If you are using a printed copy of this procedure, and not the on-screen version, then you MUST make sure the dates at the bottom of the printed copy and the on-screen version match. The on-screen version of the Collider-Accelerator Department Procedure is the Official Version. Hard copies of all signed, official, C-A Operating Procedures are available by contacting the ESSHQ Procedures Coordinator, Bldg. 911A

C-A OPERATIONS PROCEDURES MANUAL

9.1.15.a BLIP Target and Canning Record

	Hand Proc	Hand Processed Changes				
HPC No.	<u>Date</u>	Page Nos.	<u>Initials</u>			
A	Approved:	Signature with Date on File				

Collider-Accelerator Department Chairman

D. Beavis, S. Smith

Date

Note 1: Uncontrolled copy printed from electronic master that is valid at time of printing. Always check that you have the latest revision of this document before use.

Note2: Leave no blanks. Indicate 'Not Applicable (N/A)', where appropriate.

Title and Preparer

Irradiation of Ga target at BLIP to produce Ge-68/Zn-65

[MIRP-CAD]

	Instructions							
	Description	Page No.						
1.	Overview [short summary of purpose of experiment; name of principle investigator and researcher involved]	4						
2.	Target Material and Properties – [Provide physical properties of <u>each</u> <u>component/material</u> to be irradiated]	5						
3.	Target Canning Process – [provide images or drawings and reference the OPM procedures for closing and opening of target can]	6						
4.	Beam Characteristics [define required beam on target and total current required]							
5.	Proposed Experiment [Provide general description of a) how target will be supplied BLIP, b) target array in box 1 and box 2; c) thermal analysis of target material and target can d) transport of irradiated target to TPL; target opening and processing at TPL and e) disposal of waste. List persons responsible for conducting each task. If others are required to assist in the research irradiation, define level of skill of staff and contact time.]	7						
	a. Procedure for Irradiation of Target Material BLIP [Summarize steps for experiment including specialist and contact hours required for task]	7						
	b. Target Array [Define proposed target array for box 1 and box 2 including SRIM calculated entry and exit energy for each layer. Provide physical dimension of degraders, target can, materials and water gaps]	7						
	c. Thermal Analysis of Target Materials and Target Can [Provide full description of data provide to specialist for calculations and any assumption made on material for	7						

	calculations]	
	d. Transport and Processing at TPL [Provide full description of task involved and responsible persons and contact hours required]	7
	e. Disposal of waste. [describe waste to be generated and how it will be disposed of]	7
6.	Activation Analysis of Target Material and Can [Provide full list of radionuclide produced and quantities, references used for calculations, as well as decay profiles if the dose rates exceed limit for removal from BLIP hot-cell. Ensure Health Physics has reviewed data and confirms decay requirement if they are dose related. Attach analyses if any.]	8
	a. Radioactivity of each nuclide at end of bombardment (EOB), at 8 hours and 24 hours post EOB.	8
7.	Expected Dose Rate (e.g., R/h at 1 m) [provide expected dose rate using <i>Microshield or equivalent</i> calculations for the combined and separate target and can irradiated. Provide expected dose rate at EOB at BLIP and expected dose rate when delivered to TPL]	8
8.	Additional Safety Requirements [address hazardous issues related to volatiles and or corrosive materials used and any additional equipment required for this experiment; hazardous materials information must be submitted to the C-AD ESSHQ Division Head for concurrence]	9
9.	Special Operating Instructions and List of References or Supporting Documents	9
10.	Appendix [provide additional support information as required]	10-21

1. Overview
The purpose of this experiment is to irradiate Ga to produce radionuclide Ge-68 at the request of DOE isotope program

