
# TEST OF SILICON SENSORS FOR LUXE

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AIDAINNOVA 3RD ANNUAL MEETING

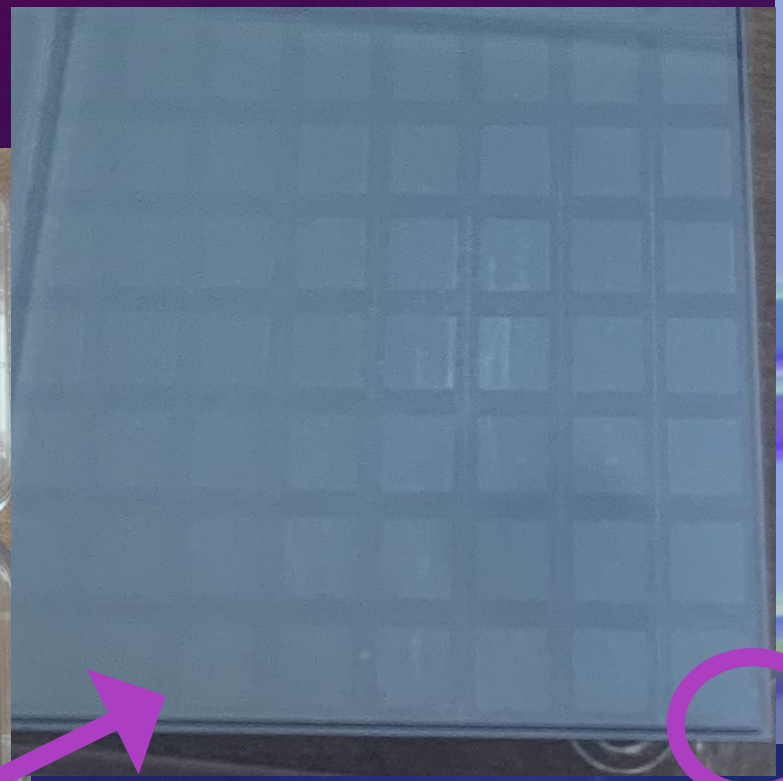
# SENSORS

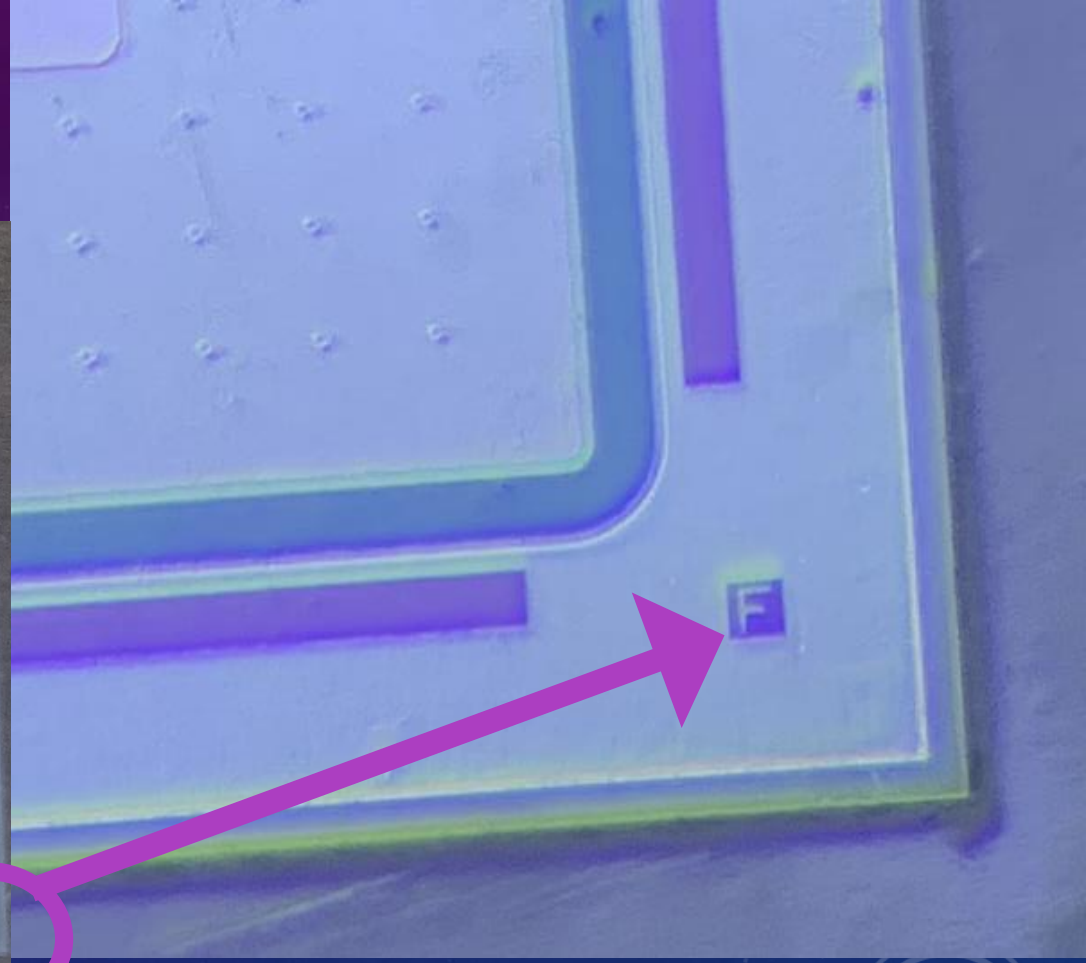
- 90 CALICE sensors received from Hamamatsu. 320 um thickness, 16x16 pads (5.5x5.5 mm2)
- Labeled and stored in dry cabinet with membrane boxes

| Parameter | Rating | Unit |
|---|---|---|
| Device type | P+ PIXEL on N substrate | |
| Chip size | 89700 ± 40 x 89700 ± 40 | μm |
| Active area | 88480 x 88480 | μm |
| Chip thickness | 320±15 | μm |
| Number of PIXELs | 256(16 x 16) | ch |
| PIXEL pitch | 5530 x 5530 | μm |
| PIXEL GAP | 10 | μm |

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| substrate resistitance | | | 3 | -- | -- | kΩ・cm |
| Full depletion voltage | Vfd | | 15 | -- | 120 | V |
| leakage current(for inner PIXEL*2) | Id | VR=200V | -- | -- | 25 | nA |
| leakage current(for outer PIXEL*2) | Id2 | VR=200V | -- | -- | 100 | nA |
| Number of NG PIXEL | | | -- | -- | 10 | ch |

