Rocky Flats-related credentials

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Contents

[Blue, green = clickable links]

I am a retired academic physicist who believes it is my professional obligation to explain moderately technical issues to those without much background in science or math, especially in the presence of ongoing misinformation. I have focused on presenting information graphically whenever possible.

Why am I entitled to make credible statements about the health impacts of residual soil plutonium around Rocky Flats? Why should you believe them? Understanding the science well enough to explain to the public requires some expertise in a variety of subdisciplines. Rather than describe these in detail, this document simply displays samples of my work since about 2016. Since my career (through 2017) involved very different subject matter, I focus on credentials relevant to radiation detection, health physics, and epidemiology.

All graphics or tables below are the result of my own measurements, calculations, and analysis. They represent a tiny fraction of what is available on my science-only website. Both this document and others linked to are best viewed with a PDF viewer; most graphics are not bitmaps.

First, this means a broad understanding of what has *already* been measured, and the scientific literature concerning the site. This includes radiation measurement technology, familiarity with existing Department of Energy data and the relative proportions of natural and man-made radioisotopes in soil, and the chemistry of Pu in Rocky Flats soil. While the actual nuclear physics required is rudimentary, an awareness of the theory helps in understanding physical ranges and the nature of biological effects from alpha and beta particles and gamma rays. It must also include how such measurements are translated into radiation *dose*, since (only) the dose determines health outcomes and long-term risk.

Background

- B.A. with honors in physics, Princeton 1974; M.S., Ph.D physics, Cornell 1981, 2-year postdoc, Ohio State University.
- Senior Scientist, Solar Energy Research Institute (now NREL), Golden, CO 1982-1989 + 1 year visiting scientist.

- Colorado School of Mines 1989-2017; physics professor. Taught mostly across graduate curriculum: mathematical physics, electrodynamics, two-semester quantum mechanics sequence, statistical mechancs and thermodyamics, condensed matter physics, solid state physics.
- Member, Health Physics Society and Central Rocky Mountain Chapter.

Research on the electronic structure and vibrational properties of ternary semiconductors, self-assembly of molecules adsorbed on ZnO surfaces.

Radiation measurement and gamma ray spectrometry expertise

- Member SAFECAST (non-governmental radiation measurement and monitoring network). GPS-enabled data-logging bGeigie nano Geiger-Müller detector for radiation surveys. I used this to survey both original Refuge trails and new trails associated with the Rocky Mountain Greenway. Excellent agreement with DOE pressurized ionization chamber measurements.
- Gamma ray spectrometry: NaI:Tl 2″ x 2″ scintillator spectrometer, GAGG scintillator with SiPM solid-state photon detection. Quantitative soil analysis permitted with GADRAS-DRF (see below).

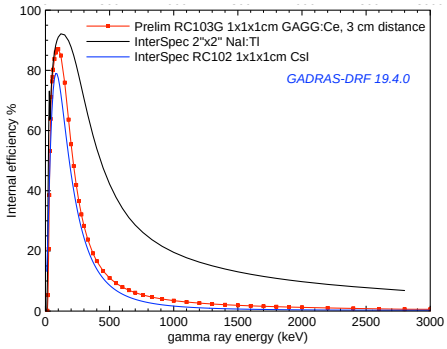

Figure 1: Modeling new detectors

Export-controlled federally maintained but publicly available software permits (after jumping through access hoops) extracting compositions from gamma ray spectra.

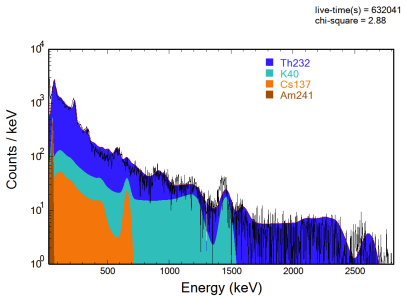

Figure 2: Gamma ray whole-spectrum fit showing contributions of natural radioisotopes, ^{241}Am (from Rocky Flats ^{241}Pu) and ^{137}Cs from fallout. Dirt sample from Rocky Flats east entrance.

