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.

9.1.15.a BLIP Target and Canning Record

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Approved: _____***Signature with Date on File***_____
Collider-Accelerator Department Chairman Date

D. Beavis

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.

Note 2: Leave no blanks. Indicate 'Not Applicable (N/A)', where appropriate.

Title and Preparer
Irradiation of GaAs Se-72 production target at 105 MeV Target Submission Number: TS-_____ [prepared by]

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 each component/material 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]	7
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.]	7
a. Procedure for Irradiation of Target Material at 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 calculated entry and exit energy for each layer. Provide physical dimension of degraders, target can, materials and water gaps. Provide total water gap for the array]	10

	c. Thermal Analysis of Target Materials and Target Can [provide full description of data to specialist for calculations and any assumption made on material for calculations]	12
	d. Transport and Processing at TPL [provide description of task involved if different from C-AD OPM 19.17.30 BLIP Target Transfer Procedure]	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 list of radionuclide produced and their quantities, references used for calculations at the time points of: end of bombardment (EOB) 1 hour after EOB and at the time of transport to TPL]	8
7.	**Expected Dose Rate (e.g., R/h at 1 m)** [provide expected dose rate using *Microshield or equivalent* calculations for the combined and separate target and can irradiated. Provide expected dose rate at EOB at BLIP, 1 h after EOB and expected dose rate at the time of transfer to TPL. Provide decay profiles if the dose rates exceeds limits set up in applicable RWP for removal from BLIP hot-cell. Attach analyses if any]	8
8.	**Additional Safety Requirements:** [provide list of isotopes for monitoring in Blip target cooling water in case of target leak/failure visual inspection schedule impact on BLIP air emissions if water gap exceeds historical values hazardous issues related to volatiles and or corrosive materials used hazardous materials information must be submitted to the C-AD ESRC]	8
9.	**Special Operating Instructions and List of References or Supporting Documents**	8
10.	**Appendix 1:** Target Array and Energy Propagation Calculations **Appendix 2:** Target Array Loading Table (LT) [provide additional supporting information as required]	10-11

1. Overview

This irradiation is a scale up of the GaAs foil irradiation carried out earlier this year Tgt_15_07 a, aiming to produce mCi quantities of Se-72. The target was redesigned (see Appendix 5 for the blueprint) to accommodate raster implementation at BLIP. The following modifications has been made:

Item	Tgt_15_07	This submission
Target capsule	0.5 inch thick Aluminium bolted	0.120 inch thick Al laser welded
Target material	GaAs foil d×h=1.1×0.020	GaAs foil d×h=2.375×0.020
Irradiation type	Dedicated	Parasitic in front of RbCl
Irradiation time	1h	At least 72 h
Beam current	Focused, 70 uA	Rastered, 165 uA

The submission below will detail these changes.

2. Target Material and Properties

Target Name:	*BXA*	**Target Submission No.** *Assign unique no.* (year-00x)	**TS-16-06**

Target Material Properties				
Purity or Grade	99.99%			
Chemical Formula	GaAs			
Physical Characteristics at 21 ºC	**solid**			
Physical Form (foil, disk, pressed pellet…)	**foil**			
Target dimensions (inches/mm)	**Diameter**	**2.375 (60.3)**	**Thickness**	**0.020 (0.508)**
Elements (%)				
Melting Point	**1238**			**ºC**
Boiling Point	**n/a**			**ºC**
Decomposition temperature	**700**			**ºC**
Thermal Conductivity	**55 $W.m^{-1}.K^{-1}$**	**Temperature dependence**	*(if available)* *n/a*	
Density	**5.32**		**g/cm^3**	

Target Material Reactions / Properties						
Does the Target material react with the following or any other material?	**Aluminium**	**no**	**Air**	**no**	**Copper**	**no**
	H_2O	**insoluble**	**S/Steel**	**no**		
	Inconel 600	**no**	**CO_2**	**no**		

Canning Material Properties				
Chemical Formula	**Aluminum**			
Can Window Thickness (inches/mm)	**0.020 (0.508) front window** **0.080 (2.032) back window**			
Can Dimensions (inches/mm)	**Diameter: 2.750 (69.85)**		**Thickness:0.120 (3.048)**	
Melting Point			**660.3**	**ºC**
Thermal Conductivity	**237 $W.m^{-1}.K^{-1}$**	**Temperature dependence**	*(if available)n/a*	
Density	**2.7**	**g/cm^3**		

