Characterization of CNM FE-I4 3D Double-Sided Pixel Detectors

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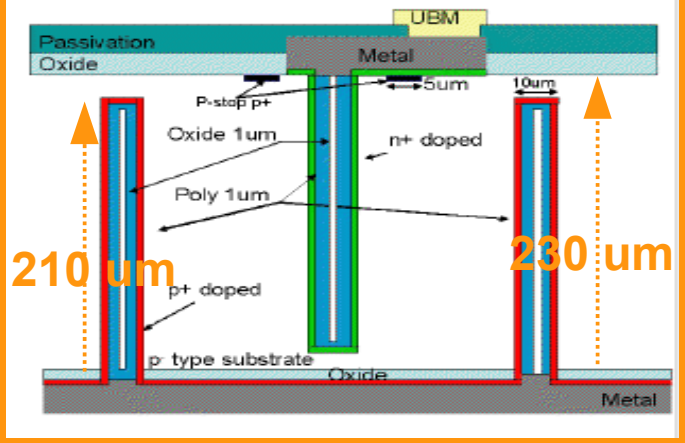
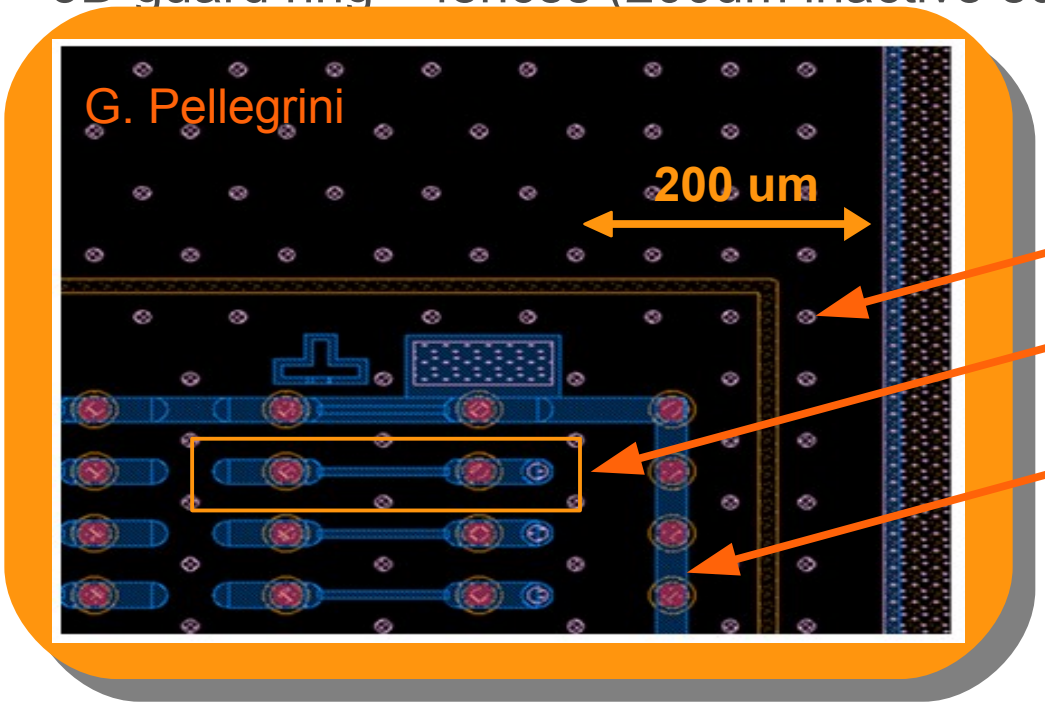
CNM double-sided devices

- 3D double-sided process, produced at CNM-Barcelona
- Columns etched from opposite sides of substrate and don't pass through full thickness
- 230um thick p-bulk, 210um long electrodes
- 2E pixel geometry
  (2 n+ readout electrodes in 50umx250um cell)
- 3D guard ring + fences (200um inactive edges)





p+ implant (fences)

