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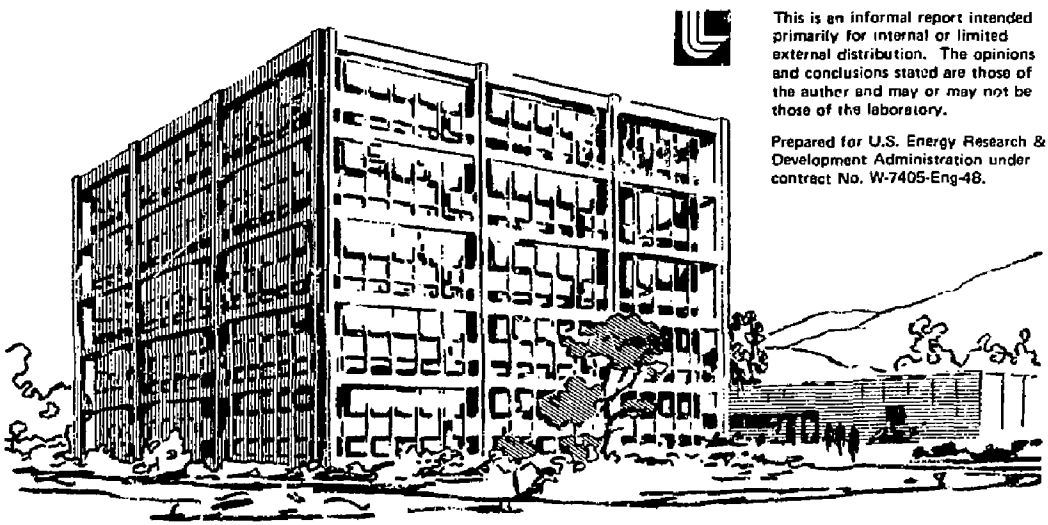
DT FUSION NEUTRON IRRADIATION OF BNL-LASL SUPERCONDUCTOR WIRES, LASL YAG, Al_2O_3 AND SPINEL, LASL-IIT MgO, YAG, Al_2O_3 AND SPINEL, AND NRL GeO_2 CRYSTALS-- DECEMBER 28, 1977

Susan C. MacLean

May 3, 1978



DT FUSION NEUTRON IRRADIATION OF BNL-LASL SUPERCONDUCTOR WIRES, LASL YAG, Al_2O_3 AND SPINEL, LASL-IIT MgO, YAG, Al_2O_3 AND SPINEL, AND NRL GeO_2 CRYSTALS*

Unclassified

December 28, 1977

Susan C. MacLean

ABSTRACT

The DT fusion neutron irradiation of eleven BNL-LAST superconductor wires, six NRL GeO_2 crystals, two YAG, two Spinel and two Al_2O_3 crystals for LASL and four LASL high purity single crystals of MgO, YAG, Spinel and Al_2O_3 is described. The sample position, beam-on time, and neutron dose record are given. The maximum fluence on any sample was 1.51×10^{16} neutrons/cm^2.

*"Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore Laboratory under contract number W-7405-ENG-48."

October 26, 1977 was reserved at the LLL Rotating Target Neutron Source (RTNS) to finish the fluence accumulation on several samples and to continue the accumulation on others.

Eleven superconductor wires from Dr. Don M. Parkin of Los Alamos Scientific Laboratory (LASL) and Dr. C. L. Snead, Jr. of Brookhaven National Laboratory (BNL) were being repeatedly irradiated to reach a fluence of 10^{18} neutrons/cm^2. The wires (19 to 28 mm long) were put in a single layer and wrapped in aluminum foil. This package had been irradiated July 26-29, 1976, September 27 through October 1, 1976, November 17 through December 2, 1976, January 3-7, 1977, January 17-21, 1977, March 14-15, 1977, August 15-19, 1977, and August 30, 1977. Nine of the wires (3 Nb_3Sn single core, 3 V_3Ga single core, 2 NbTi Supercon 402, and 1 NbTi cupronickel jacketed) had received 8×10^{17} neutrons/cm^2 from RTNS irradiations prior to the present accumulation. The remaining two wires (19-core Nb_3Sn multifilament) had received 1.8×10^{18} neutrons/cm^2 from previous RTNS irradiations. The superconductor wire sample package was sandwiched between two niobium dosimetry foils, 12 mm in diameter and 0.03 mm thick.

Dr. James M. Bunch of LASL supplied six large (20 × 10 × 5 mm each) crystal samples individually wrapped in aluminum foil and labeled. There were two samples sets, each containing Al_2O_3, Spinel, and YAG. He requested a fluence of 3×10^{16} neutrons/cm^2 on the first set of crystals and 3×10^{15} neutrons/cm^2 on the second sample set. The samples had been irradiated August 30, 1977 and received part of the desired dose.

