Parameters of the preproduction Series SiPMs for the CMS HCAL Phase I upgrade

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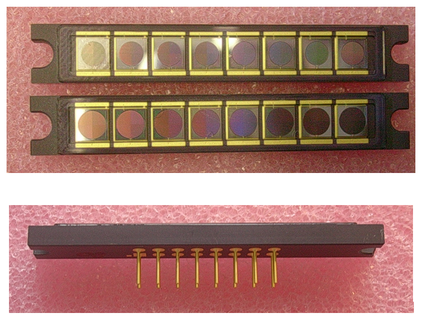
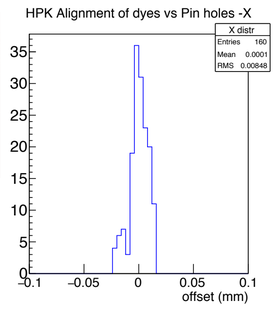
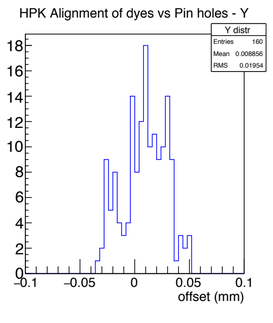
Custom packaged Arrays

With 0.3 mm glass window



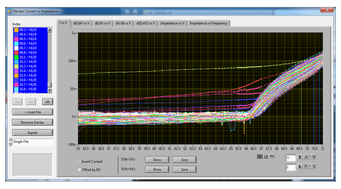


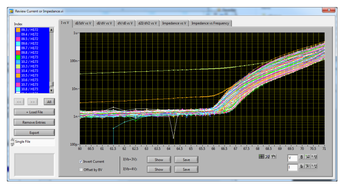


R&D on large dynamic range SiPMs in collaboration with Hamamatsu started in 2010. We now have 15 micron cell devices in 2 sizes, 2.8 mm and 3.3 mm diameter with reps. 27500 and 38500 cells. The 2.8 mm can readout a sum of 4 fibers and the 3.3 mm can readout a sum of 7 fibers

Uniformity of 175 Arrays

(total 1400 channels)



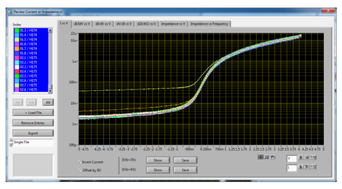


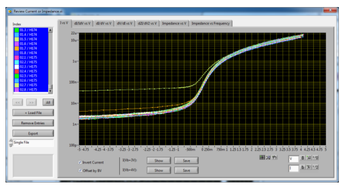
2.8 mm – 984 channels

3.3 mm – 416 channels

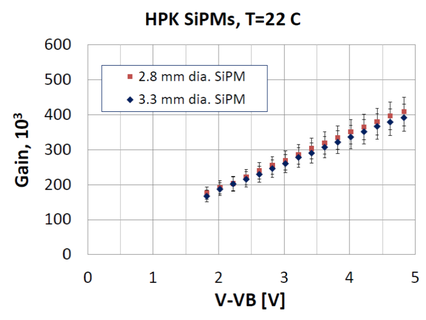
IV curve – no light
Low Dark current

A few channels show high dark current below operating voltage

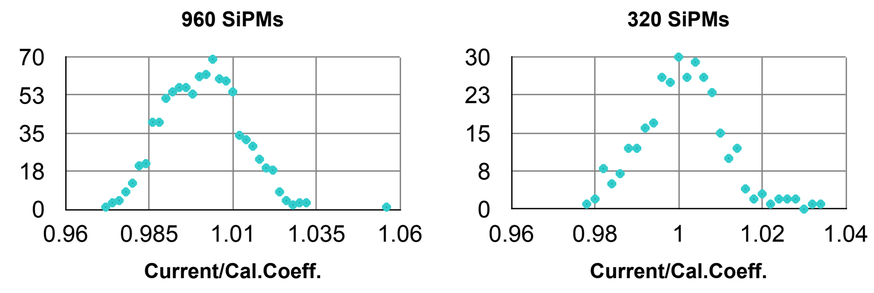




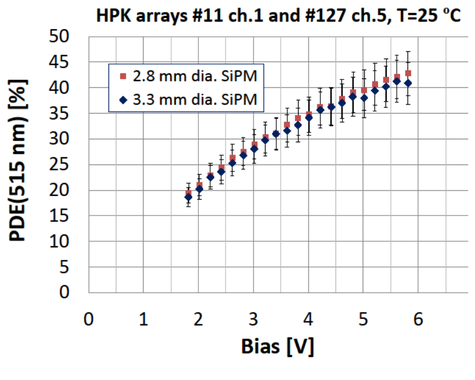
IV curve – LED illumination
Good uniformity after correction of V_b
$V_{op} = (V_{br} + 4 \text{ volts})$

