Audit of NIOSH Assessment of External Doses from Plutonium Fuel Pellets

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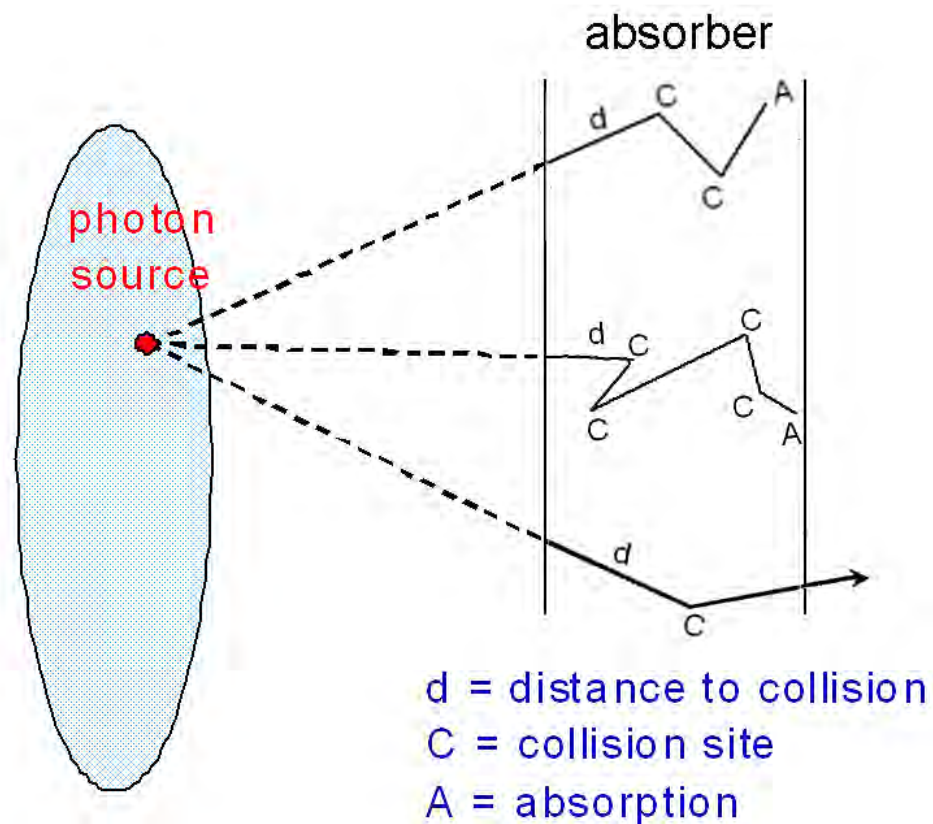Ambient Dose Equivalent Rates from External Exposure to (U,Pu)C Pellets (mrem/h)

Distance	SC&A		NIOSH		Difference[a]	
	Photons	Neutrons	Photons	Neutrons	Photons	Neutrons
1 ft	6.318	0.202	9.507	0.313	50.5%	54.7%
1 m	0.624	0.026	1.209	0.038	93.7%	47.3%

[a] NIOSH ÷ SC&A − 1

MCNP (Monte Carlo N-Particle) Radiation Transport Code

The Monte Carlo Method

- Randomly select source point from volume distribution

- Randomly select photon energy from spectrum

- Randomly select initial direction

- Randomly select distance to collision point, based on atomic cross-section

- Randomly select angles and energies of emerging particles from distributions based on cross-sections

absorber

photon source

d = distance to collision
C = collision site
A = absorption

Table A.1. Conversion coefficients for air kerma per unit fluence, K_a/Φ, of monoenergetic photons

Photon energy (MeV)	K_a/Φ (pGy/cm^2)
0.010	7.43
0.015	3.12
0.020	1.68
0.030	0.721
0.040	0.429
0.050	0.323
0.060	0.289
0.080	0.307
0.100	0.371
0.150	0.599
0.200	0.856
0.300	1.38
0.400	1.89
0.500	2.38
0.600	2.84
0.800	3.69
1.000	4.47
1.500	6.14
2.000	7.55
3.000	9.96
4.000	12.1
5.000	14.1
6.000	16.1
8.000	20.1
10.000	24.0

Data from ICRU Report 47 (ICRU, 1992a) using data from Hubbell (1982).

