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Electron Yield Properties of Low-Density Polyethylene

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Electron Yield of Low-Density Polyethylene

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Special Thanks

USU Materials Physics Group
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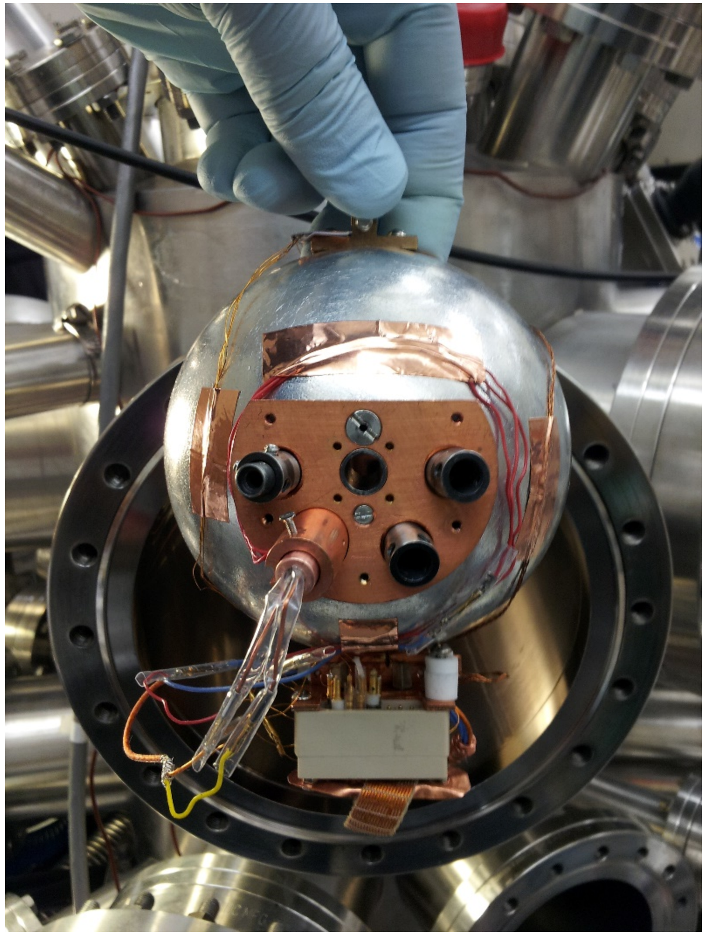
Abstract

At extremely high altitudes, spacecraft are submitted to solar radiation of varying ion flux. The radiation can induce spacecraft charging, creating unwanted effects on electrical components. The electron yield—the ratio of the number of emitted electrons to incident electrons—is a key material property that characterizes how materials will charge due to exposure to electron fluxes seen in solar radiation. The property can be researched by submitting material to electron bombardment of varying energy, within a high vacuum environment. This study focuses on a structurally simplistic polymer known as Low-Density Polyethylene (LDPE). A very interesting candidate for insulation of spacecraft equipment due to its low conductivity, chemical resistivity, and its high negative electron affinity.

HGRFA



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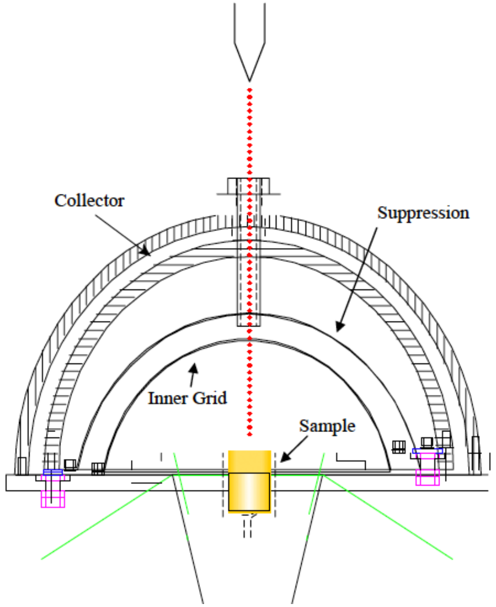

