MCNP Analysis of Neutrons Released from Jesus' Body in the Resurrection

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This paper was presented Oct. 11, 2014 at the international conference on the Shroud of Turin, titled "Shroud of Turin: The Controversial Intersection of Faith and Science" held in St. Louis October 9-12, 2014 (www.stlouisshroudconference.com). My presentation included 54 PowerPoint slides. The narration for these slides is given below similar to that presented at the conference, allowing some flexibility for completeness and a few changes and corrections. Other presentations made at this conference can be found at www.shroud.com.

Slide 1

Hello. My name is Bob Rucker and the title of my presentation is "MCNP Analysis of Neutrons Released from Jesus' Body in the Resurrection". MCNP is a commonly used nuclear analysis computer code. The acronym MCNP stands for Monte Carlo Neutron Particle. This computer code tracks neutrons or 35 other particles using a probabilistic process known as Monte Carlo theory. MCNP will be explained more fully later. The MCNP computer program was used to calculate the distribution of neutrons in Jesus' tomb on the assumption that neutrons were emitted from His body in the resurrection. This was done to explain how the Shroud of Turin can be the authentic burial cloth of Jesus and yet be C^{14} dated in 1988 to the Middle Ages.

Also considered in this presentation is the Sudarium of Oviedo, which may need some description because it is not as well known than the Shroud of Turin. The Sudarium of Oviedo is a piece of cloth measuring about 84 by 53 cm (33 by 21 inches) and is known to have been located in Oviedo, Spain, since at least 840 AD. Tradition holds that it is the face or head cloth of Jesus referred to in John 20:7. It has no image on it but has human blood on it, the same blood type as on the Shroud of Turin. It was C^{14} dated to about 700 AD.

Slide 2

I am a nuclear engineer with about 38 years experience in nuclear engineering. I earned BS and MS degrees in Nuclear Engineering at the University of Michigan, graduating in 1971. I then started working for General Atomics in San Diego performing nuclear physics calculations for core design and analysis of the Gas Cooled Fast Breeder Reactor (GCFR), the Modular High Temperature Gas-cooled Reactor (MHTGR), and various TRIGA reactors. I worked there for a total of about 24 years, and then after my project was zeroed out by the Department of Energy (DOE), I worked for about 14 years at various DOE sites around the country in Nuclear Criticality Safety. In this function, I performed MCNP calculations for operations in nuclear facilities to assure that a nuclear criticality accident was not credible, provided that operators obeyed the procedures specified in the documentation that I wrote based on my MCNP calculations. I have about 14 years experience running the MCNP computer code.

My wife and I became interested in the Shroud of Turin long before we knew each other. She was living in California and I was living in Michigan, when we both noticed a short article on the Shroud of Turin in the Parade magazine that came out with the Sunday paper. It had a small picture of the face, only about two inches square, and one paragraph stating that some people believed that this was the burial cloth of Jesus. I initially thought that this could not possible be, because if it were true, it would be one of the most valuable possessions of the human race next to the Bible, yet I had never heard of it. Later, I decided I needed to be open to its authenticity, and investigate it more fully when I could. When the June, 1980, issue of National Geographic included a four page fold out picture of the image on the shroud, and an article on the 1978 scientific investigation, I was convinced it was authentic. However, when the shroud was C^{14} dated in 1988, statistical analysis of the results supposedly dated the shroud to the Middle Ages. When I read the analysis a year or two later, it initially challenged my belief in its authenticity. But if it was a fake from the Middle Ages, I reasoned, the nail print would be in the middle of the palm, as in all other paintings from the Middle Ages, instead of the wrist. At that point in time I had about 19 or 20 years experience calculating neutron distributions in nuclear reactors, so it quickly occurred to me that if neutrons were emitted from the body of Jesus during the resurrection, some of the neutrons would be absorbed in N^{14} in the linen which would create new C^{14} in the shroud, thus explaining the incorrect date and possibly the disagreements between the reported experimental results. But at that point, I did not have the time, computer, or computer code to do the detailed calculations that would be necessary to prove the idea. For me, this idea has been sitting on the back burner for about 24 years. So I am very glad to bring the results of my calculations to you at this time.

Slide 3

In this presentation, I will first discuss the C^{14} dating of the shroud and the indications that the dating to the Middle Ages was wrong. I will then discuss my hypothesis why the dating to the Middle Ages was wrong, and explain my MCNP calculations modeling my hypothesis. The MCNP calculations make specific predictions, so that further sampling and testing ought to be done to validate the hypothesis. I hope to have time at the end for questions.

