

# Response of avalanche photodiode to alpha particles, fast neutrons, low energy gammas and electrons.

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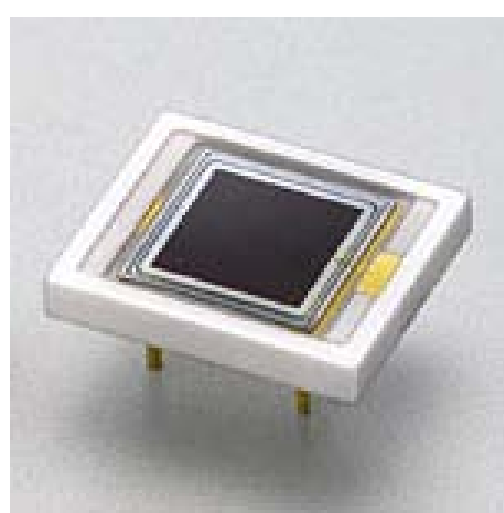
(Fermilab, USA)

\*On leave from INR, Moscow, Russia

E. Auffray, P. Lecoq

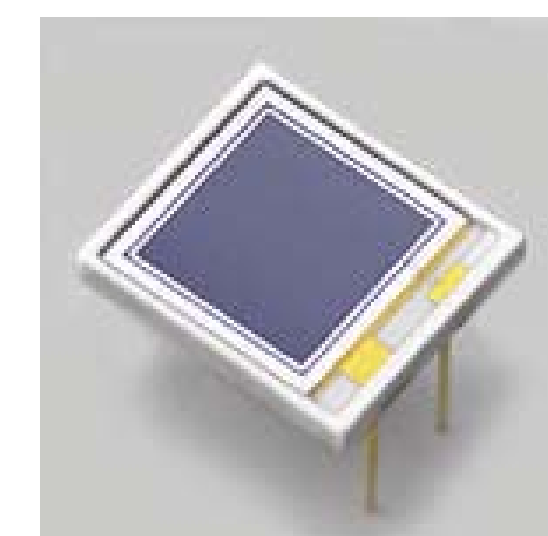
(CERN)

## Hamamatsu S8148 APD



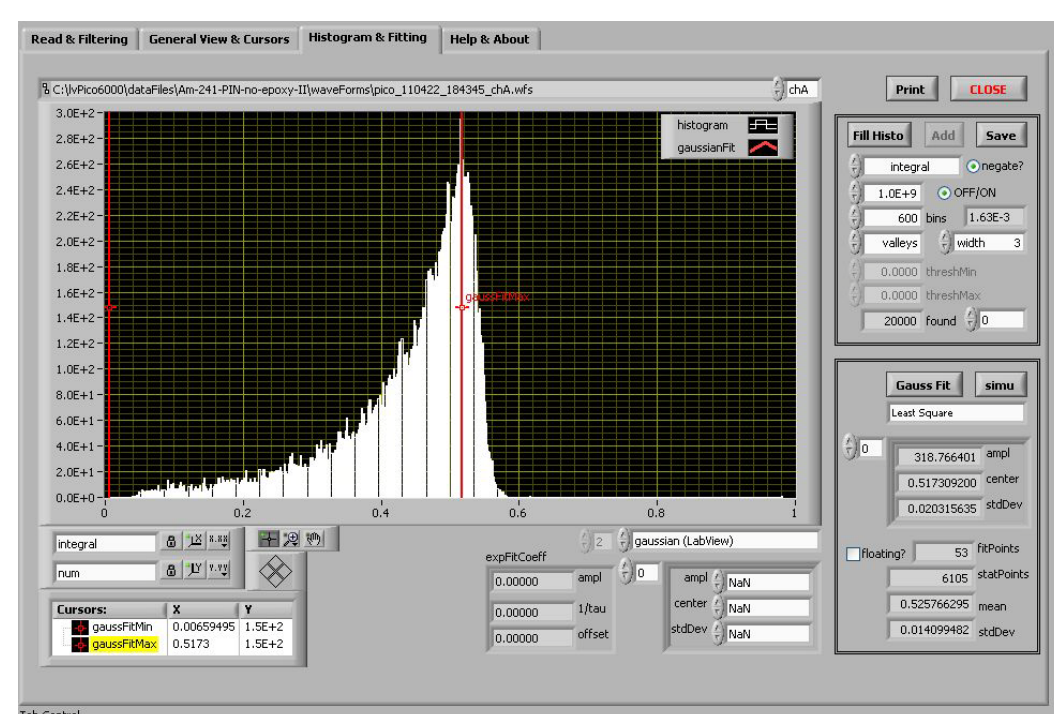
- 5x5 mm<sup>2</sup> sensitive area
- V<sub>op</sub>(M=50) = 381 V (T=22 C), C=80 pF
- Depletion layer thickness: 50 μm

