Title: CALIBRATION OF BETA-PARTICLE DETECTOR FOR STRONTIUM-89 AND STRONTIUM-90

PROJECT ADMINISTRATION DATA

OCA contact: Brian J. Lindberg 894-4820

Sponsor technical contact
MIKE NICHOLS
(404)526-3535
GEORGIA POWER COMPANY
GA POWER CENTRAL LAB- 5131 MANER RD.
SMYRNA, GEORGIA 30080

Security class (U,C,S,TS): U
Defense priority rating : N/A
Equipment title vests with: Sponsor
NONE PROPOSED OR ANTICIPATED.

Administrative comments - 
SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

Date 11/11/88

Project No. E-25-M28 / R6394-0A0

Includes Subproject No(s) N/A

School/Dept ME

Project Director(s) B. Kahn

Includes Subproject No(s) N/A

Sponsor Georgia Power Company

Title Calibration of Beta-Particle Detector for Strontium-89 and Strontium - 90

Effective Completion Date: 12/31/88 (Performance) 12/31/88 (Reports)

Grant/Contract Closeout Actions Remaining:

☑ Final Invoice or Copy of Last Invoice Serving as Final

☐ Release and Assignment

☐ Final Report of Inventions and/or Subcontract: N/R

☐ Patent and Subcontract Questionnaire sent to Project Director

☐ Govt. Property Inventory & Related Certificate

☐ Classified Material Certificate

☐ Other

Continues Project No. Continued by Project No. 

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/GTRC Supply Services
Facilities Management
Library
GTRC
Project File
Other

Contract Support Division (2)

Reports Coordinator (OCA)
Technical Completion Report
for Project E-25-M28
for the Georgia Power Co.

Calibration of Beta - Particle Detector
for Strontium-89 and Strontium-90

Reza Hashemian
Nuclear Engineering and Health Physics Program
School of Mechanical Engineering
Georgia Institute of Technology

October 1988
Introduction

Environmental radiological monitoring at nuclear power plants requires measurement of radiostrontium in samples of surface water, ground water and milk. The two strontium radionuclides of specific interest are strontium-89 (50.5 day half-life, 1.49 Mev max. beta particles) and strontium-90 (28.8 year half-life, 0.546 Mev max. beta particles). Analysis of these two radionuclides is more difficult than that of most other fission and activation products at nuclear power stations because they two do not emit gamma rays which permit non-destructive analysis. Radiostrontium must be chemically separated from the sample and then counted with a beta-particle detector. The detector used is a gas-flow proportional counter with anticoincidence background subtraction and automatic sample changer.

The detector must be calibrated for counting efficiency in order to convert the count rate to a disintegration rate in units such as disintegrations per minute, picocuries, or becquerel (disintegrations per second), so that results can be reported in terms of these values per liter or kilogram. Calibration is performed with standard solutions of strontium-89 and strontium-90 counted under the same conditions as the samples.

The counting efficiencies for strontium-89 (Sr-89), strontium-90 (Sr-90), and the yttrium-90 (Y-90) daughter of the latter must be determined precisely because all three radionuclides are measured in the same sample and must be distinguished by their radioactive ingrowth and decay patterns. Any error in the determination of one results in an opposite error in the calculated activity of the other. That is, if Sr-89 is underestimated, Sr-90 will be overestimated. Furthermore, the counting efficiency of each radionuclide depends on the sample mass, hence efficiency values must be determined for the entire range of possible sample weights.

The activity of Sr-90 and Y-90 can be determined in a sample by first chemically separating strontium and then measuring the beta-particle activity on two occasions. The first count is due to Sr-90 with a minimal count contributed by Y-90. If the sample is then measured two weeks later, the Y-90 (64.2 hour half-life, 2.28 MeV max. beta particles) daughter of Sr-90 will have grown into the sample according to a defined growth rate and the Sr-90 will have essentially remained constant.

The counting samples are conventionally prepared with a strontium "carrier" which is added at the beginning of the separation process as a measured reagent volume with known amount of activity of standardized strontium solution. The purified strontium samples are weighed before counting. The advantage of this procedure is that the recovery of strontium is determined by comparing the final weight to that of the initially added strontium, thus monitoring any losses and permitting compensation for such losses.
Self Absorption of Beta Particles

Whenever the beta activities of samples of finite thickness are measured, consideration should be given to the effect of absorption of electrons in the samples themselves. To make correction for this effect negligible, the sample thickness should be no more than about one percent of the range of the electrons. Thin samples make it possible to have only a small self-absorption correction, and it is usually necessary to arrange that samples are spread uniformly over the sample-mounting area. In this experiment, filtration is performed on a small tared sintered glass crucible filter which gives reasonable uniform deposits of precipitates on the filter paper. The precipitate has a surface area of 2.27 cm².

For the measurement of soft beta radiation from an appreciably thick sample, it is theoretically possible to calculate the effect of absorption of the radiation in the sample (self-absorption); however, no rigorous calculation is practical because it would require that the absorption curve for the radiation, the thickness of the sample, the solid angle subtended by the counter and the back-scattering effect be taken into account. If possible, the samples should be made less thick than the half-thickness value for the radiation. When thicker samples must be used, it is advisable either to standardize the thickness at a fixed value or to prepare an empirical calibration curve for different thicknesses.

Work with appreciable thick samples is most frequently necessary for the low-energy beta emitters, especially C-14 and S-35. When thicker and thicker samples are prepared from an active material—for example, BaCO₃ containing C-14—the measured counting rate at first increases because of the greater total activity in the sample and then approaches a constant value.

Procedure - Sr(NO₃)₂ Carrier + Sr-89 tracer:

1) X* ml aliquot of carrier is pipetted into each tube
2) 0.5 ml of Sr-89 tracer is added
3) Solution is diluted up to 20 ml with deionized water
4) 0.5 ml of 1N NaOH is added
5) 1.5 ml of 3N Na₂CO₃ is added
6) The mixture is heated and stirred for 20 min.
7) The solution is cooled and then centrifuged and the supernatant is discarded
8) The precipitate (ppt) is washed with water and then centrifuged, and the supernatant is discarded
9) The ppt is suspended in water and collected on a tared membrane filter (Gelman) of 25 mm diameter and 0.45-um pore size in a sintered glass crucible.
10) The ppt is washed with water, 95% Ethanol, and ether.
11) The ppt dried under a heat lamp, let cool to room temperature, and weighed.
12) The ppt is mounted on a plastic disk of 0.1 cm thickness which is covered with mylar (1.7 mg/cm²), and sealed with a plastic ring.
13) The ppt is is placed in a stainless steel holder in the detector. Beta particles are counted with a Tennelec X-B LB-5100 detector.

* X=0.1 ml, 0.2ml, 0.4ml, 0.6ml, 0.8ml, 1.0ml, 1.25ml, 1.50ml, 1.75 ml and 2.0 ml.
Dilution of Sr-89 tracer

Bottle # 2462-1

Activity of the tracer as of 10/23/1987 was 72.9 nCi/gm. 1.0167 gm of the solution had been removed by the Georgia Power Co. Lab. Received 3.21 ml of the solution. The original solution was 5.0 gm (5ml).

3.21 + 1.0167=4.2267 ml of the tracer
5 gm x 72.9 nCi/gm = 364.5 nCi

Concentration after correction for weight loss

\[ \frac{364.5 \text{ nCi}}{4.2267 \text{ ml}} = 86.24 \text{ nCi/ml} \]
(as of 10/23/1987)

\[ A = A_0 e^{-\lambda t} = 86.24 \text{ nCi} e^{-0.693 \times 164} \]
(\text{as of 4/4/1988})

\[ (\text{concentration})_A \cdot (\text{Volume})_A = (\text{concentration})_B \cdot (\text{volume})_B \]
\[ (9.085 \text{ nCi/ml}) \cdot (3.21 \text{ ml}) = (\text{concentration})_B \cdot (50. \text{ ml}) \]

\[ (\text{concentration})_B = \frac{(9.085 \text{ nCi/ml})(3.21 \text{ ml})}{50 \text{ ml}} \]
\[ = 0.583 \text{ nCi/ml} = 583 \text{ pCi/ml} \]
(As of 4/4/1988)
Procedure - Sr(NO₃)₂ carrier + Sr-90 tracer:

1. To a 100-ml water sample, X* ml of Sr(NO₃)₂ carrier and 1 ml of barium carrier (16 mg/ml) are added.

2. Make basic with a few drops of 1 N NaOH to phenolphthalein endpoint and then heat.

3. Add 5 ml of 1.5 M Na₂CO₃, stir and digest until SrCO₃ coagulates, and cool overnight. Decant as much liquid as possible, then collect precipitate by centrifuging; discard supernatant.

4. Wash precipitate with 15 ml water and discard wash solution.

5. Dissolve precipitate with 1 ml 6 N HNO₃.

6. Add 25 ml 16N HNO₃, stir, and cool in an ice bath for 5 minutes.

7. Centrifuge, discard supernatant.

8. Dissolve precipitate with 10 ml water and add 0.5 ml 0.1 M FeCl₃.

9. Heat the solution to near boiling in water bath and add 6 N NH₄OH dropwise until Fe(OH)₃ precipitates.

10. Cool, centrifuge, and transfer supernatant to a clean centrifuge tube. Discard precipitate. Note time of last precipitation; this is the beginning of yttrium ingrowth. Complete steps 11 through 18 without delay to minimize ingrowth of Y-90.

11. Add 3 drops methyl red indicator, and adjust pH to near 5 with a few ml of 1 N HCl. (Color change is from yellow to red.)

12. Add 5 ml ammonium acetate buffer solution and heat in water bath.

13. Slowly add 1 ml of 0.5 M Na₂CrO₄. Stir, heat, and centrifuge. Transfer supernatant to a clean centrifuge tube; discard residue.

14. Add 2 ml of 15 N NH₄OH to the supernatant, heat in water bath, and slowly add, with stirring, 5 ml of 1.5 M Na₂CO₃. Digest until precipitation is complete, cool, centrifuge, and discard supernatant.

15. Dissolve precipitate with 5 ml of 1 N HCl, add 10 ml water, and repeat step 14.
17. Slurry the precipitate with minimum amount of water, transfer to a tared sintered glass crucible and collect on a Gelman membrane filter of 25 mm diameter and pore size 0.45 um pore size.

18. Wash the precipitate with water, 95% ethanol, and ether.

19. Weigh the precipitate and mount it on a plastic disk (0.1 cm thickness), covered with mylar (1.7 mg/cm2), and sealed with a plastic ring.

20. Count the precipitate immediately for beta particles. The sample is placed in a stainless steel holder and counted with a Tennelec X-B LB-5100 detector.

* = 0.1ml, 0.2ml, 0.4ml, 0.6ml, 0.8ml, 1.0ml, 1.25ml, 1.50ml, 1.75ml, and 2.0ml.
Dilution of Sr-90 tracer:

Bottle #2019-10

Activity of the tracer as of 6/15/1987 was 4.48 nCi/gm. 2 ml of this solution was taken and diluted to 50 ml. The original solution was 5 ml (5gm).

\[
\text{(concentration)}_A \times \text{(volume)}_A = \text{(concentration)}_B \times \text{(volume)}_B \\
\frac{4.48 \text{ nCi/ml}}{} \times 2 \text{ ml} = \frac{(\text{concentration})_B}{50 \text{ ml}} \\
(\text{concentration})_B = \frac{4.48 \times 2}{50} = 179.2 \text{ pCi/ml as of (6/15/1987)}
\]
Results

Georgia Power Co. and Georgia Tech Environmental Radiation Lab. results are tabulated in Appendix A and B respectively for Sr-89. Appendix C and D contain results of Sr-90 and Y-90 for Georgia Power and Georgia Tech respectively.

Sr-89: Counting efficiency increases slightly as the weight of precipitate increases from about 3.5mg (0.1 ml) to 6.5mg (0.2 ml), but then decreases slowly with increase in precipitate weight. This result is observed both in Georgia Power and Georgia Tech detectors. Plotted graphs are average of at least three data points. Some points have not been used in average calculation, if those points were three standard deviation ($\pm 30$) from the mean value.

Sr-90: Counting efficiency increases sharply as the weight of precipitate increases from about 2.5 mg (0.1 ml carrier) to 5 mg (0.2 ml carrier), but then it decreases steadily with increase in precipitate weight. All the average data points except the ones for 5 mg (0.2 ml carrier) and 11 mg (0.4 ml carrier) fall within 0.25-1.5% of the plotted curve. One needs to have more data points at 0.2 ml and 0.4 ml carrier in order to determine how the efficiency behaves at these values. Fortunately, the amount of carrier that is normally used is greater than the above values, at well-defined efficiency values. Results from the Georgia Power detector and Georgia Tech are similar. Plotted on graphs are averages of three data points.

Y-90: Counting efficiency increases sharply as the weight of precipitate increases from 2.5 mg (0.1 ml carrier) to 5 mg (0.2 ml carrier), but then remains constant with increase in precipitate weight. All the average data points except the ones for 5 mg (0.2 ml carrier) and 11 mg (0.4 ml carrier) fall within 0.25-1.5% of the plotted curve. One needs to have more data points at 0.2 ml and 0.4 ml carrier in order to determine exactly how the efficiency behaves at these values. The amount of carrier that is mostly used is greater than these values. Results from the Georgia Power detector and the Georgia Tech detector are similar. Plotted graphs are averages of three data points except for 1.25 ml carrier. One of the data points at 1.25 ml had to be discarded since it did not fall within $\pm 35$ of the mean.
In summary, the % efficiency for Sr-90 is much lower than it is for Sr-89. Efficiency for Y-90 is higher than it is for Sr-90, may be lower at range 0.1-0.4 ml carrier than it is for Sr-89, but it then exceeds Sr-89 efficiency when more than 0.4 ml of carrier is used. This finding is observed both in Georgia Power and Georgia Tech detectors.

