





# ***Influence of the Electrons in Multipactor***

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***(2) Universitat de València, València, Spain.***

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***Friday, 21<sup>st</sup> November 2008***

***ECM'08 - Electron Cloud Mitigation Workshop***



European Organization for Nuclear Research

Influence of the Electrons in Multipactor

Cèsar Miquel-Espanya - ESA TEC-ETM

# Electron Control

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- Electron seeding mechanisms:
  - Radioactive source: High energy, continuous spectrum.
  - UV photoemission: Low energy, narrow (but not controllable) spectrum.
  - Regulated Electron Gun (REG): Electron energy and density controlled.

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- The radioactive sources need specially trained personnel for handling them.
- Special licenses and containers are also mandatory.
- The electrons that come out from sealed sources have a continuous spectrum with a high peak energy (MeV).
- An alternative, 'clean' mechanism based on photoelectrons is also presented here.

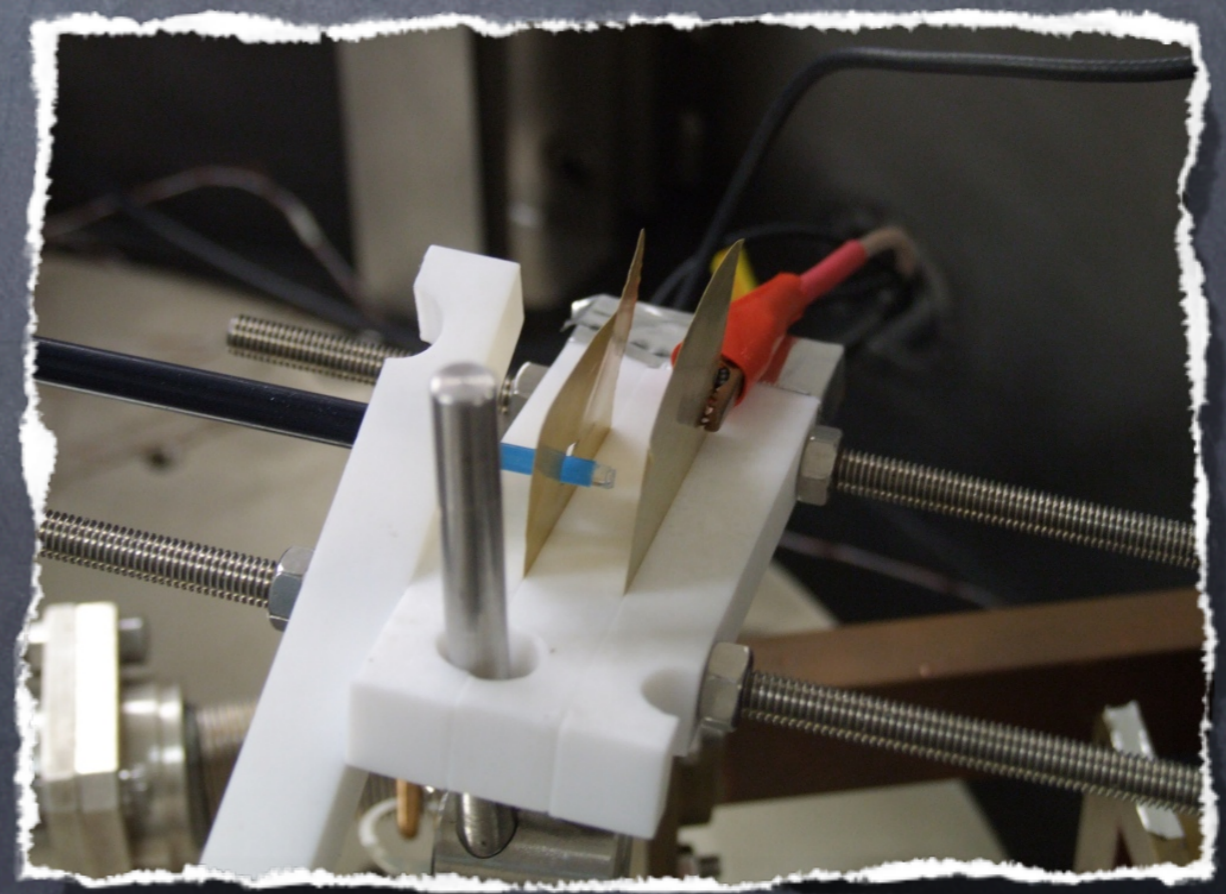
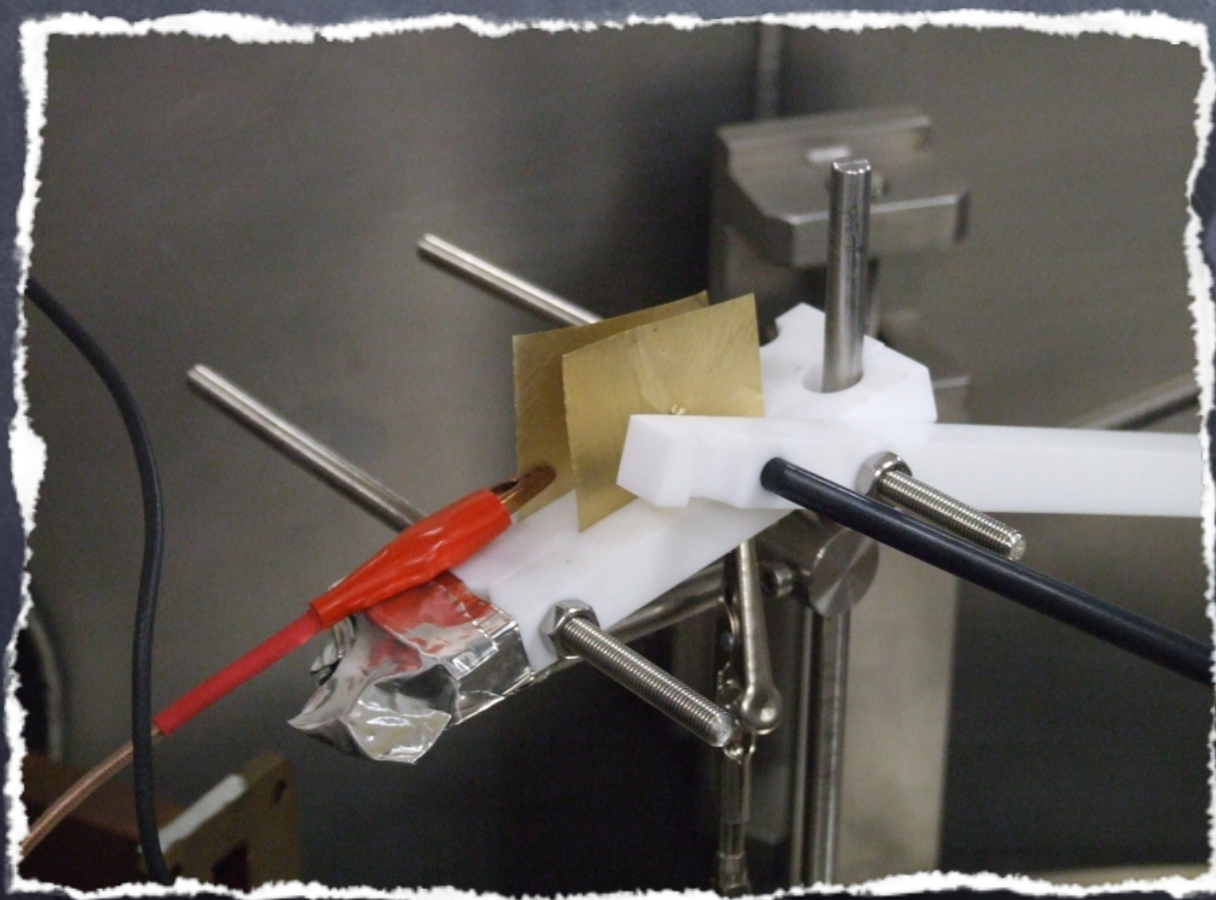
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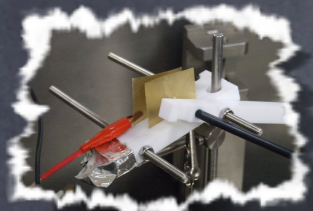
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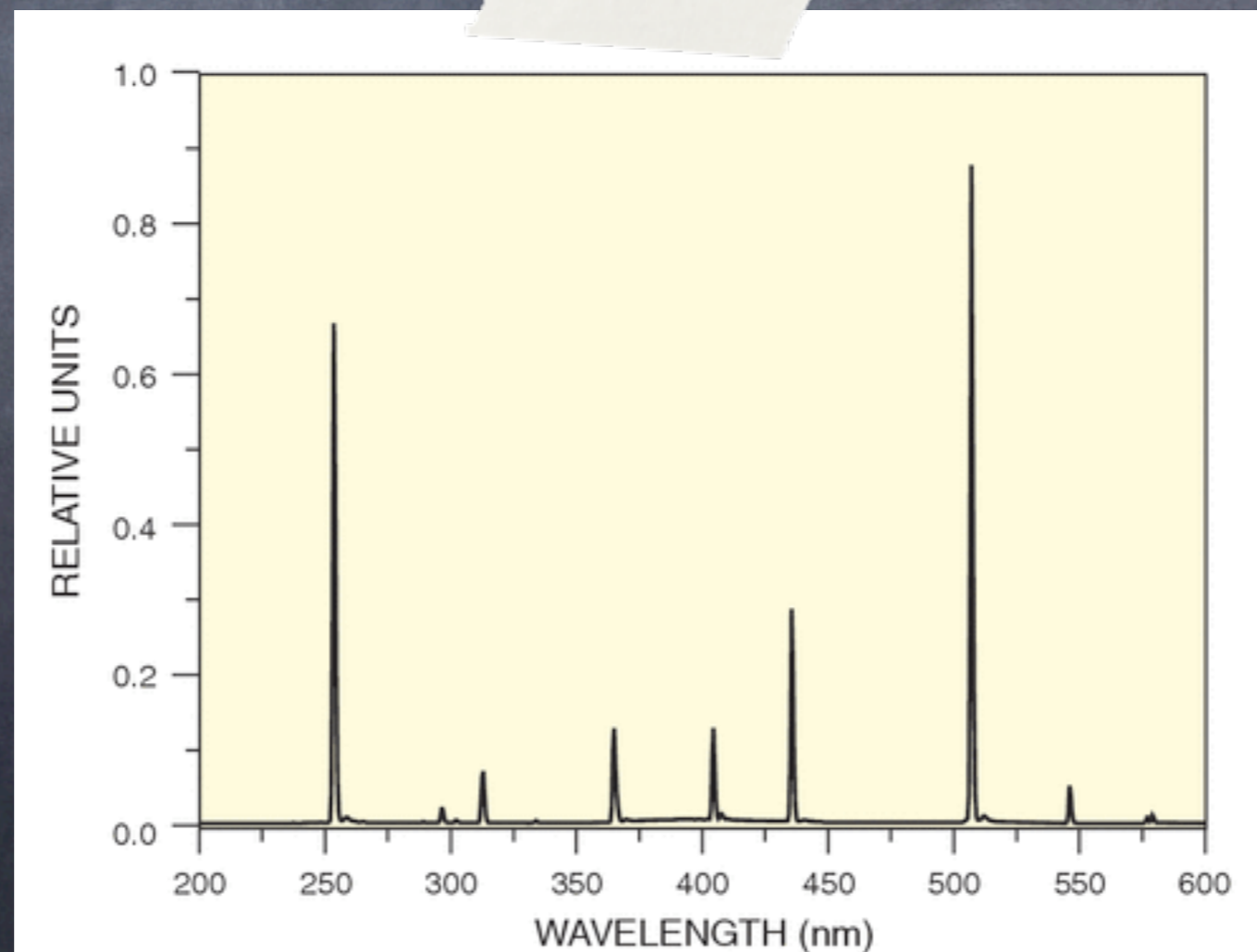
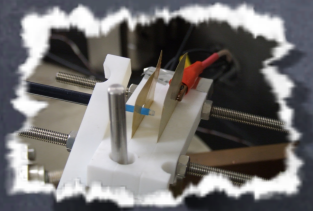
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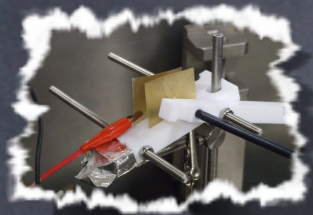
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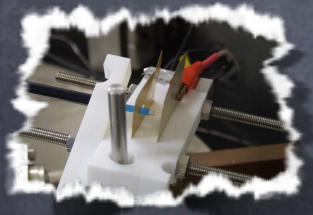
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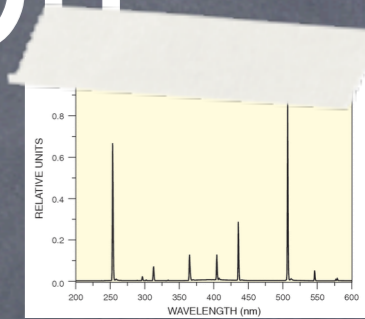
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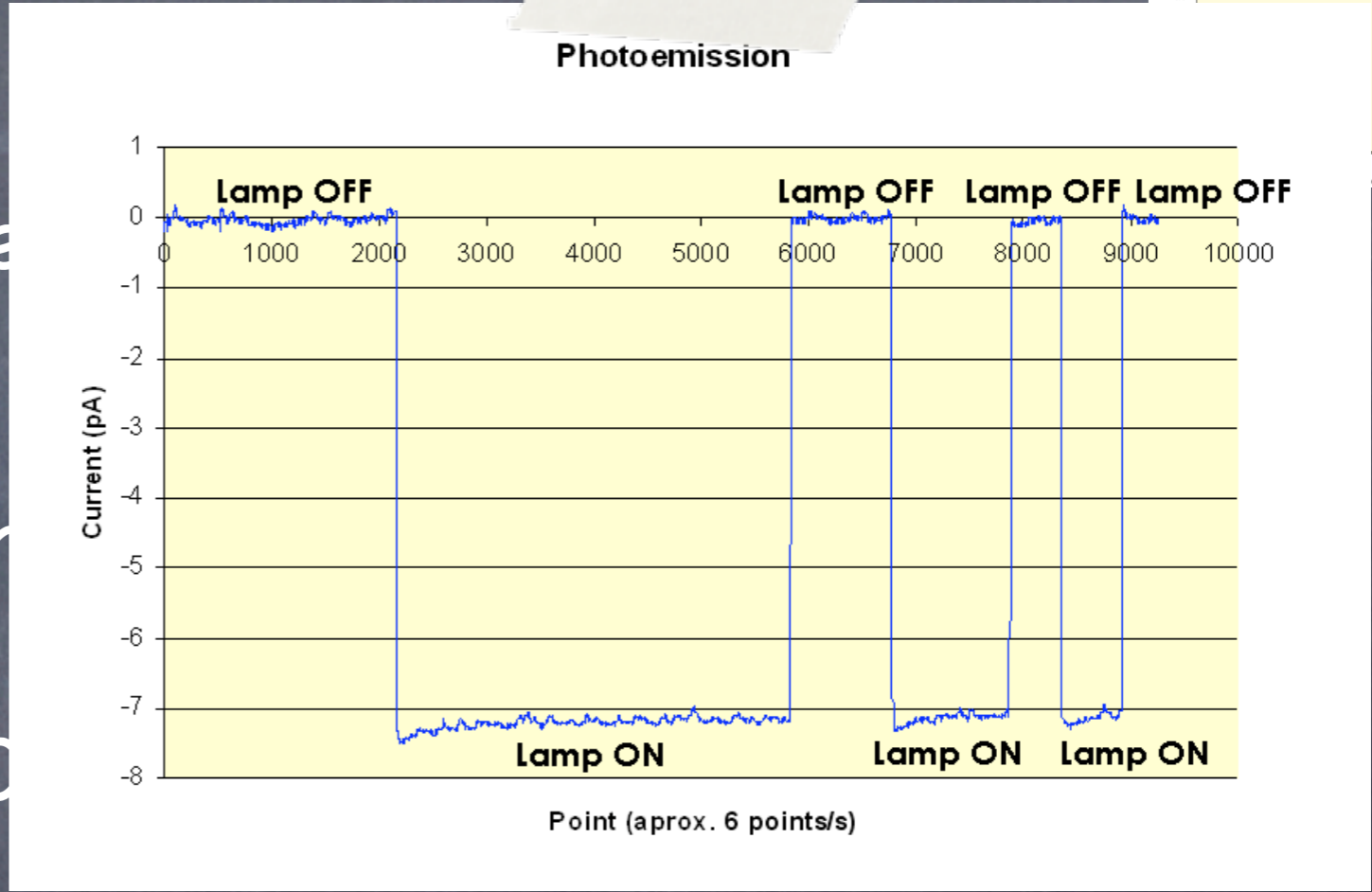
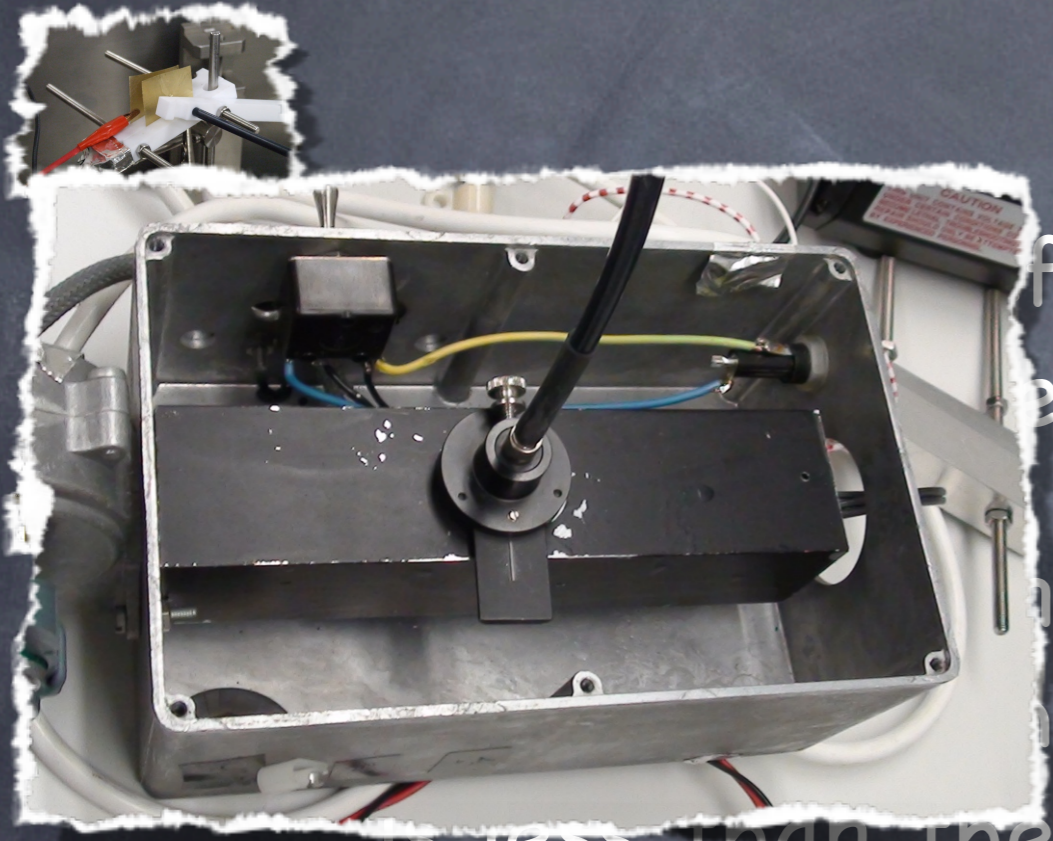
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- Relativistic/Non-relativistic treatment: The difference in the speed of the emitted electron is less than the 0.00004%.



