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PUBLIC SUBMISSION

Docket: NRC-2025-1007
Global Laser Enrichment, LLC; Paducah Laser Enrichment Facility, McCracken County, Kentucky; Notice of Intent to Conduct Scoping Process and Prepare Environmental Impact Statement

Comment On: NRC-2025-1007-0011
Global Laser Enrichment, LLC; Paducah Laser Enrichment Facility; Draft Environmental Impact Statement

Document: NRC-2025-1007-DRAFT-0019
Comment on FR Doc # 2026-05955, NRC-2025-1007-0011, from Paul Mobley

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General Comment

NRC Docket # NRC-2025-1007
Lazer Enrichment

International Committee on Radiation Risk (ICRR)
Paul Mobley
Science Secretary
USAF Civil Engineer (90s)
IUOE 150 (100% vested)
Radiacode Sub-contractor (1 year)

Author: (1) General Theory of Uranium Particle Radiocarcenogenesis https://share.google/EA9vXf7DkkBxWzENH

The International Committee on Radiation Risk ICRR was established in 2026 as a subcommittee to the Veterans for Peace Uranium Weapons Working Group. A group of people of various fields, various military branches of Veterans, scientists, researchers, Doctors etc.

Macro-dosimetry versus
Micro-dosimetry... Idaho National Laboratories comprehend the difference between these two scientific words and they understand currently we are using Macro-dosimetry across the entire nuclear/medical/commerce/etc. fields globally. Every National Laboratory across the planet fully comprends the difference between these two very different words, even though they look similar to the vast majority of the untrained ~8 billion people on this planet. The ICRR fully comprehend the difference between these two words and we can prove the NRC is not listening to the most up to date science before making any of these decisions on any topic you ask for lawful "public" comment. We comprehend the name of the game is that you legally tell the public, but the vast majority of them have no clue really what this industry AND regulators have done for decades to their own citizens of their nations.

This is not some obscure difference being pointed out by the typical "public" comment and is usually reserved for scientific journals one must pay thousands of dollars to even allow the "public" to even see it as its placed behind a paywall. You know that we know that you know we know.. and you can no longer hide behind the science any longer because we indeed know the science.

The documentation included with this public comment proves that there is indeed another way to calculate one's dose in a much more precise manner, named Micro-dosimetry, but the "shell" of a risk model provided does not show the eventual "Nano-dosimetry" that takes place as a result as well.

By law, subsection provided in the document, before moving forward with any "nuclear renaissance" plans thos agency has with the DOE and its contractors, you MUST, by danger of being sued lawfully class action by many with future corruption trials taking place, must pause every single program/project/expansion/"public comments/etc. until a full investigation occurs by the NRC and its attorneys of the difference between "Macro-Dosimetry" and "Micro-dosimetry" of which you all already know the difference, I dont have to tell you.

We, as an organization knows the truth, more than enough "public" people now know the truth, and its finally time for the NRC to stop being the nuclear industry cheerleader it became after the AEC, and be the regulators you are meant to be mandated by "the people, for the people". You have one week to respond to the ICRR Science Secretary Paul Mobley at scisec@icrrisk.org.

International Committee on Radiation Risk ICRR

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Attachments

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Nuclear and Health Physics

The Unified Precision Radiation Risk Model-39 (PRRM-39)**:** Micro-Dosimetric Correction to Macro-Dosimetric Standards

International Committee on Radiation Risk ICRR

Executive Opening Statement

The Functional Interaction Plume (FIP) Model identifies a critical failure in current ICRP and NRC dosimetry, the systematic dilution of localized energy into an organ-averaged kilogram denominator. By accounting for Alpha Recoil Displacement and Frenkel pair dissociation, this model proves that radioactive Daughter ions migrate into a 1 mm mobile plume, bypassing the ‘overkill Plateau’ to strike fresh, viable DNA. Furthermore, by incorporating a Biphasic Cell Response, we demonstrate that low-dose protracted internal exposure is mathematically more efficient at inducing Carcinogenesis than previously estimated, requiring an immediate update to NRC Level 1, 2, and 3 PRA guidelines and the ICRP risk model. This model moves beyond the flawed “Linear No-Threshold” (LNT) approach by identifying why risk is non-linear and how the “kilogram denominator” hides lethal energy density. This comprehensive framework integrates the Functional Interaction Plume (FIP) Model with specific technical known Physics regarding Alpha Recoil Displacement and Biphasic Biological Responses. The FIP Model demonstrates that at both high and low exposure rates, the detached ions in the 1 mm mobile plume (alpha) are more likely to strike fresh, viable DNA in previously untouched healthy cells. This makes each individual particle more "efficient" at causing cancer, leading to a supra-linear risk curve where the damage per unit of radiation is actually higher at lower levels than current and past risk models have accounted for in all studies utilizing the ICRP framework.

