

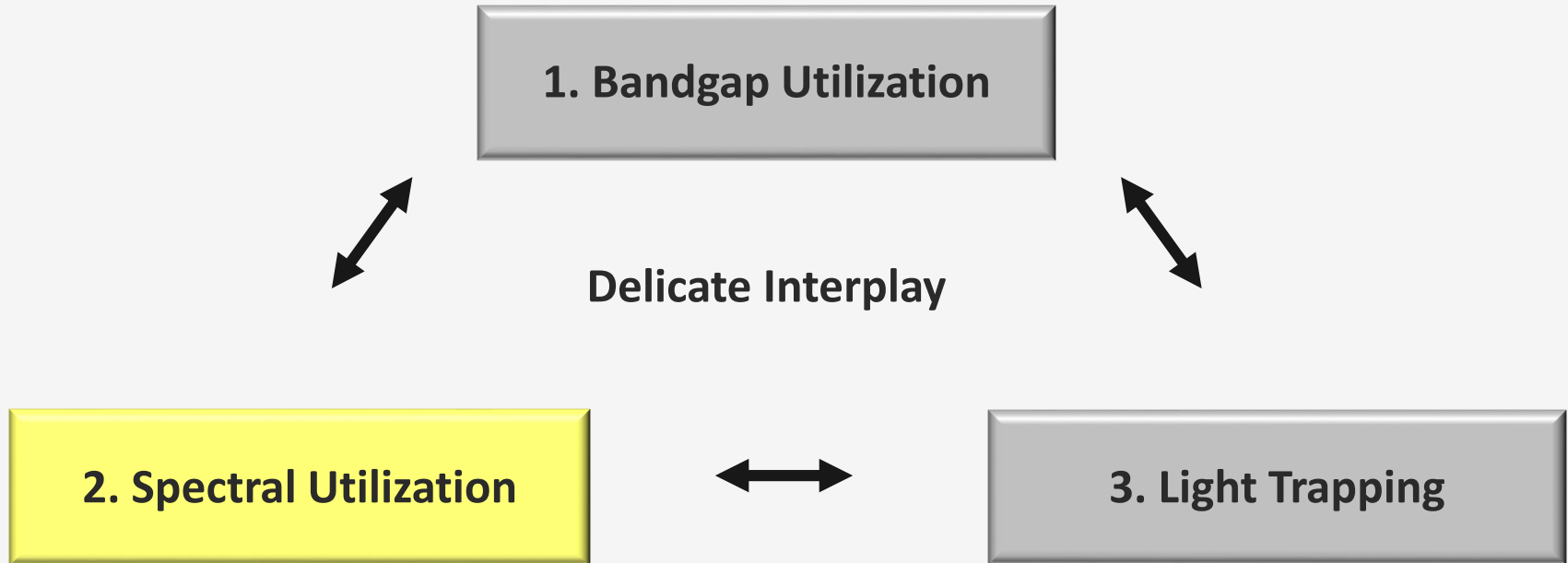
# Solar Cell Operation, Performance and Design Rules

