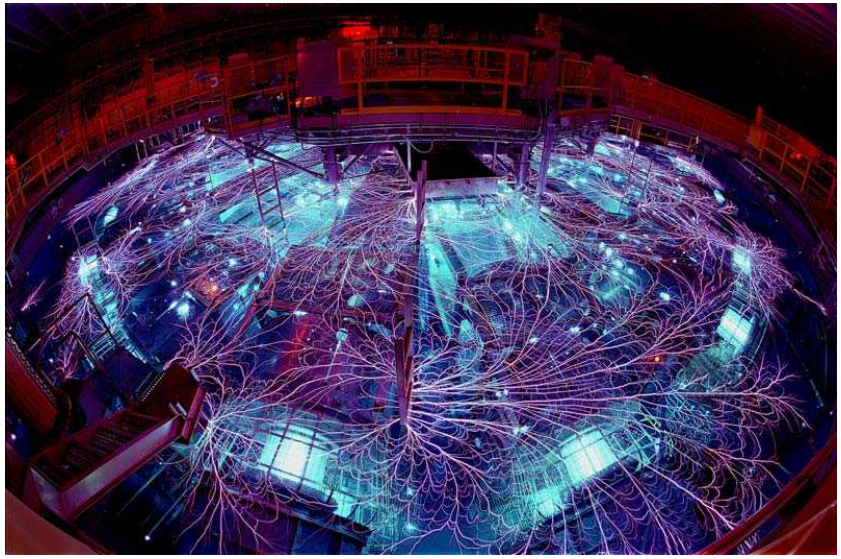
SAND2011-0387C

Low Energy Photon Detection



Detection of low energy photons beneath thin layer(s) of metal.

Patrick Beall, Radiation Protection Program, (505) 845-1261

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Problem

- Pu-239 and stainless steel components could be vaporized during experiment.
- Pu-239 and Am-241 could be deposited beneath thin layers of stainless steel on equipment and materials.
- Alpha emissions will be undetectable.

Questions

- Is it possible to detect Plutonium beneath thin layers of Stainless Steel?
- Is it possible to detect low energy photons from Plutonium?
- What about detection of other low energy photons?
- Could a detection system be developed and implemented that would support unrestricted release?
- Can you establish a detection system to save $2.5 million/year?

Method

- **Perform test counts with an Al absorber set and determine the density thickness at which detection is practical with a MDA ≤ 500 dpm.**

First test

- The first test was performed using a 2 in diameter X 2mm thick NaI probe.
- Probe was coupled to a count rate meter with no energy discriminator.
- Manufacturer listed energy range 10-200 keV.
- Probe was calibrated to Am-241 photon (59.5 keV) with an efficiency of 14%.

Results

- When test was performed to check for an efficiency to Pu-239 photon (51.6 keV) the efficiency was found to be <1%, dropping to <0.5% with the addition of only 82.8 mg/cm^2 of absorber material. Calculated on a 10 year old Pu button source.
- Decided to look exclusively for Am-241 (59.5 keV) photon

