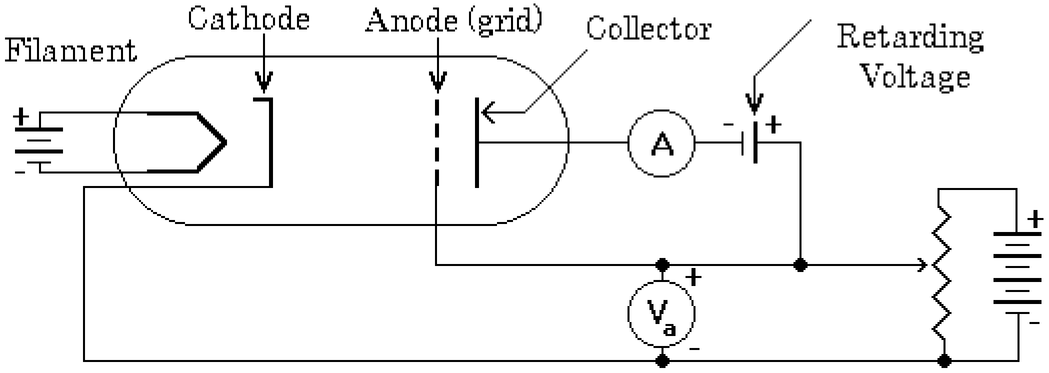
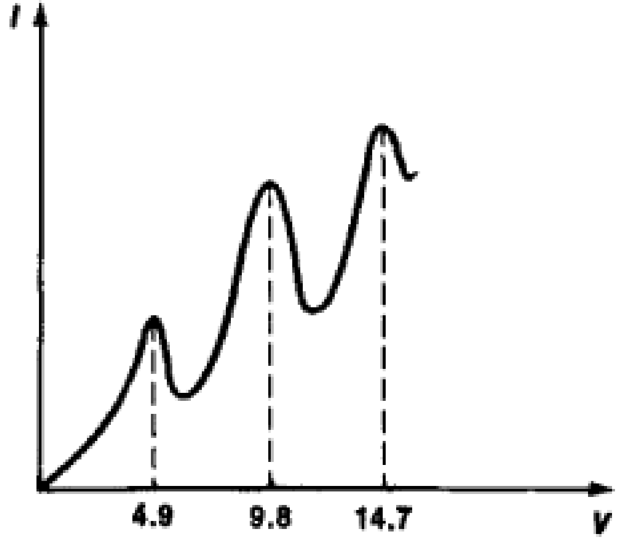
Exploring the Franck-Hertz Curve