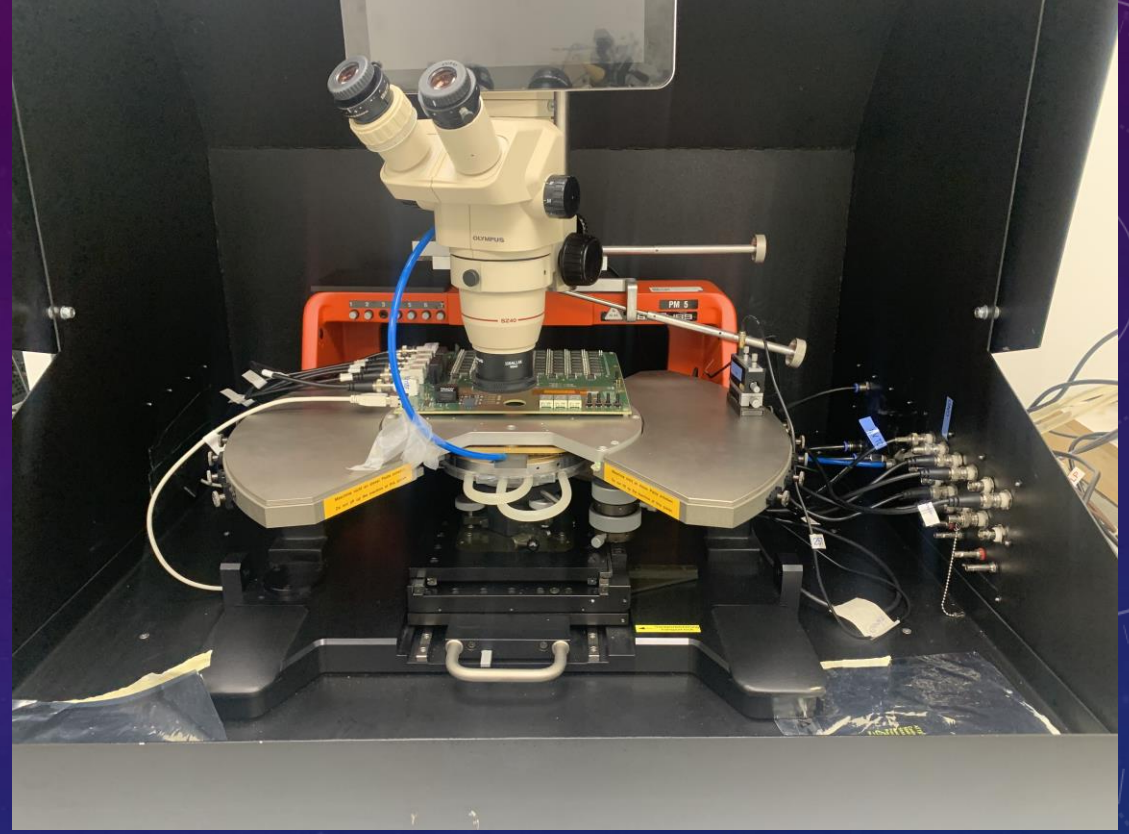
# SENSORS

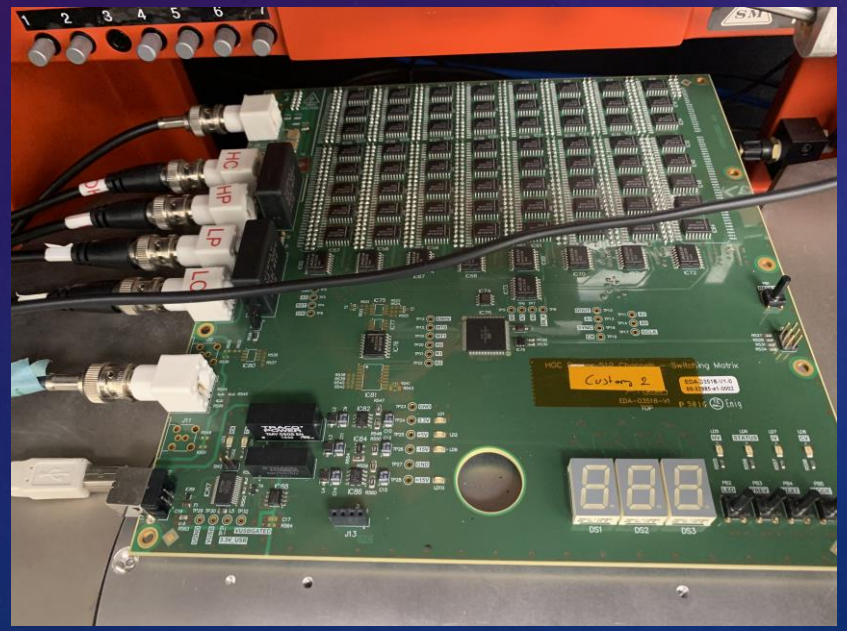




# PROBE STATION

- The manual probe station has been donated by DESY Zeuthen 15 years ago. It has been automatized by adding a switch card connected to a probe card (sensor design dependent) developed at CERN
- Originally designed for lumical sensors

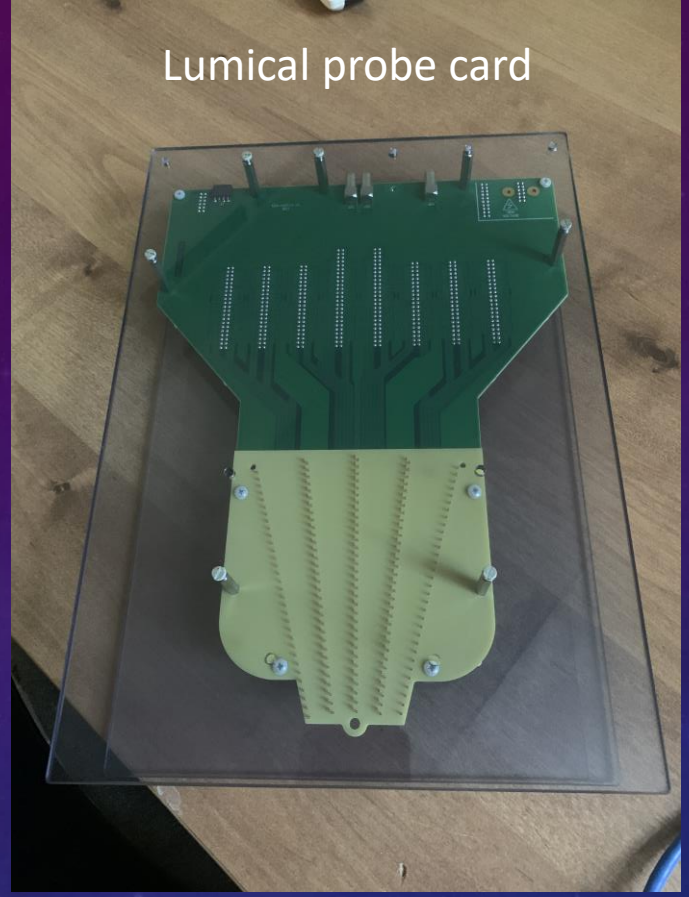




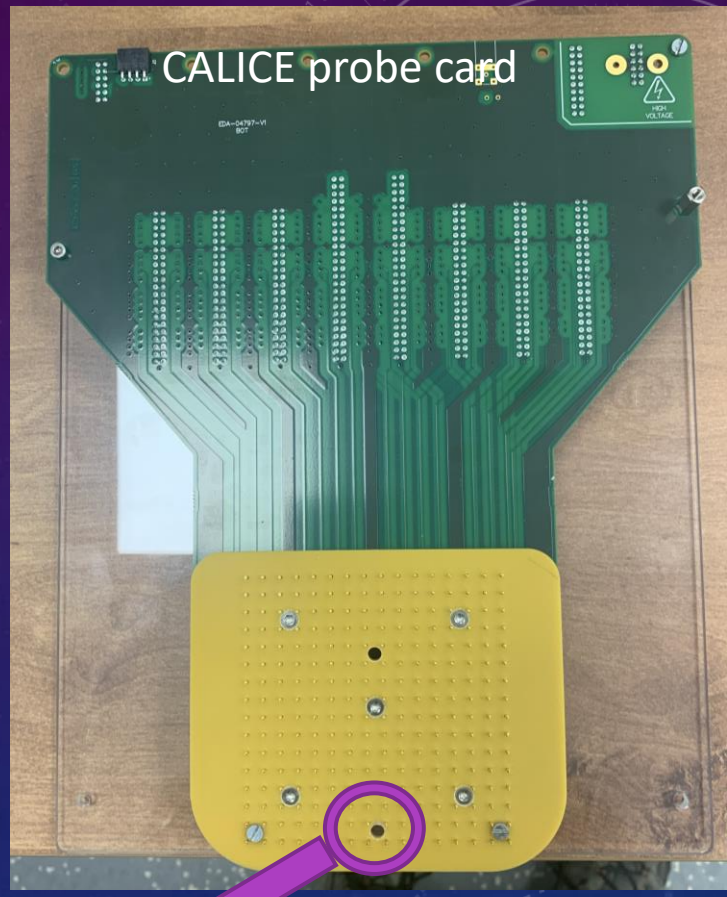
# PROBE STATION

- CALICE probe card arrived
- Probe station updated to accept the new probe card. Cooling, gas, pump cleaned and working
- Software updated for the new probe card (configuration files)

