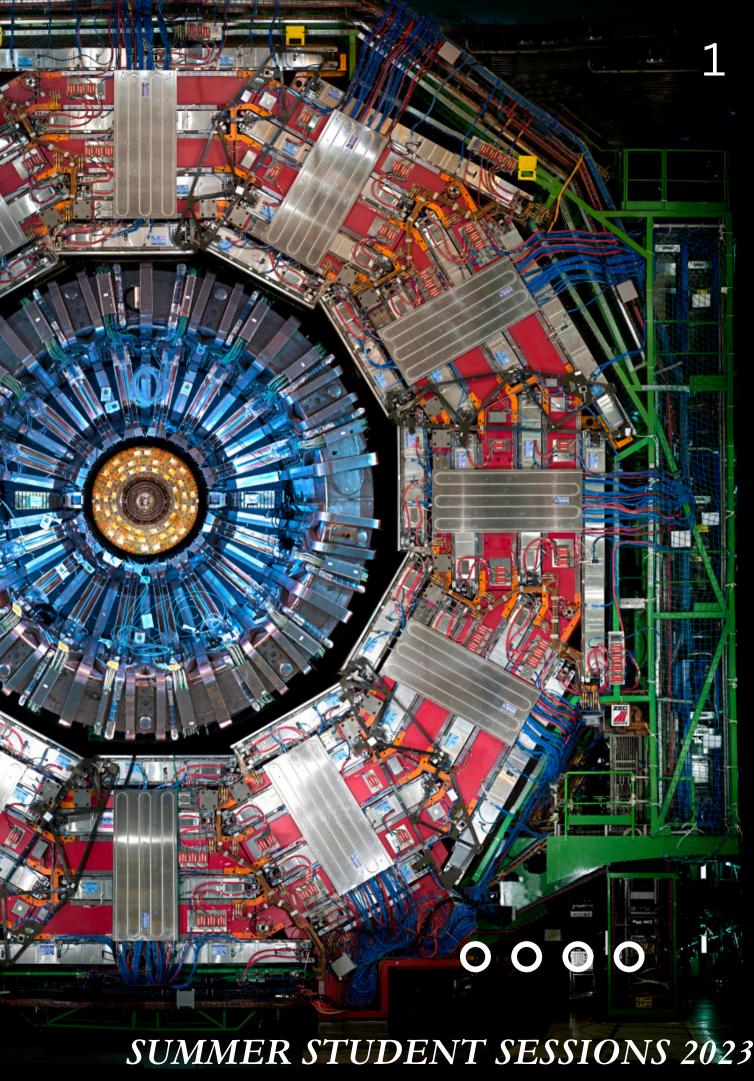


# CHARACTERISATION OF SINGLE-DIODE SILICON SENSORS FOR THE CMS HGCALPROJECT

Jenan Amer Supervisors: Leena Diehl, Oliwia Kałuzińska



# Who Am I?

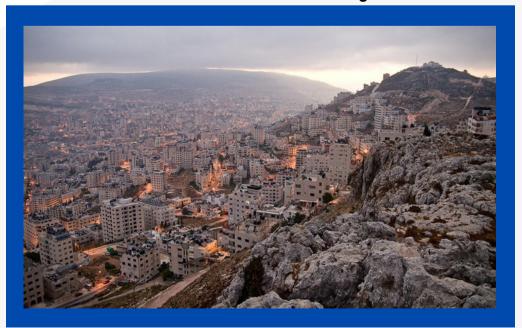
# Jenan Amer

# Bachleor in physics, An Najah National university, Palestine



## Mas-ha, Salfit

Nablus city







## An Najah National University

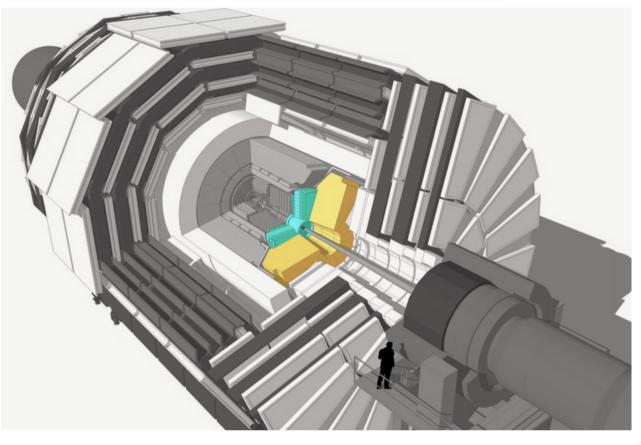
# OUTLINE

• Introduction.