Dr. Bruce D. Evans of the Naval Research Laboratory (NRL) sent six five 9's crystalline, tetragonal GeO_2 samples to receive RTNS irradiation. The crystals were irregular in shape and ranged in size from about one to five mm on a side. Dr. Evans requested that the two largest crystals be put on the top forward edge of the center crystal in the LASL front sample set. The four smallest crystals were to go in the same position on the second LASL sample set.

Four high purity single crystal samples had been received from Dr. George F. Hurley of LASL and Dr. Harold Weinstock of Illinois Institute of Technology (IIT). The samples, YAG, Spinel, Al_2O_3 and MgO, all measured approximately 4 × 4 × 4 mm. Each was individually wrapped in aluminum foil and labeled on one side. The desired fluence of 10^{17} neutrons/cm^2 was being accumulated half with the labeled faces of the crystals toward the neutron source and half with the opposite crystal faces toward the source. The

samples had been irradiated October 11-15, 1976, November 17-24, 1976, January 17-21, 1977, and August 30, 1977. The crystals were each sandwiched between niobium dosimetry foils measuring approximately 4 × 4 × 0.14 mm. The labeled sides of the YAG and Al_2O_3 samples were toward the source. The labeled sides of the Spinel and MgO crystals were away from the source. These samples were arranged in a square pattern on the back center of the first LASL crystal set.

Figure I illustrates the sample and dosimetry foil arrangement. The niobium dosimetry foils on the large LASL crystals were approximately 6 × 10 × 0.14 mm. Three dosimetry foils were put on the front and three on the back of each large crystal. The crystals were arranged with the numbers or their labels up or toward the ceiling. The dosimetry foils are listed from the top down.

First Sample Holder:

Nb-956

Superconductor Wires

Nb-957

Two large GeO_2 crystals

Nb-958	Nb-970	Nb-964
Nb-959	Nb-971	Nb-965
Nb-960	Nb-972	Nb-966
Yag-1	Al-1	Sp-1
Label to back	Label forward	Label to back
Nb-967	Ng-961	Nb-973
Nb-968	Nb-962	Nb-974
Nb-969	Nb-963	Nb-975

Nb-976	Nb-977
Spinel	MgO
Label to back	Label to back
Nb-980	Nb-981
Nb-978	Nb-979
YAG	Al_2O_3
Label forward	Label forward
Nb-982	Nb-983

Second Sample Holder: Front edge 26 mm behind front edge of first sample holder.

	Four small GeO_2 crystals	
Nb-984	Nb-987	Nb-990
Nb-985	Nb-988	Nb-991
Nb-986	Nb-989	Nb-992
YAG-2	Al-2	Sp-2
Label to back	Label to back	Label to back
Nb-993	Nb-996	Nb-999
Nb-994	Nb-997	Nb-1000
Nb-995	Nb-998	Nb-1001

The neutron irradiation was carried out by the E Division Accelerator Staff on October 20, 1977. Neutron production was monitored continuously with a proton recoil counter and recorded each hour. The dose record is attached. Beam-on time was 13.8 hours.

Following the irradiation, the sample holders were stored for a few days to allow for decay of short-lived isotopes. The dosimetry foils were then delivered to Ruth Anderson in the LLL Nuclear Chemistry Division for gamma ray counting. The GeO_2 crystals and the large YAG, Spinel and Al_2O_3 crystals were sent to Dr. Evans at NRL. The high purity single crystals were returned to Dr. Hurley at LASL. The superconductor wires were retained for further irradiation.

The average fluence on each dosimetry foil was calculated using the method described in UCRL-51393, Rev. 1. However, the cross section used for the activation of the 10.16 day isomer of niobium by 14.8 MeV neutrons was changed to 463 millibarns (UCRL-80097). The results were as follows:

Dosimetry Foil	Fluence (neutrons/cm^2)
Nb-956	1.51×10^{16}
Nb-957	1.30×10^{16}
Nb-958	5.48×10^{15}
Nb-959	8.76×10^{15}
Nb-960	6.97×10^{15}
Nb-961	3.75×10^{15}

