Silicon sensor R&D for an upgraded CMS Tracker in HL-LHC

Selcuk Cihangir

for

Simon Kwan, Pramod Lamichhane, Lenny Spiegel, Ping Tan, Andriy Zatserklyaniy

TIPP11

6/9/2011

Motivation

From CMS Technical Proposal:

The CMS tracking system has to be enhanced in three main aspects:

(i) higher radiation resistance, with respect to both instantaneous and integrated levels;

(ii) higher readout granularity, to keep the channel occupancy at an adequate level;

(iii) ability to contribute information for the Level 1 trigger.

Silicon sensors have to maintain adequate performance after accumulated radiation levels ~ *10 times higher than the requirements of the present Tracker. Thus higher* granularity and thinner sensors are required everywhere, and radically different options may be useful for the innermost pixel layers.

Motivation-Cont.

- Further upgrade issues:
  - More advanced ASIC technologies have to be used to cope with the high instantaneous rates in the inner layers,
  - Power consumption with the higher granularity has to be limited,
  - Novel powering schemes and more efficient cooling methods have to be employed to reduce the "material budget",
  - High-speed data links are required to handle the increased data volume generated by the increased granularity and by the trigger output and novel module concepts and electronics architectures need to be developed to implement on-detector data reduction.

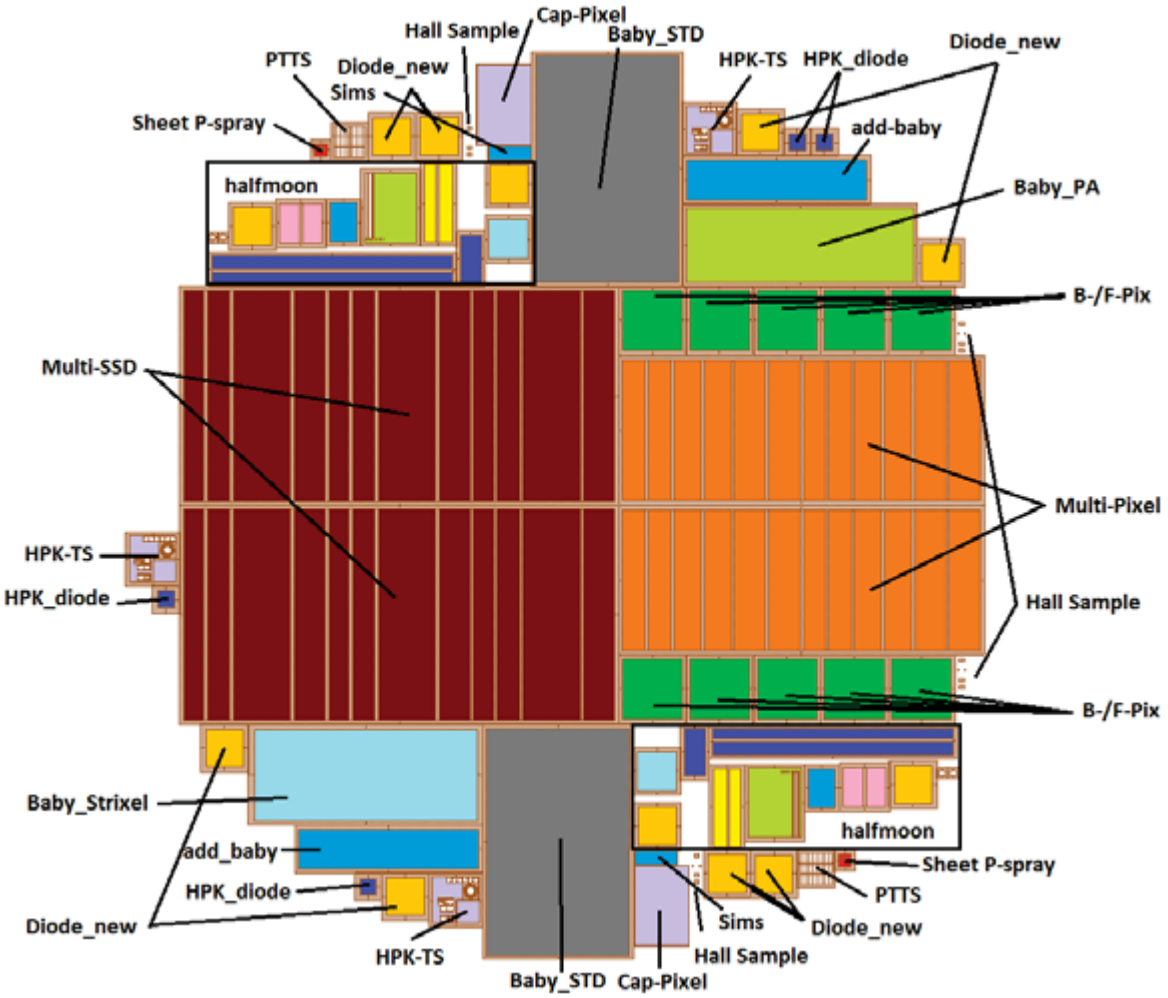
Goal

- Conduct tests, before and after irradiation, to determine the characteristics of thin, single-sided silicon sensors acquired from HPK in order to establish optimal material and strip/pixel features for the upgrade of the CMS Tracker.

- Efforts on Multi-Strip-Sliconstrip Detector (MSSD) sensors at:
  - Cern
  - Fermilab
  - Florence
  - KIT
  - Others

- Efforts at Fermilab will be described here.

HPK Wafer

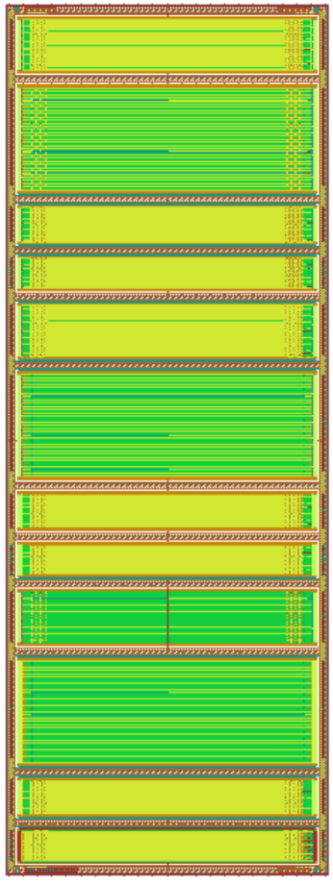


Substrate types:
FloatZone (FZ),
Magnetic-Czochralski (M)
Epitaxial (E).

p-in-n (N-type)
n-in-p (p-stop) (P-type)
n-in-p (p-spray) (Y-type)