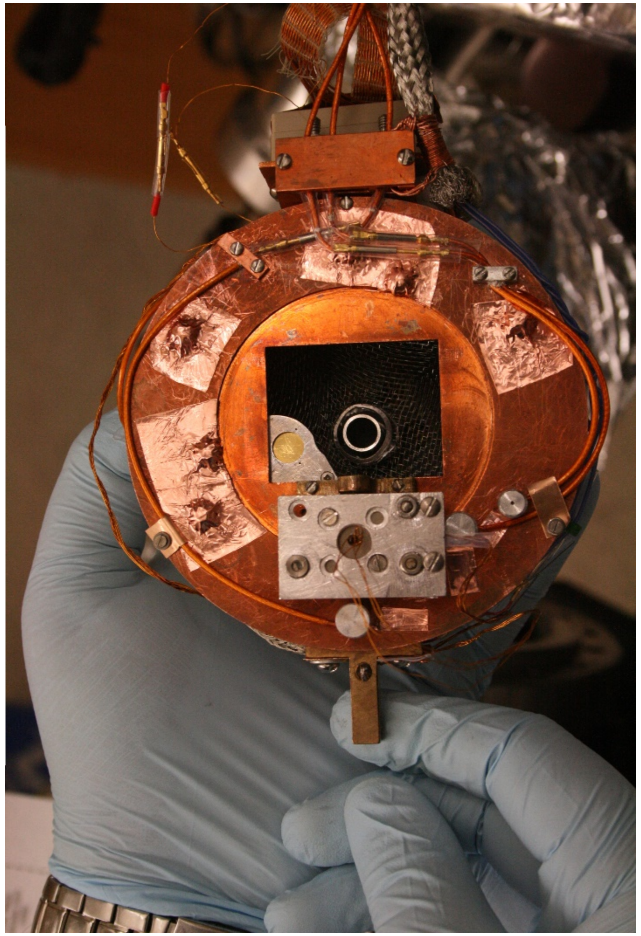

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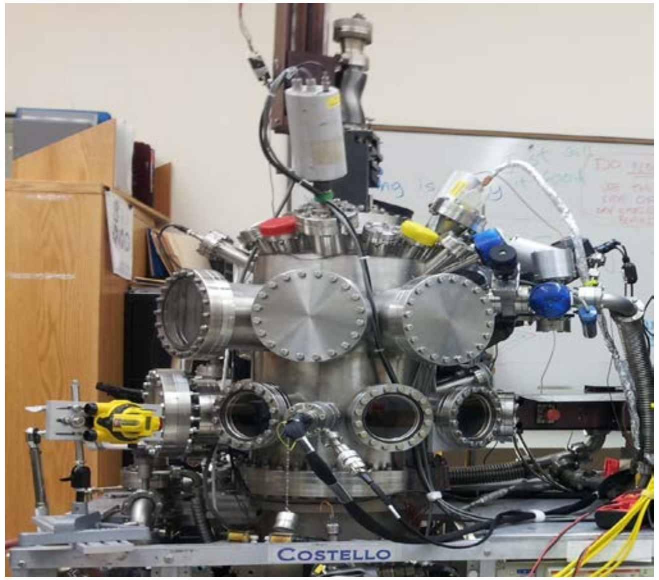
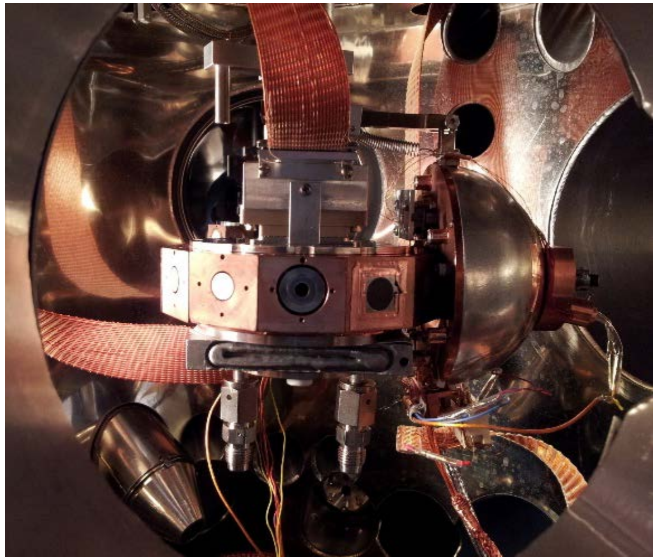
Pulsed / DC Yield



