



ORAU TEAM Dose Reconstruction Project for NIOSH

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C-123	SRS Non(CTW/Reactor) tritium dose 1984	450
C-124	SRS tritium dose 1984	451
C-125	SRS tritium dose 1985	452
C-126	SRS CTW/Reactor tritium dose 1985	453
C-127	SRS Non(CTW/Reactor) tritium dose 1985	454
C-128	SRS tritium dose 1985	455
C-129	SRS tritium dose 1986	456
C-130	SRS CTW/Reactor tritium dose 1986	457
C-131	SRS Non(CTW/Reactor) tritium dose 1986	458
C-132	SRS tritium dose 1986	459
C-133	SRS tritium dose 1987	460
C-134	SRS CTW/Reactor tritium dose 1987	461
C-135	SRS Non(CTW/Reactor) tritium dose 1987	462
C-136	SRS tritium dose 1987	463
C-137	SRS tritium dose 1988	464
C-138	SRS CTW/Reactor tritium dose 1988	465
C-139	SRS Non(CTW/Reactor) tritium dose 1988	466
C-140	SRS tritium dose 1988	467
C-141	SRS tritium dose 1989	468
C-142	SRS CTW/Reactor tritium dose 1989	469
C-143	SRS Non(CTW/Reactor) tritium dose 1989	470
C-144	SRS tritium dose 1989	471
C-145	SRS tritium dose 1990	472
C-146	SRS CTW/Reactor tritium dose 1990	473
C-147	SRS Non(CTW/Reactor) tritium dose 1990	474
C-148	SRS tritium dose 1990	475

ACRONYMS AND ABBREVIATIONS

CED	committed effective dose
CS	complete sample
CTW	construction trade worker
ECDF	empirical cumulative distribution functions
GM	geometric mean
GSD	geometric standard deviation
HTO	tritiated water
mrem	millirem
N	total number of individuals in CS
n	total number of individuals in CTW or NCTW group
NCTW	non- construction trade worker
NIOSH	National Institute for Occupational Safety and Health
NOCTS	NIOSH-OCAS Claims Tracking System
OCAS	Office of Compensation Analysis and Support
CTW/Reactor	Reactor Construction Trade Workers
R2	coefficient of determination for regression line
SRS	Savannah River Site

1.0 INTRODUCTION

In Part 1 of this report (ORAUT 2010), the tritiated water coworker model derived from a particular stratum, the Savannah River Site (SRS) construction trade workers (CTWs) for example, was compared to the coworker model derived from the complete sample of SRS workers monitored for intakes of tritiated water (HTO). The comparison of the stratum with the complete sample was performed because we were trying to decide if there was a significant advantage to the use of a stratified coworker model versus an unstratified coworker model for the CTW.

The CTW stratum is a subset of the complete sample, which means that the CTW dataset is not independent of the complete sample. This limits the statistical tests that can be performed to compare the CTW stratum to the complete sample because most statistical tests assume independence. The Monte Carlo permutation test used in Part 1 of this report (ORAUT 2010) is valid under the stated conditions, one of which is that independence of the stratum and complete sample is not required.

Once a stratified coworker model is created, the comparison of the various strata with each other could be of interest. For example, one might want to compare the CTW stratum to the stratum composed of all other workers to see if there is a significant difference in the distribution of doses received by workers in two strata. In this case, a number of other statistical tests, such as the Kuiper Test (Kuiper 1960), are available in addition to the Monte Carlo permutation test because two separate strata are independent of each other.

In this document (Part 2 of the report *Discussion of Tritium Workers at the Savannah River Site*), the following comparisons of strata are made using the Monte Carlo permutation test and the Kuiper Test (Kuiper 1960):

- Comparison of CTWs with all other workers (non-CTWs or NCTWs)
- Comparison of reactor workers with all other workers (nonreactor workers)
- Comparison of workers who were both CTW and reactor workers with all other workers

The general discussion of the Monte Carlo permutation test and concepts of drawing stratified samples in Part 1 of this report (ORAUT 2010) will be omitted in this part.

2.0 COMPARISON OF CTW AND NCTW STRATA

The coworker model for 1954 is shown in Figure 1. For 1954, the GM and GSD of all workers who were exposed to HTO (the population) are estimated from the GM and GSD of a random sample of 122 workers who were exposed to HTO and monitored for HTO (the NOCTS dataset) in 1954. Workers who were not monitored in 1954 (but perhaps should have been) are assumed to be random samples from a population of workers for whom the estimated GM and GSD are 7.79 mrem and 2.19, respectively.

2.1 SIGNIFICANCE OF STRATA

Assume the population of all workers exposed to HTO can be meaningfully divided into CTW and NCTW strata. The simple random sample of monitored workers who were monitored in 1954 was poststratified¹ into CTWs and NCTWs. The coworker models constructed for each of these strata are shown in Figures 2 and 3, respectively. A summary of the statistics for the coworker model constructed from the complete sample (CS) and the coworker models constructed from the CTW and NCTW strata is shown in Table 1.

¹ Assigned to the appropriate stratum after the sample is collected.

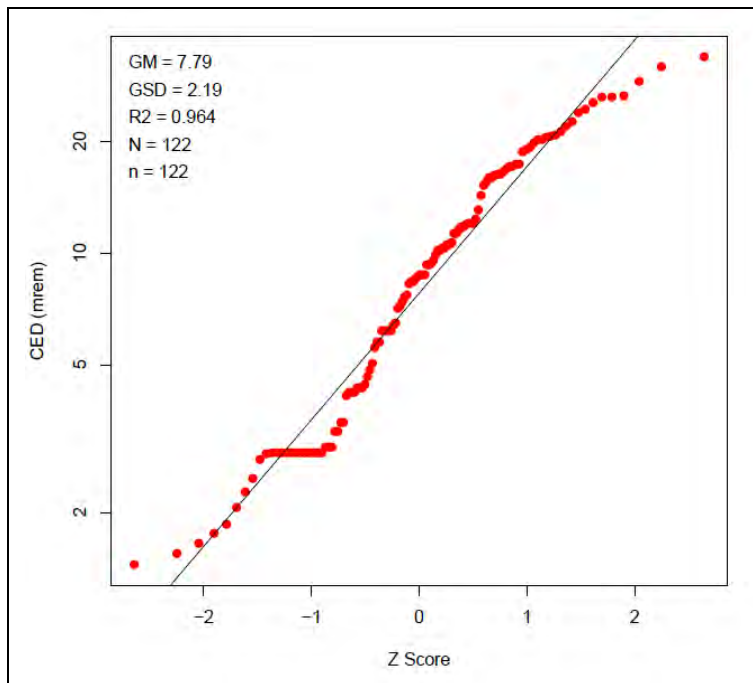


Figure 1. Tritium doses for all monitored workers in 1954.

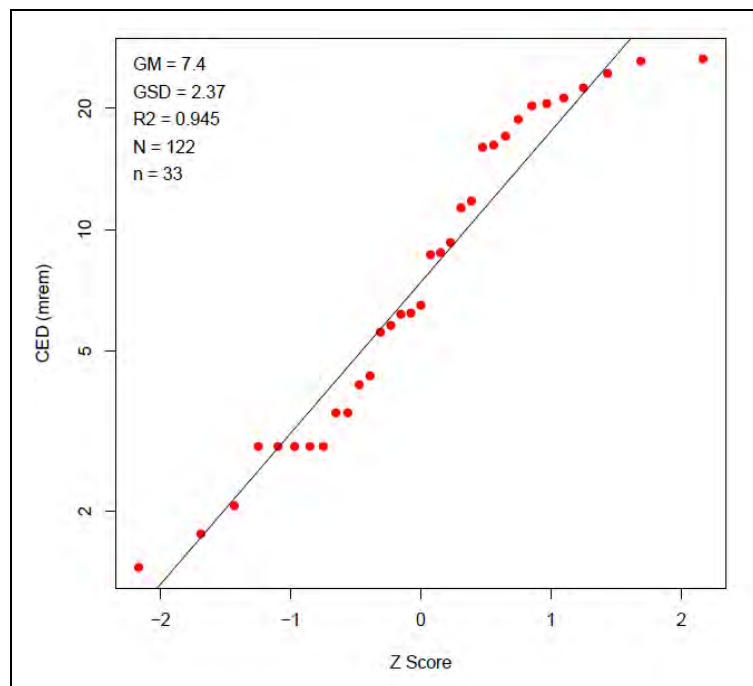


Figure 2. Tritium doses for monitored CTW in 1954.

We are interested in deciding if it is of value to stratify the HTO dose data in 1954, as suggested above. Part of this decision is based on if there is a statistically significant difference in the coworker models constructed from stratified doses. The two tests discussed below are designed to answer the question of statistical significance. However, even if there is a statistically significant difference in the coworker models, the difference might not be of practical significance.

Two different statistical tests will be used to check if there is a statistically significant difference in the coworker models constructed from stratified doses. The first test (Test A) is the same type of Monte

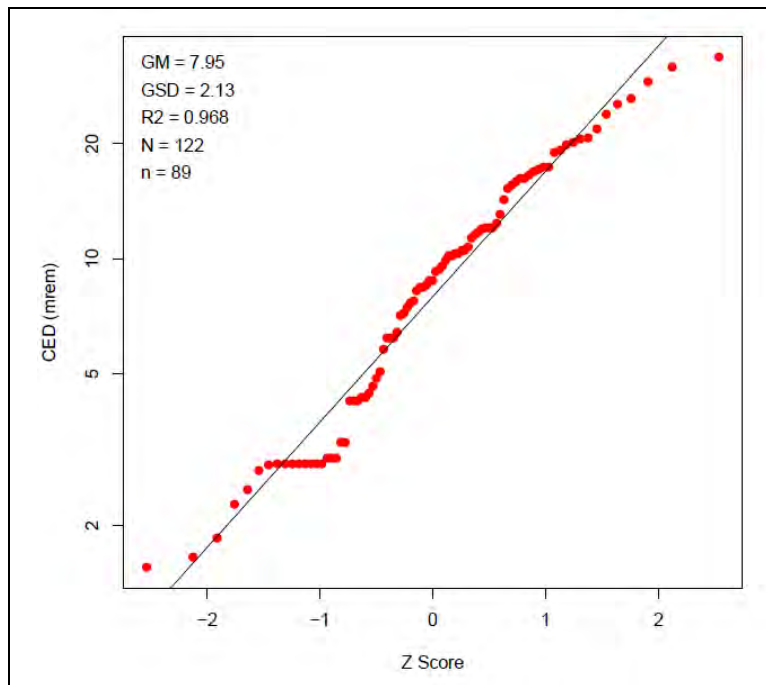


Figure 3. Tritium doses for monitored NCTW in 1954.

Table 1. Statistics for three coworker models in 1954. N is the number of workers.

	N	GM (mrem)	GSD
CS	122	7.79	2.19
CTW	33	7.40	2.37
NCTW	89	7.95	2.13

Carlo permutation test used in Part 1 of this report (ORAUT 2010). Test A is applied to the parameters obtained after fitting a separate lognormal distribution to the doses in each stratum. The second test (Test B) is the Kuiper Test (Kuiper 1960), which is a nonparametric test. Test B compares the empirical distribution functions of the doses for the two strata, without making an assumption about the distribution of the doses in each stratum.

2.1.1 Statement of Test A

Null Hypothesis H_0 :

The distribution of the doses is the same across the classification variable (CTW versus NCTW). In other words, the coworker model derived from the CTW stratum is not significantly different from the coworker model derived from the NCTW stratum.

Alternate Hypothesis H_A :

Opposite of H_0 .

Test statistic

The coworker model for HTO consists of the GM and GSD of the lognormal fit to the ordered doses for a given year. The test statistics used here are the differences between the GM and GSD from the CTW and NCTW models:

$$\Delta_{gm} = GM_{CTW} - GM_{NCTW}$$

$$\Delta_{gsd} = GSD_{CTW} - GSD_{NCTW}$$

The joint distribution of the Δ_{gm} and Δ_{gsd} under the null hypothesis is calculated using a Monte Carlo permutation test that looks at a large number of fits of 33 doses (the number of CTW workers) and 89 doses (the number of NCTW workers) taken at random from the 122 doses (the number of all monitored workers).

Rejection Region

The Δ_{gm} and Δ_{gsd} pair represents X and Y coordinates of a point on a scatter plot. The simulation consists of 10,000 such points with a 95% bivariate normal confidence ellipse constructed around the points. If the point defined by the observed Δ_{gm} and Δ_{gsd} falls outside the 95% confidence ellipse, the null hypothesis is rejected.

Conclusion

If the null hypothesis is not rejected at $\alpha = 0.05$, there is nothing here to make us believe that the coworker models from the two strata will be significantly different.

Discussion

The GM and GSD of the CTW sample in 1954 is taken to be the best estimate of the GM and GSD of all monitored CTWs in 1954, and an equivalent statement can be made for the NCTW sample. Thus, the question here is: Are the GMs and GSDs of these two samples statistically different and, if so, is the difference of practical significance?

To compare the two parameter estimates (GM and GSD) simultaneously between the CTW and NCTW samples, a Monte Carlo permutation test is used. This is the same test used in Part 1 of this report (ORAUT 2010) and is discussed in Noreen (1989, pp. 9-19), Sheskin (2007, p. 527), and Manly (2007, Chapter 1).

To explain the permutation test, doses for 1954 will be used as an example.

There are $n = 122$ doses for 1954, from which $k = 33$ doses correspond to the CTW stratum, and $n - k = 89$ doses correspond to the NCTW stratum. There are:

$$C = \frac{122!}{33!(122-33)!} = 6.889 \cdot 10^{29}$$

equally probable ways of assigning 33 different doses from a population of 122 doses to the first stratum and 89 doses to the second stratum. Each of these C combinations of 33 doses for the first stratum and 89 doses for the second stratum can potentially have its own unique test statistics. Note that only one of these allocations was actually observed. In theory, the test statistics for each of the C combinations could be calculated, and the ranges where most (95%, for example) of the test statistics occurred could be established. The observed test statistics would be considered to be not significantly different than zero if they fell in the range where 95% of the results would be observed.

While theoretically possible, the calculations above are not feasible because of the immense number of all possible assignments of samples of size $k = 33$ and size $n - k = 89$ that can be drawn from the whole dataset. However, the 95% range can be estimated using the following Monte Carlo technique

(Noreen 1989, pp. 9-19), which looks at a large number of random draws taken from the C different combinations:

1. Assume that for a specified year, there are n doses altogether, from which k doses are in the CTW stratum (where $k < n$), and the remaining $n - k$ doses are in the NCTW stratum.
2. Calculate the slope and intercept of the lognormal fit to the doses for the observed CTW stratum and for the observed NCTW stratum. Calculate the differences in GM and GSD, and plot the point defined by them.
3. From all the n doses for the specified year, randomly assign k doses to the CTW stratum, and the remaining $n - k$ doses to the NCTW stratum. Fit a lognormal model to the k doses, fit a separate lognormal model to the $n - k$ doses, calculate the differences in GM and GSD, and plot the point defined by them.
4. Repeat step 3 m times (e.g., $m = 10,000$ times). Note that each time the experiment is run a new² set of k doses and $n - k$ doses are allocated to the two strata, respectively, and new differences are calculated and plotted.
5. Calculate a 95% joint confidence ellipse of all m test statistics.
6. Repeat this procedure for each year.

This is a fairly straightforward test, the main technical challenge being to identify an area on the plot in which a large proportion of the points, 95% for example, can be found. If the observed GM and GSD differences fall within this 95% confidence area, the two coworker models are considered to not be statistically different³. On the other hand, if the observed differences fall outside the 95% confidence area, the two coworker models are considered to be statistically different.

Two different methods were used to generate the 95% confidence area. The first method assumes that Δ_{gm} and Δ_{gsd} are drawn from a bivariate normal distribution (probably a reasonable assumption) and generates a confidence ellipse based on this model (Fox 2007, p. 203; Monette 1990). For 1954, one can conclude that there is no reason to believe at the 95% confidence level that the coworker models constructed from the CTW and the NCTW strata are different (see Figure 4a).

The second method uses a bagplot (Rousseeuw, Ruts, and Tukey 1999), which is a nonparametric method that generates a polygon that contains a given fraction of the observed differences. The area defined by the 95% confidence ellipse was in general not distinguishable from the ~95% area defined by the bagplot, so the less computationally intensive confidence ellipse is used here in place of the bagplot (see Figure 4b).

2.1.2 Statement of Test B

Null Hypothesis H_0 :

The distribution of the doses is the same across the classification variable (CTW versus NCTW). In other words, the coworker model derived from the CTW stratum is not significantly different than the coworker model derived the NCTW stratum.

Alternate Hypothesis H_A :

Opposite of H_0 .

² It is possible to get the same set of doses back again but the chances of that happening are quite small.

³ Technically speaking, the null hypothesis that the differences in GM and GSD are equal to zero is not rejected.

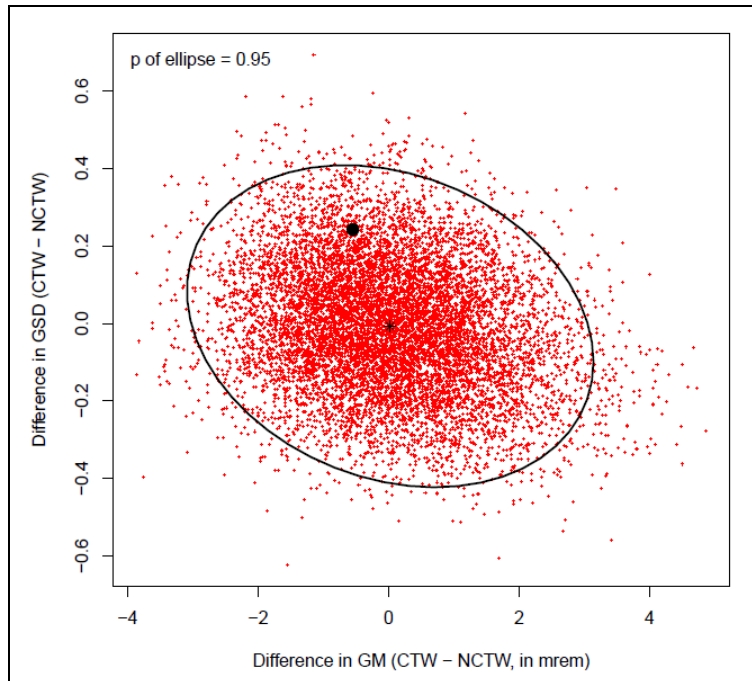


Figure 4a. Approximate Monte Carlo permutation test of CTW versus NCTW models. The black point is the delta GM and delta GSD of the observed CTW and NCTW models. The 95% confidence ellipse assumes a bivariate normal distribution.

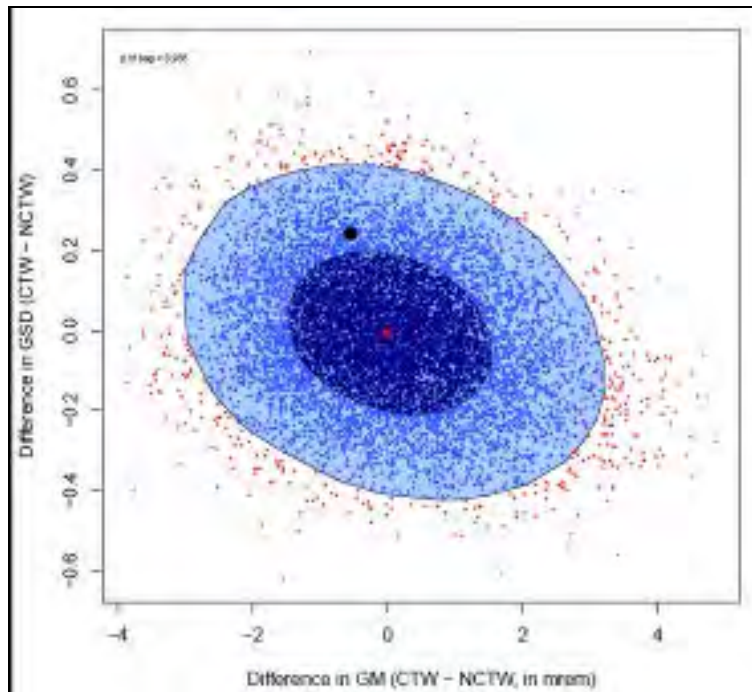


Figure 4b. Approximate Monte Carlo permutation test of CTW versus NCTW models. The black point is the delta GM and delta GSD of the observed CTW and NCTW models. The outer polygon (i.e., the bagplot) contains 95.6% of the results.

Test statistic

The test statistic is the Kuiper statistic (Stephens 1965, 1974), computed as the sum of the maximum positive and negative distances between the empirical cumulative distribution functions (ECDFs) of the CTW and NCTW doses; that is,

$$V = D^+ + D^-,$$

where

$$D^+ = \max_x [F_{CTW}(x) - F_{NCTW}(x)], D^- = \max_x [F_{NCTW}(x) - F_{CTW}(x)],$$

and $F_{CTW}(x)$, $F_{NCTW}(x)$ denote the ECDFs of the CTW and NCTW doses.

Rejection Region

If the p-value of the V statistic is less than 0.05, the null hypothesis is rejected. This test looks for any difference between the ECDFs (i.e. this is a two-sided test).

Conclusion

If the null hypothesis is not rejected at $\alpha = 0.05$, there is nothing here to make us believe that the doses from the CTW stratum and the doses from the NCTW stratum come from different populations and, as a consequence, the coworker models from the two strata will not be significantly different.

Discussion

Test A looks at the differences in the GM and GSD, which are obtained from fits to the dose data. These fits assume that the data are lognormally distributed in each stratum. The Kuiper Test (Test B), on the other hand, does not make any assumption about the distribution of the data in each stratum (Kuiper 1960). The two ECDF curves are compared and a p-value is calculated for the sum of the maximum deviations above and below the two ECDFs, under the null hypothesis that they are both random draws from the same population. The two samples are considered to be drawn from different parent populations for $p < 0.05$.

For example, in Figure 5, the ECDFs for the CTW and NCTW doses for 1954 are presented. The p-value for the Kuiper Test is $p = 0.5381$, which means that the null hypothesis is not rejected at $\alpha = 0.05$ significance level, and there is nothing here to make us believe that the doses from the CTW stratum and the doses from the NCTW stratum come from different populations (Kuiper 1960).

The Kuiper Test (Kuiper 1960) is closely related to the more well-known Kolmogorov-Smirnov Test (Hollander and Wolfe 1999, p. 178; Sheskin 2007, p. 577), which is computed as $D = \max(D^+, D^-)$, and looks at the maximum deviation between the two ECDFs. While the Kolmogorov-Smirnov Test is very sensitive around the median value, the Kuiper Test is as sensitive in the tails as in the median, and is reported to be more powerful than the Kolmogorov-Smirnov Test at detecting differences in the tails of the empirical cumulative distribution functions (Press et al. 2007, p. 738; Stephens 1974).

2.2 OTHER STRATA

A coworker model constructed from the CTW stratum was not expected to be significantly different from the coworker model constructed from the NCTW stratum because there is not an obvious process or health physics-related reason why it should be. A more logical stratum would be that of reactor workers. These workers would be expected to receive higher tritium doses than other workers because they worked in heavy-water reactors that were the primary source of HTO exposures during the years the reactors were operated. For example, compare Figures 6 and 7, where the strata are

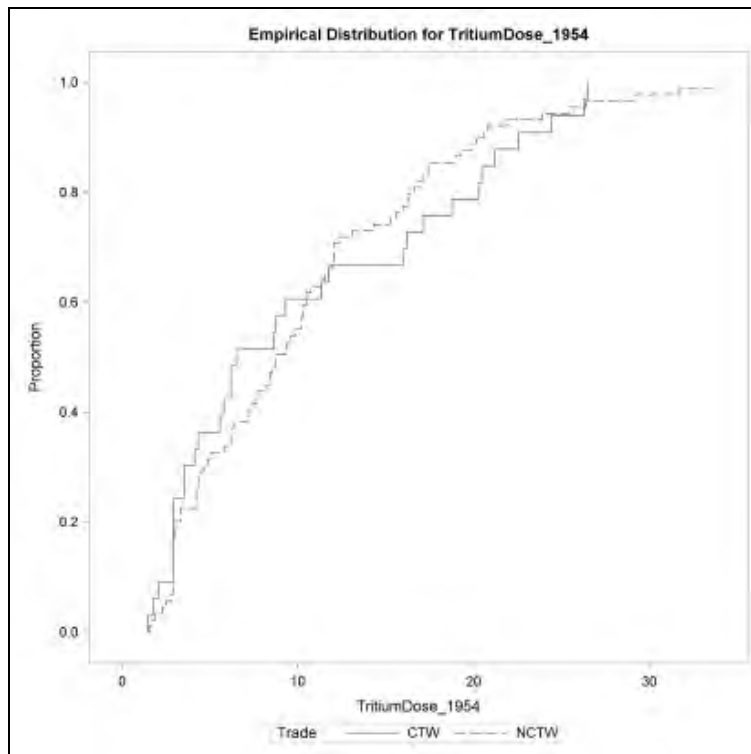


Figure 5. ECDFs of CTW and NCTW doses for 1954.

reactor/nonreactor workers in 1972 and CTW/NCTW in 1972, respectively. There is a highly significant difference between the coworker model constructed from reactor worker doses versus the nonreactor worker doses, but there is no significant difference between the coworker model constructed from CTW worker doses versus the NCTW worker doses. The Kuiper Test for the comparison between the reactor/nonreactor workers in 1972 is $p = 0$, and for the comparison between CTW/NCTW workers in 1972 is $p = 0.5138$ (Kuiper 1960). Figures 8 and 9 show the ECDFs for the reactor versus nonreactor workers, and for the CTW versus NCTW workers, for 1972, respectively.

Another approach is to create a stratum composed of CTWs who worked in the reactor areas. As discussed in the next section, the coworker models constructed from this stratum tend to be basically the same as the coworker models constructed from the stratum composed of NCTWs and CTWs who did not work in the reactor areas (i.e., all other workers); these two strata will be denoted as CTW/Reactor and Non(CTW/Reactor), respectively.

3.0 **RESULTS**

The complete output of the tests is rather large and is presented in three attachments:

- Attachment A: Comparison of CTWs to NCTWs.
- Attachment B: Comparison of Reactor Workers to Nonreactor Workers.
- Attachment C: Comparison of CTW/Reactor Workers to Non(CTW/Reactor) Workers.

3.1 **CTW VERSUS NCTW COMPARISON**

A summary of the statistical tests results for the comparison of CTW doses versus NCTW doses is given in Table 2, where the columns are defined as follows:

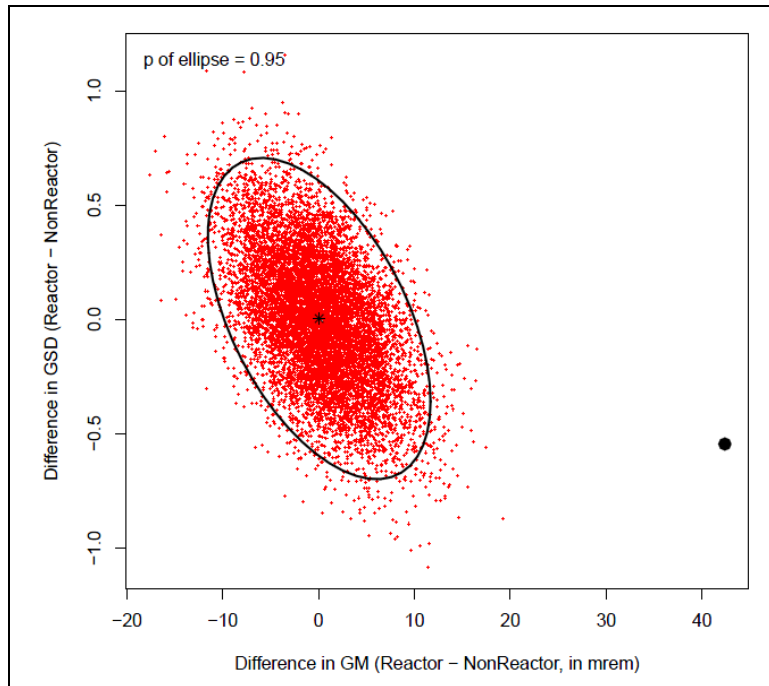


Figure 6. Monte Carlo permutation test of reactor worker versus nonreactor worker models for 1972. The black point is the delta GM and delta GSD of the observed reactor and nonreactor models.

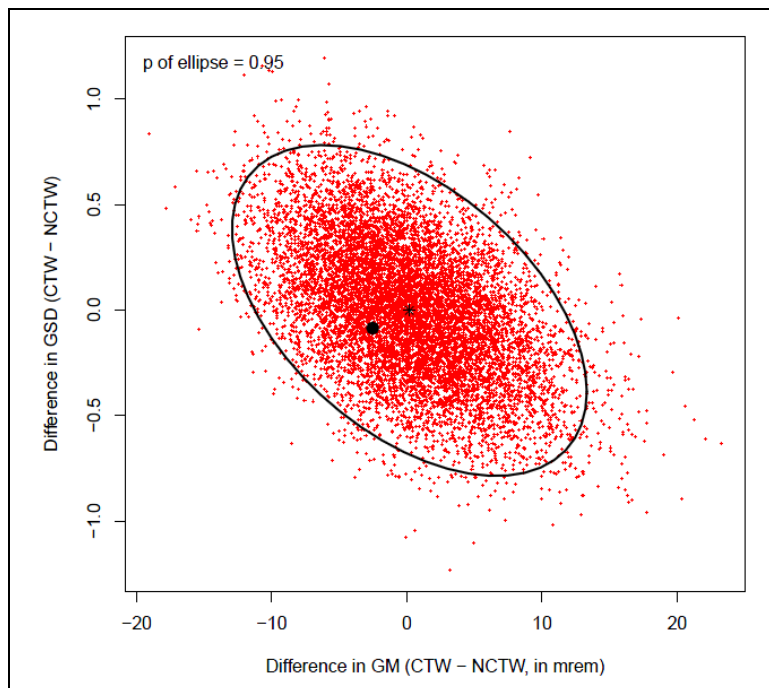


Figure 7. Monte Carlo permutation test of CTW versus NCTW models for 1972. The black point is the delta GM and delta GSD of the observed CTW and NCTW models.

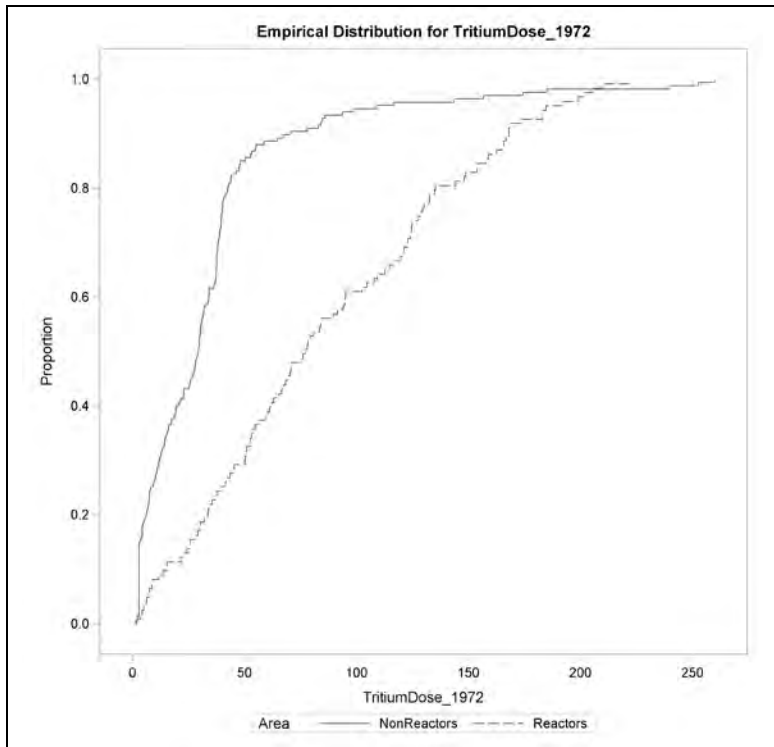


Figure 8. ECDFs of reactor and nonreactor doses for 1972.

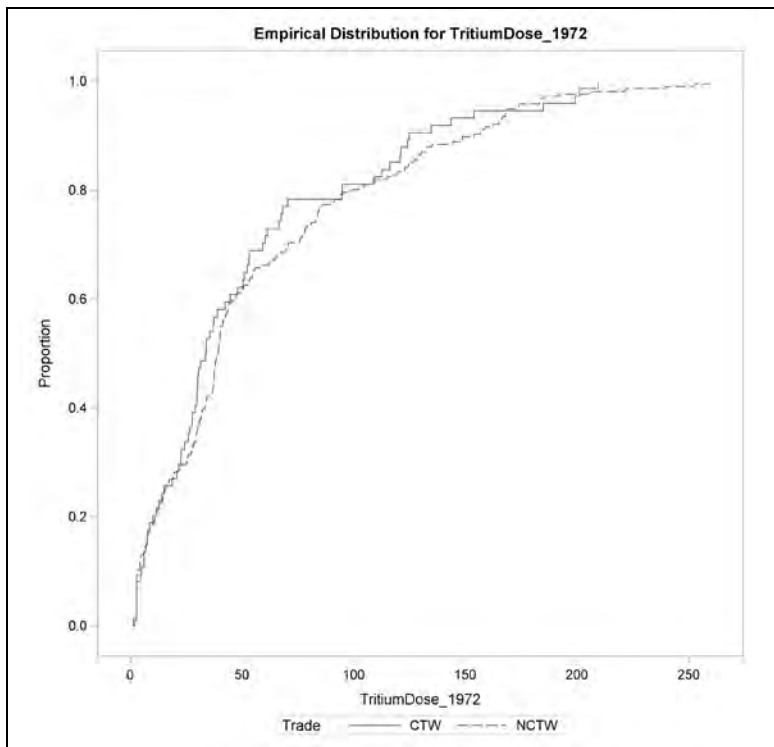


Figure 9. ECDFs of CTW and NCTW doses for 1972.

Table 2. Statistical tests for the comparison of CTW versus NCTW.

Year	Test A (p < .05)	Test B (p < .05)	Year	Test A (p < .05)	Test B (p < .05)
1954	No	No	1973	Yes	No
1955	No	No	1974	Yes	Yes
1956	No	Yes	1975	Yes	Yes
1957	No	No	1976	Yes	No
1958	No	No	1977	Yes	Yes
1959	No	No	1978	Yes	Yes
1960	No	Yes	1979	Yes	No
1961	Yes	No	1980	Yes	Yes
1962	Yes	No	1981	Yes	Yes
1963	No	No	1982	Yes	Yes
1964	Yes	No	1983	Yes	Yes
1965	No	No	1984	No	No
1966	No	No	1985	No	No
1967	Yes	No	1986	No	No
1968	Yes	No	1987	No	No
1969	No	Yes	1988	No	No
1970	Yes	Yes	1989	No	No
1971	Yes	No	1990	No	Yes
1972	No	No			

- Column 1: Year in which dose was received.
- Column 2: Is the coworker model constructed from the CTW stratum statistically different from the coworker model constructed from the NCTW stratum at the 95% confidence level, according to Test A?
- Column 3: Is the coworker model constructed from the CTW stratum statistically different from the coworker model constructed from the NCTW stratum at the 95% confidence level, according to Test B?

There are 13 years (shown in bold) in which the statistical significance of the two tests, i.e., the conclusion reached by each, are different.

3.2 REACTOR VERSUS NONREACTOR COMPARISON

A summary of the statistical tests results for the comparison of reactor doses versus nonreactor doses is given in Table 3, where the columns are defined as follows:

- Column 1: Year in which dose was received.
- Column 2: Is the coworker model constructed from the reactor stratum statistically different than the coworker model constructed from the nonreactor stratum at the 95% confidence level, according to Test A?
- Column 3: Is the coworker model constructed from the reactor stratum statistically different than the coworker model constructed from the nonreactor stratum at the 95% confidence level, according to Test B?

There are 4 years (shown in bold) in which the statistical significance of the two tests, i.e., the conclusion reached by each, are different.

Table 3. Statistical tests for the comparison of reactor versus nonreactor.

Year	Test A (p < .05)	Test B (p < .05)	Year	Test A (p < .05)	Test B (p < .05)
1954	No	No	1973	Yes	Yes
1955	No	No	1974	Yes	Yes
1956	Yes	No	1975	Yes	Yes
1957	No	No	1976	Yes	Yes
1958	Yes	Yes	1977	Yes	Yes
1959	Yes	Yes	1978	Yes	Yes
1960	Yes	Yes	1979	Yes	Yes
1961	Yes	Yes	1980	Yes	Yes
1962	Yes	Yes	1981	Yes	Yes
1963	Yes	Yes	1982	Yes	Yes
1964	Yes	Yes	1983	Yes	Yes
1965	Yes	Yes	1984	Yes	Yes
1966	Yes	Yes	1985	No	Yes
1967	Yes	Yes	1986	Yes	Yes
1968	No	Yes	1987	Yes	Yes
1969	Yes	Yes	1988	No	No
1970	Yes	Yes	1989	Yes	No
1971	Yes	Yes	1990	No	No
1972	Yes	Yes			

3.3 CTW/REACTOR VERSUS NON(CTW/REACTOR)

A summary of the statistical tests results for the comparison of CTW/Reactor doses versus Non(CTW/Reactor) doses is given in Table 4, where the columns are defined as follows:

- Column 1: Year in which dose was received.
- Column 2: Is the coworker model constructed from the CTW/Reactor stratum statistically different than the coworker model constructed from the Non(CTW/Reactor) stratum at the 95% confidence level, according to Test A?
- Column 3: Is the coworker model constructed from the CTW/Reactor stratum statistically different than the coworker model constructed from the Non(CTW/Reactor) stratum at the 95% confidence level, according to Test B?

There is one year (shown in bold) in which the statistical significance of the two tests, i.e., the conclusion reached by each, are different.

4.0 DISCUSSION

All tests of significance are at $\alpha = 0.05$, which means there is a 5% chance of concluding that the coworker models were different when in fact they were not. In summary:

- There are 19 of 37 years in which there is no significant difference (No) between the CTW and NCTW coworker models according to Test A and 24 years in which there is no significant difference (No) according to Test B.
- There are 5 of 37 years for both Test A and Test B in which there is no significant difference (No) between the reactor and nonreactor coworker.

Table 4. Statistical tests, for the comparison of CTW/Reactor versus Non(CTW/Reactor).

Year	Test A ($p < .05$)	Test B ($p < .05$)	Year	Test A ($p < .05$)	Test B ($p < .05$)
1954	No	No	1973	No	No
1955	No	No	1974	Yes	Yes
1956	No	No	1975	No	No
1957	No	No	1976	No	No
1958	No	Yes	1977	No	No
1959	Yes	Yes	1978	No	No
1960	No	No	1979	No	No
1961	No	No	1980	No	No
1962	No	No	1981	No	No
1963	No	No	1982	No	No
1964	Yes	Yes	1983	No	No
1965	No	No	1984	No	No
1966	No	No	1985	No	No
1967	No	No	1986	No	No
1968	No	No	1987	No	No
1969	No	No	1988	No	No
1970	No	No	1989	No	No
1971	No	No	1990	No	No
1972	Yes	Yes			

- There are 33 of 37 years in which there is no significant difference (No) between the CTW/Reactor and Non(CTW/Reactor) coworker models, according to Test A, and 32 of 37 years in which there is no significant difference (No) between the CTW/Reactor and Non(CTW/Reactor) coworker models, according to Test B.

In 20 of the 22 years in which there was a statistically significant difference between the CTW and NCTW models (according to either Test A or Test B), the GM of the NCTW model is greater than the GM of the CTW model, and in most of these years the GSD of the NCTW model is smaller than the GSD of the CTW model. In other words, using a stratified coworker model in this instance rather than the unstratified model would result in the CTWs getting slightly lower doses and the NCTWs getting slightly higher doses. The term “slightly” is used because the maximum differences in the GM of the CTW and GM of the NCTW are on the order of 15 mrem.

In 31 of the 32 years in which there was a statistically significant difference between the reactor and nonreactor models (according to either Test A or Test B), the GM of the reactor model is greater than the GM of the nonreactor model, and in most of these years the GSD of the reactor model is also slightly greater than the GSD of the nonreactor model. In other words, using a stratified coworker model in this instance in place of the unstratified model would result in the reactor workers getting larger doses than the nonreactor workers.

In all 5 years in which there was a statistically significant difference between the CTW/Reactor and Non(CTW/Reactor) models (according to either Test A or Test B), the GM of the CTW/Reactor model is greater than the GM of the Non(CTW/Reactor) model, and in each of these years the GSD of the CTW/Reactor model is also slightly smaller than the GSD of the Non(CTW/Reactor) model. In other words, using a stratified coworker model in this instance in place of the unstratified model would result in the CTW/Reactor workers getting slightly higher doses and the Non(CTW/Reactor) workers getting slightly lower doses. The term “slightly” is used because the maximum differences in the GM of the CTW/Reactor and GM of the Non(CTW/Reactor) is on the order of 30 mrem.

As expected, the absolute magnitude of differences between the median doses calculated between the CTW versus NCTW strata tended to be much smaller than those observed with the reactor versus nonreactor strata, which produce the largest differences in the median doses from all the comparisons.

5.0 CONCLUSION

There is no advantage in stratifying the population of all workers into CTWs versus NCTWs, because for most of the years there is no statistically significant difference between the coworker models obtained from each stratum, and in the few years when there is a significant difference the magnitude of the difference is small in terms of dose. A coworker model based specifically on the doses received by workers in the SRS reactor areas is statistically different than the coworker model obtained from all monitored workers for most years. While this difference was expected based on the nature of the work at the SRS reactors versus the work at other facilities, there is little use for a reactor-specific coworker model because it was very unlikely that a reactor worker would be unmonitored. Thus, the net result of creating a reactor-specific coworker model is to lower the doses to nonreactor workers who had a higher likelihood of being unmonitored.

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Four plots are presented for each year from 1954 to 1990. The first three are lognormal probability plots of the tritium doses for the CS of workers, the CTWs, and all other workers, who are referred to as the non-CTW or NCTW. In these plots the following statistics are presented:

- GM = geometric mean of data (intercept of line)
- GSD = geometric standard deviation of data (slope of line)
- R2 = coefficient of determination for regression line
- N = total number of individuals in CS
- n = total number of individuals in CTW or NCTW group

The fourth plot for a given year is a Monte Carlo permutation plot of the test statistics for 10,000 random draws from the CS. Each random draw from the CS is split into one part the size of the CTW and one part the size of the NCTW, and two test statistics (one for the GM and one for the GSD) are calculated for these two parts. All 10,000 pairs of test statistics are plotted and an ellipse is constructed that contains 95% of the test statistics. If the observed test statistics for the CTW and NCTW strata lie outside the ellipse, the coworker model for the CTW is different from the coworker model for NCTW.

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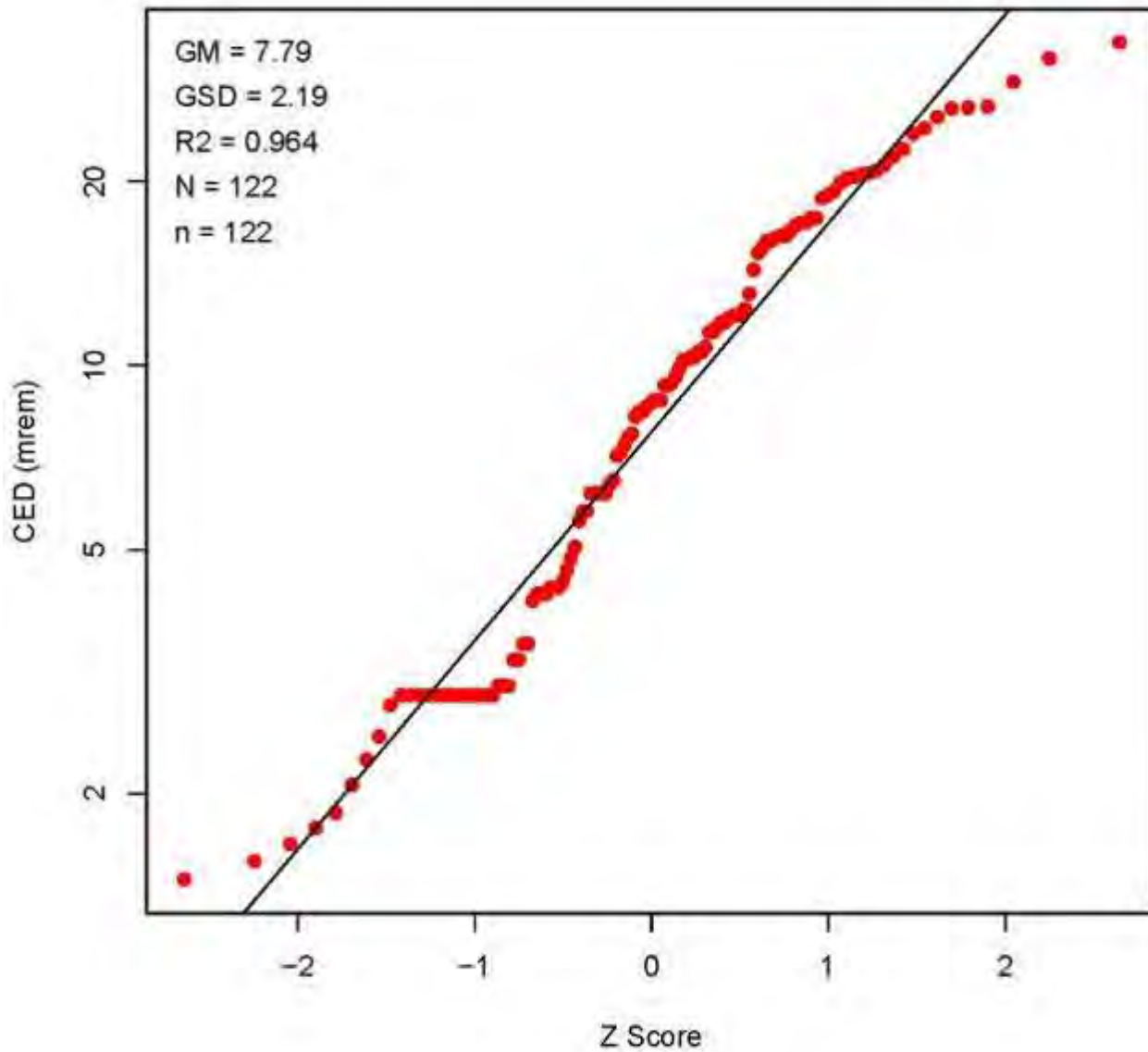


Figure A-1. SRS tritium dose 1954.

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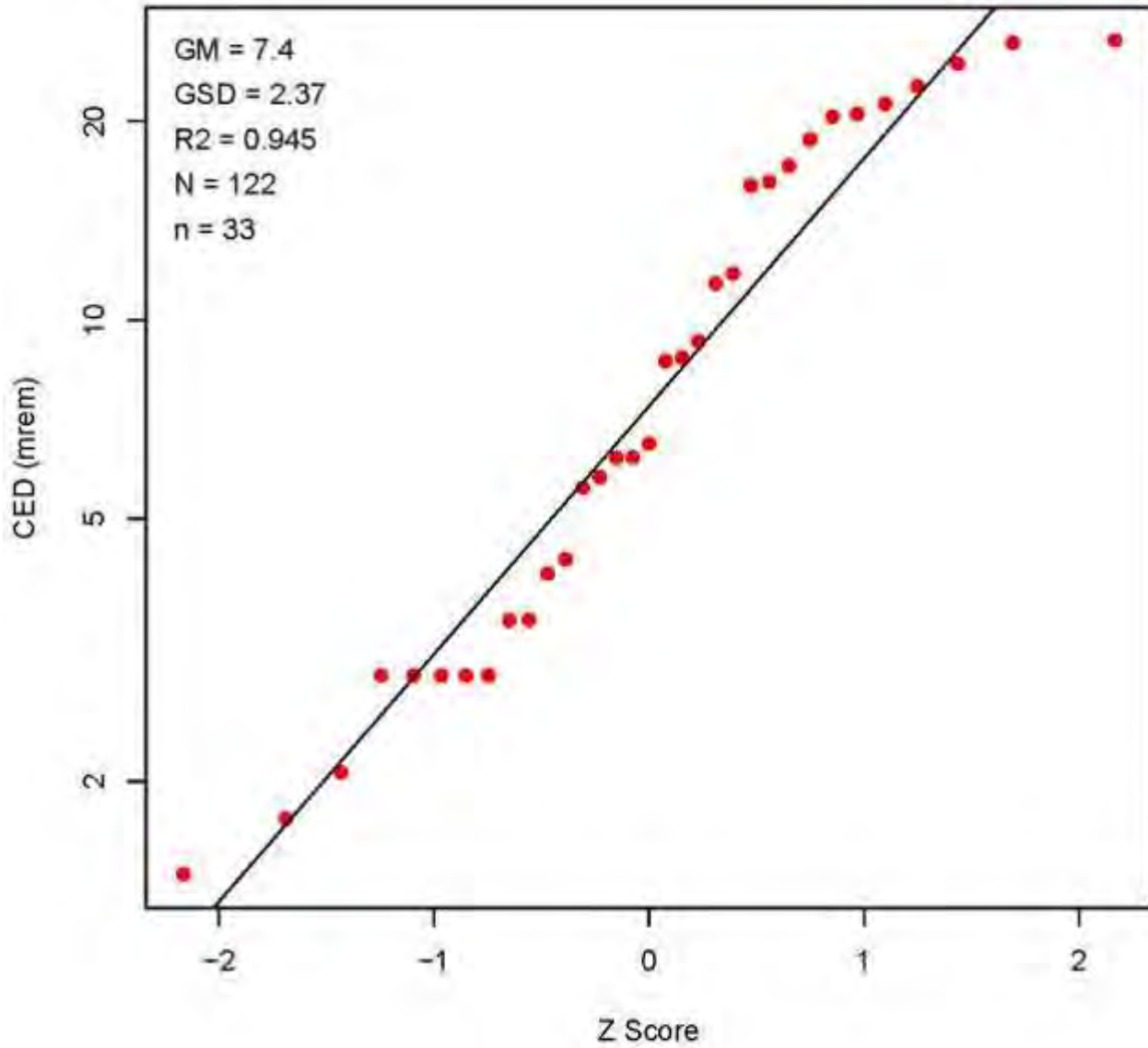


Figure A-2. SRS CTW tritium dose 1954.

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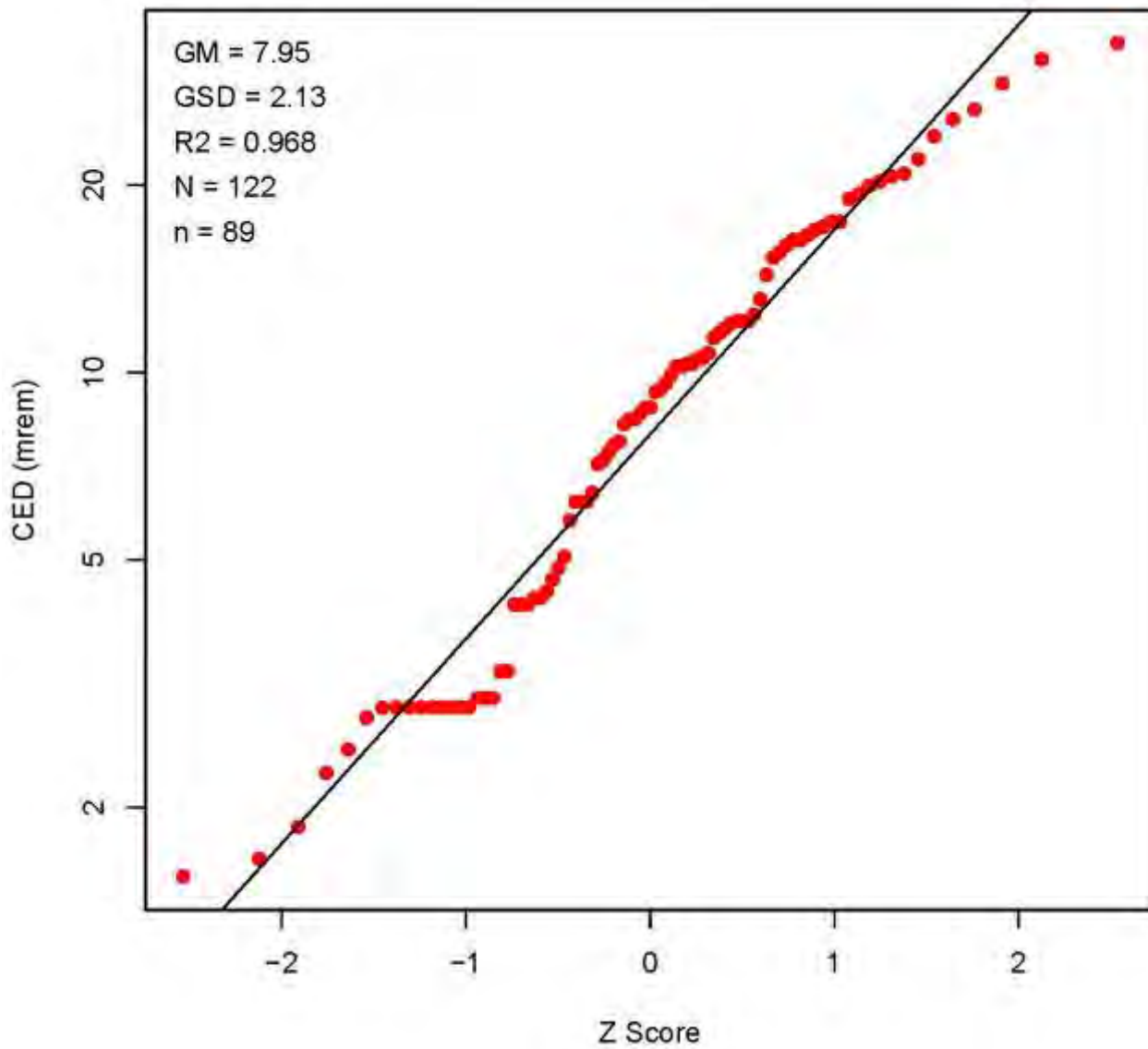


Figure A-3. SRS NCTW tritium dose 1954.

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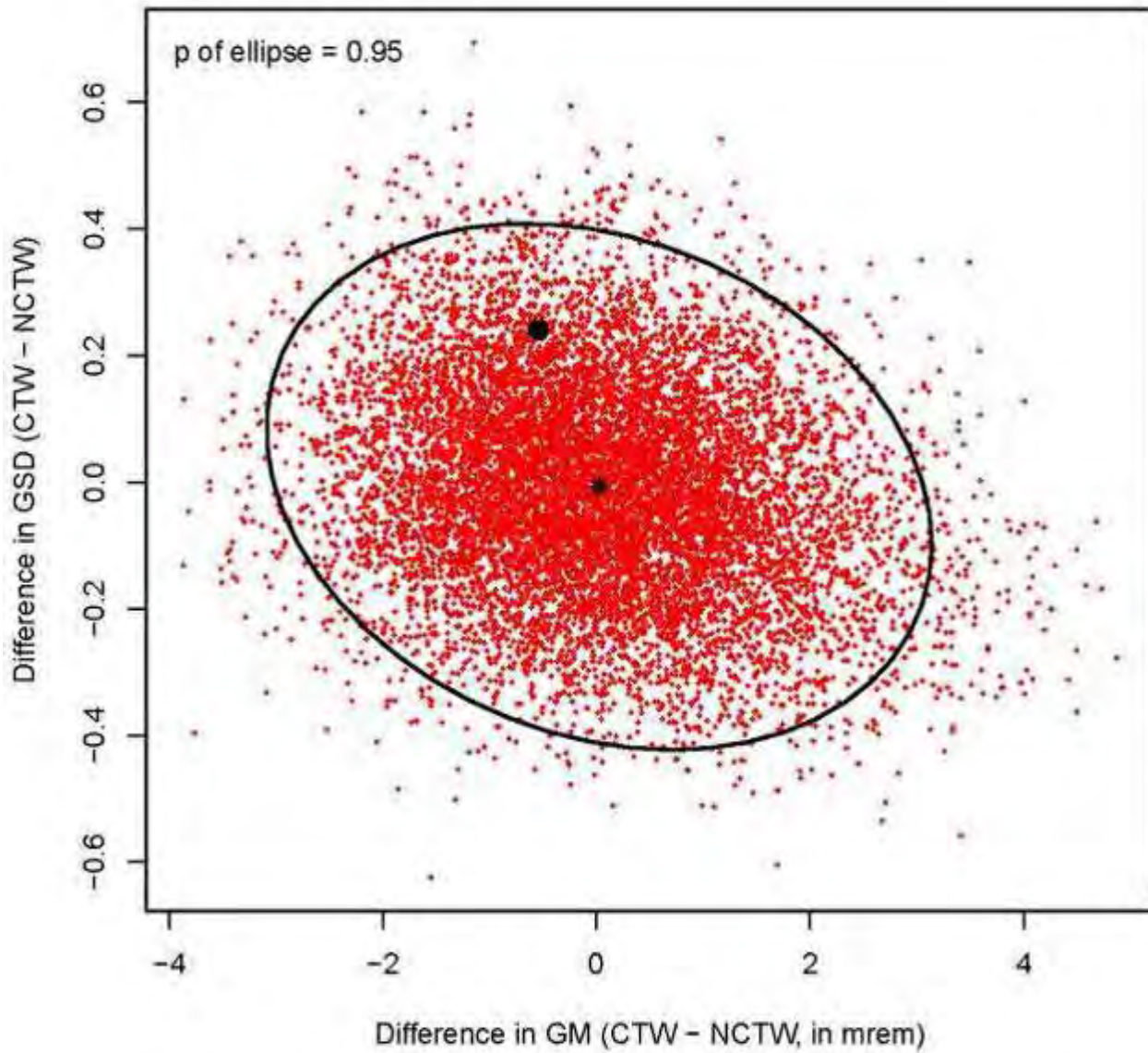


Figure A-4. SRS tritium dose 1954.

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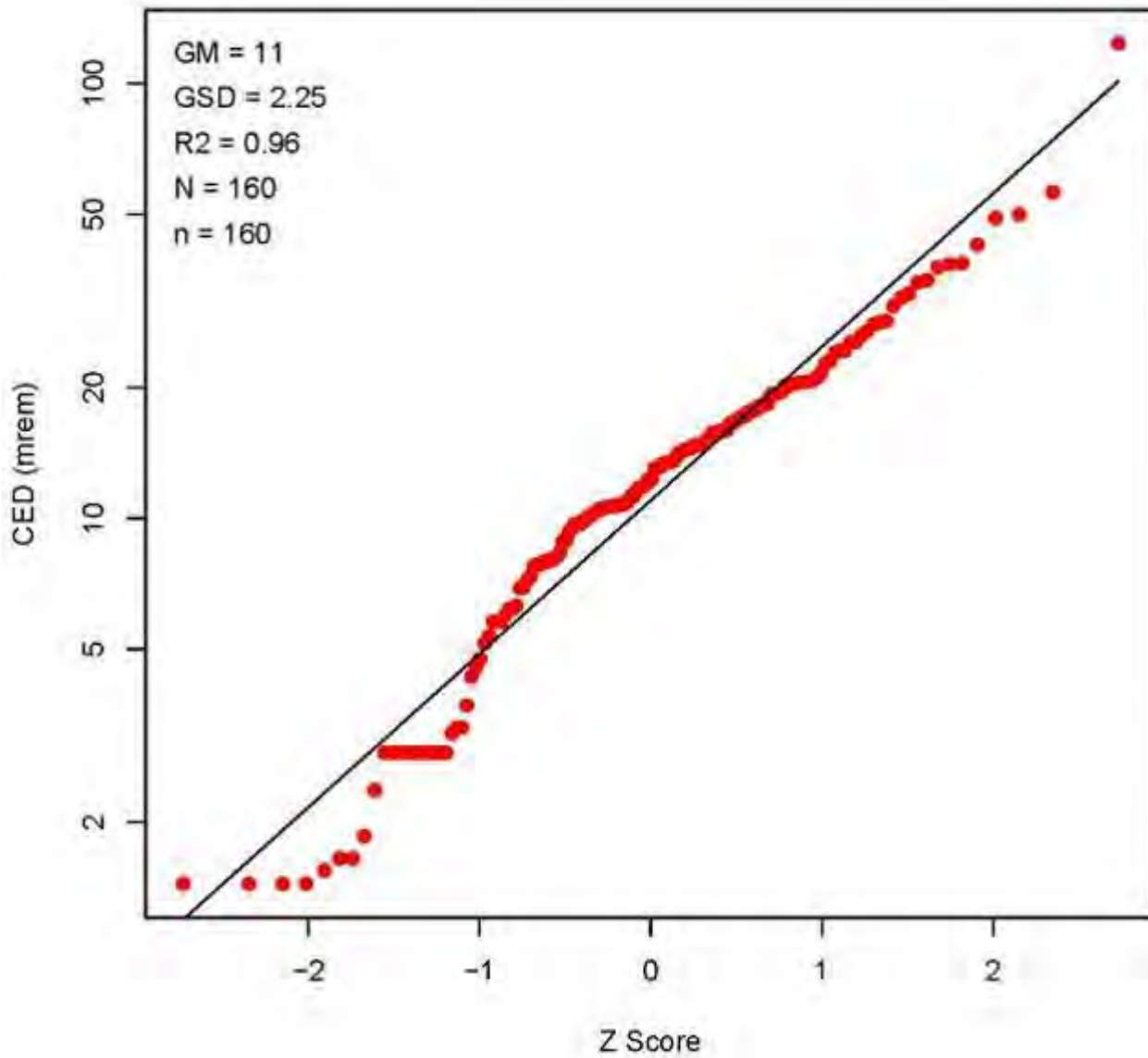


Figure A-5. SRS tritium dose 1955.

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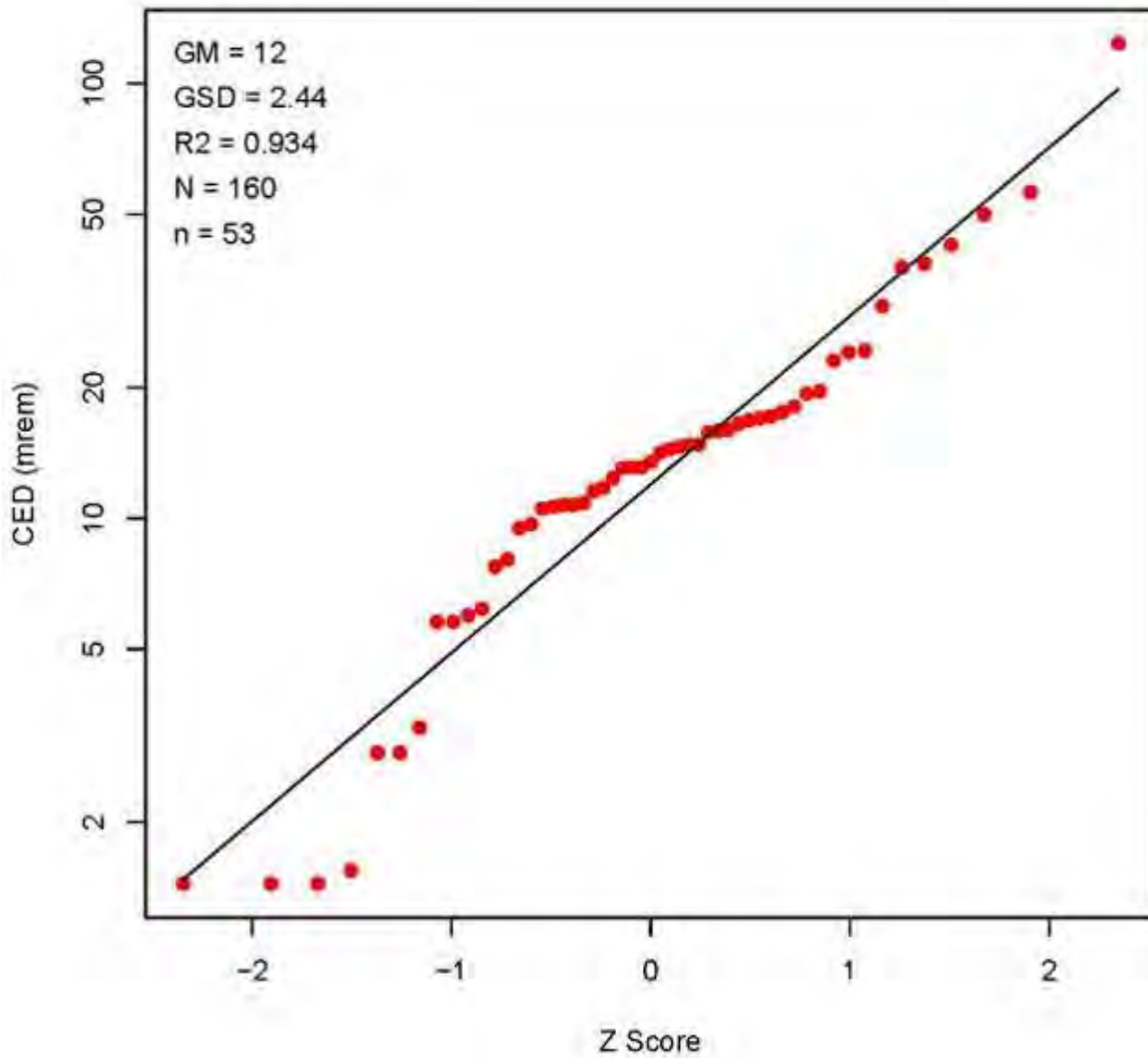


Figure A-6. SRS CTW tritium dose 1955.

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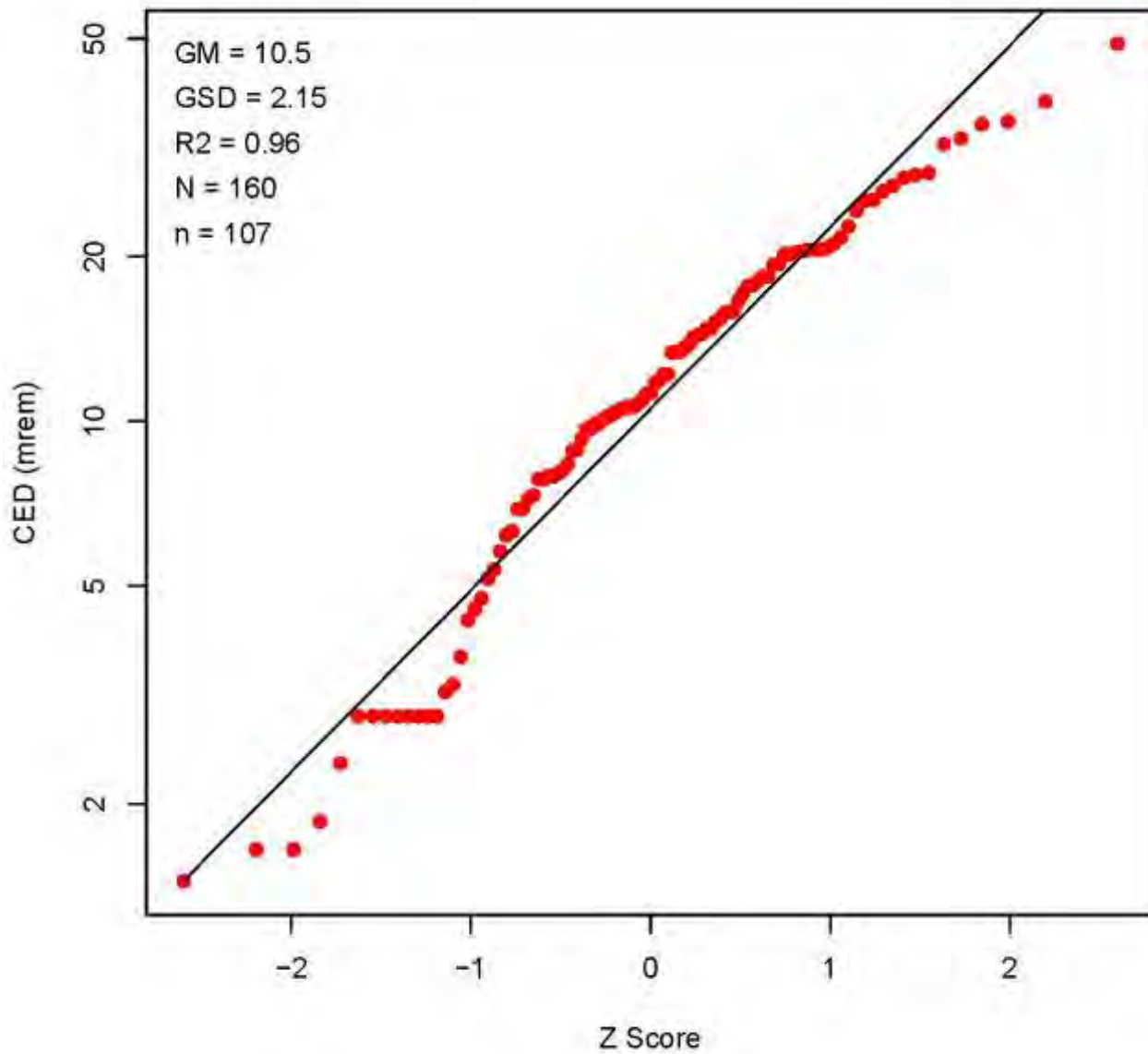


Figure A-7. SRS NCTW tritium dose 1955.

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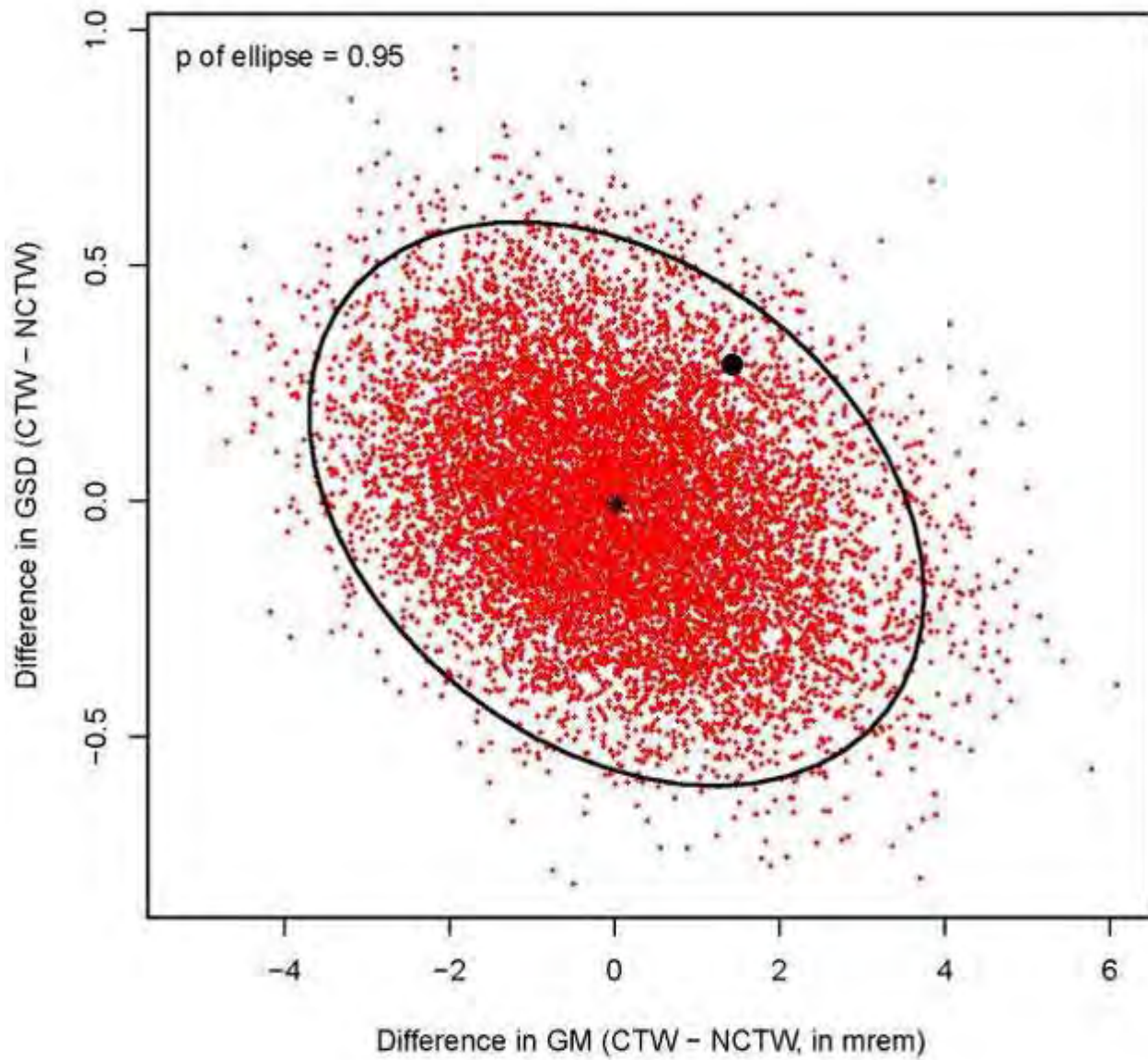


Figure A-8. SRS tritium dose 1955.

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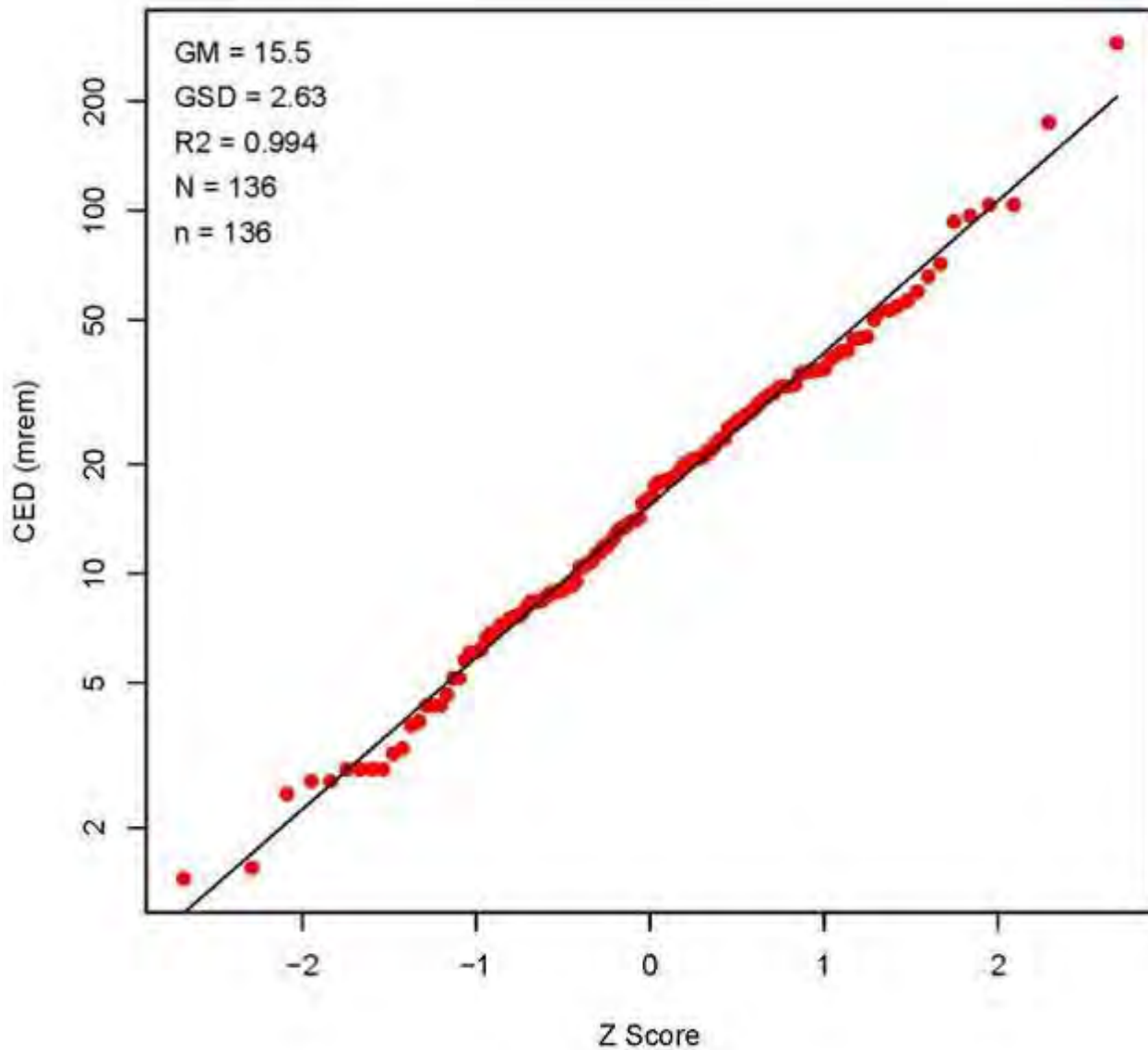


Figure A-9. SRS tritium dose 1956.

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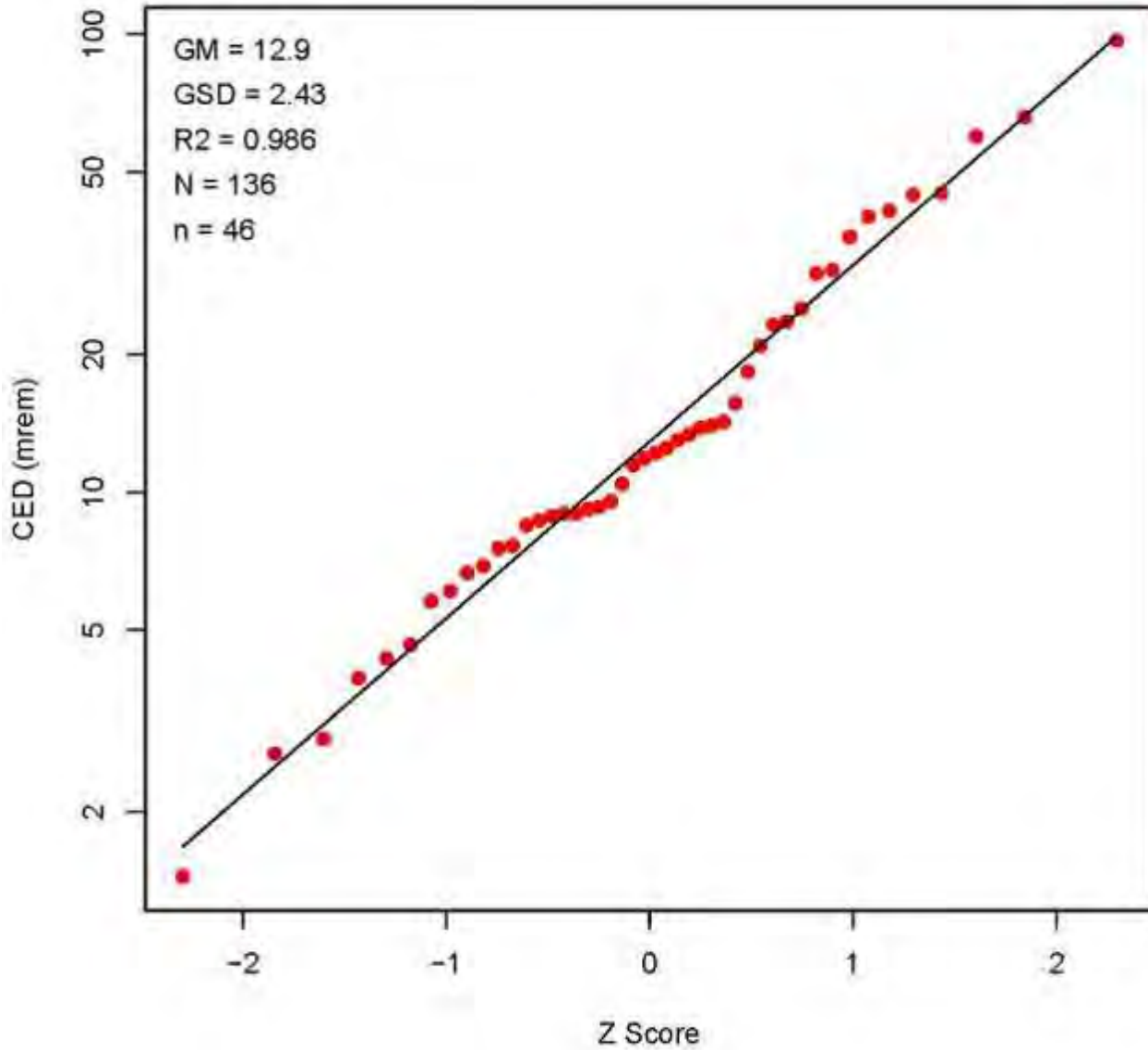


Figure A-10. SRS CTW tritium dose 1956.

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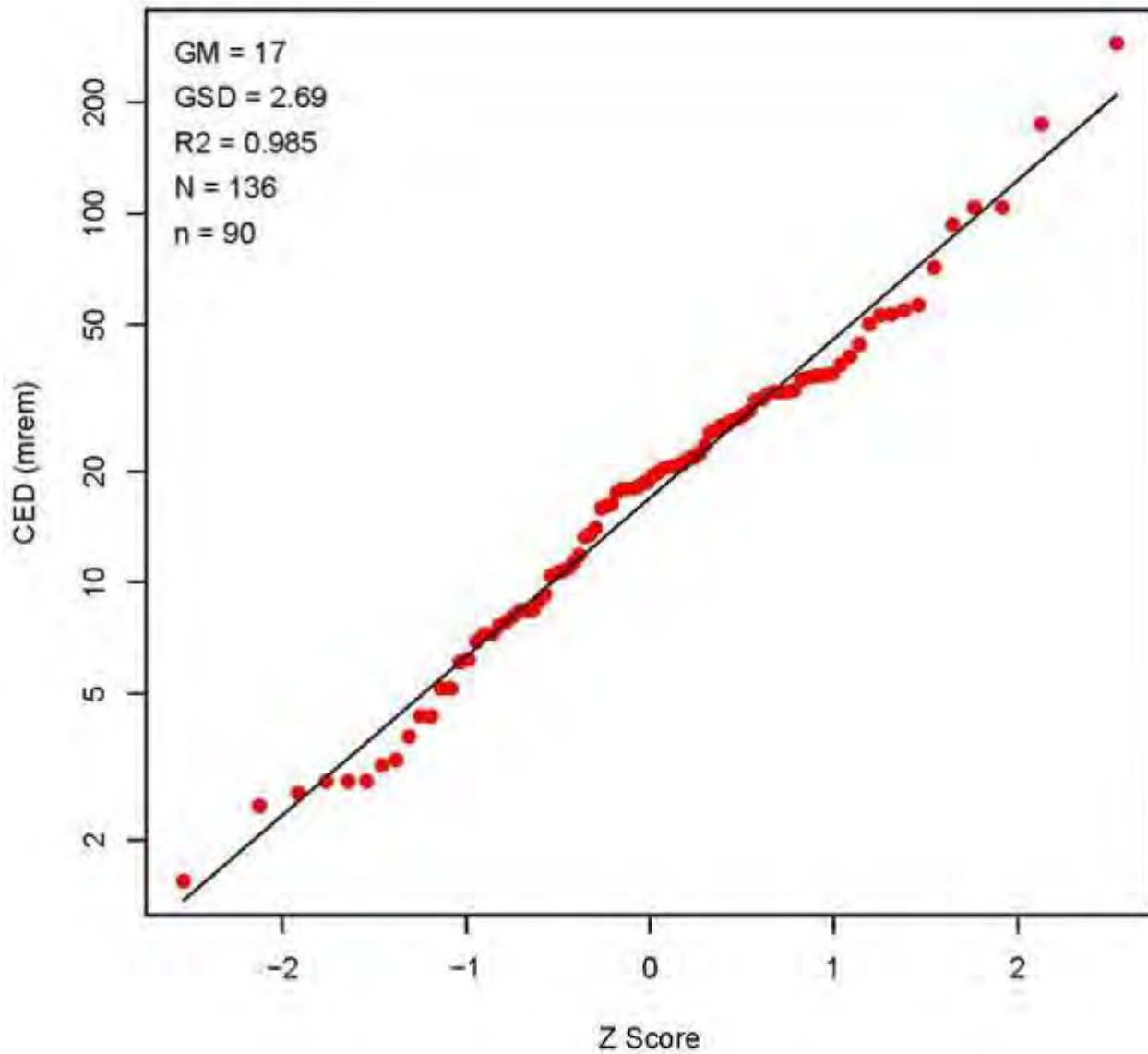


Figure A-11. SRS NCTW tritium dose 1956.

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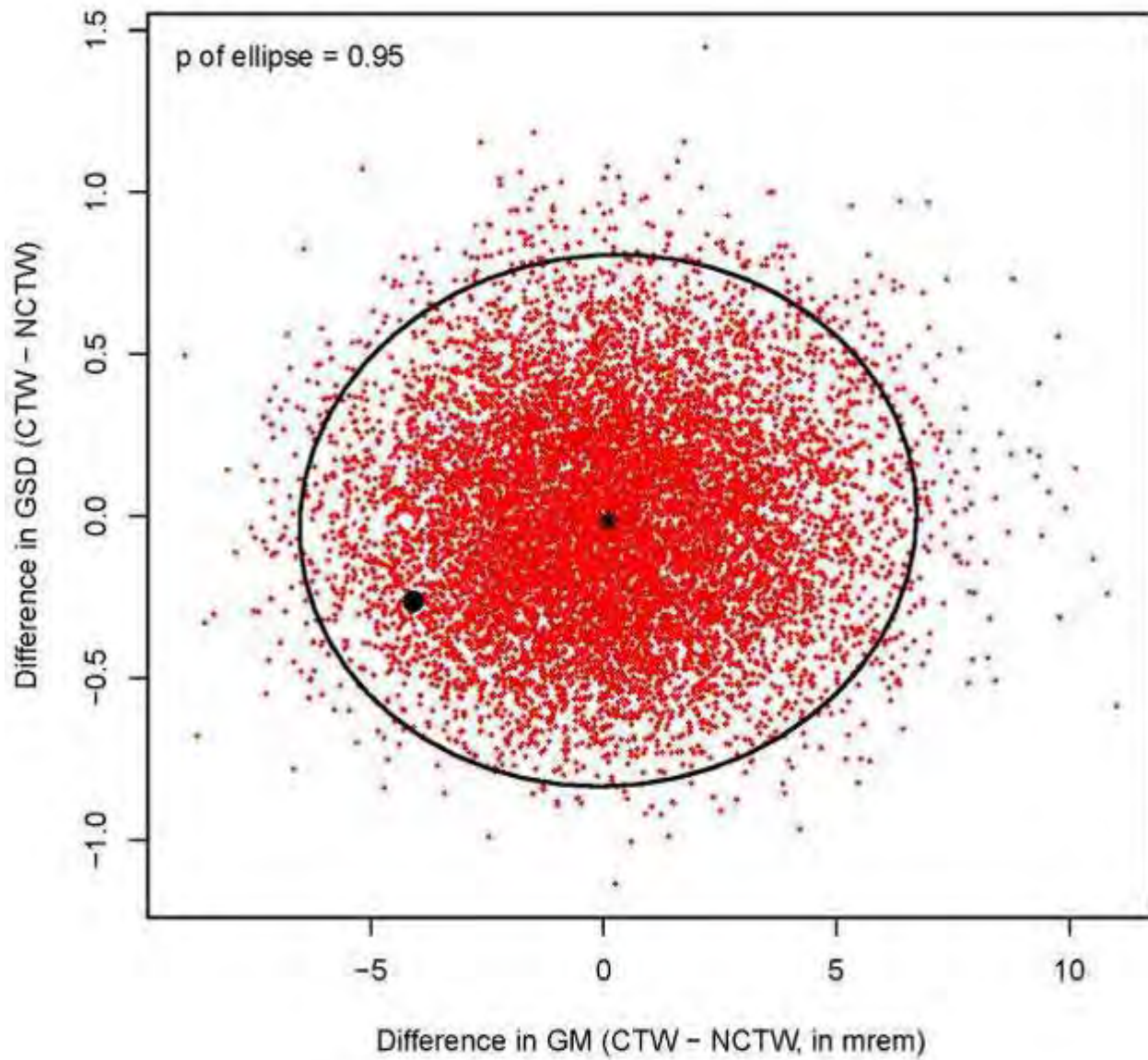


Figure A-12. SRS tritium dose 1956.

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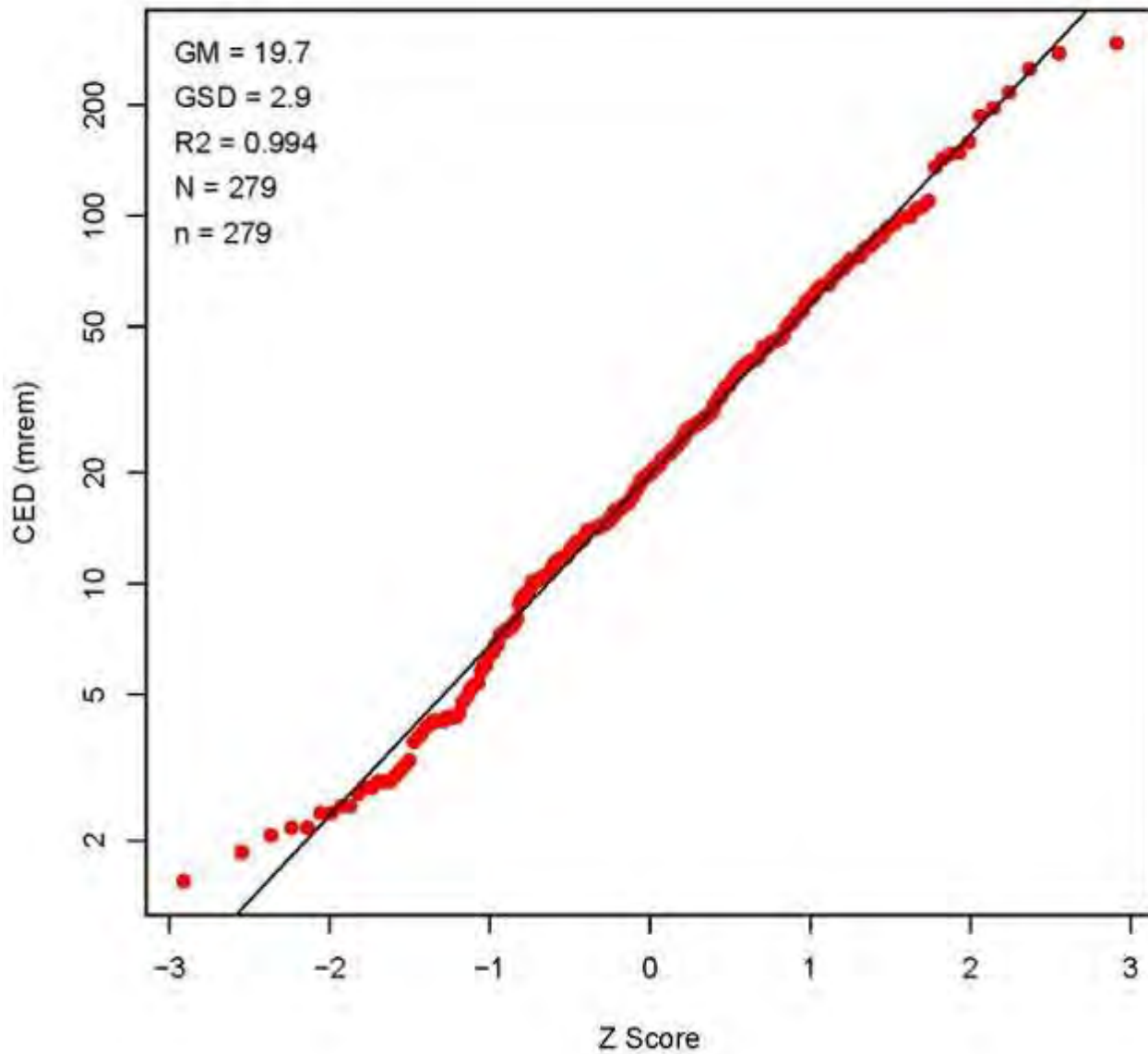


Figure A-13. SRS tritium dose 1957.

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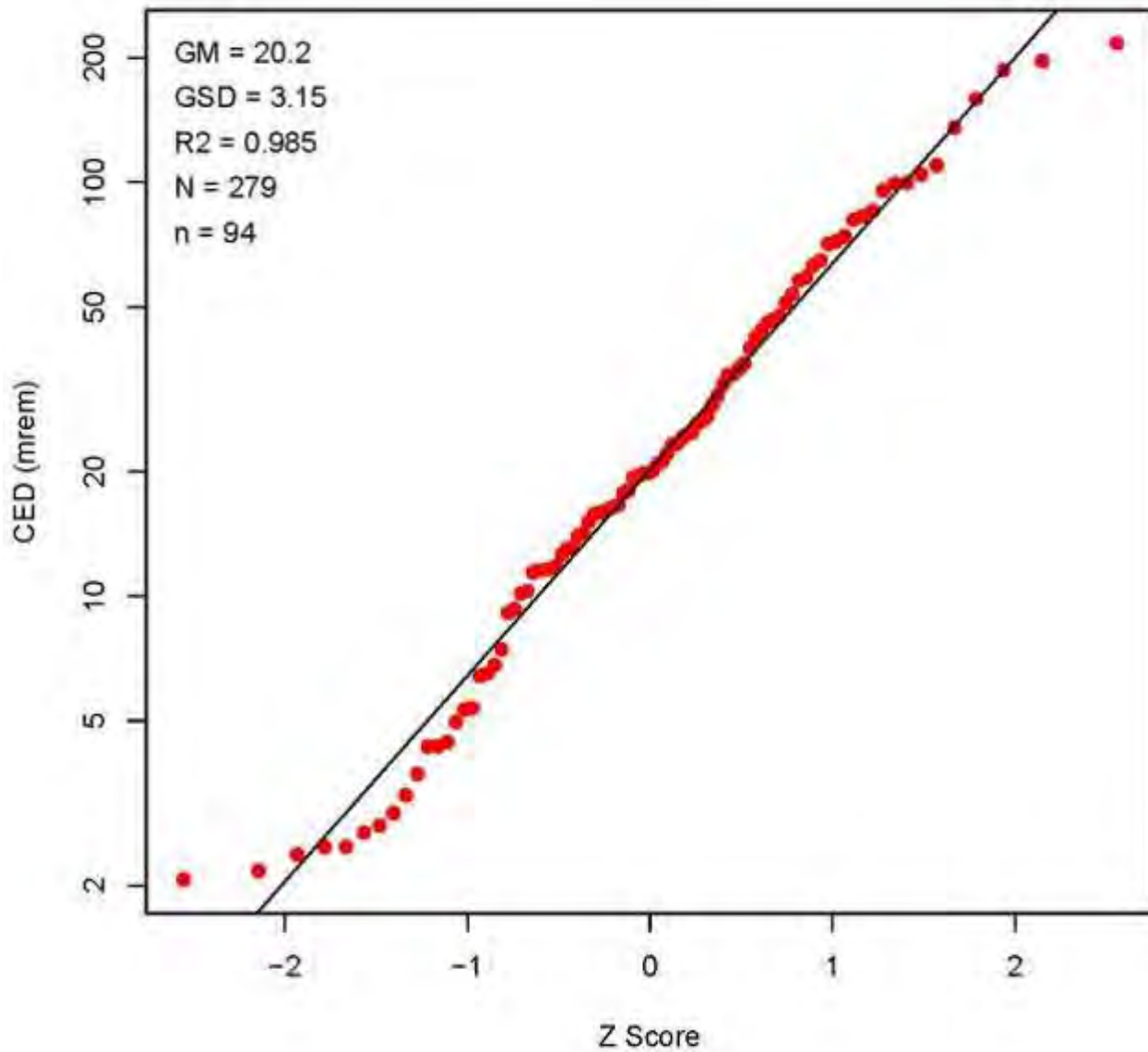


Figure A-14. SRS CTW tritium dose 1957.

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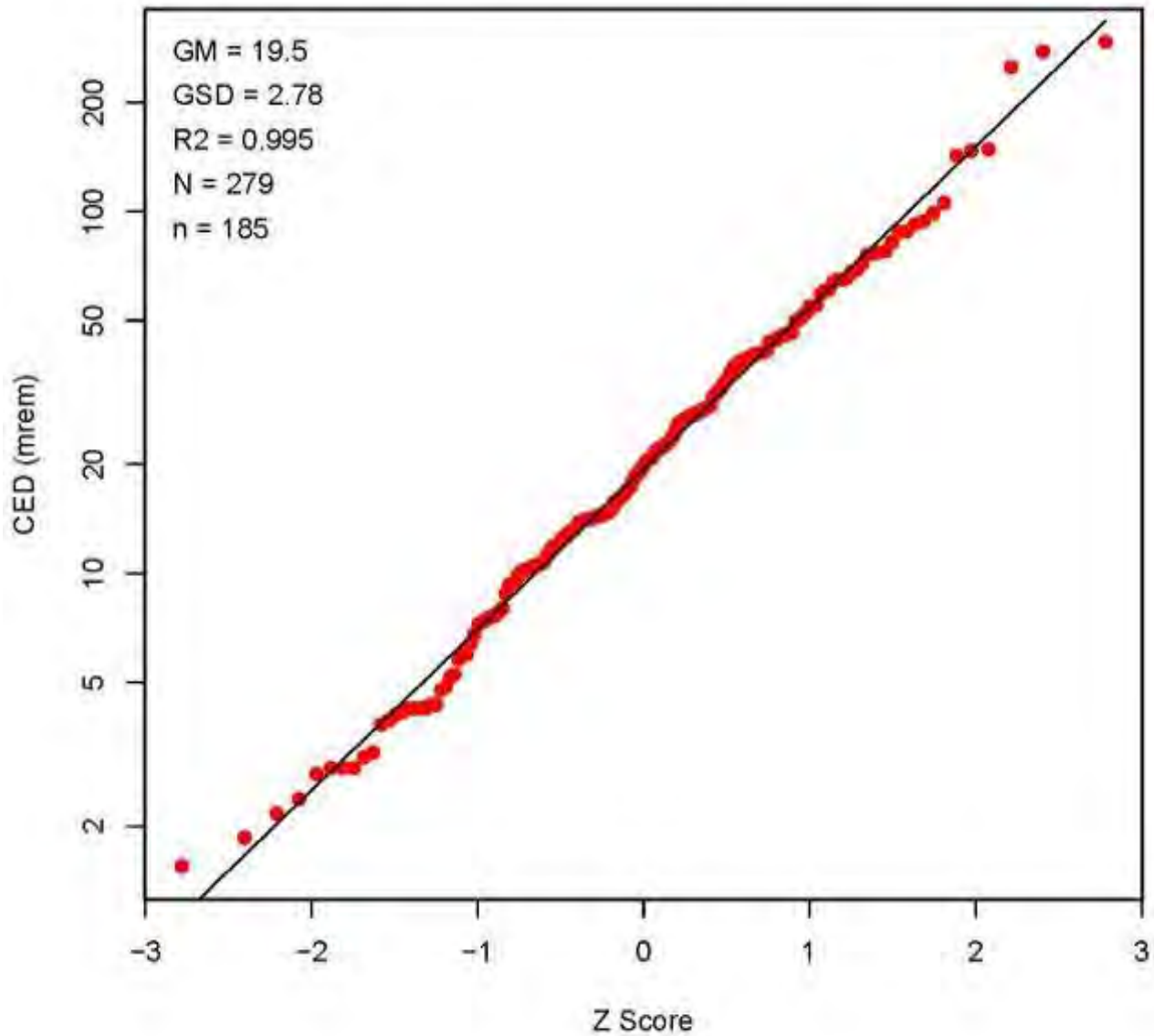


Figure A-15. SRS NCTW tritium dose 1957.

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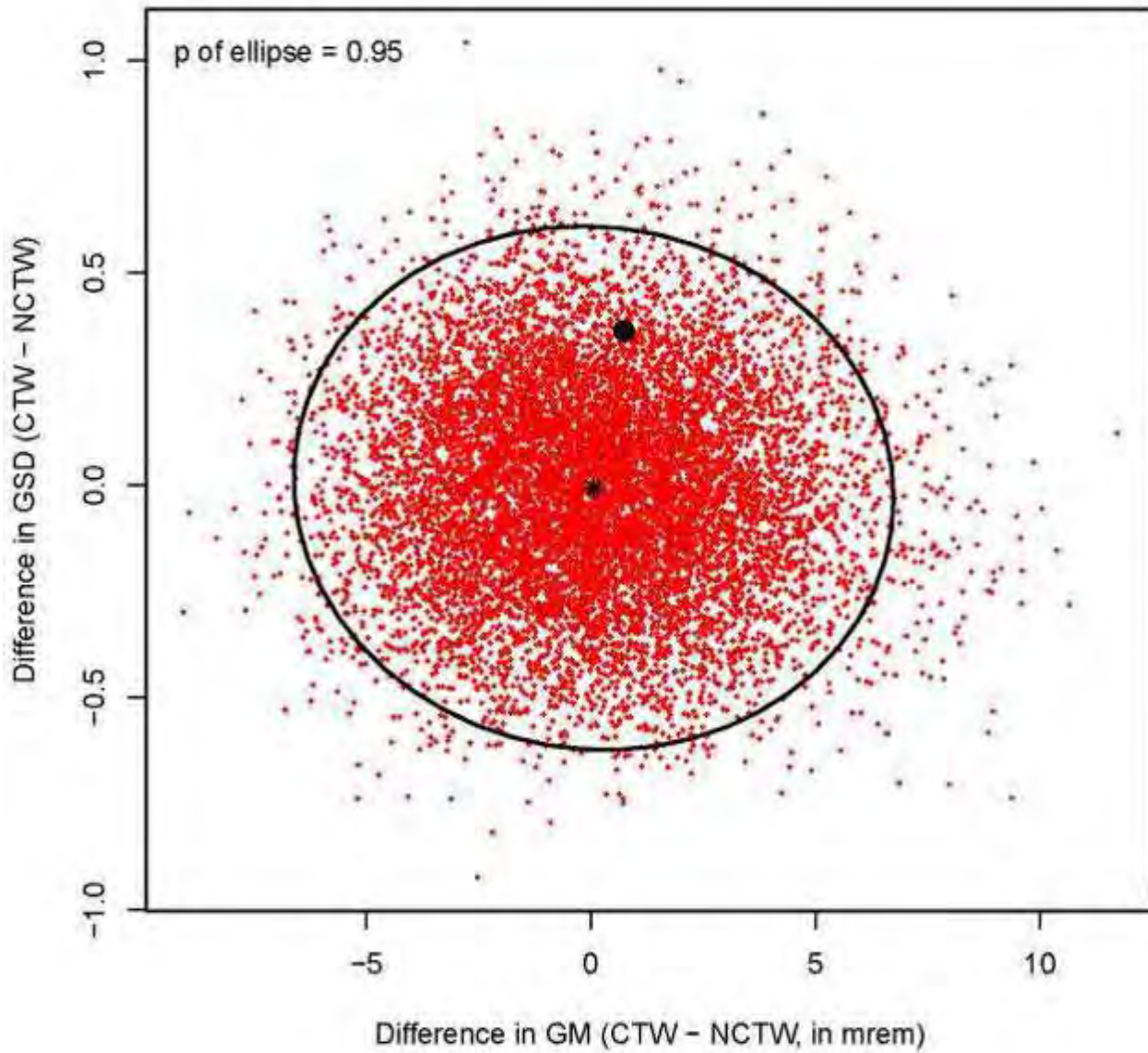


Figure A-16. SRS tritium dose 1957.

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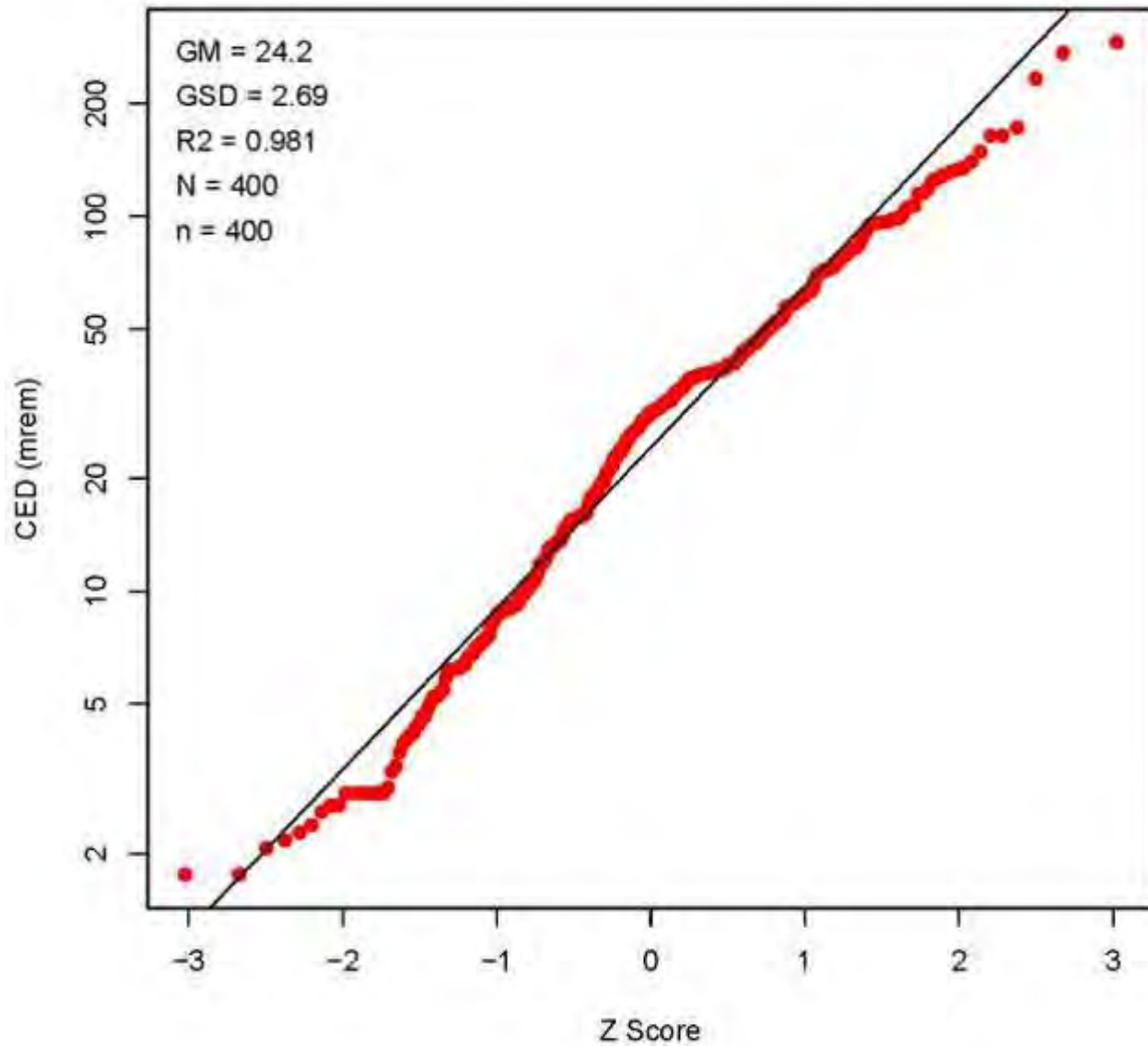


Figure A-17. SRS tritium dose 1958.

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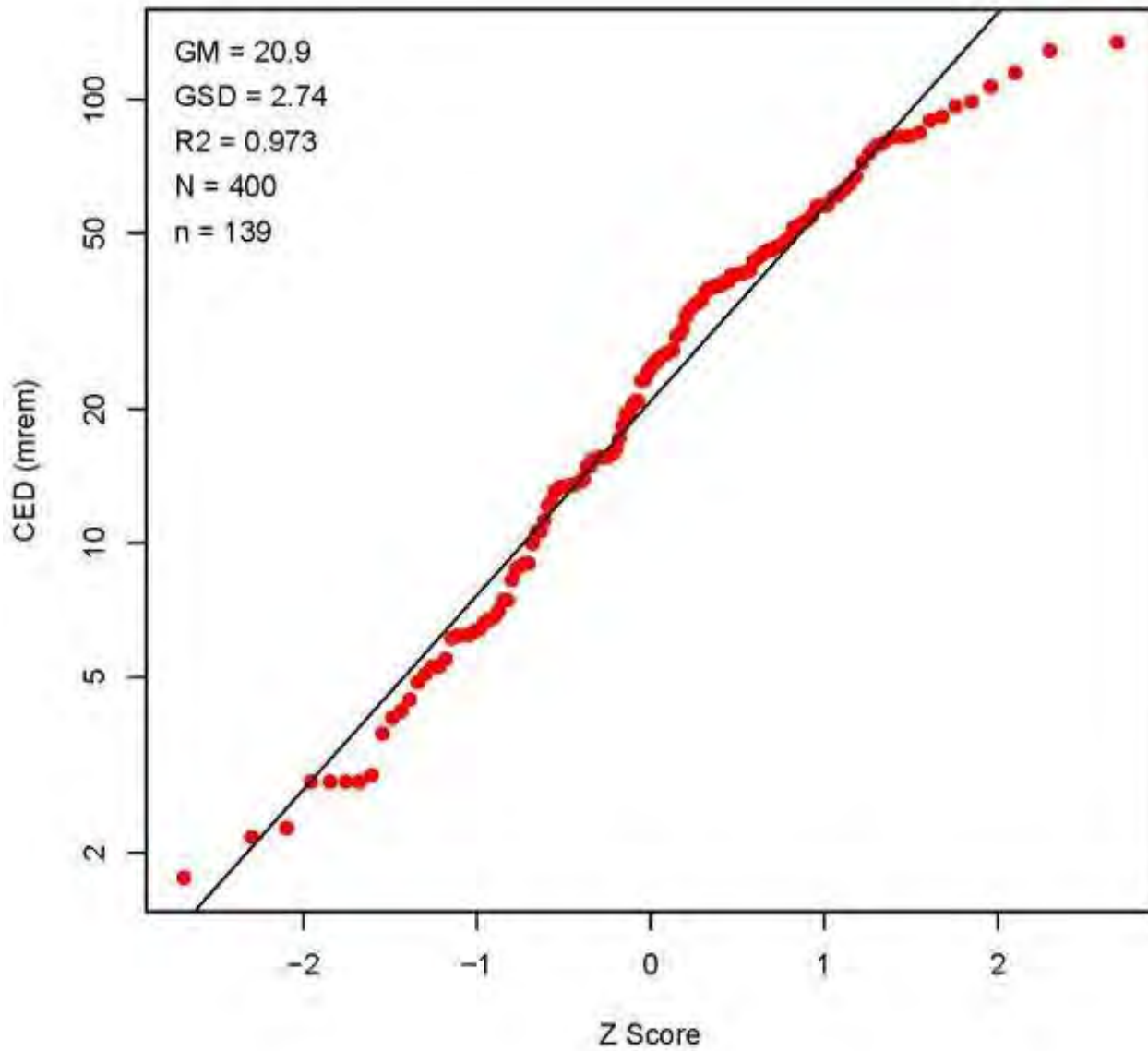


Figure A-18. SRS CTW tritium dose 1958.

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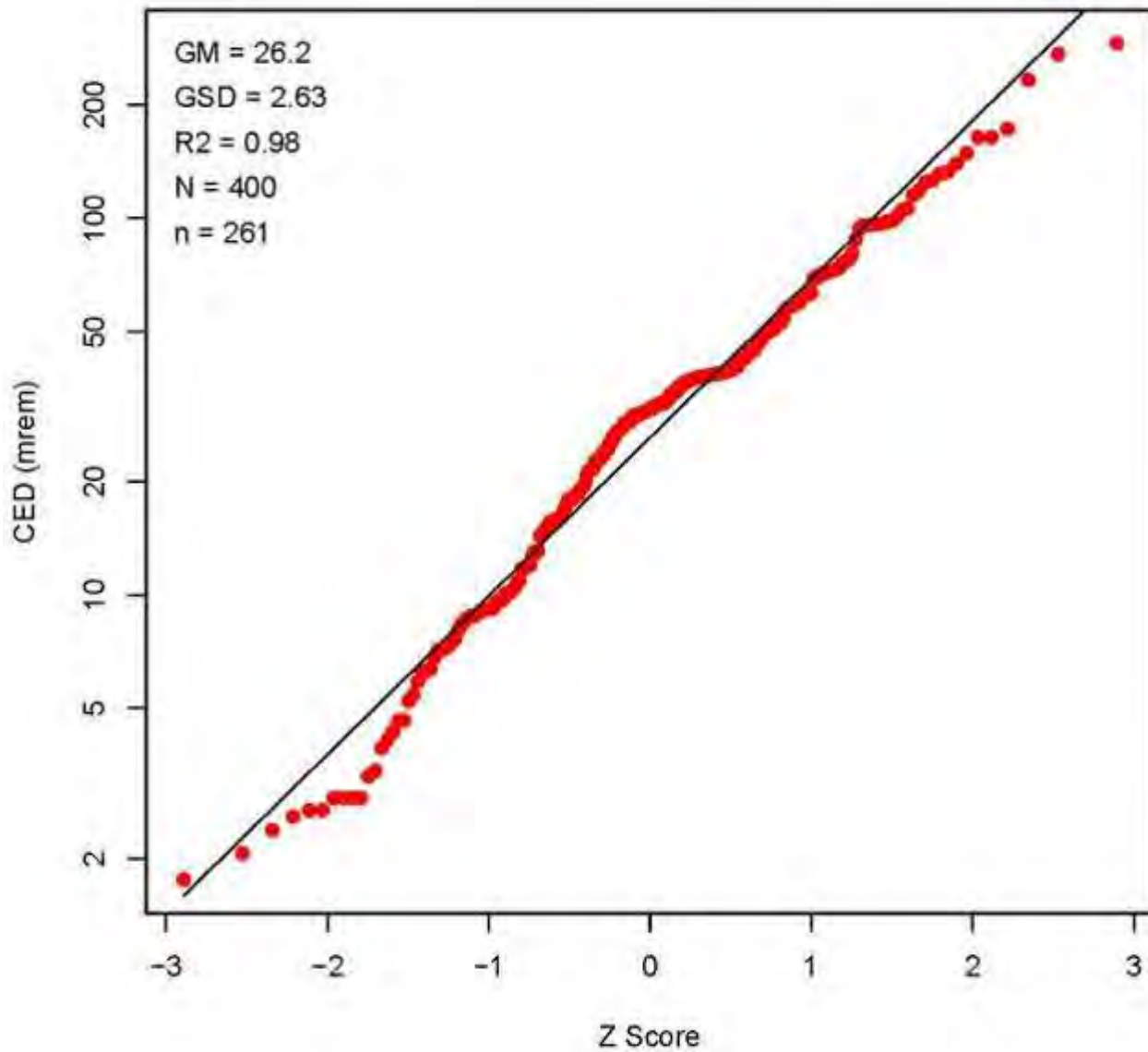


Figure A-19. SRS NCTW tritium dose 1958.

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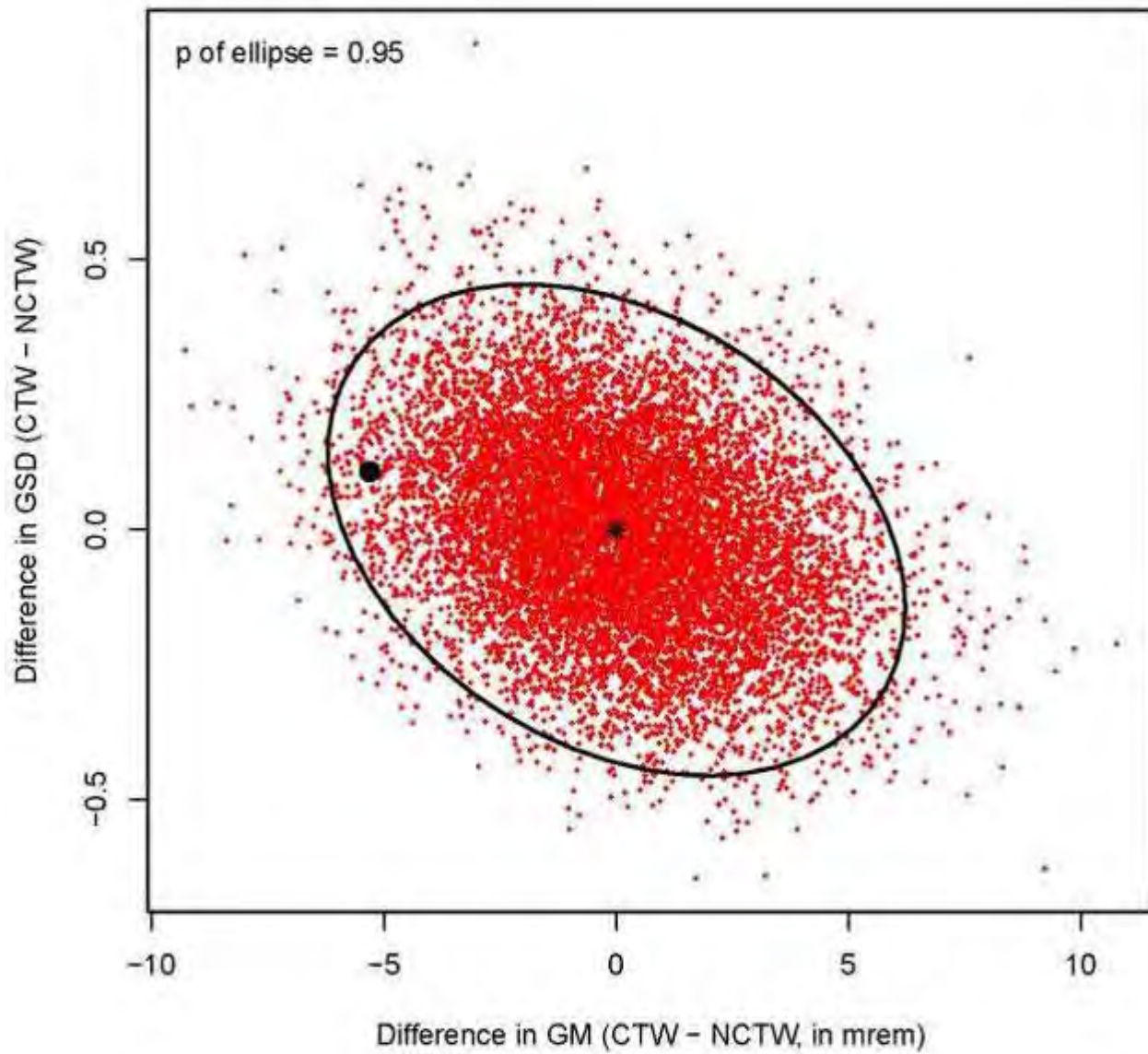


Figure A-20. SRS tritium dose 1958.

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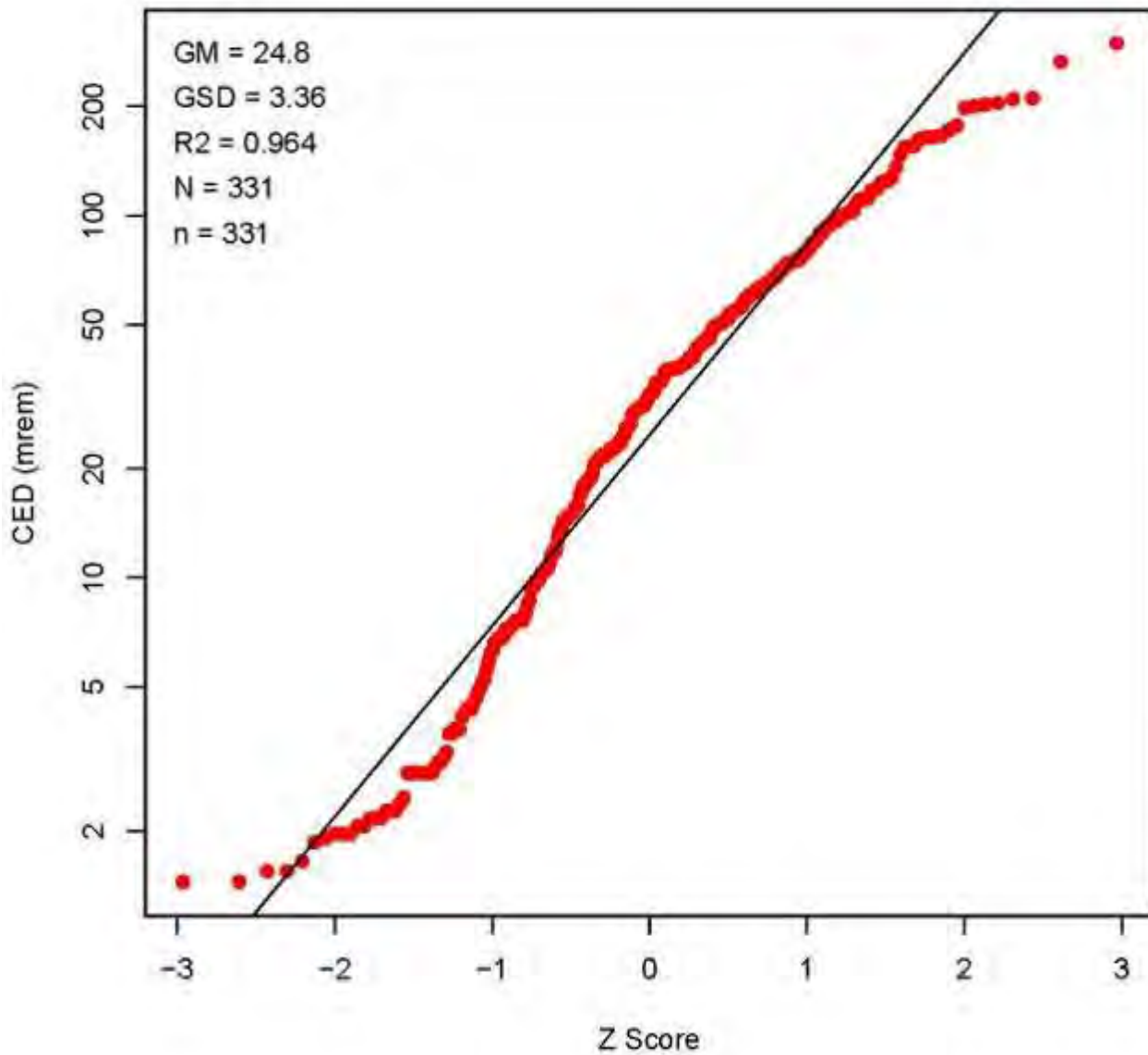


Figure A-21. SRS tritium dose 1959.

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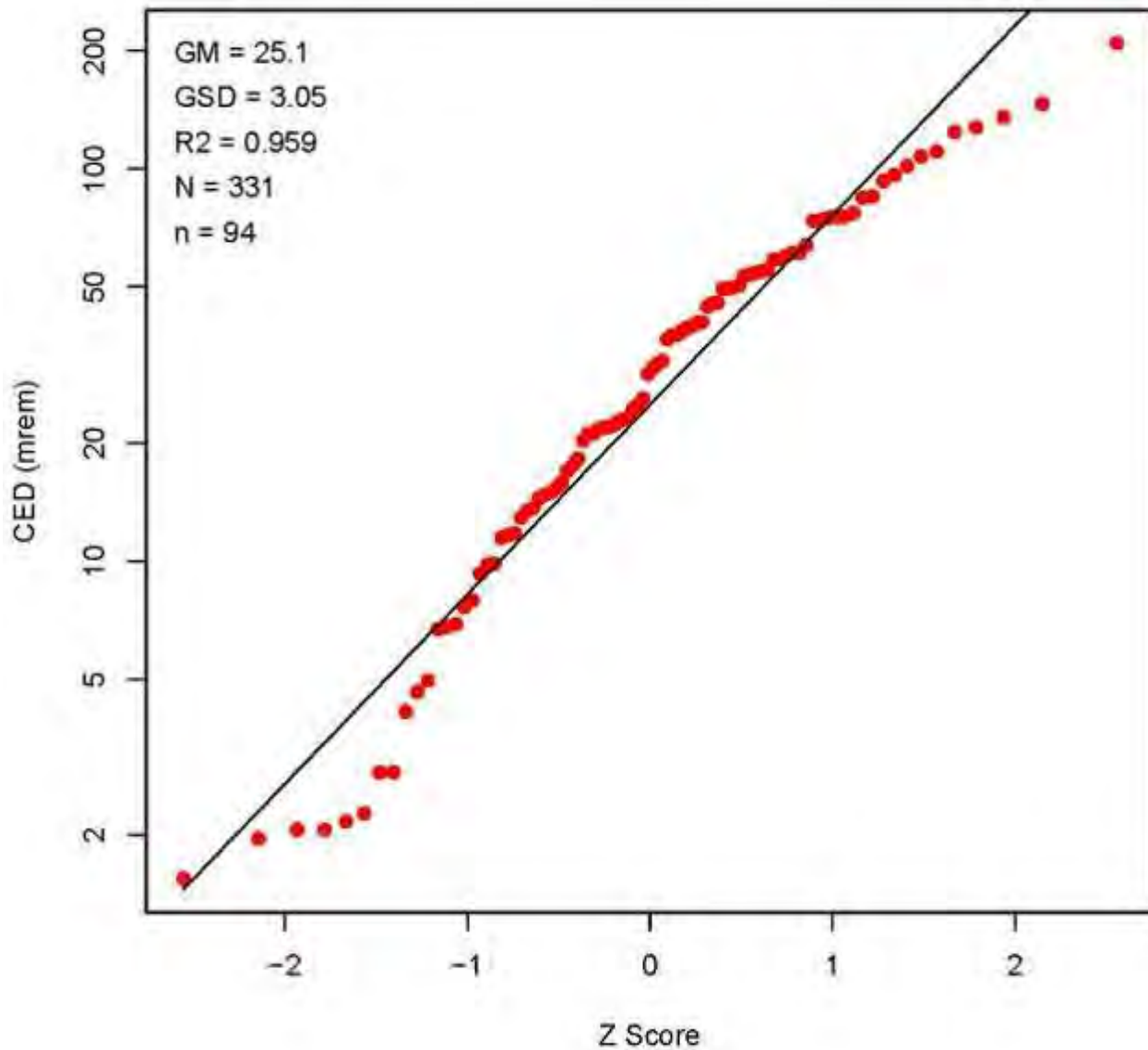


Figure A-22. SRS CTW tritium dose 1959.

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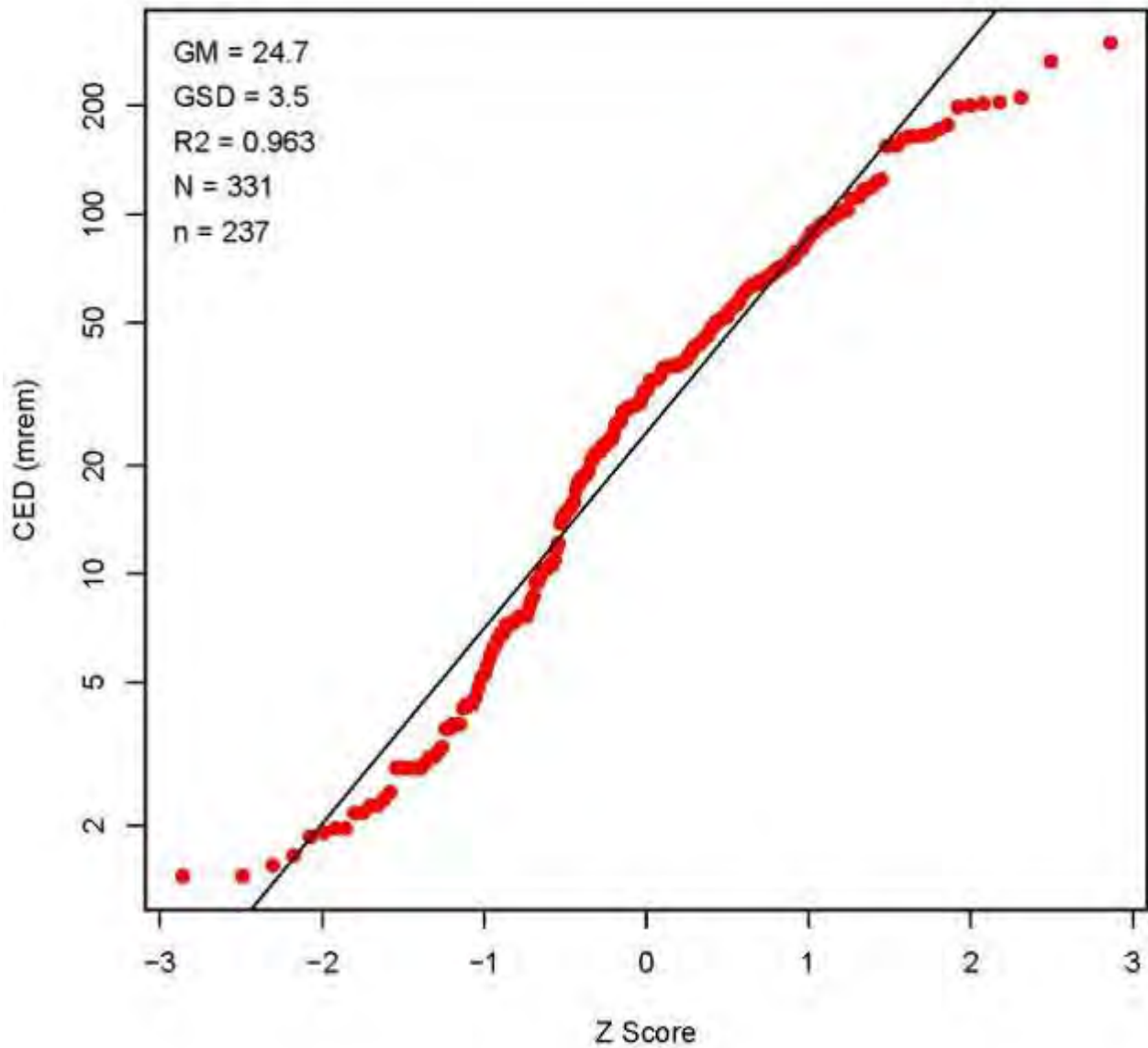


Figure A-23. SRS NCTW tritium dose 1959.

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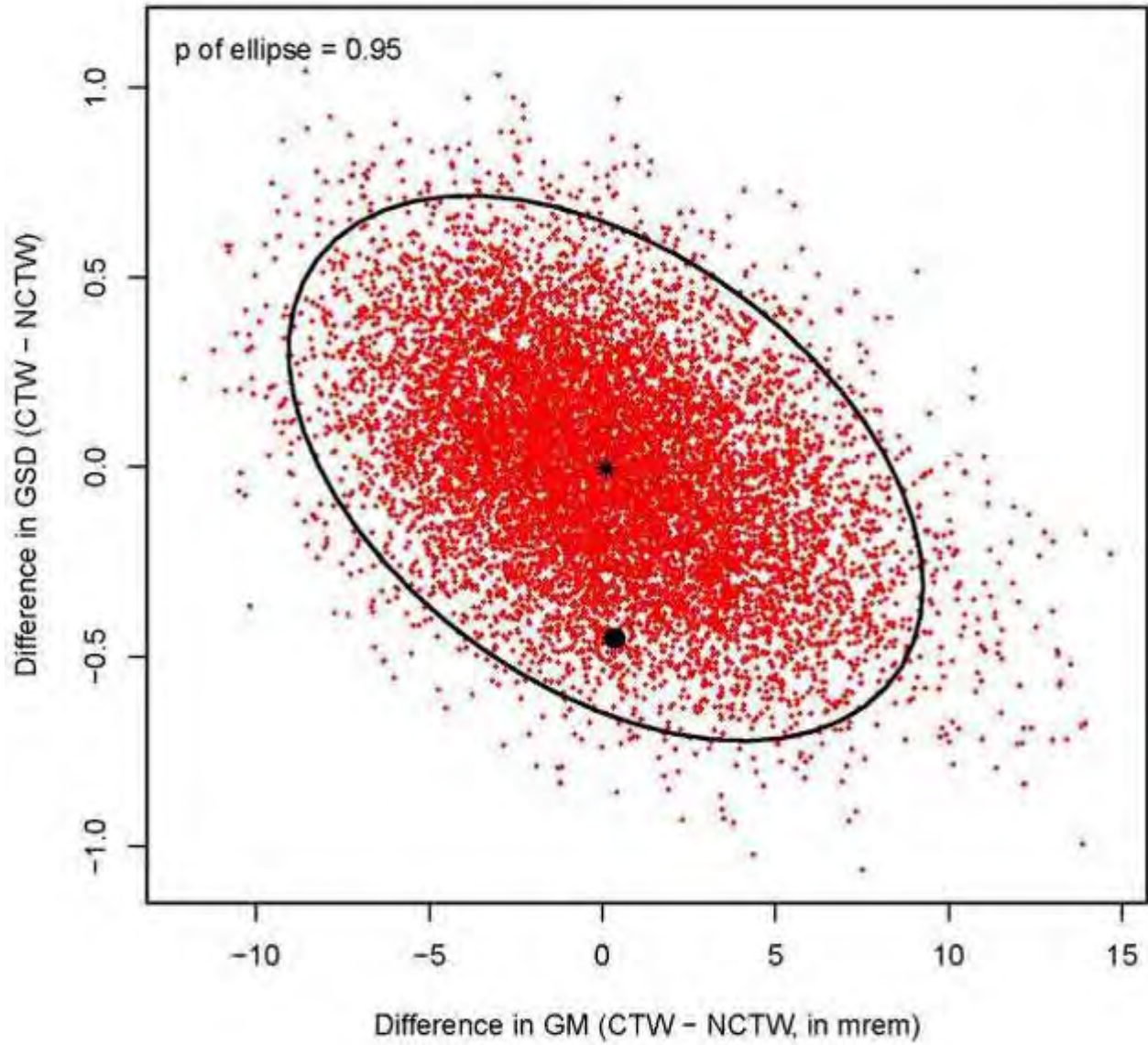


Figure A-24. SRS tritium dose 1959.

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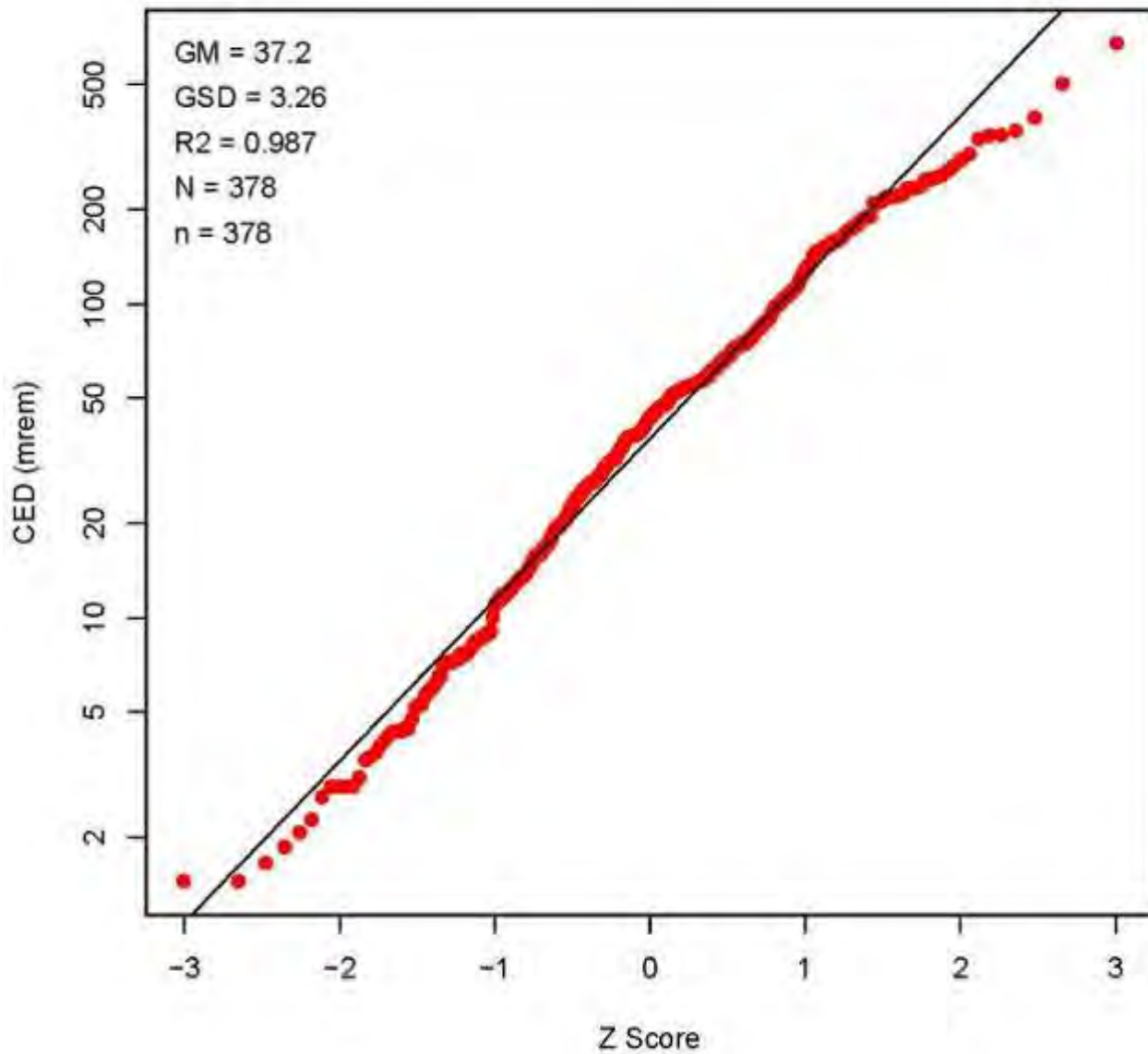


Figure A-25. SRS tritium dose 1960.

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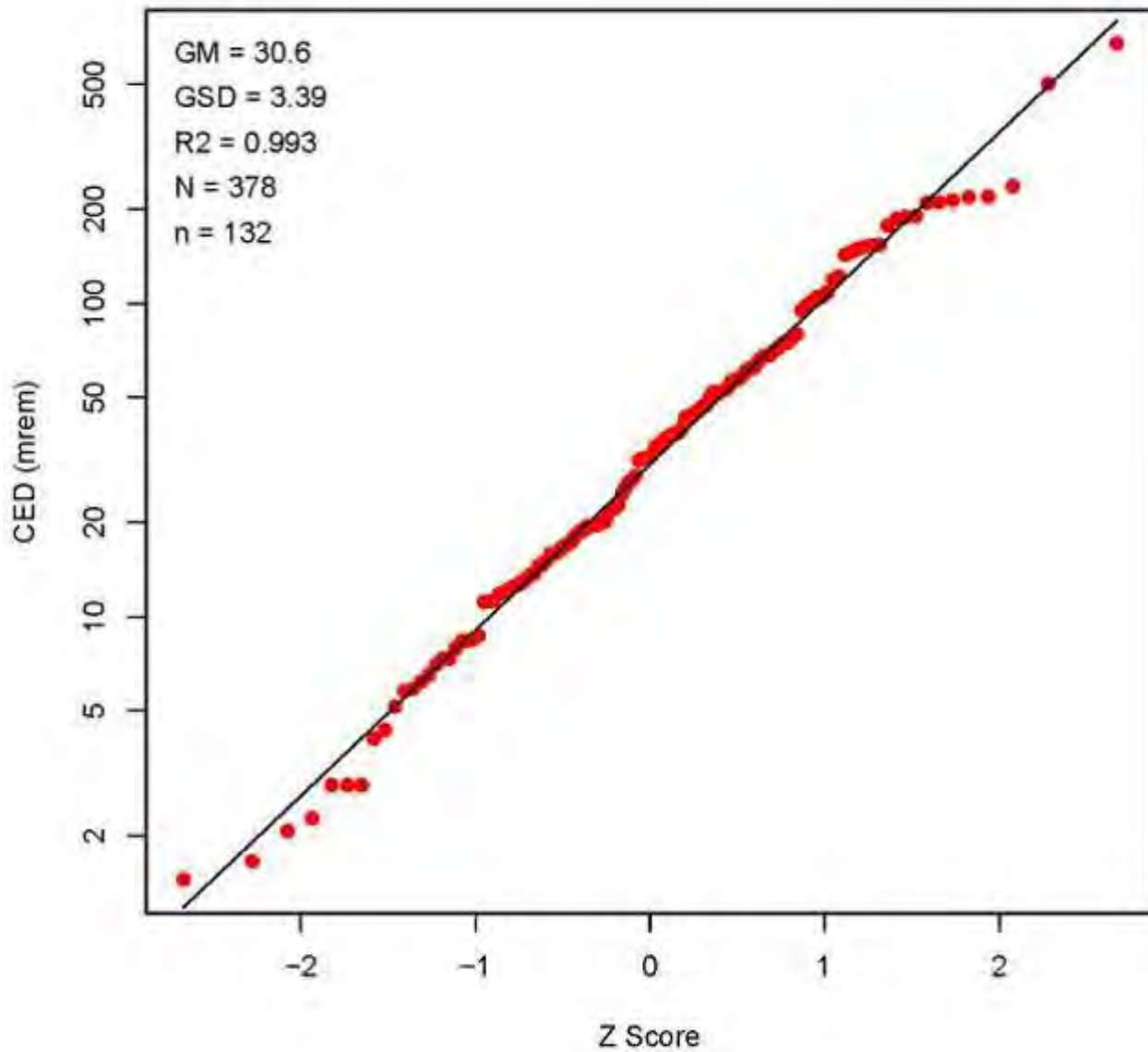


Figure A-26. SRS CTW tritium dose 1960.

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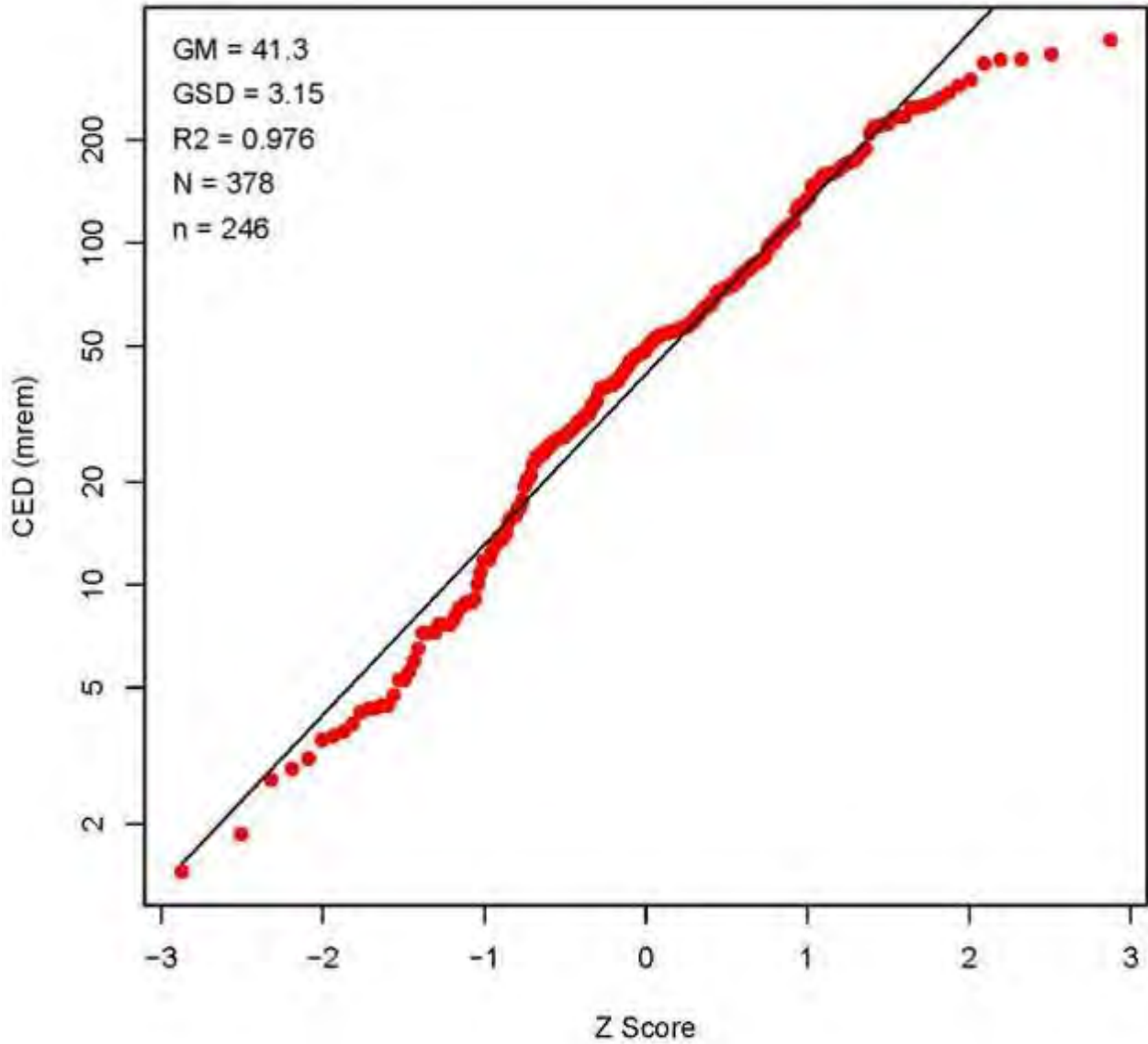


Figure A-27. SRS NCTW tritium dose 1960.

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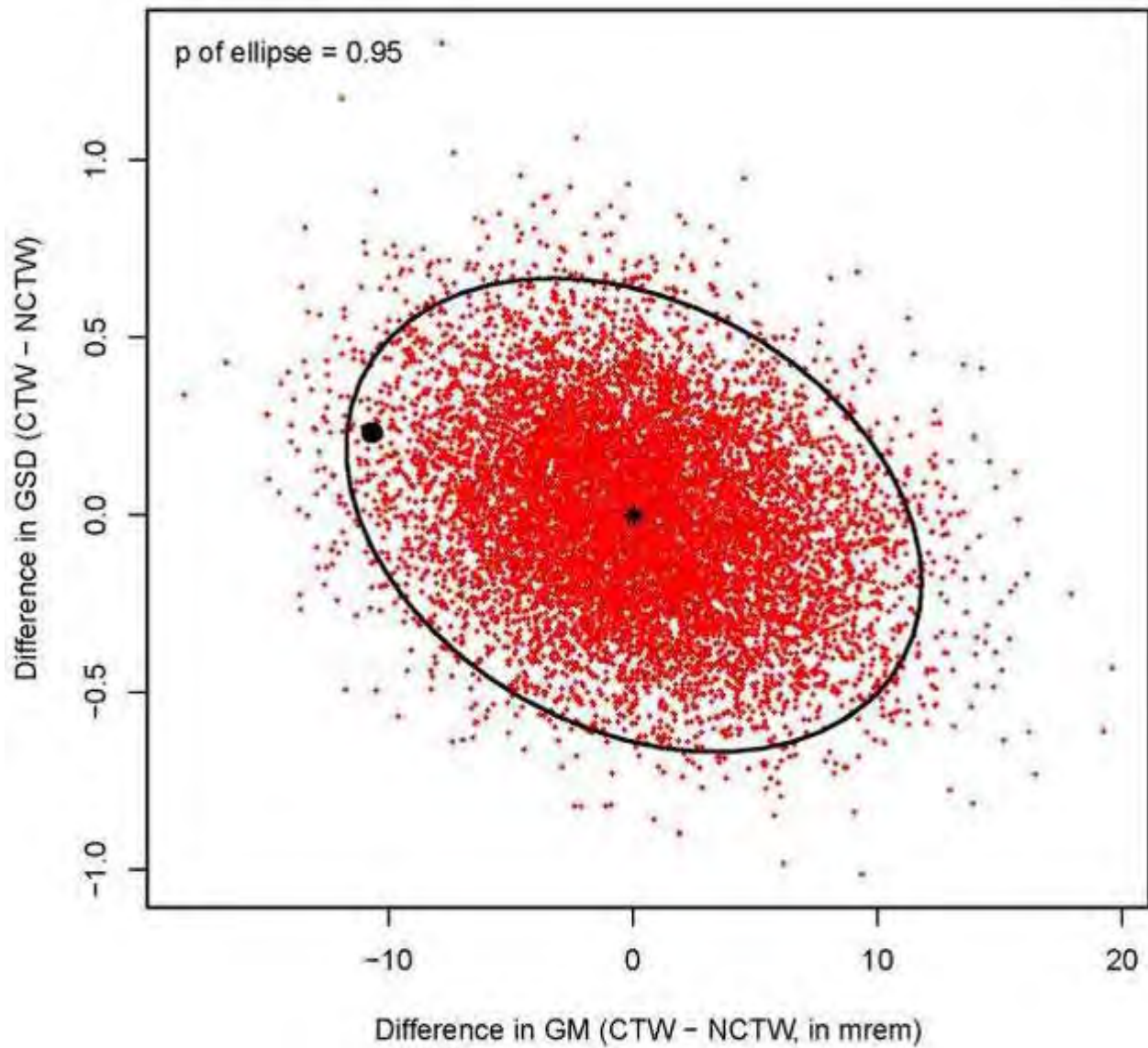


Figure A-28. SRS tritium dose 1960.

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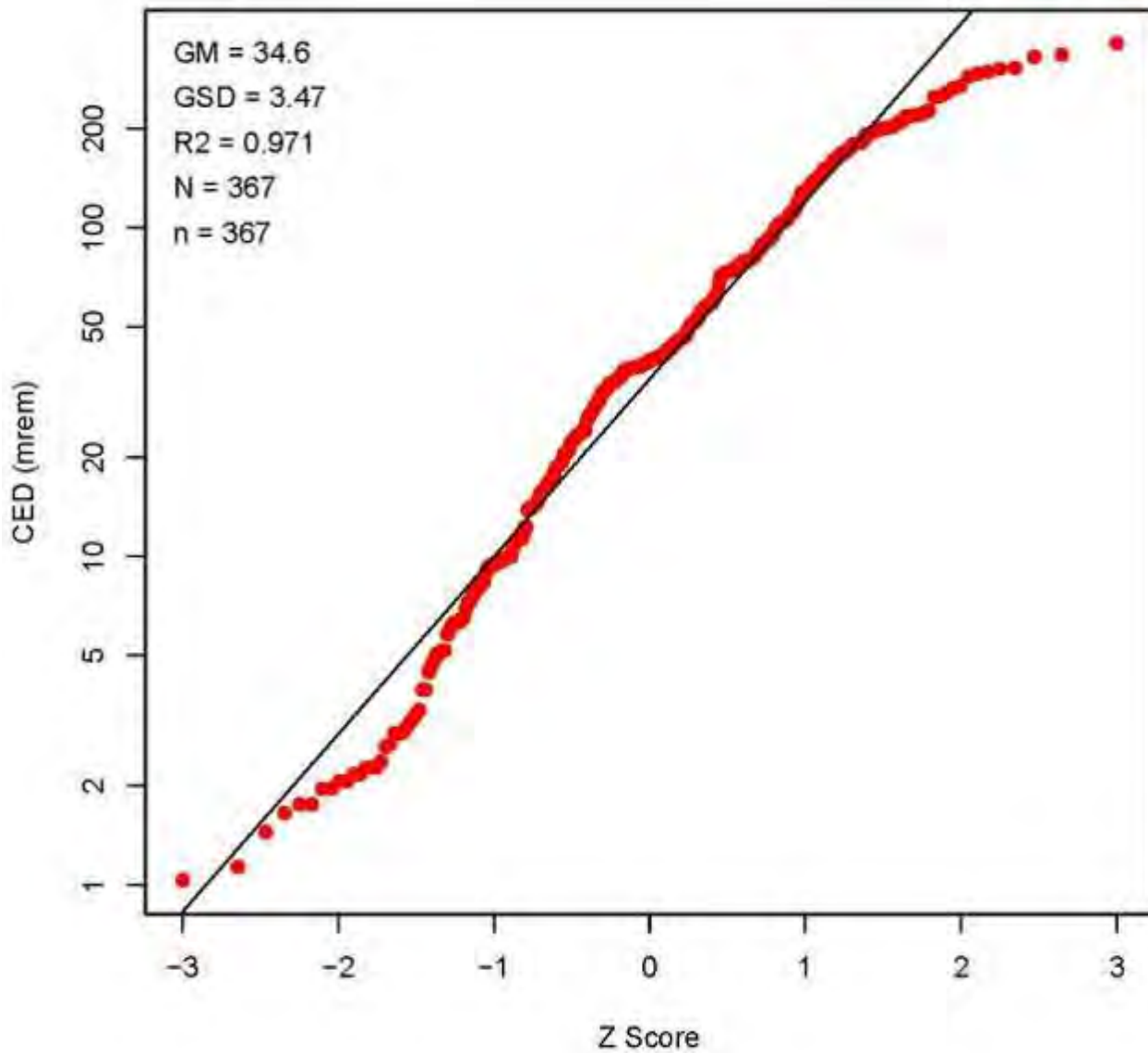


Figure A-29. SRS tritium dose 1961.

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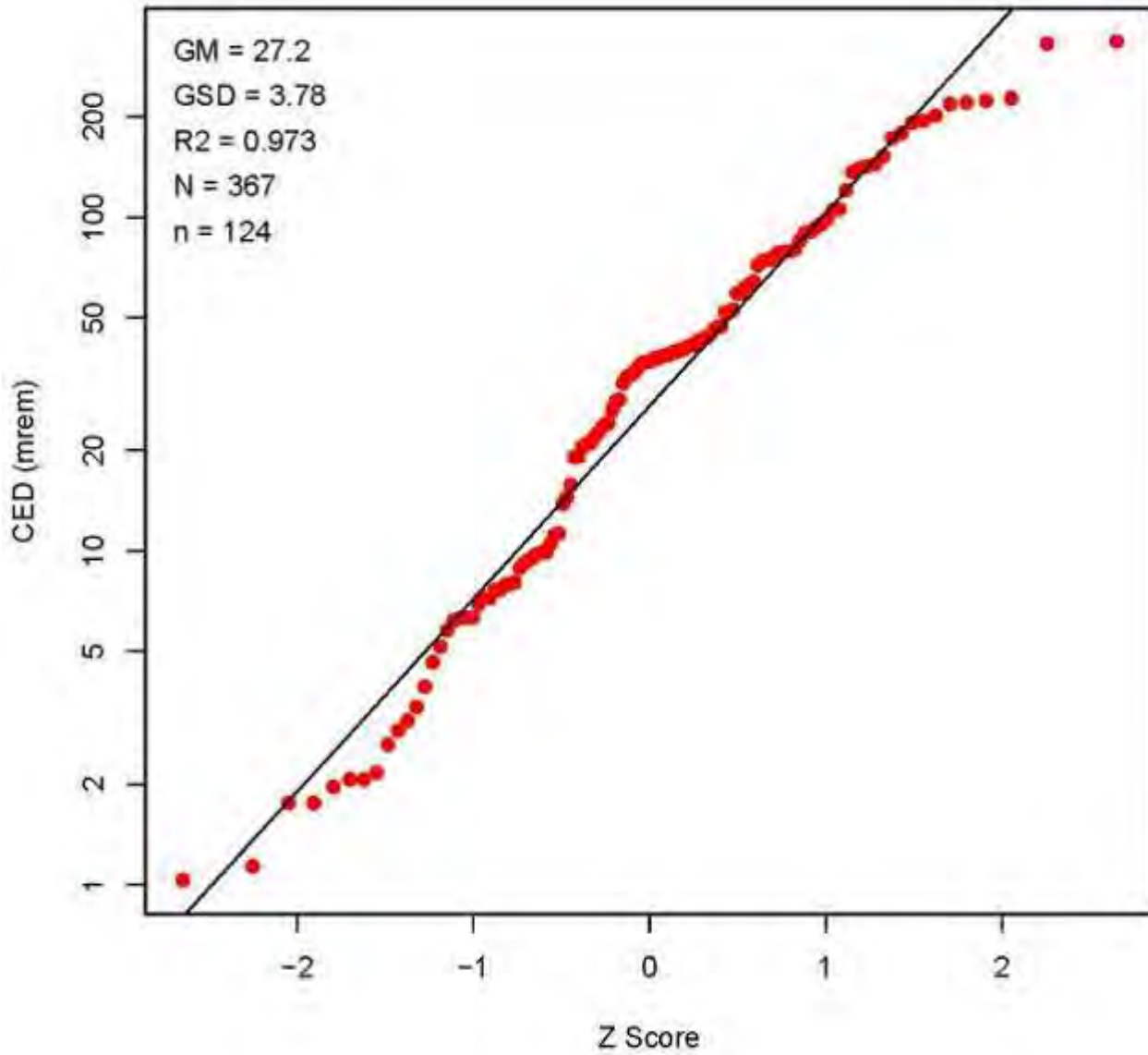


Figure A-30. SRS CTW tritium dose 1961.

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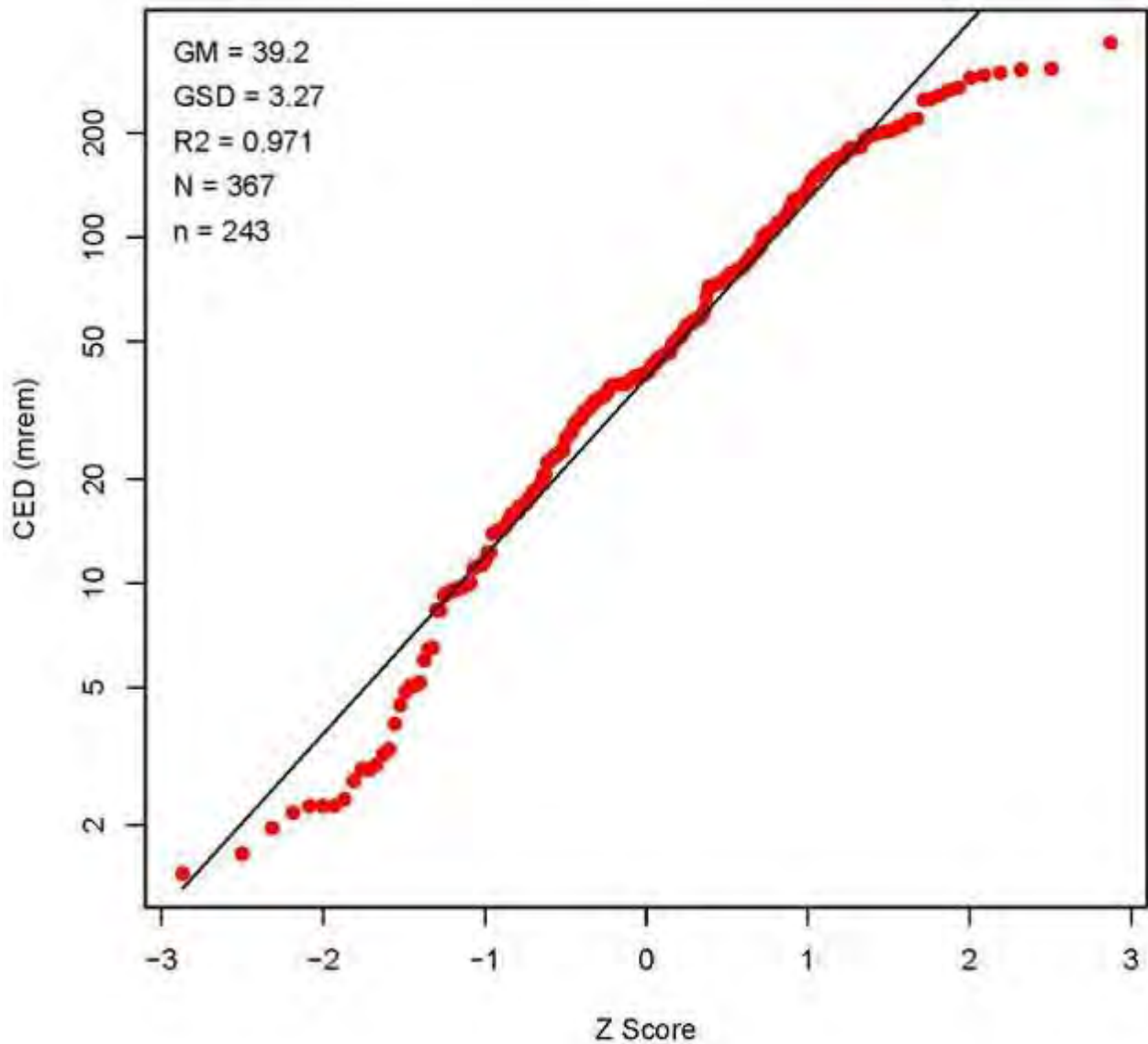


Figure A-31. SRS NCTW tritium dose 1961.

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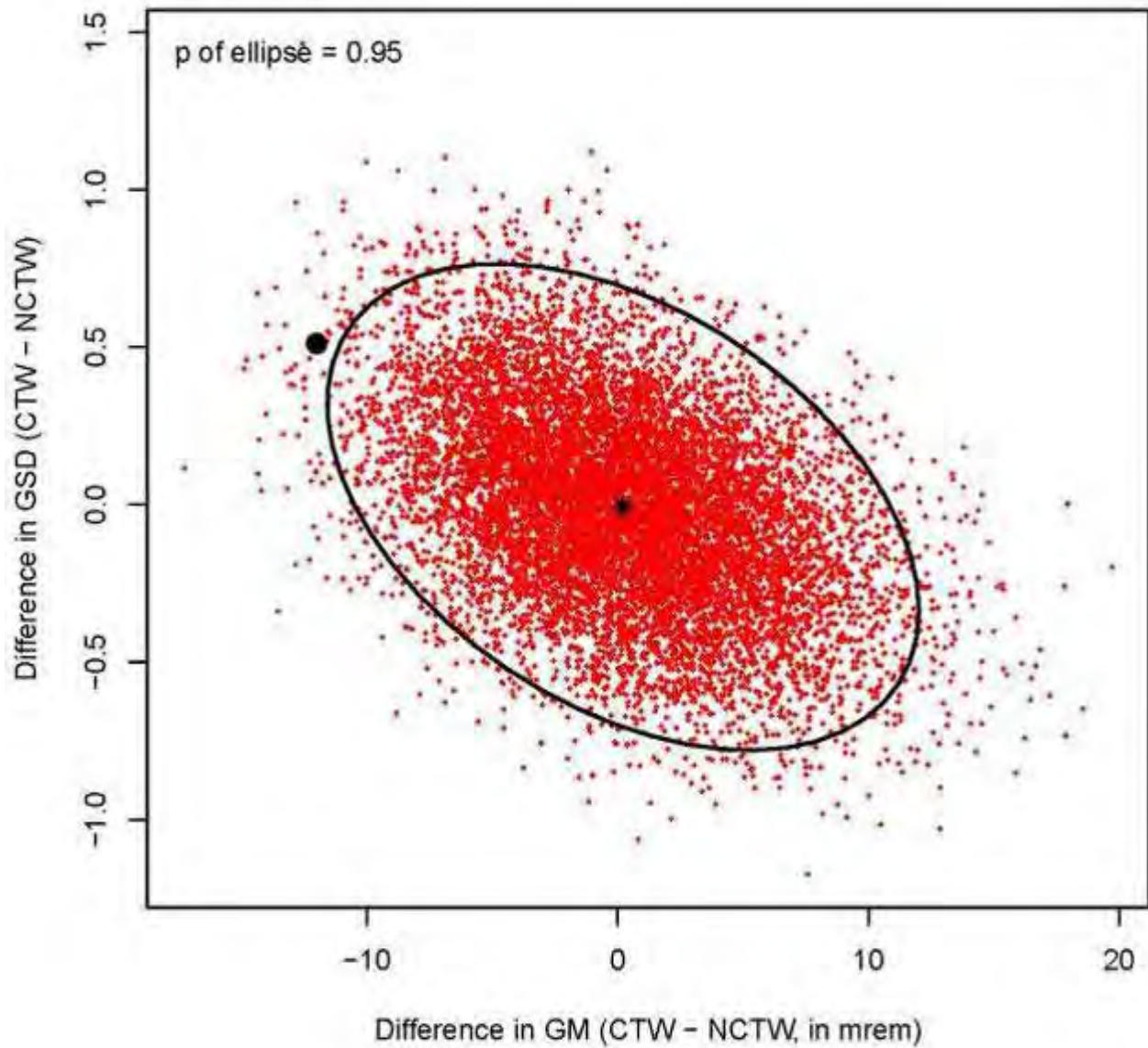


Figure A-32. SRS tritium dose 1961.

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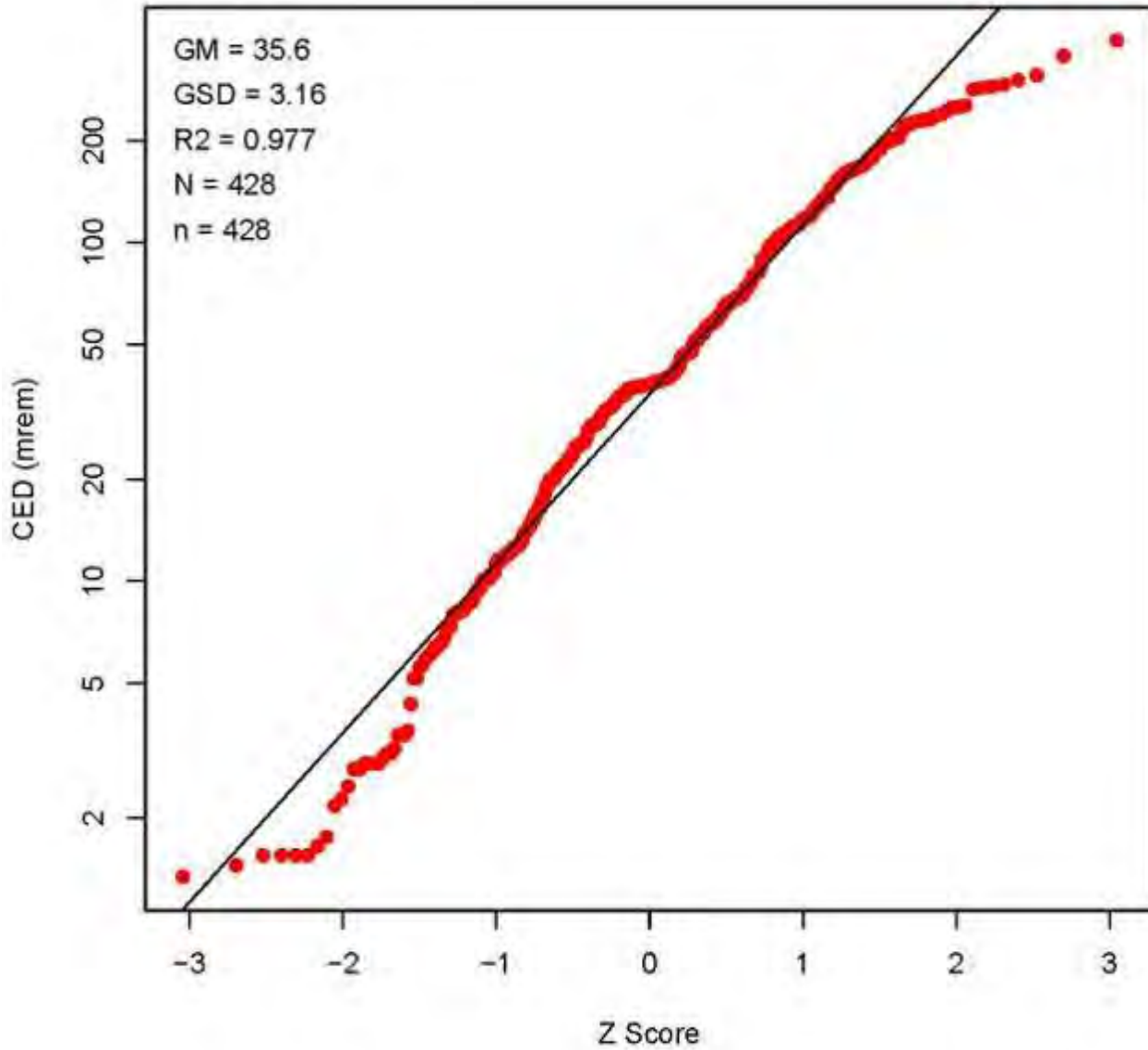


Figure A-33. SRS tritium dose 1962.

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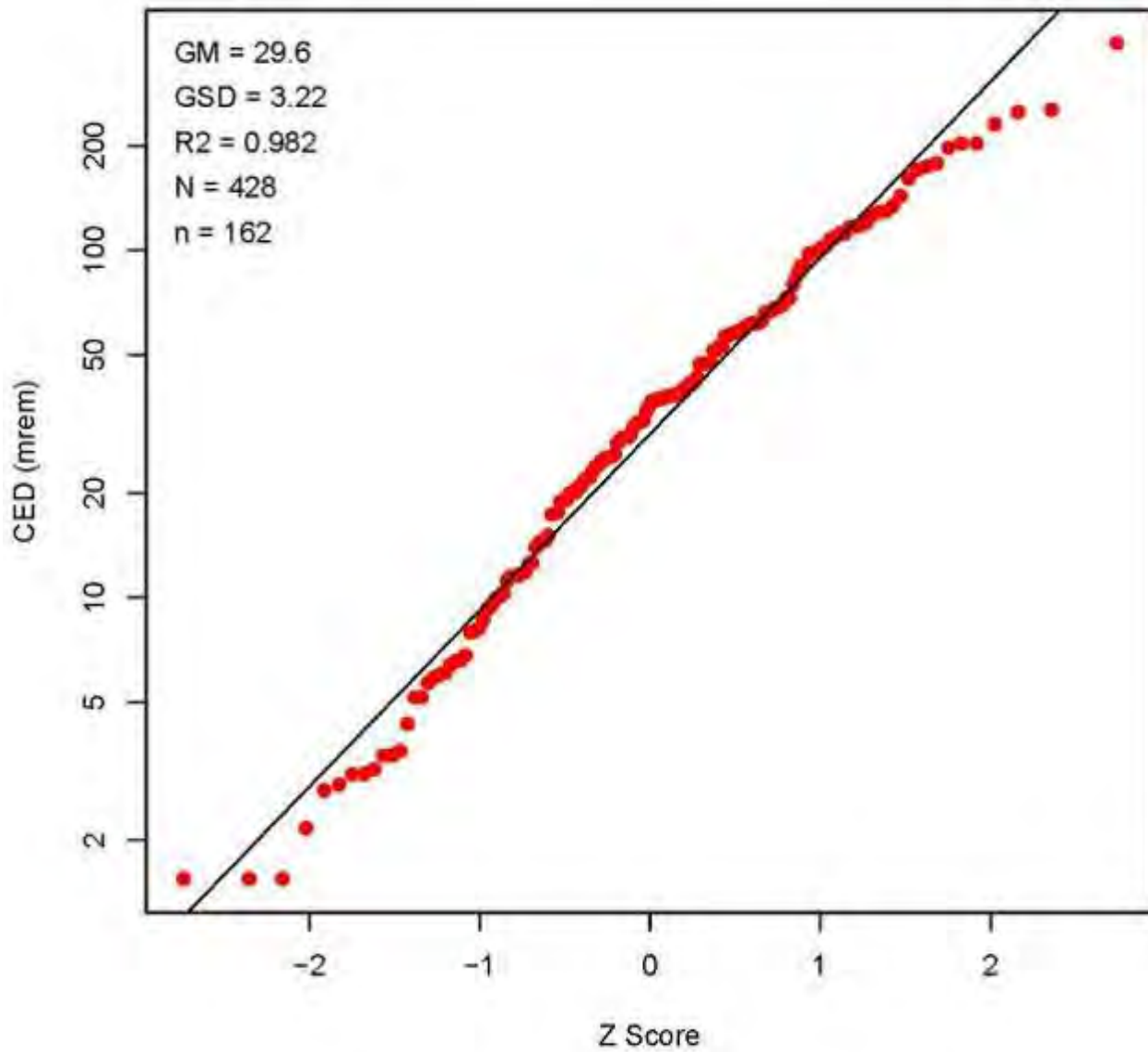


Figure A-34. SRS CTW tritium dose 1962.

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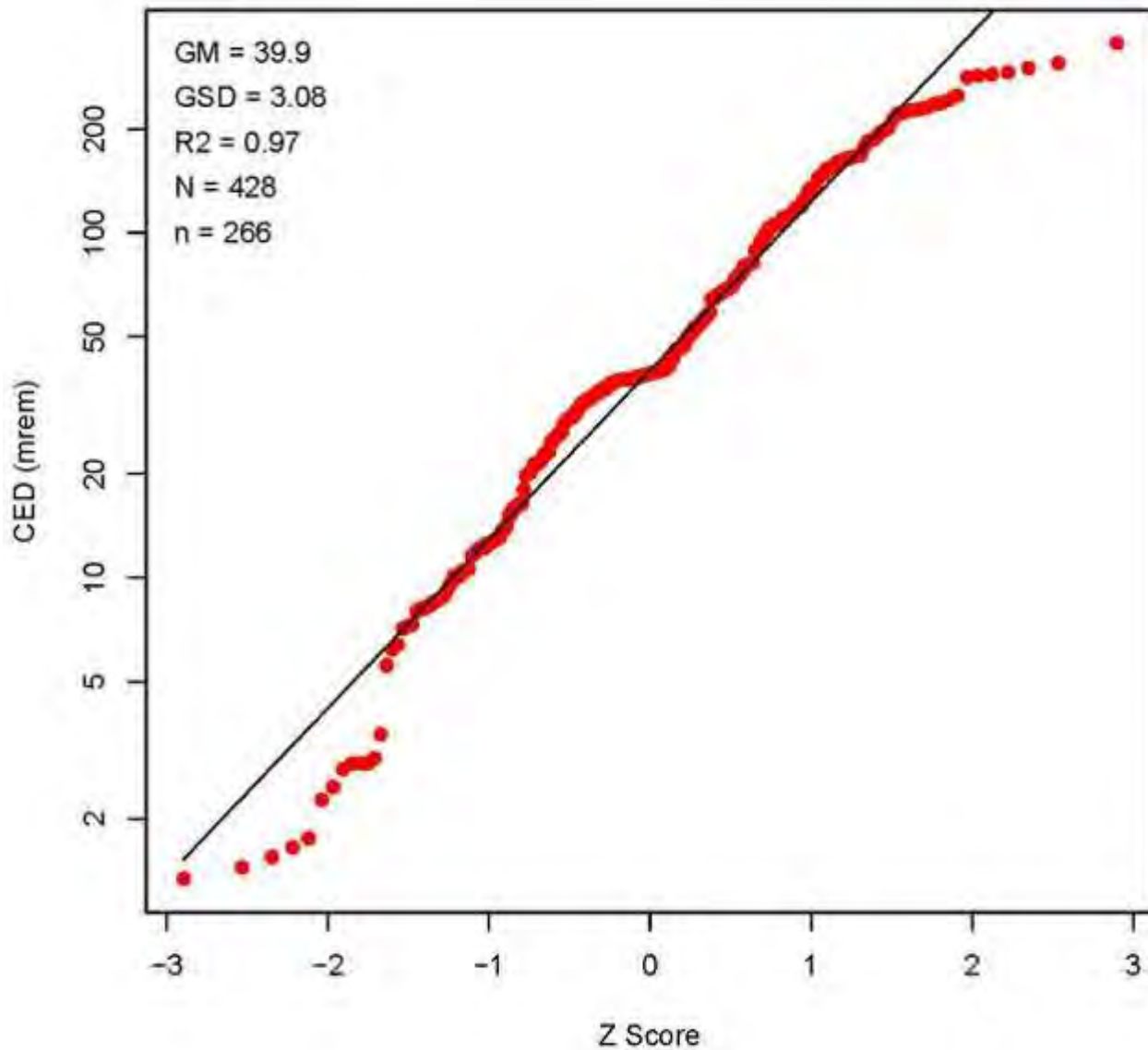


Figure A-35. SRS NCTW tritium dose 1962.

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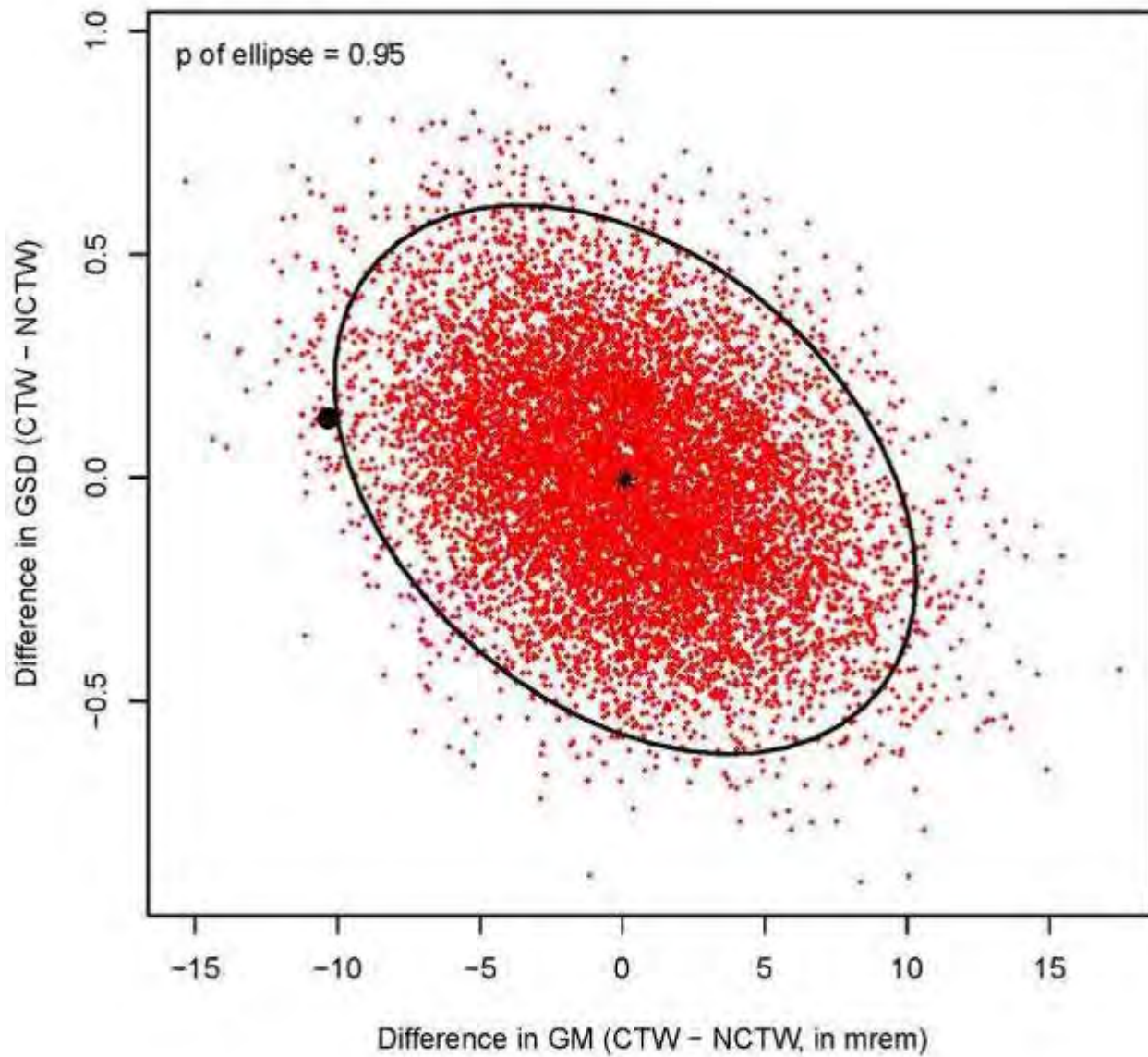


Figure A-36. SRS tritium dose 1962.

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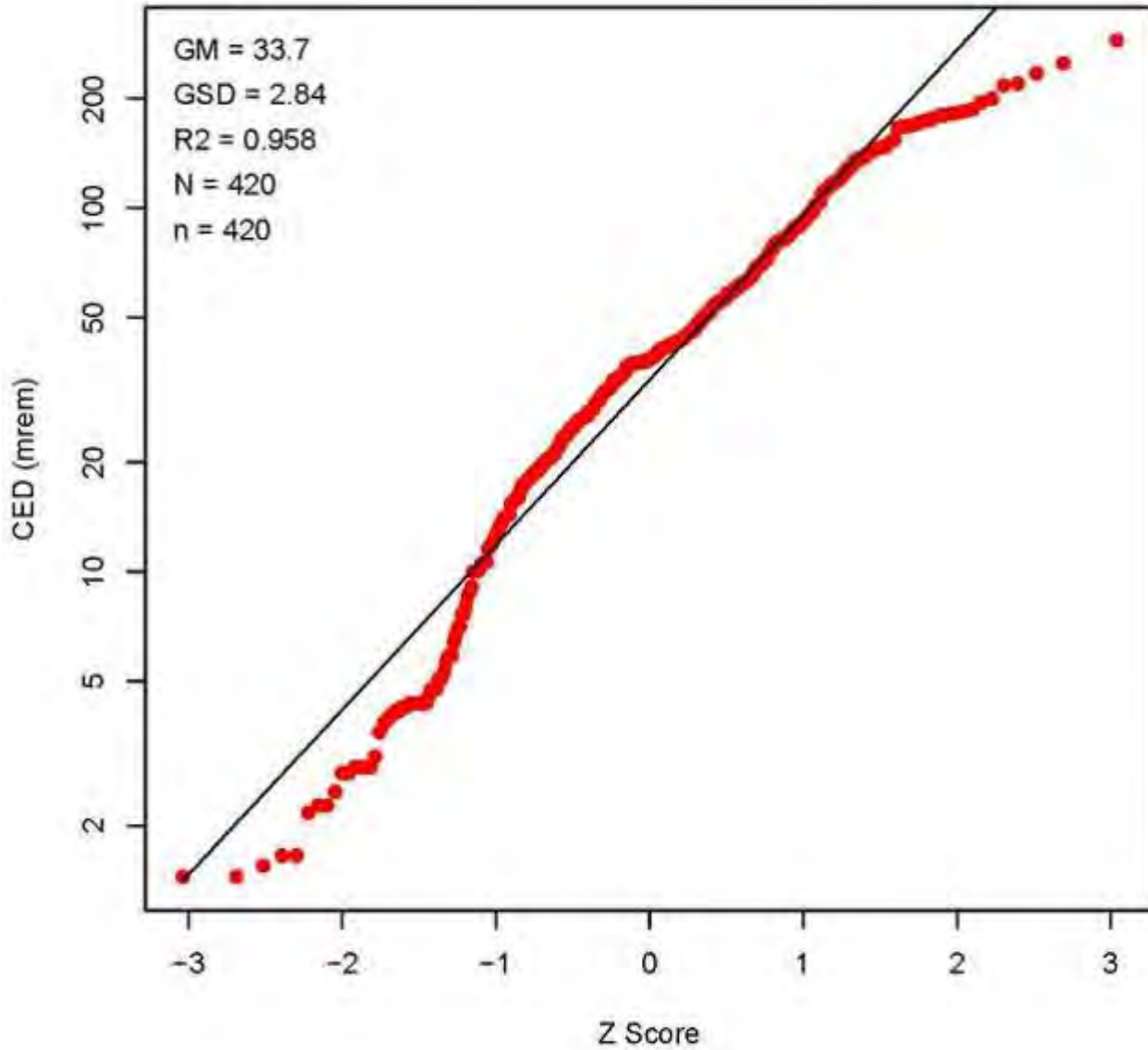


Figure A-37. SRS tritium dose 1963.

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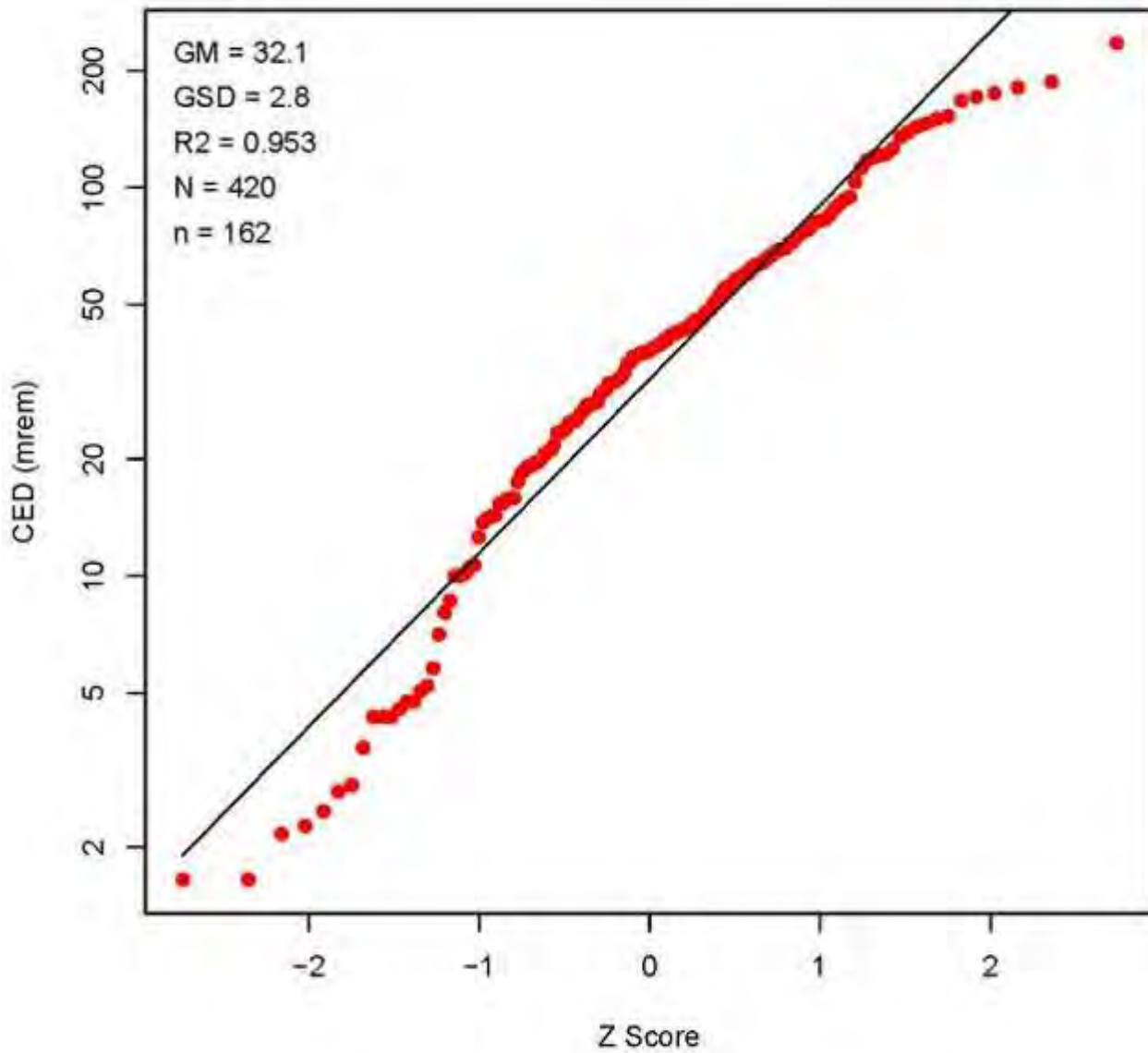


Figure A-38. SRS CTW tritium dose 1963.

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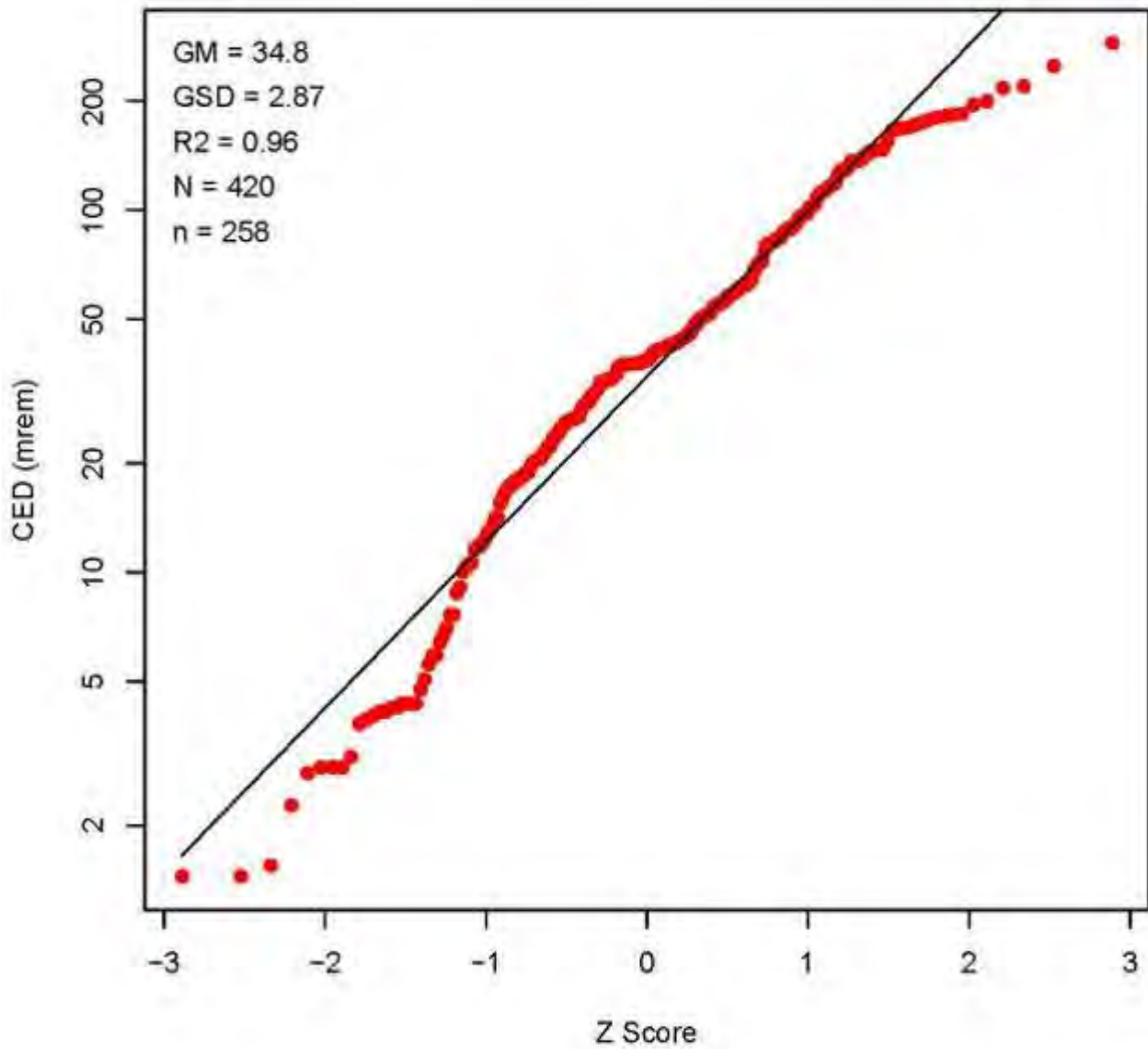


Figure A-39. SRS NCTW tritium dose 1963.

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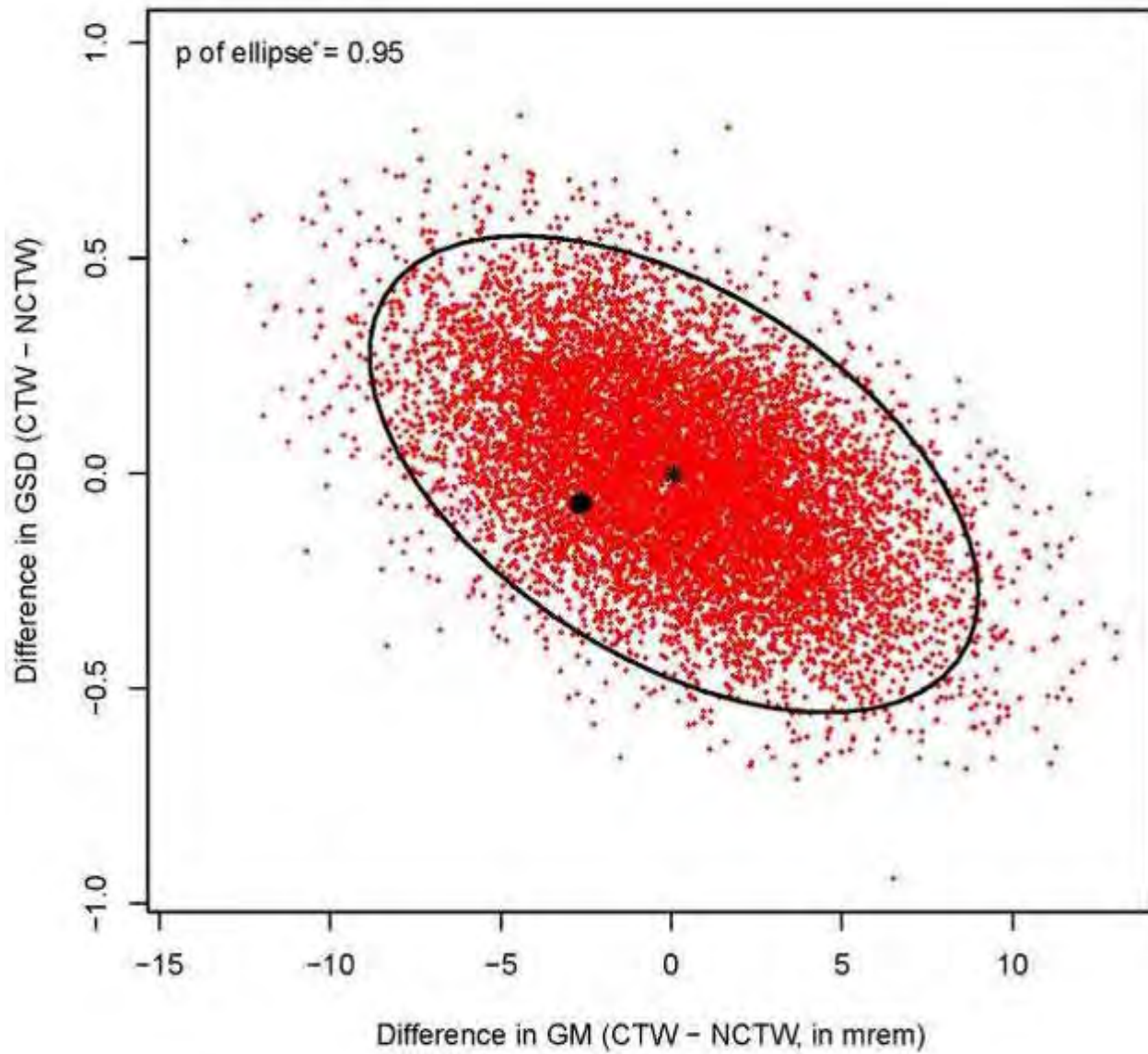


Figure A-40. SRS tritium dose 1963.

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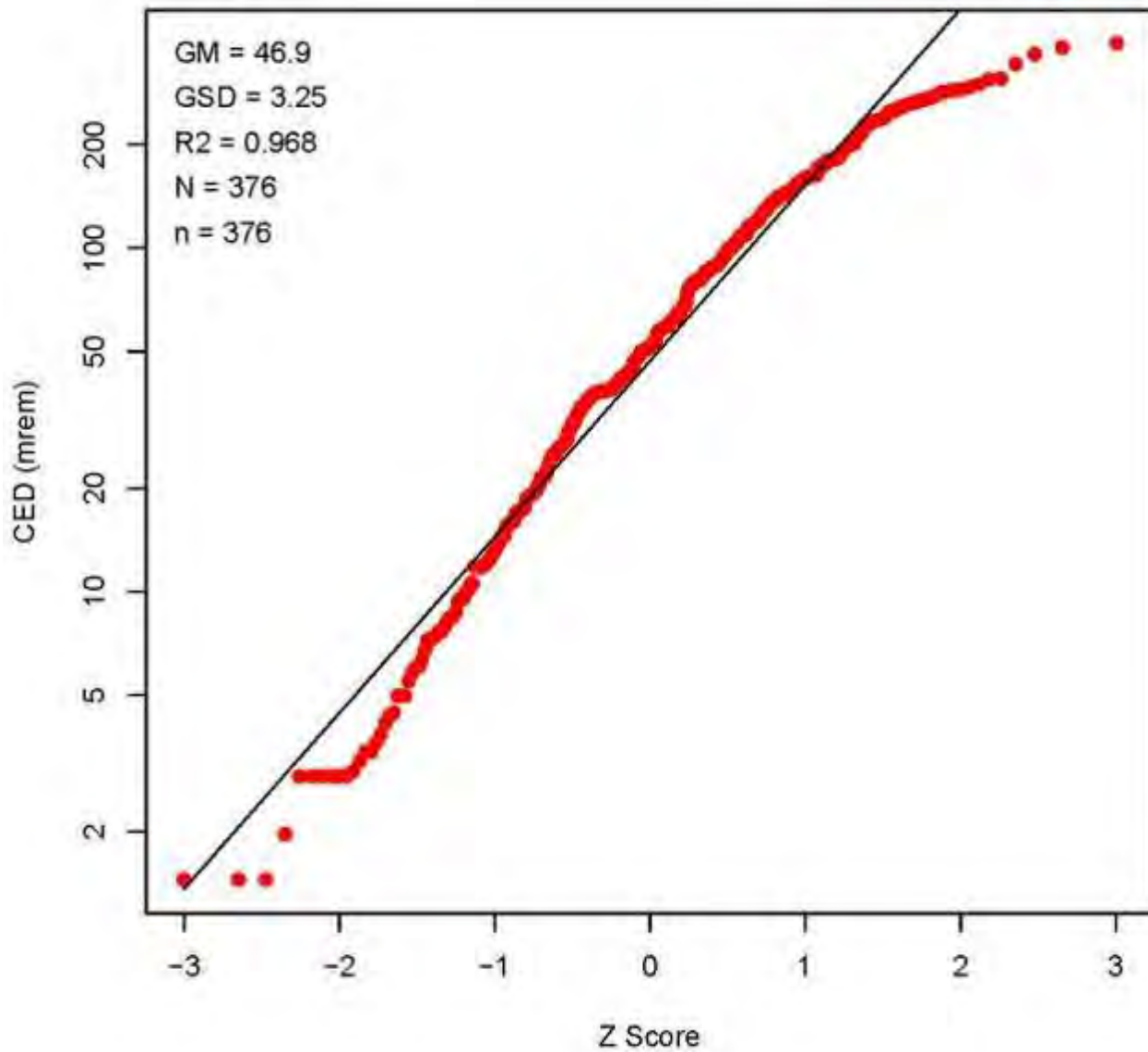


Figure A-41. SRS tritium dose 1964.

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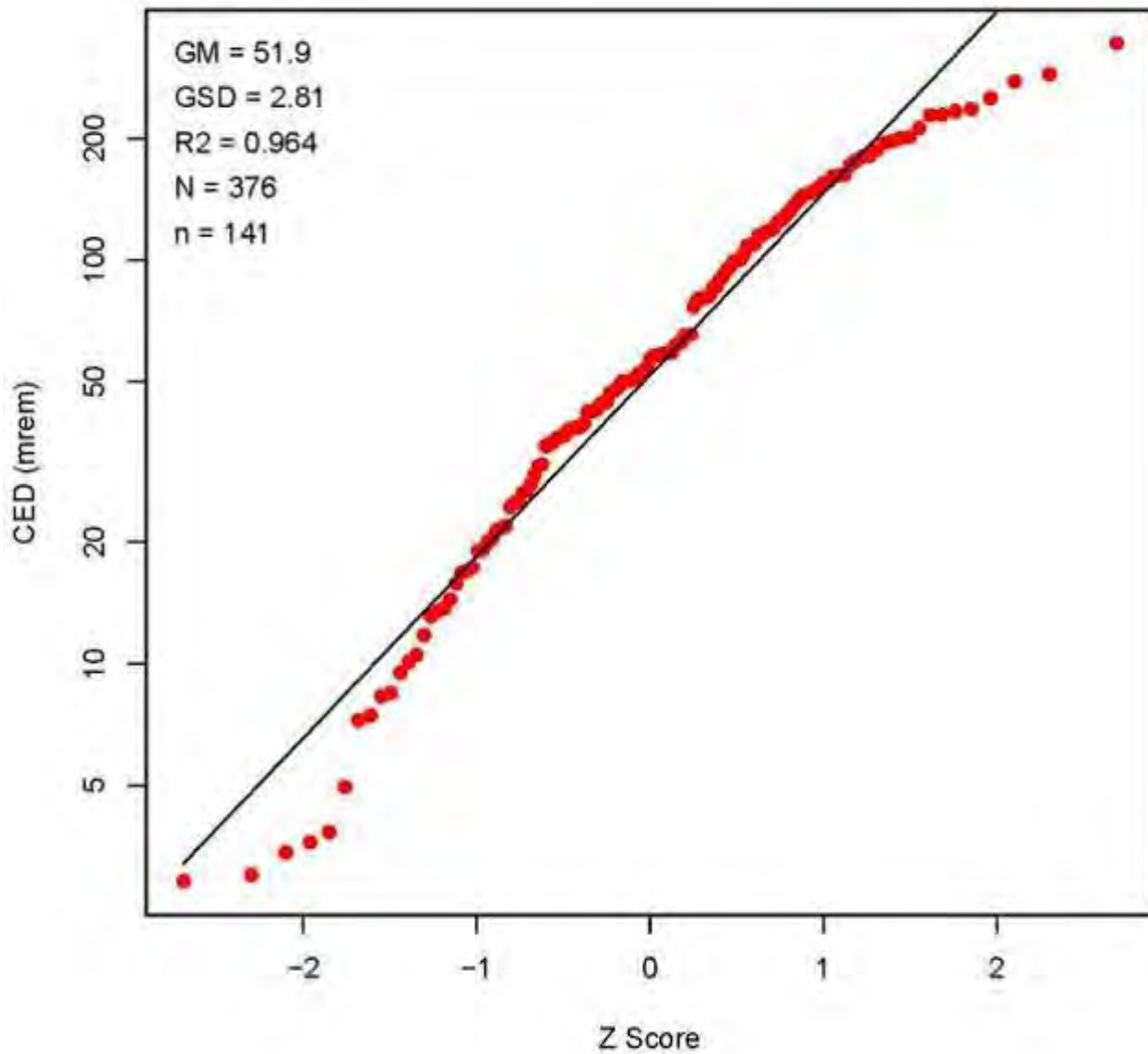


Figure A-42. SRS CTW tritium dose 1964.

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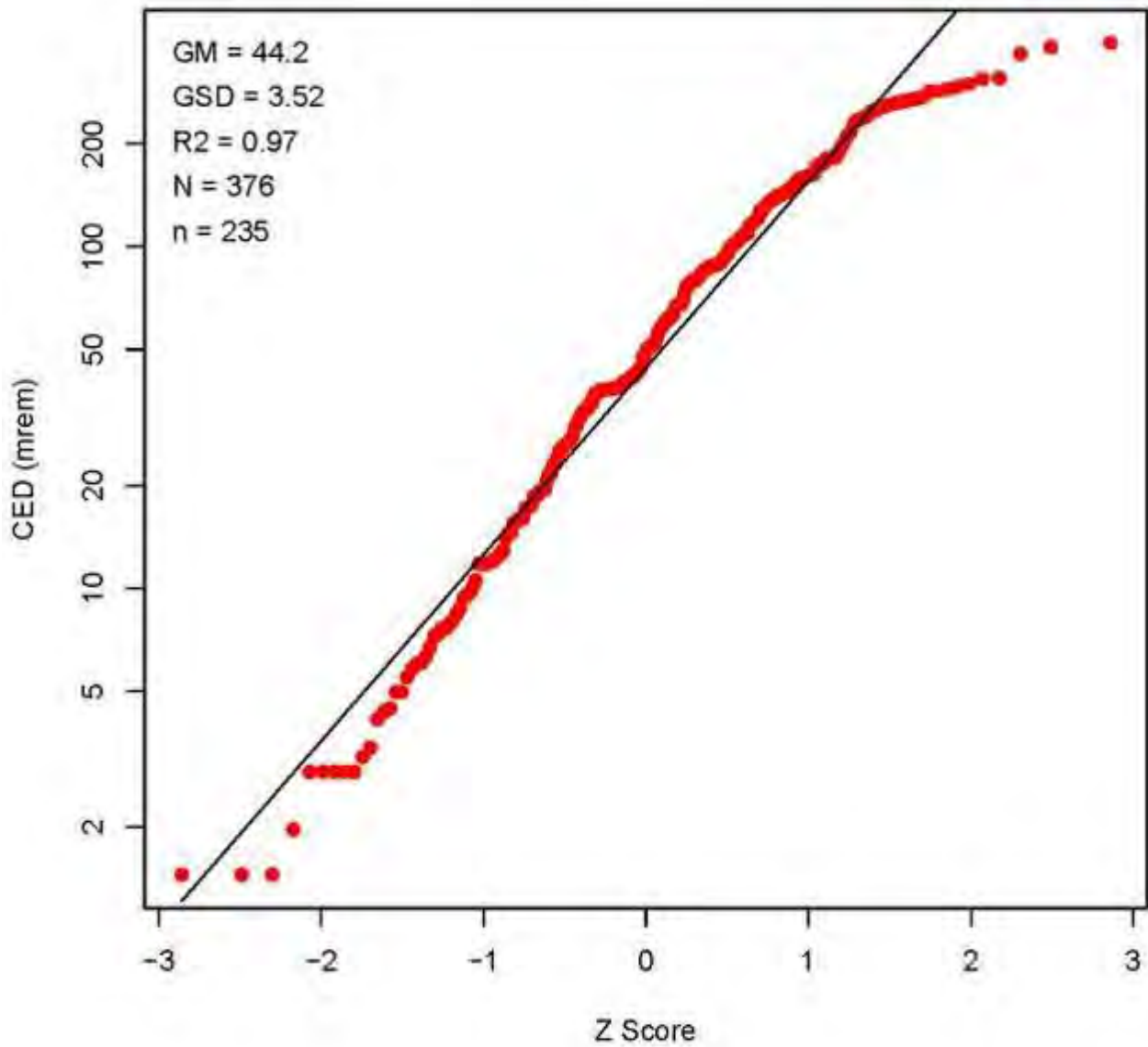


Figure A-43. SRS NCTW tritium dose 1964.

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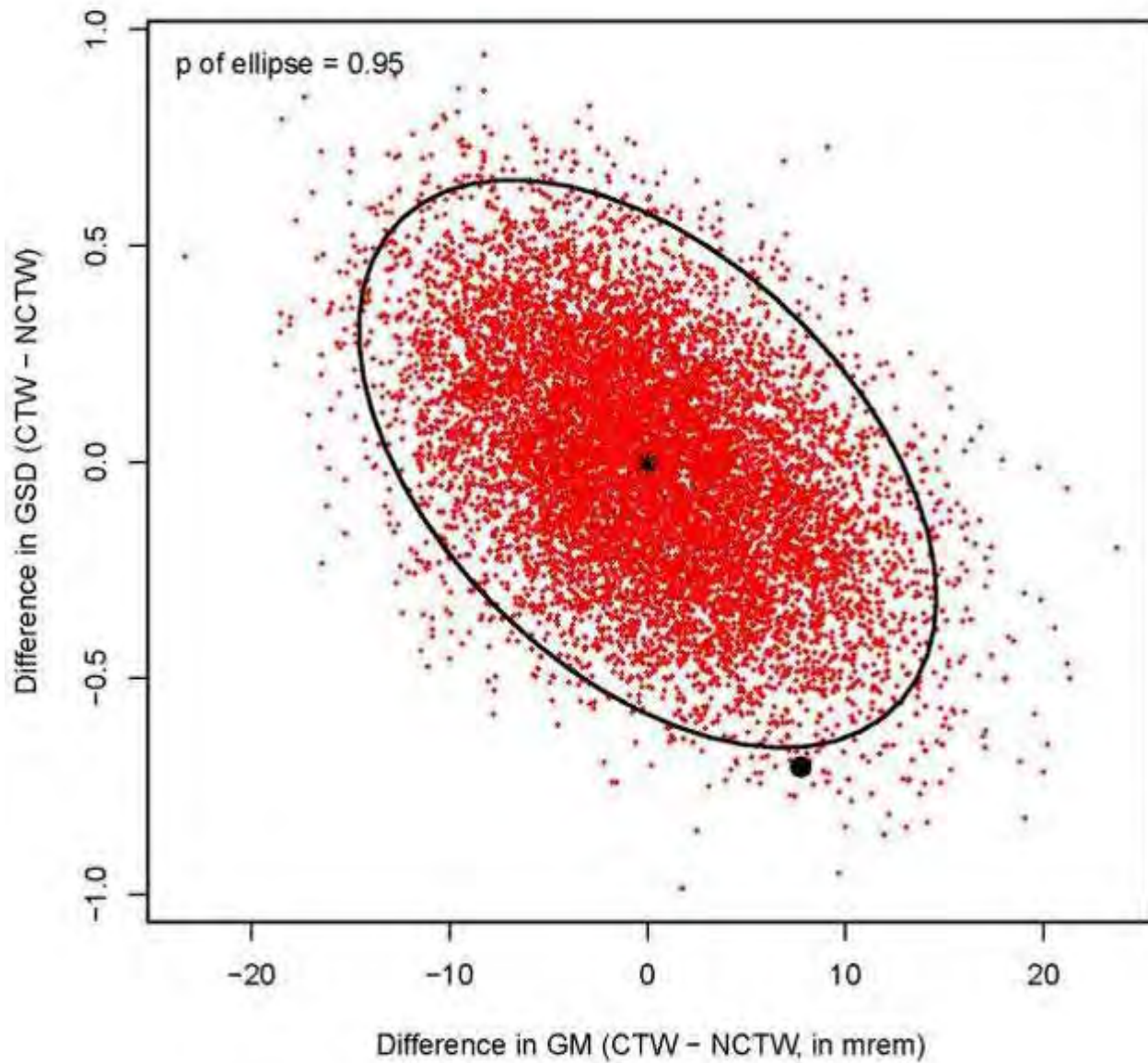


Figure A-44. SRS tritium dose 1964.

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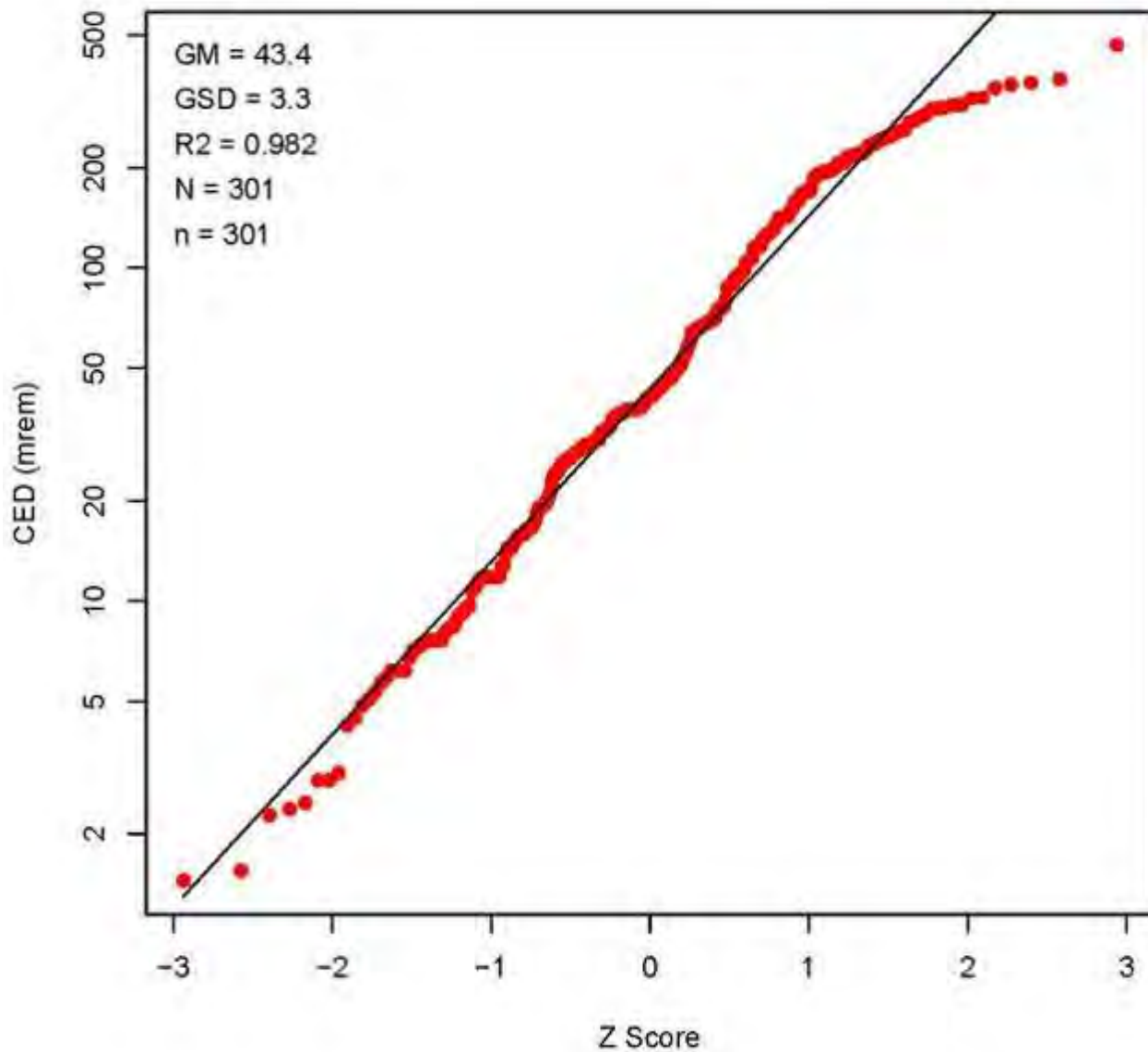


Figure A-45. SRS tritium dose 1965.

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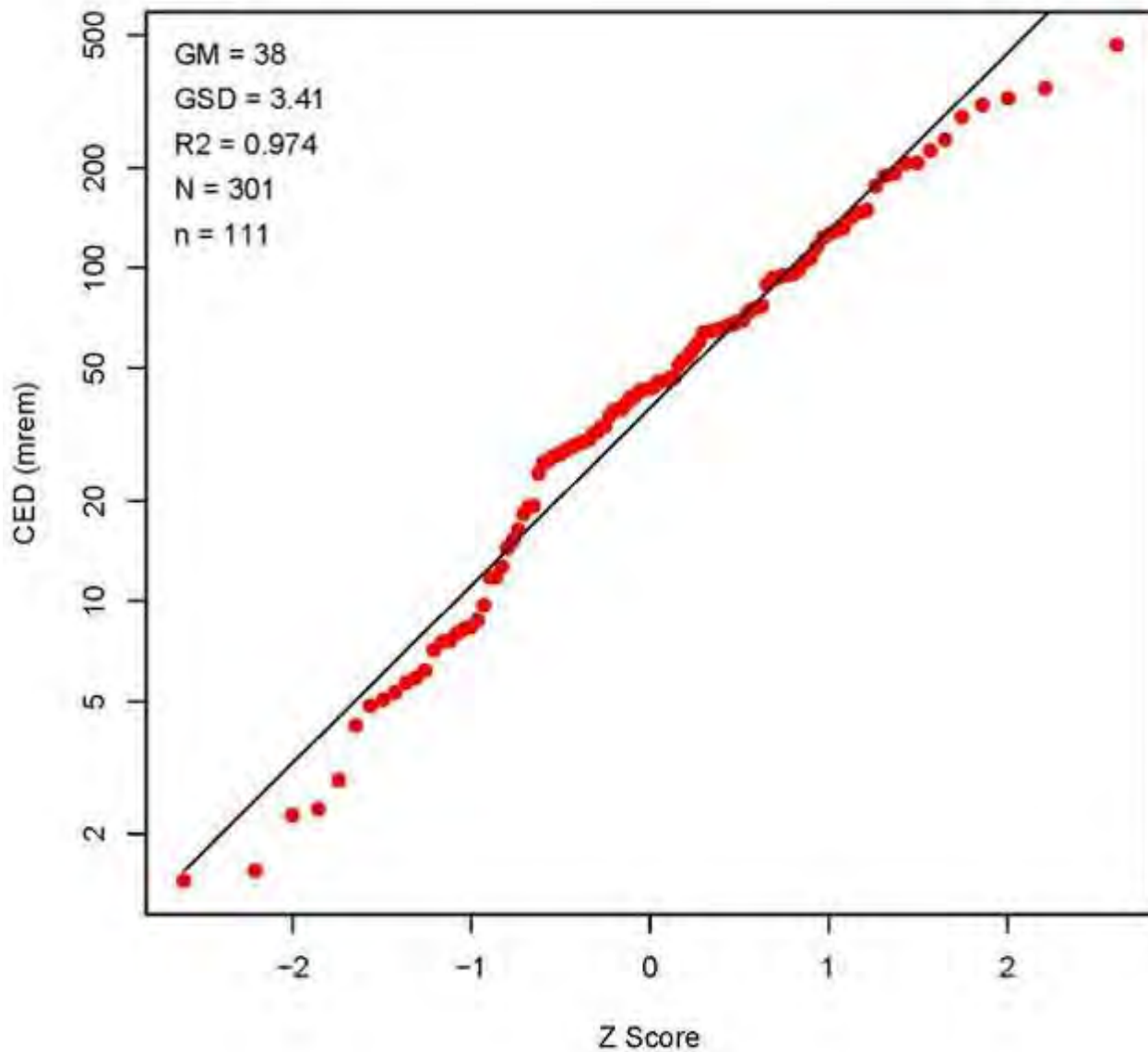


Figure A-46. SRS CTW tritium dose 1965.