Dosimetry Foil	Fluence (neutrons/cm^2)
Nb-962	5.02×10^{15}
Nb-963	4.33×10^{15}
Nb-964	3.07×10^{15}
Nb-965	4.24×10^{15}
Nb-966	3.78×10^{15}
Nb-967	3.01×10^{15}
Nb-968	3.80×10^{15}
Nb-969	3.46×10^{15}
Nb-970	7.68×10^{15}
Nb-971	1.34×10^{16}
Nb-972	1.01×10^{16}
Nb-973	2.16×10^{15}
Nb-974	2.55×10^{15}
Nb-975	2.42×10^{15}
Nb-976	4.14×10^{15}
Nb-977	4.76×10^{15}
Nb-978	4.45×10^{15}
Nb-979	5.13×10^{15}
Nb-980	2.70×10^{15}
Nb-981	2.73×10^{15}
Nb-982	2.72×10^{15}
Nb-983	2.99×10^{15}
Nb-984	6.84×10^{14}
Nb-985	7.13×10^{14}
Nb-986	6.88×10^{14}
Nb-987	6.99×10^{14}
Nb-988	7.39×10^{14}
Nb-989	7.19×10^{14}
Nb-990	6.16×10^{14}
Nb-991	6.41×10^{14}
Nb-992	6.29×10^{14}
Nb-993	4.99×10^{14}
Nb-994	5.16×10^{14}
Nb-995	5.05×10^{14}
Nb-996	5.06×10^{14}
Nb-997	5.24×10^{14}

Dosimetry Foil	Fluence (neutrons/cm^2)
Nb-998	5.04×10^{14}
Nb-999	4.44×10^{14}
Nb-1000	4.65×10^{14}
Nb-1001	4.52×10^{14}

The estimated overall uncertainty of these results is $\pm$ 7.5%. The relative uncertainty between any two values is about $\pm$ 2%. The fluences given here represent average fluences over the volume of each dosimetry foil.

