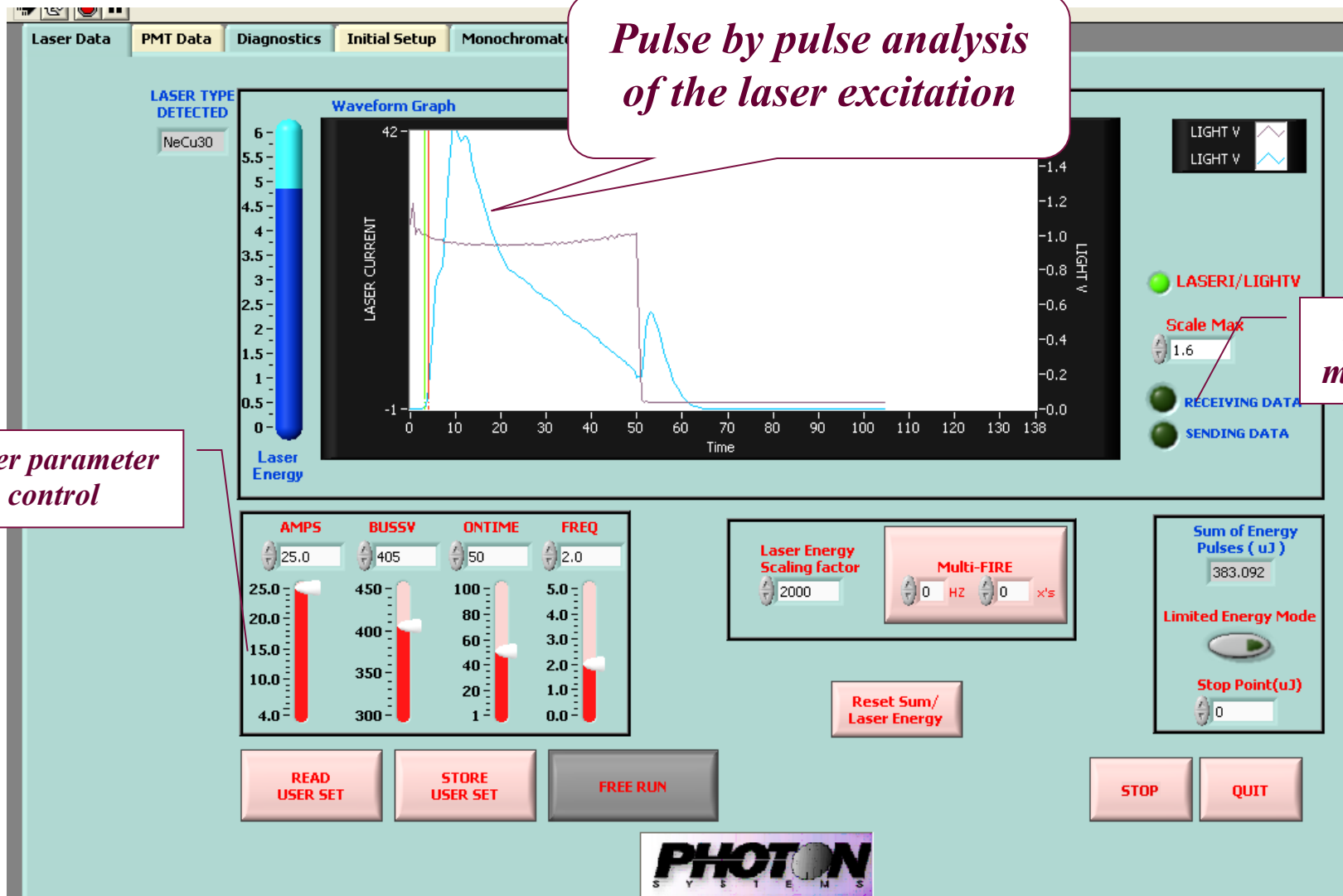
Typical Spectra



What can the Mini PL do?