## Hamamatsu PIN photodiode S3590-08

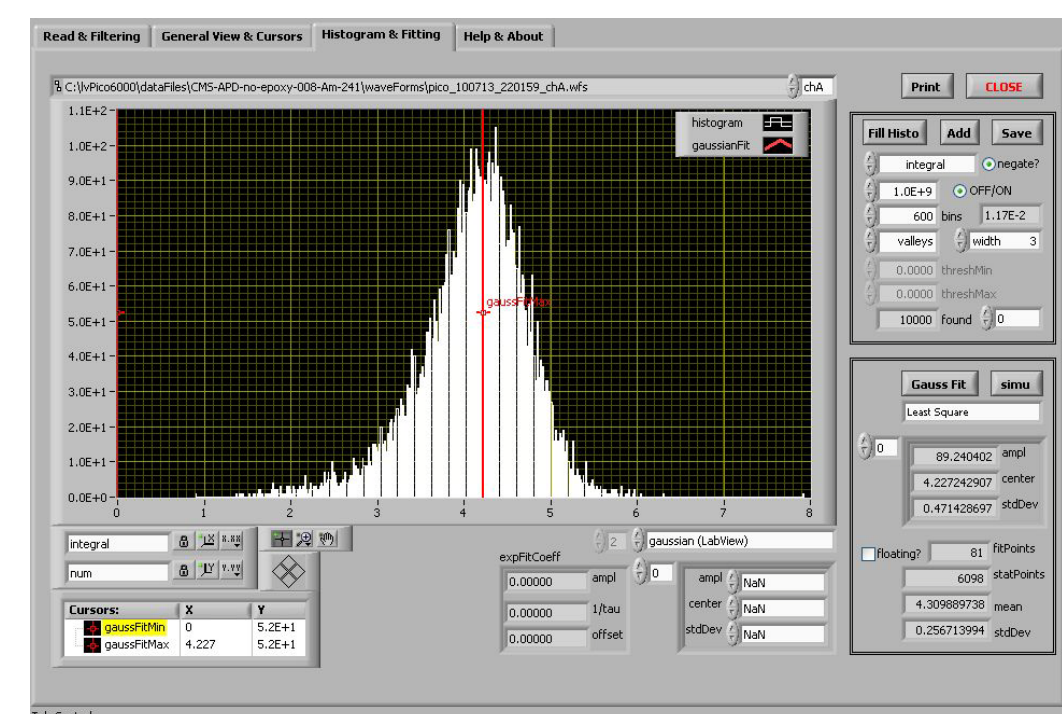


- 10x10 mm<sup>2</sup> sensitive area
- U<sub>dep</sub>=70 V, C=40 pF
- Depletion layer thickness: 300 μm

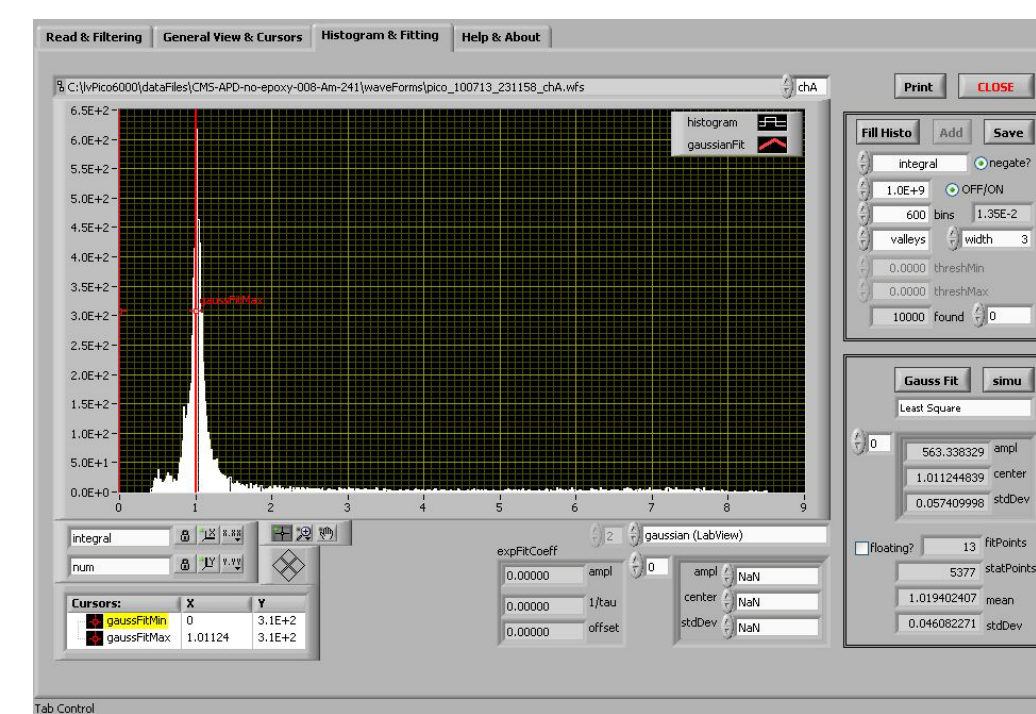
## Alphas (Am-241 source, E<sub>α</sub>~5.5 MeV)



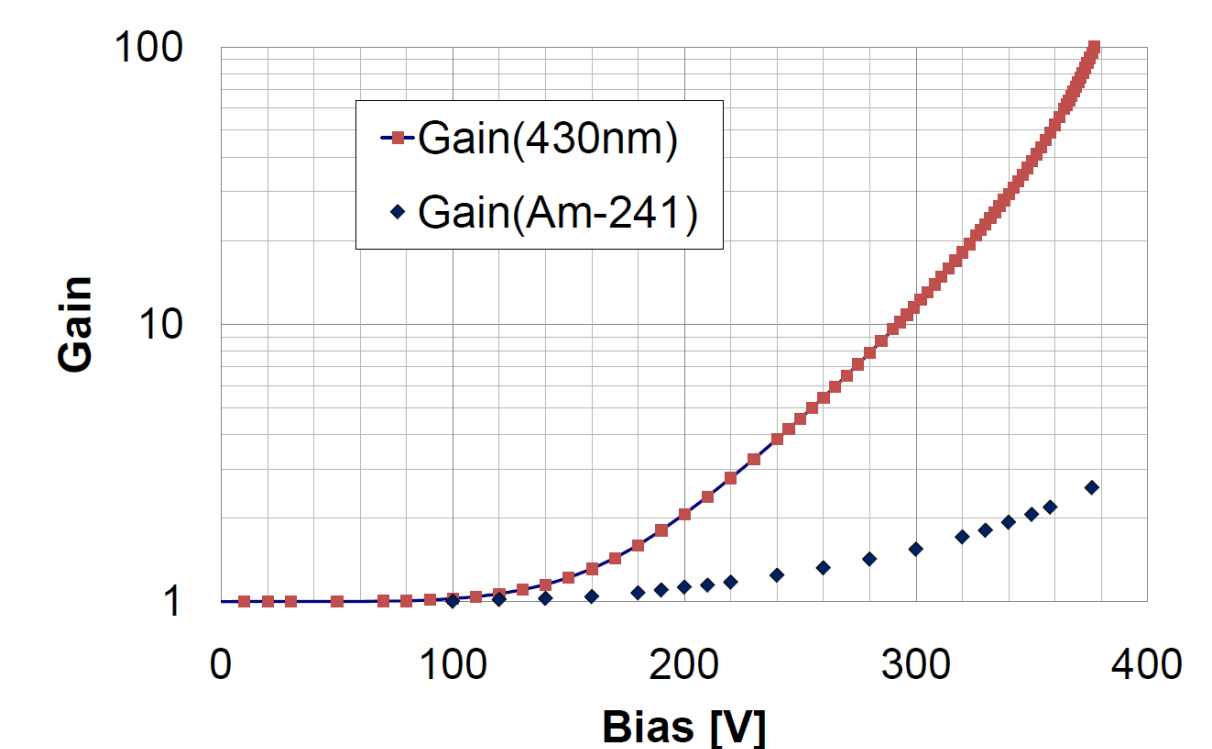
PIN amplitude spectrum (Am-241, E<sub>α</sub>=5.5 MeV, U=70 V, G<sub>a</sub>=57)