Ateeq, Bilal and Hamza

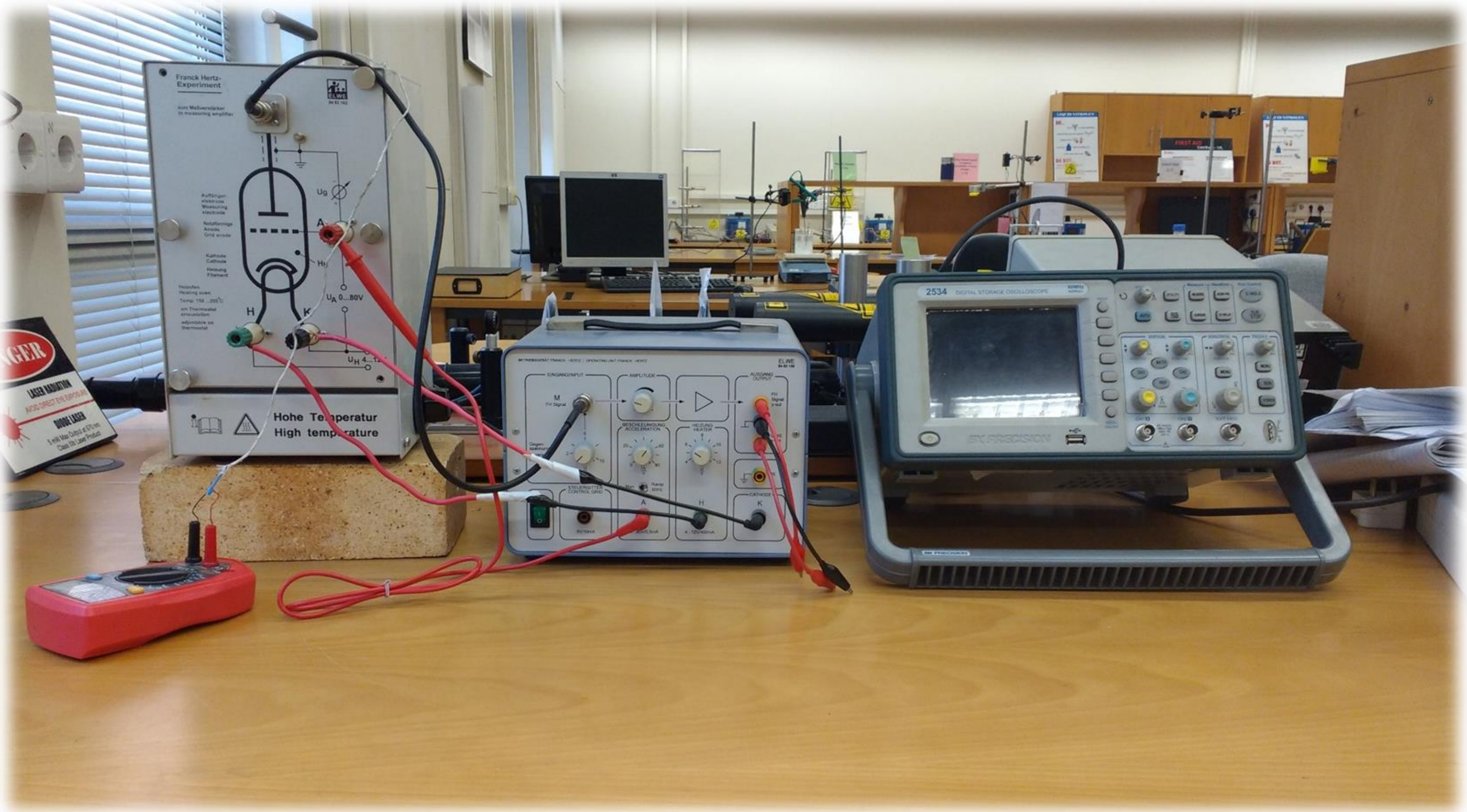
Introduction

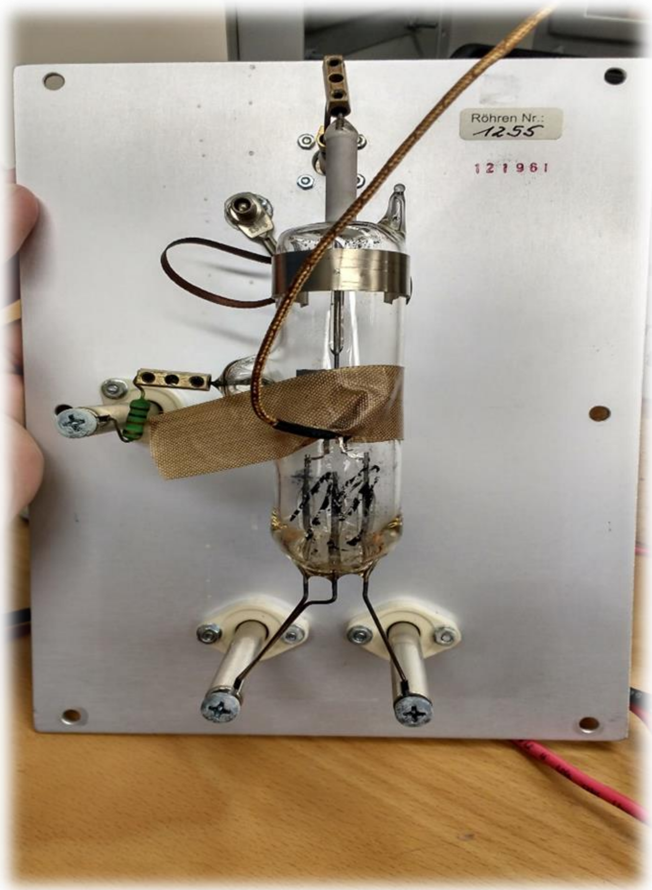
- Initially used to prove quantization of energy inside atoms
- Noble Prize in 1925





