Study of Spectral Sensitivity of G-APD in the wavelength range from 250-800 nm

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Outline

- Introduction
- Experimental Setup
- Results
- Outlook

Introduction - SiPM

SiPM is a newly developed matrix of avalanche photo diodes (APD) operated in Geiger-mode

–characteristics of a photon sensor

–many advantages over PMT

–potential to replace PMT in many applications

–possible readout of DIRC Cherenkov and TOF barrel in PANDA

Advantages:
- **insensitive to magnetic field**
- **high photon detection efficiency**
- **single photon sensitivity**
- **gain comparable to PMT**
- **no high voltage needed**
- **fast timing application**
- **easy to handle and compact in size**

Disadvantages:
- **relatively large dark count rate**

Introduction - PDE

- **Photo detection efficiency (PDE) is described as**

$$PDE = QE \times P_{avalanche} \times GF.$$

Q.E. = quantum efficiency,

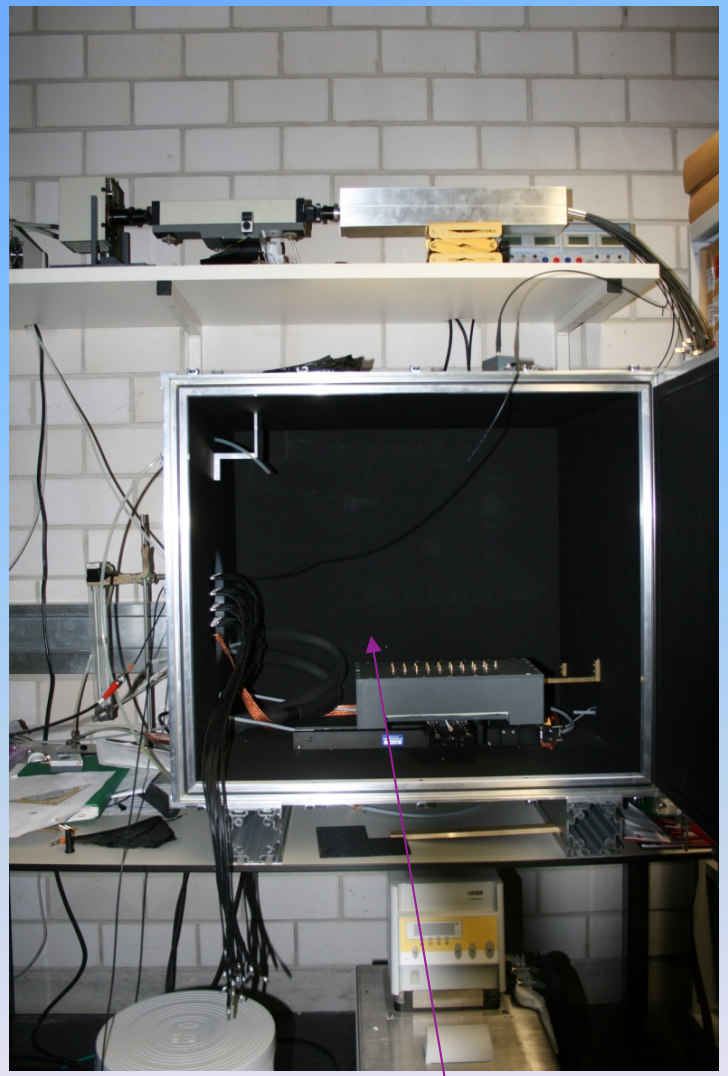
$P_{avalanche}$ = avalanche probability = (number of excited pixels) / (number of photon-incident pixels),

F_{geo} = effective pixel size / total pixel size
(ratio is small due to space needed for quenching resistance, typically 30% for pixel number 1600).

Dynamic Range of SiPM depends on
(1) Number of Pixels in SiPM (m) and
(2) PDE (ε)

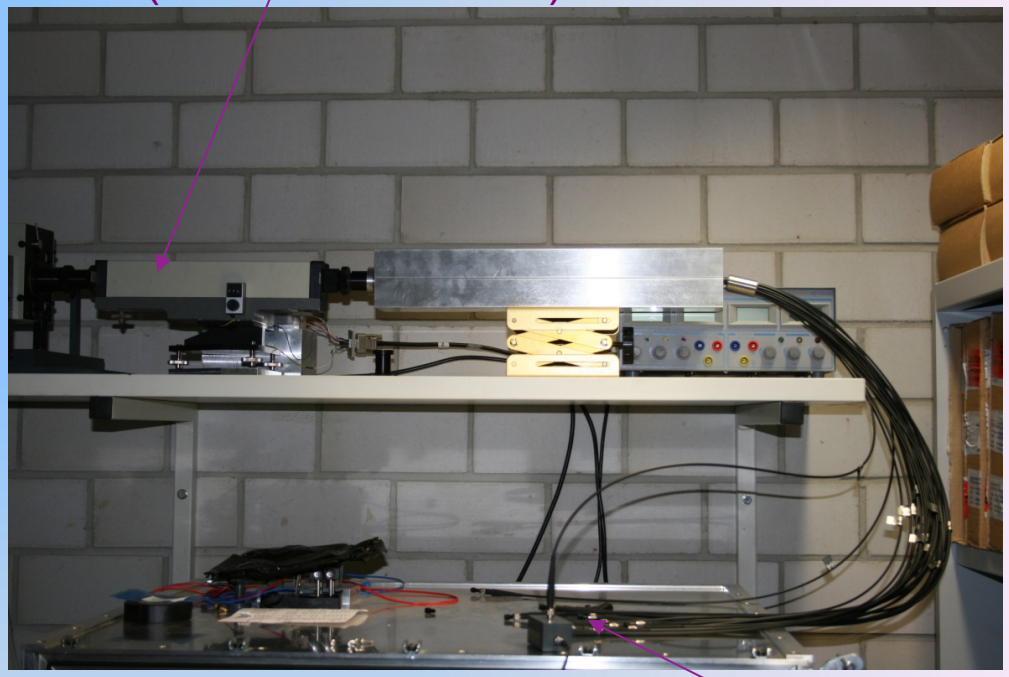
Study of PDE is important to characterize SiPM's

