



Radiation damage in silicon photomultipliers exposed to neutron radiation

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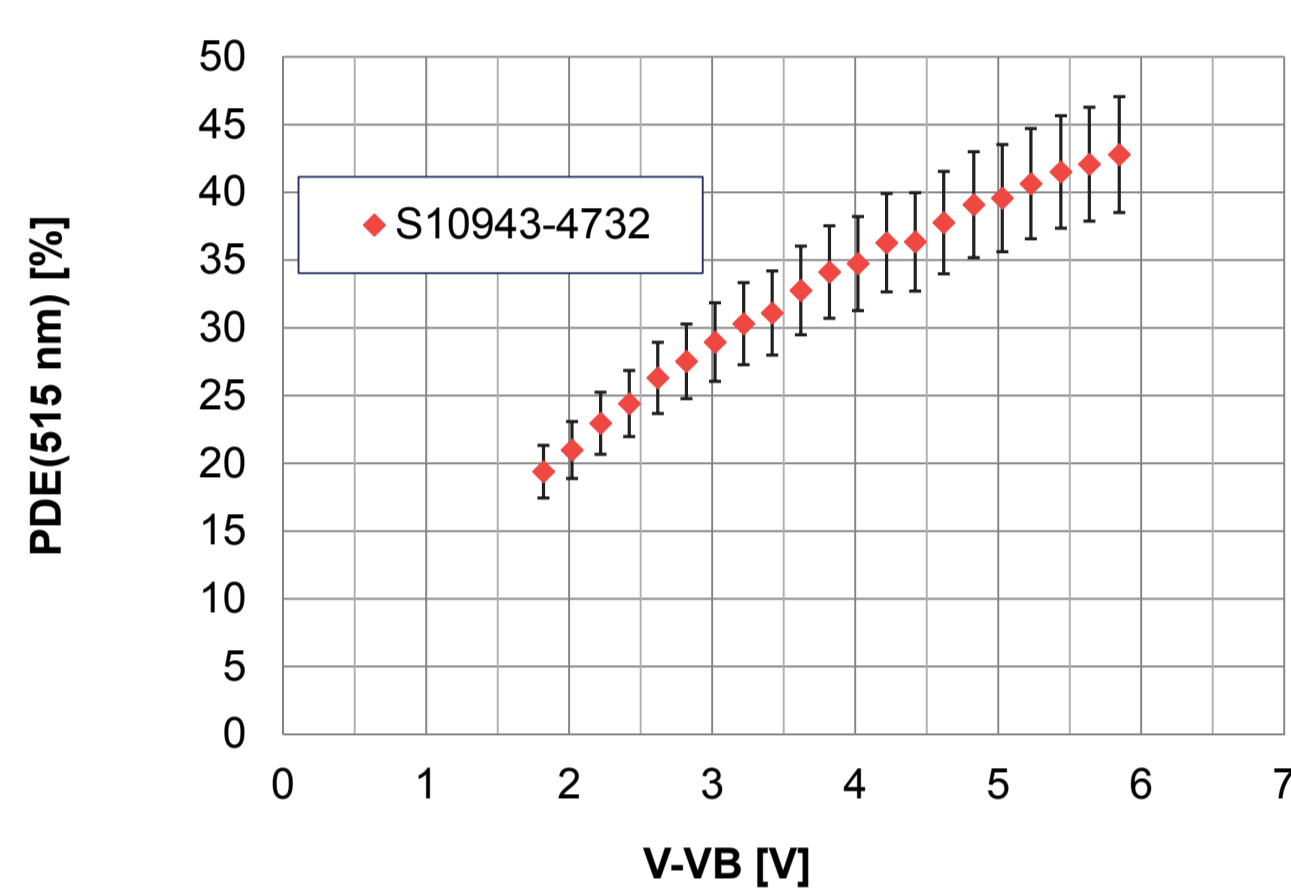


	S10943-4732	HD-1015CN
• Area (mm ²):	6.16	1
• Cell pitch (μm):	15	15
• V _b (V):	~66	~39
• Cell recovery time (ns):	8	12