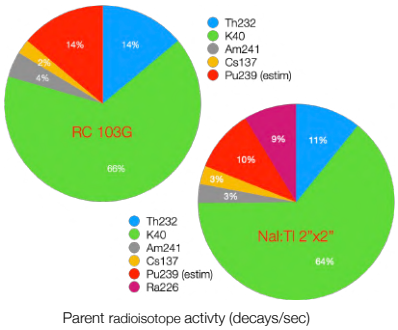

Figure 3: Contributions to radioactivity from dirt sample from east entrance, Rocky Flats. The NaI detector is much more sensitive than the RadiaCode 103G.

- Corrected published statements that bGeigie Nano calibration began to fail at high measured dose rates. Showed how detector 'dead time' can be amended to include high counts rates.
- Modeling of new portable gamma ray spectrometers.
- GADRAS-DRF 19.4.0: Detailed modeling of new class of gamma-ray spectrometers to determine composition (relative number of nuclei of particular isotope) and activity (in Bq or Ci) they contribute to sample. Used successfully on data from two different

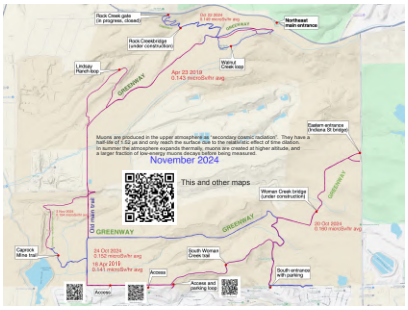

Figure 4: Trails and measured radiation levels within Refuge using GPS-enabled data-logging Geiger-Müller detector

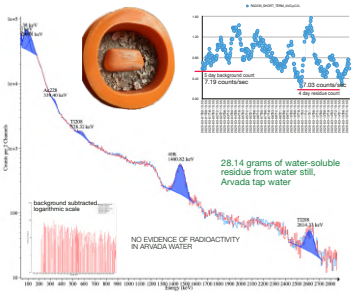

Figure 5: Measured gamma ray spectrum of mineral residue in Arvada water

Measurements relevant to recreational users of the Refuge, together with explanations of seasonal variations of background radiation (left). Gamma ray spectra of the residue from a water still confirm no evidence of radionuclides in Arvada water and slight background variations due to household radon (right).

scintillator-based gamma ray spectrometers on soil from Rocky Flats east entrance.

Software expertise relevant to radiation dosimetry and epidemiology

- GIS: ESRI account and tools, QGIS software to analyze, make maps from DOE, CDPHE, Jefferson Parkway, Fish&Wildlife data.

A great deal of publicly available and well maintained software is available from federal agencies. I have made a point of using only such tools so that others can reproduce my results.

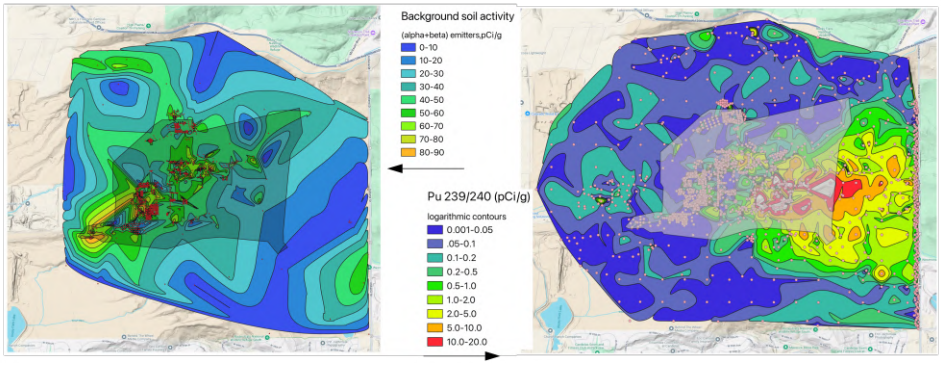

Figure 6: Gross alpha+beta soil activity (= terrestrial background), left; Pu on logarithmic scale, right. Sampling locations: red dots (left), pink dots, right.

