6th June 2023

DF characterization at INFN-Pavia

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Outline

Hardware

1. pTP evaporation apparatus
2. VUV measurement setup

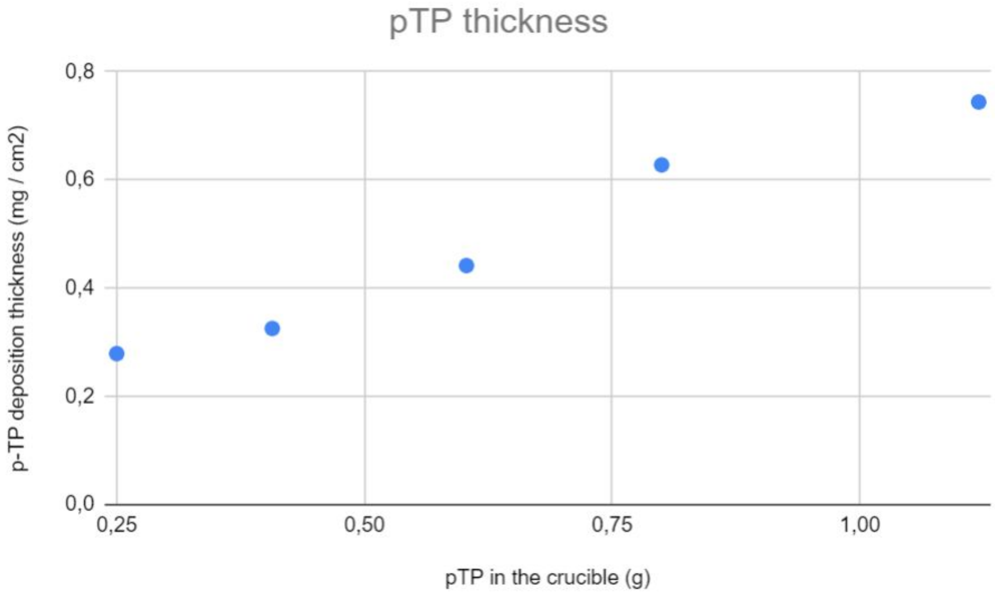
Measurements

3. First attempts to measure dichroic filters conversion+transmission efficiency (integral)
4. measurement of the pTP thickness-VS-efficiency curve

Deposition apparatus

We have an apparatus to perform pTP depositions, originally used for ICARUS PTB depositions.

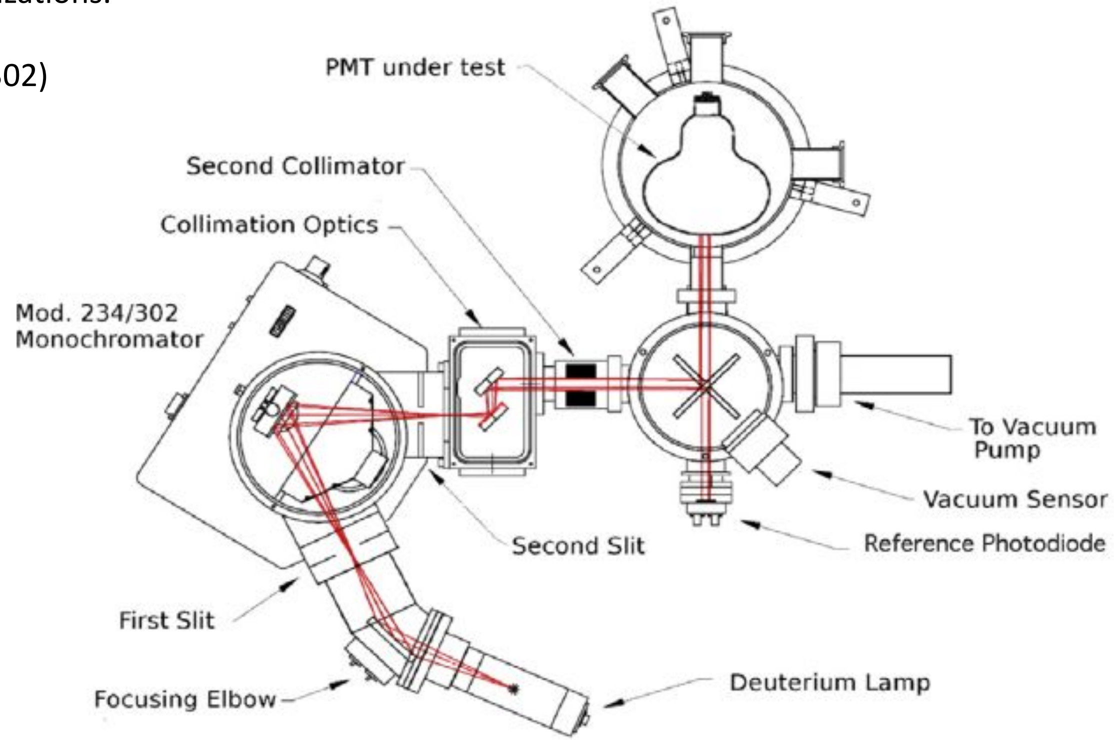
Used to evaporate **pTP on 1”-diameter 1mm-thick optical windows**, one per evaporation, at T=235 ℃. Given the flange size, we have the possibility to evaporate on larger substrates, up to ~10 cm in diameter…