Table A.21. Conversion coefficients[a] for the ambient dose equivalent, $H^*(10)$ from photon fluence and air kerma free-in-air
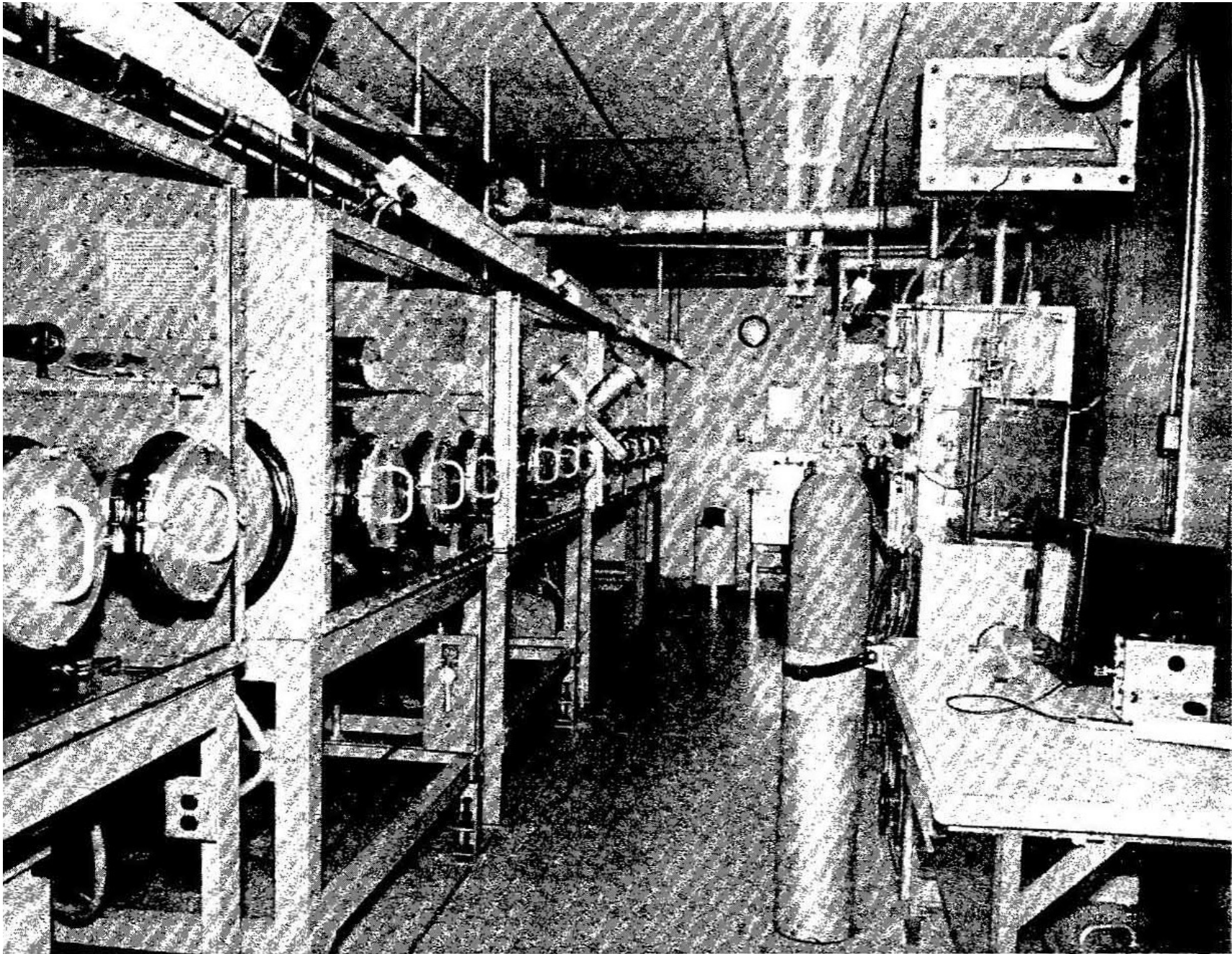
Photon energy (MeV)	$H^*(10)/K_a$ (Sv/Gy)	K_a/Φ (pGy/cm^2)	$H^*(10)/\Phi$ (pSv cm^2)
0.010	0.008	7.60	0.061
0.015	0.26	3.21	0.83
0.020	0.61	1.73	1.05
0.030	1.10	0.739	0.81
0.040	1.47	0.438	0.64
0.050	1.67	0.328	0.55
0.060	1.74	0.292	0.51
0.080	1.72	0.308	0.53
0.100	1.65	0.372	0.61
0.150	1.49	Q.600	0.89
0.200	1.40	0.856	1.20
0.300	1.31	1.38	1.80
0.400	1.26	1.89	2.38
0.500	1.23	2.38	2.93
0.600	1.21	2.84	3.44
0.800	1.19	3.69	4.38
1	1.17	4.47	5.20
1.5	1.15	6.12	6.90
2	1.14	7.51	8.60
3	1.13	9.89	11.1
4	1.12	12.0	13.4
5	1.11	13.9	15.5
6	1.11	15.8	17.6
8	1.11	19.5	21.6
10	1.10	23.2	25.6

