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Application Note AN-0108-1

Crosstalk and Simultaneous Alpha/Beta Counting

Subtitle: Why are there beta counts in my alpha source?

Even experienced users of *sensitive* low level alpha/beta counters are sometimes surprised when they count an "alpha source" and also find beta counts in their results. Remember the emphasis on the word *sensitive*. But is your "alpha source" really an "alpha only source"? The purpose for this application note is to answer this question and others related to the topic of crosstalk.

The unexpected beta counts encountered with the alpha source are referred to as alpha-to-beta crosstalk or spill-over. A similar phenomenon may be observed using a "beta source" where alpha counts appear when only betas are expected. The latter is referred to as beta-to-alpha crosstalk or spill-over. Henceforth, for the sake of brevity, we will simply call this parameter crosstalk recognizing that it is sometimes called spill-over.

Is alpha-to-beta crosstalk from an alpha source really unexpected? It is if you have never used a counter sensitive enough to detect a broad energy range of betas, AND simultaneously detect alpha particles, AND categorize them correctly. To explain this we start with a clearer definition of crosstalk.

Crosstalk Defined

As it is currently used in alpha/ beta counting applications the term crosstalk is both inappropriate and confusing. In its strictest definition and broadest context it implies an unwanted or unnatural interference. For example, everyone knows that communications crosstalk is unwanted noise. However, in the context of alpha/beta counting the phenomena may be unwanted, but not all of it is unnatural as we shall see.

In the context of <u>simultaneous</u> alpha/beta counting, crosstalk is a hold-over from the early years of alpha/beta instrumentation development. The term became synonymous with the limitations of the instrument's ability to discriminate an alpha particle from a beta particle and thus an important instrument performance specification. The amount of (or percentage of) alpha particles *thought to be misidentified* as beta particles is the alpha-to-beta crosstalk and vice versa for beta-to-alpha crosstalk.

In this context crosstalk has two components – "naturally occurring" and "instrument induced" – that combine to make up the respective total. The origins of these two components are quite different. Unfortunately these two components have become lumped together and treated as a single value. One possible reason is because they cannot be measured separately except under very controlled conditions.

An instrument manufacturer strives to measure and specify only the "instrument induced" crosstalk component and any "naturally occurring" component interferes with this measurement. To the user trying to determine the respective alpha and beta activity in his sample, all crosstalk is considered interference but the "instrument induced" component is the least predictable. In either case here is what you should know about crosstalk.

The "naturally occurring" component is due to the nuclear and atomic processes. These are determined by physical laws and vary by the radionuclide. In most alpha emitting radionuclides this component of the alpha-to-beta crosstalk exists but the instrument may not be sensitive enough to detect it. The extent to which it is observed depends upon the sensitivity of the instrument to the particular type and energy of the "naturally occurring" radiation.

The "naturally occurring" crosstalk component is best explained by using specific examples. The examples that will follow refer to six radionuclides often used to test and/or calibrate alpha/beta counting instruments.

The "instrument induced" crosstalk is dependent upon a number of factors determined by the instrument's design including but not limited to the type and quality of the detector and the signal processing electronics. It is hard to discuss this topic without getting deep into detector theory but we will attempt to do so. The "instrument induced" crosstalk is the only crosstalk referred to on any manufacturer's specification sheet. Measuring "instrument induced" crosstalk requires a radioactive source that has either no "naturally occurring" component or one that has a very predictable value of this component – easier said than done.

A closer assessment of the crosstalk topic begins with the "naturally occurring" component and concludes with the "instrument induced" component. The first step is to review the processes that contribute to radioactive decay.

Radioactive Decay Fundamentals

Radioactive decay involves three processes – *nuclear* processes, *atomic* processes, and *spontaneous fission*. For discussions regarding Protean's instrumentation only the *nuclear* and *atomic* processes are of concern. The *nuclear* processes (i.e., changes of state releasing energy within the nucleus of an atom) are associated with the emission of alpha particles, beta particles, positrons, gamma rays, and internal conversion electrons – or, some combination thereof. The *atomic* processes occur when instabilities in the orbiting electrons (promptly following a *nuclear* decay) result in a secondary release of energy. *Atomic* processes are often accompanied by the emission of characteristic X-rays and/or Auger electrons.