Slide 4

The samples cut from the shroud for the C^{14} dating were cut from the bottom near the corner as shown in the figure. If we zoom in on this area, we get the next slide.

Slide 5

This figure shows the samples that were cut from the shroud and sent to the C^{14} dating laboratories in Tucson, Arizona; in Zurich, Switzerland; and in Oxford, England. The long rectangular piece was first cut from the shroud and the seam on the edge was cut away by Giovanni Riggi on April 21, 1988. The far right sample (A1) was then cut off to be sent to the laboratory in Arizona, the next sample (Z) was cut off to be sent to Zurich, and the next sample (O) was cut off to be sent to Oxford. When the weights of these samples were compared (A1 = 39.6 mg, Z = 52.8 mg, O = 52.0 mg) and the difference in the weights recognized, an additional sample (A2 = 14.1 mg) was also cut off so that A1 and A2 could both be sent to Arizona with about the same combined weight (A1 + A2=53.7 mg) as the samples being sent to Zurich and Oxford. The entire sampled region (A1+Z+O+A2) only measured about 43 mm by 16 mm.

These samples were sent to the three dating laboratories (Arizona, Zurich, and Oxford) where they underwent measurement of the carbon isotopes to determine the C^{14} date.

Slide 6

The resulting C^{14} date measurements from the three laboratories then underwent statistical analysis and the results were published in the British journal "Nature" on Feb. 16, 1989. The title of the article in Nature was "Radiocarbon Dating of the Shroud of Turin" by P. E. Damon and many others. This article is usually referenced simply as Damon et al.

Slide 7

The final conclusion of the analysis was that the shroud had a "calibrated" date of 1260 to 1390 AD, so that it was proclaimed to be a fake from the middle ages. The analysis gave an "uncalibrated" date of 1260 AD ± 31 years. The uncalibrated date assumes a constant production rate of C^{14} in the upper atmosphere due to gamma rays entering the upper atmosphere from space. But the production rate of C^{14} in the upper atmosphere is variable as indicated by C^{14} measurements of tree rings. As a result, over the years, a correction curve has been developed to account for the variable rate of production of C^{14} in the upper atmosphere. Comparing the uncalibrated date (1260 AD ± 31 years) to this correction curve yields the calibrated date (1260 to 1390 AD), thus correcting for the variable C^{14} production rate in the upper atmosphere.

Slide 8

At this point it is necessary to understand the basics of C^{14} dating. C^{14} is produced in the upper atmosphere by gamma rays entering the upper atmosphere from space. It mixes with all the other gases in the air and gradually diffuses down to the earth where plants take it in along with the other forms of carbon (C^{12} and C^{13}) in the environment. C^{12} and C^{13} are stable, i.e. they do not decay, but C^{14} decays with a half-life of 5730 years. This means that in 5730 years you will only have half as much left as you started with, and after another 5730 years it will be reduced by half again, etc. While a plant is alive, the C^{14} that is already in the plant will be decaying but this will be compensated by new C^{14} brought into the plant from the air so that an equilibrium is reached. But as soon as the plant dies, it no longer takes in new C^{14} from the air, so that the quantity of C^{14} in the plant decreases as the C^{14} in the plant decays with a half life of 5730 years.

This applies to the flax plant from which the linen in the shroud was made. As shown on slide 8, if we assume that the flax plant is cut down at year zero on the x-axis to make the linen in the shroud, the C^{14} in the shroud would gradually decay with a 5730 year half-life. It may appear in slide 8 that the fall off from 100% after year zero is linear, but it only appears this way because the time span in the figure is only a small fraction of one 5730 year half-life.

In the example of the C^{14} dating of the shroud, the dating laboratories must have measured an average of about 92% of the original C^{14} remaining, so on the curve in slide 8, this corresponds to linen that was made from flax that was cut down 690 years previous to the standard reference date of 1950. Use of a "standard reference date", i.e. 1950, is necessary to compare dating measurements made at different times. So 690 years before present (BP), where present is defined as 1950, gives an uncalibrated date of 1950 – 690 = 1260 AD for the shroud, as shown in slide 8.