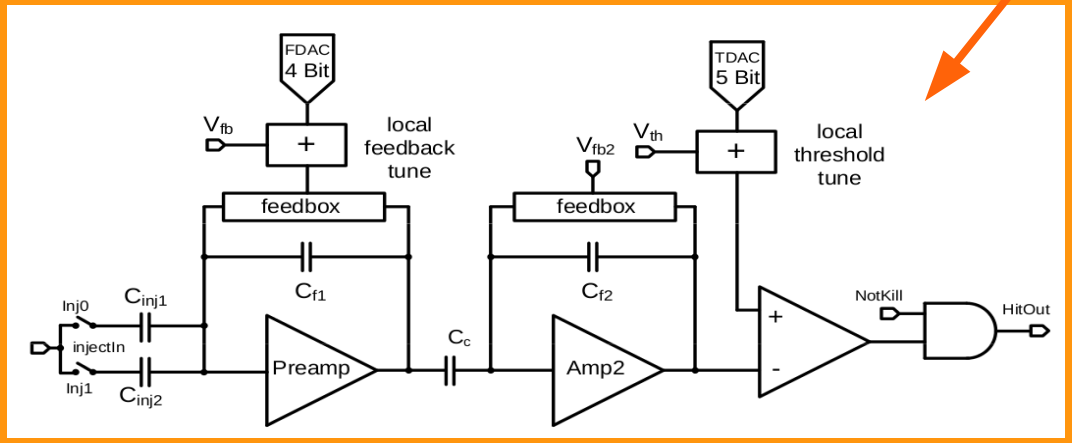
2 Electrodes in one pixel

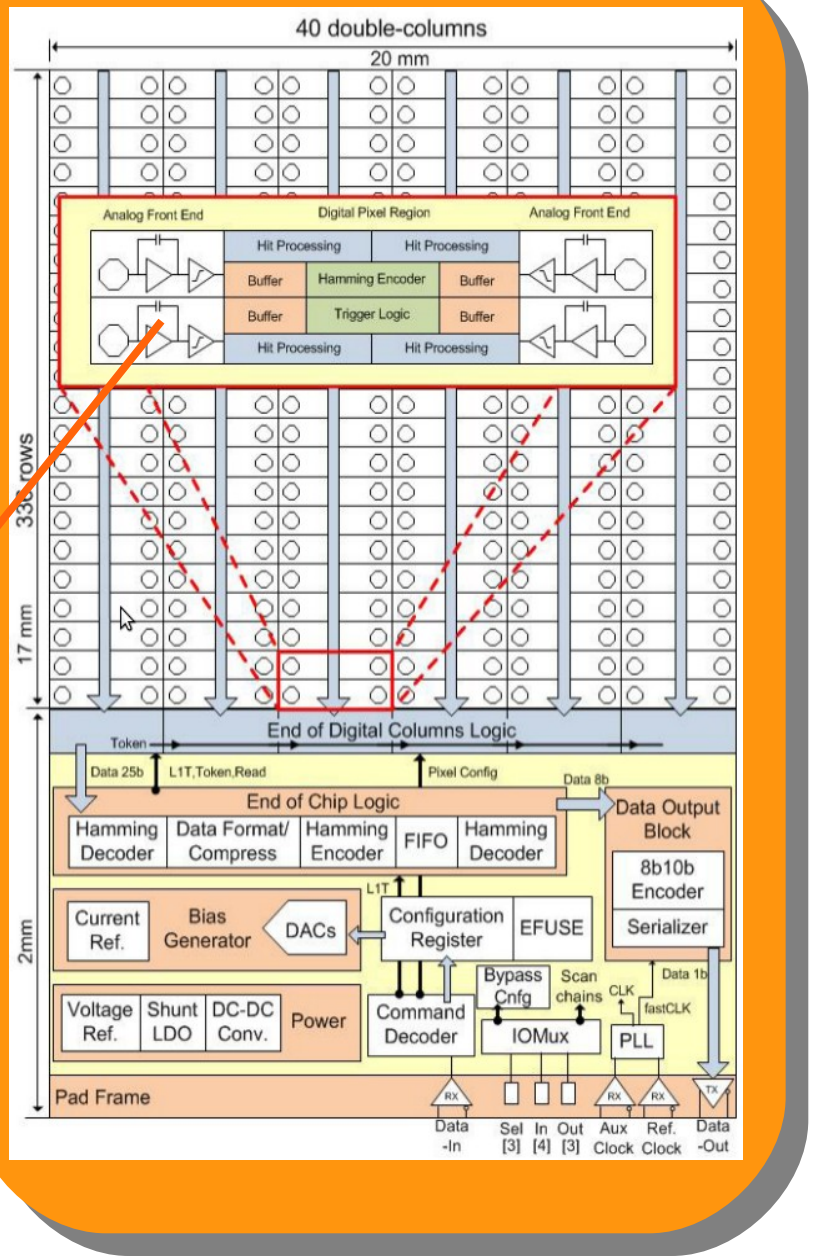
3D Guard ring

Sensor quality is measured on the wafer before dicing through the GR.

FE-I4 read-out chip

- Biggest FE (1.9X2.2cm) up to date.
- 89% active fraction
- (250umx50um) hybrid pixels arranged in 80 columns and 336 rows·
- Threshold of each pixel can be controlled by 5bits DAC (TDAC), while the TOT is tuned by 4bits DAC (FDAC).





Irradiation

- IBL pre-production studies
- The nomenclature used for the devices is:
  (Mounting)_(production)_(type)_(number), i.e. BON_CNM_3D_34

8 Un-irradiated Devices
BON_CNM_3D_38
BON_CNM_3D_57
BON_CNM_3D_98
GEN_CNM_3D_08
GEN_CNM_3D_22
GEN_CNM_3D_101
GEN_CNM_3D_102
GEN_CNM_3D_106

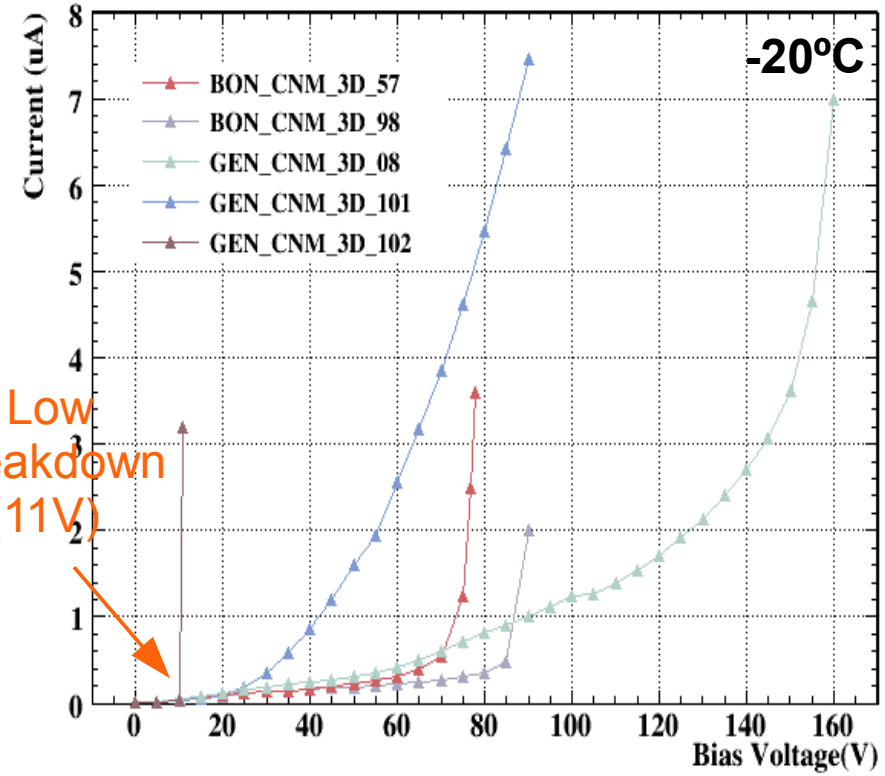
4 Proton Irradiated Devices	
BON_CNM_3D_34	**5.11E15 neq/cm2**
BON_CNM_3D_36	**6E15 neq/cm2**
BON_CNM_3D_97	**4.92E15 neq/cm2**
BON_CNM_3D_100	**1.97E15 neq/cm2**

