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Cryogenic electronics for photosensors operating in Liquid Xenon

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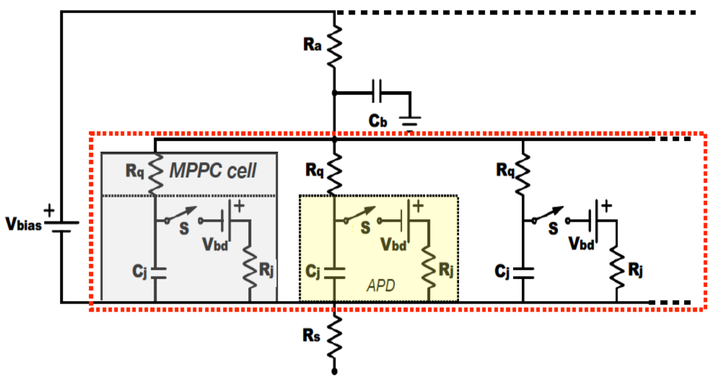
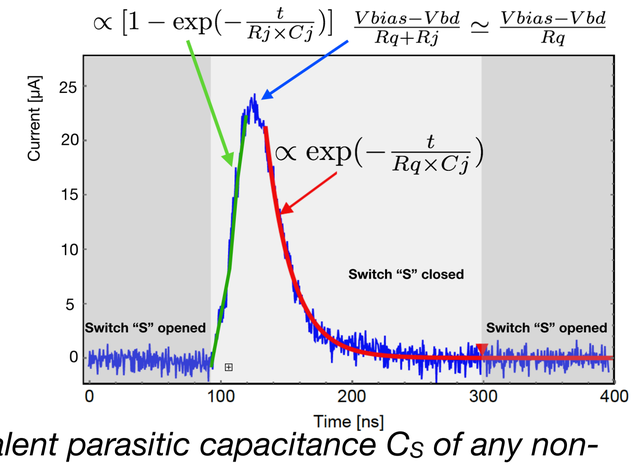
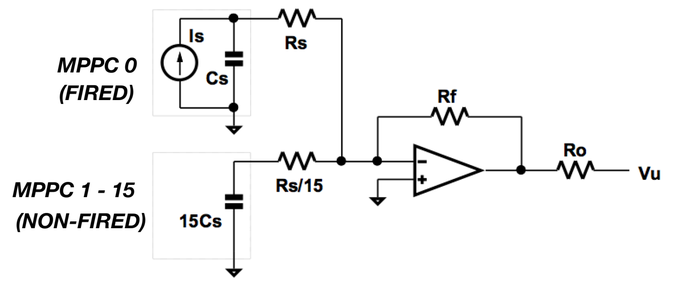
We present the performances and characterization of the cryogenic readout for an array made of S13370-3050CN (VUV4 generation) Multi-Pixel Photon Counters (MPPC) operated at liquid xenon conditions. The electronics is designed to readout a maximum 64 individual VUV4 photosensors and it is based on the Analog Devices AD8011 current feedback operational amplifier. The AD8011 has been also selected for the realization of a preamplifier embedded onto a voltage divider base for the operation of Hamamatsu R11410 photo multiplier tubes. Results from the radio-purity screening of the AD8011 are also reported.

The circuit has been designed to mitigate the nuisance contributions of non-fired MPPCs to the analog signal sum of the entire array.







