

# **Comparison of NIOSH and SC&A External Exposure Assessments at GSI**

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## PERIODS OF SITE OPERATIONS, DIVIDED ACCORDING TO LIMITING EXPOSURE SCENARIOS

- January 1, 1953: Start of covered operations under EEOICPA
  - Two 500-mCi  $^{226}\text{Ra}$  sources used for radiography, in addition to 24-MeV betatron (“Old Betatron”)
- May 21, 1962: GSI acquires two  $^{60}\text{Co}$  sources (260 and 280 mCi) to replace  $^{226}\text{Ra}$
- January 1, 1963: Assumed date St. Louis Testing Laboratories (SLTL) began radiography at GSI site, using 10-Ci  $^{60}\text{Co}$  and 50-Ci  $^{192}\text{Ir}$  sources
- 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

## SOURCES OF EXTERNAL RADIATION EXPOSURE AT GSI

(Entire period of AEC operations, unless otherwise noted)

- Exposure to direct penetrating radiation (photons) from betatron operations
  - Stray radiation during betatron operation
  - Delayed radiation from activated metals
  
- Exposure to sealed radiography sources
  - $^{226}\text{Ra}$ —2 sources, 500 mCi ea: 1953–May 21, 1962
  - $^{60}\text{Co}$ —260 & 280 mCi (initial activities): May 21, 1962–June 30, 1966
  - $^{60}\text{Co}$ —10 Ci, employed by SLTL: from January 1, 1963
  - $^{192}\text{Ir}$ —50 Ci, occasionally employed by SLTL: from January 1, 1963
  
- Exposure of skin to non-penetrating (beta) radiation
  - Natural uranium and photoactivated uranium isotopes
  - Activated steel

## BOUNDING ANNUAL EXPOSURES TO PENETRATING (PHOTON) RADIATION

Years	SC&A—applied to all employees		NIOSH		
	Bounding scenario	Dose/exposure	Source	Radiographers	Others
1953–1954	Radiographer—Ra-226	15 rem	Ra-226	3.573 R	2.087 R
1955–5/21/62		12 rem			
5/22/62–12/31/62	Betatron operator	1.35 rem*	Co-60—GSI	1.17 R	1.348 R
1/1/63–9/30/63	SLTL Co-60 source	2.669 R	Co-60—SLTL	2.671 R	
9/30/63–6/30/66	Layout man	9.2 R	Betatron	4.483 R	

\* Note change of units from previous reports

## BOUNDING SCENARIOS FOR NEUTRON AND BETA EXPOSURES

Apply to All Employees

Year	Neutron dose (rem/y)		$\beta$ dose to skin—betatron operator (rads/y)			
	SC&A Betatron operator	NIOSH Layout man	Hands & forearms		Other skin	
			SC&A	NIOSH	SC&A	NIOSH
1953-1957	0.48		33.4	25.9	6.27	2.27
1958	0.48		32.1	25.9	6.22	2.27
1959-1960	0.48		30.9	25.9	6.18	2.27
1961	0.48	0.148	34.2	29.5	6.30	2.47
1962	0.48		27.2	21.8	6.04	2.04
1963	0.47		13.9	7.0	5.56	1.23
1964	0.46		10.7	3.5	5.45	1.03
1965	0.46		10.2	3.0	5.43	1.00
1966 <sup>a</sup>	0.23	0.072	4.8	2.4 <sup>b</sup>	2.71	0.97 <sup>b</sup>