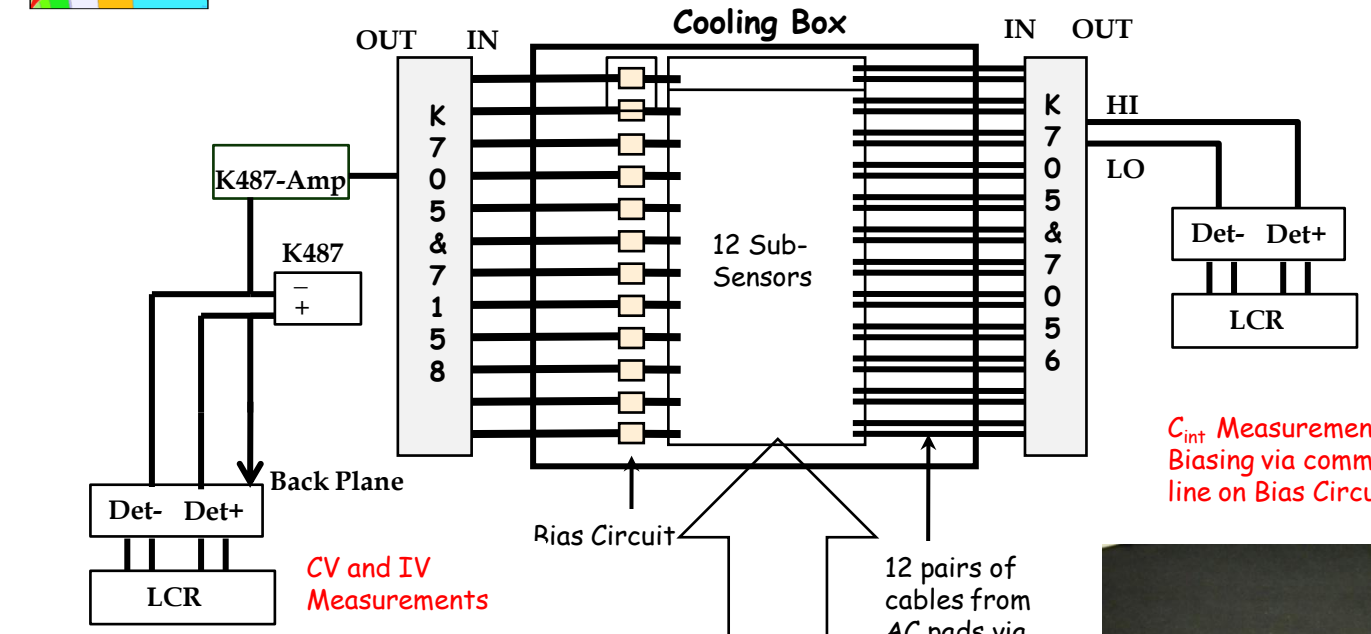
p-in-n (double metal)
n-in-p (p-stop; double metal)
n-in-p (p-spray; double metal)

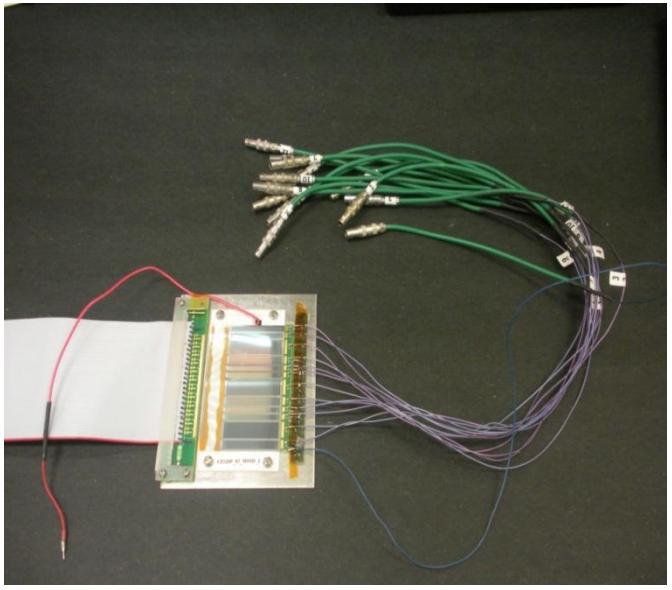
MSSD Modules



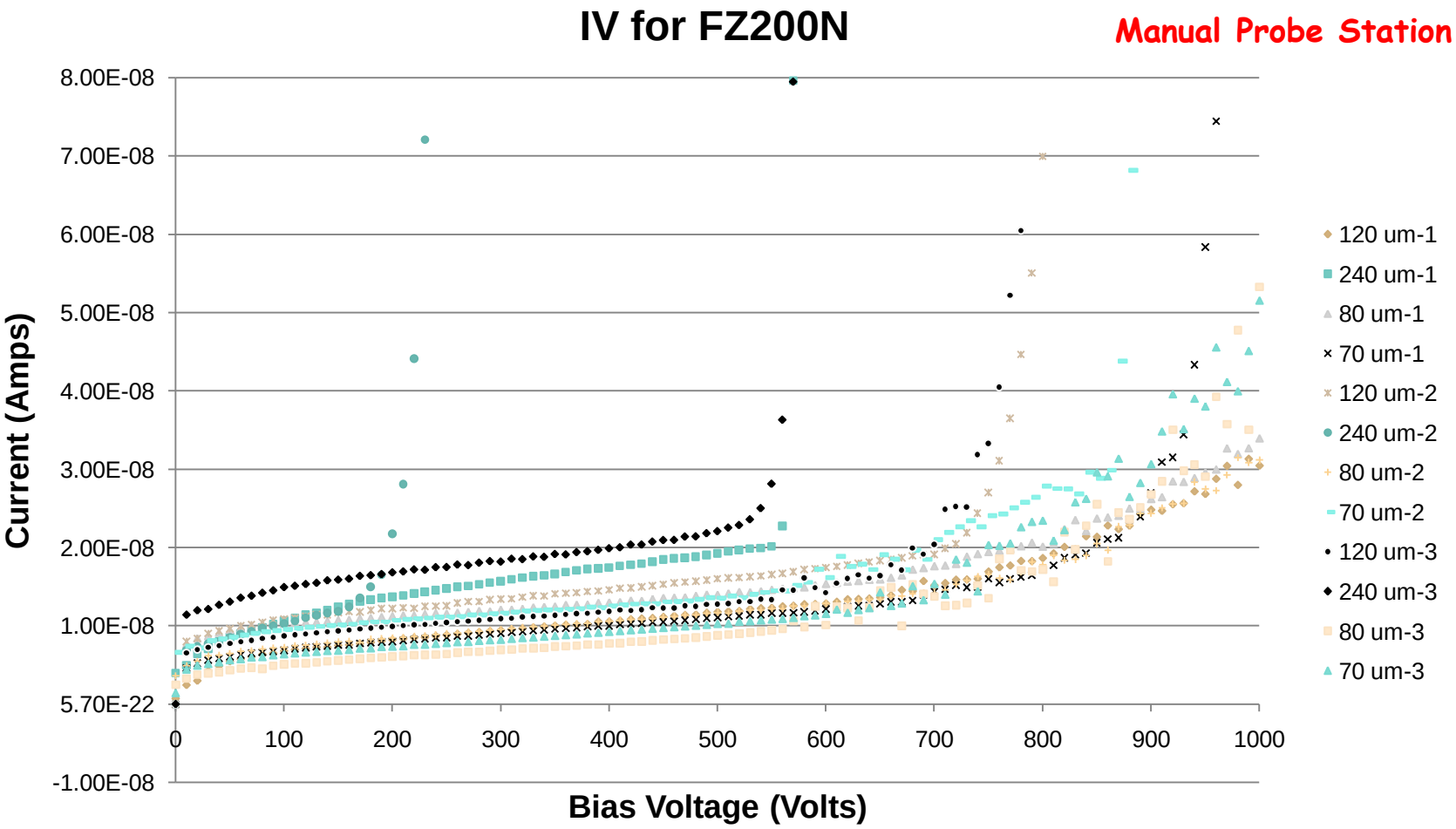
region	pitch	implant width	alu width	w/p	DC Padsize	AC Padsize
1-120	120	16	29	0.133	85x38	150x50
2-240	240	34	47	0.142	85x38	150x50
3-80	80	10	23	0.125	85x38	150x50
4-70	70	8,5	21,5	0.121	85x38	150x50
5-120	120	28	41	0.233	85x38	150x50
6-240	240	58	71	0.242	85x38	150x50
7-80	80	18	31	0.225	85x38	150x50
8-70	70	15,5	28,5	0.221	85x38	150x50
9-120	120	40	53	0.333	85x38	150x50
10-240	240	82	95	0.342	85x82	150x82
11-80	80	26	39	0.325	85x38	150x50
12-70	70	22,5	35,5	0.321	85x38	150x50

