Measurements of Irradiated 3D Strips Sensors

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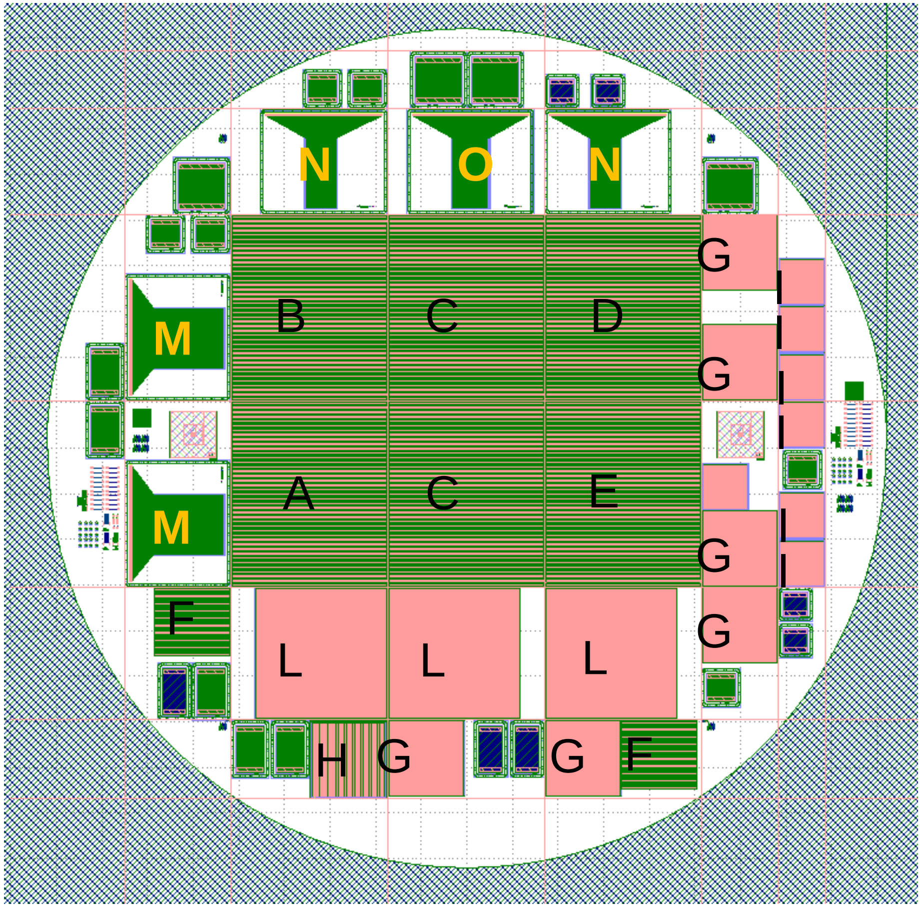
First Small-Pitch Run for High Luminosity LHC

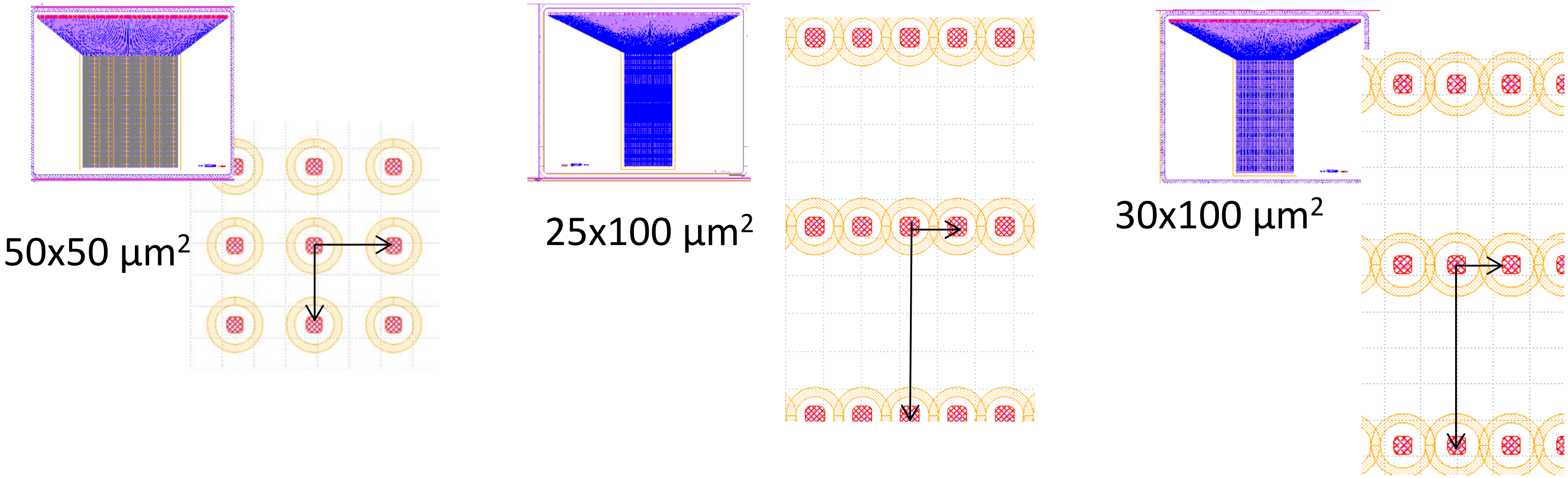
- Run 7781, 3D Double Side Process, 230um thin wafers



