Multi-wavelength Study of PPDs using an OPO Tunable Pulse Laser Microscope System

Koji YOSHIMURA and Isamu NAKAMURA
for KEK Detector R&D Group

NDIP2011 July 8, 2011, Lyon

Outline

Introduction

OPO Laser Microscope

Commissioning

- Power and wavelength measurement
- PPD test
- Photon detection efficiency

Summary & Future works

NDIP2011 July 8, 2011, Lyon

Introduction

NDIP2011 July 8, 2011, Lyon

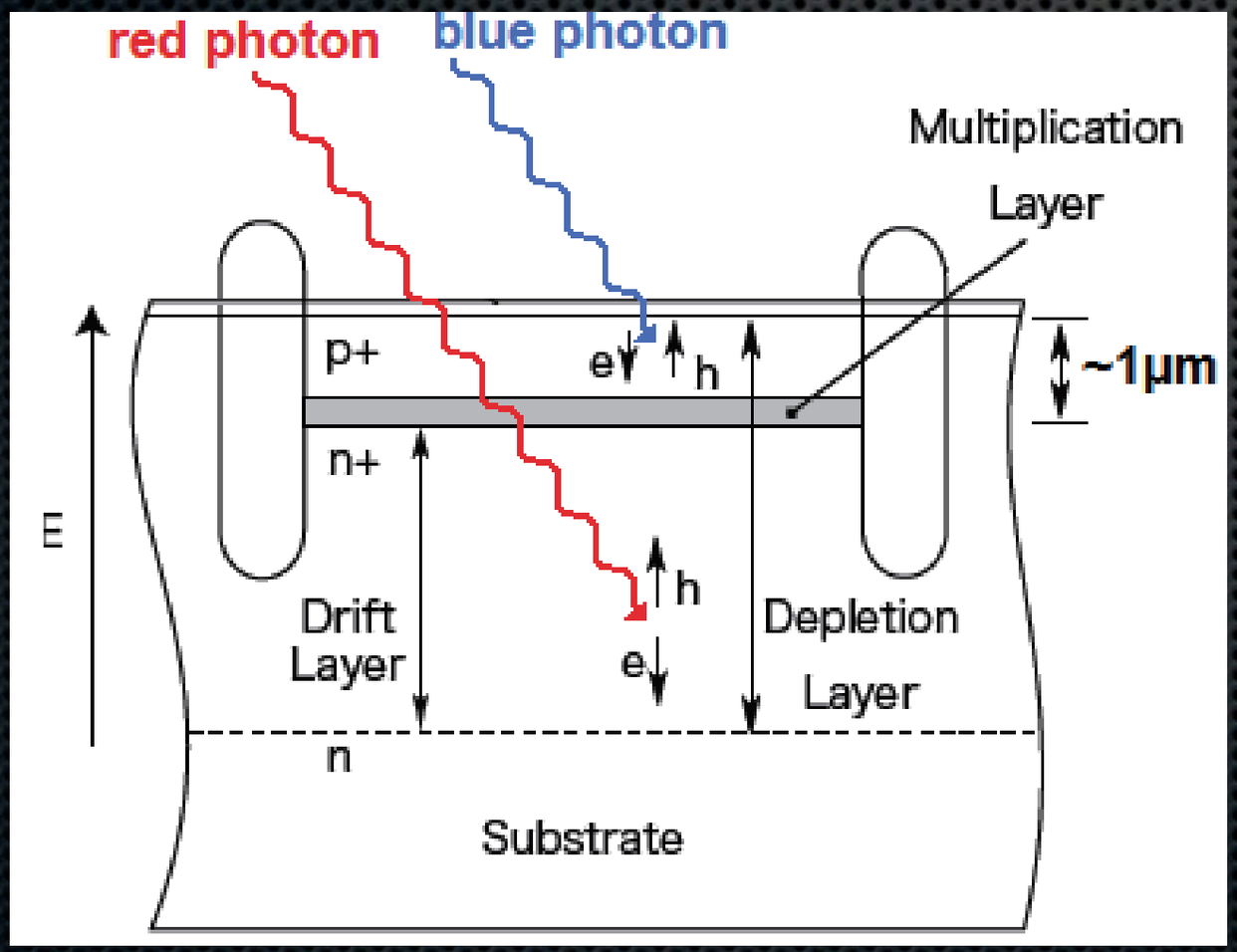
Motivation

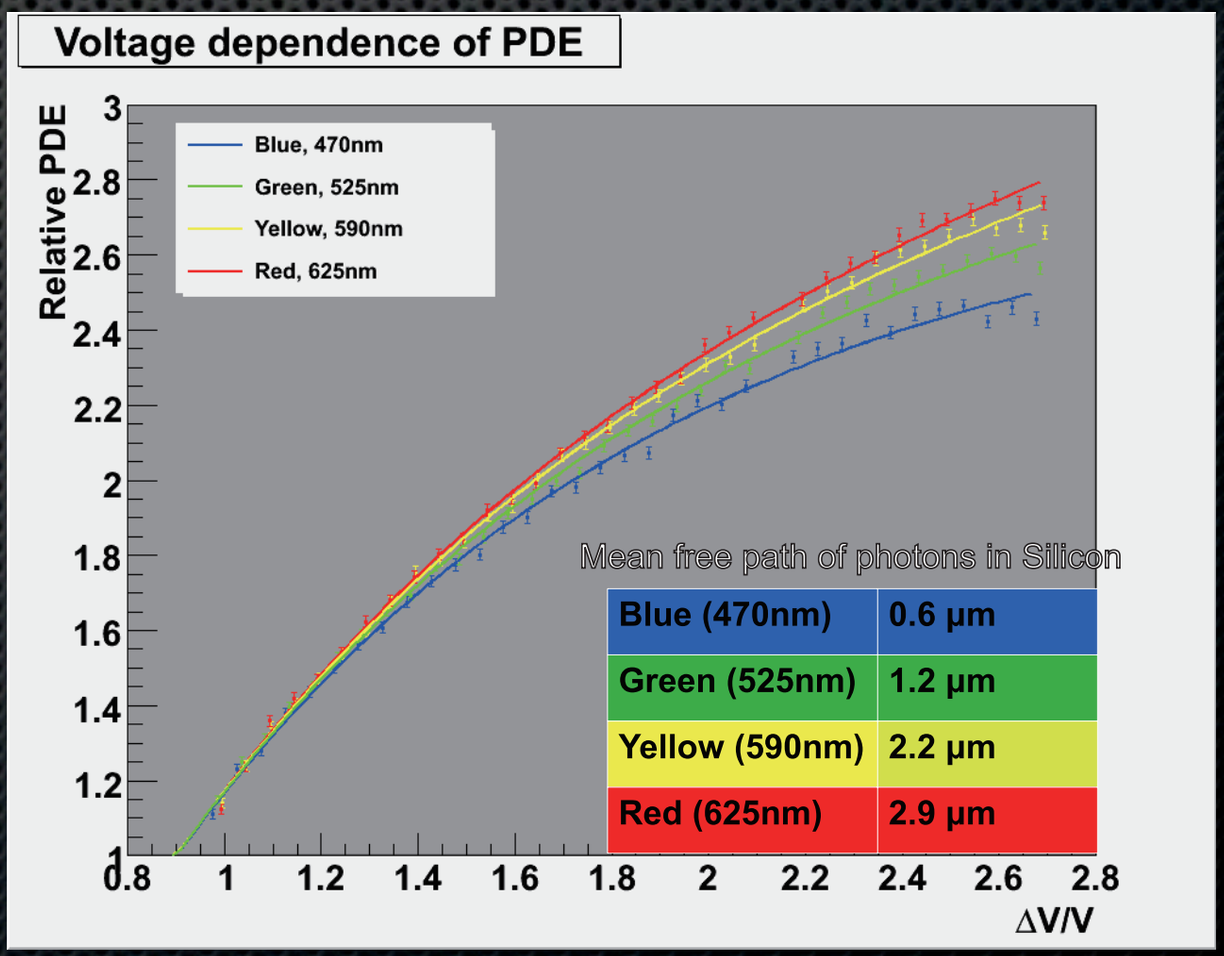
Why is multi-wavelength light usuful for study PPDs?

Variety of applications which cover different range of wave length

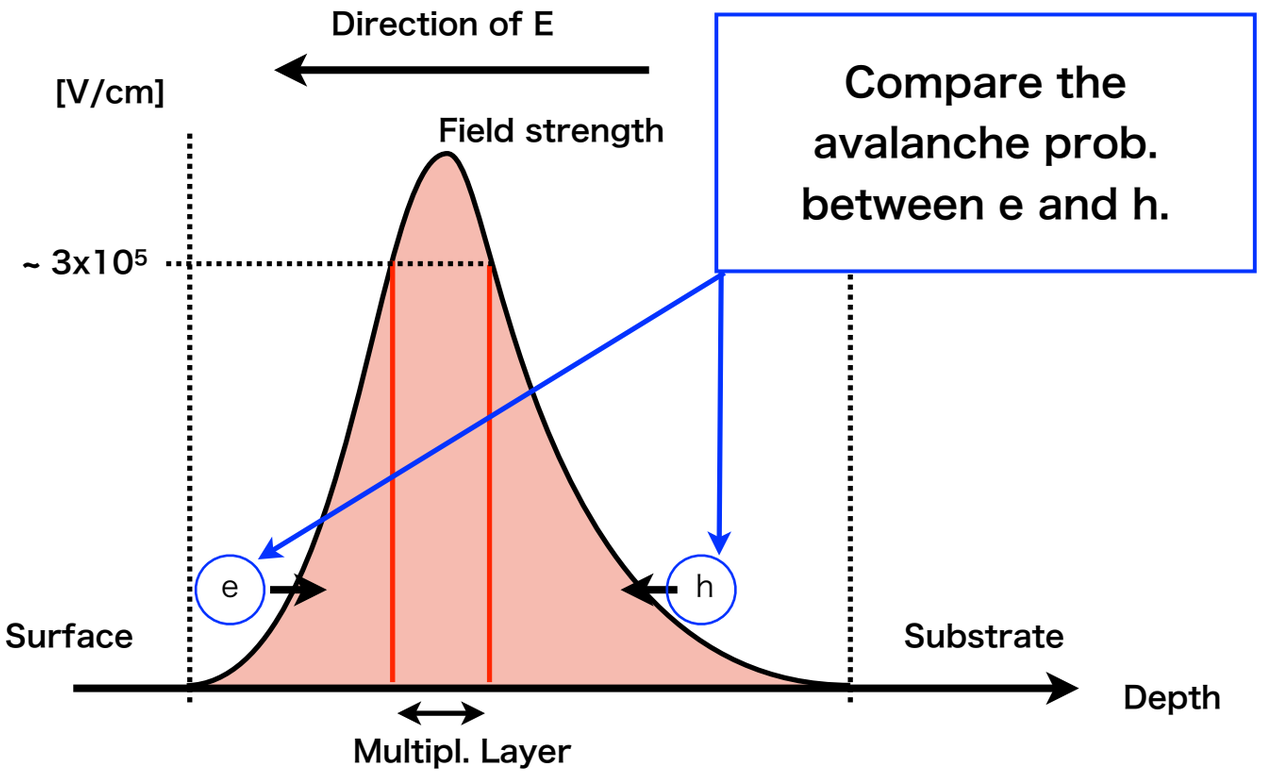
Understanding of sensor structure and mechanism

Orme's Study (PD'09)

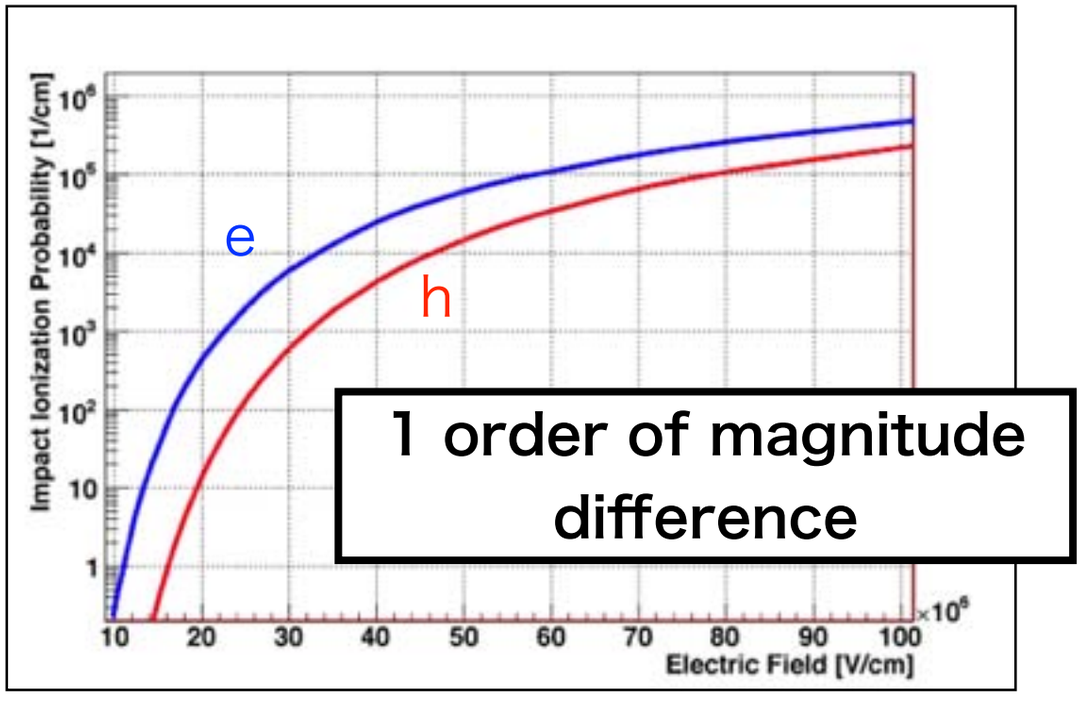




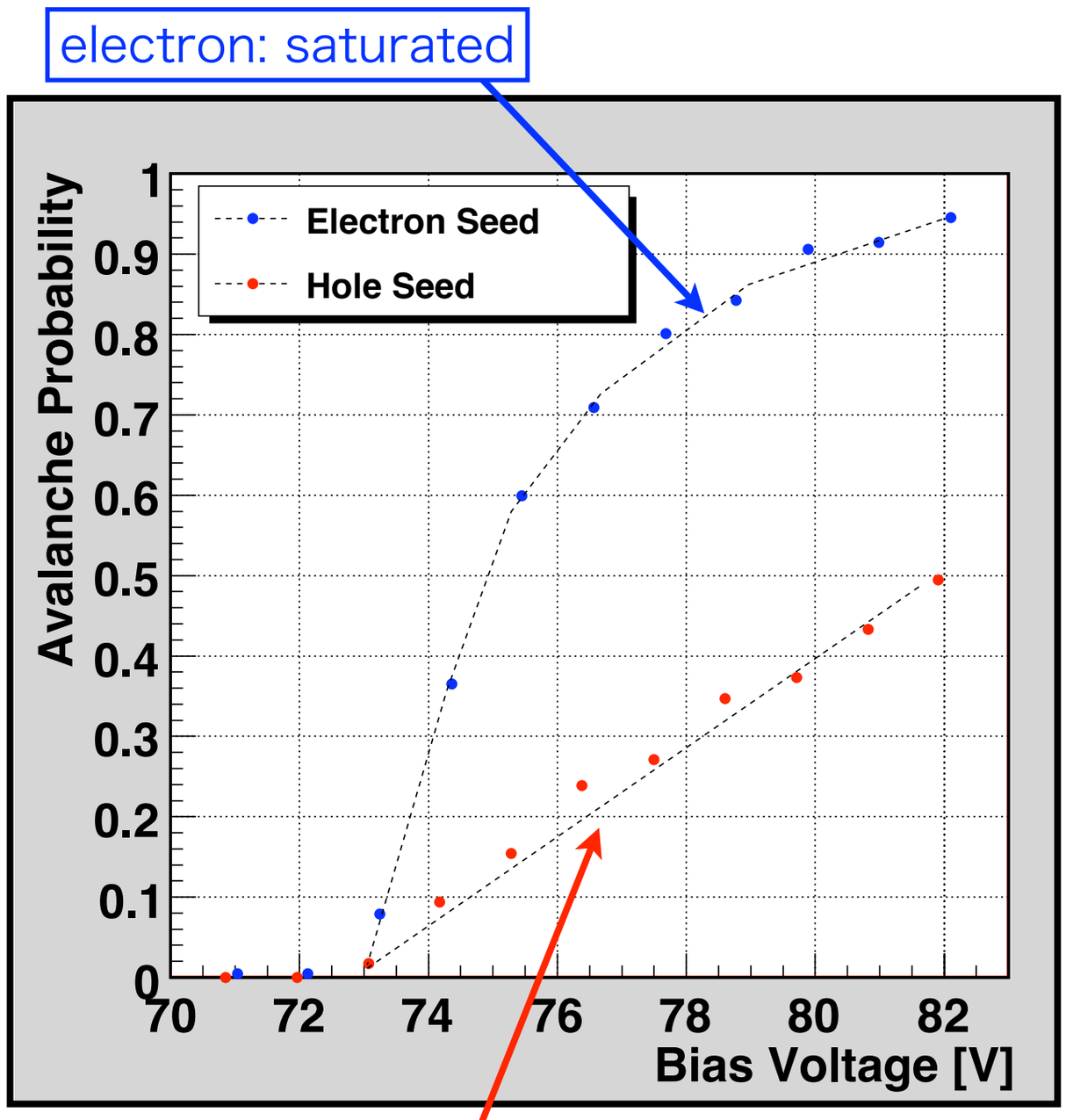
Geiger Efficiency



Impact ionization prob.



