Data Release:

Ionization yield measurement in a germanium CDMSlite detector using photo-neutron sources

SuperCDMS Collaboration[1]

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Files included in this package:

- *Fig1_YieldDataPoints_Literature.txt.*
- *Fig1_YieldModel_Literature.txt.*
- *Fig2_5Tower.png.*
- *Fig2_ExperimentalSetup.png.*
- *Fig3_CutEfficiencies.txt.*
- *Fig4_Simulated_NeutronDistributions.txt.*
- *Fig5_NeutronXsecs_Realizations.txt.*
- *Fig6_Bkgs.txt.*
- *Fig7_NeutronONDistribution.txt.*
- *Fig8_Result.txt*
- *PN_DataRelease_Readme.pdf.*

The SuperCDMS collaboration practices sharing data on the work it publishes, in the form of data release packages. The data release packages are available as supplementary material on the relevant arXiv article, as well as on the SuperCDMS Collaboration website. This document concerns research published in the paper titled "Ionization yield measurement in a germanium CDMSlite detector using photo-neutron sources" and gives information on: (i) what files exist in this data release package, and (ii) how information can be extracted from the files provided. This data release package has eight text files, two image files and one pdf file, as listed in the box alongside. The sections in this "read me" document are created such that each section elaborates on a particular figure from the published research article, and provides information on how to read the text file(s) to recreate them. All text files provided can be opened with any text editor, and also using softwares like libre office calc, microsoft excel, google sheets, etc. They are essentially csv files with a tabular space used as the delimiter. For any additional figures or information on this research work, please check the public documentation page by SuperCDMS on its website.

1 Figure 1: Yield measurements from literature

The first figure of the paper shows the various ionization yield measurements made with Germanium. Some measurements are discrete while others are in the form of a yield models. To reproduce this result, use the text files with prefix "Fig1". The text files have multiple columns with a repetitive pattern as described in Table 1.

Table 1: Column descriptions for the text files to make figure 1 of the paper. The columns in the file for discrete yield data points are listed in the second column of the table below, while the columns of the continuous yield models are listed in the third column of the table below. Here "N/A" means not applicable.

Column	Discrete Measurements	Model	Description
col1	X_*expt*	X_*expt*	True recoil energy in keV
col2	Y_*expt*	Y_*expt*	Ionization yield
col3	ErrorX_*expt*	N/A	Error in recoil energy in keV
col4	ErrorY_*expt*	N/A	Error in ionization yield

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The file "Fig1_YieldDataPoints_Literature.txt" consists information of only discrete yield data points. It has information from 13 experimental measurements. Each measurement has 4 parameters as shown in Table 1. The file has a total of 52 columns. The header of each column indicates which experimental measurement (eg. Simon, Baudis, etc.) it belongs to. The term "*expt*" in Table 1 is a placeholder for the actual experiment's name described in the column header of the text file. Additionally, in the text file, "IF" in the header *CollarIF* stands for Iron filter, and "TN" in the header *CollarTN* stands for thermal neutrons.

The file "Fig1_YieldModel_Literature.txt" has measurements that are in the form of yield models. It has 4 measurements contained as shown in Table 1. Each measurement occupies 2 columns for its X and Y co-ordinate values. The file also has 1σ upper, and 1σ lower limits of the model provided by Scholz, and Collar. Thus the text file has a total of 16 columns.

2 Figure 2: Experimental Setup

The two image files titled "Fig2_5Tower.png" and "Fig2_ExperimentalSetup.png" have been provided. The file "Fig2_ExperimentalSetup.png" is made with GEANT4, while "Fig2_5Tower.png" comes from technical design renditions used for the SuperCDMS Soudan experiment.

3 Figure 3: Cut efficiencies

Table 2: Column descriptions for the text file to reproduce figure 3 of the paper.

Column	Quantity	Description
col1	X_*dataset*	Total phonon energy in keV
col2	Y_*dataset*	Cut efficiency
col3	ErrorX_*dataset*	Uncertainty in total phonon energy in keV
col4	ErrorY_*dataset*	1-σ Uncertainty in cut efficiency

The file "Fig3_CutEfficiencies.txt" contains the necessary information to reproduce the analysis cut efficiencies of all the data sets. The neutron-ON data sets will have a "Be" label after the gamma source (eg. SbBe), while the neutron-OFF data sets will only have the gamma source in the title (eg. Sb). The file has 4 columns for each data set, totaling to 24 columns for all the 6 data sets combined. The information contained in each of the columns have been described Table 2. Here "*dataset*" can be any of the neutron-ON or neutron-OFF data sets. The column headers within the text files define the data set.

4 Figure 4: Simulated neutron energy distributions

For figure 4 of the paper, use the file "Fig4_Simulated_ NeutronDistributions.txt". The file has 5 columns for each of the two data sets (i.e. Sb and Y), adding up to a total of 10 column. The information of each of the five columns are described in Table 3. The words "*source*" in the table is a placeholder for the relevant data set i.e. Sb or Y. In the description and column headers, "NR" is nuclear recoil, "ER" is electron recoil. For the Sb source, the bin width is 0.05 keV, and for the Y source it is 0.1 keV. In the paper, the figure has been plotted to a range of 0 to 5 keV for Sb, and 0 to 15 keV for Y.