VUV measurement apparatus

Used in the past for PMT and coating characterizations.

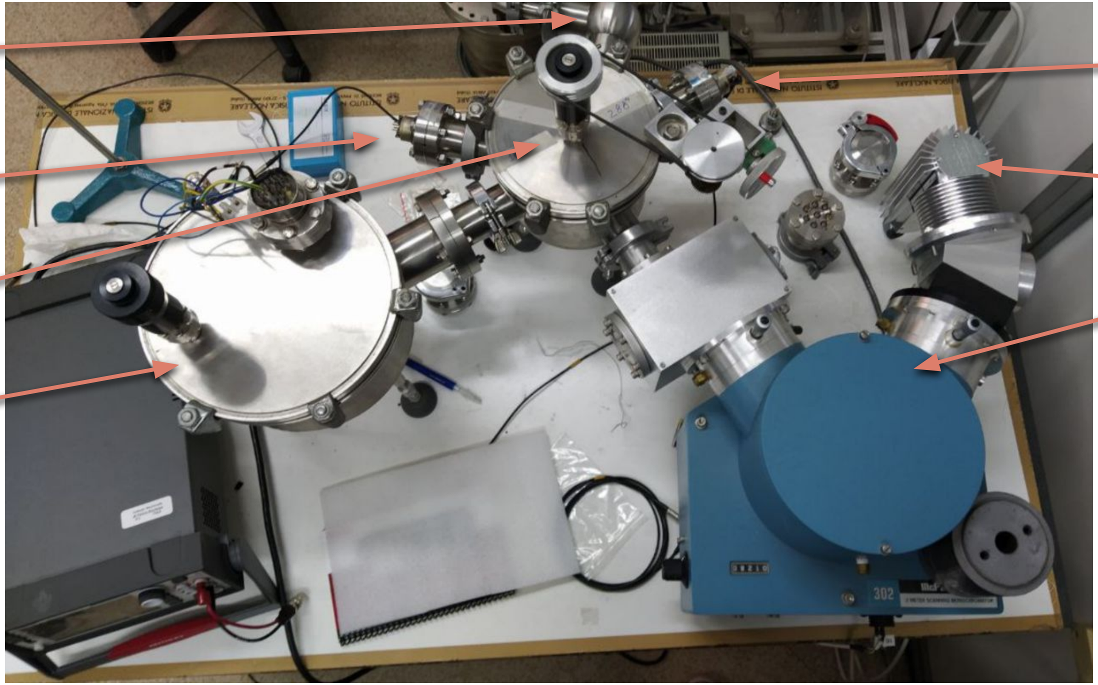
- ➢ Monochromator VUV (McPherson 234/302)
- ➢ Deuterium lamp
- ➢ Rotating mirror (Al + MgF_2)
- ➢ Calibrated photodiode
- ➢ Measurement chamber with PMT



VUV measurement apparatus

current configuration

- To the pumps and venting valve
- Calibrated photodiode #2
- Rotating mirror
- Test chamber (with sample and PMT)