There are an abundance of modern physics text books describing all of these processes in detail. Handbooks like the one referenced below include compilations of the decay schemes for the individual radioactive isotopes in terms of processes involved, type and energy of the emissions, and their relative intensities.[1]

The decay tables presented in the following paragraphs were copied from the handbook titled *Radioactive Decay Data Tables* compiled and written by David C. Kocher of the Oak Ridge National Laboratory. This handbook is available from the U.S. Department of Energy's Technical Information Center and we highly recommend it.

The header in each of the following data tables gives the title of the decay data set, the half-life, and the low-intensity cutoff limit for the separate listing of radiations in the table. In each of the tables the radiations are listed in the first column by type. The second and third columns provide the energy in keV and intensity in number per 100 decays of the parent, respectively. The last column gives the mean energy emitted per unit of cumulated activity in units of gram-rads/microcurie-hour. If this last column confuses you ignore it. For our purposes, only the first three columns are pertinent.

Radionuclides used to Test and Calibrate Instruments

The examples in the following sections discuss six sources (four alphas and two betas) often used to test and calibrate alpha/beta counting instruments. Sources are designated as alpha, beta, or gamma based upon their primary or most intense method of nuclear decay. **That does not mean that these sources emit only one type of radiation!** In fact the conservation laws dictate that a single type of radiation never occurs during a radioactive decay. The decay tables demonstrate this fact. To further complicate matters, the daughter products created from the decay of a parent radionuclide and present in the source often decays as well through its own unique scheme.

Why did we choose the six sources discussed below? Only two of these were chosen as the manufacturer's preferred sources – Po-210 for alpha testing and Sr/Y-90 for beta testing. We emphasize that these two sources are used for testing instrument performance but are not necessarily recommended for instrument calibration. For that we rely on the various agencies that produce specific analytical methods.

The analytical methods for determining levels of alpha and beta emitting radiation generally include the instrument calibration techniques which establish the calibrated conversion factors. These factors are used to turn raw numbers into useful results.[2] These techniques stipulate or recommend particular radionuclides pertinent to and representative of those expected in the unknown samples being analyzed. Three such radionuclides frequently recommended for alpha calibrations are Am-241, Th-230 and Pu-239. Two radionuclides frequently recommended for beta calibrations are Sr/Y-90 and Cs-137.

Manufacturers prefer to measure and specify beta efficiency and beta-to-alpha crosstalk using a Sr/Y-90 source. It covers a broad range of beta energies and has emerged as a pseudo standard. Coincidentally this radionuclide is also widely recommended for beta calibrations in many of the analytical methods.

Manufacturers prefer to measure and specify alpha efficiency and alpha-to-beta crosstalk using a Po-210 source even though it is not generally recommended as a calibration source.

Beware of Sources with Windows

Commercial sources are often covered by a window ranging in density from 100 to 1000 µgm/cm^2. These windows protect the instrument from source contamination and the source from loss of activity in case it is mishandled. The window also absorbs energy from the emitted particles and makes it impossible to get accurate efficiency and crosstalk values. Will each of your samples include a window? If the answer to this question is "no", think twice about using these sources for anything other than testing and certainly do not expect to reproduce any of the instrument makers specifications.

"Naturally Occurring" Alpha-to-Beta Crosstalk from Alpha Sources

Three radionuclides frequently recommended in analytical methods for alpha calibrations are Am-241, Th-230 and Pu-239. These radionuclides have significant "naturally occurring" crosstalk components as discussed below. Instrument manufacturers prefer to write performance specifications around Po-210 because it has no "naturally occurring" crosstalk component. The dichotomy of purpose for these two preferences creates confusion and false expectations for "real world samples" which will be explained.

The "naturally occurring" component of alpha-to-beta crosstalk is somewhat predictable for low mass samples by examining the isotope's decay tables. Realistic values must be determined empirically (i.e., from an instrument calibration). This natural part of the alpha-to-beta crosstalk is due to the physics of radioactive decay. Crosstalk compensation (if compensation is indeed needed) requires an understanding of its origins (as alluded to above) and the application of crosstalk subtraction using mass dependent calibration factors.

The Manufacturer's Preferred Alpha Source

Po-210 is a pseudo standard used by manufacturers to specify alpha detection performance. Why is it preferred? With regard to efficiency specifications Po-210 alpha emissions are of a relatively high energy and deliver results that look good. With regard to alpha-to-beta crosstalk specifications Po-210's decay scheme (as shown in the table below) presents no interference from "naturally occurring" crosstalk (i.e., ~100% decay through the emission of 5.3 MeV alphas). Among alpha emitters, Po-210 is unique in this respect and allows the manufacturer to check the "instrument induced" component of alpha-to-beta crosstalk. But are all Po-210 sources suitable for this measurement? This question and that of alpha-to-beta crosstalk in general comes up so often that it begs for the more detailed examination that follows.

