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Source and Background Gamma-ray Spectra

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October 24, 2005

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September 29, 2003
Revised October 20, 2005

1 Introduction

For this study, we have made spectra and integral count rate estimates for a trivial detector configuration with a variety of unclassified gamma-ray sources. The source/background spectra and absolute flux are taken from cumulative distribution files created from MCNP simulations prepared by Ron Wurtz and Mike Frank. The simulated objects were criticality assemblies (test setups to develop benchmarks for establishing safety margins in handling fissile material) taken from the International Handbook of Evaluated Criticality Safety Benchmark Experiments (Nuclear Energy Agency, 2001). These objects were placed inside a 30 cm box with packing material that corresponds to roughly 0.5 radiation lengths (X_0). The simulations were repeated with an additional 7cm thick steel box enclosure. [1]

We determine the signal and background count rates for a 1 m^3 cubical detector with an *a priori* efficiency of 30%, i.e., we arbitrarily assume that for each photon that reaches the detector there is a 30% chance of it being detected. We consider a point source at 50 m away in vacuum along a line perpendicular to one of the detector faces. For the background case, we assume that the background is isotropic and the detector is perfectly shielded on one face (e.g., mimicking the case where the ground shields the bottom of the detector).Table 1 shows the count rate for each source with various cuts on the gamma-ray energy. The total count rate coming out of a surface for the background model is 0.4 counts/second/cm^2.

Table 1: Counts per second for 1 m^3 detector with 30% efficiency at 50 m (in vacuum) from the source.

	$\geq$ 100 keV	$\geq$ 200 keV	$\geq$ 500 keV	$\geq$ 1000 keV
Background	5888.9	4785.8	2876.7	1394.0
11kg HEU	15.8	1.52	0.70	0.40
11kg HEU + 7cm Fe	0.128	0.116	0.086	0.056
11kg vHEU	14.8	0.80	0.16	0.03
11kg vHEU + 7cm Fe	0.021	0.017	0.009	0.003
1.7kg WGPu	89.7	51.9	3.3	0.33
1.7kg WGPu + 7cm Fe	0.85	0.71	0.14	0.05

Figures 1- 4 show the source spectra (in both linear and logarithmic scale) with and without 7cm iron shielding. Note that the absolute rate is meaningful, it is the rate registered by the hypothetical 30% efficient one meter cube detector. The histogram bin size in the figures is 1 keV.

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[1]All of the source/background configurations given below are available in H4, the Geant4 simulation implemented by the High Energy Physics group for gamma-ray detector studies.
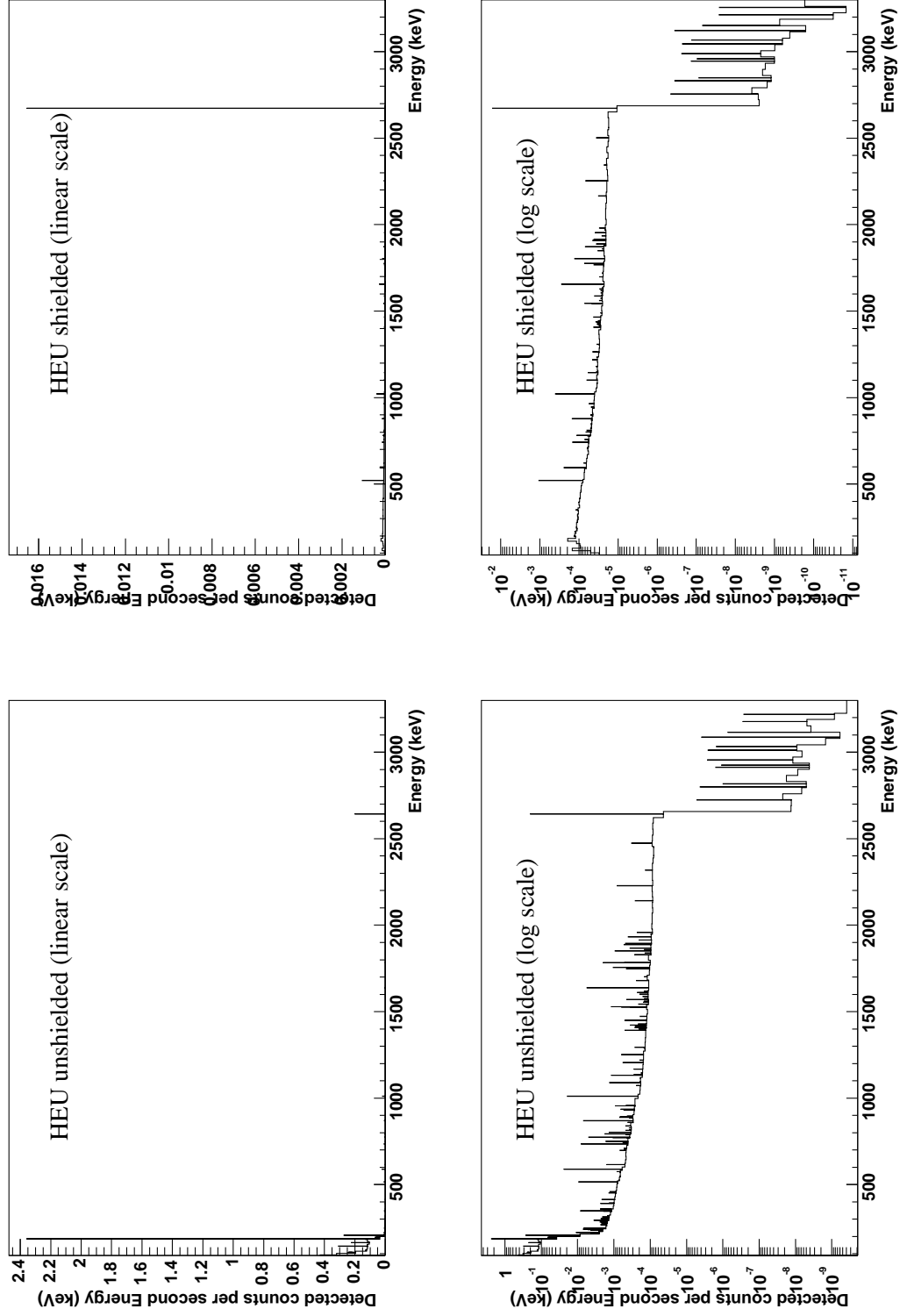
HEU shielded (linear scale)

