

Influence of Radiation Damage on SiPM's performance

100 mm x 5 mm x 2 mm BC422 + S13360-3050PE

0 hours of irradiation, $I_{\text{SiPM-Left}} = \sim 0.15 \text{ microA}$; $I_{\text{SiPM-Right}} = \sim 0.15 \text{ microA}$;

Some tests were done on big scintillator bars for about a day. SiPM prototypes were used for triggering purposes ~120 cm away from the focus position. They were irradiated a bit. As the previous prototypes showed no difference in performance up to this level of irradiation, we take as a 0 point the moment we started with our measurements.

0 hours of irradiation, $I_{\text{SiPM-Left}} = \sim 2 \text{ microA}$; $I_{\text{SiPM-Right}} = \sim 2 \text{ microA}$;

Run #	HV	CFD_th	Efficiency	$\sigma_{\text{T(L-R)}}$	$\sigma_{\text{T([L+R]/2)}}$
6031	55V	-20 mV	99.5 % \pm 0.1 %	156 ps	78 ps

5 hours of irradiation, $I_{\text{SiPM-Left}} = \sim 83 \text{ microA}$; $I_{\text{SiPM-Right}} = \sim 83 \text{ microA}$;

Rate(2mm x 2mm) = 49 kHz

Run #	HV	CFD_th	Efficiency	$\sigma_{\text{T(L-R)}}$	$\sigma_{\text{T([L+R]/2)}}$
6032	55 V	-10 mV	99.6 % \pm 0.1 %	200 ps	100 ps
6033	55 V	-20 mV	98.5 % \pm 0.1 %	200 ps	100 ps
6034	55 V	-20 mV	98.2 % \pm 0.1 %	199 ps	100 ps
6035	55.5 V	-20 mV	99.4 % \pm 0.1 %	189 ps	95 ps
6036	55.5 V	-30 mV	98.1 % \pm 0.1 %	190 ps	95 ps
6038	56 V	-10 mV	99.2 % \pm 0.1 %	185 ps	93 ps
6037	56 V	-20 mV	99.4 % \pm 0.1 %	186 ps	93 ps
6039	56 V	-30 mV	99.1 % \pm 0.1 %	186 ps	93 ps

+5 hours of irradiation, $I_{\text{SiPM-Left}} = \sim 132 \text{ microA}$; $I_{\text{SiPM-Right}} = \sim 140 \text{ microA}$;

Rate(2mm x 2mm) = 46 kHz

Run #	HV	CFD_th	Efficiency	$\sigma_{\text{T(L-R)}}$	$\sigma_{\text{T([L+R]/2)}}$
6041	55 V	-10 mV	98.3 % \pm 0.1 %	223 ps	112 ps
6042	55 V	-20 mV	95.9 % \pm 0.1 %	225 ps	113 ps
6043	55 V	-30 mV	85.3 % \pm 0.1 %	226 ps	113 ps
6046	55.5 V	-5 mV	97.1 % \pm 0.1 %	JUNK	JUNK
6044	55.5 V	-10 mV	98.0 % \pm 0.1 %	215 ps	108 ps
6048	55.5 V	-10 mV	97.2 % \pm 0.1 %	210 ps	105 ps
6045	55.5 V	-20 mV	97.3 % \pm 0.1 %	216 ps	108 ps
6047	55.5 V	-30 mV	93.1 % \pm 0.1 %	216 ps	108 ps
6049	56 V	-10 mV	96.8 % \pm 0.1 %	206 ps	103 ps
6050	56 V	-20 mV	97.4 % \pm 0.1 %	209 ps	105 ps
6051	56 V	-30 mV	96.6 % \pm 0.1 %	209 ps	105 ps
6052	57 V	-10 mV	96.9 % \pm 0.1 %	205 ps	103 ps
6053	57 V	-20 mV	97.2 % \pm 0.1 %	207 ps	104 ps
6054	57 V	-30 mV	97.1 % \pm 0.1 %	208 ps	104 ps

+6 hours of irradiation, $I_{\text{SiPM-Left}} = \sim 190 \text{ microA}$; $I_{\text{SiPM-Right}} = \sim 190 \text{ microA}$;
 $\text{Rate}_{(2\text{mm} \times 2\text{mm})} = 47 \text{ kHz}$