## Spectral Utilization I - External Quantum Efficiency

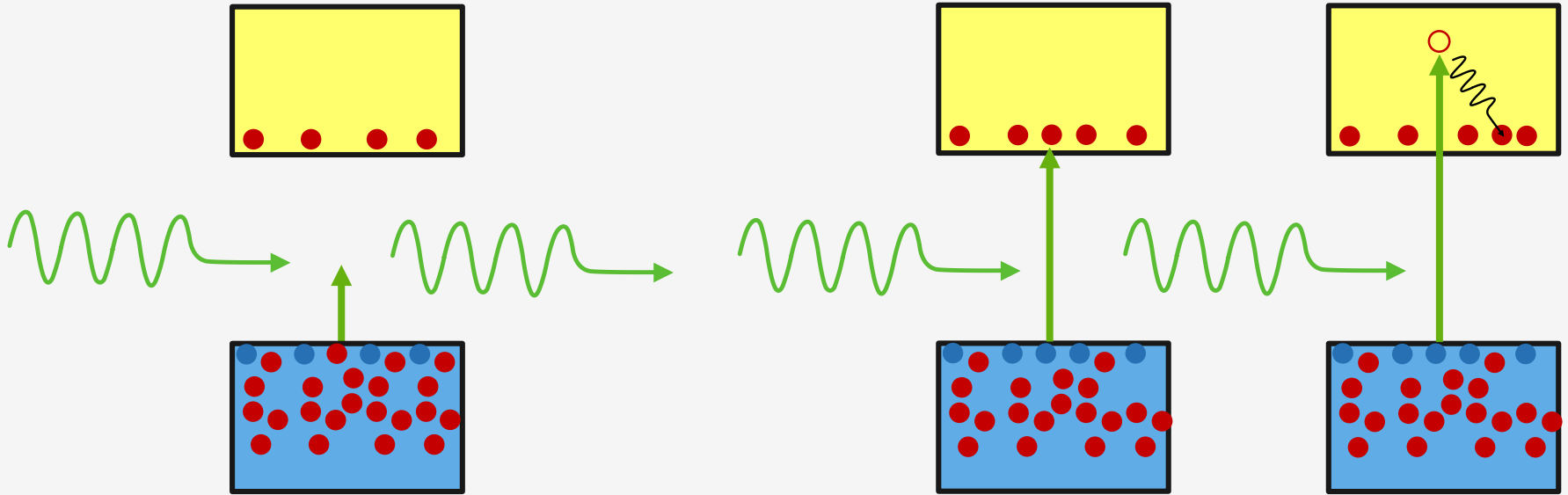
*Week 3.3.2*

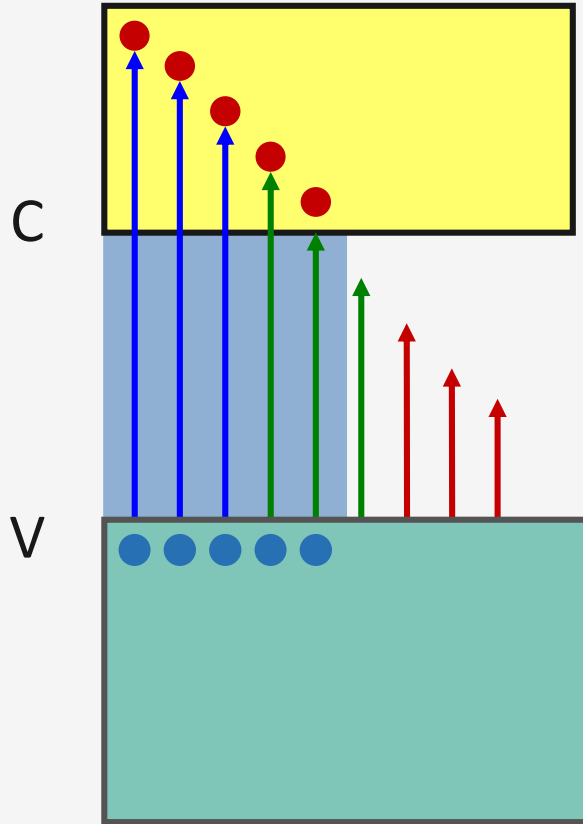
Arno Smets

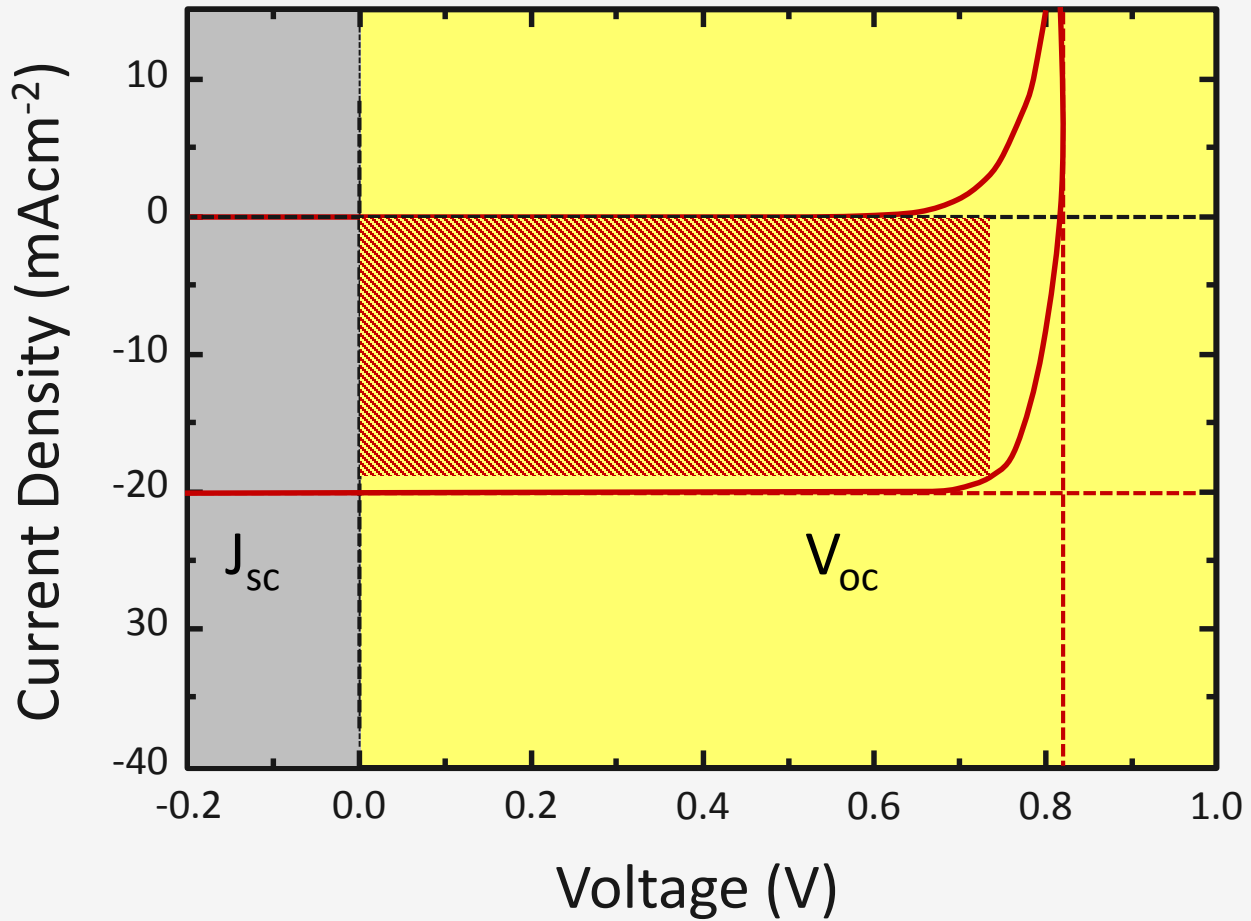
# Design Rules Solar Cells

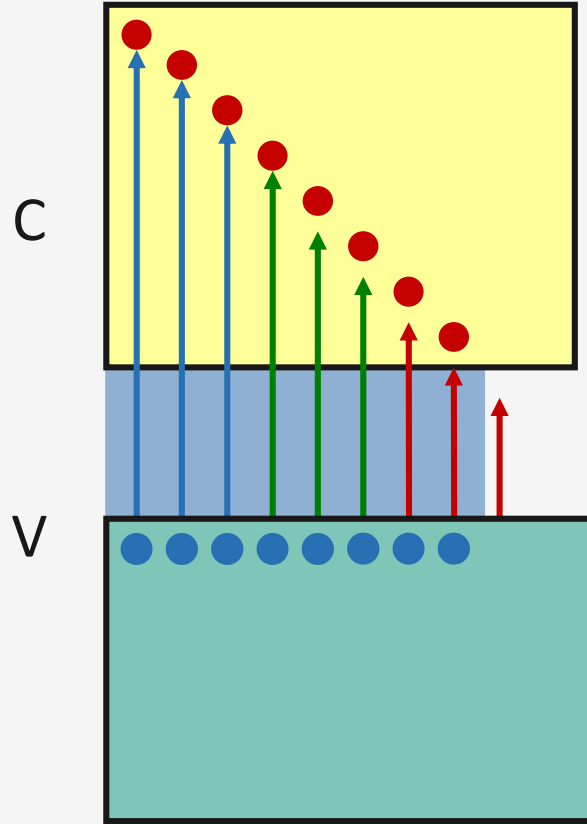