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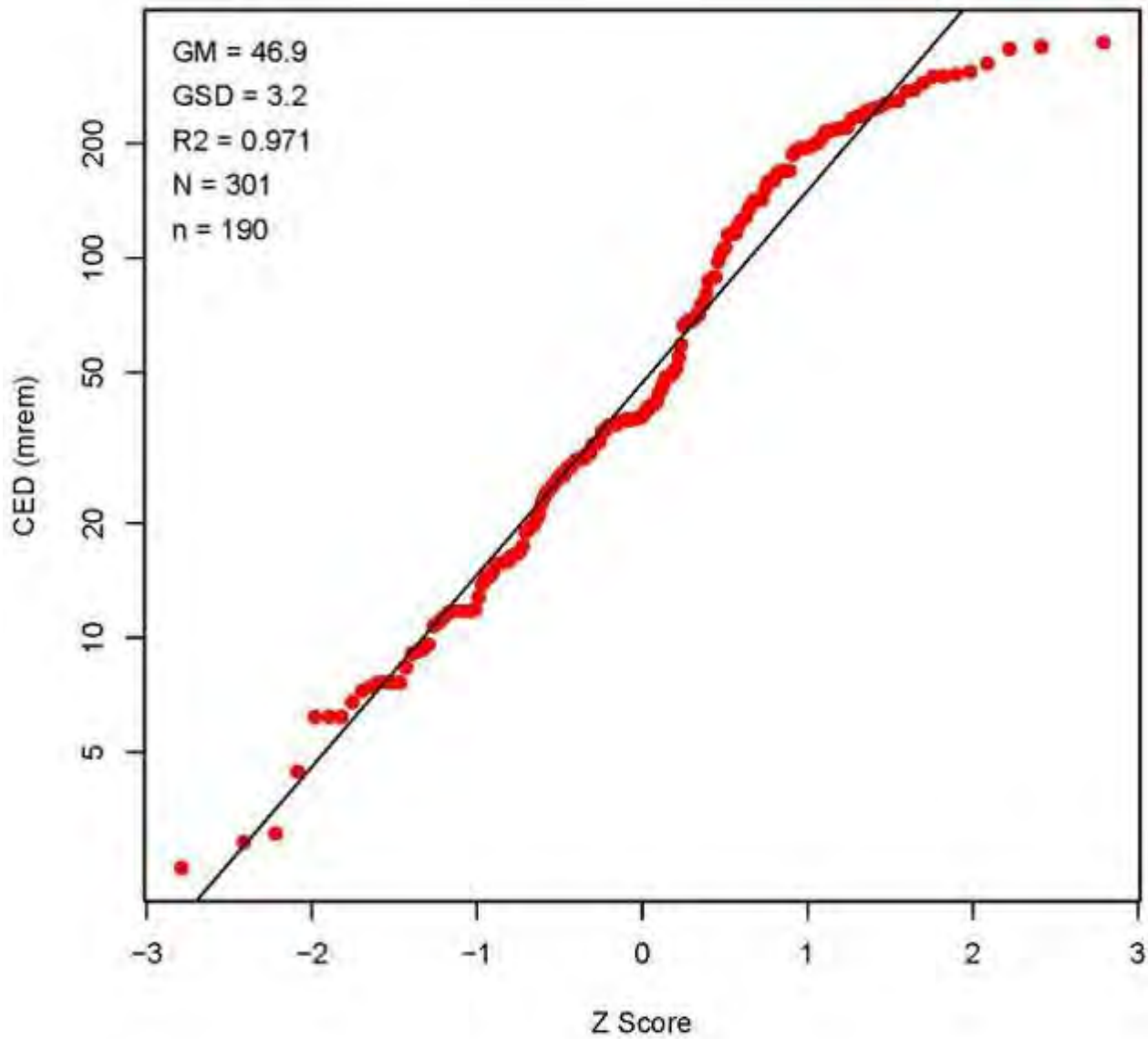


Figure A-47. SRS NCTW tritium dose 1965.

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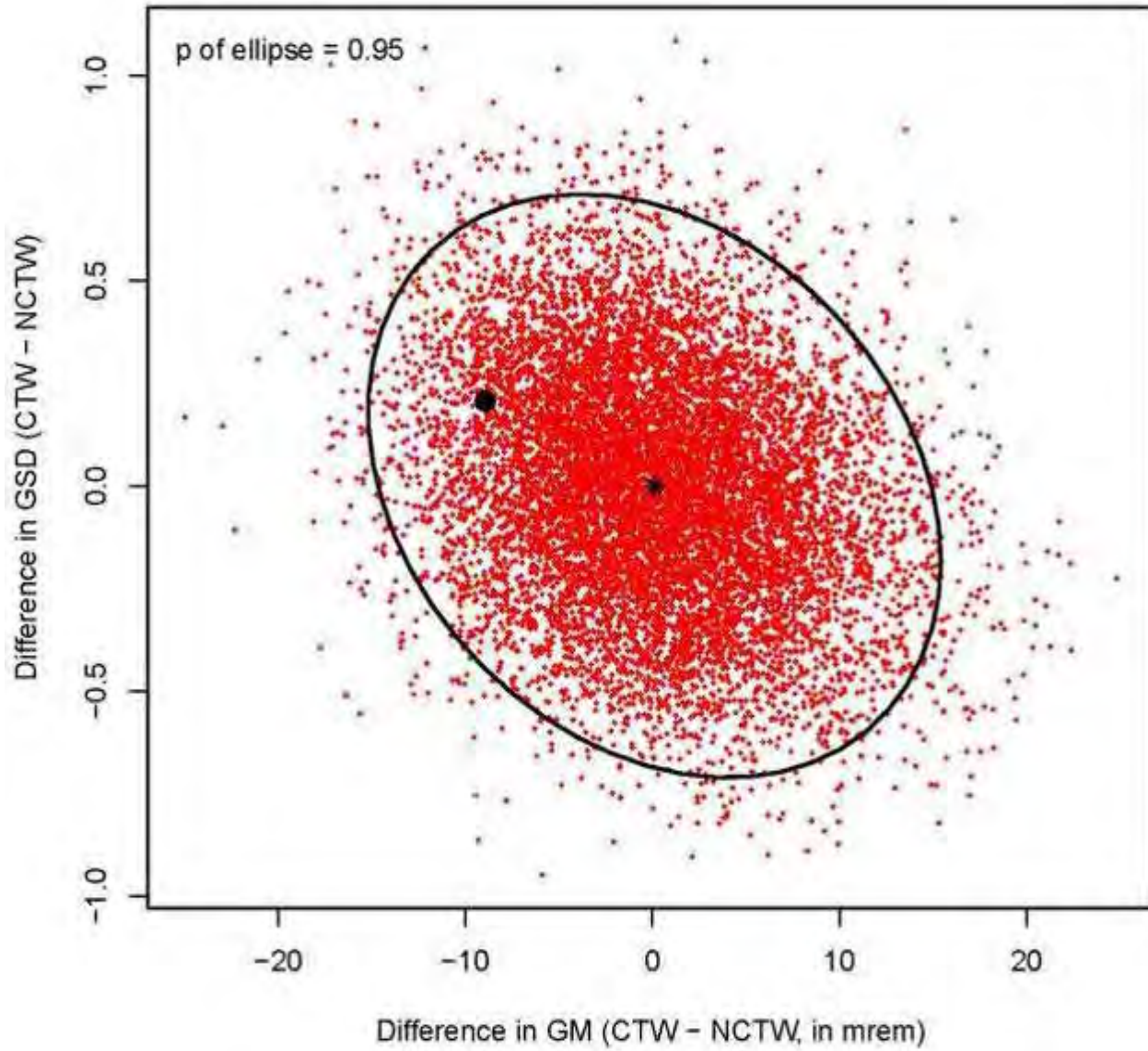


Figure A-48. SRS tritium dose 1965.

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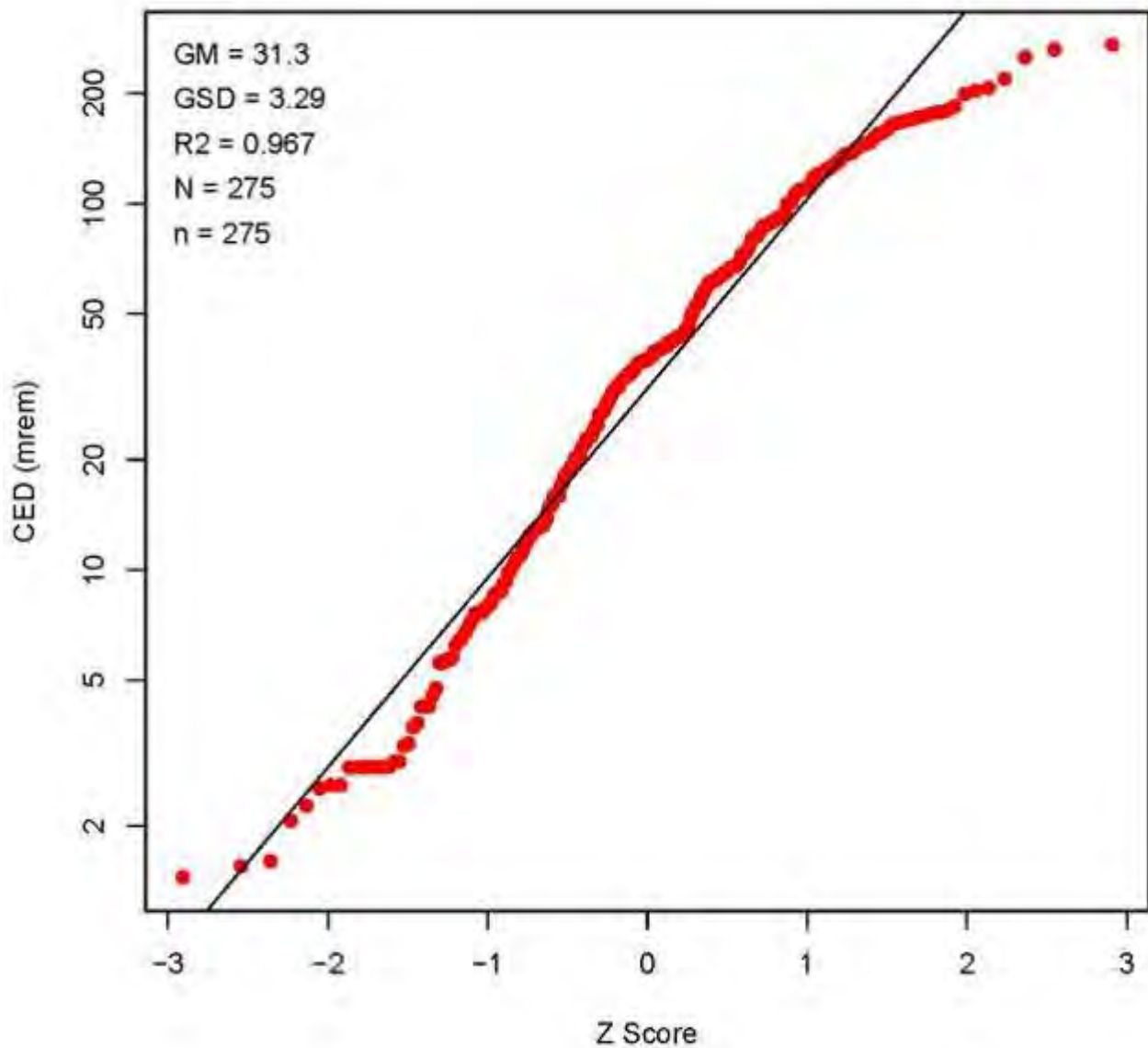


Figure A-49. SRS tritium dose 1966.

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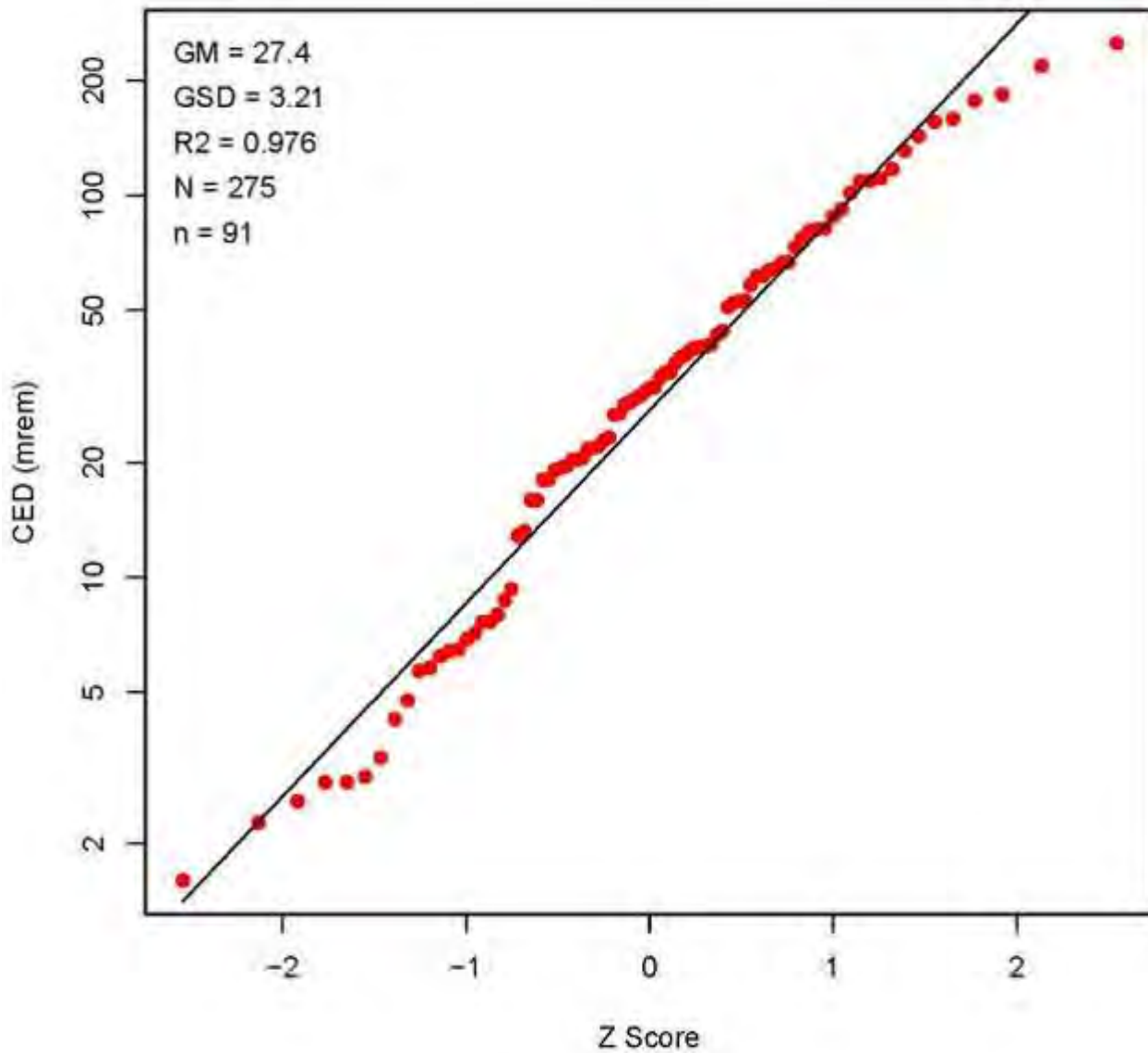


Figure A-50. SRS CTW tritium dose 1966.

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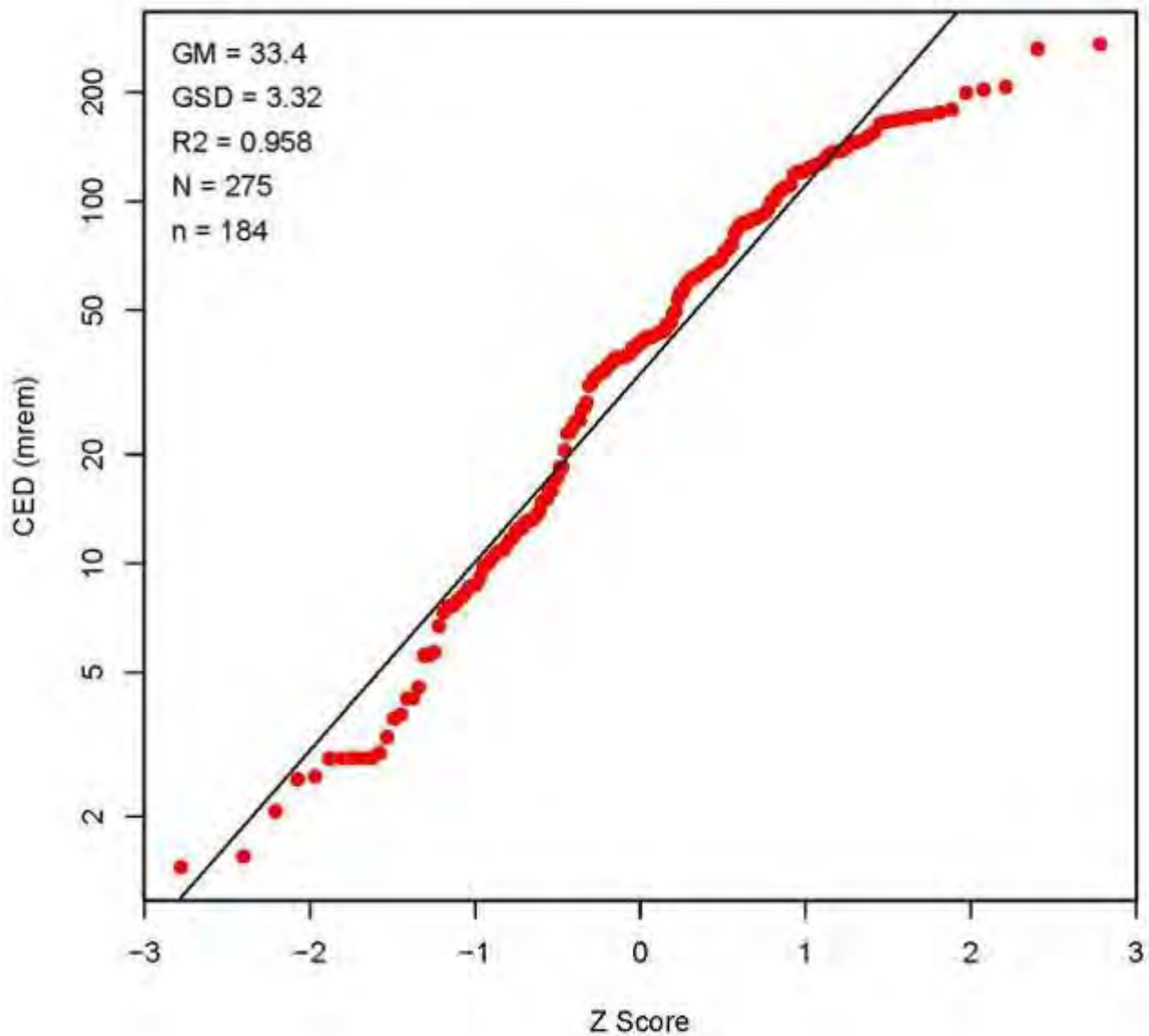


Figure A-51. SRS NCTW tritium dose 1966.

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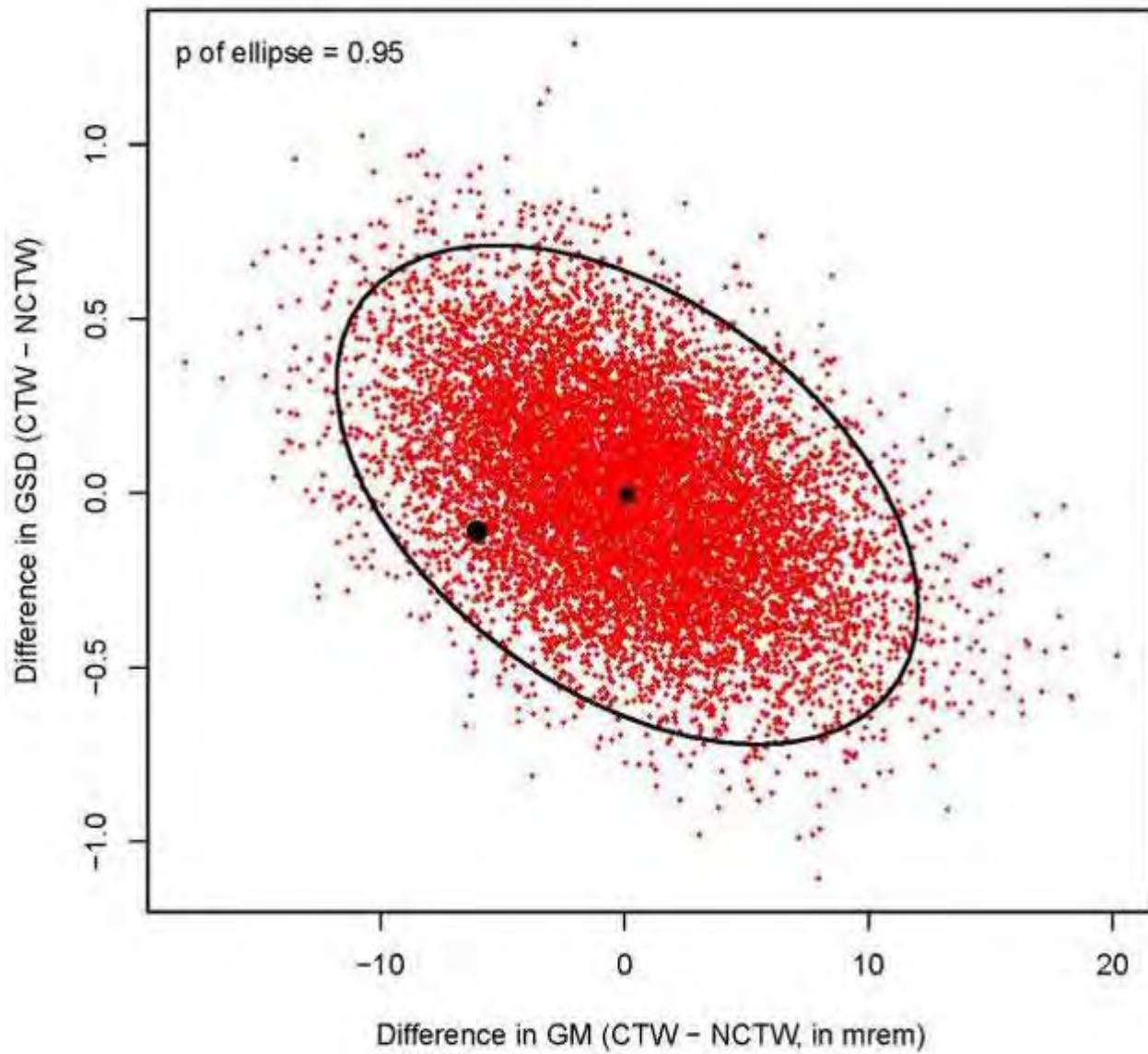


Figure A-52. SRS tritium dose 1966.

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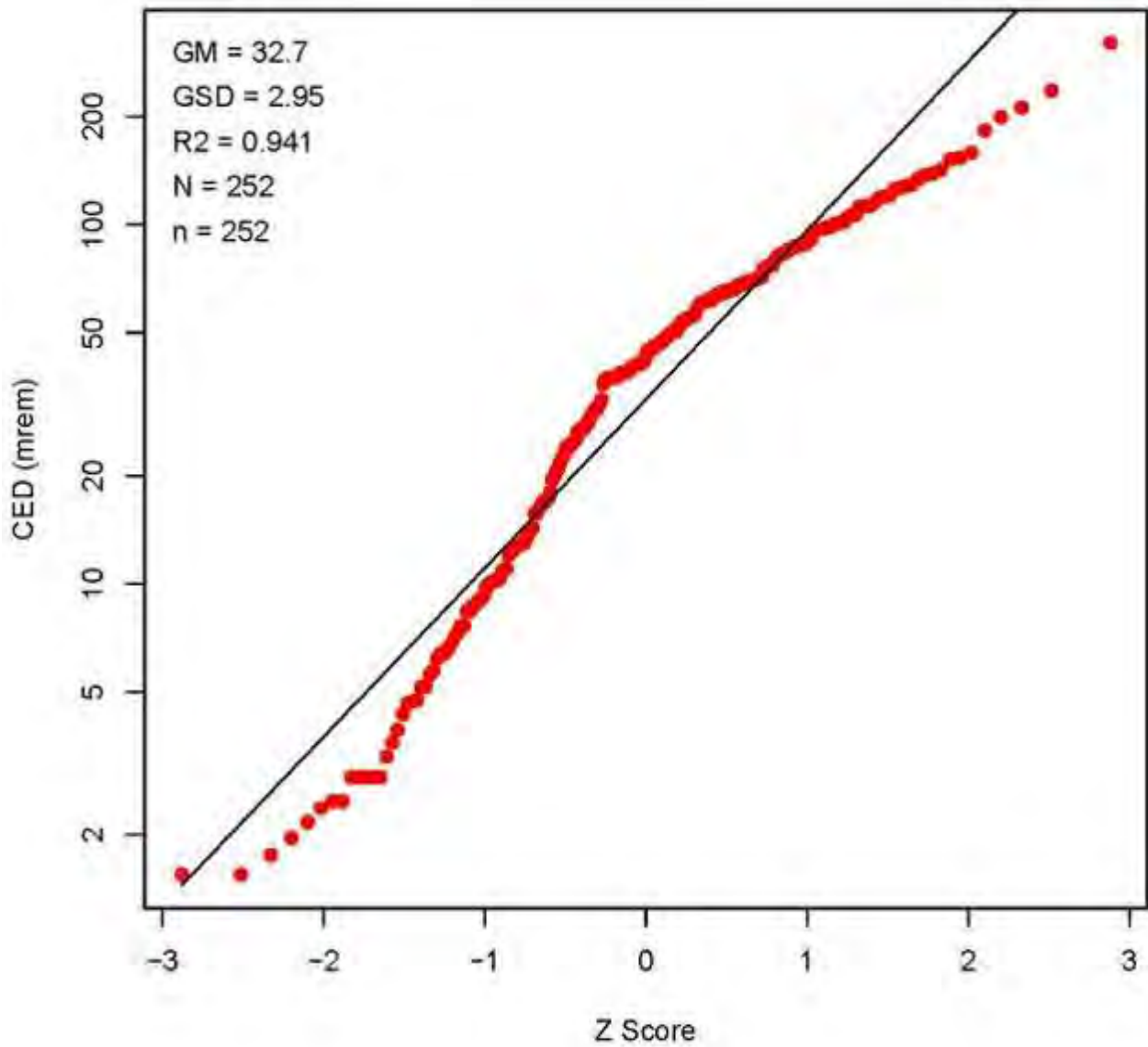


Figure A-53. SRS tritium dose 1967.

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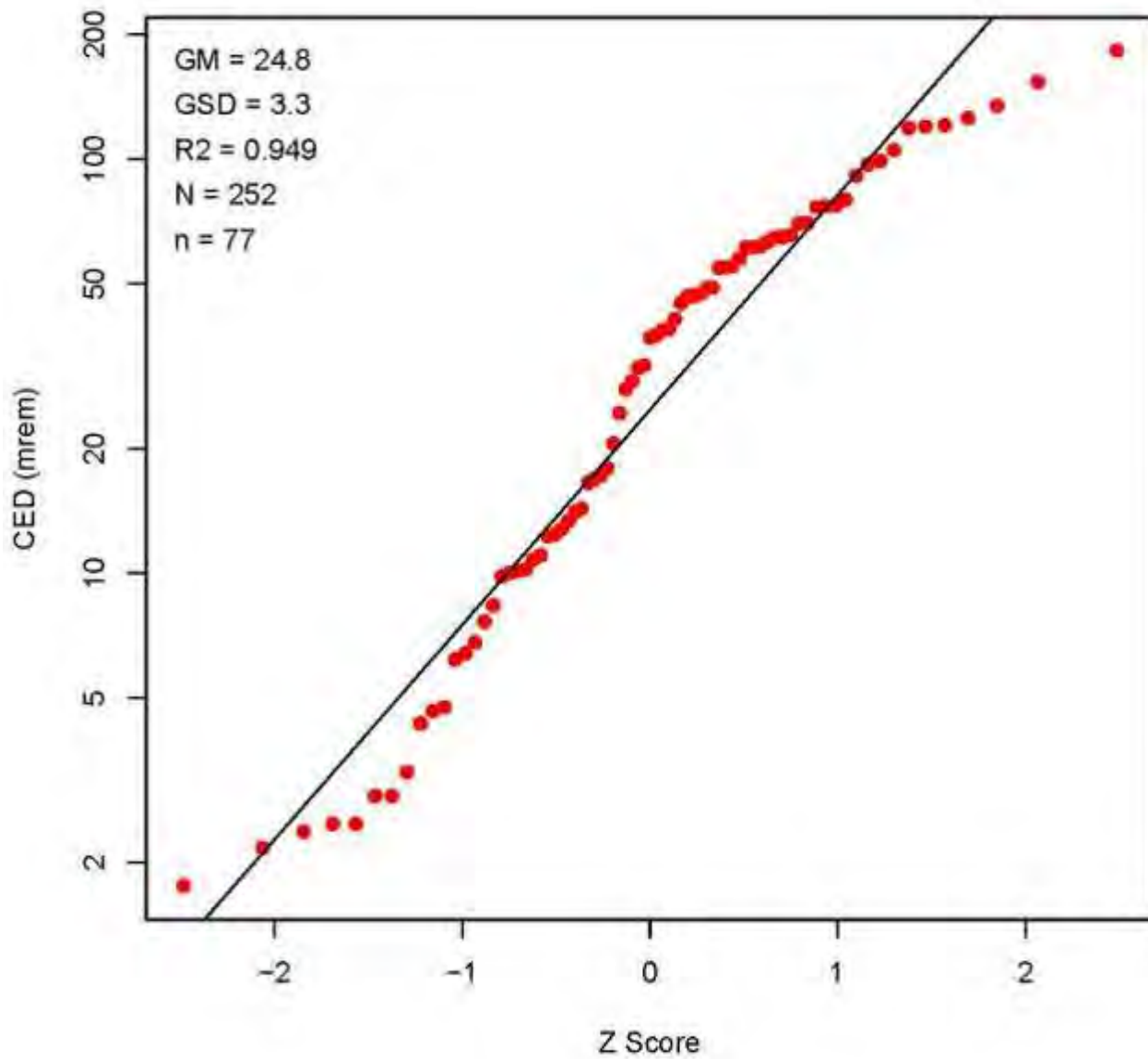


Figure A-54. SRS CTW tritium dose 1967.

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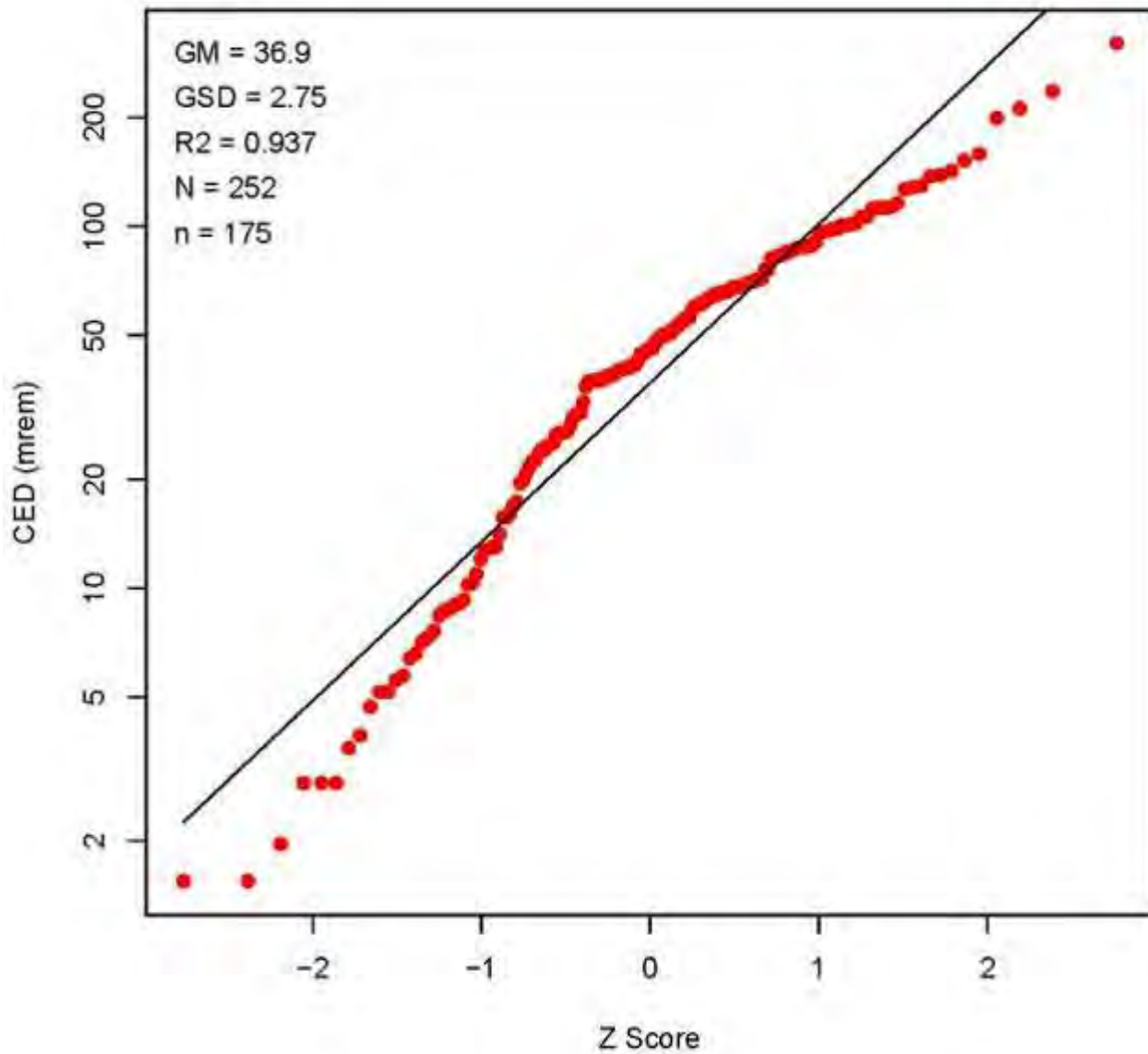


Figure A-55. SRS NCTW tritium dose 1967.

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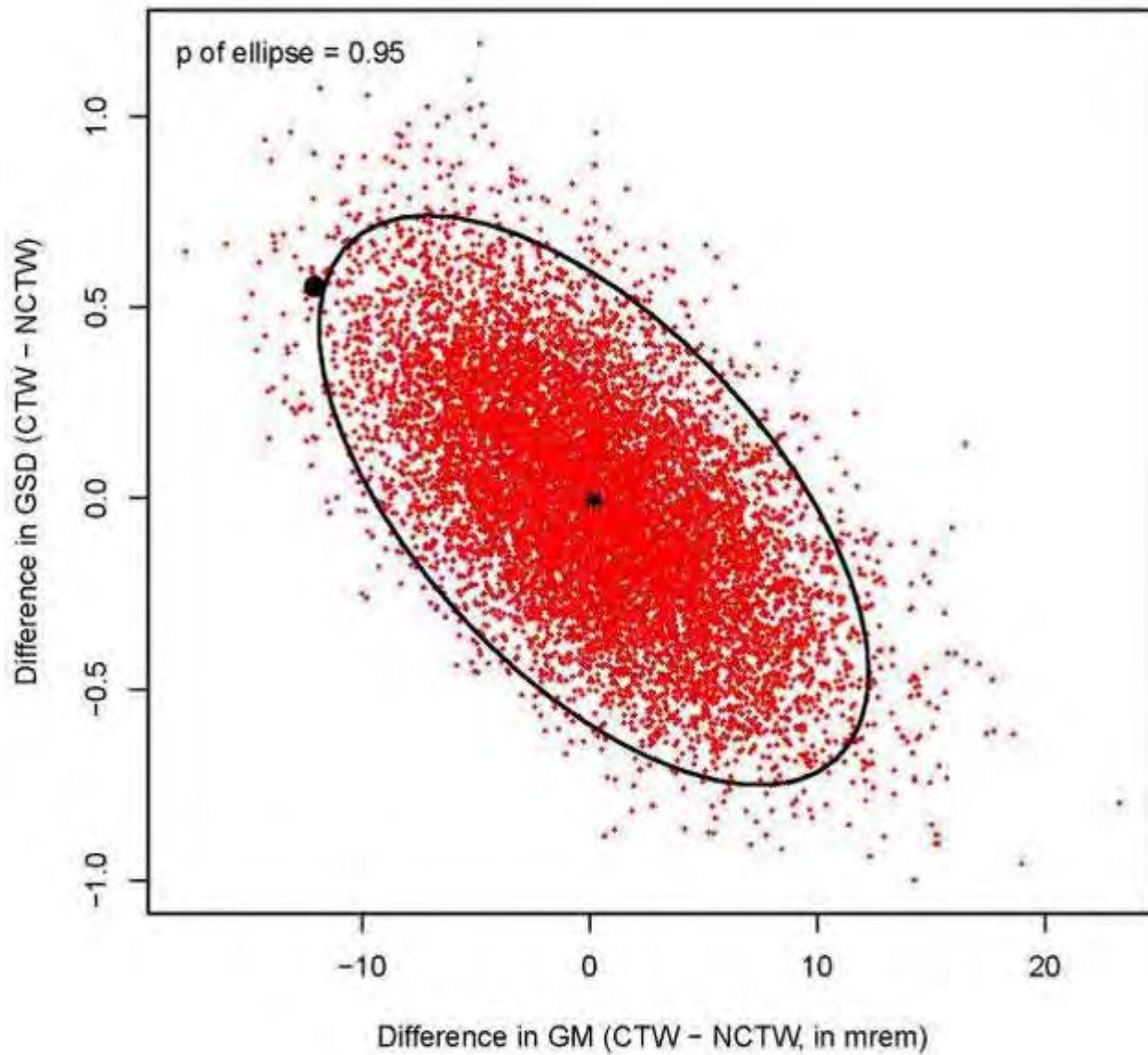


Figure A-56. SRS tritium dose 1967.

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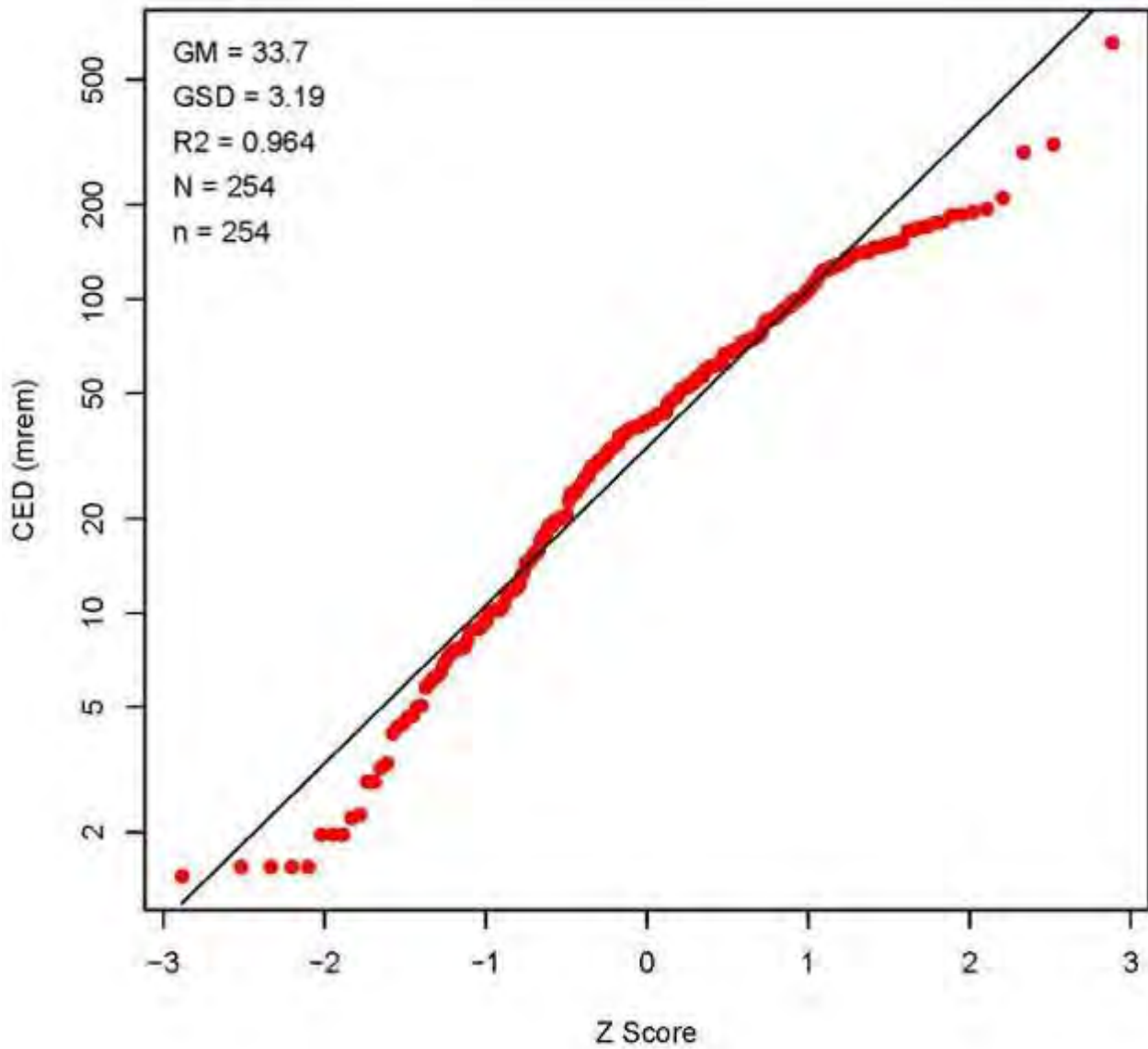


Figure A-57. SRS tritium dose 1968.

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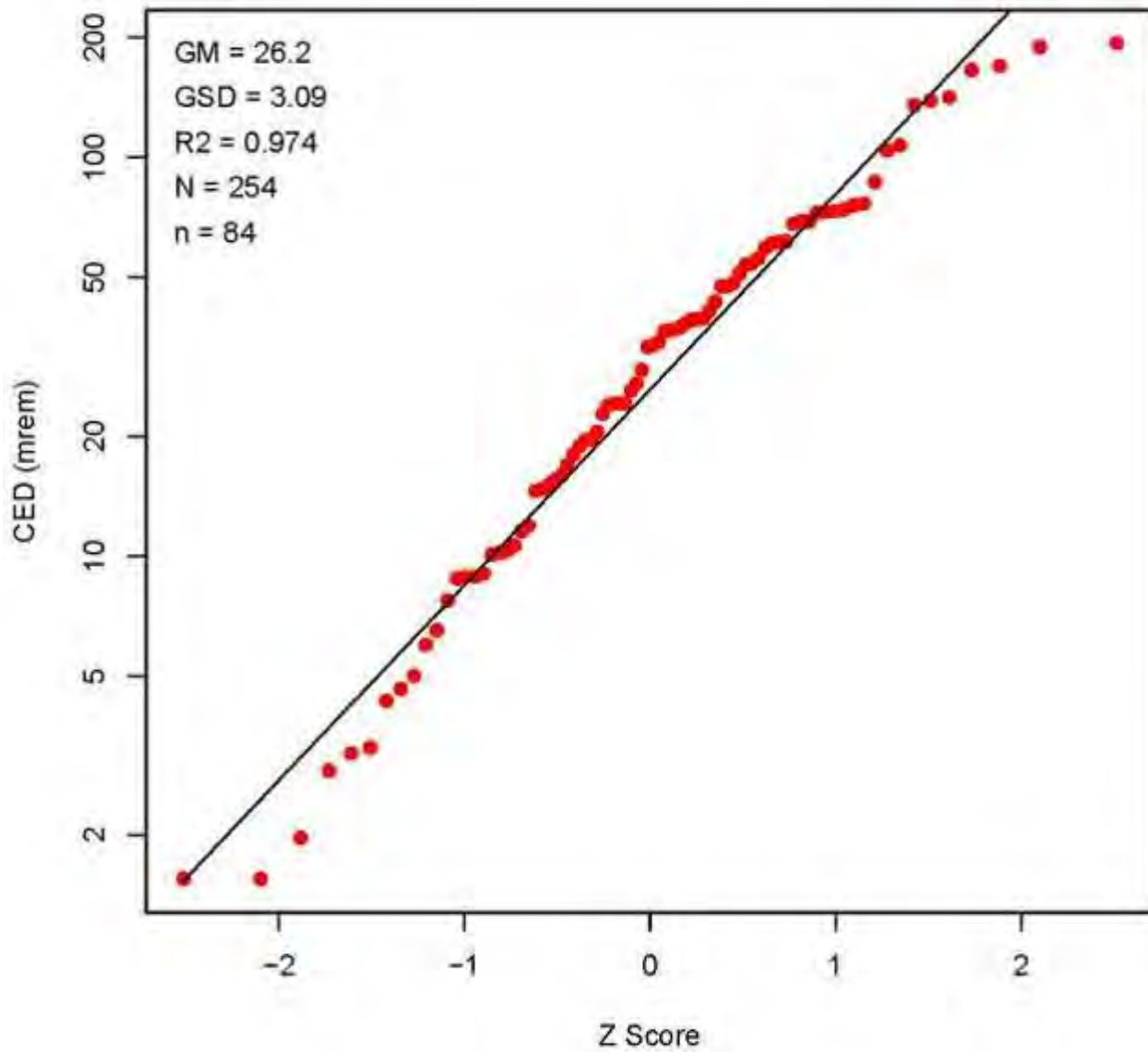


Figure A-58. SRS CTW tritium dose 1968.

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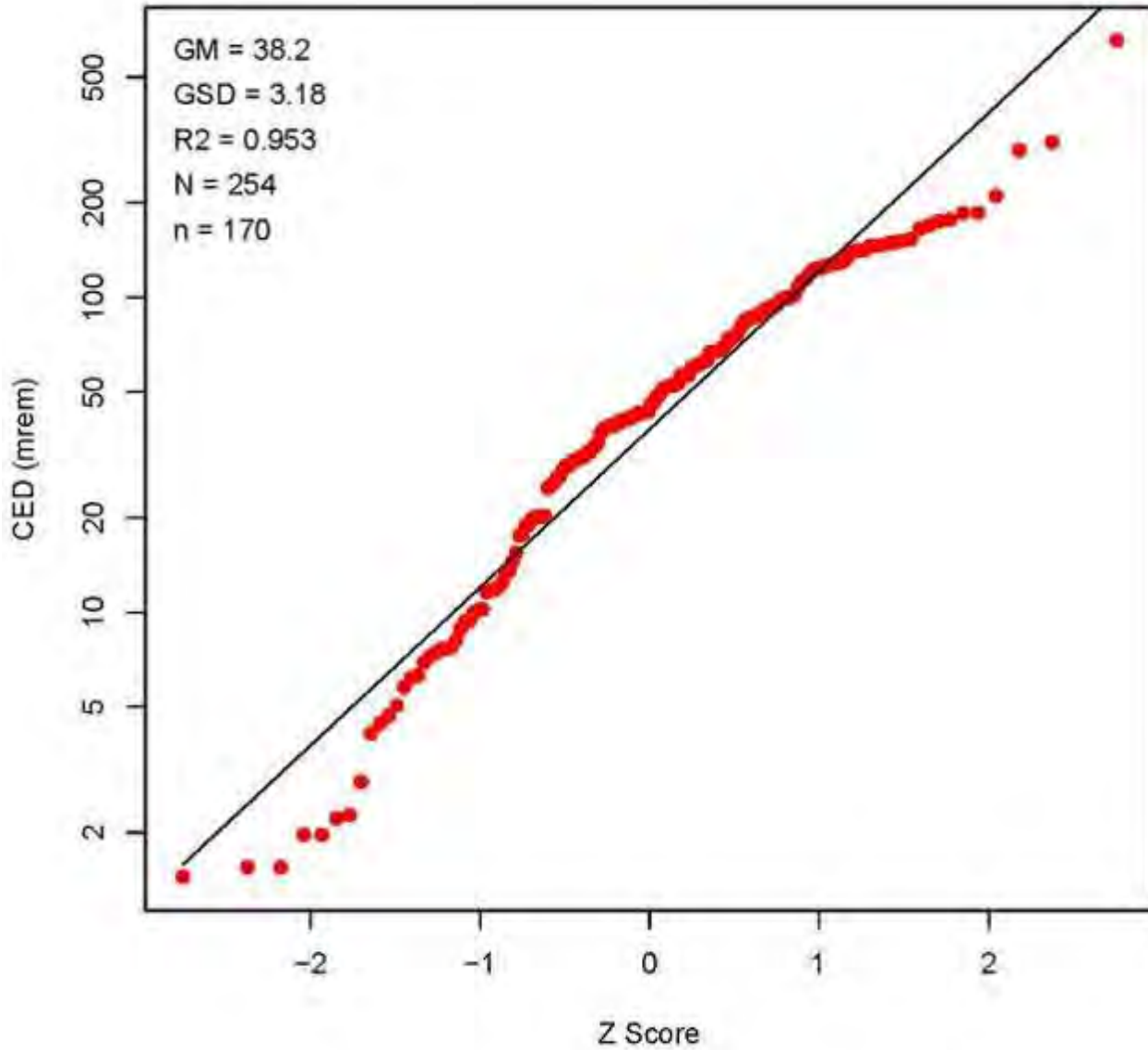


Figure A-59. SRS NCTW tritium dose 1968.

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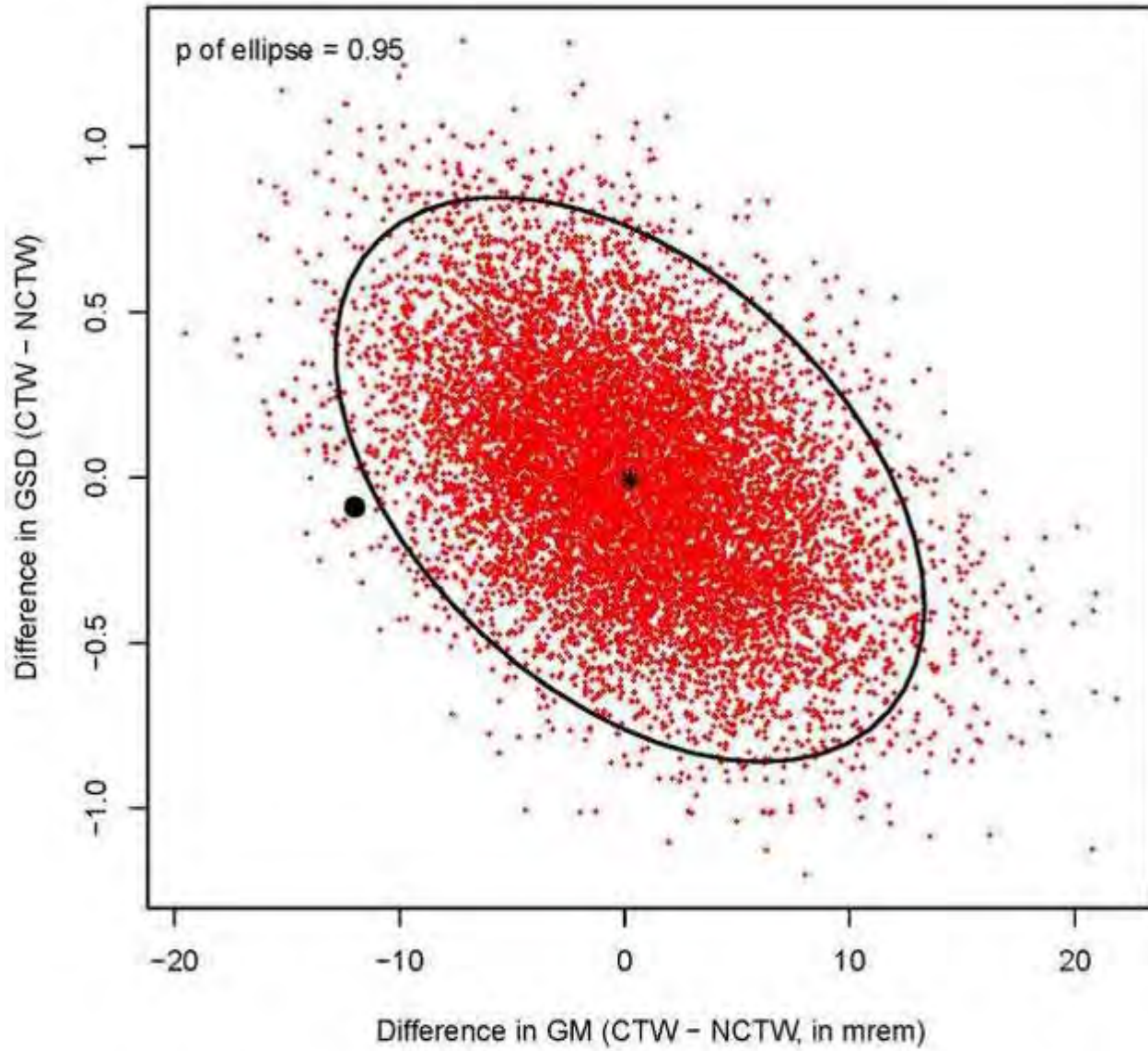


Figure A-60. SRS tritium dose 1968.

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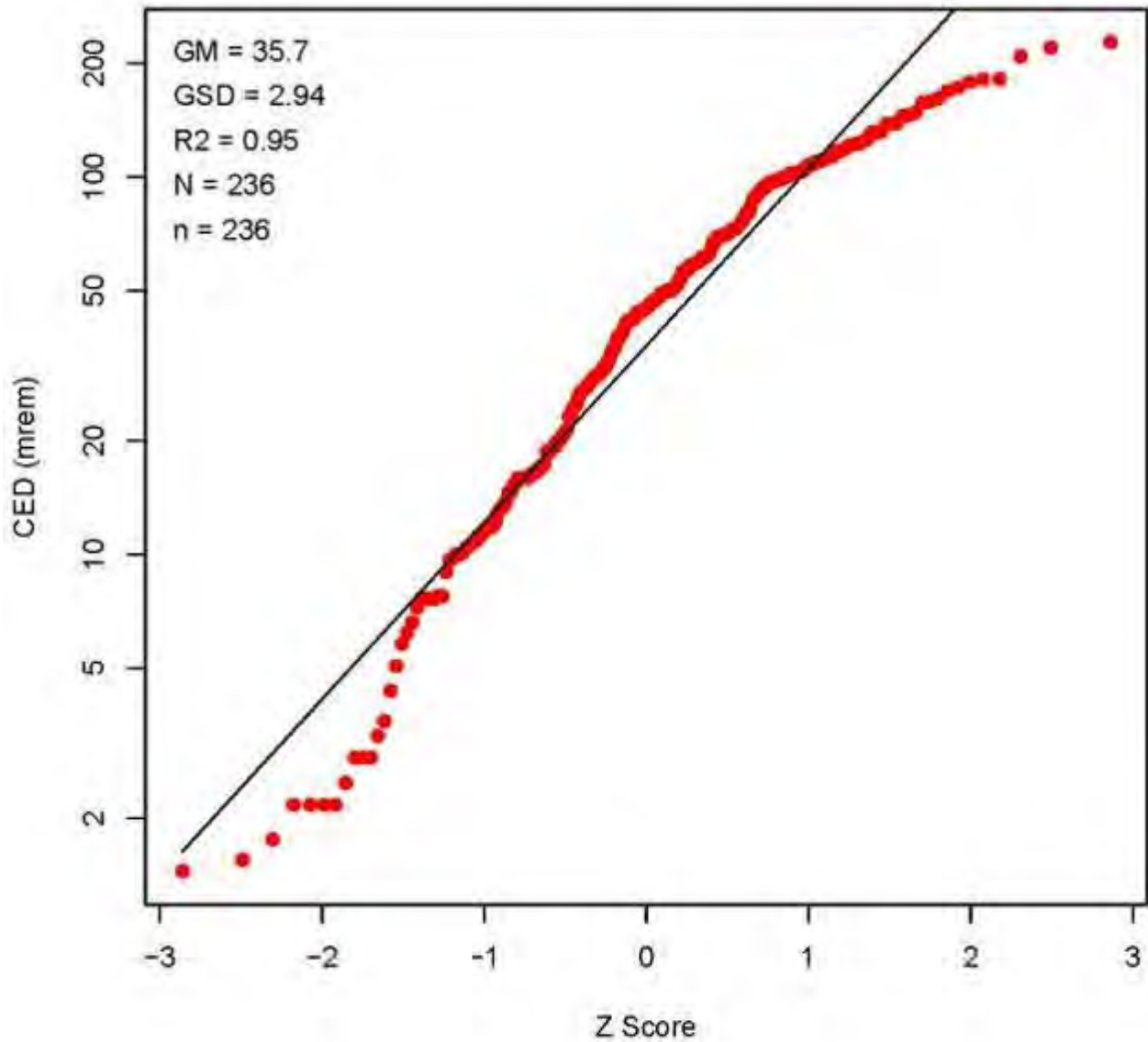


Figure A-61. SRS tritium dose 1969.

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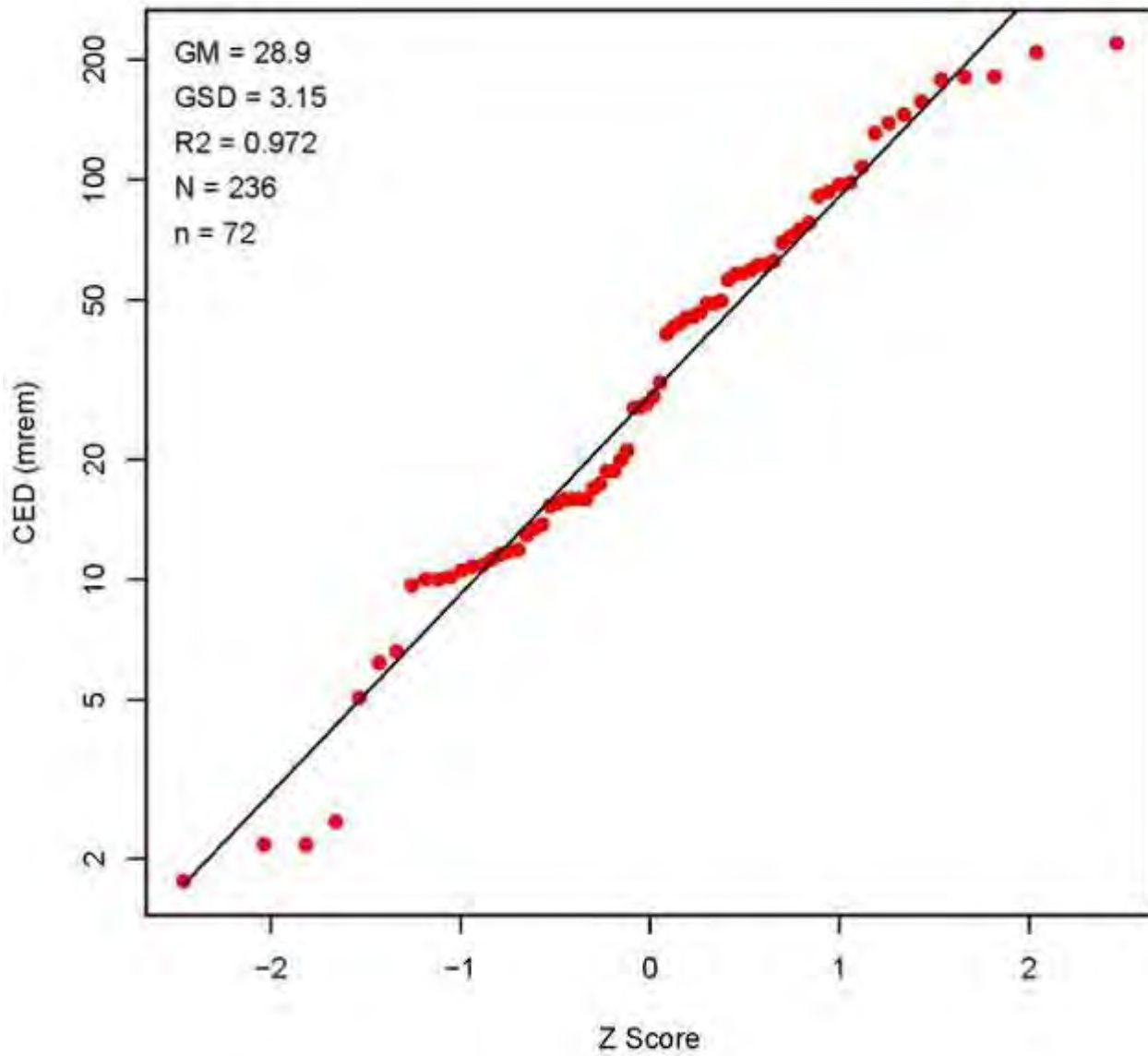


Figure A-62. SRS CTW tritium dose 1969.

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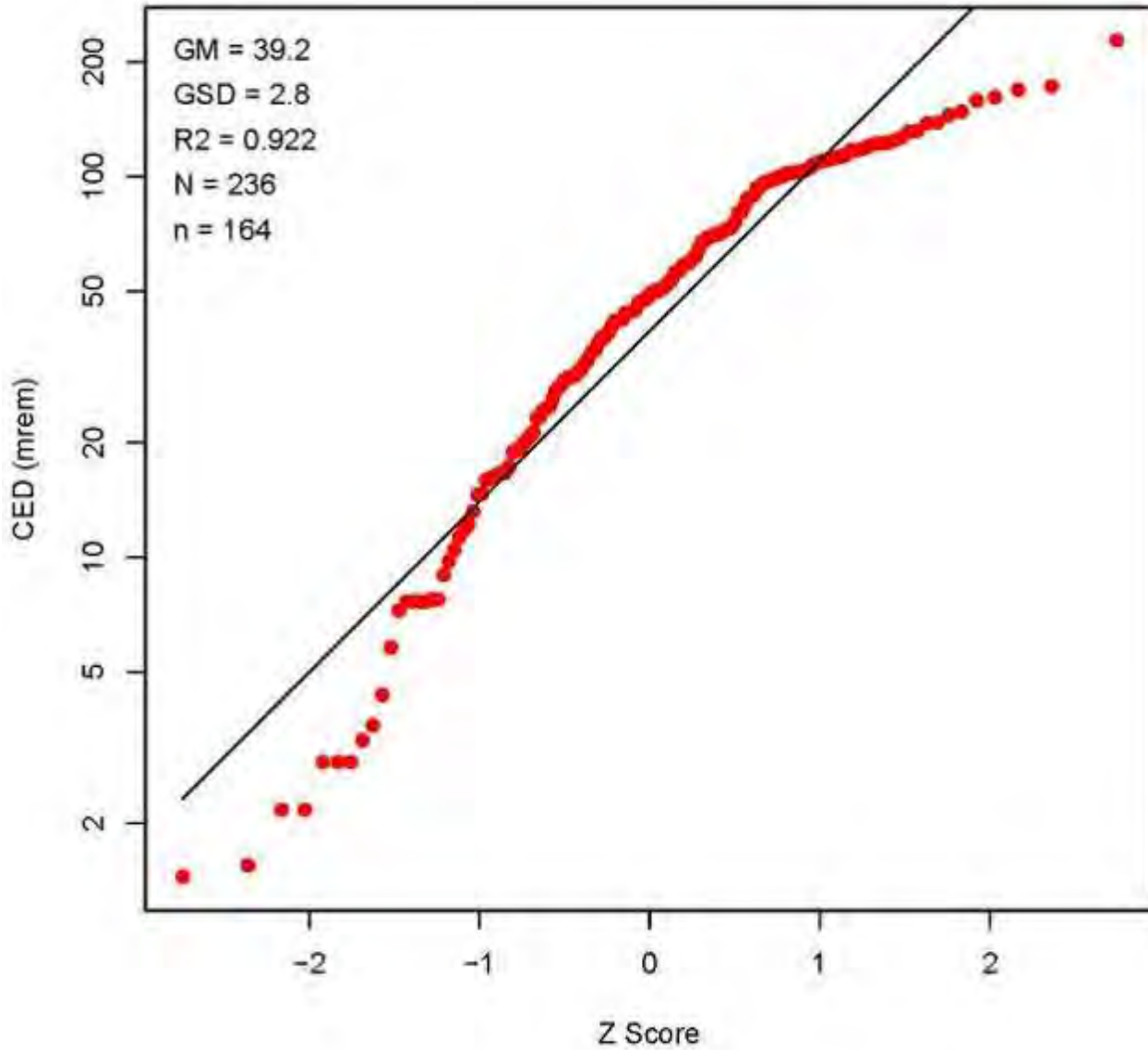


Figure A-63. SRS NCTW tritium dose 1969.

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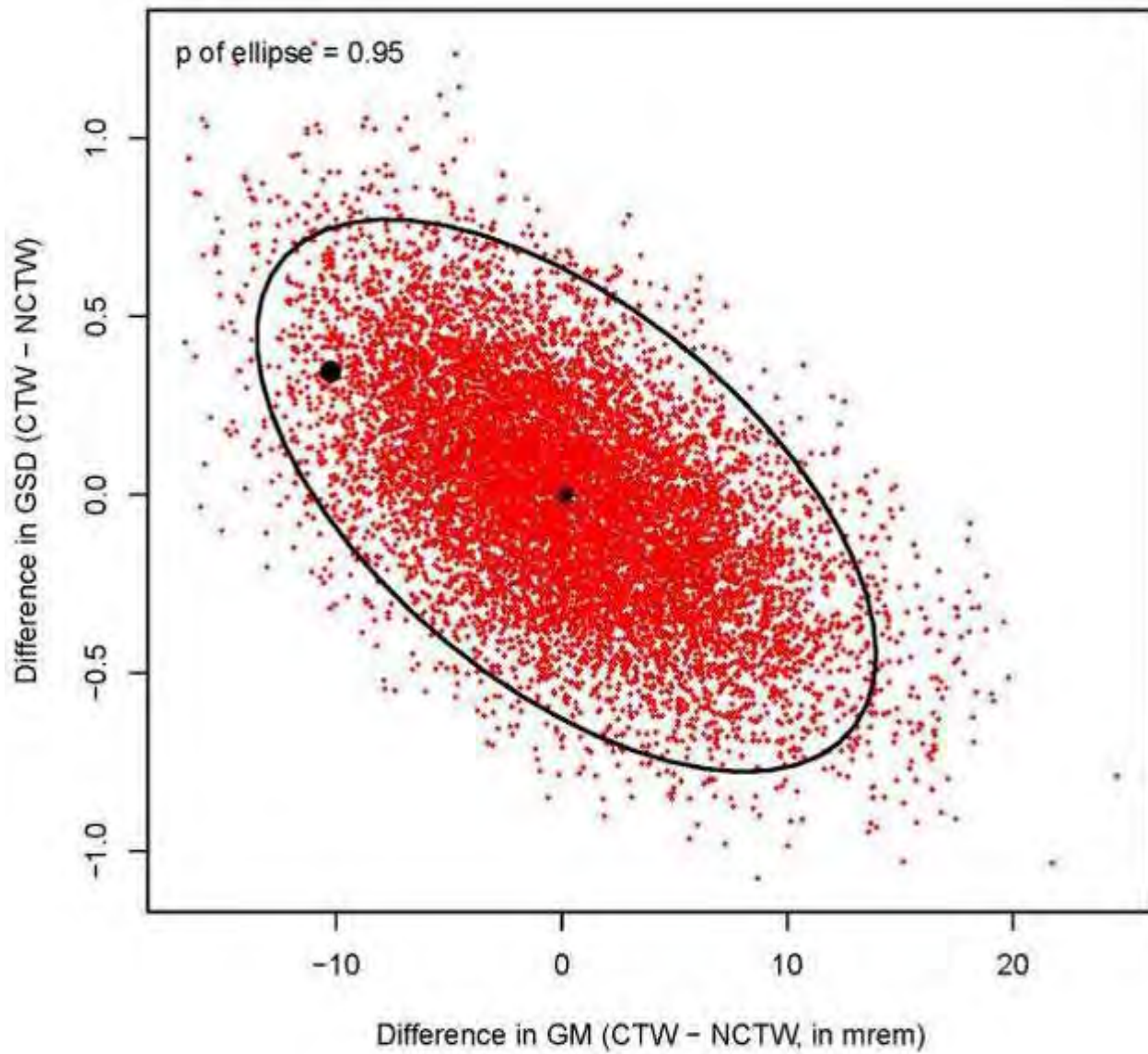


Figure A-64. SRS tritium dose 1969.

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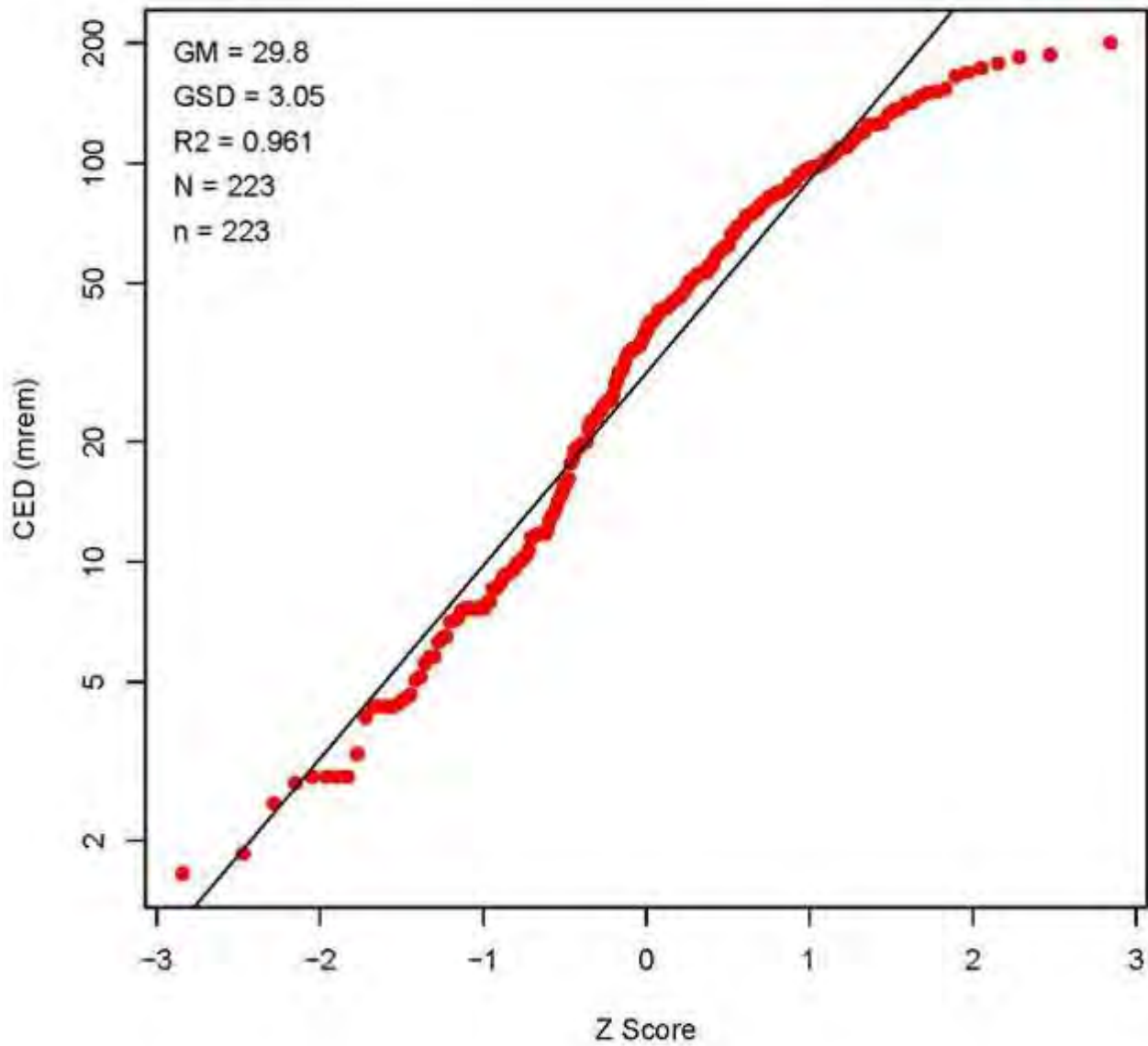


Figure A-65. SRS tritium dose 1970.

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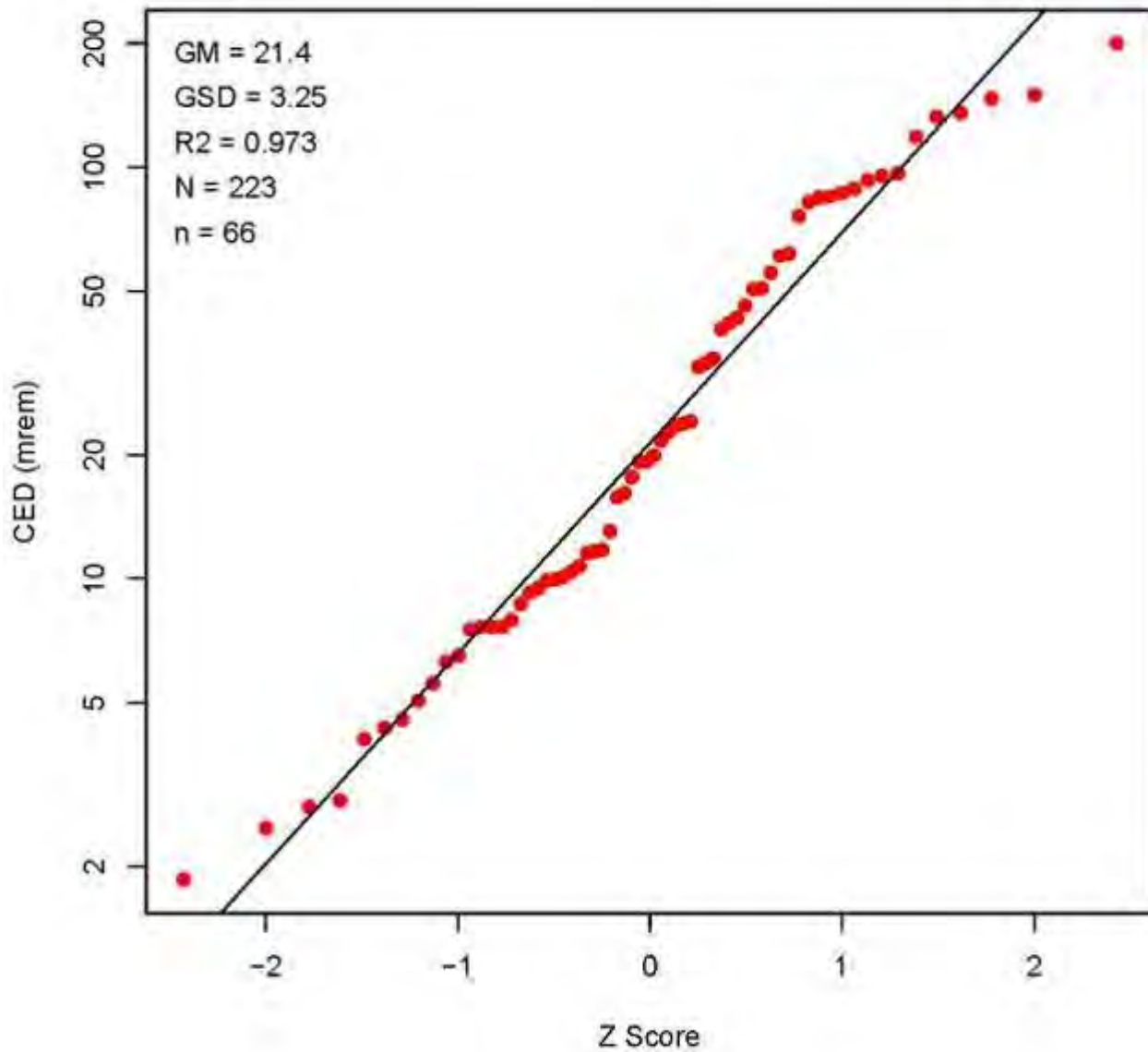


Figure A-66. SRS CTW tritium dose 1970.

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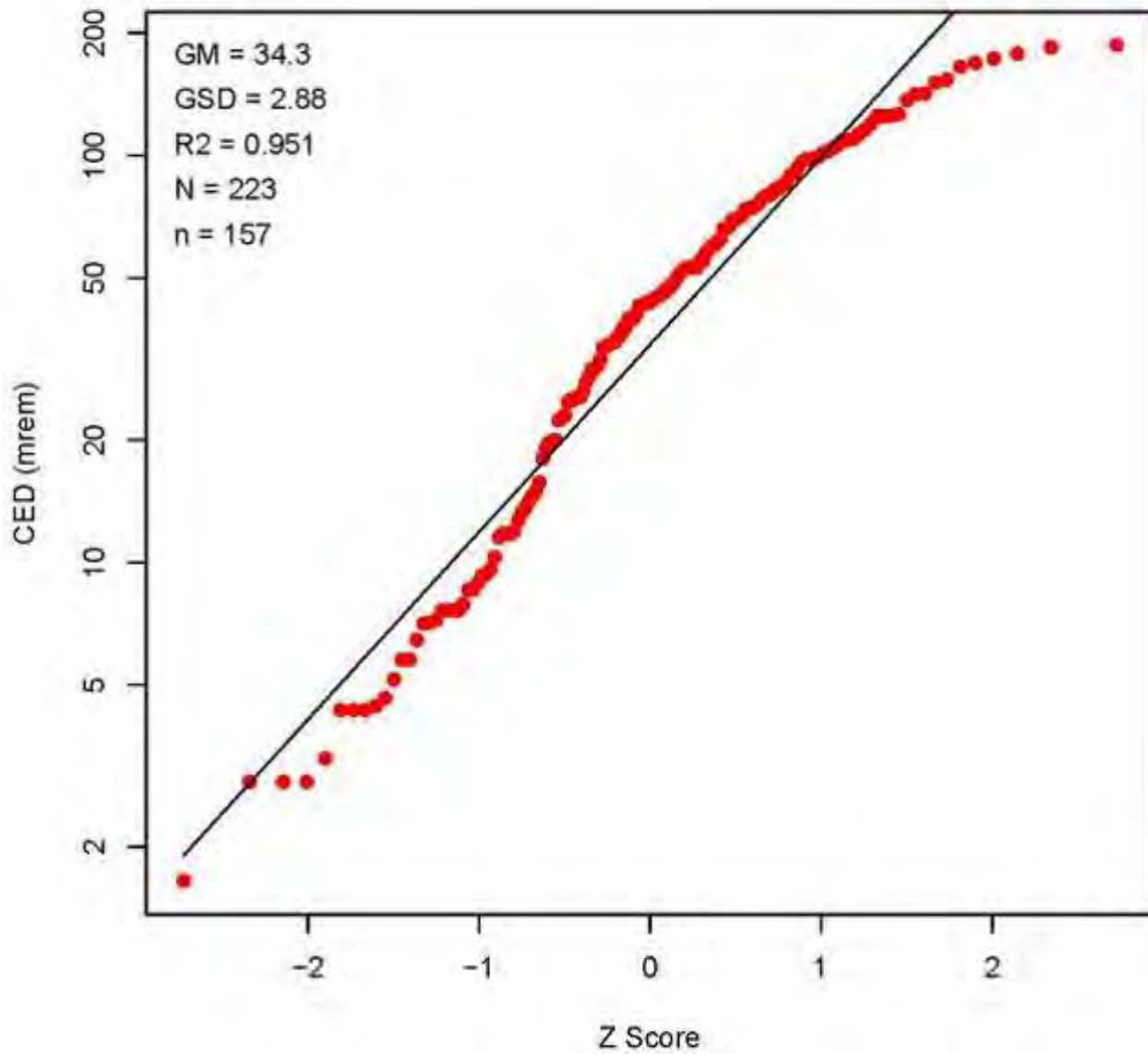


Figure A-67. SRS NCTW tritium dose 1970.

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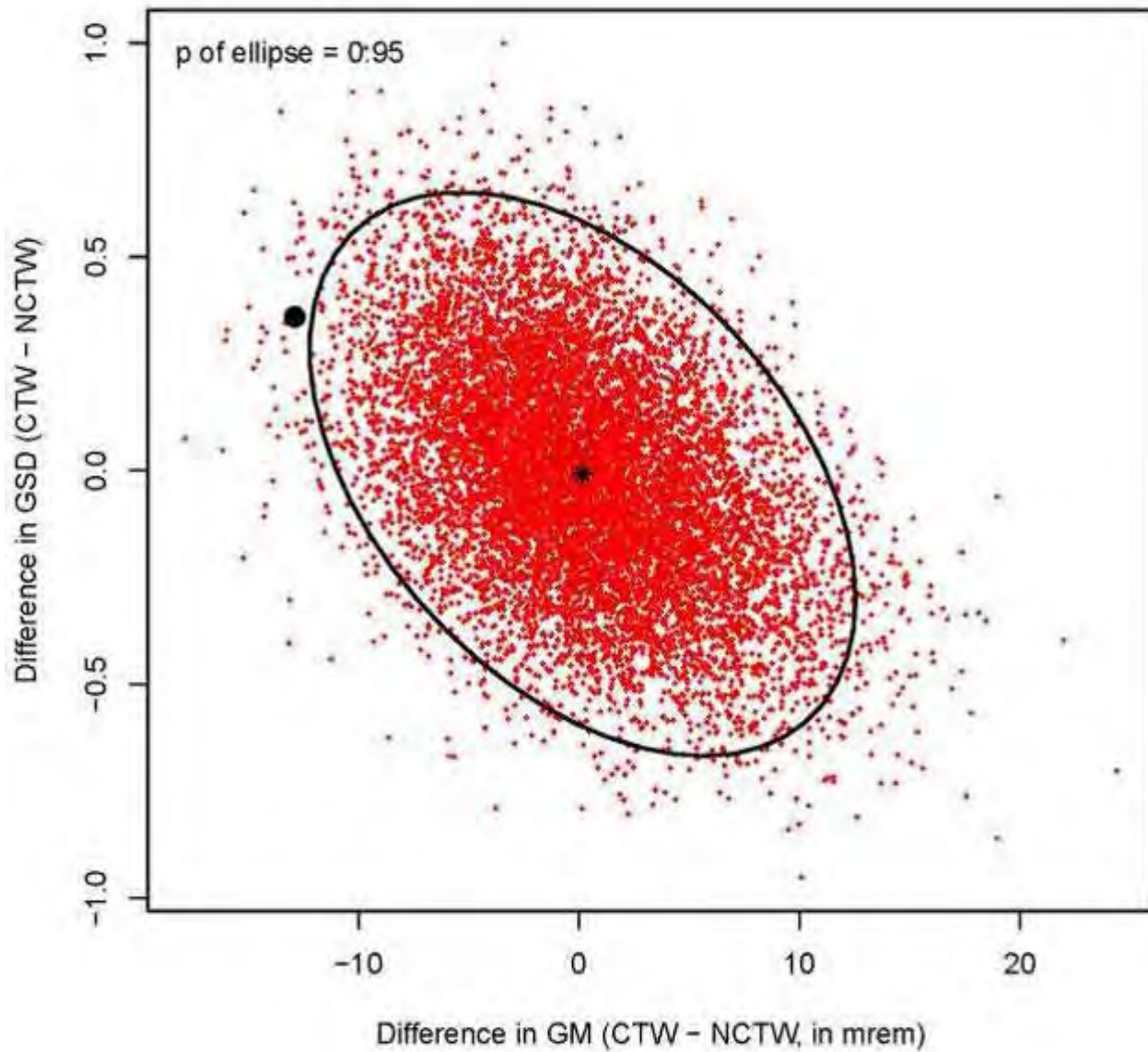


Figure A-68. SRS tritium dose 1970.

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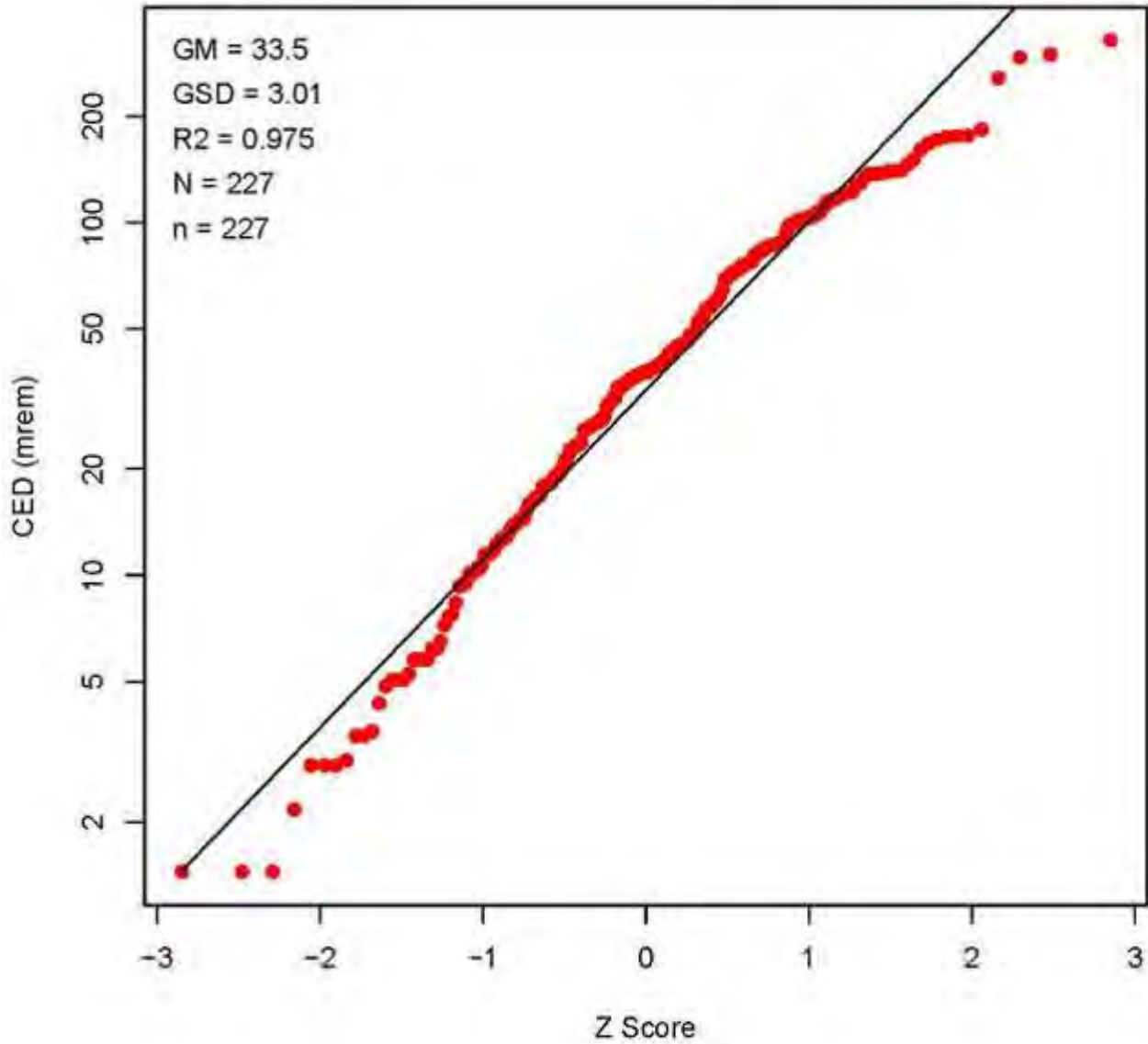


Figure A-69. SRS tritium dose 1971.

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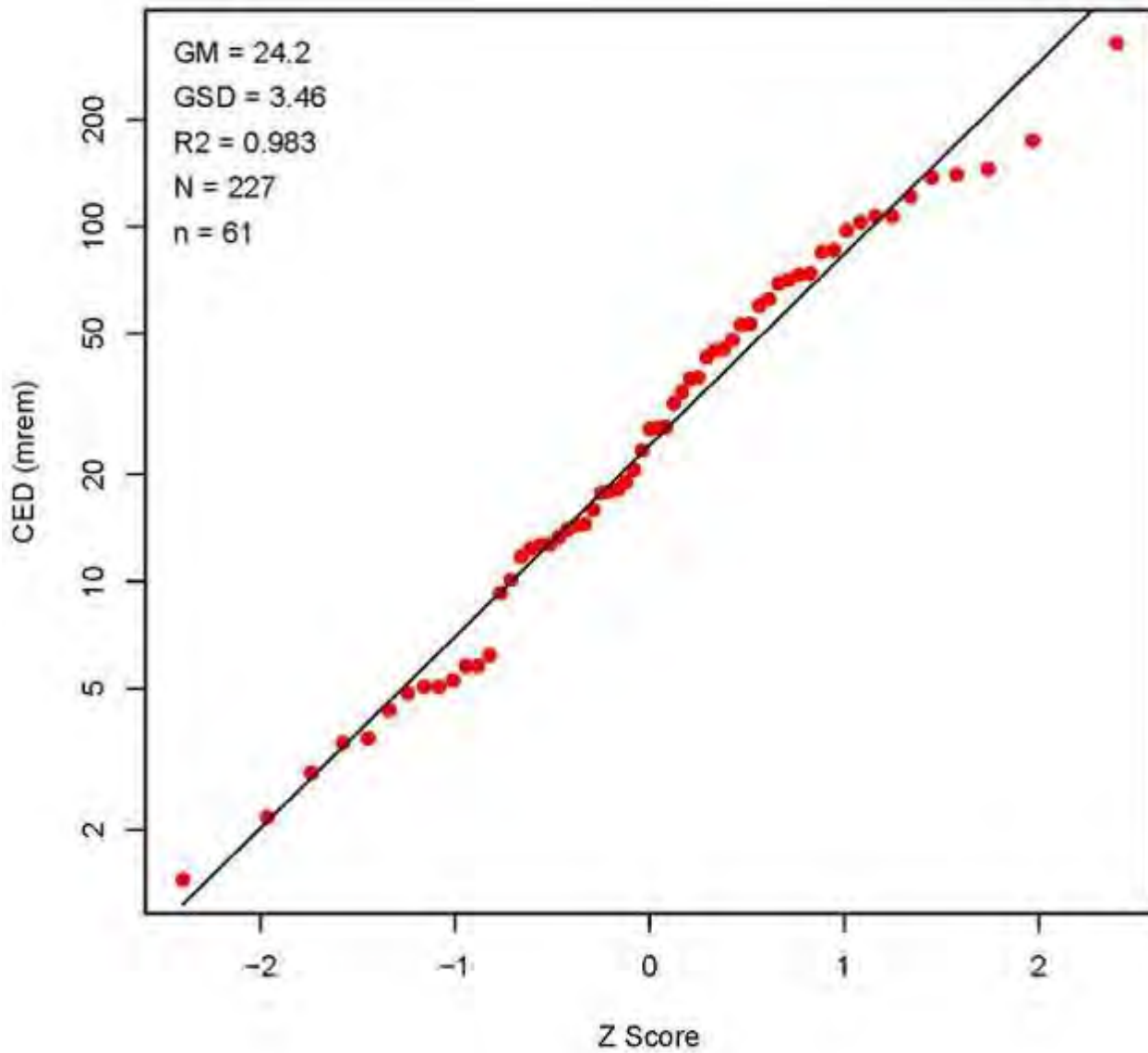


Figure A-70. SRS CTW tritium dose 1971.

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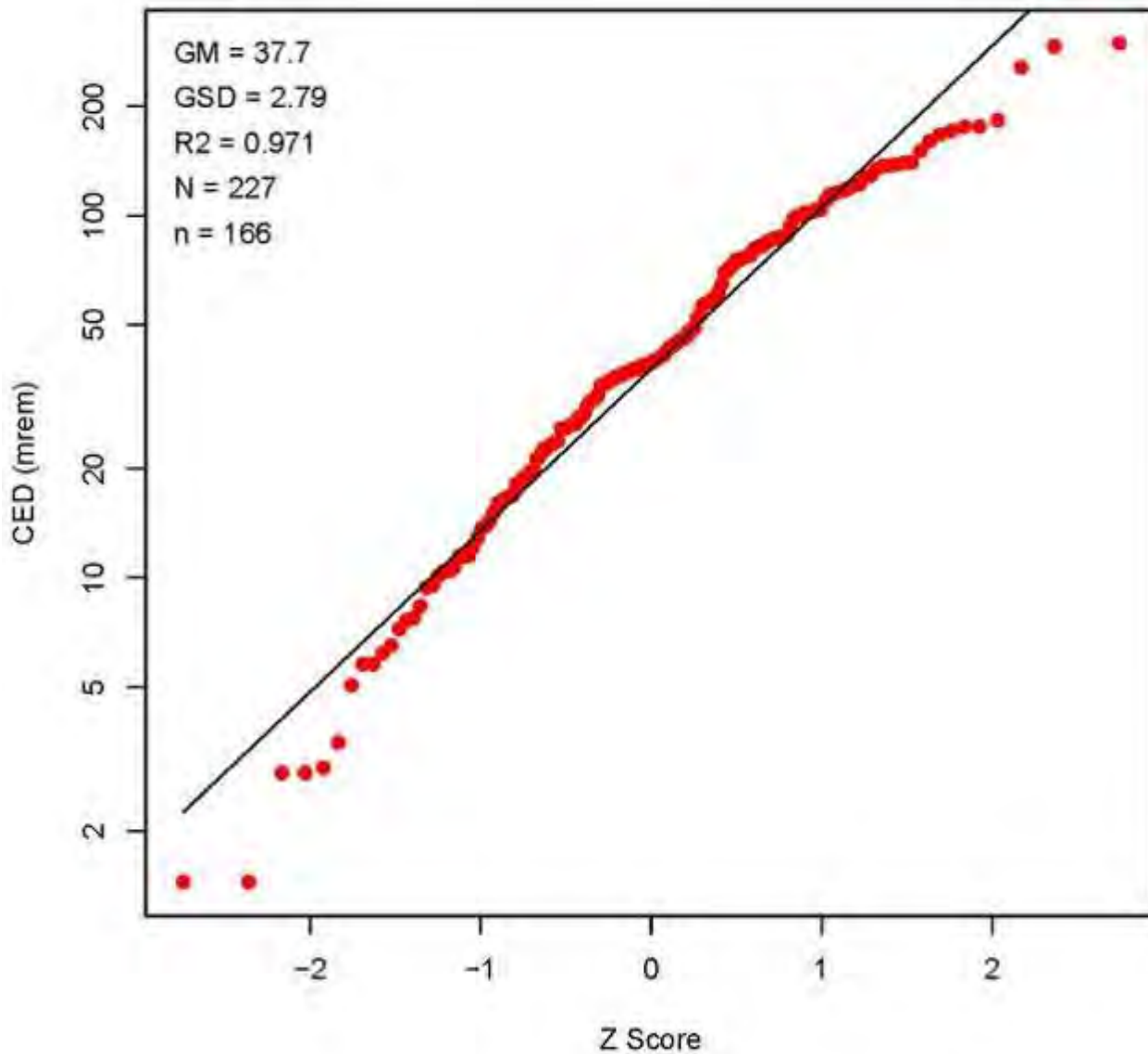


Figure A-71. SRS NCTW tritium dose 1971.

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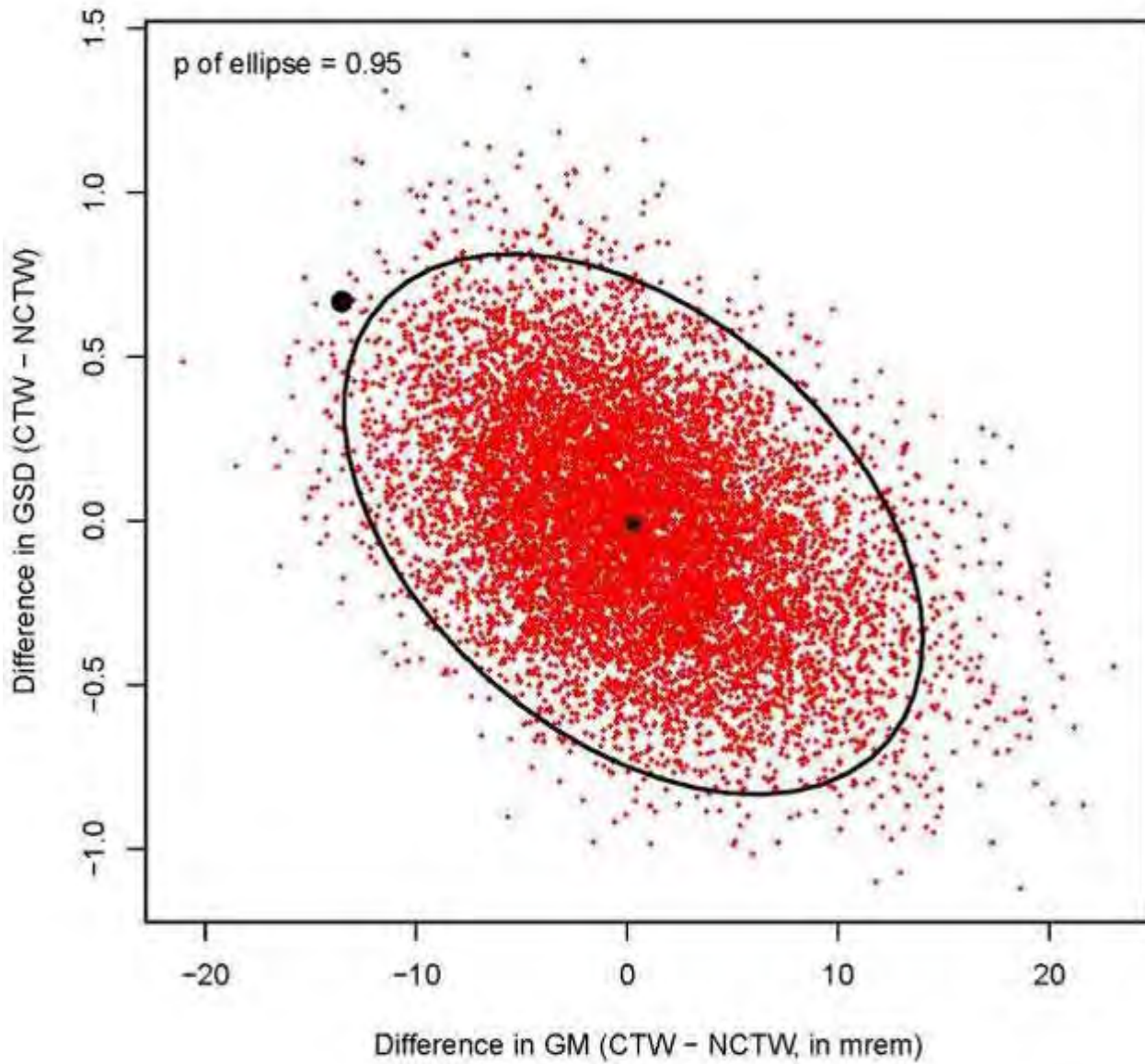


Figure A-72. SRS tritium dose 1971.

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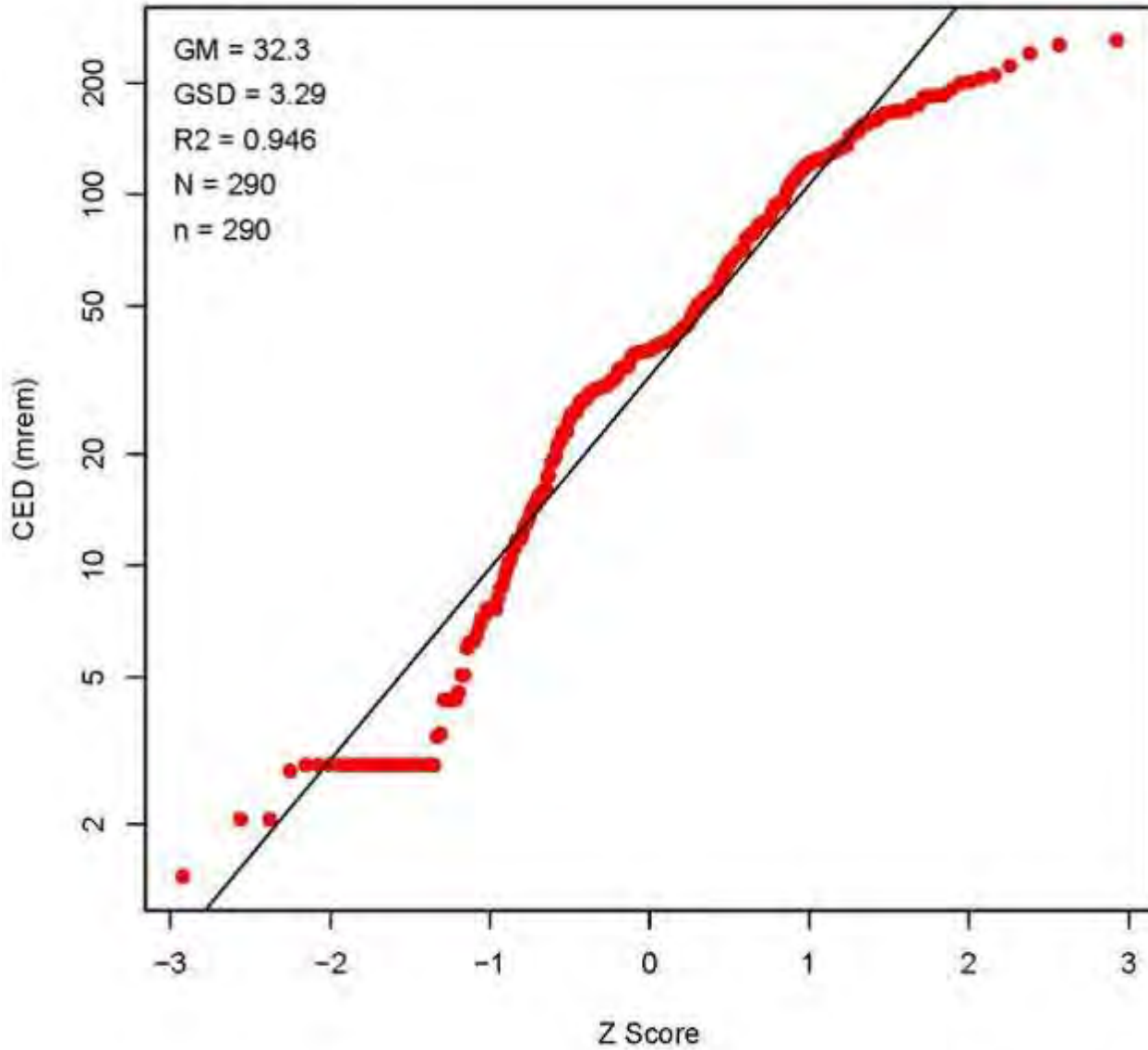


Figure A-73. SRS tritium dose 1972.

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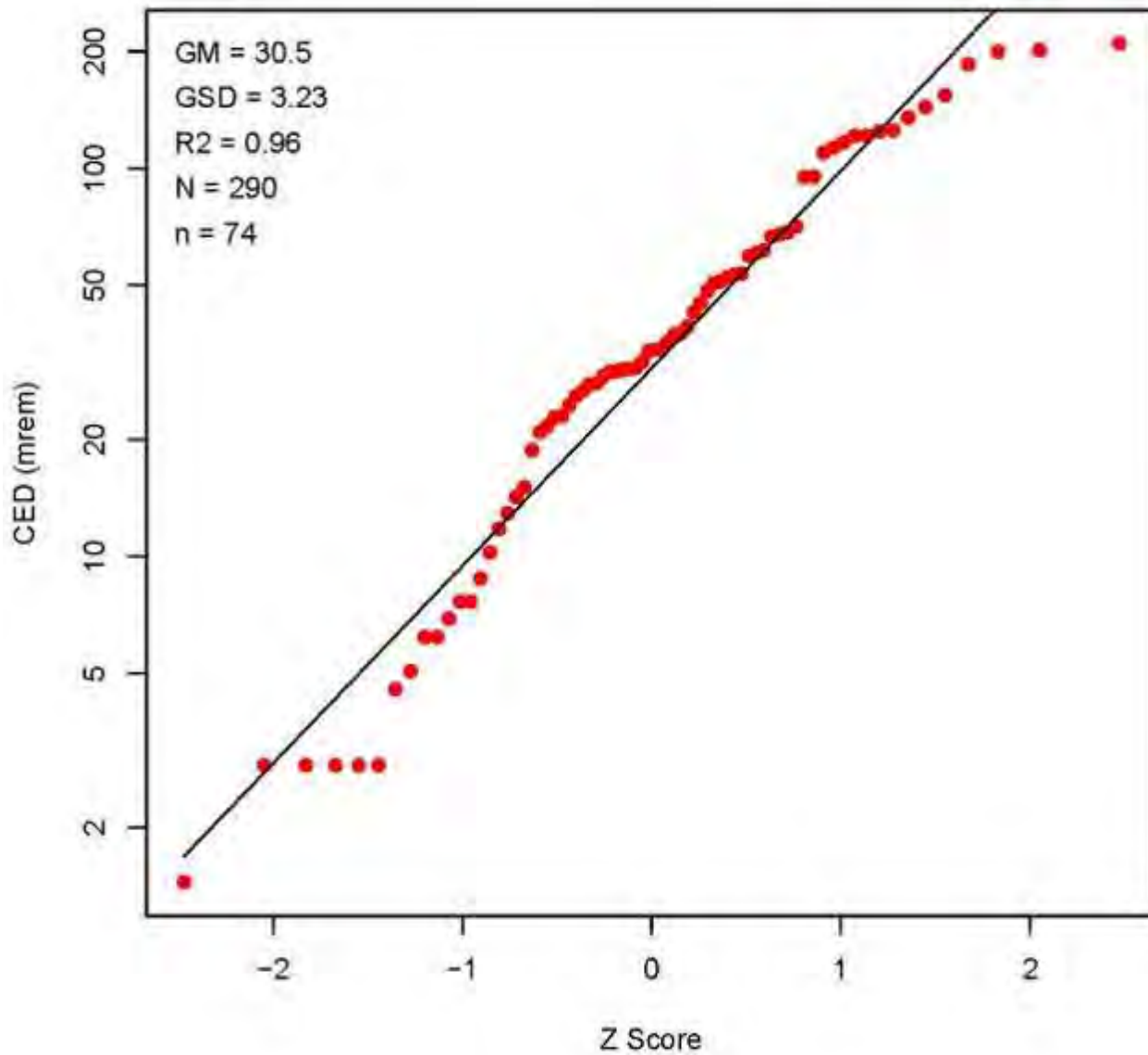


Figure A-74. SRS CTW tritium dose 1972.

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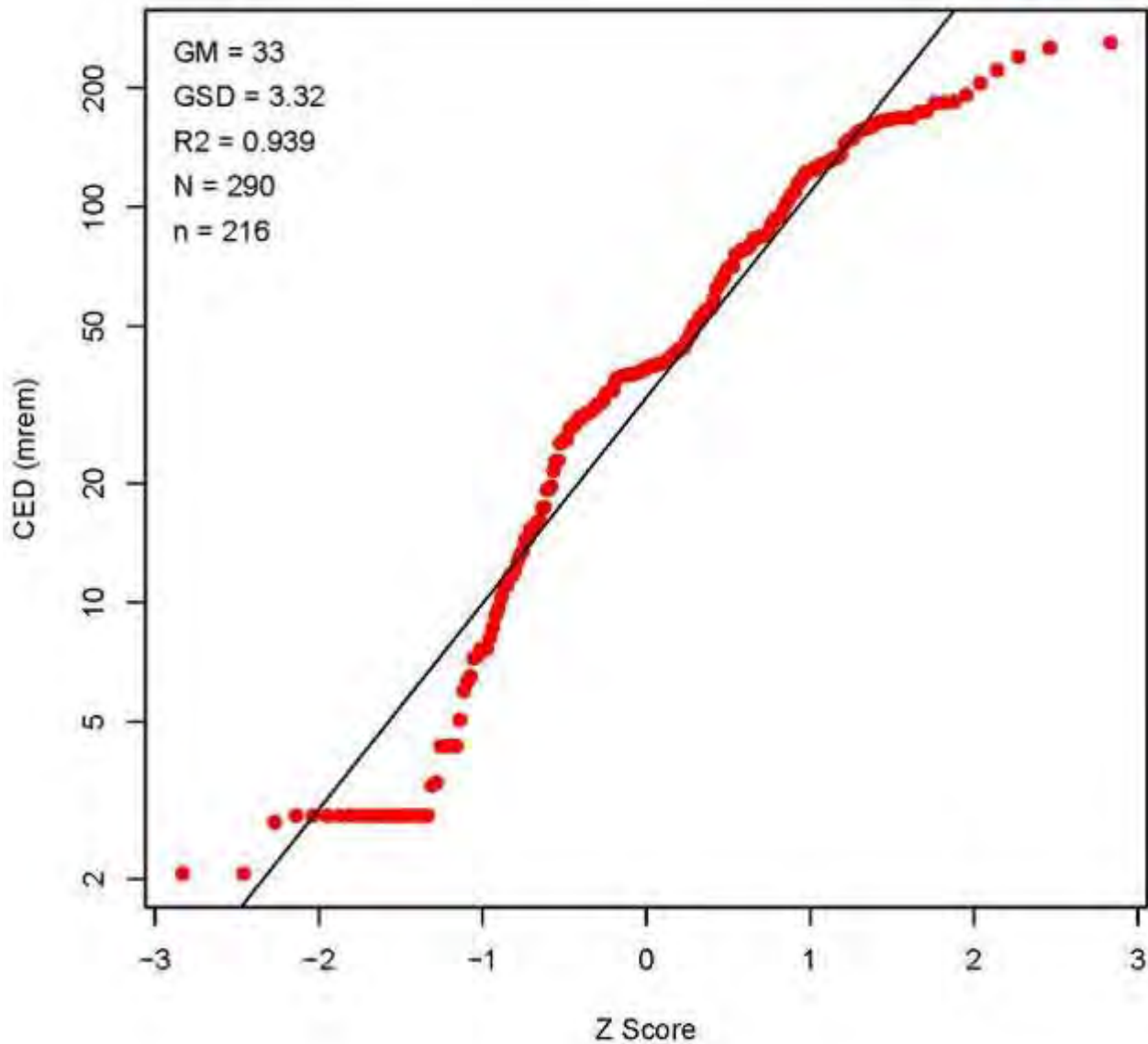


Figure A-75. SRS NCTW tritium dose 1972.

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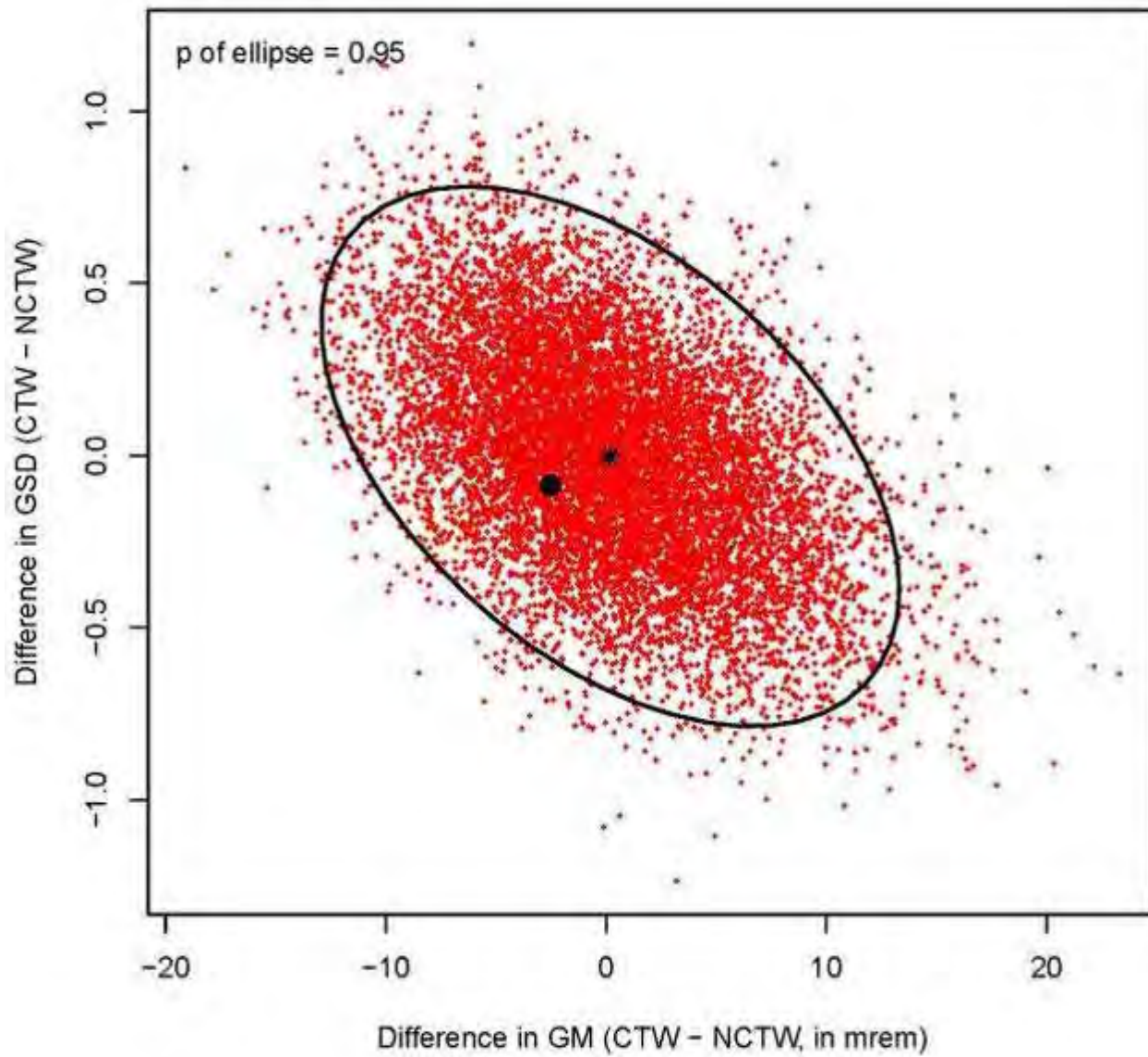


Figure A-76. SRS tritium dose 1972.

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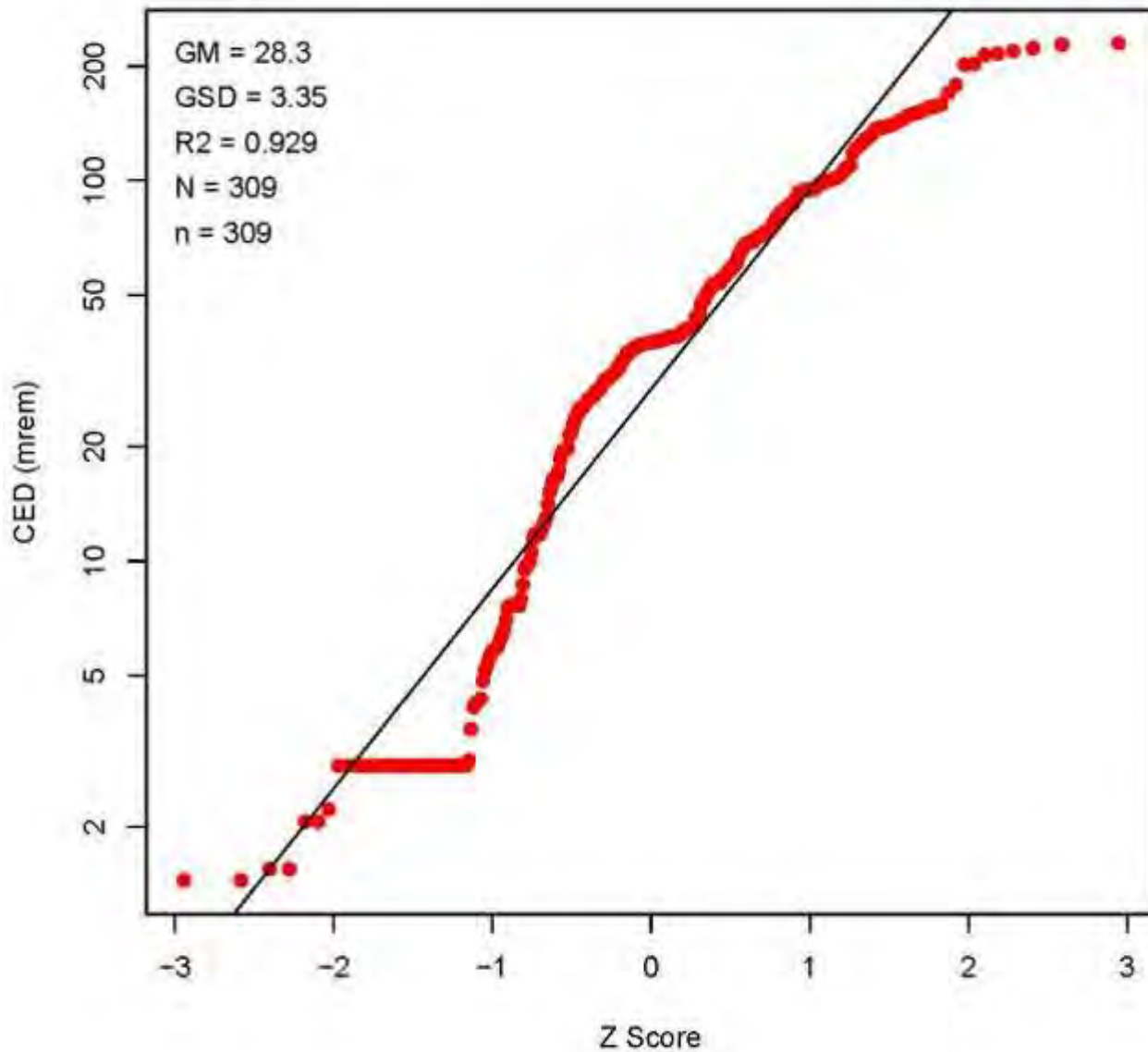


Figure A-77. SRS tritium dose 1973.

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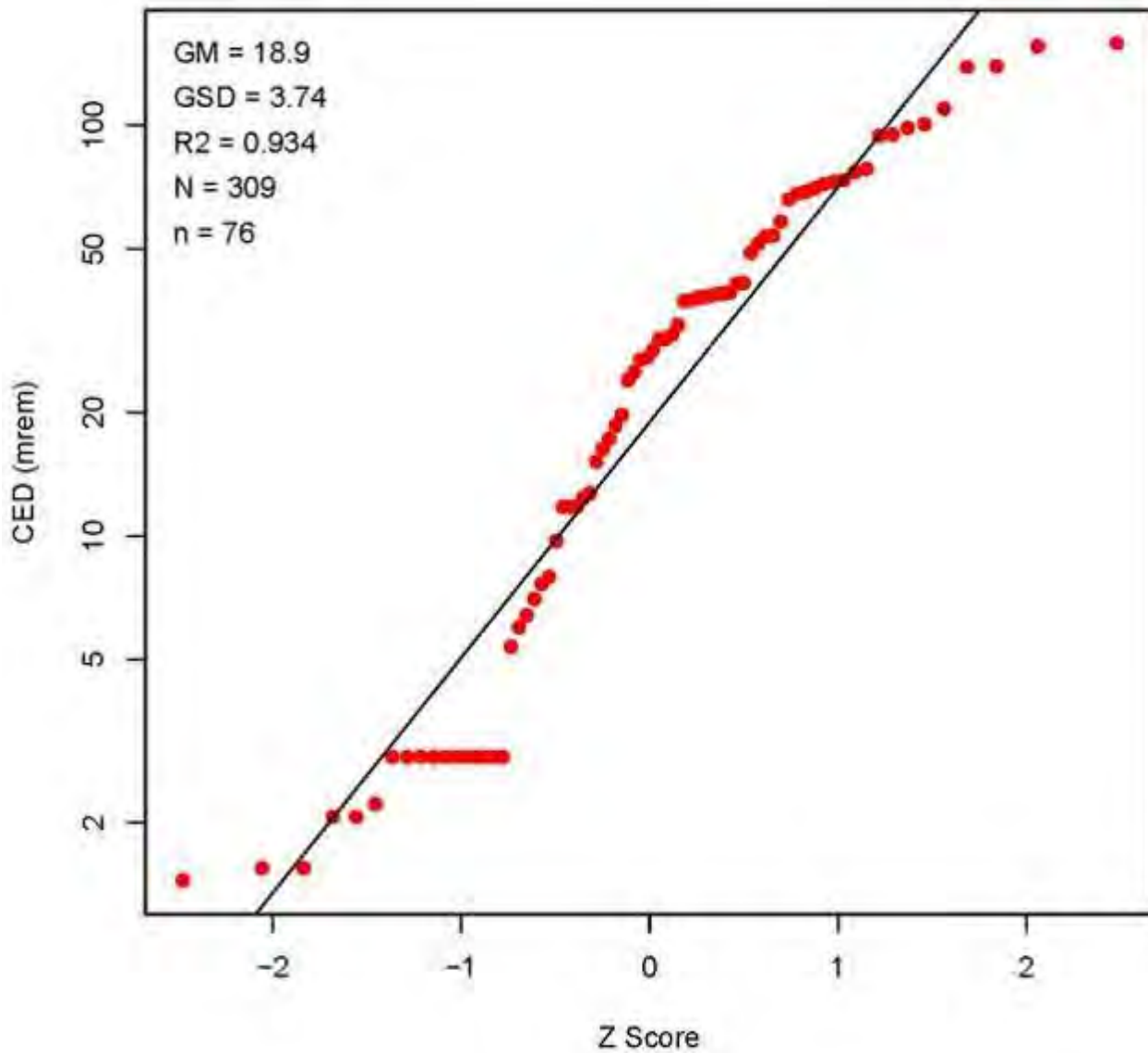


Figure A-78. SRS CTW tritium dose 1973.

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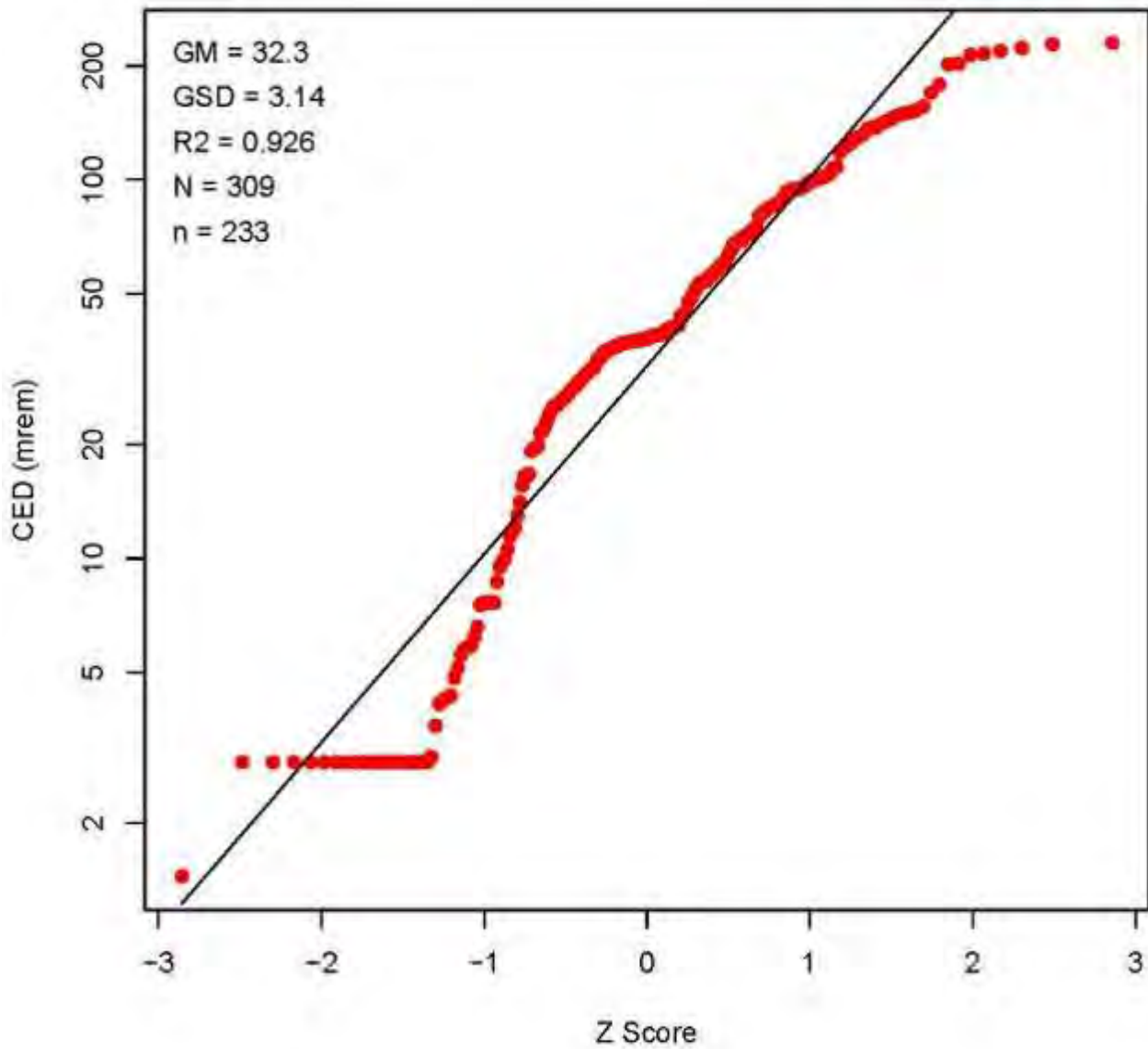


Figure A-79. SRS NCTW tritium dose 1973.

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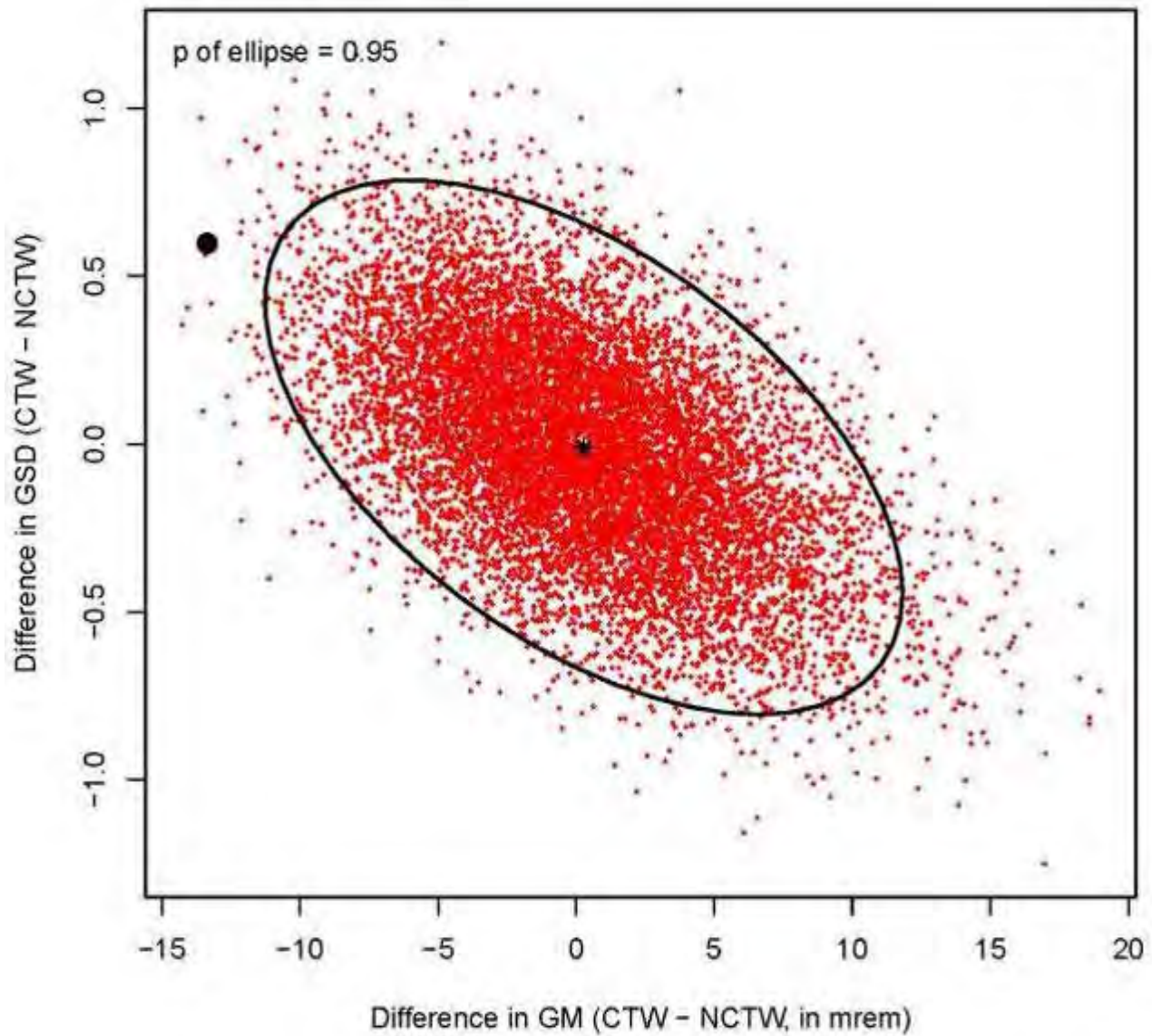


Figure A-80. SRS tritium dose 1973.

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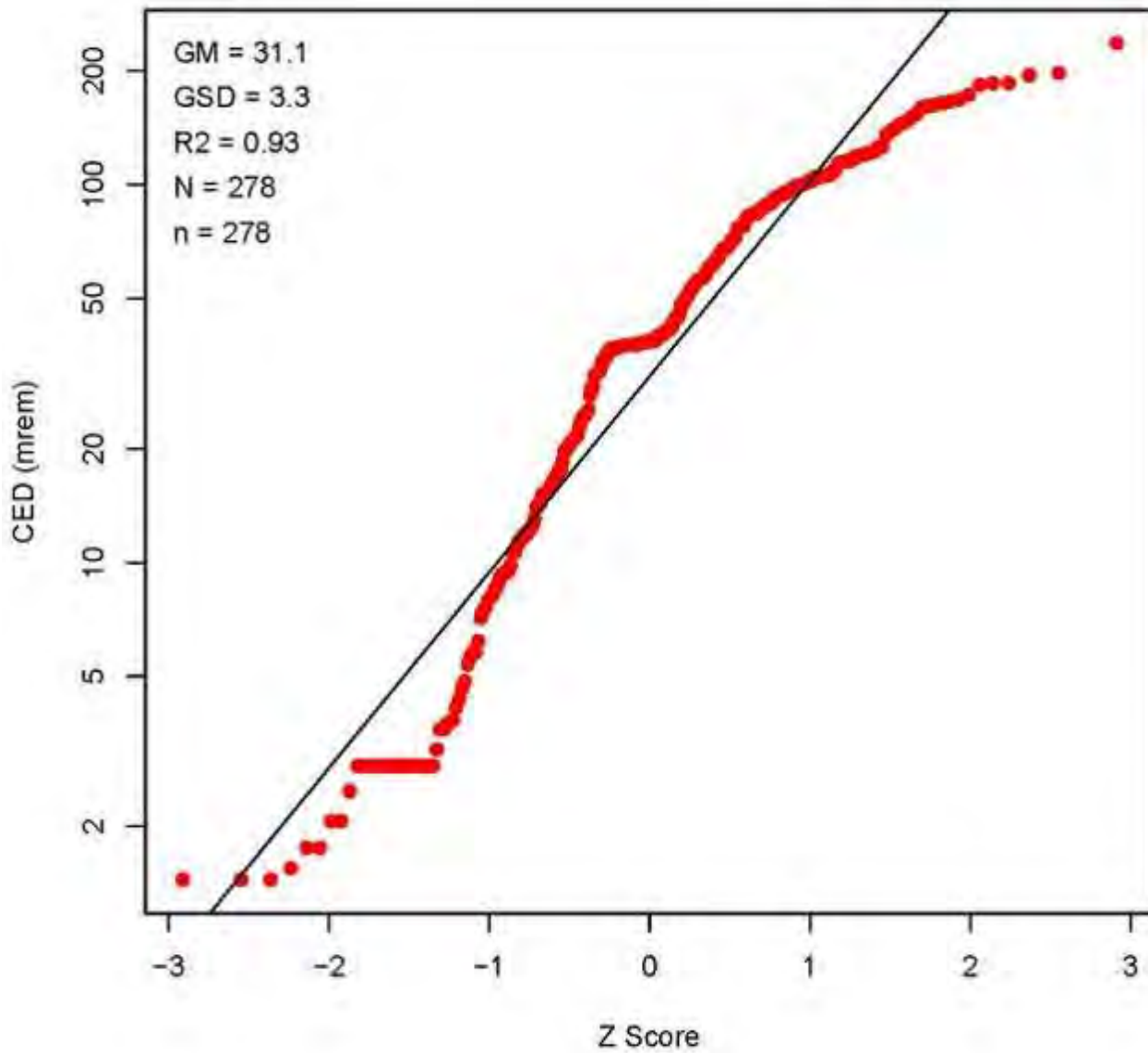


Figure A-81. SRS tritium dose 1974.

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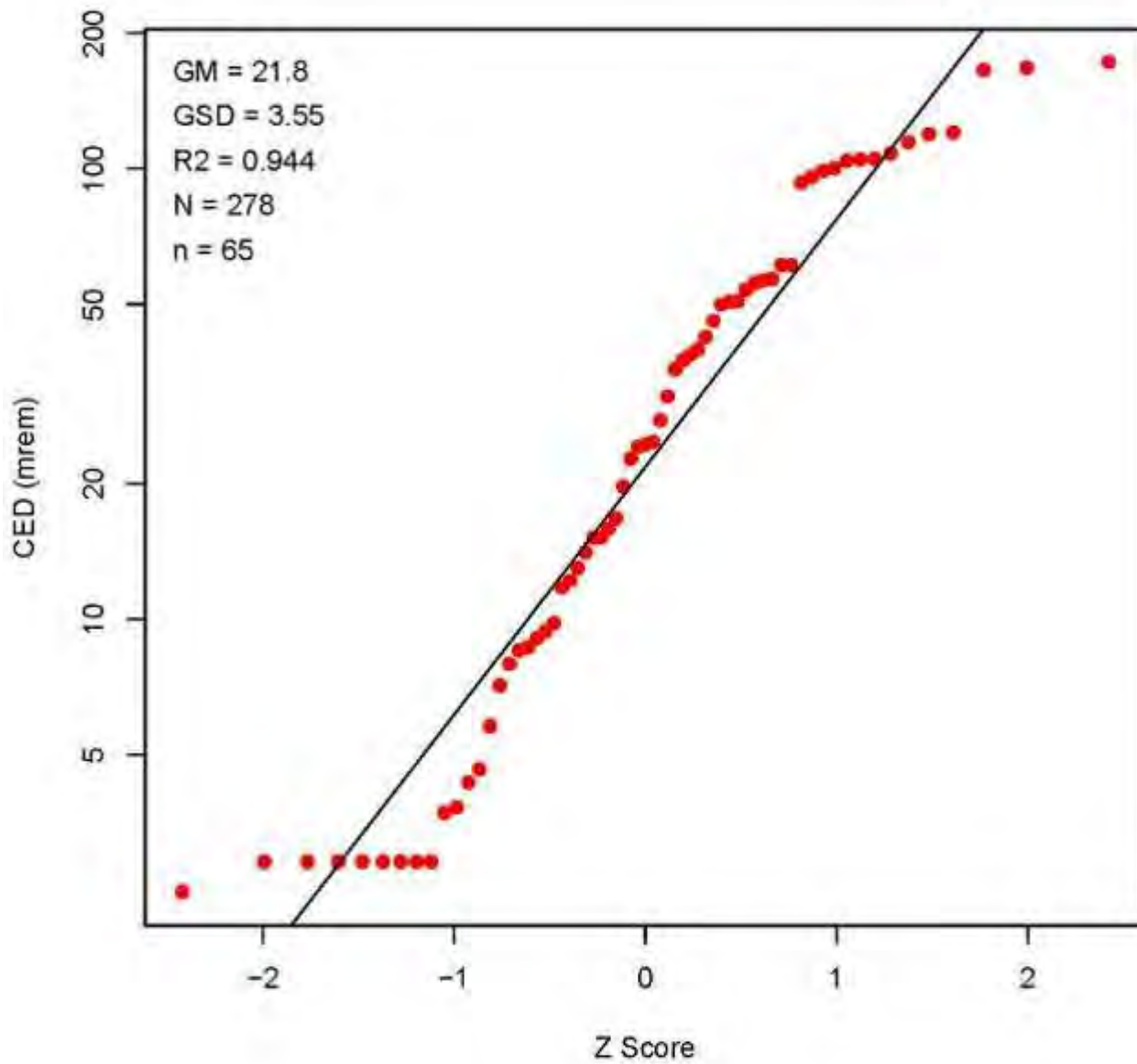


Figure A-82. SRS CTW tritium dose 1974.

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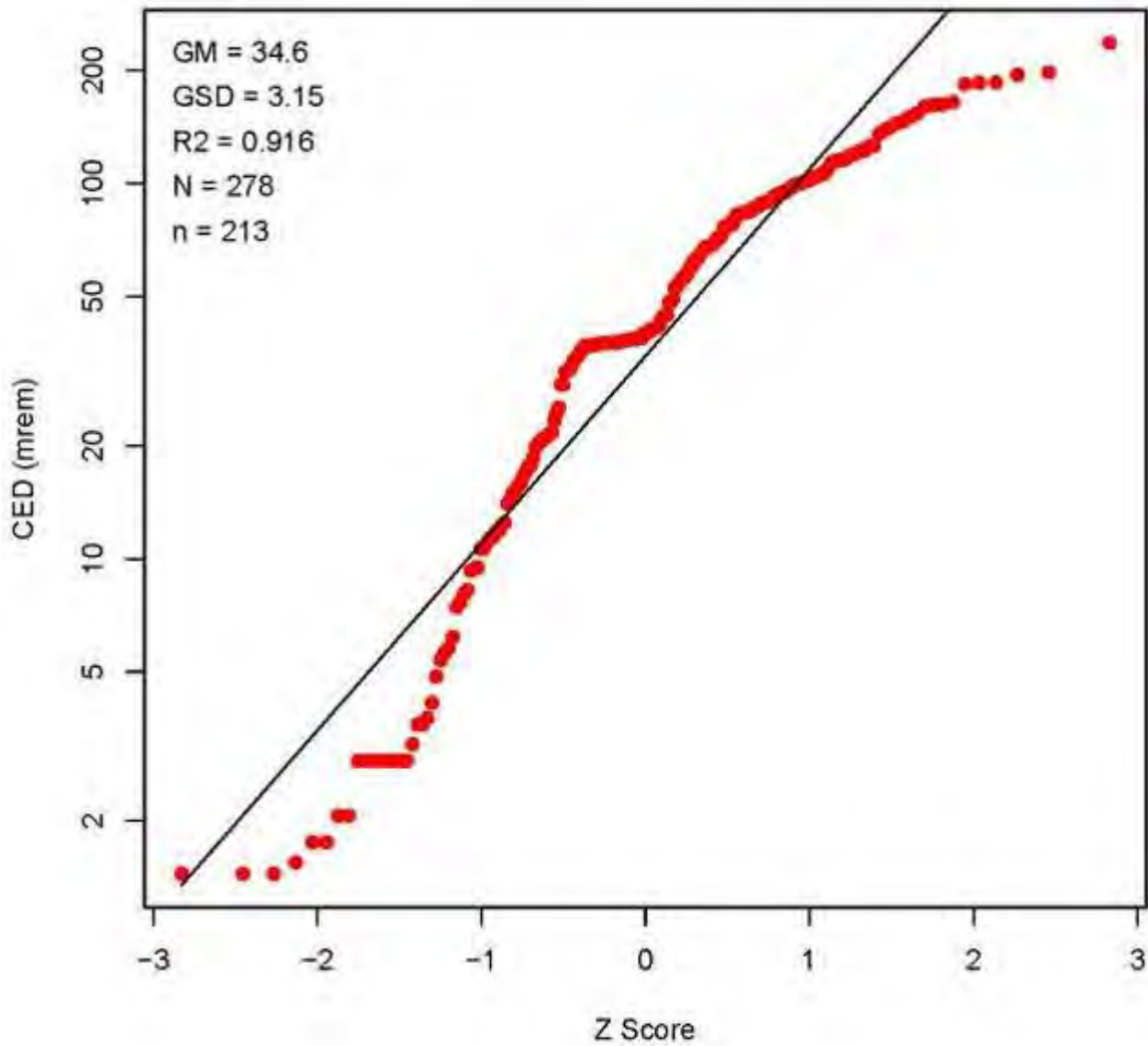


Figure A-83. SRS NCTW tritium dose 1974.

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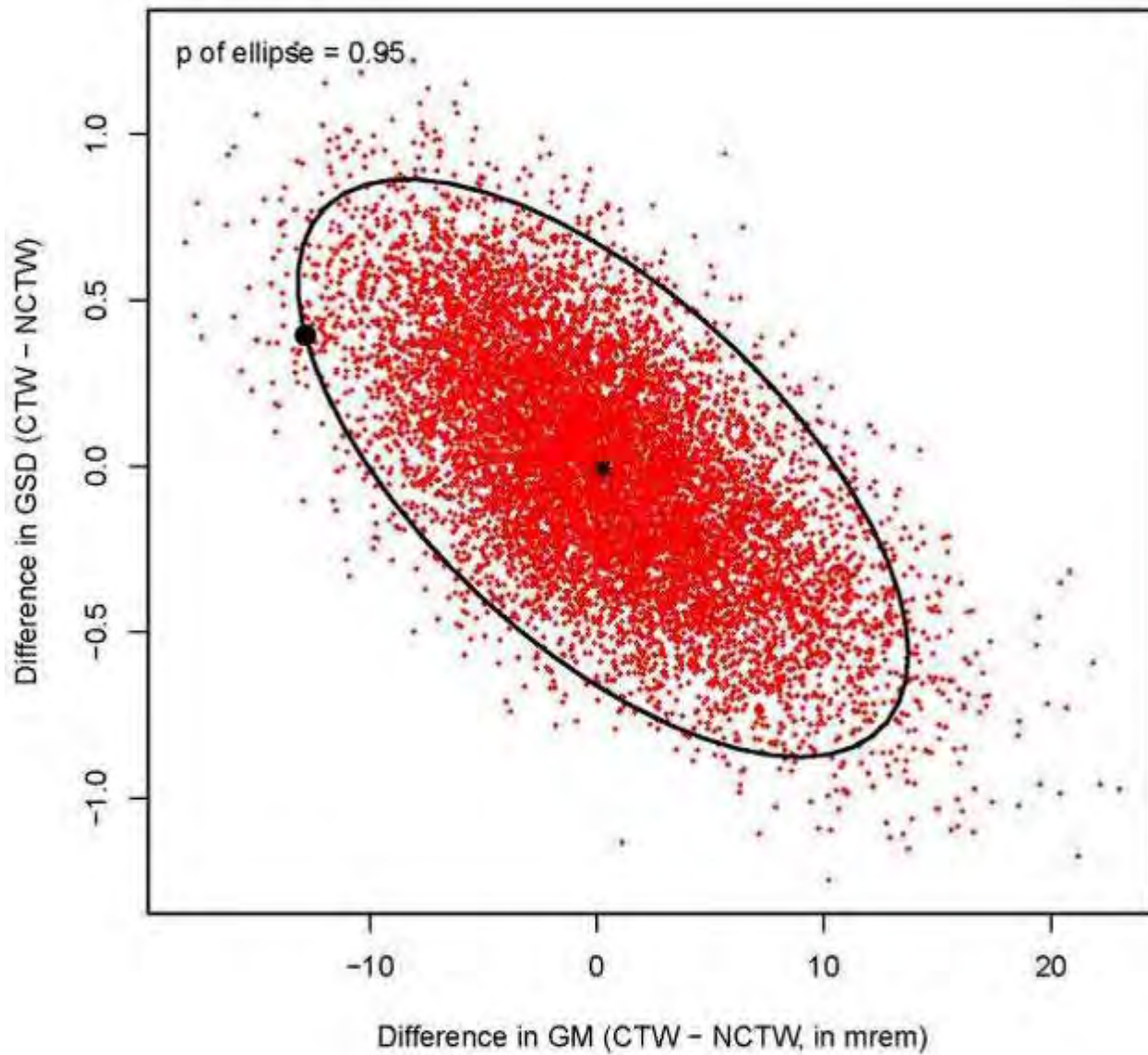


Figure A-84. SRS tritium dose 1974.

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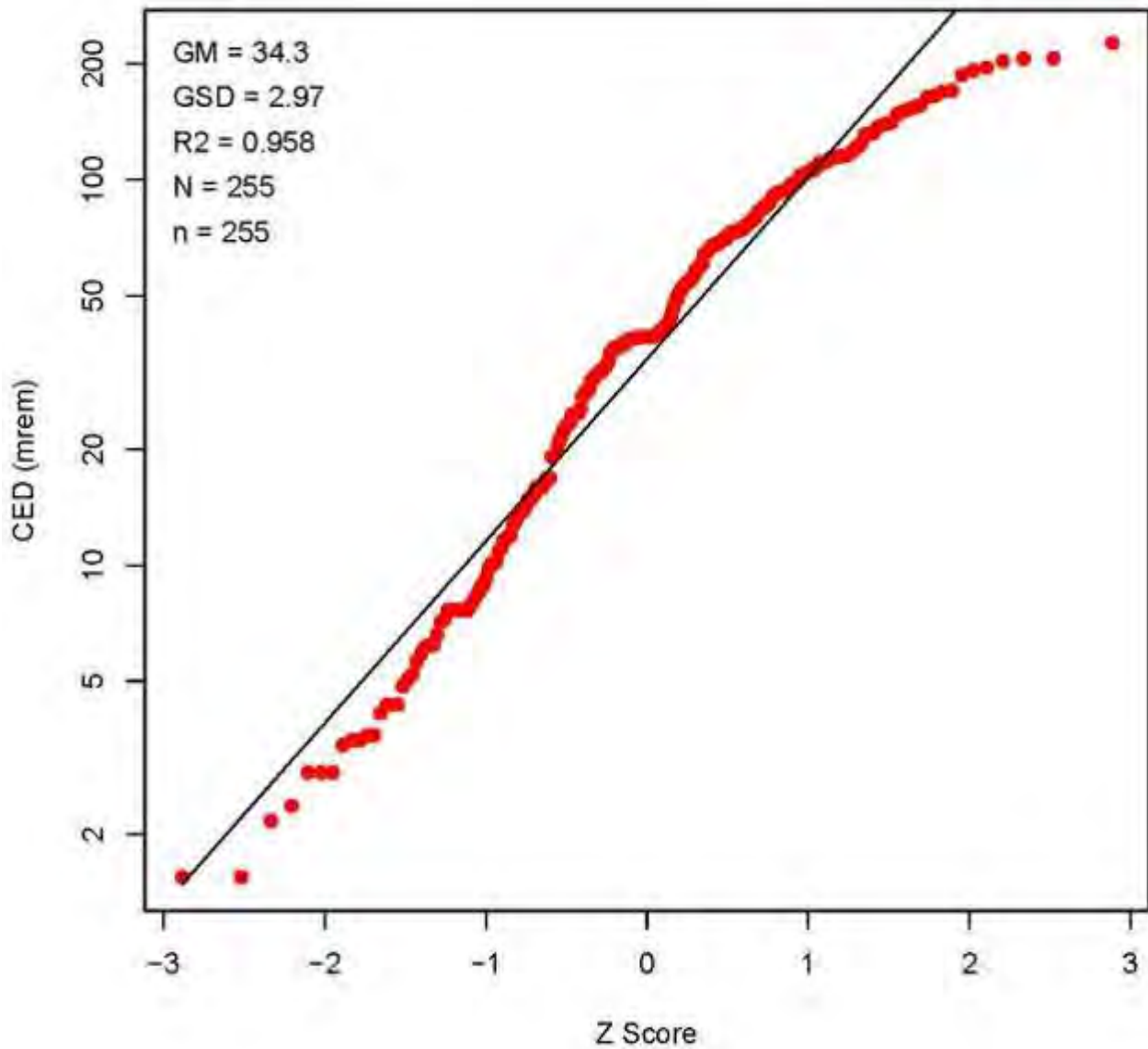


Figure A-85. SRS tritium dose 1975.

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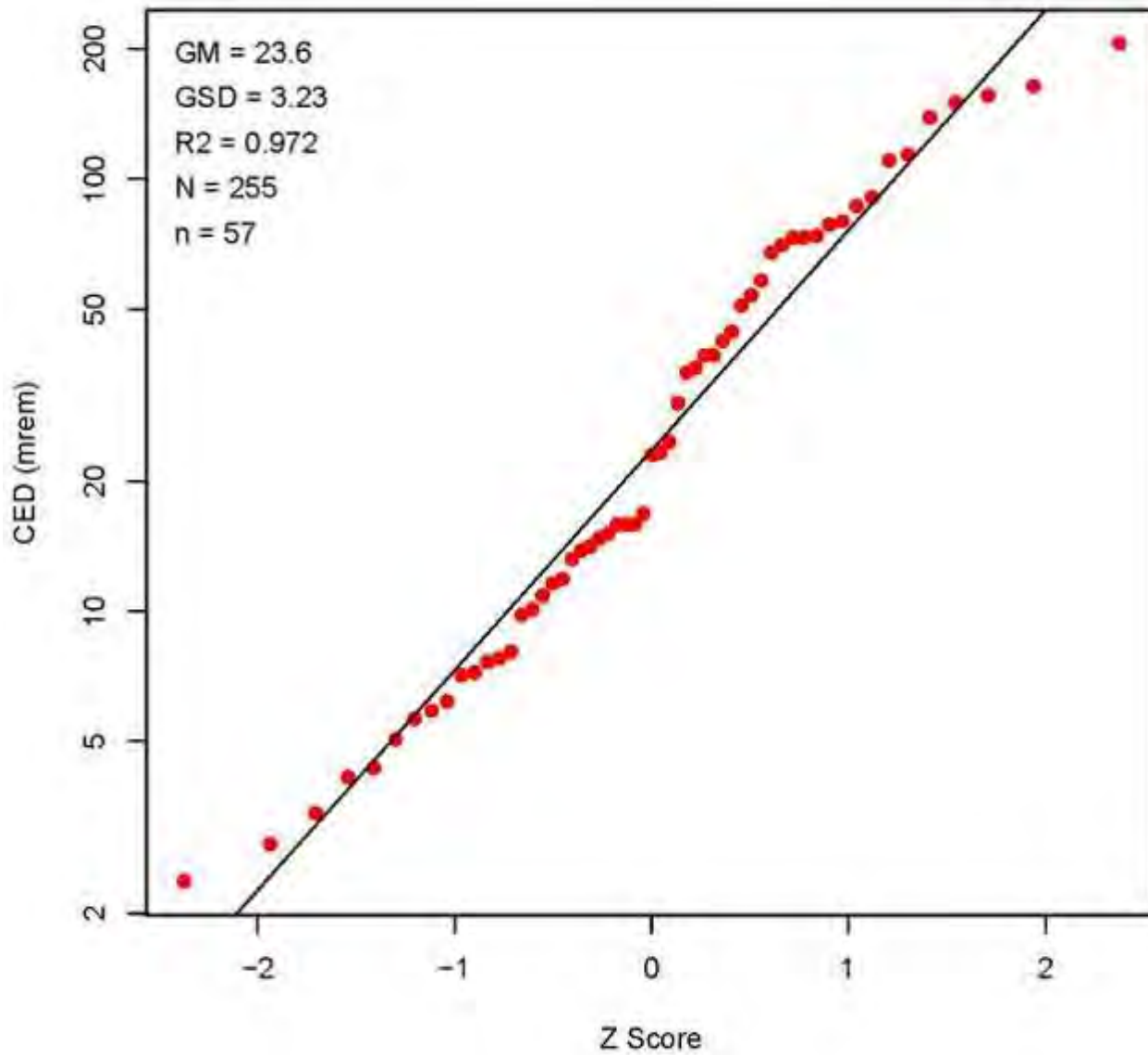


Figure A-86. SRS CTW tritium dose 1975.

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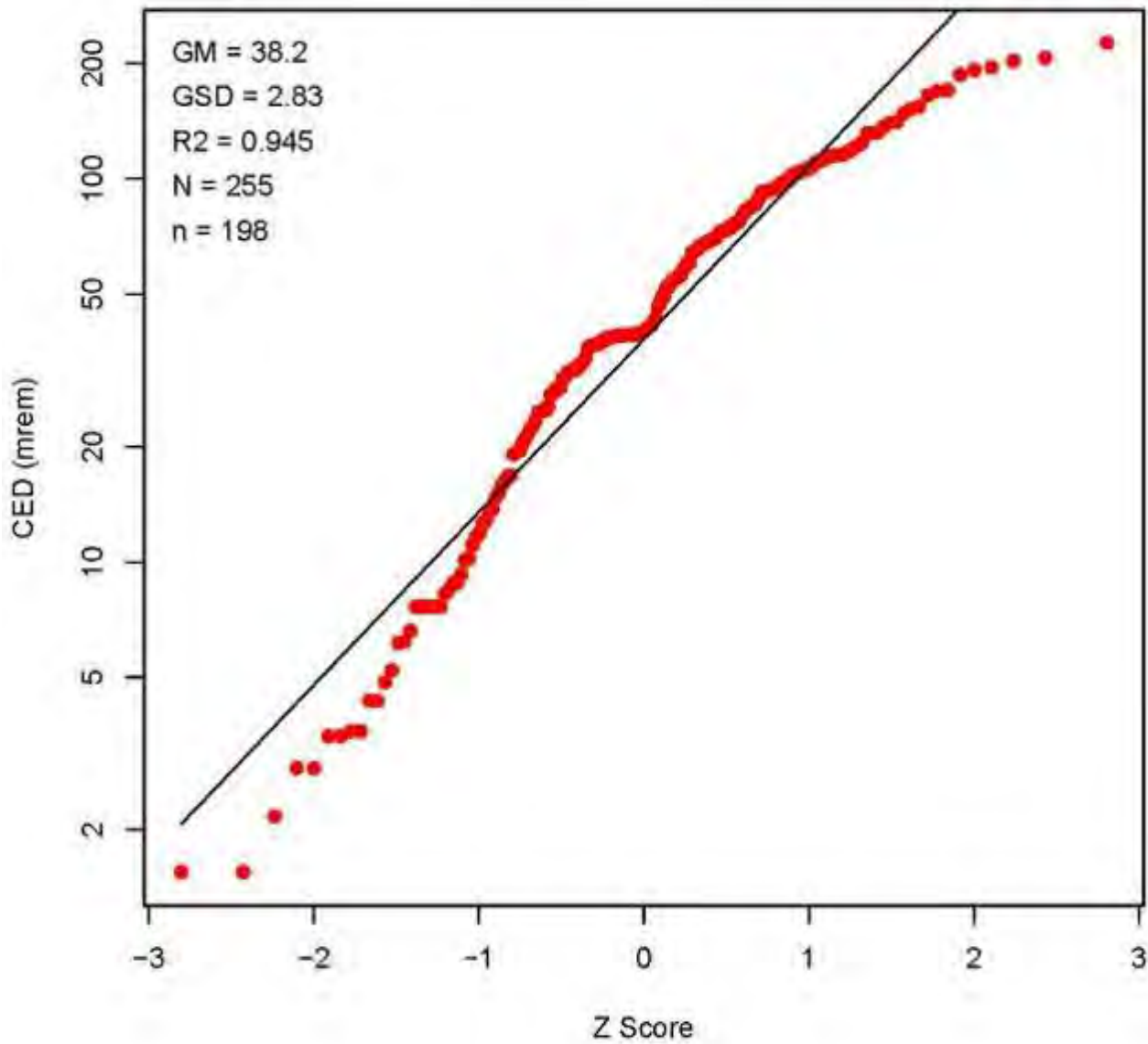


Figure A-87. SRS NCTW tritium dose 1975.

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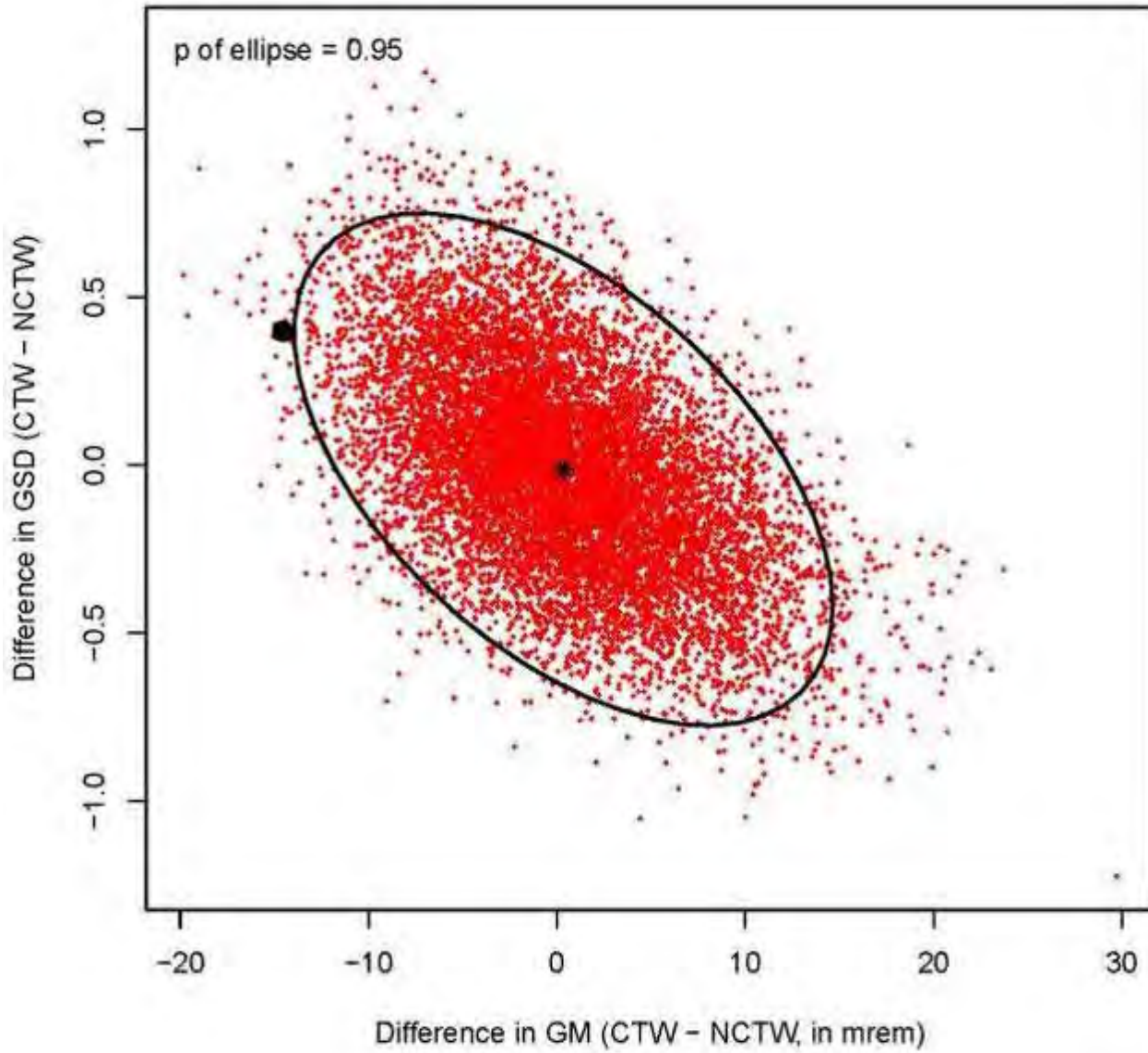


Figure A-88. SRS tritium dose 1975.

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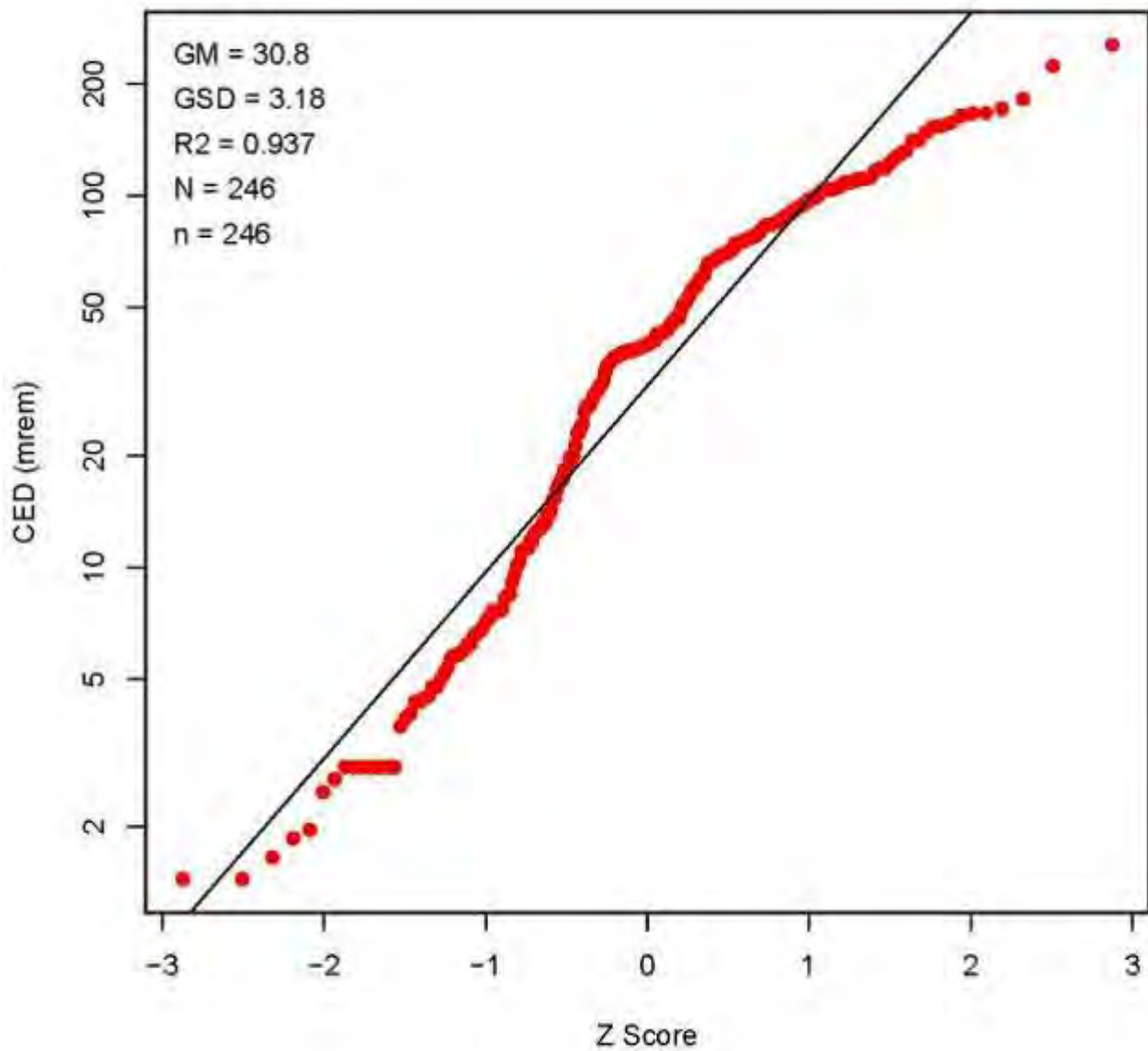


Figure A-89. SRS tritium dose 1976.

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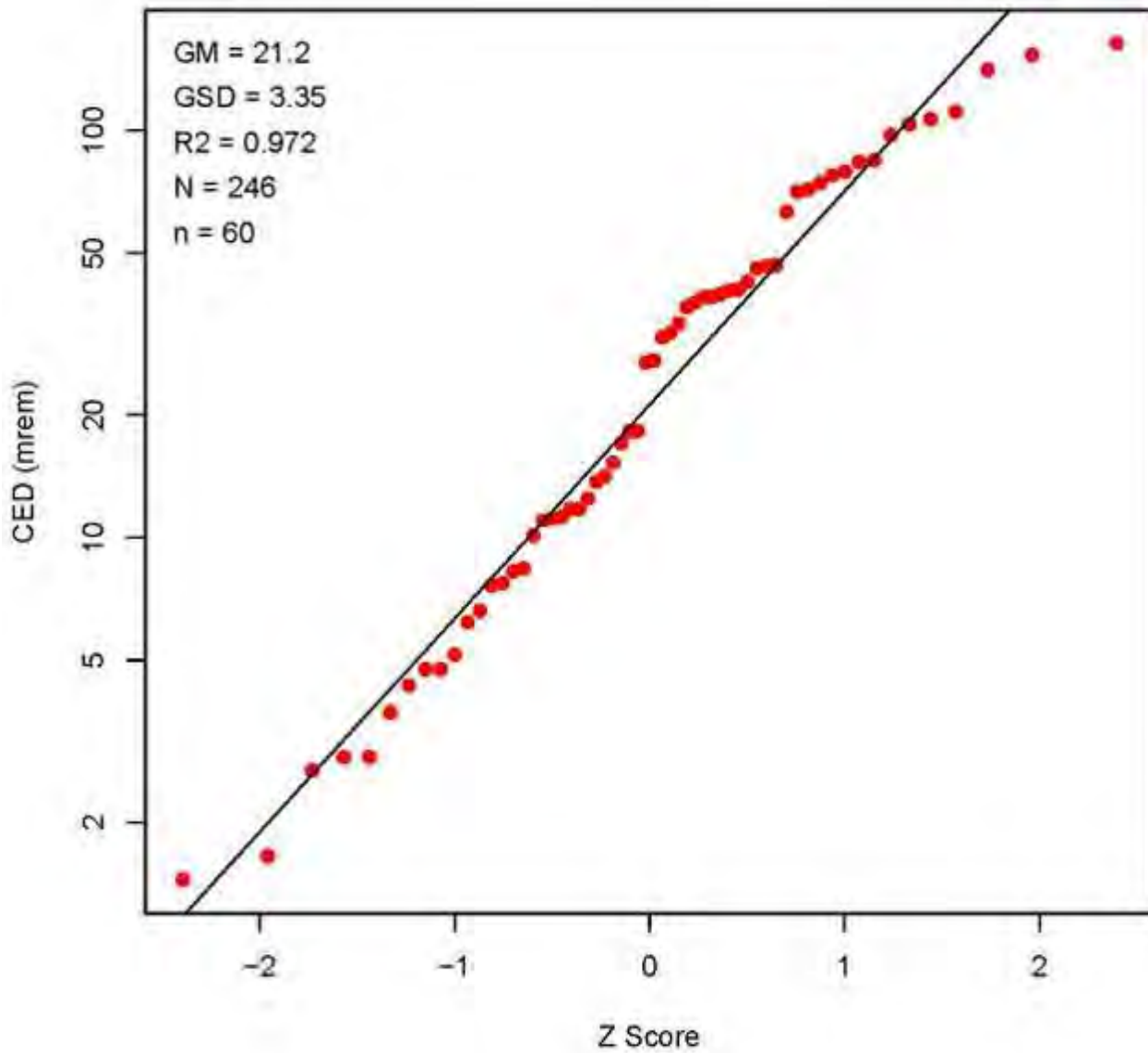


Figure A-90. SRS CTW tritium dose 1976.

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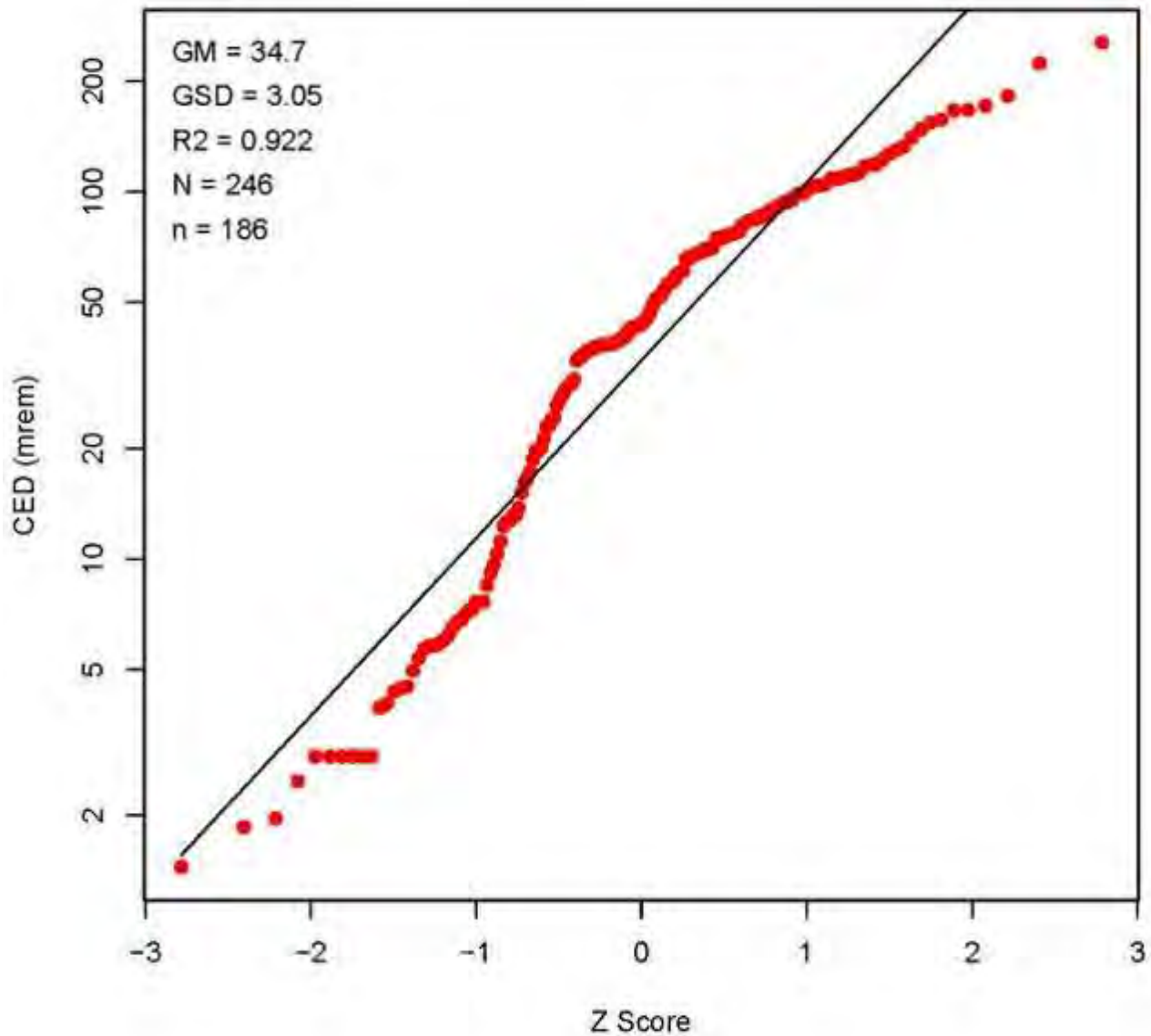


Figure A-91. SRS NCTW tritium dose 1976.

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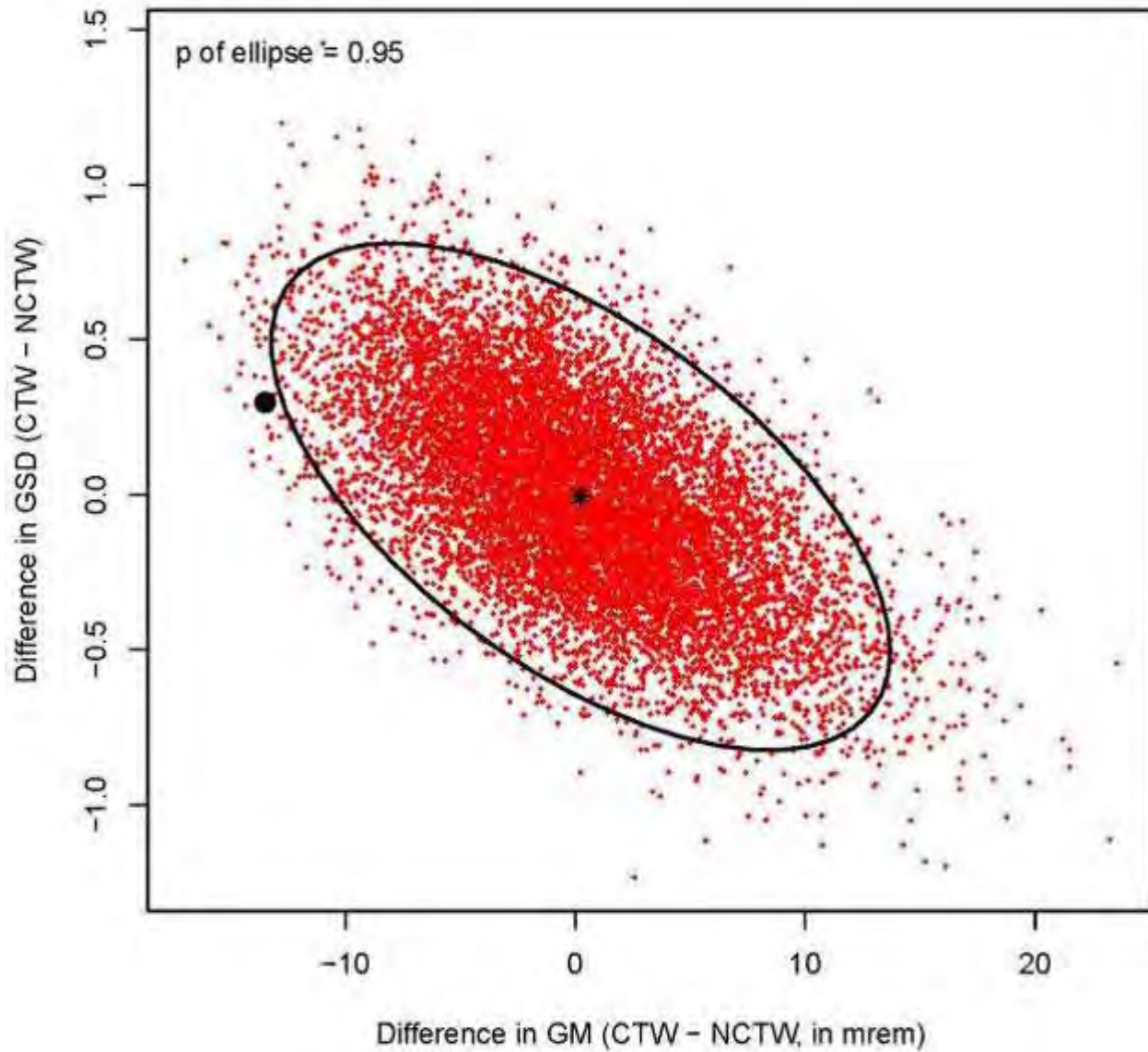


Figure A-92. SRS tritium dose 1976.

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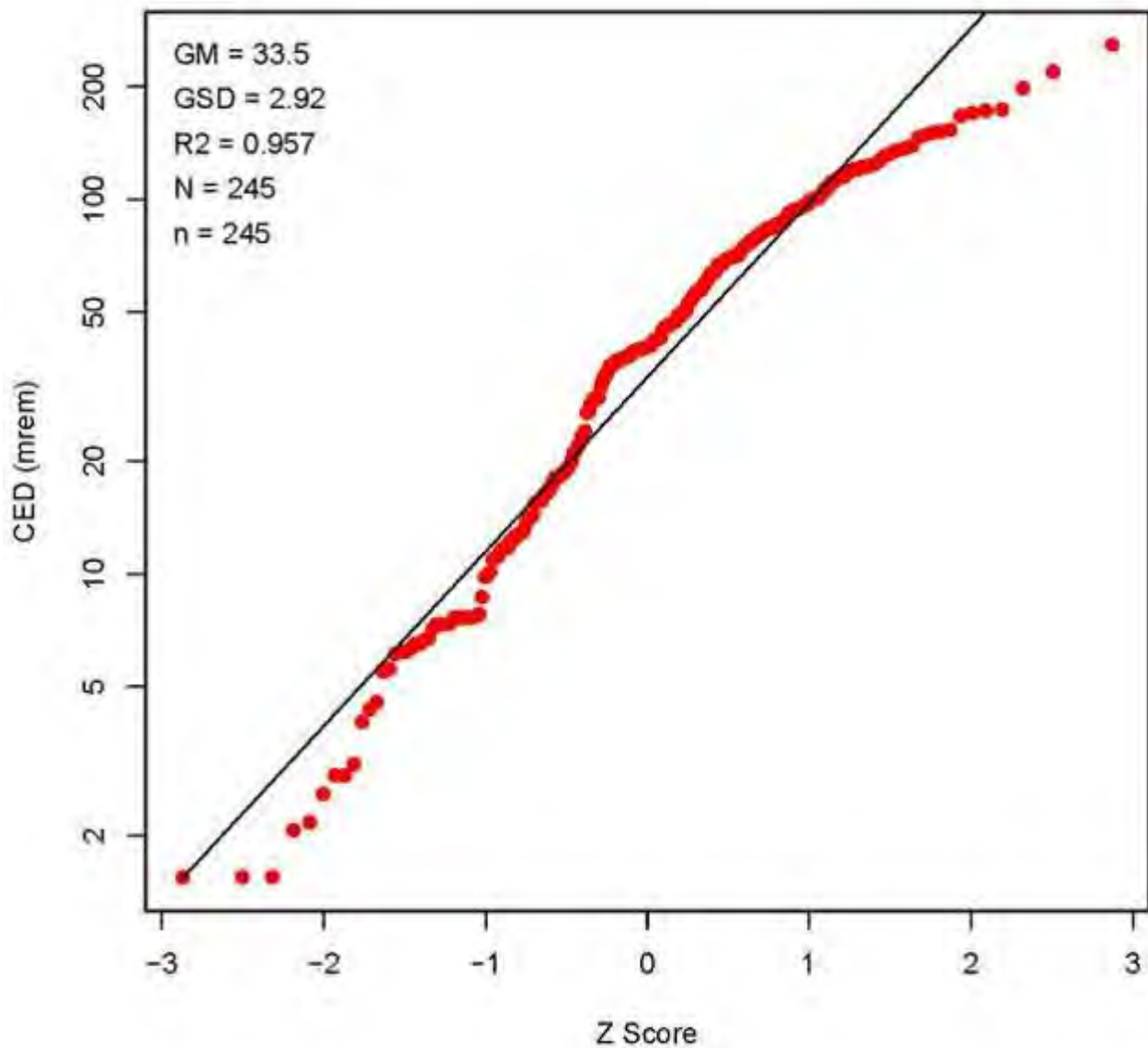


Figure A-93. SRS tritium dose 1977.

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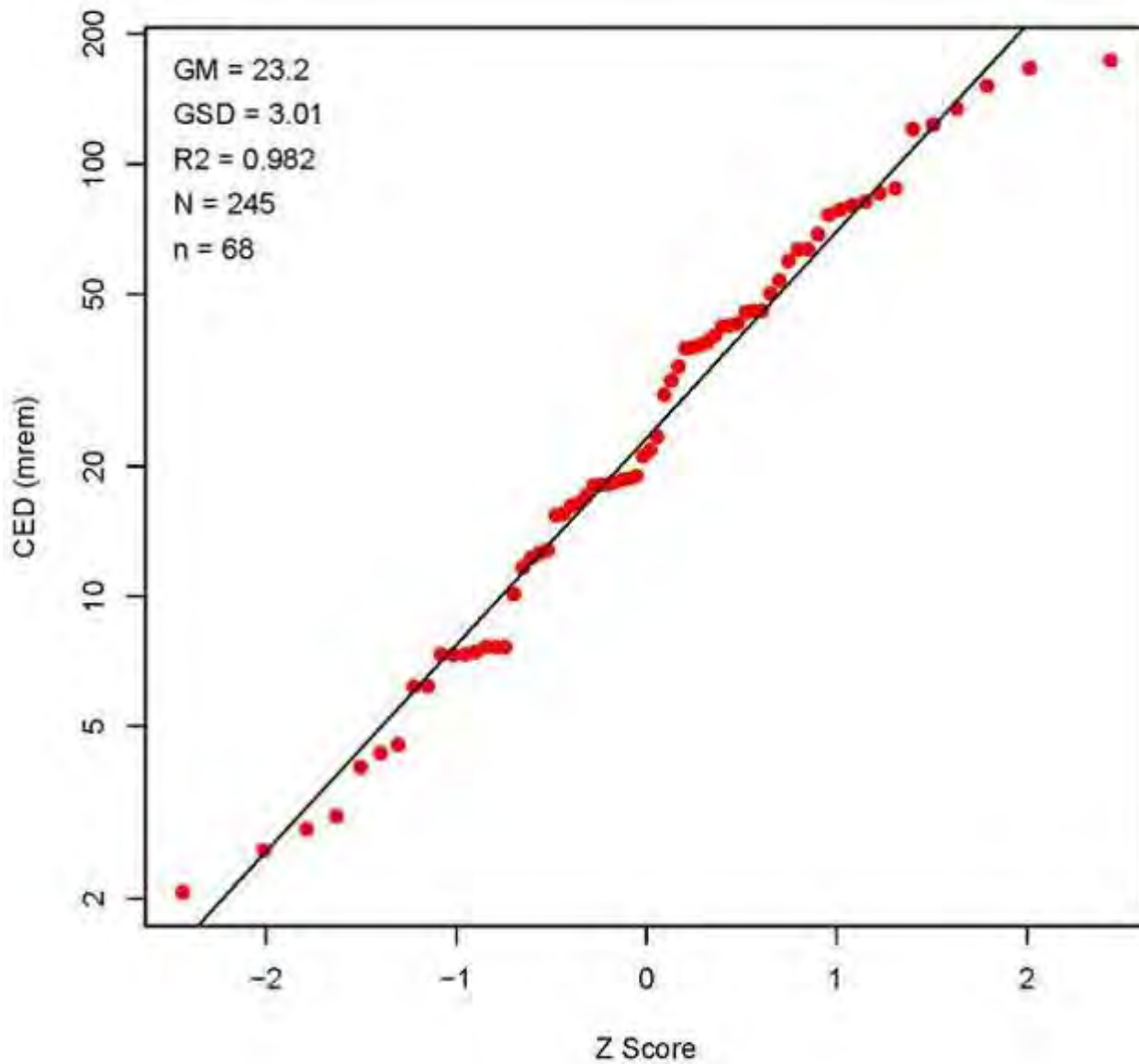


Figure A-94. SRS CTW tritium dose 1977.

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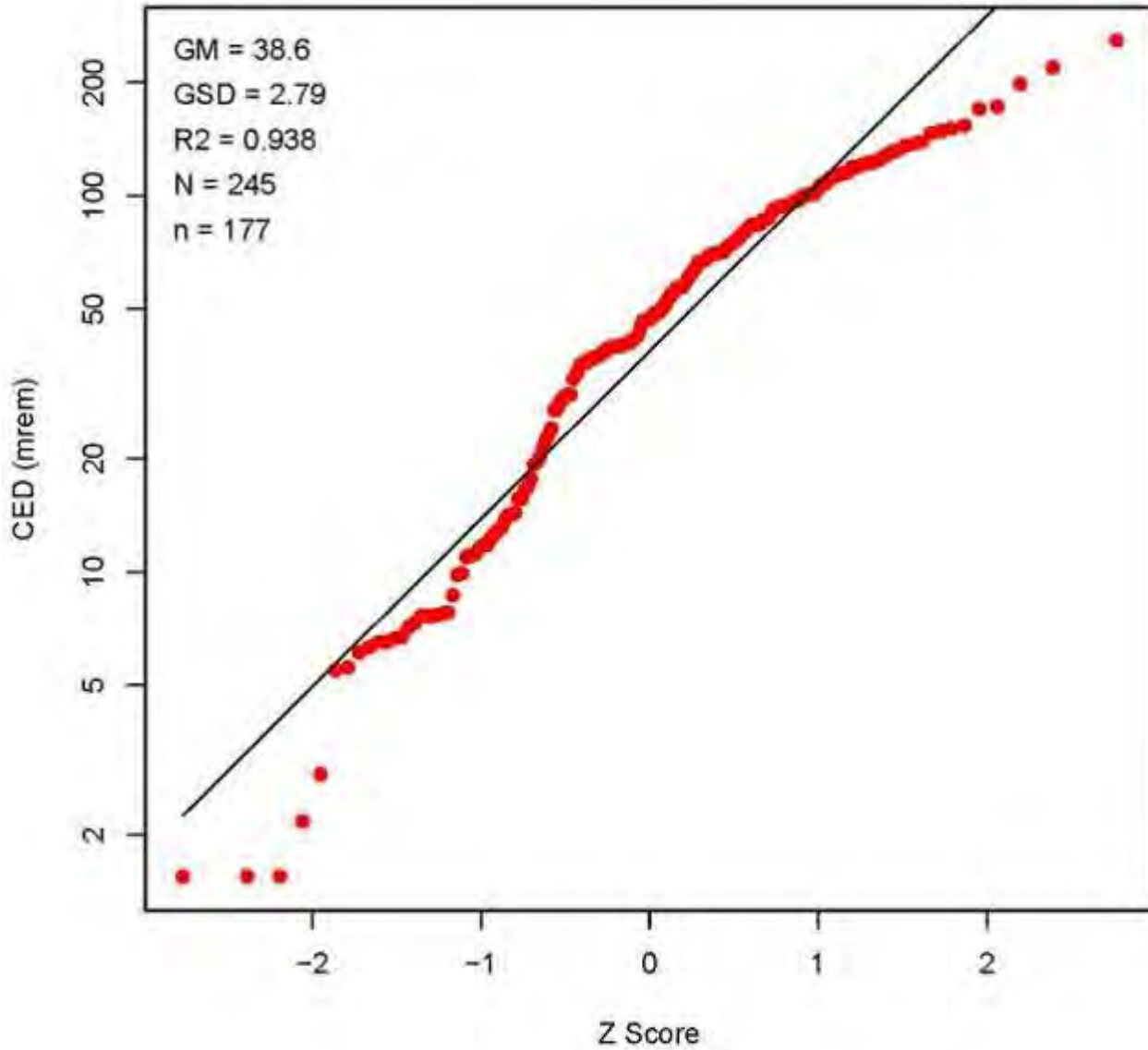


Figure A-95. SRS NCTW tritium dose 1977.

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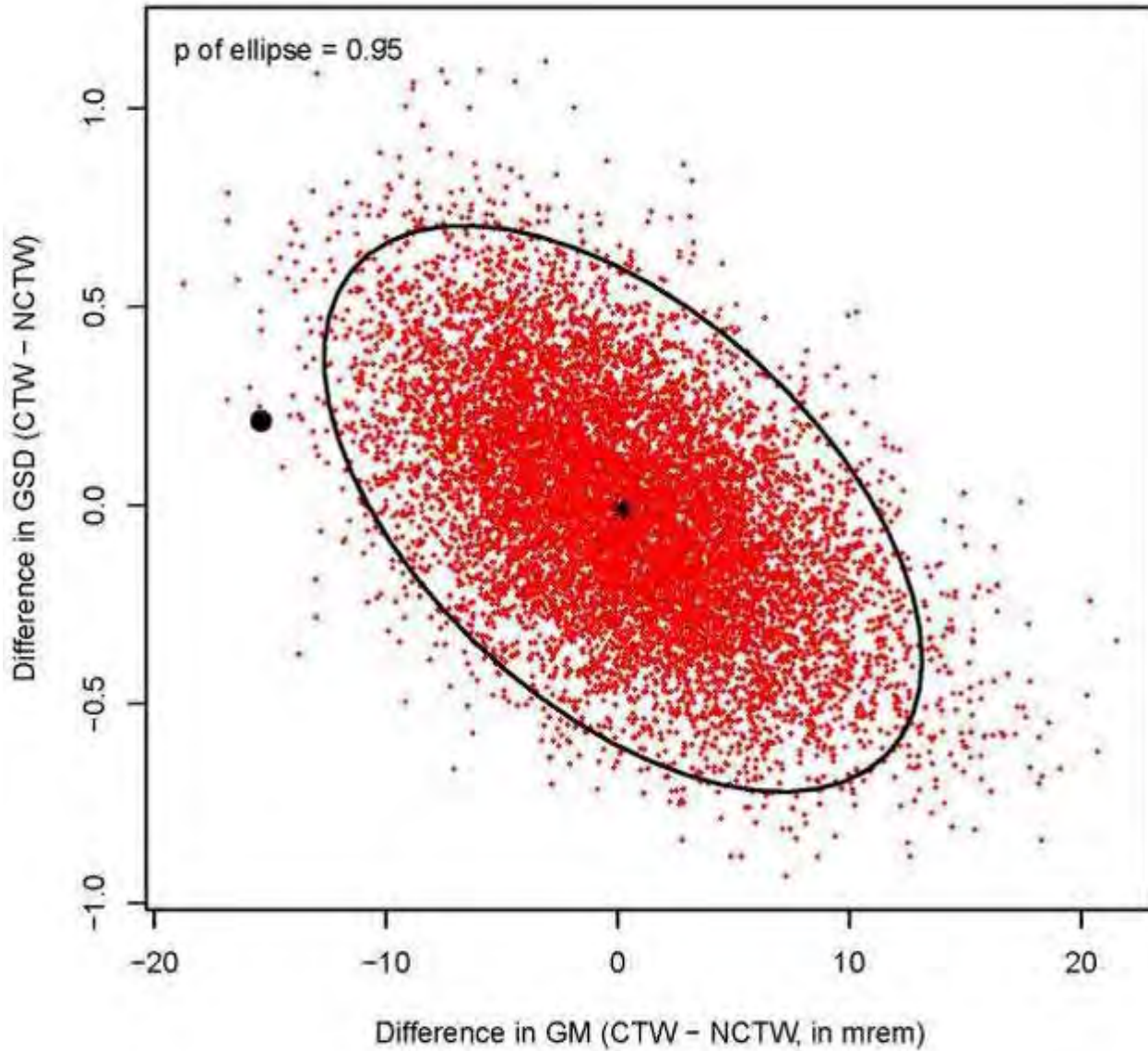


Figure A-96. SRS tritium dose 1977.

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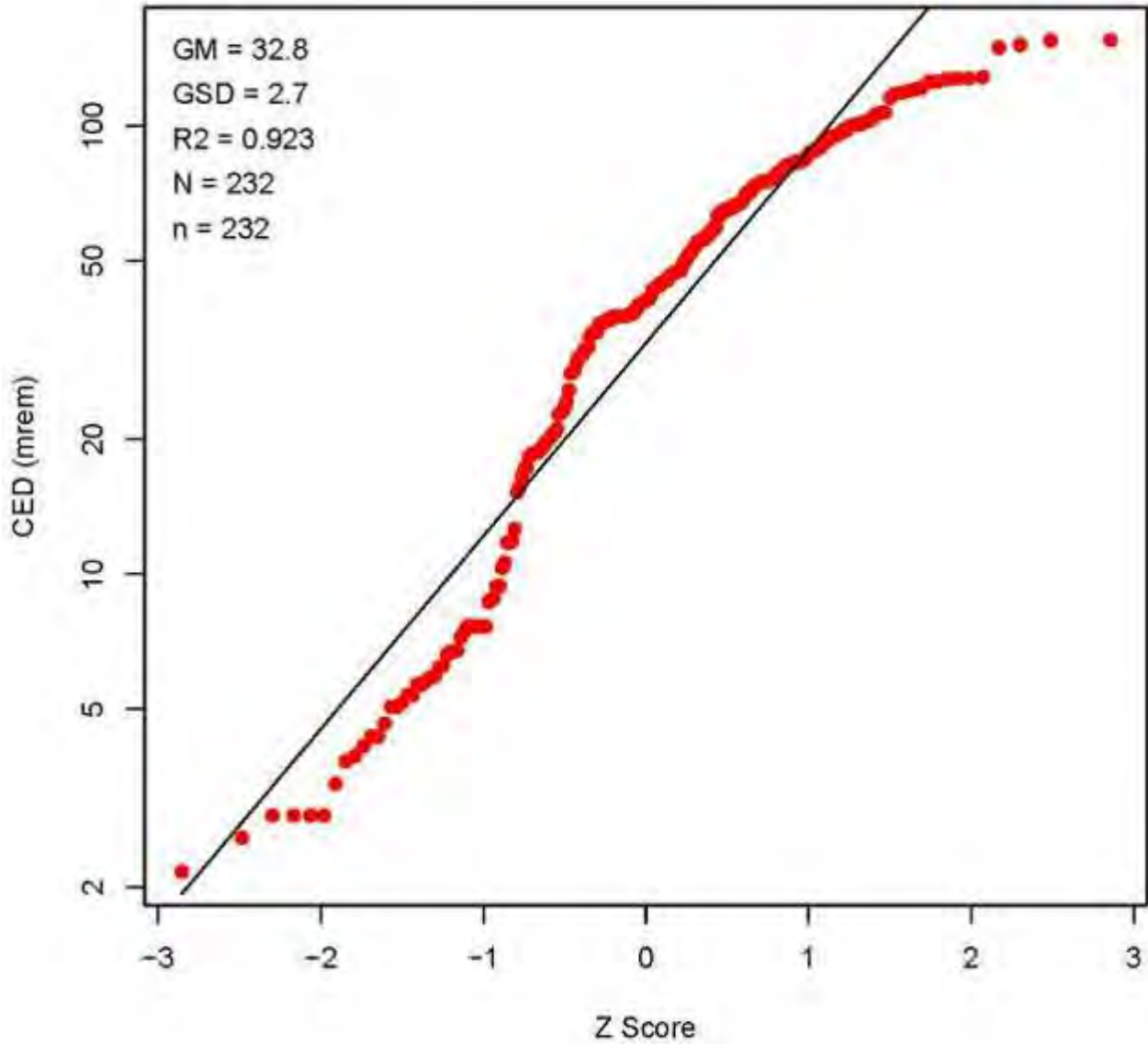


Figure A-97. SRS tritium dose 1978.

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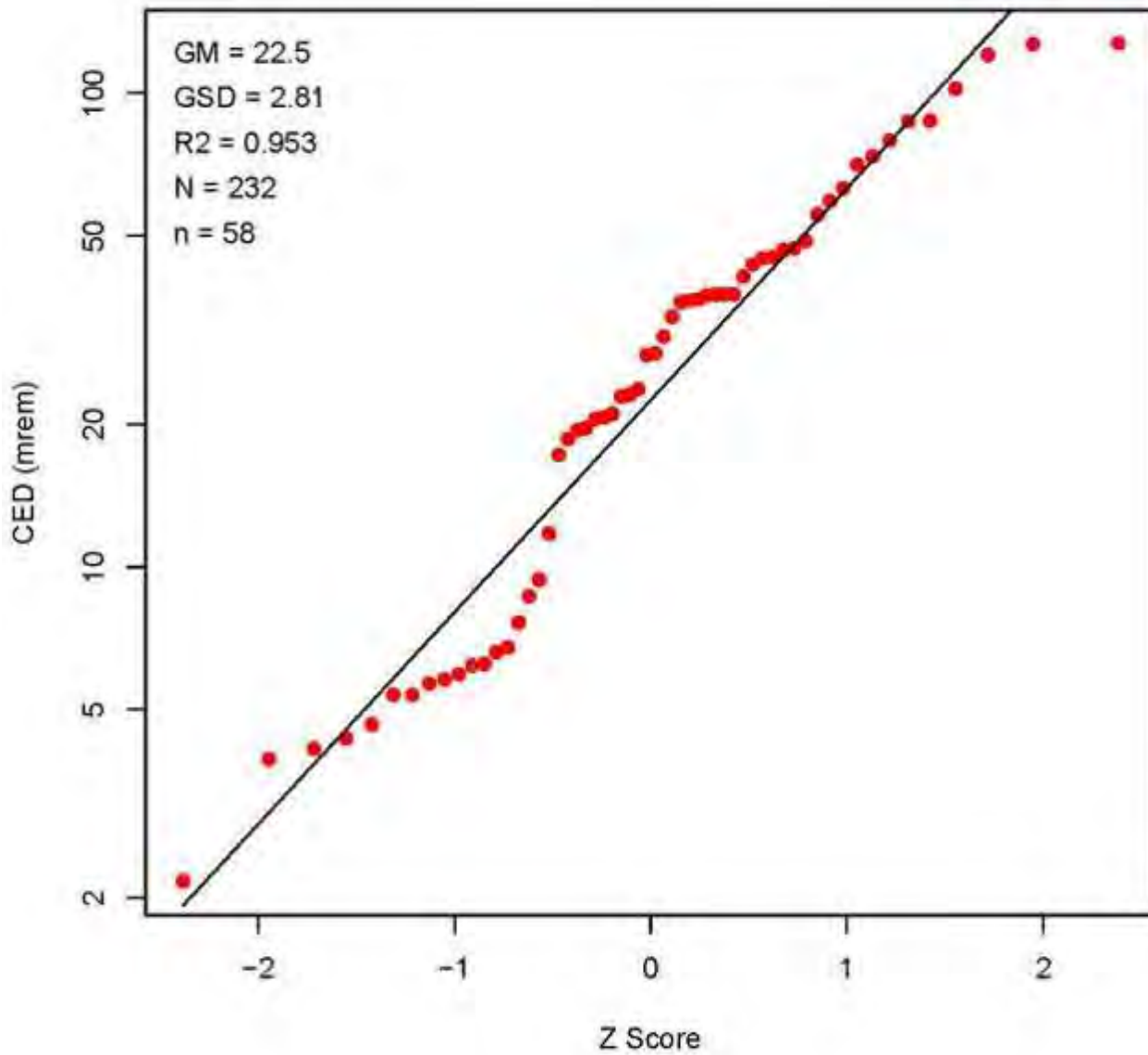


Figure A-98. SRS CTW tritium dose 1978.

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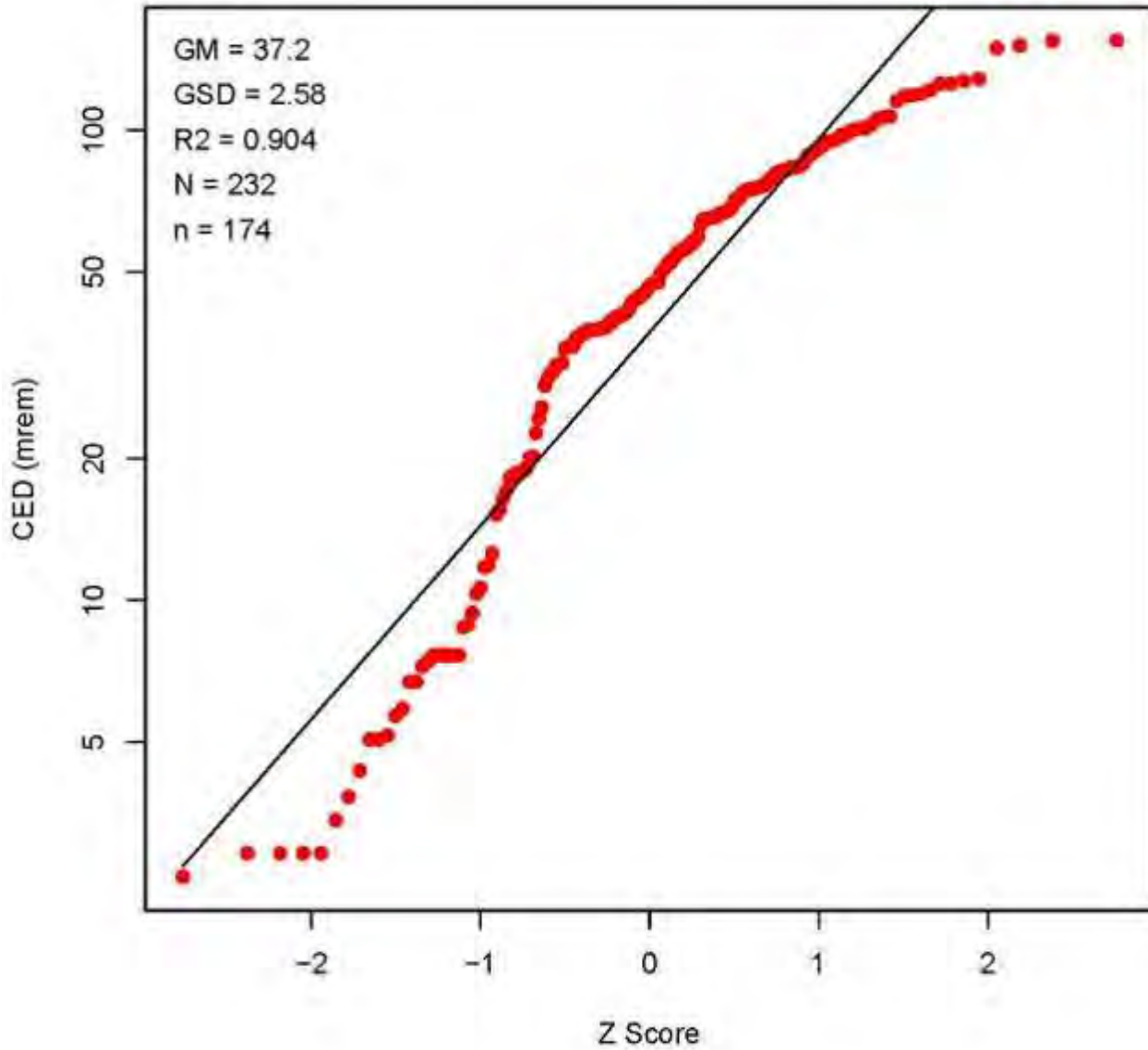


Figure A-99. SRS NCTW tritium dose 1978.

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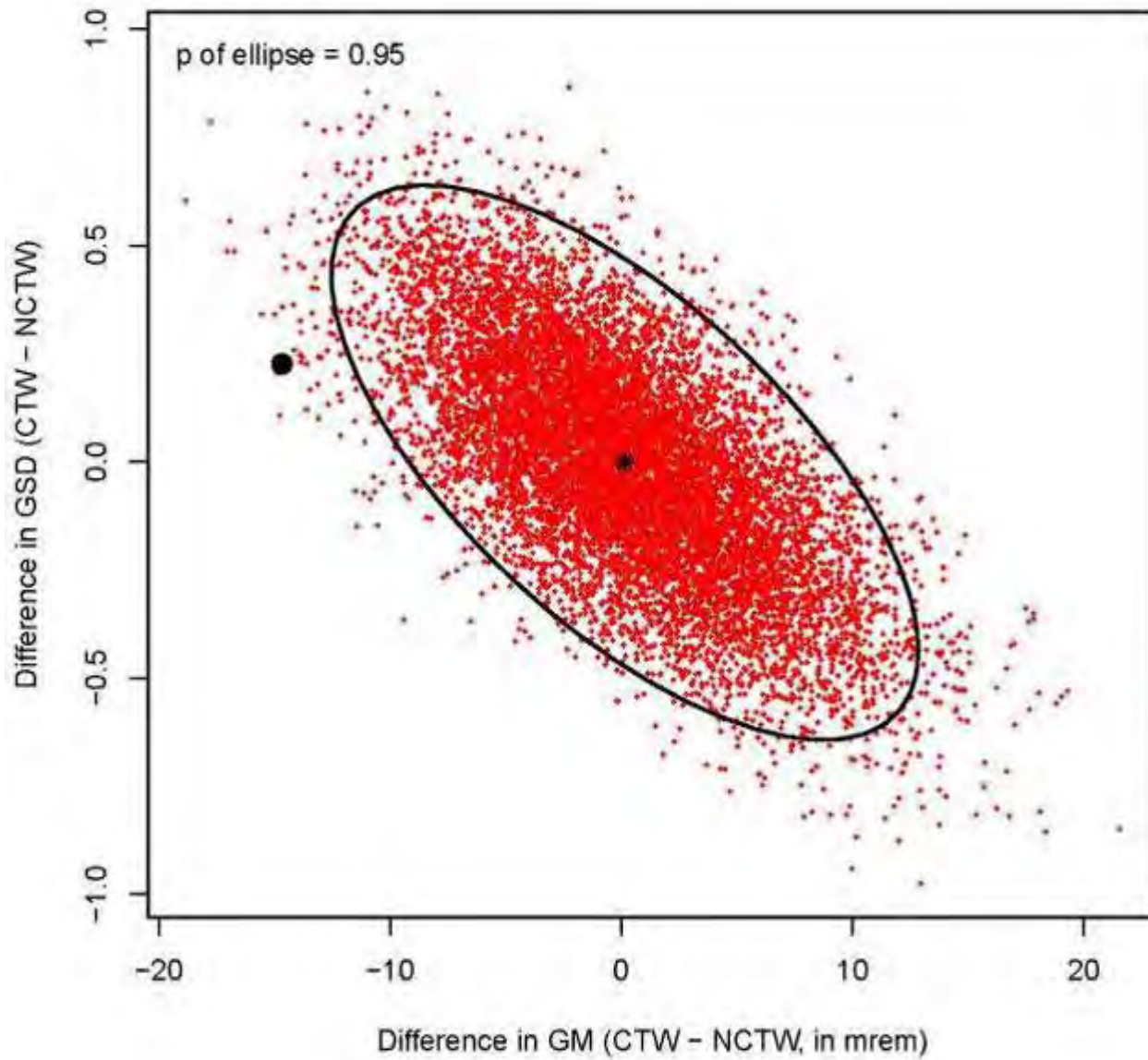


Figure A-100. SRS tritium dose 1978.

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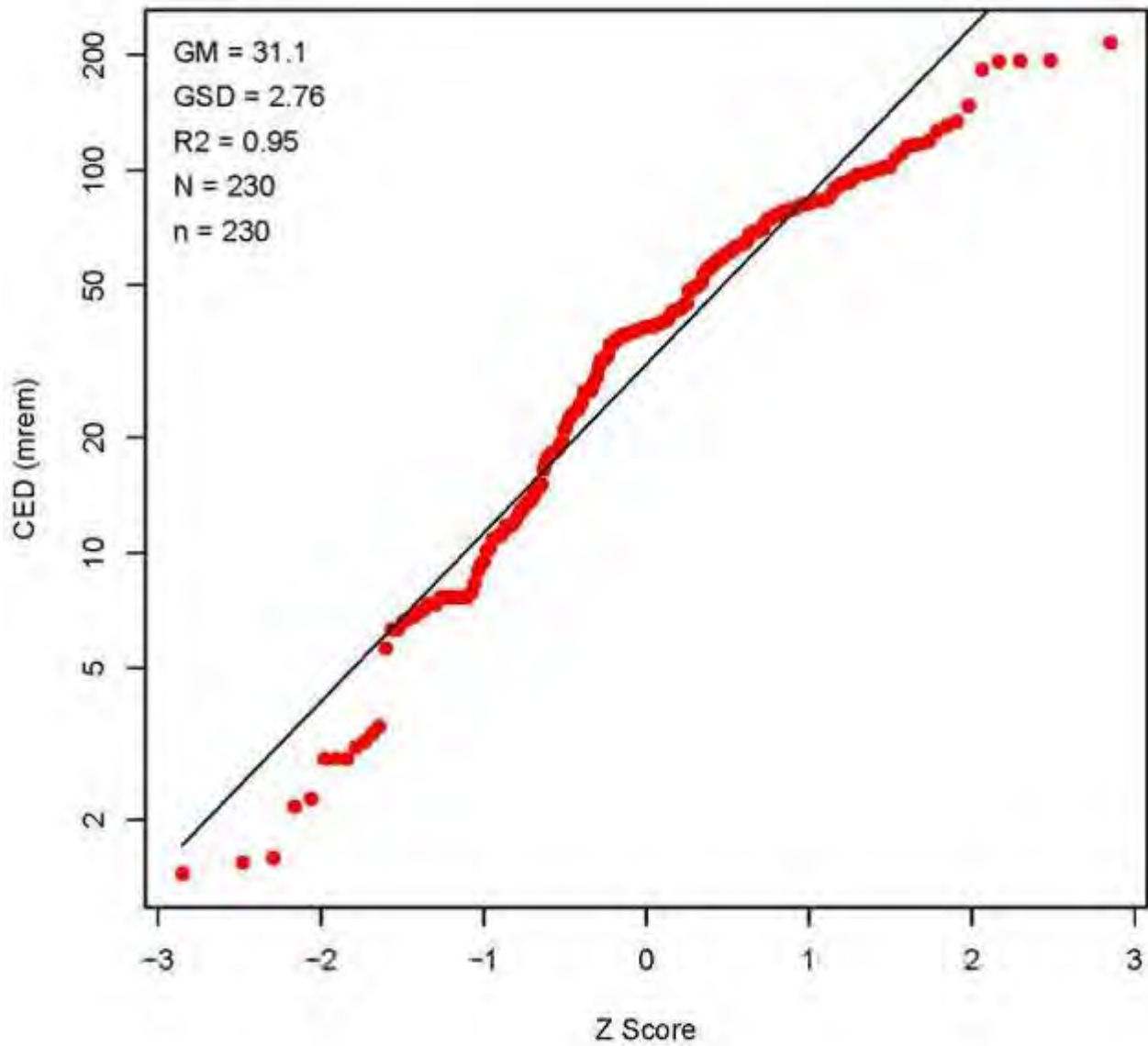


Figure A-101. SRS tritium dose 1979.

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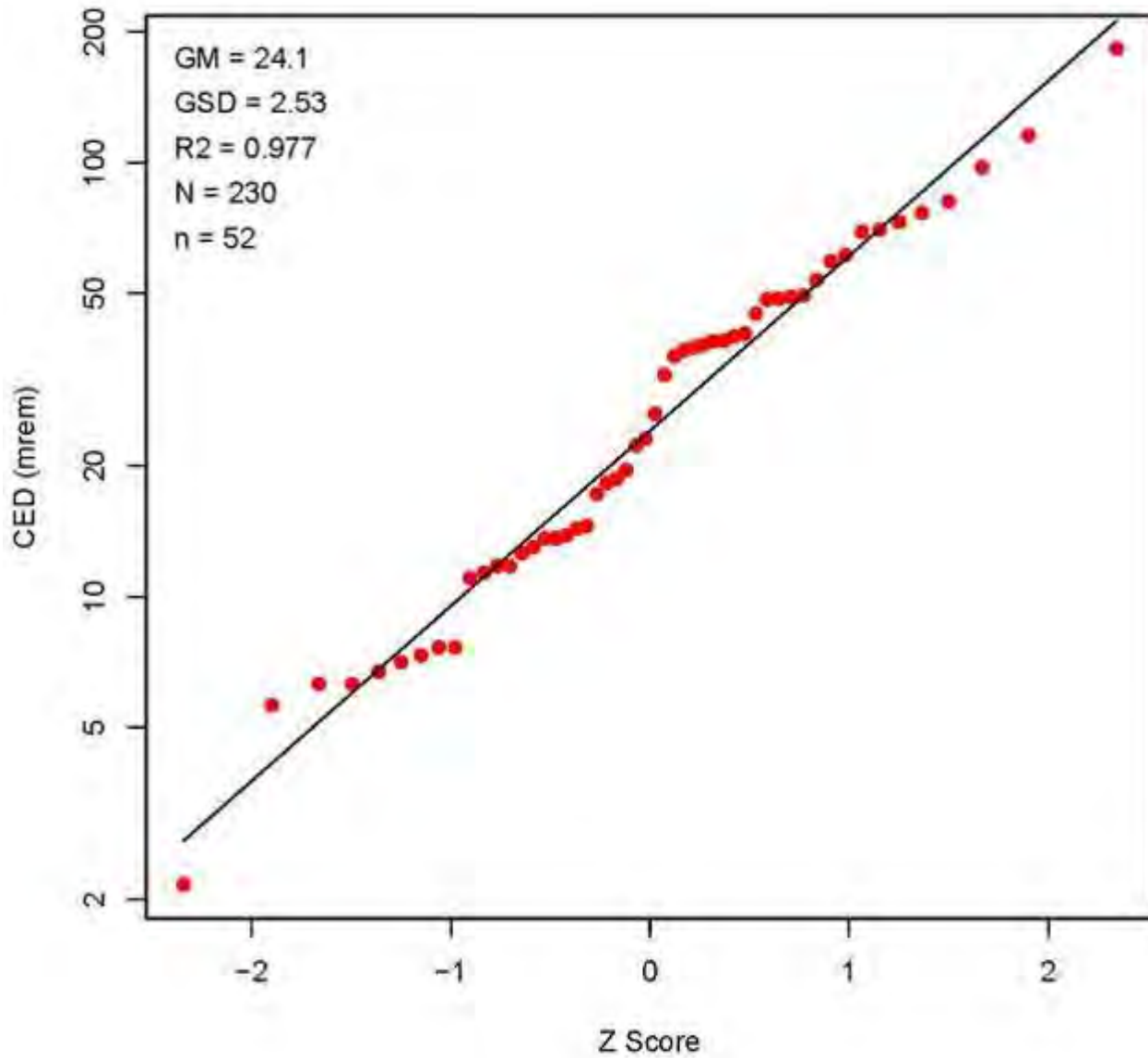


Figure A-102. SRS CTW tritium dose 1979.

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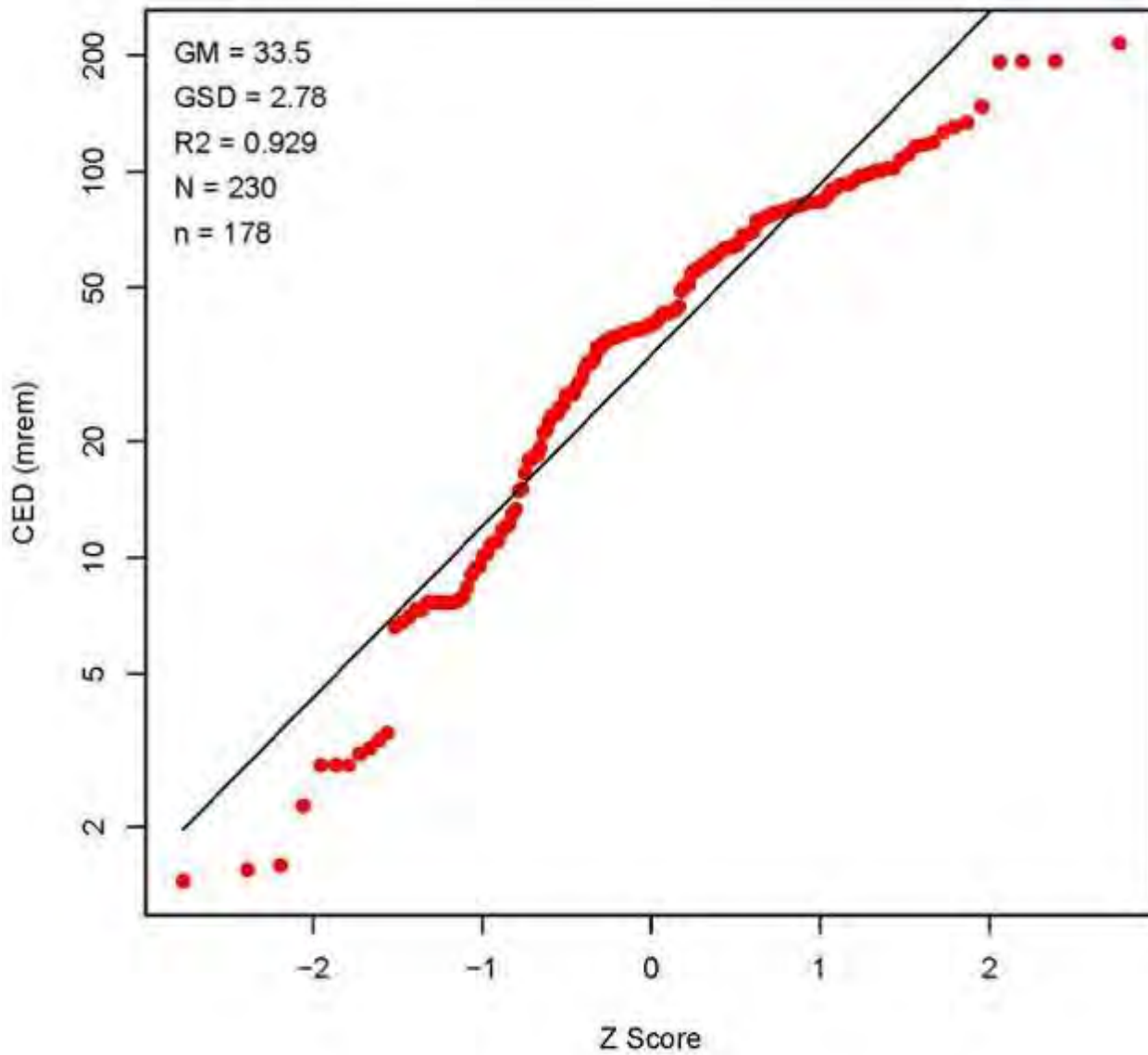


Figure A-103. SRS NCTW tritium dose 1979.

