LAWRENCE LIVERMORE LABORATORY
University of California/Livermore, California/94550

UCRL-51310—Addendum

SPECTRA OF NEUTRONS FROM DEUTERON BOMBARDMENT OF LIGHT NUCLEI

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(Ph.D. Thesis)

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MASTER

REPORT OF THE LAWRENCE LIVERMORE LABORATORY

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Spectra:	

<u>Lab</u> <u>angle (deg)</u>	<u>Bombarding</u> <u>energy (MeV)</u>
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Thick Li Targets:

3.5	5.00	.	.	.	.	.	2
9.2	5.00	.	.	.	.	.	3
16.7	5.00	.	.	.	.	.	4
23.8	5.00	.	.	.	.	.	5
32.3	5.00	.	.	.	.	.	6
5.5	9.00	.	.	.	.	.	7
9.2	9.00	.	.	.	.	.	8
16.7	9.00	.	.	.	.	.	9
3.5	14.00	.	.	.	.	.	10
9.2	14.00	.	.	.	.	.	11
16.7	14.00	.	.	.	.	.	12
23.8	14.00	.	.	.	.	.	13
32.3	14.00	.	.	.	.	.	14
3.5	16.00	.	.	.	.	.	15
9.2	16.00	.	.	.	.	.	16
16.7	16.00	.	.	.	.	.	17
23.8	16.00	.	.	.	.	.	18
32.3	16.00	.	.	.	.	.	19
(Bias = 1.6 MeV) 3.5	19.00	.	.	.	.	.	20
9.2	19.00	.	.	.	.	.	21
16.7	19.00	.	.	.	.	.	22
23.8	19.00	.	.	.	.	.	23
32.3	19.00	.	.	.	.	.	24
(Bias = 2.5 MeV) 3.5	19.00	.	.	.	.	.	25
9.2	19.00	.	.	.	.	.	26
16.7	19.00	.	.	.	.	.	27
23.8	19.00	.	.	.	.	.	28
32.3	19.00	.	.	.	.	.	29

Thick ¹⁰Be Targets:

3.5	3.00	.	.	.	.	.	30
9.2	3.00	.	.	.	.	.	31
16.7	3.00	.	.	.	.	.	32

<u>Lab</u> <u>angle (deg)</u>	<u>Bombarding</u> <u>energy (MeV)</u>						
23.8	3.00	.	.	.	.	.	33
32.3	3.00	.	.	.	.	.	34
3.5	8.84	.	.	.	.	.	35
9.2	8.84	.	.	.	.	.	36
16.7	8.84	.	.	.	.	.	37
23.8	8.84	.	.	.	.	.	38
32.3	8.84	.	.	.	.	.	39
3.5	9.97	.	.	.	.	.	40
9.2	9.97	.	.	.	.	.	41
16.7	9.97	.	.	.	.	.	42
23.8	9.97	.	.	.	.	.	43
32.3	9.97	.	.	.	.	.	44
3.5	10.97	.	.	.	.	.	45
9.2	10.97	.	.	.	.	.	46
16.7	10.97	.	.	.	.	.	47
23.8	10.97	.	.	.	.	.	48
32.3	10.97	.	.	.	.	.	49
3.5	11.99	.	.	.	.	.	50
9.2	11.99	.	.	.	.	.	51
16.2	11.99	.	.	.	.	.	52
23.8	11.99	.	.	.	.	.	53
32.3	11.99	.	.	.	.	.	54
3.5	14.05	.	.	.	.	.	55
9.2	14.05	.	.	.	.	.	56
16.7	14.05	.	.	.	.	.	57
23.8	14.05	.	.	.	.	.	58
32.3	14.05	.	.	.	.	.	59
3.5	16.07	.	.	.	.	.	60
9.2	16.07	.	.	.	.	.	61
16.7	16.07	.	.	.	.	.	62
23.8	16.07	.	.	.	.	.	63
32.3	16.07	.	.	.	.	.	64
3.5	18.09	.	.	.	.	.	65
9.2	18.09	.	.	.	.	.	66
16.7	18.09	.	.	.	.	.	67
23.8	18.09	.	.	.	.	.	68
32.3	18.09	.	.	.	.	.	69
(Bias = 2.5 MeV) 3.5	19.00	.	.	.	.	.	70
9.2	19.00	.	.	.	.	.	71