2 Neutron Irradiated Devices	
BON_CNM_3D_35 (SCC 82)	**5.11E15 neq/cm2**
BON_CNM_3D_37 (SCC81)	**5.11E15 neq/cm2**

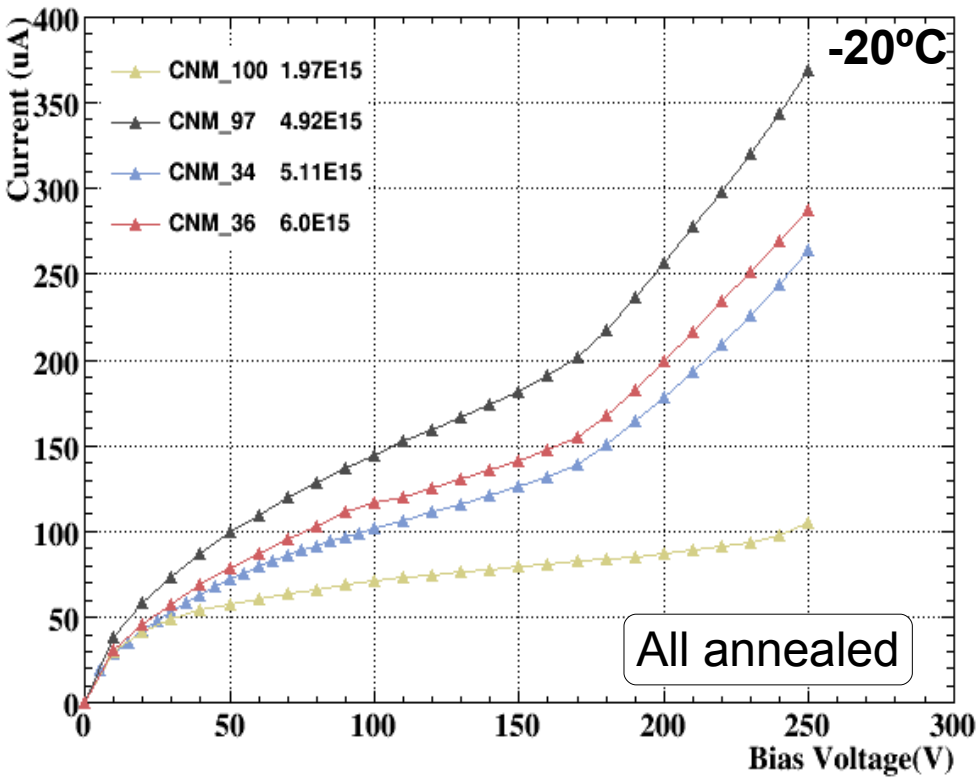
- Proton irradiation was done in Karlsruhe(Germany) and neutron irradiation in Ljubljana(Slovenia).

IV-Measurements

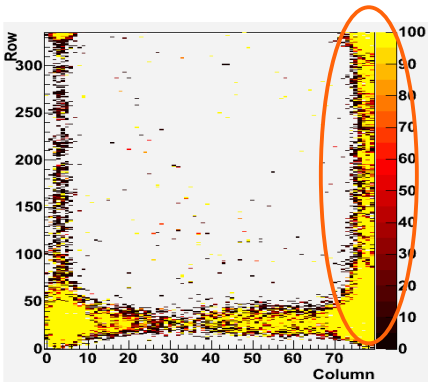
Un-irradiated

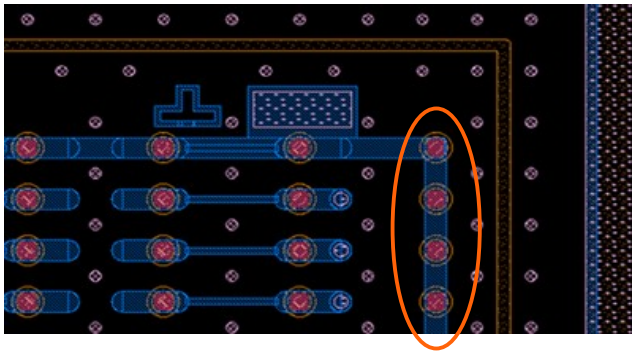


Proton-irradiated



- Leakage current of CNM devices is along the guard ring.
- Production yield is good at 60%