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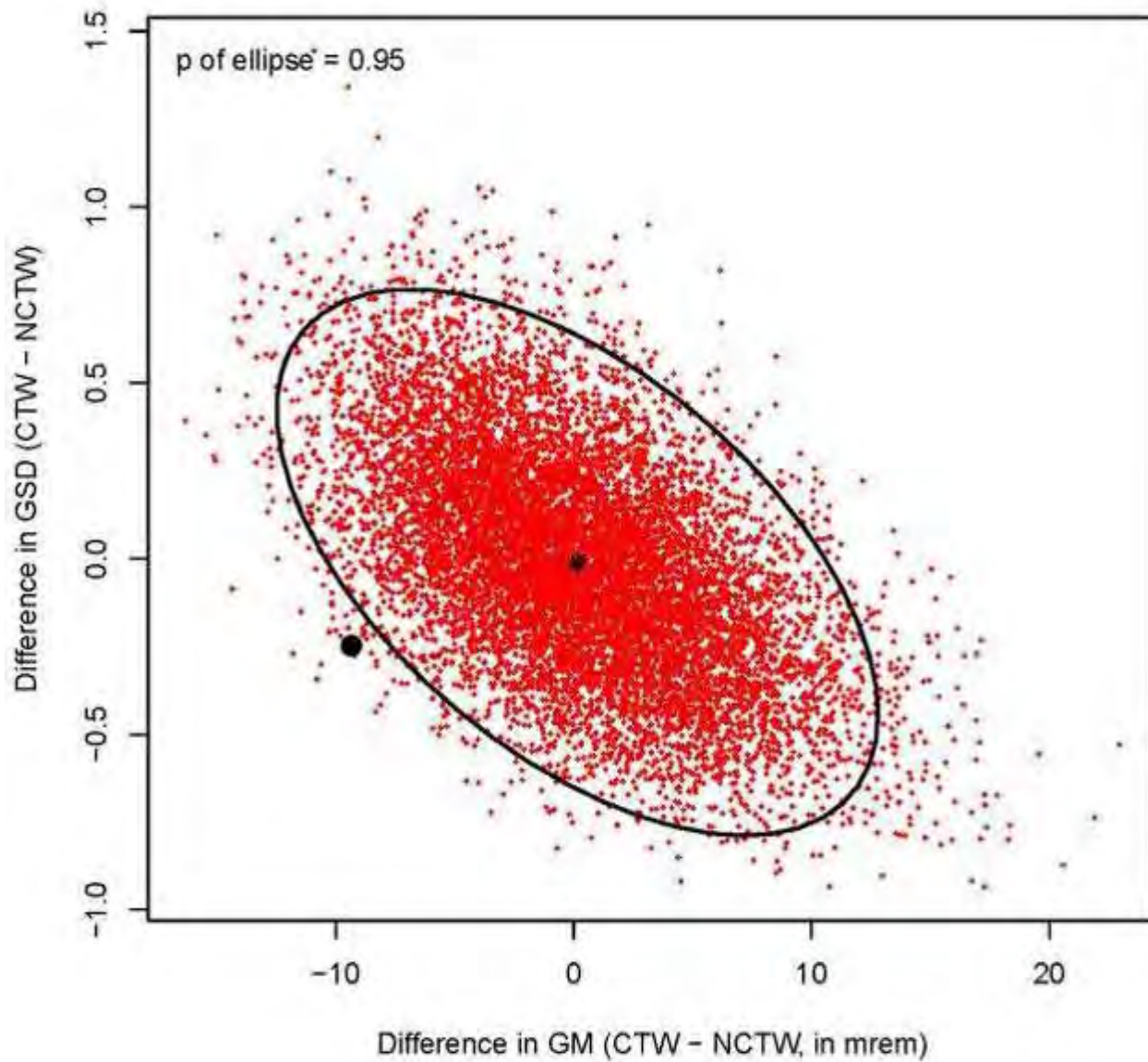


Figure A-104. SRS tritium dose 1979.

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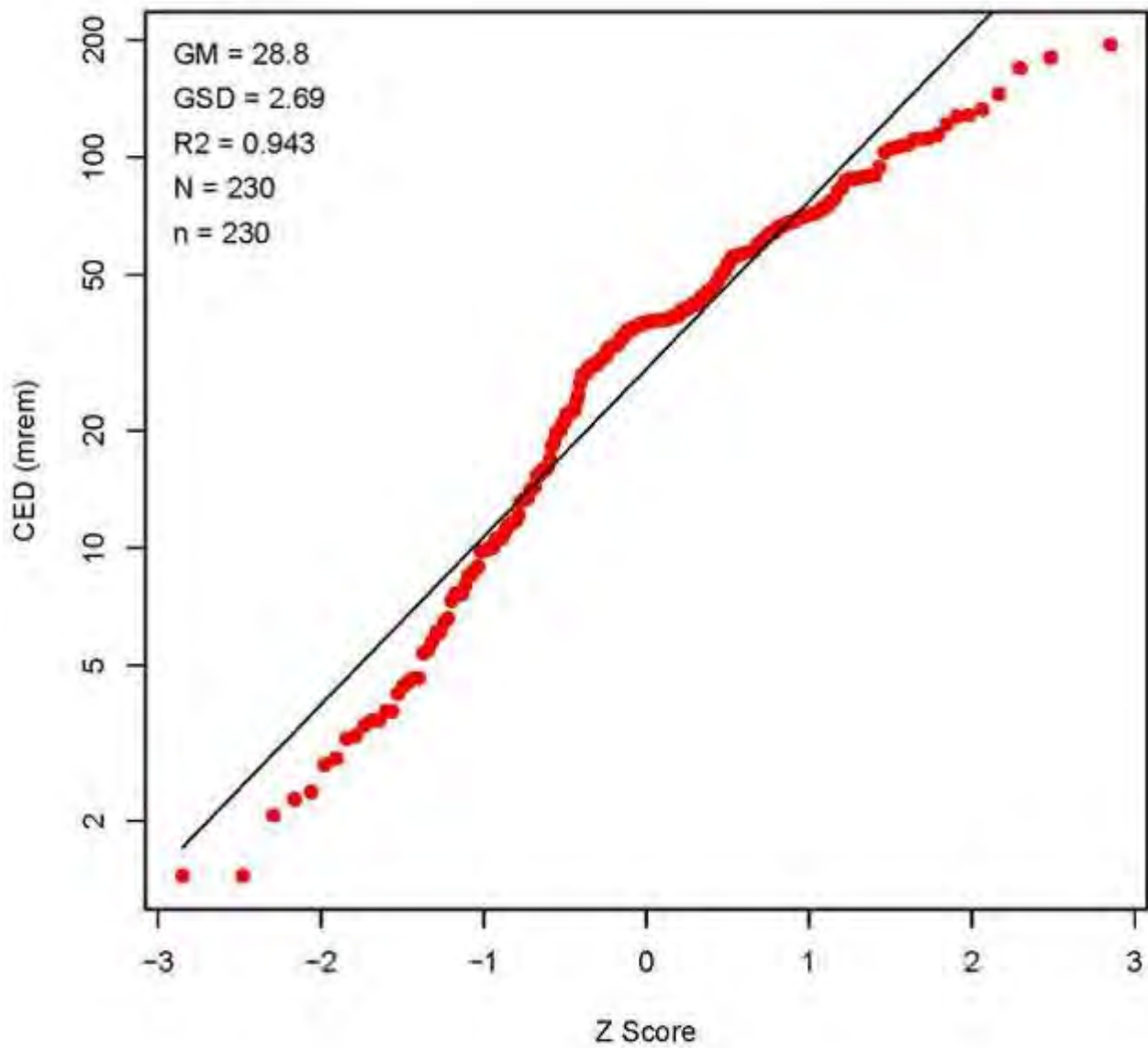


Figure A-105. SRS tritium dose 1980.

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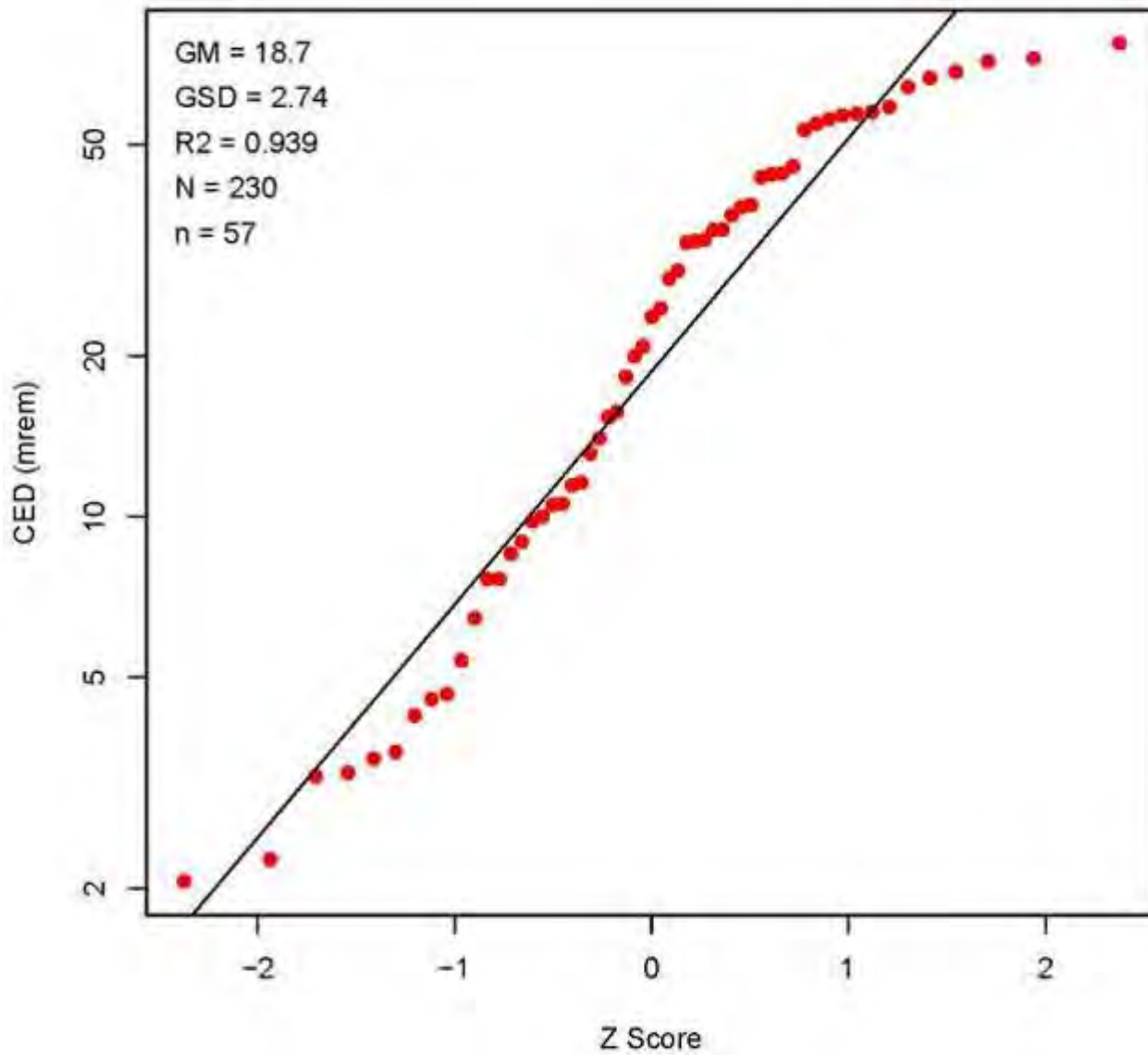


Figure A-106. SRS CTW tritium dose 1980.

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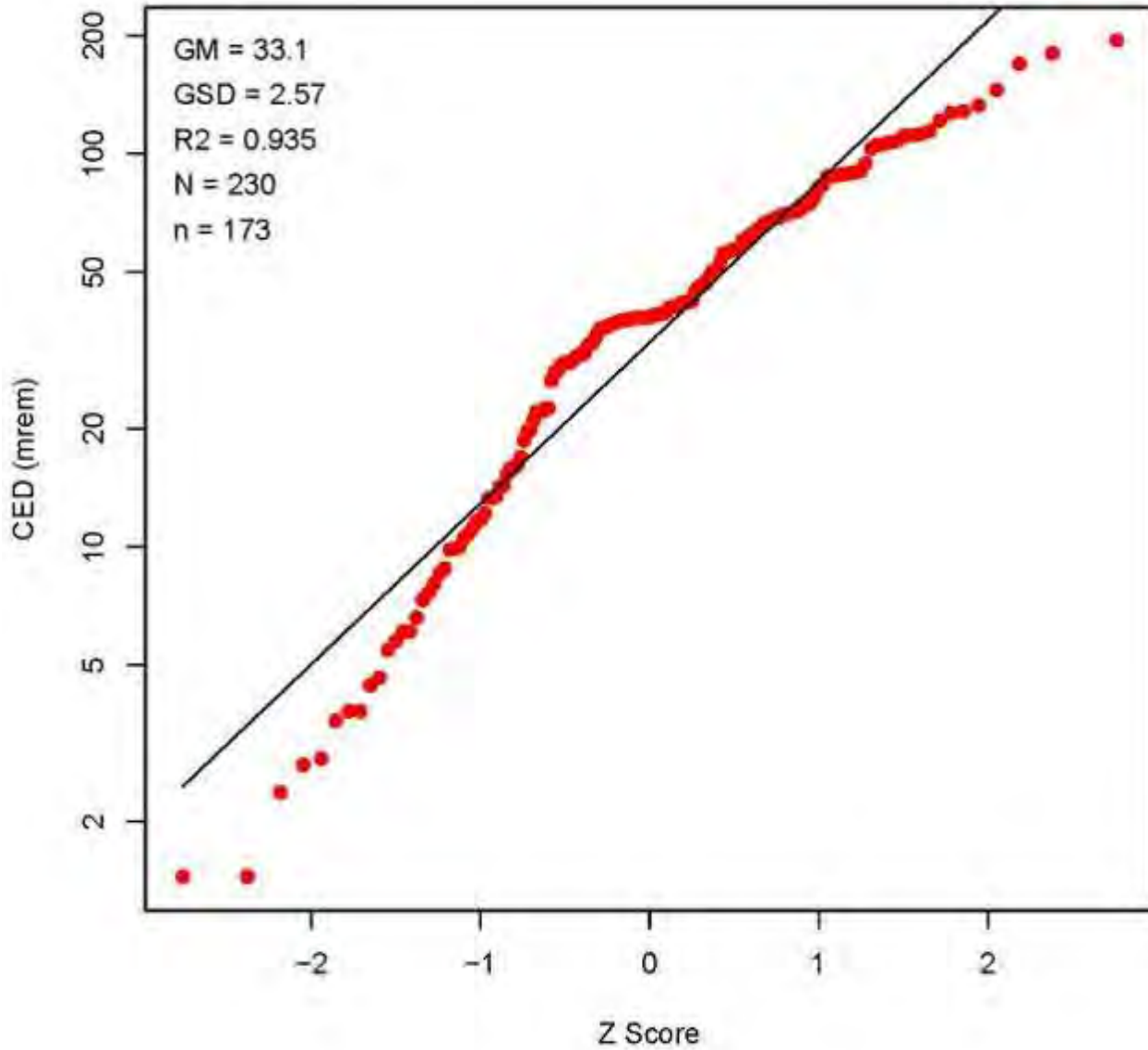


Figure A-107. SRS NCTW tritium dose 1980.

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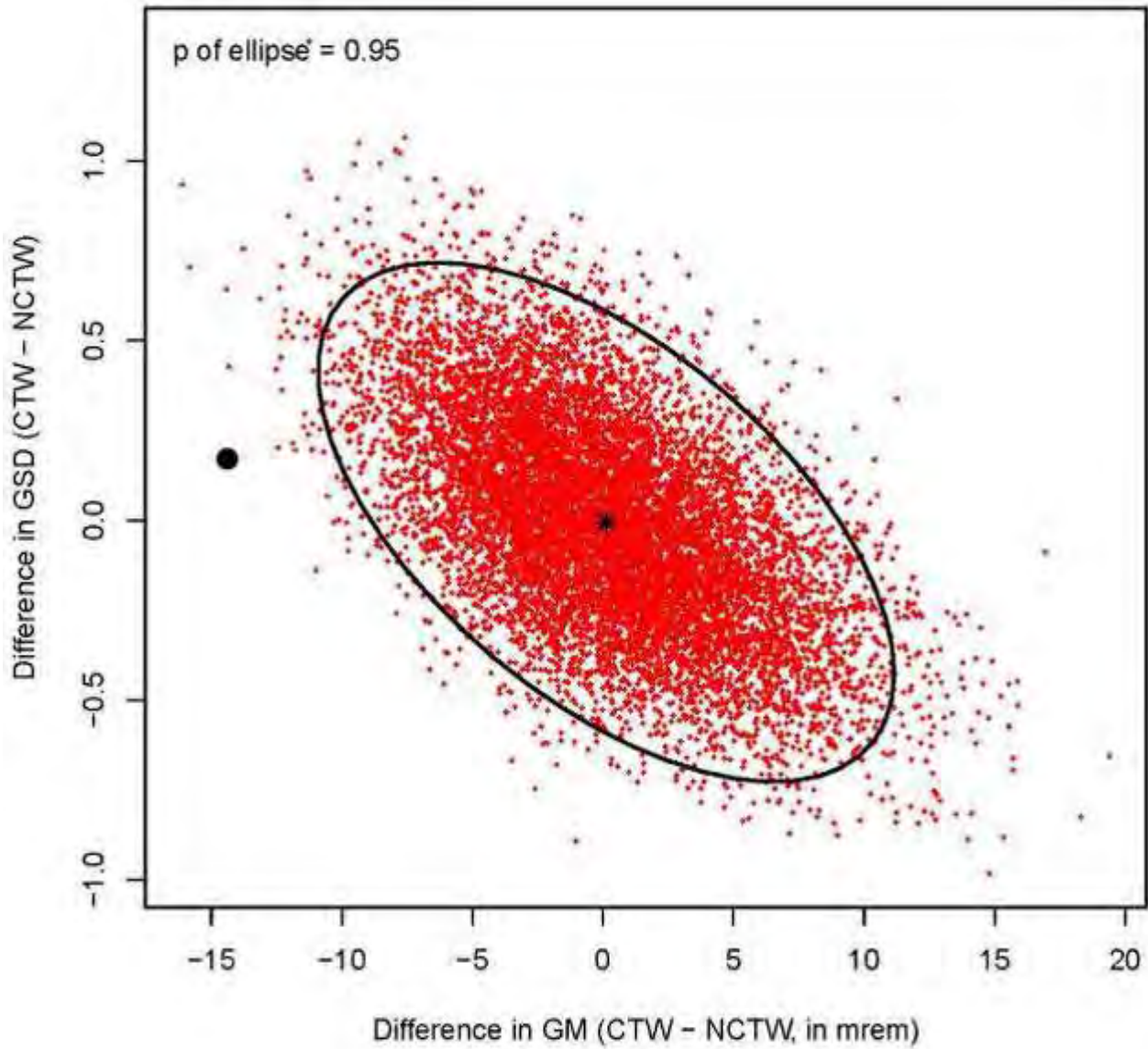


Figure A-108. SRS tritium dose 1980.

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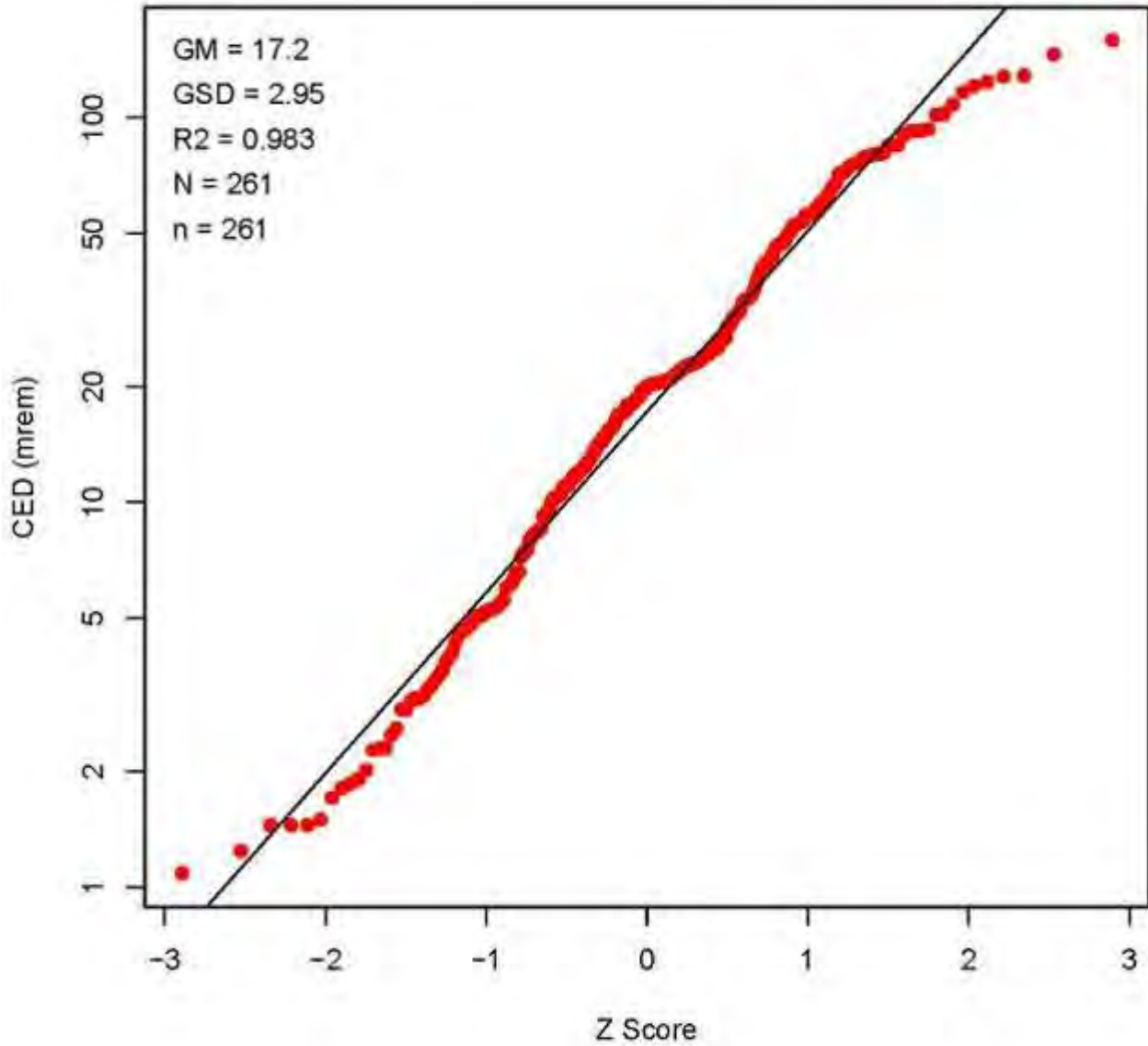


Figure A-109. SRS tritium dose 1981.

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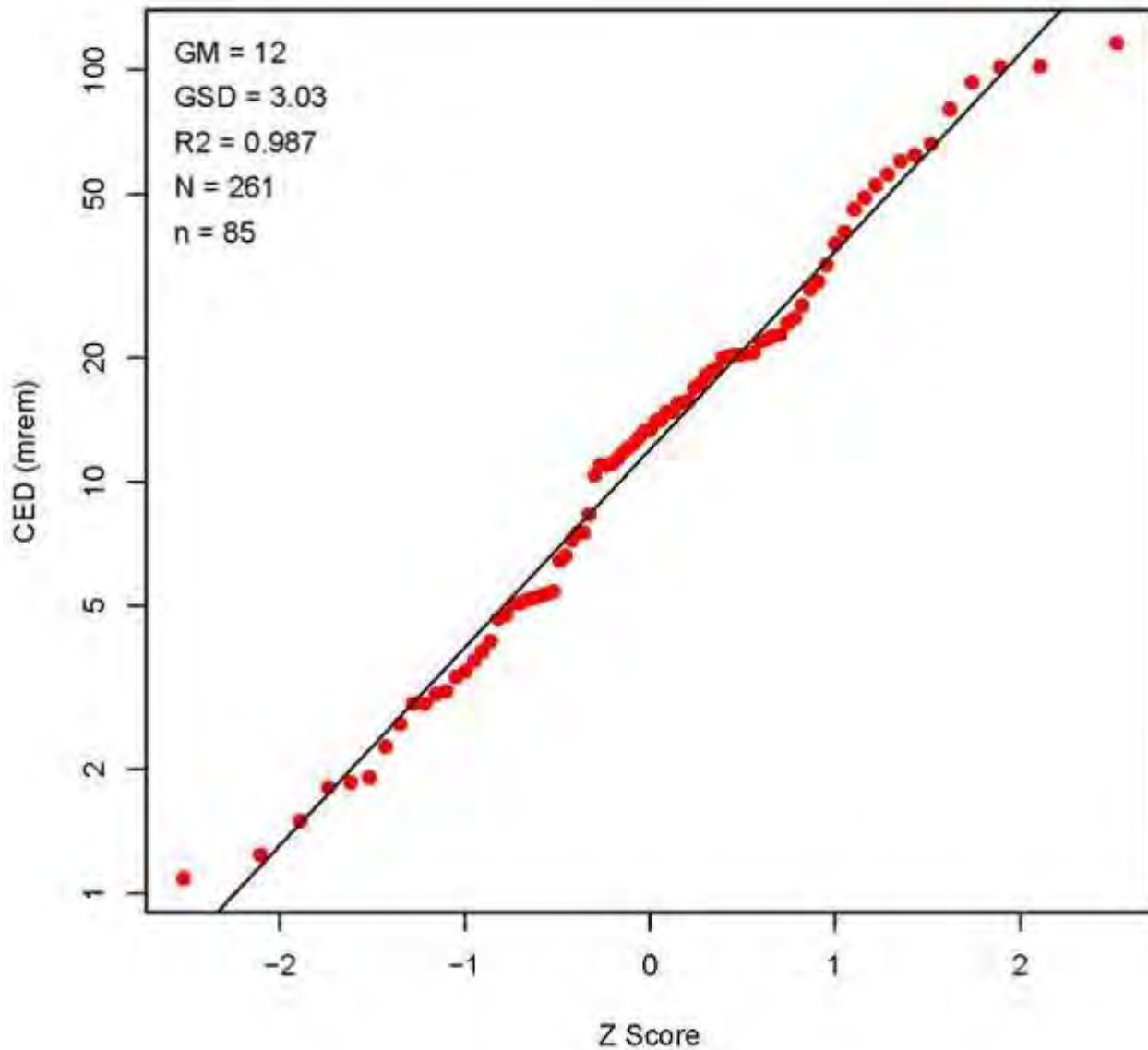


Figure A-110. SRS CTW tritium dose 1981.

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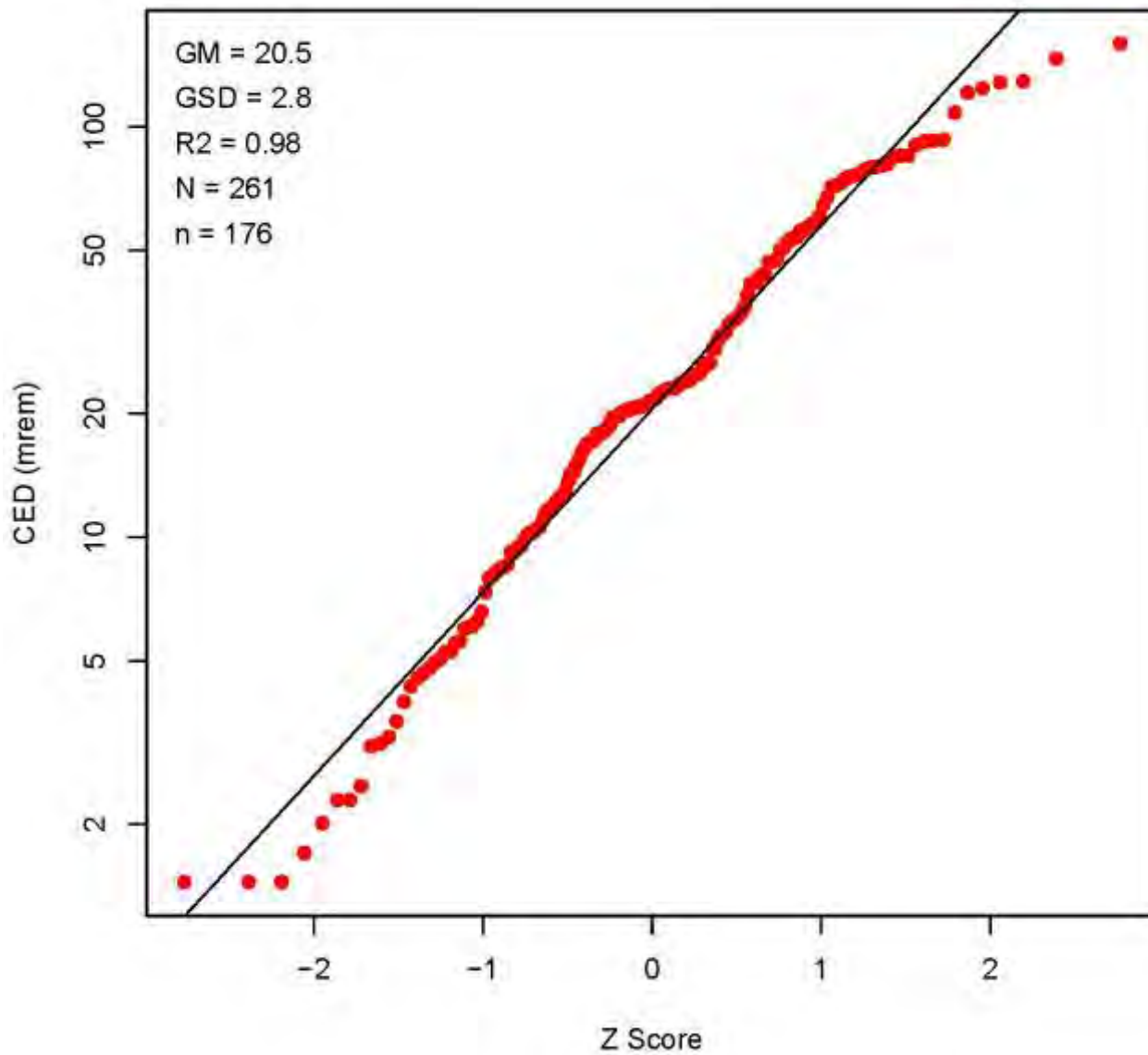


Figure A-111. SRS NCTW tritium dose 1981.

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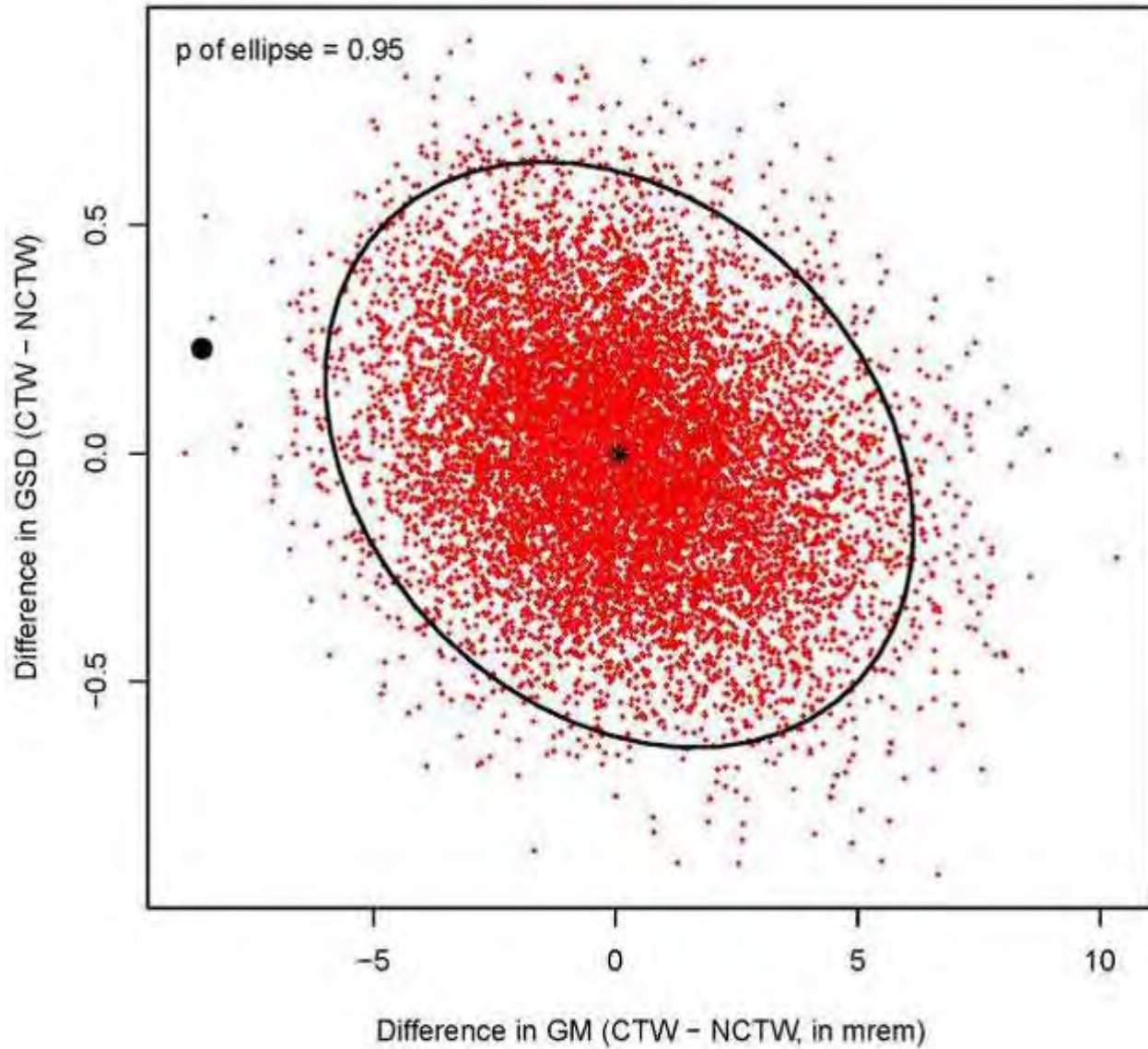


Figure A-112. SRS tritium dose 1981.

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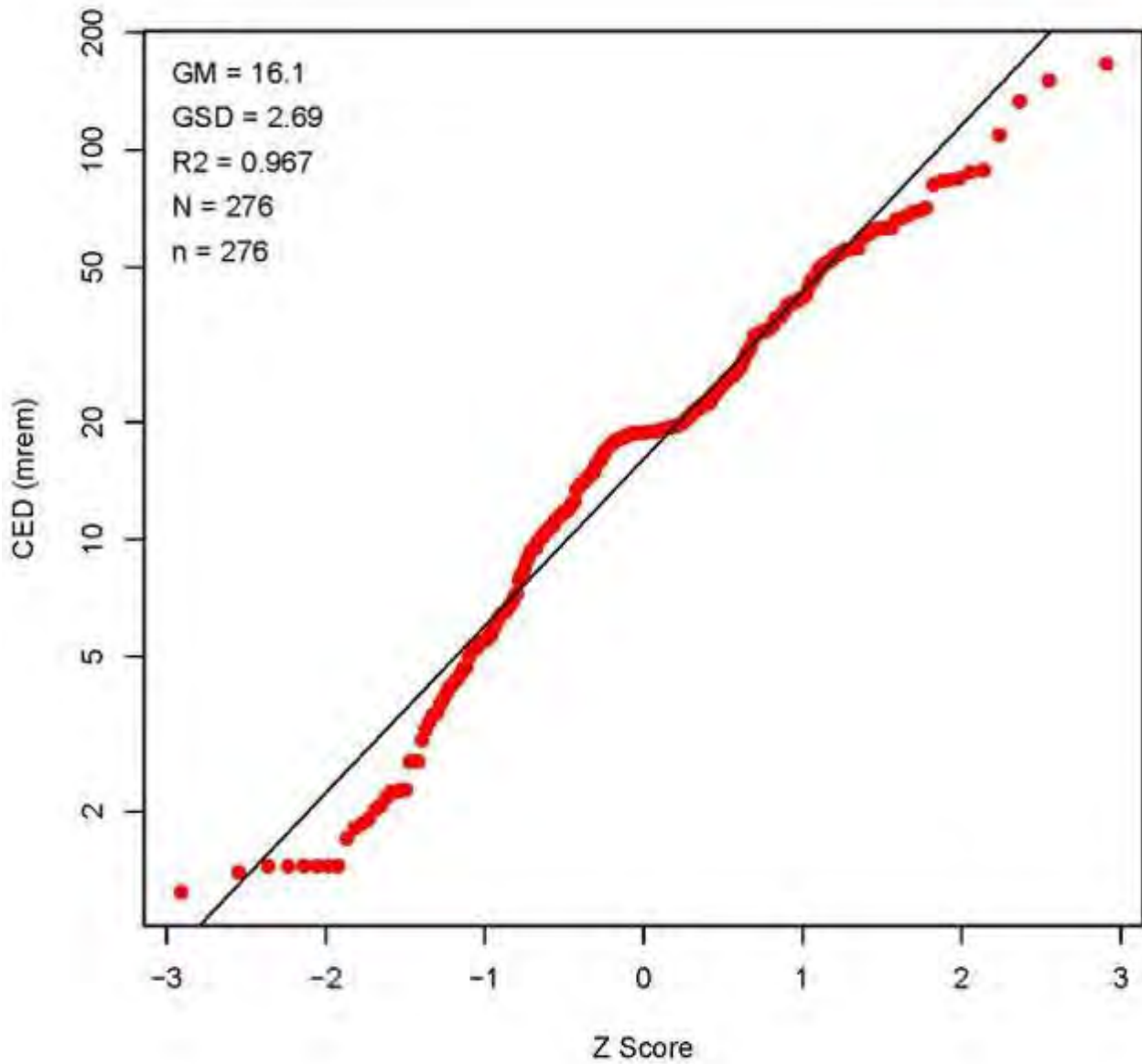


Figure A-113. SRS tritium dose 1982.

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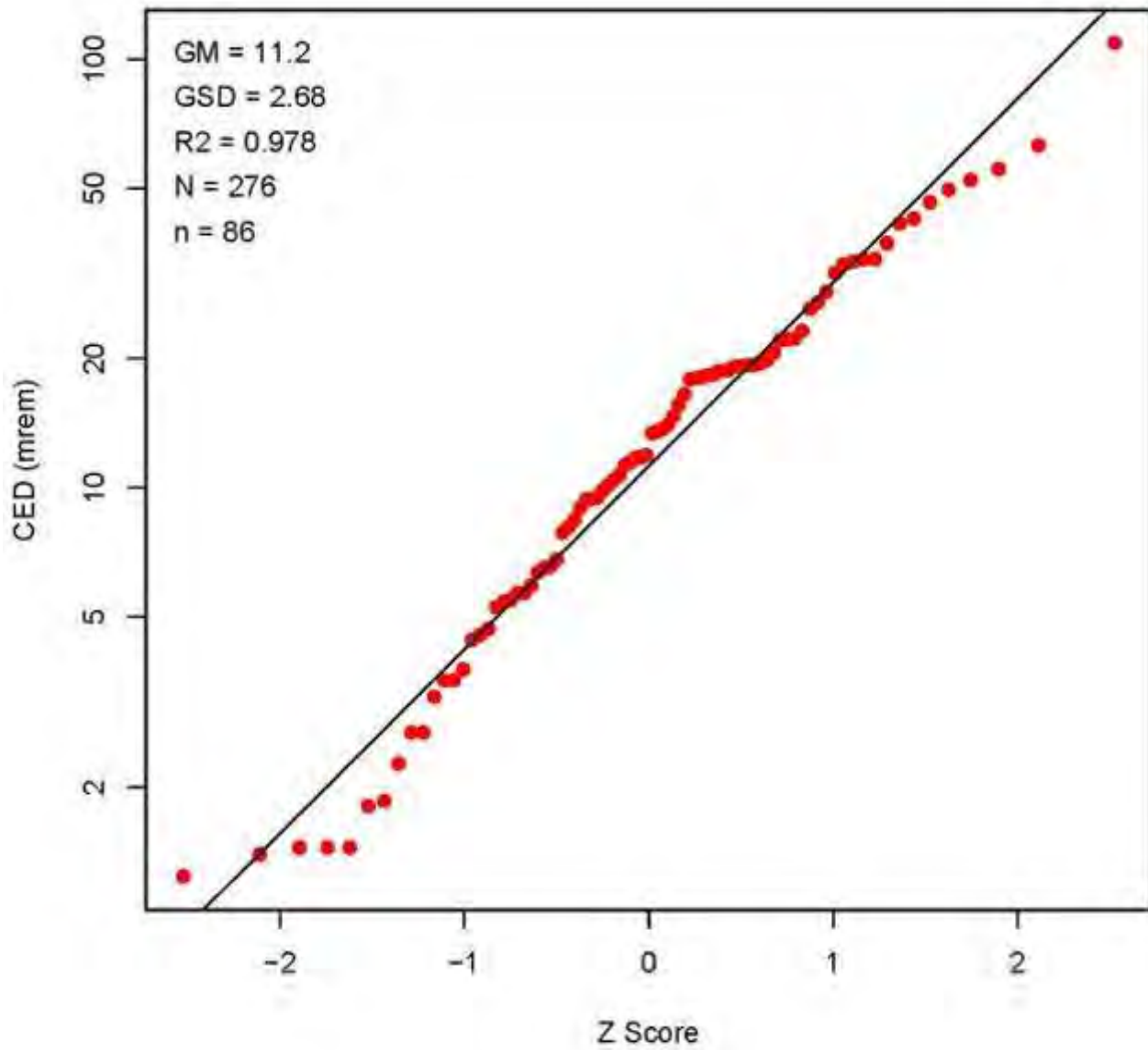


Figure A-114. SRS CTW tritium dose 1982.

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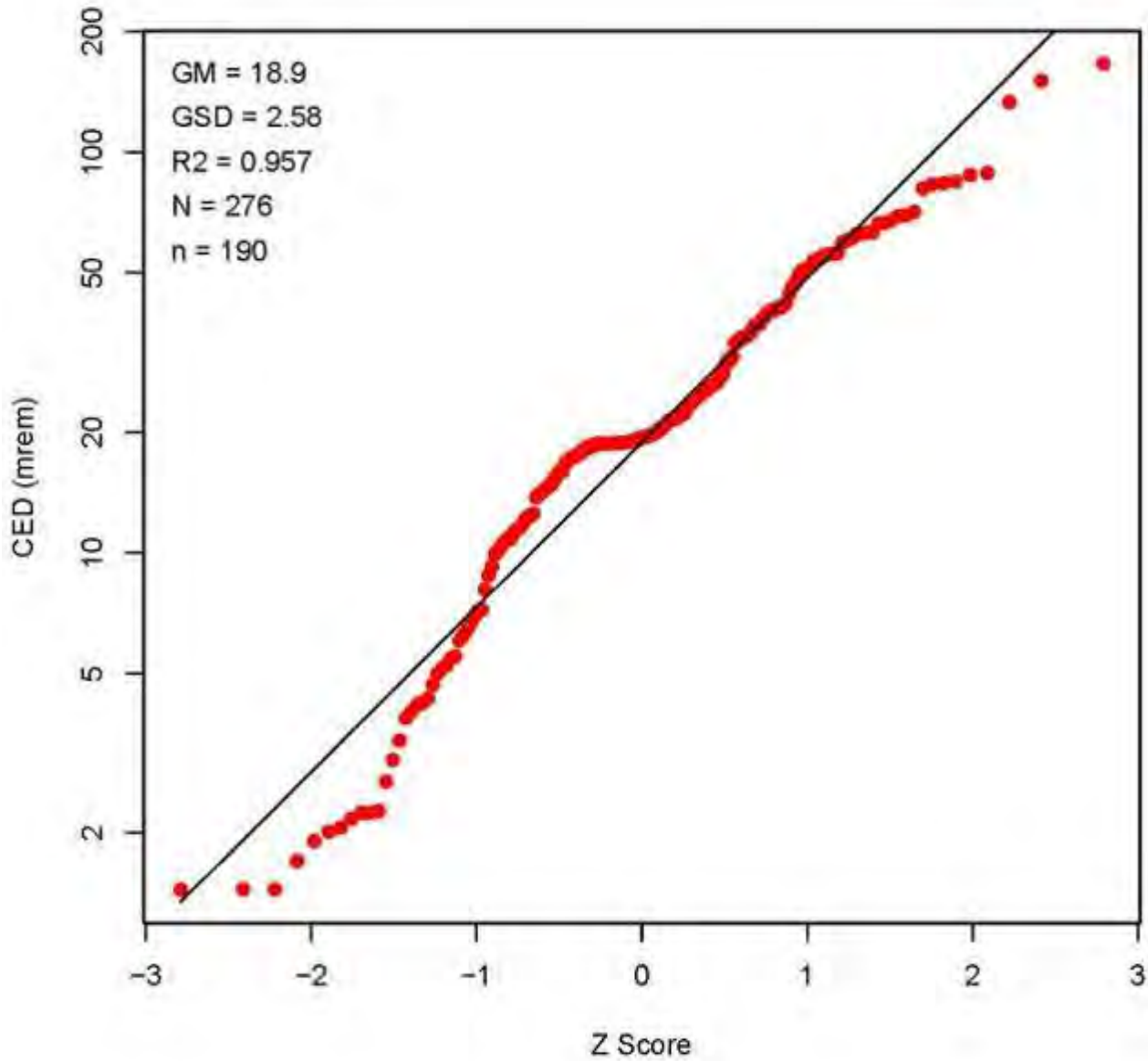


Figure A-115. SRS NCTW tritium dose 1982.

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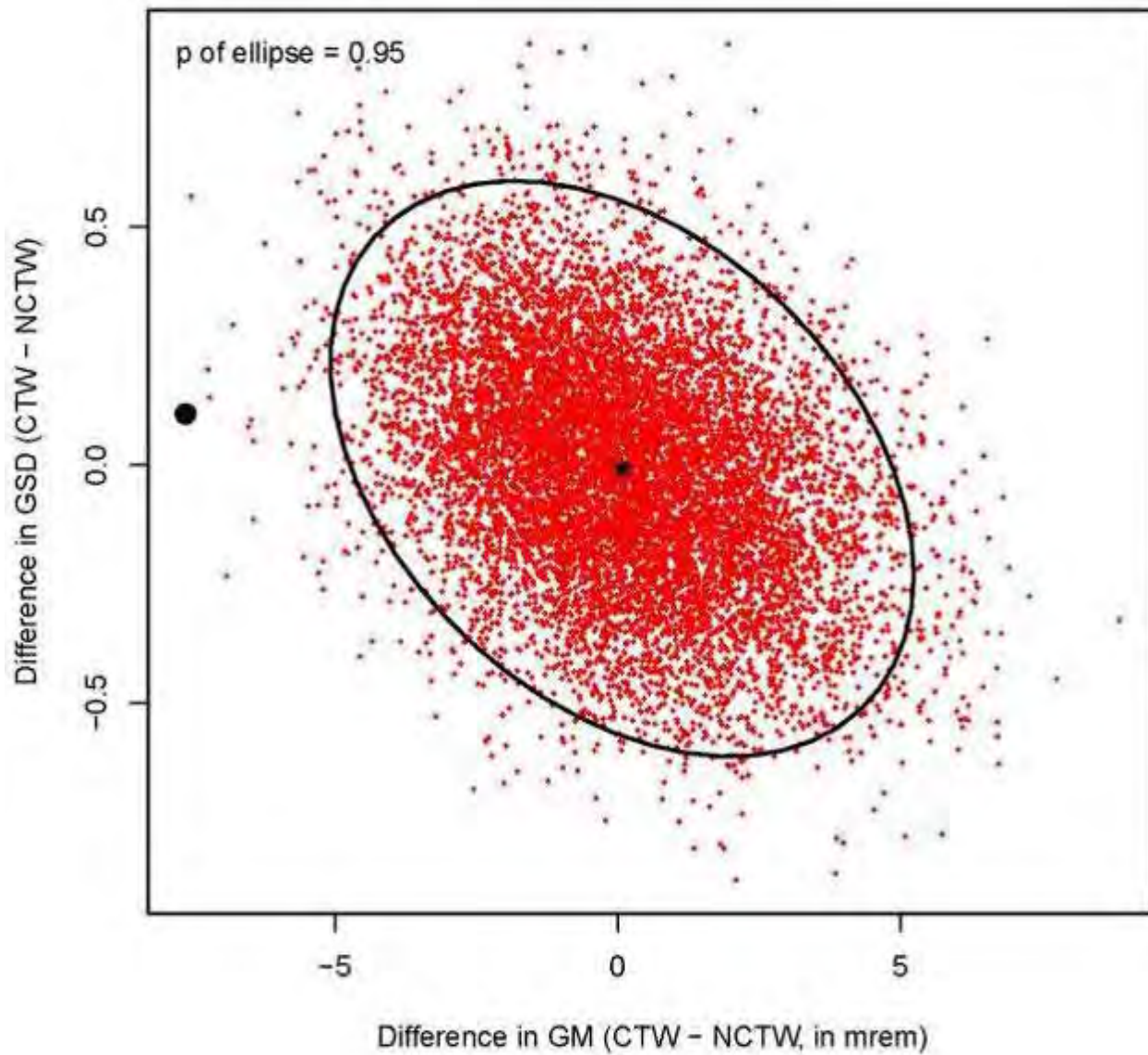


Figure A-116. SRS tritium dose 1982.

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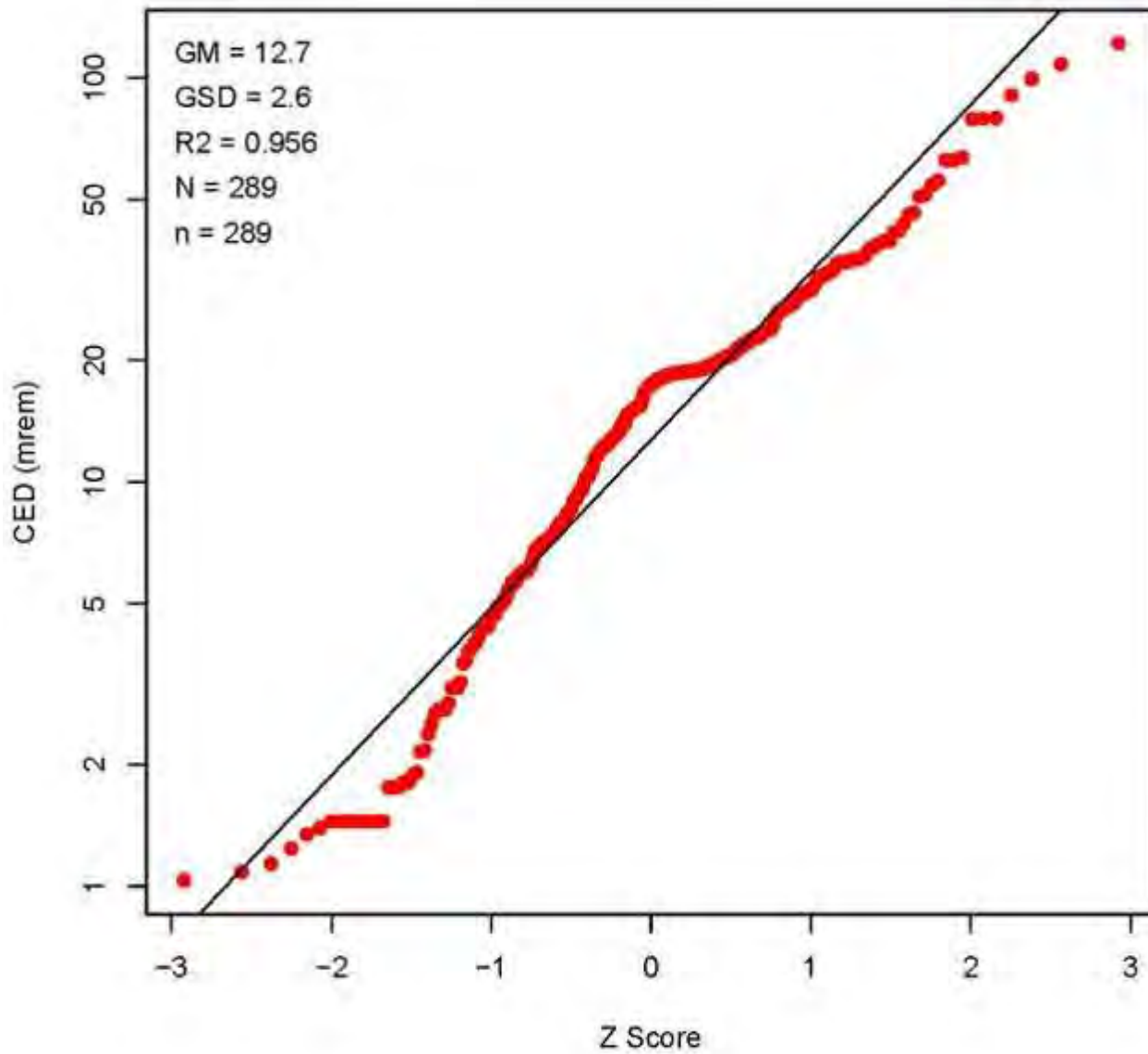


Figure A-117. SRS tritium dose 1983.

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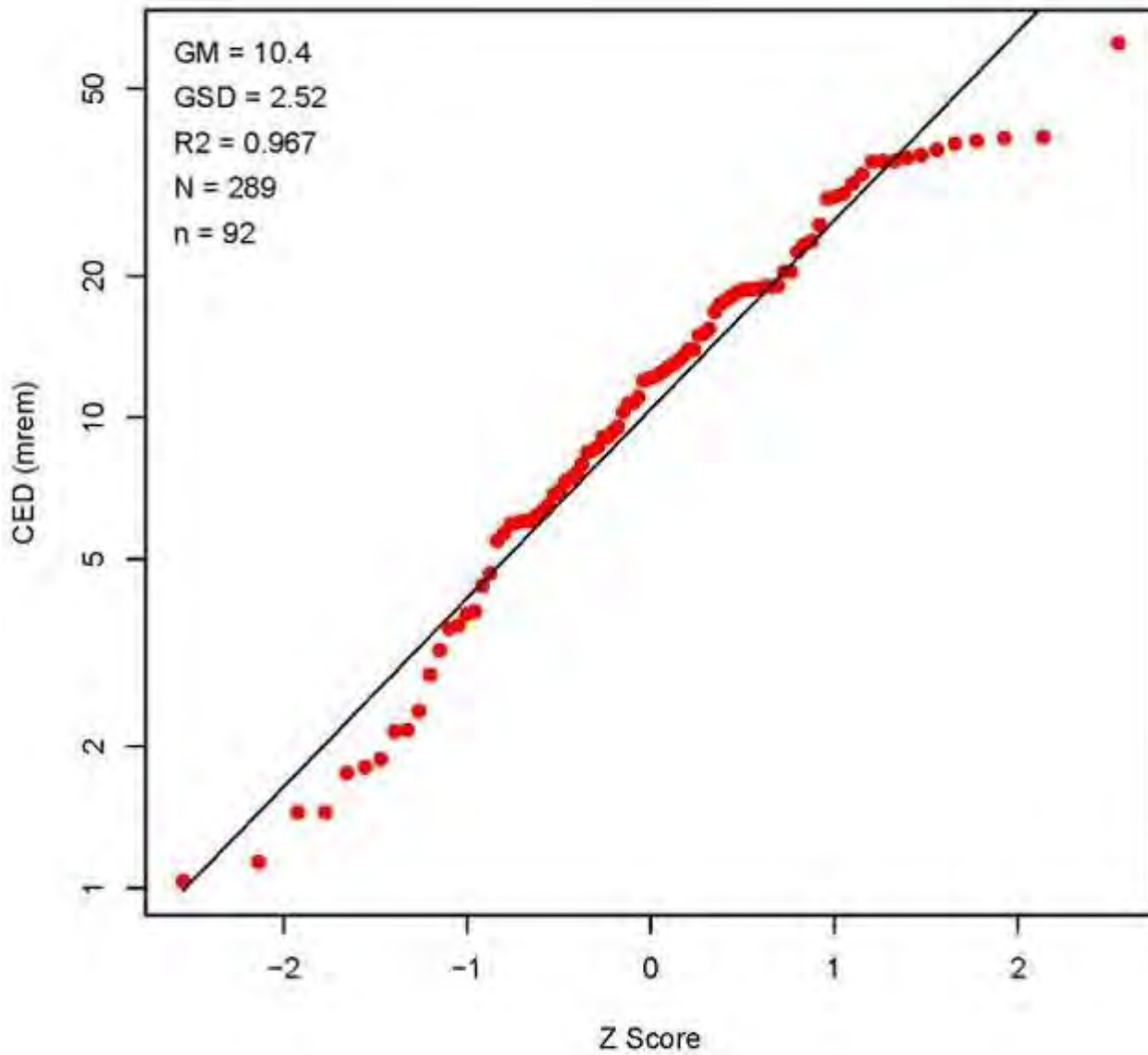


Figure A-118. SRS CTW tritium dose 1983.

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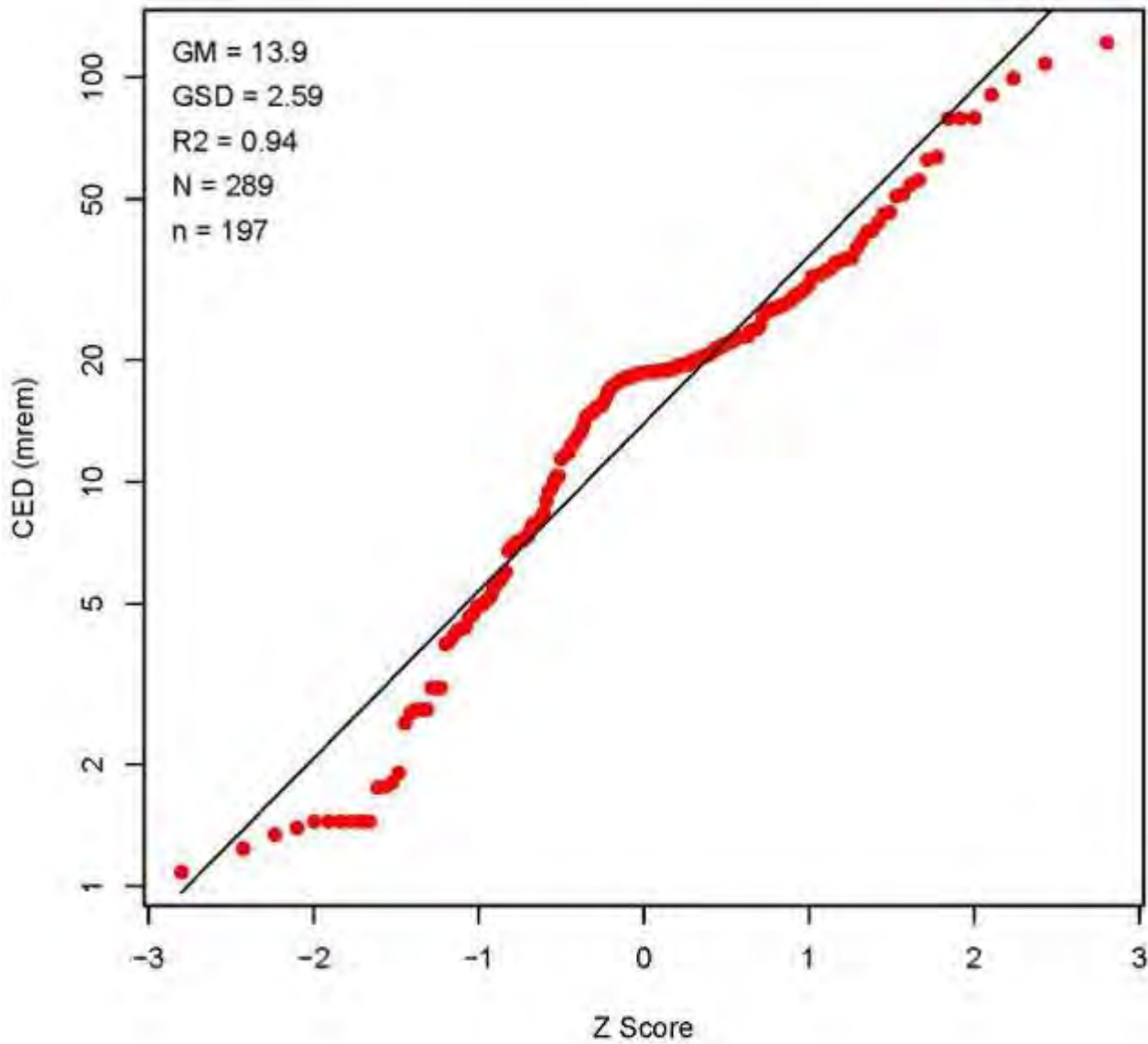


Figure A-119. SRS NCTW tritium dose 1983.

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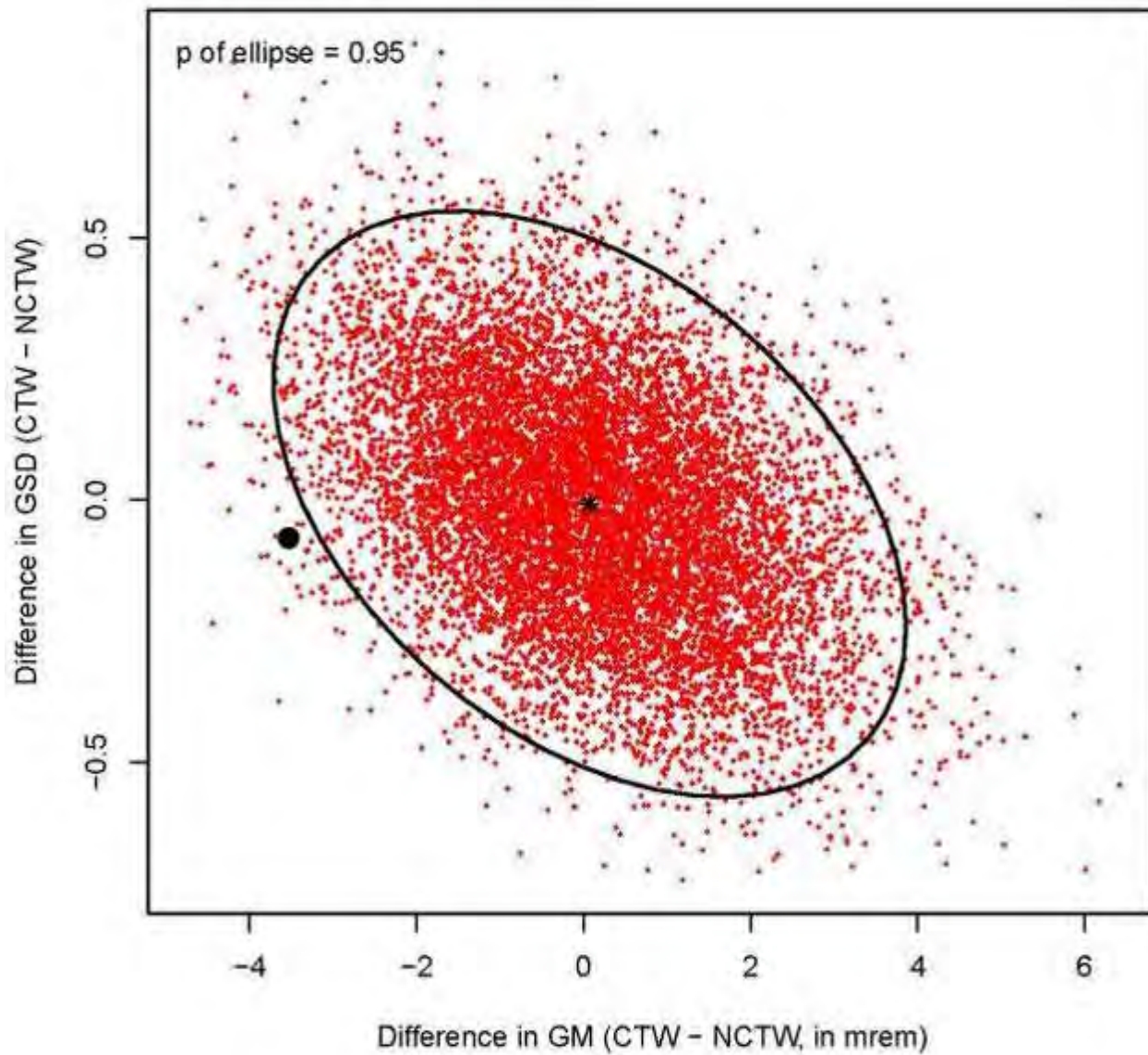


Figure A-120. SRS tritium dose 1983.

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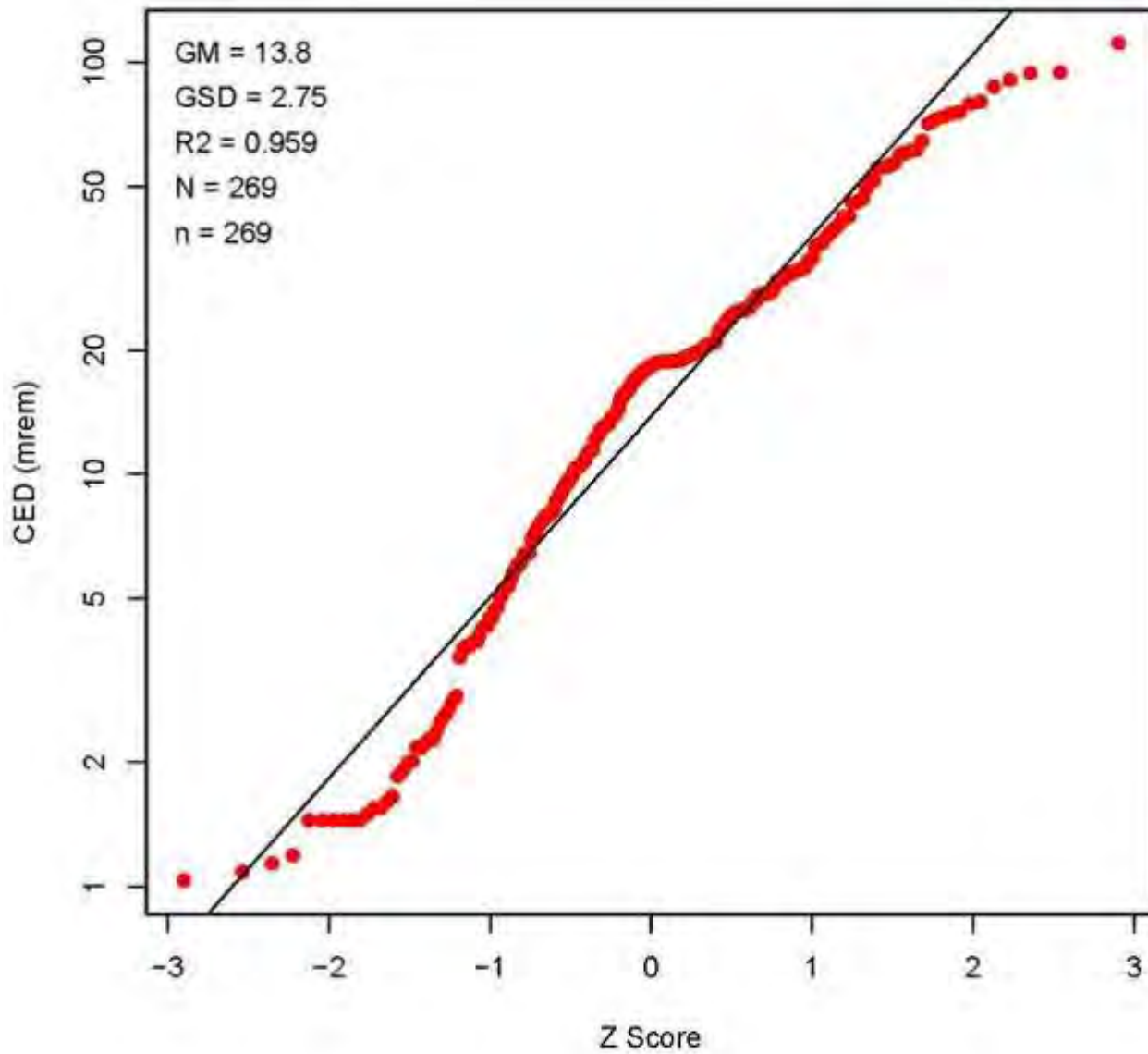


Figure A-121. SRS tritium dose 1984.

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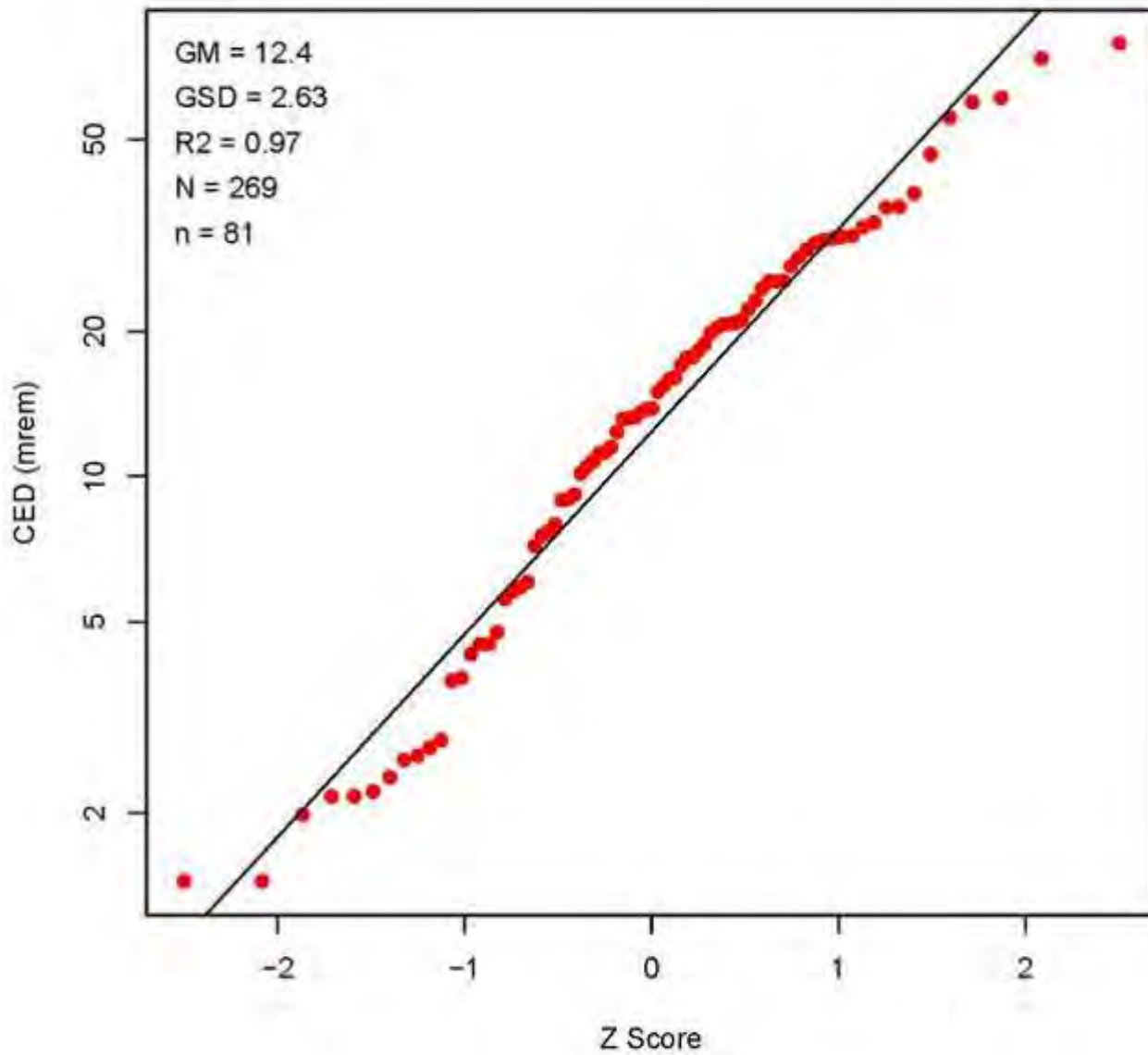


Figure A-122. SRS CTW tritium dose 1984.

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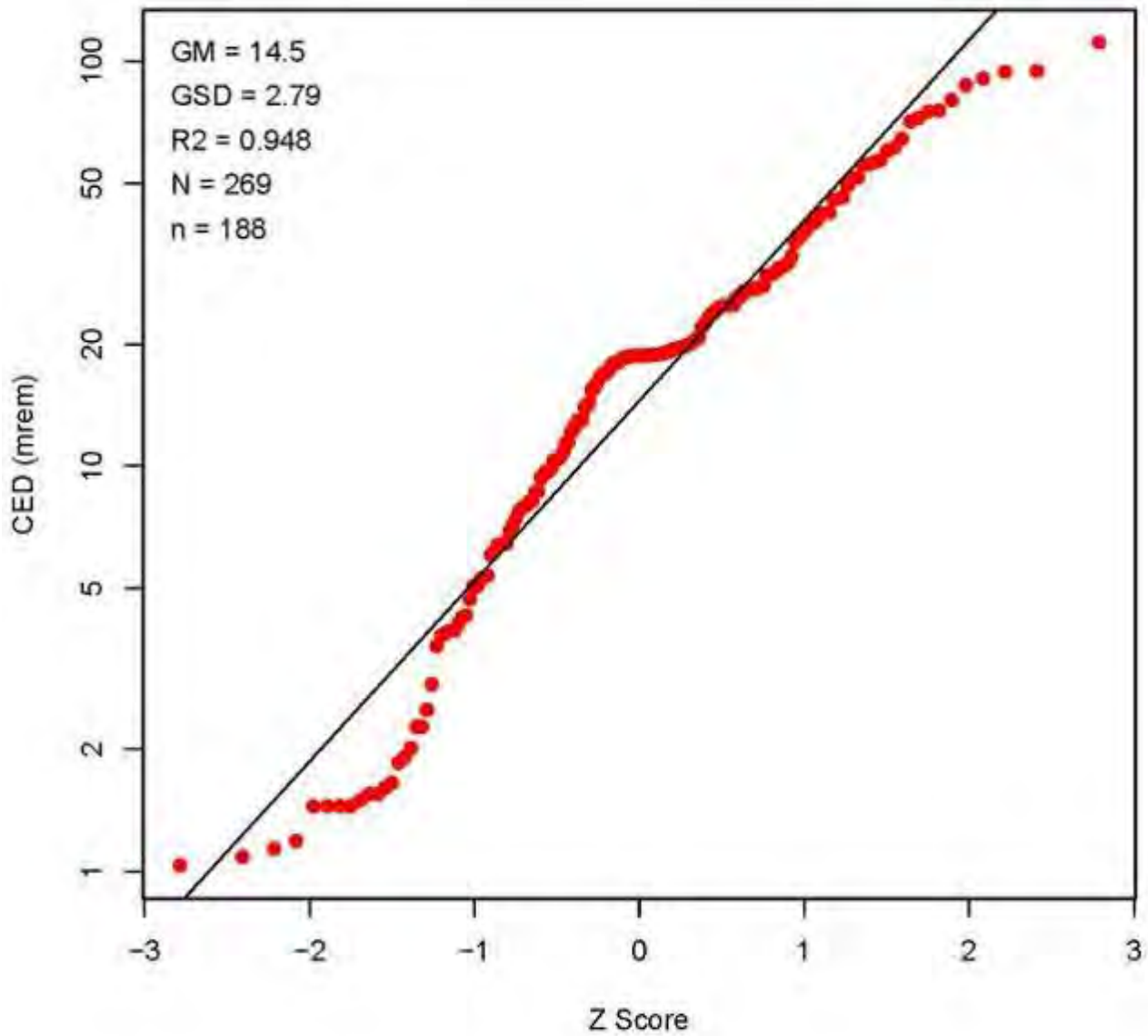


Figure A-123. SRS NCTW tritium dose 1984.

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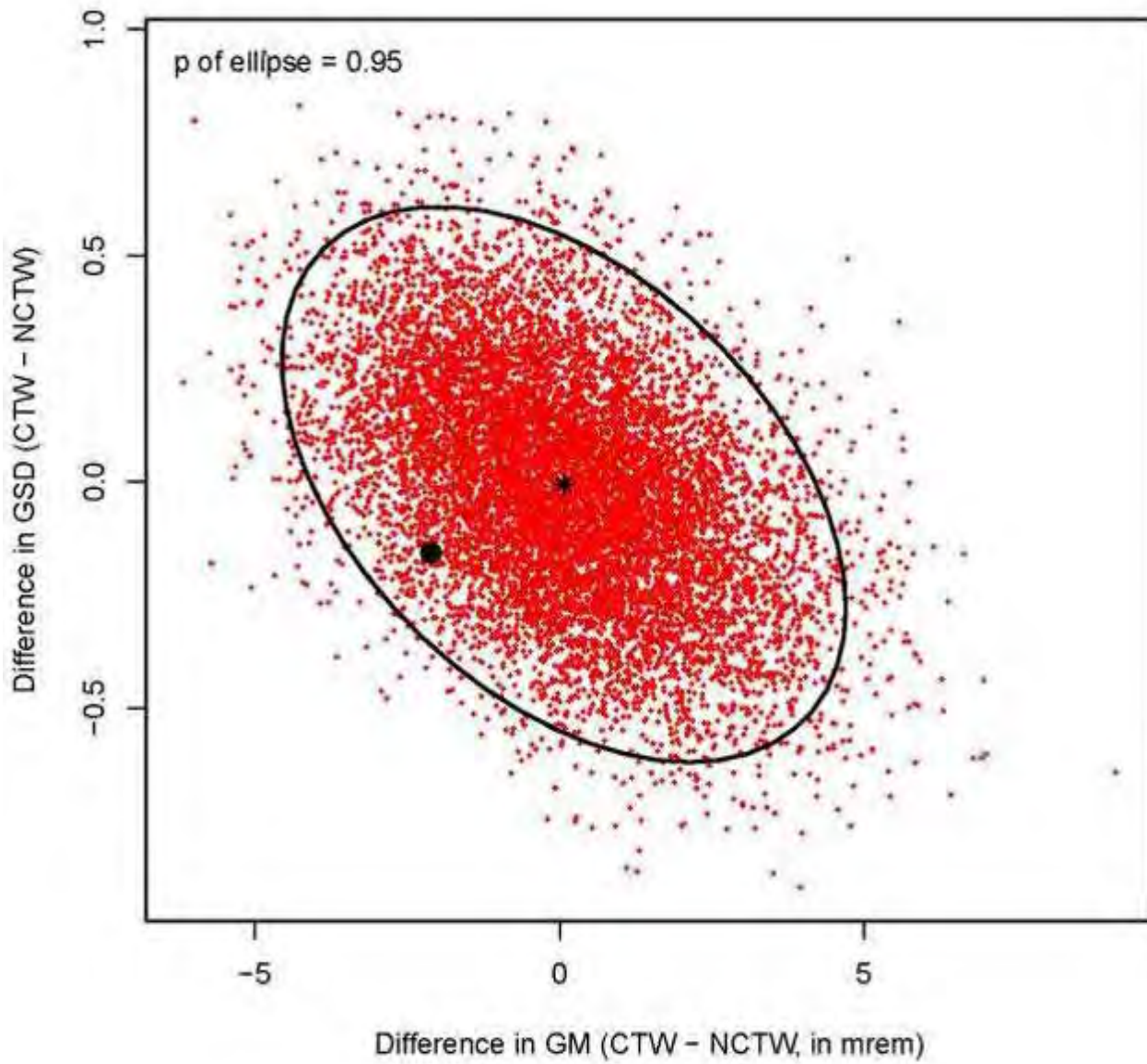


Figure A-124. SRS tritium dose 1984.

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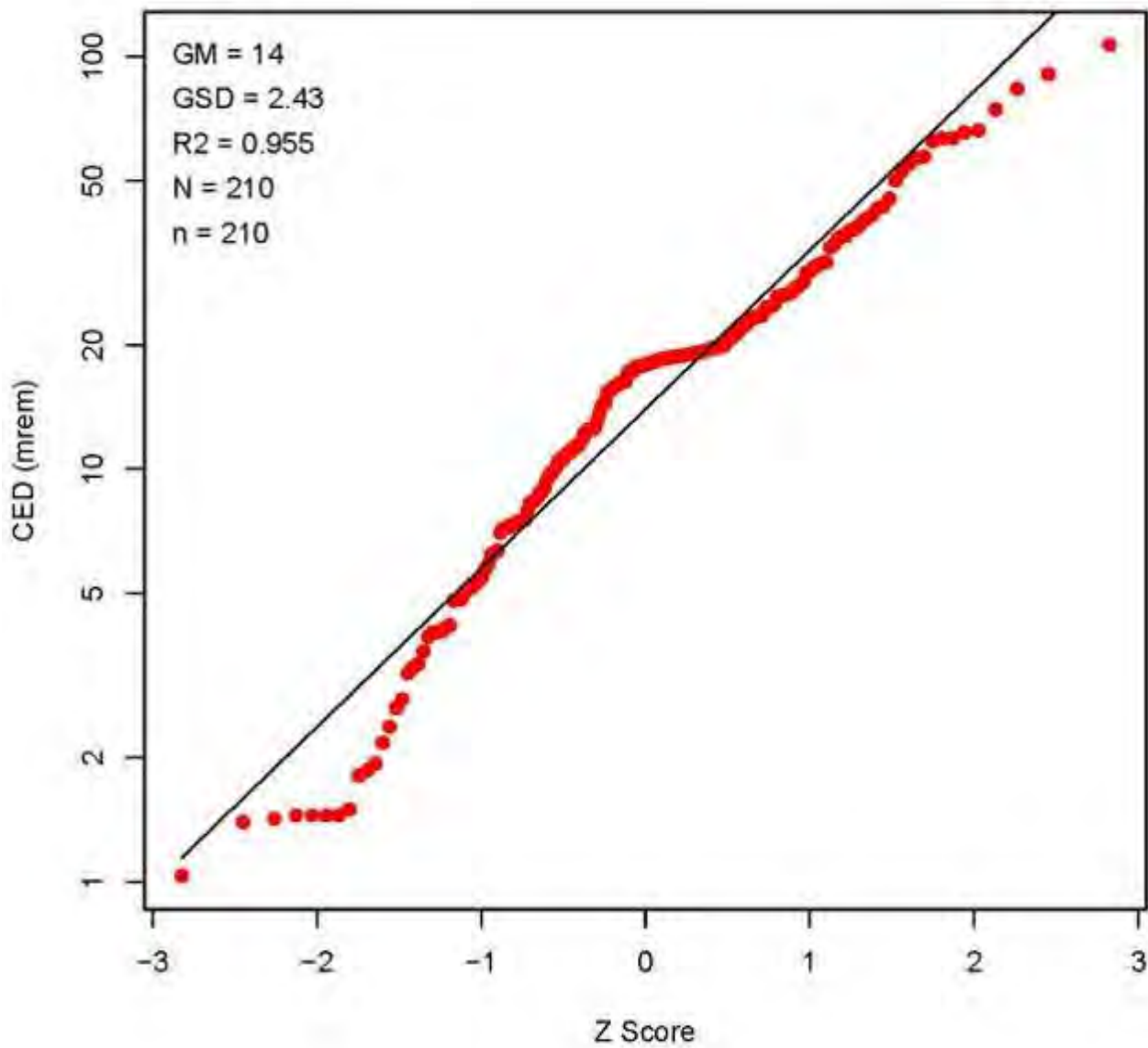


Figure A-125. SRS tritium dose 1985.

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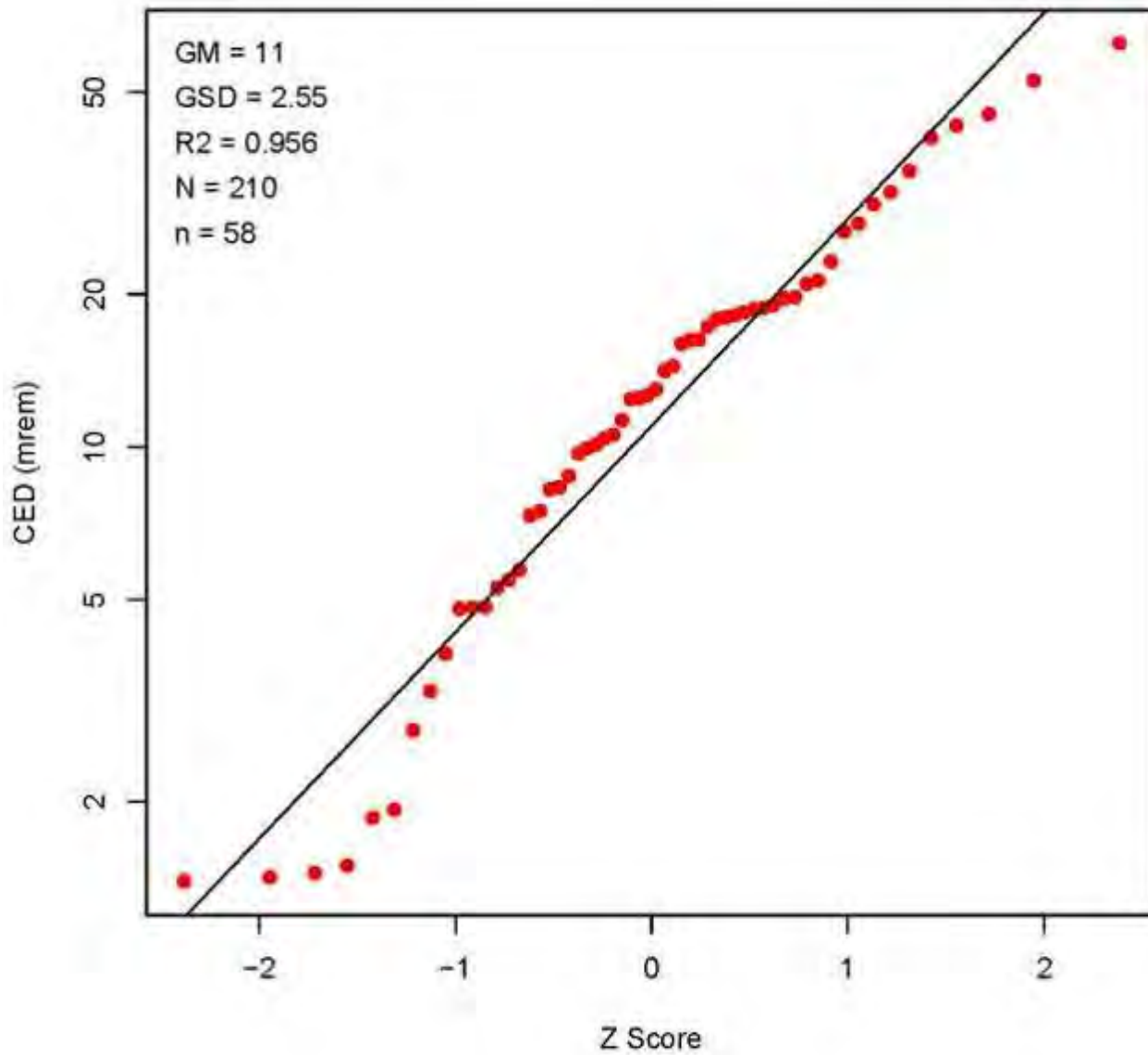


Figure A-126. SRS CTW tritium dose 1985.

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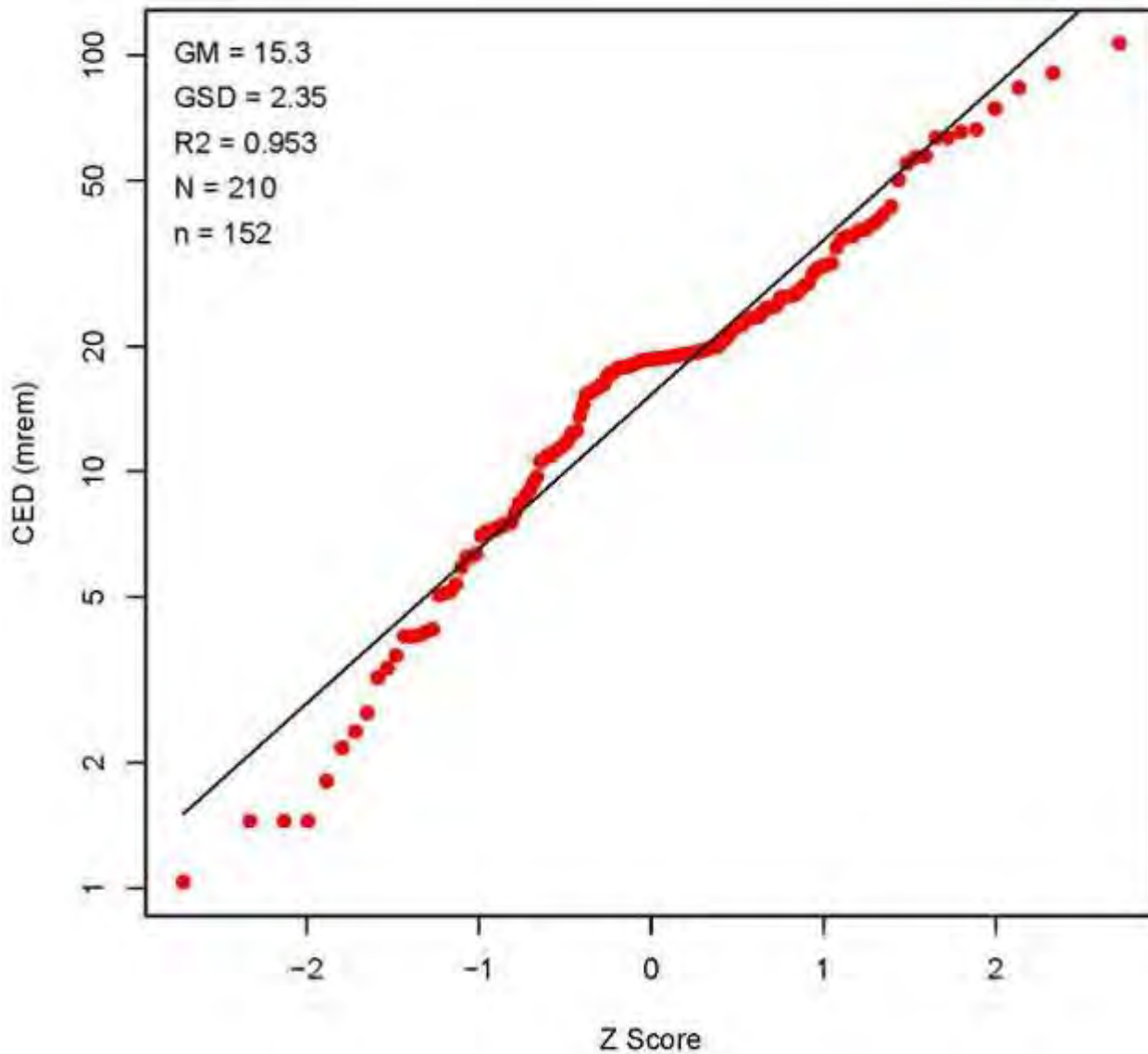


Figure A-127. SRS NCTW tritium dose 1985.

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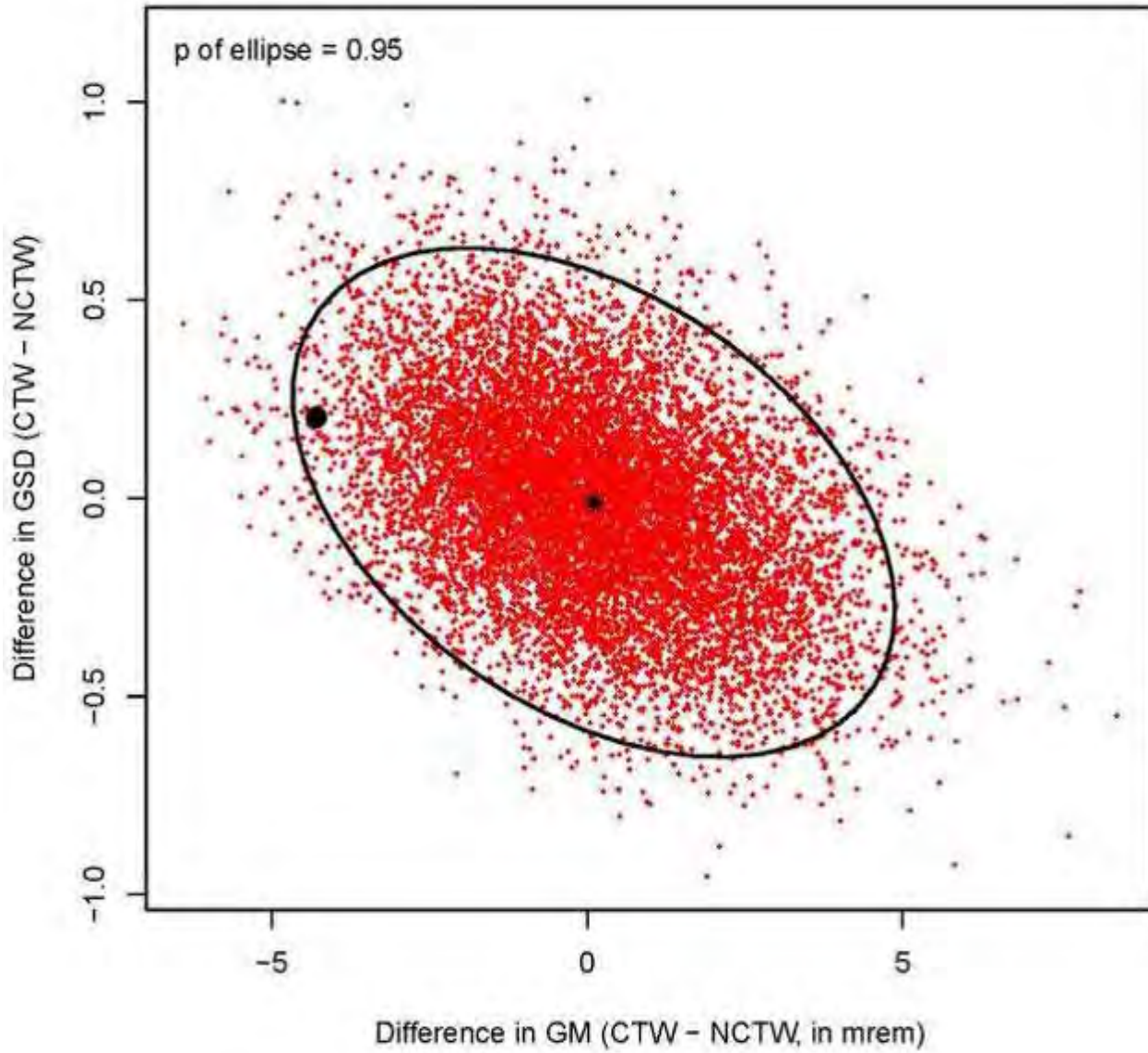


Figure A-128. SRS tritium dose 1985.

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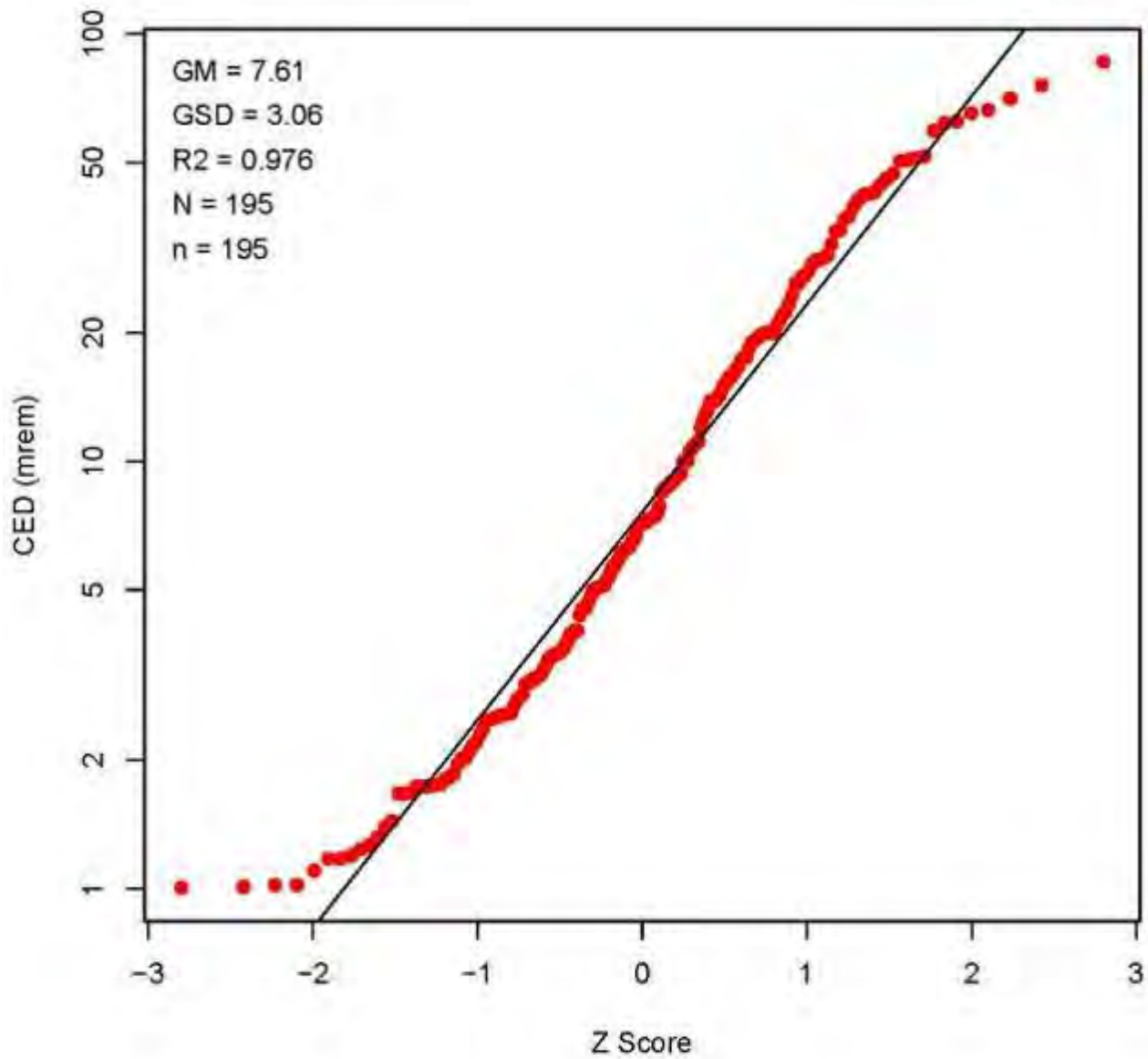


Figure A-129. SRS tritium dose 1986.

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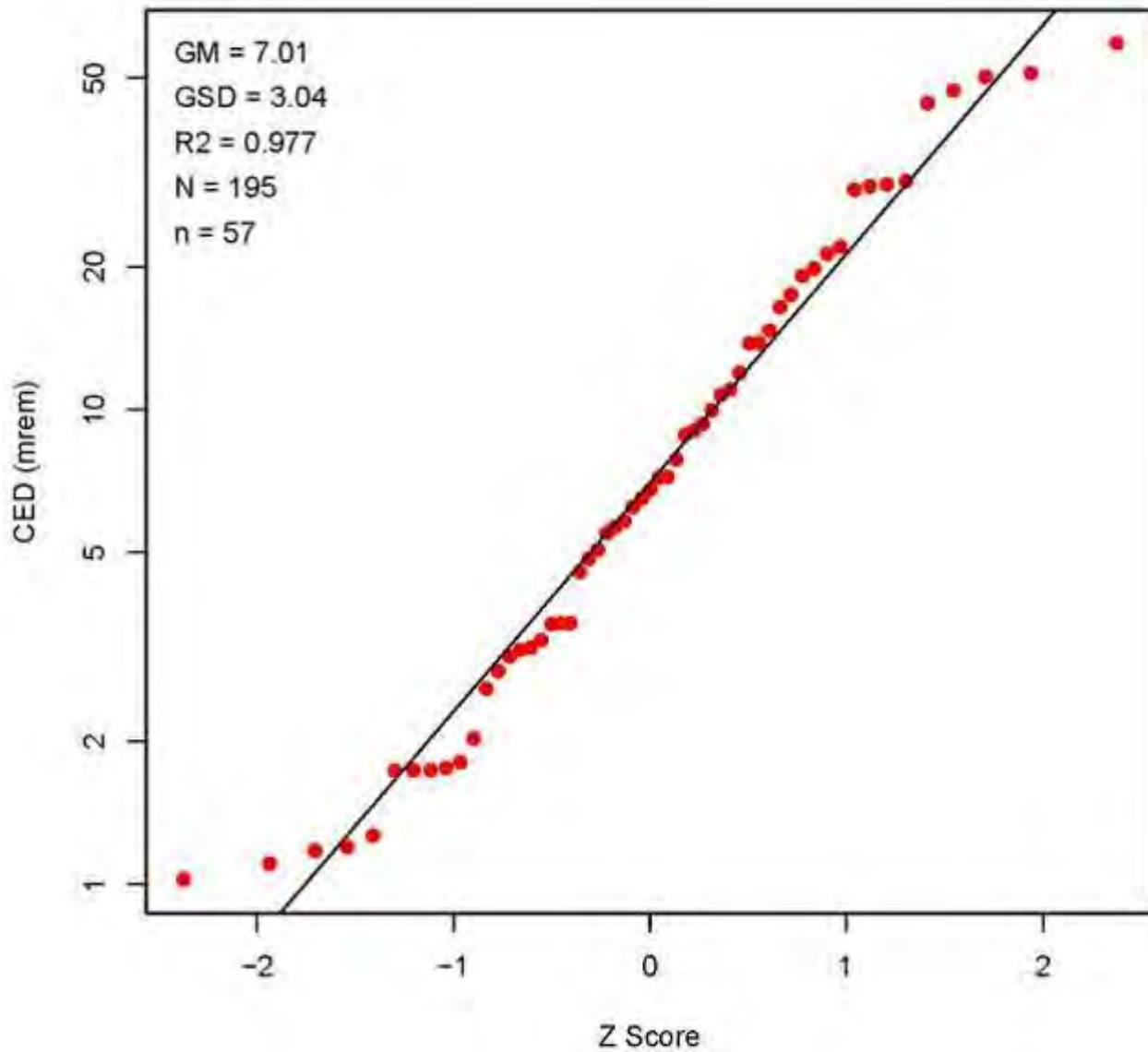


Figure A-130. SRS CTW tritium dose 1986.

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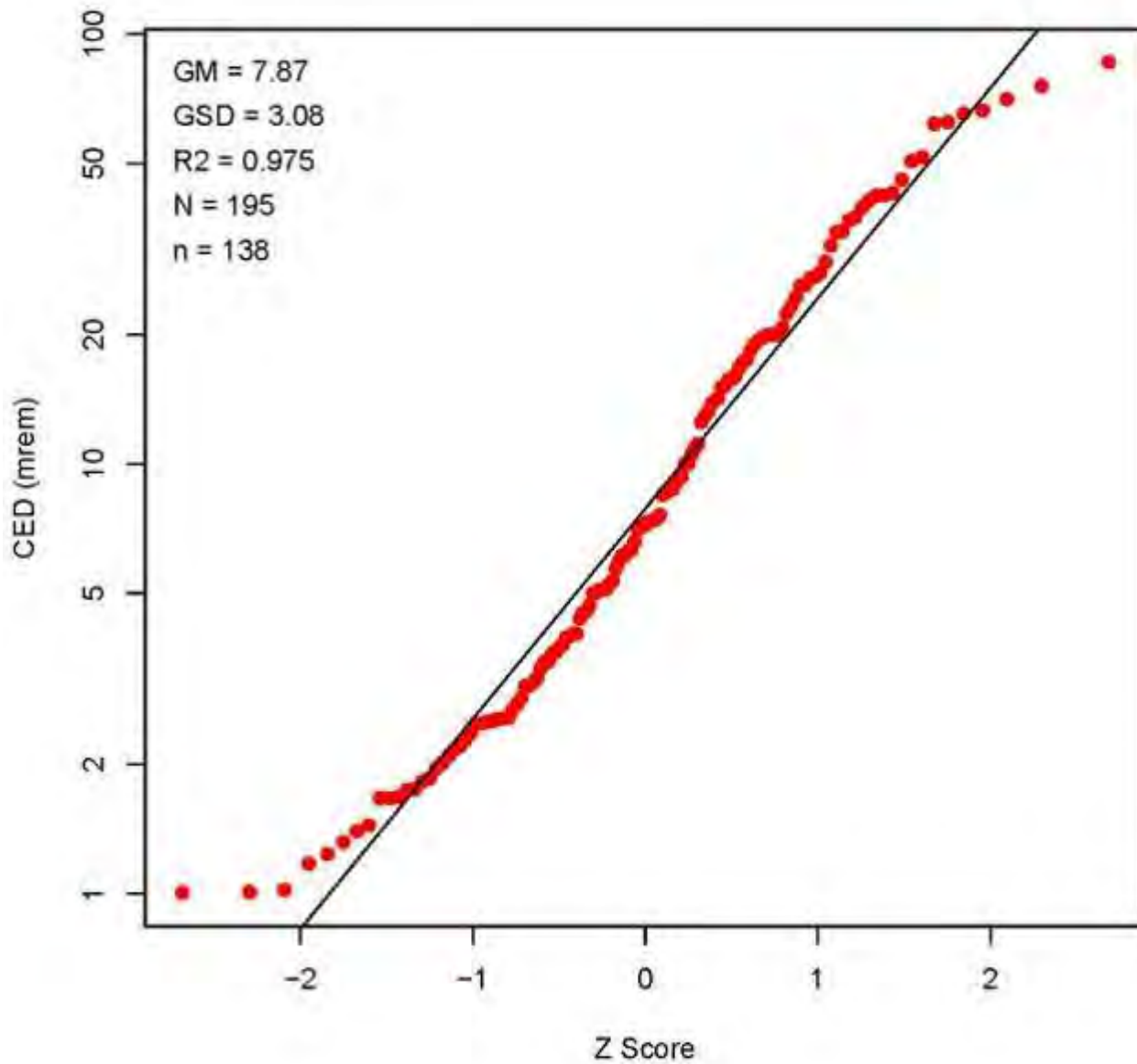


Figure A-131. SRS NCTW tritium dose 1986.

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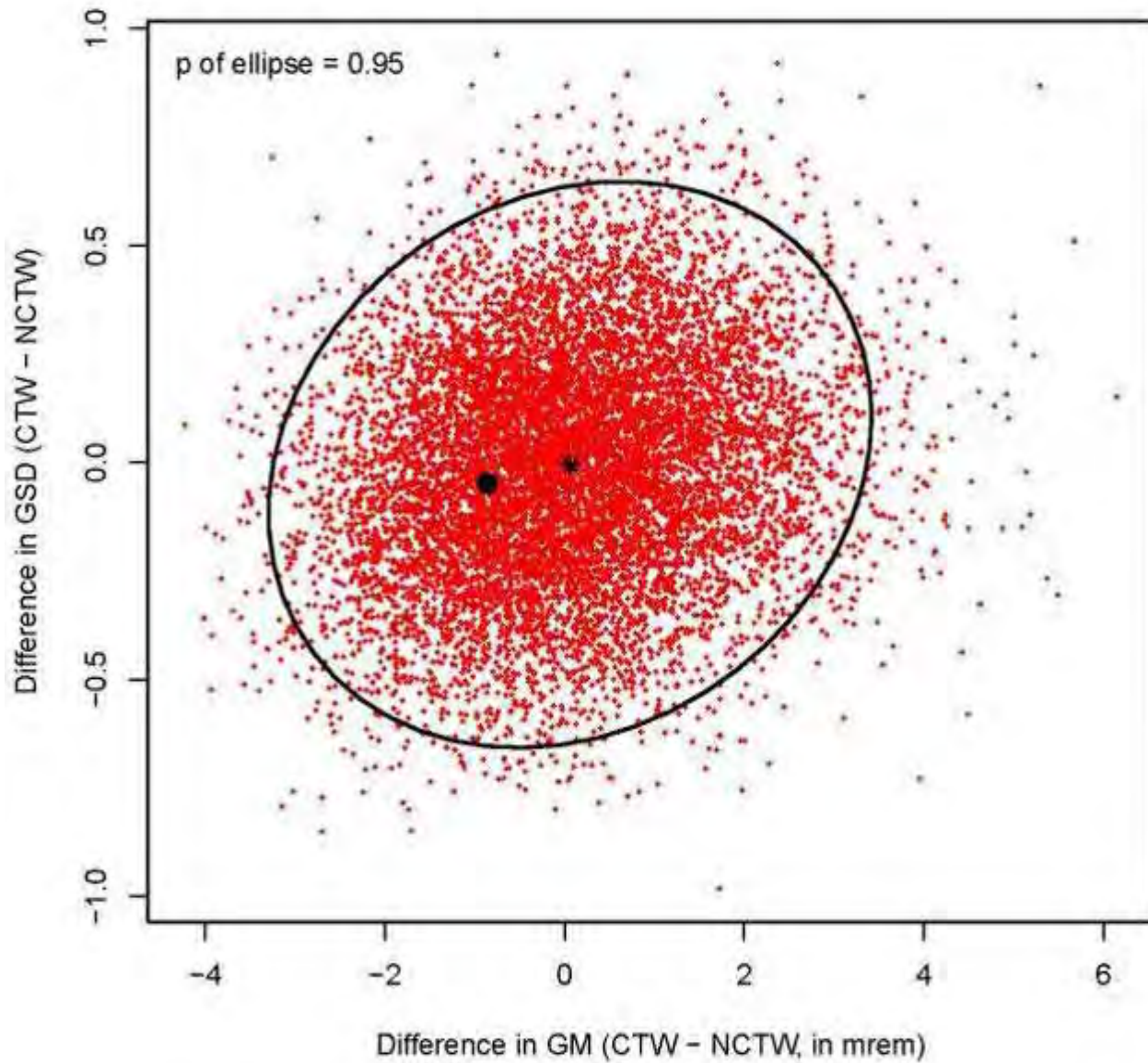


Figure A-132. SRS tritium dose 1986.

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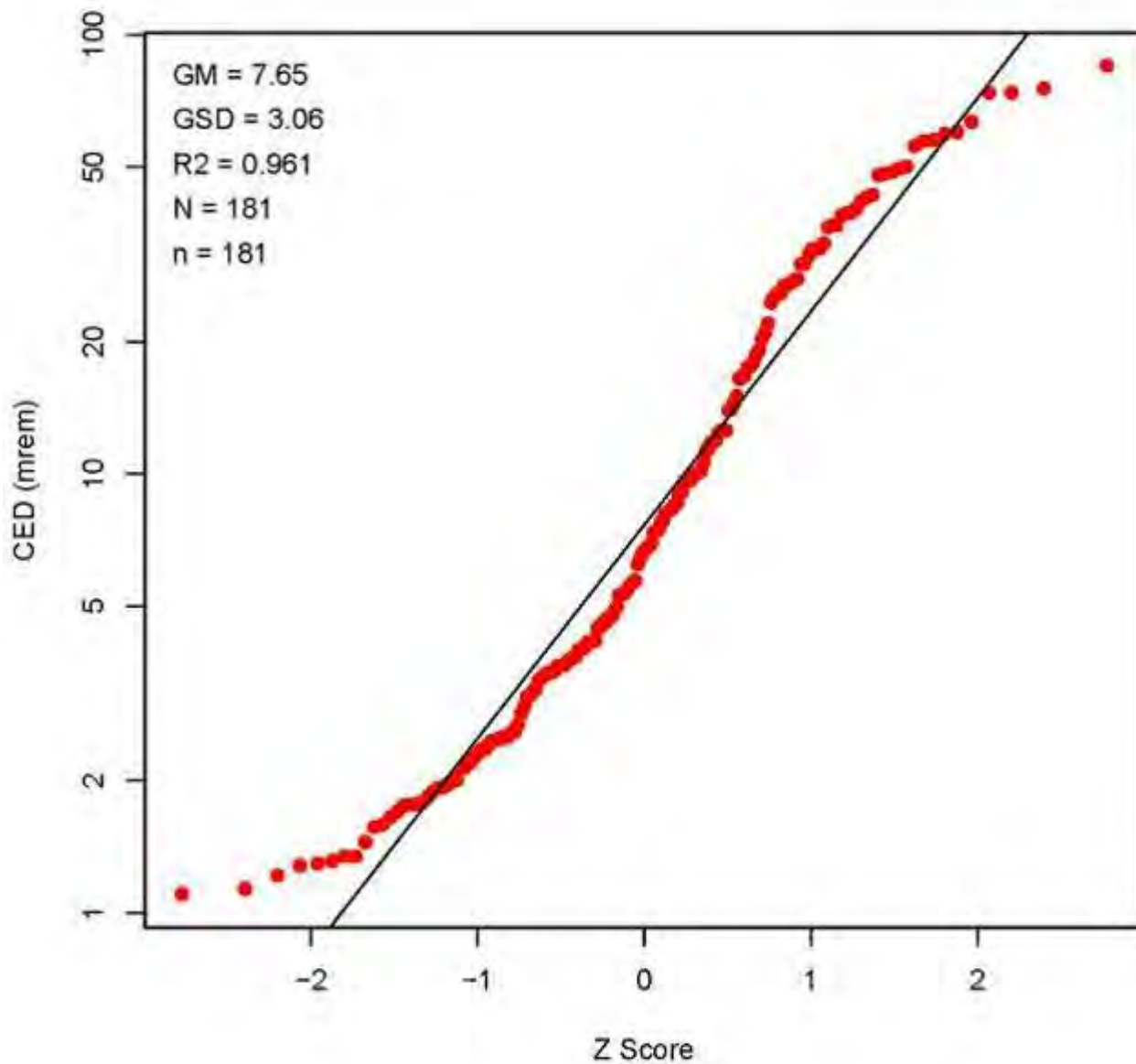


Figure A-133. SRS tritium dose 1987.

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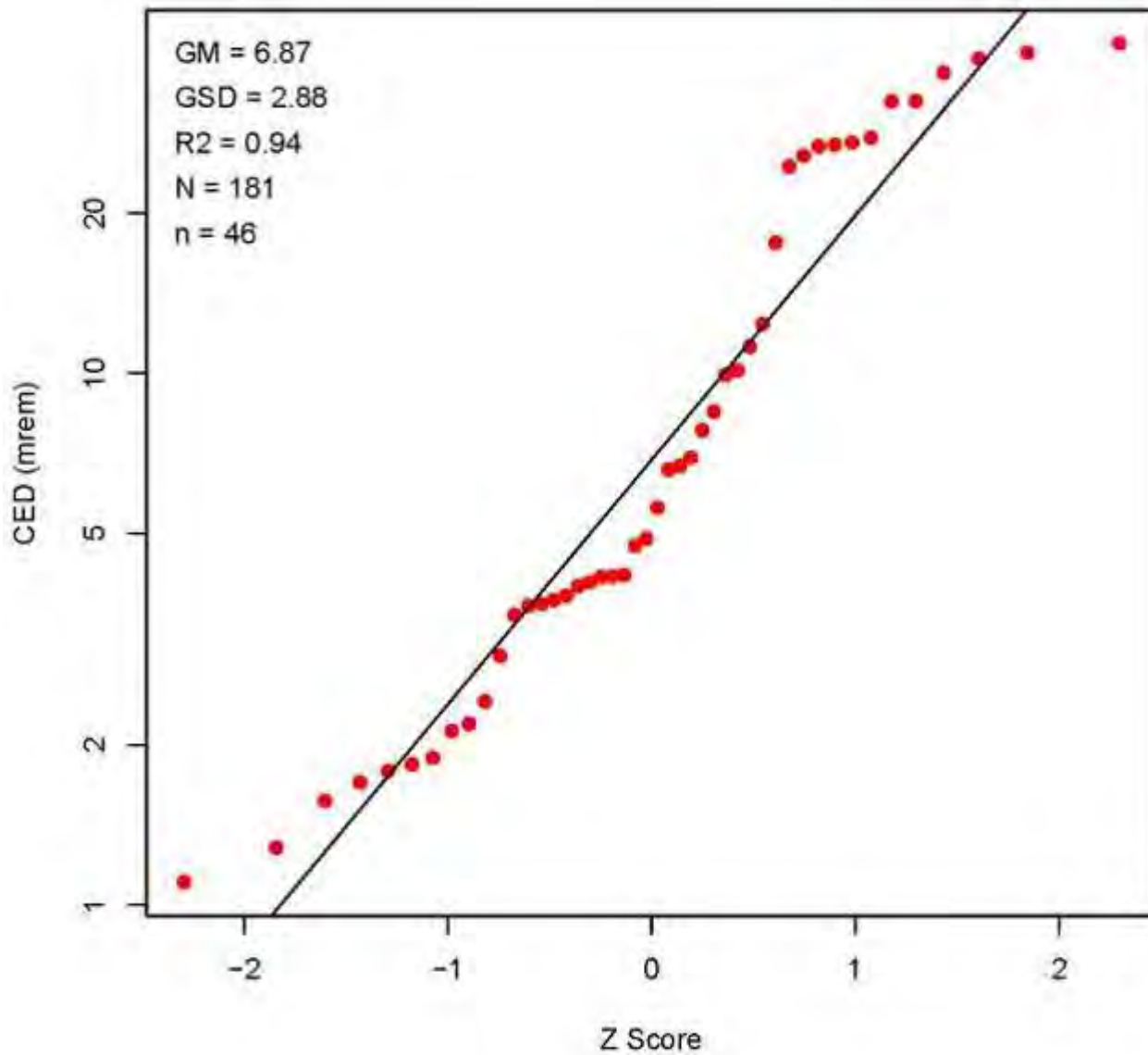


Figure A-134. SRS CTW tritium dose 1987.

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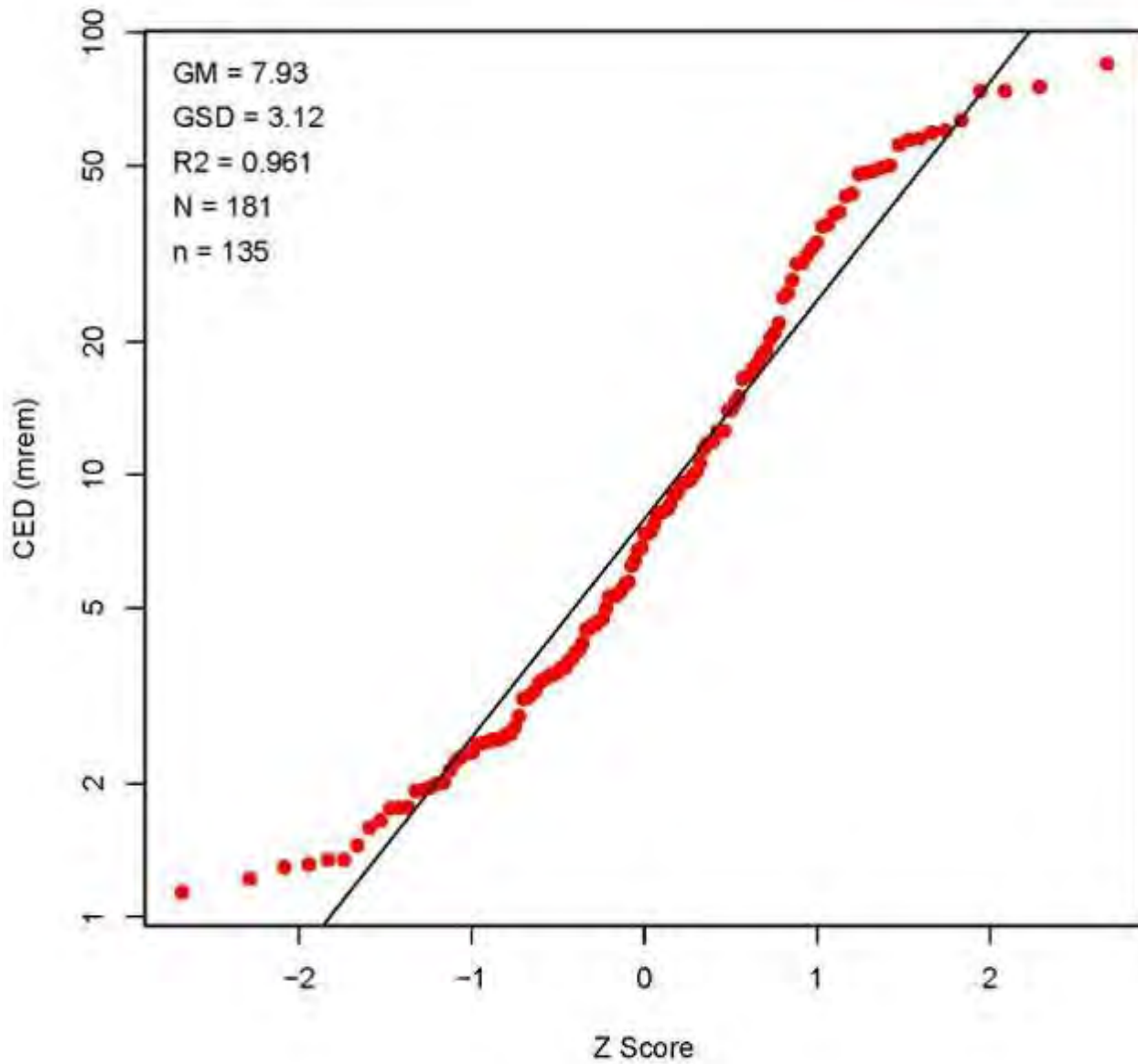


Figure A-135. SRS NCTW tritium dose 1987.

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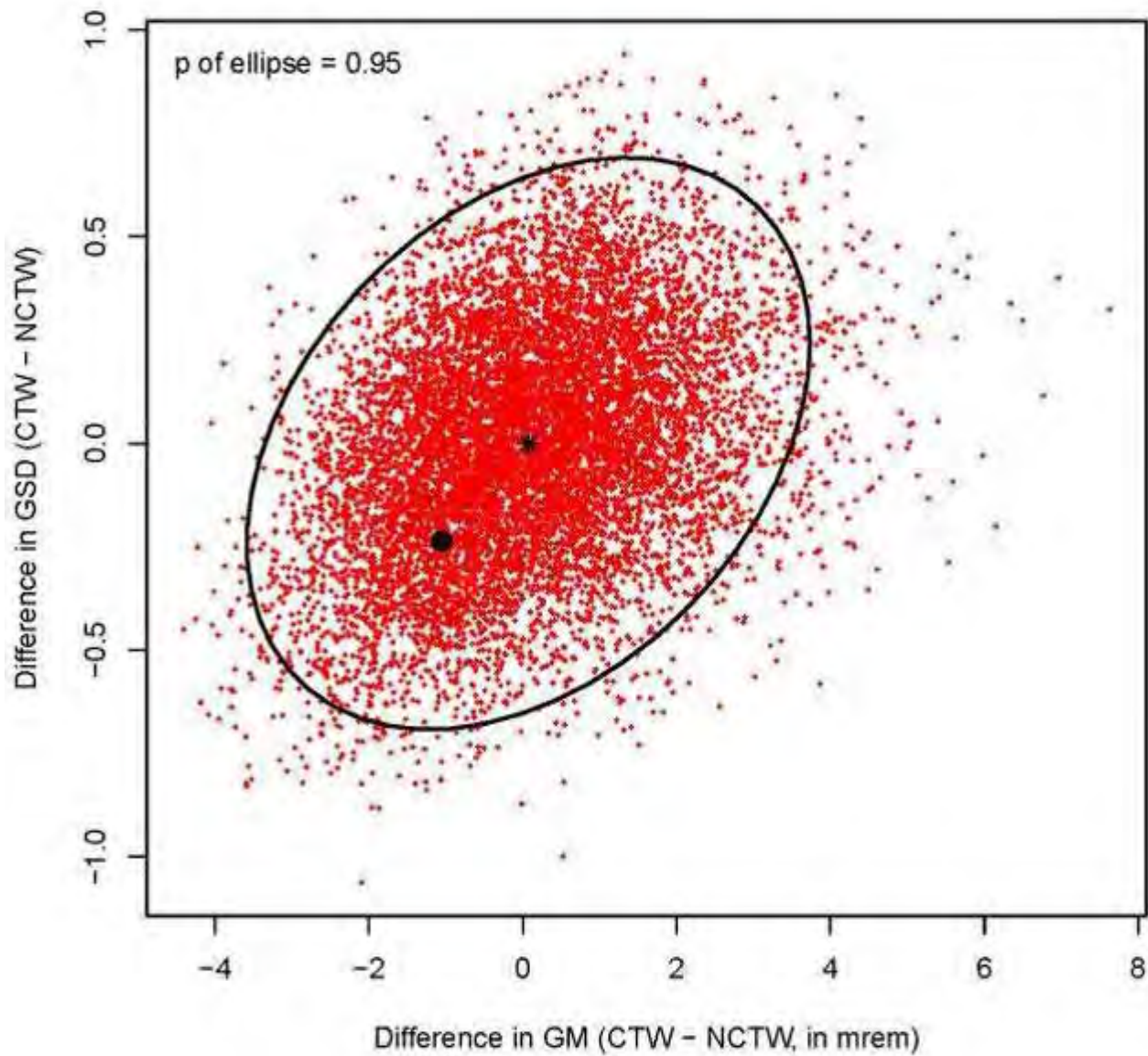


Figure A-136. SRS tritium dose 1987.

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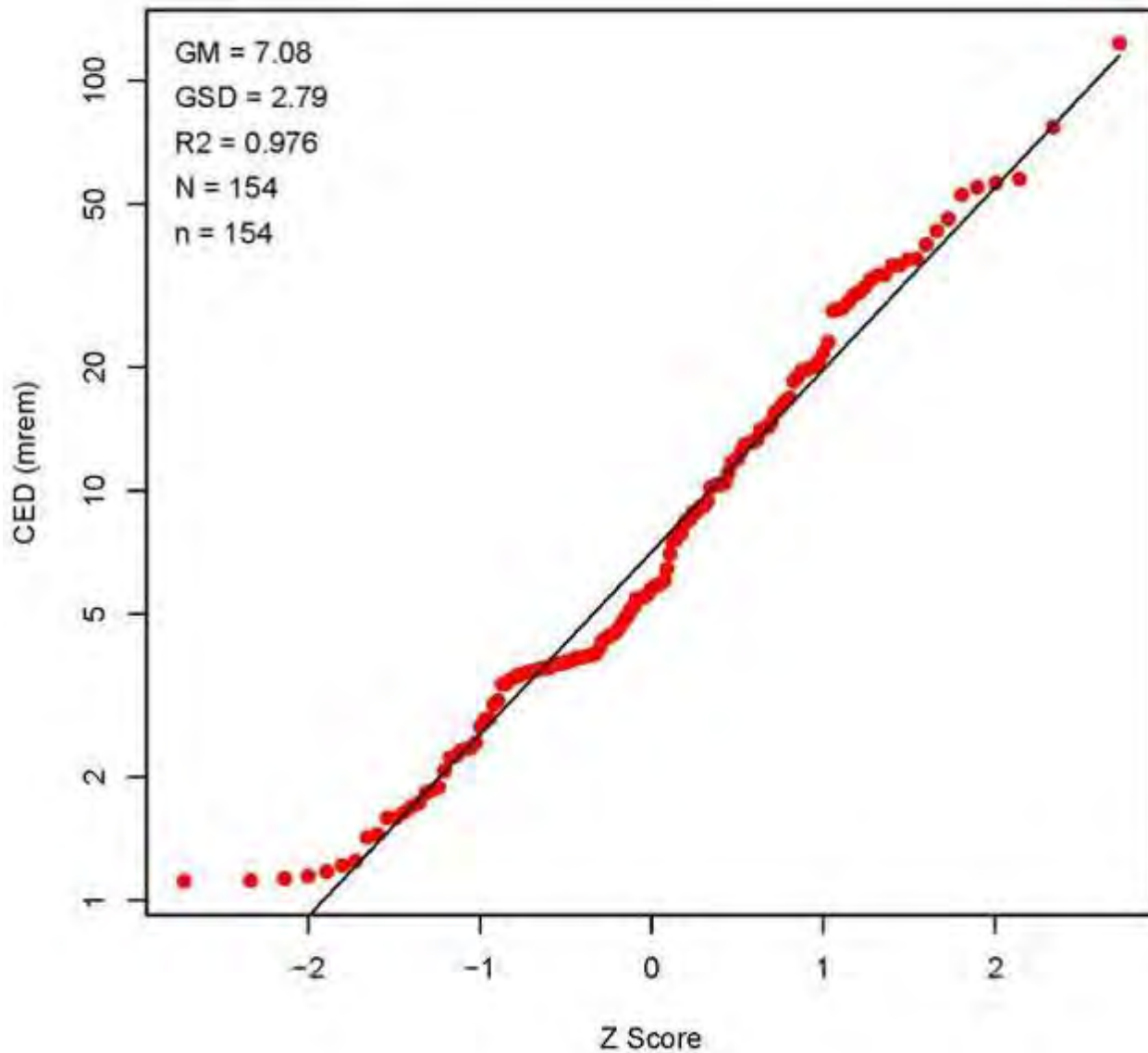


Figure A-137. SRS tritium dose 1988.

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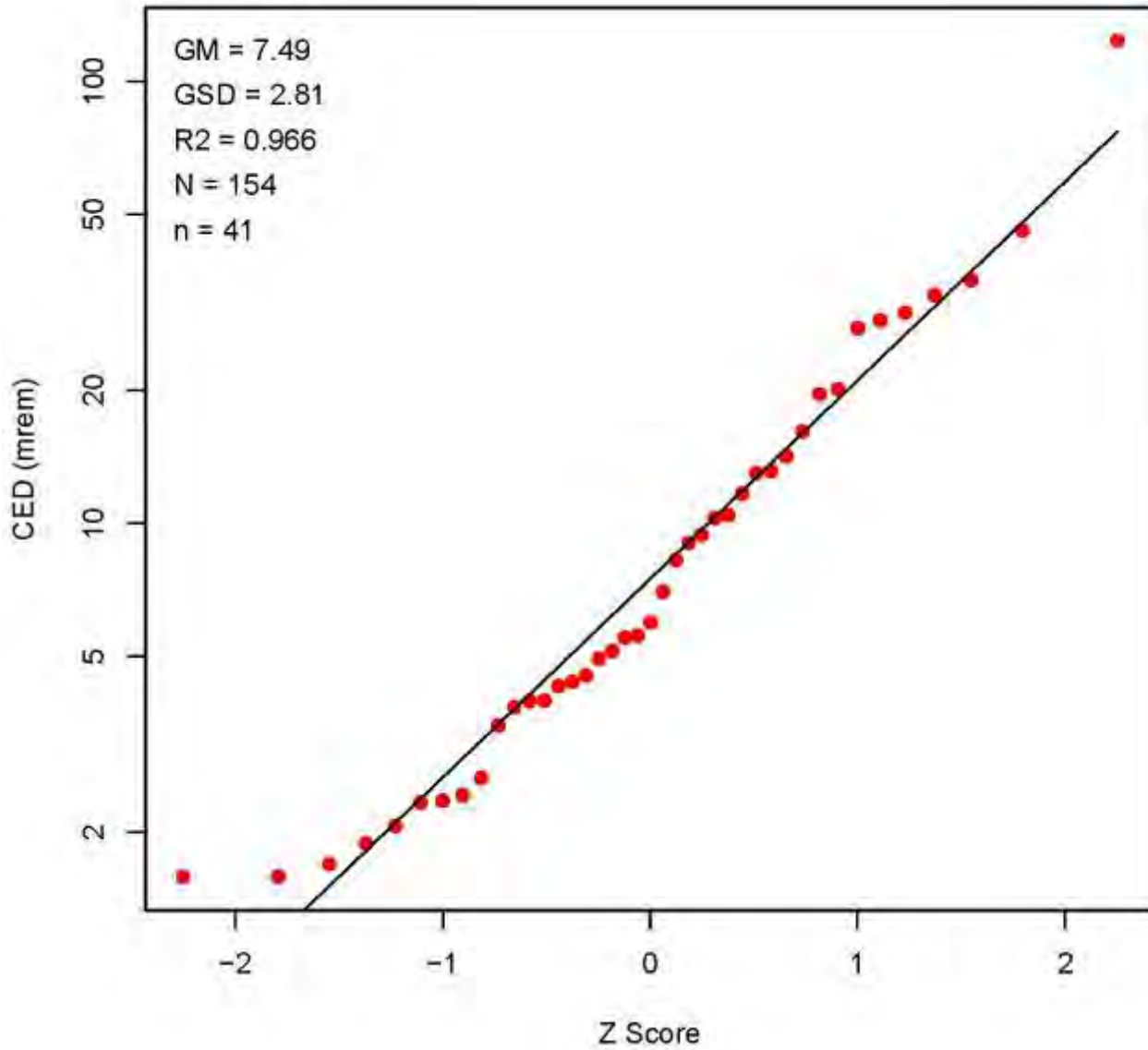


Figure A-138. SRS CTW tritium dose 1988.

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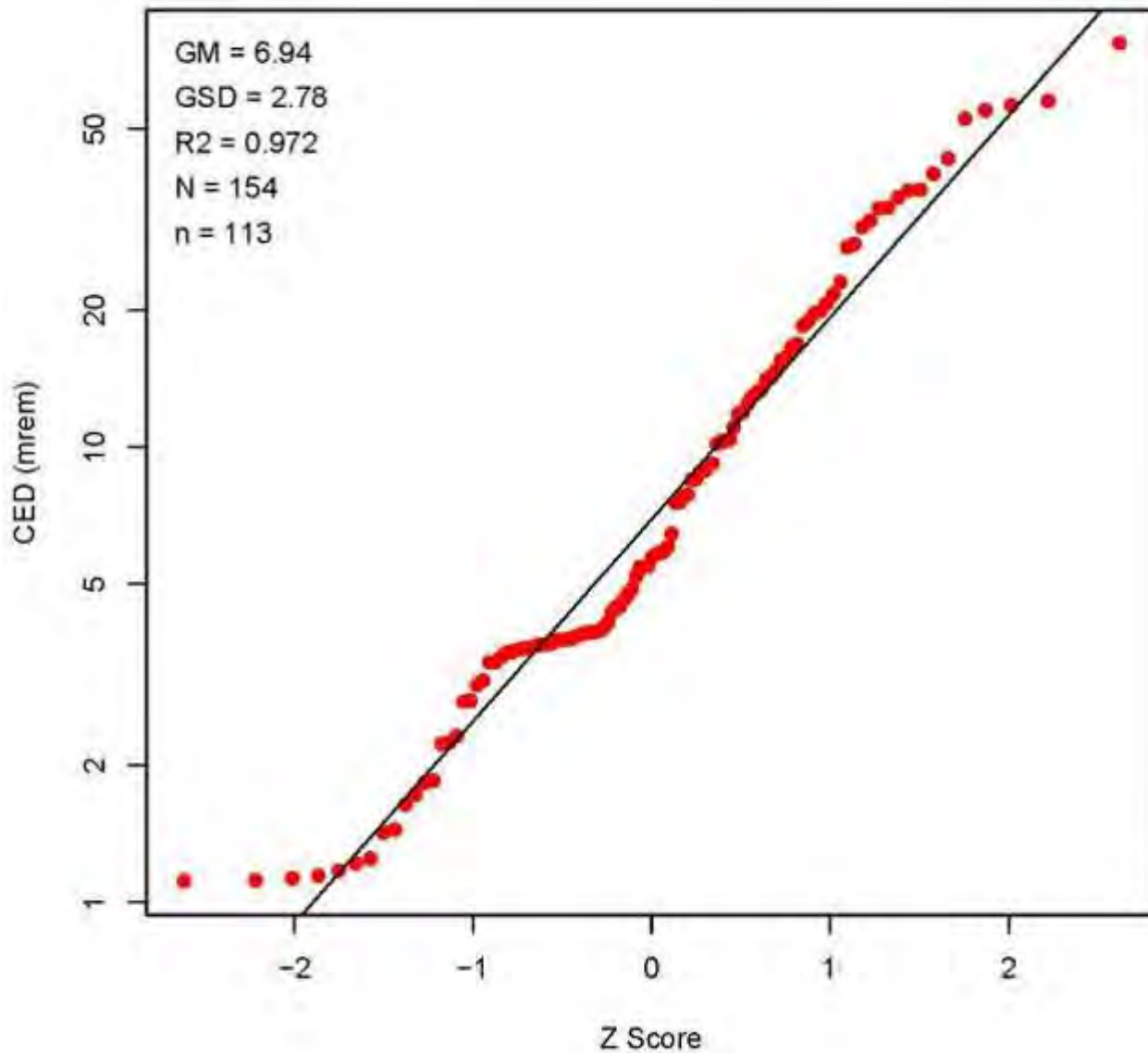


Figure A-139. SRS NCTW tritium dose 1988.

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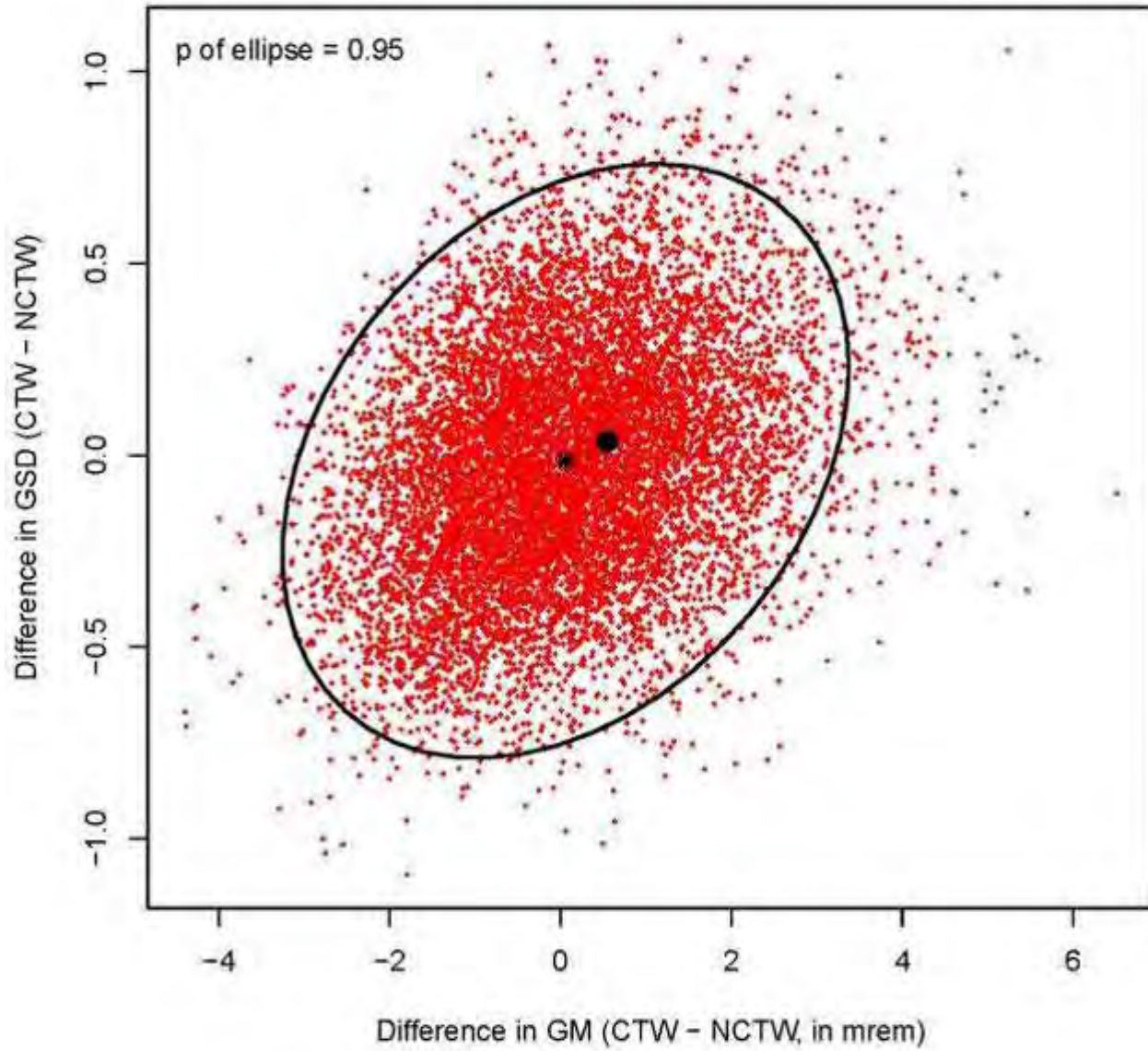


Figure A-140. SRS tritium dose 1988.

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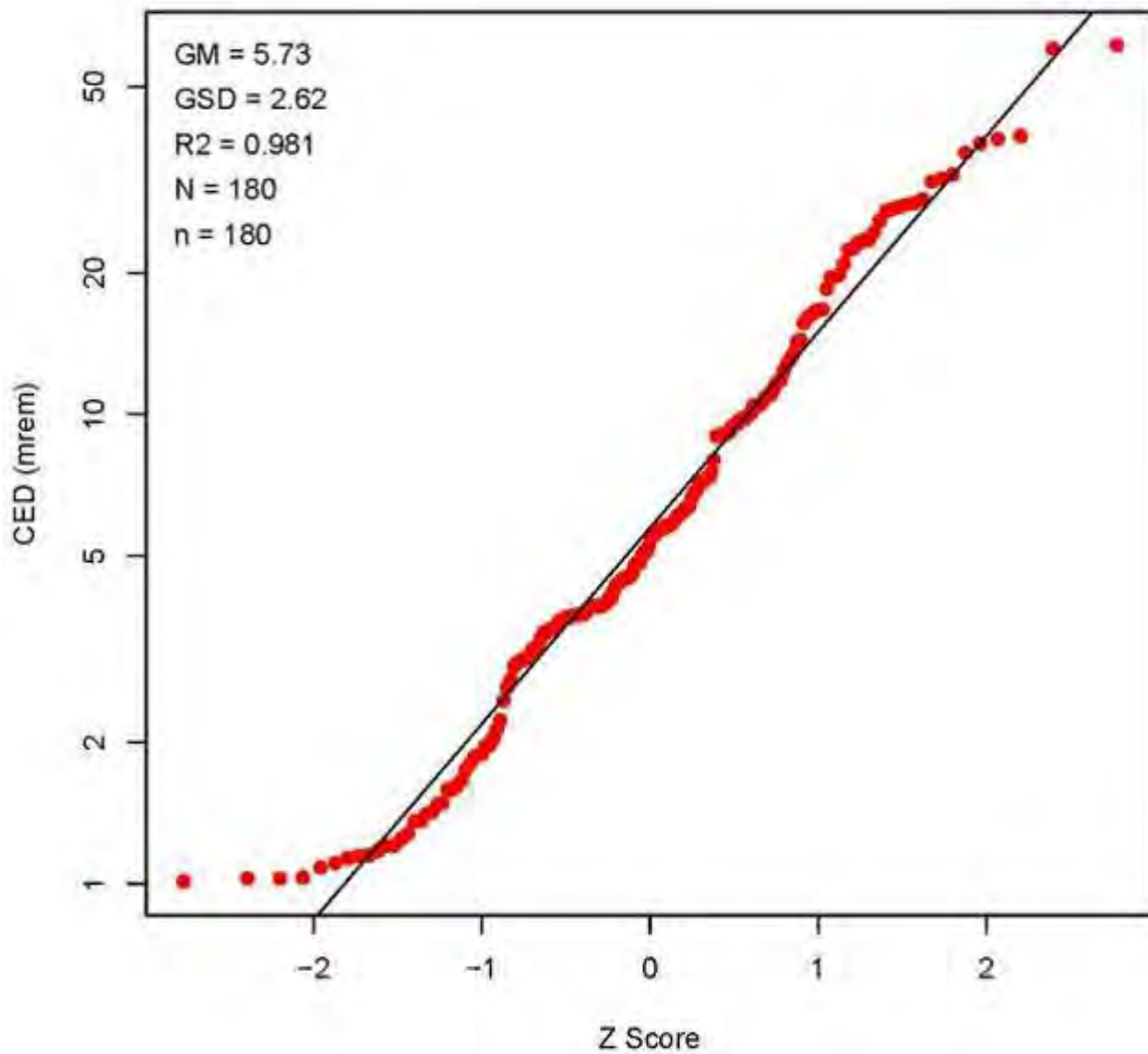


Figure A-141. SRS tritium dose 1989.

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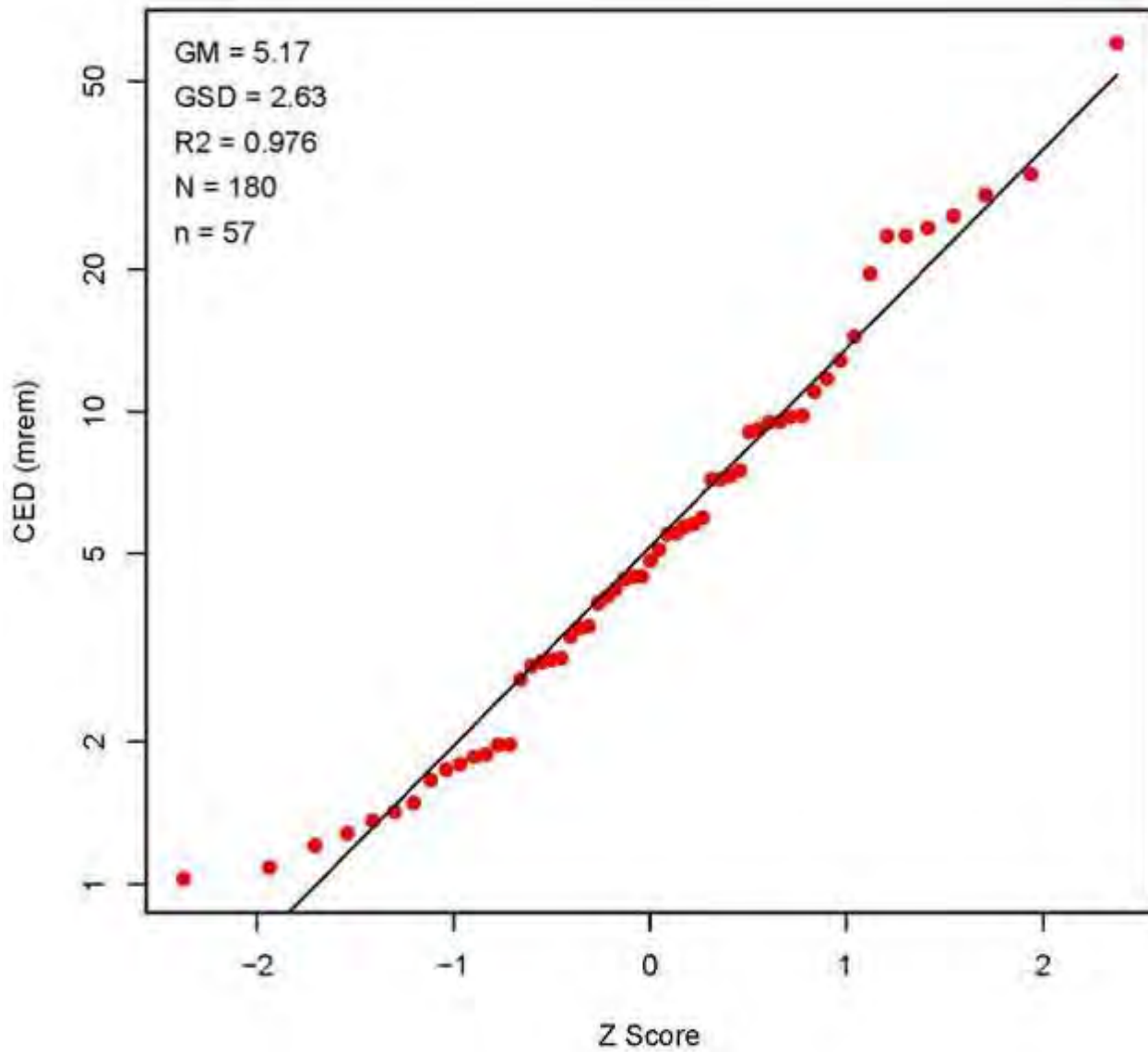


Figure A-142. SRS CTW tritium dose 1989.

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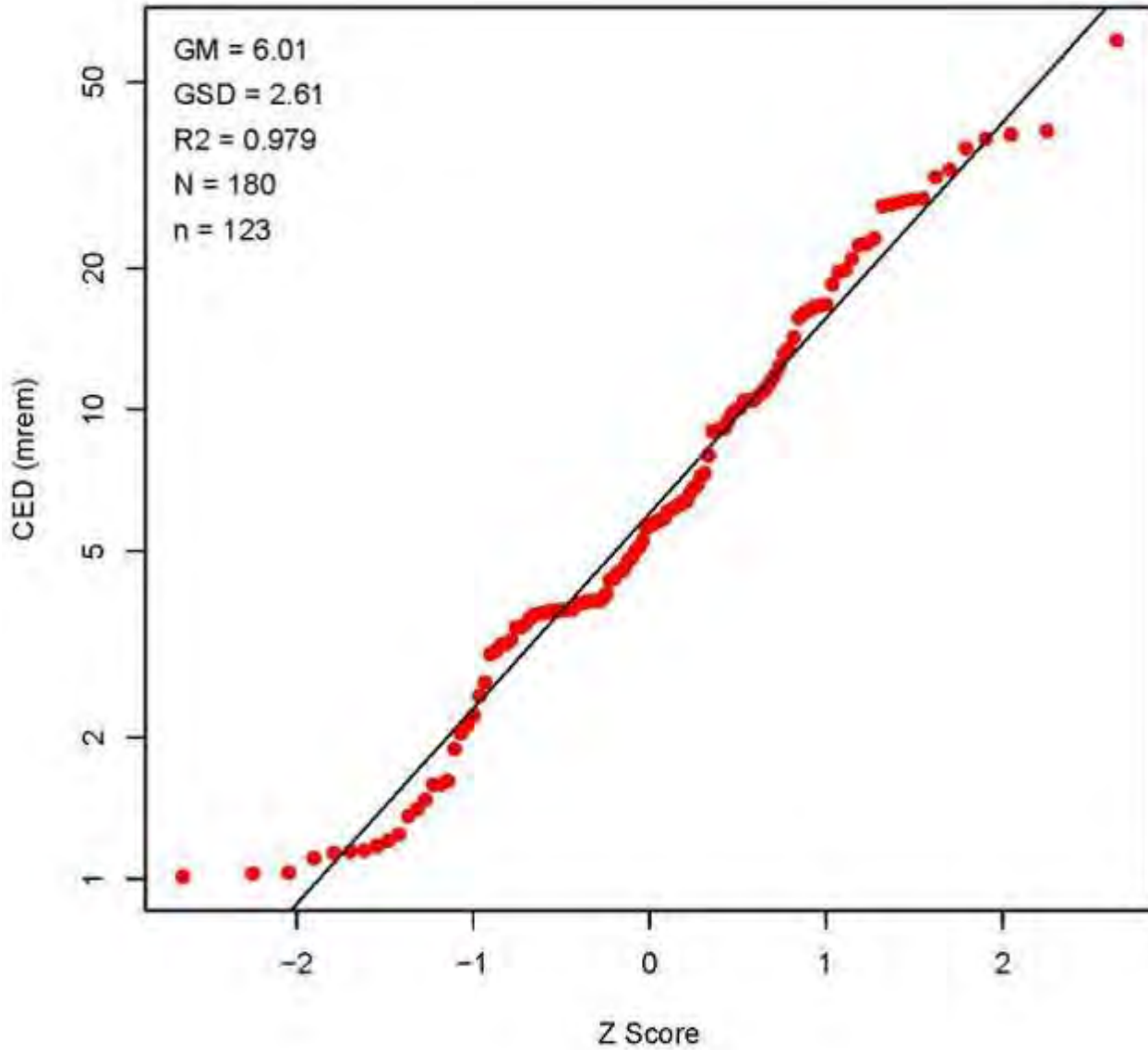


Figure A-143. SRS NCTW tritium dose 1989.

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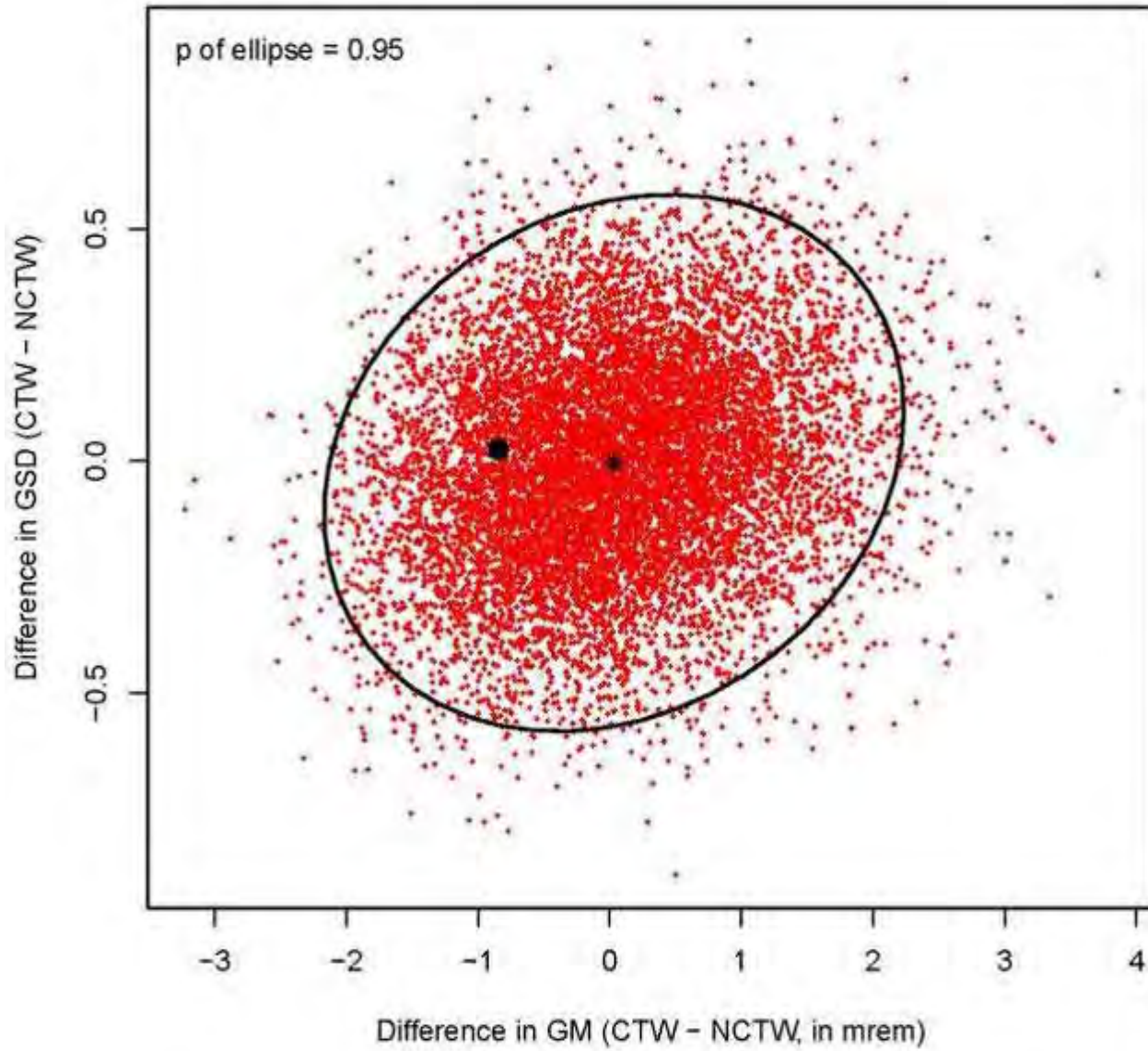


Figure A-144. SRS tritium dose 1989.

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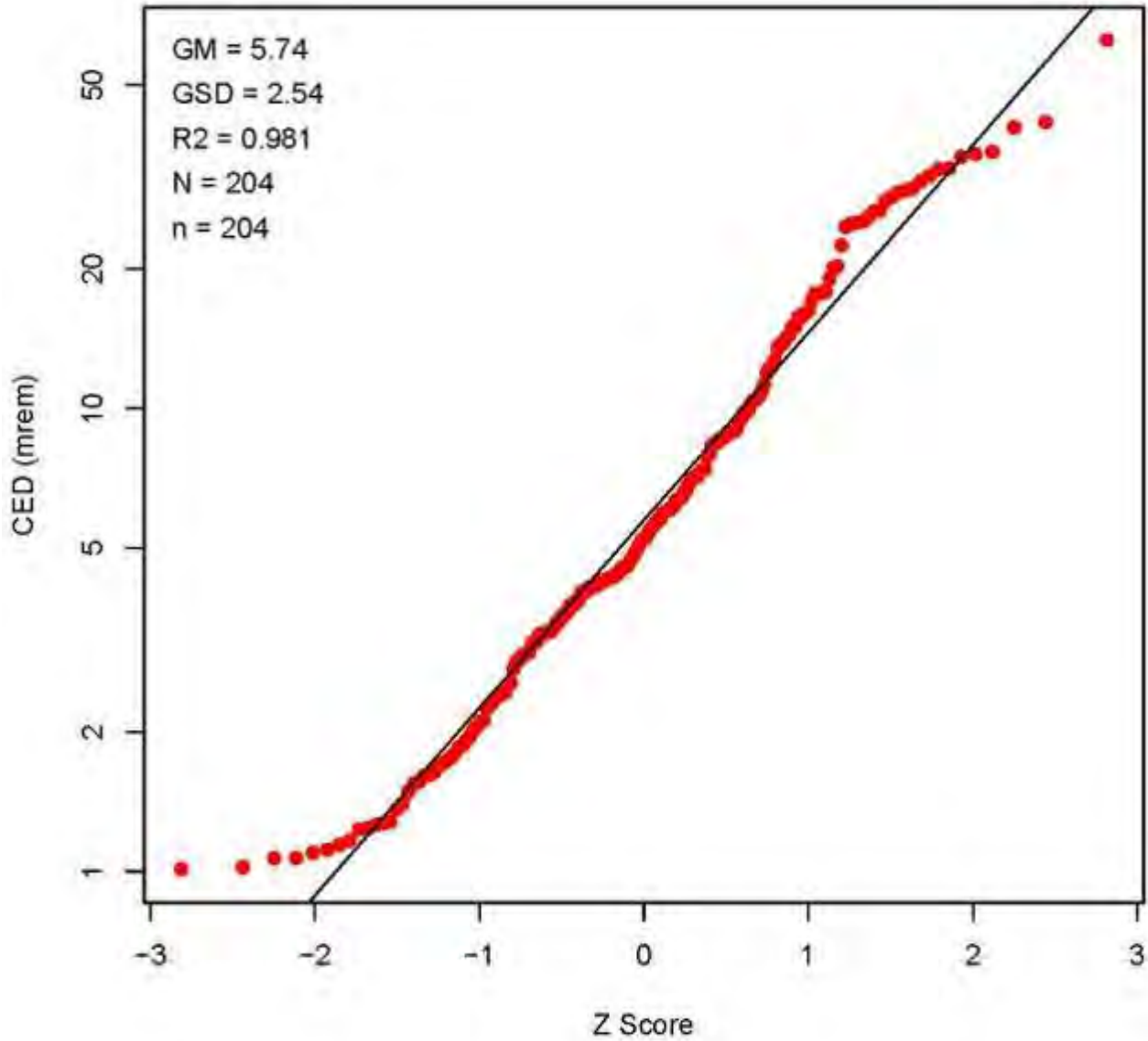


Figure A-145. SRS tritium dose 1990.

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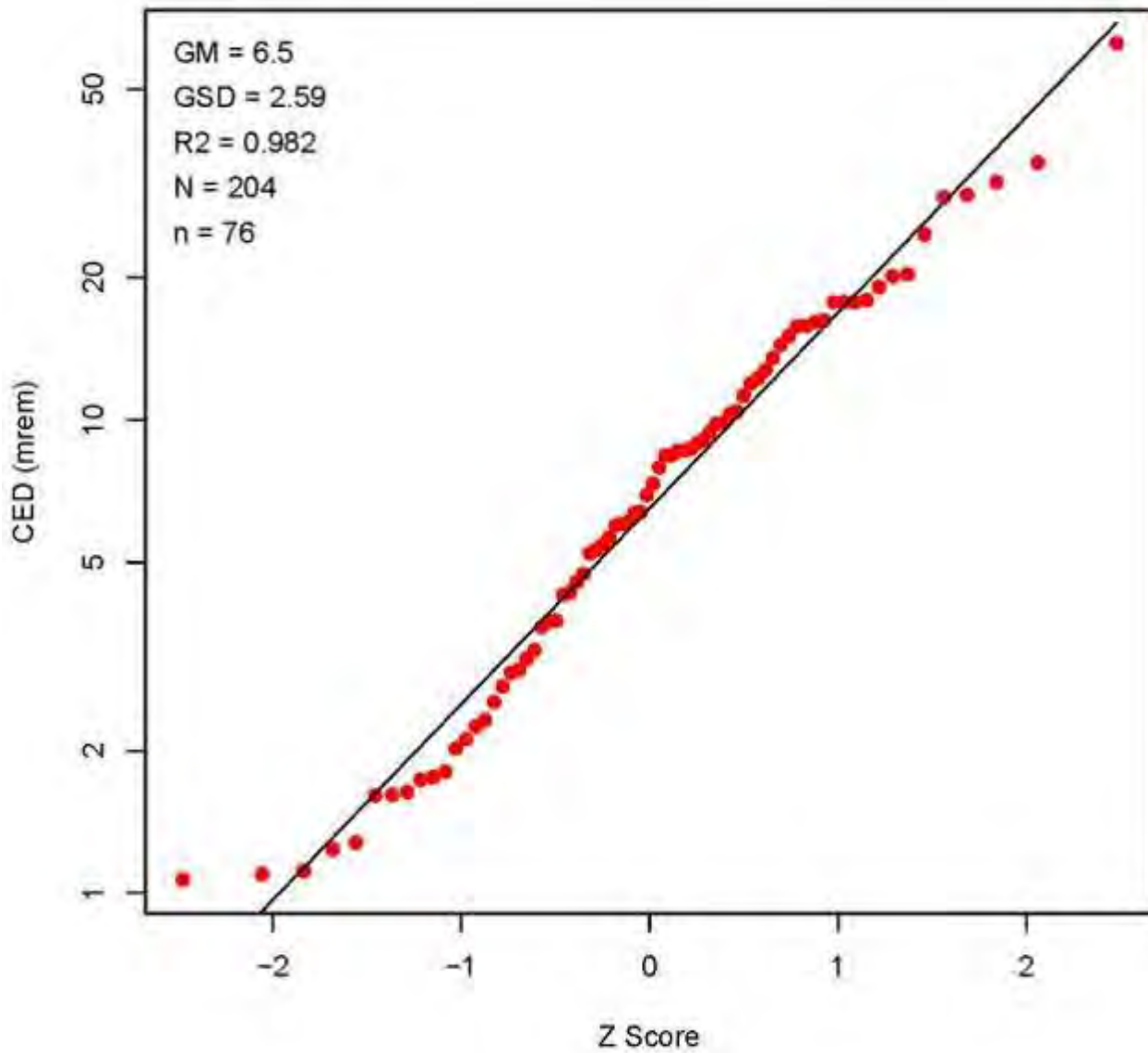


Figure A-146. SRS CTW tritium dose 1990.

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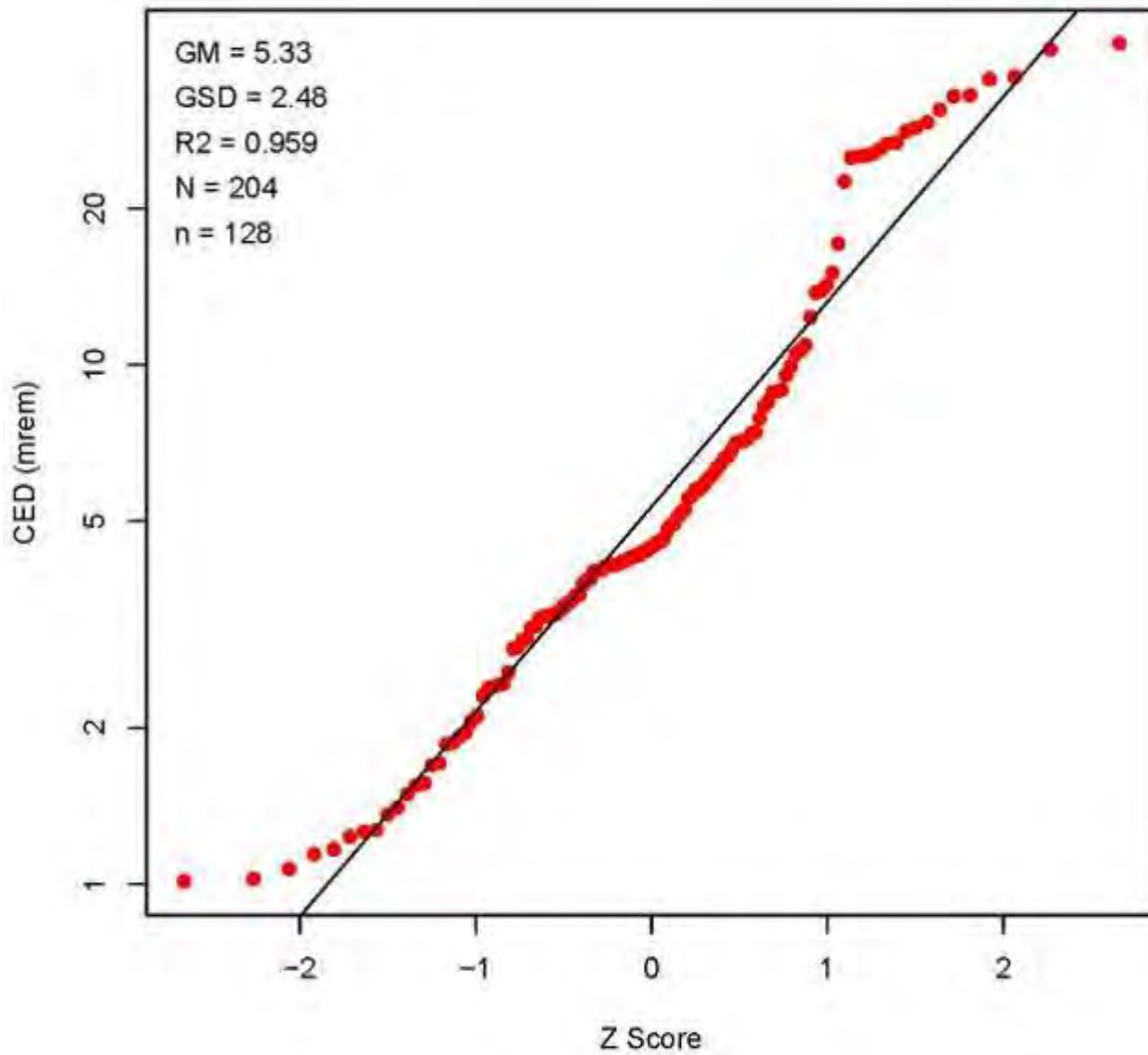


Figure A-147. SRS NCTW tritium dose 1990.

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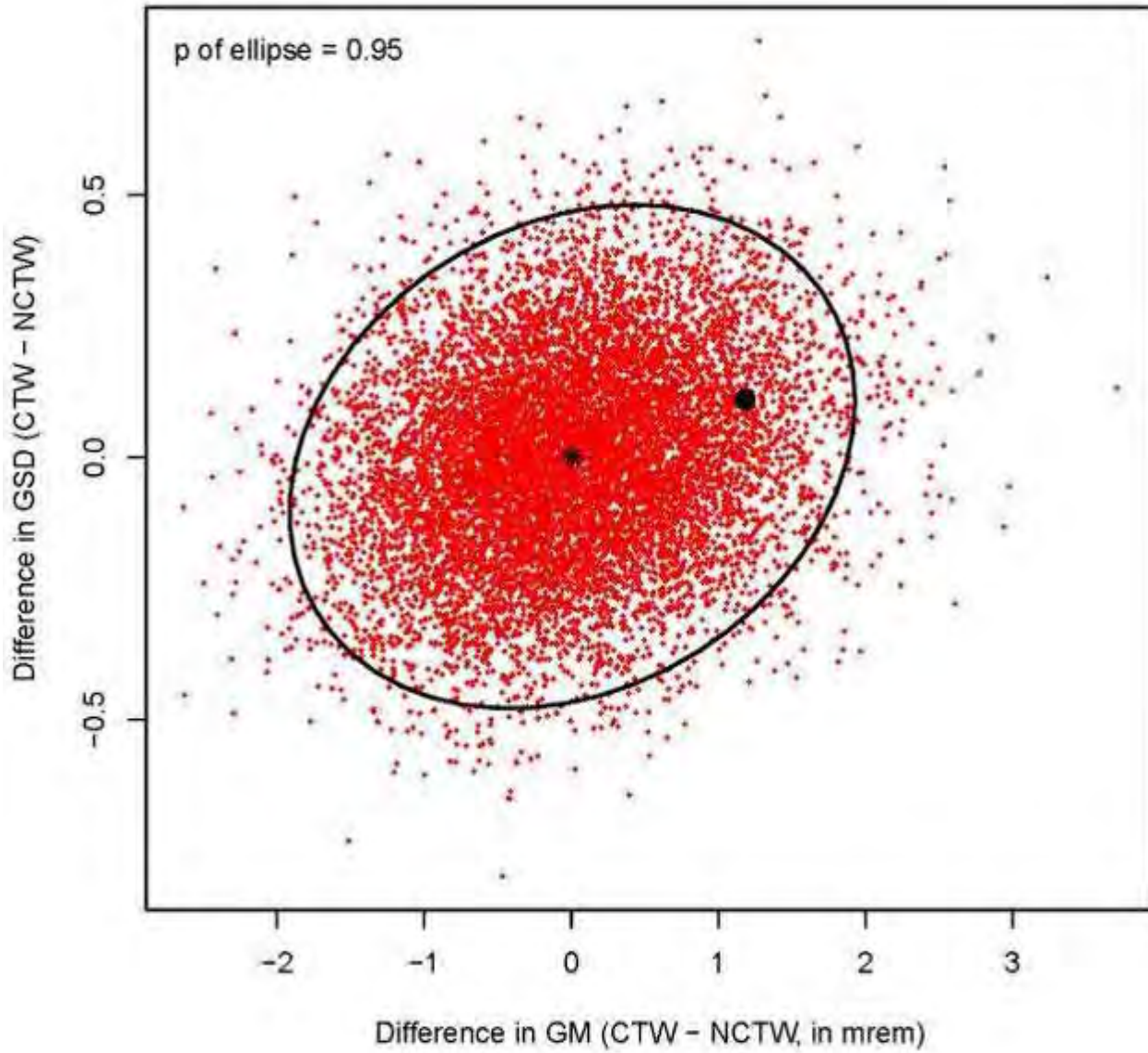


Figure A-148. SRS tritium dose 1990.

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Four plots are presented for each year from 1954 to 1990. The first three are lognormal probability plots of the tritium doses for the CS of workers, the reactor workers, and all other workers, who are referred to as the nonreactor workers. In these plots the following statistics are presented:

- GM = geometric mean of data (intercept of line)
- GSD = geometric standard deviation of data (slope of line)
- R2 = coefficient of determination for regression line
- N = total number of individuals in CS
- n = total number of individuals in CTW or NCTW group

The fourth plot for a given year is a Monte Carlo permutation plot of the test statistics for 10,000 random draws from the CS. Each random draw from the CS is split into one part the size of the reactor workers and one part the size of the nonreactor workers and two test statistics (one for the GM and one for the GSD) are calculated for these two parts. All 10,000 pairs of test statistics are plotted and an ellipse is constructed that contains 95% of the test statistics. If the observed test statistics for the reactor and nonreactor strata lie outside of the ellipse, the coworker model for the reactor workers is different from the coworker model for nonreactor workers.

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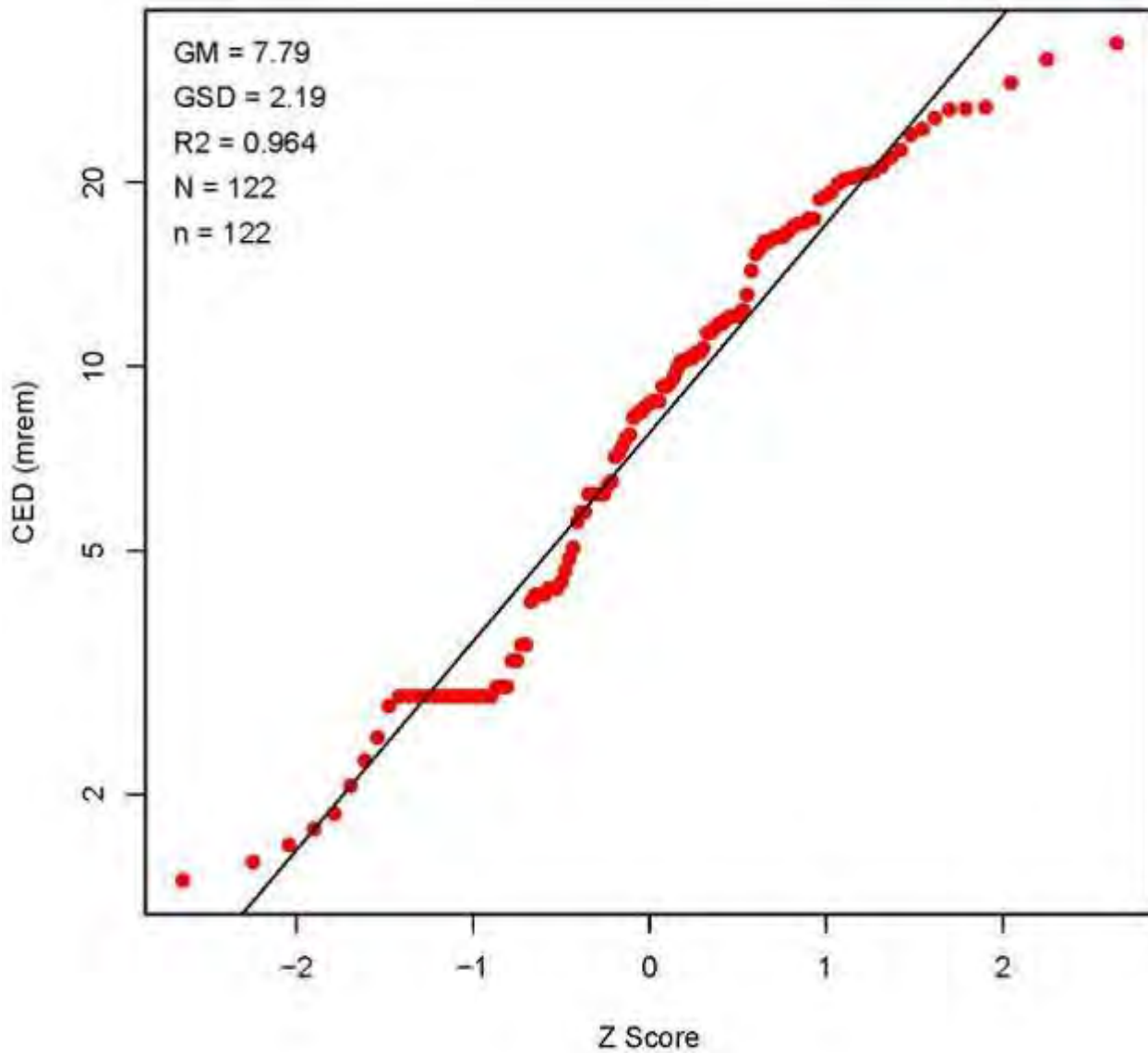


Figure B-1. SRS tritium dose 1954.

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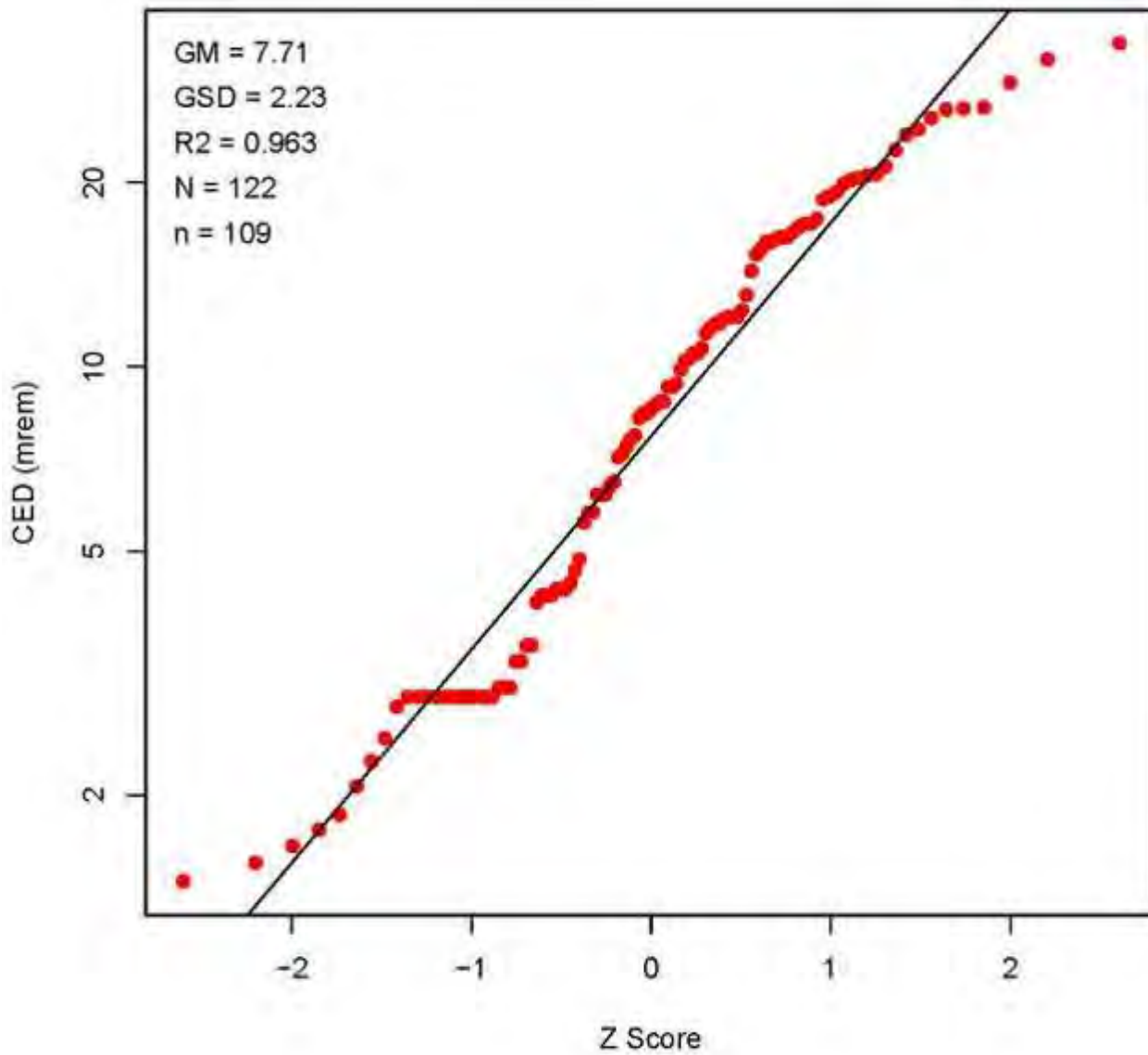


Figure B-2. SRS reactor tritium dose 1954.

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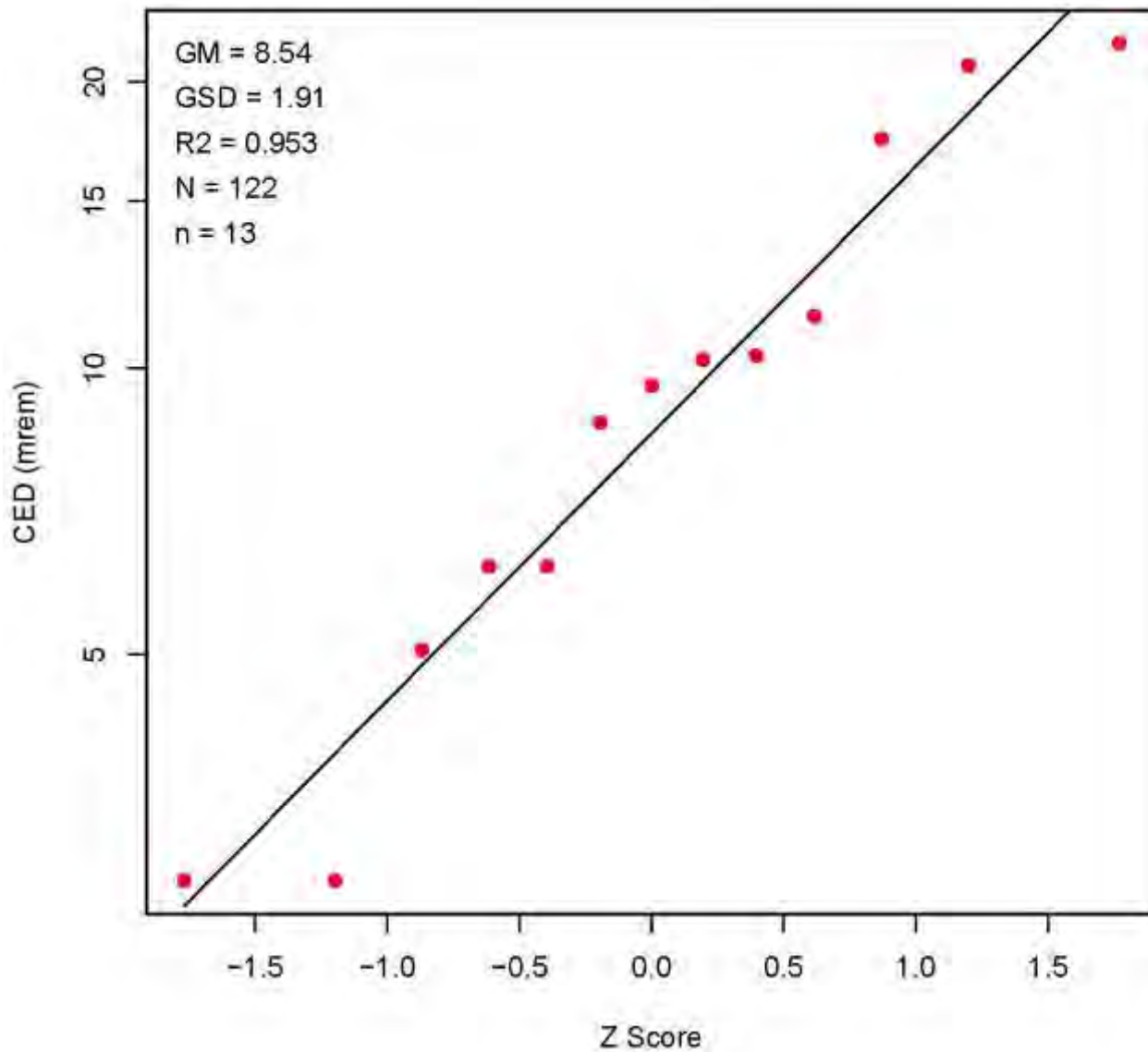


Figure B-3. SRS nonreactor tritium dose 1954.

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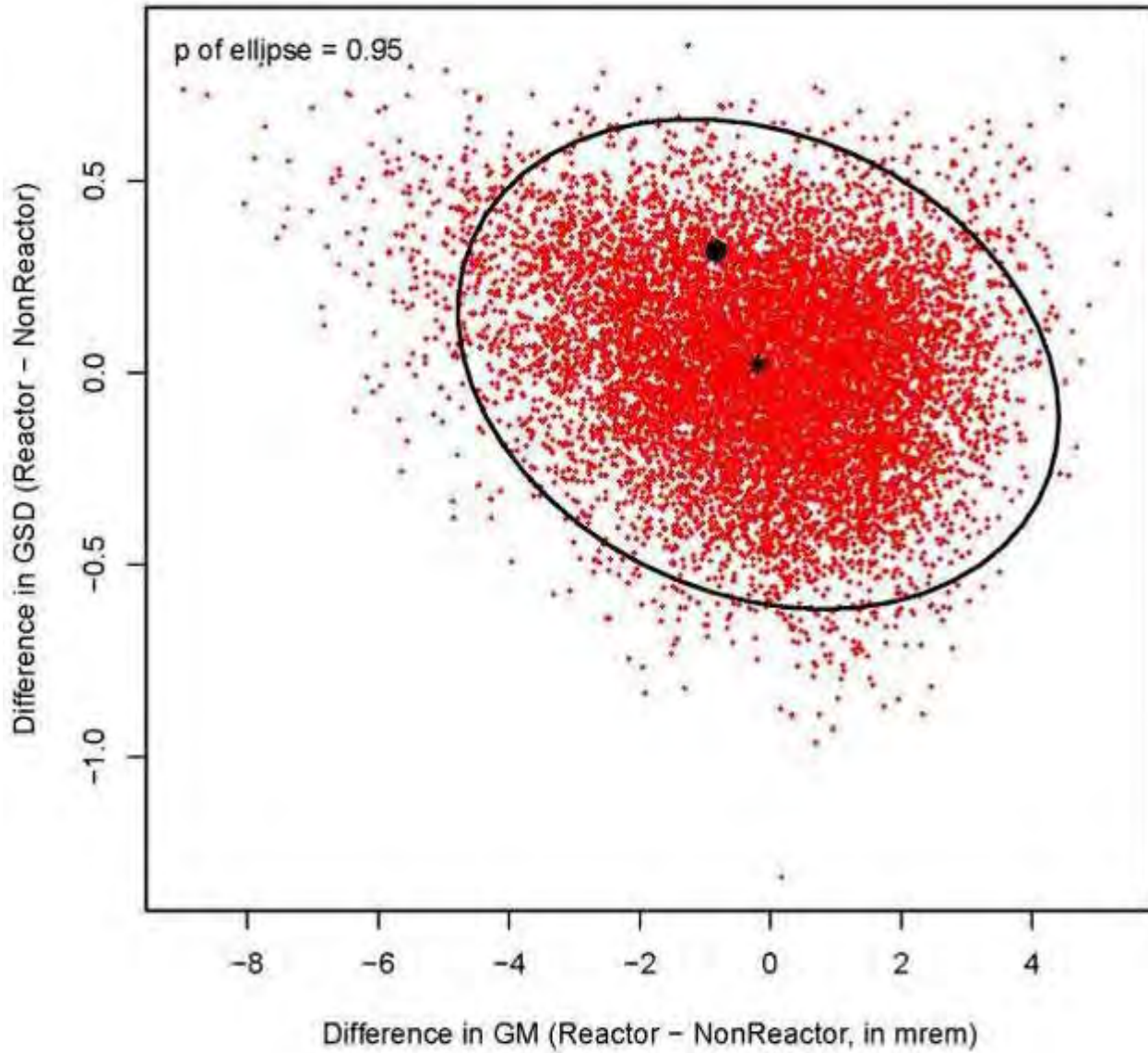


Figure B-4. SRS tritium dose 1954.

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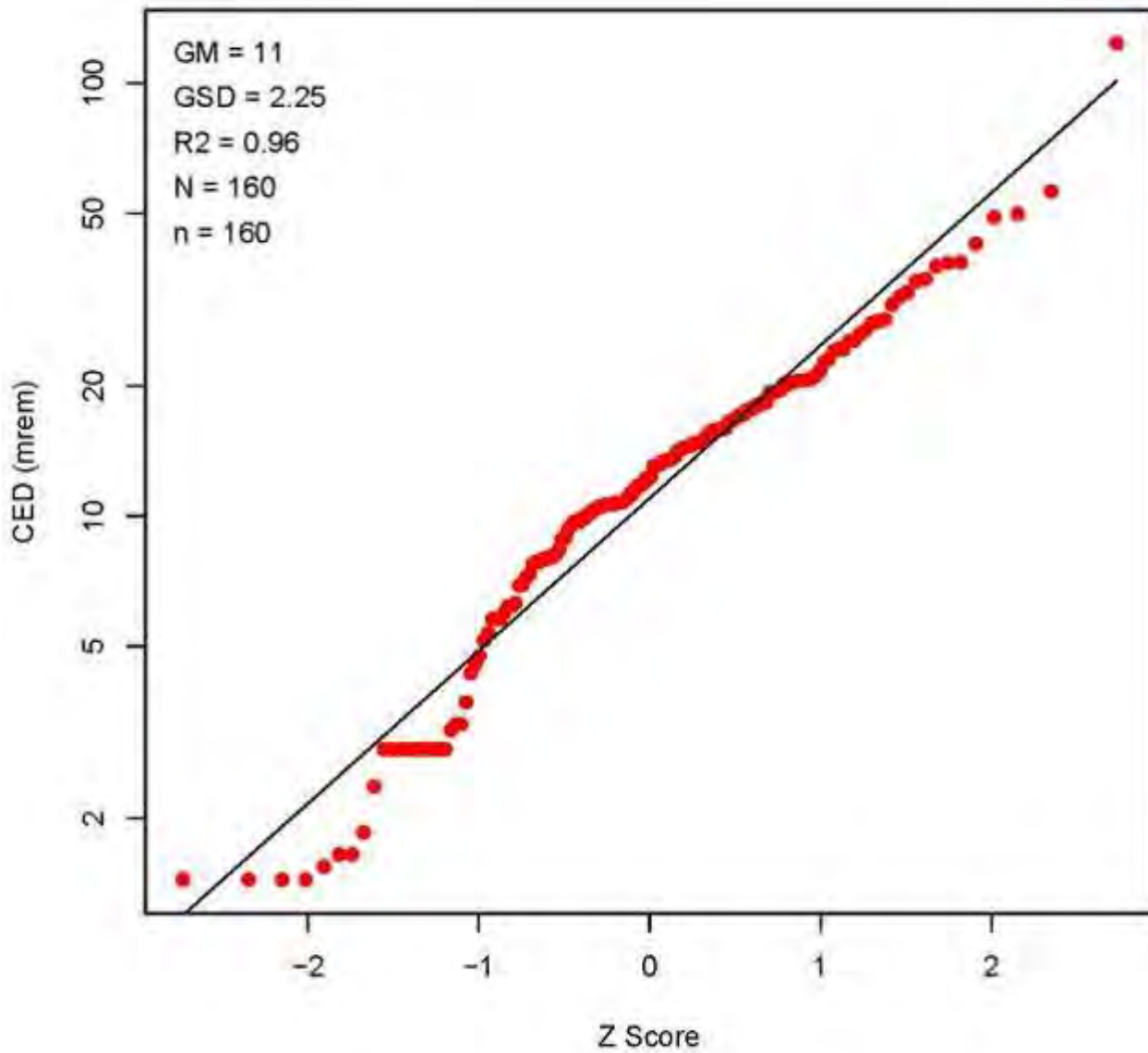


Figure B-5. SRS tritium dose 1955.

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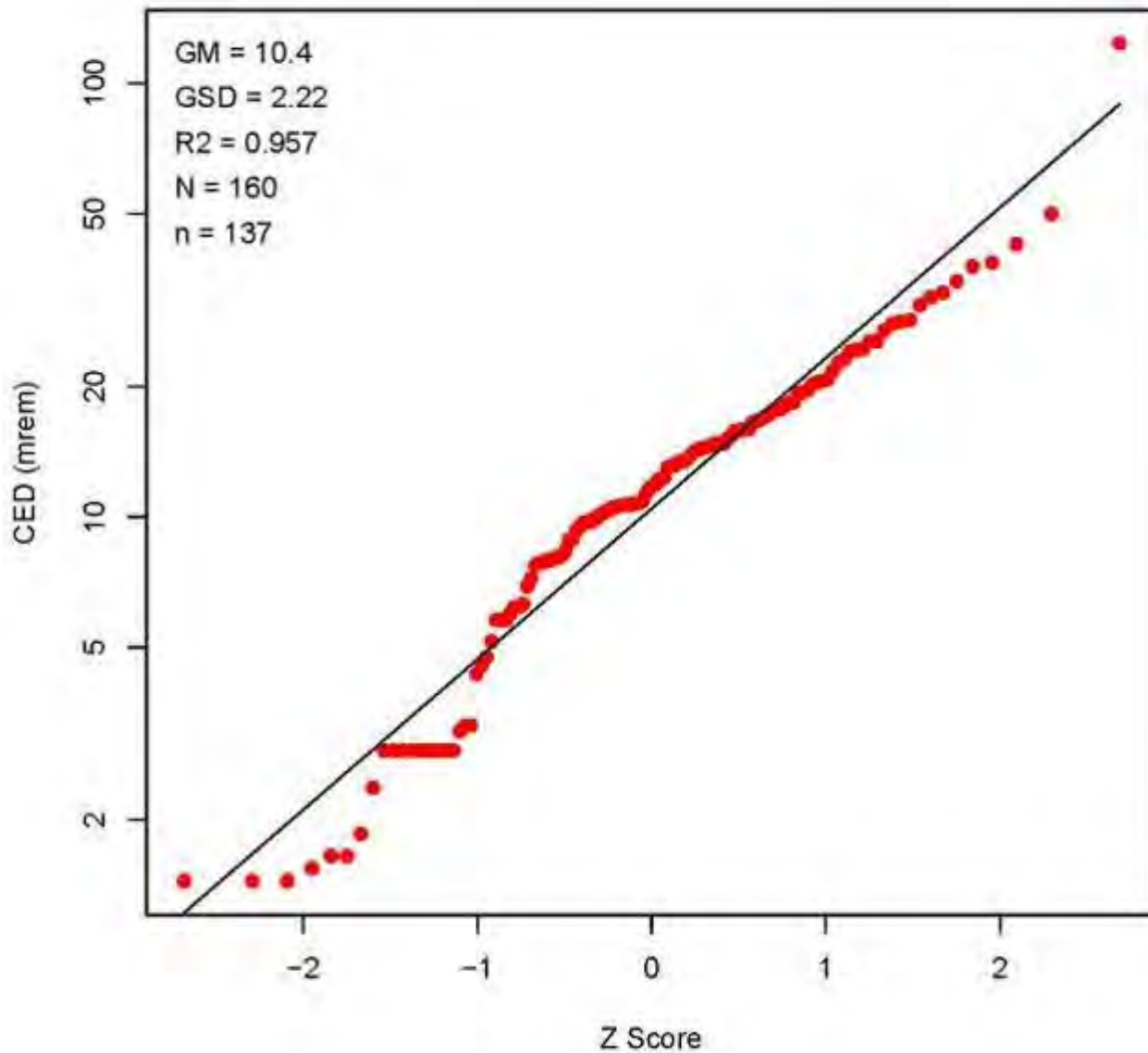


Figure B-6. SRS reactor tritium dose 1955.

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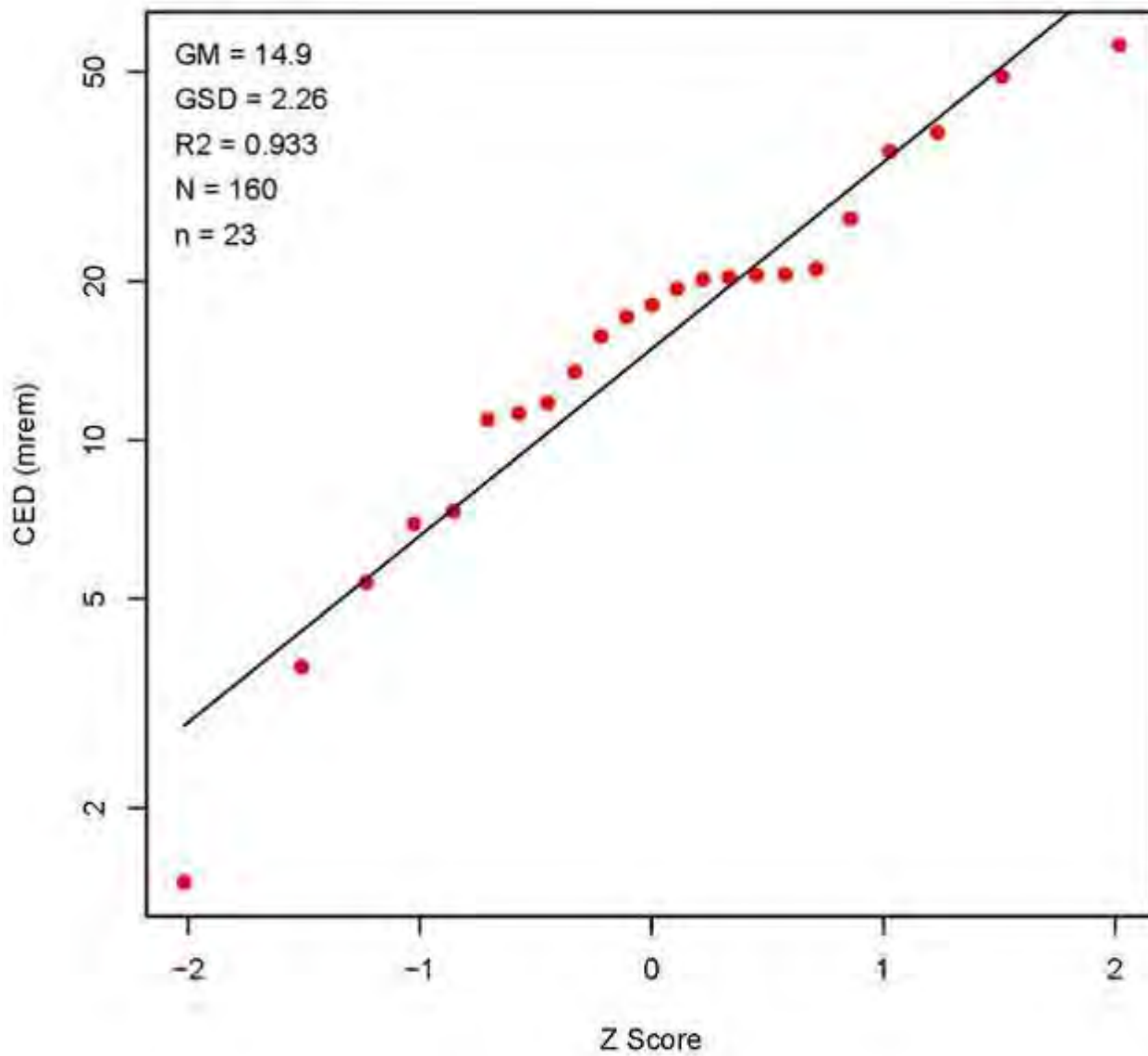


Figure B-7. SRS nonreactor tritium dose 1955.

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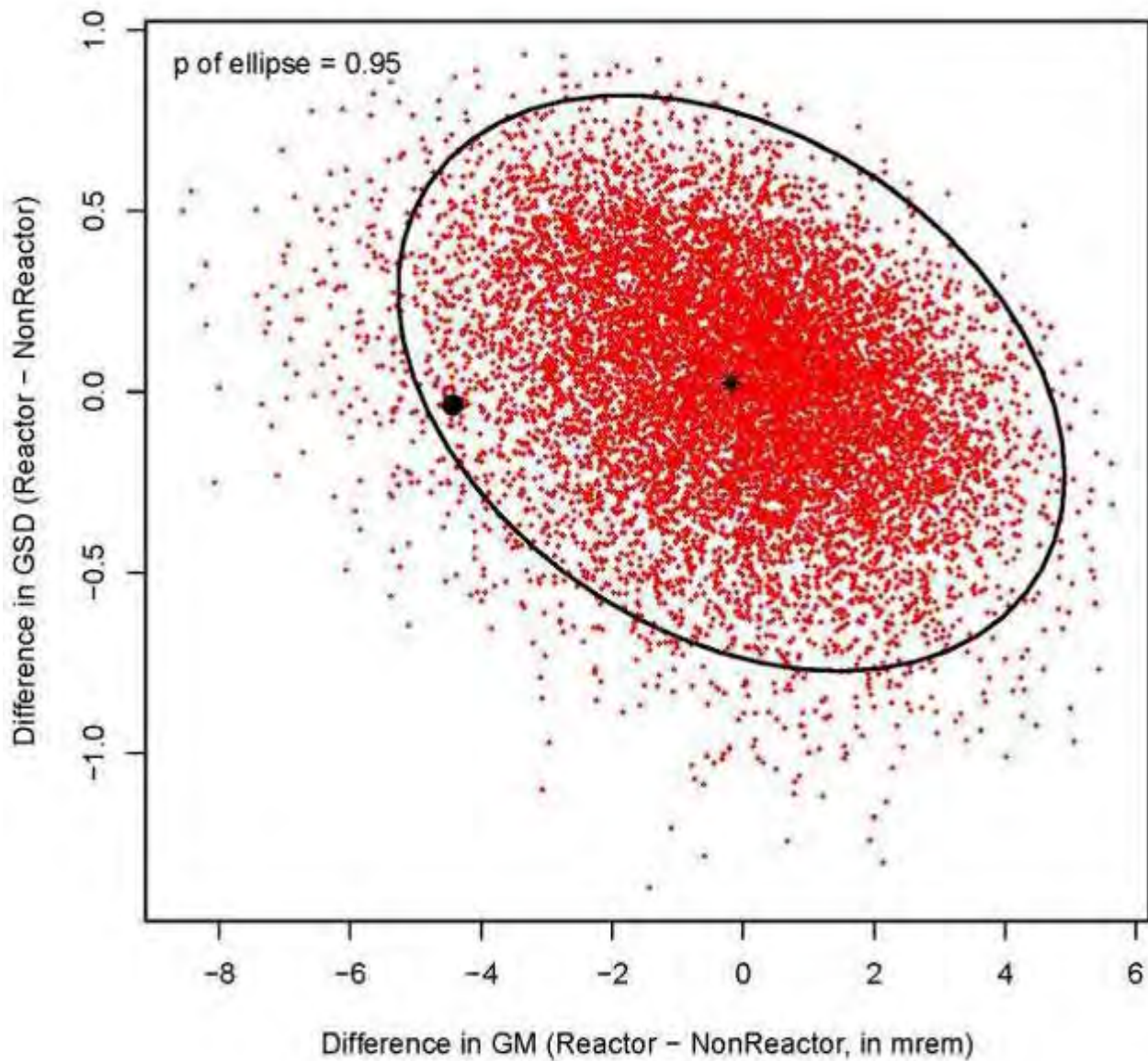


Figure B-8. SRS tritium dose 1955.

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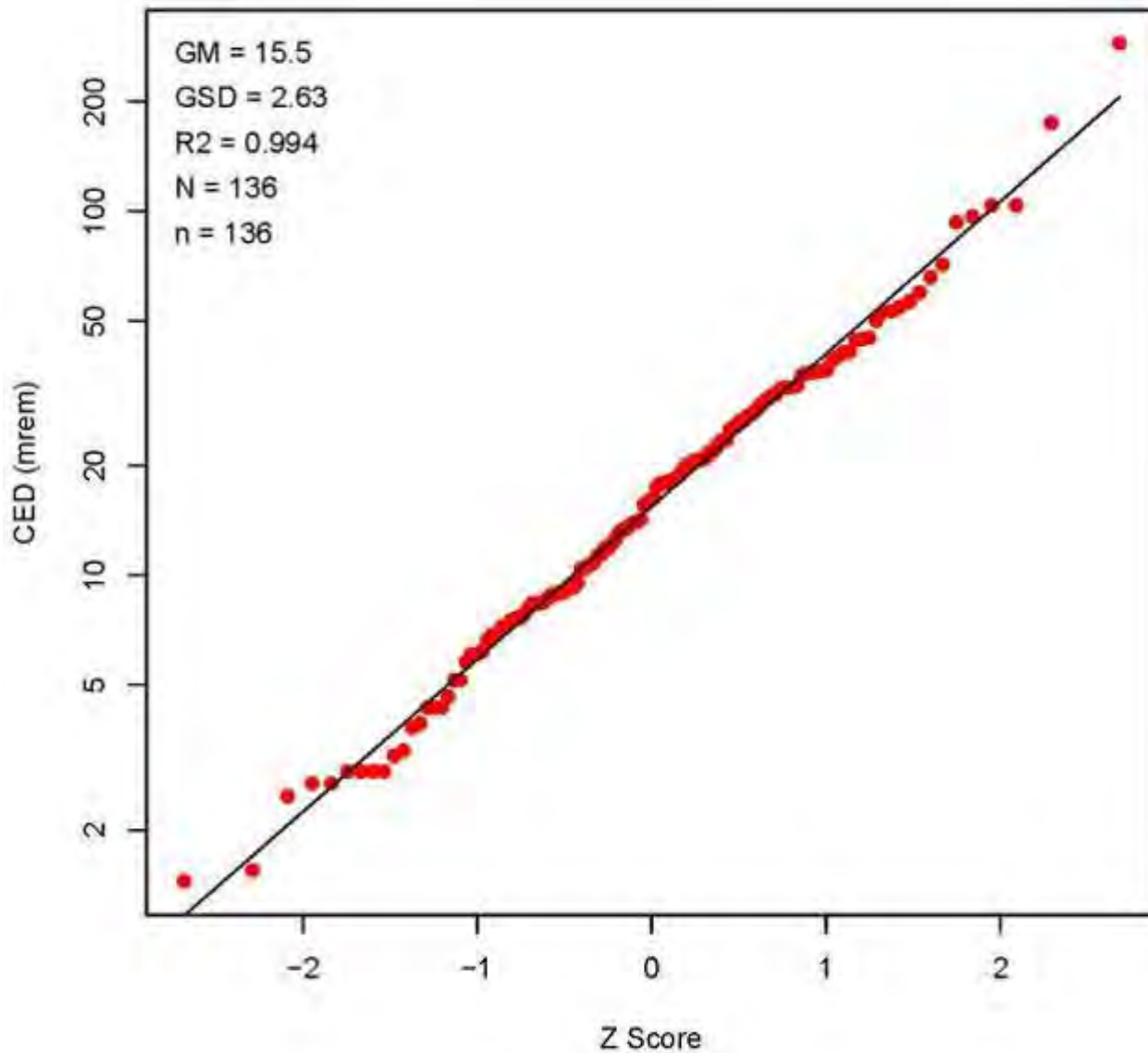


Figure B-9. SRS tritium dose 1956.

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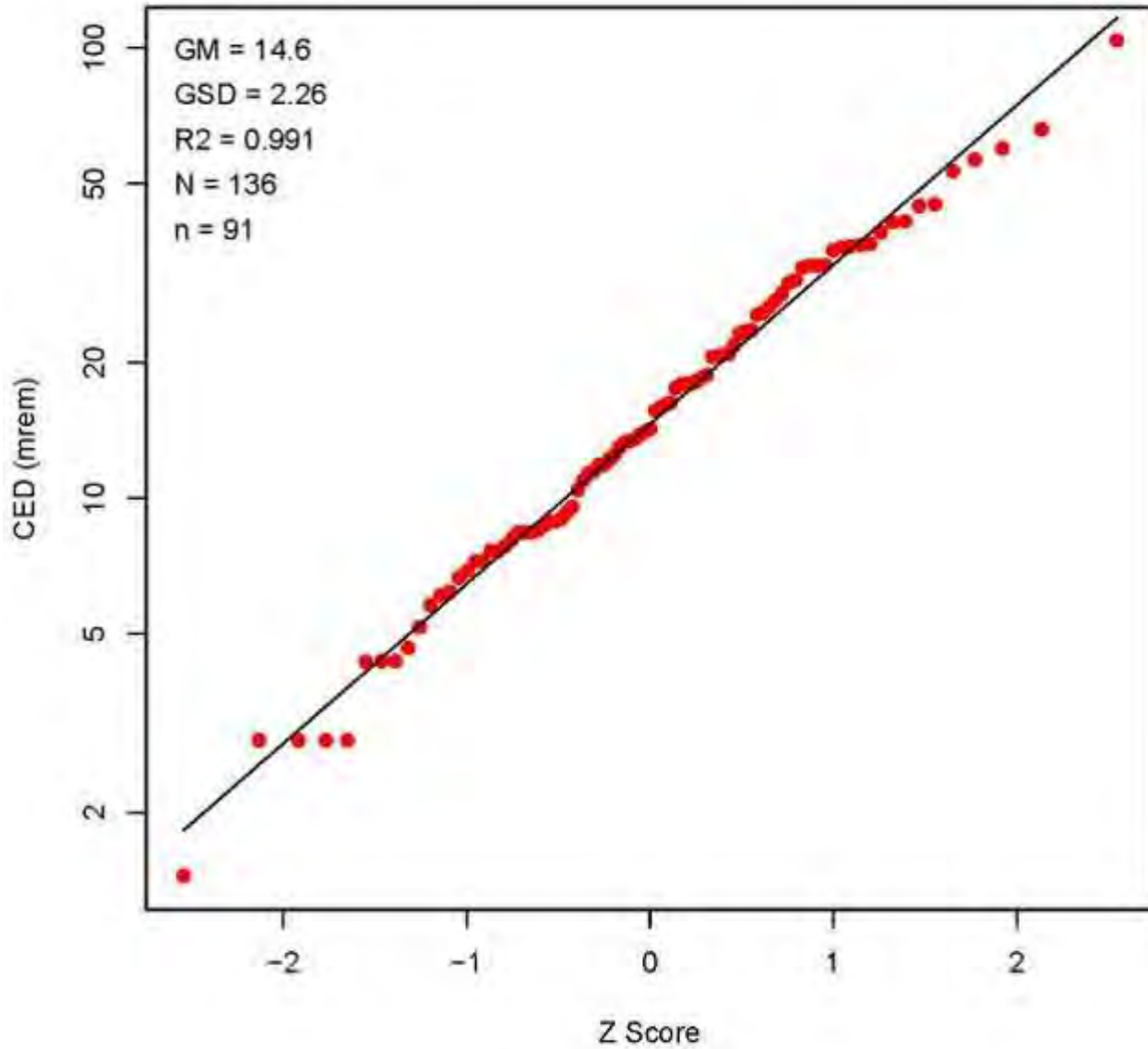


Figure B-10. SRS reactor tritium dose 1956.

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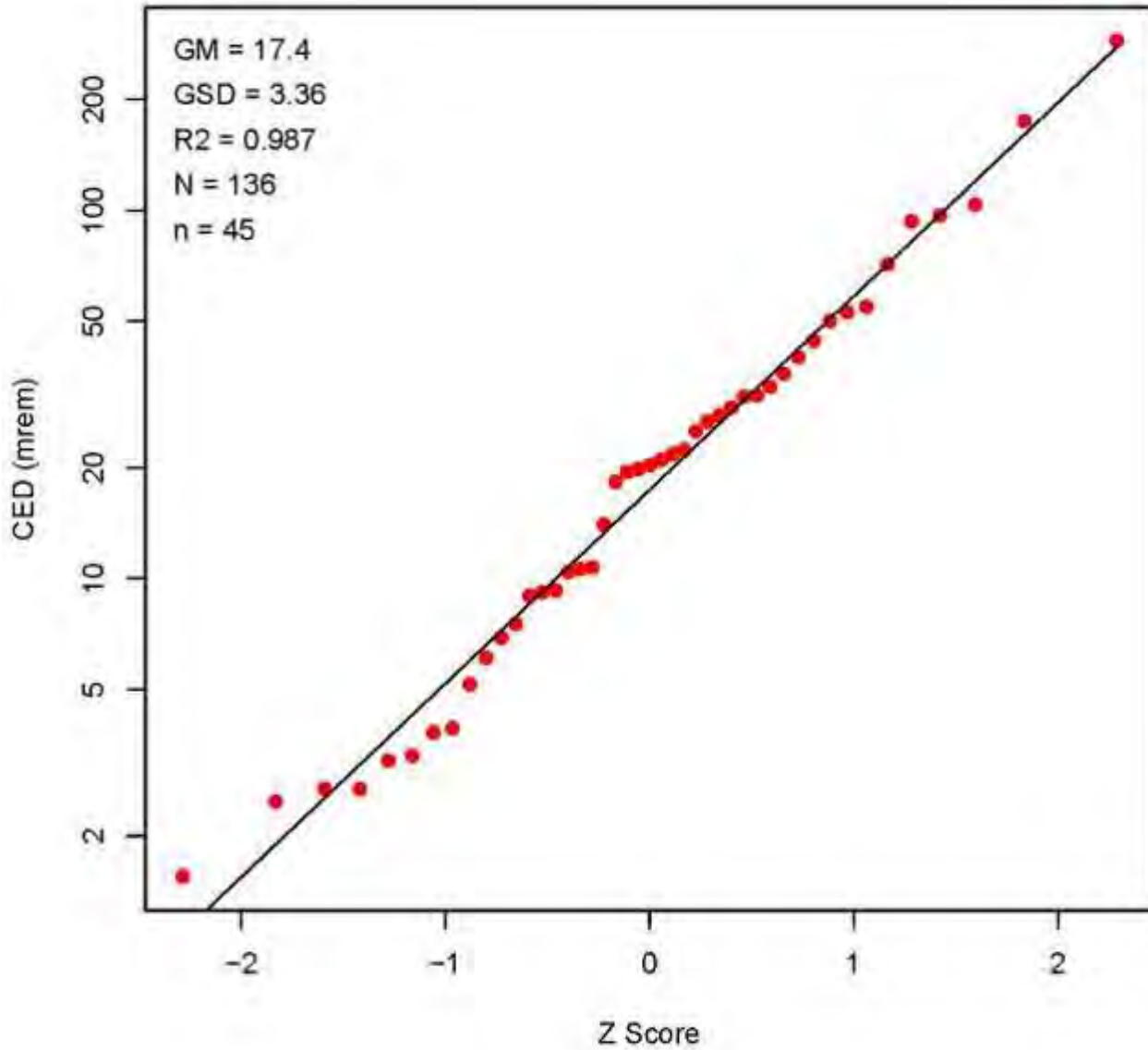


Figure B-11. SRS nonreactor tritium dose 1956.

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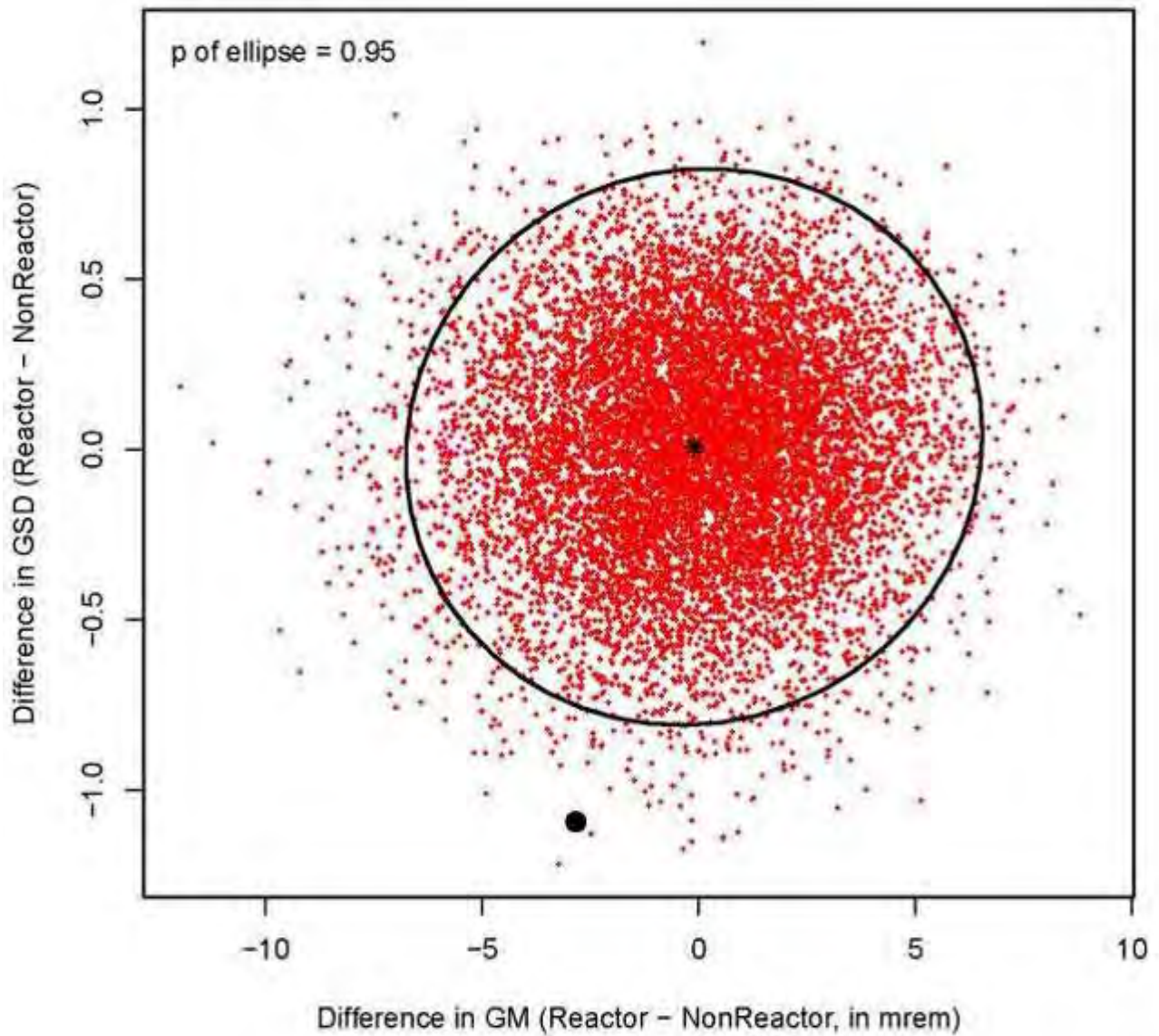


Figure B-12. SRS tritium dose 1956.