Lumical probe card

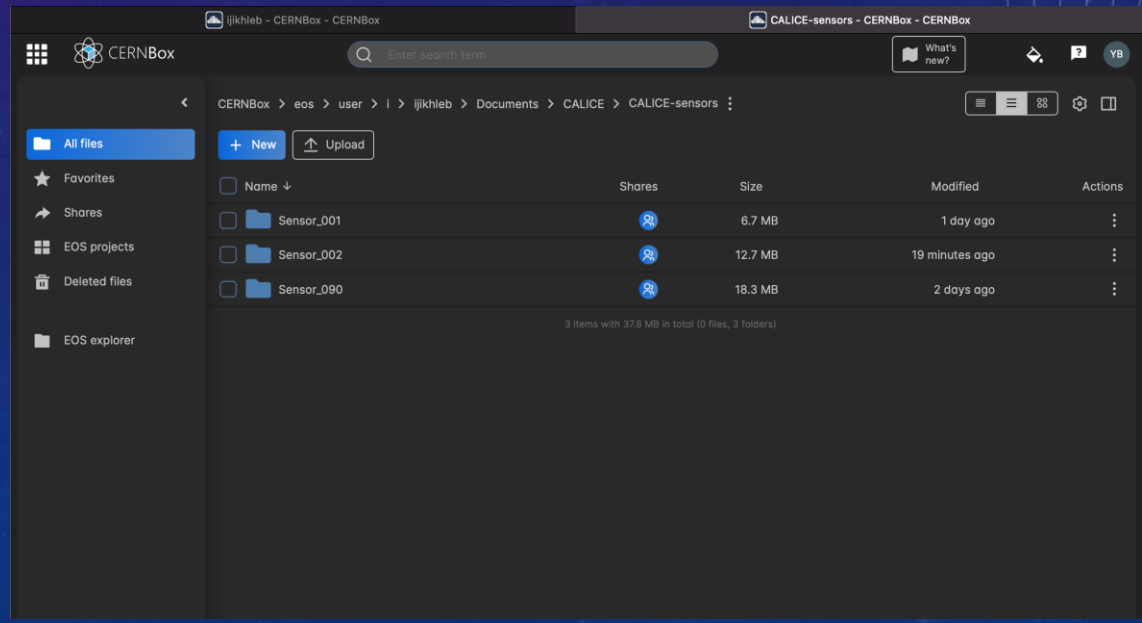


CALICE probe card



# SENSOR DATA

- Data from the probe station are saved on the local computer
- Then transferred to the CERN cloud (CERNBOX accessible by the collaboration)
- Analyzed by python soft to produce plots and alarm if needed
- For each sensor, one excel file produced with 256 sheets containing plots (CV,IV) for each pad. The excel file is uploaded to the CERN cloud.

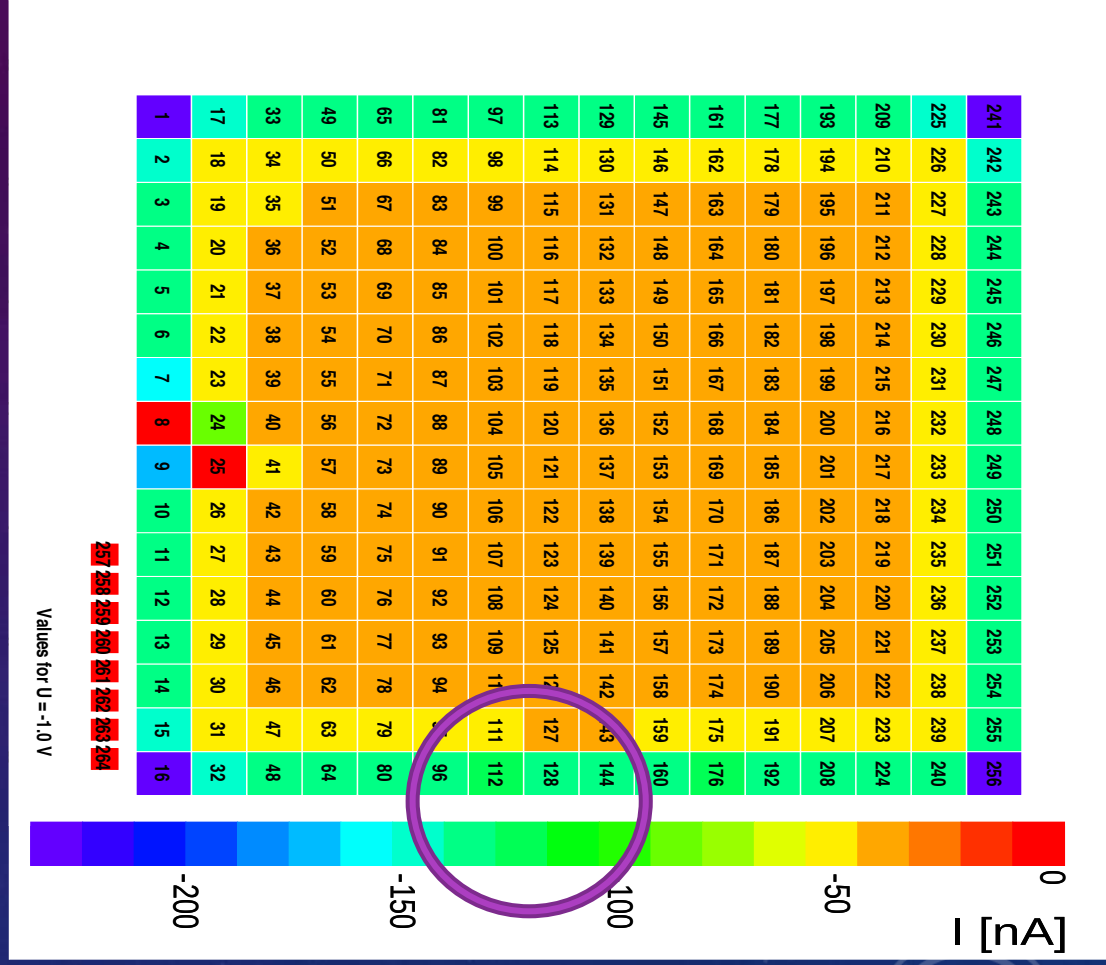


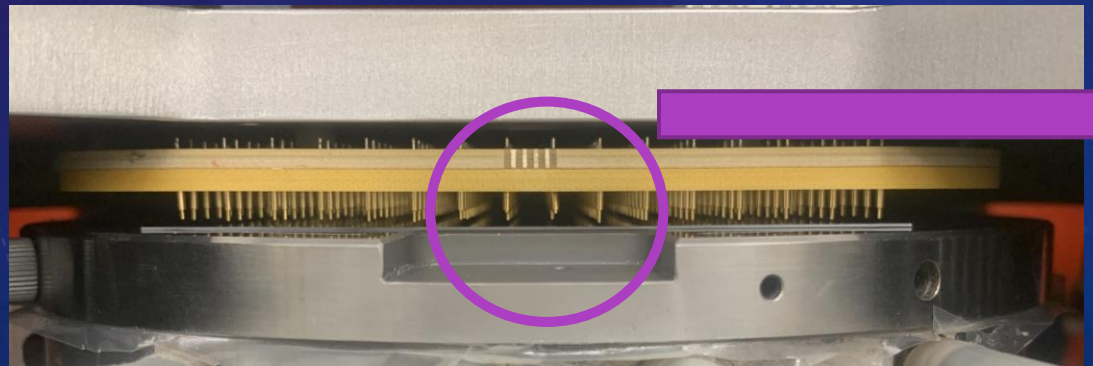

**Sensors and infrastructure :**

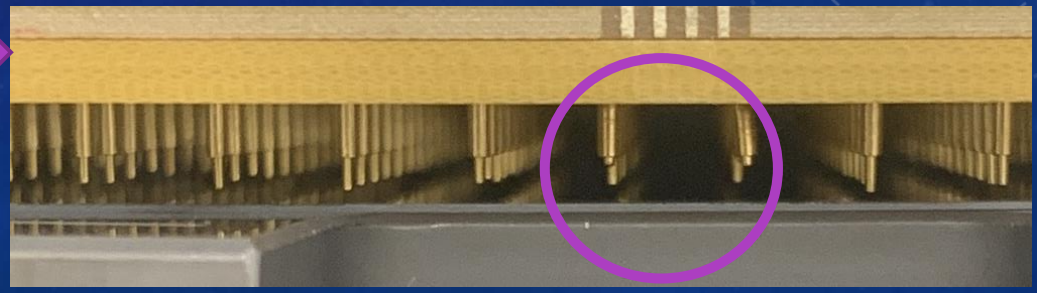
- **All sensors arrived and stored in good conditions**
- **Probe station has been modified and ready to test**
- **Data are saved and shared with the collaboration**