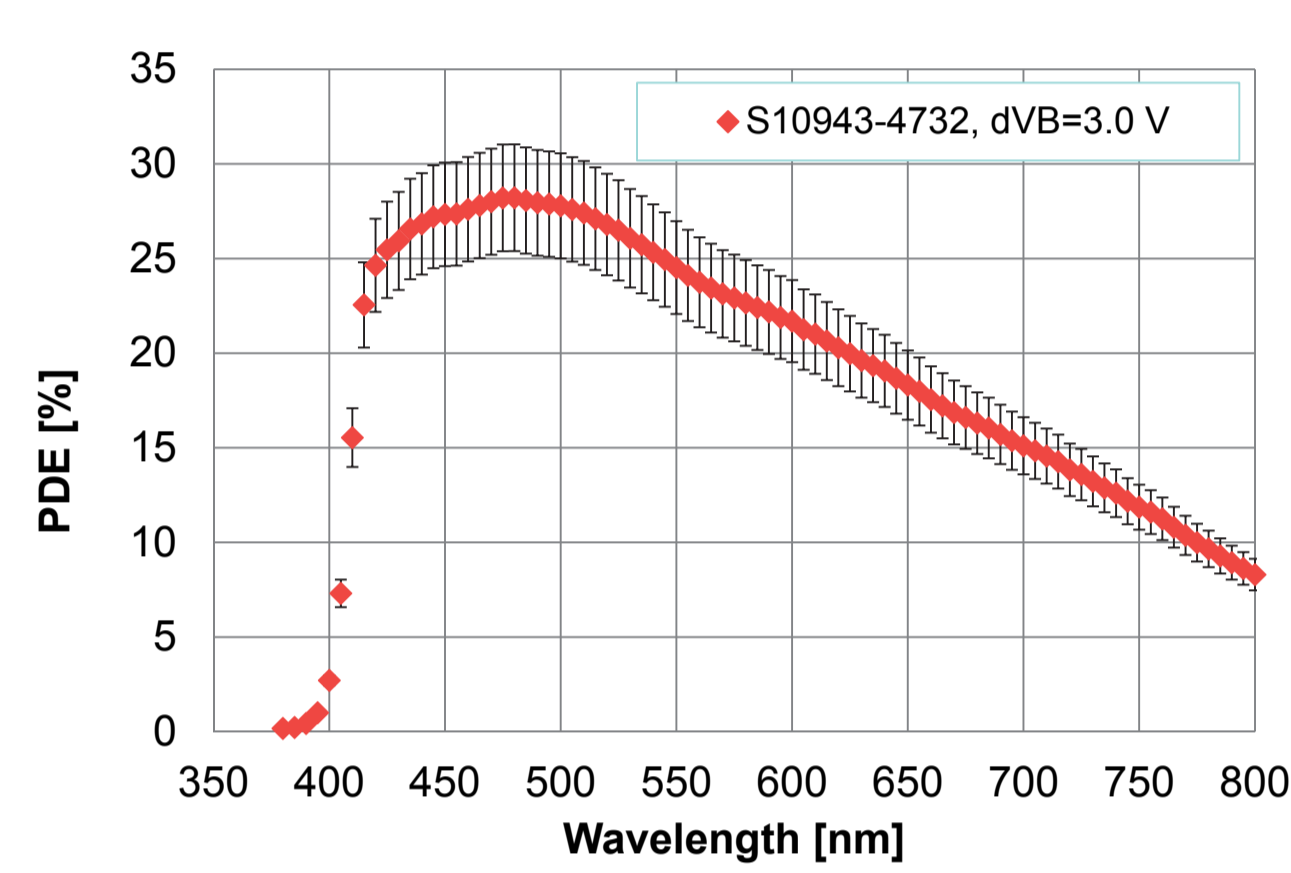
Introduction

We studied performances of two SiPMs before and after irradiation at Lubljana reactor. These high density (15 μm cell pitch size) SiPMs were developed by Hamamatsu (in cooperation with the CMS SiPM group) for the CMS HCAL Upgrade Phase I project. The S10943-4732 is a photosensor selected for the CMS HE HCAL where the SiPMs will be exposed to 2*10¹¹ n/cm² (1 MeV equivalent) for the operation time of the SLHC (integrated luminosity - 5000 fb⁻¹). The HD-1015CN SiPM was developed using new Hamamatsu trench technology to reduce optical cross-talk (X-talk) between SiPM cells. It is considered as one of candidates for the CMS HCAL barrel upgrade. The SiPMs were irradiated with reactor neutrons up to 1 MeV equivalent fluence of 2*10¹² n/cm² (that corresponds to the maximum integrated neutron fluence in the HCAL barrel for full time of the SLHC operation).

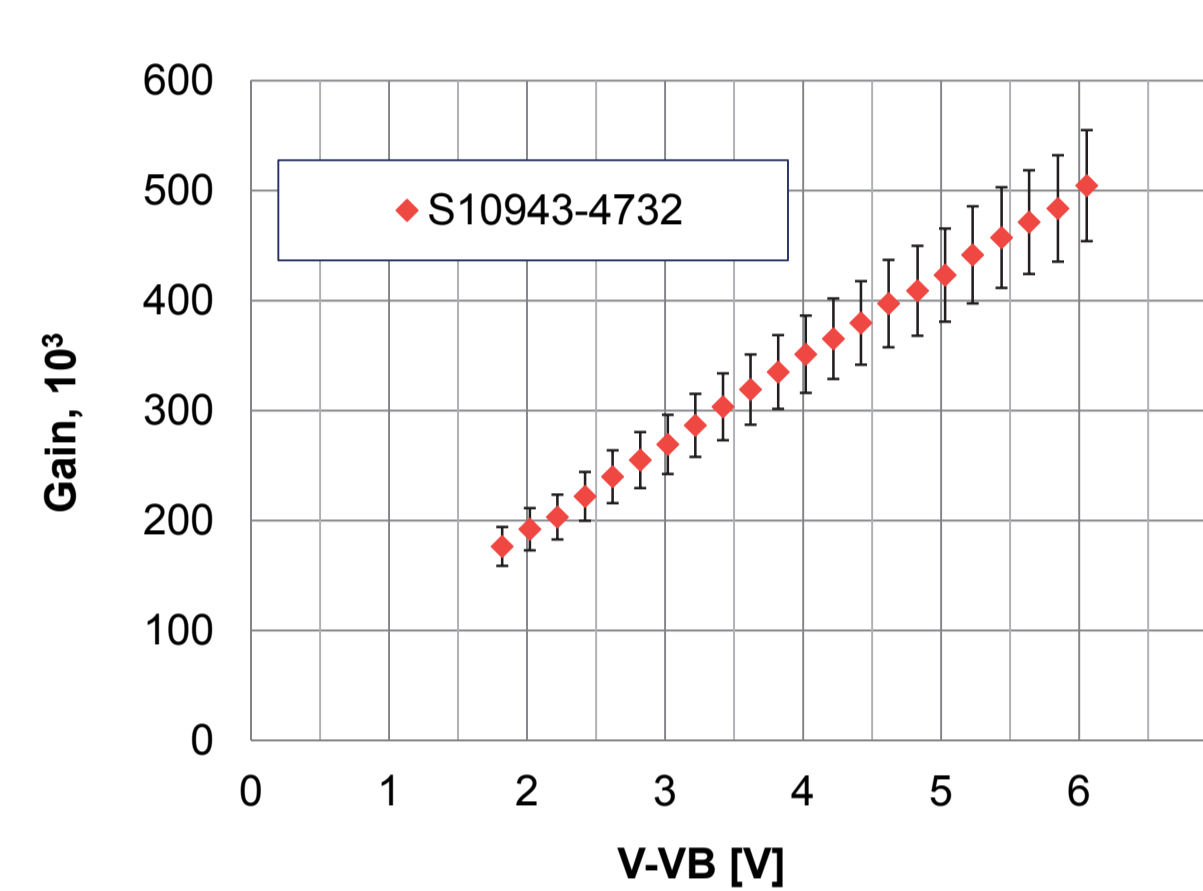
Main parameters of two Hamamatsu high density SiPMs (measured before irradiation)