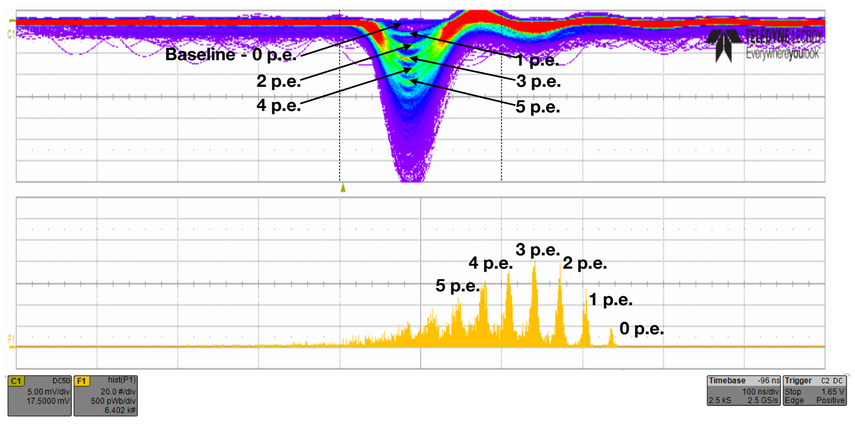
The resistor R_S is used to decouple the MPPC equivalent parasitic capacitance C_S of any non-fired photosensor from the operational amplifier.

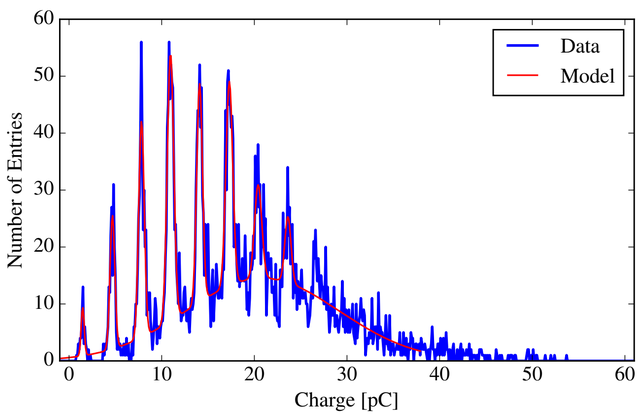
Model of a 16-channel array being exposed to a single photon. The signal is represented by I_S connected in parallel with C_S towards ground. All the quenching resistors are connected in parallel: the equivalent resistance << R_S.

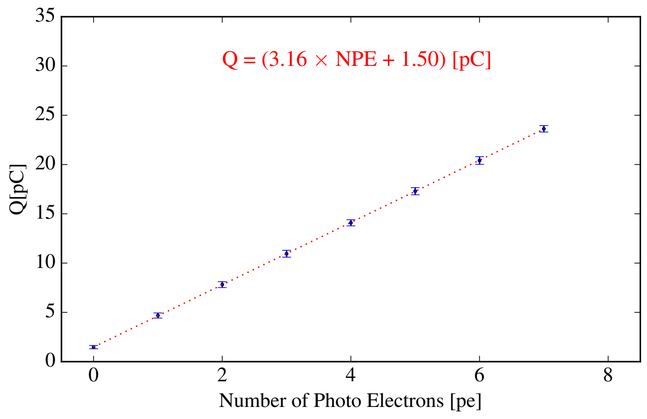
4x4 VUV4 array operated at LXe conditions

*Single Photon Counting capability assessment for 16 individual photosensors (~1.44 cm² of sensitive area) operated as single channel (**F. Arneodo et Al., NIM A (2018) Vol. 893, 117-123**).*

- *Low intensity pulsed UV Led*
- *DAQ through Lecroy HDO6104.*
- *Gain ~ 2 x 10^7 @ (3 V OVV, 175 K)*
- *NO hardware filter*
- *No Y-axis increased resolution*
- *NO offline filter*
- *Infinite persistance mode.*







- *8 gaussian functions used to fit the charge distribution*
- *The charge of the 1 p.e. is (3.21 ± 0.26) pC*
- *The overall charge noise (pedestal) is (1.47 ± 0.16) pC*