- Wideband gap PL
 - ~250nm-700nm analysis for the PL 5.0 system
 - ~230nm-700 analysis for the PL 5.5 system
- Surface contamination with Fluorescence detection
- Raman analysis (35 cm^{-1} resolution)

Operation of Mini PL



Pulse by pulse analysis of the laser excitation

Laser parameter control

Data monitor

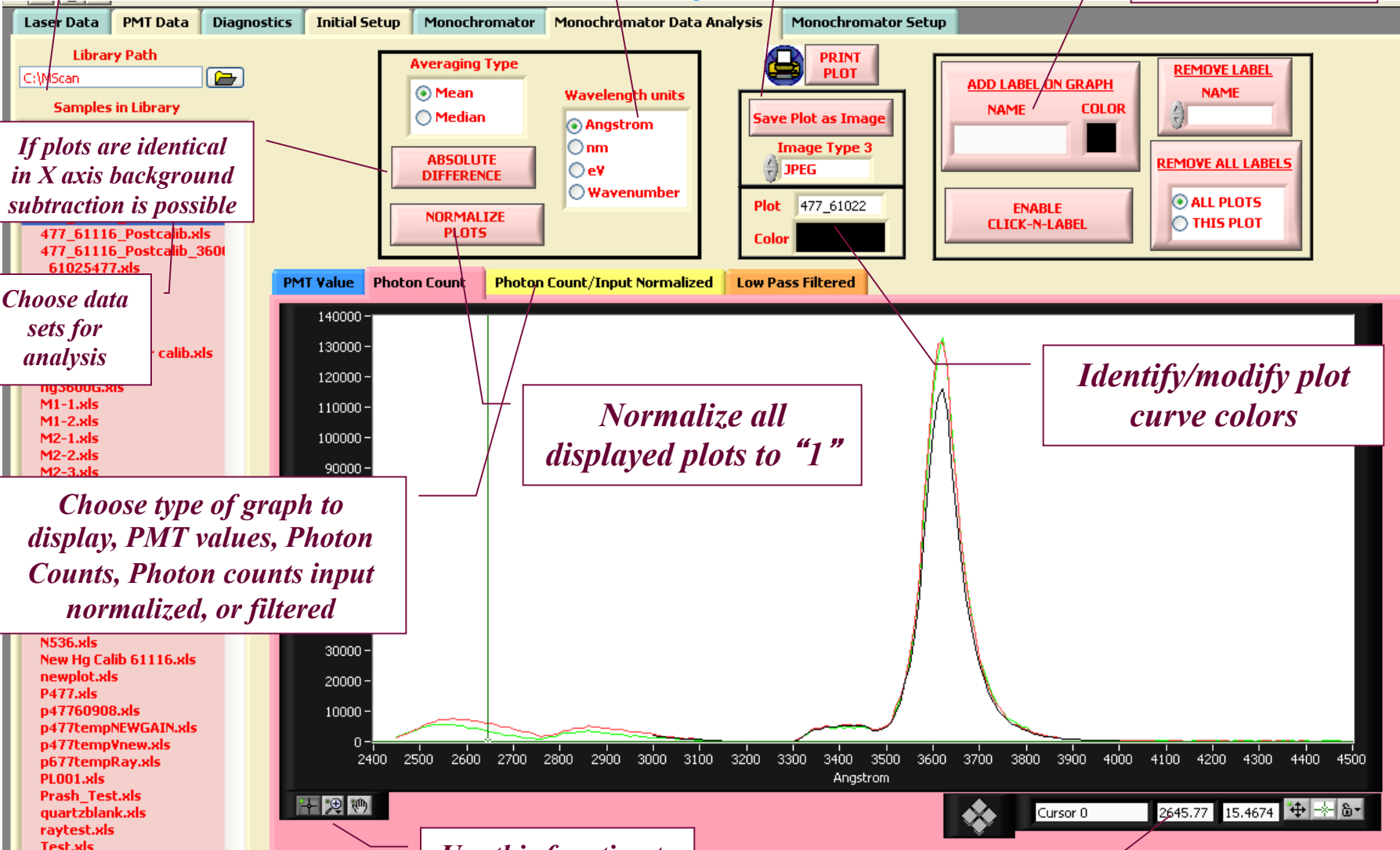
Data ANALYSIS

Choose data file set for analysis

X axis scale type A, nm, eV cm⁻¹

Save plot view, jpg, bmp etc

Add/Remove labels



If plots are identical in X axis background subtraction is possible

Choose data sets for analysis

Choose type of graph to display, PMT values, Photon Counts, Photon counts input normalized, or filtered