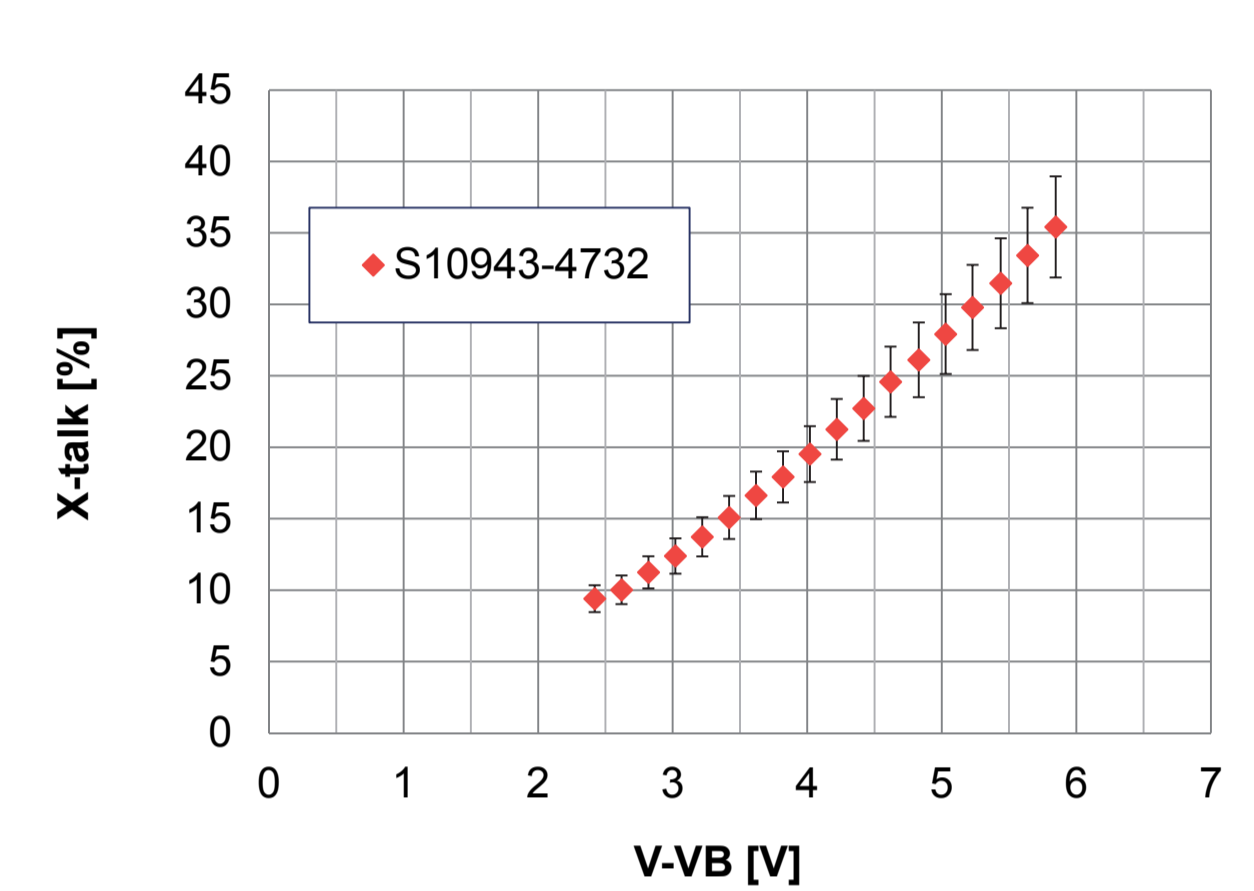
PDE vs. V-VB for S10943-4732 SiPM



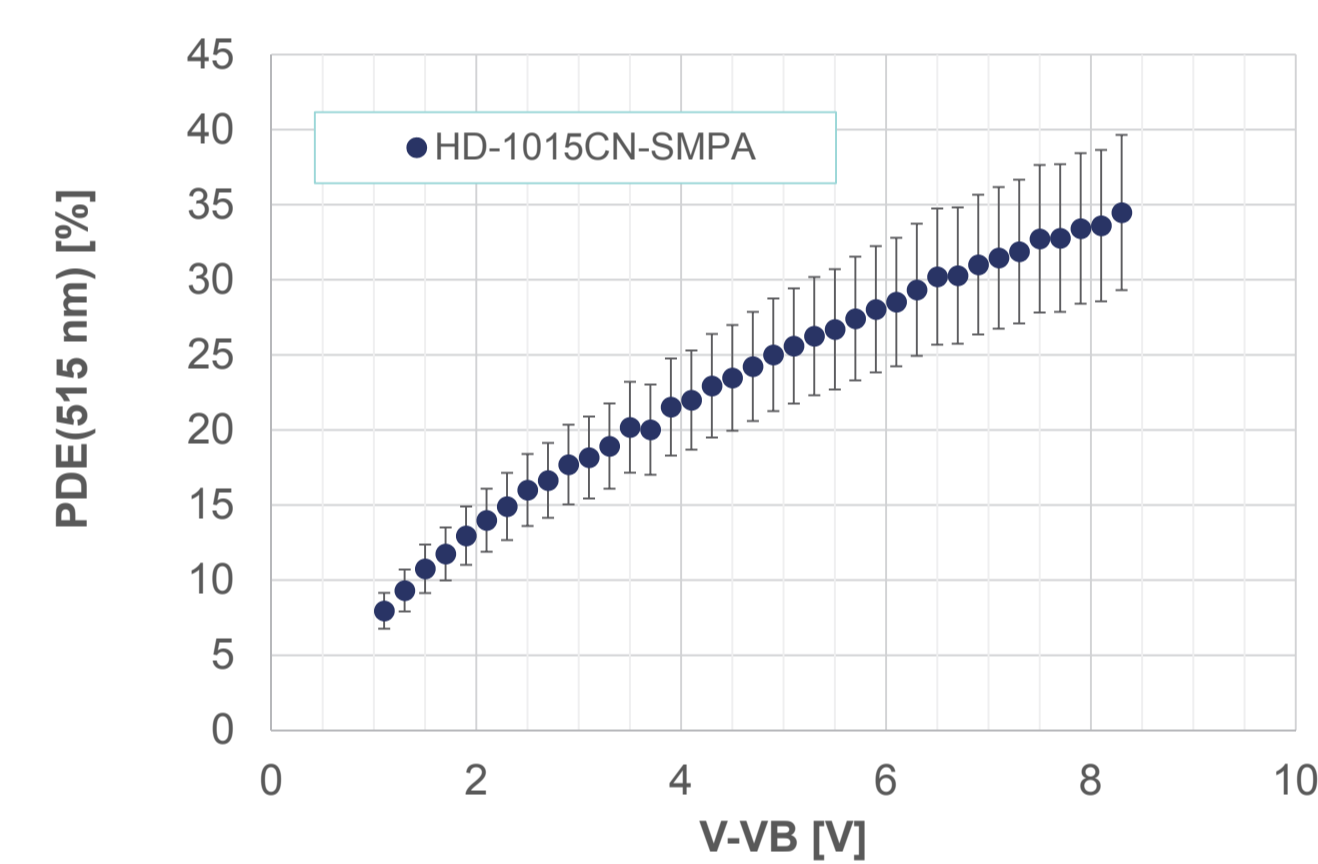
