



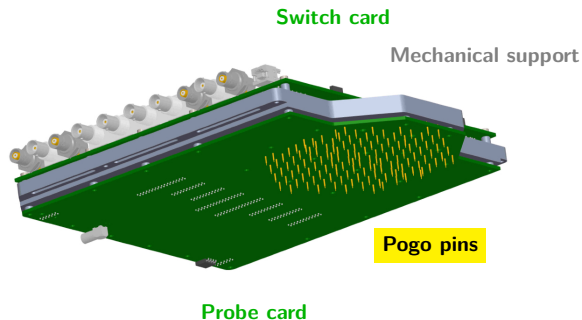
LumiCal sensor testing in Tel Aviv using the new probe card / switch card system

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Probe/Switch card concept

- ▶ CMS HGCAL will have 600 m^2 of multi-pad silicon sensors (1 cm^2 cells)
- ▶ System needed for sensors electrical characterisation (IV, CV)

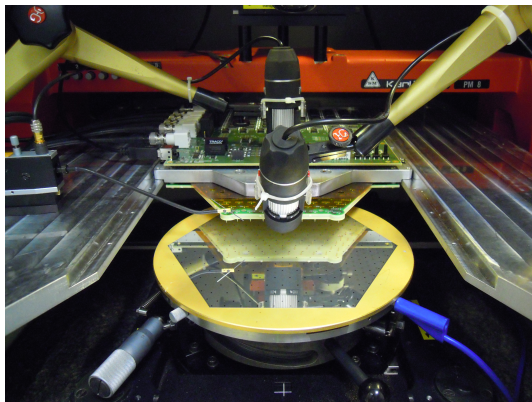


- ▶ Commercial switching units expensive → custom design of switching system by Szymon Kulis
- ▶ Switching card for measurement of various sensor layouts up to 512 cells
- ▶ Mother-daughter card system of switch card and probe card with pogo pins

- ▶ Probe cards adaptable to sensor geometry → not limited to HGCAL

Probe/Switch card concept

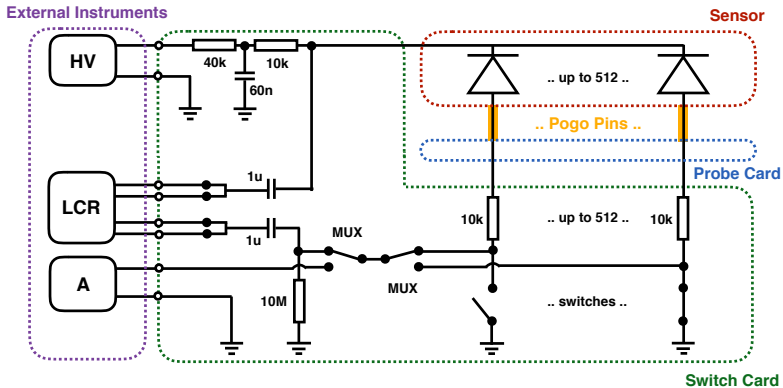
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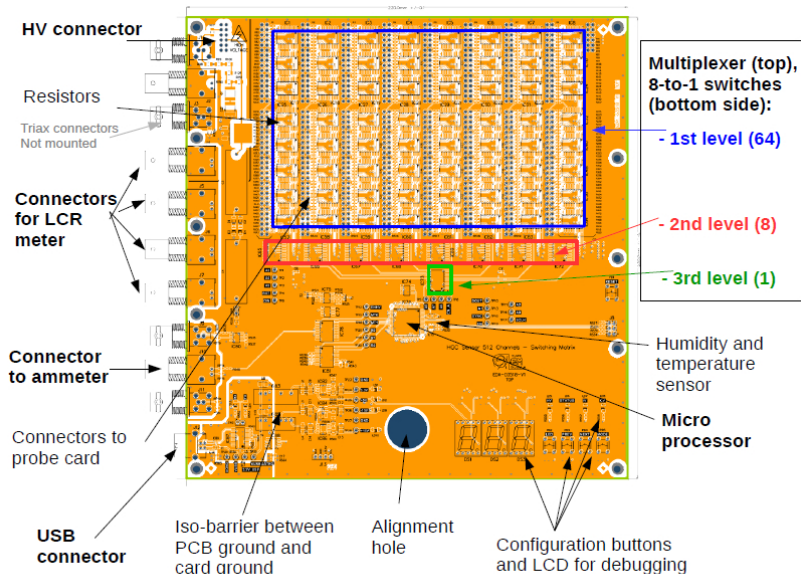
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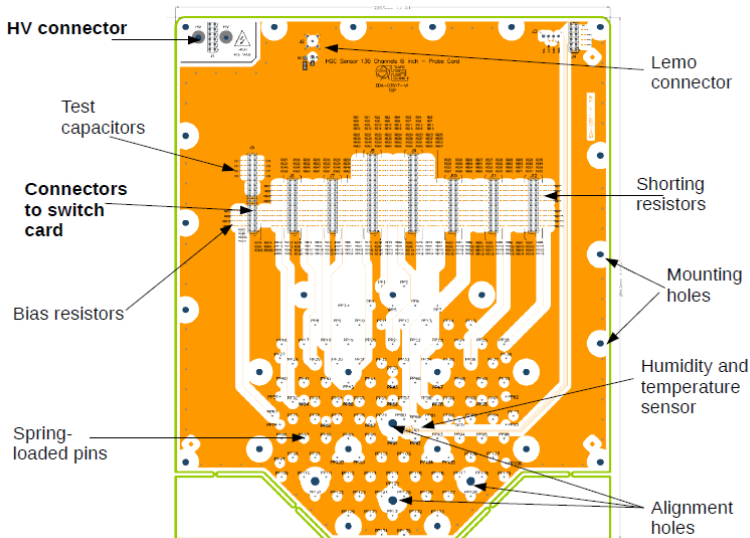
Probe/Switch card circuit