Normalize all displayed plots to "1"

Identify/modify plot curve colors

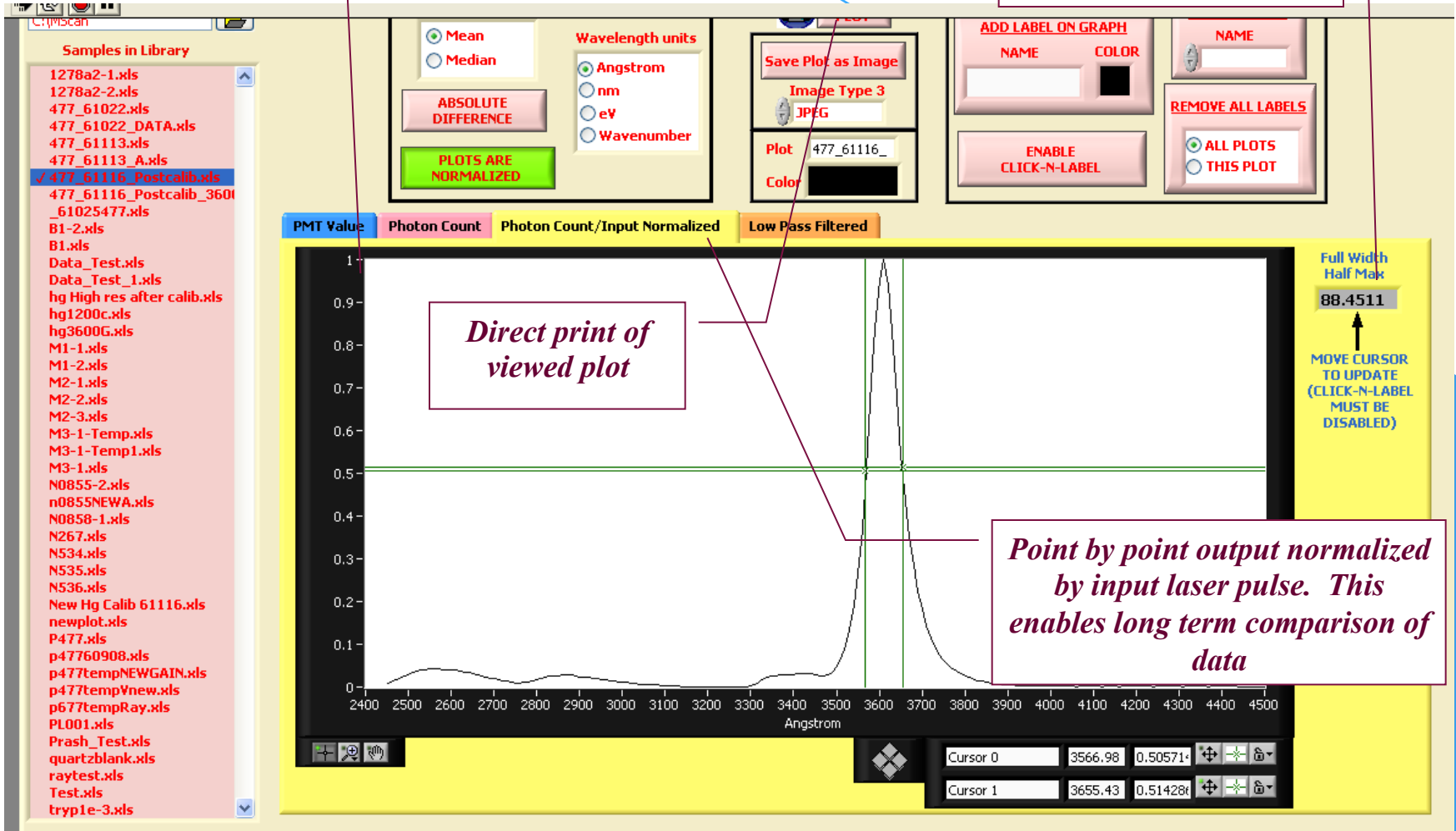
Use this function to enhance graphic views

