

# Spectroscopy Systems Users Manual

: Photoluminescence & Photoluminescence excitation  
Measurement System

DONGWOO OPTRON CO., LTD.  
**LEADING SPECTROSCOPY COMPANY**

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# 1. General Safety Instructions

## 1-1. Warning

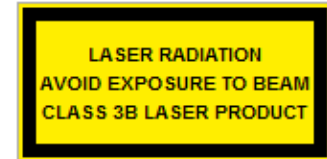
1. Laser
  - Do not expose eyes to laser directly.
  - Do not expose the skin to laser.
2. Detector( Andor iDus CCD)
  - Do not expose the CCD to laser directly.

## 1-2. Laser Radiation Safety

1. Before turn on the Laser, wear the laser goggle(488nm ,514nm).
2. Laser class : Class 3B

A Class 3B laser is hazardous if the eye is exposed directly, but diffuse reflections such as from paper or other [matte](#) surfaces are not harmful. Continuous lasers in the wavelength range from 315 nm to far infrared are limited to 0.5 W.

For pulsed lasers between 400 and 700 nm, the limit is 30 mW. Other limits apply to other wavelengths and to [ultrashort pulsed](#) lasers. Protective eyewear is typically required where direct viewing of a class 3B laser beam may occur. Class-3B lasers must be equipped with a key switch and a safety interlock. **(Refer to wikipedia)**



## 1-3. Maintenance Safety Instructions

### Location & environment

- 1) Dust free and air-conditioned area.
- 2) Temperature stable area ( $21^{\circ}\text{C}\pm 2^{\circ}\text{C}$ ).
- 3) Electric Power grounded and stable area.
- 4) Shielded area against electromagnetic field.
- 5) Flat and vibration free area.
- 6) Humidity : <40%

#### 1. Monochromator :

- After long term pass, the mirror & grating of monochromator can be oxidize.  
The steam in the air is possible to accelerate the oxidation speed of the mirror & grating (Monochromator optics).

#### 2. Sample chamber :

- Do not shock

#### 3. Detector

- When the PDS-01 turned on. Do not expose PDS-01 (PMT tube) from the room light
- Before turn on & off the PS/TC-1 power supply, the temperature must set to 25degree cellcius.

#### 4. High voltage shock

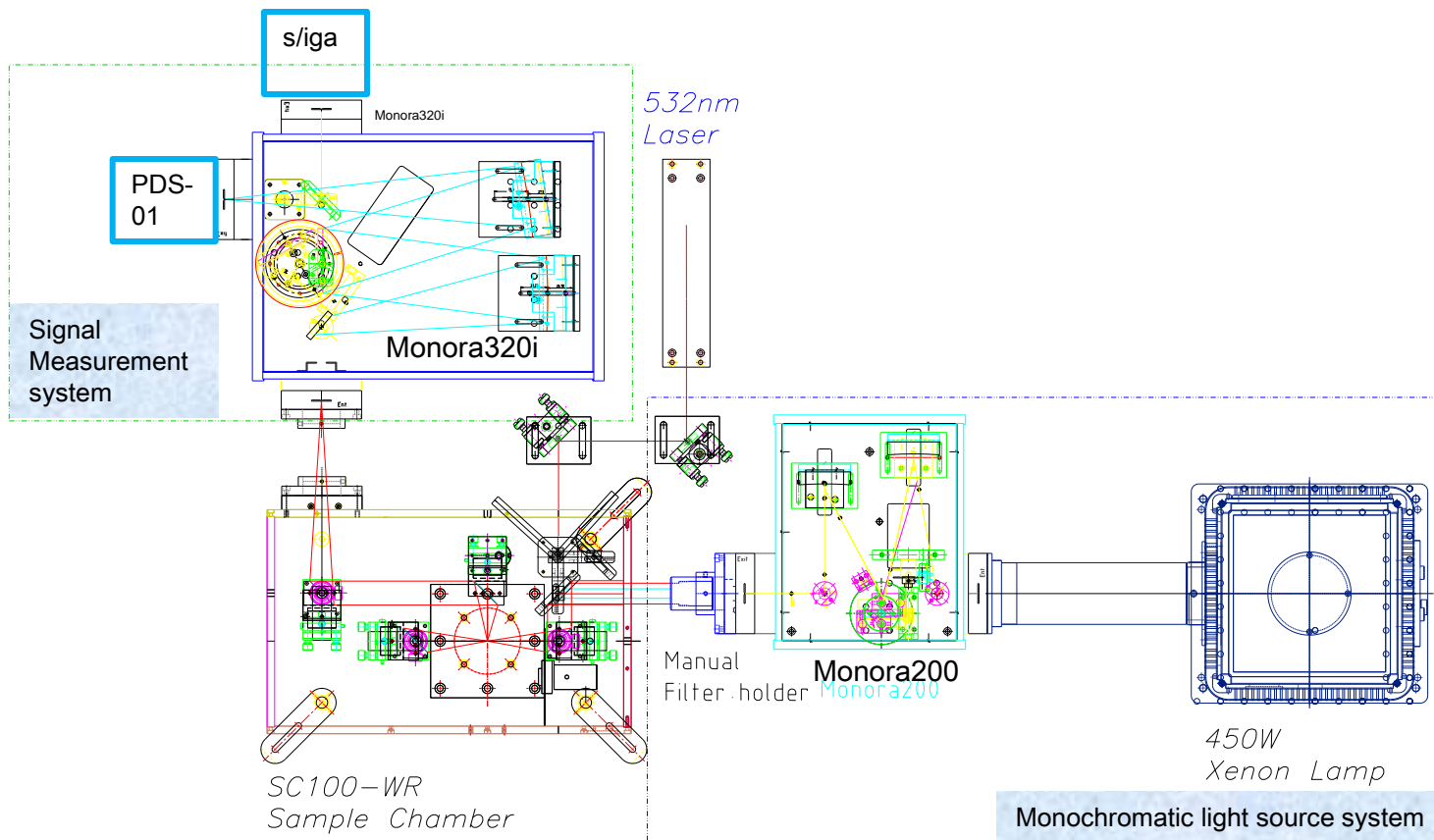
- 4-1. While the system is running, if you turn on or off the compressor or chiller  
It is possible to the electronic circuit of devices
- 4-2. While the computer is running, if you turn on or off the compressor or chiller  
It can damaged the hard disk by arc, then you have to format or change the hard disk.

## 2. Instruments

Device	Model	EA
Detector	PDS-01	1
	S/IGA-025/020-TE2-H	1
Monochromator 1	Monora200	1
Monochromator 2	Monora320i	1
Sample chamber	SC100-WR	1
Laser 1	532nm Laser Model: GL532NA-100	1
450W Xe lamp set	Model: Xe450W	1
Computer	Main body	1
	LCD Monitor	1
	Key board	1
	Mouse	1
Software	Win7 CD	1
	Monoscan 4.1	1
	Monoworks4.3.1	1
Filter	ZUL400	1
	BLP02-532R	1
	LP750	1
	LP940	1

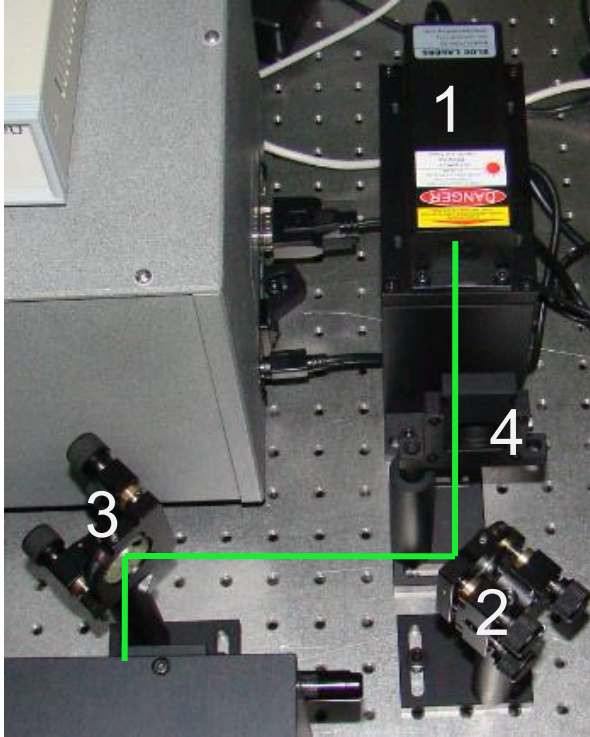


### 3. System diagram



PL&PLE System – Beam Line Diagram

#### 4. Laser : 532nm DPSS Laser



#### Specification

Manufacture: Shanghai Laser optics century

Model: GL532NA-100

Wavelength: 532nm

Beam Power : ~ 100 mW

1. 532nm Laser head
2. Mirror 1
3. Mirror 2
4. Filter holder (accessory)



Laser power supply

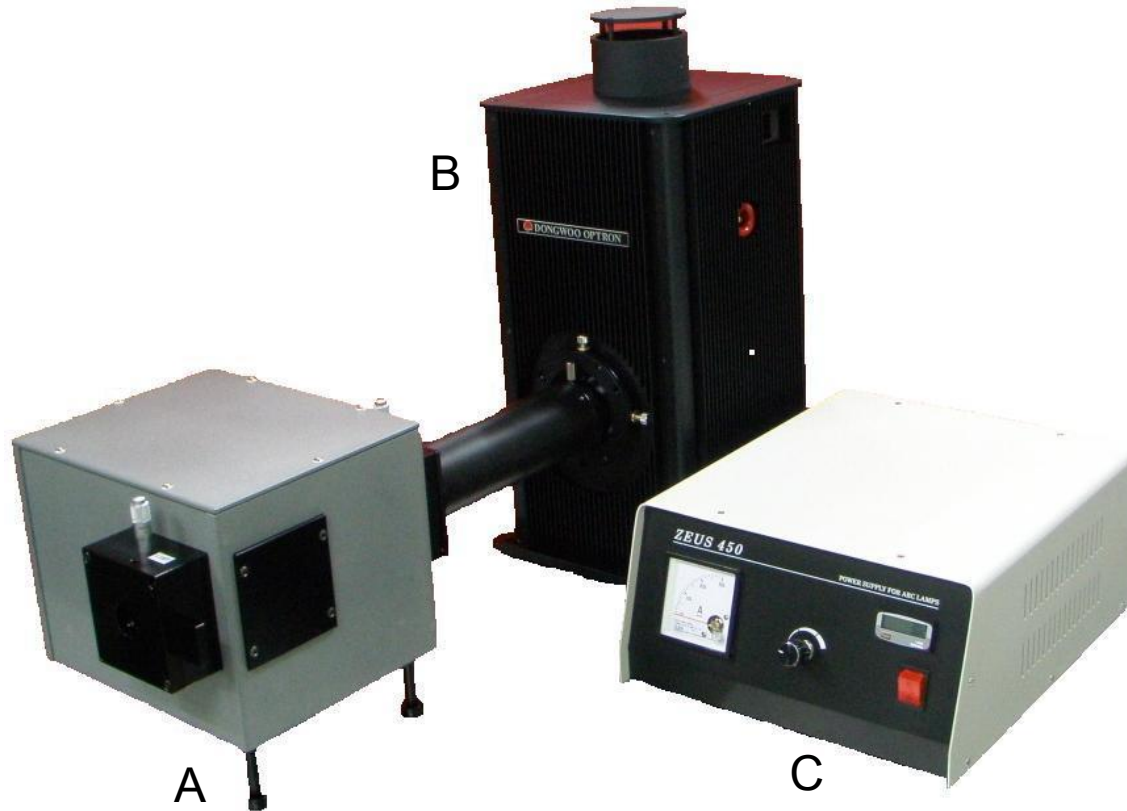
#### Laser on

1. Turn on the front power button
2. Switch on the key
3. Adjust the beam power by dial

#### Laser off

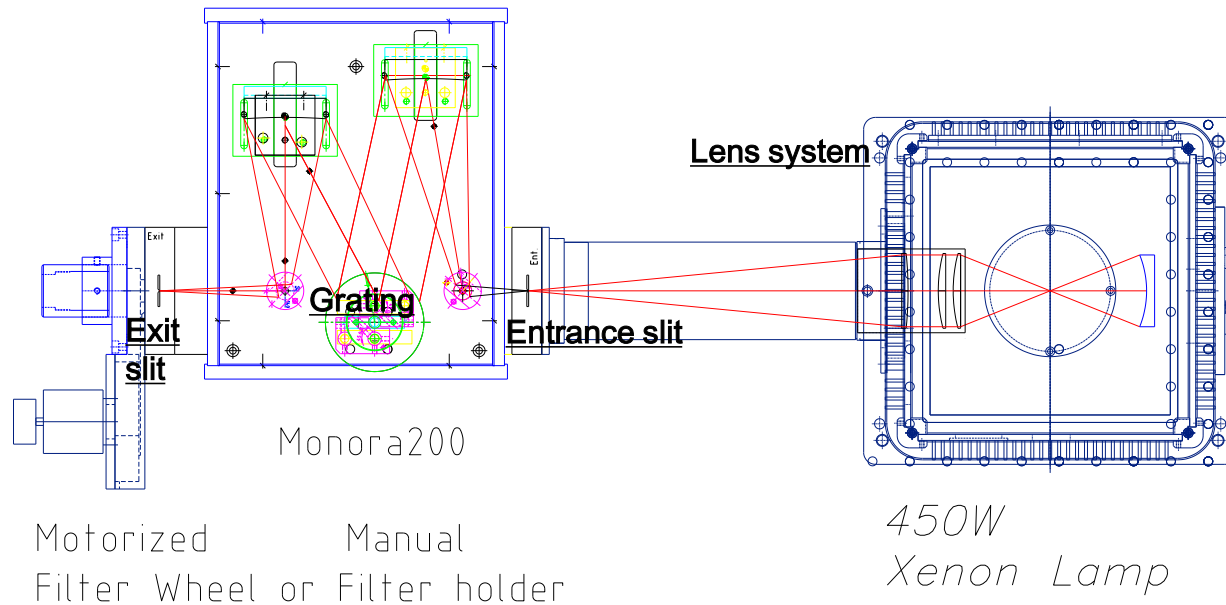
1. Minimize the beam power by dial
2. Switch off the key
3. Turn off the front power button

5. Monochromatic light source system (Monora200&450W Xenon Lamp)  
5-1. external configuration



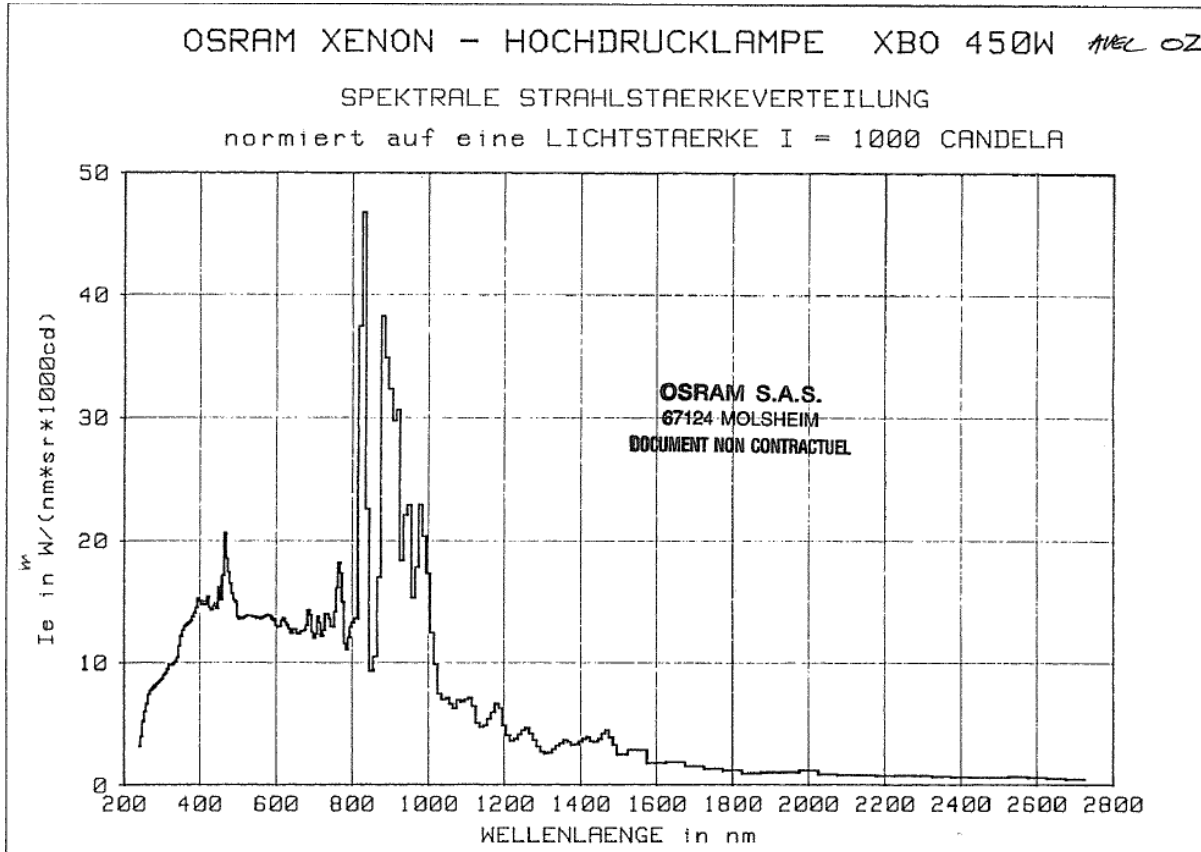
A. Monochromator (Monora200)    B. Xenon Lamp 450W    C. ZEUS Power supply

5. Monochromatic light source system (Monora200&450W Xenon Lamp)  
5-2. Internal configuration



1. Selection of the monochrome light from UV to NIR Xenon light.
2. The monochromatic light source system is composed of Monora200 & Xenon Lamp 450W. Xenon Lamp 450W emits the power full light & the lens system, it focuses the xenon beam into Monora200 via entrance Slit. The grating makes the spectrum, by rotating the grating, choose the monochrome light.

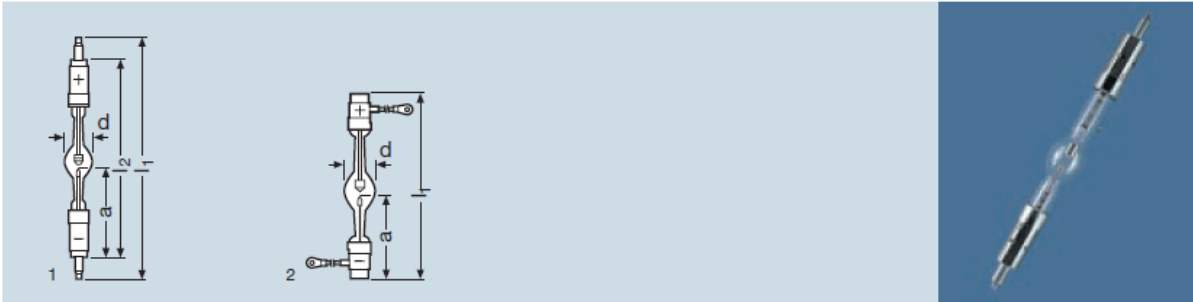
5. Monochromatic light source system  
5-3. Xenon light Spectra (XBO450W)



Xenon Spectrum


## 5. Monochromatic light source system

### 5-4. Xenon lamp specification













Their main characteristics and advantages are as follows:

- Very high luminance (point light source)
- Daylight color temperature of approx. 6000 K
- High color rendering index (Ra > 95)
- Continual color quality, irrespective of lamp type and lamp wattage
- Hot restart
- DC operation
- Dimmable
- Long life

Product reference	Product number	W	V	A	lm	cd	cd/cm <sup>2</sup>	A	t [h]	
XBO 450 W <sup>(3/4)</sup>	4008321082640	450	17	25	13000	1300	35000	17 ... 30	2000	s 30
XBO 450 W/1	4008321082510	450	17	25	13000	1300	45000	17 ... 30	800	s 100
XBO 450 W/2 OFR	4008321082626	450	17	25	13000	1300	35000	17 ... 30	2000	s 30

Product reference										
				d [mm]	l1 max. [mm]	l2 max. [mm]	a [mm]	<sup>1)</sup>		No.
XBO 450 W <sup>(3/4)</sup>	req.	–	0,9x2,7	29	260	212	95,5	SFa20-8	SFa20-10	1
XBO 450 W/1	req.	req.	0,7x2,2	29	260	212	95,5	SFa20-8	SFa20-10	1
XBO 450 W/2 OFR	req.	–	0,9x2,7	29	177	–	79	SK19/36	SK19/36	2

OFR = Ozone-free version  
req. = required

1) Distance from end of base to tip of electrode (cold)

3) Also available in ozone-free version with the same data : XBO450 WOFR

2) For vertical burning position: anode (+) on top

4) Also available in Suprasil quartz version: XBO450W/4

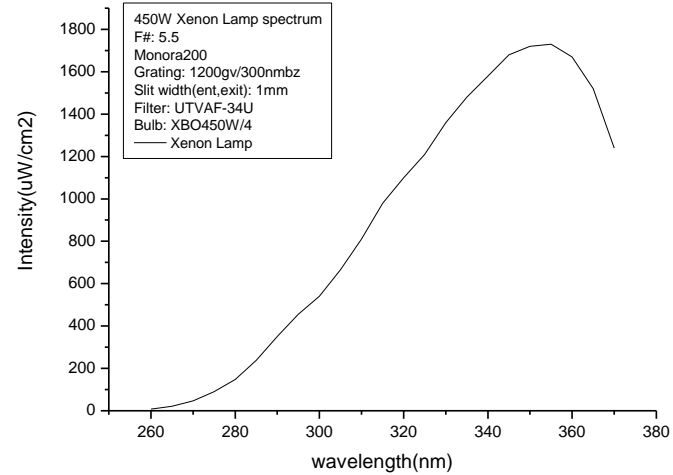
## 5. Monochromatic light source system

### 5-5. Xenon Lamp : Spectrum & Beam intensity

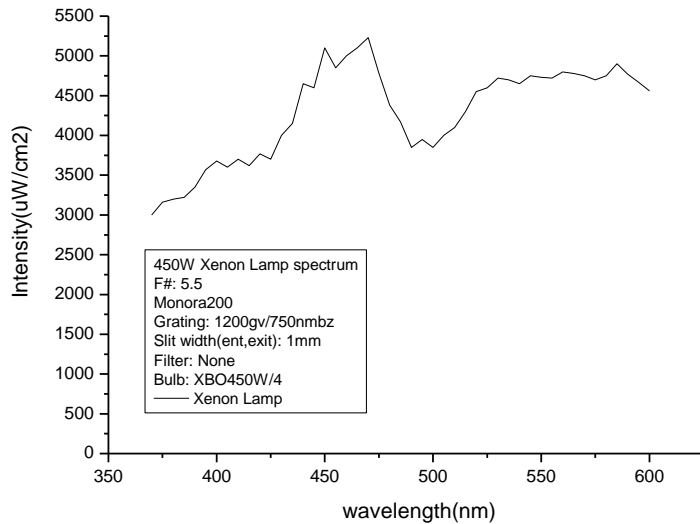
Monochromator : Monora200 (Dongwoo optron)  
 Slit width (Entrance&Exit) : 1mm  
 Radiometer : ILT4000&SEL623/K9  
 (International light technology)

UV Range & VIS Range (360~420nm) : 1200gv/300nmbz  
 260nm~360nm : UV Filter passed

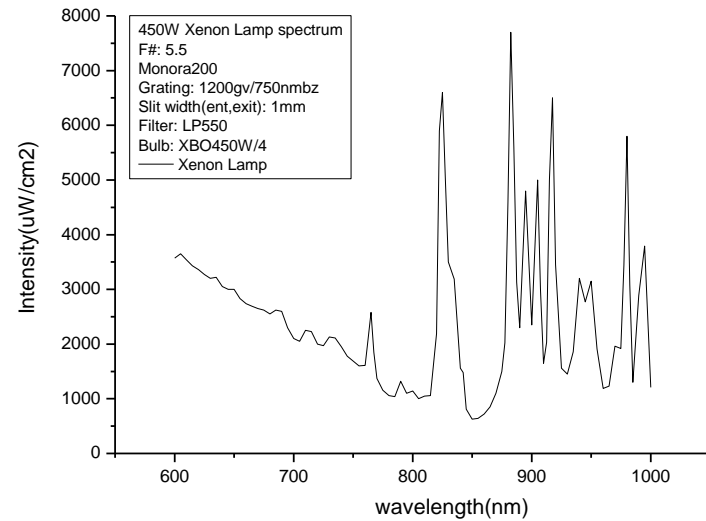
VIS Range & NIR Range (420~1000nm) : 1200gv/750nmbz  
 600nm~1000nm : LP550 Filter passed