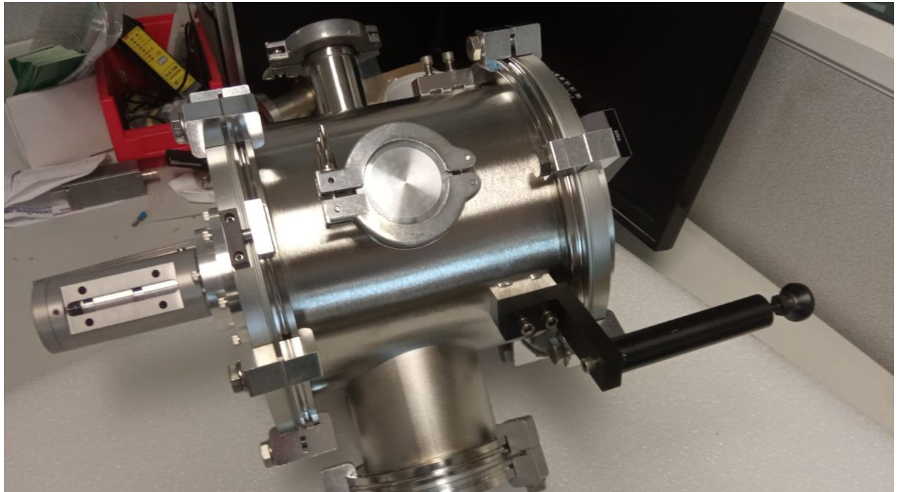
- Calibrated photodiode #1
- Deuterium lamp
- Monochromator

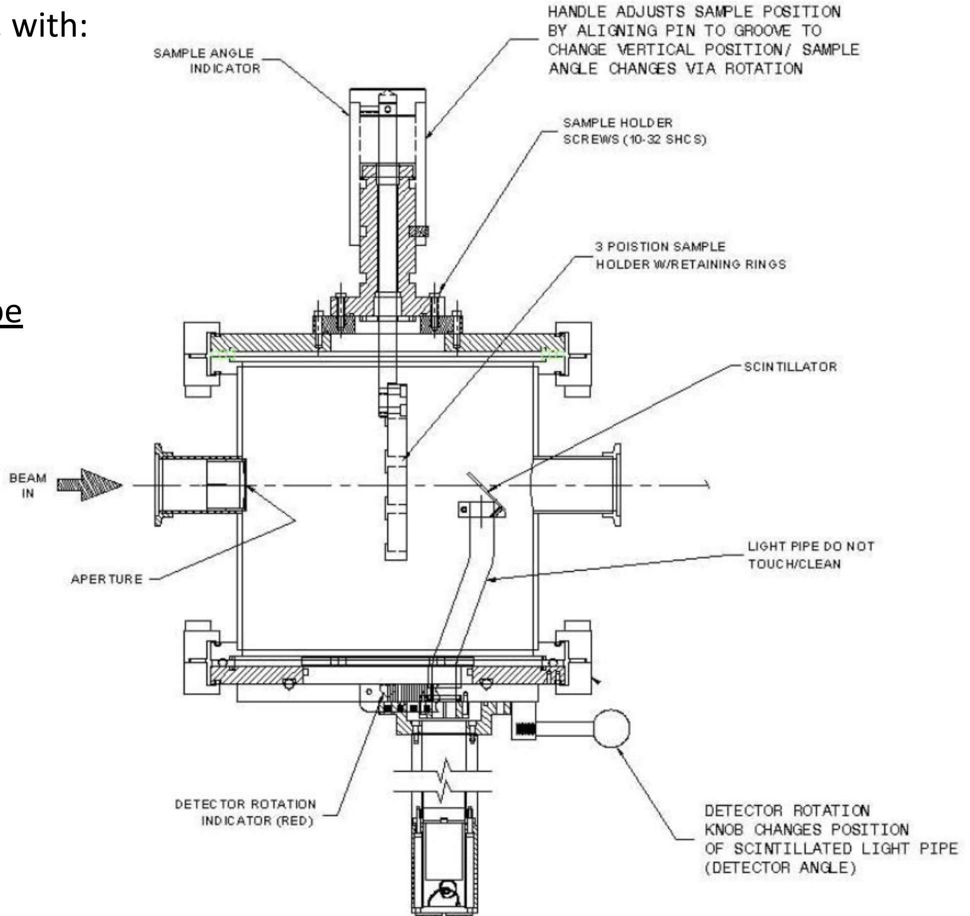
Caveat: we are <u>not fully confident about the values given by the photodiodes</u>, that's why we mounted both… please consider any absolute scale here reported as very preliminary