Experimental Setup for PDE measurement

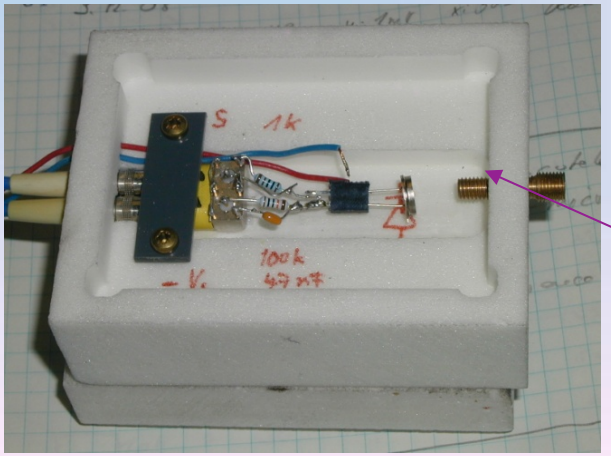


Light tight box

Monochromator
(200 nm – 800 nm)

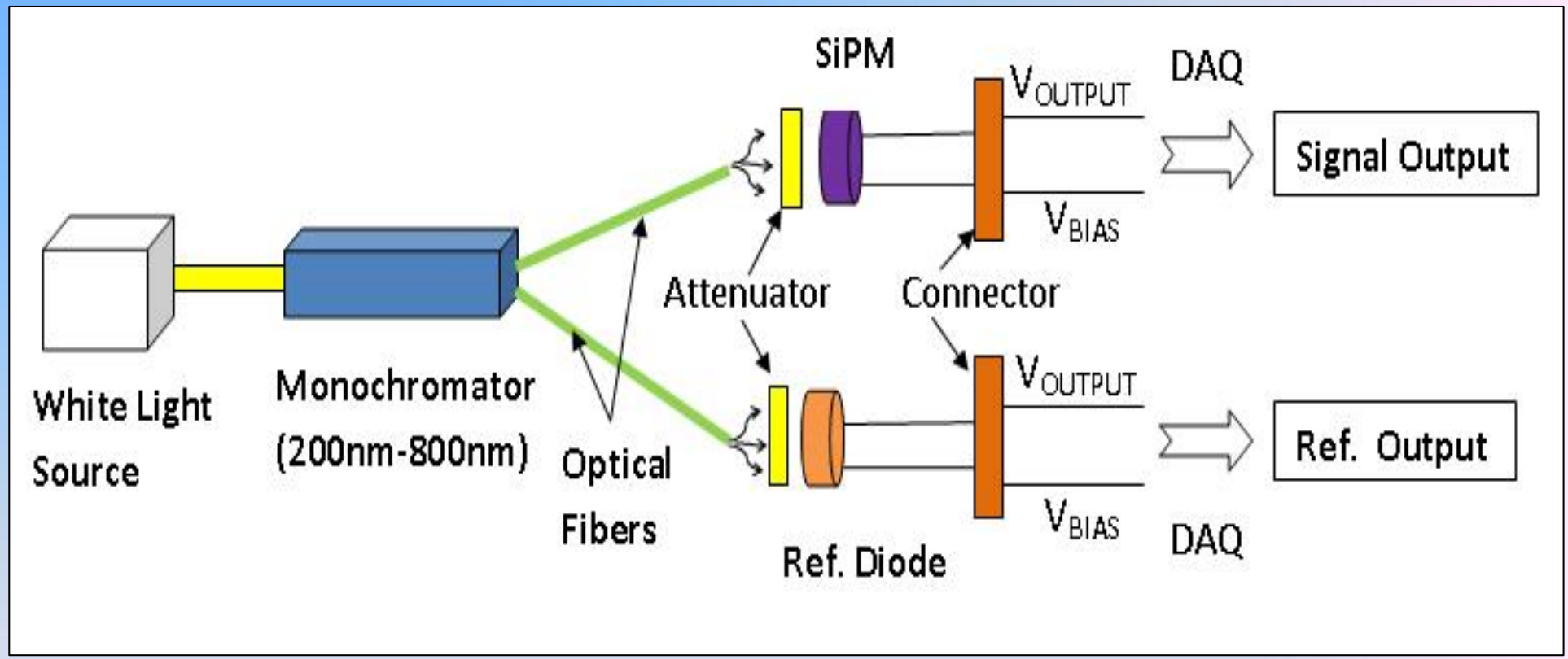


Calibrated
PIN diode



G-APD box

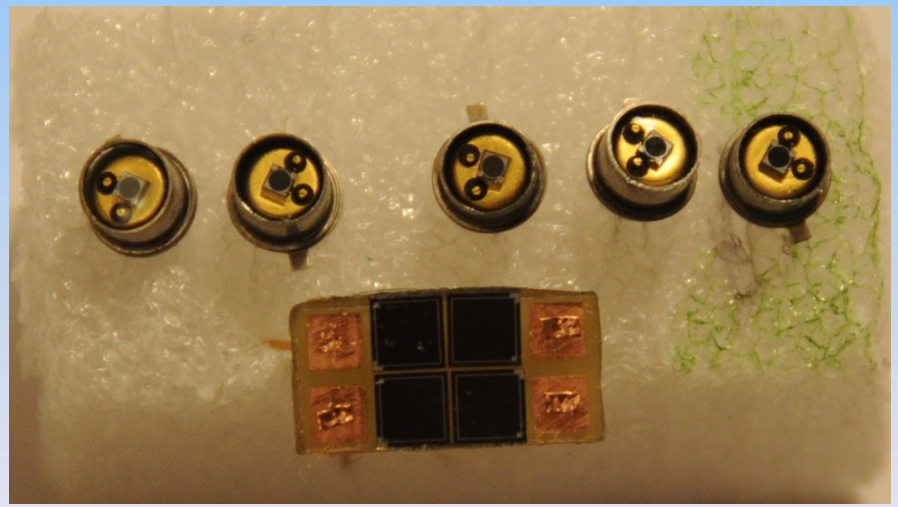
Schematic of Experimental Setup for PDE measurement



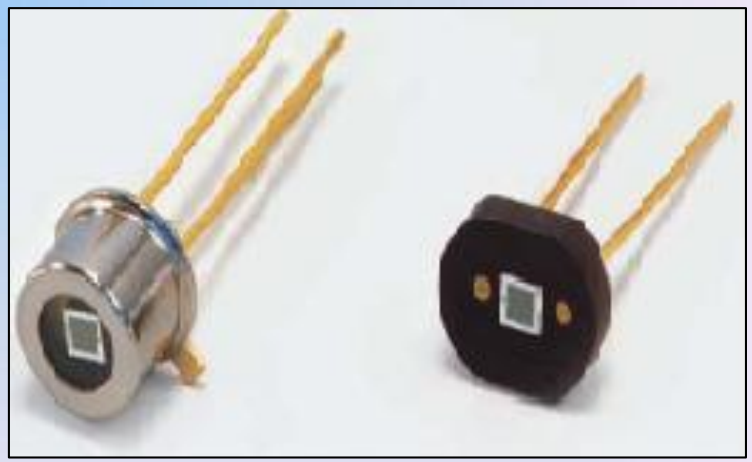
SiPM Sensors

SiPM sensors tested: MPPC from Hamamatsu, MAPD3N from Zecotek

Device	Active Area (mm^2)	Pixel Size (μm)	Pixel Density ($1/mm^2$)
MPPC-11-25	(1×1)	25	1600
MAPD3N	(3×3)	7	15000
MAPD3N	(1×1)	7	15000