# Photoemission Verification



Number of electrons generated:  $44 \cdot 10^6 \text{ e}^-/\text{s}$



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# Test Set-Up

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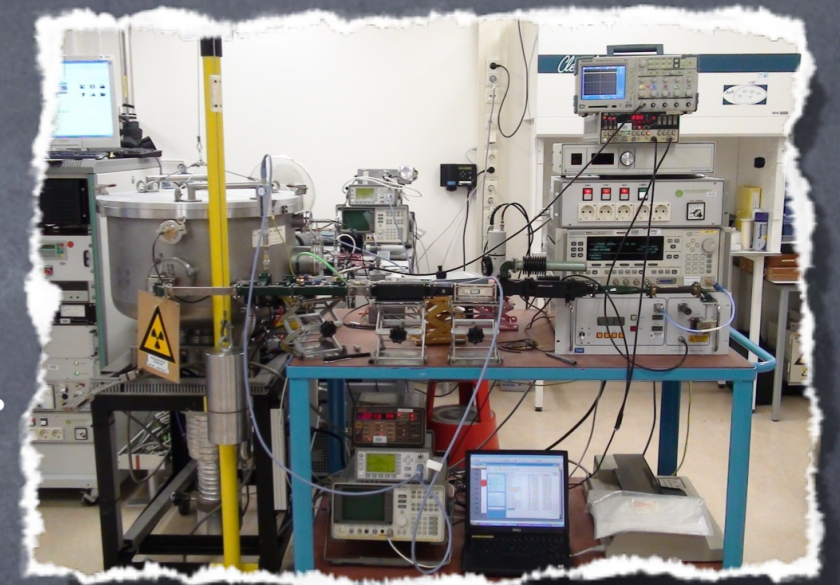
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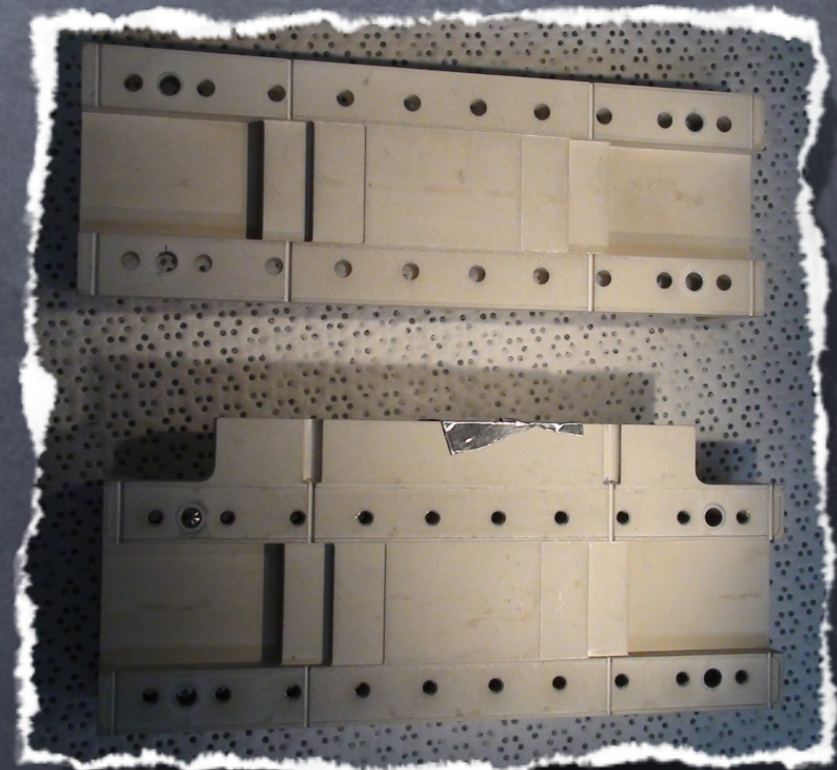
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  - Quartz optic fibers.
- Detection methods:
  - Nulling of the forward and reverse signals.
  - 3rd Harmonic.
  - Electrometer.
  - Pressure gauge variations.



# UV Test Samples

## UV Test Samples

- Two waveguide transformers with a 0.14 mm gap were tested in Ku-band.
  - All of them are made of aluminium and have a silver plating.
  - Sample A: No special treatment.
  - Sample B: Treated to alter the secondary emission yield (SEY).



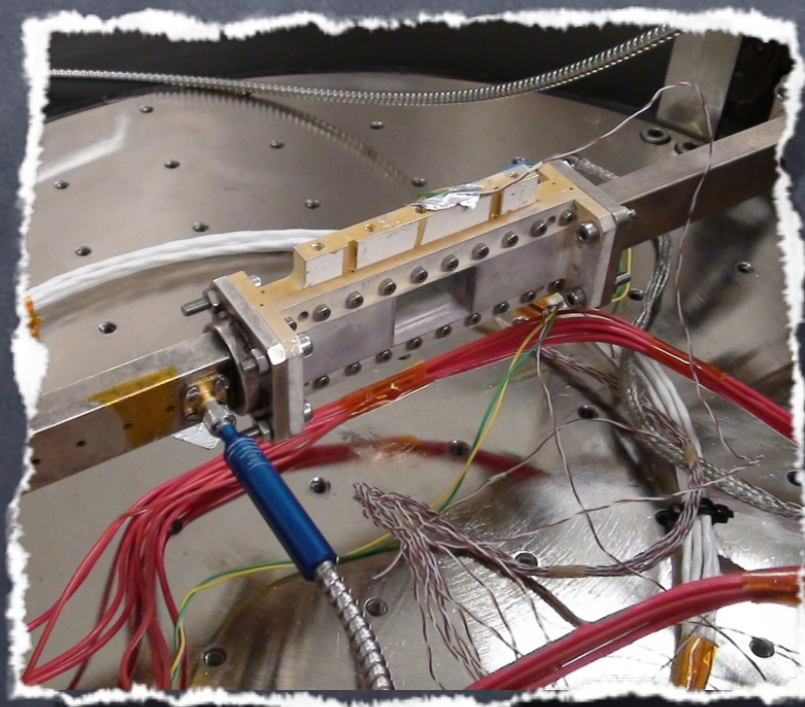
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# Multipactor Threshold

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- The tests (all at 11.8 GHz) were run in three different configurations: With a  $^{90}\text{Sr}$  radioactive source, UV and with no electron seeding.

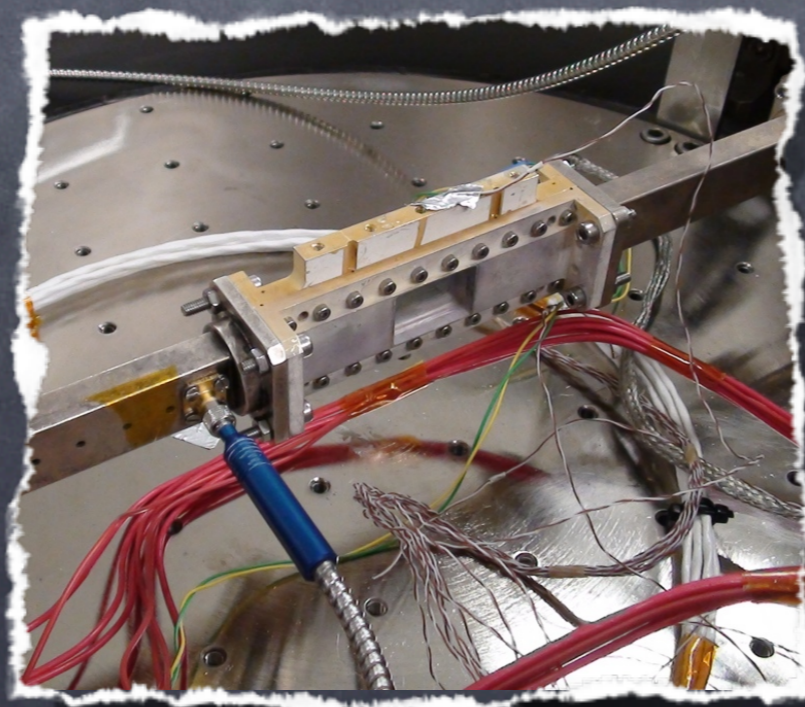




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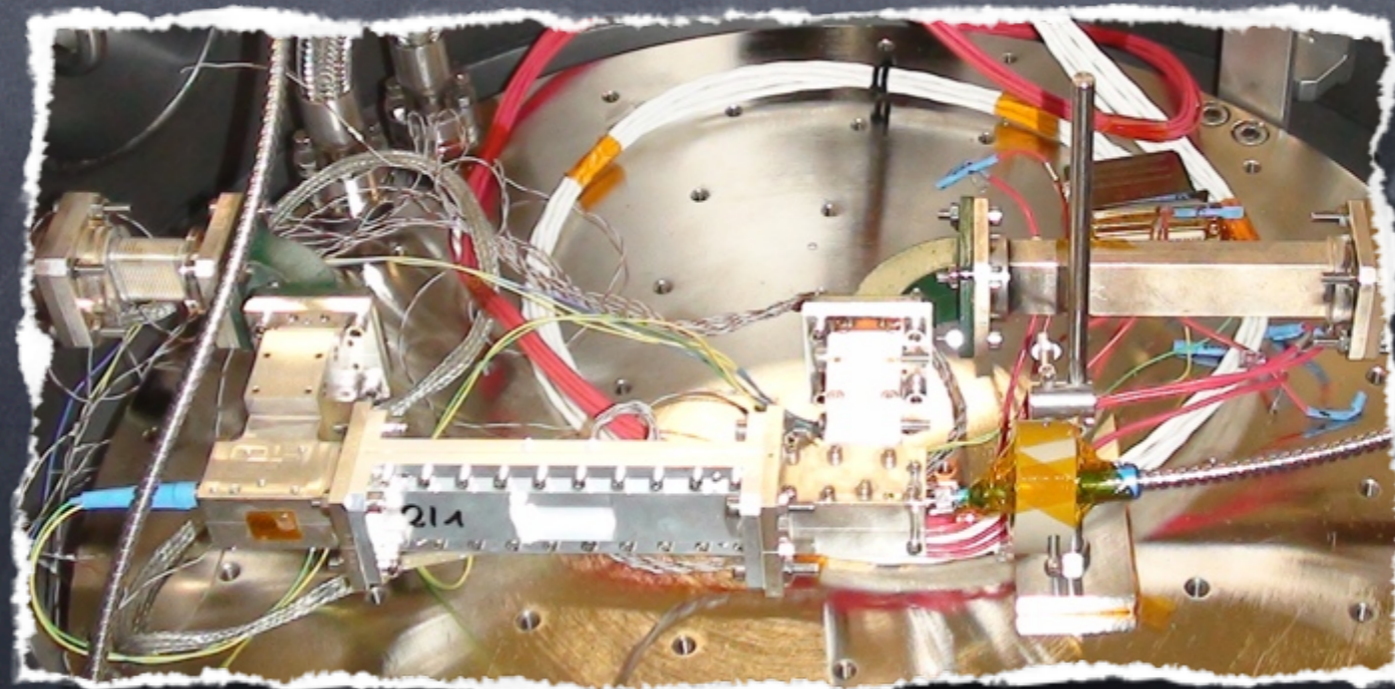
Sample	$^{90}\text{Sr}$	UV light	No electron seeding
A	700 W	800 W	1300 W
B	1100 W	1500 W	1800 W



# UV Light Orientation

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- The difference in the RF power threshold is related to the way we illuminate the DUT.
  - Using a pair of bends (from the Regulated Electron Gun set-up) we managed to illuminate the gap following the z-axis. Doing so, we recover the same RF power values as with the radioactive source.



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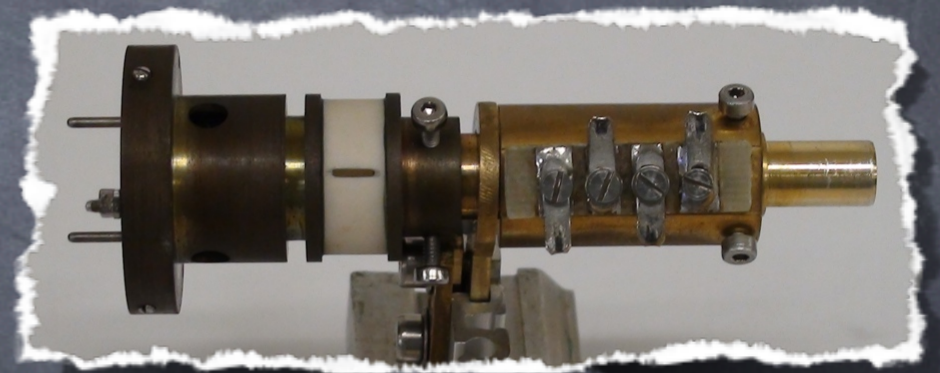
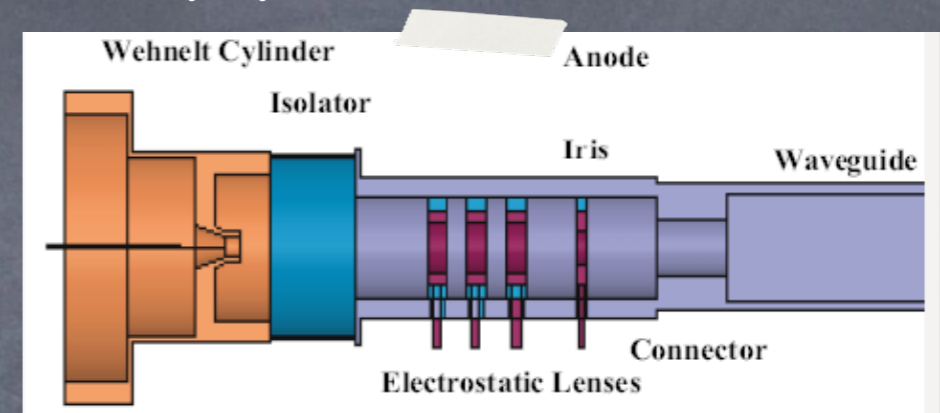
# The REG

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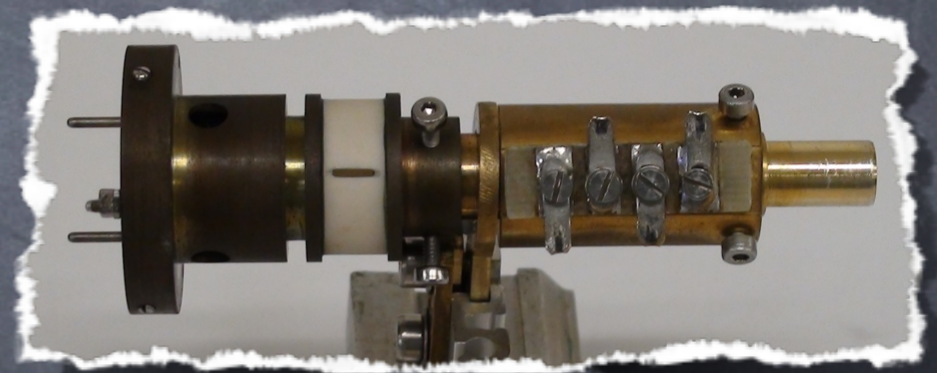
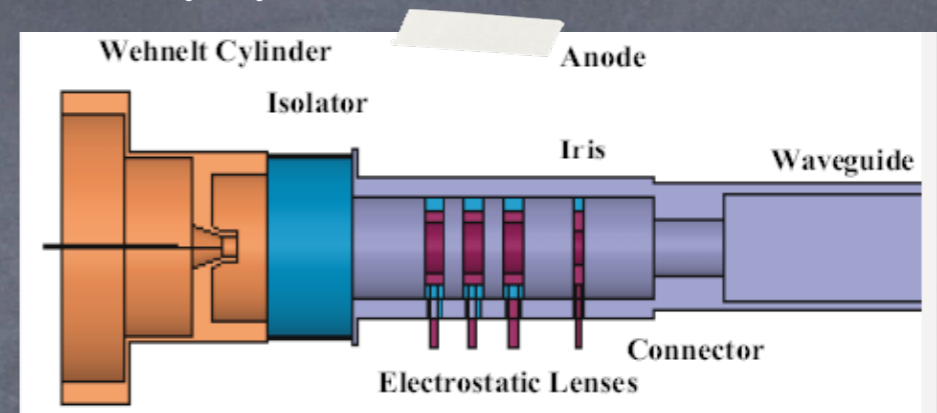
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- Developed by Tesat-Spacecom (D) under TRP ESA funding.
- Parts:
  - Tungsten filament.
  - Wehnelt cylinder.
  - Electrostatic lenses.
  - Iris.
  - Anode.