PDE vs. wavelength for S10943-4732 SiPM



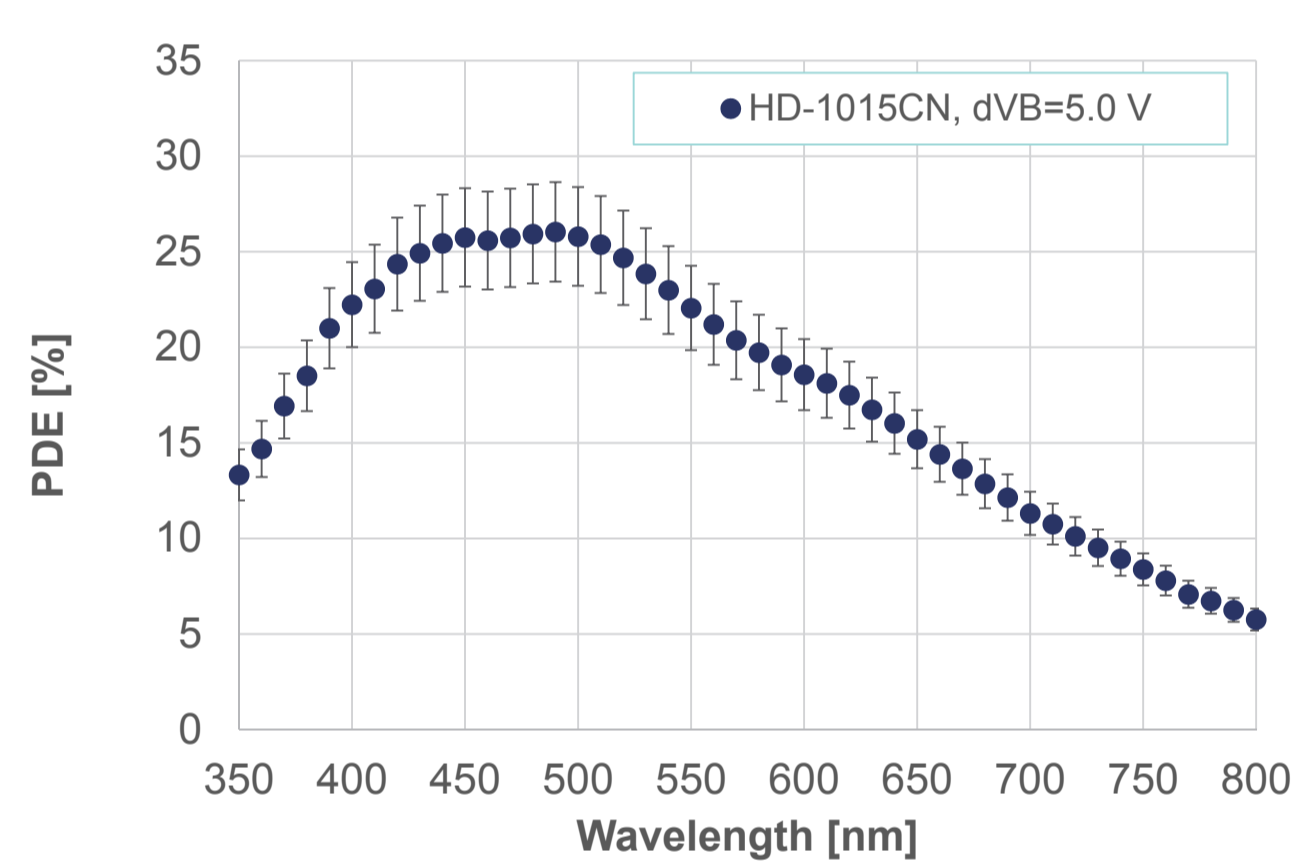
Gain vs. V-VB for S10943-4732 SiPM



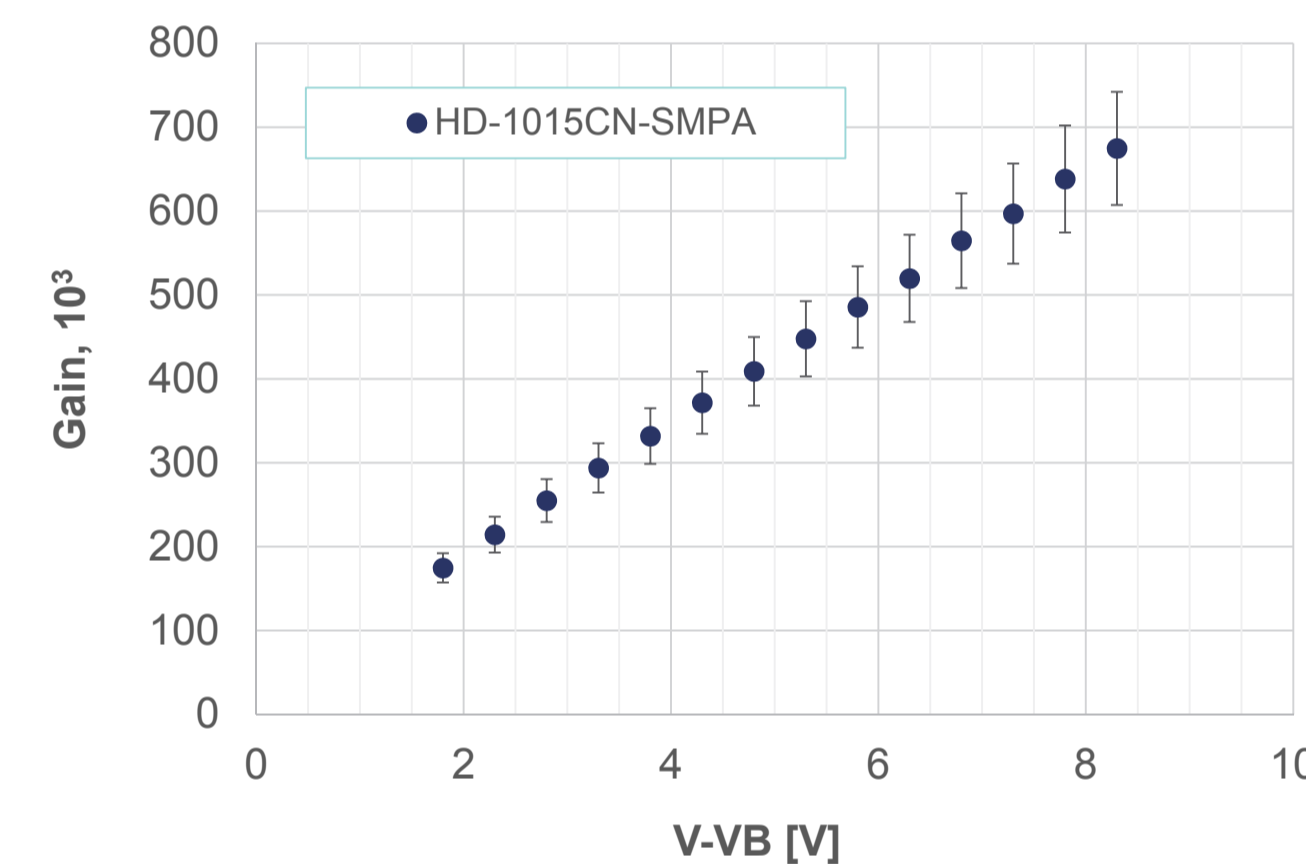