The right panel shows *all* data points from Pu sampling, from pre- and post-cleanup DOE data, through Jefferson Parkway sampling, Ketterer sampling, and Fish&Wildlife sampling. Agreement is quite good between different measurement campaigns. Note ^{239}Pu activity is 100-1000 times smaller than background soil activity (left panel) over most of Refuge.

- InterSpec: gamma ray spectrometry and dosimetry package, permits identification of unfamiliar radionuclides.
- RESRAD Onsite: from soil concentrations of radionuclides and input amounts of yearly soil inhalation and ingestion, predict detailed doses per year over decades or centuries. Uses International Committee on Radiological Protection [ICRP] dose coefficients. This package is very widely used to assure compliance with radiation exposure standards on mitigated sites, including Rocky Flats.

- SEERStat: follow cancer statistics nationally in order to carefully distinguish between incidence and prevalence of diseases.

Figure 7: Well known 1996 map redrawn with Google Maps.

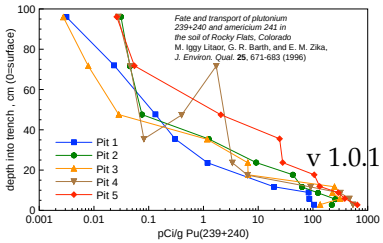

Figure 8: It is crucial to make old data available: pre cleanup pit samples to determine Pu profile with depth.

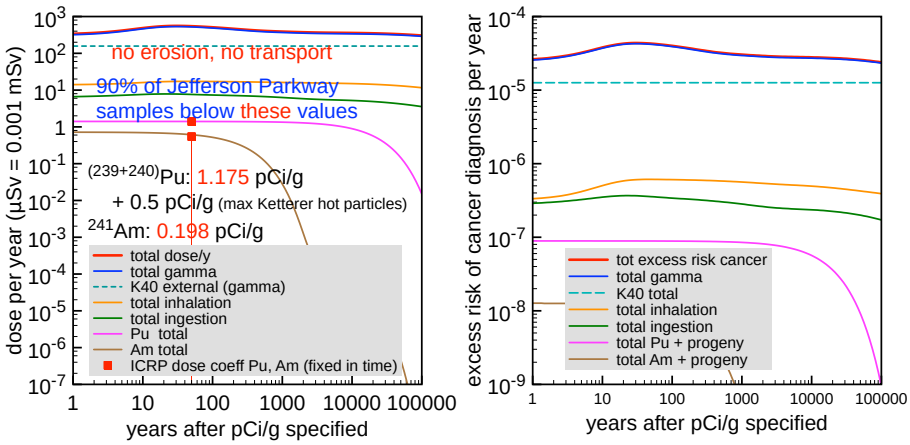

Figure 9: Using NIST 'soil standards' for Rocky Flats soil and radioactive equilibrium, yearly doses and total excess risk of cancer as calculated using RESRAD without transport, rain, erosion. Red squares on left show agreement with direct calculation using ICRP dose coefficients for low-solubility Pu and Am. Note logarithmic scales. Using overestimate of soil Pu, excess risk attributable to Pu and Am is roughly 320 times smaller than from natural gamma rays.

Risks from Rocky Flats plutonium are calculated to be hundreds of times smaller than those from natural radioisotopes. RESRAD inputs are taken from international recommended dose and risk coefficients, updated every few years.

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- Gamma ray spectrometry: NaI:Tl 2″ x 2″ scintillator spectrometer, GAGG scintillator with SiPM solid-state photon detection. Quantitative soil analysis permitted with GADRAS-DRF (see below).