3. Target Canning Process
The target will be laser welded under He by EB industries

4. Beam Characteristics		
Beam pattern (rastered/focused)	**Rastered**	
Incident LINAC energy	**116.5**	**MeV**
Energy on Target Material	**105**	**MeV**
Maximum Instantaneous Current permitted	**165**	**µA**
Average Current Desired	**165**	**µA**
Total Integrated Charge Desired	**At least 11880**	**µA-hrs**

5. Experiment Description

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

Follow CAD OPM 19.17.20 to install or remove the target. Position the target with window upstream

Inspect in one hour and at the end of the day.

5.b Target array in Box 1 and Box 2 (detailed in Appendix 1):

The irradiation is parasitic in front of RbCl. The target was designed to degrade the energy equivalent to the current stainless steel degrader.

5.c Thermal analysis of target material and target can (attach analyses if any): see Appendix 3 for details. Summary is given here:

Maximum GaAs target Temperature = 107 °C
GaAs – Melting Point Temperature = 1238 °C
• SAFE
Maximum Aluminum Temperature = 100 °C
Aluminum – Melting Point Temperature = 660°C
• SAFE
• Maximum heat flux at water surface = 30.9 W/cm2
• *Forced Convection* Critical Heat Flux = 207 W/cm2
• SAFE

Performed by: C Cullen Date: 04/21/2016 Checked by: TBD Date:

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

5.e Disposal of waste:

Liquid waste will be neutralised 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

Produced radionuclides were determined experimentally and scaled up taking into account current and time of irradiation. Activation of Al body was calculated based on Na-22 and Na-24 cross sections at 105 MeV. The data given for 2 irradiation scenarios: 3 days and 7 days. The dat is provided for EOB and at 24 h after EOB.

Isotope	Half life, d	3 days at 165 uA		7 days at 165 uA	
		A^{EOB}, mCi	A^{24h}, mCi	A^{EOB}, mCi	A^{24h}, mCi
As-71	2.72	2937.7	2274.3	4573.8	3535.3
As-72	1.08	3072.7	1648.1	3557.1	1933.9
As-73	80.3	112.8	111.04	258.7	255.8
As-74	17.77	434.7	418.4	940.5	904.0
Se-72	8.4	62.4	57.1	124.9	2.7117e+000
Ga-67	3.26	2043.3	1651.8	3354.9	2711.7
Zn-65	243.93	26.2	26.1	60.8	60.8
Na-24	0.1	4705	155.4	4878	1609.8
Na-22	949	37	37	85	85

Decay Requirements

Depending on the actual dose rate 24 h cool off period may be required. RCT will make a determination

7. Expected Dose Rate

Calculated using Microshield 7

Exposure rate to BLIP operator, mR/h			
3 days at 165 uA		7 days at 165 uA	
At EOB	24 hours after	At EOB	24 hours after
31.3	10.5	32.6	10.9

8. Additional Safety Requirements

The target material is not soluble in water so in case of target failure it will fall on to the bottom of the tank.

Nuclides released to Blip Target Cooling Water in the unlikely event of target leak/failure

Nuclide	Half life	Eγ (abundance, %)
As-71	2.72 d	174.95 (82.4)
As-72	1.08 d	833.99 (81%)
Ga-67	3.26 d	184.58 (21.4)