<sup>a</sup> Doses prorated to first 6 months, except as noted

<sup>b</sup> Doses should be prorated to first 6 months

## DETAILED DISCUSSION OF BOUNDING SCENARIOS

### Radiographer Using $^{226}\text{Ra}$ : 1953-May 21, 1962

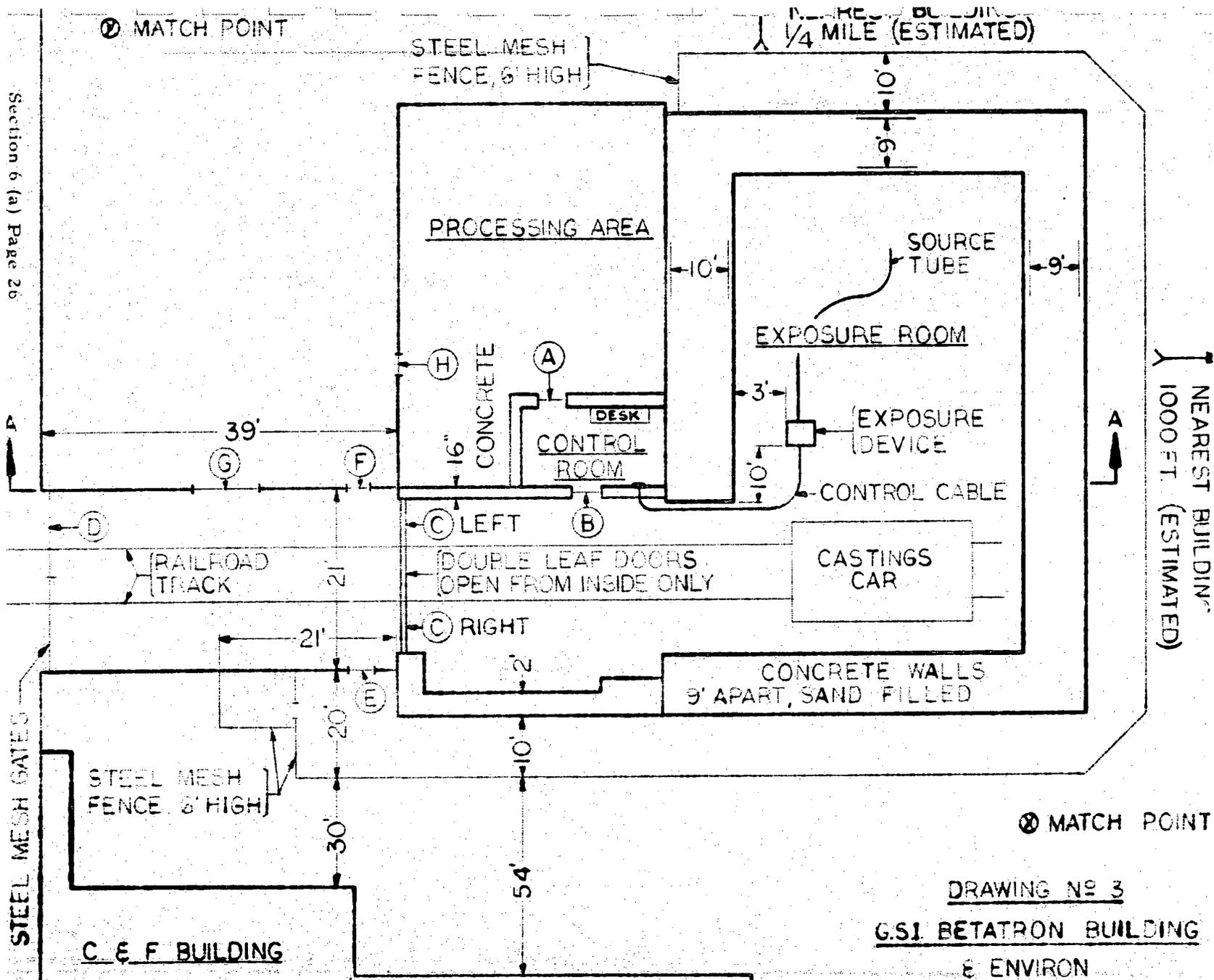
- “During this period [1953–1962] the exposure limits published by the A.E.C. at the applicable time were followed. They were never exceeded and averaged under 25%.” (GSI AEC license application)
- AEC Form 4: Occupational External Exposure History of GSI worker
  - 18 quarters (July 1, 1957–December 31, 1961)
  - 9.1 rem total, 2.02 rem/y
  - Worker performed radiography on weekends
    - 1–2 shifts, 80%–90% of the time
    - 40–90 shifts/y: 22–50 mrem/shift
  - Extrapolate dose to full-time radiographer, 65 h/wk: 9–20 rem/y
  - Worker testified he wore film badge while performing radiography
- MCNPX and exposure rate analysis, based on worker's account of radiographic practices: ~10 R/y (~11 rem/y)