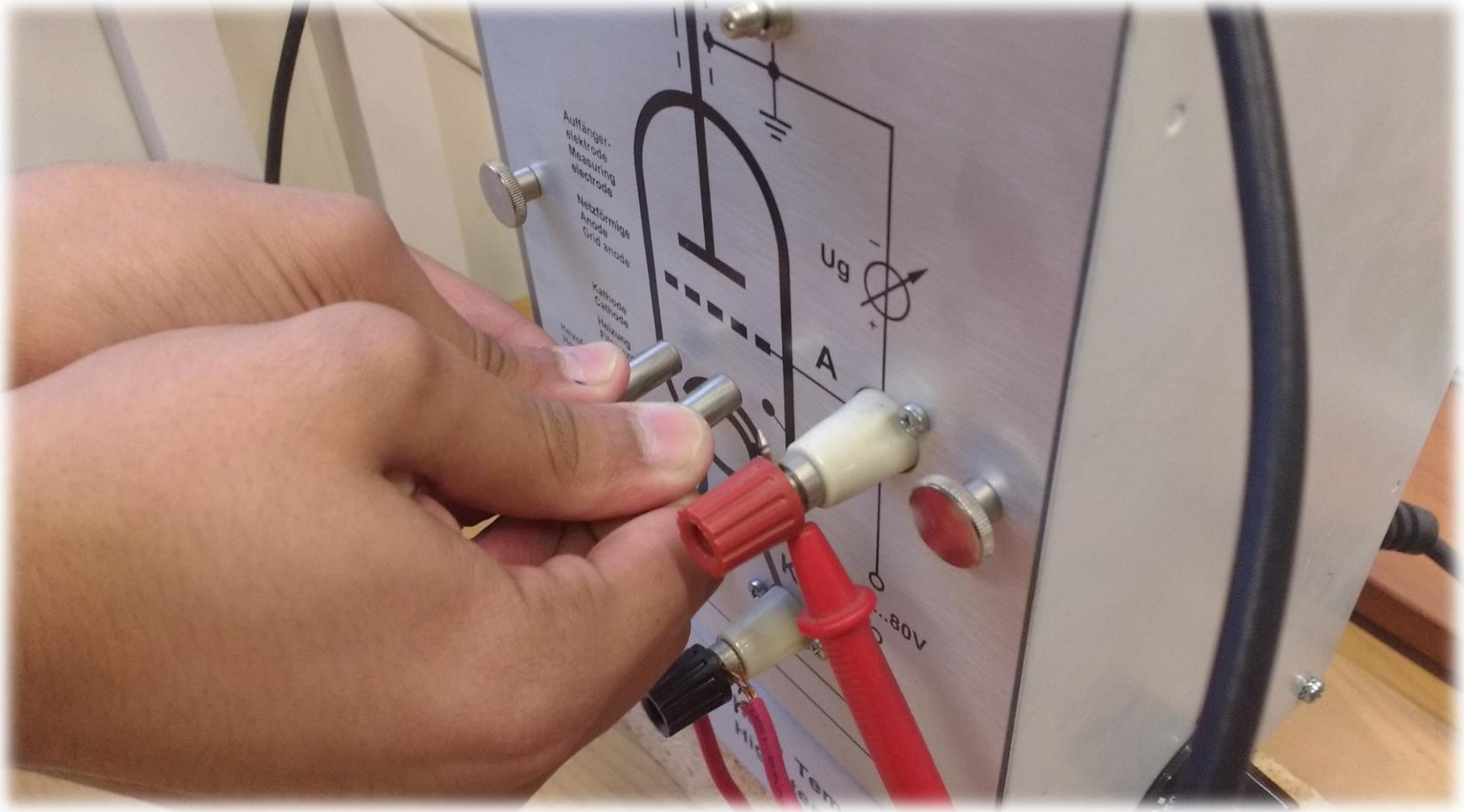
Experimental Setup



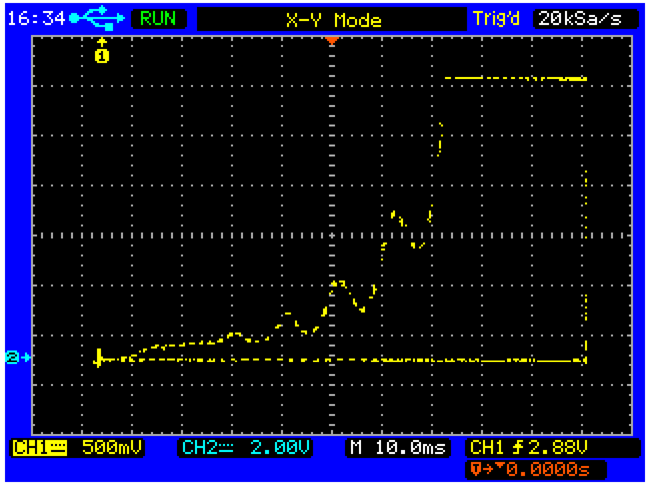


Effect of Magnetic Field

How did we apply mag. Field?