UV Range

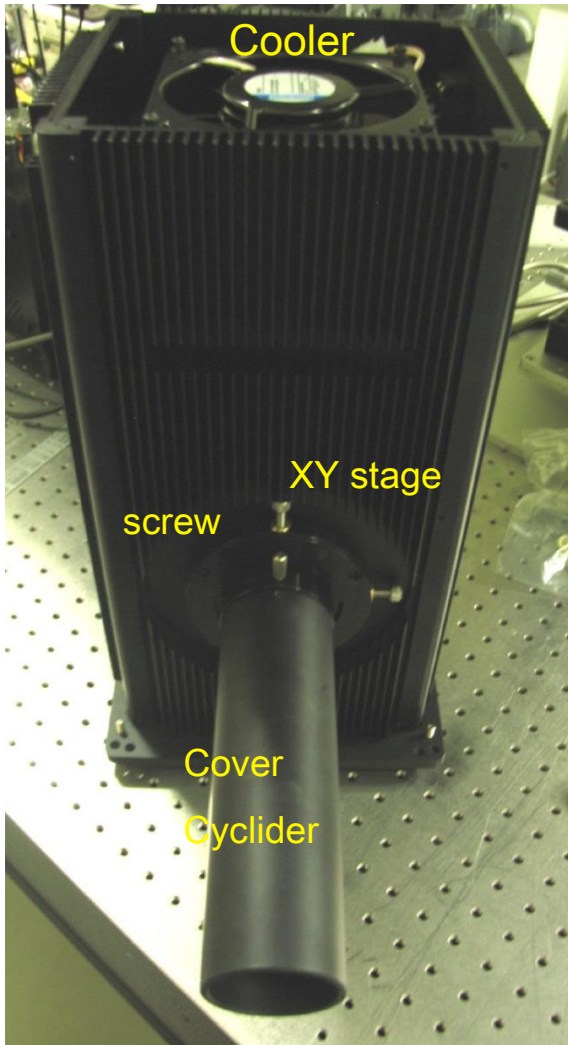


VIS Range

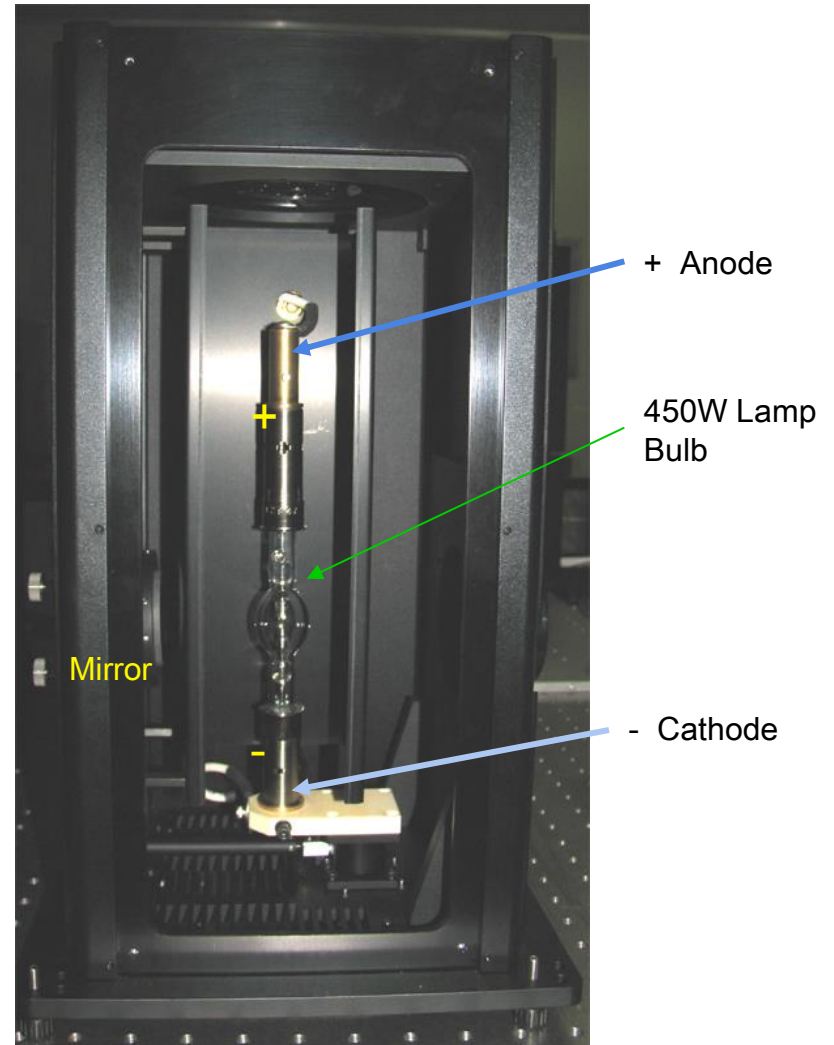


NIR Range

5. Monochromatic light source system  
5-6. Xenon Lamp : Part



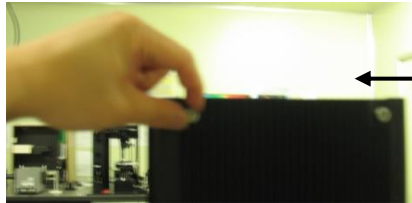
outside Part



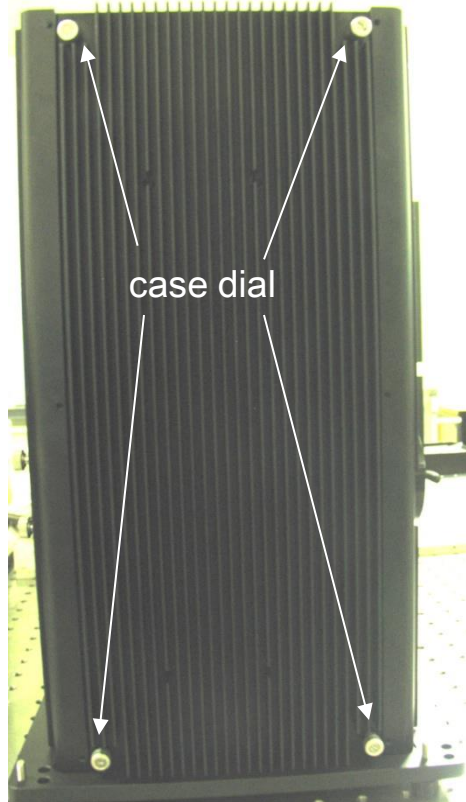
Inside Part



5. Monochromatic light source system  
5-7. Xenon Lamp : Lamp exchange1

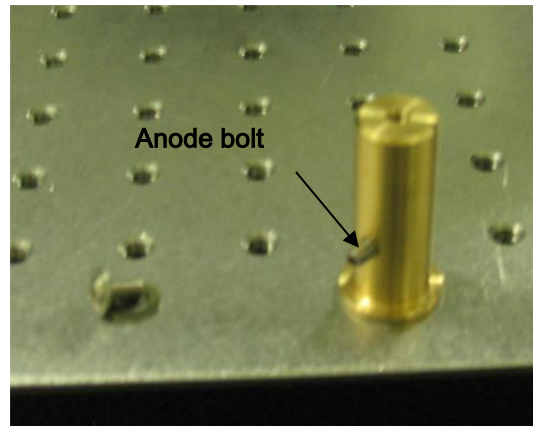


← : Rotate the dial to open

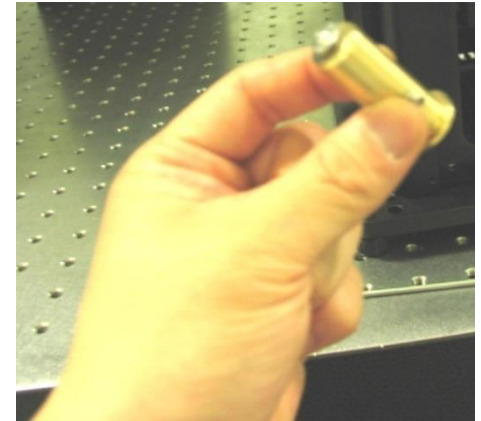


Case open

5. Monochromatic light source system  
5-8. Xenon Lamp : Lamp exchange2



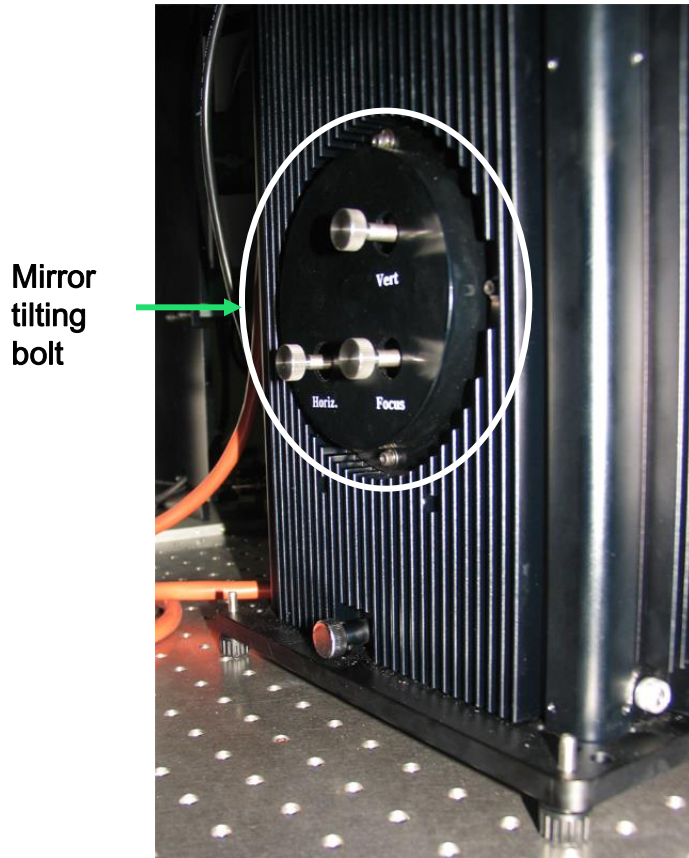
2. Washer & metal housing



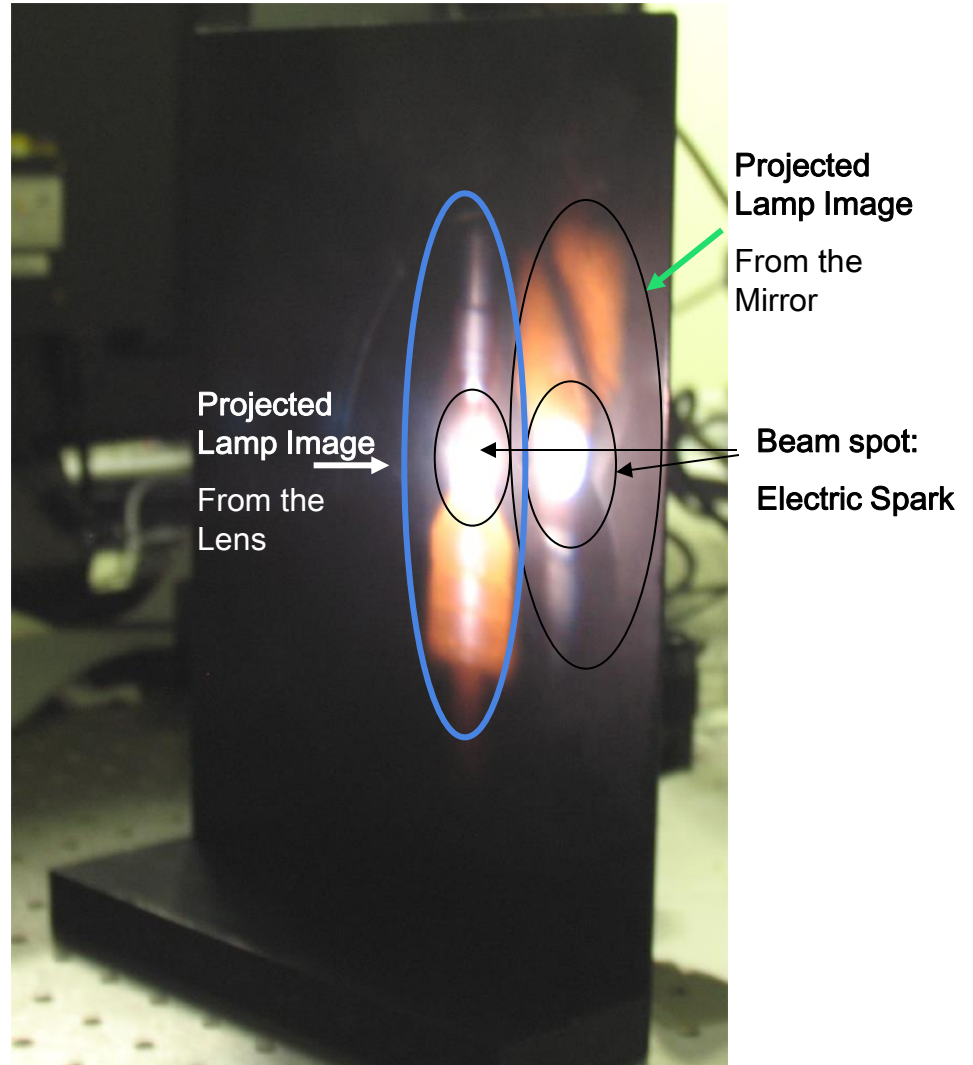
3. metal housing

1. Release the bolt of - (Cathode)
  2. Release the bolt of + (Anode)
  3. Remove the bulb from the Metal housing
  4. Remove the bulb from the - (Cathode)
  5. Keep the lamp inside of Lamp case.
  6. Attach the new lamp
  7. Attachment of Lamp
- 4->3->2->1

5. Monochromatic light source system  
5-9. Xenon Lamp : Align



1. Adjust the Mirror tilting bolt to clear the image from the lens and mirror.
2. Adjust the Mirror tilting bolt to overlap the image from the lens and mirror.



5. Monochromatic light source system  
5-10. Xenon Lamp : power supply

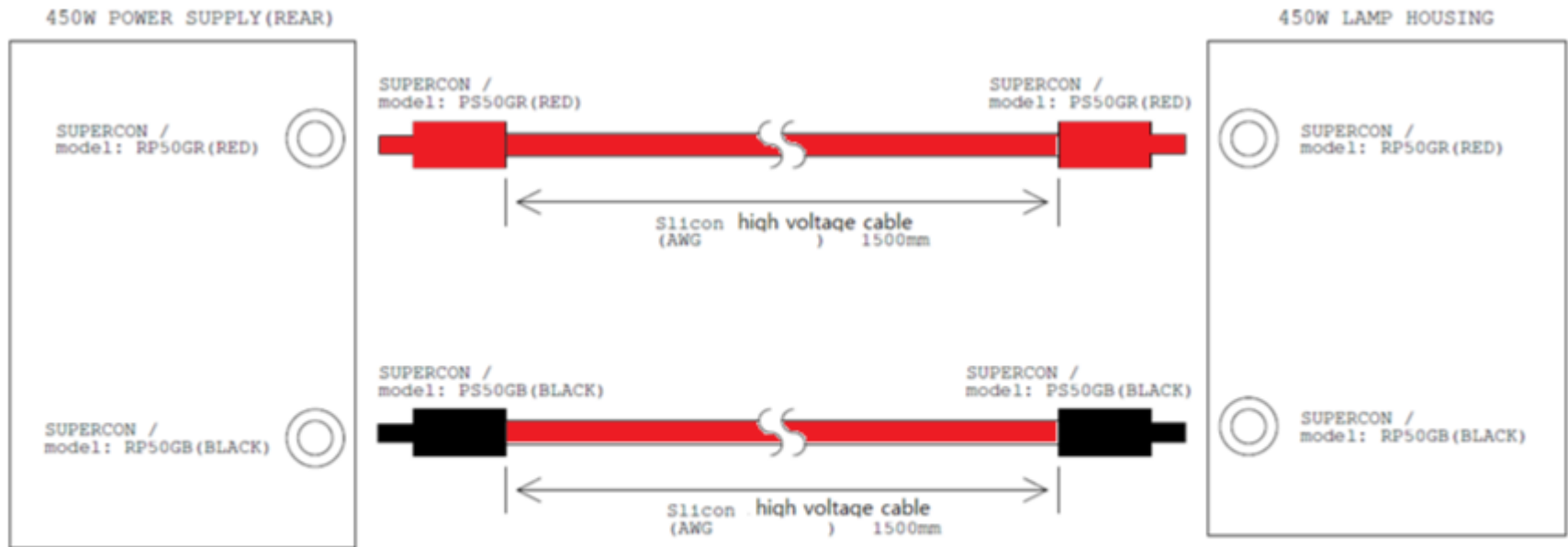


ZEUS450

- |                           |                                 |                                |
|---------------------------|---------------------------------|--------------------------------|
| 1. Ampere adjustment dial | 2. LED : Indication of Lamp on  | 3. Power button                |
| 4. operation time meter   | 5. -cathode (high voltage plug) | 6. + anode (high voltage plug) |
| 7. Power socket           | 8. Ground port                  |                                |

\* Ground the zeu spower supply via ground port '8'

Output Voltage : 17V current : 25A



Connection diagram  
Between xenon lamp housing & Power Supply - ZEUS450

## 5. Monochromatic light source system

### 5-11. Xenon Lamp : operation

1. Switch On the ZEUS Power supply
2. To turn on the cooler of xenon lamp housing, Plug in the cooler of xenon lamp housing  
the xenon lamp housing has no cooler switch

\*\* If the lamp doesn't turned on, read & follow below steps

The repetition of successive ignition attempts involves a temperature rise of some components of the power supply, that can lead to breakage.

To avoid any risk, it is advised to limit the number of ignitions in 3 consecutive trials.

Another option is to wait a period of 20 to 30 seconds between each ignition to allow the cooling of Components.



## 5. Monochromatic light source system

### 5-12. Xenon Lamp : **CAUTION**

#### A. Lamp cables

These cables carry very high voltage and are therefore both high generators of electromagnetic interferences and very sensitive to capacitive effects. Cables must go to the lamp as directly as possible, without crossing other cables. The 2 cables should be spaced one from another by at least 1 centimeter.

Cables must not go along any metal plate. In case these cables pass through one or more plates, the crossing must be made through a non-metallic material, for example by using a plastic grommet.

#### B . Operation & cable connections

1. You must turn off the monochromator& computer, detector before turn on or off the ZEUS Power supply  
\*\* It is possible to damage the other devices (computer or etc..)

2. After turn off the xenon lamp, operate the cooler over than 20 minutes

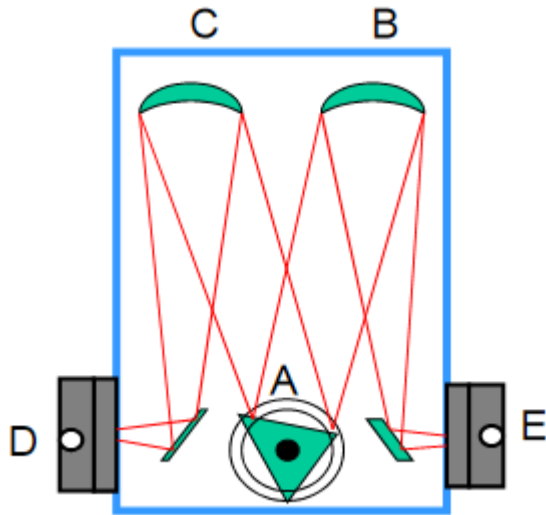
3. Do not connect the monochromator& PowerSupply -ZEUS450 to same extension socket (Below picture)

But, If you want strongly connect the PowerSupply -ZEUS450 & monochromator to same extension socket (Below picture)

1 . Before turn on the PowerSupply -ZEUS450, Pull out the Plug from extension socket.



5. Monochromatic light source system  
5-13. Monochromator: Parts

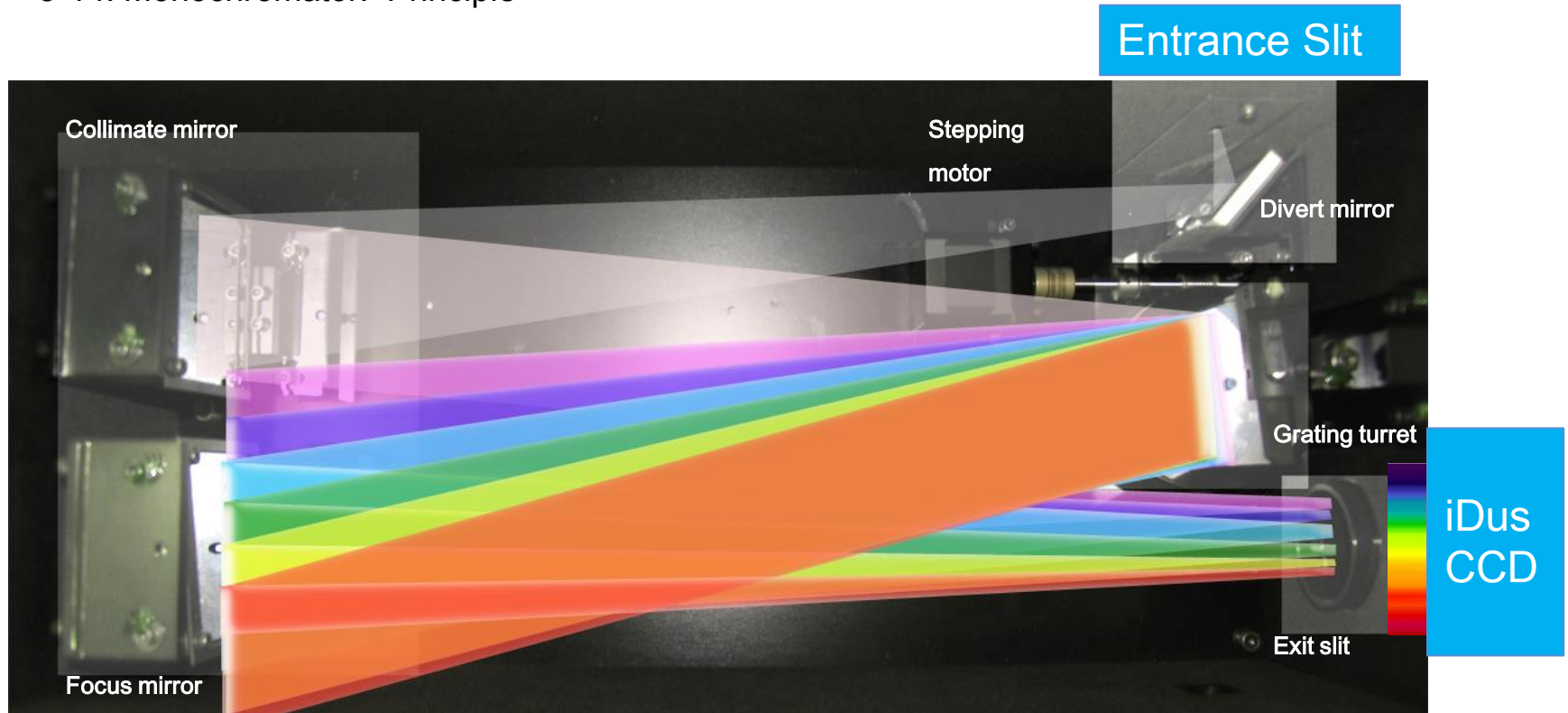


Grating	working Range
600gv/300nmbz	250nm~450nm
600gv/500nmbz	350nm ~ 800nm
600gv/1.0umbz	800nm~1.6um
600gv/1.6umbz	1.2um~2.6um

- A. Grating turret
- B. Collimation Mirror
- C. Focus Mirror
- D. side exit Slit
- E. side entrance Slit



5. Monochromatic light source system  
 5-14. Monochromator: Principle



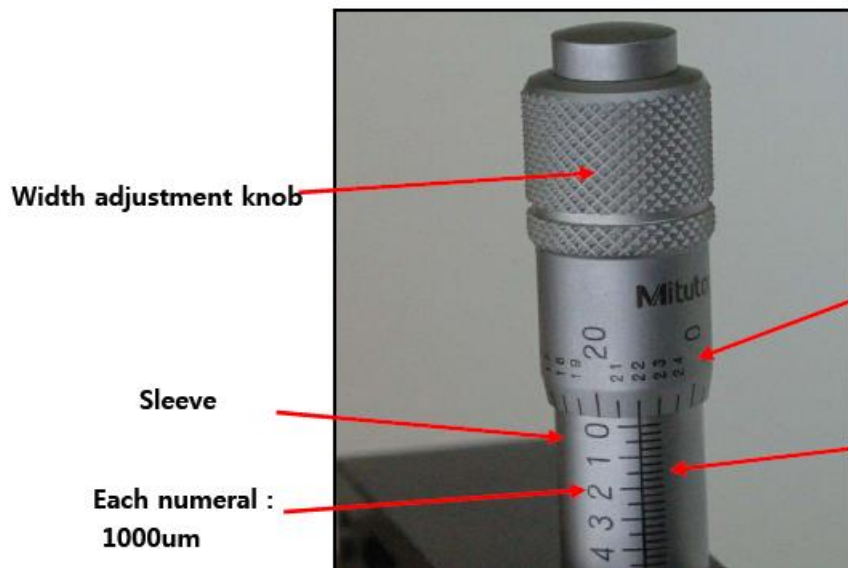
Diffraction equation

$$a(\sin \theta_i + \sin \theta_d) = m\lambda \quad (m = 0, \pm 1, \pm 2, \dots) \quad (\theta_d < 0) \quad \theta_i : \text{Angle of incidence} \quad \theta_d : \text{Diffraction angle}$$

a: line distance of grating , If the grating is 1200grooves, a= 1mm/1200

Wavelength selecting by grating rotation

5. Monochromatic light source system  
5-15. Monochromator : Micrometer head

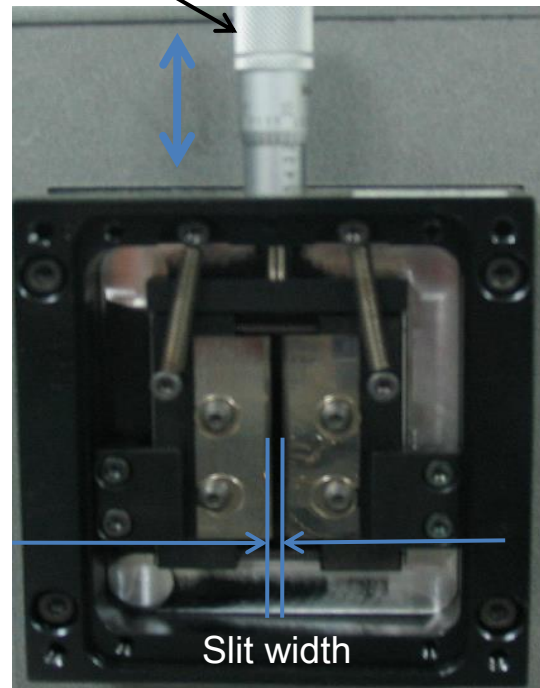


Micrometer head

Each division :  
10um

Each division :  
250um or 50um

Micrometer head



Slit housing

\* Adjust the slit width by Micrometer

5. Monochromatic light source system  
5-15. Monochromator : Micrometer adjusting



0um



10um



20um



50um



1000um



500um



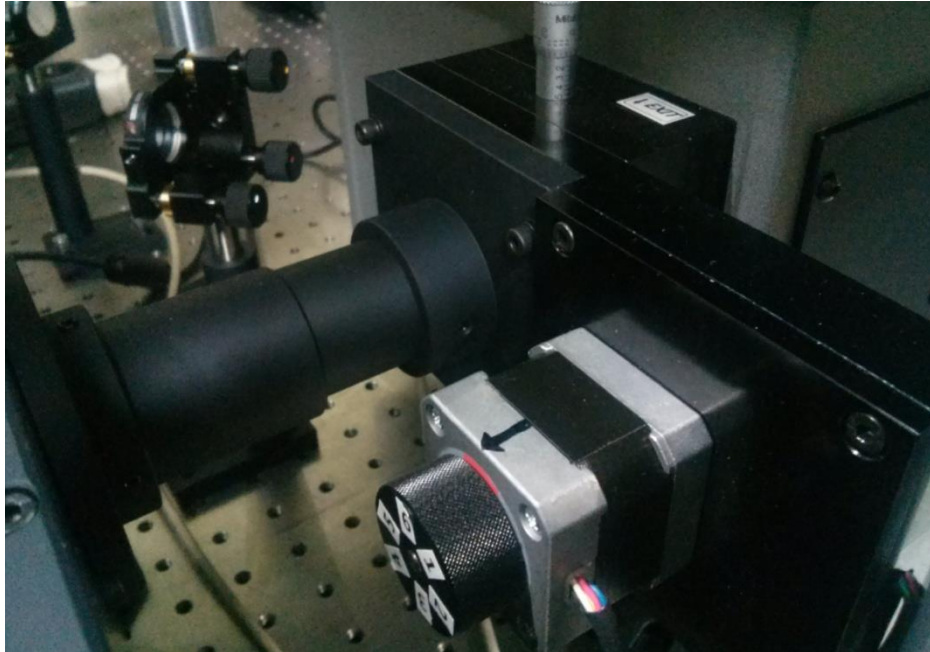
250um



100um

Slit adjustment : X um (Slit width)

5. Monochromatic light source system
  - 5-16. Monochromator : Motorized Filter wheel



The motorized filterwheel attached to exit slit

Available filter size&quantaty:

The order sorting filter attached

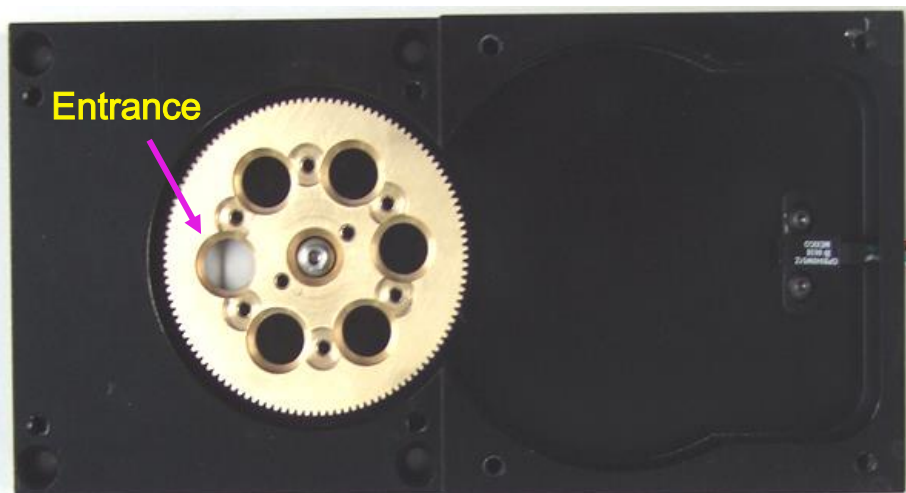
Dia12mm & Thickness 3mm, 6ea

The motorized filterwheel controlled by monoscan & monoworks software

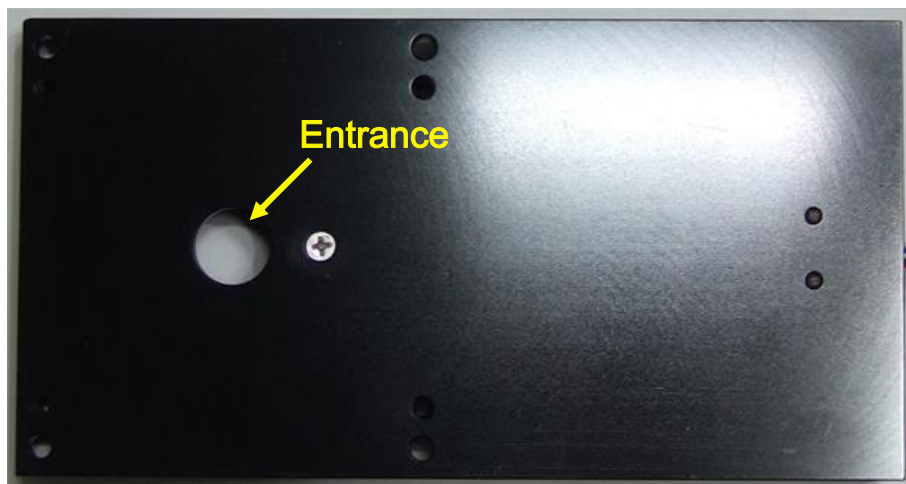
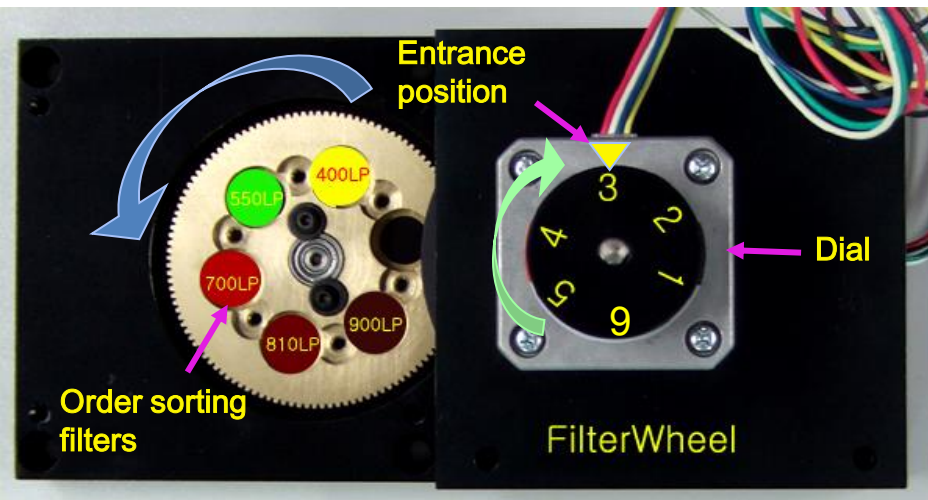
If the monochromator power off, then you can choose the filter manually



