Burdening Port Hope:

Material releases, human exposure and biological effects remain unclear and unmeasured

Port Hope

October 10, 2006

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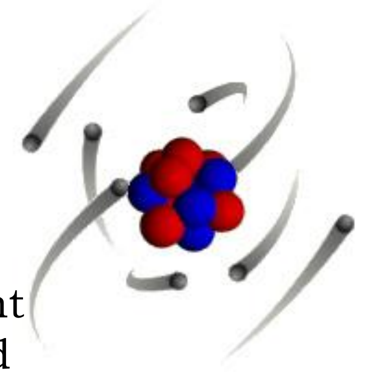
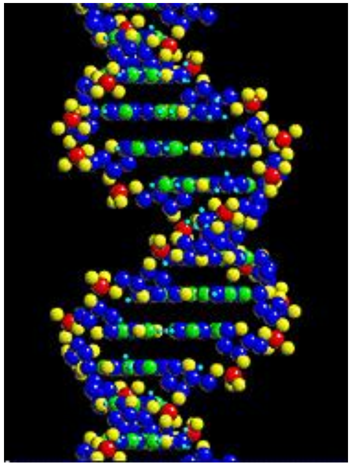


The uniquely violent and concentrated energy-transfers, resulting from xrays (and other types of ionizing radiation), are simply absent in a cell's natural biochemistry. As a result of these "grenades" and "small bombs," both strands of opposing DNA can experience a level of mayhem far exceeding the damage which metabolic free-radicals (and most other chemical species) generally inflict upon a comparable segment of the DNA double helix.



Dr Kleihues, Director, IARC
International Agency for Research on Cancer (IARC)

The global burden of cancer is on the increase. Ten million people developed a malignant tumour in 2000. … , the number of new cases will rise by half by 2020 – to 15 million new cancer cases per year. For every person with cancer, there are families and friends who also must cope with the threat and fear of the disease.

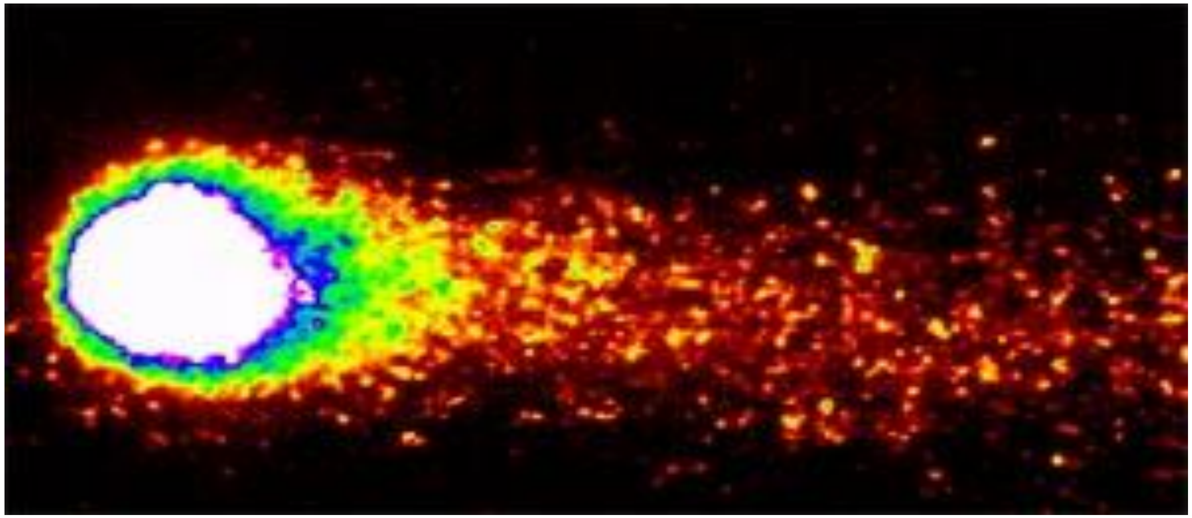


Photo of uranium annihilating a DNA molecule

CNSC's licensed Cameco products

- 2,800 tonnes/yr of uranium as UO2
- 12,5000 tonnes/yr uranium at UF6
- 2,000 tonnes/yr DU (depleted uranium) and uranium metals and alloys
- 1,000 tonnes/yr UO2 and 1,000 tonnes/ADU (ammonium diuranate) waste recovery
- Increase to 45 tU/day in 2003
- Licensed waste
  - Uranium discharge to atmosphere.
  - Uranium discharge to water courses
  - Several million cubic meters of waste licensed separately from current operations and not factored into "operating release limits" (i.e. public dose).

Cameco's uranium emissions and sources

- Uranium-loaded, airborne powders, particulates, dusts, smoke and gases. U is presented in both pure and compound forms.
    - UO_2 main plant stack air emissions
    - North UO_2 stack emissions
    - UF_6 main stack emissions
    - E-UF_6 plant (not in operation)

- Direct gamma radiation from all of the above and …
    - Centre pier (uranium storage; DUO_2/Ti; military uranium; magnox)
    - Dorset St east warehouse
    - Recycling operation

- Incinerator – no quantity of discharged uranium reported

- Uranium emissions to free flowing water courses - plant discharge direct to Lake Ontario, to municipal sewage treatment, to storm sewer. The quantities are unreported.
    - 2001, DRL was 1018.85 Kg/yr (1 metric tonne of uranium)
    - Actuals were reported to range between 2 Kg/y to 5 Kg/y.

Emissions and sources

- Neutron radiation from U238, uranium materials' stockpiles, containers; from depleted uranium, enriched uranium, UF6, uranium powder mixed with dysprosium and beryllium.

- 2282 t of UO2 rich NH4NO3 – ammonium nitrate fertilizer - 10 mg/L (10 PPM) and 370 Bq/L (U and Ra).

- Soil and surface "shine" (i.e. fallout) (depositions of the low-mobility, insoluble industrial-commercial, anthropogenic uranium).

- 34 t/mo UF6 slurry, shipped to Utah for recovery of uranium.

- Floods, storms, snow melt wash uranium-rich fall-out and dust out of facilities into streets and sewers.