	<u>Lab angle (deg)</u>	<u>Bombarding energy (MeV)</u>						
	16.7	19.00	.	.	.	.	.	72
	23.8	19.00	.	.	.	.	.	73
	32.3	19.00	.	.	.	.	.	74
(Bias = 1.6 MeV)	3.5	19.00	.	.	.	.	.	75
	9.2	19.00	.	.	.	.	.	76
	16.7	19.00	.	.	.	.	.	77
	23.8	19.00	.	.	.	.	.	78
	32.3	19.00	.	.	.	.	.	79
	3.5	20.00	.	.	.	.	.	80
	9.2	20.00	.	.	.	.	.	81
	32.3	20.00	.	.	.	.	.	82

Thick ^{12}C Targets:

	3.5	11.99	.	.	.	.	.	83
	9.2	11.99	.	.	.	.	.	84
	16.7	11.99	.	.	.	.	.	85
	23.8	11.99	.	.	.	.	.	86
	32.3	11.99	.	.	.	.	.	87
	3.5	14.05	.	.	.	.	.	88
	9.2	14.05	.	.	.	.	.	89
	16.7	14.05	.	.	.	.	.	90
	23.8	14.05	.	.	.	.	.	91
	32.3	14.05	.	.	.	.	.	92
	3.5	16.07	.	.	.	.	.	93
	9.2	16.07	.	.	.	.	.	94
	16.7	16.07	.	.	.	.	.	95
	23.8	16.07	.	.	.	.	.	96
	32.3	16.07	.	.	.	.	.	97
	3.5	18.09	.	.	.	.	.	98
	9.2	18.09	.	.	.	.	.	99
	16.7	18.09	.	.	.	.	.	100
	23.8	18.09	.	.	.	.	.	101
	32.3	18.09	.	.	.	.	.	102

Thin D_2 Targets:

	3.5	16.55	.	.	.	.	.	103
	9.2	16.55	.	.	.	.	.	104
	32.3	16.55	.	.	.	.	.	105
	3.5	18.58	.	.	.	.	.	106
	9.2	18.58	.	.	.	.	.	107
	32.3	18.58	.	.	.	.	.	108

<u>Thin ^9Be Targets:</u>	<u>Lab angle (deg)</u>	<u>Bombarding energy (MeV)</u>						
	3.5	5.00	.	.	.	.	.	109
	9.2	5.00	.	.	.	.	.	110
	16.7	5.00	.	.	.	.	.	111
	23.8	5.00	.	.	.	.	.	112
	32.3	5.00	.	.	.	.	.	113
	3.5	6.97	.	.	.	.	.	114
	9.2	6.97	.	.	.	.	.	115
	16.7	6.97	.	.	.	.	.	116
	23.8	6.97	.	.	.	.	.	117
	32.3	6.97	.	.	.	.	.	118
	3.5	8.03	.	.	.	.	.	119
	9.2	8.03	.	.	.	.	.	120
	16.7	8.03	.	.	.	.	.	121
	23.8	8.03	.	.	.	.	.	122
	32.3	8.03	.	.	.	.	.	123
	3.5	8.84	.	.	.	.	.	124
	9.2	8.84	.	.	.	.	.	125
	16.7	8.84	.	.	.	.	.	126
	23.8	8.84	.	.	.	.	.	127
	32.3	8.84	.	.	.	.	.	128
	3.5	9.97	.	.	.	.	.	129
	9.2	9.97	.	.	.	.	.	130
	16.7	9.97	.	.	.	.	.	131
	23.8	9.97	.	.	.	.	.	132
	32.3	9.97	.	.	.	.	.	133
	3.5	11.03	.	.	.	.	.	134
	9.2	11.03	.	.	.	.	.	135
	16.7	11.03	.	.	.	.	.	136
	23.8	11.03	.	.	.	.	.	137
	32.3	11.03	.	.	.	.	.	138
	3.5	12.04	.	.	.	.	.	139
	9.2	12.04	.	.	.	.	.	140
	16.7	12.04	.	.	.	.	.	141
	23.8	12.04	.	.	.	.	.	142
	32.3	12.04	.	.	.	.	.	143
	3.5	13.04	.	.	.	.	.	144
	9.2	13.04	.	.	.	.	.	145
	16.7	13.04	.	.	.	.	.	146

