Absolute Measurement of the Quantum Efficiency of a Classical PMT

Task: measure the QE of a PMT in the wavelength interval 200 to 800 nm. Discuss the result, its precision and possible error sources.

Set-up:
- PMT
- Xe-lamp
- monochromator
- reference photodiode
- Keithley picoampere meter
- PC (Labview)

Principle of the QE determination

$$\varepsilon_Q(\lambda) = \frac{N_e}{N_\gamma(\lambda)} = \frac{N_e \cdot e \cdot t}{N_\gamma(\lambda) \cdot e \cdot t} = e \cdot \frac{I_{photo}}{\Phi_\gamma(\lambda)}$$

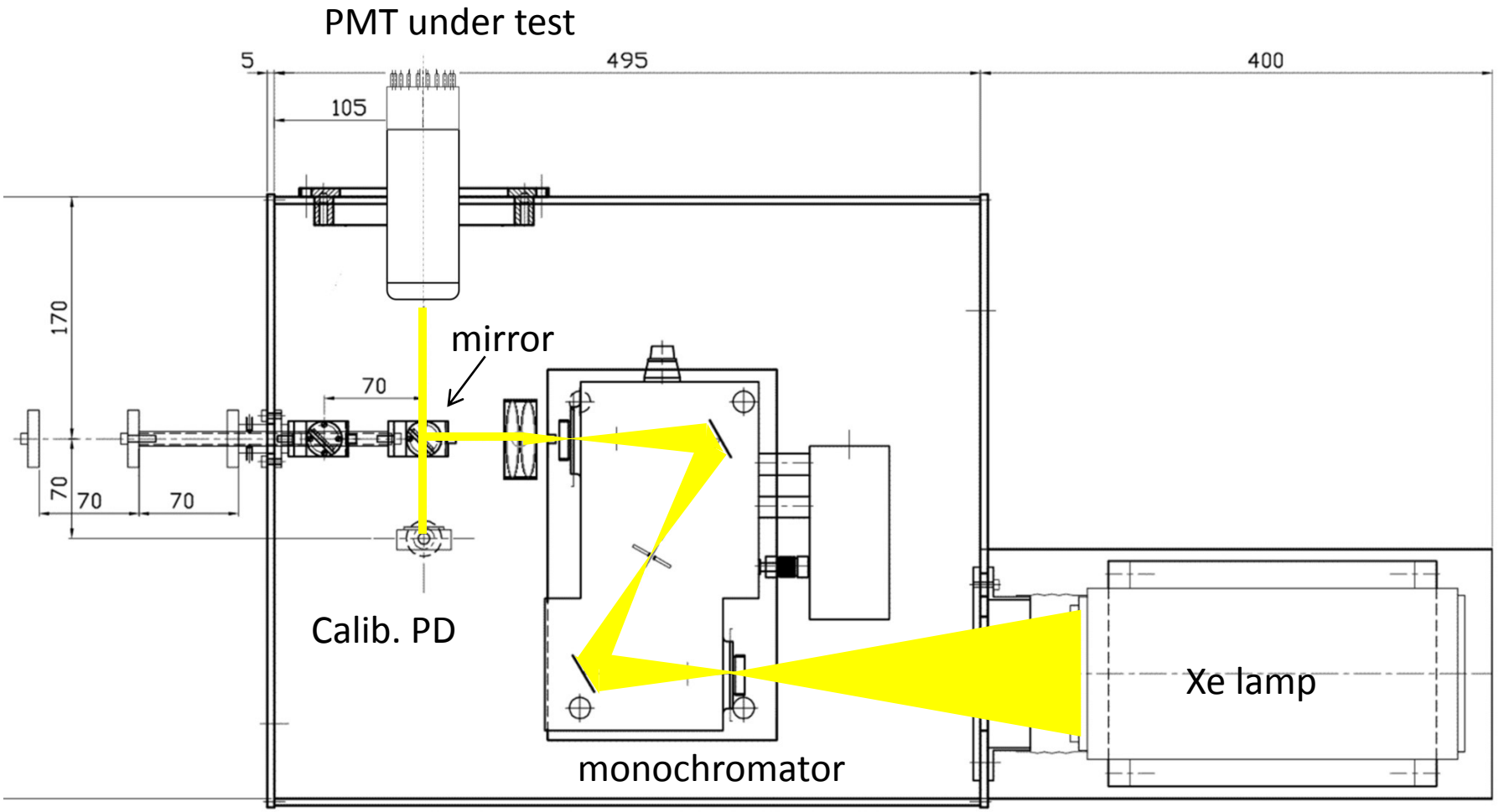
$\Phi_\gamma(\lambda)$ Photon flux, unknown !

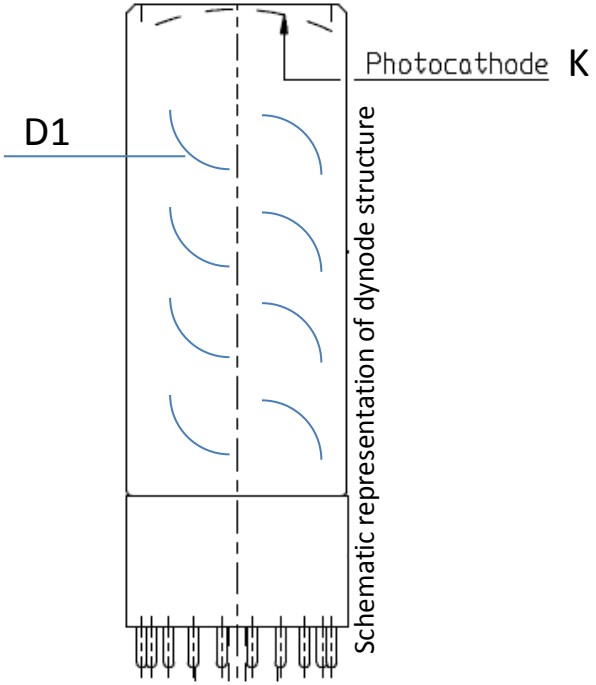
Use a reference detector with known (calibrated) ε_Q to determine the photon flux