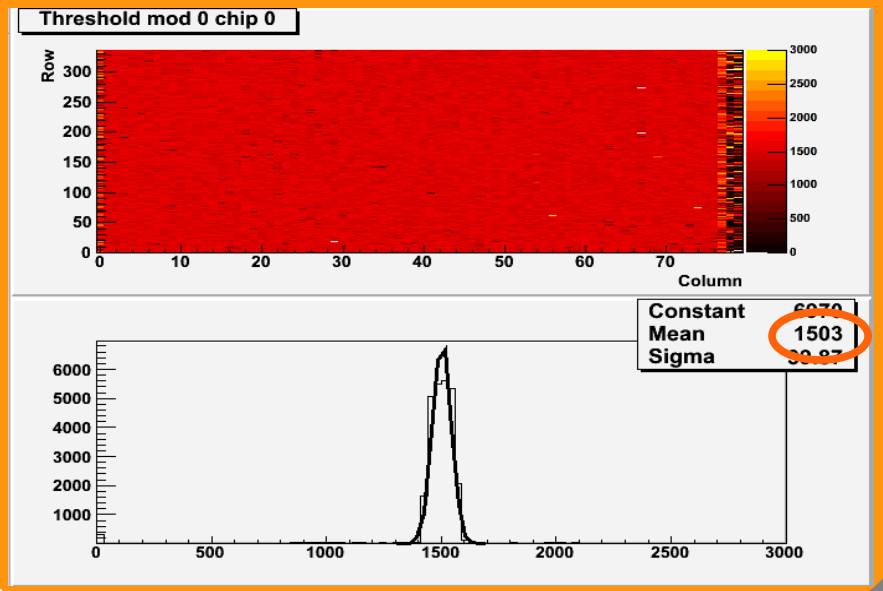


Characterization of un-irr CNM-3D FE-I4 devices

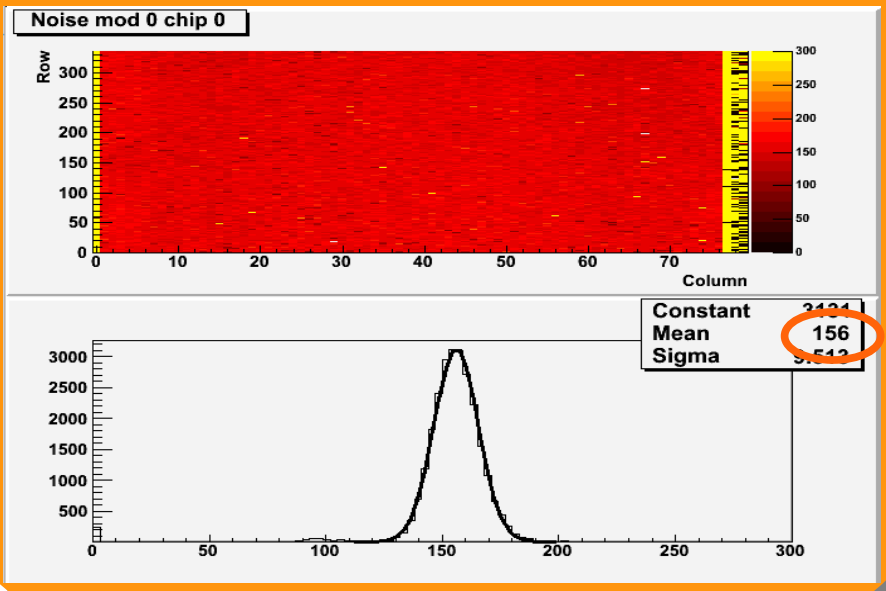
Tuning to low thresholds

- Un-irradiated devices were tuned to thresholds lower than 1500e including edges.
- Results for 1500e tuning of CNM_3D_08 are shown

Threshold

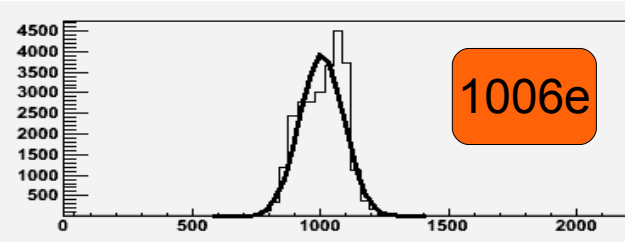


Noise



GEN_CNM_3D_08 (SCC 55)

- Able to tune to lower thresholds (1000e).