9. Special Operating Instructions

Supporting Documentation	
References	

Appendix 1

Target Array and Energy Propagation Calculations

TITLE: Irradiation of GaAs Se-72 production target at 105 MeV_____

Target Array Number: TA-16-06_____

Preparer: Medvedev_____

(a) 2016 Energy: 116.5 MeV rastered beam

water displacement by can	layer number	Layer	Material	density	thickness inches	thickness mm	Ei	Eout	delta E
	1	Be window	Berillium	1.85	0.012	0.305	116.50	116.20	0.30
	2	AlBeMet window	AlBeMet	2.10	0.012	0.305	116.20	115.86	0.34
	3	Beamline window	stainless steel	7.99	0.031	0.787	115.86	113.00	2.86
	4	water gap	water	1.00	0.106	2.692	113.00	111.18	1.81
	5	BOX front window	stainless steel	7.99	0.020	0.508	111.18	109.26	1.92
	6	water gap	water	1.00	0.200	5.080	109.26	105.72	3.54
GaAs target beam welded 0.120	7	Front window	Aluminum	2.70	0.020	0.508	105.72	104.97	0.75
	8	GaAs wafer	GaAs	5.32	0.020	0.508	104.97	103.73	1.24
	9	Back window	Aluminum	2.70	0.080	2.032	103.73	100.66	3.07
	10	water gap	water	1.00	0.200	5.080	100.66	96.89	3.77
1st RbCl 0.670	11	can window	inconel	8.43	0.012	0.305	96.89	95.52	1.37
	12	RbCl salt	RbCl	2.20	0.646	16.398	95.52	75.97	19.55
	13	can window	inconel	8.43	0.012	0.305	75.97	74.33	1.63
	14	water gap	water	1.00	0.200	5.080	74.33	69.54	4.79
2nd RbCl 0.524	15	can window	inconel	8.43	0.012	0.305	69.54	67.80	1.75
	16	RbCl salt	RbCl	2.20	0.500	12.701	67.80	47.46	20.33
	17	can window	inconel	8.43	0.012	0.305	47.46	45.13	2.34
	18	water gap	water	1.00	0.200	5.080	45.13	37.78	7.34
0.754	19	Al stop	Al	2.70	0.754	19.152	37.78	stop	37.78
	20	water gap	water	1.00	0.200	5.080	0.00	0.00	

RSC Approval:	**Date Approved:**

Appendix 2

Target Loading Table

Title Irradiation of GaAs Se-72 production target at 105 MeV

Target Array Number: **TA-16-06**_____

Preparer: Medvedev_____

Proposed Run Time (e.g. days, hrs.): **72 hours**

Desired Completion Date: **June 15, 2016**

Requested Beam Energy (MeV):**116.5**

Requested Beam Current (µA):**165**

	Item	Type and stamped ID (*if available*)	Layer #'s from "Target Array and Energy Propagation Calculations"	Thickness *inch*	Thickness *mm*	BLIP Operator *(Initial)*	Witness *(Initial)*
Box 1	1	Water gap	6	0.200	5.08		
	2	GaAs target	7-9	0.120	3.048		
	3	Water gap	10	0.200	5.08		
	4	1st RbCl	11-13	0.670	17.02		
	5	Water gap	14	0.200	5.08		
	6	2nd RbCl	15-17	0.524	13.31		
	7	Water gap	18	0.200	5.08		
	8	Al beam stop	19	0.754	19.15		
	9	Water gap	20	0.200	5.08		
	10	n/a	n/a	n/a	n/a	n/a	n/a

RSC Approval:

Date Approved:

Appendix 3

Thermal analysis

Thermal Analysis of GaAs Target in Laser Welded Aluminum Target Holder

Chris Cullen

April 21, 2016

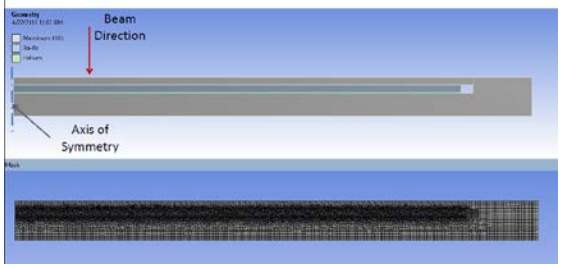
Finite Element Model

- 2D Axi-symmetric model
- Aluminum Target Holder
- Steady-state analysis
- 22.5 gpm total cooling water flow
- five targets & six water gaps in array
- Laser welded target in Helium environment

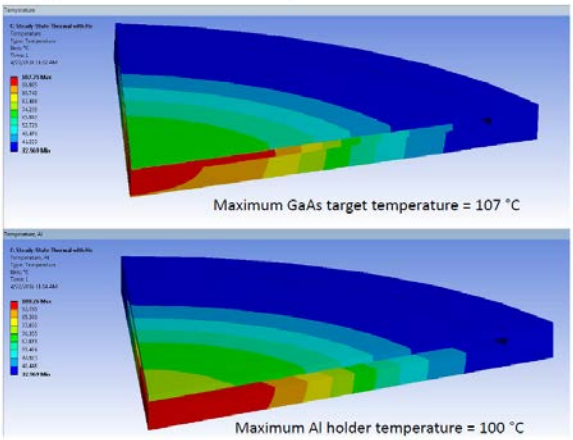
Conditions

- Pulse width = 0.000450 sec
- Pulse Frequency = 6.667 Hz
- 116.5 MeV
- 165 µA
- 825 Watts total deposition
- Beam parameters
  - Raster: 12.5 mm (4x), 5.5 mm (1x)
  - Gaussian: 11 mm FWHM