<u>Lab angle (deg)</u>	<u>Bombarding energy (MeV)</u>						
23.8	13.04	.	.	.	.	.	147
32.3	13.04	.	.	.	.	.	148
3.5	14.05	.	.	.	.	.	149
9.2	14.05	.	.	.	.	.	150
16.7	14.05	.	.	.	.	.	151
23.8	14.05	.	.	.	.	.	152
32.3	14.05	.	.	.	.	.	153
3.5	15.06	.	.	.	.	.	154
9.2	15.06	.	.	.	.	.	155
16.7	15.06	.	.	.	.	.	156
23.8	15.06	.	.	.	.	.	157
32.3	15.06	.	.	.	.	.	158
3.5	16.07	.	.	.	.	.	159
9.2	16.07	.	.	.	.	.	160
16.7	16.07	.	.	.	.	.	161
23.8	16.07	.	.	.	.	.	162
32.3	16.07	.	.	.	.	.	163
3.5	18.09	.	.	.	.	.	164
9.2	18.09	.	.	.	.	.	165
16.7	18.09	.	.	.	.	.	166
23.8	18.09	.	.	.	.	.	167
32.3	18.09	.	.	.	.	.	168

SPECTRA OF NEUTRONS FROM DEUTERON BOMBARDMENT OF LIGHT NUCLEI

Abstract

Spectra of neutrons produced in the bombardment of light nuclei by deuterons were measured in order to investigate the usefulness of the reactions as high intensity neutron sources. Neutrons

emitted at angles up to 32° were studied for thin targets of deuterium and beryllium, and for thick targets of lithium, beryllium, and carbon, and for bombarding energies up to 20 MeV.

Introduction

This report contains neutron energy spectra measured with time-of-flight techniques at the Lawrence Livermore Laboratory Cyclotroon Facility to provide information on intense sources of fast neutrons. Details of these measurements are described in a previous report, Neutrons From Deuteron Bombardment of Light Nuclei,^{*} to which this report is an addendum.

Spectra of neutrons from thick Li, Be, and C targets and thin D_2 and Be targets are presented in the form of computer-generated plots. In each of these five groups, the spectra are arranged in order of increasing deuteron energy, and for each deuteron energy, the spectra

are arranged in order of increasing lab angle. The Table of Contents lists these spectra by target material, lab angle, and bombarding energy.

On each figure is noted the reaction, the target thickness in mg cm^{-2} , an identifying number for the measurement, the bombarding energy in MeV, the date of the measurement, the angle with respect to the deuteron beam at which the neutrons were detected, the discriminator level (bias) on recoil-proton energy, and the scintillator material (NE-213). The spectrum on page includes a key which will serve to clarify these notations as they appear in the remainder of the plots. For stopping targets, the target thickness is the deuteron range. Error bars indicate statistical errors. Scale uncertainties, due largely to detector efficiency uncertainties, are about 10%.

^{*}K. A. Weaver, Neutrons From Deuteron Bombardment of Light Nuclei, Lawrence Livermore Laboratory, Rept. UCRL-51310 (1973).

① REACTION THK ${}^7\text{Li}(\text{d},\text{n}){}^8\text{Be}$ ② TARGET 24.2 mg cm^{-2} THICK
 ③ RUN NO. 60810 ④ $E_{\text{in}} = 5.00 \text{ MeV}$ ⑤ 06/08/72

⑦ $\theta_{\text{lab}} = 3.5^\circ$ ⑧ E_n (LAB) MeV ⑨ BIAS=2.5 MEV (NE213)

KEY

1. Reaction: Thick ${}^7\text{Li}(\text{d},\text{n}){}^8\text{Be}$
2. Target: 24.2 mg cm^{-2} thick
3. Run number (for identification only)
4. Bombarding energy, $E_{\text{in}} = 5.00 \text{ MeV}$
5. Date of run
6. Yield - neutrons/(MeV microcoulomb steradian) or cross section - millibarns/(steradian MeV)
7. Lab angle, or angle with respect to deuteron beam at which neutrons were detected, $\theta_{\text{lab}} = 3.5^\circ$
8. Neutron energy, E_n (lab) in MeV
9. Discriminator level (bias) on recoil-proton energy. In all cases, NE-213 was the scintillator material