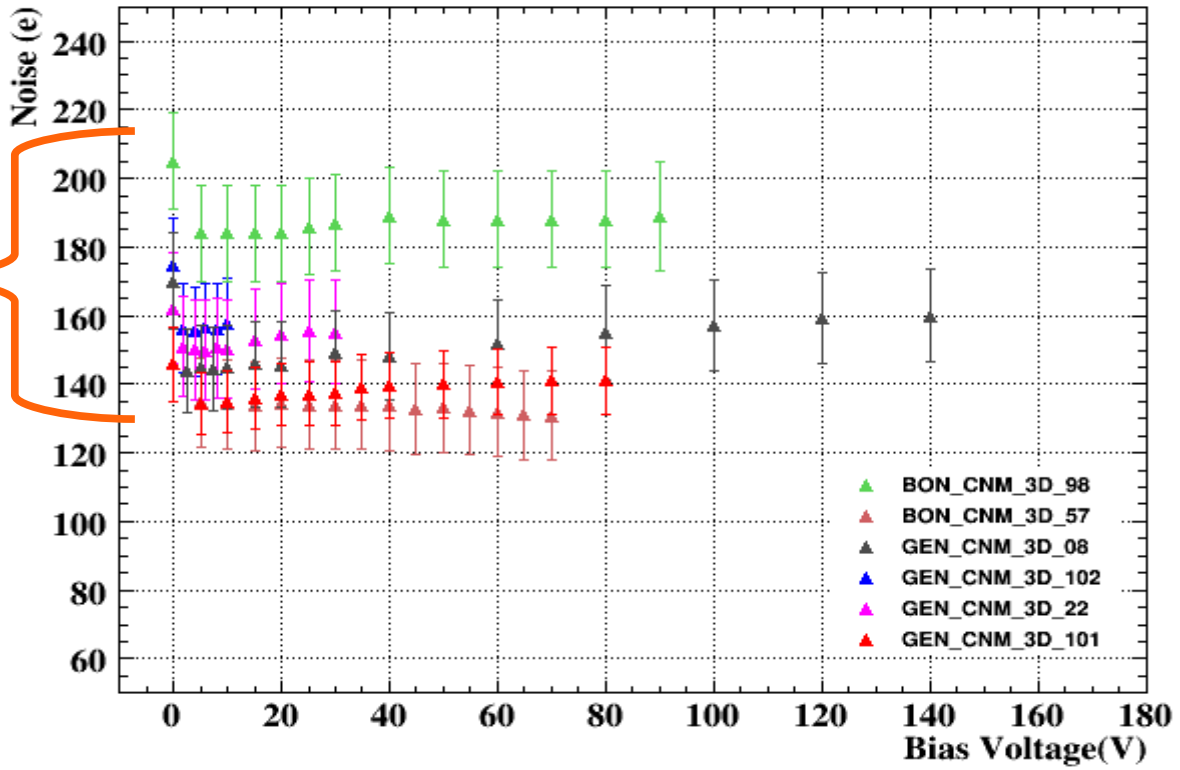
BON_CNM_3D_57

Characterization of un-irr CNM-3D FE-I4 devices

Noise studies

- Noise was scanned within HV ranging from 0V to the breakdown voltage of each device.
- These scans were done after tuning to 3200e.

Low Noise Range 120e to 200e

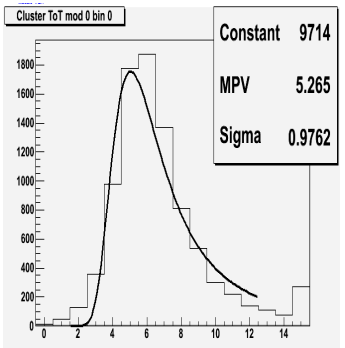


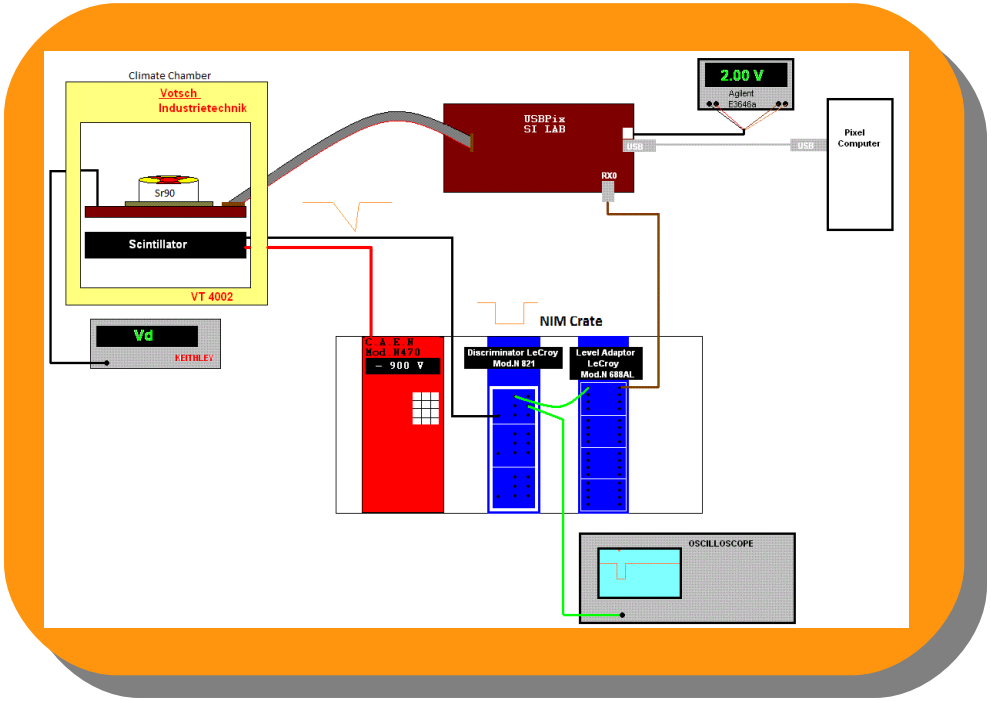
- Results showed constant behavior of the noise before breakdown HV.

