Lab 2: Wave-Particle Duality

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Michigan Math and Science Scholars
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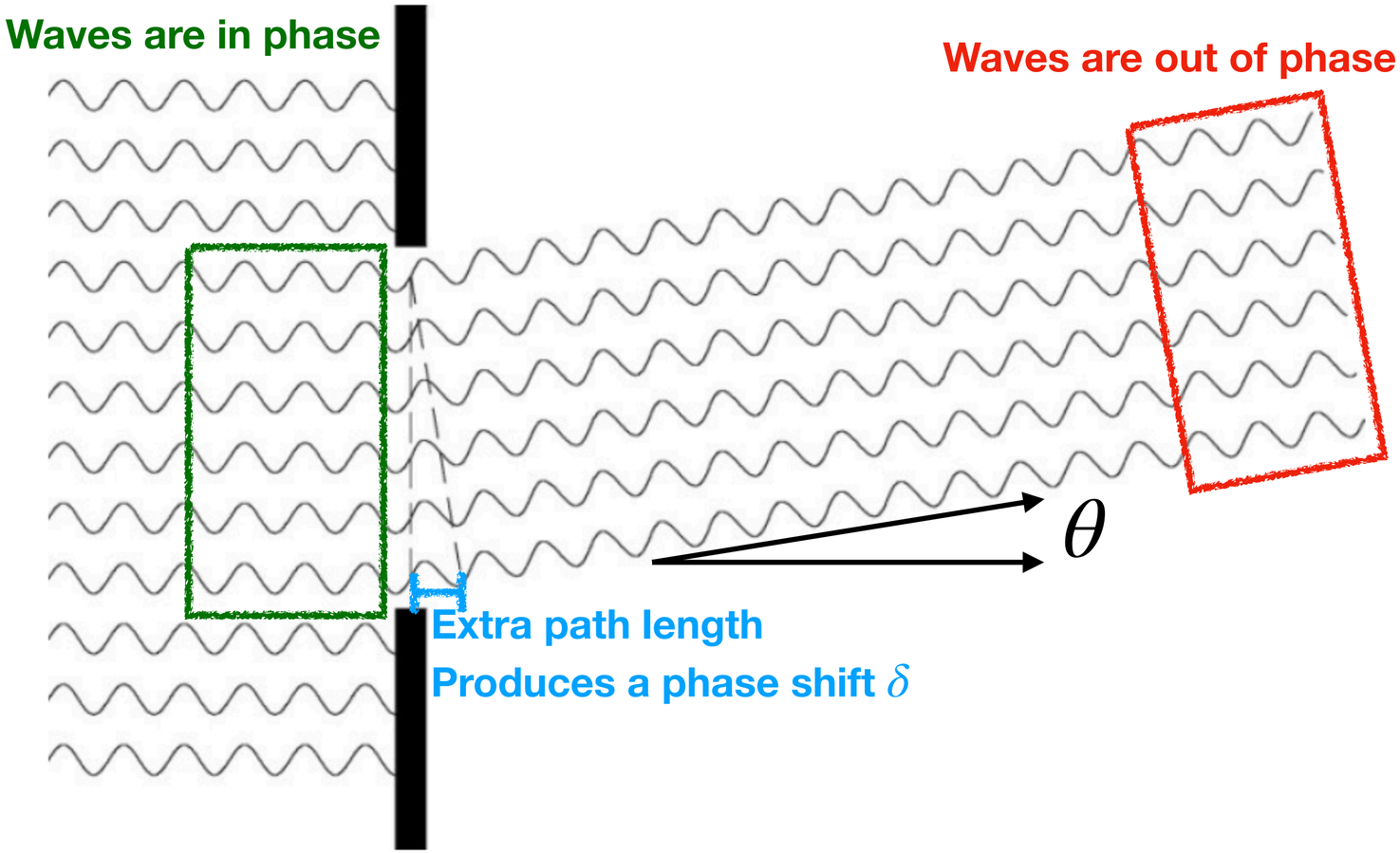
Light Waves

- **You may be familiar with two concepts:**
  - 1. Light is “a wave”
  - 2. Light is made up of individual “photons” or “light particles”

- **So which is it? Is light a wave or a particle? Today we will see that it is *both*.**

Diffraction

- **Diffraction occurs when light goes through a thin opening**
- **Constructive and destructive interference occurs as a function of the angle θ**
  - In phase = constructive interference
  - Out of phase = destructive interference
- **How do the waves go from in phase to out of phase?**
  - Extra path length increases with θ