VUV measurement apparatus

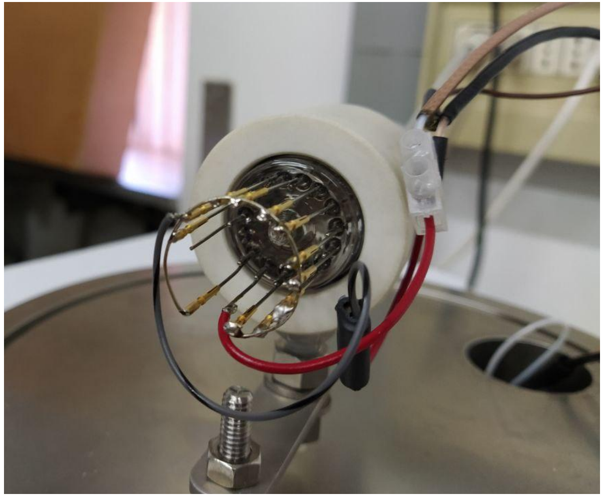
We will receive in these days a new measurement chamber, with:

- ➢ a 3 samples holder
- ➢ possibility to rotate the samples
- ➢ possibility to rotate the light pipe around the sample
- ➢ detects VUV light thanks to a scintillator… <u>needs to be modified to detect pTP emission</u>

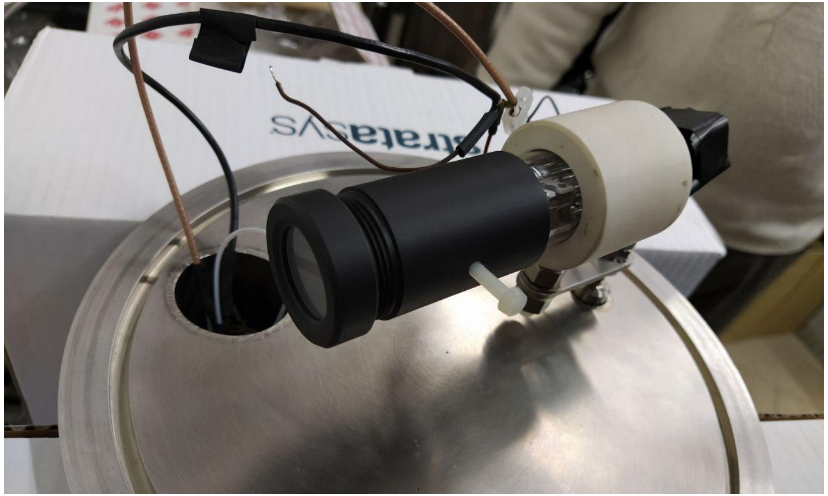




PMT assembly



The window under test is placed into the black support which is then fixed to the PMT body.



In the first measurements the PMT dynodes were short-circuited and operated at +150 V (i.e. PMT gain=1).

Now we introduced a voltage divider to obtain the conventional supply scheme. However we operate at a voltage (470 V) lower than the typical one because of current saturation.

→ PMT gain to be measured!