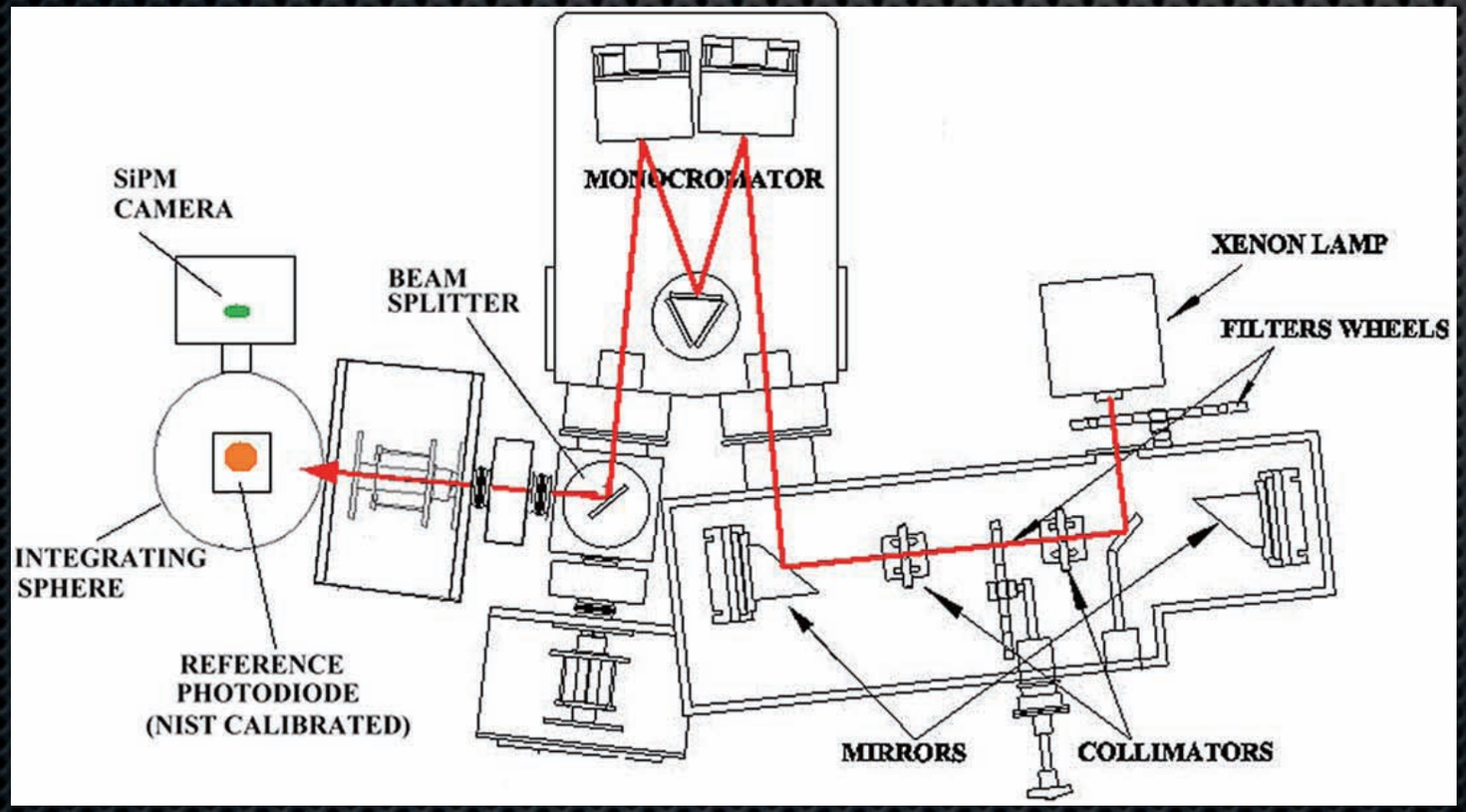
Simulation Results



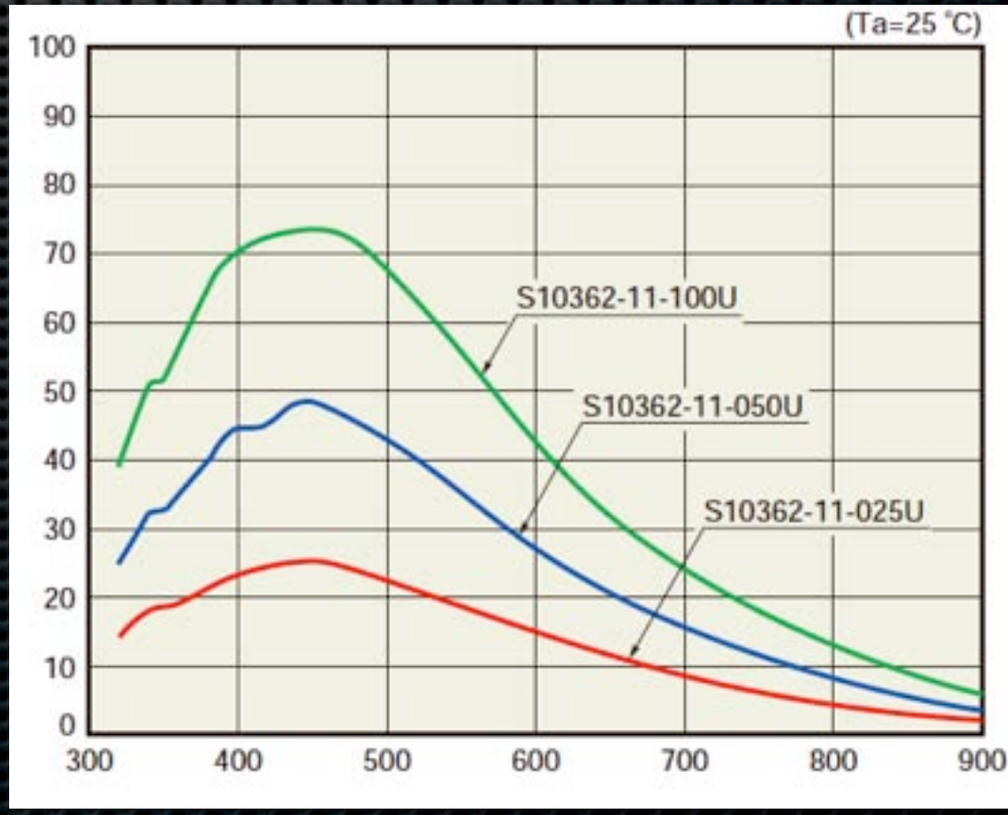
H.Otono, et al., PANIC08

LED or DC light with Monochrometer?

LED (Laser)	DC Lamp with monochrometer
Discrete samples	Continuous
Pulse	DC
No Cross talk/After pulse	Incl. Cross talk/After pulse
Need reference	Si Photo diode as a reference



G. Bonanno et al. NIM A610



HPK data

Microscope system

Study pixel by pixel

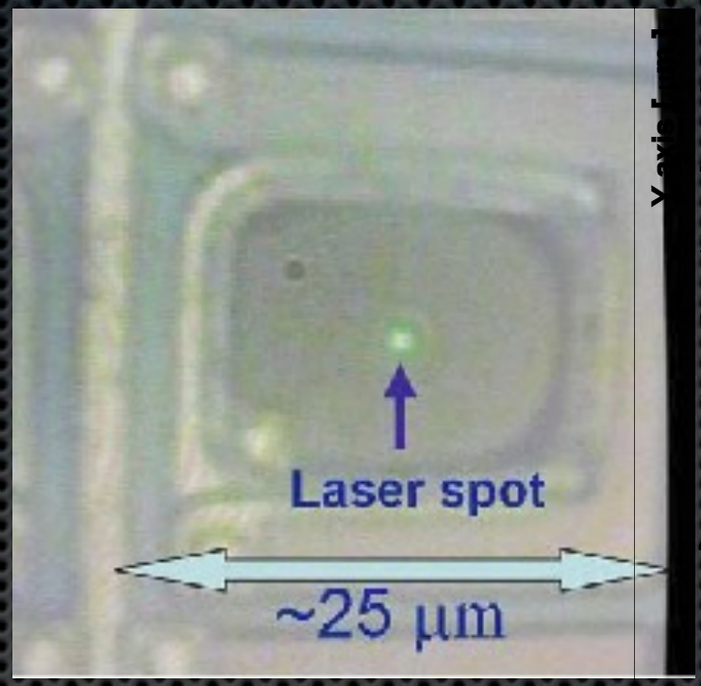
Geometrical fill factor

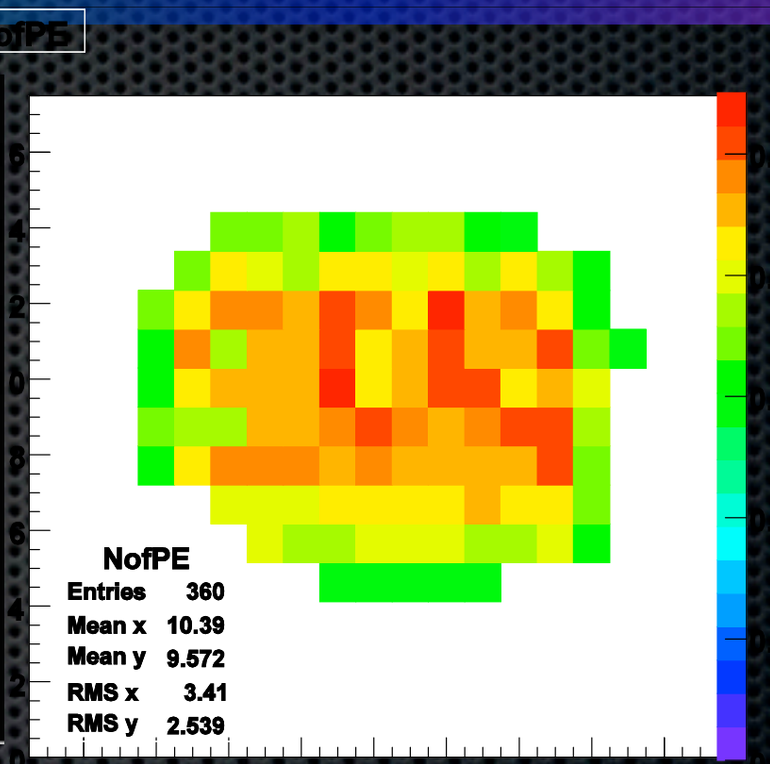
Uniformity

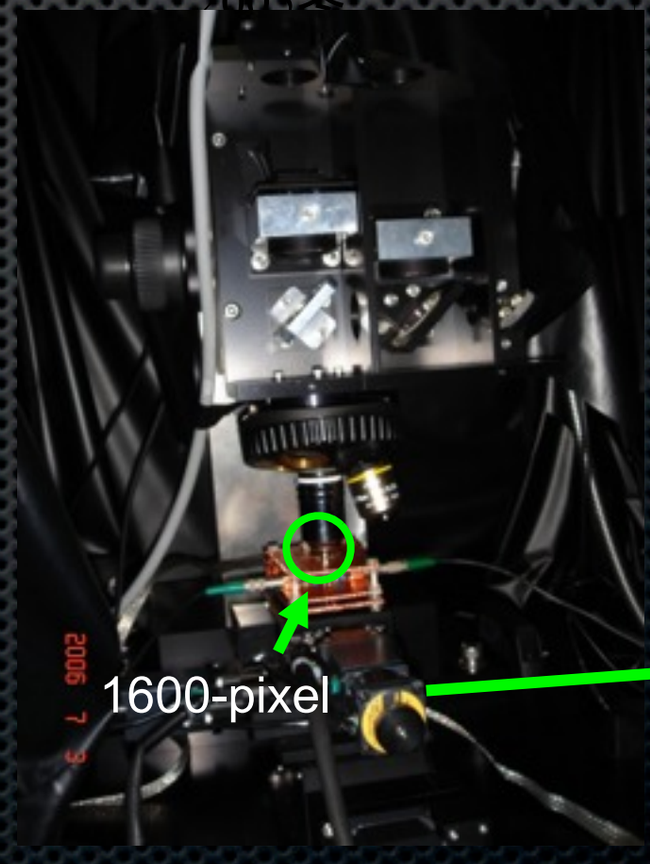
Edge effect

Spot size ~ μm

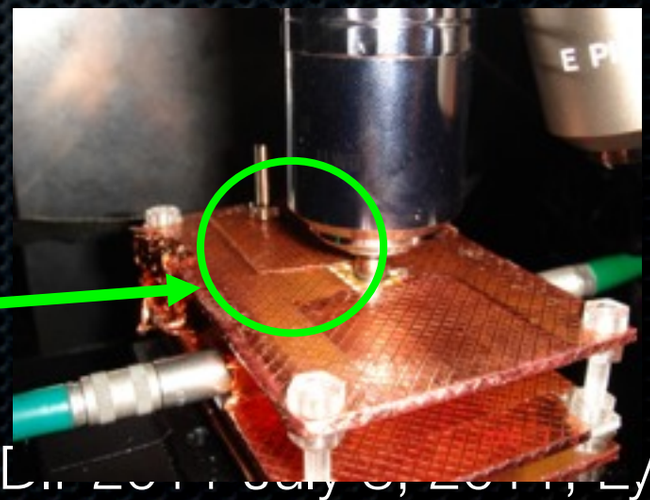
Multi-wavelength laser & microscope could be used for 3D-probe for solid state photon sensor