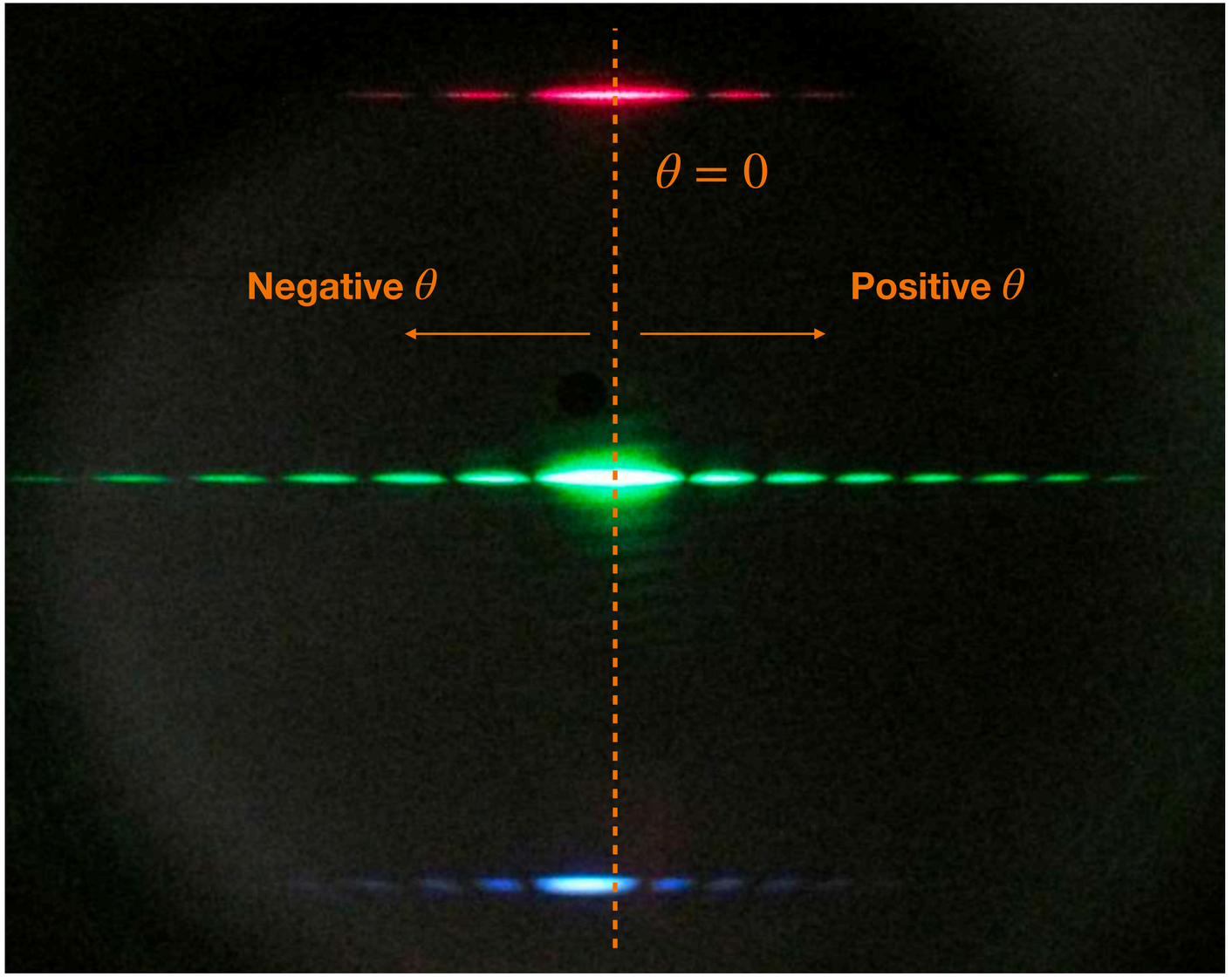
Diffraction patterns

- **An interference pattern is produced when we shine light through a small slit**
- **The locations of the dark bands are:**

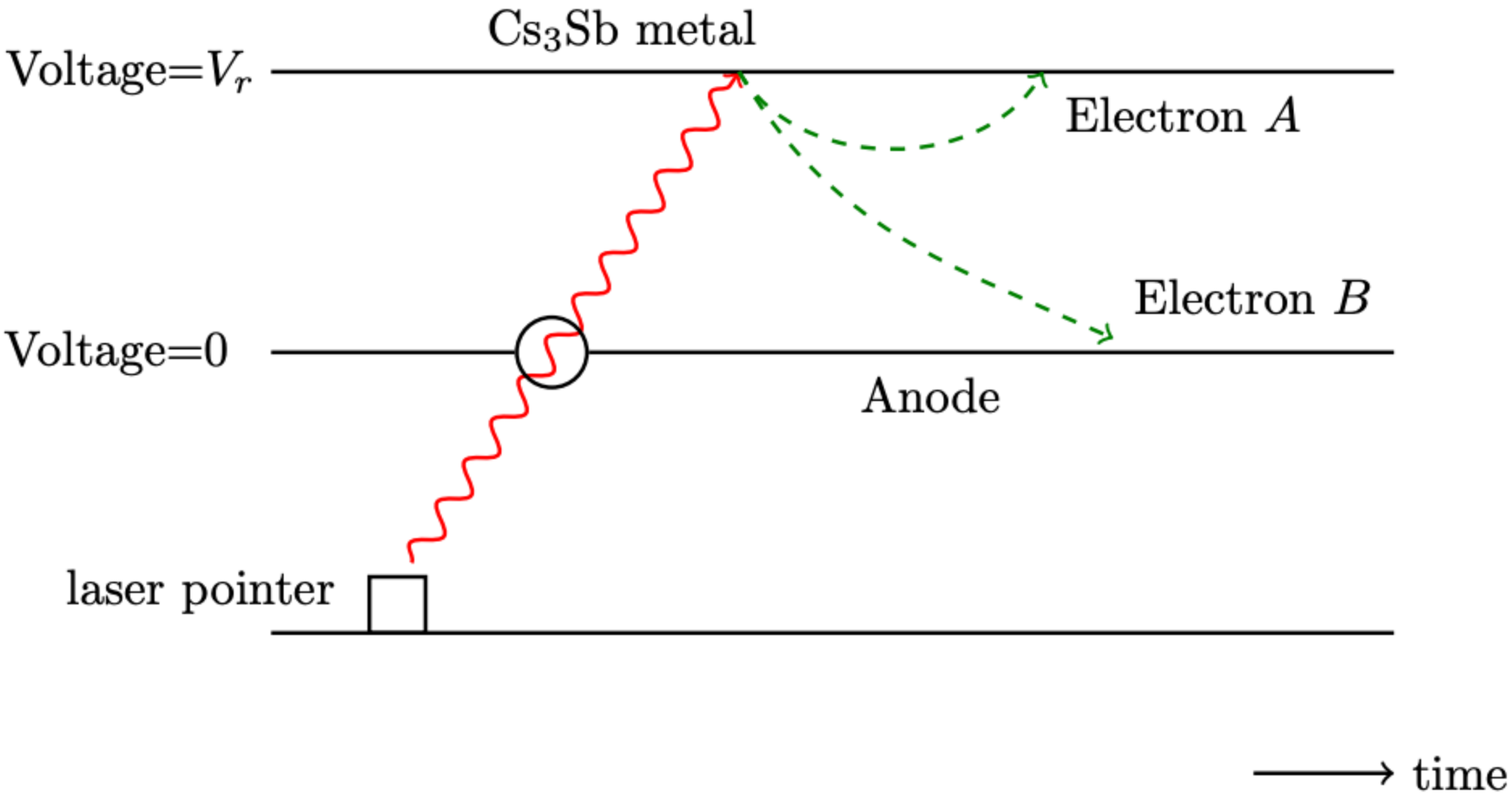
$$\sin\theta = n\frac{\lambda}{a}$$

  - The sine means we expect a periodic interference pattern

- **You will verify the mathematical relationships between wave parameters and interference patterns in the first part of the lab**
- **This interference demonstrates that light is a wave!**