Table 3: Column descriptions for the text file to reproduce figure 4 of the paper.

Column	Quantity	Description
col1	X_*source*	True recoil energy in keV
col2	Y_*source*ER	Counts of ERs
col3	Y_*source*NRsingle	Counts of single scatter neutrons for a NR
col4	Y_*source*NRmultiple	Counts of multiple scatter neutrons for a NR
col5	Y_*source*All	Counts of all NRs and ERs

5 Figure 5: Neutron-nucleus cross sections

Table 4: Column descriptions for the text file to reproduce figure 5 of the paper.

Column	Quantity	Description
col1	X_*realization*	Neutron energy in keV
col2	Y_*realization*	Cross section in barn

Use the file named "Fig5_NeutronXsecs_Realizations.txt" to produce figure 5 of the published article. There are 3 examples of realisations for the neutron-nucleus cross sections as a function of neutron energy. The cross section and neutron energies of each realisation is listed in the text file, adding up to a total of 6 columns. The term "*realization*" in the table is a placeholder for any of the three realizations. The column header will specifies the example number of the realization (i.e. realization1, realization2, or realization3). Table 4 provides information on each column in the text file for a given realization.

6 Figure 6: Neutron-OFF energy distributions

To reproduce the neurton-OFF data, and the individual and combined background models, use the file "Fig6_Bkgs.txt". There are 8 columns for each of the data sets (i.e. Sb at 70 V, Y at 70 V, and Y at 25 V) as described in Table 5. The "*source*" in Table 5 can be replaced by a given data set. The text file has a total of 24 columns for the 3 data sets combined.

Table 5: Column descriptions for the text file to reproduce figure 6 of the paper.

Column	Quantity	Description
col1	X_*source*	Total phonon energy of the experiment data in keV
col2	Y_*source*	Counts of experiment data
col3	ErrorX_*source*	Error in total phonon energy in keV
col4	ErrorY_*source*	Error in counts
col5	X_*source*model	Total phonon energy of the model data in keV
col6	Y_*source*Compton	Counts of model data
col7	Y_*source*EC	Counts of model data
col8	Y_*source*Bkgmodel	Counts of model data

7 Figure 7: Neutron-ON energy distributions

Table 6: Column descriptions for the text file to reproduce figure 7 of the paper.

Column	Quantity	Description
col1	X_*source*	Total phonon energy of the experiment data in keV
col2	Y_*source*	Counts of experiment data
col3	ErrorX_*source*	Error in total phonon energy in keV
col4	ErrorY_*source*	Error in counts
col5	X_*source*fit	Total phonon energy of the likelihood fit result in keV
col6	Y_*source*fit	Counts of likelihood fit result
col7	ErrorX_*source*fit	Error in the total phonon energy in fit result in keV
col8	ErrorY_*source*fit	Error in counts of likelihood fir result
col9	X_*source*bkg	Total phonon energy of background model in keV
col10	Y_*source*bkg	Counts of background model

To draw the neutron-ON data, the best likelihood fit result of the modified Lindhard function described in the paper, and the final background model, use the file "Fig7_NeutronON Distribution.txt". The file contains 30 columns. Each data set (i.e. Sb at 70 V, Y at 70 V, and Y at 25 V) has 10 columns dedicated to it. Table 6 describes what information is stored in each of these 10 columns for a given data set. The term "*source*" is a placeholder for the data set in the description provided in table 6. The column header in the text file has the appropriate data set labelled.

8 Figure 8: Results

The result comprises of the yield curve, and its uncertainties. The uncertainties are not symmetric hence their upper, and lower limits are different. The uncertainties are also split into multiple components. The information to reproduce the result can be found in the file "Fig8_Result.txt". Table 7 gives the information one can extract from each of the columns in the text file. The file has a total of 13 columns. Columns 1 and 7 are the same quantity. In the paper, the results have been compared with the standard Lindhard model. Information on the plotting the Lindhard model can be found in the text file given for figure 1.

Table 7: Column descriptions for the text file to reproduce figure 8 of the paper.

Column	Quantity	Description
col1	X_Result	True recoil energy in keV
col2	Y_Result	Ionization yield
col3	ErrorXhigh_Result	Upper limit on Uncertainty in recoil energy in keV
col4	ErrorXlow_Result	Lower limit on Uncertainty in recoil energy in keV
col5	ErrorYhigh_Result	Upper limit on Uncertainty in yield
col6	ErrorYlow_Result	Lower limit on Uncertainty in yield
col7	X_Uncertainty	True recoil energy in keV
col8	Y_ExpStat	Uncertainty in experimental statistics
col9	Y_SimStat	Uncertainty in simulation statistics
col10	Y_BkgSys	Uncertainty in background systematics
col11	Y_CutEffSys	Uncertainty in analysis cut efficiencies
col12	Y_FanoSys	Uncertainty in Fano factor systematics
col13	Y_NeutronXsecSys	Uncertainty in neutron-nucleus cross sections