Detected counts per second Energy (keV)

0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0

500   1000   1500   2000   2500   3000
Energy (keV)

HEU shielded (log scale)

Detected counts per second Energy (keV)

10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}

500   1000   1500   2000   2500   3000
Energy (keV)

HEU unshielded (linear scale)

Detected counts per second Energy (keV)

2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0

500   1000   1500   2000   2500   3000
Energy (keV)

HEU unshielded (log scale)

Detected counts per second Energy (keV)

1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}

500   1000   1500   2000   2500   3000
Energy (keV)

Figure 1: Counts per second of unshielded (left) and shielded (right) HEU as detected by a 1 m^3 detector with 30% efficiency at 50 m from the source.
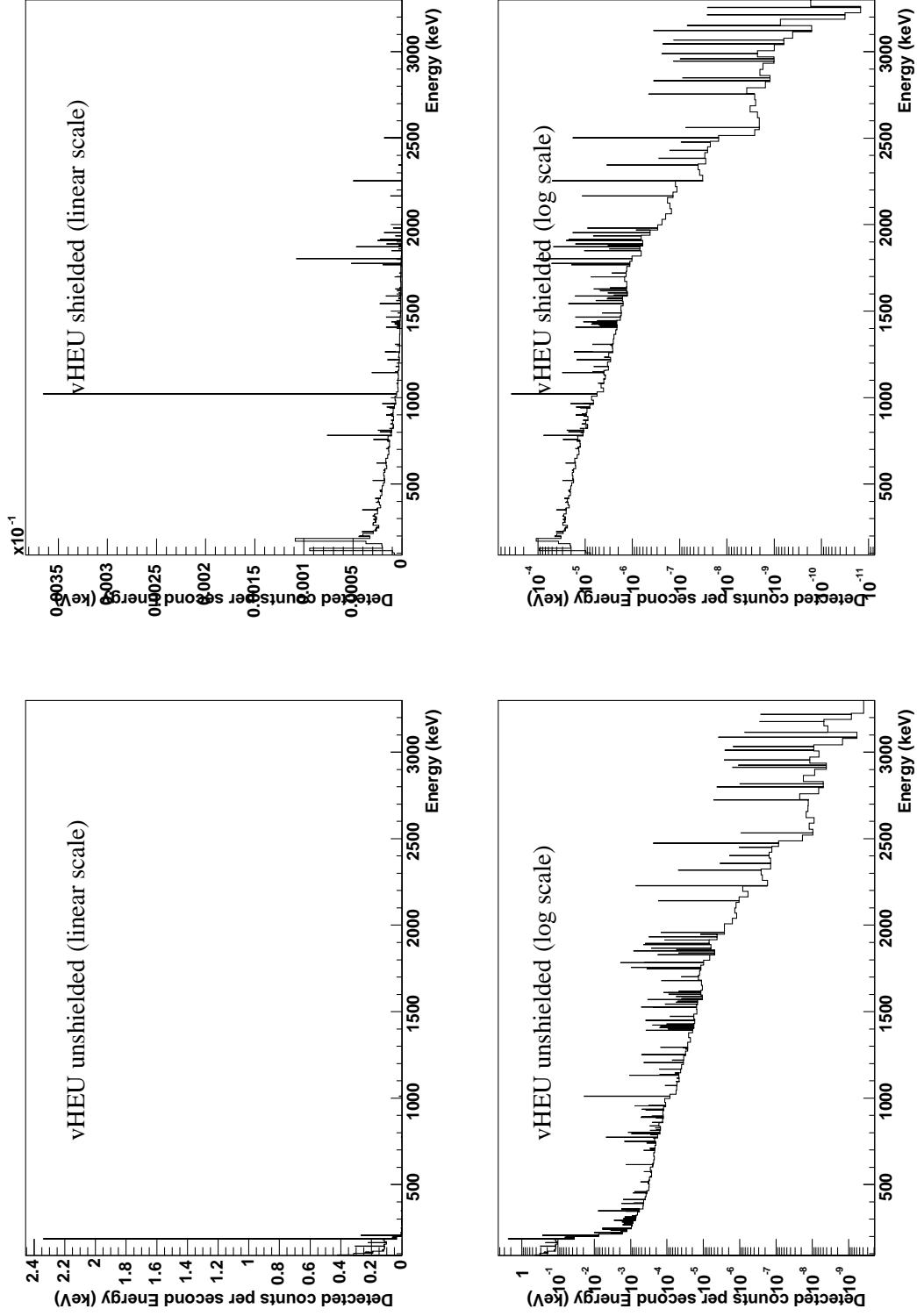
Figure 2: Counts per second of unshielded (left) and shielded (right) vHEU as detected by a 1 m^3 detector with 30% efficiency at 50 m from the source.
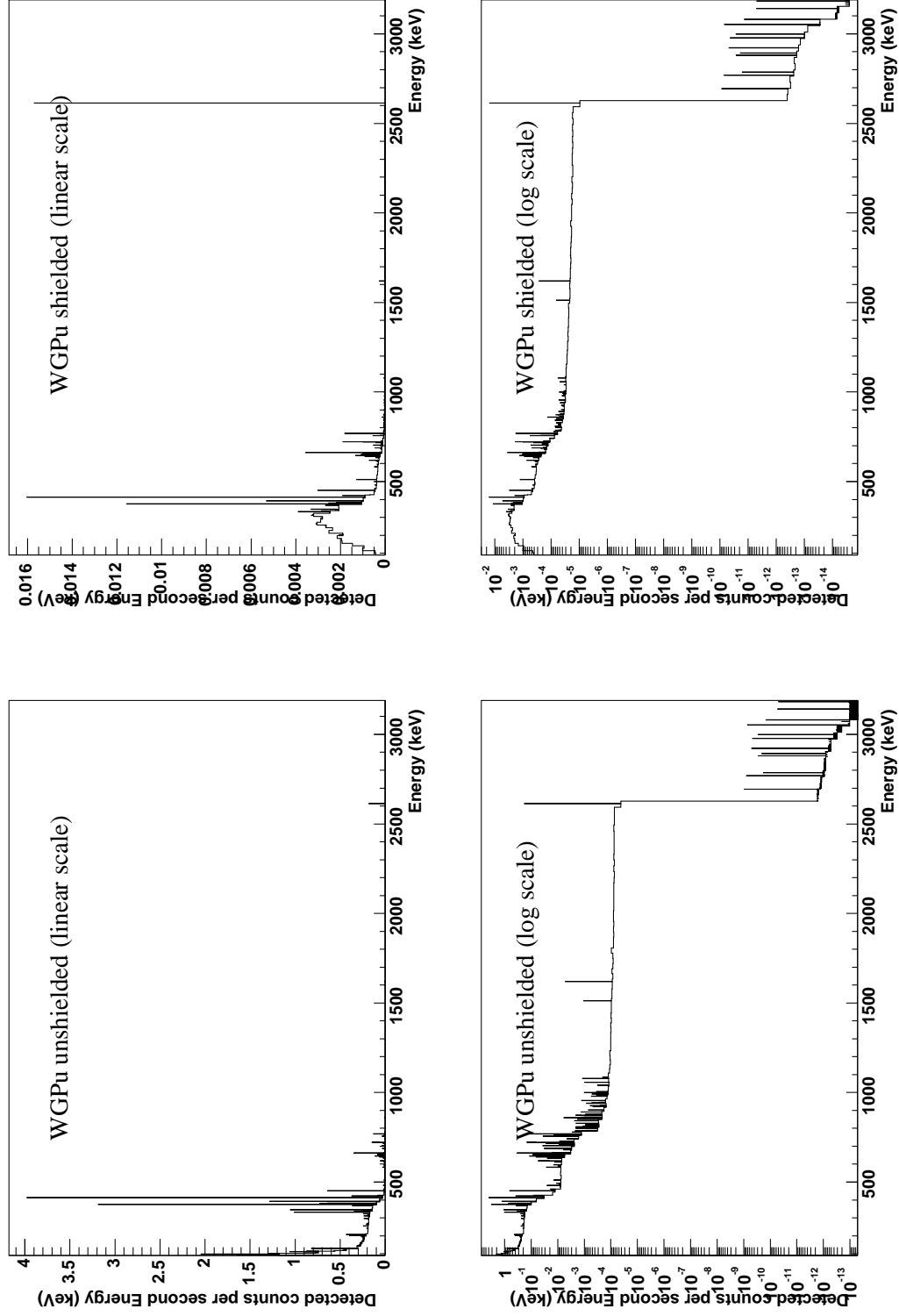
3