The yield for Sr-90 was lower than it is for Sr-89 because there are many more steps in the Sr-90 procedure than there are for Sr-89. Therefore, there is a tendency for lower recovery for Sr-90.
References


* The above sources were not found at the Georgia Tech library.
APPENDIX A

GA Power Results (SR-89)
**Sr(NO₃)₂ carrier + Sr-89 tracer**

**GA Power Detector**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Average Gross Count (CPM)</th>
<th>% Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>3.39</td>
<td>96.6</td>
<td>180.85</td>
<td>49.1</td>
</tr>
<tr>
<td></td>
<td>5/9/1988</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>3.90</td>
<td>&gt;100</td>
<td>169.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5/17/1988</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>3.69</td>
<td>100</td>
<td>146.41</td>
<td>44.5</td>
</tr>
<tr>
<td></td>
<td>5/24/1988</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>3.56</td>
<td>100</td>
<td>115.69</td>
<td>48.8</td>
</tr>
<tr>
<td></td>
<td>6/14/1988</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>3.60</td>
<td>100</td>
<td>99.51</td>
<td>48.7</td>
</tr>
<tr>
<td></td>
<td>6/24/1988</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Counting time = 100 min.
Sample Calculation:

Average Gross Count = 180.85 cpm

BKG Count = 1.22 cpm

Counting time = 100 min

% Yield = 96.6

$$E = \frac{180.25 - 1.22}{(0.966)(291.5 Pci)(0.22)(e^{-0.693x39/50.5})} = 49.1\%$$
**Sr(NO₃)₂ Carrier + Sr-89 tracer:**

**GA Power Detector—**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Average Gross Count (CPM)</th>
<th>% Efficiency (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>6.16</td>
<td>87.8</td>
<td>161.85</td>
<td>50.3</td>
</tr>
<tr>
<td></td>
<td>(4/12/1988)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>6.65</td>
<td>94.8</td>
<td>187.17</td>
<td>49.7</td>
</tr>
<tr>
<td></td>
<td>(4/15/1988)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>6.81</td>
<td>97.0</td>
<td>198.02</td>
<td>49.3</td>
</tr>
<tr>
<td></td>
<td>(4/18/1988)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>7.13</td>
<td>100</td>
<td>115.26</td>
<td>48.6</td>
</tr>
<tr>
<td></td>
<td>(6/14/1988)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>6.77</td>
<td>96.5</td>
<td>101.14</td>
<td>51.3</td>
</tr>
<tr>
<td></td>
<td>(6/24/1988)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Counting time = 100 min.
Sample Calculation:

Average Gross Count = 161.85 CPM
BKG Count = 1.21 CPM
Counting time = 100 min.
% yield = 87.8

\[ \varepsilon = \frac{161.85 - 1.21}{(0.878)(291.5 \text{ PCI})(2.22)(e^{-0.693 \times 42})} = 50.3\% \]
SR(NO₃)₂ Carrier + Sr-89 tracer:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Average Gross Count (CPM)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.4</td>
<td>13.44</td>
<td>95.7</td>
<td>169.75</td>
<td>48.4</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>13.71</td>
<td>97.7</td>
<td>181.01</td>
<td>46.6</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>13.54</td>
<td>96.5</td>
<td>196.52</td>
<td>49.2</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>16.40</td>
<td>&gt;100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>14.57</td>
<td>&gt;100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>15.27</td>
<td>&gt;100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>13.76</td>
<td>98.0</td>
<td>211.67</td>
<td>49.4</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>13.85</td>
<td>98.7</td>
<td>211.81</td>
<td>49.1</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>14.03</td>
<td>99.9</td>
<td>208.29</td>
<td>47.6</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost during mounting.
  Counting time = 100 min.

* This sample was not used to plot.
Sample calculation:

Average Gross count = 181.01 CPM
BKG Count = 1.19 CPM
Counting time = 100 min.
% yield = 97.7

\[ \varepsilon = \frac{181.01 - 1.19}{(0.977)(291.5 \text{ PCI})(2.22)(e^{-0.693 \times 36})} = 46.6 \% \]
SR (No3)2 Carrier + Sr-89 tracer:

GA Power Detector:

<table>
<thead>
<tr>
<th>Sample (Date) (4/12/88)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Average Gross Count (CPM)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.6</td>
<td>20.21</td>
<td>96.0</td>
<td>170.04</td>
<td>48.4</td>
</tr>
<tr>
<td>2</td>
<td>20.45</td>
<td>97.1</td>
<td>184.42</td>
<td>47.8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>20.36</td>
<td>96.7</td>
<td>193.46</td>
<td>48.3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>20.56</td>
<td>97.6</td>
<td>101.15</td>
<td>50.8</td>
<td></td>
</tr>
</tbody>
</table>

Counting time = 100 min.
Sample calculation:

Average Gross Count = 170.04 CPM
BKG Count = 1.21 CPM
Counting time = 100 min
% Yield = 96.0

\[ \varepsilon = \frac{170.04 - 1.21}{(0.96)(291.5 \text{ PCI})(2.22)(e^{0.693 \times 4})} = \]
SR(NO3)2 Carrier + Sr-89 Tracer:

GA Power Detector:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Average Gross Count (CMP)</th>
<th>% Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (4/12/88)</td>
<td>0.8</td>
<td>26.93</td>
<td>95.9</td>
<td>165.40</td>
<td>47.0</td>
</tr>
<tr>
<td>2 (4/15/88)</td>
<td></td>
<td>27.45</td>
<td>97.8</td>
<td>180.30</td>
<td>46.4</td>
</tr>
<tr>
<td>* 3 (4/18/88)</td>
<td></td>
<td>27.43</td>
<td>97.7</td>
<td>181.03</td>
<td>44.7</td>
</tr>
<tr>
<td>4 (4/29/88)</td>
<td></td>
<td>27.48</td>
<td>97.9</td>
<td>181.39</td>
<td>49.2</td>
</tr>
<tr>
<td>5 (4/29/88)</td>
<td></td>
<td>27.59</td>
<td>98.3</td>
<td>182.51</td>
<td>49.3</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost during mounting.
  Counting time = 100 min.

* This sample was not used to plot.
Sample calculation:

Average Gross Count = 165.4 CPM
BKG Count = 1.21 CPM
Counting time = 100 min

\% Yield = 95.9

\[ \varepsilon = \frac{165.4 - 1.21}{(0.959)(291.5 \text{ PCI})(2.22)(e^{-0.693 \times 42})} = 47.0 \% \]
SR(NO3)2 carrier + Sr-89 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (mg)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Average Gross Count (CPM)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5/9/88)</td>
<td>1.0</td>
<td>35.12</td>
<td>100</td>
<td>179.85</td>
<td>47.1</td>
</tr>
<tr>
<td>2 (5/16/88)</td>
<td>5</td>
<td>35.19</td>
<td>100</td>
<td>164.42</td>
<td>46.1</td>
</tr>
<tr>
<td>3 (5/17/88)</td>
<td>5</td>
<td>34.49</td>
<td>98.3</td>
<td>155.29</td>
<td>44.9</td>
</tr>
<tr>
<td>4 (5/24/88)</td>
<td>5</td>
<td>34.03</td>
<td>97.0</td>
<td>146.51</td>
<td>46.0</td>
</tr>
<tr>
<td>5 (5/24/88)</td>
<td>5</td>
<td>34.75</td>
<td>99.0</td>
<td>146.7</td>
<td>47.0</td>
</tr>
</tbody>
</table>

*A A small amount of sample was lost during mounting.

Counting time = 100 min.

*This sample was not used to plot
Sample Calculation:

Average Gross Count = 164.42 CPM
BKG Count = 1.22 CPM
Counting time = 100 min.

% Yield = 100

$$
\varepsilon = \frac{164.42 - 1.22}{(1)(291.5 \text{ PCI})(2.22)(\frac{-0.693 \times 44}{50.5})} = 46.1\% $$
**Sr(NO$_3$)$_2$ Carrier + Sr-89 tracer:**

### GA Power Detector

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Average Gross Count (CMP)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5/9/88)</td>
<td>1.25</td>
<td>43.91</td>
<td>100</td>
<td>175.93</td>
<td>46.1</td>
</tr>
<tr>
<td>2 (5/10/88)</td>
<td></td>
<td>42.93</td>
<td>97.9</td>
<td>163.11</td>
<td>45.5</td>
</tr>
<tr>
<td>3 (5/14/88)</td>
<td></td>
<td>44.29</td>
<td>100.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (5/18/88)</td>
<td></td>
<td>42.65</td>
<td>97.2</td>
<td>143.9</td>
<td>46.9</td>
</tr>
<tr>
<td>5 (6/14/88)</td>
<td></td>
<td>43.60</td>
<td>99.4</td>
<td>107.65</td>
<td>45.6</td>
</tr>
</tbody>
</table>

Counting time = 100 min.
Sample calculation:

Average Gross Count = 175.93 CPM

BKG Count = 1.22 CPM

Counting time = 100 min.

% Yield = 100

$$\epsilon = \frac{175.93 - 1.22}{(1)(291.5 \text{ PCI})(2.22)(e^{-0.693 \times 39})} = 46.1\%$$
**Sr(No3)2 carrier + sr-89 tracer:**

**Gamma Power Detector**

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% yield</th>
<th>Average Gross Count (cpm)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5/9/88)</td>
<td>1.5</td>
<td>52.08</td>
<td>98.9</td>
<td>168.84</td>
<td>44.7</td>
</tr>
<tr>
<td>2 (5/10/88)</td>
<td>5</td>
<td>52.49</td>
<td>99.7</td>
<td>161.74</td>
<td>44.3</td>
</tr>
<tr>
<td>3 (5/16/88)</td>
<td>5</td>
<td>51.86</td>
<td>98.5</td>
<td>160.95</td>
<td>45.8</td>
</tr>
<tr>
<td>4 (5/24/88)</td>
<td>5</td>
<td>51.26</td>
<td>97.4</td>
<td>140.36</td>
<td>45.7</td>
</tr>
<tr>
<td>5 (5/24/88)</td>
<td>5</td>
<td>52.33</td>
<td>99.4</td>
<td>142.57</td>
<td>45.5</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost during mounting.
  Counting time = 100 min.

* This sample was not used to plot.
Sample Calculation:

Average Gross Count = 161.74 CPM
BKG Count = 1.21 CPM
Counting time = 100 min
% Yield = 99.7

$$\epsilon = \frac{161.74 - 1.21}{(0.997)(291.5\text{ PCI})(2.22)(e^{-0.693\times 42})} = 44.3\%$$
SR(NO3)2 Carrier + SR-89 tracer:

GA Power Detector -

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Average Gross Count (CPM)</th>
<th>% Efficiency (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5/10/88)</td>
<td>1.75</td>
<td>60.31</td>
<td>98.2</td>
<td>155.80</td>
<td>43.3</td>
</tr>
<tr>
<td>2 (5/17/88)</td>
<td>5</td>
<td>60.41</td>
<td>98.4</td>
<td>155.12</td>
<td>44.8</td>
</tr>
<tr>
<td>* 3 (5/24/88)</td>
<td>5</td>
<td>60.86</td>
<td>99.1</td>
<td>136.47</td>
<td>43.6</td>
</tr>
<tr>
<td>4 (6/14/88)</td>
<td>5</td>
<td>60.83</td>
<td>99.1</td>
<td>104.36</td>
<td>44.4</td>
</tr>
<tr>
<td>5 (6/24/88)</td>
<td>5</td>
<td>60.93</td>
<td>99.2</td>
<td>91.38</td>
<td>45.1</td>
</tr>
</tbody>
</table>

* The sample had to be remounted on the ring at GA Power lab, because it was not flat; therefore, there was some loss of the sample. Counting time = 100 min.

* This sample was not used to plot
Sample Calculation:

Average Gross Count = 155.80 CPM

BKG Count = 1.21 CPM

Counting time = 100 min.

% Yield = 98.2

$$\epsilon = \frac{155.80 - 1.21}{(0.982)(291.5 \text{ PCI})(2.02)(e^{0.693 \times 42} / 50.5)} = 43.3\%$$
SR(NO3)2 Carrier + SR-89 Tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Average Gross Count (CPM)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5/10/88)</td>
<td>2.0</td>
<td>69.34</td>
<td>98.8</td>
<td>154.88</td>
<td>42.8</td>
</tr>
<tr>
<td>2 * (5/16/88)</td>
<td>5</td>
<td>70.30</td>
<td>100.2</td>
<td>154.17</td>
<td>43.2</td>
</tr>
<tr>
<td>3 * (5/17/88)</td>
<td>5</td>
<td>69.20</td>
<td>98.6</td>
<td>143.94</td>
<td>41.4</td>
</tr>
<tr>
<td>4 (5/24/88)</td>
<td>5</td>
<td>69.60</td>
<td>99.2</td>
<td>138.26</td>
<td>44.2</td>
</tr>
<tr>
<td>5 (6/14/88)</td>
<td>5</td>
<td>69.60</td>
<td>99.2</td>
<td>101.50</td>
<td>43.1</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost during mounting.

Counting time = 100 min.