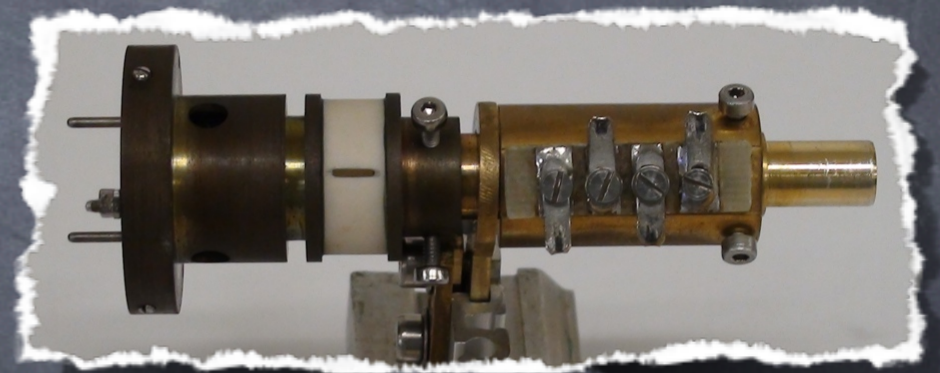
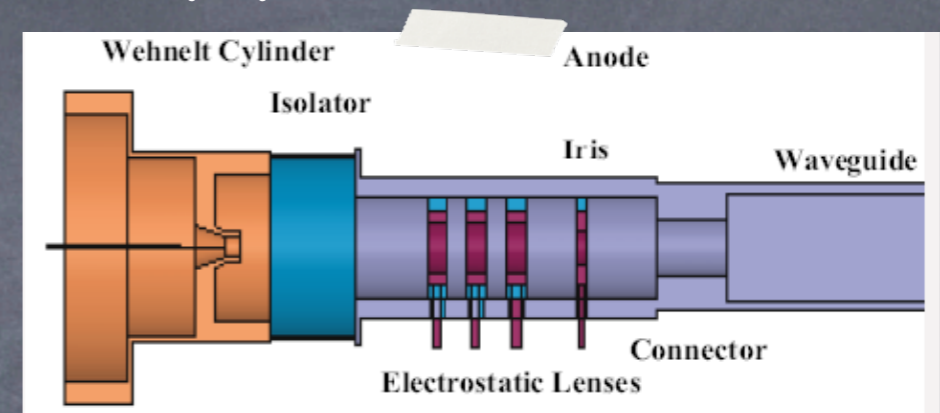
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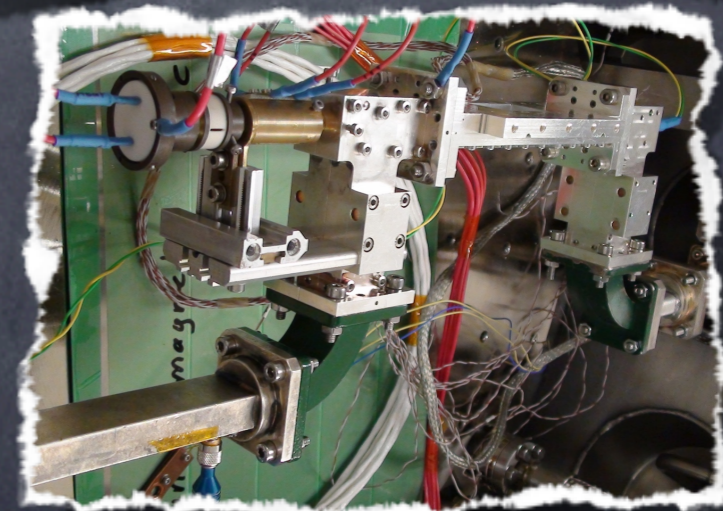
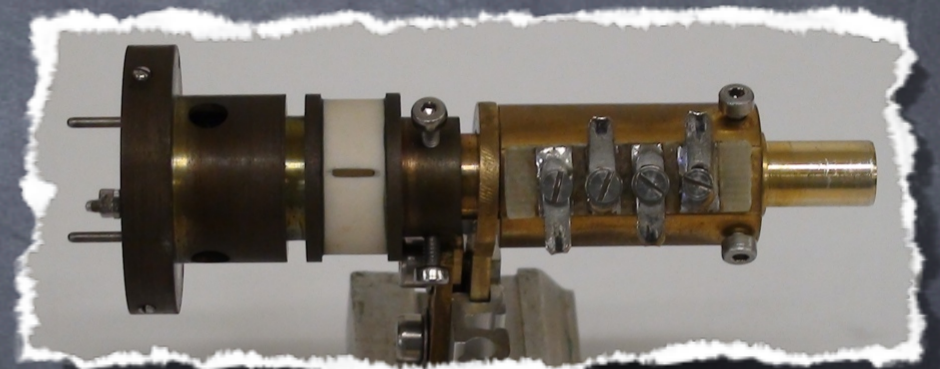
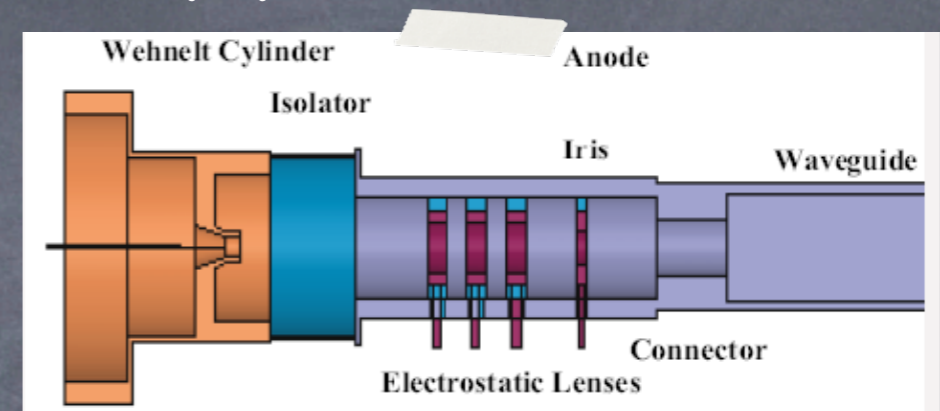
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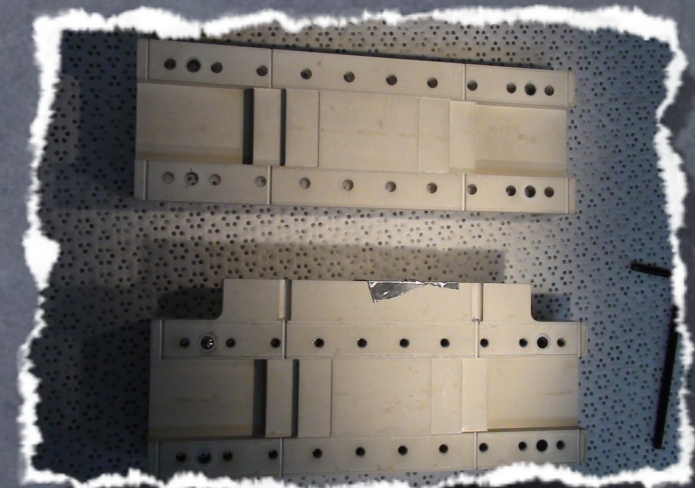
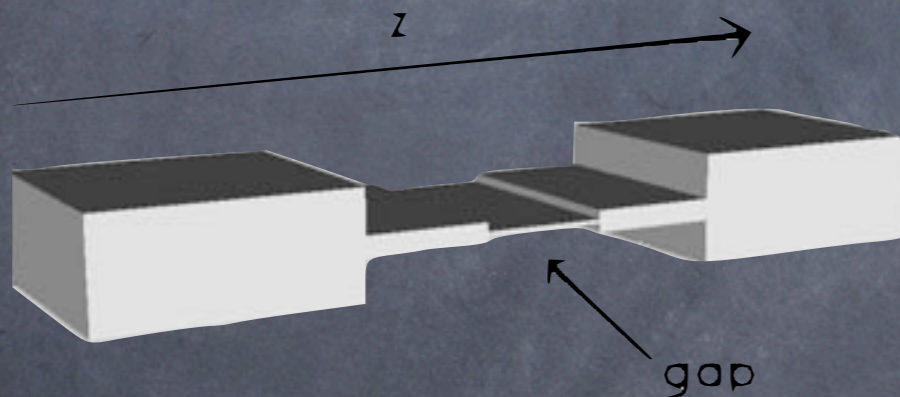
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- Electron energy adjustable from 20 to 1000 eV.
- Adjustable electron density.
- Point directly to the DUT.



# REG Test Sample

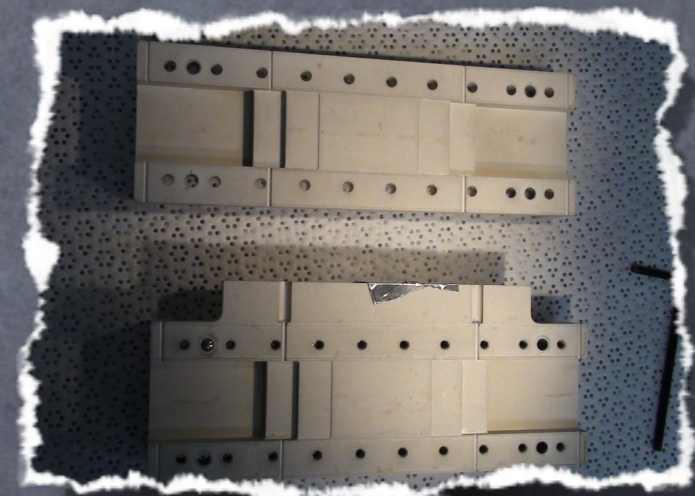
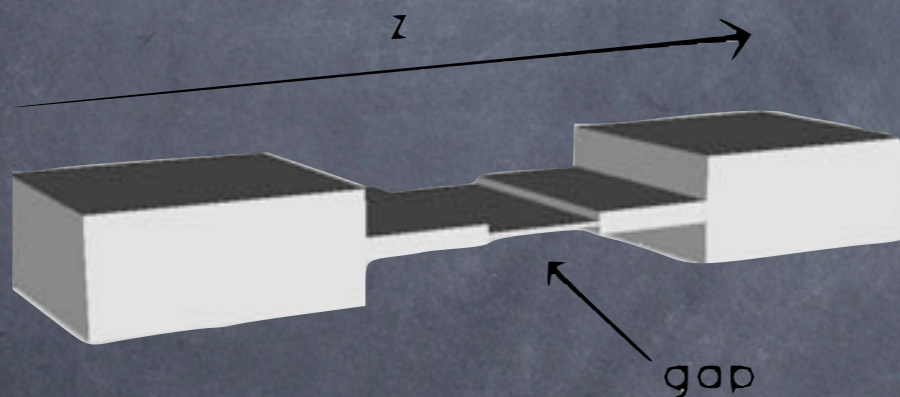
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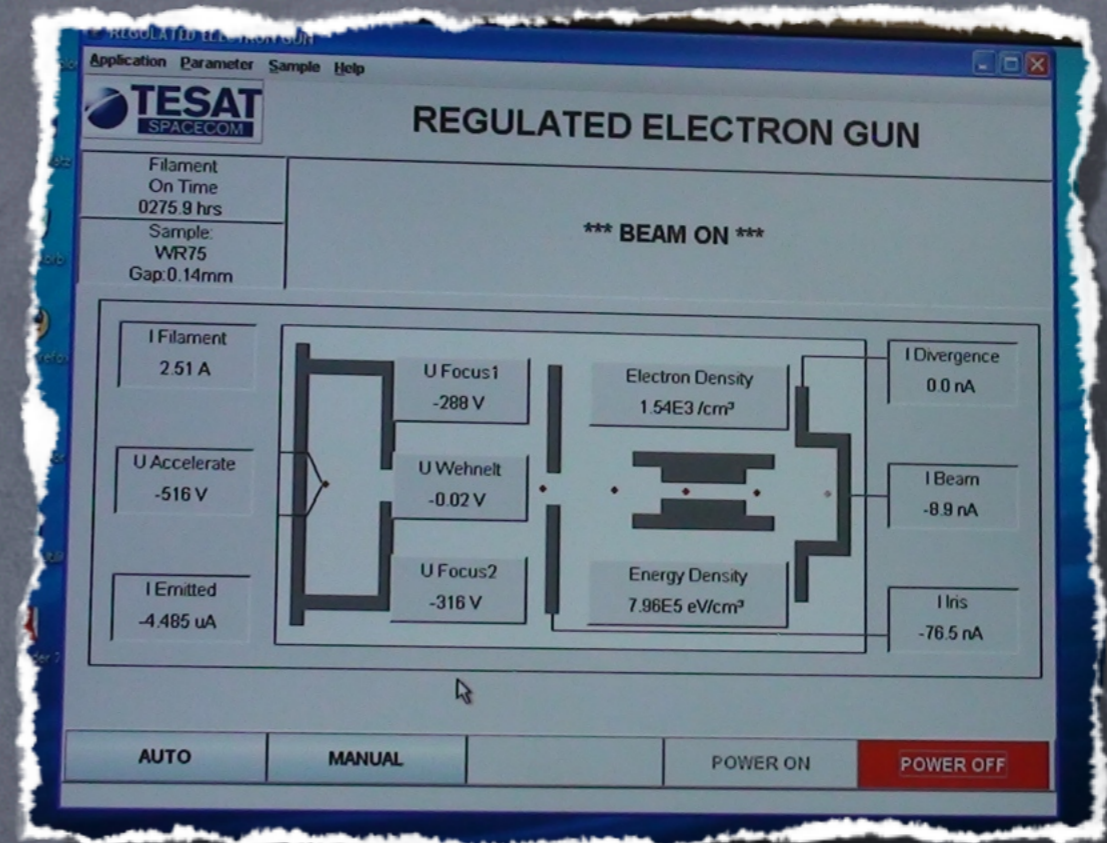


- The predicted multipactor RF power threshold using **FEST<sub>3D</sub>** was 700 W.

# REG Operation

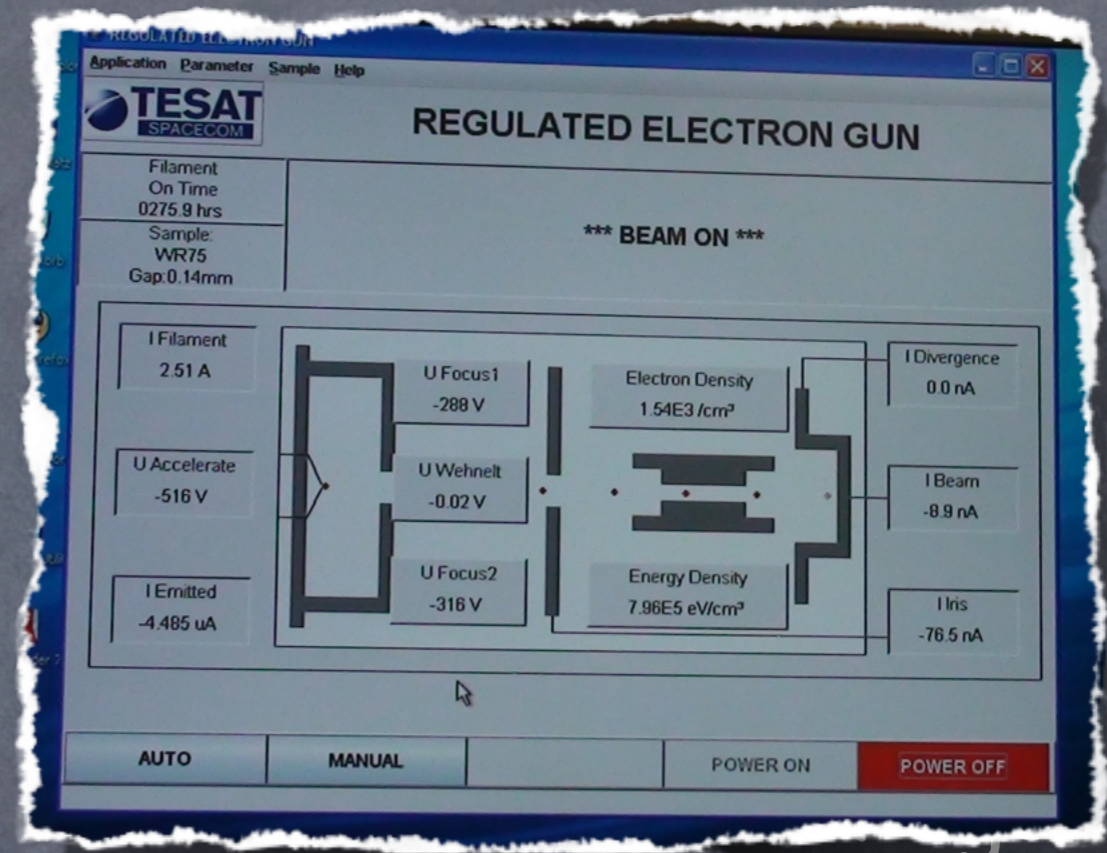
## REG Operation

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- Information:
  - Filament current.
  - Acceleration voltage.
  - Focus voltage.
  - Beam current.
  - Electron density.
  - Energy density.