- 8um holes
- Radiation hardness of strips with different geometries.
- 4 sides slim edges, 100um and 200um.

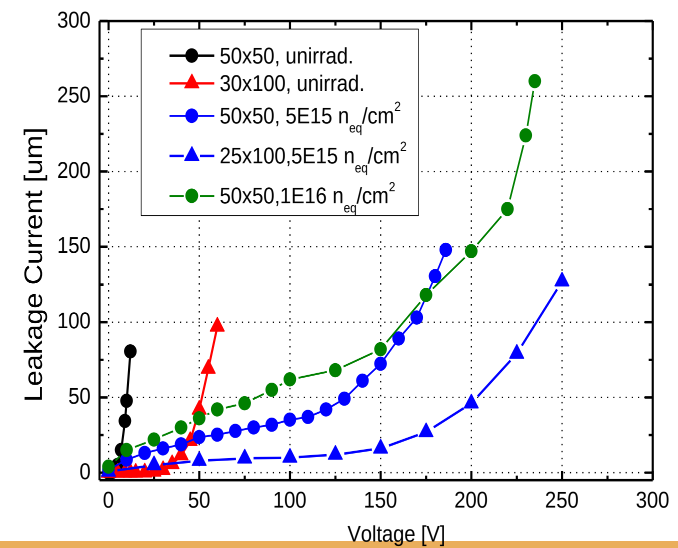
- A: 25x250 µm² 2E - standard FE-I4
- B: 25x500 µm² 5E – i.e. 5x "25x100" 1E, with 3DGR
- C: 50x50 µm² 1E with the rest connected to GND with 3DGR
- D: 25x100 µm² 2E with the rest connected to GND
- E: 50x50 µm² with the rest connected to GND without 3DGR
- F : FEI3 device: 50x50 µm² with rest to GND with 3D GR
- G: ROC4sens 50x50 µm²
- H: PSI46dig
- I: FERMILAB RD ROC 30x100 µm²
- L: Velopix 55x55 µm²
- **M: Strip 50x50 µm²**
- **N: Strip 25x100 µm²**
- **O: Strip 30x100 µm²**
- P: Pad diodes 25x25, 25x50, 30x50, 50x50 µm²

Strips sensors study



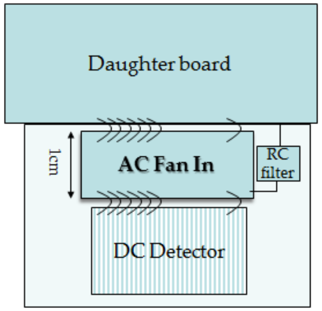
- 3D strip detectors irradiated at different fluences with neutrons at JSI Ljubljana

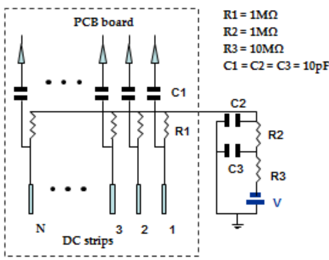
Strip	Pixel cell size (μm^2)	L_{el} (μm)	Fluence (n_{eq}/cm^2)
7781-8-M2	50x50 1E	35	-
7781-4-O	30x100 1E	52	-
7781-4-M1	50x50 1E	35	5e15
7781-4-N1	25x100 1E	51	5e15
7781-4-M2	50x50 1E	35	1e16