APD amplitude spectrum (Am-241, E<sub>α</sub>=5.5 MeV, U=70 V, G<sub>a</sub>=500)

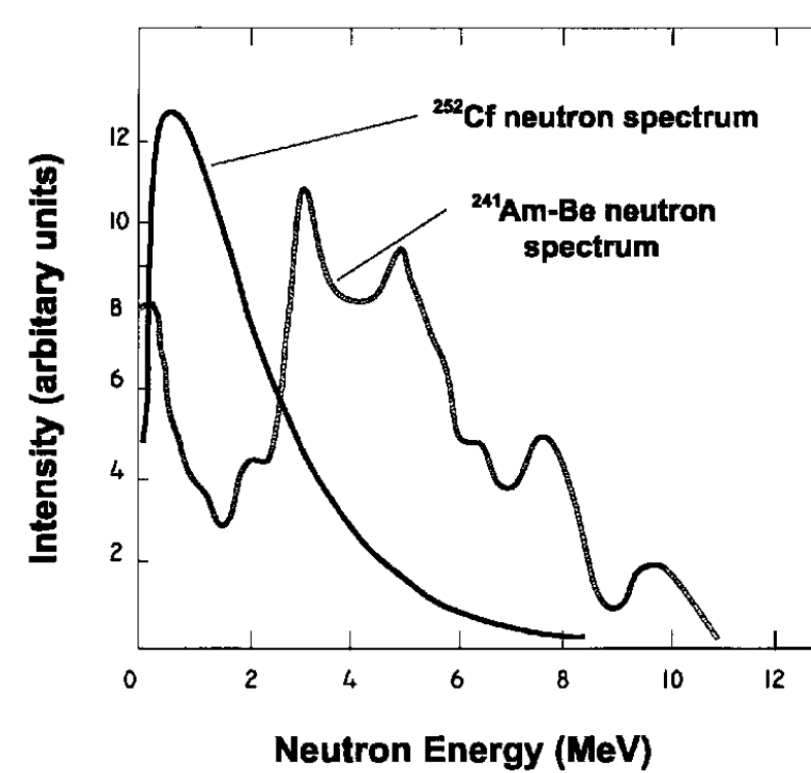


APD amplitude spectrum (Am-241, E<sub>α</sub>=5.5 MeV, U=381 V, G<sub>a</sub>=57)

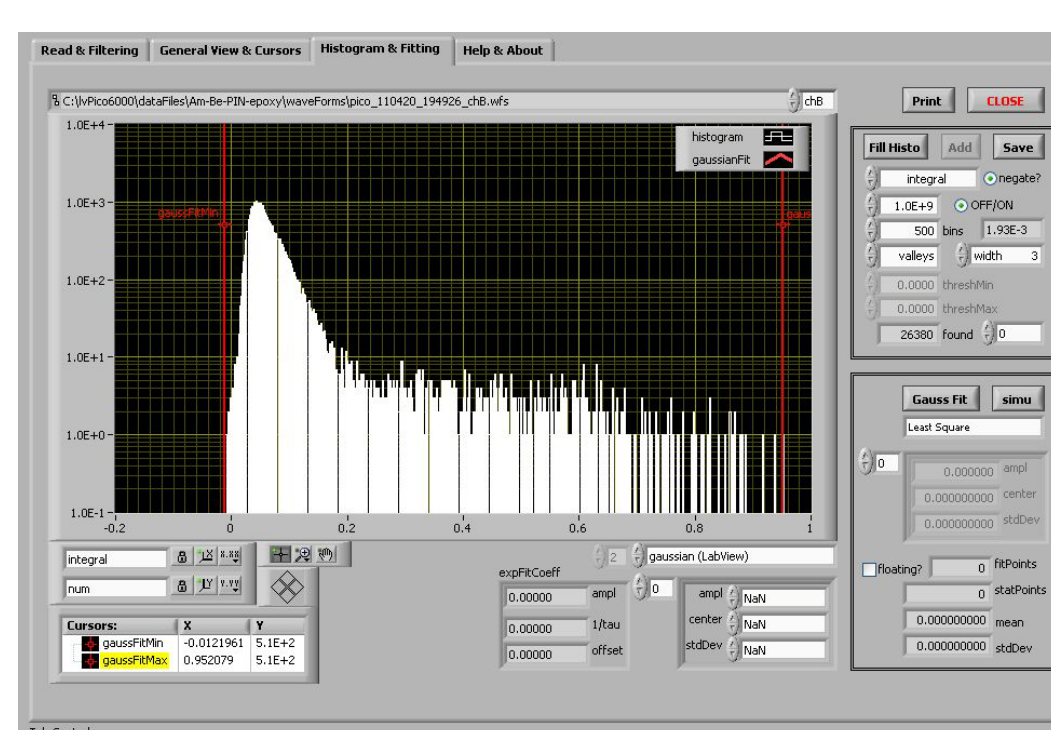


APD gain measured with light and alphas (Am-241, E<sub>α</sub>=5.5 MeV)