- UF6 cylinder leaks

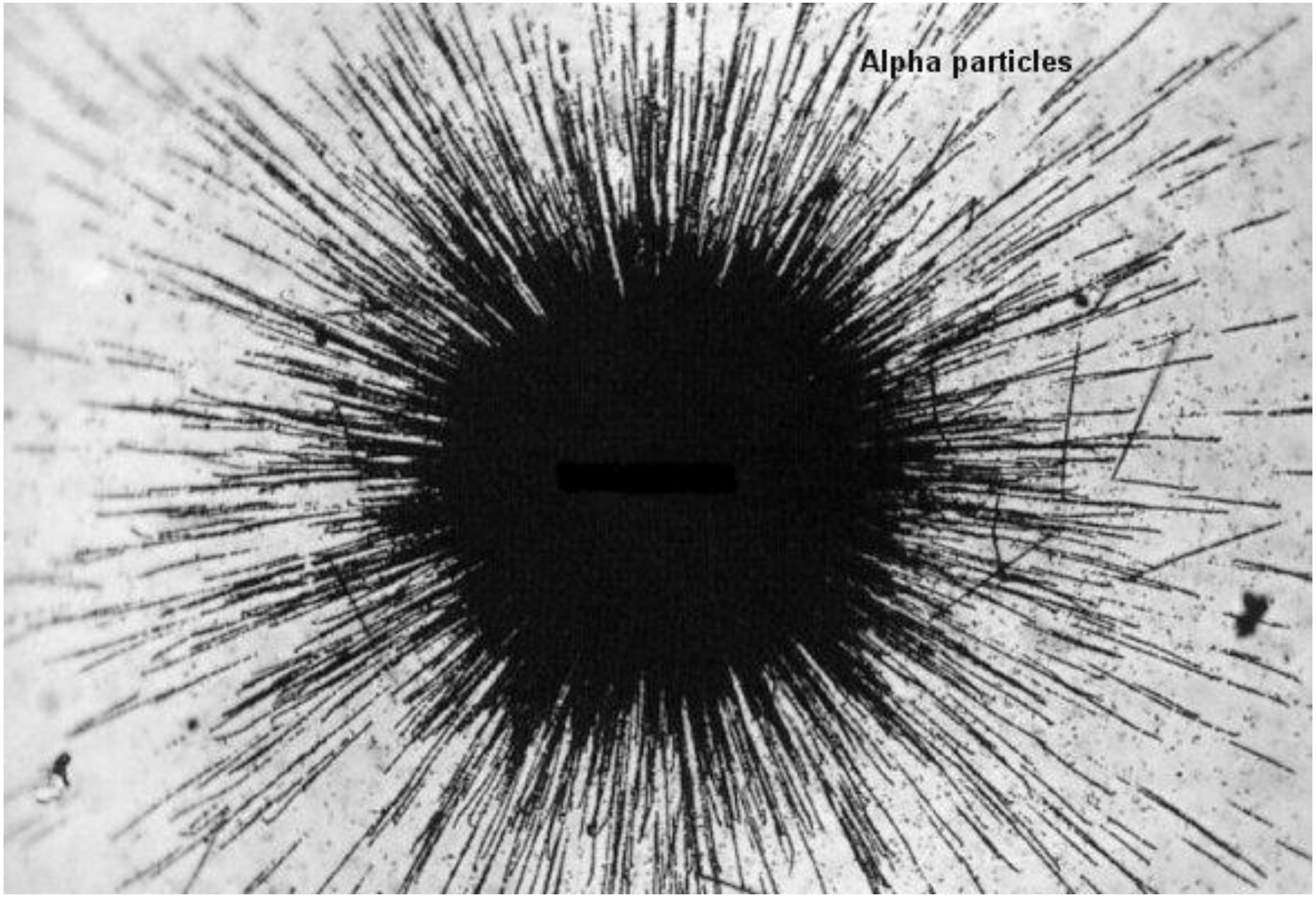
Ionizing radiation

Alpha, beta, gamma and neutron radiations are continuously delivered into Port Hope's breathing and living space, directly from Cameco's facilities and as products of the nuclear waste discharged into the community's air, soils and water.

Artificial radiation emitters are permanently incorporated into all our bodies in Port Hope; and, are continuously reinforced by the arrival of fresh radiogenic materials, hourly.

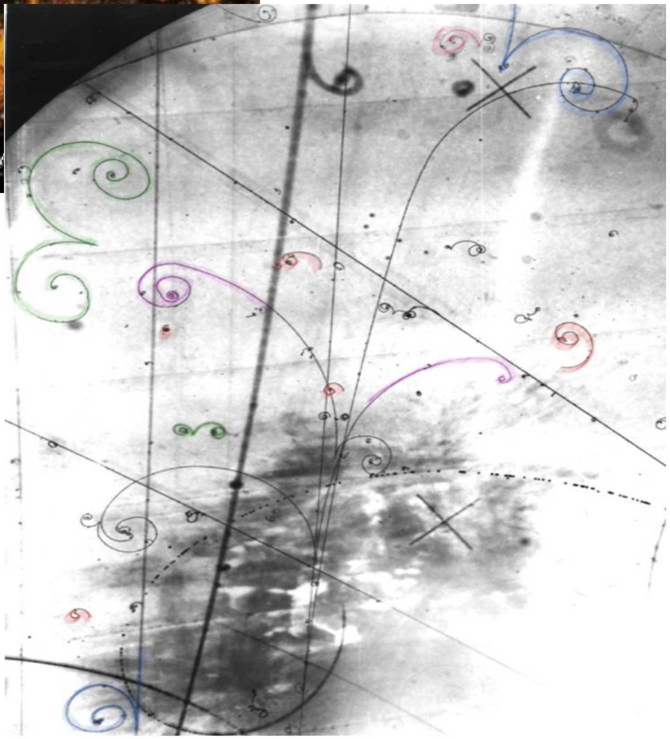
Tasteless, colorless and odourless ...

… but nonetheless deadly to cells and genetic materials



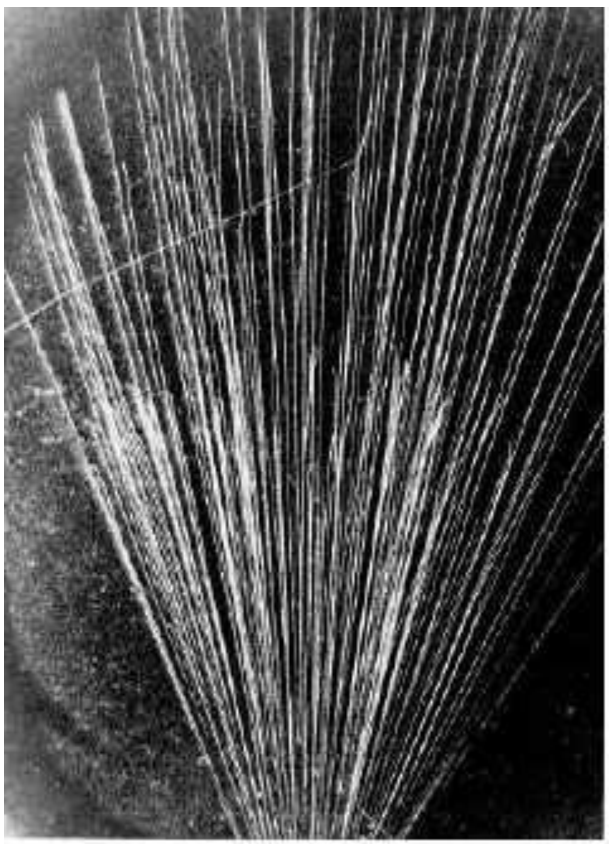
Ionizing radiation's character: Linear Energy Transfer

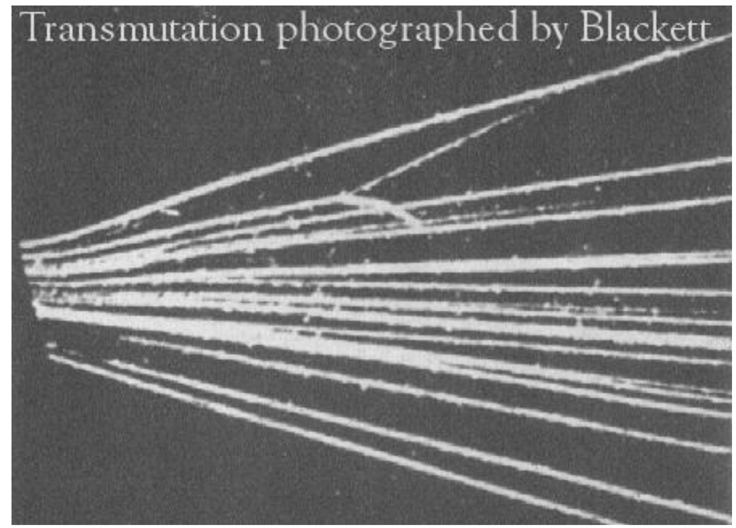
Elementary particle tracks exemplifying ionizations by charged particles