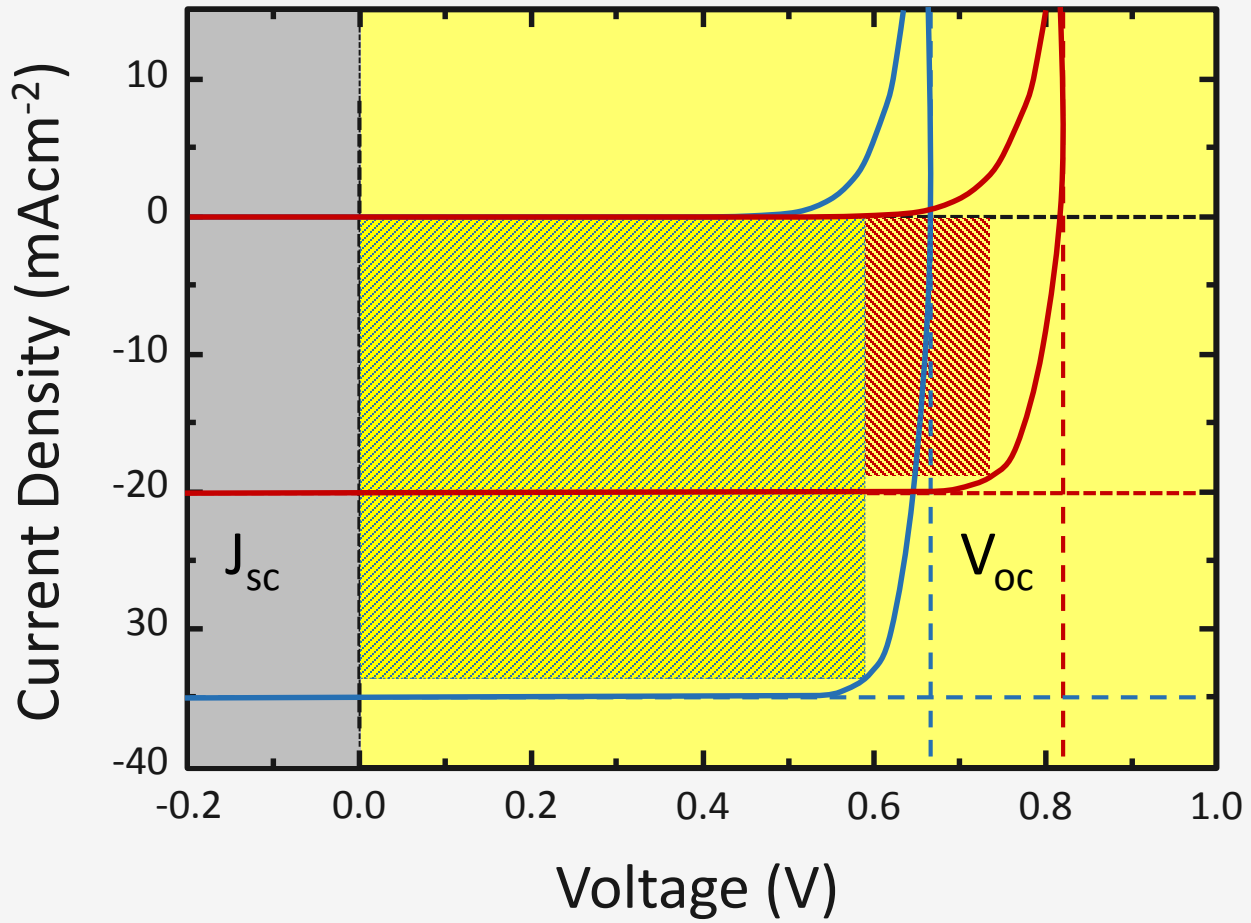
# Light Absorption



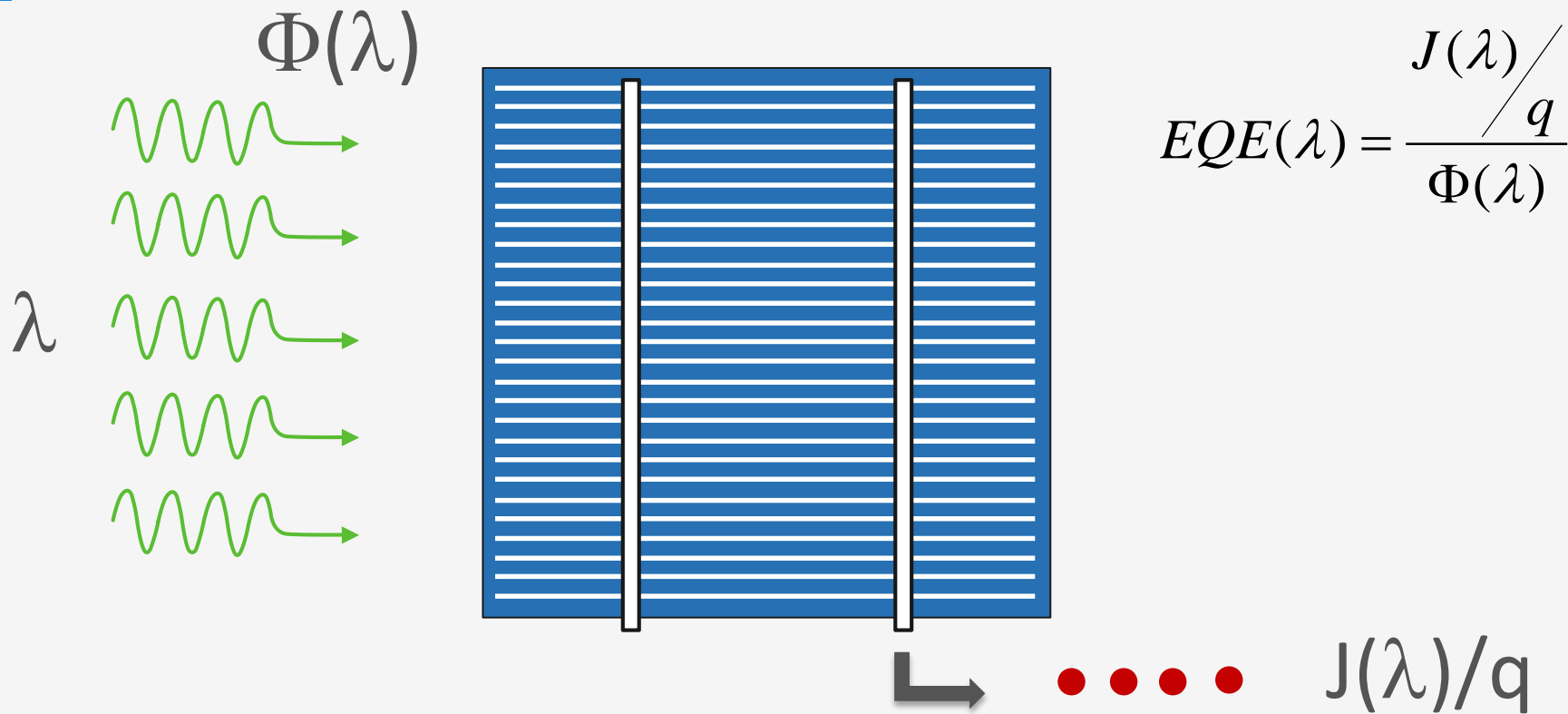






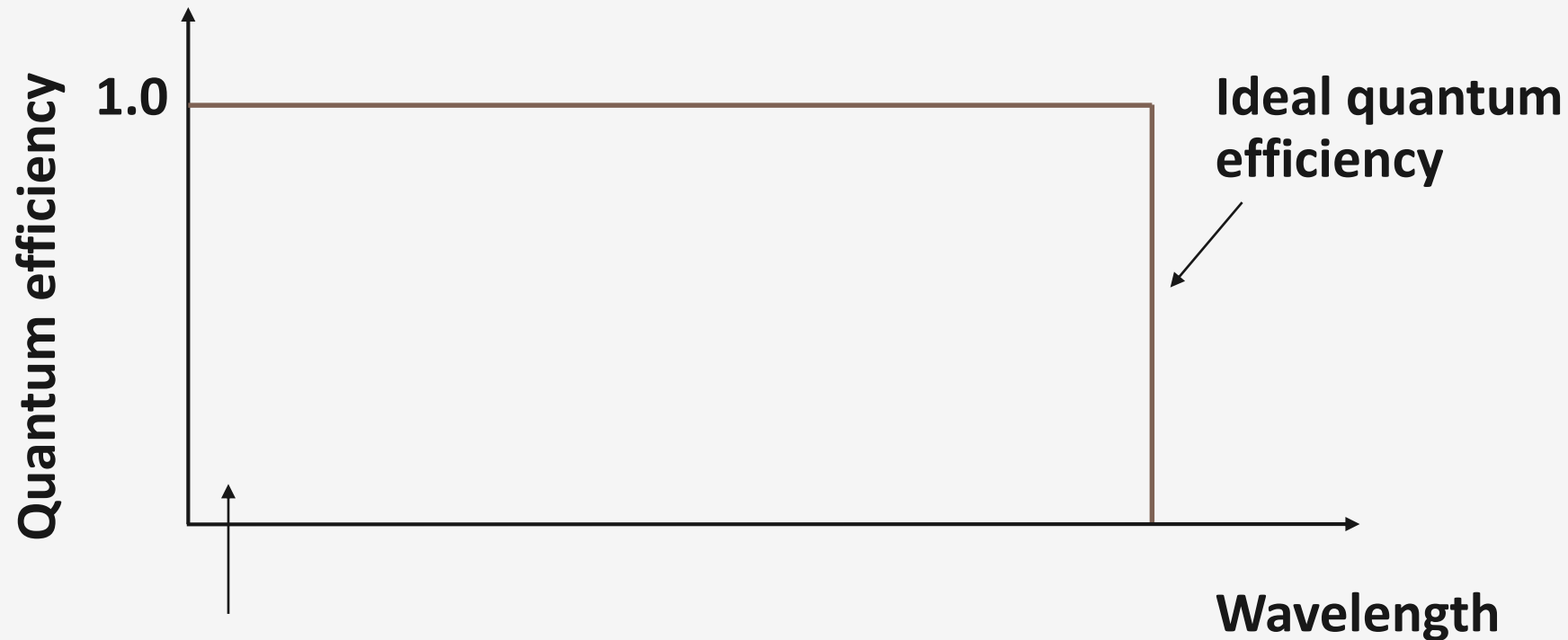


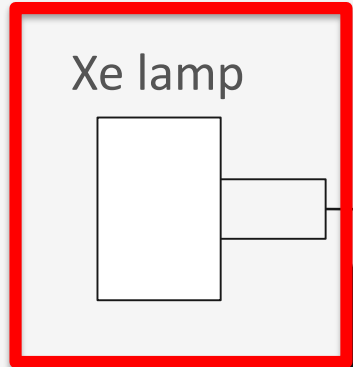
# External quantum efficiency





# External quantum efficiency





Xe lamp