2. Target Material and Properties										
Target Name:	e:			Target & Canning No.			<u>TBD</u>			
	As	ssign uni	que no.	(year-00x)						
		Tar	get Mate	rial Pr	operties					
Purity or Grade	99.999%	1								
Chemical Formula	Ga									
Physical Characteristics at 70 °F or 21 °C		Solid (m	elting po	oint 29	.78 °C)					
Physical Form		Foil		n/a		Pov	wder	n/a	l	
		Diamete (inches/i	_	2.250)	Pre (To	essed orr)	n/a	l	
Elements (%)		Ga								
Melting Point			29.78	°C			n/a	°F		
Boiling Point			2403	°C			n/a	۰F		
Thermal Conductivity		40.6 W.m ⁻¹ .K ⁻¹ Temperature dependence			(if available)					
Density		Sol. 5.904, liq. 6.095			g/cm ³					
Specific Heat		25.86	25.86 J/mol.K							
		Target M	aterial R	eactio	ns / Proper	ties				
Does the Target material	Alun	ninium no)	Air	oxi	ide	C	O ₂	no
react with any of the following?	Н	[2 O	no I		Lead	n	0	Zi	nc	no
	Incor	nel 600 np)	S/Steel	no		Niob	oium	Yes at 400°C¹
		Canr	ning Mat	erial P	roperties					
Chemical Formula		Nb								
Can Wall Thickness (inche	s/mm)	0.012 (0.3048)								
Can Dimensions (inches/mm)		Can Diameter 2.75 (69.85)		59.85)	Can Width: 0.220 (5.588)			220 (5.588)		
Melting Point			2468	°С		n/a °F				
Thermal Conductivity		54 W	54 W.m ⁻¹ .K ⁻¹ Temperature dependence			(if available)n/a				
Density			8.57	g/cm	3					
Specific Heat		24.60				J/mol	J/mol.K			

¹ Kelman L.R., Wilkinson, W.D., Yagee, F.L. Resistance of Metals to Attack by Liquid Metals, Argonne National Laboratory report ANL-4417, July 1950, pp139.

3. Target Canning Process								
The target has been beam-welded by EB industries, following CAD OPM 19.17.1								

4. Beam Characteristics						
Beam shape:		Rastered				
Raster parameters:		Gaussian beam spot 12mm FWHM, rotation frequency 5kHz, 4 sweeps 15mm radius per one sweep 5.5mm radius				
Power density:		110 watt/mm	2			
Maximum Instantaneous Current Desired	145		μА			
Average Current Desired	145		μА			
Total Integrated Current Desired	97440 (4 weeks at 145)	MeV)	μA-hrs			
Maximum Proton Energy on Target Material	28		MeV			

5. Experiment Description

5.a Procedure for irradiation of target material in BLIP:

Irradiate target at BLIP in the low energy slot for 4 weeks at 145 uA and transport to BLIP after irradiation. Follow CAD OPM 19.17.20 to install or remove the target.

5.b Target array in Box 1:

Target array is given in the Appendix 1. Briefly, upstream to downstream: [vacuum degrader], [1st RbCl] [2nd RbCl], [Ga target] with 5 mm water gaps

5.c Thermal analysis of target material and target can (attach analyses if any):

The summary of successfully irradiated and processed targets is given under 9. Special Operating Instructions. See details of thermal analysis in the appendix 2

Summary & Conclusion

- Maximum Gallium temperature = 433 °C
- Ga boiling temperature = 2400 °C
- SAFE
- Maximum Niobium temperature = 379 °C
- Nb reacts with Ga at 400°C
- SAFE
- Maximum Nb heat flux at water surface = 207 W/cm²
- Critical Heat Flux = 227 W/cm²
- Safe

5.d Transport of irradiated target to TPL, target opening and processing:

Follow CAD OPM 19.17.30 to transport the target from BLIP in a pig

Follow CAD OPM 19.9.4. to open the target using target cutter

Follow 19.18.30 Ge-68 from Ga Metal Targets for target processing

5.e Disposal of waste:

Liquid waste will be neutralized and disposed in D tank system. Target body will be disposed as TPL solid waste CAD OPM 19.30.3

6. Activation Analysis of Target Material and Can

Target material:

The activation of Ga metal was calculated **using activation equation**² **and cross section data assuming 4 week** irradiation. See Appendix 3 for cross section data. The Table contains the list of the nuclides contributing to the dose rate.

Nuclide	T1/2, d	Activity EOB, Ci		
Ge-68	287	2.81	2.80	2.76
Ga-68	0.047	2.81	2.80	2.76
Ge-69	1.625	36.34	23.74	1.84
Ga-67	3.263	2.53	2.05	0.57
Zn-65	244	0.57	0.57	0.56

Target cladding:

Since the beam will stop in Ga metal and will not reach downstream window only the upstream Nb window will be activated. Activation of the upstream Nb window is **insignificant** compared to activation of Ga metal due to small thickness and unfavourable cross section data (see appendix 4). Nuclides produced in the Nb window are Zr-88 (83.4 d, E=392.8 keV (I=94.5%)), Zr-89 (78.4 h, 909.2 keV, (I=99.87%)).