Rocky Flats related expertise

- My physics background provides more than sufficient nuclear physics expertise to understand all relevant datasets, dosimetry of radionuclides, ICRP publications, nuclear tables, RESRAD.
- Since about 2016 I have closely followed Rocky Flats publications from peer-reviewed scientific literature, DOE and other government publications in U.S. and abroad. To honor copyright restrictions, I have occasionally re-plotted relevant data when needed for use in white papers below.
- I analyzed and publicized NIST 'soil standard' data relevant to assessing relative contribution of Pu, Am to Rocky Flats soil radioactivity. These were the first definitive assessment of relative contributions from Pu.
- Older published data (augmented with my own Refuge measurements) place Rocky Flats background radiation in geographical

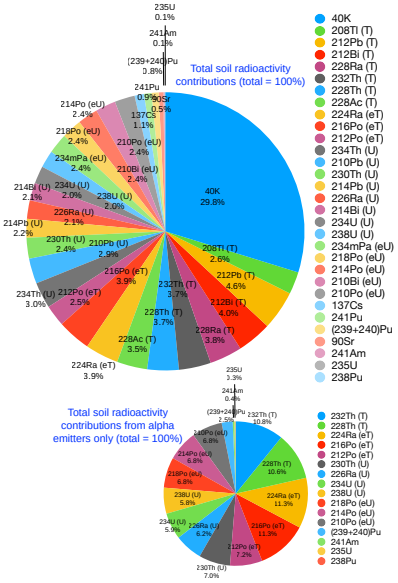


Figure 10: Results for NIST 'soil standards' (used for calibrations by radiation measurement labs internationally) prepared from 1978 samples of Rocky Flats soil at two locations. These have been augmented by 'decay daughters' not measured by NIST, assuming secular equilibrium.

context (and in agreement with several other measurements).

- At present there are 3414 published documents with Rocky Flats in the name or abstract, in a fully-indexed library of PDF files maintained via Mendeley. Many more on radiation epidemiology, cancer statistics, ionizing radiation biomarkers, ICRP publications, and federal and state documents.
- I have analyzed in detail and mapped recent measurements by the Fish&Wildlife Service and by the Jefferson Parkway Public Highway Authority. By contrast, measurements by Dr. Michael Ketterer done for the Rocky Mountain Peace and Justice Center have only been informally 'published' as posters and affidavits, never as peer-reviewed articles, presumably since the Peace&Justice Center retains intellectual property rights.
- Anti-nuclear groups neither discuss nor acknowledge radiation *dose*. So I have prepared careful analyses of all of Dr. Ketterer's data on 'hot particles' measured on the eastern boundary of the Refuge, and on airborne plutonium in dust measurements made on an extremely windy day in April 2024. In all cases careful dose estimates are made and Ketterer's data is presented in clean tabular form. These are authoritative statements of his measurements with all analysis shown and complete literature citations.
- *Epidemiology:* Anti-Refuge groups are generally uninformed about epidemiology and radiation-induced illnesses.

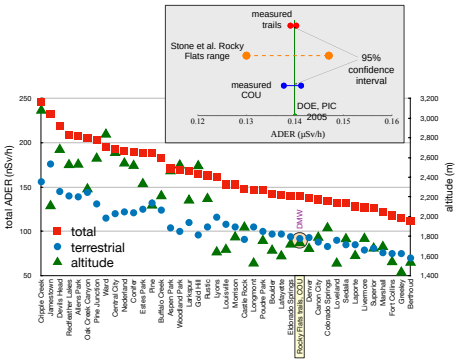


Figure 11: Measured Front Range city data resolved into contributions from soil radioactivity and cosmic rays. Note Rocky Flats data lies between Eldorado Springs and Denver values.

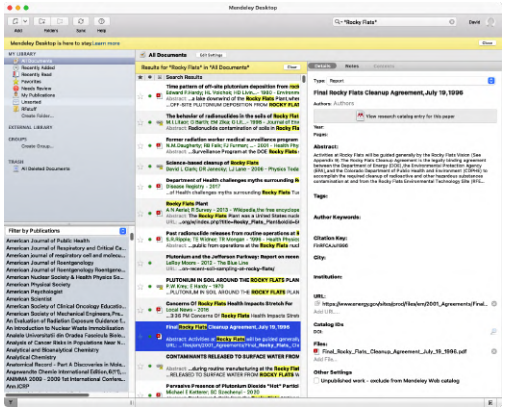


Figure 12: Mendeley permits instant access to details of thousands of imported and indexed documents related to Rocky Flats, radiation epidemiology, and other technical documents.

source	*dose advice*	*dose* (12 h)	*dose* (1 y)
PuO_2	DOE	1.55×10^{-3}	0.0793
(outdoor) radon	DOE granular	1.67	1,220
background	direct measurement	1.68	1,230

Figure 13: Table comparing radiation doses (mSv) from inhaled PuO_2, outdoor radon, and background radiation using Ketterer air filtration data of April 2024.