The photoelectric effect



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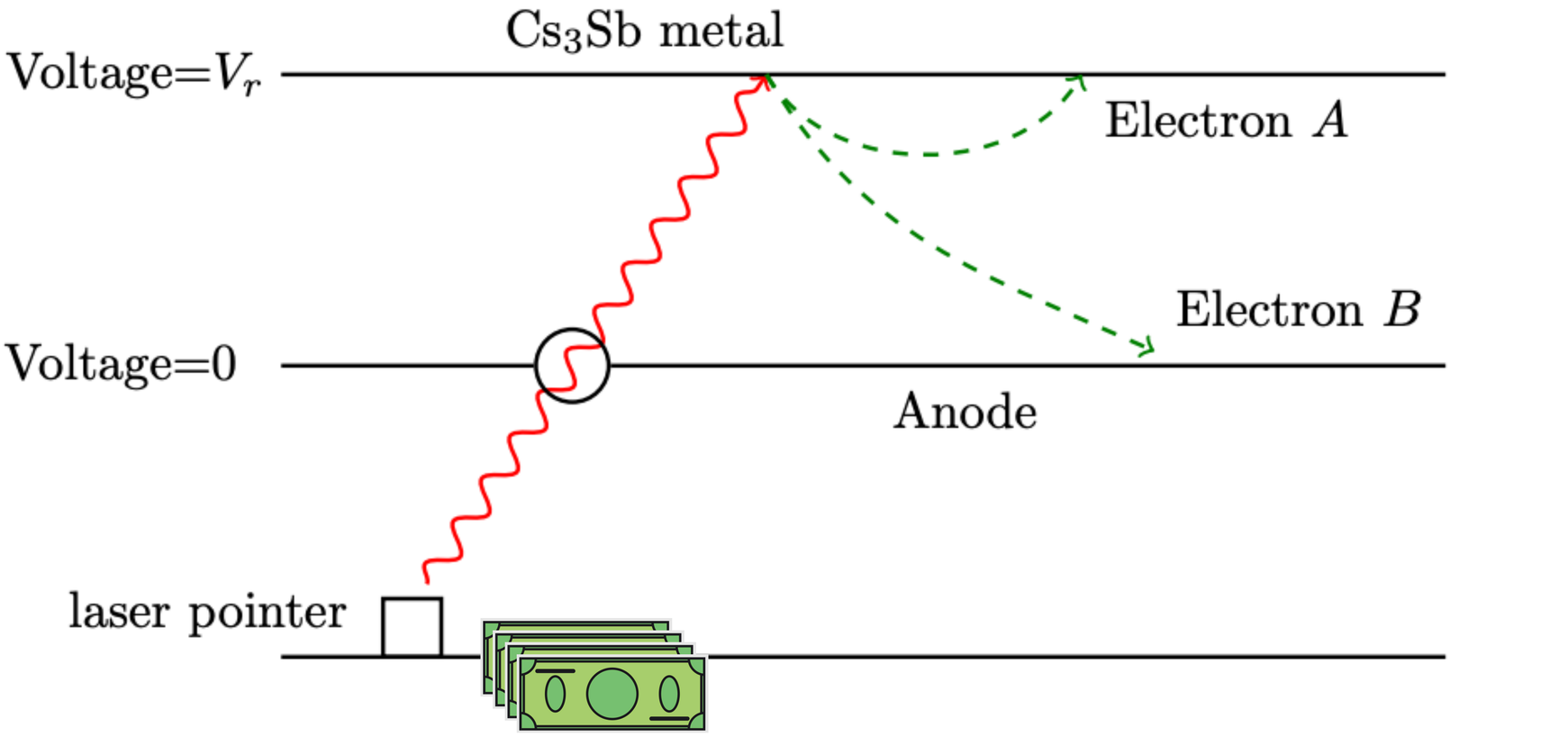
  - Photons start with a certain amount of energy (represented as money)



Start with 4 units of energy

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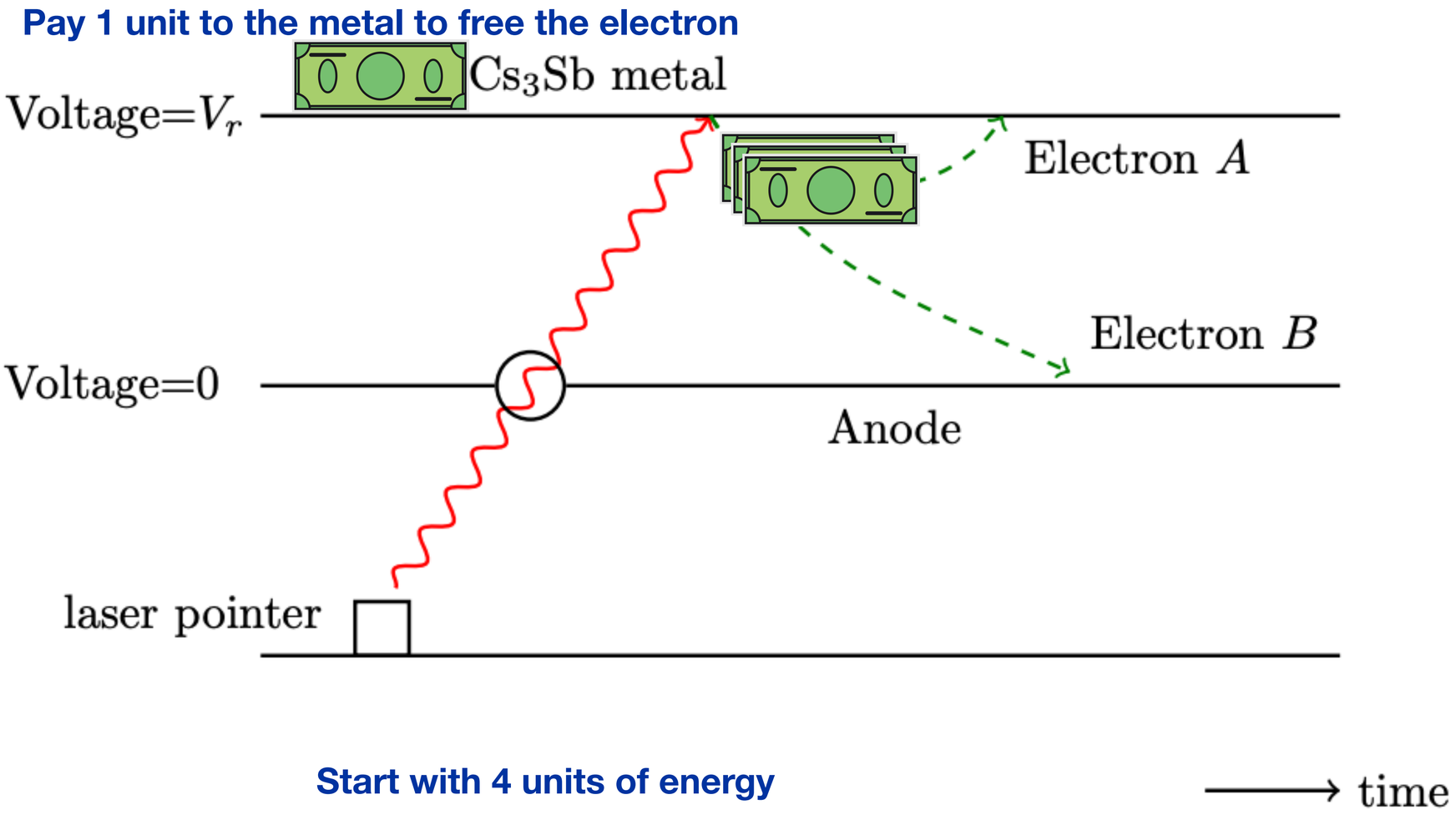