Figure 3: Counts per second of unshielded (left) and shielded (right) WGPu as detected by a 1 m^3 detector with 30% efficiency at 50 m from the source.
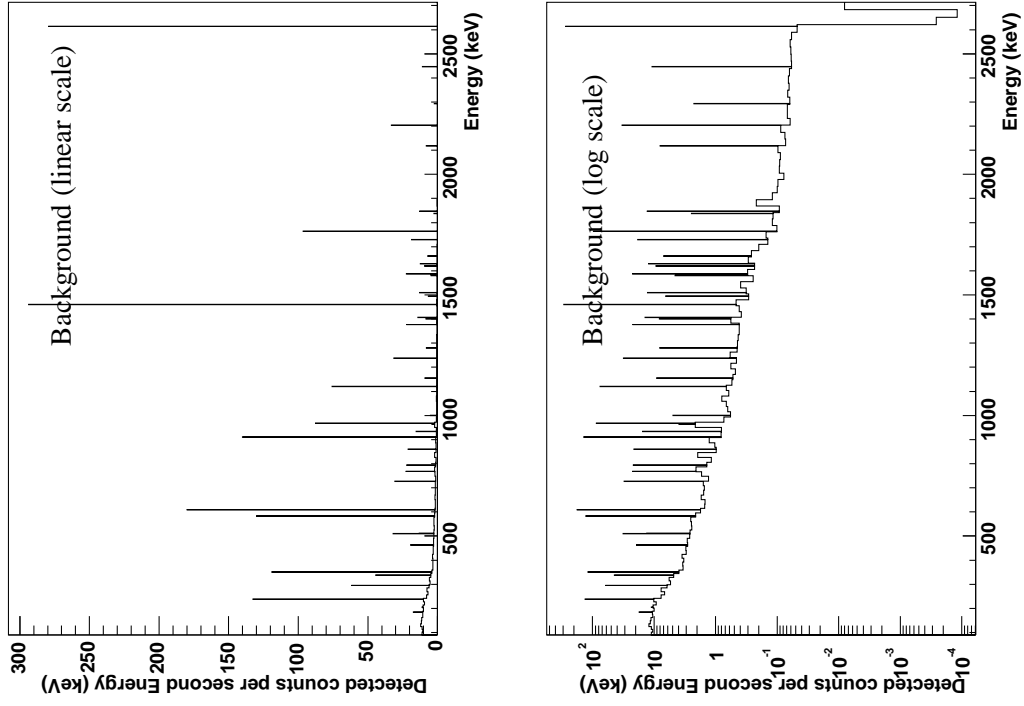
Figure 4: Counts per second of background as detected by a 1 m^3 detector with 30% efficiency.

5