# DATA TAKING

- 1st step : contact test to be sure all the pads are touching the probe pins. Takes few minutes
- 2nd step IV test.
- 3rd step CV test.
- We are adding the following steps :
  - Rotation of the sensors (90 degrees)
  - Contact test
  - IV and CV for the missing pins



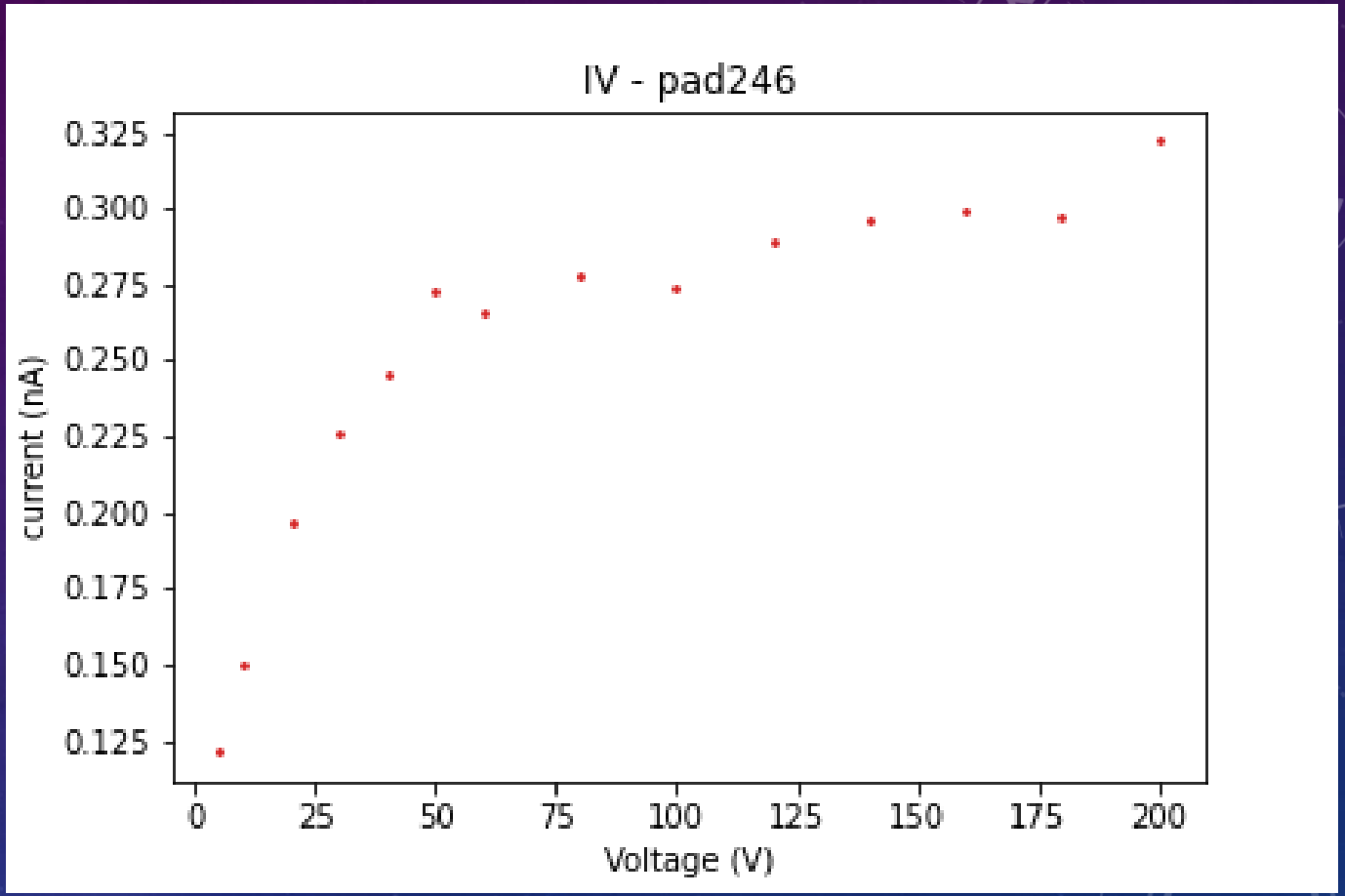


# IV MEASUREMENT

Checked the influence of different parameters: delay between measurements, delay between voltage change,…

System tuned

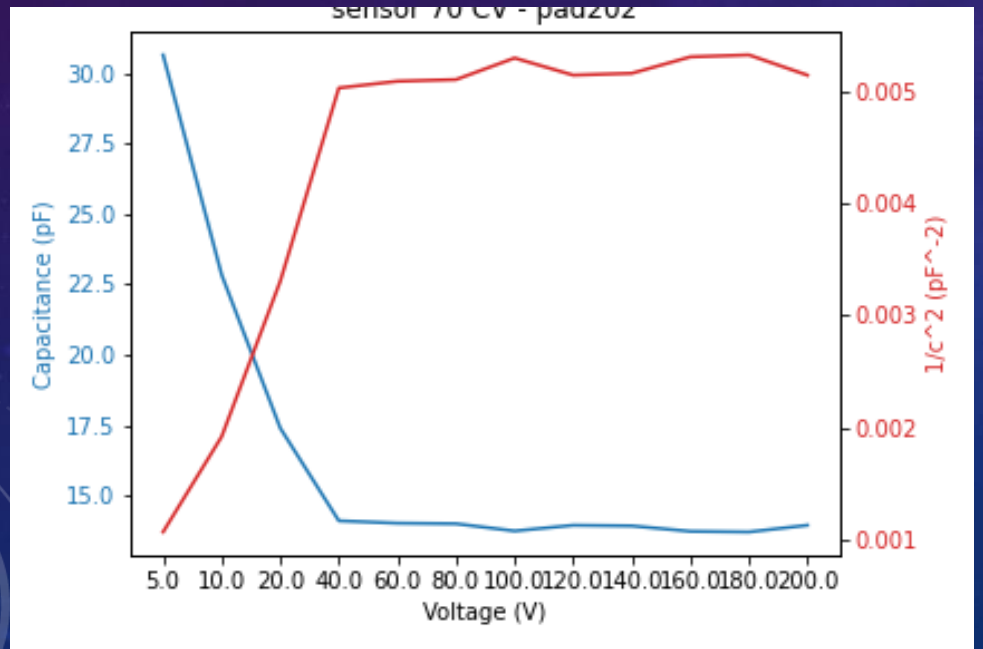
**Up to now, 25 x 256 pads measured with current plateau**