5. Monochromatic light source system  
 5-16. Monochromator : Motorized Filterwheel



Front



Back

- Attach to Entrance slit of Monora320i
- In order to order sort, Select LP filter.
- Rotate dial to "Entrance position"

**Dial # Longpass filter**

- |    |         |
|----|---------|
| 1. | none    |
| 2. | LP400nm |
| 3. | none    |
| 4. | LP750nm |
| 5. | none    |
| 6. | none    |

5. Monochromatic light source system  
5-17. Monochromator : Motorized filter wheel changing

1. Activate the monoscan4.1 software
2. Type 'fg #' in command line ( below command)  
(#: 1,2,3,4,5,6) & enter
3. Then the motorized filter wheel change the filter

Command

FG1 : filter 1  
FG2 : filter 2  
FG3 : filter 3  
FG4 : filter 4  
FG5 : filter 5  
FG6 : filter 6

5. Monochromatic light source system  
5-18. Monochromator : Manual Filter holder



Manual filter holder

- Diameter 1" or 25mm Filter available
- 4 holed filter mount
- Filter holding by screw



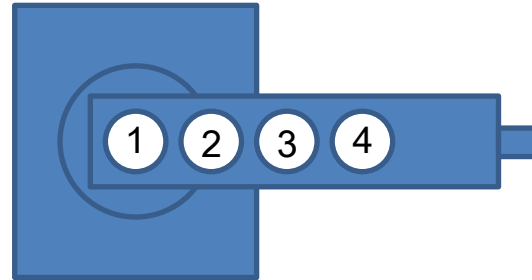
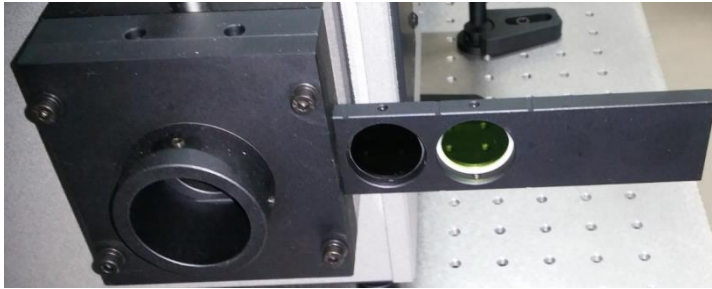
Manual filter holder mount

- Attaching to exit slit mount
- Filter holder holding by screw

Filter for 2<sup>nd</sup>, 3<sup>rd</sup> order beam sorting

5. Monochromatic light source system  
5-18. Monochromator : Manual Filter holder

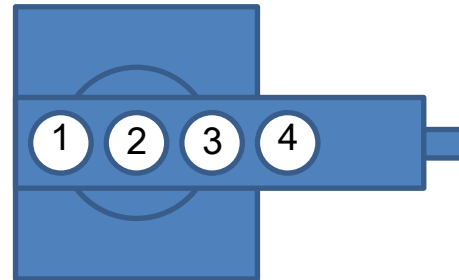
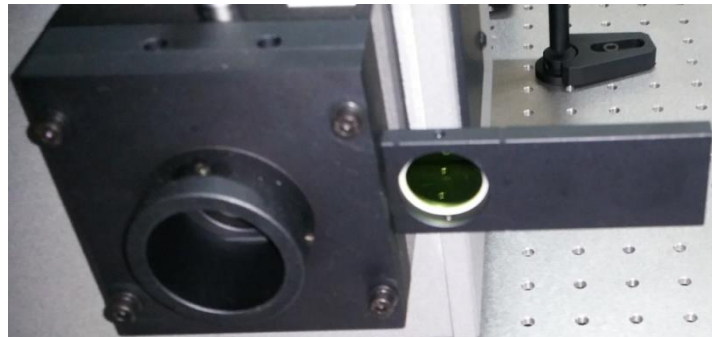
Number1 filter



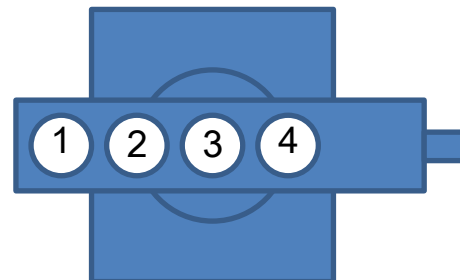
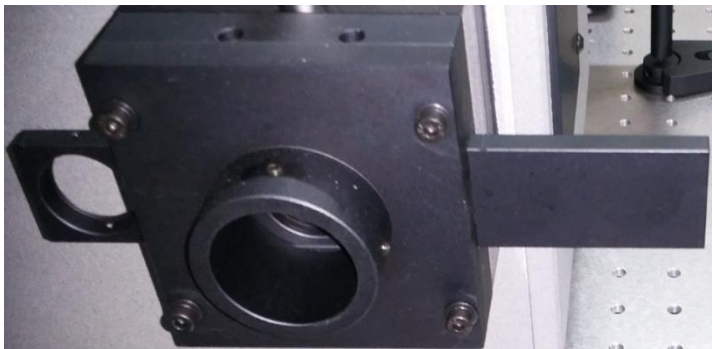
Longwavepass filter

1. none
2. ZUL400
3. LP750

Number2 filter

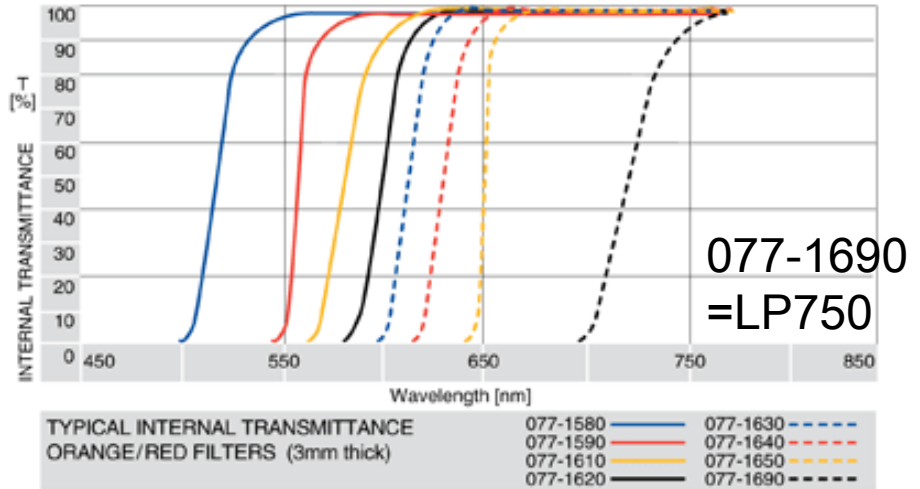
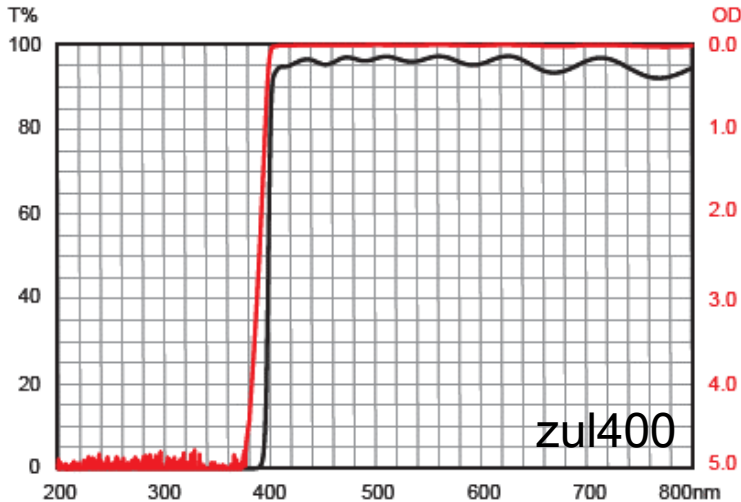


Number3 filter





5. Monochromatic light source system  
5-19. Order sorting filter



Same position	Same position
1 <sup>st</sup> order	2 <sup>nd</sup> order
400nm	400nm X 2
	800nm

Ex) If the output beam is 800nm,  
then the 400nm can included with 800nm,  
(you can see the 800nm with 400nm beam)  
Because  $800\text{nm} \times 1 = 400\text{nm} \times 2 = 800\text{nm}$ .

\* To understand, Please see chap 5-14

So, it needs to sort the 400nm beam by order sorting filter

**077-1690 = LP750**

5. Monochromatic light source system  
 5-20. Excitation beam

Excitation beam wavelength	Manual Order sorting filter	Motorized Order sorting filter	Lamp	Monora200 Grating
300m ~ 420nm	Number 1 None	Number 1 None	450W Xe Lamp	600gv/300nmbz
420nm~800nm	Number 2 ZUL400	Number 2 ZUL400	450W Xe Lamp	420nm~500nm : 600gv/300nmbz 500nm~800nm : 600gv/500nmbz
800nm~ 1500nm	Number3 LP750	Number4 LP750	450W Xe Lamp	800nm~1400nm: 600gv1.0umbz

5. Monochromatic light source system  
5-21. Monochromator : Rear panel



Back Side

A. Power port    B. Power switch    C. LED  
D. RS232C port    E. USB port

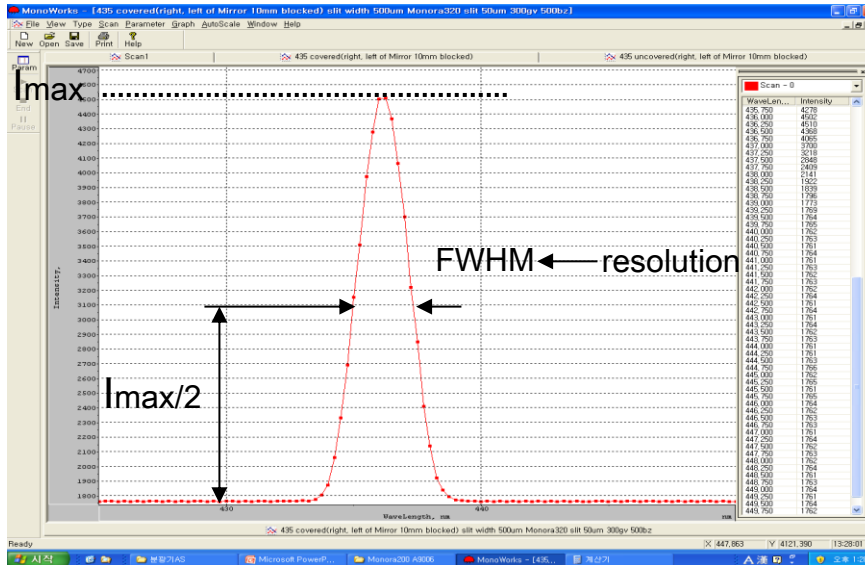
Monochromator operation

1. Turn on the power switch(B).  
then, the LED(busy, power) will flashing. during the LED(busy, power) flashing,  
the monochromator initialize the grating position.

After the LED(bussy) flash off, You can communicate & use the monochromator

## 5. Monochromatic light source system

### 5-22. Monochromator : Resolution

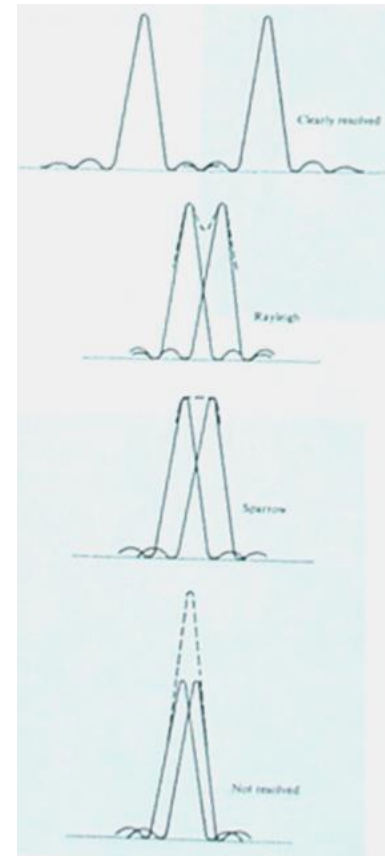
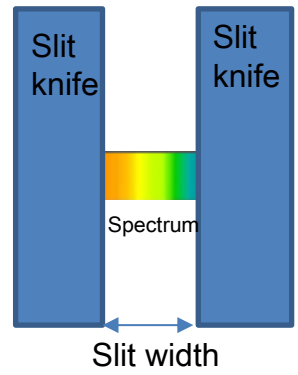


Resolution

Monochromator : Monora200  
 Grating : 600gv/500nmbz  
 Peak position : 435.84nm  
 Slit width FWHM  
 (Full width half maximum)

10um	0.4 nm
100um	1 nm
250um	2 nm
500um	4 nm
1000um	8 nm
2000um	16 nm
3000um	24 nm
4000um	32 nm
5000um	40 nm

- In case the Slit width (entrance & Exit) is same



Resolved

Rayleigh

Sparrow

Not resolved

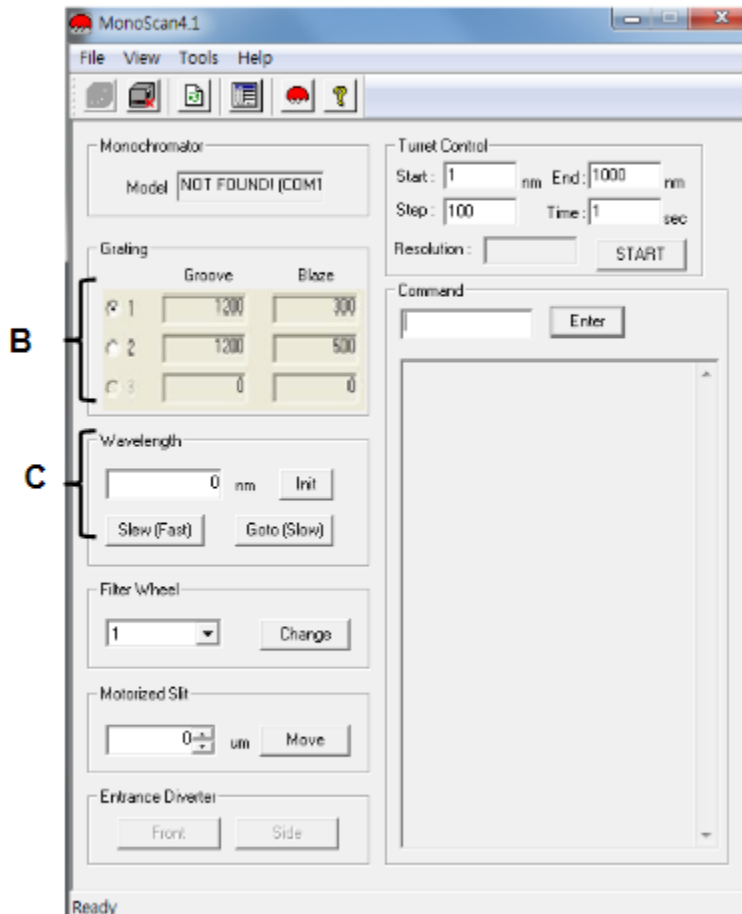
Refer to 'Optics' 4<sup>th</sup> edition, p576, Eugene Hecht

By the modulation of the slit width of monochromator, Modulate the Resolution of monochromator.

The Resolution means the reference can distinguishable with the two signal which is nearby each other.

The Resolution is identified as a FWHM of peak.

5. Monochromatic light source system  
 5-23. Monochromator : wavelength changing



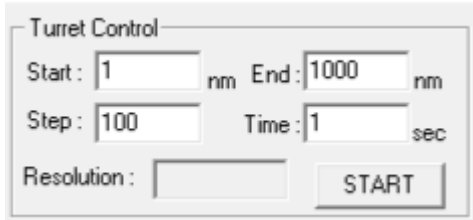
1. Activate Monoscan4.1 software
2. Click the Tools in menu of Monoscan4.1 software (A)
3. Select COM port & Click 'OK' in settings (A)

\* then, you will see the information of Monora200  
**If you connect the monochromator by USB cable you must install Virtual com port About installation, PI see monoscan4.1 manual Chap 6, 7**

Wavelength selection

4. Select grating (B) in Grating menu, then the grating turret rotate to the grating.
5. After select the grating, Type wavelength & Click 'Slew' in wavelength menu(C)

5. Monochromatic light source system  
5-24. Monochromator : Turret control



Turret Control

Start : 1 nm End : 1000 nm

Step : 100 Time : 1 sec

Resolution :  START

Monoscan4.1 software provide the Grating turret control function.  
This function doesn't provide measurement function.  
But, if you keep time with another device. It will be useful tool.

Turret control

Example) Start : 1nm End : 1000nm

Step : 100 Time : 1sec

\*\* Step resolution :  $(1000\text{nm} - 1\text{nm}) / 100 = 10\text{nm}$

The output beam from exit slit change from 1nm to 1000nm

While the wavelength changing,

The grating will stop at each wavelength position for 'Time' (1sec)

6. SC100-WR  
6-1. Introduction

Function

1. PL Measurement
2. ATR Measurement
3. Low temperature(80K) PL & ATR measurement

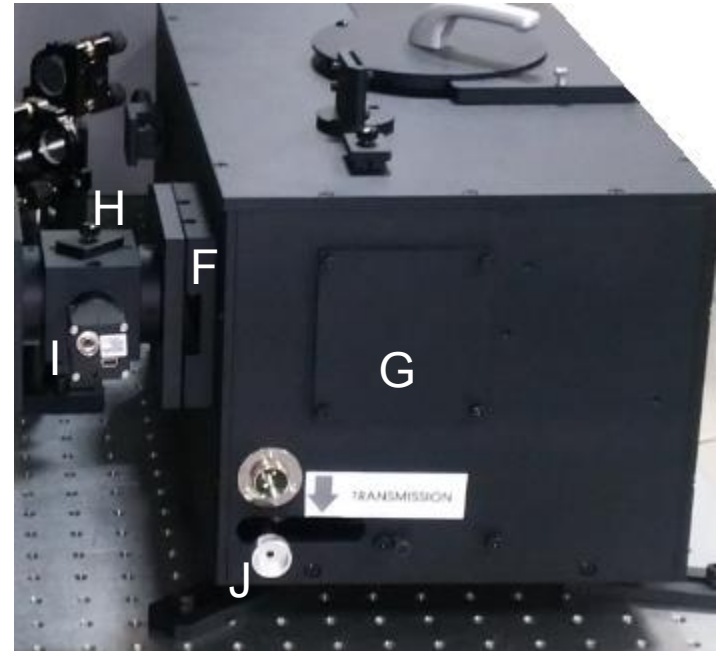
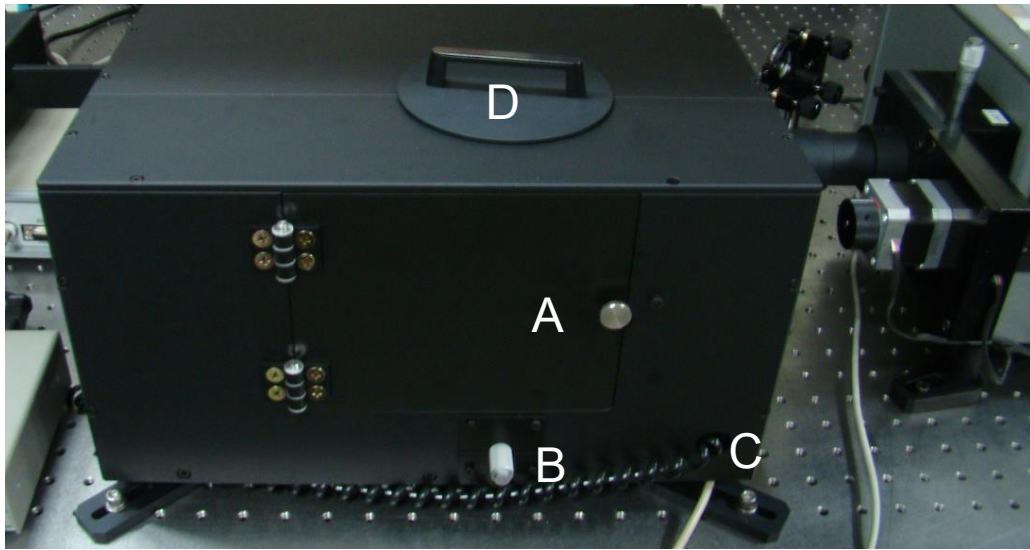
Features :

1. Sample holder for sample holding
2. Cryogenic (80K) system (optional) for Low temperature(80K) PL & ATR test
3. Micrometer stage for sample alignment
4. Diverting mirror for Two entrance
5. Beam delivering : Optics part for Laser focusing & PL beam collimation & focusing

Available measurement range : 300nm to 2.6um

Beam size at Focal point : ~100um@ 1mRad Divergence beam

6. SC100-WR  
6-2. Exterior



A. Door B. Micrometer knob C. chopper line D. Cap E. 4 holed Filter holder  
F. Filter holder mount G. Side exit H. Beamsplitter I. CCD J. R/T changing dial  
\* R/T : Reflectance/Transmittance



6. SC100-WR  
6-3. Manual filter holder & mount



Manual filter holder

- Diameter 1" or 25mm Filter available
- 4 holed filter mount
- Filter holding by screw



Manual filter holder mount

- Attaching to exit slit mount
- Filter holder holding by screw

**Please Read this article**

Filter for PL measurement

: Without the Laser cutoff filter,

You will measure the PL with laser beam

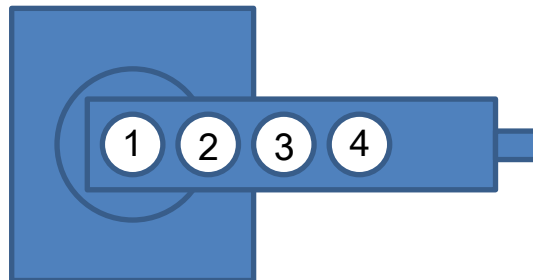
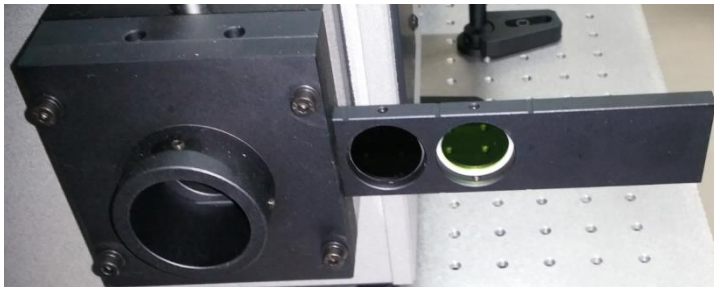
But generally, The laser beam is very brighter than PL beam

Then the laser beam makes strong noise in the spectrometer

It will interfere the measurement

6. SC100-WR  
6-4. Filter selecting

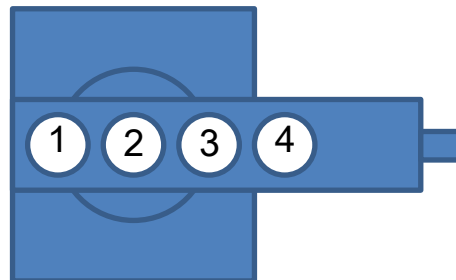
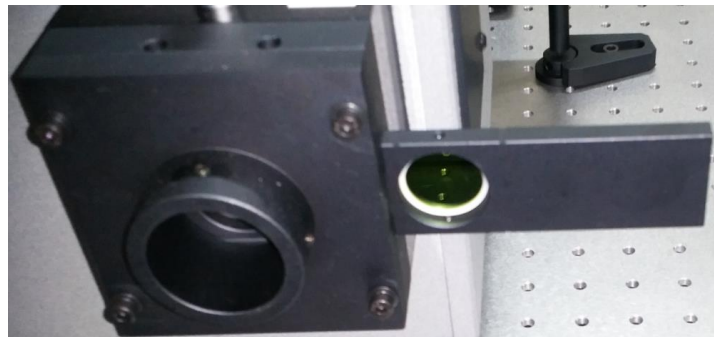
Number1 filter



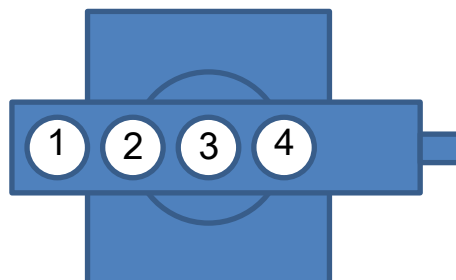
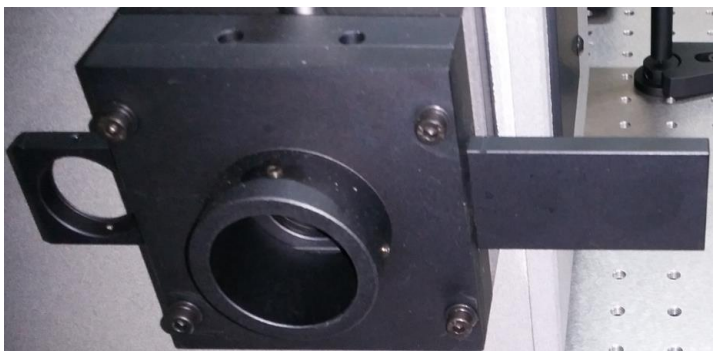
Longwavepass filter