Set or locate cursor location

More analysis info

All plots normalized to 1 for comparison

Full Width Half Max (FWHM)



Click on
Monochromator page

Align Sample
This function moves you to Laser Page and
enables you to optically locate sample in
laser beam and do a rough focus.

Focus sample
Once the sample is in the beam you
can use this button to optimize the
signal. If you do not know where the
center wavelength of the sample is
you will then need to do a Quick
Scan

The screenshot displays the 'Monochromator Data Analysis' page of the Photon Systems software. The main window features a large plot with 'Amplitude' on the y-axis (0 to 5) and 'POINTS COLLECTED' on the x-axis (0 to 100). The plot shows a signal that rises to a plateau around 20 points, has a sharp dip at approximately 55 points, and then continues to rise. Above the plot are three status indicators: 'PMT1' (green), 'Quiscent1' (green), and 'Photon Count 1' (green). To the right of the plot is a 'Photon Counts' histogram showing three distinct peaks labeled 1, 2, and 3. Below the plot are several control elements: a 'Laser Energy' vertical bar on the left, a 'DETECTOR ENABLED' button, a 'FIRE LASER READ PMT' button, and a 'Points to collect' slider set to 100. A 'Reset and Run @ 3 hz' button is also present. Below these are 'Stop' and 'Continue' buttons. To the right of the plot area are 'PMT VALUE' and 'Photon Cnt 1' waveforms, and a 'PMT VALUES' section with a '64' input field and a '17549' output field. On the far right, there are 'RECEIVING DATA' and 'SENDING DATA' status indicators, a 'Photon Count Cluster' field showing '3.63443E+6', and a 'Serial#' field showing '56'. Below the main plot area is a detailed control panel for 'PMTGAIN 1' (set to 27889), 'Control Voltage 1 %' (set to 53), and 'DAQ Output Voltage 1' (set to 0.47849). This panel includes several gain and capacitor selection buttons (0.047uF, 4700pF, 470pF, 47pF), a 'GAIN 1' slider, and various timing and offset adjustment sliders. A schematic diagram of the PMT circuit is shown on the right side of this panel. At the bottom of the interface, there is a 'Read PMT Settings from RAM' button, a large blue display showing '60347', and several 'Initial Value' fields with values like 57907, 59611, and 60347.

*Click on
Monochrometer page*

Align Sample

This function moves you to Laser Page and enables you to optically locate sample in laser beam and do a rough focus.

Focus sample

Once the sample is in the beam you can use this button to optimize the signal. If you do not know where the center wavelength of the sample is you will then need to do a Quick Scan

The screenshot displays the Photon Systems software interface with several key components:

- Navigation Tabs:** Laser Data, PMT Data, Diagnostics, Initial Setup, Monochromator, Monochromator Data Analysis, Monochromator Setup.
- Control Panels:**
 - Wavelength units:** Angstrom (selected), nm, eV, Wavenumber.
 - SAVE DATA:** Add To Library, Save Plot as Image (Image Type 1: JPEG).
 - PMT Value:** .047uF, 4700pF, 470pF, 47pF. PMT Control Voltage %: 100. FIRE LASER READ PMT button. PMT Value: 3397.
 - Monochromator Setup:** Start Wavelength: 2400, End Wavelength: 4500, PMT Threshold: H 60000, L 2000. Step Size: 50. No Of Pulses /Step: 1. Pulse Rate: 5.
- Plots:**
 - Upper Right:** Photon Count vs Wavelength plot showing a peak at approximately 3600 nm.
 - Main:** PMT Value vs Wavenumber plot showing a peak at approximately 2681.8 cm⁻¹.
- Buttons:** ALIGN SAMPLE, FOCUS SAMPLE, Goto Wavelength, Current Wavelength, WITH AGC, SET DEFAULTS, INSTRUMENT MANUAL, Laser, VISIT PHOTON SYSTEMS WEBSITE.