# Tests



## Tests

- More than 60 multipactor tests in the same sample were performed varying the electron density and energy density ( $f=11.8$  GHz).

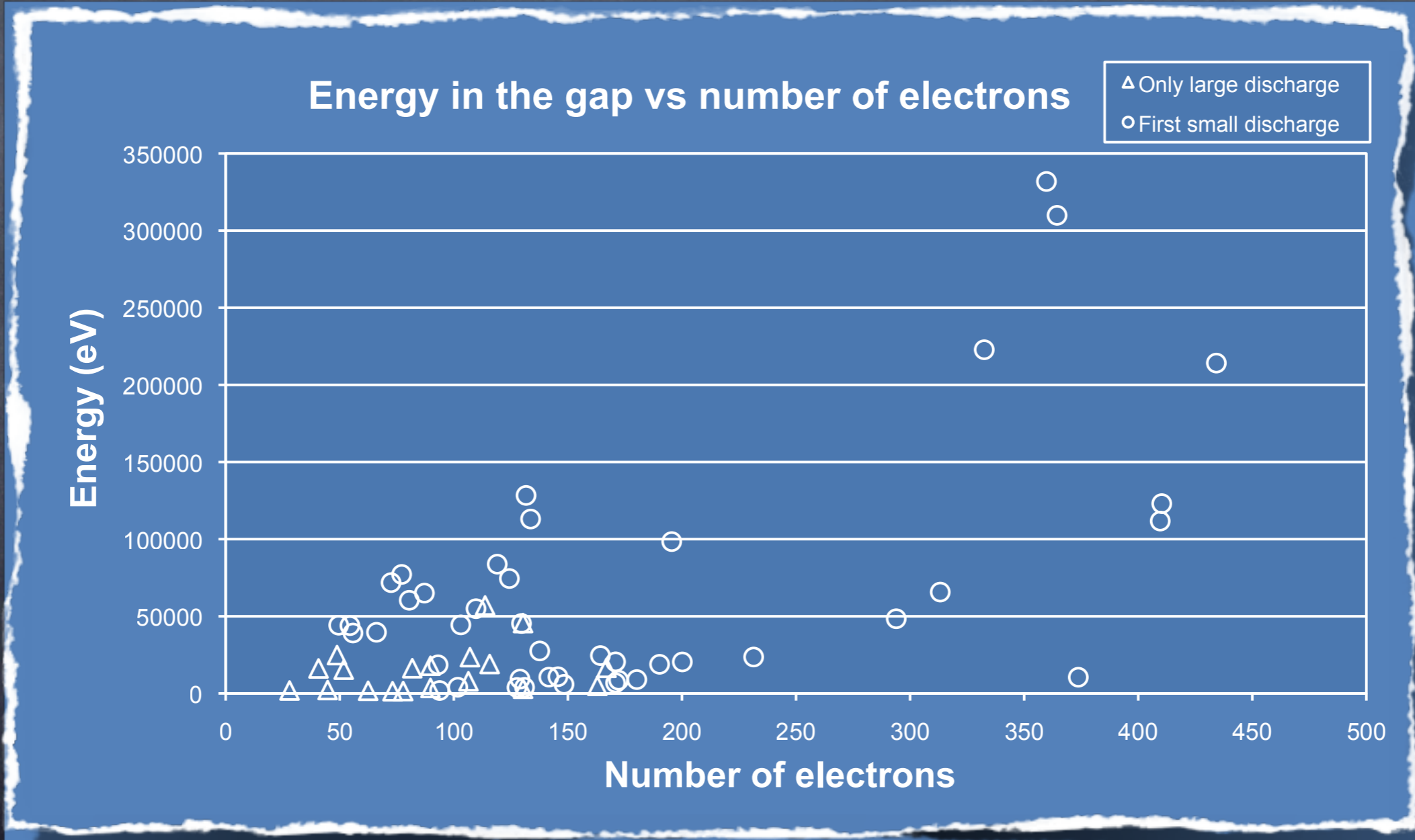
## Tests

- More than 60 multipactor tests in the same sample were performed varying the electron density and energy density ( $f=11.8$  GHz).
- From the REG software retrieved data (electron density and energy density) one can easily calculate:
  - Energy per electron.
  - Number of electrons inside the gap at any given time.

# Test Results: Two Behaviours

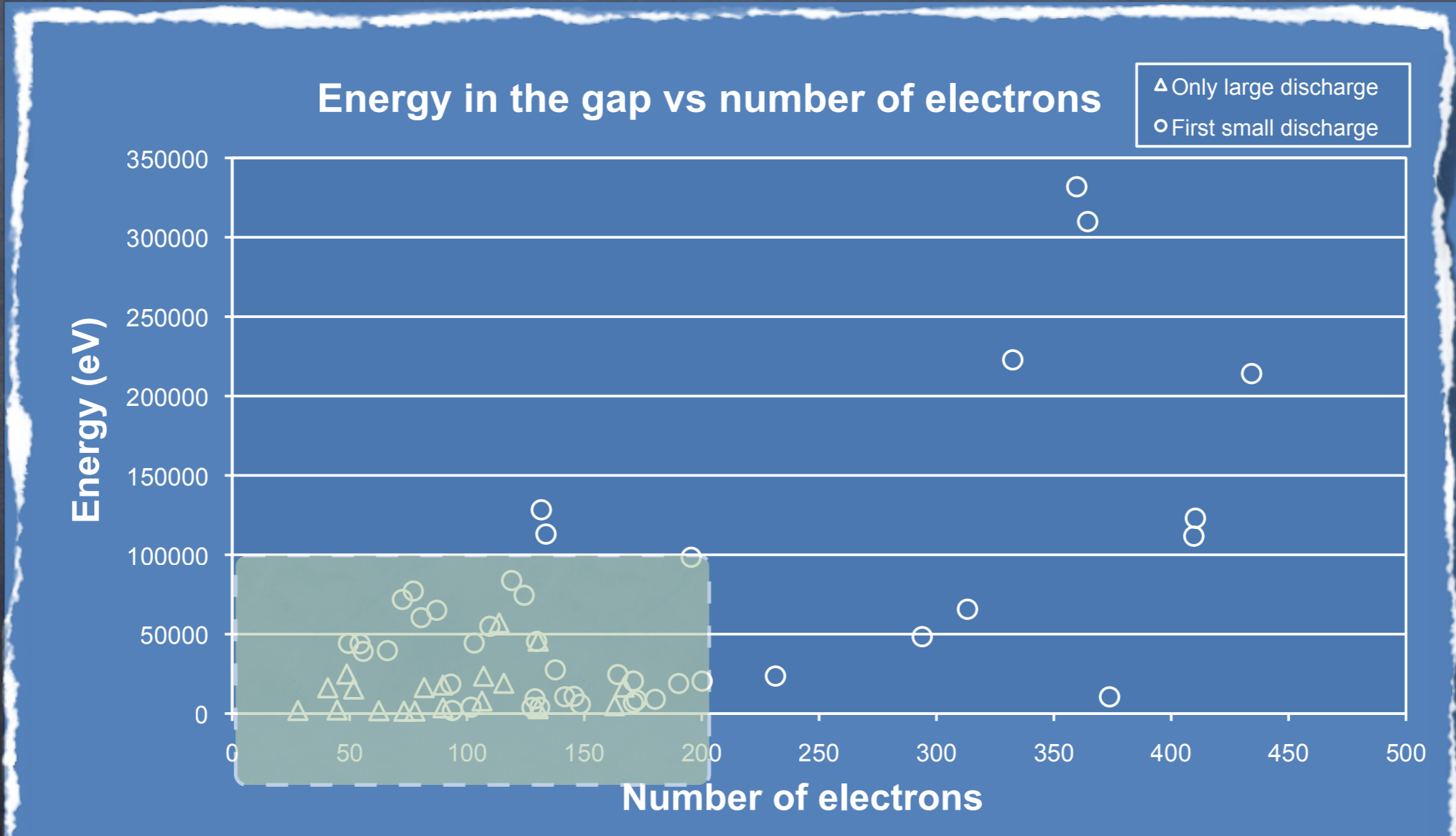
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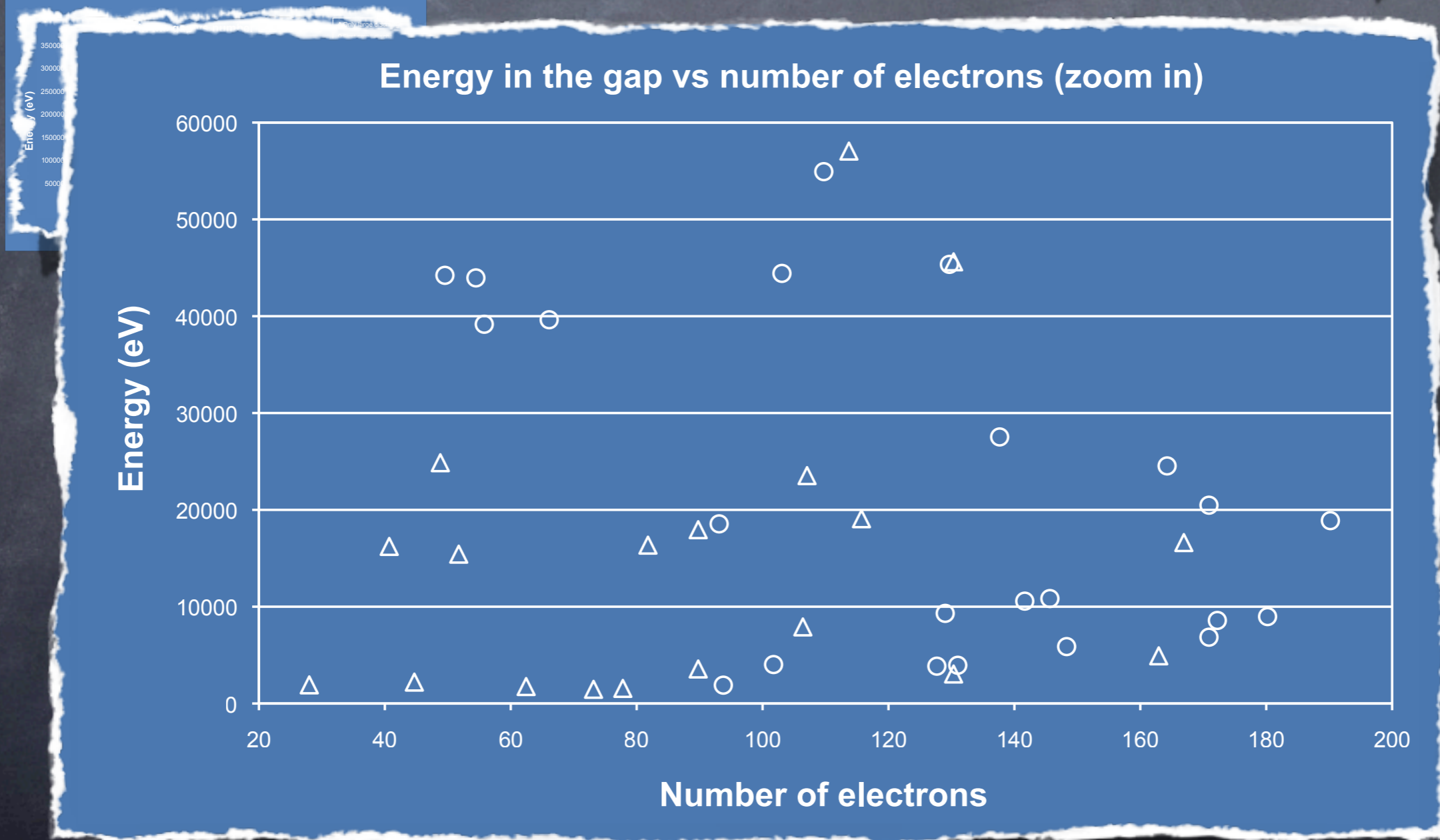


The 'only large discharge' behaviour is restricted to a small part

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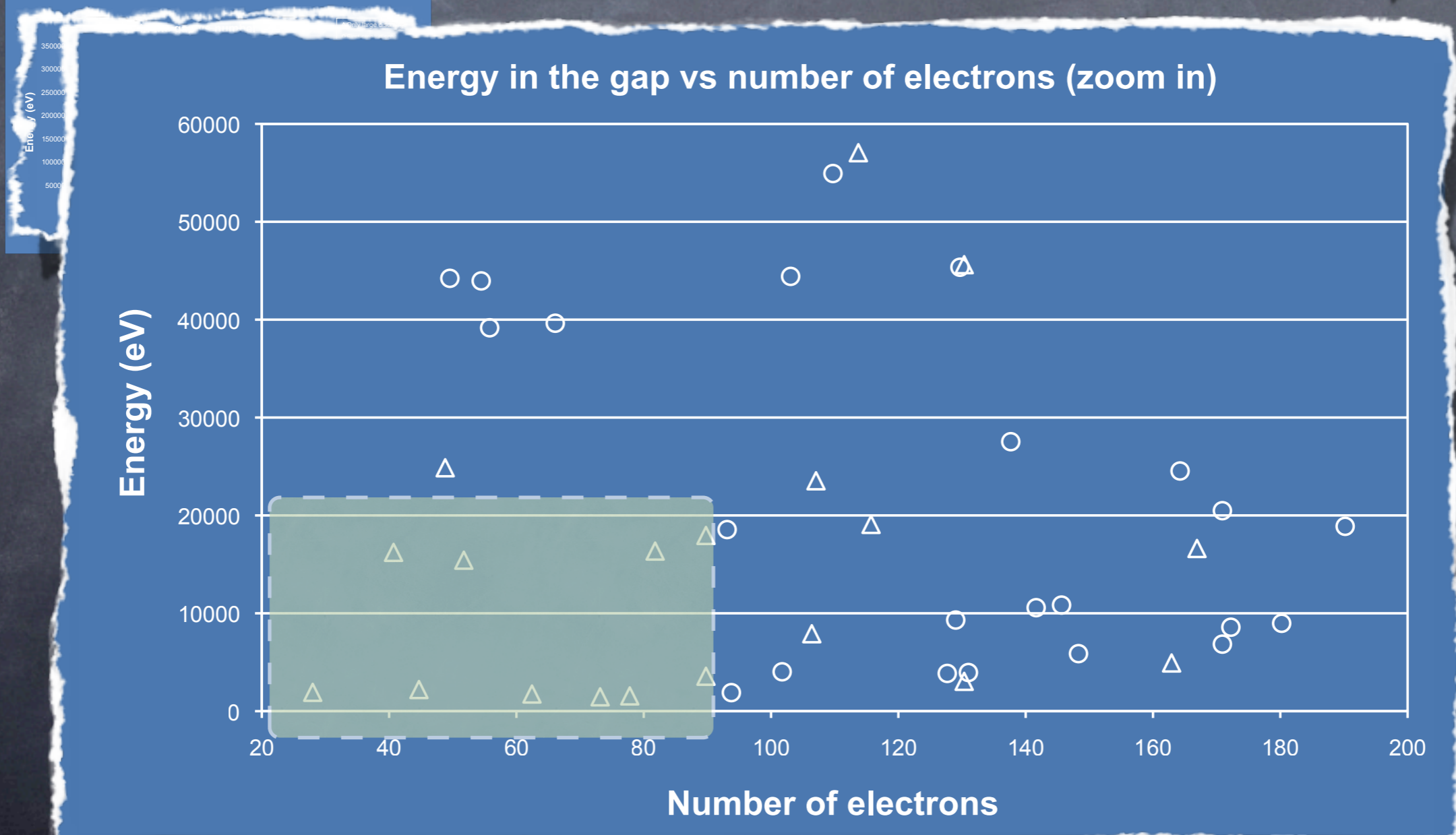
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Energy in the gap vs number of electrons:

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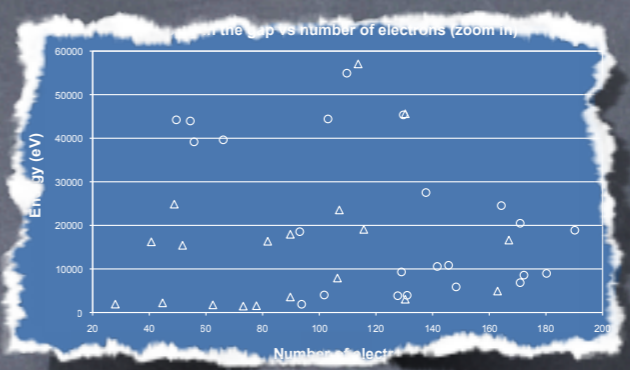
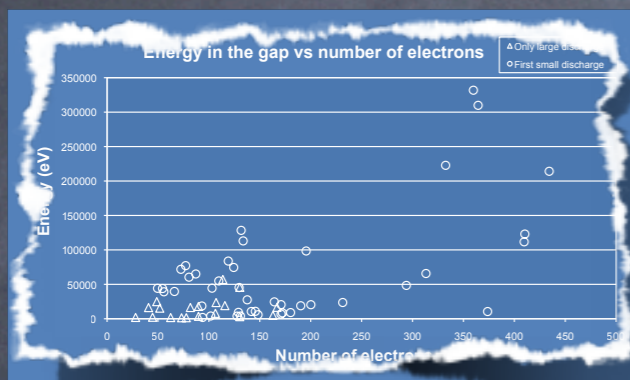


