Subject: The Proportional Probe

RE: Conventions used:
Gammas and X-Rays are both electromagnetic radiation and are identical except for their origin. If the photon come from the nucleus it is called a gamma, if it comes from the electron shell area it is called an X-Ray. Other types of photons such as Bremsstrahlung and Annihilation have other genesis mechanisms. Since in this report we are first and foremost interested in the energy of the photon, not it's origin, we call them all 'photons' for simplicity. Be aware that once the energy is calculated, the true nature may then be surmised, then proper name applied to that photon.

Some fusioneers are doing neutron activation experiments, the proof of which involves gamma spectroscopy.

I thought I would share my recent efforts in 2-50 keV low energy detection/identification.

Most of us use NaI(Tl) scintillation detectors for energy studies, those are effective for mid to higher energies (50keV - 3 MeV)
A a typical NaI(Tl) is blind to the low energy realm not because of the crystal's ability to respond, but because the crystal is fragile and hygroscopic so must be enclosed in a robust housing to protect it. This robustness of housing material introduces enough mass between the source and crystal to block the lowest energy spectrum.
Response of NaI(Tl) is highly dependant on energy, and not in a linear fashion.This phenomena is well studied and all commercial probes have charts available delineating the response at different energies. In the present application, the interest is identifying the energy, not necessarily quantifying it.

A typical stainless steel enclosure is good to only around >30 keV, while an aluminum housing can see down to about 10-20 keV. Beryllium can pass 2-3 keV easily, depending on the thickness of the window.

Certain experiments involve the photon spectrum well below 20 keV, so special housings and detectors are in order.

Types of commercial, readily available detectors:

LEG or Low Energy Gamma scintillation probes are indeed made with thin entrance windows, which can pass the required spectrum. Generally these are made of thin section NaI(Tl), so thin it has little or no response to energies above about 100 keV at all. Typical dimensions are 1 or 2 inches diameter and 1 or 2 mm thick.
Special versions are available called FIDLERs to 5 inches diameter. Window material varies according to price, with beryllium the preferred but most costly. Such very low Z and thin windows are sometimes protected with a layer of Kapton for strength.

Some examples are;
Ludlum 44-3. 1" X 1 mm 10-50 keV
Ludlum 44-17 2" X 2 mm 10-200 keV

Thermo G5 FIDLER (Field Instrument for Detection of Low Energy Radiation) 5" X 1.6 mm >10 keV

Bicron 1XM.040BP-X / a.k.a. Canberra Model 1701 1" X 1mm, Be windowed, integral collimator slit. 3-100 keV for Be window, 10-100 keV for aluminum window versions.

Typical applications for thin section NaI(Tl) probes are EDS (Energy Dispersive X-Ray Spectroscopy), XRF (X-Ray Fluorescent spectroscopy) and detection of the presence of plutonium (17 keV L X-Ray et. al.), I-125 (27-35 keV), and Am-241 (4 to 59.5 keV).

Many varieties and brands of these have been tested at the Home Lab and by and large I do not get an adequate spectrum from them. Detection yes, good spectrum no. The ideal thickness for obtaining a good resolution LE spectrum appears to be about 3-4 mm. I made such a probe based upon the surplus DT-590A probe with very good results.

One advantage to exploring the very low energy realm is that little or no shielding is needed over the probe. 1/4" is fine for the thicker of the sodium iodide probes mentioned, while the thinner ones don't really benefit from any shielding at all.

The Gas Filled Proportional Counter:

Proportional counters are a different beast entirely. Labs use them routinely to make extraordinarily low energy, high resolution measurements. In that application, gas-flow devices are employed, requiring a tank of pressurized "nuclear counting gas" be available, often the P-10 variety containing 90% Argon and 10% Methane.

Most of these employ true gas-flow, in which a continuous stream of gas is fed through the probe. A few allow the probe to be initially pressurized, then used for a period of time without further gas added. The main application is for beta-gamma detection and discrimination, not something commonly needed in the Home Lab, at least to this extent. There are a few air-proportional probes that work with regular atmospheric air, but this air must be dehumidified, and the HV adjusted per the altitude of use.

While this may be within in the reach of the serious Home Lab experimenter, the complexity and cost make these proportional type systems prohibitive for the student.

Still, there are significant advantages to proportional detectors, mostly in the gamma energy detection and IDENTIFICATION capabilities, down at the extreme low end.
So we have decided to concentrate on permanently sealed, heavy gas filled proportional probes with beryllium windows. Their high initial cost is offset by the extremely efficient and above all, SIMPLE implementation.

Typical examples are the LND models 45419 (Xenon filled) and 45431 (Krypton filled) and 45152 (Neon/Argon filled), all with beryllium side windows.

The instrument for this test is a older model RSG-30A, Xenon filled, side beryllium window with an aluminum end window as well. The side window if preferred for ultra low energy studies as it allows entrance of the lowest energy photon , and selectively applies them to only the mid portion of the anode wire, the so called "sweet spot".
While the modern equivalent LND probes will work at least as well, their $1000+ price tag is not as attractive as the $50 surplus price for the RSG-30A.