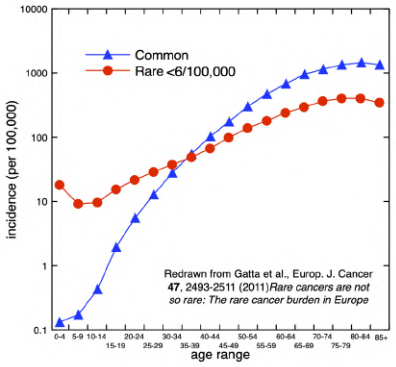


Figure 14: Major revisions of what is a rare cancer have occurred since about 2011.

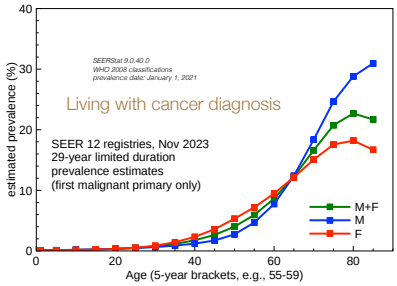


Figure 15: Downwinders appear to confuse cancer *prevalence* with *incidence*. Prevalence (living with cancer) is growing simply because medical treatments are very effective.

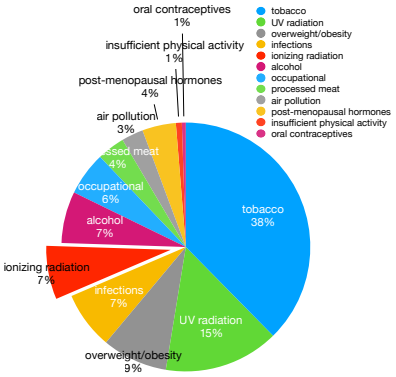


Figure 16: Findings of a 2018 Danish study about the causes of cancer.

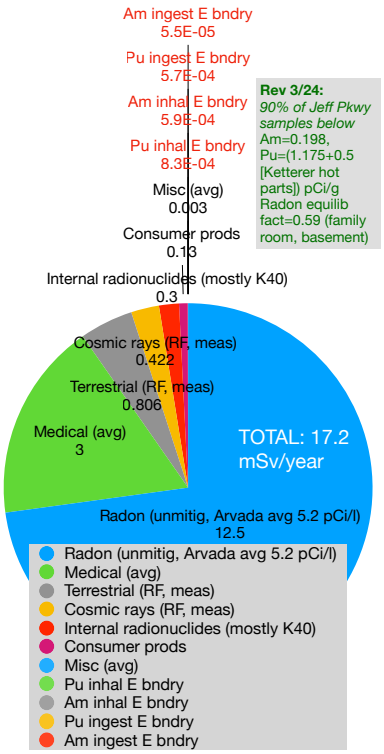


Figure 17: For people living on eastern boundary of the Refuge, estimated contributions to total annual radiation dose.

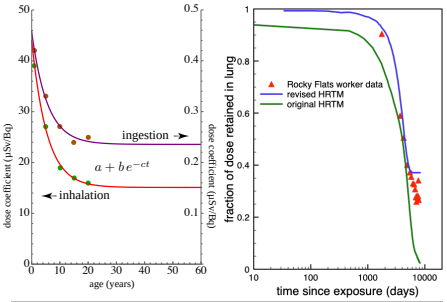
Community involvement with Rocky Flats

- Set up, maintain non-profit website Rocky Flats Neighbors to provide science based information about Rocky Flats and its surroundings. Web pages and blog may have *opinions*; documents do not. Example: medical misinformation
- Presentation for Candelas residents,
- Presentation for Westminster City Council, July 15, 2024
- Detailed coverage of radon and impact of mitigation.
- Survey of local perception of Refuge safety via hyperlocal NextDoor.
- Surveys of nearby neighborhoods about trustworthy information sources