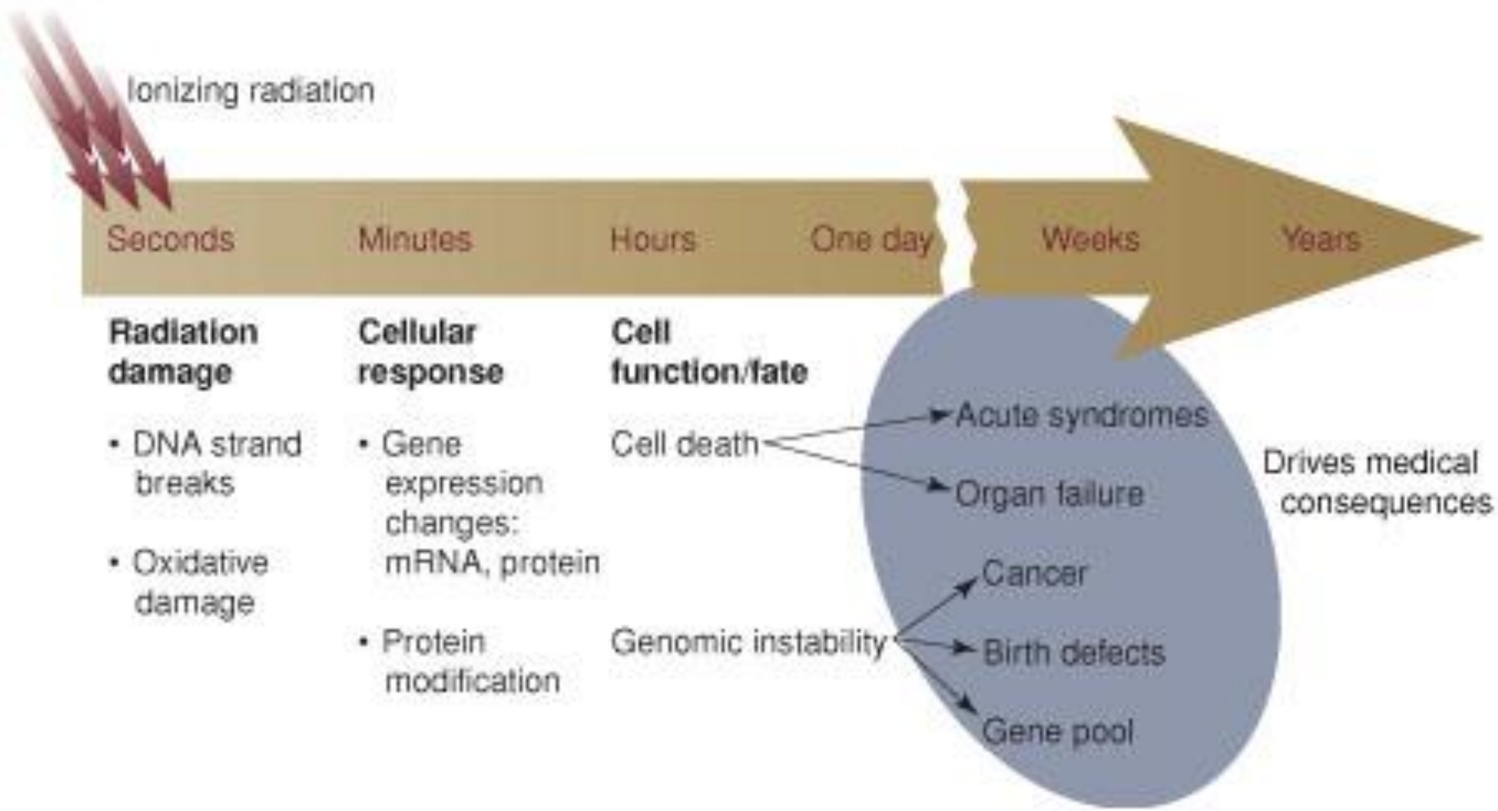
Electron – positron tracks (pair formation)

Alpha are dense and heavy high energy particles – each track consists of 10's of thousands to millions of ionizations in less than a millimetre.





LET's outcomes



Source: LLNL

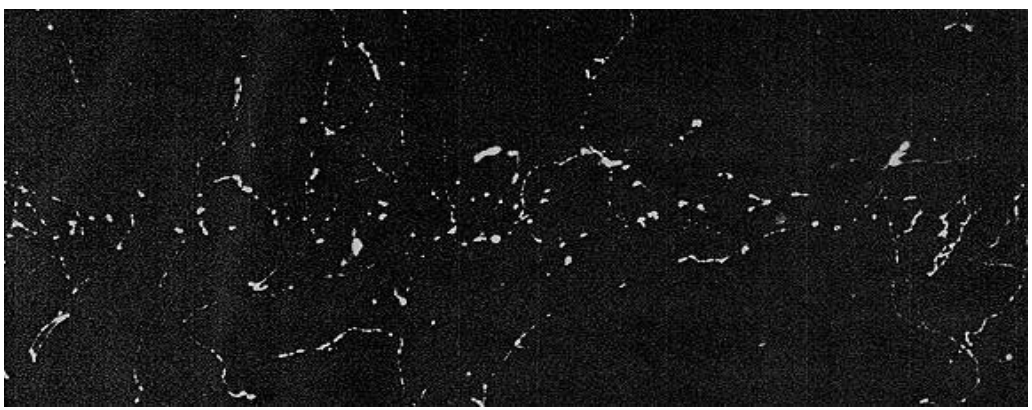
Ionizing radiation: "Q" – the relative biological effectiveness

Type	**HIGH Linear Energy Transfer Radiations**		**LOW Linear Energy Transfer Radiation**	
Features	**α-Radiation** **Alpha**	**n-Radiation** **Neutron**	**β-Radiation** **Beta**	**γ-Radiation** **Gamma**
Nature	Particle radiation			EM radiation – no mass
Composition	He (helium) nuclei	Free nuclei of an atom	Unbound electrons – "e"	Photon (light packets)
Charge	Positive (+2)	No charge (0)	Negative (-1)	Pure energy, neutral (0)
Mass	6.64 X10e-24 g 4.003 amu	1.68X10e-24 g 1.0087 amu	9.11X10e-28g 0.00055 amu	0
Energy eV	4 - 8 MeV	2keV – 20MeV	Several keV to 5 MeV	0.5 MeV – >5 MeV
Relative size	7,352 X's larger than e	1,838 X's larger than "e"	10e-16 cm	No mass
Bio-damage efficiency Ionization Penetration Attenuation Dose	4K -9K ion pairs/um tissue 10 cm in air 60 um in tissue Dose Q – 20 Most efficient, most damage.	A few K to Millions of ions/um tissue. Induces radiation in targets. Free "n" life – 12 – 15 minutes Dose Q: •CNSC: 3 – 20 •LANL: 3 – 300	6-8 ion pairs/um tissue 4 meters in air Few mm in tissue Dose Q: 1	Indirectly ionizing Kilometres in air. Meters in tissues. Dose Q - 1
Velocity, c	1/20 c (0e7 m/s)	Thermal n - 2.2 Km/s	0.9 C	C - 1.0