Chopper

Wheel with  
'grey' filters

Grating  
monochromator

Monitor cell

Computer

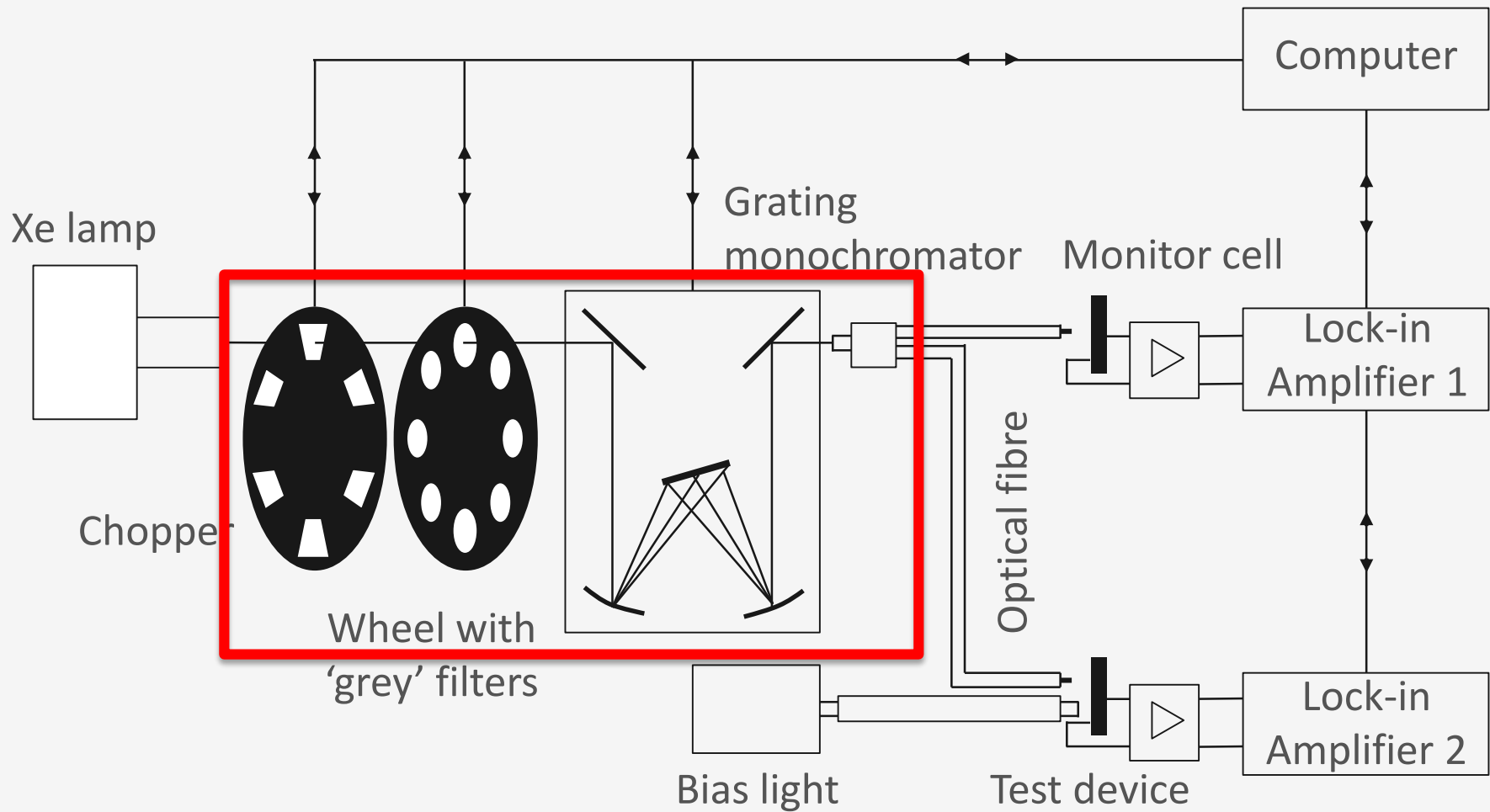
Lock-in  
Amplifier 1

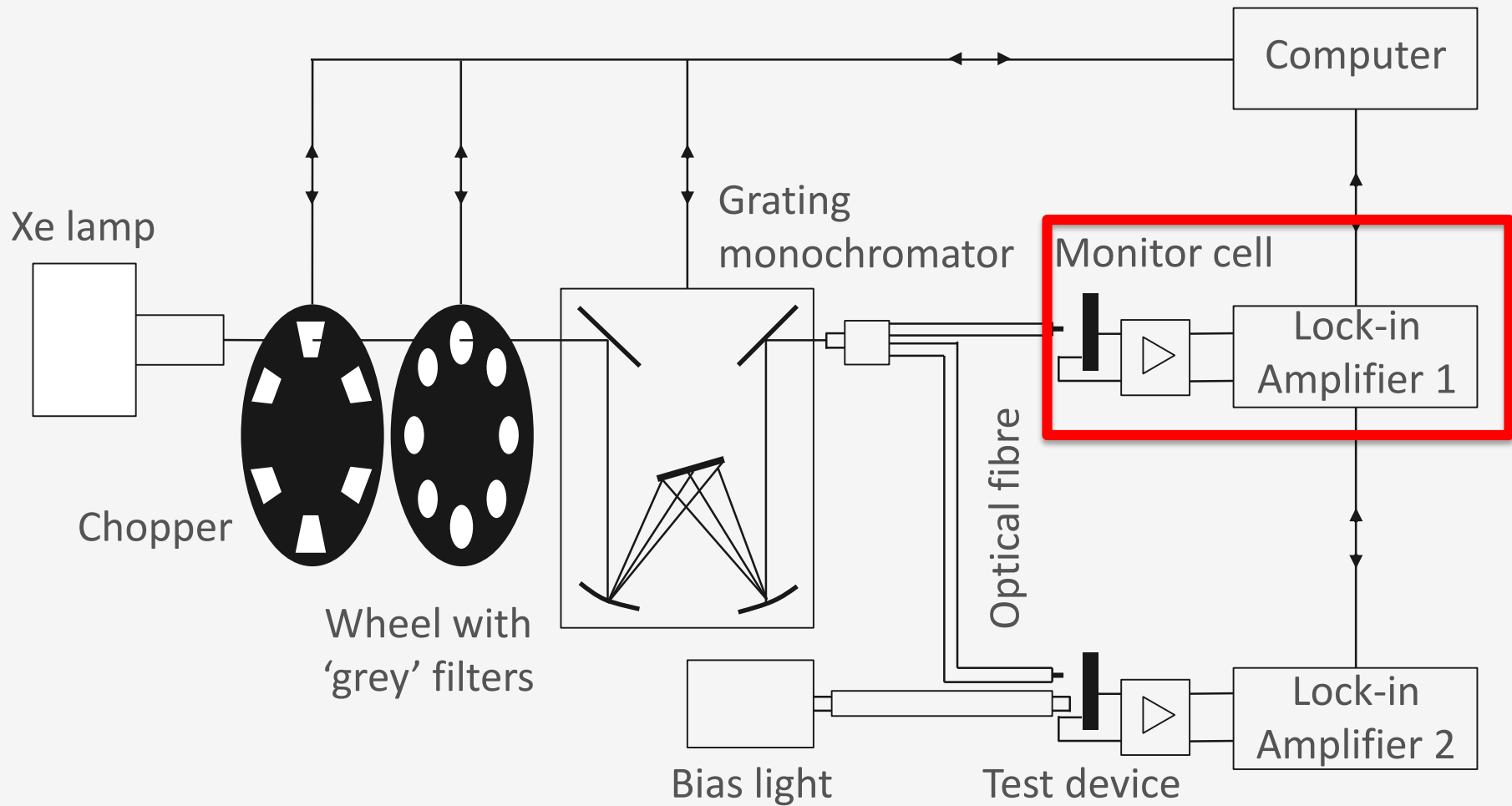
Lock-in  
Amplifier 2

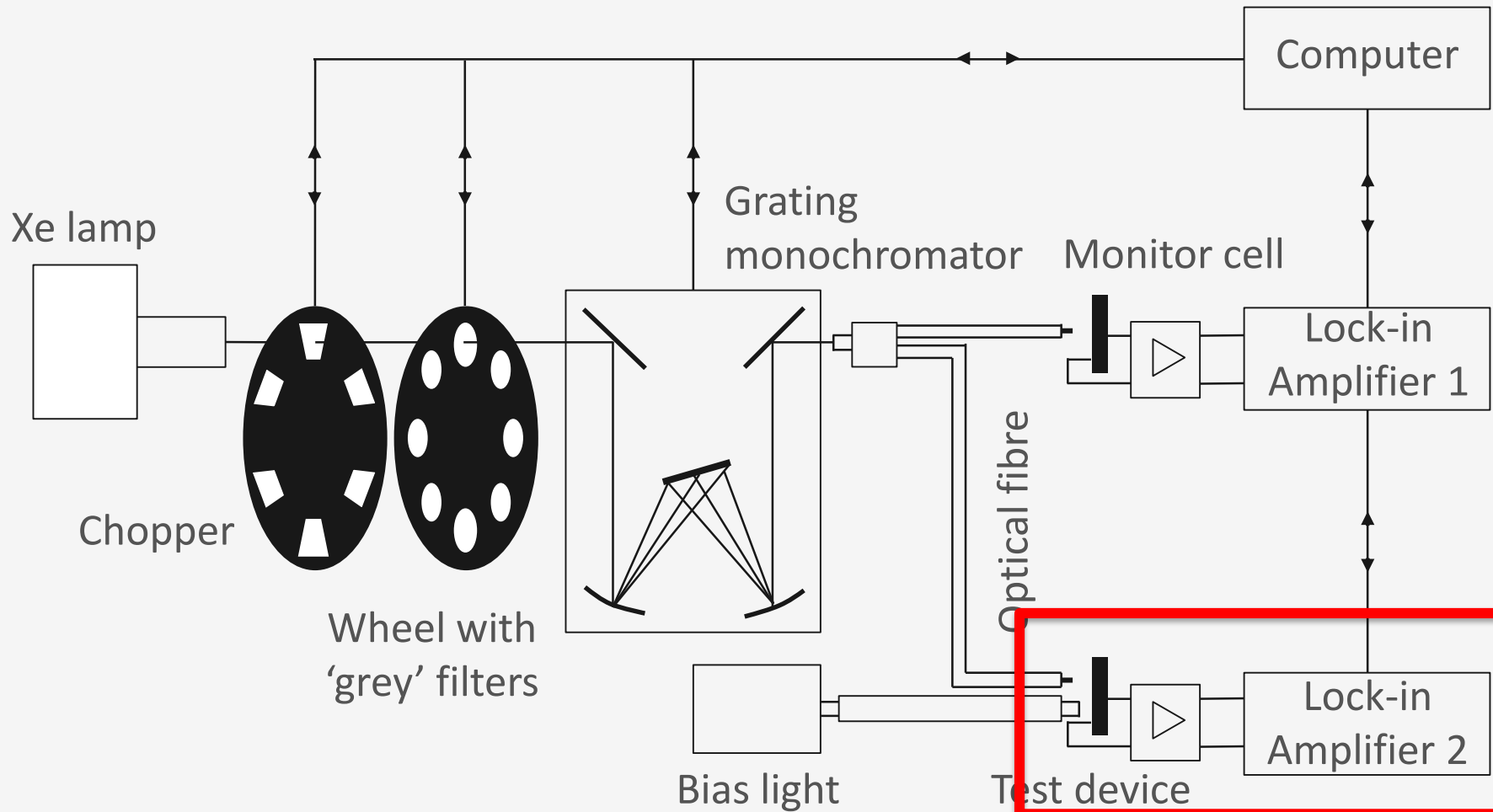