Po-210 Alpha Source Decay Table

• ^{210}Bi β^- Decay (5.013 d 5) I (min) = 0.10%
%β^- Decay = 99.99987 1
Feeds ^{210}Po
%α Decay = 0.00013 1

β^- 1	max	1161.4 10		
	avg	389.0 4	99.9998	0.829

• ^{210}Po α Decay (138.378 d 7) I (min) = 0.10%

α 1	5304.51 7	99.9989	11.30

Other Po-210 Source Considerations

The Po-210 decay table indicates that there is no decay path other than through a single alpha emission. None-the-less, the results of a simultaneous count collected from a typical Po-210 source may also include a beta contribution that varies from 1% to 6% of the alpha counts. Is this beta contribution “instrument induced” or is it an impurity in the source? Source impurities cannot be discounted and are controlled by the method of source production.

Pb-210 is the parent of Bi-210 and decays with a half-life of 22.3 years. The table for Bi-210 is shown above since it feeds Po-210. Bi-210 has a short half-life and will soon decay away unless it is in transient equilibrium with any Pb-210, its parent, that also happens to be in the source. Notice from the table above that Bi-210 is a beta emitter. Any such impurity would appear as alpha-to-beta crosstalk in a simultaneous measurement. The suggestion here is that Pb-210 and Bi-210 is in fact contained in some Po-210 source solutions as impurities. This is further evidenced by the following findings.

Most Po-210 sources are made by spontaneously depositing a diluted acid solution onto a silver (or nickel) foil backing. The following excerpt regarding the production of a Po-210 source is from the publication titled *Users’ Guides for Radioactivity Standards* produced by Nuclear Science subcommittees of the U.S. “National Academy of Sciences – National Research Council” and issued in 1974.[3]

> … However, since the deposition potential for bismuth is close to that of polonium, ^{210}Bi (RaE) is also deposited in many cases. Electro-deposition with controlled potential can avoid co-deposition of ^{210}Bi.

In other words, a Po-210 source made using controlled electro-deposition techniques is the most suitable type for crosstalk measurements where the “naturally occurring” component of the source is expected to be zero. The downside to using this type of source is that electro-deposited Po-210 sources are relatively expensive and commercial availability is limited. On the other hand, commercial Po-210 sources produced using the diluted acid solution technique are not expensive and are readily available. Using these sources the interference from Bi-210 may contribute a beta crosstalk in the range of 2-5%, which is still suitable for verifying the absence of an "instrument induced" component.

Po-210 has a short half-life and the source will only be of practical use for about 18 months. Unless the analysis is specifically for Po-210 almost no one uses it as a calibration source as it is not representative of environmental alpha emitters of interest. Every other alpha emitter includes "naturally occurring" alpha-to-beta crosstalk (see the examples below) which may require compensations from simultaneous counts by using a calibrated correction parameter. Knowing all of this you may question the value or necessity of obtaining a source that's only use is to verify to the n^{th} degree a specification that has little practical application.

Alpha Sources Preferred in Analytical Method Calibrations

Theses radionuclides are widely available in many forms, generally have a long half-life, and decay predominantly by emitting moderately energetic alphas. The numerous conversion electrons, X-rays and low energy gamma rays combine to contribute to the observed "naturally occurring" crosstalk.

Consider Th-230, one of these radionuclides. If an instrument existed that was equally efficient at detecting betas, conversion electrons, Auger electrons, x-rays, and alphas the contributions of each is predictable from the branching ratios of the decay tables. This would assume there are no other contributing factors. In the ideal instrument the beta counts (i.e., "naturally occurring" component of the alpha-to-beta crosstalk) from Th-230 would be approximately 40% of the alpha counts. This is the total branching from the "other-than-alpha" decay lines as reported in the tables.