ALiBaVa System

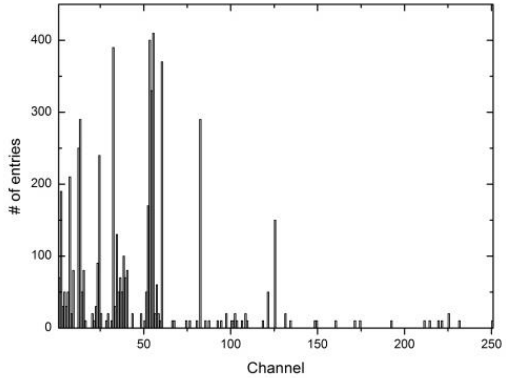
- Charge Collection done by ALiBaVa readout system
- Setup at CNM-IMB-CSIC
- 2 analogue front-end ASIC (Beetle) chips provide amplification and shaping of signal
- AC pitch adaptors employed
- Raw data sent to a PC via USB connection
- Analysis of data with software based on ROOT framework
- Measurements done in a freezer at T=-25C



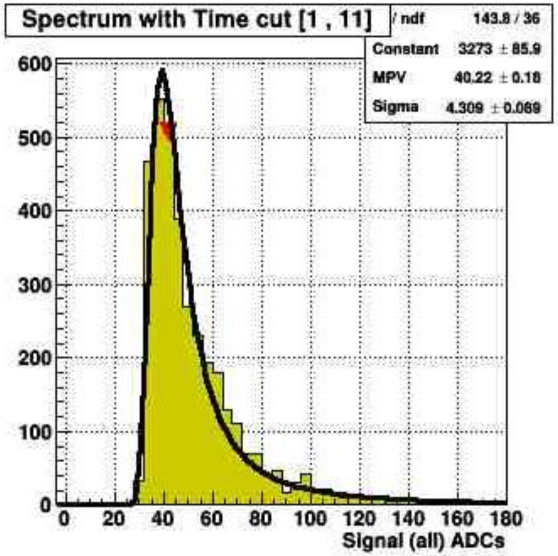


^{90}Sr Source Measurements

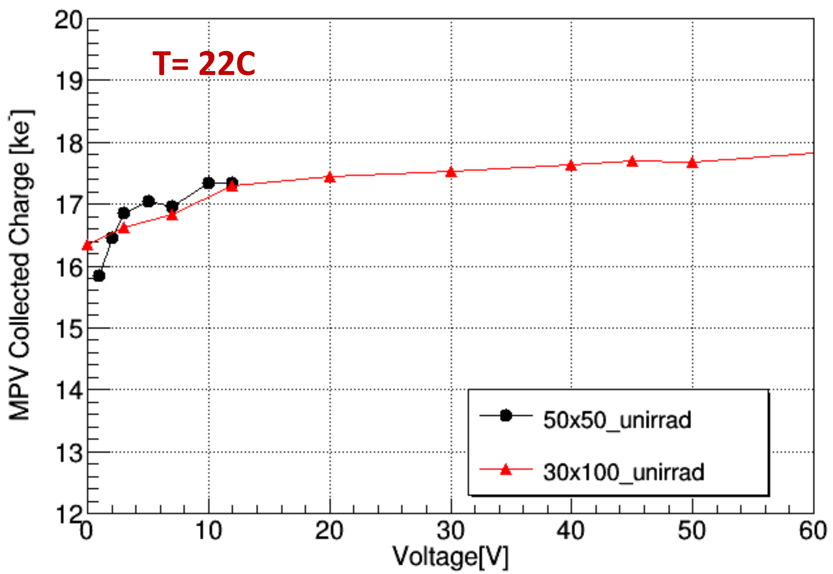
- MIPs from a ^{90}Sr source used to perform charge collection measurements
- Considered events in time window of 10 ns around maximum