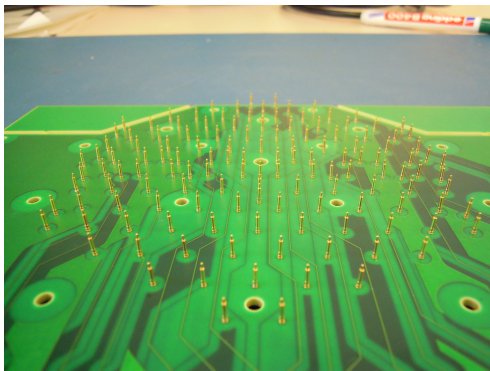
Switch card



HGCal probe card



Pogo pins

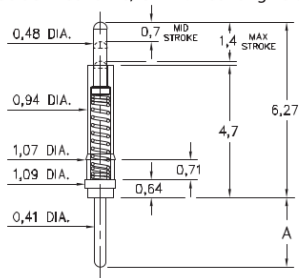


0985

0985-X-15-20-71-14-11-0

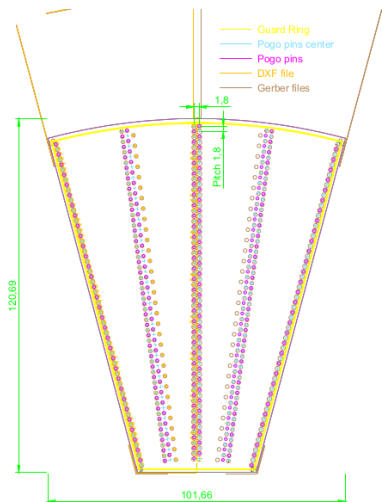
Standard stroke

Solder mount in 0,49 min. mounting hole

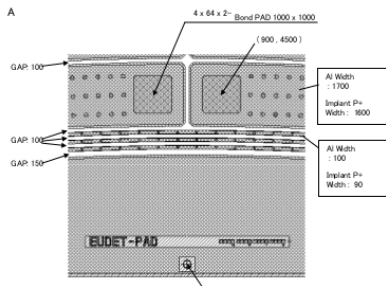


- ▶ Pogo pins MILL-MAX 0985-1-15-20-71-14-11-0
- ▶ Pogo pins soldered into PCB by hand
- ▶ Precision good enough to for LumiCal contact pad of 1 mm^2

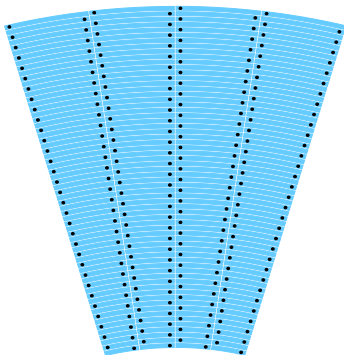
LumiCal contact pad positions



- ▶ Small disagreement between various input files of sensor layout (DXF files, Gerber)
- ▶ PCB designer at CERN had to make a choice on which source to use
- ▶ For contact pads with 1 mm^2 size small differences become important