The 'only large discharge' is the only one in the low energy/few electrons region

## Test Results: Two Behaviours

Energy in the gap vs number of electrons:

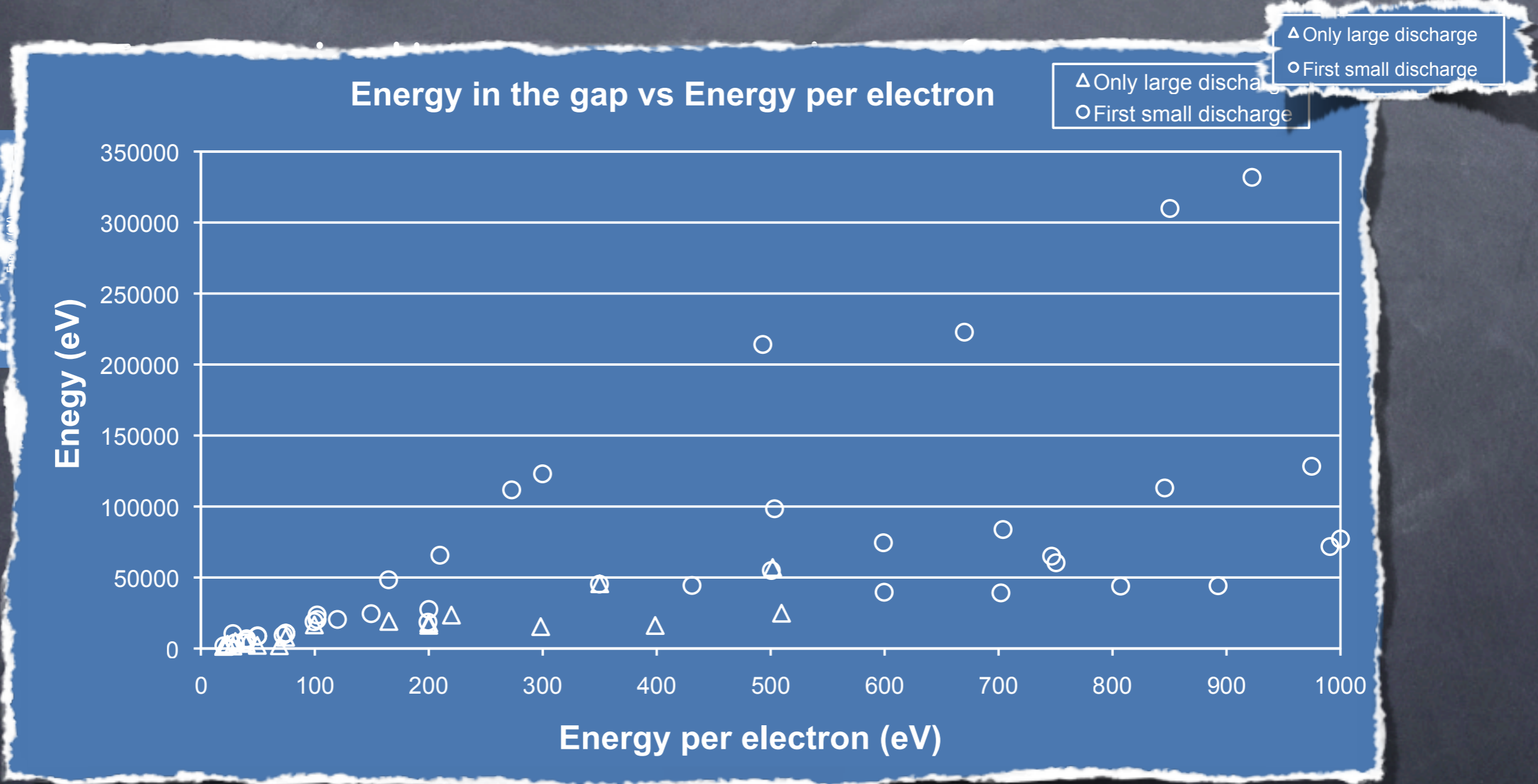
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Energy in the gap vs energy per electron:

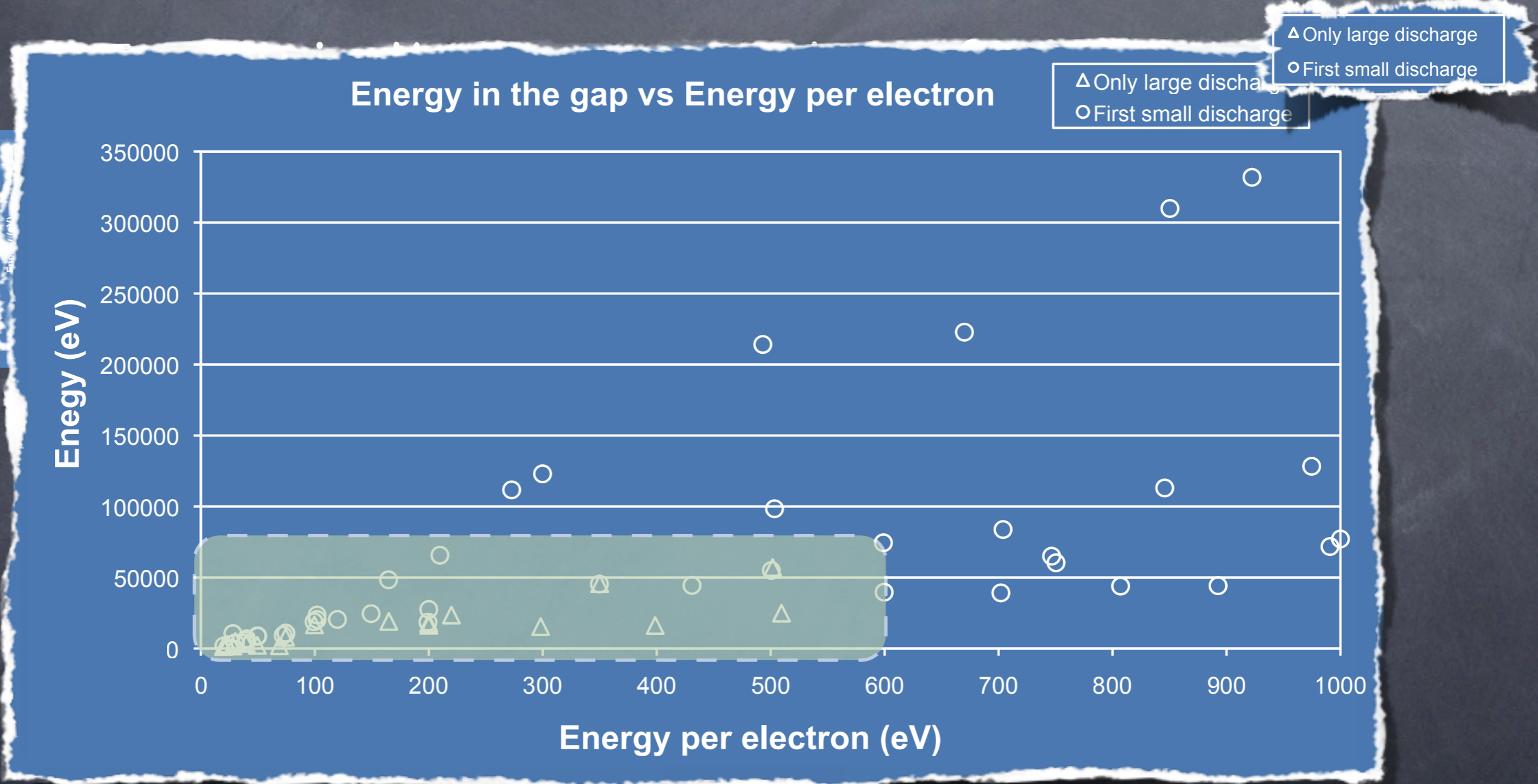


# Test Results: Two Behaviours



For each energy per electron value the 'only large discharge' occurs for lower values of the energy in the gap.

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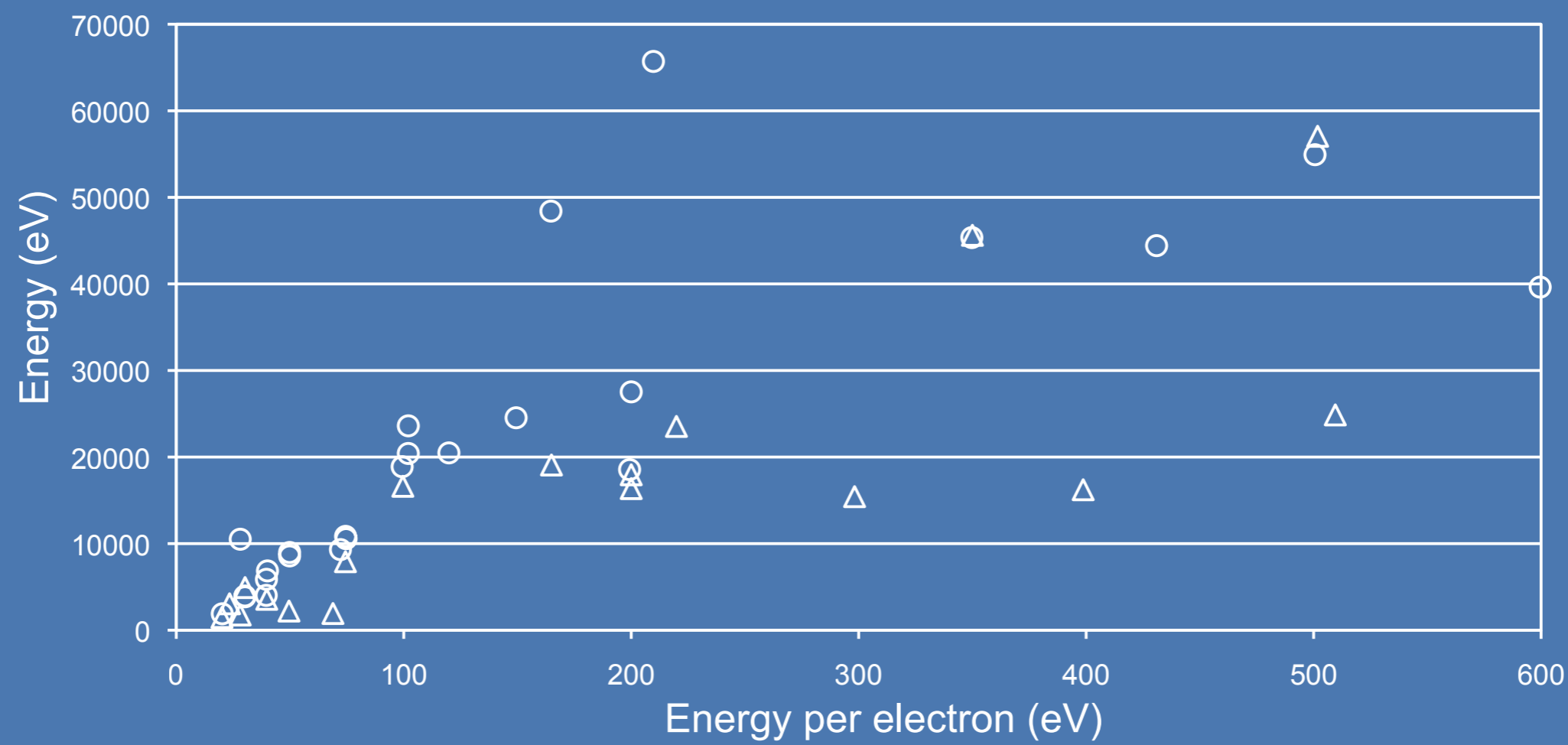


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Energy in the gap vs Energy per electron (zoom in)

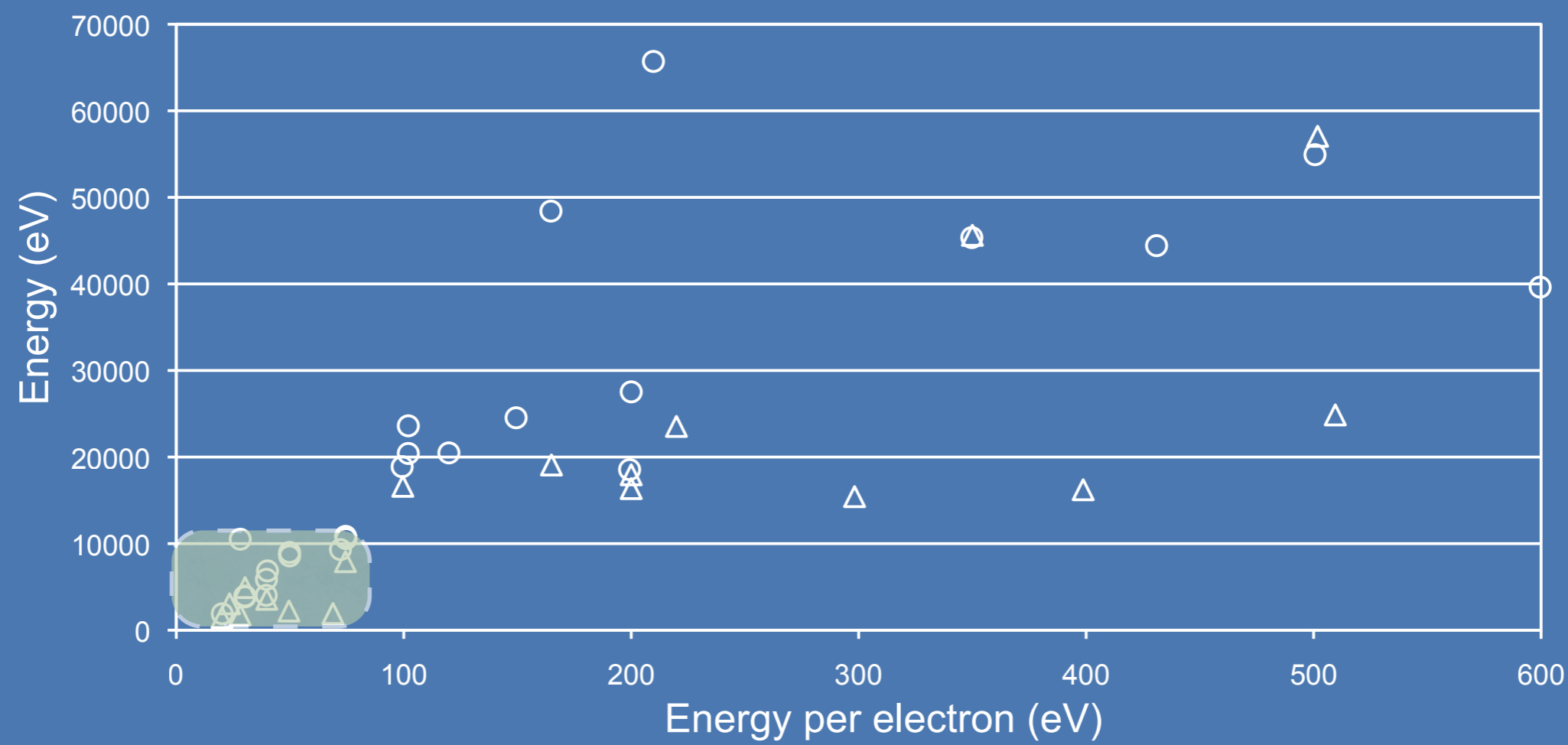


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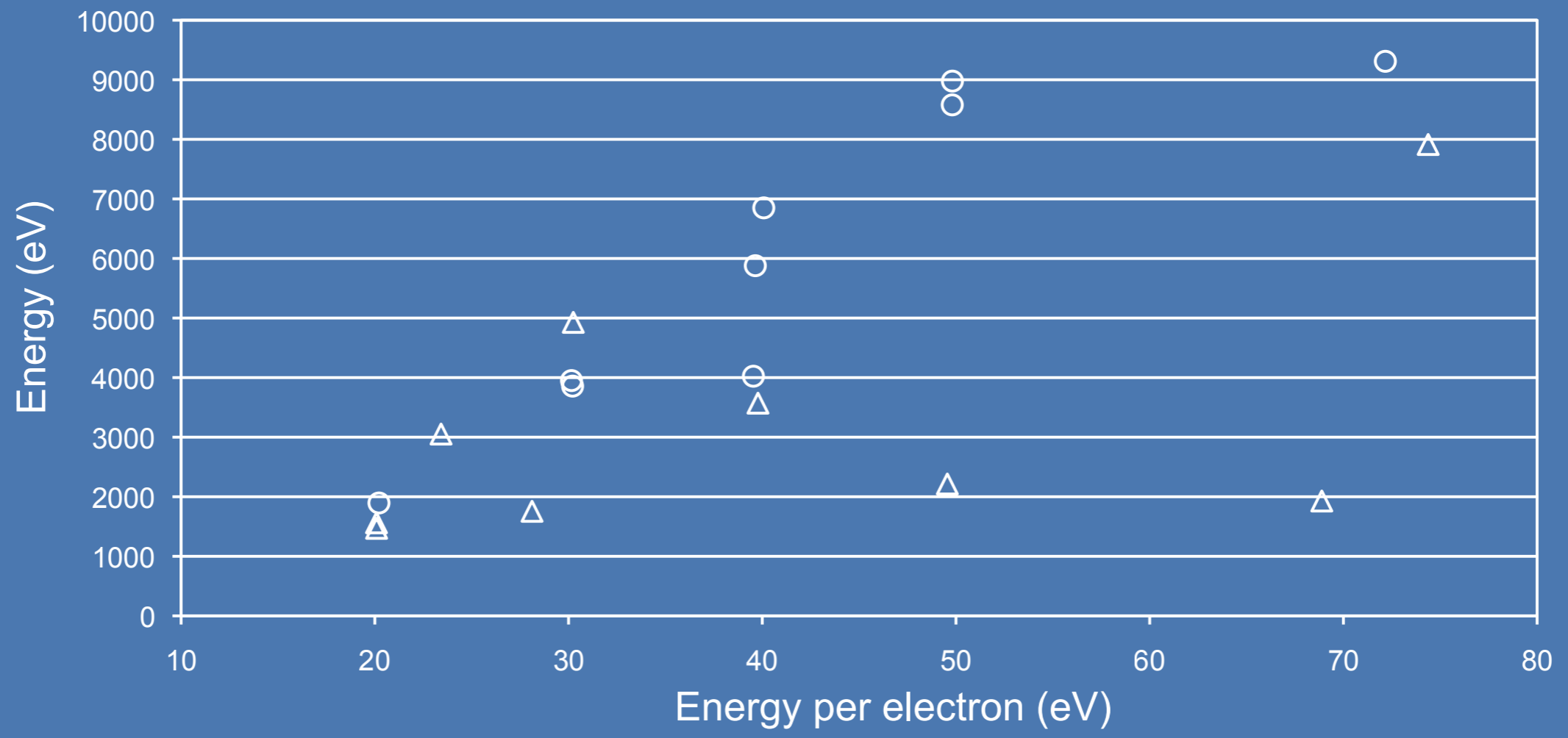