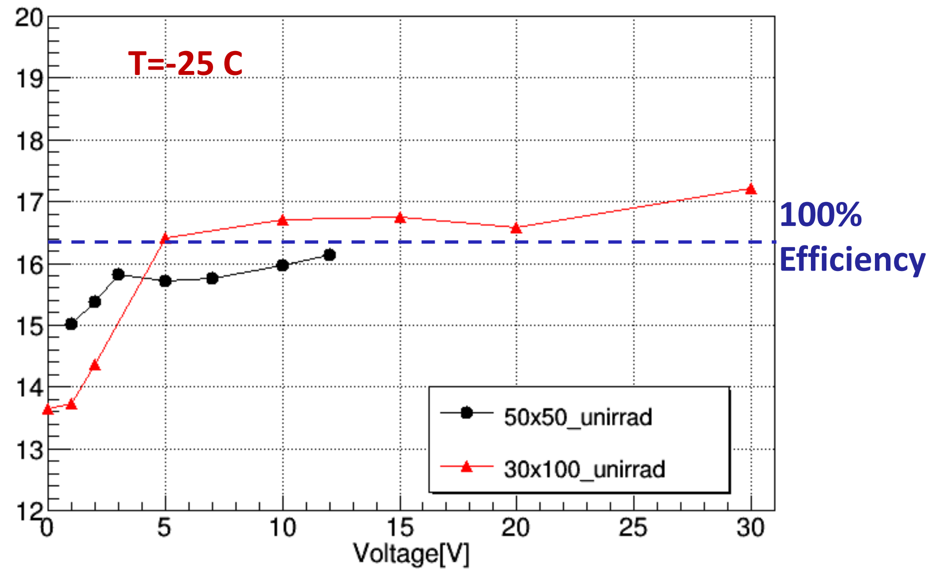


- A signal pulse obtained with average over a sufficiently large sample
- Resulting spectrum fitted with a convolution of a Gaussian and Landau distribution to determine MPV



Unirradiated Strips Measurements

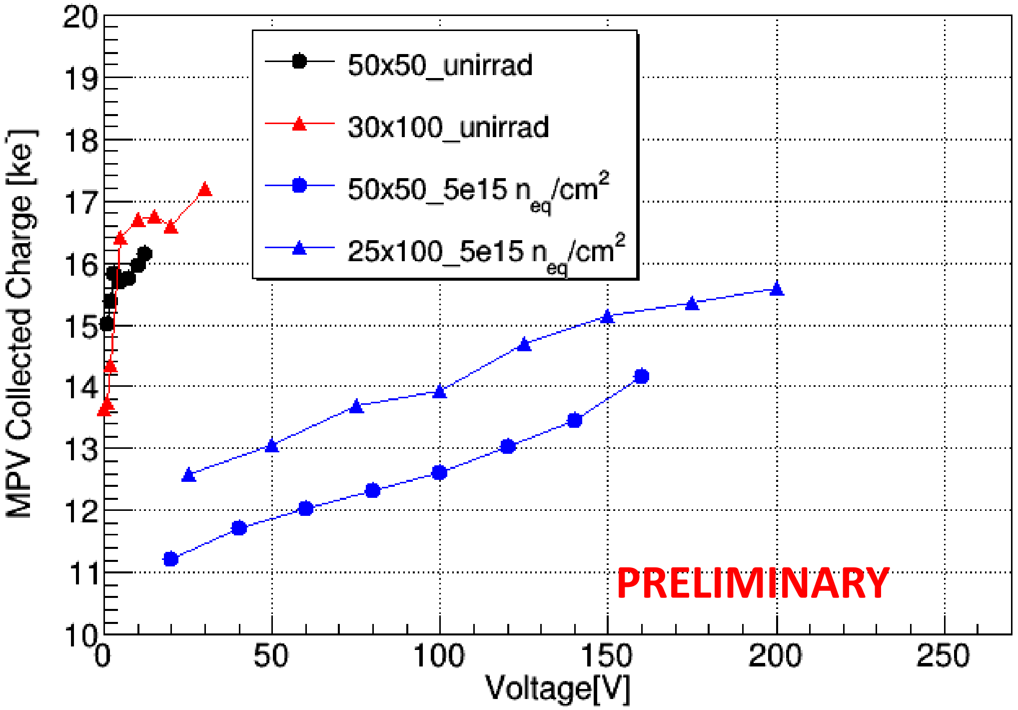




- Measurements at T=-25C done in a freezer
- 50x50 μm^2 and 30x100 μm^2 active at 0V
- A large part of charge (95%) collected at full depletion (~5V)
- Same charge collected, as expected for samples of the same thickness (230 μm)
- Differences in T compatible within the systematic and Beetle calibration uncertainties (~6%* not included in the plots)