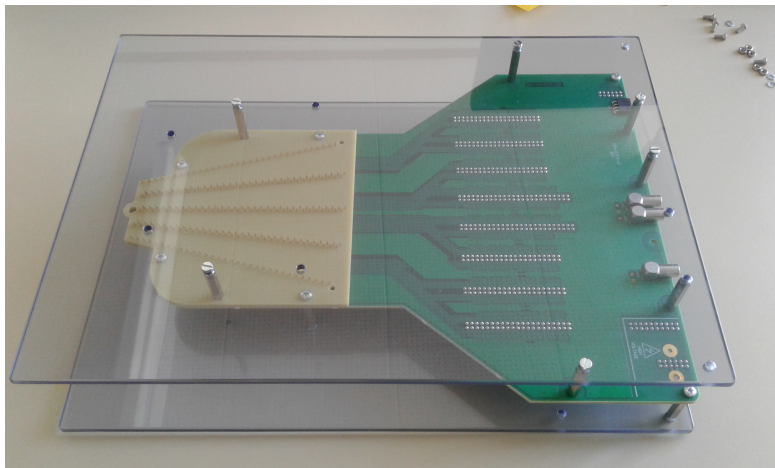


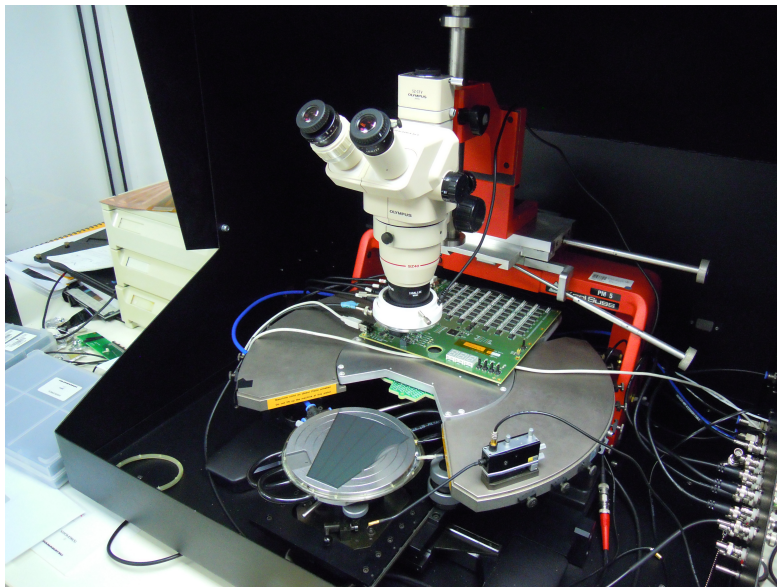
LumiCal contact pad positions



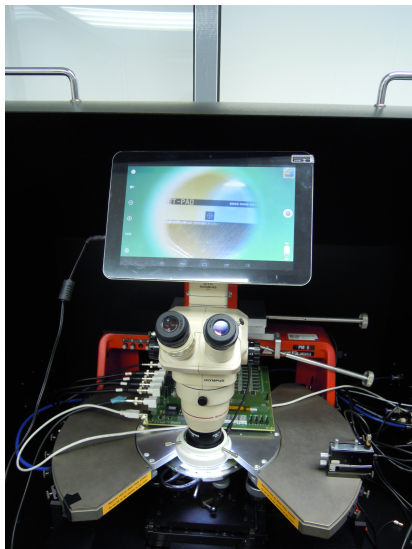
- ▶ Pogo pins were chosen to be in odd cells on the left side and in even cells on the right side

LumiCal Probecard





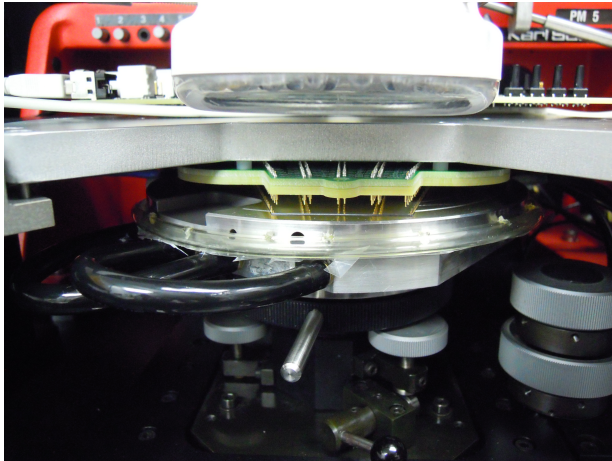
Alignment (1)