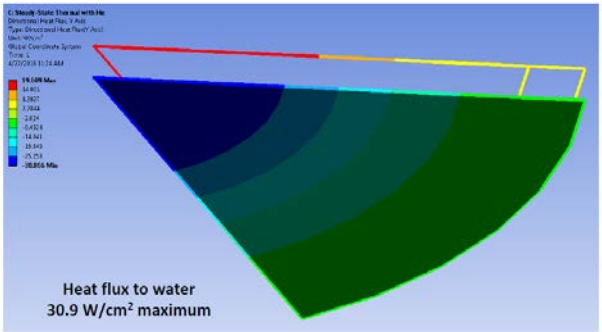
Finite Element Model Geometry & Mesh



Target & Holder Temperature Distribution



Fluid Interface Heat Flux



Summary and Conclusion

Maximum GaAs target Temperature = 107 °C

GaAs – Melting Point Temperature = 1238 °C

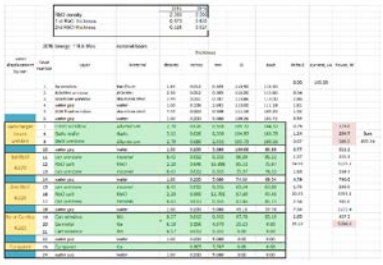
- SAFE

Maximum Aluminum Temperature = 100 °C

Aluminum – Melting Point Temperature = 660°C

- SAFE
- Maximum heat flux at water surface = 30.9 W/cm2
- *Forced Convection* Critical Heat Flux = 207 W/cm2
- SAFE

Backup Slide



Appendix 4

Microshield 7 reports

MicroShield 7.02
BNL (7.02-0000)

Date	By	Checked

Filename	Run Date	Run Time	Duration
3 days_EOB.ms7	May 24, 2016	3:03:38 PM	00:00:00

Project Info	
Case Title	GaAs BLIP 3 days 165
Description	Dose rate BLIP from GaAs at EOB, 3 days of beam
Geometry	3 - Disk

Source Dimensions	
Radius	6.033 cm (2.4 in)

Dose Points			
A	X	Y	Z
#1	76.2 cm (2 ft 6.0 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Shield 1	12.0 in	Air	0.00122
Shield 2	6.0 in	Lead	11.34
Air Gap		Air	0.00122

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

Nuclide	Ci	Bq	µCi/cm²	Bq/cm²
As-71	2.9400e+000	1.0878e+011	2.5716e+004	9.5149e+008
As-72	3.0720e+000	1.1366e+011	2.6871e+004	9.9421e+008
As-73	1.1200e-001	4.1440e+009	9.7966e+002	3.6247e+007

As-74	4.3500e-001	1.6095e+010	3.8049e+003	1.4078e+008
Ga-67	2.0430e+000	7.5591e+010	1.7870e+004	6.6119e+008
Na-22	3.7000e-002	1.3690e+009	3.2364e+002	1.1975e+007
Na-24	4.7100e+000	1.7427e+011	4.1198e+004	1.5243e+009
Se-72	6.2000e-002	2.2940e+009	5.4231e+002	2.0065e+007
Zn-65	2.6200e-002	9.6940e+008	2.2917e+002	8.4793e+006

Buildup: The material reference is Shield 2 **Integration Parameters**	
Radial	20
Circumferential	20