As member here are aware from their He3 proportional neutron detector work, all proportional tubes work in the "proportional region" of the gas ionization curve,
with gas fill/pressure combinations requiring generally much higher HV than a typical GM tube. At the same time the recovered pulse is of a much lower Voltage peak than a GM tube, requiring the metering unit to be able to provide up to 2500V DC and to respond to 1 to 2 mV pulses.

For LE gamma work we want a fill gas to be as dense as possible, in order to optimize the chance of interaction with the weak photons, hence the choice of Xenon fill.

Most if not all instruments will require an external preamp to gather the low Voltage pulses to amplify them for application to the MCA or rate meter. Since we are using the SPECTECH UCS-20 as our MCA, the matching SPECTECH PA-1 preamplifier (slightly modified was chosen.

NIM users have a broad range of suitable preamps available to match their existing systems.

My application is twofold. First is the examine the incredibly low energy X-Rays given off by stable elements when they are excited by an external energy (X-Rays or electron beams). This <20 keV capability allows examination of the L and M shell X-rays, which are very much lower energy than the K shell X-Rays I've been using.

Secondly, a sort of take of of the above reason, is to examine naturally occurring L and M X-Rays emitted by the daughter products of radioactive elements.

The first such test was on Am-241, an examination of the Np L and M shell X-Rays.

The attached scan shows the result with my notes as to the presumed sources and energies of the photons detected. The unlabeled peak at 8.5 keV has not yet been identified.

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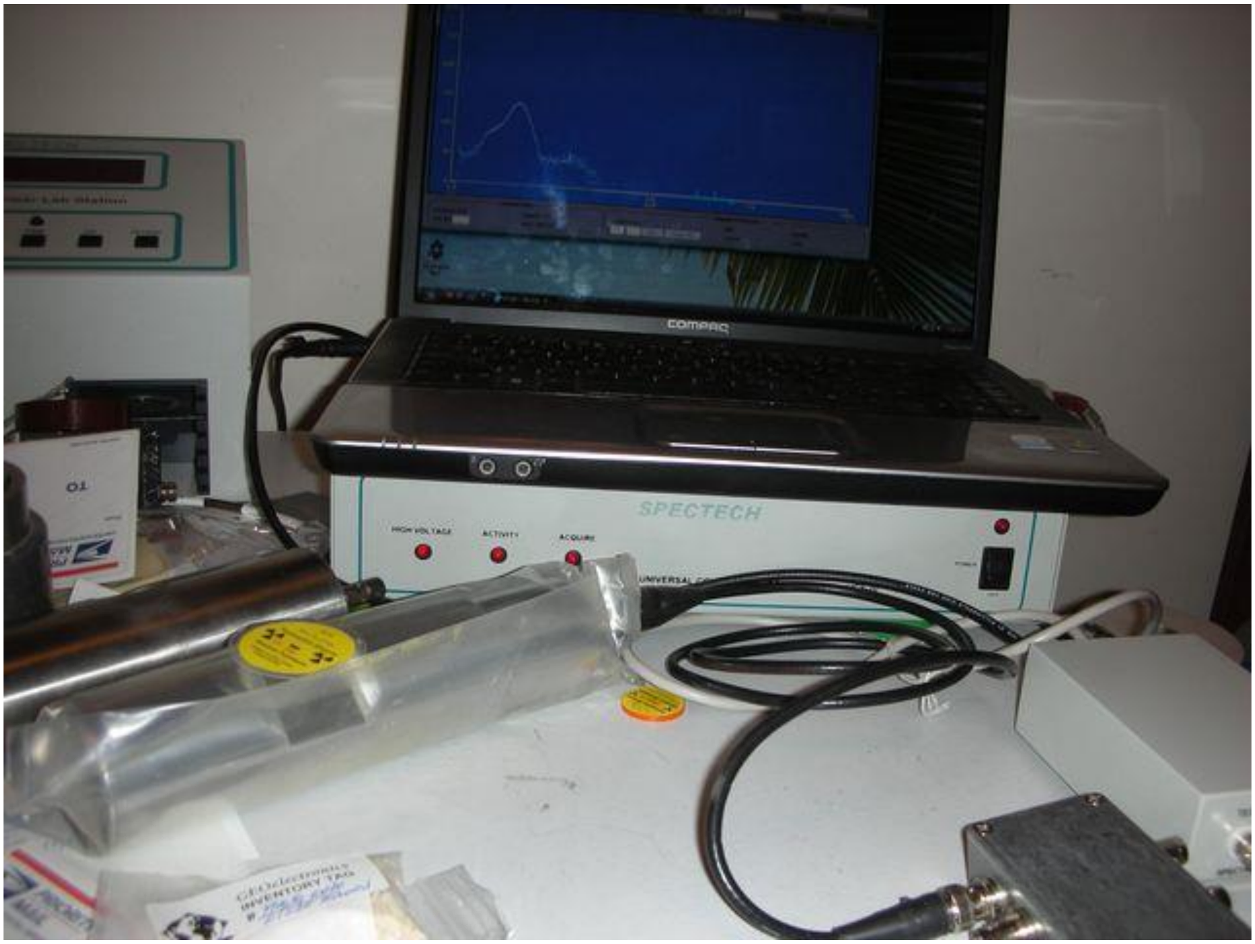
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