- The LHC upgrade and CMS.
- What is HGCAL?
- My Work
  - Silicon sensors.
  - Electrical characterization of single diodes.
  - Results.
- Conclusion and ongoing work.

11 August, 2023

# THE LHC UPGRADE **AND OUR MOTIVATION**



# What is HGCAL?

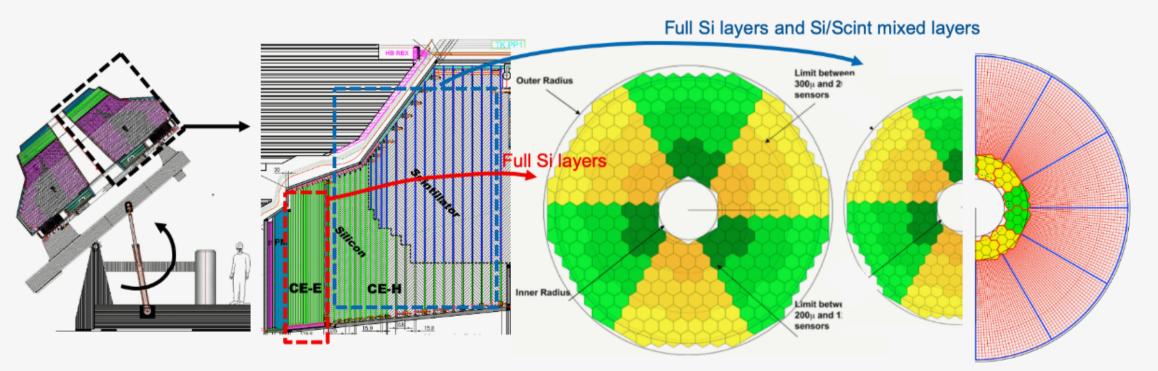
Three different thicknesses: 300 µm, 200 µm (Float zone) and 120 µm (Epitaxial).

Fluences of up to  $1e16 \text{ neq/cm}^2$ 

CMS is a general purpose detector.

## LHC $\rightarrow$ HL-LHC $\sim$ 200 pileups per bunch crossing.

CMS Endcap Calorimeter will be replaced by the High Granularity Calorimeter (HGCAL) for the HL-LHC

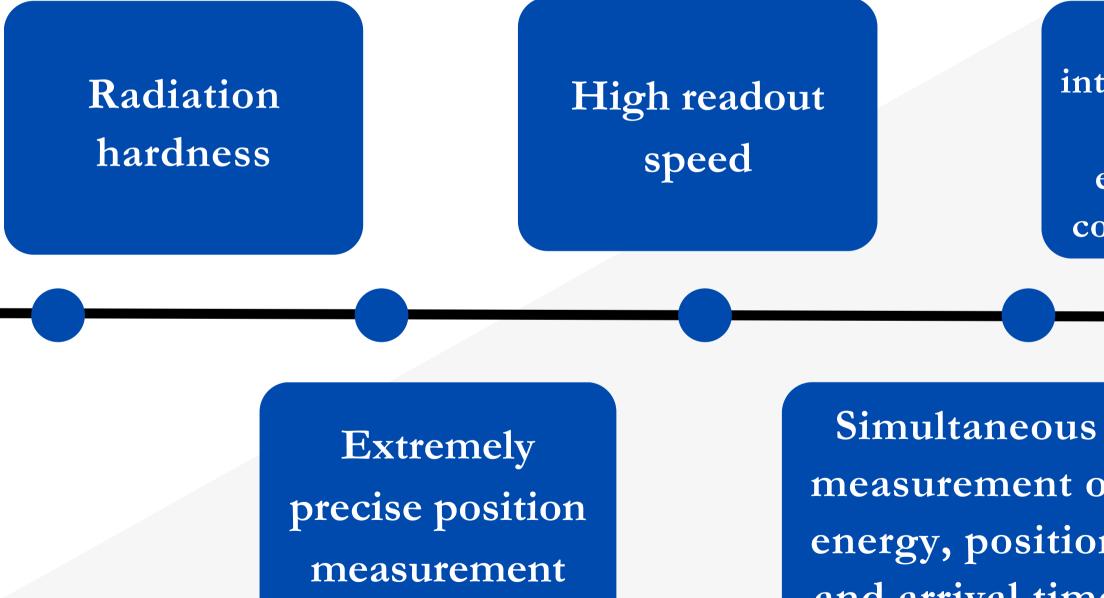


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### HGCAL will use ~ 620 m<sup>2</sup> silicon sensors produced on 8-inch wafers.

