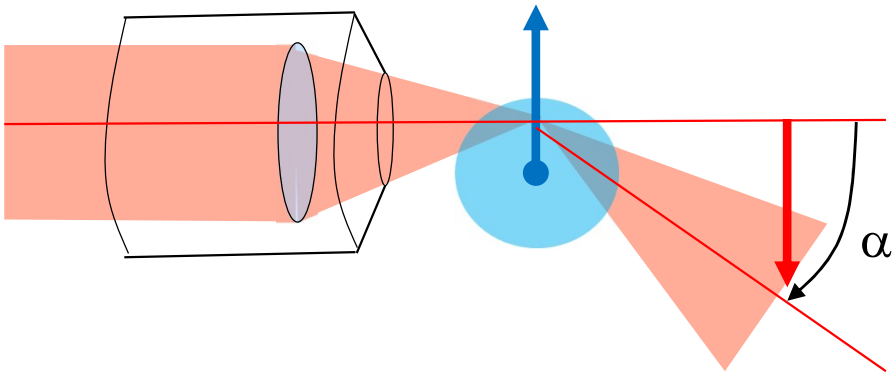
Exercice 1.1:
optical tweezer

Estimez l'intensité optique minimale permettant de soulever la bille.

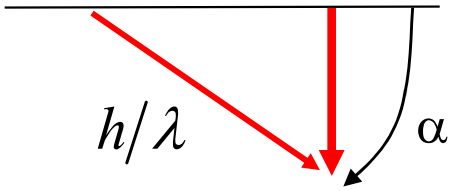
Diamètre	D=2.5um
Densité	$\rho=10^3$ Kg/m^3
Angle de déflection	$\alpha=10^o$



Exercice 1.1: optical tweezer

Poids de la bille: $$P_b = \frac{4}{3}\pi\left(\frac{D}{2}\right)^3 \cdot \rho \cdot g = 82\,[fN]$$

Variation d'impulsion d'un seul photon: $$\Delta p_\gamma = \frac{h}{\lambda}\sin(\alpha)$$

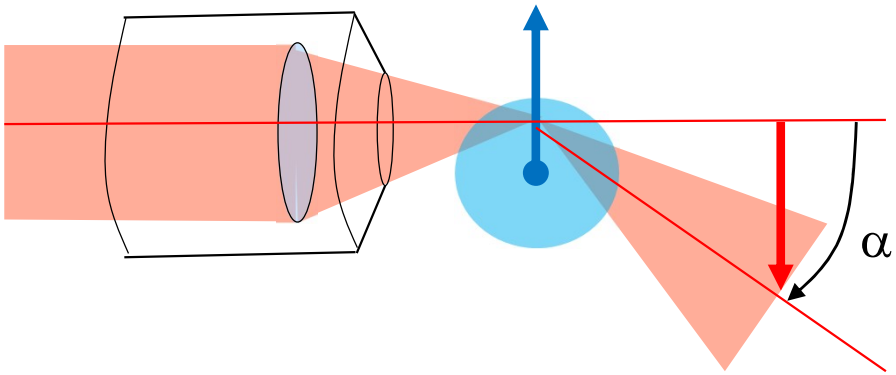


Nombre de photons nécessaires par seconde

$$N_\gamma = P_b / \Delta p_\gamma = \frac{82\,[fN]}{h \cdot \sin(\alpha)} \cdot \lambda$$

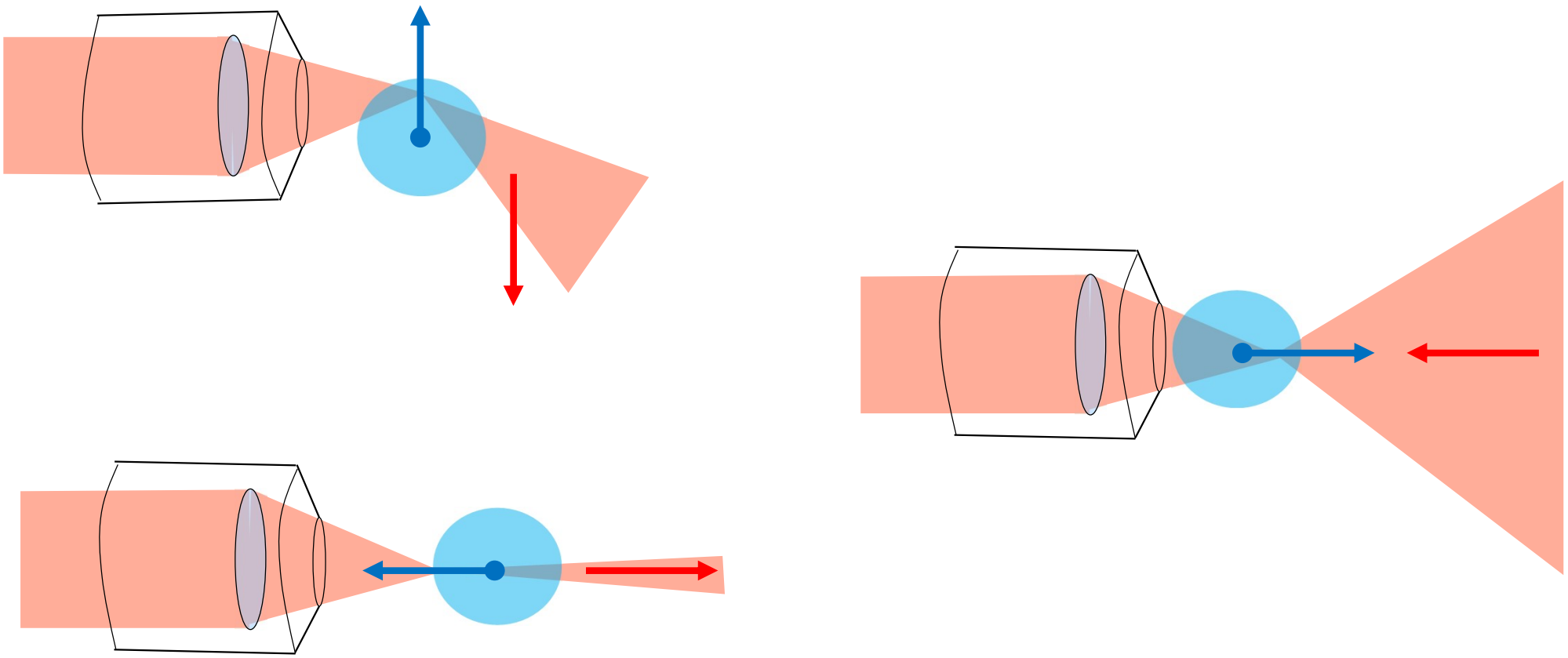
Puissance optique minimale:

$$I_{\min} = N_\gamma \cdot \frac{hc}{\lambda} = P_b \cdot \frac{c}{\sin(\alpha)} = 0.14\,[mW]$$



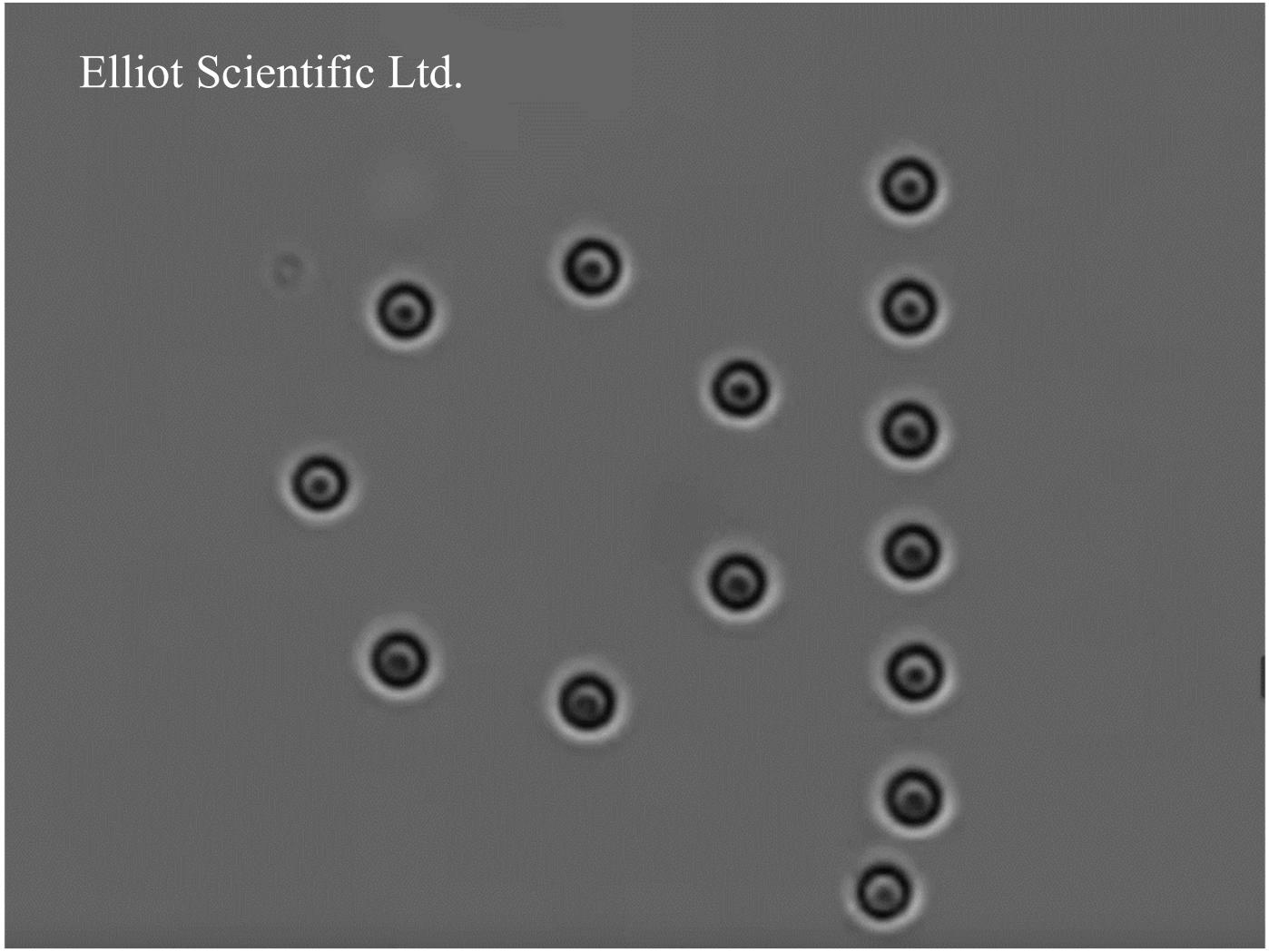
Optical tweezer: principe et application