Relative biological damage:
Linear Energy Transfer (LET) effects

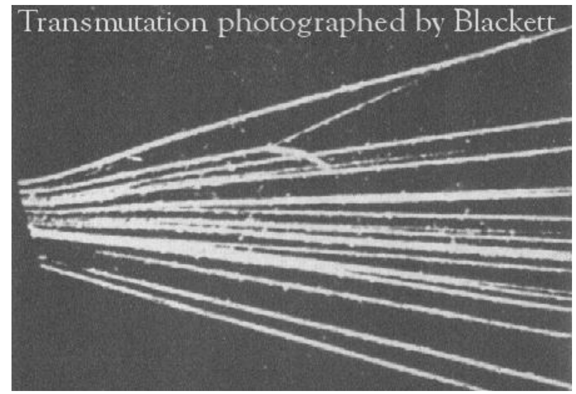
Low LET radiations

Electron tracks

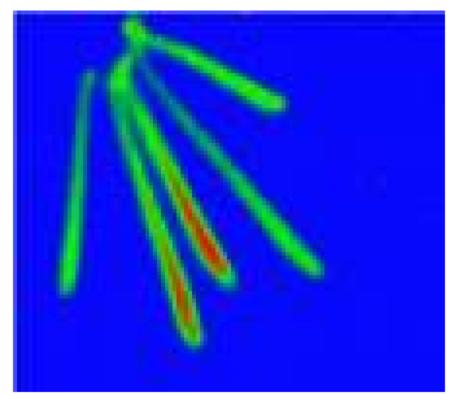


Gamma effects

High LET radiations

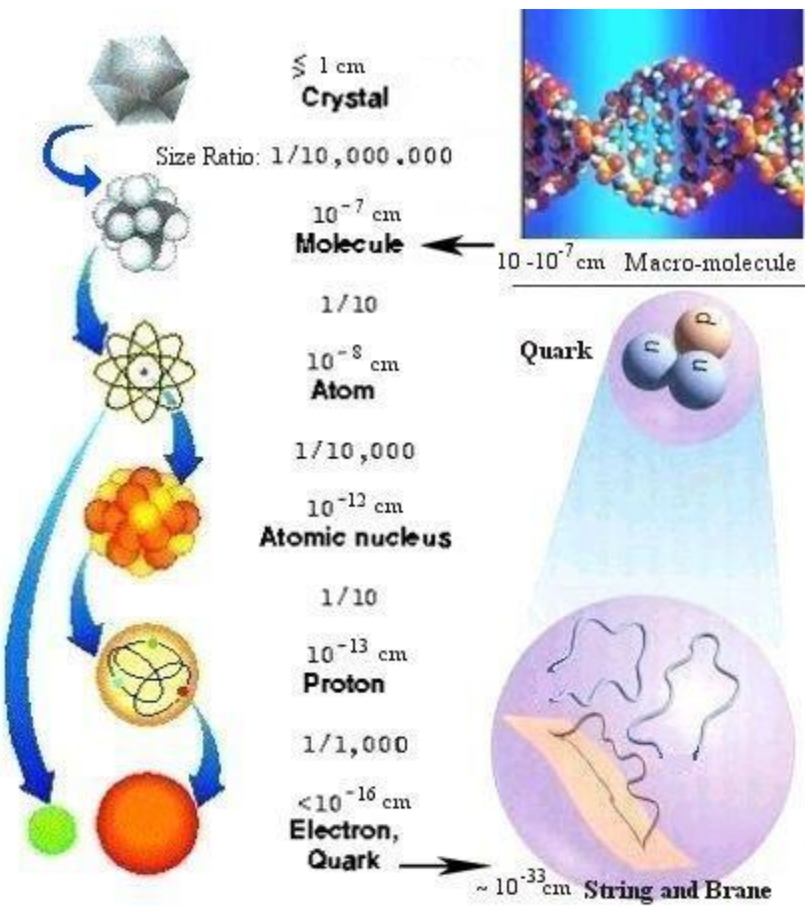


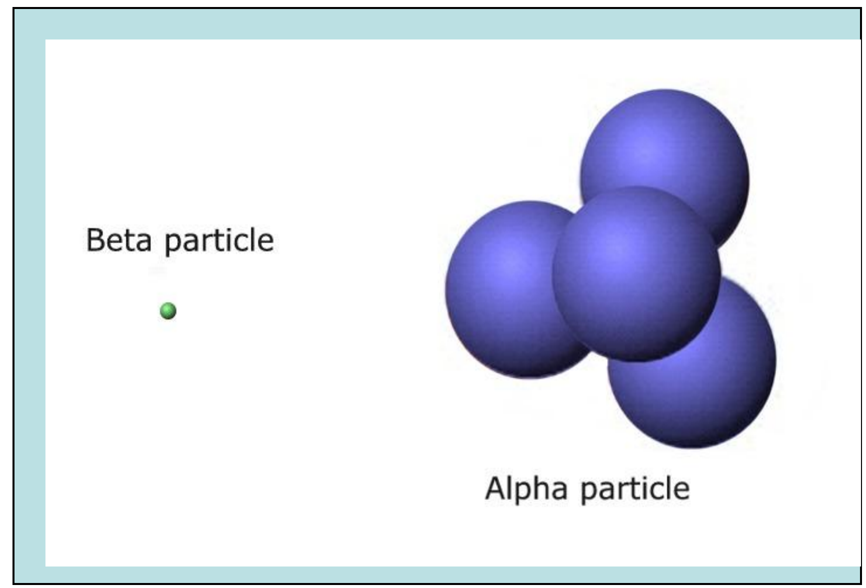
Alpha tracks



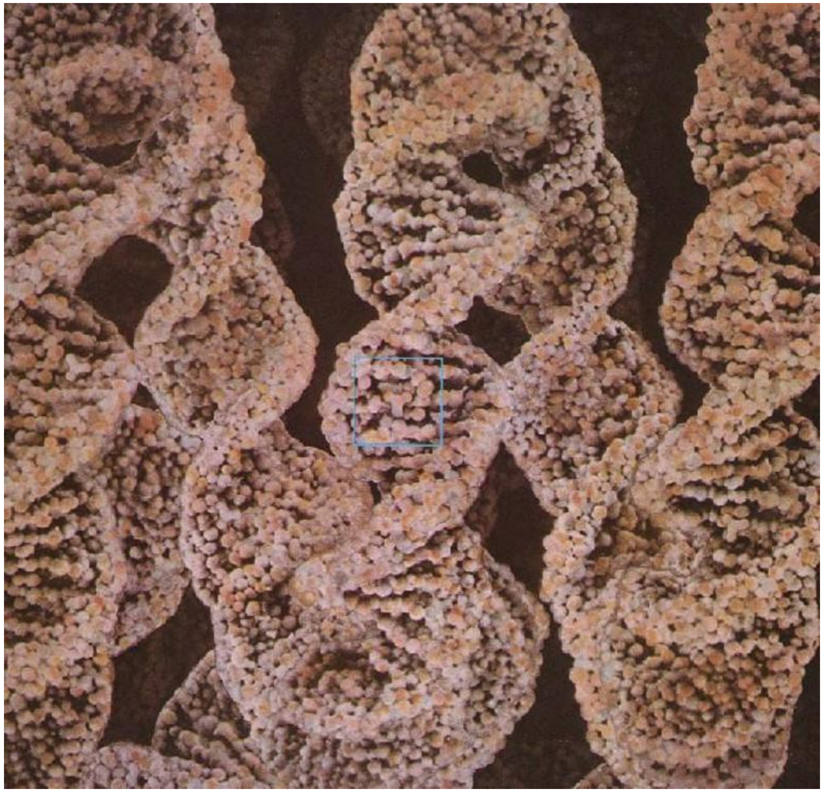
Neutron effects

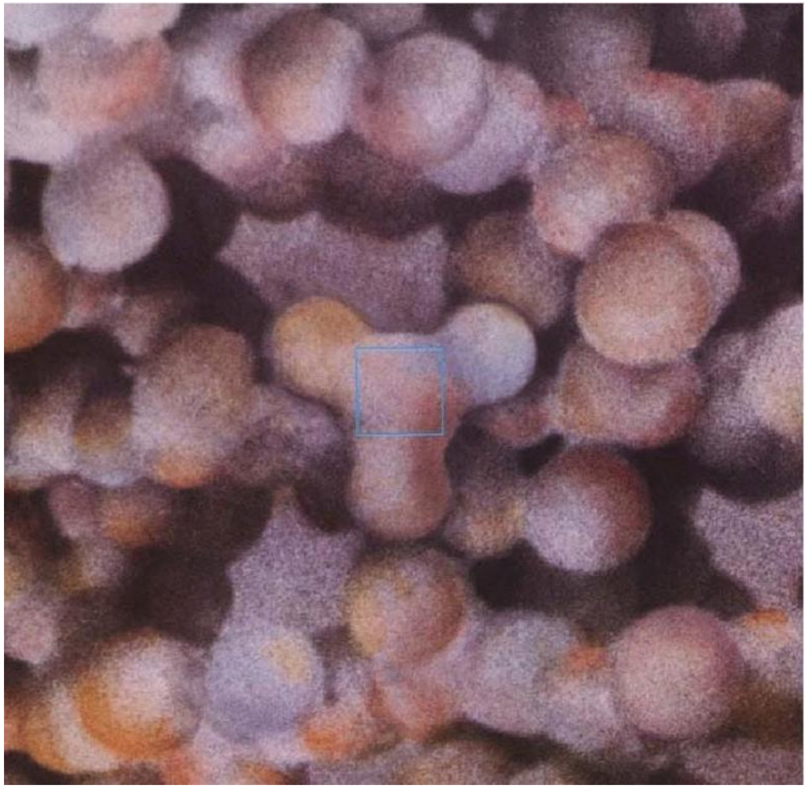
The wide, open space of atoms and molecules and their size relative to ionizing radiation (particles and photons)





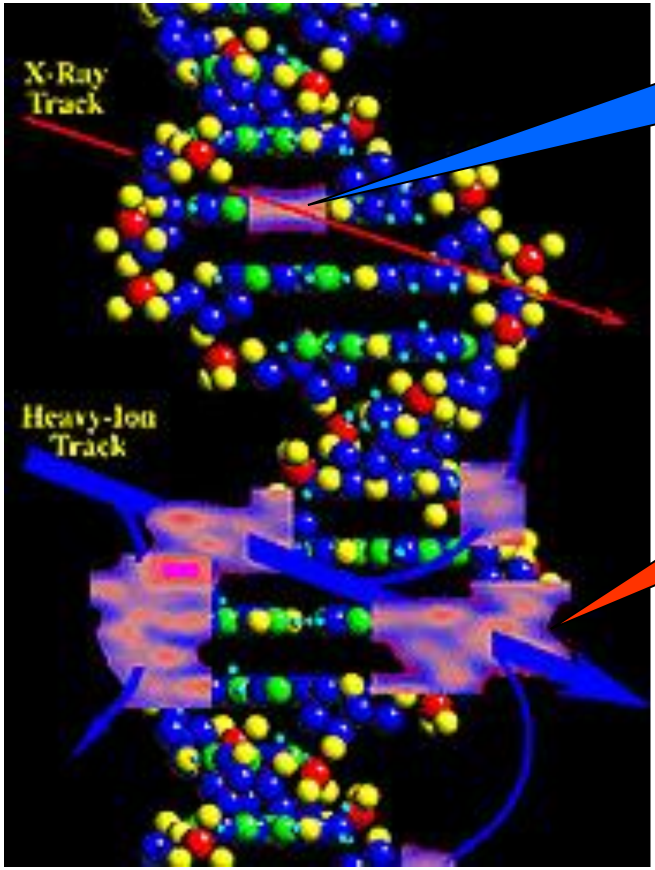
DNA coil @ 10 e-8 (marked with square) in double –helix





DNA 10 e-9

Scale and comparative effects of high vs. low LET ionizing radiation



Gamma, X-Rays & Beta particles– Low LET

Alpha particles and neutrons – High LET

Neutron ("n")emissions

Origin of artificial neutrons:

- (a, n) reactions occur when alpha emitters are mixed with light elements: uranium-fluorine, uranium-beryllium, uranium-dysprosium, uranium-magnesium.
- SF – spontaneous fission – uranium has high SF factor

Ingredients of nuclear fuels and critical mass generators use the physics of the (a, n) reactions to start up a reactor and drive it towards criticality.