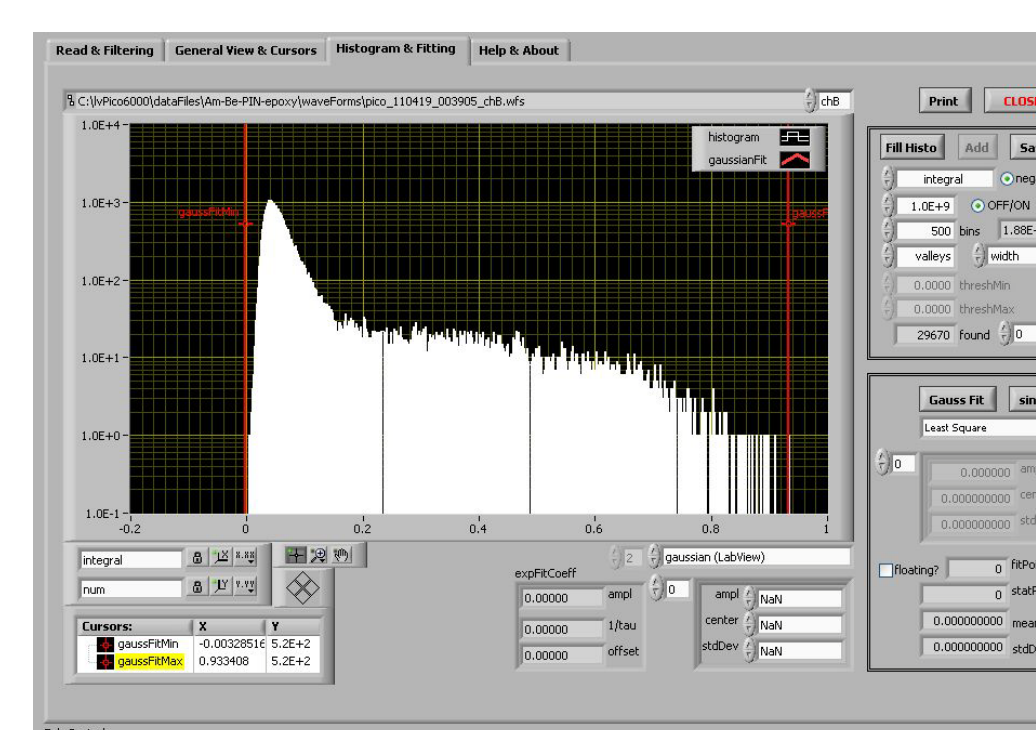
## Neutrons (Am-Be source)



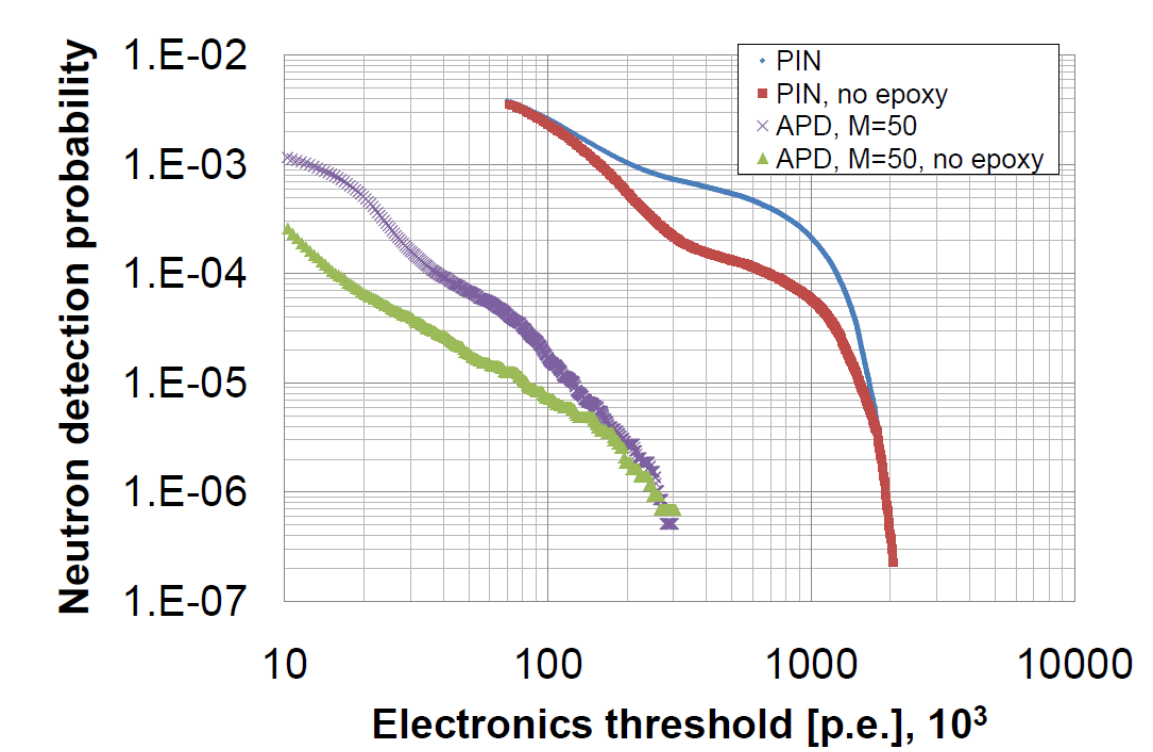
Neutron energy spectra for Am-Be and Cf-252 sources



Amplitude spectrum, Am-Be source, PIN without epoxy, G<sub>a</sub>=57, U=70 V, 2 mV threshold