Principe: conservation de l'impulsion



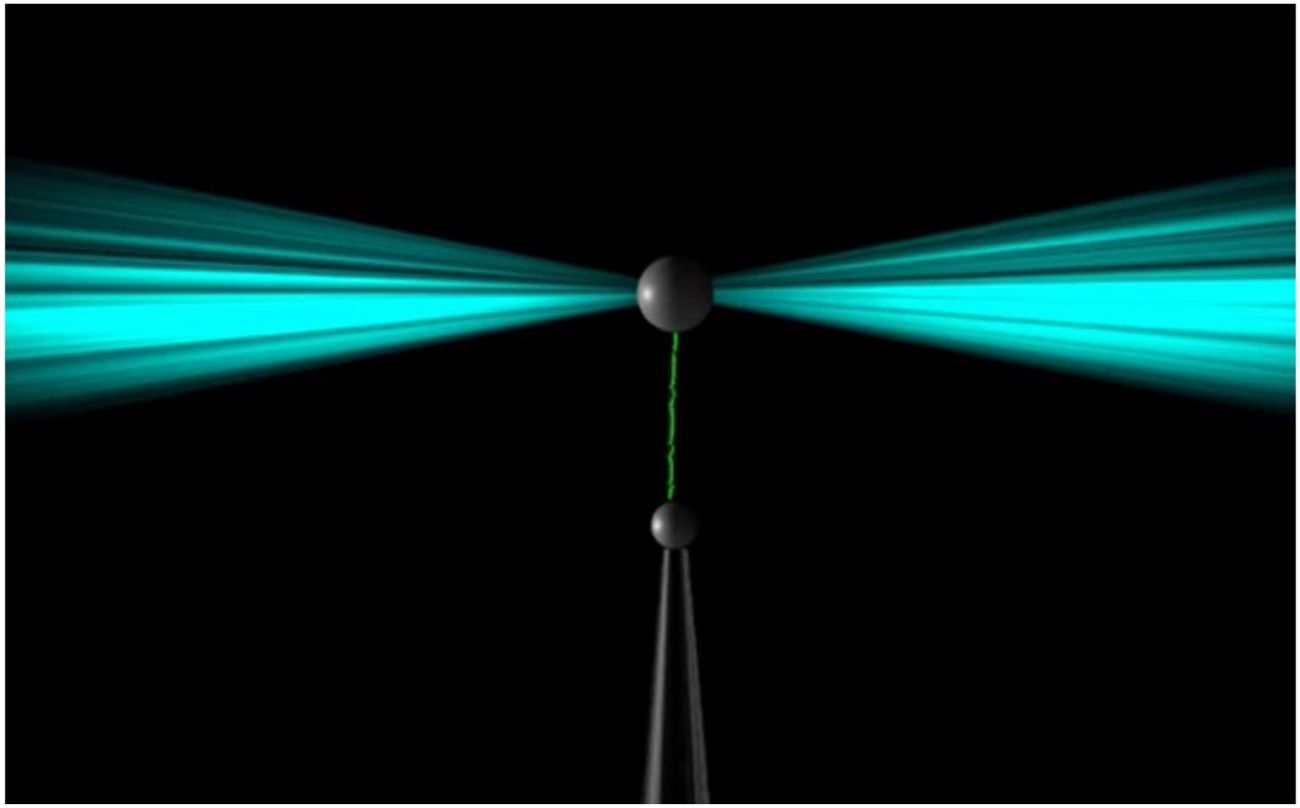
La bille diélectrique est repoussée vers le point focal

Optical tweezer



https://www.youtube.com/watch?v=ju6wENPtXu8

Optical tweezer



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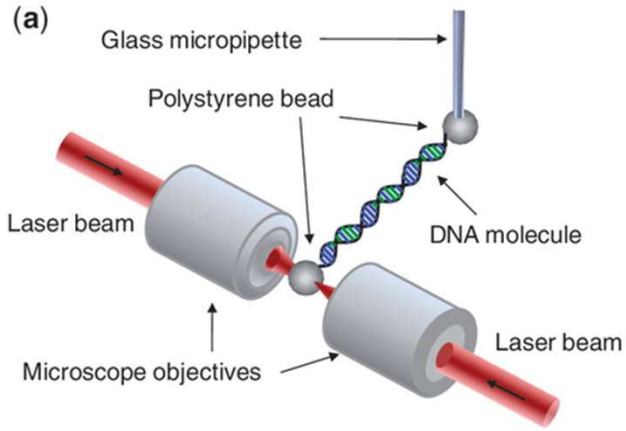