## Betatron Operator

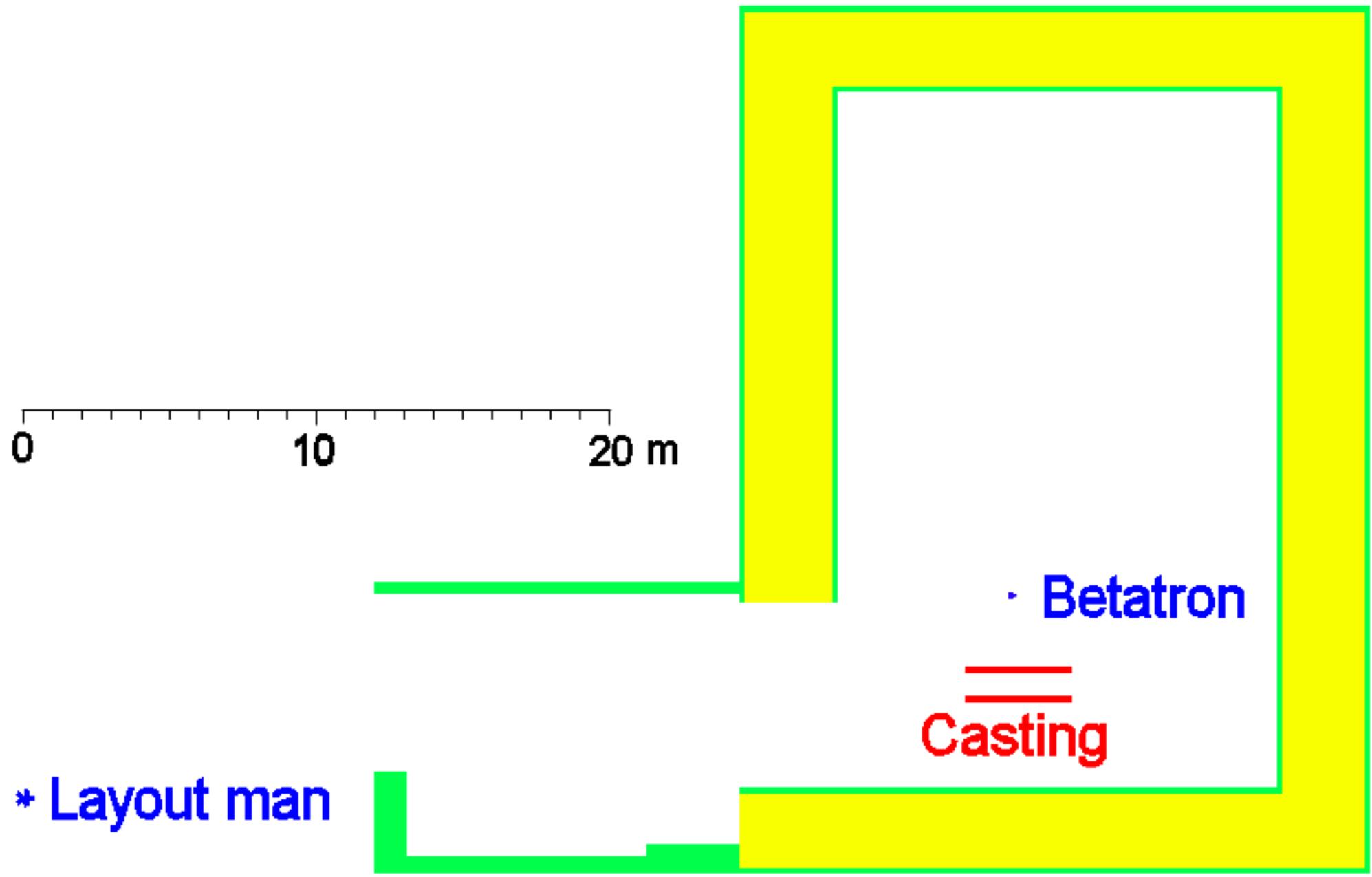
- Maximum dose of 26 mrem/week, due to hypothetical 30 keV radiation from behind, film badge partially shielded by operator's body

## Exposure to SLTL Sources

- Maximum exposure duration:
  - 180 h longest shot
  - 10 shots during 6-month period
  - Maximum fraction of time:  $180 \text{ h} \times 10 \text{ shots} \times 6 \text{ mo} \div 12 \text{ mo/y} = 3,600 \text{ h/y} \div 8760 \text{ h/y} = 41\%$
- Exposure rate at exclusion area boundary: 2 mR/h
  - Maximum exposure of worker at boundary:  $2 \text{ mR/h} \times 3250 \text{ h/y} \times 0.41 = 2.67 \text{ R/y}$



New Betatron Building (A.E.C. license application)



MCNPX Model of Exposure Geometry of Layout Man