IV, CV & C_{int} Measurement Setup

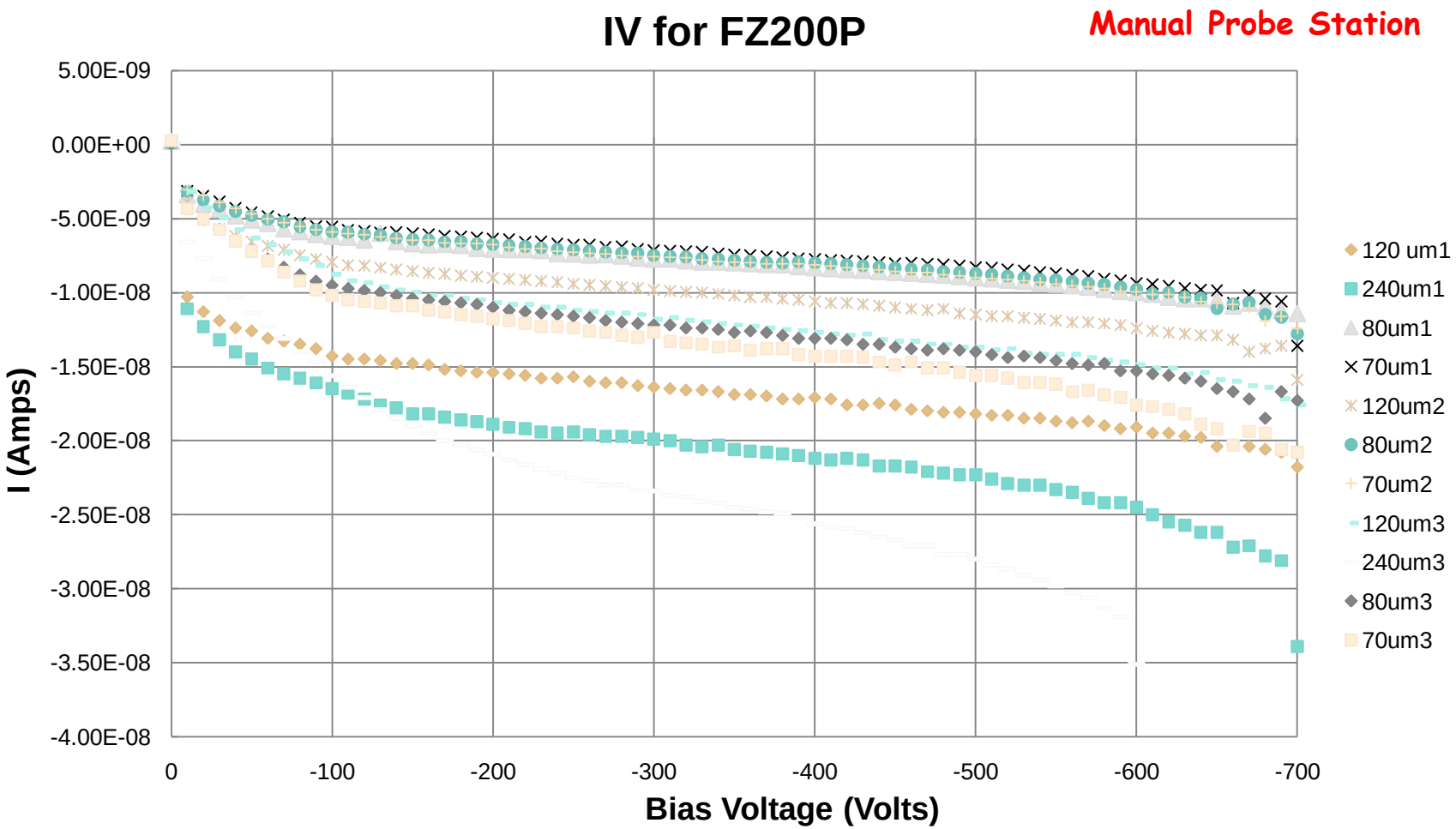




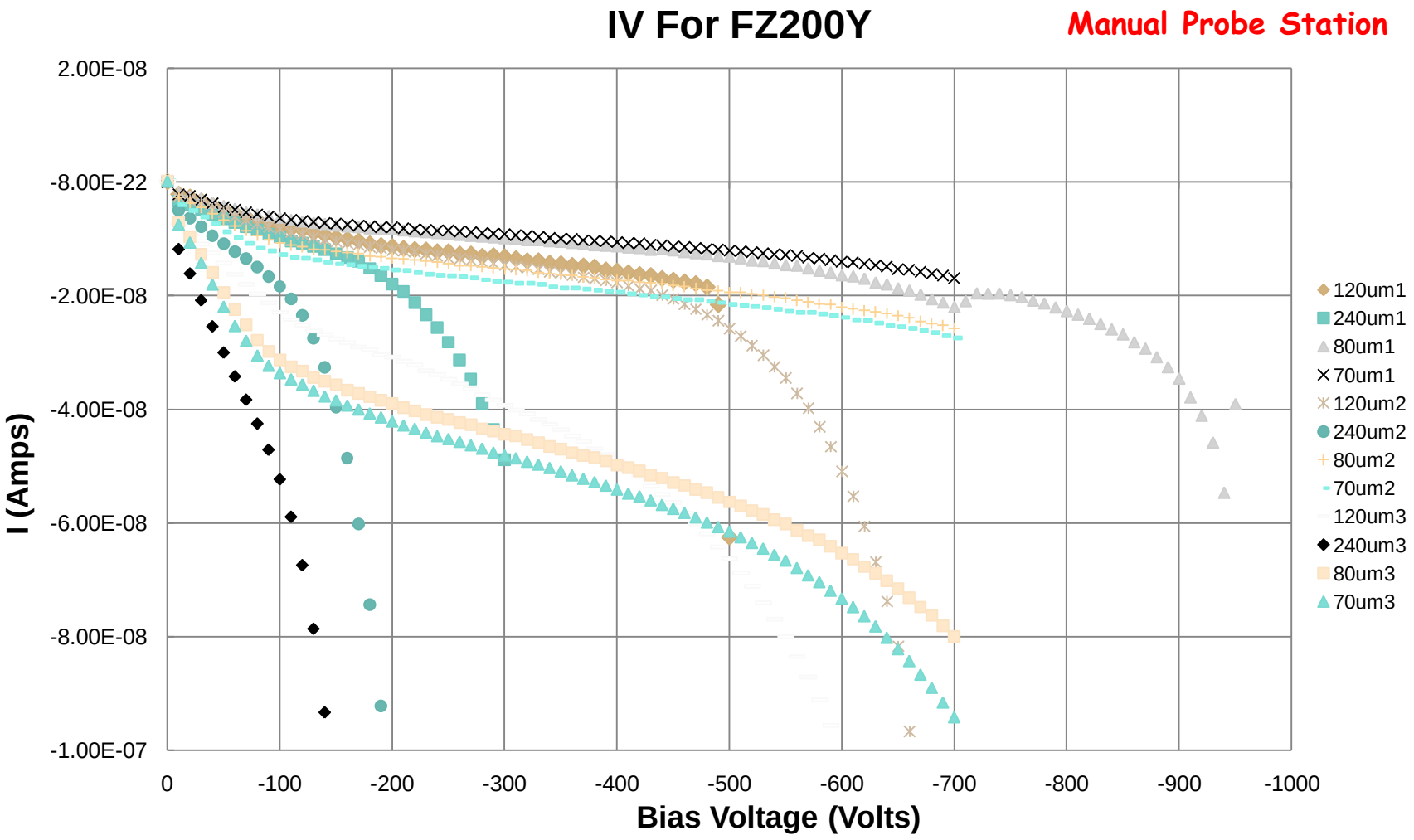
Sensor Measurements
IV Curve



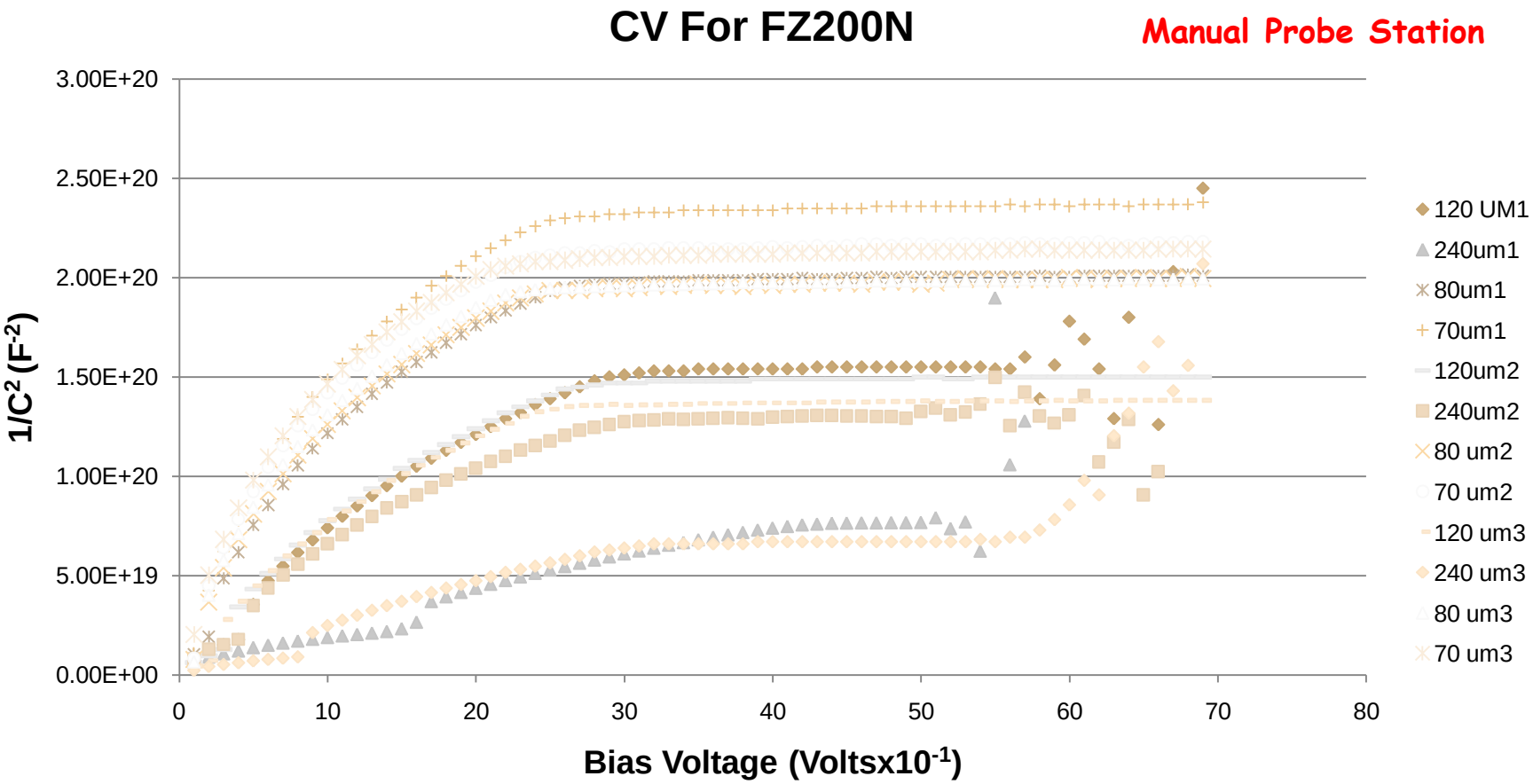
Sensor Measurements
IV Curve