* These samples were not used to plot.
Sample Calculation:
Average Gross Count = 154.88 CPM
BKG Count = 1.21 CPM
Counting time = 100 min.
\% Yield = 98.8

\[ \varepsilon = \frac{154.88 - 1.21}{(0.988)(291.5 \text{ PCI})(2.22)(e^{-0.693 \times 42})} = 42.8\% \]
Appendix B

GA Tech Results (sr.89)
SR(No3)2 carrier + Sr-89 tracer

<table>
<thead>
<tr>
<th>Sample</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Gross Count (50 min)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 5/9/1988</td>
<td>0.1</td>
<td>3.39</td>
<td>96.6</td>
<td>7234</td>
<td>48.18</td>
</tr>
<tr>
<td>* 2 5/17/1988</td>
<td>&quot;</td>
<td>3.90</td>
<td>&gt;100</td>
<td>7160.5</td>
<td>46.07</td>
</tr>
<tr>
<td>3 5/24/1988</td>
<td>&quot;</td>
<td>3.69</td>
<td>100</td>
<td>6400.66</td>
<td>45.32</td>
</tr>
<tr>
<td>4 6/19/1988</td>
<td>&quot;</td>
<td>3.56</td>
<td>100</td>
<td>5036.5</td>
<td>46.01</td>
</tr>
<tr>
<td>5 6/24/1988</td>
<td>&quot;</td>
<td>3.60</td>
<td>100</td>
<td>4989.25</td>
<td>47.02</td>
</tr>
</tbody>
</table>

* This sample was not used to plot
Sample Calculation:

Total Gross Count = 7234
BKG = 56
Counting time = 50 min.
Yield = 96.6

\[ \varepsilon = \frac{7234 - 56}{(0.966)(291.5 \text{ PCI})(2.22)(e^{-0.693 \times 54})(50 \text{ min})} = 48.18\% \]
**SR(No3)2 Carrier + SK-89 tracer:**

**GA Tech Detector:**

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Gross Count (100 min)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (4/12/1988)</td>
<td>0.2</td>
<td>6.16</td>
<td>87.8</td>
<td>24690</td>
<td>50.3</td>
</tr>
<tr>
<td>2 (4/15/1988)</td>
<td>4</td>
<td>6.65</td>
<td>94.8</td>
<td>23045</td>
<td>44.1</td>
</tr>
<tr>
<td>3 (4/18/1988)</td>
<td>4</td>
<td>6.81</td>
<td>97.0</td>
<td>23918</td>
<td>47.9</td>
</tr>
<tr>
<td>4 (6/14/1988)</td>
<td>4</td>
<td>7.13</td>
<td>100</td>
<td>*5129.5</td>
<td>46.9</td>
</tr>
<tr>
<td>5 (6/24/1988)</td>
<td>4</td>
<td>6.77</td>
<td>96.5</td>
<td>*5120.5</td>
<td>50.0</td>
</tr>
</tbody>
</table>

* They were counted for 50 min.
Sample Calculation:

Total Gross Count = 24690
BKG = 127
Counting time = 100 min.
% yield = 87.8

\[

e = \frac{24690 - 127}{(0.878)(291.5 \text{ PCI})(2.22)(e^{-0.693 x 11})(100)} = 50.3\%
\]
**Sr(NO₃)₂ Carrier + Sr-89 Tracer:**

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Gross Count (50 min)</th>
<th>% Efficiency ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 1 (4/12/88)</td>
<td>0.4</td>
<td>13.44</td>
<td>95.7</td>
<td>+24,007</td>
<td>44.8</td>
</tr>
<tr>
<td>2 (4/15/88)</td>
<td></td>
<td>13.71</td>
<td>97.7</td>
<td>+26,346</td>
<td>39.6</td>
</tr>
<tr>
<td>3 (4/18/88)</td>
<td></td>
<td>13.54</td>
<td>96.5</td>
<td>+24,807</td>
<td>48.7</td>
</tr>
<tr>
<td>4 (4/29/88)</td>
<td></td>
<td>16.40</td>
<td>&gt;100</td>
<td>10,669.5</td>
<td>—</td>
</tr>
<tr>
<td>5 (4/29/88)</td>
<td></td>
<td>14.57</td>
<td>&gt;100</td>
<td>10,553</td>
<td>—</td>
</tr>
<tr>
<td>6 (4/29/88)</td>
<td></td>
<td>15.27</td>
<td>&gt;100</td>
<td>10,349.5</td>
<td>—</td>
</tr>
<tr>
<td>7 (5/12/88)</td>
<td></td>
<td>13.76</td>
<td>98.0</td>
<td>9,446.25</td>
<td>46.6</td>
</tr>
<tr>
<td>8 (5/12/88)</td>
<td></td>
<td>13.85</td>
<td>98.7</td>
<td>9,809.25</td>
<td>48.0</td>
</tr>
<tr>
<td>9 (5/12/88)</td>
<td></td>
<td>14.03</td>
<td>99.9</td>
<td>9,469.5</td>
<td>45.8</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost during mounting.
+ They were counted for 100 min.
* This sample was not used to plot
Sample Calculation:

Total Gross Count = 21,346
BKG = 110
Counting time = 100 min

% Yield = 97.7

\[ \epsilon = \frac{21346 - 110}{(0.977)(291.5 \text{ Pci})(2.22) \left( e^{-0.693 \times 12 \frac{1}{50.5}} \right)(100 \text{ min})} = 39.6\% \]
Sr(NO₃)₂ Carrier + Sr-89 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Gross Count (100 min)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (4/12/88)</td>
<td>0.6</td>
<td>20.21</td>
<td>96.0</td>
<td>24,201</td>
<td>45.1</td>
</tr>
<tr>
<td>+ 2 (4/15/88)</td>
<td></td>
<td>20.45</td>
<td>97.1</td>
<td>21,678</td>
<td>41.0</td>
</tr>
<tr>
<td>3 (4/18/88)</td>
<td></td>
<td>20.36</td>
<td>96.7</td>
<td>23,464.5</td>
<td>47.1</td>
</tr>
<tr>
<td>4 (6/24/88)</td>
<td></td>
<td>20.56</td>
<td>97.6</td>
<td>4,975.75</td>
<td>48.0</td>
</tr>
</tbody>
</table>

* It was counted for 50 min.
+ It was not used to plot.
Sample Calculation:

Total Gross Count = 24,201
BKG = 127
Counting time = 100 min.
% Yield = 96.0

\[ \varepsilon = \frac{24,201 - 127}{(0.96)(291.5 \text{ Pci})(2.22)(e^{-0.693x11050.5}) (100 \text{ min})} = 45.1 \% \]
sr(No3)2 carrier + sr-89 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Gross Count (100 min)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (4/12/88)</td>
<td>0.8</td>
<td>26.93</td>
<td>95.9</td>
<td>25,432</td>
<td>47.4</td>
</tr>
<tr>
<td>2 (4/15/88)</td>
<td>5</td>
<td>27.45</td>
<td>97.8</td>
<td>26,741</td>
<td>40.9</td>
</tr>
<tr>
<td>3 (4/18/88)</td>
<td>5</td>
<td>27.43</td>
<td>97.1</td>
<td>21,391</td>
<td>43.2</td>
</tr>
<tr>
<td>4 (4/29/88)</td>
<td>5</td>
<td>27.48</td>
<td>97.9</td>
<td>10,287.5</td>
<td>48.1</td>
</tr>
<tr>
<td>5 (4/29/88)</td>
<td>5</td>
<td>27.59</td>
<td>98.3</td>
<td>10,250</td>
<td>47.7</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost during mounting.
+ They were counted for 50 min.
* This sample was not used to plot
☆ It was not used to plot
Sample Calculation:

Total Gross Count = 25,432
BKG = 127
Counting time = 100 min
% yield = 96.0

\[ \varepsilon = \frac{25,432 - 127}{0.96(291.5 \text{ PCl})(2.22)(e^{0.693 \times 11})(100 \text{ min})} = 49.4\% \]
Sr(NO₃)₂ Carrier + Sr-89 tracer:

GA Tech Detector -

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (mg)</th>
<th>Weight of Precipitate (mg)</th>
<th>% yield</th>
<th>Total Gross Count (50min)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5/9/88)</td>
<td>1.0</td>
<td>35.12</td>
<td>100</td>
<td>7,062.5</td>
<td>45.4</td>
</tr>
<tr>
<td>2 (5/16/88)</td>
<td>6</td>
<td>35.19</td>
<td>100</td>
<td>6,911</td>
<td>43.8</td>
</tr>
<tr>
<td>* 3 (5/17/88)</td>
<td>6</td>
<td>34.49</td>
<td>98.3</td>
<td>6,628</td>
<td>-</td>
</tr>
<tr>
<td>4 (5/24/88)</td>
<td>6</td>
<td>34.03</td>
<td>97.0</td>
<td>6,366.66</td>
<td>46.5</td>
</tr>
<tr>
<td>5 (5/24/88)</td>
<td>6</td>
<td>34.75</td>
<td>99.0</td>
<td>6,491</td>
<td>47.1</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost during mounting.
* It was not used to plot.
Sample Calculation:

Total Gross Count = 7,062.5
BKG Count = 56
Counting time = 50 min.

\[% \text{ Yield} = 100 \]

\[\epsilon = \frac{7,062.5 - 56}{(1)(291.5 \text{ PCI})(2.22)(e^{-0.693 \times 56})(50 \text{ min.})} = 45.4\% \]
SR(NO₃)₃ carrier + Sr-89 tracer:

GA Tech Detector:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% yield</th>
<th>Total Gross Count (50 min)</th>
<th>% Efficiency (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5/9/88)</td>
<td>1.25</td>
<td>43.91</td>
<td>100.1</td>
<td>7,004</td>
<td>45.0</td>
</tr>
<tr>
<td>2 (5/10/88)</td>
<td></td>
<td>42.93</td>
<td>97.9</td>
<td>6,984.5</td>
<td>44.0</td>
</tr>
<tr>
<td>3 (5/16/88)</td>
<td></td>
<td>44.27</td>
<td>100.9</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4 (5/24/88)</td>
<td></td>
<td>42.65</td>
<td>97.2</td>
<td>6,151.33</td>
<td>44.8</td>
</tr>
<tr>
<td>5 (6/14/88)</td>
<td></td>
<td>43.60</td>
<td>99.4</td>
<td>4,897.5</td>
<td>45.0</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Gross Count = 7004
BKG Count = 56
Counting time = 50 min.

% Yield = 100

\[
\varepsilon = \frac{7004 - 56}{(1)(291.5 \text{ PCI})(2.22)(\frac{0.693 \times 54}{50.5})(50 \text{ min})} = 45.0\%
\]
**Sr(NO₃)₂Carrier + Sr-89 tracer:**

**GA Tech Detector**

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Gross Count (50 min)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1 (5/9/88)</td>
<td>1.5</td>
<td>52.08</td>
<td>98.9</td>
<td>6,739</td>
<td>43.8</td>
</tr>
<tr>
<td>2 (5/10/88)</td>
<td></td>
<td>52.49</td>
<td>99.7</td>
<td>6,849</td>
<td>43.9</td>
</tr>
<tr>
<td>3 (5/14/88)</td>
<td></td>
<td>51.86</td>
<td>98.5</td>
<td>6,839</td>
<td>44.0</td>
</tr>
<tr>
<td>4 (5/24/88)</td>
<td></td>
<td>51.26</td>
<td>97.4</td>
<td>6,165.33</td>
<td>44.8</td>
</tr>
<tr>
<td>5 (5/24/88)</td>
<td></td>
<td>52.33</td>
<td>99.4</td>
<td>6,329.66</td>
<td>45.7</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost during mounting.
* This sample was not used to plot.
Sample Calculation:

Total Gross Count = 6,849
BKG Count = 42
Counting time = 50 min
% yield = 99.7

\[ \epsilon = \frac{6,849 - 42}{(0.997)(291.5 \text{ PCI})(2.22)(e^{-0.693 \times \frac{53}{50.5}})(50 \text{ min})} = 43.7\% \]
SR(N03)2 Carrier + Sr-89 tracer:

GA Tech Detector

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Carrier (mg)</th>
<th>%Yield</th>
<th>Total Gross Count (50 min)</th>
<th>%Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5/10/88)</td>
<td>1.75</td>
<td>60.31</td>
<td>98.2</td>
<td>6,660</td>
<td>43.1</td>
</tr>
<tr>
<td>2 (5/19/88)</td>
<td>5</td>
<td>60.41</td>
<td>98.4</td>
<td>6,799.5</td>
<td>44.4</td>
</tr>
<tr>
<td>* 3 (5/24/88)</td>
<td>5</td>
<td>60.86</td>
<td>99.1</td>
<td>5,968</td>
<td>43.3</td>
</tr>
<tr>
<td>4 (6/14/88)</td>
<td>5</td>
<td>60.83</td>
<td>99.1</td>
<td>4,9160</td>
<td>43.8</td>
</tr>
<tr>
<td>5 (6/24/88)</td>
<td>5</td>
<td>60.93</td>
<td>99.2</td>
<td>4,6011.25</td>
<td>43.7</td>
</tr>
</tbody>
</table>

* The sample had to be remounted on the ring at GA Power lab because it was not flat; therefore, there was some loss of the sample.
* This sample was not used to plot.
Sample Calculation:

Total Gross Count = 6,660
BKG Count = 42
Counting time = 50 min.

% Yield = 98.2

\[ \epsilon = \frac{6,660 - 42}{(0.982)(291.5 \text{ pci})(2.2)(e^{-0.693 \times 53}}{50 \text{ min}} = 43.1\% \]
SR\((\text{No3})_2\) carrier + SR-89 tracer:

GA Tech Detector

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% yield</th>
<th>Total Gross Count (50 min)</th>
<th>% Efficiency (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5/10/88)</td>
<td>2.0</td>
<td>69.34</td>
<td>98.8</td>
<td>6,621.5</td>
<td>42.6</td>
</tr>
<tr>
<td>* 2 (5/16/88)</td>
<td></td>
<td>70.30</td>
<td>100.2</td>
<td>6,614.5</td>
<td>41.9</td>
</tr>
<tr>
<td>* 3 (5/17/88)</td>
<td></td>
<td>69.20</td>
<td>98.6</td>
<td>6,381.5</td>
<td>41.1</td>
</tr>
<tr>
<td>4 (5/24/88)</td>
<td></td>
<td>69.60</td>
<td>99.2</td>
<td>6,011.33</td>
<td>43.5</td>
</tr>
<tr>
<td>5 (6/14/88)</td>
<td></td>
<td>69.60</td>
<td>99.2</td>
<td>4,679</td>
<td>43.0</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost during mounting.
* These samples were not used to plot.
Sample Calculation:

Total Gross Count = 63621.5
BKG Count = 42
Counting time = 50 min.
% Yield = 98.8

\[ \epsilon = \frac{63621.5 - 42}{(0.98)(291.5 \text{ pci})(2.22)(e^{-0.693x53})}\frac{50.5}{50 \text{ min}} = 42.6\% \]
APPendix C
GA Power Results (5R-90 and 7-90)
sr(NO3)2Carrier + sr-90 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Initial Gross Count (cpm)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1 (7/14/88)</td>
<td>0.1</td>
<td>4.79</td>
<td>&gt;100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>s</td>
<td>2.77</td>
<td>78.9</td>
<td>78.38</td>
<td>9.93</td>
</tr>
<tr>
<td>+3 (7/21/88)</td>
<td>s</td>
<td>1.17</td>
<td>33.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (7/28/88)</td>
<td>s</td>
<td>2.55</td>
<td>72.65</td>
<td>83.84</td>
<td>9.52</td>
</tr>
<tr>
<td>5 (8/25/88)</td>
<td>s</td>
<td>2.61</td>
<td>74.36</td>
<td>80.96</td>
<td>8.1</td>
</tr>
</tbody>
</table>