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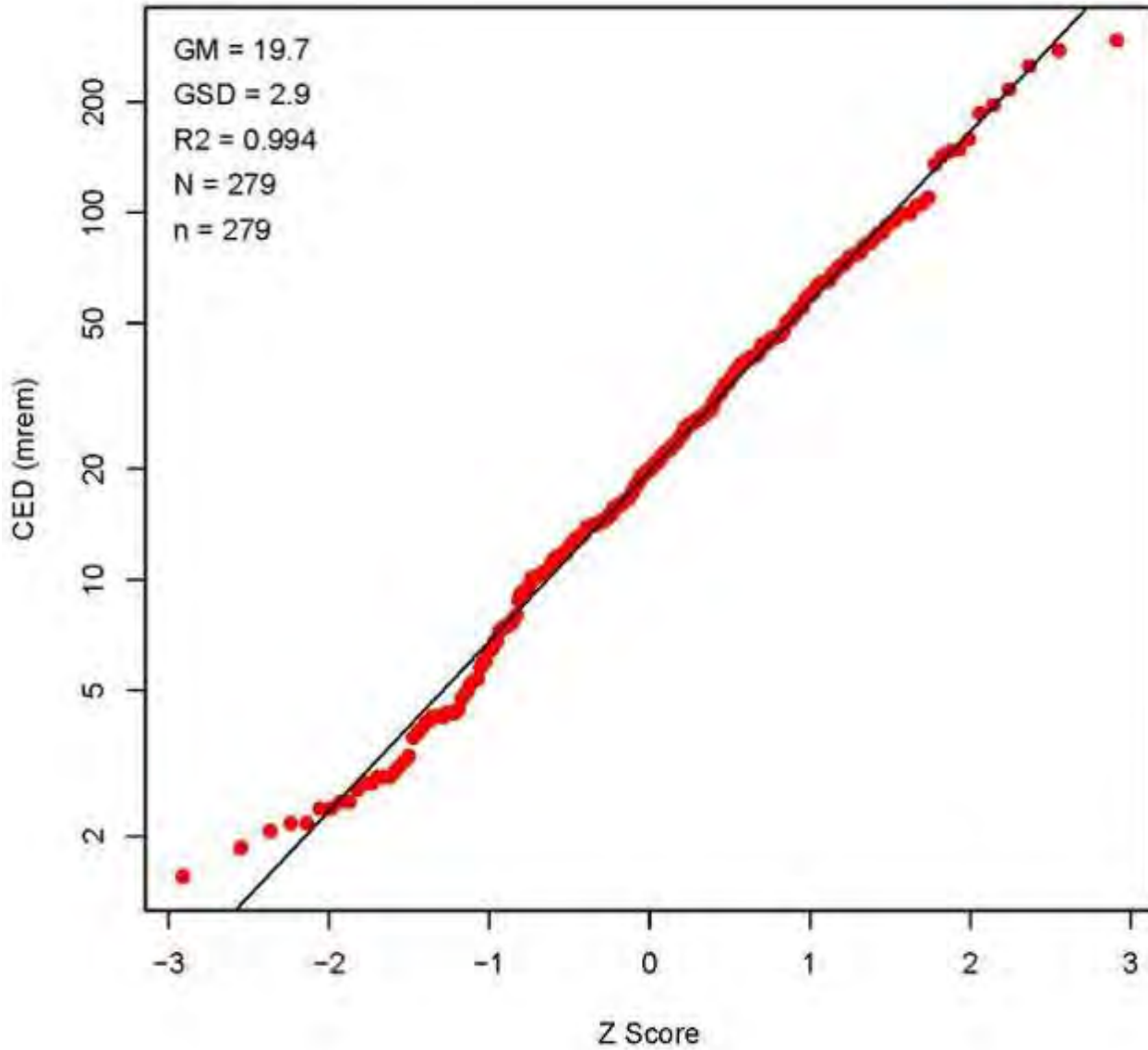


Figure B-13. SRS tritium dose 1957.

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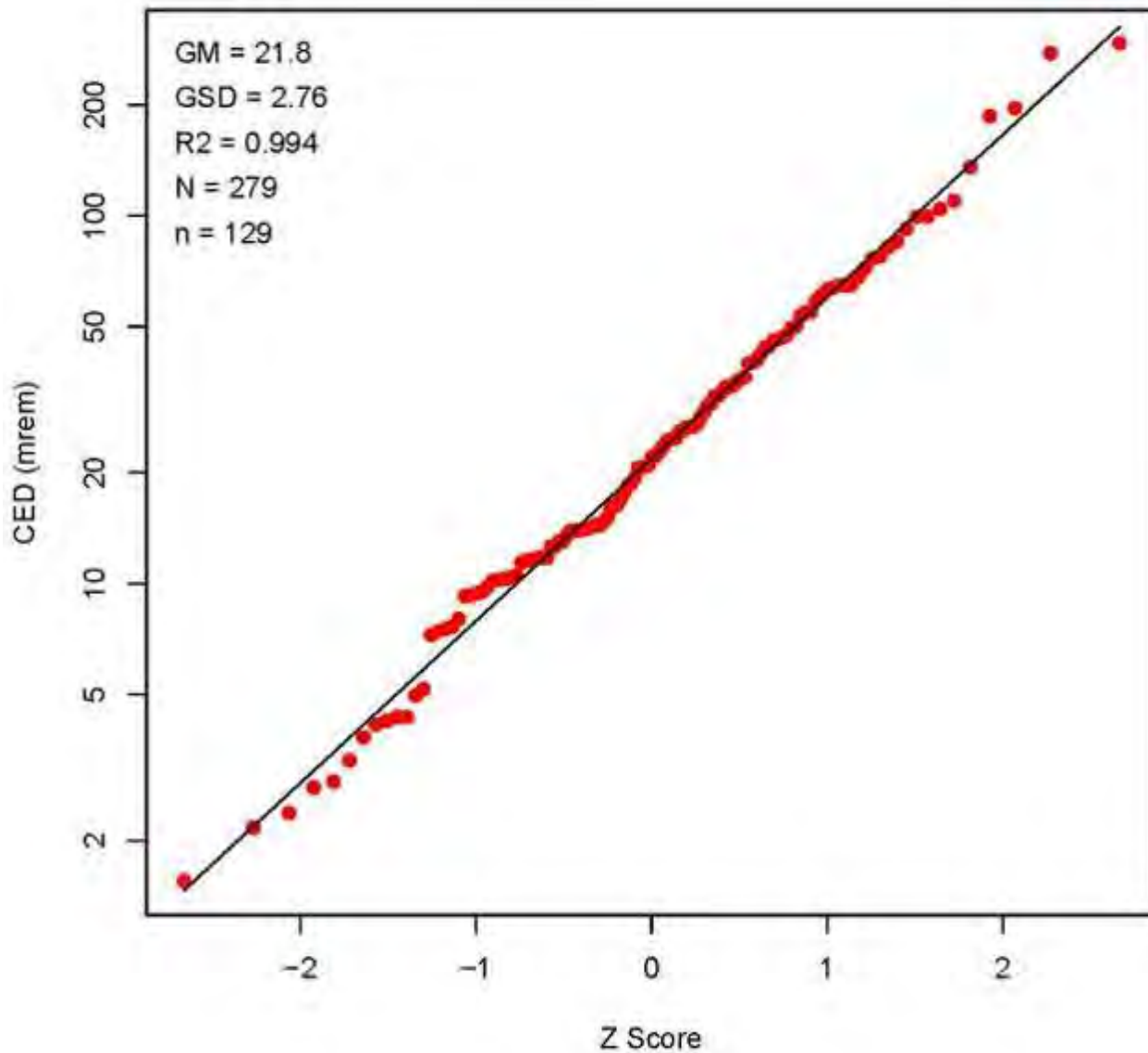


Figure B-14. SRS reactor tritium dose 1957.

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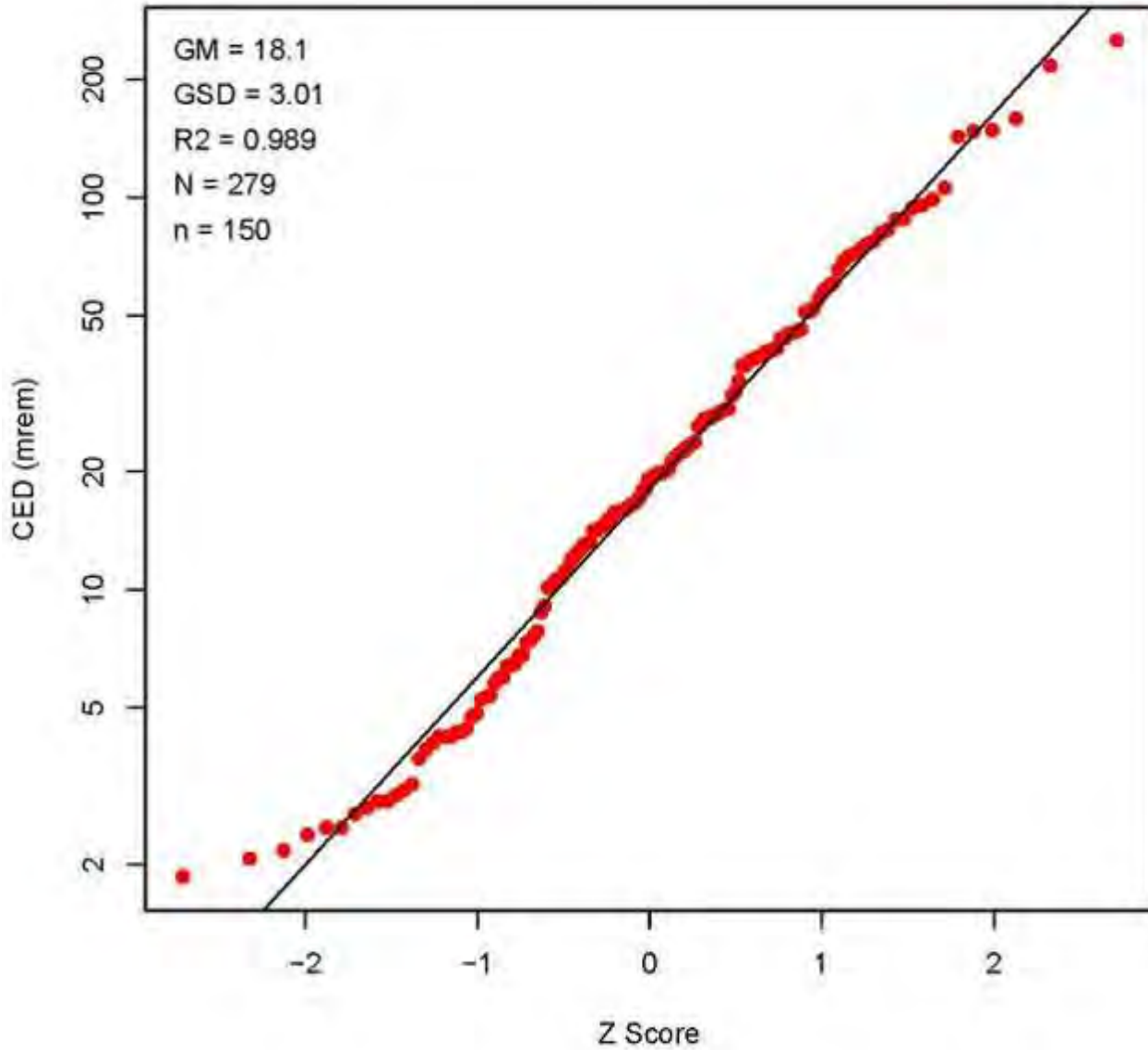


Figure B-15. SRS nonreactor tritium dose 1957.

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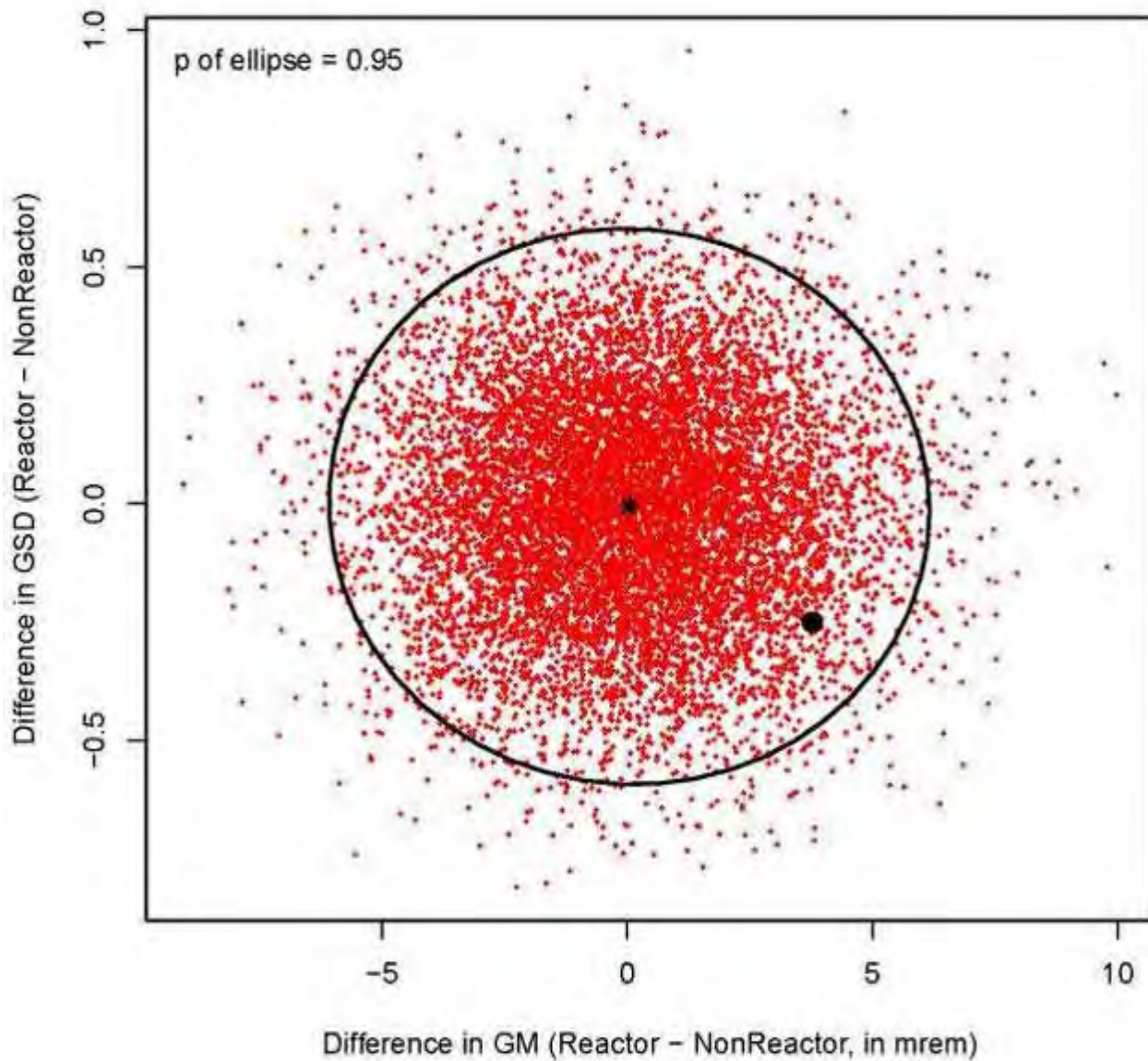


Figure B-16. SRS tritium dose 1957.

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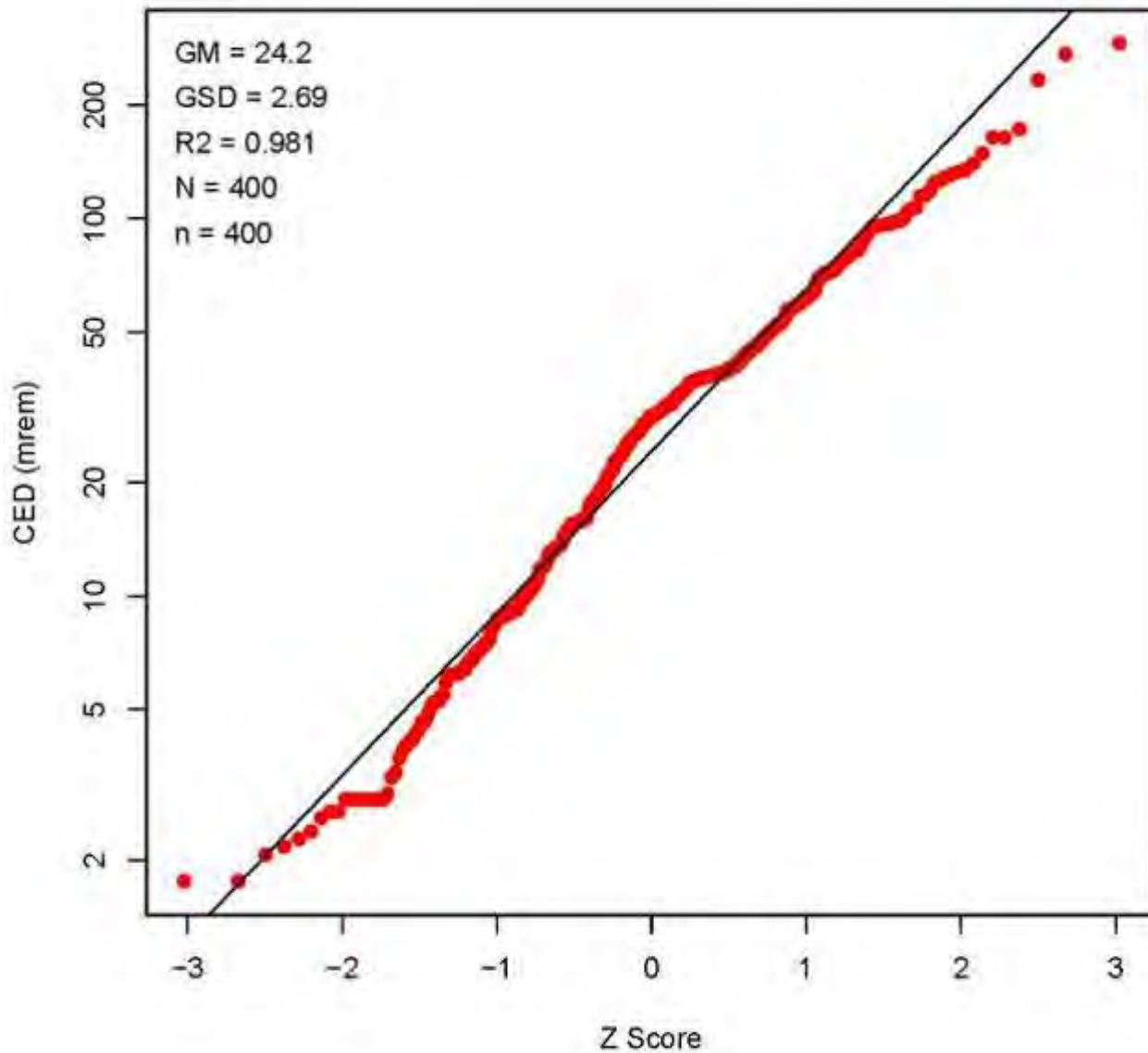


Figure B-17. SRS tritium dose 1958.

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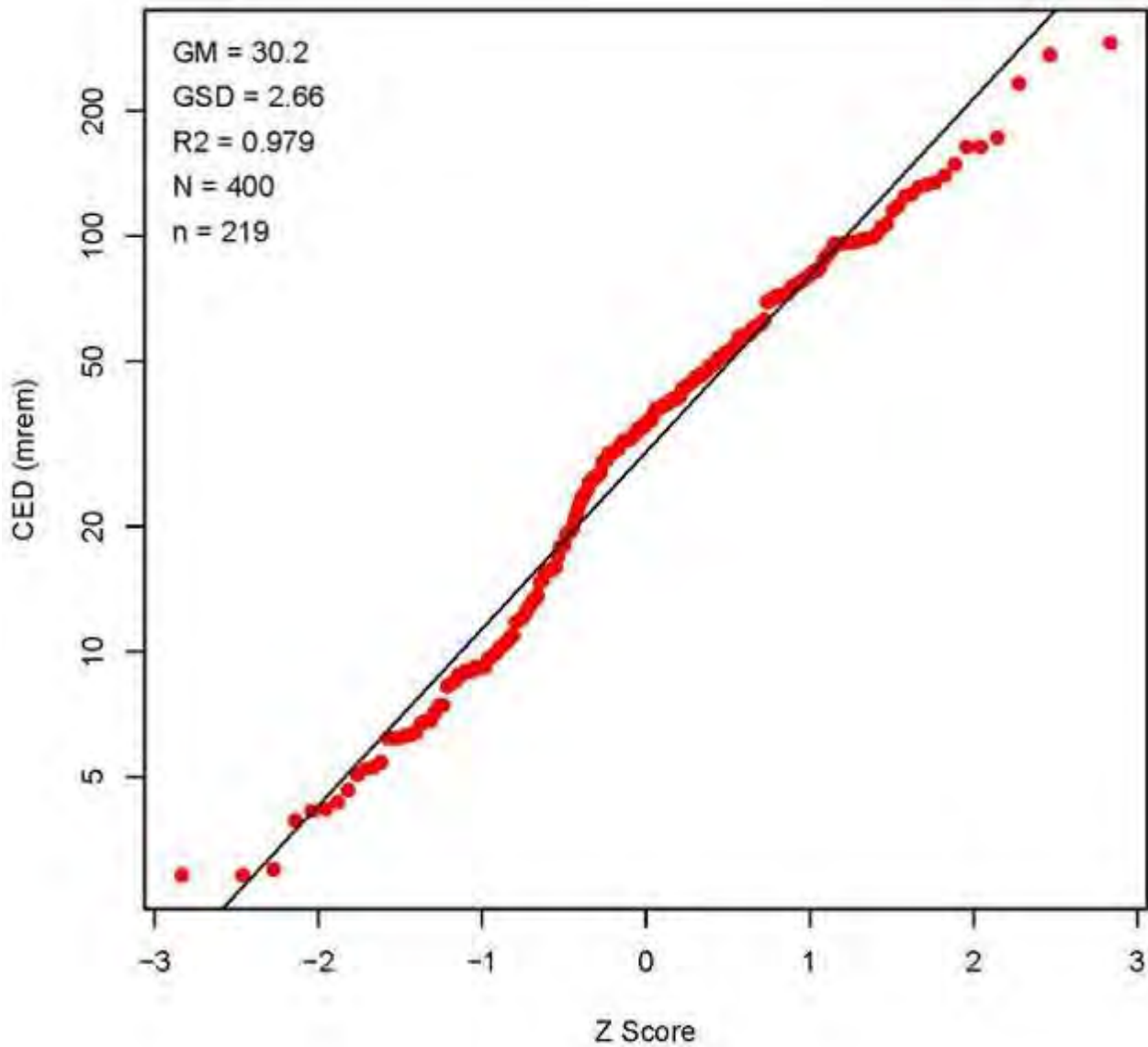


Figure B-18. SRS reactor tritium dose 1958.

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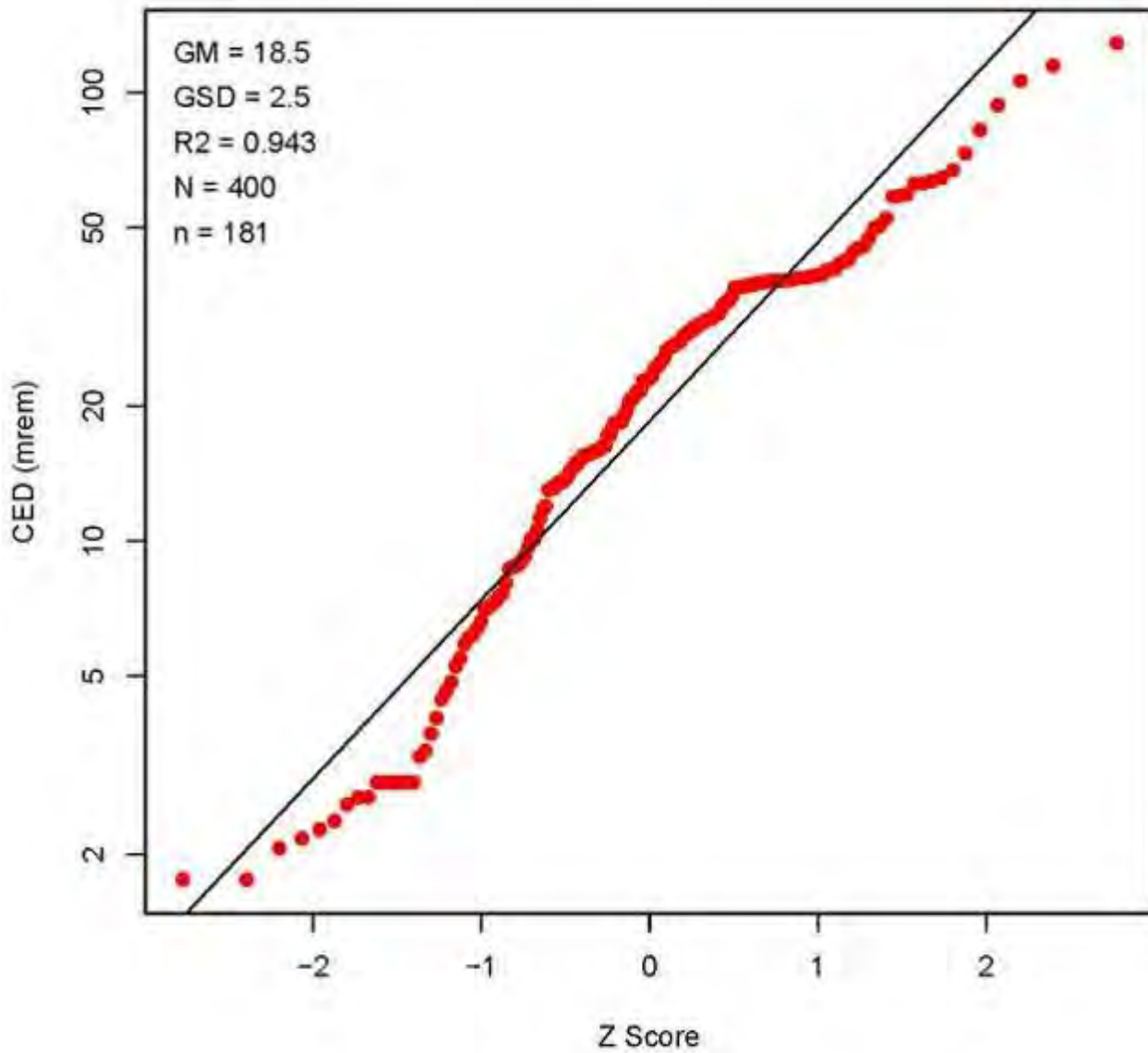


Figure B-19. SRS nonreactor tritium dose 1958.

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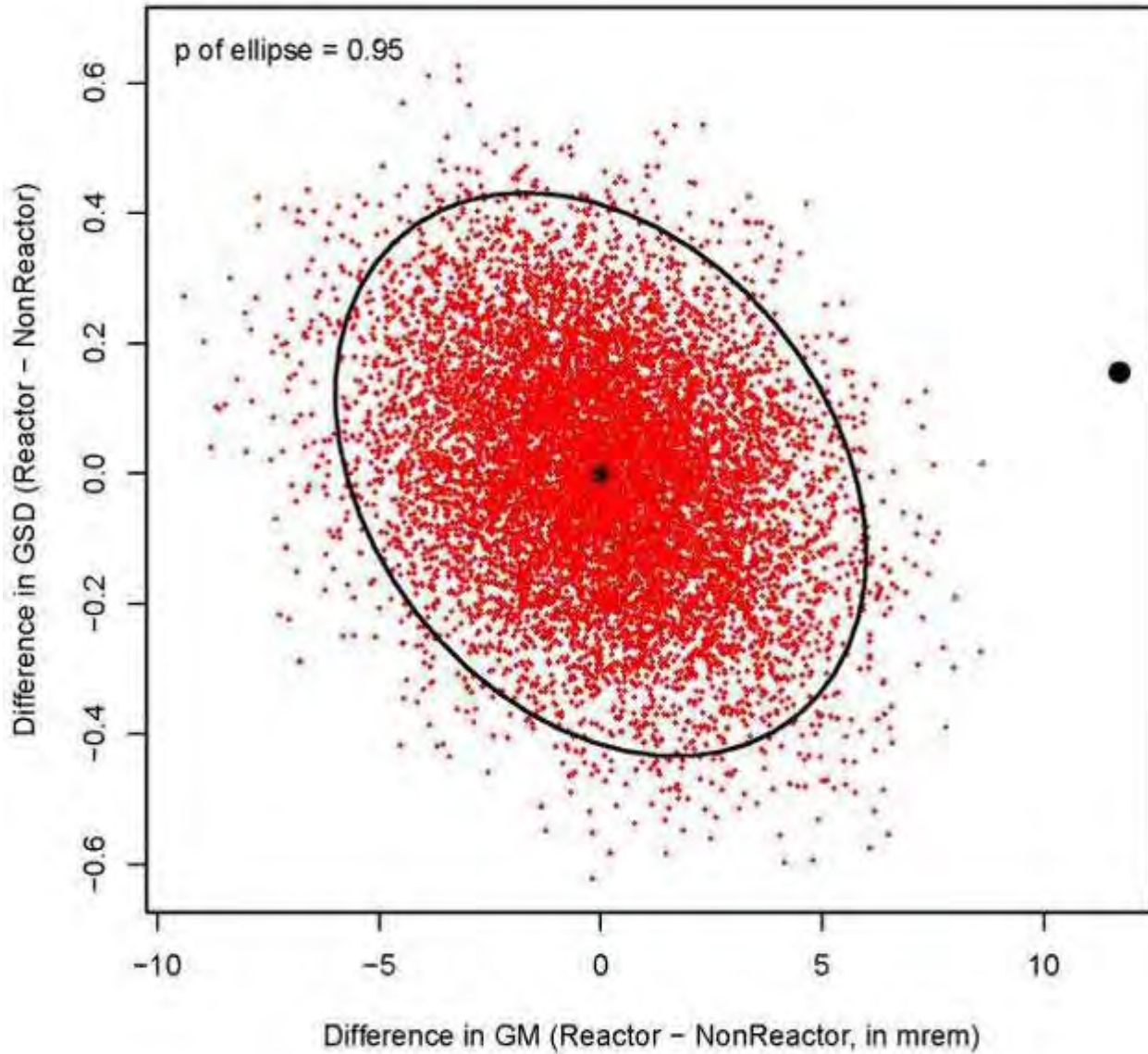


Figure B-20. SRS tritium dose 1958.

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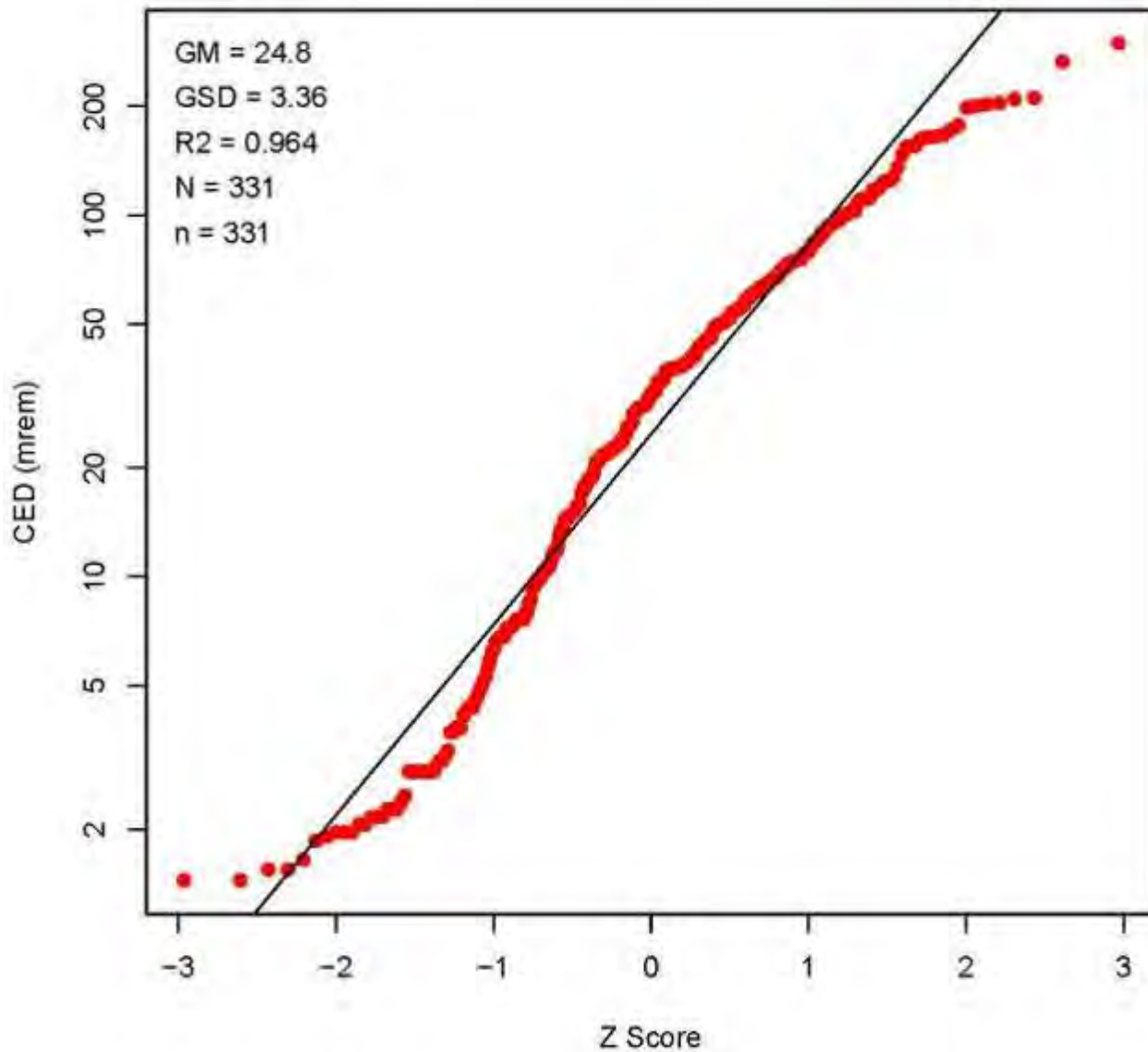


Figure B-21. SRS tritium dose 1959.

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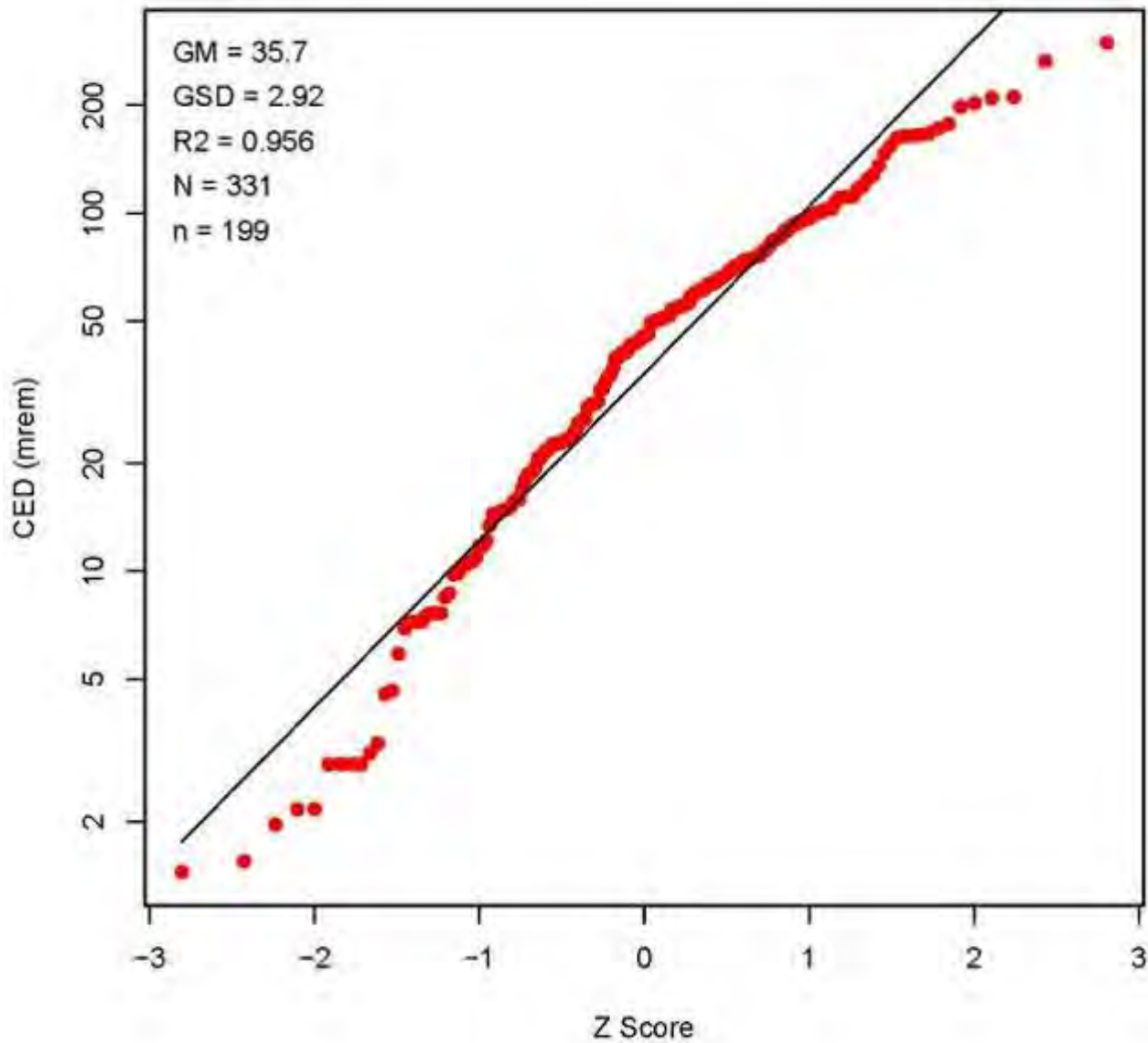


Figure B-22. SRS reactor tritium dose 1959.

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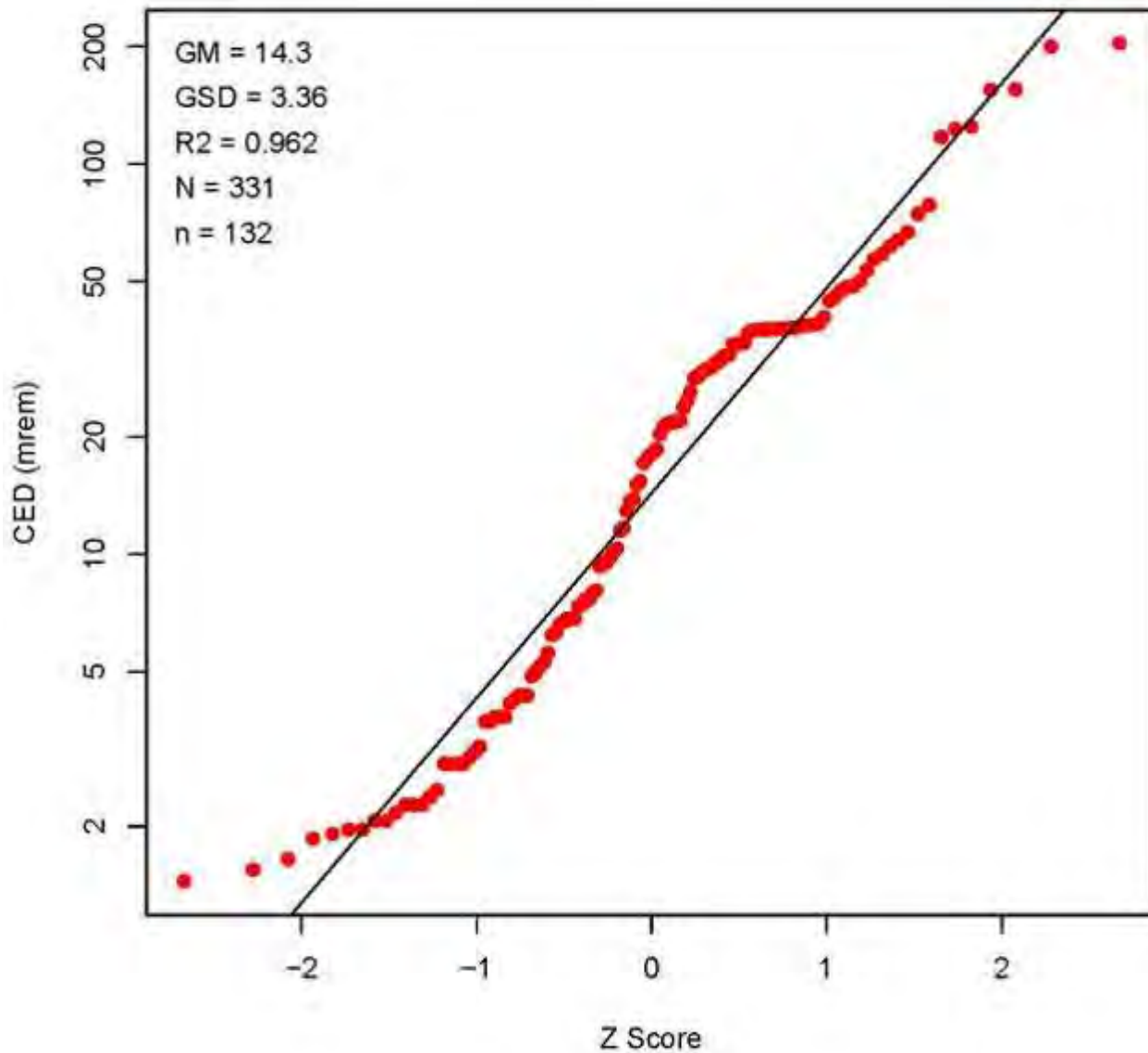


Figure B-23. SRS nonreactor tritium dose 1959.

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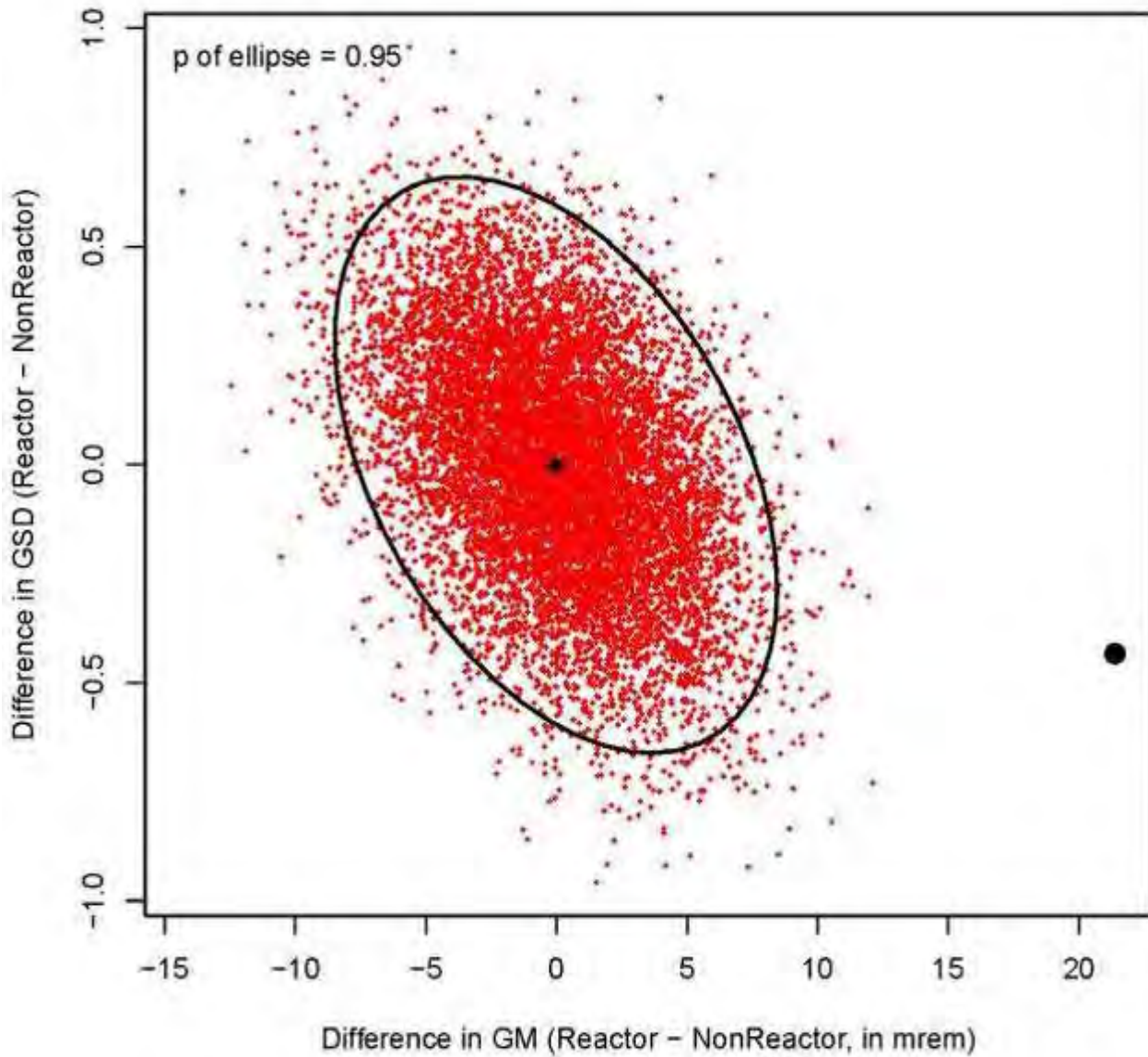


Figure B-24. SRS tritium dose 1959.

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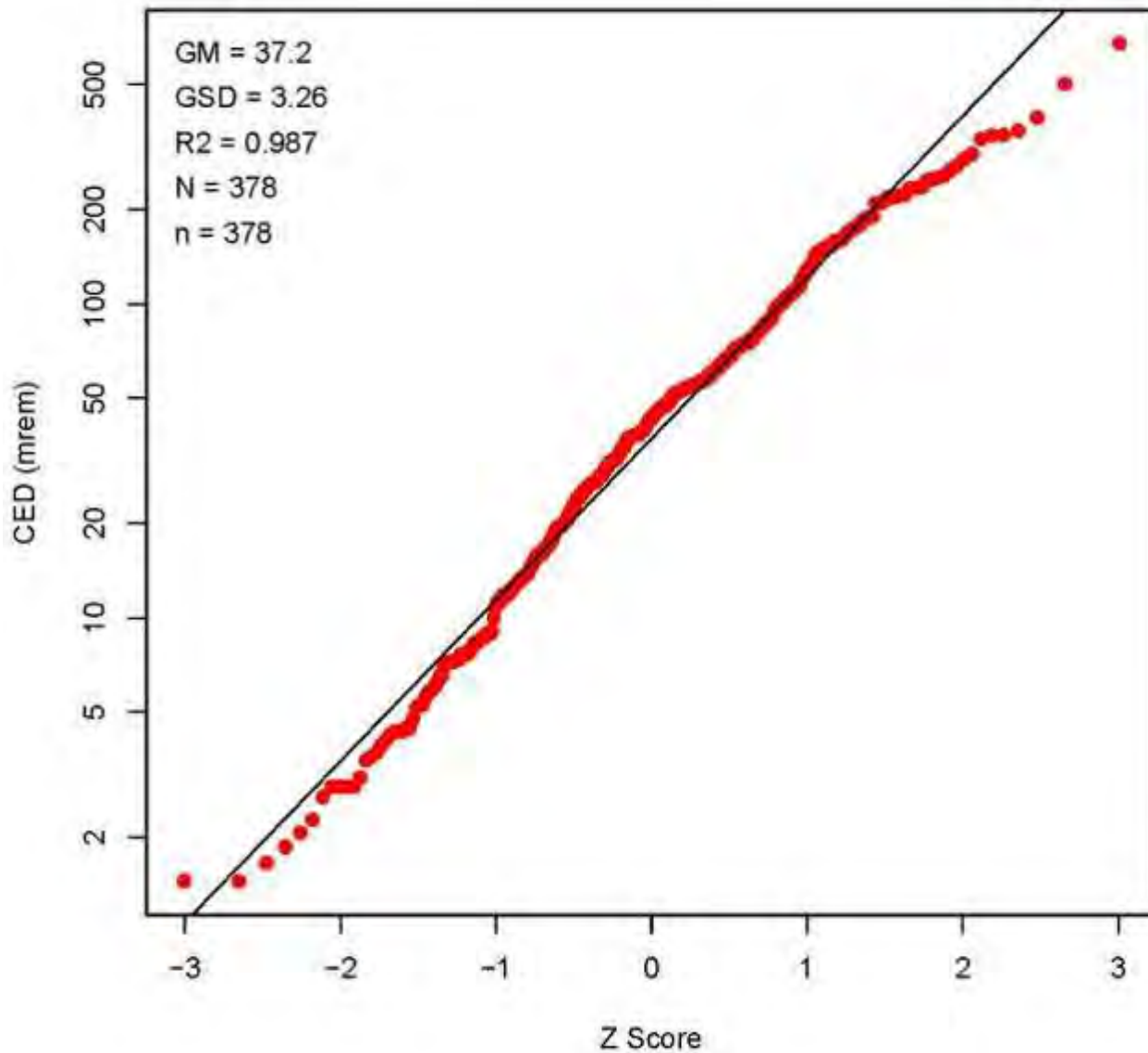


Figure B-25. SRS tritium dose 1960.

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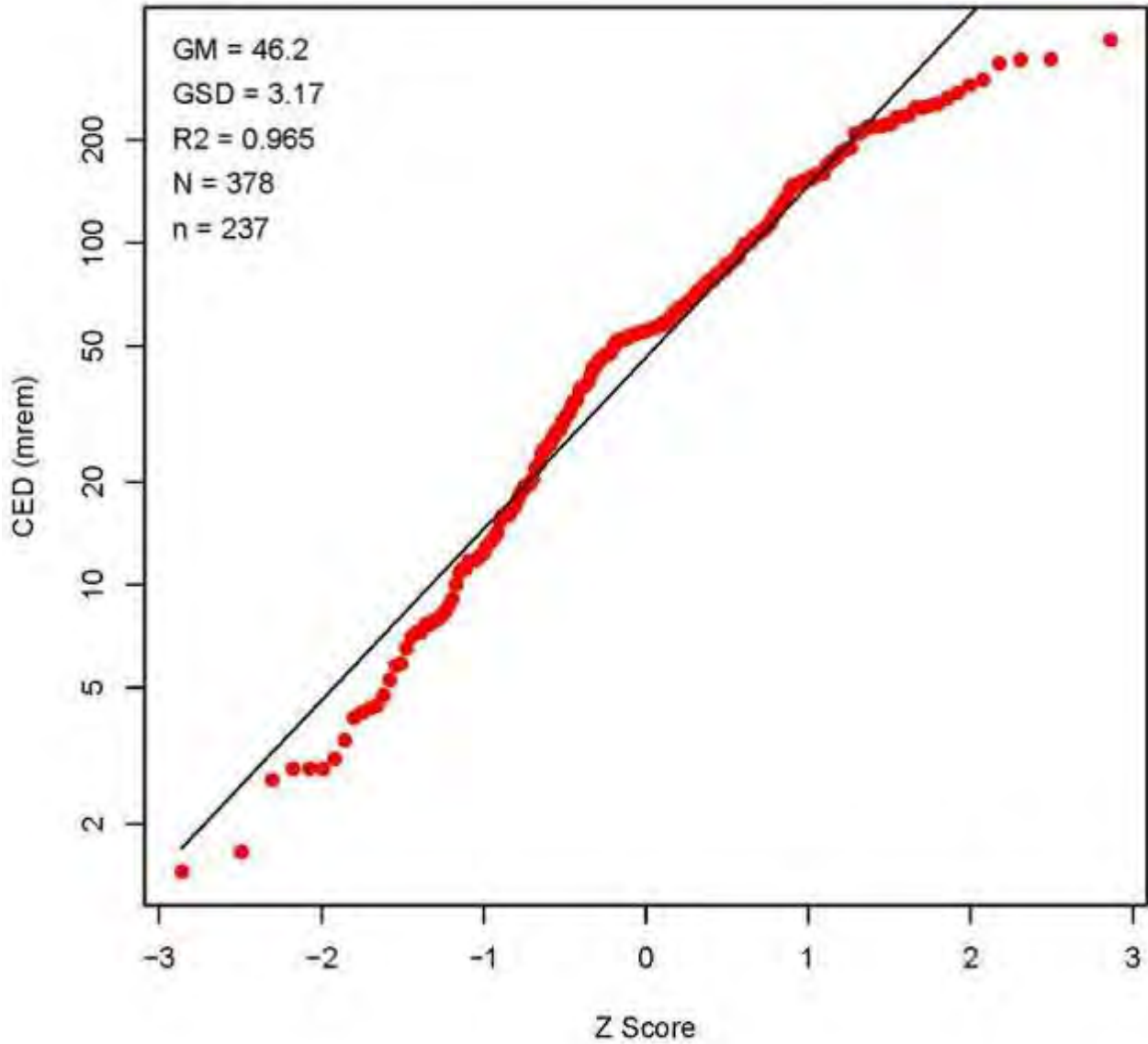


Figure B-26. SRS reactor tritium dose 1960.

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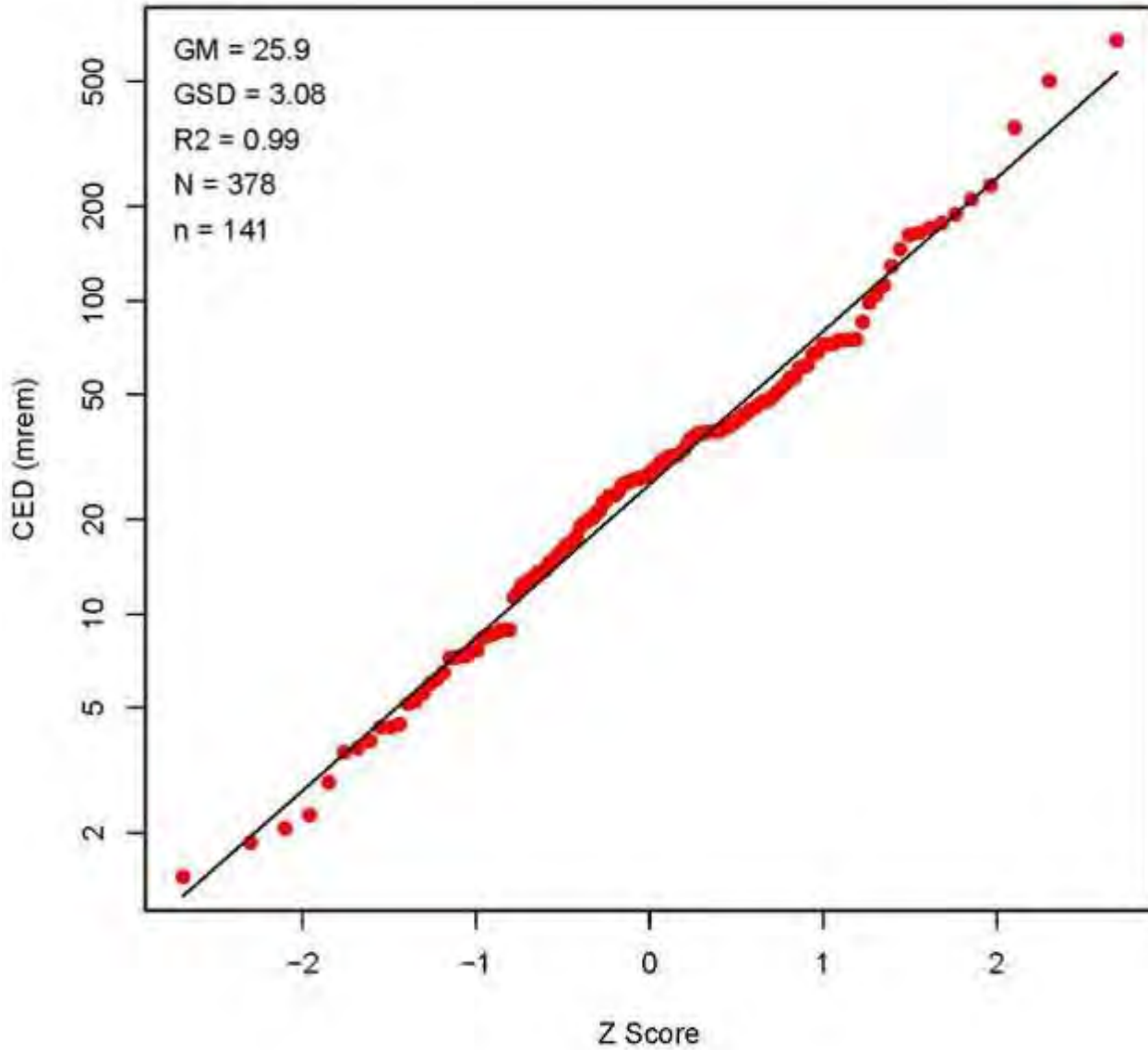


Figure B-27. SRS nonreactor tritium dose 1960.

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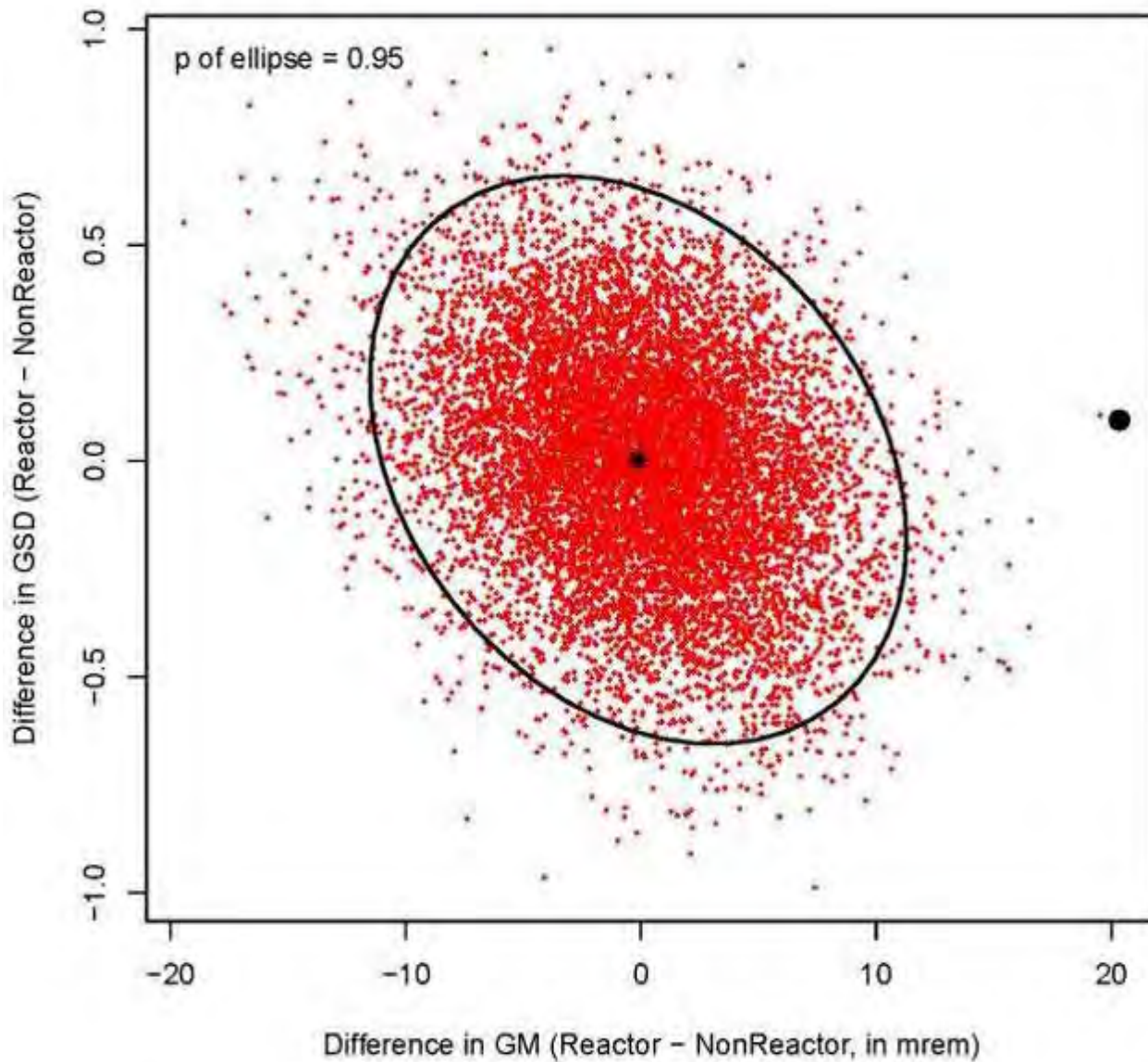


Figure B-28. SRS tritium dose 1960.

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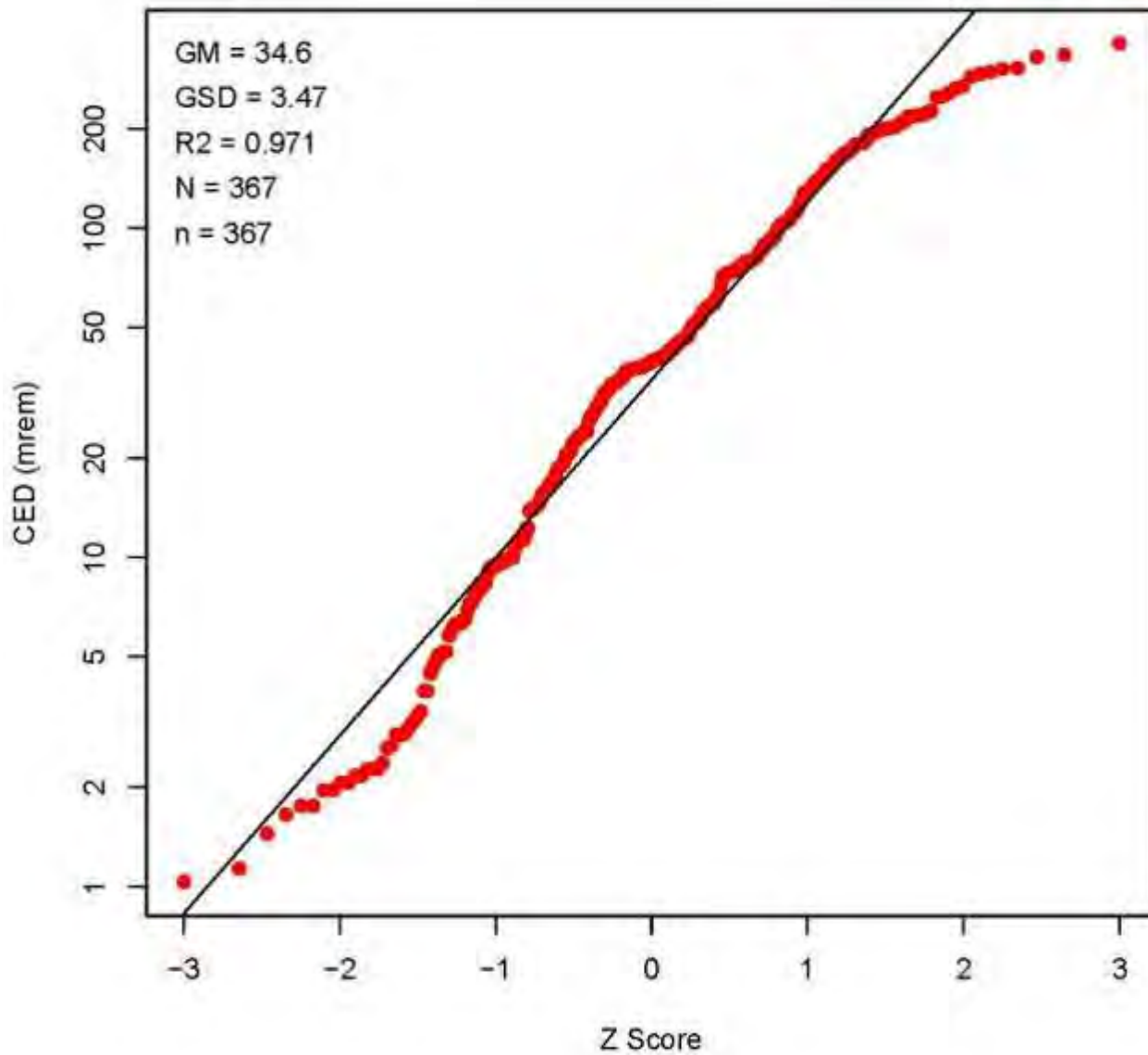


Figure B-29. SRS tritium dose 1961.

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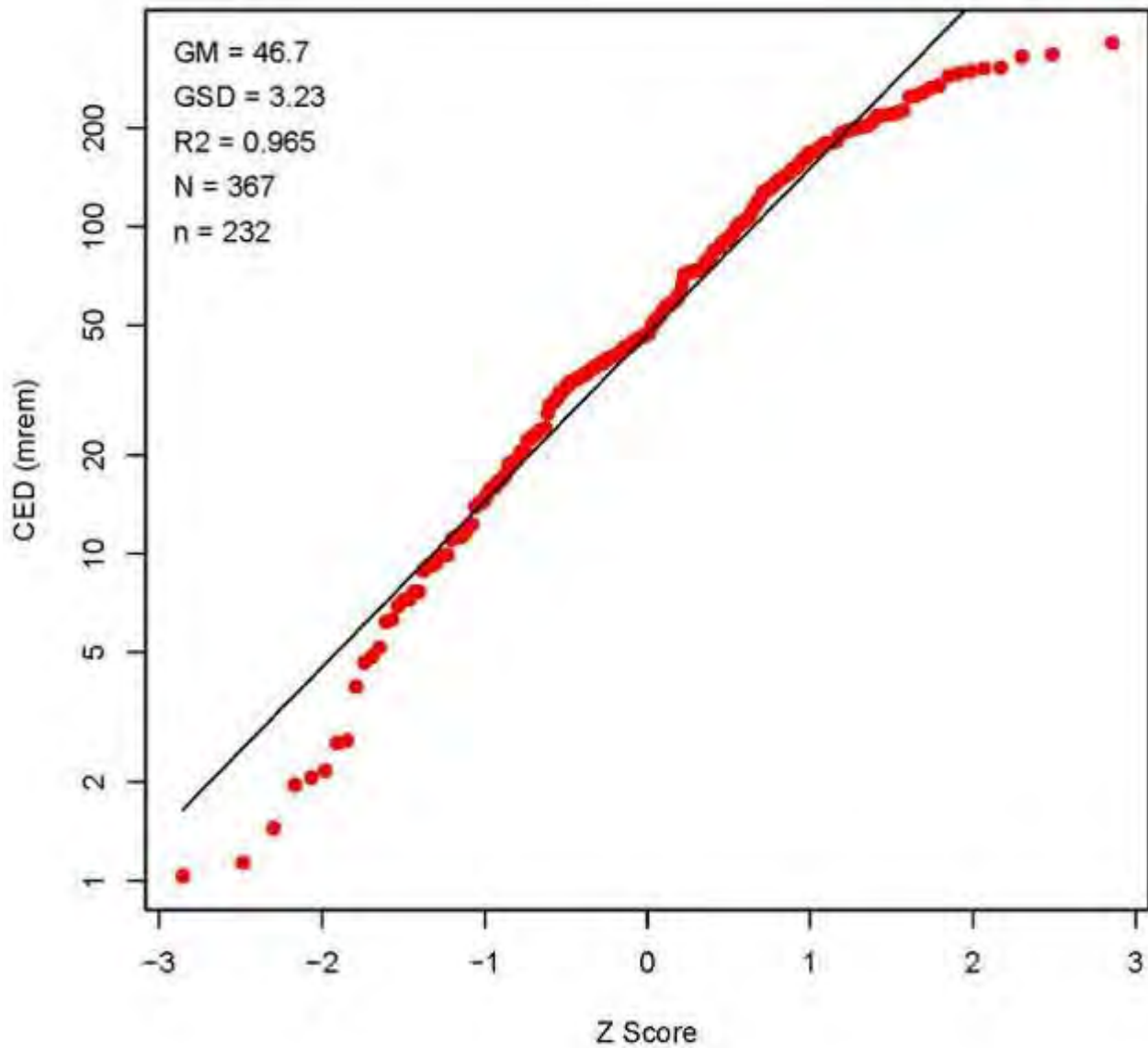


Figure B-30. SRS reactor tritium dose 1961.

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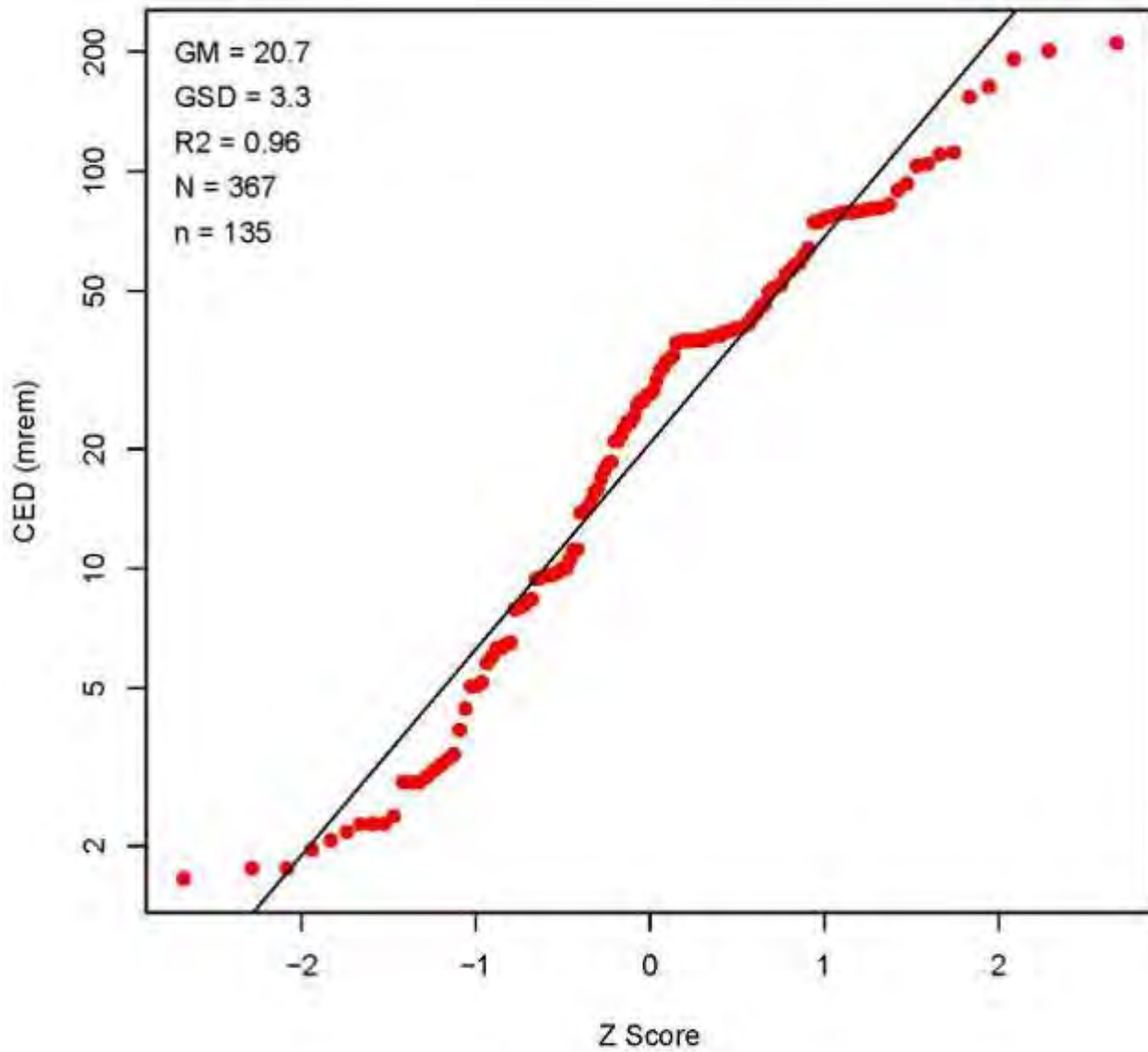


Figure B-31. SRS nonreactor tritium dose 1961.

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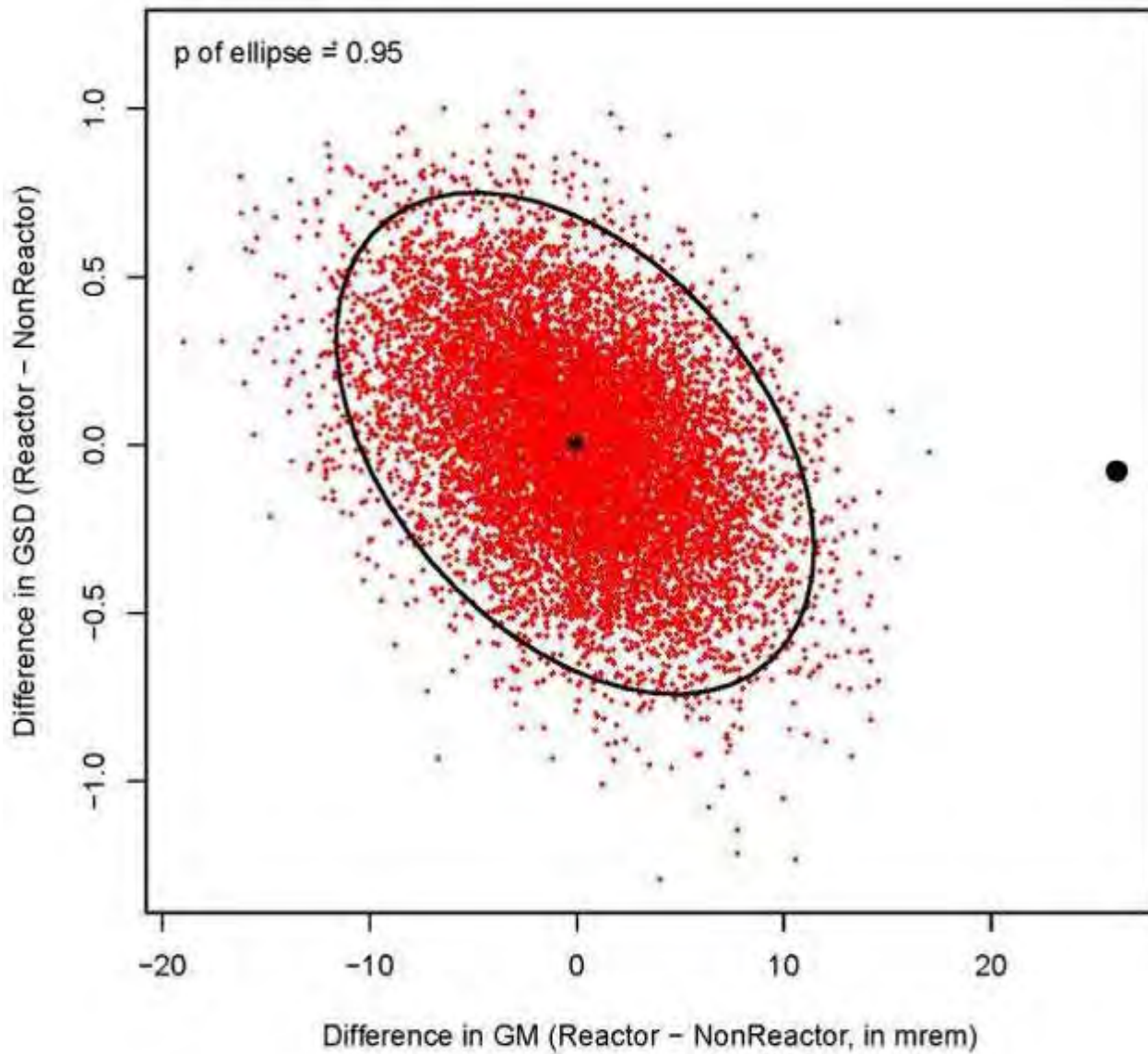


Figure B-32. SRS tritium dose 1961.

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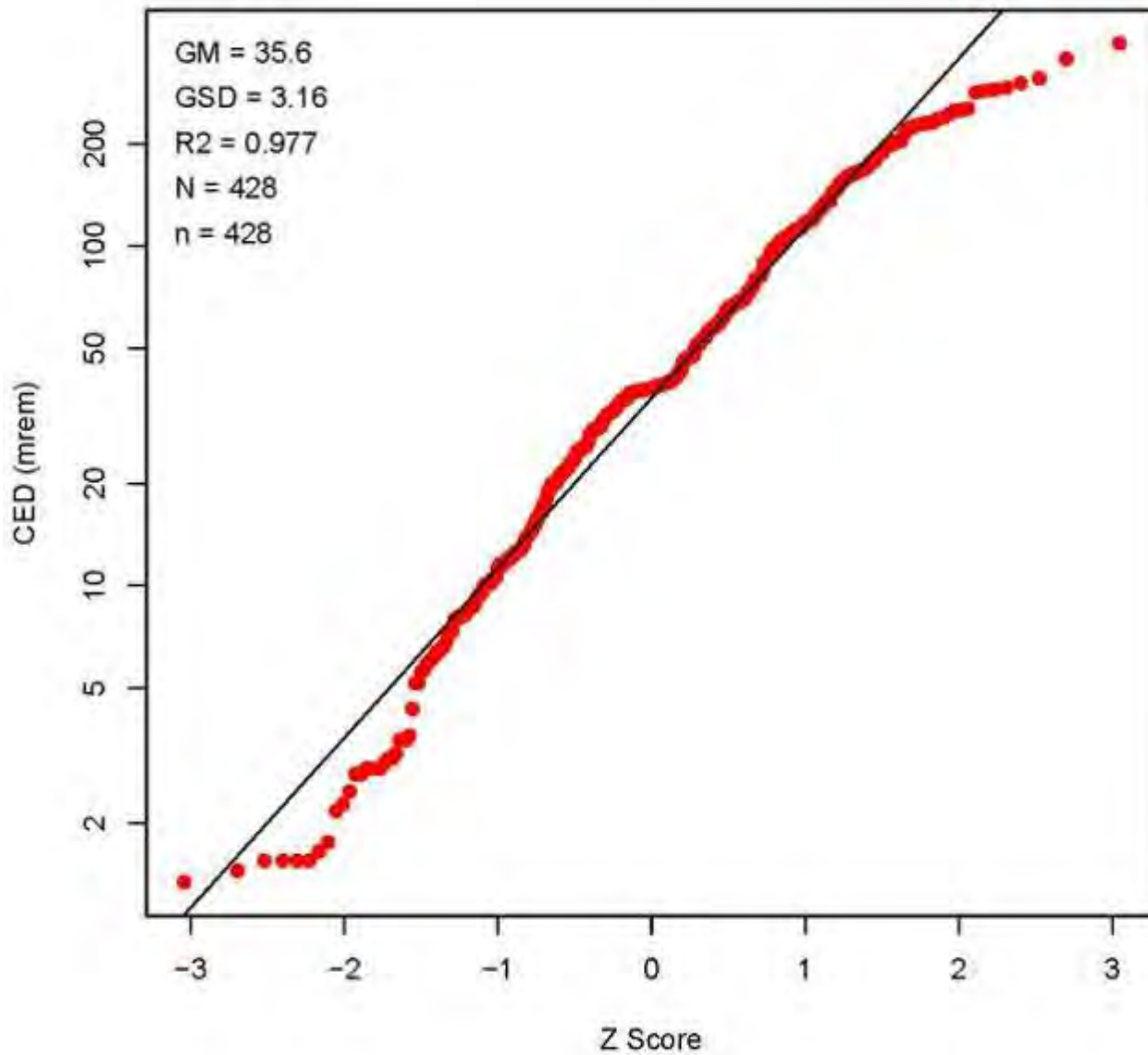


Figure B-33. SRS tritium dose 1962.

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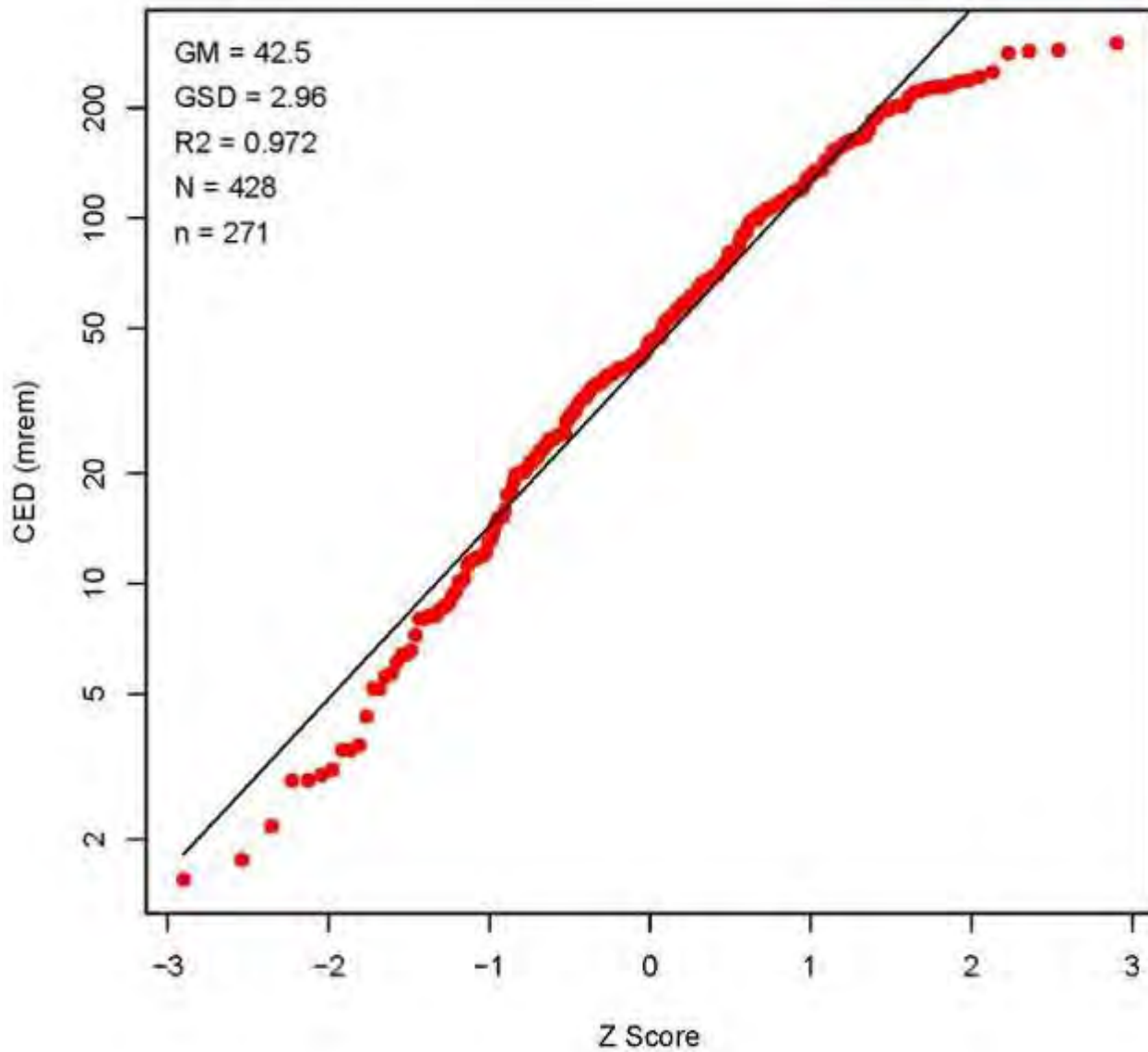


Figure B-34. SRS reactor tritium dose 1962.

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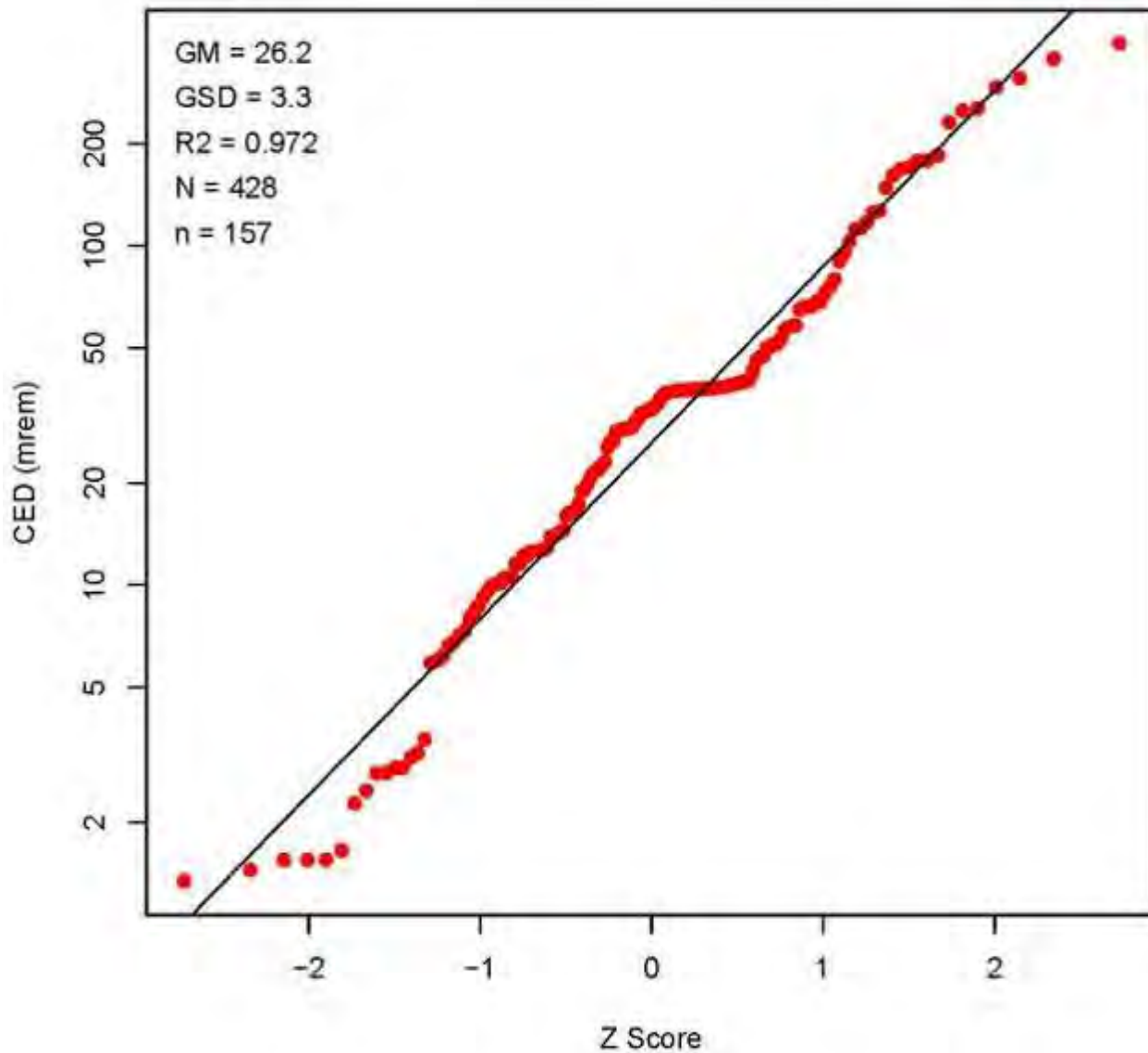


Figure B-35. SRS nonreactor tritium dose 1962.

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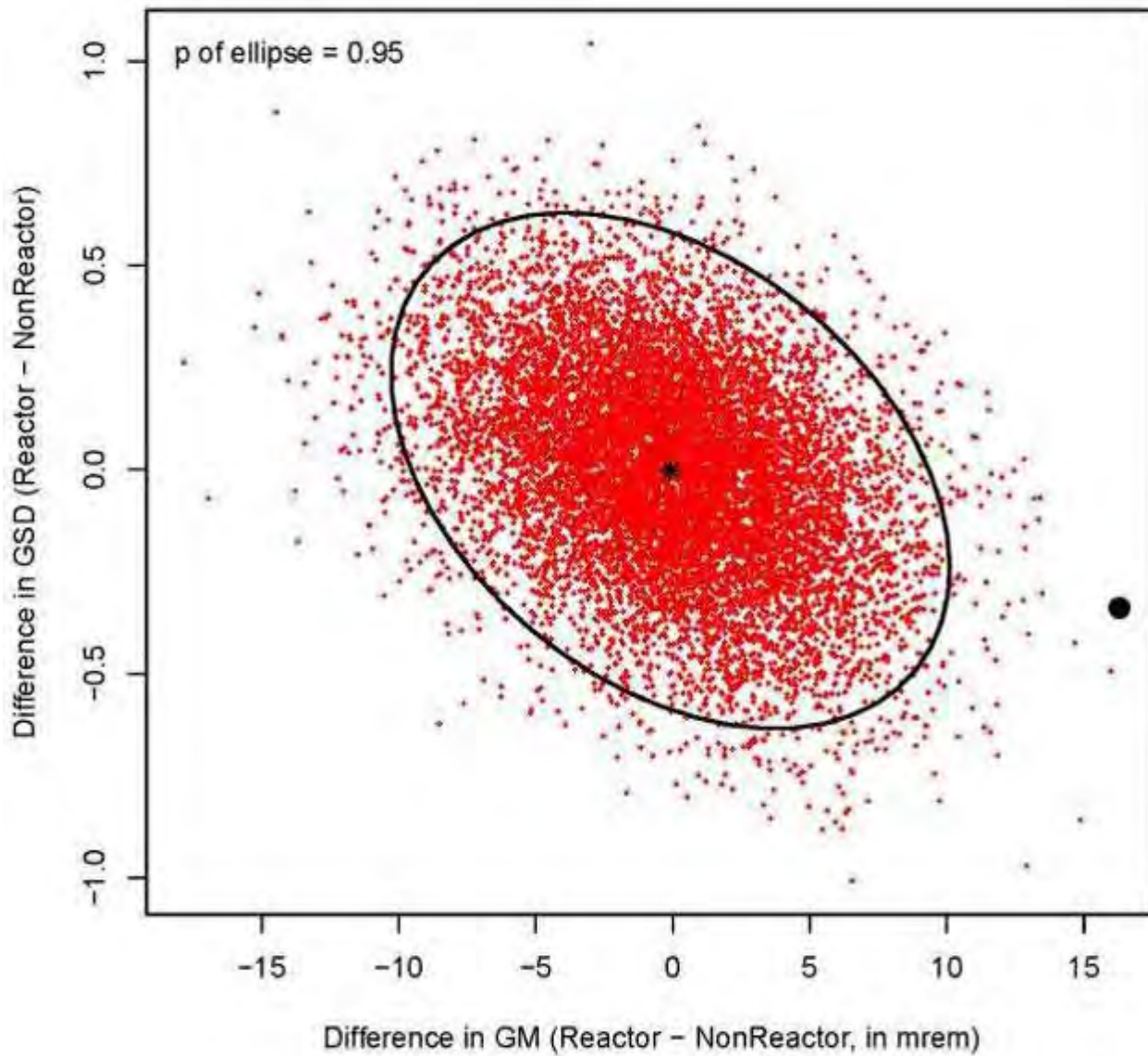


Figure B-36. SRS tritium dose 1962.

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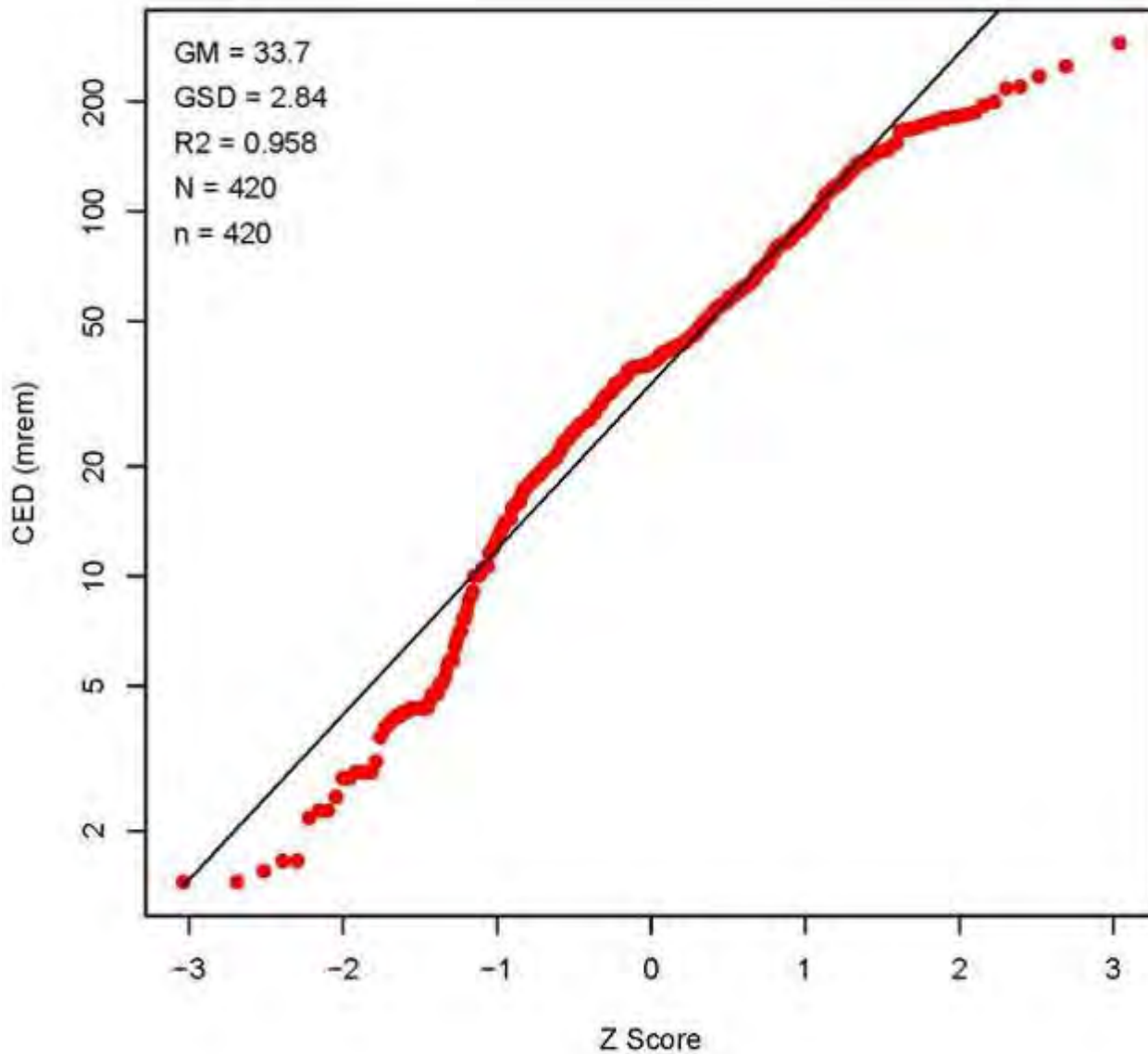


Figure B-37. SRS tritium dose 1963.

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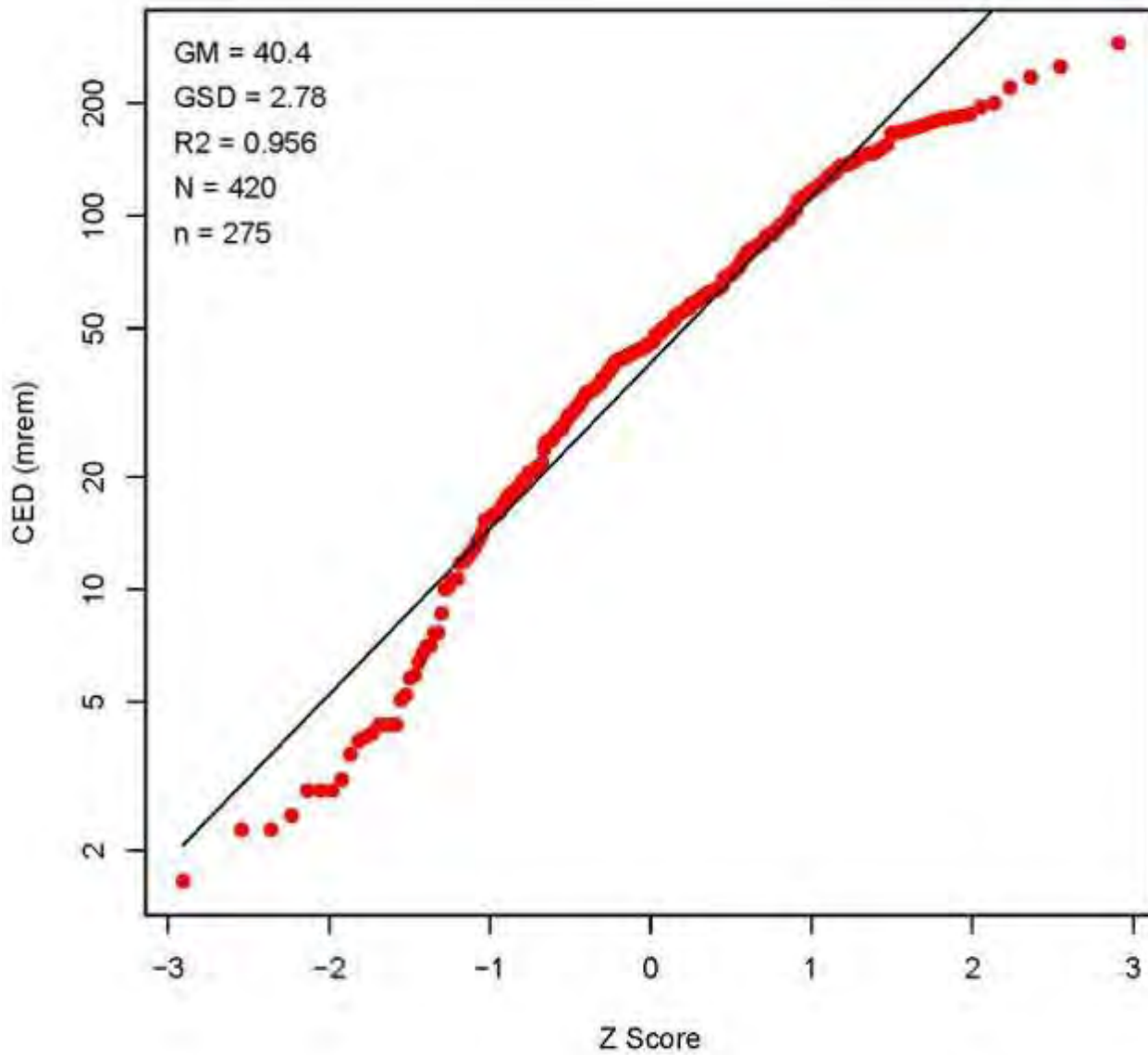


Figure B-38. SRS reactor tritium dose 1953.

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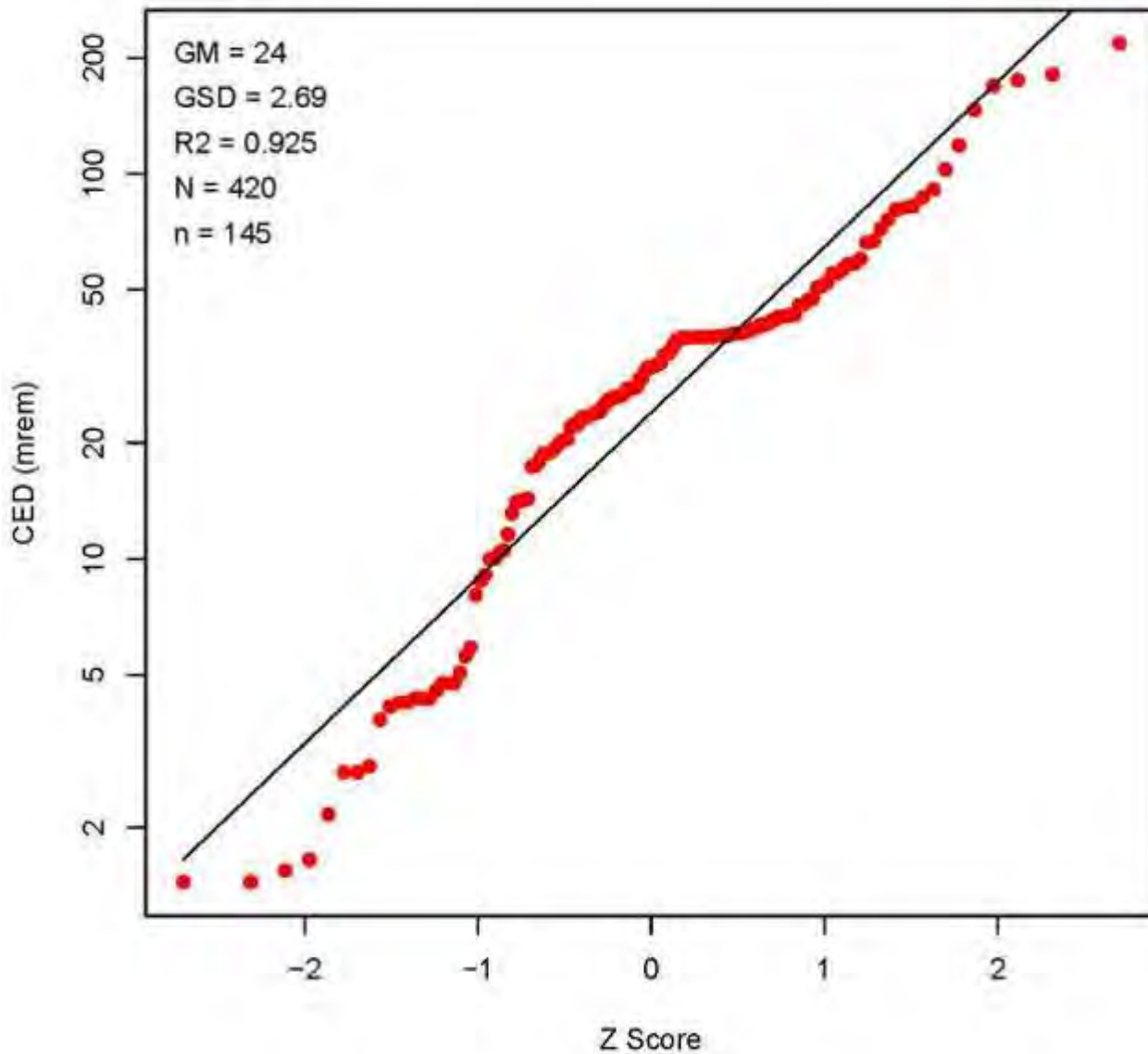


Figure B-39. SRS nonreactor tritium dose 1963.

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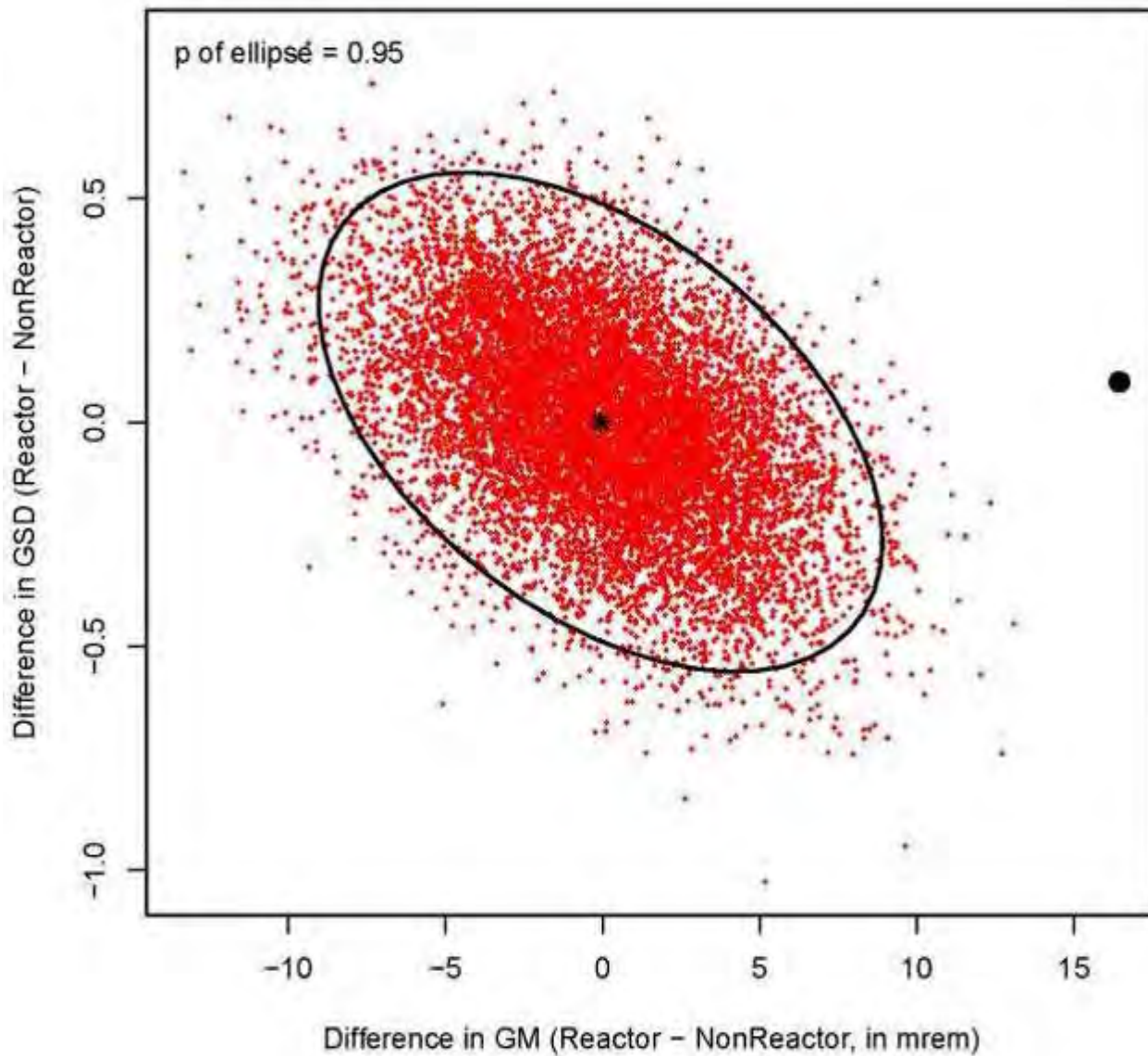


Figure B-40. SRS tritium dose 1963.

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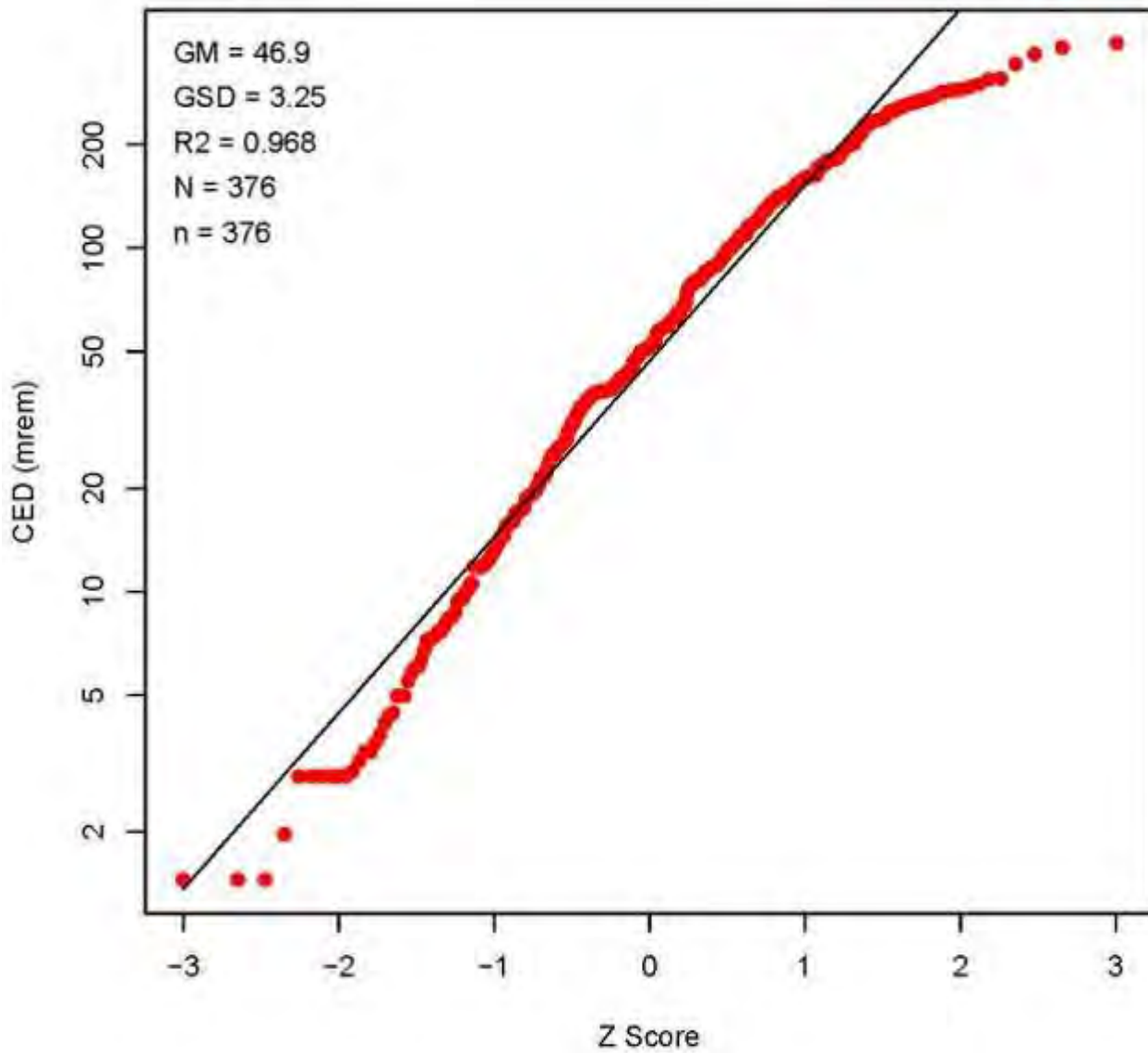


Figure B-41. SRS tritium dose 1964.

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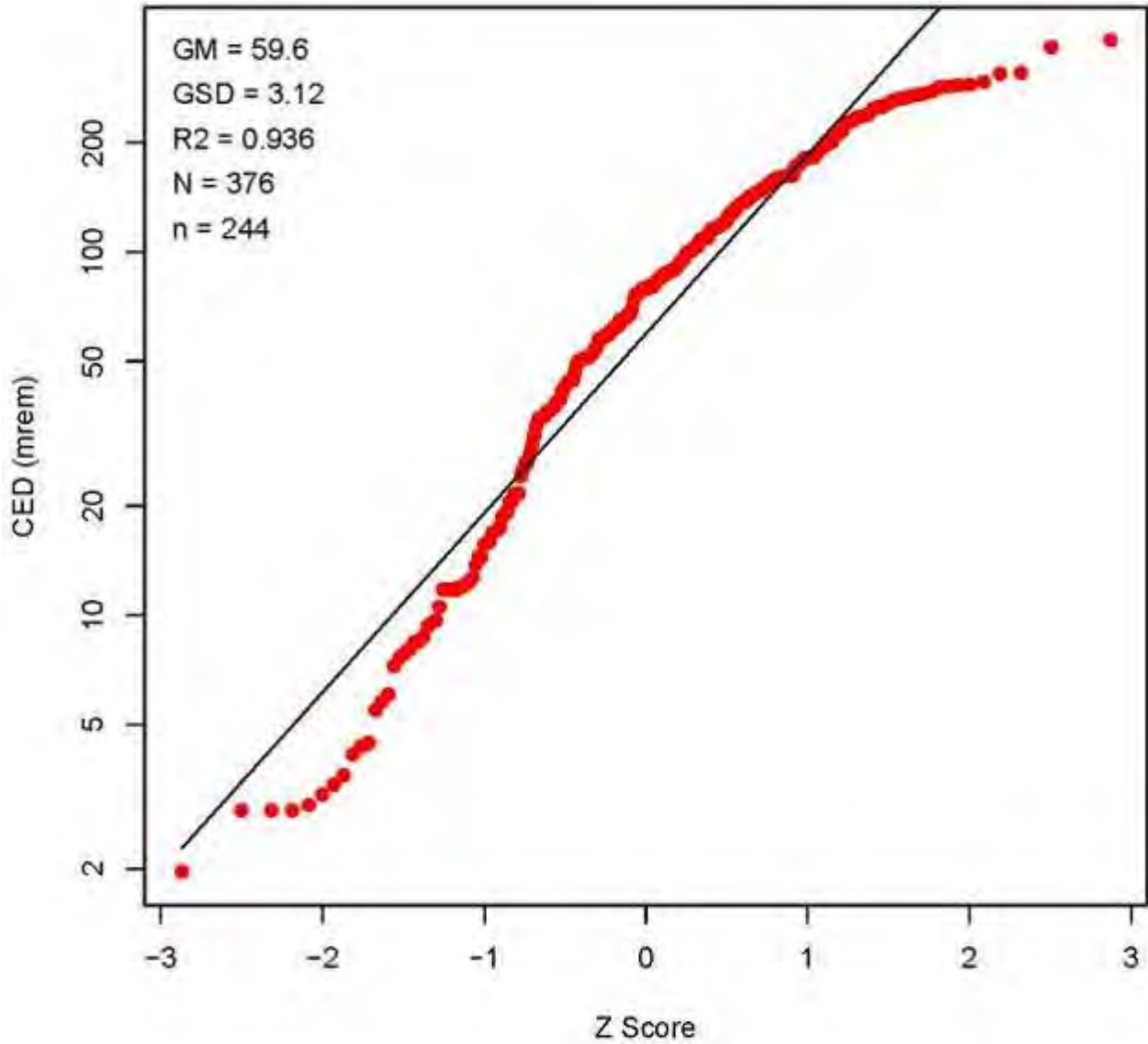


Figure B-42. SRS reactor tritium dose 1964.

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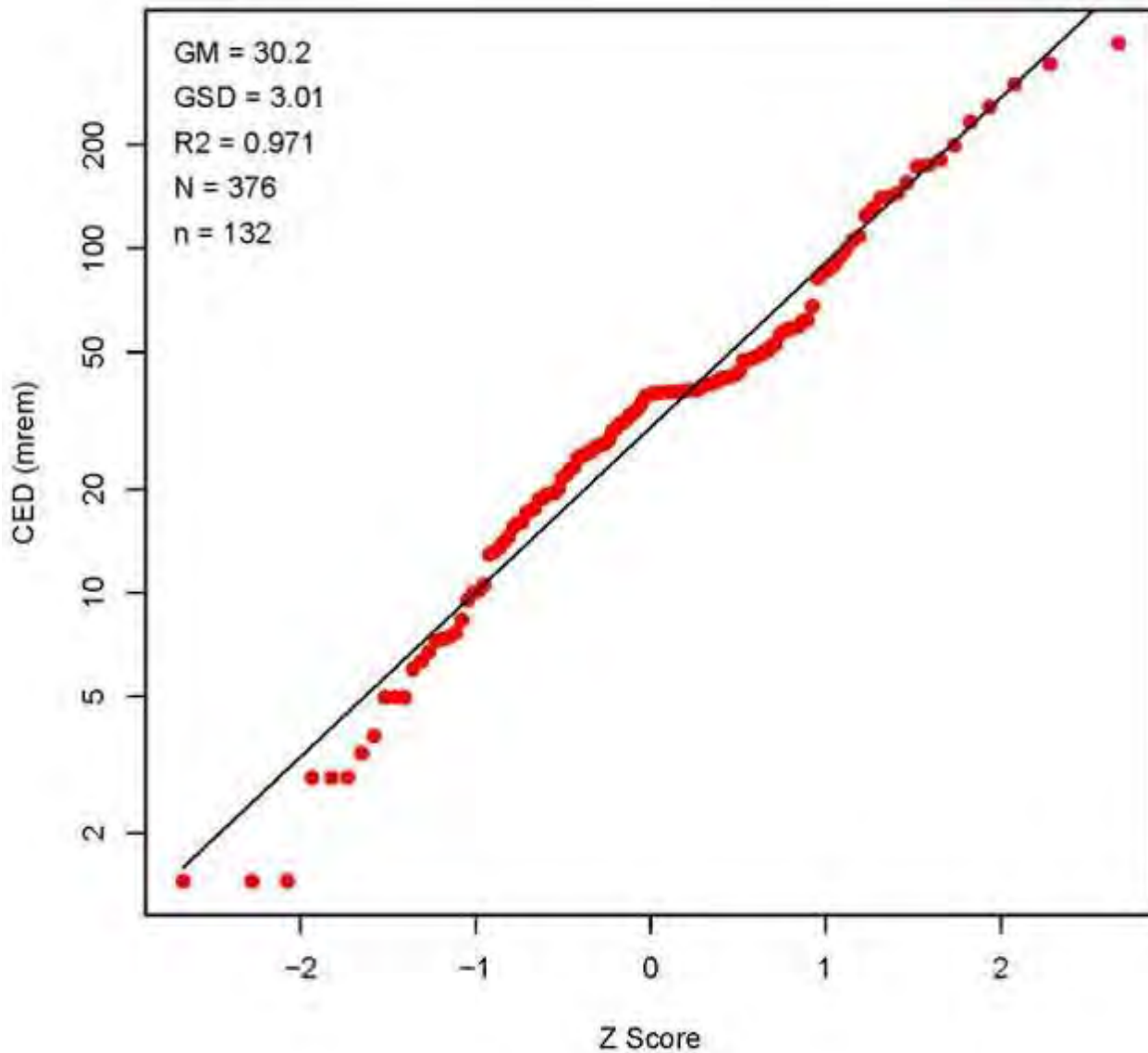


Figure B-43. SRS nonreactor tritium dose 1964.

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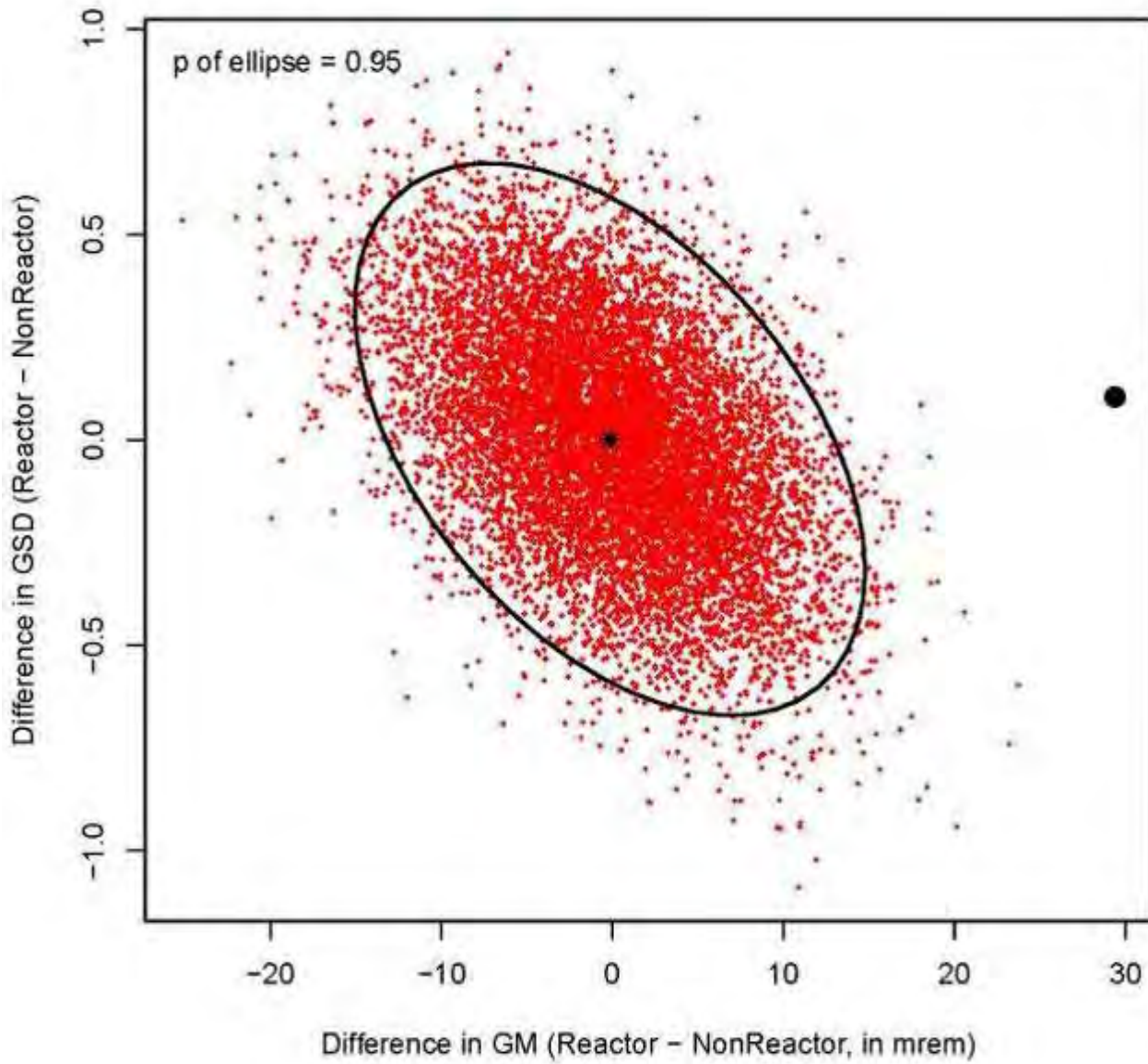


Figure B-44. SRS tritium dose 1964.

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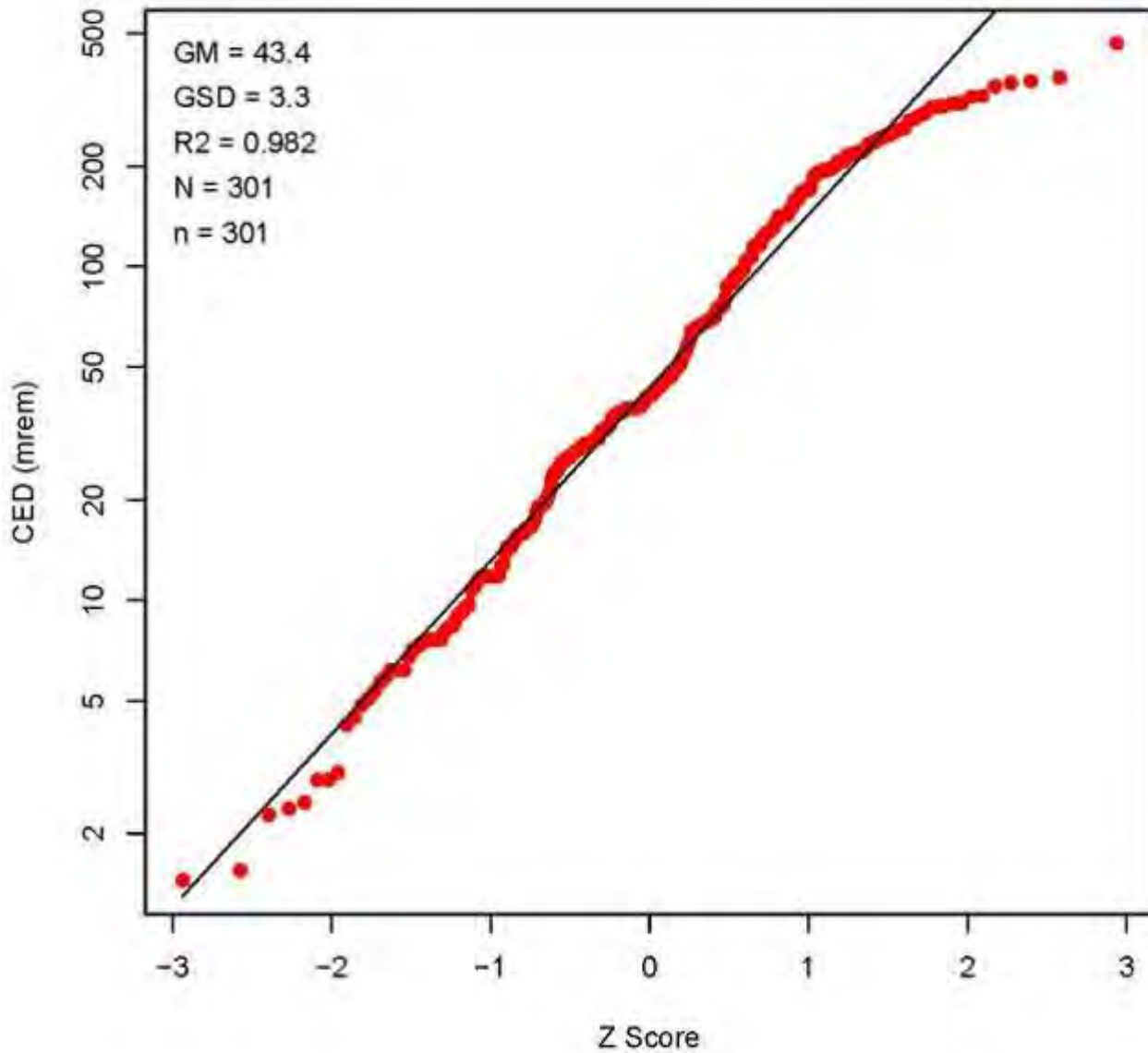


Figure B-45. SRS tritium dose 1965.

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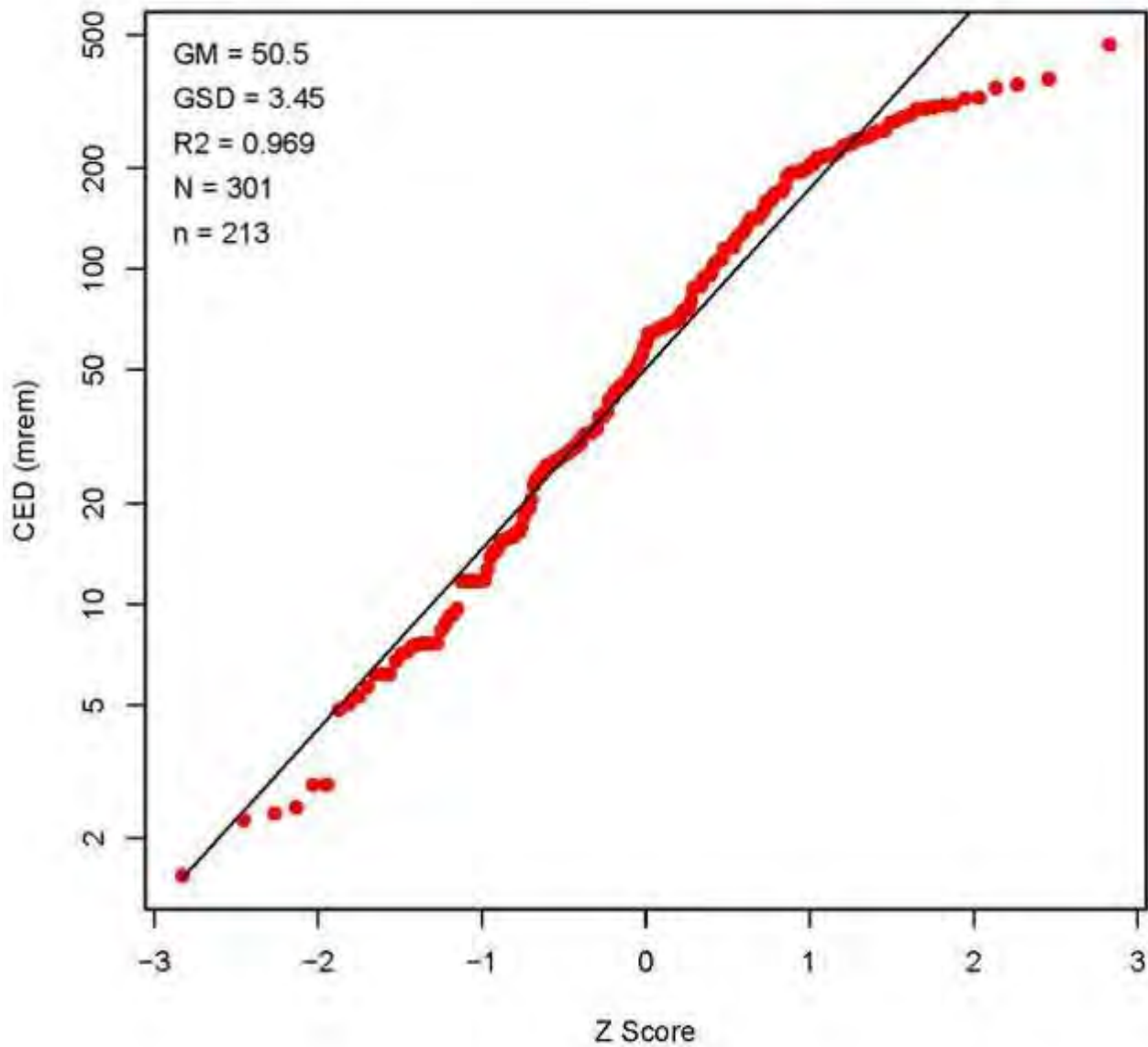


Figure B-46. SRS reactor tritium dose 1965.

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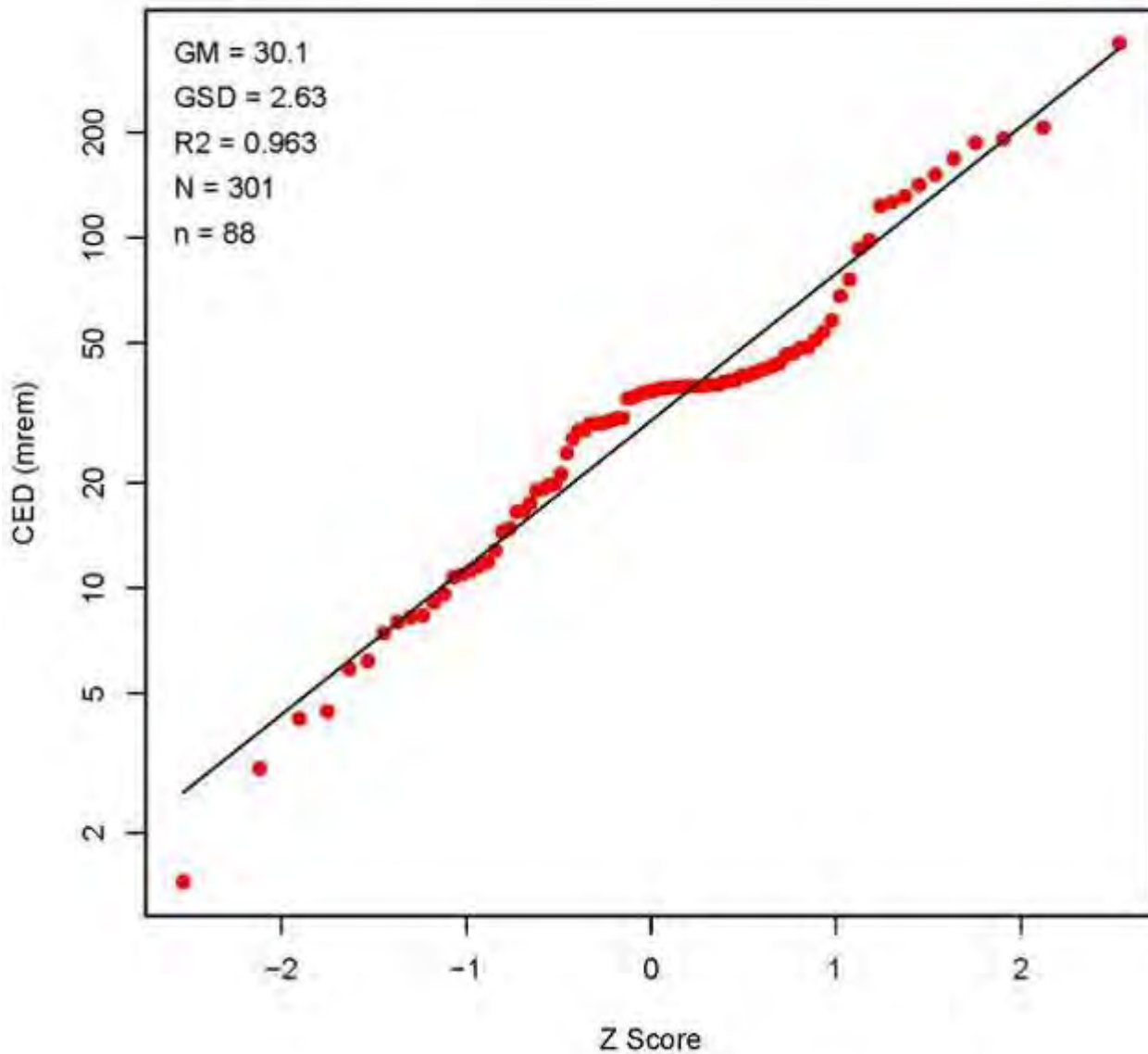


Figure B-47. SRS nonreactor tritium dose 1965.

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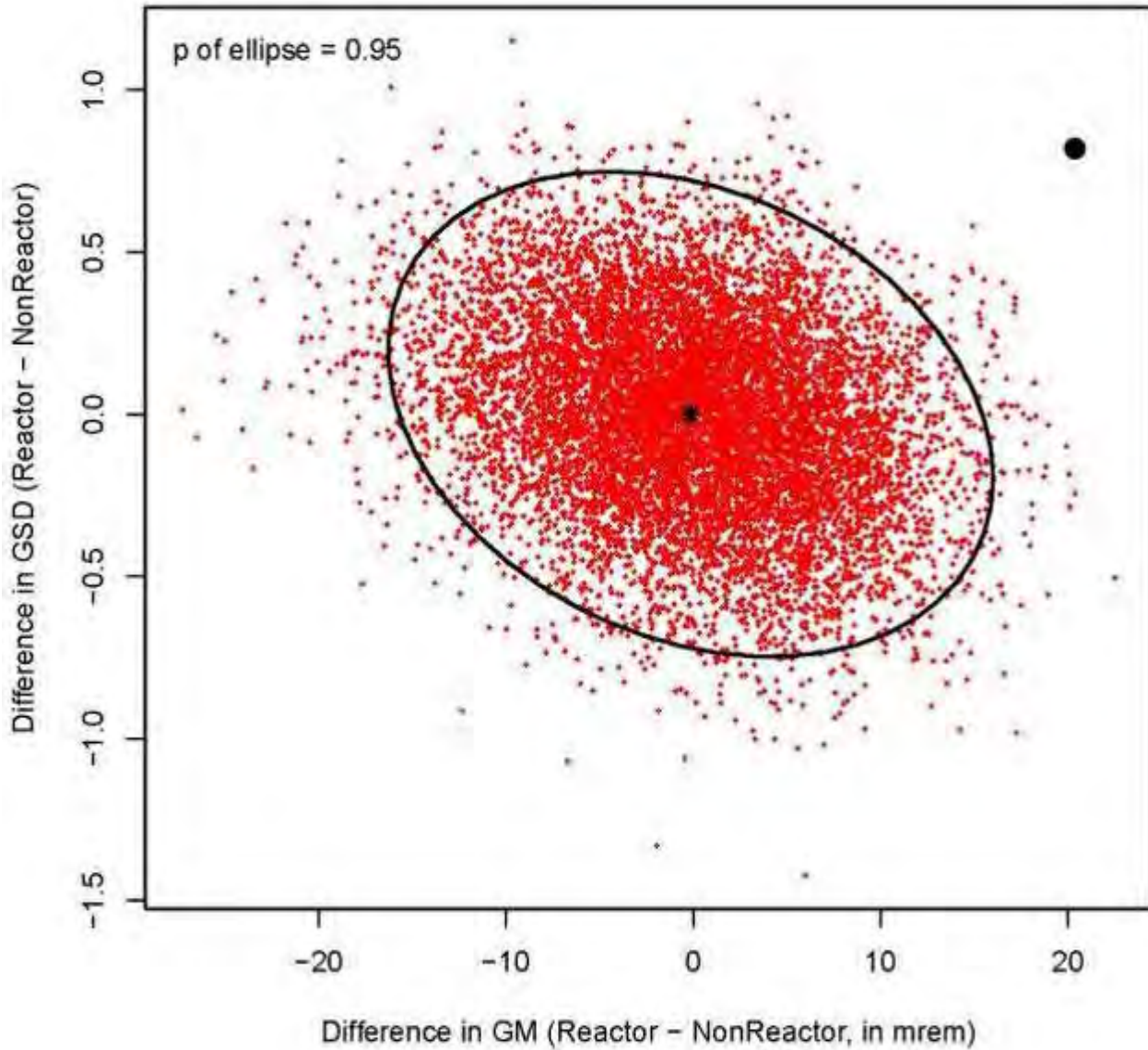


Figure B-48. SRS tritium dose 1965.

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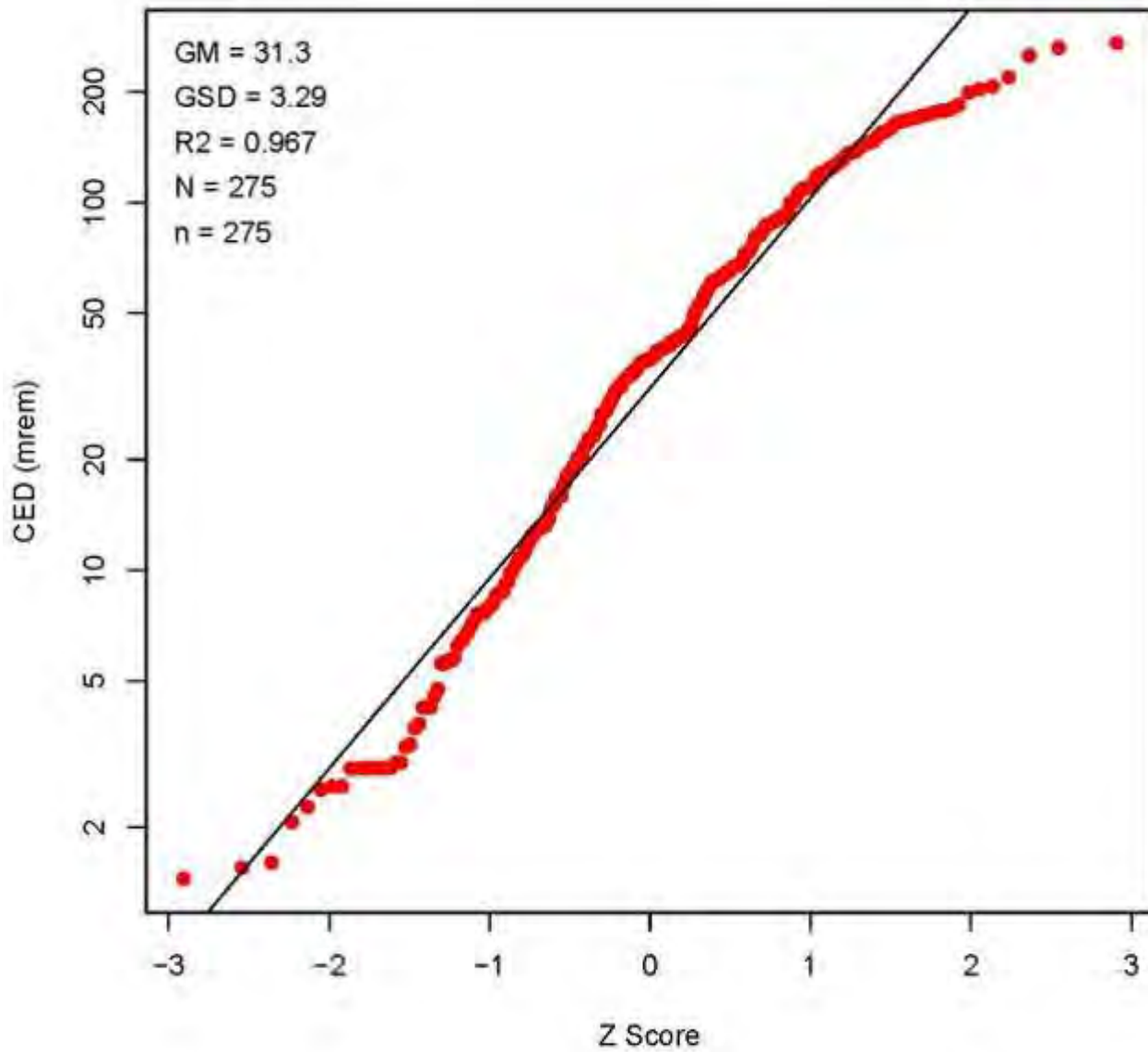


Figure B-49. SRS tritium dose 1966.

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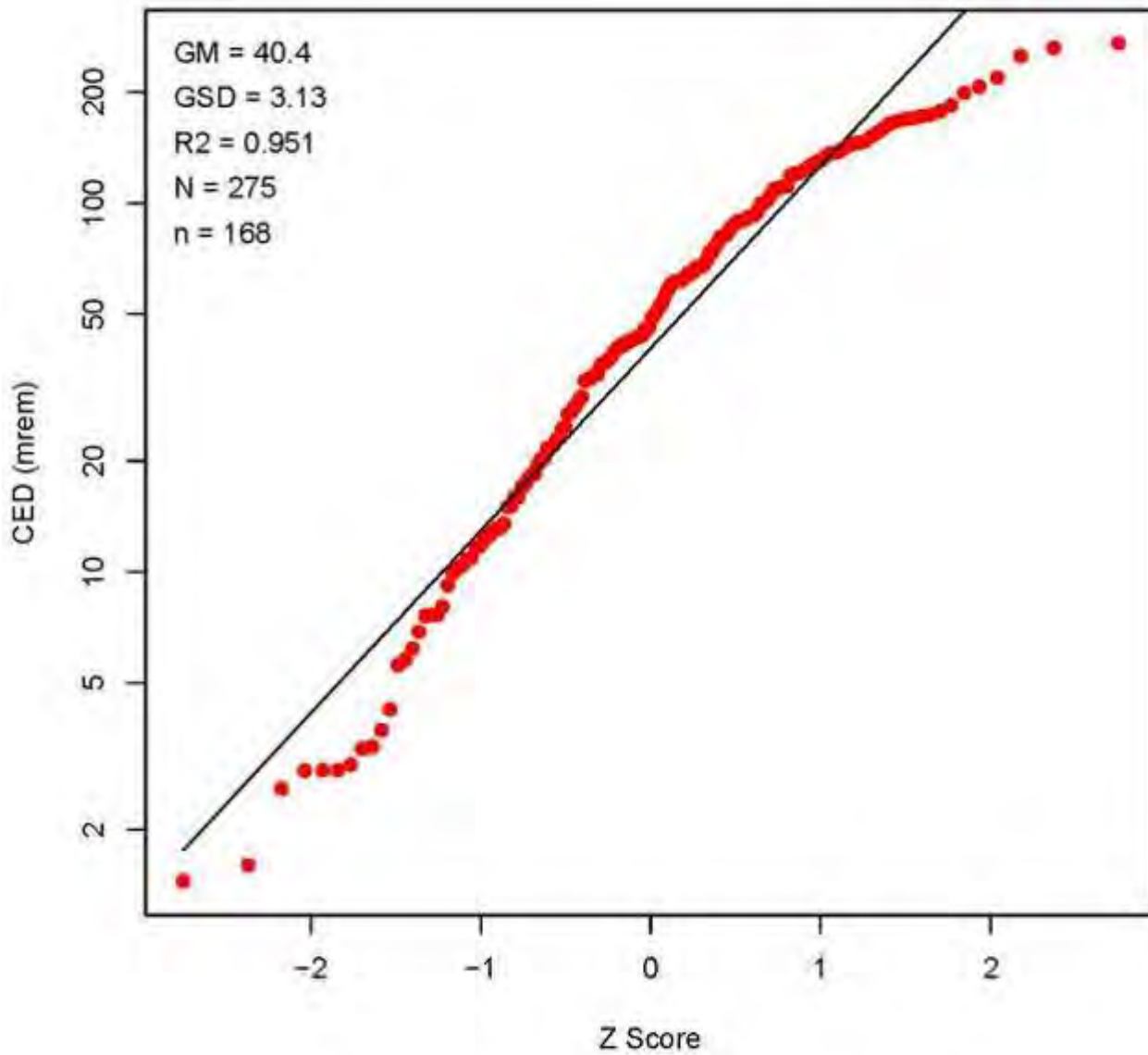


Figure B-50. SRS reactor tritium dose 1966.

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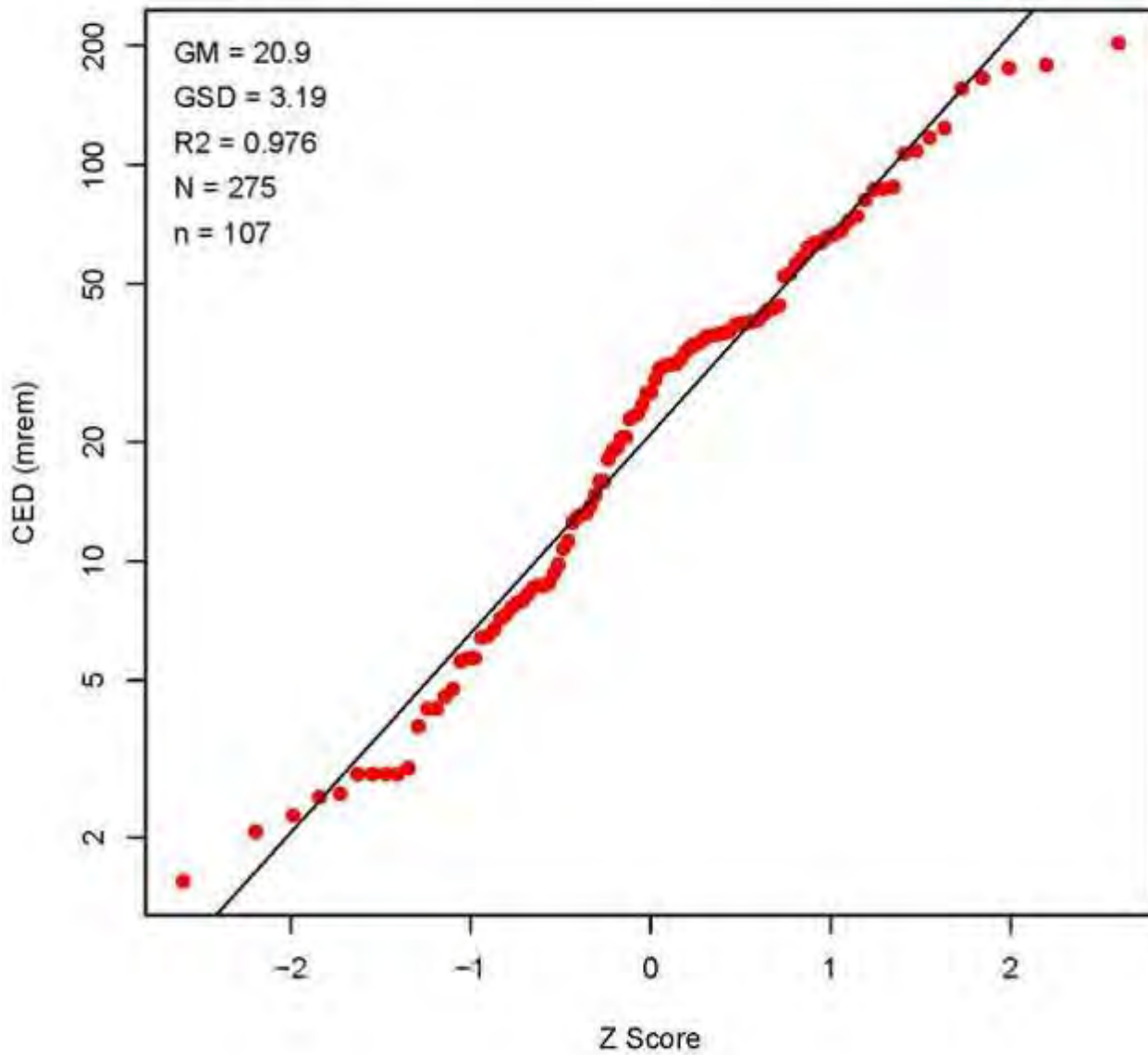


Figure B-51. SRS nonreactor tritium dose 1966.

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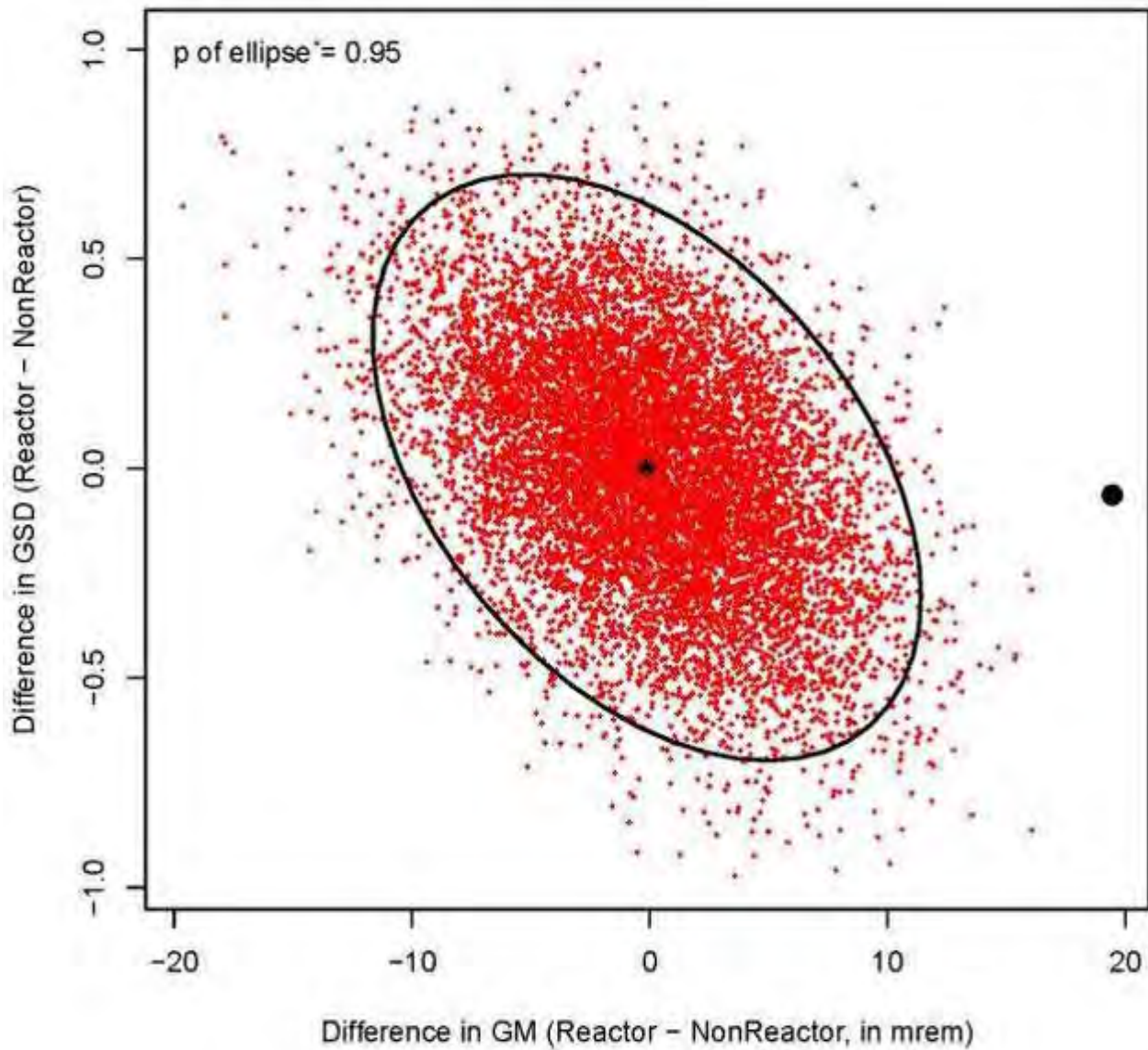


Figure B-52. SRS tritium dose 1966.

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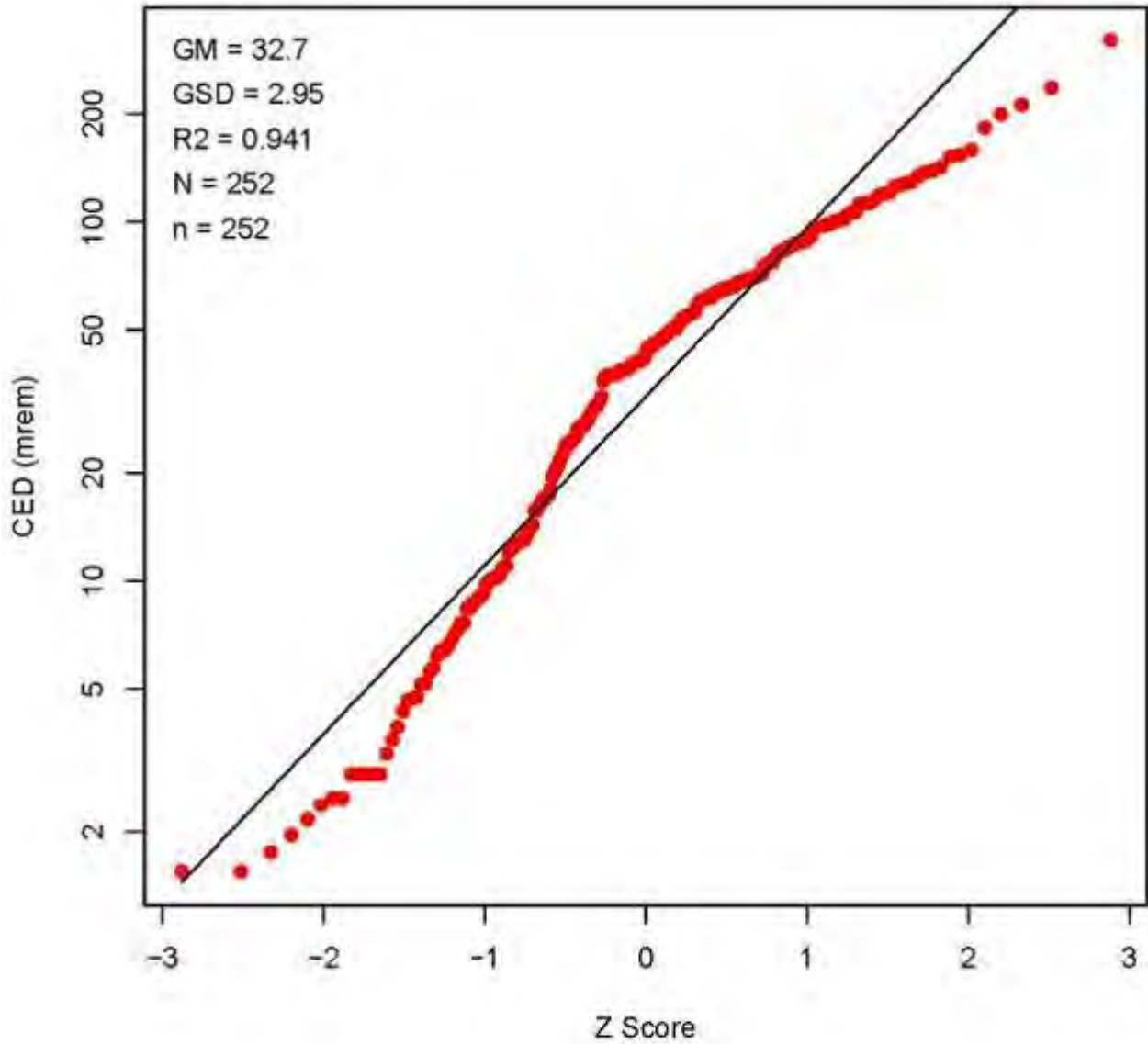


Figure B-53. SRS tritium dose 1967.

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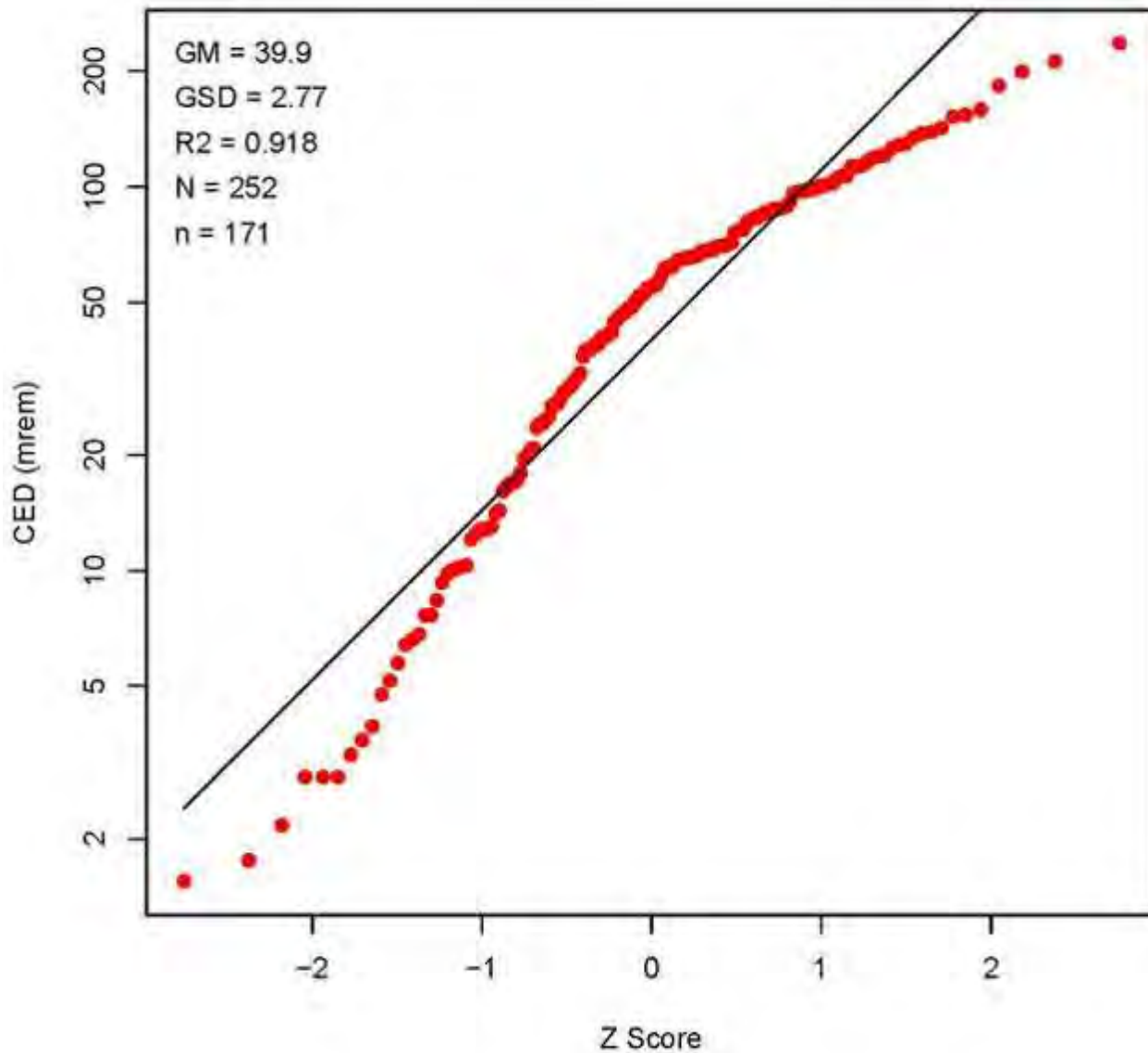


Figure B-54. SRS reactor tritium dose 1967.

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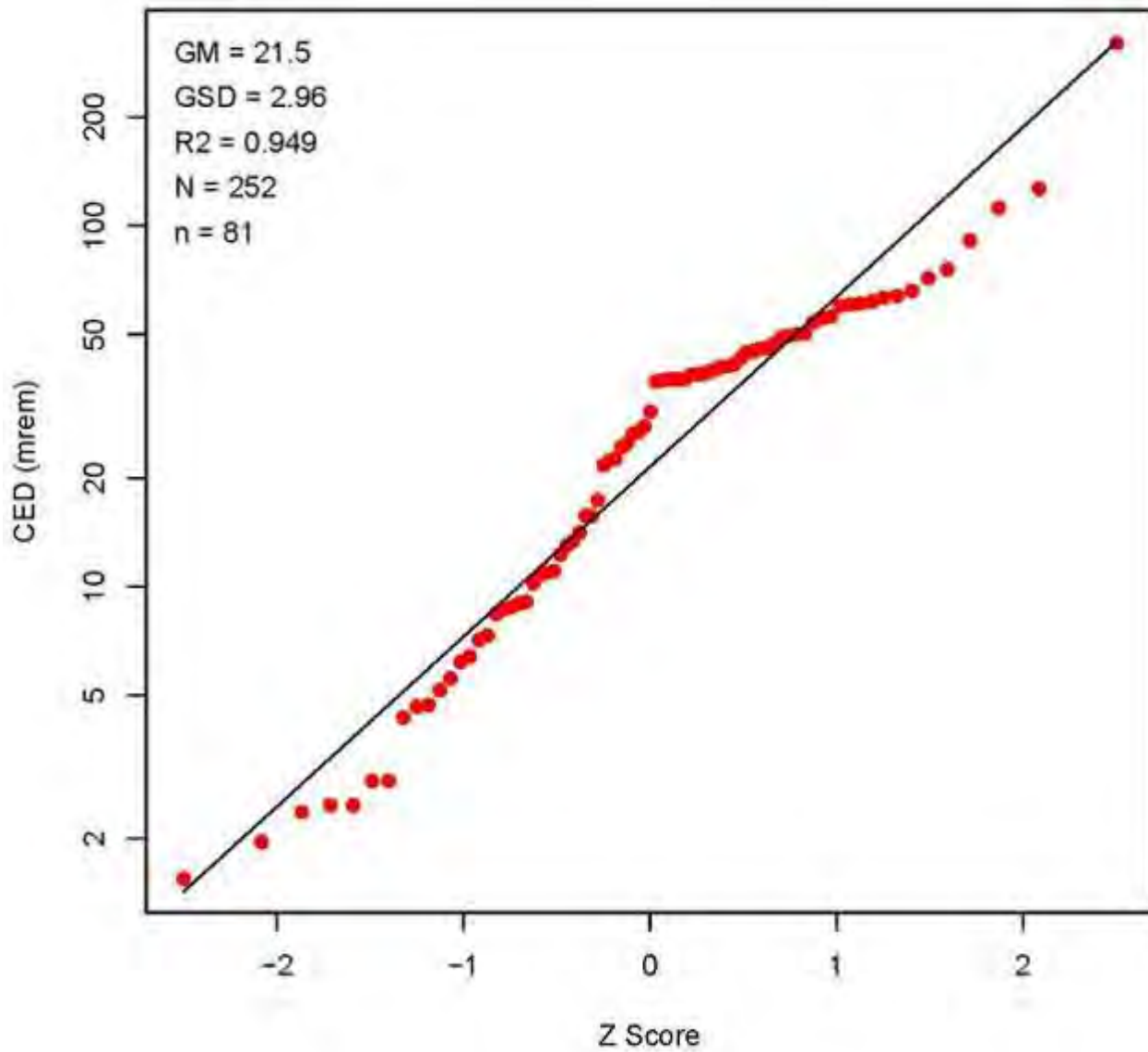


Figure B-55. SRS nonreactor tritium dose 1967.

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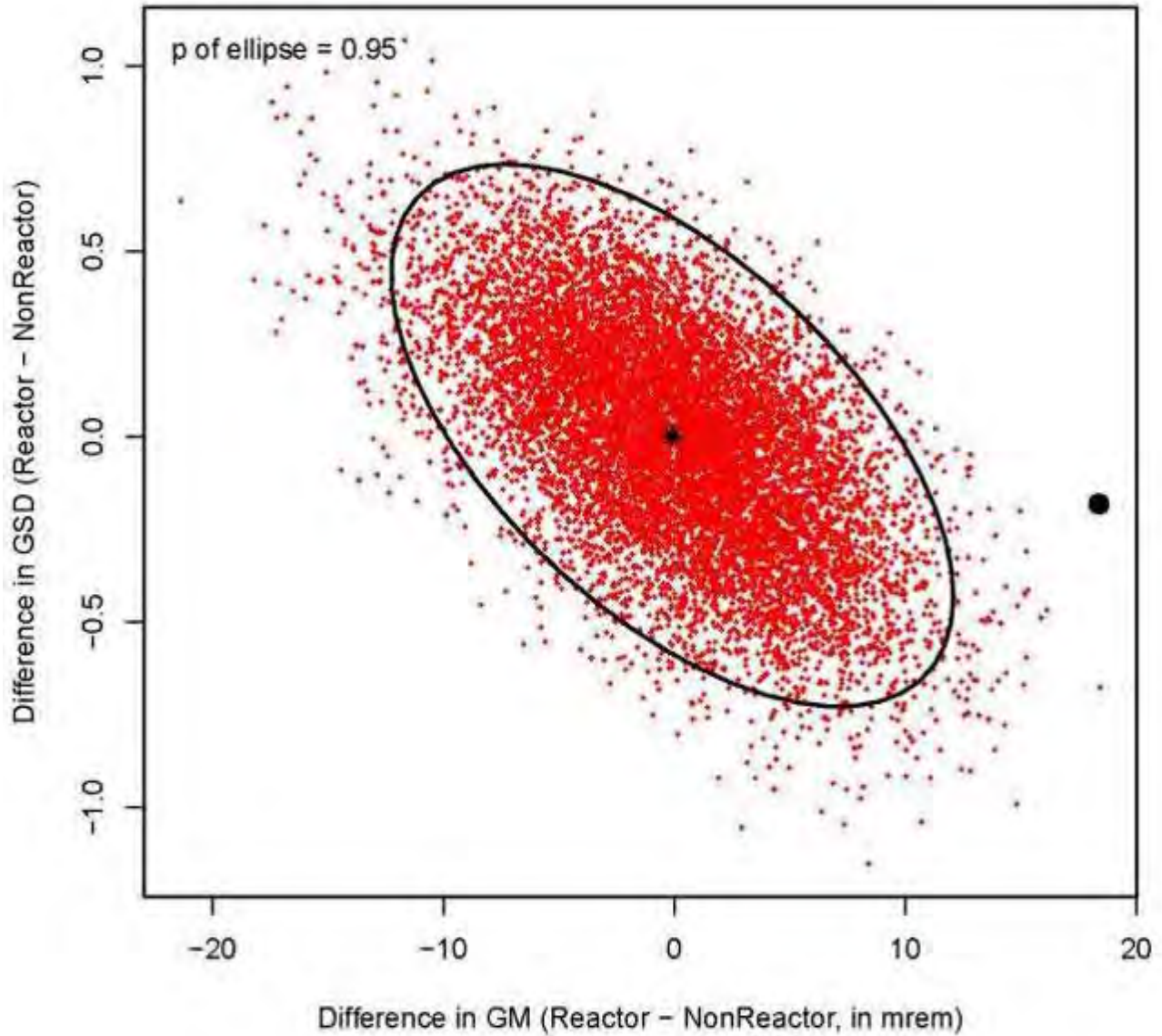


Figure B-56. SRS tritium dose 1967.

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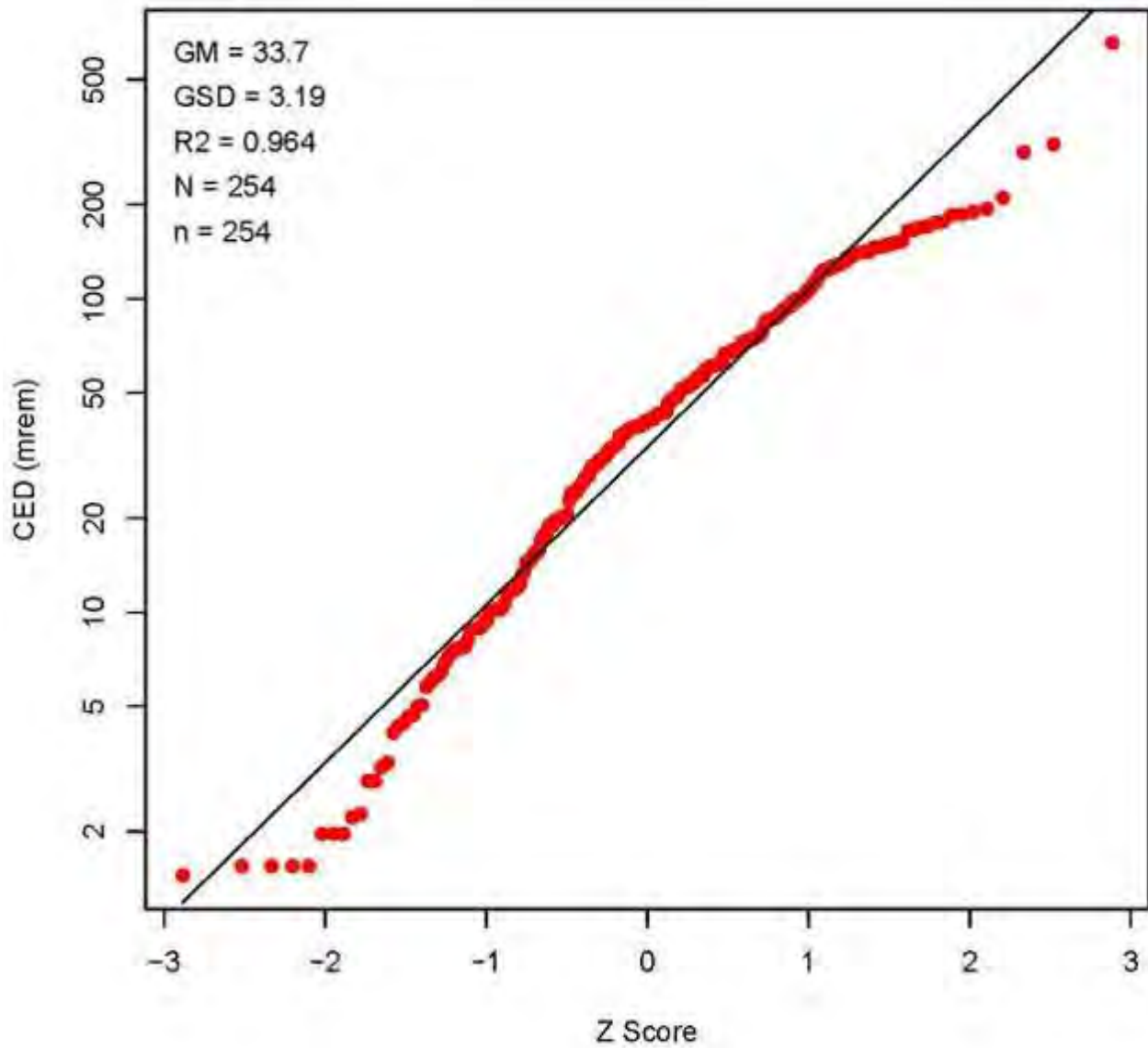


Figure B-57. SRS tritium dose 1968.

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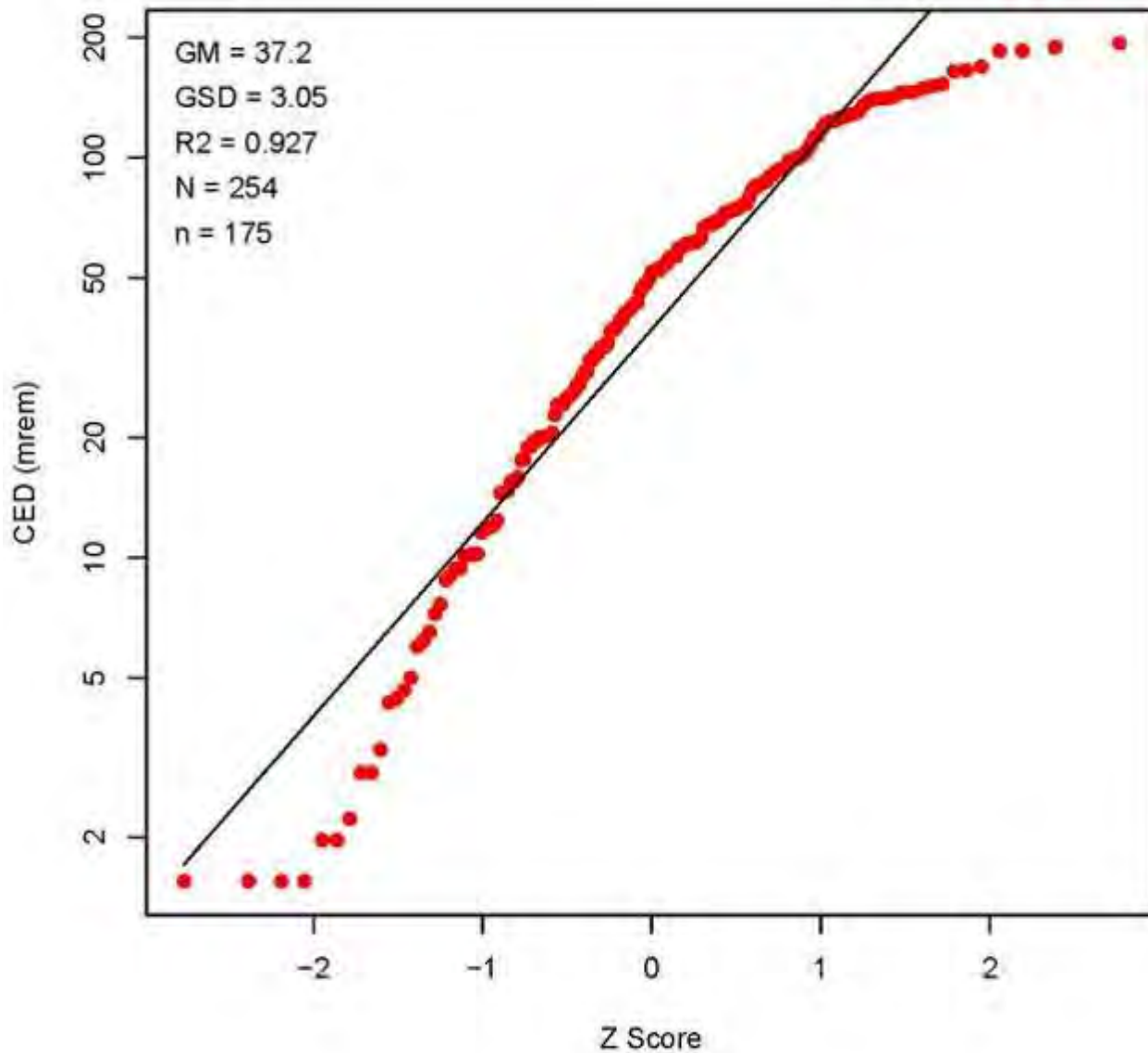


Figure B-58. SRS reactor tritium dose 1968.

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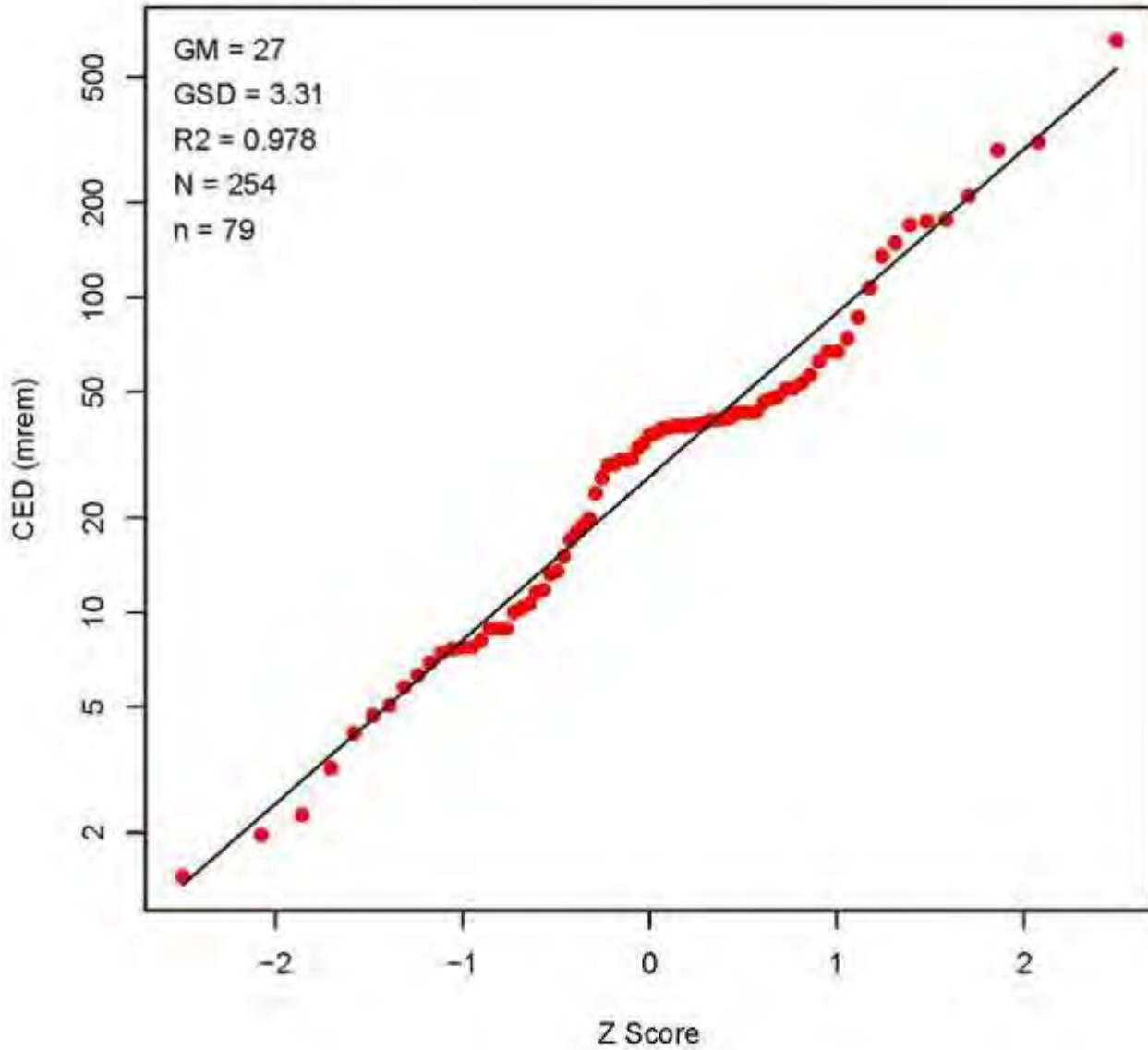


Figure B-59. SRS nonreactor tritium dose 1968.

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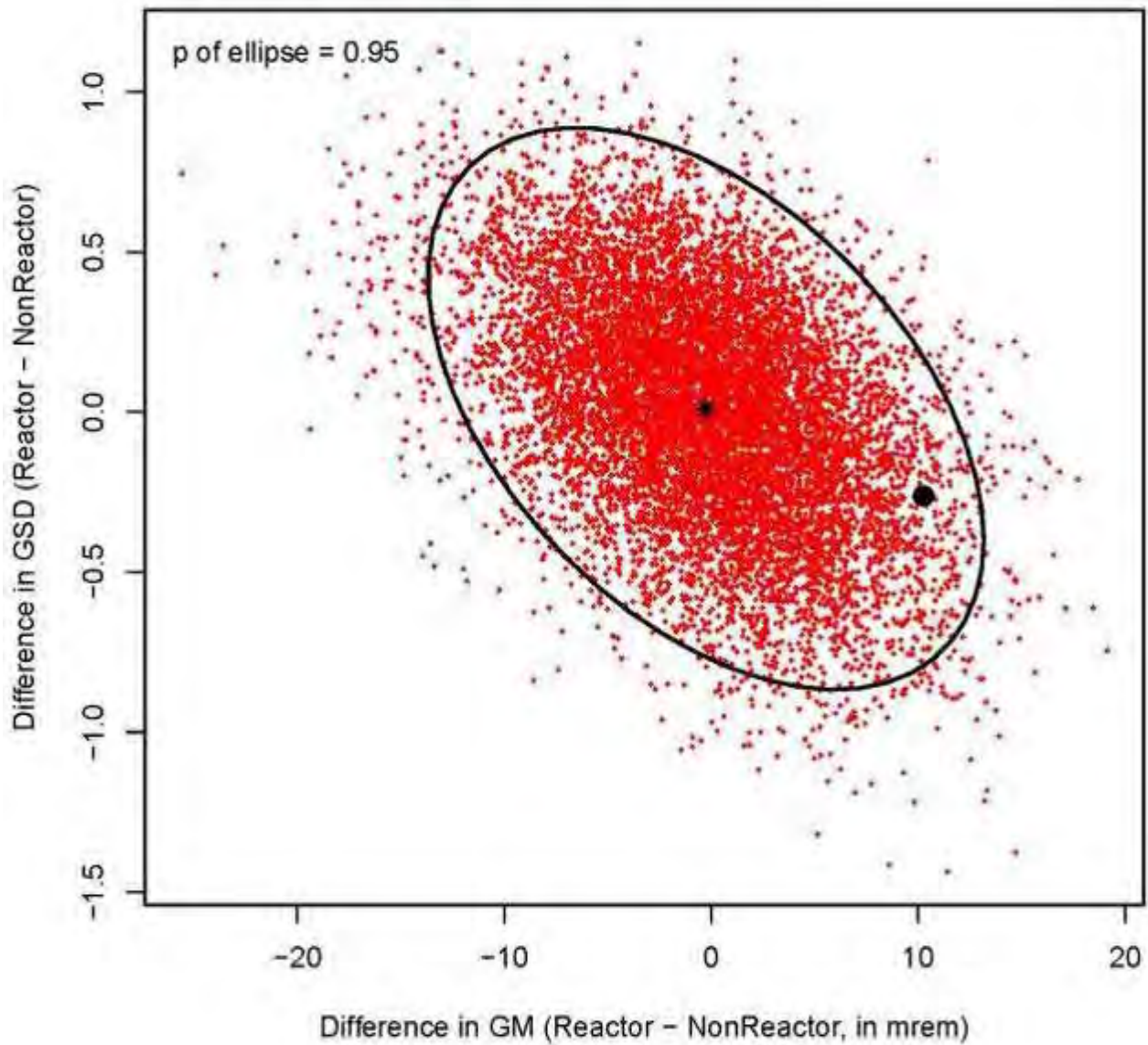


Figure B-60. SRS tritium dose 1968.

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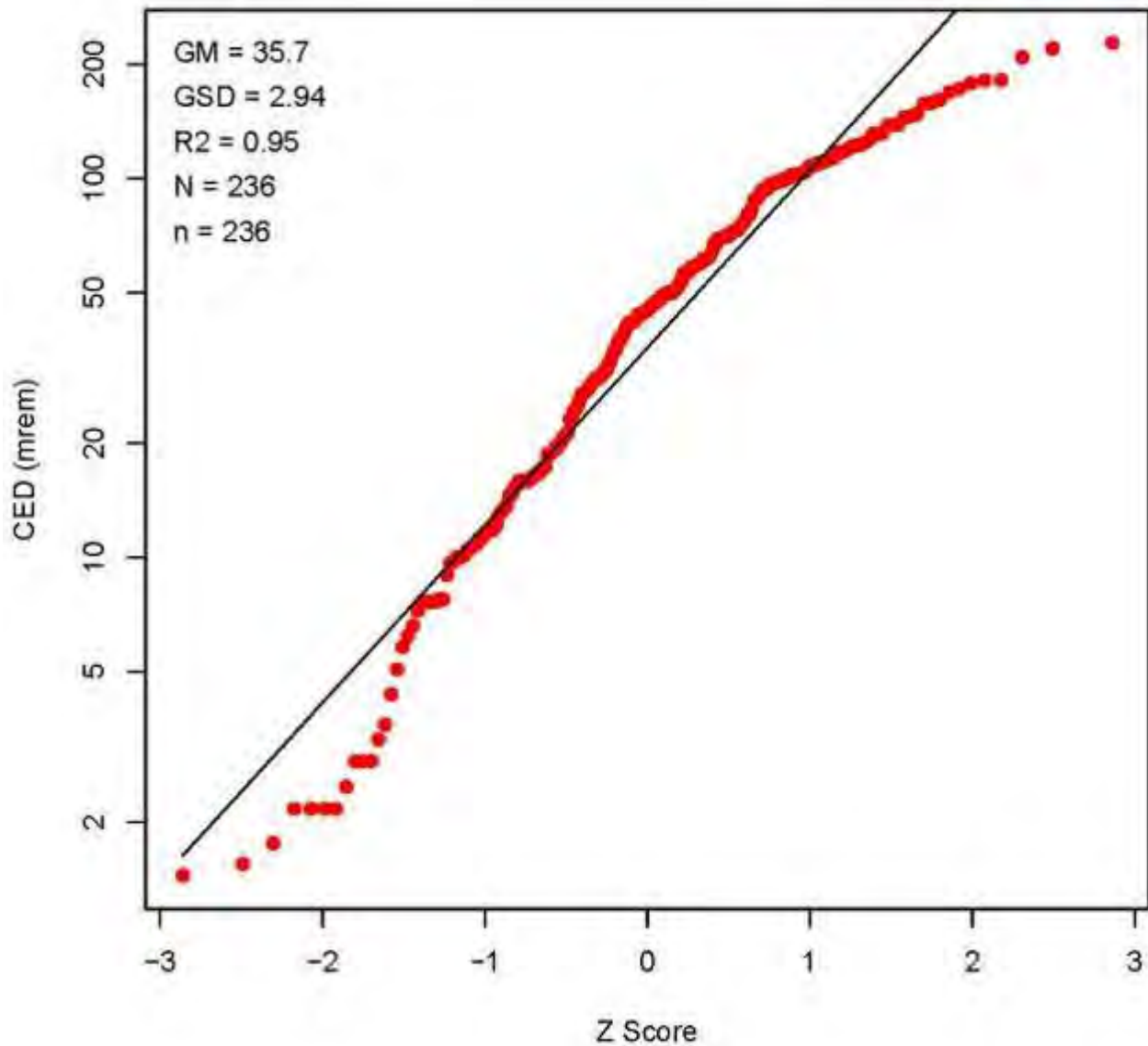


Figure B-61. SRS tritium dose 1969.

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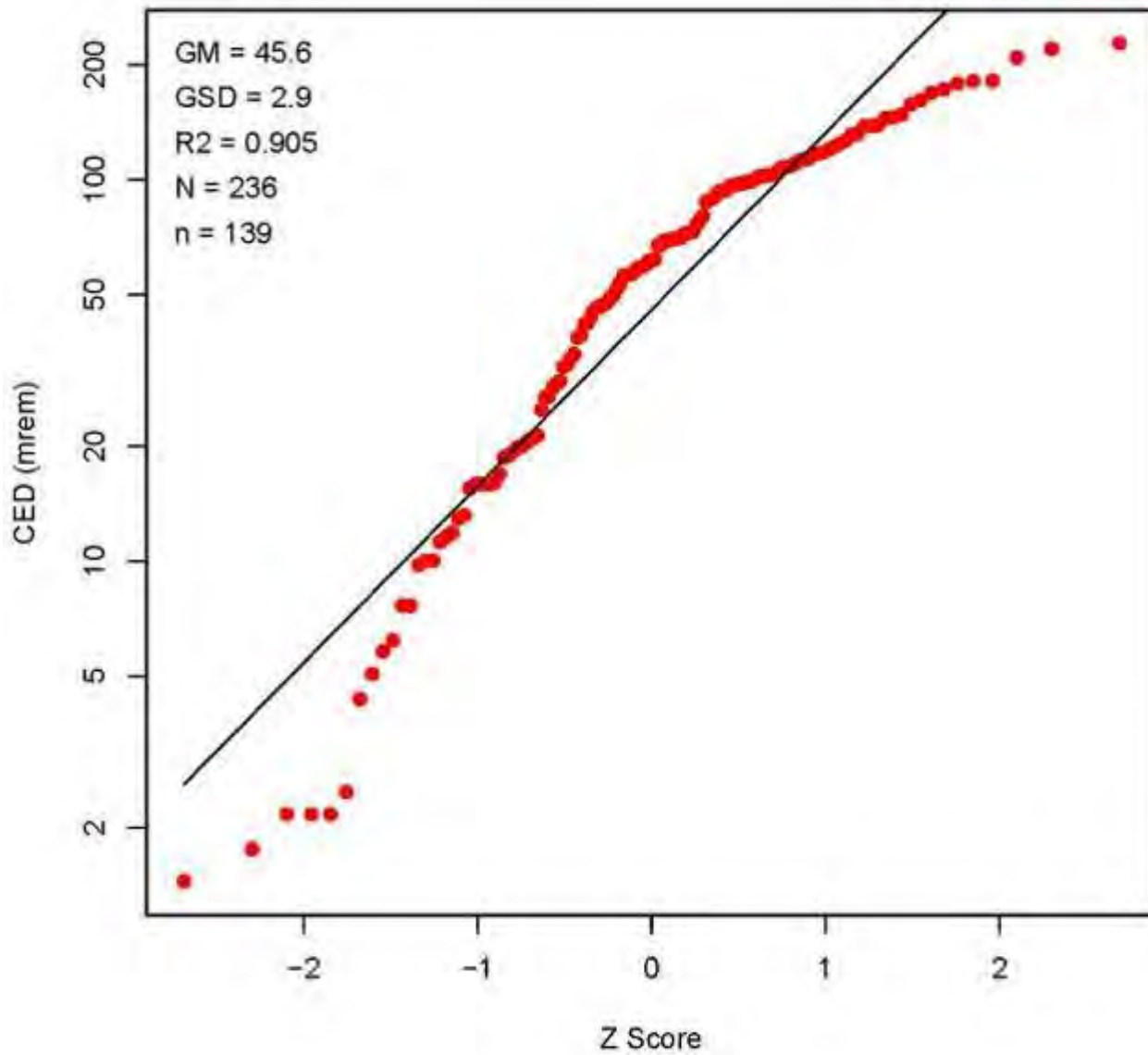


Figure B-62. SRS reactor tritium dose 1969.

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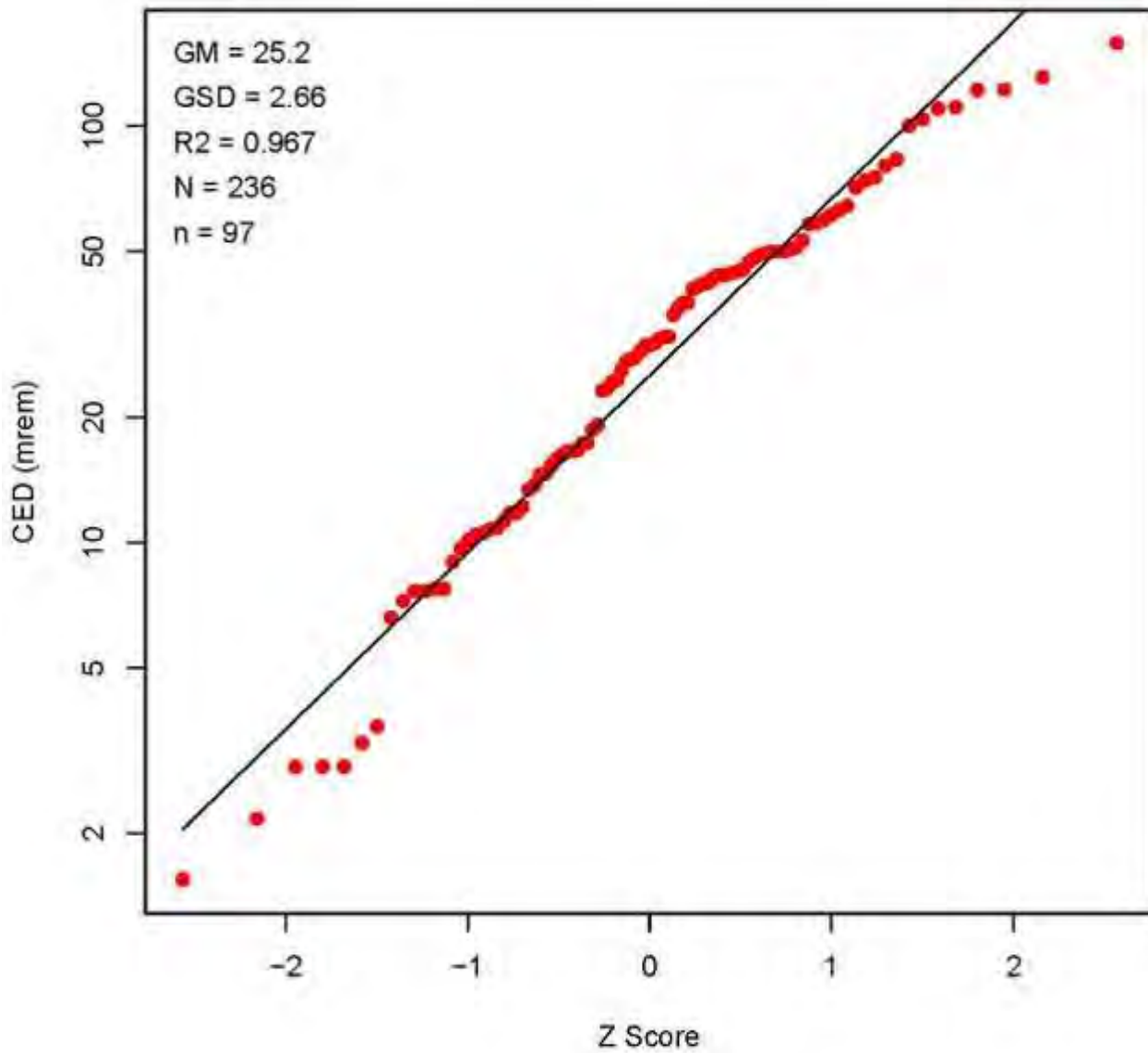


Figure B-63. SRS nonreactor tritium dose 1969.

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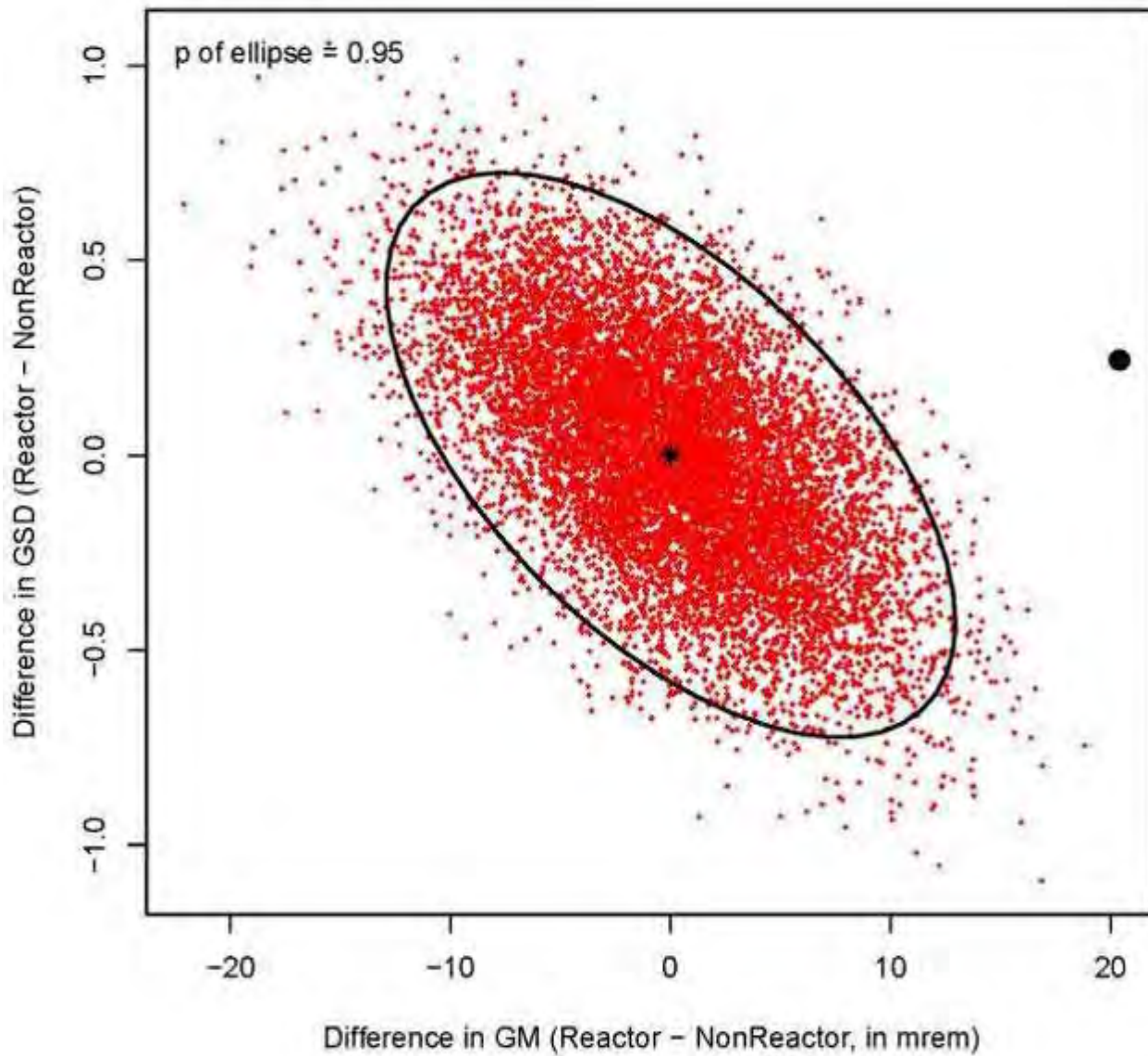


Figure B-64. SRS tritium dose 1969.

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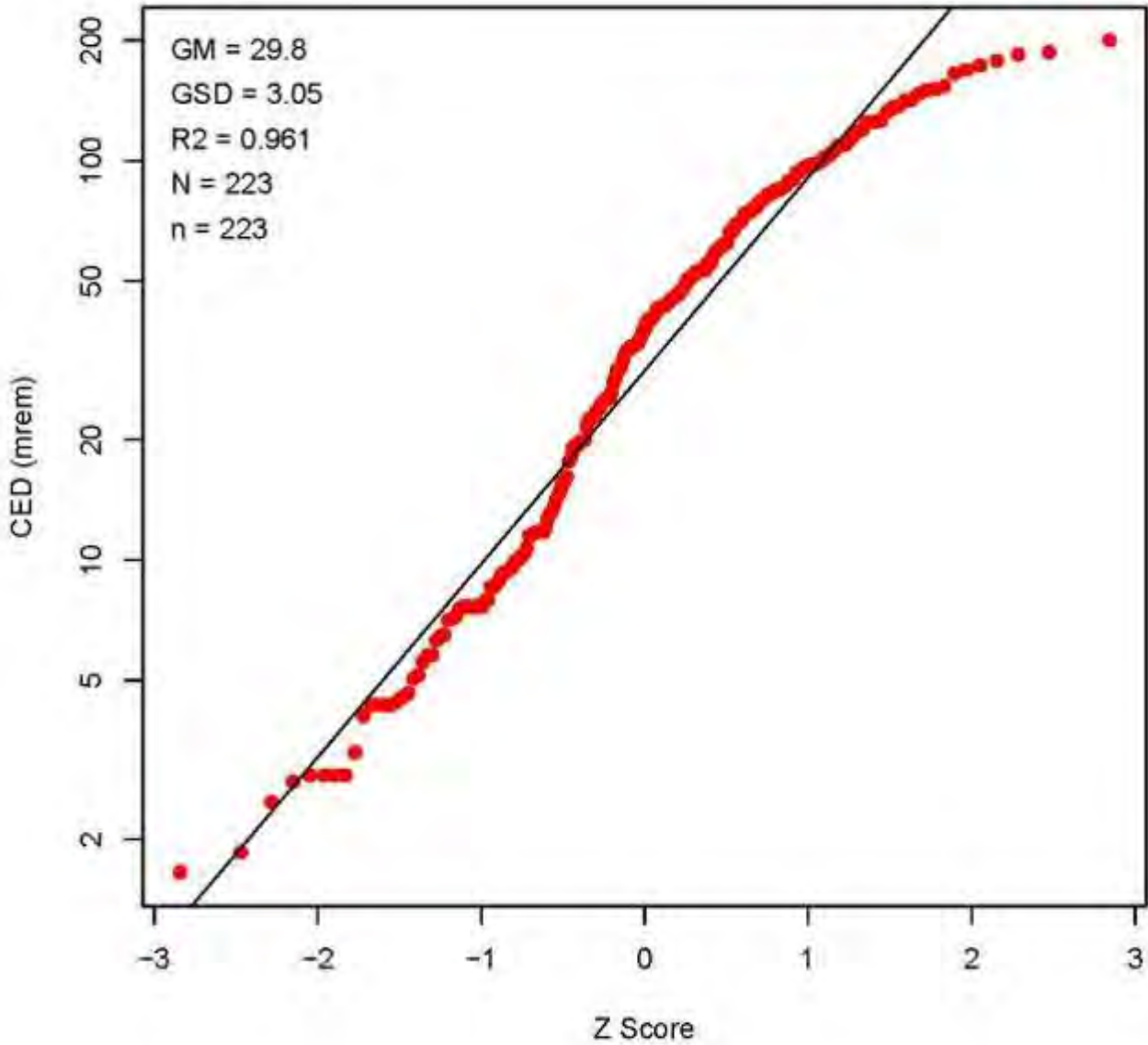


Figure B-65. SRS tritium dose 1970.

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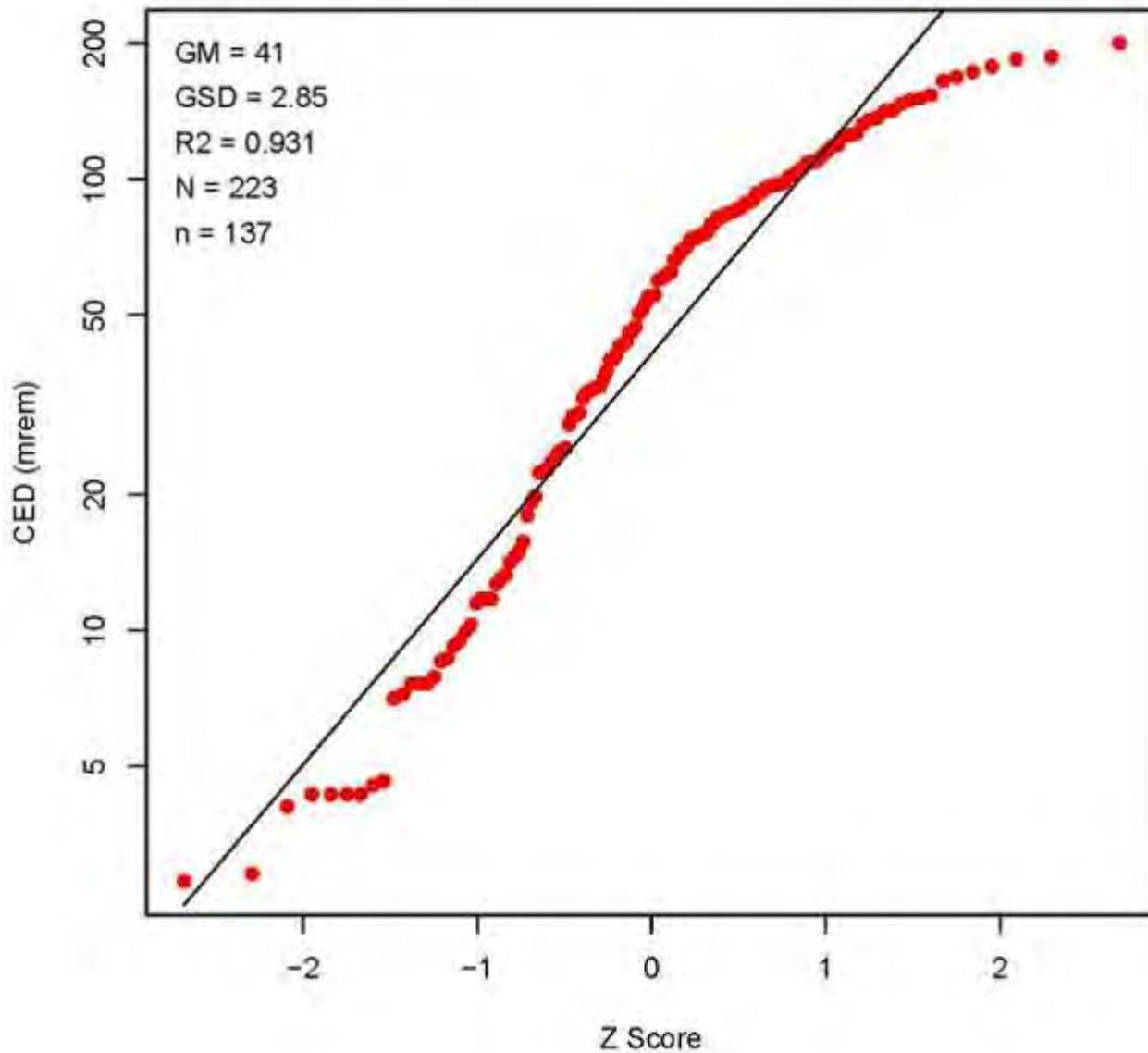


Figure B-66. SRS reactor tritium dose 1970.

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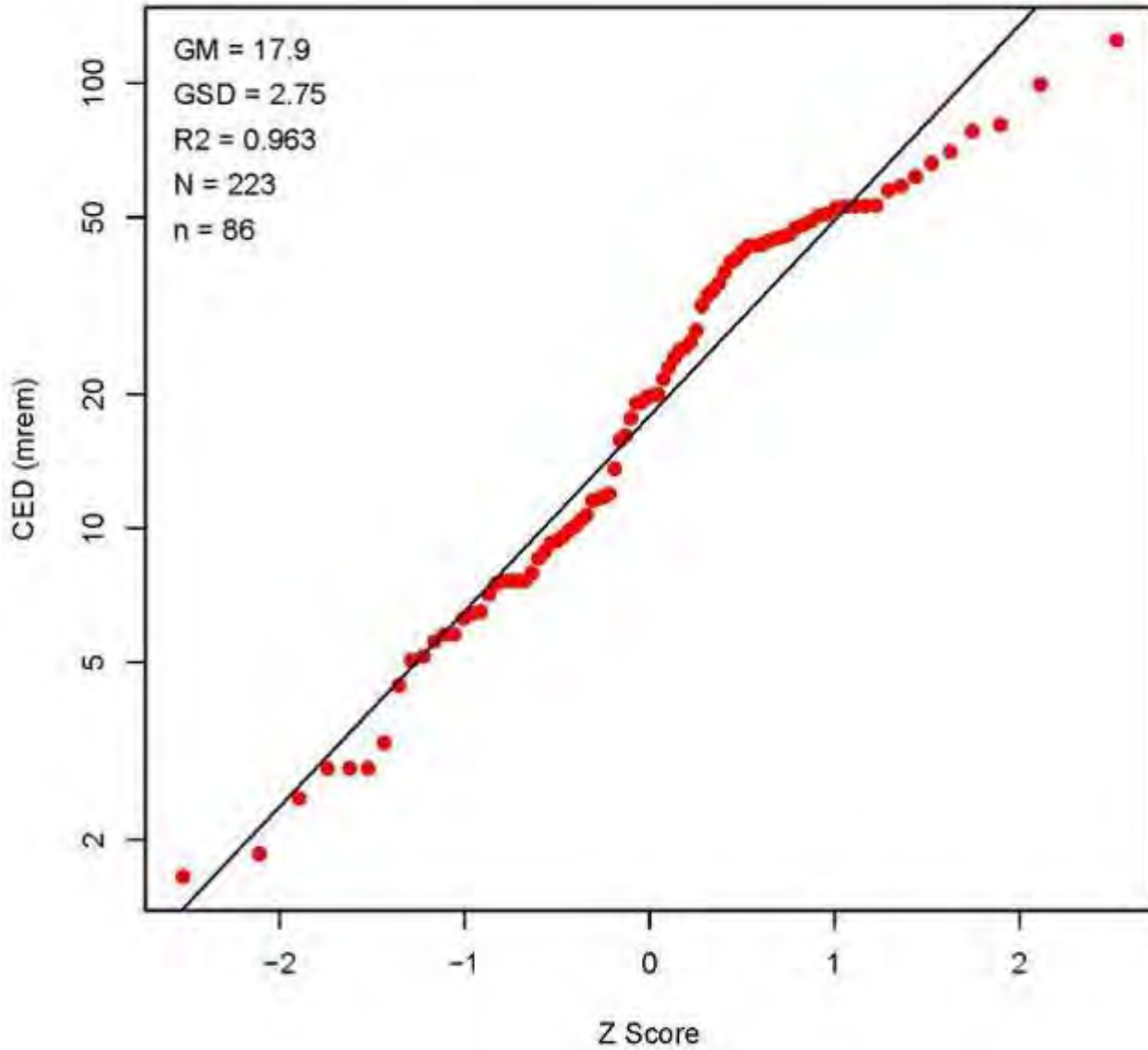


Figure B-67. SRS nonreactor tritium dose 1970.

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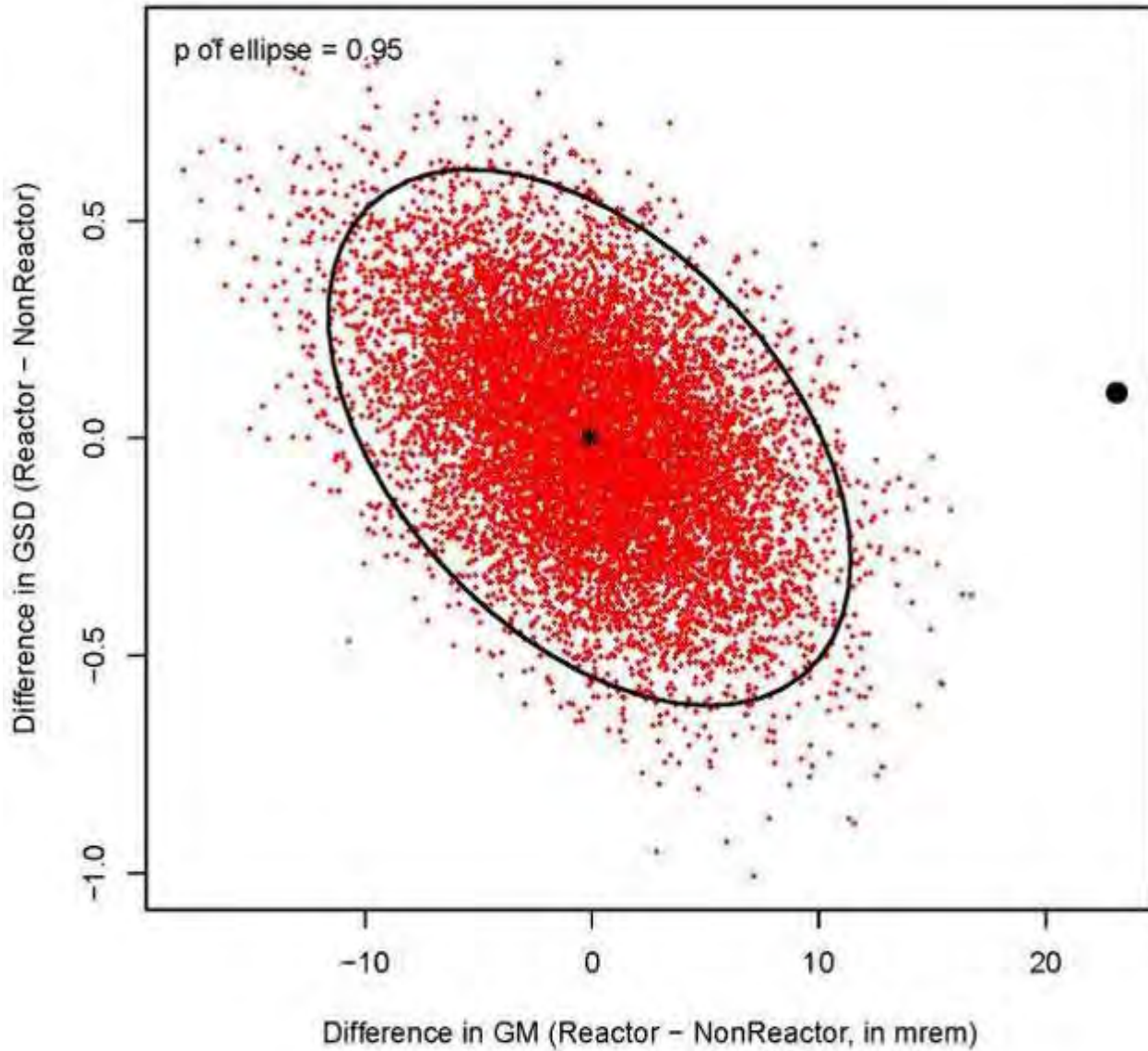


Figure B-68. SRS tritium dose 1970.

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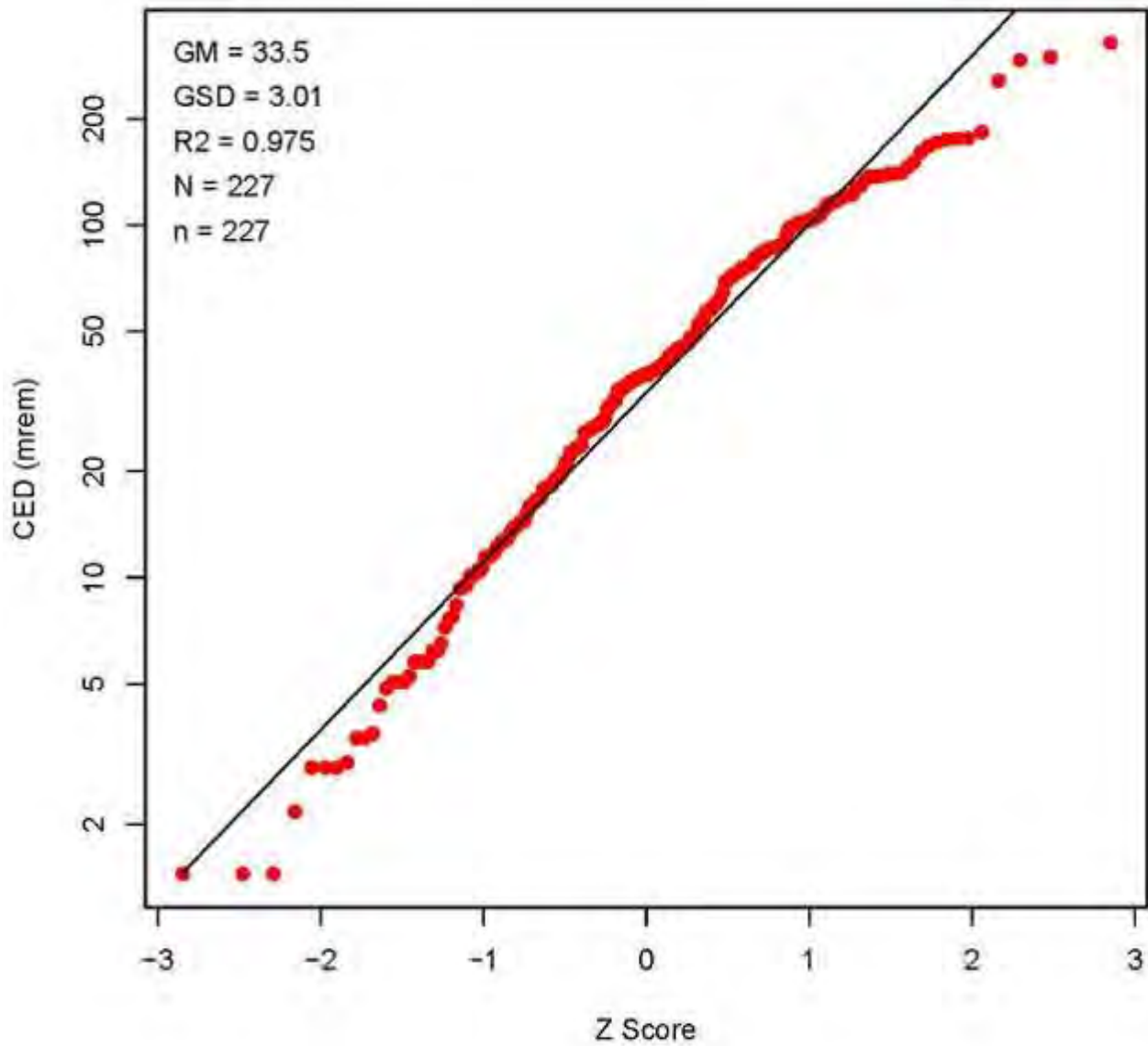


Figure B-69. SRS tritium dose 1971.