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.038e+11	0.000e+00	1.864e-22	0.000e+00	1.598e-23
0.02	2.133e+07	0.000e+00	5.104e-26	0.000e+00	1.768e-27
0.05	1.767e+09	0.000e+00	1.152e-23	0.000e+00	3.070e-26
0.1	3.127e+10	0.000e+00	1.520e-05	0.000e+00	2.325e-08
0.15	9.911e+10	8.236e-140	5.543e-20	1.356e-142	9.128e-23
0.2	1.776e+10	6.077e-67	6.544e-22	1.073e-69	1.155e-24
0.3	1.590e+10	2.859e-24	1.068e-21	5.424e-27	2.027e-24
0.4	4.634e+09	1.184e-12	2.862e-12	2.306e-15	5.577e-15
0.5	2.776e+11	7.835e-06	2.264e-05	1.538e-08	4.445e-08
0.6	2.288e+10	2.601e-04	8.153e-04	5.077e-07	1.591e-06
0.8	9.318e+10	4.336e-01	1.564e+00	8.247e-04	2.974e-03
1.0	8.764e+09	8.538e-01	3.310e+00	1.574e-03	6.101e-03
1.5	1.789e+11	5.336e+02	2.165e+03	8.978e-01	3.642e+00
2.0	2.921e+09	3.096e+01	1.271e+02	4.787e-02	1.966e-01
3.0	1.762e+11	5.024e+03	2.024e+04	6.816e+00	2.746e+01
4.0	3.152e+08	1.249e+01	4.892e+01	1.545e-02	6.052e-02
Totals	**1.035e+12**	**5.603e+03**	**2.259e+04**	**7.780e+00**	**3.137e+01**

MicroShield 7.02
BNL (7.02-0000)

Date	By	Checked

Filename	Run Date	Run Time	Duration
3 days_EOB.ms7	May 24, 2016	3:06:48 PM	00:00:00

Project Info	
Case Title	GaAs BLIP 3 days 165
Description	Dose rate BLIP from GaAs at 24h after EOB, 3 days of beam
Geometry	3 - Disk

Source Dimensions	
Radius	6.033 cm (2.4 in)

Dose Points			
A	X	Y	Z
#1	76.2 cm (2 ft 6.0 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Shield 1	12.0 in	Air	0.00122
Shield 2	6.0 in	Lead	11.34
Air Gap		Air	0.00122

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

Nuclide	Ci	Bq	µCi/cm²	Bq/cm²
As-71	2.2743e+000	8.4150e+010	1.9893e+004	7.3606e+008
As-72	1.6481e+000	6.0981e+010	1.4416e+004	5.3339e+008
As-73	1.1104e-001	4.1084e+009	9.7124e+002	3.5936e+007
As-74	4.1835e-001	1.5479e+010	3.6593e+003	1.3539e+008
Ga-67	1.6518e+000	6.1116e+010	1.4448e+004	5.3458e+008
Ge-71	1.4774e-001	5.4664e+009	1.2923e+003	4.7814e+007
Na-22	3.6973e-002	1.3680e+009	3.2340e+002	1.1966e+007
Na-24	1.5537e+000	5.7488e+010	1.3590e+004	5.0284e+008
Se-72	5.7089e-002	2.1123e+009	4.9936e+002	1.8476e+007

Zn-65	2.6126e-002	9.6665e+008	2.2852e+002	8.4552e+006

Buildup: The material reference is Shield 2 Integration Parameters	
Radial	20
Circumferential	20

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	8.436e+10	0.000e+00	1.514e-22	0.000e+00	1.299e-23
0.02	1.650e+07	0.000e+00	3.948e-26	0.000e+00	1.368e-27
0.05	1.658e+09	0.000e+00	1.081e-23	0.000e+00	2.880e-26
0.1	2.528e+10	0.000e+00	1.228e-05	0.000e+00	1.879e-08
0.15	7.667e+10	6.371e-140	4.288e-20	1.049e-142	7.061e-23
0.2	1.435e+10	4.912e-67	5.289e-22	8.669e-70	9.336e-25
0.3	1.275e+10	2.292e-24	8.563e-22	4.347e-27	1.624e-24
0.4	3.691e+09	9.427e-13	2.280e-12	1.837e-15	4.442e-15
0.5	1.700e+11	4.797e-06	1.386e-05	9.416e-09	2.721e-08
0.6	1.770e+10	2.013e-04	6.308e-04	3.928e-07	1.231e-06
0.8	5.027e+10	2.339e-01	8.436e-01	4.449e-04	1.605e-03
1.0	6.465e+09	6.299e-01	2.441e+00	1.161e-03	4.500e-03
1.5	6.068e+10	1.810e+02	7.343e+02	3.046e-01	1.235e+00
2.0	1.576e+09	1.670e+01	6.857e+01	2.583e-02	1.060e-01
3.0	5.859e+10	1.670e+03	6.729e+03	2.266e+00	9.129e+00
4.0	1.465e+08	5.805e+00	2.273e+01	7.182e-03	2.813e-02
Totals	**5.842e+11**	**1.875e+03**	**7.558e+03**	**2.605e+00**	**1.050e+01**