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 ○ First small discharge

Energy in the gap vs Energy per electron (second zoom in)

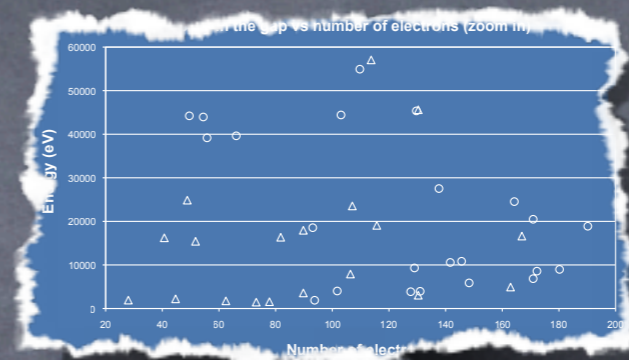
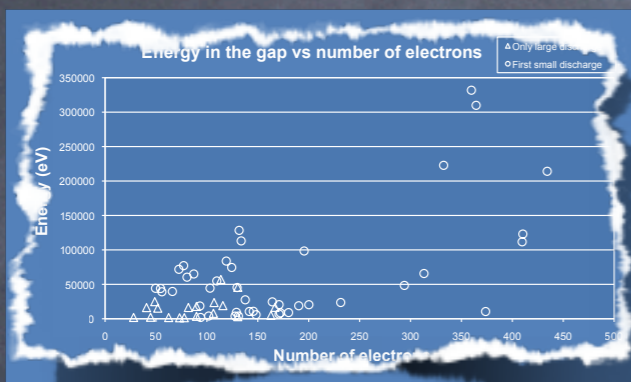


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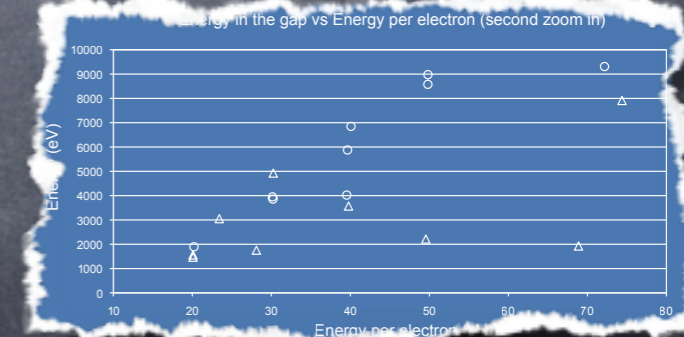
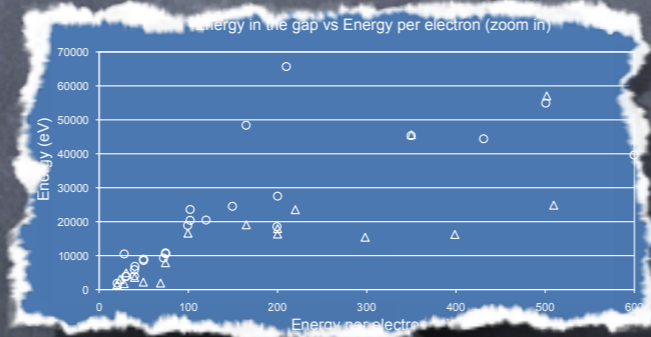
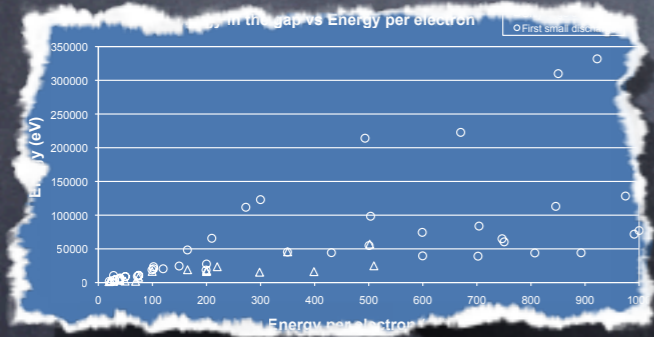
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Energy in the gap vs number of electrons:

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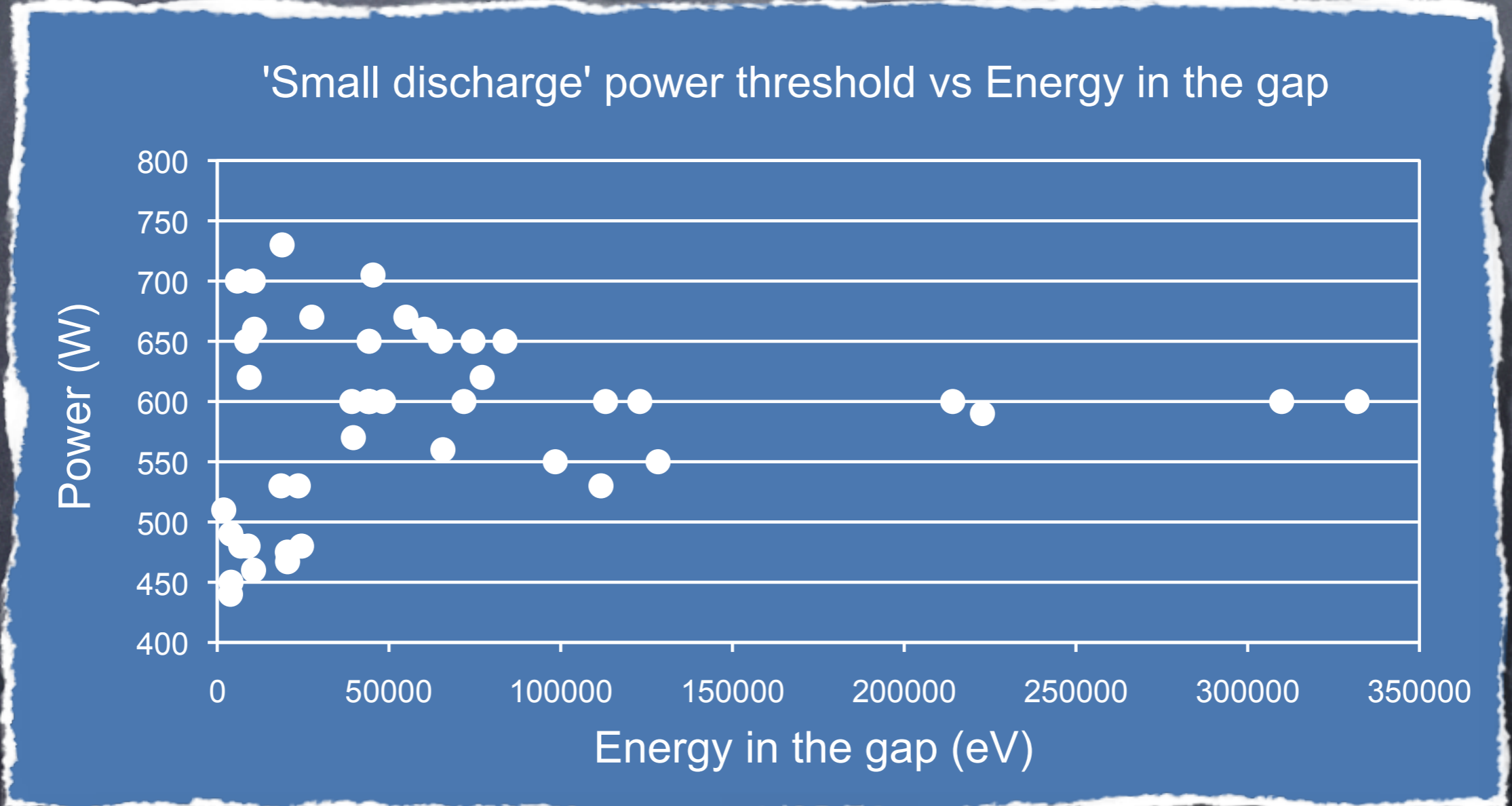
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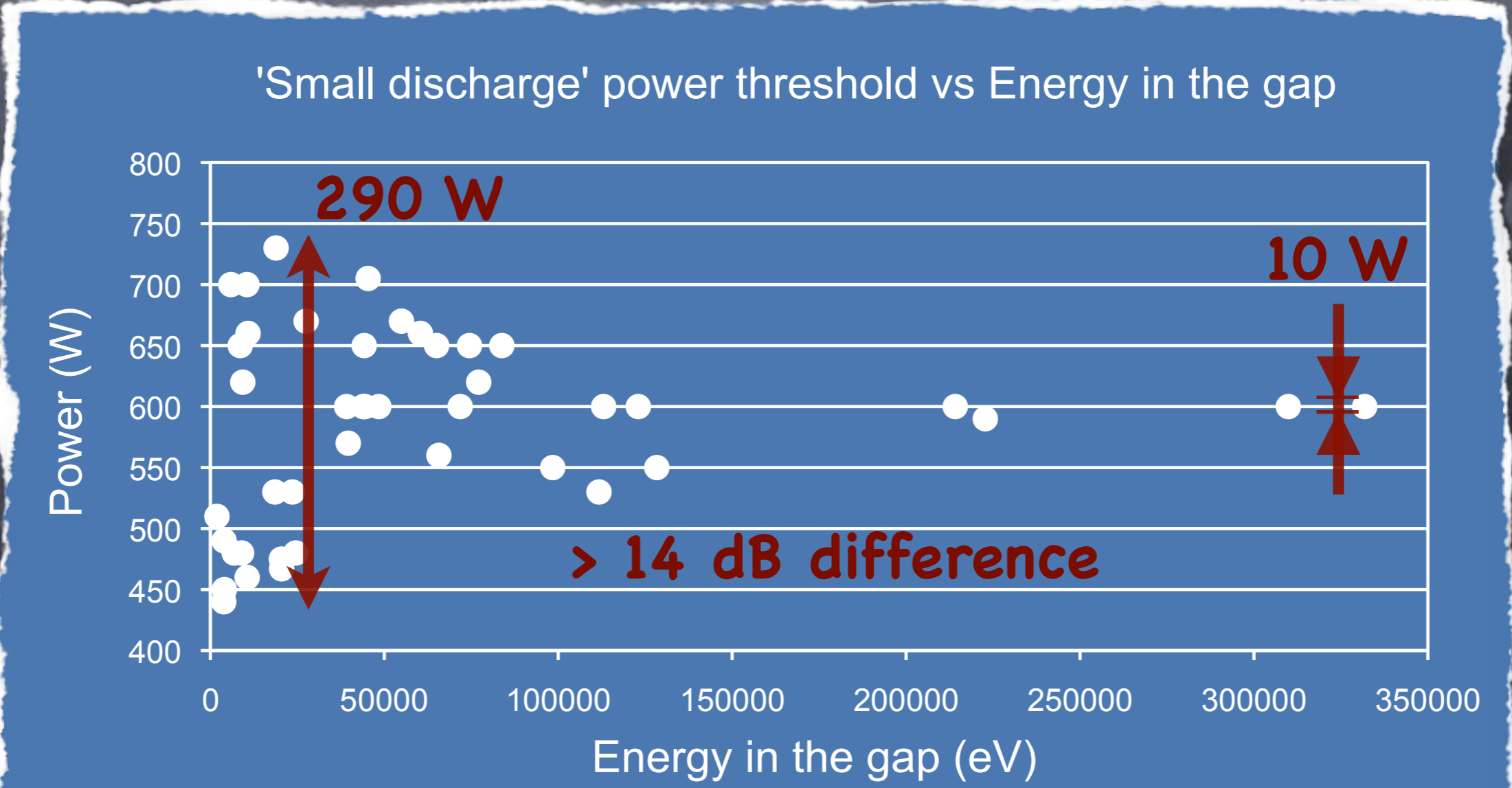
RF power threshold for the 'small discharge':





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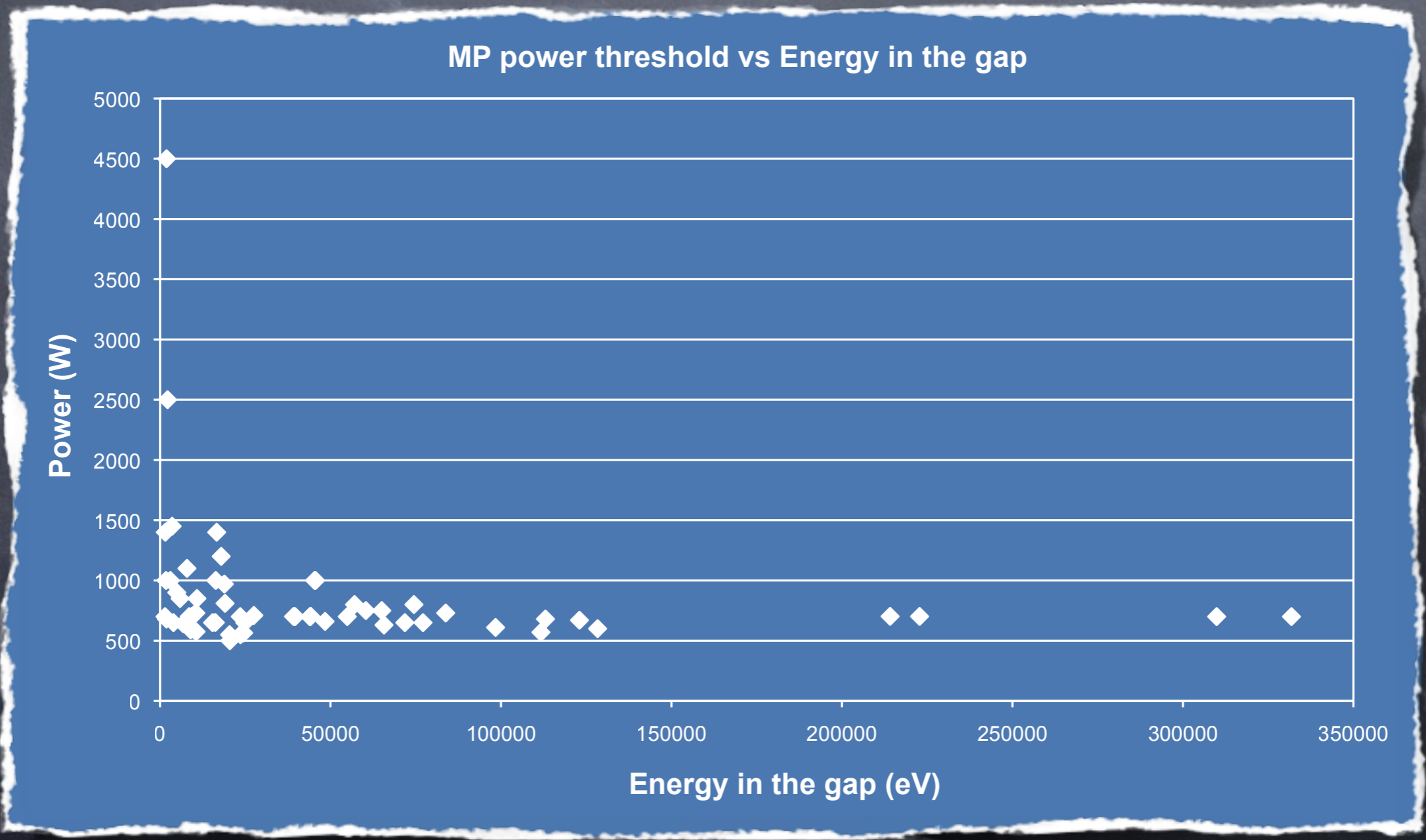


The dispersion of the MP RF power threshold decreases with the total energy.