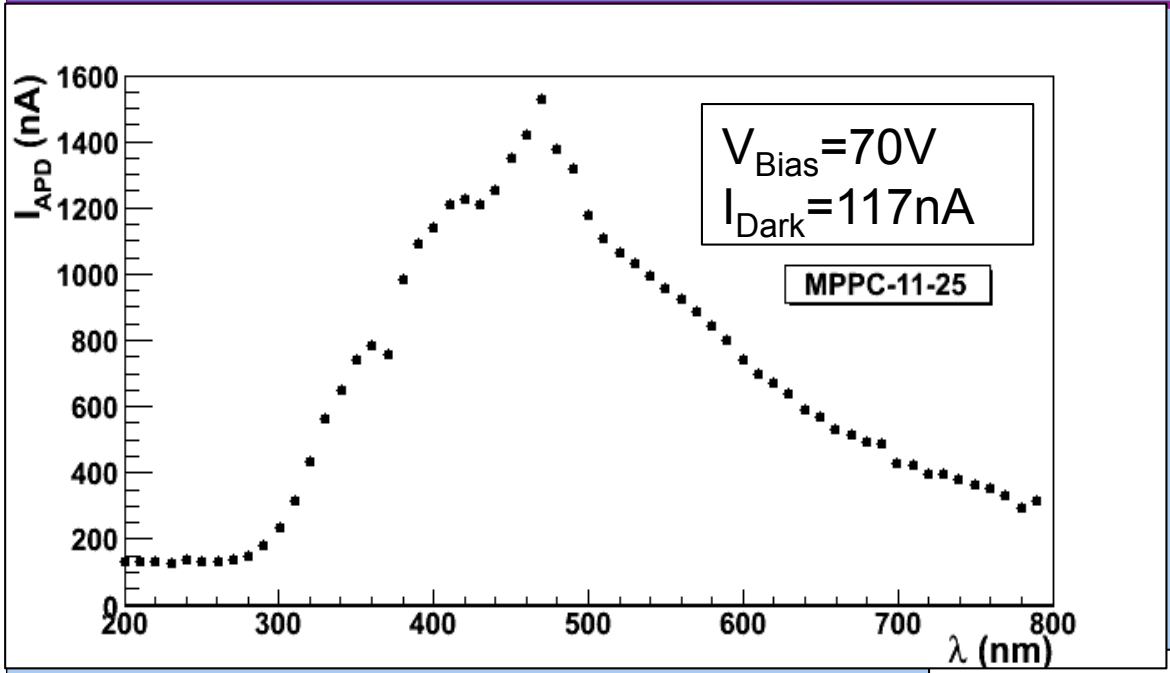


MAPD3N from Zecotek



MPPC from Hamamatsu

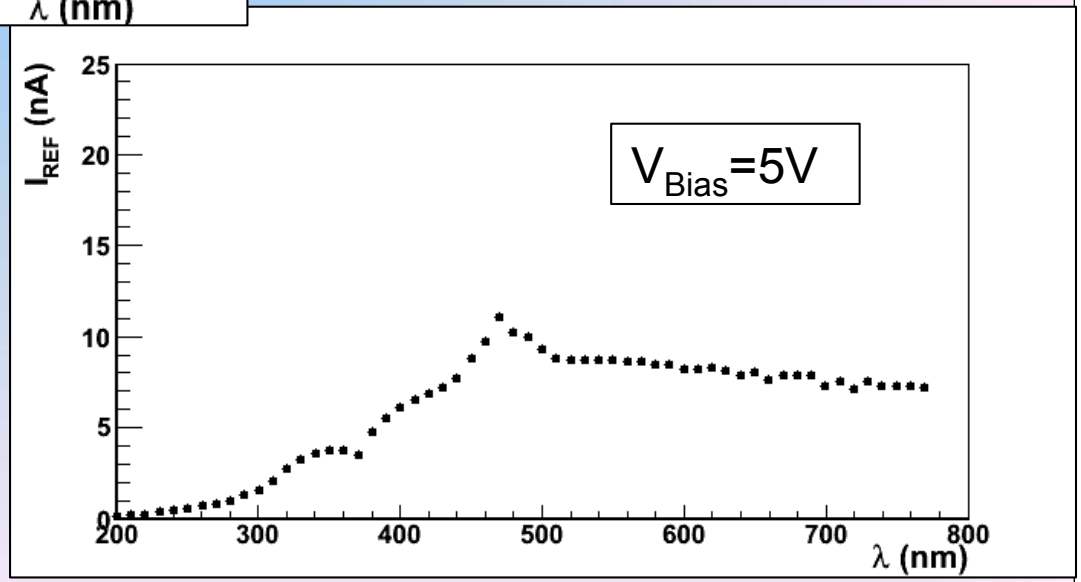
Current of SiPM and Ref. PIN Diode



Hamamatsu Sensor
MPPC-11-25

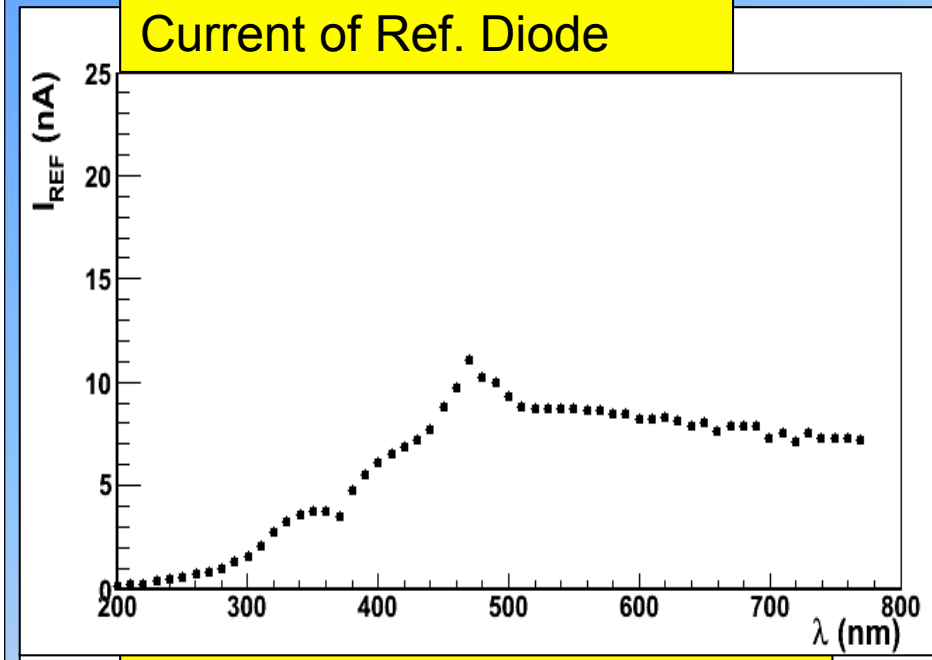
Current of SiPM sensor