# WHY SILICON SENSORS?



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**Possibility of** integrating detector and readout electronics on a common substrate

measurement of energy, position and arrival time

# 0000 HOWSILICON SENSORS WORK?

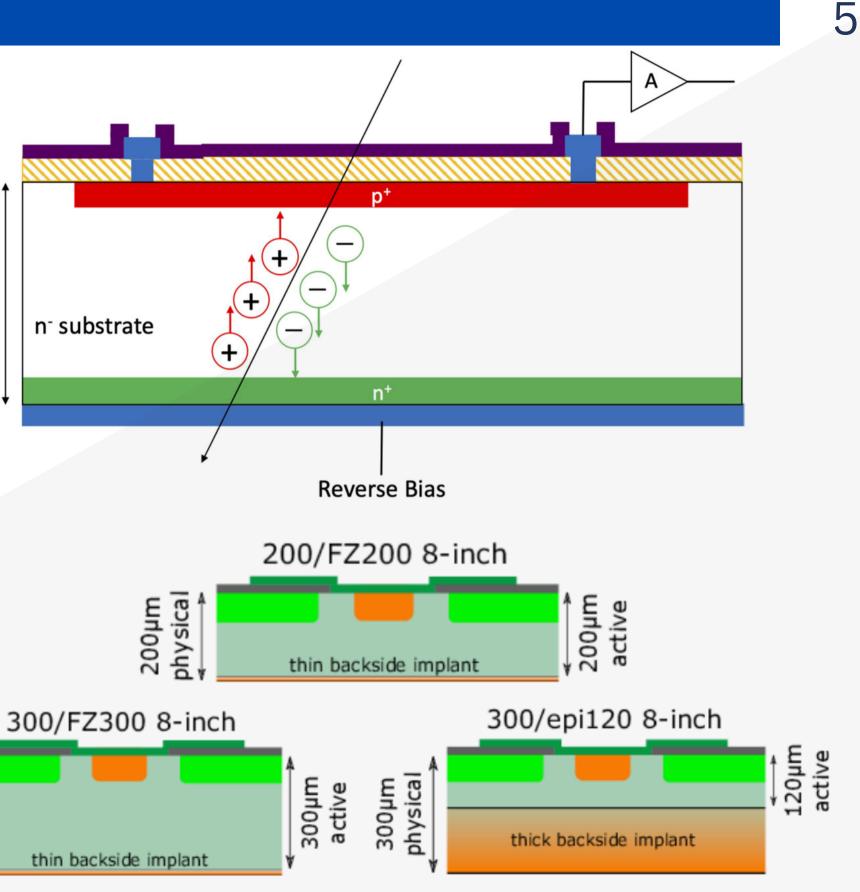
- Charged particles traversing the detector create electron-hole pairs.
- The electron-hole pairs are separated by an electric field and drift to the electrodes. This is the signal we are looking for.

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300µm physical

D

300, 200 and 120 µm; FZ denotes float zone process and epi – epitaxial process



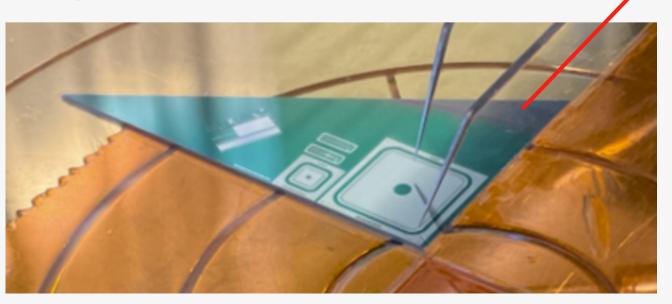


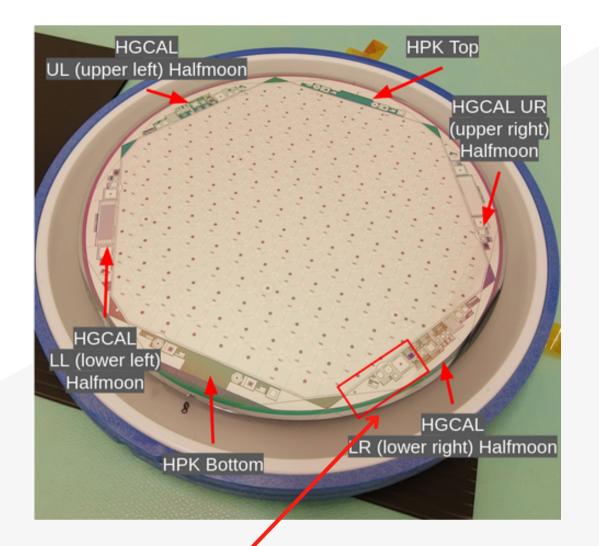
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Sensors cross section (not to scale):