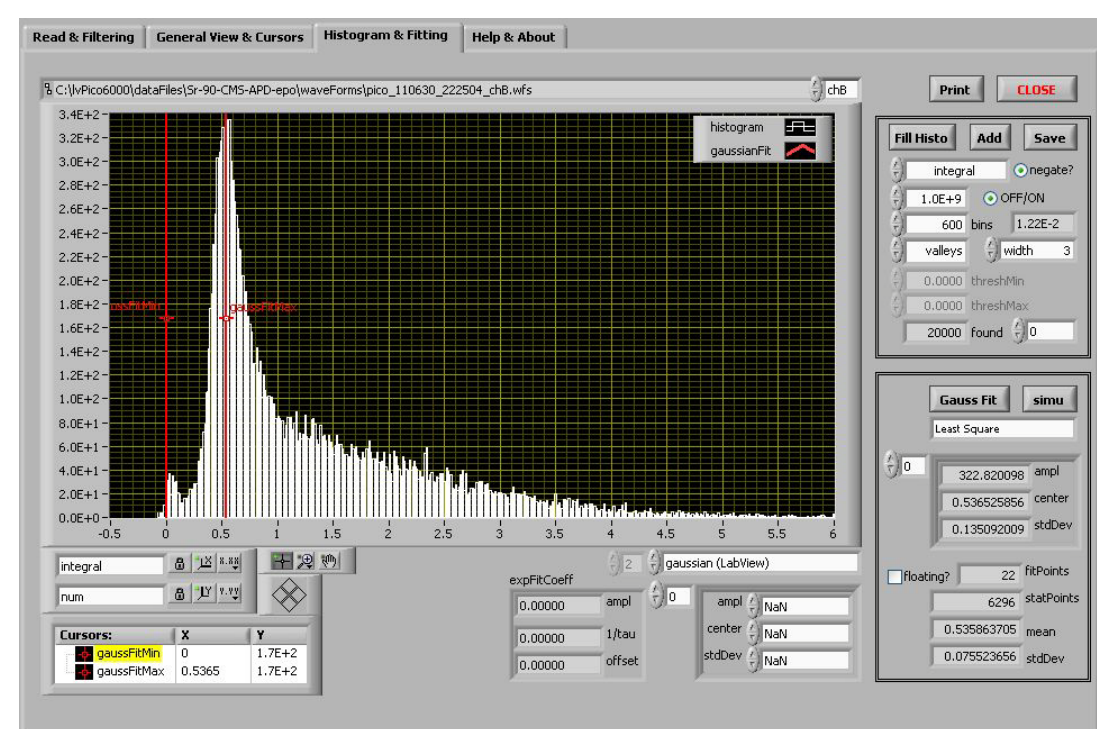


Amplitude spectrum, Am-Be source, PIN with epoxy, U=70 V, G<sub>a</sub>=57, 2 mV threshold

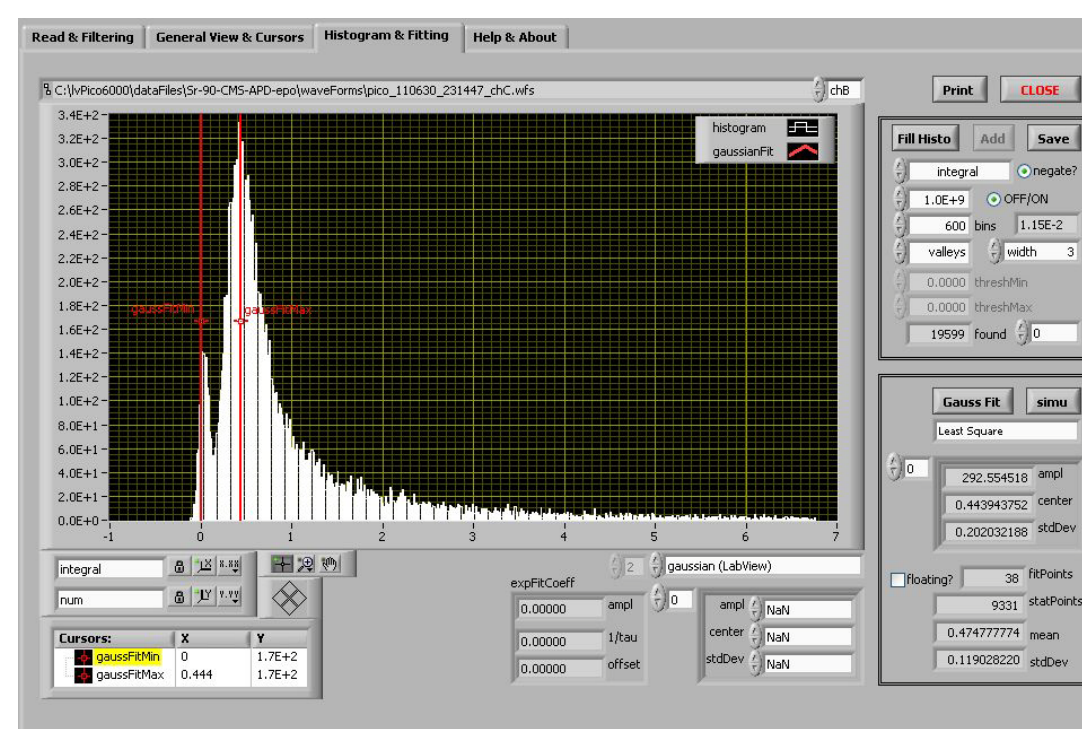


Neutron detection probability vs. electronics threshold for APD and PIN photodiode (Am-Be source)