Current of Ref. PiN Diode

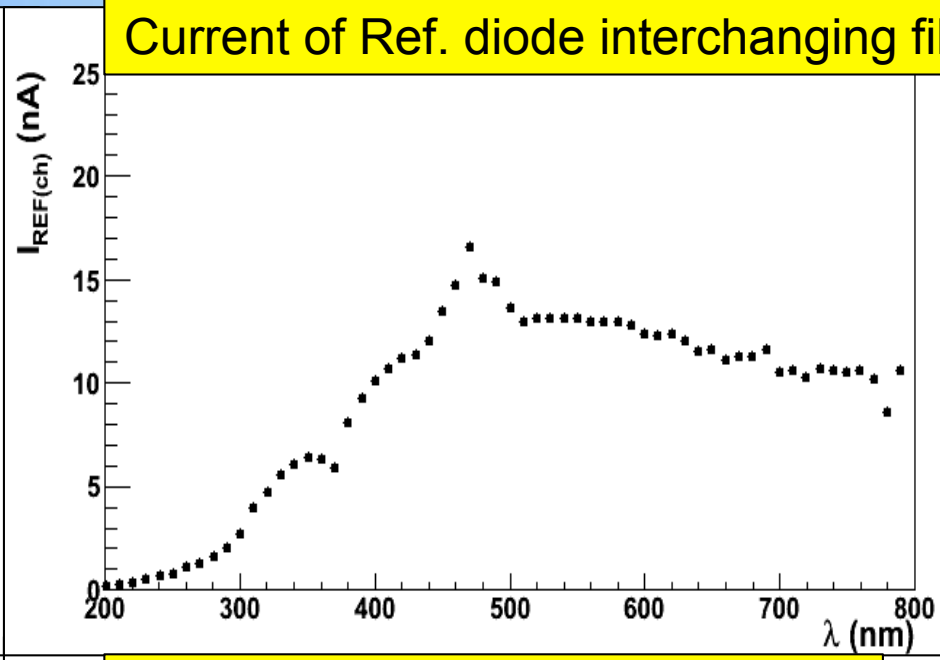


Currents with Fibers exchanged

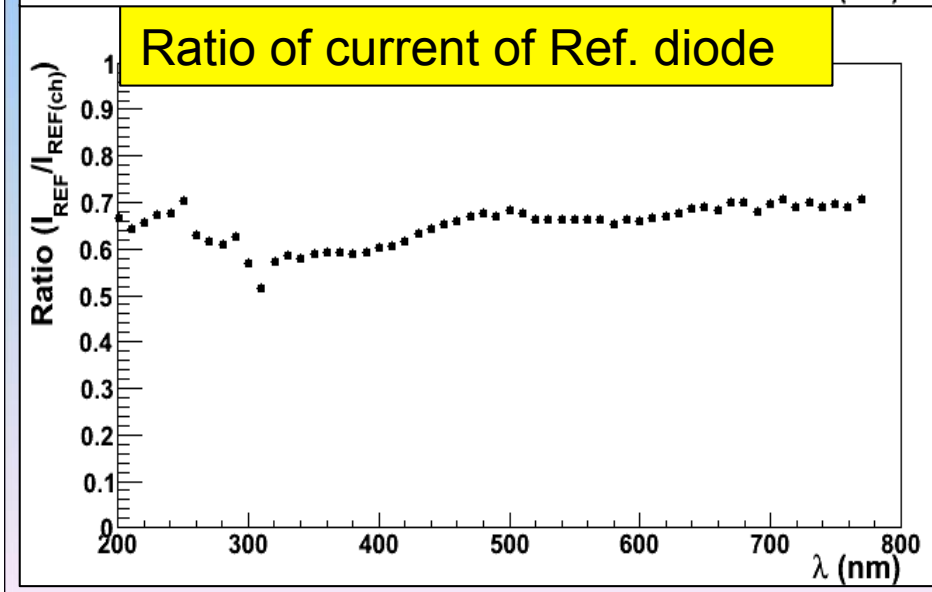
Current of Ref. Diode



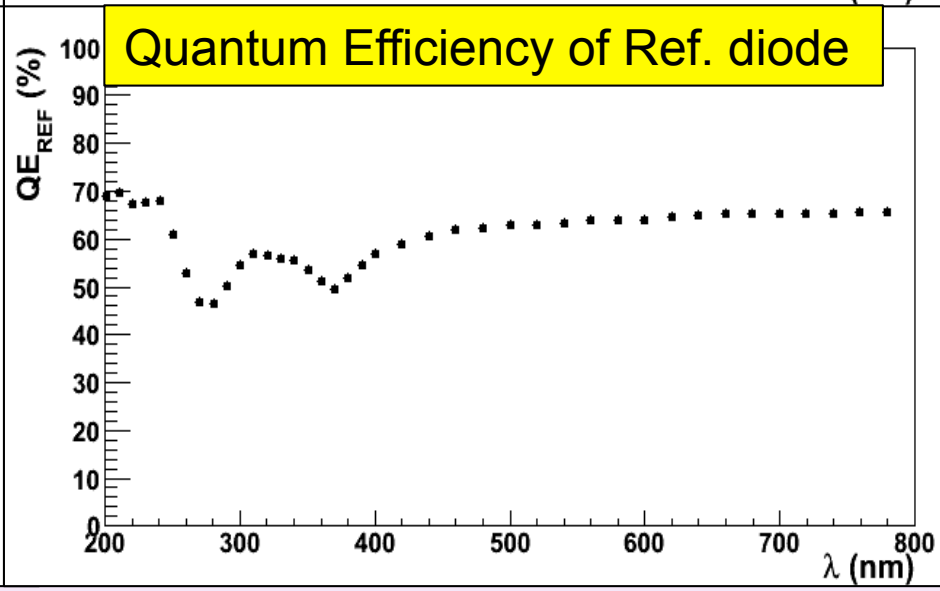
Current of Ref. diode interchanging fiber