Slide 9

The previous slide was for the case where the C^{14} atoms in the linen simply decayed without any new C^{14} being created in the linen. Slide 9 shows how things change if it is assumed that neutrons are emitted from the body of Jesus while in the tomb, so that new C^{14} is produced in the linen. New C^{14} atoms are produced as follows. If neutrons are emitted from within Jesus' body in the tomb due to the resurrection, then a small fraction of those would be absorbed in the N^{14} in the linen. When a neutron is absorbed in a N^{14} atom, a proton is ejected leaving a new C^{14} atom, i.e. $N^{14} + n \rightarrow C^{14} + p$. This newly created C^{14} atom is indistinguishable from the C^{14} atoms already in the linen from the growing flax plant, so it would mislead the interpretation of the experimental results.

The production of new C^{14} atoms in the shroud at the time of the resurrection is shown in slide 9 by the vertical red line, assuming that the time between the flax plant being cut down to make the linen and the time of the resurrection is minimal. The vertical red line is drawn to show an increase of 16% in the C^{14} content in the shroud. This is the amount the C^{14} must increase to result in an apparent C^{14} date of 1260 AD rather than the true date of about 30 AD. The death, burial, and resurrection of Jesus are usually dated to either 30 or 33 AD. The sloping red line shows that once the burst of neutrons from the resurrection is dissipated, which would happen in less than a second, the increased C^{14} content then in the shroud would decay with the usual 5730 year half-life. When the dating laboratories measured the C^{14} content and found that about 92% of the original C^{14} was remaining, they used the black line to date the shroud, effectively assuming that no neutrons were released in the tomb in the resurrection, whereas I am suggesting that they were actually on the C^{14} decay curve indicated by the red line, since neutrons were released by Jesus' body in the resurrection. With 92% of the pre-resurrection C^{14} content remaining, the red line would indicate that the flax plant was cut down 1920 years prior to the standard reference date of 1950. Thus, under this scenario, the Shroud of Turin would be dated at 1950 – 1920 = 30 AD instead of 1260 AD.

Slide 10

This is the big picture. If neutrons were released from Jesus' body in the tomb, then some of them would have been absorbed in N^{14} in the shroud to produce new C^{14} atoms, which would cause it to be C^{14} dated younger than its true age.

Slide 11

I would like to offer some additional background at this point, because you may be wondering what a neutron is or what C^{14} is. Slide 11 shows a diagram of a carbon atom. An atom is similar in some respects to our solar system. The vast majority of the mass in our solar system is concentrated at the center of the solar system in the sun, and the much lighter planets move around the sun in their orbits. This is also true in an atom. The vast majority of the mass in an atom is concentrated in the nucleus at the center of the atom. The nucleus is composed of protons, which have a positive charge, and neutrons, which have no charge. A carbon atom has six electrons which move around the nucleus in their orbits. Each electron has a negative charge. There are two electrons in an inner orbit. These two electrons fill this inner orbit. There are also four electrons in an outer orbit. This outer orbit can contain up to eight electrons. For this reason, each carbon atom tries to fill the outer orbit by sharing electrons of other atoms, including other carbon atoms. This sharing of electrons binds the atoms together in what are called covalent bonds, thus allowing carbon to form millions of different organic compounds, which allows life to exist in the universe.

Since each carbon atom has six electrons, each of which is negatively charged, there must be six protons in the nucleus of each carbon atom to allow the entire atom to be neutral. To prevent the six protons in the nucleus from repelling each other because like charges repel, thus destroying the nucleus, they must be held together by neutrons in the nucleus. 99% of all carbon atoms are C^{12}, with 6 protons and 6 neutrons in the nucleus, thus making a total of 12 total protons + neutrons in the nucleus. 1% of all carbon atoms are C^{13}, with 6 protons and 7 neutrons in the nucleus, thus making a total of 13 total protons + neutrons in the nucleus. Only a very small fraction of all the carbon atoms are C^{14} atoms, containing 6 protons and 8 neutrons. In this study, the atom fraction of C^{14} in the carbon in the shroud was assumed to be 1.5×10^{-12}. Since the ratio of neutrons to protons is higher in C^{14} atoms, the C^{14} atoms are not stable and they decay with the 5730 year half-life.

This indicates that neutrons are a natural part of the elements in the human body. We don't normally encounter neutrons simply because they are bound up with the protons in the nuclei of the various elements in the human body.