Technical Abstract: The PRRM-39 Unified Framework

A Unified Precision Risk Model is designed for external Macrodosimetry and internal Microdosimetry incorporating High-Z Photo-Electric Synergism and Universal Legislative Parity. PRRM-39 replaces the current ICRP 103 and NRC 10 CFR 20+ models of "Whole-Organ Averaging" and identifies the **Alpha Recoil Displacement Effect** as the primary mechanism of internal damage, creating a **1 mm Mobile Plume** (alpha) of High-LET ions. This model explicitly corrects for the "kilogram denominator" and incorporates the **Adaptive Response Variable (R_a)**, **Overkill Factor (O_k)**, **Particle-to-Plume Correction (K_p)**, **Functional Interaction Mass (m_i)**, **Precision Parameter Matrix (S_m)** and **Micro-Volume Weighting (W_u)**. Traditional internal dosimetry models, such as the ICRP publications, fail to account for the localized intensity of discrete radioactive particles. These models rely on whole-organ averaging by use of the kilogram denominator which mathematically dilutes lethal energy deposits and ignores the physical mechanisms and total chemical radiogenotoxicity of heavy metal radionuclides.

Solution

The **PRRM-39** is a new physics-based model ceasing to utilize averaging methodology and begins measuring occurrences at the microscopic level. Through Micro-Mass Interactions, the Alpha Recoil Effect, Bio-Molecular Anchors and more, society will now be provisioned the most comprehensive and accurate risk model to date not only providing the flaws of the current risk model used by professionals all over the world for the last 50+ years, but provides the scientific basis and key alternatives to remedy those flaws and ushers in a properly regulated industry around the world.

Executive Summary

1. The systematic failure of the kilogram denominator in current standards (ICRP) calculate Absorbed Dose and Equivalent Dose by averaging energy over an entire body or 1 kg organ mass thereby mathematically diluting concentrated energy. The FIP Model identifies that alpha decay is a discrete event interacting with a 4.19 mg Functional Interaction Mass (Mf), revealing a 250,000-fold discrepancy in localized energy density.
2. The FIP Solution The FIP Model identifies the physical mechanisms-Alpha Recoil and ionic migration allowing radioactive isotopes to bypass the “overkill plateau”. By shifting from organ-averaging to the 4 mg plume mass, we provide a biologically accurate assessment of the 39-fold increased risk hidden in current records.
3. A Gulf War Veteran supplied his VA records with multiple bioassays and others showing the evidence with several data points one of which was provided by the Mirion RDS-100V Scintillator the soldier acquired on site and recorded 886 RADS on his abdomen while cleaning DU dust. Current standard models "erased" this intensity by averaging it over his 80 kg body for his external exposures and 1 kg lung mass for internal exposures, resulting in a recorded dose of 1.4 REM. The FIP Model proves the 886 RADS was a localized "Hot Zone" where energy was concentrated in mobile plumes, not a whole-body field. Many years spread between bioassays clearly shows his excretion of specific uranium radioisotopes 20 years later is explained by our model while the current model assumes a negligible effect and no proper explanation for the inventory of the excretion bioassay.
4. Historical Empirical validation of the Wismut Miner Cohort data of 400,000 miners in Germany and the Czech Republic, and much more, shows “low dose” groups had higher cancer occurrences than currently predicted while the PRRM-39 model perfectly explains this gap.

The Physical Mechanisms

Alpha Recoil Displacement Effect (E_r)

Alpha decay produces a recoil energy to the resulting Daughter nucleus (E_r) of 72-100 keV. This "kick" physically detaches the daughter nucleus from the PM10 Parent complex causing a Displacement Cascade of Frenkel pairs of Uranyl ions, decay or fission products, and many other probable constituents. Nanoclusters of various radionuclides with varying chemical properties, solubility and subsequent decays including nuclear recoils become mobile from a once thought stationary intact Parent complex. Even with all these interactions, the amount of mass still doesn't equal 1 kilogram and conversely more radiation is added to the equation than in the current risk model that would've been wasted to the "Overkill Plateau".

- **Formula:** $E_r = \frac{m_a}{M_d} \times E_a \approx 72 - 100\ \text{keV}$

Frenkel Pair Dissociation (N_d)

Nuclear Recoil from alpha emissions creates a displacement cascade of ~1,152 atoms (Frenkel Pairs) per event. In fluid, these atoms dissociate, creating thousands of particles from one parent grain. First, the Ballistic phase whereby the recoiling atom strikes a neighboring atom triggering a chain reaction of high energy collisions followed by the Thermal Spike, the sharing of a large amount of kinetic energy among so many atoms that the local area briefly melts into maximum disorder and finally the Quenching stage where the atoms rapidly cool with most atoms falling back into a lattice structure with a small percentage remaining trapped as defects. In the case of the outer surface of the PM10 Parent complex at a depth of ~2 nm or more, these Frenkel pairs become detached thereby entering the interstitial fluid surrounding the cells.