X-talk vs. V-VB for S10943-4732 SiPM



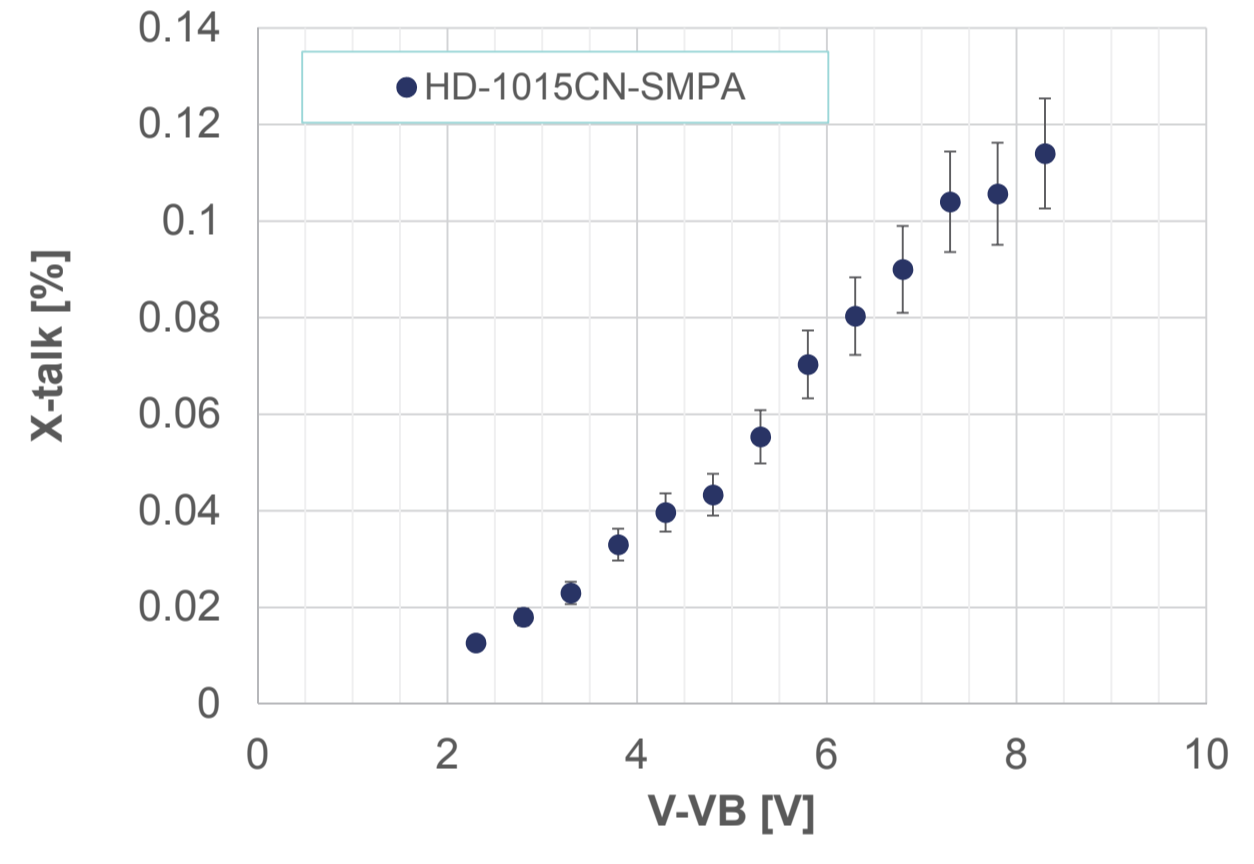
PDE vs. V-VB for HD-1015CN SiPM