* It was not used to plot

+ Low yield, it was not used to plot
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Final Gross Count (CPM)</th>
<th>Final Time (t_f) (hr)</th>
<th>% Efficiency (E) of Sr-90</th>
<th>% Efficiency (E) of Y-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/14/88)</td>
<td>0.1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>5</td>
<td>158.12</td>
<td>425.42</td>
<td>22.89</td>
<td>28.75</td>
</tr>
<tr>
<td>3 (7/21/88)</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4 (7/28/88)</td>
<td>5</td>
<td>160.94</td>
<td>462.83</td>
<td>26.87</td>
<td>32.30</td>
</tr>
<tr>
<td>5 (8/25/88)</td>
<td>5</td>
<td>160.02</td>
<td>438.92</td>
<td>25.22</td>
<td>30.35</td>
</tr>
</tbody>
</table>
Sample Calculation:

Initial Gross Count (CPM) = 78.38
Initial Time ($t_i$) = 7.93 hr

Final Gross Count (CPM) = 158.12
Final Time ($t_f$) = 425.42 hr

Activity of Sr-90 ($A_{Sr-90}$) = 387.22 dpm/ml

Yield = 78.9

$A_{Sr-90} = (179.2 \text{ PCI/ml}) \left( e^{-\frac{(0.693)(407)}{28.6 \times 365}} \right) (2.22 \text{ dpm/PCI}) = 387.22 \text{ dpm/ml}

BKG$_x$ = 1.23 CPM  
BKG$_f$ = 158.12 CPM

1. \[
\frac{R_i}{A_{sr}} \times (\text{Yield of Sr}) = \epsilon_s + \epsilon_y \left( 1 - e^{-\frac{(0.693)(t_i)}{\text{half-life of Sr}}} \right)
\]

2. \[
\frac{R_f}{A_{sr}} \times (\text{Yield of Sr}) = \epsilon_s + \epsilon_y \left( 1 - e^{-\frac{(0.693)(t_f)}{\text{half-life of Sr}}} \right)
\]

$R_x = 78.38 - 1.23 = 77.15 \text{ CPM}$

$R_f = 158.12 - 1.22 = 156.9 \text{ CPM}$

1. \[
\frac{77.15}{387.22(0.789)} = \epsilon_s + \epsilon_y \left( 1 - e^{-\frac{(0.693)(7.93)}{64.2}} \right)
\]

2. \[
\frac{156.9}{387.22(0.789)} = \epsilon_s + \epsilon_y \left( 1 - e^{-\frac{(0.693)(425.42)}{64.2}} \right)
\]

1. \[-1 \left\{ 0.2525231 = \epsilon_s + 0.0820382 \epsilon_y \right\}
\]

2. \[0.5135564 = \epsilon_s + 0.9898689 \epsilon_y
\]

\[0.260333 = 0.9078307 \epsilon_y\]

$\epsilon_y = 28.75 \%
\]

$\epsilon_s = 22.89 \%$
SR(NO₃)₂ Carrier + Sr-90 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% yield</th>
<th>Initial Gross Count (CPM)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/14/88)</td>
<td>0.2</td>
<td>4.48</td>
<td>63.8</td>
<td>95.25</td>
<td>13.02</td>
</tr>
<tr>
<td>2 (7/21/88)</td>
<td>5</td>
<td>4.11</td>
<td>58.5</td>
<td>89.24</td>
<td>9.32</td>
</tr>
<tr>
<td>3 (8/25/88)</td>
<td>5</td>
<td>6.19</td>
<td>88.18</td>
<td>120.01</td>
<td>11.48</td>
</tr>
<tr>
<td>Sample (Date)</td>
<td>Carrier (ml)</td>
<td>Final Gross Count (CPM)</td>
<td>Final Time (lt) (hr)</td>
<td>% Efficiency (E) of Sr-90</td>
<td>% Efficiency (E) of Y-90</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>-------------------------</td>
<td>---------------------</td>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>1 (7/14/88)</td>
<td>0.2</td>
<td>183.08</td>
<td>492.92</td>
<td>32.67</td>
<td>41.12</td>
</tr>
<tr>
<td>2 (7/21/88)</td>
<td>5</td>
<td>178.50</td>
<td>368.30</td>
<td>34.60</td>
<td>44.51</td>
</tr>
<tr>
<td>3 (8/25/88)</td>
<td>5</td>
<td>236.38</td>
<td>442.25</td>
<td>30.33</td>
<td>39.07</td>
</tr>
</tbody>
</table>
Sample Calculation:

Initial Gross Count (CPM) = 95.25

Initial Time (t_i) = 13.02 hr

Final Gross Count (CPM) = 183.08

Final Time (t_f) = 492.92 hr

Activity of Sr-90 (A_{Sr-90}) = 387.30 dpm/ml

% yield = 63.8

\[ A_{sr-90} = 179.2 \text{ Pci/ml} \left( e^{-\frac{(0.693)(t_i)}{2.303}} \right) (2.22 \text{ dpm/ml}) = 387.30 \text{ dpm/ml} \]

BKG = 1.19 CPM, BKG_f = 1.22 CPM

1. \[ \frac{R_i}{(A_{sr})(\text{yield of Sr})} = \epsilon_{sr} + \epsilon_y (1 - e^{-\frac{t_i}{t_{1/2}}}) \]

2. \[ \frac{R_f}{(A_{sr})(\text{yield of Sr})} = \epsilon_{sr} + \epsilon_y (1 - e^{-\frac{t_f}{t_{1/2}}}) \]

R_i = 95.25 - 1.19 = 94.06 CPM

R_f = 183.08 - 1.22 = 181.86 CPM

1. \[ \frac{94.06}{(387.30)(0.638)} = \epsilon_{sr} + \epsilon_y (1 - e^{-\frac{13.02}{64.2}}) \]

2. \[ \frac{181.86}{(387.30)(0.638)} = \epsilon_{sr} + \epsilon_y (1 - e^{-\frac{492.92}{64.2}}) \]

1. \[ 0.3806596 = 0.131136 \epsilon_y \]

2. \[ 0.735985 = 0.995111 \epsilon_y \]

\[ \frac{0.3553254}{0.8639974} = \epsilon_y \]

\[ \epsilon_y = 41.12\% \]

\[ \epsilon_{sr} = 32.67\% \]
**Sr(NO₃)₂ Carrier + Sr-90 tracer:**

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% yield</th>
<th>Initial Gross Count (CPM)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (9/7/88)</td>
<td>0.4</td>
<td>10.14</td>
<td>72.24</td>
<td>96.22</td>
<td>9.1</td>
</tr>
<tr>
<td>2 (7/14/88)</td>
<td>.5</td>
<td>11.48</td>
<td>81.77</td>
<td>125.71</td>
<td>16.35</td>
</tr>
<tr>
<td>* 3 (8/25/88)</td>
<td></td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4 (9/3/88)</td>
<td>.5</td>
<td>11.67</td>
<td>83.12</td>
<td>115.69</td>
<td>7.37</td>
</tr>
</tbody>
</table>

* Sample was lost while centrifuging.
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Final Gross Count (CPM)</th>
<th>Final Time (hr)</th>
<th>% Efficiency (of SK-90)</th>
<th>% Efficiency (of Y-90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>0.4</td>
<td>198.33</td>
<td>439.42</td>
<td>30.14</td>
<td>40.63</td>
</tr>
<tr>
<td>2 (7/14/88)</td>
<td>5</td>
<td>242.74</td>
<td>494.58</td>
<td>32.15</td>
<td>44.33</td>
</tr>
<tr>
<td>3 (8/25/88)</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4 (9/1/88)</td>
<td>5</td>
<td>239.30</td>
<td>456.60</td>
<td>32.45</td>
<td>42.06</td>
</tr>
</tbody>
</table>
Sample Calculation:

Initial Gross Count (CPM) = 96.22
Initial Time \(t_i\) = 9.1 hr
Final Gross Count (CPM) = 198.33
Final Time \(t_f\) = 439.42 hr
Activity of Sr-90 \(A_{\text{Sr-90}}\) = 387.48 dpm/ml

\% Yield = 72.24

\[ A_{\text{Sr-90}} = (179.2 \text{ PCI/ml}) \left( e^{-\frac{(0.693)(9.1)}{28.6 \times 365}} \right)(2.22 \text{ dpm/PCI}) = 387.48 \text{ dpm/ml} \]

BK \(G_i = 1.21 \text{ CPM} \) ** BK \(G_f = 1.22 \text{ CPM} \)**

\[ \frac{R_i}{(A_{sr})(\text{yield of sr})} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_i)}{64.2}} \right) \]

\[ \frac{R_f}{(A_{sr})(\text{yield of sr})} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_f)}{64.2}} \right) \]

\( R_i = 96.22 - 1.21 = 95.01 \text{ CPM} \)

\( R_f = 198.33 - 1.22 = 197.11 \text{ CPM} \)

\[ \frac{95.01}{(387.48)(0.7224)} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(9.1)}{64.2}} \right) \]

\[ \frac{197.11}{(387.48)(0.7224)} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(439.42)}{64.2}} \right) \]

1. \( -1 \{ 0.3394238 = \varepsilon_{sr} + 0.09235586 \varepsilon_y \} \)

2. \( 0.7041746 = \varepsilon_{sr} + 0.9912899 \varepsilon_y \)

\[ 0.3649528 = 0.8977313 \varepsilon_y \]

\[ \varepsilon_y = 40.63 \% \]

\[ \varepsilon_{sr} = 30.14 \% \]
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Initial Gross Count (CPM)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>0.6</td>
<td>16.25</td>
<td>77.18</td>
<td>116.51</td>
<td>12.43</td>
</tr>
<tr>
<td>2 (7/14/88)</td>
<td>5</td>
<td>15.14</td>
<td>71.89</td>
<td>125.91</td>
<td>19.68</td>
</tr>
<tr>
<td>3 (8/25/88)</td>
<td>5</td>
<td>17.78</td>
<td>84.42</td>
<td>133.39</td>
<td>14.82</td>
</tr>
<tr>
<td>Sample (Date)</td>
<td>Carrier (ml)</td>
<td>Final Gross Count (CPM)</td>
<td>Final Time (t(t)) (hr)</td>
<td>% Efficiency (Æ) of Sr-90</td>
<td>% Efficiency (Æ) of Y-90</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>-------------------------</td>
<td>------------------------</td>
<td>---------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>1 (7/7/88)</td>
<td>0.6</td>
<td>239.64</td>
<td>442.75</td>
<td>32.58</td>
<td>47.53</td>
</tr>
<tr>
<td>2 (7/14/88)</td>
<td>5</td>
<td>237.60</td>
<td>496.25</td>
<td>35.25</td>
<td>49.89</td>
</tr>
<tr>
<td>3 (8/25/88)</td>
<td>5</td>
<td>261.72</td>
<td>445.60</td>
<td>33.64</td>
<td>46.64</td>
</tr>
</tbody>
</table>
Sample Calculation:

Initial Gross Count (CPM) = 116.51

Initial Time (t_i) = 12.43 hr

Final Gross Count (CPM) = 239.64

Final Time (t_f) = 442.75 hr

Activity of Sr-90 (A_{sr, q_0}) = 387.48 dpm/ml

% Yield = 77.18

\[
A_{sr, q_0} = (179.2 \text{ PCi/ml}) \left( e^{(28.6 \times 365)} \right) (2.22 \text{ dpm/PCi}) = 387.48 \text{ dpm/ml}
\]

BKG_i = 1.21 CPM, BKG_f = 1.22 CPM

\[
\frac{R_i}{(A_{sr})(\text{yield of } sr)} = \epsilon_{sr} + \epsilon_y (1 - e^{\frac{-(0.693)(t_f)}{64.2}})
\]

\[
\frac{R_f}{(A_{sr})(\text{yield of } sr)} = \epsilon_{sr} + \epsilon_y (1 - e^{\frac{-(0.693)(t_f)}{64.2}})
\]

R_i = 116.51 - 1.21 = 115.3 CPM

R_f = 239.64 - 1.22 = 238.42 CPM

\[
1. \frac{115.3}{(387.48)(0.7718)} = \epsilon_{sr} + \epsilon_y (1 - e^{\frac{-(0.693)(12.43)}{64.2}})
\]

\[
2. \frac{238.42}{(387.48)(0.7718)} = \epsilon_{sr} + \epsilon_y (1 - e^{\frac{-(0.693)(442.75)}{64.2}})
\]

\[
1. \{0.3855232 = \epsilon_{sr} + 0.1255623 \epsilon_y \}
\]

\[
2. 0.7971938 = \epsilon_{sr} + 0.9915974 \epsilon_y
\]

\[
0.4116706 = 0.8660351 \epsilon_y
\]

\[
\epsilon_y = 47.53 \%
\]

\[
\epsilon_{sr} = 32.58 \%
\]
SR(NO₃)₂ Carrier + Sr-90 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Initial Gross Count (CPM)</th>
<th>Initial Time(h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>0.8</td>
<td>21.66</td>
<td>77.16</td>
<td>116.07</td>
<td>15.76</td>
</tr>
<tr>
<td>2 (7/21/88)</td>
<td>5</td>
<td>21.92</td>
<td>78.10</td>
<td>113.16</td>
<td>10.98</td>
</tr>
<tr>
<td>3 (9/1/88)</td>
<td>5</td>
<td>24.83</td>
<td>88.43</td>
<td>134.73</td>
<td>10.72</td>
</tr>
<tr>
<td>Sample (Date)</td>
<td>Carrier (ml)</td>
<td>Final Gross Count (CPM)</td>
<td>Final Time (tf) (hr)</td>
<td>%Efficiency (E) of Sr-90</td>
<td>%Efficiency (E) of Y-90</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>-------------------------</td>
<td>----------------------</td>
<td>--------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>1 (7/7/88)</td>
<td>0.8</td>
<td>232.43</td>
<td>446.08</td>
<td>31.13</td>
<td>46.58</td>
</tr>
<tr>
<td>2 (7/21/88)</td>
<td>5</td>
<td>243.44</td>
<td>369.13</td>
<td>31.48</td>
<td>49.55</td>
</tr>
<tr>
<td>3 (9/1/88)</td>
<td>5</td>
<td>288.92</td>
<td>458.27</td>
<td>33.52</td>
<td>51.13</td>
</tr>
</tbody>
</table>
Sample Calculation:

Initial Gross Count (CPM) = 116.07
Initial Time (t_i) = 15.76 hr
Final Gross Count (CPM) = 231.21
Final Time (t_f) = 446.08 hr

Activity of Sr-90 (A_{sr-90}) = 387.48 dpm/ml

% Yield = 77.16

$A_{sr-90} = (179.2 \text{ Pcl} / \text{ml}) \left( \frac{(0.693)(397)}{e^{28.6 \times 365}} \right) \left( 2.22 \frac{\text{dpm}}{\text{Pcl}} \right) = 387.48 \frac{\text{dpm}}{\text{ml}}$

BKG_i = 1.21 CPM, BKG_f = 1.22 CPM

1. \[ \frac{R_i}{(A_{sr})(\text{Yield of sr})} = \epsilon_{sr} + \epsilon_y \left( 1 - e^{-\frac{(0.693)(t_i)}{t_{1/2} of y}} \right) \]

2. \[ \frac{R_f}{(A_{sr})(\text{Yield of sr})} = \epsilon_{sr} + \epsilon_y \left( 1 - e^{-\frac{(0.693)(t_f)}{t_{1/2} of y}} \right) \]

\[ R_i = 116.07 - 1.21 = 114.86 \text{ CPM} \]

\[ R_f = 232.43 - 1.22 = 231.21 \text{ CPM} \]

1. \[ \frac{114.86}{(387.48)(0.7716)} = \epsilon_{sr} + \epsilon_y \left( 1 - e^{-\frac{(0.693)(15.76)}{64.2}} \right) \]

2. \[ \frac{231.21}{(387.48)(0.7716)} = \epsilon_{sr} + \epsilon_y \left( 1 - e^{-\frac{(0.693)(446.08)}{64.2}} \right) \]

1. \[ 0.3841516 = \epsilon_{sr} + 0.1564361 \epsilon_y \]

2. \[ 0.7732845 = \epsilon_{sr} + 0.9918941 \epsilon_y \]

\[ 0.3891349 = 0.835458 \epsilon_y \]

\[ \epsilon_y = 46.58\% \]

\[ \epsilon_{sr} = 31.13\% \]
**$\text{Sr(NO}_3\text{)}_2$ carrier + Sr-90 tracer:**

**GA Power Detector:**

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (mL)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Initial Gross Count (CPM)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>1.0</td>
<td>29.39</td>
<td>83.76</td>
<td>126.03</td>
<td>19.1</td>
</tr>
<tr>
<td>* 2 (7/21/88)</td>
<td>5</td>
<td>28.80</td>
<td>82.05</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 (7/28/88)</td>
<td>5</td>
<td>29.88</td>
<td>85.13</td>
<td>117.86</td>
<td>9.18</td>
</tr>
<tr>
<td>4 (9/1/89)</td>
<td>5</td>
<td>31.38</td>
<td>89.40</td>
<td>132.64</td>
<td>14.05</td>
</tr>
</tbody>
</table>

* A little of ppt. was lost while mounting.
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Final Gross Count (CPM)</th>
<th>Final Time ($t_f$) (hr)</th>
<th>% Efficiency ($\text{E}$) of Sr-90</th>
<th>% Efficiency ($\text{E}$) of Y-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>1.0</td>
<td>249.74</td>
<td>449.42</td>
<td>29.64</td>
<td>47.29</td>
</tr>
<tr>
<td>* 2 (7/21/88)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>3 (7/28/88)</td>
<td>*</td>
<td>263.44</td>
<td>464.5</td>
<td>30.77</td>
<td>49.16</td>
</tr>
<tr>
<td>4 (9/1/88)</td>
<td>*</td>
<td>272.44</td>
<td>459.93</td>
<td>31.28</td>
<td>47.65</td>
</tr>
</tbody>
</table>
Sample Calculation:

Initial Gross Count (CPM) = 126.03
Initial Time (t_i) = 19.1 hr
Final Gross Count (CPM) = 249.74
Final Time (t_f) = 449.42 hr

Activity of Sr-90 (A_{sr-90}) = 387.48 dPM/ml

% Yield = 83.76

A_{sr-90} = (179.2 Pci/ml) \left( \frac{-(0.693)(397)}{e^{28.6 \times 365}} \right) (2.22 dPM/Pci) = 387.48 \text{ dPM/ml}

BKG_i = 1.21 CPM, BKG_f = 1.22 CPM

1. \( \frac{R_i}{(A_{sr})(\text{Yield of sr})} = \epsilon_{sr} + \epsilon_y (1 - e^{-\frac{-(0.693)(t_i)}{64.2}}) \)

2. \( \frac{R_f}{(A_{sr})(\text{Yield of sr})} = \epsilon_{sr} + \epsilon_y (1 - e^{-\frac{-(0.693)(t_f)}{64.2}}) \)

R_i = 126.03 - 1.21 = 124.82 CPM
R_f = 249.74 - 1.22 = 248.52 CPM

1. \( \frac{124.82}{(387.48)(0.8376)} = \epsilon_{sr} + \epsilon_y (1 - e^{-\frac{-(0.693)(19.1)}{64.2}}) \)

2. \( \frac{248.52}{(387.48)(0.8376)} = \epsilon_{sr} + \epsilon_y (1 - e^{-\frac{-(0.693)(449.42)}{64.2}}) \)

1. \(-1 \{ 0.3845683 = \epsilon_{sr} + 0.1863076 \epsilon_y \}

2. \( 0.765886 = \epsilon_{sr} + 0.9921811 \epsilon_y \)

\( 0.3811177 = 0.8058735 \epsilon_y \)

\( \epsilon_y = 47.29 \% \)

\( \epsilon_{sr} = 29.64 \% \)
### SR (No3)² Carrier + SR-90 Tracer

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Initial Gross Count (CPM)</th>
<th>Initial Time (ti) (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/11/88)</td>
<td>1.25</td>
<td>40.95</td>
<td>93.3</td>
<td>107.38</td>
<td>7.78</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>5</td>
<td>38.68</td>
<td>88.2</td>
<td>116.38</td>
<td>9.6</td>
</tr>
<tr>
<td>3 (9/1/88)</td>
<td>5</td>
<td>40.82</td>
<td>93.04</td>
<td>132.23</td>
<td>17.37</td>
</tr>
<tr>
<td>Sample (Date)</td>
<td>Carrier (ml)</td>
<td>Final Gross Count (CPM)</td>
<td>Final Time (hr)</td>
<td>% Efficiency (E) of Sr-90</td>
<td>% Efficiency (E) of Y-90</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>-------------------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>1 (7/11/88)</td>
<td>1.25</td>
<td>241.28</td>
<td>418.85</td>
<td>26.09</td>
<td>40.77</td>
</tr>
<tr>
<td>2 (7/19/88)</td>
<td>5</td>
<td>263.08</td>
<td>427.08</td>
<td>28.97</td>
<td>48.18</td>
</tr>
<tr>
<td>3 (9/1/88)</td>
<td>5</td>
<td>280.10</td>
<td>461.60</td>
<td>27.91</td>
<td>50.09</td>
</tr>
</tbody>
</table>
Sample Calculation:

Initial Gross Count (CPM) = 107.38
Initial Time \( t_i \) = 7.78 hr

Final Gross Count (CPM) = 241.28
Final Time \( t_f \) = 418.85 hr

Activity of Sr-90 \( A_{Sr-90} \) = 387.37 dpm/ml

\% yield = 93.3%

\[ A_{Sr-90} = (179.2 \text{ PCl/ml}) \left( \frac{-0.693(t_f)}{28.6 \times 365} \right) \left( 2.22 \text{ dpm/PCl} \right) = 387.37 \text{ dpm/ml} \]

\[ BKG_i = 1.22 \text{ CPM, } BKG_f = 1.23 \text{ CPM} \]

1. \[ \frac{K_i}{(A_{sr})(\text{yield of Sr})} = \varepsilon_{Sr} + \varepsilon_y \left( 1 - e \frac{-0.693(t_i)}{t_{1/2} \text{ of Y}} \right) \]

2. \[ \frac{K_f}{(A_{sr})(\text{yield of Sr})} = \varepsilon_{Sr} + \varepsilon_y \left( 1 - e \frac{-0.693(t_f)}{t_{1/2} \text{ of Y}} \right) \]

\[ R_i = 107.38 - 1.22 = 106.16 \text{ CPM} \]

\[ R_f = 241.28 - 1.23 = 240.05 \text{ CPM} \]

1. \[ \frac{106.16}{(387.37)(0.933)} = \varepsilon_{Sr} + \varepsilon_y \left( 1 - e \frac{-0.693(7.78)}{64.2} \right) \]

2. \[ \frac{240.05}{(387.37)(0.933)} = \varepsilon_{Sr} + \varepsilon_y \left( 1 - e \frac{-0.693(418.85)}{64.2} \right) \]

1. \[ 0.2937333 = \varepsilon_{Sr} + 0.0805506 \varepsilon_y \]

2. \[ 0.6641926 = \varepsilon_{Sr} + 0.9891243 \varepsilon_y \]

\[ 0.3704593 = 0.9085737 \varepsilon_y \]

\[ \varepsilon_{Sr} = 40.77 \% \]

\[ \varepsilon_{Sr} = 26.09 \% \]

\[ \varepsilon_{Sr} = 26.09 \% \]
Calculation of standard deviation ($\sigma$):

\[
\%E = 40.77, \; 48.18, \; 50.09
\]
\[
\text{Range} = 50.09 - 48.18 = 1.91
\]
\[
\text{Mean} = \frac{48.18 + 50.09}{2} = 49.13
\]

\[
\sigma = (\text{Range}) \times (\text{Multiplying factor})
\]
\[
= (1.91) \times (0.886) = 1.69
\]
\[
\text{Mean} \pm 3\sigma = 49.13 \pm 3(1.69) \Rightarrow 54.2, 44.06
\]

Since 40.77 does not fall within these two values, it can be discarded.

Multiplying factor = 0.886 for two measurements, from NCRP report #59, p. 316.
SR(NO3)2 carrier + Sr-90 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Initial Gross Count (CPM)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 1 (7/11/88)</td>
<td>1.50</td>
<td>53.65</td>
<td>&gt;100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>5</td>
<td>45.64</td>
<td>86.7</td>
<td>112.70</td>
<td>11.27</td>
</tr>
<tr>
<td>+ 3 (7/28/88)</td>
<td>5</td>
<td>44.12</td>
<td>83.80</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 (9/1/88)</td>
<td>5</td>
<td>45.82</td>
<td>87.03</td>
<td>153.08</td>
<td>32.97</td>
</tr>
<tr>
<td>5 (9/6/88)</td>
<td>5</td>
<td>42.92</td>
<td>81.52</td>
<td>137.52</td>
<td>34.63</td>
</tr>
</tbody>
</table>

(*, +) They were not used to plot.
+ It was only counted for 30 min due to some problem with Power.
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Final Gross Count (CPM)</th>
<th>Final Time (hr)</th>
<th>% Efficiency (e) of Sr-90</th>
<th>% Efficiency (e) of Y-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 1 (7/11/88)</td>
<td>1.50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>-</td>
<td>256.36</td>
<td>428.33</td>
<td>27.60</td>
<td>48.87</td>
</tr>
<tr>
<td>+ 3 (7/28/88)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 (9/6/88)</td>
<td>-</td>
<td>259.44</td>
<td>345.42</td>
<td>31.21</td>
<td>46.81</td>
</tr>
<tr>
<td>5 (9/16/88)</td>
<td>-</td>
<td>242.72</td>
<td>347.08</td>
<td>27.64</td>
<td>50.32</td>
</tr>
</tbody>
</table>

(*, +) They were not used to Plot.
Sample Calculation:

Initial Gross Count (CPM) = 112.70

Initial Time (t_i) = 11.27 hr

Final Gross Count (CPM) = 256.36

Final Time (t_f) = 428.33 hr

Activity of Sr-90 (A_{sr-90}) = 387.22 dpm/ml

% Yield = 86.7

\[ A_{sr-90} = \frac{179.2 \text{ PCI/ml}}{e^{\frac{(0.693)(407)}{28.6 \times 365}}} \times \frac{2.22 \text{ dpm/PCI}}{\text{dpm/ml}} = 387.22 \text{ dpm/ml} \]

BKG_i = 1.23 CPM, BKG_f = 1.22 CPM

1. \[ \frac{R_i}{(A_{sr})(\text{yield of sr})} = \varepsilon_{sr} + \varepsilon_y \left(1 - e^{\frac{(0.693)(t_i)}{64.2}}\right) \]

2. \[ \frac{R_f}{(A_{sr})(\text{yield of sr})} = \varepsilon_{sr} + \varepsilon_y \left(1 - e^{\frac{(0.693)(t_f)}{64.2}}\right) \]

\[ R_i = 112.70 - 1.23 = 111.47 \text{ CPM} \]

\[ R_f = 256.36 - 1.22 = 255.14 \text{ CPM} \]

1. \[ \frac{111.47}{(387.22)(0.867)} = \varepsilon_{sr} + \varepsilon_y \left(1 - e^{\frac{(0.693)(11.27)}{64.2}}\right) \]

2. \[ \frac{255.14}{(387.22)(0.867)} = \varepsilon_{sr} + \varepsilon_y \left(1 - e^{\frac{(0.693)(428.33)}{64.2}}\right) \]

1. \[ 1 - \left\{ \frac{0.3320329}{0.1145442} = \varepsilon_{sr} + 0.875638 \varepsilon_y \right\} \]

2. \[ \frac{0.7599791}{0.9901822} = \varepsilon_{sr} + 0.9901822 \varepsilon_y \]

\[ \varepsilon_y = 48.87 \% \]

\[ \varepsilon_{sr} = 27.60 \% \]
SR(NO3)2 Carrier + Sr-90 tracer:

GA Power Detector -

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Initial Gross Count (CPM)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 1 (7/11/88)</td>
<td>1.75</td>
<td>62.13</td>
<td>&gt;100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (7/11/88)</td>
<td></td>
<td>54.73</td>
<td>89.1</td>
<td>113.32</td>
<td>12.93</td>
</tr>
<tr>
<td>3 (9/6/88)</td>
<td></td>
<td>53.15</td>
<td>86.53</td>
<td>146.86</td>
<td>36.3</td>
</tr>
<tr>
<td>4 (9/6/88)</td>
<td></td>
<td>55.32</td>
<td>90.06</td>
<td>148.42</td>
<td>37.97</td>
</tr>
</tbody>
</table>

* It was not used to plot
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Final Gross Count (CPM)</th>
<th>Final Time (hr)</th>
<th>% Efficiency (ε) of Sr-90</th>
<th>% Efficiency (ε) of Y-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/11/88)</td>
<td>1.75</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>5</td>
<td>257.74</td>
<td>430.01</td>
<td>26.14</td>
<td>48.53</td>
</tr>
<tr>
<td>3 (9/6/88)</td>
<td>5</td>
<td>253.28</td>
<td>348.75</td>
<td>27.84</td>
<td>48.78</td>
</tr>
<tr>
<td>4 (9/6/88)</td>
<td>5</td>
<td>265.28</td>
<td>350.42</td>
<td>24.73</td>
<td>52.46</td>
</tr>
</tbody>
</table>
Sample Calculation:

Initial Gross Count (CPM) = 113.32

Initial Time (t_i) = 12.93 hr

Final Gross Count (CPM) = 257.74

Final Time (t_f) = 430.01 hr

Activity of Sr-90 (A_{Sr-q_0}) = 387.22 dpm/ml

% Yield = 89.1

A_{Sr-q_0} = \left( \frac{179.2 \text{ Pci}}{\text{ml}} \right) \left( \frac{(0.693)(467)}{e^{28.6 \times 365}} \right) (2.22 \text{ dpm/Pci}) = 387.22 \text{ dpm/ml}

BKG_i = 1.23 \text{ CPM, BKG}_F = 1.22 \text{ CPM}

1. \quad \frac{R_i}{(A_{Sr})(\text{yield of Sr})} = \epsilon_{Sr} + \epsilon_y \left( 1 - e^{-\frac{(0.693)(t_i)}{69.2}} \right)

2. \quad \frac{R_f}{(A_{Sr})(\text{yield of Sr})} = \epsilon_{Sr} + \epsilon_y \left( 1 - e^{-\frac{(0.693)(t_f)}{69.2}} \right)

R_i = 113.32 - 1.23 = 112.09 \text{ CPM}

R_f = 257.74 - 1.22 = 256.52 \text{ CPM}

1. \quad \frac{112.09}{(387.22)(0.891)} = \epsilon_{Sr} + \epsilon_y \left( 1 - e^{-\frac{(0.693)(12.93)}{69.2}} \right)

2. \quad \frac{257.74}{(387.22)(0.891)} = \epsilon_{Sr} + \epsilon_y \left( 1 - e^{-\frac{(0.693)(430.01)}{69.2}} \right)

1. -1 \left\{ 0.3246254 = \frac{\epsilon_{Sr} + 0.1302691}{0.9966296} \epsilon_y \right\}

2. \quad 0.742009 = \epsilon_{Sr} + 0.9963586 \epsilon_y

\begin{align*}
0.4173155 &= 0.8600895 \epsilon_y \\
\epsilon_y &= 48.53 \%
\end{align*}

\begin{align*}
\epsilon_{Sr} &= 26.14 \%
\end{align*}
**Sr(NO₃)₂ Carrier + Sr-90 tracer:**

**GA Power Detector:**

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Initial Gross Count (CPM)</th>
<th>Initial Time (t₁) (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/11/88)</td>
<td>2.0</td>
<td>67.51</td>
<td>96.2</td>
<td>104.56</td>
<td>10.28</td>
</tr>
<tr>
<td>* 2 (7/28/88)</td>
<td>5</td>
<td>61.41</td>
<td>87.48</td>
<td>127.78</td>
<td>—</td>
</tr>
<tr>
<td>3 (9/6/88)</td>
<td>5</td>
<td>63.04</td>
<td>89.80</td>
<td>141.76</td>
<td>39.38</td>
</tr>
<tr>
<td>4 (9/6/88)</td>
<td>5</td>
<td>65.64</td>
<td>93.50</td>
<td>155.34</td>
<td>41.05</td>
</tr>
</tbody>
</table>

* A little bit of ppt. was lost while mounting.
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Final Gross Count (CPM)</th>
<th>Final Time ($t_f$) (hr)</th>
<th>%Efficiency ($E$) of Sr-90</th>
<th>%Efficiency ($E$) of Y-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/11/88)</td>
<td>2.0</td>
<td>254.56</td>
<td>423.85</td>
<td>22.95</td>
<td>45.50</td>
</tr>
<tr>
<td>* 2 (7/28/88)</td>
<td>s</td>
<td>257.32</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 (9/6/88)</td>
<td>s</td>
<td>257.86</td>
<td>351.83</td>
<td>24.87</td>
<td>50.32</td>
</tr>
<tr>
<td>4 (9/6/88)</td>
<td>s</td>
<td>261.00</td>
<td>353.5</td>
<td>25.82</td>
<td>47.23</td>
</tr>
</tbody>
</table>
Sample Calculation:

Initial Gross Count (CPM) = 104.56
Initial Time (t_i) = 10.28 hr
Final Gross Count (CPM) = 254.56
Final Time (t_f) = 423.85 hr
Activity of Sr-90 (A_{Sr-90}) = 387.37 dpm/ml

\% yield = 96.2

\[ A_{Sr-90} = \left( 179.2 \text{ pCi/ml} \right) \times \left( e^{-\frac{(0.693)(%)}{28.6 \times 365}} \right) \times 2.22 \text{ dpm/\text{mCi}} = 387.37 \text{ dpm/ml} \]

BKG_i = 1.22 CPM, BKG_f = 1.23 CPM

1. \[ \frac{R_i}{(A_{Sr})(\text{yield of Sr})} = \epsilon_{Sr} + \epsilon_{Y} \left( 1 - e^{-\frac{t_i}{t_{1/2} of Y}} \right) \]

2. \[ \frac{R_f}{(A_{Sr})(\text{yield of Sr})} = \epsilon_{Sr} + \epsilon_{Y} \left( 1 - \frac{(0.693)(t_i)}{t_{1/2} of Y} \right) \]

\[ R_i = 104.56 - 1.22 = 103.34 \text{ CPM} \]

\[ R_f = 254.56 - 1.23 = 253.33 \text{ CPM} \]

1. \[ \frac{103.34}{(387.37)(0.962)} = \epsilon_{Sr} + \epsilon_{Y} \left( 1 - \frac{(0.693)(10.28)}{64.2} \right) \]

2. \[ \frac{253.33}{(387.37)(0.962)} = \epsilon_{Sr} + \epsilon_{Y} \left( 1 - \frac{(0.693)(423.85)}{64.2} \right) \]

1. \[ 0.2773111 = \epsilon_{Sr} + 0.1050311 \epsilon_{Y} \]

2. \[ 0.6798069 = \epsilon_{Sr} + 0.9896958 \epsilon_{Y} \]

\[ 0.4024958 = 0.7846647 \epsilon_{Y} \]

\[ \epsilon_{Y} = 45.50 \% \]

\[ \epsilon_{Sr} = 22.95 \% \]
Figure #5

- Average Value (Y-90)
- Average Value (Sr-90)
- Average Value (Sr-89)
Appendix D

GA Tech Results (SR-90 and Y-90)
Sr(NO₃)₂ Carrier + Sr-90 tracer:

GA Tech Detector -

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (t₁) (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X 1 (7/14/88)</td>
<td>0.1</td>
<td>4.79</td>
<td>&gt; 100</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td></td>
<td>2.77</td>
<td>78.9</td>
<td>3684</td>
<td>4.5</td>
</tr>
<tr>
<td>+ 3 (7/21/88)</td>
<td></td>
<td>1.17</td>
<td>33.3</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4 (7/28/88)</td>
<td></td>
<td>2.55</td>
<td>72.65</td>
<td>3825</td>
<td>5.92</td>
</tr>
<tr>
<td>5 (8/25/85)</td>
<td></td>
<td>2.61</td>
<td>14.36</td>
<td>3708</td>
<td>3.78</td>
</tr>
<tr>
<td>Sample (Date)</td>
<td>Carrier (ml)</td>
<td>Total Final Gross Count (50 min)</td>
<td>Final Time (E)</td>
<td>% Efficiency (E) of Sr-90</td>
<td>% Efficiency (E) of Y-90</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
<td>---------------------------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>* 1 (7/14/88)</td>
<td>0.1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td></td>
<td>7465</td>
<td>464.48</td>
<td>22.57</td>
<td>26.18</td>
</tr>
<tr>
<td>+ 3 (7/21/88)</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4 (7/28/88)</td>
<td></td>
<td>7976</td>
<td>446.02</td>
<td>24.90</td>
<td>31.83</td>
</tr>
<tr>
<td>5 (8/25/88)</td>
<td></td>
<td>7441</td>
<td>419.5</td>
<td>24.37</td>
<td>27.40</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 3684
Initial Time \( (t_i) = 4.5 \text{ hr} \)
Total Final Gross Count = 7465
Final Time \( (t_f) = 464.48 \text{ hr} \)
Activity of \( \text{Sr}-90 \) \( (A_{\text{sr}-90}) = 387.22 \text{ dpm/ml} \)
Yield = 78.9
\[
A_{\text{sr}-90} = (179.2 \text{ pCi/ml}) \left( e^{\frac{-0.693(464.48)}{28.6 \times 365}} \right) (2.22 \text{ dpm/pCi}) = 387.22 \text{ dpm/ml}
\]
BKG \(_L = 46.25 \), \( \text{BKG} \(_F = 44.25 \)

1. \[
\frac{R_i}{(A_{\text{sr}})\text{(yield of sr)}} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{\frac{-0.693(t_i)}{t_{1/2 \text{ of y}}}} \right)
\]

2. \[
\frac{R_f}{(A_{\text{sr}})\text{(yield of y)}} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{\frac{-0.693(t_f)}{t_{1/2 \text{ of y}}}} \right)
\]

\[
R_i = \frac{3684 - 46.25}{50} = 72.75 \text{ CPM}
\]
\[
R_f = \frac{7465 - 44.25}{50} = 148.41 \text{ CPM}
\]

1. \[
\frac{72.75}{(387.22)(0.789)} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{\frac{-0.693(4.5)}{64.2}} \right)
\]

2. \[
\frac{148.41}{(387.22)(0.789)} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{\frac{-0.693(464.48)}{64.2}} \right)
\]

1. \[
-1 \left\{ \frac{0.2381212}{0.0474138} \right\} = \varepsilon_{\text{sr}} + 0.0474138 \varepsilon_y
\]

2. \[
0.4859674 = \varepsilon_{\text{sr}} + 0.9933542 \varepsilon_y
\]

\[
\frac{0.2471462}{0.9459441} = \varepsilon_y
\]

\[
\varepsilon_y = 26.18\%
\]

\[
\varepsilon_{\text{sr}} = 22.57\%
\]
SR(No3)2 Carrier + Sr-90 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (t) (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/14/88)</td>
<td>0.2</td>
<td>4.48</td>
<td>63.8</td>
<td>4008</td>
<td>5.85</td>
</tr>
<tr>
<td>2 (7/21/88)</td>
<td>5</td>
<td>4.11</td>
<td>58.5</td>
<td>4112</td>
<td>4.78</td>
</tr>
<tr>
<td>3 (8/25/88)</td>
<td>5</td>
<td>6.19</td>
<td>88.18</td>
<td>5306</td>
<td>4.63</td>
</tr>
<tr>
<td>Sample (Date)</td>
<td>Carrier (ml)</td>
<td>Total Final Gross Count (50 min)</td>
<td>Final Time (hr)</td>
<td>% Efficiency (e) of Sr-90</td>
<td>% Efficiency (e) of Y-90</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------</td>
<td>----------------------------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>1 (7/14/88)</td>
<td>0.2</td>
<td>8513</td>
<td>485.18</td>
<td>29.67</td>
<td>39.03</td>
</tr>
<tr>
<td>2 (7/21/88)</td>
<td>5</td>
<td>8570</td>
<td>363.1</td>
<td>33.75</td>
<td>42.40</td>
</tr>
<tr>
<td>3 (8/25/88)</td>
<td>5</td>
<td>11334</td>
<td>420.33</td>
<td>28.96</td>
<td>37.71</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 4008
Initial Time \( t_i \) = 5.85 hr
Total Final Gross Count = 8513
Final Time \( t_f \) = 485.18 hr
Activity of \( \text{Sr}-90 \) \( (A_{\text{Sr-90}}) = 387.30 \text{ dpm/ml} \)
% yield = 63.8
\( A_{\text{Sr-90}} = (19.2 \text{ PCI/ml}) \left( e^{-\frac{(0.693)(485.18)}{206.6}} \right) (2.22 \text{ dpm/PCI}) = 387.30 \text{ dpm/ml} \)
BKG \( i = 47.20 \quad \text{BKG} \_f = 50.66 \)

1. \( \frac{R_i}{(A_{\text{Sr}}) \times \text{yield of Sr}} = \varepsilon_{\text{Sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_i)}{64.2}} \right) \)

2. \( \frac{R_f}{(A_{\text{Sr}}) \times \text{yield of Sr}} = \varepsilon_{\text{Sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_f)}{64.2}} \right) \)

\( R_i = \frac{4008 - 47.20}{50} = 79.22 \quad \text{CPM} \)
\( R_f = \frac{8513 - 50.66}{50} = 169.25 \quad \text{CPM} \)

1. \( \frac{79.22}{(387.30)(0.638)} = \varepsilon_{\text{Sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(5.85)}{64.2}} \right) \)