Ratio of current of Ref. diode

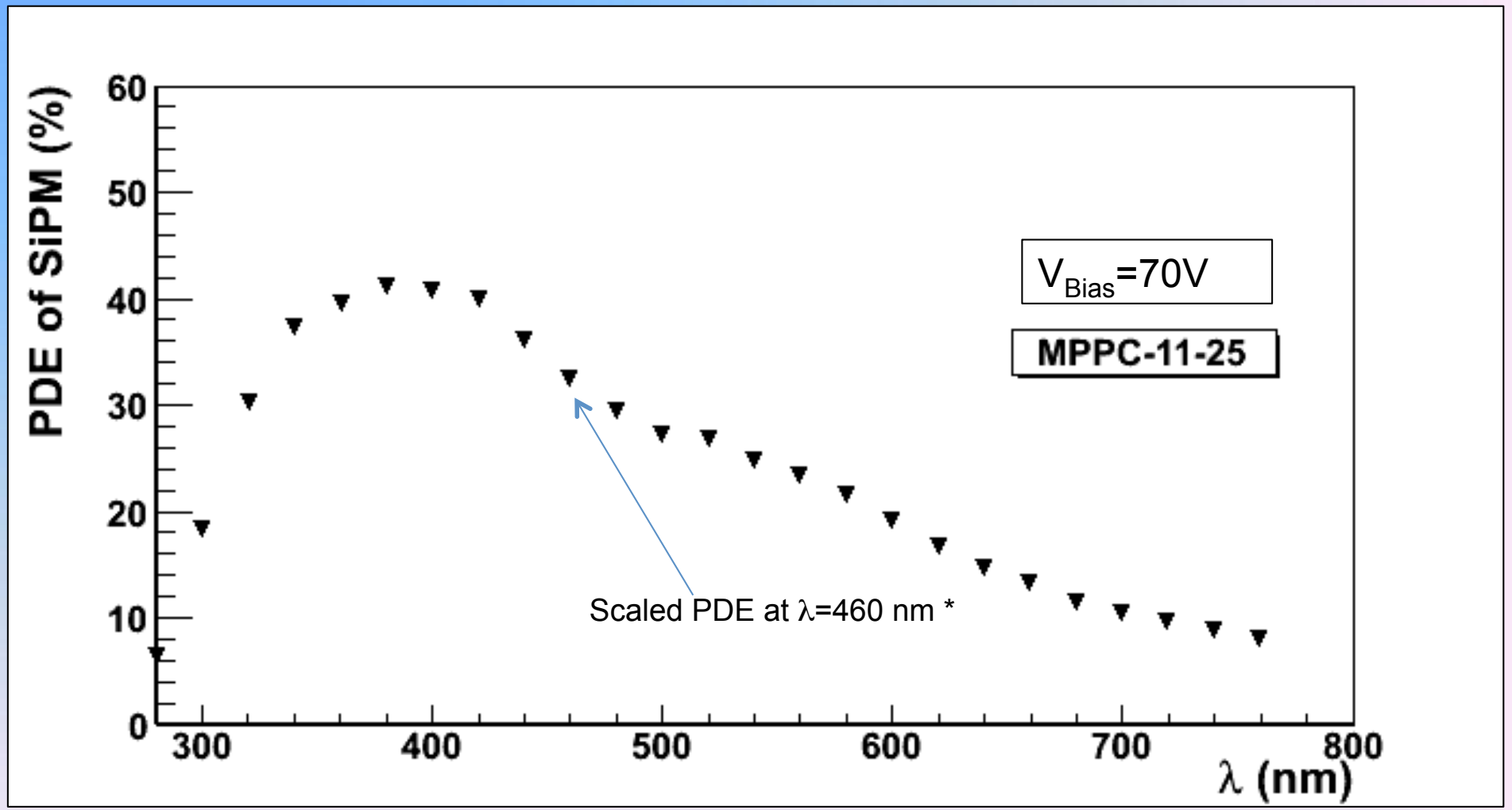


Quantum Efficiency of Ref. diode



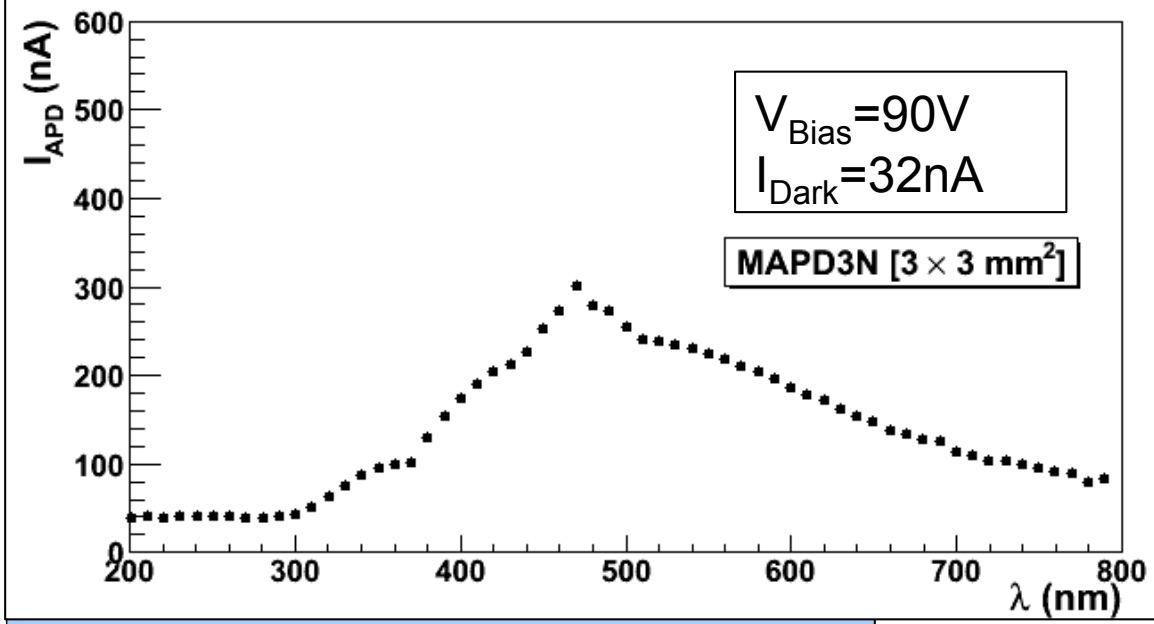
Photon Detection Efficiency

Hamamatsu Sensor MPPC-11-25



* D. Renker, PSI (Private Communication)