Decay Requirements

Decay At BLIP for 7 days is required

7. Expected Dose Rate

The dose rate was calculated using Microshied 7.02 based on the data for Ga target. The dose rate to the operator at BLIP after 28 days irradiation at $145 \,\mu\text{A}$ is $0.73 \,\text{mR/h}$

²Helus, F., Wobler, G., 1983. Activation techniques, in: Helus, F., Colombetti, L.G. (Eds.), Radionuclide Production. CRC Press, Inc., p. 95

The dose rate after 24 h cool off time is 0.48 mR/h The dose rate after 7 days cool off time is 0.045 mR/h See appendix 5 for Microshield reports.

8. Additional Safety Requirements

Target needs to undergo visual inspection 1 h after bombardment commencement, at the end of the day, and next day, weekly, and every time it is lifted. BLIP Cooling water will be monitored for Zn-65 peak at 1115 keV

9. Special Operating Instructions/Additional considerations

Summary of irradiated and processed Ga metal targets (provided by J. Fitzsimmons)

	06/01/ 2012	07/02/ 2012	08/09/ 2012	05/23/ 2013	08/26/ 2013
Target name	BQR	BQQ	BQU	BPR	BPS
Irradiation charge µA-h*	36008	40352	24950	44814	31916
Ge (mCi) Leached	700	610	257	410	359-430
Total Ge-68 recovered mCi	666	595	257	420	408
Ge activity recovered by fraction mCi	666	128/465°/<5	257	140/274	408
mCi/ μA-h	0.0194	0.0151	0.0103	0.0091	0.0135
μCi/ μA-h	19.44	15.12	10.30	9.15	13.47

^{*}irradiated according to production schedule

Supporting Documentation						
References						

Appendix 1.Proton Energy Profile for Ga target Array

layer number	Layer	Material	density	inches	mm	Ei	Eout
_		5		0.040		110 =0	110.00
1	Be window	Berillium	1.85	0.012	0.305	116.50	116.20
2	AlBeMet window	AlBeMet	2.10	0.012	0.305	116.20	115.86
3	Beamline window	stainless steel	7.99	0.031	0.787	115.86	113.00
4	water gap	water	1.00	0.106	2.692	113.00	111.18
5	BOX front window	stainless steel	7.99	0.020	0.508	111.18	109.26
6	water gap	water	1.00	0.200	5.080	109.26	105.72
7	stainless steel	stainless steel	7.99	0.058	1.473	105.72	99.88
8	water gap	water	1.00	0.200	5.080	99.88	96.08
9	can window	inconel	8.43	0.012	0.305	96.08	94.71
10	RbCl salt	RbCl	2.20	0.670	17.018	94.71	74.19
11	can window	inconel	8.43	0.012	0.305	74.19	72.53
12	water gap	water	1.00	0.200	5.080	72.53	67.64
13	can window	inconel	8.43	0.012	0.305	67.64	65.86
14	RbCl salt	RbCl	2.20	0.524	13.309	65.86	43.72
15	can window	inconel	8.43	0.012	0.305	43.72	41.23
16	water gap	water	1.00	0.200	5.080	41.23	33.25
17	Can window	Nb	8.57	0.012	0.305	33.25	30.40
18	Ga metal	Ga	6.10	0.196	4.979	30.40	stop
19	Can window	Nb	8.57	0.012	0.305	0.00	0.00
20	water gap	water	1.00	0.200	5.080	0.00	0.00
21	Copper	Cu	8.96	0.348	8.839	0.00	0.00
22	water gap	water	1.00	0.200	5.08	0.00	0.00
					-		