Sample 'white papers' relevant to Rocky Flats

These are fully illustrated with clickable citations and relevant mathematics, meant for readers with college-level math, physics, and chemistry. Topics covered and links (green links)

- How people think about radiation
- Radiation, biology, and health physics



route	source	date	ref	dose coef	risk coef
inhal	Public Health Service	11/2010	Tox profile Pu [10]	(16.4)	9.00×10^{-9}
inhal	ICRP	2012	ICRP Pub 119 [11]	16	8.80×10^{-9}
inhal	RESRAD 7.2	3/2018	DCFPAK3.02 [12]	16.0	8.96×10^{-9}
inhal	RESRAD 7.2	3/2018	DCFPAK3.02 [12]	96.4	9.58×10^{-9}
ingest	Public Health Service	11/2010	Tox profile Pu [10]	(.136)	7.46×10^{-9}
ingest	ICRP	2012	ICRP Pub 119 [11]	0.25	1.38×10^{-8}
ingest	RESRAD 7.2	3/2018	DCFPAK3.02 [12]	0.251	4.71×10^{-9}
ingest	RESRAD 7.2	3/2018	DCFPAK3.02 [12]	0.204	3.61×10^{-9}

dose coefficients

pCi/g (uniform)

$$\text{Pu}\ (16.0 \times 0.840 + 0.251 \times 36.5) \times \left(\lambda_{un} + \lambda_{hp}\right) \times 0.037$$

$$\text{Am}\ (96.4 \times 0.840 + 0.204 \times 36.5) \times \left(\lambda_{un} + \lambda_{hp}\right) \times 0.037$$

mass of dirt (g) inhaled/y

mass of dirt (g) ingested/y

pCi/g (hot particles)

dose/year in μSv

Figure 18: Rocky Flats workers have contributed to knowledge about Pu in the body and recommendations from the International Commission on Radiological Protection.

- Radiation doses: large, small, unavoidable
- Cancer epidemiology
- From radiation dose to cancer risk
- 'Recent' developments in low-dose radiation [beyond LNT]
- Ongoing developments in radiation epidemiology

Non-technical documents

- Summary of NIST data
- Web page graphics of recent measurements
- Background radiation on Refuge trails (older)
- New Greenway trails and access points
- What's in Refuge soil?
- Hot particles in Rocky Flats soil
- The Jefferson Parkway hot particle sample
- Jefferson Parkway sampling
- Information-dense 4-page flyer with data and rebuttals of anti-Refuge statements; Summary

What physicists know about nuclear physics

Most Ph.D physicists, no matter what their research field, have significant familiarity with nuclear physics by way of training in quantum mechanics. The following would probably be familiar to any such physicist. (Most topics were covered in graduate classes I taught.)

- α decay (the WKB tunneling calculation which traces the immense range of α-emitting radionuclide half-lives and the semi-empirical mass formula results to explain the narrow range of α energies.
- β decay, 'phase space' effects, Kurie plots, and the neutrino mass: relevant to details of beta decay
- Internal conversion (electromagnetic process) relaxation of nucleus with emission of atomic electron
- Complete analysis of steady state radon concentrations in a room much wider than it is tall