REACTION THK 7LI (D,N) 8BE TARGET 24.2 mg cm⁻² THICK
 RUN NO. 60810 E_{in} = 5.00MEV 06/08/72

REACTION THK 7Li (D,N)8Be

TARGET

24.2 mg cm⁻² THICK

RUN NO. 60810

E_{in} = 5.00 MEV

06/08/72

REACTION THK 7LI(D,N)8BE

TARGET

24.2 mg cm⁻² THICK

RUN NO. 60810

E_{in} = 5.00 MEV

06/08/72

REACTION THK 7L1 (D,N)8BE

TARGET

24.2 mg cm^{-2} THICK

RUN NO. 60810

$E_{in} = 5.00 \text{ MEV}$

06/08/72

REACTION THK 7Li (D,N) 8Be

TARGET

67.2 mg cm⁻² THICK

RUN NO. 60813 E_n = 9.00MEV

06/08/72

REACTION THK 7LI (D,N)8BE TARGET 67.2 mg cm⁻² THICK
 RUN NO. 60813 E_{in} = 9.00MEV 06/08/72

REACTION THK 7Li(D,N)8Be

TARGET

67.2 mg cm⁻² THICK

RUN NO. 60813

E_{in} = 9.00 MeV

06/08/72

REACTION THK 7Li(D,N)8Be

TARGET 147.4 mg cm⁻² THICK

RUN NO. 60603 E_{in} = 14.00 MeV

06/06/72

REACTION THK 7Li(D,N)8Be

TARGET 147.4 mg cm⁻² THICK

RUN NO. 60603 E_{in} = 14.00MEV

06/06/72

REACTION THK 7LI (D,N) 8BE TARGET 147.4 mg cm⁻² THICK
 RUN NO. 60603 E_{in} = 14.00MEV 06/06/72

REACTION THK 7LI (D,N)8BE

TARGET 147.4 mg cm⁻² THICK

RUN NO. 60603 E_{in} = 14.00MEV

06/06/72

REACTION THK 7Li(D,N)8BE TARGET 147.4 mg cm⁻² THICK
RUN NO. 60603 E_{in} = 14.00 MEV 06/06/72

REACTION THK 7Li(D,N)8Be

TARGET 187.4 mg cm⁻² THICK

RUN NO. 60604 E_{in} = 16.00 MEV

06/06/72

REACTION THK 7LI(D,N)8BE TARGET 187.4 mg cm⁻² THICK
RUN NO. 60604 E_{in} = 16.00MEV 06/06/72

REACTION THK 7Li (D,N)8Be

TARGET 197.4 mg cm⁻² THICK

RUN NO. 60604 E_{in} = 16.00MEV

06/06/72

REACTION THK 7Li(D,N)8Be

TARGET 187.4 mg cm⁻² THICK

RUN NO. 60604 E_{in} = 16.00MEV

06/06/72

REACTION THK 7LI(D,N)8BE TARGET 187.4 mg cm⁻² THICK
RUN NO. 60604 E_{in} = 16.00MEV 06/06/72

REACTION THK 7LI(D,N)8BE TARGET 255.5 mg cm⁻² THICK
RUN NO. 60606 E_{in} = 19.00MEV 06/06/72

REACTION THK 7Li(D,n)8Be

TARGET 255.5 mg cm⁻² THICK

RUN NO. 60606 E_{in} = 19.00MEV

06/06/72

REACTION THK 7LI (D,N) 8BE

TARGET 255.5 mg cm⁻² THICK

RUN NO. 60606 E_n = 19.00MEV

06/06/72

REACTION THK 7LI(D,N)8BE

TARGET 255.5 mg cm⁻² THICK

RUN NO. 60606 E_{in} = 19.00MEV

06/06/72

REACTION THK 7LI(D,N)8BE

TARGET 255.5 mg cm⁻² THICK

RUN NO. 60606

E_{in} = 19.00MEV

06/06/72

REACTION THK 7Li (D,N)8Be

TARGET 255.5 mg cm⁻² THICK

RUN NO. 60608

E_{in} = 19.00 MEV

06/06/72

REACTION THK 7Li (D,N)8Be

TARGET 255.5 mg cm⁻² THICK

RUN NO. 60608

E_{in} = 19.00 MEV

06/05/72

REACTION THK 7Li(D,N)8Be

TARGET 255.5 mg cm⁻² THICK

RUN NO. 60608 E_{in} = 19.00 MEV

06/06/72

REACTION THK 7LI(D,N)8BE TARGET 255.5 mg cm⁻² THICK
 RUN NO. 60608 E_{in} = 19.00MEV 06/06/72

REACTION THK 7Li (D,N) 8Be

TARGET 255.5 mg cm⁻² THICK

RUN NO. 60608 E_{in} = 19.00 MEV

06/06/72

REACTION THK 9BE(D,N)10B

TARGET

11.1 mg cm⁻² THICK