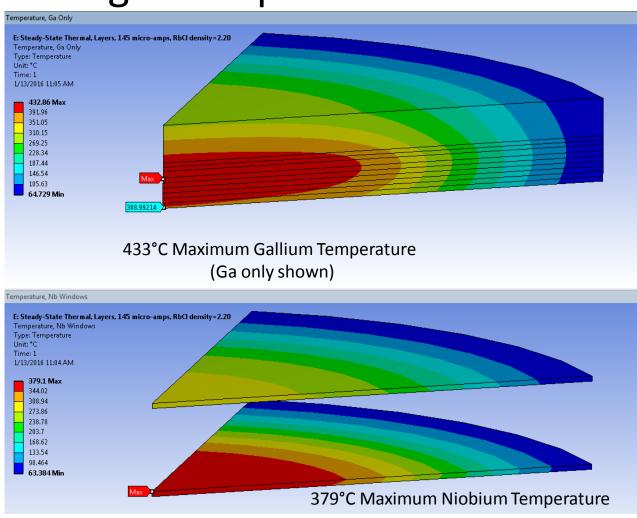
Appendix 2

Heal load analysis

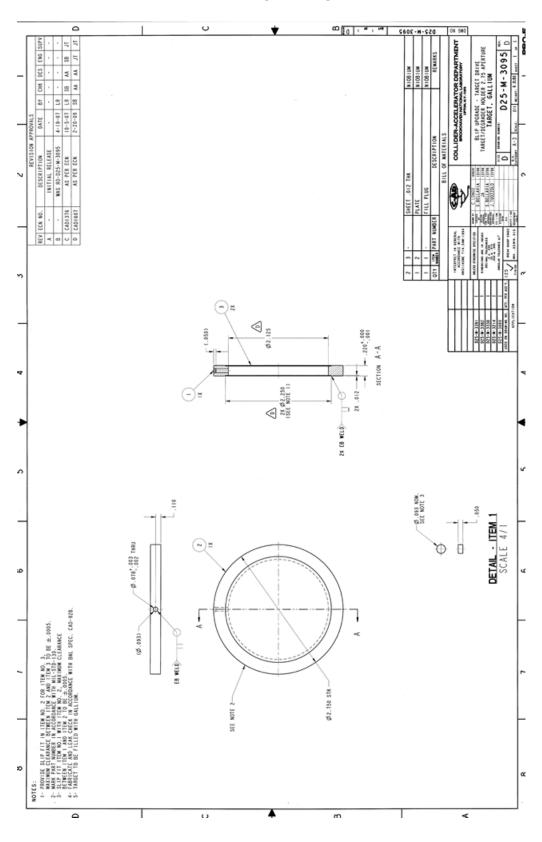
provided by Chris Cullen

Gallium Target, Niobium Holder Thermal Analysis Chris Cullen January 13, 2016	Conditions • Steady state average current = 145 μA, 116 MeV • Pulse width = .000450 sec • Pulse Frequency = 6.667 Hz • 4820 Watts (32.3 MeV) total power deposited • Assumed RbCl density = 2.20 gm/cc • 5 targets, (6) .20" water gaps • Target placed in upstream box • Gaussian Beam FWHM=12.0 mm • Z axis energy deposition gradient included to account for Bragg Peak • Raster pattern 15 mm & 5.5 mm radii (4:1)
Finite Element Model • 2D Axi-symmetric model • Niobium target holder • Steady-state analysis • Steady state water cooling = 5604 W/m ² *°C (22.5 gpm mass flow)	Generic Target • Axi-symmetric analysis region highlighted in blue – Ref. D25-M-3095
Finite Element Model Target Geometry Note: (1975) The Value of Control of Co	Summary & Conclusion • Maximum Gallium temperature = 433 °C • Ga boiling temperature = 2400 °C • SAFE • Maximum Niobium temperature = 379 °C • Nb reacts with Ga at 400°C • SAFE • Maximum Nb heat flux at water surface = 207 W/cm ² • Critical Heat Flux = 227 W/cm ² • Safe
Reference Slides • Files - D:\Jobs - Active\BLIP\Target Analyses\FY 16\Ga\Ga Thermal with Raster. wbpj - D:\Jobs - Active\BLIP\Target Analyses\FY 16\Ga\BIP-HTC-R2 Ga Thermal.xlsx, CHFs Bernath Correlation - D:\Jobs - Active\BLIP\Target Analyses\FY 16\Ga\FY2016 RbCl energy propogation_raster_Cu_stop_10_28.xlsx	Target drawing is on the page 13: D25-M-3095