1. none
2. zul400
3. LP532
4. LP940

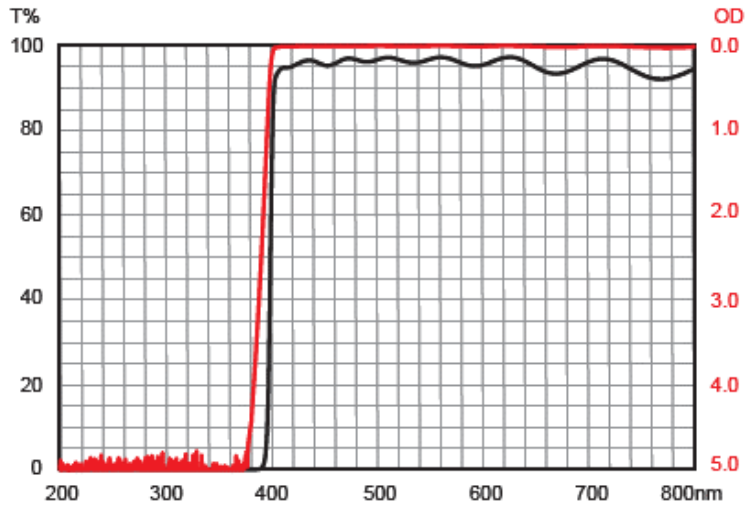
Number2 filter



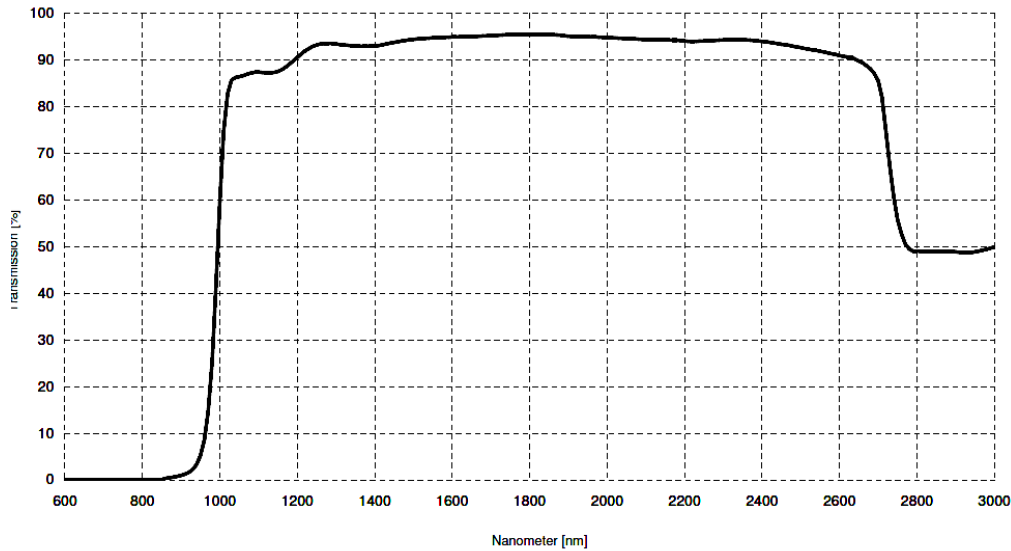
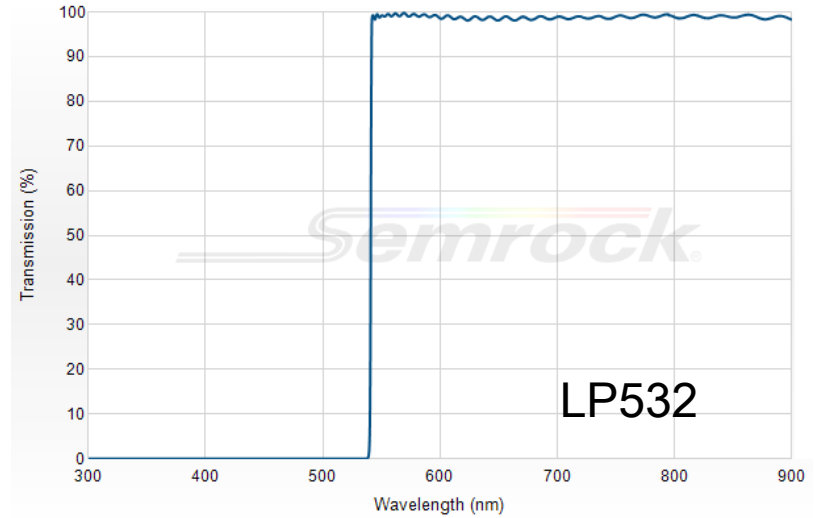
Number3 filter



6. SC100-WR  
6-5. Transmittance data of Longwavepass Filter

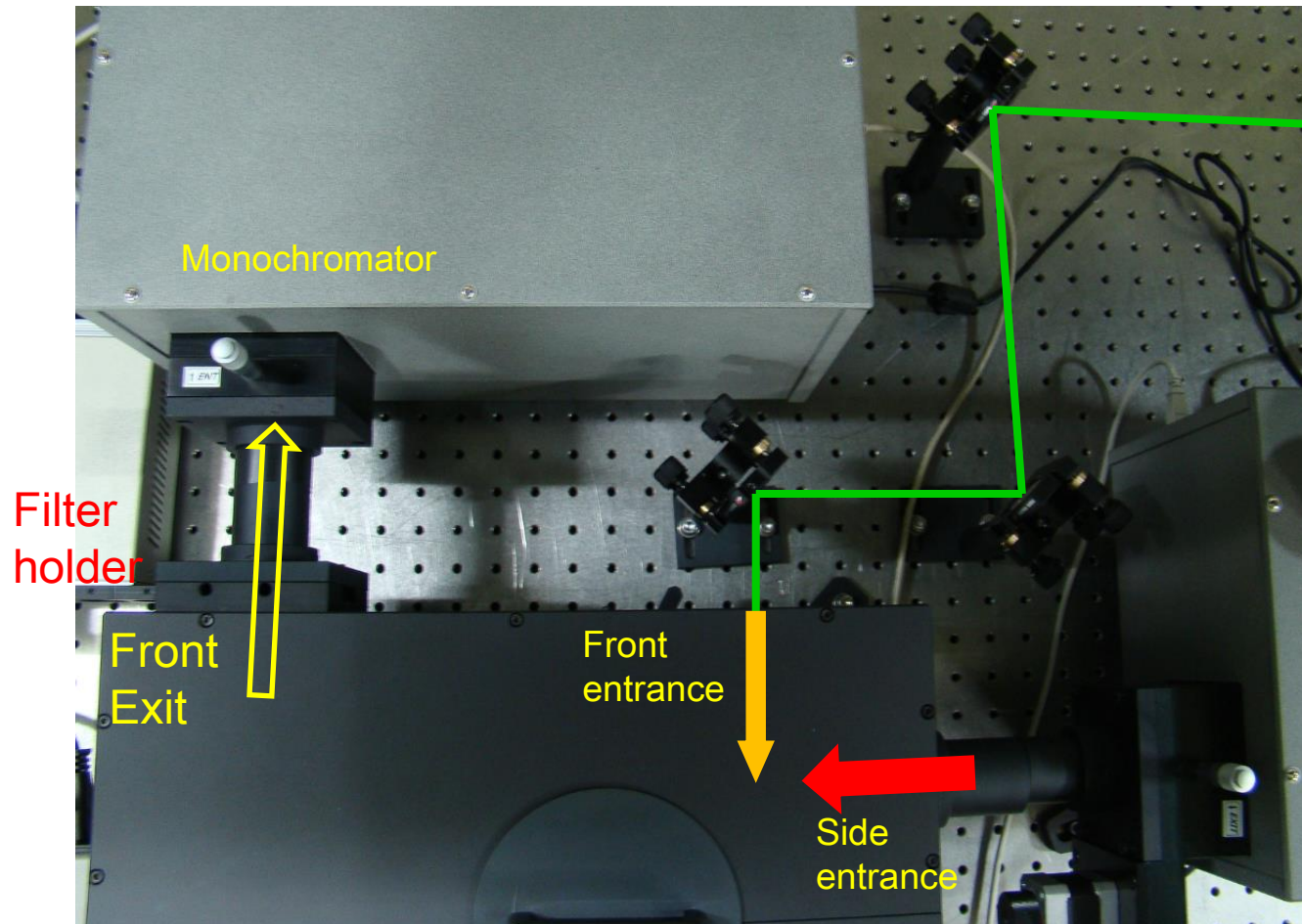


Black line: zul400



LP940

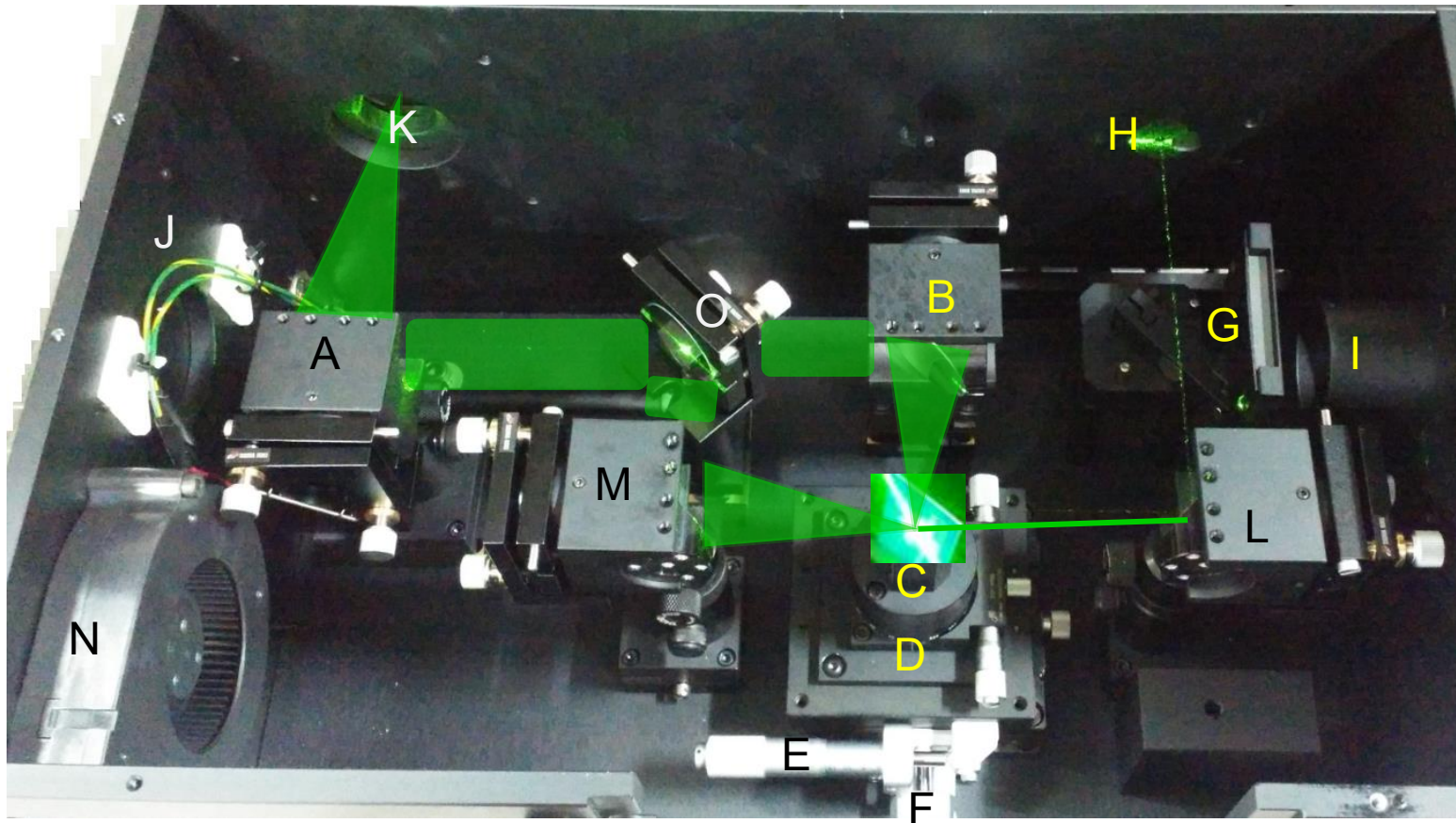
6. SC100-WR  
6-6. entrance& exit, beam delivery line



Front entrance hole diameter : 4mm (only for Laser Beam)  
Side entrance hole diameter : 20mm (Laser Beam or Lamp)  
Front/Side entrance can select by diverter mirror  
Front exit hole diameter : 20mm (PL beam or reflected / Transmitted beam)



6. SC100-WR  
6-7. Interior & Beam line



- A. Focusing mirror 1    B. Collimation mirror 1    C. Sample holder    D. Rotation Stage    E. Y-stage    F. X-stage  
 G. Diverting mirror 1    H. Front Entrance(diameter: 4mm)    I. Side Entrance (diameter : 20mm)    J. Side exit    K. front exit  
 L. Focusing Mirror 2    M. Collimation mirror 2    N. FAN    O. Diverter mirror 2

## 6. SC100-WR

### 6-8 . PL(photoluminescence) alignment & delivering in sample chamber

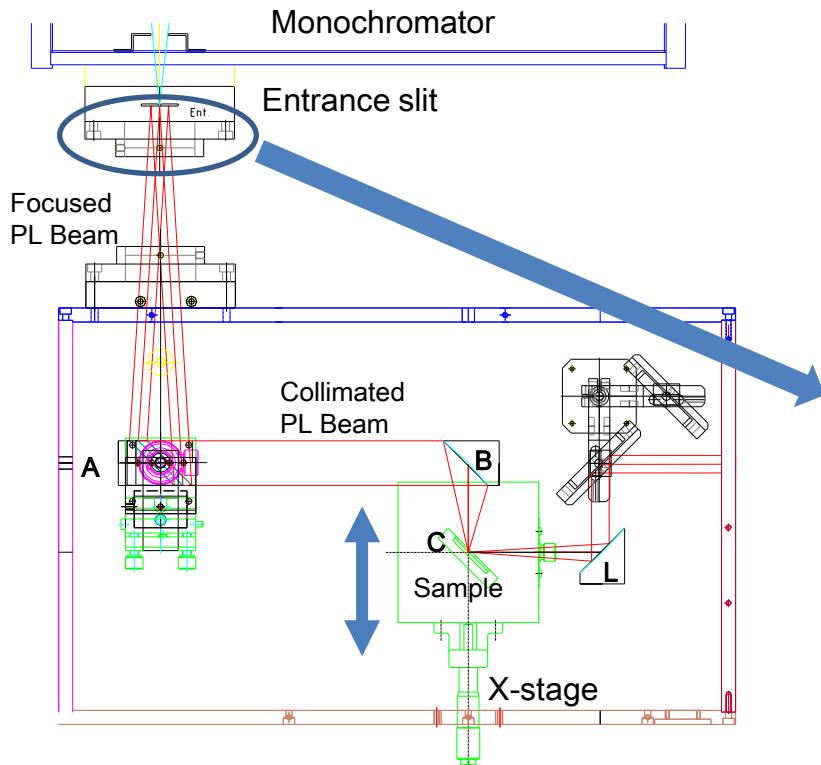
The laser beam generate the PL from sample, The PL delivered & focused to entrance slit of monochromator by optics of sample chamber

#### Reflective type scattered beam (PL or reflected beam) generating & delivering process

1. To excite & make small beamspot at the sample which holding to 'C', The laser beam focus to 'C' by 'L',
2. To make a collimation beam, The scattering beam from 'C' collimated by 'B'
3. To deliver the collimated beam to monochromator, The 'A' focus the collimation beam to entrance of monochromator

#### Transmittive type scattered beam (PL or Transmission beam) - generating & delivering process

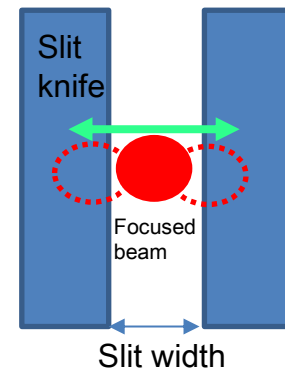
1. To excite & make small beamspot at the sample which holding to 'C', The laser beam focus to 'C' by 'L',
2. To make a collimation beam, The scattering beam from 'C' collimated by 'M'
3. Move the 'O' to Arrow, as below picture  
\* for the Reflective type scattered beam (PL or reflected beam) measurement the dial should be 'Reflection' as below picture
4. To deliver the collimated beam to monochromator, The 'A' focus the collimation beam to entrance of monochromator



#### Alignment principle

If you adjust the X-stage, the focused beam spot will move at Entrance slit,

The focused beam should pass the entrance slit to detect the signal.

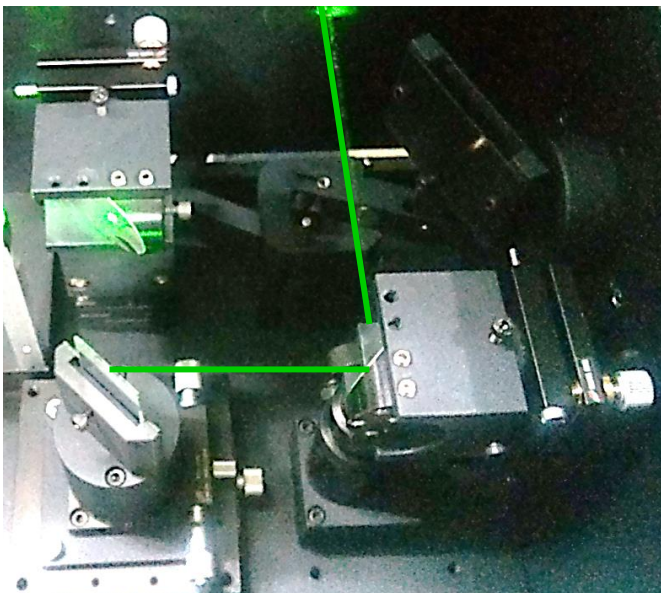
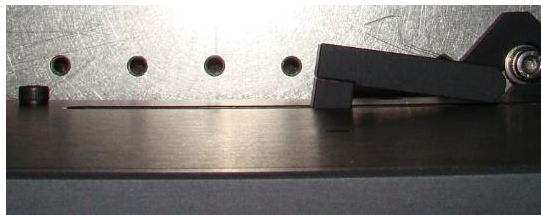


6. SC100-WR  
6-9-1. Diverter mirror 1 for entrance port selection

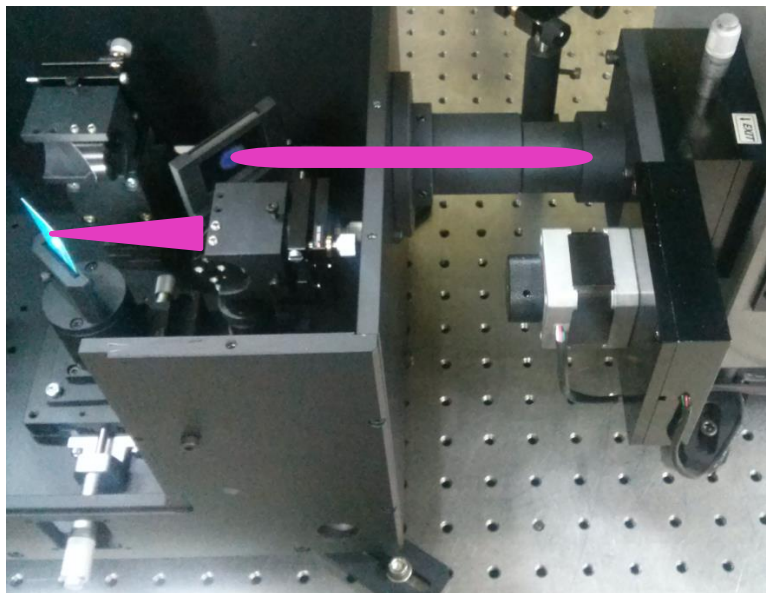
Diverting mirror bar position A



Diverting mirror bar position B

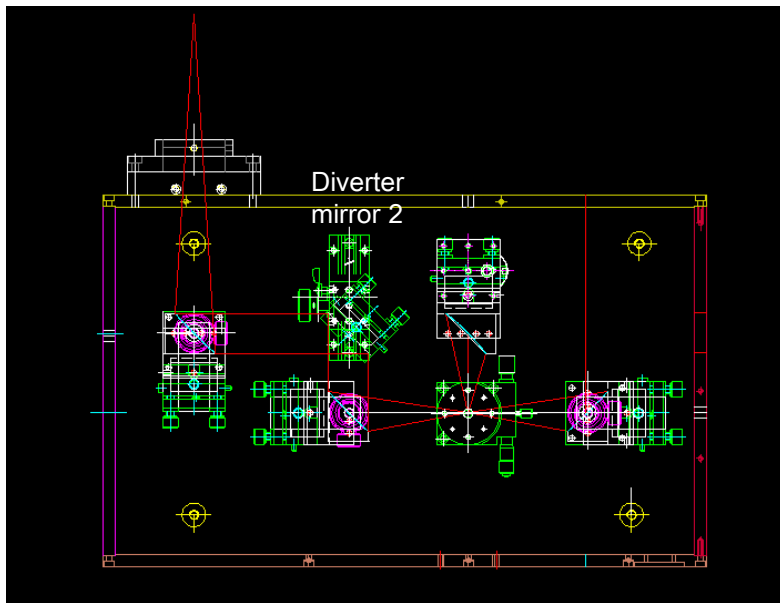


Front Entrance(diameter: 4mm) Selected For Laser beam

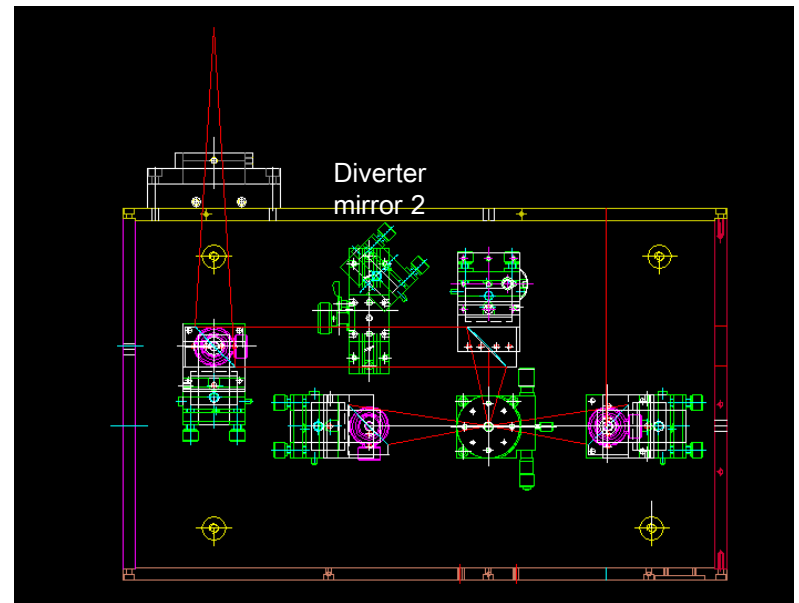


Side Entrance(diameter: 20mm) selected For monochrome light

6. SC100-WR  
6-9-2. Diverter mirror 2 for R/T measurement selection

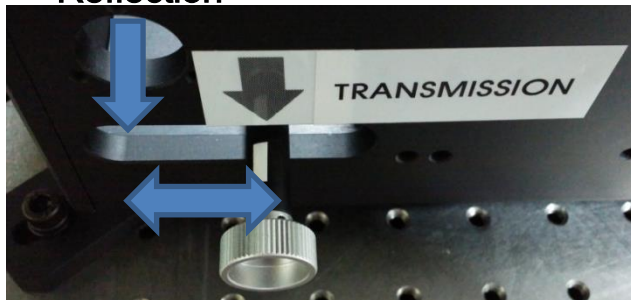


Reflection beam measurement



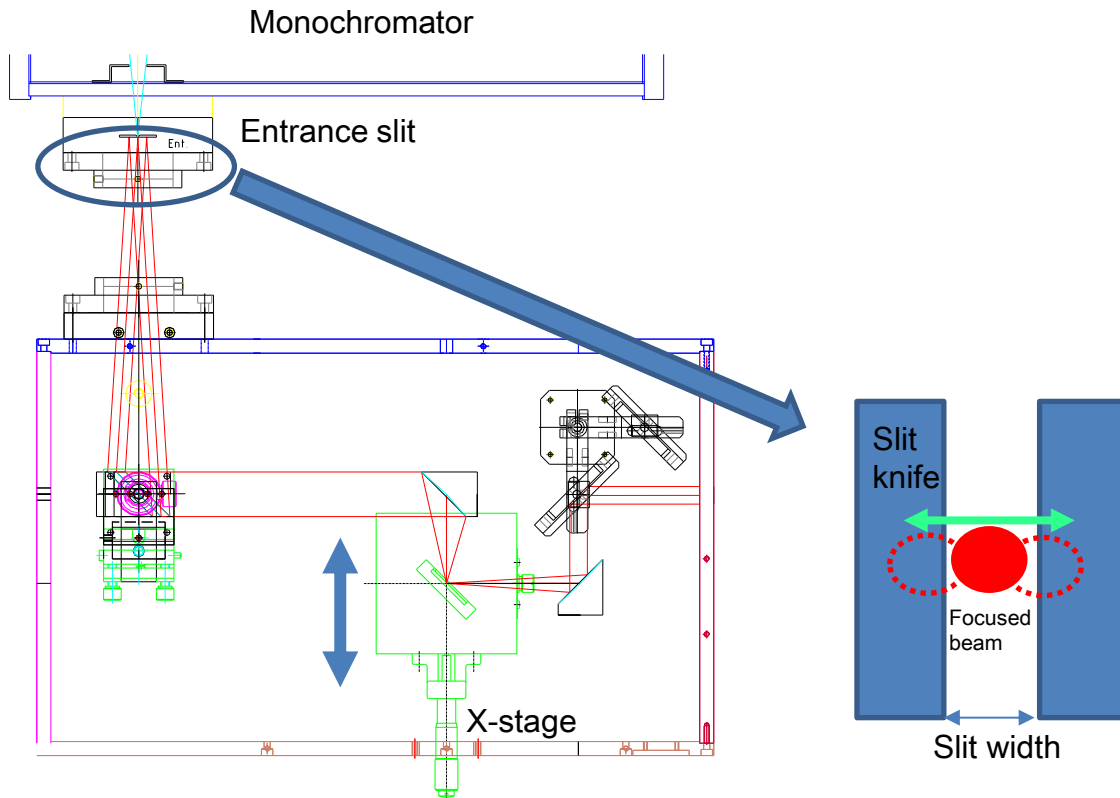
Transmission beam measurement

**Reflection**





6. SC100-WR  
6-10-1. sample alignment for reflection

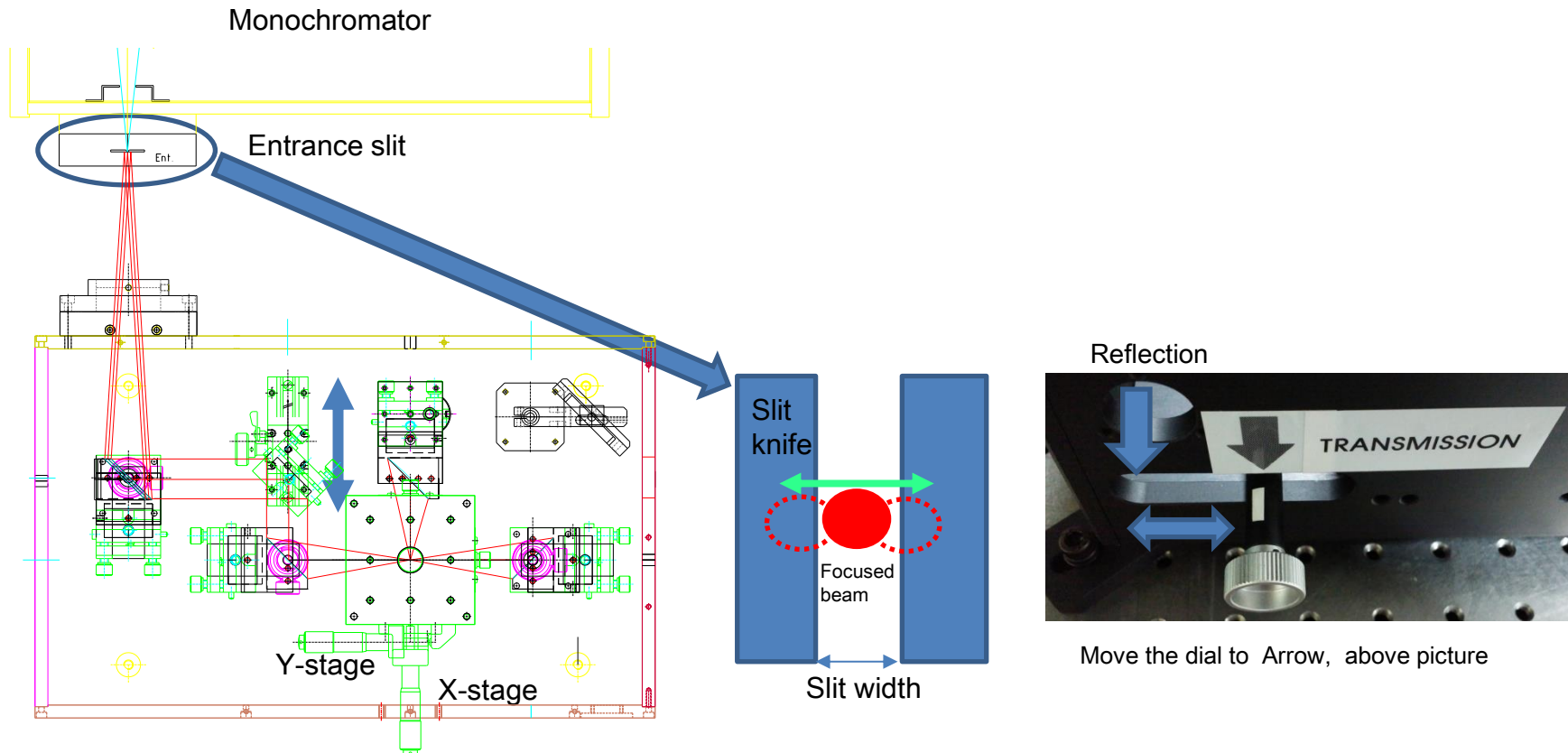


After load sample, if you adjust the X-stage, the focused beam spot will move at Entrance slit,