2. \( \frac{169.25}{(387.30)(0.638)} = \varepsilon_{\text{Sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(485.18)}{64.2}} \right) \)

\( 1 - \left\{ \frac{0.3205861}{0.3643664} = \frac{\varepsilon_{\text{Sr}} + 0.06119447 \varepsilon_y}{0.9334903 \varepsilon_y} \right\} \)

\( 0.6849525 = \frac{\varepsilon_{\text{Sr}} + 0.994685 \varepsilon_y}{0.3643664} = 0.9334903 \varepsilon_y \)

\( \varepsilon_y = 39.03 \% \)
\( \varepsilon_{\text{Sr}} = 29.67 \% \)
sr(NO₃)₂ Carrier + Sr-90 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>0.4</td>
<td>10.14</td>
<td>72.24</td>
<td>4701</td>
<td>8.18</td>
</tr>
<tr>
<td>2 (7/14/88)</td>
<td>5</td>
<td>11.48</td>
<td>81.77</td>
<td>5479</td>
<td>6.7</td>
</tr>
<tr>
<td>*3 (8/25/88)</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 (9/1/88)</td>
<td>5</td>
<td>11.67</td>
<td>83.12</td>
<td>5141</td>
<td>3.93</td>
</tr>
</tbody>
</table>

* Sample was lost while centrifuging
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Total Final Gross Count (50 min)</th>
<th>Final Time (tf), hr</th>
<th>% Efficiency (ε) of Sr</th>
<th>% Efficiency (ε) of Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>0.4</td>
<td>9532</td>
<td>435.25</td>
<td>30.01</td>
<td>38.05</td>
</tr>
<tr>
<td>2 (7/14/88)</td>
<td></td>
<td>11797</td>
<td>486.03</td>
<td>31.30</td>
<td>43.12</td>
</tr>
<tr>
<td>3 (8/25/88)</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 (9/1/88)</td>
<td>0.5</td>
<td>11411</td>
<td>447.33</td>
<td>30.02</td>
<td>41.12</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 4701

Initial Time (t₁) = 8.18 hr

Total Final Gross Count = 9532

Final Time (t₂) = 435.25 hr

Activity of Sr-90 (A_{Sr-90}) = 387.48 dpm/ml

Yield = 72.24

A_{Sr-90} = (179.2 Pci/ml)(\frac{-(0.693)(397)}{e^{2.22 \times 345}})(2.22 dpm/Pci) = 387.48 dpm/ml

BKG = 50.37 → BKG = 54.6

1. \[ \frac{R_i}{(A_{Sr})(yield \ of \ sr)} = \epsilon_{sr} + \epsilon_y \left(1 - e^{-\frac{(0.693)(t_i)}{64.2}}\right) \]

2. \[ \frac{R_f}{(A_{Sr})(yield \ of \ sr)} = \epsilon_{sr} + \epsilon_y \left(1 - e^{-\frac{(0.693)(t_f)}{64.2}}\right) \]

R_i = \frac{4701 - 50.37}{50} = 93.01 CPM

R_f = \frac{9532 - 54.6}{50} = 189.55

1. \[ \frac{93.01}{(387.48)(0.7224)} = \epsilon_{sr} + \epsilon_y \left(1 - e^{-\frac{(0.693)(8.18)}{64.2}}\right) \]

2. \[ \frac{189.55}{(387.48)(0.7224)} = \epsilon_{sr} + \epsilon_y \left(1 - e^{-\frac{(0.693)(435.25)}{64.2}}\right) \]

1. \{-1 \left\{ 0.3322787 = \epsilon_{sr} + 0.084512 \ \epsilon_y \right\} \}

2. \[ \frac{0.6771685}{0.3448898} = \epsilon_{sr} + 0.9908888 \ \epsilon_y \]

\[ \frac{0.3448898}{0.3448898} = 0.9063767 \ \epsilon_y \]

\[ \epsilon_y = 38.05 \% \]

\[ \epsilon_{sr} = 30.01 \% \]
### SR(NO3)2 Carrier + SR-90 Tracer:

#### GA Tech Detector:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (t2) (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>0.6</td>
<td>16.25</td>
<td>77.18</td>
<td>5249</td>
<td>7.33</td>
</tr>
<tr>
<td>2 (7/14/88)</td>
<td>5</td>
<td>15.14</td>
<td>71.89</td>
<td>5326</td>
<td>7.53</td>
</tr>
<tr>
<td>3 (8/12/88)</td>
<td>5</td>
<td>17.78</td>
<td>84.42</td>
<td>5639</td>
<td>5.47</td>
</tr>
<tr>
<td>Sample (Date)</td>
<td>Carrier</td>
<td>Total Final Gross Count (50 min)</td>
<td>Final Time ($t_f$), (hr)</td>
<td>% Efficiency (e) of sr</td>
<td>% Efficiency (e) of y</td>
</tr>
<tr>
<td>---------------</td>
<td>---------</td>
<td>---------------------------------</td>
<td>--------------------------</td>
<td>------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>1 (7/7/88)</td>
<td>0.6</td>
<td>11493</td>
<td>436.83</td>
<td>31.29</td>
<td>45.61</td>
</tr>
<tr>
<td>2 (7/14/88)</td>
<td>5</td>
<td>11483</td>
<td>486.87</td>
<td>34.15</td>
<td>48.22</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>12897</td>
<td>421.17</td>
<td>31.54</td>
<td>47.67</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 5249
Initial Time ($t_i$) = 7.33 hr

Total Final Gross Count = 11493
Final Time ($t_f$) = 436.08 hr

Activity of $sr$-aq ($A_{sr,qo}$) = 387.48 dPM/ml

\[
\% \text{ Yield} = 77.18
\]

$A_{sr,qo} = (179.2 \text{ PCI/ml})(e^{-\frac{(0.693)(344)}{22.6 \times 365}})(2.22 \text{ dPM/PCI}) = 387.48 \text{ dPM/ml}

BKG$_i$ = 50.37 CPM, BKG$_f$ = 54.6 CPM

1. \[
\frac{R_i}{(A_{sr})(\text{yield of } sr)} = \epsilon_s + \epsilon_y \left(1 - e^{-\frac{-(0.693)(t_i)}{t_{1/2}\text{ of } y}}\right)
\]

2. \[
\frac{R_f}{(A_{sr})(\text{yield of } sr)} = \epsilon_s + \epsilon_y \left(1 - e^{-\frac{-(0.693)(t_f)}{t_{1/2}\text{ of } y}}\right)
\]

\[
R_i = \frac{5249 - 50.37}{50} = 103.97 \text{ CPM}
\]

\[
R_f = \frac{11493 - 54.6}{50} = 228.77 \text{ CPM}
\]

1. \[
\frac{103.97}{(387.48)(0.7718)} = \epsilon_s + \epsilon_y \left(1 - e^{-\frac{-(0.693)(7.33)}{64.2}}\right)
\]

2. \[
\frac{228.77}{(387.48)(0.7718)} = \epsilon_s + \epsilon_y \left(1 - e^{-\frac{-(0.693)(436.08)}{64.2}}\right)
\]

1. \[
0.3476483 = \epsilon_s + 0.0760736 \epsilon_y
\]

2. \[
0.7649209 = \epsilon_s + 0.9909704 \epsilon_y
\]

\[
0.4192726 = 0.9148968 \epsilon_y
\]

$\epsilon_y = 45.61 \%$

$\epsilon_{sr} = 31.29 \%$

102
Sr(NO₃)₂ Carrier + Sr-90 tracer:

**GA Tech Detector—**

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (t₀) (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/1/88)</td>
<td>0.8</td>
<td>21.66</td>
<td>77.16</td>
<td>4988</td>
<td>6.5</td>
</tr>
<tr>
<td>2 (7/21/88)</td>
<td></td>
<td>21.92</td>
<td>78.10</td>
<td>4994</td>
<td>7.12</td>
</tr>
<tr>
<td>3 (9/1/88)</td>
<td></td>
<td>24.83</td>
<td>88.43</td>
<td>5930</td>
<td>4.77</td>
</tr>
<tr>
<td>Sample (Date)</td>
<td>Carrier (ml)</td>
<td>Total Final Gross Count (50 min)</td>
<td>Final Time (hr)</td>
<td>% Efficiency (Sr-90)</td>
<td>% Efficiency (Y-90)</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>---------------------------------</td>
<td>----------------</td>
<td>----------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>1 (7/2/88)</td>
<td>0.8</td>
<td>11264</td>
<td>436.93</td>
<td>29.95</td>
<td>45.44</td>
</tr>
<tr>
<td>2 (7/21/88)</td>
<td></td>
<td>11551</td>
<td>363.93</td>
<td>29.17</td>
<td>47.90</td>
</tr>
<tr>
<td>3 (9/1/88)</td>
<td></td>
<td>13851</td>
<td>448.17</td>
<td>31.98</td>
<td>49.27</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 4988

Initial Time \((t_i)\) = 6.5 hr

Total Final Gross Count = 11264

Final Time \((t_f)\) = 436.9 hr

Activity of Sr-90 \((A_{\text{sr-90}})\) = 387.48 dpm/ml

Yield = 77.16

\[ A_{\text{sr-90}} = (179.2 \text{ Pci/ml}) \left( e^{-\frac{(0.693)(t_f)}{2.22}} \right) \]

BKG = 50.37 \( \rightarrow \) BKG = 54.6

1. \[ \frac{R_i}{(A_{\text{sr}})(\text{yield of sr})} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{-\frac{t_i}{2.22}} \right) \]

2. \[ \frac{R_f}{(A_{\text{sr}})(\text{yield of sr})} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{-\frac{t_f}{2.22}} \right) \]

\[ R_i = \frac{4988 - 50.37}{50} = 98.75 \text{ CPM} \]

\[ R_f = \frac{11264 - 54.6}{50} = 224.19 \text{ CPM} \]

1. \[ \frac{98.75}{(387.48)(0.7716)} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{-\frac{6.5}{64.2}} \right) \]

2. \[ \frac{224.19}{(387.48)(0.7716)} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{-\frac{224.19}{64.2}} \right) \]

1. \( -1 \left\{ \begin{array}{l} 0.330277 = \varepsilon_{\text{sr}} + 0.677586 \varepsilon_y \\ \end{array} \right\} \]

2. \[ 0.7498013 = \varepsilon_{\text{sr}} + 0.9910526 \varepsilon_y \]

\[ 0.4195233 = 0.923294 \varepsilon_y \]

\[ \varepsilon_y = 45.44\% \]

\[ \varepsilon_{\text{sr}} = 29.95\% \]
\( \text{Sr(NO}_3\text{)}_2 \) Carrier + Sr-90 tracer:

**GA Tech Detector**

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of precipitate (mg)</th>
<th>% Yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (t) (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>1.0</td>
<td>29.39</td>
<td>83.76</td>
<td>4899</td>
<td>6.08</td>
</tr>
<tr>
<td>* 2 (7/12/88)</td>
<td>5</td>
<td>28.80</td>
<td>82.05</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 (7/28/88)</td>
<td>5</td>
<td>29.88</td>
<td>85.13</td>
<td>5672</td>
<td>6.75</td>
</tr>
<tr>
<td>4 (9/1/88)</td>
<td>5</td>
<td>31.38</td>
<td>89.40</td>
<td>5628</td>
<td>5.6</td>
</tr>
</tbody>
</table>

* Some of ppt. was lost while mounting, it was not used to plot.
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Total Final Gross Count (50 min)</th>
<th>Final Time (µp) (hr)</th>
<th>% Efficiency (e) of Sr-90</th>
<th>% Efficiency (e) of y-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/7/88)</td>
<td>1.0</td>
<td>12390</td>
<td>438.18</td>
<td>26.72</td>
<td>49.73</td>
</tr>
<tr>
<td>2 (7/21/88)</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 (7/28/88)</td>
<td>5</td>
<td>12692</td>
<td>446.85</td>
<td>30.89</td>
<td>46.31</td>
</tr>
<tr>
<td>4 (9/11/88)</td>
<td>5</td>
<td>13000</td>
<td>449.0</td>
<td>29.64</td>
<td>45.76</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 4899
Initial Time \( t_i \) = 6.08 hr
Total Final Gross Count = 12390
Final Time \( t_f \) = 438.18 hr
Activity of \( \text{Sr-90} \) (\( A_{\text{Sr-90}} \)) = 387.48 dpm/ml

\[ \% \text{Yield} = 83.76 \]

\[ A_{\text{Sr-90}} = \left( \frac{179.2 \text{ pCi}}{\text{ml}} \right) \left( e^{-\frac{(0.693)(397)}{28.6 \times 365}} \right) \times 2.22 \text{ dpm/pCi} = 387.48 \text{ dpm/ml} \]

\[ \text{BKG}_i = 50.37 \quad \text{BKG}_f = 54.6 \]

1. \[ \frac{R_i}{(A_{\text{Sr}})(\text{yield of Sr})} = \varepsilon_{\text{Sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_i)}{64.2}} \right) \]

2. \[ \frac{R_f}{(A_{\text{Sr}})(\text{yield of Sr})} = \varepsilon_{\text{Sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_f)}{64.2}} \right) \]

\[ R_i = \frac{4899 - 50.37}{50} = 96.97 \text{ CPM} \]

\[ R_f = \frac{12390 - 54.6}{50} = 246.71 \text{ CPM} \]

1. \[ \frac{96.97}{(387.48)(0.8376)} = \varepsilon_{\text{Sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(6.08)}{64.2}} \right) \]