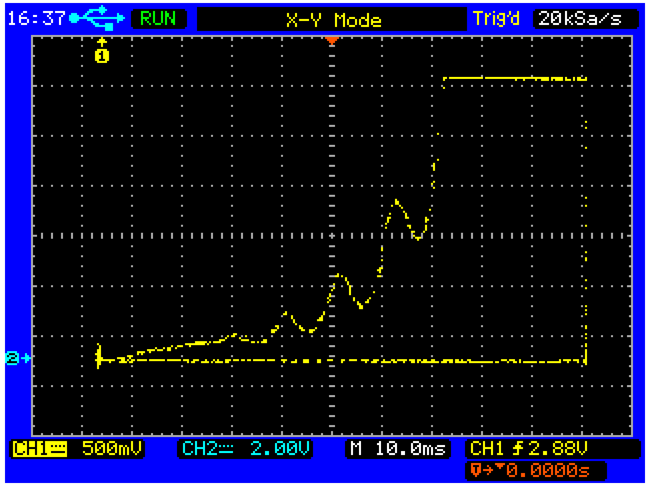


No magnet

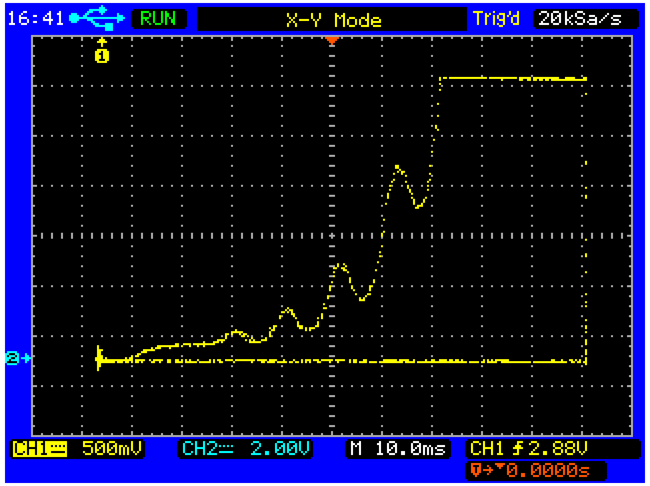


16:34
RUN
X-Y Mode
Trig'd
20kSa/s
CH1 500mV
CH2 2.00V
M 10.0ms
CH1 2.88V
0.0000s

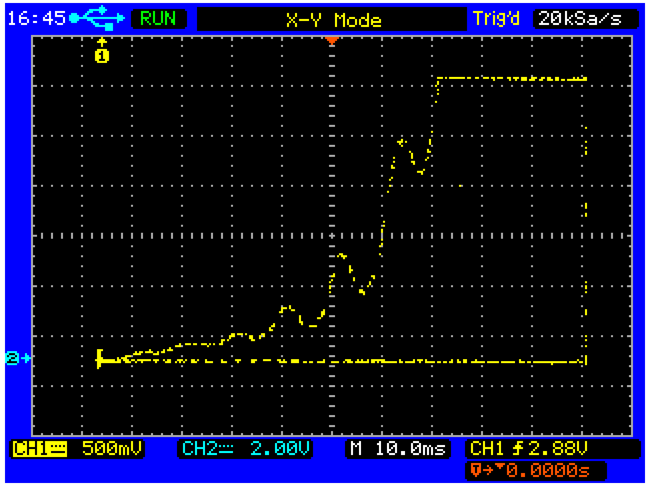
1 magnet


16:37
RUN
X-Y Mode
Trig'd
20kSa/s
CH1 500mV
CH2 2.00V
M 10.0ms
CH1 2.88V
0.0000s

2 magnets


16:41
RUN
X-Y Mode
Trig'd
20kSa/s
CH1 500mV
CH2 2.00V
M 10.0ms
CH1 2.88V
0.0000s

3 magnets


16:45
RUN
X-Y Mode
Trig'd
20kSa/s
CH1 500mV
CH2 2.00V
M 10.0ms
CH1 2.88V
0.0000s

Probabilities using Franck-Hertz

Our Mathematical Model

$$K_{avg} = \sum_{i=0}^{n} ([\prod_{j=0}^{i} P_j].[1 - P_{i+1}].[(K_o + eV) - iE_o])$$

- K_{avg} is the average kinetic energy of electrons reaching the collector
- E_o is the 1st excitation energy of mercury
- n is the maximum number of inelastic collisions possible under a given anode potential V
- P_i is the probability that electron will undergo an inelastic collision with an atom after it has become capable of excitation for the ith time

Its important to understand these Probablilities P_1, P_2, P_3 ....