<u>Slide 12</u>

The number of neutrons, protons, and electrons in a human body can be calculated from the various elements in the body. Slide 12 shows the weight percents of the various elements for a 70 kg (154 lb) person. Based on the number of neutrons, protons, and electrons in each of these elements, and an estimated weight of 170 lb for the man whose image is on the shroud, the data in the following table can be calculated.

<u>Slide 13</u>

For the typical person, about 45% of their body weight is neutrons, 55% is protons, and only 0.03% is electrons. For a 170 lb person such as Jesus, it is calculated that there would be about 2.09×10^{28} neutrons, 2.55×10^{28} protons, and the same number (2.55×10^{28}) of electrons. The point is that there would be a very large number of neutrons in Jesus' body, about 2.09×10^{28}. This is 2 followed 28 zeros, which is a very large number. This number is even bigger than our national debt.

<u>Slide 14</u>

It is important to recognize that many things happened in Jesus' resurrection, but one of the most significant is that Jesus' body disappeared from the tomb. Consider what this means. A person's body consists of various organs and tissues such as heart, liver, skin, etc. And these are composed of various proteins, which are organic molecules. And these molecules are composed of the atoms of various elements. And these atoms are composed of neutrons, protons, and electrons. Thus, saying that Jesus' body disappeared from the tomb is equivalent to saying that the atoms that composed his body, including the neutrons, protons, and electrons, disappeared from the tomb.

The question might arise, "Where did Jesus' body go?" The layman would typically answer, "Jesus' body went to heaven by the power of God." The Biblical terminology might be that He was "translated to glory." But the interesting response is what the physicist ought to say, "The atoms in Jesus' body, including the neutrons, protons, and electrons transitioned into an alternate dimensionality by an unknown process." Since this transition is by an unknown process, neutron emission from the body of Jesus can not be ruled out.

Slide 15

To determine what would happen if neutrons were released from Jesus' body in the tomb, detailed nuclear analysis calculations would be required. I performed these calculations on my home computer using the MCNP nuclear analysis computer code, which I had been using for over ten years in my work in nuclear criticality safety. MCNP calculates the neutron distribution in the geometry that is modeled in the computer code. In these calculations, what I modeled in MCNP was Jesus' body in a burial cloth lying on the back bench in a tomb. MCNP calculates the neutron distribution, and other requested information, by following one neutron at a time up to a specified maximum number of neutrons. For these calculations I ran 30 million neutrons to reduce the statistical uncertainty to a reasonable level. Each calculation ran for 6 to 13 hours on my desktop computer.

Slide 16

To help you understand where we are going with this, I would like to show you one of the main conclusions, which is the following. If 3.04×10^{18} thermal neutrons were released during the disappearance of Jesus' body from the tomb in His resurrection, it would increase the average C^{14} content in the shroud samples by 16%. This would shift the C^{14} date for the shroud samples from 30 AD to 1260 AD.

Slide 17

We can now calculate the fraction of the neutrons that are in Jesus' body that must be emitted in the resurrection. Since 3.04×10^{18} neutrons must be released in the body to produce a 1260 AD date in the sample region, and there are 2.09×10^{28} neutrons in the body, the fraction of neutrons that must be emitted from body is 1.5×10^{-10}, which is 1.5 neutrons per ten billion in the body. This means that in the disappearance of the body, the process by which the neutrons transitioned into the alternate dimensionality was 99.999999985% efficient. The remaining 0.000000015% of the neutrons were released into the tomb and resulted in the wrong C^{14} date for the samples.

Slide 18

Up to this point we have considered the C^{14} dates obtained by the three laboratories as though they all obtained the same value, the average value of 1260 AD. But they actually obtained three different values that did not agree well with each other, as indicated in slide 18. The authors of the statistical analysis published in the British journal Nature in 1989 (Damon et al) recognized that there appeared to be a significant difference between the three laboratory dates. To test whether this was so, they performed what is called a chi-squared statistical analysis test on the values. Their conclusion based on this test was that the range of the sample values (1304, 1274, and 1200) was probably inconsistent with the stated random measurement errors ($\pm$ 31, $\pm$ 24, and $\pm$ 30).