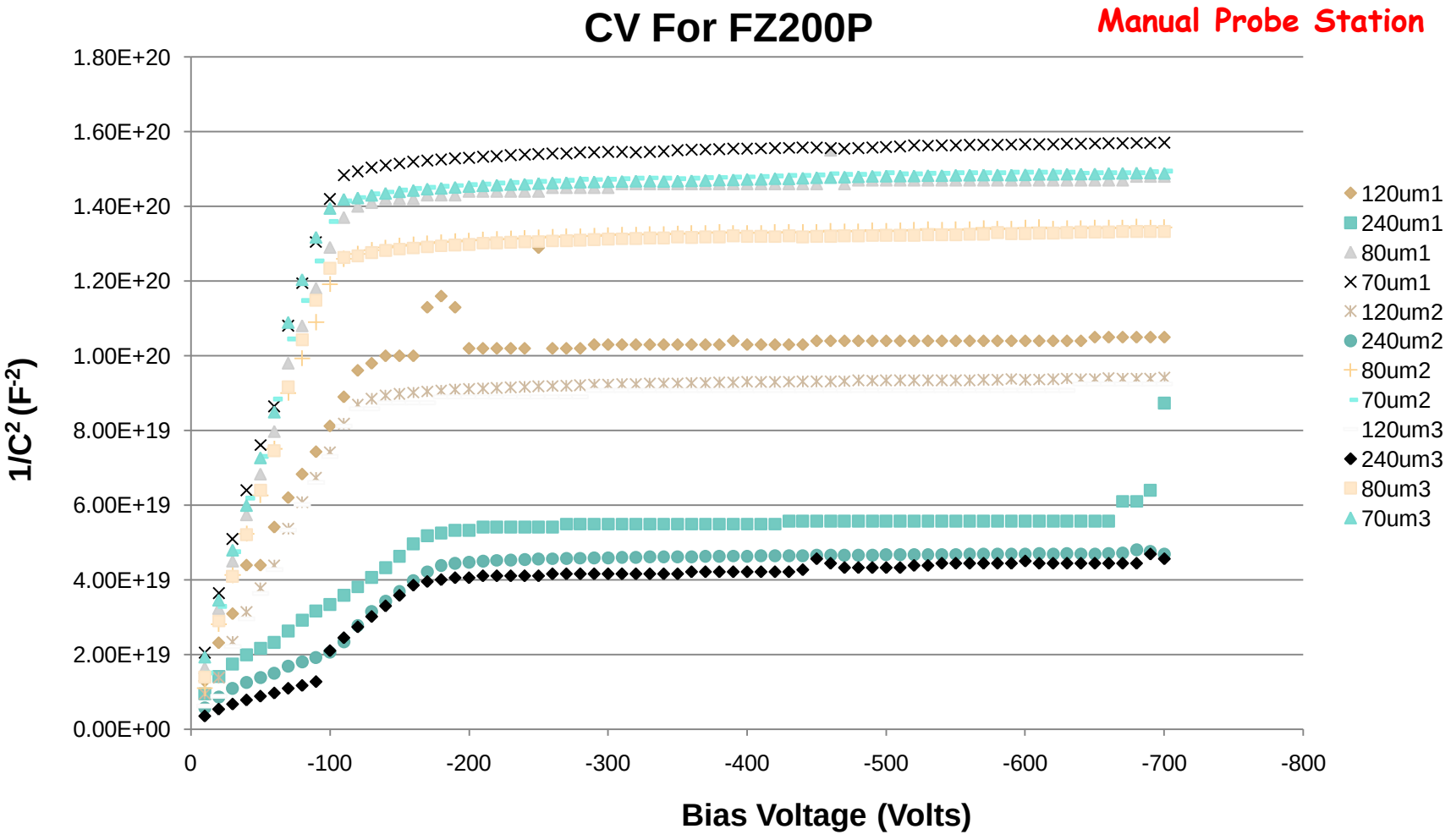
Sensor Measurements
IV Curve



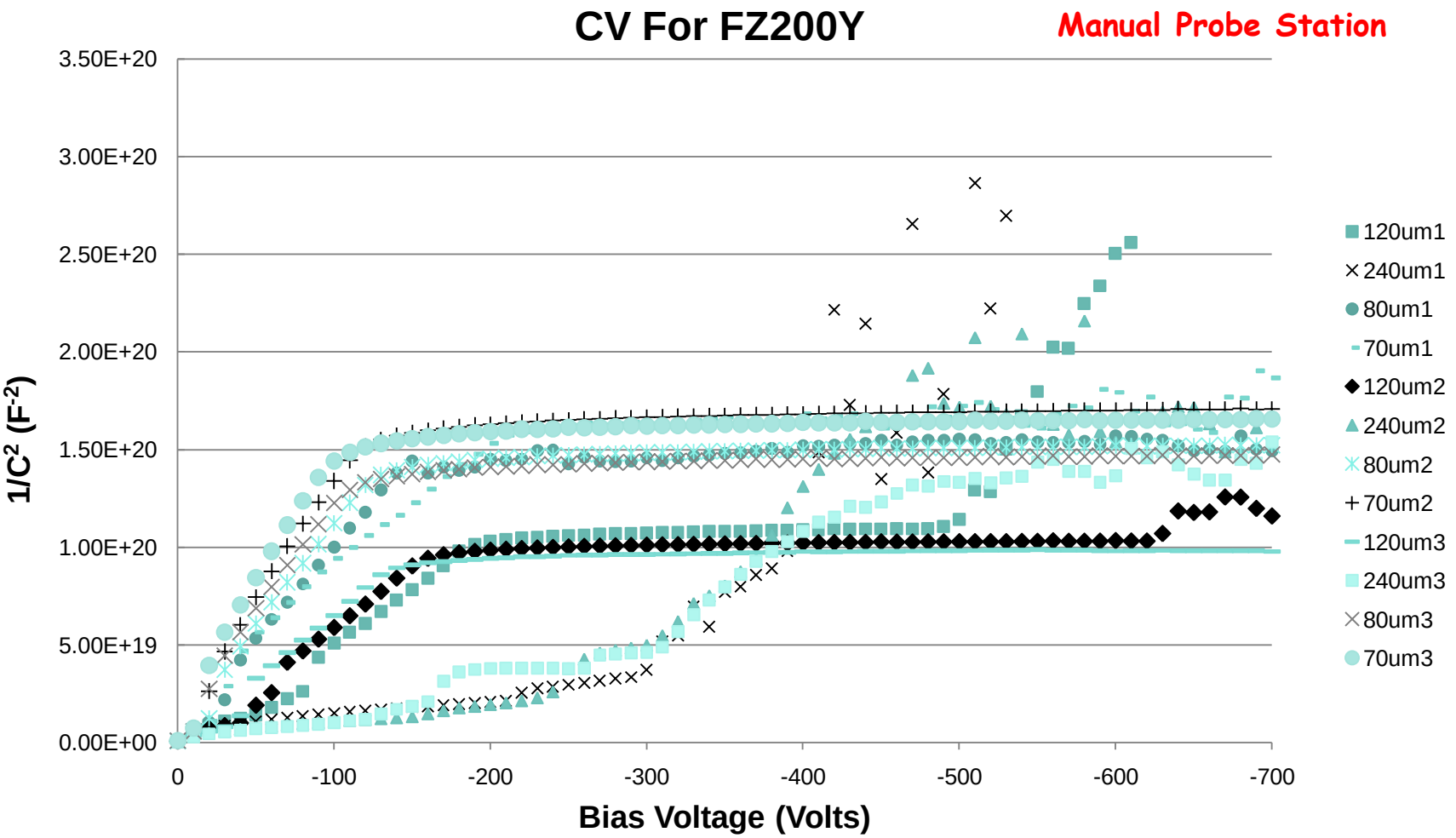
Sensor Measurements
CV Curve



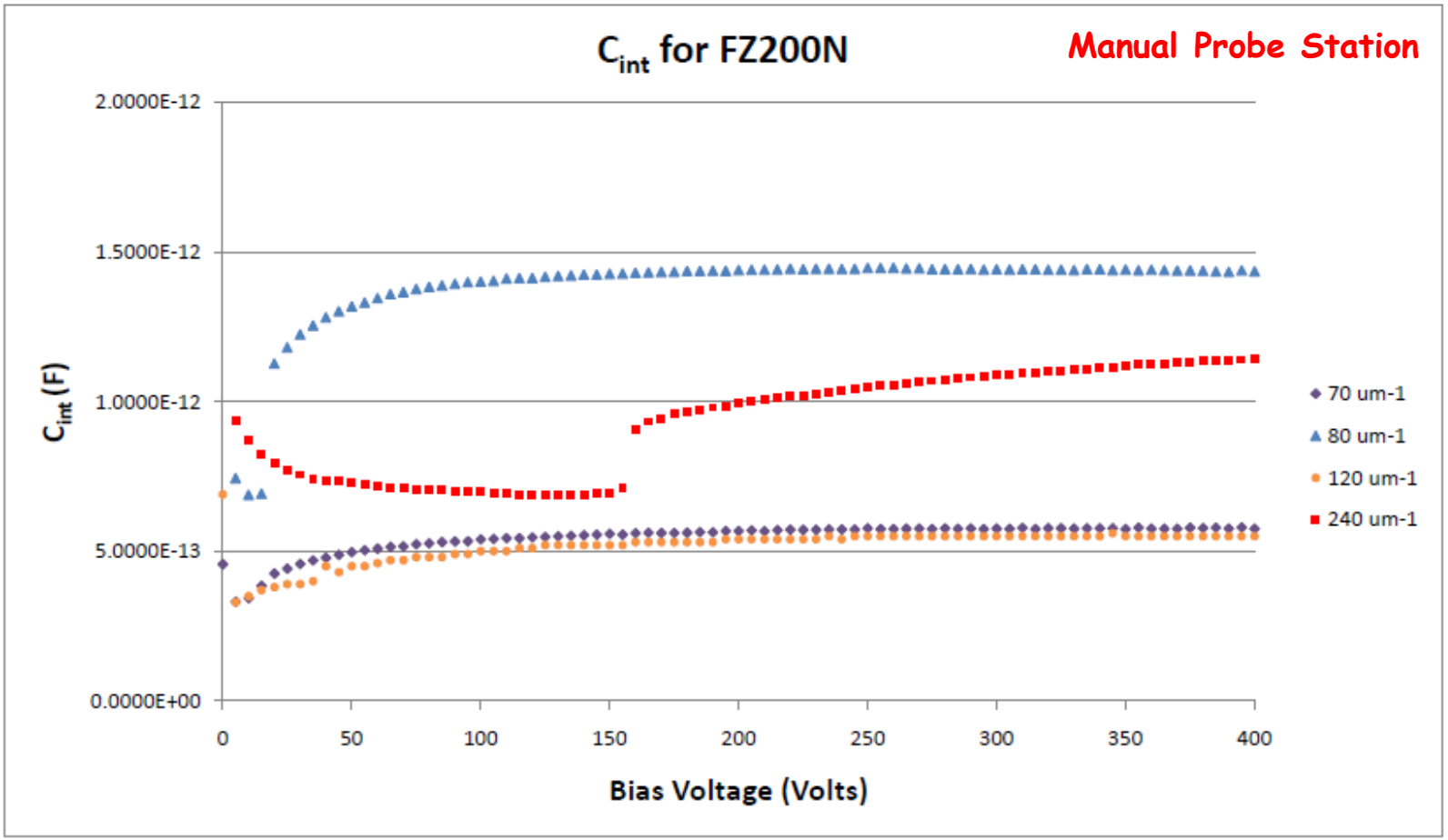
Sensor Measurements
CV Curve