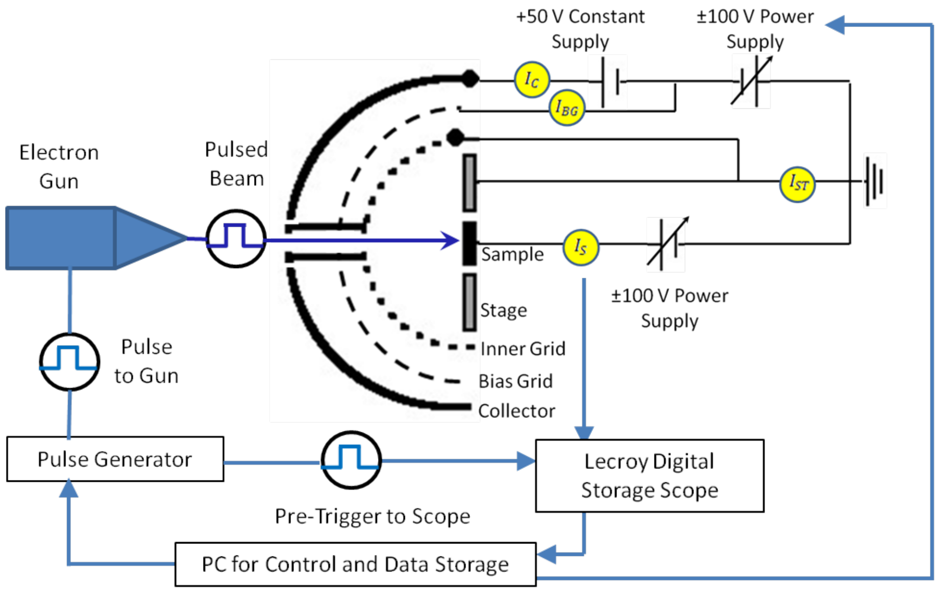


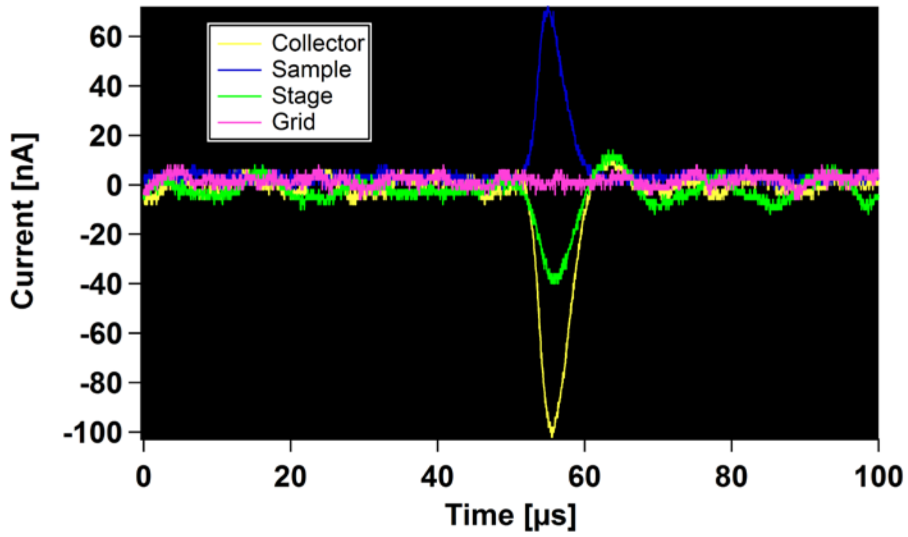
- Tank Pressure (10^{-7} Torr – 10^{-9} Torr)
- STAIB Gun (10 eV – 5 keV)
- HEED Gun (5 keV – 30 keV)