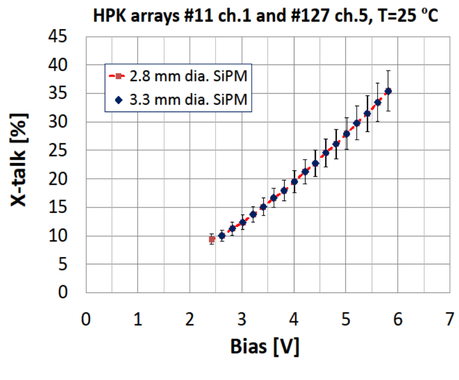


Low gain and uniformity to match the required large 10^4 dynamic range needed in the CMS-HCAL



PDE and Crosstalk





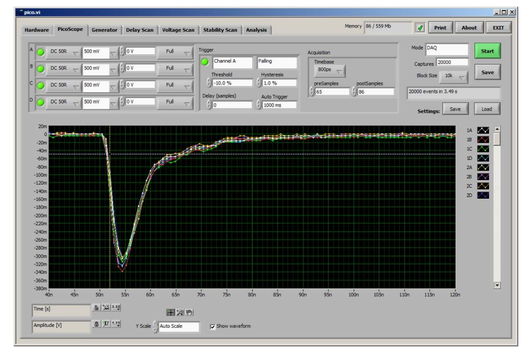
HPK uses a transparent MFQR (Metal Film Quenching Resistor) to deliver high PDE for small cell (15 x15 micron) devices

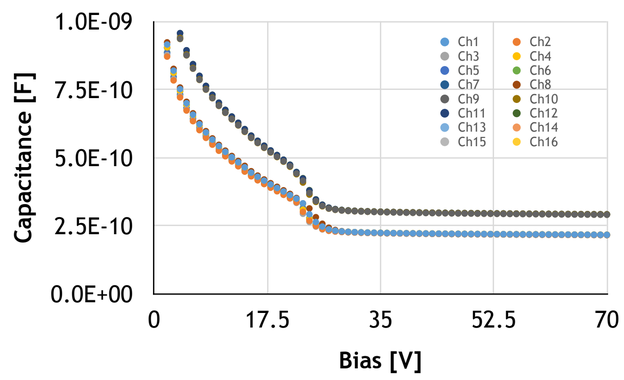
A trade off between PDE and Crosstalk is made (no trench technology)
CMS HCAL has a limited internal resolution 100%/√E

Fast Laser Response

Fast laser response for 2.8 mm into 15 ohm

Fast laser response for 3.3 mm into 15 ohm

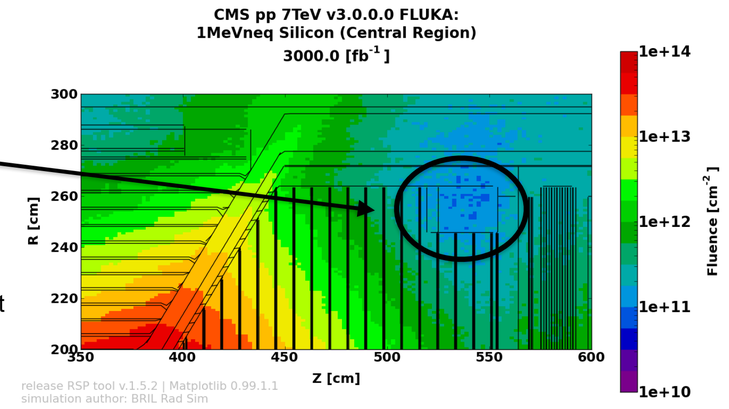




Forward current measurement gives us Rq < 850 kohm

Because of low capacitance;
resp. 210 pF and 330 pF we have a recovery time of **7-8ns**

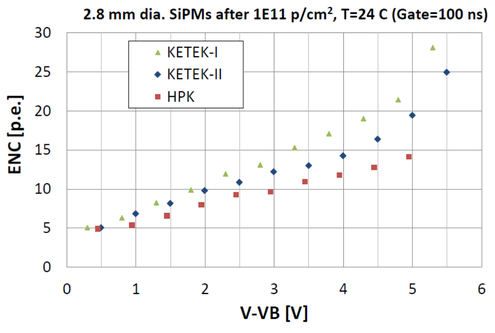
Radiation Studies



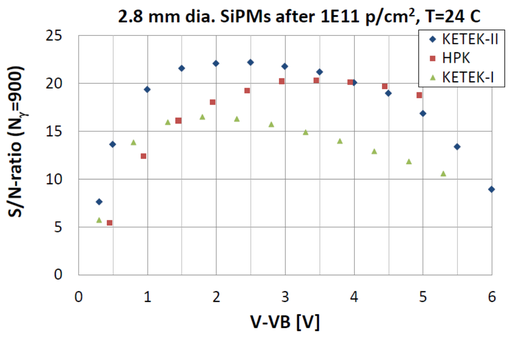
Location of the CMS HCAL electronics (readout box)

We anticipate a dose of 10^{11} neutrons (1 MeV eq)/cm² in the lifetime of the experiment

Expected noise after radiation (comparison of two vendors)



S/N was compared for different thickness of devices for KETEK



We have developed a Glass Window because epoxy acts as a scintillator producing noise signals, “Spikes” in the CMS trigger