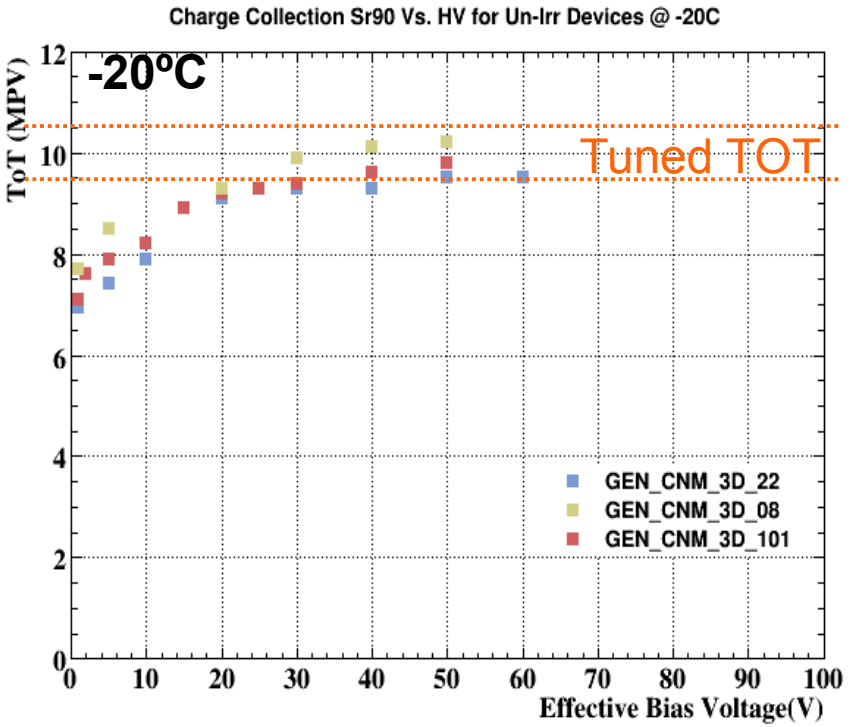
Studies with radioactive source

Source scans

- Beta source (Sr90)
- External trigger setup
- Fitting Landau distribution TOT(MPV) Charge collection
  In the plot no TOT to charge calibration







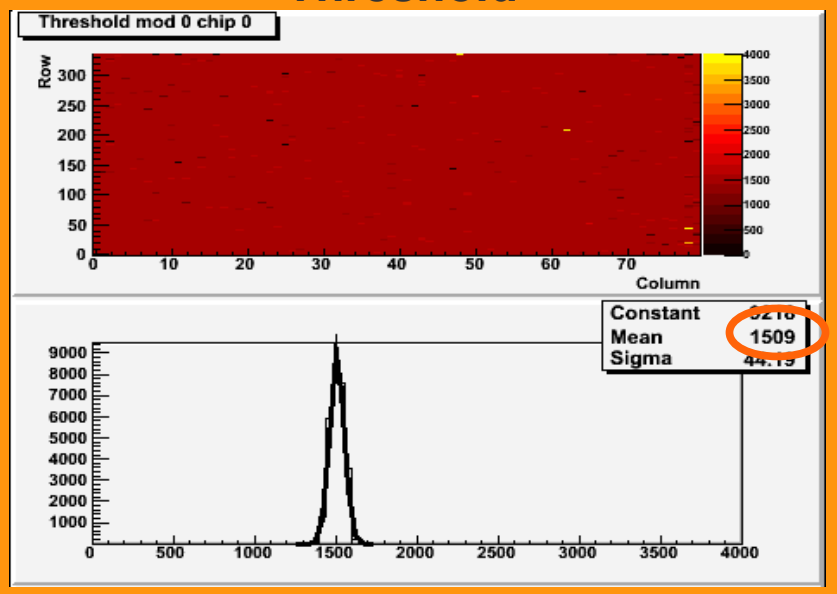
Veff: taking into account voltage drop in PCB

Characterization of p-irr. CNM-3D FE-I4 Devices

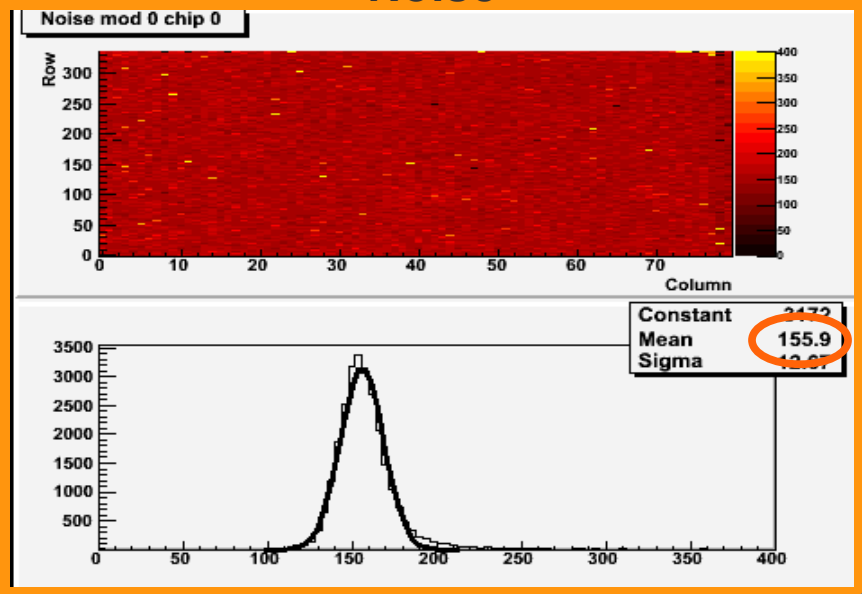
Tuning to low thresholds

- All p-irr devices were tuned to 3 different thresholds, 3200e, 2500e and 1500e, the last one was used in the TestBeam.
- Tuning was done at -20C and edges were included.