If the focused beam is located at side of entrance slit, then cannot pass the Entrance slit

The focused beam should pass the entrance slit for the measurement,  
The x- stage can adjust the entrance slit transmittance for focused beam

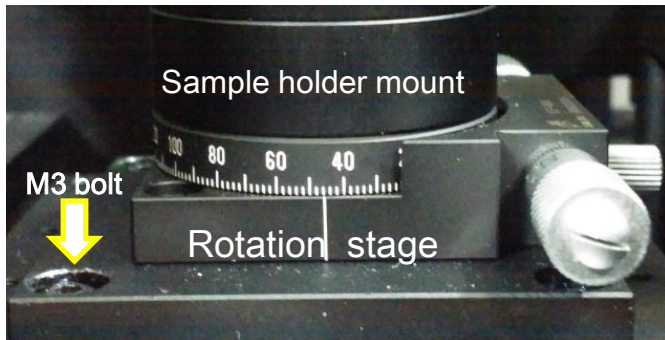
6. SC100-WR  
6-10-2. sample alignment for Transmission



After load sample, if you move the dial, the focused beam spot will move at Entrance slit,  
If the focused beam is located at side of entrance slit, then cannot pass the Entrance slit  
The focused beam should pass the entrance slit for the measurement,  
The dial can adjust the entrance slit transmittance of focused beam

The Y-stage can adjust the beamspot size of entrance slit of monochromator, it mean it adjust transmittance of focused beam

6. SC100-WR  
6-11. sample holder



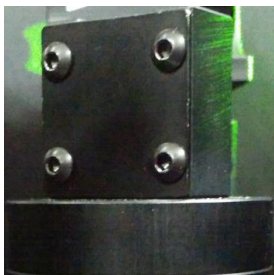
Rotation stage : It can adjust reflection angle.  
Example)

45 degree : For the Reflection measurement

55 degree : For the PL & PLE measurement

Sample holder mount : sample holder holding

Sample holder mount :  
Assembly of rotation stage & sample holder mount  
Attachable by M3 bolt

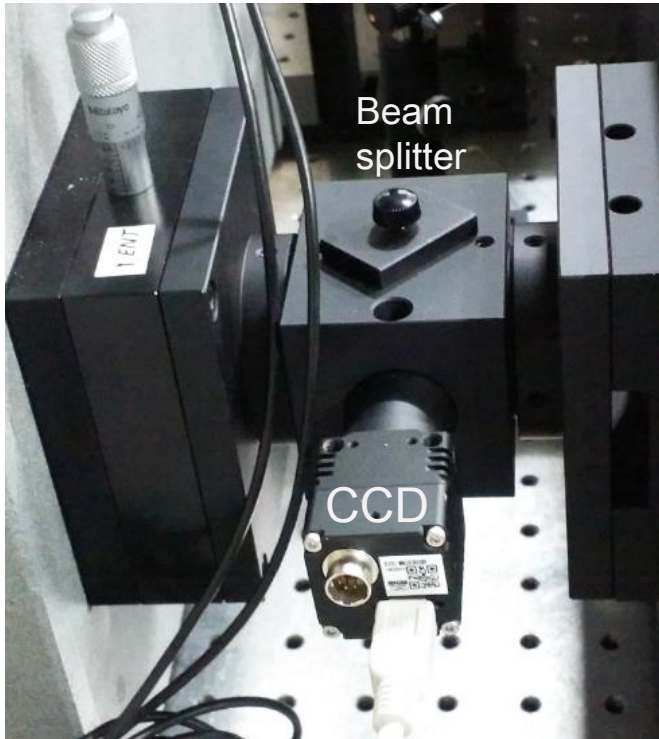


Cubic sample holder  
: For liquid or powder sample



Slide glass sample holder  
: for plate sample

6. SC100-WR  
6-12. Image system



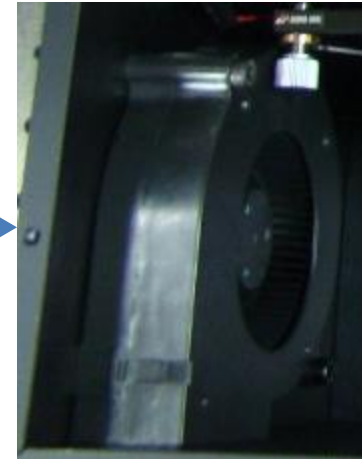
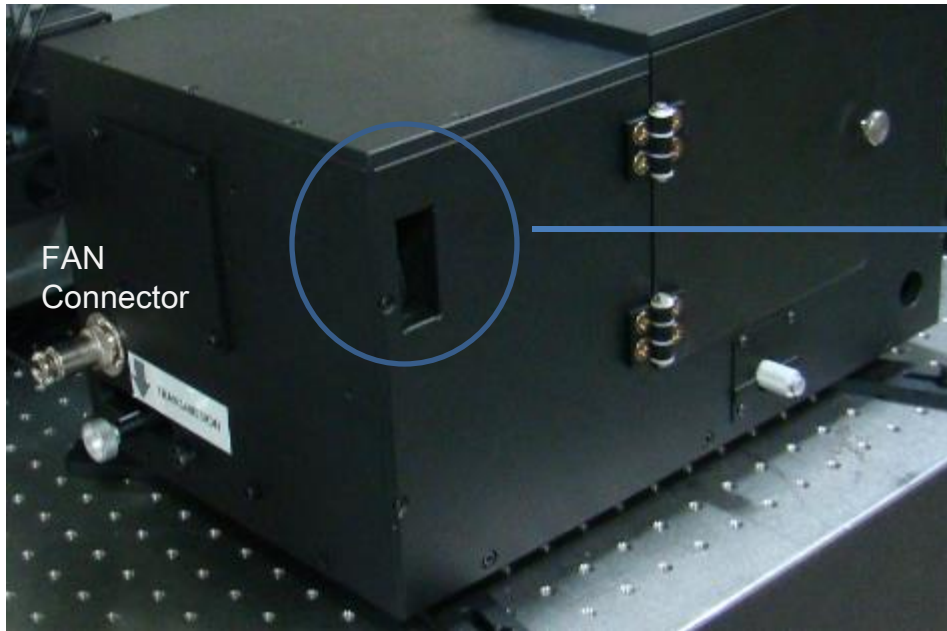
Beam splitter

you can see the sample & excitation beam image  
by CCD (C-mount) & beamsplitter

But, if you remove the beamsplitter, you cannot see the image

When you measure the signal remove the beam splitter.  
When you see the image then, put the beamsplitter

6. SC100-WR  
6-13. Blower FAN

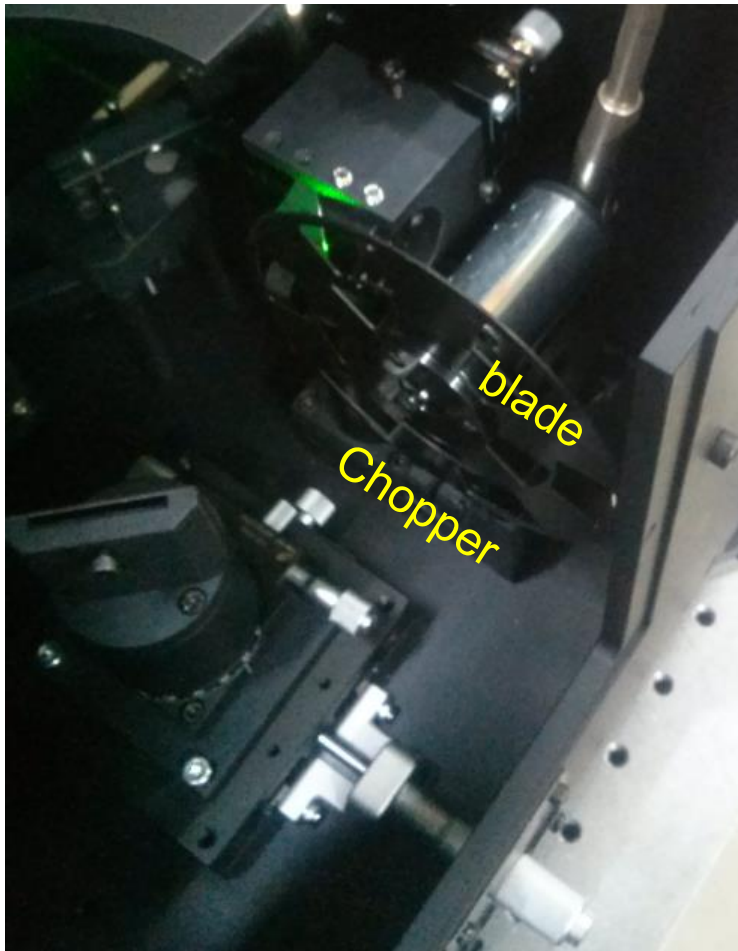


Blower fan : equipped in sample chamber

**FAN:** When the humidity inside of sample chamber increase by Cryogenic system or something.  
By evacuating the air inside of sample chamber by FAN, it can keep the humidity of sample chamber

Power supply for FAN : 12V DC, 2A

6. SC100-WR  
6-14. Chopper



\*\*This sample chamber doesn't include the chopper

You can attached the chopper (Model: SR540, Manufacture: Stanford research)  
the chopper needs for the PBS detector & Lock in amplifier

But if you use the CCD, turn off the chopper & rotate the blade to pass the beam

6. SC100-WR  
6-15. Cryogenic system (80K)



The SC100-WR sample chamber provide the installation of Cryogenic system (80K) for low temperature(80K) PL ATR Measurement

By putting the liquid Nitrogen into the cryostat, Temperature goes down to 80K

The heater of cryogenic system control the temperature

- A. Vacuum shroud
- B. cryostat
- C. Sensor&Heater control cable
- D. Vacuum valve
- E. Vacuum hose

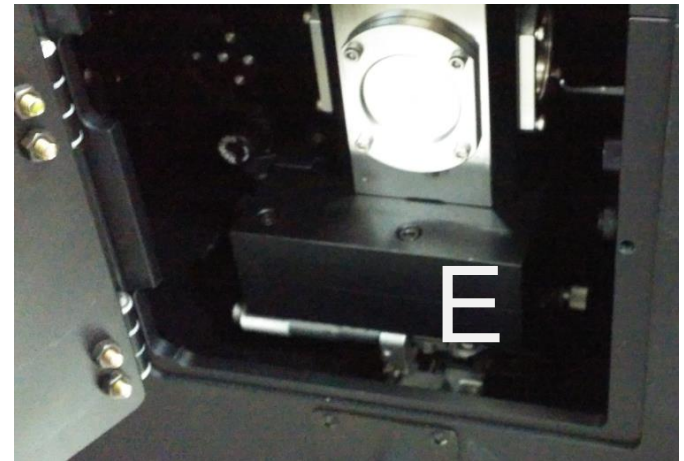
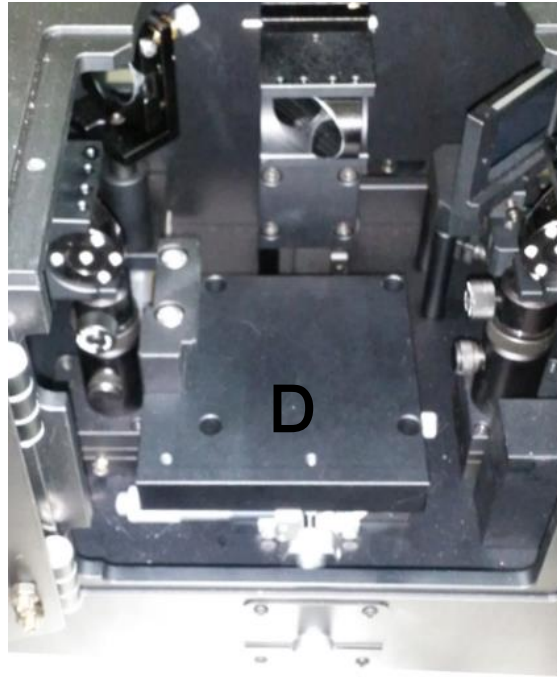
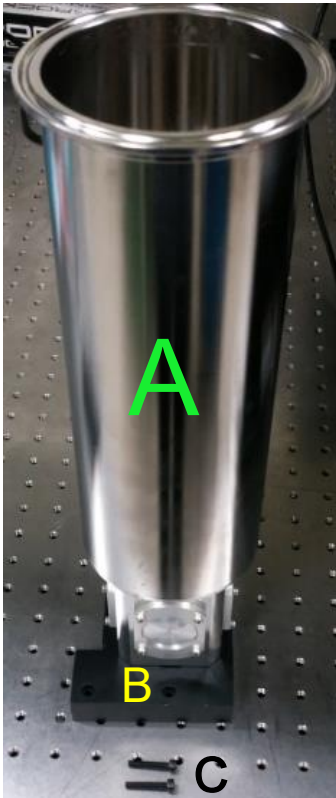
**CAUTION**

Before use the cryogenic system(80K)

You must turn on the blower FAN of sample chamber to reduce the humidity



6. SC100-WR  
6-16. Vacuum shroud installation



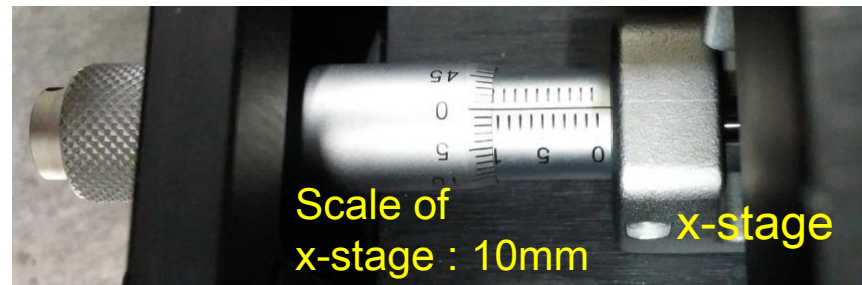
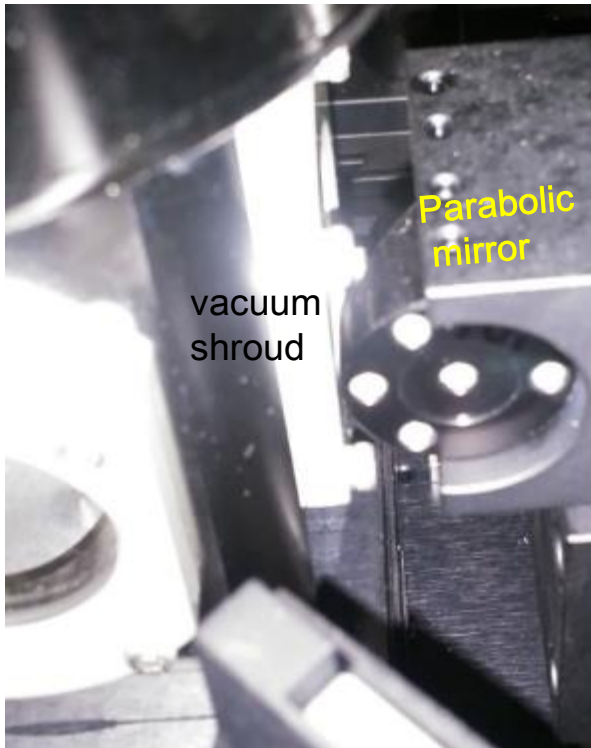
- A. Vacuum shroud : 2 or 3 windows(Dia 38mm, T=3mm) attached    B. Vacuum shroud mount    C. M4-25 bolt 2ea  
D. Stage mount : Attached on the XY stage  
E. Vacuum shroud & Vacuum shroud mount connected to Stage mount by M4-25 bolt

Attachment

1. Open the door of sample chamber
2. Insert the Vacuum shroud&Vacuum shroud mount to Stage mount
3. Connect the Vacuum shroud & Vacuum shroud mount to Stage mount by M4-25 bolt



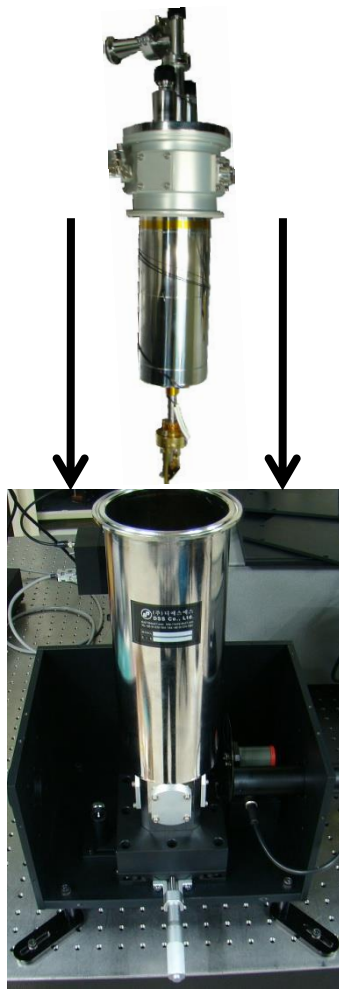
6. SC100-WR  
6-17. CAUTION : Alignment



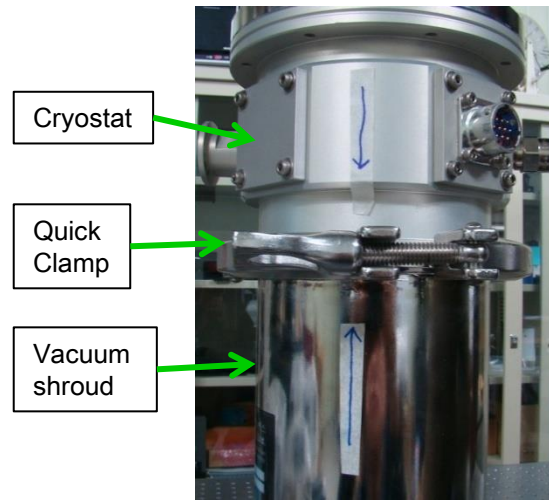
When you adjust the x-stage to align, the vacuum shroud can touch the Parabolic mirror.  
When the scale of x-stage is 10mm, the distance between parabolic mirror & vacuum shroud is almost  $<2\text{mm}$  .

Therefore, please don't decrease the scale of x-stage under the 10mm

6. SC100-WR  
6-18. Cryostat mounting



Put the cryostat into the Vacuum shroud.

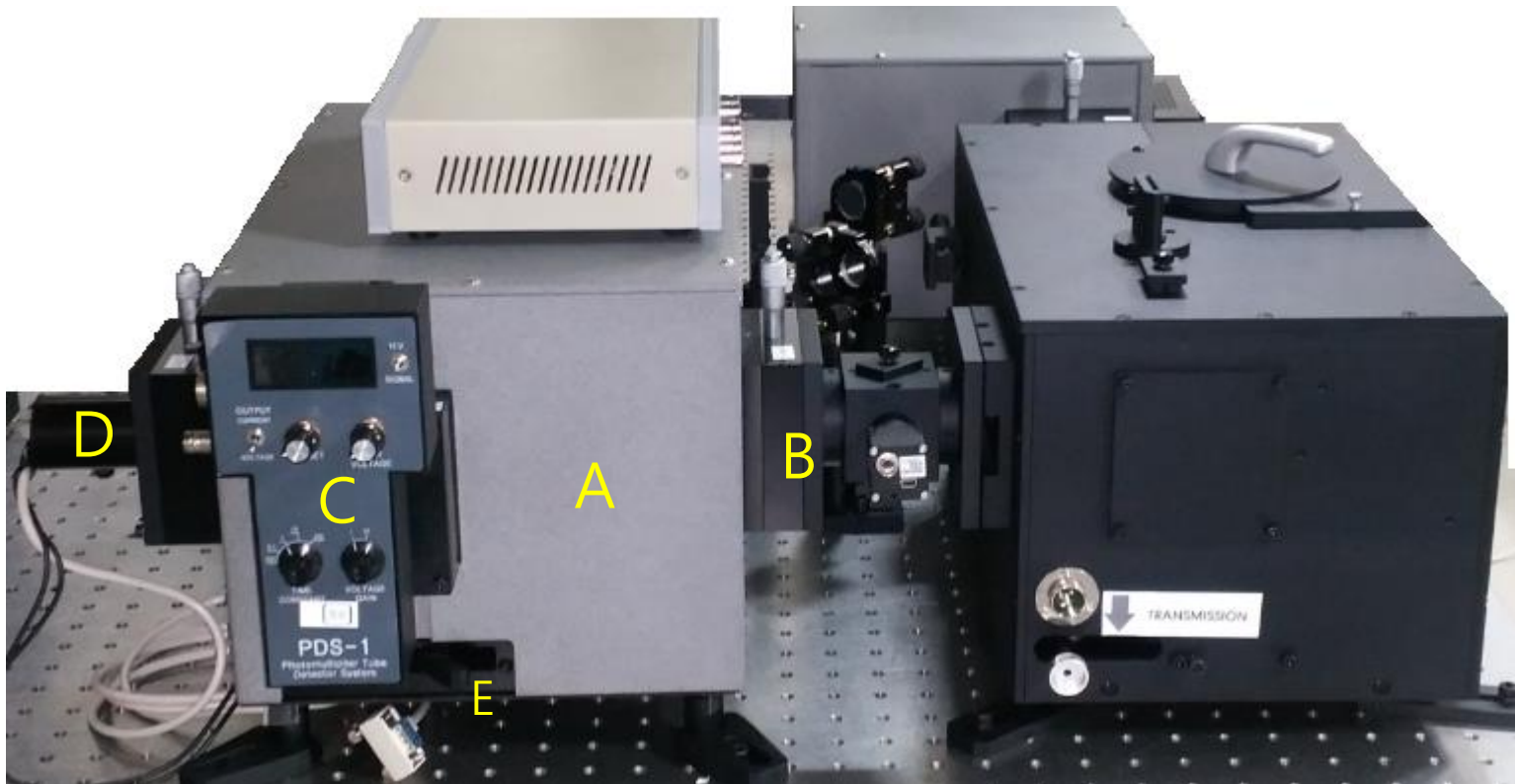


1. Rotate the Cryostat to the arrow of vacuum shroud & Cryostat point to each other
2. Attach the Quick Clamp & hold



3. Attach the Vacuum hose & temperature controller cable to Cryostat

7. Signal Measurement system  
7.1 Exterior



Signal Measurement system

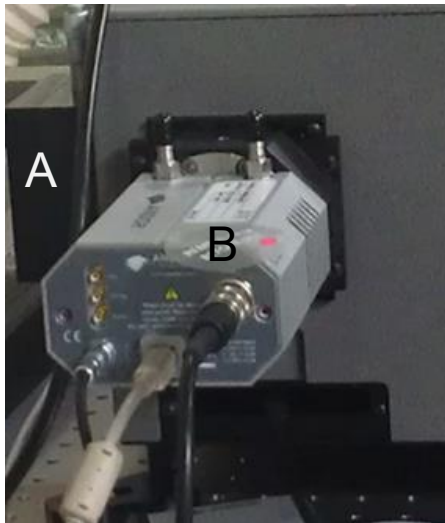
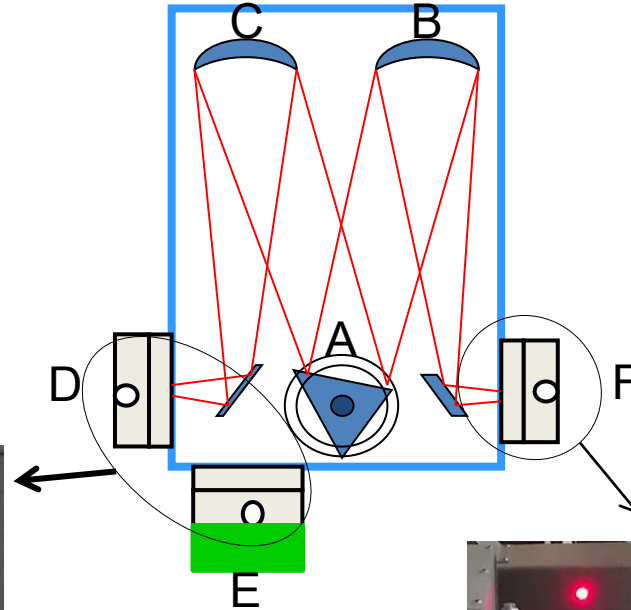
A. Monochromator: Monora320i B. Entrance slit C. PDS-01 D. S/IGA detector E. Diverter mirror bar

# 7. Signal Measurement system

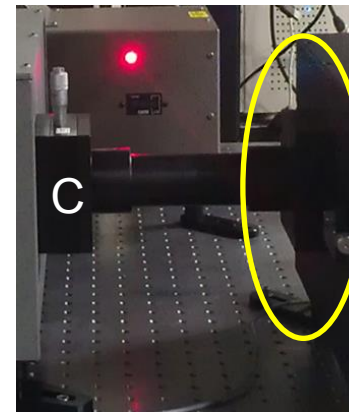
## 7.2 Monochromator : Body

Model : Monora320i  
 Grating :  
 1. 1200gv/500nm  
 Range : 330nm~830nm  
 2. 1200gv/750nm  
 Range : 500nm~1.2um  
 3. 600gv/1.6um  
 Range : 1.0um~2.6um

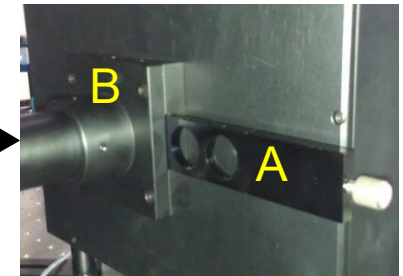
Monochromator part  
 A : Grating  
 B : Collimation Mirror  
 C : Focus Mirror  
 D : Side exit Slit  
 E : Front exit Slit  
 F : Side entrance Slit