- Once electron is capable of excitation then P_1 is the probability that electron will undergo an inelastic collision before leaving the tube.
- Once electron is capable of 2^{nd} excitation then P_2 is the probability that electron will undergo 2^{nd} inelastic collision before leaving the tube.
- And so on …

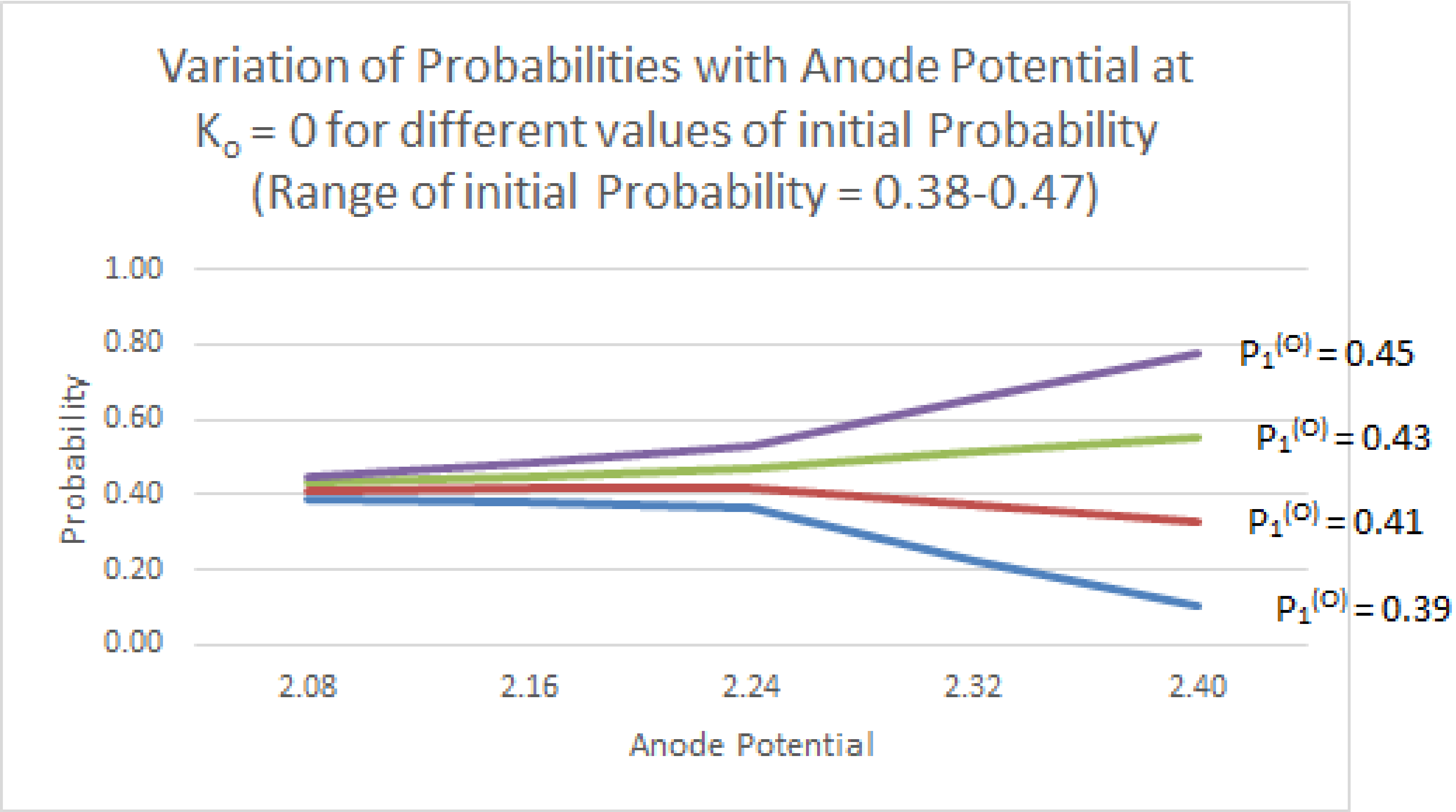
Modeling Probabilities

- Variation of P_1 with anode potential V
- For n=1: $K_{avg} = (K_o+eV) – P_1E_o$
- By simple mathematics we found that:

$$P_1 = \left(\frac{i}{io}\right)^2 P_1^{(o)} + \left[\frac{1}{Eo}\left((K_o+eV)-\left(\frac{i}{io}\right)^2(K_o+eV_o)\right)\right]$$