PDE vs. wavelength for HD-1015CN SiPM

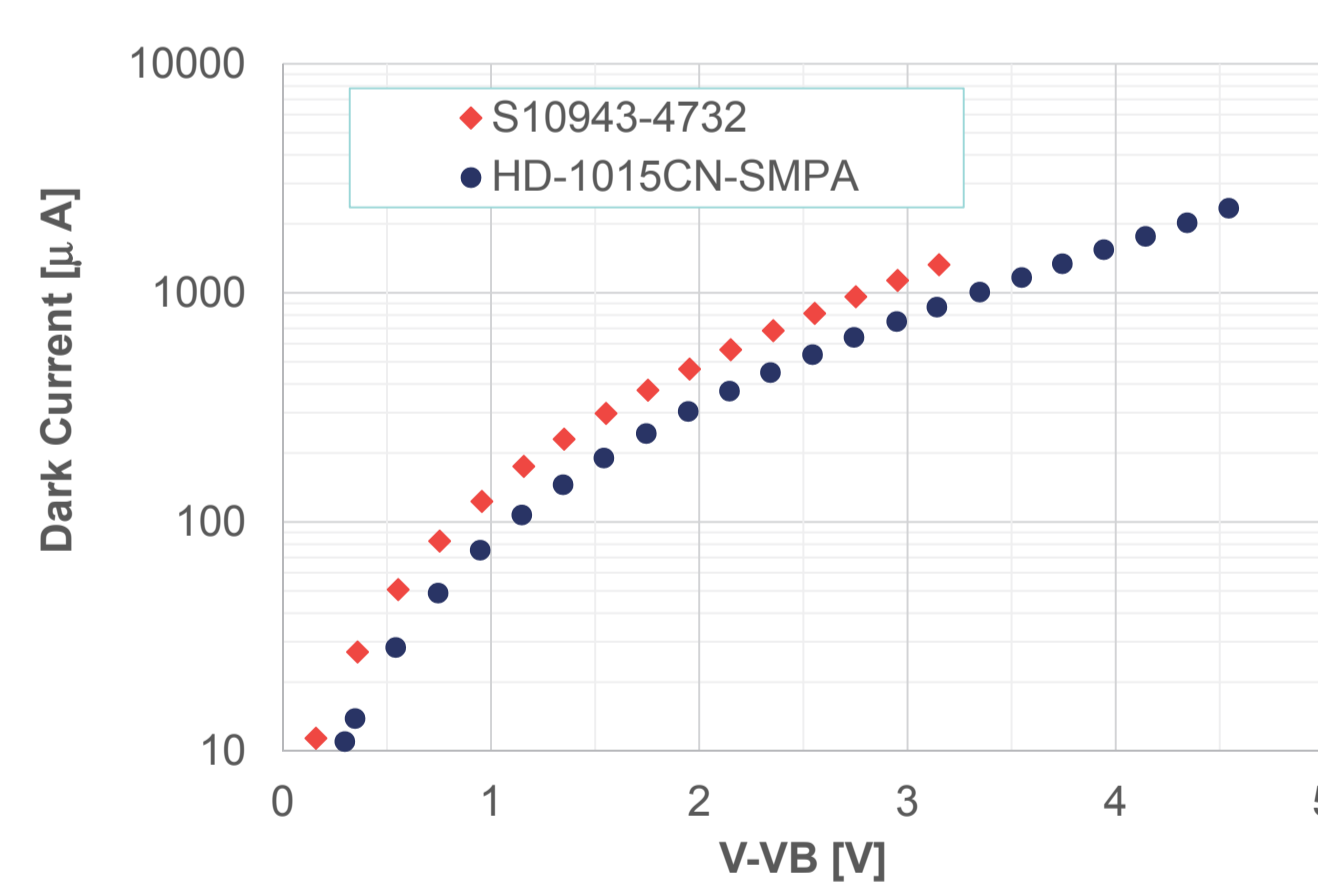


Gain vs. V-VB for HD-1015CN SiPM

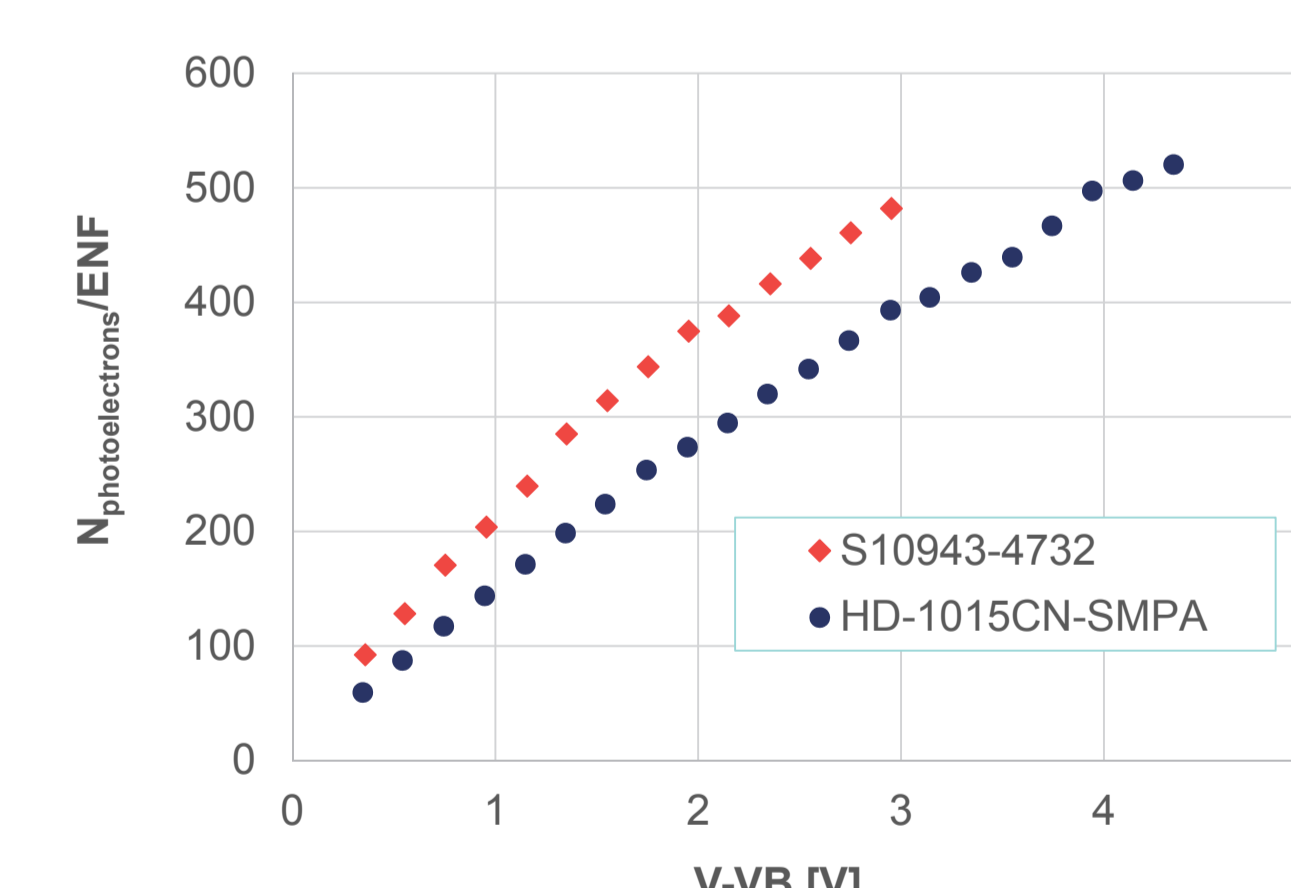