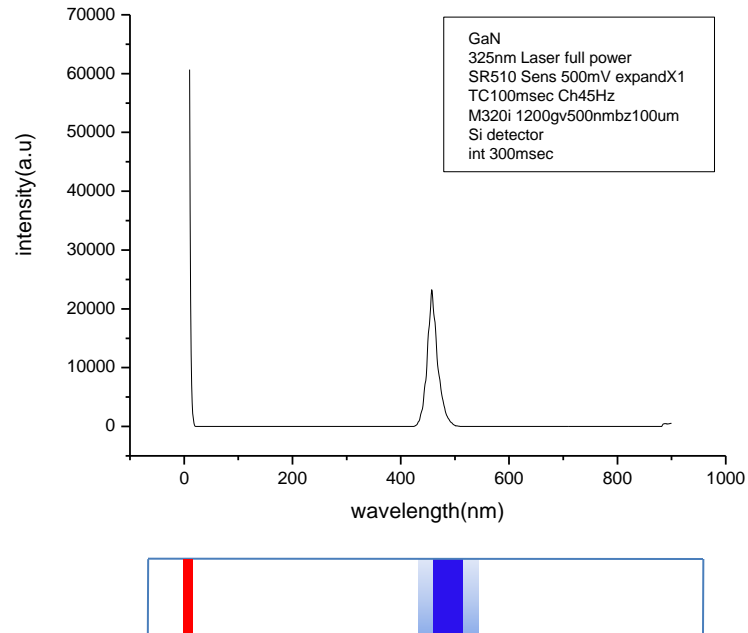
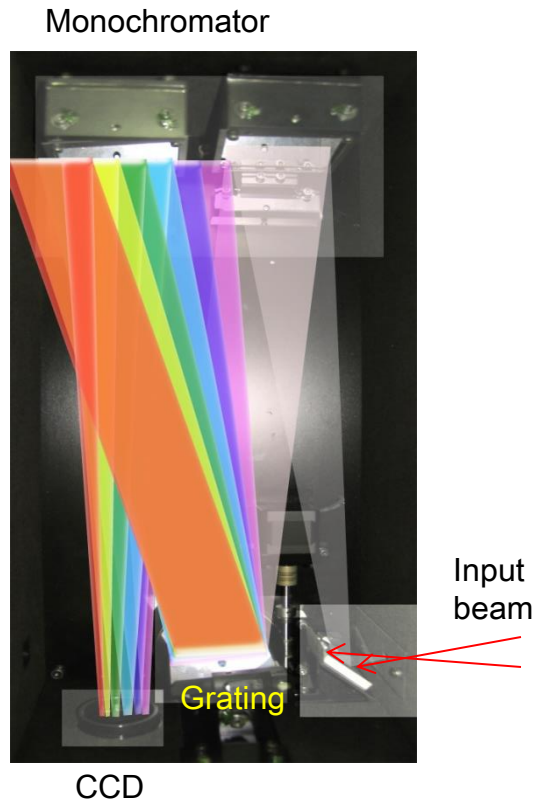
Detector mount  
 A. Side Slit B. iDus CCD



Beam input  
 A. Longwavepass filter holder  
 B. Longwavepass filter holder mount  
 C. Entrance Slit



## 8. Measurement : 8.1 Spectrum in monochromator

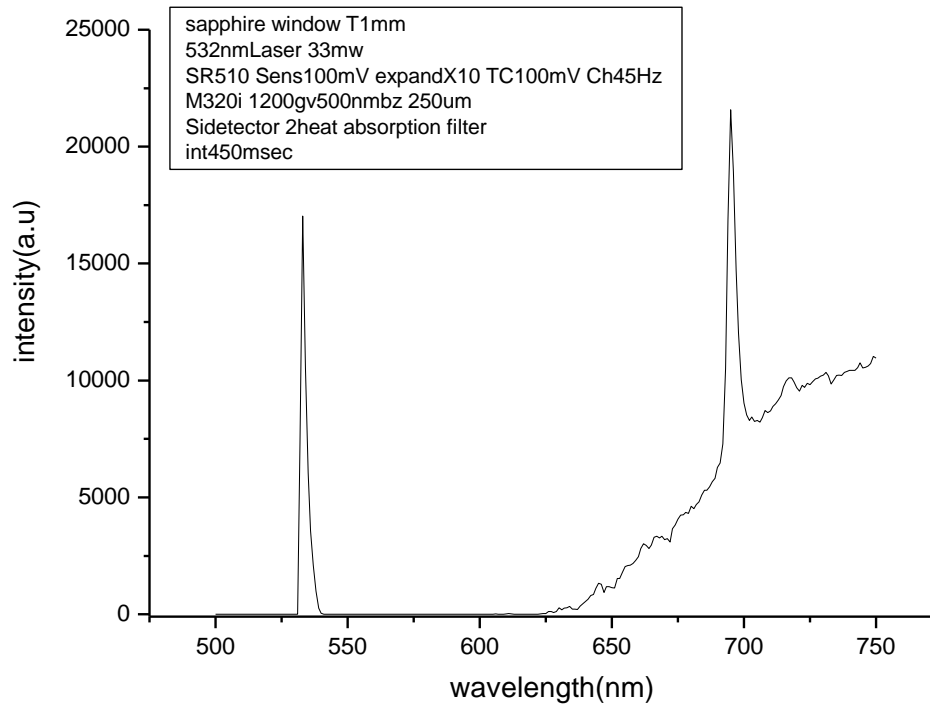


The input beam divide  $0^{\text{th}}$  order beam(reflection beam) and spectrum by grating in monochromator & those are project on CCD

Ex)  
0th Beam Power: ~30% of input beam  
Spectrum power: depends on sample

Generally, the  $0^{\text{th}}$  order beam is much higher than spectrum signal  
So, you can use the  $0^{\text{th}}$  order beam for alignment.

## 8. Measurement : 8.2 Scan with excitation beam



When you measure the PL with excitation beam (Laser, monochrome light)  
You should cut the excitation beam by longwavepass filter  
Because in case the laser beam intensity is much higher than pl signal  
It will act as a noise & the background signal will increase.  
Especially, for the very small pl signal, it's necessary

Above Graphic is the PL spectrum of Sapphire.  
532nm is laser beam, 690nm is sharp PL peak of sapphire,  
LP532 (longwavepass filter to cut the 532nm laser beam)used  
If didn't use the longwavepass filter(LP532), couldn't measure the PL

When consider the transmittance of LP532 filter  
The 532nm laser intensity is 50,000 times higher than above graphic (532nm laser intensity)

## 8. Measurement : 8.3 Measurement Wavelength Range

Measurement wavelength	Laser Choose only 1	Monochrome light	Longwave pass Filter : SC100-WR	Monora320i Grating	Detector
330nm ~ 650nm	325nm laser	<325nm	LP325	1200gv/500nmbz	PDS-01: 250nm ~ 750nm Si : 330nm~1050nm
540nm ~ 1050nm	325nm, 532nm laser	<532nm	LP532	540~850nm : 1200gv/500nmbz 850~1000nm : 1200gv/500nmbz	PDS-01: 250nm ~ 750nm Si : 330nm~1050nm
1050nm ~ 2100nm	325nm,532nm, laser	<1000nm	LP940	600gv/1.6umb	InGaAS(1.9): 800nm~ 1.9um

Monochrome light (refer to chap5.18)

## 9. System operation procedure

### PhotoLuminescence measurement without Cryogenic system

Turn on the device as following

1. Laser (Refer to Chap )
2. Monochromator
3. computer
4. detector or CCD

System off procedure : 4 -> 3-> 2 -> 1

\* After finish the operation, The CCD need the time to cool itself. About Half hour

### PhotoLuminescence measurement with Cryogenic system

Turn on the device as following

1. Laser (Refer to chap )
2. Cryogenic system ( Vacuum pump, temperature controller Refer to Cryogenic system(80K) Manual )

\* After complete the preparation of Cryogenic system & operate it, (refer to Chap 5-4. )

3. Monochromator
4. computer
5. detector or CCD

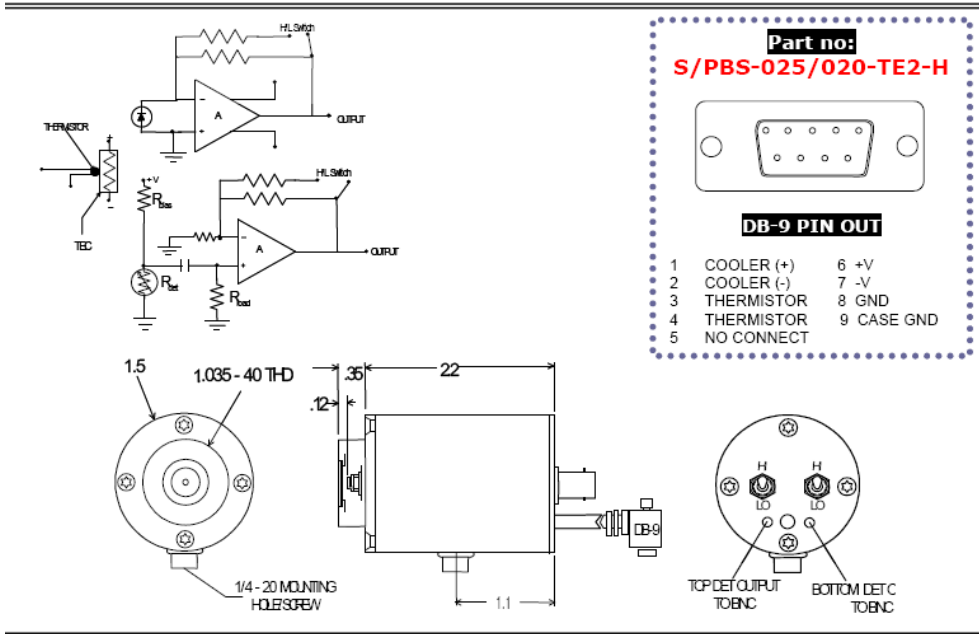
System off procedure : 5 -> 4 -> 3-> 2 -> 1



## 10. Measurement : Photo diode

### 10.1.1 Detector: S/PBS-025/020-TE2-H Specification

#### 2 - COLOR PHOTODETECTOR / RECEIVER



This unit is a high performance two color "sandwich" photodetector/receiver operated with a thermoelectric cooler for stabilization/cooling and dual gain FET input transimpedance amplifiers.

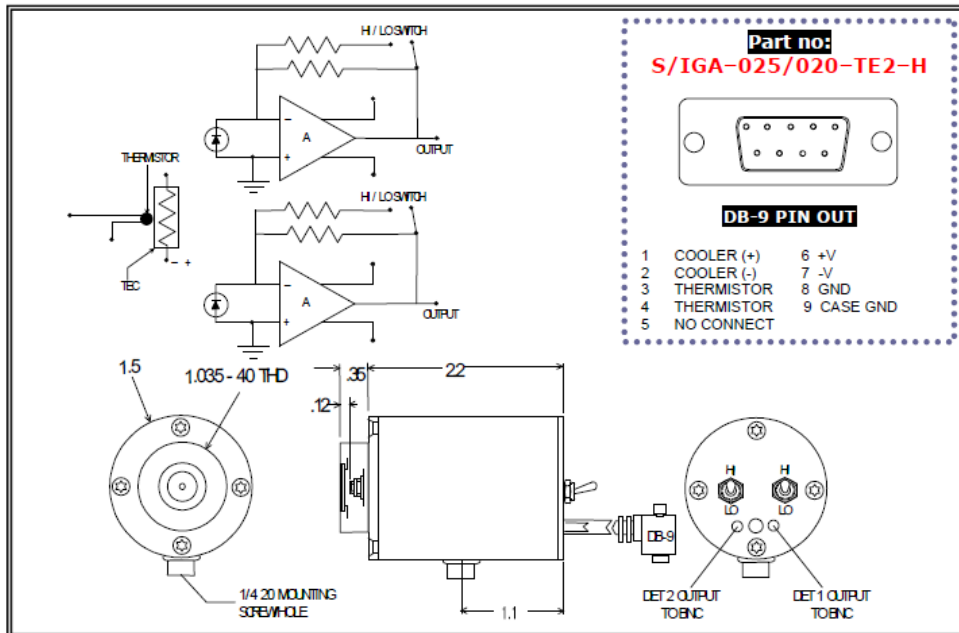
The output voltage is proportional to the input signal current (photodiode) or the input voltage (photoconductor):  **$V_{out} = I_{signal} \cdot R_f \cdot A$**   
**DC coupled circuit is used for the photodiode,** while an AC coupled circuit is used for the photoconductor. Care should be taken in shielding the unit from stray light during operation to prevent saturation of the amplifiers (and potential failure).

#### SPECIFICATIONS

Detector Type	2.5 mm dia Si Photodiode / 2 x 2 mm Pbs Photoconductor			
Operating Temperature - °C	22 @ $I_{teC} = 0.0A$		-30 @ $I_{teC} = 0.6A$	
Operating Wavelength - $\mu m$	0.3 - 1.0	1.0 - 2.6	0.3 - 1.0	1.0 - 2.8
Responsivity - V/W @ pk	$0.6 \times 10^9 / 10^8$	$5.0 \times 10^6 / 10^5$	$0.6 \times 10^9 / 10^8$	$2.0 \times 10^7 / 10^6$
Noise - $\mu V/Hz^{1/2}$	6.0 / 0.6	15 / 1.5	3.6 / 0.4	10 / 1.0
NEP - W/Hz <sup>1/2</sup> @ pk	$1 \times 10^{-14}$	$3 \times 10^{-12}$	$6 \times 10^{-15}$	$1 \times 10^{-12}$
Bandwidth (-3dB) - Hz	DC - 200 / 2k	5 - 500	DC - 200 / 2k	5 - 300
Power Requirements	+/- 9 VDC to +/- 15 VDC			
Connections	Two shielded signal cables terminated with a BNC. Shielded power cable terminated with a DB-9 connector directly couples the unit with the PS/TC-1 Low Noise Power Supply.			

## 10. Measurement : Photo diode

### 10.1.2 Detector: S/IGA-025/020-TE2-H Specification



This unit is a high performance two color "sandwich" photodetector/receiver operated with a thermoelectric cooler for stabilization/cooling and dual gain FET input transimpedance amplifiers.

The output voltage is proportional to the input signal current (photodiode) or the input voltage (photoconductor):  $V_{out} = I_{signal} \cdot R_f \cdot A$   
**DC coupled circuit is used for the photodiode,** while an AC coupled circuit is used for the photoconductor. Care should be taken in shielding the unit from stray light during operation to prevent saturation of the amplifiers (and potential failure).

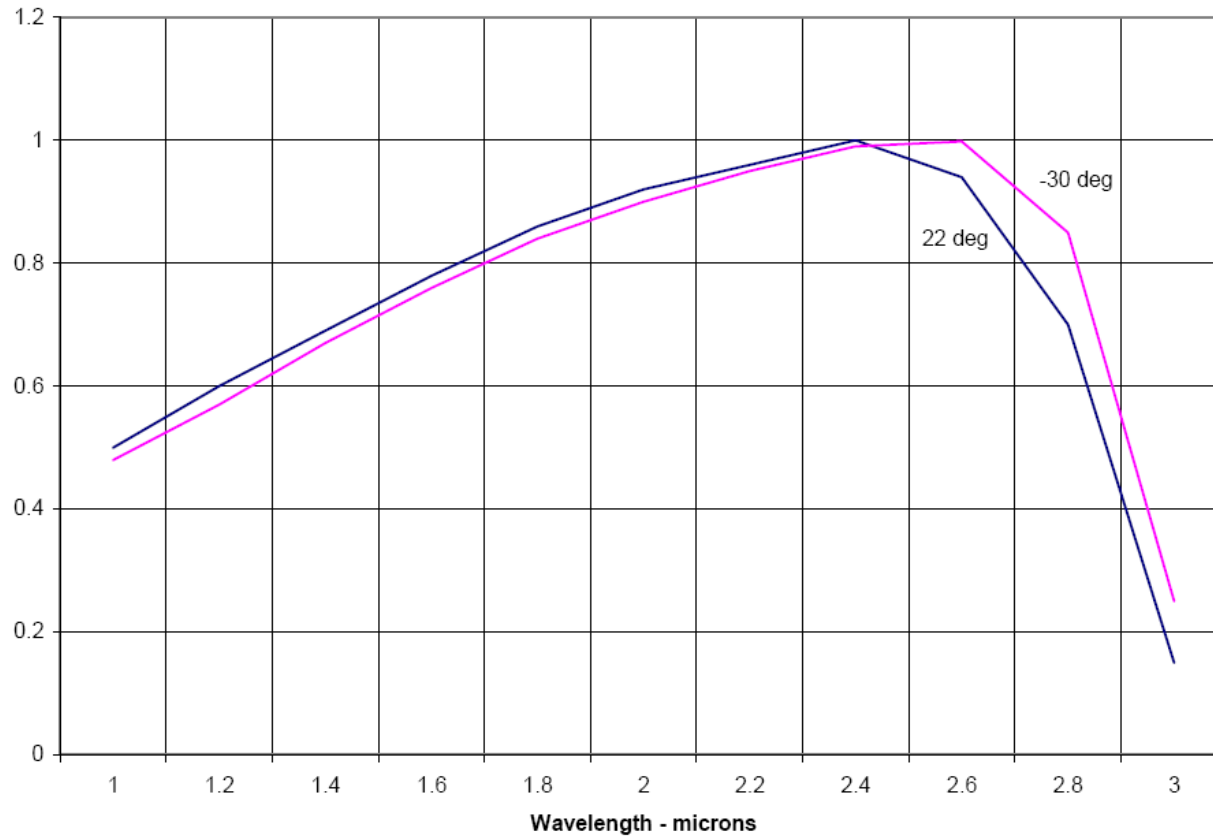
**Application Note** This unit is a high performance two color "sandwich" photodiode / receiver operated with a thermoelectric cooler for stabilization/cooling and dual gain FET input transimpedance amplifiers. The output voltage is proportional to the input signal current:  $V_{out} = I_{signal} \cdot R_f \cdot A$ . The PD/AMP are DC coupled dual gain systems. Care should be taken in shielding the unit from stray light during operation to prevent saturation of the amplifiers (and potential failure).

### SPECIFICATIONS

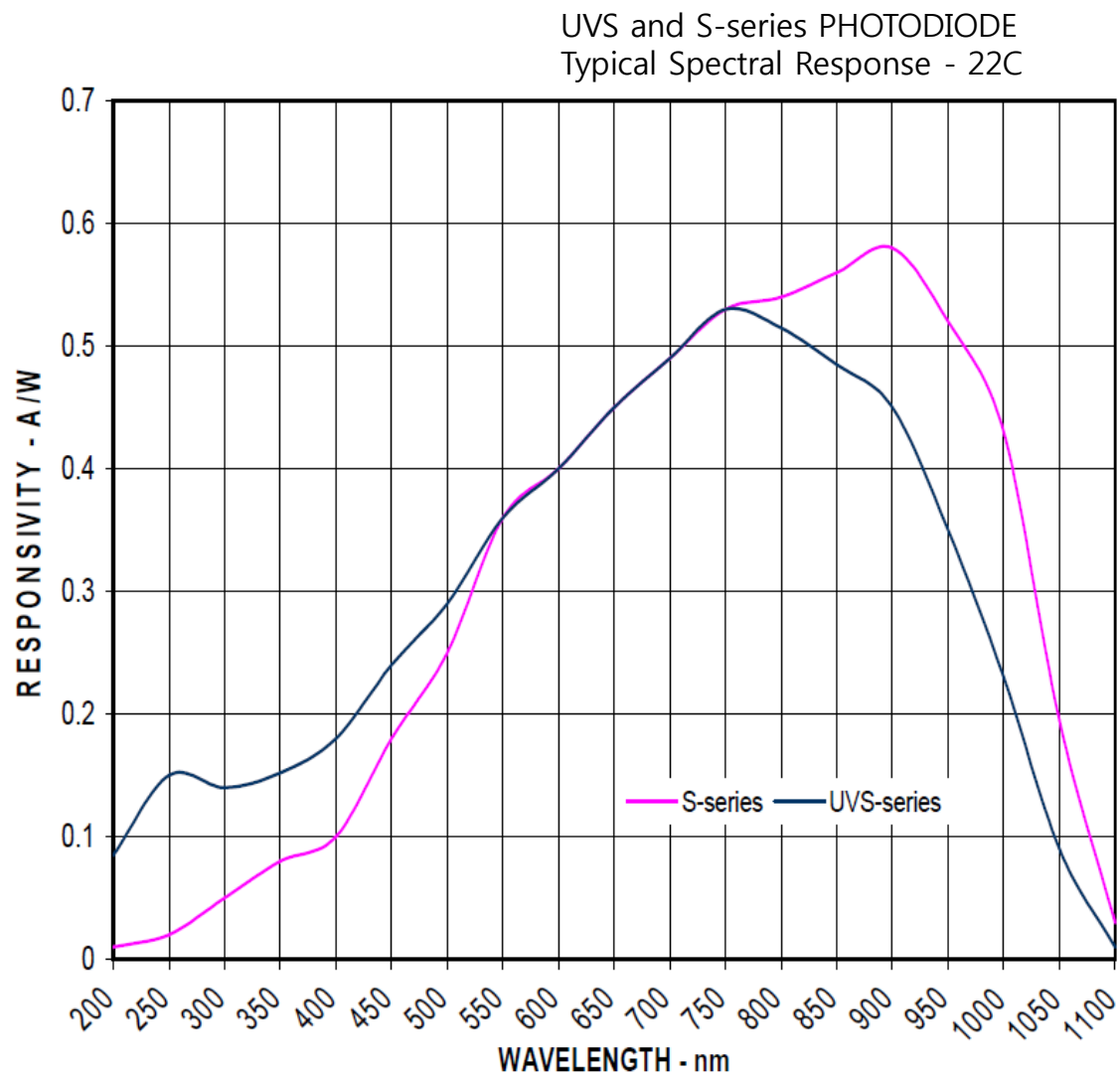
Detector Type	2.5 mm dia Si Photodiode / 2 mm dia InGaAs Photodiode			
Operating Temperature - °C	22 @ $I_{tec} = 0.0 \text{ A}$		-30 @ $I_{tec} = 0.6 \text{ A}$	
Operating Wavelength - $\mu\text{m}$	0.3 - 1.0	1.0 - 1.7	0.3 - 1.0	1.0 - 1.6
Responsivity - V/W @ pk	$0.6 \times 10^9 / 10^8$	$0.6 \times 10^8 / 10^7$	$0.6 \times 10^9 / 10^8$	$0.6 \times 10^8 / 10^7$
Noise - V/Hz <sup>1/2</sup>	$6 \times 10^{-6} / 10^{-7}$	$4.0 \times 10^{-6} / 10^{-7}$	$3.6 \times 10^{-6} / 10^{-7}$	$1.2 \times 10^{-6} / 10^{-7}$
NEP - W/Hz <sup>1/2</sup> @ pk	$1 \times 10^{-14}$	$7 \times 10^{-14}$	$< 6 \times 10^{-15}$	$< 2 \times 10^{-14}$
Bandwidth (-3dB) - Hz	DC - 2k			
Power Requirements	+/- 9 VDC to +/- 15 VDC			
Connections	Two shielded signal cables terminated with a BNC. Shielded power cable terminated with a DB-9 connector directly couples the unit with the PS/TC-1 Low Noise Power Supply.			

## 10.2 PBS Spectral Response Graph

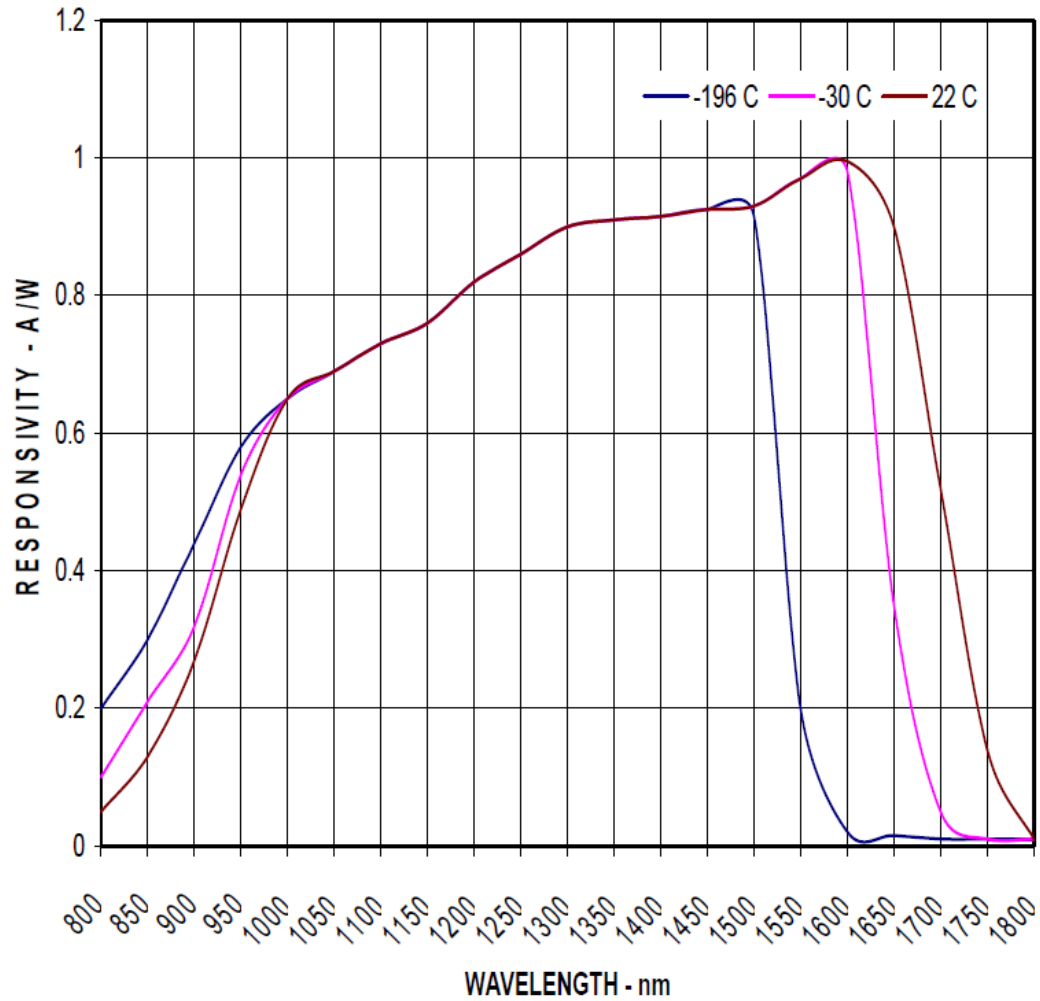
### TYPICAL PBS RELATIVE SPECTRAL RESPONSE



## 10.3 Si Spectral Response Graph

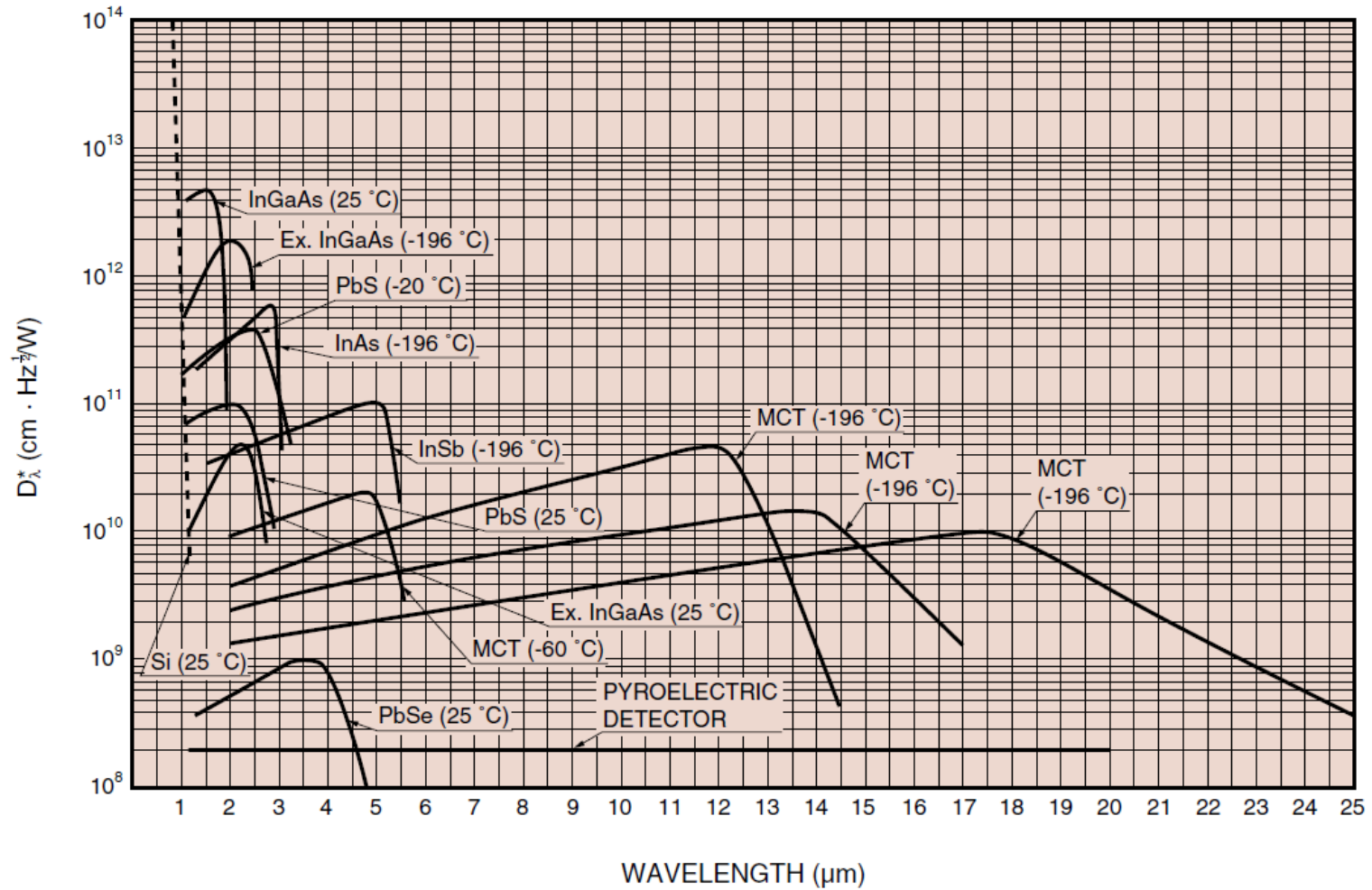


## 10.4 IGA Spectral Response Graph



## 10.5 detectivity

### ● Typical spectral response characteristics of Hamamatsu compound semiconductor photosensors



[photodetector](#) is a [figure of merit](#) used to characterize performance, equal to the reciprocal of [noise-equivalent power](#) (NEP), normalized per square root of the sensor's area and frequency bandwidth (reciprocal of its sampling rate).

$$\text{Detectivity} = D^* = \frac{\sqrt{Af}}{NEP} \quad (\text{cm} \cdot \sqrt{\text{Hz}}/\text{W})$$

A : the area of the photosensitive region of the detector  
f : frequency bandwidth.