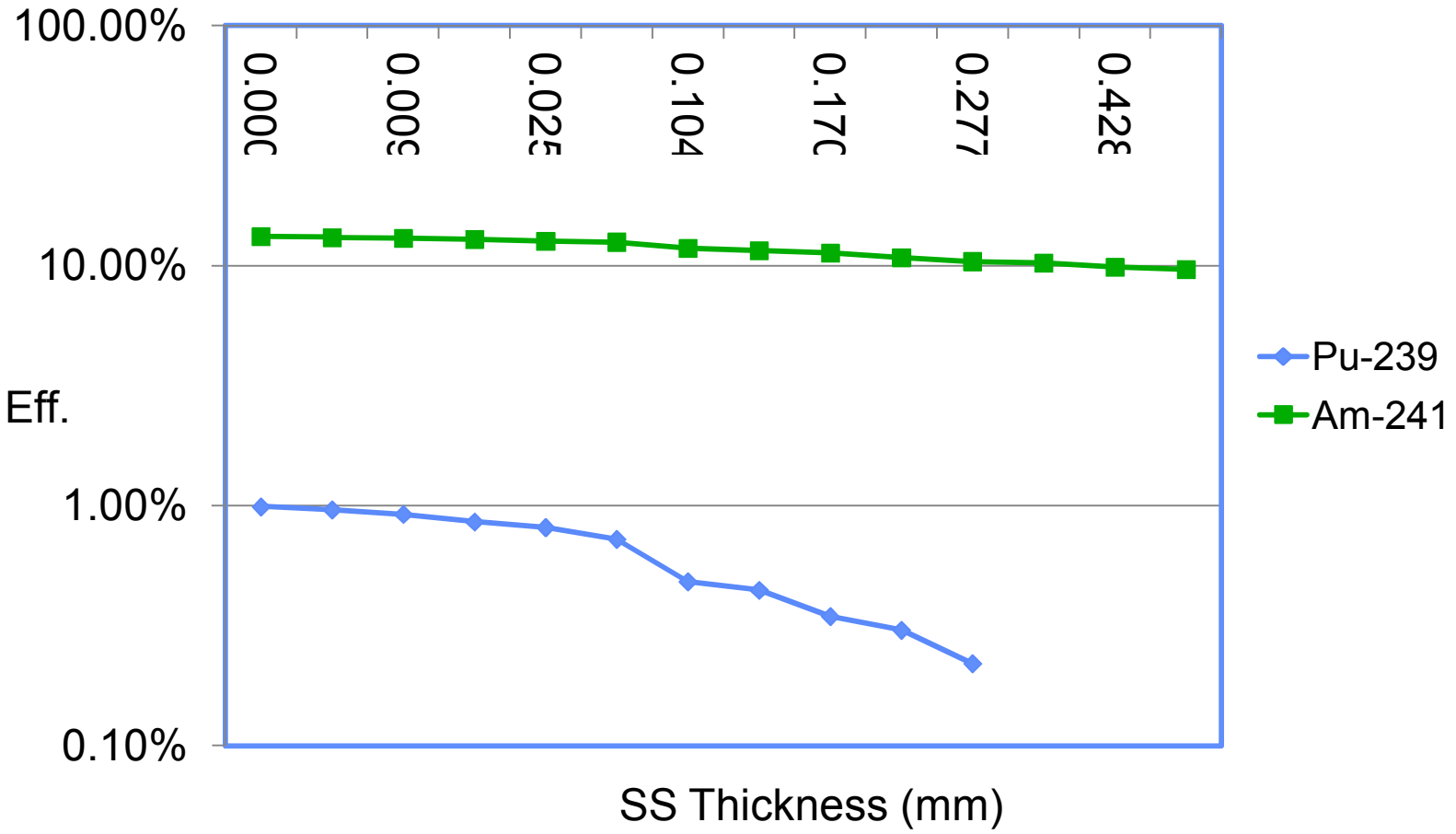
Probability of Photons per decay

LBNL Isotopes Project - LUNDS Universitet[1]							
	Am-241					Pu-239	
Emissions Type	keV	%			Emissions Type	keV	%
g	26.3	2.4			g	51.6	0.03
g	59.5	35.9			g	38.7	0.01
x	13.8	1.07			x	20.2	0.38
x	14.0	9.6			x	20.8	0.08
x	16.8	2.5			x	20.5	0.02
x	17.1	1.5			x	20.7	0.02
x	17.8	5.7			x	13.6	1.57
x	18.0	1.37			x	17.2	1.57
x	20.8	1.39					
Total		61.43					3.68

Am-241 Efficiency

Density Thickness (mg/cm^2)	Equivalent SS thickness	Bkgd	Ave Source reading (3 counts)	Net	4π Efficiency	DPM
0	0.000	1257	315667	314410	13.24%	2375400
6.8	0.009	1257	310333	309076	13.01%	
20.3	0.026	1257	302000	300743	12.66%	
82.8	0.105	1257	282000	280743	11.82%	
109.2	0.138	1257	275667	274410	11.55%	
136.2	0.172	1257	269333	268076	11.29%	
171.7	0.217	1257	258333	257076	10.82%	
221.6	0.281	1257	248667	247410	10.42%	
276.4	0.350	1257	245000	243743	10.26%	
342.4	0.433	1257	235667	234410	9.87%	
426.5	0.540	1257	230333	229076	9.64%	

Efficiency For Stainless Steel



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MDA Low Energy Gamma Scintillator

(2 in diameter x 2 mm thick)					
Efficiency	14%			Efficiency	11%
BKGD	MDA			BKGD	MDA
1100	5525			1100	7032
1050	5400			1050	6873
1200	5767			1200	7339
1250	5884			1250	7488
1300	5998			1300	7634
1350	6111			1350	7777
1400	6221			1400	7918
Efficiency based upon 20.3 cm^2 area. And one minute count times.					