Predicting the "naturally occurring" crosstalk component from a real detector is best left to observation. Using a GFPC instrument all of the other-than-alpha emissions produce electrons to some extent and these are categorized as betas while the alphas are categorized as alphas. The actual measured ratios depend upon the detector's response to these alphas, electrons, and x-rays based upon energy. The GFPC detector has a very efficient response for low energy x-rays (>4keV) and electrons (> 40 keV for a thin windowed GFPC) and for alphas "once they enter the counting gas". The ratio of these efficiencies will skew the expected branching ratios given in the decay tables. Other contributing factors that affect the efficiencies and therefore the crosstalk is determined by the sample media (backscatter), planchet depth (i.e., energy absorption in the air prior to contacting the entrance window), the sample's mass and self absorption, the particle's angle of incidence which determines the degree of contact with the air, and the density of the entrance window. Given all of these variables, it is virtually impossible to predict a crosstalk percentage value.

The tables below are included for reference. Also included are typical alpha efficiency values and the observed “naturally occurring” alpha-to-beta crosstalk component for a low mass sample of the radionuclide in a stainless steel planchet.

Am-241 Alpha Source Decay Table

● ^{241}Am α Decay (432.2 y 5) I (min) = 0.10%
Feeds ^{237}Np
% Spontaneous Fission = 3.77E−10 8

ce-L- 2	3.9182 14	16.1 12	0.0013
Auger-L	10	31 5	0.0067
ce-L- 5	10.778 10	14.8 17	0.0034
ce-L- 7	20.30 5	1.6 4	0.0007
ce-MNO- 2	20.622 4	5.5 6	0.0024
ce-L- 8	20.996 10	9.1 10	0.0040
ce-MNO- 5	27.482 11	5.0 6	0.0029
ce-L- 10	33.133 20	0.89 12	0.0006
ce-MNO- 7	37.01 5	0.59 12	0.0005
ce-L- 12	37.1102 14	30.9 19	0.0244
ce-MNO- 8	37.700 11	3.2 4	0.0026
ce-MNO-10	49.837 21	0.33 4	0.0003
ce-M- 12	53.814 4	7.6 5	0.0088
ce-NOP-12	58.0363 13	2.69 19	0.0033
ce-L- 18	76.543 20	0.27 6	0.0004
ce-MNO-18	93.247 21	0.104 22	0.0002
α 1	5388.0 10	1.40 20	0.161
α 2	5442.98 13	12.8 20	1.48
α 3	5485.74 12	85.2 8	9.96
α 4	5512.0 20	0.20 5	0.0235
α 5	5544.3 3	0.34 5	0.0402

20 weak α's omitted:
$E\alpha(avg) = 5308.2$; $\Sigma I\alpha = 0.03\%$

X-ray L	13.9	43 5	0.0126
γ 2	26.3450 10	2.40 10	0.0013
γ 5	33.205 10	0.106 11	≈0
γ 12	59.5370 10	35.9 6	0.0455

137 weak γ's omitted:
$E\gamma(avg) = 69.2$; $\Sigma I\gamma = 0.18\%$

Planchet Depth:	0 Inch (0mm)	¼ Inch (6.4mm)
Typical 4π Alpha Efficiency:		
Electroplated 47mm Disk	43%	31%
Evaporated Source		21%
Typical Alpha-to-Beta Crosstalk:		
Electroplated 47mm Disk	40%	45%
Evaporated Source		38%

Th-230 Alpha Source Decay Table

• ^{230}Th α Decay (7.7E4 y 3) I (min) = 0.10%
Feeds ^{226}Ra
% Spontaneous Fission ≤ 5E−11

Auger-L	9	8.4 10	0.0016
ce-L- 1	48.4353 25	16.9 11	0.0174
ce-M- 1	62.8500 25	4.6 3	0.0061
ce-NOP- 1	66.464 3	1.64 11	0.0023
α 1	4476	0.12	0.0114
α 2	4621.0 15	23.40 10	2.30
α 3	4687.5 15	76.3 3	7.62

5 weak α's omitted:
$E\alpha$(avg) = 4367.8; $\Sigma I\alpha$ = 0.31%

X-ray L	12.3	8.4 10	0.0022
γ 1	67.6720 20	0.373 21	0.0005

10 weak γ's omitted:
$E\gamma$(avg) = 168.1; $\Sigma I\gamma$ = 0.07%

Planchet Depth:	0 Inch (0mm)	¼ Inch (6.4mm)
Typical 4π Alpha Efficiency:		
Electroplated 47mm Disk	42%	28%
Evaporated Source		23%
Typical Alpha-to-Beta Crosstalk:		
Electroplated 47mm Disk	26%	32%
Evaporated Source		30%