[a] Data compiled from ICRU Report 47 (1992a) using Hubbell and Seltzer (1995). The K_a/Φ data are slightly different from those used for the protection quantities (see Table A.1) which used earlier data from Hubbell (1982).
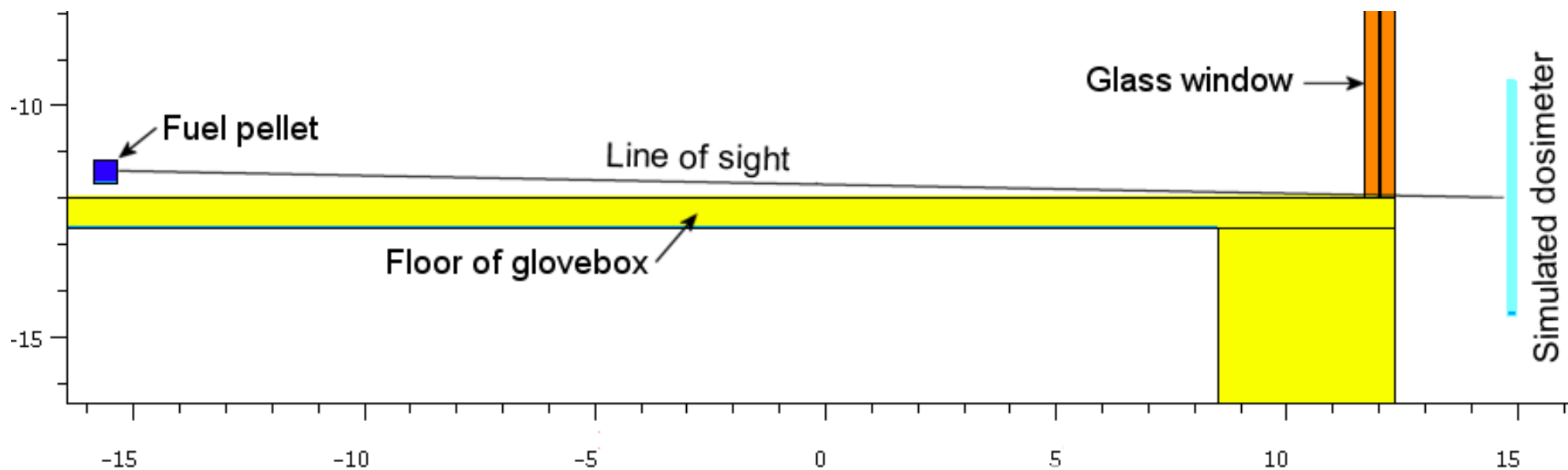
Incorrect H*(10) conversion coefficients

Finding 1: NIOSH used H*(10) conversion coefficients from photon fluence, based on outdated data, that resulted in a reduction of approximately 2% in the H*(10) doses from [241]Am.

Portion of Work Area of Plutonium Research Facility Showing Glovebox Arrangement

Glovebox Geometry Used in NIOSH MCNP Analysis (scales in cm)

MCNP6 version 1.0 Known Issues, LA-UR-13-22900

Selection of Low Priority Bugs in MCNP6:

14) Incorrect source biasing with -31 function. Artf23313.

Bug Fixes for MCNP Version 6.2, LA-UR-18-20808

Tracking Number	Category	Description
artf23313	Source	Incorrect source biasing if using the '-31' special function on the SB card

Finding 2: NIOSH used incorrect source biasing in the MCNP dose analyses.

Ambient Photon Dose Equivalent Rates from External Exposure to (U,Pu)C Pellets
Recalculated Without Source Bias (mrem/h)

Distance	SC&A	NIOSH-recalc	Difference[a]
1 ft	6.318	3.458	-45%
1 m	0.624	0.474	-24%

[a] NIOSH ÷ SC&A − 1

Finding 3: The simulated dosimeters in the glovebox geometry modeled by NIOSH are partially shielded by the floor of the glovebox, which reduces the calculated doses.

Ambient Photon Dose Equivalent Rates from External Exposure to (U,Pu)C Pellets Source Elevated 24 cm Above Glovebox Floor (mrem/h)

Distance	SC&A	NIOSH-recalc	Difference[a]
1 ft	6.318	6.316	-0.03%
1 m	0.624	0.598	-4.17%

[a] NIOSH ÷ SC&A − 1