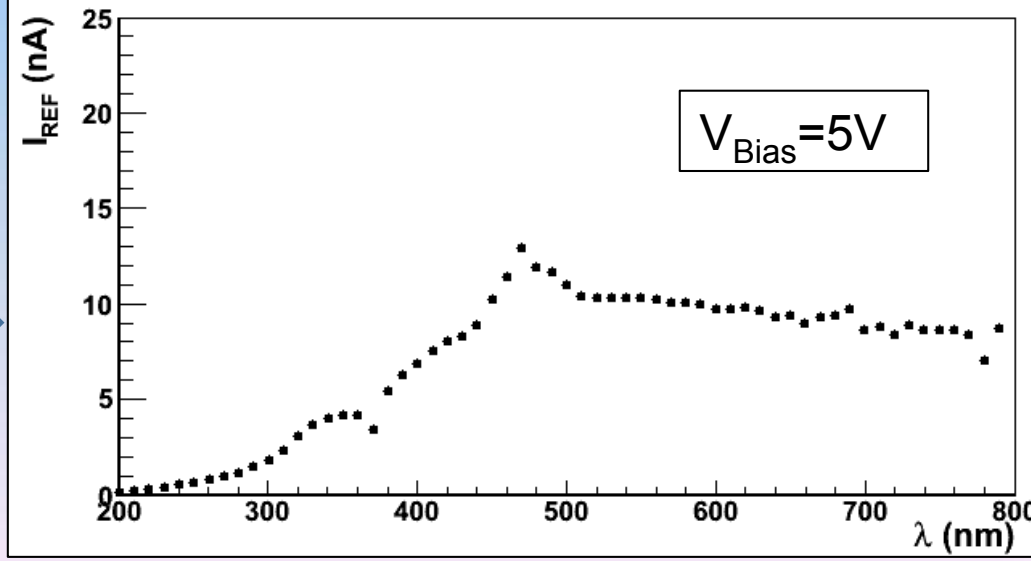
Current of SiPM and Ref. PIN Diode



Zecotek Sensor
MAPD3N [3 × 3 mm²]