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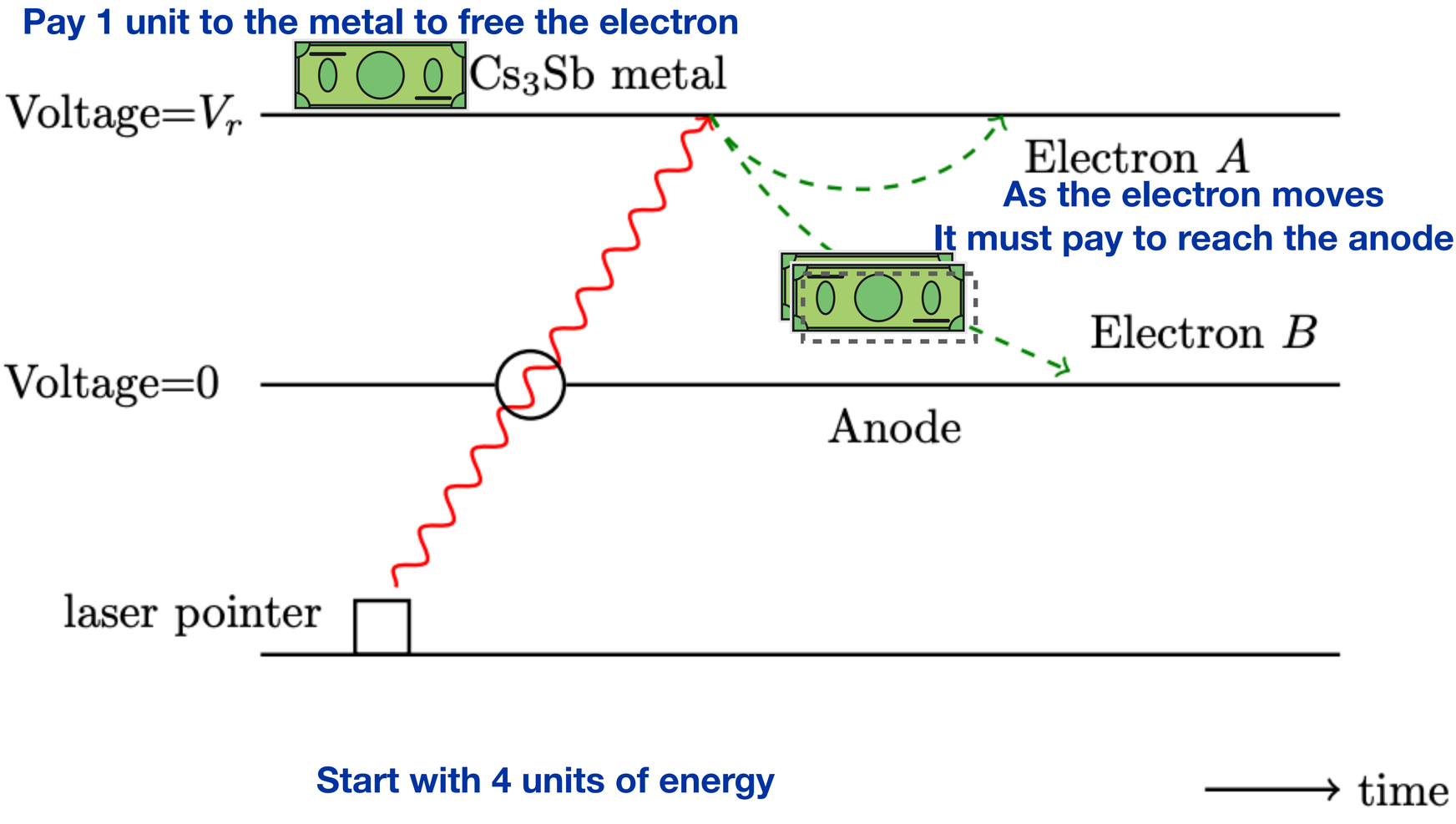

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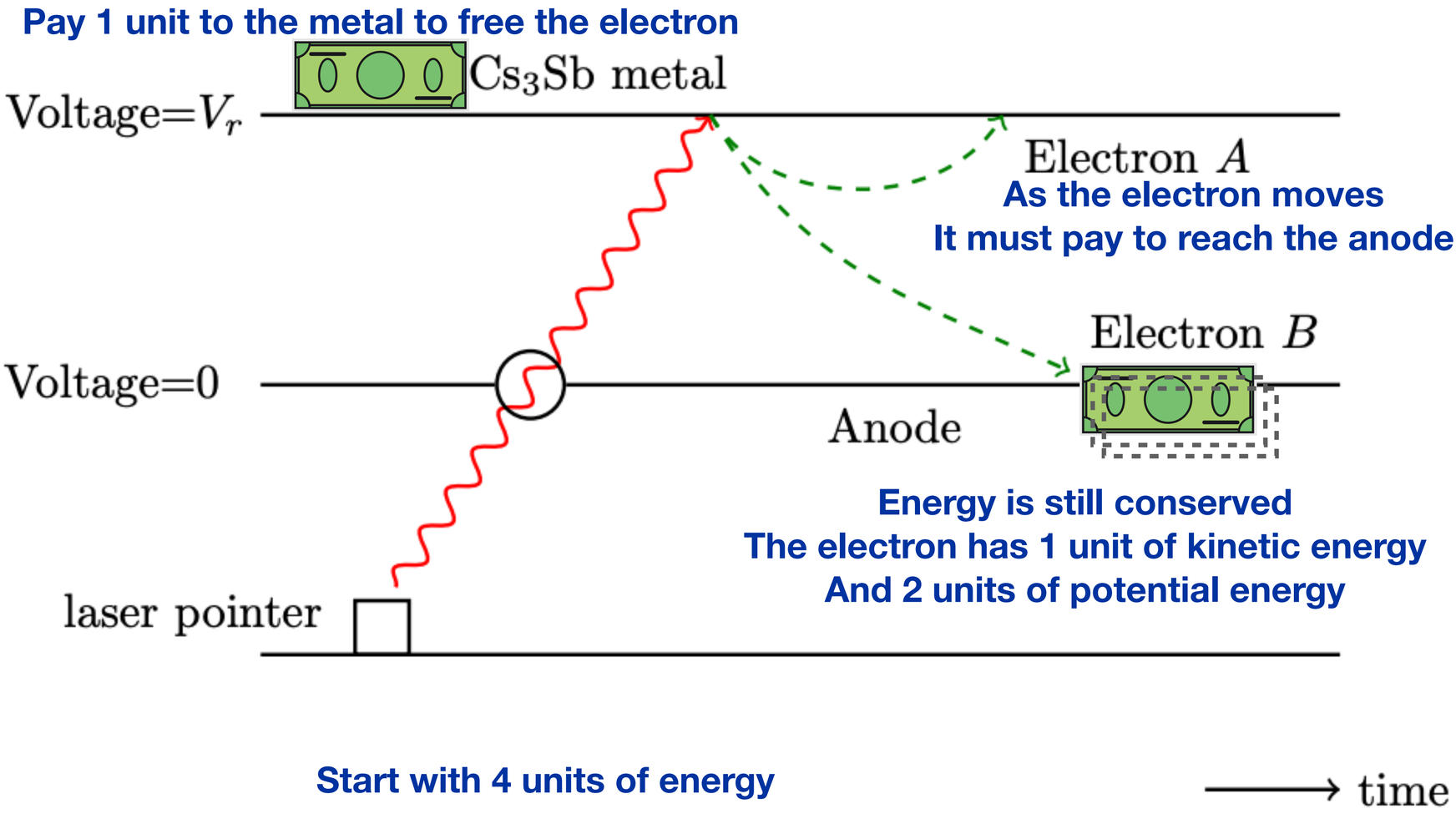