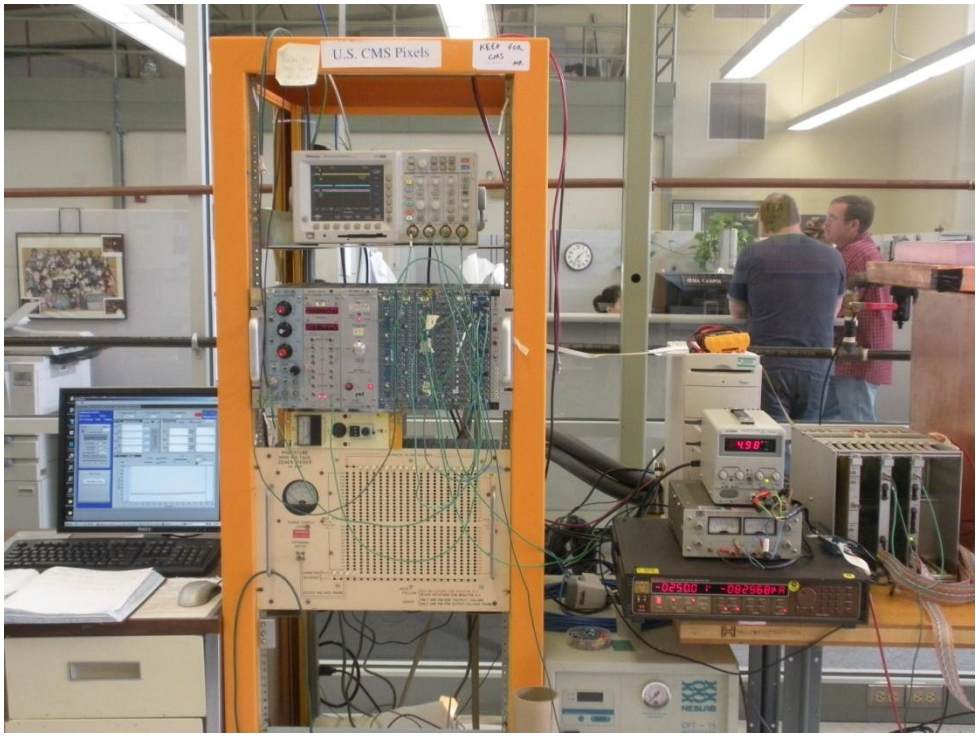
Sensor Measurements
CV Curve



Sensor Measurements
Interstrip Capacitance

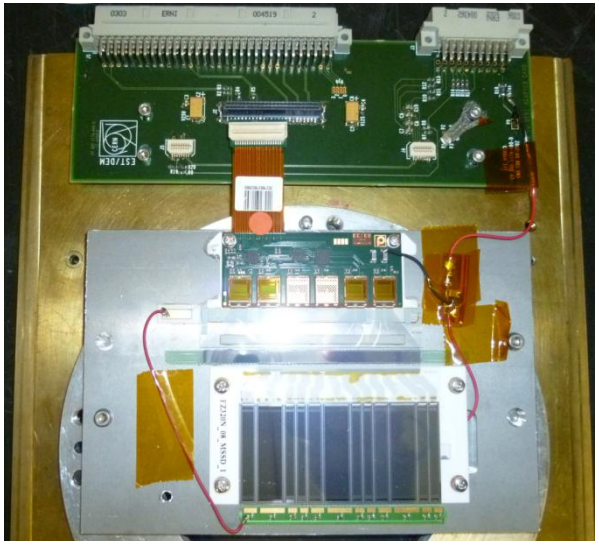


Source Measurement with ARCS

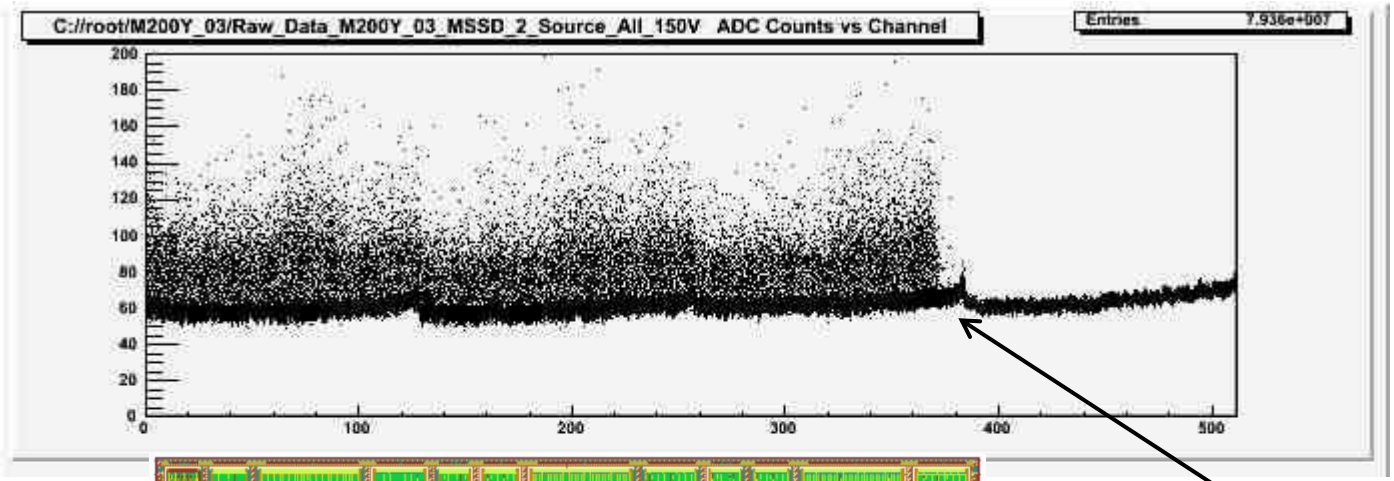