- **Formula:** $N_d = \frac{0.8 \times E_r}{2E_d} \approx 1152$ atoms displaced

Isotopic Transmutation Chain (I_t)

Each link in the decay chain ($^{238}_{92}U \rightarrow ^{234}_{90}Th \rightarrow ^{234}_{91}Pa \rightarrow ^{234}_{92}U + ^{0}_{-1}\beta$) involves a new recoil event over time resulting in a plume around the Parent complex resembling the umbra and penumbra of a sunspot on the sun but instead of temperature being the difference between them, density of Frenkel pairs is the difference in this instance. In a PM10 size particle of uranium, there is ~13 trillion uranium atoms with the decay in secular equilibrium up to $^{234}_{92}U$, one should expect to see 1150-200 alpha decays and subsequent recoils from $^{234}_{92}U$ alone in a month's time.

Micro-dosimetry and Denominator Correction

I. **Functional Mass Interaction (M_f)**

Replaces the 1 kg (10^6 mg) organ mass with the ~1 mm plume mass.

Formula: $(\frac{4}{3}\pi(r_{drift})^3) \times p \approx$ **4.19 mg**

II. **Particle-to-Plume Correction (K_p)**

The scale multiplier for volume expansion.

Formula: $K_p = \frac{V_{plume}}{V_{static}} = \frac{(1000\mu m)^3}{(40\mu m)^3} \approx$ **39.0**

III. **Precision Parameter Matrix (*P*)**

Dose no longer is a single number alternatively instead is a matrix incorporating:

Aerosol Size (AMAD): 1, 5, 10 μm

Density (*p*): 19.0 g/mL (bulk DU example)

Shape Factor (*x*): 1.5

Biological Systems: Non-Linear and Biphasic Response

Biphasic Non-Linearity ($\mathbf{B_\phi}$)

The FIP Model rejects the Linear No-Threshold (LNT) model elucidating at low doses, the **Inverse Dose-Rate Effect** makes the plume highly efficient at striking fresh DNA.

- **Supra-Linear Phase:** Maximum risk per unit of radiation increased as the ratio of prior wasted energy is added to new cells.
- **Redistribution Phase:** Unlike the "Overkill Plateau," nuclear recoil causes a **redistribution** to healthy cells rather than wasted on cells that have undergone apoptosis ultimately leading to a **Translocation** of the dose.

Chemical Synergism ($\boldsymbol{S_c}$)

Uranium has a heavy-metal toxicity $\left(\mathbf{UO_2^{2+}}\right)$ that binds to the Phosphates groups in the DNA backbone and other sources, thereby inhibiting DNA repair enzymes such as **PARP-1.**

- **Factor:** $S_c \approx$ **1.5** (Radiation + Chemical Inhibition)

Macrophage "Trojan Horse" and Radiation Induced Bystander Effect (RIBE)

- **Nodal Dose ($\mathbf{M_{nodes}}$):** Particles migrate and carried by Macrophages to the lymph nodes where doses are **10x higher** than lung tissue.
- **Bystander Effect** ($\boldsymbol{\beta}$): Irradiated cells signal stress to neighboring cells manifesting damage, mutations or changes in behavior. Mechanisms for communication include Gap Junctional Intercellular Communications (GJIC) and other signaling factors such as Reactive Oxygen Species (ROS), amplifying affects at "low doses".

The Unified Precision Radiation Risk Model-39 Functional Interaction Plume (FIP) Risk Equation

PRRM-39 **VS** **ICRP-103**

$$H_{true} = \left(\frac{\text{Energy}}{M_f + M_{nodes}}\right) \times \left(\frac{w_\mu \times S_c \times R}{\Lambda \times D_p}\right) \qquad H_T = \sum w_R, D_T, r$$

Parameter Symbol	Identifier	Value (Proposed Standard)	Definition
H_{true}	Precision Equivalent Dose	250,000×/ 39× Current Risk	Full Mass Spectrum of Micro-dosimetric measurements
Energy	Decay Energy	Joules/ Milligram (g) (eV)	Energy per "proper" Unit Mass
M_f	Plume Mass	Adjustable Mass	One size does NOT fit all Functional Interaction Mass (FIP)
M_{nodes}	Lymphatic Mass	Adaptive Mass	Mass of regional Lymph Nodes where S-type particles migrate/ macrophage transport
w_μ	Micro-Weighting	Adjustable Weighting	Decay emissions are within an energy range, so should weighting
S_c	Chemical Synergism	Variable	Factor for Uranyl ion inhibition of DNA repair enzymes
$\underline{R}$	Recoil Constant (Range)	Alpha/Beta Neutron/Proton Photo-Electric	Kinetic energy of the recoiling Daughters nucleus
Λ	Plume Dilation	Radiation Type Dependent	Percentage of ejected ions interaction with healthy DNA
D_p	Dispersion Factor	Radiation Type Dependent	Plume Geometry Constant Defines the spatial "kill zone" created as ejected ions mobilize in interstitial fluid

Nuclear Regulatory Commission (NRC) Laser Enrichment facilities and any other NRC topic

For the sake of time, the vast remainder of the ICRR risk model will be omitted from this NRC public comment. The remaining documentation will soon be ready for pre-print and will then be sent out to every scientific journal editor for review.