- Conductors
  - No difference between Pulsed and DC measurements

- Insulators
  - Embedded charge
  - Difference between Pulsed and DC measurements
  - Flooding (UV LED & Flood Gun)

Pulsed Backscattered and Secondary Yield Measurements





Charges

$$Q_{incident} = Q_{sample} + Q_{collector} + Q_{Grid} + Q_{stage}$$
$$Q_{emitted} = Q_{collector} + Q_{Grid} + Q_{stage}$$

Currents

$$(TEY)\ \sigma = \frac{Q_{emit}}{Q_{incident}} = \frac{\int [I_{collector} + I_{grid} + I_{stage}]\ dt}{\int [I_{sample} + I_{collector} + I_{grid} + I_{stage}] dt}$$

$$(BSEY)\ \eta = \frac{Q_{emit}}{Q_{incident}} = \frac{C \int I_{collector}\, dt}{\int [I_{sample}+I_{collector}+I_{grid}+I_{stage}]\ dt}$$

(SEY) $\delta = \sigma - \eta$

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Simple 1D Yield Model Fitting Functions

SEY Yield Model

1D SEY Model

$$\delta(E_0) = {E_0}^{m-n} / 2 \cdot \varepsilon \cdot \gamma \left(1 - e^{-\gamma \cdot {E_0}^{n}}\right)$$

Parameters:

m- left slop on a log graph

(m-n)- right slope on a log graph

ε- vertical shift of left side on a log graph

γ- vertical shift of right side on a log graph

BSEY Yield Model

BSEY 3Param Fit

$$\eta(E_0) = \begin{cases} 0 & if\ E_0 \leq 50\ eV \\ \dfrac{\log\left(E_0/50\ eV\right)}{\log\left(E_{max}/50\ eV\right)} \cdot \left[(\eta_{max} - \eta_0) \cdot e^{\frac{-(E_0 - E_{max})}{E_{max}}} + \eta_0\right] & if\ 50\ eV < E_0 \leq E_{max} \\ \left[(\eta_{max} - \eta_0) \cdot e^{\frac{-(E_0 - E_{max})}{E_{max}}} + \eta_0\right] & if\ E_{max} < E_0 \end{cases}$$