Pu-239 Alpha Source Decay Table

● ^{239}Pu α Decay (24131 y 16) I (min) = 0.10%
Feeds ^{235}U
% Spontaneous Fission = 4.4E−10 13

ce-MNO- 2	7.3920 4	19.0 12	0.0030
ce-L- 3	8.33 10	0.18 17	≈0
Auger-L	9.89	3.5 6	0.0007
ce-L- 4	16.93 3	2.8 6	0.0010
ce-L- 6	24.46 5	0.11 10	≈0
ce-L- 8	29.86 3	4.78 21	0.0030
ce-MNO- 4	33.14 3	1.00 24	0.0007
ce-M- 8	46.07 3	1.32 6	0.0013
ce-NOP- 8	50.18 3	0.493 22	0.0005
α 1	5104.6 10	11.50 20	1.25
α 2	5142.9 8	15.10 20	1.65
α 3	5155.4 7	73.3 7	8.05

20 weak α's omitted:
Eα(avg) = 5007.5; ΣIα = 0.11%

X-ray L	13.6	4.4 6	0.0013

173 weak γ's omitted:
Eγ(avg) = 112.9; ΣIγ = 0.05%

Planchet Depth:	0 Inch (0mm)	¼ Inch (6.4mm)
Typical 4π Alpha Efficiency:		
Electroplated 47mm Disk	43%	25%
Evaporated Source		
Electroplated 47mm Disk	7%	10%
Evaporated Source		

"Naturally Occurring" Beta-to-Alpha Crosstalk from Beta Sources

Fortunately there is no "naturally occurring" beta-to-alpha crosstalk from the beta sources. If any alpha counts appear there is either contamination in the source or the counts are "instrument induced".

The decay tables for two of the radionuclides commonly used to calibrate and test the beta response with alpha/beta counters are included below. Following each table is a note addressing frequently asked questions regarding the radionuclides use. Also included are typical efficiencies for a distributed source counted in a ¼ inch deep stainless steel planchet.

Sr-90 Beta Source Decay Table

● ^{90}Sr β^- Decay (28.6 y 3) I (min) = 0.10%
Feeds ^{90}Y (64.1 h)

β^- 1 max	546.0 20		
avg	195.8 8	100	0.417

● ^{90}Y β^- Decay (64.1 h 1) I (min) = 0.10%

β^- 1 max	2283.9 25		
avg	934.8 12	99.988 1	1.99

1 weak β's omitted:
Eβ(avg) = 186.5; ΣIβ= 0.01%

Planchet Depth:	0 Inch (0mm)	¼ Inch (6.4mm)
Typical 4π Beta Efficiency:		
Electroplated 47mm Disk	54%	40%
Evaporated Source		38%

A pitfall to avoid when using a Sr-90 source to calibrate an instrument is failing to include the contributions of Y-90 in the source's total activity. Some suppliers only include the Sr-90 activity on the source's certification sheet. As soon as a Sr-90 source is produced it begins to decay into Y-90. About 3 weeks after the source is made Y-90 is in transient equilibrium with Sr-90 and the total activity of the source's beta emissions will double. If you fail to include these emissions when the efficiency is calculated your 4π counting efficiency will be twice as high as actual.

Cs-137 Beta Source Decay Table

• ^{137}Cs β^- Decay (30.17 y 3) I (min) = 0.10%
% Feeding to ^{137}Ba (2.522 m) = 94.6 5

β- 1 max	511.6	9			
avg	156.8	4	94.6	5	0.316
β- 2 max	1173.2	9			
avg	415.2	4	5.4	5	0.0478
total β-					
avg	170.8	5	100.0	7	0.364

• ^{137}Ba IT Decay (2.552 m 2) I (min) = 0.10%

Auger-L	3.67		7.6	5	0.0006
Auger-K	26.4		0.80	22	0.0004
ce-K- 1	624.208	5	8.08	22	0.107
ce-L- 1	655.660	5	1.46	4	0.0204
ce-MNO- 1	660.356	5	0.480	14	0.0068
			18.42		
X-ray L	4.47		1.0	3	≈0
X-ray Kα2	31.8171	3	2.07	9	0.0014
X-ray Kα1	32.1936	3	3.82	16	0.0026
X-ray Kβ	36.4		1.39	6	0.0011
γ 1	661.649	5	89.98	24	1.27

10.02

Planchet Depth:	0 Inch (0mm)	¼ Inch (6.4mm)
Typical 4π Beta Efficiency:		
Electroplated 47mm Disk	43%	37%
Evaporated Source		34%

An issue similar to that of Sr-90/Y-90 calibration sources is encountered when using Cs-137 as a beta efficiency calibration standard. You must include the contributions of its daughter to the total beta activity. As the Cs-137 source decays, 94.6% of the betas transition through Ba-137. The Ba-137 conversion electrons elevate the total beta activity of the source by about 9.5% (0.946 x 10.02 ≈ 9.5%). A detailed description of this subject is provided in Protean's application note titled *Calibrating Gross Beta Counters with Cs-137* (AN-0301).