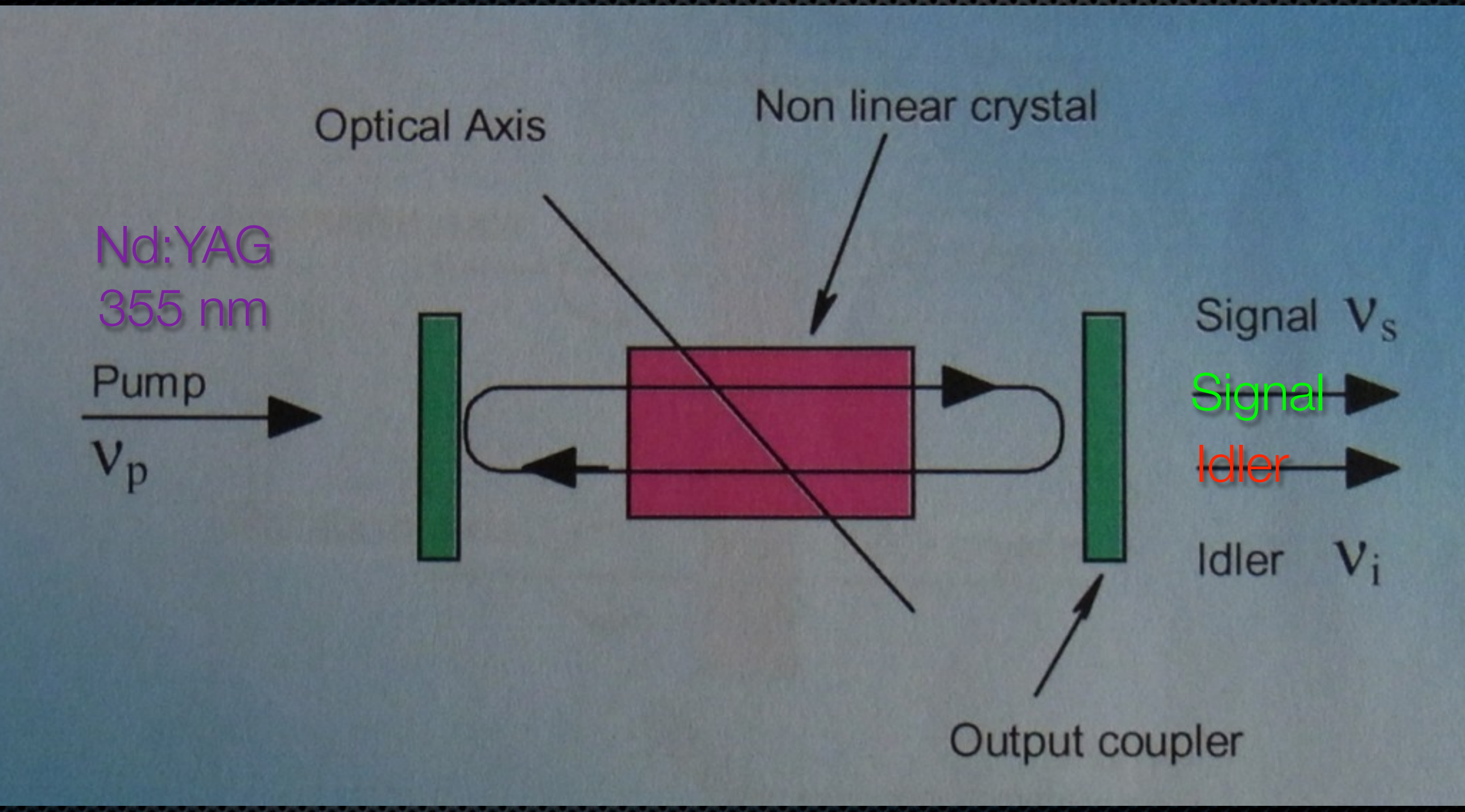
- YAG Laser, λ = 532 nm
- Pulse width ~ 2 nsec
- Pulse rate ~ 8 kHz
- Spot size ~ 1 μm



OPO Laser Microscope

NDIP2011 July 8, 2011, Lyon

OPO (Optical Parameteric Oscillator)

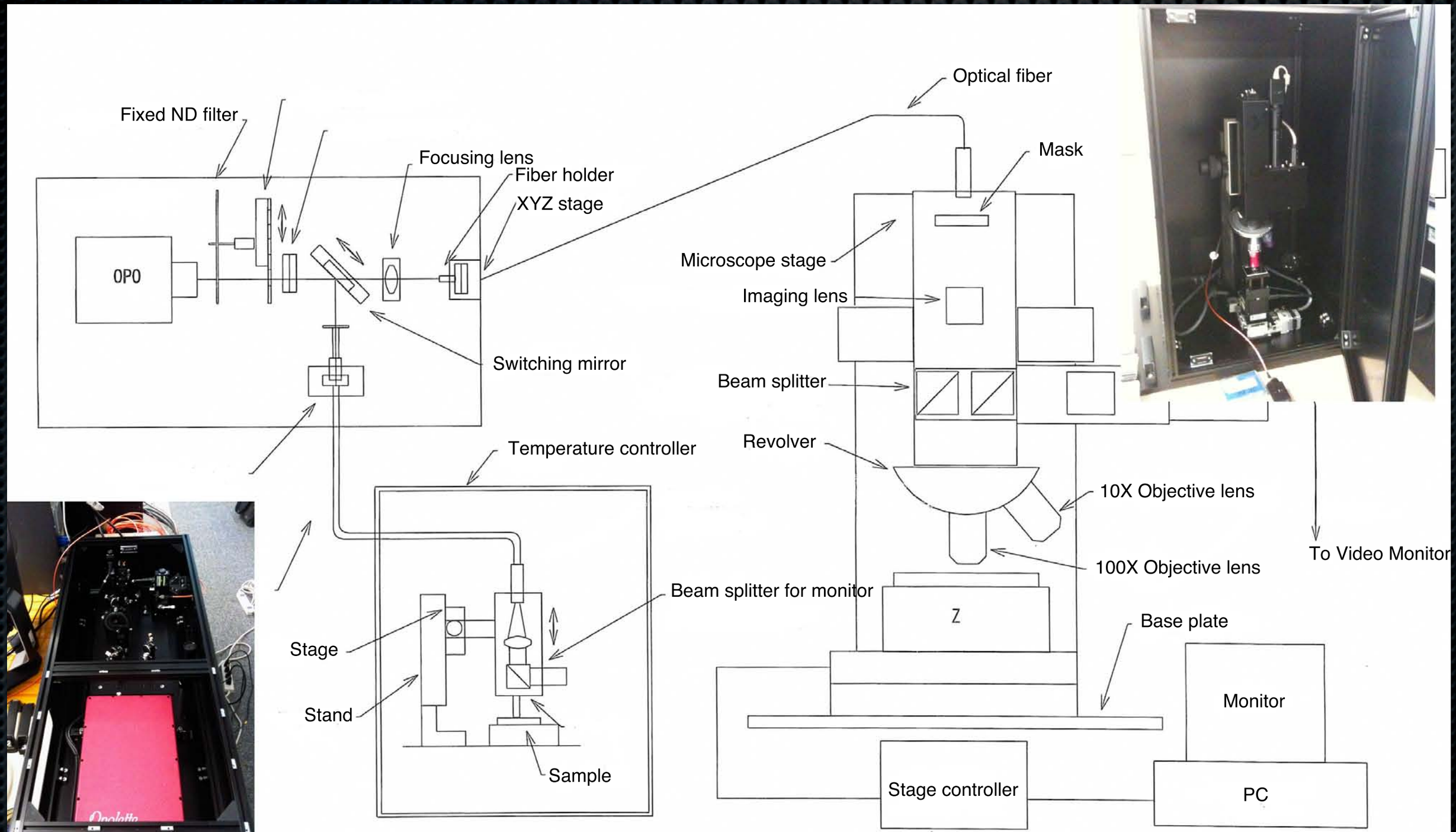


OPO (Optical Parameteric Oscillator)

Opolette™ (HE) 355 II + UV

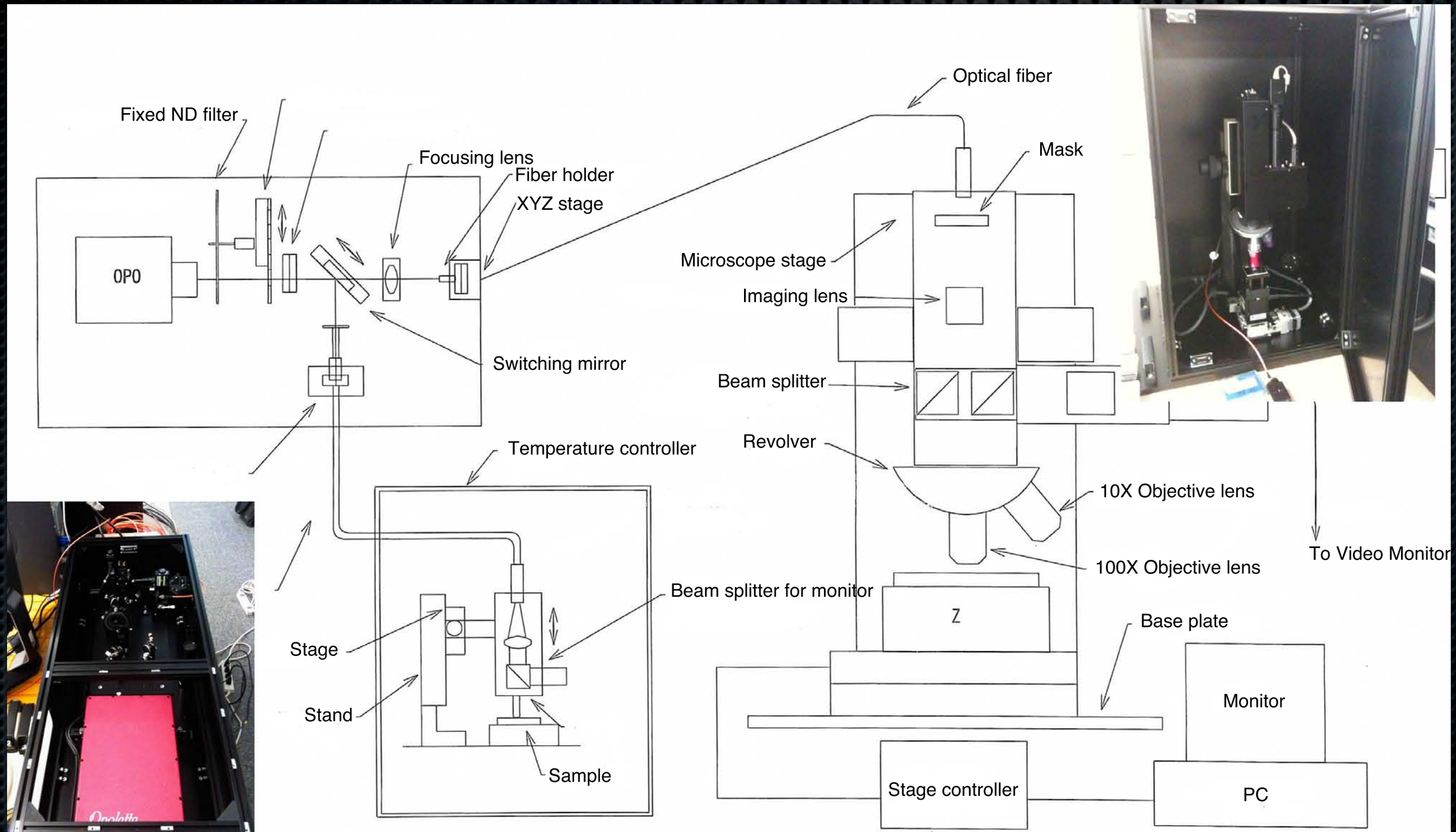
Pump Laser Specifications		
Pump Laser	Nd:YAG	Flashlamp pumped
Pump Wavelength	355 nm	
Pulse Repetition Rate (PRR)	20 Hz	Lower rep rate can be selected
Pulse length	5 ns	Nominal
Beam Diameter	3 (4) mm	Nominal
External Trigger	Lamp and Q-Switch	Flashlamp has to operate at designed PRR
OPO Parameters		
Wavelength Tuning Range	210 - 355 nm & 410 - 2200 nm	Extended UV tuning range
Peak OPO Energy	3.5 (8.5) mJ	See tuning graph
Peak UV Energy	0.3 (1) mJ	
Spectral Linewidth	~ 4 - 7 cm^{-1}	
Beam Divergence	Horizontal < 10 mrad Vertical ~ 2 mrad	FWHM
Polarization	Signal: Horizontal Idler: Vertical UV: Vertical	Linear polarization
Computer Control	All the laser and OPO functions	ON, OFF, Power, Rep-Rate, Tuning, Scan

