

Comparison of Updated NIOSH and SC&A Exposure Assessments at GSI

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PERIODS OF SITE OPERATIONS, DIVIDED ACCORDING TO LIMITING EXPOSURE SCENARIOS

- October 1, 1952: Start of covered operations under EEOICPA
 - Two 500-mCi ^{226}Ra sources used for radiography, in addition to 24-MeV betatron (“Old Betatron”)
- May 21, 1962: GSI acquires two ^{60}Co sources (260 and 280 mCi) to replace ^{226}Ra
- October 1, 1963: Assumed date “New Betatron” began operation at Commonwealth foundry in Granite City; Old Betatron upgraded to 25 MeV
- June 30, 1966: End date of last MCW purchase order—beginning of residual period

BOUNDING SOURCES OF EXTERNAL RADIATION EXPOSURE AT GSI (Entire period of AEC operations, unless otherwise noted)

- Exposure to sealed radiography sources
 - ^{226}Ra —2 sources, 500 mCi ea: October 1, 1952 to May 21, 1962
- Exposure to direct penetrating radiation (photons + neutrons) from betatron operations
 - Stray radiation during betatron operation
 - Delayed radiation from activated metals
- Exposure of skin to non-penetrating (beta) radiation
 - Natural uranium and photoactivated uranium isotopes
 - Activated steel

BOUNDING EXTERNAL EXPOSURES OF NONADMINISTRATIVE PERSONNEL (OPERATIONAL PERIOD)

Radium Era: Exposure to Penetrating (Photon) Radiation

Bounding scenario	Dose/exposure		Years	
	SC&A & NIOSH	NIOSH	NIOSH	SC&A
Radiographer using Ra-226	6.279–9.69–15 rem*	1952–1957	1952–1960 [†]	
	6.279–9.69–12 rem*	1958–1963	1961–1962 [†]	

* Triangular distribution—as per W-G meeting 2/21/2013

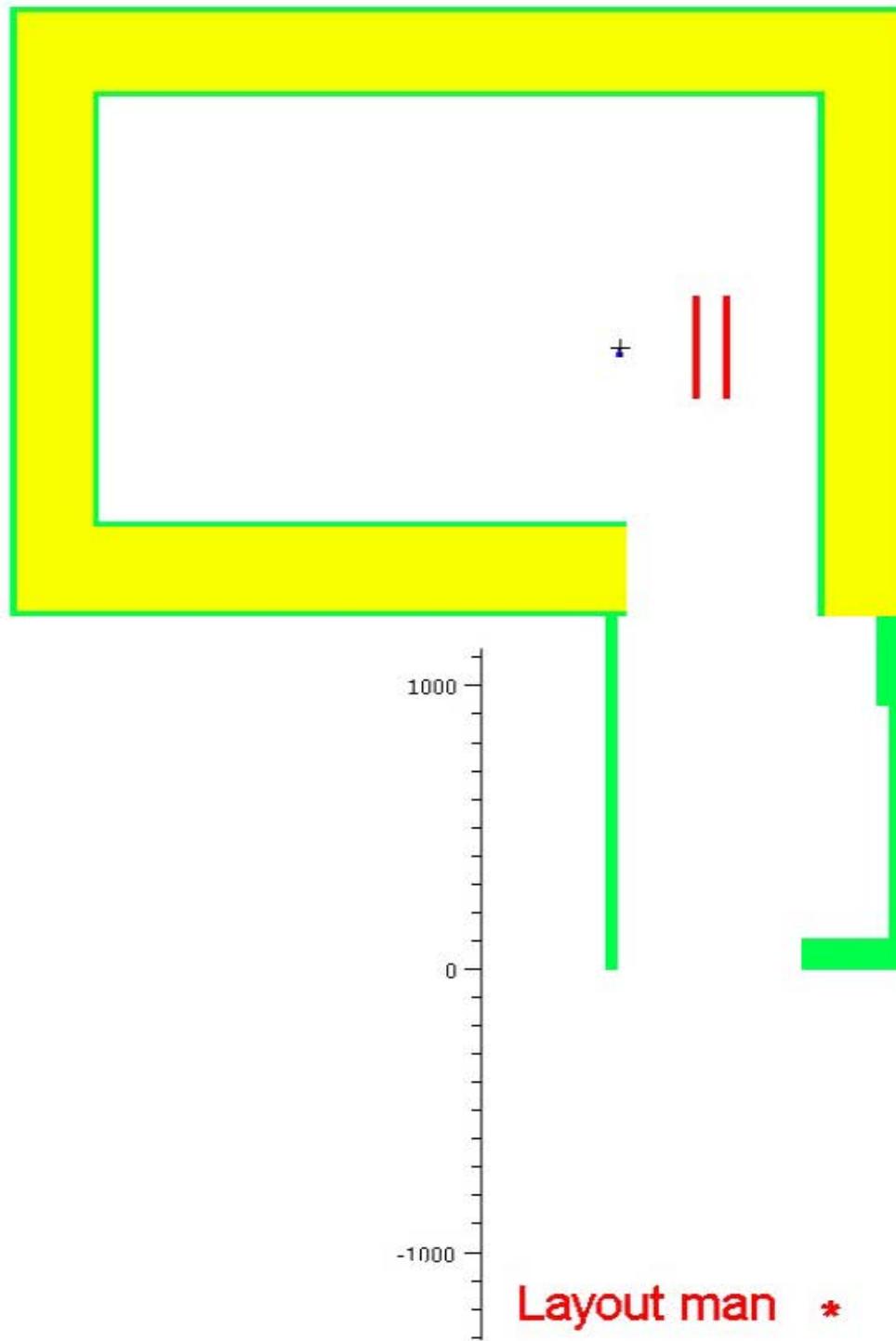
[†] Revised dates, based on date of revised AEC rule