Dichroic sample preparation

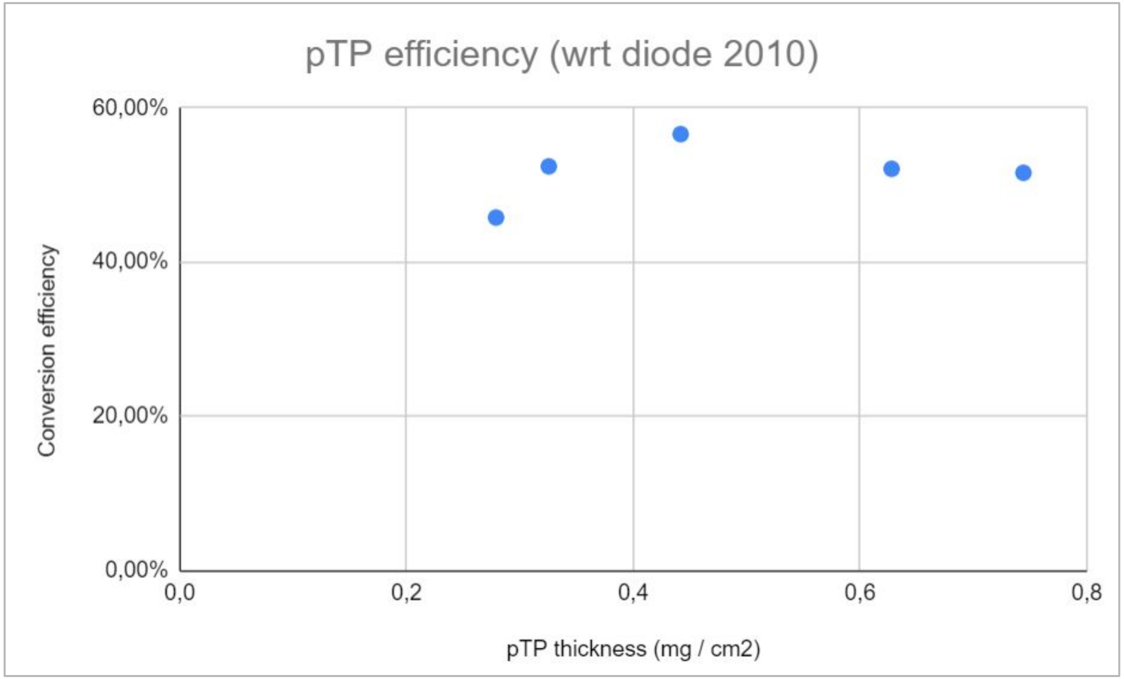
The test setup has been prepared for round 1"-diameter samples (to match the PMT window), so we first tried to <u>cut the dichroic filters with laser cutter</u>: probably it is not the best way…
An alternative approach is to create a sample support capable to hold windows of any shape, avoiding any cut requirement.

So far we cut 5 samples from 5 different DF, obtaining these integral efficiency values: **27% 26% 16% 14% 13%**

Here the efficiency is given by both the wavelength conversion from pTP and the transmission throughout the DF.

pTP efficiency VS thickness curve

We evaporated 5 fused-silica windows with different amounts of pTP. Obtaining this curve for the conversion efficiency.



Please remember that 1) uncertainties are not shown here and 2) absolute scale is very preliminary.

Backup

Photodiode (2010) efficiency

Results: (Far uv photodiode, International Radiation Detectors, Inc. model AXUV-100, serial no. 09-317, measured June 16, 2010.)

Wavelength (nm)	Responsivity (A /W)	Quantum Efficiency (electron / photon)	Relative Uncertainty (%)
116.4	0.1669	1.7774	9%
118.0	0.1604	1.6856	9%
121.6	0.1684	1.7174	9%
→ 125.4	0.1665	→ 1.6459	2%
→ 135.4	0.1516	→ 1.3879	2%
140.3	0.1426	1.2601	2%
144.1	0.1362	1.1716	2%
148.7	0.1274	1.0625	2%
154.5	0.1204	0.9661	2%
160.8	0.1130	0.8709	2%
164.8	0.1066	0.8018	2%
170.0	0.0975	0.7114	2%
175.0	0.0934	0.6618	2%
182.3	0.0888	0.6036	2%
187.9	0.0877	0.5784	2%
193.7	0.0857	0.5482	2%
200.0	0.0836	0.5180	2%
206.7	0.0808	0.4844	2%
213.8	0.0789	0.4573	2%
221.4	0.0781	0.4373	2%
229.6	0.0809	0.4367	2%
238.5	0.0874	0.4545	2%
253.7	0.0729	0.3561	3%

Interpolating between 125.4 nm and 135.4 nm we get:

1.6459 + (1.3879-1.6459) / 10 nm * 2.6 nm

= **1.579** electron/photon

Conversion efficiency calculation

The PMT current is given by:

$$I_{PMT} = q_e \cdot \dot{N}_{128nm} \cdot \epsilon_{pTP} \cdot \epsilon_{geo} \cdot \epsilon_{window} \cdot QE_{PMT}$$