OPO Laser Micro scope system



OPO Tunable Pulse Laser Microscope System

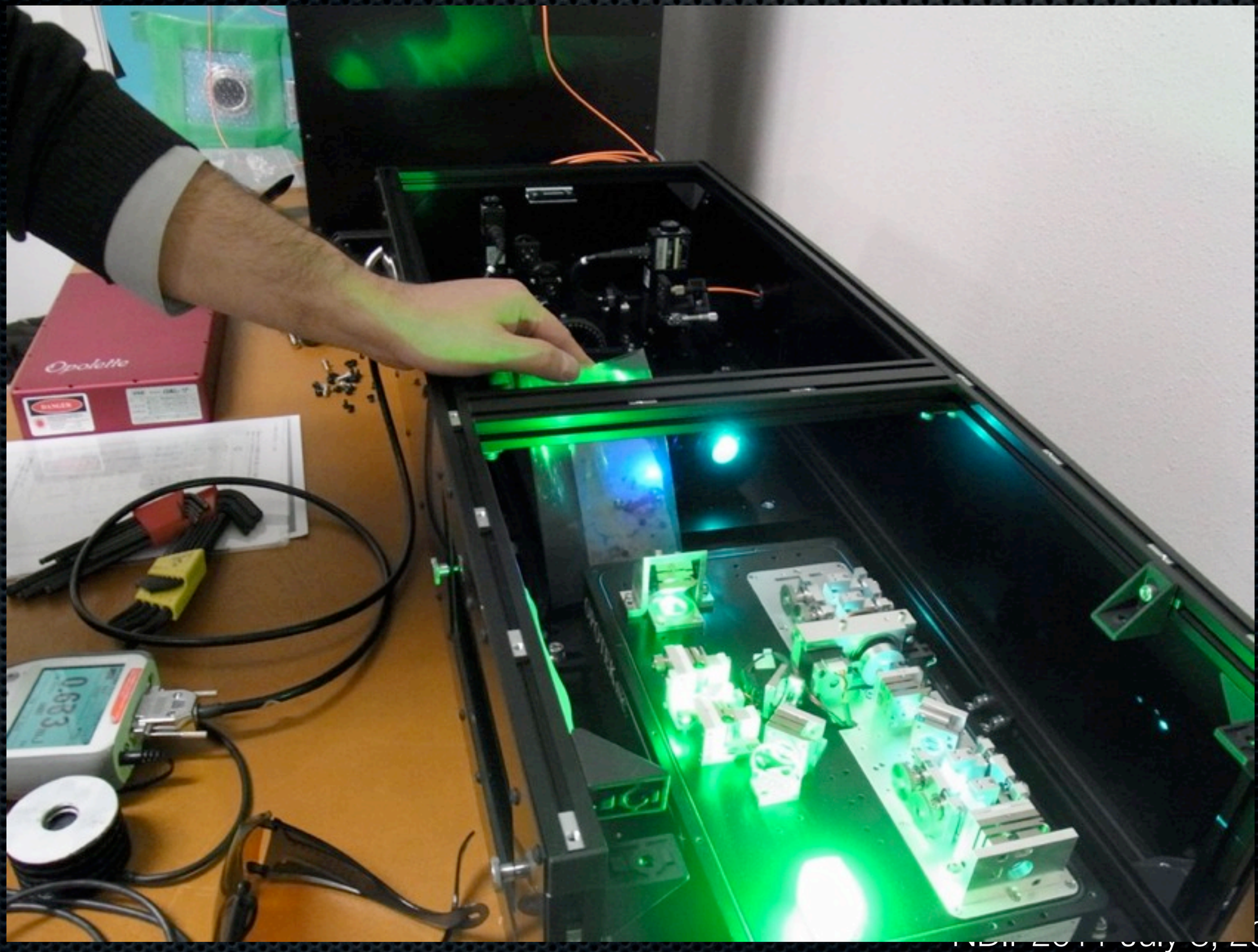
OPO Laser Micro scope system



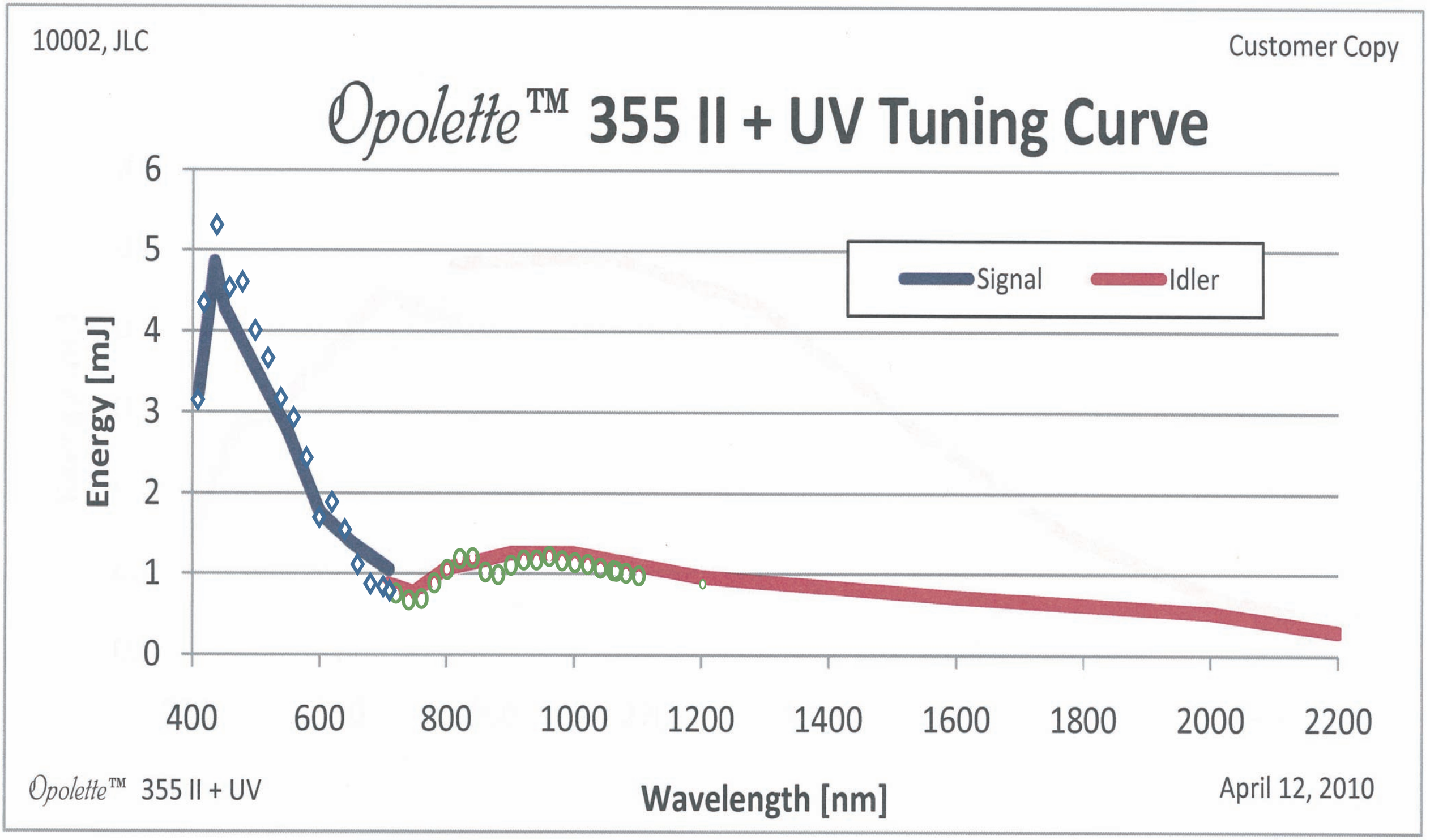
OPO Tunable Pulse Laser Microscope System

Commissioning

Measurement of Power

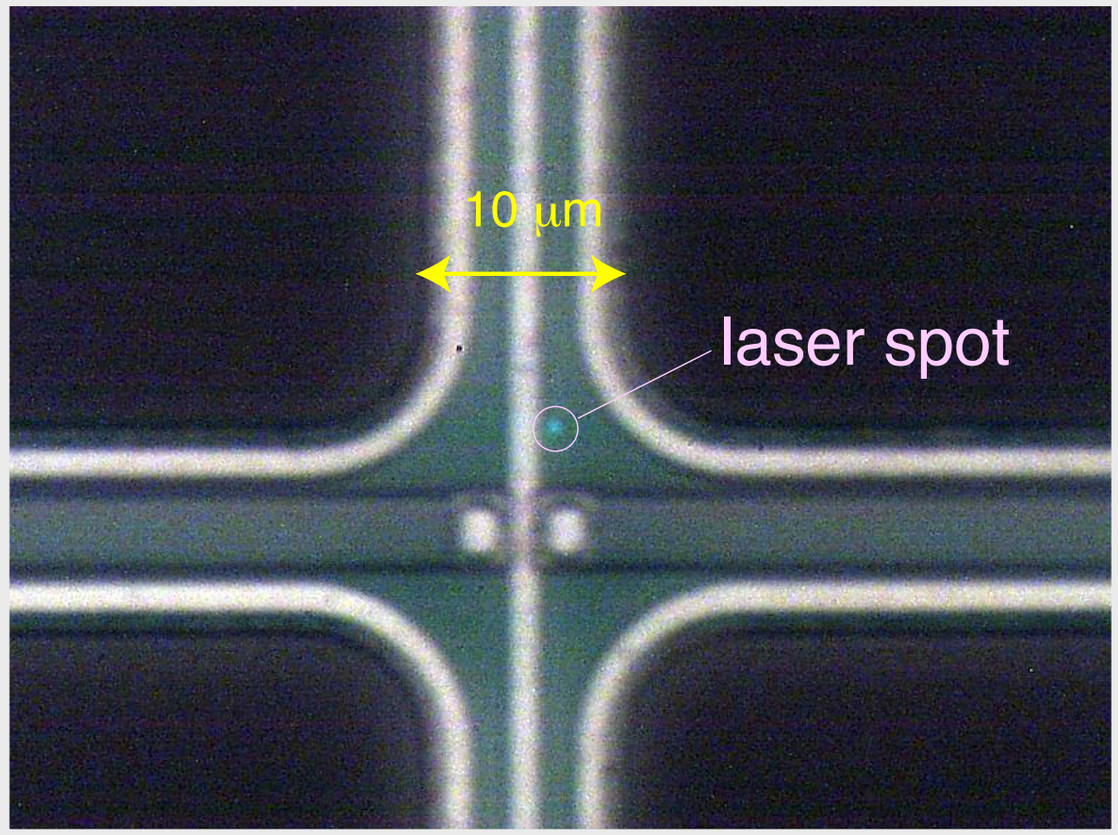


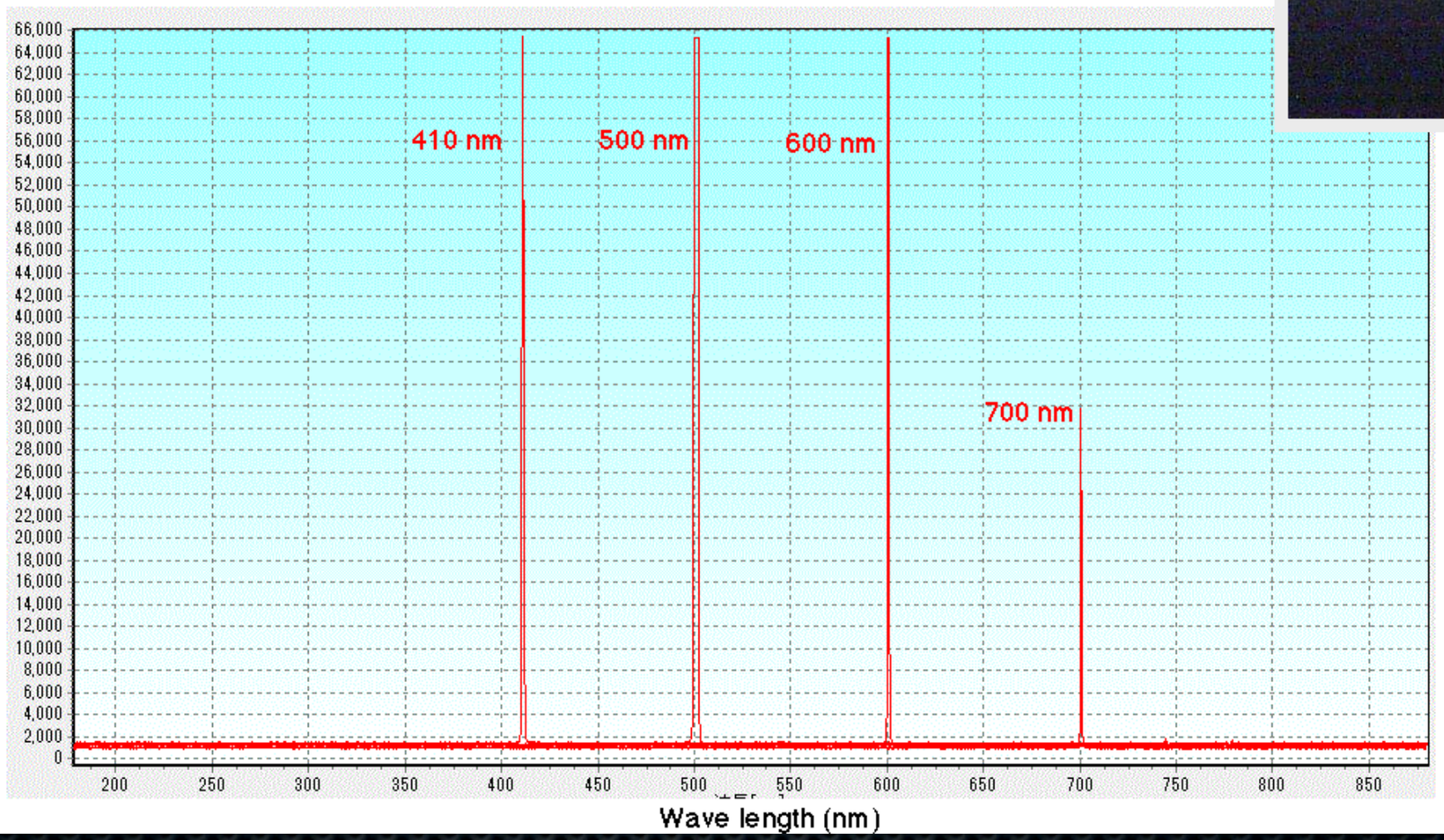
Measurement of Power



Linewidth and Spot size

Spectral linewidth is very sharp.
No contaminations.





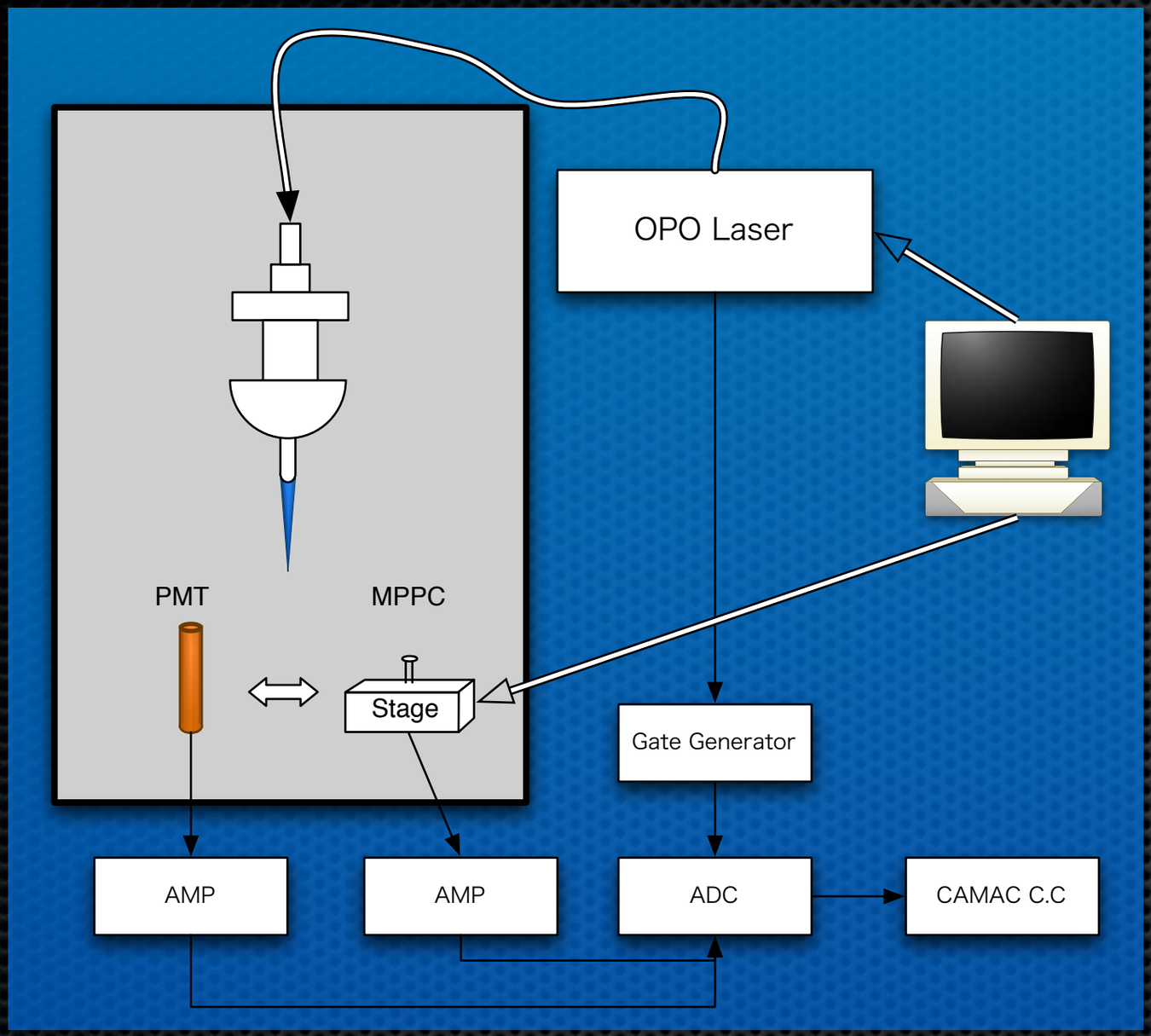
Spot size is as small as 1μm.