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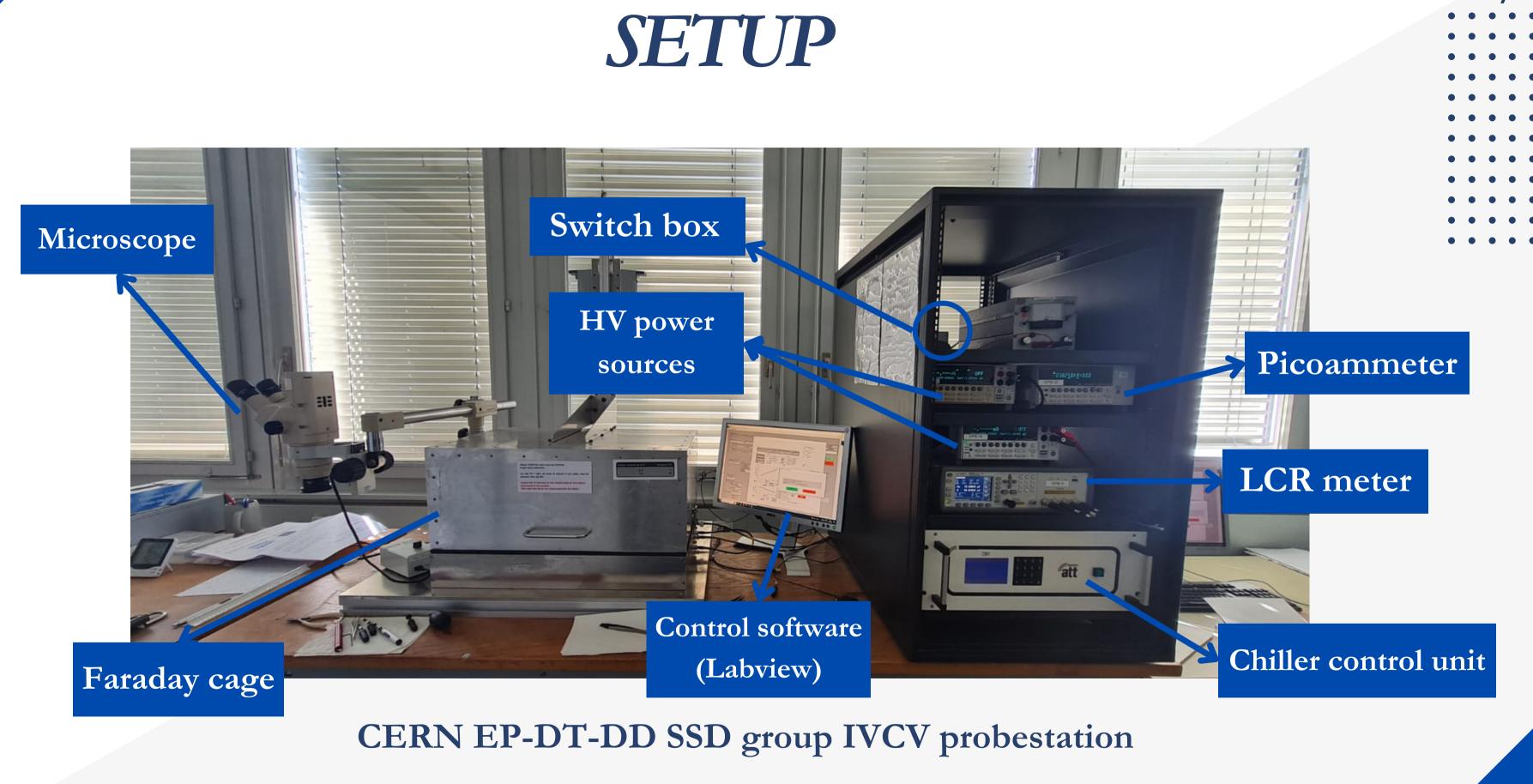
- FULL SENSORS AND **DIODE TEST STRUCTURES**
- Circular wafers are cut into Hexagonal full sensors.
- Remaining space is used for the small diode test structures.
- Set of pre-series and pre-production diodes were irradiated at JSI (Jozef Stefan Institute) in June 2023
- Electrical characterization through CV/IV measurements is performed on the diodes.