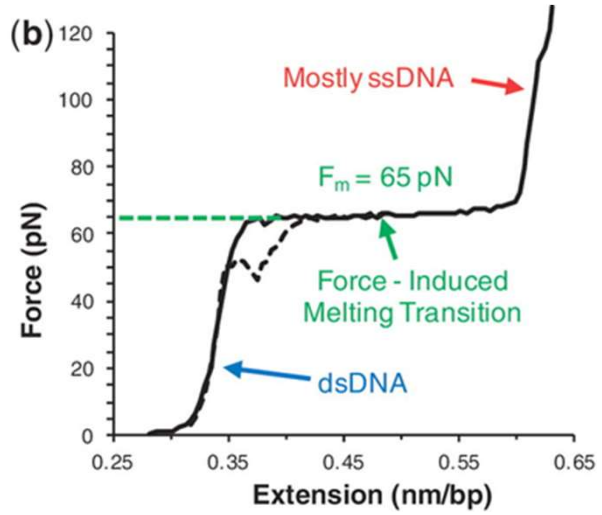

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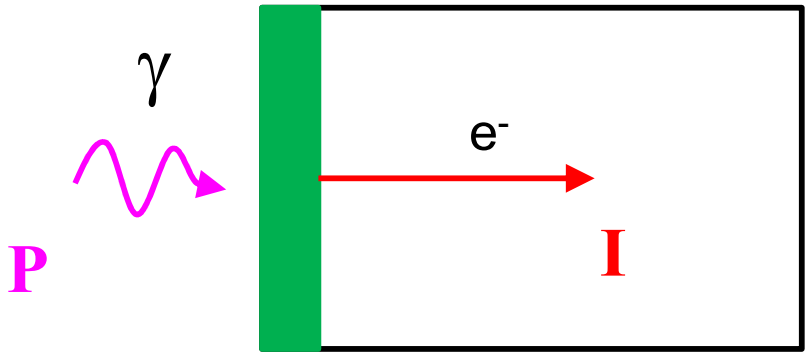
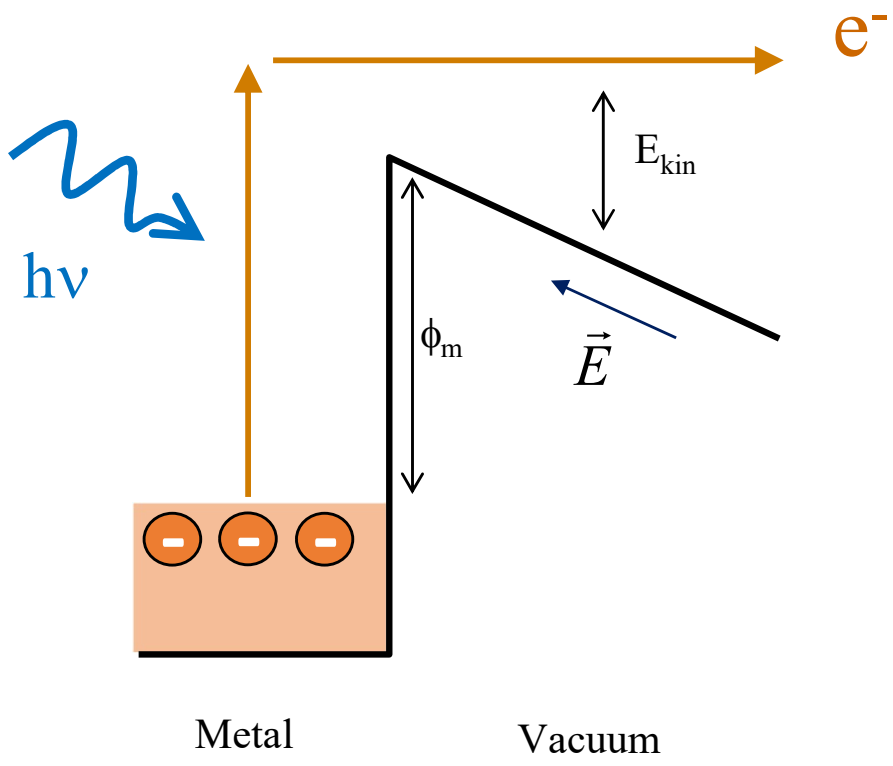
Exercice 1.2: PMT et photo-émission





On envoie P=1 mW de lumière sur une plaque de métal (fonction d'extraction ϕ_m=1.35 eV). Seulement 25% des photons sont convertis en électrons si leur énergie est suffisante.

Calculez le courant I récolté en fonction de la longueur d'onde de la lumière.

Exercice 1.2: PMT et photo-émission

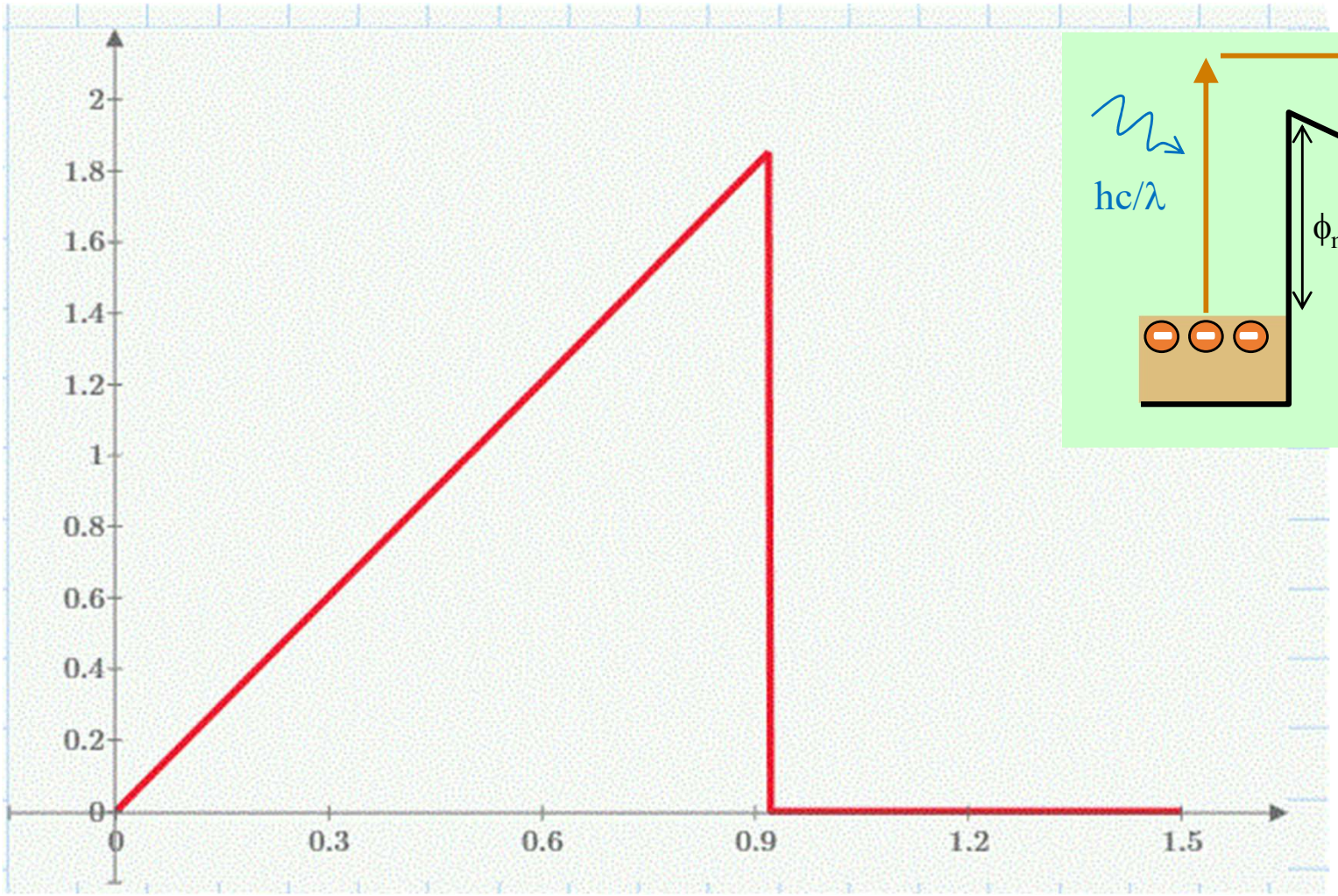
Nombre de photons par seconde: $N_{\gamma,in} = \frac{P}{h\upsilon} = \frac{P \cdot \lambda}{hc}$