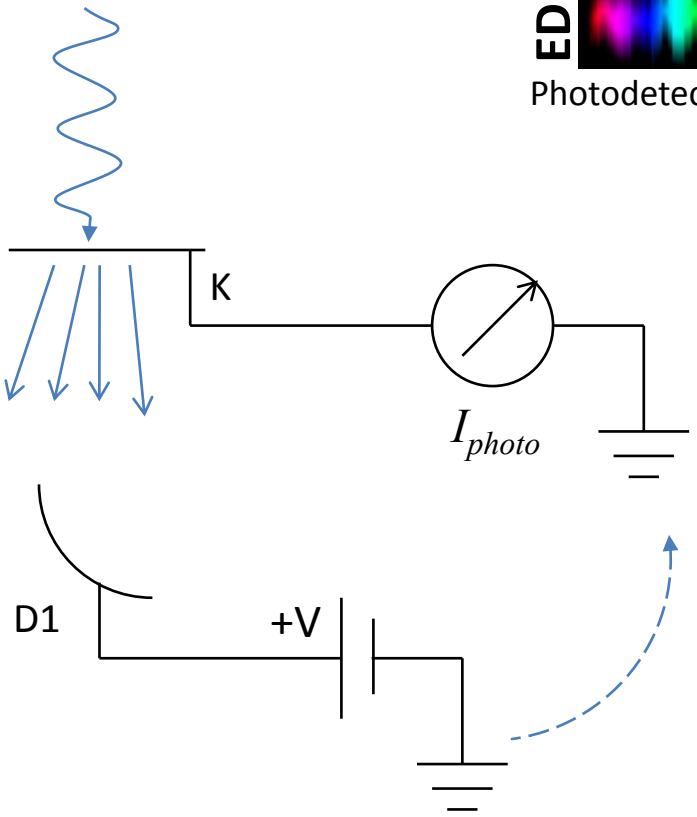
$$\varepsilon_Q(\lambda)\Big|^{REF} = e \cdot \frac{I_{photo}^{REF}}{\Phi_\gamma(\lambda)} \quad \Rightarrow \quad \Phi_\gamma(\lambda) = e \cdot \frac{I_{photo}^{REF}}{\varepsilon_Q(\lambda)\Big|^{REF}}$$

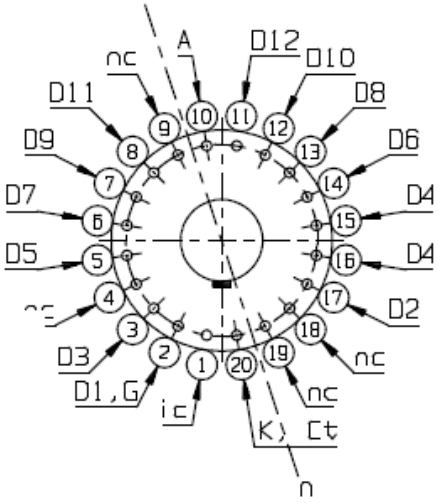
(DUT = Detector Under Test
REF = Reference Detector)

$$\varepsilon_Q(\lambda)\Big|^{DUT} = e \cdot \frac{I_{photo}^{DUT}}{\Phi_\gamma(\lambda)} = \frac{I_{photo}^{DUT}}{I_{photo}^{REF}} \varepsilon_Q(\lambda)\Big|^{REF}$$


PMT under test
5
495
400
105
170
mirror
70
70
70
70
Calib. PD
monochromator
Xe lamp


Photocathode K
D1
Schematic representation of dynode structure


K
I_{photo}
D1
+V


A
nc
D12
D10
D11
D8
D9
D6
D7
D4
D5
D4
D2
D3
nc
D1, G
nc
K
Ct

The 818-UV Low-Power UV Enhanced Silicon (Si) Photodetector is supplied with a NIST traced calibration report that details individual detector responsivity measured with and without attenuator over the 200 to 1100 nm wavelength range.

Model	818-UV
Detector Type	Semiconductor
Spectral Range	200 to 1100 nm
Active Diameter	1.13 cm
Detector Active Area	1 cm^2
Material	Silicon-UV Enhanced
Power Density, Average Max w/ Attenuator	0,2 W/cm^2
Power Density, Average Maximum w/o Attenuator	0,2 W/cm^2
Pulse Energy, Maximum - w/ Attenuator	0,1 $\mu J/cm^2$
Pulse Energy, Maximum - w/o Attenuator	0.1 nJ/cm^2
Uniformity	±2 %
Shunt Resistance	≥10 MΩ
Calibration Uncertainty	4% @ 200-219nm 2% @ 220-349nm 1% @ 350-949nm 4% @ 950-1100 nm
Calibration Uncertainty, w/ Attenuator	8% @ 200-219nm 2% @ 220-349nm 1% @ 350-949nm 4% @ 950-1100nm
NEP	0.45 pW/√Hz
Reverse Bias, Maximum	5 V
Linearity	±0.5 %
Connector Type	BNC