The NRC still utilizes the older 1977 ICRP recommendations and has even after the ICRP has updated their modeling. Finally now, the NRC is attempting to get on board with the ICRP 103 framework used around the world for years now, of which in of itself is extremely flawed. Now, the current Presidential Administration has handed down directives not based on science, but instead based on simply updating our nuclear arsenal and subsidies for Advanced Nuclear Reactors. While undoubtedly everyone will point out the various issues with the various designs, fuels and coolants, this is all after the fact that current regulatory framework for not only Radiological Risk, but also Site Risk as well has been outright wrong since its inception.

The ICRR Unified Precision Radiation Risk Model-39 proves beyond a shadow of a doubt the current risk models flaws and provides the proper regulatory framework moving forward. The vast majority of all agencies across the world understand that the current Macrodosimetry system can never apply to the Microdosimetry world we live within.

The Administrative Procedures Act (APA) 5 U.S.C. § 706 requires agencies base decisions based on a *"rational connection between the facts found and the science made"*. This law requires the Commission to further investigate the flaws of the current ICRP model.

The Information Quality Act (IQA) ensures when new information comes available, the Commission is obligated to guarantee that objectivity, utility and most importantly integrity makes up the basis of NRC rulemaking. The NRC has the societal responsibility to not only hear new information, but to act based on that new information. The Commission has a non-discretionary duty to ensure its safety standards are grounded in the best available science. The introduction of this new ionizing radiation risk model constitutes significant new information that necessitates a re-evaluation of the current regulatory framework. Failure to consider evidence that contradicts the existing model by orders of magnitude violates the reasoned decision-making requirement of the Administrative Procedure Act. Under 10 CFR § 51.92, the NRC must prepare a supplemental Environmental Impact Statement (EIS) if there are significant new circumstances or information relevant to environmental concerns. Suggested Language for the Comment We submit that the current NRC risk assessment constitutes a fundamental flaw in the regulatory basis for advanced reactor licensing. Under the Hard Look doctrine of NEPA, the NRC cannot legally ignore peer-reviewed evidence showing a variance of multiple orders of magnitude from current projections. We formally request that the NRC stay the comment period to conduct. a technical bridge analysis between the existing LNT-based models and the provided data to ensure the integrity of the public record. These are not minor deviations but instead systematic failures with nothing to explain it.

We have prepared a small section on the PRAs Level 1, 2 and 3 for review and by law you are forced to investigate this further to ensure the most up to date nuclear and health physics are on record.

Level 1 reliability data is only half of the equation; the other half is Human Reliability Analysis (HRA) and Habitability.

1. The Human Component Failure Rate:

NUREG/CR-6928 provides the data for hardware, but NUREG-1842 and NUREG-1792 (the HRA guidelines) provide the data for the people operating that hardware. In a Level 1 sequence (like a Feed-and-Bleed or a small-break LOCA), the reliability of the system depends on an operator entering a zone to manually align a valve or check a breaker.

If the NRC's current dose model says an operator can spend 30 minutes in a Level 1 recovery area safely, but our Mobile Plume model shows they are actually taking a much higher effective hit to their lungs from suspended PM10 dust, then the Human Failure Event probability in your PSA just skyrocketed to 1.0 (certain failure). You can have the most reliable pump in NUREG/CR-6928, but if the human required to flip the switch is incapacitated by a concentrated alpha-emitter plume you didn't account for, the Core Damage Frequency (CDF) is wrong.

The new Part 53 framework is moving toward a Technology-Inclusive approach. This means we aren't just looking at "did the pump break?" but "is the overall safety case sound?" If your Level 1 PSA relies on a kilogram denominator to claim operator safety during a mitigation sequence, you are ignoring the Alpha Recoil Displacement that physically compromises your most important component, the human operator.

So, while our model doesn't change the failure rate of a check valve, it fundamentally resets the Error Forced Context (EFC) for the personnel required to keep that valve from becoming a Level 2 release.

In closing, the International Committee on Radiation Risk ICRR is made up of experts and researchers around the world and we strive to present the most up to date Nuclear and Health Physics available. We provide bit a portion of our new Unified Precision Radiation Risk Model-39 and look forward to working with regulatory bodies and industry alike to develop the most accurate Ionizing Radiation risk model to supply the world with a proper dose estimate. We challenge the NRC to make the correct, lawful decision and pause the licensing of new experimental "advanced", yet old designs, nuclear reactors. We would like to thank the NRC for facilitating an arena for discussion to occur and would invite the Commissioners and Inspector General to contact the ICRR for future discussions.