Alignment between probe card and sensor

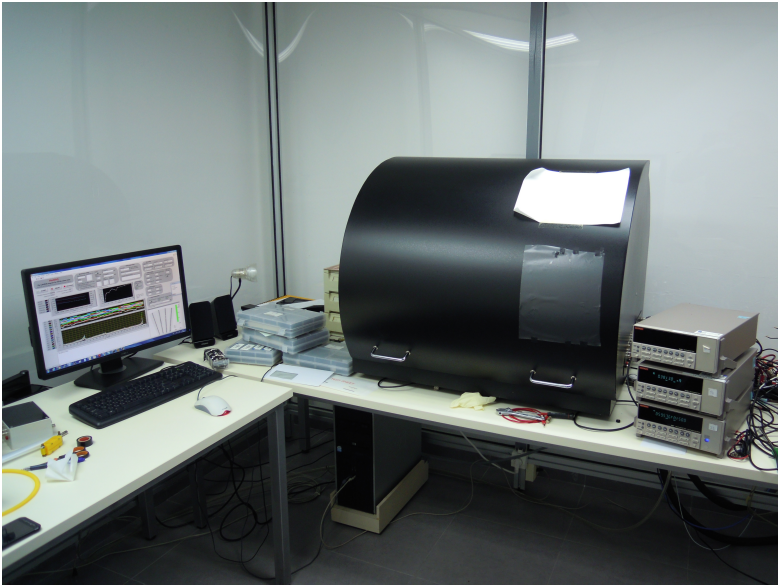
- 1 Rotation of sensor by eye (last slide)
- 2 Move chuck in and out of probe station (y-direction) and look through hole in probe card that should be above cell columns 2 and 3
- 3 If the rotation is correct, one can always see the border between columns 2 and 3, otherwise correct rotation of chuck
- 4 Place sensor such that the target on the sensor bottom is exactly below the hole in the probe card

Alignment (2)

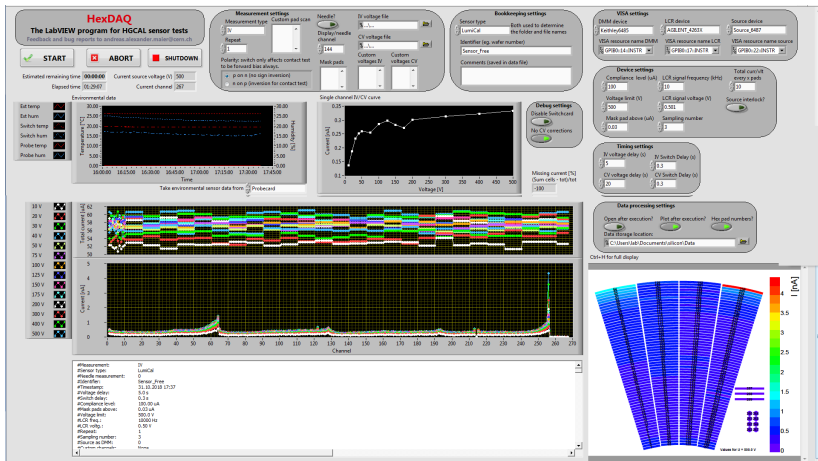


- 5 Cross check pogo pins and cell positions from the front by eye
- 6 Contact the sensor with the probe card

Dark box and clean room



Data Acquisition and Analysis

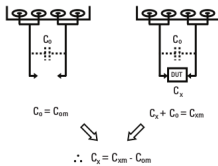


- ▶ LabVIEW implementation “HexDAQ”, analysis tool “HexPlot”
- ▶ Needed to implement TAU lab instruments into HexDAQ
 - ▶ Keithley 6487 (source meter), Keithley 6485 (picoammeter), Agilent E4263B (LCR meter)

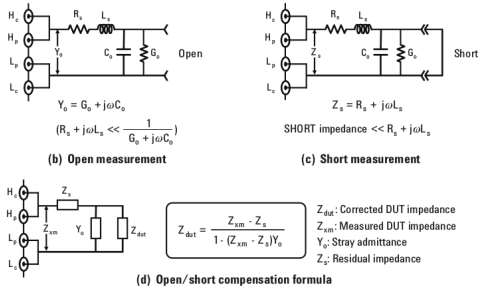
- ▶ None of the sensor guard rings was so far connected during the measurement
- ▶ There was always at least one cell for which we could not establish a contact
- ▶ With un-contacted probe card and with 0 V, power supply shows always a total current of 50 μ A
 - ▶ To be investigated (suggestion: remove ground connection of inner shield of triax connector of picoammeter)
- ▶ Correction of capacitance values
 - ▶ Capacitance values shown in the following are without open and short correction, just from C_p -D readout of the LCR meter
 - ▶ The values of the test capacitors on the probe card as well as the values of the cell capacitances fit rather well the expectations
 - ▶ To be investigated (Normally we see parasitic capacitances from PCBs. Can be corrected by applying open and short correction →)