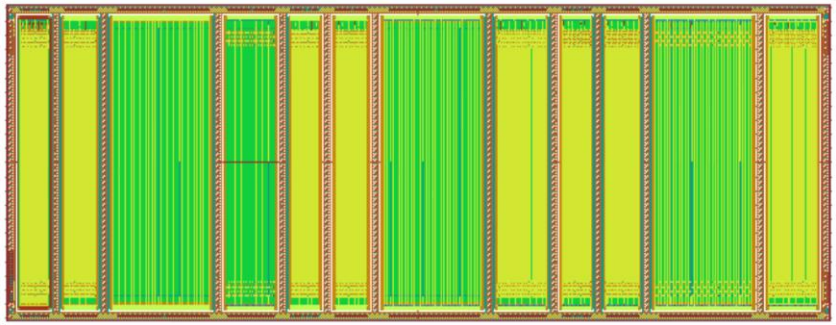
ARCS Setup

Sensor-Hybrid Assembly for Source Measurement



Source Measurement (M200Y_03_MSSD_2)



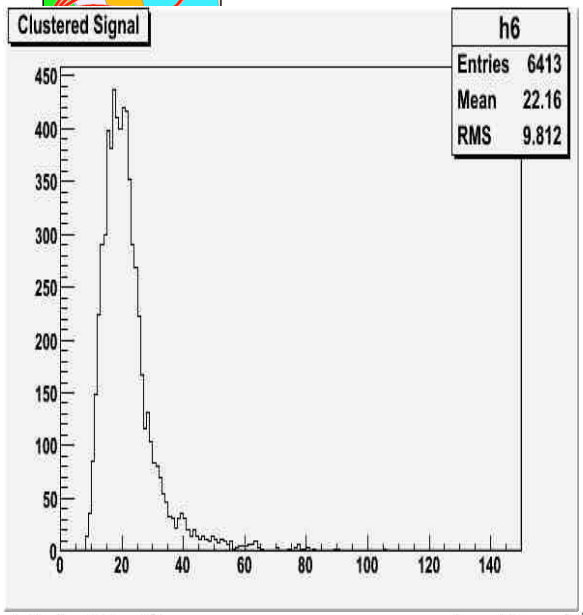


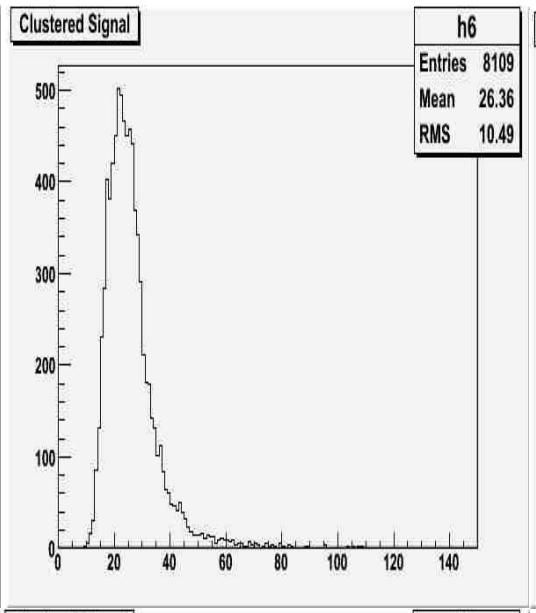