Where the photon flux is measured with the calibrated diode:

$$I_{diode} = q_e \cdot \dot{N}_{128nm} \cdot \epsilon_{diode}$$

So the overall and the p-Terphenyl conversion efficiencies are respectively:

$$\epsilon_{pTP} \cdot \epsilon_{geo} \cdot \epsilon_{window} \cdot QE_{PMT} = \frac{I_{PMT} \cdot \epsilon_{diode}}{I_{diode}}$$

$$\epsilon_{pTP} = \frac{I_{PMT} \cdot \epsilon_{diode}}{I_{diode} \cdot \epsilon_{geo} \cdot \epsilon_{window} \cdot QE_{PMT}}$$

Assuming:

- Diode efficiency ε_{diode} = 1.58 electron/photon
- Geometrical efficiency ε_{geo} = 50%
- Window transmission efficiency ε_{window} = 90%
- PMT Q.E. = 25% *(from 300 to 400 nm)*

And measuring:

- ➢ I_{diode} = 625 pA
- ➢ I_{PMT} = 543 pA

We get:

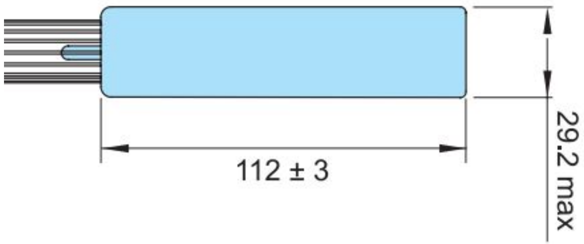
- ➔ overall efficiency = 1.37
- ➔ ε_{pTP} = 12.2

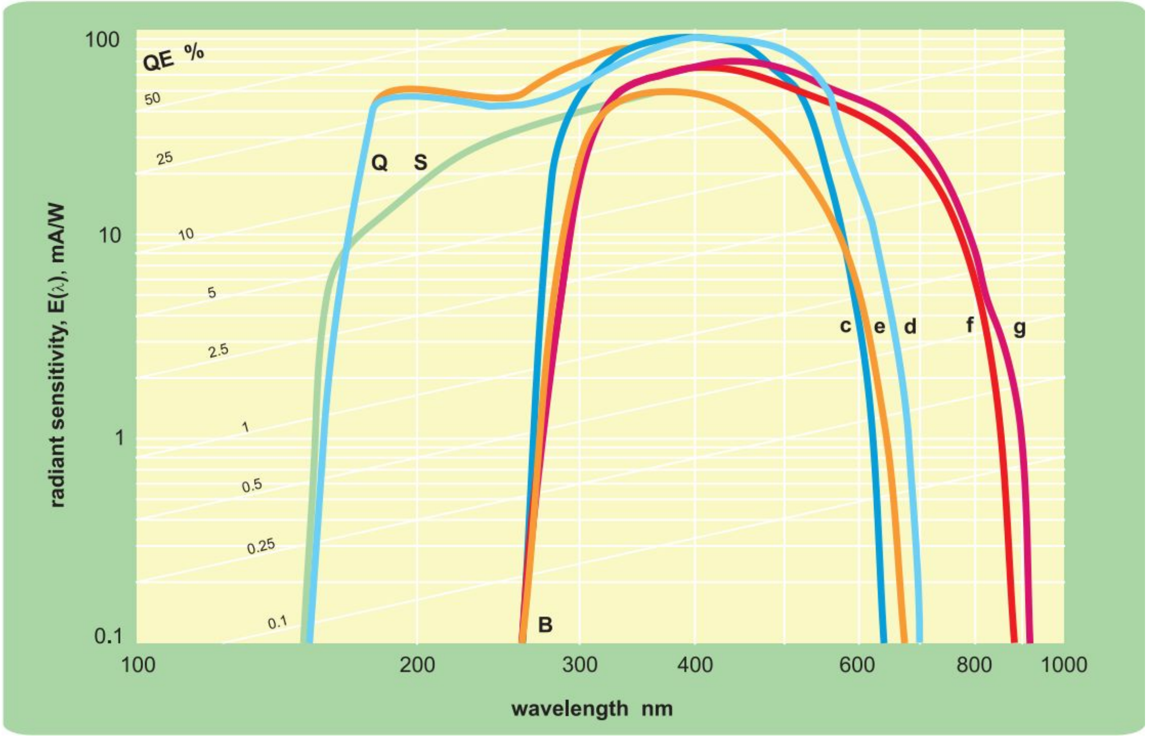
Photomultiplier tube

Model: **9325QFLB**
by *ET enterprises - Electron Tubes*
(previously named D830Q)