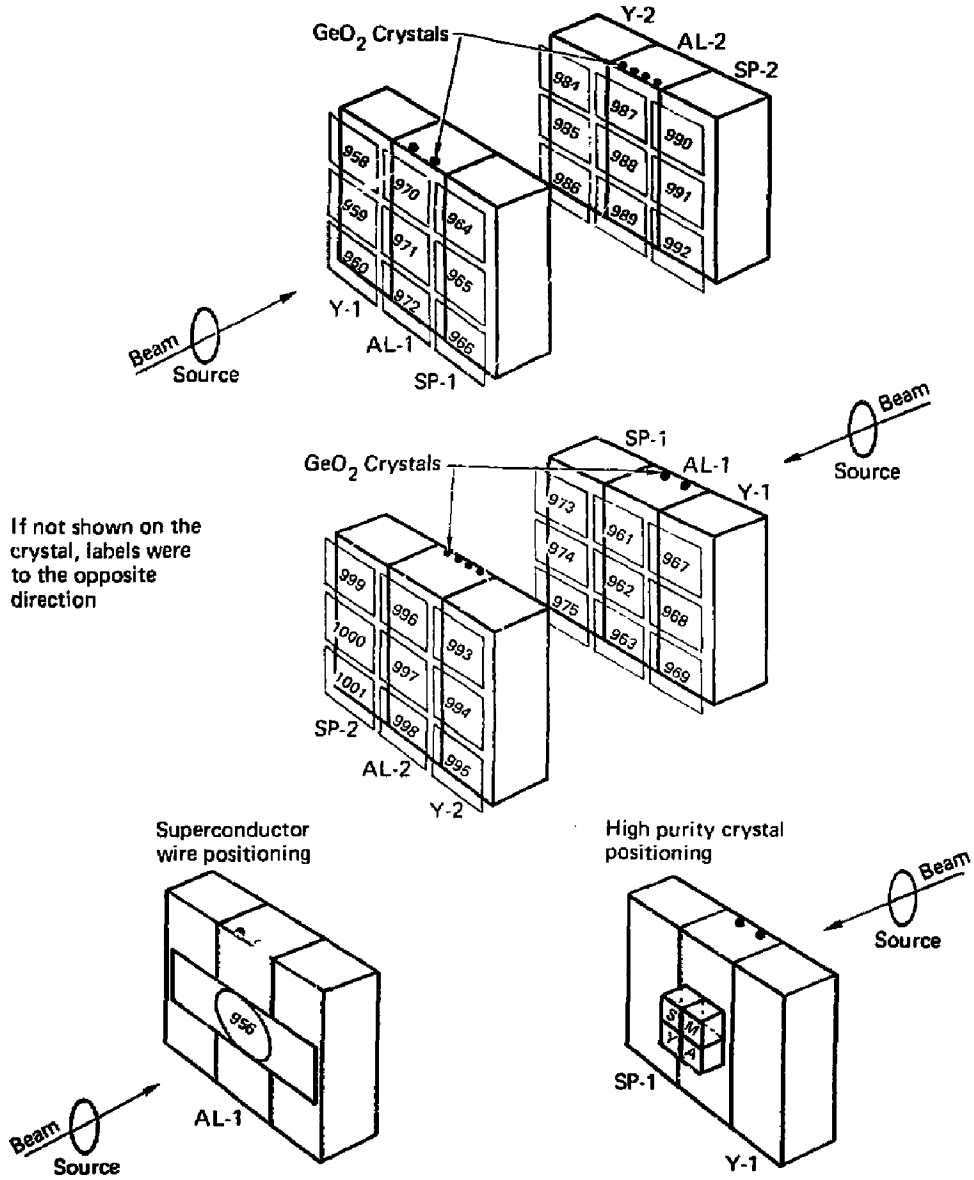

GeO_2 Crystals
Y-2
AL-2
SP-2
984
987
990
985
988
991
986
989
992
958
970
964
959
971
965
960
972
966
Y-1
AL-1
SP-1
Beam
Source
GeO_2 Crystals
SP-1
AL-1
Y-1
973
961
967
974
962
968
975
963
969
999
996
993
1000
997
994
1001
998
995
SP-2
AL-2
Y-2
Beam
Source
If not shown on the crystal, labels were to the opposite direction
Superconductor wire positioning
956
AL-1
Beam
Source
High purity crystal positioning
S
M
Y
A
SP-1
Y-1
Beam
Source

FIGURE I

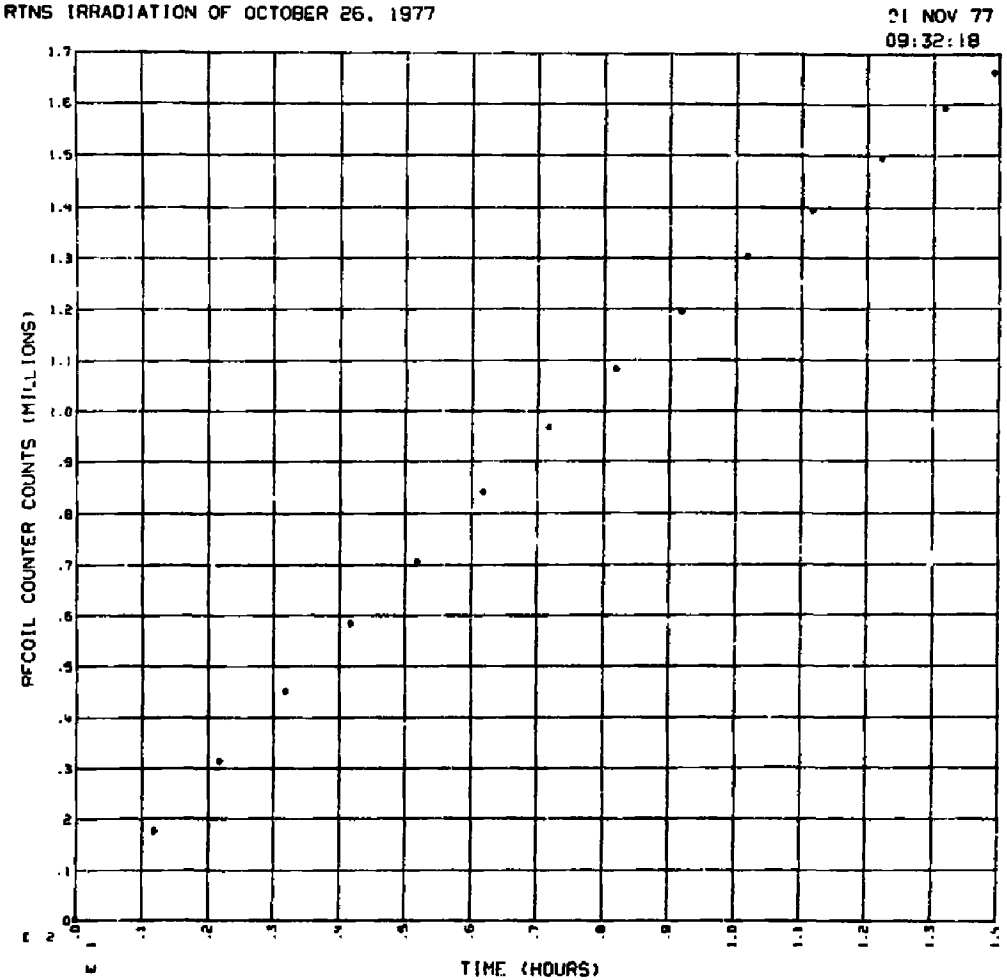

RTNS IRRADIATION OF OCTOBER 26, 1977
21 NOV 77
09:32:18
RFCOIL COUNTER COUNTS (MILLIONS)
TIME (HOURS)

FIGURE II

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