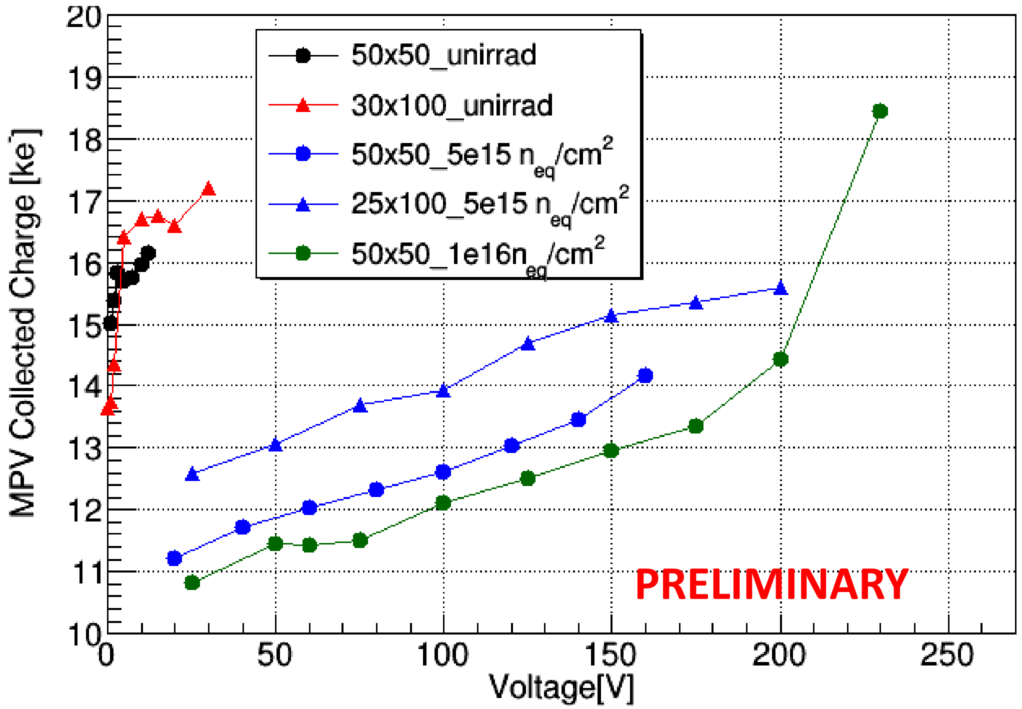
* M.Kohler et al.,NIMA 659(2011) 272

Irradiated Strip Measurements



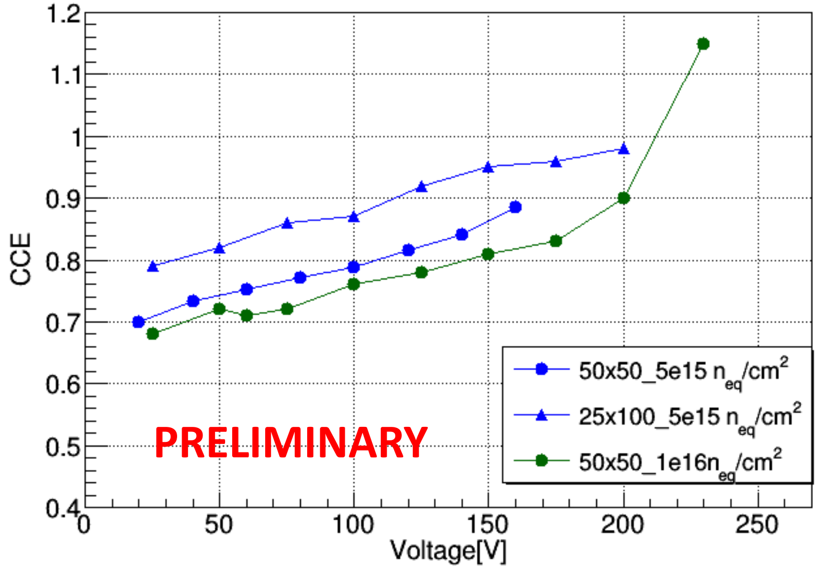
- Irradiated with neutrons at JSI Ljubljana to **5e15 $n_{eq}cm^{-2}$**
- Calibration done with the unirradiated sensors at the same temperature
- 25x100 μm^2 collected more charge that 50x50 μm^2 for the same fluence