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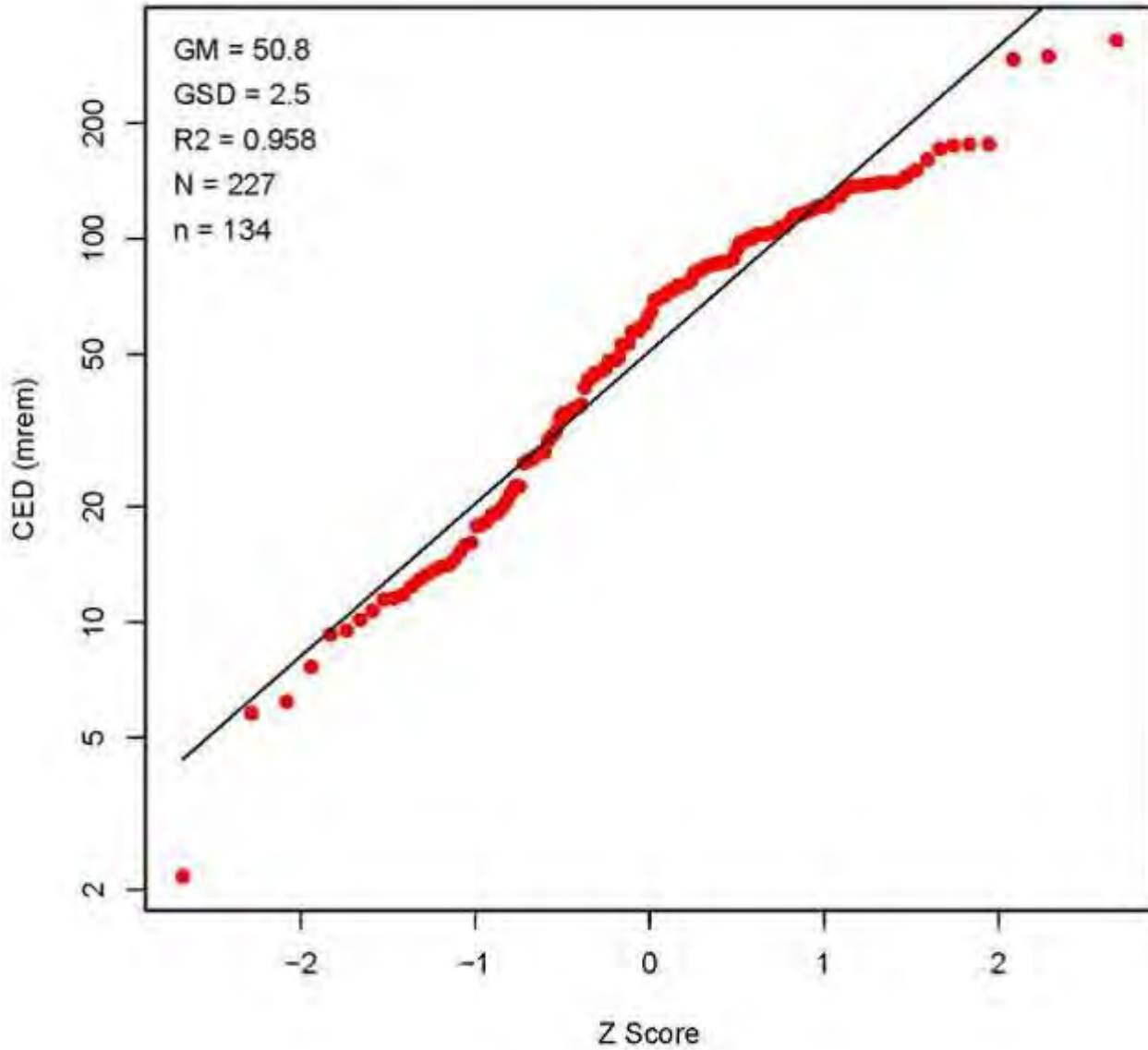


Figure B-70. SRS reactor tritium dose 1971.

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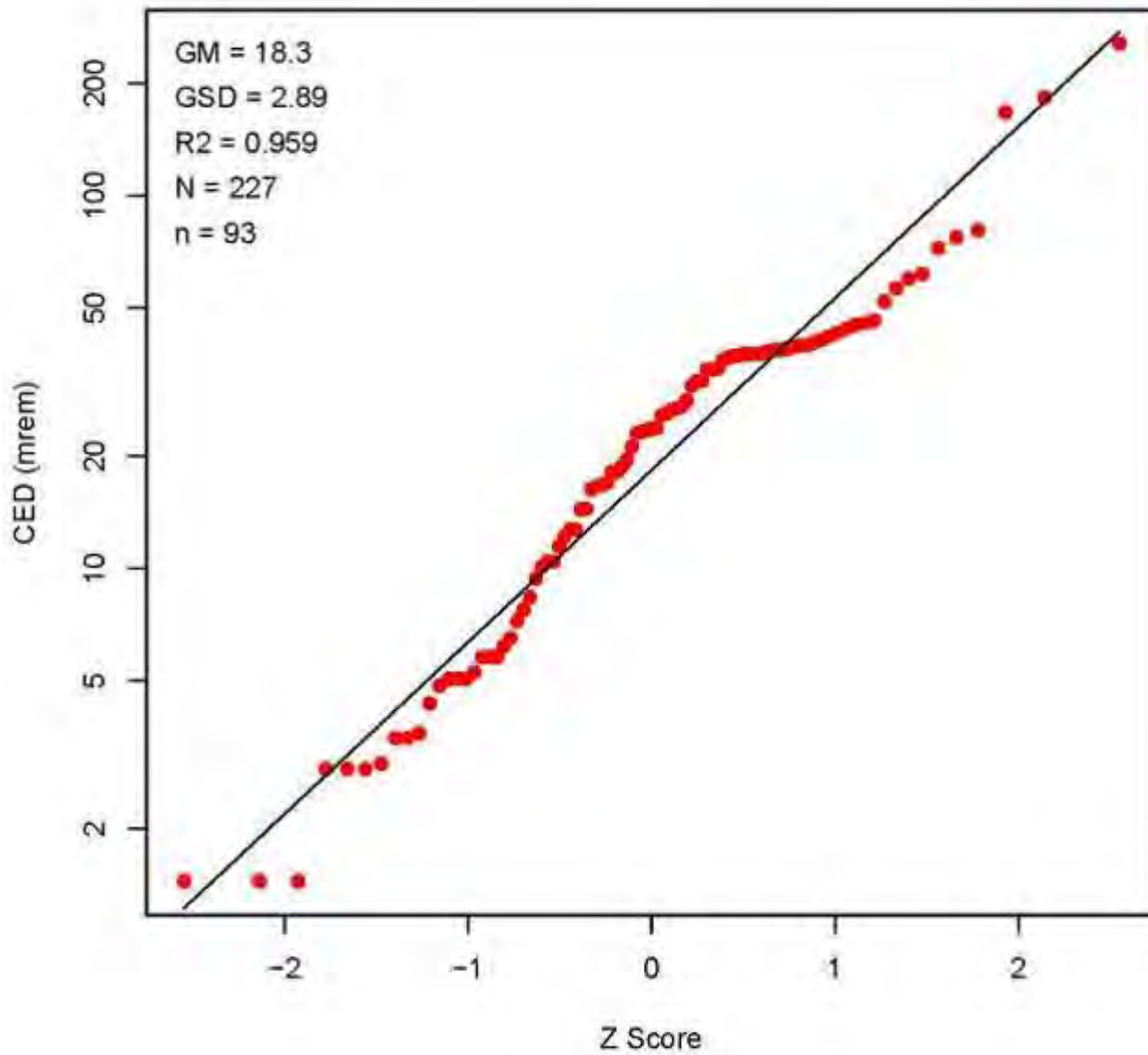


Figure B-71. SRS nonreactor tritium dose 1971.

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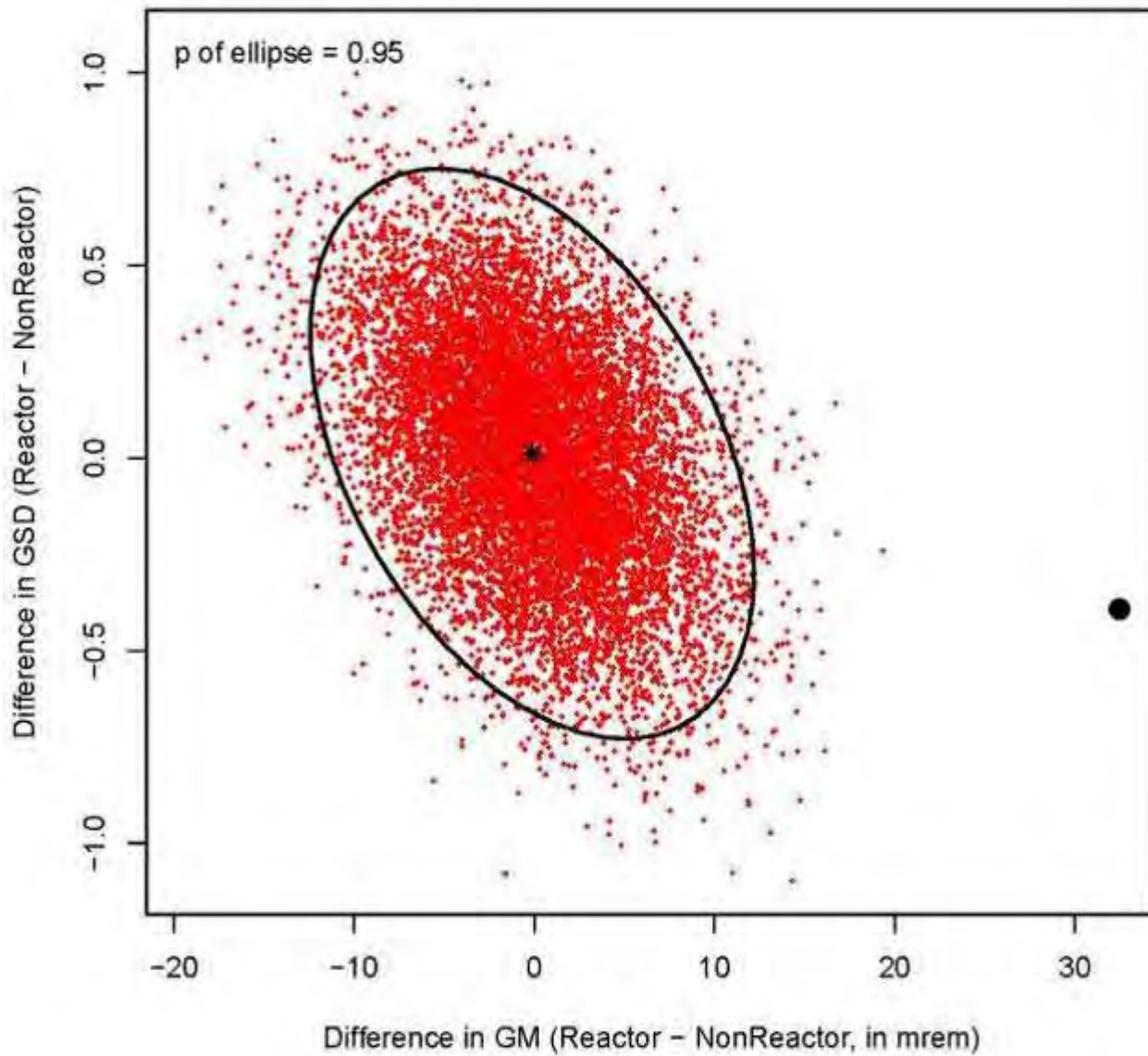


Figure B-72. SRS tritium dose 1971.

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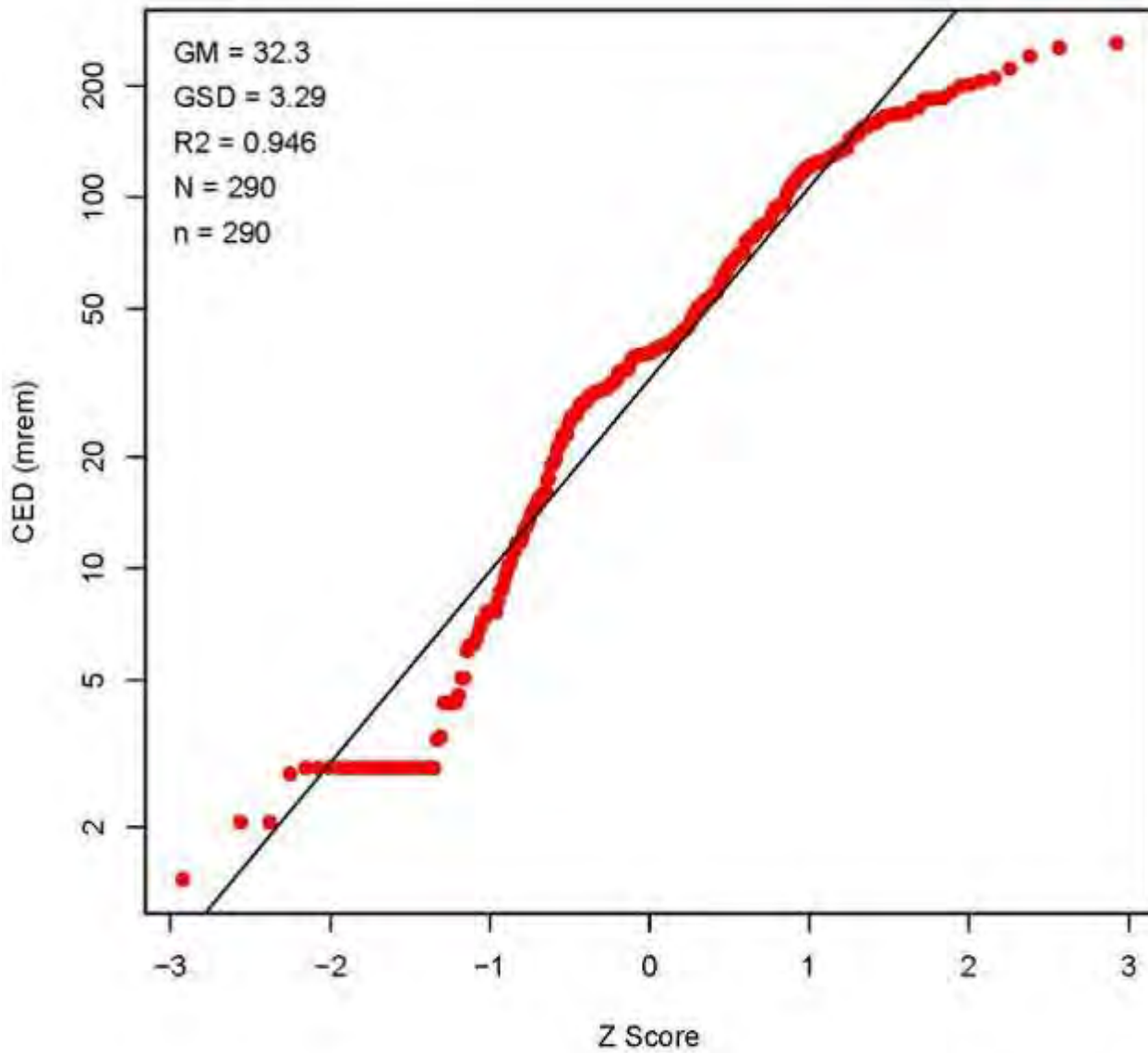


Figure B-73. SRS tritium dose 1972.

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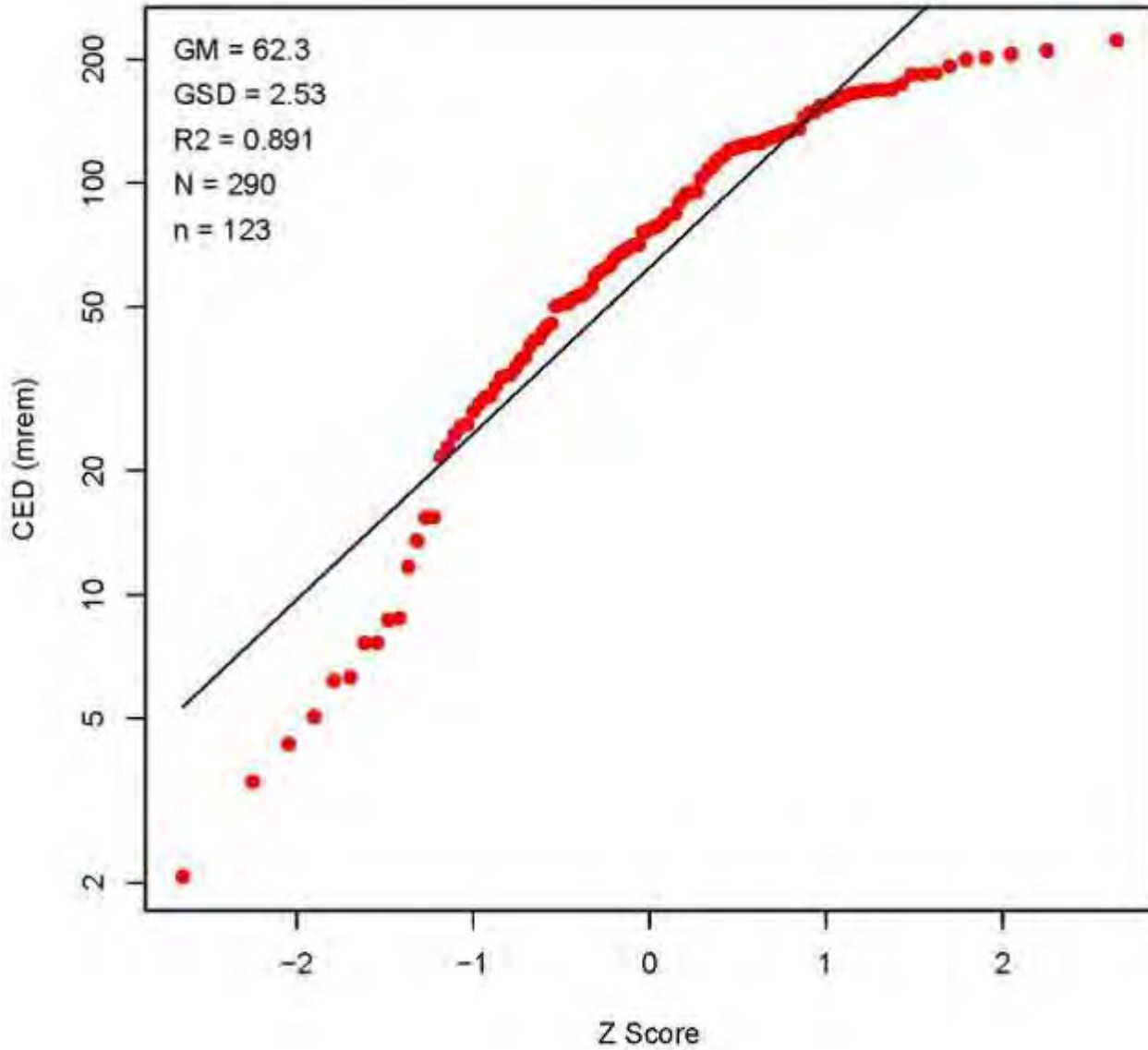


Figure B-74. SRS reactor tritium dose 1972.

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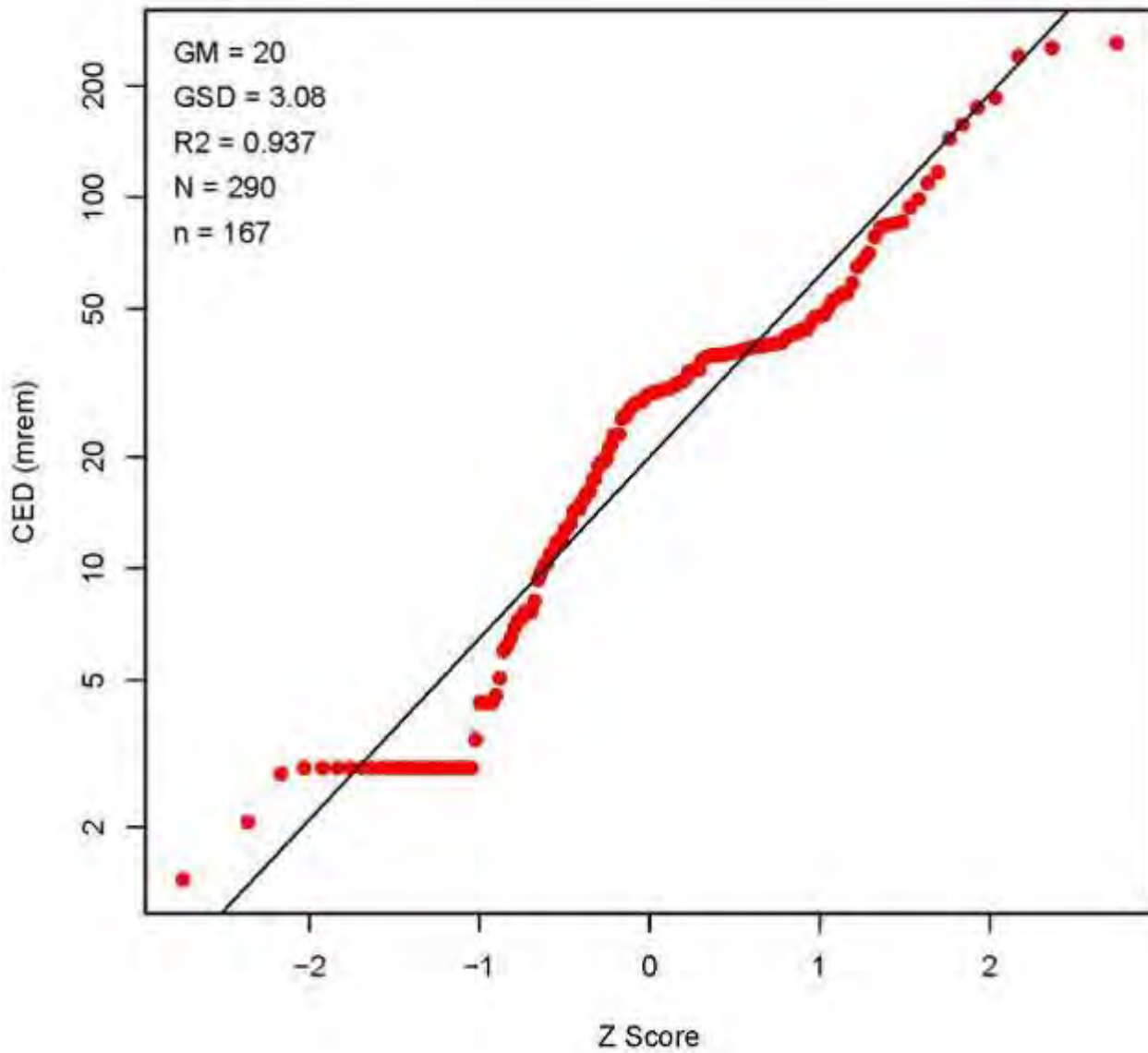


Figure B-75. SRS nonreactor tritium dose 1972.

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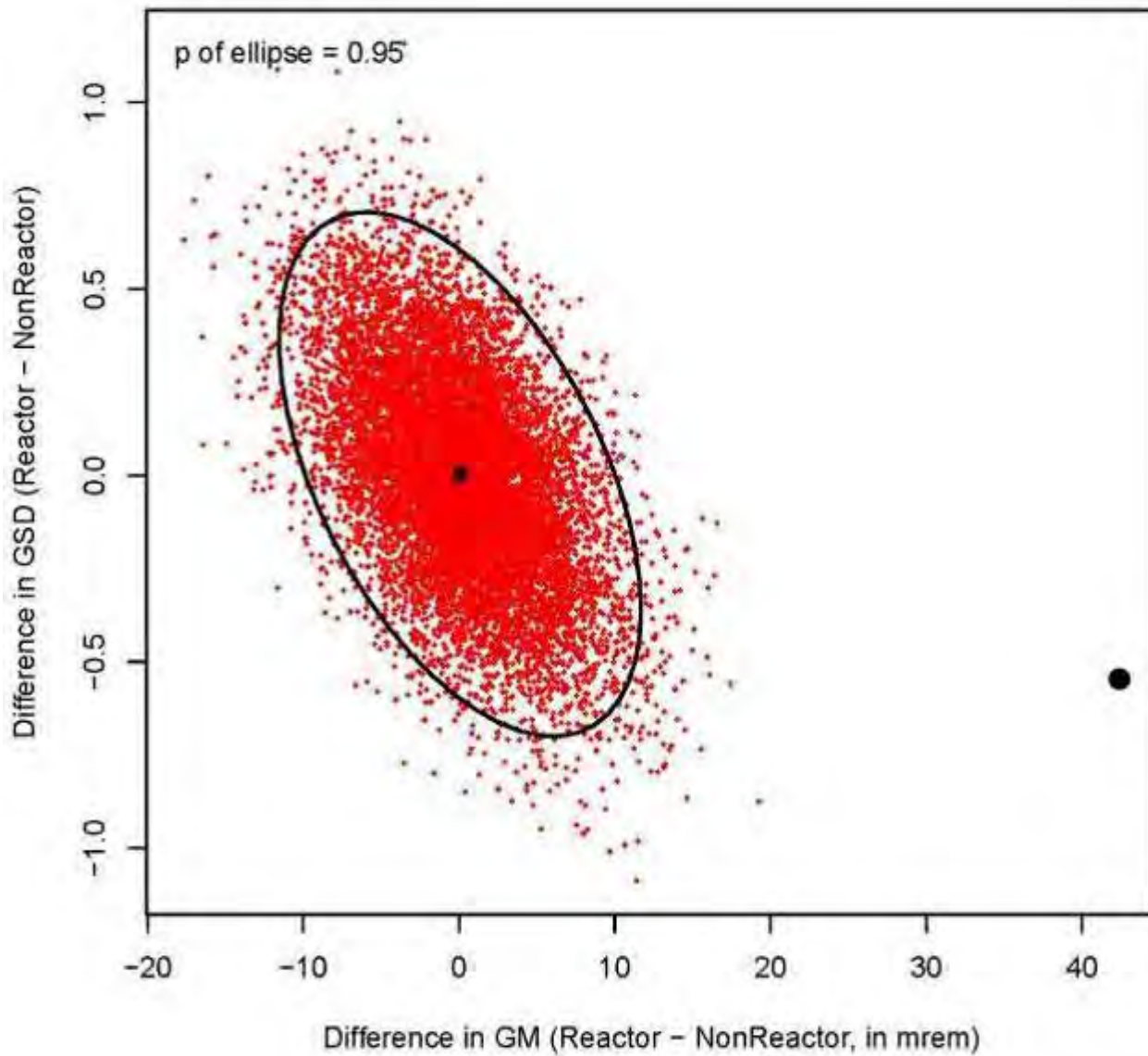


Figure B-76. SRS tritium dose 1972.

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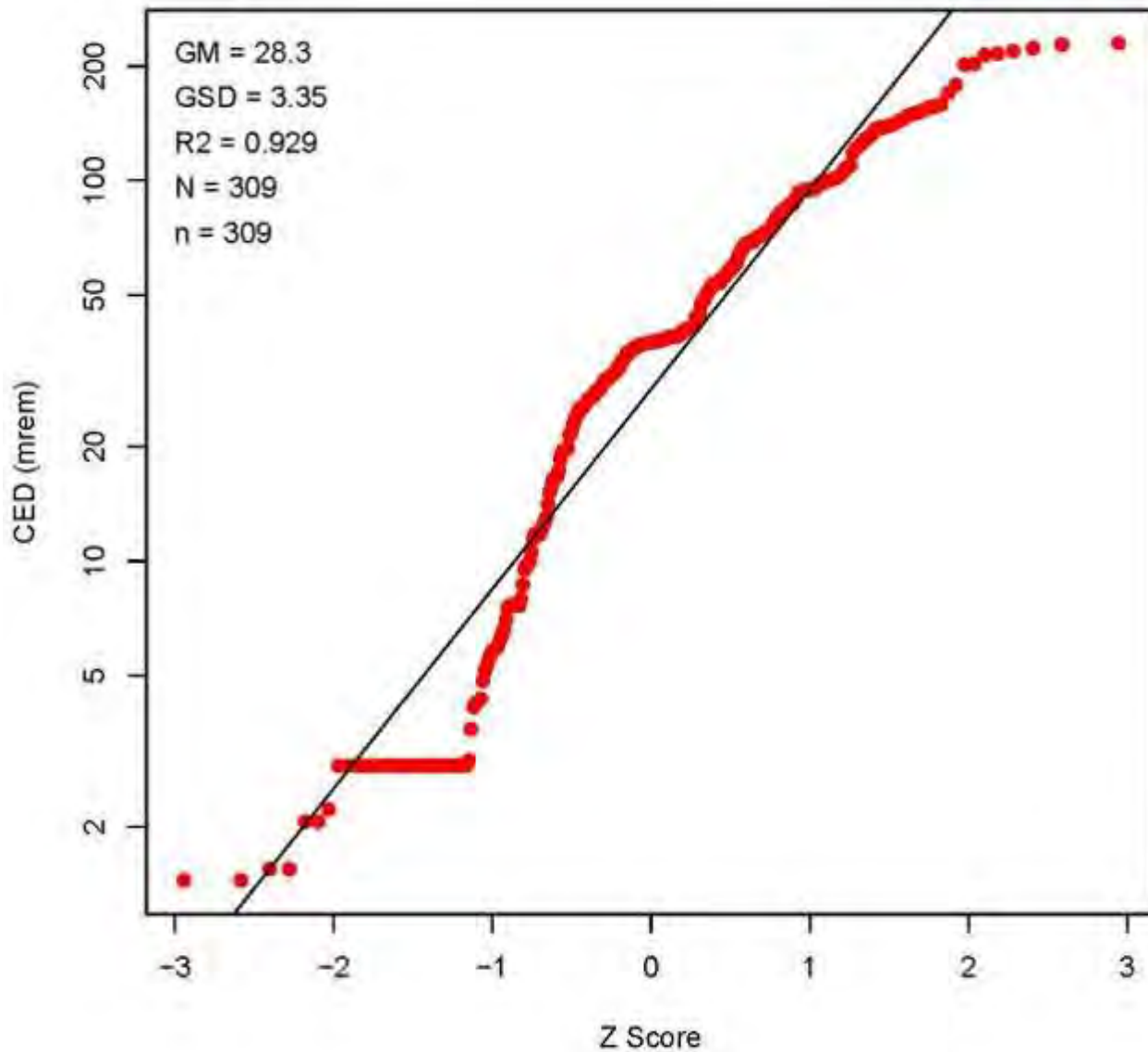


Figure B-77. SRS tritium dose 1973.

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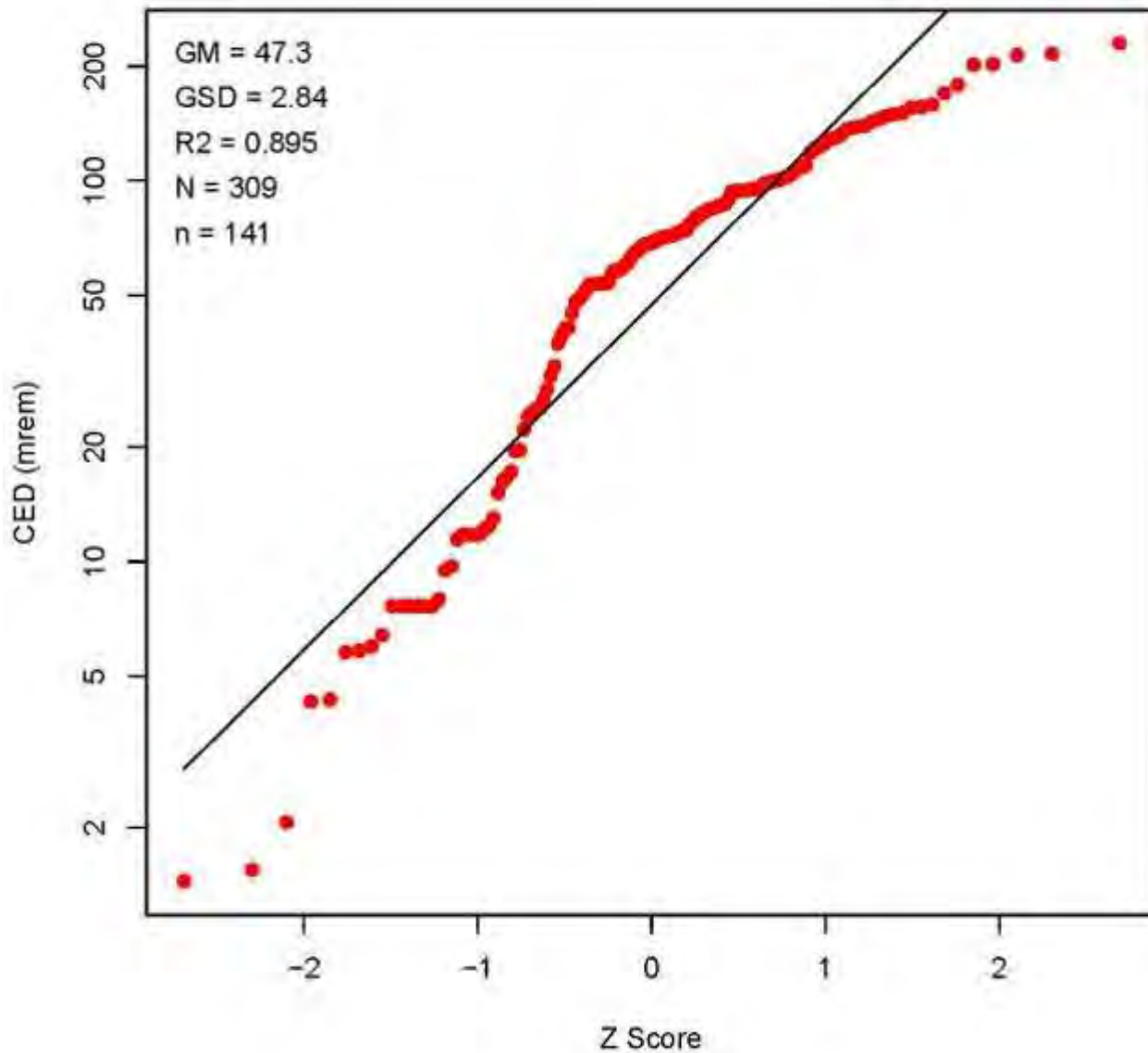


Figure B-78. SRS reactor tritium dose 1973.

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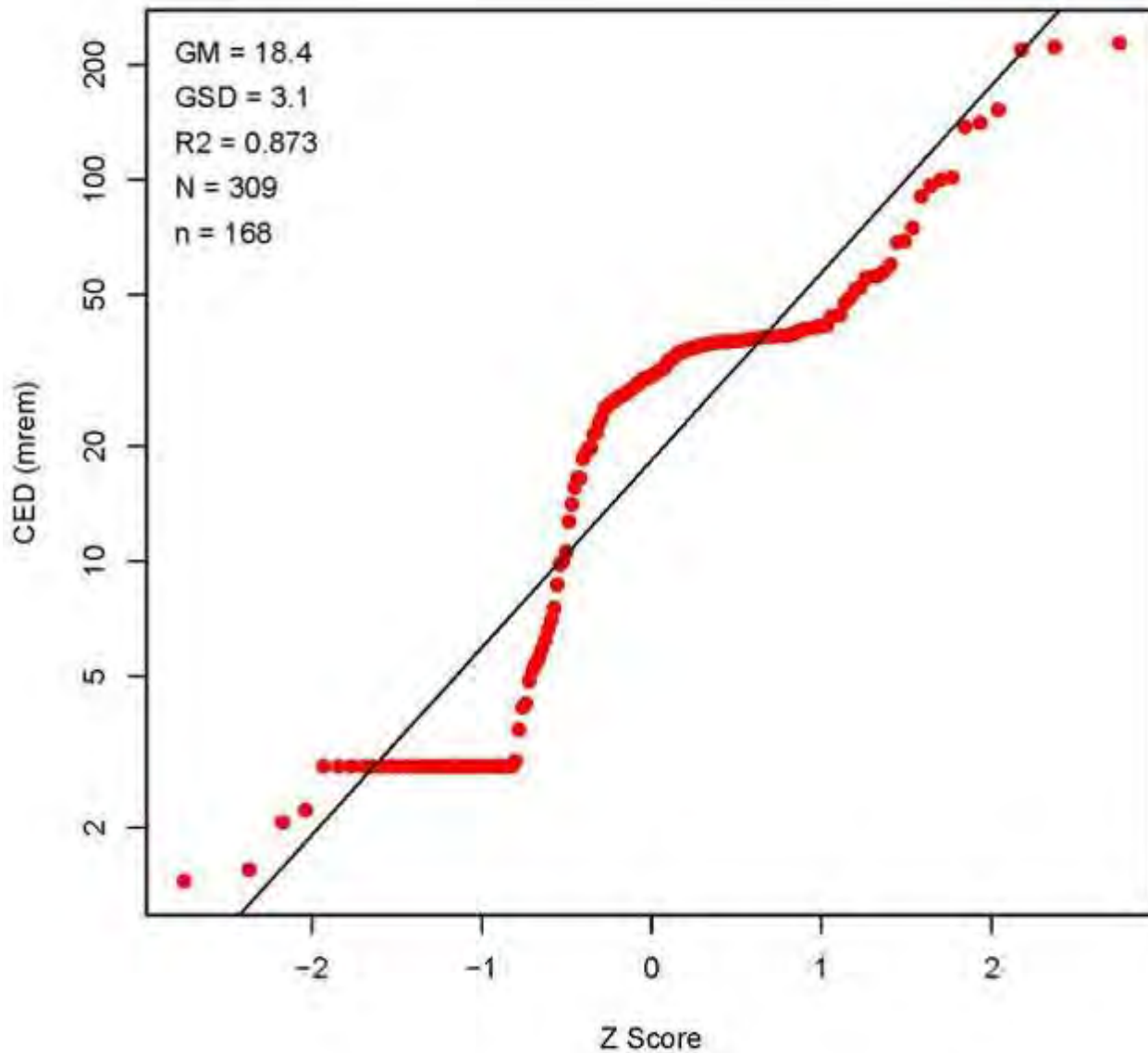


Figure B-79. SRS nonreactor tritium dose 1973.

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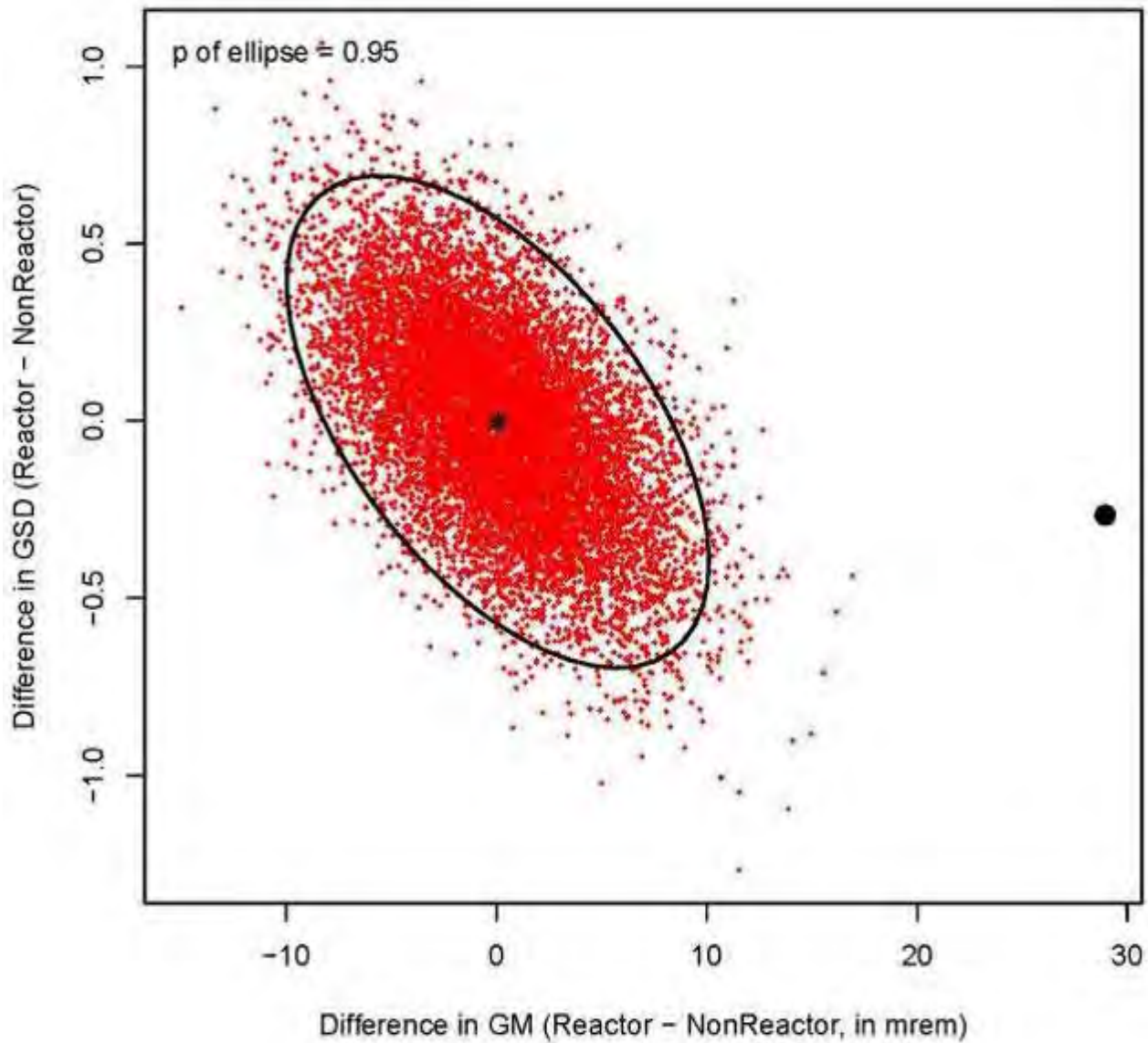


Figure B-80. SRS tritium dose 1973.

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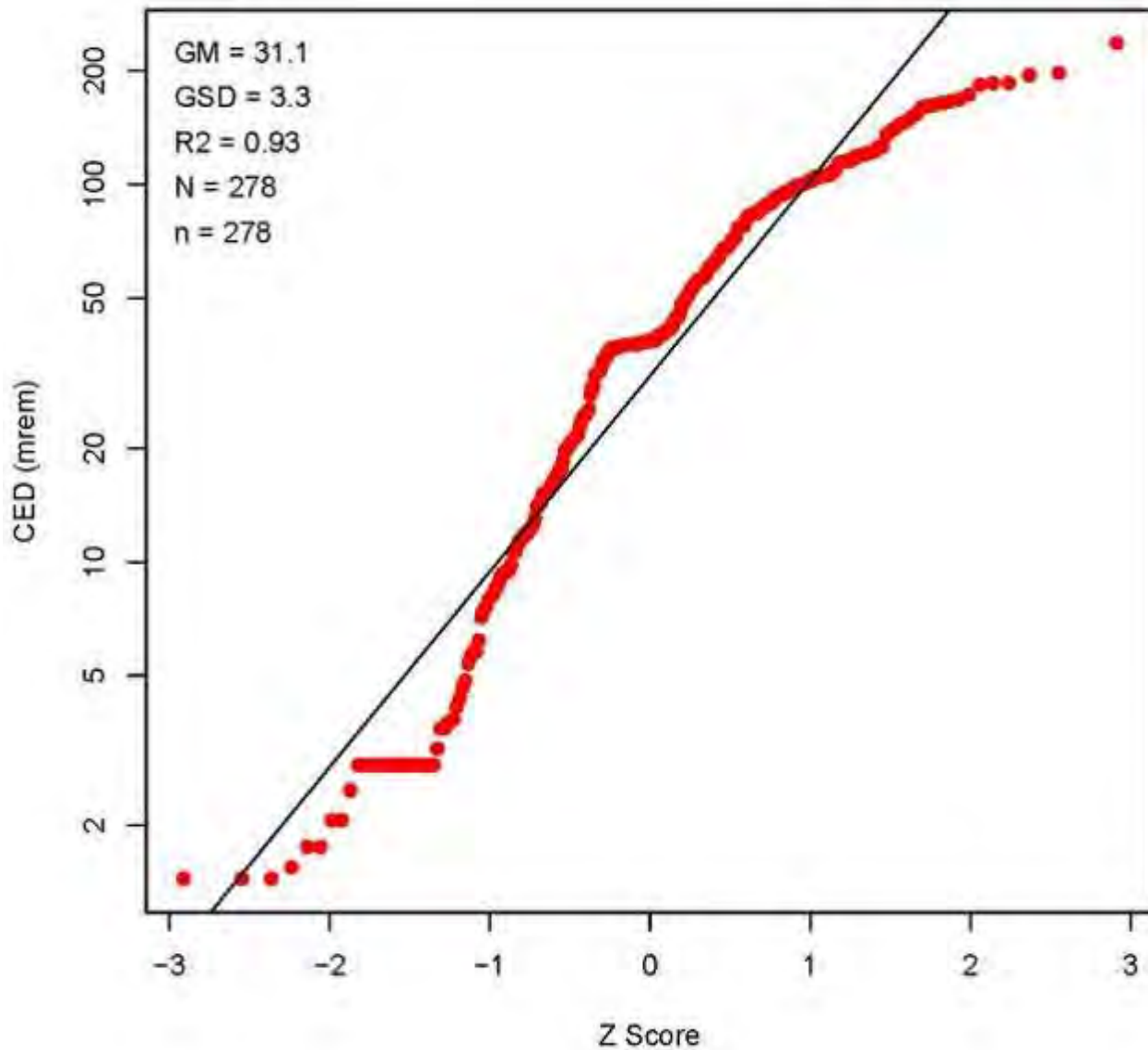


Figure B-81. SRS tritium dose 1974.

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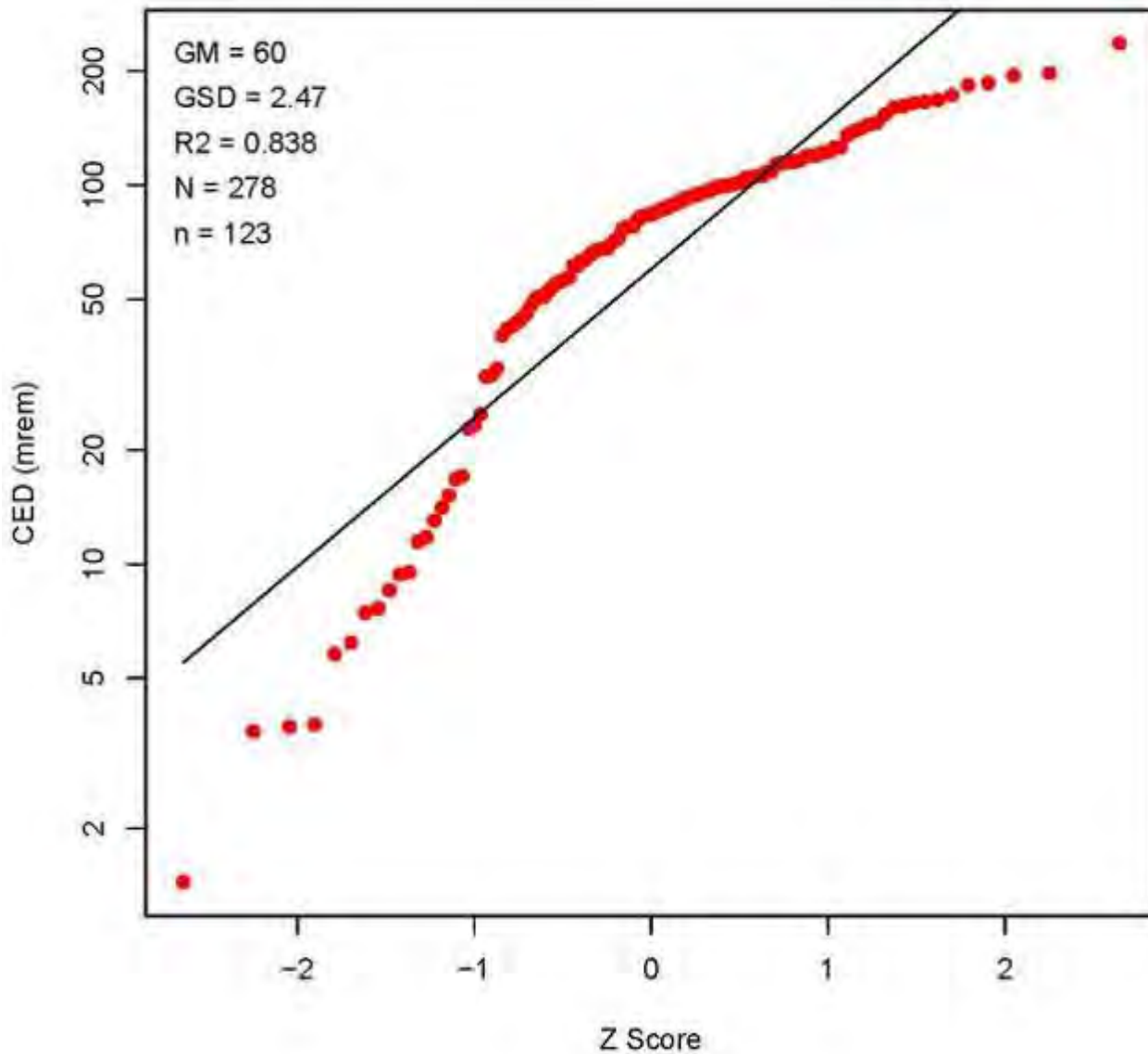


Figure B-82. SRS reactor tritium dose 1974.

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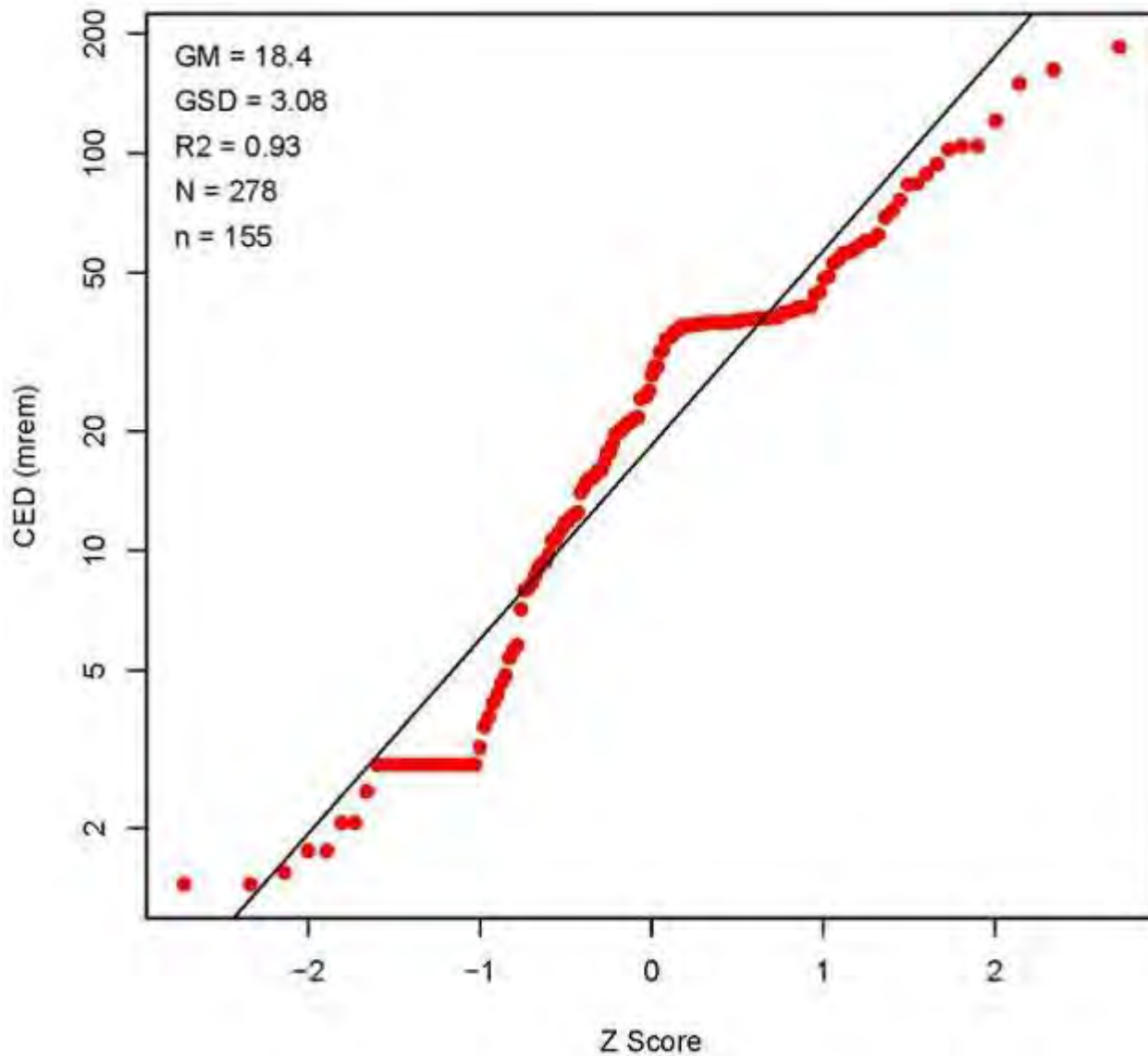


Figure B-83. SRS nonreactor tritium dose 1974.

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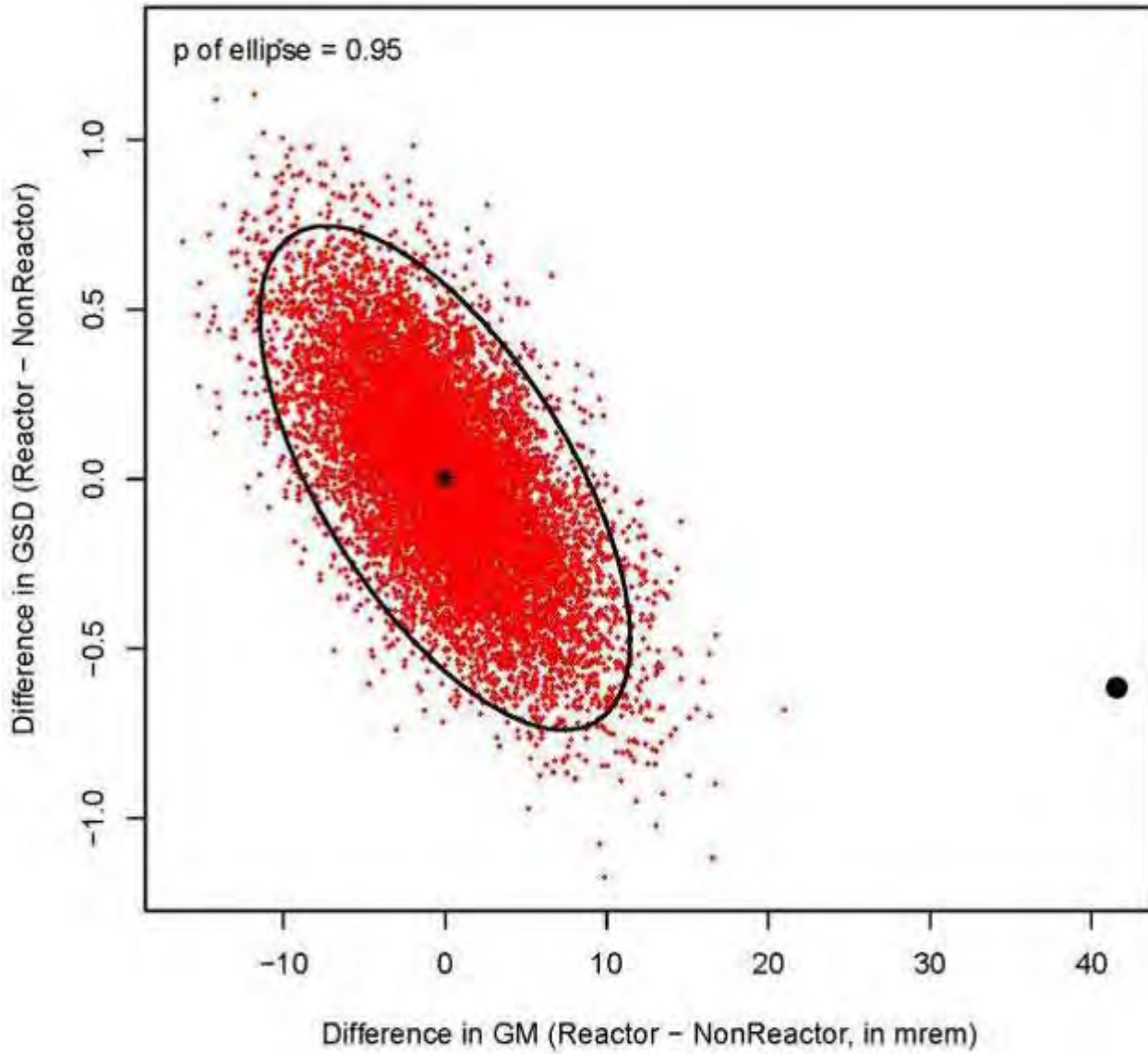


Figure B-84. SRS tritium dose 1974.

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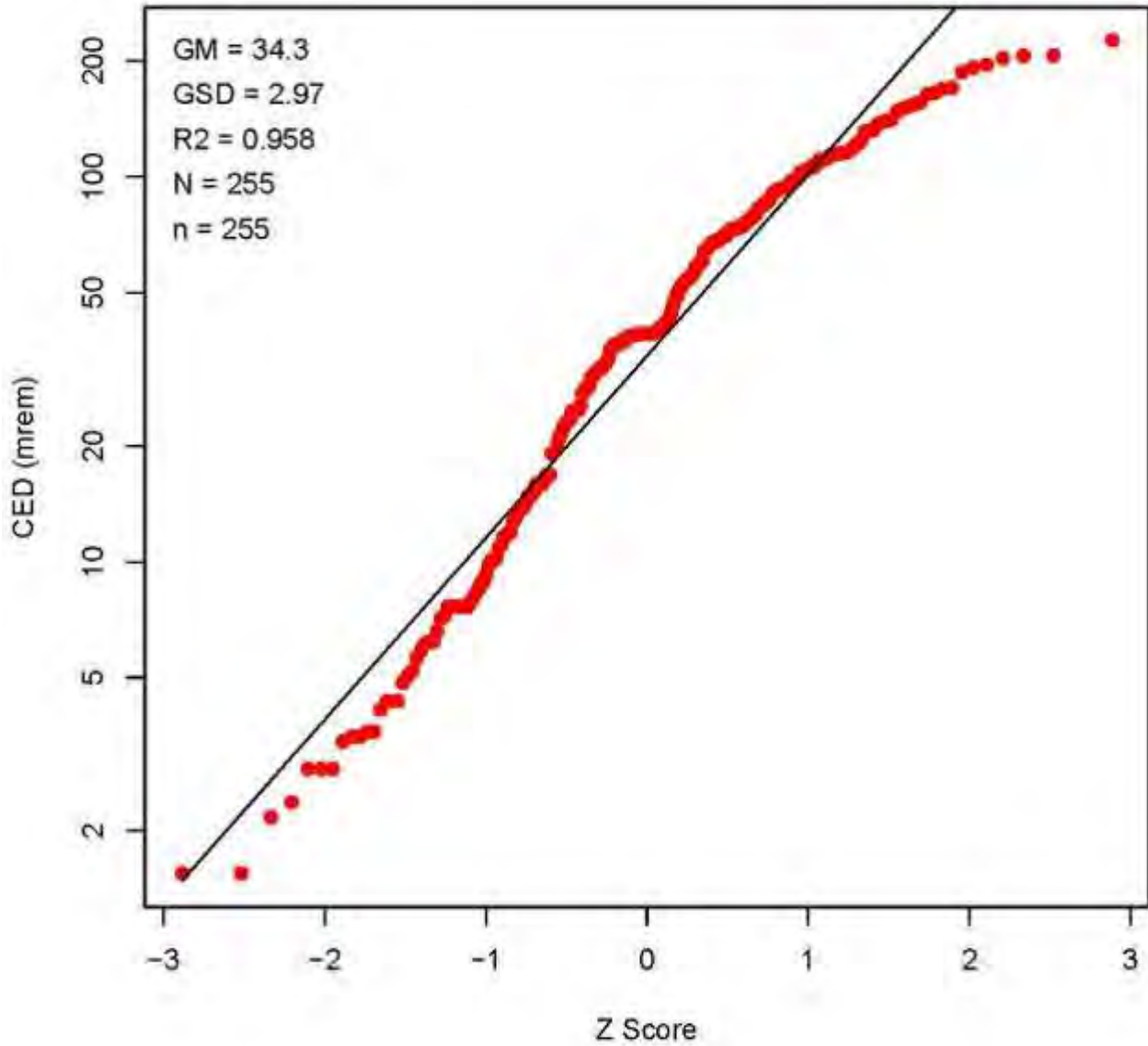


Figure B-85. SRS tritium dose 1975.

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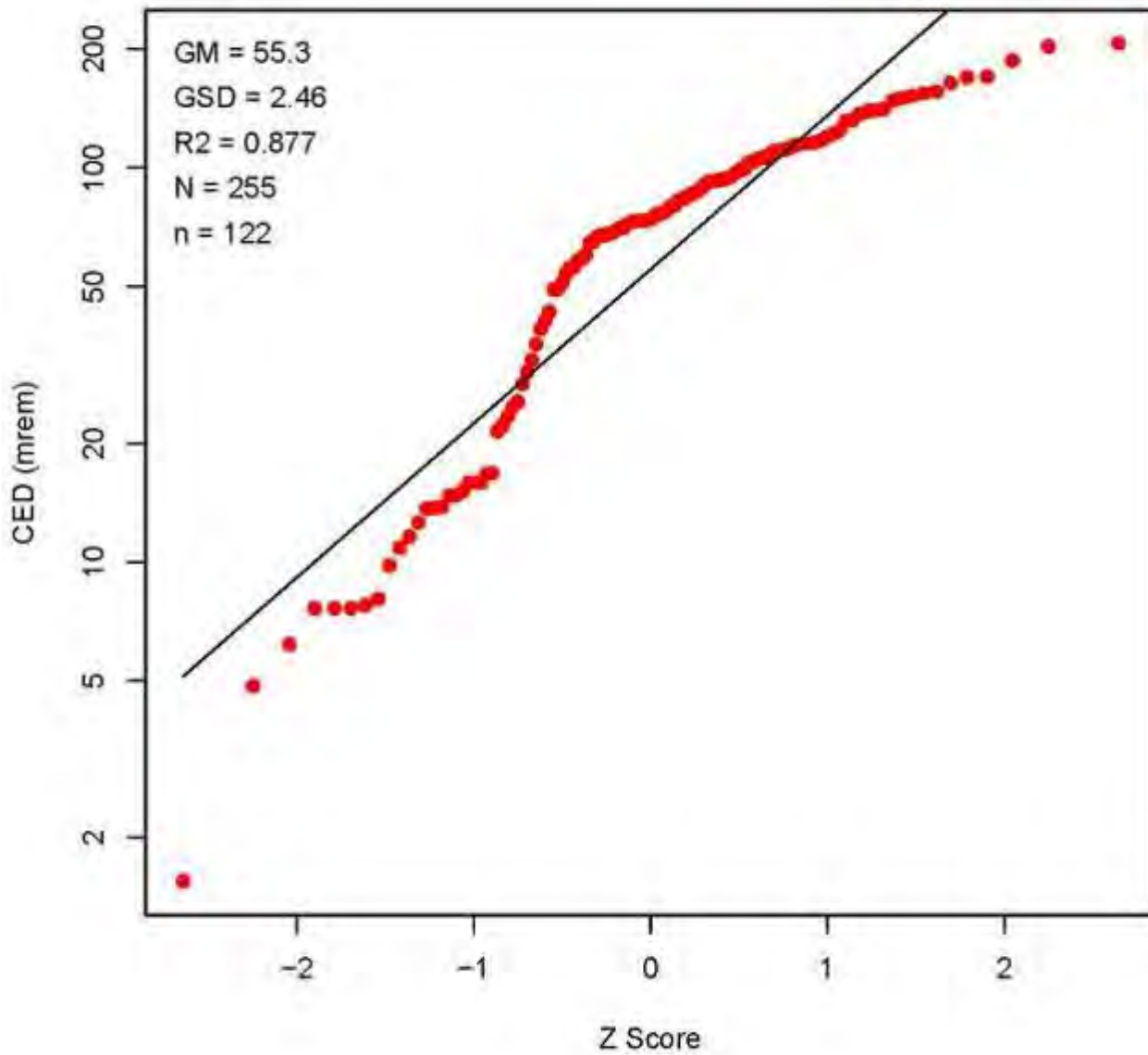


Figure B-86. SRS reactor tritium dose 1975.

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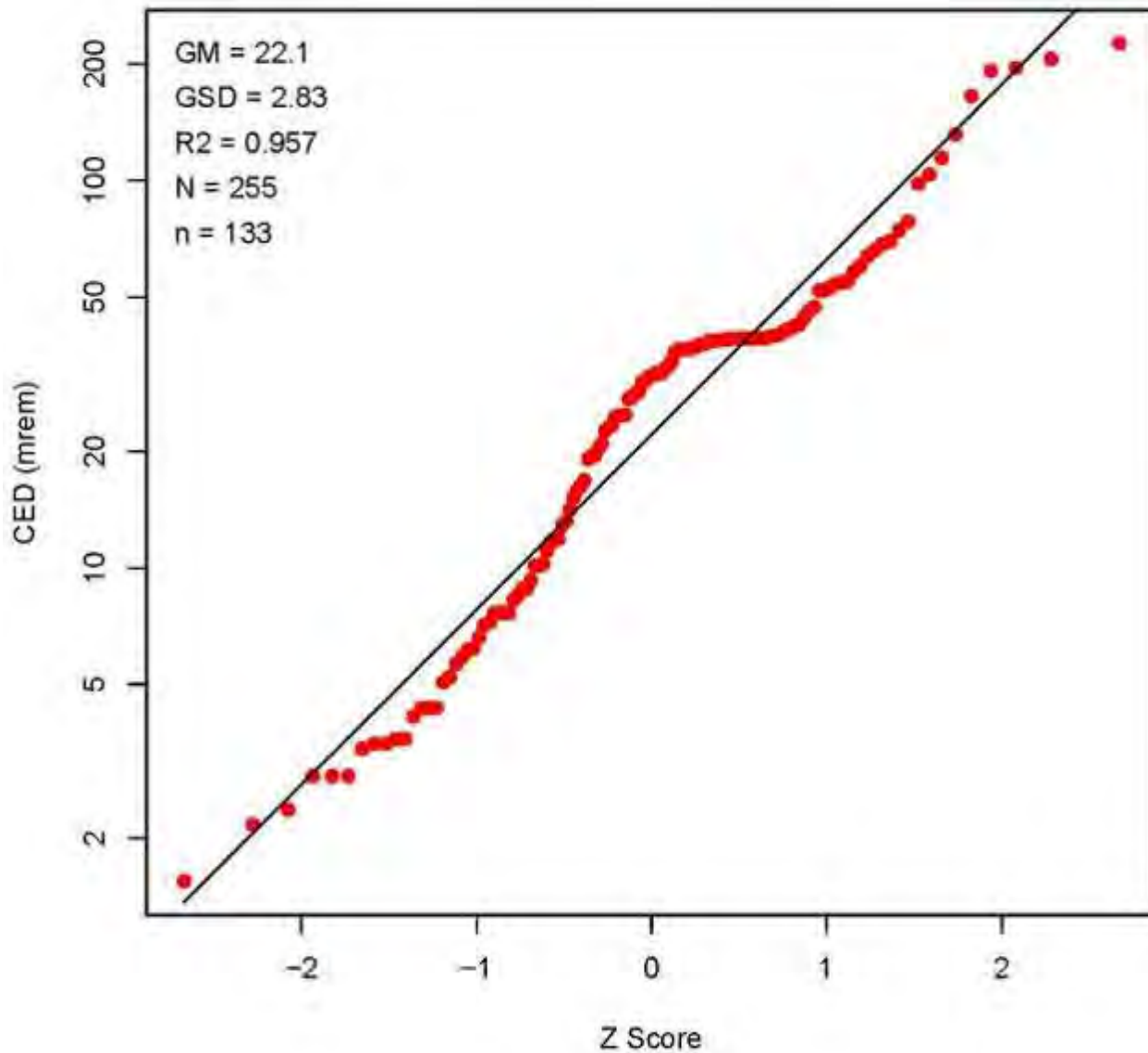


Figure B-87. SRS nonreactor tritium dose 1975.

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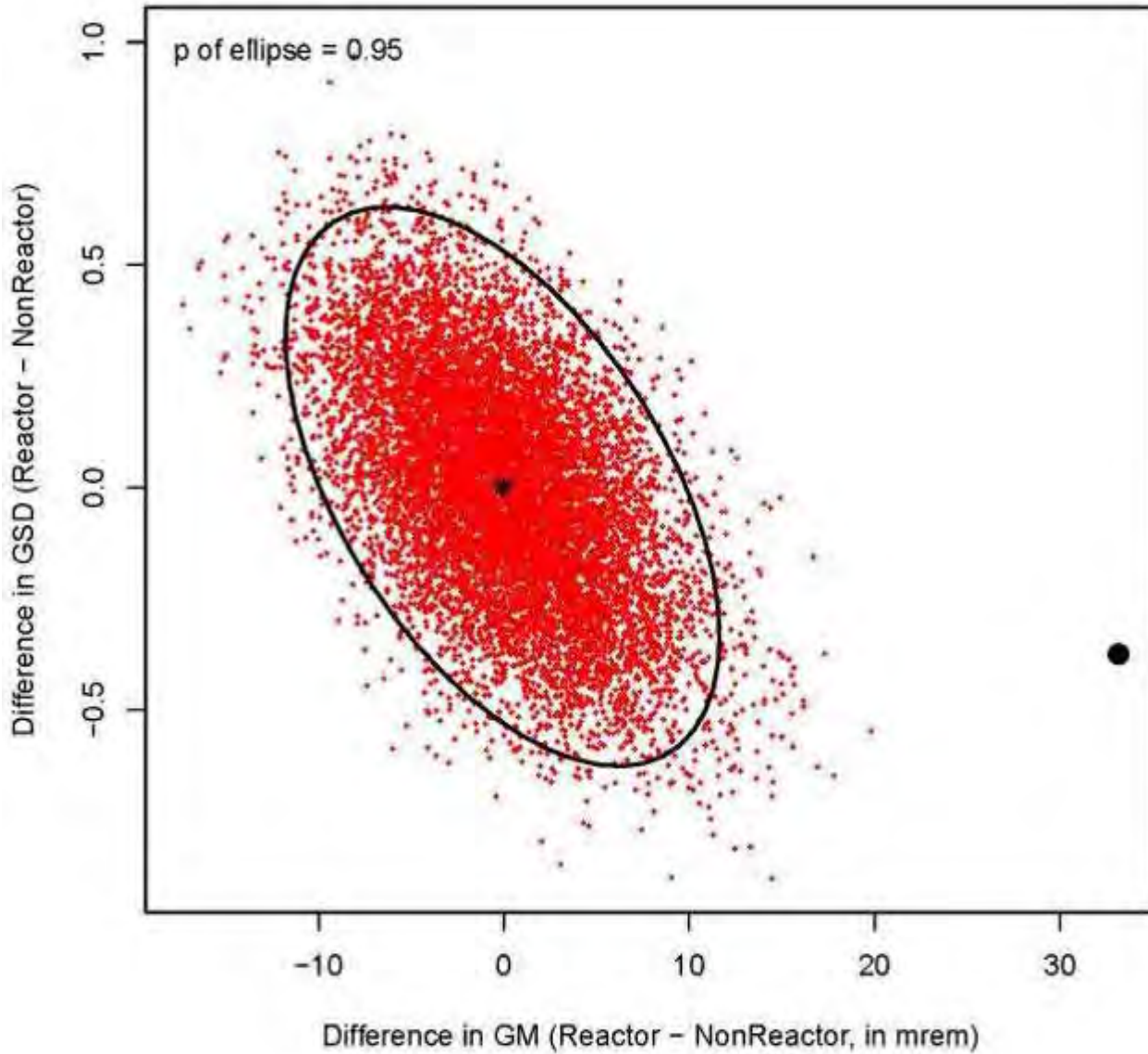


Figure B-88. SRS tritium dose 1975.

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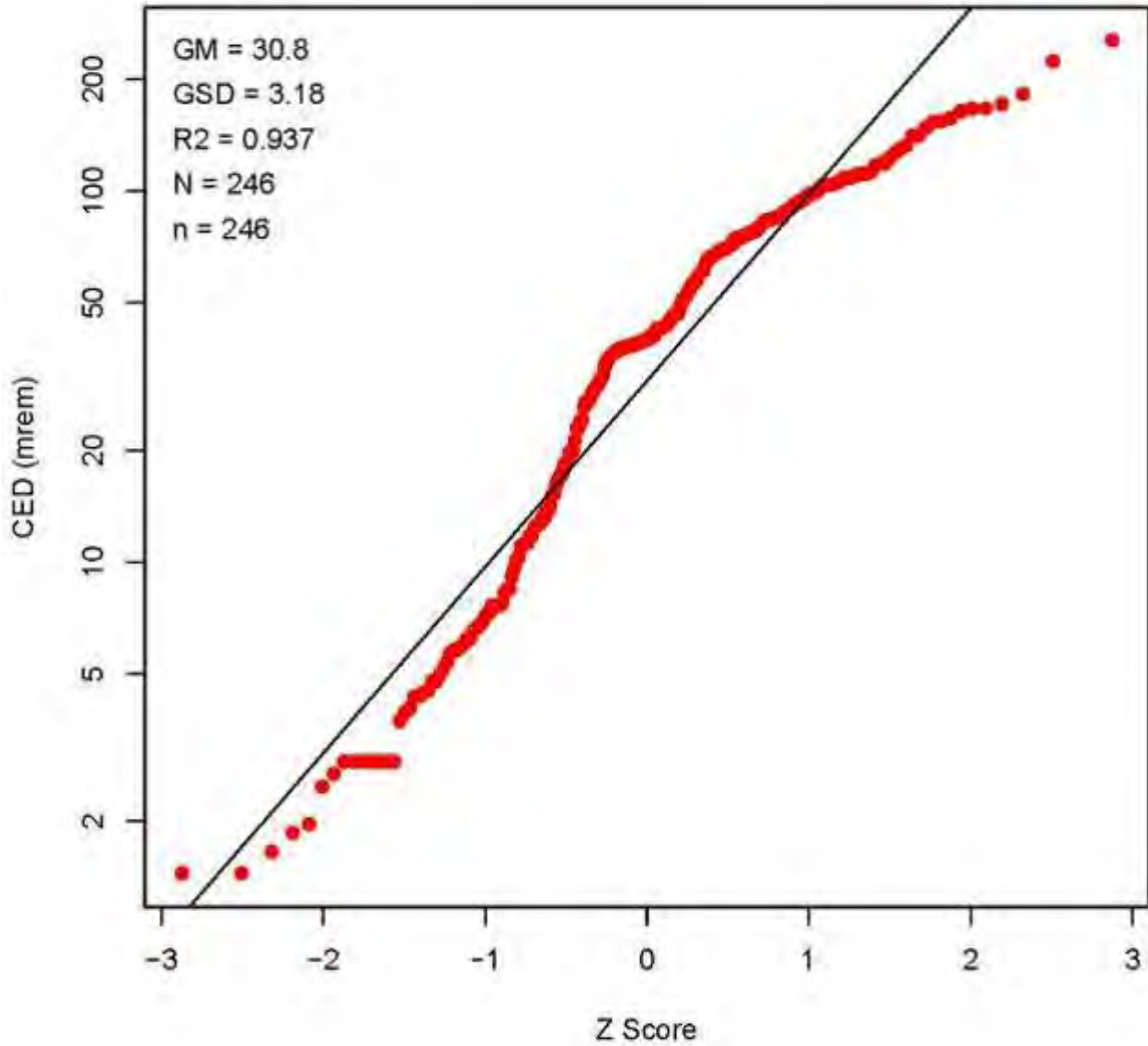


Figure B-89. SRS tritium dose 1976.

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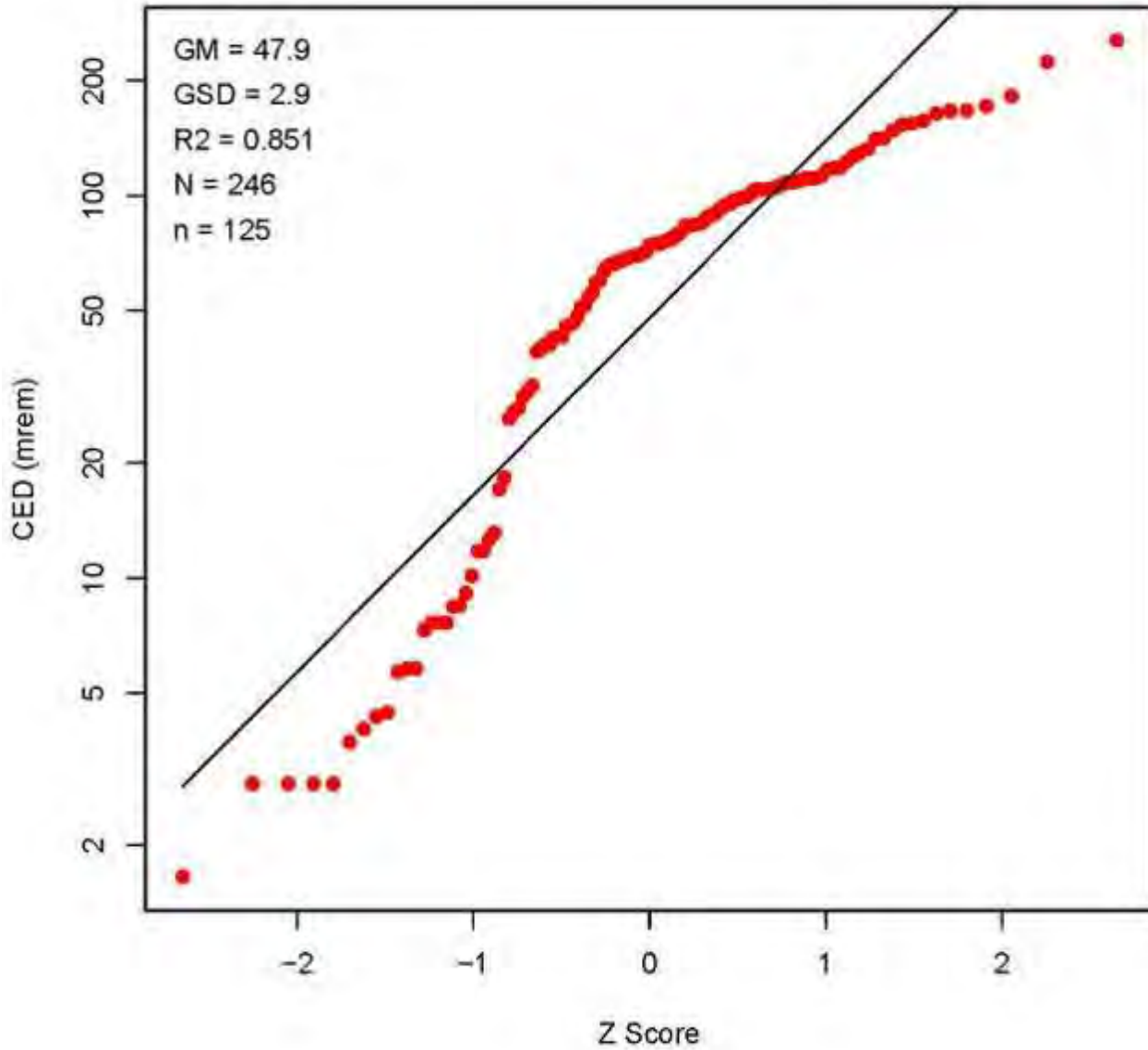


Figure B-90. SRS reactor tritium dose 1976.

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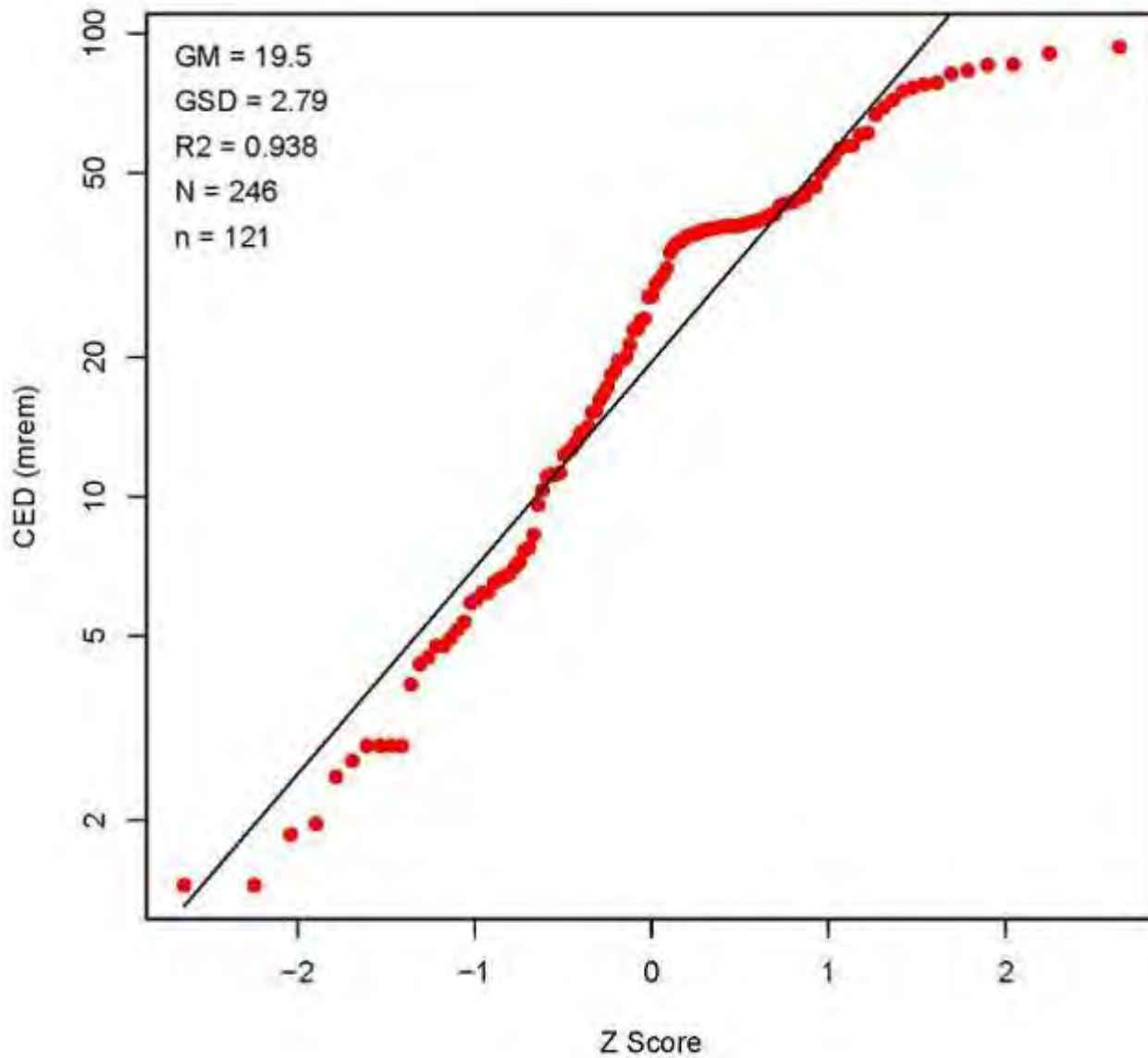


Figure B-91. SRS nonreactor tritium dose 1976.

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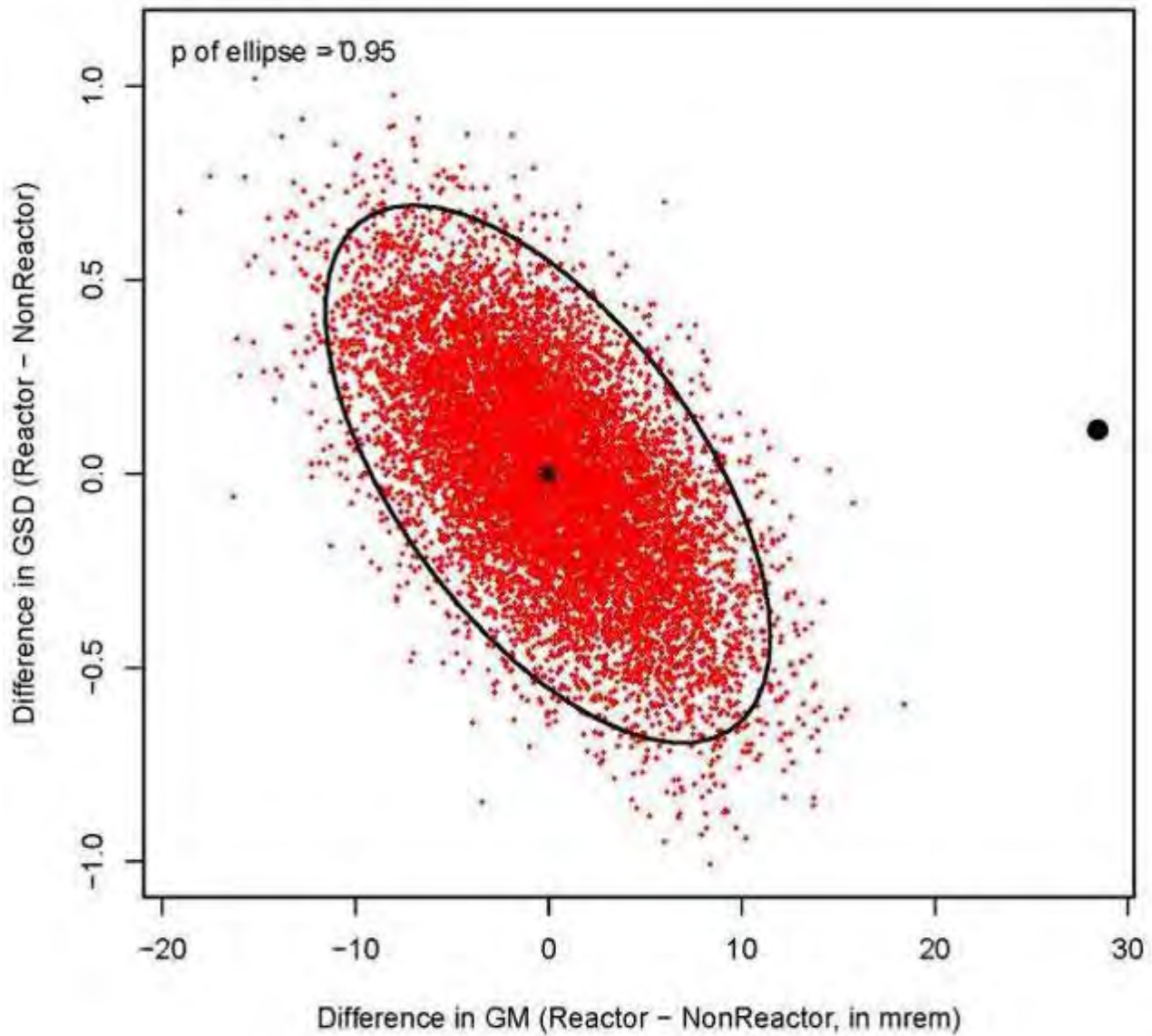


Figure B-92. SRS tritium dose 1976.

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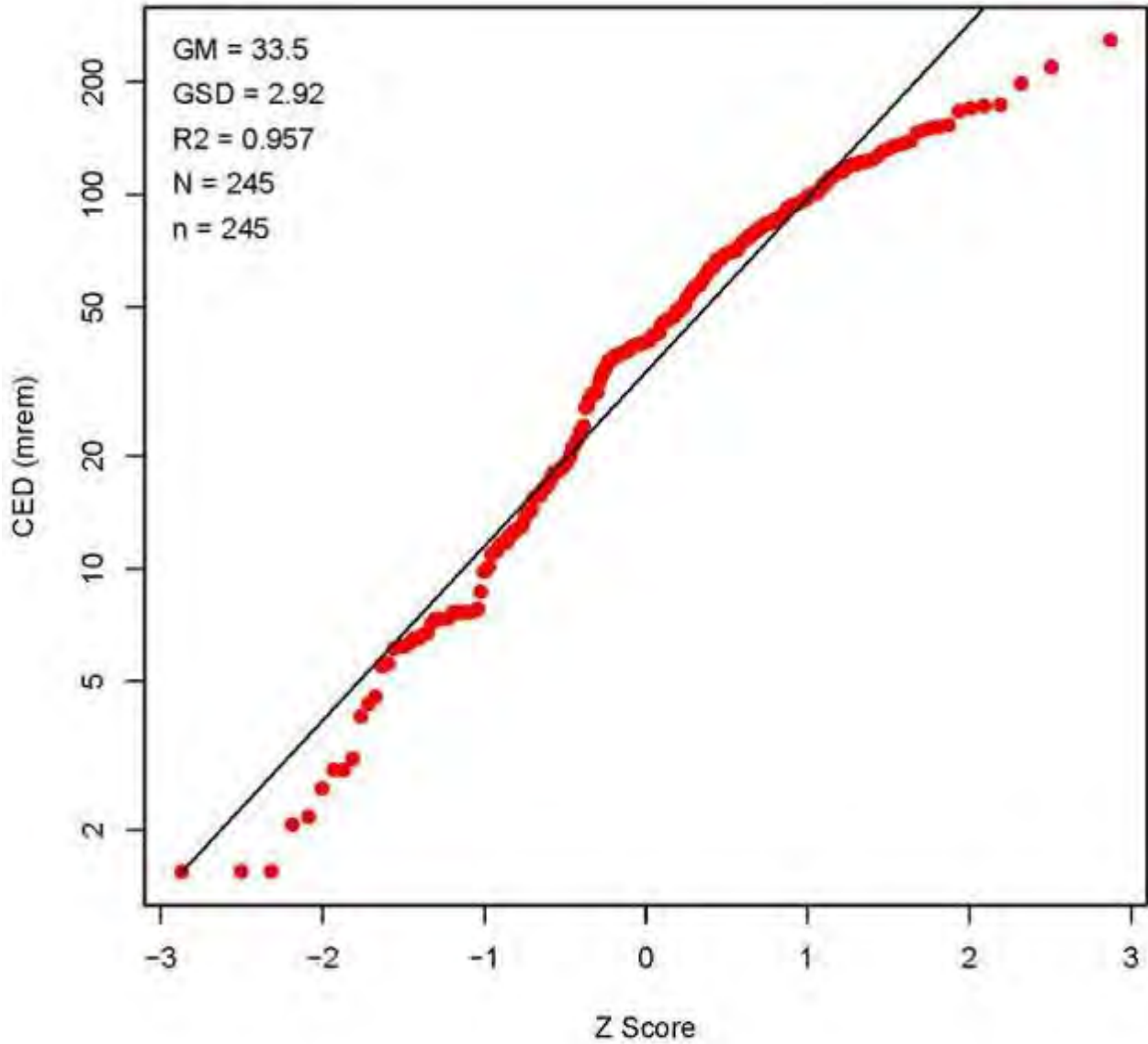


Figure B-93. SRS tritium dose 1977.

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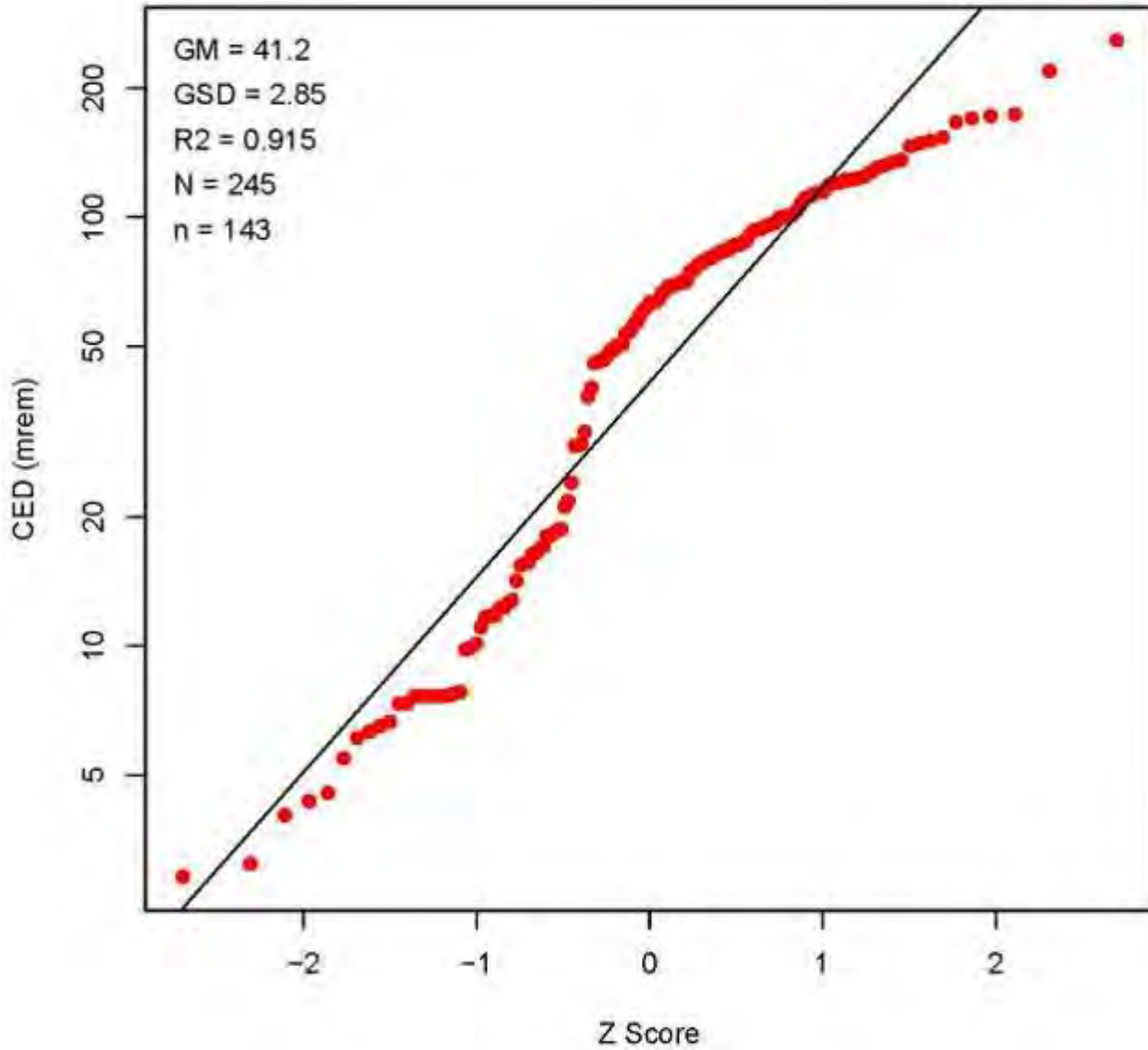


Figure B-94. SRS reactor tritium dose 1977.

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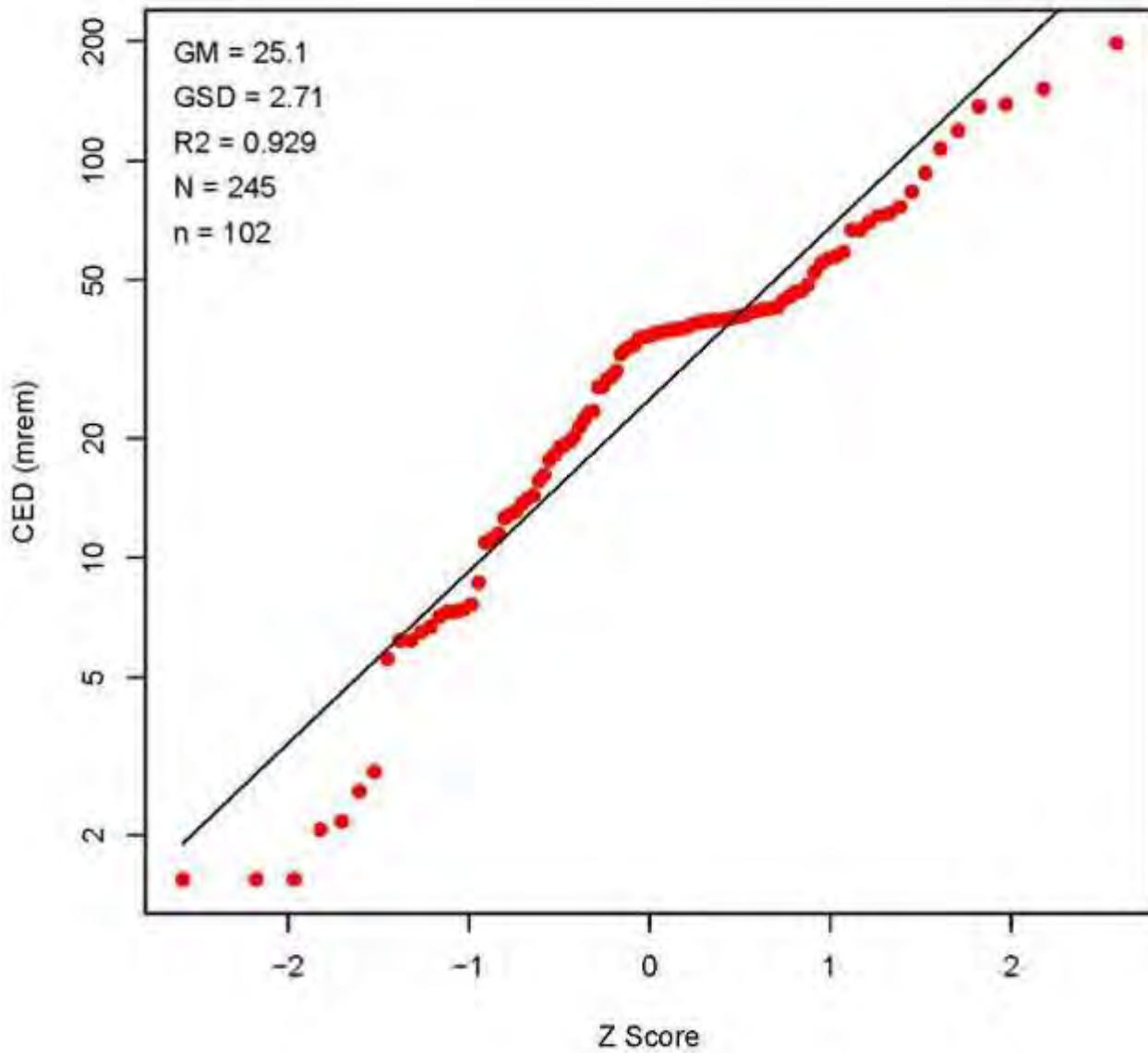


Figure B-95. SRS nonreactor tritium dose 1977.

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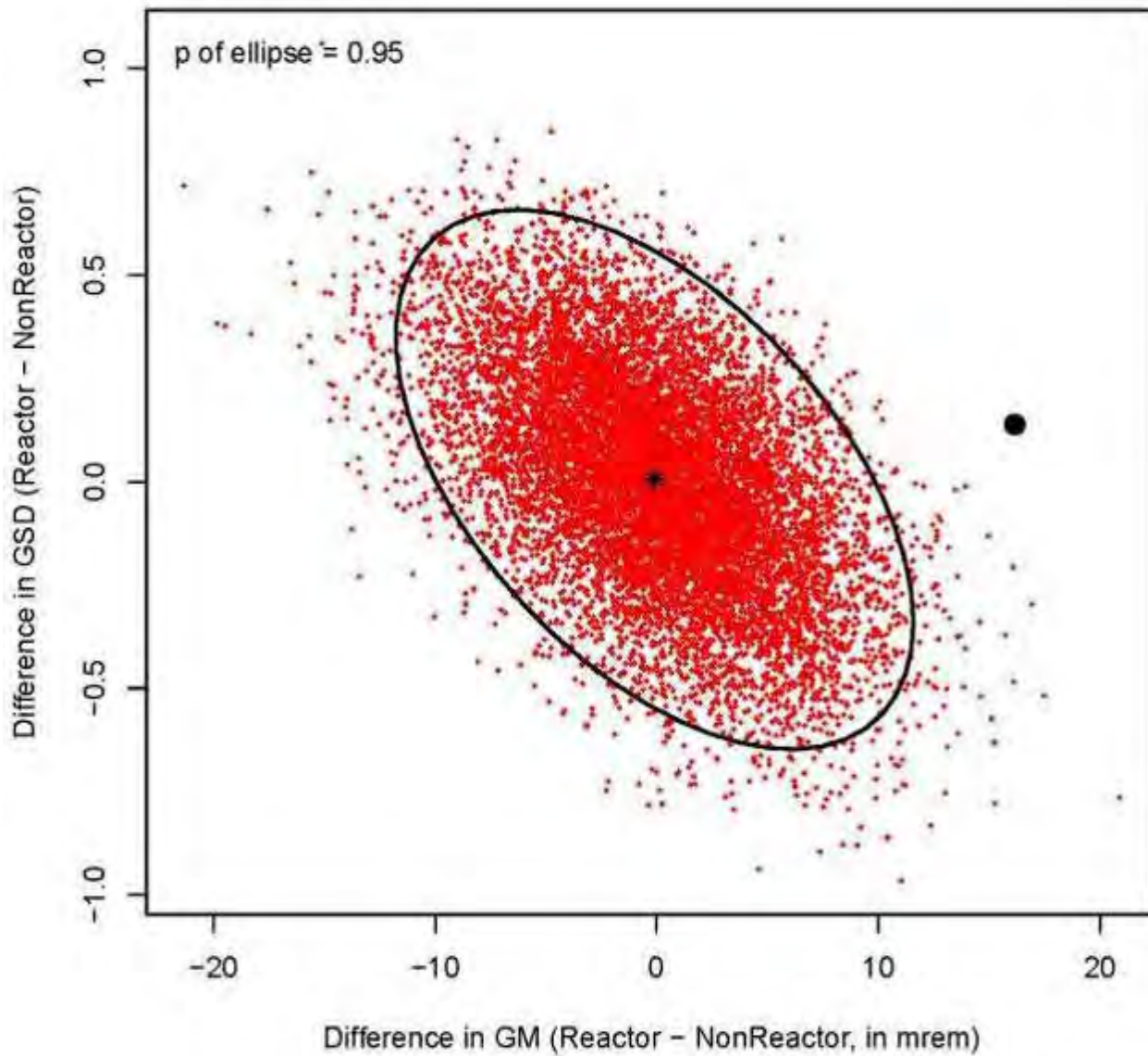


Figure B-96. SRS tritium dose 1977.

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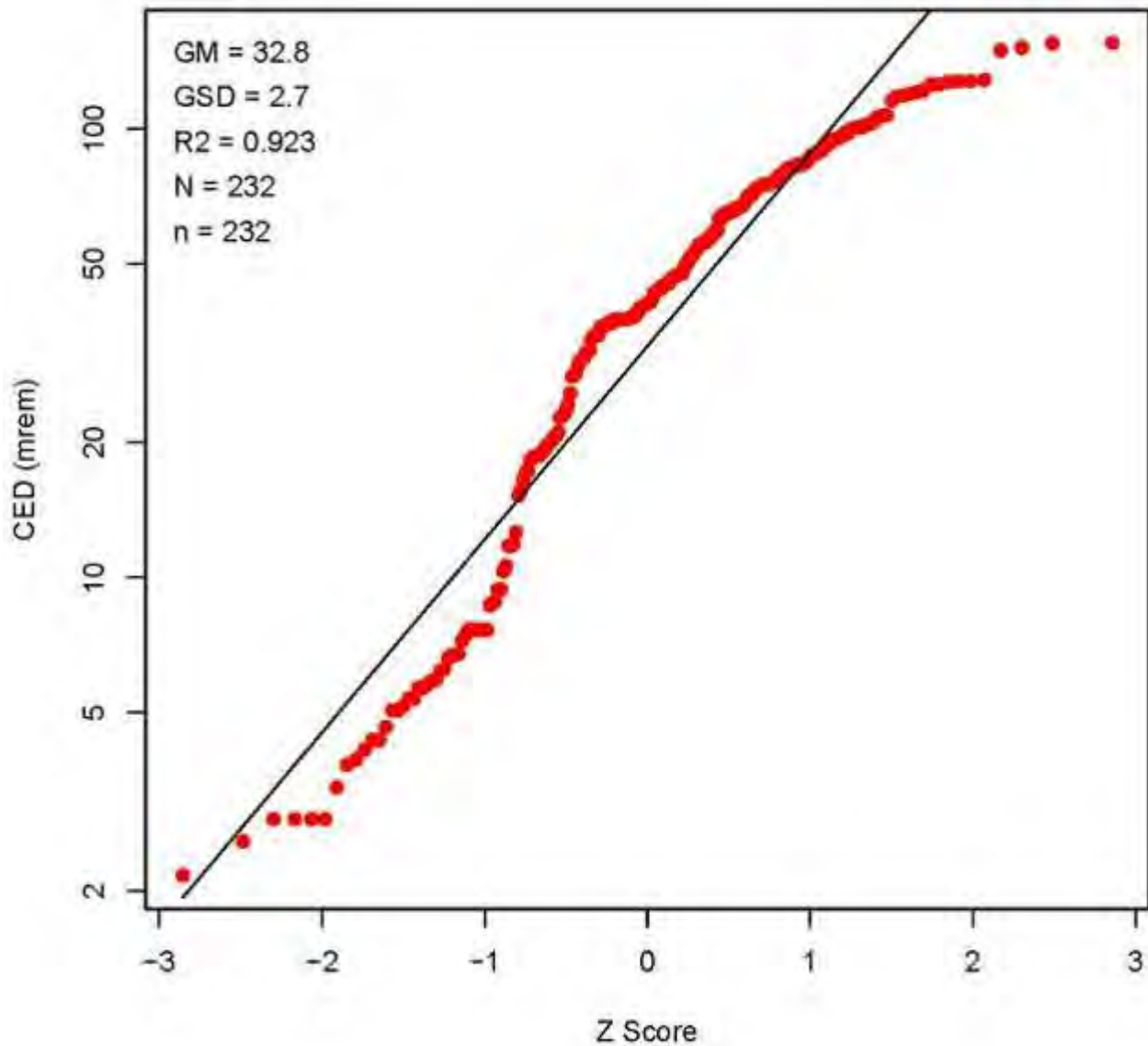


Figure B-97. SRS tritium dose 1978.

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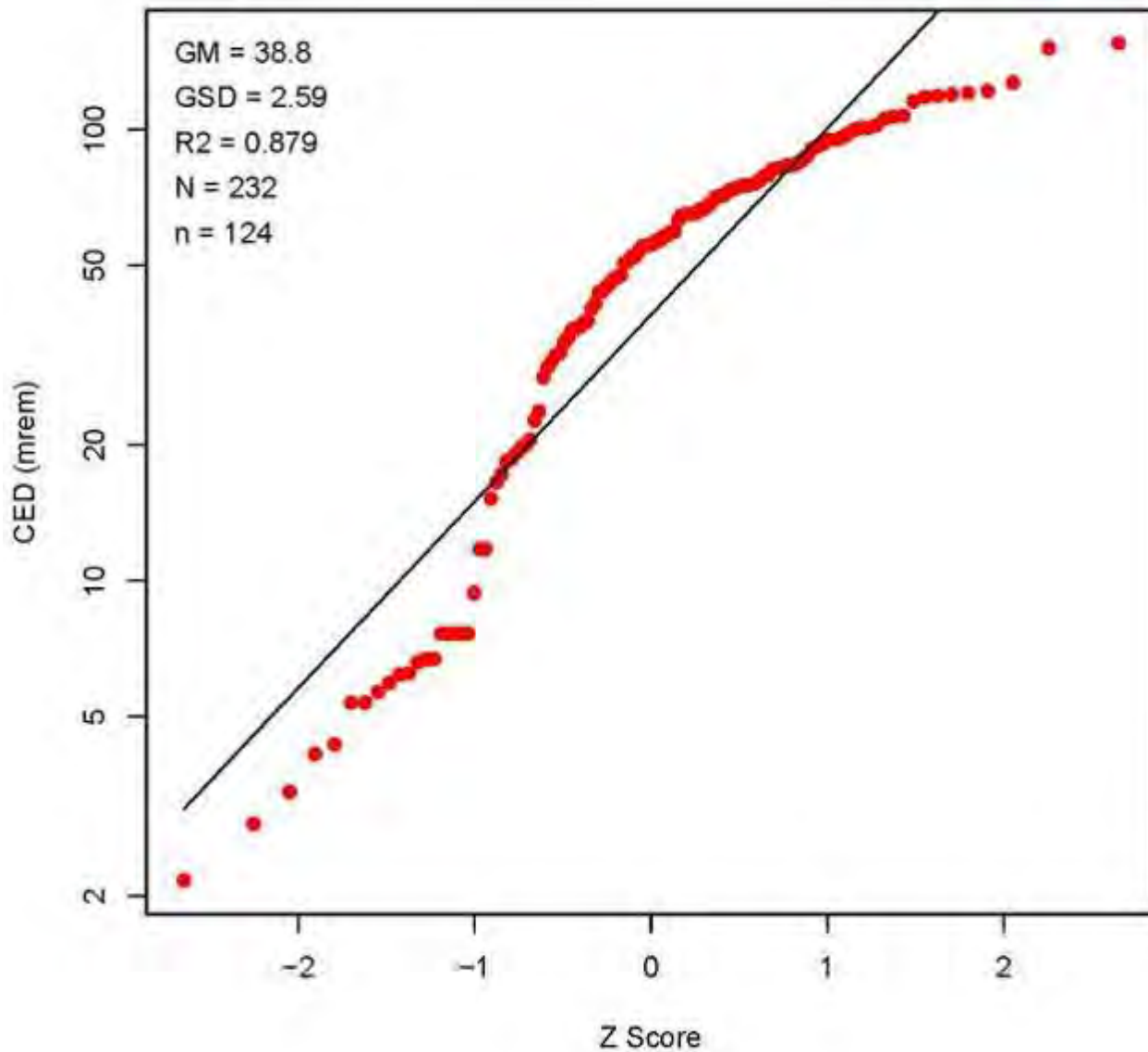


Figure B-98. SRS reactor tritium dose 1978.

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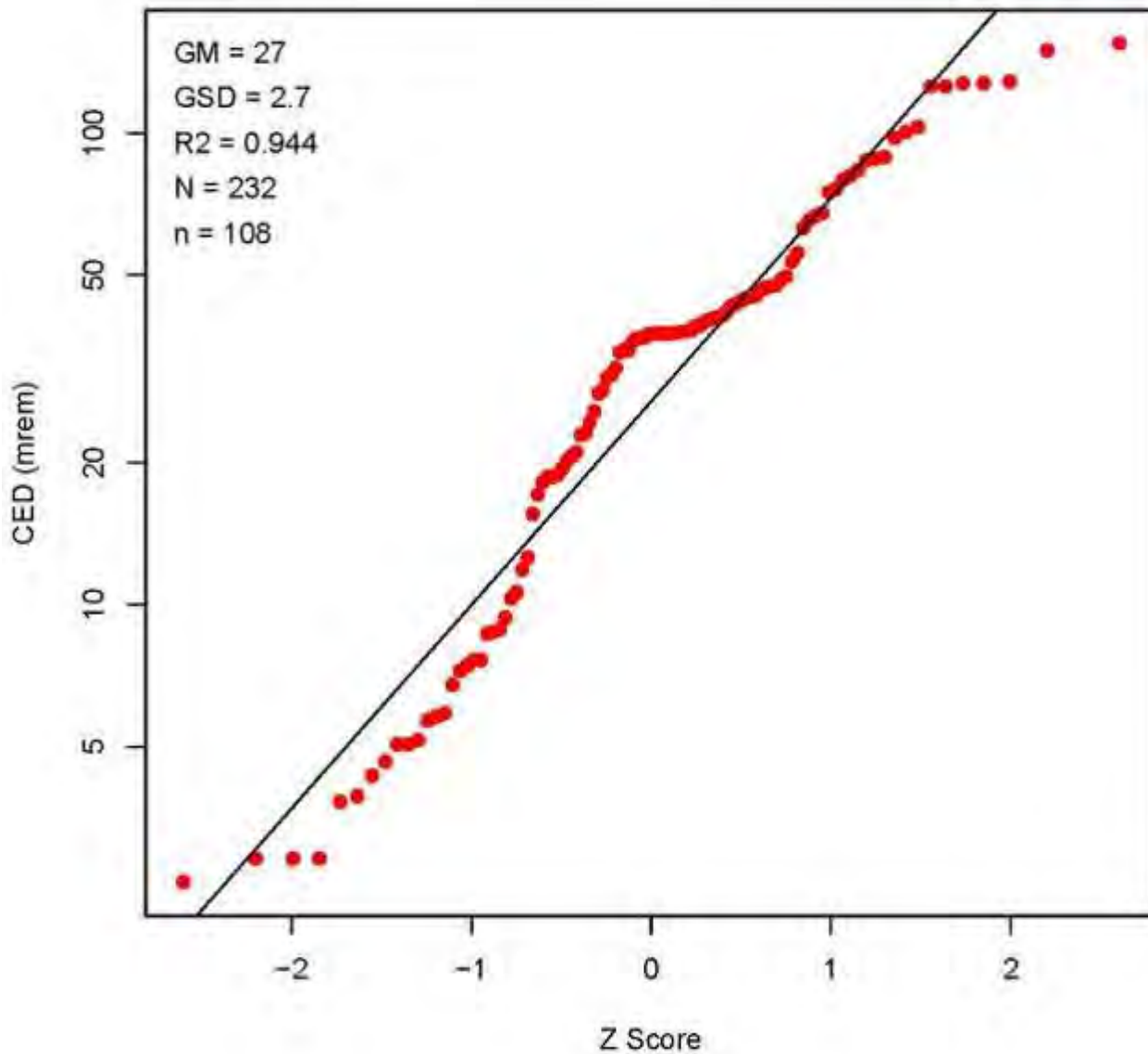


Figure B-99. SRS nonreactor tritium dose 1978.

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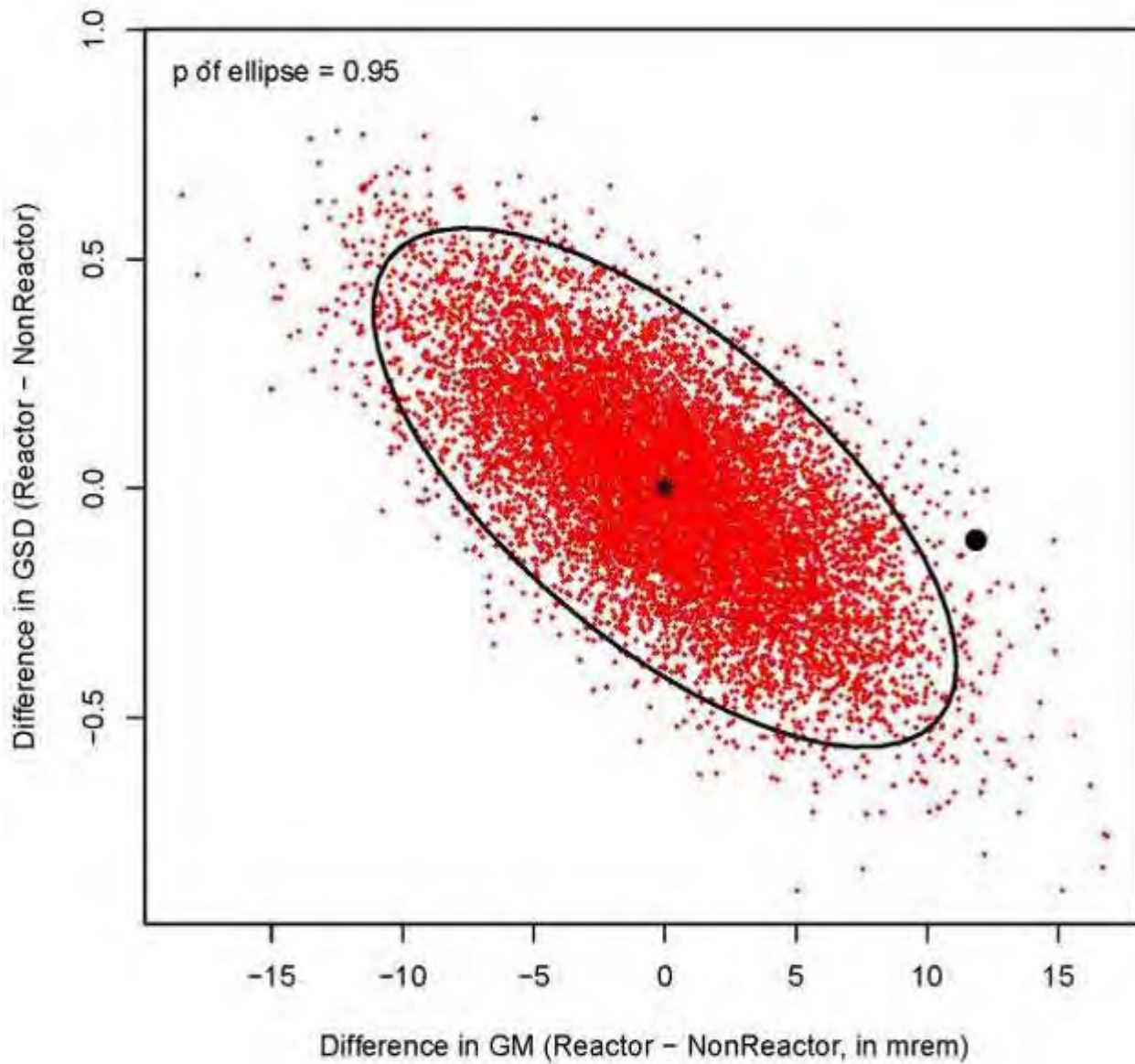


Figure B-100. SRS tritium dose 1978.

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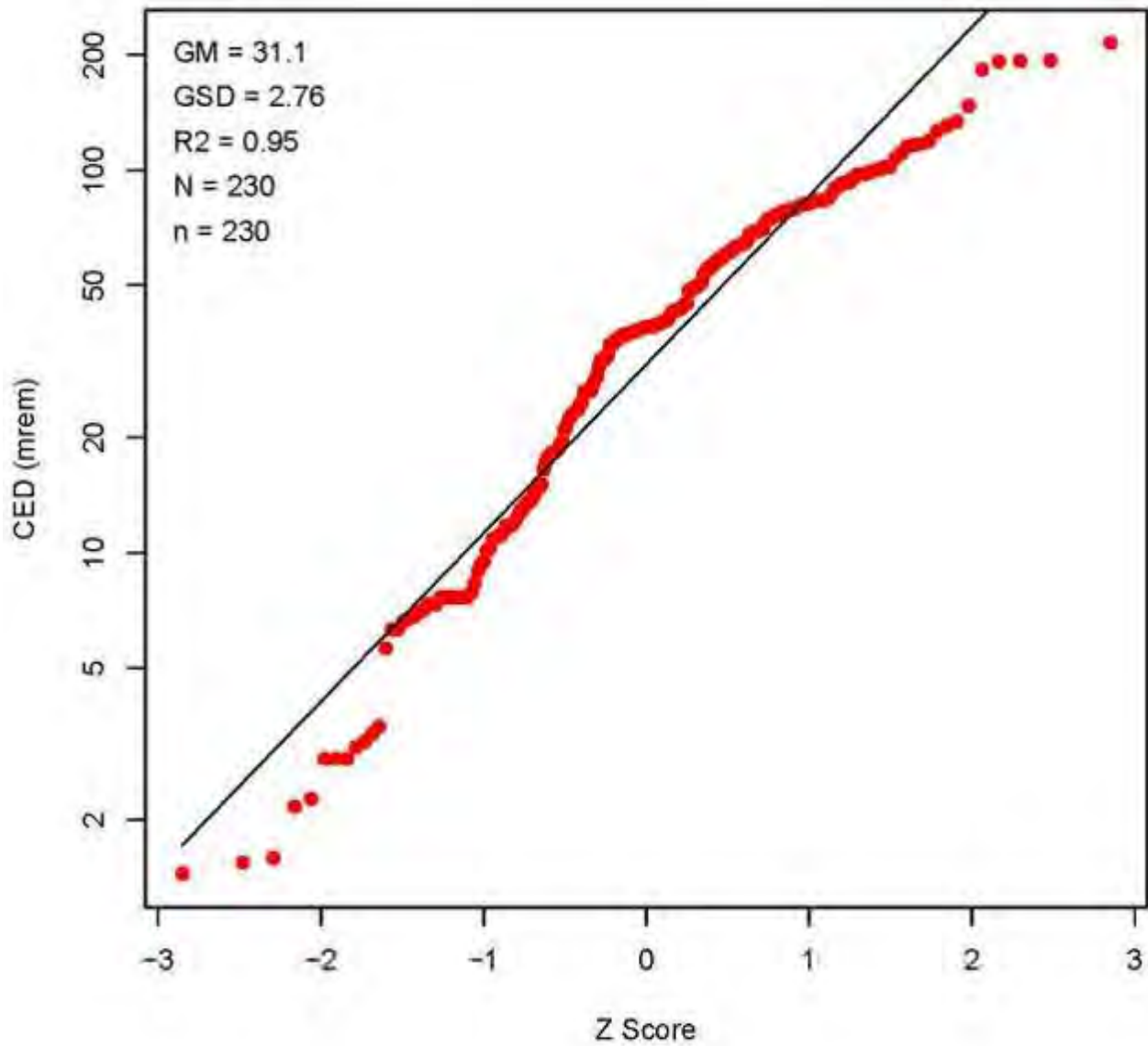


Figure B-101. SRS tritium dose 1979.

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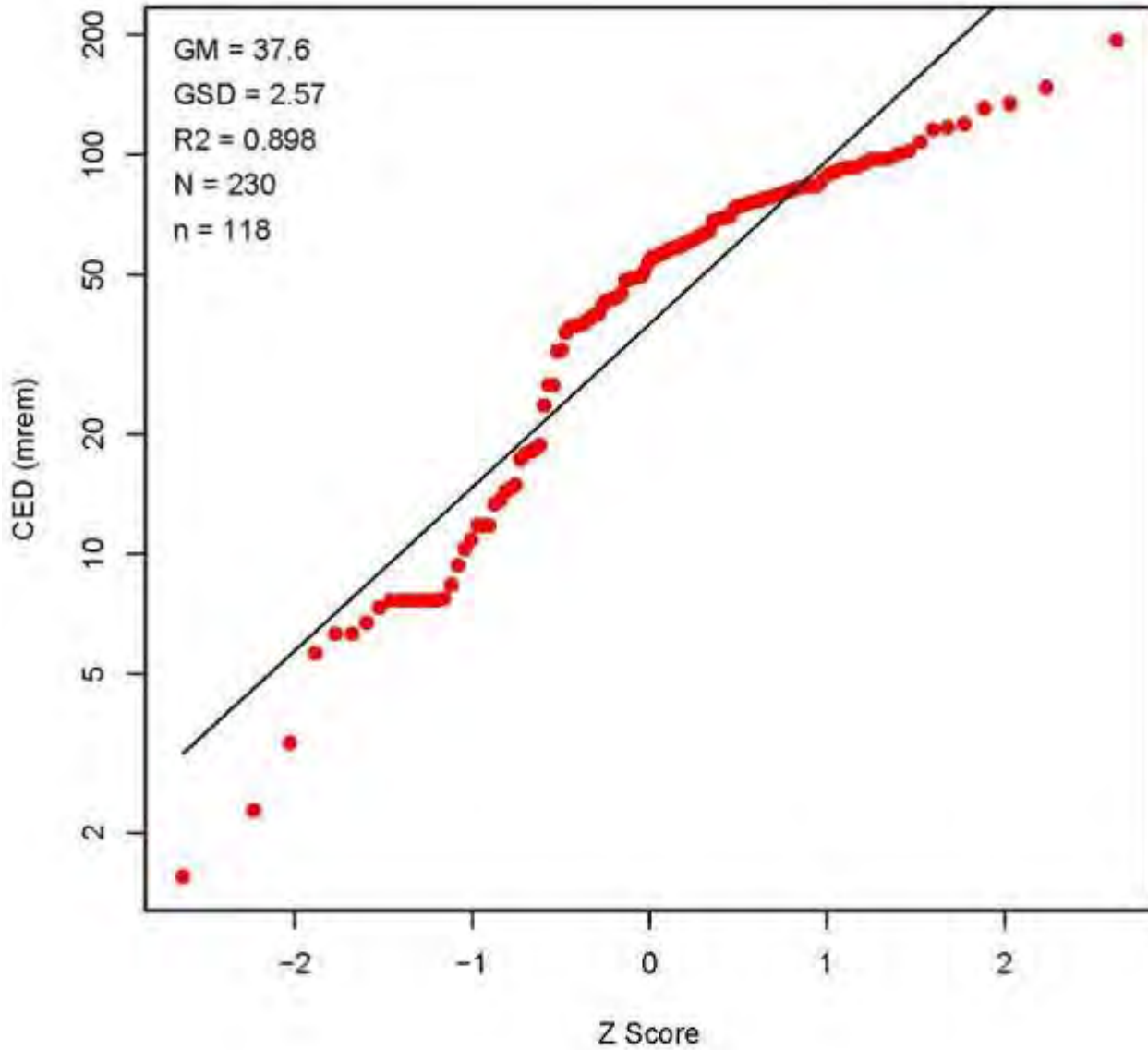


Figure B-102. SRS reactor tritium dose 1979.

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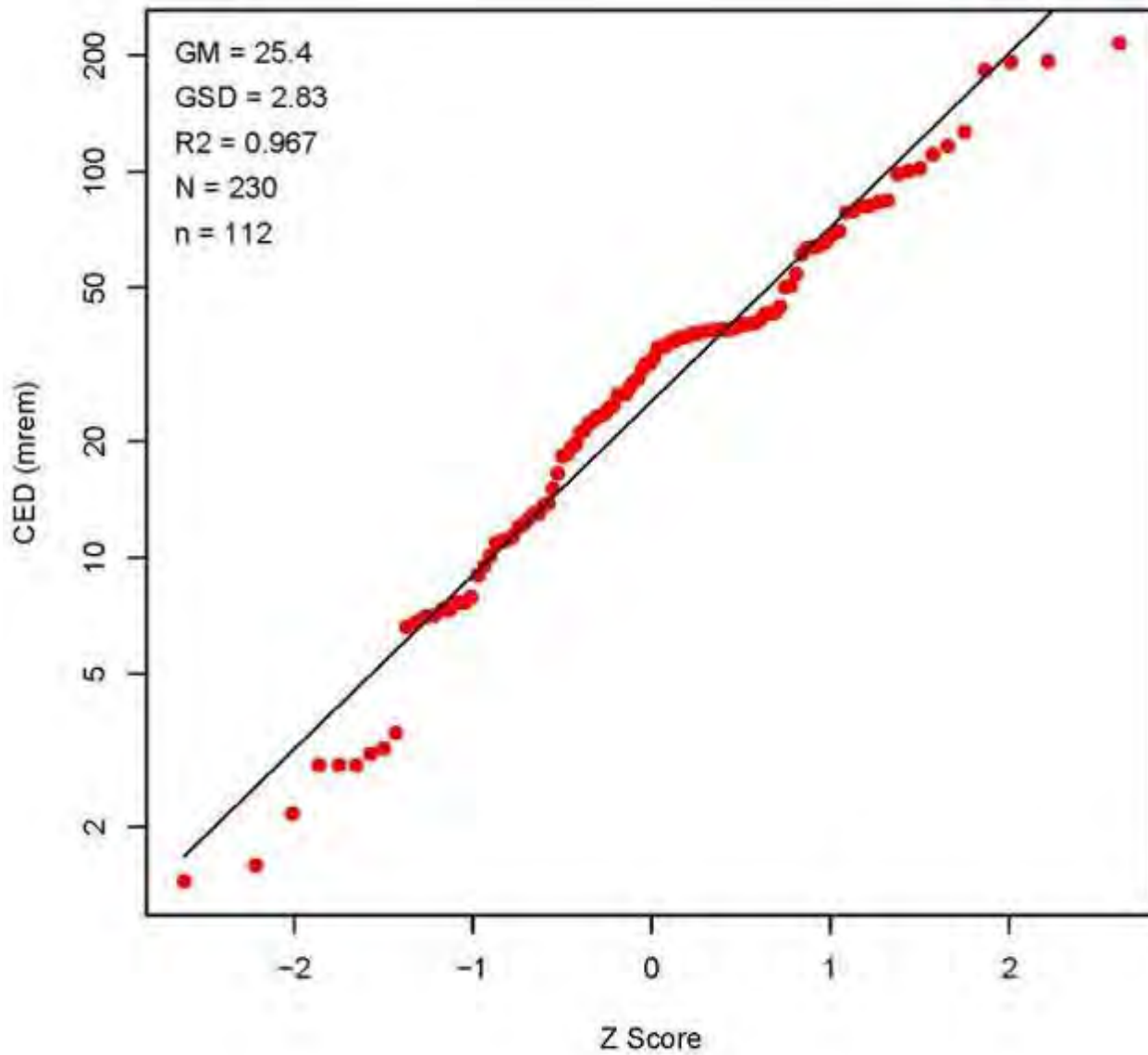


Figure B-103. SRS nonreactor tritium dose 1979.

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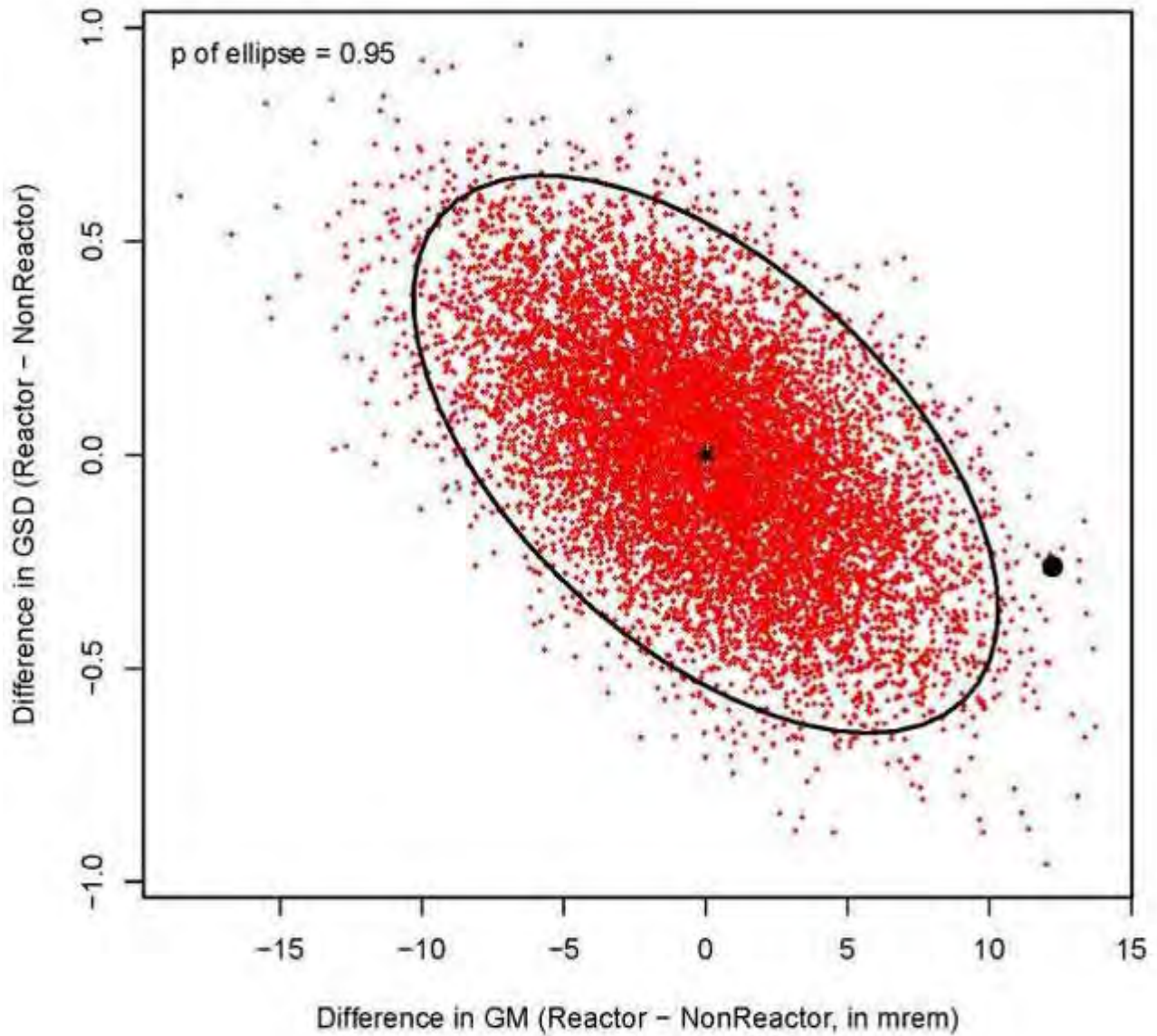


Figure B-104. SRS tritium dose 1979.

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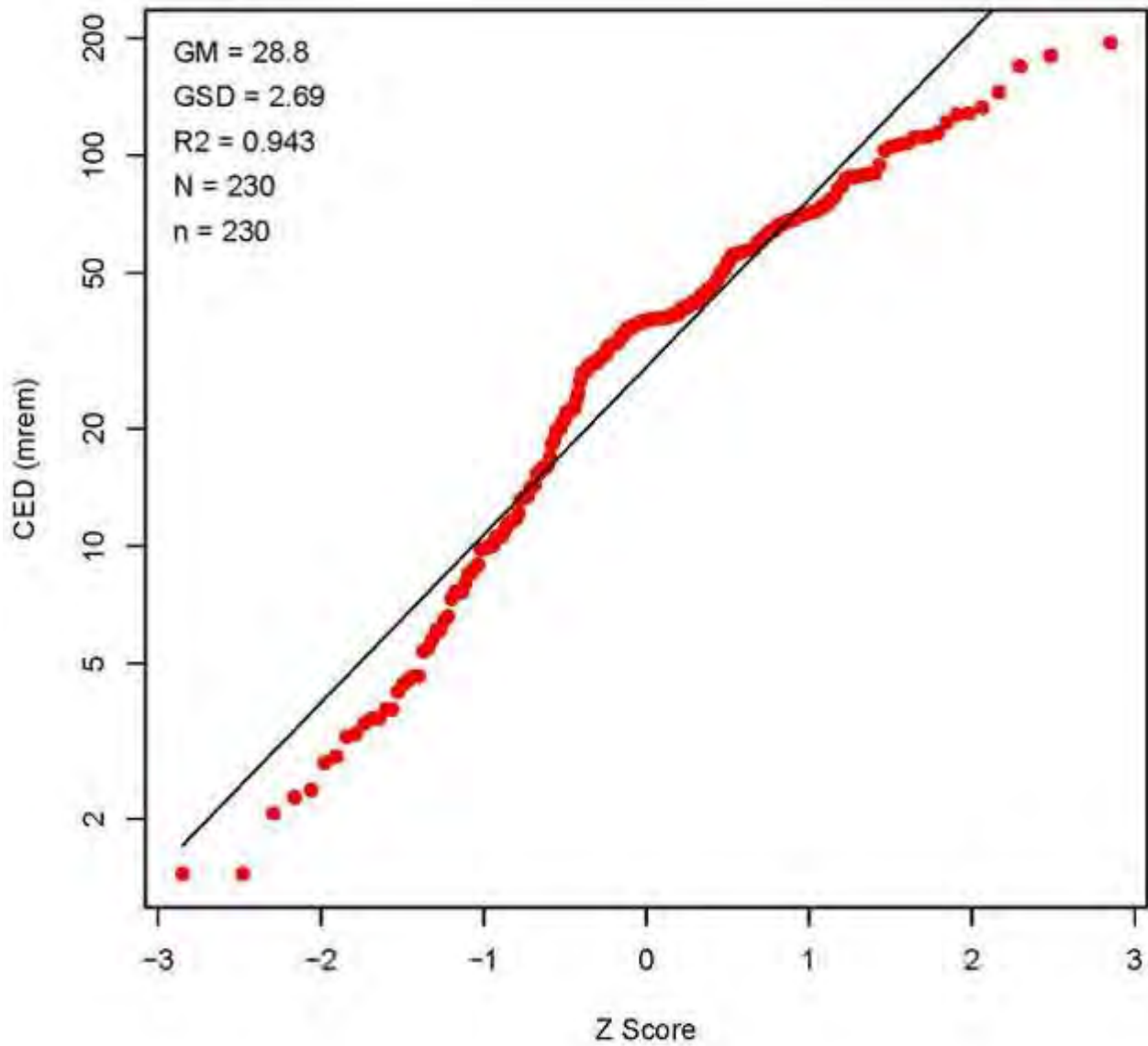


Figure B-105. SRS tritium dose 1980.

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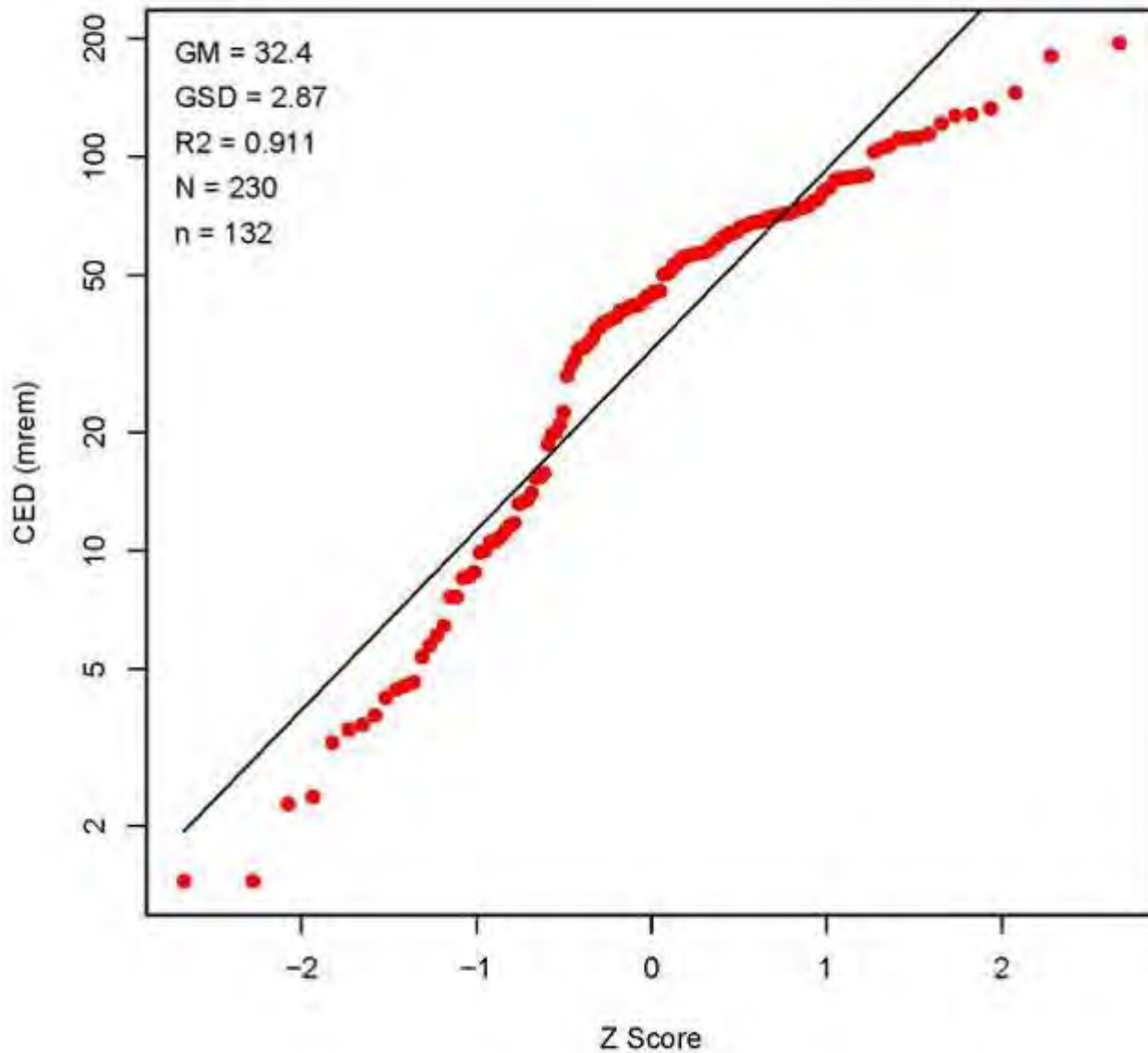


Figure B-106. SRS reactor tritium dose 1980.

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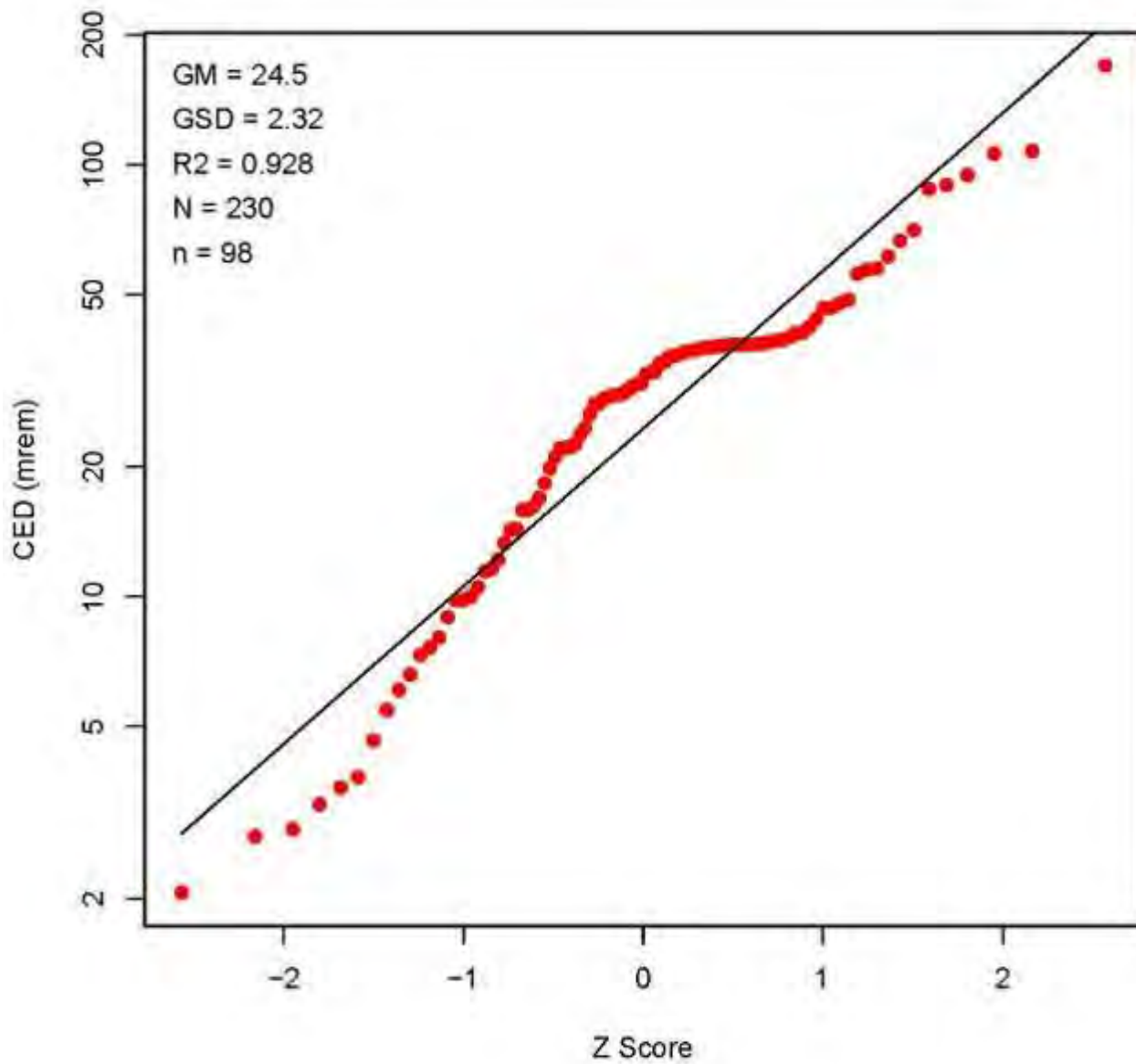


Figure B-107. SRS nonreactor tritium dose 1980.

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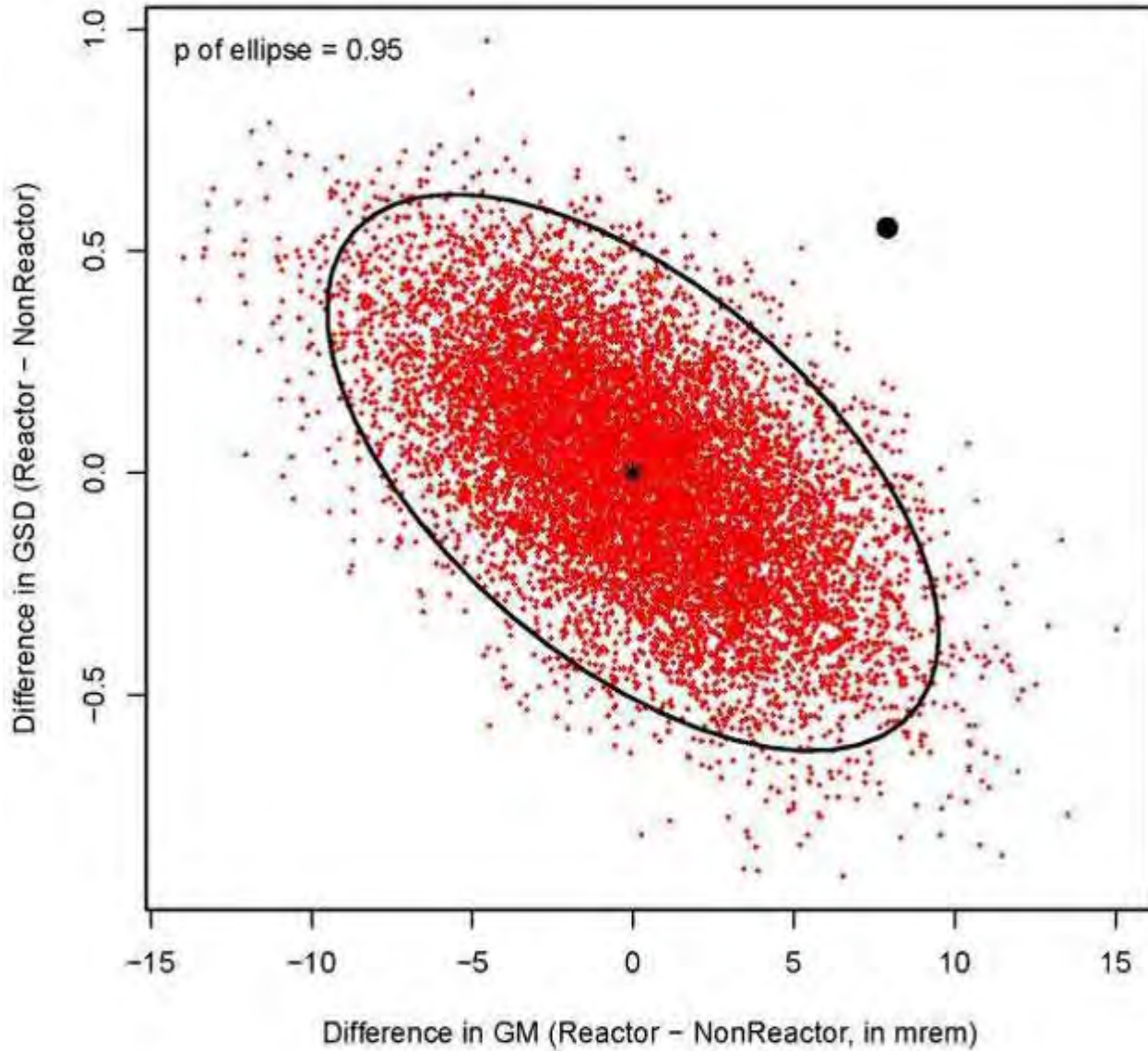


Figure B-108. SRS tritium dose 1980.

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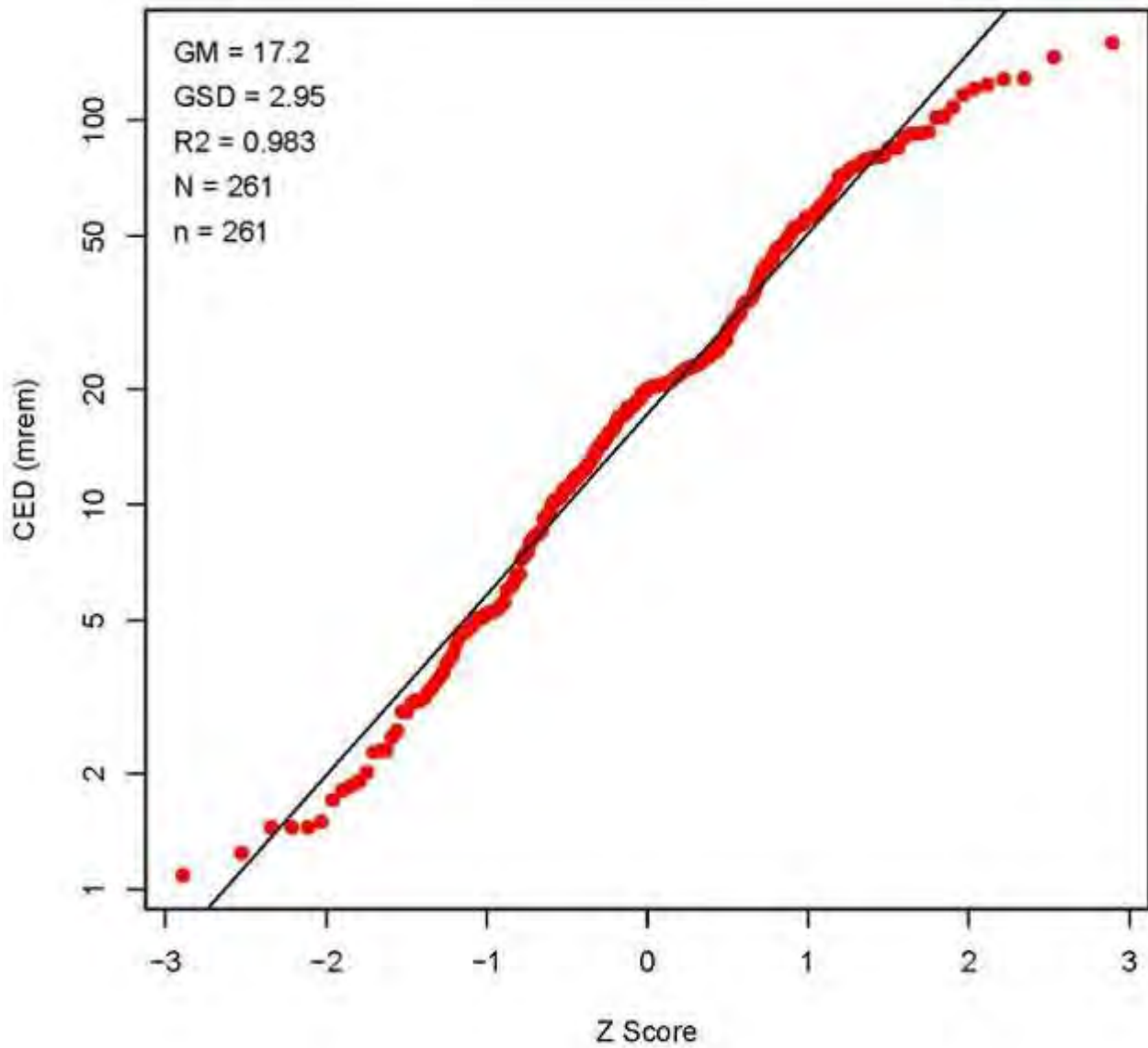


Figure B-109. SRS tritium dose 1981.

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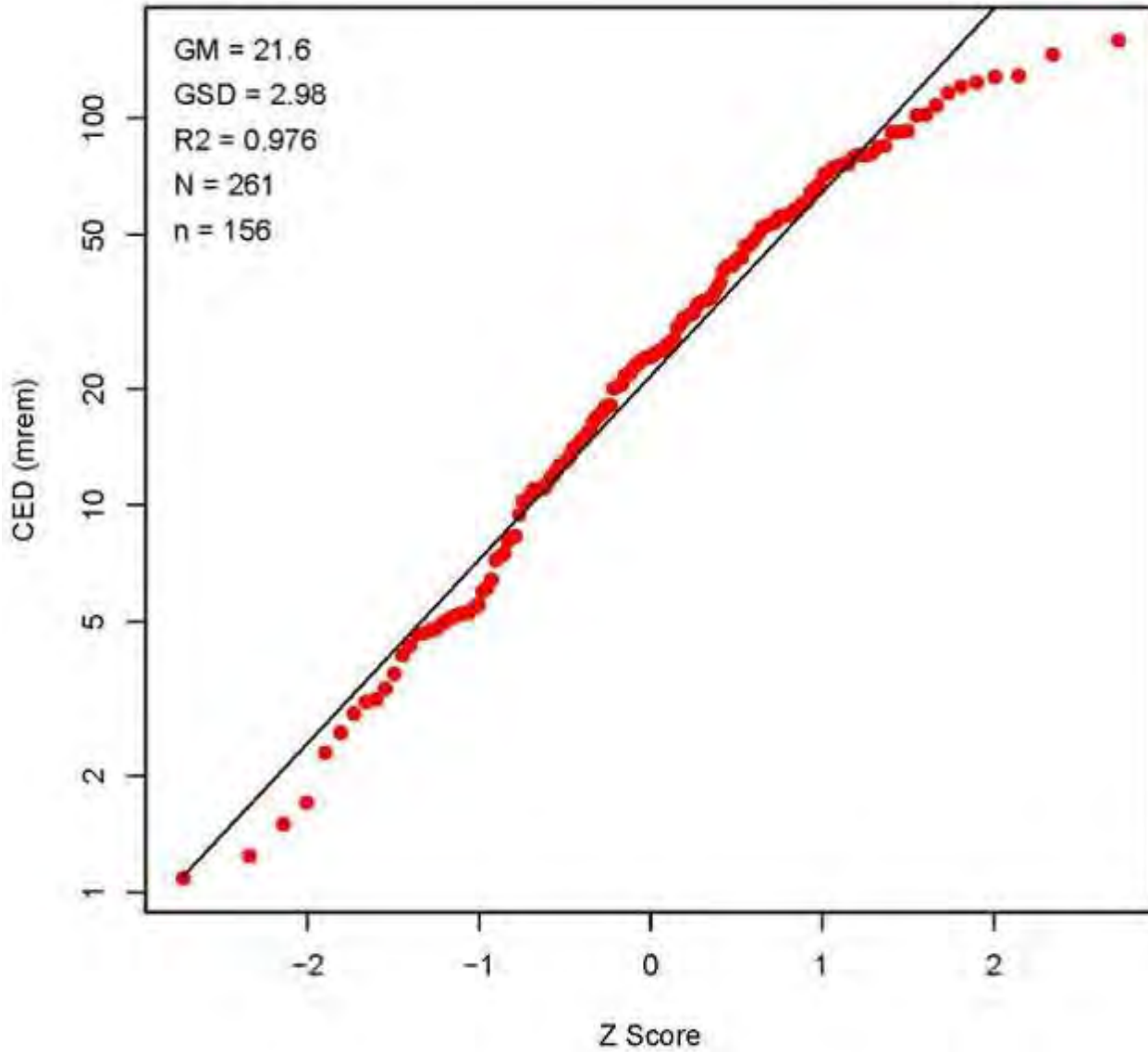


Figure B-110. SRS reactor tritium dose 1981.

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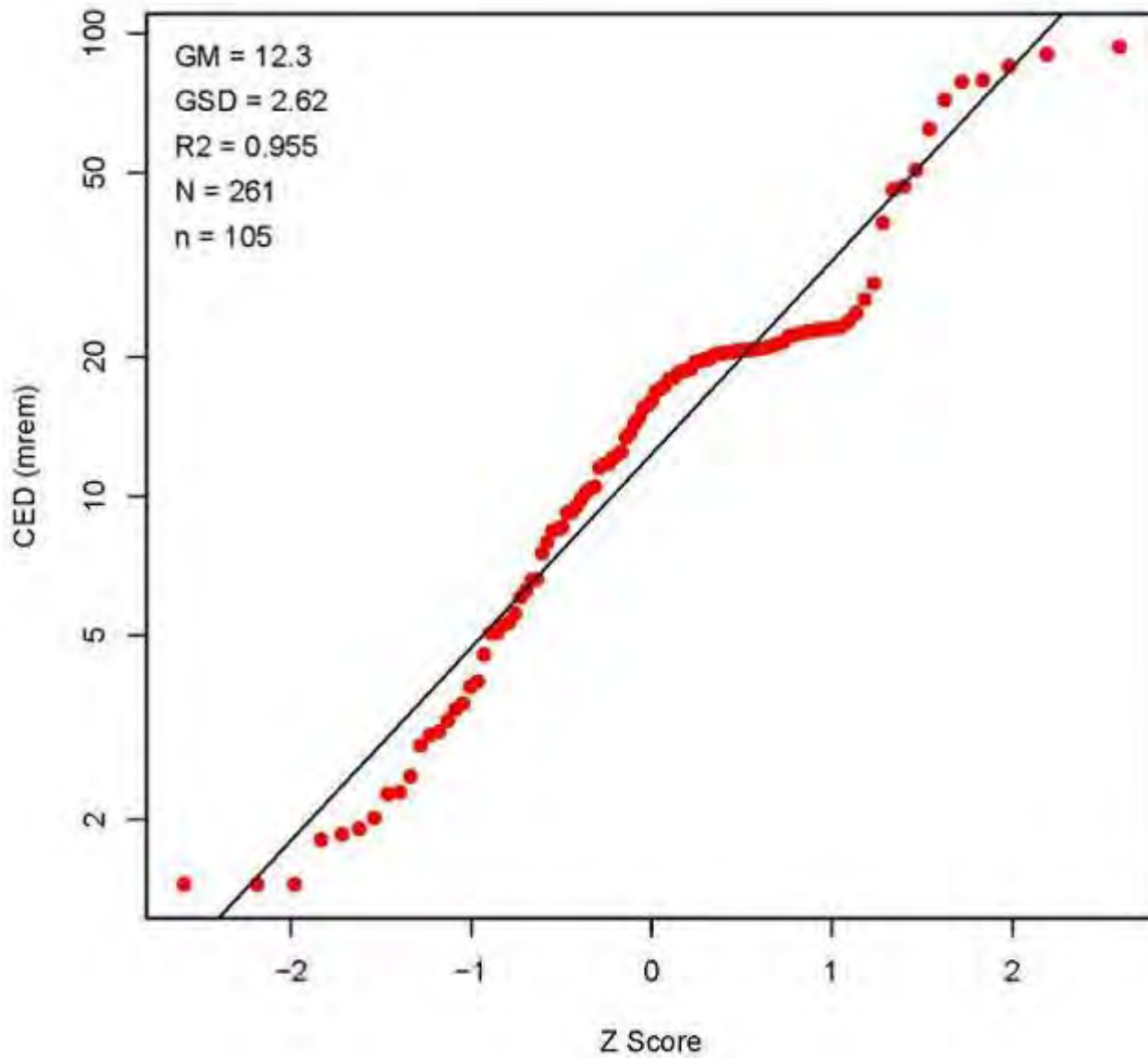


Figure B-111. SRS nonreactor tritium dose 1981.

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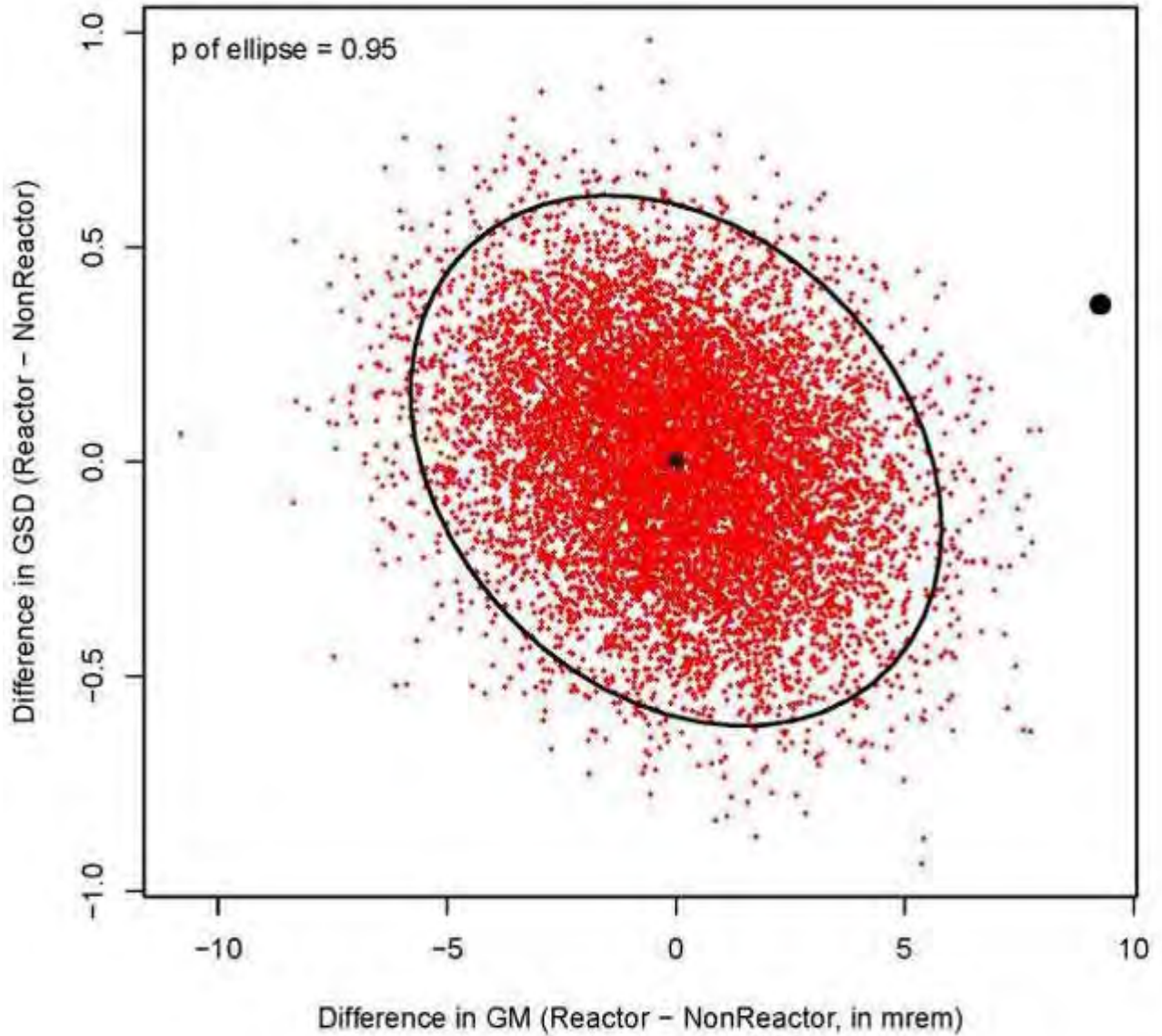


Figure B-112. SRS tritium dose 1981.

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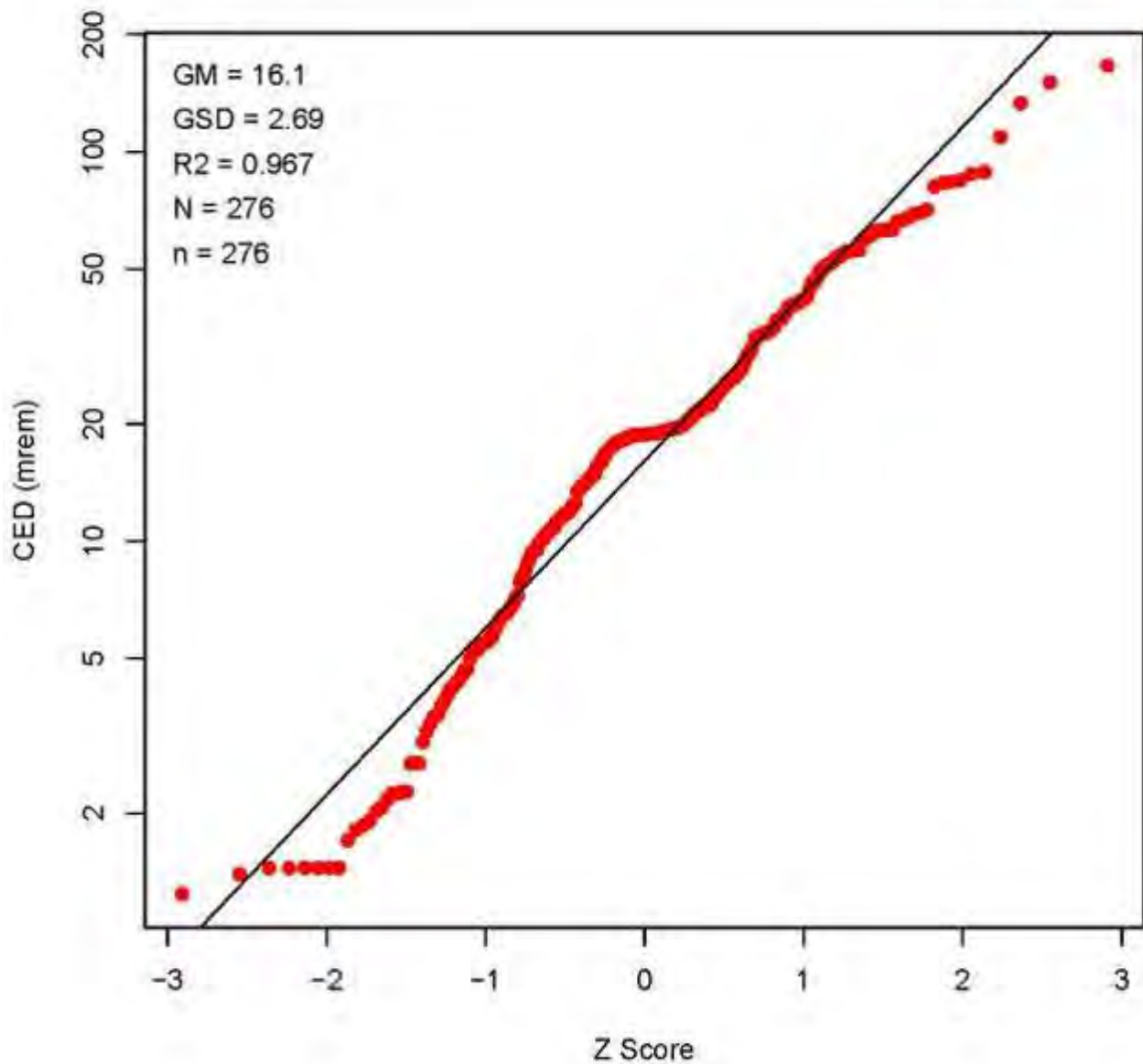


Figure B-113. SRS tritium dose 1982.

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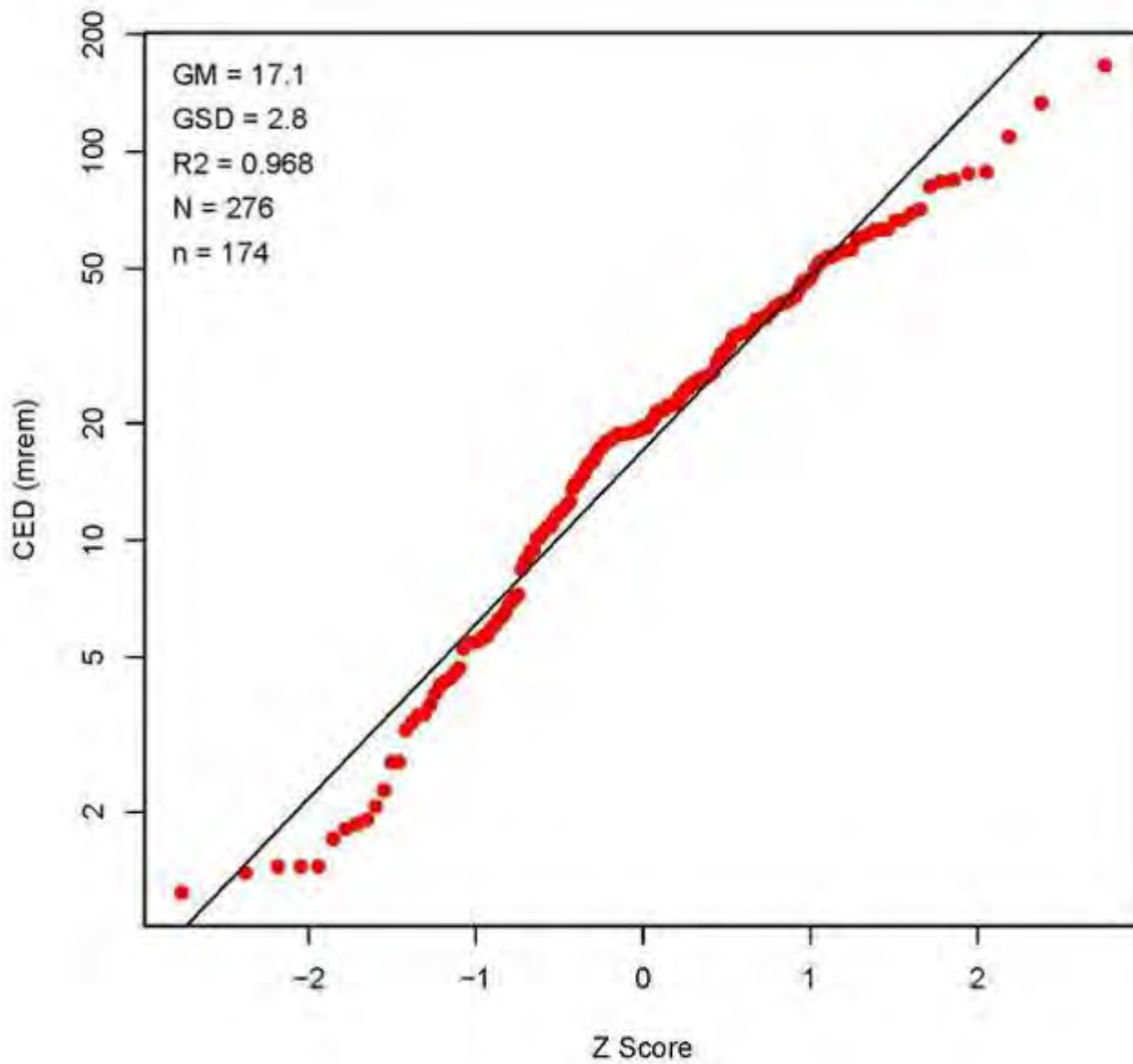


Figure B-114. SRS reactor tritium dose 1982.

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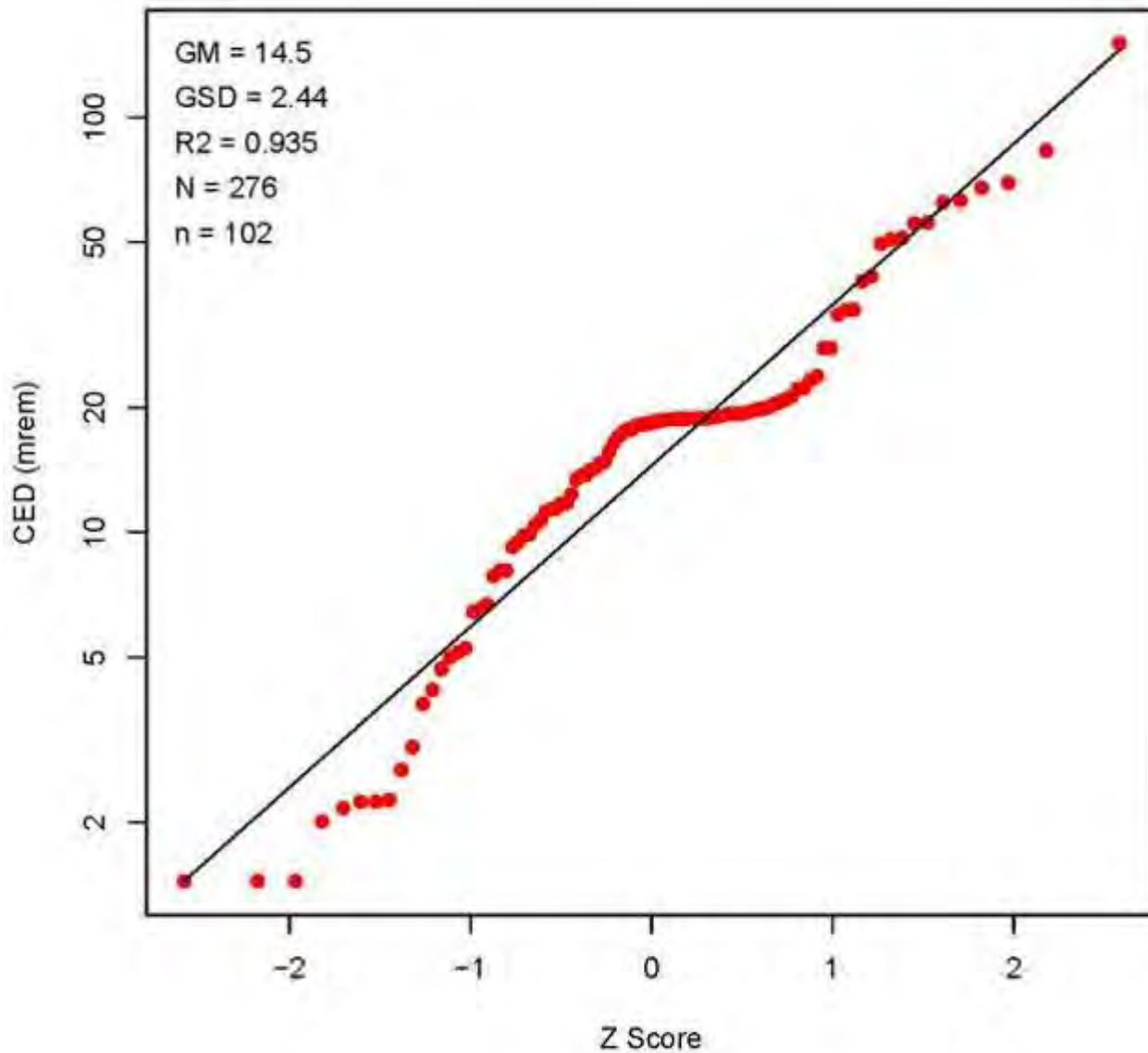


Figure B-115. SRS nonreactor tritium dose 1982.

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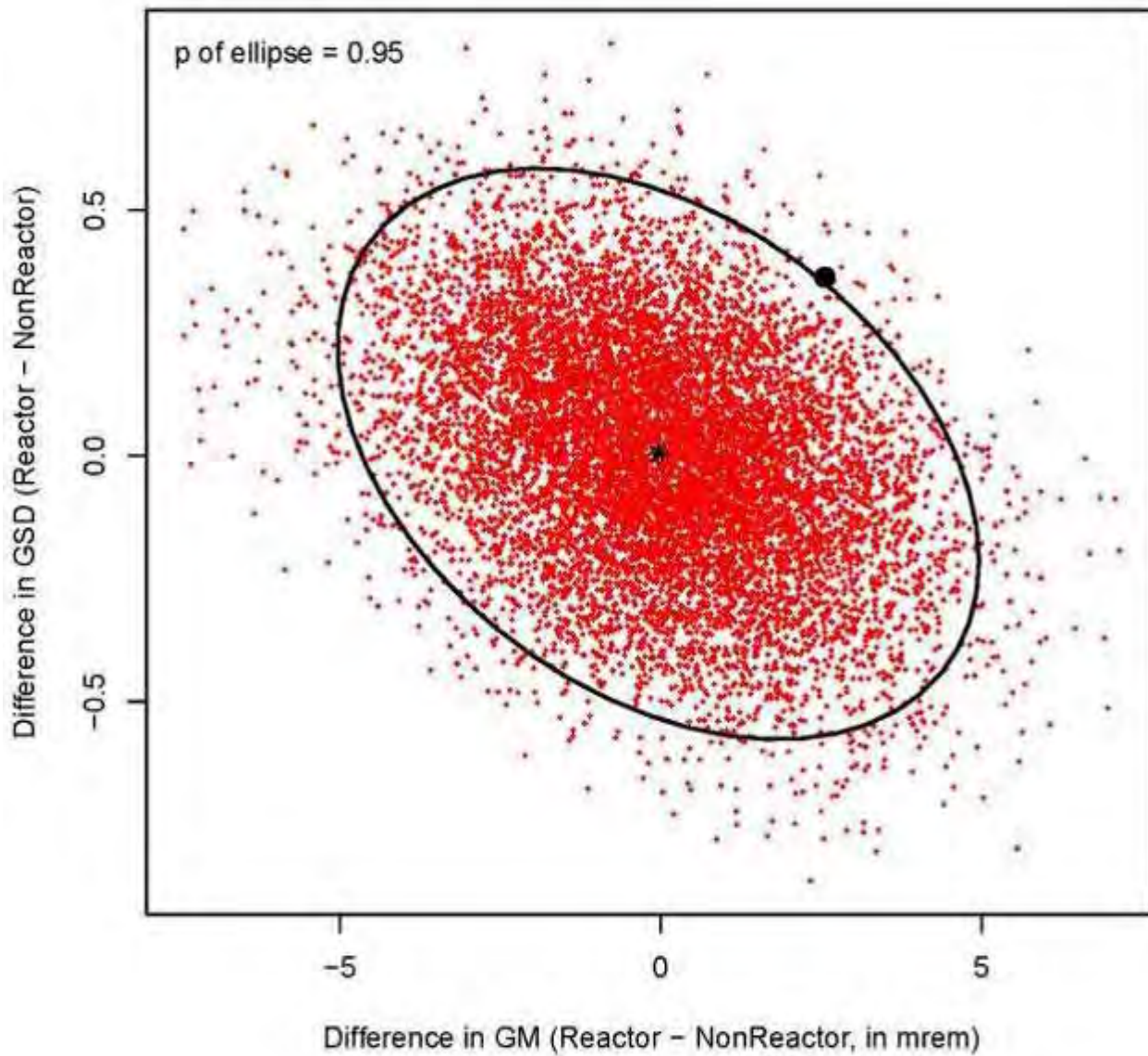


Figure B-116. SRS tritium dose 1982.

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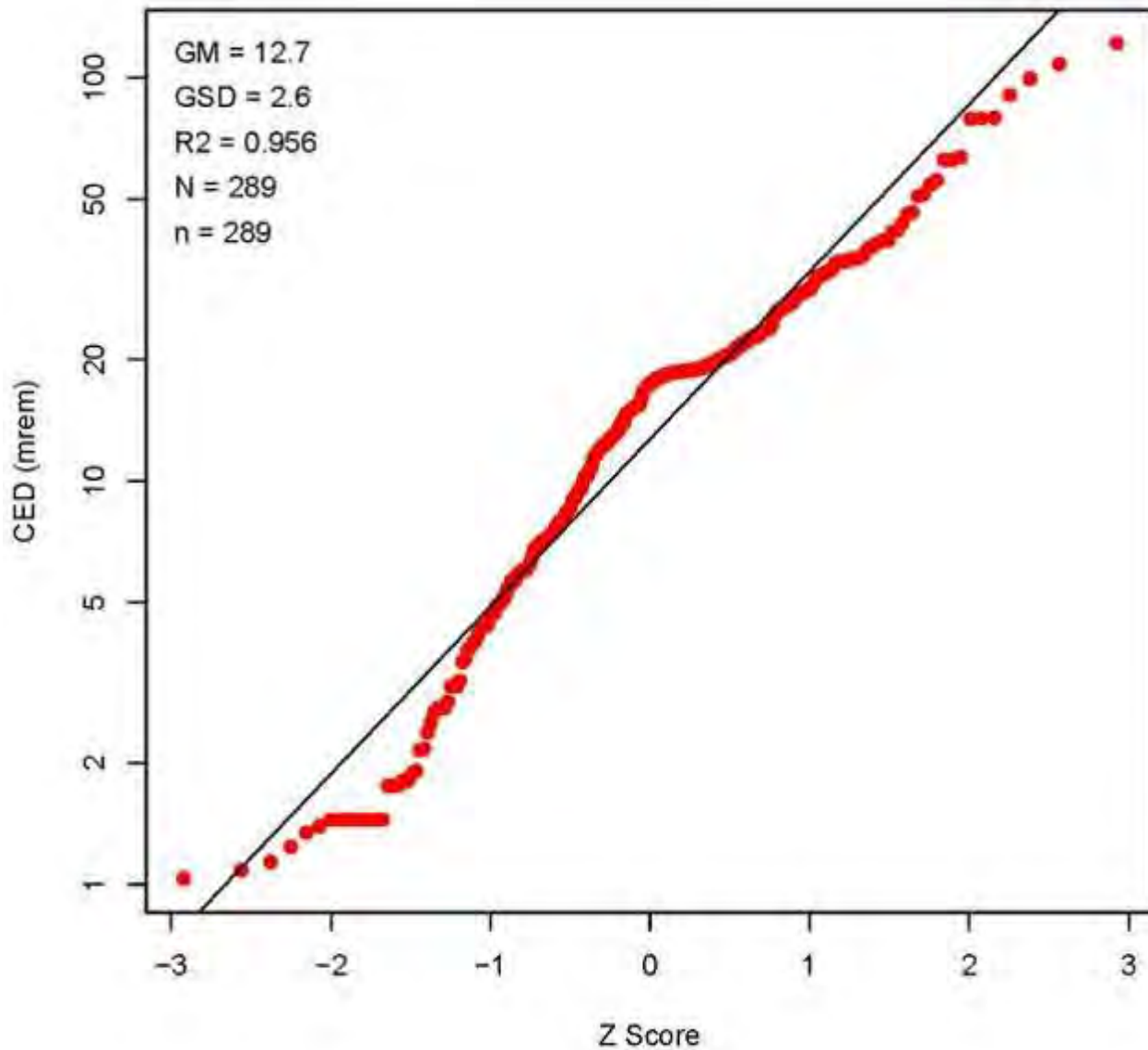


Figure B-117. SRS tritium dose 1983.

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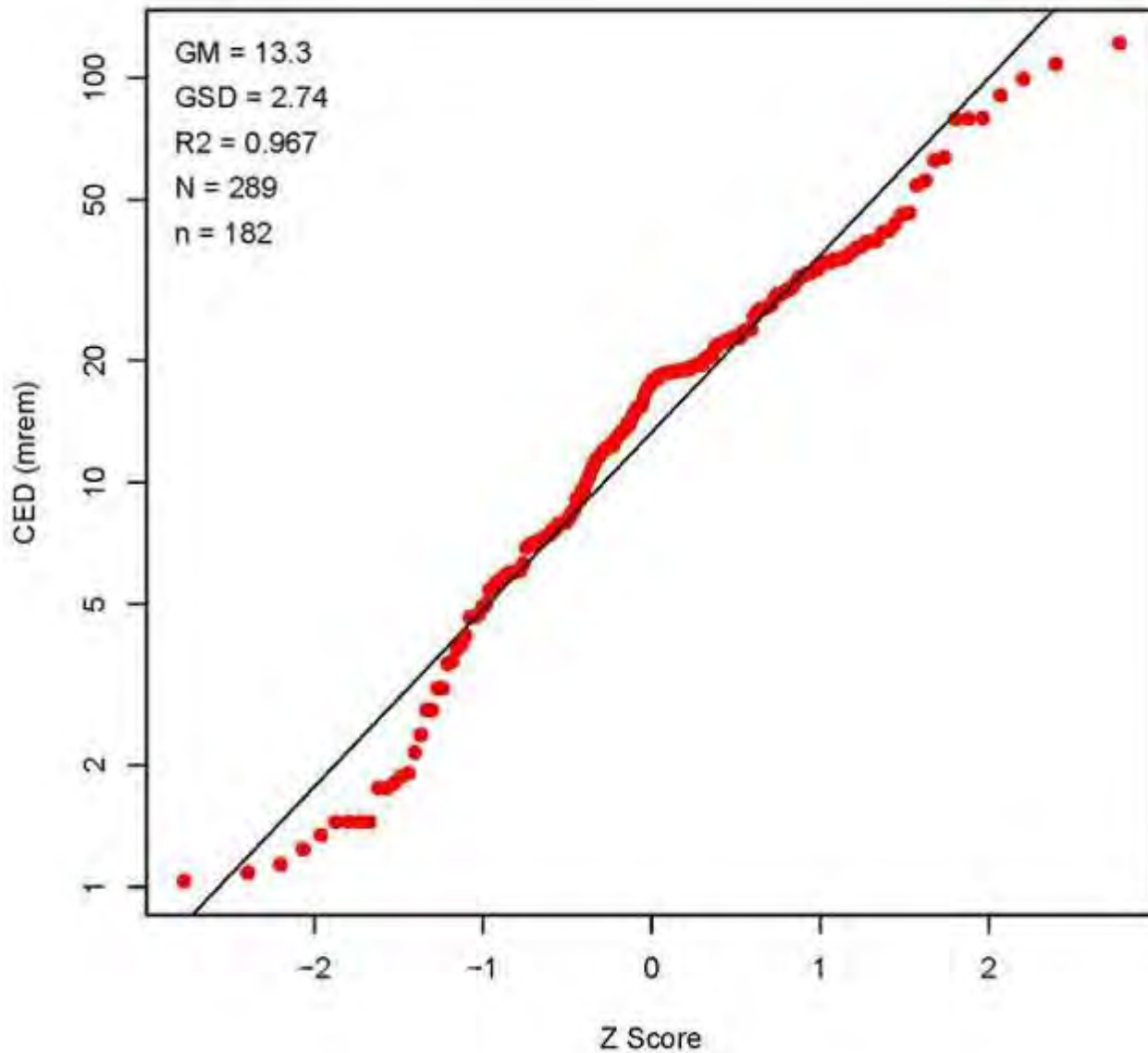


Figure B-118. SRS reactor tritium dose 1983.

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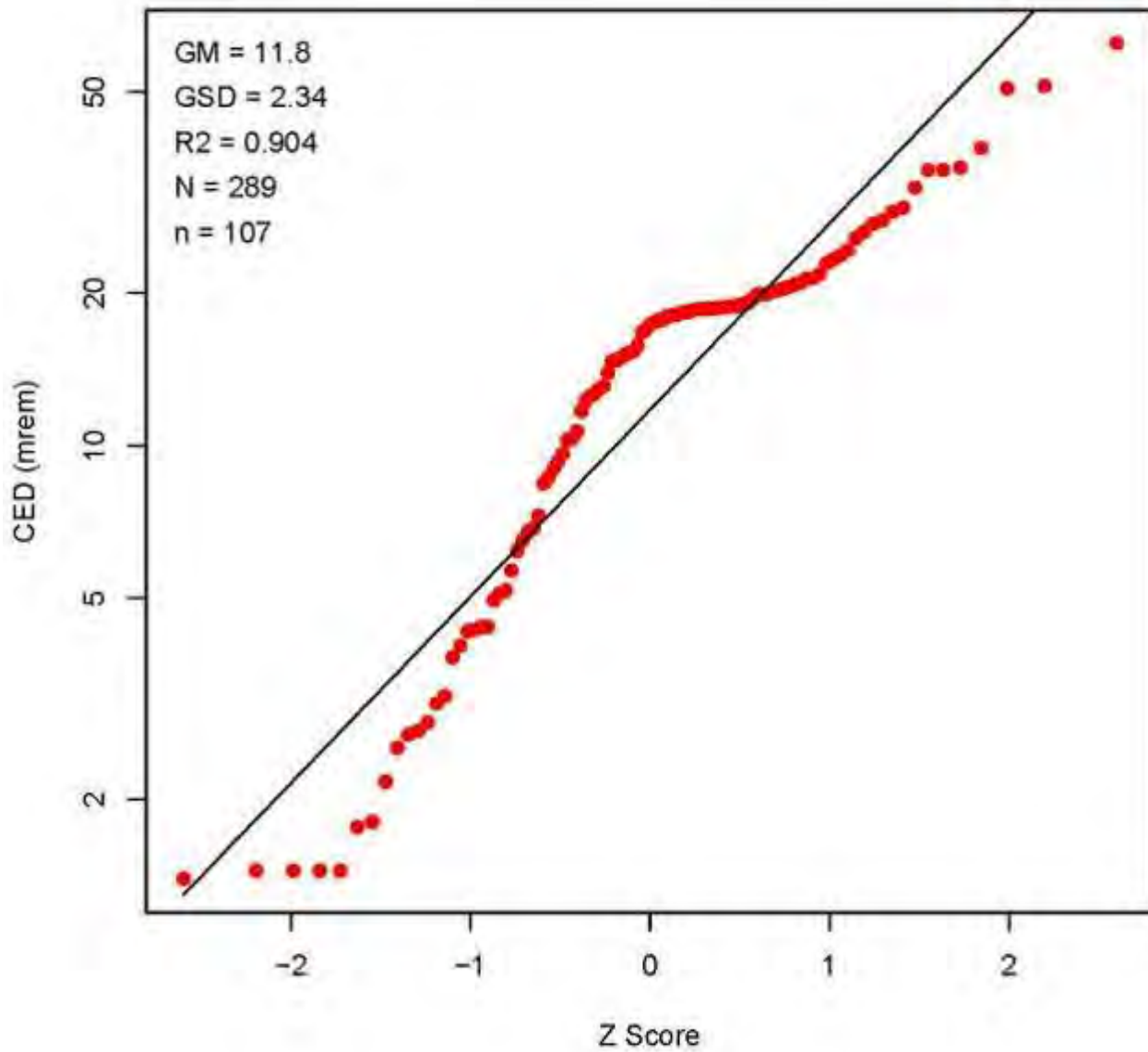


Figure B-119. SRS nonreactor tritium dose 1983.

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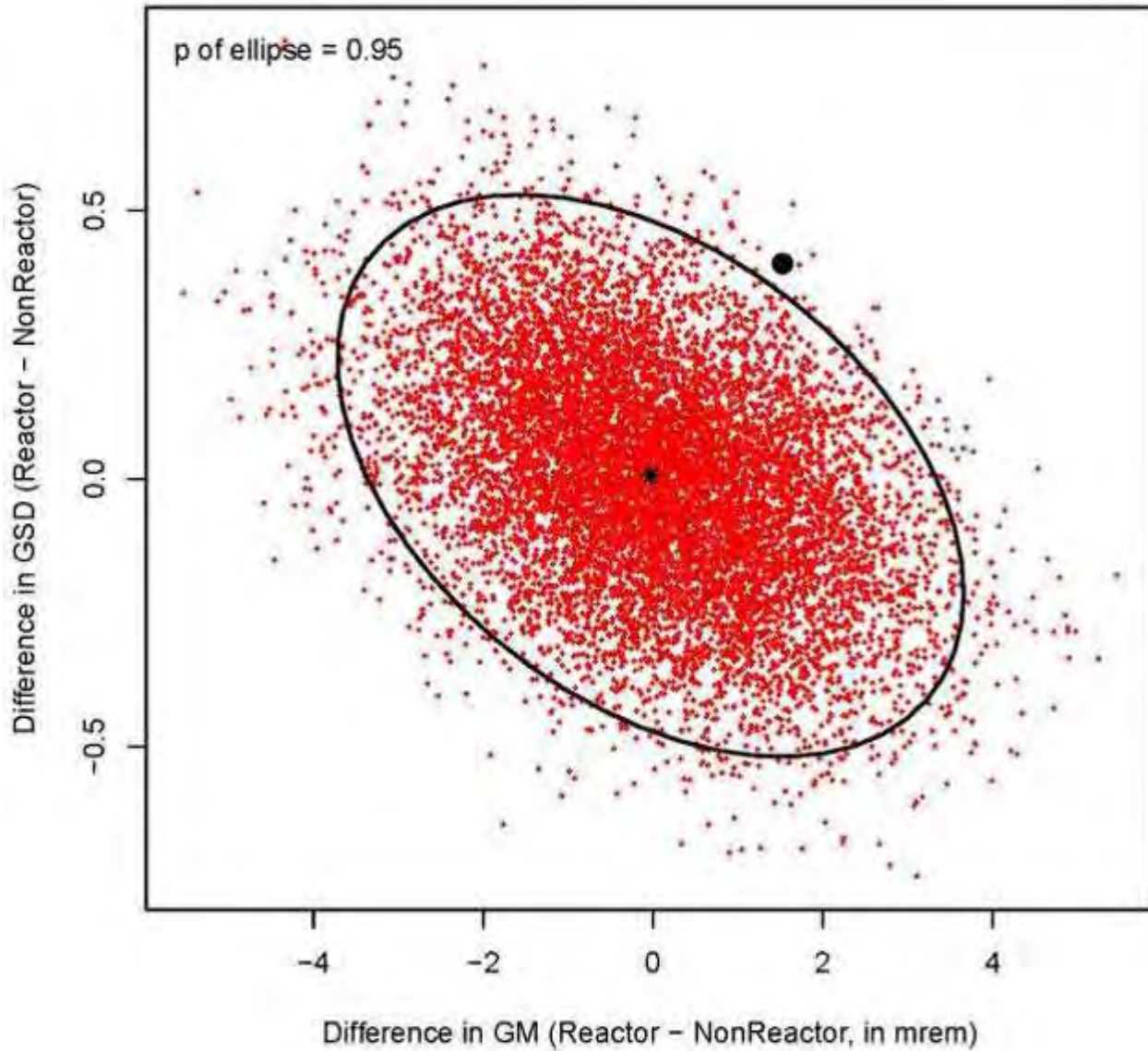


Figure B-120. SRS tritium dose 1983.

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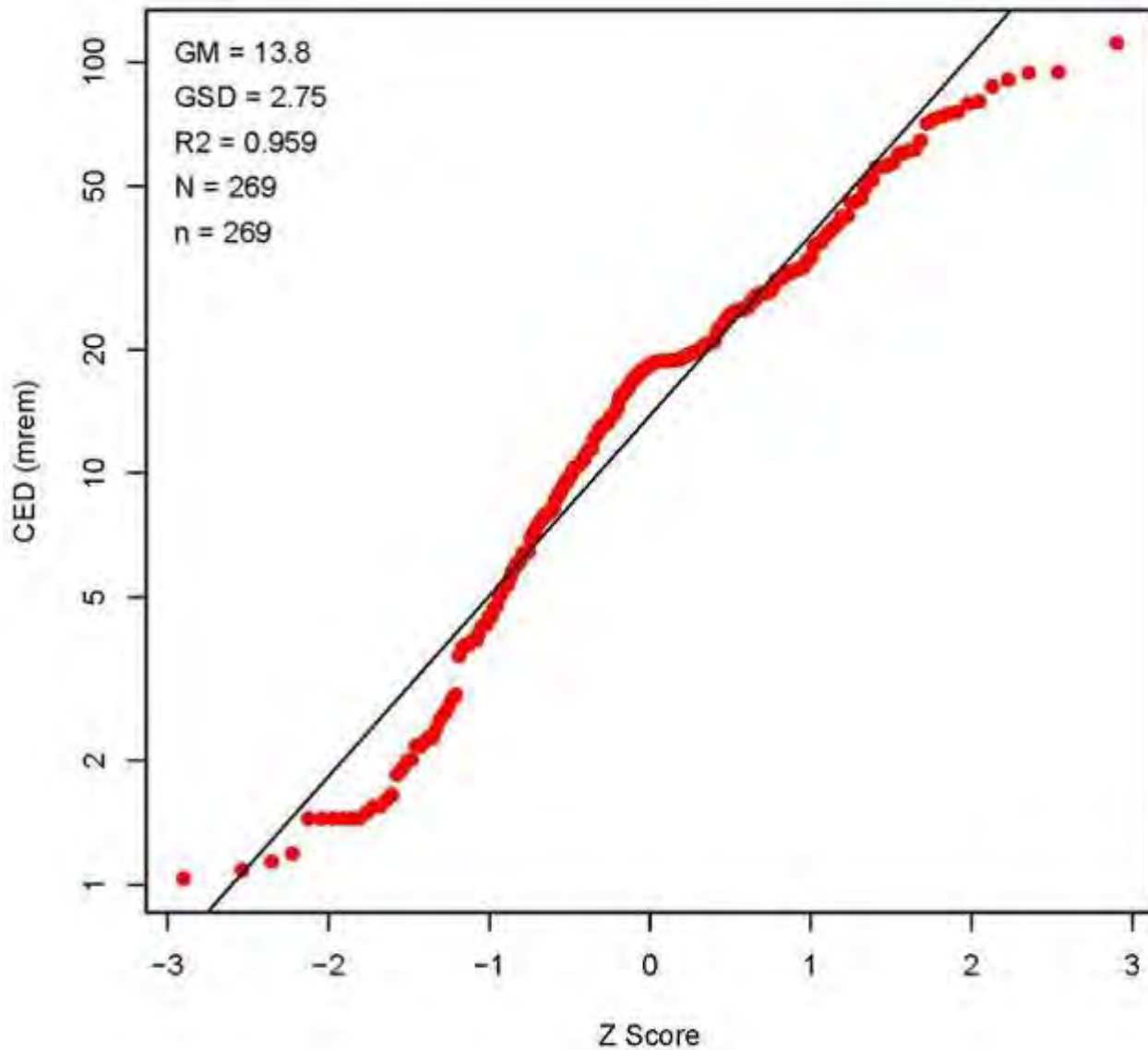


Figure B-121. SRS tritium dose 1984.

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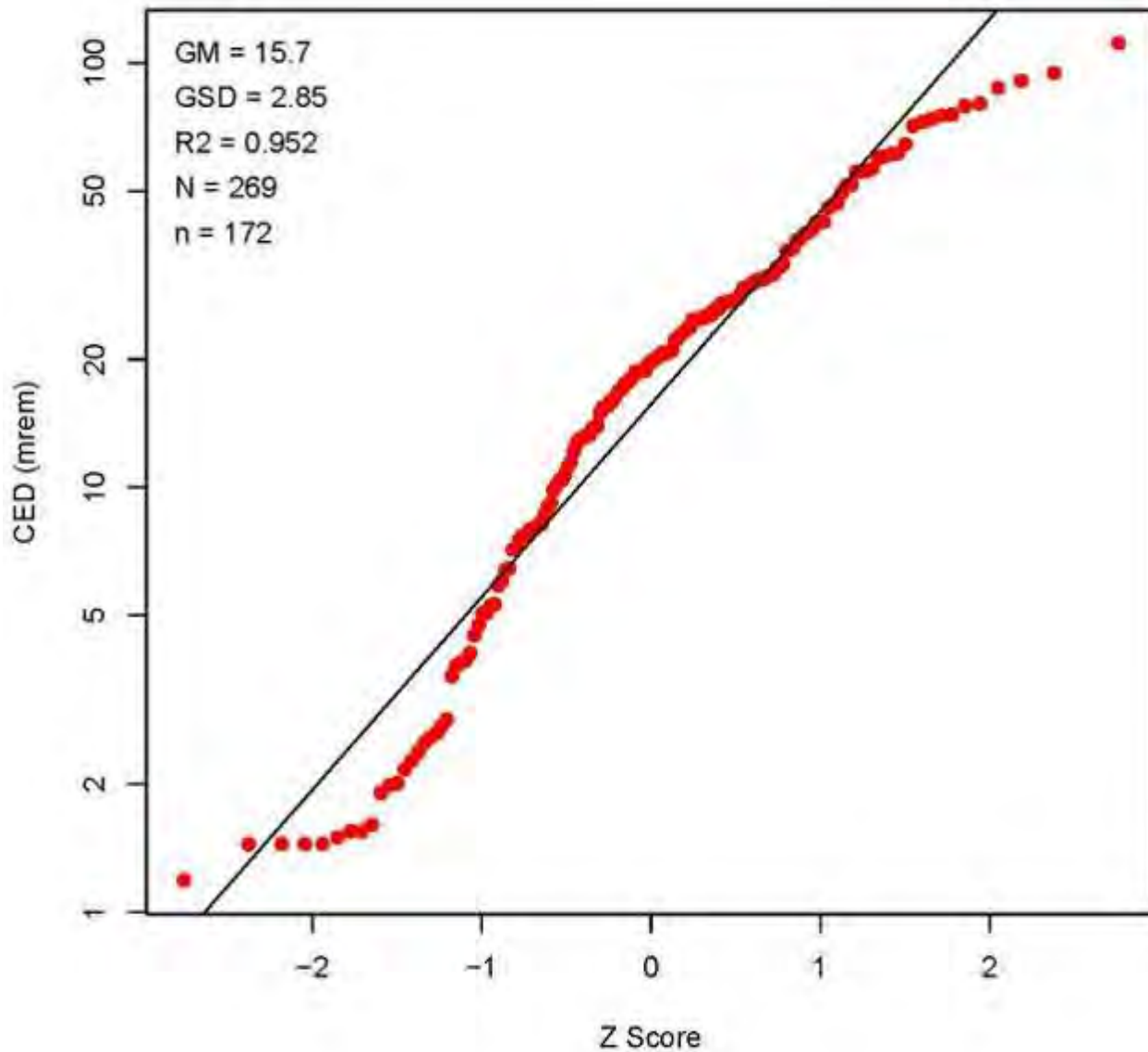


Figure B-122. SRS reactor tritium dose 1984.

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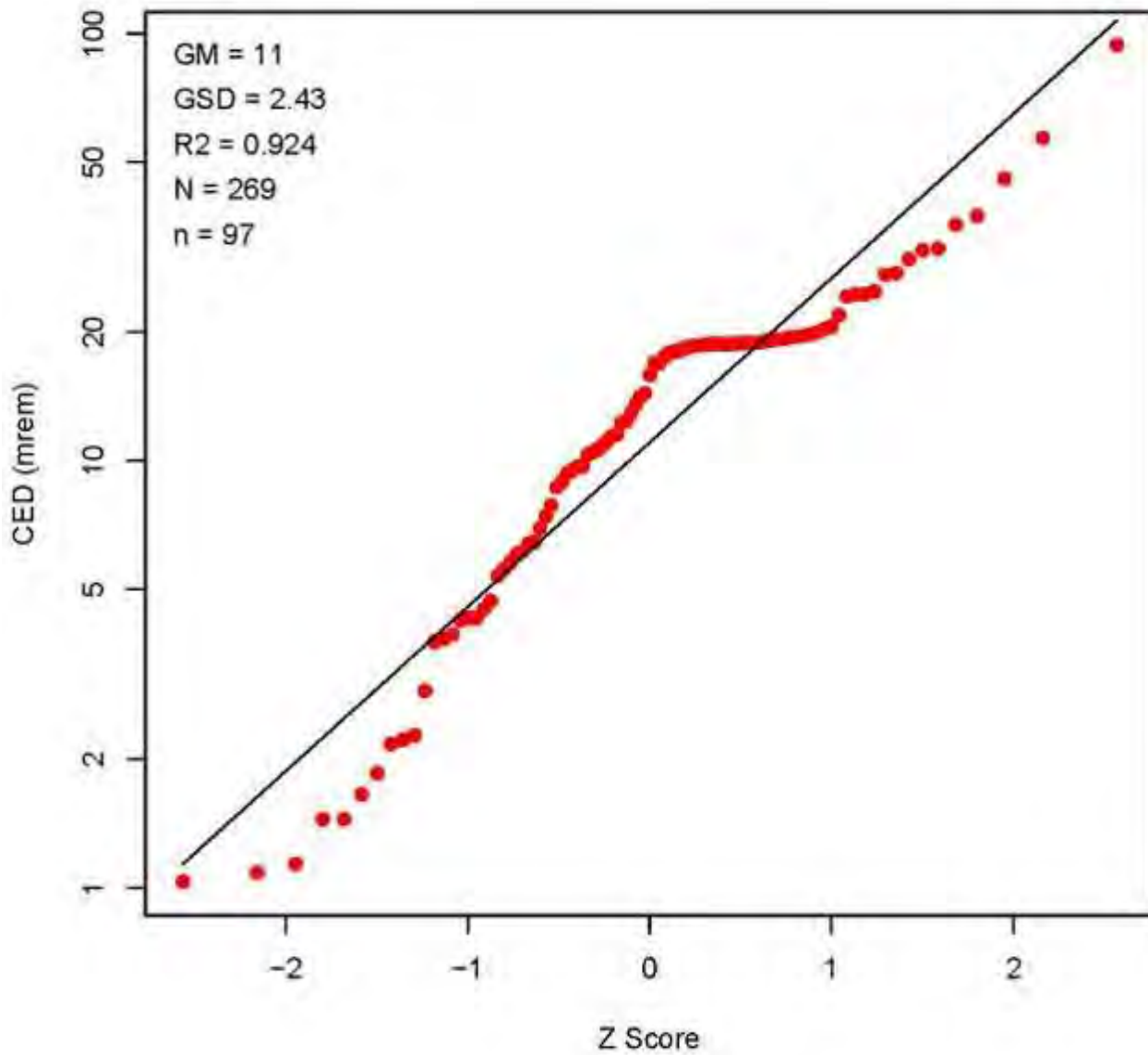


Figure B-123. SRS nonreactor tritium dose 1984.

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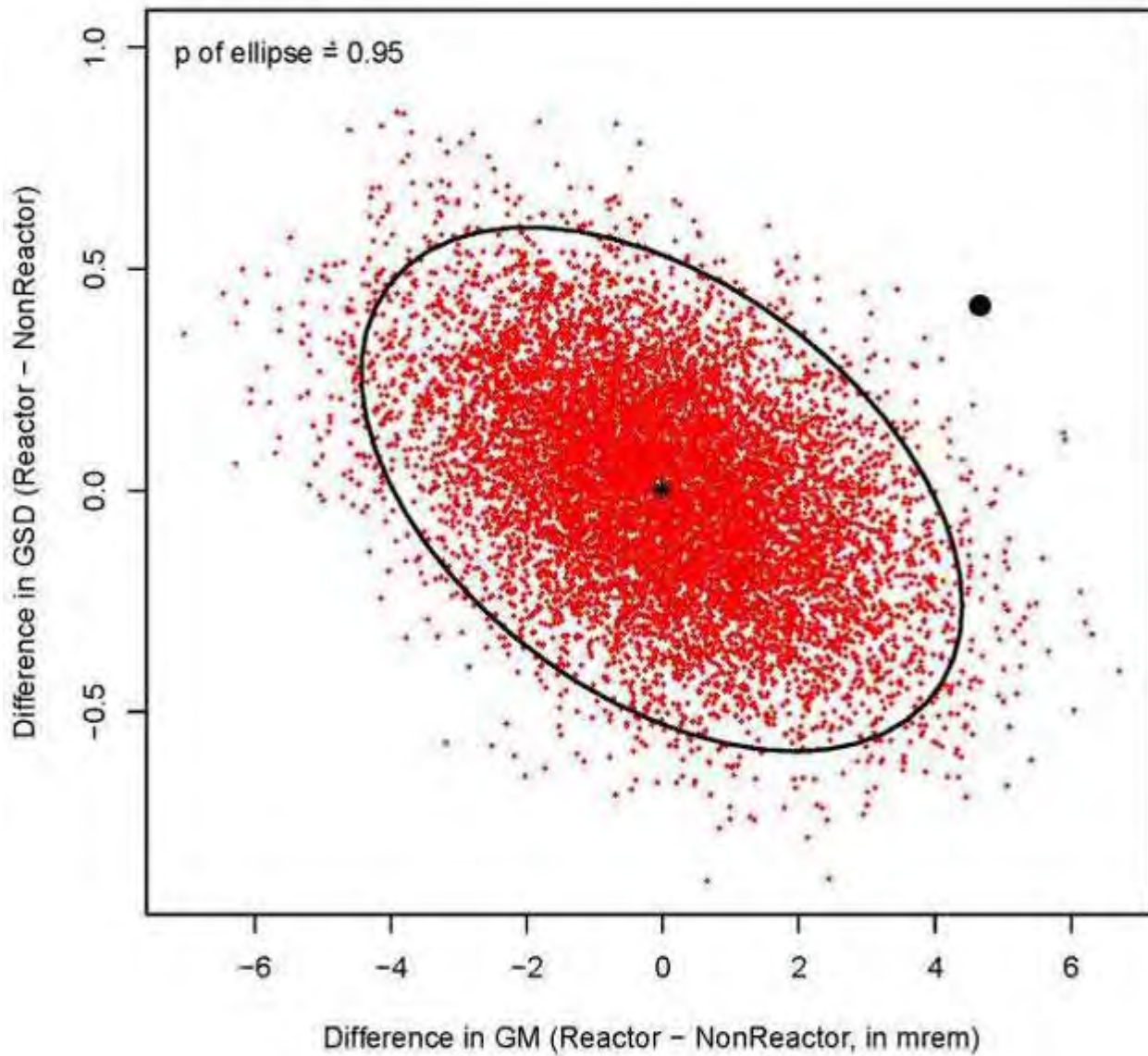


Figure B-124. SRS tritium dose 1984.

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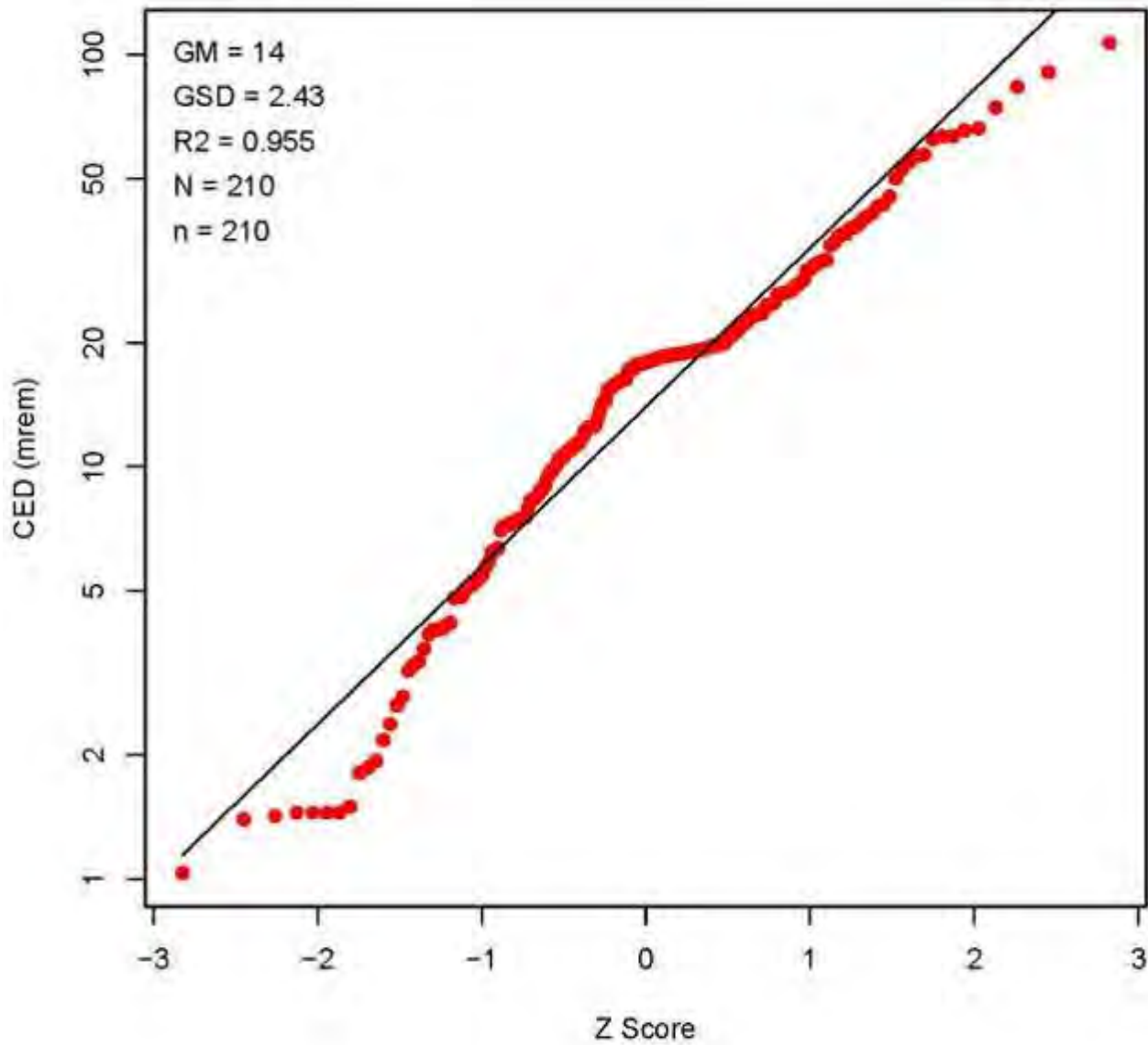


Figure B-125. SRS tritium dose 1985.

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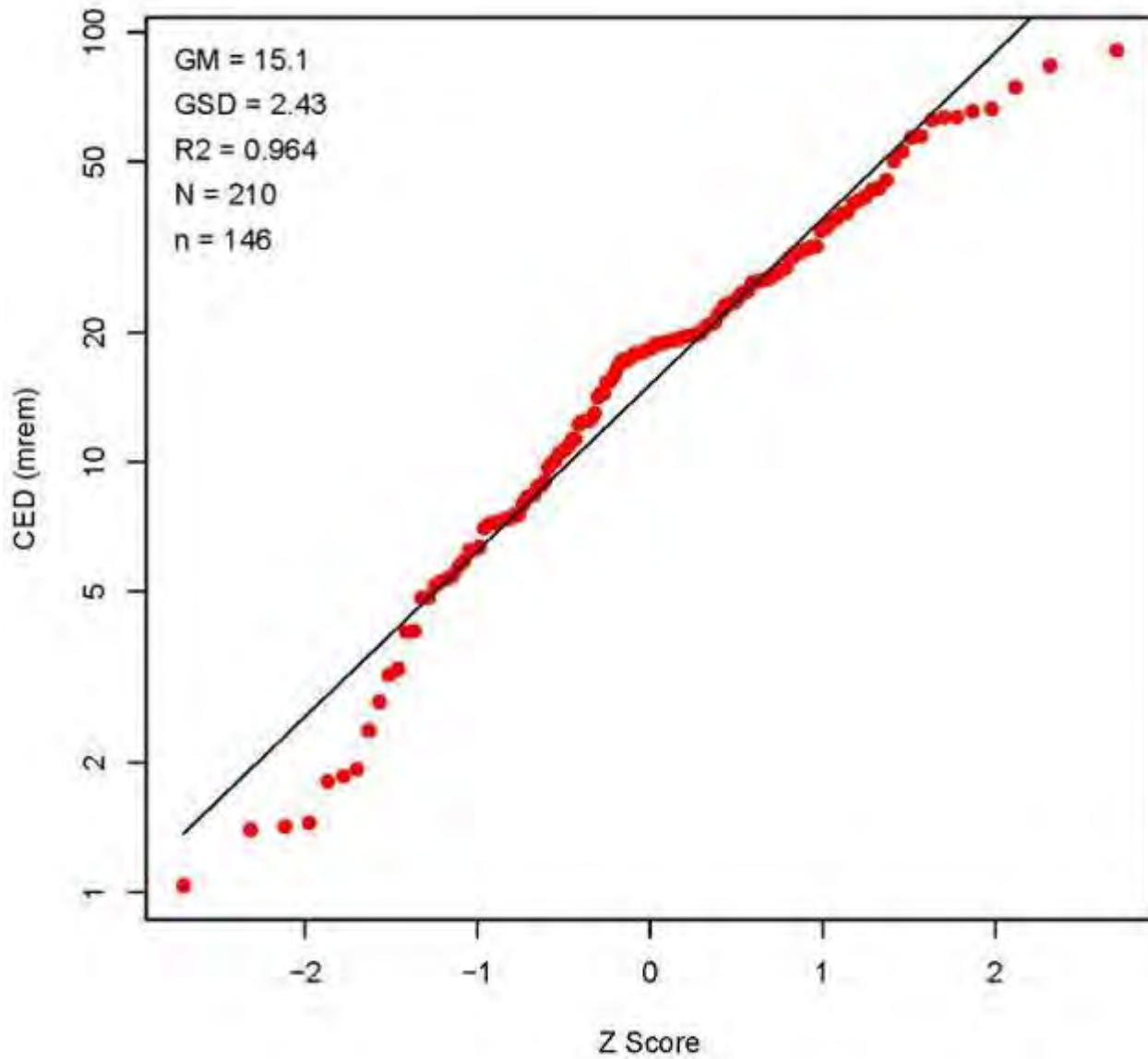


Figure B-126. SRS reactor tritium dose 1985.