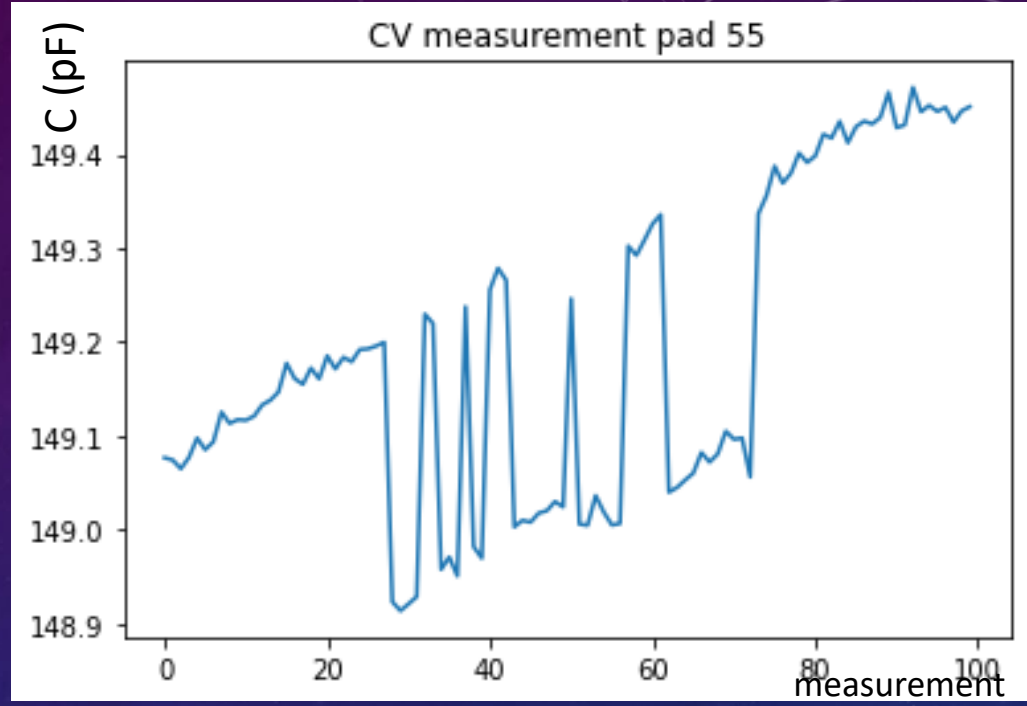


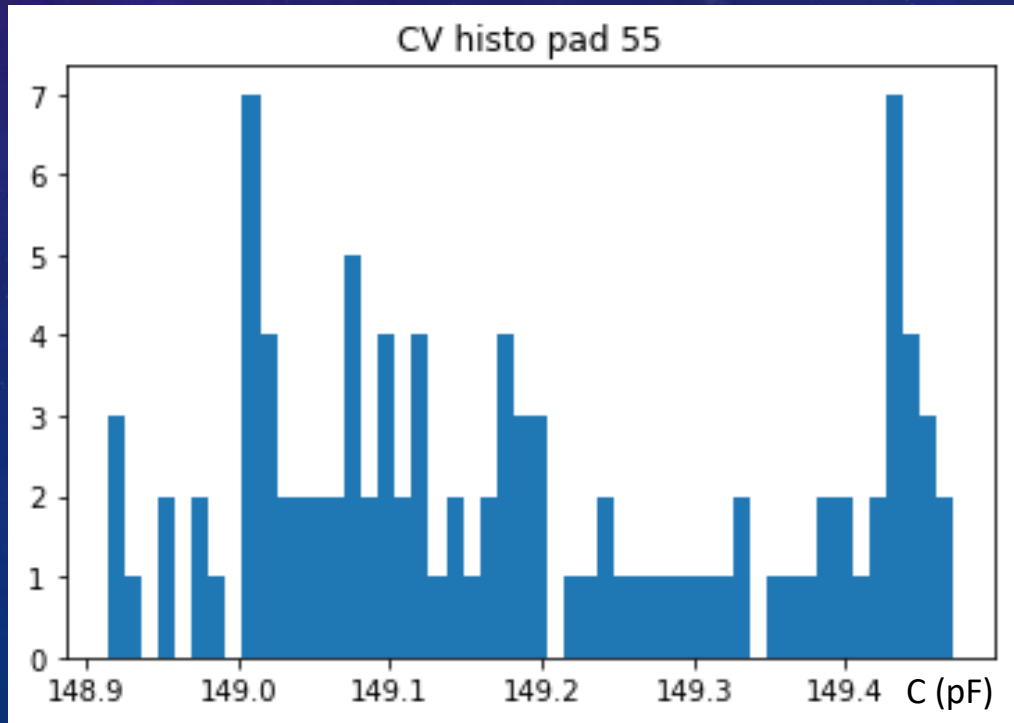
# CV MEASUREMENT

- 100 CV measurement on the same pad to check the repeatability
- Measurement of the system every 10 CV measurements (to be subtracted)

$$Capacitance_{sensor} = C_{measured} - C_{station}$$

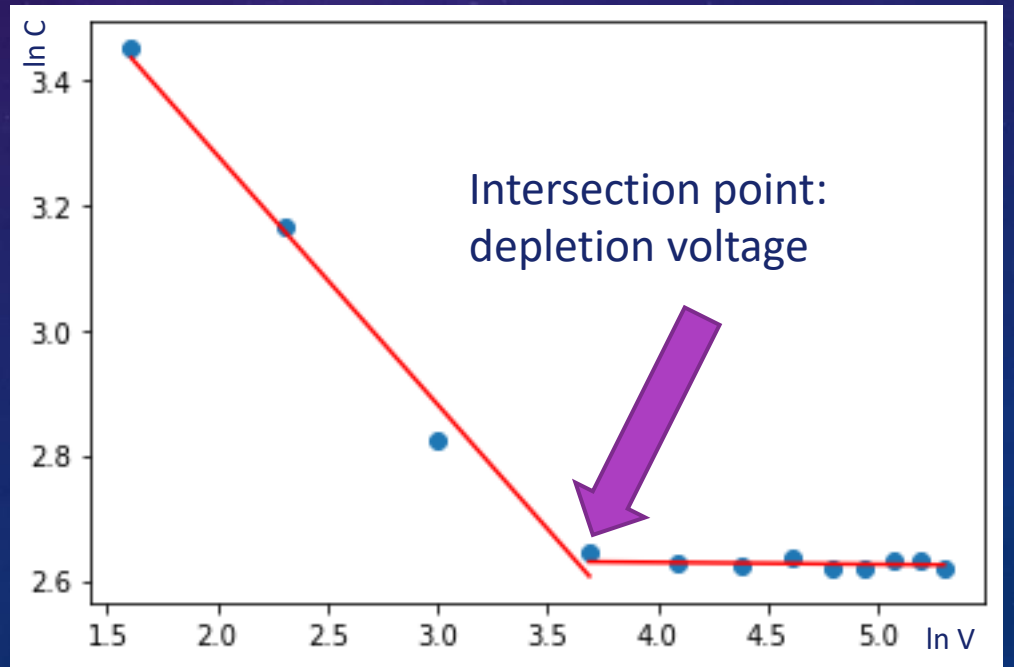


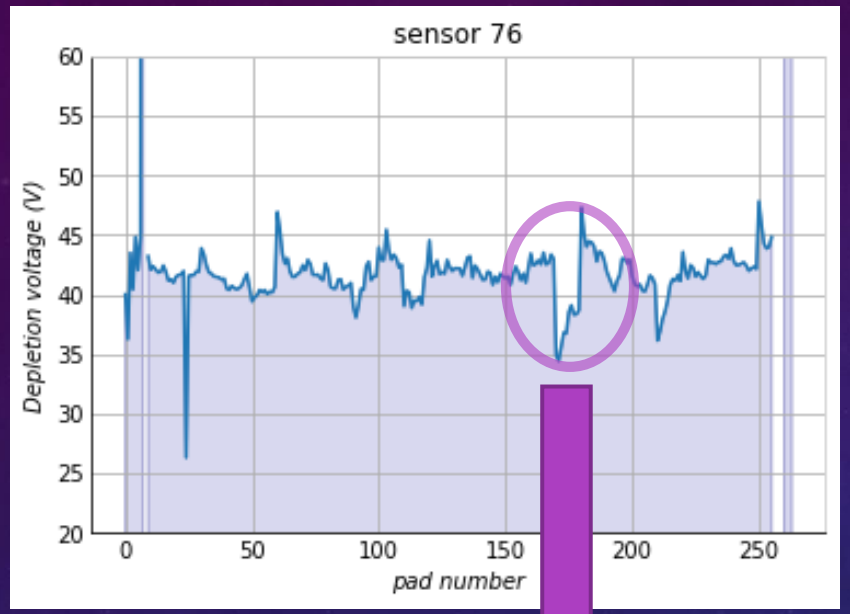
# DEPLETION VOLTAGE

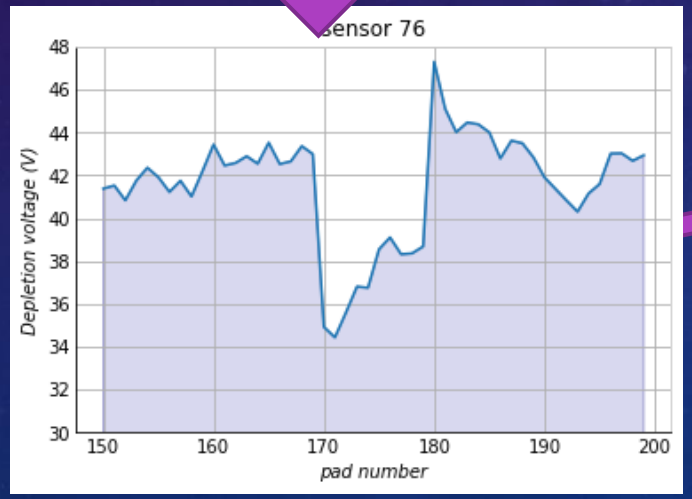
- It is possible to extract the depletion voltage from the CV measurement; the capacitance can be modelized by:
- $C_g = A\frac{\varepsilon_{Si}\varepsilon_0}{w} = \begin{cases} A\sqrt{\frac{\varepsilon_{Si}\varepsilon_0 e N_d}{2V}} \; for\; V < V_d, A: pad\; area\; Nd: number\; of\; donor, V\; bias\; voltage \\ A\frac{\varepsilon_{Si}\varepsilon_0}{w_m} \; for\; V > Vd, w_m\; max. depletion\; width \end{cases}$
- So if we take the log of Cg, we should obtain two lines. The intersection of these lines is giving the depletion voltage