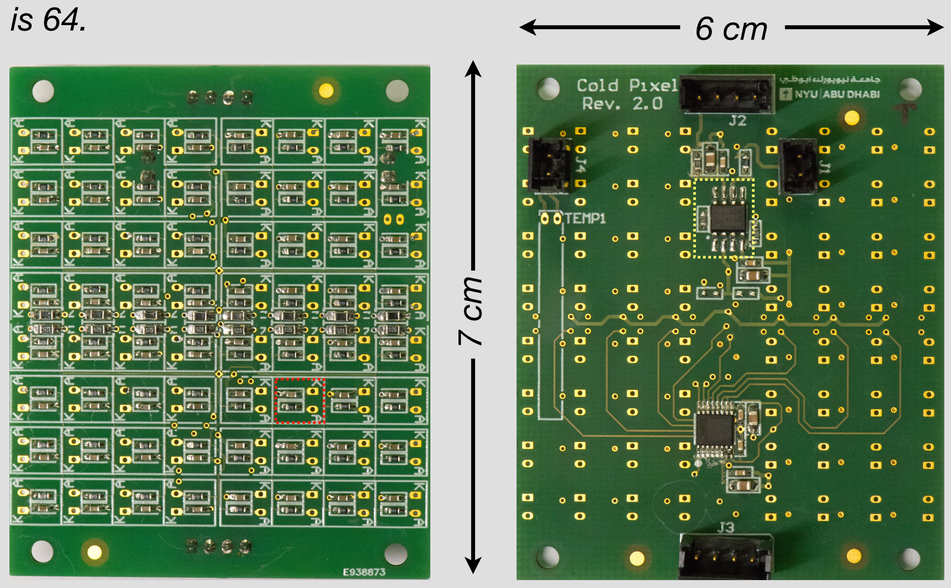
AD8011 Radio-Purity screening

Radio Nuclide	Activity [mBq/kg]	Concentration [10^{-9}g/g]	Activity [μBq/pc]	Activity SMD* [mBq/kg]
Ra-228	<39	<9.6	< 2.9	280+-40
Th-228	(60 ± 20)	(15 ± 4)	(5 ± 1)	290+-30
Ra-226	(50 ± 20)	(4 ± 2)	(4 ± 1)	810+-40
Th-234	(1.0 ±0.5)X10^3	(80 ± 40)	(70 ± 40)	(4.9 ±0.7)X10^3
Pa-234m	<1,400	<110	< 100	(4.1 ±1.1)X10^4
U-235	<50	<88	< 3.7	240+-80
K-40	<700	<2.3 X 10^4	< 51	(1.2 ±0.2)X10^3
Cs-137	<3.3	-	< 0.24	<7.4
Co-60	<3.4	-	< 2.5	<5.8

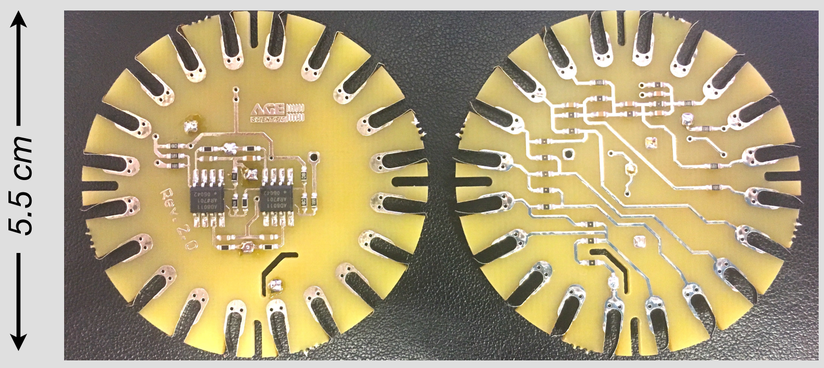
*SMD RESISTOR RMCF0805JT15M0

AD8011 based electronics

The cryogenic electronics for the readout of a VUV4 based array. The maximum allowed number of individual photosensor is 64.



The dashed red box indicates the socket for the positioning of a VUV4 sensor. The dashed yellow box, the AD8011.



- *~ 80 MHz Bandwidth for typical signal with <4 ns rise time*
- *IN/OUT impedance 50 Ohm*
- *2X AD8011 operational amplifiers (± 5V, can be "unbalanced" to match the dynamics)*
- *Low Noise (< 200 μV RMS @ 5X amplification)*
- *Designed for 0.5 X & (5 X to 15 X) dedicated outputs*
- *Power consumption: Min 6 mW, Max 20 mW (amplification unaffected, only dynamic range involved)*