Irradiated Strip Measurements



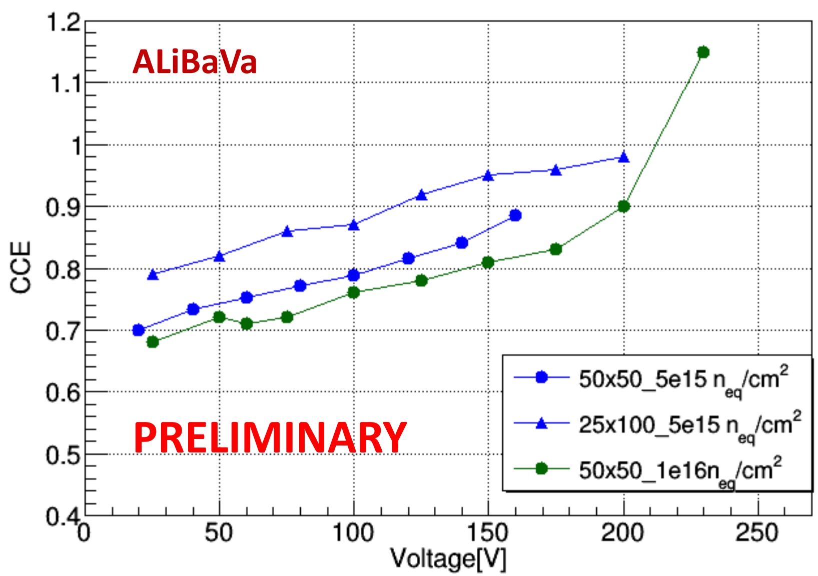
- Irradiated with neutrons at JSI Ljubljana to **5e15 $n_{eq}cm^{-2}$** and to **1e16 $n_{eq}cm^{-2}$**
- Calibration done with the unirradiated sensors at the same temperature
- 25x100µm^2 collected more charge that 50x50 µm^2 for the same fluence
- The 50x50 µm^2 still collects similar charge for higher irradiation fluences
- Clear charge multiplication effects for 1e16 $n_{eq}cm^{-2}$ irrad. sensor with a bias voltage > 200 V

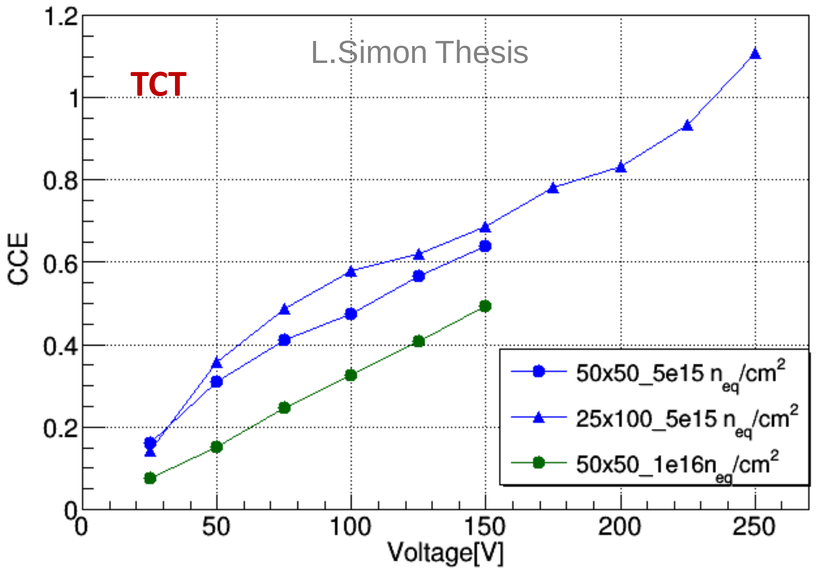
Charge Collection Efficiency



- Plots normalized to the maximum value of CC average (~16Ke$^-$) of unirradiated sensors
- At 150V, 85% CCE for the 50x50 µm^2, up to 95% for the 25x100 µm^2 at 5e15n$_{eq}$cm^{-2}
- At 220V, 100% CCE achieved by 50x50 µm^2 at 1e16 n$_{eq}$cm^{-2}

Charge Collection Efficiency

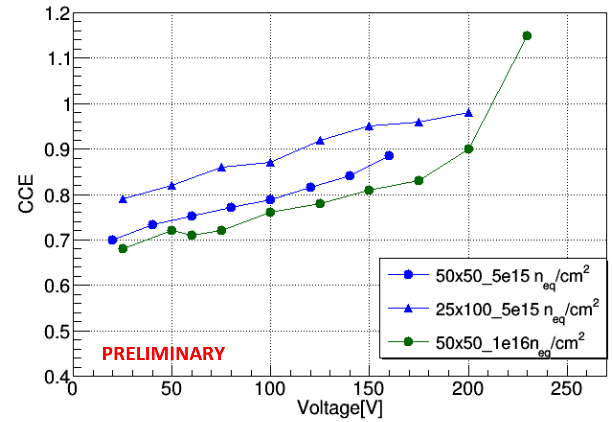




- Plots normalized to the maximum value of CC average (~16Ke^-) of unirradiated sensors
- At 150V, 85% CCE for the 50x50 μm^2, up to 95% for the 25x100 μm^2 at 5e15$n_{eq}cm^{-2}$
- At 220V, 100% CCE achieved by 50x50 μm^2 at 1e16 $n_{eq}cm^{-2}$
- In general, higher CCE with respect to the TCT measurements
- Investigations still on-going