In nuclear fission and fusion bombs, Californium and Polonium are high-volume alpha emitters that when mixed with DU (238U) and H3 (tritium), generate an instant, dense flux (energetic field) of neutrons.

One (1) 48W or 48X canister contains 13 tonnes of pure separated UF6,

(a, n) + SF result in 569,000 neutrons per second/canister

Does not include the 50 – 100 kilo's of "heels" of uranium daughter products in-growth (thorium protactinium, etc) or possible transuranics from canisters used by uranium enrichment facilities.

UF6 cylinder emissions

Depleted UF_6 Cylinder Storage Yard at Portsmouth, OH

One (1) 48W or 48X canister contains 13 tonnes of "pure separated UF6"; its (a, n) + SF reactions result in the production of 569,000 neutrons per second/canister ...

Residual contaminants in UF6 canisters

Statement of Work: Cylinder Management

DUF6 Conversion

John Shepard

Source Evaluation Board

US DOE

Dec 2000

- Heels mass ranged from 216 - 1399 pounds of uranium progeny – beta and gamma emitters; and,
- Transuranics (if cylinders are interchanged with enrichment plants (i.e. Paducha cylinders)

Ionizing radiation

NIOSH National Institute for Occupational Safety and Health

- **NIOSH CARCINOGEN LIST**
- Center for Disease Control, USA http://www.cdc.gov/niosh/npotocca.html#uz
  - » **Uranium, insoluble compounds**
  - » **Uranium, soluble compounds**