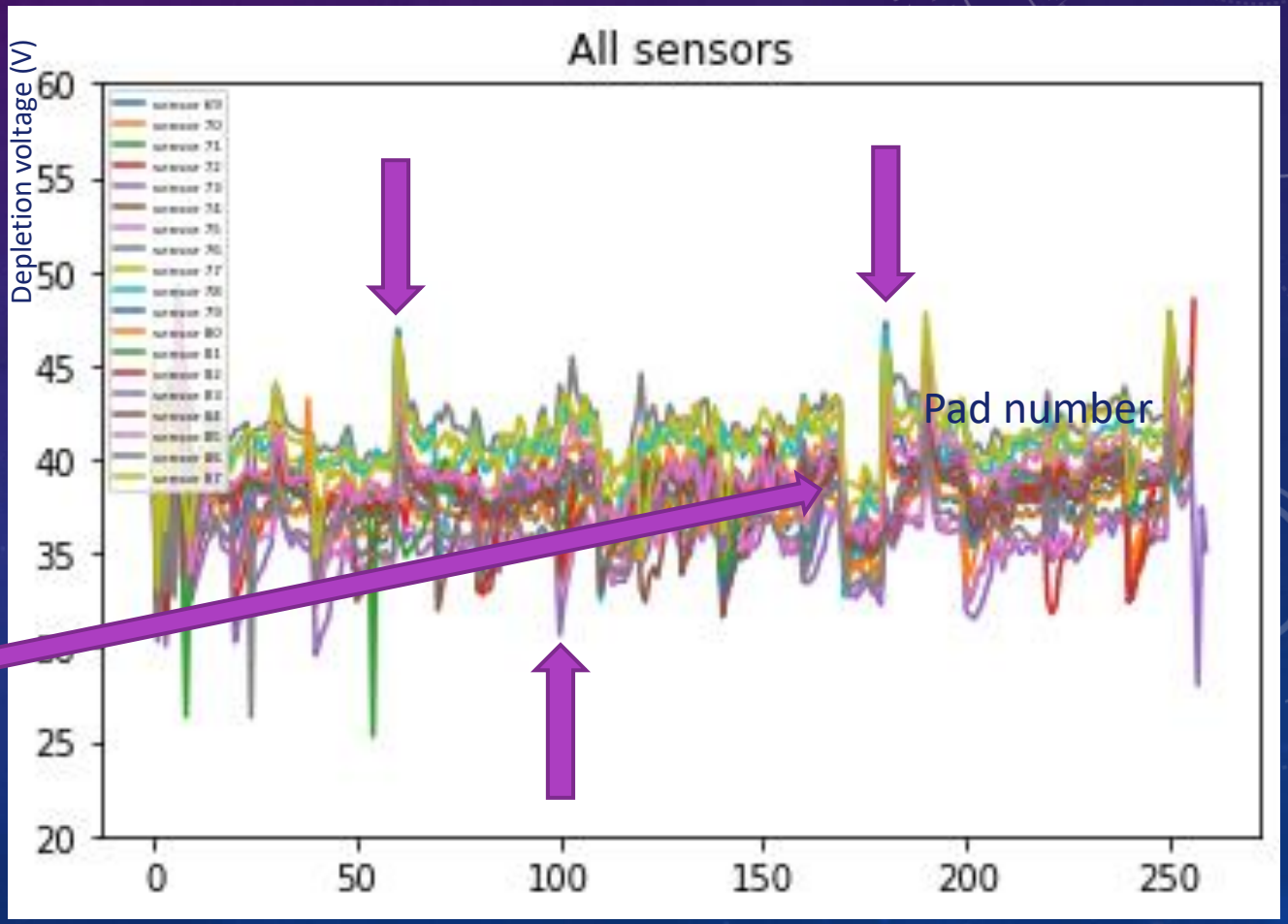
# DEPLETION VOLTAGE

- Define the depletion voltage per pad :



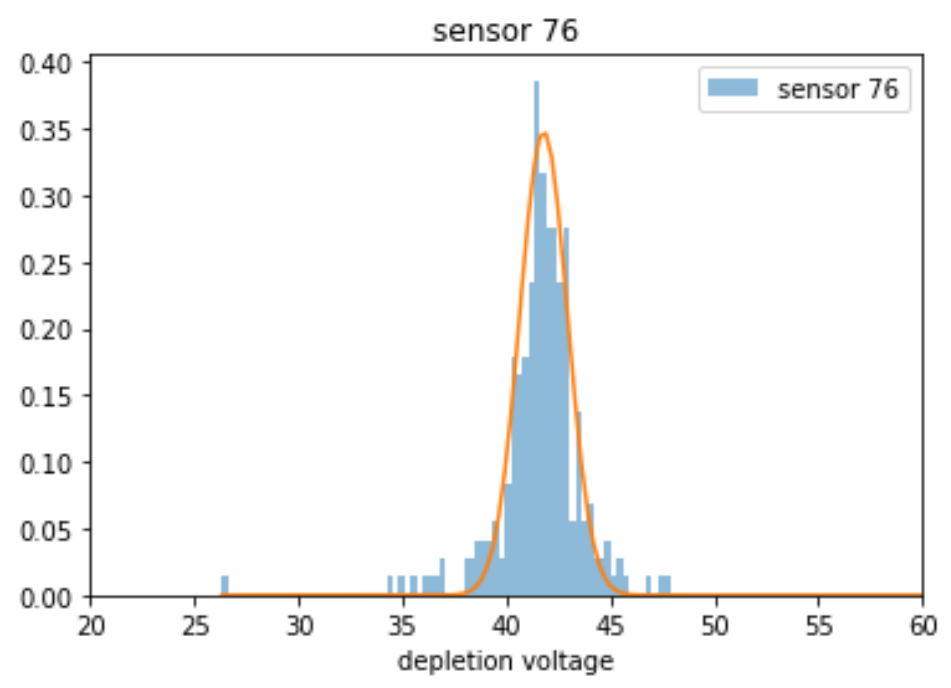




| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 241 | 242 | 243 | 244 | 245 | 246 | 247 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 |
| 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 |
| 209 | 210 | 211 | 212 | 213 | 214 | 215 | 216 | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 |
| 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 |
| 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 |
| 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 |
| 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 |
| 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 |
| 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 |
| 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 |
| 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