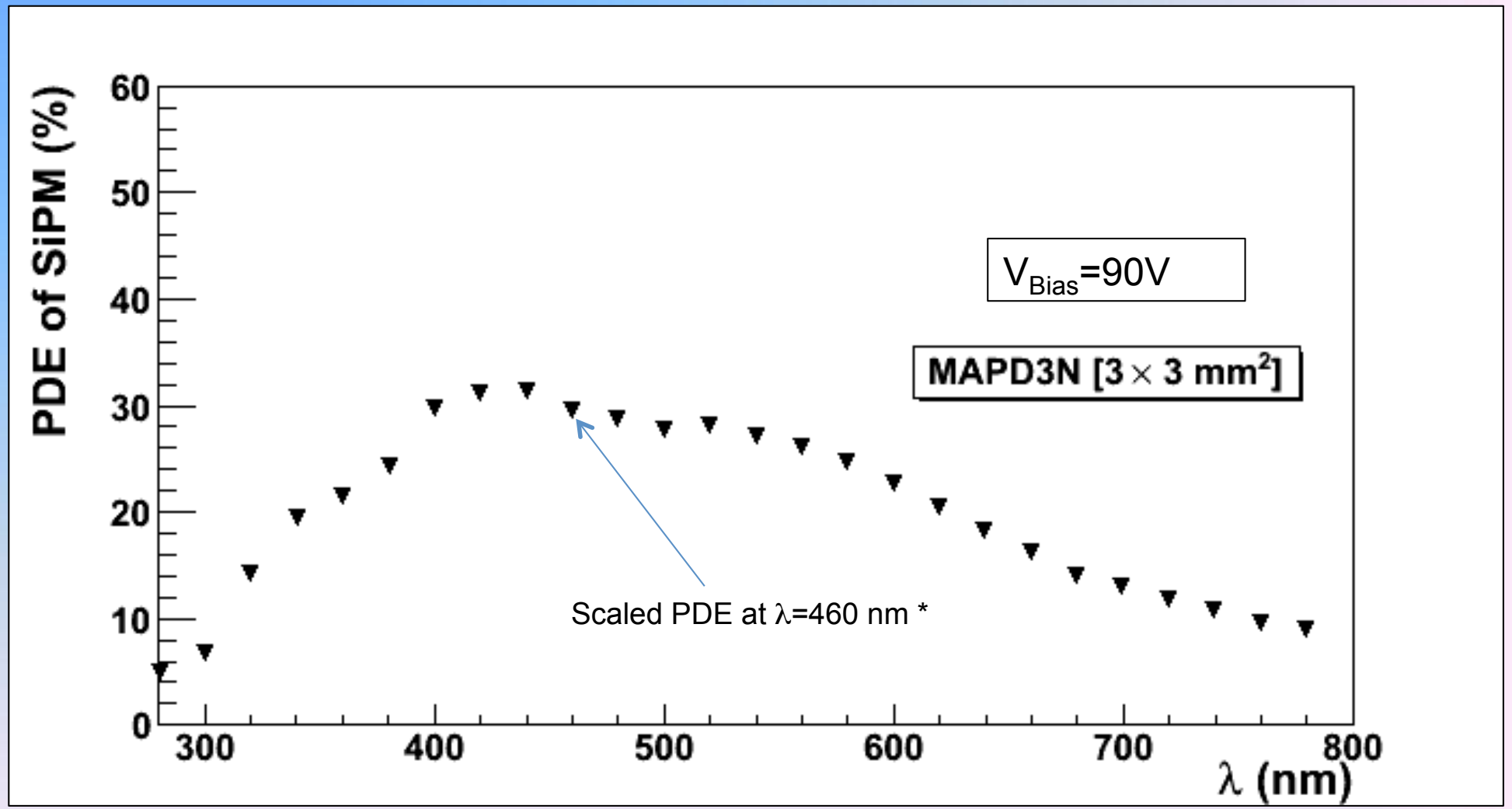
Current of SiPM sensor

Current of Ref. PiN Diode



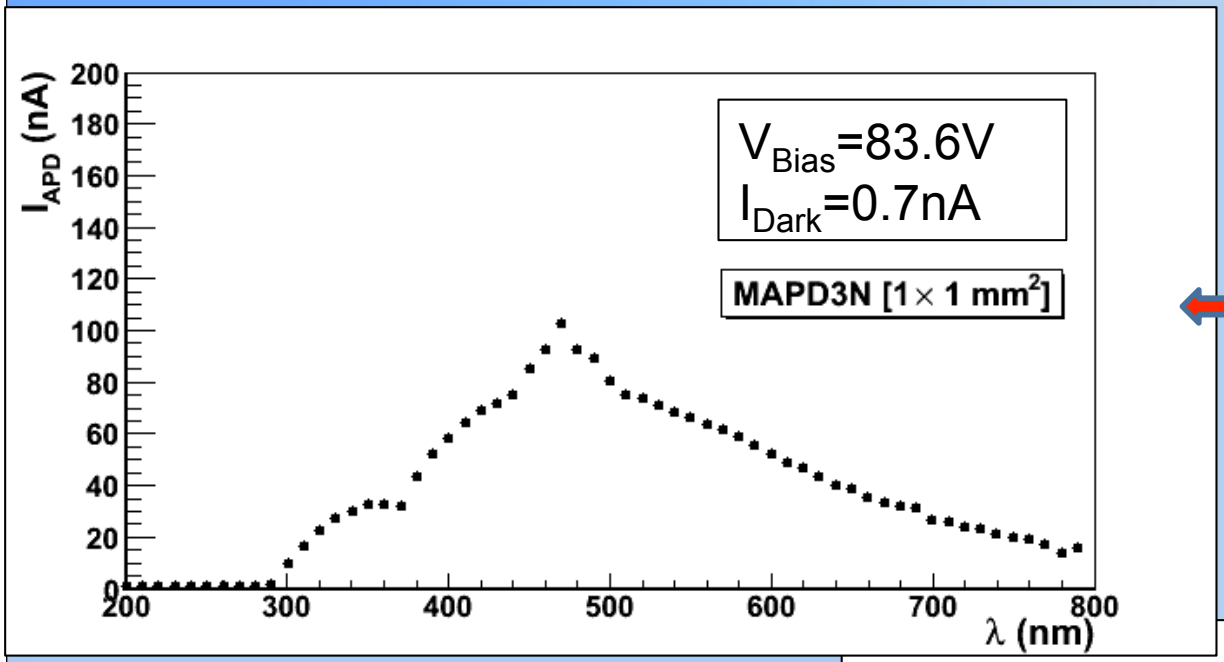
Photon Detection Efficiency

Zecotek Sensor MAPD3N [3 × 3 mm^2]



* Yu. Musienko, CERN (Private Communication)

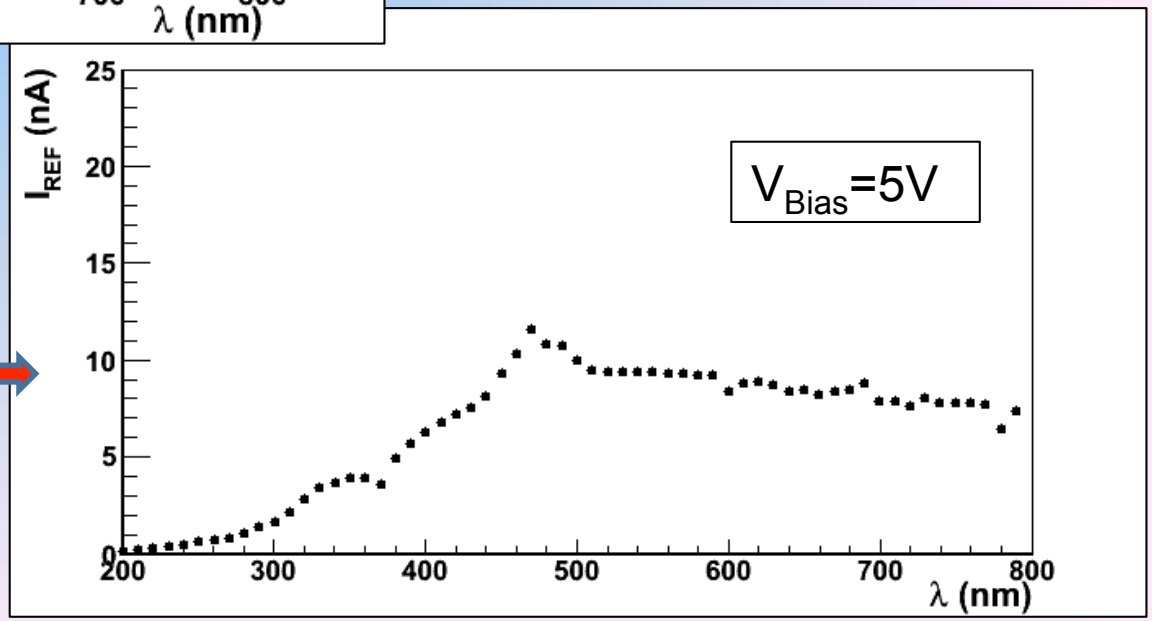
Current of SiPM and Ref. PIN Diode



Zecotek Sensor
MAPD3N [1 × 1 mm^2]