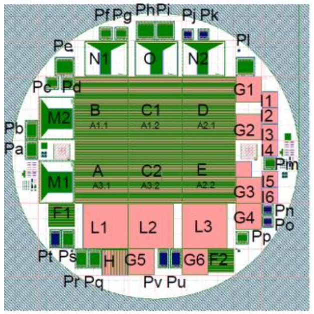
Summary

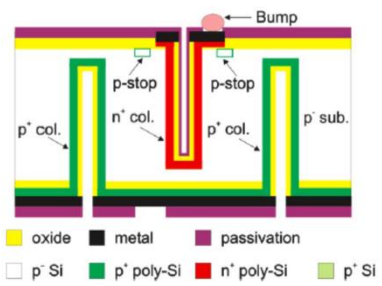
- 3 small-pitch strips devices tested with ALiBaVa System
- At 150V, **85%** CCE for the **50x50**μm², up to **95%** for the **25x100** μm² for irradiation at 5e15 $n_{eq}cm^{-2}$
- At 220V, 100% CCE achieved by 50x50μm², 1e16 $n_{eq}cm^{-2}$
- On-going study of both the geometry up 2e16 $n_{eq}cm^{-2}$



Outlook of 3D run production at CNM

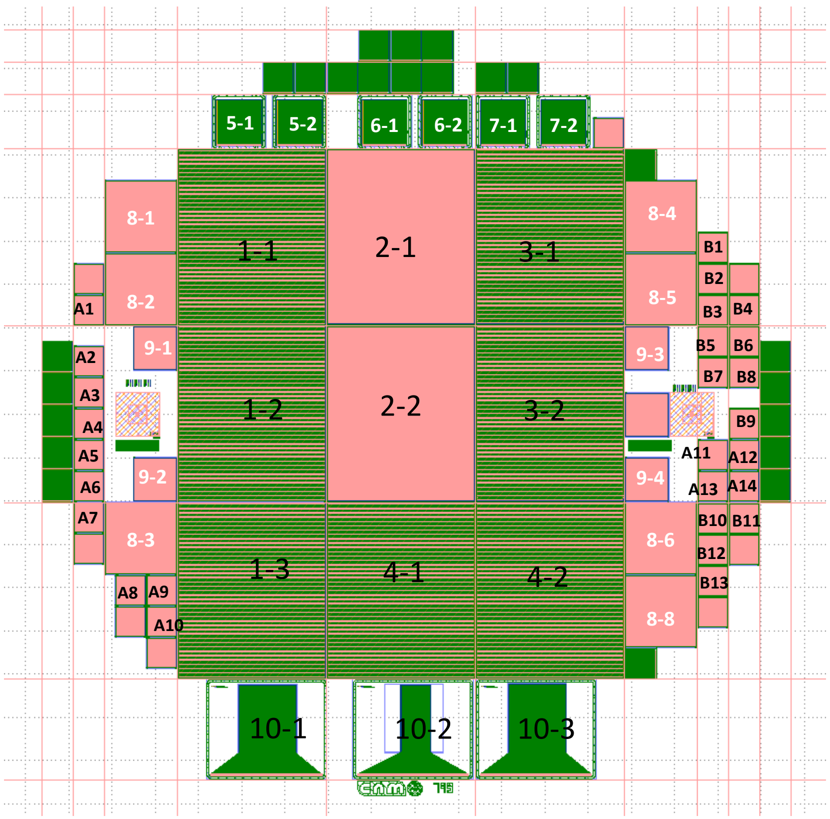
- Second small-pitch run 9194, 3D Double Side Process, 200um thin wafers, concluding in this week
- Futher 3D runs on-going...