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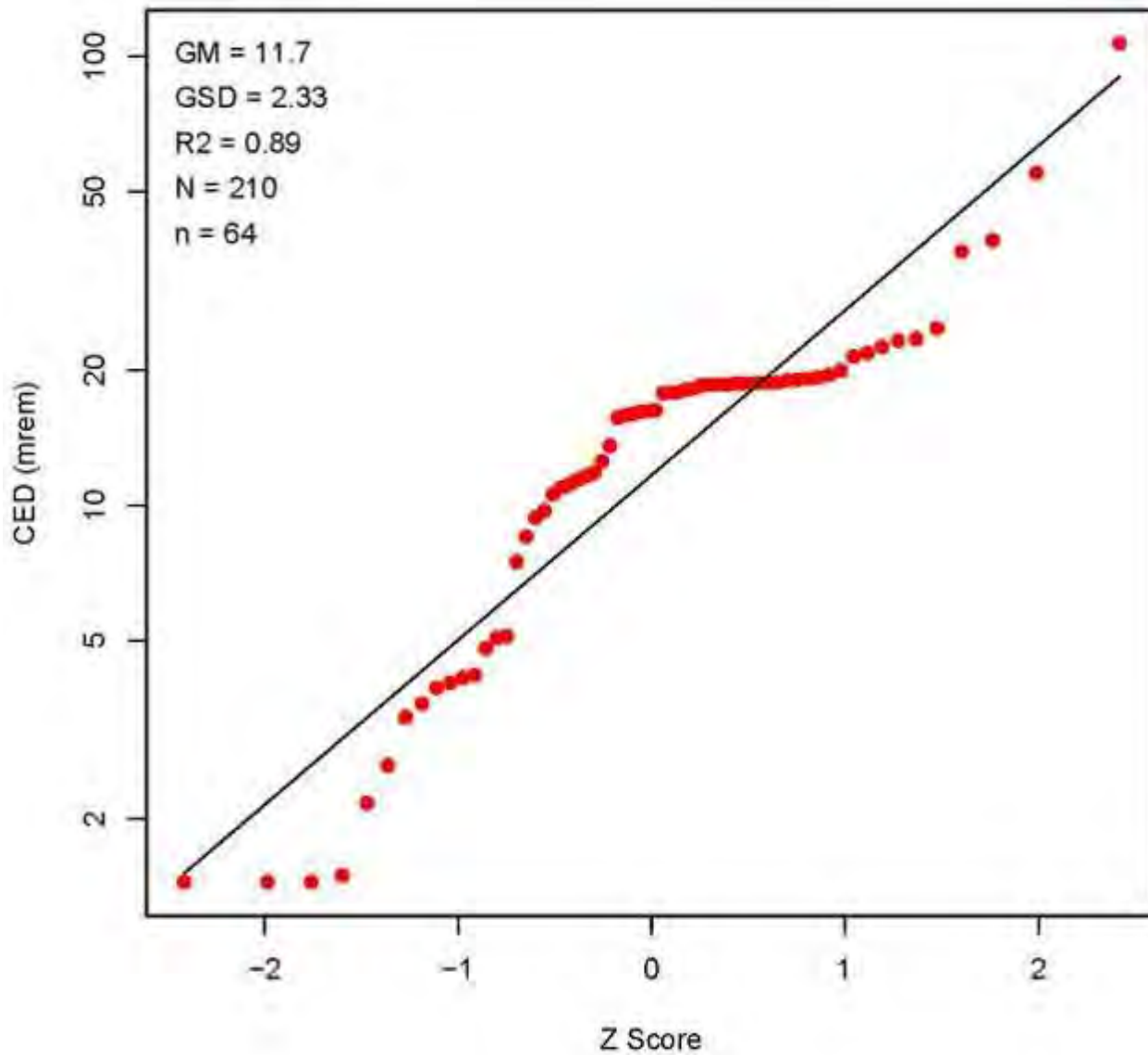


Figure B-127. SRS nonreactor tritium dose 1985.

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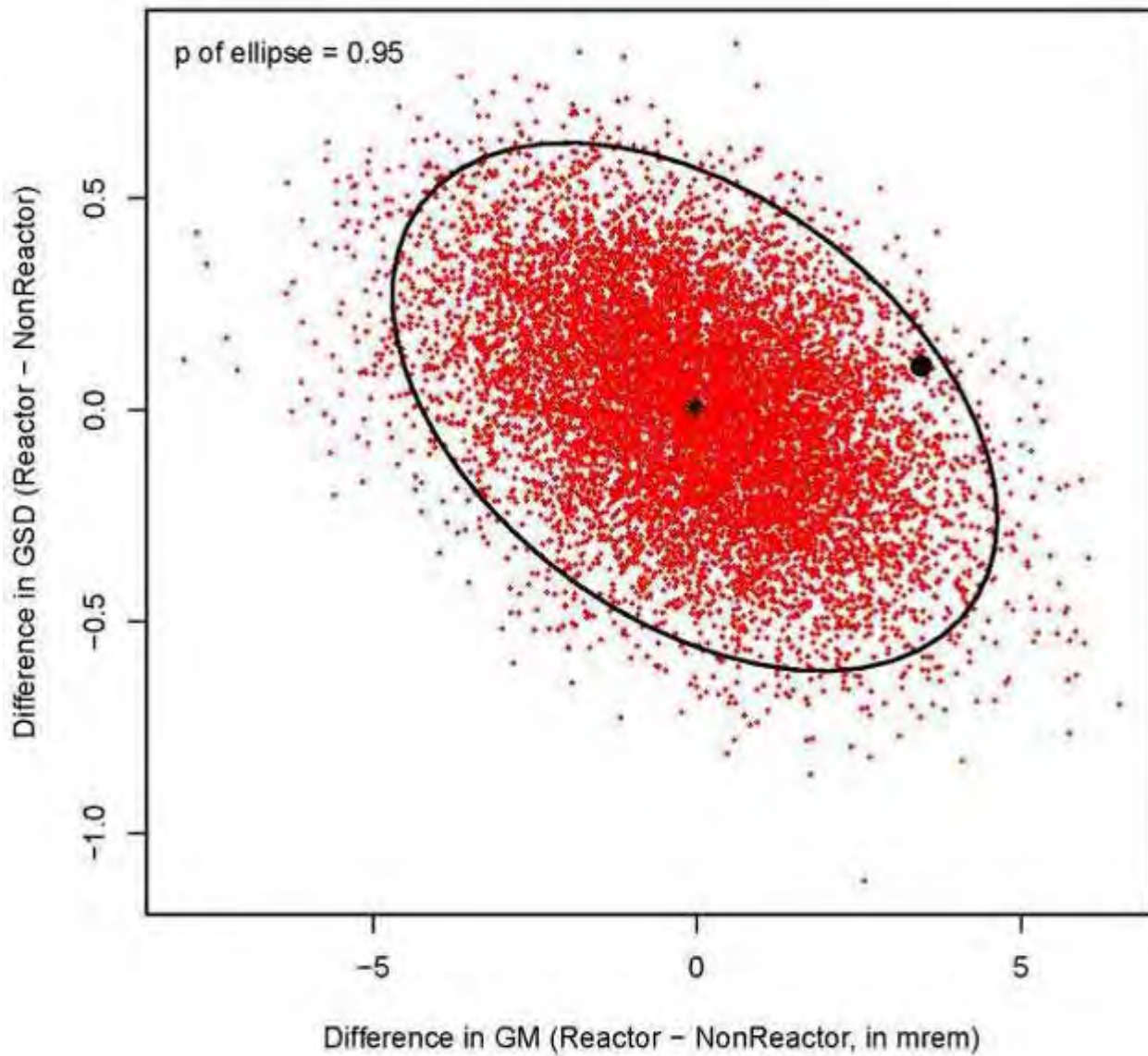


Figure B-128. SRS tritium dose 1985.

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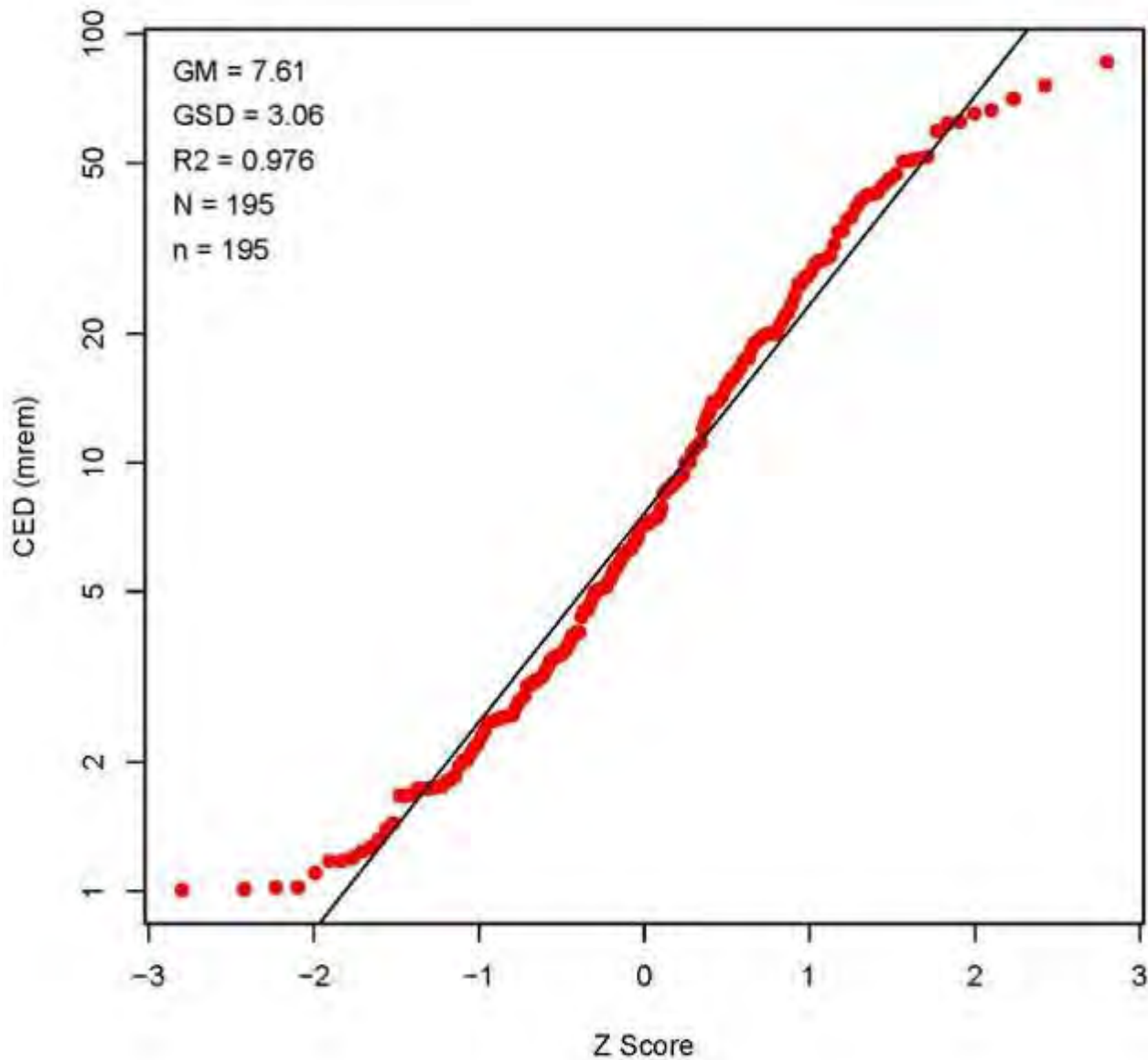


Figure B-129. SRS tritium dose 1986.

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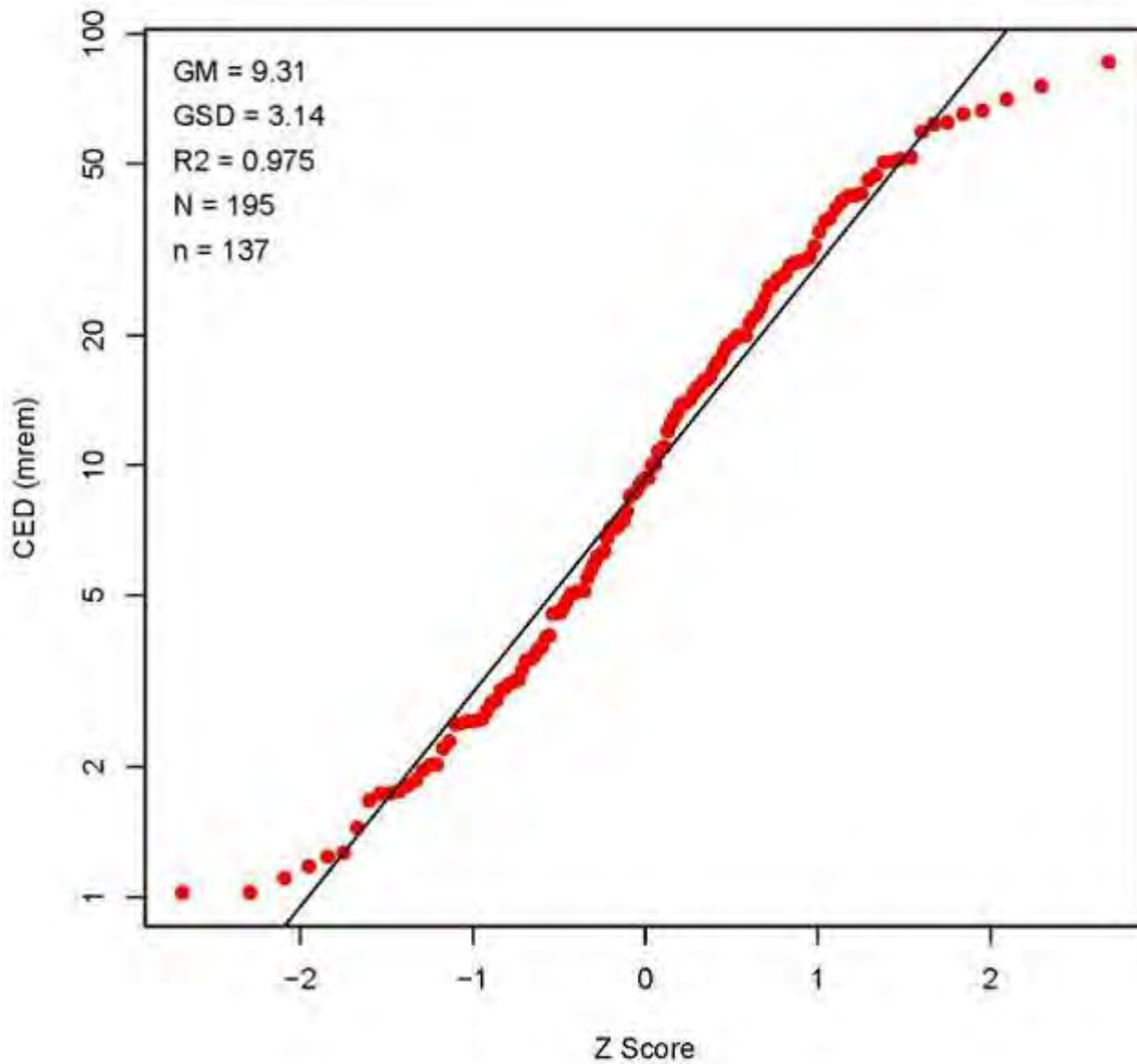


Figure B-130. SRS reactor tritium dose 1986.

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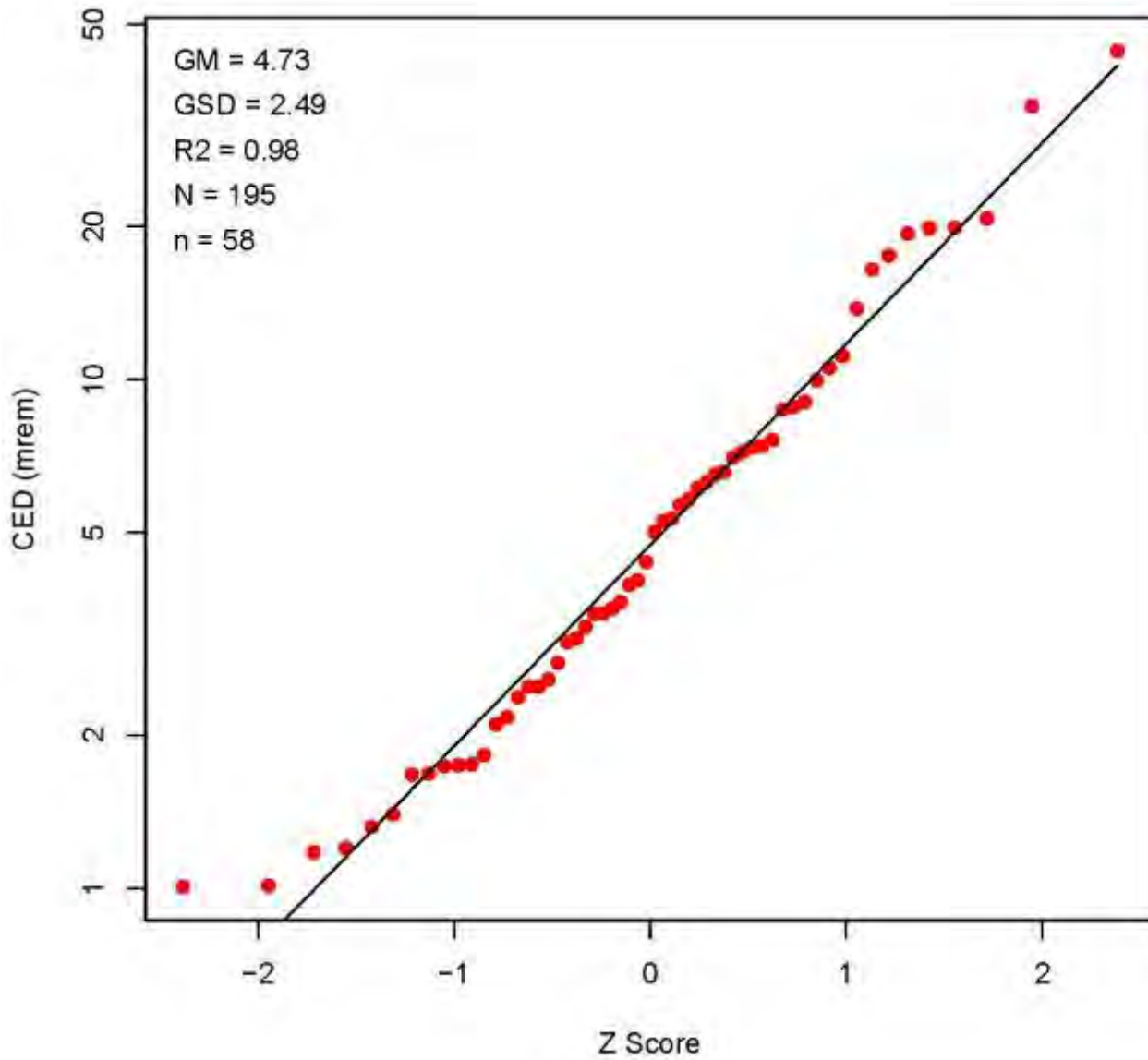


Figure B-131. SRS nonreactor tritium dose 1986.

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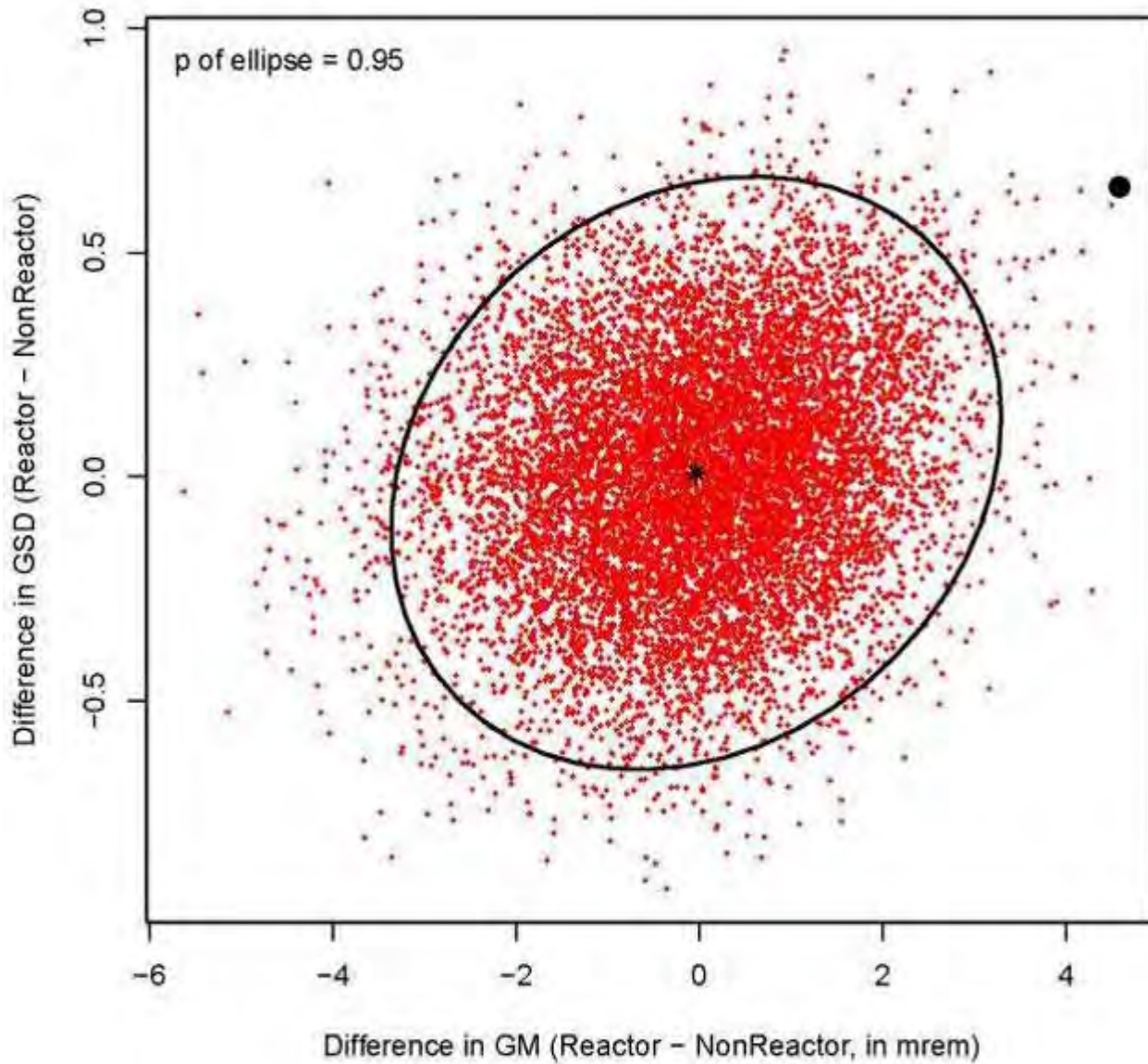


Figure B-132. SRS tritium dose 1986.

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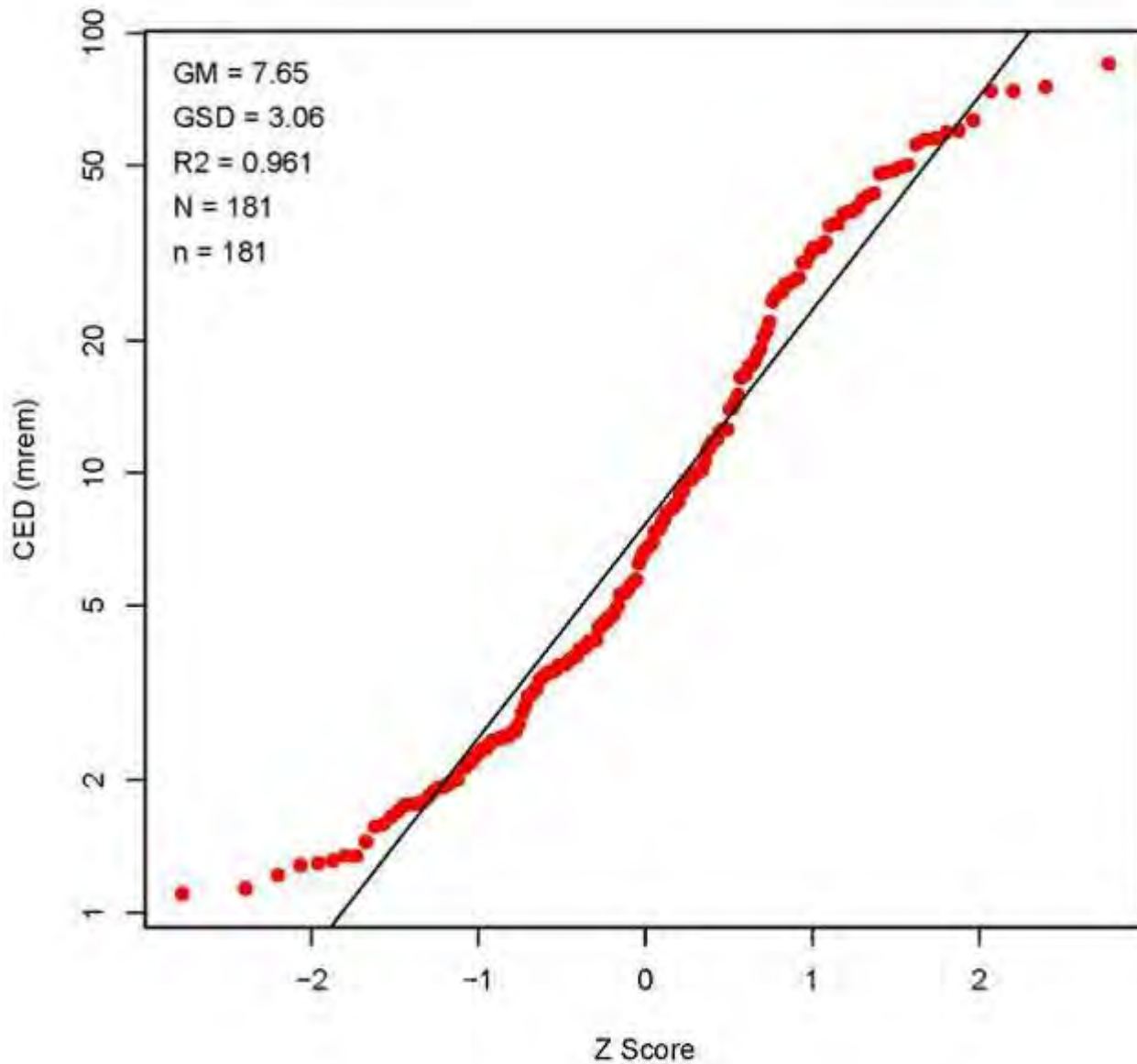


Figure B-133. SRS tritium dose 1987.

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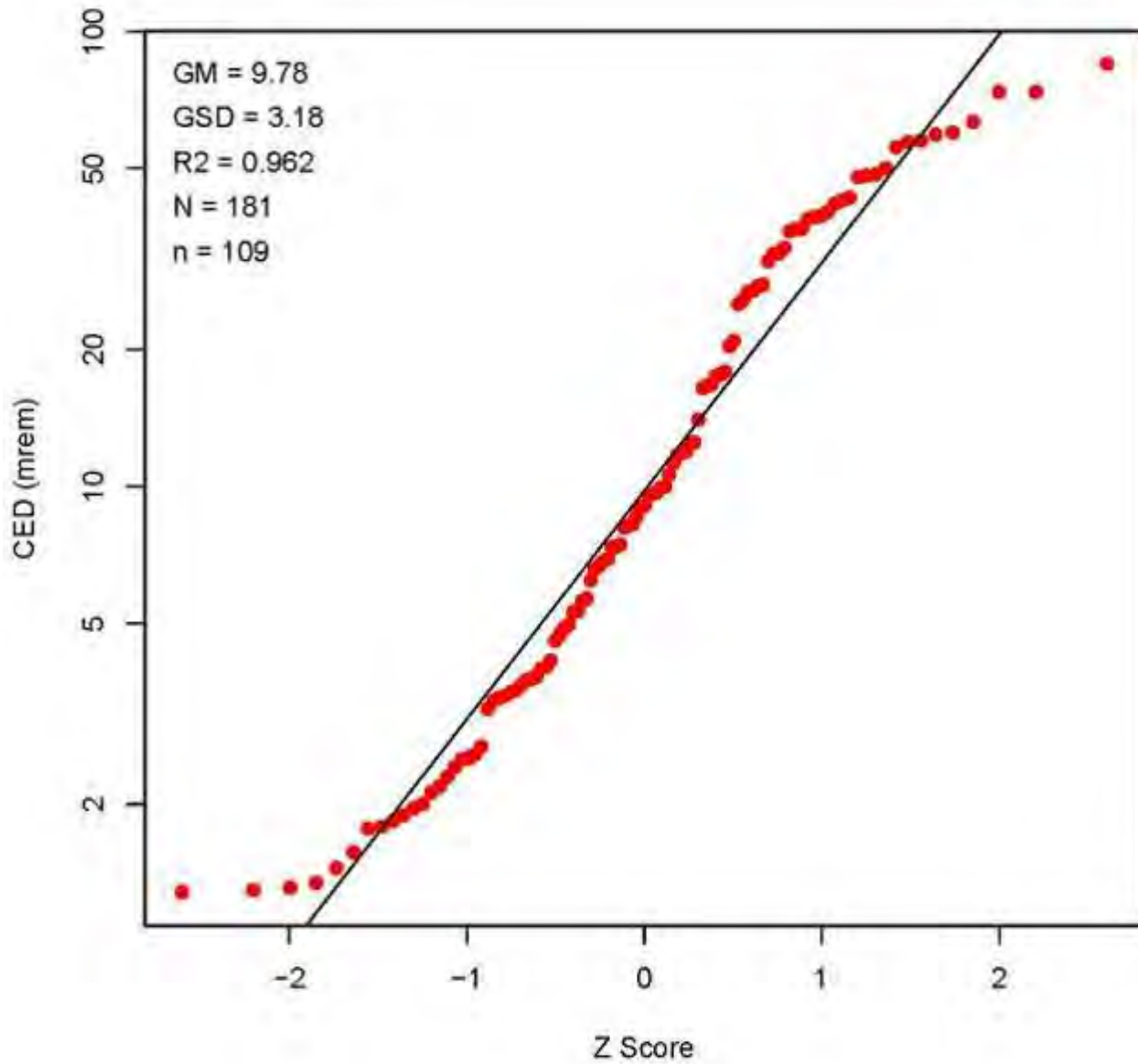


Figure B-134. SRS reactor tritium dose 1987.

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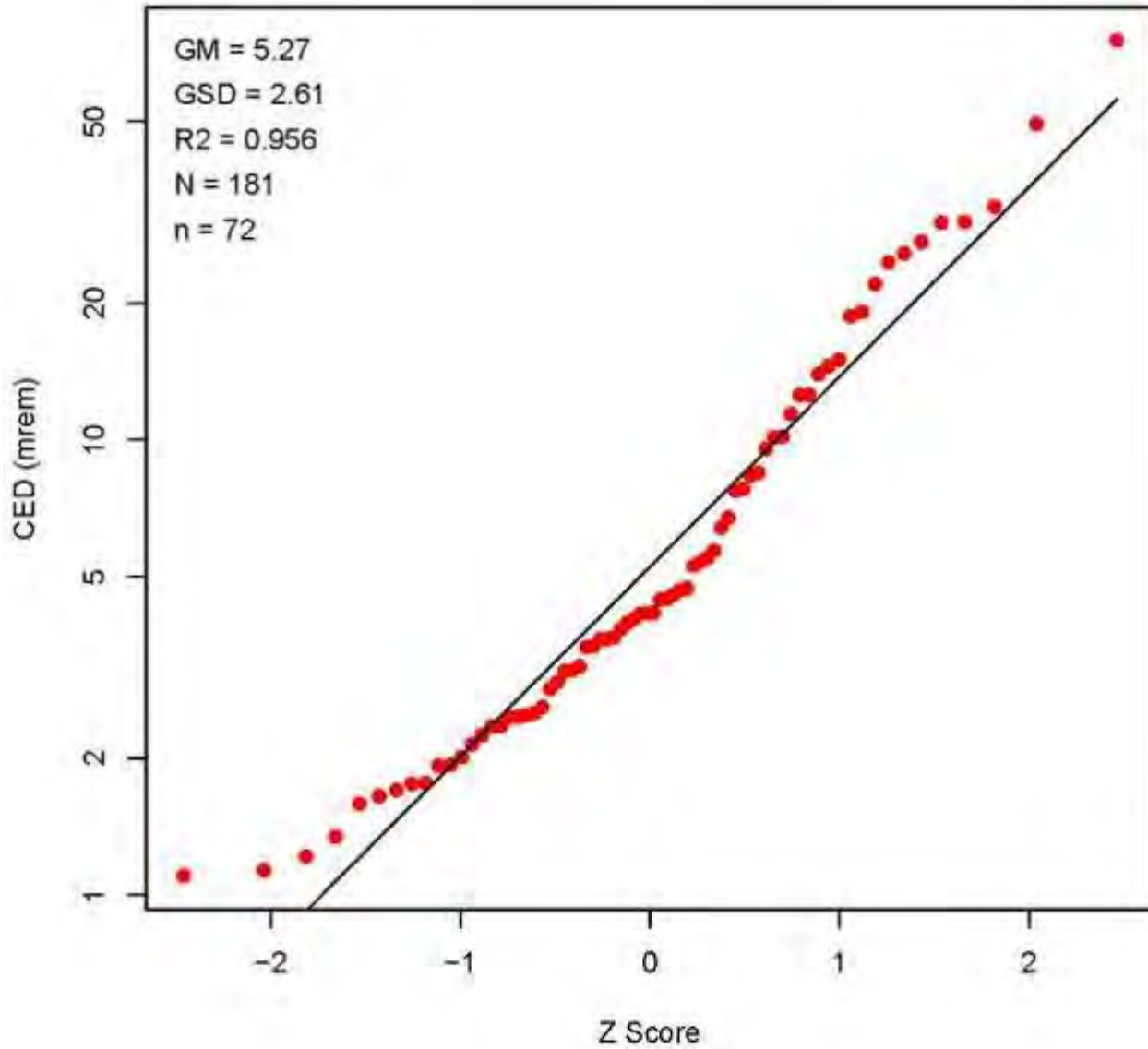


Figure B-135. SRS nonreactor tritium dose 1987.

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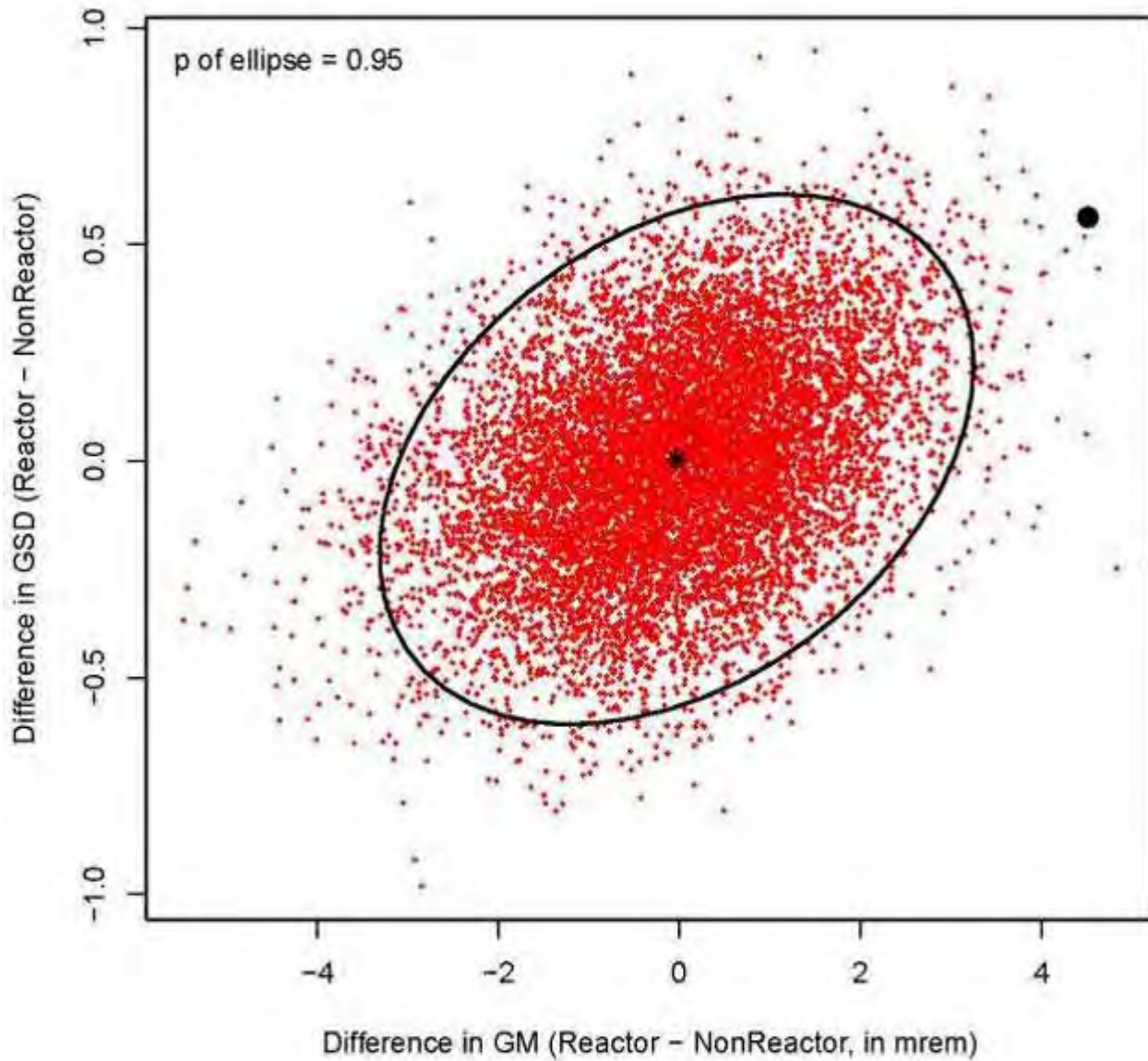


Figure B-136. SRS tritium dose 1987.

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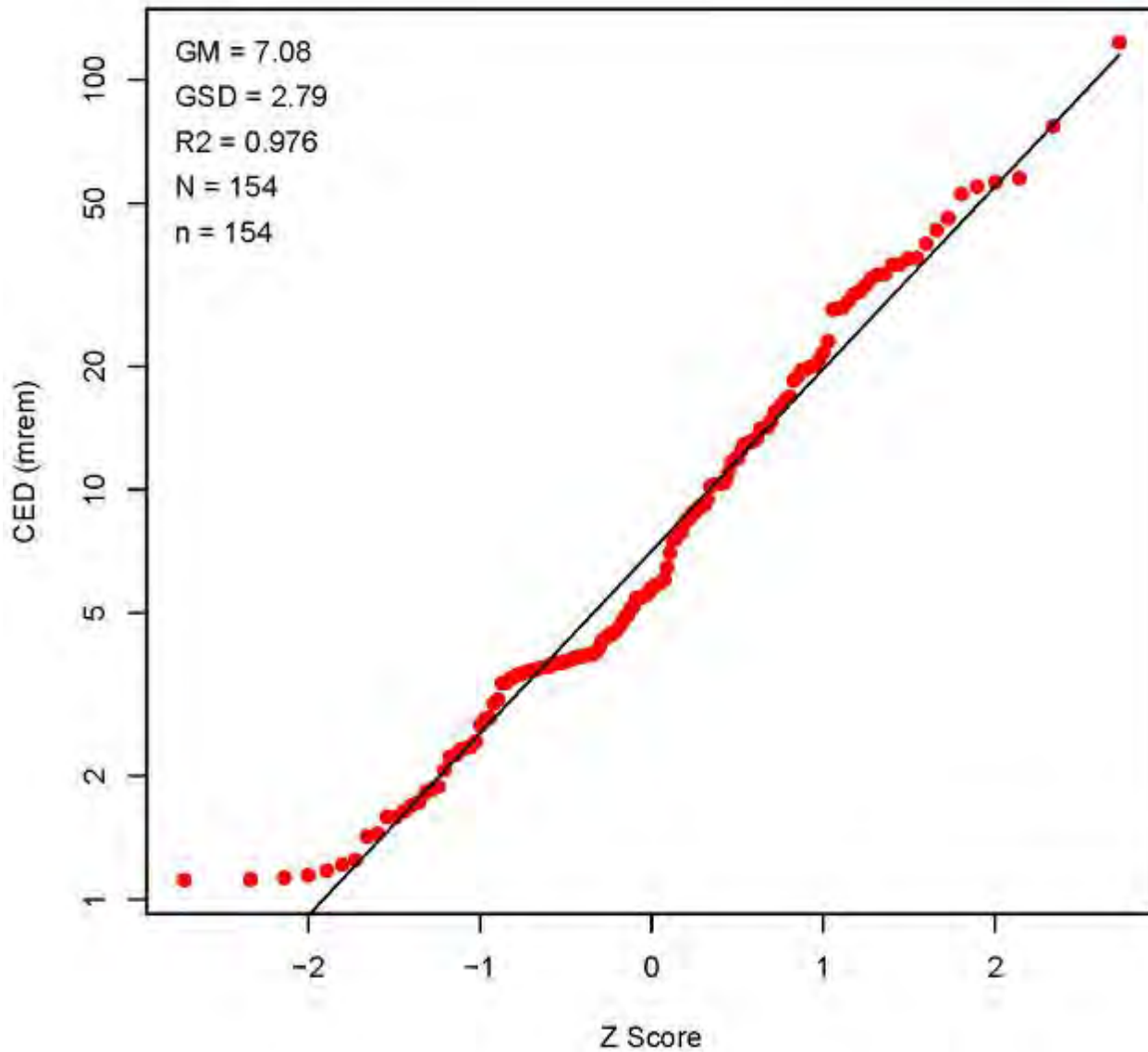


Figure B-137. SRS tritium dose 1988.

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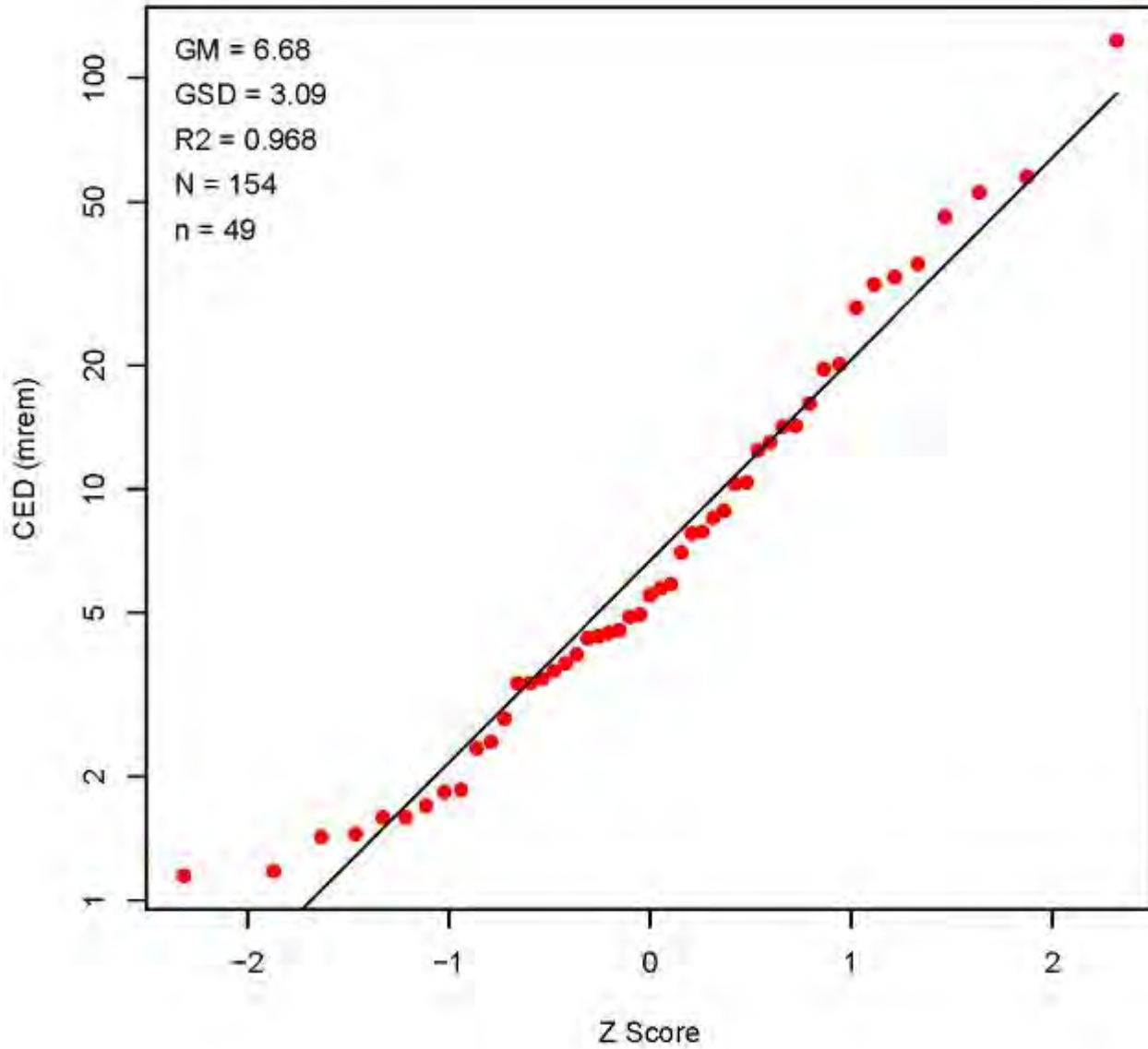


Figure B-138. SRS reactor tritium dose 1988.

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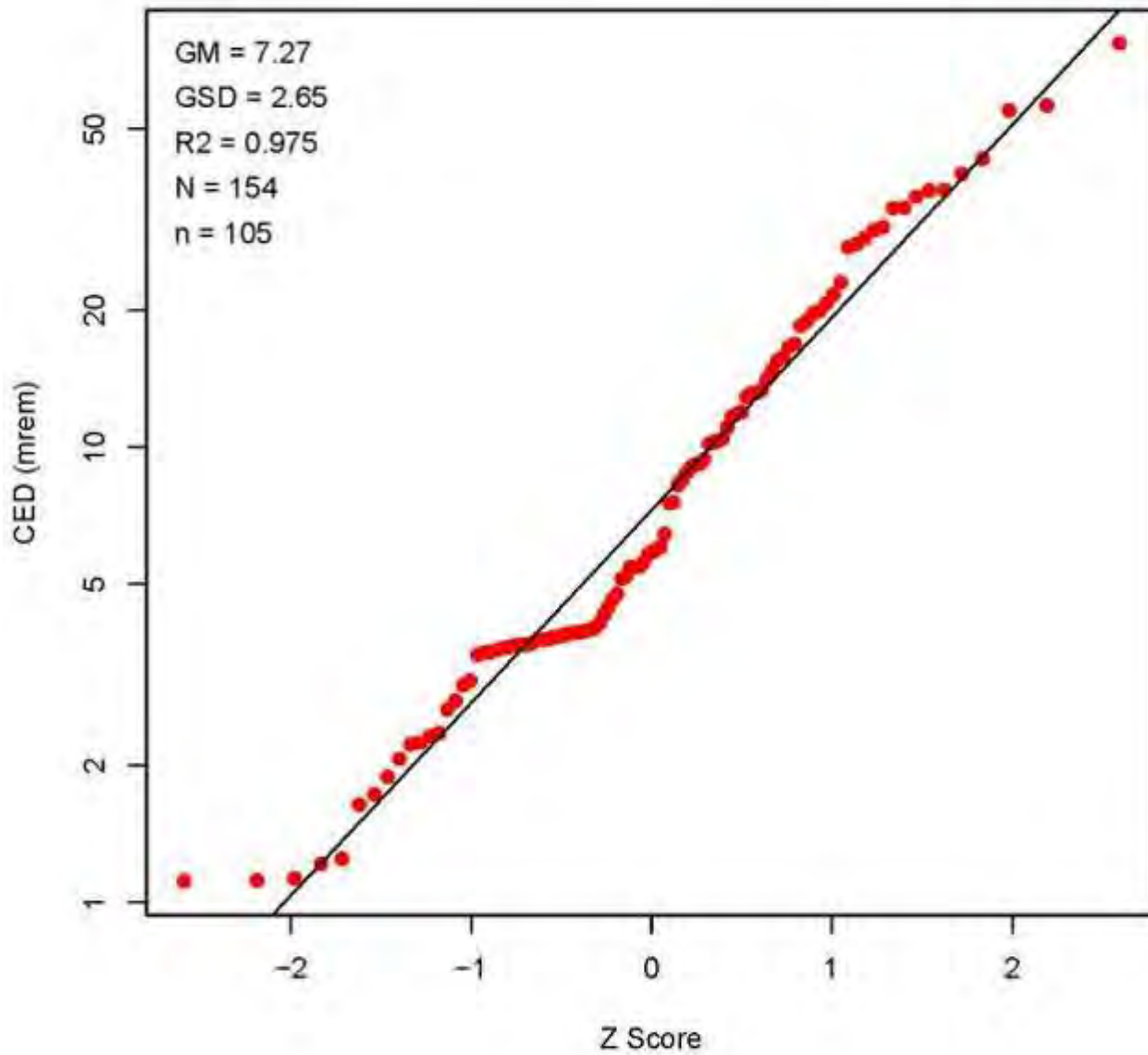


Figure B-139. SRS nonreactor tritium dose 1988.

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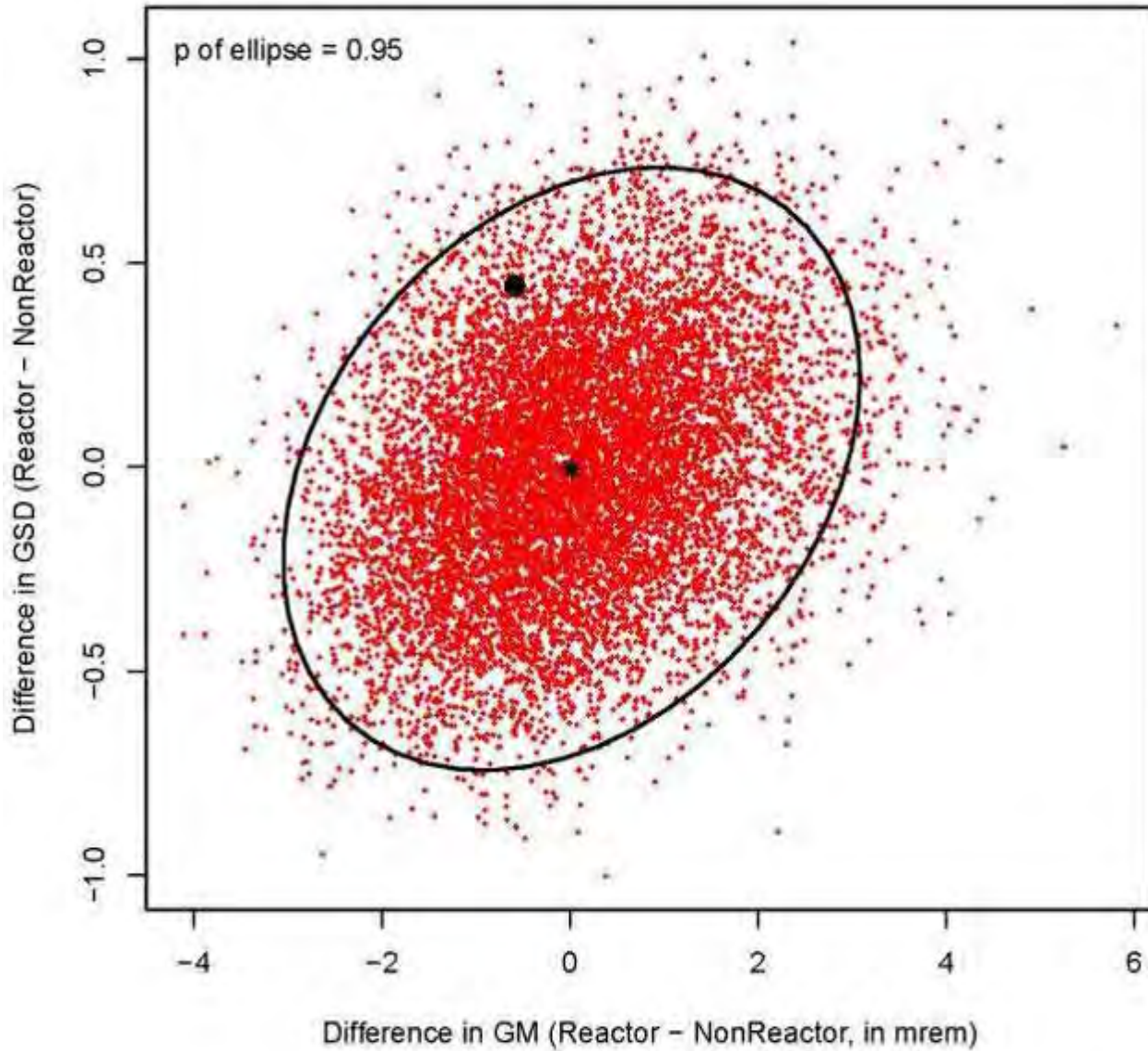


Figure B-140. SRS tritium dose 1988.

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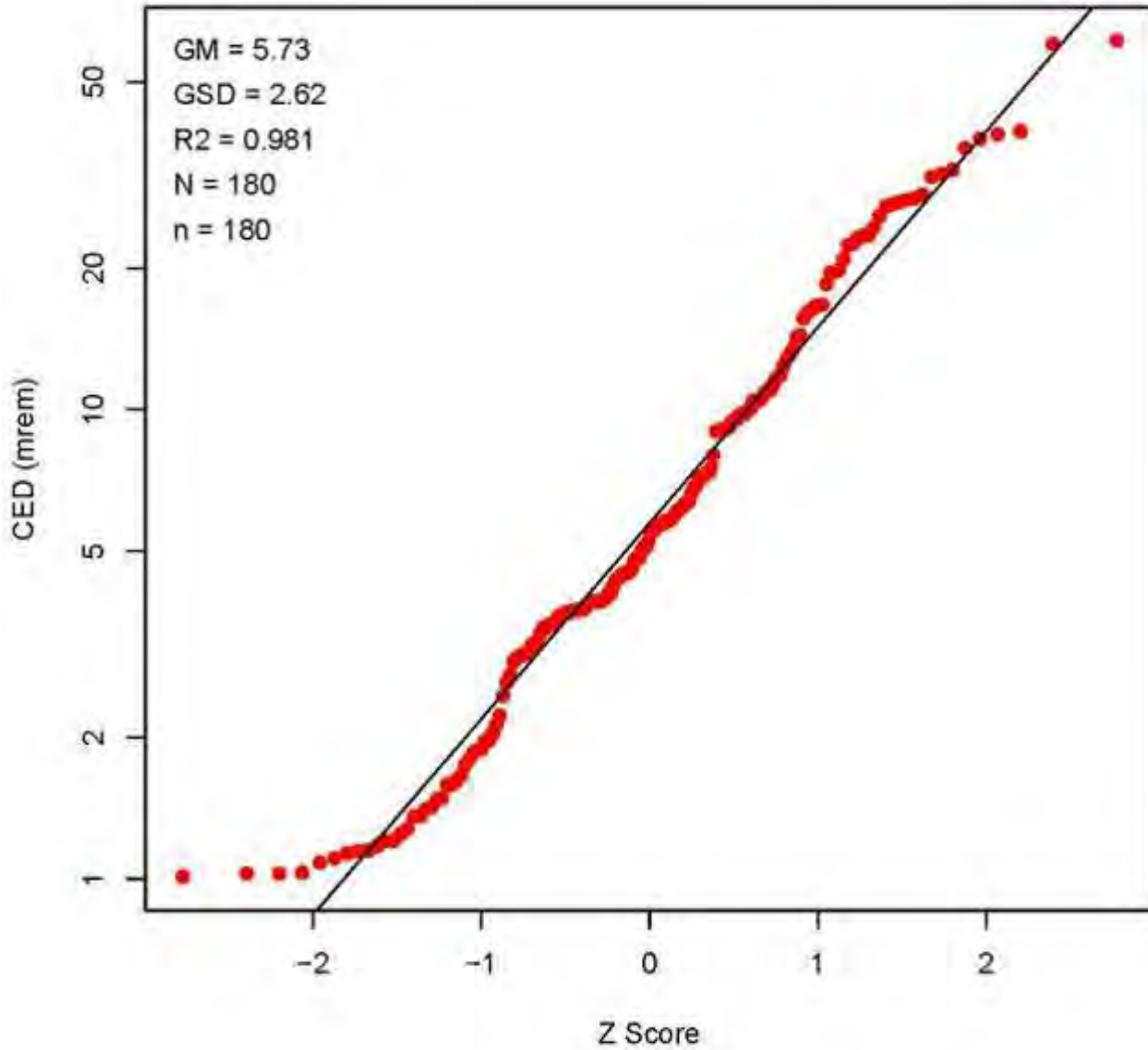


Figure B-141. SRS tritium dose 1989.

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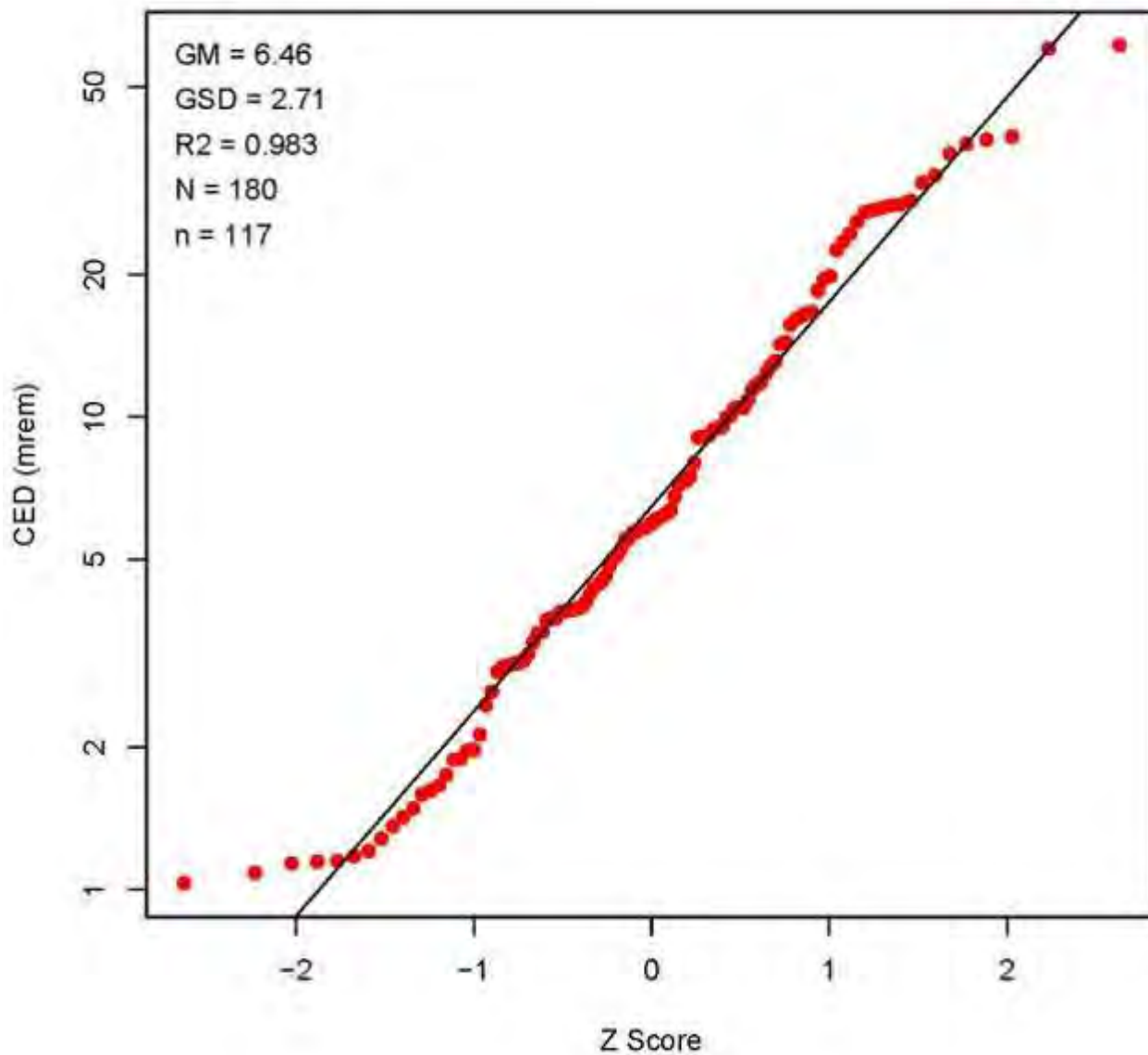


Figure B-142. SRS reactor tritium dose 1989.

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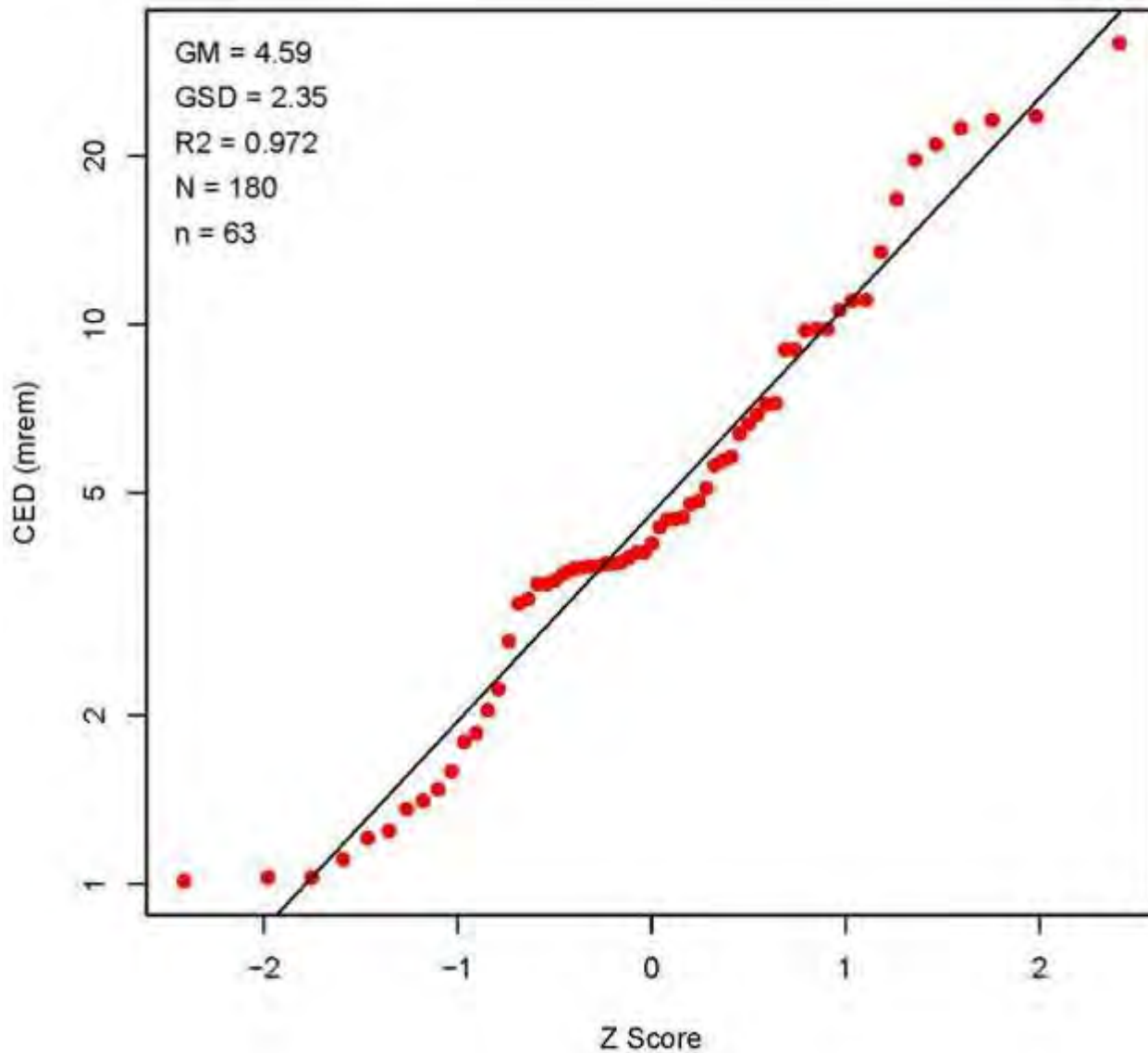


Figure B-143. SRS nonreactor tritium dose 1989.

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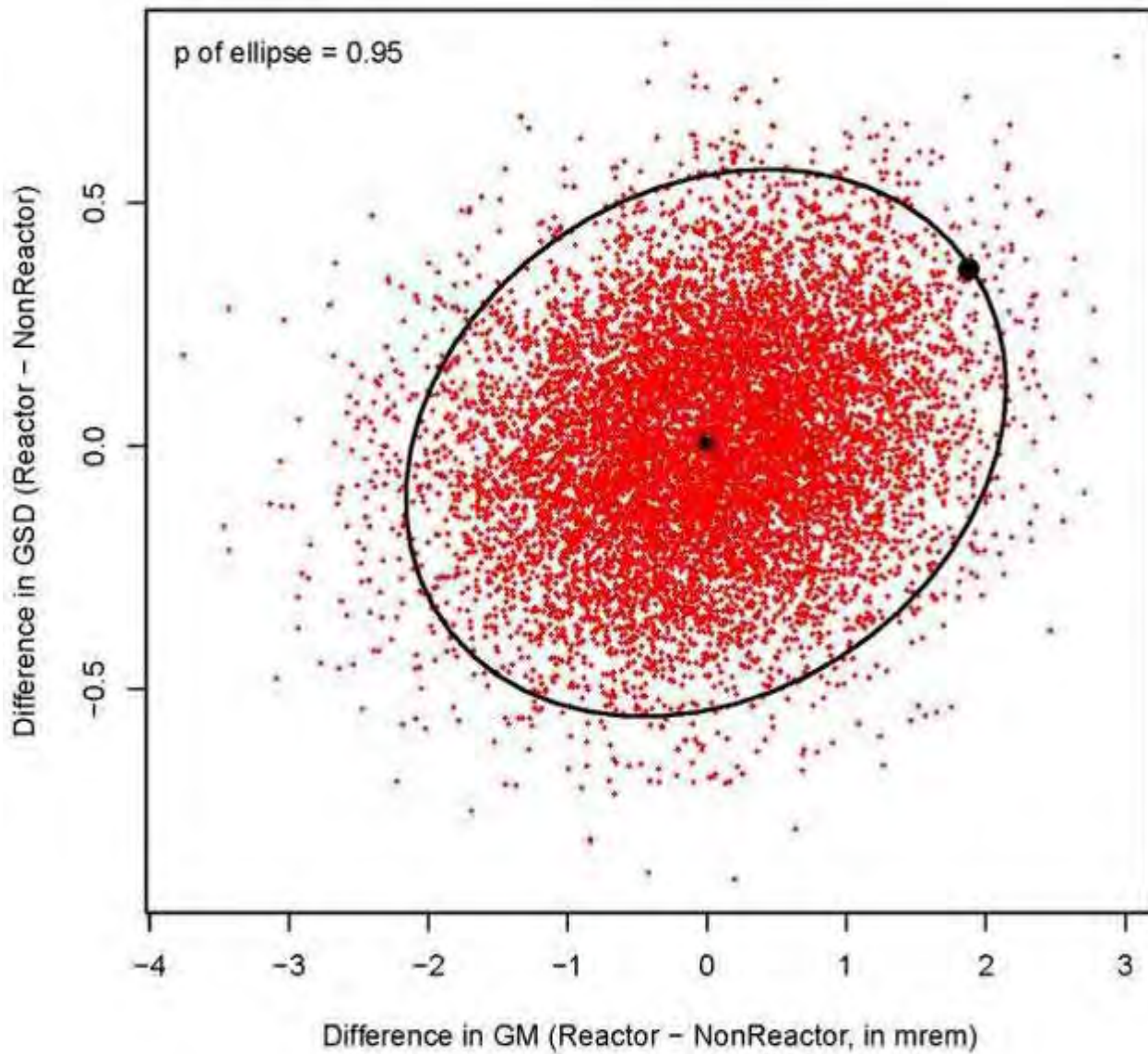


Figure B-144. SRS tritium dose 1989.

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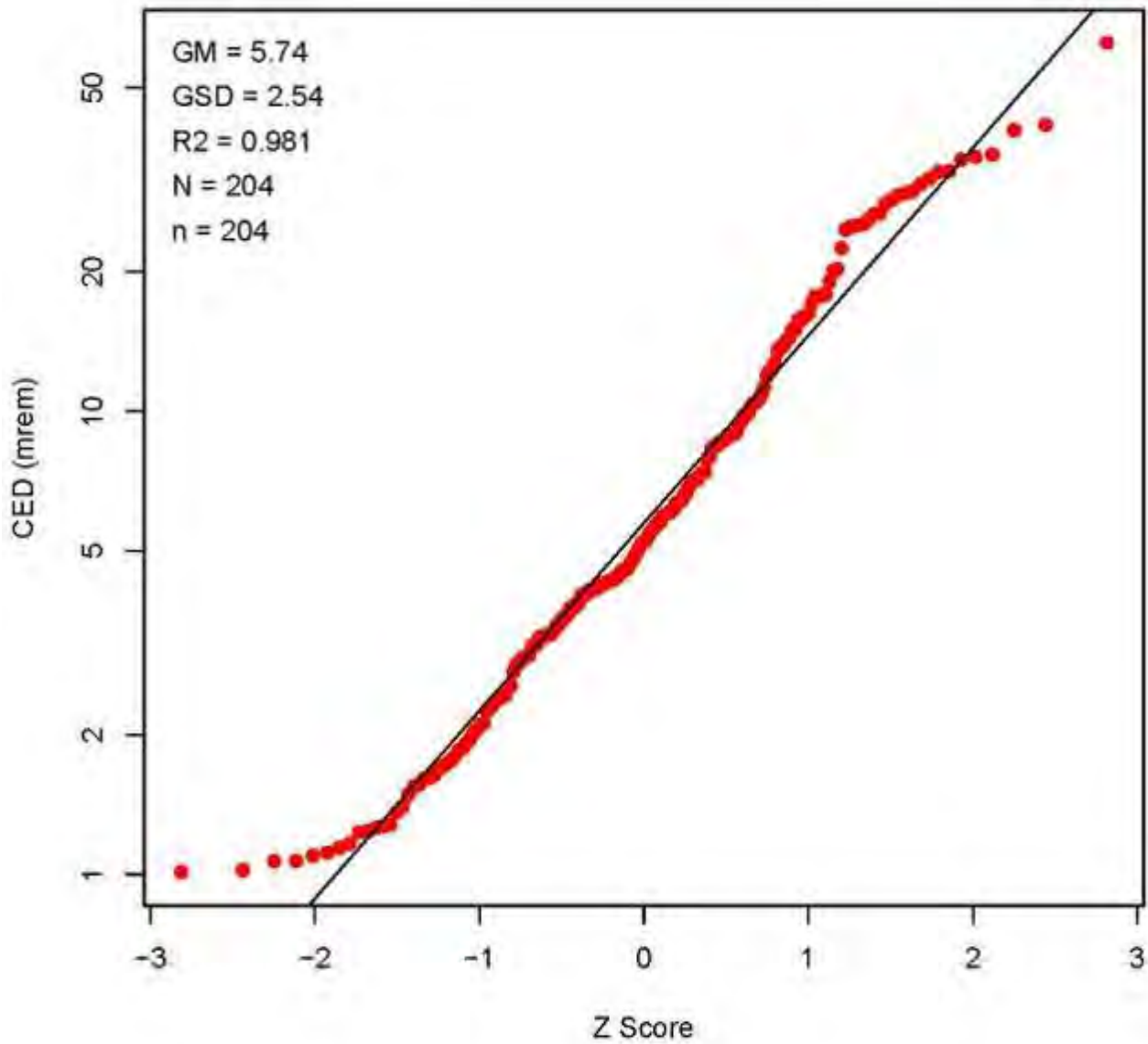


Figure B-145. SRS tritium dose 1990.

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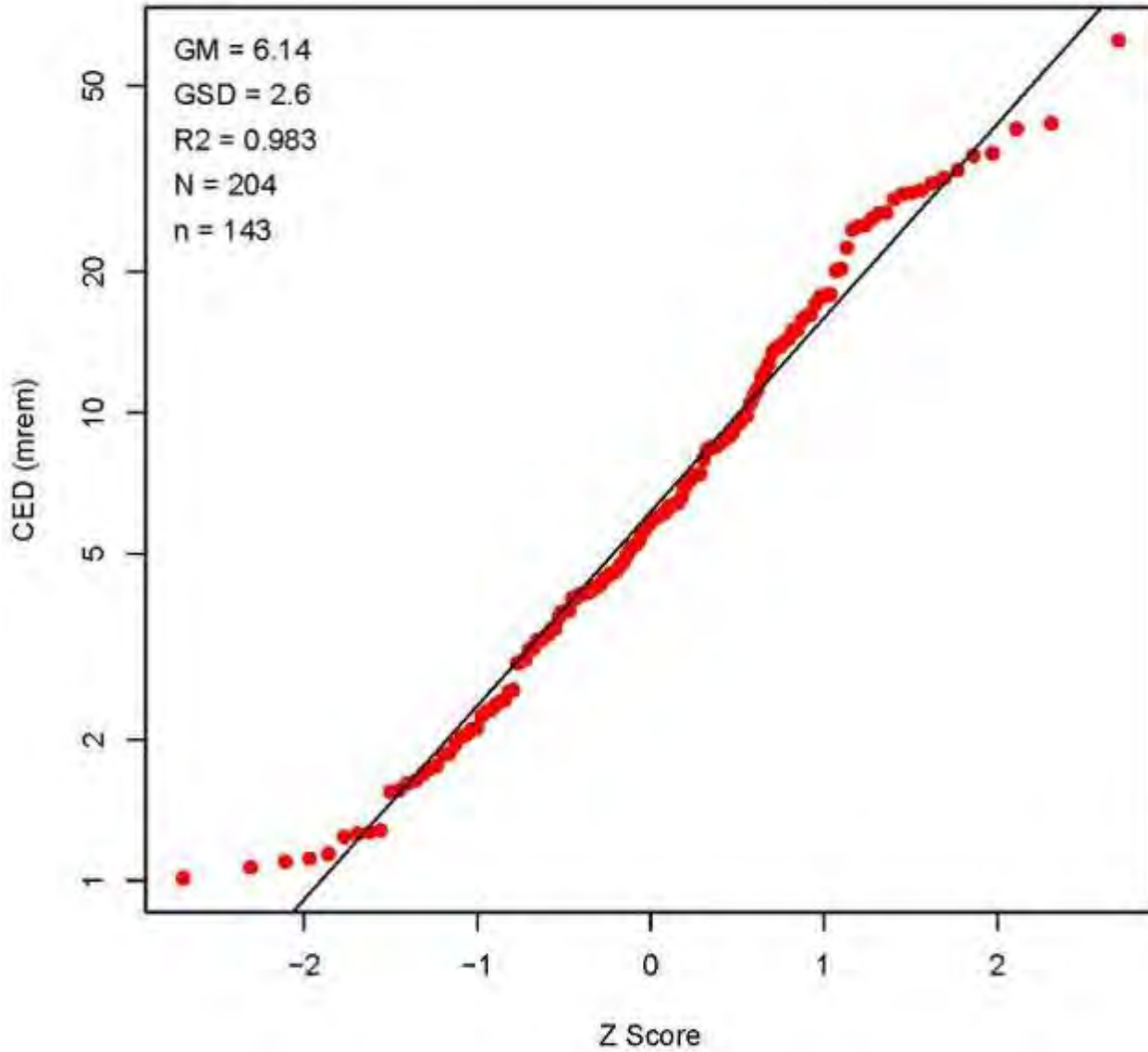


Figure B-146. SRS reactor tritium dose 1990.

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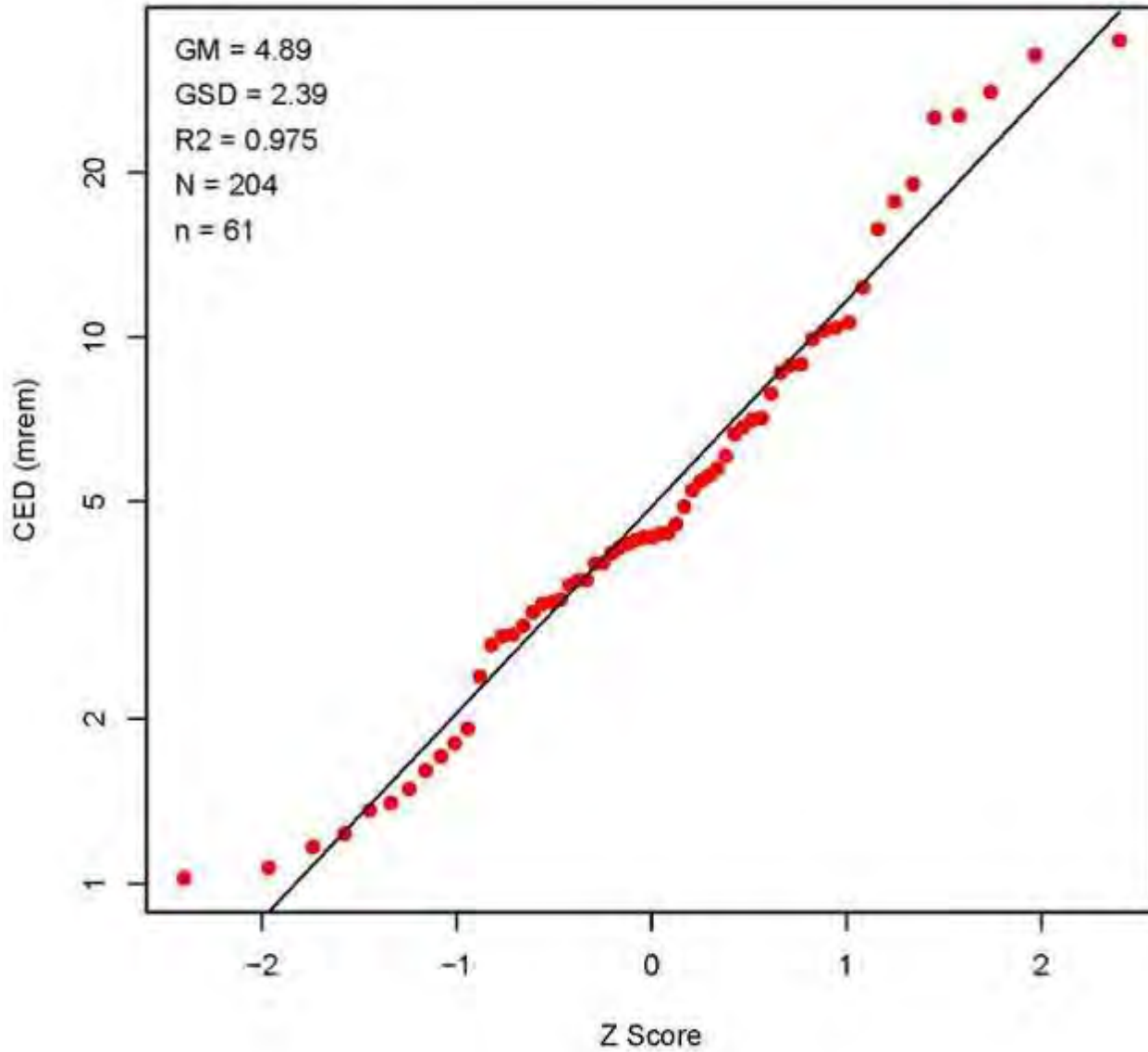


Figure B-147. SRS nonreactor tritium dose 1990.

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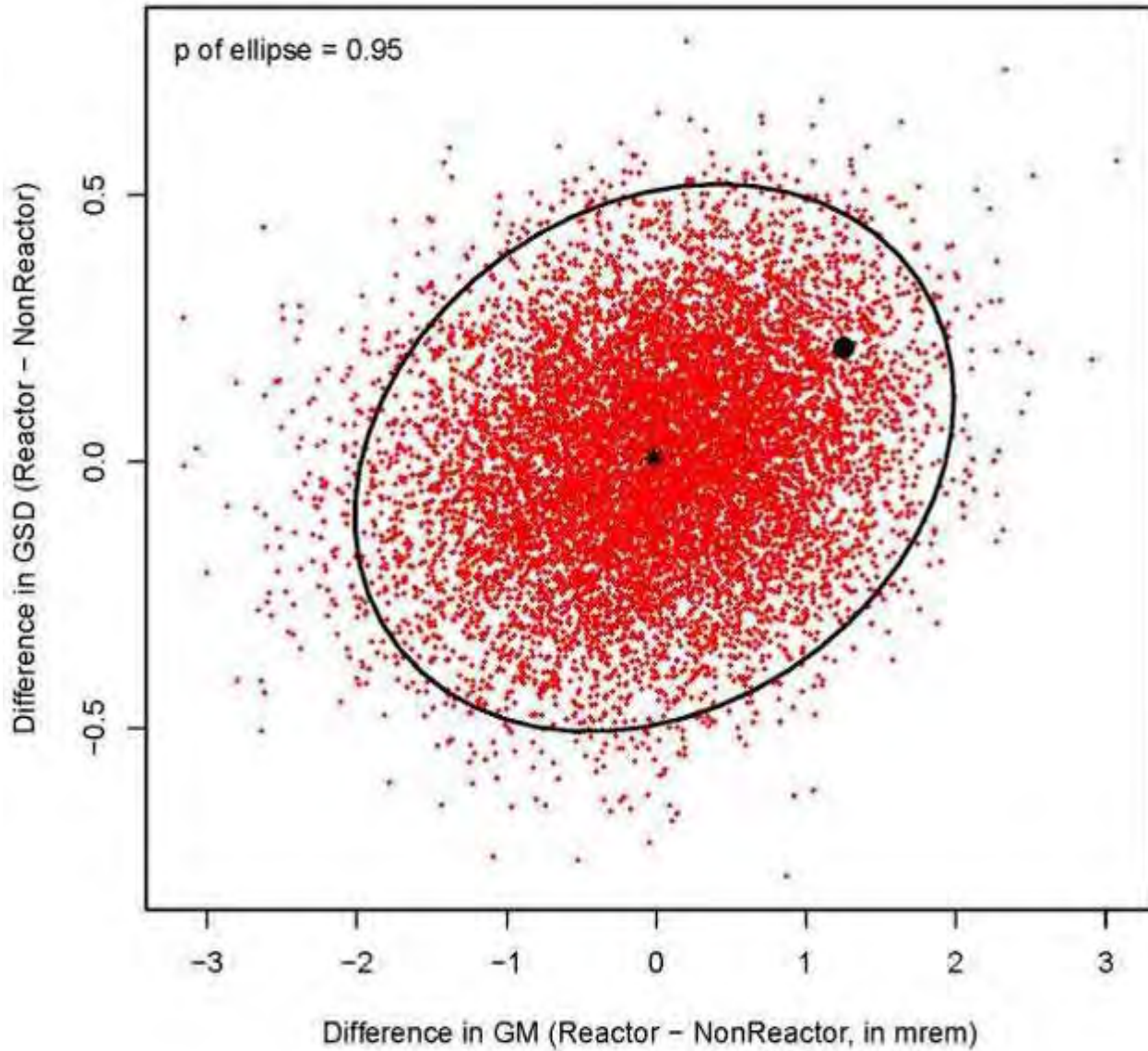


Figure B-148. SRS tritium dose 1990.

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Four plots are presented for each year from 1954 to 1990. The first three are lognormal probability plots of the tritium doses for the CS of workers, the CTWs who worked in the reactor areas (CTW/Reactor), and all other workers (Non(CTW/Reactor)). In these plots the following statistics are presented:

- GM = geometric mean of data (intercept of line)
- GSD = geometric standard deviation of data (slope of line)
- R2 = coefficient of determination for regression line
- N = total number of individuals in CS
- n = total number of individuals in CTW or NCTW group

The fourth plot for a given year is a Monte Carlo permutation plot of the test statistics for 10,000 random draws from the CS. Each random draw from the CS is split into one part the size of the CTW/Reactor workers and one part the size of all other workers and two test statistics (one for the GM and one for the GSD) are calculated for these two parts. All 10,000 pairs of test statistics are plotted and an ellipse is constructed that contains 95% of the test statistics. If the observed test statistics for the CTW/Reactor and all other workers strata lie outside the ellipse, the coworker model for the CTW/Reactor workers is different from the coworker model for all other workers.

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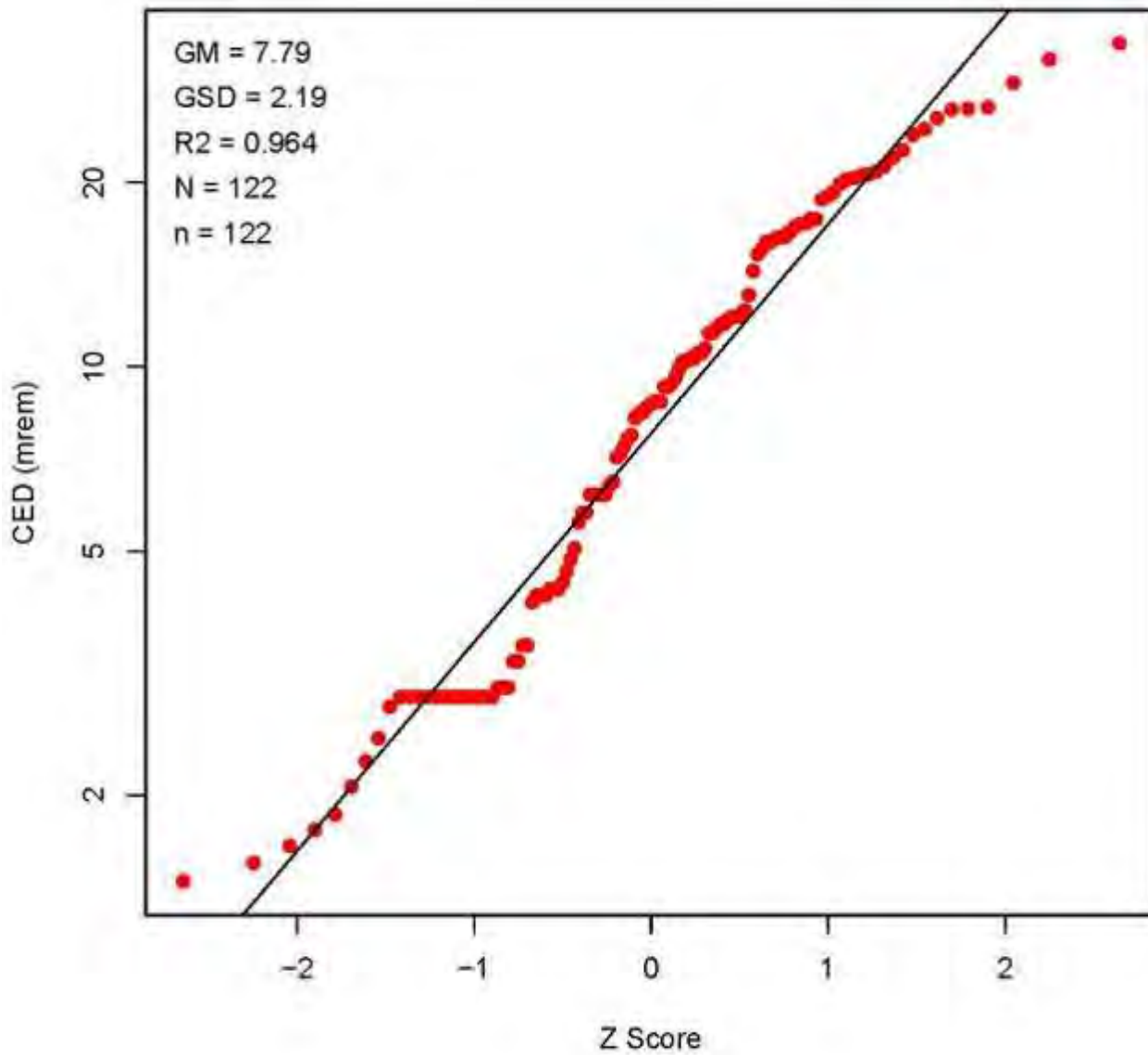


Figure C-1. SRS tritium dose 1954.

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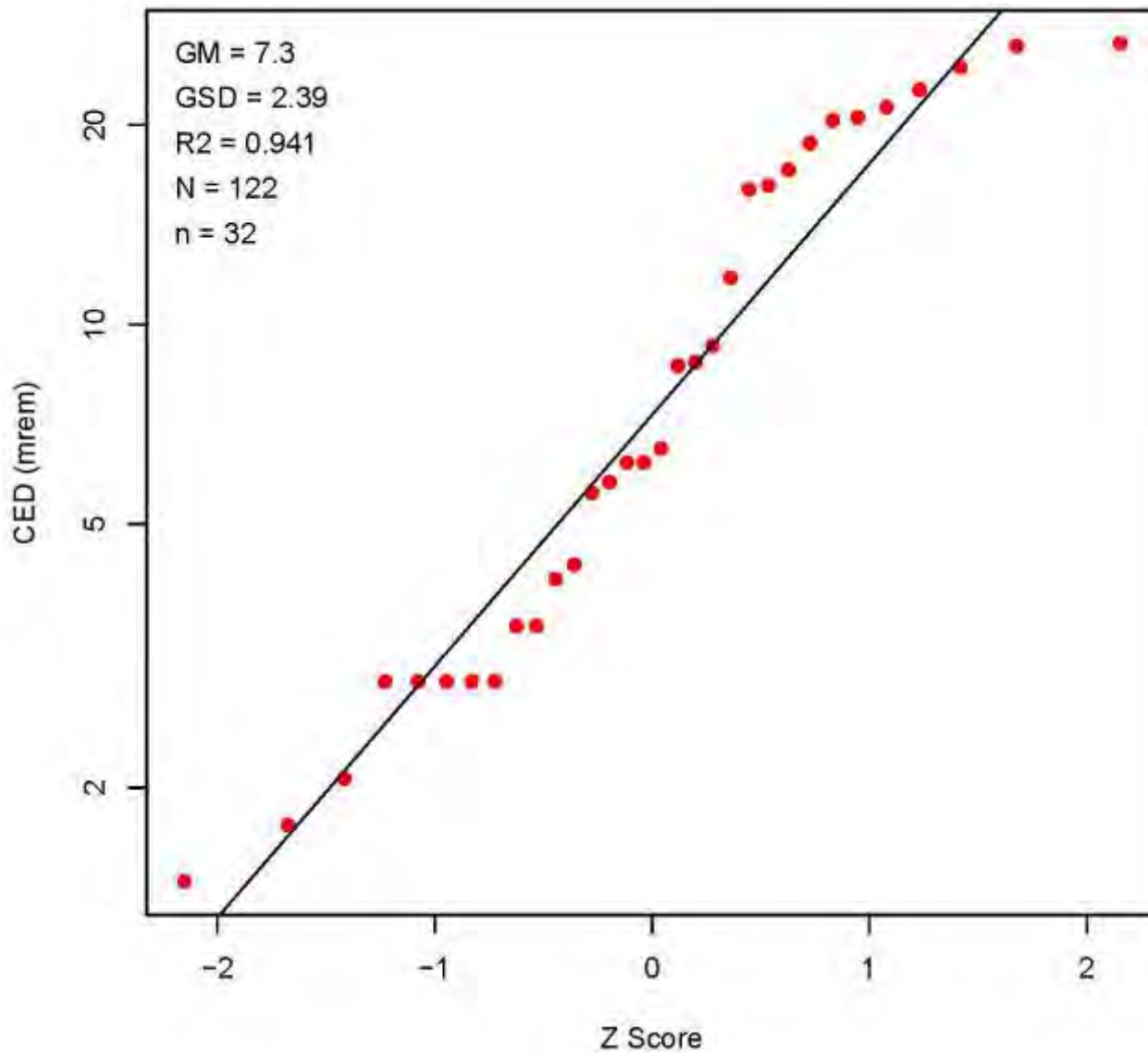


Figure C-2. SRS CTW/Reactor tritium dose 1954.

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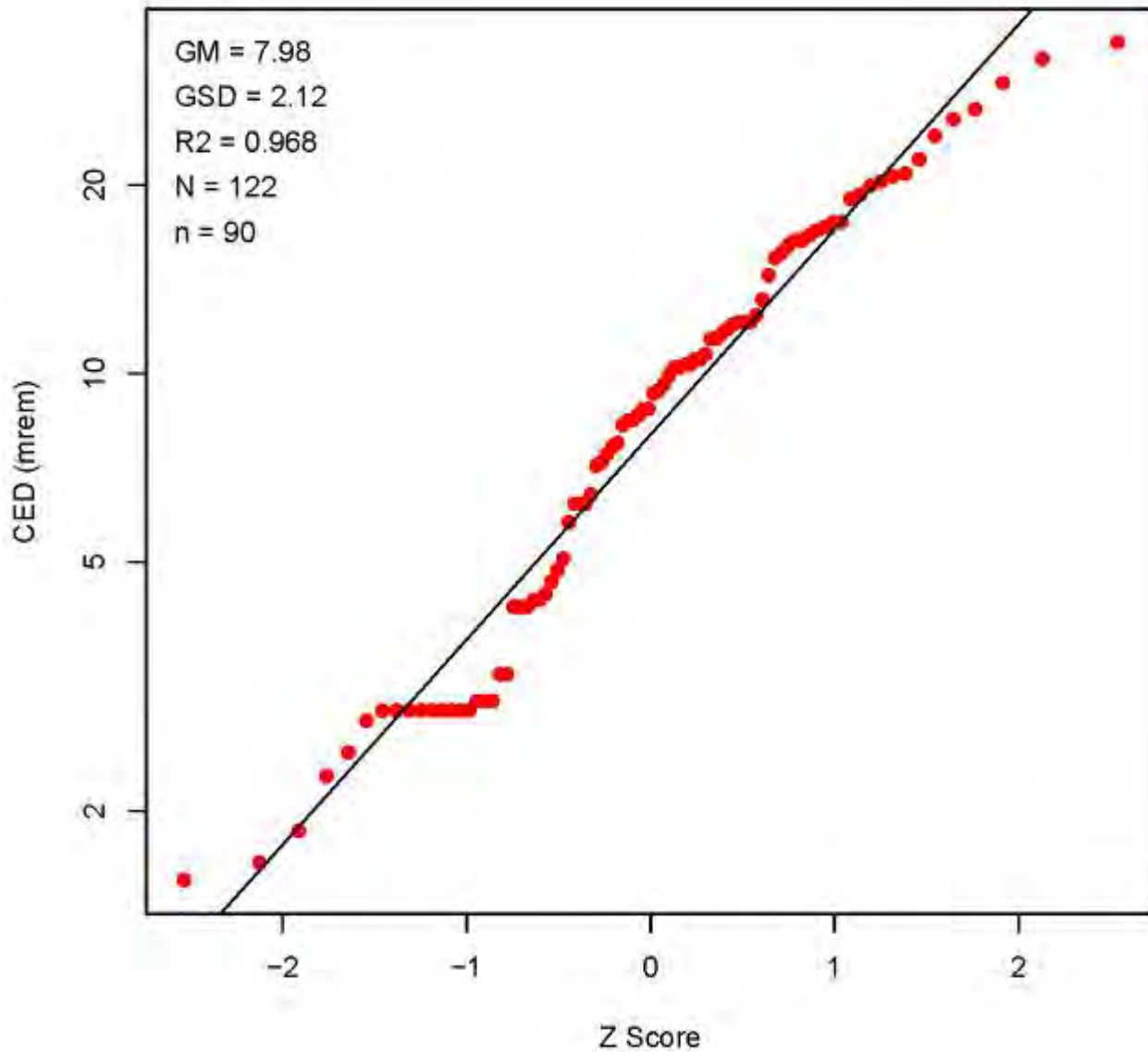


Figure C-3. SRS Non(CTW/Reactor) tritium dose 1954.

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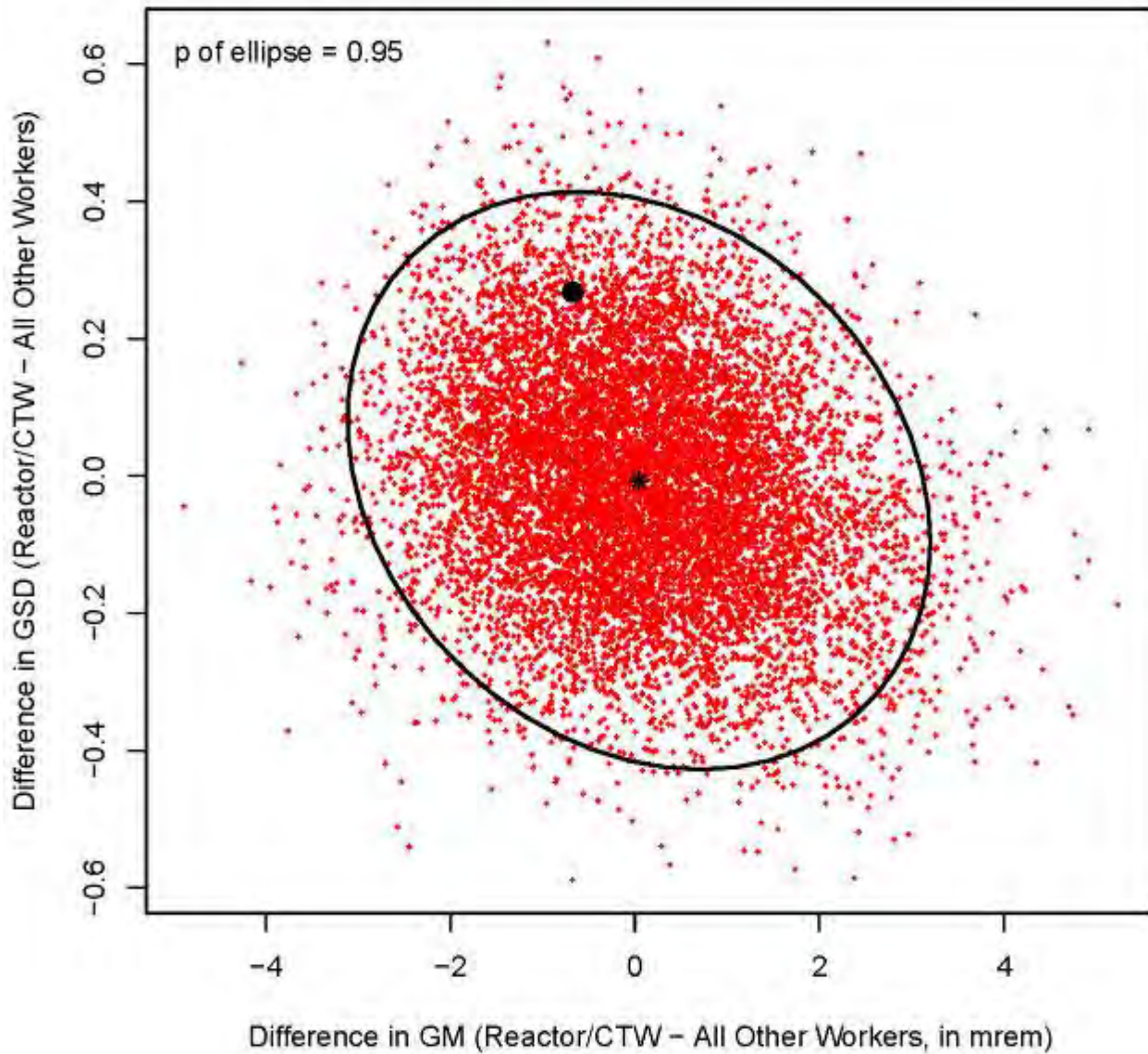


Figure C-4. SRS tritium dose 1954.

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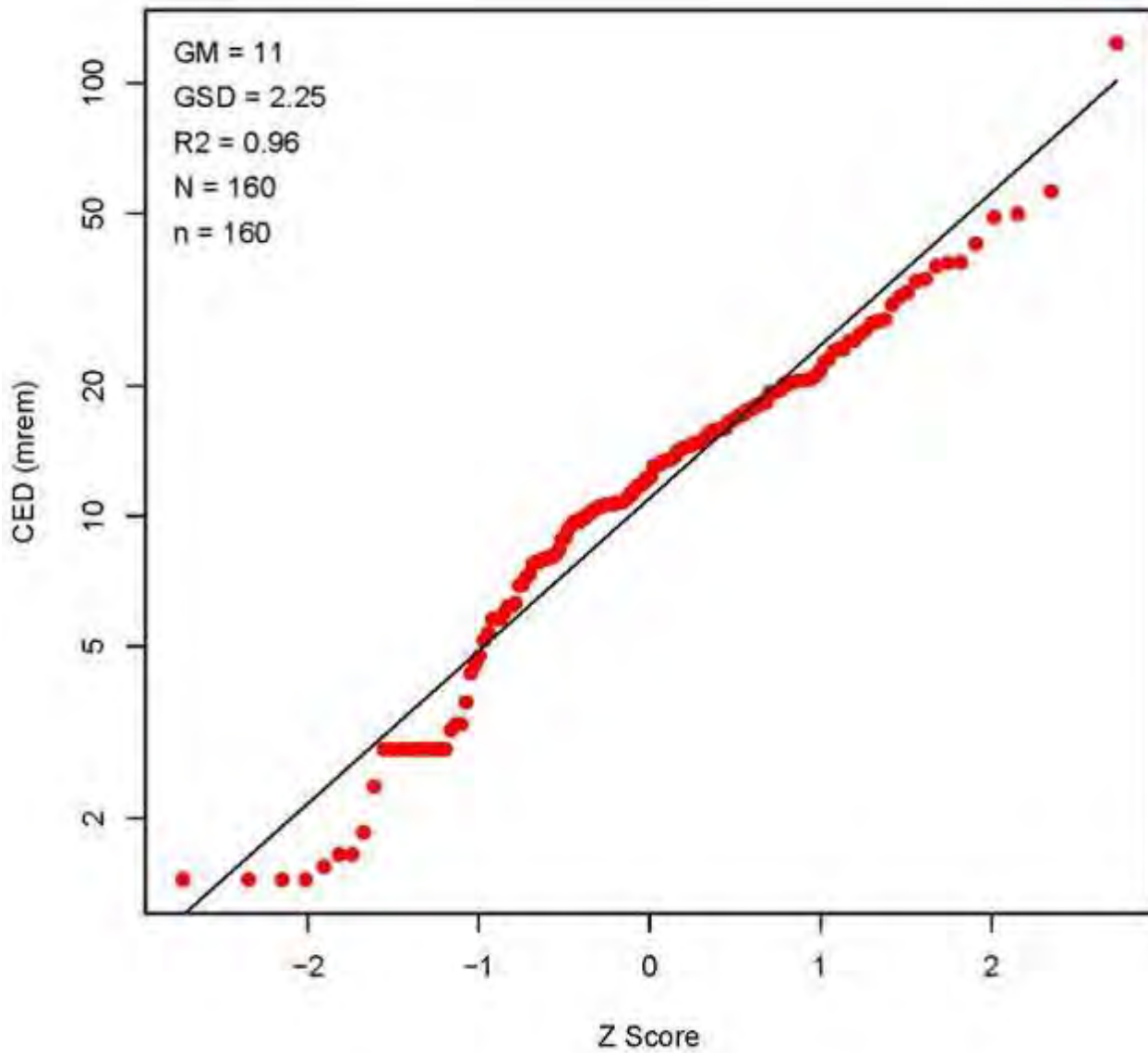


Figure C-5. SRS tritium dose 1955.

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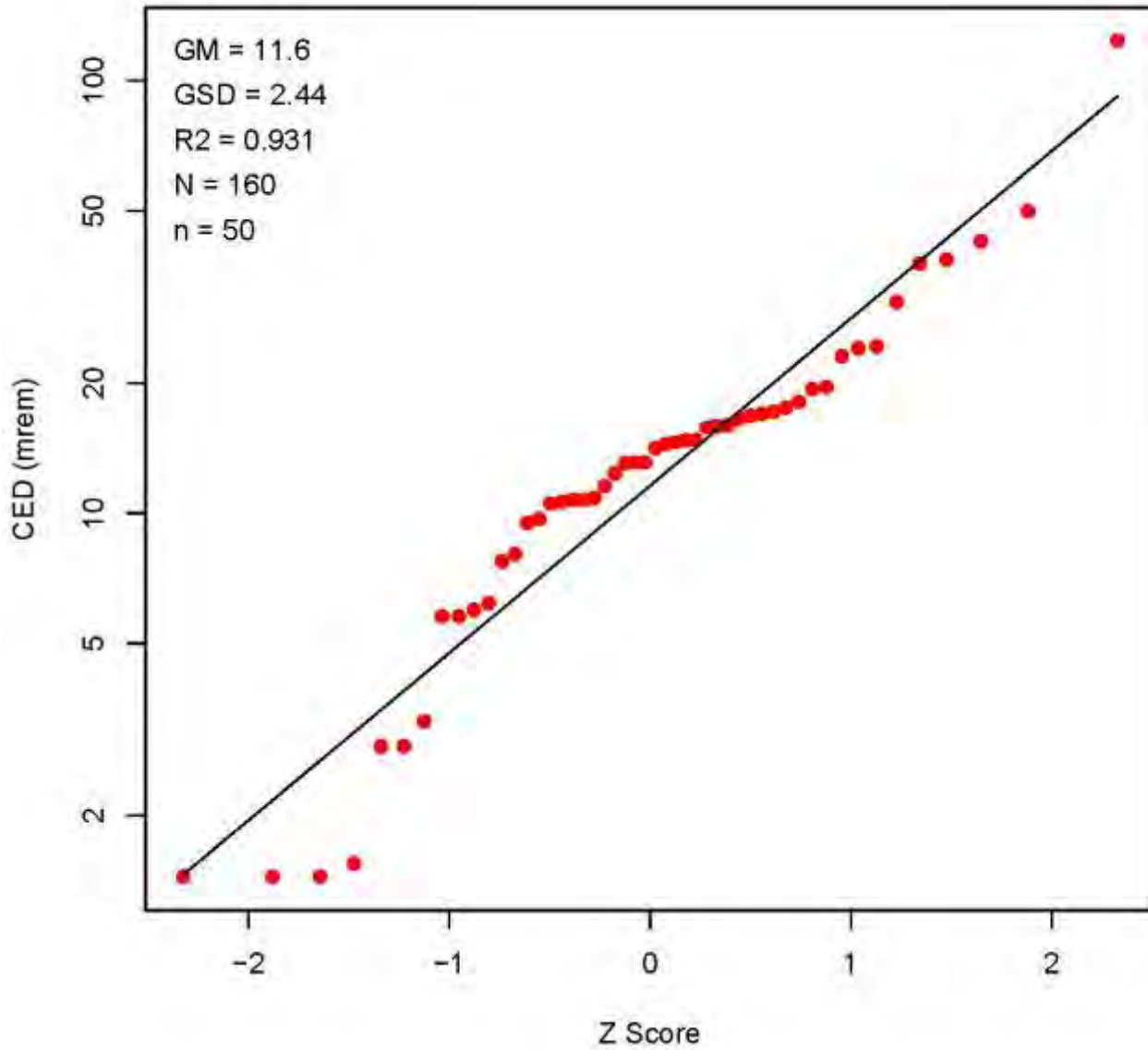


Figure C-6. SRS CTW/Reactor tritium dose 1955.

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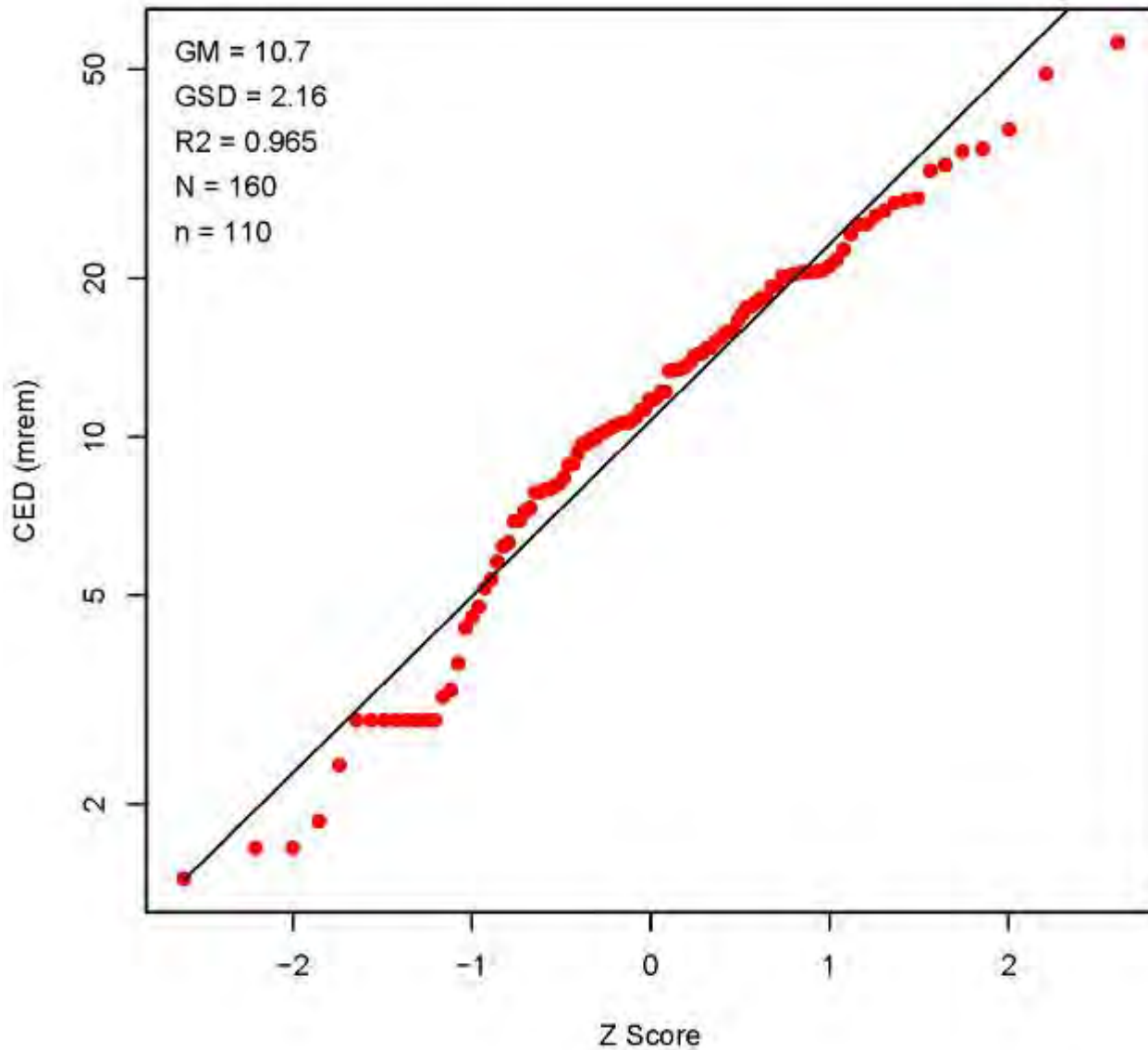


Figure C-7. SRS Non(CTW/Reactor) tritium dose 1955.

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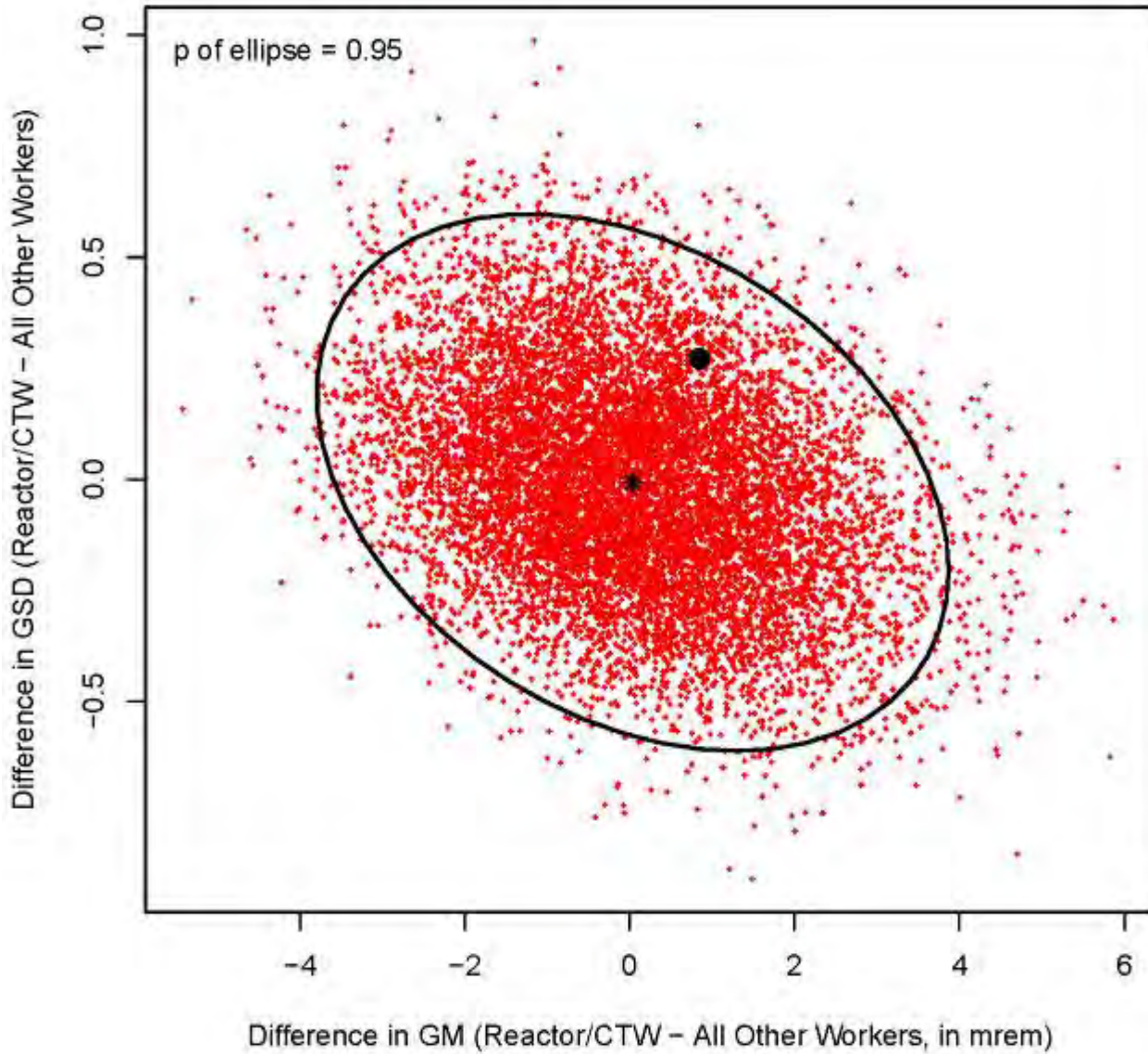


Figure C-8. SRS tritium dose 1955.

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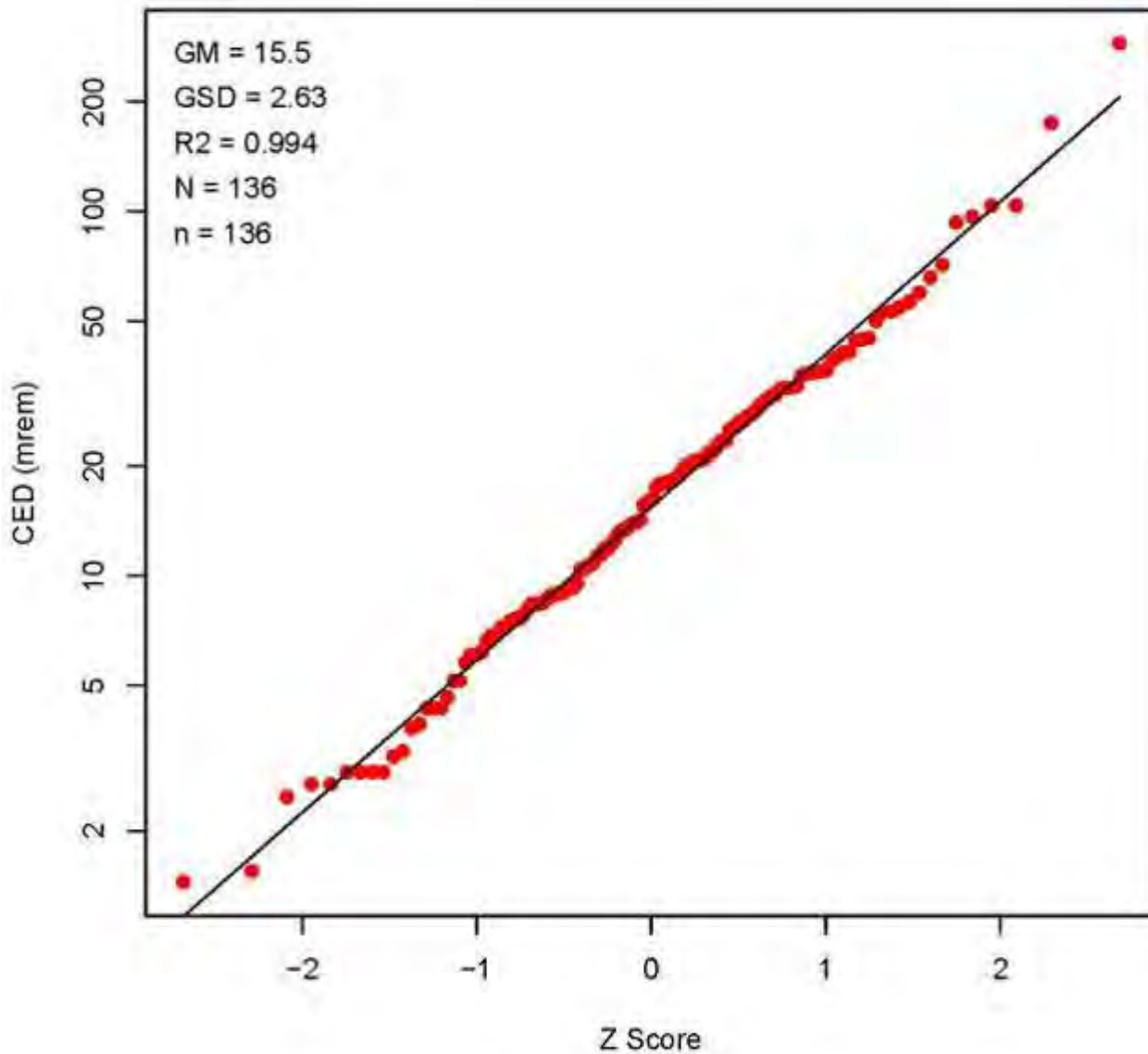


Figure C-9. SRS tritium dose 1956.

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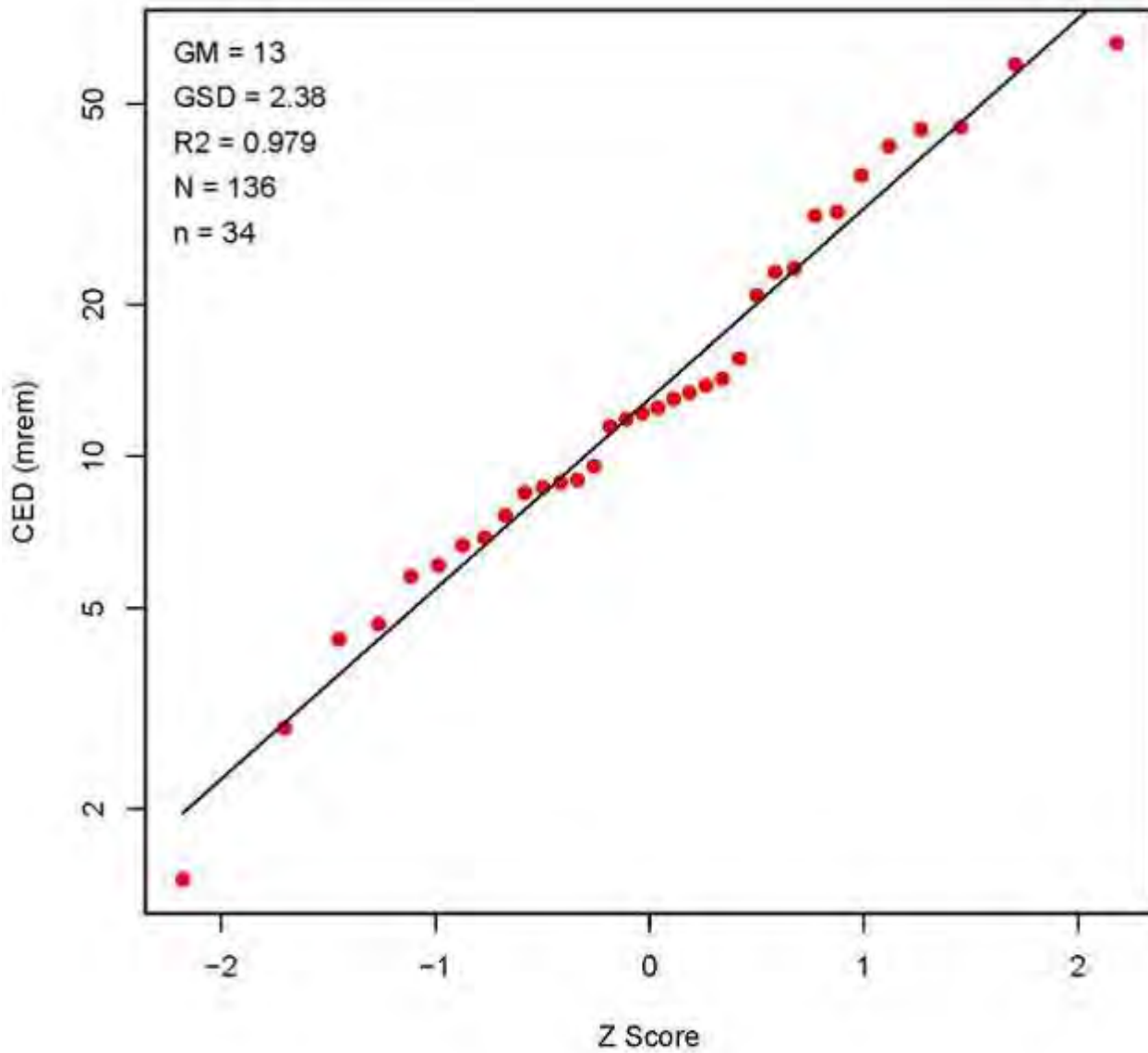


Figure C-10. SRS CTW/Reactor tritium dose 1956.

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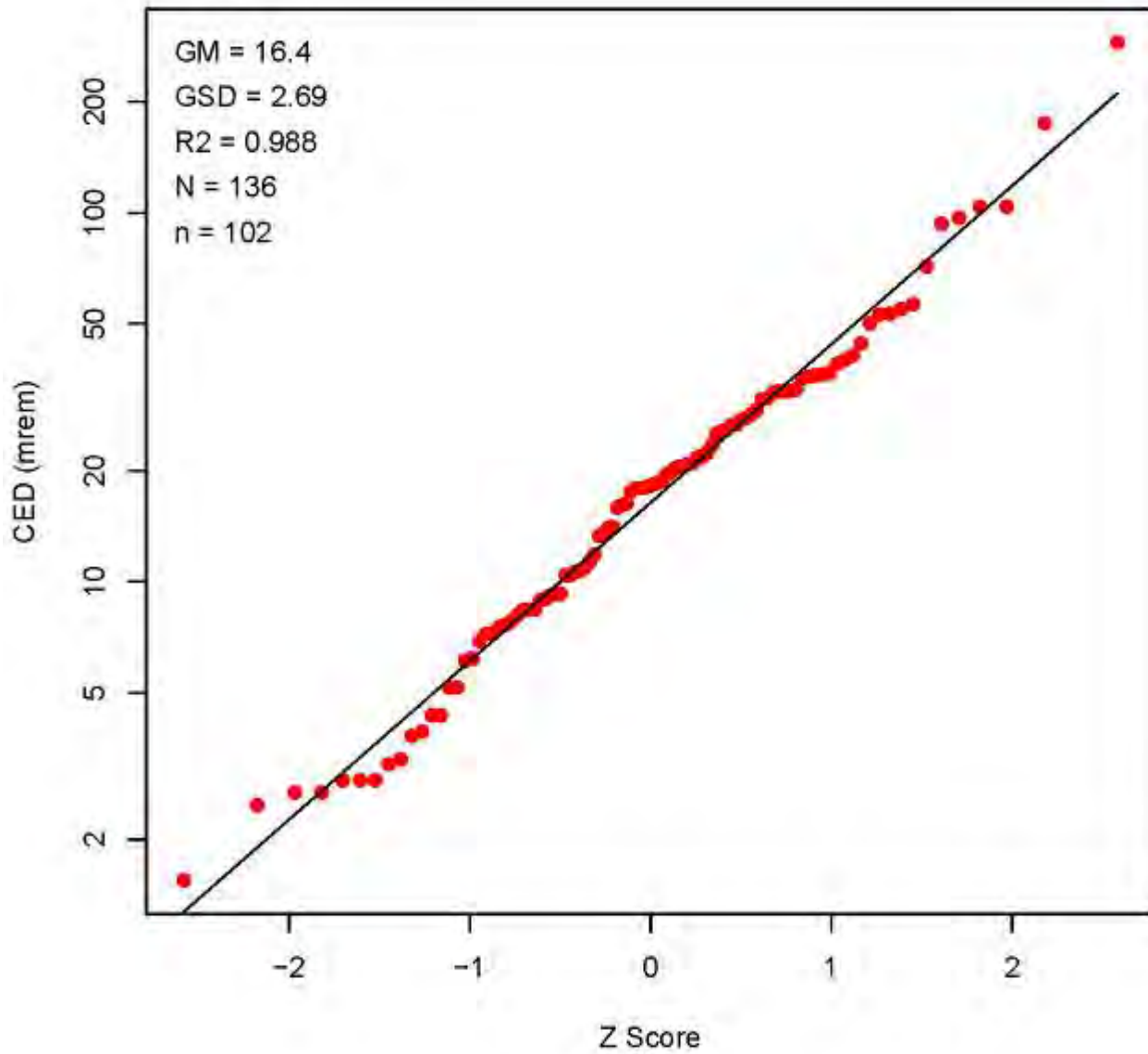


Figure C-11. SRS Non(CTW/Reactor) tritium dose 1956.

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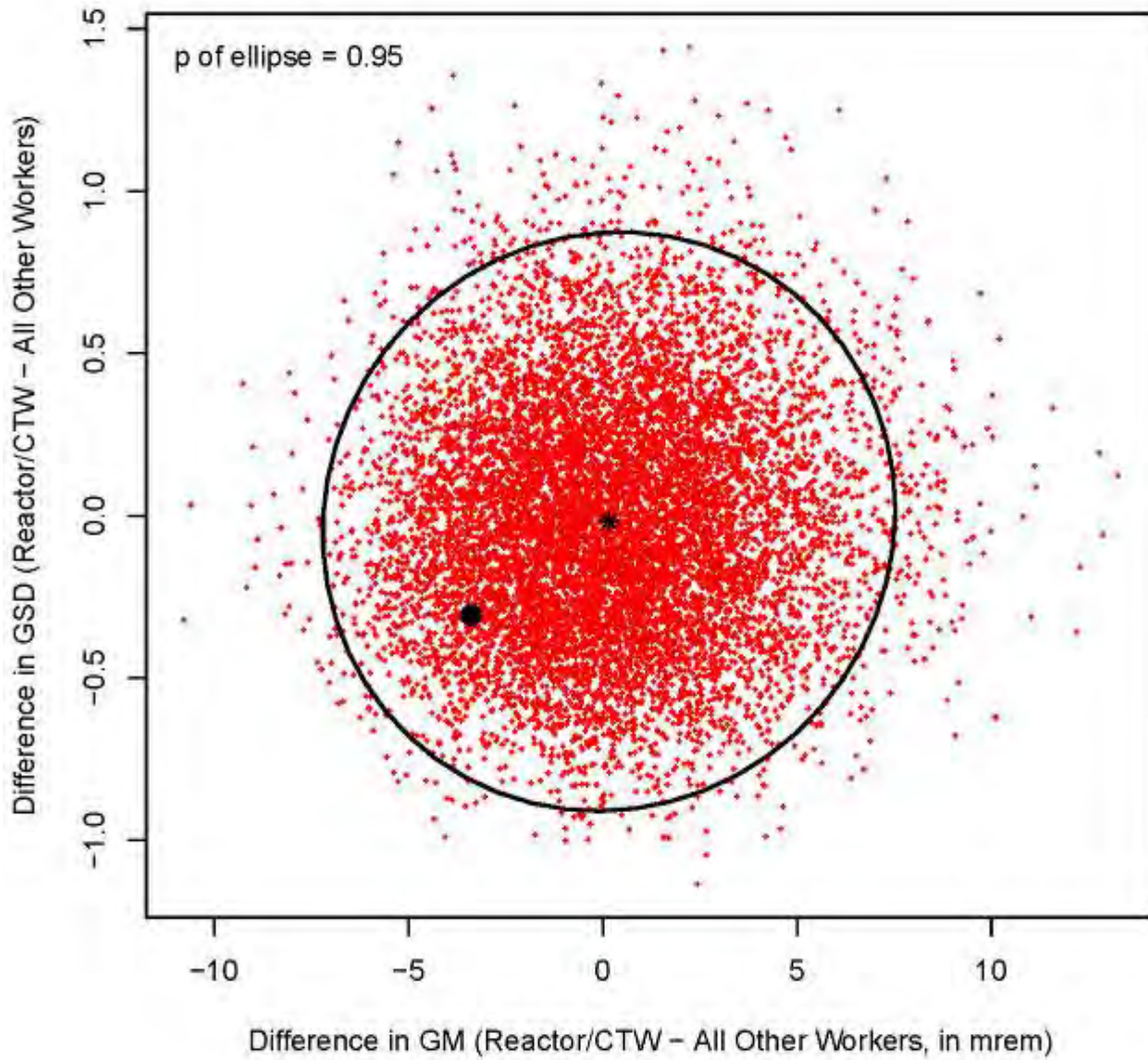


Figure C-12. SRS tritium dose 1956.

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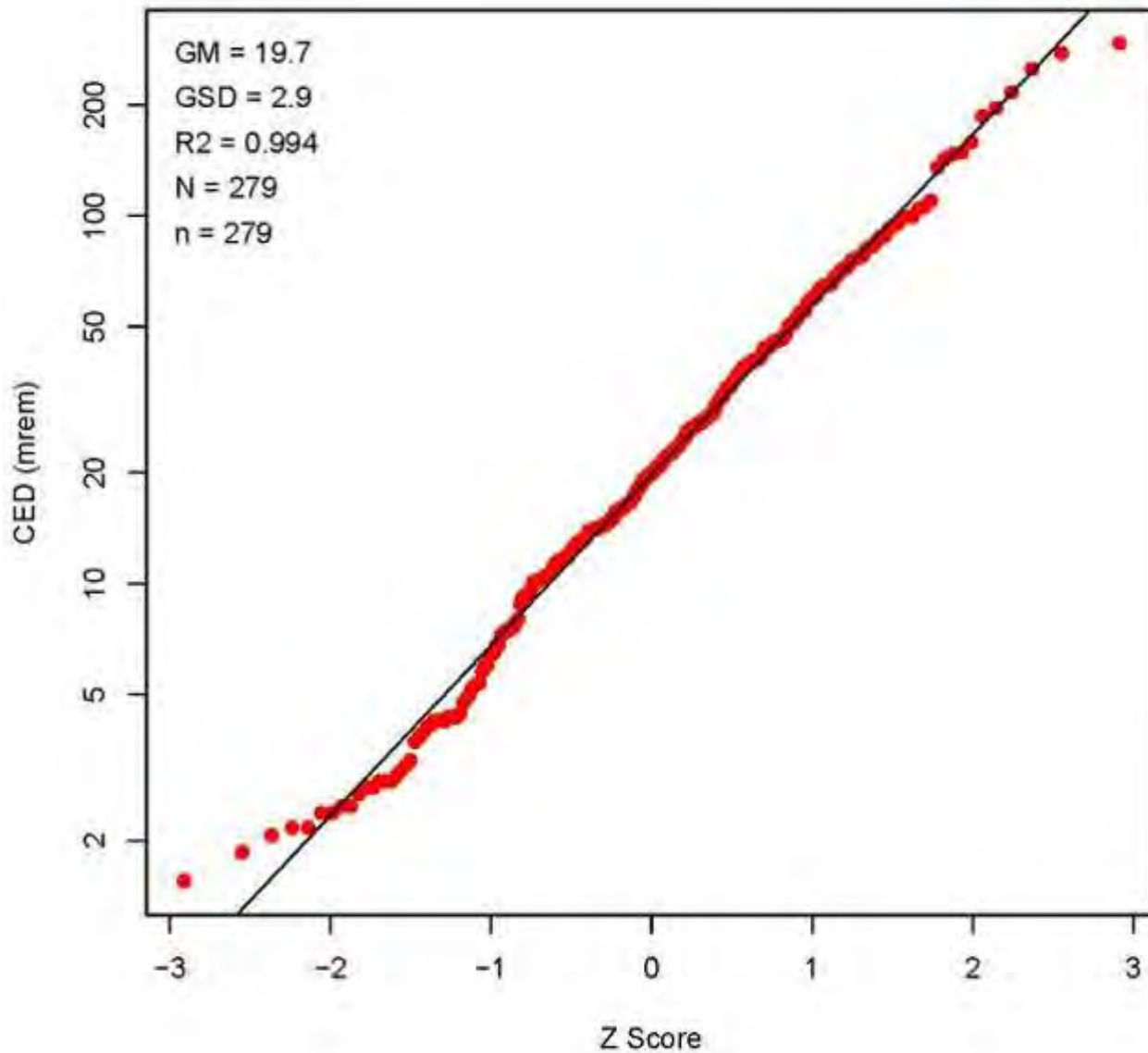


Figure C-13. SRS tritium dose 1957.

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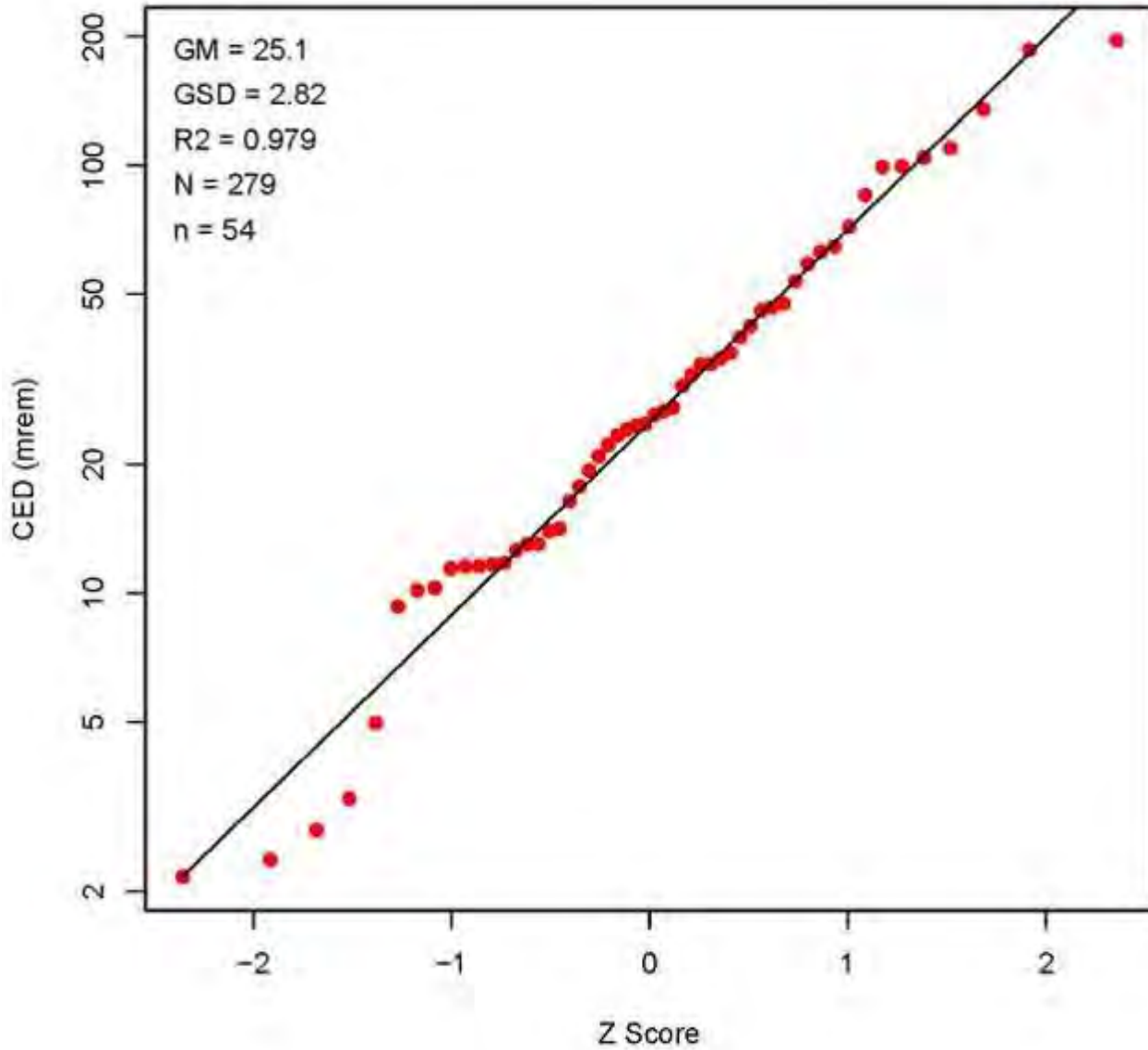


Figure C-14. SRS CTW/Reactor tritium dose 1957.

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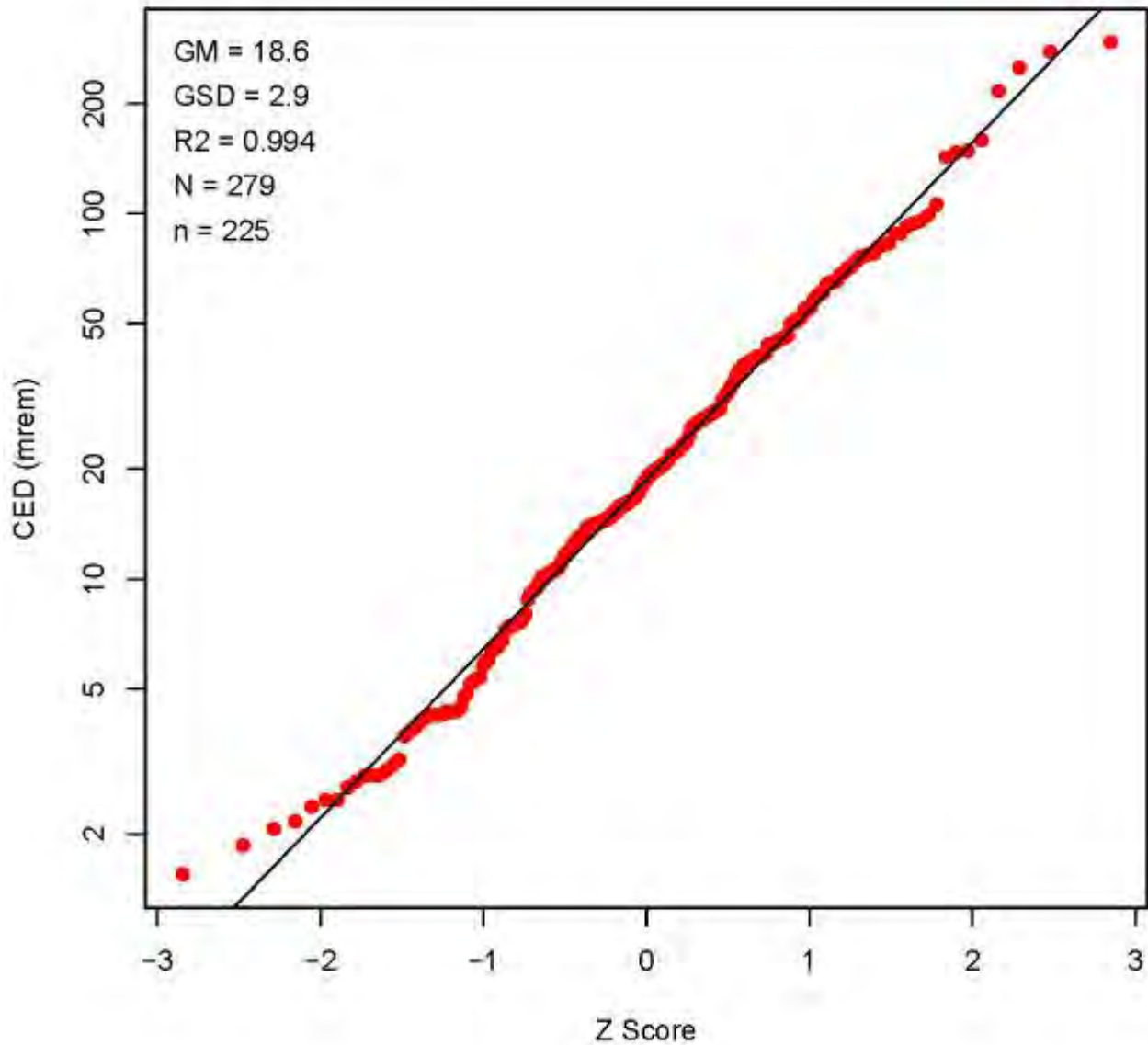


Figure C-15. SRS Non(CTW/Reactor) tritium dose 1957.

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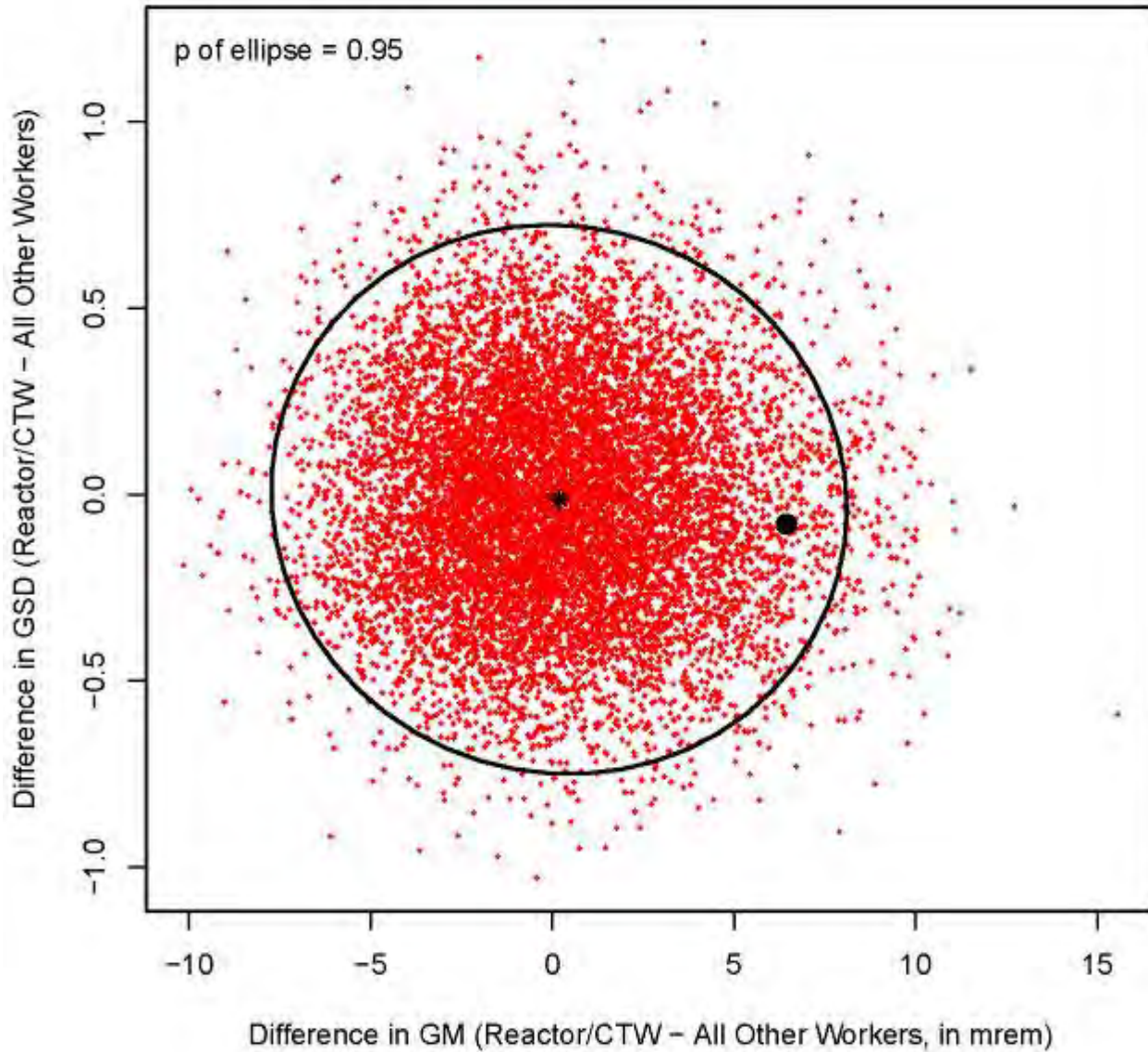


Figure C-16. SRS tritium dose 1957.

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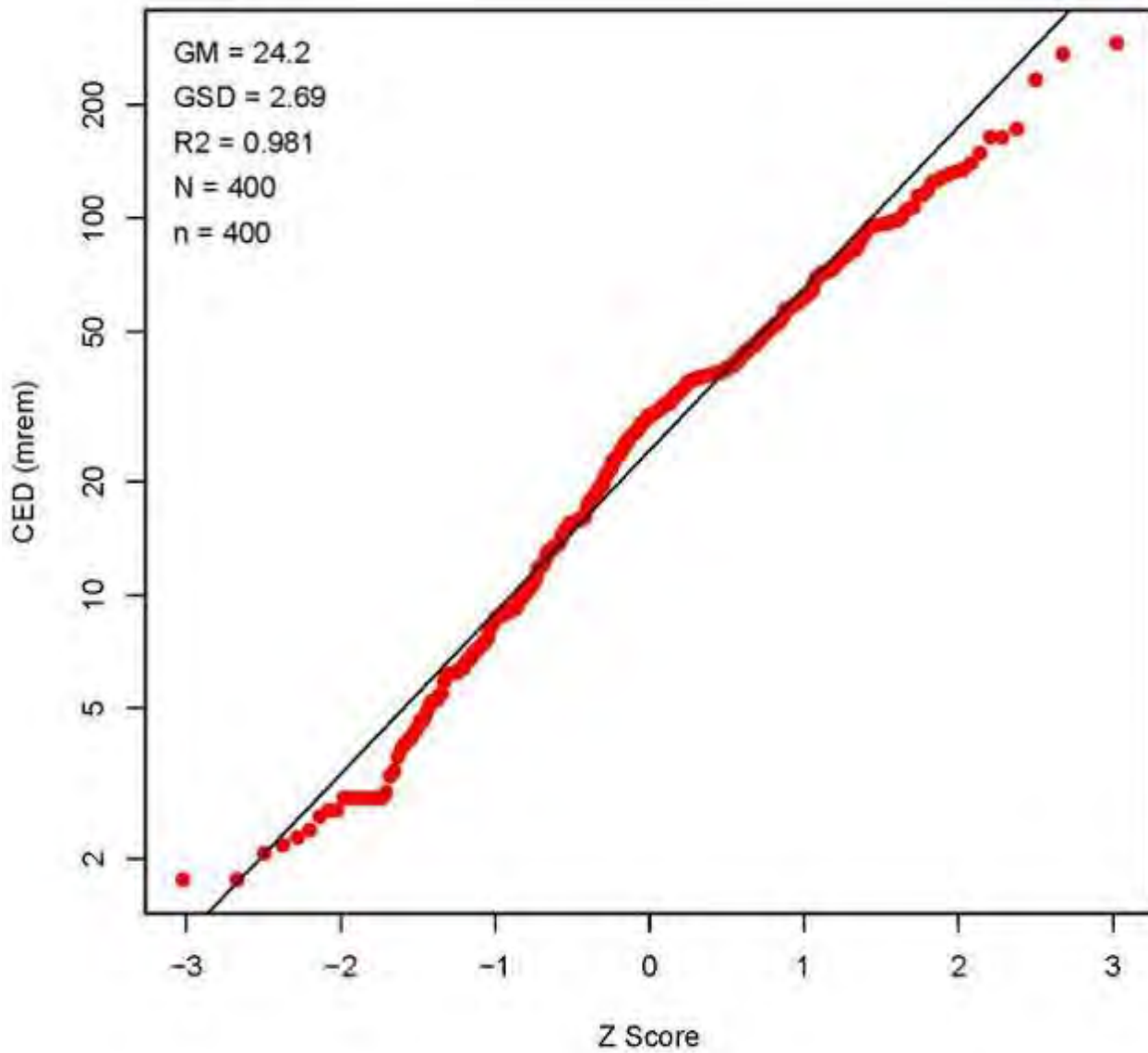


Figure C-17. SRS tritium dose 1958.

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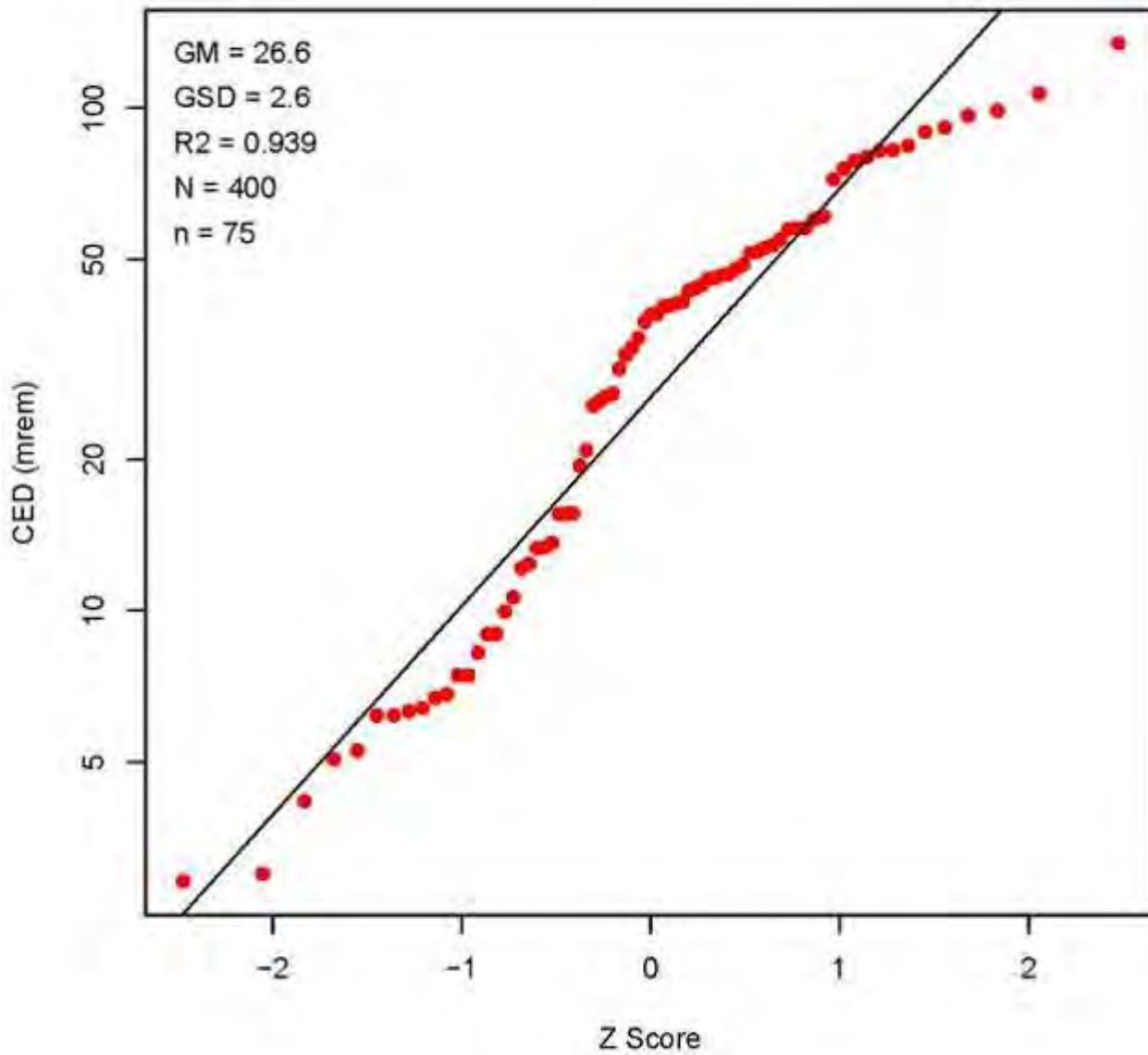


Figure C-18. SRS CTW/Reactor tritium dose 1958.

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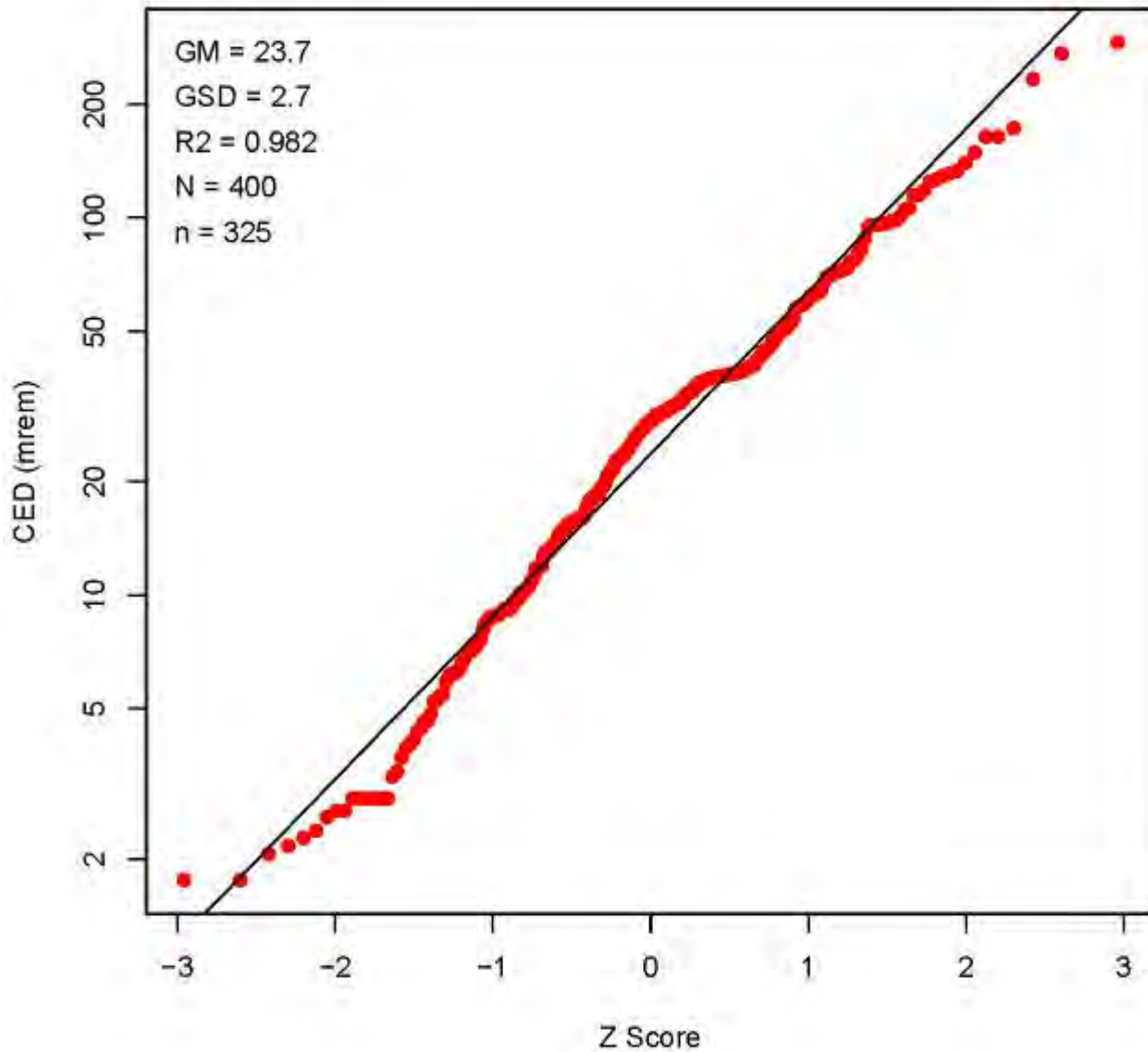


Figure C-19. SRS Non(CTW/Reactor) tritium dose 1958.

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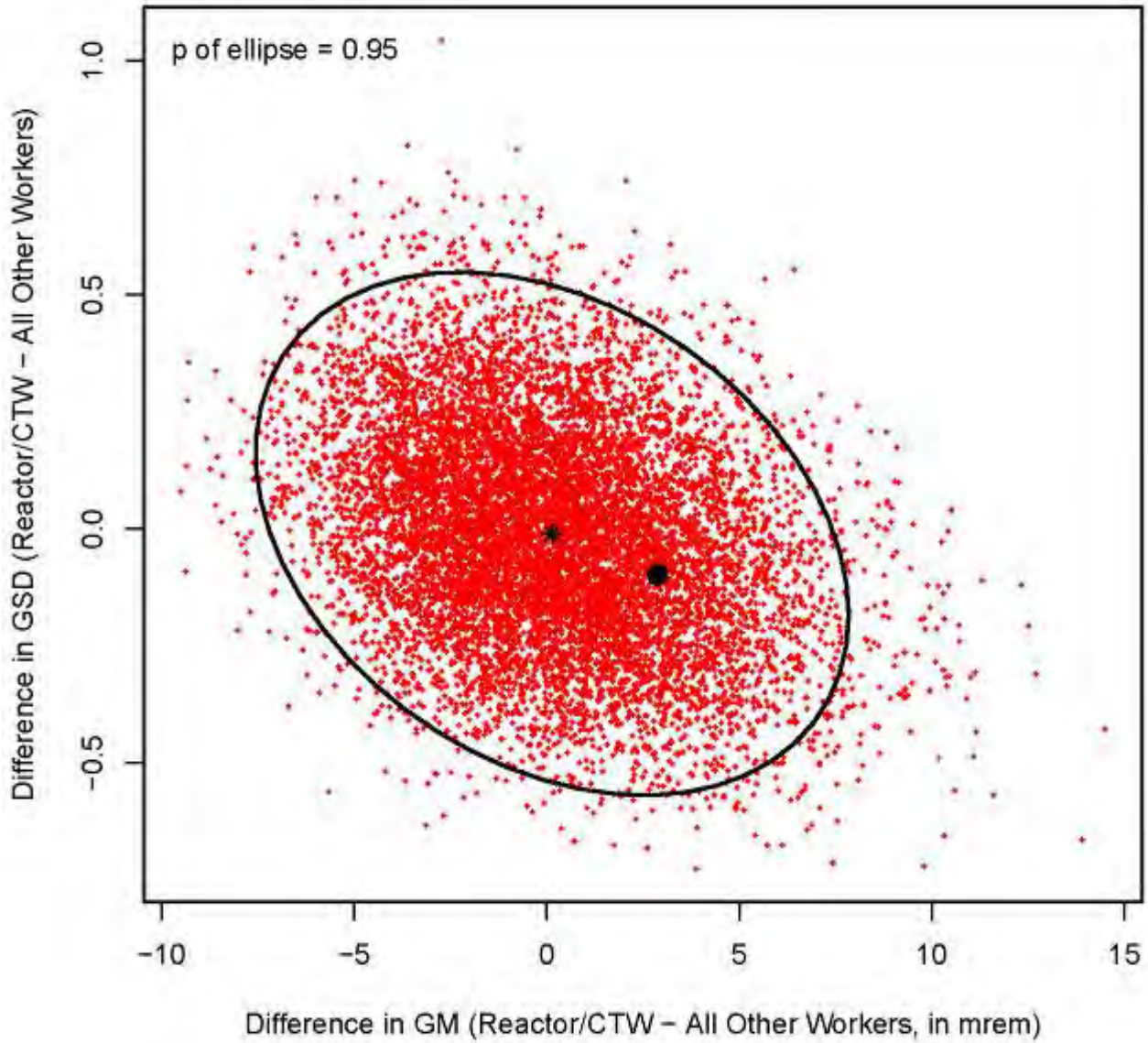


Figure C-20. SRS tritium dose 1958.

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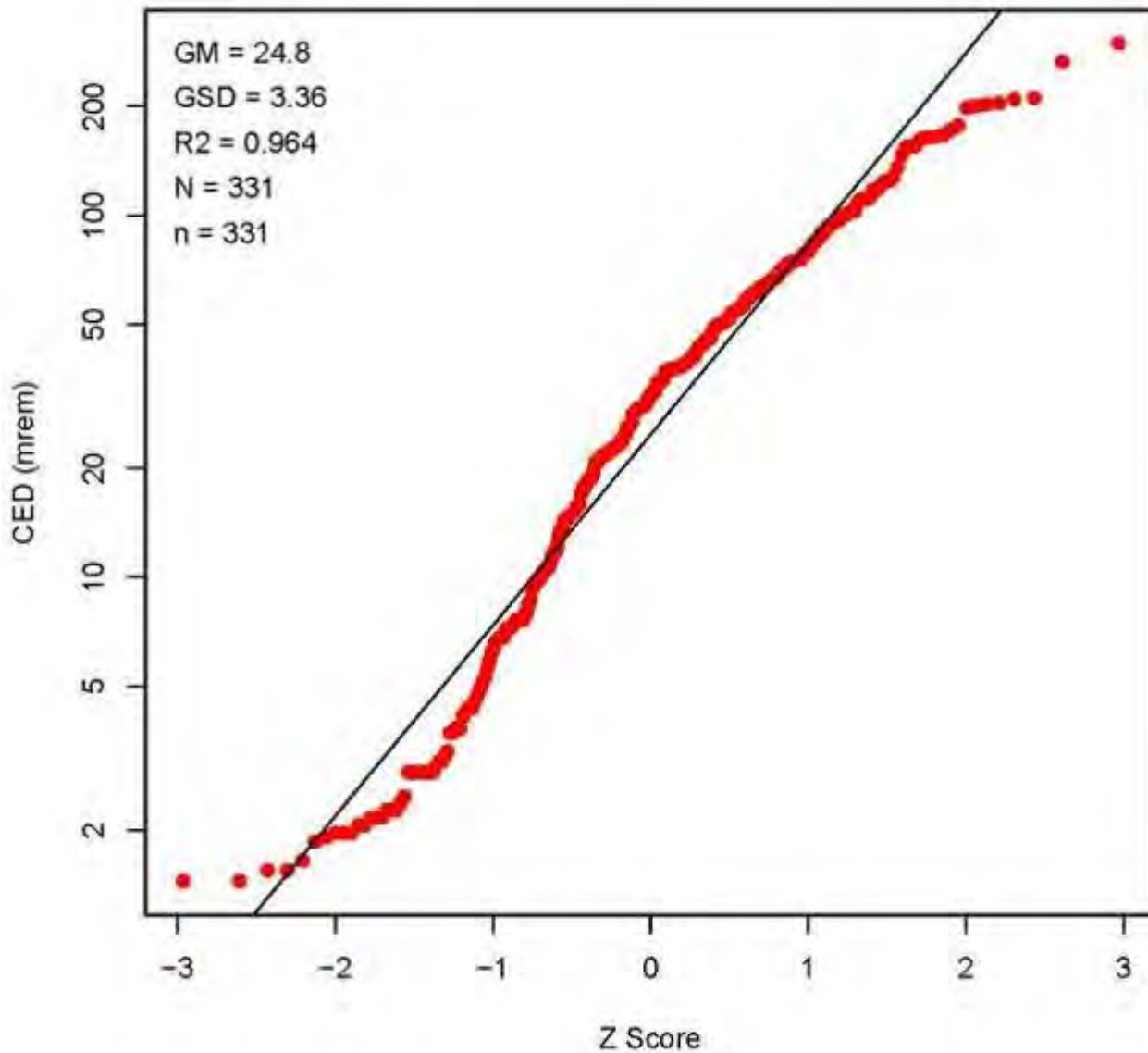


Figure C-21. SRS tritium dose 1959.

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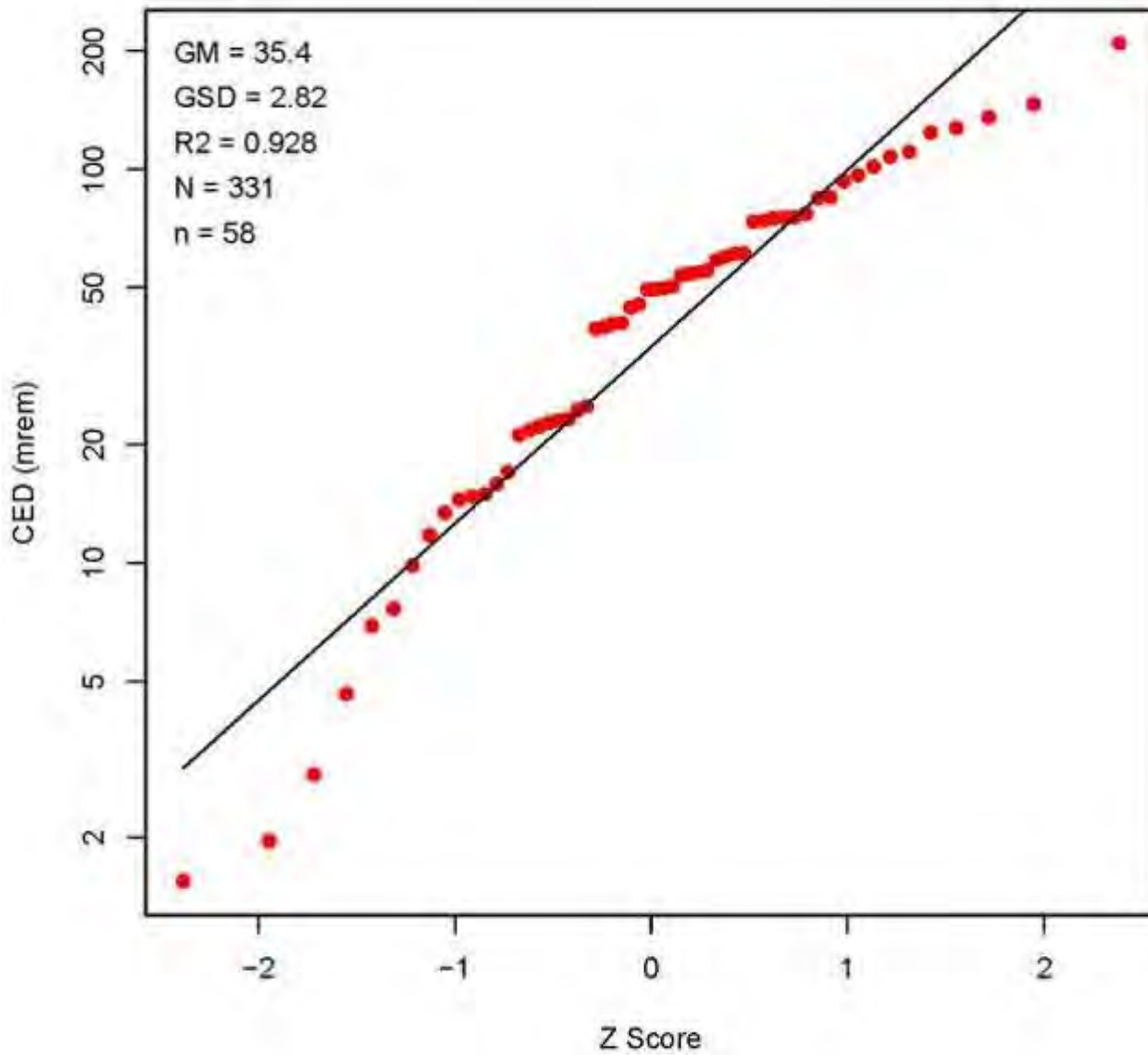


Figure C-22. SRS CTW/Reactor tritium dose 1959.

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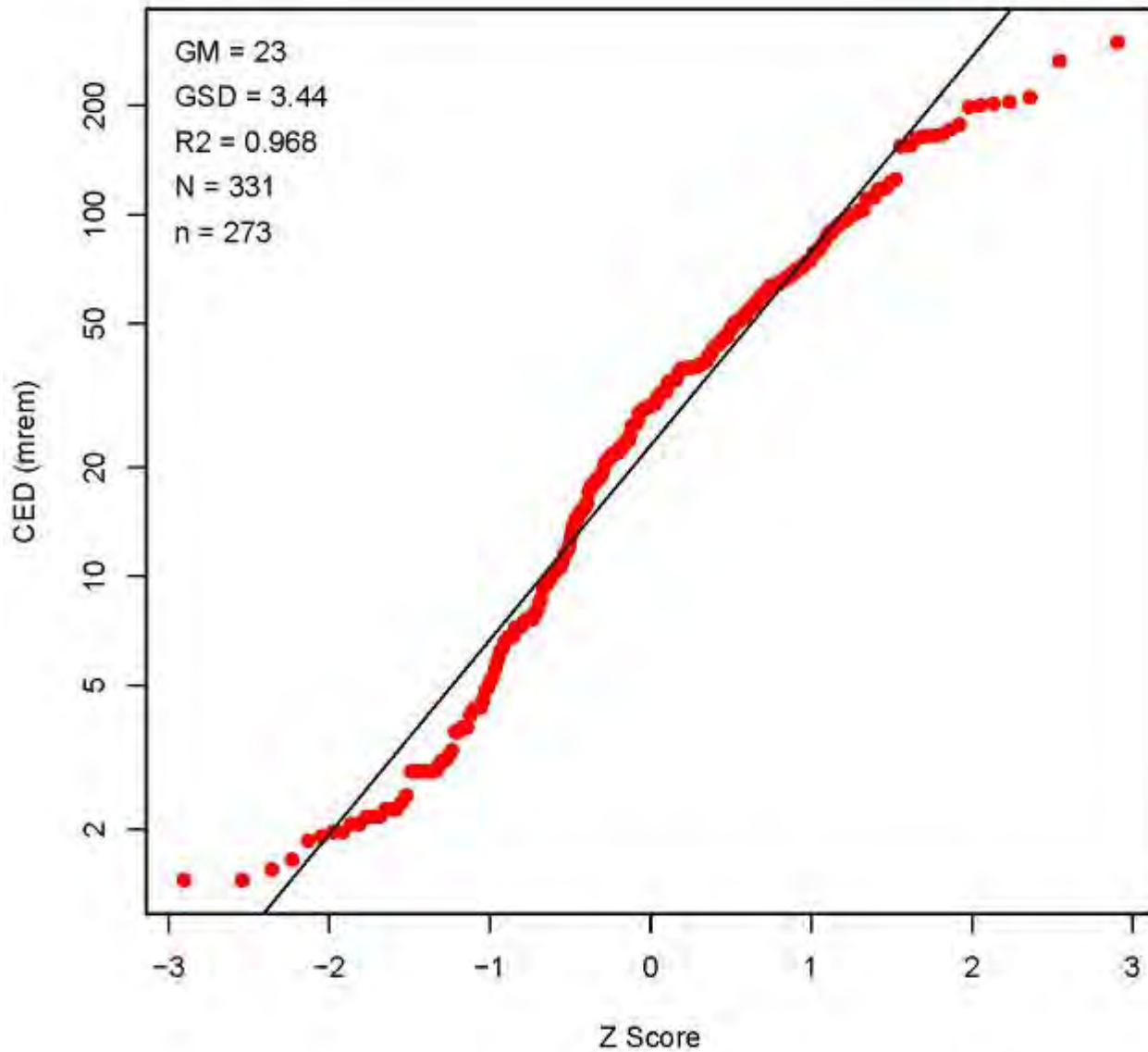


Figure C-23. SRS Non(CTW/Reactor) tritium dose 1959.

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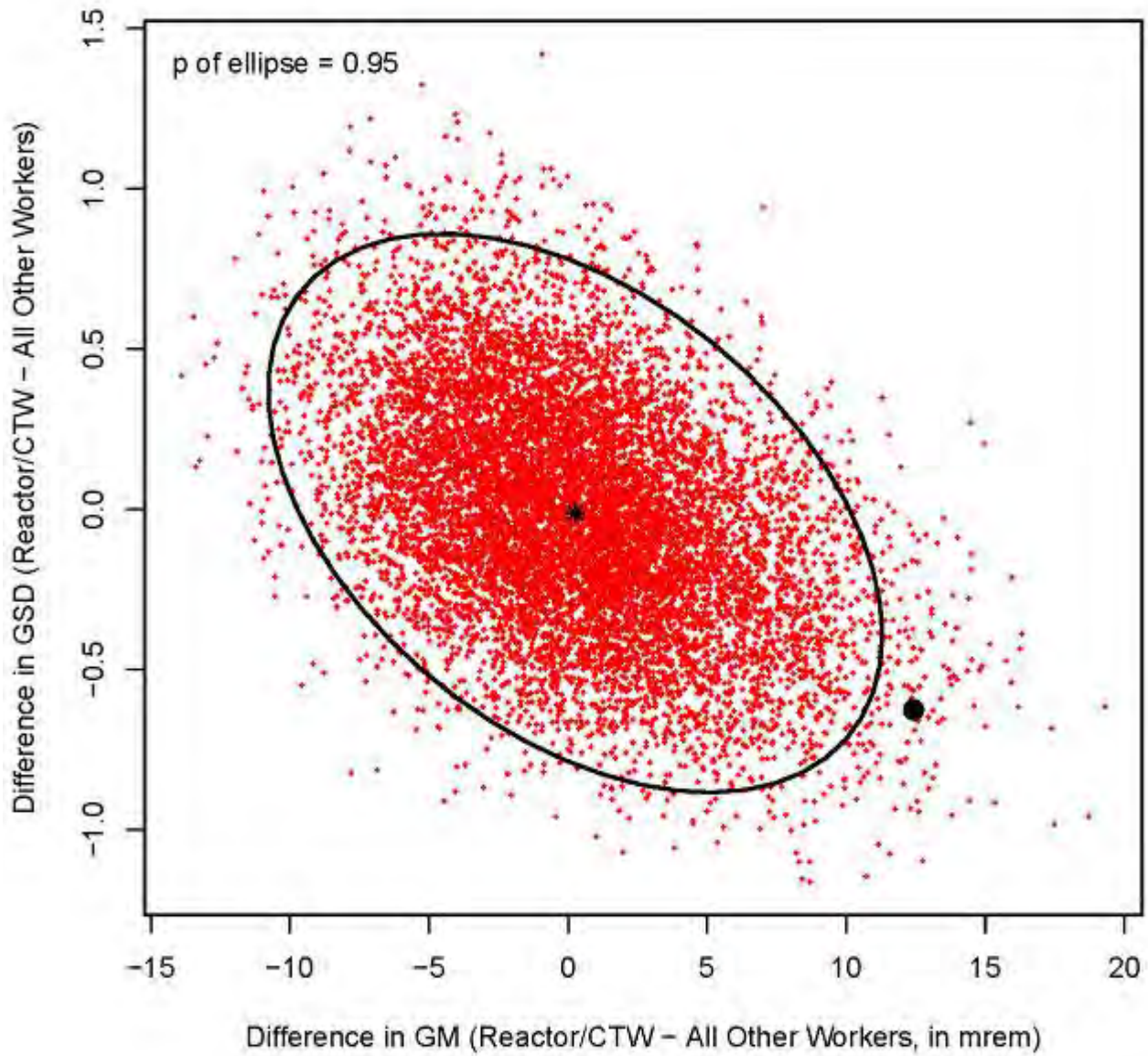


Figure C-24. SRS tritium dose 1959.

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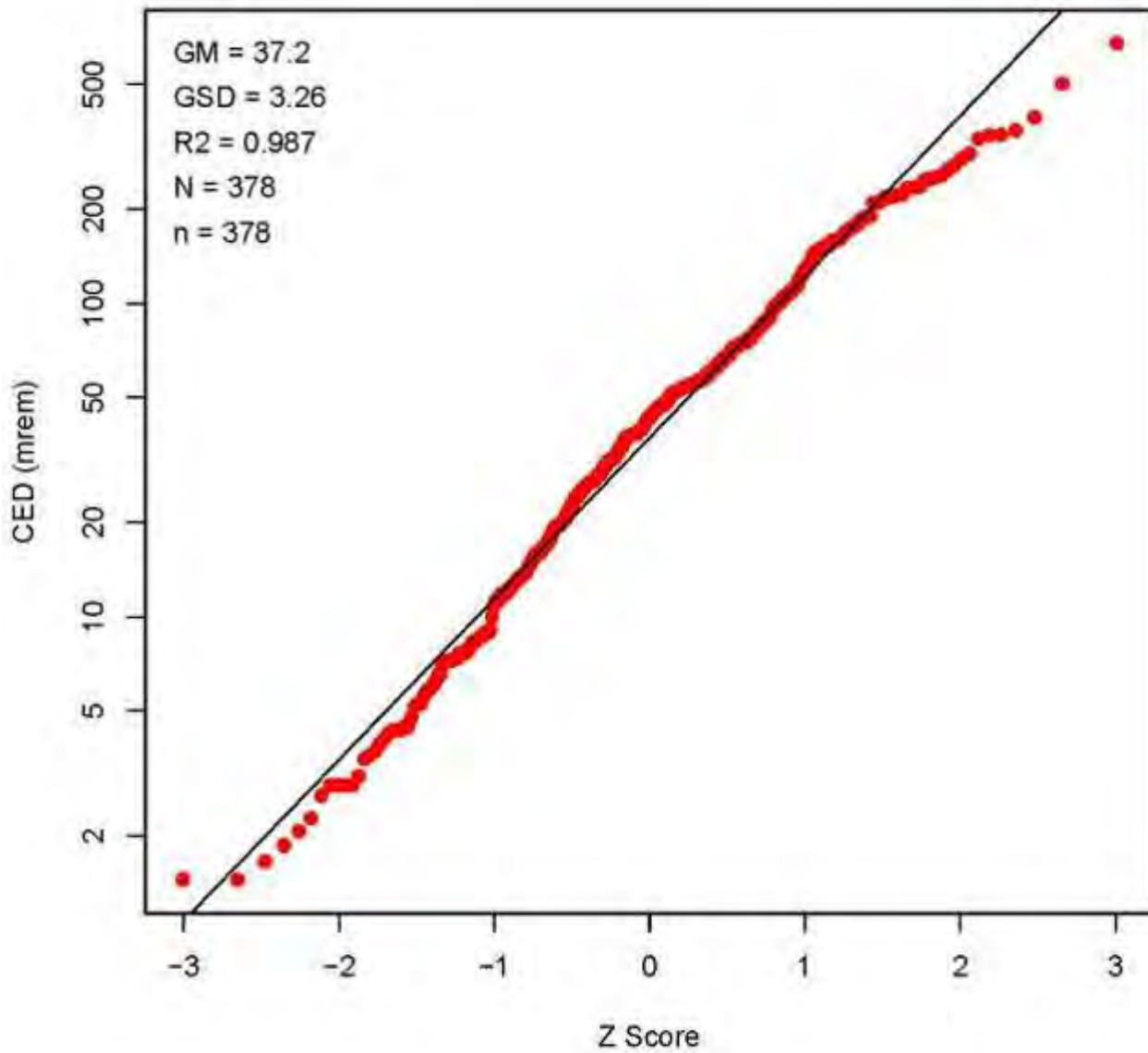


Figure C-25. SRS tritium dose 1960.

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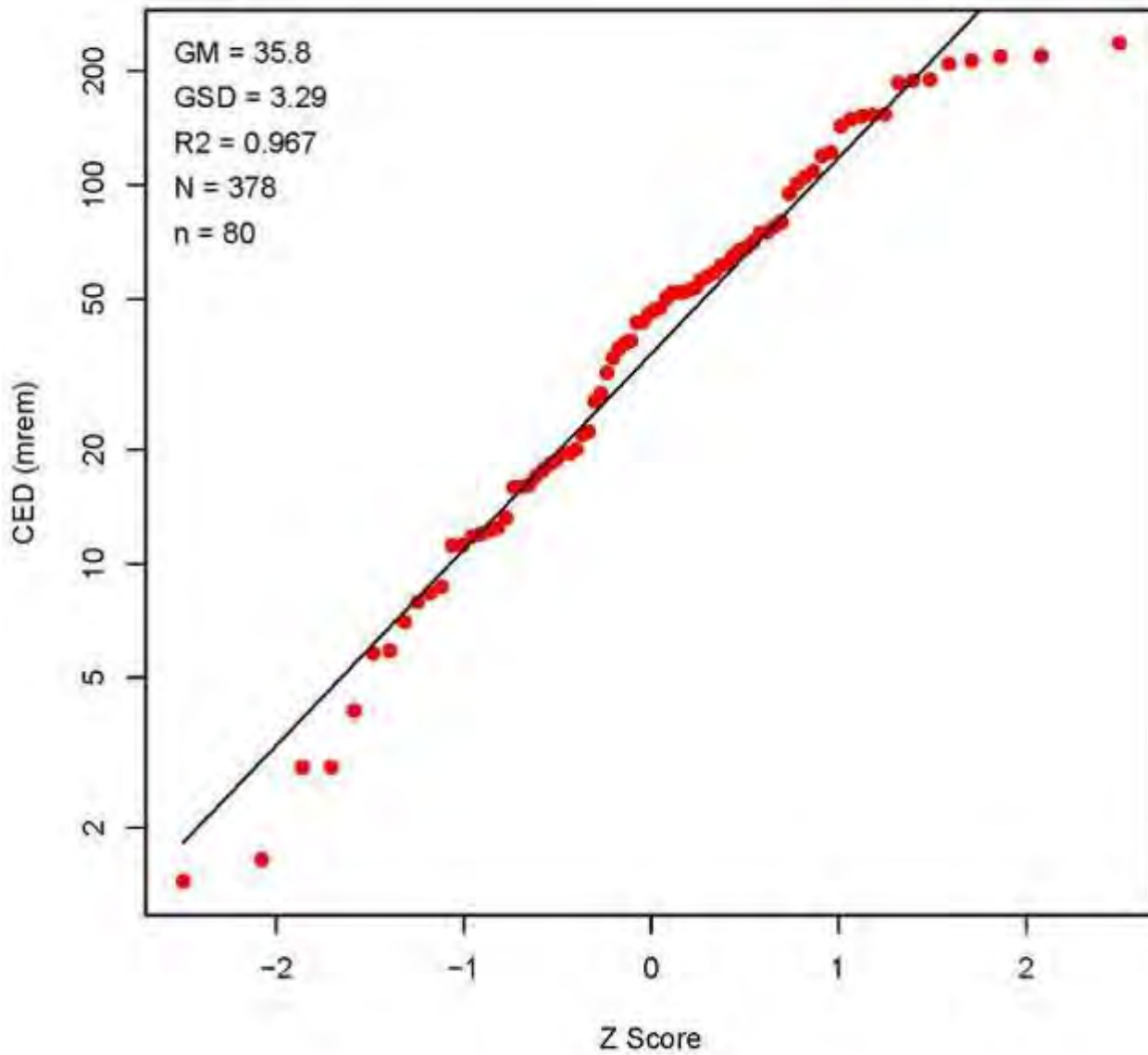


Figure C-26. SRS CTW/Reactor tritium dose 1960.

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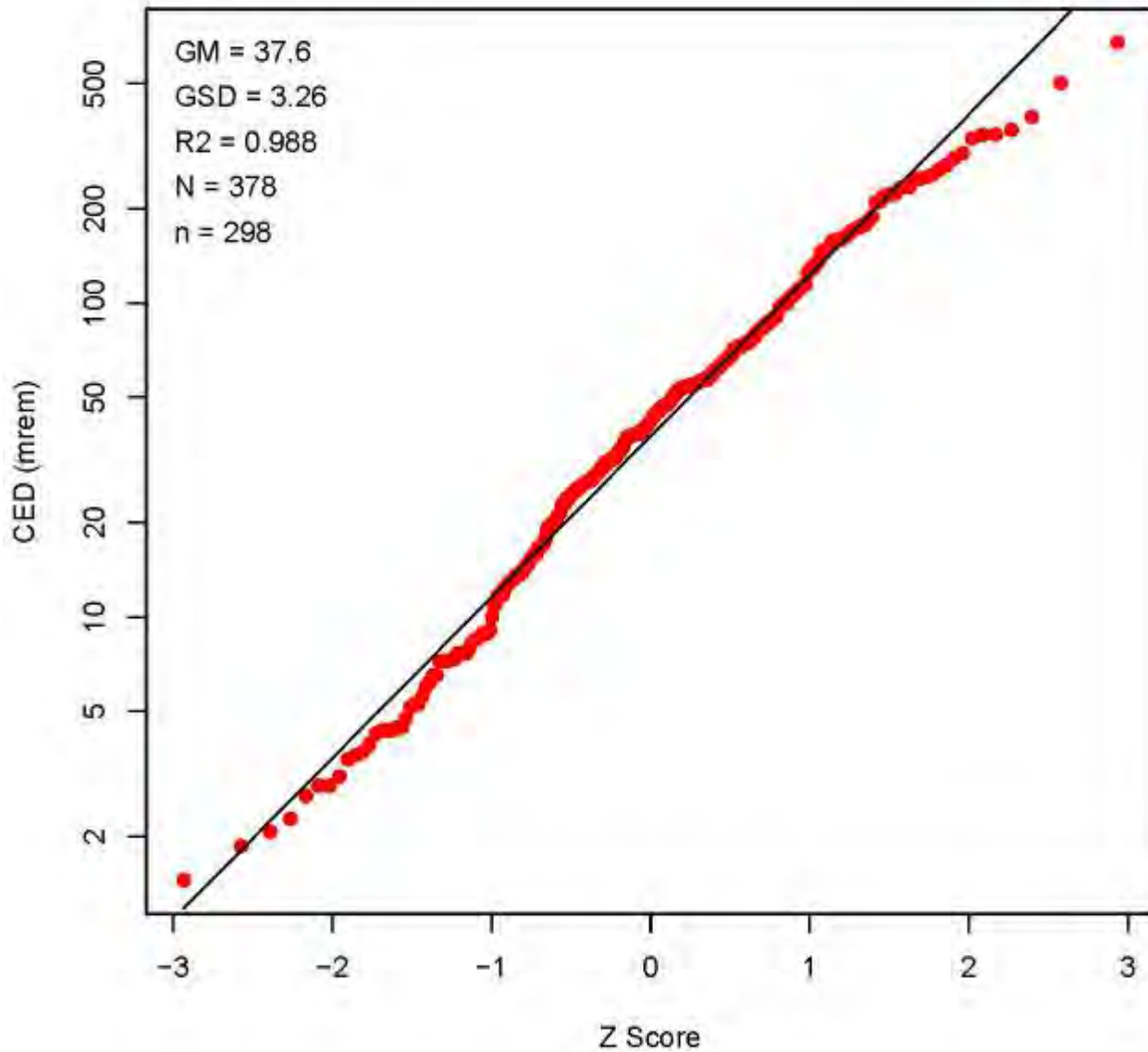


Figure C-27. SRS Non(CTW/Reactor) tritium dose 1960.

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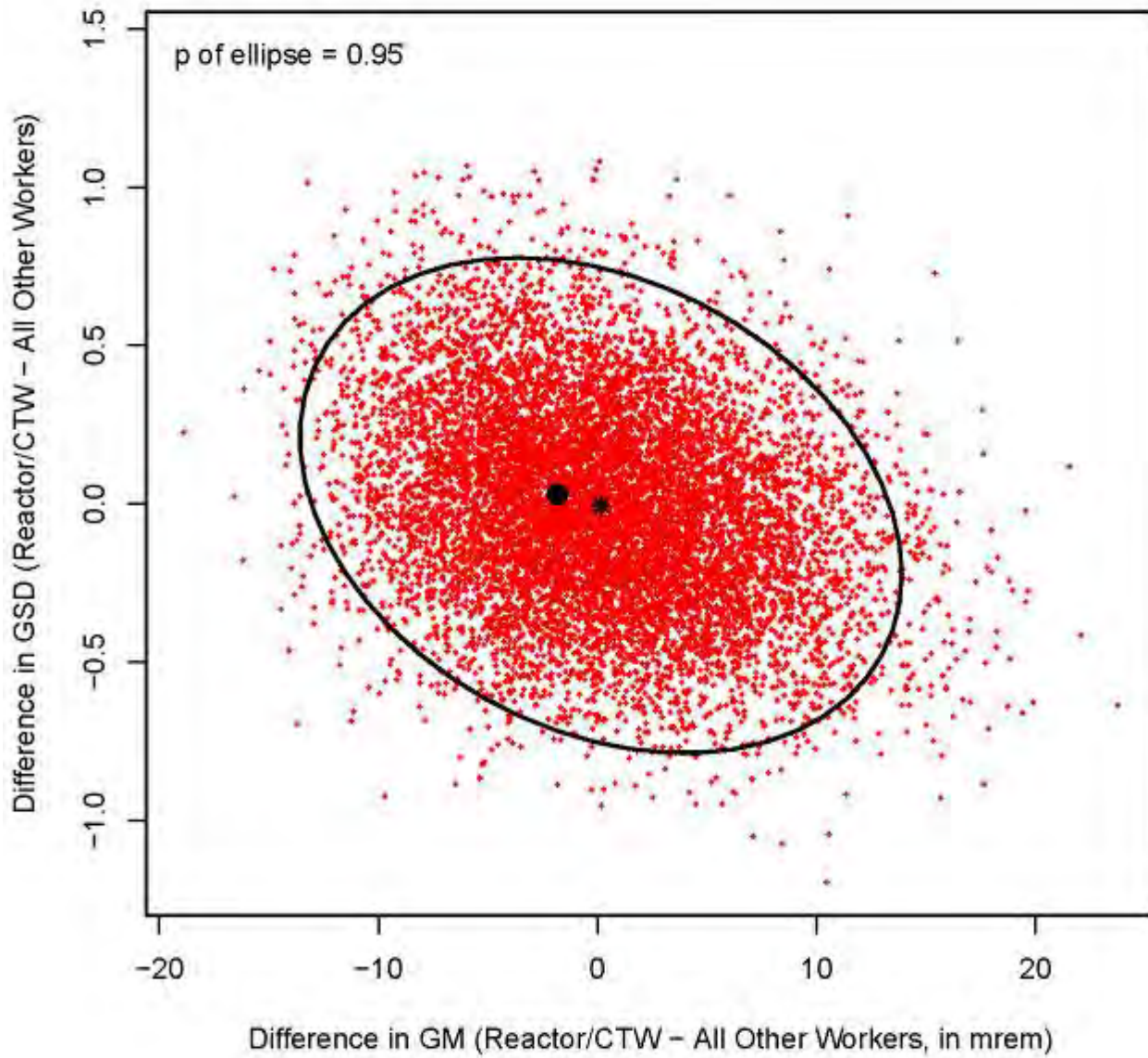


Figure C-28. SRS tritium dose 1960.

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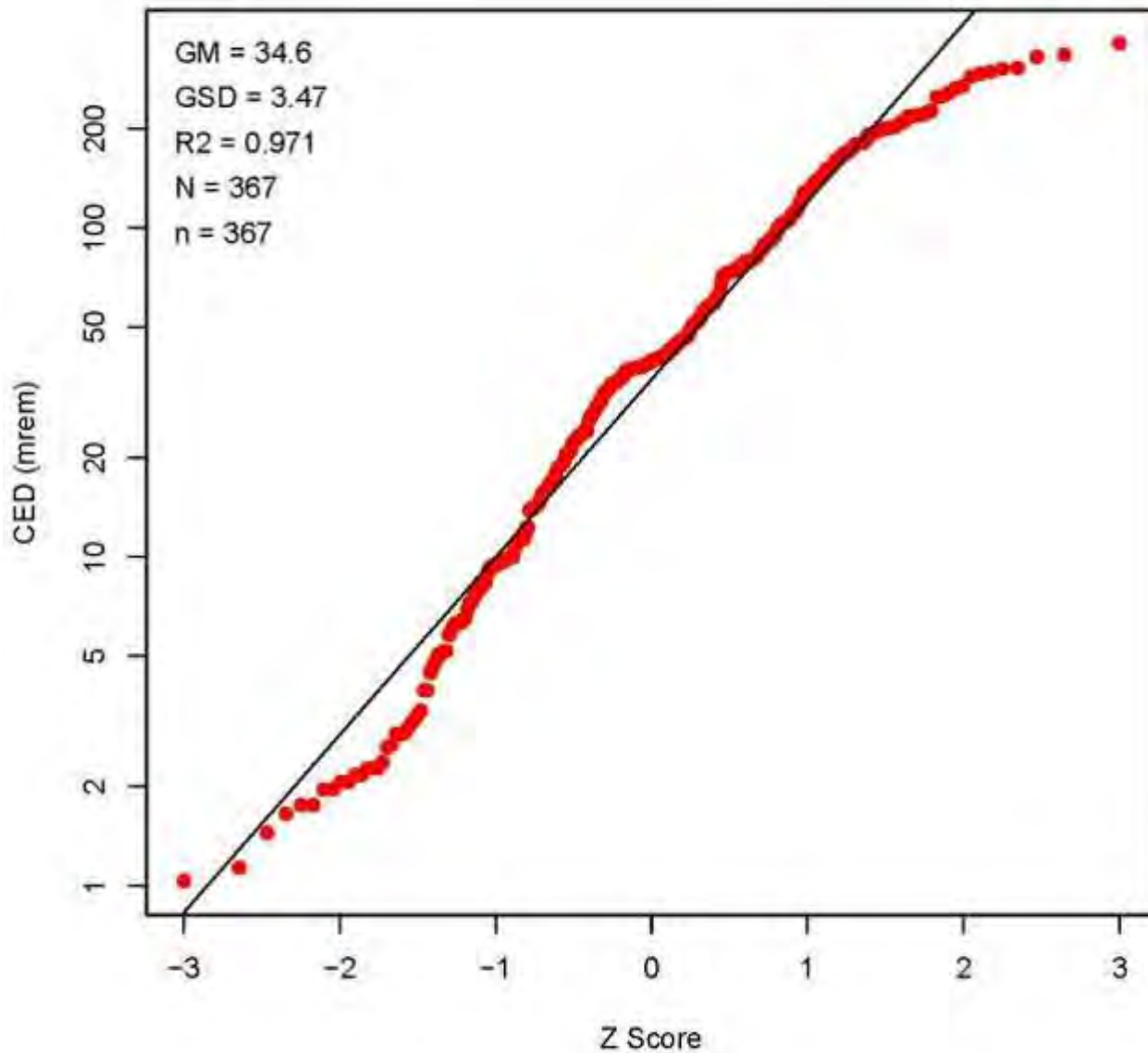


Figure C-29. SRS tritium dose 1961.

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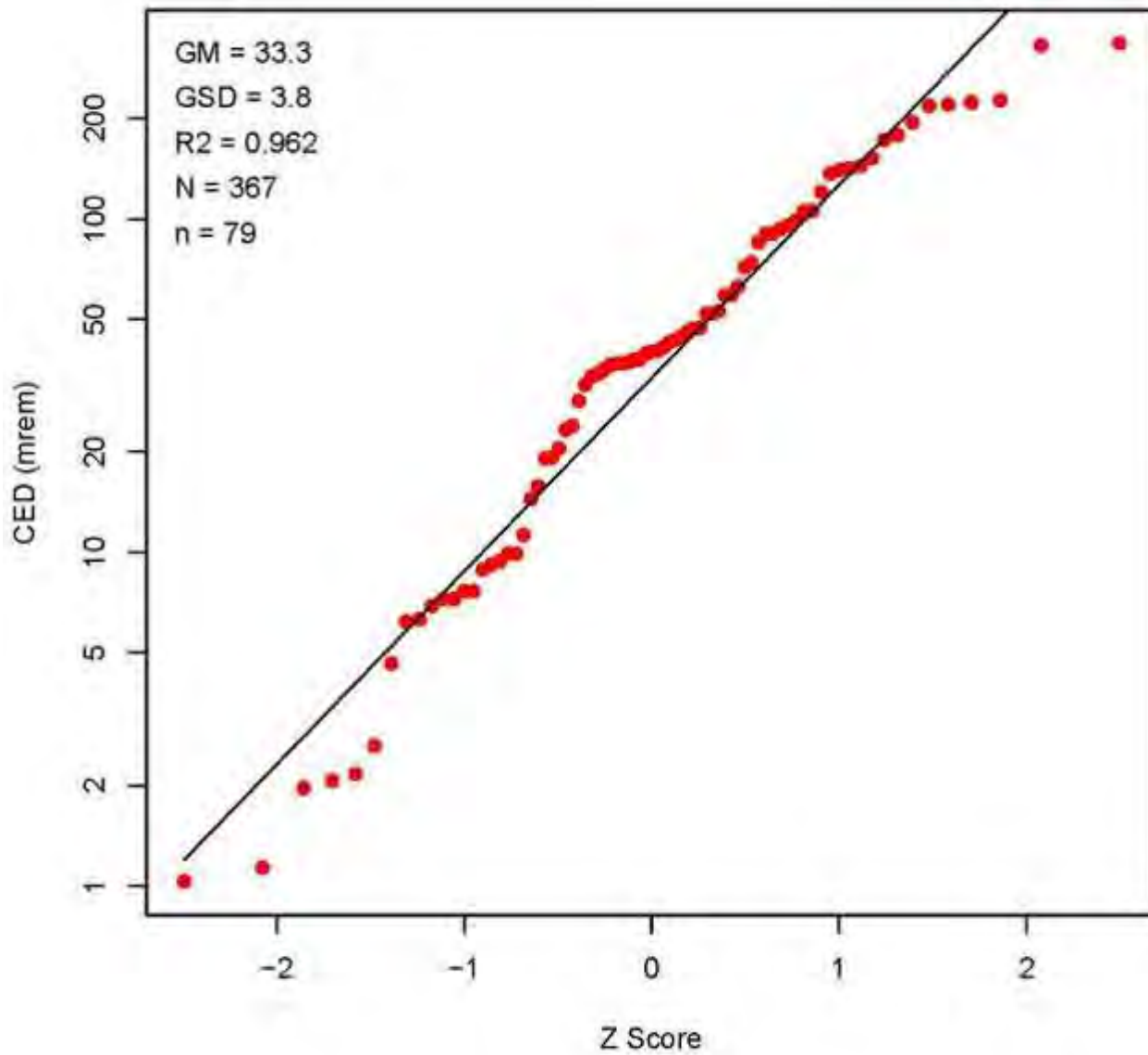


Figure C-30. SRS CTW/Reactor tritium dose 1961.

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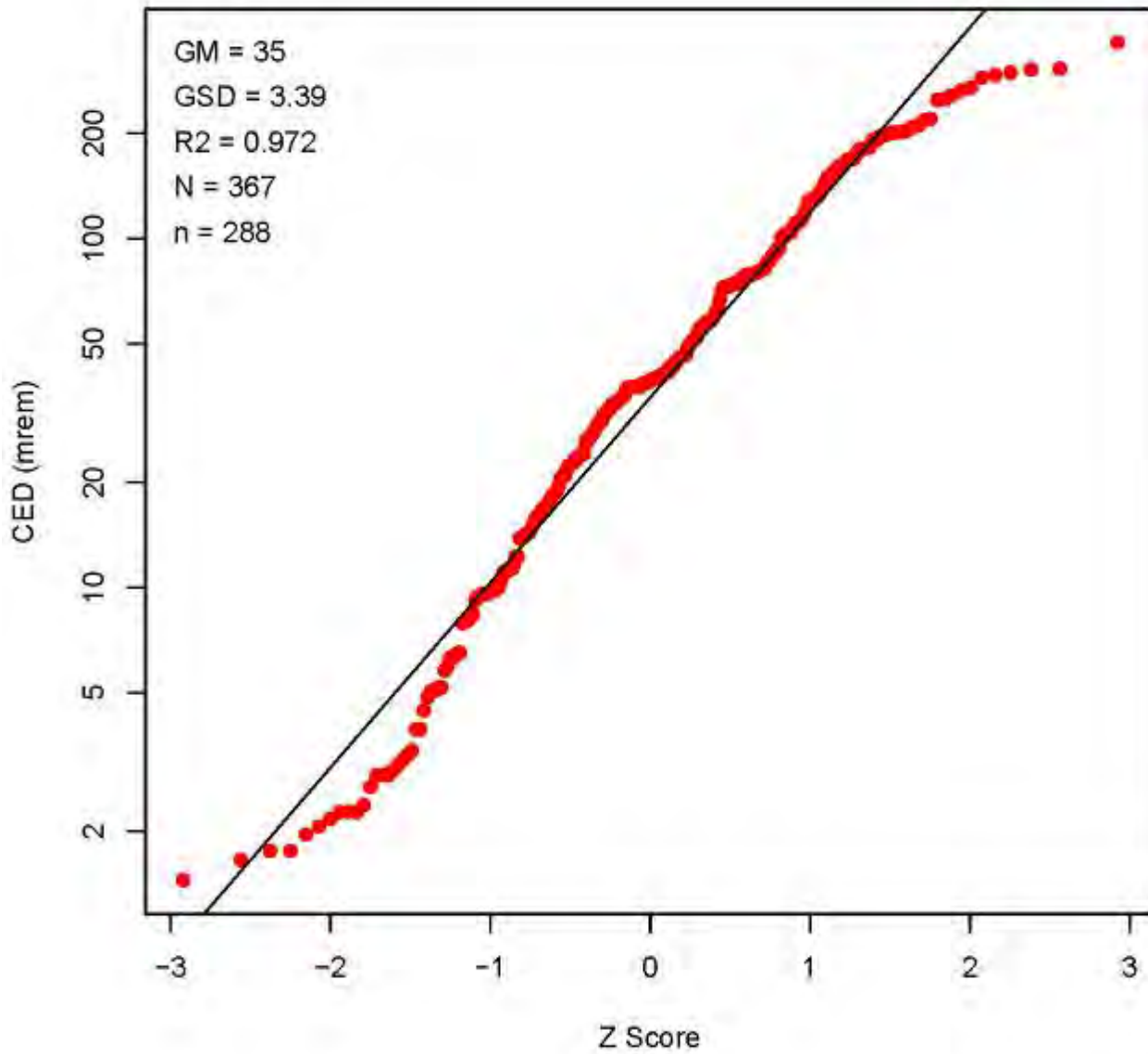


Figure C-31. SRS Non(CTW/Reactor) tritium dose 1961.

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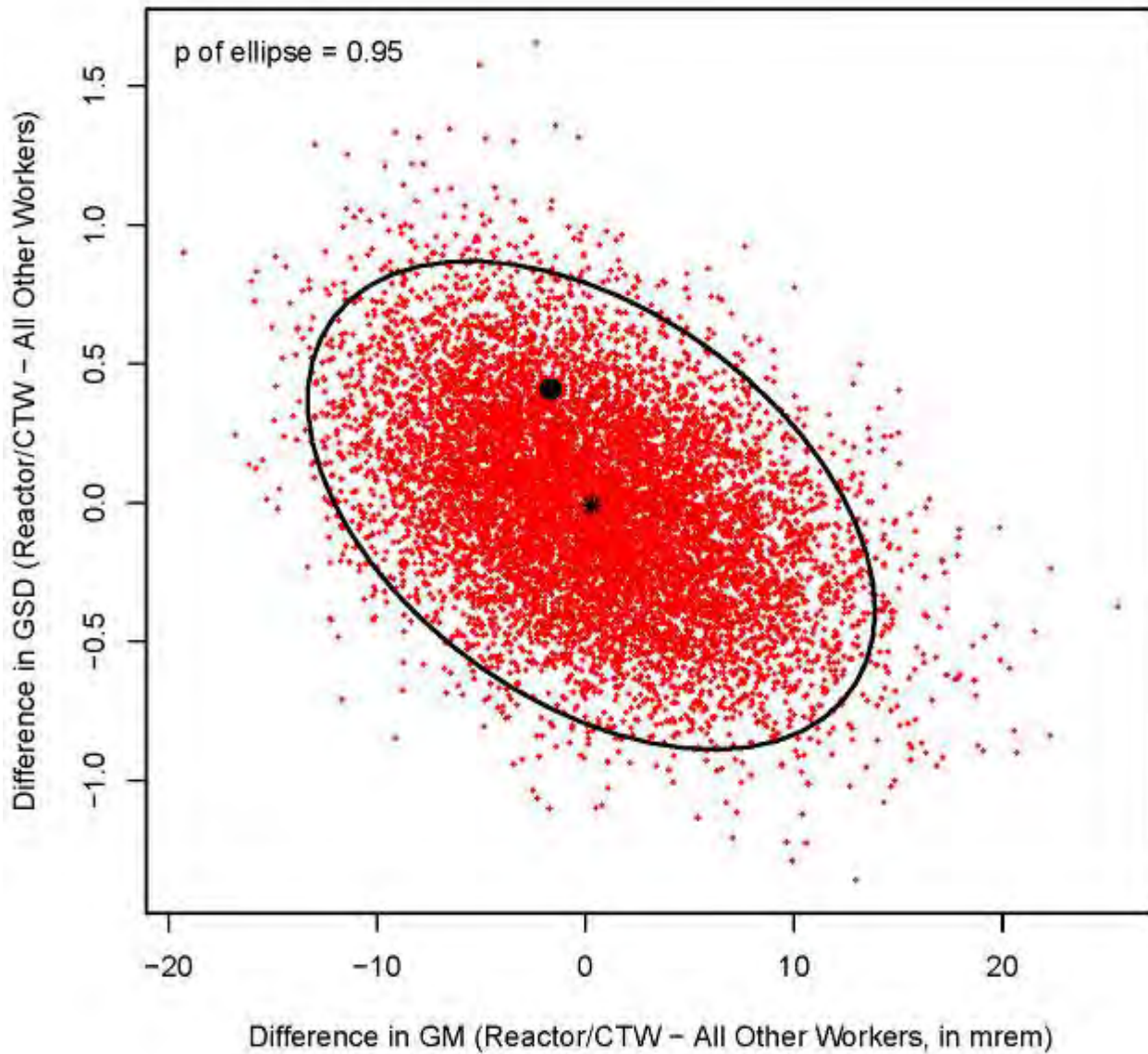


Figure C-32. SRS tritium dose 1961.

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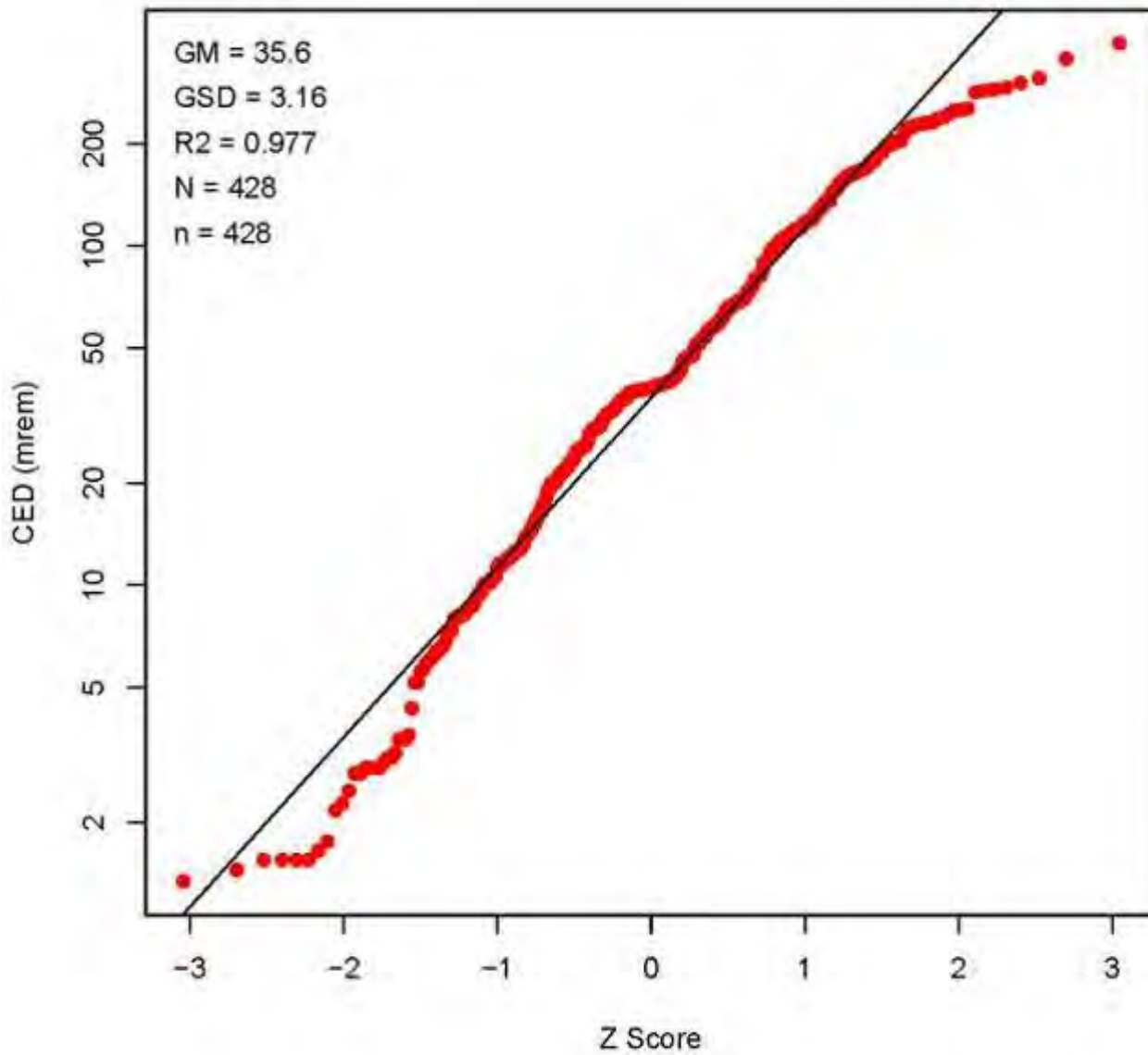


Figure C-33. SRS tritium dose 1962.

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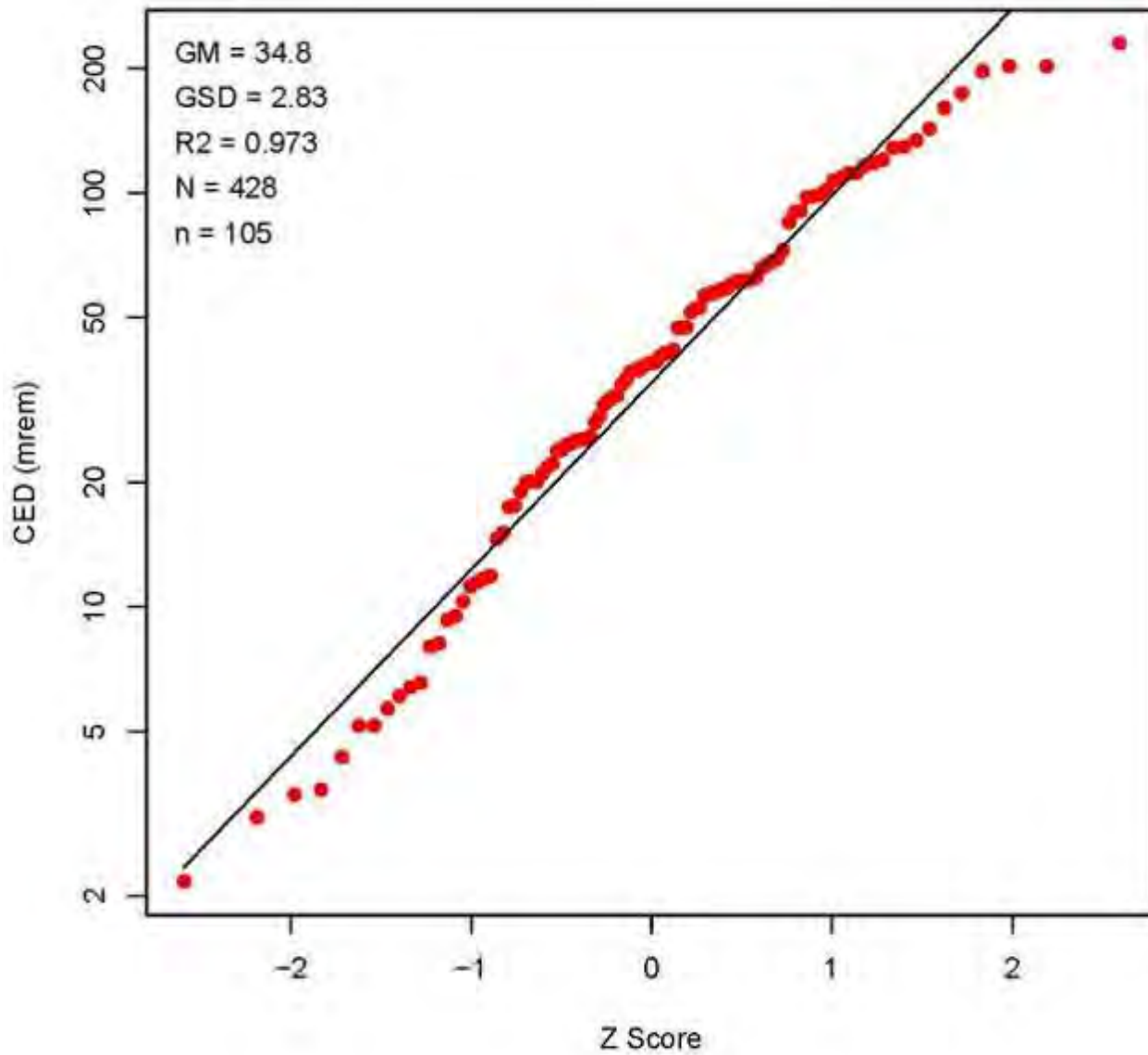


Figure C-34. SRS CTW/Reactor tritium dose 1962.