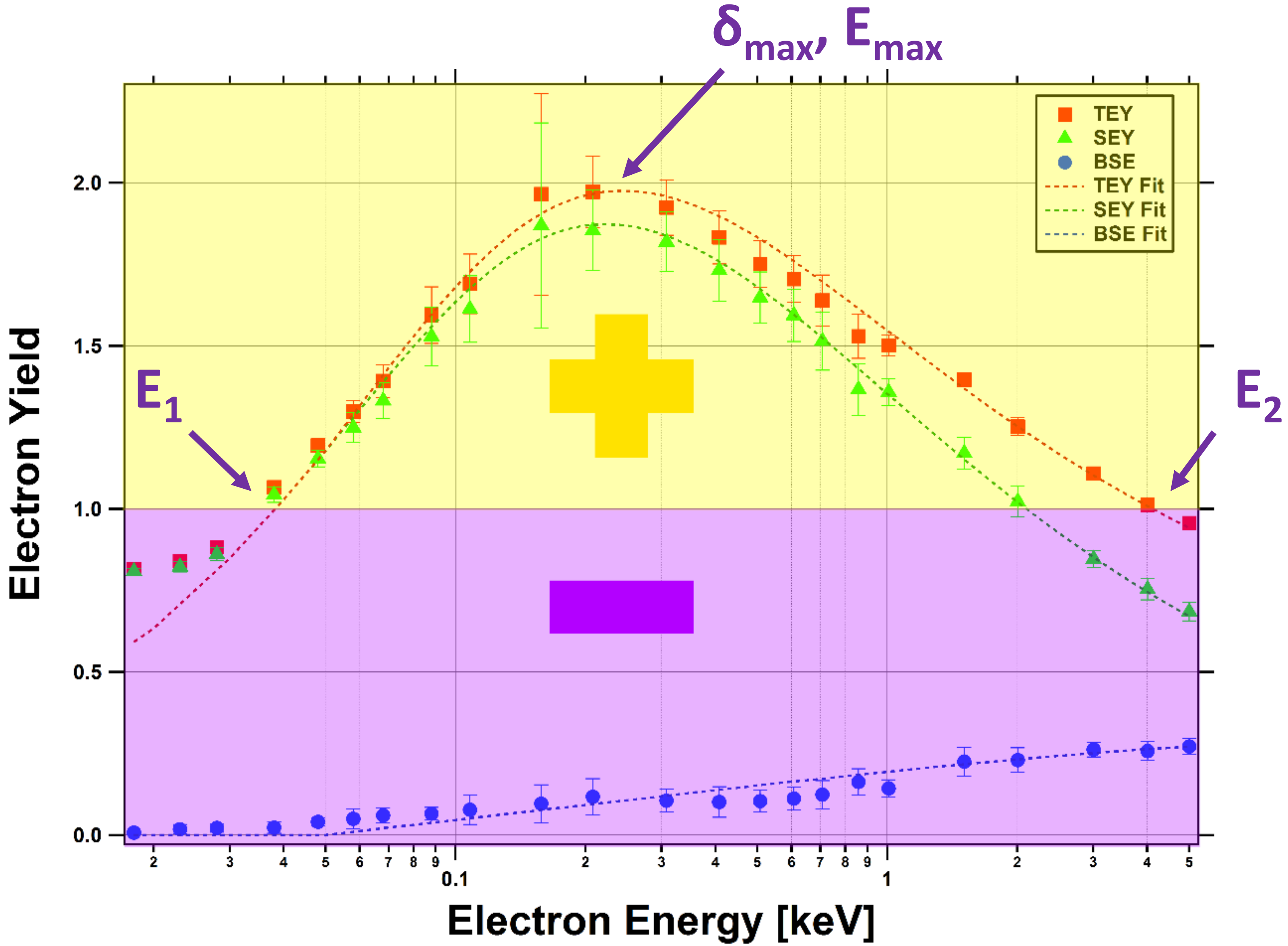
Parameters

E_{max}- energy of max BSEY

η_{max}- maximum BSEY

η_0- asymptotic BSEY for large incident energies.

Tungsten Pulsed Yield



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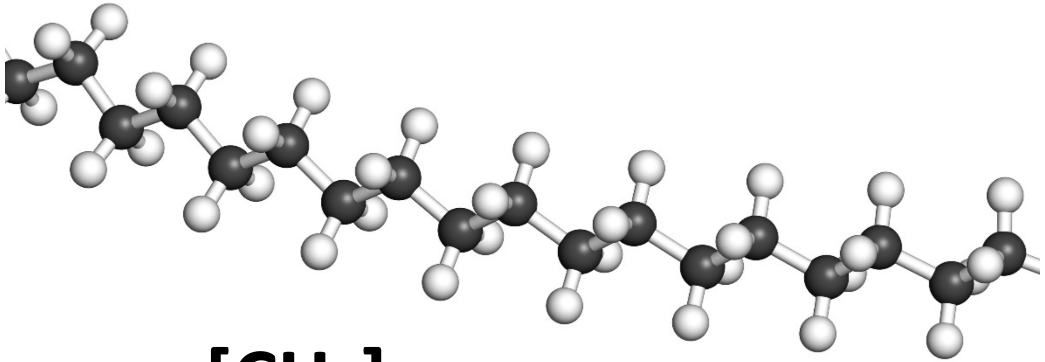
LDPE

- High material resilience
- High chemical resistance
  - Acids
  - Bases
- Range of uses
  - Industrial packaging
  - Laboratory bottles
  - Insulator for electrical equipment on satellites