X-talk vs. V-VB for HD-1015CN SiPM

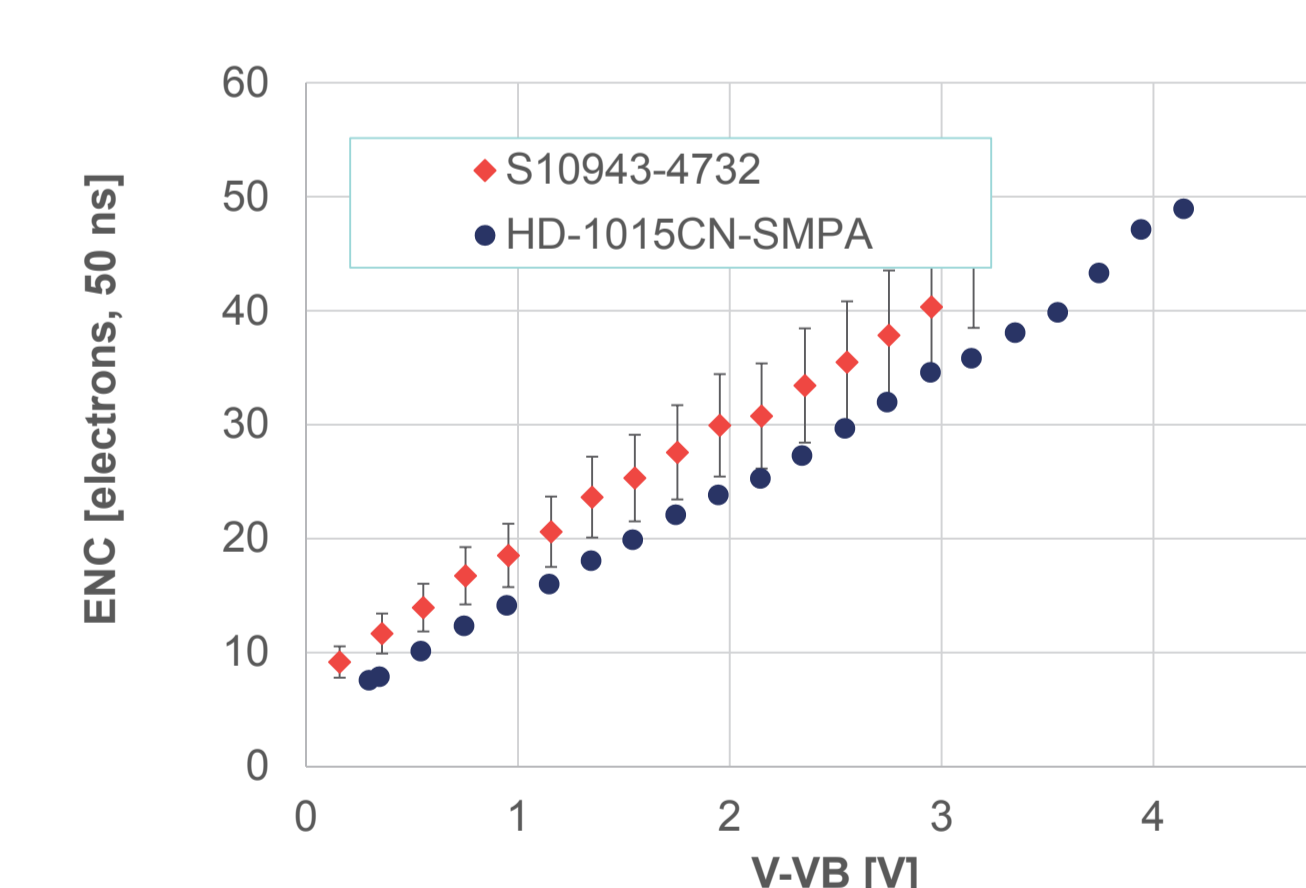
S10943-4732 and HD-1015CN SiPMs after 2*10¹² n/cm²