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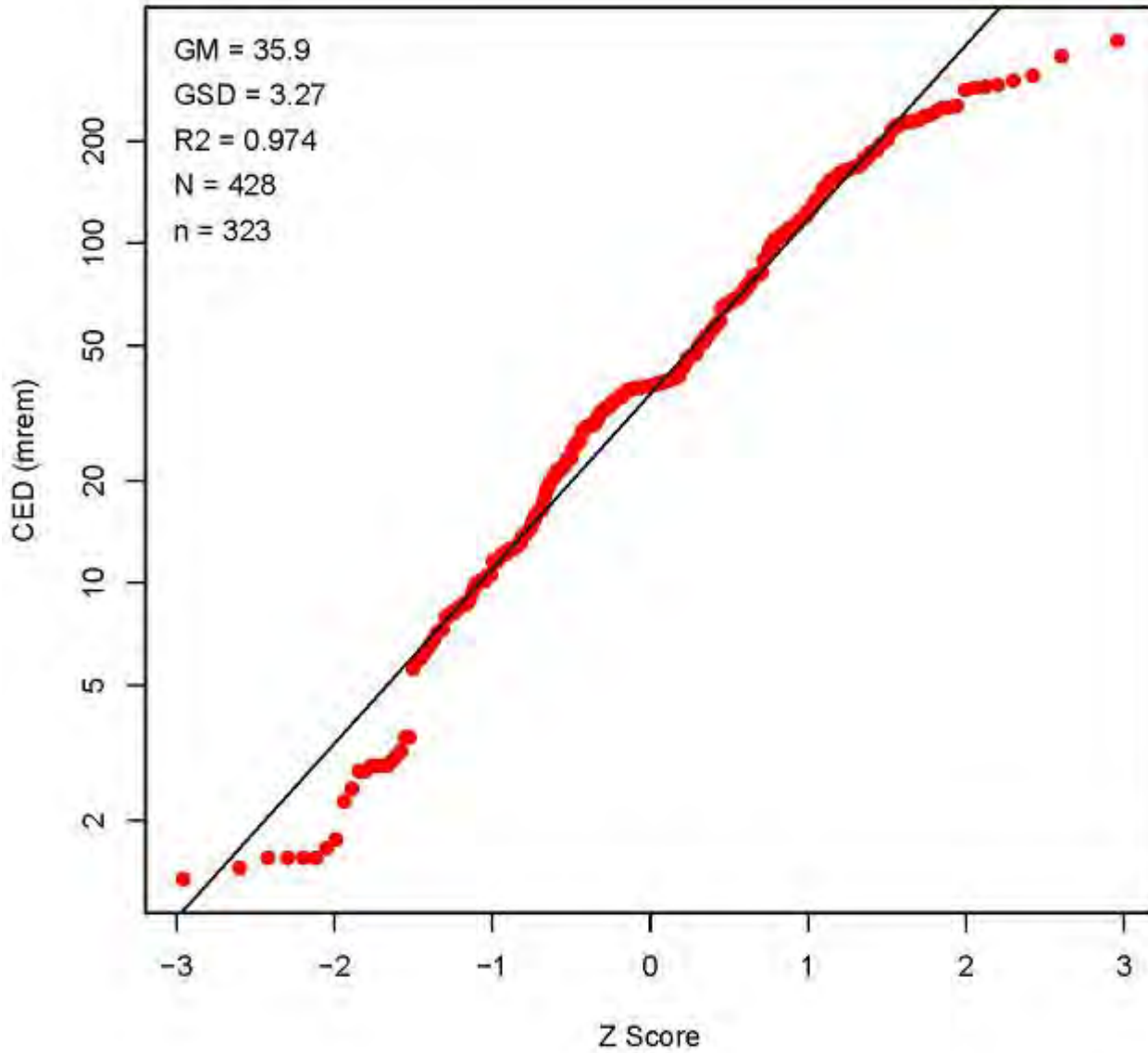


Figure C-35. SRS Non(CTW/Reactor) tritium dose 1962.

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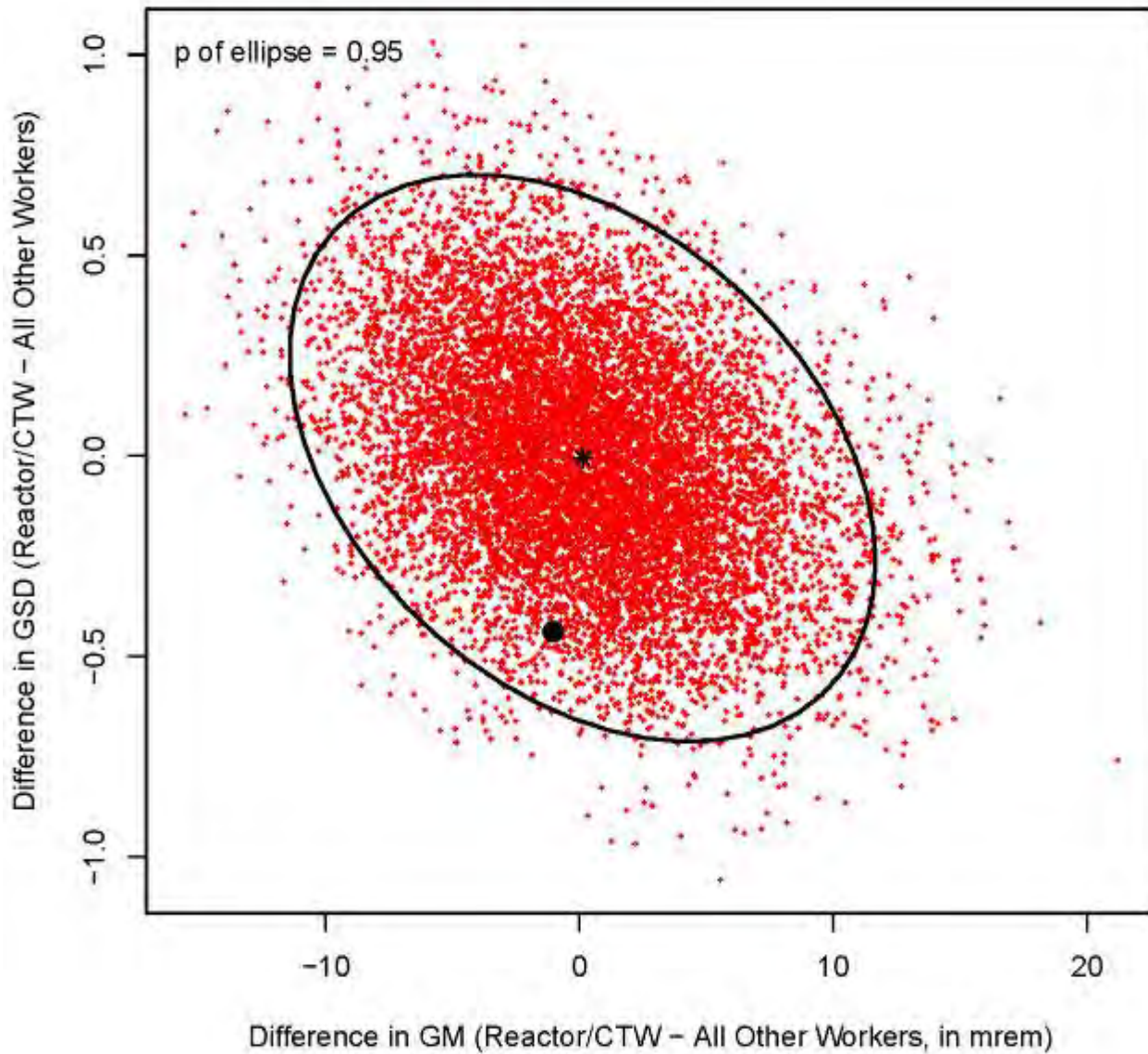


Figure C-36. SRS tritium dose 1962.

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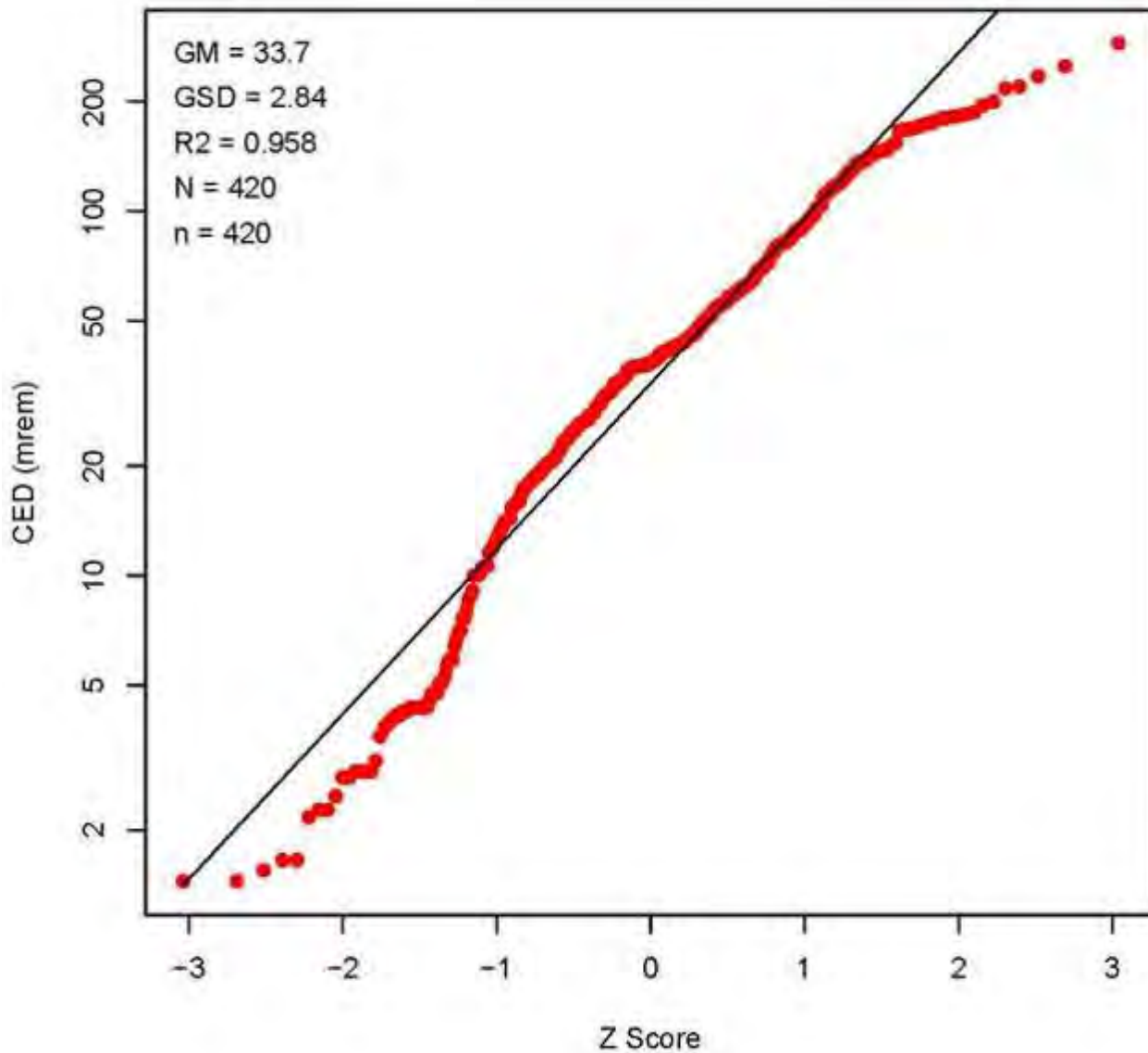


Figure C-37. SRS tritium dose 1963.

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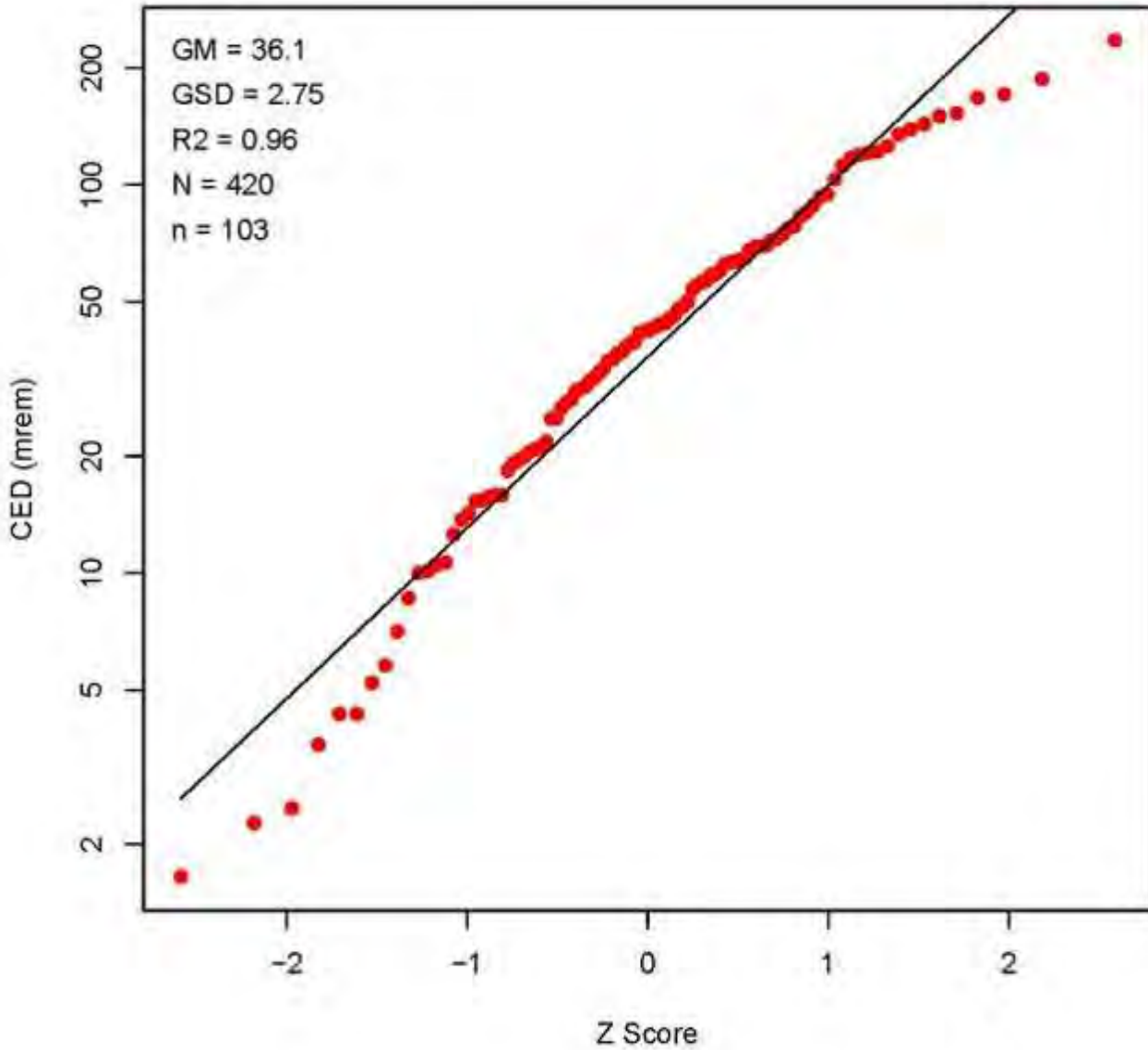


Figure C-38. SRS CTW/Reactor tritium dose 1963.

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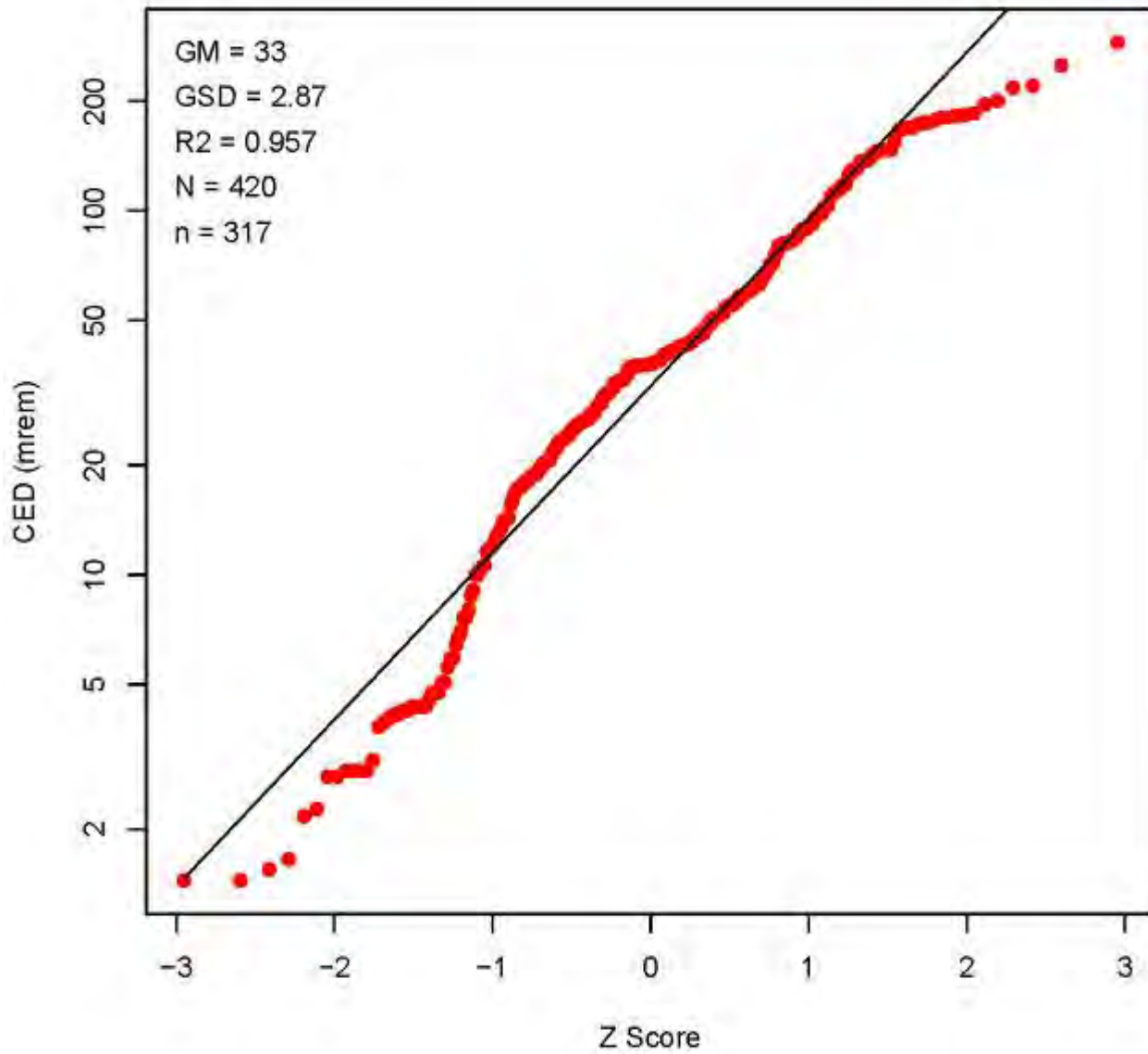


Figure C-39. SRS Non(CTW/Reactor) tritium dose 1963.

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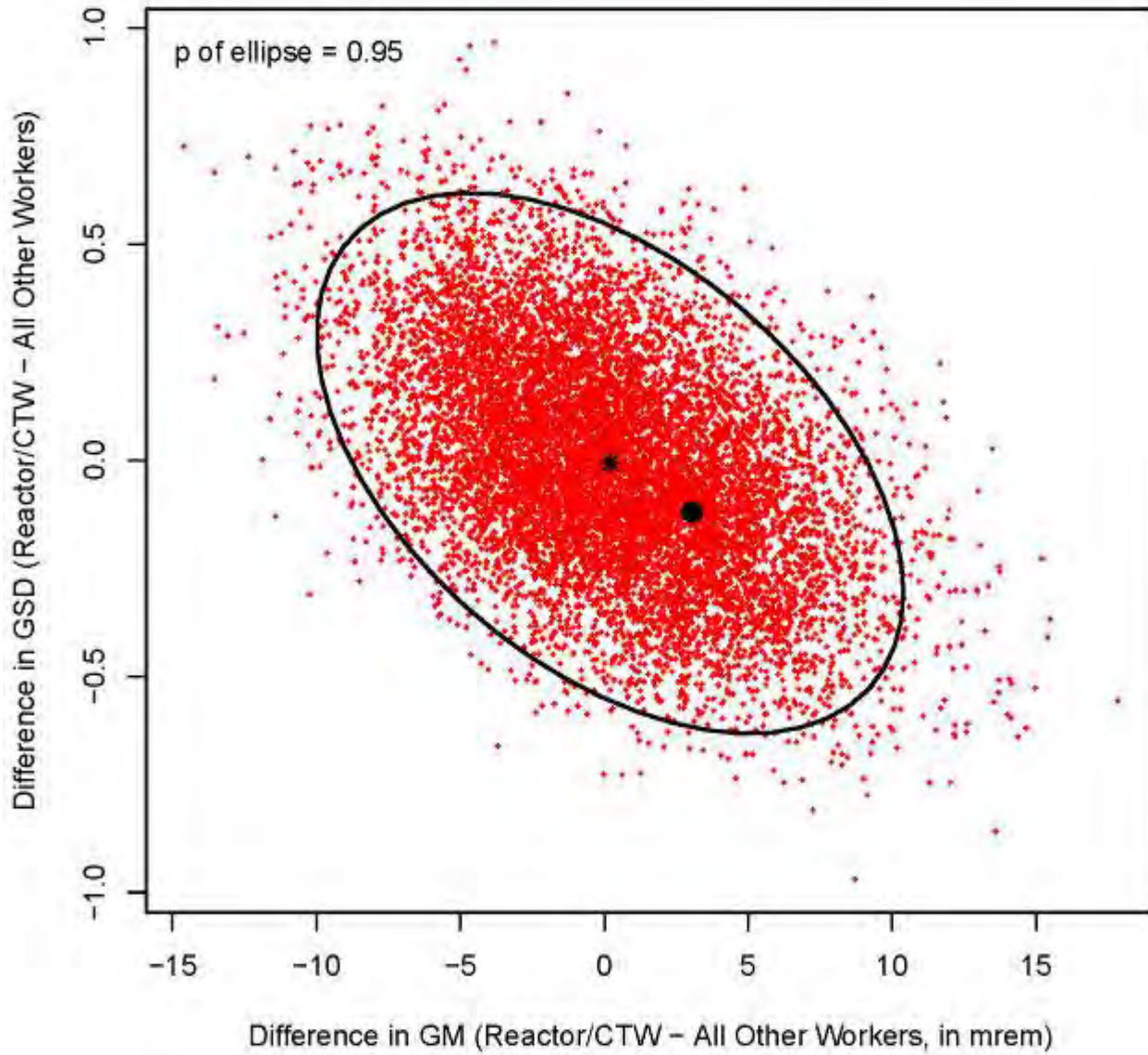


Figure C-40. SRS tritium dose 1963.

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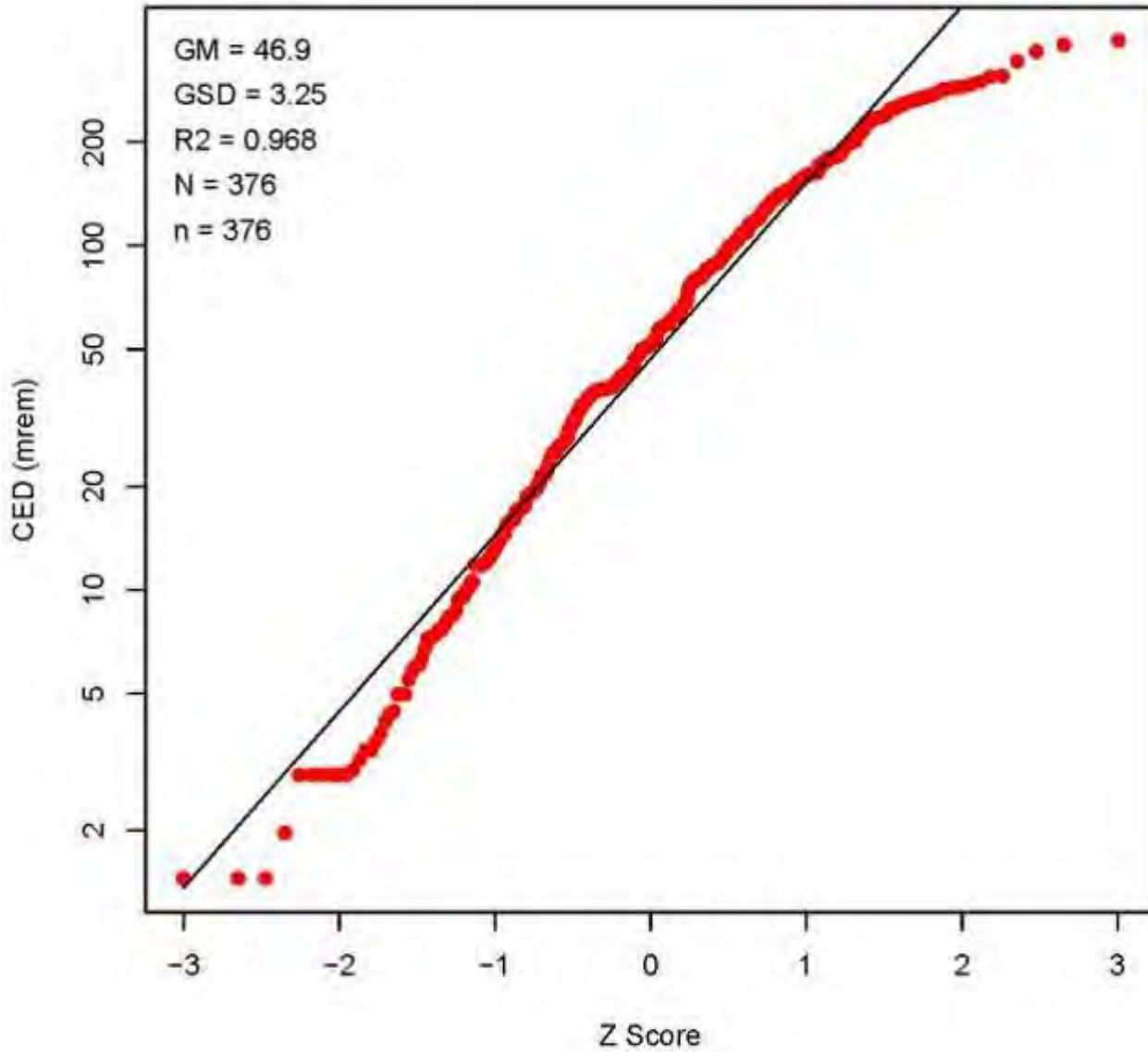


Figure C-41. SRS tritium dose 1964.

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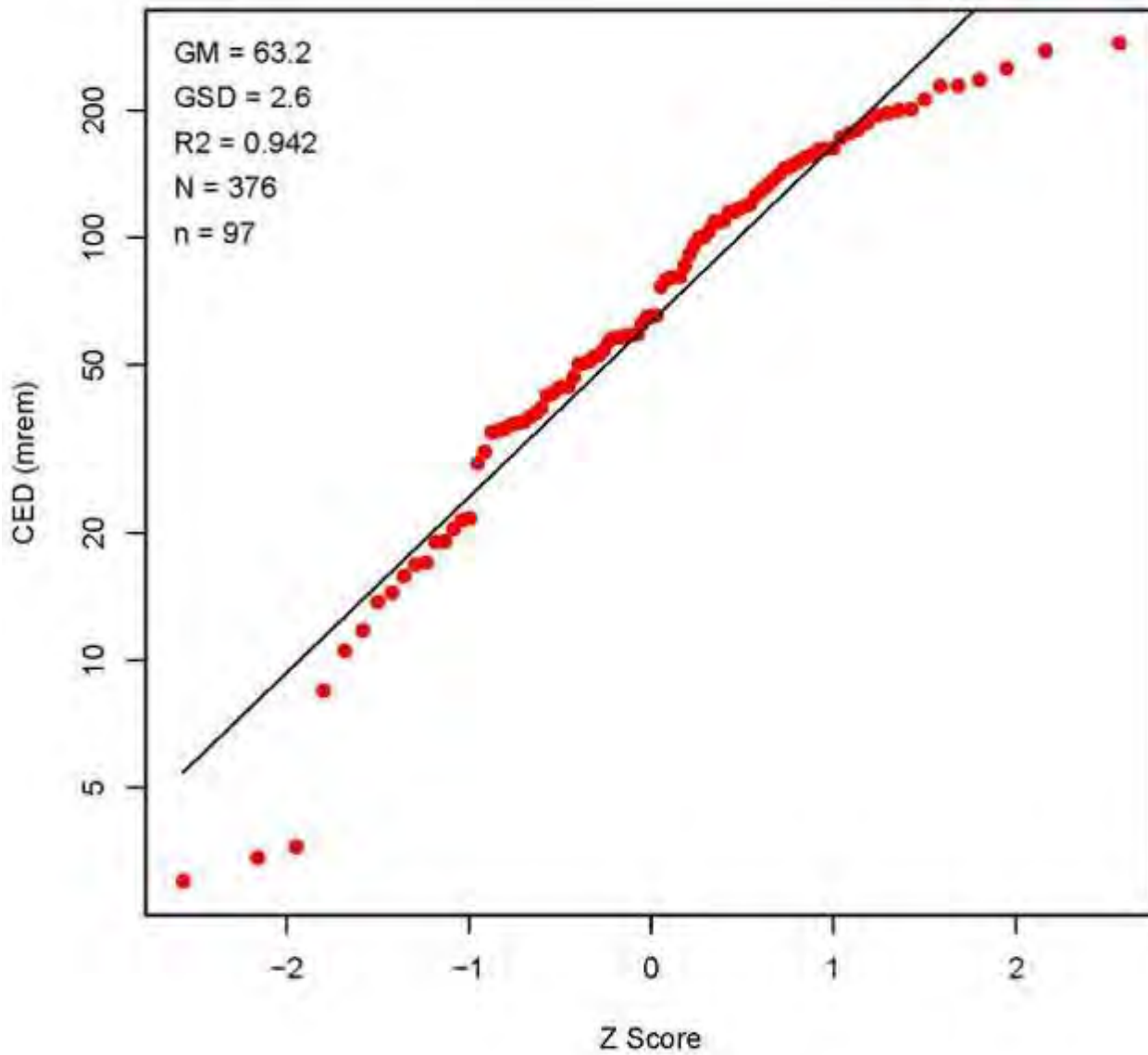


Figure C-42. SRS CTW/Reactor tritium dose 1964.

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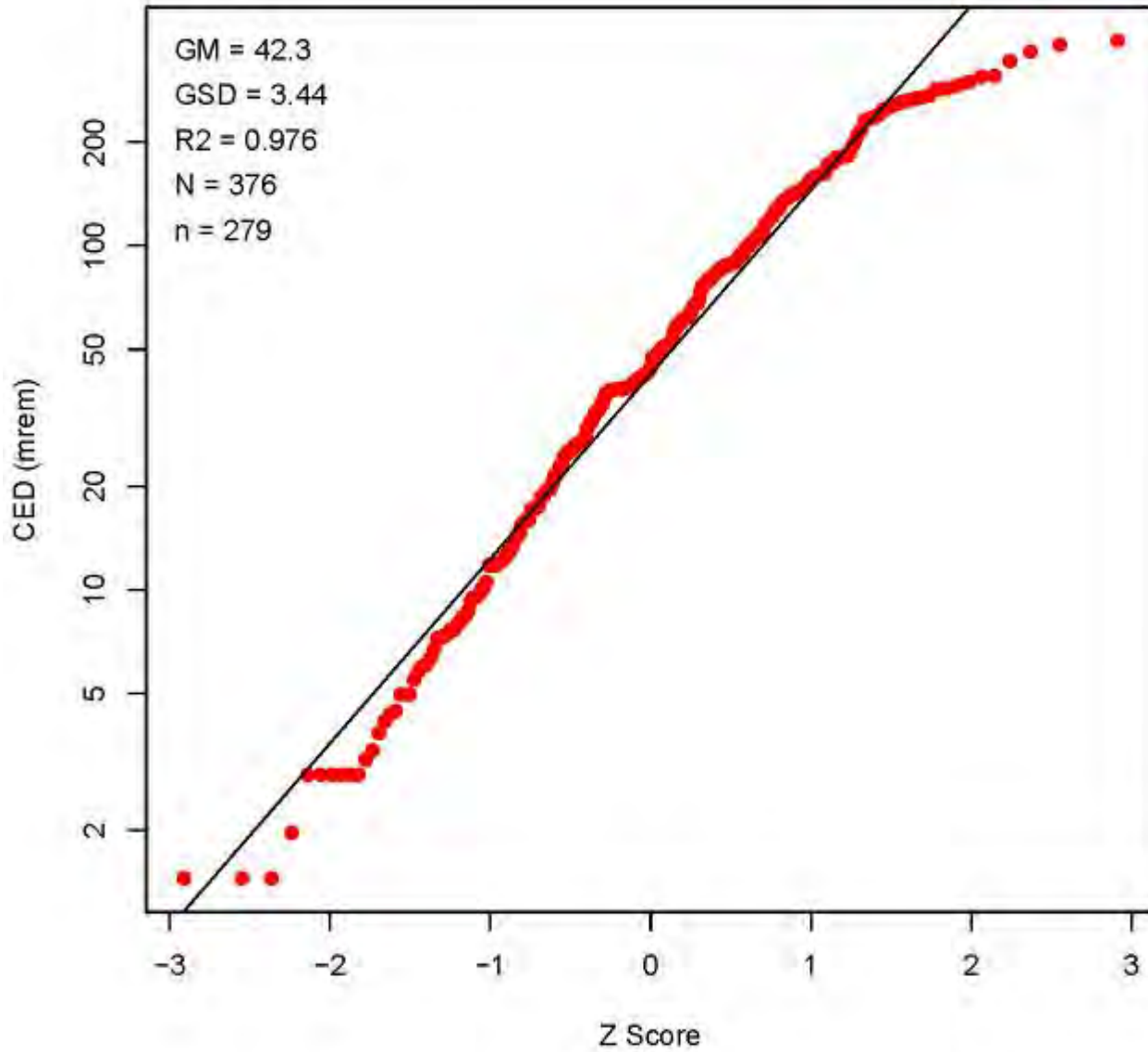


Figure C-43. SRS Non(CTW/Reactor) tritium dose 1964.

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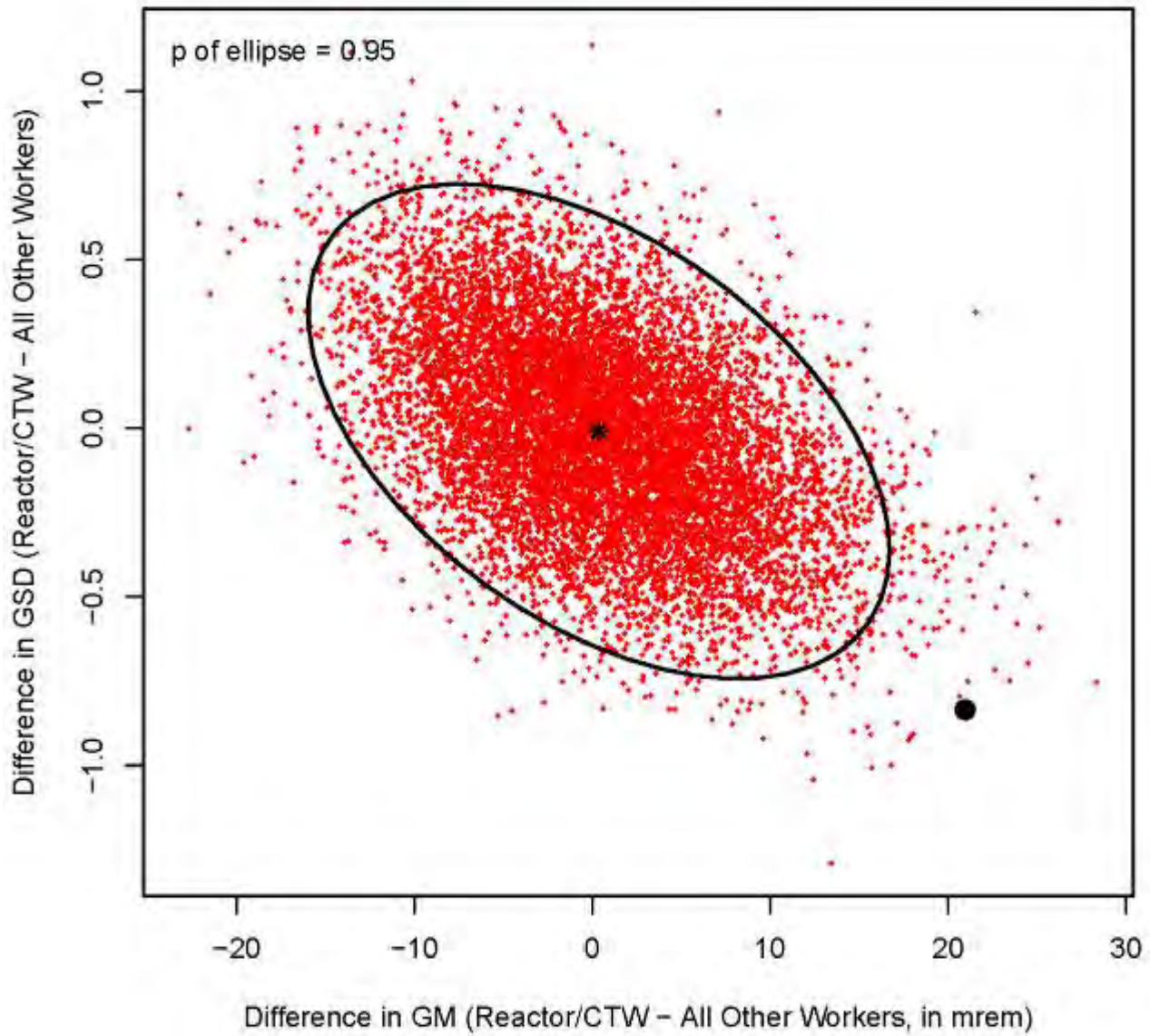


Figure C-44. SRS tritium dose 1964.

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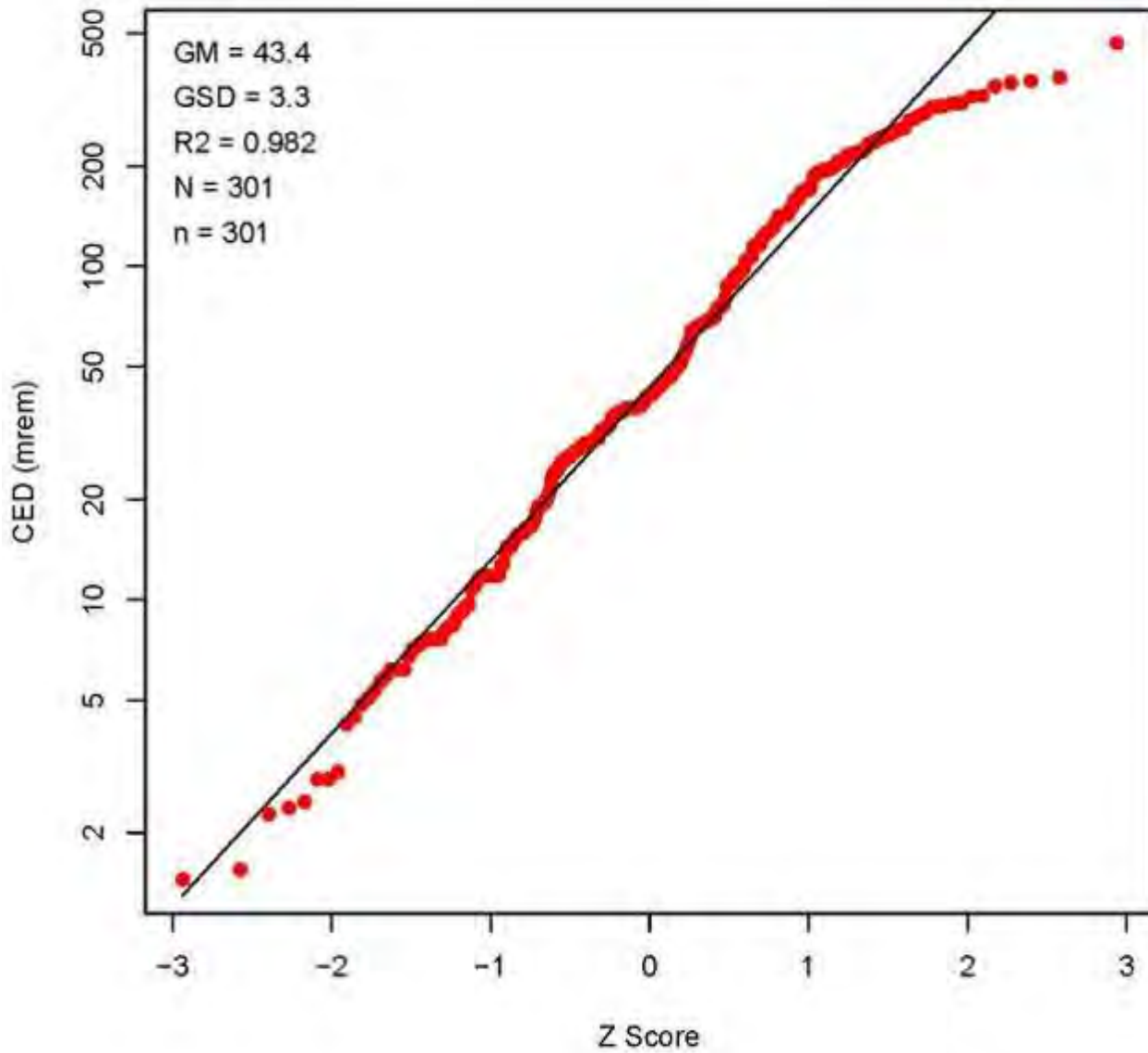


Figure C-45. SRS tritium dose 1965.

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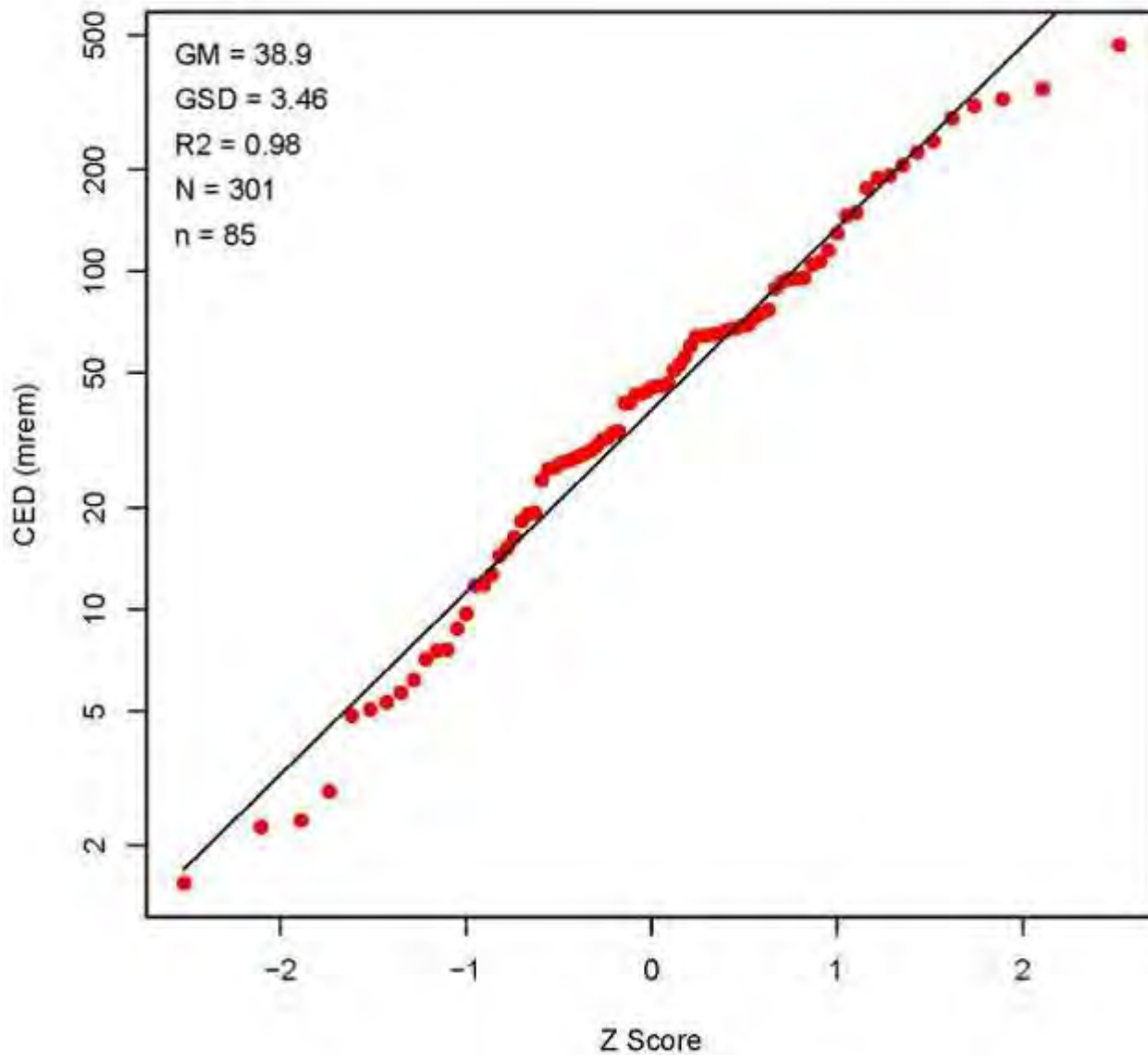


Figure C-46. SRS CTW/Reactor tritium dose 1965.

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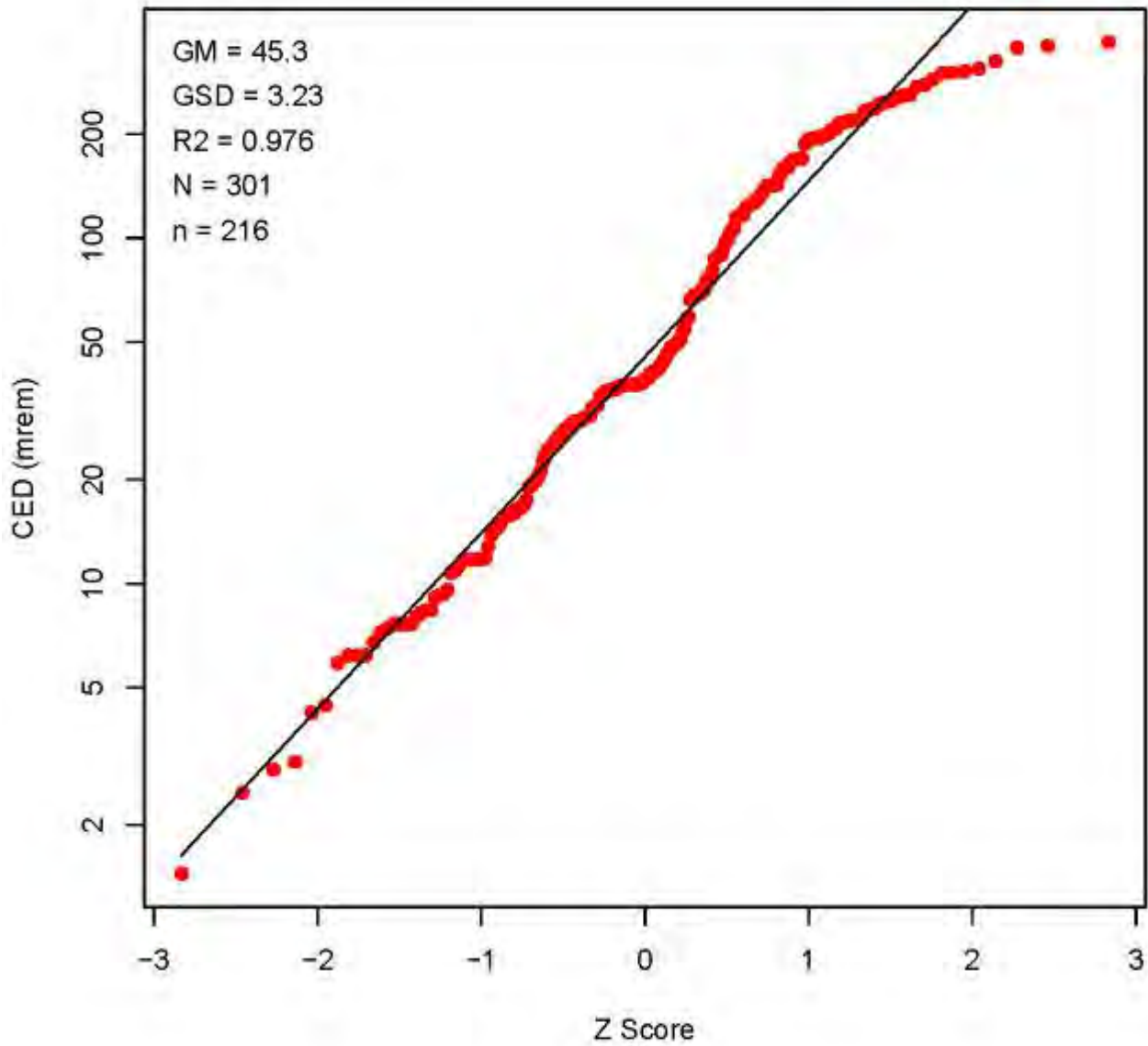


Figure C-47. SRS Non(CTW/Reactor) tritium dose 1965.

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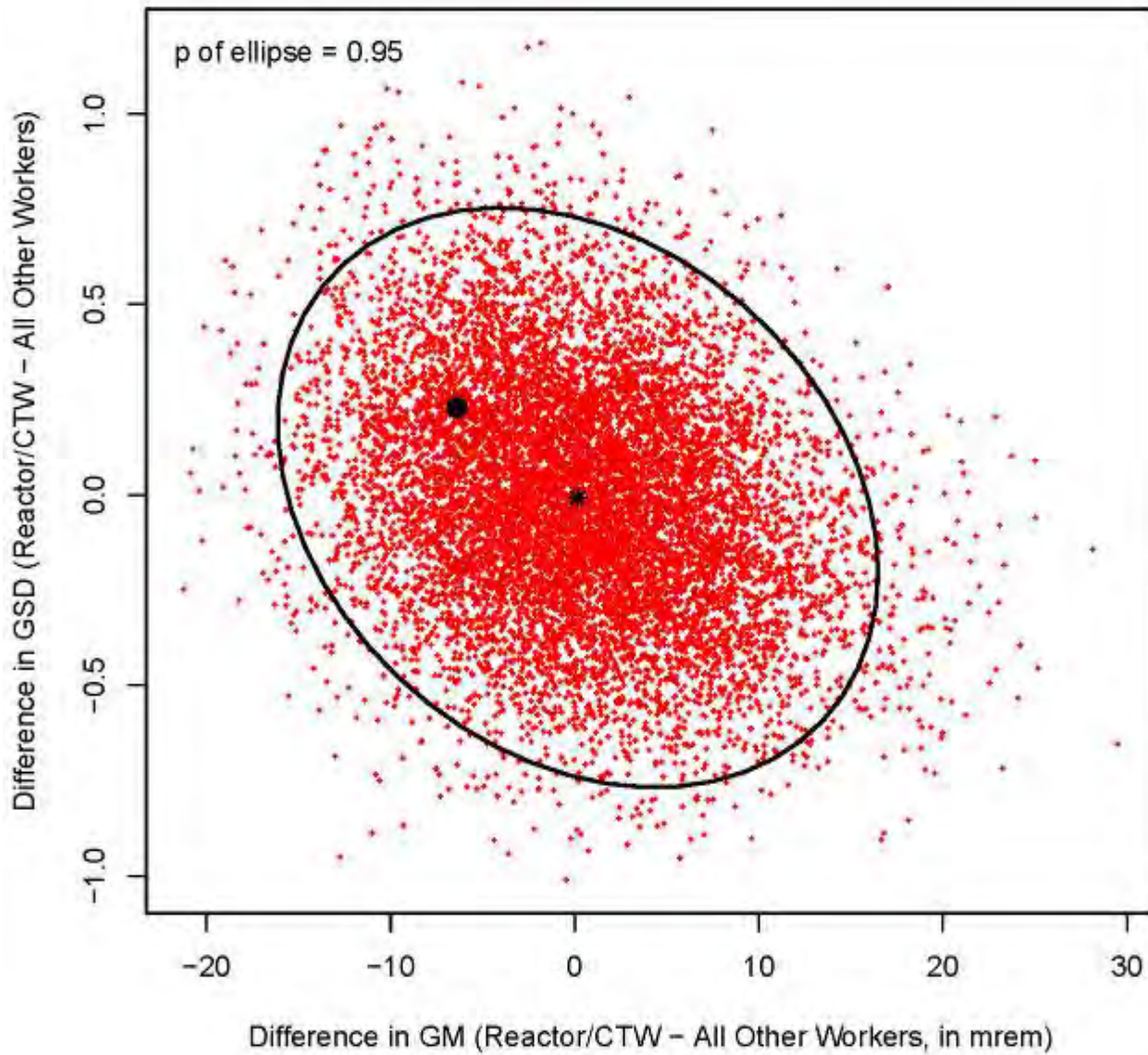


Figure C-48. SRS tritium dose 1965.

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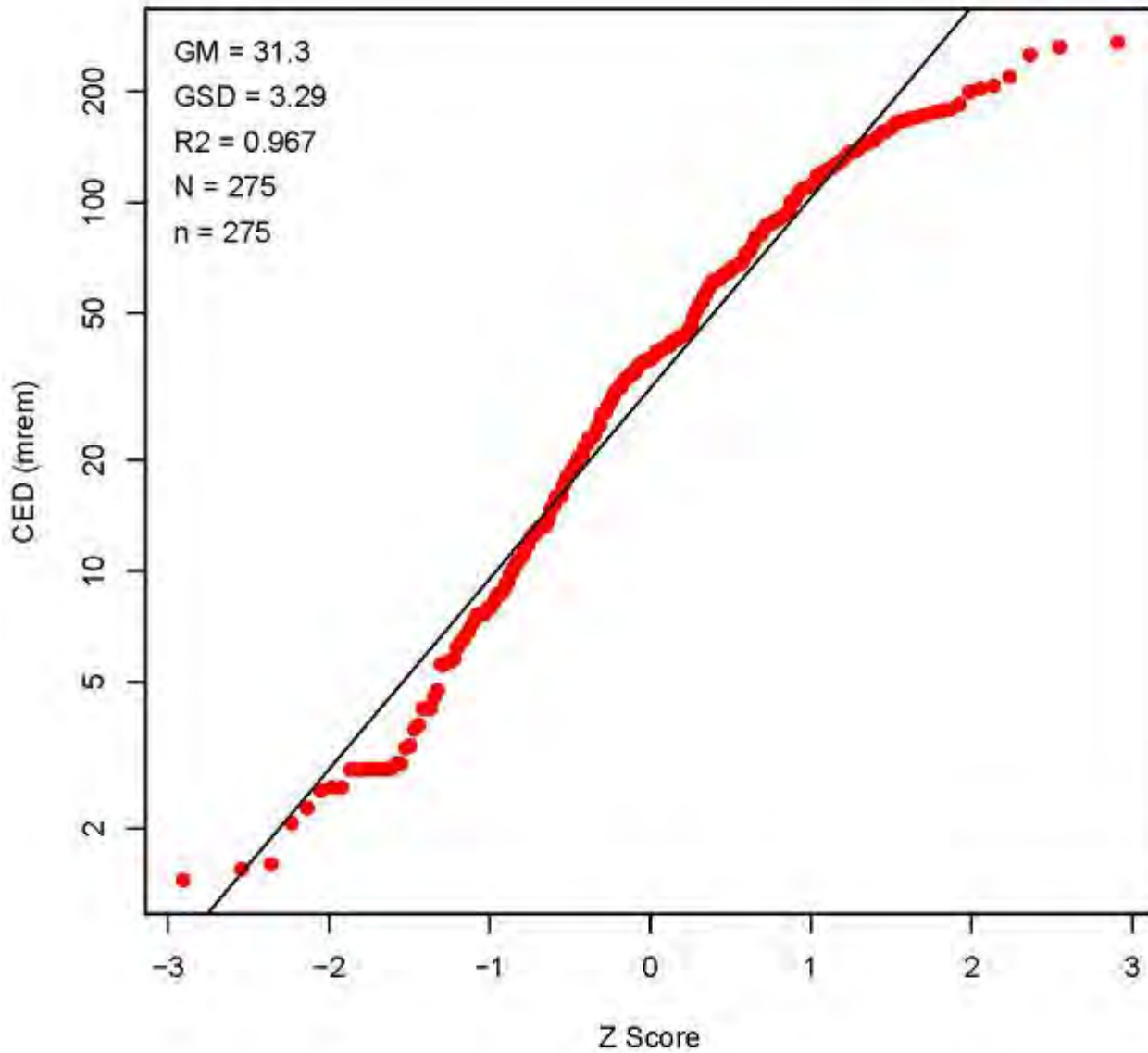


Figure C-49. SRS tritium dose 1966.

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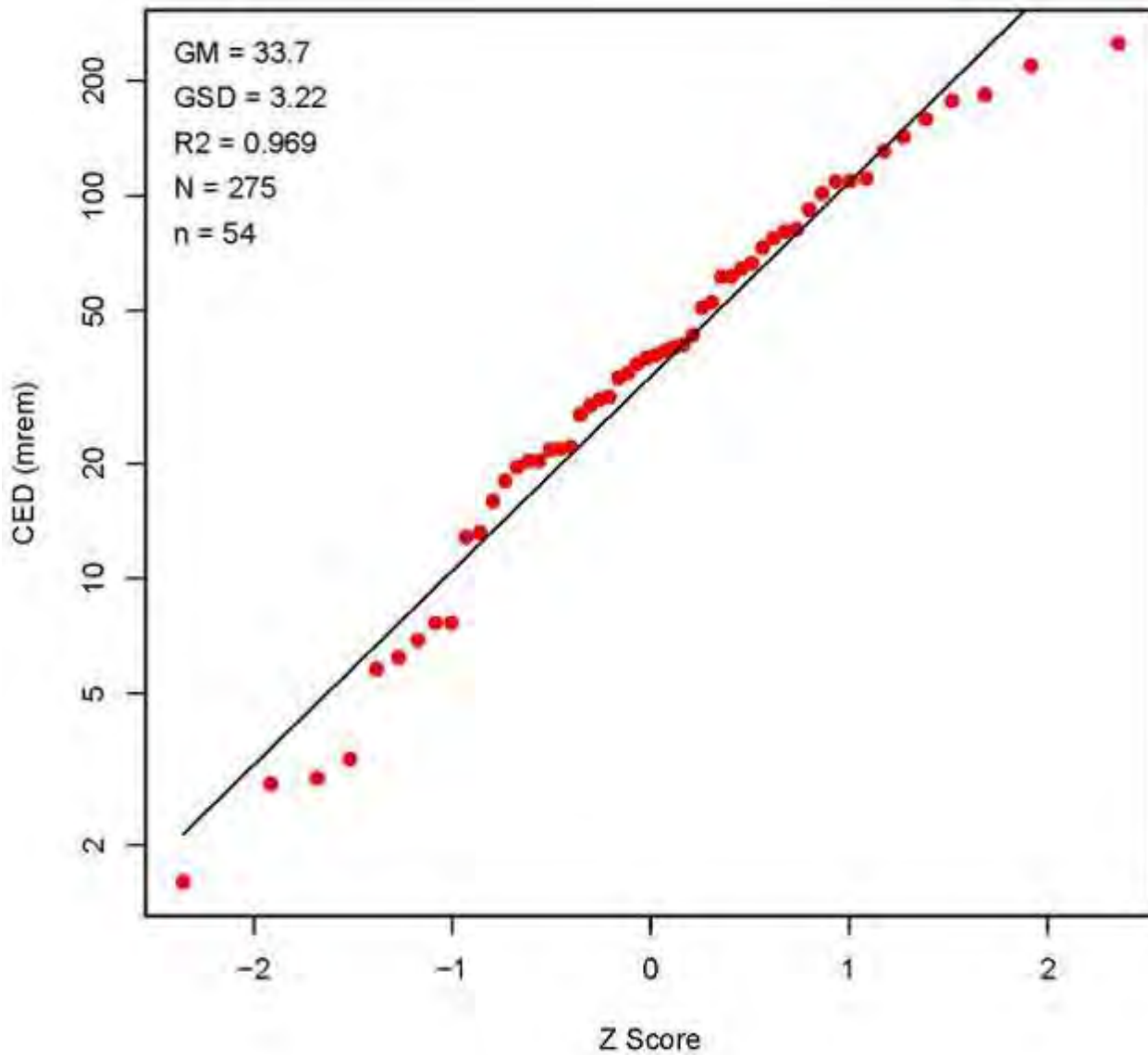


Figure C-50. SRS CTW/Reactor tritium dose 1966.

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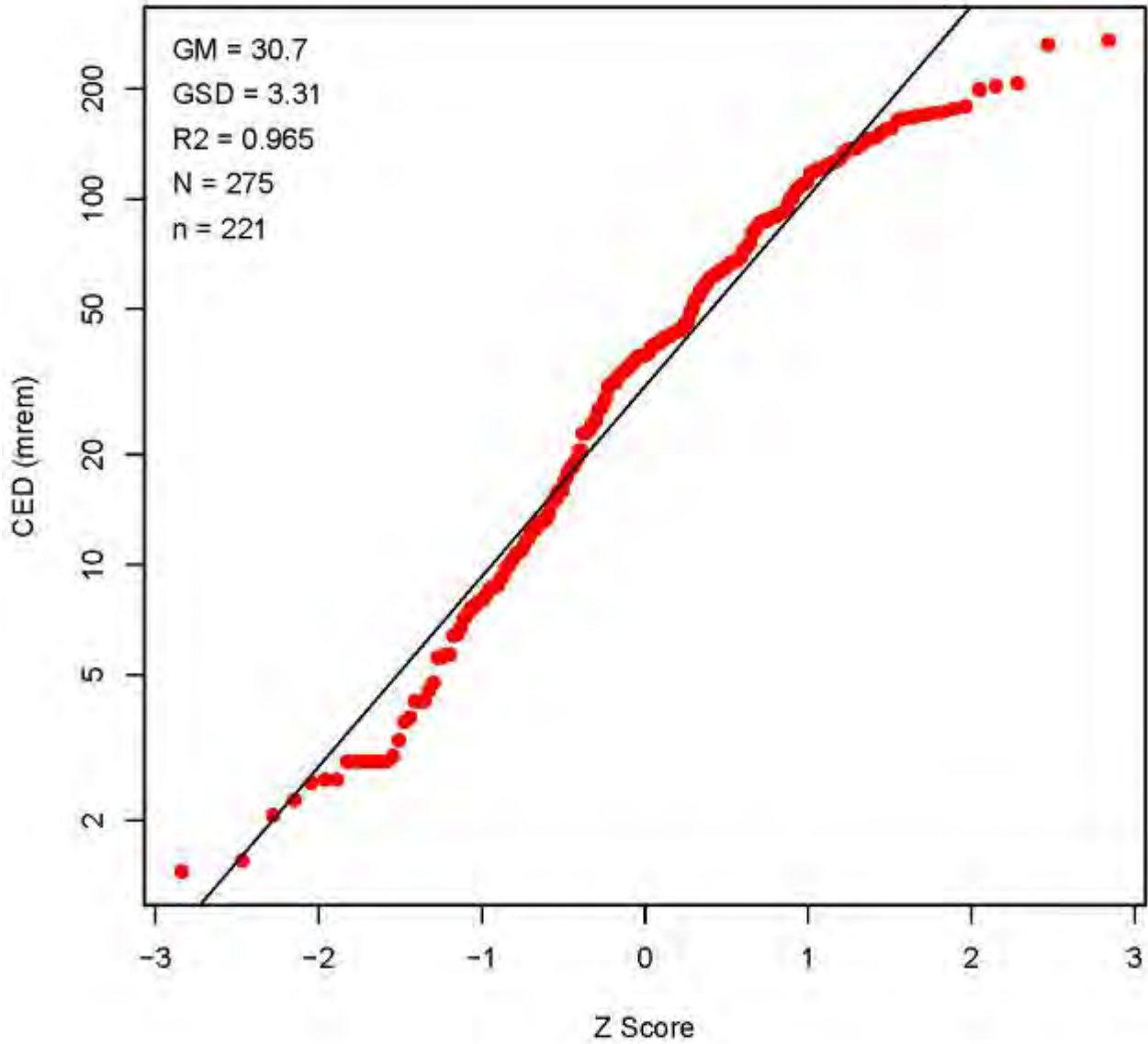


Figure C-51. SRS Non(CTW/Reactor) tritium dose 1966.

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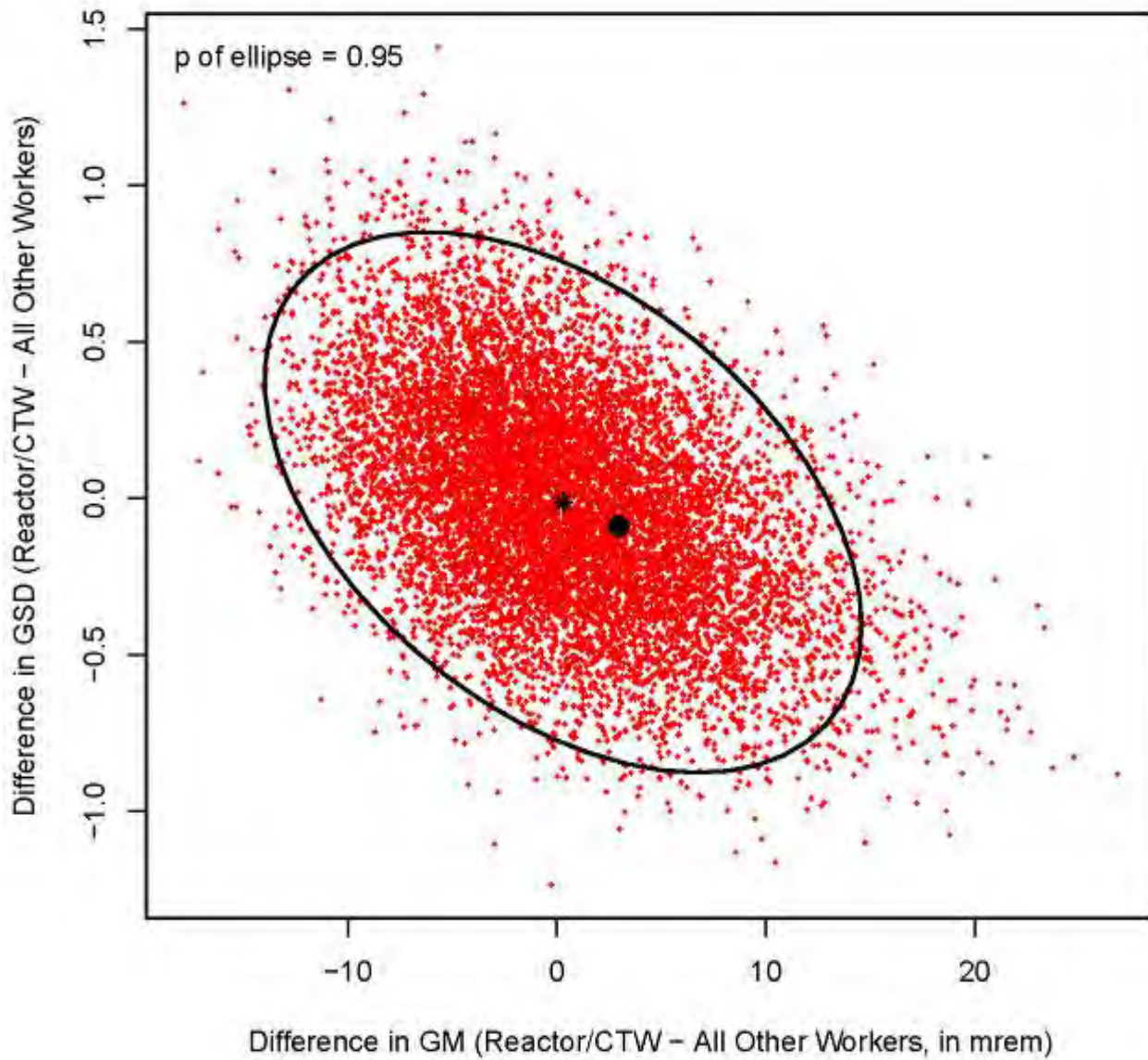


Figure C-52. SRS tritium dose 1966.

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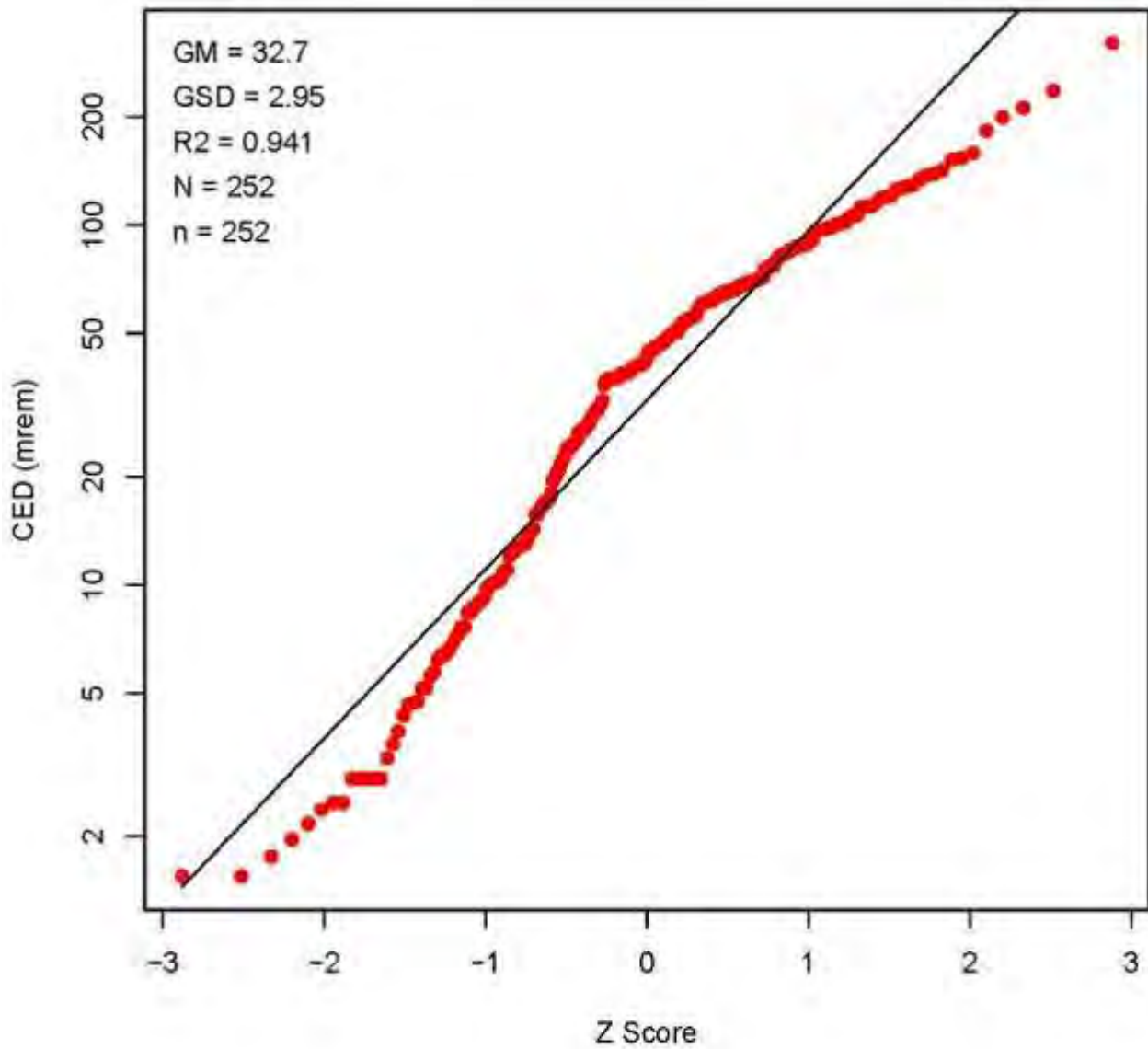


Figure C-53. SRS tritium dose 1967.

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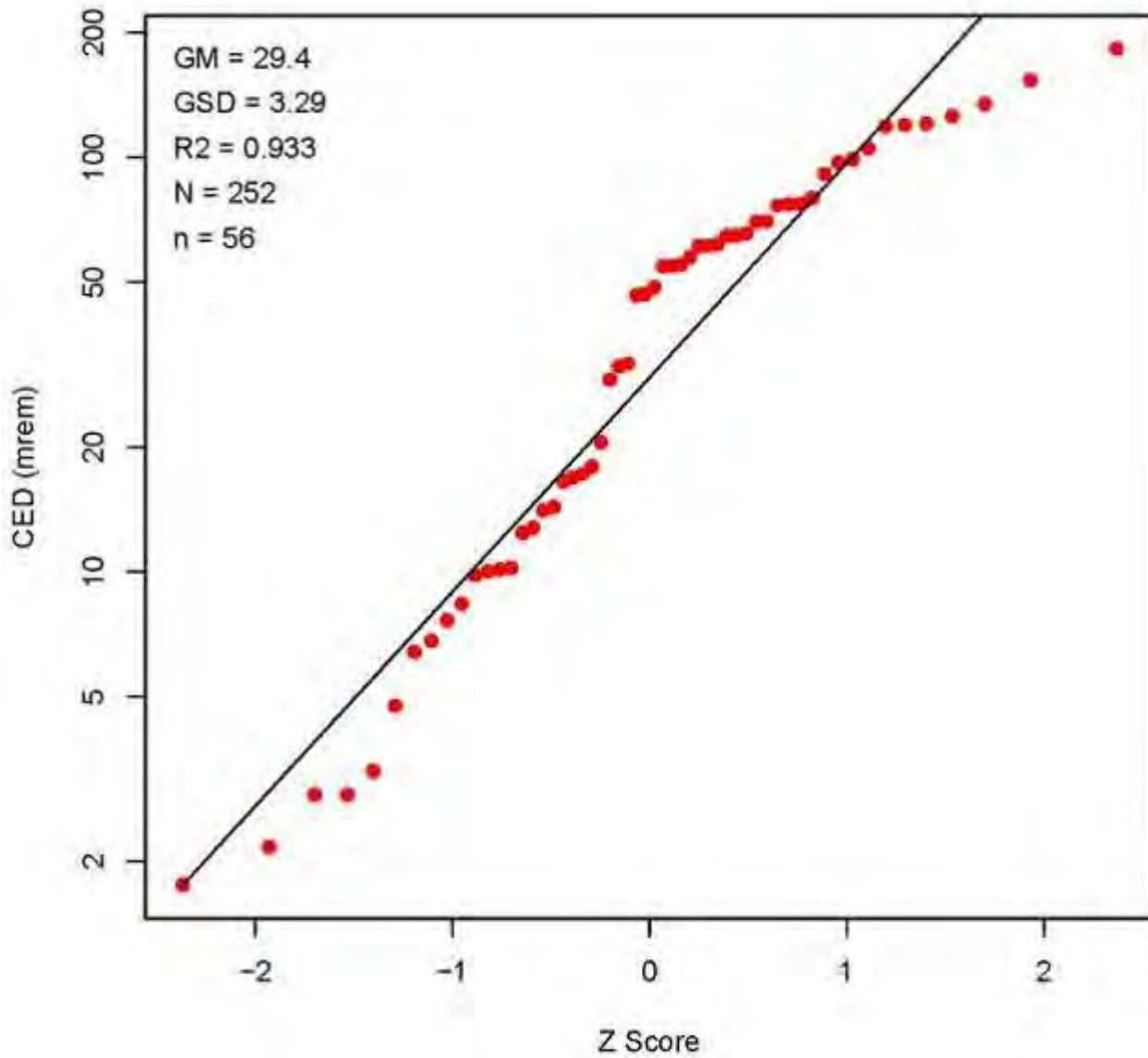


Figure C-54. SRS CTW/Reactor tritium dose 1967.

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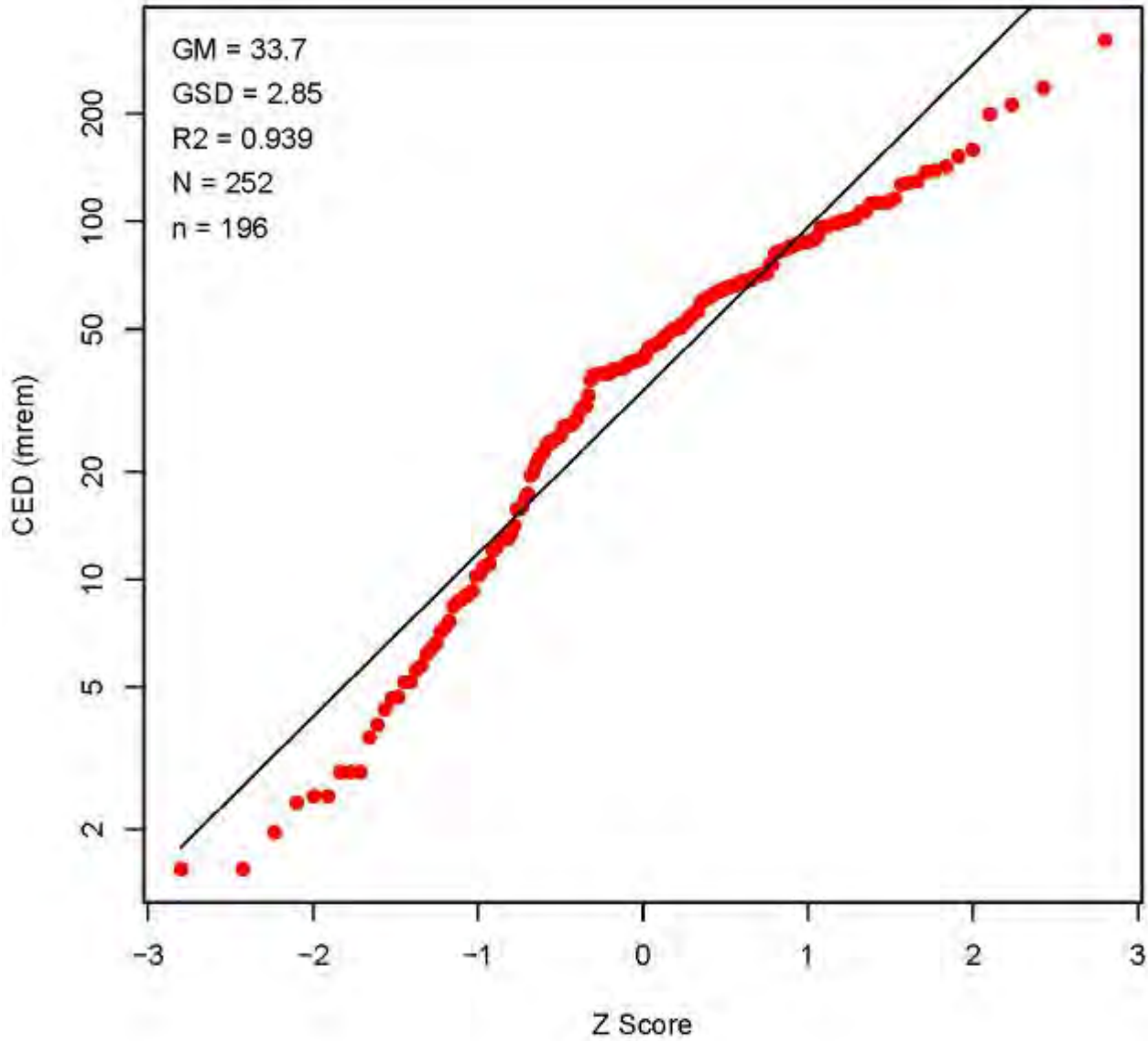


Figure C-55. SRS Non(CTW/Reactor) tritium dose 1967.

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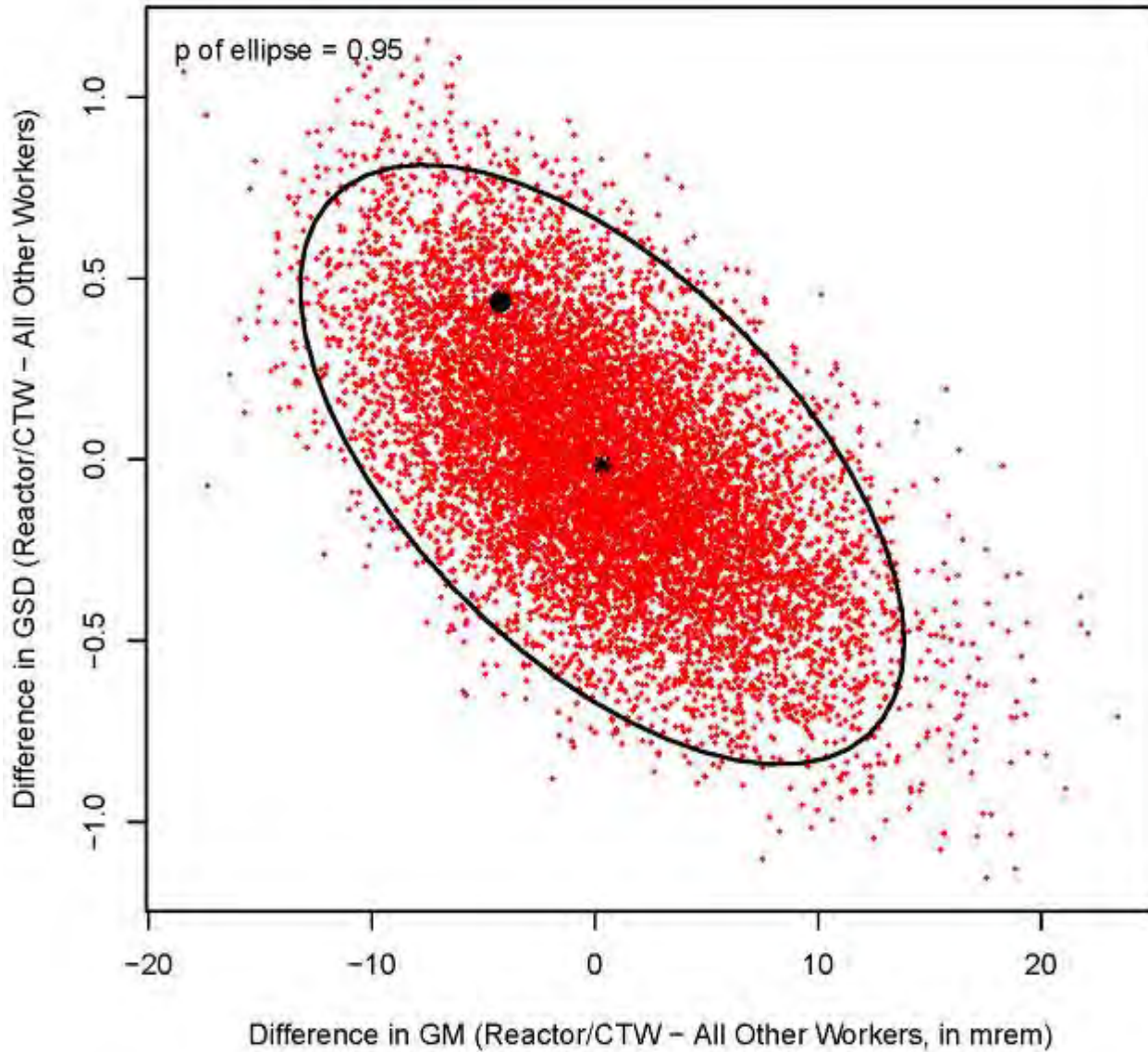


Figure C-56. SRS tritium dose 1967.

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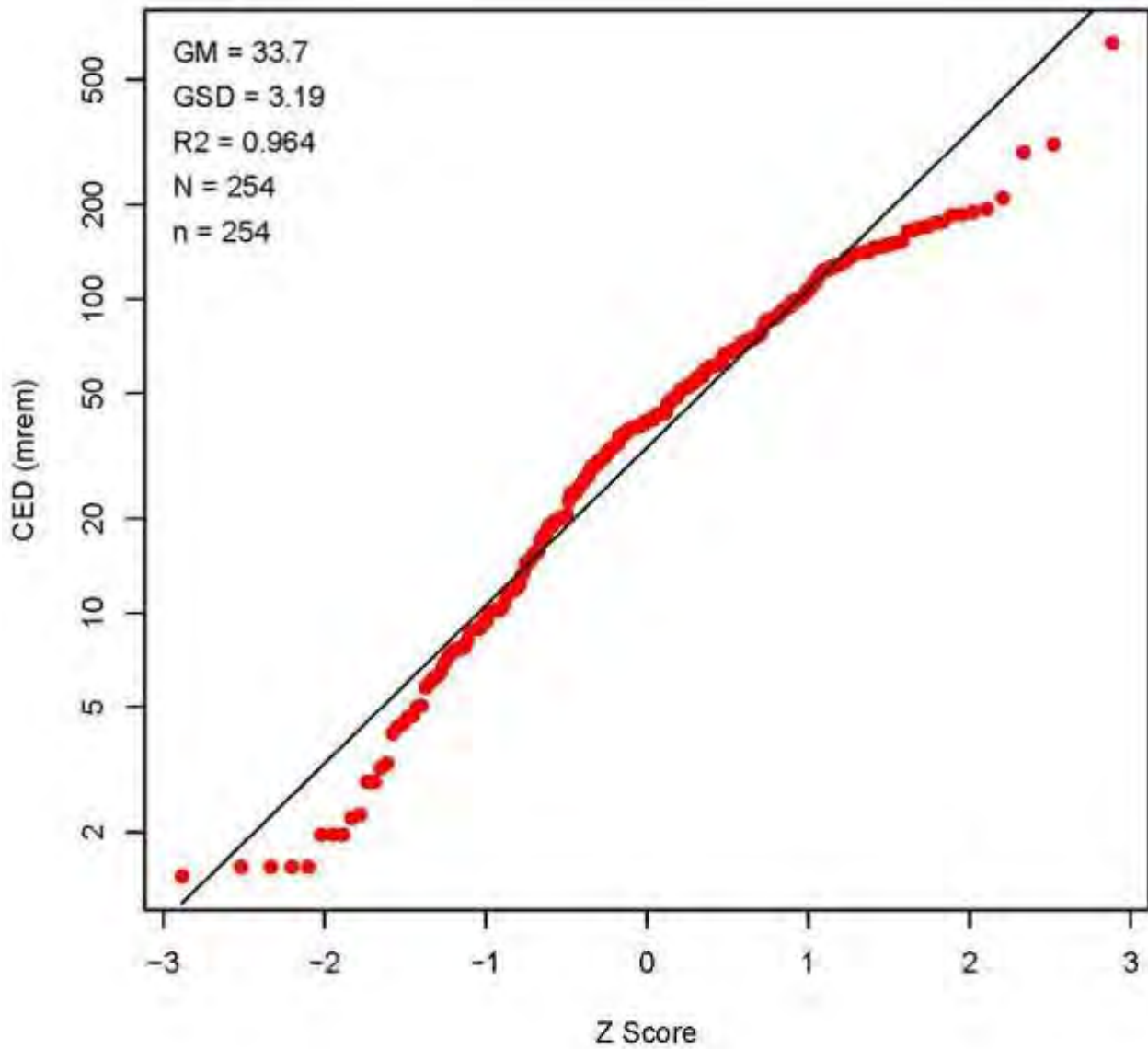


Figure C-57. SRS tritium dose 1968.

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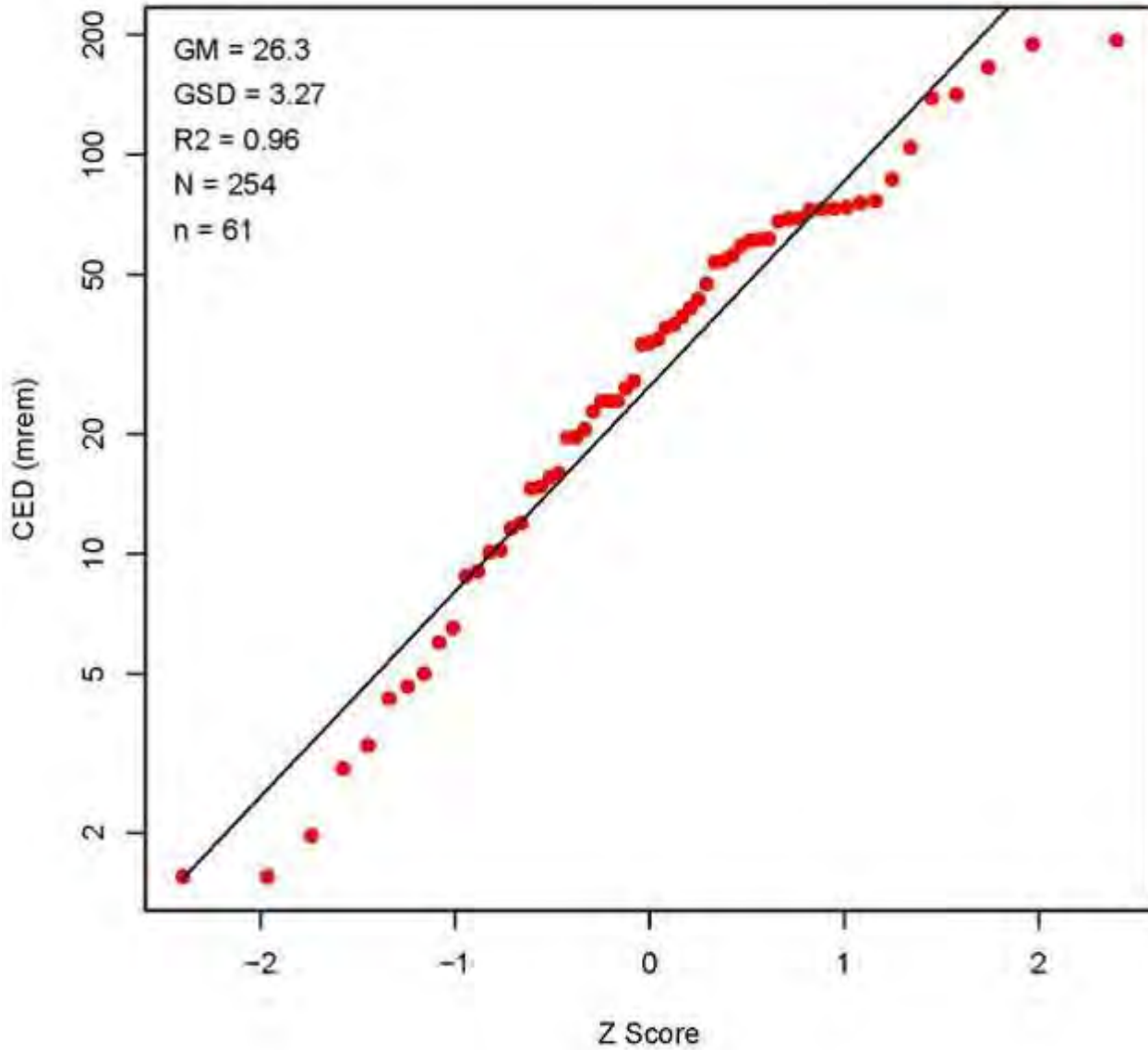


Figure C-58. SRS CTW/Reactor tritium dose 1968.

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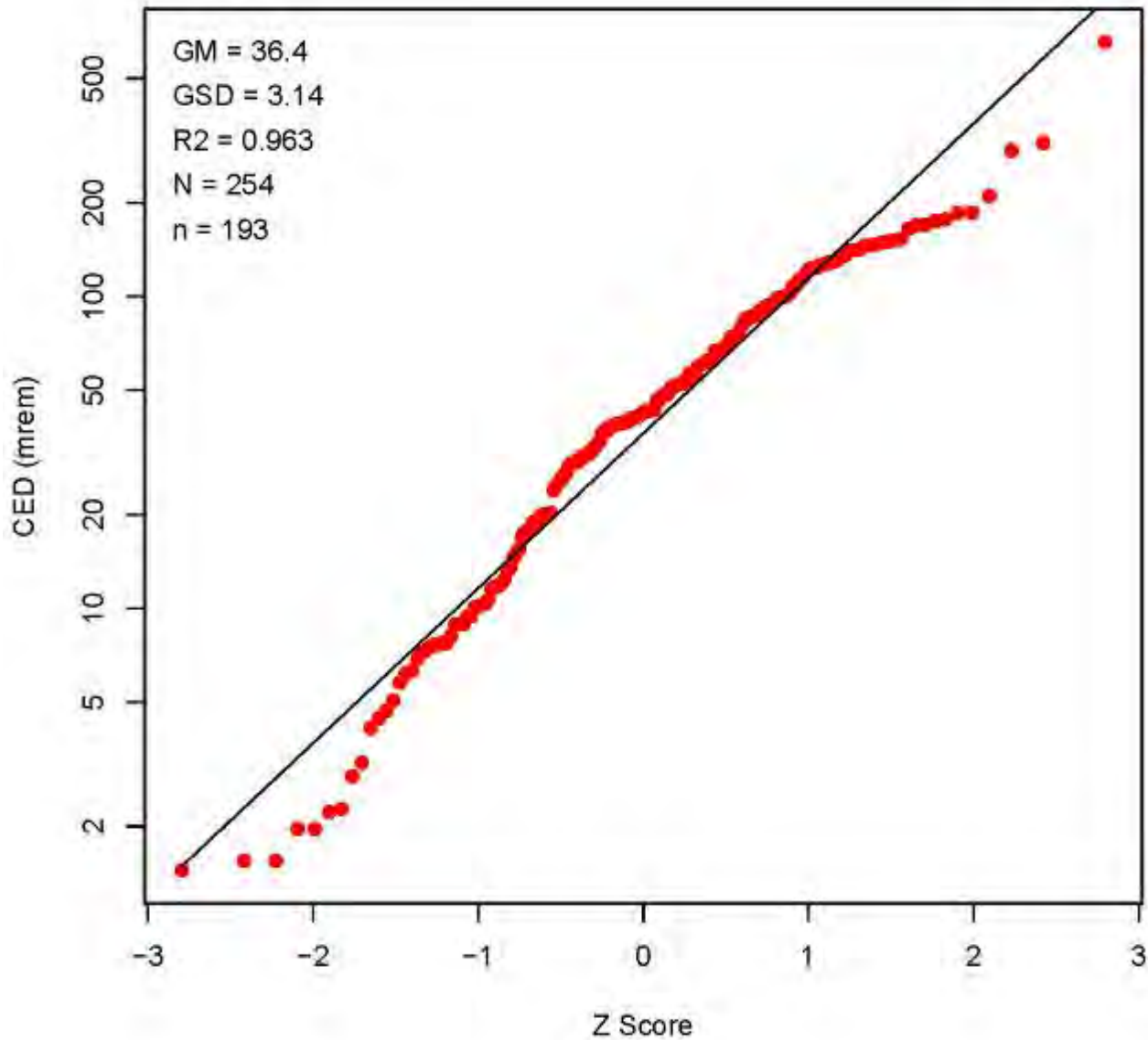


Figure C-59. SRS Non(CTW/Reactor) tritium dose 1968.

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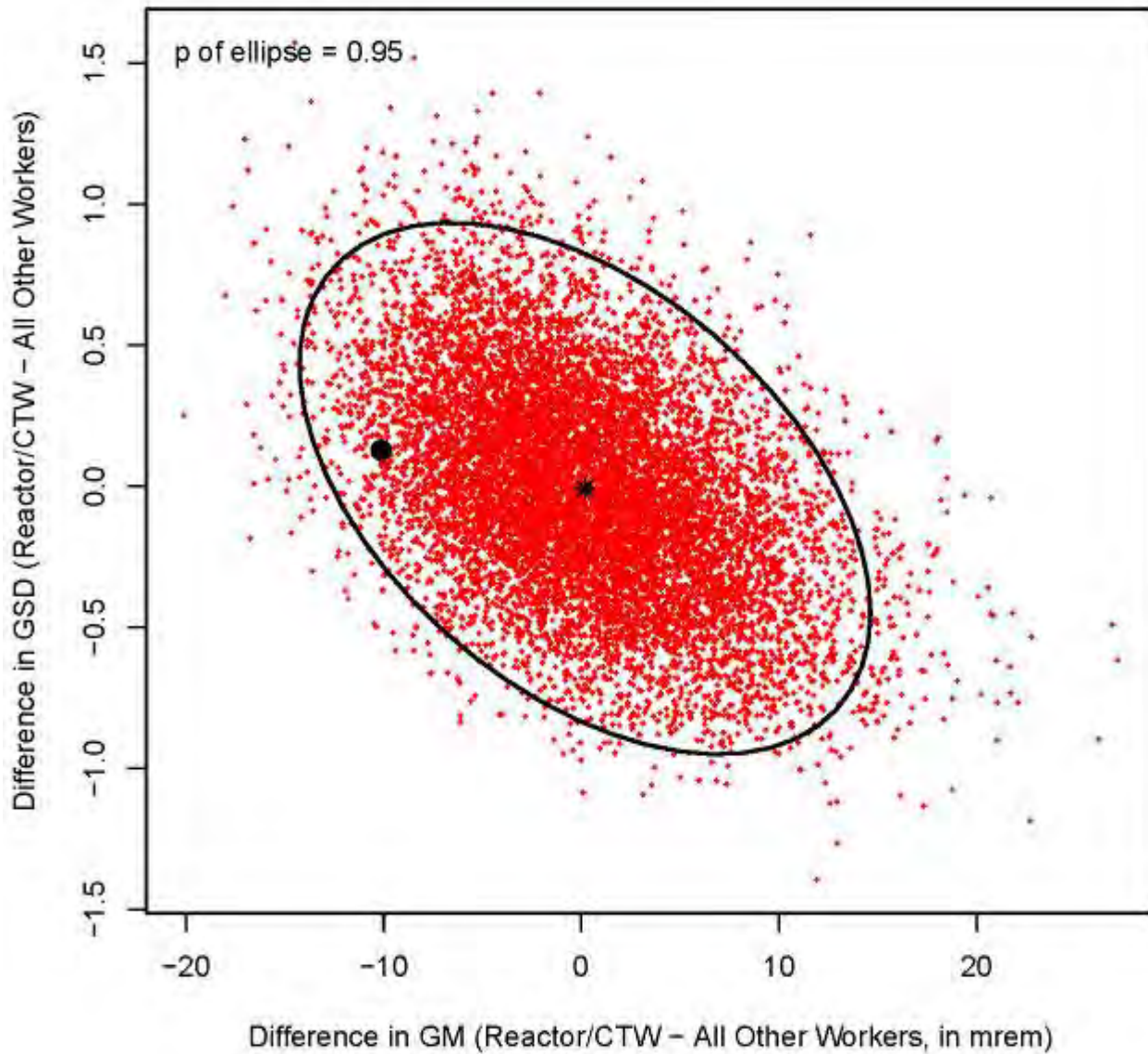


Figure C-60. SRS tritium dose 1968.

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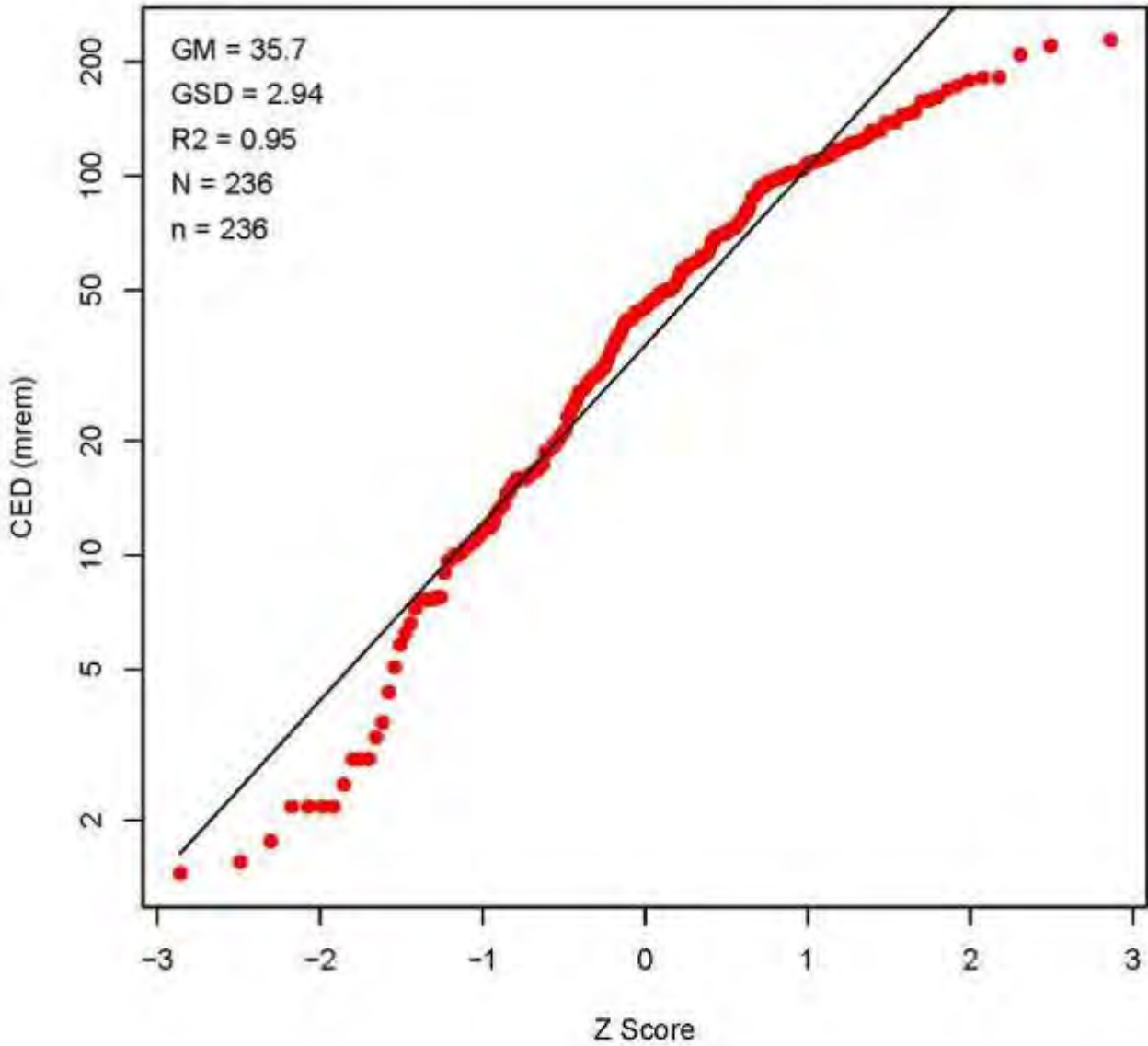


Figure C-61. SRS tritium dose 1969.

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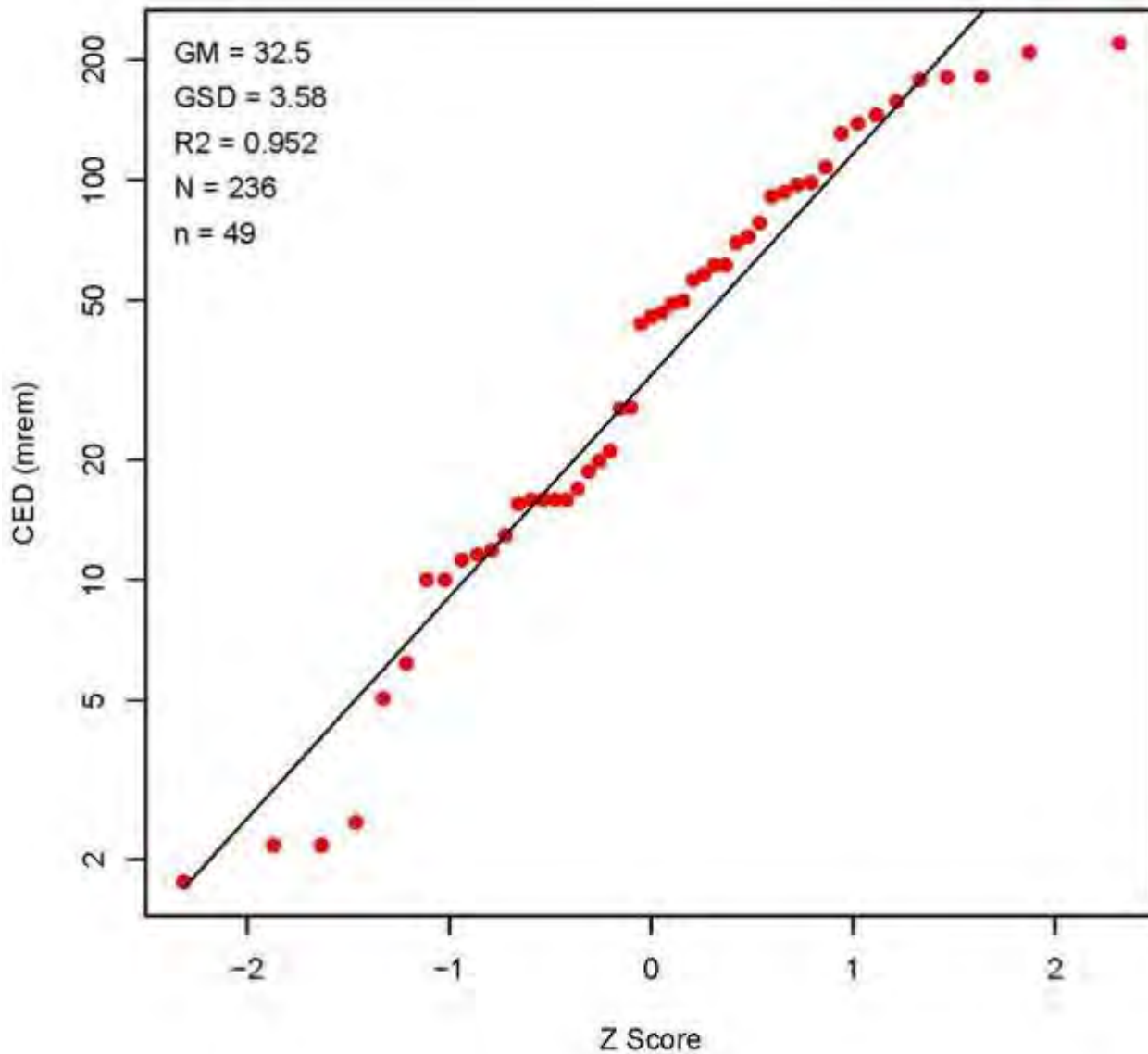


Figure C-62. SRS CTW/Reactor tritium dose 1969.

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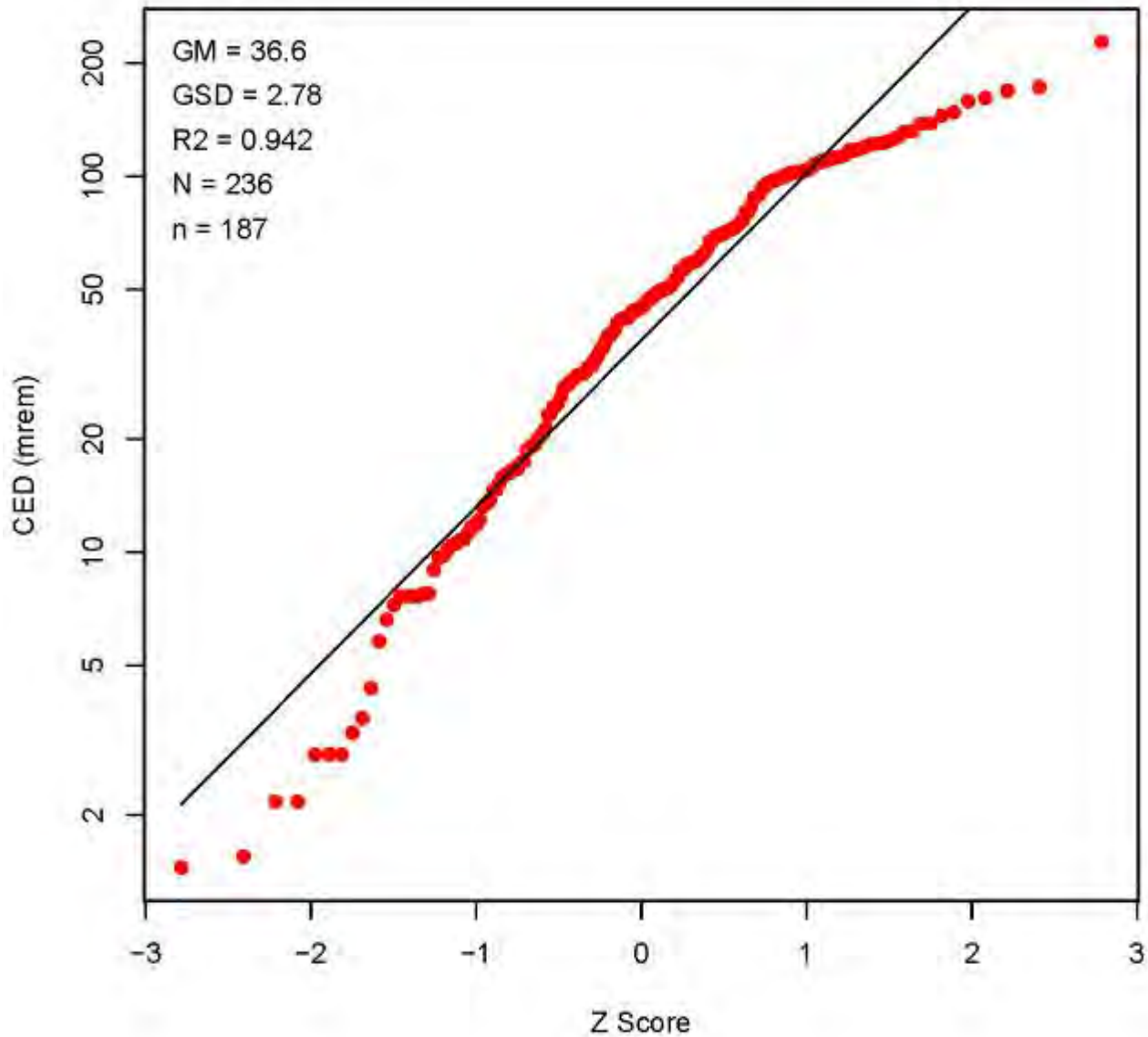


Figure C-63. SRS Non(CTW/Reactor) tritium dose 1969.

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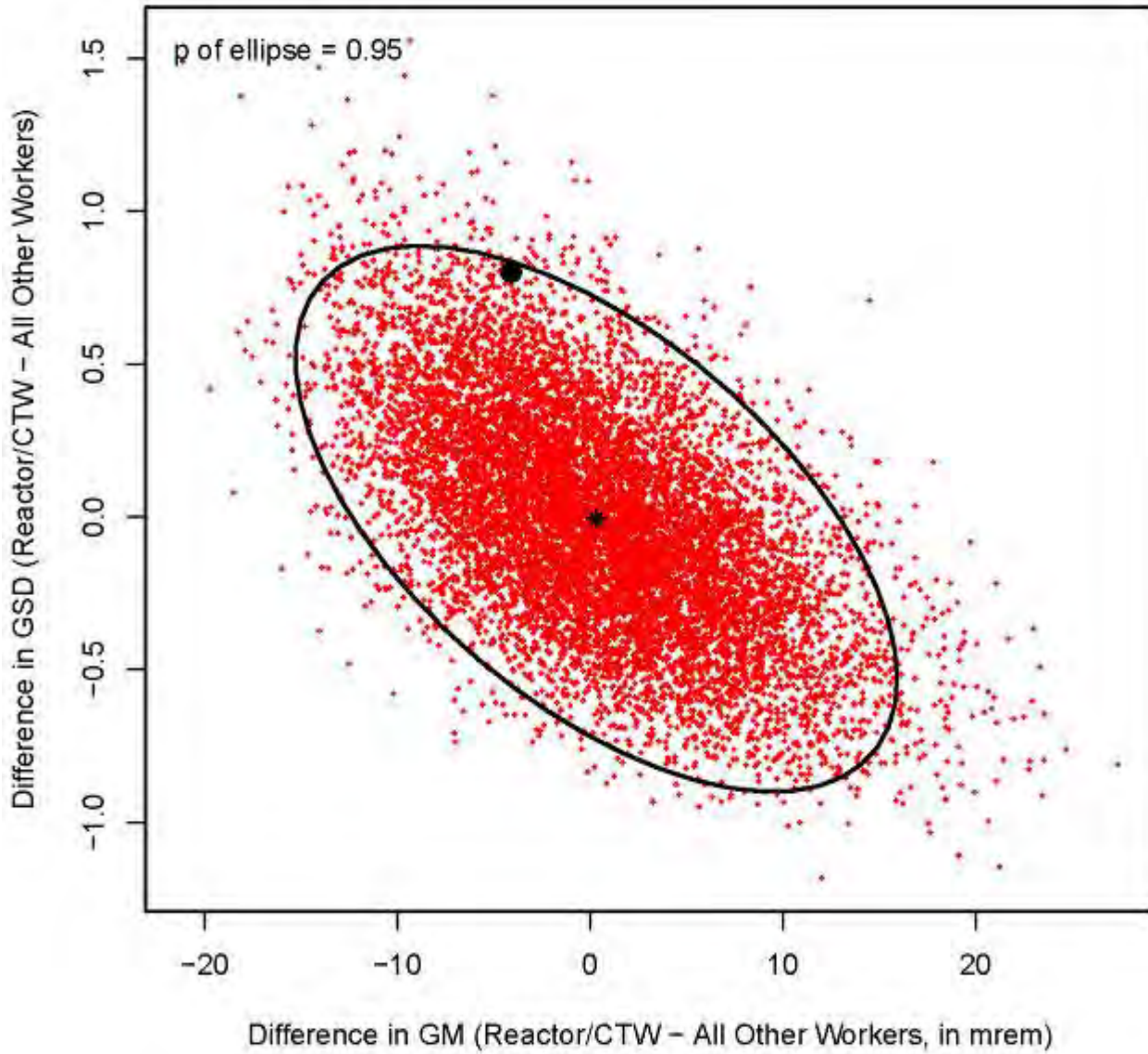


Figure C-64. SRS tritium dose 1969.

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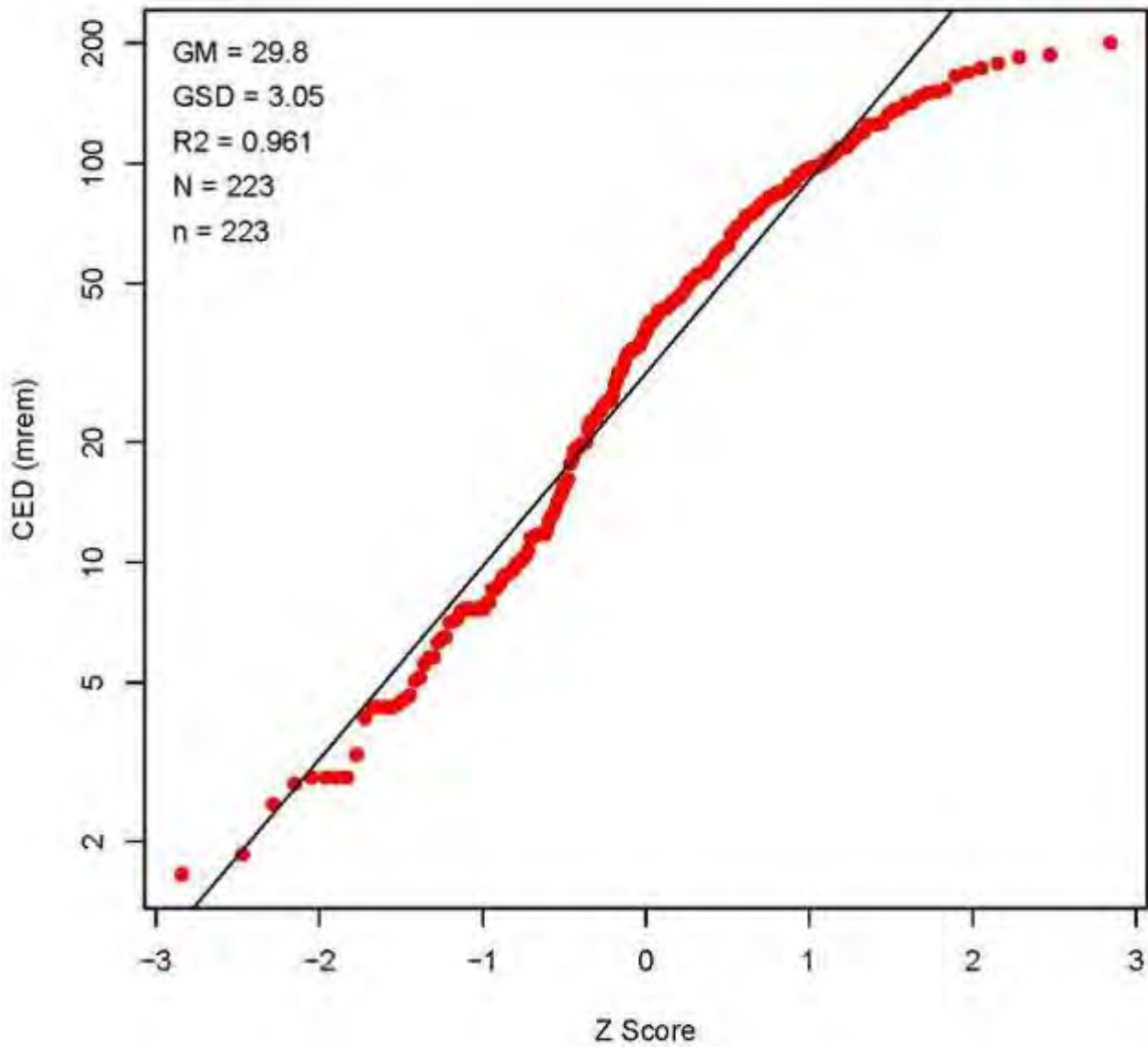


Figure C-65. SRS tritium dose 1970.

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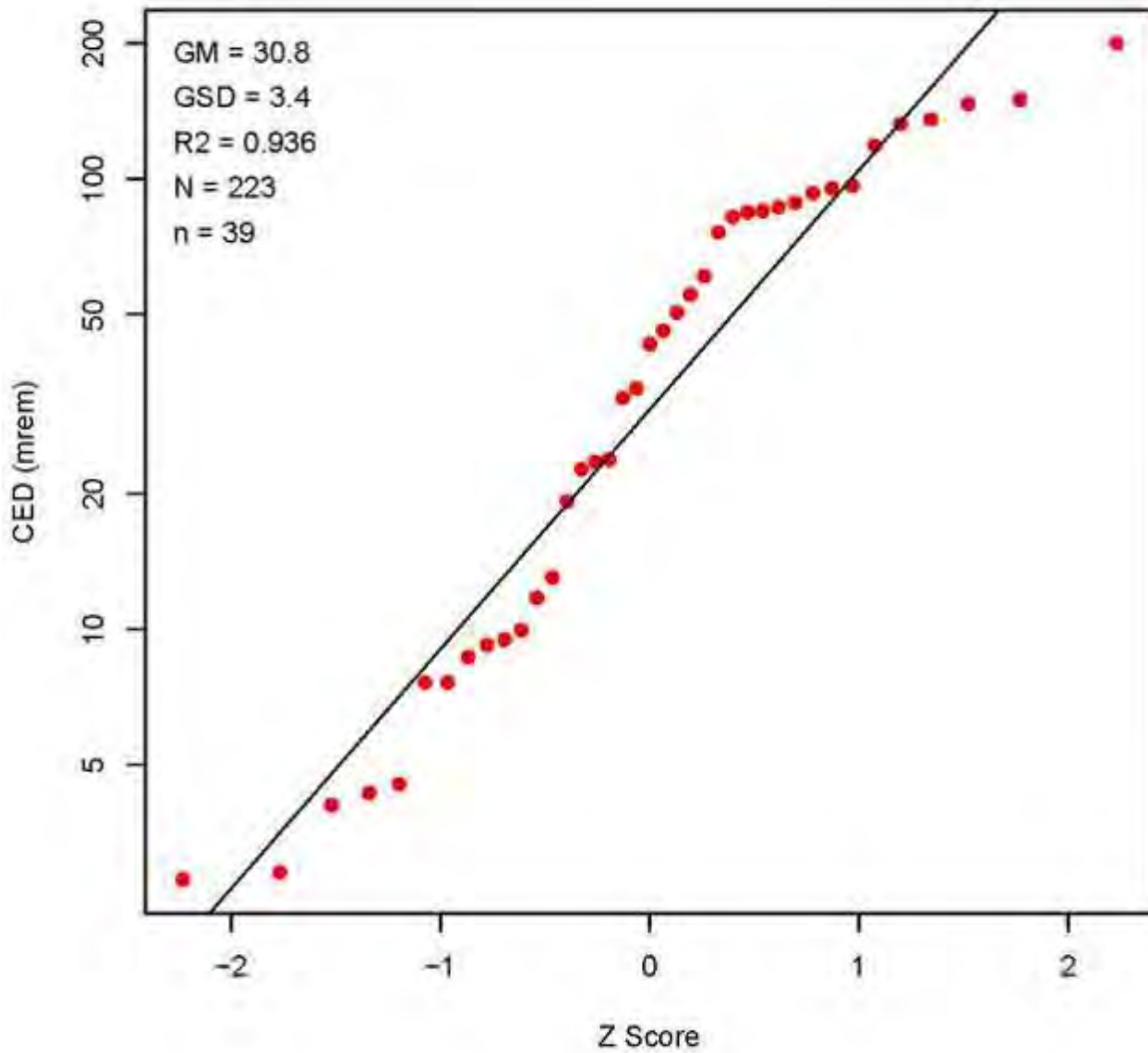


Figure C-66. SRS CTW/Reactor tritium dose 1970.

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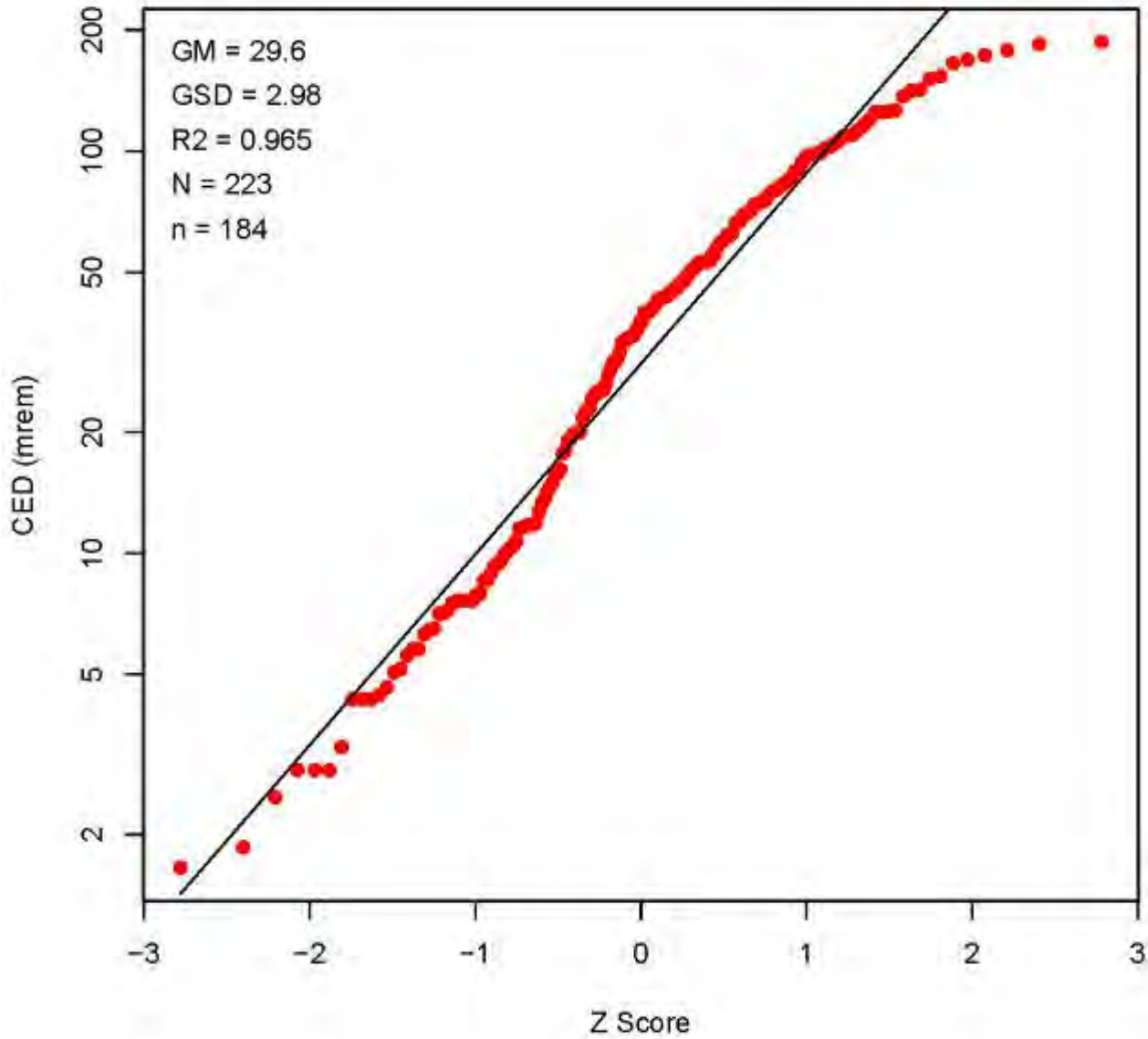


Figure C-67. SRS Non(CTW/Reactor) tritium dose 1970.

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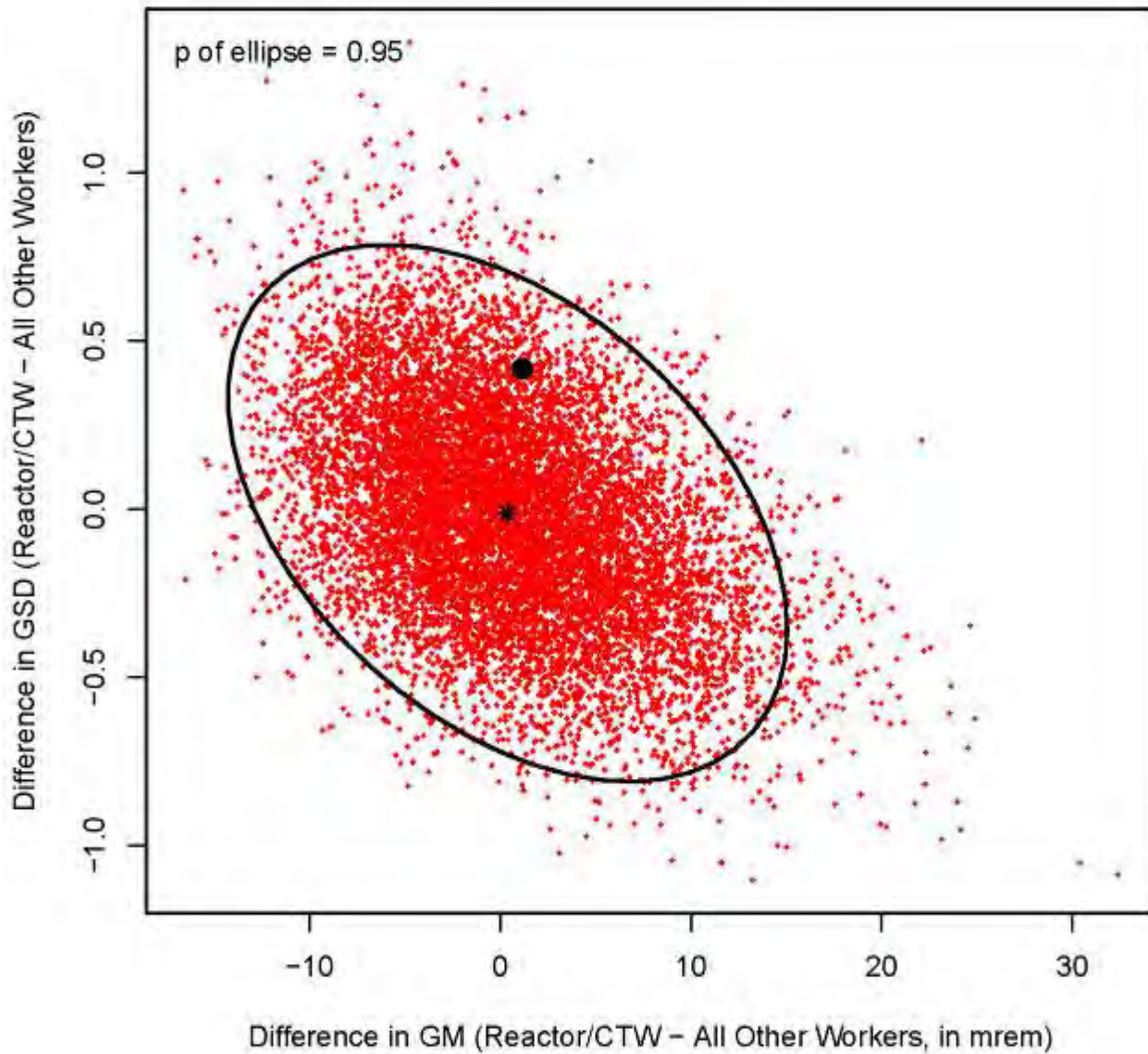


Figure C-68. SRS tritium dose 1970.

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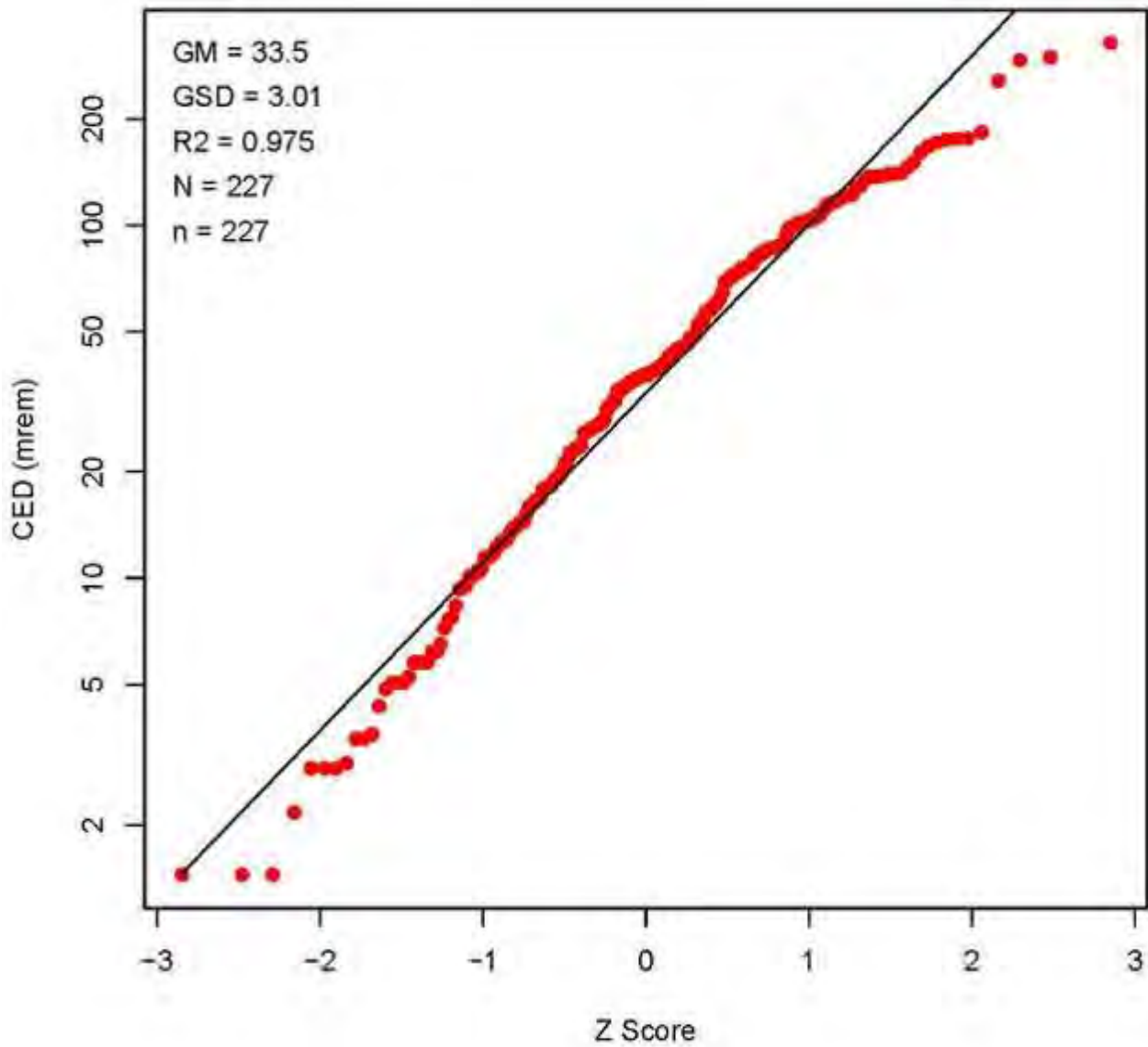


Figure C-69. SRS tritium dose 1971.

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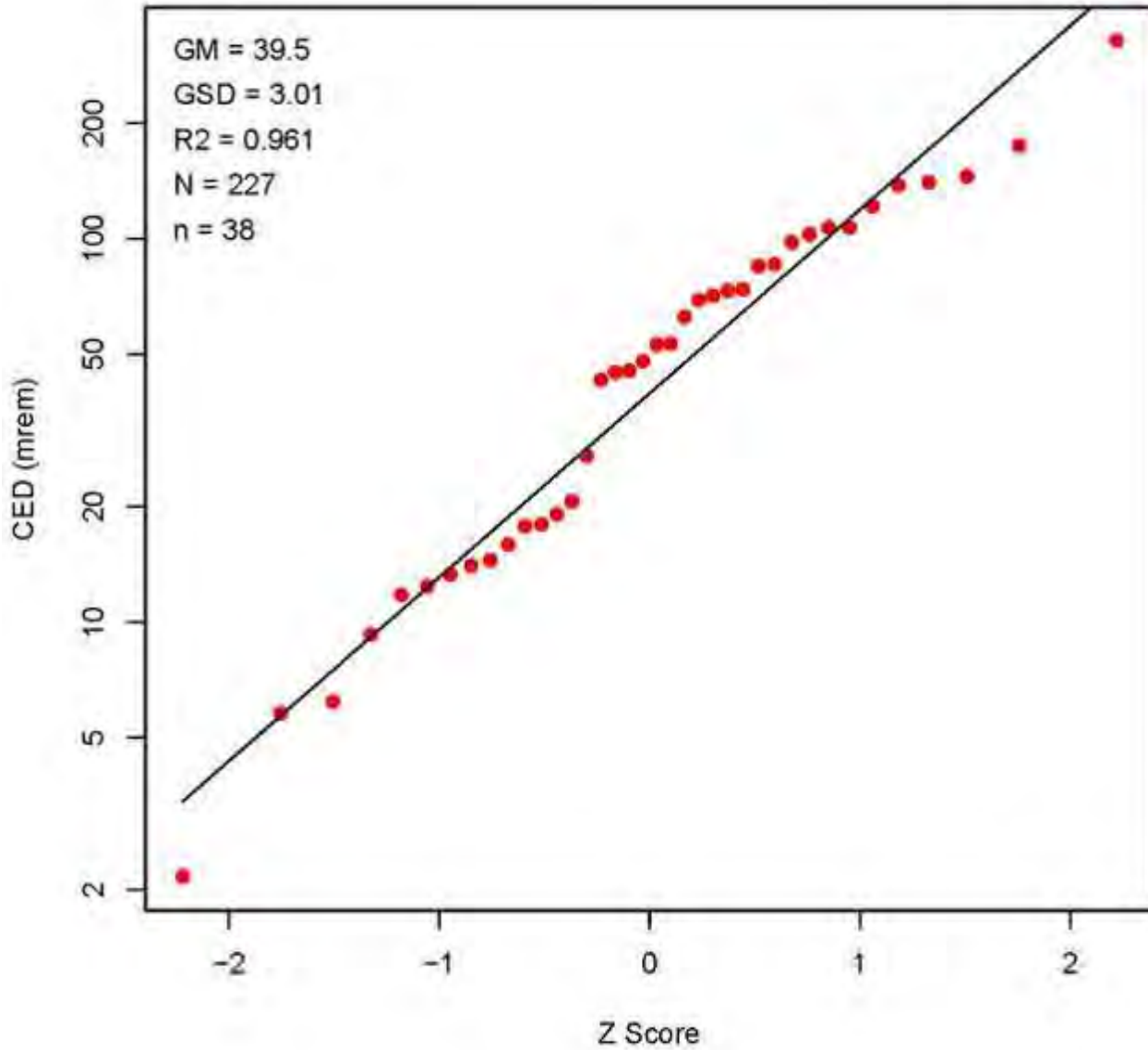


Figure C-70. SRS CTW/Reactor tritium dose 1971.

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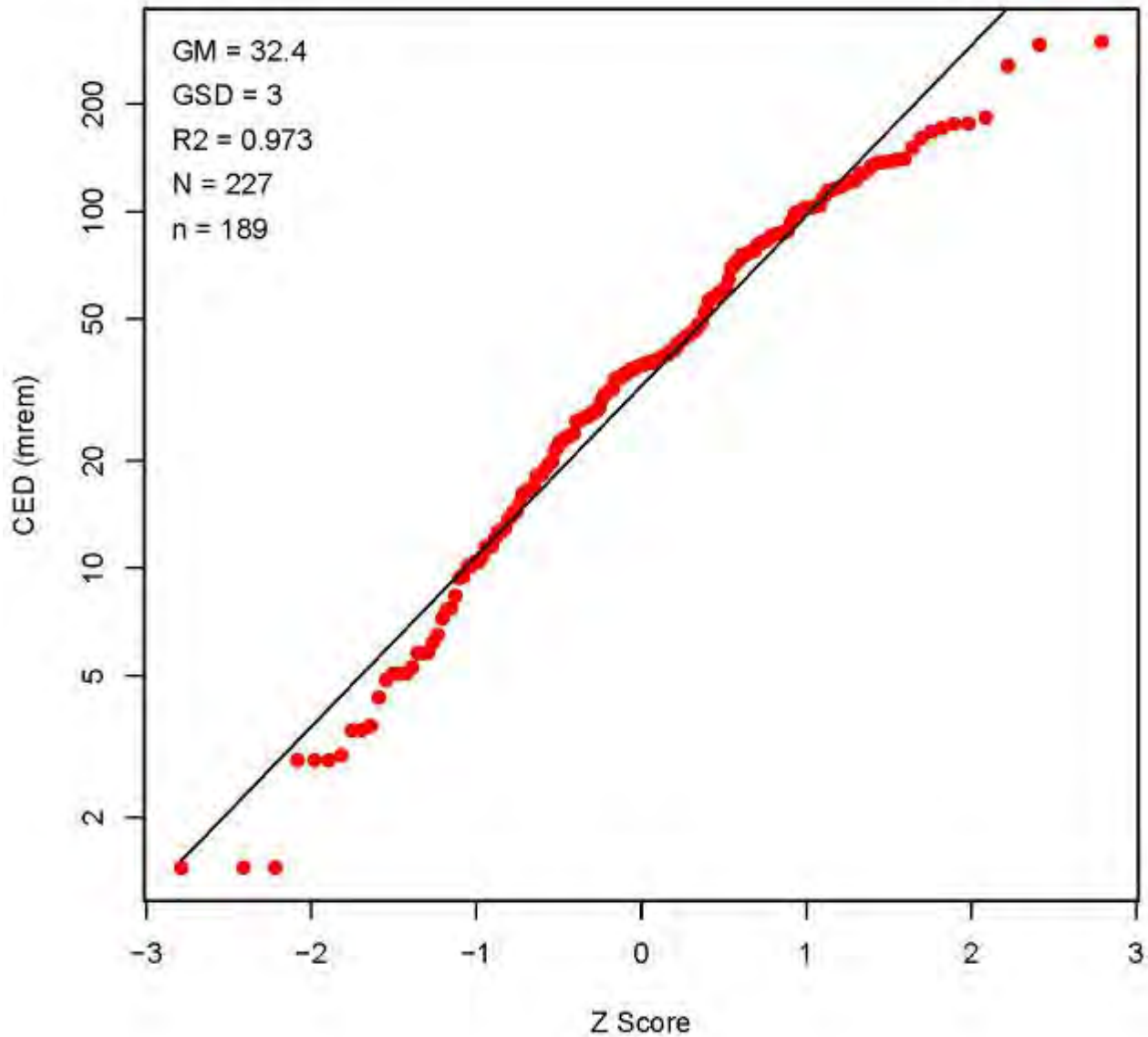


Figure C-71. SRS Non(CTW/Reactor) tritium dose 1971.

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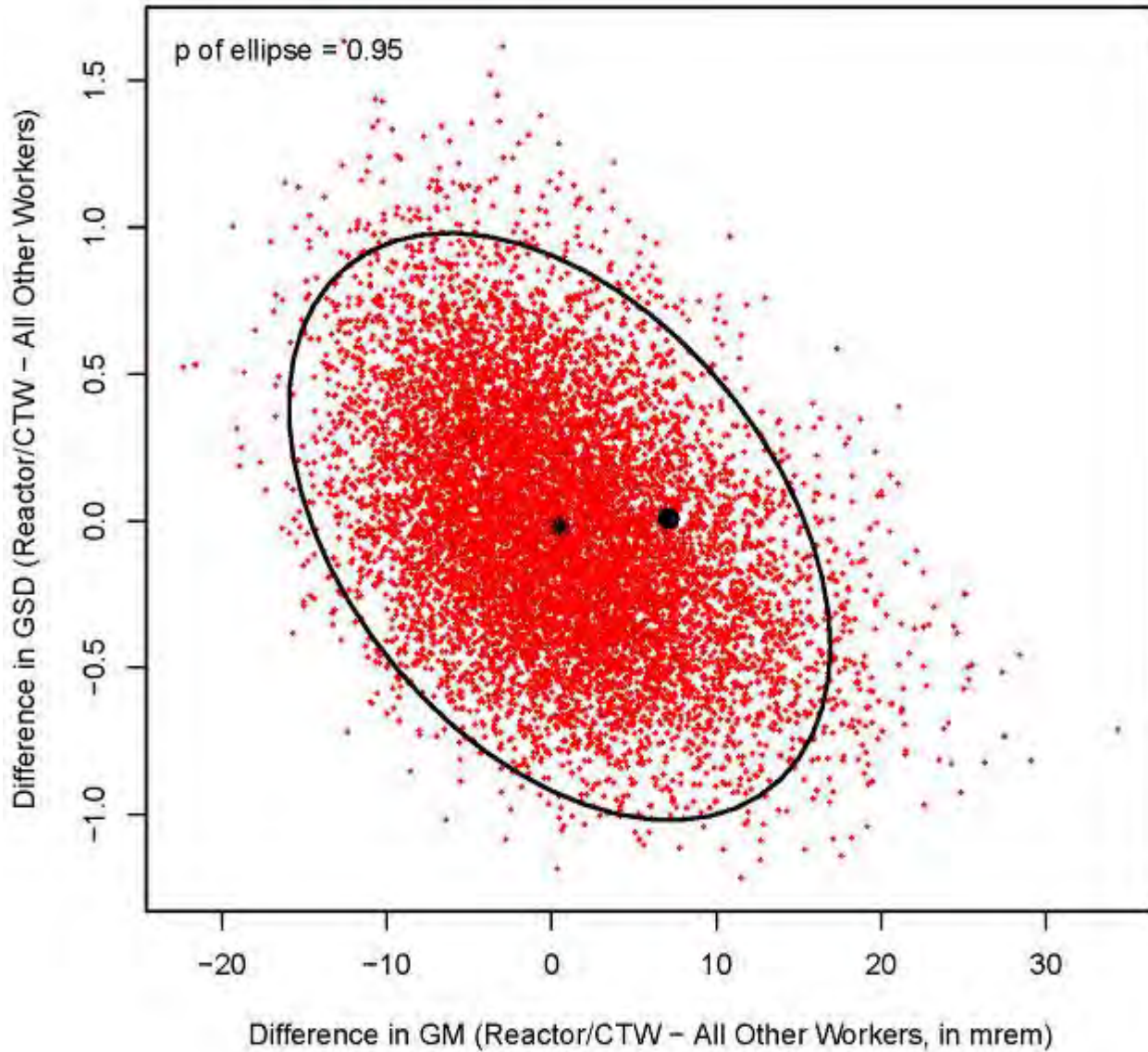


Figure C-72. SRS tritium dose 1971.

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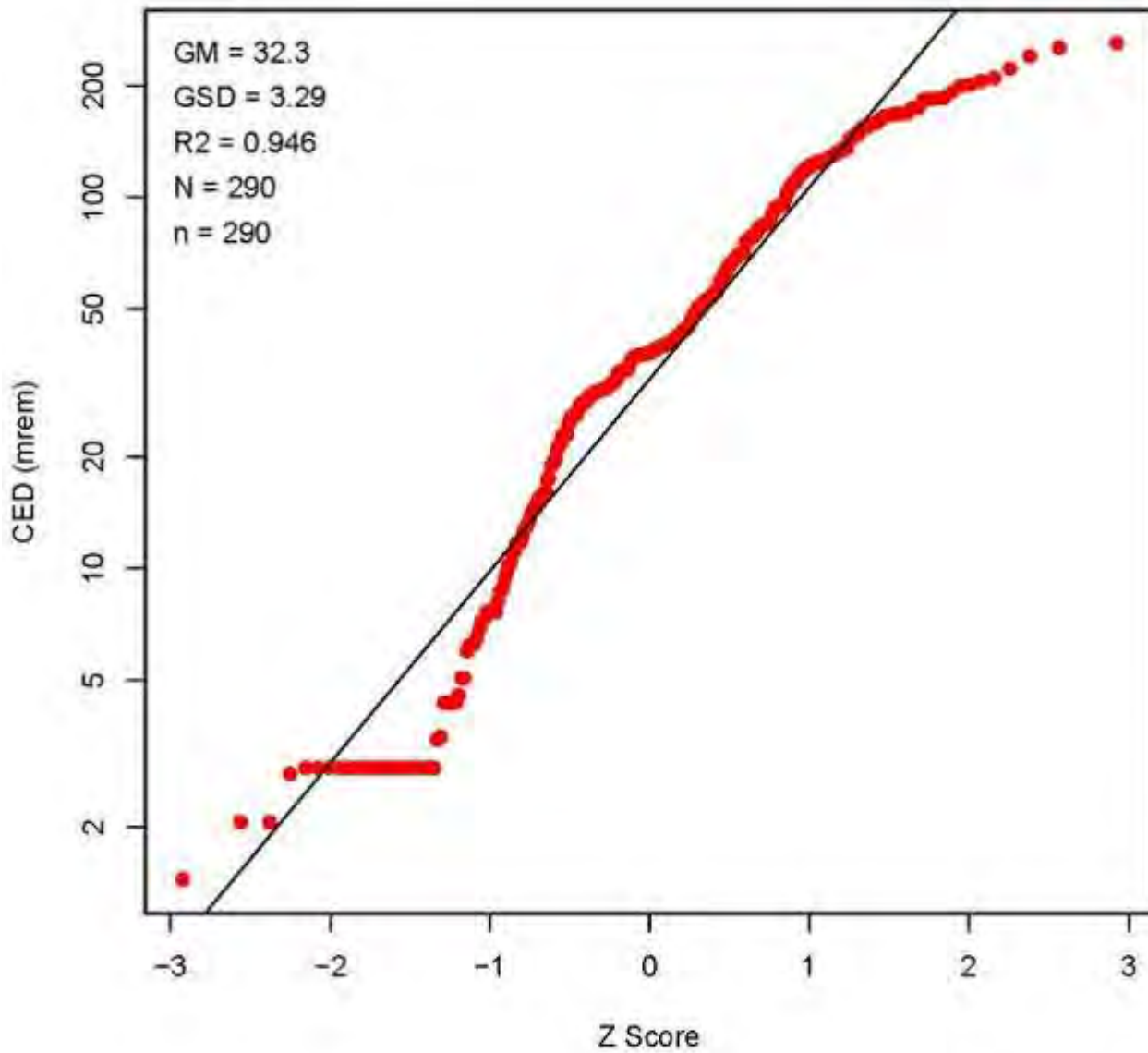


Figure C-73. SRS tritium dose 1972.

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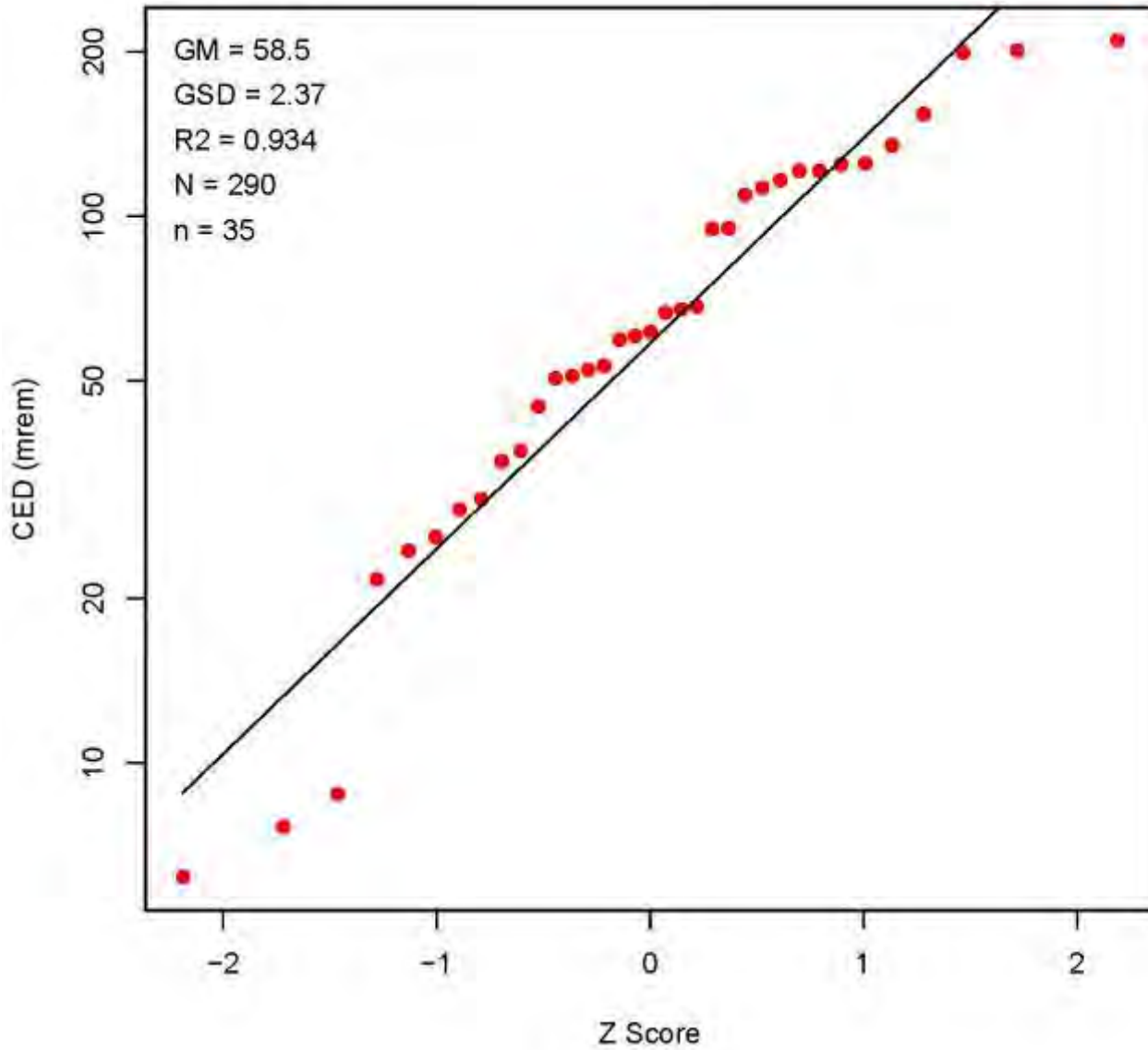


Figure C-74. SRS CTW/Reactor tritium dose 1972.

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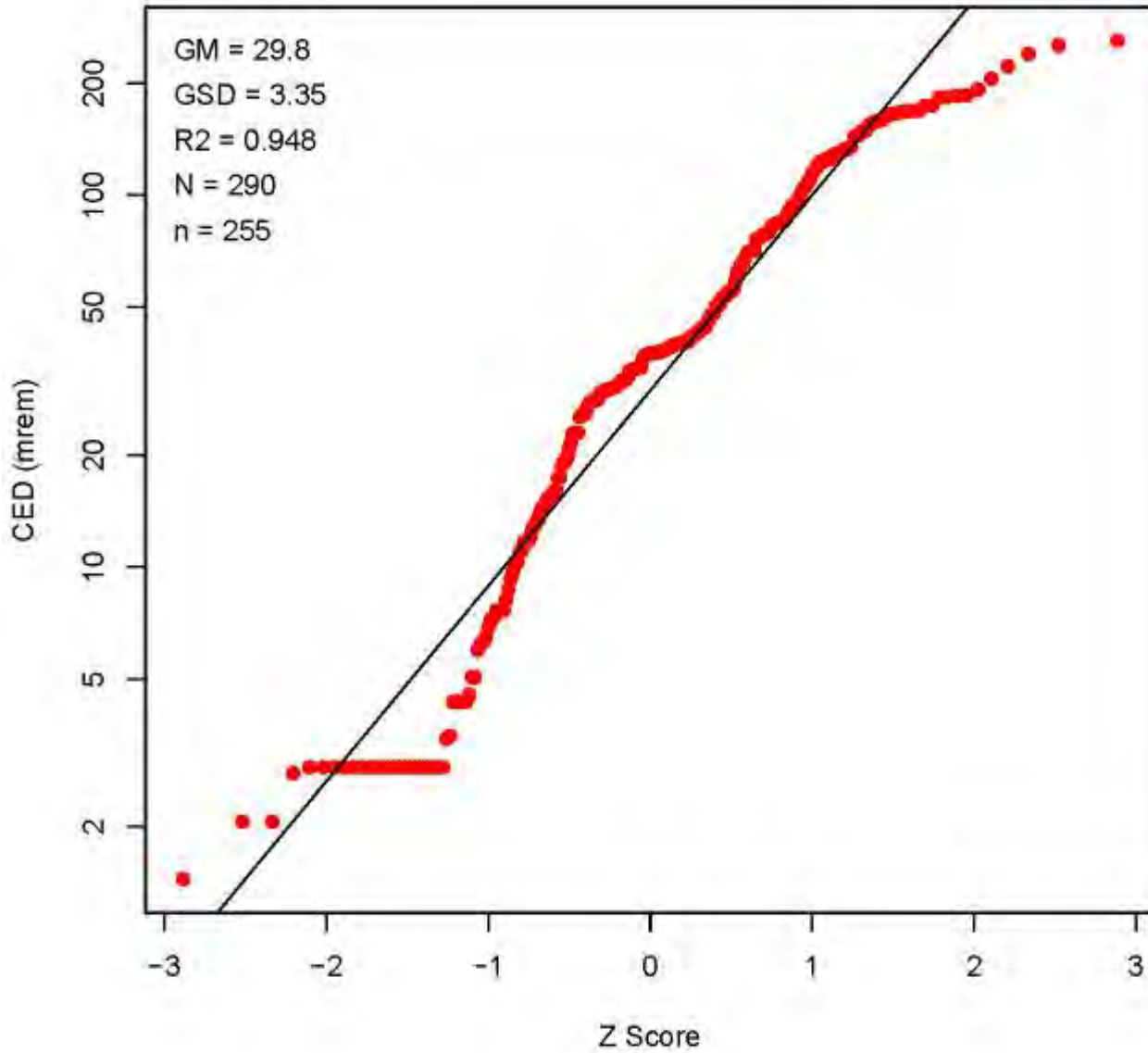


Figure C-75. SRS Non(CTW/Reactor) tritium dose 1972.

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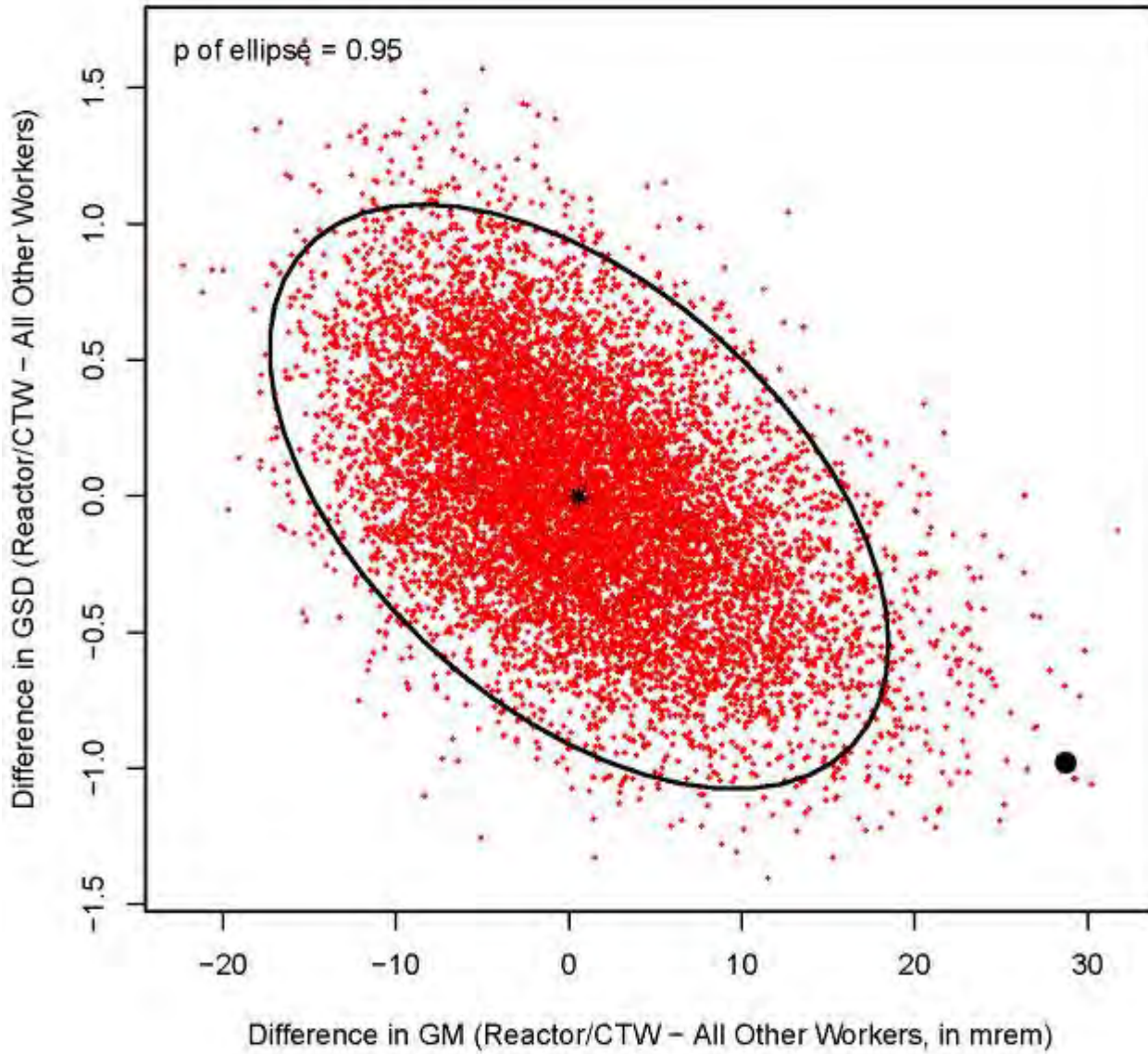


Figure C-76. SRS tritium dose 1972.

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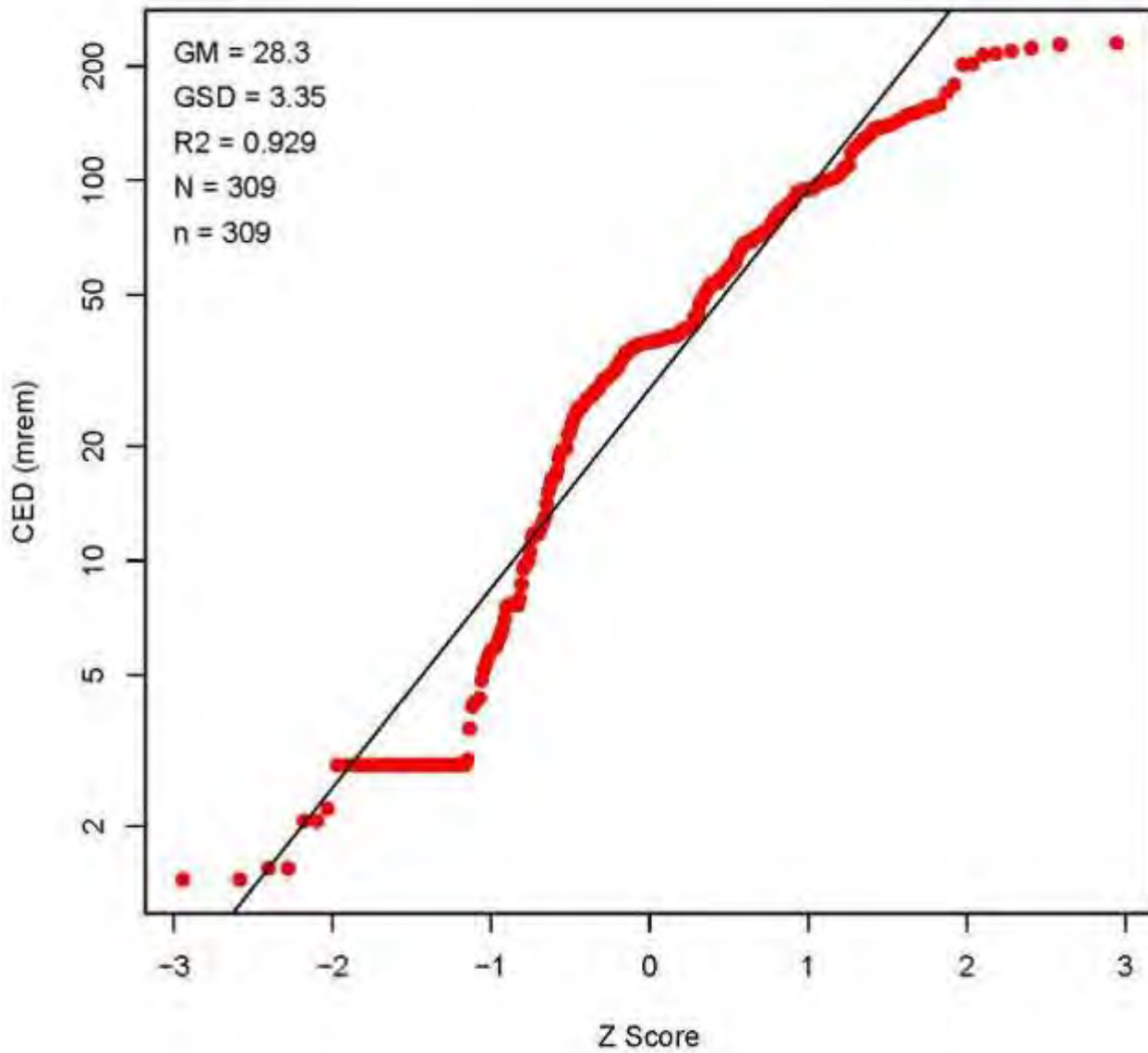


Figure C-77. SRS tritium dose 1973.

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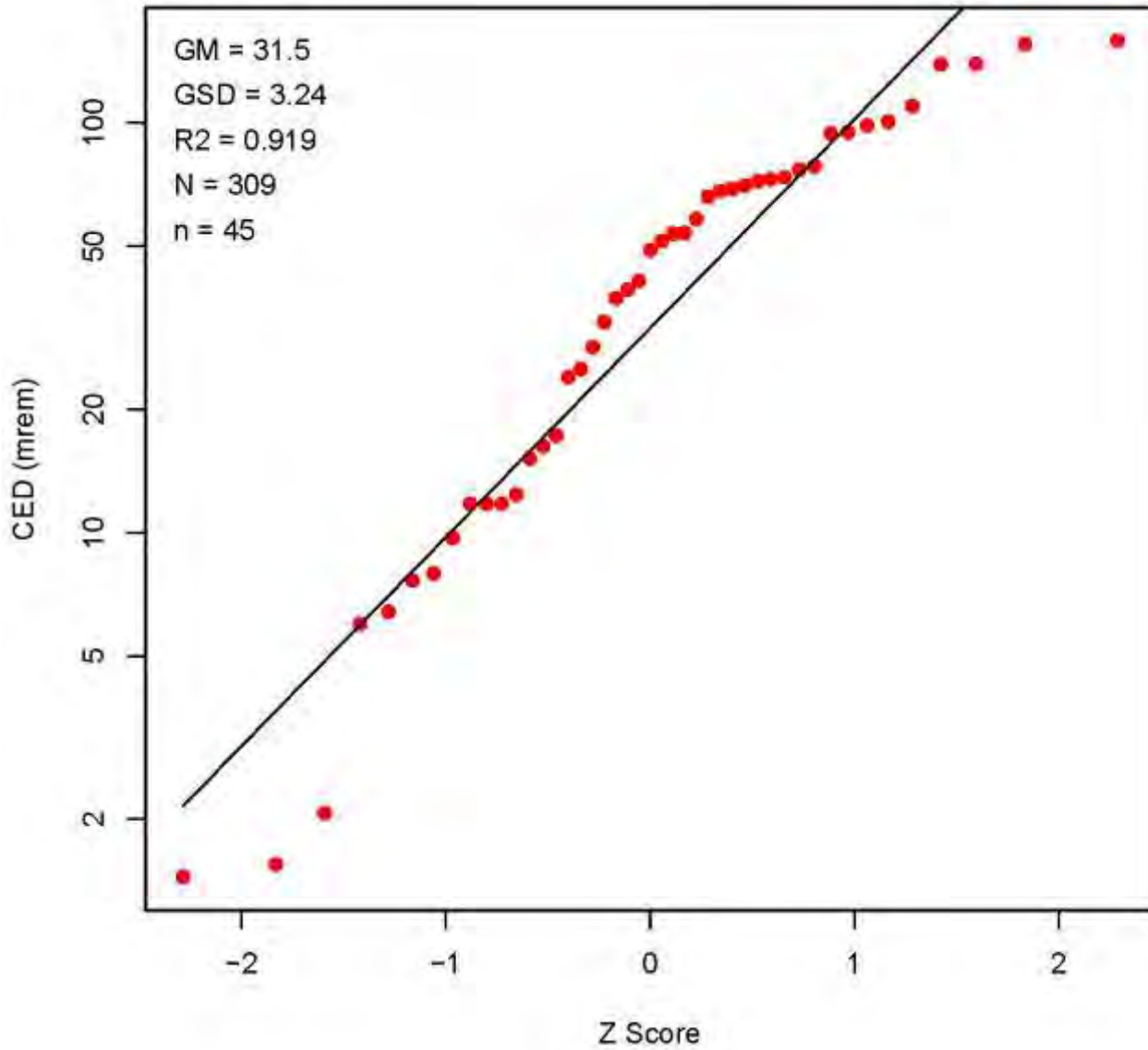


Figure C-78. SRS CTW/Reactor tritium dose 1973.

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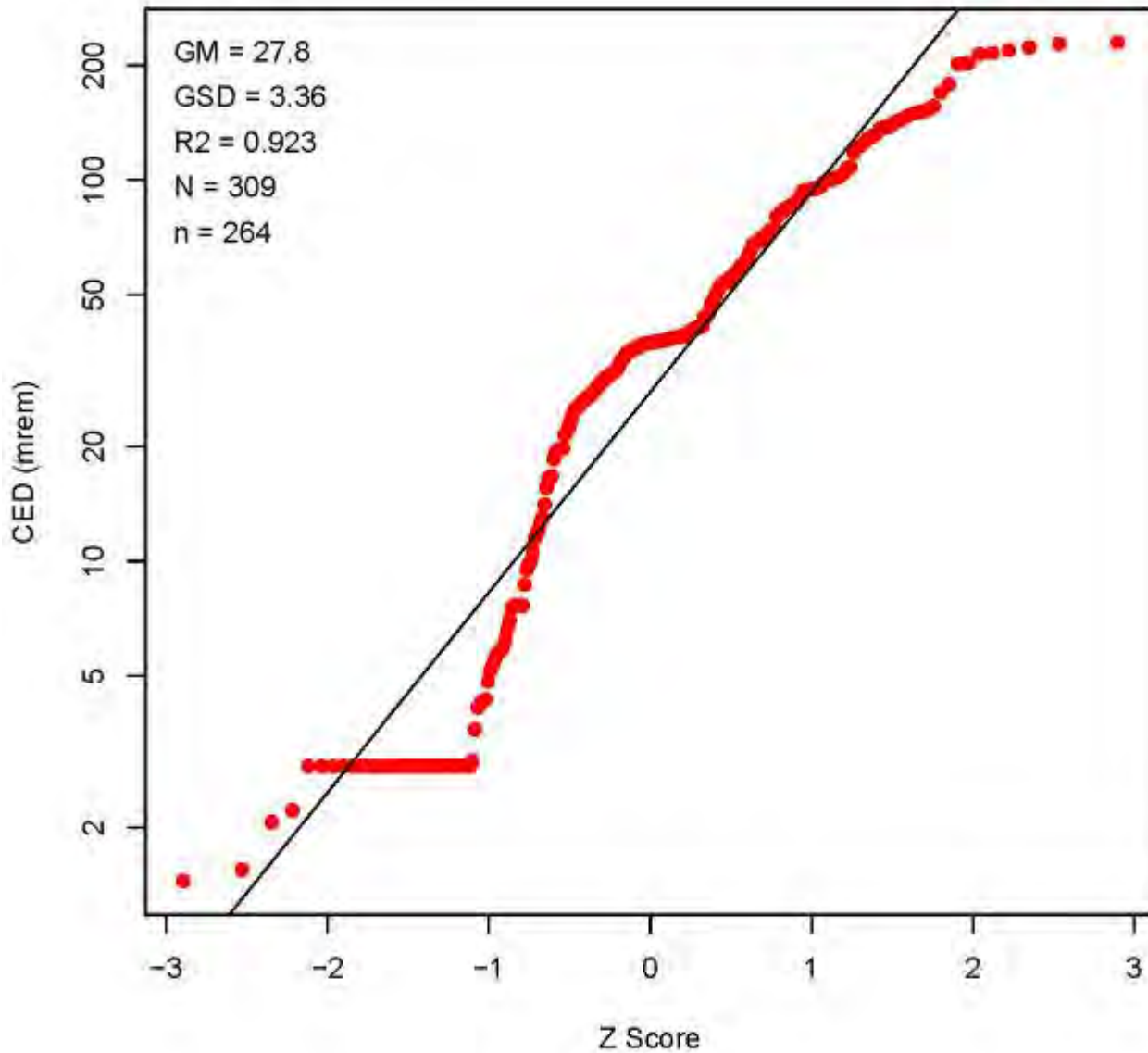


Figure C-79. SRS Non(CTW/Reactor) tritium dose 1973.

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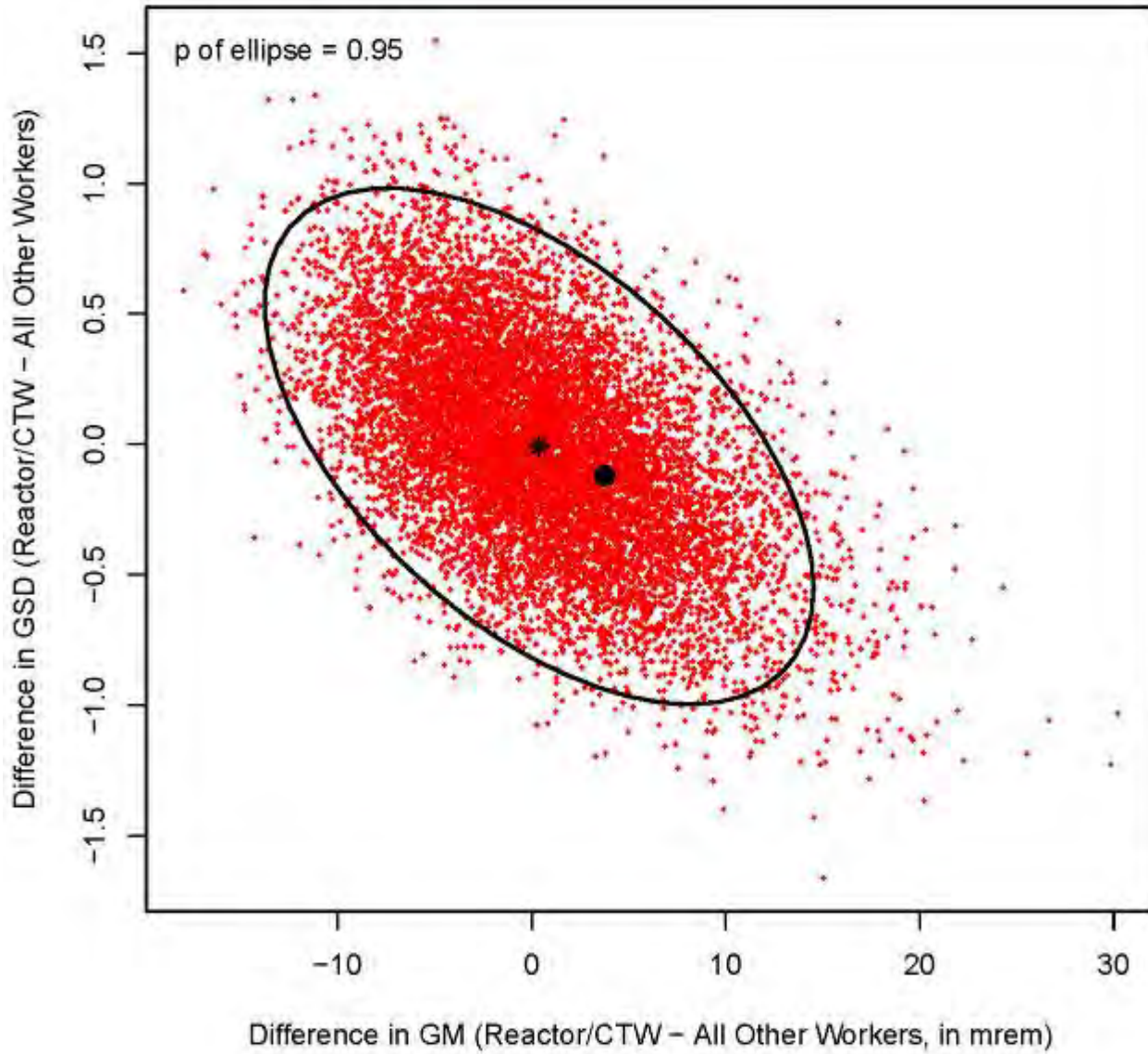


Figure C-80. SRS tritium dose 1973.

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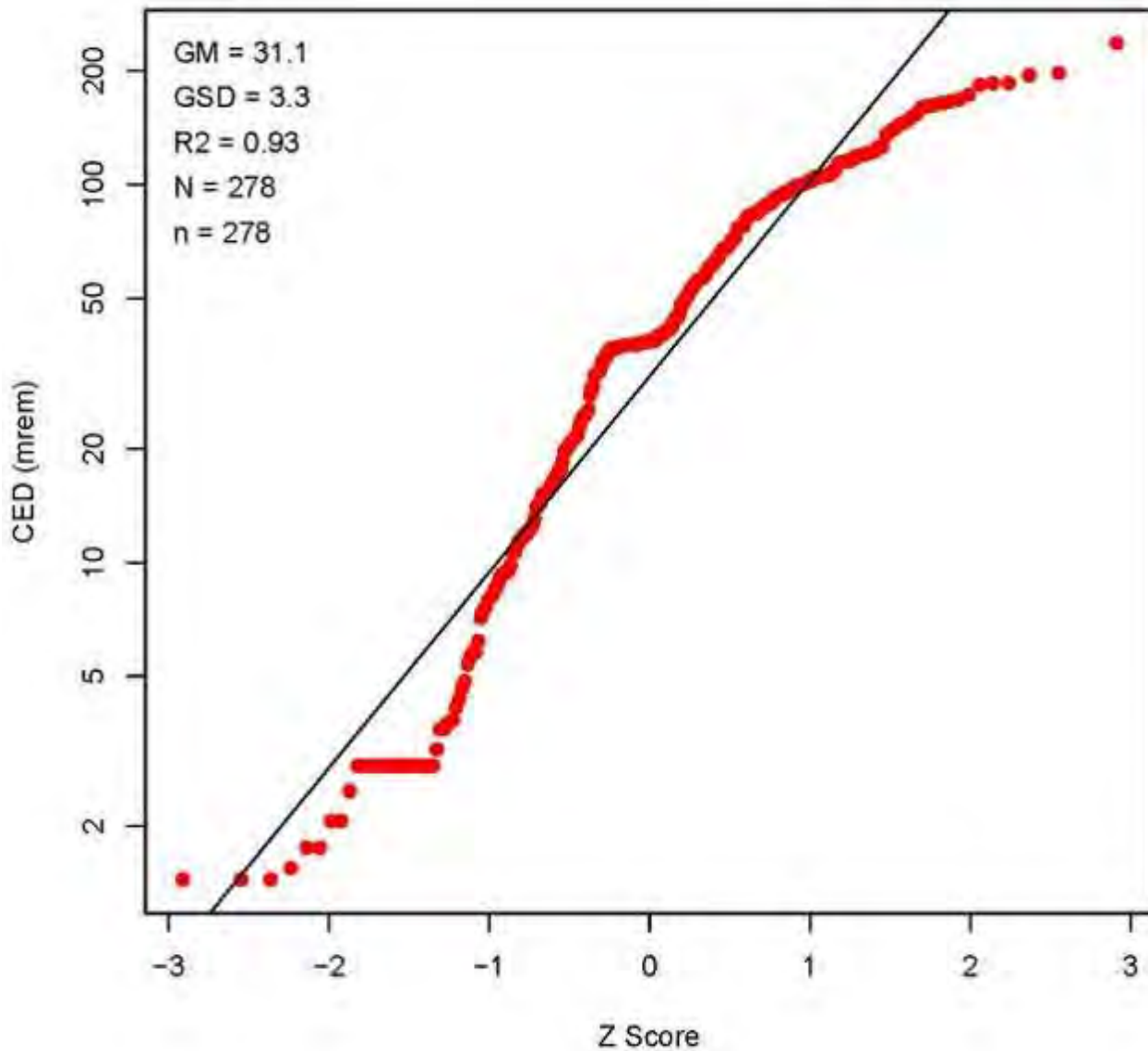


Figure C-81. SRS tritium dose 1974.

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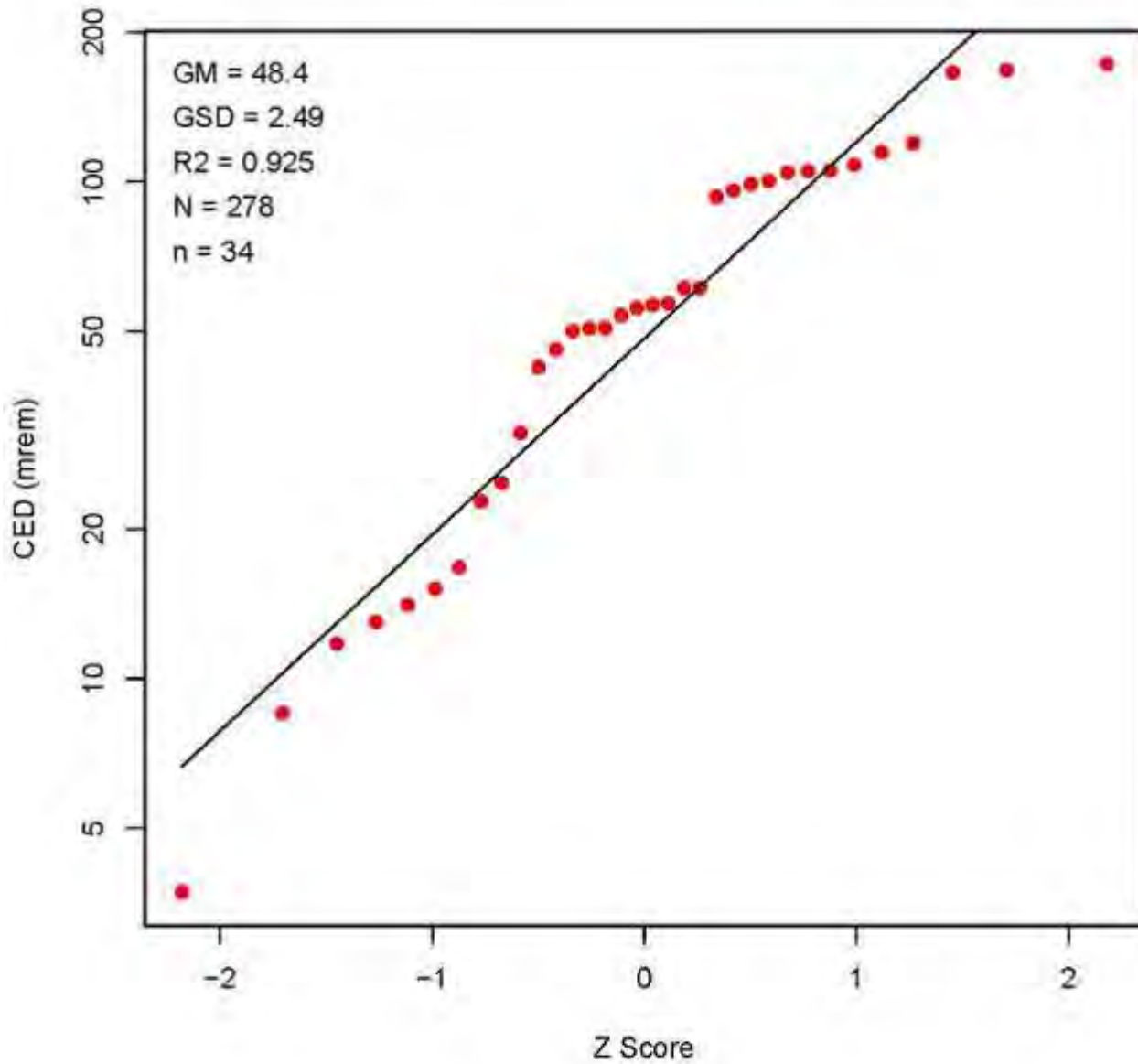


Figure C-82. SRS CTW/Reactor tritium dose 1974.

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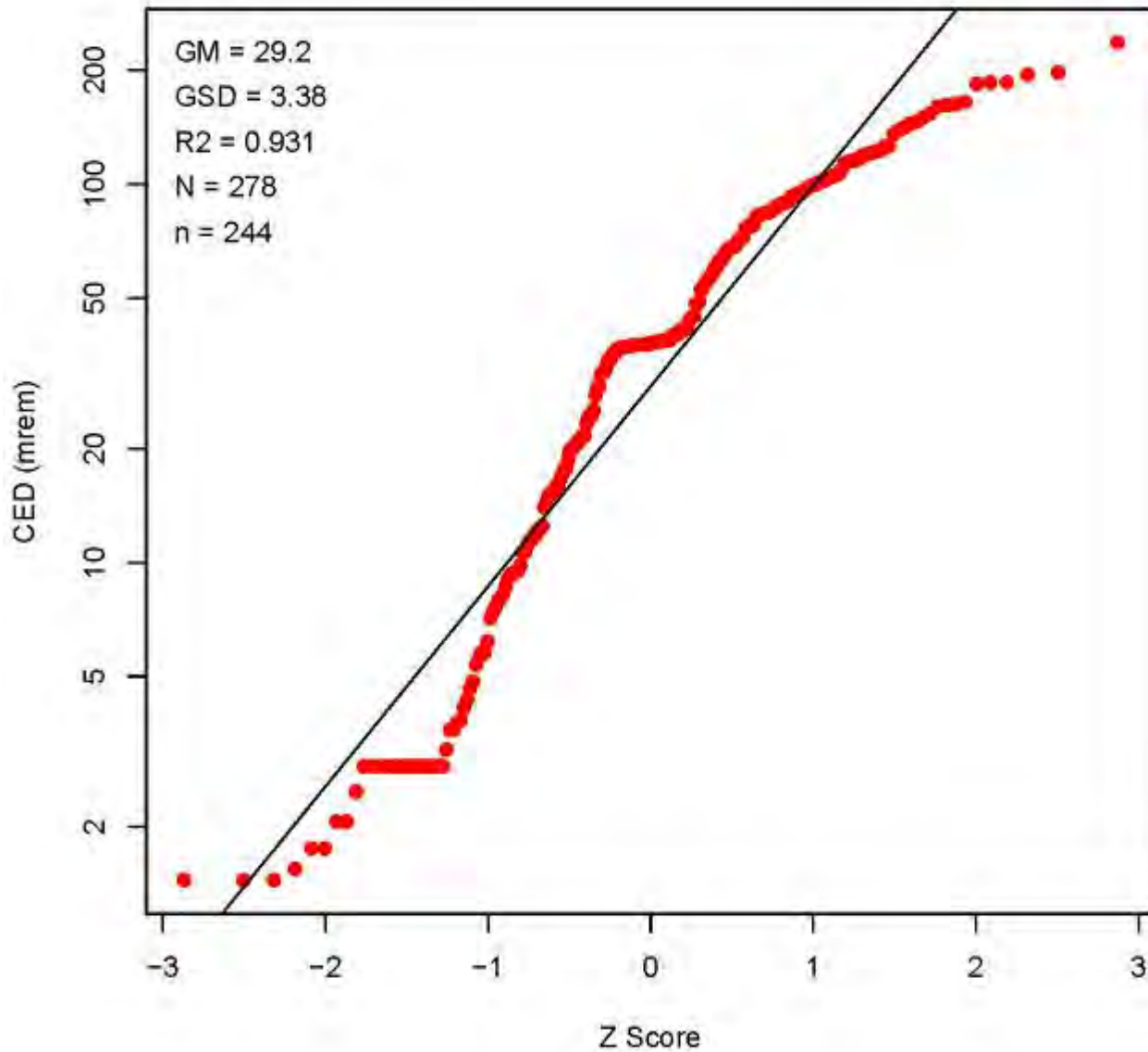


Figure C-83. SRS Non(CTW/Reactor) tritium dose 1974.

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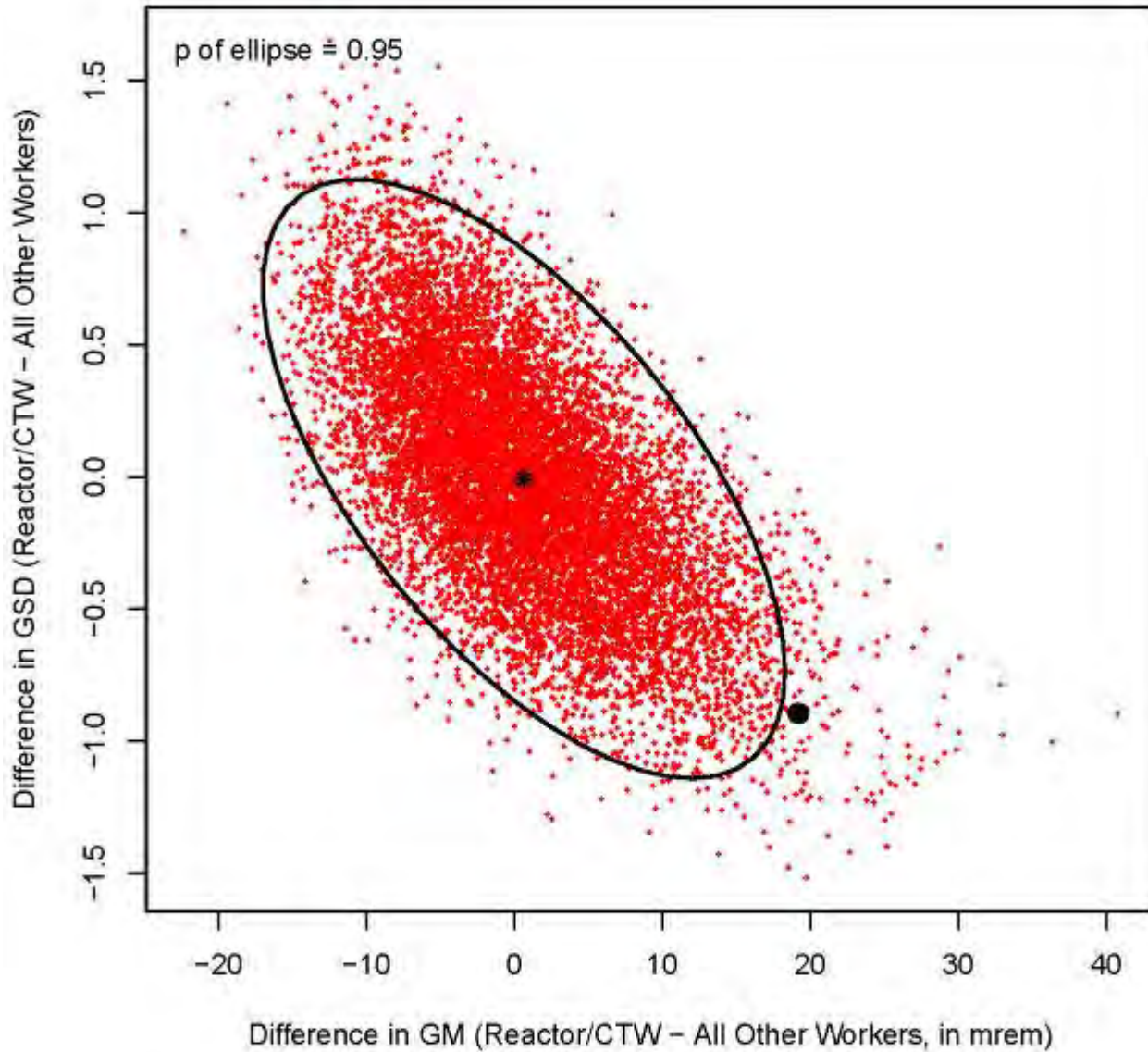


Figure C-84. SRS tritium dose 1974.

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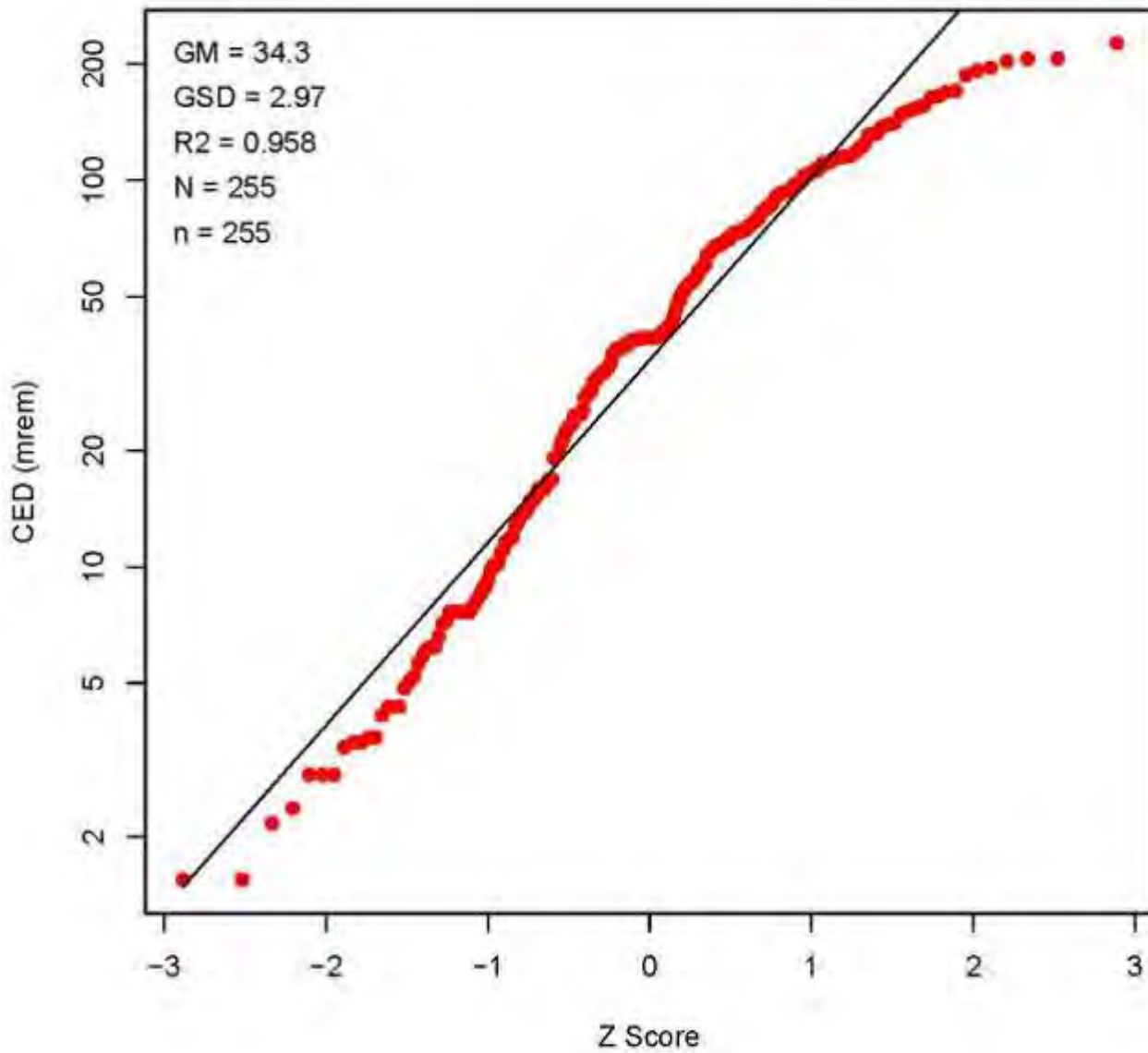


Figure C-85. SRS tritium dose 1975.

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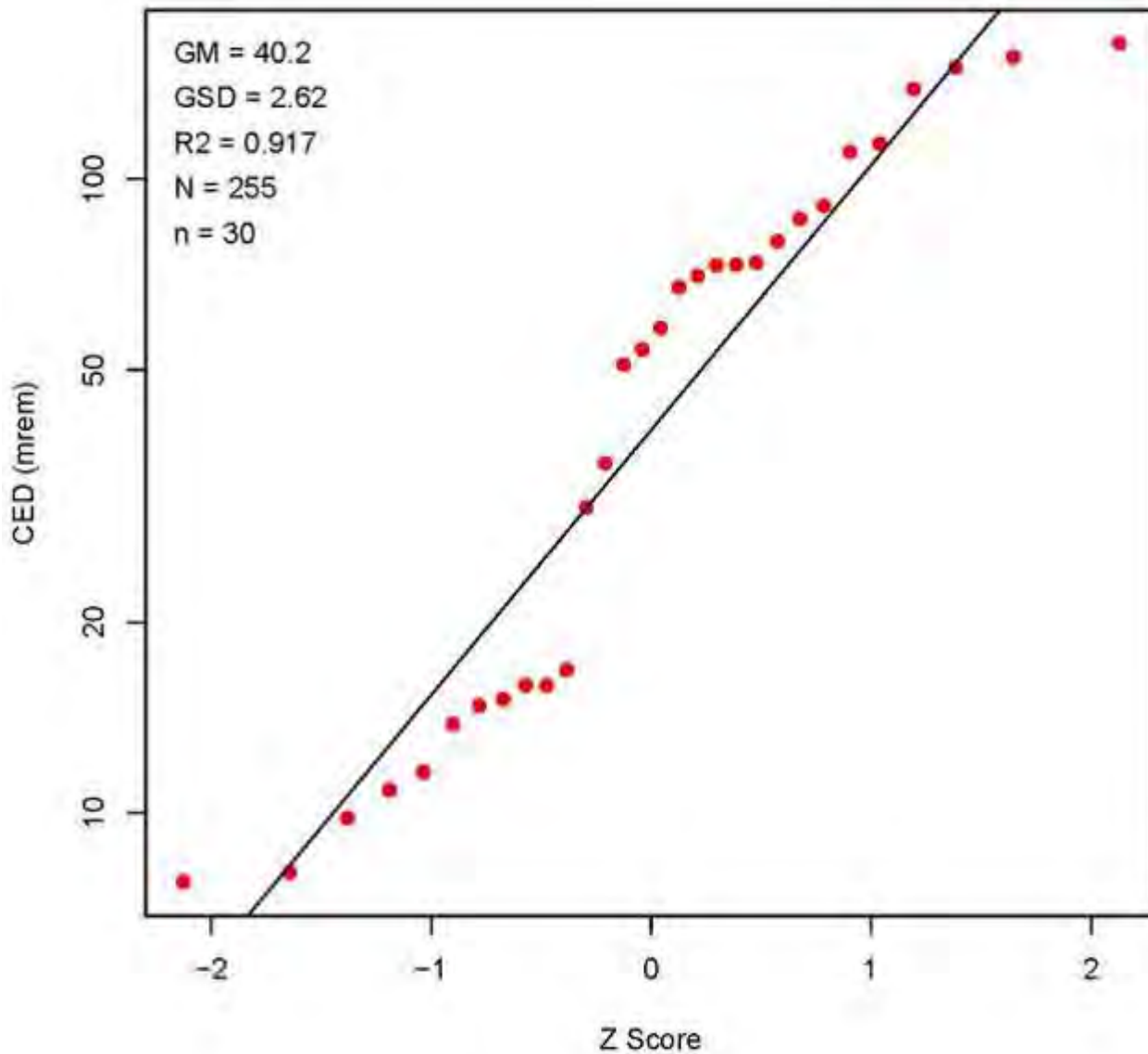


Figure C-86. SRS CTW/Reactor tritium dose 1975.

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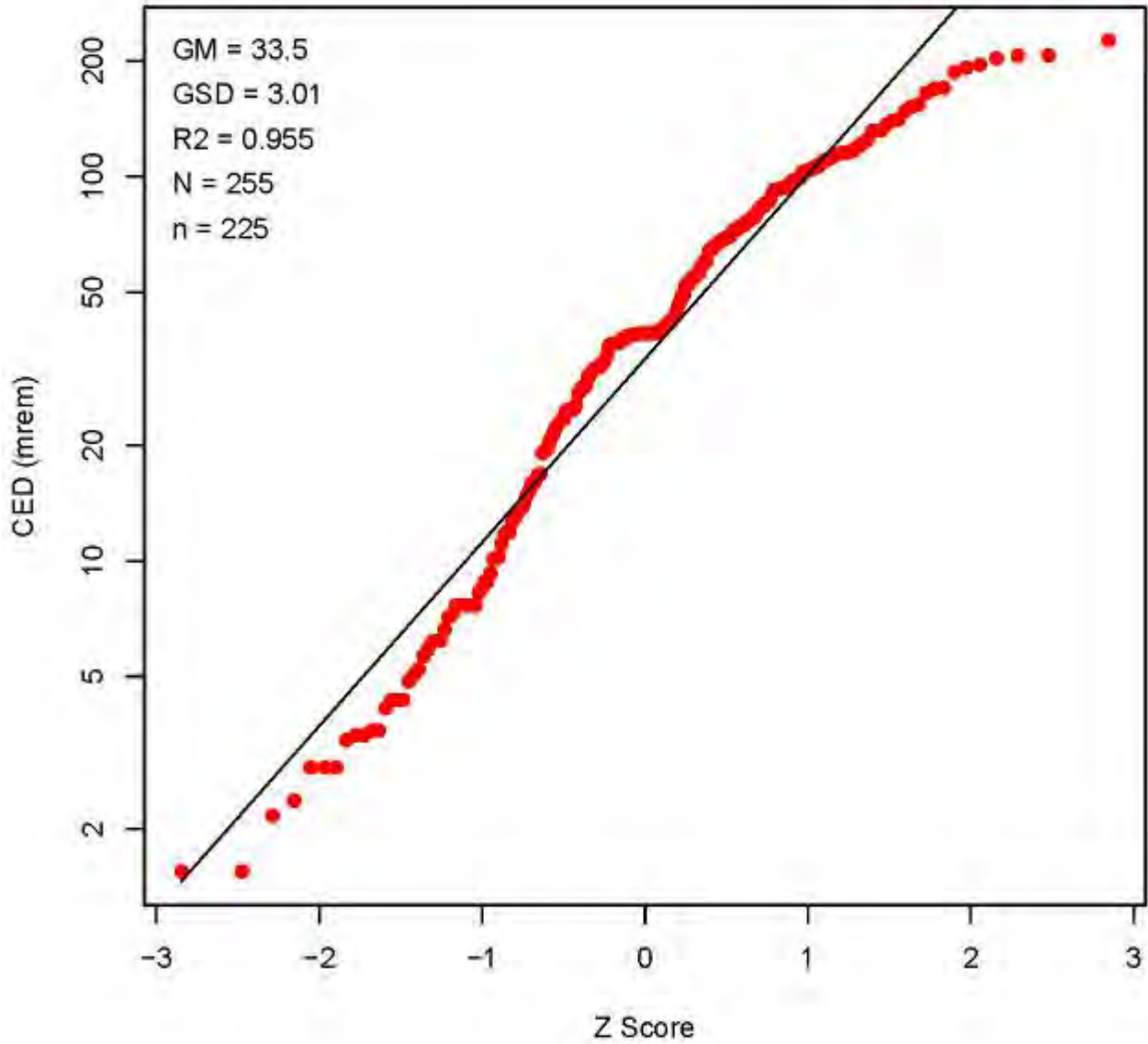


Figure C-87. SRS Non(CTW/Reactor) tritium dose 1975.

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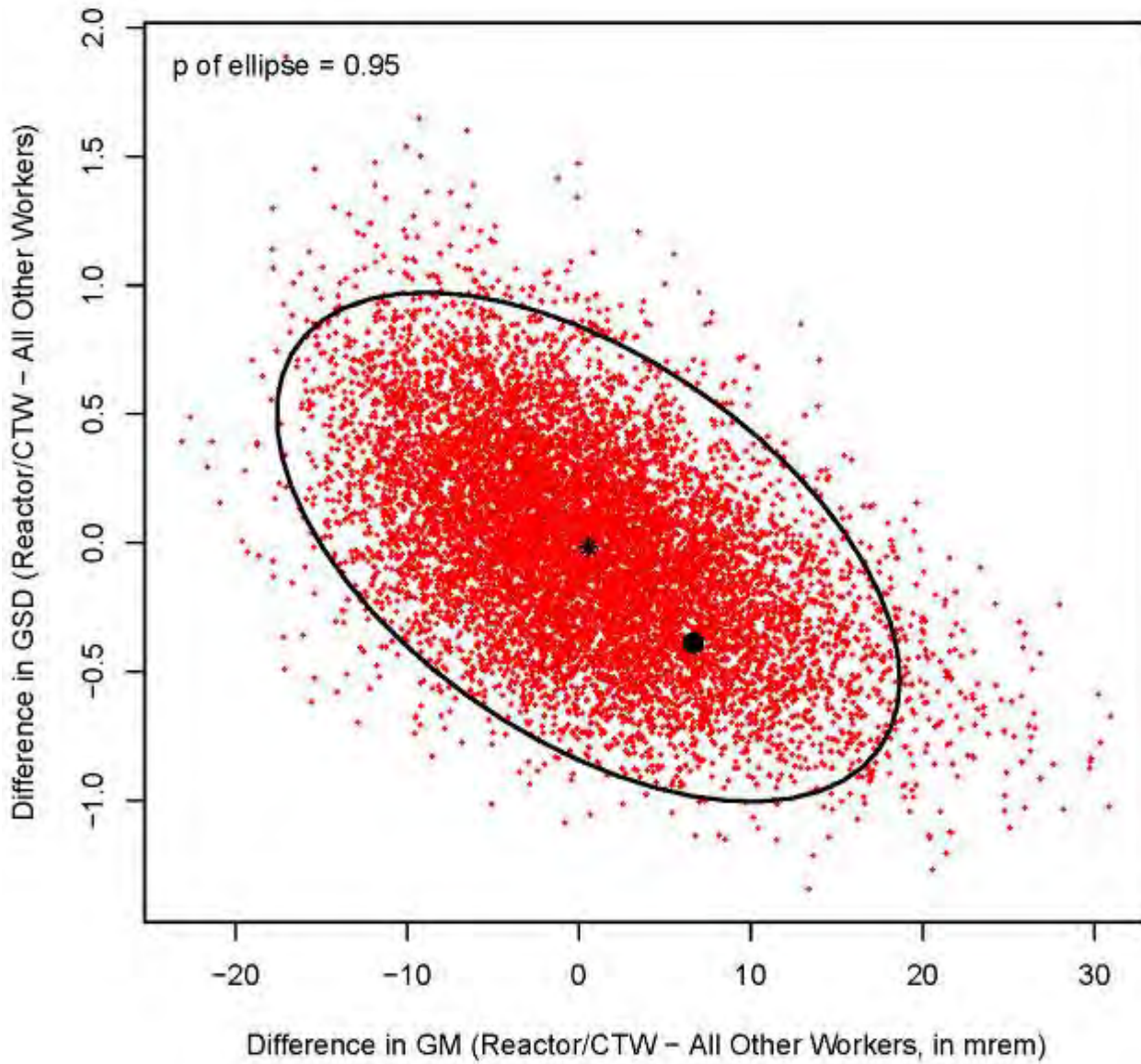


Figure C-88. SRS tritium dose 1975.

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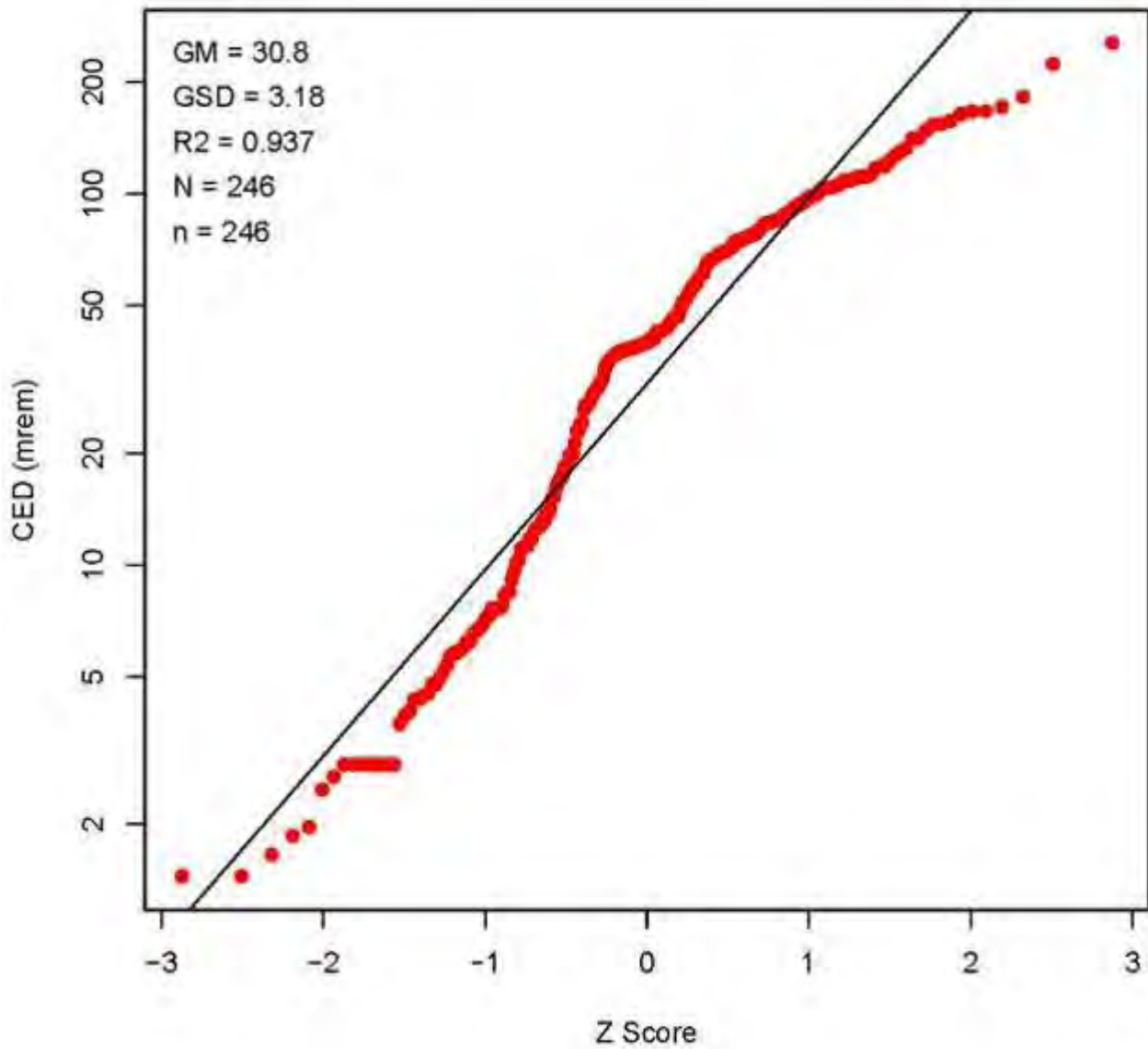


Figure C-89. SRS tritium dose 1976.

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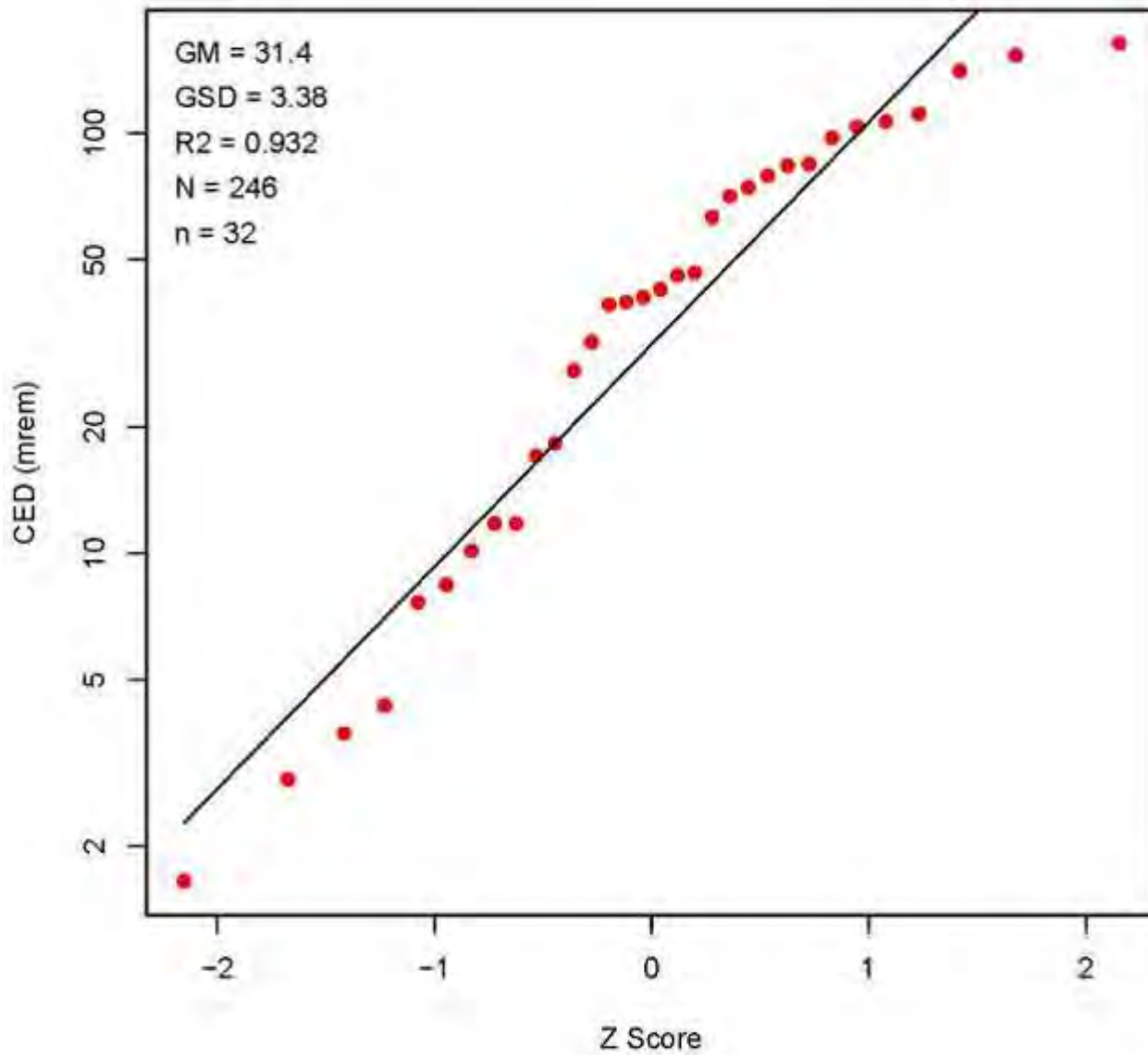


Figure C-90. SRS CTW/Reactor tritium dose 1976.

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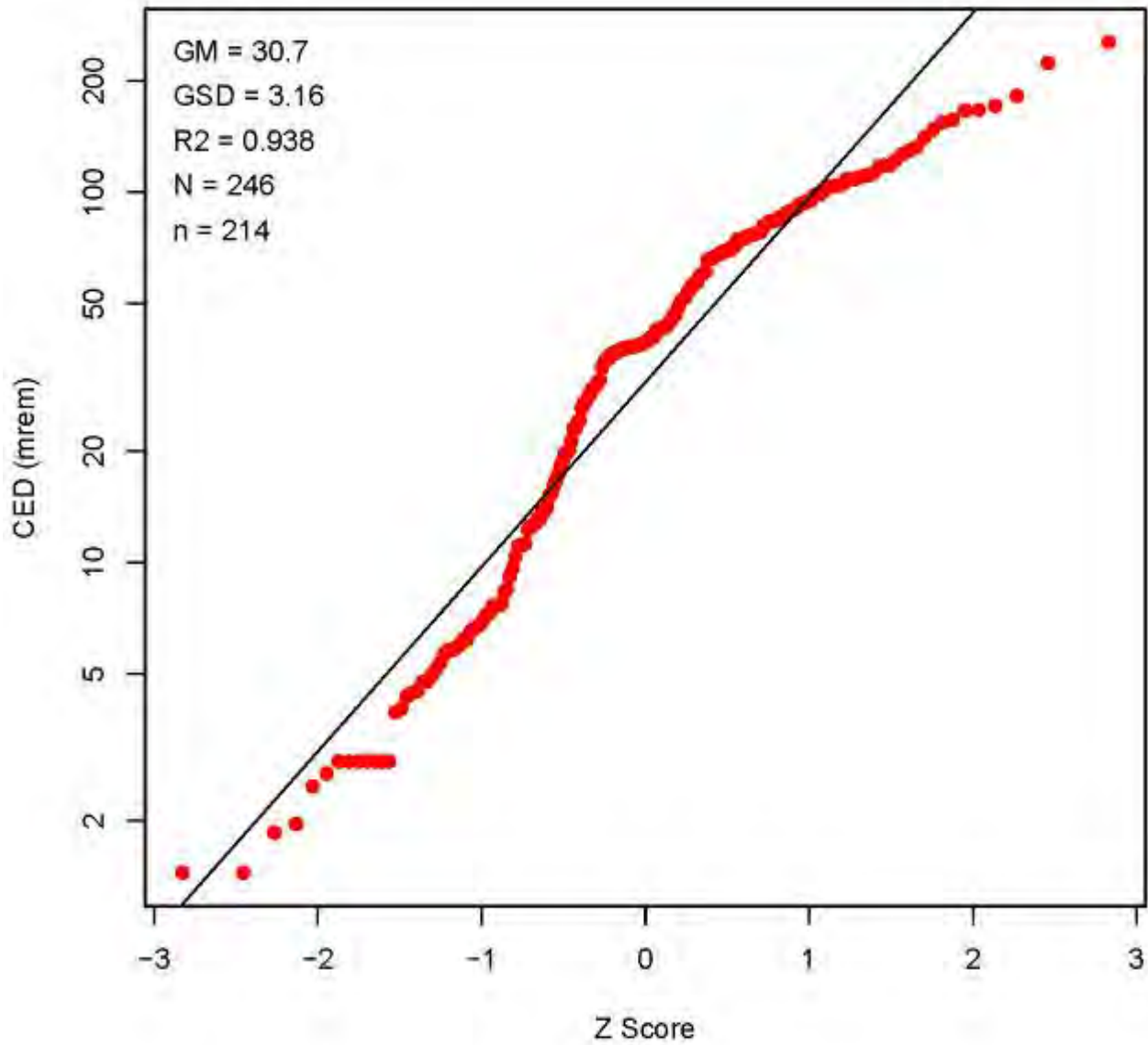


Figure C-91. SRS Non(CTW/Reactor) tritium dose 1976.