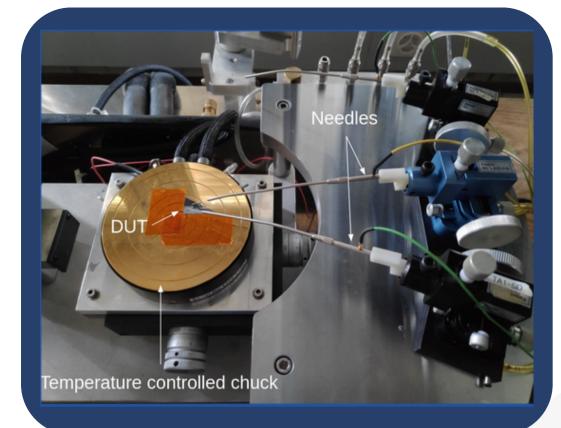




# ELECTRICAL CHARACTERIZATION PROCESS

Inside the Faraday cage is where the test area is





CV and IV Measurements done on a temperature controlled chuck





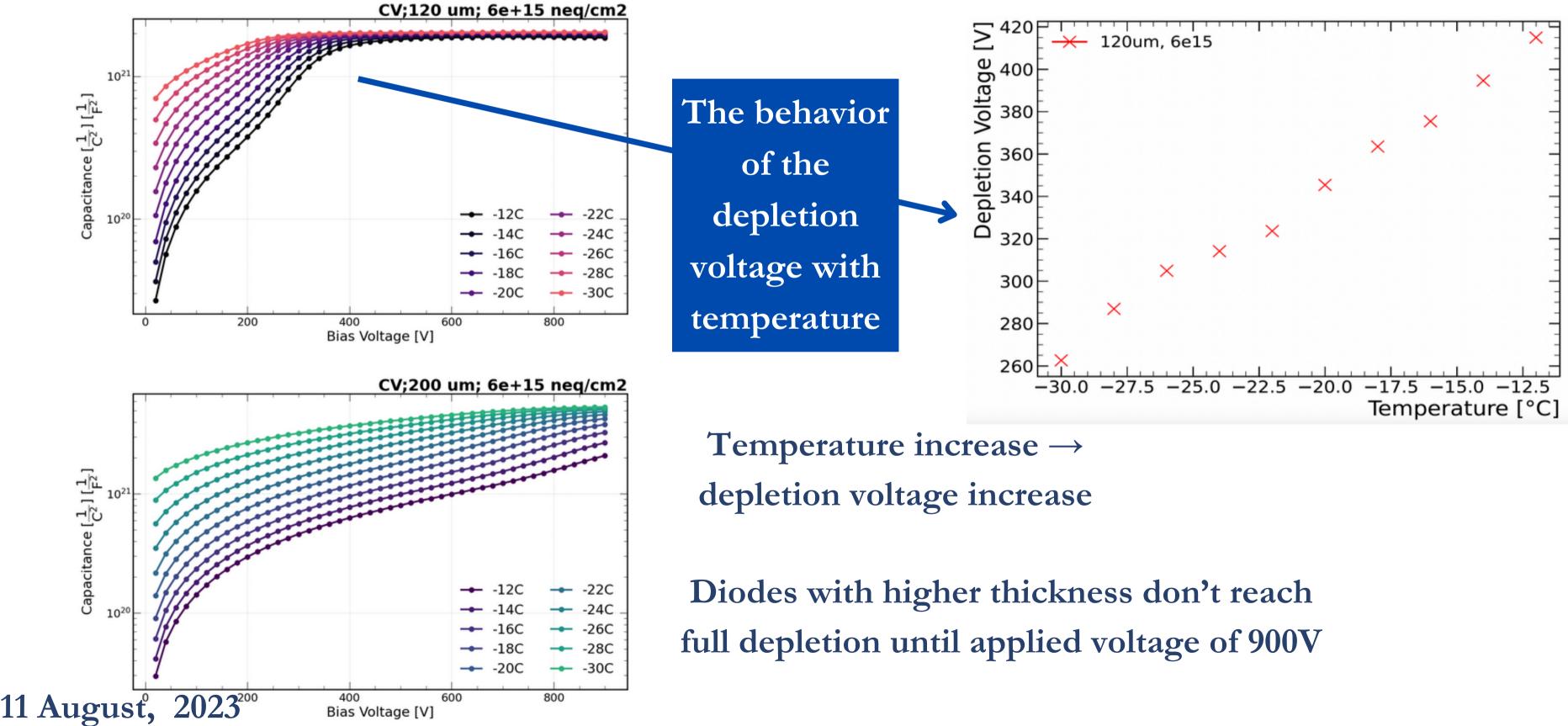
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## Measurements controlled by Labview