Part of the last sub-sensor is shadowed by the Al plate's edge

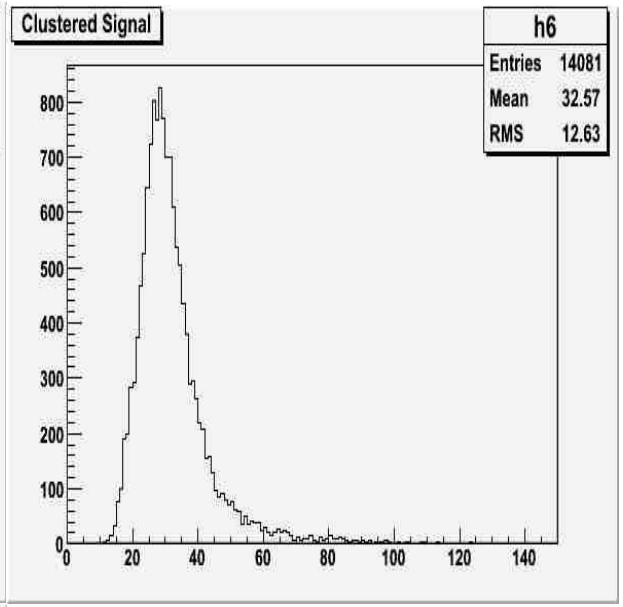
Source illuminates about three sub-sensors, it is moved over the sensor to cover all sub-sensors