Fused silica window

Q.E. about 25% and almost flat from 300 to 350 nm (light blue curva)

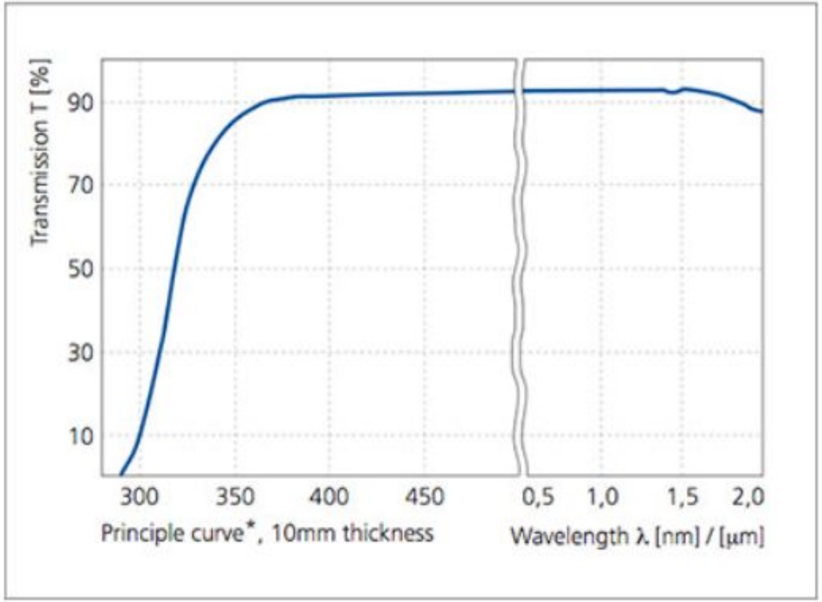




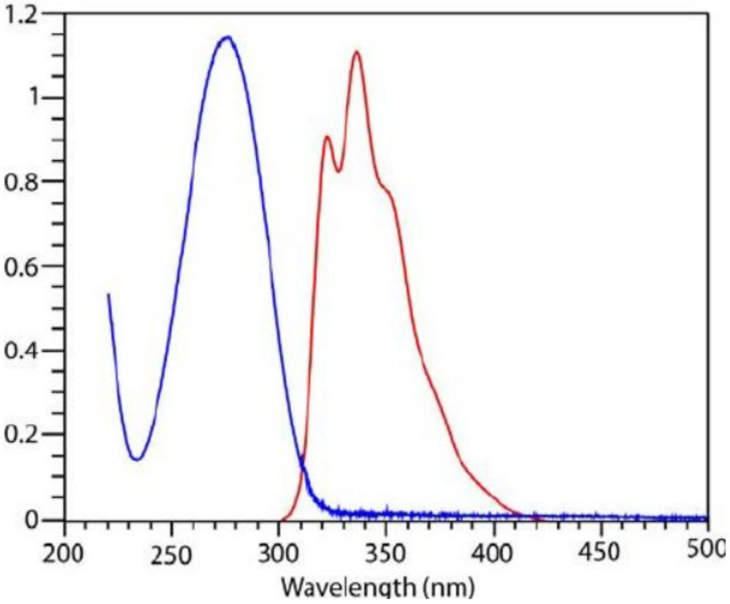
Datasheet here: https://www.javanelec.com/CustomAjax/GetAppDocument/6ca0a372-97f1-4ebf-9009-2db1058d0ce5?type=1&inlineName=True

N-BK7 glass transmittance

Transmission spectrum of N-BK7 for 10 mm glass thickness



pTP absorption and emission spectrum for reference



Data not from the window producer, just a proxy

https://www.pgo-online.com/intl/BK7.html#:~:text=N%2DBK7%20is%20a%20very,of%20the%20purest%20raw%20ingredients.