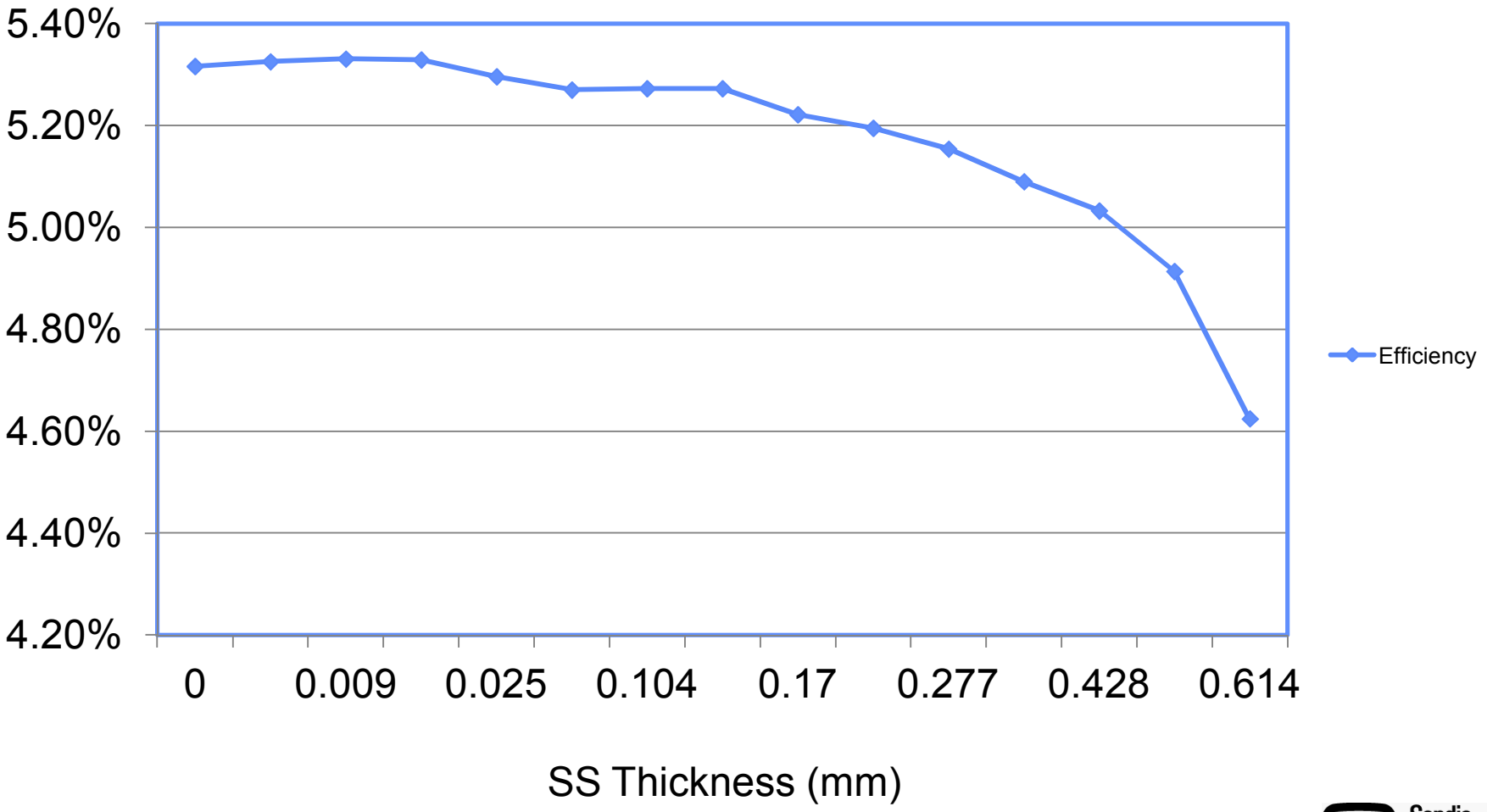
Second test

- The second experiment was performed using a 3x3 in NaI crystal with an energy discriminator.
- An 10 keV Region of Interest, i.e. 55 – 65 keV was set to look specifically for the Am-241 (59.5 keV) photon.

3X3 Detector Efficiency – Am-241

Density Thickness (mg/cm^2)	Equivalent SS thickness	Bkgd (cps)	Ave Source Reading (3 counts)	Net	4π Efficiency
0	0.000	9.66	2055	2046	5.32%
6.8	0.009	9.66	2061	2051	5.33%
20.3	0.026	9.66	2048	2038	5.30%
82.8	0.105	9.66	2039	2029	5.27%
109.2	0.138	9.66	2039	2029	5.27%
136.2	0.172	9.66	2019	2009	5.22%
171.7	0.217	9.66	2009	1999	5.19%
221.6	0.281	9.66	1993	1983	5.15%
276.4	0.350	9.66	1968	1959	5.09%
342.4	0.433	9.66	1946	1937	5.03%
426.5	0.540	9.66	1901	1891	4.91%

Efficiency of Detection Through SS



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Minimum Detectable Activity

Efficiency	5.30%	5.20%	5.10%	5.00%
BKGD (cpm)	MDA (dpm)	MDA (dpm)	MDA (dpm)	MDA (dpm)
540	798	813	829	846
600	841	857	873	891
660	881	898	916	934

Based on 125 cm^2 probe area and 400 second count times.

Approaching the Goal

- We can detect Pu-239 below thin layers of stainless steel via detection of photons from it's decay product Am-241.
- Release limits of detection have not been reached, however we are close.
- We will continue efforts to develop a detection system to support release of potentially contaminated equipment and materials

References

1. *LBNL Isotopes Project Nuclear Data Dissemination Home Page. Retrieved January 18, 2011, from http://ie.lbl.gov/toi.html*