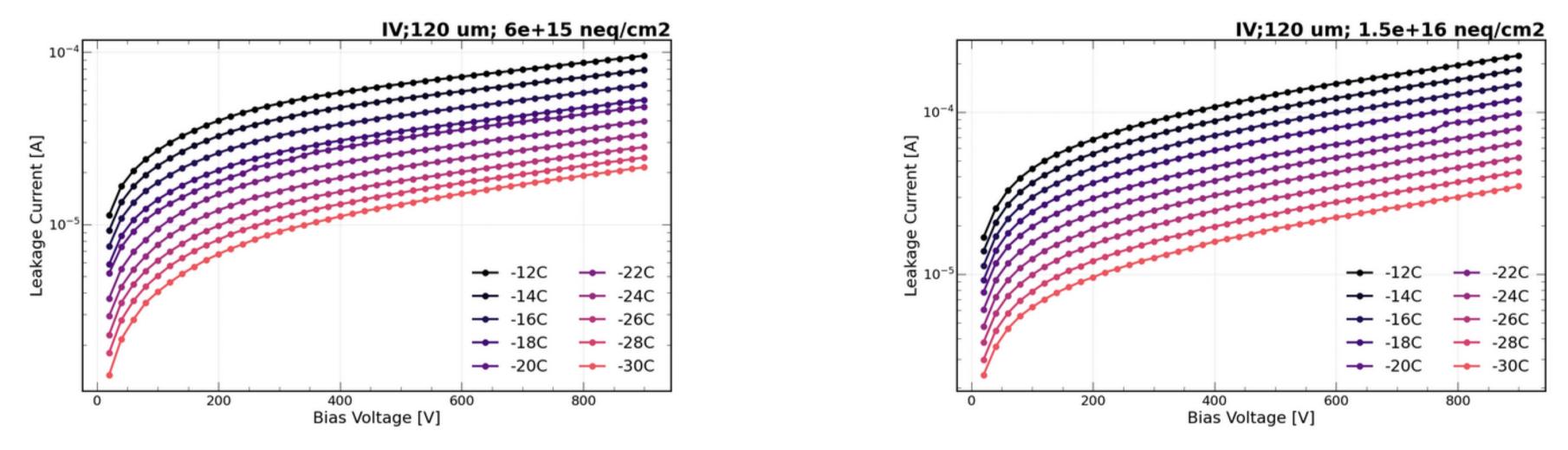
Contact is done with the DUT at the pad and at the guard ring