$-[CH_2]_n-$

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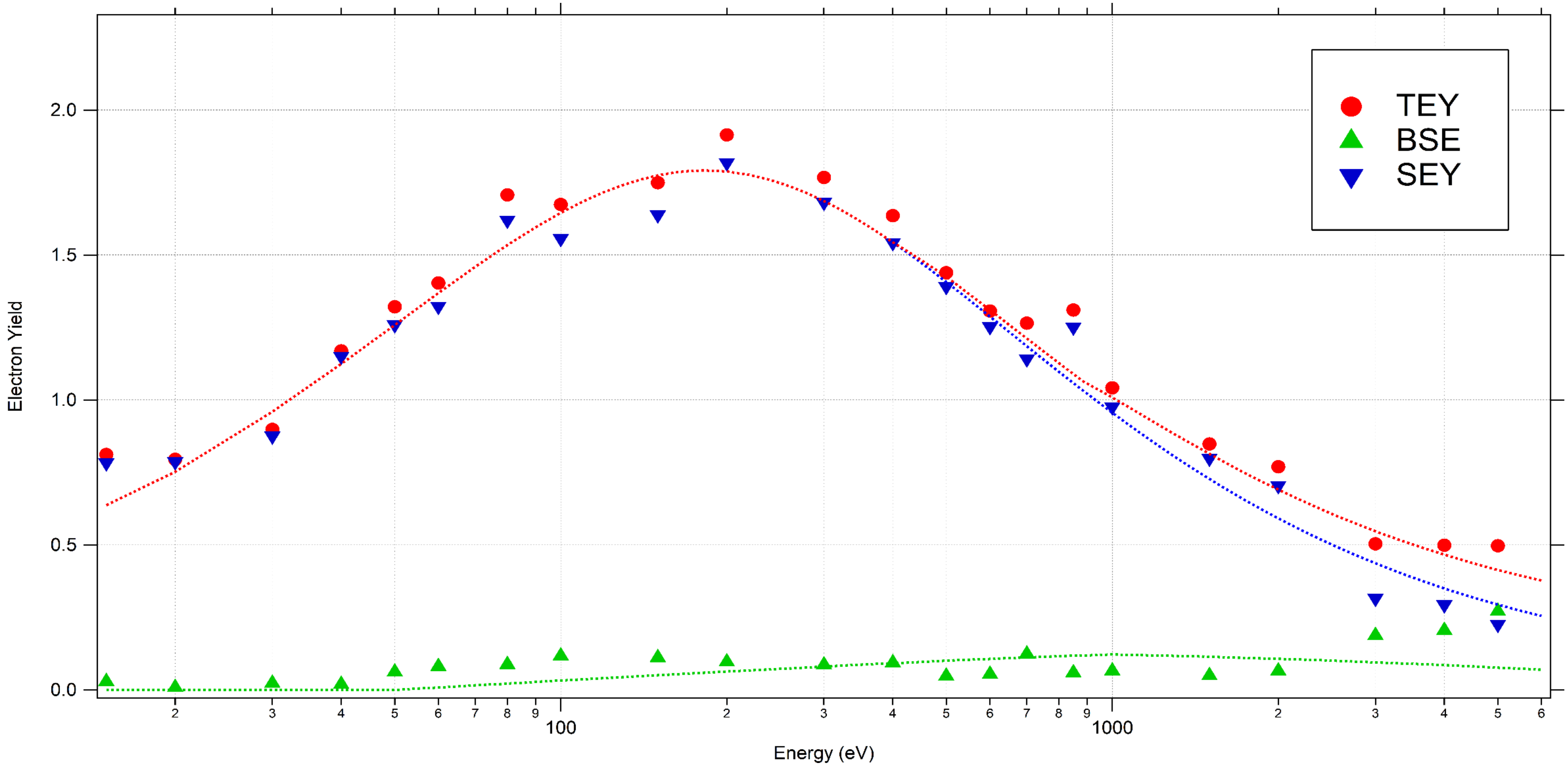
LDPE (Graph)