"Instrument Induced" Crosstalk Components

The "instrument induced" beta-to-alpha and alpha-to-beta crosstalk component of a properly adjusted Protean GFPC (gas flow proportional counter) instrument, is negligible. Protean's design of GFPC instruments has eliminated the "instrument induced" components of beta-to-alpha and alpha-to-beta crosstalk without using a traditional "dead band" approach. Some of Protean's literature describes this as *loss-free counting*. More information may be found on Protean Instrument's website (www.proteaninstrument.com).

Proper adjustment of the instrument was emphasized in the previous paragraph. This subject is only briefly discussed here as it is covered in detail in instrument manuals. Adjustment of a GFPC always begins by generating a beta response curve (the beta plateau). This process accumulates and plots counts from a beta source as the detector's bias voltage is increased in small increments. The required source is a Sr/Y-90 point source (not a distributed source) and the source must be placed as close to the detector window as practical. Only under these conditions can you truly gauge the detector's response without introducing geometrical effects that cloud the issue.

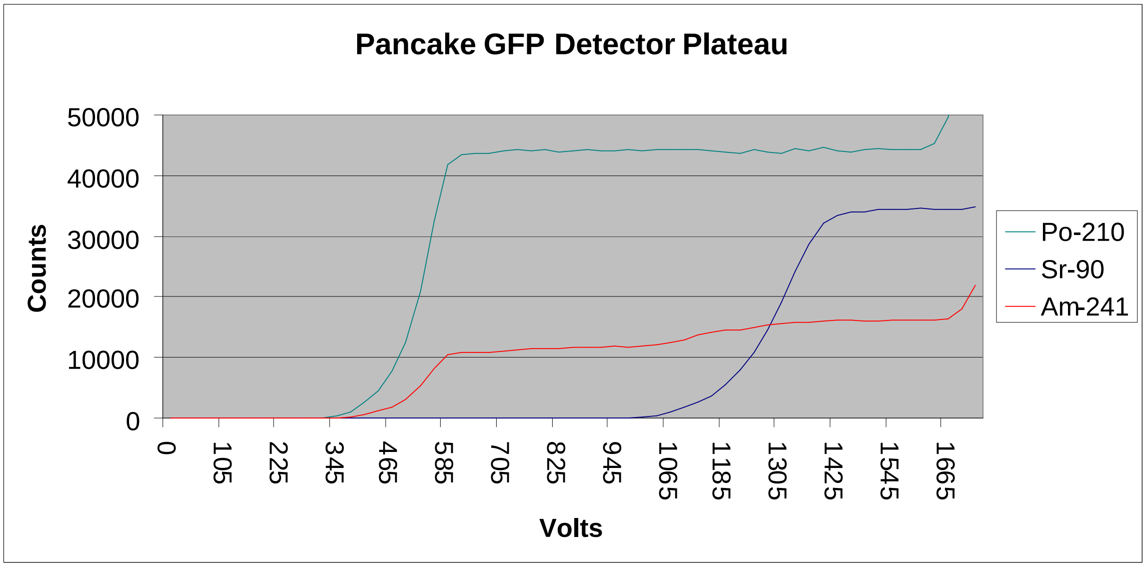
GFPC detectors are supplied with a continuously replenished flow of counting gas. The gas is ionized by the radiation that enters its volume. At the center of the volume is a thin anode wire that is kept at a positive bias voltage with respect to the walls of the detector that are designated the cathode. Ionized gas molecules are collected by this cathode. Negatively charged electrons released from the ionization process will be accelerated towards the positive anode wire where a voltage pulse will be observed. As the electrons accelerate they are subjected to more collisions with gas molecules thus releasing more electrons. This process creates a multiplication affect inside the detector and ultimately produces an observable pulse.

