Bridging the Price/Performance Gap Between Silicon Drift and Silicon PIN Diode Detectors

at booth #204

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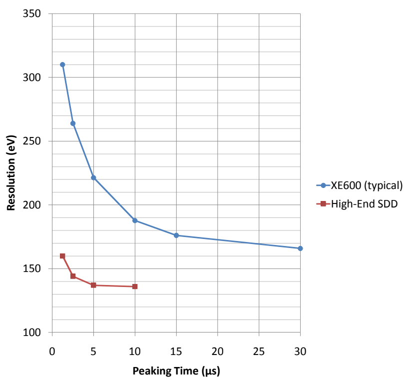
High End SDD vs. Moxtek XE600 PIN Diode Detector

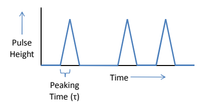


The XE600 detector uses a 400 µm PIN diode. The resolution is measured at 5.9 keV. All measurements are made at -25°C.

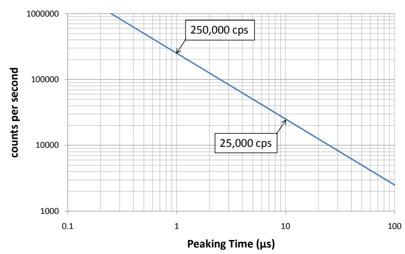
The **SDD** has much **better resolution** performance, but it also has about **3 times the cost** of a PIN diode detector.

Count Rate verses Peaking Time

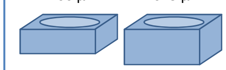
When the signal from an x-ray photon passes through a shaping amplifier, it is converted into a voltage pulse with a given shape (commonly a triangular shape). A stream of detected photons results in in a series of peaks—each peak representing a detected photon (or "count"). The peaking time (τ) is the time between the beginning of the voltage pulse and its peak. ***Shorter peaking times*** make it possible to collect ***more counts in a given amount of time***.



$$\text{Count Rate} \approx \frac{1}{2\tau}\left(\frac{\text{Live time}}{\text{Real time}}\right)$$



Reducing Diode Capacitance



$$\text{Anode-to-Backside Capacitance} = \varepsilon\,\frac{\text{Area}}{\text{Thickness}}$$

A 6 mm² diode:

- 400 µm: 1.6 pF
- 625 µm: 1.0 pF
- 875 µm: 0.7 pF

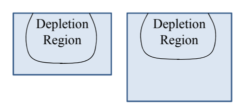
Thicker Diode → Less Capacitance

→ Better Resolution

Depletion Region:

$$\text{Depletion Thickness} = \sqrt{\frac{2\varepsilon V_{bias}}{q N_d}}$$

Thicker Depletion Region → Less Capacitance



A Thicker Depletion Region Requires Either:

1. Larger V_{bias}
2. Smaller N_d (Higher Resistivity)

Additional Challenge:

Leakage Current ∝ Depleted Volume

Solutions:

1. Very Low Leakage Current Process
2. Lower operating temperature

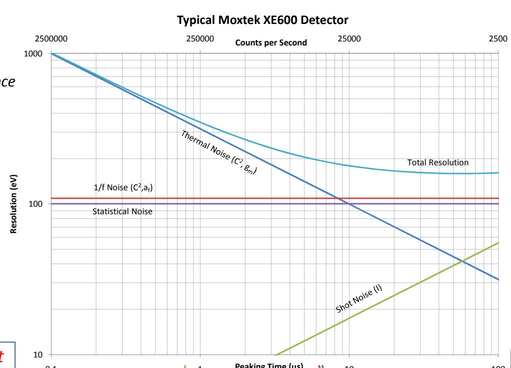
Resolution Components

C: Total Capacitance

g_m: JFET Transconductance

a_f: 1/f Noise Coefficient

I: Leakage Current

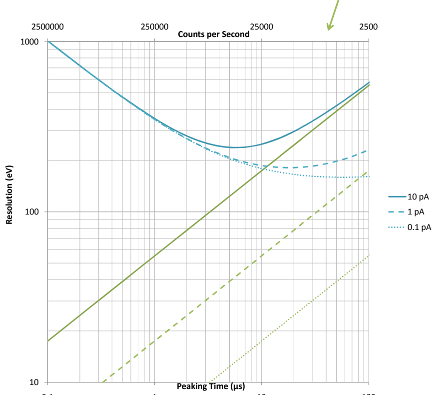


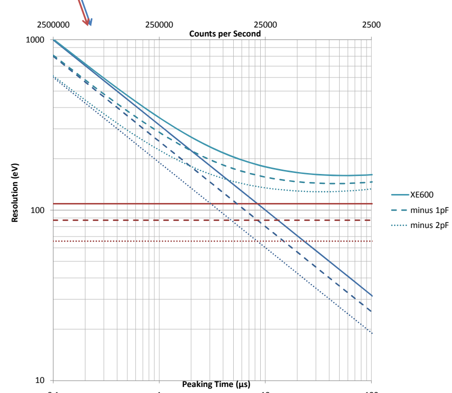
Lower leakage current
→Better Resolution at
***Longer** Peaking Times*

Leakage Current

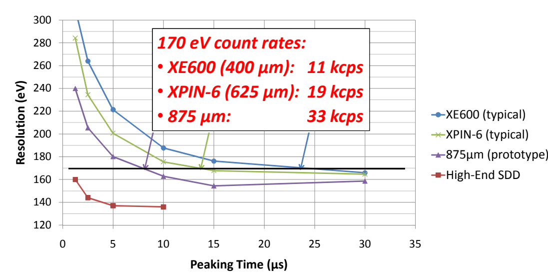
Capacitance

Lower Capacitance
→ Better Resolution at
***Shorter** Peaking Times*





Resolution Measurements

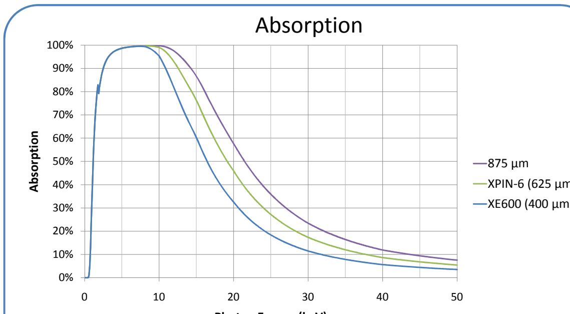


XPIN-6 measurements are made at -25°C and with a diode bias of 130 V.

Measurements with the prototype 875-µm detector were made at -45°C and with a diode bias of 300 V.

Achieving 875-µm performance comparable to what is shown here with lower biases and higher operating temperatures are challenges to be resolved.

Absorption



Above about 25 keV, absorption is proportional to thickness for these thicknesses, so an ***875 µm diode*** has more than ***twice the absorption*** as the 400 µm-thick ***XE600***.