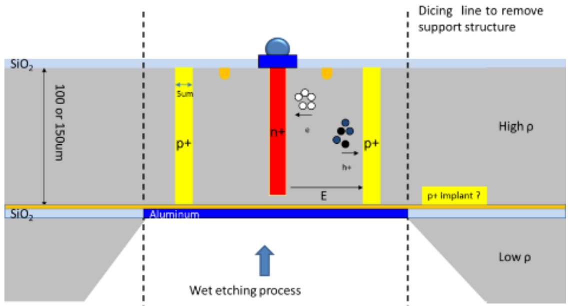




Run 9052

- Single Side, SOI wafers 150um and 100um, small pitch
- Ready in September 2017



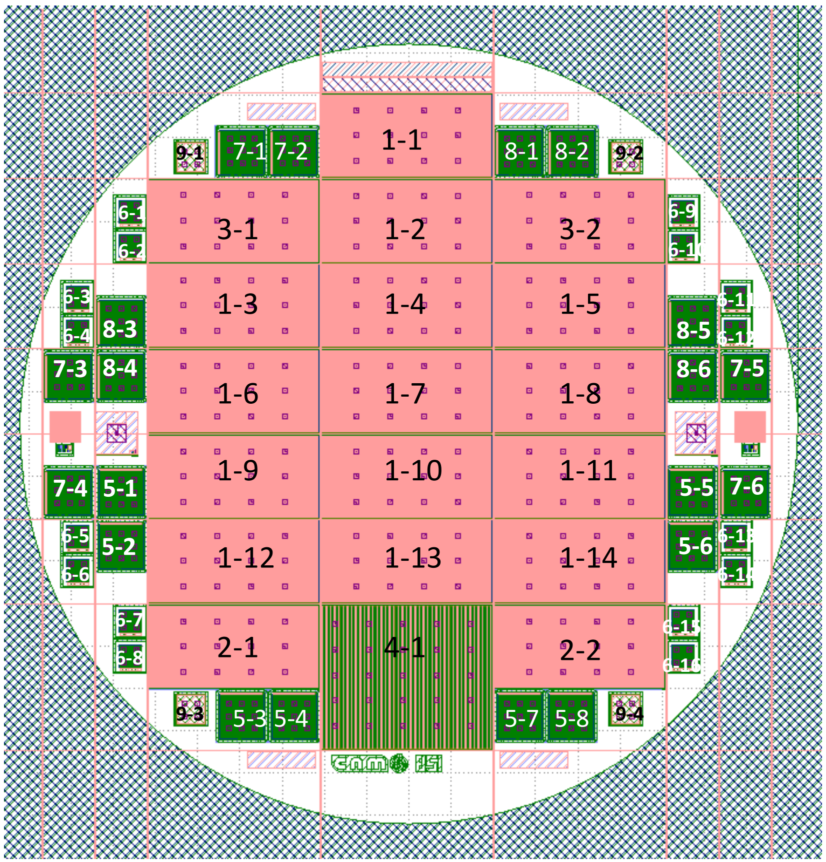


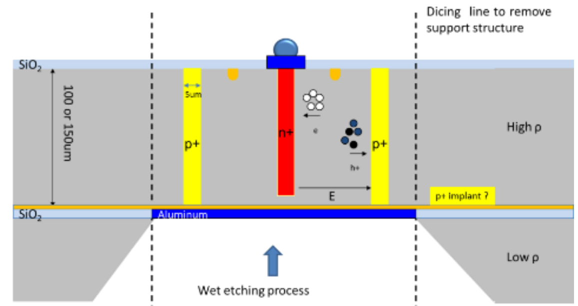
- 1-X FE-I4 standard (50x125um^2)
- 2-X FE-I4 50x50um^2
- 3-X FE-I4 50x50um^2 part of the pixel shorted
- 4-X FE-I4 25x50um^2 part of the pixel shorted
- 5-x Diodes 50x50um^2
- 6-x Diodes 25x50um^2
- 7-x Diodes 50x125um^2
- 8-x CMS PSI 50x50um^2
- 9-X Fermilab chip 30x50um^2
- 10-X strips 50x50, 25x50, 50x125um^2

- A-X 50x50um^2, 1E (64x64)
- B-X 50x50um^2, 2E (64x64)

Run 9761

- 3D Single Side, SOI wafers 150um, 100um and 72um, RD53
- Ready in September 2017





- 1-x RD53A 50x50um^2
- 2-x RD53A 2E 25x50um^2
- 3-x RD53A 1E 25x100um^2
- 4-1 FE-I4 (50x50um^2)

Diodes
- 5-x 50x50um^2 100x100 electrodes
- 6-x 50x50um^2 50x50 electrodes
- 7-x 25x50um^2 50x50 electrodes
- 8-x 25x100um^2 50x50 electrodes

MOS
- 9-x 3500x3500 um^2

Thank you for your attention!