RUN NO. 60807 E_{in} = 3.00MEV

06/08/72

REACTION THK 9BE(D,N)10B

TARGET

11.1 mg cm⁻² THICK

RUN NO. 60807

E_{in} = 3.00MEV

06/08/72

REACTION THK 9BE(D,N)10B

TARGET 11.1 mg cm⁻² THICK

RUN NO. 60807 E_n = 3.00MEV

06/08/72

REACTION THK 9BE(D,N)10B

TARGET

11.1 mg cm⁻² THICK

RUN NO. 60807

E_{in} = 3.00MEV

06/08/72

REACTION THK 9BE(D,N)10B

TARGET

11.1 mg cm⁻² THICK

RUN NO. 60807

E_{in} = 3.00MEV

06/08/72

REACTION THK 9BE(D,N)10B

TARGET

68.5 mg cm⁻² THICK

RUN NO. 12011

E_{in} = 8.84 MEV

01/20/72

REACTION THK 9BE(D,N)10B TARGET 68.5 mg cm⁻² THICK
 RUN NO. 12011 E_{in} = 8.84MEV 01/20/72

REACTION THK 9BE(D,N)10B TARGET 68.5 mg cm⁻² THICK
 RUN NO. 12011 E_{in} = 8.84MEV 01/20/72

REACTION THK 9BE(D,N)10B

TARGET

68.5 mg cm⁻² THICK

RUN NO. 12011

E_{in} = 8.84 MEV

01/20/72

REACTION THK 9BE(D,N)10B

TARGET

68.5 mg cm⁻² THICK

RUN NO. 12011

E_{in} = 8.84 MEV

01/20/72

REACTION THK 9BE(D,N)10B

TARGET

85.7 mg cm⁻² THICK

RUN NO. 12006

E_{in} = 9.97 MEV

01/20/72

REACTION THK 9BE(D,N)10B

TARGET

85.7 mg cm⁻² THICK

RUN NO. 12006

E_{in} = 9.97 MEV

01/20/72

REACTION THK 9BE(D,N)10B

TARGET

85.7 mg cm⁻² THICK

RUN NO. 12006

E_{in} = 9.97 MeV

01/20/72

REACTION THK 9BE(D,N)10B

TARGET

85.7 mg cm⁻² THICK

RUN NO. 12006

E_n = 9.97MEV

01/20/72

REACTION THK 9BE(D,N)10B TARGET 85.7 mg cm⁻² THICK
 RUN NO. 12006 E_{in} = 9.97MEV 01/20/72

REACTION THK 9BE(D,N)10B

TARGET 101.3 mg cm⁻² THICK

RUN NO. 12001 E_{in} = 10.97MEV

01/20/72

REACTION THK 9BE(D,N)10B TARGET 101.3 mg cm⁻² THICK
 RUN NO. 12001 E_{in} = 10.97MEV 01/20/72

REACTION THK 9BE(D,N)10B TARGET 101.3 mg cm⁻² THICK
 RUN NO. 12001 E_{in} = 10.97MEV 01/20/72

REACTION THK 9BE(D,N)10B

TARGET 101.3 mg cm⁻² THICK

RUN NO. 12001 E_n = 10.97MEV

01/20/72

REACTION THK 9BE(D,N)10B

TARGET 101.3 mg cm⁻² THICK

RUN NO. 12001 E_{in} = 10.97MEV

01/20/72

REACTION THK 9BE(D,N)10B

TARGET 118.1 mg cm⁻² THICK

RUN NO. 12404 E_{in} = 11.99MEV

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 118.1 mg cm⁻² THICK

RUN NO. 12404 E_{in} = 11.99MEV

01/24/72

REACTION THK 9BE(D,N)10B TARGET 118.1 mg cm⁻² THICK
 RUN NO. 12404 E_{in} = 11.99MEV 01/24/72

REACTION THK 9BE(D,N)10B

TARGET 118.1 mg cm⁻² THICK

RUN NO. 12404 E_{in} = 11.99MEV

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 118.1 mg cm⁻² THICK

RUN NO. 12404

E_{in} = 11.99 MEV

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 155.2 mg cm⁻² THICK

RUN NO. 12410 E_{in} = 14.05 MEV

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 155.2 mg cm⁻² THICK

RUN NO. 12410

E_{in} = 14.05 MEV

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 155.2 mg cm⁻² THICK

RUN NO. 12410

E_{in} = 14.05 MEV