Target Temperature Profile



Ga target drawing



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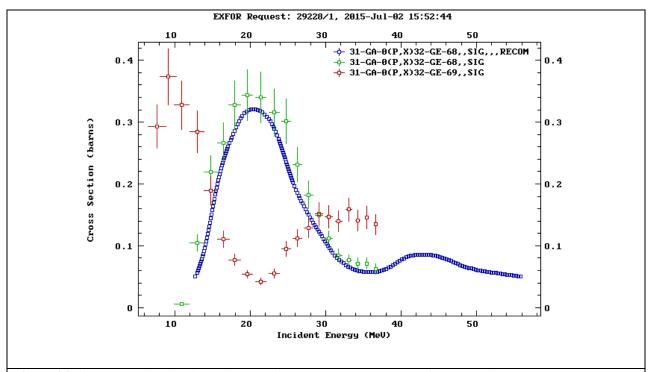


Figure A3-1. Cross section data for production of Ge-68 and Ge-69 isotopes from natural Ga

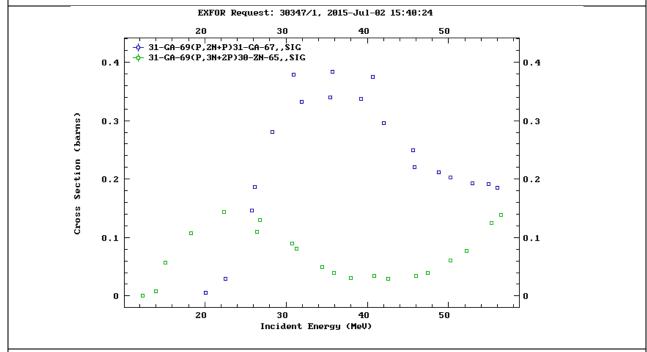
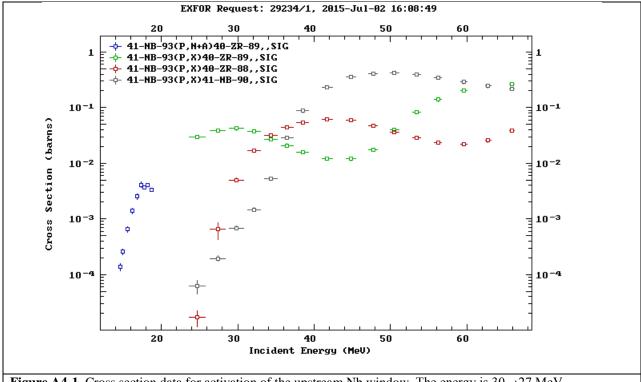


Figure A3-2. Cross section data for production of Ga-67 and Zn-65 isotopes from Ga-69

Appendix 4 Cross section data for activation of Nb window for proton energy ~30→27 MeV



Appendix 5

Microshield reports

Dose rate to the operator from Ga target at BLIP at EOB

	MicroShield 7.02 BNL (7.02-0000)									
	Γ		Ву			C	hecked			
	Filename						ate	Run Time	Duration	
	Ga tarş	get EO		uA beam.ms7		January 4		4:22:51 PM	00:00:00	
	Project Info									
	Case T	itle				Ga BLIP	@EOB			
	Descrip	tion		Do	se rat	e EOB after	4 weeks a	ıt 145 uA		
	Geome	etry			8 - Cy	ylinder Volu	me - End	Shields		
			Source 1	Dimensions						
	Height			0.498 cm (0.2	2 in)					
	Radius			3.493 cm (1.4	in)					
			Dose	Points			The intent image record to displayed	The file angular hard record, control or district Verify for the life globs to the control file and fundamental		
A	X			Y		Z				
#1	0.0 cm (0.0 in)	76.2 cı	m (2 ft 6.0 in)	0.0	cm (0.0 in)				
			Sh	iields						
5	Shield N	Din	nension	Material		Density				
	Source	1.3	164 in ³	Gallium		6.095				
	Shield 1 12.0 in			Air		0.00122				
	Shield 2 .5 in		.5 in	Stainless ste	el	8				
,	Shield 3 6.0		5.0 in	Lead		11.34				
	Shield 4		.5 in	Stainless ste	el	8				
	Air Gap			Air		0.00122				

Source Input: Grouping Method - Standard Indices Number of Groups: 25 Lower Energy Cutoff: 0.015 Photons < 0.015: Excluded Library: ICRP-38

Page 16 of 21

Nuclide	Ci	Bq	μCi/cm³	Bq/cm ³
Ga-67	2.5300e+000	9.3610e+010	1.3262e+005	4.9069e+009
Ga-68	2.8100e+000	1.0397e+011	1.4730e+005	5.4500e+009
Ge-68	2.8100e+000	1.0397e+011	1.4730e+005	5.4500e+009
Ge-69	3.6340e+001	1.3446e+012	1.9049e+006	7.0481e+010
Zn-65	5.6700e-001	2.0979e+010	2.9721e+004	1.0997e+009