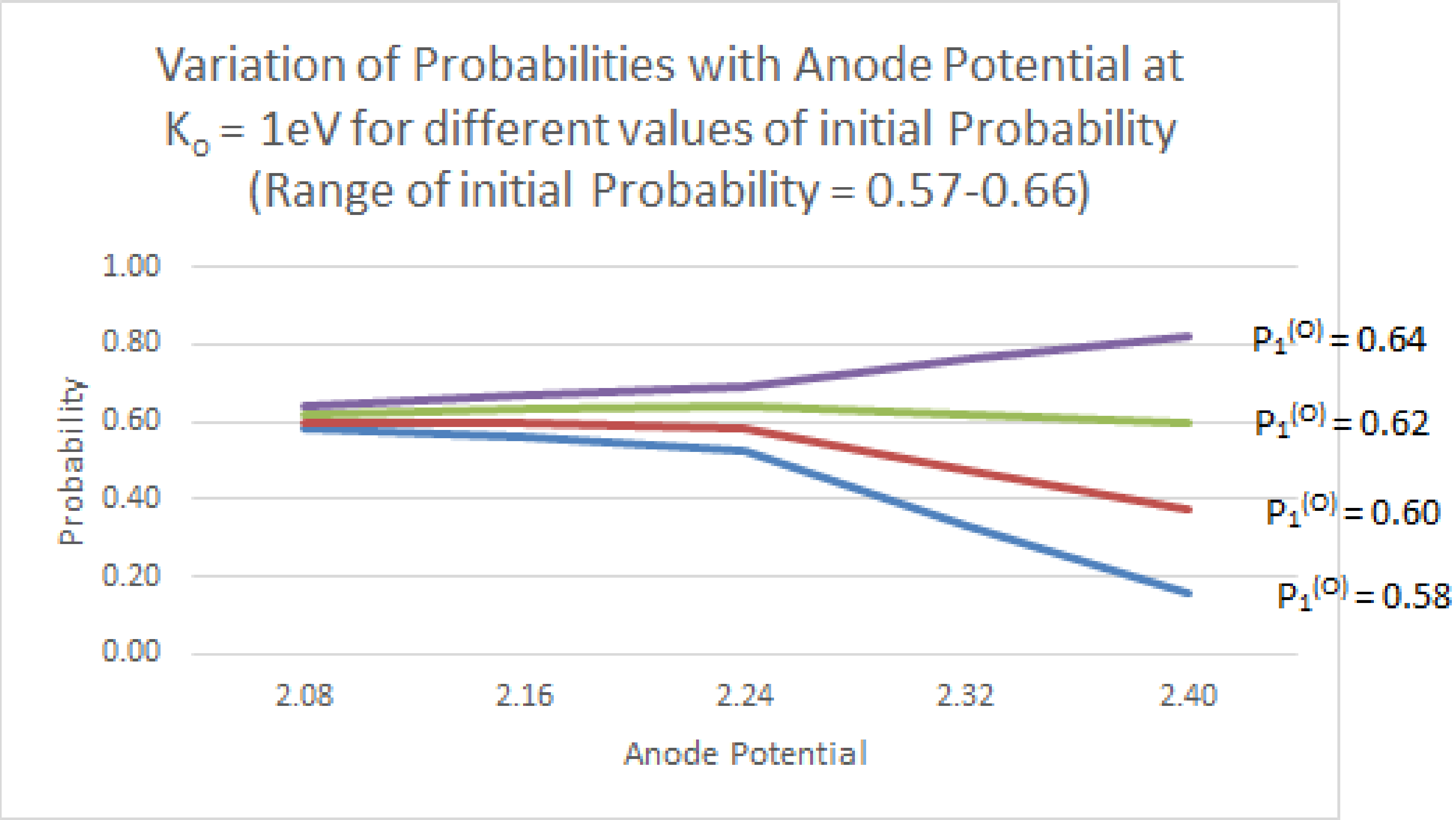
  - i is the collector current
  - V is the anode potential