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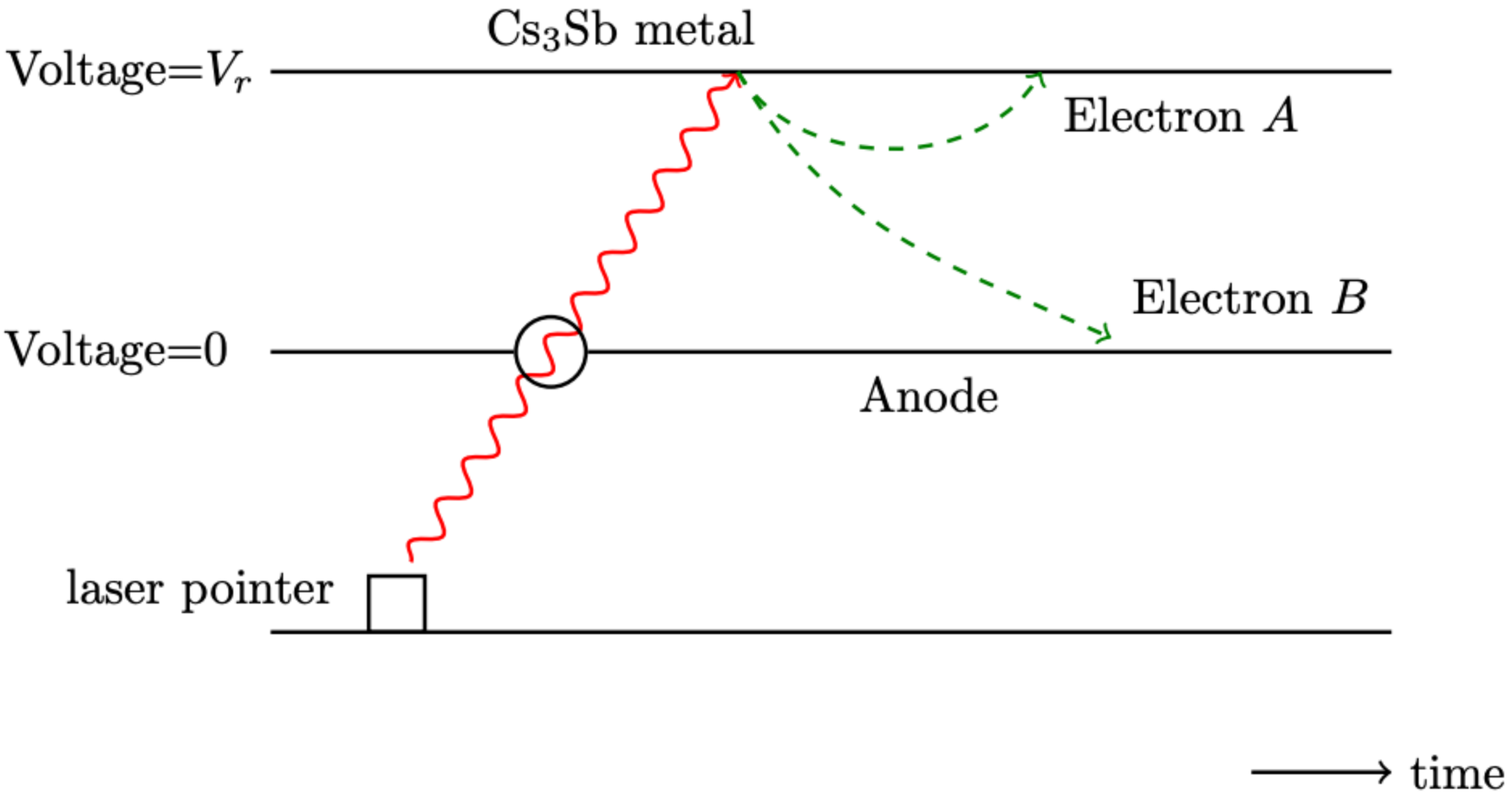