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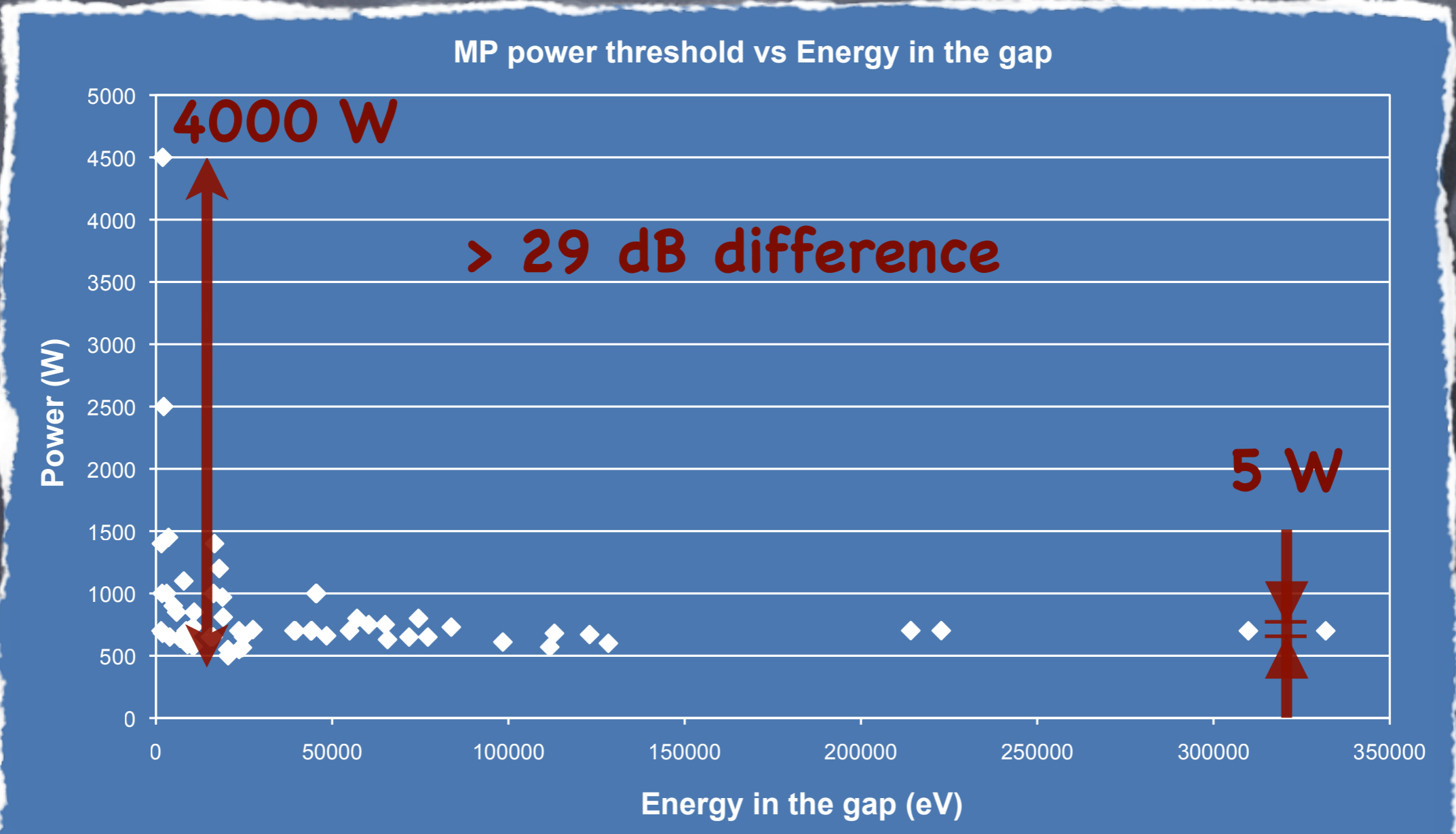
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● MP power threshold for all the tests:



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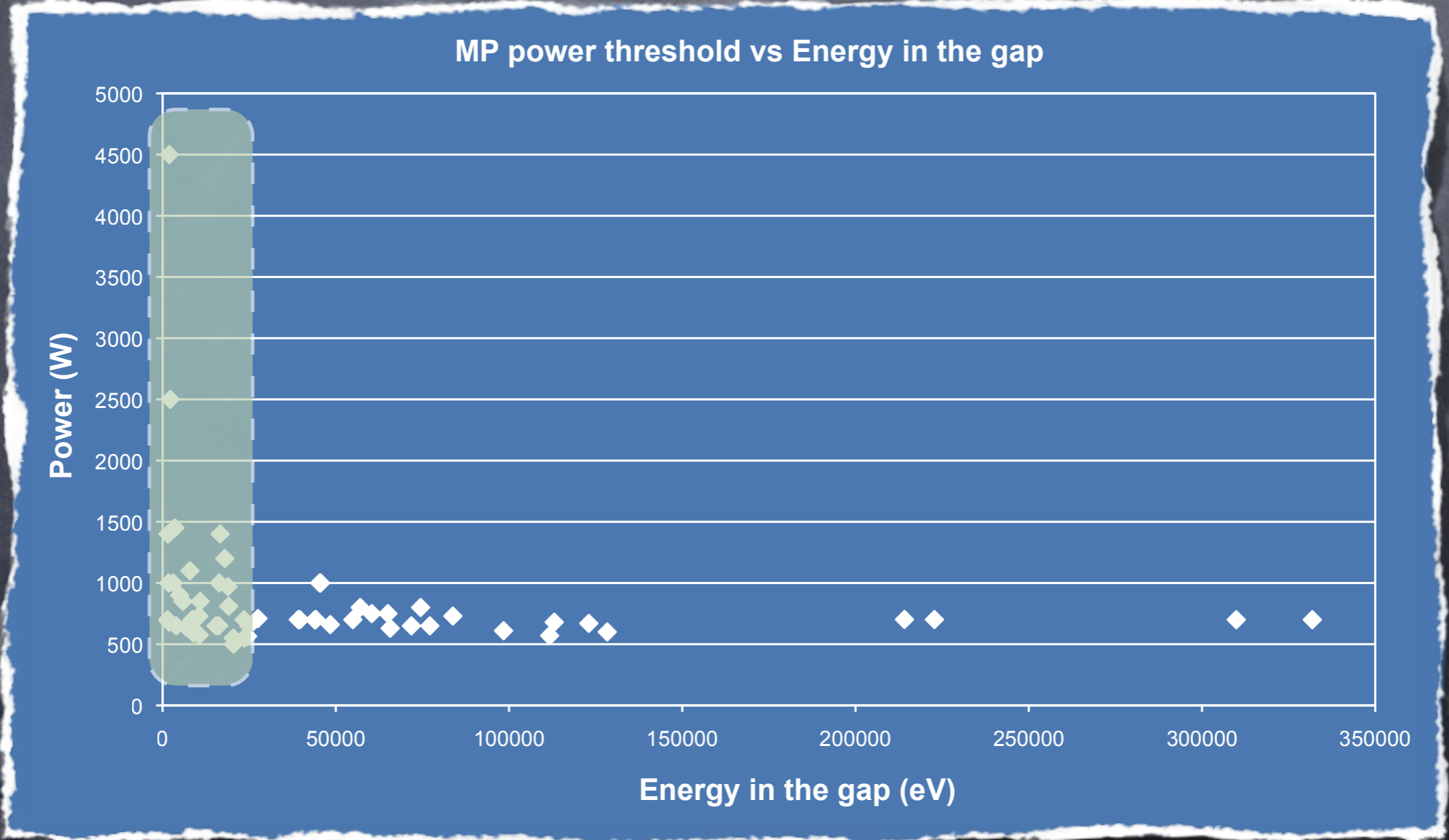
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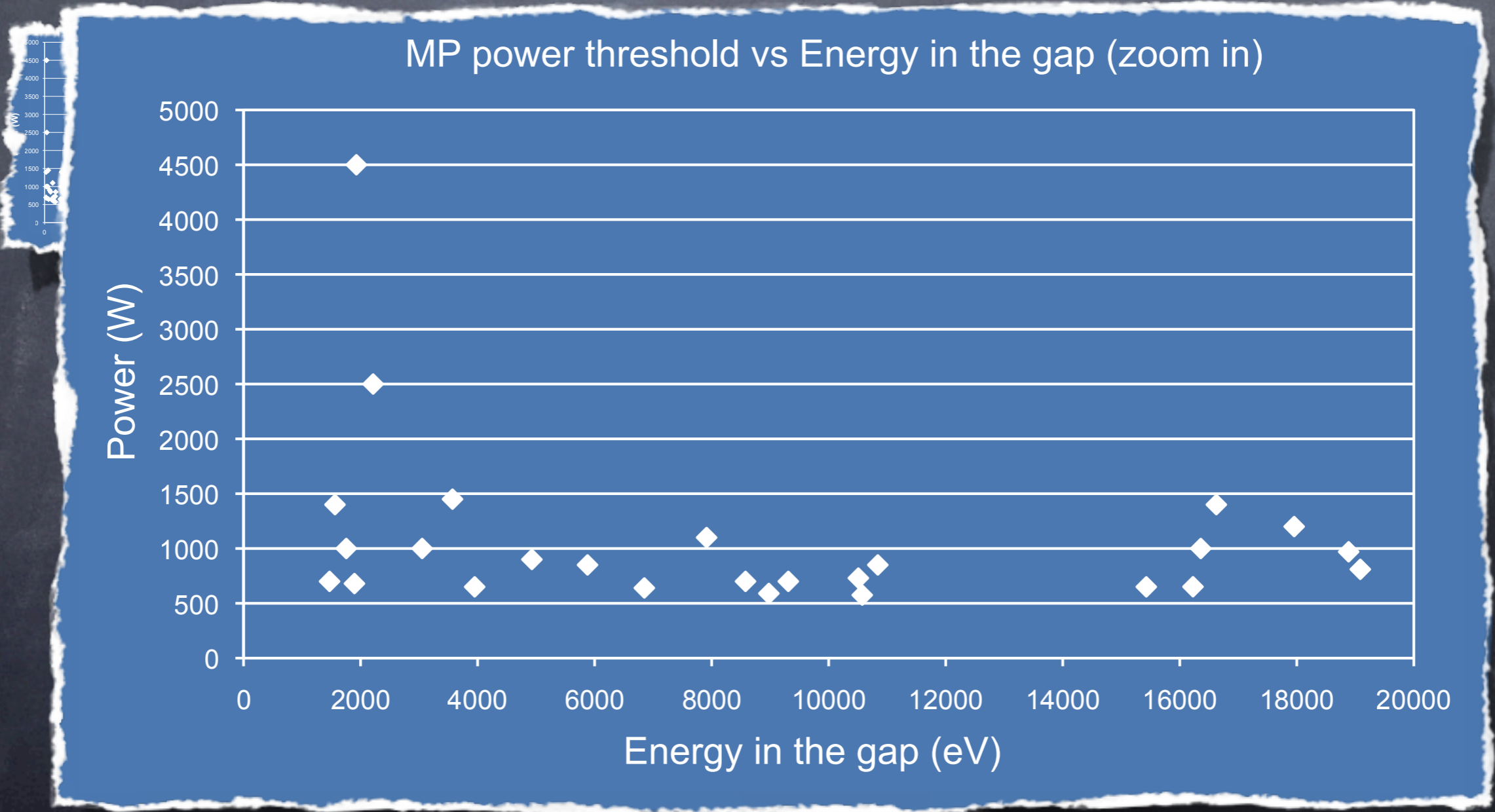
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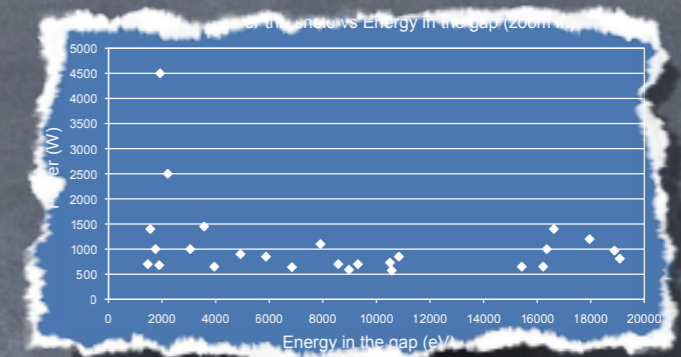
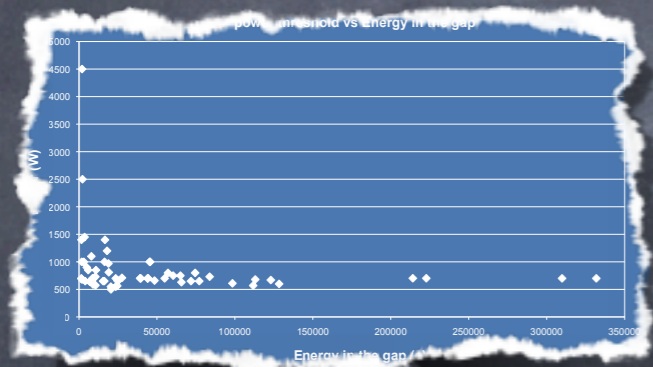
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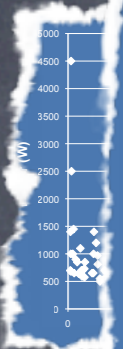
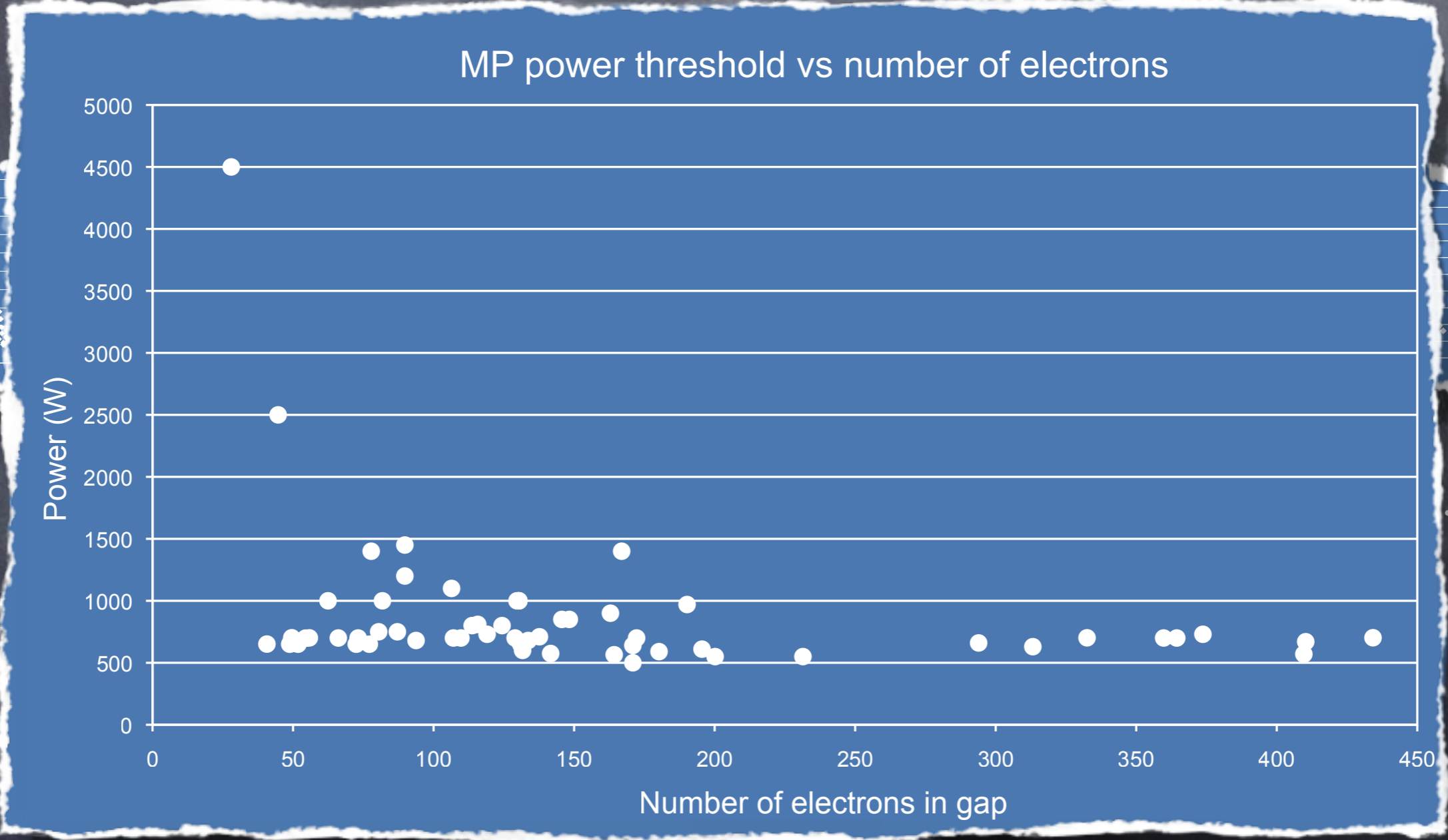
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- MP power threshold for all the tests:



- MP power threshold in terms of the number of electrons:

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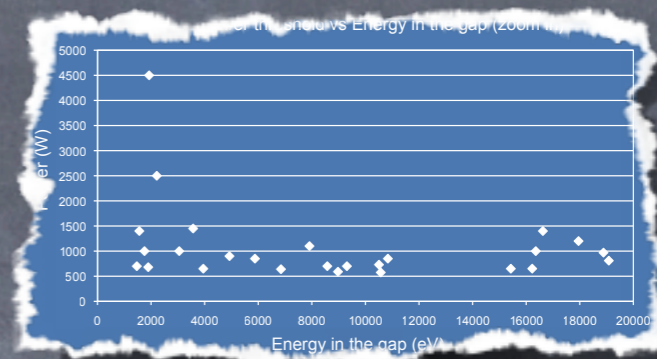
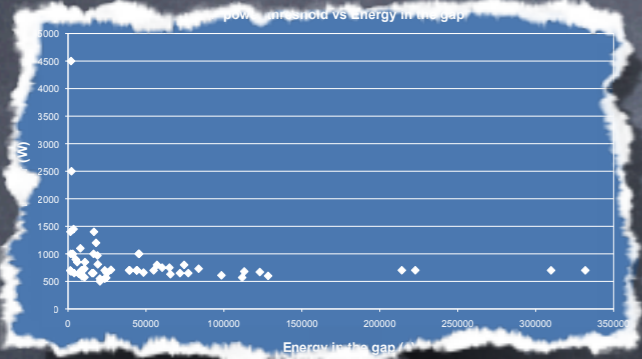


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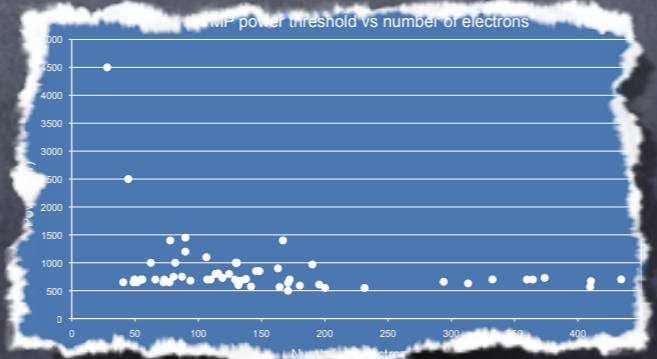


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- Using the photoelectric effect the moment when the electrons are seeded is controlled by simply opening a shutter.
- The difference in the RF power between the radioactive source and the UV is related to the distance from the gap to where we illuminate with UV.