At $K_o = 0$



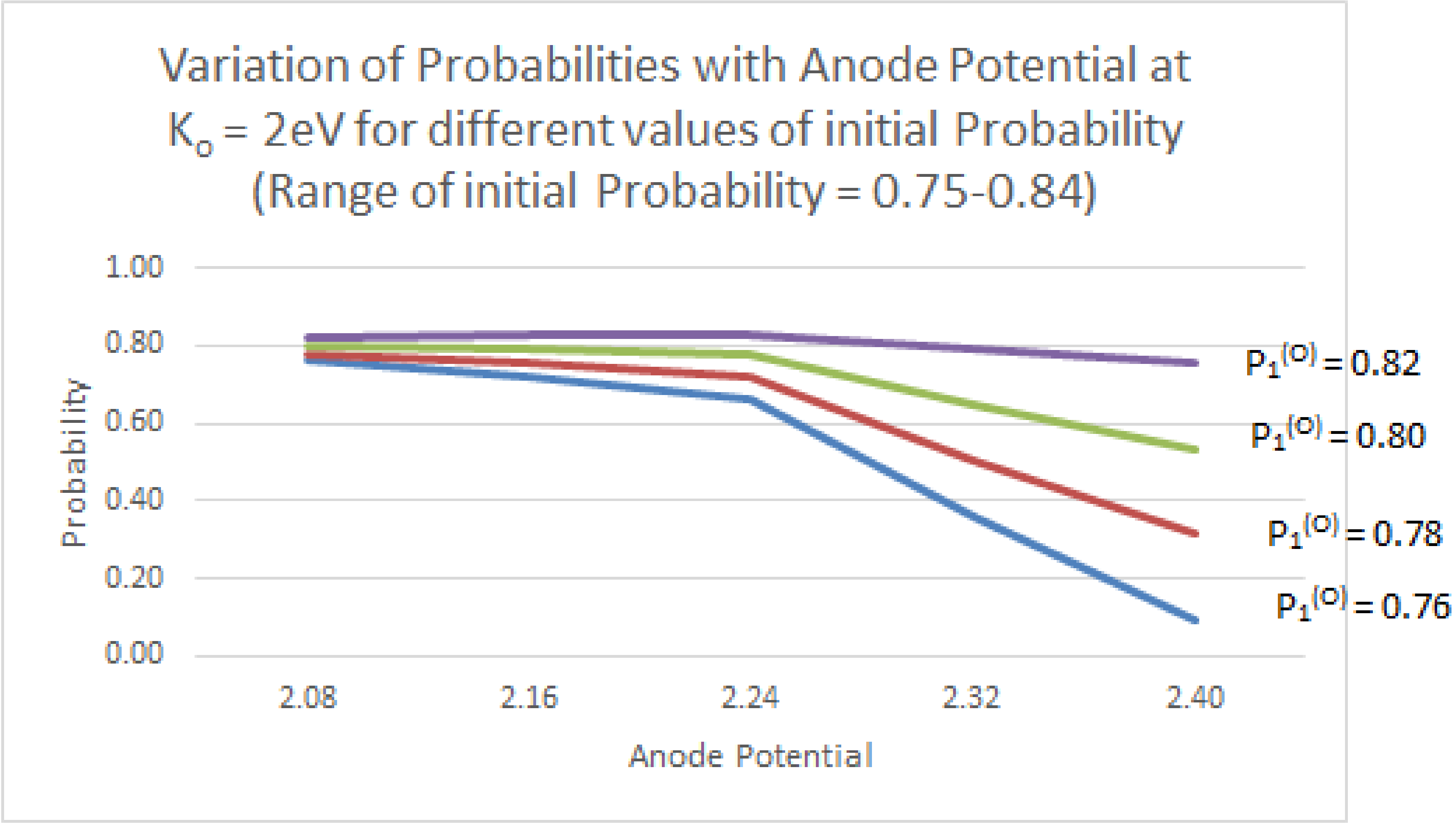
Variation of Probabilities with Anode Potential at
K₀ = 0 for different values of initial Probability
(Range of initial Probability = 0.38-0.47)
1.00
0.80
0.60
0.40
0.20
0.00
Probability
2.08
2.16
2.24
2.32
2.40
Anode Potential
P1(O) = 0.45
P1(O) = 0.43
P1(O) = 0.41
P1(O) = 0.39