Nombre de photons récoltés par seconde: $N_{\gamma,out} = 25\% \cdot N_{\gamma,in} = \frac{1}{4}\frac{P \cdot \lambda}{hc}$

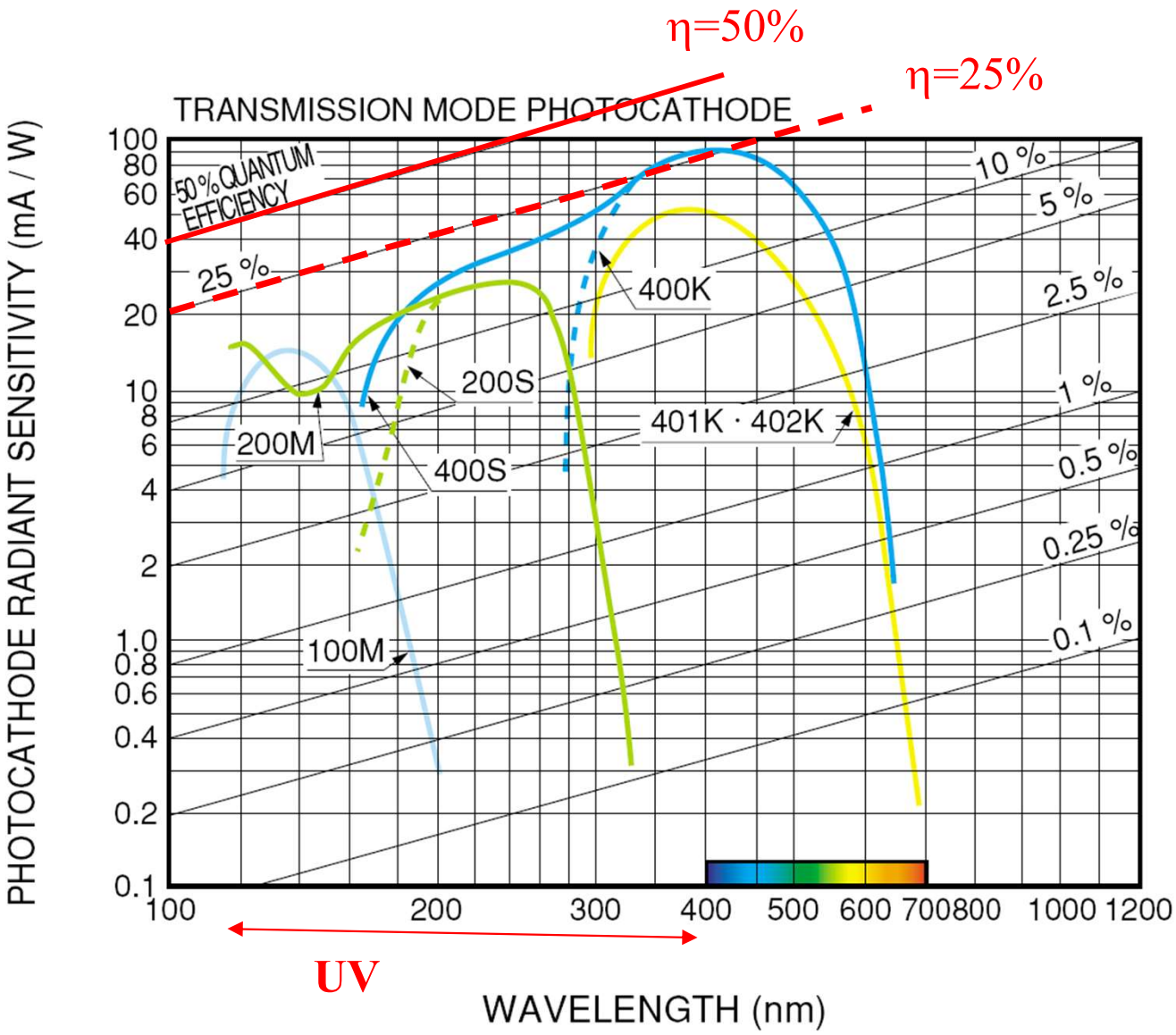
Courant: $I = q \cdot N_{\gamma,out} = \frac{1}{4}\frac{q}{hc} \cdot P \cdot \lambda$