This inconsistence can be easily seen by subtracting the Oxford date from the Arizona date, recognizing that the specified dates are actually probability distributions. The Arizona value of 1304 AD $\pm$ 31 is a distribution that peaks at 1304 AD with 68% of the distribution within $\pm$ 31 years of the peak, i.e. between 1273 and 1335. The Oxford value of 1200 AD $\pm$ 30 is a distribution that peaks at 1200 AD with 68% of the distribution within $\pm$ 30 years of the peak, i.e. between 1170 and 1230. Subtracting the Oxford distribution from the Arizona distribution yields a new distribution with a peak at 1304 – 1200 = 104. To determine the one sigma standard deviation for the new distribution requires the $\pm$ 31 and $\pm$ 30 one sigma values from Arizona and Oxford to be added statistically: square root of $(31^2 + 30^2) = 43$ years. So the result of subtracting the Oxford distribution from the Arizona distribution is a difference of 104 $\pm$ 43 years. But 104 divided by 43 = 2.42, so the 104 difference between the peaks is 2.42 times the one sigma standard deviation of the difference. Since this is greater than 2.0, there is less than a 5% probability that the calculated difference of 104 is actually consistent with a zero value, which would be required if Oxford were actually consistent with Arizona for the stated random measurement errors.

The chi-squared test discussed in Damon et al came to the same conclusion that there was only a 5% probability that the range of the sample values (1304, 1274, and 1200) was consistent with the stated random measurement errors ($\pm$ 31, $\pm$ 24, and $\pm$ 30). In other words, there was a 95% chance that the range in the sample values (1304, 1274, and 1200) was due to something other than random measurement errors. Thus, there must be something causing a systematic error component in the difference between the sample values. But if something is causing the 1304 value to be so much higher than the 1200 value, then whatever this is could be affecting all three sample values (1304, 1274, and 1200), so that it would be very wrong to simply average the three values and report the result as conclusive. Yet this is what was done in Damon et al to obtain a 1260 AD date for the Shroud of Turin.

Slide 19

The C^{14} dates and their one sigma uncertainties from each laboratory are plotted in slide 19. In plotting the 1304 value for Arizona, there is uncertainty as to what x-value to use. If the 1304 value reported from Arizona includes analysis of both samples sent to them (A1 and A2) as appears to be the case from Damon et al, then the average x-value is about 6.6 cm from the edge of the shroud. But if Arizona only analyzed the larger sample A1 as is often assumed in subsequent analysis, then the average x-value would be about 7.5 cm from the edge of the shroud. The important point of this slide is that Damon et al, in averaging the three values to get the 1260 date, would effectively be plotting the black dashed line at a constant 1260 value, as shown on the slide. This dashed black line at 1260 AD only goes through one of the data points – that from Zurich at 1274 AD ± 24 years. This plot again implies that there is probably something that is causing the reported dates to differ, so that they should not be simply averaged to a 1260 value. This conclusion has also been reached by more than one detailed statistical analysis.

Slide 20

One example of this is Bryon Walsh's presentation at the Shroud of Turin conference in 1999 in Richmond. The title of his presentation was "The 1988 Shroud of Turin Radiocarbon Tests Reconsidered." Using two common statistical analysis techniques, he concluded that the Oxford and Arizona sample values were statistically different. In statistical terminology, he concluded that these two samples did not come from the same population. This means that it would not be appropriate to average the values together, as was done in the statistical analysis published in 1989 (Damon et al). Something was causing these samples to give different values.

Slide 21

Let's look again at the plot of the three C^{14} dates reported by the three laboratories, but instead of simply averaging the three values and plotting the result as a horizontal line as in slide 19, this time I used EXCEL to calculate a least squares linear fit to the three data points as shown in red in this slide. This least squares linear fit is a straight line that minimizes the square of the differences between the line and the data points. It is the "best fit" line through the three C^{14} dates. The equation for this line is $y = 57.1x + 920.7$. Notice that the coefficient on the "x" term is 57.1. This coefficient is the slope, or gradient, of the line, where the slope is equal to the change in the "y" value per change in the "x" value. Because the y-axis is in years and the x-axis is the distance from the edge of the shroud in centimeters (cm), the slope is in units of years per cm. So the slope of the line that best fits through the three C^{14} dates reported by the three laboratories is 57.1 years/cm. This means that if the sample point is one cm further from the edge of the shroud, then the C^{14} date would be about 57 years higher, i.e. more recent. This is a very significant change in the C^{14} date with distance. The cause for this slope in the C^{14} dates needs to be determined.