## 10.6 detector power supply(PS/TC-1)



Turn on  
Procedure

Turn off procedure  
: 3->1->2

1. Set to 25degree



2. Power on



3. Set to -30 degree  
Stabilizing: Red LED



4. Stabilized : Green LED

Keep the procedure



## 10.7 Detector: PDS-01 Specification

The Photomultiplier Tube(PMT) is the main elements of the PDS-01 detector .  
The PDS-1 detector measure several uVolt signal.

**Caution: Do not expose to Room Light after turn on the PDS-01)**

The R928 and R955 feature extremely high quantum efficiency, high current amplification, good S/N ratio and wide spectral response from UV to near infrared. The R928 employs a UV glass envelope and the R955 has a fused silica envelope for UV sensitivity extension. The R928 and R955 are well suited for use in broad-band spectrophotometers, atomic absorption spectrophotometers, emission spectrophotometers and other precision photometric instruments.

### FEATURES

- Wide Spectral Response
  - R928 ..... 185 nm to 900 nm
  - R955 ..... 160 nm to 900 nm
- High Cathode Sensitivity
  - Luminous ..... 250  $\mu$ A/lm
  - Radiant at 400 nm ..... 74 mA/W
- High Anode Sensitivity (at 1000 V)
  - Luminous ..... 2500 A/lm
  - Radiant at 400 nm .....  $7.4 \times 10^5$  A/W
- Low Drift and Hysteresis



Fig 37. PMT Tube

# PHOTOMULTIPLIER TUBES R928, R955

## MAXIMUM RATINGS (Absolute Maximum Values)

Parameter	Value	Unit	
Supply Voltage	Between Anode and Cathode	1250	V
	Between Anode and Last Dynode	250	V
Average Anode Current <sup>A</sup>	0.1	mA	

## SPECIFICATIONS

### GENERAL

Parameter	Description/Value	Unit	
Spectral Response	R928	185 to 900	nm
	R955	160 to 900	nm
Wavelength of Maximum Response	400	nm	
Photocathode	Material	Multialkali	—
	Minimum Effective Area	8 × 24	mm
Window Material	R928	UV glass	—
	R955	Fused silica	—
Dynode	Secondary Emitting Surface	Multialkali	—
	Structure	Circular-cage	—
	Number of Stages	9	—
Direct Interelectrode Capacitances	Anode to Last Dynode	4	pF
	Anode to All Other Electrodes	6	pF
Base	11-pin base JEDEC No. B11-88	—	
Weight	Approx. 45	g	
Operating Ambient Temperature	-30 to +50	°C	
Storage Temperature	-30 to +50	°C	
Suitable Socket	E678-11A (Sold Separately)	—	
Suitable Socket Assembly	E717-63 (Sold Separately)	—	
	E717-74 (Sold Separately)	—	

Figure 1: Typical Spectral Response

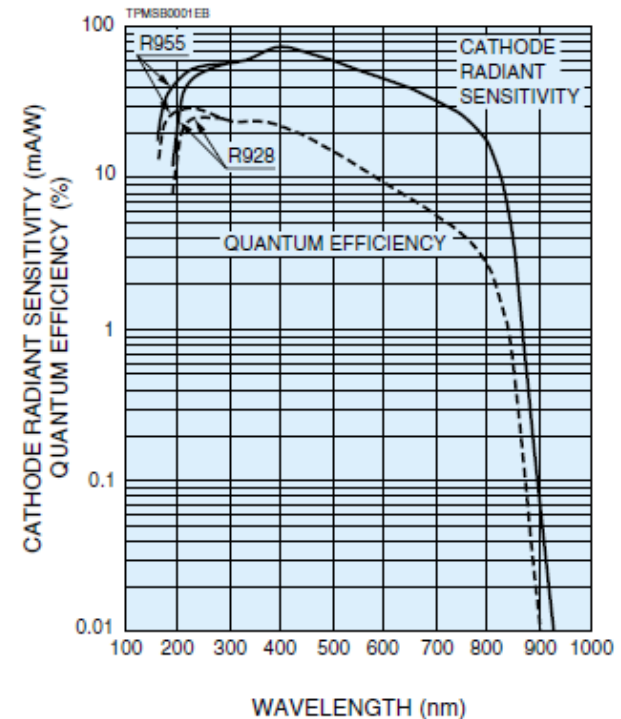


Fig 38. Specification

## 10.8 Detector: PDS-01 exterior

- A : Power Button
- B : Toggle Button(H.V(High voltage), signal Selection)
- C : Toggle Button (Voltage, Ampere selection)
- D : Offset modulation dial :  
Modulation of background signal
- E : High Voltage modulation dial :  
Modulation of High voltage  
( High voltage(H.V) range :  $250V < H.V < 1200V$  )
- F : time constant selection (unit: msec)
- G : Voltage Gain selection
- **Warning:**  
**The 10 which is displayed on LCD Panel 'K' value is maximum value (it mean 10Volt),**  
**so if the signal is '10' then, Cover the PDS-01 from the light** or decrease the High voltage.

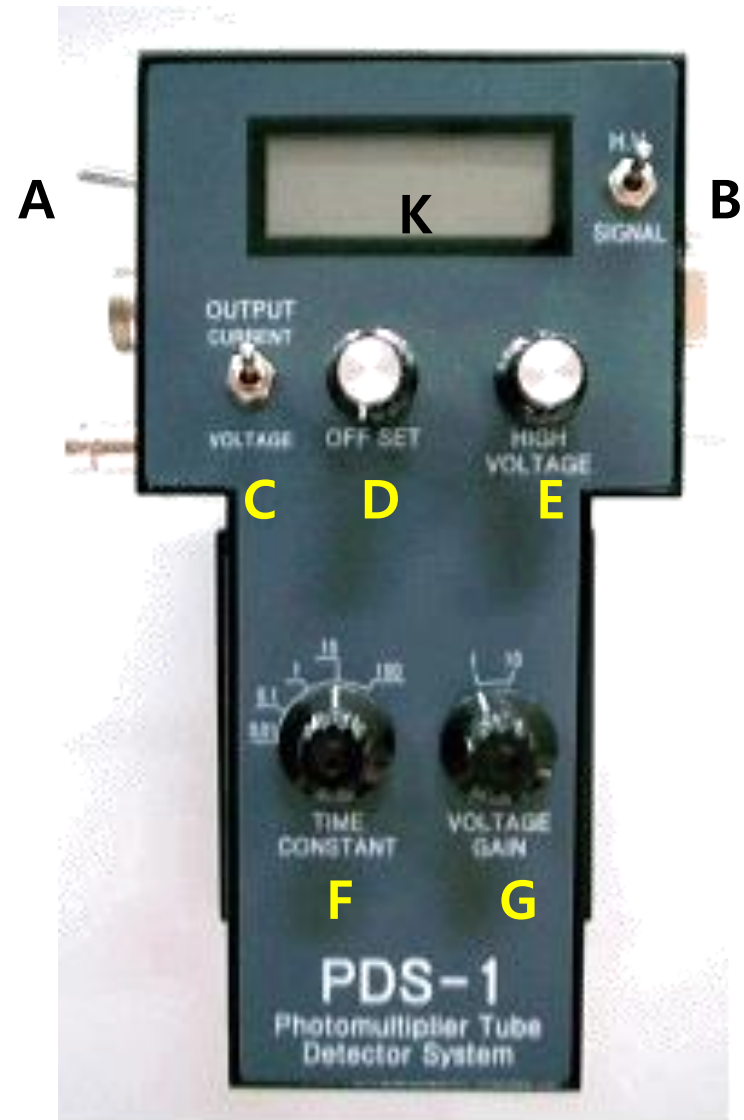
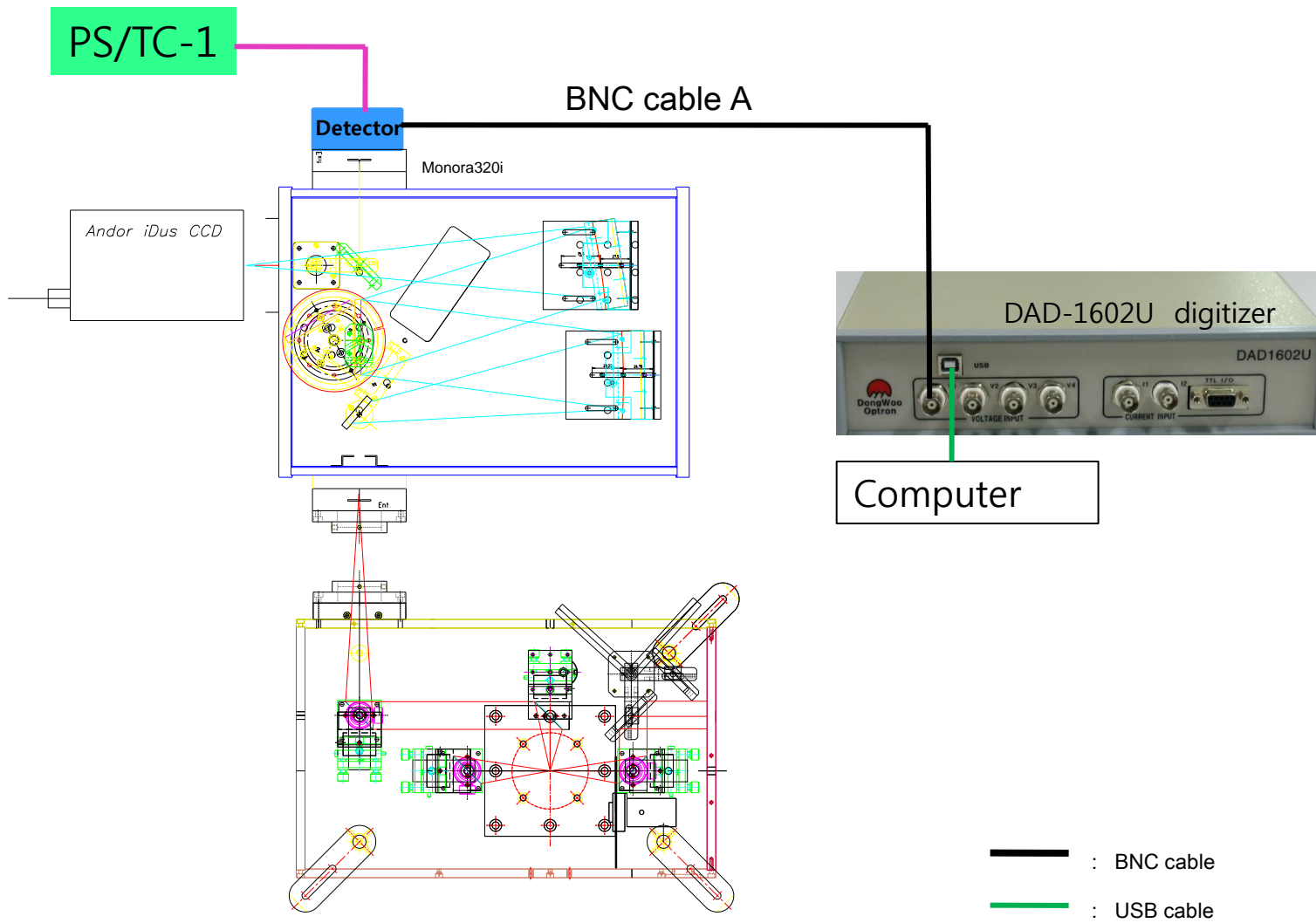


Fig 39. PDS-01

# 10.9 System connection diagram



- : BNC cable
- : USB cable

## 10.10 System operation procedure with Laser & photodiode

1. Attach the sample to sample holder (refer to Chap6-10)
2. Put & hold the sample holder in SC100-WR (refer to Chap6-10)
3. Select the measurement range (refer to Chap 8.3)
4. Close the entrance slit of monora320i (ref chap 5.15)
5. Turn on the laser (select 325,532,830nm laser, refer to Chap 4.1, 4.2, 4.3)
6. Select the Longwavepass filter. (refer to Chap 6.2~6)
7. Turn on the monochromator & select grating
8. Turn on the PC/TC-1 (refer to chap 10.6)
9. Turn on the computer

Turn off procedure : 9->8->7->5

- Chap8.3 In the table, As the measurement range choose the each part

## 10.11 System operation procedure with Monochrome light source & photodiode

1. Attach the sample to sample holder (refer to Chap6-10)
2. Put & hold the sample holder in SC100-WR (refer to Chap6-10)
3. Select the measurement range (refer to Chap 8.3)
4. Close the entrance slit of monora320i (ref chap 5.15)
5. Turn on the Xenon lamp (refer to Chap 5.11,12)
6. Turn on the Cooler of Xenon lamp housing
7. Turn on the monochromator(Monora200,Monora320i) & select grating
8. Turn on the PC/TC-1 (refer to chap 10.6)
9. Turn on the computer

Turn off procedure : 9->8 ->7->5->6

- Chap8.3 In the table, As the measurement range choose the each part..
- After turn off the xenon lamp, the Cooler of Xenon lamp housing needs work for 20min.

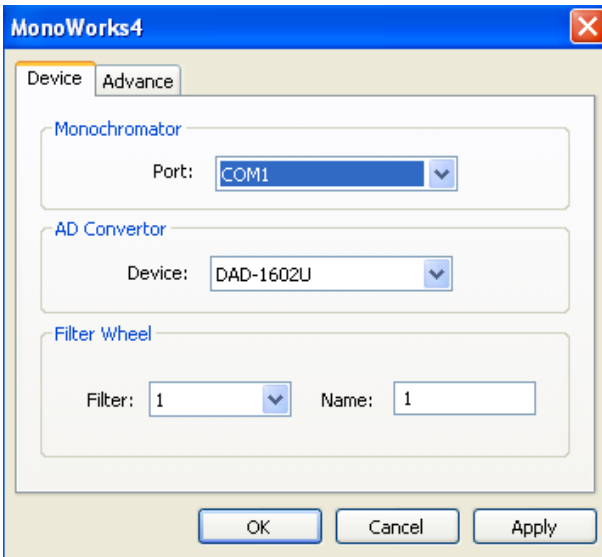
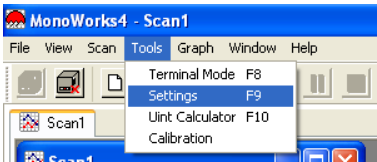
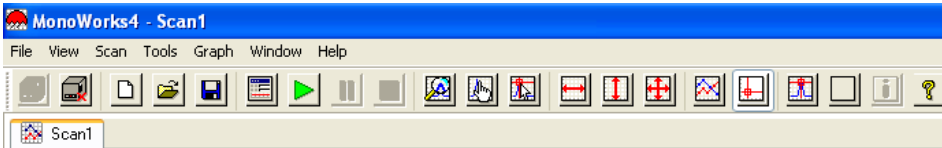
### **CAUTION !!**

You must keep this procedure,  
If not, it is possible to damage to computer or the other devices

## 10.12 Alignment procedure



Refer to Monoworks program manual



The maximum signal level is 65,555.  
If the signal is saturated,  
then put the ND filter or  
decrease the exposure time

### Preparation

1. Double click Monoworks4 program
2. Click the Tools & Settings(or F9) in menu bar
3. Select 'COM#'
4. Select 'DAD-1602U' in Device
5. Click 'OK'

### Alignment

1. Click 'F5' then the monochromator parameter window display
  2. Change the wavelength, wavelength is 0nm.
  3. Open the Entrance slit, the width is 1mm (refer to chap6.1.5, 6.1.6)
  4. Adjust the sample position by X-stage
- \* As the sample close to focal plane, the signal will increase then,
5. Narrow the entrance slit width , the signal decrease
- Repeat 4,5
6. after completed, set to 10um of entrance slit

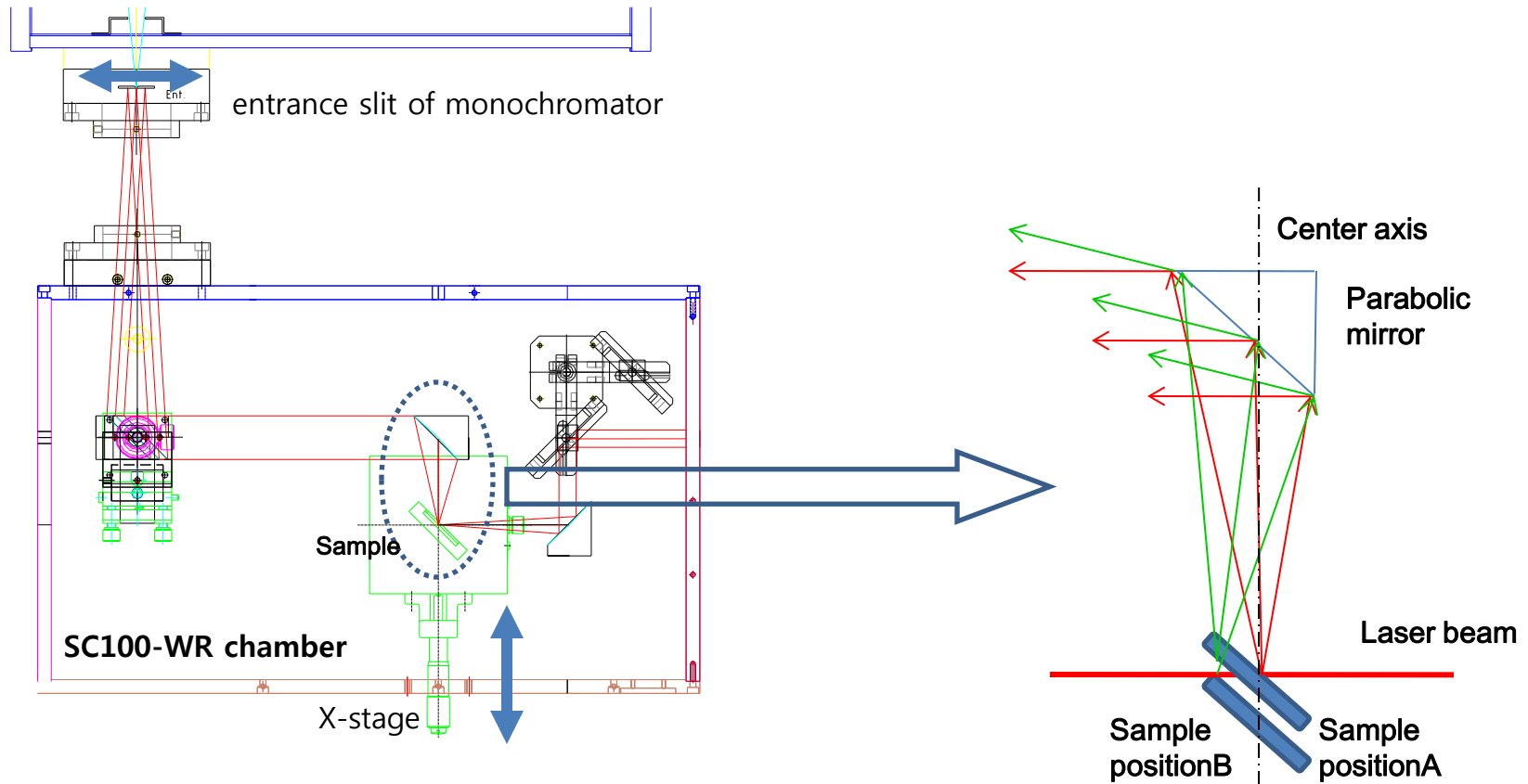
### Measurement range

Refer to Chap 8.1,As the table of Chap 8.1 select&operate each devices, filter

### Resolution & exposure time

1. The entrance slit width control the resolution of spectrum.
2. The beam intensity is proportional to entrance slit width or excitation beam intensity
3. The exposure time of CCD increase or decrease the signal.
  - The signal can be saturate, when you increase the excitation beam intensity or entrance slit width.
  - You need to find out the optimal entrance slit width & exposure time for sample.

## 10.13 Alignment briefing

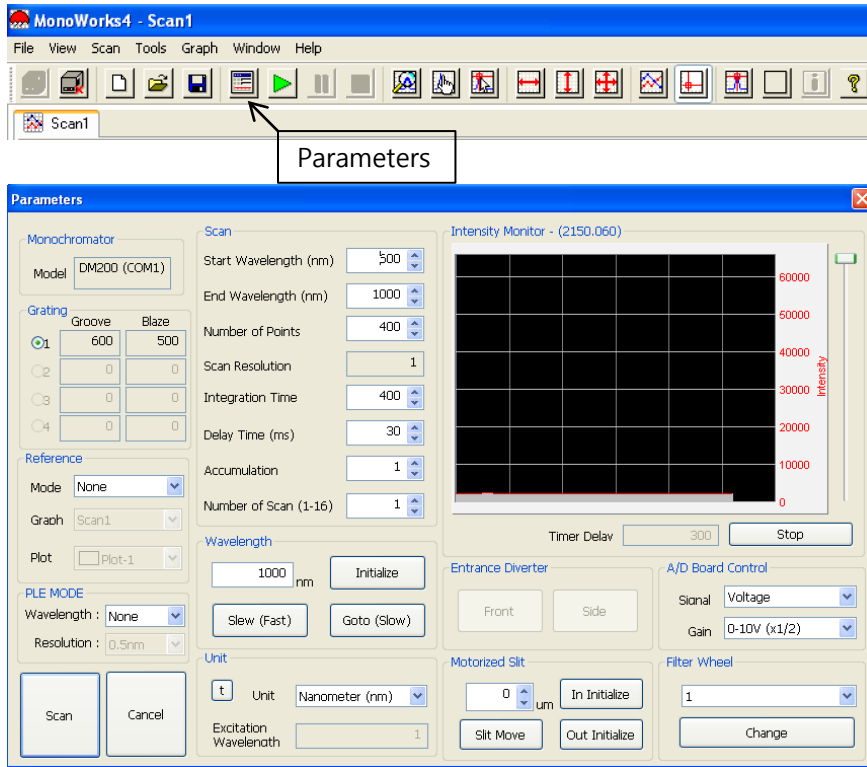


After load sample, If the sample is positioned to center axis of parabolic mirror Then the beam from sample will focusing to entrance slit of monochromator Then the beam from sample can pass the entrance slit of monochromator but If you adjust the X-stage, the focused beam spot will move at Entrance slit,

The x- stage can adjust the entrance slit transmittance of PL beam



## 10.14 Spectrum scan with photodiode



Parameter window

1. Double click Monoworks4 program
2. Click 'Parameters'
3. Select grating (1200gv/300nmbz) in Grating menu
4. Select the 'None' in Reference Mode
5. Select the 'None' in PLE MODE
10. Type the 'Start wavelength' & 'End wavelength'
11. Type the 'Number of Point'
12. Input the below parameter.

Integration Time : 10msec ~1300msec  
it is similar with exposure time.

Delay time : 30msec(ms)  
Default value  
Accumulation : 1~15

Number of Scan : 1~15  
automatic scan function

13. Click 'Scan'

### Measurement range

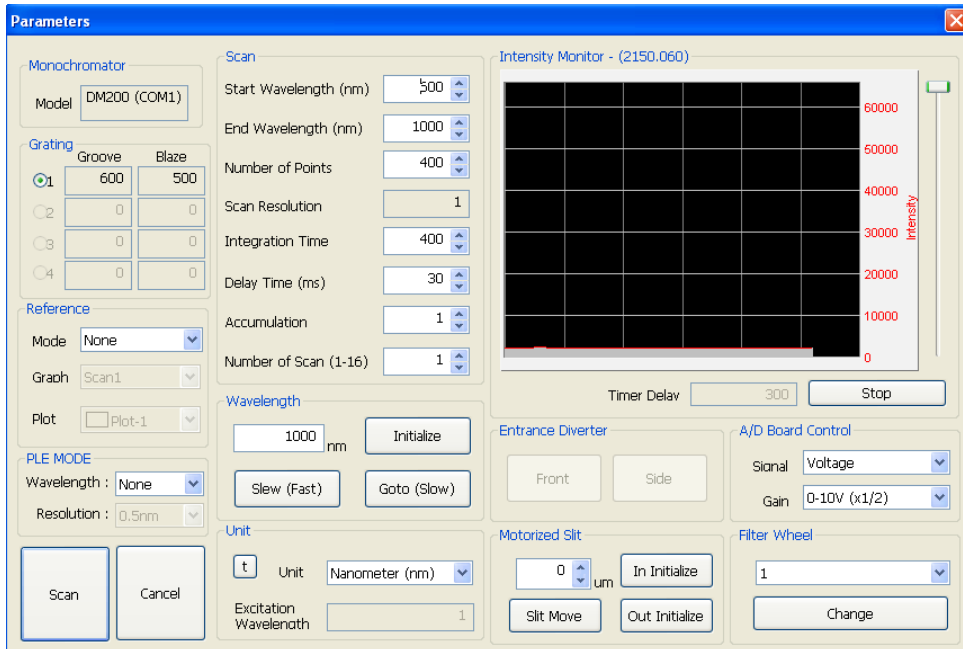
Refer to Chap 8.1, As the table of Chap 8.1  
select & operate each devices, filter

### Resolution & exposure time

1. The entrance slit width control the resolution of spectrum.
2. The integration time increase or decrease the signal to noise ratio  
If the integration time is long, the signal to noise ratio increase.

- The signal can be saturate, when you increase the entrance slit width.
- You need to find out the optimal entrance slit width & integration time for sample.

## 10.15 Trouble shooting : signal is always '0'



After turn on the detector, AD board, computer

If the monoworks software showing '0' signal  
In Intensity monitor of parameter window

Even the light doesn't come to detector (Dark)  
The signal should be bigger than '0'

Then, follow below procedure.