Threshold



Noise



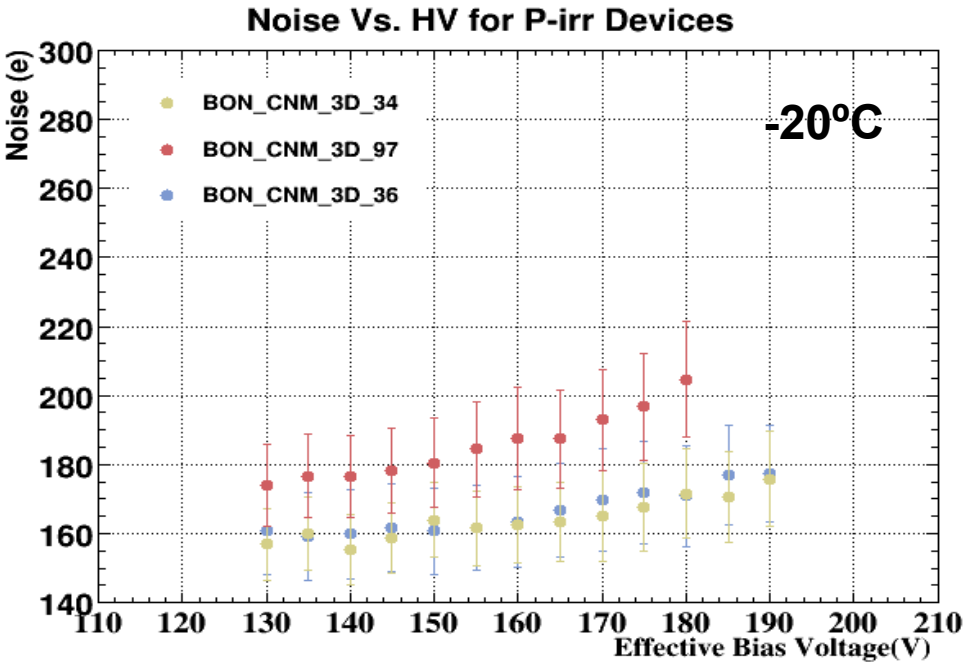
BON_CNM_3D_34 **5.11E15 neq/cm2**

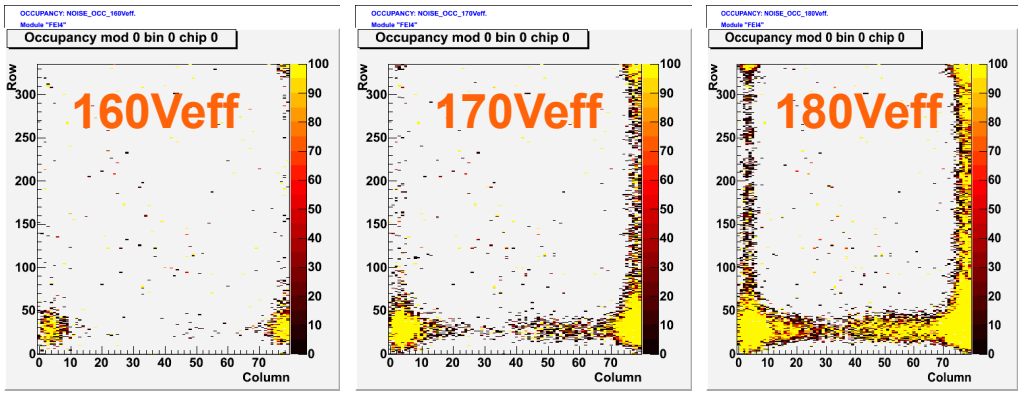
- Even after **5.11E15 neq/cm2** proton irradiation and including the edge columns, the noise was 156e(GOOD), i.e low thresholds operation possible for irradiated devices.
- After tuning this device, it was sent to CERN TestBeam(Sept.). (see S. Tsiskaridze talk)

Characterization of p-irr. CNM-3D FE-I4 Devices

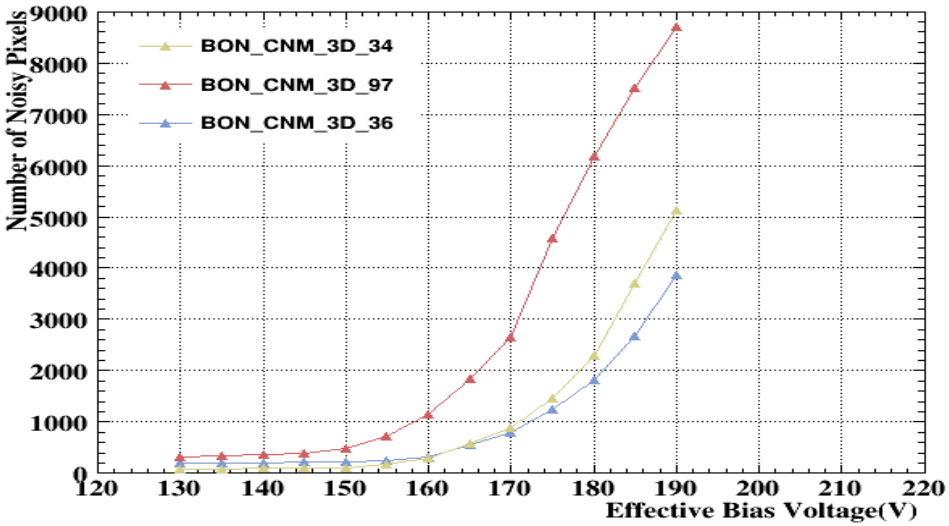
Noise studies

- Noise scan for 3 devices from 0V to 190Veff.
- Noise Occupancy plots show the increase of number of noisy pixels with HV.