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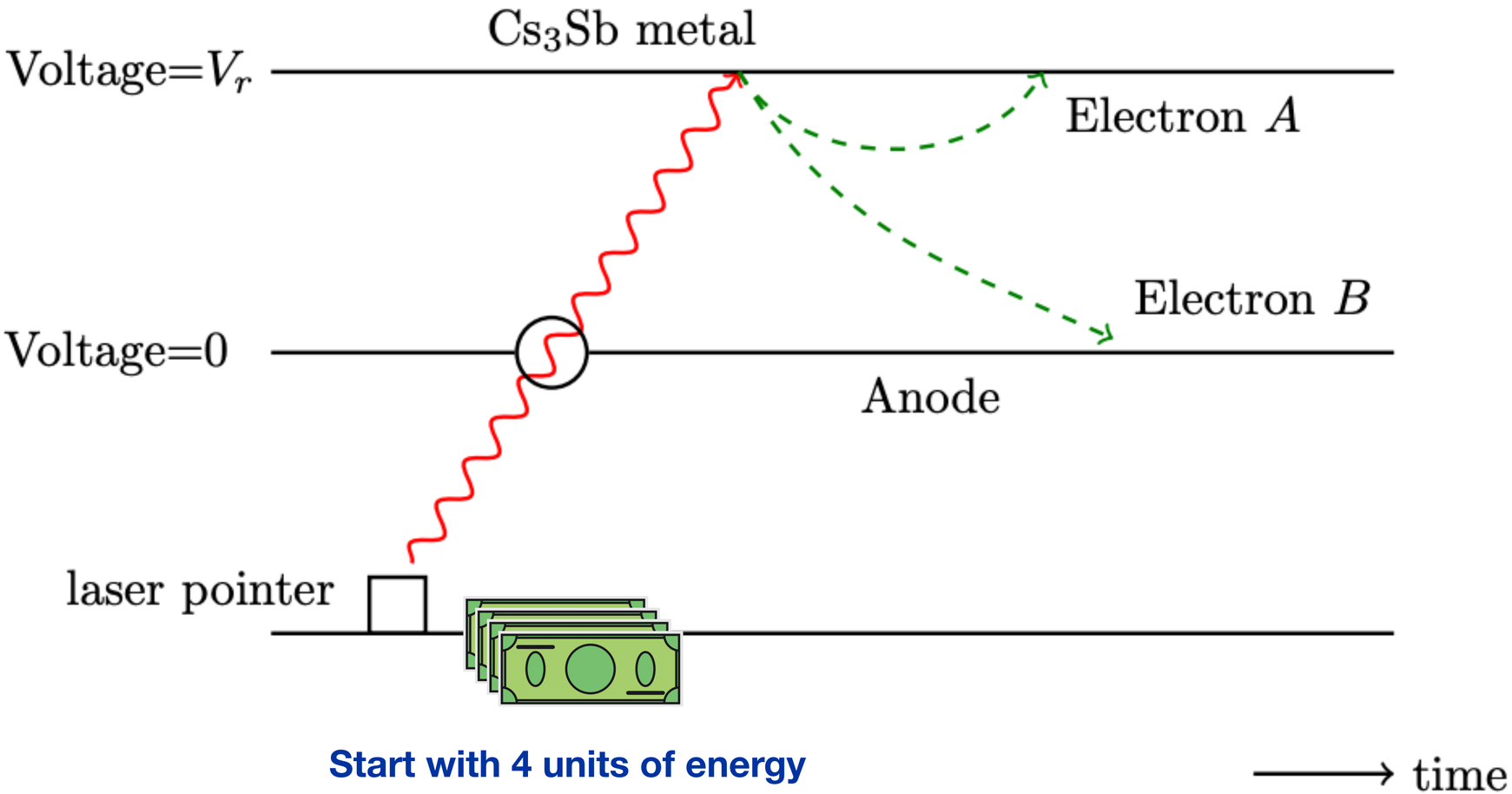

Kevin Nelson

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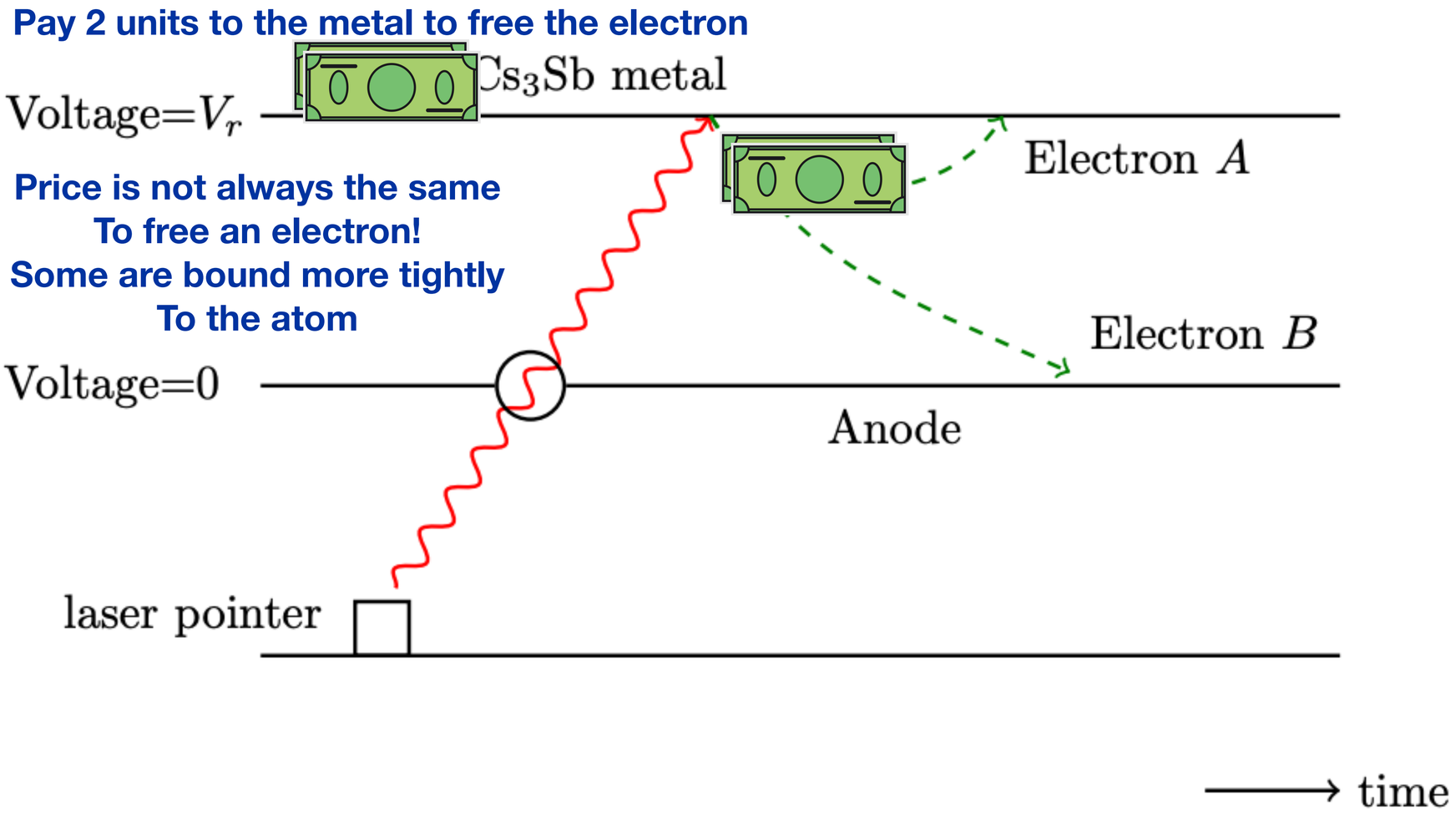