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 155.2 mg cm⁻² THICK

RUN NO. 12410 E_{in} = 14.05 MEV

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 155.2 mg cm⁻² THICK

RUN NO. 12410 E_{in} = 14.05 MEV

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 196.8 mg cm^{-2} THICK

RUN NO. 12413 $E_n = 16.07\text{MEV}$

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 196.8 mg cm⁻² THICK

RUN NO. 12413 E_{in} = 16.07 MEV

01/24/72

TARGET 196.8 mg cm⁻² THICK

01/24/72

REACTION THK 9BE(D,N)10B

TARGET 196.8 mg cm⁻² THICK

RUN NO. 12413 E_{in} = 16.07 MEV

01/24/72

REACTION THK 9BE(D,N)10B TARGET 196.8 mg cm⁻² THICK

RUN NO. 12413 E_{in} = 16.07MEV 01/24/72

REACTION THK 9BE(D,N)10B

TARGET 243.9 mg cm⁻² THICK

RUN NO. 12503 E_{in} = 18.09MEV

01/25/72

REACTION THK 9BE(D,N)10B

TARGET 243.9 mg cm⁻² THICK

RUN NO. 12503 E_{in} = 18.09 MEV

01/25/72

REACTION THK 9BE(D,N)10B

TARGET 243.9 mg cm⁻² THICK

RUN NO. 12503 E_{in} = 18.09 MEV

01/25/72

REACTION THK 9BE(D,N)10B

TARGET 243.9 mg cm⁻² THICK

RUN NO. 12503 E_{in} = 18.09MEV

01/25/72

REACTION THK 9BE(D,N)10B

TARGET 243.9 mg cm⁻² THICK

RUN NO. 12503 E_{in} = 18.09 MEV

01/25/72

REACTION THK 9BE(D,N)10B

TARGET 267.6 mg cm⁻² THICK

RUN NO. 60609

E_{in} = 19.00 MEV

06/06/72

REACTION THK 9BE(D,N)10B TARGET 267.6 mg cm⁻² THICK
 RUN NO. 60609 E_{in} = 19.00MEV 06/06/72

REACTION THK 9BE(D,N)10B

TARGET 267.6 mg cm⁻² THICK

RUN NO. 60609

E_{in} = 19.00MEV

06/06/72

REACTION THK 9BE(D,N)10B

TARGET 267.6 mg cm^{-2} THICK

RUN NO. 60609

$E_n = 19.00 \text{ MEV}$

06/06/72

REACTION THK 9BE(D,N)10B

TARGET 267.6 mg cm⁻² THICK

RUN NO. 60609 E_{in} = 19.00MEV

06/06/72

REACTION THK 9BE(D,N)10B

TARGET 267.6 mg cm⁻² THICK

RUN NO. 60610 E_{in} = 19.00MEV

06/06/72

REACTION THK 9BE(D,N)10B

TARGET 267.6 mg cm⁻² THICK

RUN NO. 60610

E_{in} = 19.00 MEV

06/06/72

REACTION THK 9BE (D,N)10B

TARGET 267.6 mg cm⁻² THICK

RUN NO. 60610 E_{in} = 19.00MEV

06/06/72

REACTION THK 9BE(D,N)10B TARGET 267.6 mg cm⁻² THICK
 RUN NO. 60610 E_{in} = 19.00MEV 06/06/72

REACTION THK 9BE(D,N)10B

TARGET 267.6 mg cm⁻² THICK

RUN NO. 60610 E_{in} = 19.00MEV

06/06/72

REACTION THK 9BE(D,N)10B

TARGET 293.4 mg cm⁻² THICK

RUN NO. 111605

E_{in} = 20.00MEV

11/16/72

REACTION THK 9BE(D,N)10B

TARGET 293.4 mg cm⁻² THICK

RUN NO. 111605 E_{in} = 20.00MEV

11/16/72

REACTION THK 9BE(D,N)10B TARGET 293.4 mg cm⁻² THICK
 RUN NO. 111605 E_{in} = 20.00MEV 11/16/72

REACTION THK 12C(D,N)13N

TARGET 110.8 mg cm⁻² THICK

RUN NO. 12402 E_{in} = 11.99 MeV

01/24/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$ TARGET 110.8 mg cm^{-2} THICK
 RUN NO. 12402 $E_{in} = 11.99\text{MEV}$ 01/24/72