Buildup: The material reference is Shield 3 Integration Parameters	
Radial	

Radial	20
Circumferential	10
Y Direction (axial)	10

	Results									
Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup		Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup					
0.1	3.869e+10	0.000e+00	1.909e-05	0.000e+00	2.920e-08					
0.2	2.793e+10	5.473e-68	1.045e-21	9.660e-71	1.845e-24					
0.3	3.382e+10	6.452e-25	2.307e-21	1.224e-27	4.375e-24					
0.4	5.435e+09	1.968e-13	4.818e-13	3.835e-16	9.387e-16					
0.5	1.121e+12	5.423e-06	1.602e-05	1.064e-08	3.144e-08					
0.6	1.584e+11	3.554e-04	1.147e-03	6.936e-07	2.238e-06					
0.8	1.387e+11	1.563e-01	5.901e-01	2.973e-04	1.122e-03					
1.0	3.684e+11	1.007e+01	4.147e+01	1.857e-02	7.644e-02					
1.5	4.731e+10	5.011e+01	2.218e+02	8.431e-02	3.732e-01					
2.0	9.411e+09	4.042e+01	1.824e+02	6.251e-02	2.820e-01					
3.0	5.147e+05	6.826e-03	3.028e-02	9.261e-06	4.108e-05					
Totals	1.949e+12	1.008e+02	4.462e+02	1.657e-01	7.327e-01					

Dose rate to the operator at BLIP 24 hours past EOB, 28 d of beam

MicroShield 7.02 BNL (7.02-0000)										
D	ate		By				Cl	necked		
	Filename						ate	Run	Time	Duration
Ga targ			uA beam.ms7				, 2016		49 PM	00:00:00
]	Projec	t Info					
Case Ti	itle				Ga	BLIP	@EOB			
Descript	tion		D	ose rat	e EOB	after	4 weeks a	t 145 u.	A	
Geome	try			8 - Cy	linder	Volur	ne - End S	Shields		
		Source D	imensions							
Height			0.498 cm (0.2	2 in)						
Radius			3.493 cm (1.4	4 in)						
		Dose	Points	1			The british strange current in all phayers	The Bis May have been record, covered, or distinct Verly	that the little gallets, to the securities and treation.	
A X			Y	Z						
#1 0.0 cm (0	0.0 in)	76.2 cm	n (2 ft 6.0 in)	0.0	cm (0.0) in)				
		Shi	ields							
Shield N	Dime	nsion	Material		Den	sity				
Source	1.16	4 in ³	Gallium		6.0	95				
Shield 1		0 in	Air		0.00					
Shield 2		in	Stainless ste	eel	8					
Shield 3 Shield 4	6.0	in	Lead Stainless sto	201	11.					
Air Gap	.3	111	Air	361	0.00					
Source Input: Grouping Method - Standard Indices Number of Groups: 25 Lower Energy Cutoff: 0.015 Photons < 0.015: Excluded										
Nuclide		Ci		rary: . Bq	ICRP-	30	μCi/cm ³	3	I.	Sq/cm ³
Ga-67	2.04	455e+000		34e+01	10	1	.0722e+0			573e+009

Ga-68	2.8037e+000	1.0374e+011	1.4697e+005	5.4378e+009
Ge-68	2.8032e+000	1.0372e+011	1.4694e+005	5.4369e+009
Ge-69	2.3734e+001	8.7816e+011	1.2441e+006	4.6032e+010
Zn-65	5.6539e-001	2.0919e+010	2.9637e+004	1.0966e+009

Buildup: The material reference is Shield 3 Integration Parameters					
Radial	20				
Circumferential	10				
Y Direction (axial)	10				