Bias light

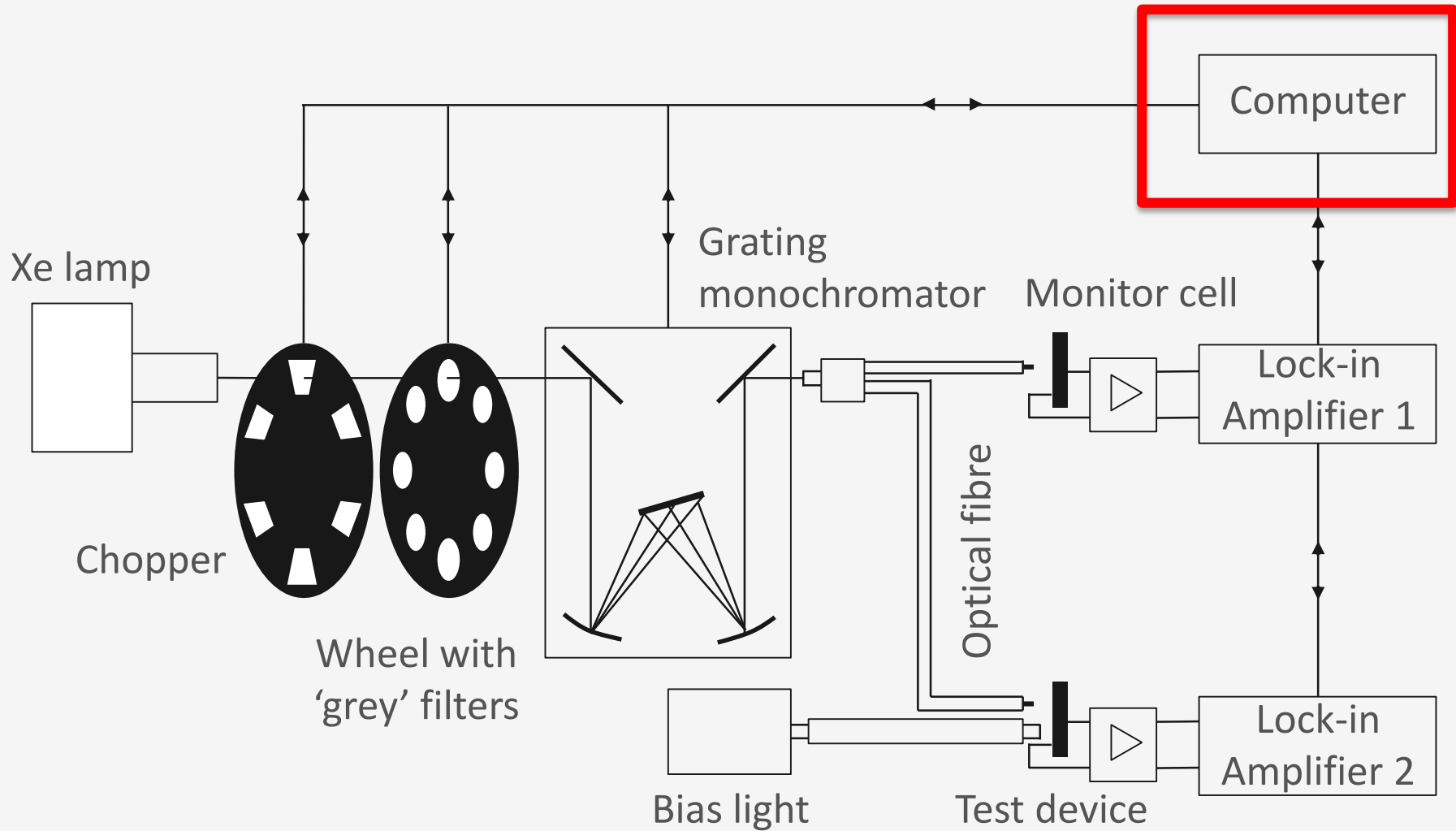
Test device

Optical fibre









# External quantum efficiency

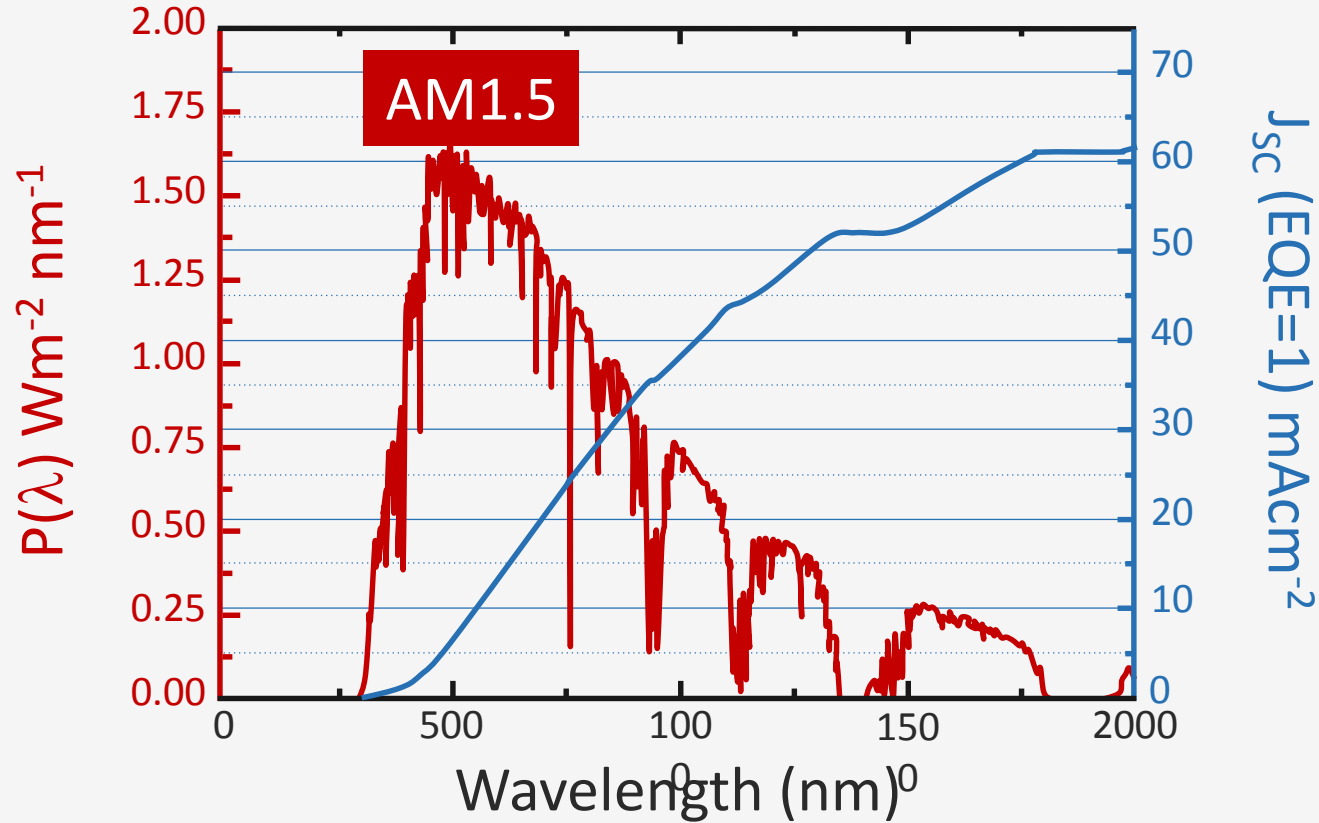
$$J_{SC}(V = 0V) = q \int_0^{\lambda} \Phi_{AM1.5}(\lambda) EQE(\lambda) d\lambda$$