CV temperature Scans





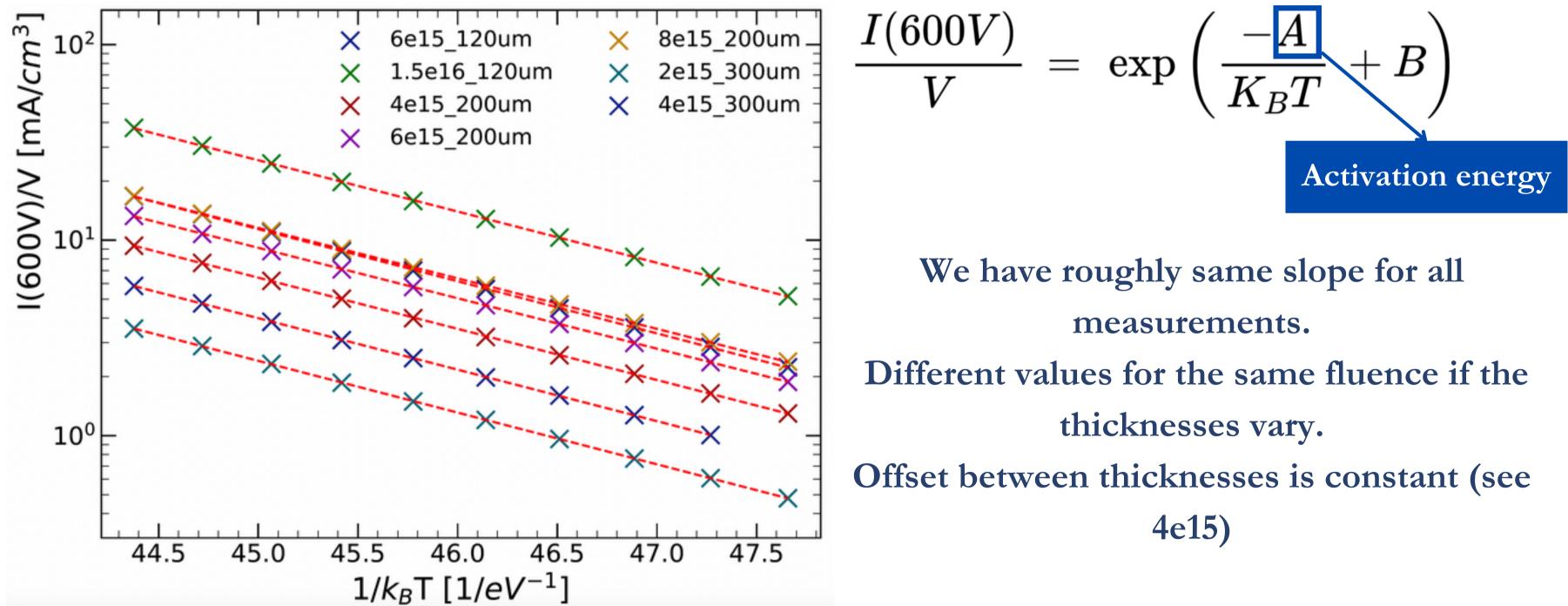
IV temperature scans



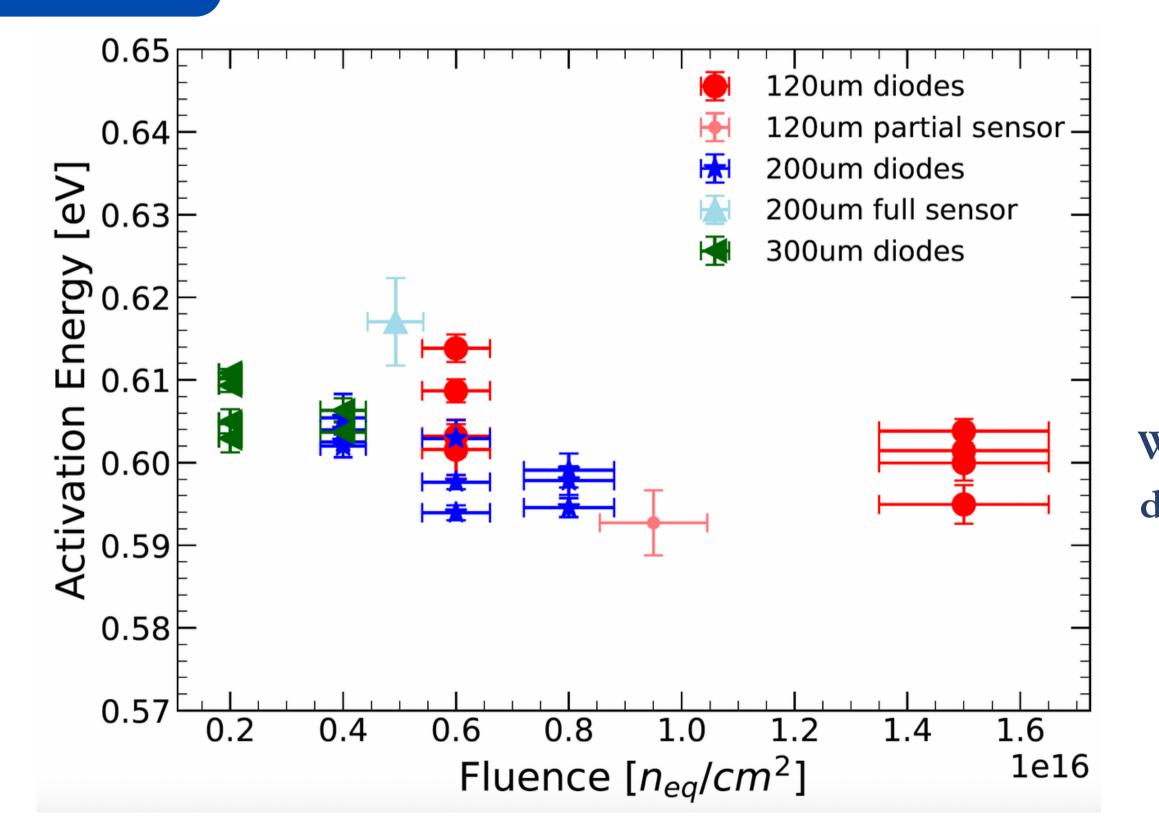
- For the same thickness of diodes the leakage current increases for higher fluences.
- The value of the leakage current also increases exponentially for the irradiated diodes as the temperature is increased.