(100 x opjective lense)

MPPC Test

NDIP2011 July 8, 2011, Lyon

Test Measurement of PDE



MPPC: HPK S10362-11-100c 100pix 1mm^2

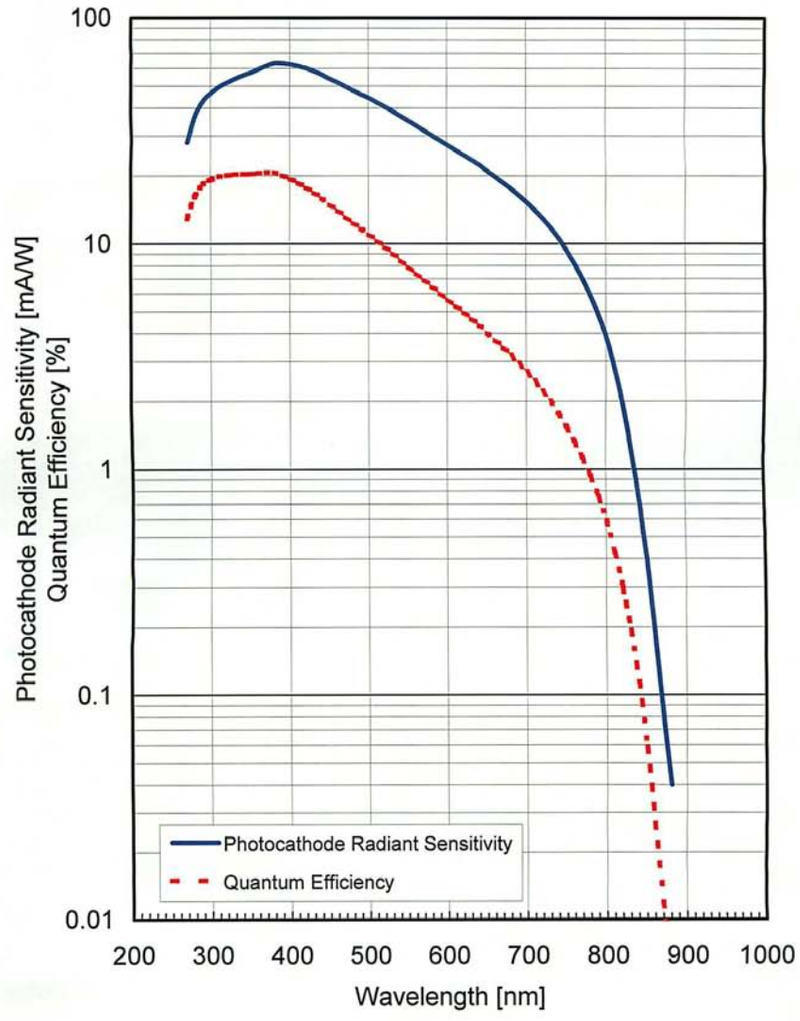
PMT: HPK H4535MOD ϕ15 photo Cathod

Reference PMT

PMT with Calibration data

Spectral Response Characteristics

Tube Type	H4535MOD	Max. Q.E.	20.6 %
Serial No.	NL1192	Wavelength of max.	380 nm
Date	Feb.08, 2011		
Tested by	H.OISHI		
Note	φ15mm		



HAMAMATSU

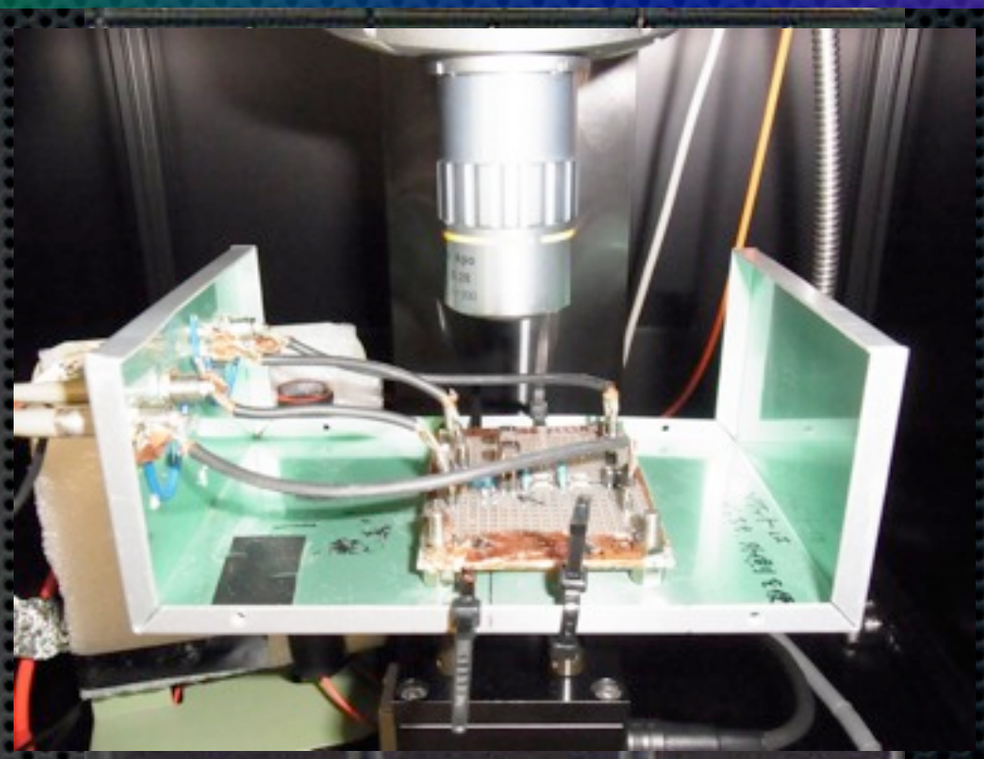
Beam spot size

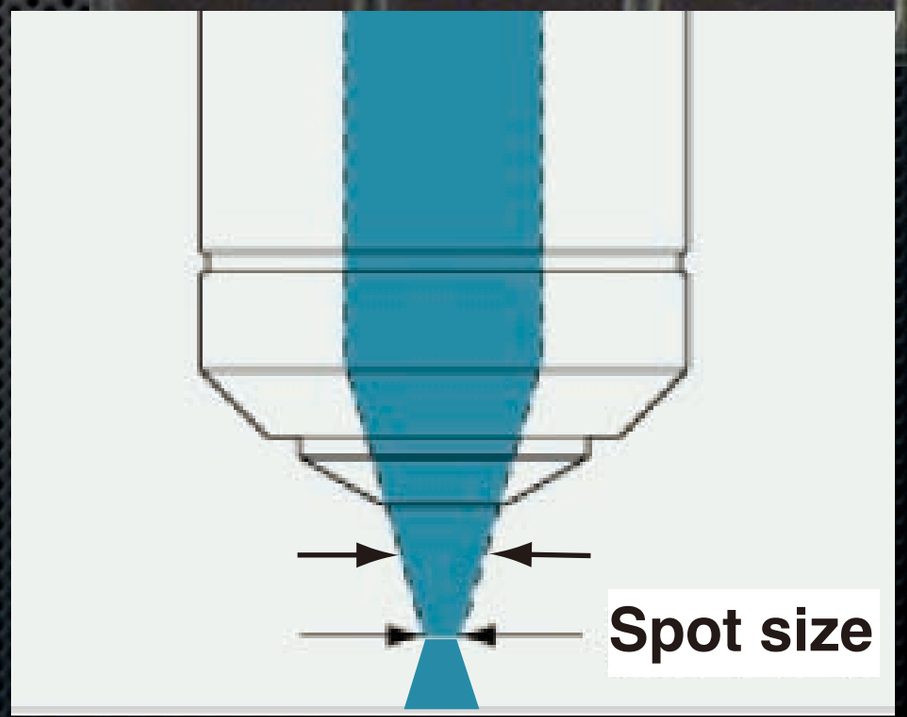
Spot size control

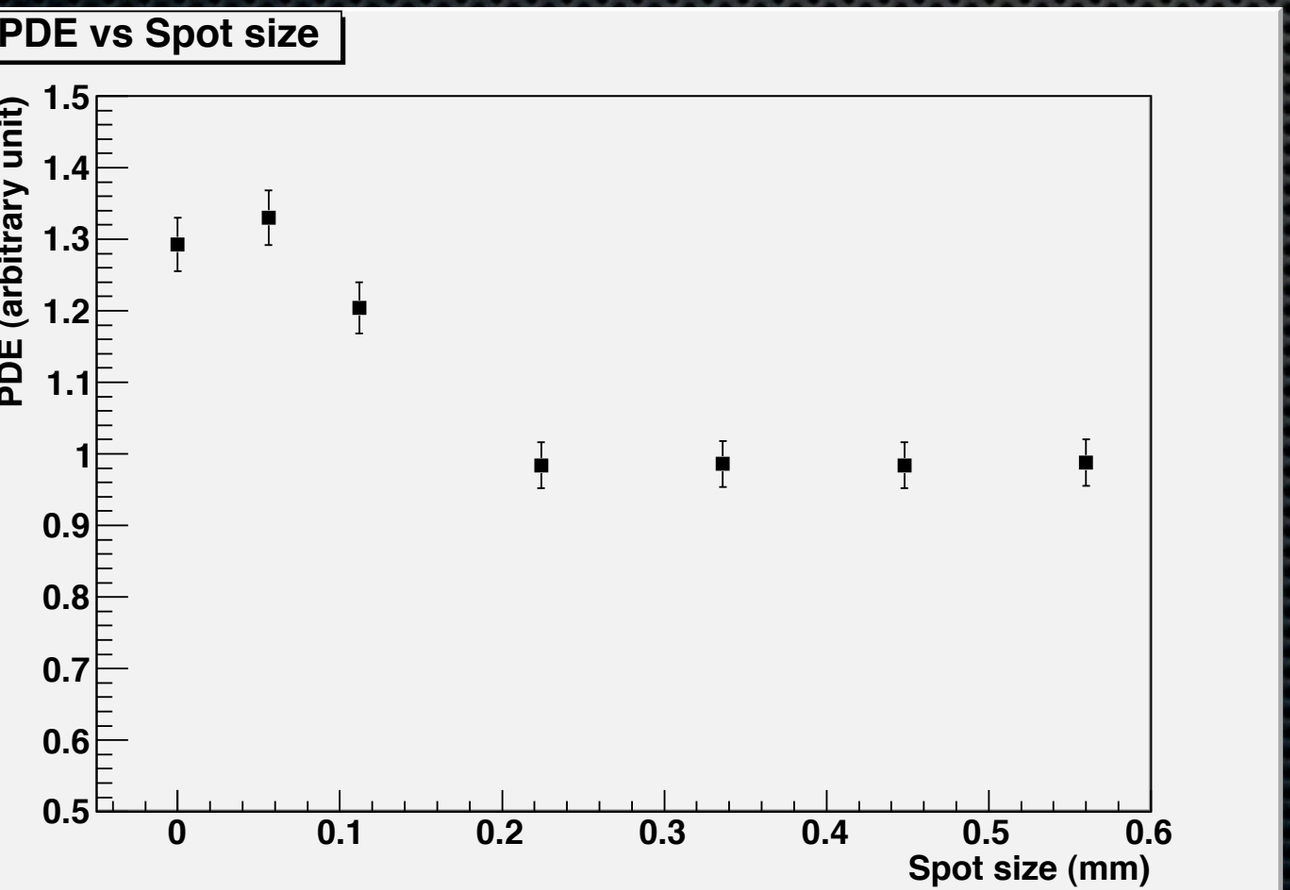
We defocus the image to get large spot size.

ϕ0.5 mm is used for MPPC.