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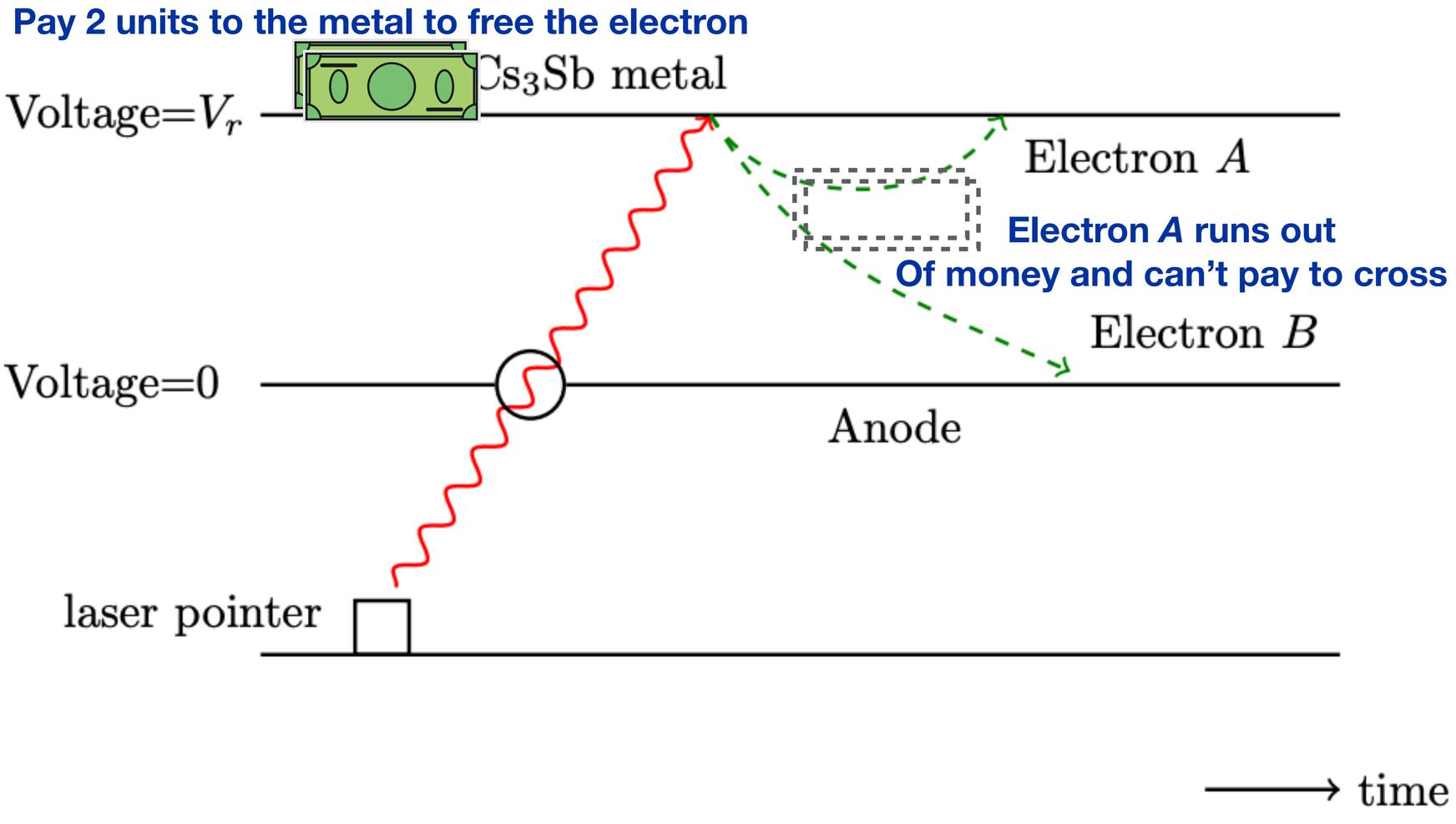

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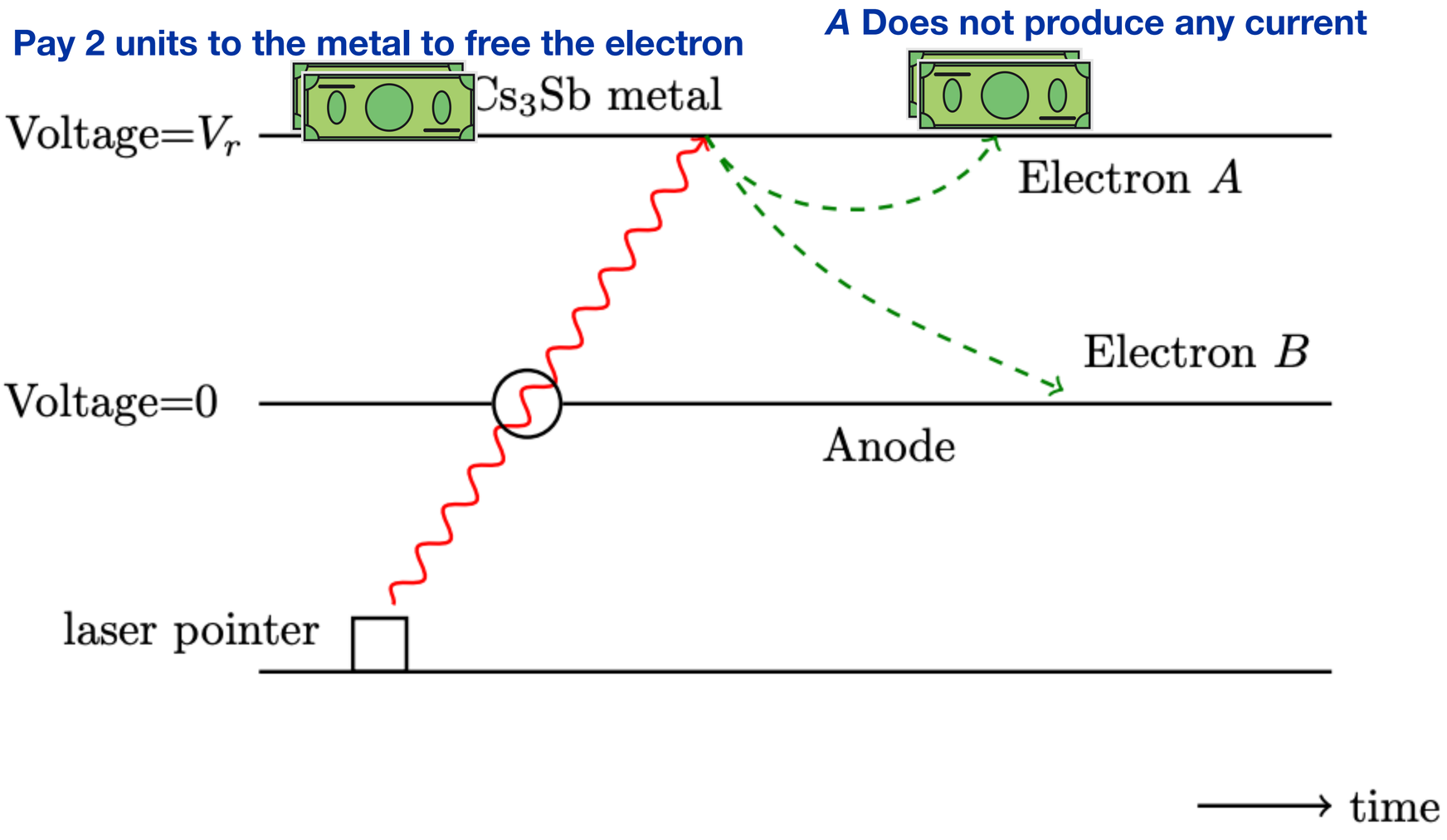