Until this specific issue of the differences between Macro-Dosimetry and Micro-Dosimetry is resolved, any further action by the NRC after being publicly notified will face obvious criminal negligence charges. You all have been notified

International Committee on Radiation Risk (ICRR)

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Nuclear and Health Physics

General Theory of Uranium Particle Radiocarcenogenesis

Paul Mobley
Civil/Operating Engineer

Abstract

Radioactive decay is well understood in society today with the comprehension of various types of radioactive emissions e.g. Alpha, Beta, Gamma, X-ray and Neutron radiations with various characteristics and energies. These radiations are the governing force behind our global nuclear industry and the regulations associated with radiological material handling and environmental emissions.

The foundation of regulatory thresholds for ionizing radiation exposure, since its discovery more than 100 years ago, has drastically changed several times over a century as new research and evidence is presented creates a drastic change to the risk model. In this paper, it will be demonstrated how we are at that same impasse where at the precipice we must change our calculation of risk based on the available scientific literature and agree that the current risk model, just as it has been several times before, has not afforded society proper dose estimates for the decades it has been deployed.

- Equivalent Dose

  $$H_T = \sum_R w_R D_{T,R}$$

  Discoveries made long ago and even still currently today, show how this widely used equation formulated during the 1960s-1970s, has several flaws ultimately leading to an underestimation of the actual dose received. Integrated Aggregate Dose by averaging a dose has been the “Gold Standard” since the Japanese Lifespan Study when the innocent Japanese people suffered greatly even far from the thermal blast radius due to ~95% of the Uranium not undergoing fission becoming broken up into nanoparticles and creating the black rain of fallout ultimately ingested by millions of people in Japan and around the globe.

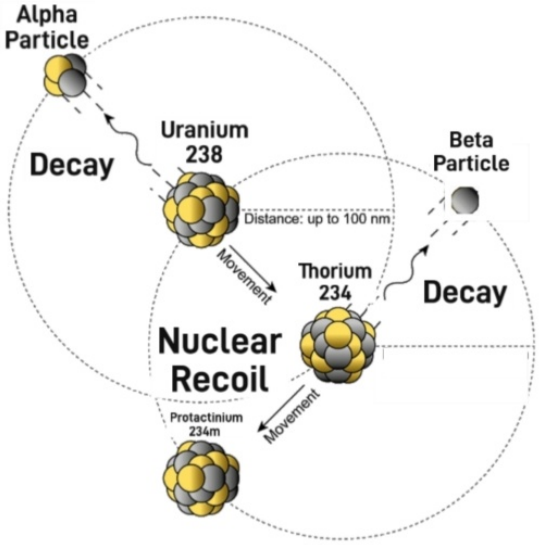
Radiological Kinematics

Conservation of Momentum and Nuclear Recoil

The word Recoil itself is an intuitive word most people recognize from various life experiences and can be applied elsewhere to gain an understanding of something unknown. The prime analogy used to explain this fundamental law most times is a gun firing a bullet whereby when it's fired, the projectile carries away the largest portion of the energy followed by a recoil in the opposite direction that causes a "kick" to the person holding the weapon. Understanding this phenomena affords us the ability to pose a few scientifically based questions regarding the basic geometric dimensions utilized throughout our entire nuclear industrial regulations. The following will focus primarily on the Alpha decay mode from point sources such as Uranium, Plutonium or Thorium and will be named "Parent Complex" representing the initial PM10 dust particle that would be inhaled and lodged deep in the Alveoli region within the lungs.

Alpha Decay and Daughter Recoil

- Total Energy Released (Q)
  $Q = (m_{parent} - m_{daughter} - m_{\alpha})c^2.$
- Conservation of Momentum
  $m_{\alpha}v_{\alpha} = m_R v_R.$
- Alpha Particle Velocity
  $K_{\alpha} = \frac{1}{2} m_{\alpha} v_{\alpha}^2 \Longrightarrow \boldsymbol{v_{\alpha}} = \sqrt{\frac{\boldsymbol{2K_{\alpha}}}{\boldsymbol{m_{\alpha}}}} = \sqrt{\frac{\boldsymbol{2Q}}{\boldsymbol{m_{\alpha}}}}$
- Daughter Recoil Kinetic Energy
  $K_R = Q - K_{\alpha} = Q\,\frac{m_{\alpha}}{m_{\alpha} + m_R}.$
- Daughter Recoil Velocity
  $v_R = \sqrt{\frac{2K_R}{m_R}} = \sqrt{\frac{2Q}{m_R}\,(1 + \frac{m_R}{m_{\alpha}})}.$



This equates to the energy of the Alpha particle on average to be ~4.5-5 Million electron Volts (MeV) and the velocity of 3-5% the speed of light or 9-15 million meters per second (m/s).