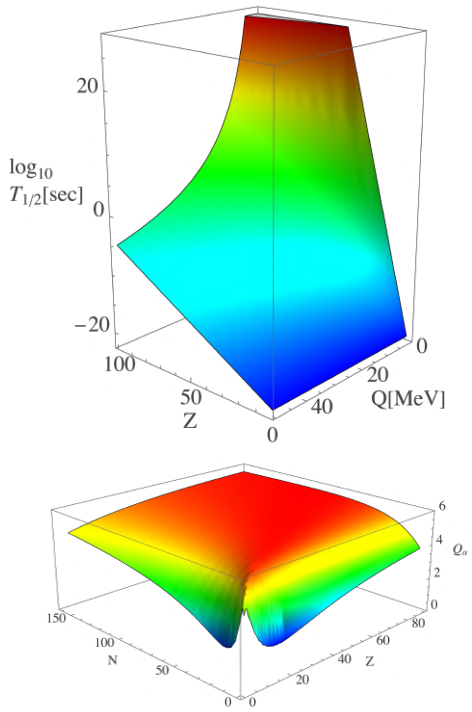


Figure 19: The range of half-lives of alpha emitters from WKB calculation (top) and narrow distribution of alpha particle energies (lower panel).

- Elastic scattering of electrons from nuclei using Woods-Saxon potential, compared with experiment
- The deuteron binding potential and its stability
- Mössbauer effect: recoilless emission of gamma rays by nuclei in a solid
- The nuclear hyperfine interaction and the 21 cm line
- Calculations to disprove famous 'discovery' of cold fusion

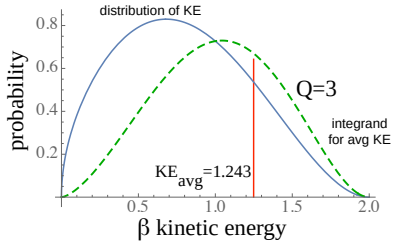


Figure 20: Distribution of beta particle energy given sharing with neutrino.

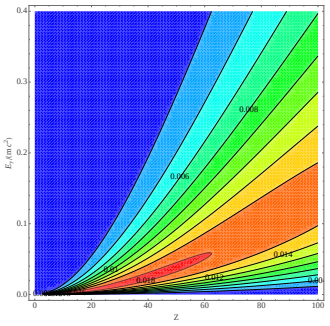


Figure 21: Dependence of photoelectric effect on γ energy and atomic number

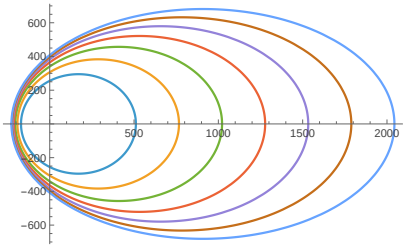


Figure 22: Energy of Compton-scattered gamma rays by polar angle of scattering.

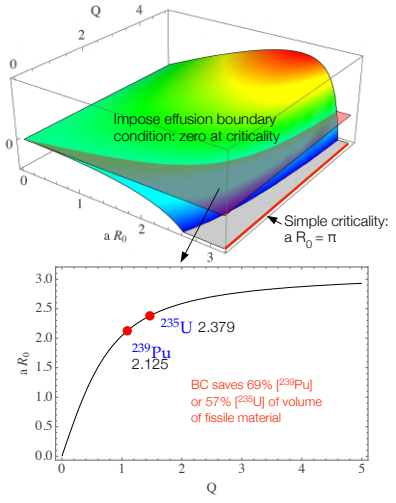


Figure 23: Criticality of spheres of fissile materials from careful solutions of the neutron diffusion equation.

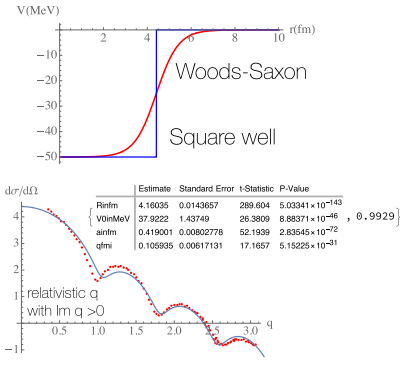


Figure 24: Woods-Saxon nuclear potential and computed elastic electron scattering (first Born approximation) compared with experimental data.

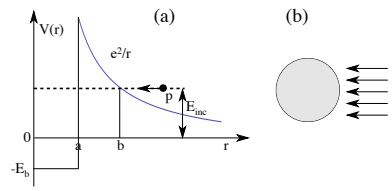


Figure 25: Flux of protons which can tunnel through the Coulomb barrier of a hydrogenic nucleus.