Open and short corrections

Open correction

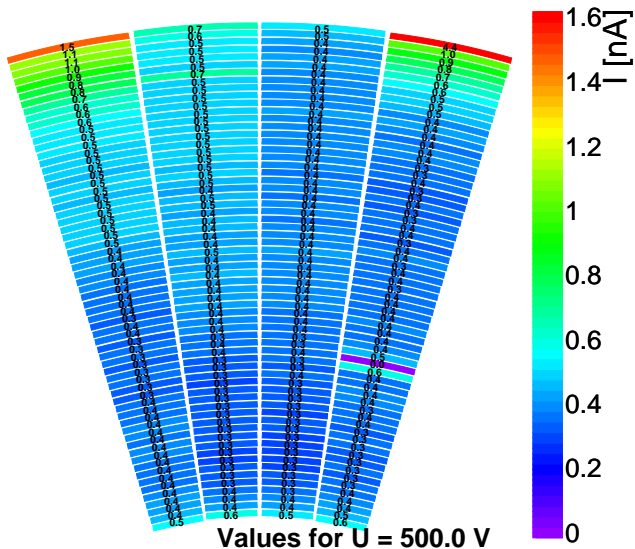


Open and short correction

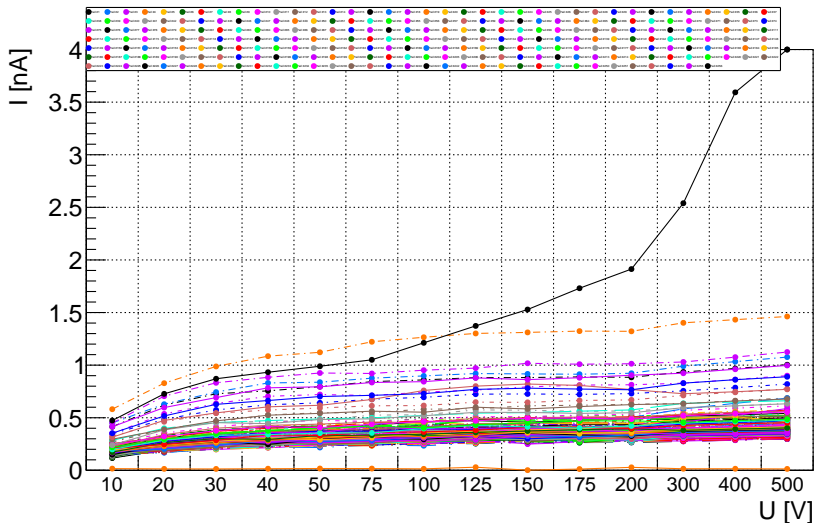


- ▶ Source: Keysight Impedance Measurement Handbook
- ▶ Full correction requires readout of Impedance and Phase from LCR meter