The reciprocal recoil imparted on the Daughter nucleus has the energy of ~70-150 kiloelectron Volts (keV) and the velocity of 230,000-260,000 meters per second (m/s).

The moment these well known decays occur (cause), a resulting reaction takes place (affect) rarely discussed beyond the laboratory or classroom but has a profound impact.

Metallic Bond and Binding Energy

Lattice Structure of Uranium

At room temperature, refined uranium atoms naturally arrange themselves into a complex orthorhombic lattice structure with low-symmetry and an anisotropic metal with physical properties of significantly varying thermal expansion depending on the direction of the crystal. Uranium atoms form a quintuple bond and despite this high bond order, the U-U metallic bond energy is relatively modest at 222 kilojoules per mole (kj/mol) or ~0.5-1.5 electron Volts (eV). The outside layer of the mass would form covalent bonds with oxygen in the air to form Uranium Oxide (U-O) or in water form Uranyl ions with a binding energy of ~7-8 electron Volts (eV) and if ingested, it has the potential to form Uranyl Phosphates which are harder for the body to clear.

- General Thermochemistry

$$\Delta H = \sum \text{Bonds Broken} - \sum \text{Bonds Form}$$

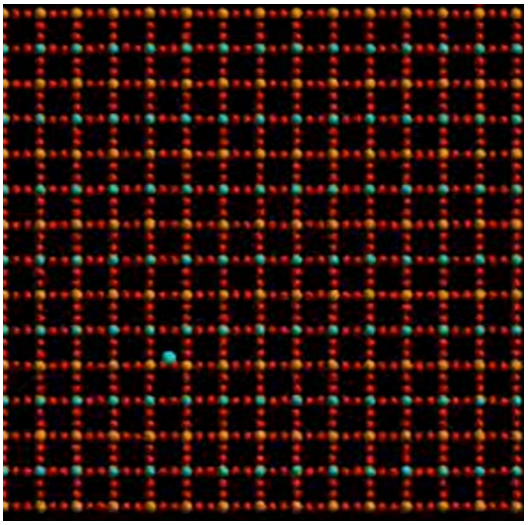
The energy from a single nuclear recoil caused from the conservation of momentum from the alpha emission of ~70,000-150,000 eV is ~10,000 times the binding energy of U-O covalent bond energy of ~7-8 eV and ~100,000 times the binding energy of the U-U metallic bond of ~0.5-1.5 eV. It becomes very clear at the atomic level, the event of alpha decay becomes much more than just the energy of the alpha particle itself.

Bond/Event type	Typical energy (eV)	Strength
Metallic Bond U-U	~0.5-1.5 eV	Moderate
Covalent Bond U-O	~7-8 eV	Moderate
Nuclear Recoil	70,000-150,000 eV	Extreme

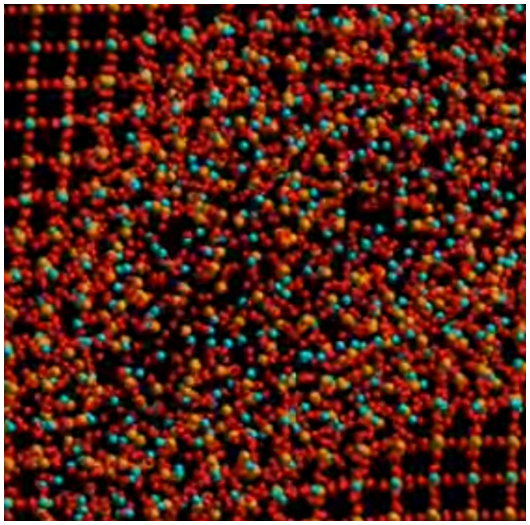
Metallic Lattice Interactions

During the interaction of alpha recoil, a displacement cascade is caused from a single recoiling Daughter atom kinetically slams into the lattice crystalline structure and displaces thousands of other atoms. Deeper than the surface layer and in the first picoseconds, three distinct stages occur causing a cascade of interactions. First, the Ballistic phase whereby the recoiling atom strikes a neighboring atom triggering a chain reaction of high energy collisions followed by the Thermal Spike, the sharing of a large amount of kinetic energy among so many atoms that the local area briefly melts into maximum disorder and finally the Quenching stage where the atoms rapidly cool with most atoms falling back into a lattice structure with a small percentage remaining trapped as defects. The creation of Frenkel pairs made up of thousands of empty lattice sites along with Metamictization forming an amorphous ceramic glass structure further increasing mobility.