MicroShield 7.02
BNL (7.02-0000)

Date	By	Checked

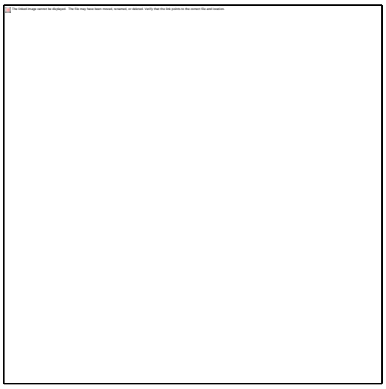
Filename	Run Date	Run Time	Duration
7 days_EOB.ms7	May 24, 2016	3:11:25 PM	00:00:00

Project Info	
Case Title	GaAs BLIP 7 days 165
Description	Dose rate BLIP from GaAs at EOB, 7 days of beam
Geometry	3 - Disk

Source Dimensions	
Radius	6.033 cm (2.4 in)

Dose Points			
A	X	Y	Z
#1	76.2 cm (2 ft 6.0 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Shield 1	12.0 in	Air	0.00122
Shield 2	6.0 in	Lead	11.34
Air Gap		Air	0.00122



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

Nuclide	Ci	Bq	µCi/cm²	Bq/cm²
As-71	4.5700e+000	1.6909e+011	3.9973e+004	1.4790e+009
As-72	3.5600e+000	1.3172e+011	3.1139e+004	1.1521e+009
As-73	2.5800e-001	9.5460e+009	2.2567e+003	8.3498e+007
As-74	9.4000e-001	3.4780e+010	8.2221e+003	3.0422e+008
Ga-67	3.3540e+000	1.2410e+011	2.9337e+004	1.0855e+009
Na-22	8.5000e-002	3.1450e+009	7.4349e+002	2.7509e+007
Na-24	4.8800e+000	1.8056e+011	4.2685e+004	1.5793e+009
Se-72	1.2500e-001	4.6250e+009	1.0934e+003	4.0455e+007
Zn-65	6.1000e-002	2.2570e+009	5.3356e+002	1.9742e+007

Buildup: The material reference is Shield 2
Integration Parameters

Radial	20
Circumferential	20

Results					
Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.683e+11	0.000e+00	3.020e-22	0.000e+00	2.591e-23
0.02	3.316e+07	0.000e+00	7.933e-26	0.000e+00	2.748e-27
0.05	3.689e+09	0.000e+00	2.405e-23	0.000e+00	6.407e-26
0.1	5.133e+10	0.000e+00	2.494e-05	0.000e+00	3.816e-08
0.15	1.541e+11	1.280e-139	8.616e-20	2.108e-142	1.419e-22
0.2	2.914e+10	9.973e-67	1.074e-21	1.760e-69	1.895e-24
0.3	2.583e+10	4.644e-24	1.735e-21	8.809e-27	3.292e-24
0.4	7.484e+09	1.911e-12	4.623e-12	3.724e-15	9.007e-15
0.5	3.604e+11	1.017e-05	2.940e-05	1.997e-08	5.771e-08
0.6	3.911e+10	4.447e-04	1.394e-03	8.680e-07	2.721e-06
0.8	1.085e+11	5.047e-01	1.820e+00	9.599e-04	3.462e-03
1.0	1.331e+10	1.297e+00	5.027e+00	2.390e-03	9.266e-03
1.5	1.876e+11	5.596e+02	2.270e+03	9.416e-01	3.820e+00
2.0	3.400e+09	3.604e+01	1.480e+02	5.573e-02	2.288e-01
3.0	1.829e+11	5.213e+03	2.100e+04	7.073e+00	2.849e+01
4.0	3.518e+08	1.394e+01	5.461e+01	1.725e-02	6.756e-02
Totals	**1.335e+12**	**5.825e+03**	**2.348e+04**	**8.091e+00**	**3.262e+01**

MicroShield 7.02
BNL (7.02-0000)