REACTION THK 12C(D,N)13N

TARGET

110.8 mg cm⁻² THICK

RUN NO. 12402 E_{in} = 11.99 MEV

01/24/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$

TARGET 110.8 mg cm^{-2} THICK

RUN NO. 12402 $E_{\text{in}} = 11.99\text{MEV}$

01/24/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$

TARGET 110.8 mg cm^{-2} THICK

RUN NO. 12402 $E_{\text{in}} = 11.99 \text{ MeV}$

01/24/72

REACTION THK 12C(D,N)13N

TARGET 145.3 mg cm⁻² THICK

RUN NO. 12411 E_{in} = 14.05 MEV

01/24/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$

TARGET 145.3 mg cm^{-2} THICK

RUN NO. 12411 $E_{\text{in}} = 14.05\text{MEV}$

01/24/72

REACTION THK 12C(D,N)13N TARGET 145.3 mg cm⁻² THICK

RUN NO. 12411 E_{in} = 14.05 MEV 01/24/72

REACTION THK 12C(D,N)13N

TARGET 145.3 mg cm⁻² THICK

RUN NO. 12411 E_{in} = 14.05MEV

01/24/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$ TARGET 145.3 mg cm^{-2} THICK
 RUN NO. 12411 $E_{\text{in}} = 14.05\text{MEV}$ 01/24/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$

TARGET 183.8 mg cm^{-2} THICK

RUN NO. 12412 $E_{\text{in}} = 16.07\text{MEV}$

01/24/72

REACTION THK 12C(D,N)13N TARGET 183.8 mg cm⁻² THICK
 RUN NO. 12412 E_n = 16.07MEV 01/24/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$ TARGET 183.8 mg cm^{-2} THICK
 RUN NO. 12412 $E_{\text{in}} = 16.07\text{MEV}$ 01/24/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$

TARGET 183.8 mg cm^{-2} THICK

RUN NO. 12412 $E_{\text{in}} = 16.07\text{MEV}$

01/24/72

REACTION THK 12C(D,N)13N

TARGET 183.8 mg cm⁻² THICK

RUN NO. 12412 E_n = 16.07 MEV

01/24/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$ TARGET 227.9 mg cm^{-2} THICK

RUN NO. 12504 $E_n = 18.09\text{MEV}$ 01/25/72

REACTION THK 12C(D,N)13N

TARGET 227.9 mg cm⁻² THICK

RUN NO. 12504 E_{in} = 18.09 MEV

01/25/72

REACTION THK 12C(D,N)13N TARGET 227.9 mg cm⁻² THICK
 RUN NO. 12504 E_{in} = 18.09MEV 01/25/72

REACTION THK 12C(D,N)13N

TARGET 227.9 mg cm⁻² THICK

RUN NO. 12504

E_{in} = 18.09 MEV

01/25/72

REACTION THK $^{12}\text{C}(\text{D},\text{N})^{13}\text{N}$

TARGET 227.9 mg cm^{-2} THICK

RUN NO. 12504 $E_{\text{in}} = 18.09\text{MEV}$

01/25/72

REACTION D(D,N)³He

TARGET

1.7 mg cm⁻² THICK

RUN NO. 111708

E_{in} = 16.55 MEV

11/17/72

REACTION D(D,N)3HE

TARGET

1.7 mg cm⁻² THICK

RUN NO. 111708

E_{in} = 16.55 MEV

11/17/72

REACTION D(D,N)³He

TARGET

1.7 mg cm⁻² THICK

RUN NO. 111708

E_{in} = 16.55 MEV

11/17/72

REACTION D(D,N)3HE

TARGET

1.7 mg cm⁻² THICK

RUN NO. 111714

E_{in} = 18.58 MEV

11/17/72

REACTION D(D,N)3HE

TARGET

1.7 mg cm⁻² THICK

RUN NO. 111714

E_{in} = 18.58 MEV

11/17/72

REACTION D(D,N)³He

TARGET

1.7 mg cm⁻² THICK

RUN NO. 111714

E_{in} = 18.58 MEV

11/17/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 60809

E_n = 5.00MEV

06/08/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 60809

E_{in} = 5.00MEV

06/08/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 60809

E_{in} = 5.00MEV

06/08/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 60809

E_{in} = 5.00 MEV

06/08/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 60809

E_{in} = 5.00MEV

06/08/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12107

E_{in} = 6.97 MeV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12107

E_{in} = 6.97MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12107

E_{in} = 6.97 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12107

E_{in} = 6.97MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12107

E_{in} = 6.97 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12108

E_{in} = 8.03 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12108

E_{in} = 8.03MEV

01/21/72

REACTION THIN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12108

E_{in} = 8.03 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12108

E_{in} = 8.03 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12108

E_{in} = 8.03 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12114

E_{in} = 8.84 MeV

01/21/72

REACTION THN 9BE(D,N)10B TARGET 9.9 mg cm⁻² THICK
 RUN NO. 12114 E_{in} = 8.84MEV 01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12114