# External quantum efficiency

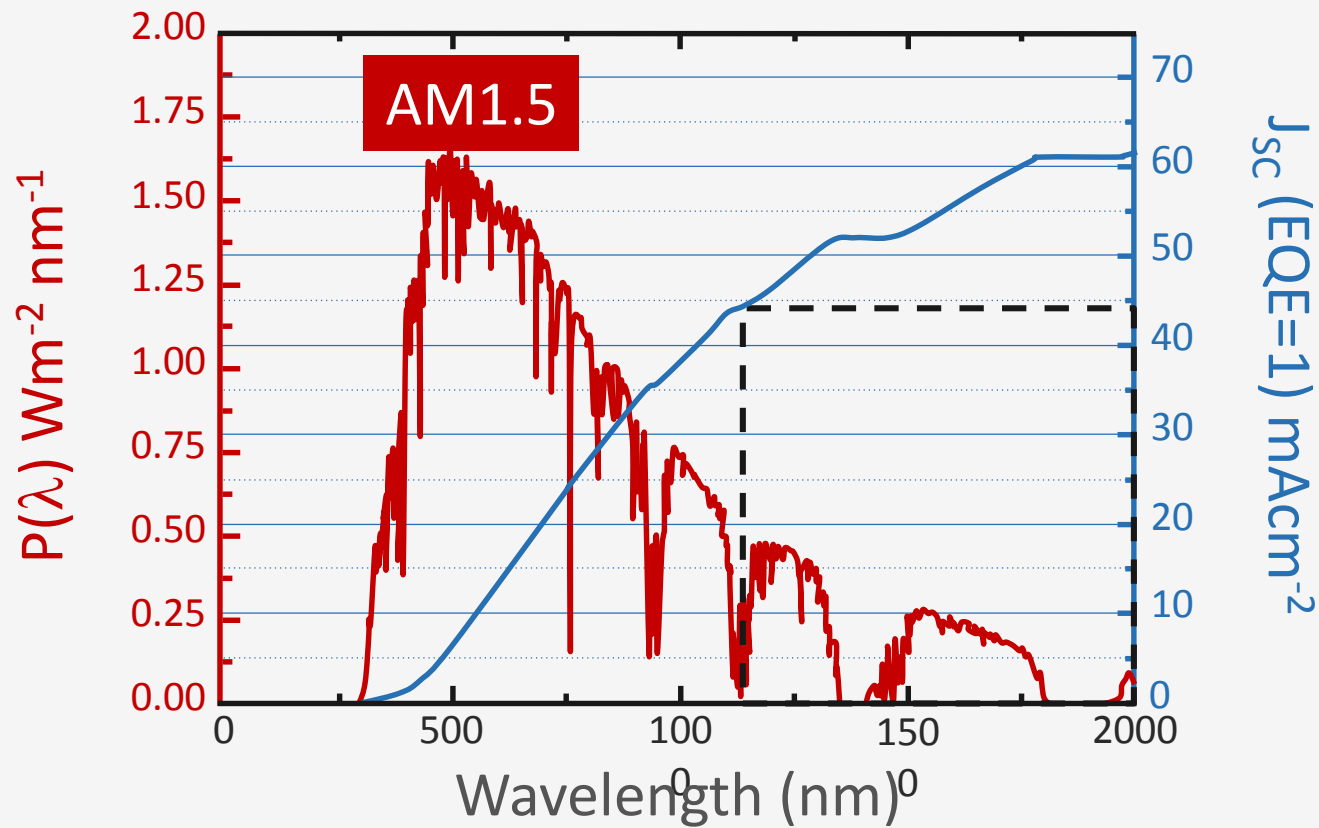
$$\begin{aligned} J_{SC}(V = 0V) &= q \int_0^{\lambda} \Phi_{AM1.5}(\lambda) EQE(\lambda) d\lambda \\ &= q \int_0^{\lambda} \frac{P_{AM1.5}(\lambda) \lambda}{hc} EQE(\lambda) d\lambda \end{aligned}$$