ϕ10 mm is used for PMT







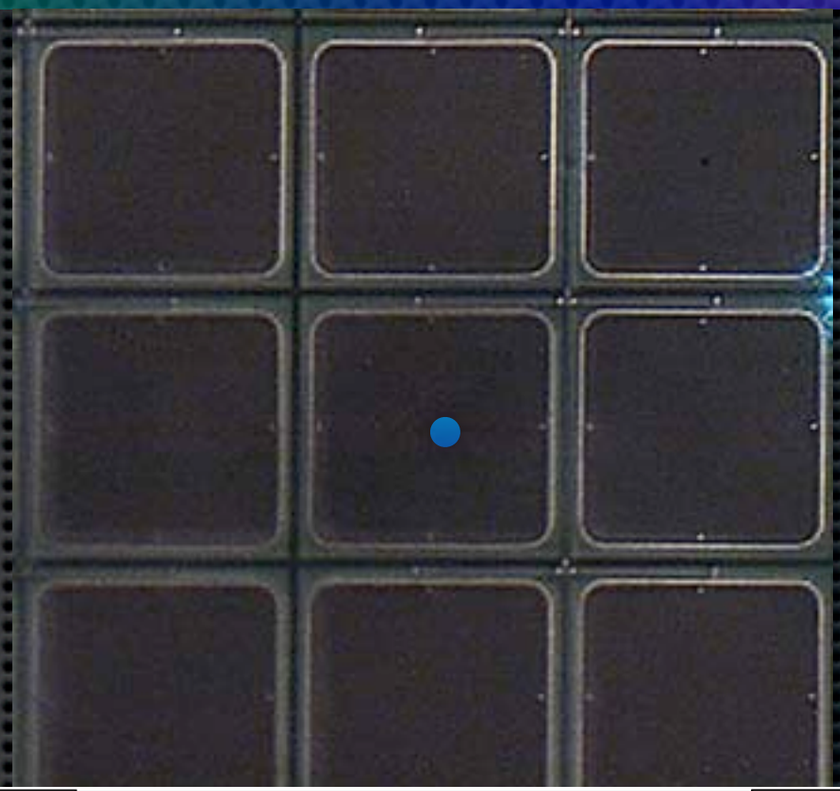
Beam spot size

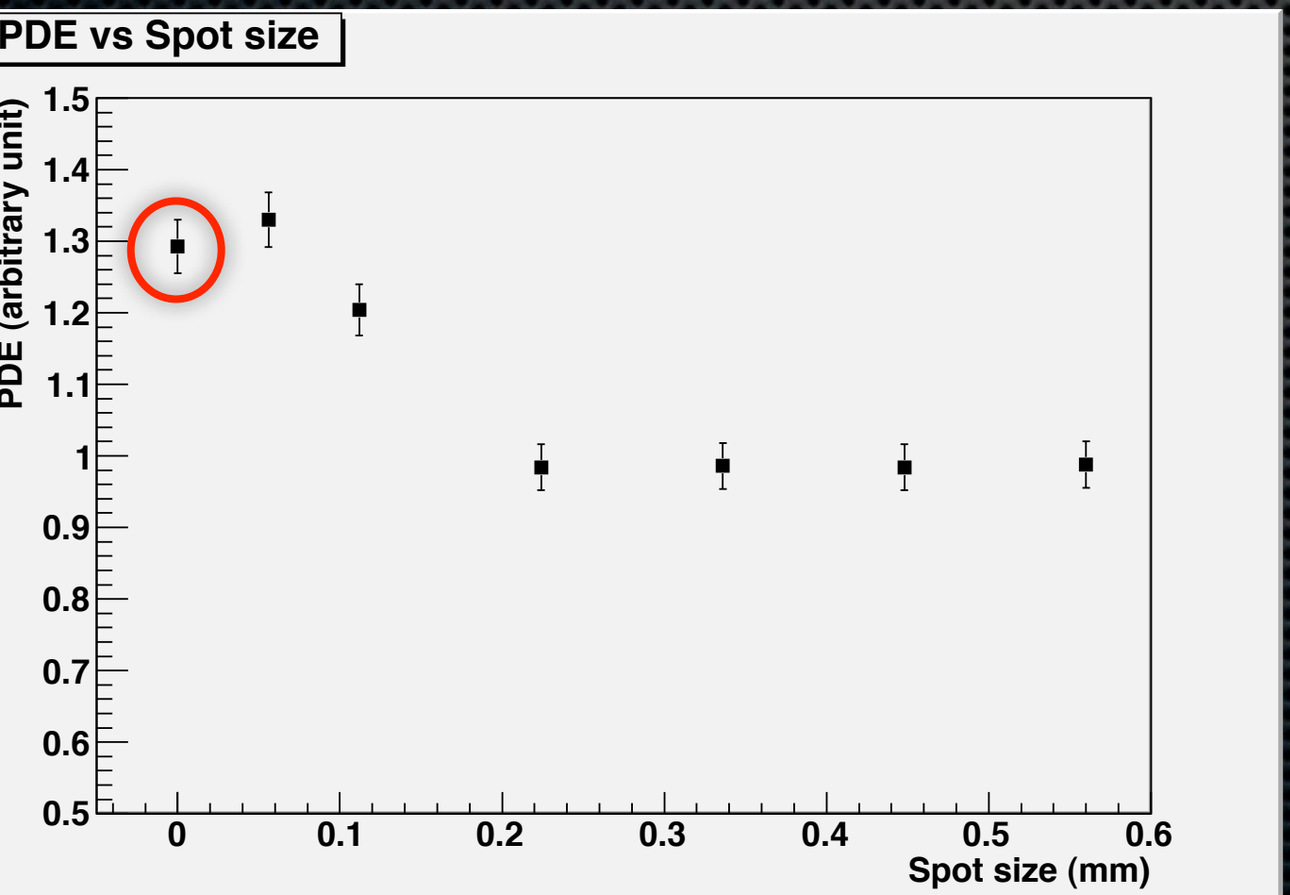
Spot size control

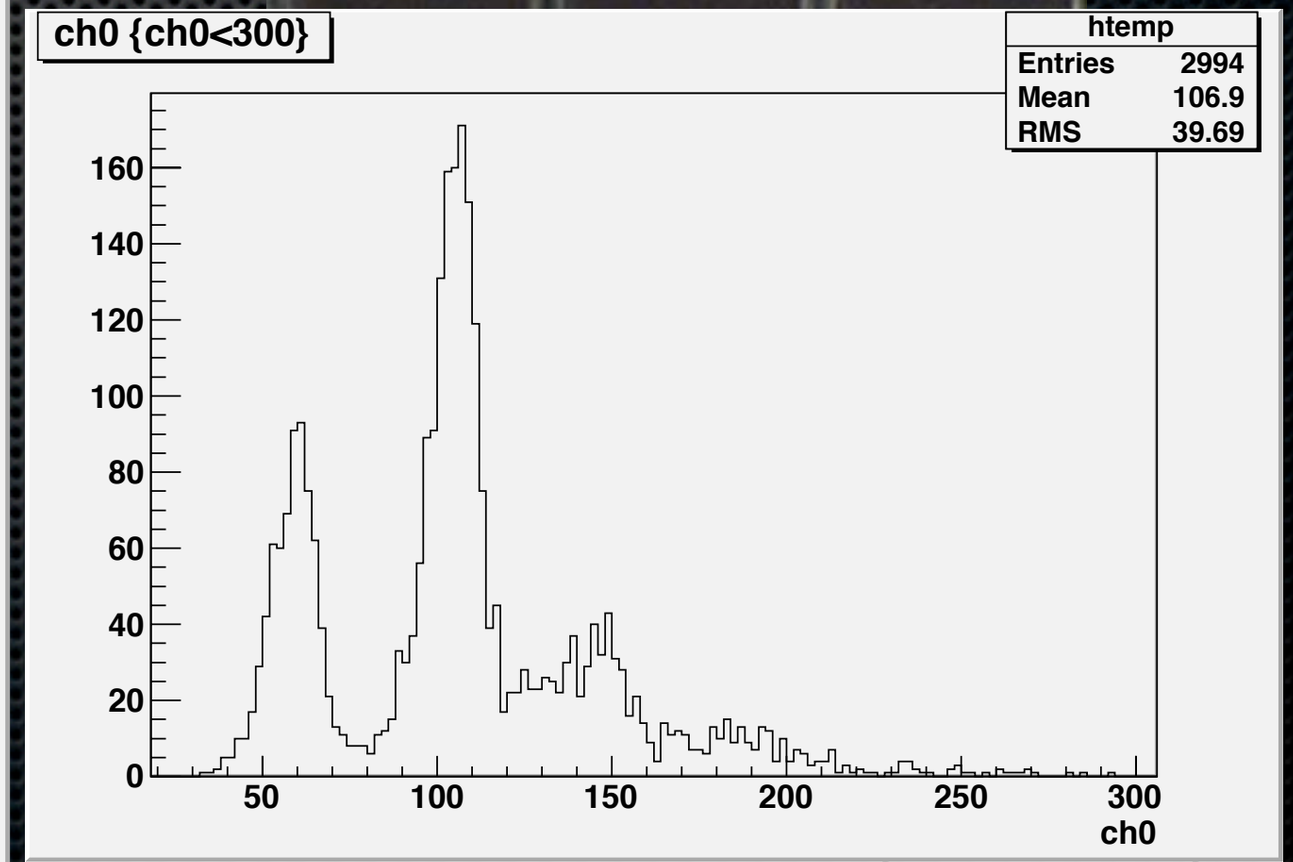
We defocus the image to get large spot size.

ϕ0.5 mm is used for MPPC.

ϕ10 mm is used for PMT







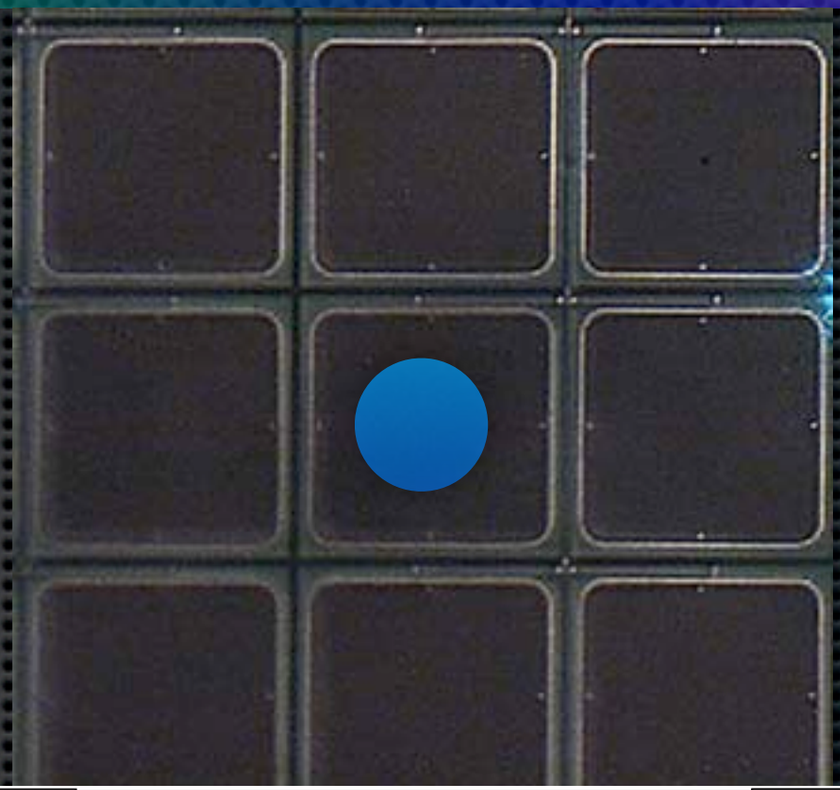
Beam spot size

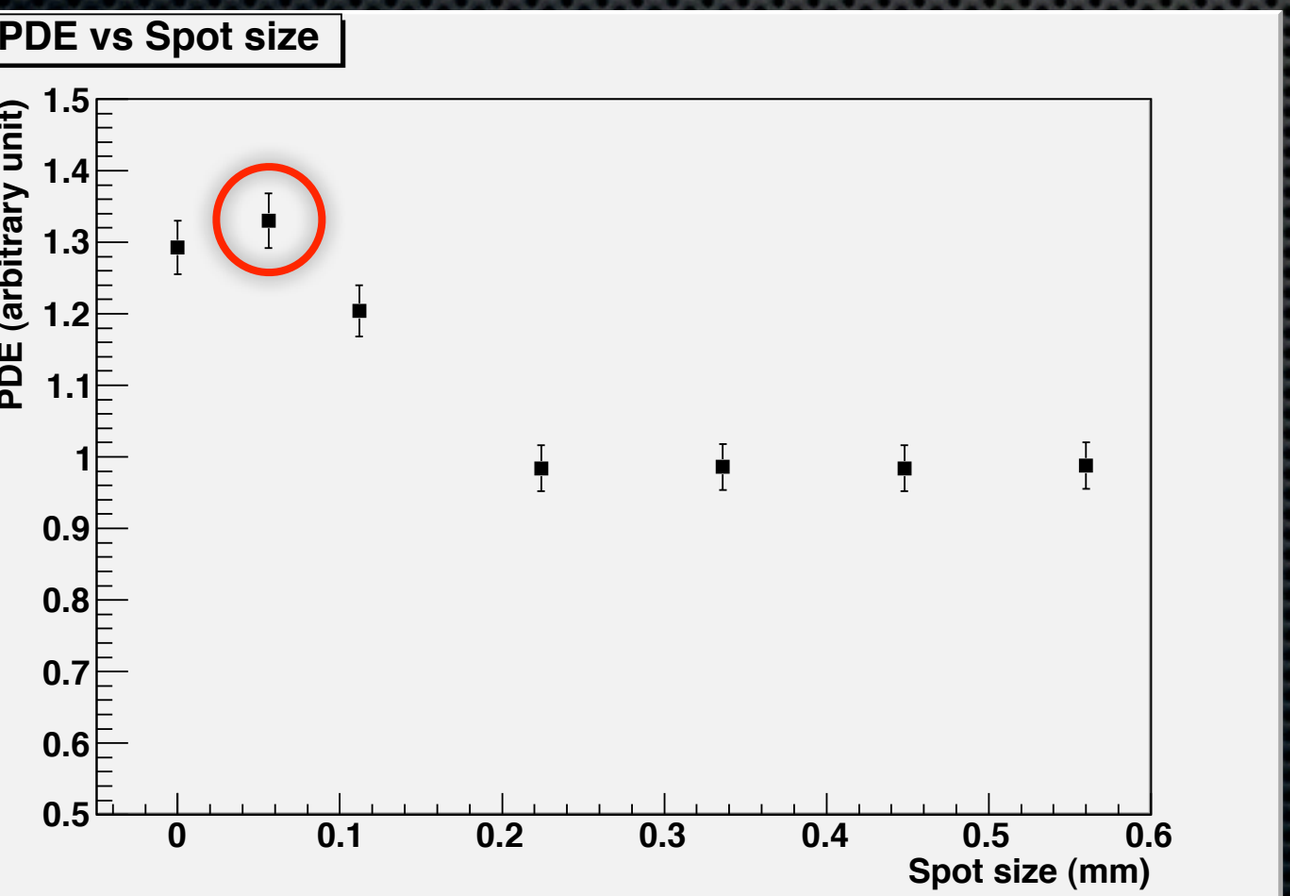
Spot size control

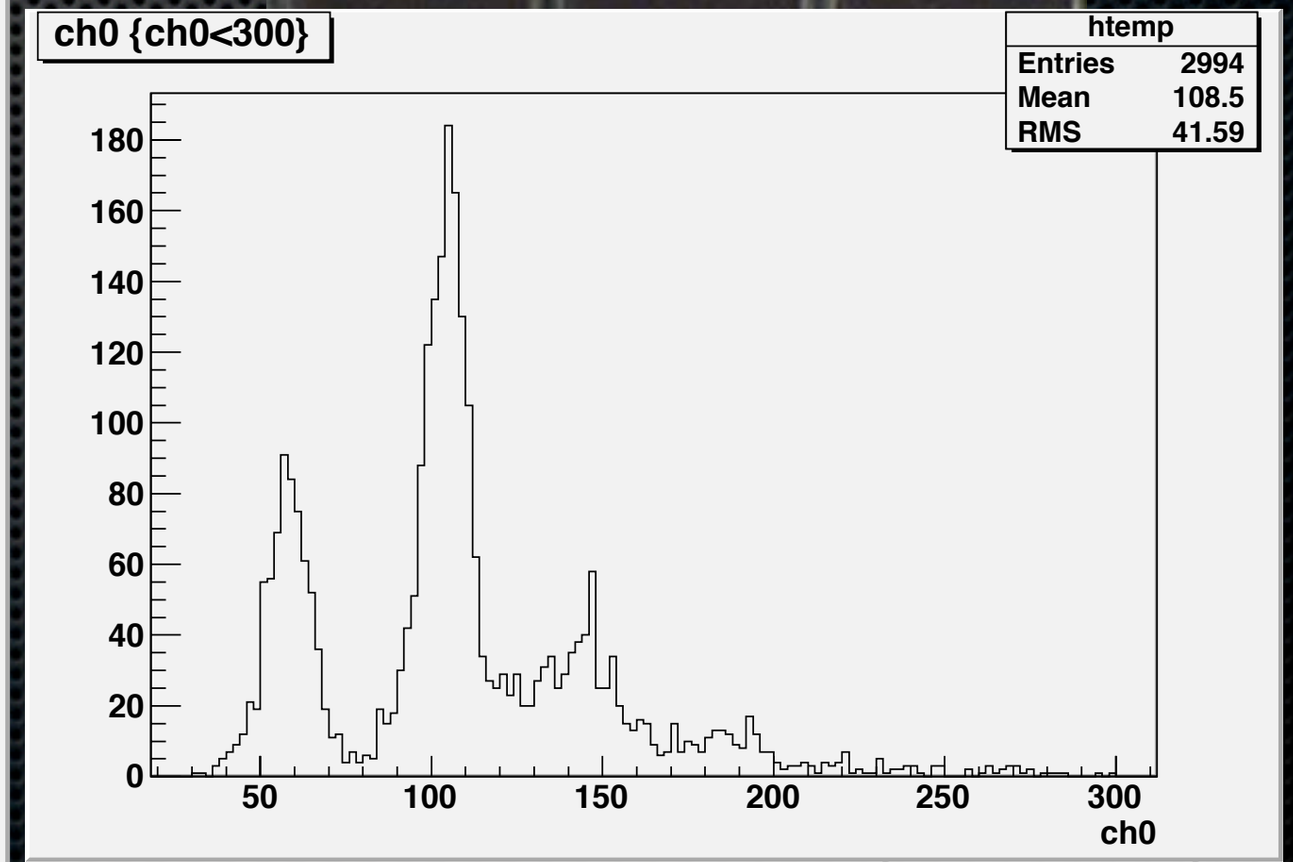
We defocus the image to get large spot size.