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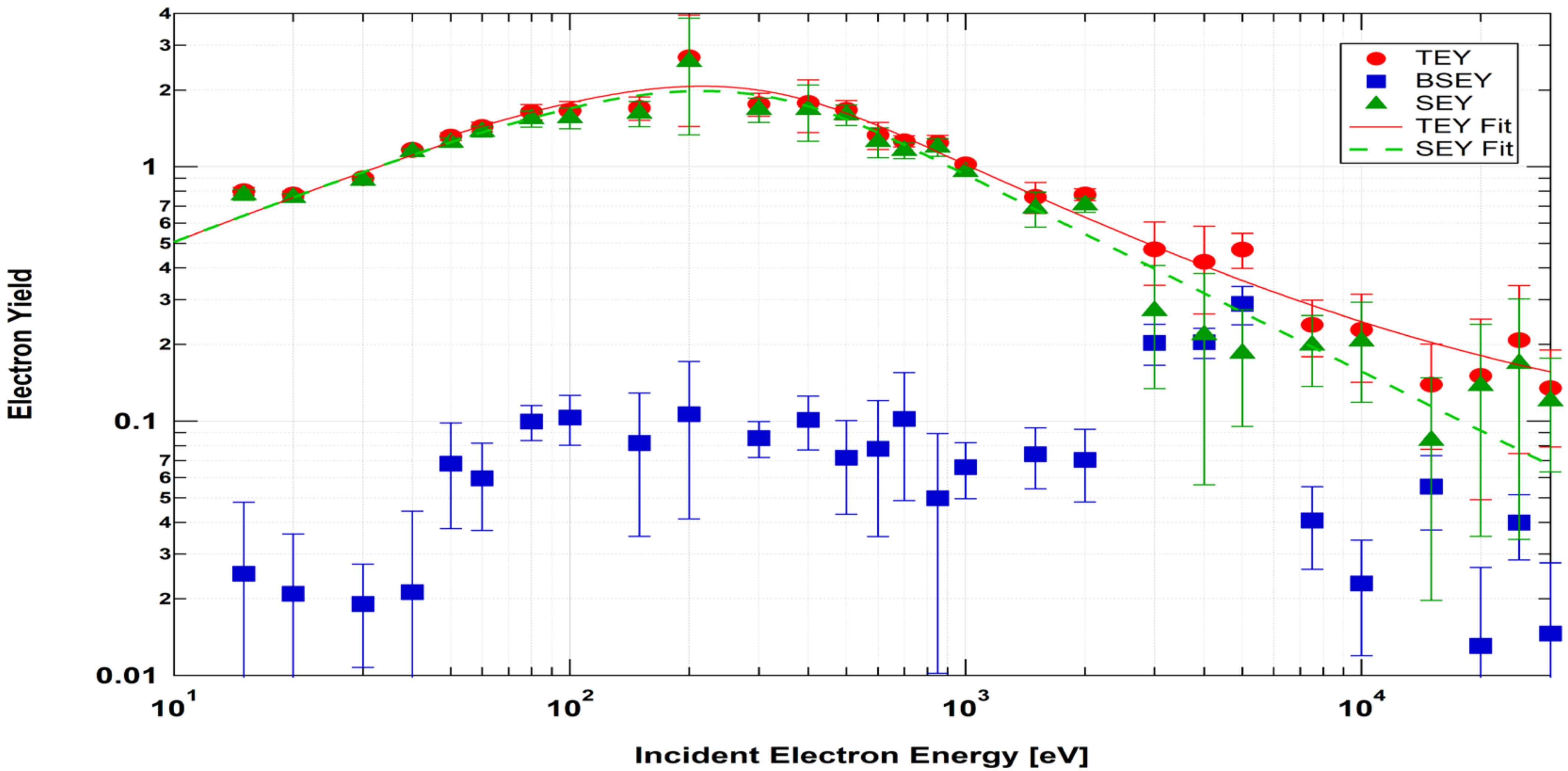
LDPE (Graph)