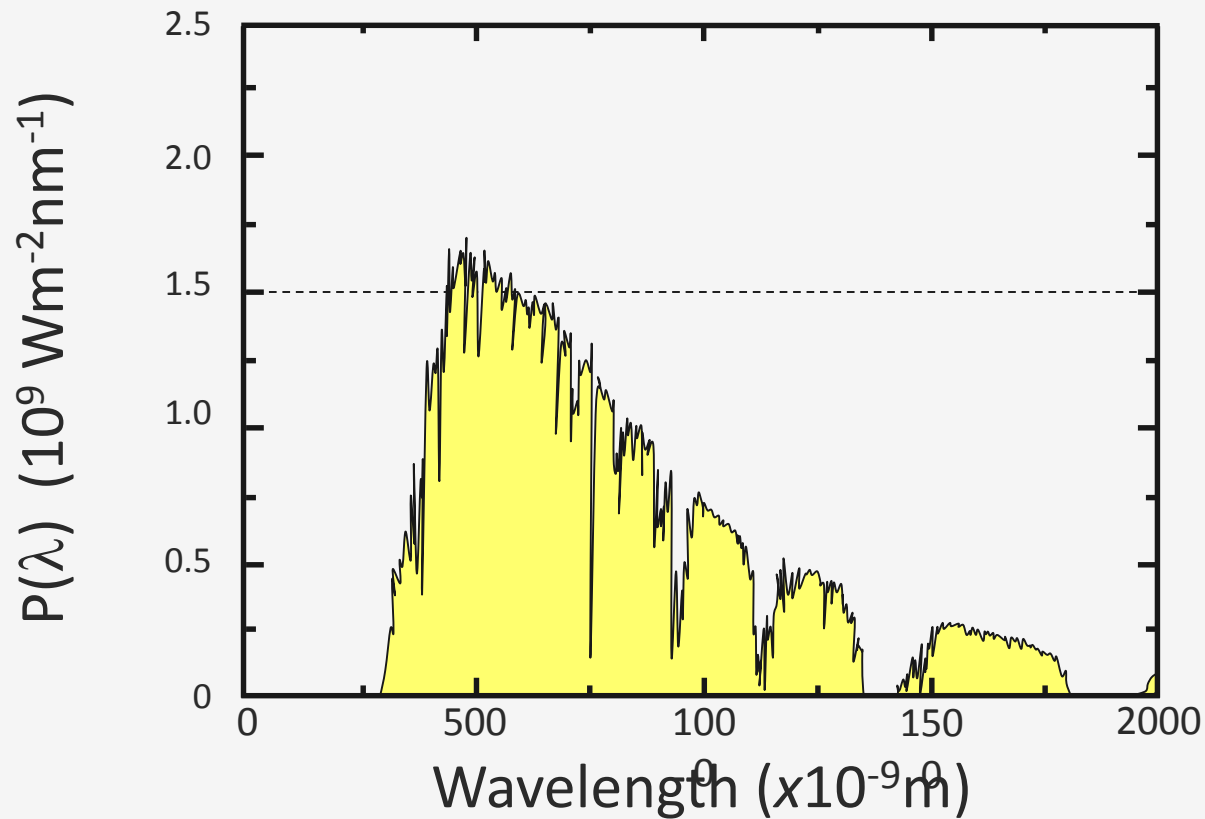
# Relation EQE and $J_{sc}$



# Relation EQE and $J_{sc}$

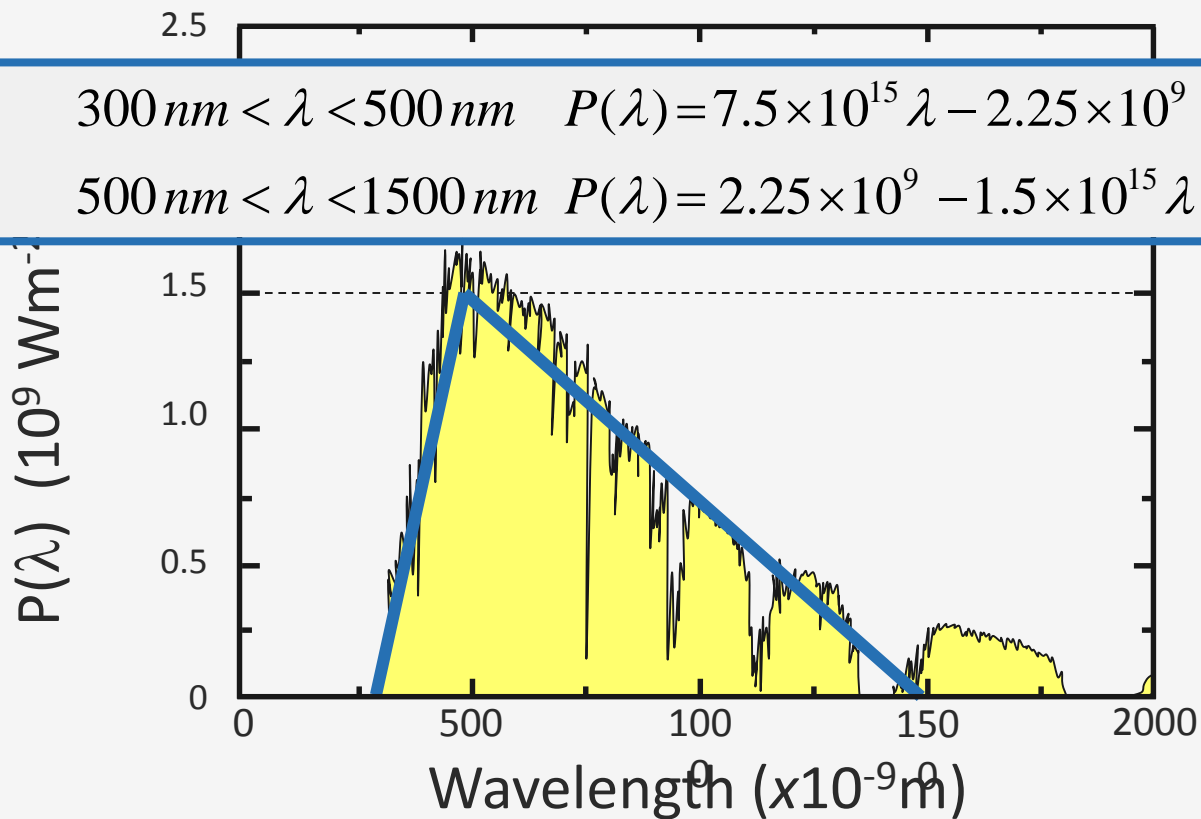


# Example

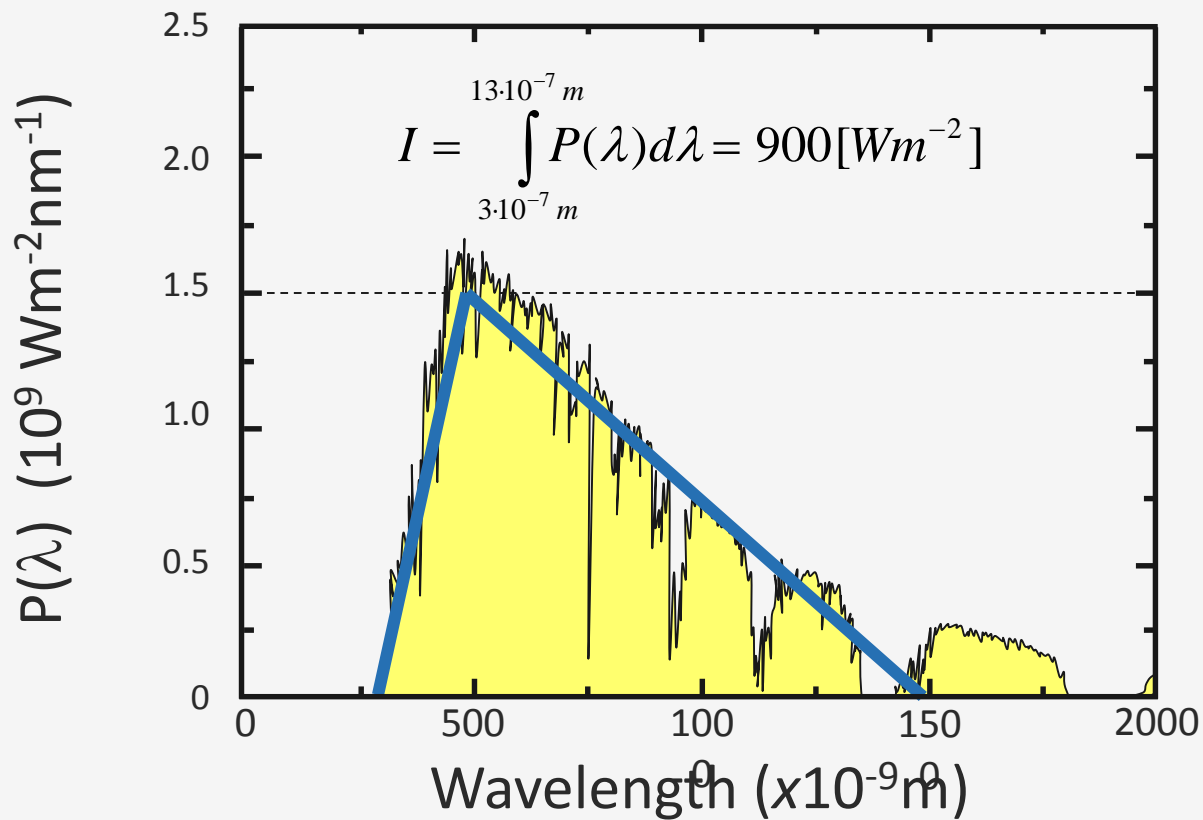


# Example

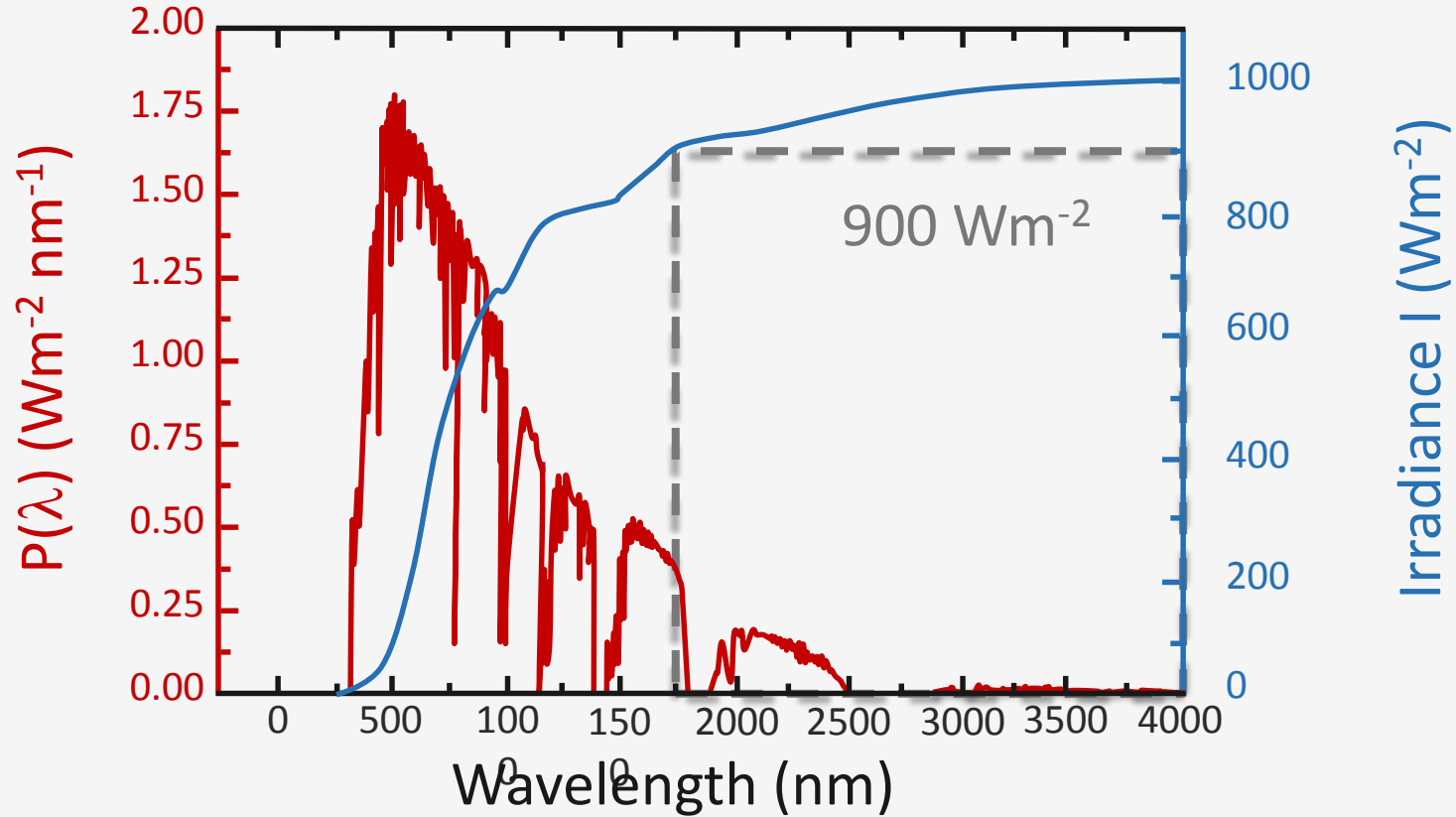
$$300 \text{ nm} < \lambda < 500 \text{ nm} \quad P(\lambda) = 7.5 \times 10^{15} \lambda - 2.25 \times 10^9 \text{ [Wm}^{-2}\text{m}^{-1}\text{]}$$
$$500 \text{ nm} < \lambda < 1500 \text{ nm} \quad P(\lambda) = 2.25 \times 10^9 - 1.5 \times 10^{15} \lambda \text{ [Wm}^{-2}\text{m}^{-1}\text{]}$$