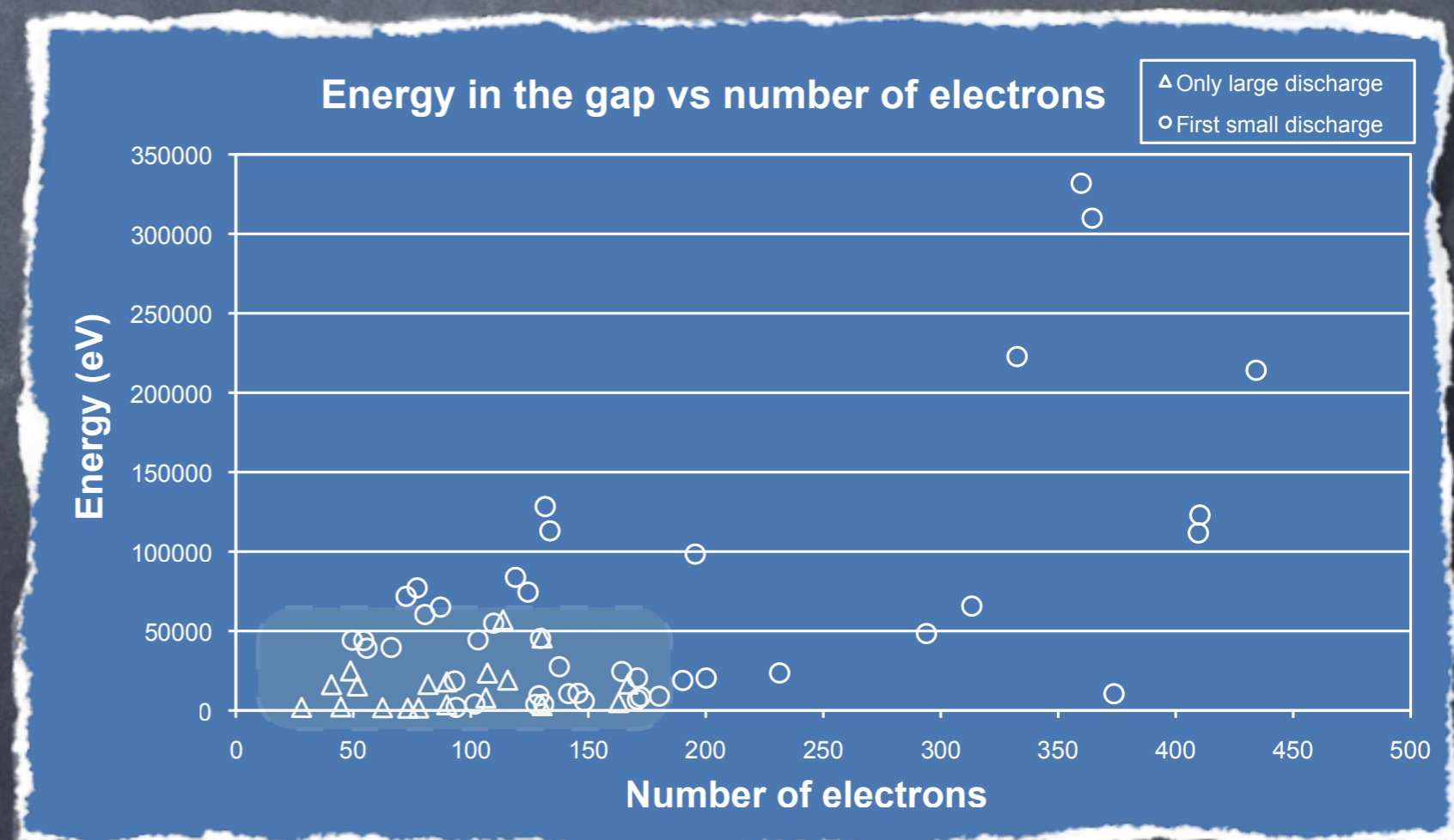
# Conclusions (REG)

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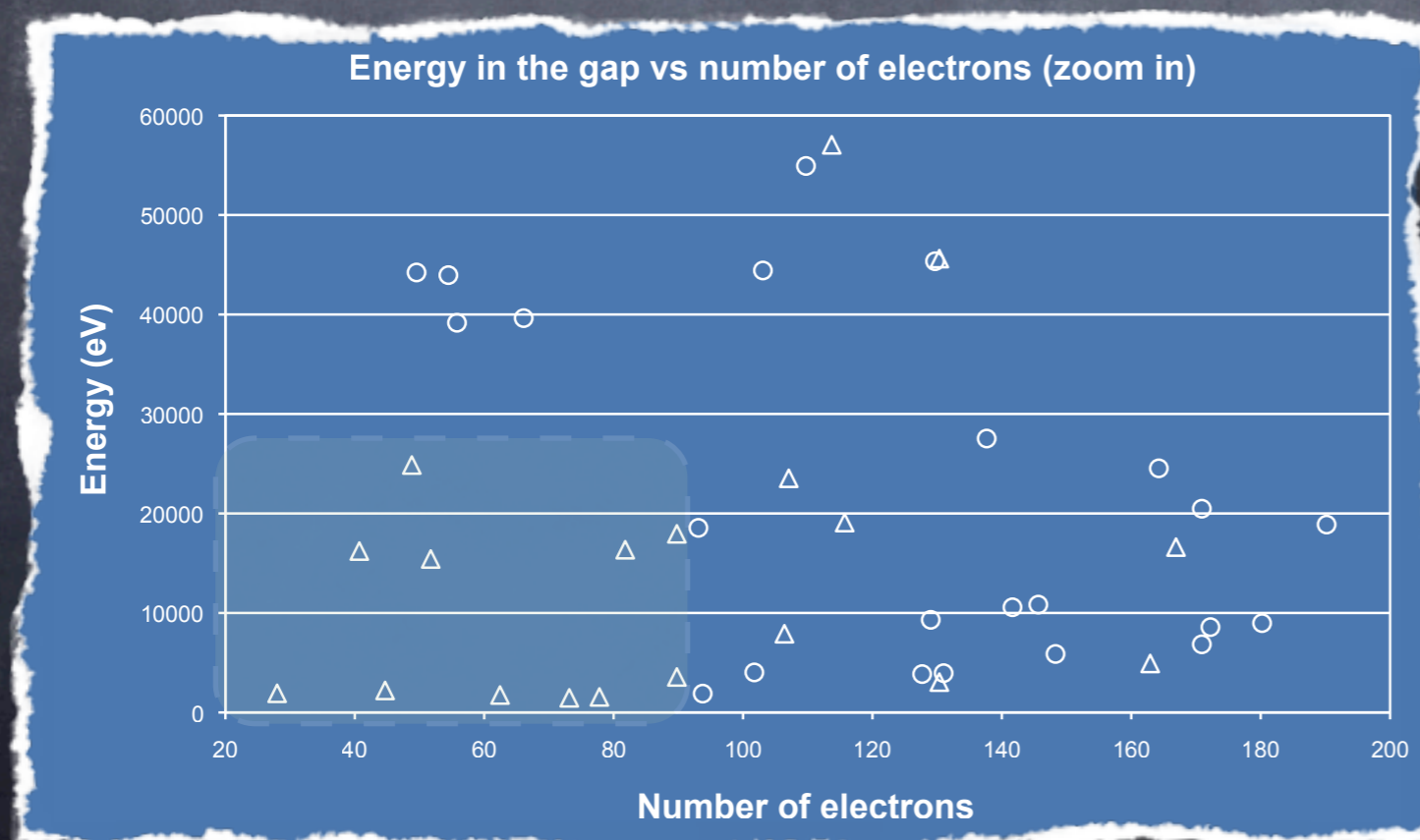
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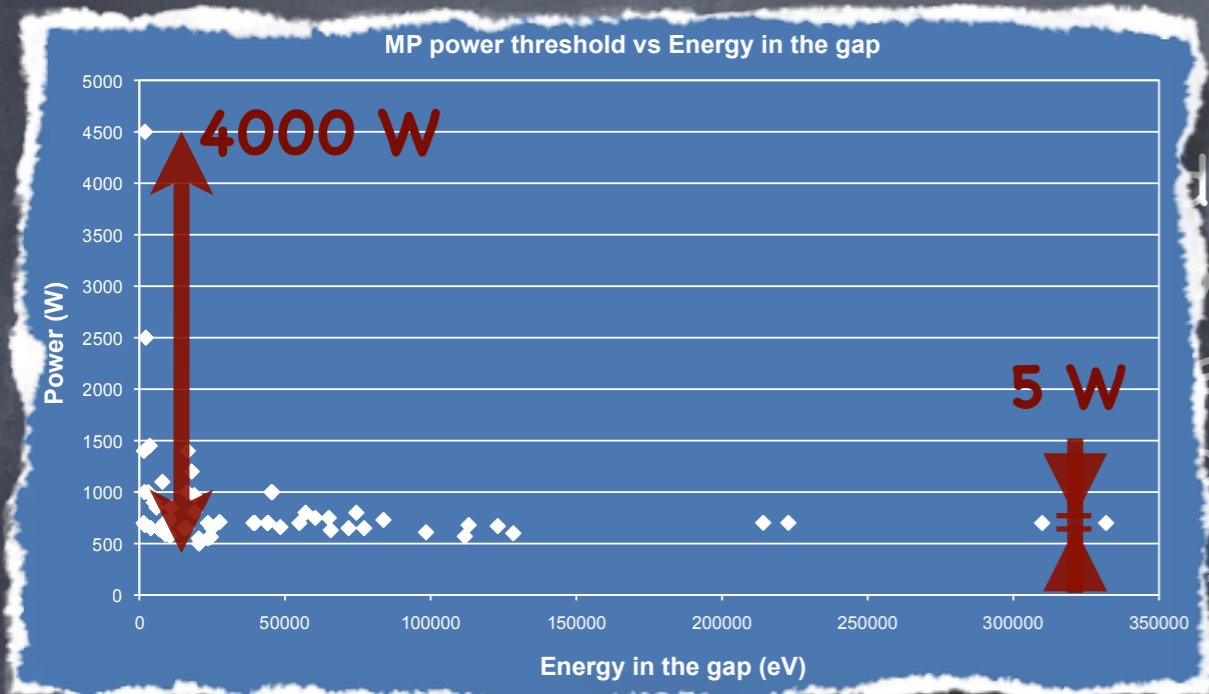
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## Conclusions (REG)



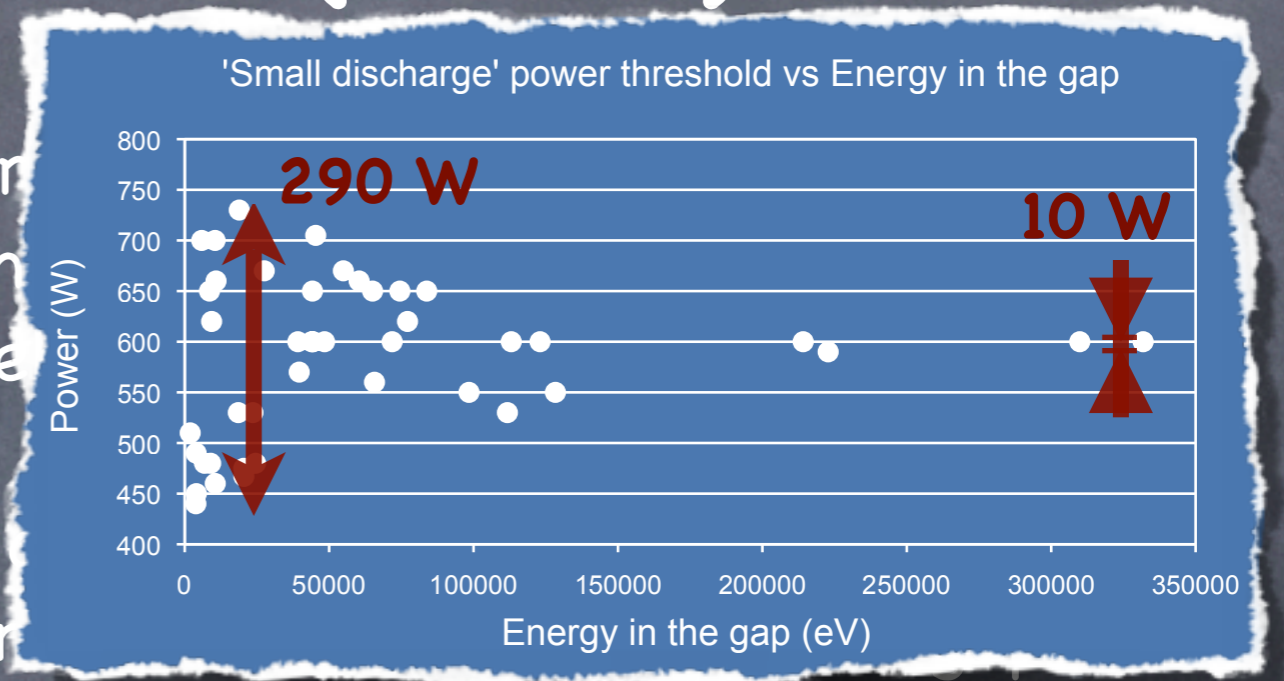
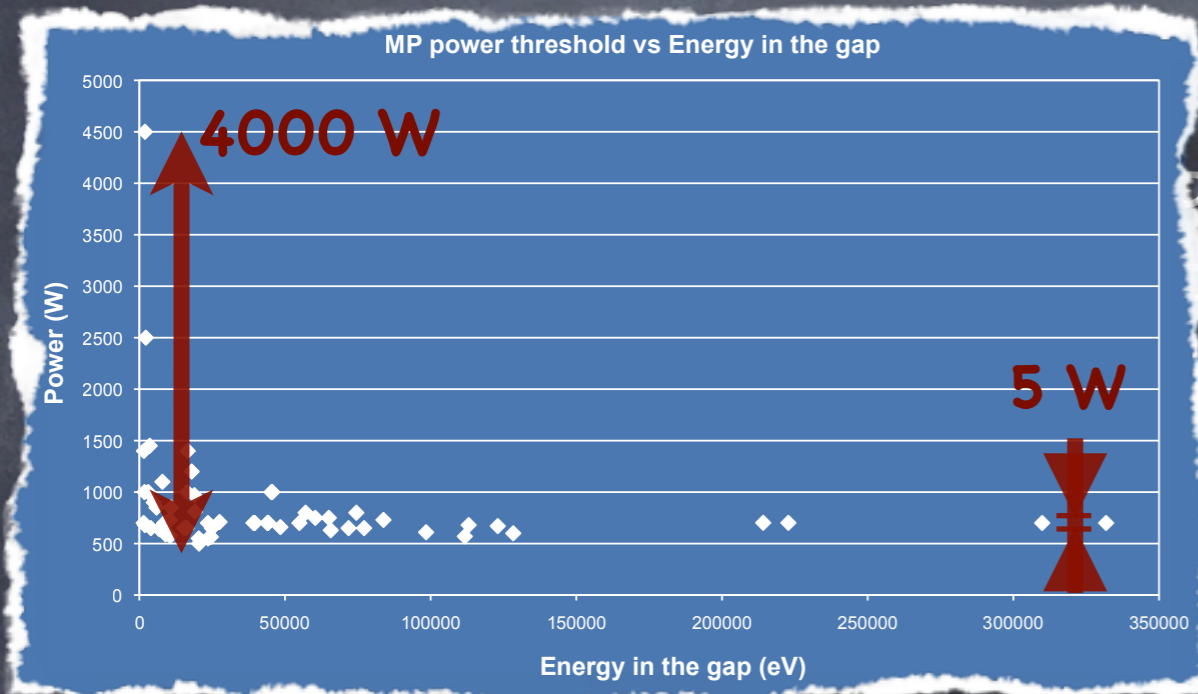
Wide array of different energy densities  
for the electron beam.

'Large discharge' behaviour occurs in a small part  
of the region.

Power observed for the region with  
energies less than 25 keV in the gap.

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## Conclusions (REG)



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- The REG produced a wide array of different energy densities and electron densities for the electron beam.
- The 'only large discharge' behaviour occurs in a small part of the configuration space.
  - It is the only behaviour observed for the region with less than 90 electrons and less than 25 keV in the gap.
- The dispersion of the RF power for the 'large discharges' decreases with the total energy in the gap.
  - The same dependence is found for the RF power level at which the 'small discharges' appear.
- The number of electrons and the energy per electron that lead to uniform RF power MP threshold is now defined.