Longueur d'onde limite: $h\upsilon_{\min} = \frac{hc}{\lambda_{\max}} = q \cdot \phi_m \quad \Rightarrow \quad \lambda_{\max} = \frac{hc}{q\phi_m} = \frac{1.24}{\phi_{m,eV}}$

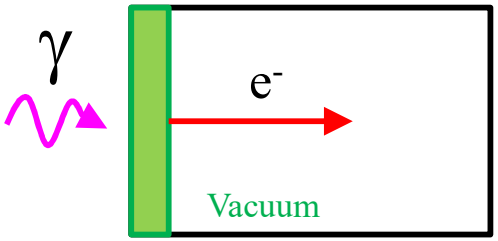
Exercice 1.2: PMT et photo-émission



Photocathode Spectral Response
valeur pratiques

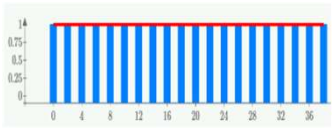


Transmission

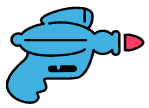


Hamamatsu Catalog

Exercice 1.3: Beam splitter: Single photon

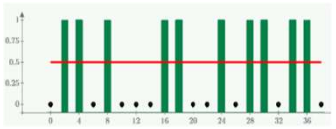


Single photon



BS1

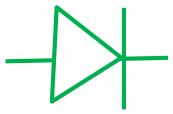
$1/\sqrt{2}$



0 1

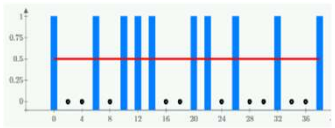
50%

$1/\sqrt{2}$



SPD 3

1 0



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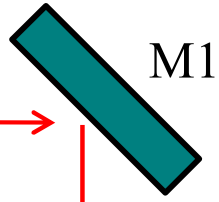
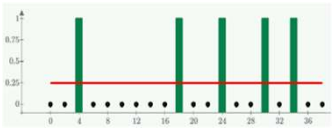


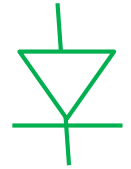
M1

25%



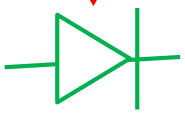
BS2

$1/\sqrt{2}$

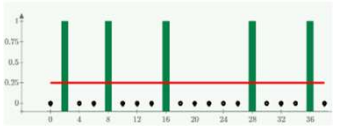


SPD 1

$1/\sqrt{2}$



SPD 2



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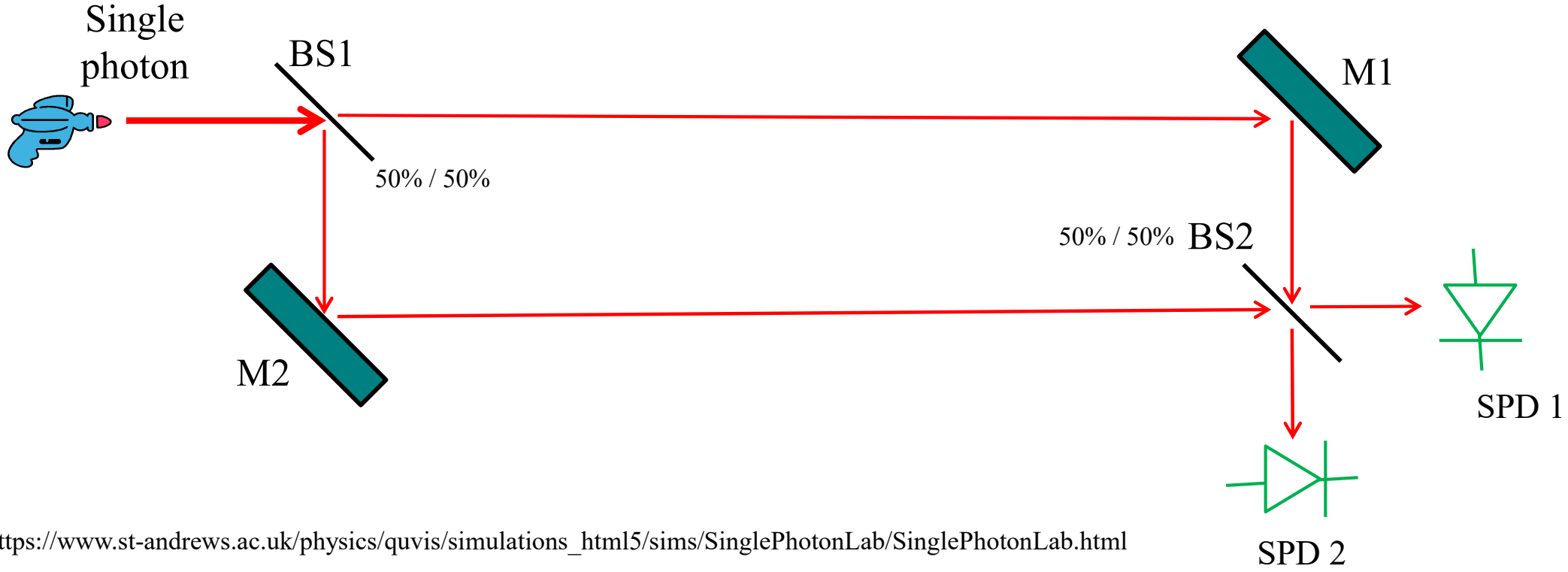
Exercice 1.4: Mach Zehnder interferometer: Single photon