ϕ0.5 mm is used for MPPC.

ϕ10 mm is used for PMT







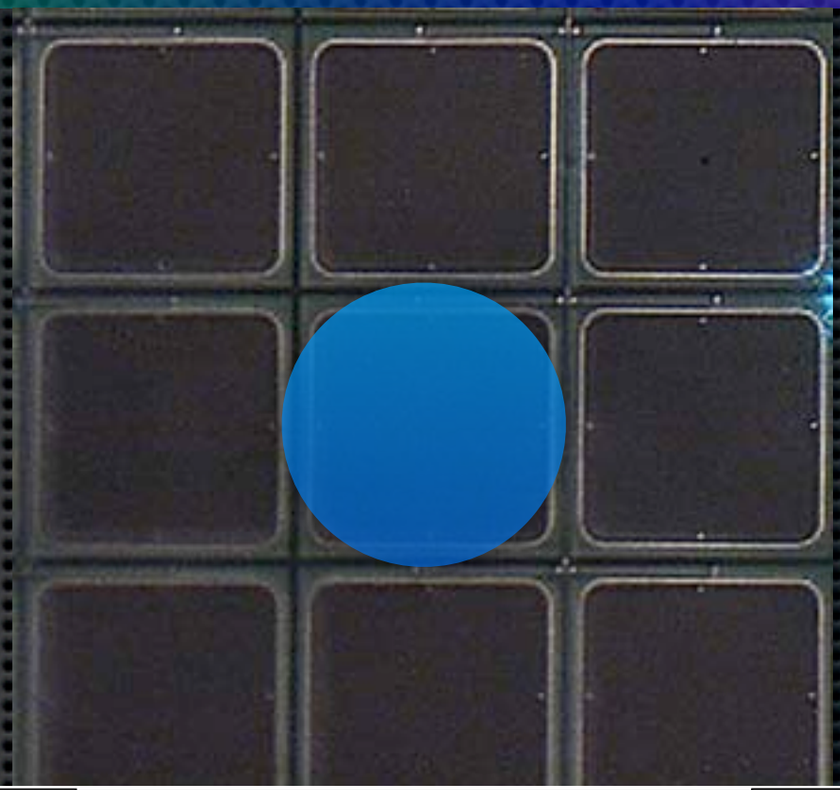
Beam spot size

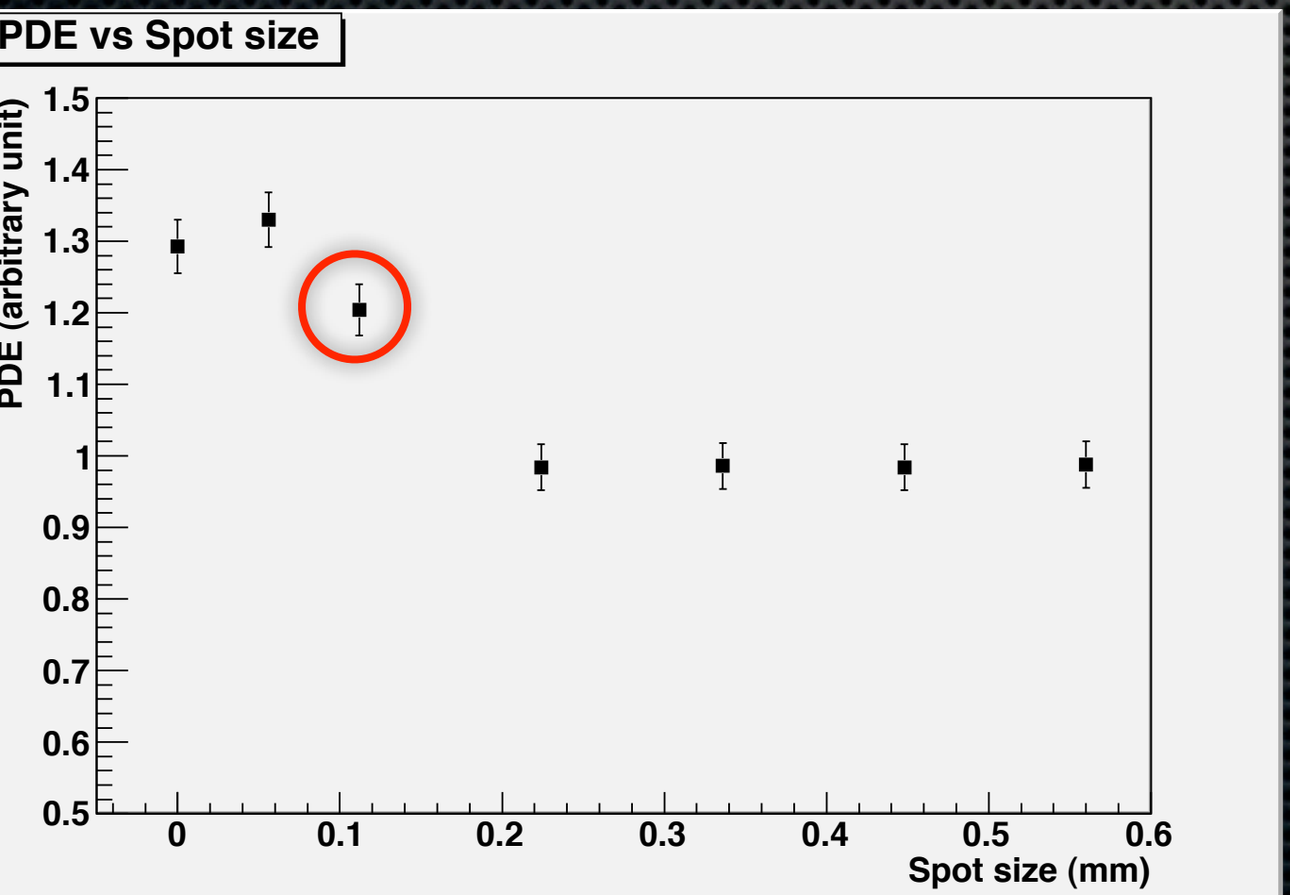
Spot size control

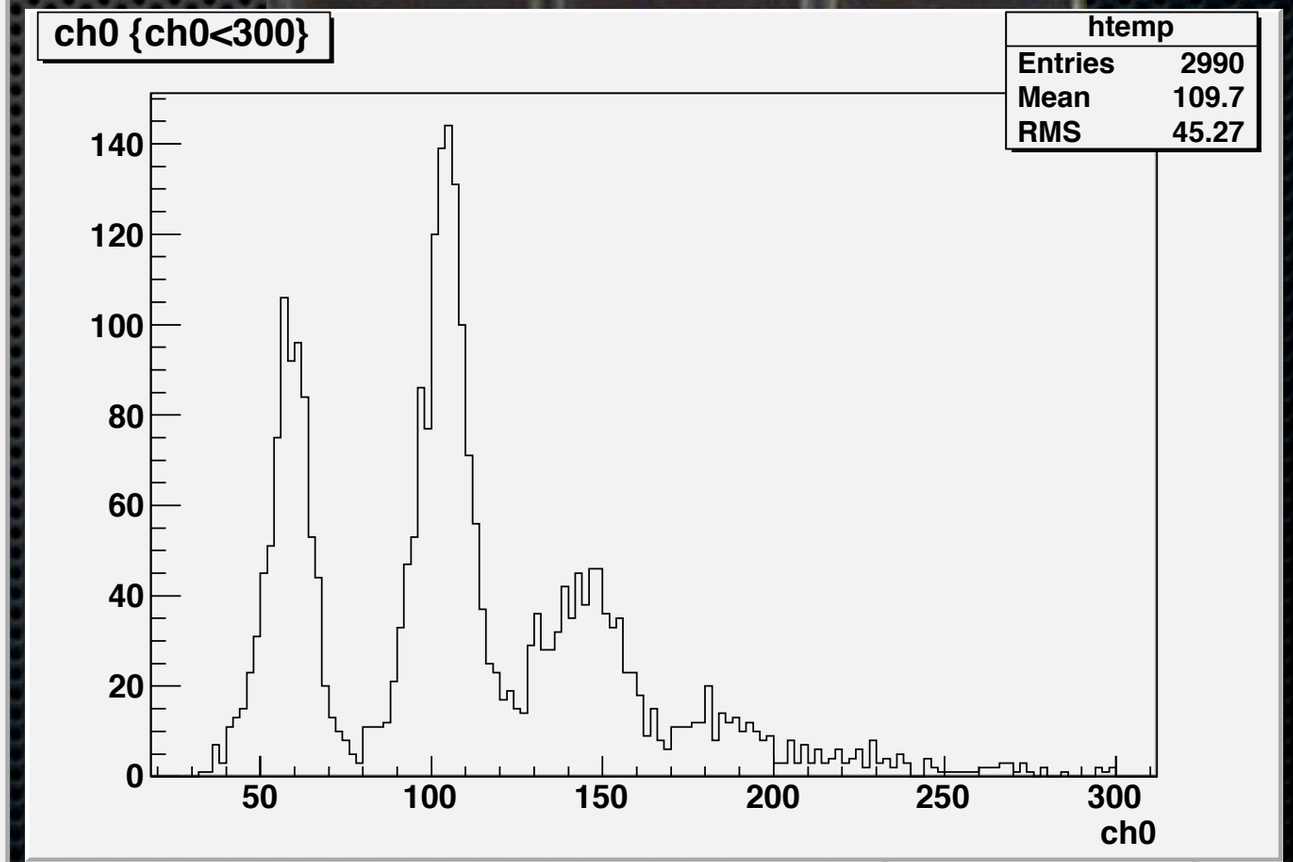
We defocus the image to get large spot size.

ϕ0.5 mm is used for MPPC.