WHO

International Agency for Research on Cancer

PRESS RELEASE **N° 168** 20 April 2006

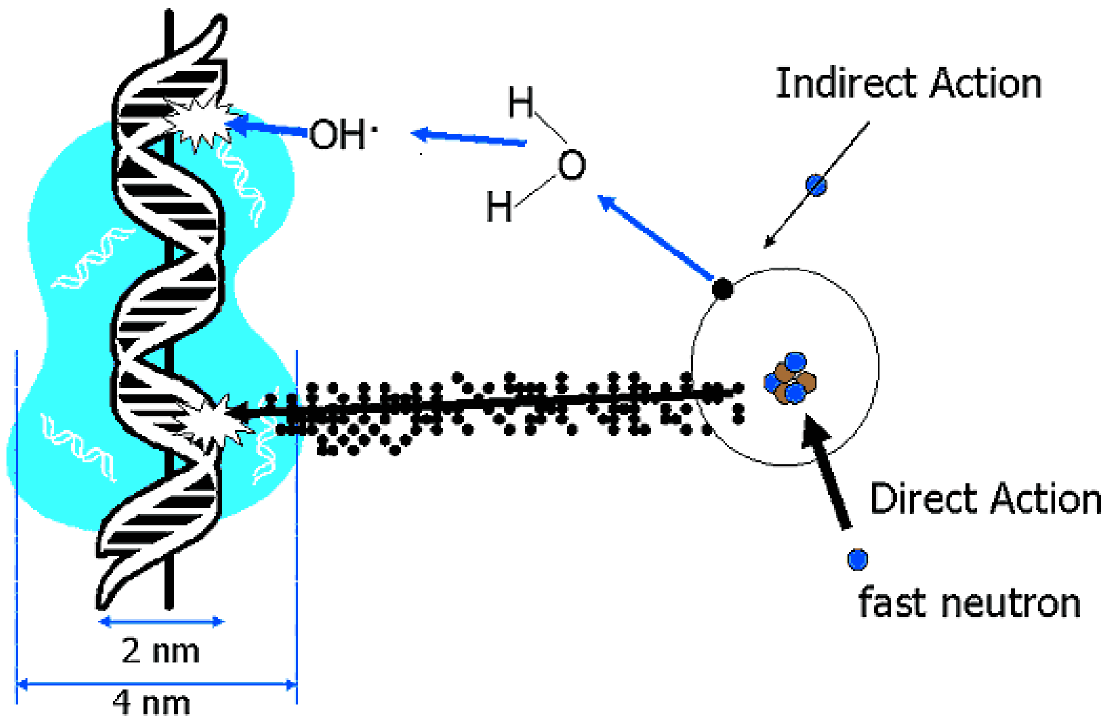
Group 1: Carcinogenic to humans

Radionuclides, a-particle-emitting, internally deposited (Vol. 78; 2001)

Radionuclides, b-particle-emitting, internally deposited (Vol. 78; 2001)

Neutrons (neutral particles) collide with nuclei of atoms and initiate a series of massive, indirect effects

Neutrons are penetrating like gamma but many times larger



Uranium discharged by monitored stacks
Cameco Port Hope Conversion Facility

UF6 and UO2 stack releases are combined – Uranium mass only, no other metals			
2000 – 2001 Licensing period average	**2001 study to set PHCF ORL's (Operating Release Limits)**	**2001 Future release targets provided to CNSC**	**2002 – 2005 Licensing Period average**
Actuals reported to CNSC	Consultants' measurements, empirical study for DRL's	Predicted for "future period" – basis for current licence approval	Actual emissions for period avg./yr
6.16 gU/hr	**15.17 gU/hr**	**29.9 gU/hr**	**14.22 gU/hr**
54.O KgU/yr	**133 KgU/yr**	**262.1 KgU/yr**	**122.5 KgU/Yr**

*Fugitive emissions and unmonitored release point not included
gU/hr - Grams of uranium per hour released into atmosphere
KgU/yr - Kilograms of uranium per year released

Stack discharge rates and volumes compared by licensing periods

Reported releases 2000 – 2001 Previous Licensing Period average	Reported releases 2002 – 2005 Current Licensing Period average (4 years data available)
6.16 gU/hr **54.0 KgU/yr**	**14.0 gU/hr** **122.72 KgU/Yr**

Reported emissions have increased ~ 2.3 X's (230%) over the previous licensing period.

gU/hr – Grams of uranium per hour
KgU/yr – Kilograms of uranium per year

Extremely shocking:
CNSC permitted maximum stack discharge limits

1996 – 2011 Licensed Limits for Uranium Set by the Canadian Nuclear Safety Commission	Reported 2000 – 2001 Licensing Period average	Reported 2002 – 2005 Licensing Period average
440.00 gU/hr 3,850.04 tonnes of uranium per year	6.16 gU/hr 54.0 KgU/yr	14.22 gU/hr 124.7 KgU/Yr

Immediately Dangerous to Life or Health

NTIS Publication No. PB-94-195047

Insoluble Uranium - Revised IDLH: 10 mg (milligrams) U/m3

Basis for revised IDLH: The revised IDLH for insoluble uranium compounds is 10 mg U/m3 based on sub-chronic inhalation toxicity data in animals [ILO 1972] and to be consistent with soluble uranium compounds which have a revised IDLH of 10 mg U/m3. [Note: NIOSH recommends as part of its carcinogen policy that the "most protective" respirators be worn for insoluble uranium compounds at concentrations above 0.2 mg/m3.]

Soluble Uranium - Revised IDLH: 10 mg (milligrams) U/m3

Basis for revised IDLH: The revised IDLH for soluble uranium compounds is 10 mg U/m3 based on chronic toxicity data in animals [Wilson et al. 1953]. [Note: NIOSH recommends as part of its carcinogen policy that the "most protective" respirators be worn for soluble uranium compounds at concentrations above 0.05 mg U/m3.]

Air concentrations of uranium (suspended particulate)

•Cameco monitoring stations avg.	
2000 – 2001	0.004 ugU/m3
2002 – 2005	0.087 ugU/m3
•North America background	
	0.0000625 ugU/m3
•NIOSH IDLH 10mg U/m3 -	10,000.00 ugU/m3
•At the stack mouths (est.)	
IDLH at 3 seconds UF6	3,940.00 ugU/m3/s (est.)
IDHL at 15 seconds UO2	770.00 ugU/m3/s (est.)
•CNSC permissible levels	122,000.00 ugU/m3/s (est.)
440 gmU/hr	

CNSC regulatory limits exceed levels classed as Immediately Dangerous to Life and Health

Uranium in Port Hope soils		
Uranium in soil	**Levels**	
1. Ontario mean	2 mgU/Kg – 2 PPM	CCEM proposes in 2006
2. Port Hope range	0.6 mgU/Kg – 258 mgU/Kg	Agri Land 23 PPM Res, Parks 23 PPM Commercial 33 PPM
3. Port Hope mean	13.9 mgU/Kg	Industrial 300 PPM
4. MOE for PH	33 mgU/Kg or 33 PPM – 97.5%	Abundances of uranium in ore at world's largest uranium mine, Langer Heinrich Uranium Project, Namibia: 300 PPM uranium
5. Unregulated dispersal	10 PPM UO2 as Fertilizer	
5. Cameco 2005/06	0.1 ppm – 59 ppm Avg. 8 PPM	

MOE's study of uranium levels in soils – showed annual increases:

From 0.85 ppm to 1.78 ppm in 1997

From 1.78 ppm to 3.93 ppm in 1998.

MOE found uranium concentrations up to 135 ppm in 1986.

MOE for PH is recommending establishing a baseline of 33 mgU/Kg or 33 PPM – 97.5%

Uranium in air

No legal standard for U in air
Ontario MOE proposes: 0.48 ugU/m3

1. North America norm NCRP 1999	0.000025 – 0.0001 ugU/m3	Cameco Reports in Licensing document
2. Mean - Ontario	0.0001 ugU/m3	
3. Health Canada Cameco 2002	0.002 - 0.004 ugU/m3	28 fold increase in upper release levels (2800%)
4. 2 Km from Cameco, (Ahier and Tracy, 1997)	0.00006 - 0.076 ugU/m3	
5. Cameco 1996 – 2001 avg.	0.002 – 0.006 ugU/m3	
6. 2001 – 2006 avg.	0.002 - 0.172 ugU/m3	

Is there a point (place and time) of IDLH in Port Hope?