	Results									
Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup		Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup					
0.1	3.128e+10	0.000e+00	1.543e-05	0.000e+00	2.361e-08					
0.2	2.163e+10	4.239e-68	8.094e-22	7.482e-71	1.429e-24					
0.3	2.453e+10	4.679e-25	1.673e-21	8.877e-28	3.173e-24					
0.4	4.233e+09	1.533e-13	3.752e-13	2.987e-16	7.311e-16					
0.5	7.961e+11	3.851e-06	1.138e-05	7.560e-09	2.233e-08					
0.6	1.034e+11	2.321e-04	7.490e-04	4.531e-07	1.462e-06					
0.8	9.062e+10	1.022e-01	3.857e-01	1.943e-04	7.336e-04					
1.0	2.455e+11	6.711e+00	2.763e+01	1.237e-02	5.093e-02					
1.5	3.094e+10	3.277e+01	1.450e+02	5.513e-02	2.440e-01					
2.0	6.198e+09	2.662e+01	1.201e+02	4.117e-02	1.857e-01					
3.0	5.135e+05	6.811e-03	3.021e-02	9.240e-06	4.099e-05					
Totals	1.354e+12	6.621e+01	2.932e+02	1.089e-01	4.814e-01					

Dose rate to the operator at BLIP 7 days past EOB, 28 d of beam

						ield 7.02 2-0000)	,		
	Da	ate		Ву			C	hecked	
]	Filename	}		Rı	ın Date	Run Time	Duration
C	Ga targe	et EOB	_28d 145	uA beam.ms7		Janua	ary 4, 2016	4:27:53 PM	00:00:00
			_]	Project	t Info			
Ca	ase Tit	le				Ga BI	LIP @EOB		
De	scripti	on		Dos			ays, 4 weeks		
G	eometr	У			8 - Cyl	linder V	olume - End	Shields	
			Source 1	Dimensions					
Не	eight			0.498 cm (0.	2 in)				
Ra	adius			3.493 cm (1.	4 in)				
			Dose	e Points	1		The local strap current to stop	gyat. The file registers bearinessed, treatment, or addition fromly that the lift gallets to the corner life, and beaution	
A	X			Y		Z			
#1 0.0	cm (0	.0 in)	76.2 ci	m (2 ft 6.0 in)	0.0	cm (0.0 i	<u>in)</u>		
	T T		Sł	nields	1				
Shield	l N		ension	Materia	l	Densi	ty		
Sourc			64 in ³	Gallium		6.09			
Shield			.0 in	Air	_	0.0012	22		
Shield			in .	Stainless st	eel	8			
Shield			0 in 5 in	Lead Stainless st	ee1	11.34	+		
Air G		<u></u>	, 111	Air		0.0012	22		
	<u> </u>		Source	e Input: Group Numb Lower E Photons	per of C nergy s < 0.01	Groups: Cutoff:	25 0.015 uded	dices	
Nucli	ide		Ci		Bq		μCi/cm	3	Bq/cm ³

5.7135e-001

Ga-67

2.9950e+004

2.1140e+010

1.1081e+009

Ga-68	2.7635e+000	1.0225e+011	1.4486e+005	5.3598e+009
Ge-68	2.7631e+000	1.0223e+011	1.4484e+005	5.3589e+009
Ge-69	1.8420e+000	6.8156e+010	9.6558e+004	3.5726e+009
Zn-65	5.5583e-001	2.0566e+010	2.9136e+004	1.0780e+009

Buildup: The material reference is Shield 3 Integration Parameters					
Radial	20				
Circumferential	10				
Y Direction (axial)	10				

Results					
Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup		Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.1	8.737e+09	0.000e+00	4.310e-06	0.000e+00	6.594e-09
0.2	5.237e+09	1.026e-68	1.959e-22	1.811e-71	3.458e-25
0.3	4.466e+09	8.520e-26	3.046e-22	1.616e-28	5.778e-25
0.4	1.046e+09	3.787e-14	9.270e-14	7.380e-17	1.806e-16
0.5	2.300e+11	1.113e-06	3.287e-06	2.185e-09	6.452e-09
0.6	8.060e+09	1.808e-05	5.835e-05	3.530e-08	1.139e-07
0.8	7.157e+09	8.069e-03	3.046e-02	1.535e-05	5.794e-05
1.0	3.177e+10	8.687e-01	3.576e+00	1.601e-03	6.592e-03
1.5	2.504e+09	2.652e+00	1.174e+01	4.462e-03	1.975e-02
2.0	6.172e+08	2.651e+00	1.196e+01	4.100e-03	1.849e-02
3.0	5.061e+05	6.713e-03	2.978e-02	9.108e-06	4.040e-05
Totals	2.996e+11	6.186e+00	2.733e+01	1.019e-02	4.493e-02