ϕ10 mm is used for PMT







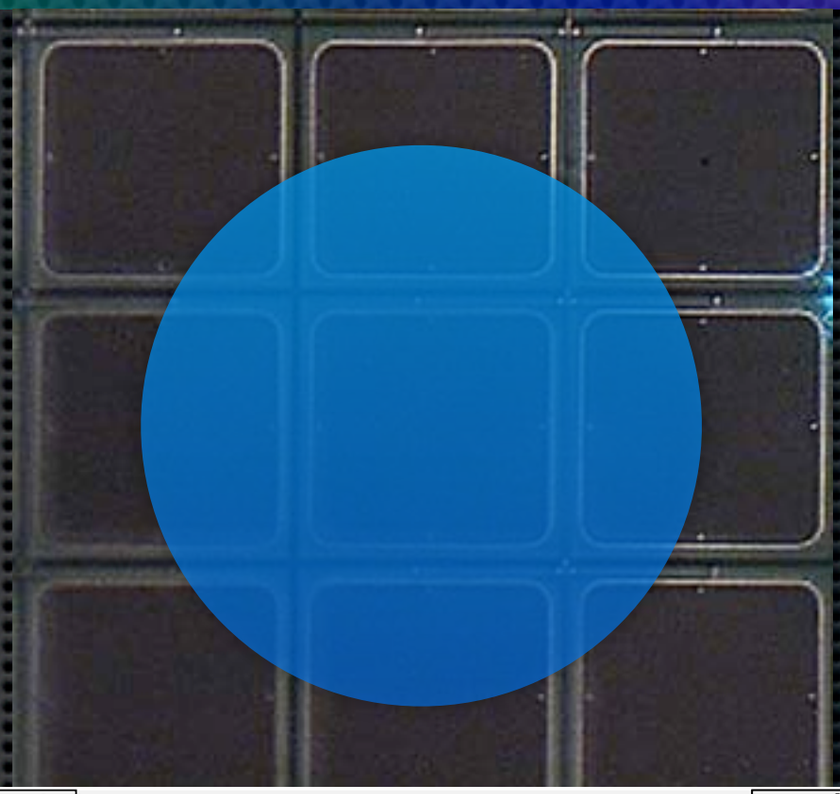
Beam spot size

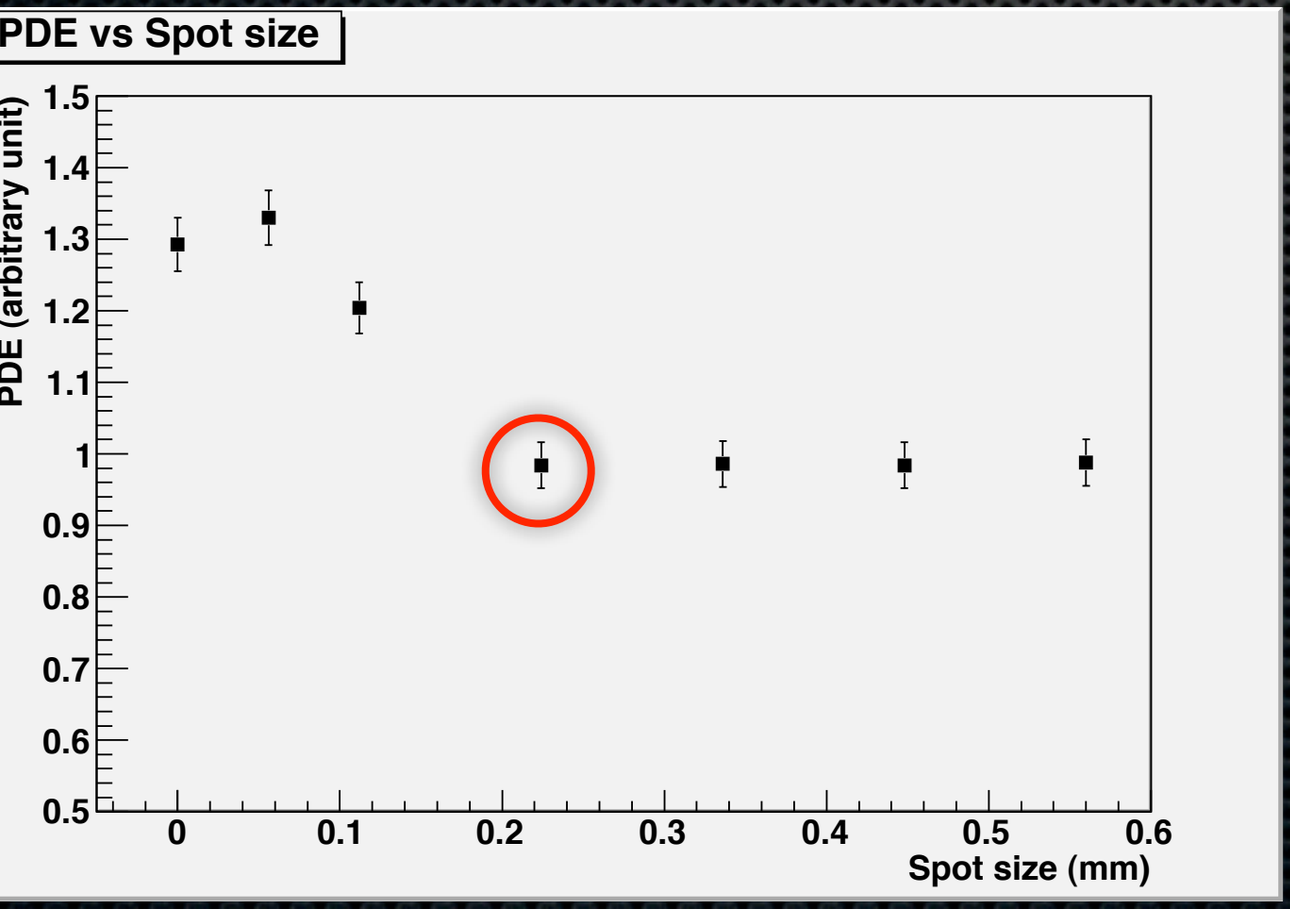
Spot size control

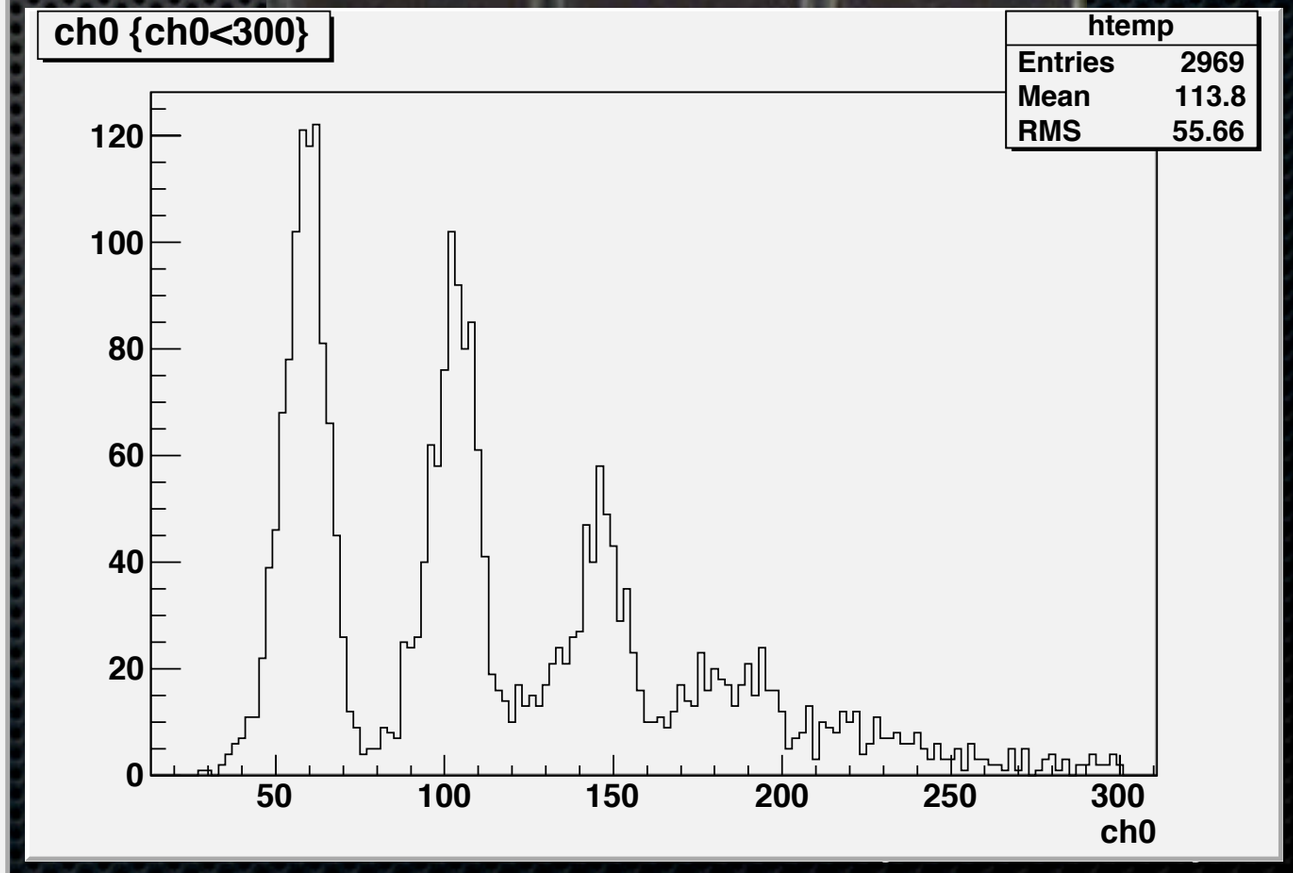
We defocus the image to get large spot size.

ϕ0.5 mm is used for MPPC.

ϕ10 mm is used for PMT





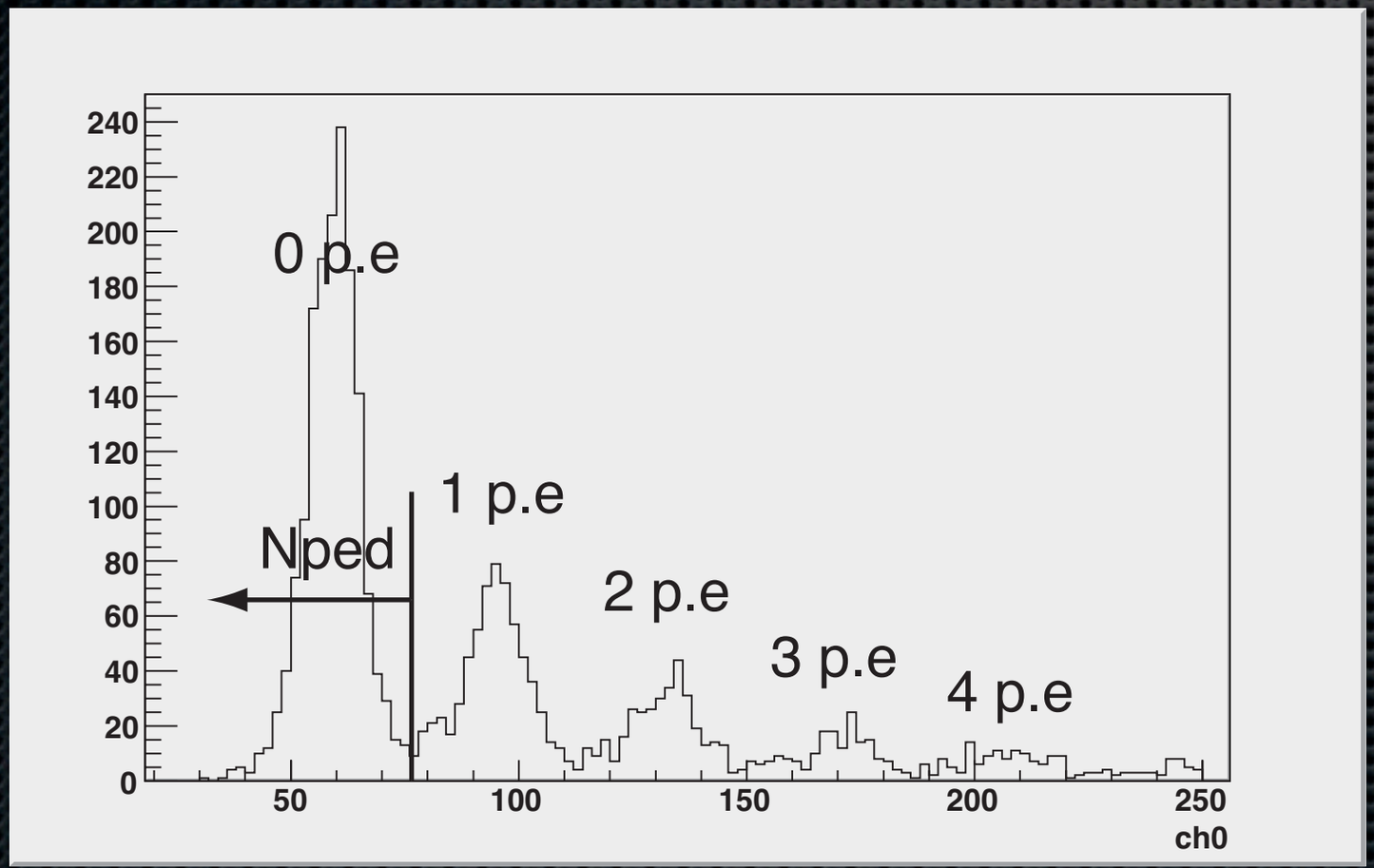


PDE measurement

Npe was extimated by using pedestal information.

(with some corrections of dark noise)

to avoid crosstalk and after pulse effect.



$$P(n)=\mu^n e^{-\mu}/n!$$

$$P(0)=N_{ped}/N_{all}$$

$$= e^{-\mu}$$

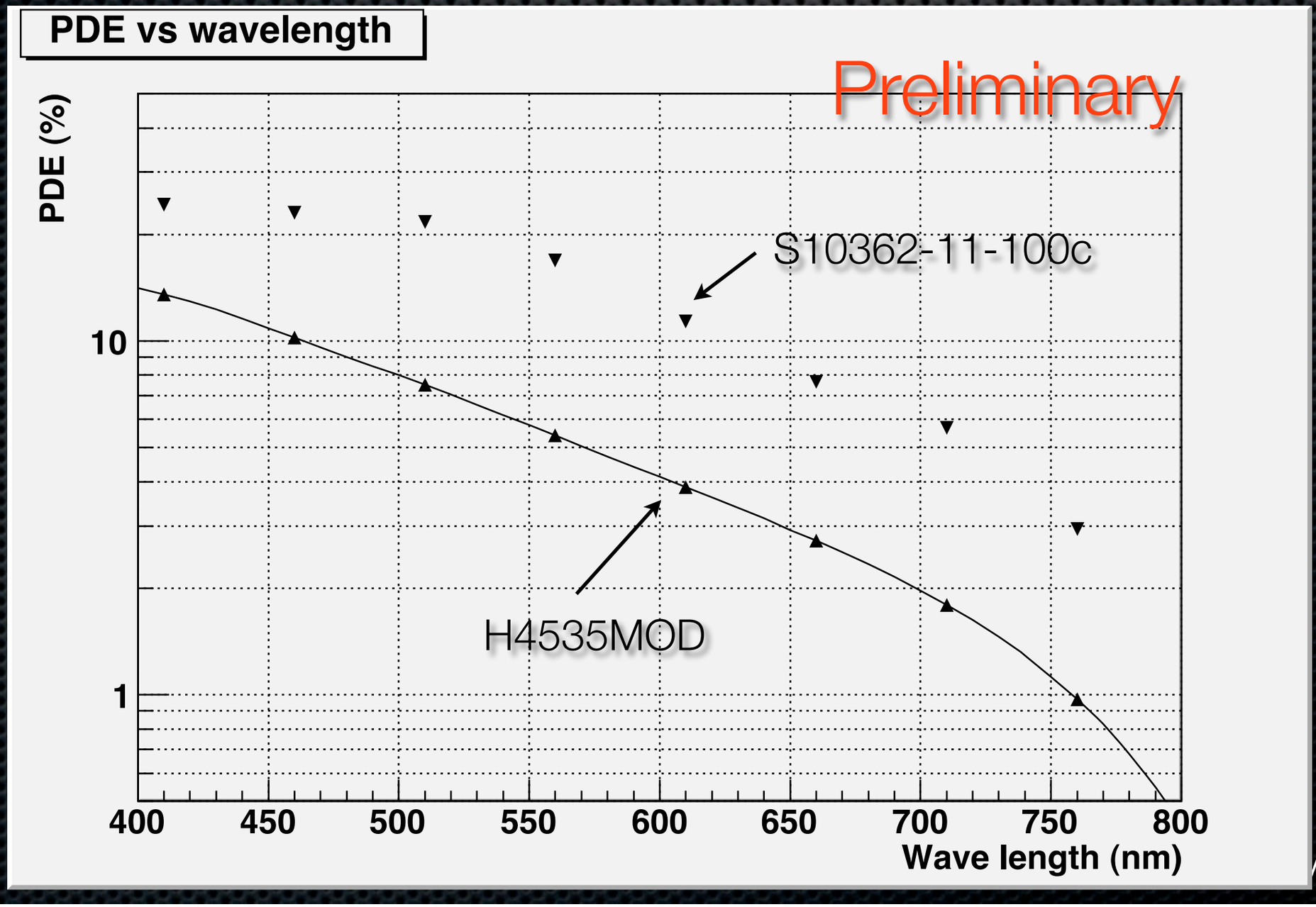
$$\mu=-\ln(N_{ped}/N_{all})$$

PDE measurement

Npe was extimated by using pedestal information.

(with some corrections of dark noise)

to avoid crosstalk and after pulse effect.



Issues

We found the following problems during commisioning:

Low repetition rate

20 Hz at maximum

Long measurement time

→ Temperature control

Automation

Stability

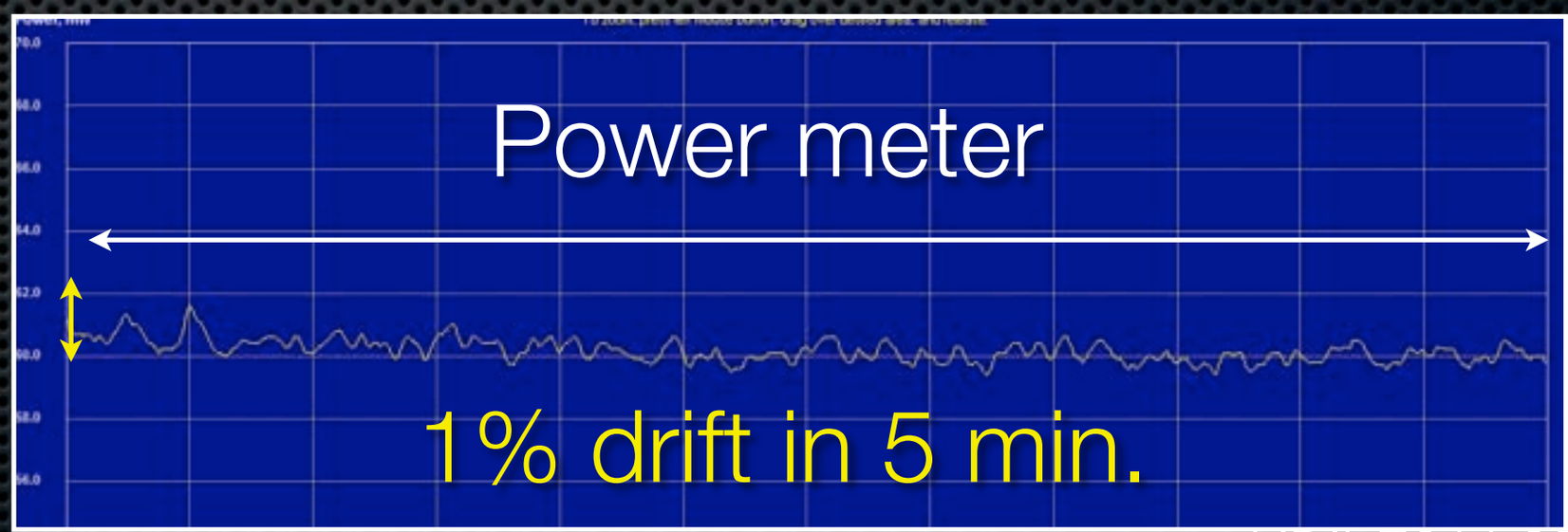
Power is not absolutely stable.

→ Power monitor

EM Noise

Servo motor generate severe noise.

→ Improve stage, shielding



Summary & Future works

Multi-wavelength measurement

- Useful to probe in depth direction

OPO laser micro scope system :

- Pulsed laser with 5 ns width
- 410 nm ~ 2100 nm continuously tunable
- ~ μm spot size
- Low repetition rate 20 Hz
- Stability

Several issues to be solved:

- Stability → Realtime power monitor
- Automation → Developing Kit
- Stage → Larger Stage to accomodate larger sensors

Study of various PPDs

Acknowledgement

Special Thanks to

Ms. Ikemoto (KEK)

Mrs. Mine and II (Japan Laser)

Mr. Oki (OK-Lab)