Arrhenius plot



Activation energy vs the Fluence



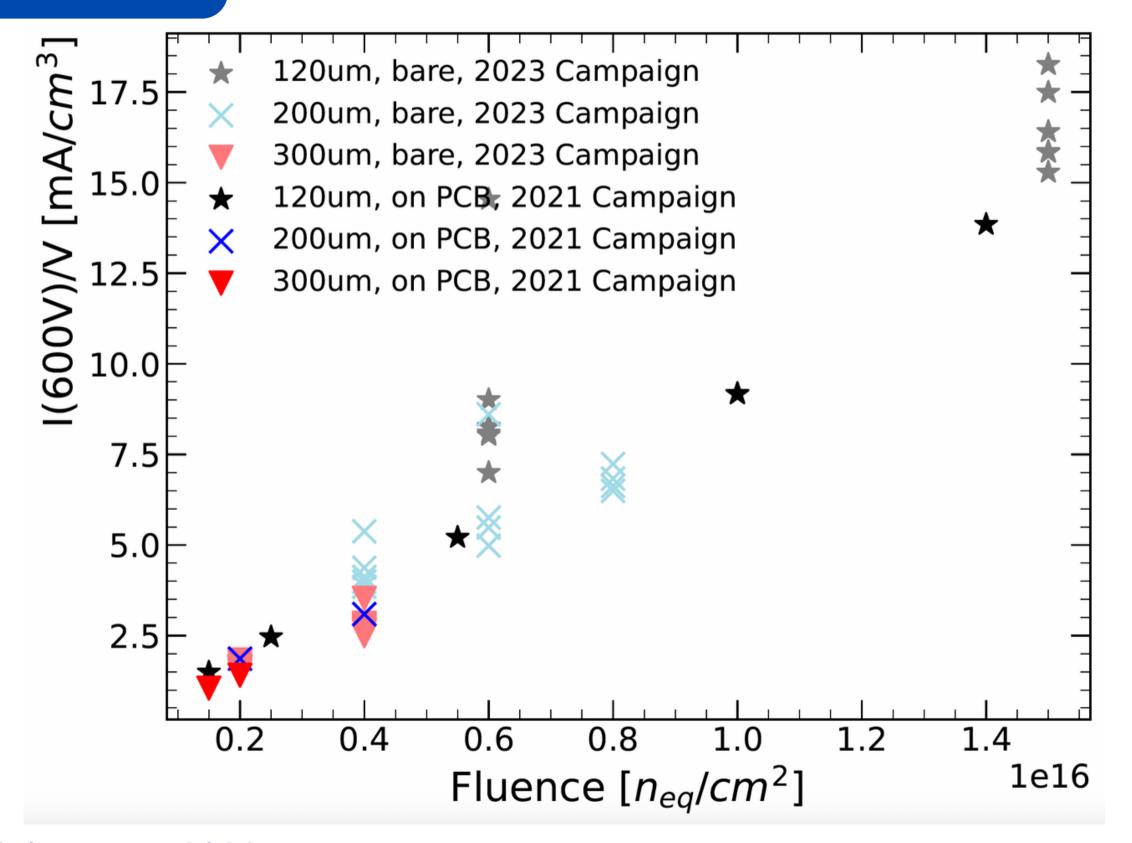


## Offset between thickness

## Slight fluence dependence possible

We are still investigating this possible dependance by increasing the sample of sensors tested.

# I\_leak/V vs fluence (alpha plot)



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We have large spread for the new sensors compared to previous campaigns.

A slight difference between thicknesses for the same fluence was also observed with the old sensors

$$\frac{l}{v} = \alpha \cdot \phi$$

# Conclusion

- Temperature studies were performed on seven diodes of different thicknesses and fluences.
- Results are in agreement with what we expected:
  - Exponential increase of current with temperature.
  - Shift of depletion voltage with temperature in CV measurements.

# Ongoing work

Investigation of possible fluence dependencies in the activation energy, investigation of the larger spread in the alpha plot.



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# THANK YOU

Any questions?