Quick Scan

This function sets the step size to 5nm, Number of pulses to 1 and Pulse rate to max. It is used to understand basic spectrum of your sample. Upon completion you can:

- Click on wavelength chart in upper right to position the monochromator automatically,*
- Often it is best to then go back to focus sample to peak up the best response at the best wavelength.*
- Select desired wavelength range, Start and End,*
- Usually a smaller step size will yield better resolution and for a final plot if the signal is noisy, a higher number of pulses to average is desired,*
- In most cases a pulse rate of 5/sec is optimal*
- NOW YOU WILL OPERATE THE SYSTEM IN "Auto Run With AGC"*



PMT Value

Photon Count

Photon Count/Input Normalized

Low Pass Filtering

PMT Gain Capacitor

PMT Control Voltage 9%

EXPE

PMT U1



.04

PMT Value

Photon Count

Photon Count/Input Normalized

Low Pass Filtering

PMT Value

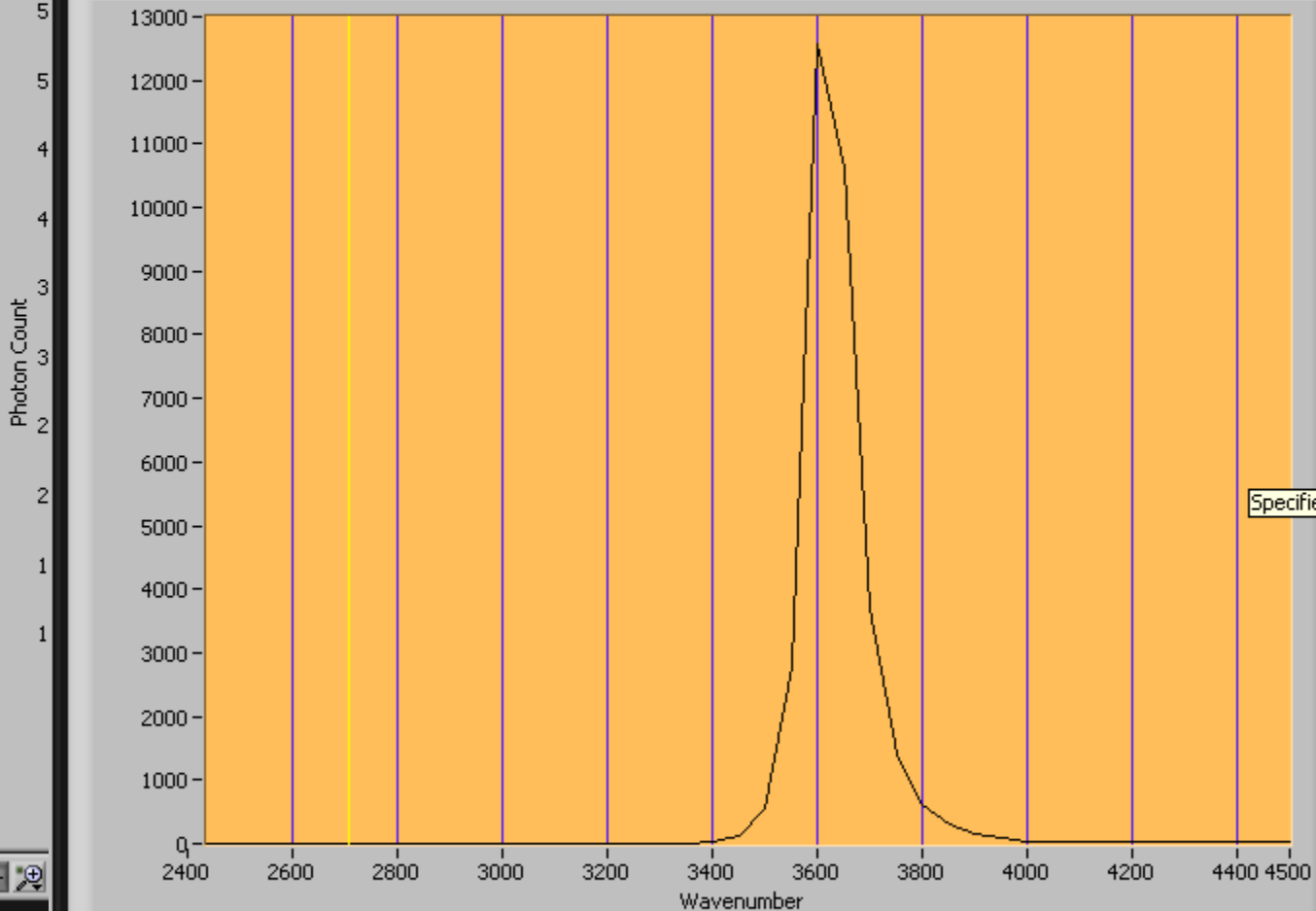
Photon Count

PMT Value

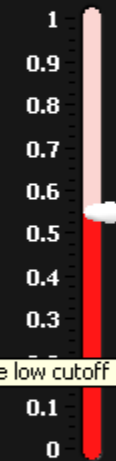
Photon Count

Photon Count/Input Normalized

Low Pass Filtering



Specifies the low cutoff frequency



Lower Cut-Off

0.548837

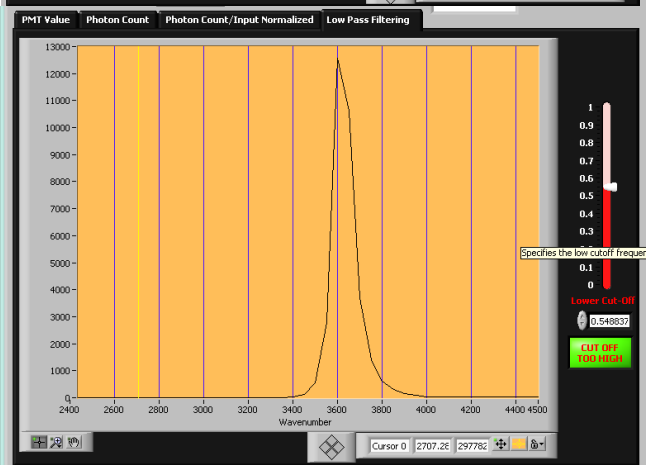
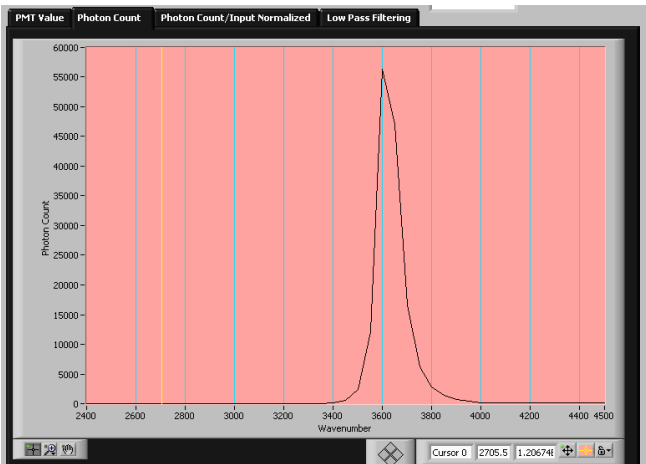
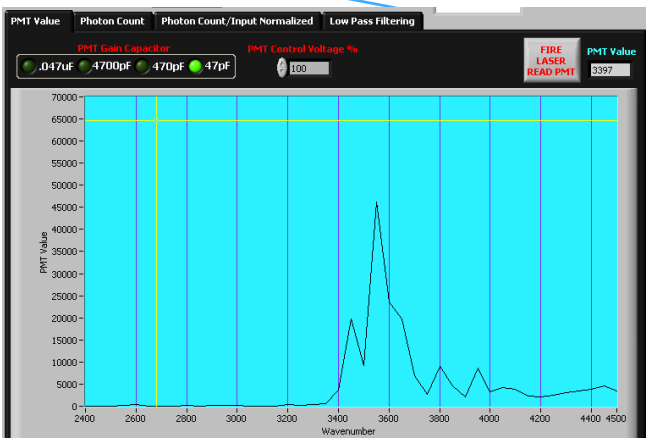
CUT OFF TOO HIGH