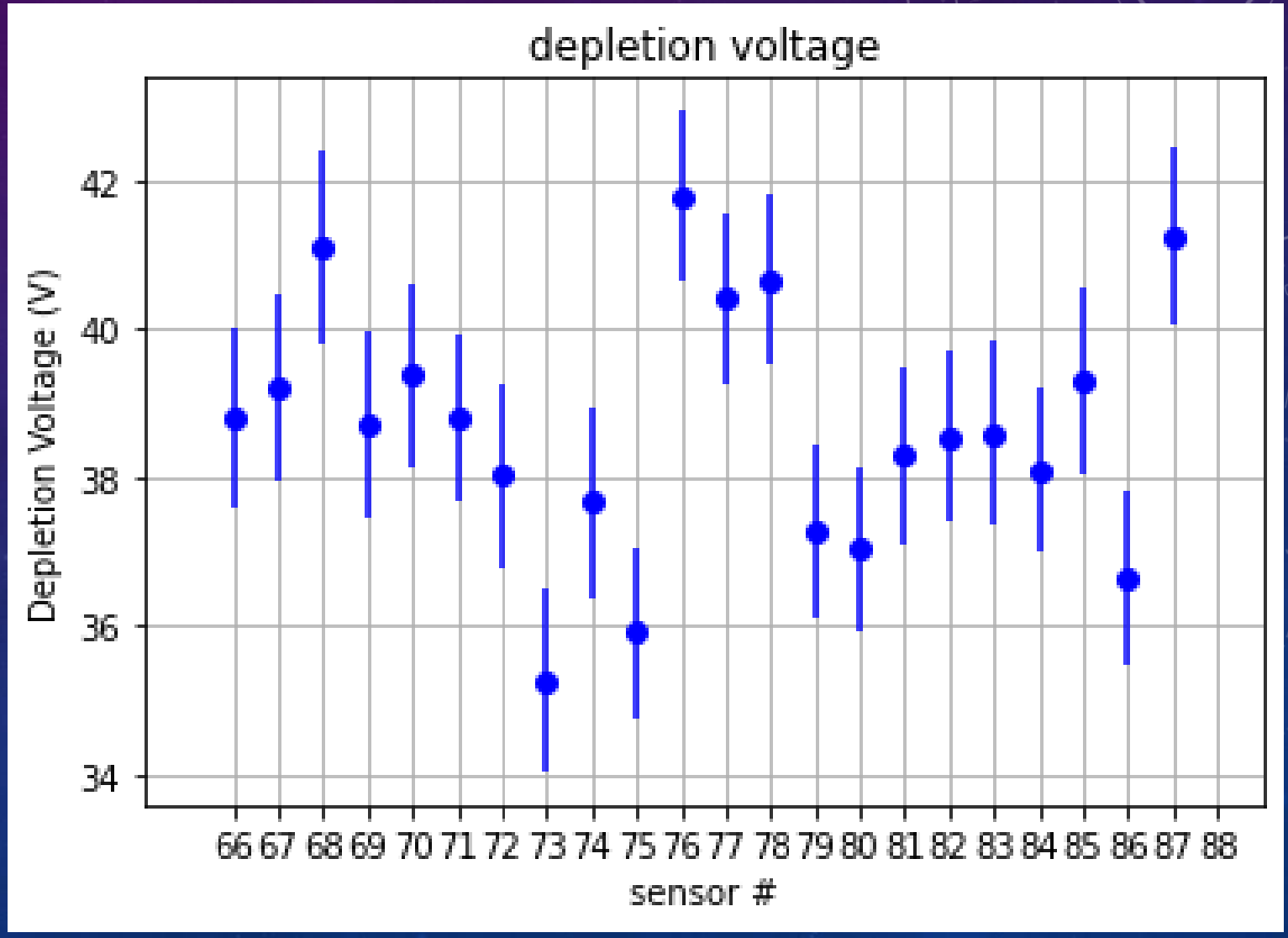


# DEPLETION VOLTAGE

- Fit per sensor -> mean, sigma




**This corresponds to the expected values**

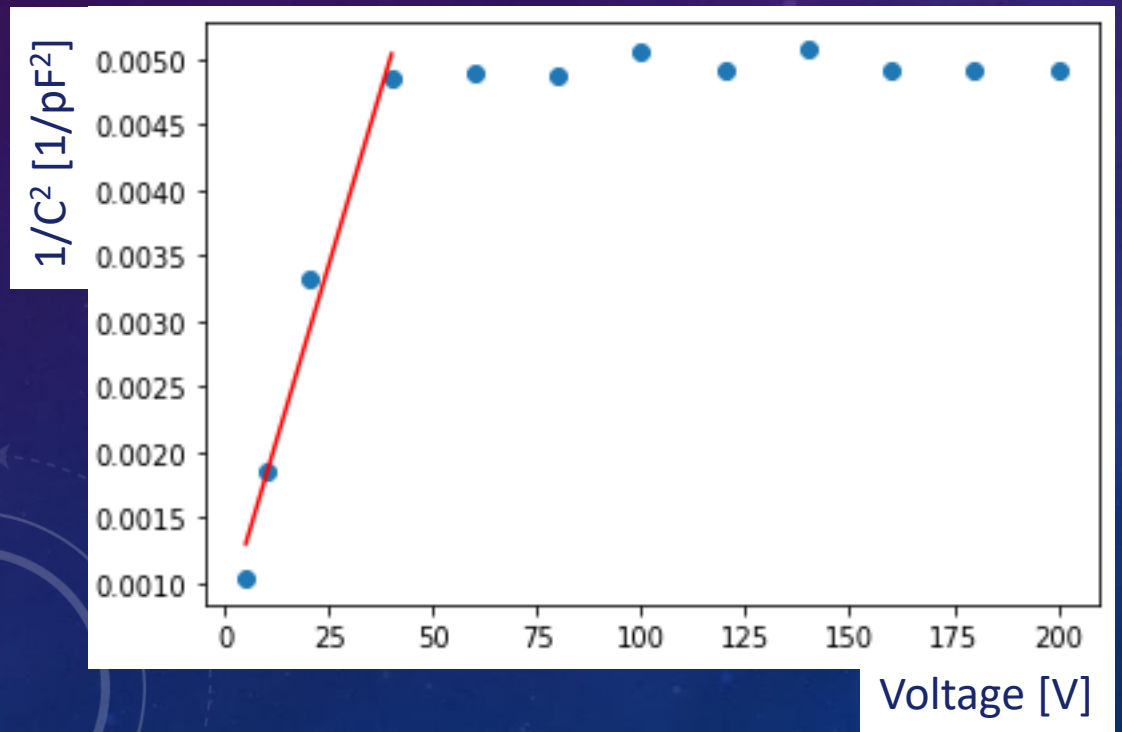


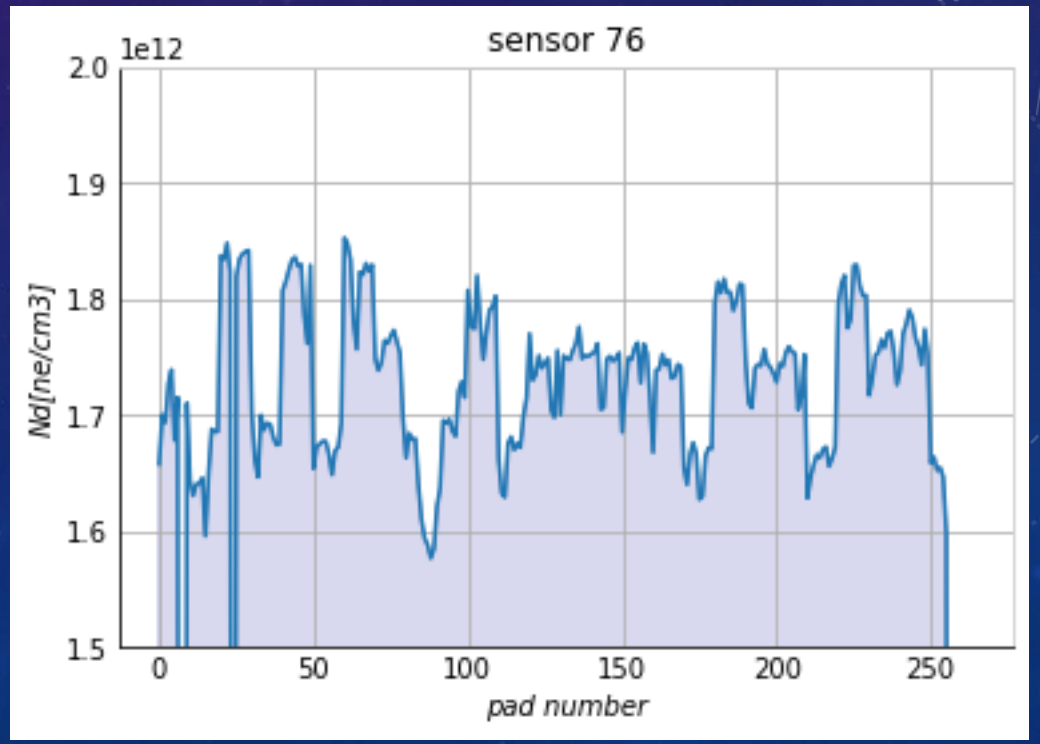
# DONOR DENSITY

- It is possible to determine the donor density using the formula :