Date	By	Checked

Filename	Run Date	Run Time	Duration
7 days_EOB.ms7	May 24, 2016	3:13:01 PM	00:00:00

Project Info	
Case Title	GaAs BLIP 7 days 165
Description	Dose rate BLIP from GaAs 24 h after EOB, 7 days of beam
Geometry	3 - Disk

Source Dimensions	
Radius	6.033 cm (2.4 in)

Dose Points			
A	X	Y	Z
#1	76.2 cm (2 ft 6.0 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Shield 1	12.0 in	Air	0.00122
Shield 2	6.0 in	Lead	11.34
Air Gap		Air	0.00122

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

Nuclide	Ci	Bq	µCi/cm²	Bq/cm²
As-71	3.5353e+000	1.3081e+011	3.0923e+004	1.1441e+009
As-72	1.9339e+000	7.1556e+010	1.6916e+004	6.2589e+008
As-73	2.5578e-001	9.4640e+009	2.2373e+003	8.2781e+007
As-74	9.0402e-001	3.3449e+010	7.9074e+003	2.9257e+008
Ga-67	2.7117e+000	1.0033e+011	2.3719e+004	8.7761e+008
Ge-71	2.2965e-001	8.4971e+009	2.0087e+003	7.4323e+007
Na-22	8.4938e-002	3.1427e+009	7.4295e+002	2.7489e+007
Na-24	1.6098e+000	5.9563e+010	1.4081e+004	5.2099e+008
Se-72	1.1510e-001	4.2587e+009	1.0068e+003	3.7250e+007
Zn-65	6.0827e-002	2.2506e+009	5.3205e+002	1.9686e+007

Buildup: The material reference is Shield 2
Integration Parameters

Radial	20
Circumferential	20

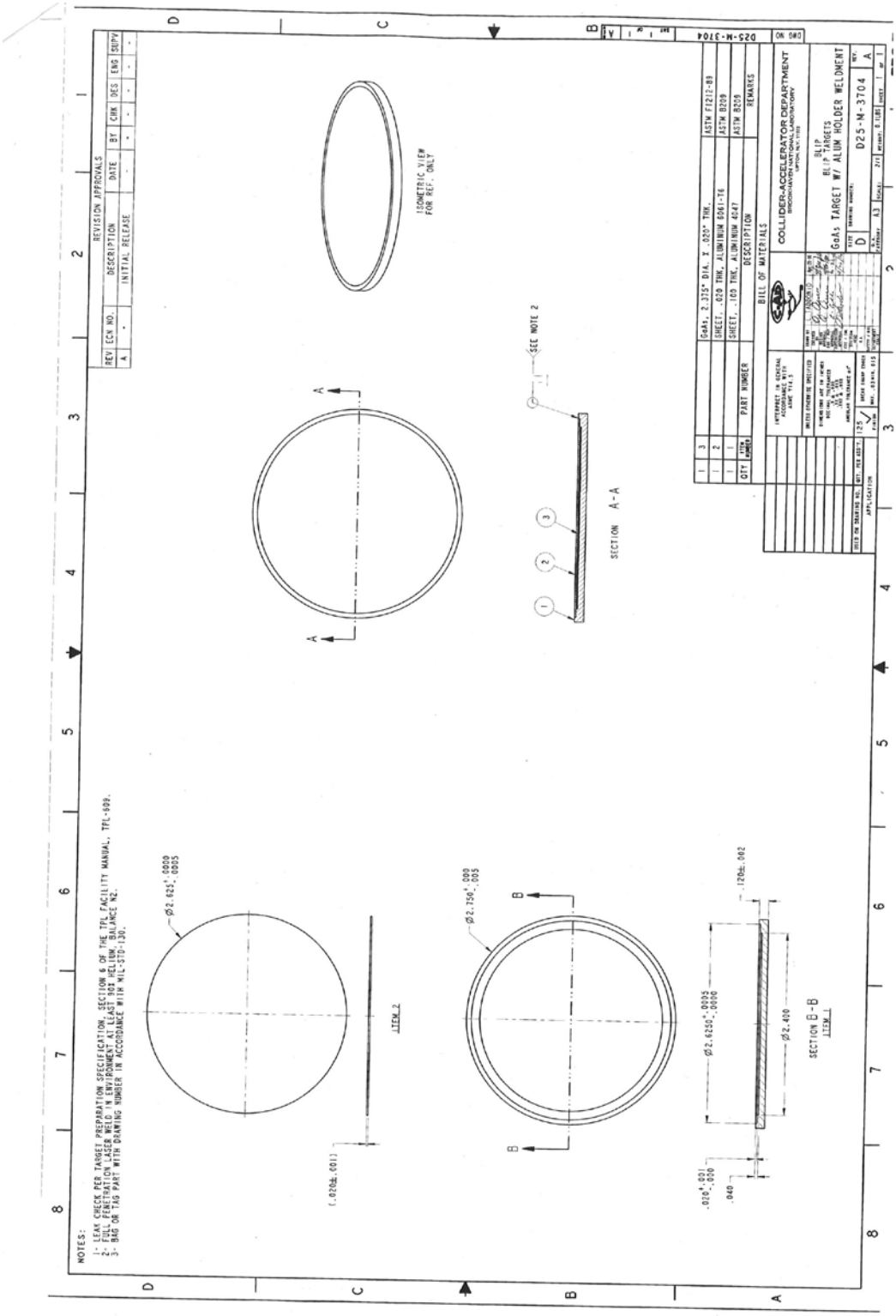
Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup

0.015	1.386e+11	0.000e+00	2.487e-22	0.000e+00	2.133e-23
0.02	2.565e+07	0.000e+00	6.137e-26	0.000e+00	2.126e-27
0.05	3.468e+09	0.000e+00	2.261e-23	0.000e+00	6.023e-26
0.1	4.149e+10	0.000e+00	2.016e-05	0.000e+00	3.084e-08
0.15	1.192e+11	9.904e-140	6.665e-20	1.631e-142	1.098e-22
0.2	2.356e+10	8.061e-67	8.680e-22	1.423e-69	1.532e-24
0.3	2.071e+10	3.723e-24	1.391e-21	7.062e-27	2.639e-24
0.4	5.973e+09	1.525e-12	3.689e-12	2.972e-15	7.188e-15
0.5	2.309e+11	6.517e-06	1.883e-05	1.279e-08	3.697e-08
0.6	3.262e+10	3.709e-04	1.162e-03	7.239e-07	2.269e-06
0.8	5.935e+10	2.762e-01	9.959e-01	5.253e-04	1.894e-03
1.0	1.009e+10	9.825e-01	3.808e+00	1.811e-03	7.020e-03
1.5	6.496e+10	1.938e+02	7.860e+02	3.260e-01	1.322e+00
2.0	1.861e+09	1.972e+01	8.099e+01	3.050e-02	1.252e-01
3.0	6.086e+10	1.735e+03	6.990e+03	2.354e+00	9.484e+00
4.0	1.669e+08	6.615e+00	2.591e+01	8.184e-03	3.205e-02
Totals	**8.138e+11**	**1.957e+03**	**7.888e+03**	**2.721e+00**	**1.097e+01**

Appendix 5

GaAs target blueprint


REVISION APPROVALS
REV ECN NO. DESCRIPTION DATE BY CHK DES ENG SUPV
A - INITIAL RELEASE - - - - - -
ISOMETRIC VIEW FOR REF. ONLY
SEE NOTE 2
SECTION A-A
SECTION B-B
ITEM 1
ITEM 2
NOTES:
1- LEAK CHECK PER TARGET PREPARATION SPECIFICATION, SECTION 6 OF THE TPL FACILITY MANUAL, TPL-609.
2- FULL PENETRATION LASER WELD IN ENVIRONMENT AT LEAST 90% HELIUM, BALANCE N2.
3- BAG OR TAG PART WITH DRAWING NUMBER IN ACCORDANCE WITH MIL-STD-130.
GaAs, 2.375" DIA. X .020" THK. ASTM F1212-89
SHEET, .020 THK, ALUMINUM 6061-T6 ASTM B209
SHEET, .100 THK, ALUMINUM 4047 ASTM B209
QTY PART NUMBER DESCRIPTION REMARKS
BILL OF MATERIALS
COLLIDER-ACCELERATOR DEPARTMENT
BROOKHAVEN NATIONAL LABORATORY
BLIP
BLIP TARGETS
GaAs TARGET W/ ALUM HOLDER WELDMENT
D25-M-3704
D25-M-3704
APPLICATION