2. \[ \frac{246.71}{(387.48)(0.8376)} = \varepsilon_{\text{Sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(438.18)}{64.2}} \right) \]

\[ 1 - \left\{ 0.2987629 = \varepsilon_{\text{Sr}} + 0.0635226 \varepsilon_y \right\} \]

\[ 0.7601033 = \varepsilon_{\text{Sr}} + 0.9911725 \varepsilon_y \]

\[ 0.4613403 = 0.9276499 \varepsilon_y \]

\[ \varepsilon_y = 49.73\% \]

\[ \varepsilon_{\text{Sr}} = 26.72\% \]
Sr(NO₃)₂ carrier + Sr-90 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/11/88)</td>
<td>1.25</td>
<td>40.95</td>
<td>93.3</td>
<td>5020</td>
<td>4.45</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>5</td>
<td>38.68</td>
<td>88.2</td>
<td>5387</td>
<td>5.33</td>
</tr>
<tr>
<td>3 (9/1/88)</td>
<td>5</td>
<td>40.82</td>
<td>93.04</td>
<td>5408</td>
<td>6.43</td>
</tr>
<tr>
<td>Sample (Date)</td>
<td>Carrier (ml)</td>
<td>Total Final Gross Count (50 minutes)</td>
<td>Final Time (tf) (hr)</td>
<td>% Efficiency of Sr-90</td>
<td>% Efficiency of Y-90</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------</td>
<td>-------------------------------------</td>
<td>---------------------</td>
<td>----------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>1 (7/11/88)</td>
<td>1.25</td>
<td>11916</td>
<td>418.85</td>
<td>25.60</td>
<td>40.48</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>5</td>
<td>13158</td>
<td>465.17</td>
<td>28.56</td>
<td>48.55</td>
</tr>
<tr>
<td>3 (9/11/88)</td>
<td>5</td>
<td>13613</td>
<td>499.83</td>
<td>26.52</td>
<td>49.38</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 5020
Initial Time \( (t_i) = 4.45 \) hr
Total Final Gross Count = 11916
Final Time \( (t_f) = 418.85 \) hr

Activity of \( \text{sr}-q_0 \) \( (A_{\text{sr},q_0}) = 387.37 \) dpm/ml

\[ A_{\text{sr}-q_0} \approx \left(179.2 \text{ Pci/ml} \right) \left( e^{-(0.693)(418)} \right) \approx 387.37 \text{ dpm/ml} \]

\[ \% \, \text{yield} = 93.3 \%
\]

\[ BKG = 50.66 \quad \text{and} \quad BKG_f = 53.6 \]

\[ \text{1) } \frac{R_i}{(A_{\text{sr}}) \text{ (yield of sr)}} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_i)}{64.2}} \right) \]

\[ \text{2) } \frac{R_f}{(A_{\text{sr}}) \text{ (yield of sr)}} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_f)}{64.2}} \right) \]

\[ R_i = \frac{5020 - 50.66}{50} = 99.39 \text{ CPM} \]

\[ R_f = \frac{11916 - 53.6}{50} = 237.25 \text{ CPM} \]

\[ \text{1) } \frac{99.39}{(387.37)(0.933)} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(4.45)}{64.2}} \right) \]

\[ \text{2) } \frac{237.25}{(387.37)(0.933)} = \varepsilon_{\text{sr}} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(418.85)}{64.2}} \right) \]

\[ \begin{aligned} \text{1) } &0.2750015 = \varepsilon_{\text{sr}} + 0.0468996 \varepsilon_y \\ \text{2) } &0.6564453 = \varepsilon_{\text{sr}} + 0.9891243 \varepsilon_y \end{aligned} \]

\[ 0.3814438 = 0.9422247 \varepsilon_y \]

| \varepsilon_y = 40.48 \% |
| \varepsilon_{\text{sr}} = 25.60 \% |
SR(NO3)2 Carrier + Sr-90 tracer:

GA Tech Detector —

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1 (7/11/88)</td>
<td>1.50</td>
<td>53.65</td>
<td>&gt;100</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>5</td>
<td>45.64</td>
<td>86.7</td>
<td>50.32</td>
<td>6.17</td>
</tr>
<tr>
<td>3 (7/28/88)</td>
<td>5</td>
<td>44.12</td>
<td>83.80</td>
<td>51.53</td>
<td>7.45</td>
</tr>
<tr>
<td>4 (9/16/88)</td>
<td>5</td>
<td>45.82</td>
<td>87.03</td>
<td>5188</td>
<td>4.1</td>
</tr>
<tr>
<td>5 (9/16/88)</td>
<td>5</td>
<td>42.92</td>
<td>81.52</td>
<td>4888</td>
<td>4.95</td>
</tr>
</tbody>
</table>

* It was not used to plot
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Total Final Gross Count (50 min)</th>
<th>Final Time (zf) (hr)</th>
<th>% Efficiency (e) of Sr90</th>
<th>% Efficiency (e) of Y-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 1 (7/11/88)</td>
<td>1.50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 (7/19/88)</td>
<td>5</td>
<td>12103</td>
<td>466.0</td>
<td>26.78</td>
<td>45.34</td>
</tr>
<tr>
<td>3 (7/28/88)</td>
<td>5</td>
<td>12442</td>
<td>447.68</td>
<td>27.58</td>
<td>49.32</td>
</tr>
<tr>
<td>4 (9/6/88)</td>
<td>5</td>
<td>12335</td>
<td>332.82</td>
<td>28.61</td>
<td>45.80</td>
</tr>
<tr>
<td>5 (9/6/88)</td>
<td>5</td>
<td>11808</td>
<td>333.45</td>
<td>28.27</td>
<td>47.78</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 503.2
Initial Time ($t_i$) = 6.17 hr
Total Final Gross Count = 12103
Final Time ($t_f$) = 466.0 hr
Activity of Sr-90 ($A_{Sr-90}$) = 387.22 dpm/ml
% Yield = 86.7

$A_{Sr-90} = (179.2 \text{ PCI/ml}) \left( \frac{0.693(707)}{2.22 \text{ dpm/ml}} \right) = 387.22 \text{ dpm/ml}$

BKG$_i$ = 46.25
BKG$_f$ = 44.25

1. \[ \frac{R_i}{(A_{Sr})(\text{Yield of Sr})} = \epsilon_{Sr} + \epsilon_Y(1 - e^{-\frac{(0.693)(t_i)}{t_{1/2} of Y}}) \]

2. \[ \frac{R_f}{(A_{Sr})(\text{Yield of Sr})} = \epsilon_{Sr} + \epsilon_Y(1 - e^{-\frac{(0.693)(t_f)}{t_{1/2} of Y}}) \]

$R_i = \frac{503.2 - 46.25}{50} = 99.71 \text{ CPM}$
$R_f = \frac{12103 - 44.25}{50} = 241.13 \text{ CPM}$

1. \[ \frac{99.71}{(387.22)(0.867)} = \epsilon_{Sr} + \epsilon_Y(1 - e^{-\frac{(0.693)(6.17)}{64.2}}) \]

2. \[ \frac{241.13}{(387.22)(0.867)} = \epsilon_{Sr} + \epsilon_Y(1 - e^{-\frac{(0.693)(466)}{64.2}}) \]

1. \[ -1(0.2970036 = \epsilon_{Sr} + 0.064342 \epsilon_Y) \]

2. \[ 0.7182479 = \epsilon_{Sr} + 0.9934147 \epsilon_Y \]

\[ \frac{0.4212443}{0.9290727} = 0.4534 \]

\[ \epsilon_Y = 45.34\% \]

\[ \epsilon_{Sr} = 26.78 \]
SR(NO₃)₂ Carrier + Sr-90 tracer

GA Tech Detector

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>%Yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (t₁) (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 1 (7/11/88)</td>
<td>1.75</td>
<td>62.13</td>
<td>7100</td>
<td>4501</td>
<td>—</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td></td>
<td>54.73</td>
<td>89.1</td>
<td>5091</td>
<td>7.0</td>
</tr>
<tr>
<td>3 (9/16/88)</td>
<td></td>
<td>53.15</td>
<td>86.53</td>
<td>4906</td>
<td>5.78</td>
</tr>
<tr>
<td>4 (9/16/88)</td>
<td></td>
<td>55.32</td>
<td>90.06</td>
<td>5064</td>
<td>6.63</td>
</tr>
</tbody>
</table>

* It was not used to plot
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Total Final Gross Count (50 min)</th>
<th>Final Time (hr)</th>
<th>% Efficiency (6) of Sr-90</th>
<th>% Efficiency (6) of Y-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/11/88)</td>
<td>1.75</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 (7/17/88)</td>
<td>5</td>
<td>12597</td>
<td>467.25</td>
<td>25.80</td>
<td>47.27</td>
</tr>
<tr>
<td>3 (9/6/88)</td>
<td>5</td>
<td>12404</td>
<td>334.48</td>
<td>26.11</td>
<td>49.21</td>
</tr>
<tr>
<td>4 (9/6/88)</td>
<td>5</td>
<td>12583</td>
<td>335.32</td>
<td>25.55</td>
<td>47.86</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 5091
Initial Time \( (t_i) = 7.0 \) hr
Total Final Gross Count = 12597
Final Time \( (t_f) = 467.25 \) hr

Activity of Sr-90 \( (A_{sr-90}) = 387.22 \)

\( \% \) Yield = 89.1

\[ A_{sr-90} = \left( 179.2 \text{ PCI/ml} \right) \left( \frac{28.6 \times 365}{2.22 \text{ dpm/PCI}} \right) = 387.22 \text{ dpm/ml} \]

BKG = 46.25; BKG = 44.25

\[
1. \quad \frac{R_i}{(A_{sr})(\text{yield of sr})} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{\frac{-0.693(t_i)}{64.2}} \right)
\]

\[
2. \quad \frac{R_f}{(A_{sr})(\text{yield of sr})} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{\frac{-0.693(t_f)}{64.2}} \right)
\]

\[
R_i = \frac{5091 - 46.25}{50} = 100.89 \text{ CPM}
\]

\[
R_f = \frac{12597 - 44.25}{50} = 251.05 \text{ CPM}
\]

\[
1. \quad \frac{100.89}{(387.22)(0.891)} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{\frac{-0.693(7.0)}{64.2}} \right)
\]

\[
2. \quad \frac{251.05}{(387.22)(0.891)} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{\frac{-0.693(467.25)}{64.2}} \right)
\]

\[
1. \quad -1 \left\{ 0.2924237 = \frac{\varepsilon_{sr}}{\varepsilon_{sr} + 0.0727765 \varepsilon_y} \right\}
\]

\[
2. \quad 0.7276537 = \frac{\varepsilon_{sr}}{\varepsilon_{sr} + 0.99355 \varepsilon_y}
\]

\[
0.43523 = 0.9207735 \varepsilon_y
\]

\[
\varepsilon_y = 47.27 \%
\]

\[
\varepsilon_{sr} = 25.80 \%
\]
SY(No3)2 Carrier + Sr-90 tracer:

<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Weight of Precipitate (mg)</th>
<th>% Yield</th>
<th>Total Initial Gross Count (50 min)</th>
<th>Initial Time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/11/88)</td>
<td>2.0</td>
<td>67.51</td>
<td>96.2</td>
<td>4680</td>
<td>6.97</td>
</tr>
<tr>
<td>* 2 (7/28/88)</td>
<td>.5</td>
<td>61.41</td>
<td>87.48</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 (9/6/88)</td>
<td>.5</td>
<td>63.04</td>
<td>89.80</td>
<td>4881</td>
<td>7.22</td>
</tr>
<tr>
<td>4 (9/6/88)</td>
<td>.5</td>
<td>65.64</td>
<td>93.50</td>
<td>5140</td>
<td>8.05</td>
</tr>
</tbody>
</table>

* A small amount of sample was lost while mounting.
* It was not used to plot.
<table>
<thead>
<tr>
<th>Sample (Date)</th>
<th>Carrier (ml)</th>
<th>Total Final Gross Count (50 min)</th>
<th>Final Time (zf) (hr)</th>
<th>% Efficiency (E) of Sr-90</th>
<th>% Efficiency (E) of Y-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (7/11/88)</td>
<td>2.0</td>
<td>12316</td>
<td>452.3</td>
<td>21.88</td>
<td>44.53</td>
</tr>
<tr>
<td>2 * (7/28/88)</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 (9/6/88)</td>
<td>5</td>
<td>12616</td>
<td>335.92</td>
<td>24.15</td>
<td>49.69</td>
</tr>
<tr>
<td>4 (9/6/88)</td>
<td>5</td>
<td>12485</td>
<td>336.33</td>
<td>24.41</td>
<td>45.73</td>
</tr>
</tbody>
</table>
Sample Calculation:

Total Initial Gross Count = 4680
Initial Time ($t_i$) = 6.99 hr
Total Final Gross Count = 12316
Final Time ($t_f$) = 452.3 hr
Activity of Sr-90 ($A_{Sr-90}$) = 387.37 dpm/ml
\% Yield = 96.2

$A_{Sr-90} = (179.2 \text{ Pci/ml}) \left( e^{-\frac{(0.693)(40)}{28.6 \times 365}} \right) \left( 2.22 \text{ dpm/Pci} \right) = 387.37 \text{ dpm/ml}$

BKG$_i$ = 50.66, BKG$_f$ = 53.6

1. \[ R_i = \frac{A_{Sr}(\text{yield of Sr})}{100} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_i)}{\text{t}_{1/2} \text{ of y}}} \right) \]

2. \[ R_f = \frac{A_{Sr}(\text{yield of Sr})}{100} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(t_f)}{\text{t}_{1/2} \text{ of y}}} \right) \]

$R_i = \frac{4680 - 50.66}{50} = 92.59 \text{ CPM}$

$R_f = \frac{12316 - 53.6}{50} = 245.25 \text{ CPM}$

1. \[ \frac{92.59}{(387.37)(0.962)} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(6.97)}{64.2}} \right) \]

2. \[ \frac{245.25}{(387.37)(0.962)} = \varepsilon_{sr} + \varepsilon_y \left( 1 - e^{-\frac{(0.693)(452.3)}{64.2}} \right) \]

1. $-1 \left\{ 0.2484637 = \varepsilon_{sr} + 0.97249762 \varepsilon_y \right\}$

2. $0.6581243 = \varepsilon_{sr} + 0.9924204 \varepsilon_y$

\[ \frac{0.4096606}{0.9199442} = 0.9199442 \varepsilon_y \]

\[ \varepsilon_y = 44.53\% \]

\[ \varepsilon_{sr} = 21.88\% \]
Figure #6

% Efficiency (E) of Sr-90 vs. Weight of Precipitate (mg)
Figure #7

1. This Point was discarded.

© Average Value (Y-90)

% Efficiency (E) of Y-90

Weight of Precipitate (mg)
Figure #8

- Average Value (SR-90)
- Average Value (Y-90)
- Average Value (SR-89)