IDLH for Uranium (NIOSH) – 10 micrograms mgU/m3

Stack discharge	2001	2005
UF6	2.843 mgU/s	2.94 mgU/s
UO2	0.279 mgU/s	0.77 mgU/s

If standing at the stacks' lips, it would take <5 seconds for UF6 and about 15 seconds for UO2 to release a uranium concentration equivalent to the US National Institute for Occupational Safety and Health's emission exposure level classed as:

Immediately Dangerous to Life and Health

Port Hope's burden (1)

1. There are instruments monitoring site-derived gamma radiation but there is no monitoring of (1) residents exposure to airborne uranium or (2) the pathways of airborne uranium and its deposition patterns.

2 No program of measurement has been undertaken to determine the uptake, retention and fate of inhaled uranium by a Port Hope resident (non nuclear workers).

3 Cameco's dose estimate method, developed by SENES Consulting, and approved/used by CNSC (i.e. to report to the UN, the IEAE, NEA, etc) does not make reference to a radiological dose estimate for (1) internally deposited radionuclides or (2) accumulating internal burden of uranium (only a chemical dose).

4. The continuous accumulation of bioavailable uranium compounds deposited to PH soils, building surfaces, playgrounds, sidewalks, roads & building sites is not acknowledged as a chronic contributor to pubic dose.

5. Insoluble uranium's biological burden to individuals, based on the concentrations of uranium at the levels reported in PH & by the CCEM imply an annual net accumulation in PH residents bodies.

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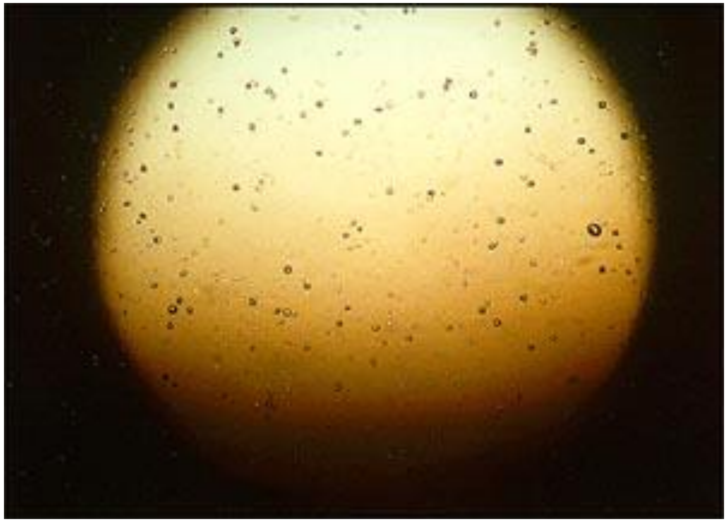
Radon alpha ionizing the atoms of a photographic plate



Port Hope's burden (2)

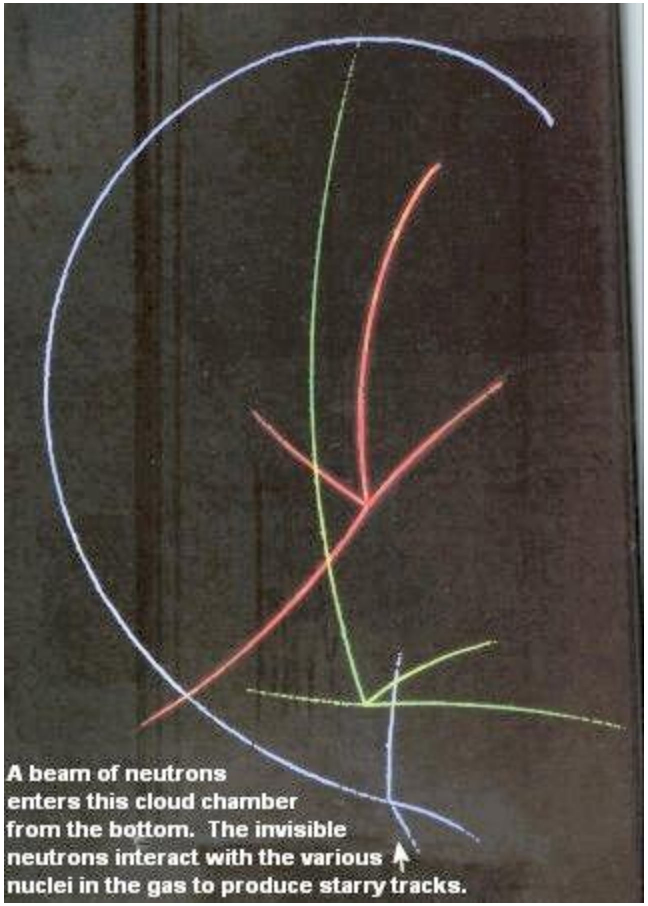
6. According to SENES Consulting (2001, the major contribution of gamma radiation in PH is (1) natural background, (2) historical contamination (Eldorado), and (3) historical facility contamination that <u>cannot be attributed to the current operation</u> [yet there are references to plant emissions of 105 uR/hr).

7. Neutron radiation is not monitored. Each 14 t UF6 canister produces over 450,000 High LET neutrons every/second. Neutrons can "activate" (transform) sodium, potassium, magnesium and iron molecules in the body so they become radiation emitters.

8 SEU, enriched U, U/Dysprosium and 238U are important neutron emitters. Uranium powder mixtures that produce neutrons and gamma radiation not reflected in licensing reports: Beryllium/Uranium, Dysprosium/Uranium, Depleted Uranium/Titanium.

9. Neutrons are 3 to 20 times more damaging to human cells and genetic materials than gamma radiation. Alpha emissions from internalized uranium are 20 times more damaging to the body than gamma and beta radiation.

Neutrons collide with and activate nuclei



Port Hope's burden (3)

10. There are stored and licensed radionuclides in Port Hope facilities that are not mentioned in the dose models and exposure reports, including: Thorium, DUO2, SEU, LEU, HEU, transuranics' heels in UF6 canisters.

11. Radon levels in Port Hope are frequently and officially attributed to "natural background uranium". Port Hope's Radon levels are unusually high and cannot be explained by natural background.

12. The fate of uranium discharged to Lake Ontario is not reported by Cameco or CNSC.

13. CNSC approved Cameco dose model and coefficients based on empirical studies conducted (2000) using quantities for airborne exposure to uranium ½ of today's levels and 1997 population levels.

14. CNSC treats each licence holder independently without reference to the collective public impacts from (1) all facilities, (2) facility historic contamination and (3) town historic contamination. Cameco's emissions (current operations) are judged to be 16% of PH's radiation dose.