At K_o = 1eV



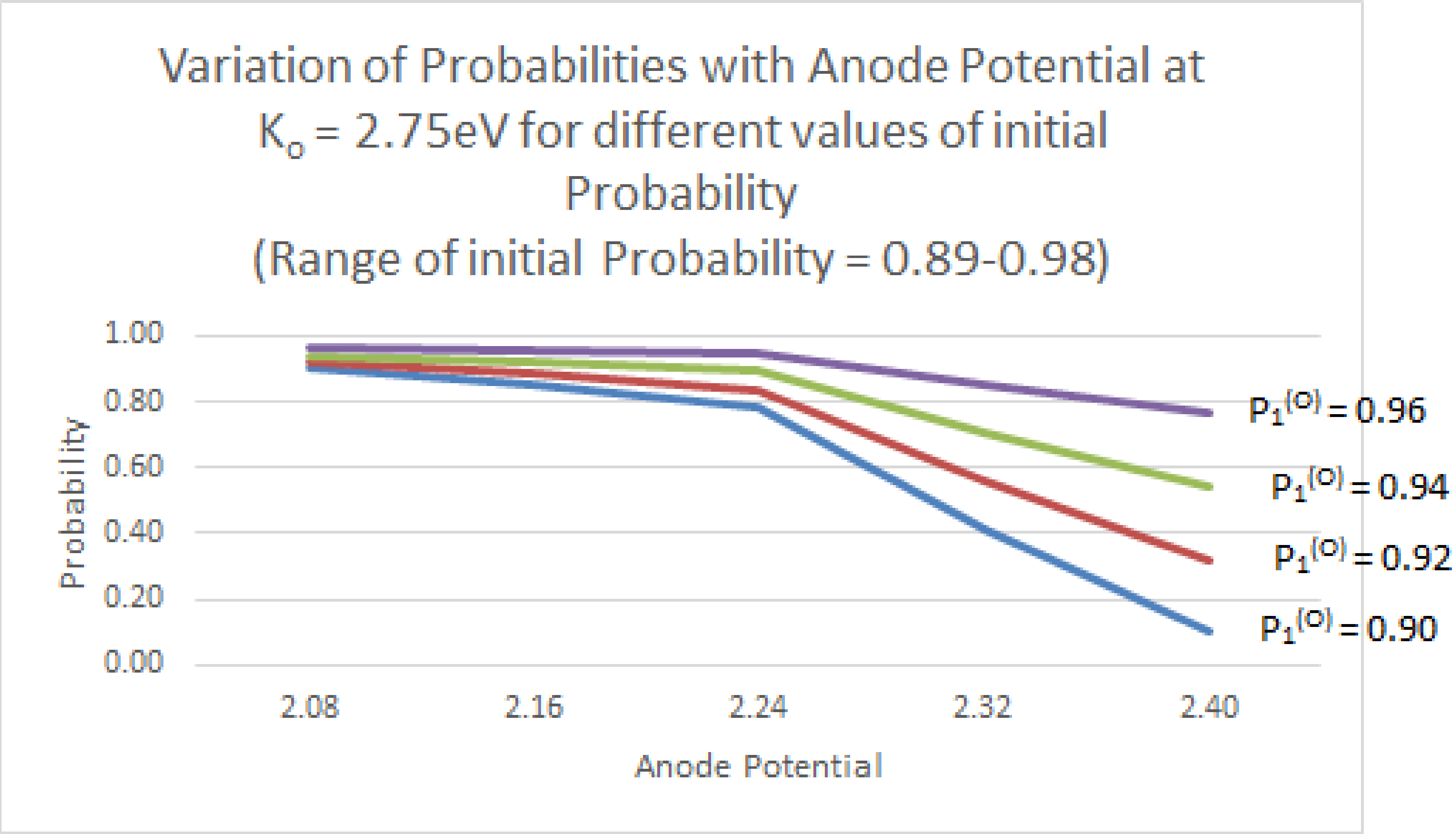
Variation of Probabilities with Anode Potential at
K_o = 1eV for different values of initial Probability
(Range of initial Probability = 0.57-0.66)
1.00
0.80
0.60
0.40
0.20
0.00
Probability
2.08
2.16
2.24
2.32
2.40
Anode Potential
P1(O) = 0.64
P1(O) = 0.62
P1(O) = 0.60
P1(O) = 0.58

At K_o = 2eV



Variation of Probabilities with Anode Potential at
K_o = 2eV for different values of initial Probability
(Range of initial Probability = 0.75-0.84)
1.00
0.80
0.60
0.40
0.20
0.00
Probability
2.08
2.16
2.24
2.32
2.40
Anode Potential
$P_1^{(O)} = 0.82$
$P_1^{(O)} = 0.80$
$P_1^{(O)} = 0.78$
$P_1^{(O)} = 0.76$

At $K_o = 2.75eV$


Variation of Probabilities with Anode Potential at
K_o = 2.75eV for different values of initial
Probability
(Range of initial Probability = 0.89-0.98)
1.00
0.80
0.60
0.40
0.20
0.00
Probability
2.08
2.16
2.24
2.32
2.40
Anode Potential
P_1^(O) = 0.96
P_1^(O) = 0.94
P_1^(O) = 0.92
P_1^(O) = 0.90