E_{in} = 8.84 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12114

E_{in} = 8.84 MeV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

9.9 mg cm⁻² THICK

RUN NO. 12114

E_{in} = 8.84 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12115

E_{in} = 9.97MEV

01/21/72

REACTION THN 9BE(D,N)10B TARGET 14.7 mg cm⁻² THICK
 RUN NO. 12115 E_{in} = 9.97MEV 01/21/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12115

E_{in} = 9.97 MeV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12115

E_{in} = 9.97 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12115

E_{in} = 9.97 MEV

01/21/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12607

E_{in} = 11.03 MEV

01/26/72

REACTION ${}^9\text{Be}(\text{D}, \text{N}){}^{10}\text{B}$

TARGET 14.7 mg cm^{-2} THICK

RUN NO. 12607 $E_{\text{in}} = 11.03 \text{ MeV}$

01/26/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12607

E_{in} = 11.03 MEV

01/26/72

REACTION THN 9BE(D,N)10B TARGET 14.7 mg cm⁻² THICK
 RUN NO. 12607 E_{in} = 11.03 MEV 01/26/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12607

E_{in} = 11.03 MEV

01/26/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12604

E_{in} = 12.04 MEV

01/26/72

REACTION THN 9BE(D,N)10B TARGET 14.7 mg cm⁻² THICK
 RUN NO. 12604 E_{in} = 12.04 MEV 01/26/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12604

E_{in} = 12.04 MEV

01/26/72

REACTION THN 9BE(D,N)10B TARGET 14.7 mg cm⁻² THICK
 RUN NO. 12604 E_n = 12.04MEV 01/26/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12604

E_{in} = 12.04 MEV

01/26/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12603

E_{in} = 13.04 MEV

01/26/72

REACTION THN 9BE(D,N)10B TARGET 14.7 mg cm⁻² THICK
 RUN NO. 12603 E_{in} = 13.04 MEV 01/26/72

REACTION THN 9BE(D,N) γ 0B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12603

E_{in} = 13.04 MEV

01/26/72

REACTION THN 9BE(D,N)10B

TARGET

14.7 mg cm⁻² THICK

RUN NO. 12603

E_{in} = 13.04 MEV

01/26/72

REACTION THN 9BE(D,N)10B TARGET 14.7 mg cm⁻² THICK
 RUN NO. 12603 E_{in} = 13.04 MEV 01/26/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12518

E_n = 14.05 MEV

01/25/72

REACTION THN 9BE(D,N)10B TARGET 19.2 mg cm⁻² THICK
 RUN NO. 12518 E_{in} = 14.05 MEV 01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12518

E_{in} = 14.05 MEV

01/25/72

REACTION THN 9BE(D,N)10B TARGET 19.2 mg cm⁻² THICK
 RUN NO. 12518 E_{in} = 14.05 MEV 01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12518

E_{in} = 14.05 MEV

01/25/72

REACTION THN 9BE(D,N)10B TARGET 19.2 mg cm⁻² THICK
 RUN NO. 12517 E_{in} = 15.06 MEV 01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12517 E_{in} = 15.06 MEV

01/25/72

REACTION THN 9BE(D,N)10B TARGET 19.2 mg cm⁻² THICK
 RUN NO. 12517 E_{in} = 15.06 MEV 01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12517 E_{in} = 15.06 MEV

01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12517 E_{in} = 15.06 MEV

01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12512

E_{in} = 16.07 MeV

01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12512

E_{in} = 16.07 MEV

01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12512 E_{in} = 16.07 MEV

01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12512

E_{in} = 16.07 MEV

01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12512 E_{in} = 16.07 MEV

01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12506

E_{in} = 18.09 MEV

01/25/72

REACTION THN 9BE(D,N)10B TARGET 19.2 mg cm⁻² THICK
 RUN NO. 12506 E_{in} = 18.09MEV 01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12506

E_{in} = 18.09 MEV

01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12506 E_{in} = 18.09 MEV

01/25/72

REACTION THN 9BE(D,N)10B

TARGET

19.2 mg cm⁻² THICK

RUN NO. 12506

E_{in} = 18.09 MEV

01/25/72