Before Recoil



After Recoil



Surface Fragmentation and Ejection

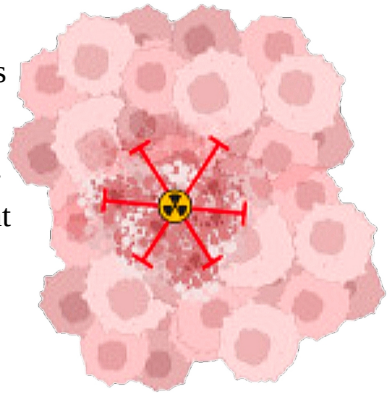
On the exterior surface area of the inhaled Uranium Parent complex, fragmentation of the lattice occurs creating the formation of micro cracks and pores. The kinetic energy is so intense, the Daughter radionuclide is ejected up to 100 nanometers (nm) in tissue from the initial Parent complex thereby causing fragmented groupings of uranium atoms to become freed from the complex. Due to the constant Alpha particle emission and subsequent nuclear recoil displacement cascade causes a constant increase in solubility allowing the interstitial fluid to leach atoms more quickly. The isotropic release of alpha particles surrounded by cells creates damage to the cell membranes and no longer able to keep these recoiled ejecta from entering the interstitial fluid surrounding the cells.

Relative Biological Effectiveness

Linear Energy Transfer and Cell Apoptosis

For half a century, the International scientific community and industry have used a very specific and simple geometry to explain ones internal dose from PM10 type Alpha emitting particles taken up by biological life. Tissue density plays a pivotal role in the amount of energy absorption and attenuation, but generally cells in the immediate vicinity do not fair well.

Alpha Emitting Particle

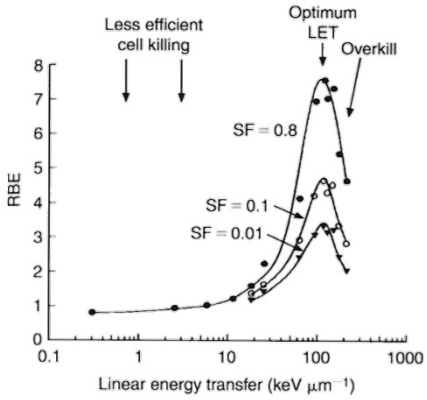


Ionizing Radiation, with the exception of Beta radiation, radiates isotropically outward in a straight line vector thereby causing the deposition of energy along the track it travels. The characteristics of Alpha radiation is it encounters a Bragg Peak near the end of its track where it deposits the majority of the ~4.5-5 MeV energy. The measure of Linear Energy Transfer LET is simply the amount of energy divided by the distance of the track within the medium it travels.

- Linear Energy Transfer
  $LET = \mathrm{d}E_{\mathrm{abs}} \ / \ \mathrm{d}x$

In the case of lung tissue cells, the range of an Alpha particle is a distance of ~40 microns. This equates to the dimensions of an ~80 micron sphere of cells that have undergone apoptosis due to the ionization caused by multiple Alpha particles over a relatively short period of time.

Ultimately, Alpha radiation is considered to be high LET radiation measured to be on average ~100-200 keV/micron (*u*m) with an affinity for DNA Double Strand Breaks (DSB). The biological detriment encountered by the immediate 4 cells in all directions, damages the cell membranes and becomes the basic geometric dimensions utilized to create a “plateau” of the dose from an Alpha emitting particle at ~100 keV/micron. The premise then became, since all the cells surrounding the Alpha emitting particles are dead, then any subsequent alpha emissions can not “overkill” the cells within the range of their possible tracks and therefore the internal dose decreases drastically.



The overkill plateau is represented in this graph as functions of Relative Biological Effectiveness and Linear Energy Transfer. This was the motivation based on simple geometry in essence to cap the RBE to a ceiling and in affect creates arguably major flaws of our current risk models with no accounting of nuclear recoil within the scope of the International dose coefficients software and the Macrodosimetry averaging methodology.

Complexity of In-Vivo Biological Systems

Microdosimetry, Dose Translocation and Migration

Due to the microscopic realty of Alpha radiation and subsequent nuclear recoils, averaging any dose over a large amount of mass such as a kilogram or an entire organ irrefutably dilutes the dose over larger amounts of mass even when the said range of Alpha radiation is 40 microns. By spreading this dose of an ~80 micron sphere of mass over an entire kilogram or organ in of itself creates an underestimation of the proper dose without question.

Since we can conclude the cell membranes of all surrounding cells would be damaged, there would be nothing to stop the ejected Uranium and decayed daughters caused by nuclear recoil from not only becoming mobile beyond the dimensions of the RBE “overkill” plateau sphere, but go on to cause biological damage to other sensitive cells and much more.

Macrophages, the lungs clearance mechanism of Phagocytosis is attracted to the “Hot Particle” Parent complex lodged deep in the Alveoli region, will attempt to clear the Alpha emitting radionuclide mass by wrapping its membrane around the particle. Unfortunately, the macrophage will most times encounter an Alpha emission that will result in the death of the macrophage causing an interaction with the digestive enzymes and converting insoluble oxides into Uranyl Phosphates which may be more difficult for the body to clear. Certain instances have found with a failed attempt of a clearance by the macrophage, the particle may end up in various parts of the body including other lung tissue cells, the lymph nodes, Kidney, bone and bone marrow, brain, heart, and more..