Port Hope's Burden (4)

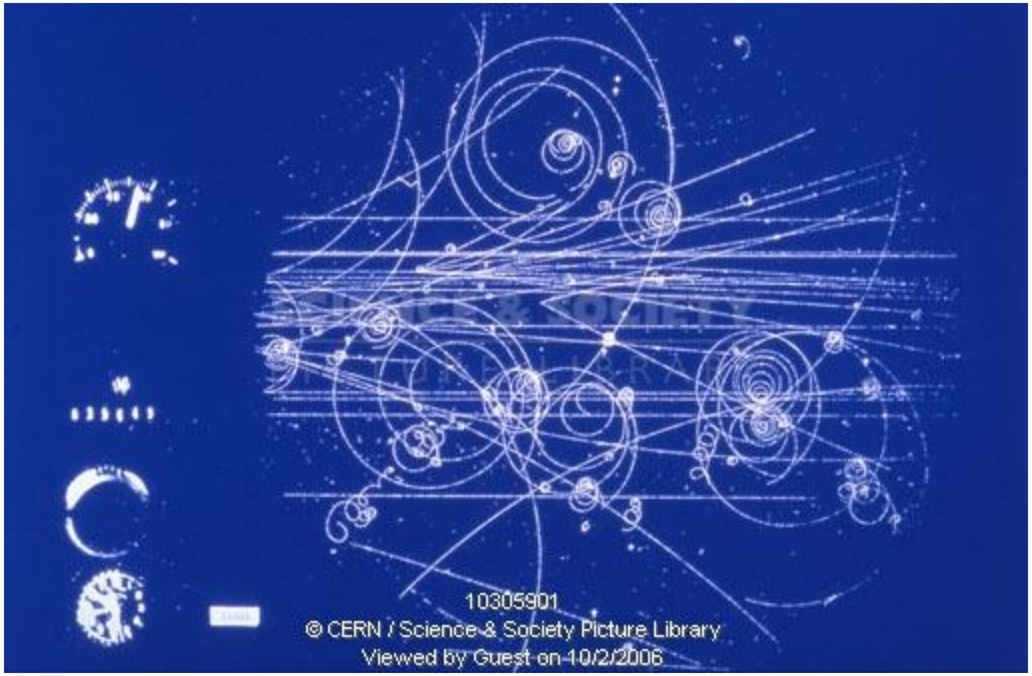
15. Dose is recalculated from zero-point annually. Limits to emissions are derived from dividing the radioactivity from Cameco by the PH population. The more residents, the lower the dose. Amalgamation and housing developments have significantly reduced dose. That's how there can be a reported 5 year decline in public dose levels (when emissions are up).

16. Not all uranium emission sources are accounted for in the models and reports. Only 3 "major stack samples" out of over several dozen release points are reported.

17. CNSC and Cameco documents report air releases of uranium have reduced by almost 25% during the licensing period – a review of the numbers shows a 28-fold increase in the range of releases of airborne uranium and a three fold increase in the mass of releases of airborne uranium (yet Cameco reports a 74% reduction in public dose).

18. Port Hope is at risk from a regulatory change in permissible limits to uranium in soil. The proposal it to revise PH's background to 33PPM and allow Cameco and other industrial property to have 300 PPM – a level of uranium equivalent to viable uranium ore bodies.

19. Vision 2010 is potentially a point of significant increase in airborne uranium (and progeny) and local gamma levels.



Annihilation of matter by a directed energy weapon's experiment

Bio-kinetics of Uranium

- Type of U
- Bio-clearance
- Half-life
- Solubility
- Particle features
- Dose effect
- Radiation emissions, exposure, effect, dose
- Chemistry
- Detecting and measuring urine
- Bio background
- Gulf War
- Afghanistan
- Non-exposed populations
- Nuclear workers

“Characterizing” the contaminant

“Physico-chemical” form of the contaminant

Dose depends on (1) amount of energy transferred (intensity) and (2) the length of time cells are exposed to the radiation.

Inhaled, absorbed and ingested uranium and uranium-rich compounds are the most dangerous forms of exposure

The “dose” of internally deposited radionuclides depends on:

The metabolic path the contaminant follows in the body

Each nuclide and form by which it is presented to the body has determinable chemical and physical characteristics.

The biological half-life is the point at which one-half of the mass of the radionuclide material remains inside the body.

Bio-half-life and metabolic route are first determined by “solubility”.

Physical and chemical properties determine the half-life.

Solubility classes

- “ … dose from inhaled uranium dust is … complicated …, given the wide range of physical and chemical forms of uranium … in a multi-product site …”

- Products and airborne materials

- UO3 is converted to “high purity, ceramic-grade UO2 powder”
- DUO4 enrichment plant tails and DU stockpiles converted to DU metal
- UO3 is converted to UF6

Classification of uranium compounds for worker inhalation

Solubility classes, retention of inhaled nuclides		
Type	**ICRP 1994b**	**Cameco's compounds**
< 10 days F (fast) D (days)	Soluble: UF_6 gas and liquid, UO_2F_2, $UO_2(NO_3)_2$, UO2Cl2,	
10 –100 days M (moderate) W (weeks)	Less soluble compounds: UO4, UO_3, UF_4, $UCl_{4,}$, ADU, solid UF5, solid UF4, U2O7, solid UF6, mixed oxides	
>100 days S (slow) Y (years)	Highly insoluble compounds: High-fired compounds $UO_{2,}$ $U_3O_{8.,\ U}$ hydrides and U carbides Sub-class Q	

Particulate physical characteristics

Aerodynamics (transport in air, rate of decent)

Respirable; inhalable

Solubility

Diameter

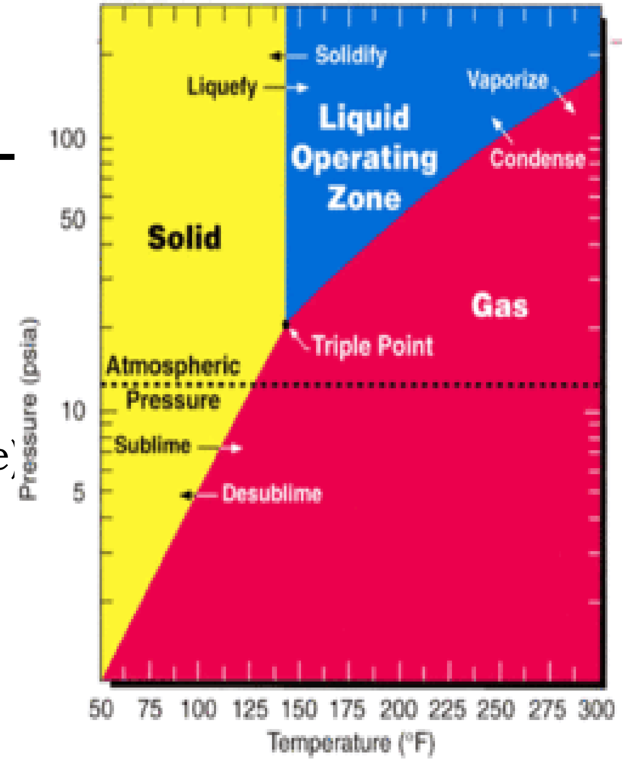
Symmetry

Sorption

Density

Solubility

Physical and chemical features of UF6 and DUF6



Gaseous and liquid UF6 are soluble.

UF6 from the facility is considered “separated”.

Fresh UF6 immediately begins to decay to Th and Pa.

UF6 exposed to water converts to UO2F2 (uranyl fluoride)

UF6 in lungs, half-time <20 minutes.

10 mg UO@F2/kg body wt produces renal injury.

Alpha radiation bombardment “disassociates” UF6 and creates UF5 – a powder form of uranium fluoride.

UF6 gas desublimes to solid at 134 F. UF6 solid and UF5 are slowly soluble.

Layers form on surface of the solid UF6 act as diffusion barrier that limits access of water.

UF forms complexes in contact with metals. UF6 gas reacts with hydrocarbons; forming a black residue of uranium-carbon compounds; in the liquid phase UF6 + hydrocarbons may explode.

Sources

- Assessment of Source Emissions from Uranium Refining and Conversion Facilities in Canada, CNSC Staff Report, Presented to NEA, Japan, CNSC, Oct 2001
- Development of Operating Release Levels for the Cameco Uranium Conversion Facility at Port Hope, SENES, 2001
- CNSC Staff Report – CMD 06-H18, Cameco Class B1 Nuclear Facility Licensing Renewal Report
- Cameco and Zircatec monthly and annual regulatory reports to Canadian Nuclear Safety Commission