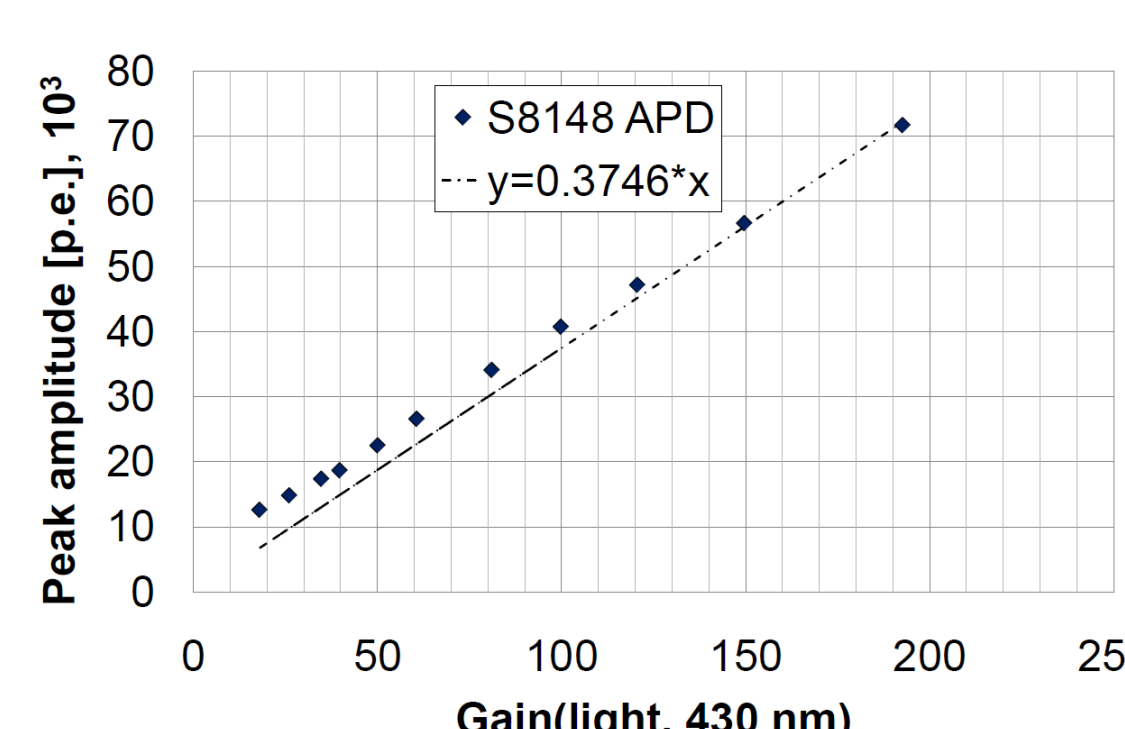
## Electrons (Sr-90 source, E<sub>max</sub>=2.38 MeV)



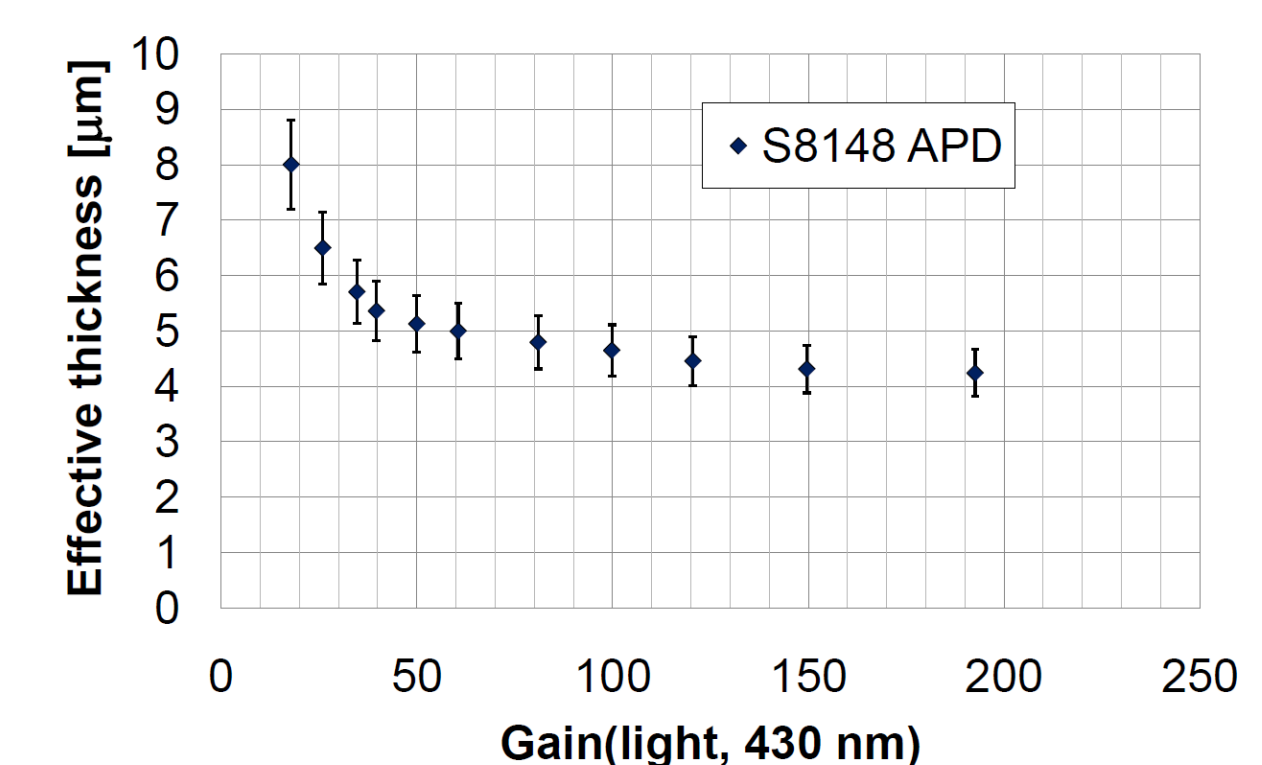
Amplitude spectrum, PIN, U=70 V, G<sub>a</sub>=2500