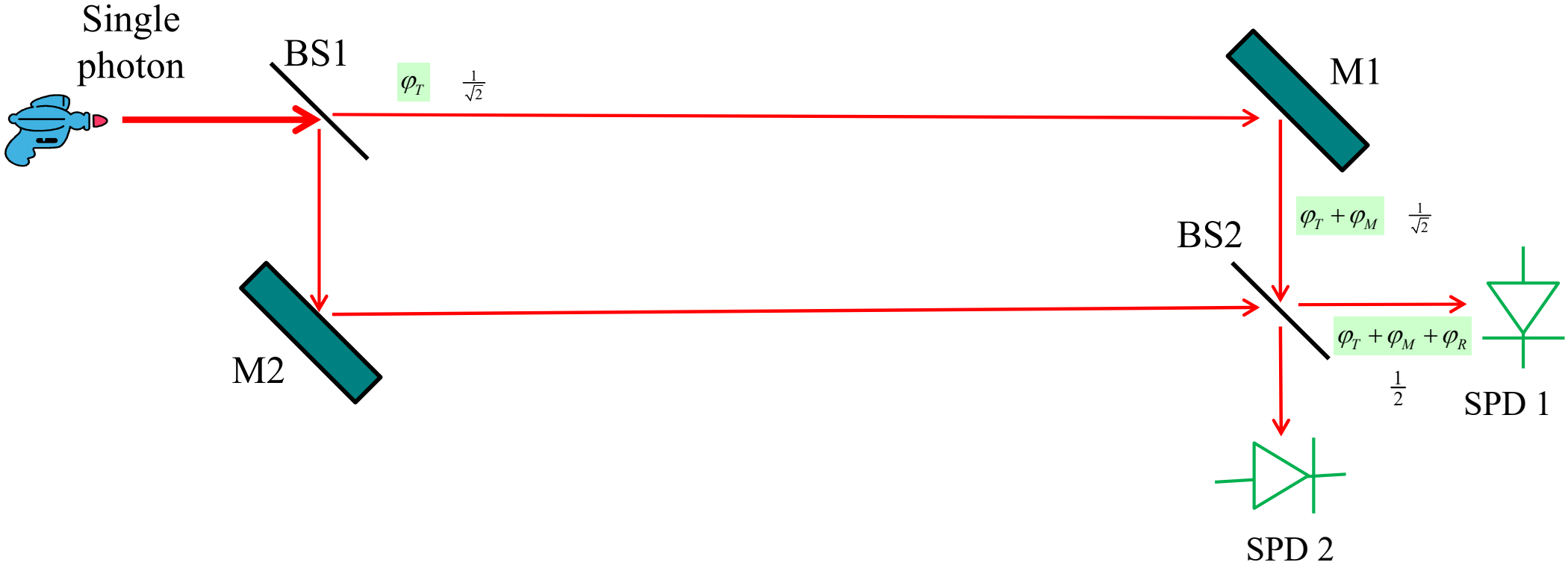


https://www.st-andrews.ac.uk/physics/quvis/simulations_html5/sims/SinglePhotonLab/SinglePhotonLab.html

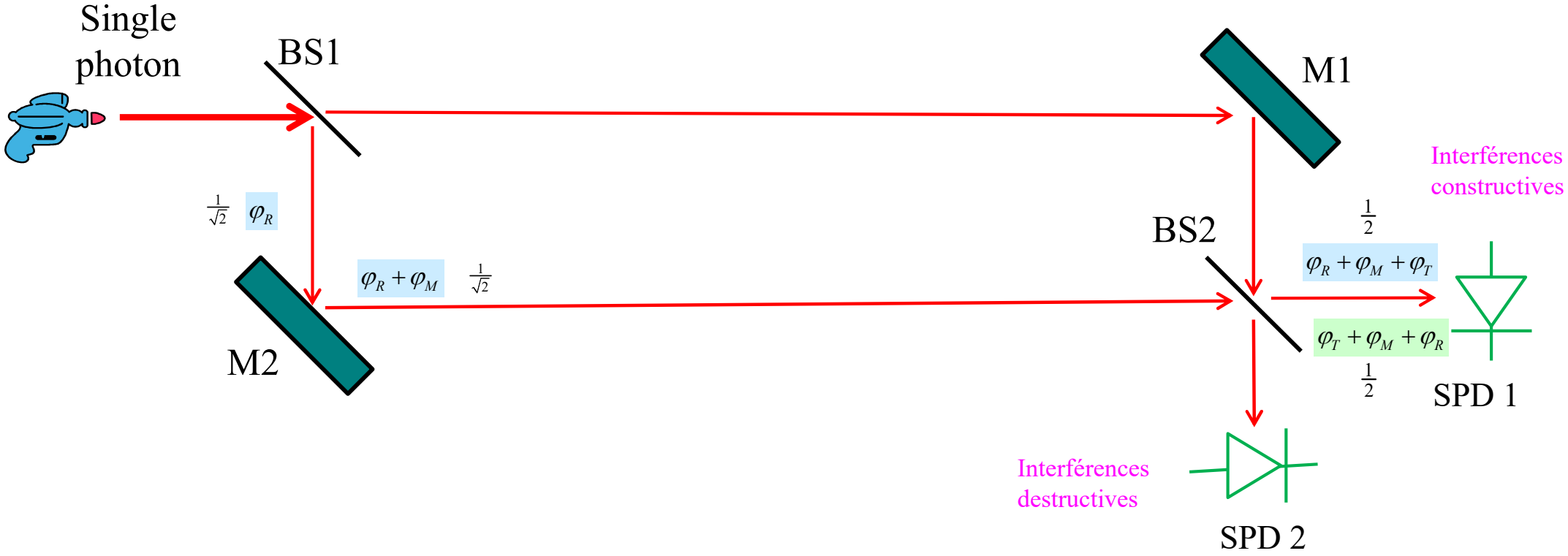
Avec un interféromètre totalement symétrique et l'émission d'un seul photon à la fois, quelle est la probabilité:

- de déclencher à la fois SPD1 et SPD2
- de déclencher SPD1 uniquement
- de déclencher SPD2 uniquement

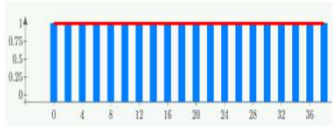
Exercice 1.4: Mach Zehnder interferometer: Single photon

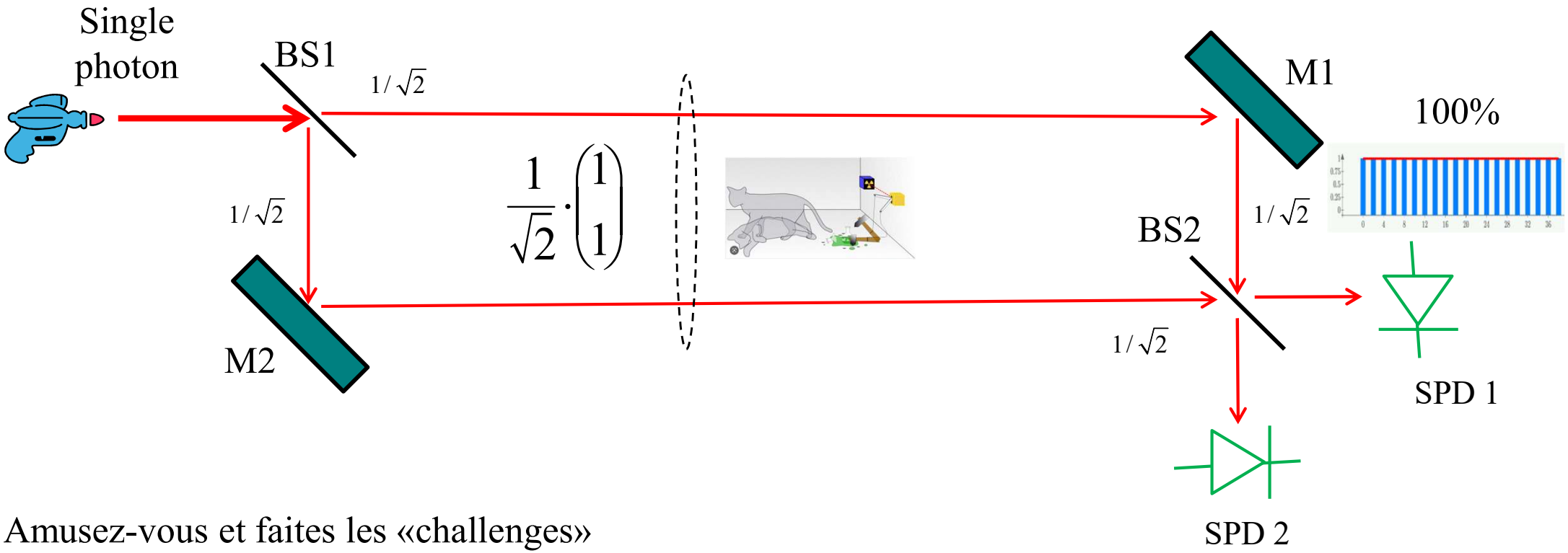


Exercice 1.4: Mach Zehnder interferometer: Single photon



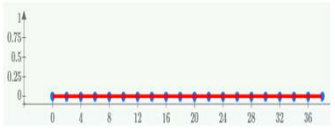
Exercice 1.4: Mach Zehnder interferometer: Single photon





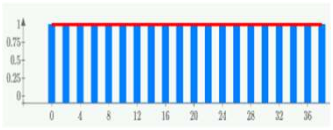
Amusez-vous et faites les «challenges»

https://www.st-andrews.ac.uk/physics/quvis/simulations_html5/sims/SinglePhotonLab/SinglePhotonLab.html

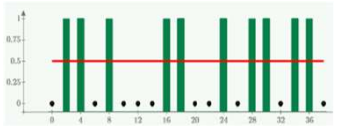


0%

Exercice 1.3: Complément



Single photon



50%

0 1

BS1

$1/\sqrt{2}$

M1

$1/\sqrt{2}$

BS2

$1/\sqrt{2}$

SPD 3

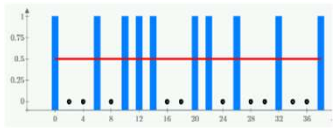
SPD 1

$1/\sqrt{2}$

SPD 2

1 0

Réémission



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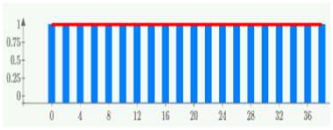
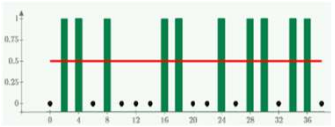
Exercice 1.3: Complément



Single photon



50%

BS1

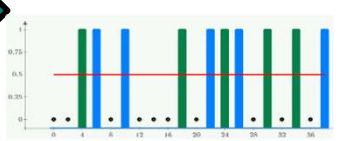
$1/\sqrt{2}$

$1/\sqrt{2}$

$\begin{pmatrix} 0 \\ 1 \end{pmatrix}$ ou $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$

M1

50%



BS2

$1/\sqrt{2}$

SPD 1

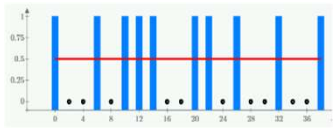
$1/\sqrt{2}$

SPD 3

1 0

Réémission

SPD 2



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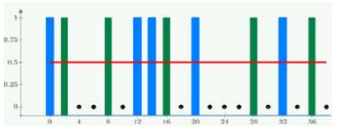

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