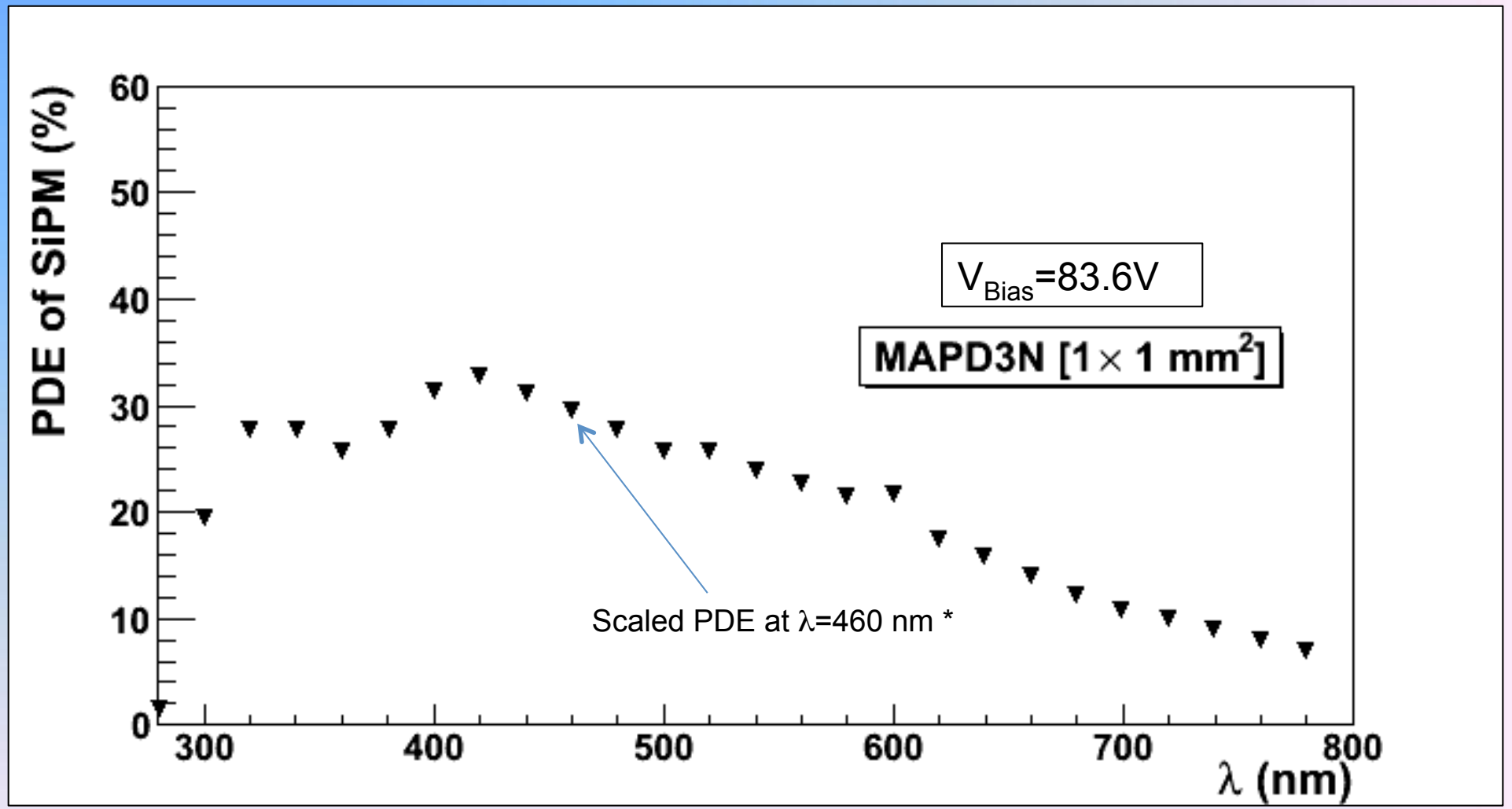
Current of SiPM sensor

Current of Ref. PiN Diode



Photon Detection Efficiency

Zecotek Sensor MAPD3N [1 × 1 mm^2]

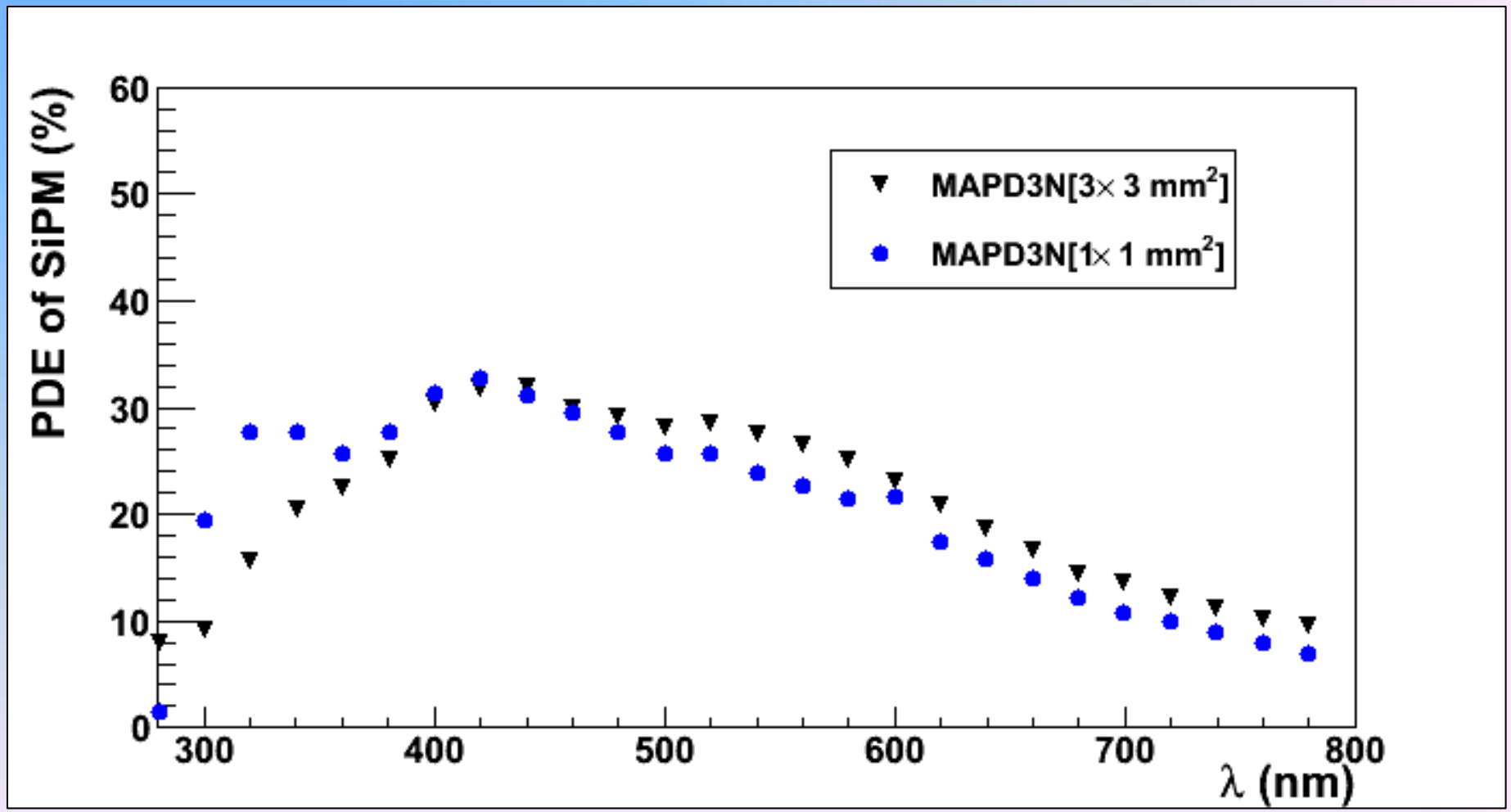


* Yu. Musienko , CERN(Private Communication)

Photon Detection Efficiency

Zecotek Sensor MAPD3N [3 × 3 mm²] V_{Bias}=90V

Zecotek Sensor MAPD3N [1 × 1 mm²] V_{Bias}=83.6V



Outlook

- Due to epoxy coating the SiPM sensors are not sensitive in UV region. Measurement of the SiPM's without the epoxy coating is planned (useful to understand the intrinsic Efficiency of the sensors in the UV region, important for Cherenkov Photon Detection)

- Absolute measurement of PDE with proper optical setup instead of relative sensitivity measurement

- Study of Temperature Dependence of PDE

- Proper measurement of Dark Current (depends on current of SiPM)

- Use of Pulsed Light Source instead of DC light source