New Betatron Building in Operation

Bounding scenario	Years		Photon exposure		Neutron dose (rem)	
	SC&A	NIOSH	SC&A (R)	NIOSH (rem)	SC&A	NIOSH
Layout man	1963-1966	1964-1966	9.20	4.483	0.46	0.148

Basis for Disagreement Between SC&A and NIOSH: External Photon Exposure of Layout Man During New Betatron Era

- NIOSH used 15 betatron scenarios
 - 45° angle to axis not consistent with industrial radiography
 - Arbitrary selection of betatron positions and orientations
 - Normalized to 10 mR/week at film-badge storage rack
 - Shielding by outer wall of control room understated due to assumed low density of concrete blocks
 - No shielding by interior walls or equipment
 - Landauer zeroed control badge (No. 000)—doses reported only if
 - >50 mrem *or*
 - >½ of worker badges
 - No information on Badge No. 1: “BETATRON CTL”—may have been in Old Betatron Building (location of supervisor’s office)
 - Location of layout man on RR track unrealistic and not claimant favorable
 - SC&A scenario leads to reasonable upper-bound exposures
- NIOSH included heavy steel door (0.85 in)
 - Workers described ribbon door, made of thin sheet metal



SC&A Model of Exposure Geometry of Layout Man

BOUNDING SCENARIOS FOR NEUTRON AND BETA EXPOSURES

Year	Neutron dose (rem/y)		β dose to skin—betatron operator (rads/y)			
	SC&A Betatron operator	NIOSH Layout man	Hands & forearms		Other skin	
			SC&A ^a	NIOSH ^b	SC&A ^a	NIOSH ^b
1952 ^c -1957	0.48		33.4	28.5	6.3	3.90
1958	0.48		32.1	28.5	6.2	3.90
1959-1960	0.48		30.9	28.5	6.2	3.90
1961	0.48	0.148	34.2	32.0	6.3	4.07
1962	0.48		27.2	24.5	6.0	3.71
1963	0.47		13.9	9.9	5.6	3.00
1964	0.46		10.7	6.4	5.4	2.84
1965	0.46		10.2	5.9	5.4	2.81
1966 ^d	0.23	0.072	4.8	2.7	2.7	1.39

^a From SC&A White Paper: March 12, 2012

^b From Dave Allen's White Paper: October 10, 2013

^c Covered period began October 1, 1952

^d Doses prorated to first 6 months

BOUNDING INTERNAL EXPOSURES: Apply to All Employees

Start Date	End Date	U work hours/year		Inhalation dpm/cal. day		Δ
		SC&A	NIOSH	SC&A	NIOSH	
10/1/52	2/28/58	437.5	337.5	113.09	91.4	24%
3/1/58	6/30/58	375.0	337.5	98.97	91.4	8%
7/1/58	6/30/66	SC&A and NIOSH Concur				—
7/1/66	12/31/93	—	—	14.3 ^{a,b}	1.44 ^{a,c}	890%

^a Exponentially decreasing during residual period, according to OTIB-70

^b Based on RF = 10⁻⁵

^c Based on RF = 10⁻⁶