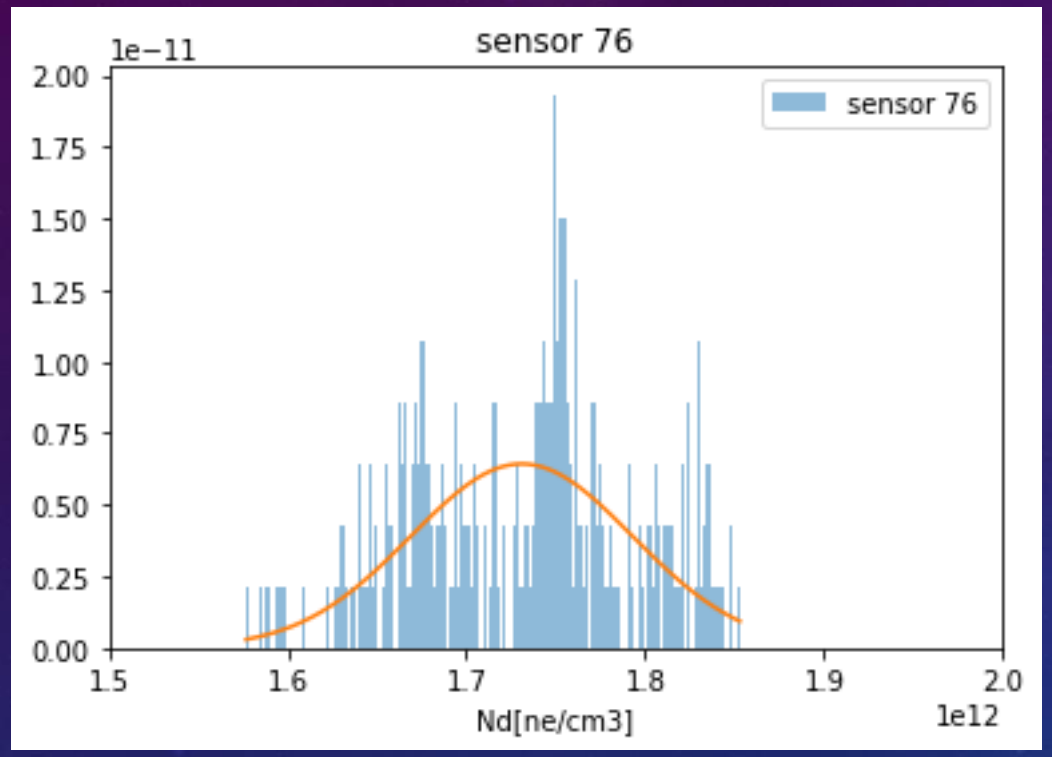
$$\frac{1}{C^2} = \frac{2}{\varepsilon e N_d A^2} V$$

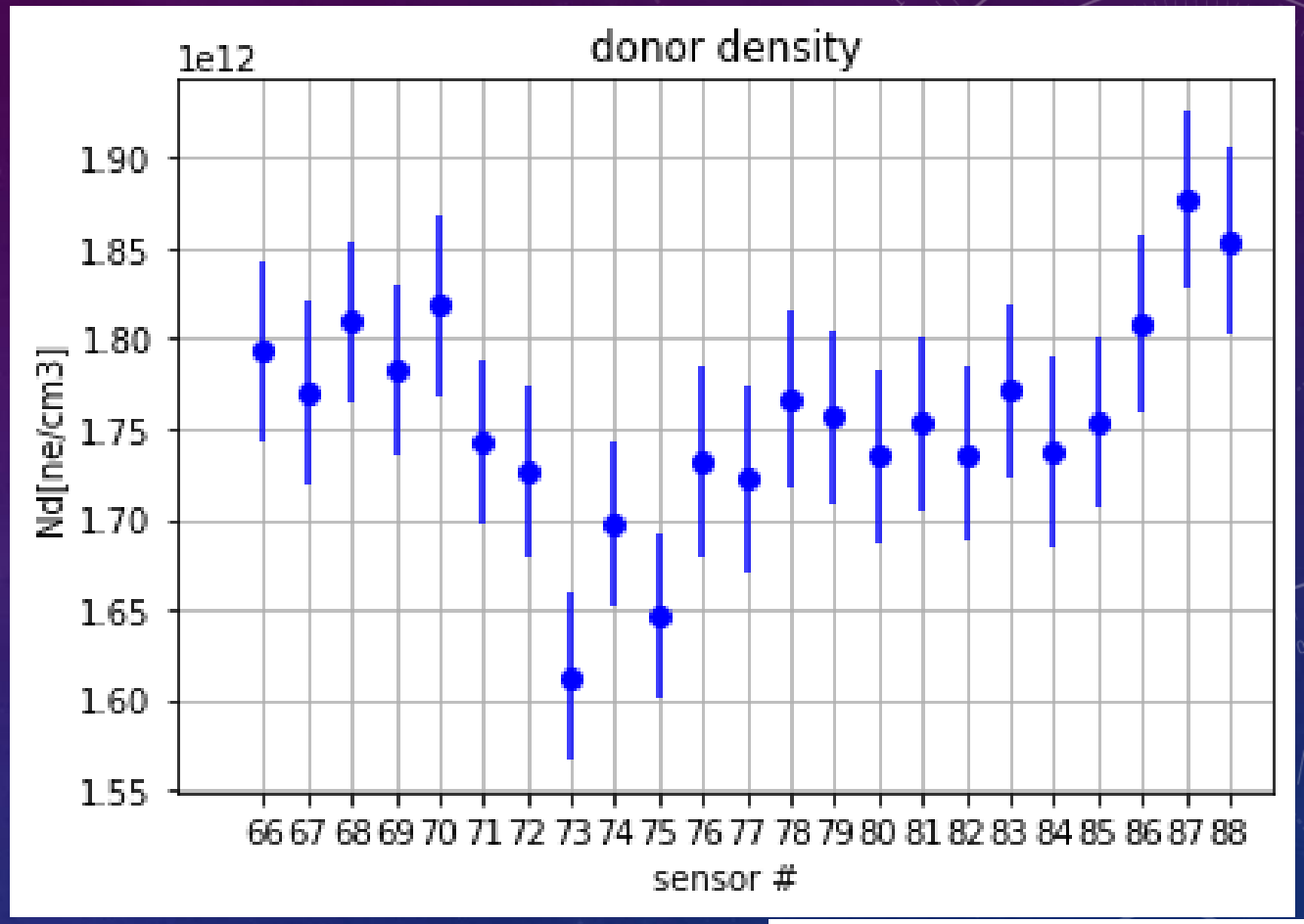
Where $N_d$ is the donor density and A is the pad area



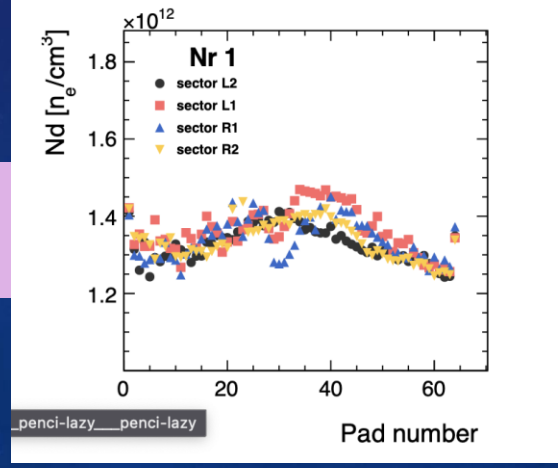



# DONOR DENSITY




This is compatible with the values found with lumical sensor



# CONCLUSION

- We have a working setup to characterize silicon sensors, including analysis and storage : we can test two sensors a day (without the rotation)
- All the pads of the tested sensors have a plateau in the IV plot
- Using the CV measurement, it is possible to extract the depletion voltage and the donor density. These extracted values are compatible with expectations

# THANKS