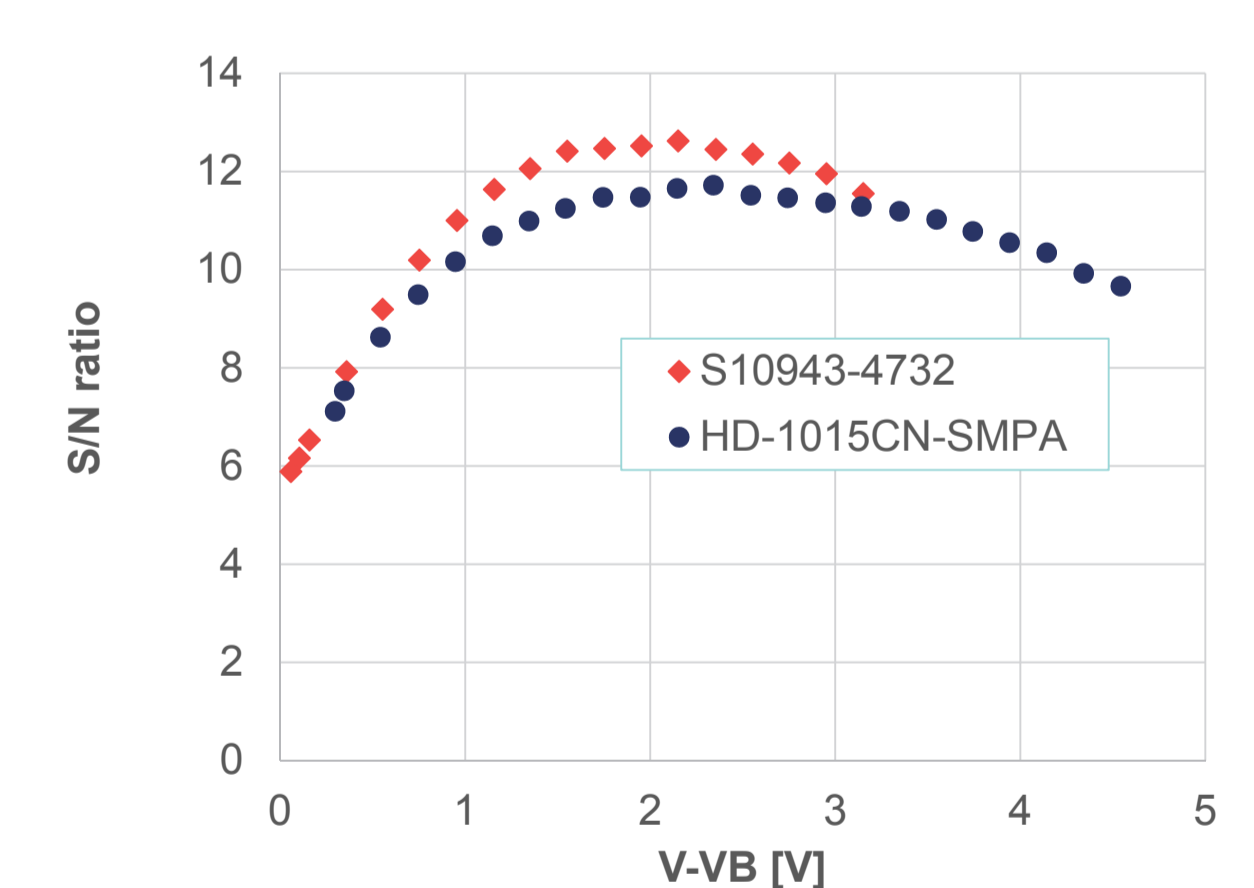
Dark current vs. V-VB measured for the SiPMs after irradiation at T=23 °C



N_{ph}/F vs. V-VB for irradiated SiPMs (T=23 °C, <N_s>~ 2100 photons/pulse)



ENC vs. V-VB for irradiated SiPMs (gate=50 ns, T=23 °C)



S/N ratio vs. V-VB measured after irradiation (<N_s>~ 2100 photons/pulse, T=23 °C)

Summary

Two high density SiPMs from Hamamatsu (developed for the CMS HCAL Upgrade Phase I project) were irradiated with reactor neutrons up to 1 MeV equivalent fluence of 2*10¹² n/cm².

Measurements of the most important SiPM parameters were performed before irradiation. The S10943-4732 SiPM can reach high PDE=25% at relatively low SiPM overvoltage (V-VB=2.5 V). However the SiPM's X-talk at this overvoltage is relatively high (12%). Relatively high overvoltage (V-VB=5V) has to be applied to the HD-1015CN SiPM to reach 25 % PDE. However the X-talk at this overvoltage remains very small (<0.05%).

Dark current and noise vs. bias dependence were measured at T=23°C after 15 hours of annealing at 70 °C. Their response to pulsed LED light was measured using 515 nm fast LED. To compare performances of SiPMs after irradiation dark current and noise (measured using 50 ns integration time) for smaller size SiPM were recalculated taking into account difference in the sensitive area.

Dark current and noise was measured to be smaller for the irradiated HD-1015CN type SiPM. However the Signal/Noise ratio after irradiation was found to be slightly better for the S10943-4732 SiPM due to its higher PDE.