Amplitude spectrum, APD, M<sub>APD</sub>=50, G<sub>a</sub>=2500

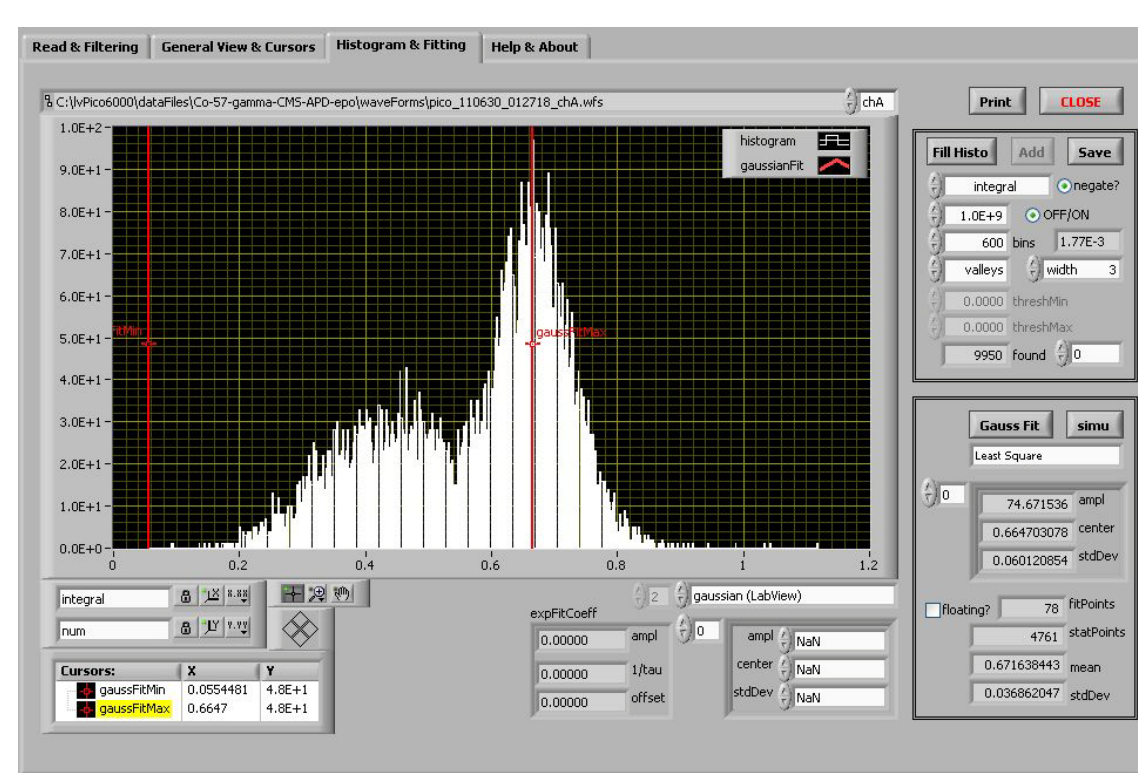


Sr-90 peak amplitude vs. APD gain

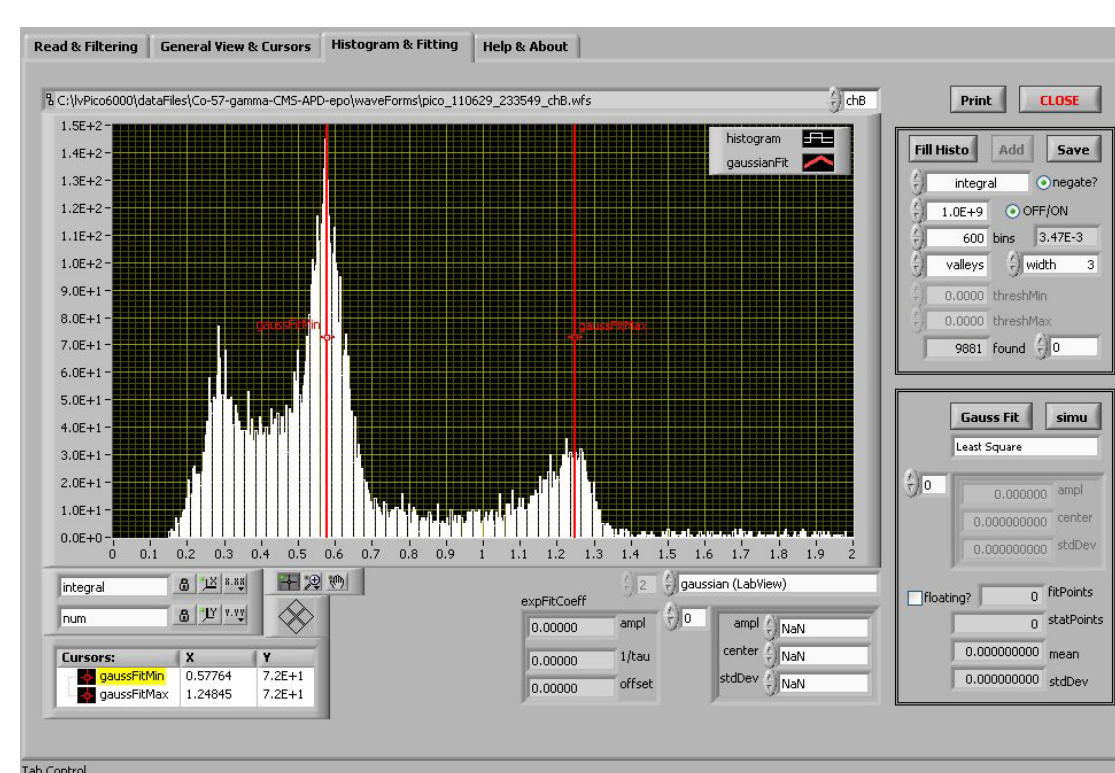


S8148 APD "effective thickness" vs. gain

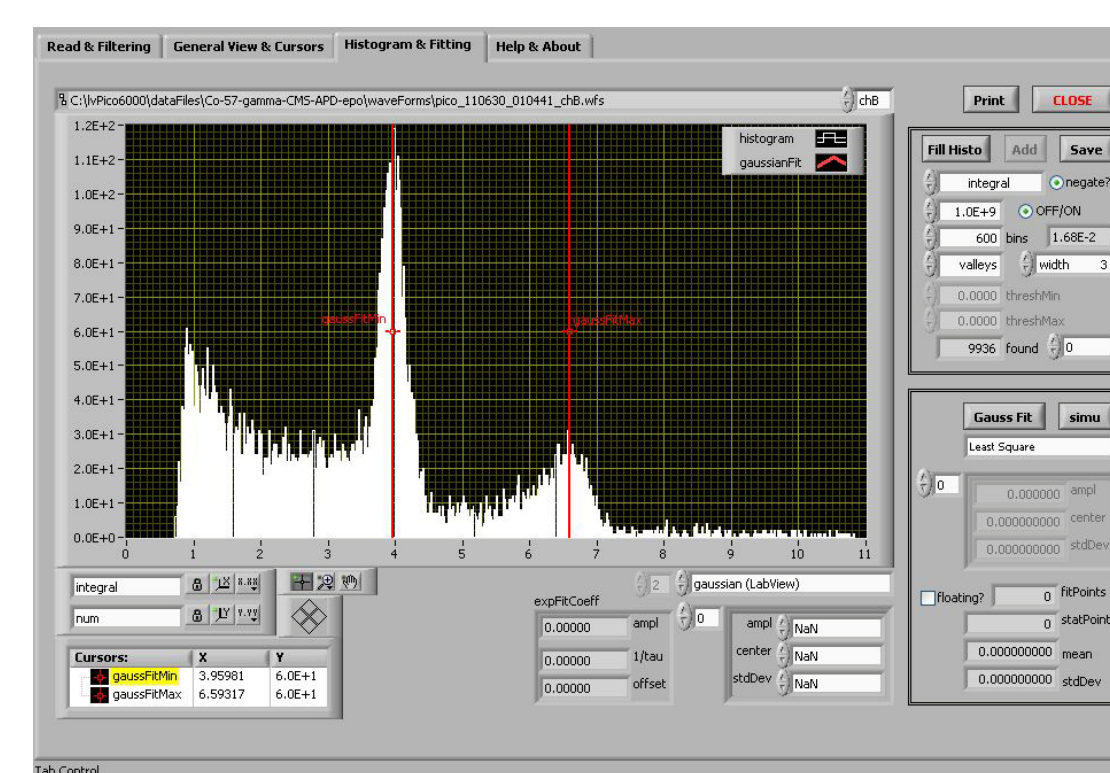
## Gammas (Co-57 source, E<sub>γ</sub>=6.4, 14.41, 122.06 keV)



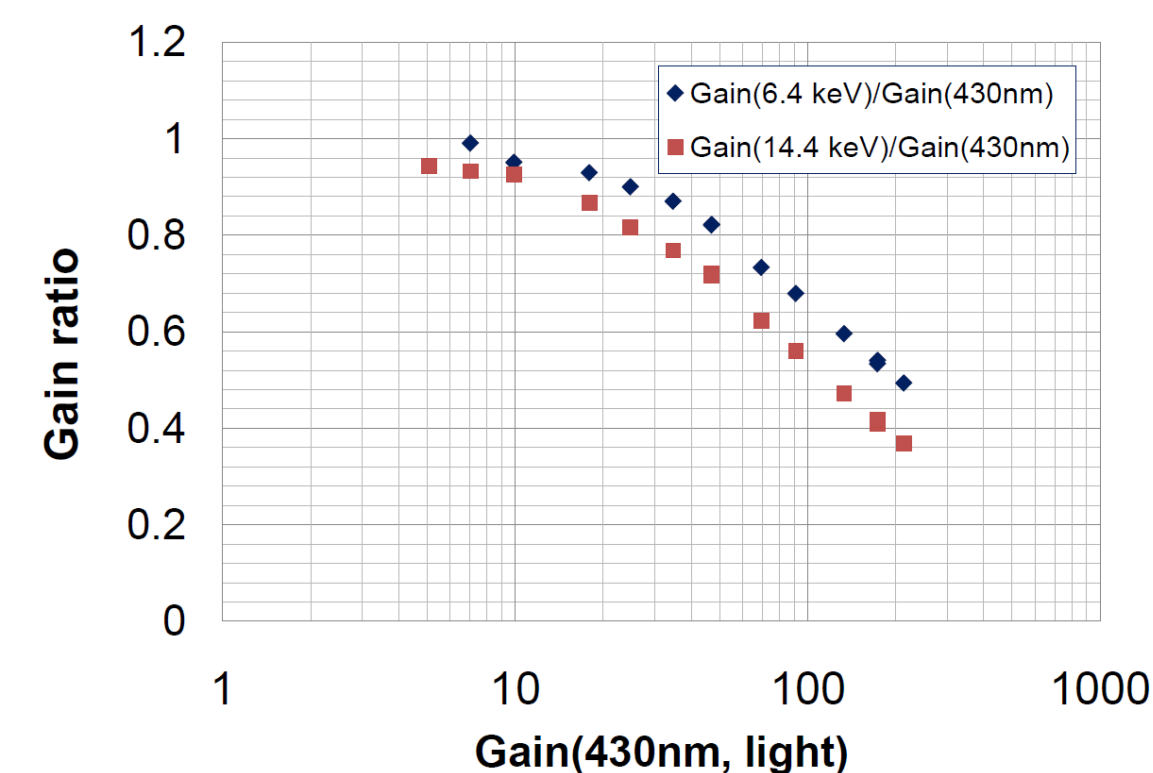
Amplitude spectrum, PIN, (G<sub>a</sub>=2500, E<sub>γ</sub>=122.06 keV)



Amplitude spectrum, APD, M<sub>APD</sub>=18 (G<sub>a</sub>=2500, E<sub>γ</sub>=6.4, 14.41 keV)



Amplitude spectrum, APD, M<sub>APD</sub>=242, (G<sub>a</sub>=2500, E<sub>γ</sub>=6.4, 14.41 keV)



Gain(gammas)/Gain(light) ratio measured with Co-57 source (E<sub>γ</sub>=6.4, 14.41 keV) vs. APD gain

## Summary

The response of the S8148 APD and S3590-08 PIN photodiode from Hamamatsu Photonics to alpha particles, fast neutrons, gammas and electrons was studied using Am-241, Am-Be and Sr-90 radioactive sources. The amplitude spectra were measured in a wide range of APDs' gain (10-200). Attenuation of the APD gain was found for low energy gammas and alpha particles. The effect was found to be stronger for higher APD gain. It was also found that some of alpha particles and neutrons produced anomalously large signals in the APD. The neutron signal rate significantly increased when the APD and PIN photodiode windows were protected with an epoxy layer. The probability that neutrons cause detectable signals in the APD and PIN photodiode was measured in dependence on the electronics threshold.