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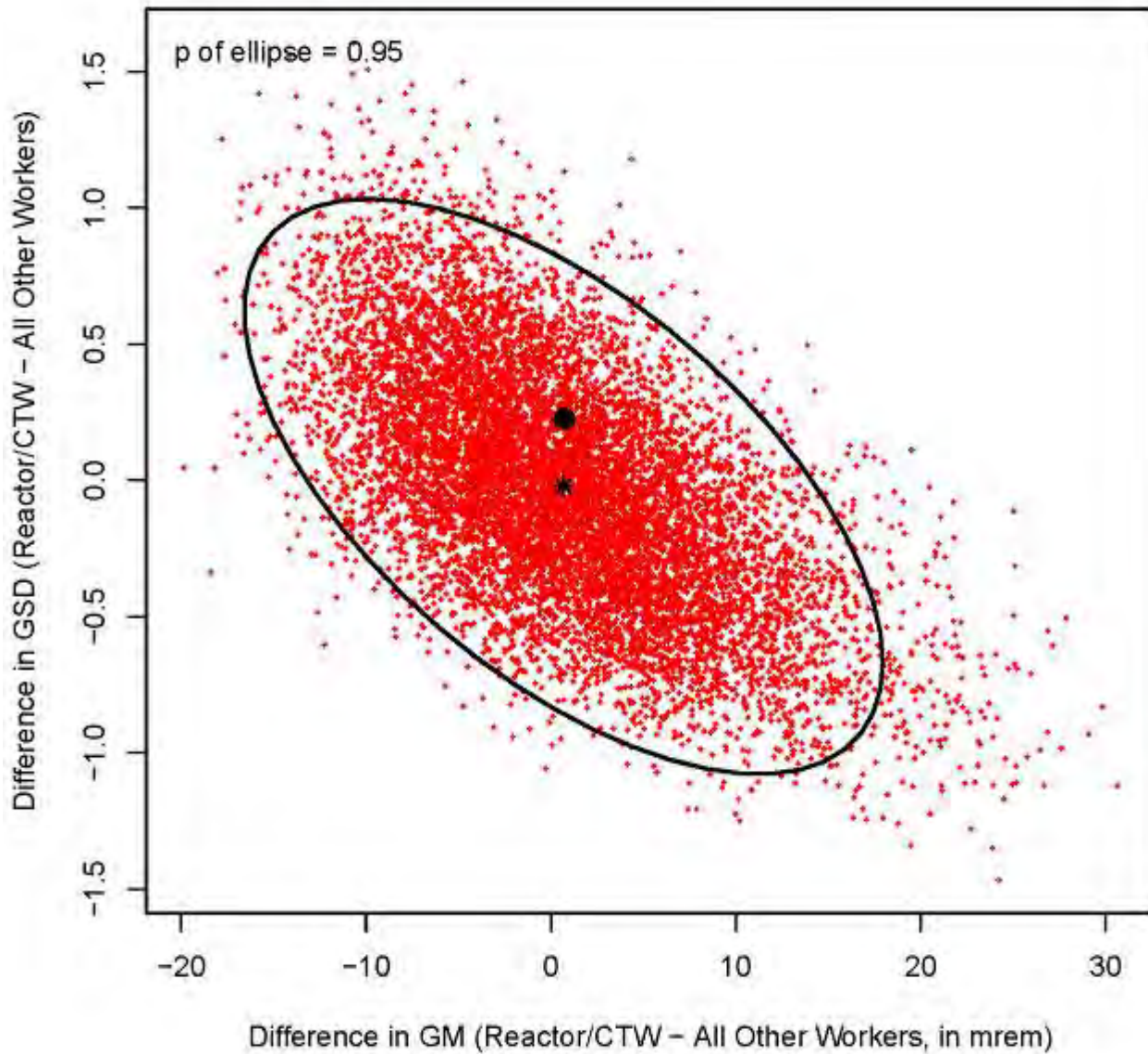


Figure C-92. SRS tritium dose 1976.

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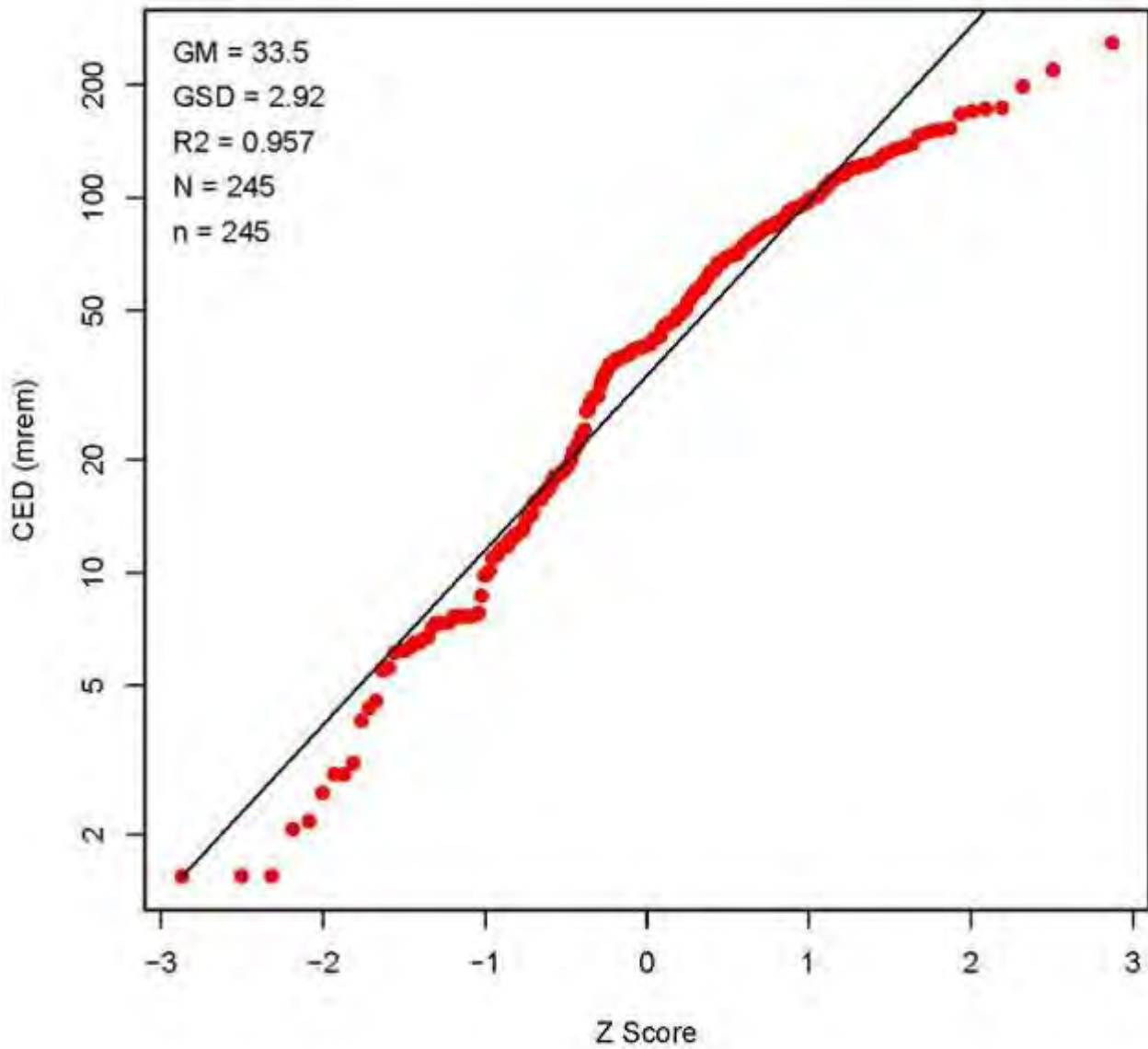


Figure C-93. SRS tritium dose 1977.

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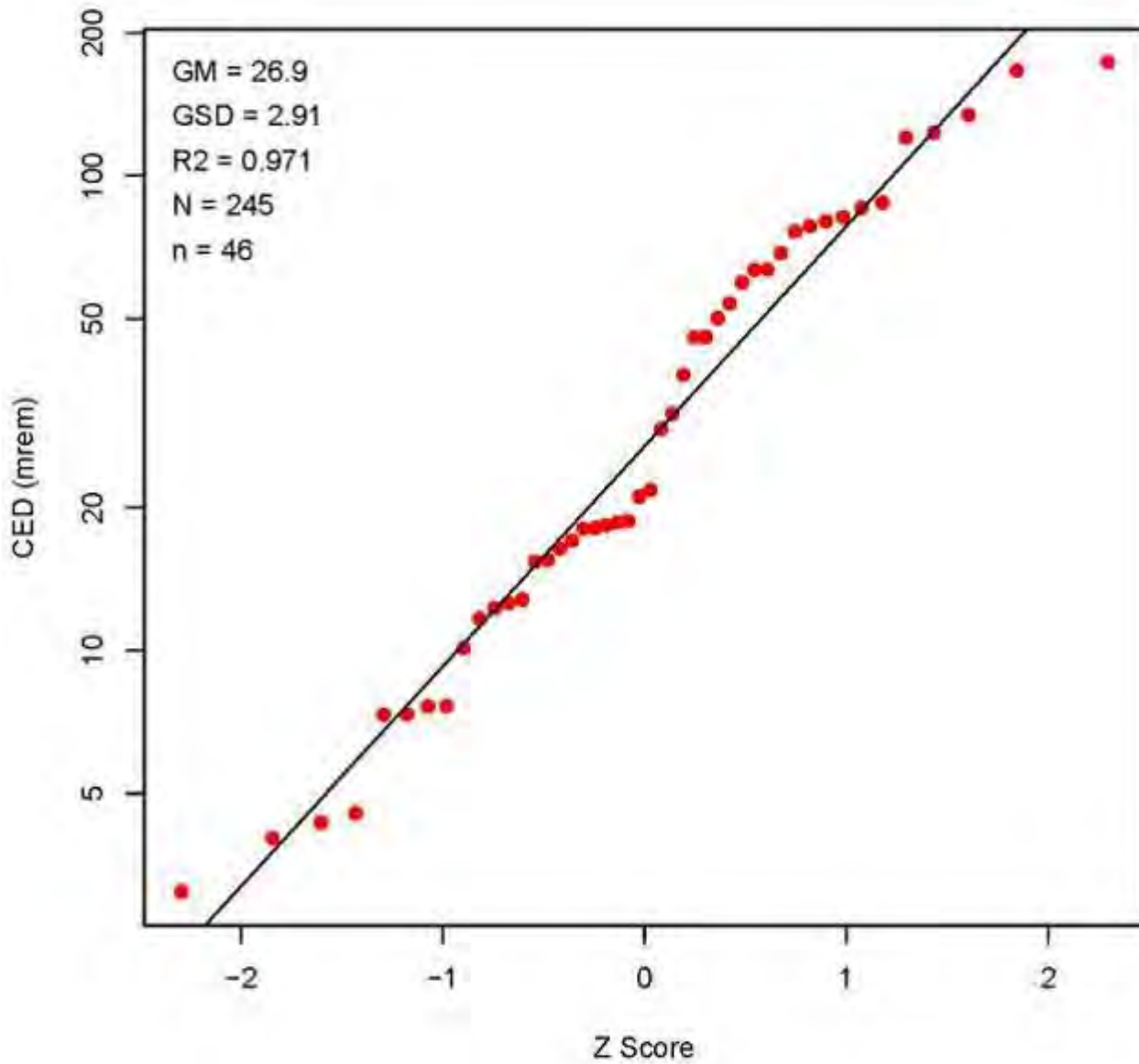


Figure C-94. SRS CTW/Reactor tritium dose 1977.

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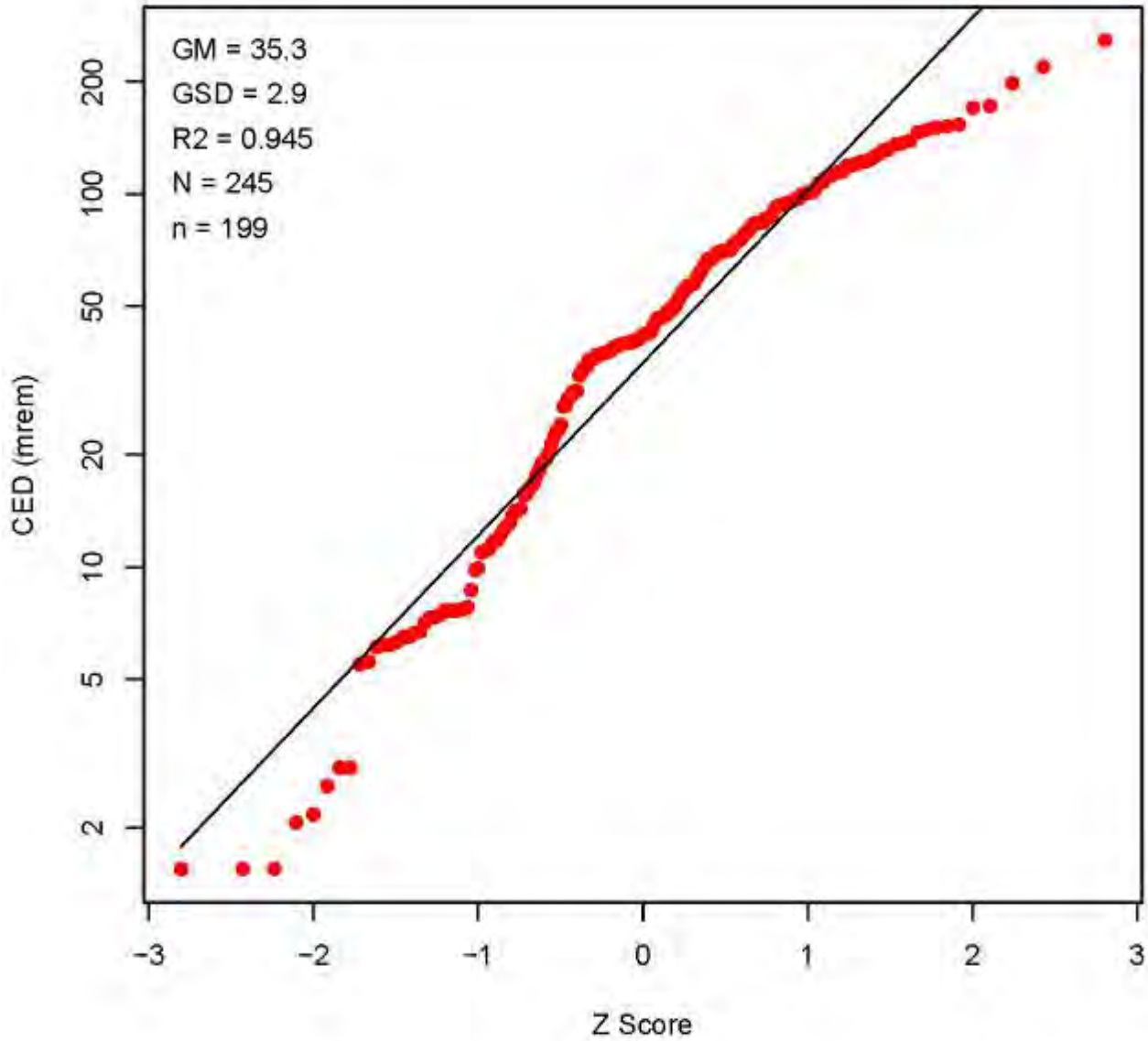


Figure C-95. SRS Non(CTW/Reactor) tritium dose 1977.

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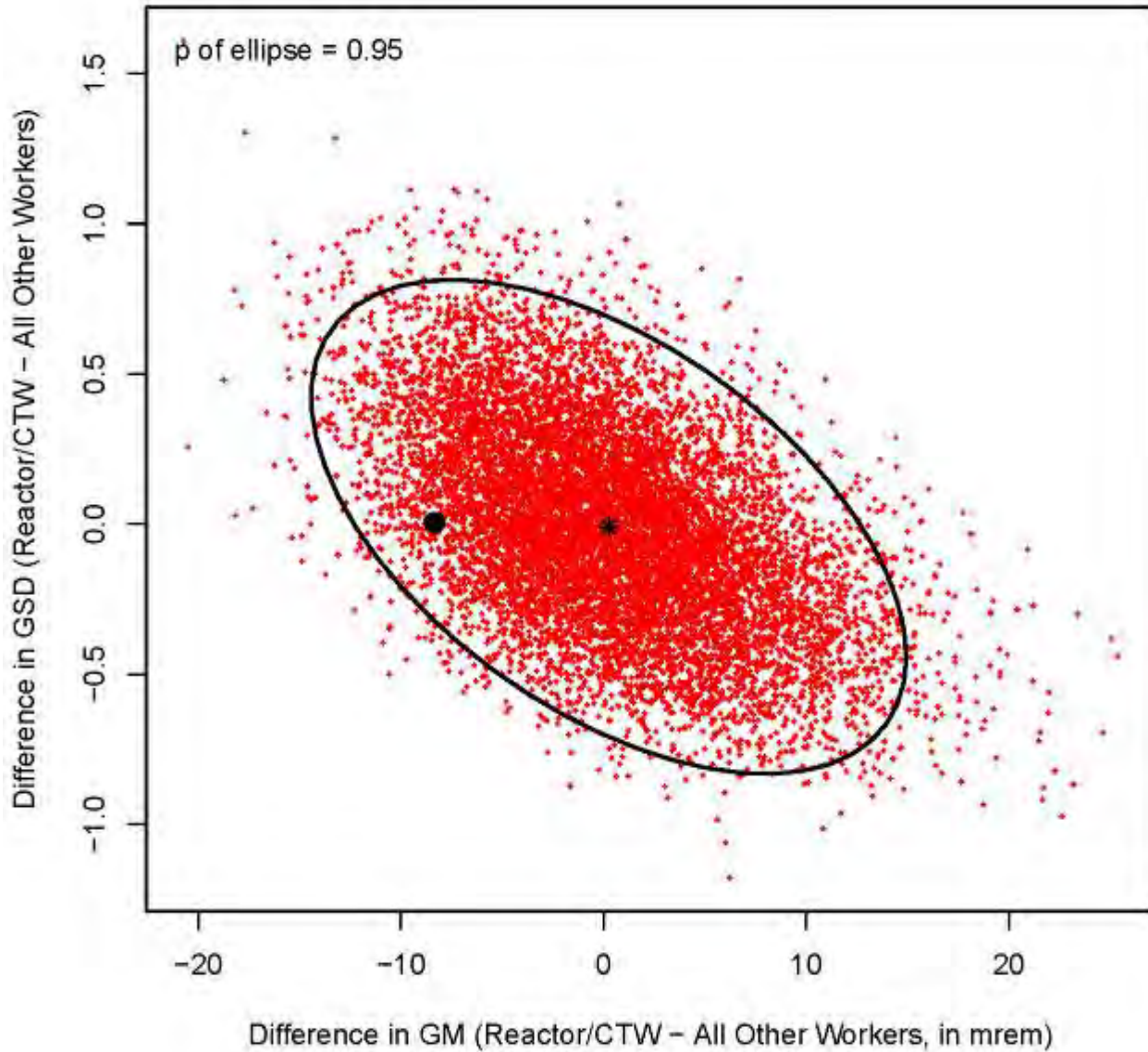


Figure C-96. SRS tritium dose 1977.

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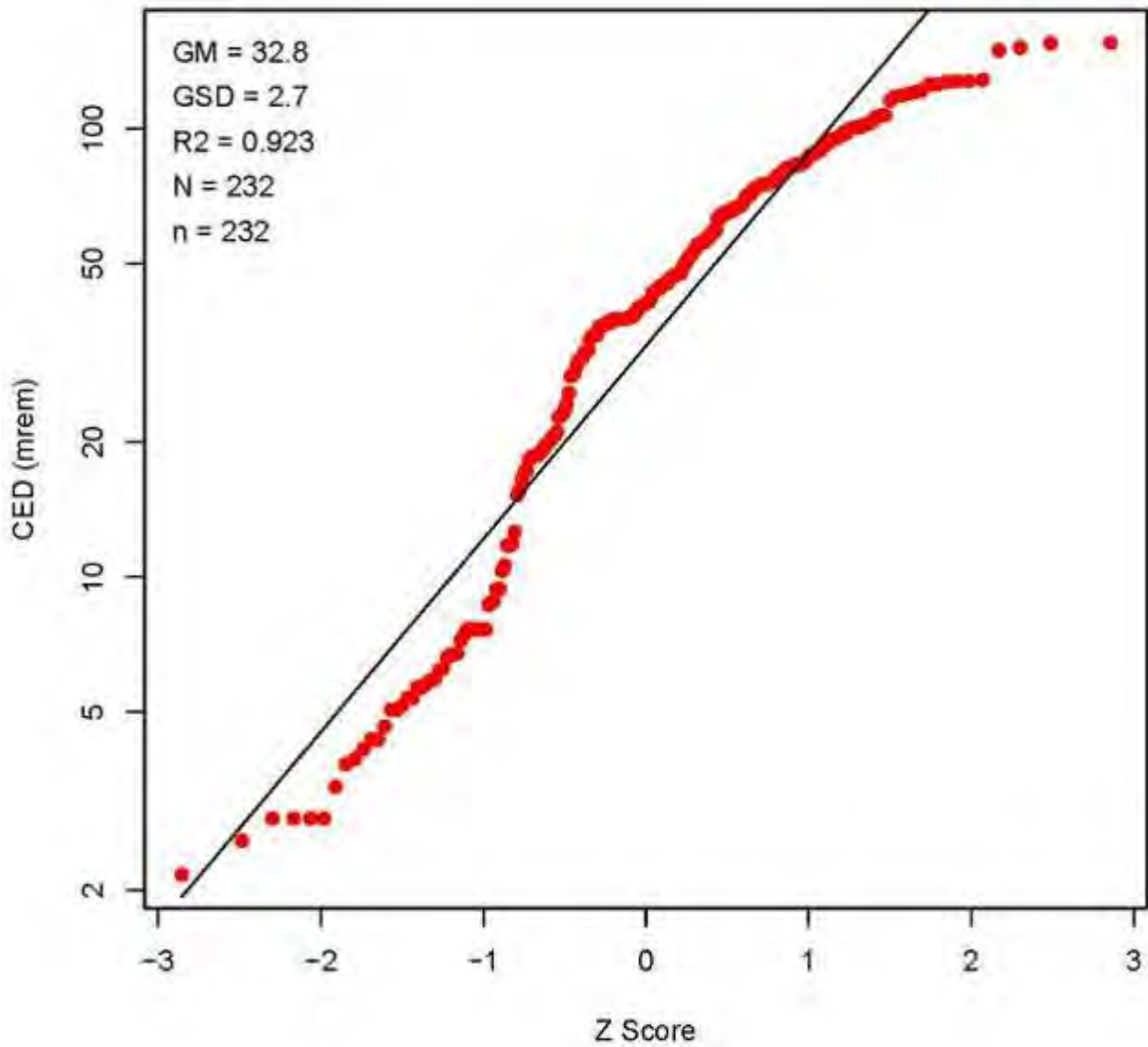


Figure C-97. SRS tritium dose 1978.

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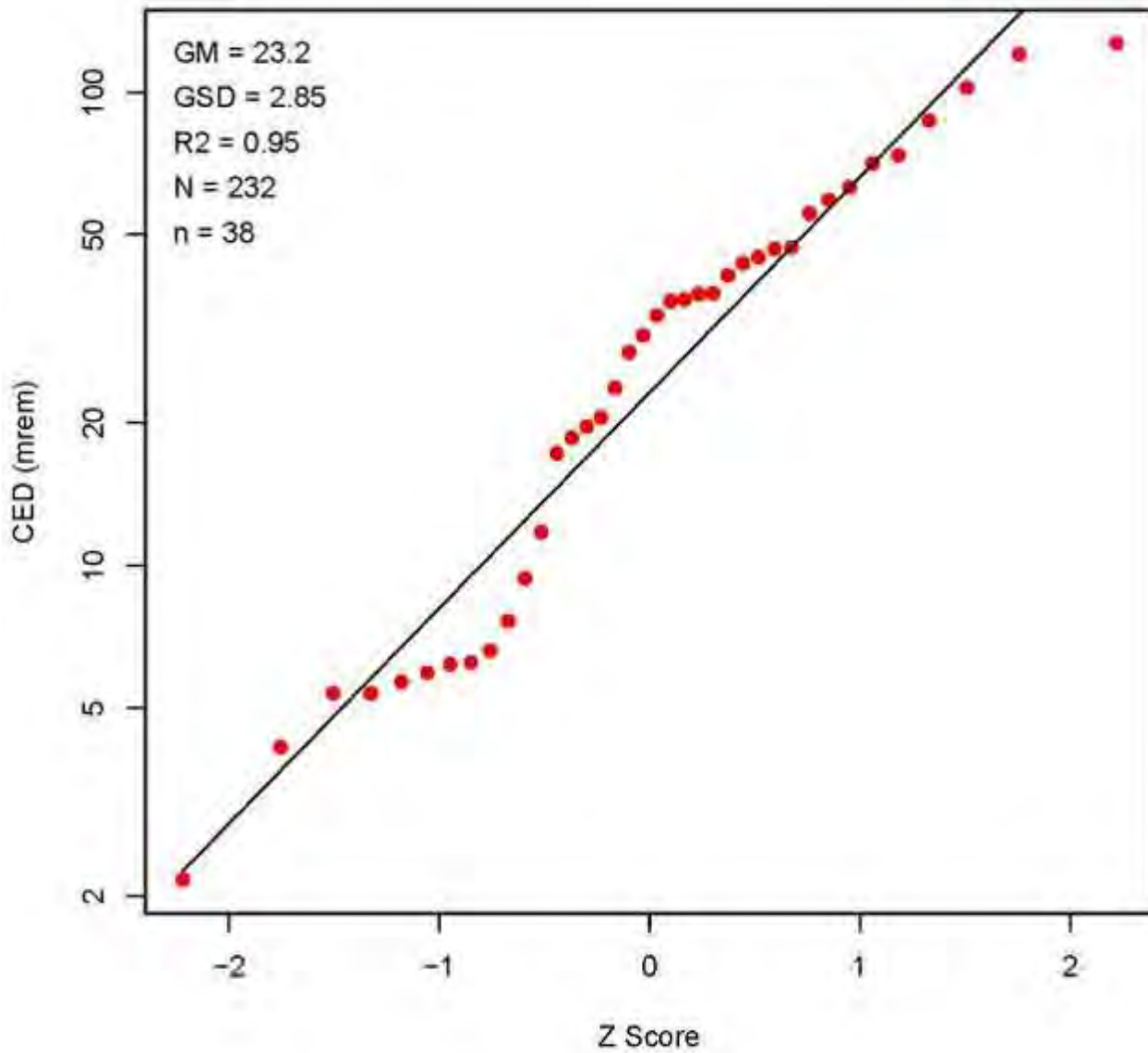


Figure C-98. SRS CTW/Reactor tritium dose 1978.

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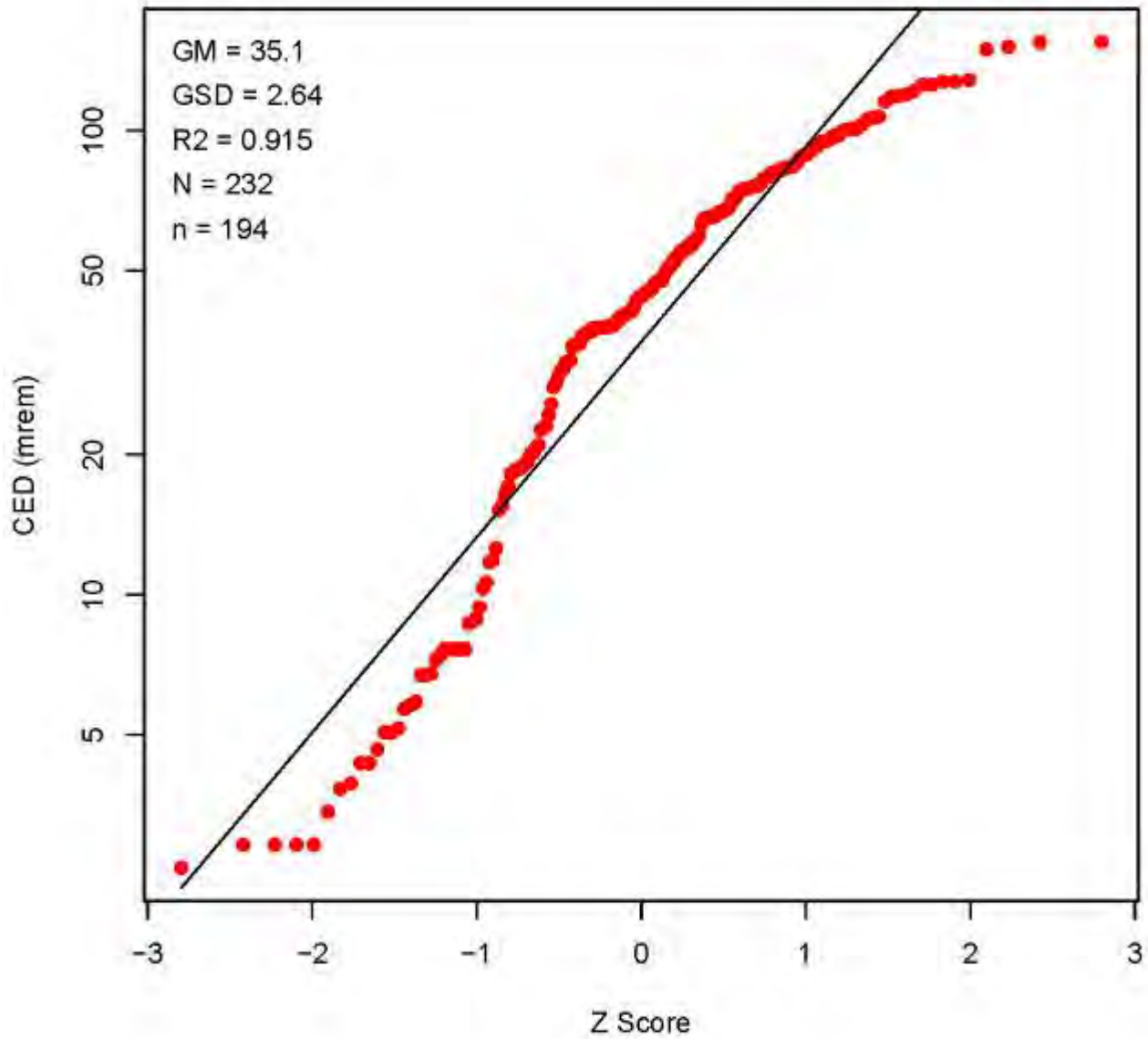


Figure C-99. SRS Non(CTW/Reactor) tritium dose 1978.

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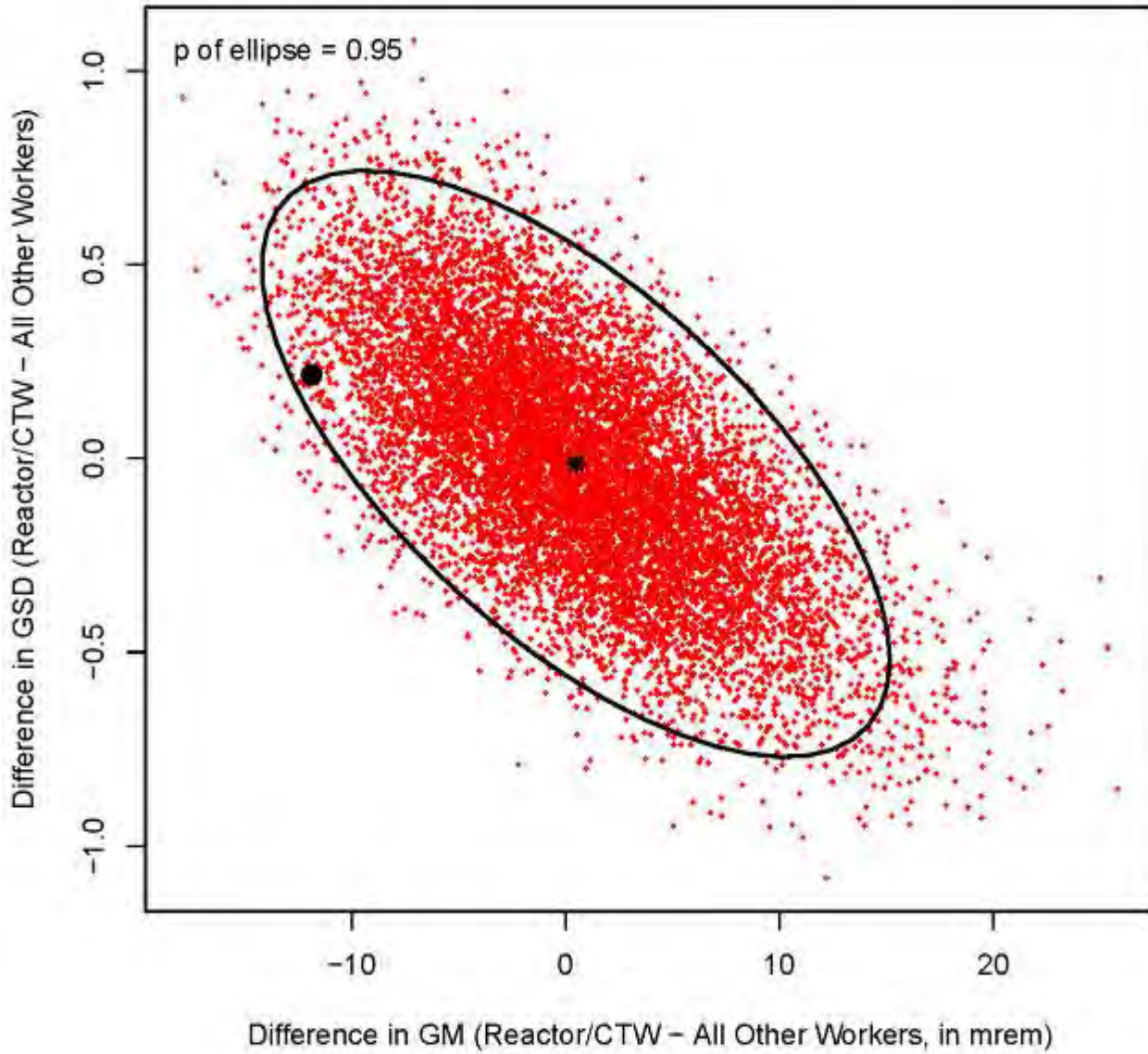


Figure C-100. SRS tritium dose 1978.

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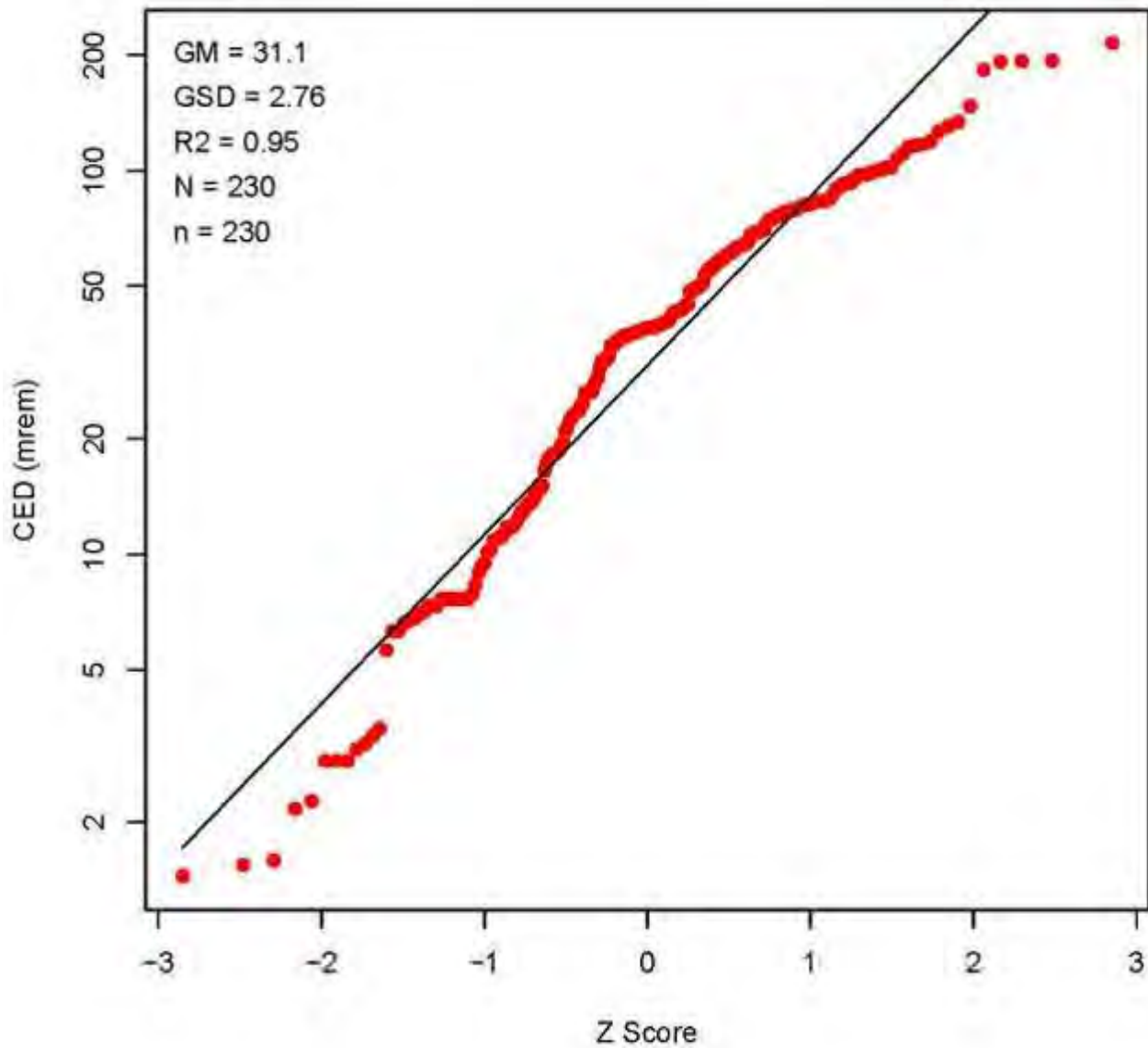


Figure C-101. SRS tritium dose 1979.

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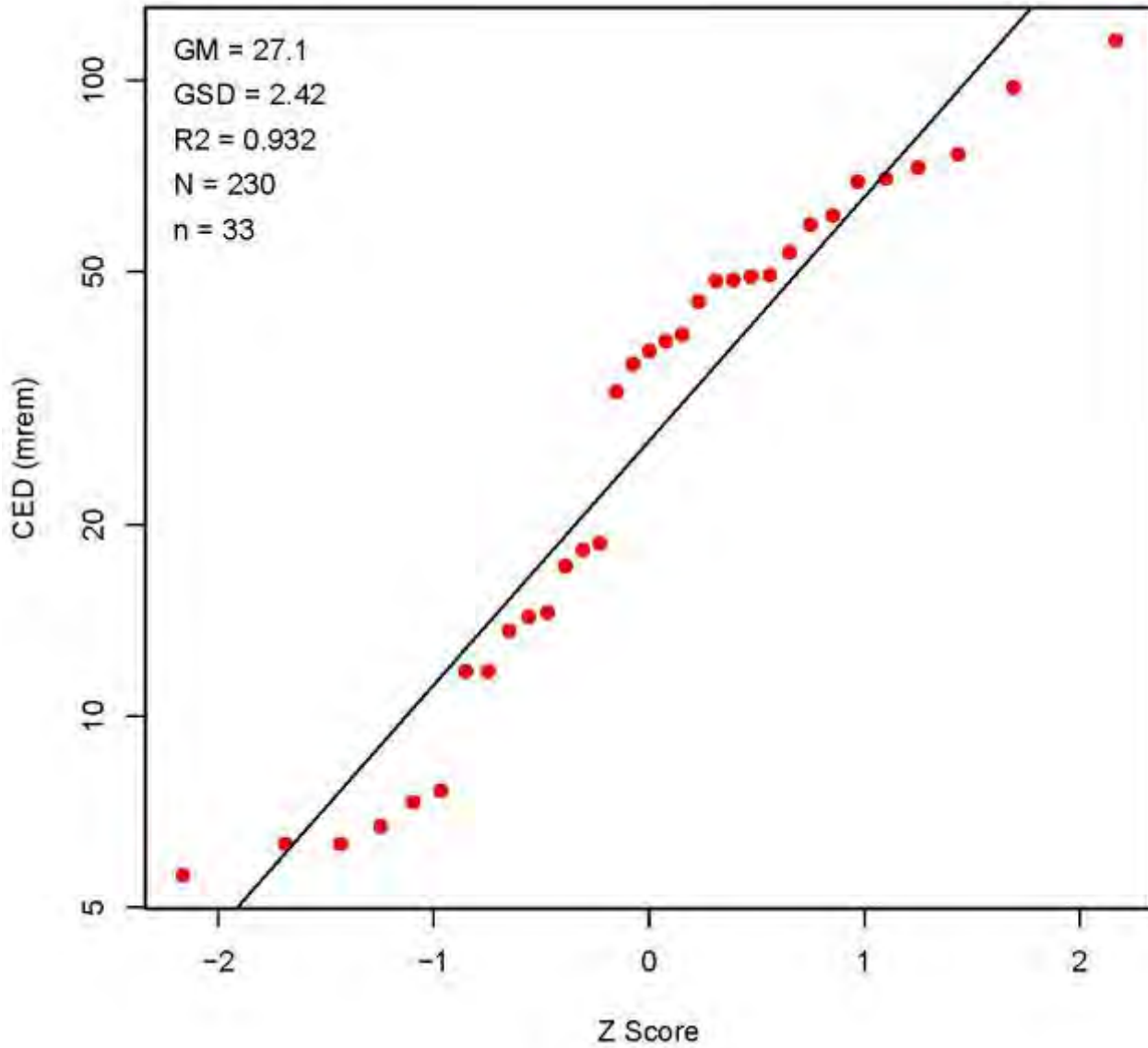


Figure C-102. SRS CTW/Reactor tritium dose 1979.

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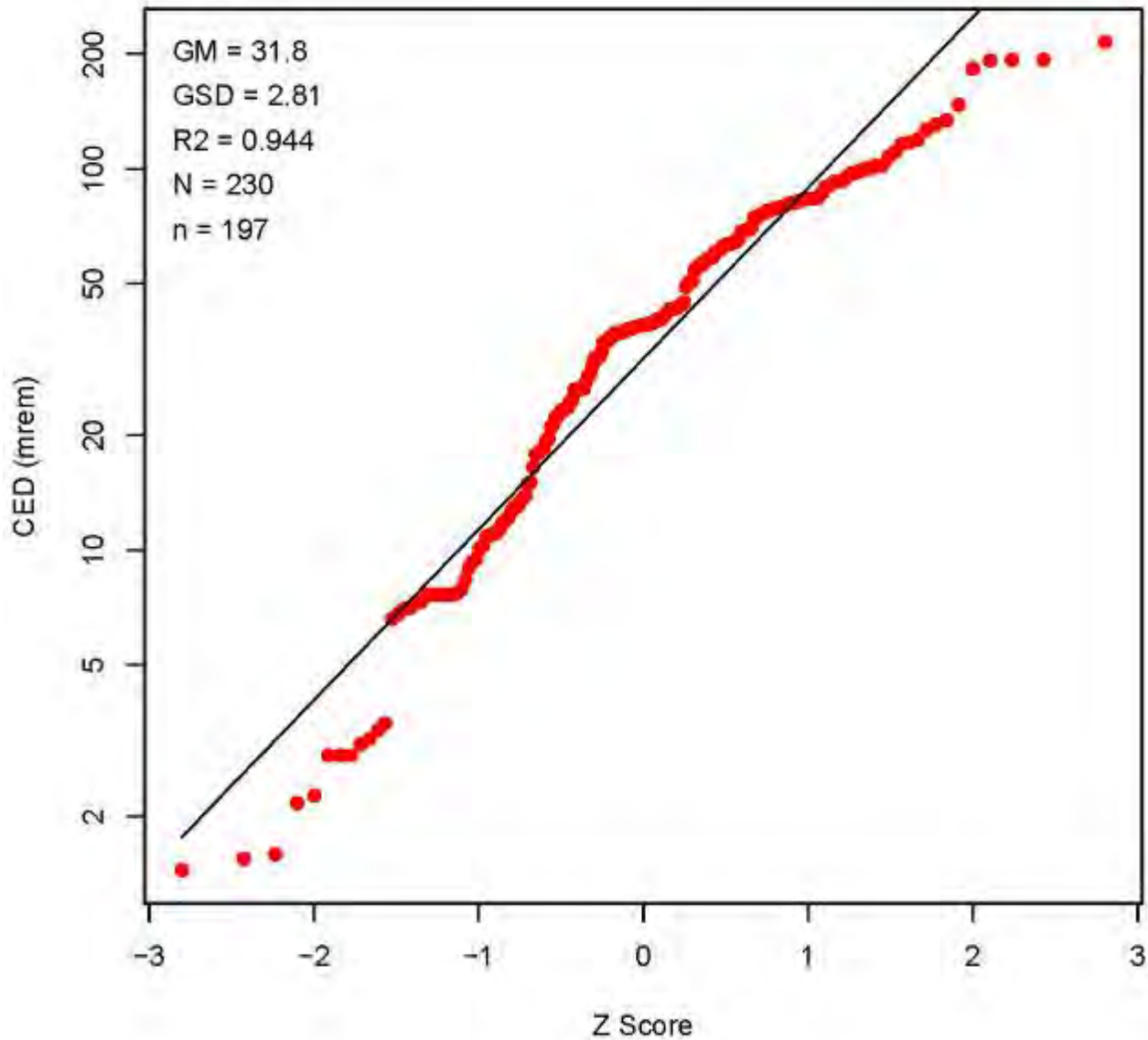


Figure C-103. SRS Non(CTW/Reactor) tritium dose 1979.

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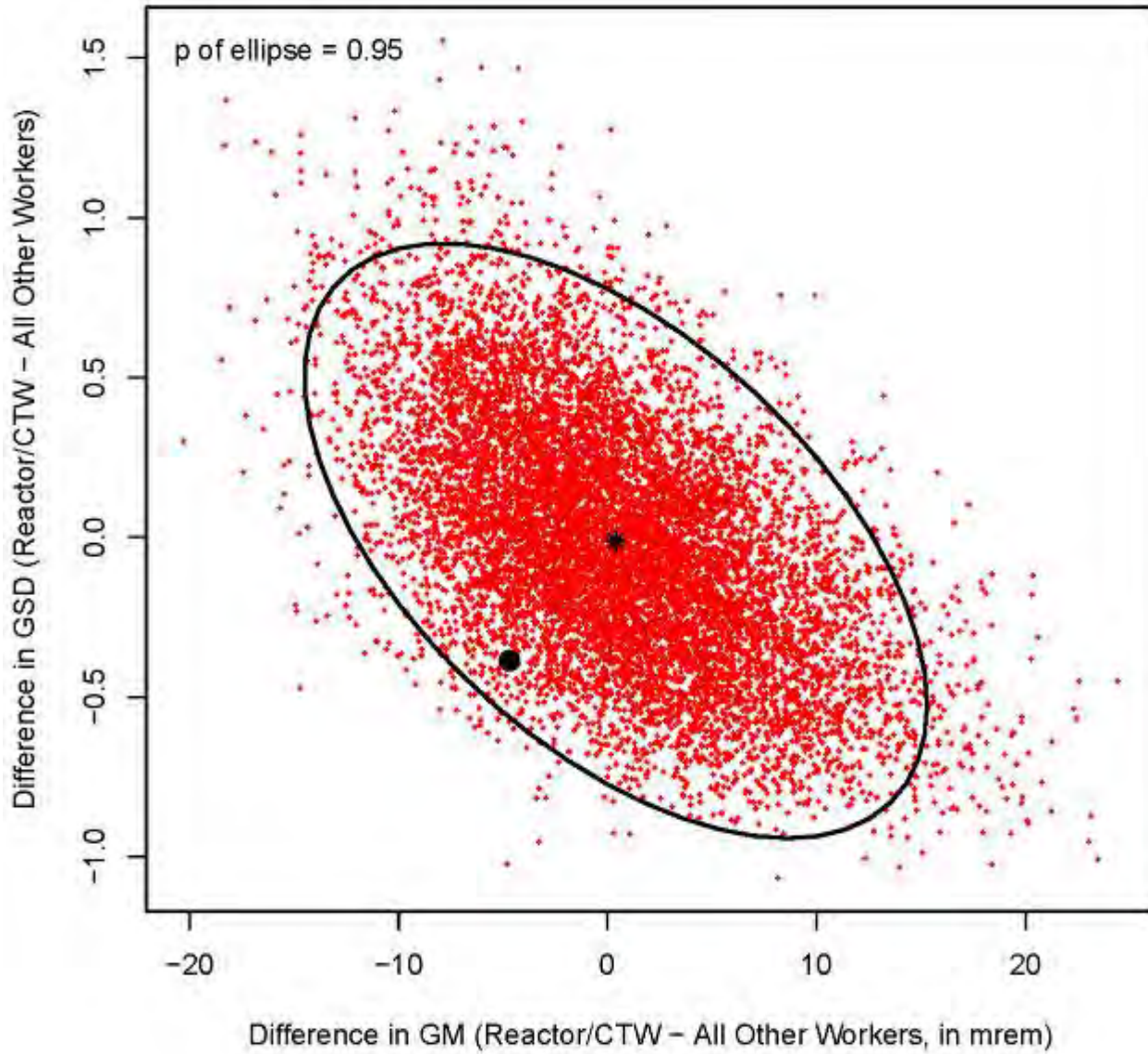


Figure C-104. SRS tritium dose 1979.

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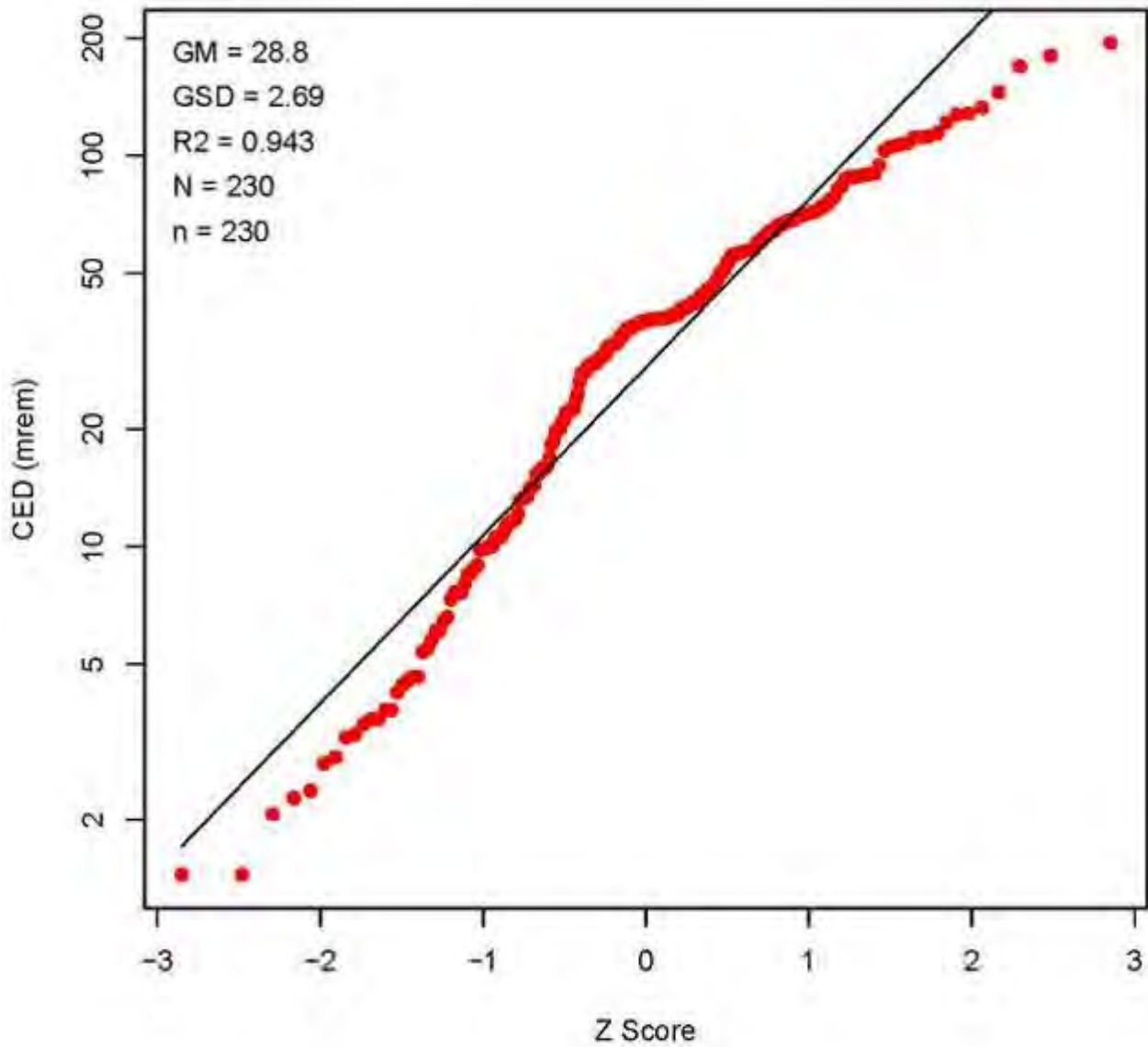


Figure C-105. SRS tritium dose 1980.

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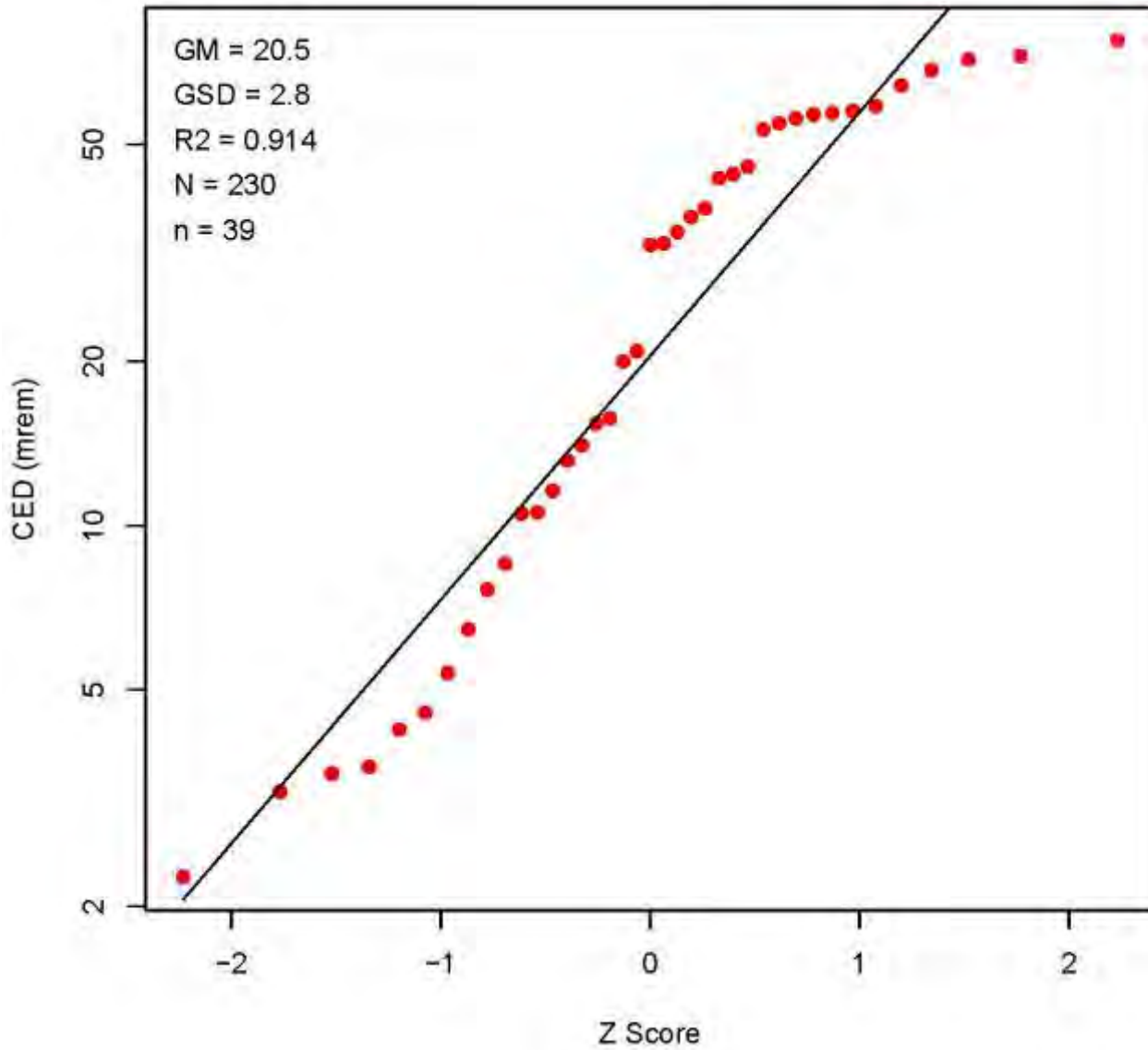


Figure C-106. SRS CTW/Reactor tritium dose 1980.

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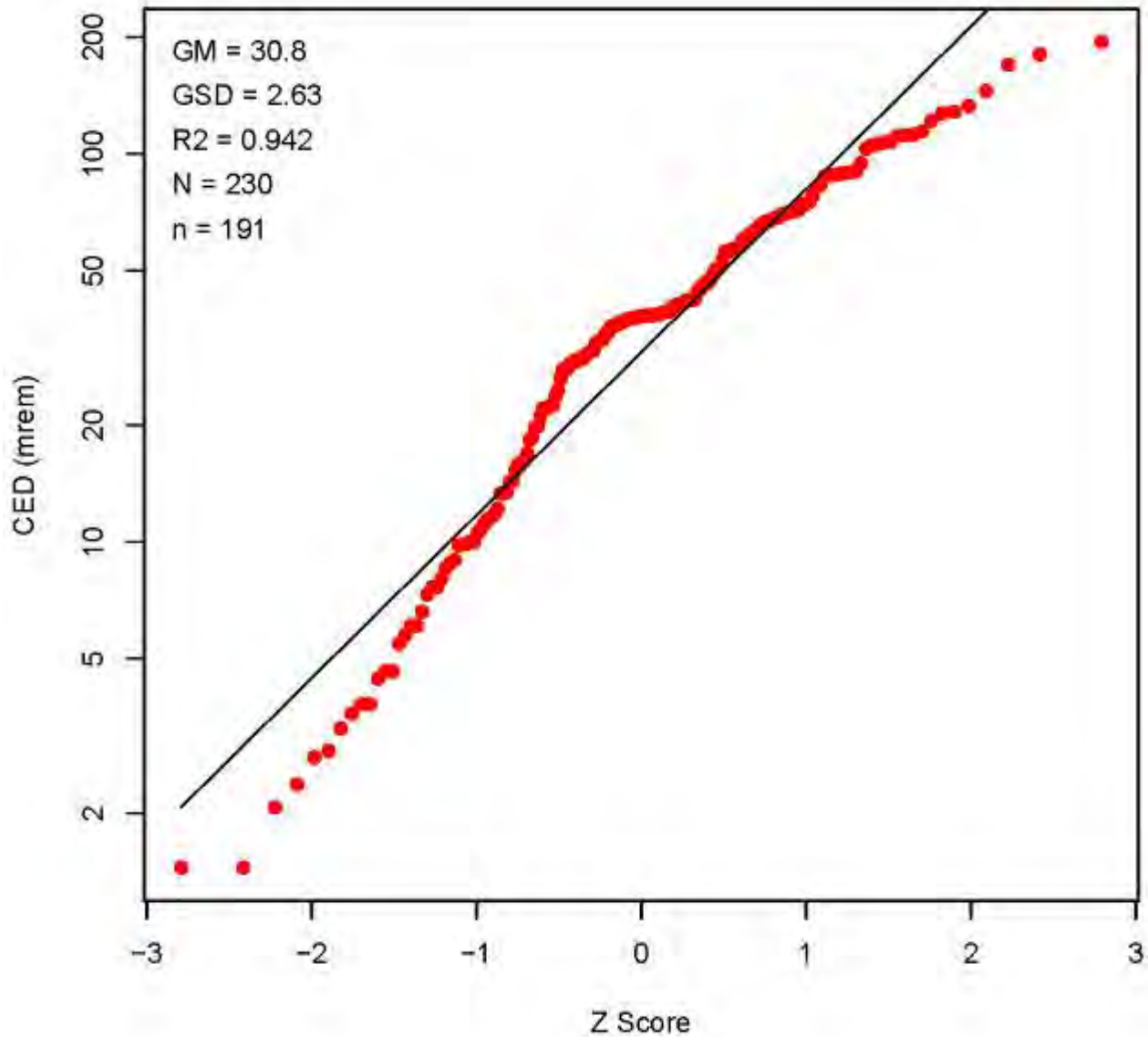


Figure C-107. SRS Non(CTW/Reactor) tritium dose 1980.

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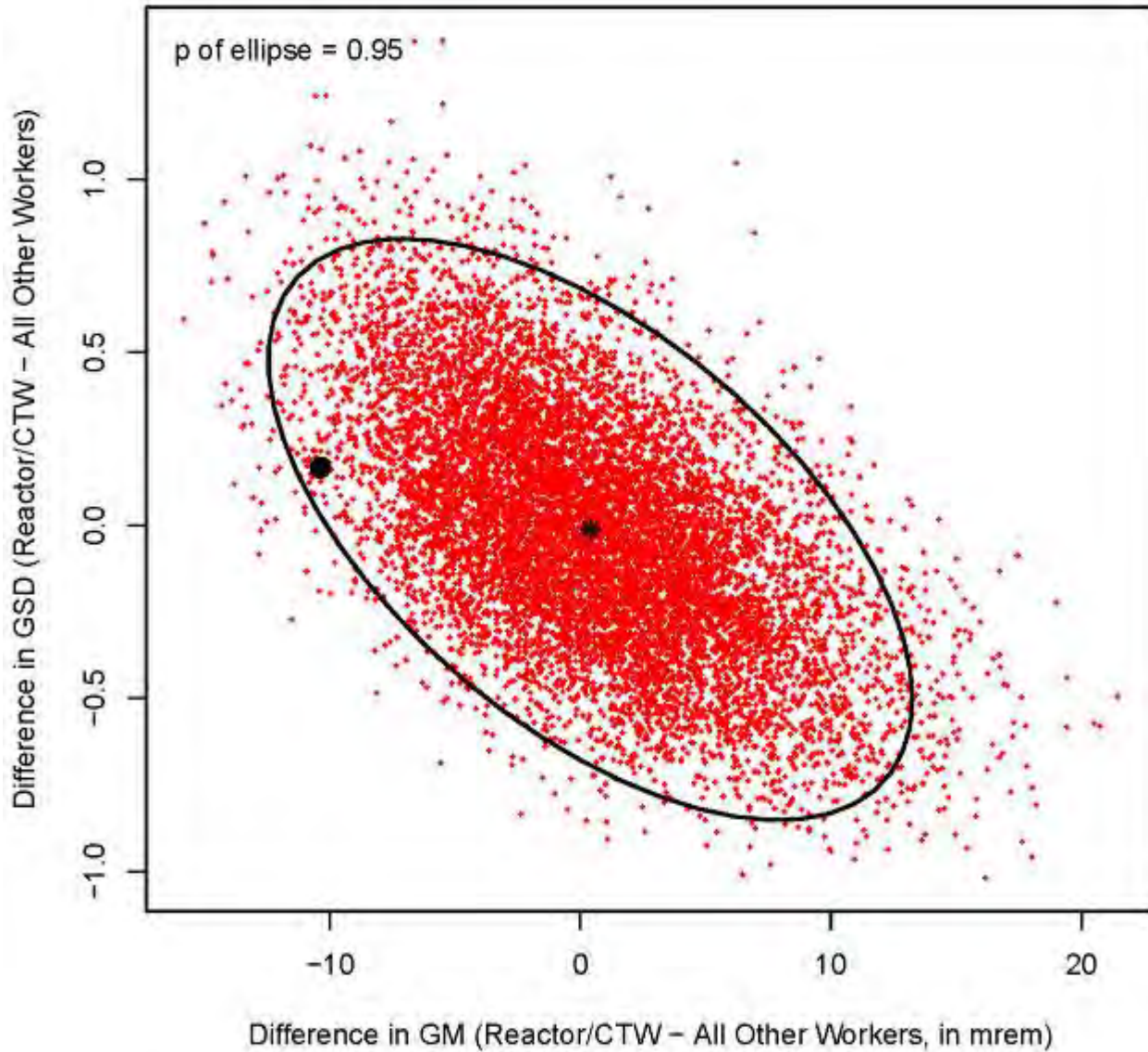


Figure C-108. SRS tritium dose 1980.

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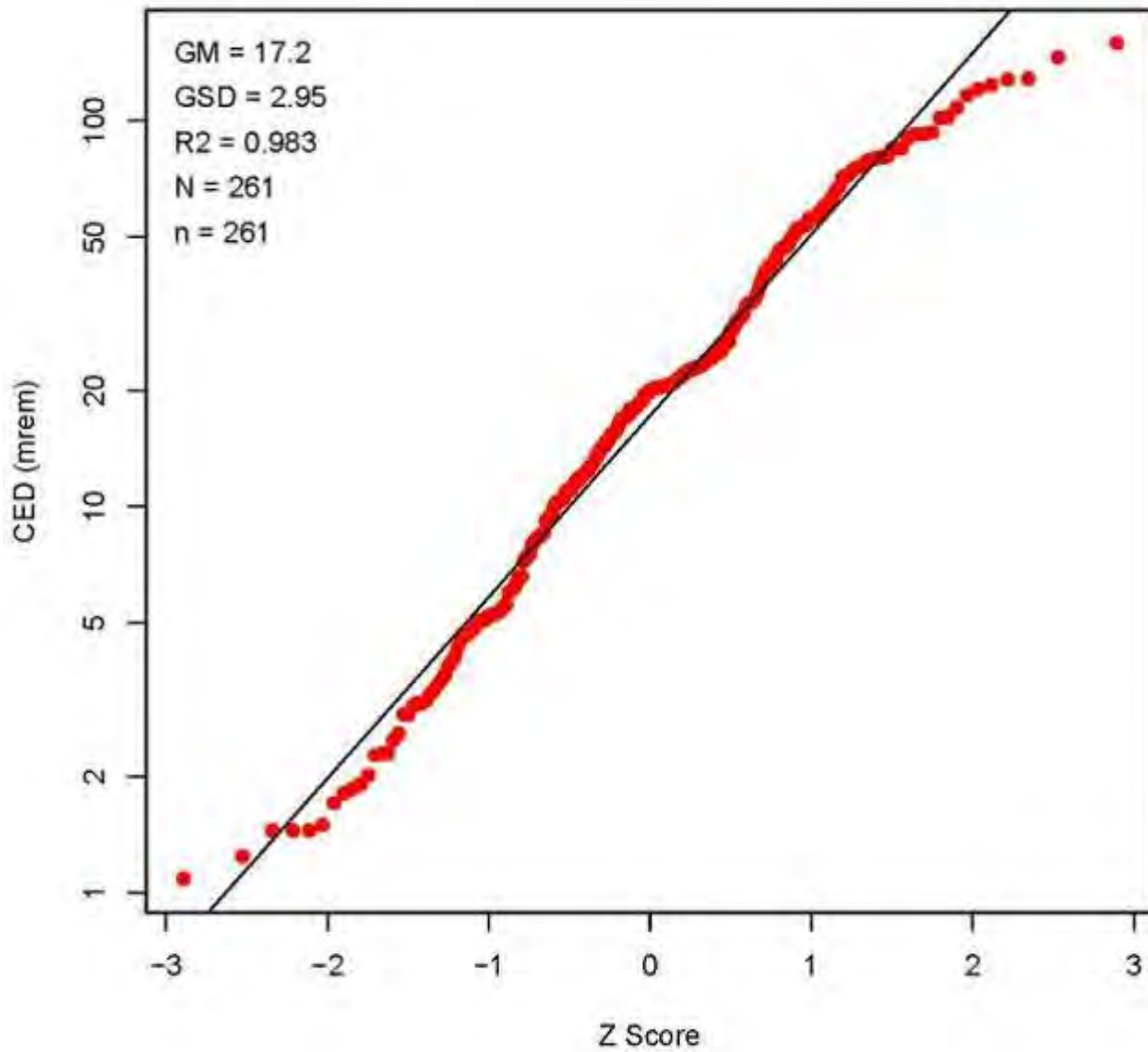


Figure C-109. SRS tritium dose 1981.

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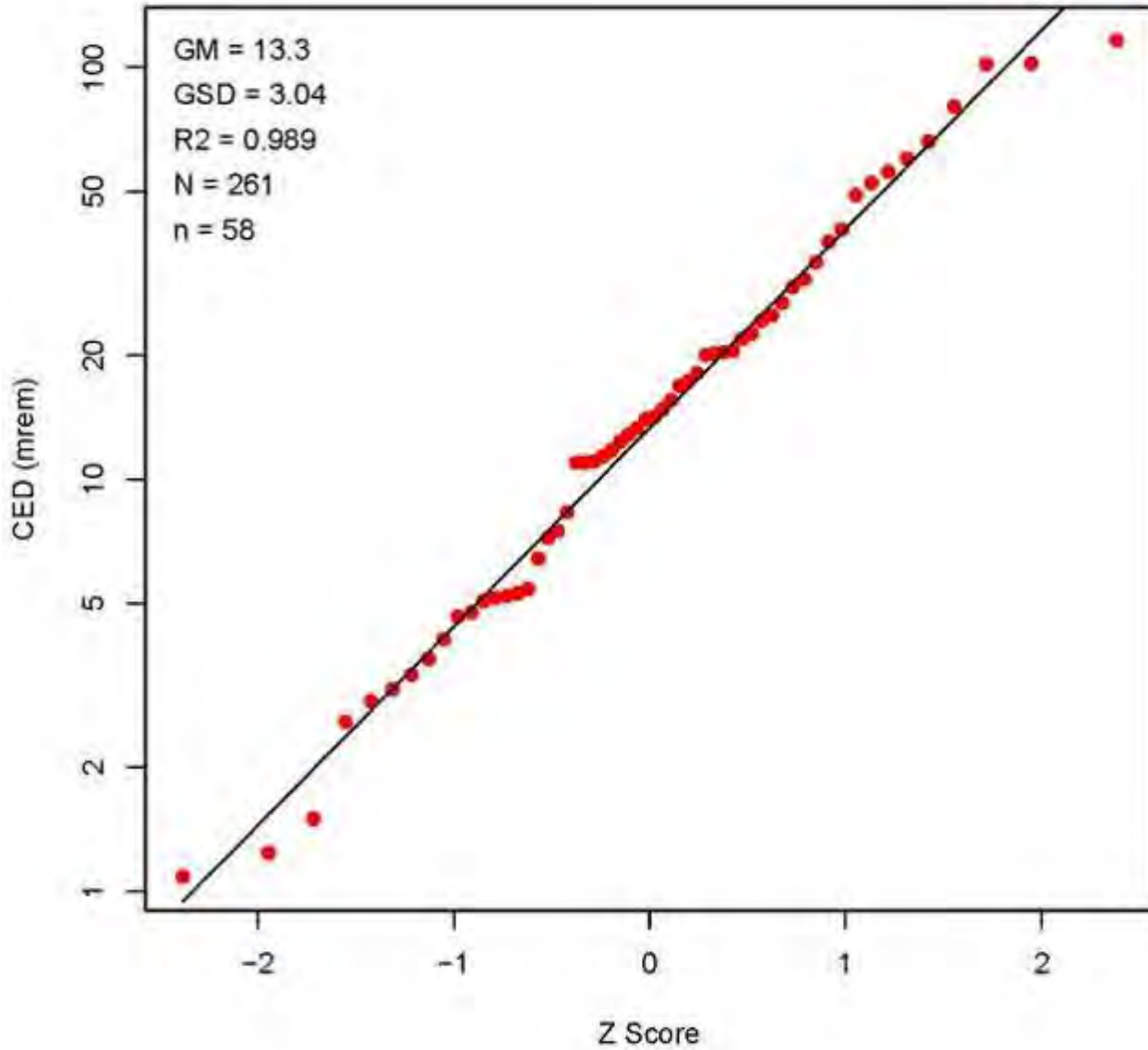


Figure C-110. SRS CTW/Reactor tritium dose 1981.

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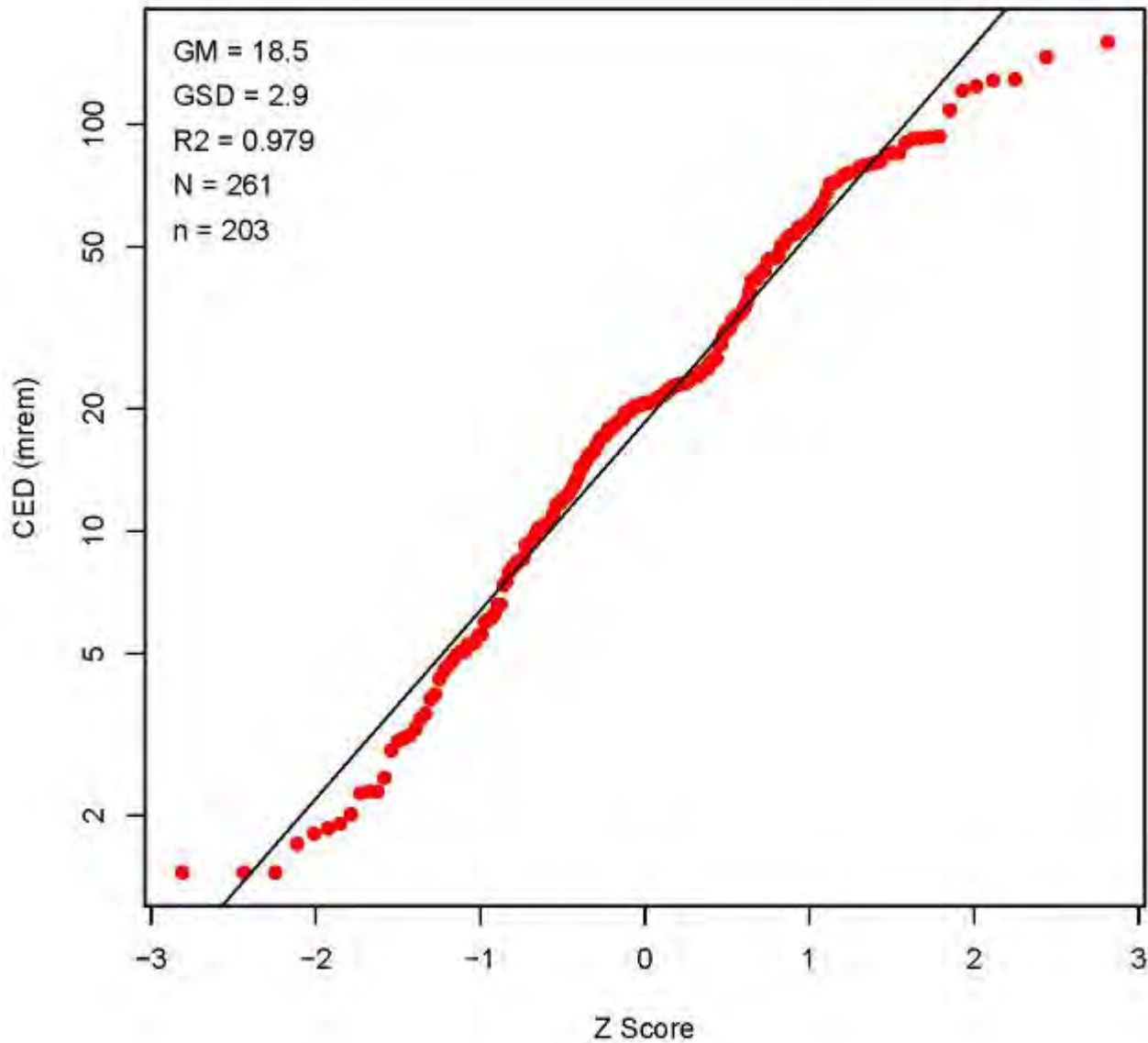


Figure C-111. SRS Non(CTW/Reactor) tritium dose 1981.

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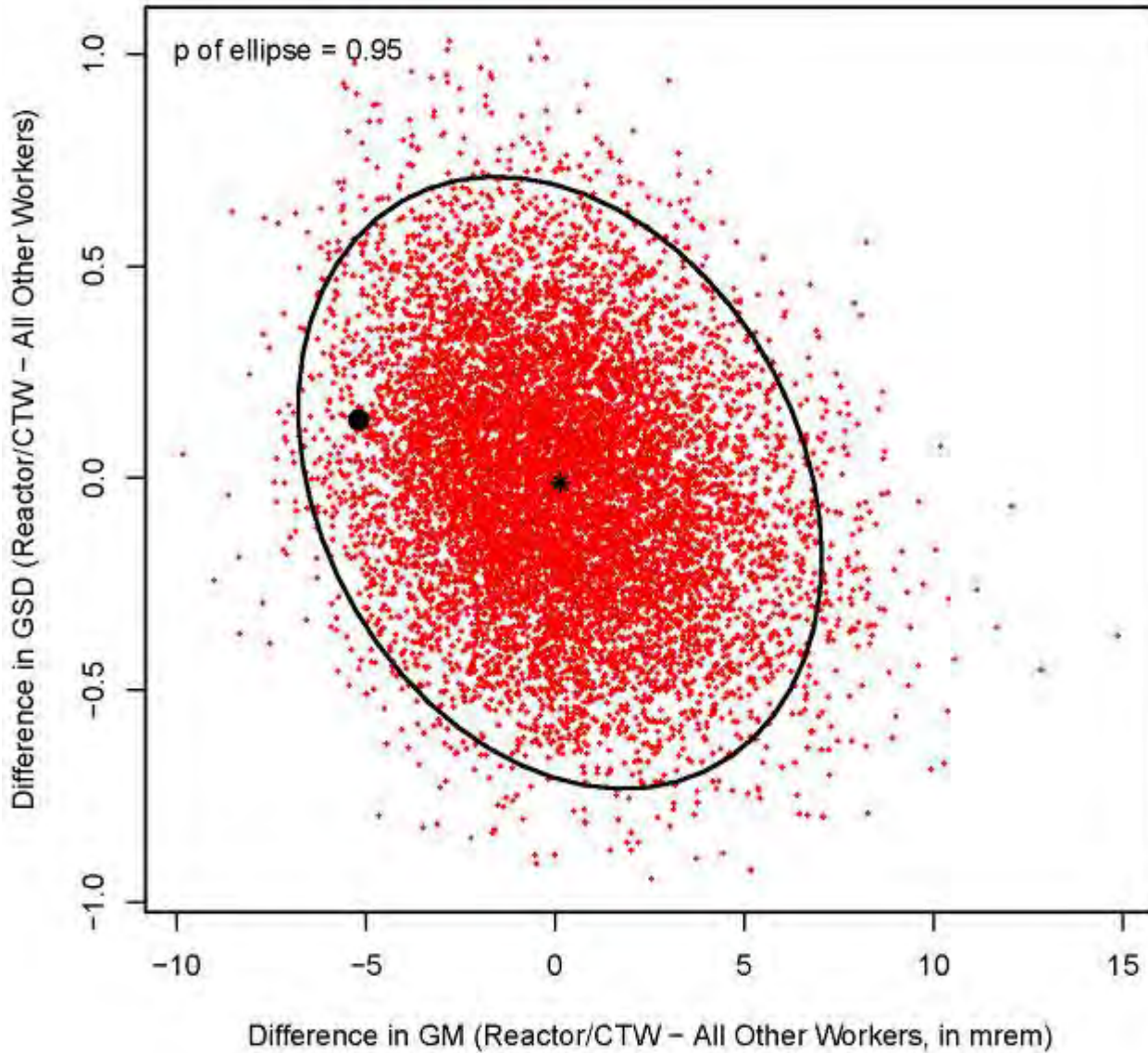


Figure C-112. SRS tritium dose 1981.

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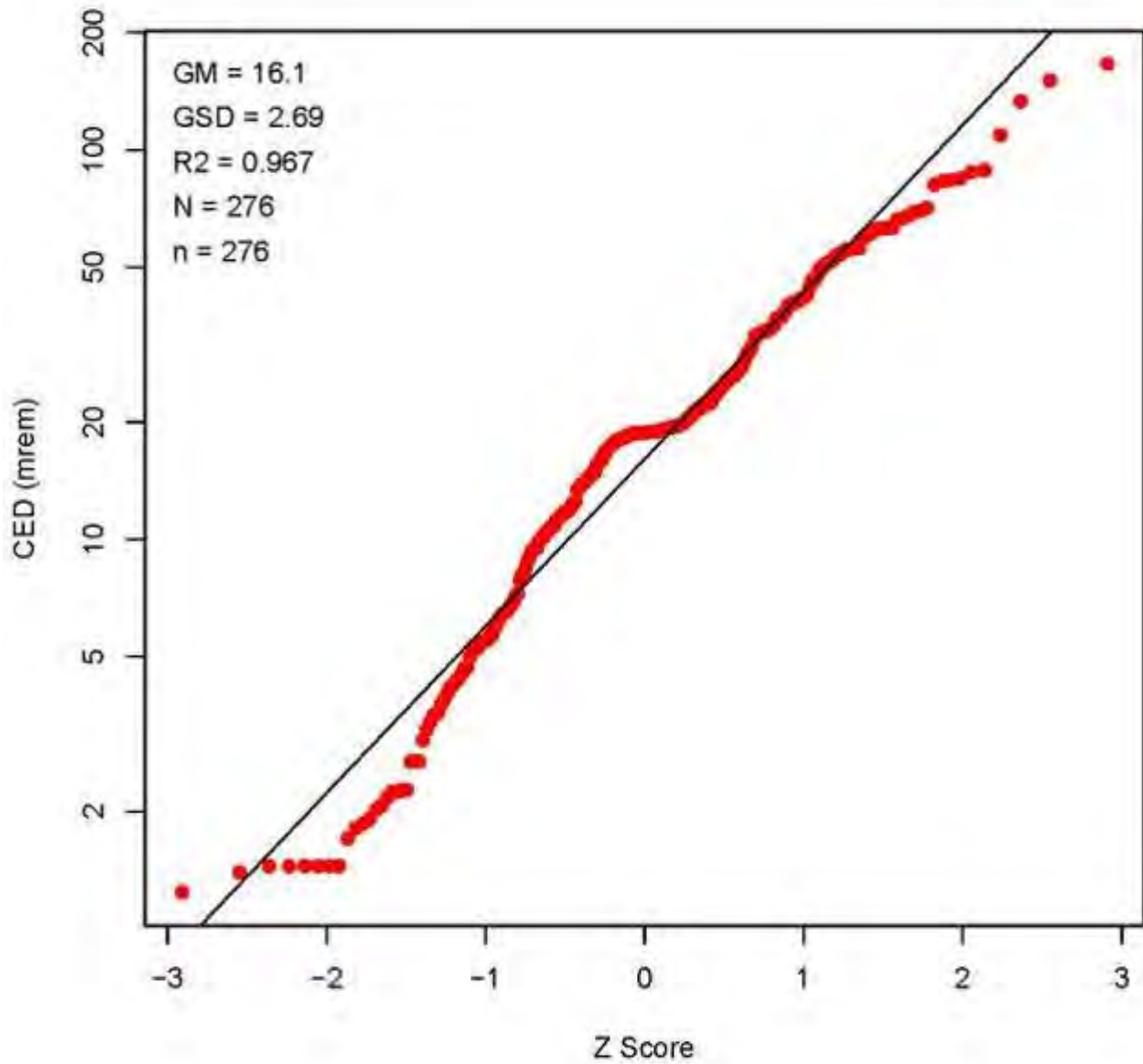


Figure C-113. SRS tritium dose 1982.

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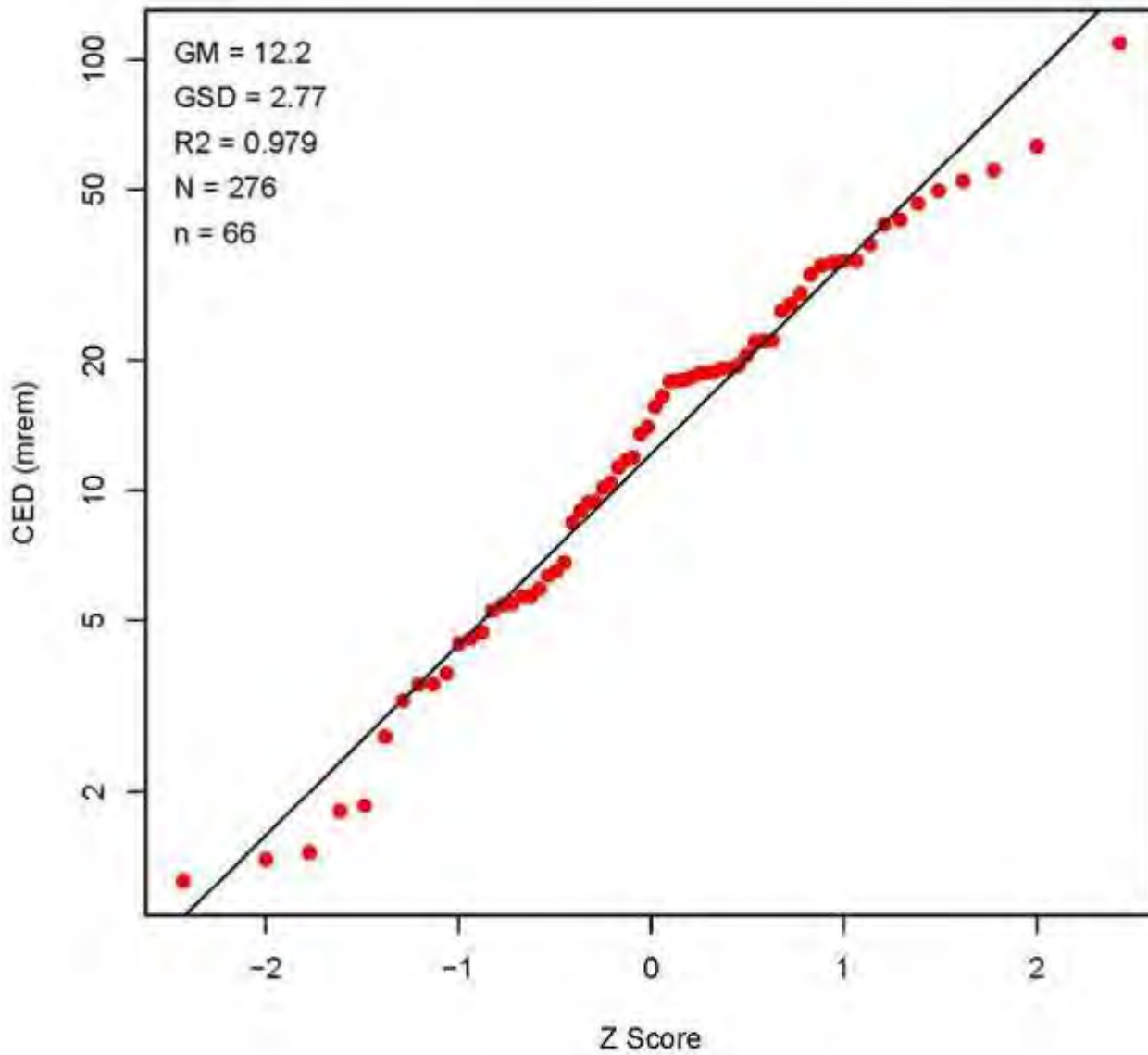


Figure C-114. SRS CTW/Reactor tritium dose 1982.

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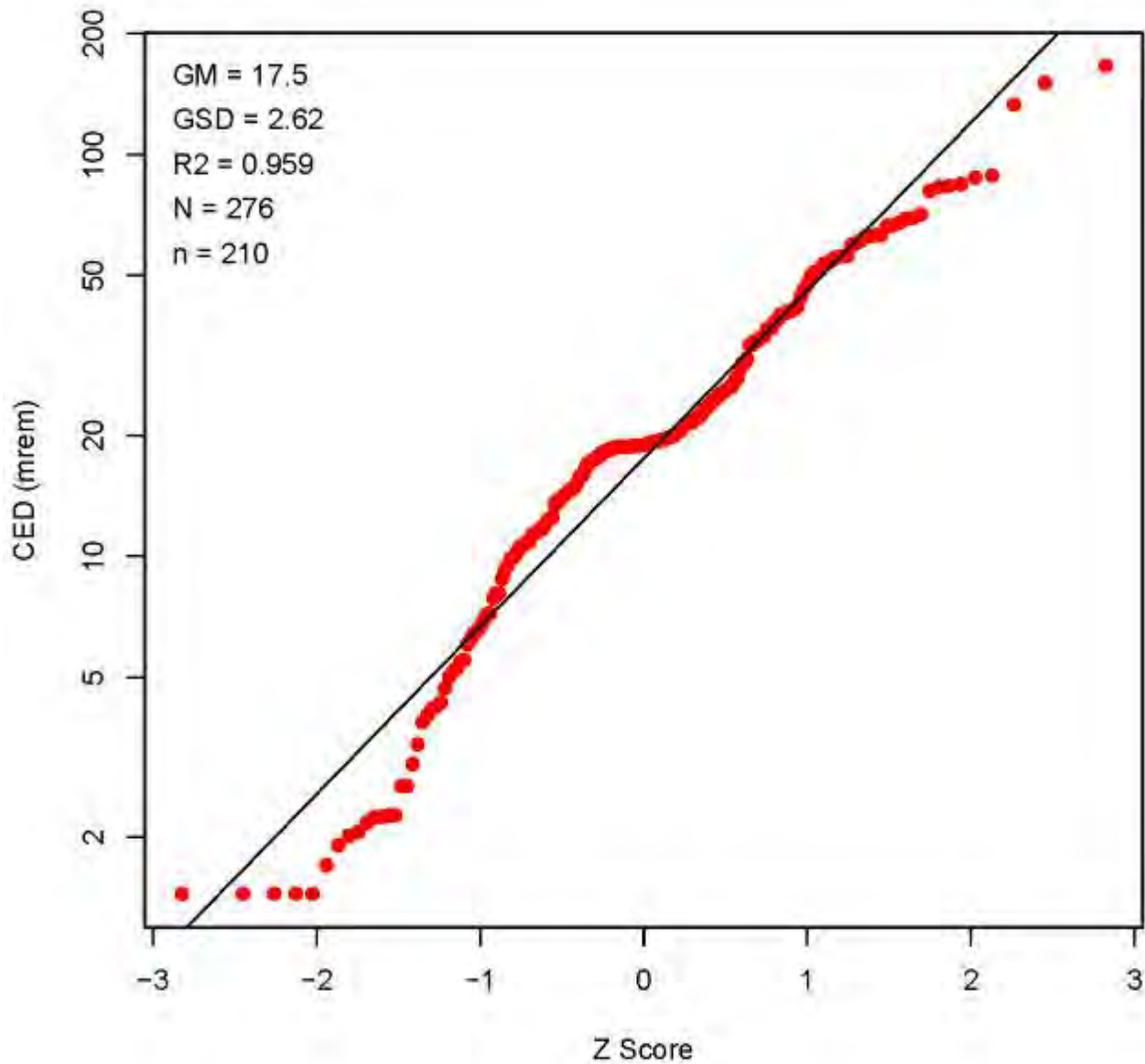


Figure C-115. SRS Non(CTW/Reactor) tritium dose 1982.

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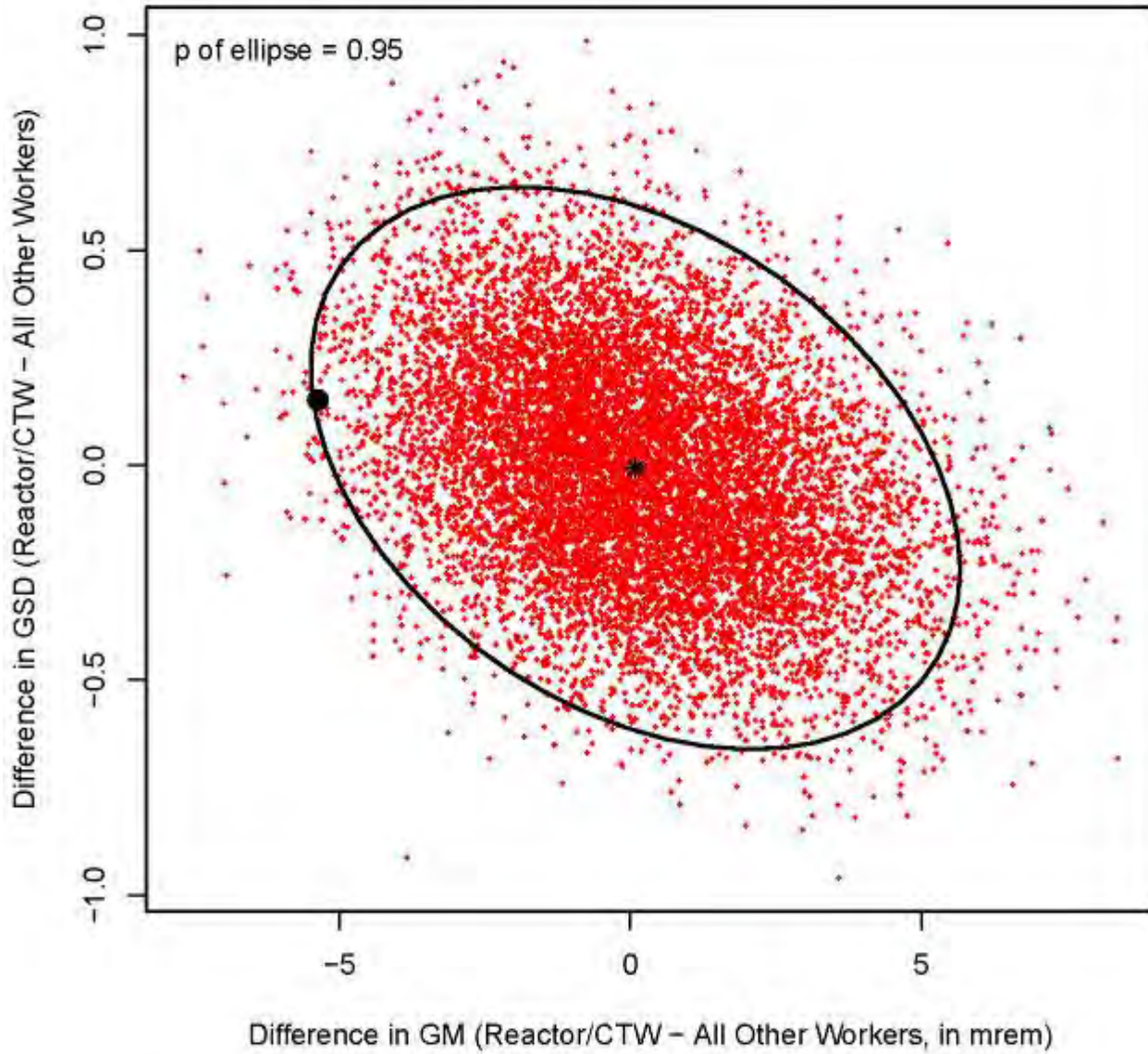


Figure C-116. SRS tritium dose 1982.

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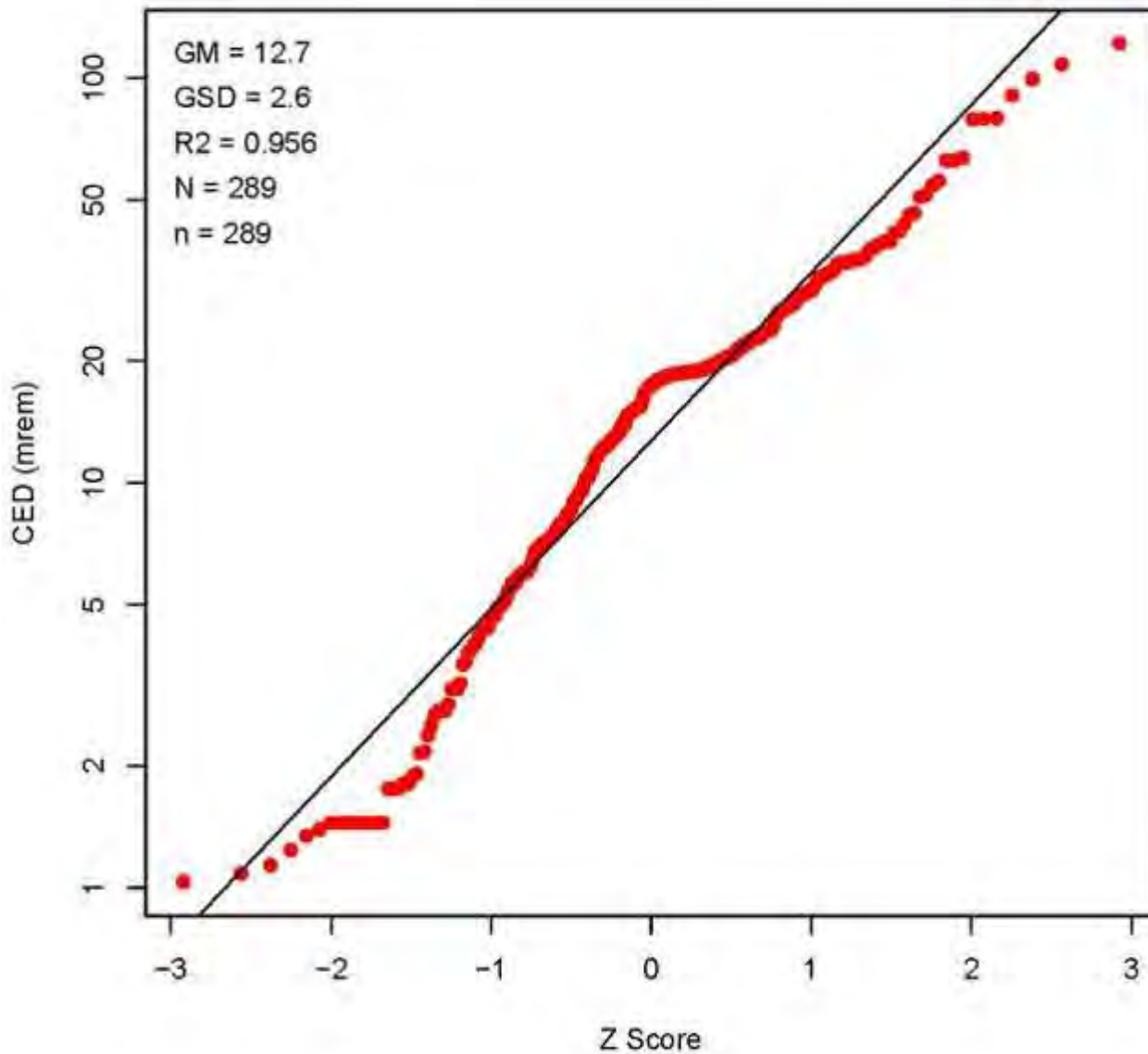


Figure C-117. SRS tritium dose 1983.

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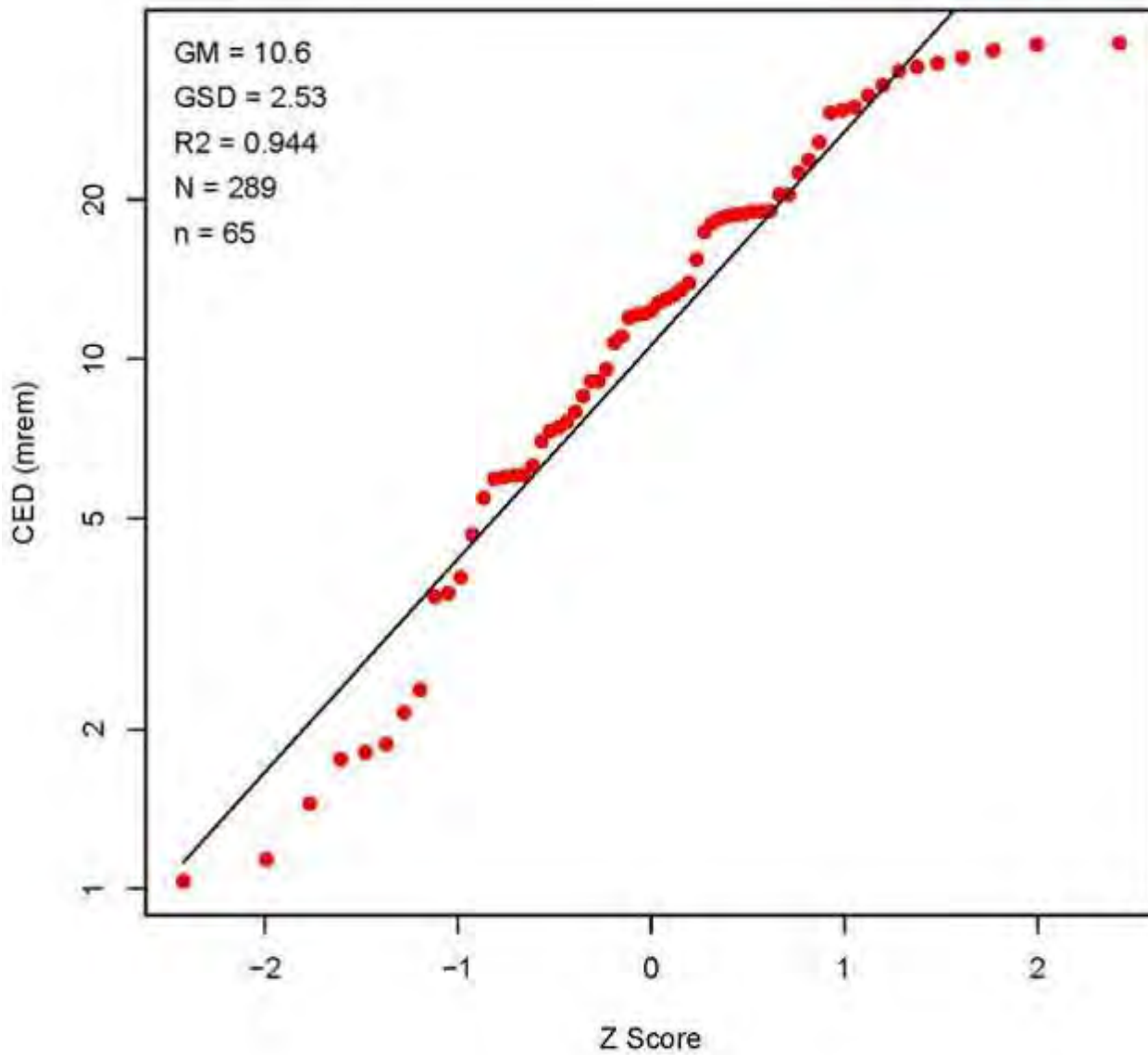


Figure C-118. SRS CTW/Reactor tritium dose 1983.

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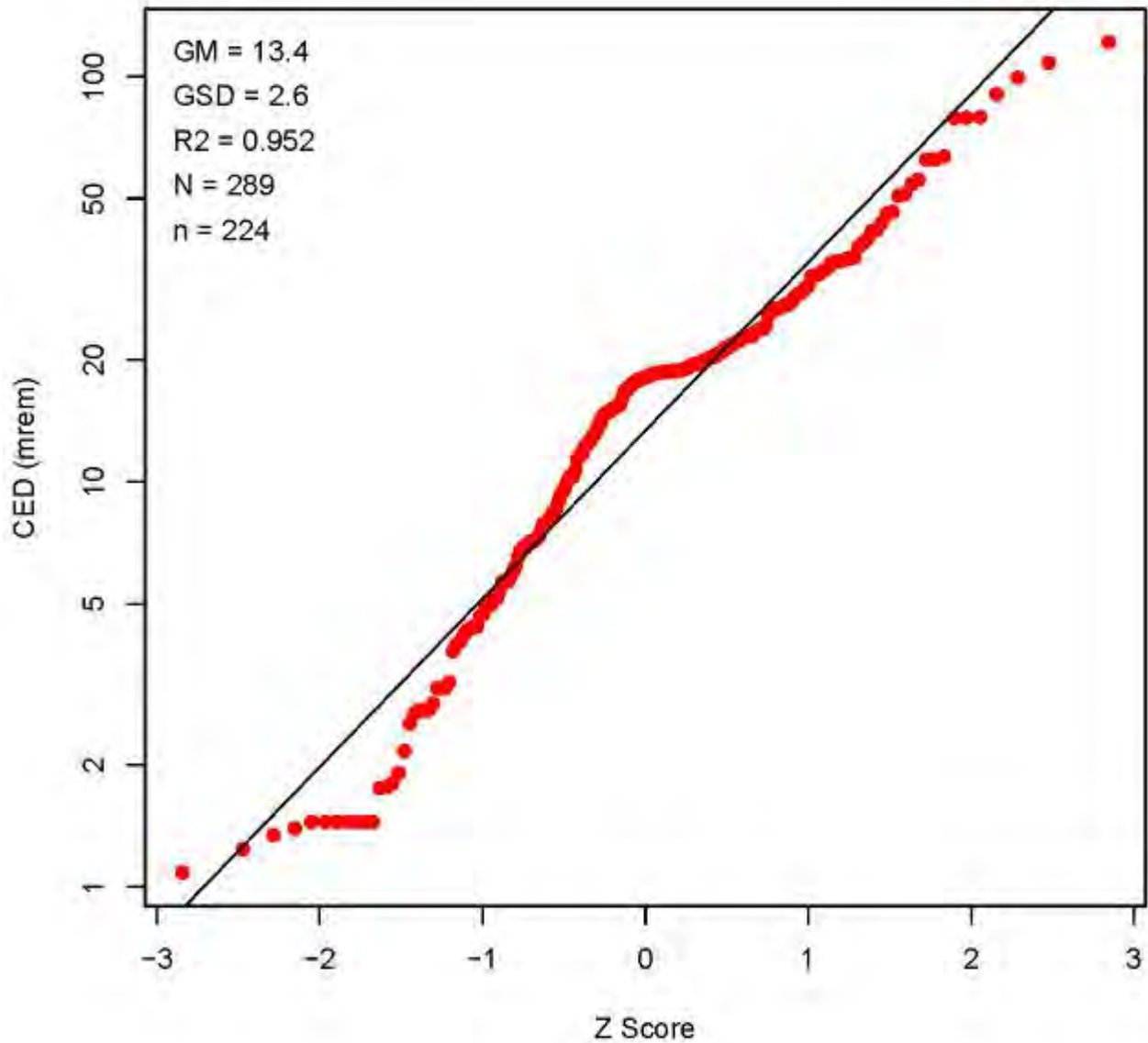


Figure C-119. SRS Non(CTW/Reactor) tritium dose 1983.

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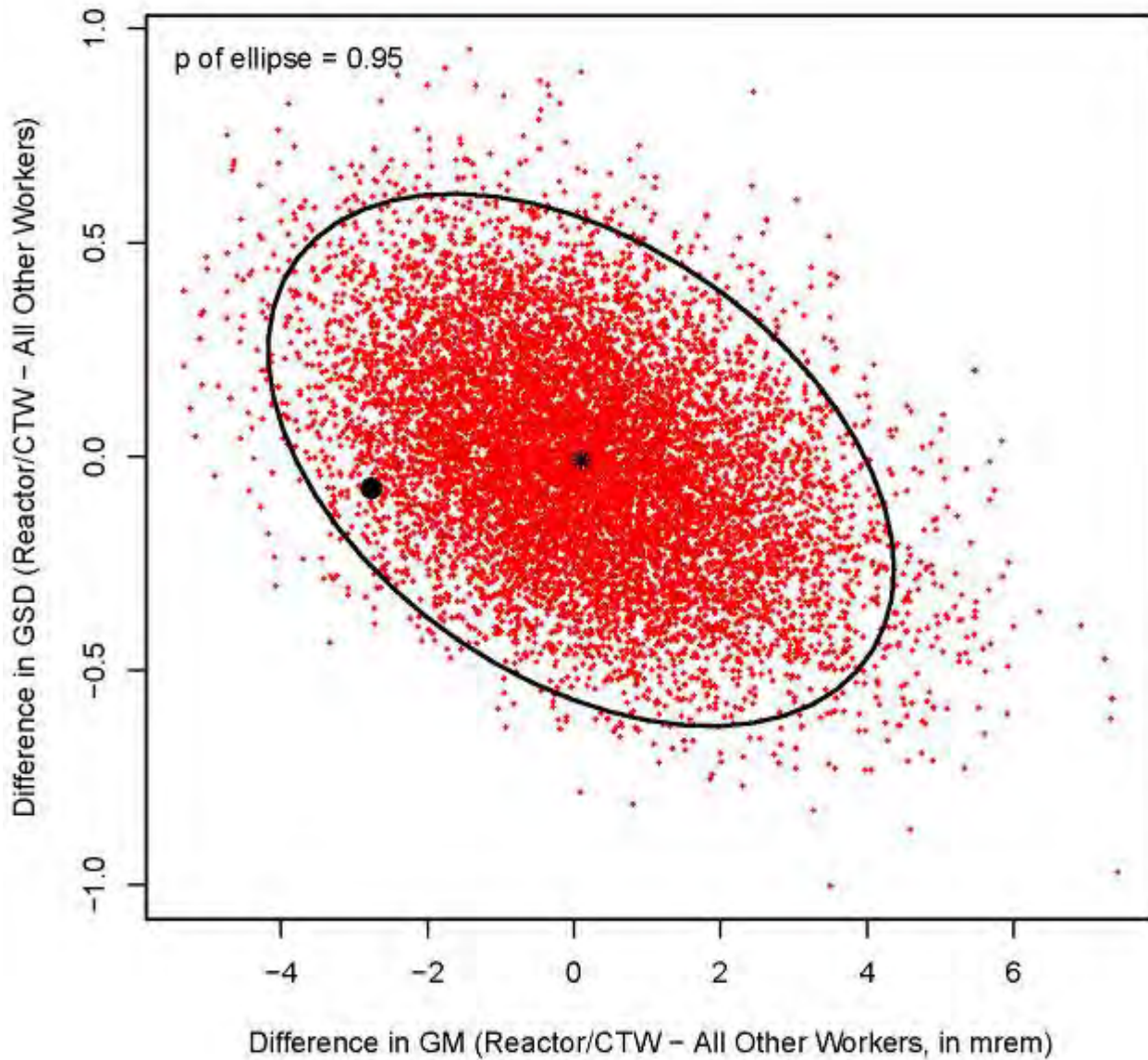


Figure C-120. SRS tritium dose 1983.

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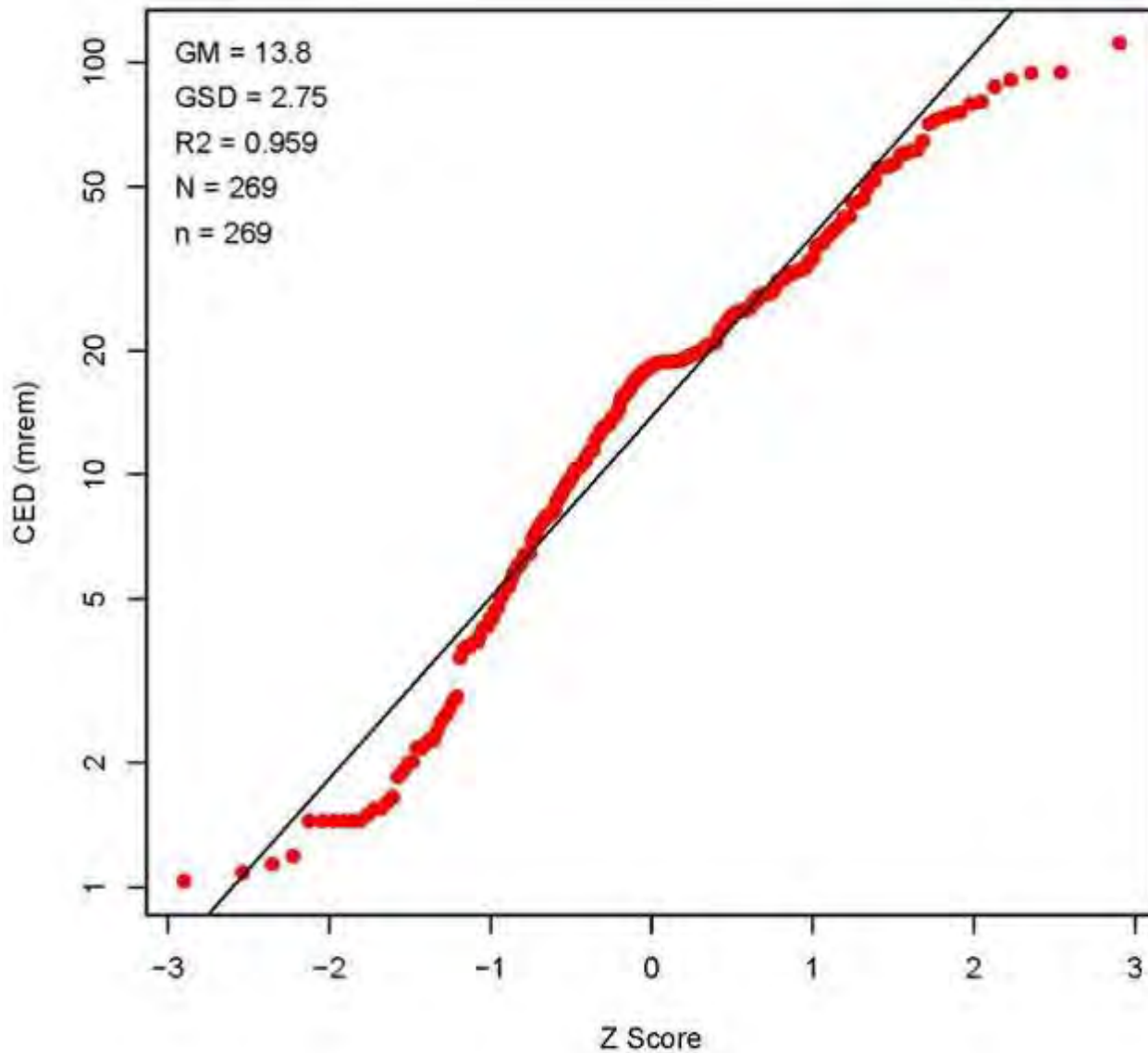


Figure C-121. SRS tritium dose 1984.

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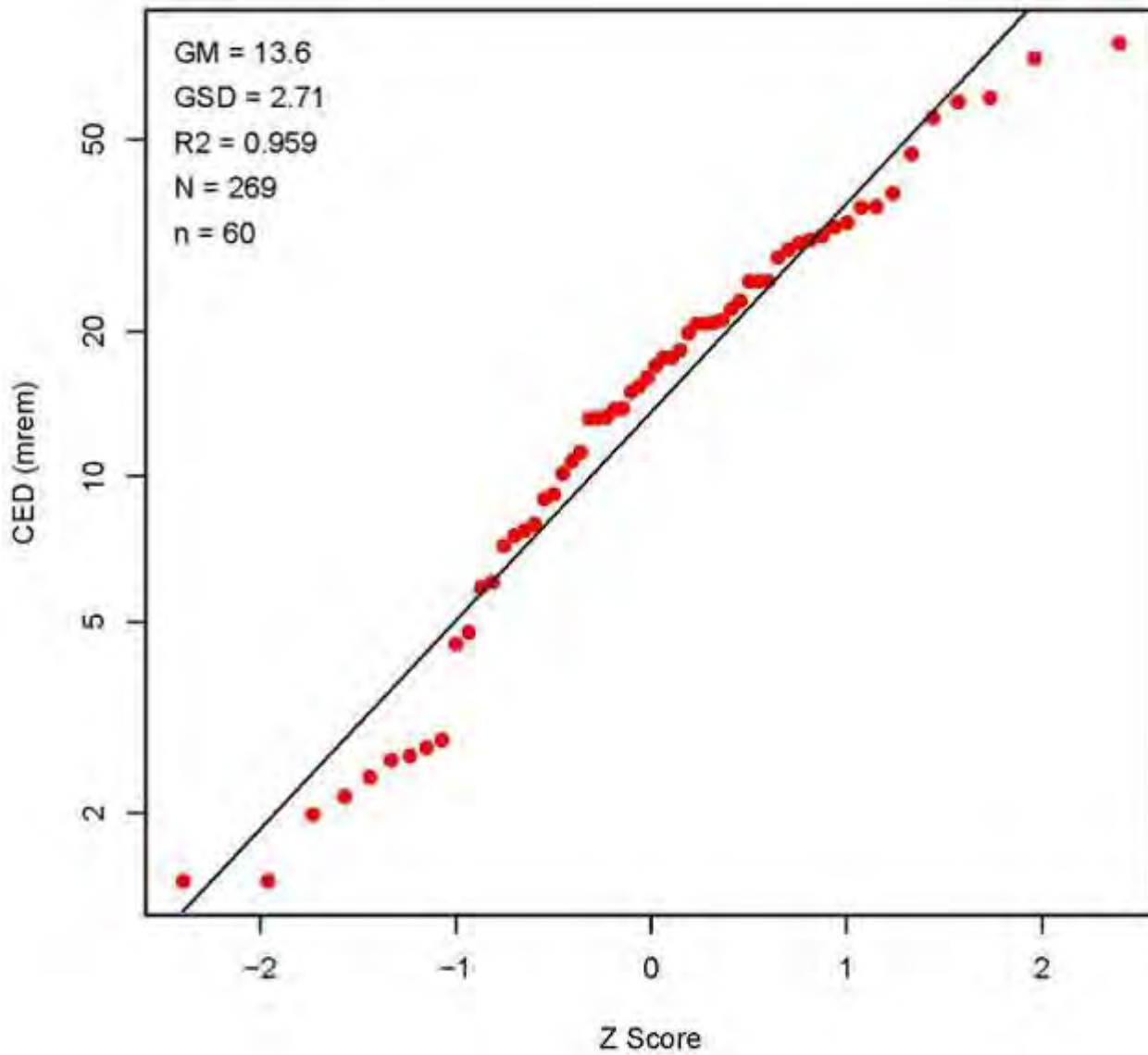


Figure C-122. SRS CTW/Reactor tritium dose 1984.

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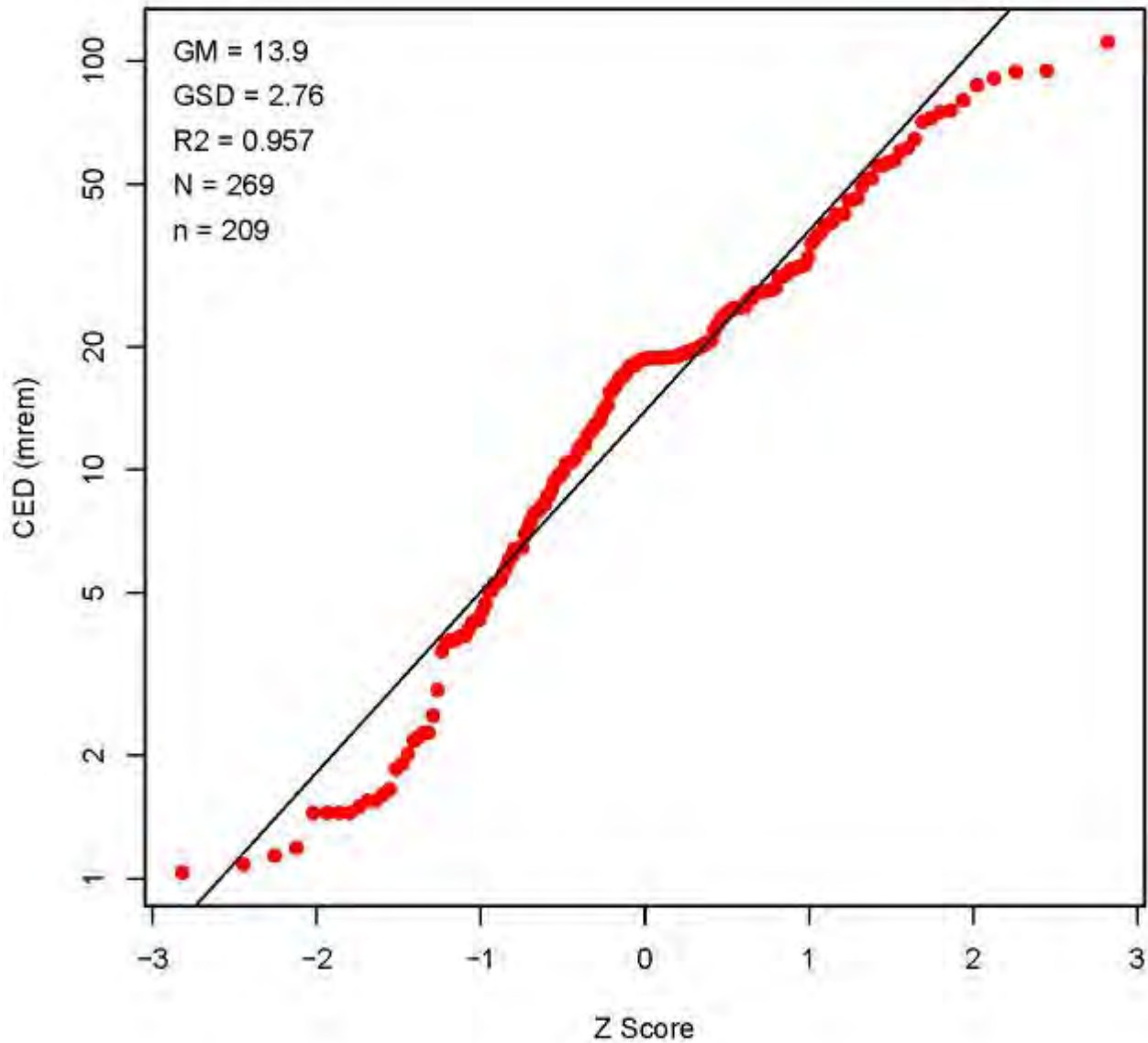


Figure C-123. SRS Non(CTW/Reactor) tritium dose 1984.

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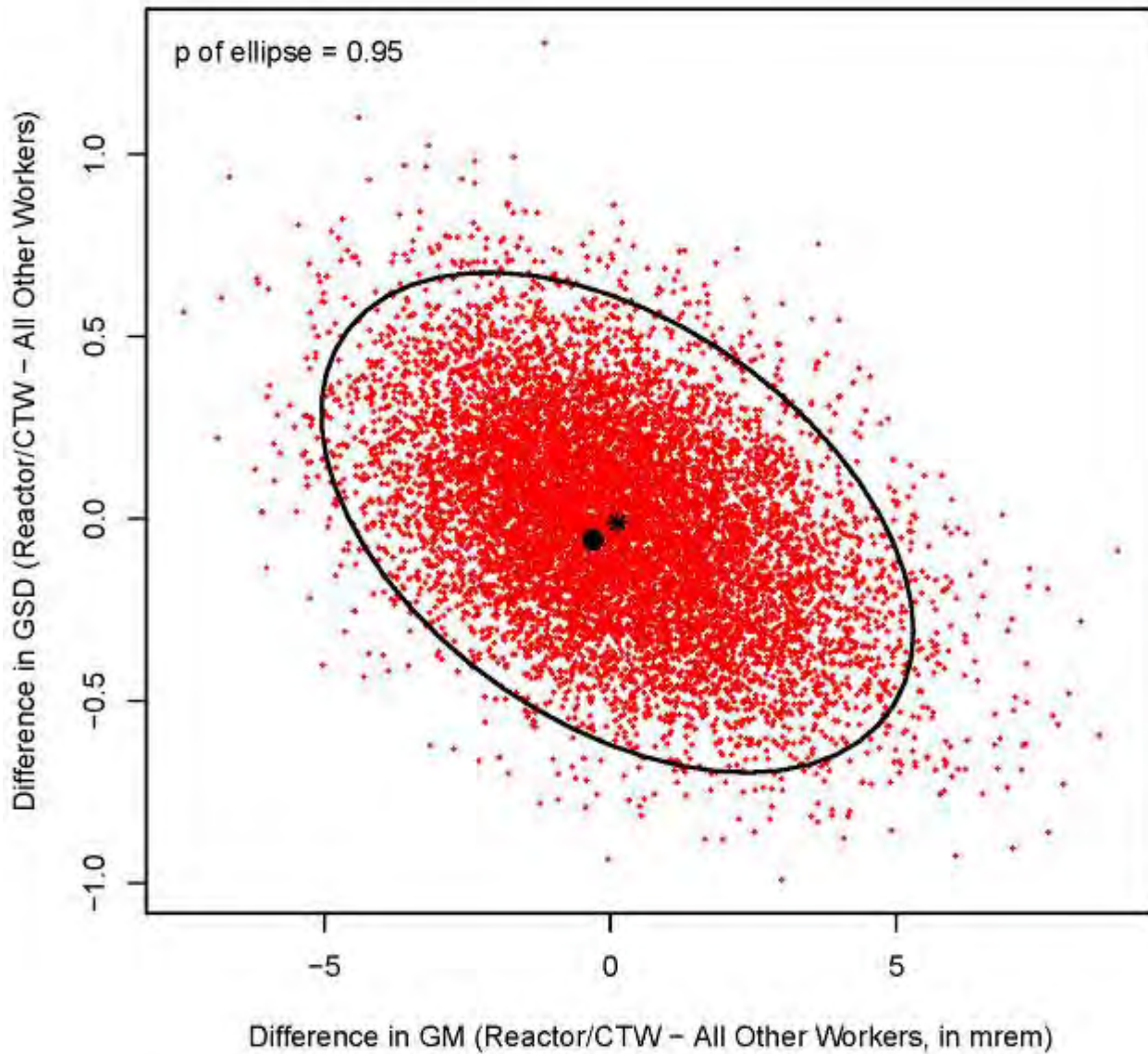


Figure C-124. SRS tritium dose 1984.

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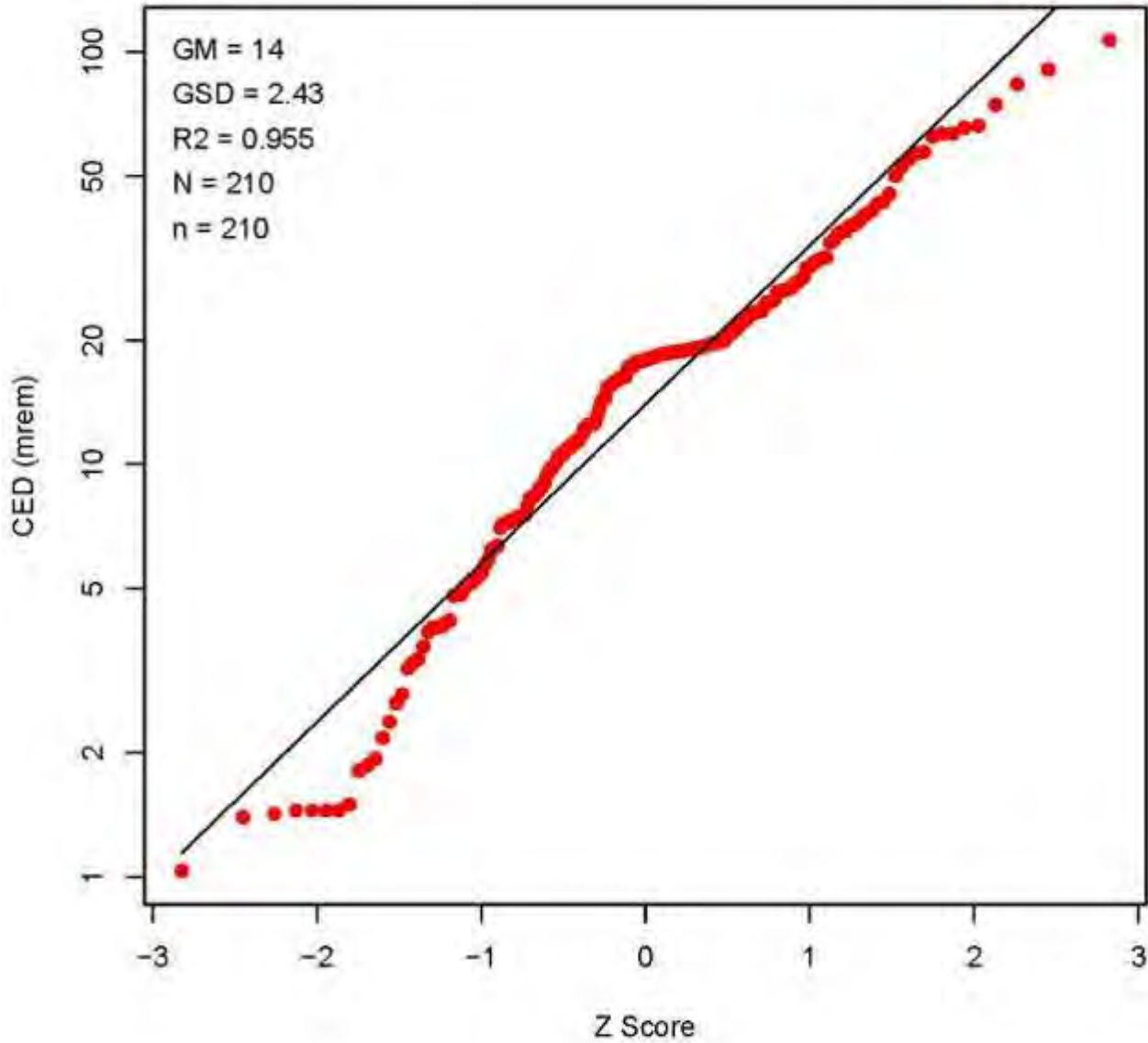


Figure C-125. SRS tritium dose 1985.

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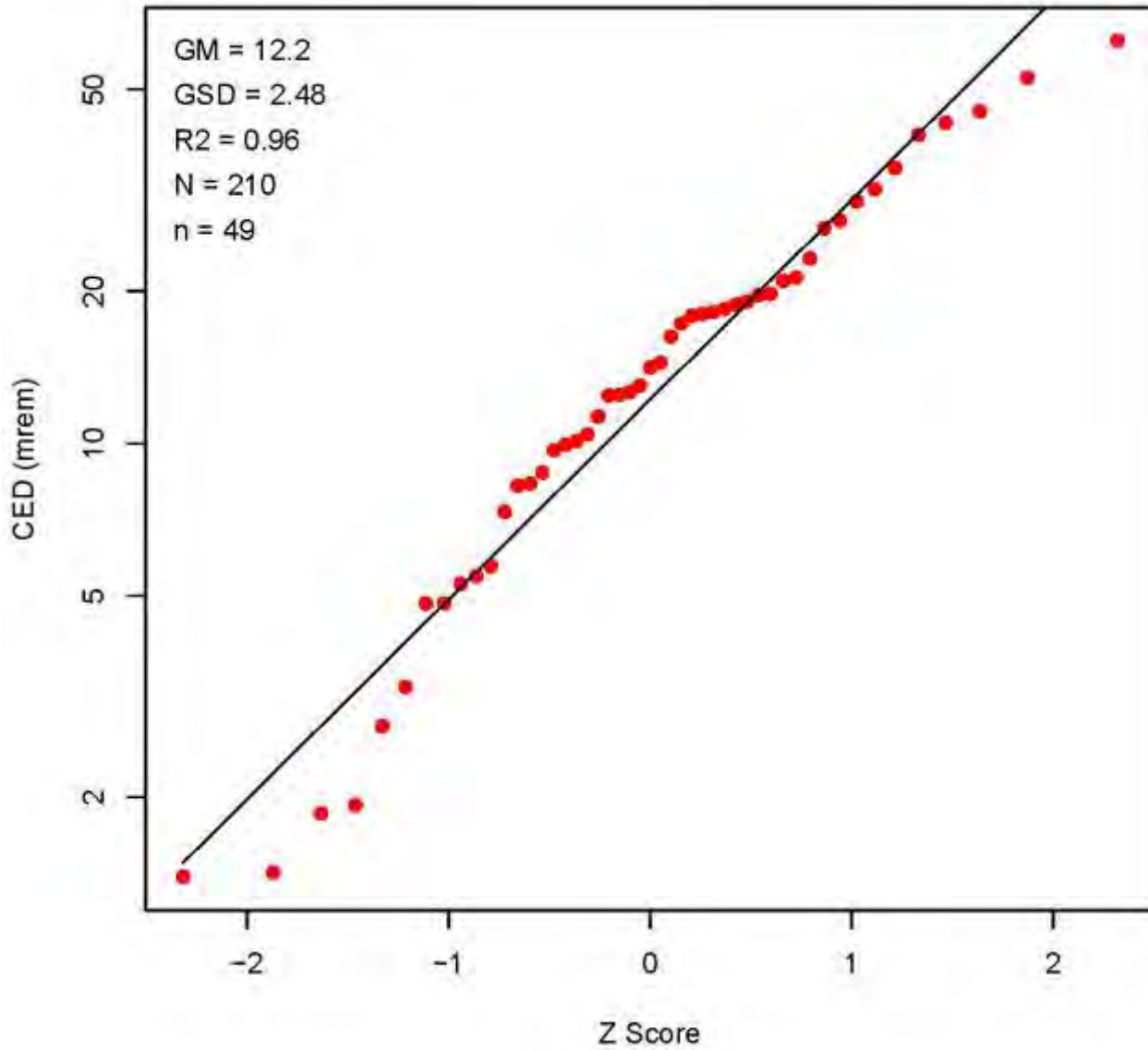


Figure C-126. SRS CTW/Reactor tritium dose 1985.

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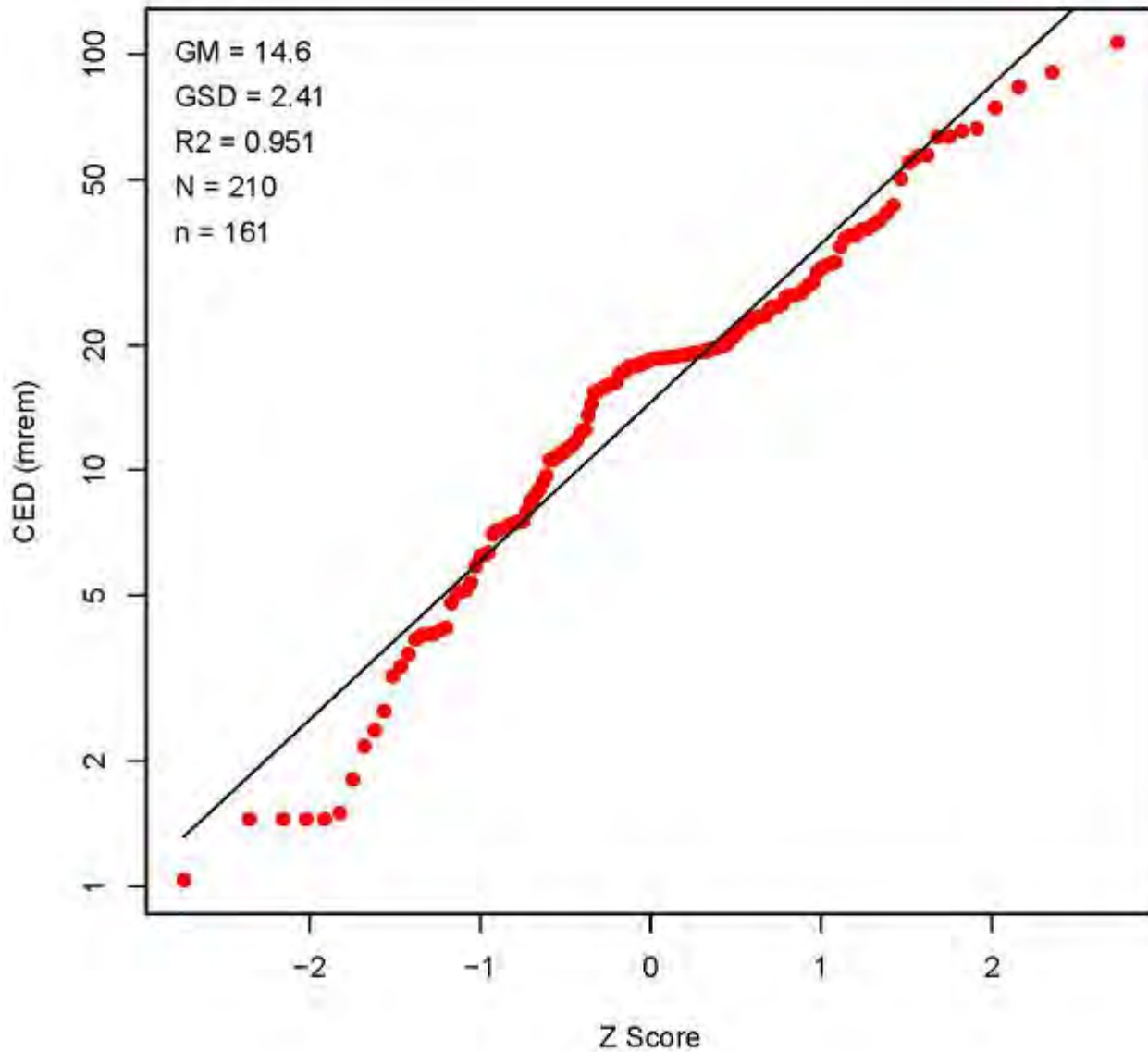


Figure C-127. SRS Non(CTW/Reactor) tritium dose 1985.

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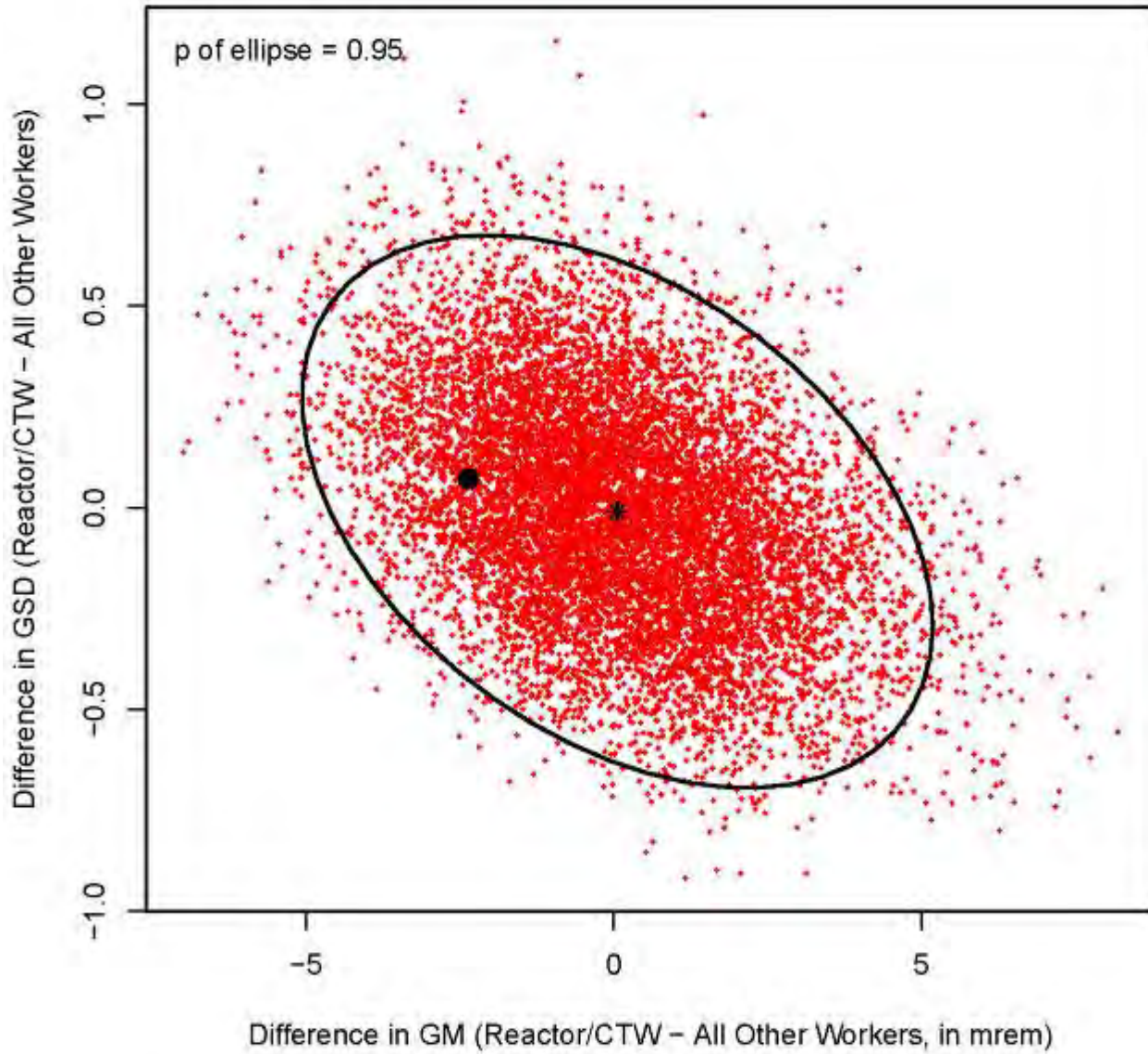


Figure C-128. SRS tritium dose 1985.

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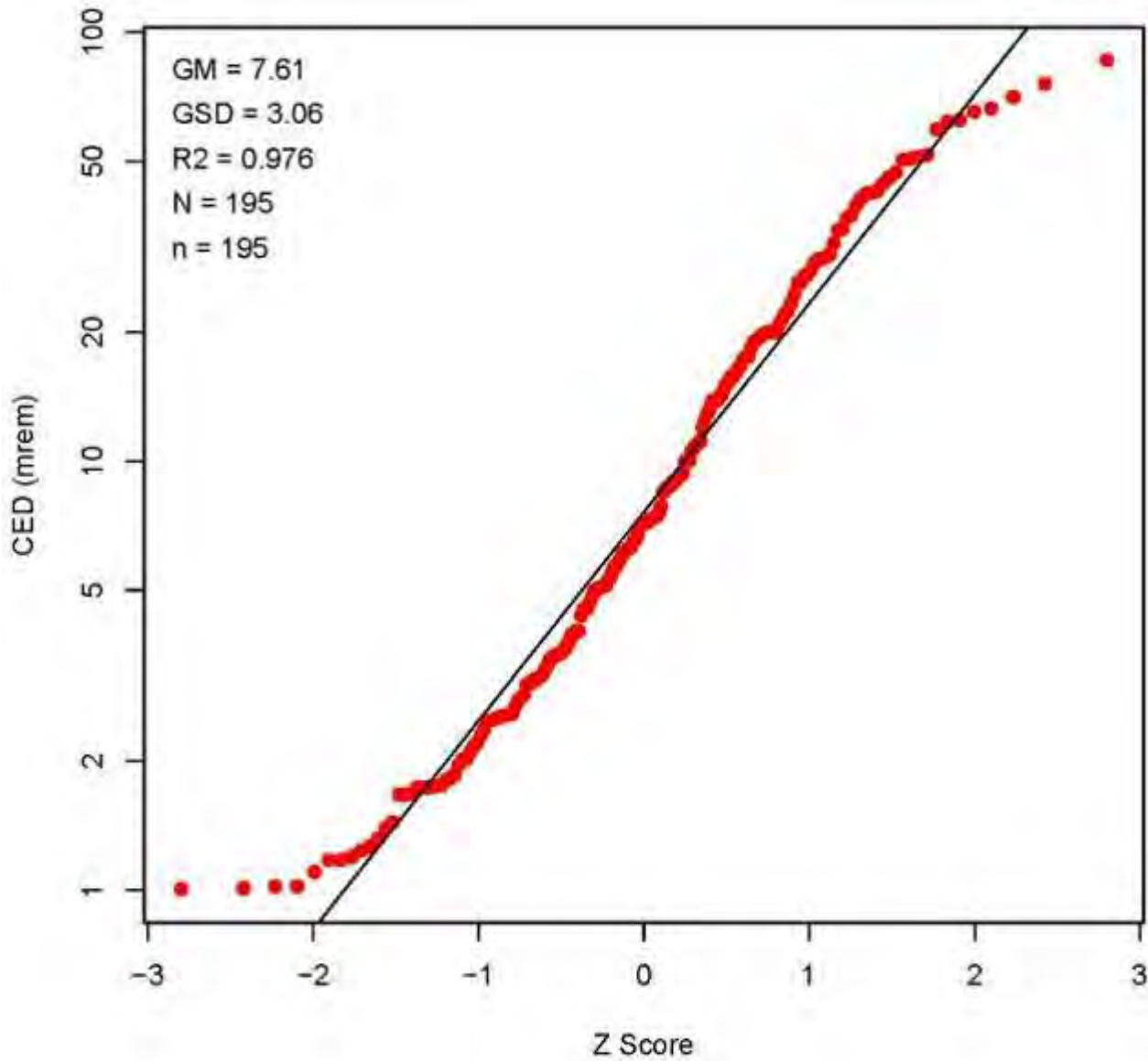


Figure C-129. SRS tritium dose 1986.

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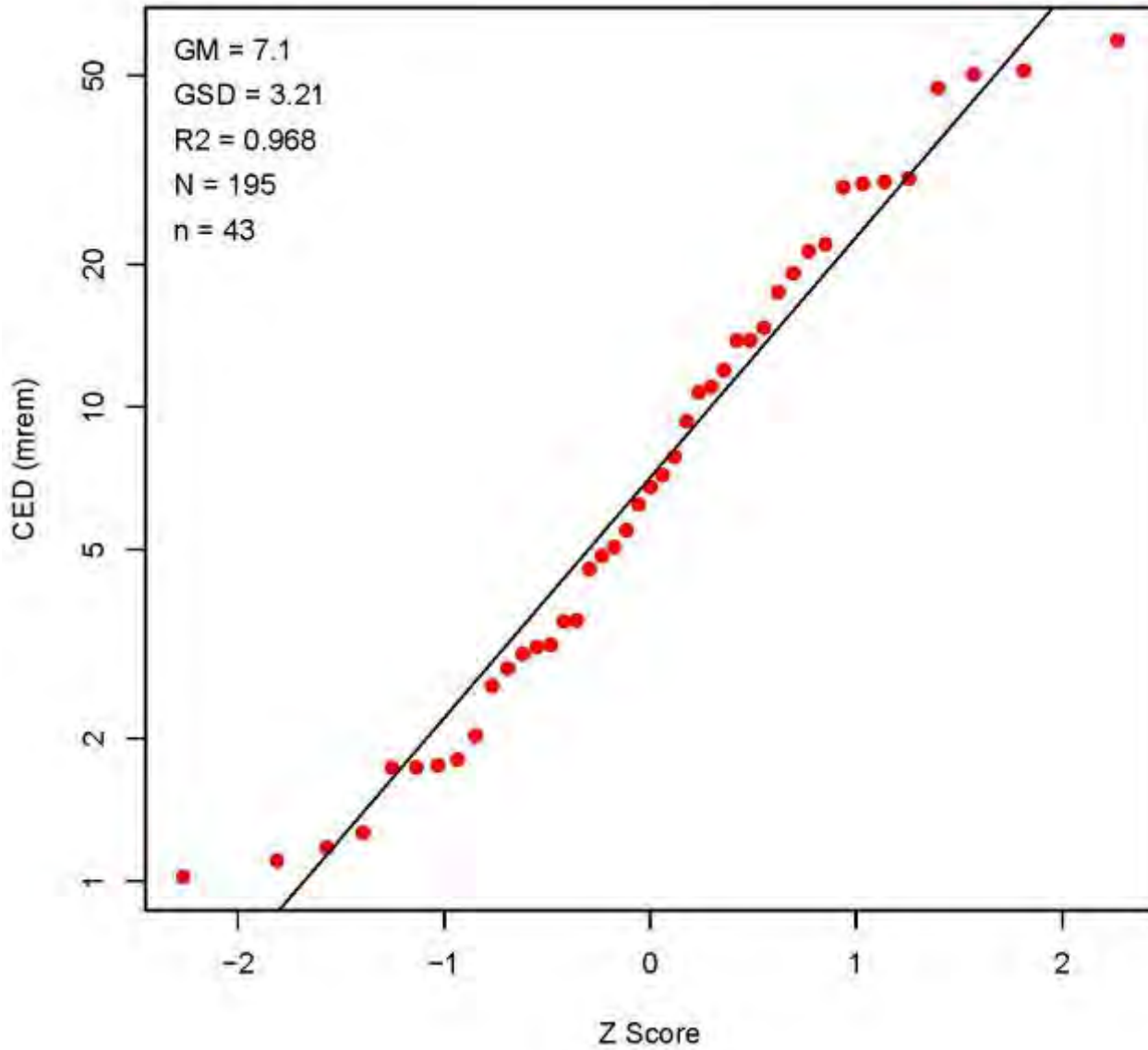


Figure C-130. SRS CTW/Reactor tritium dose 1986.

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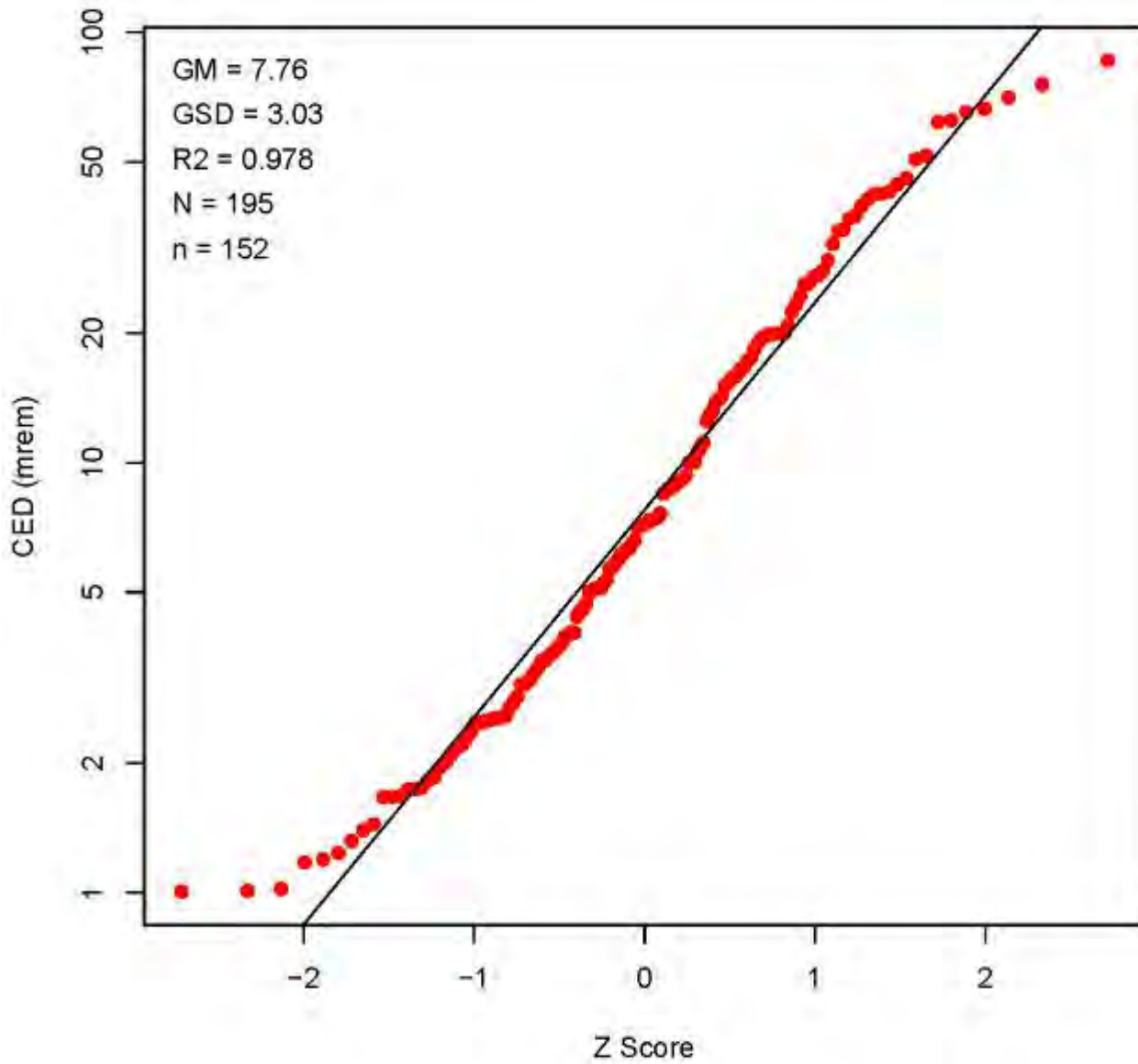


Figure C-131. SRS Non(CTW/Reactor) tritium dose 1986.

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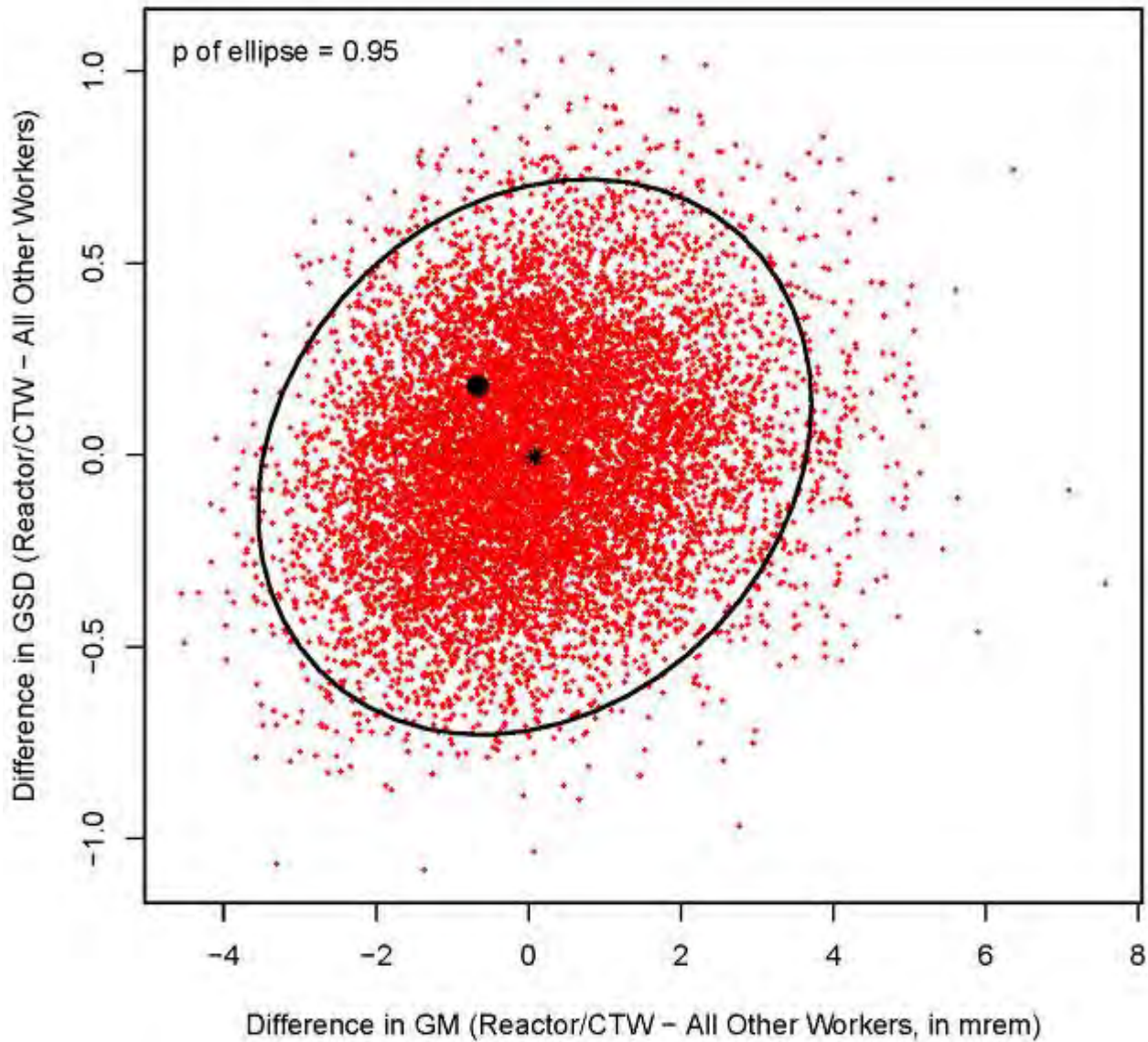


Figure C-132. SRS tritium dose 1986.

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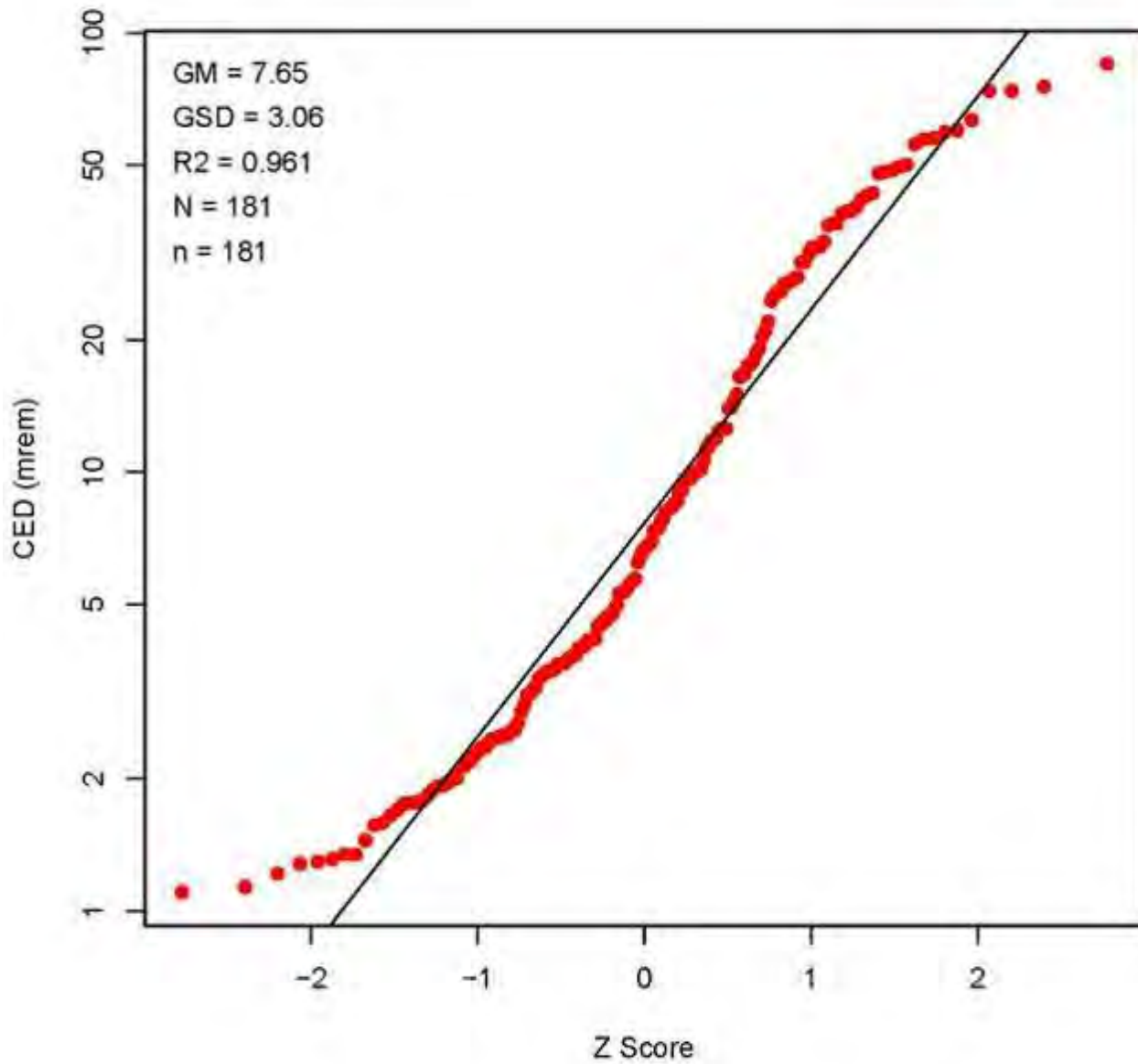


Figure C-133. SRS tritium dose 1987.

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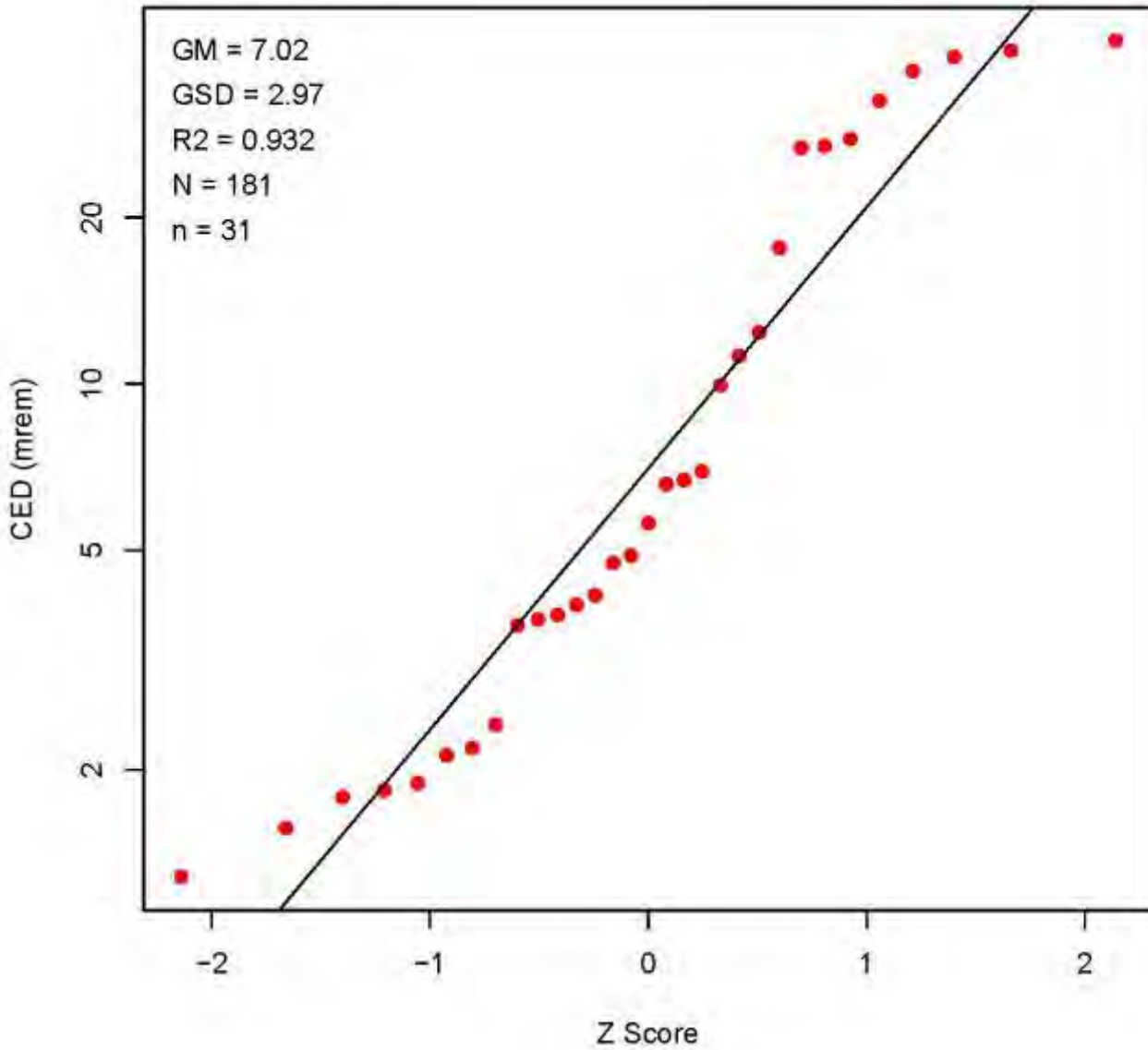


Figure C-134. SRS CTW/Reactor tritium dose 1987.

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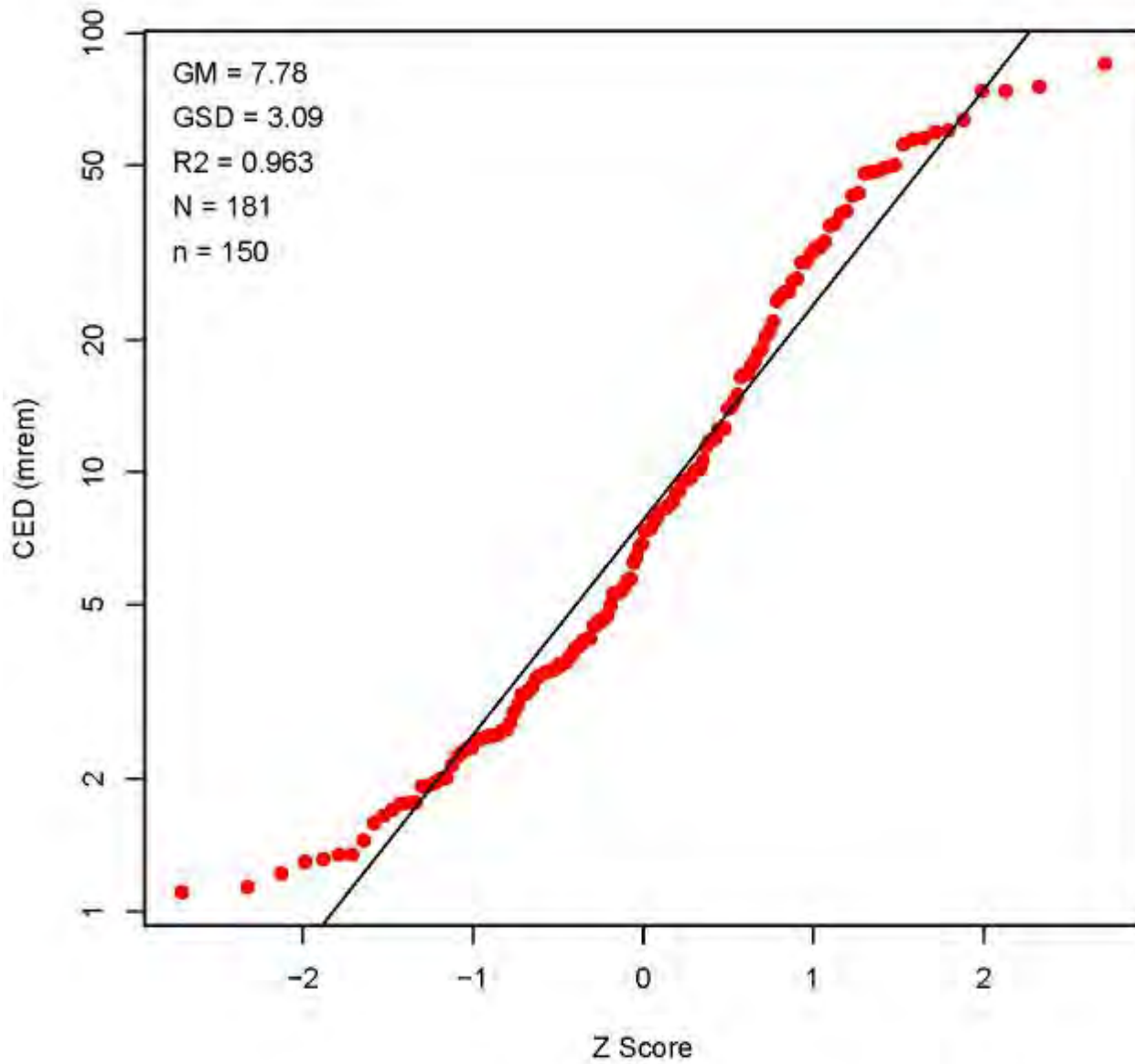


Figure C-135. SRS Non(CTW/Reactor) tritium dose 1987.

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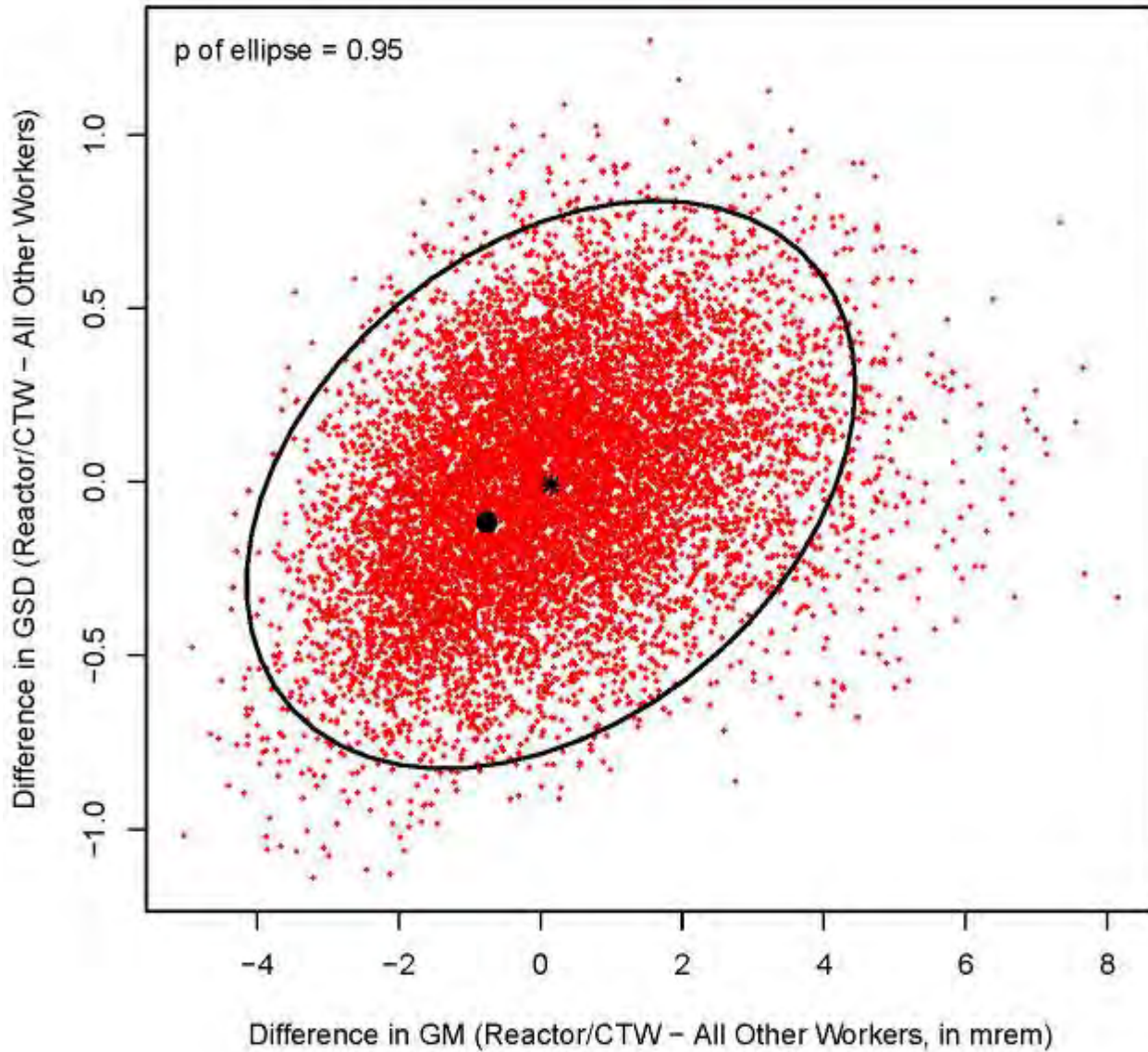


Figure C-136. SRS tritium dose 1987.

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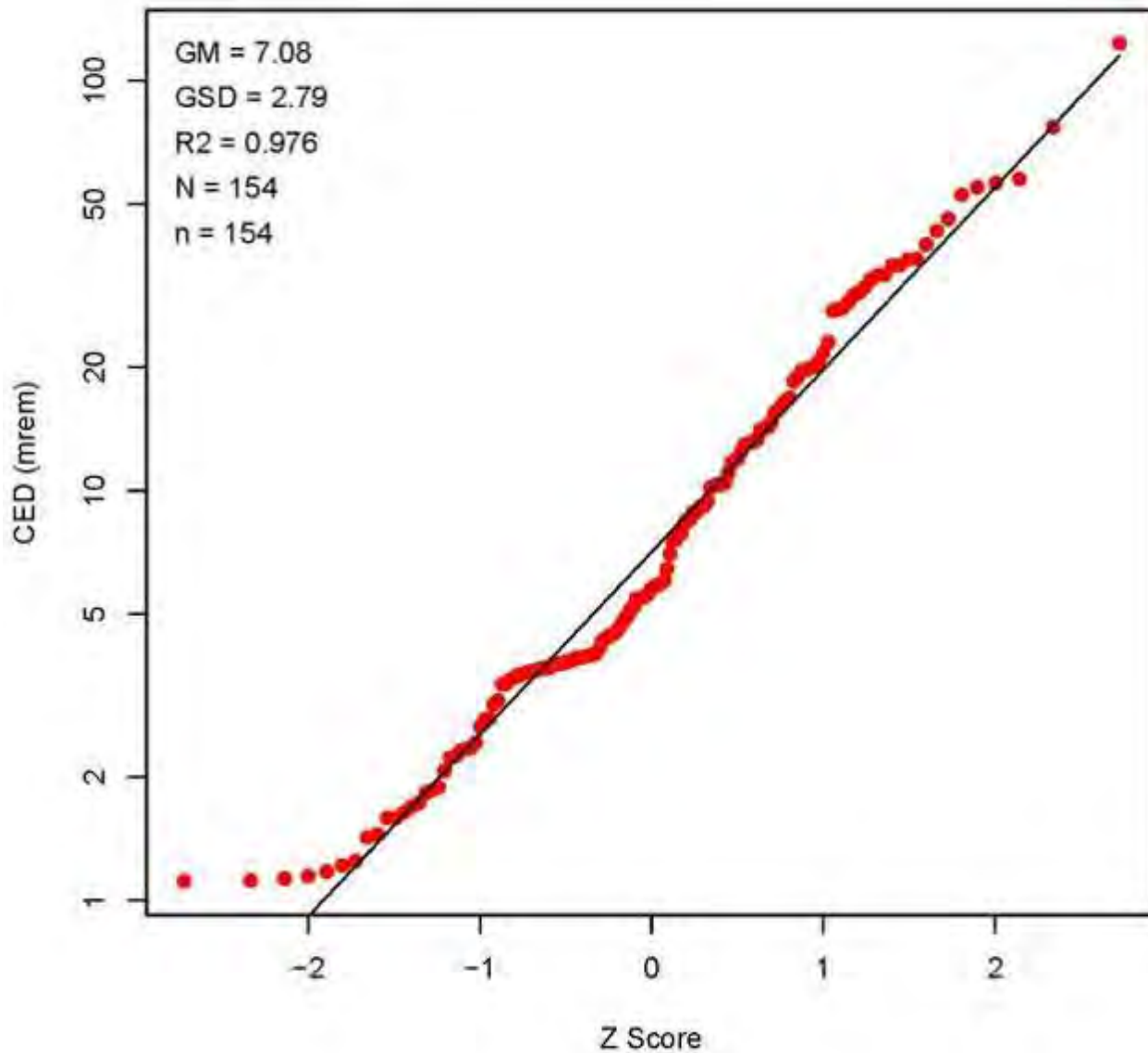


Figure C-137. SRS tritium dose 1988.

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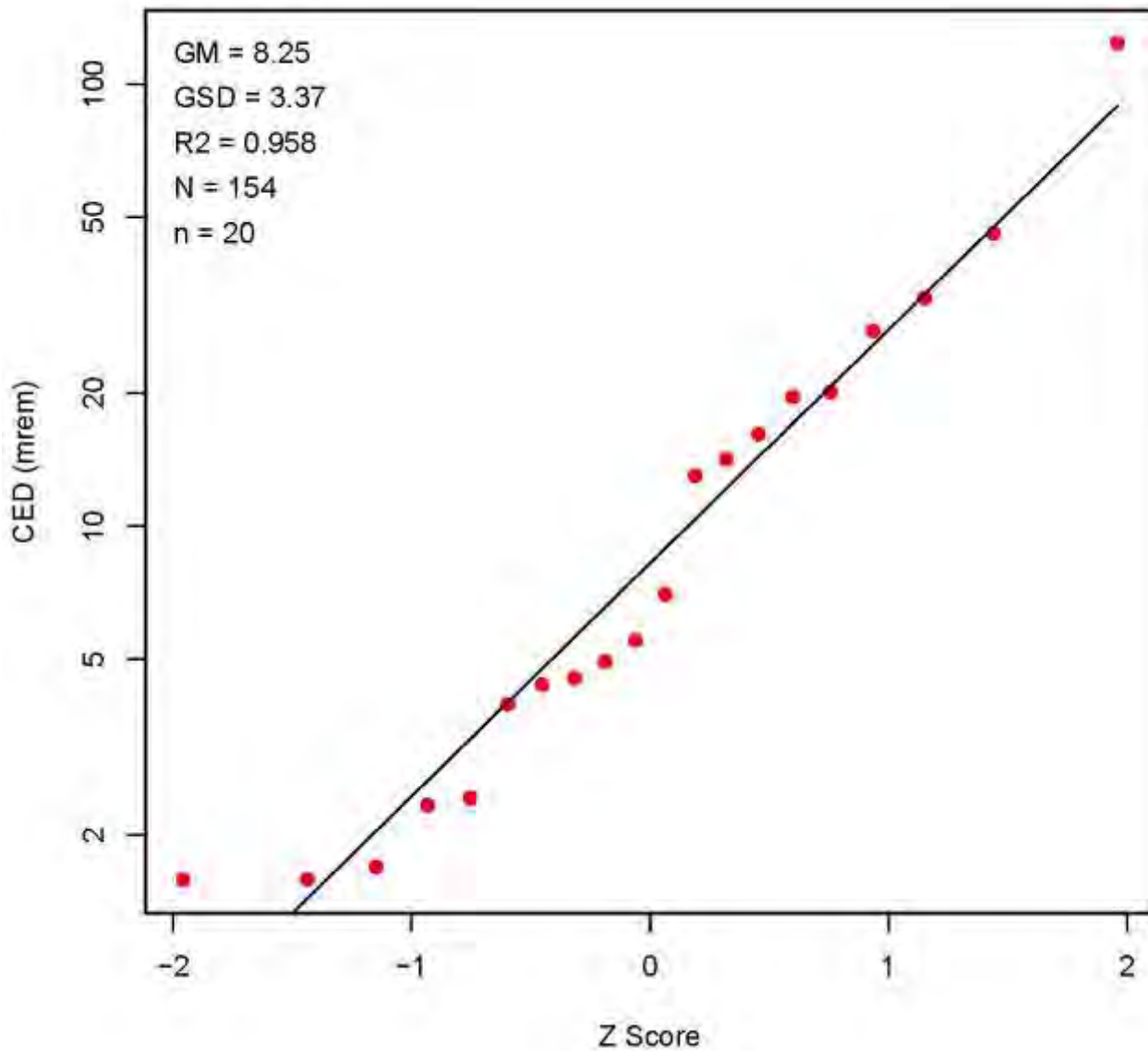


Figure C-138. SRS CTW/Reactor tritium dose 1988.

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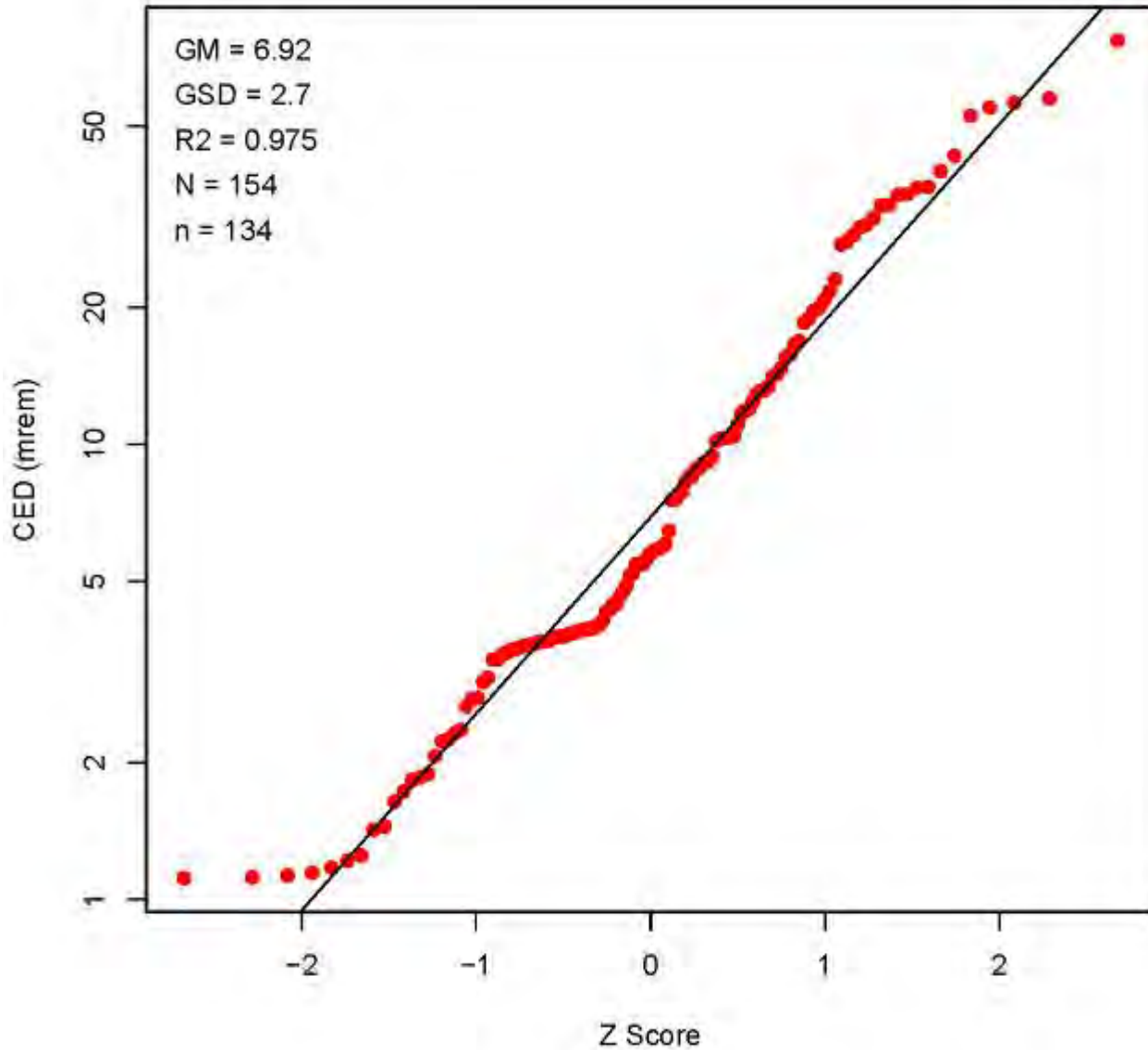


Figure C-139. SRS Non(CTW/Reactor) tritium dose 1988.

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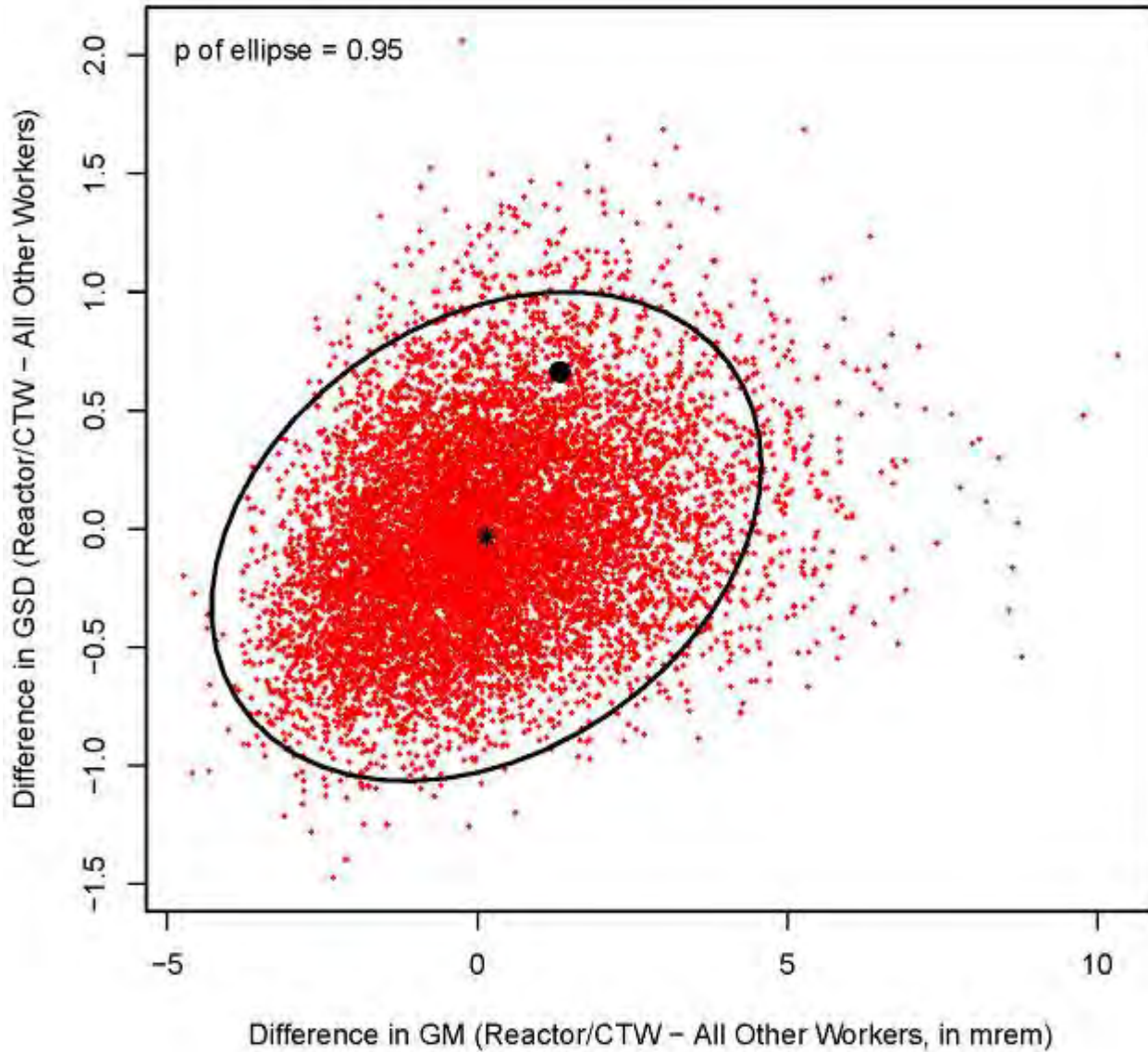


Figure C-140. SRS tritium dose 1988.

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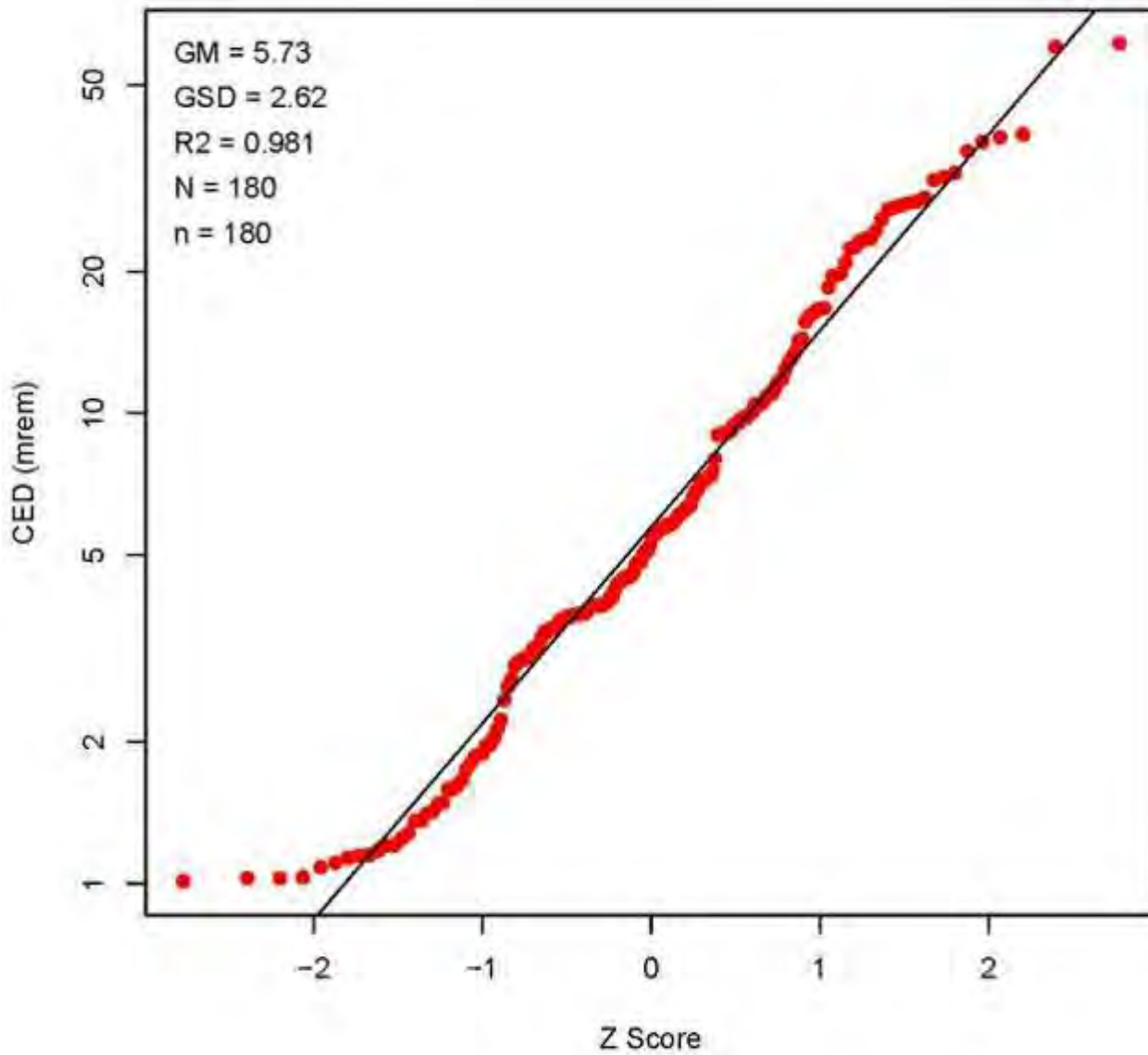


Figure C-141. SRS tritium dose 1989.

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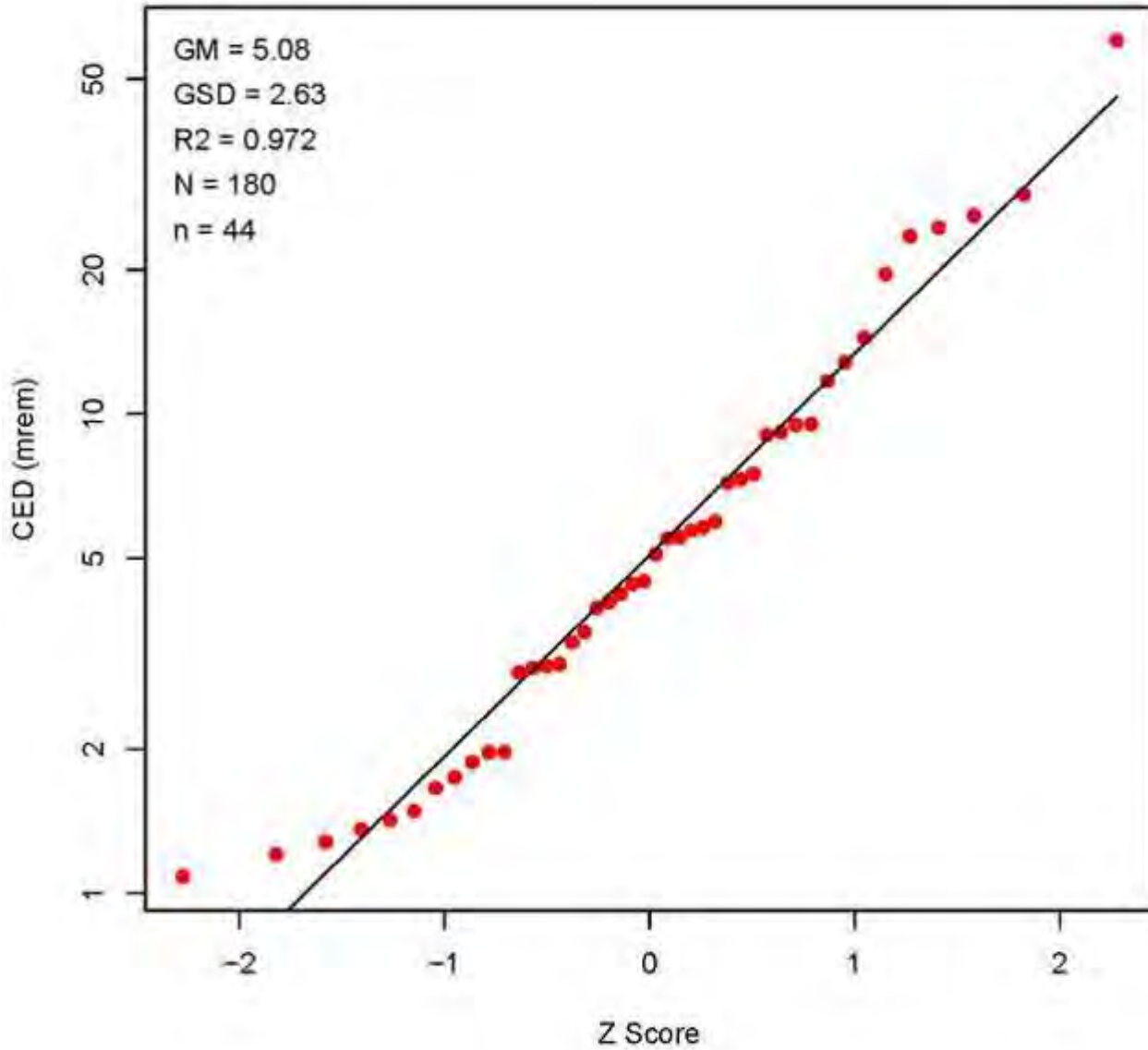


Figure C-142. SRS CTW/Reactor tritium dose 1989.

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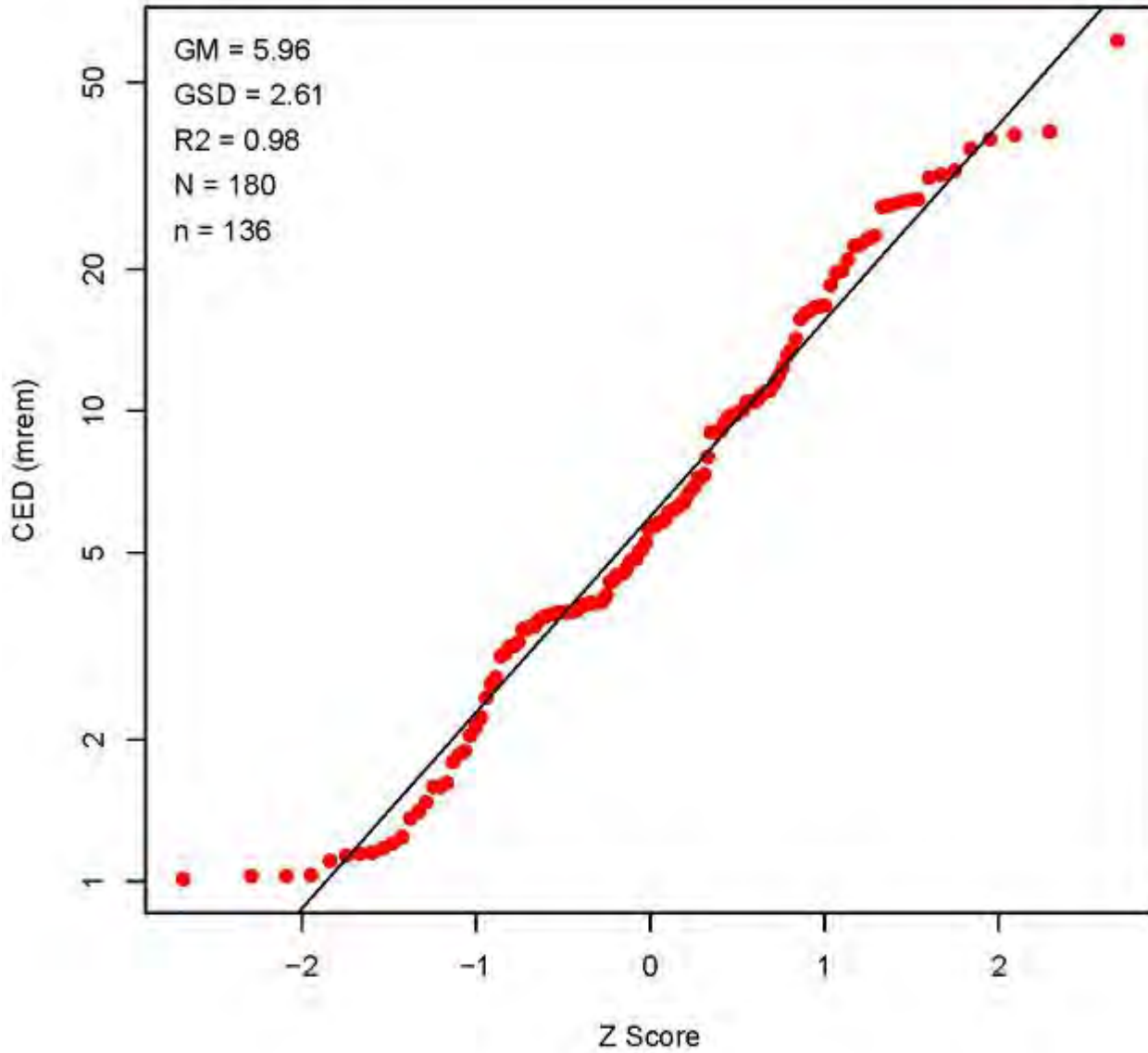


Figure C-143. SRS Non(CTW/Reactor) tritium dose 1989.

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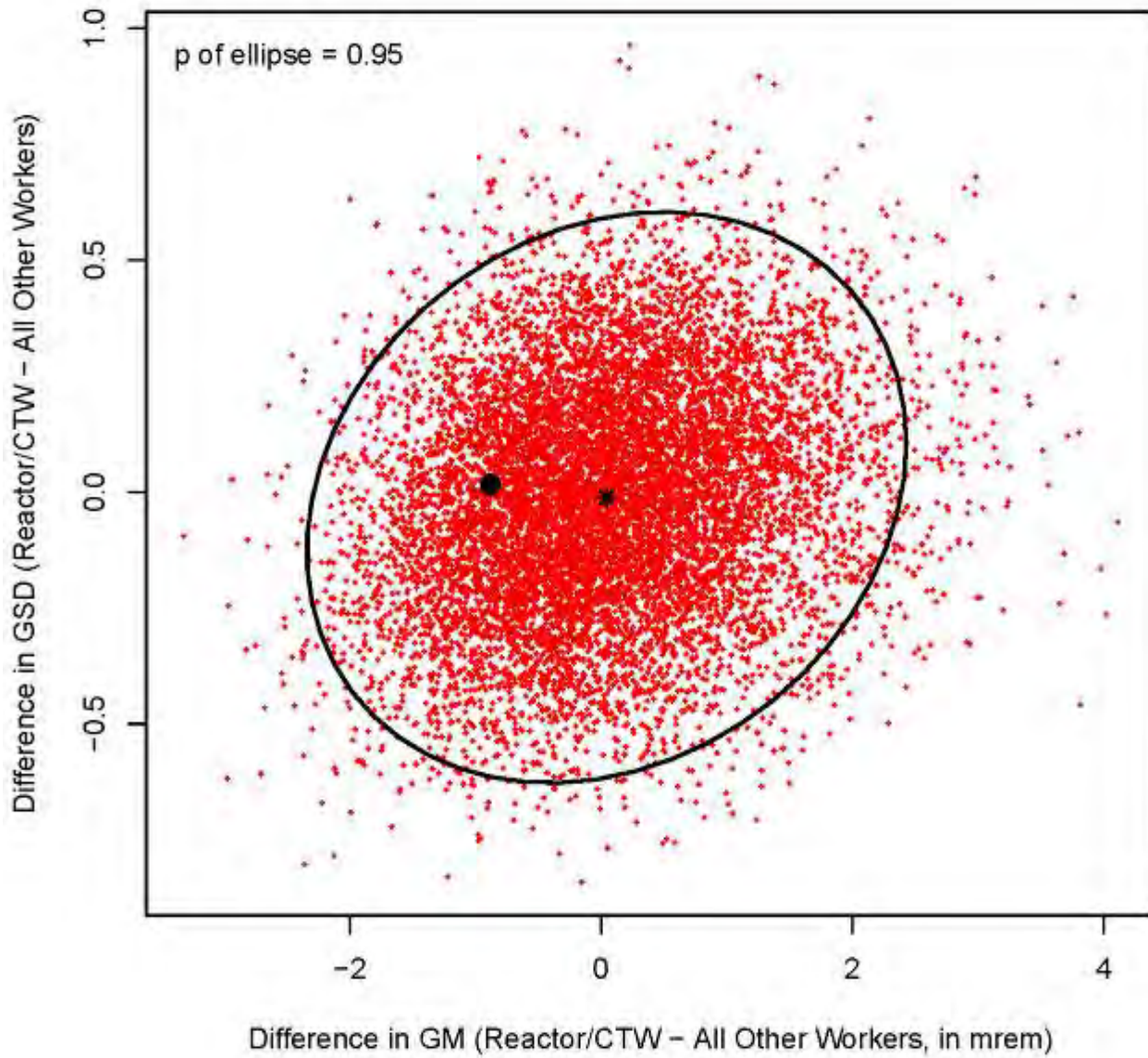


Figure C-144. SRS tritium dose 1989.

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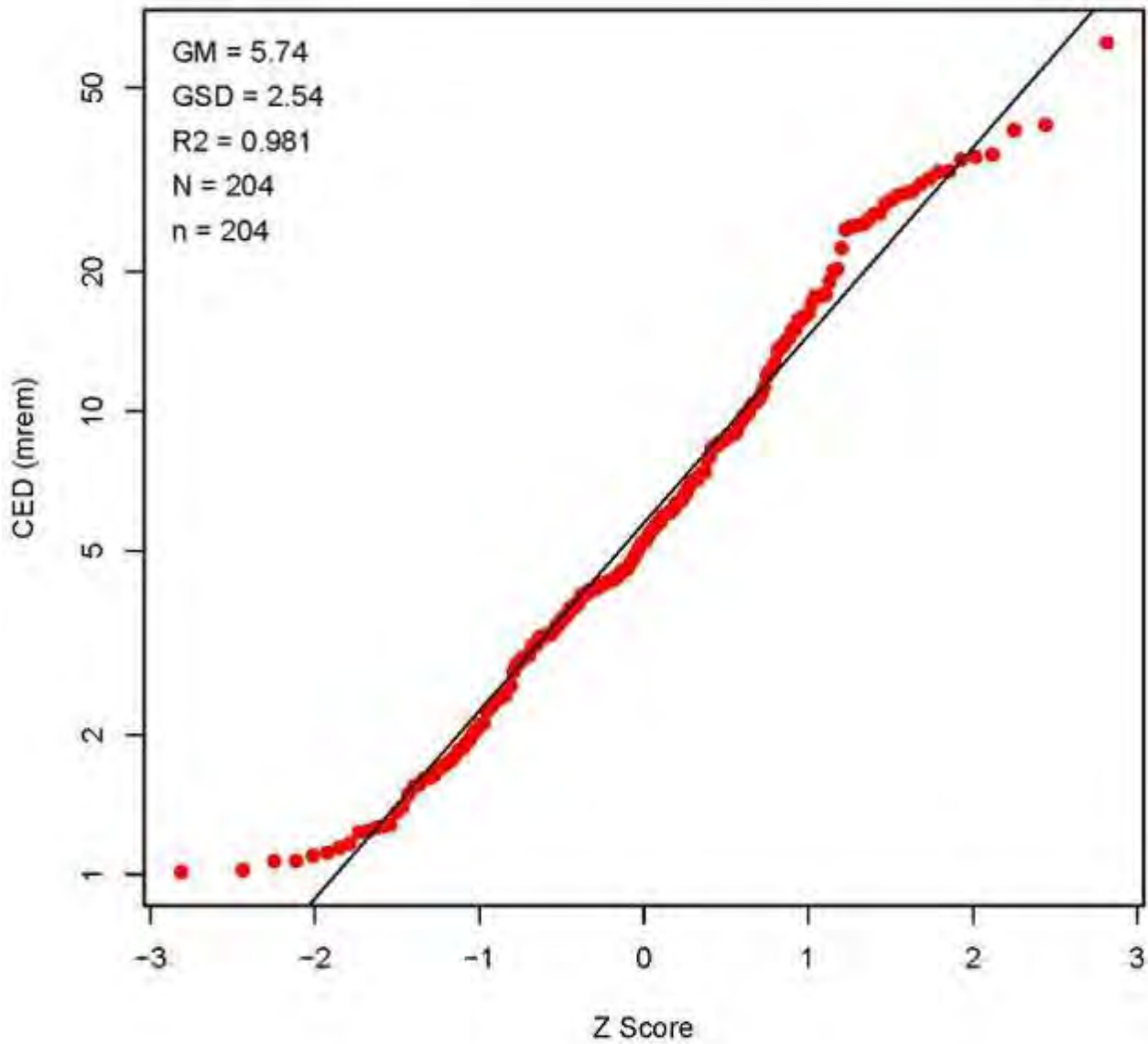


Figure C-145. SRS tritium dose 1990.

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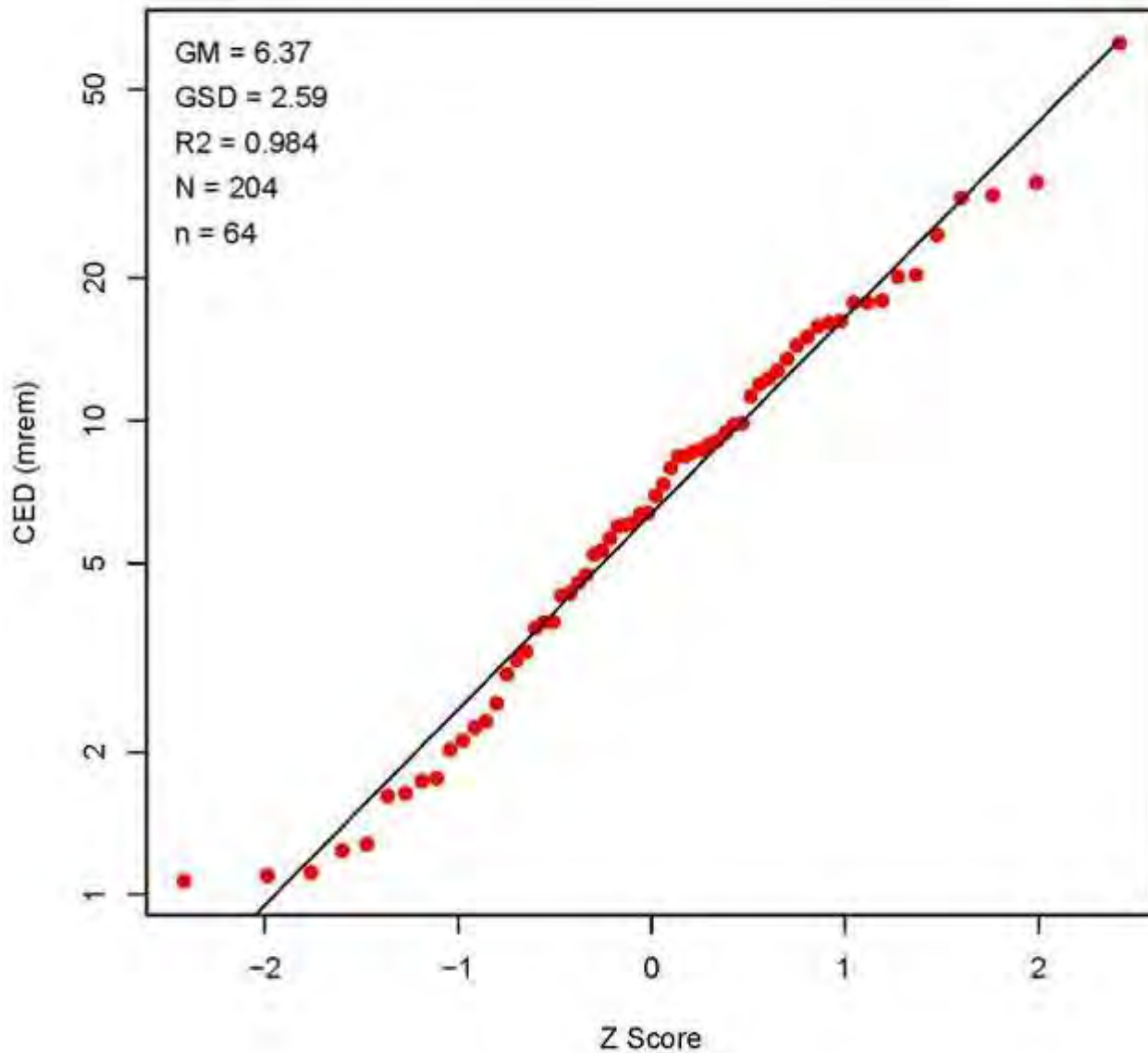


Figure C-146. SRS CTW/Reactor tritium dose 1990.

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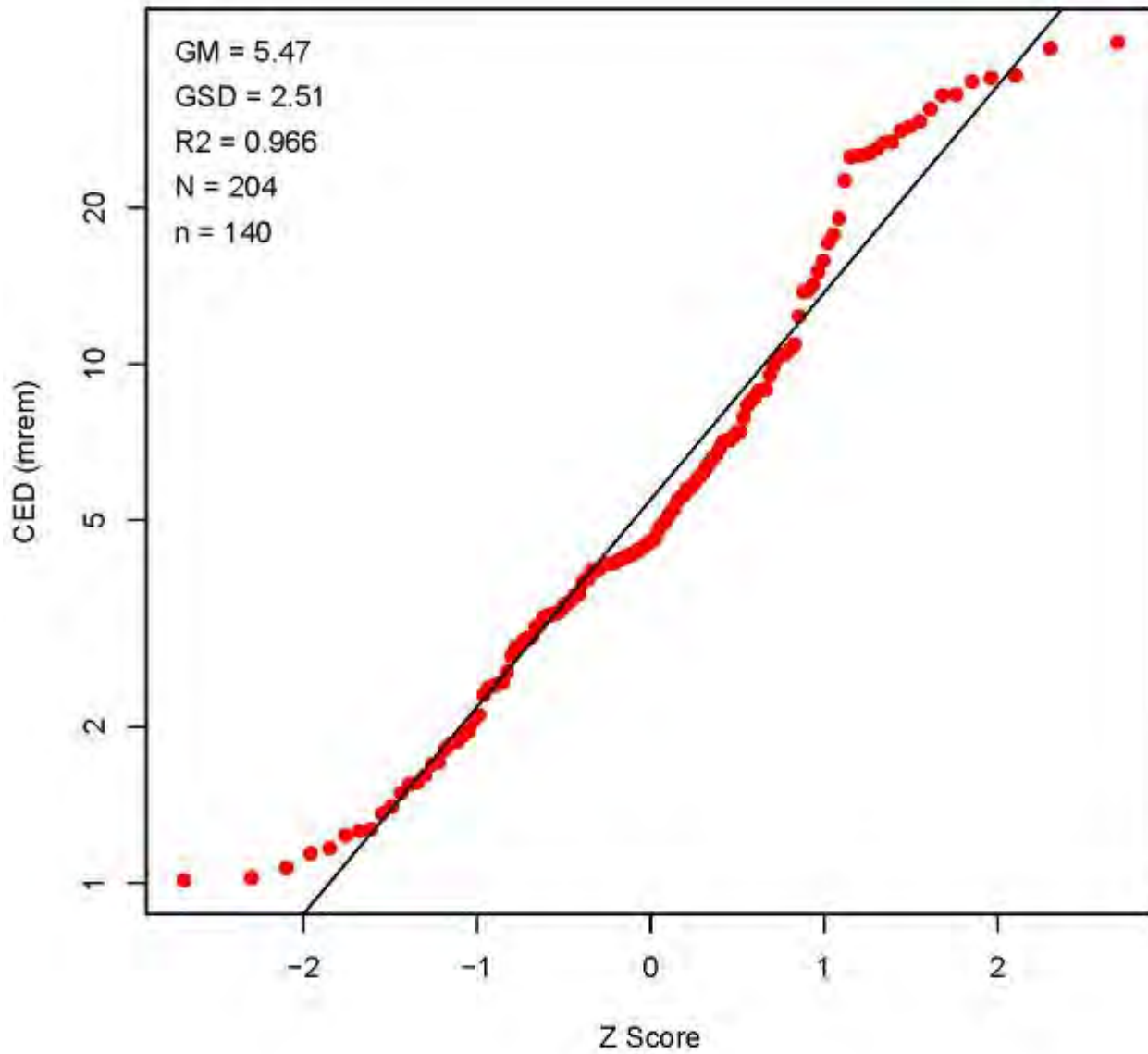


Figure C-147. SRS Non(CTW/Reactor) tritium dose 1990.

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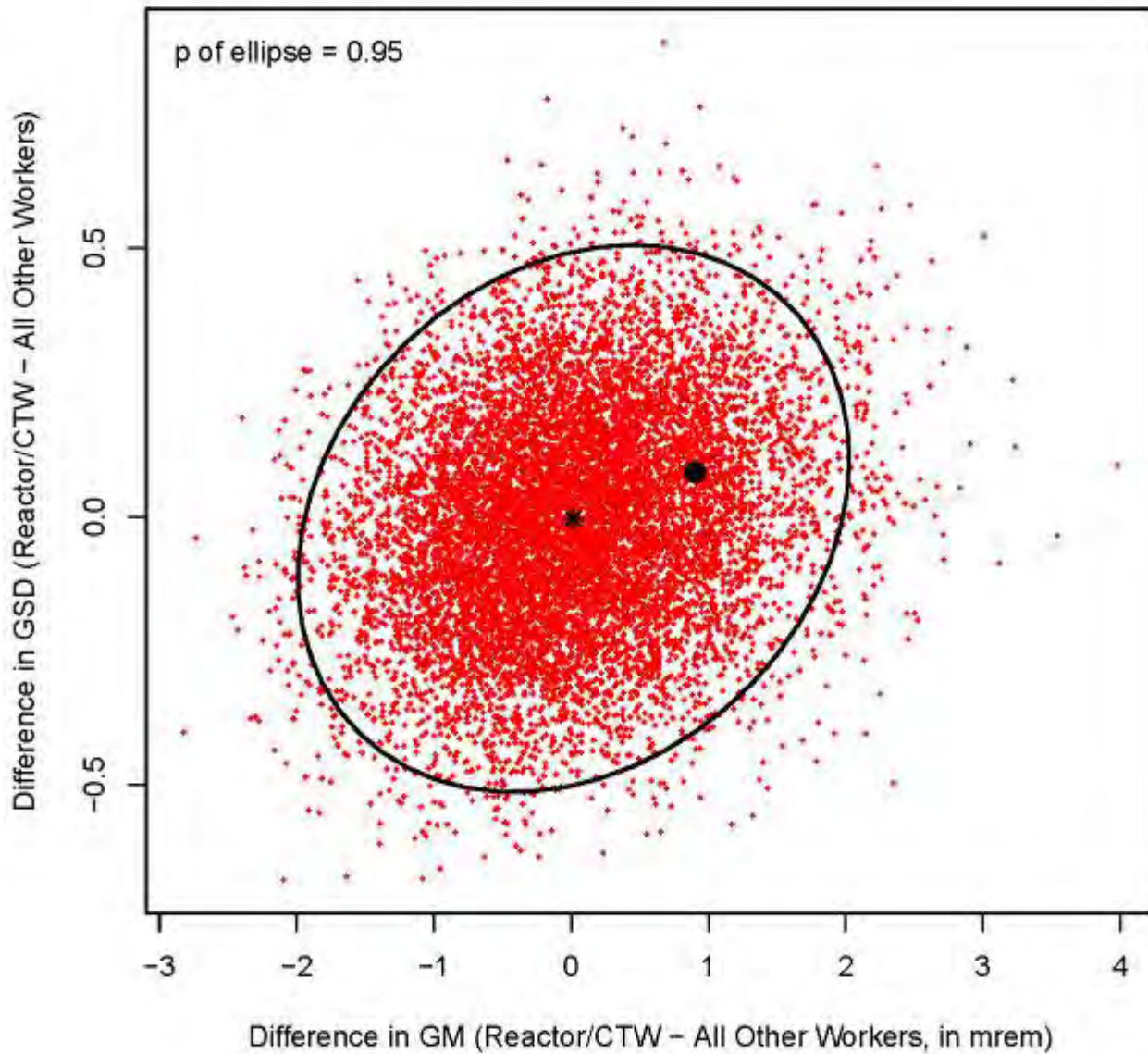


Figure C-148. SRS tritium dose 1990.