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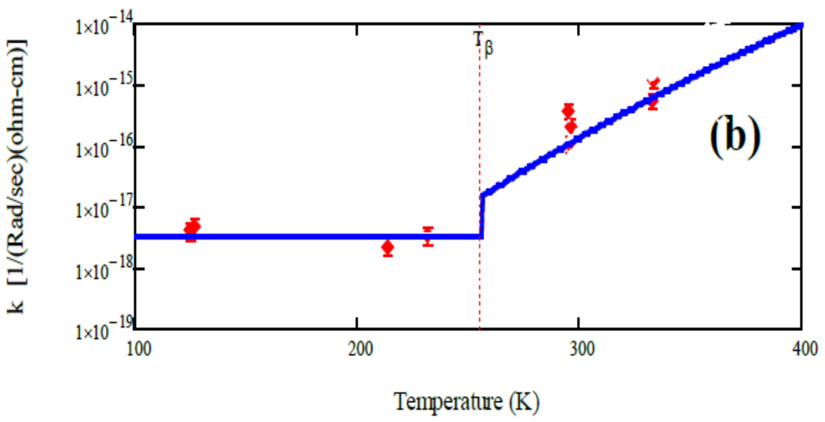
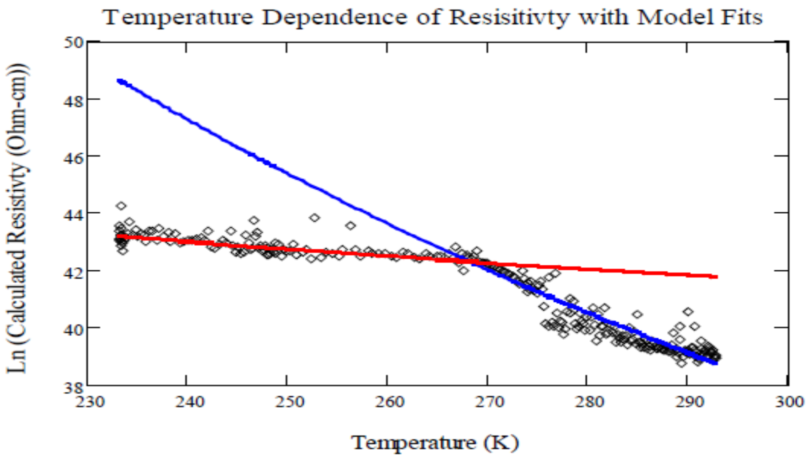
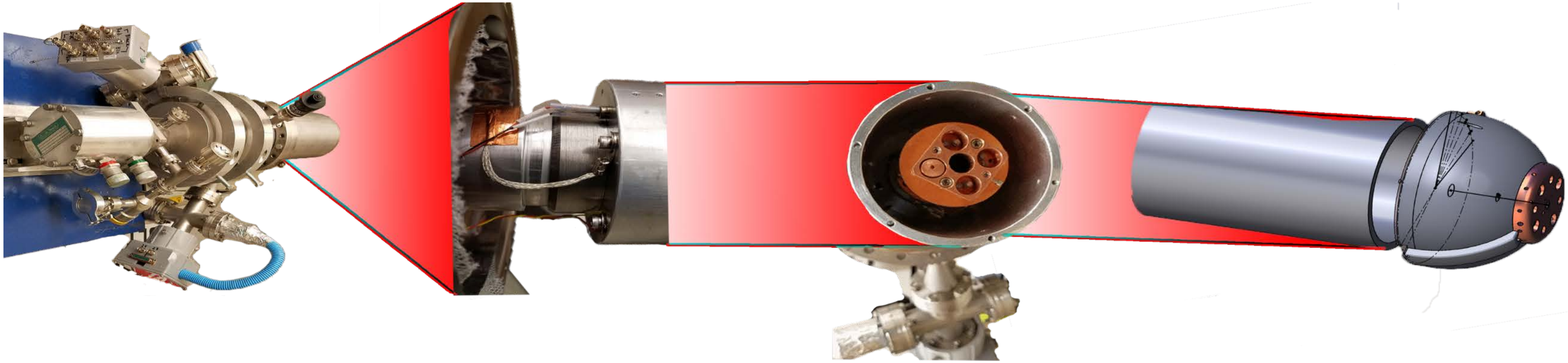
Next step for LDPE



Radiation Induced Conductivity vs. T



Bulk Resistivity vs. T



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