Research (*PubMed ID:40068777*) indicates by not accounting for the affect of nuclear recoil causing a Translocation of the dose elsewhere such as the kidney, the current calculation under-estimates the dose to just the kidney alone of ~10% or more and overestimates the dose to the initial site of spherical apoptosis by up to 23% with the majority of that overestimate ending up elsewhere in the body. These groupings of uranium atoms ejected due to the cascade still must encounter Alpha emissions that will occur elsewhere in the body not represented or accounted for with the current RBE plateau model. The physics proves a dose to an alpha emitting particle could never plateau due to the decay constant of Alpha radiation and the continuous ejection of uranium and radioactive daughter atoms like a generator well beyond 80 microns in the surrounding area. A cloud of Uranyl ions and other Uranium compounds, daughter radionuclides, decay recoil fragments of fission/decay products and other constituents associated with the characteristics of the Parent complex all become mobile well beyond the dimensions governed by the range of the isotropic emissions of the Alpha particles themselves.

Conclusion

Based on available research released in the past 50 years since the development and formulation of Equivalent Dose ($H_T = \sum_R w_R D_{T,R}$), several irrefutable flaws result in a clear under-estimation of an internal dose estimate creating errors of considerable magnitude. The Epidemiological studies are very clear showing the cancer, cardiovascular and other ailments including rare diseases, are above national averages and statistically the most probable cause to the affect. Adversely, based on the calculations utilizing arguably critically inadequate Weighting Factors (wR) equating to a negligible effect, it's then argued proven statistical increases of contamination and the associated negative health impact couldn't be due to the synergistic effects of the chemical and radiological effluents released from their operations because their flawed dose estimate equation states otherwise.

Generally, only half of the laws of physics during radiological emissions are well understood by the global populous be it the average person or the typical nuclear industry worker alike. Many may grasp the various radiation types and some of their characteristics, but rarely at the atomic level is Alpha nuclear recoil discussed let alone the implications of the occurrence inside a persons body.

In a Science Direct publication titled *"Alpha spectrometry: Avoiding recoil contamination of solid state alpha detectors"*, researchers elucidate the absolute need to shield and attenuate the ejected daughter radionuclides and lattice fragments of the Alpha emitting Parent complex. Their findings were at a measuring time of 300,000 s (~3.5 days) in low vacuum and at a distance of ~5 mm between the detector and source with a thin VYNs film between would allow all Alpha particles through but block the constituents caused by the recoil measured at ~62 counts, when applying 3V negative potential across a cathode with no film resulted in ~2,873 counts and finally with no film shield or negative potential voltage applied ~4074 counts were obtained. At a distance of ~5000 microns (5mm), thousands more counts can be attributed to Alpha recoil ejections resulting in 65 times the amount of counts at 125 times the distance of a typical Alpha particle track in tissue. This interaction taking place inside a complex biological system with fluid dynamics, tissue regeneration, clearance mechanisms, bloodstream etc., the geometric dimensions utilized to describe internal doses are inaccurate by orders of magnitude.

Related literature "*Researchers (e.g., Kurijff et al., 2019)* have placed Actinium-225 inside nanoparticles thereby placing them into physiological fluid and found up to 100% of the daughter isotopes (like Bismuth-213) were "kicked out" of their molecular cages into the surrounding fluid as a result of the Alpha recoil energy.

Nuclear and Health Physics have evolved over a century since radioactivity was first discovered before even Absorbed Dose was known. In the early 1900s the accepted thresholds were equivalent to 60 REM annually, then by the 1950 it went down to over half and by the 1970s the Internationally accepted threshold changed yet again for a nuclear worker to just 5 REM annually. Just as in the late 20th century, today we are at that same precipice where the need to change the current measure and understanding of risk supersedes "national security" through military operations utilizing uranium materials and munitions, energy independence or corporate and political portfolios.

It is unequivocal the evidence more than suggests and correlates major flaws of the past and current risk model for internal dose estimates utilizing the equation and parameters of Equivalent Dose will not and have not for over 50 years provided a single person with a proper dose estimate from internal exposures to alpha emitting particles. Heavy discussions within the International Commission on Radiological Protection ICRP seen from their 2021 publication stating themselves Equivalent Dose is an improper calculation for internal exposure to Alpha radiation and in the ICRP Draft Report also discuss the inefficiencies of Effective Dose as well.

Therefore, until further review and reformulation of the equation, Weighting Factors, Microdosimetry with energy deposition/absorption focused locally at the point of interest, accounting and acknowledgement of nuclear recoils drastic influence on dose estimates via a change in the geometric area of biological effectiveness…all internal dose estimates using the current system with the units REM or Sievert are irrefutably null and void.

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