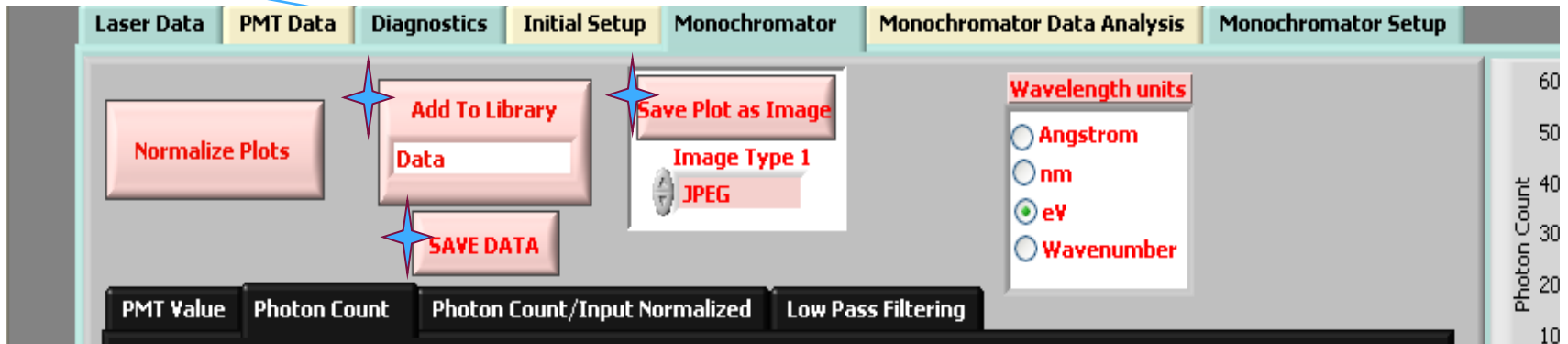
Cursor 0 2707.2E 297782



PHOTON SYSTEMS



- **PMT(Photon Multiplier Tube) view** shows the actual counts from the A-D, Range 200-65280. In addition is displayed the Gain 28-100% of the PMT(corresponding to the actual High Voltage being applied to to the cathode). The 4 decades of electronic gain are also displayed, 47pf-.047uf capacitors used in integrating the PMT cathodal current.
- The **Photon Count** view shows the actual calibrated photons hitting the photo cathode of the PMT. This is calculated knowing the QE and spectral response as well as accurate capacitor values, A-D well voltage and the Gain for the PMT. The Gain and QE are calibrated in a Look Up Table (LUT) at the factory and the Capacitor values are measured each time data is take as environmental conditions may affect these values.
- The **Photon Count/Input Normalized** view provides the most accurate display of the output. In this case the Signal is divided by the input power of the laser(uJ) resulting in a normalized signal which is independent of the input power or energy of the laser. Over long periods of operation this will provide a solid comparison of the data.
- **Low Pass Filtering** view provides a filter to enable analysis of noise or low output signals Absolute wavelength stability should not be assumed on this setting.



Saving Data/Information

Add Data to library.

This function takes the current data used to display the various graphs, PMT, Photon Count etc and saves them to a previously defined library. All the data necessary to recreate these are in an Excel formatted file. In addition, this library is used for the Monochromator Data Analysis Tab. Here you just type in the name of the data in the “white” area and press Add To Library.