Leakage current @ 500 V

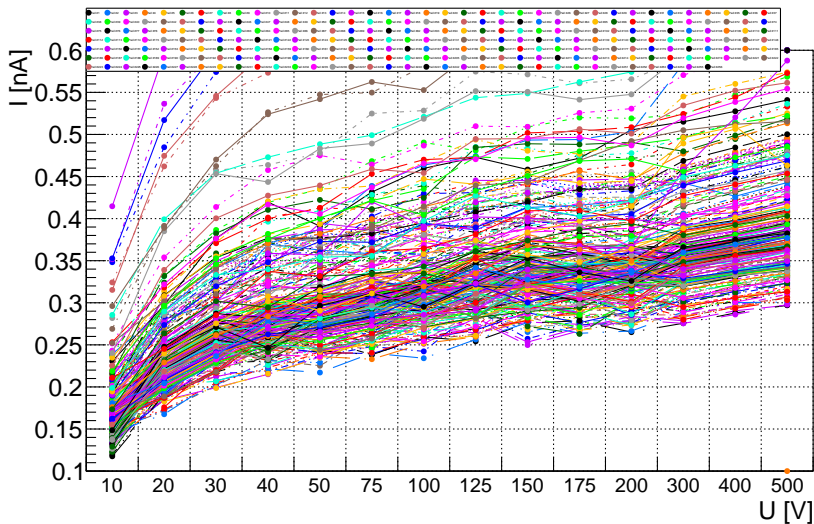


Leakage current vs. voltage

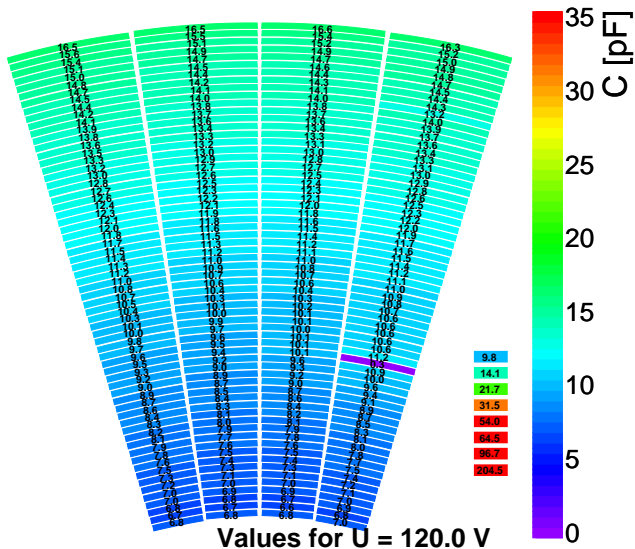


Leakage current vs. voltage

Zoom

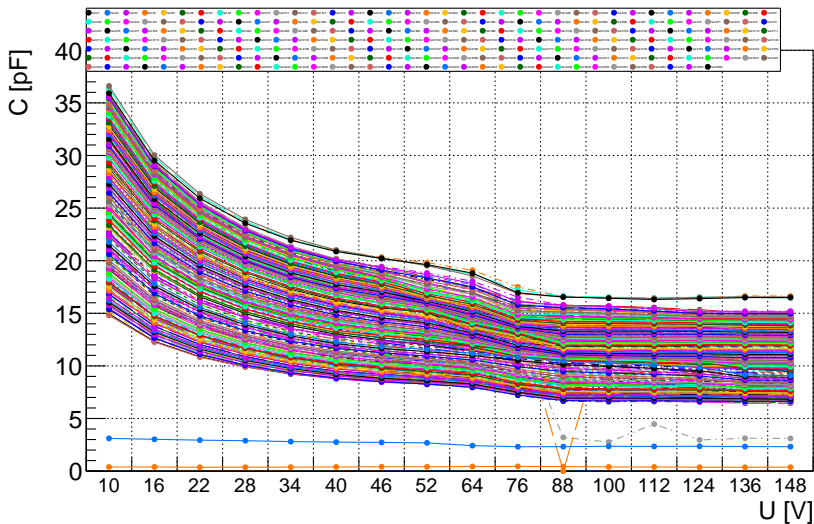


Capacitance @ 120 V

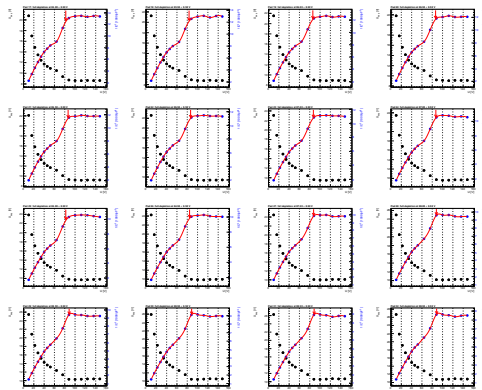


Capacitance

(w/o correction yet)



Depletion voltage



- ▶ **C versus V** and $1/C^2$ versus V for few example cells
- ▶ **Spline fit**: Extract depletion voltage from point of largest curvature
- ▶ Open items
 - ▶ Open and short correction
 - ▶ Understand LCR meter mode

- ▶ Probe card produced for LumiCal sensor layout
- ▶ Probe card adapter produced for PM5 probe station
- ▶ Probe and switch card system installed at TAU
- ▶ Implementation of TAU lab instruments into LabVIEW programme
- ▶ First IV and CV measurements with one LumiCal sensor
- ▶ Testing duration depends on number of voltage steps
- ▶ ~ 2 sensors per day possible with $O(15)$ voltage steps for IV and CV
- ▶ Understand baseline total current, capacitance measurement