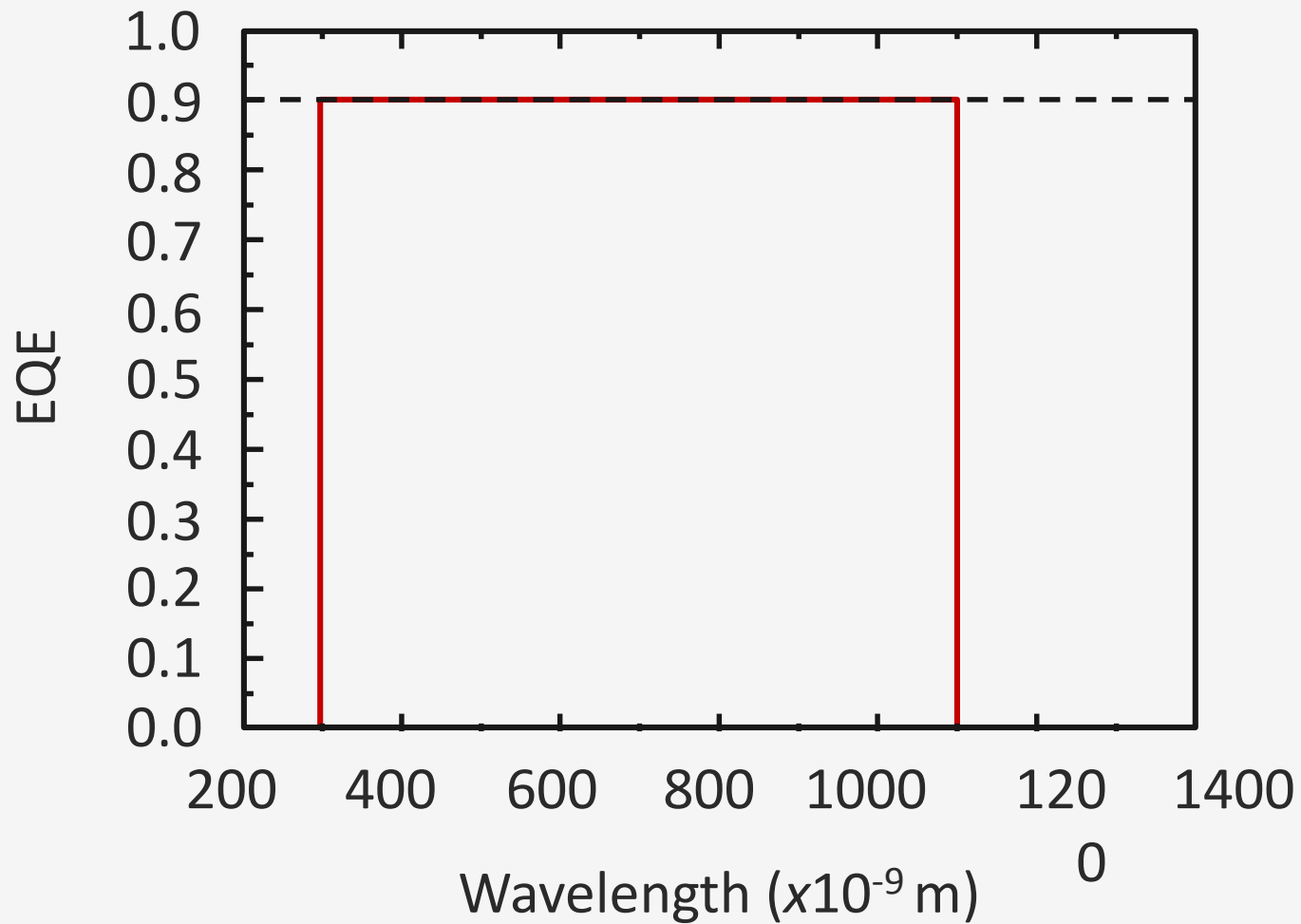


# Example

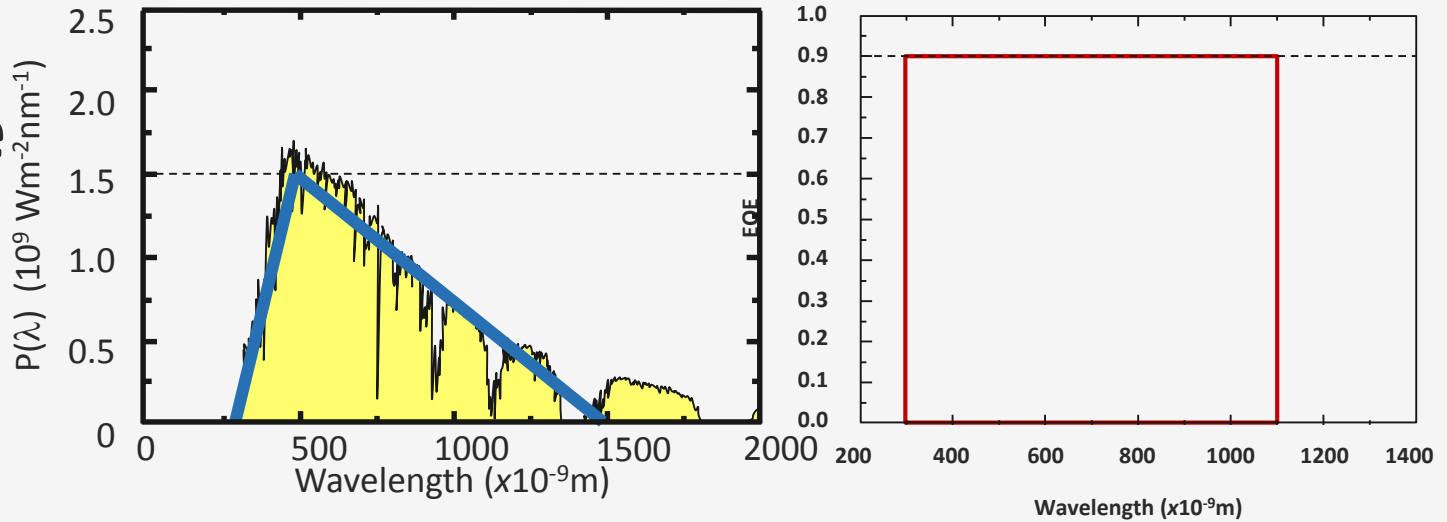


# Available power in the sunlight





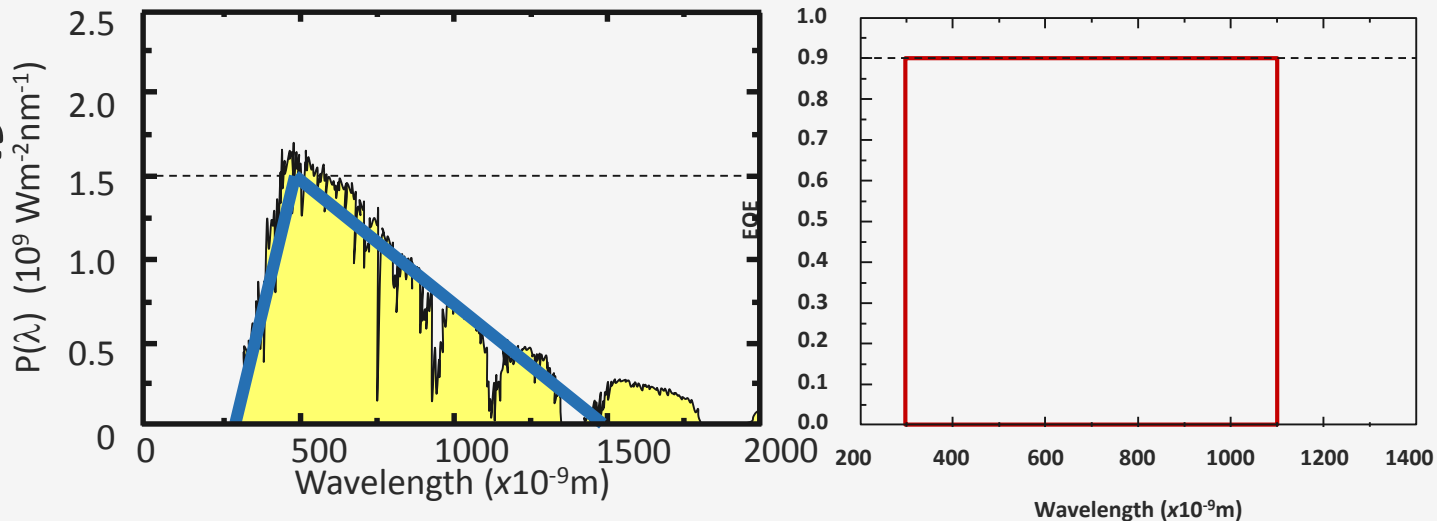
# Example



$$\begin{aligned}
 J_{sc} &= e \int_{3 \cdot 10^{-7} \text{ m}}^{11 \cdot 10^{-7} \text{ m}} \Phi(\lambda) EQE(\lambda) d\lambda = EQE \times e \times \int_{3 \cdot 10^{-7} \text{ m}}^{11 \cdot 10^{-7} \text{ m}} \Phi(\lambda) d\lambda = EQE \times e \times (\Phi_{300-500 \text{ nm}} + \Phi_{500-1100 \text{ nm}}) = \\
 &= 0.9 \times 1.6 \cdot 10^{-19} \cdot (3.28 \cdot 10^{20} \text{ m}^{-2} \text{ s}^{-1} + 2.41 \cdot 10^{21} \text{ m}^{-2} \text{ s}^{-1}) = 394 \text{ [Am}^{-2}\text{]} \\
 &= 394 \text{ [1000 mA / (10000 cm}^{-2}\text{)]} = 39.4 \text{ [mA cm}^{-2}\text{]}
 \end{aligned}$$



# Example



$$EQE = 100\%$$

$$J_{SC} = 43.7 [\text{mAcm}^{-2}]$$

# Relation EQE and $J_{sc}$