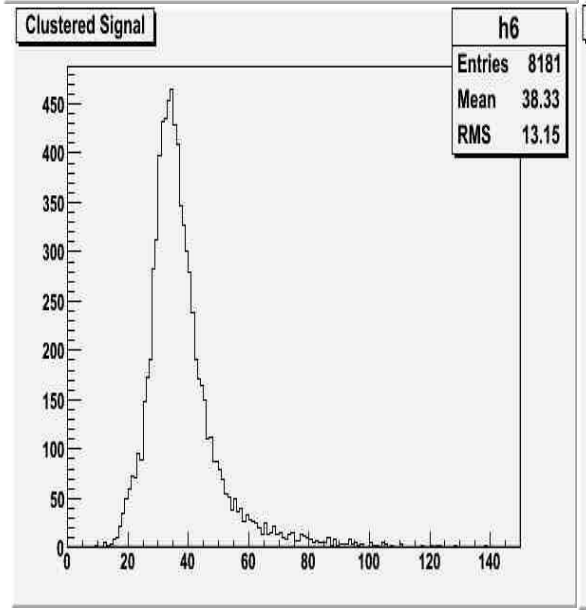
It seems 240 and 120 μm sub-sensors have higher counts signal
V_b= 150V
Sr90 Beta-source

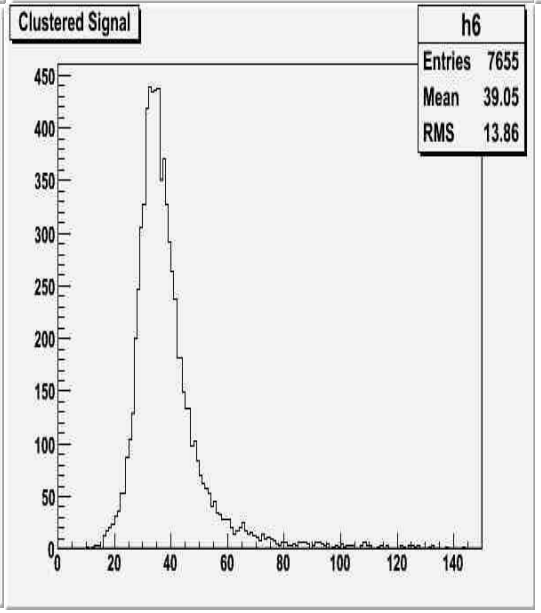
Source Measurement (FZ320N_05_MSSD_2)





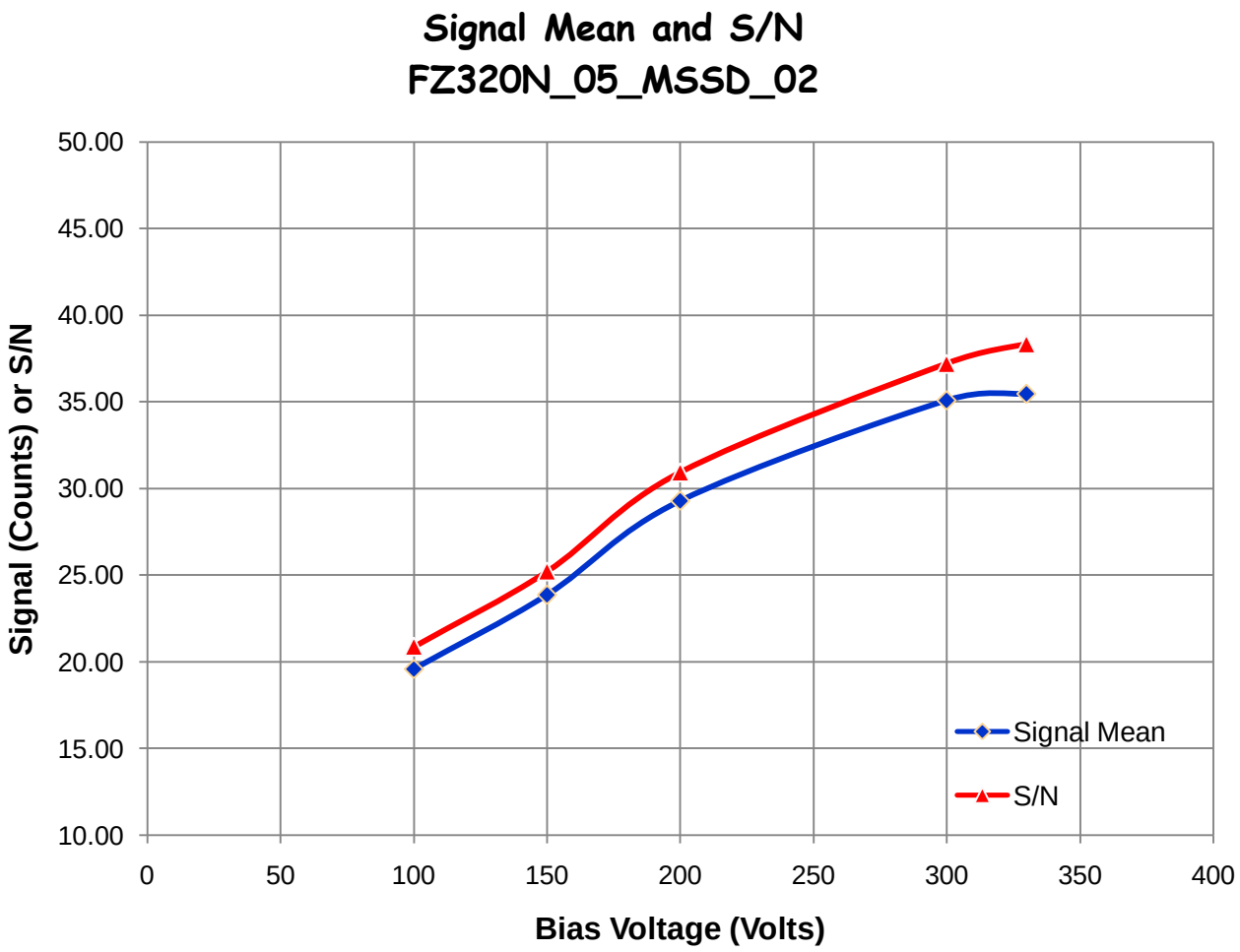






Signal on Sub-sensor 80 μm-3 at V_b= 100V, 150V, 200V, 300V, 330V Sr90 Beta source

FZ320N_05_MSSD_2



Summary

- IV measurements with "switching" is about to start.
- CV measurement with "switching" needs to be improved: Values are 10x higher-due to interference of the other sub-sensor circuits.
- Source measurements at ARCS are continuing. We need to speed up the procedure by becoming more proficient in time.
- We can do IV and CV measurement in "cold" also.
- We can do source measurement in "cold": working on noise problem.