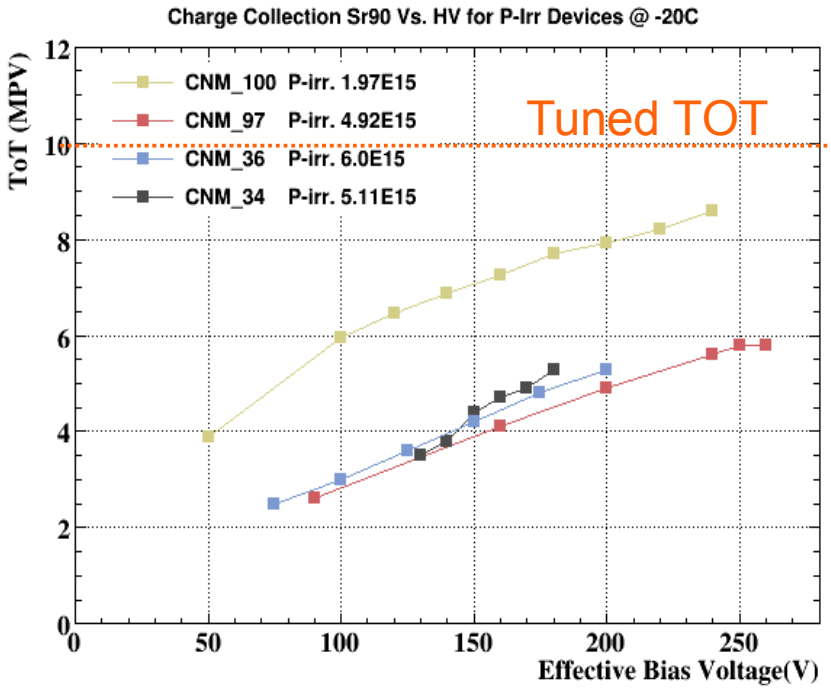
Counting noisy pixels

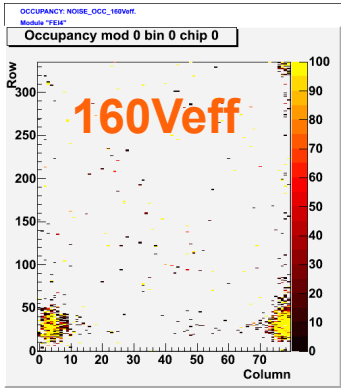


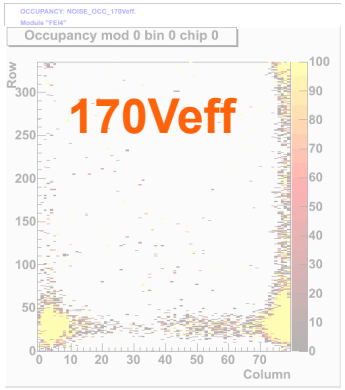
For V>160Veff number of noisy pixels start to increase drastically.

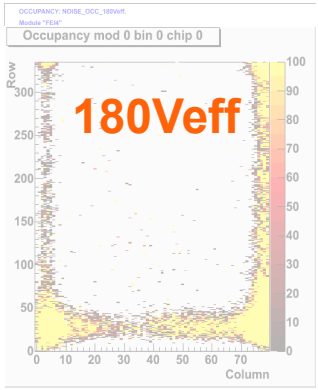
Studies with radioactive source (Sr90)

- Studies with radioactive source (Sr90) were done for p-irr devices at different HV.

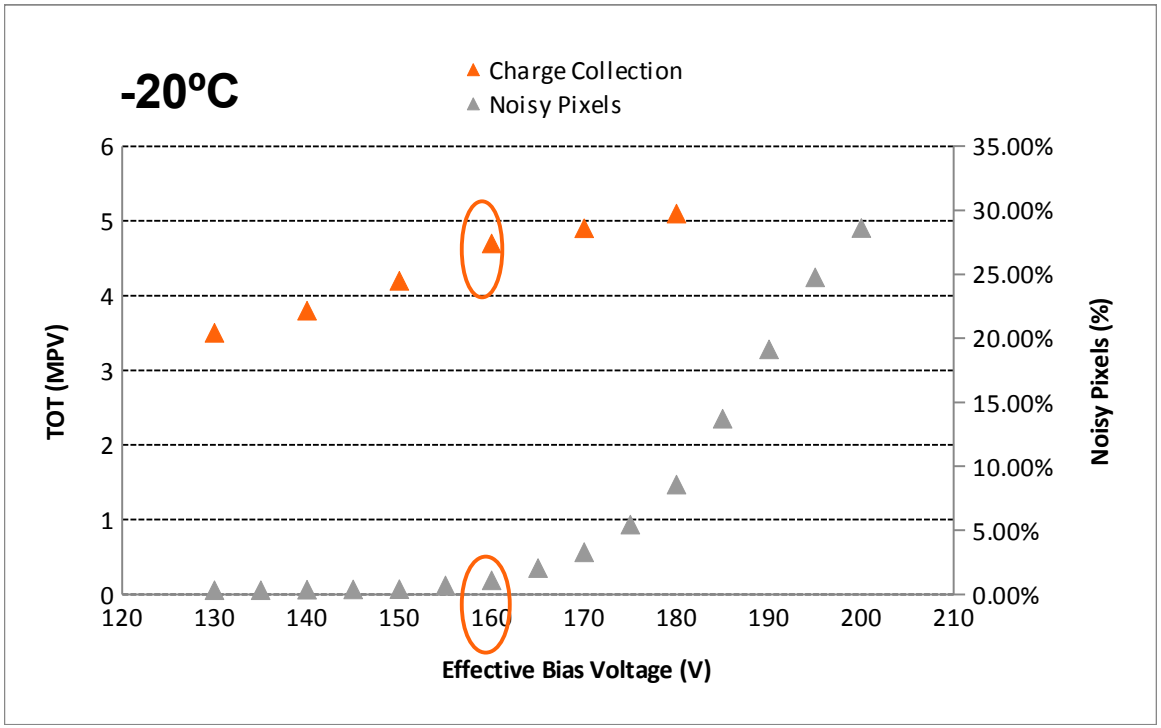








- **160Veff optimal**: low pixel occupancy due to noise, and provides good charge collection.



BON_CNM_3D_34 **5.11E15 neq/cm2**

Summary

- CNM 3D FE-I4 devices were characterized in IFAE before and after irradiation, and sent to the beam tests.
- The devices have low noise level even after irradiation and including edges.
- Optimal Voltage was obtained to be 160Veff for CNM devices