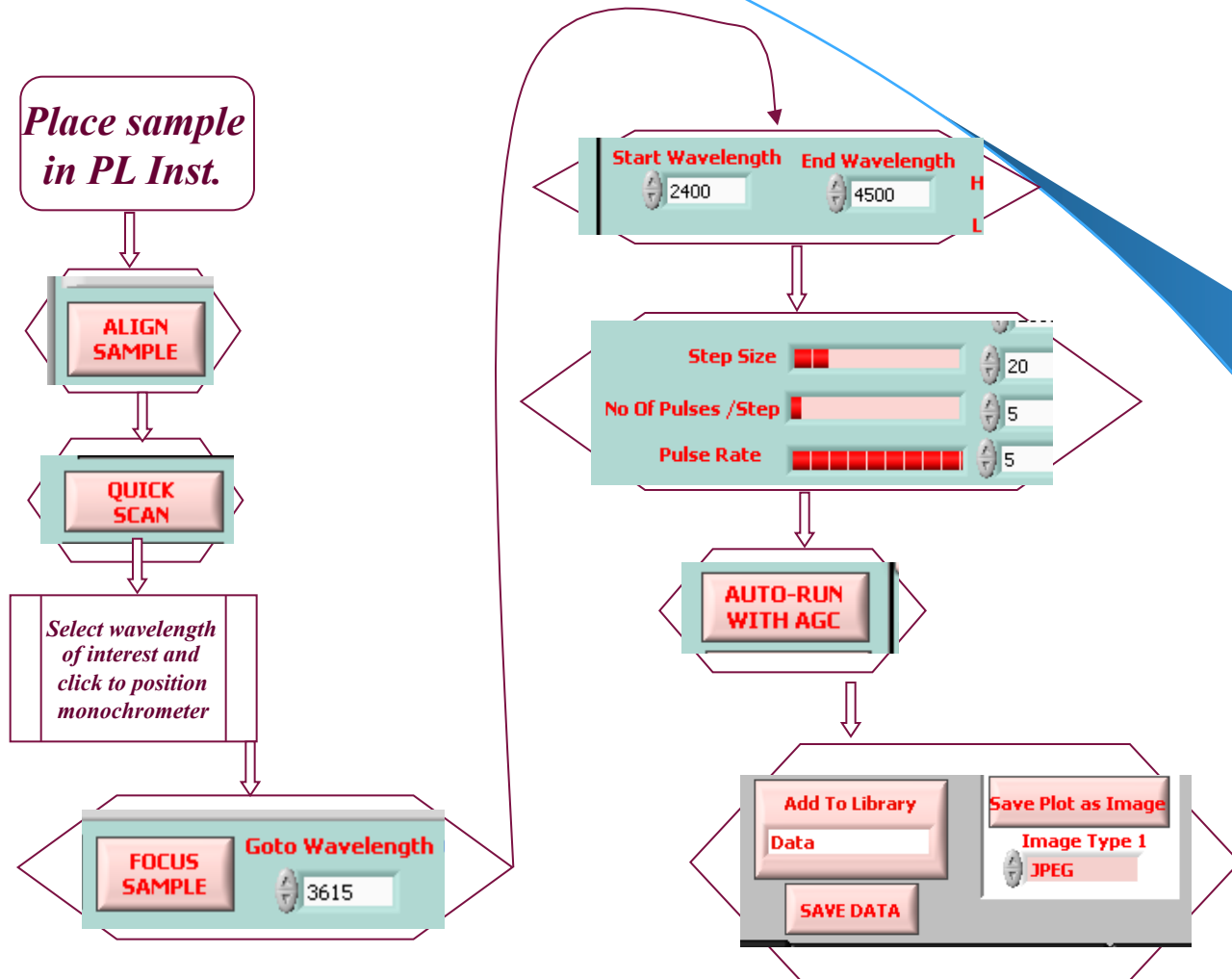
Save Plot as Image.

This function enables you to save the currently displayed plot directly as an image in either Jpg, Bmp or other popular formats. Note that manipulation of this plot is not available in the display mode. However, you can save as many different views, scales etc with this function. The save location is the same as the library.

Save Data.

This function saves all the data, including each data point taken, laser energy at that point, PMT gain, Capacitor value, Background light value etc etc. This is also in an Excel formatted file. Each of these files contains thousands of data

Typical New Sample application



Deep UV Semiconductor Sources

Emission wavelength versus AlGa_{1-x}N Composition