Alpha particles have a high ionization potential and leave many ions. Beta particles have less potential and thus produce fewer ions. A useful characteristic of GFPC detectors is the distinctive regions revealed by the beta response curve. In the first region, designated the "alpha only" region, the detector lacks the multiplication factor necessary to see the beta particles but all of the alphas that enter its volume are registered. In the second region, the "alpha + beta" region, the ionization from the beta particle is amplified enough to be detected and as the voltage is increased a plateau is reached where all of the betas are detected. The alphas are also detected in this region and are easily distinguished from the betas due to the significantly greater magnitude of the resulting pulse.

Proper adjustment for the alpha only voltage is at Protean's recommended voltage of 705 volts. This voltage ensures that the instrument response is on the flat area of a Po-210 alpha plateau but below the beta response region. It is not necessary to gather an alpha plateau to check this setting as the design and factory adjustments of the instrument assures the recommended voltage is proper. Any misalignment of the factory adjustments will be revealed from the beta plateau that should always be verified.

Proper adjustment of the "alpha + beta" voltage is achieved when the high voltage is set at the knee of the beta plateau (nominally ~1500 volts). This procedure is described in detail in the instrument's manual. This voltage ensures that the operating point is on the flat areas of both the alpha plateau and the beta plateau. The energy range of the Sr/Y-90 betas represents a worst case condition for determining the proper operating point.

Typical plateaus are shown in the figure below. In this graph the alpha response has been extended to zero volts for the purpose of explanation. The important area is the overlapping regions of the plateaus (above 705 volts). Actual instrument plateau collection procedures begin at this voltage and increment in 30 volt steps in order to enhance the resolution and minimize the overall time for the data collection.



The figure above also includes an extended response from a distributed Am-241 source in a ¼ inch planchet. This radionuclide's response was included for comparison. The area between 500 and 1000 volts is considered the alpha region. Notice that above 1000 volts a beta response is super-imposed on the Am-241 curve. This beta response is from Am-241's "naturally occurring" component of the alpha-to-beta crosstalk.

"Instrument Induced" Alpha-to-Beta Crosstalk from Alpha Sources

Traditionally any "instrument induced" component was caused by overlapping regions of the alpha and beta discriminators. Protean's instrument design has eliminated this overlap and thus this component of the crosstalk.

Sources with high activity may saturate the detector and linear electronics. In severe cases a pulse overshoot may occur and result in false beta counts. To avoid this we recommend that the test and calibration source activities be less than 30,000 dpm (500 Bq).

A way to confirm that the beta counts from a simultaneous count of Po-210 (or any other alpha emitter) are not "instrument induced" is to first count the source in the "alpha only" mode (with the voltage set to 705 volts for Protean's GFP detectors). Compare those counts to the alpha counts reported from a simultaneous or "alpha + beta" mode count (with the voltage set to ~1500 volts for Protean's GFP detectors).

The reported alpha counts should be within 5% of each other (assuming neither of the counts is statistically limited).

"Instrument Induced" Beta-to-Alpha Crosstalk from Beta Sources

Traditionally any "instrument induced" component was caused by overlapping regions of the alpha and beta discriminators. Protean's instrument design has eliminated this overlap and thus this component of the crosstalk.

One possible exception is associated with high activity sources where pulse pile-up may occur (i.e., two or more beta decays occur so closely in time that they add together to produce a single pulse that is misidentified as an alpha event). We recommend that the activity of calibration sources used with low level alpha/beta counters should be no more than 30,000 dpm (500 Bq) for this reason.

Summary

Crosstalk is a loosely defined parameter. The expectation is that when an alpha source is counted only alphas will be reported, no betas. Conversely, it is expected that when a beta source is counted only betas will be reported, no alphas. When the expected is not realized explanations are sought.

The flaw in this expectation is that all crosstalk is unnatural and is caused by the counting instrument. While this may be true for beta sources and beta-to-alpha crosstalk it is not true for alpha sources and alpha-to-beta crosstalk.

Once this premise is accepted it becomes clearer that there are two components to crosstalk – "natural" and "instrument induced". Manufacturers specify only the "instrument induced" component. Accurately measuring this component is totally dependent upon knowing with certainty the characteristics of the specific source used to make the measurement. If you can't duplicate the manufacturer's specification the unanswered question is "How much do you really know about your test and calibration sources?"

References:

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3. Polonium – Chemistry, *Users' Guides for Radioactivity Standards*, National Academy of Sciences – National Research Council, February 1974, NTIS