Run #	HV	CFD_th	Efficiency	$\sigma_{\text{T(L-R)}}$	$\sigma_{\text{T([L+R]/2)}}$
6079	55 V	-5 mV	98.0 % \pm 0.1 %	JUNK	JUNK
6080	55 V	-10 mV	99.3 % \pm 0.1 %	235 ps	118 ps
6081	55 V	-20 mV	97.4 % \pm 0.1 %	236 ps	118 ps
6082	55 V	-30 mV	87.6 % \pm 0.1 %	235 ps	118 ps
6083	56 V	-10 mV	98.7 % \pm 0.1 %	224 ps	112 ps
6084	56 V	-20 mV	99.1 % \pm 0.1 %	223 ps	112 ps
6085	56 V	-30 mV	97.3 % \pm 0.1 %	226 ps	113 ps
6086	57 V	-10 mV	98.8 % \pm 0.1 %	222 ps	111 ps
6087	57 V	-20 mV	99.2 % \pm 0.1 %	223 ps	112 ps
6088	57 V	-30 mV	98.8 % \pm 0.1 %	223 ps	112 ps
6089	58 V	-10 mV	99.0 % \pm 0.1 %	JUNK	JUNK
6090	58 V	-20 mV	98.8 % \pm 0.1 %	223 ps	112 ps
6091	58 V	-30 mV	99.1 % \pm 0.1 %	226 ps	113 ps
6092	58 V	-40 mV	98.4 % \pm 0.1 %	225 ps	113 ps

+4 hours of irradiation, $I_{\text{SiPM-Left}} = \sim 220 \text{ microA}$; $I_{\text{SiPM-Right}} = \sim 220 \text{ microA}$;
 $\text{Rate}_{(2\text{mm} \times 2\text{mm})} = 47 \text{ kHz}$

Run #	HV	CFD_th	Efficiency	$\sigma_{\text{T(L-R)}}$	$\sigma_{\text{T([L+R]/2)}}$
6100	55 V	-10 mV	99.3 % \pm 0.1 %	248 ps	124 ps
6101	55 V	-20 mV	96.6 % \pm 0.1 %	245 ps	123 ps
6102	55 V	-30 mV	84.5 % \pm 0.1 %	240 ps	120 ps
6103	56 V	-10 mV	98.6 % \pm 0.1 %	228 ps	114 ps
6104	56 V	-20 mV	99.1 % \pm 0.1 %	232 ps	116 ps
6105	56 V	-30 mV	96.7 % \pm 0.1 %	240 ps	120 ps
6106	56 V	-40 mV	89.1 % \pm 0.1 %	230 ps	115 ps
6107	57 V	-10 mV	98.5 % \pm 0.1 %	228 ps	114 ps
6108	57 V	-20 mV	99.2 % \pm 0.1 %	228 ps	114 ps
6109	57 V	-30 mV	98.6 % \pm 0.1 %	236 ps	118 ps
6110	57 V	-40 mV	95.9 % \pm 0.1 %	236 ps	118 ps
6111	58 V	-10 mV	99.2 % \pm 0.1 %	JUNK	JUNK
6112	58 V	-20 mV	98.8 % \pm 0.1 %	229 ps	115 ps
6113	58 V	-30 mV	99.0 % \pm 0.1 %	231 ps	116 ps
6114	58 V	-40 mV	97.8 % \pm 0.1 %	232 ps	116 ps
6115	56 V	MCFD=20		548 ps	
6116	56 V	MCFD=25		528 ps	
6117	56 V	MCFD=30		406 ps	

Same conditions, different irradiation times

Irradiation Time	Run #	HV	CFD_th	Efficiency	$\sigma_{T(L-R)}$
0 Hour	6031	55 V	-20 mV	99.5 % \pm 0.1 %	156 ps
5 Hours	6033	55 V	-20 mV	98.5 % \pm 0.1 %	200 ps
10 Hours	6042	55 V	-20 mV	95.9 % \pm 0.1 %*	225 ps
16 Hours	6081	55 V	-20 mV	97.4 % \pm 0.1 %	236 ps
20 Hours	6101	55 V	-20 mV	96.6 % \pm 0.1 %	245 ps

*Strange, could be wrong CFD.

Best results

Irradiation Time	Run #	HV	CFD_th	Efficiency	$\sigma_{T(L-R)}$
0 Hour	6031	55 V	-20 mV	99.5 % \pm 0.1 %	156 ps
5 Hours	6037	56 V	-20 mV	99.4 % \pm 0.1 %	186 ps
10 Hours	6050	56 V	-20 mV	97.4 % \pm 0.1 %*	209 ps
16 Hours	6087	57 V	-20 mV	99.2 % \pm 0.1 %	223 ps
20 Hours	6108	57 V	-20 mV	99.2 % \pm 0.1 %	228 ps

*Strange, could be wrong CFD.

Dark Current increase

Irradiation Time	Rate	HV	I	$\Delta I/h$	$\Delta I/(h*Rate)$
0 Hour		55 V	~2 microA		
5 Hours	49 kHz	55 V	~83 microA	16.2 microA / h	0.33
10 Hours	46 kHz	55 V	~135 microA	10.4 microA / h	0.23
16 Hours	47 kHz	55 V	~190 microA	9.2 microA / h	0.20
20 Hours	47 kHz	55 V	~220 microA	7.0 microA / h	0.15