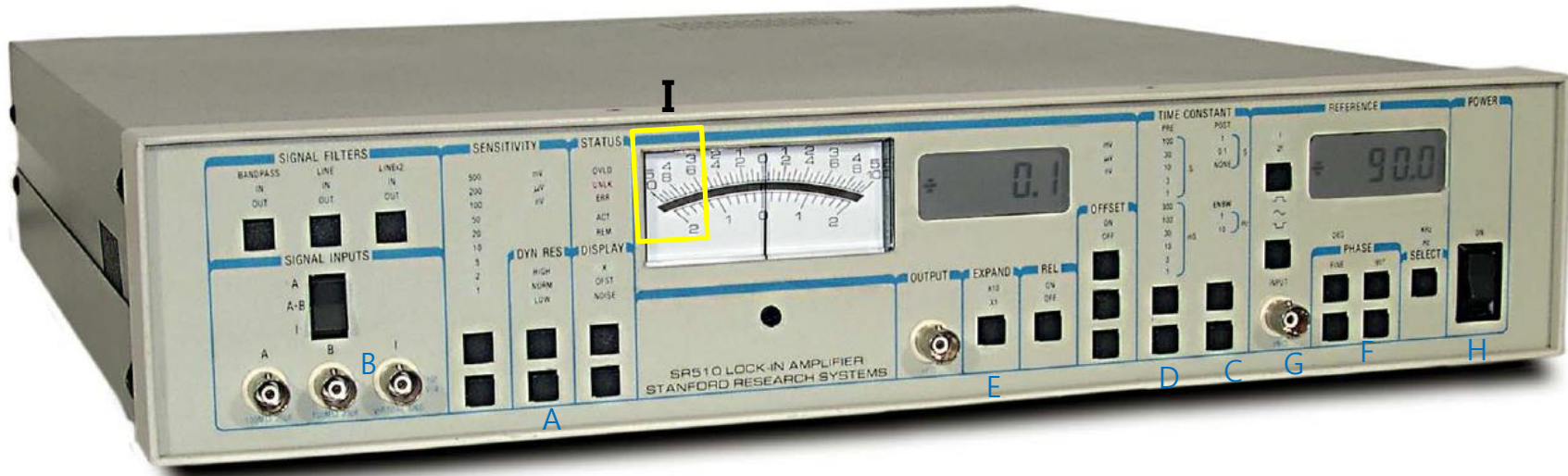
AD board checking

1. Close the monoworks
2. Turn off the AD board
3. Disconnect the usb cable from AD board
4. Connect the usb cable to AD board
5. turn on the AD board
6. Open the monoworks

Detector checking

1. Check the bnc cable connection with detector
  2. Did you turn on the PS/TC-1 ?
  3. Did you connect cable with PS/TC-1 & detector?
- Detector : S/PBS-025/020-TE2-H

## 11. Measurement with Lock in amplifier : 11-1. Exterior



Lock in Amplifier  
 Manufacture:  
 Stanford Research Systems  
 Model: SR510

	Part	Function & connection
<b>A</b>	Sensitivity modulation button	Signal Amplification
<b>B</b>	Signal Input port	Connect the BNC cable to the detector
<b>C</b>	Time constant modulation button	
<b>D</b>	OFFset modulation button	Background signal modulation
<b>E</b>	Output signal port	Connect the BNC cable to the USB A/D Board
<b>F</b>	Phase shift modulation button	+/- 90 degree phase modulation
<b>G</b>	Reference signal Input port	Connect the BNC cable to the chopper controller
<b>H</b>	Power button	
<b>I</b>	status	Alarm

## 11-2. principle

A lock-in amplifier (also known as a phase-sensitive detector) is a type of [amplifier](#) that can extract a [signal](#) with a known [carrier wave](#) from an extremely noisy environment

Lock-in measurements require a frequency reference. Typically an experiment is excited at a fixed frequency (from an oscillator or function generator, chopper) and the lock-in detects the response from the reference frequency. In the diagram below, the reference signal is a square wave at frequency  $\omega_r$ . This might be the sync output from a chopper. If the sine output from the chopper is used to excite the experiment, the response might be the signal waveform shown below.

The signal is  $V_{sig} \sin(\omega_r t + \theta_{sig})$

where  $V_{sig}$  is the signal amplitude.

The Lock in amp generates its own sine wave, shown as the lock-in reference below.

The lock-in reference is  $V_L \sin(\omega_L t + \theta_{ref})$ .

The Lock in amp amplifies the signal and then multiplies it by the lock-in reference using a phase-sensitive detector or multiplier. The output of the PSD is simply the product of two sine waves.

$$\begin{aligned} V_{psd} &= V_{sig} V_L \sin(\omega_r t + \theta_{sig}) \sin(\omega_L t + \theta_{ref}) \\ &= \frac{1}{2} V_{sig} V_L \cos([\omega_r - \omega_L]t + \theta_{sig} - \theta_{ref}) - \frac{1}{2} V_{sig} V_L \cos([\omega_r + \omega_L]t + \theta_{sig} + \theta_{ref}) \end{aligned}$$

The PSD output is two AC signals, one at the difference frequency  $(\omega_r - \omega_L)$  and the other at the sum frequency  $(\omega_r + \omega_L)$ .

If the PSD output is passed through a low pass filter, the AC signals are removed.

What will be left? In the general case, nothing. However, if  $\omega_r$  equals  $\omega_L$ ,

the difference frequency component will be a DC signal. In this case, the filtered PSD output will be

$$V_{psd} = \frac{1}{2} V_{sig} V_L \cos(\theta_{sig} - \theta_{ref}) \quad \text{if } \theta_{ref} = 0$$

Then,  $V_{psd} = \frac{1}{2} V_{sig} V_L \cos \theta_{sig}$  ....eq1) By modulation of  $\theta_{sig}$ , the signal amplitude will vary. the phase shift modulation button modulate the  $\theta_{sig}$  (phase) of lock in amplifier (Ref to Chap 7)

This is a very nice signal - it is a DC signal proportional to the signal amplitude. (Ref to SR810 manual, [www.thinkSRS.com](http://www.thinkSRS.com))

# 11-3. Connections with system

Lock in Amplifier: SR510



BNC cable A

output

REF IN

BNC cable B

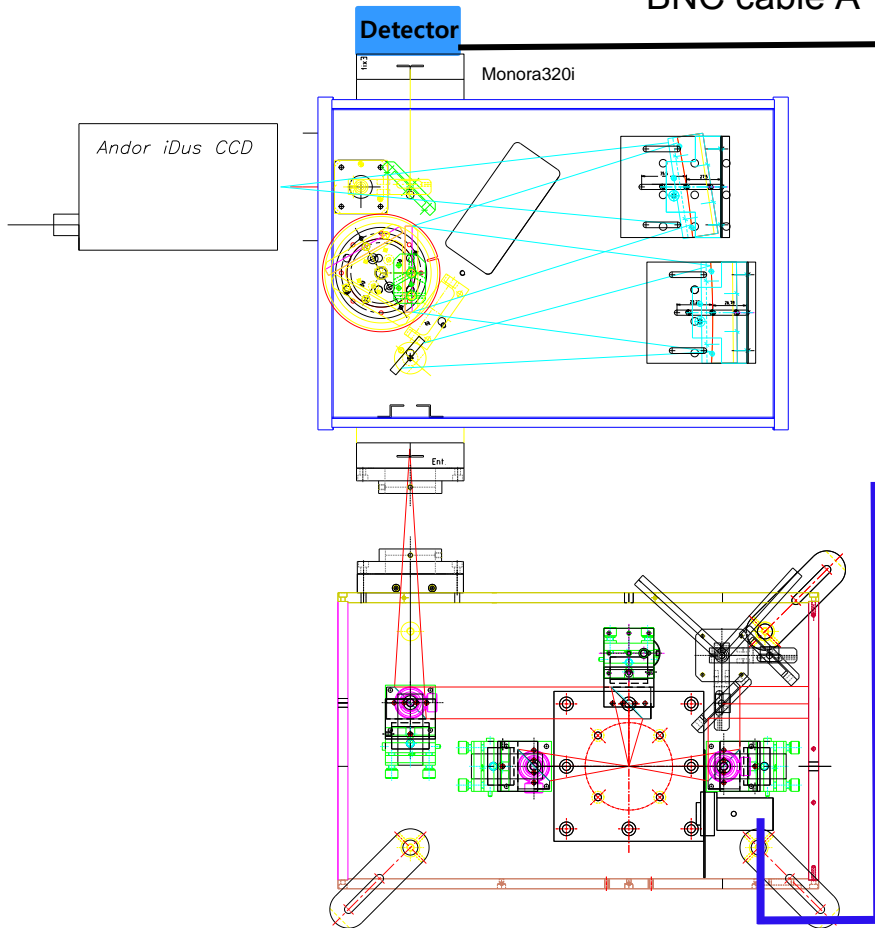


BNC cable C

Computer



SR540 Chopper controller



- : BNC cable
- : USB cable

#### 11-4. Lock in amplifier parameter

	Integration time - Monoworks 4.3.1	Lock in amplifier Time constant	Chopper frequency
Speed1	1300msec	300msec	20Hz
Speed2	1000msec	100msec	45Hz
Speed3	400msec	30msec	130Hz

## 11-5. measurement

### Test condition

Sample : GaN

1. Laser : 325nm DPSS Laser  
(30mW on sample surface)
2. Spectrometer : Monora320  
Grating : 1200/500nm  
Slit Width (entrance, exit): 100um
3. Lock in amplifier : SR510  
Sensitivity : 500mV  
Time constant : 100msec  
Chopper frequency : 45Hz
4. Monoworks program  
Input range : 0-1Volt  
Integration time : 300msec
5. Detector : Si S/PBS-025/020-TE2-H  
( cooling temperature : - 30degree)

### Preparation

1. Put the LP325 Filter into filter holder mount
  2. Adjust the slit width of Entrance & exit of Monora320,  
the slit width is 0um.
- Detector : S/PBS-025/020-TE2-H
1. Select the Si detector & connect  
the Si cable to lock in amplifier
  2. Set the Gain to X10
- Sample chamber
1. Put the sample in sample holder
- Lock in Amplifier : SR510
1. Set the sensitivity to 500mV
  2. Set the time constant to 100msec
  3. Set the Chopper frequency to 45Hz

### Measurement procedure

1. Adjust the slit width of Entrance & exit of Monora320,  
the slit width is 100um.
2. Activate the monoworks
3. Adjust the X-stage of sample chamber.  
Adjust the Phase (Next page) to maximize the signal
4. Scan the spectrum

## 11.6 Phase modulation

Lock in amp output signal :

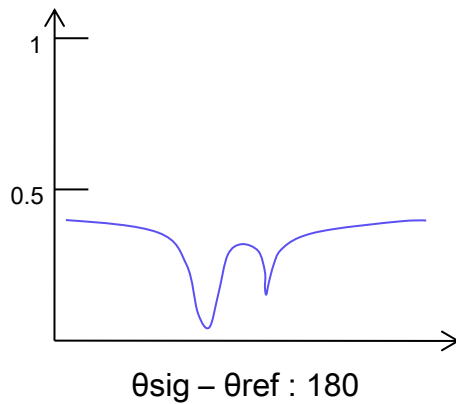
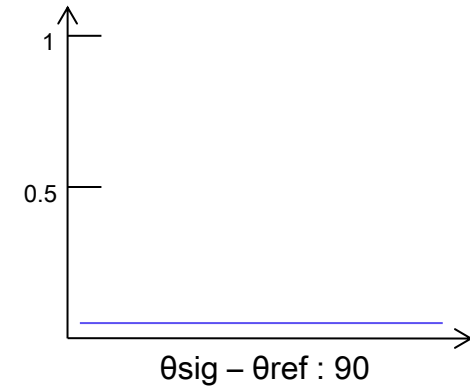
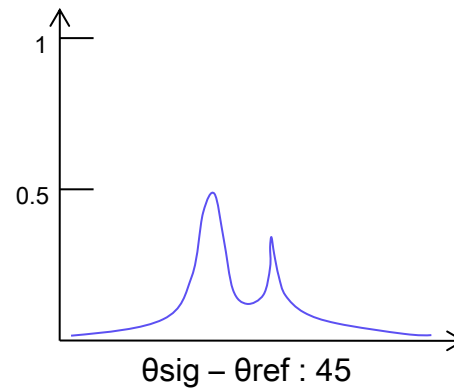
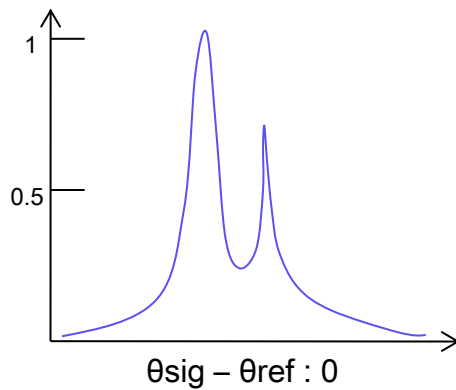
$$V_{psd} = \frac{1}{2} V_{sig} V_L \cos(\theta_{sig} - \theta_{ref})$$

$\cos(\theta_{sig} - \theta_{ref})$  :

$\theta_{sig} - \theta_{ref}$  : 0, 90, 180, 270, 360

The output signal depends on the phase ( $\theta_{sig} - \theta_{ref}$ ).

The below graph shows the phase effect. (The graph is PL signal)



\* The signal is sensitive to phase  
If  $\theta_{sig} - \theta_{ref} = 0$  then, the output signal is maximum.



## 11.7 Trouble shooting

### **Caution**

1. Check the alarm led (refer to chap 11-1, I )
  - 1-1. If the OVLD is alarming, decrease the sensitivity.
  - 1-2. If the UNLK is alarming, disconnect & connect the BNC cable to REF IN (refer to chap 11-1 ) but still alarming, then check the resistivity of BNC cable C by multi meter (refer to chap 11-1 )

## 12. PLE Measurement : 12-1. Preparation of signal measurement system

### Example1) PLE spectrum of GaN(LED)

The Graph1 is the PL spectrum(excited by 340nm beam Monochromae light) of GaN (Multi quantum well) wafer

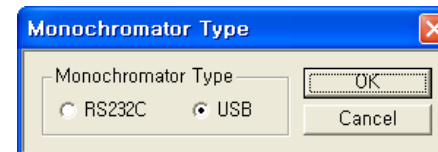
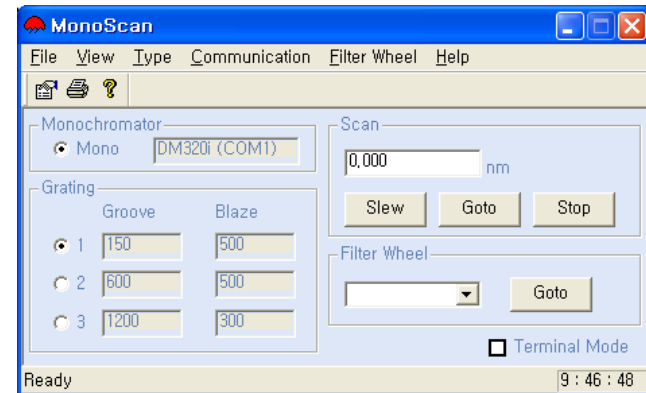
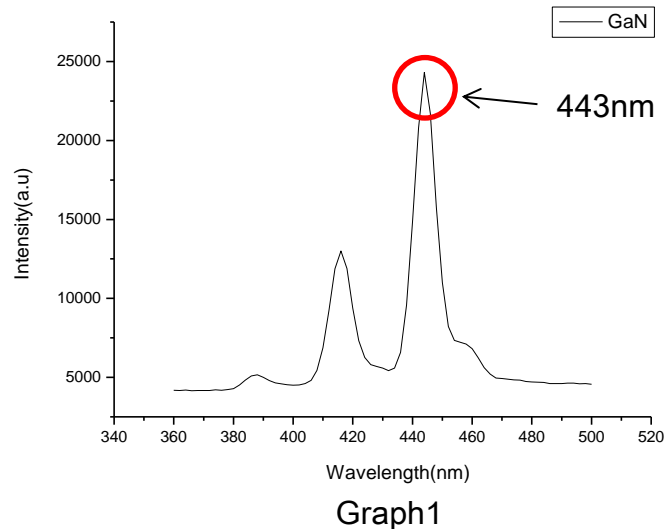
we have measured the PL spectrum(Graph1) of GaN (Multi quantum well) wafer.

& we want to measure the PLE spectrum at the peak (Graph1, 443nm, red circle) of the PL spectrum of GaN (Multi quantum well) wafer

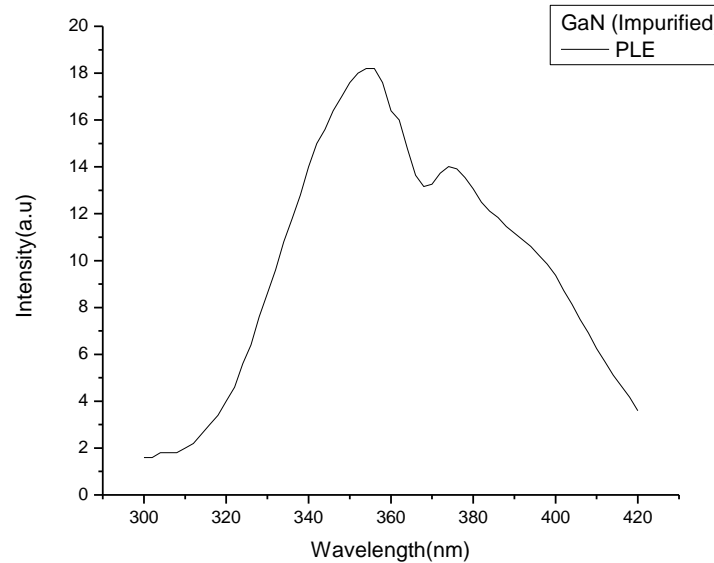
2. Activate Monoscan4.1 software
3. Click the Type in menu of Monoscan4.1 software
4. Select 'COM#' & Click 'OK' \* then, you will see the information of Monora320i

PL wavelength selection

5. Select #1 grating (1200gv/500nmbz) in Grating menu
6. Type '443' & Click 'Slew' in Scan menu \* the grating will rotate to 443nm of #1 Grating.
7. Adjust the slit width of Entrance & exit of Monora500i, the slit width is 2mm.
8. Put the LP325 Filter into filter holder mount



## 12. PLE Measurement : 12-2. Preparation



Lamp: 450W Xenon Lamp

Monochromator : Monora200

1. Adjust the slit width of Entrance & exit of Monora200, the slit width is 2mm.

Lock in Amplifier : SR510

1. Set the sensitivity to 50mV
2. Set the time constant to 100msec
3. Set the Chopper frequency to 45Hz

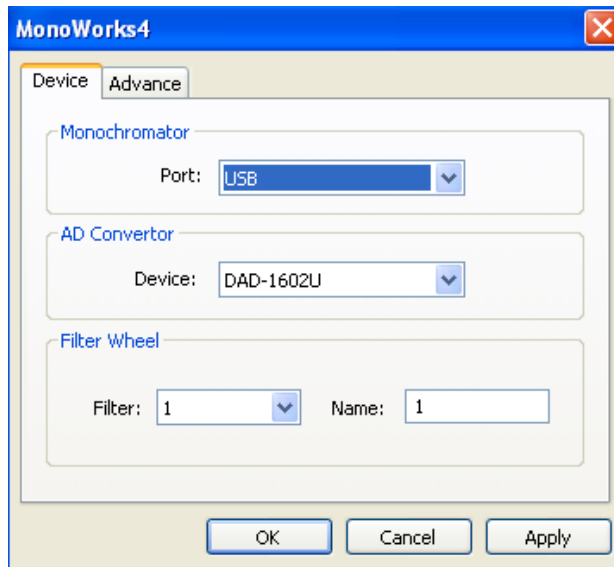
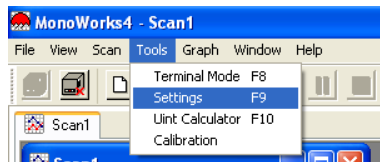
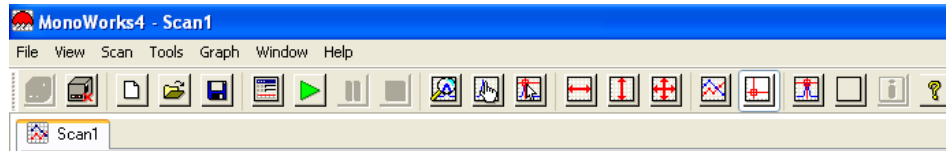
Detector : S/PBS-025/020-TE2-H

1. Select the Si detector & connect the Si cable to lock in amplifier
2. Set the Gain to X10

Monoworks program

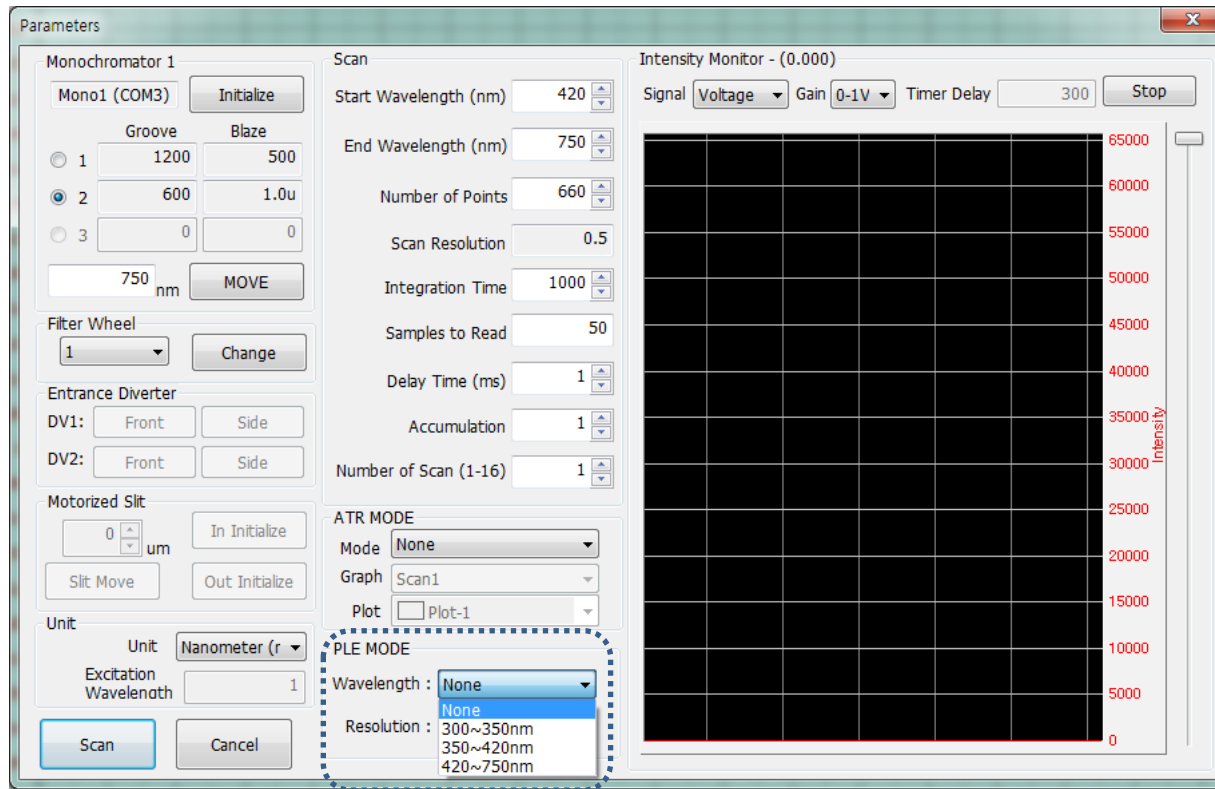
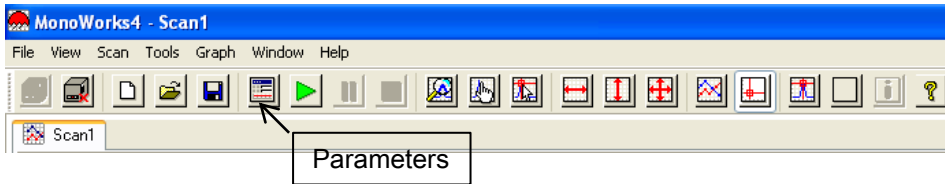
1. Input range : 0-1Volt
2. Integration time : 300msec

## 12. PLE Measurement : 12-3. monoworks4.1



1. Double click Monoworks4 icon in desktop : menu bar
2. Click the Tools & Settings(or F9) in menu bar of Monoworks4
3. Select 'Com #' in Port for Monora200
4. Select 'DAD-1602U' in Device
5. Click 'OK'

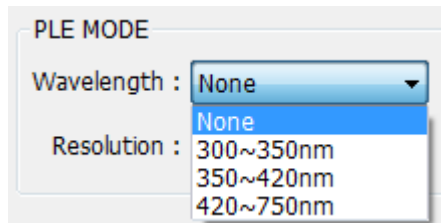
## 12. PLE Measurement : 12-3. monoworks4.1



Parameter window

6. Click 'Parameters'
7. Select #1 grating (1200gv/500nmbz) in Grating menu
8. Select the 'None' in Reference Mode
9. Select the measurement range in PLE MODE
  - \* You can select only one range
10. Select the Resolution in PLE MODE
11. Input the below parameter.
  - Integration Time : 1000msec.
  - Delay time : 30msec
  - Accumulation : 1
  - Number of Scan : 1
12. Click 'Scan' in Parameter window
  - You can scan only one range in window
  - If you want measure different range Create new window.

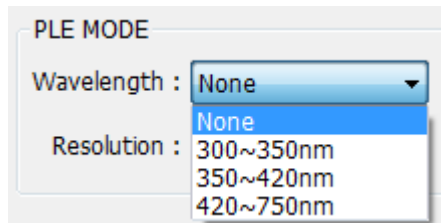
## 12. PLE Measurement : 12-4. manual operating method



Range	Grating	Motorized filter wheel
300nm~350nm	600gv/300nmbz	1 : None
350nm~420nm	600gv/300nmbz	2 : None
420nm~750nm	600gv/500nmbz	3 : zu1400

After select a range & resolution  
Scan, then the monoworks software  
It will change the grating & filter automatically as the range

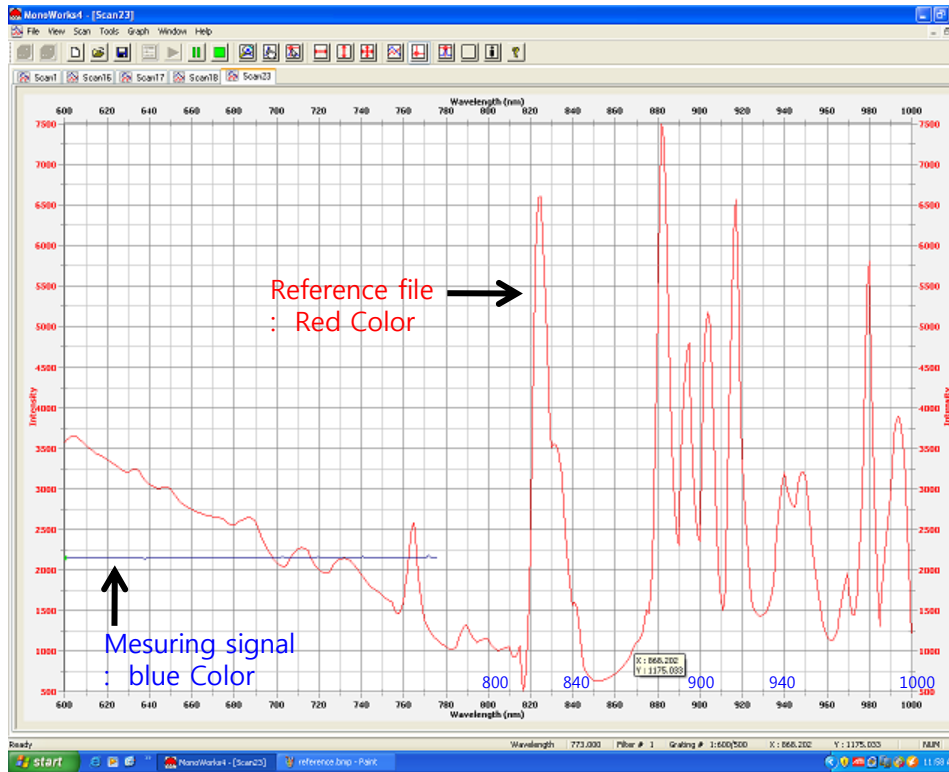
12. PLE Measurement : 12-5. automatic operating method



Range	Grating	Motorized filter wheel
300nm~350nm	600gv/300nmbz	1 : None
350nm~420nm	600gv/300nmbz	2 : None
420nm~750nm	600gv/500nmbz	3 : zu1400

After select a range & resolution  
Scan, then the monoworks software  
It will change the grating & filter automatically as the range

## 12. PLE Measurement : 12-6. PLE signal calculation



PLE Signal measurement window

Once you click the scan, the computer load the **Reference file** & scan the spectrum, after finished the scan, The computer perform below calculation.

$$\text{PLE signal} = \frac{\text{Measuring signal}}{\text{Reference file}} \times \text{Reference file}$$
 means beam power data each wavelength. It calculate the PL efficiency of PL signal vs excitation beam each wavelength.

Signal level of **Measuring signal** must bigger than reference file.

If not, it will show incorrect PLE data.

While the software scanning the PLE signal, check signal level.

If the **Measuring signal** level is less than the **Reference file** then Increase the sensitivity of lock in amplifier