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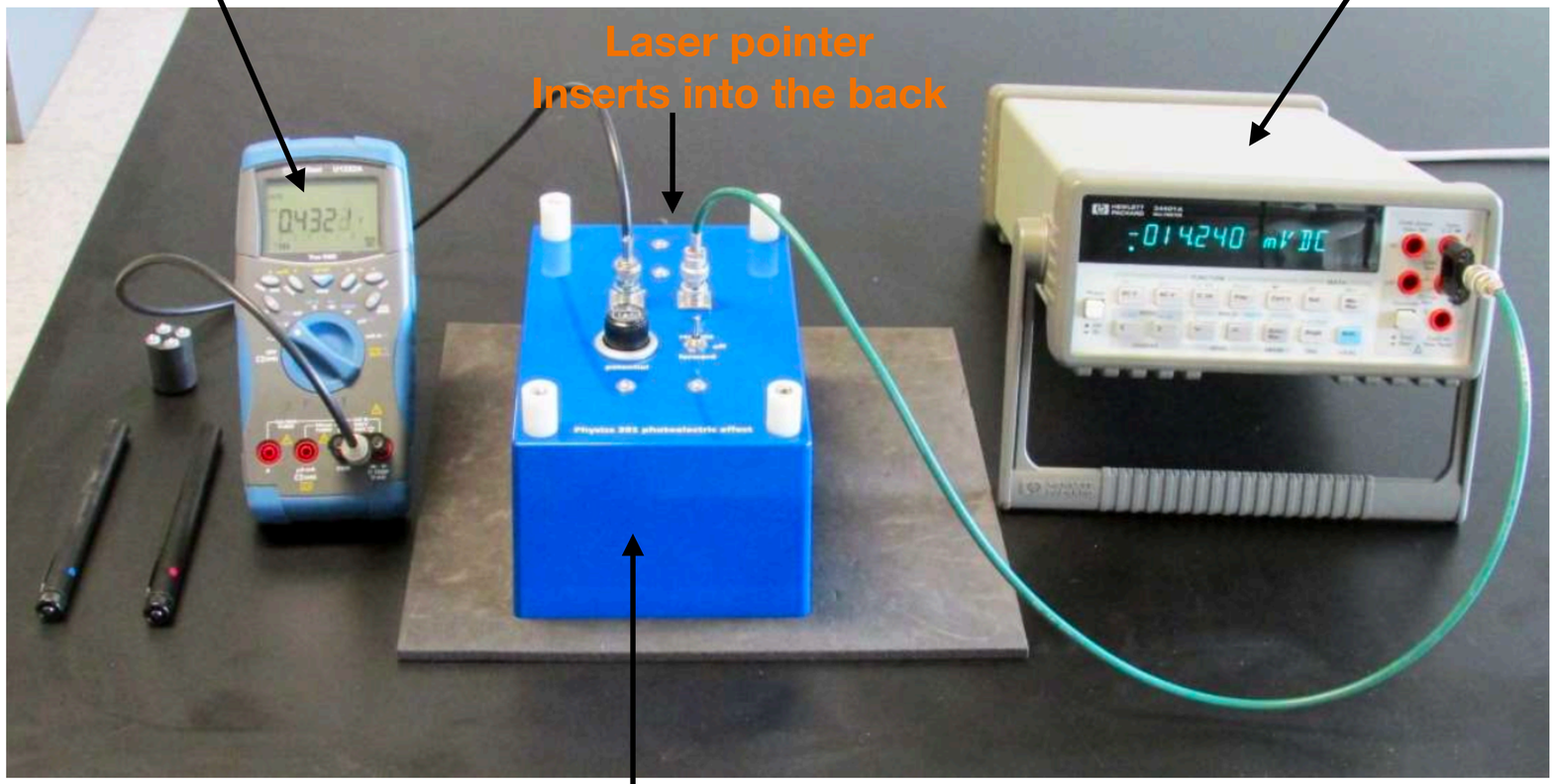
- **Energy of freed electrons is not a function of light intensity, only frequency! This proves that light is made of *particles*!**

Experimental setup

Current monitor
Measure the photocurrent here

Voltage source
You set the value of the voltage here



Photoelectric effect
Occurs in this box

IMPORTANT: SET TO “REVERSE” MODE

Fitting data with equations

- **Today we will use our first *Juypter notebook* to analyze data with a computer**

- **This is a simple python script to fit some data with a function and plot the results**

In [33]:

```
'''
This code is used to set up the fitting library.  Run this block without modification.
'''

%matplotlib notebook
import matplotlib.pyplot as plt
import numpy as np
import scipy.optimize as opt

'''
Arguments:
  - func:   the callable function used to fit the data.
            First argument must be the indpendent variable, rest of arguments are free parameters
  - xdata:  list of x axis coordinates of the data
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Always put detailed comments In your code so you remember What you meant later!

Run the “Curve fit” function

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Return results

Fitting data with equations

- This is the result of running the code with the appropriate data and function from this lab.
- The parameter we are interested in is what voltage do we apply to completely stop the flow of current
- The code will automatically determine this value for you