Slide 22

According to the hypothesis that neutrons were emitted from Jesus' body in the tomb, this slope in the C^{14} dates occurs because the true value of the C^{14} in each of the three samples was different. This results from the three sample points experiencing different amounts of neutron absorption, caused by the shape of the neutron distribution in the tomb.

Slide 23

Slide 9 showed that a 16% increase in the C^{14} in the samples sent to the laboratories would result in a C^{14} date of 1260 AD, but these were average values. If neutrons were released from Jesus' body in the tomb, then each of the samples sent to the three laboratories would have experienced a different amount of neutron absorption in N^{14} because of their separate locations on the shroud. This different amount of neutron absorption in N^{14} would have resulted in the deviation in C^{14} dates by the three laboratories. As shown in this slide, the sample tested by Arizona must have a 16.66% increase in the C^{14} in the shroud so that when it decays (shown on the magenta line), and projected onto the decay curve without new C^{14} formed in the shroud (shown on the black line), the age is determined to be 646 years before 1950. This is equivalent to the 1304 date obtained from the Arizona sample. Similarly, the sample sent to the laboratory in Zurich must have experienced a 16.24% increase in the C^{14}, resulting in an age of 676 years before 1950, which is equivalent to a date of 1274 AD. And the sample sent to the laboratory in Oxford must have experienced a 15.20% increase in the C^{14}, resulting in an age of 750 years before 1950, which is equivalent to a date of 1200 AD.

Slide 24

There are three mysteries related to C^{14} dating of the Shroud of Turin and the Sudarium of Oviedo.

1. How can the shroud be authentic if C^{14} dating placed its origin in the Middle Ages?
2. Why was there such poor agreement between the C^{14} dates for the three shroud samples?
3. How can the Sudarium of Oviedo be authentic if C^{14} dated it to about 700 AD?

Slide 25

The objective of this presentation is to explain these three mysteries with one hypothesis. The hypothesis can be simply stated: neutrons were released from Jesus' body in the tomb.

Slide 26

What are the reasons that we should even consider the possibility that neutrons were released from Jesus' body in the tomb? First, this hypothesis explains the three mysteries, which will be described shortly. Second, it is consistent with the disappearance of the body. The atoms of Jesus' body, including all of the neutrons, protons, and electrons disappeared from the tomb. Where did they go? We can not exclude the possibility that a small fraction of the neutrons, protons, and electrons were emitted or left behind when the majority of them disappeared from the tomb. And third, Jesus' body emitting neutrons is consistent with particles forming the image on the shroud. It was scientifically proven in 1978 that the image on the shroud could not be a painting, a rubbing, a scorch, or a photograph. And it can't be the result of applying an acid to the linen because there is no evidence of capillarity. The only remaining known possibility is that the image of a crucified man on the shroud is a radiation burn. Experiments have been performed with protons and with ultraviolet light (photons) which have proven that either of these two particles can create a discoloration on linen that is similar in appearance to the discoloration on the tips of the shroud's micro-fibers. So if protons or photons were released from Jesus' body to form the image on the shroud, it is not unreasonable to assume that neutrons were also released from Jesus' body in the tomb.

Slide 27

The idea that Jesus' body released neutrons in the tomb is not a new idea. As a matter of fact, it is the first documented explanation for the wrong C^{14} date. This explanation was given by Thomas J. Phillips of the High Energy Physics Laboratory at Harvard in the same issue of the British journal Nature (Feb. 16, 1989) that contained the statistical analysis by Damon et al. In this article, Phillips said that Jesus' body "may also have radiated neutrons, which would have irradiated the shroud and changed some of the nuclei to different isotopes by neutron capture. In particular, some C^{14} could have been generated."

Slide 28

In my computer calculations, I performed an analysis of neutrons released from Jesus' body in the tomb using the MCNP nuclear analysis code. MCNP is an acronym that stands for Monte Carlo Neutron Particle. MCNP calculates the distribution of neutrons, or 35 other particles, in a geometry defined by the user, using what is called Monte Carlo theory. This is a process wherein MCNP calculates a long series of random numbers in order to follow one particle at a time through the defined geometry, including all possible interactions with other atoms, until enough particles have been run to obtain an acceptable uncertainty in the desired answer.

In the calculations reported here, MCNP calculated the first random number between zero and 1.0 to determine where on the x-axis in the body the first neutron would be started. A second random number between zero and 1.0 was then calculated to determine where on the y-axis in the body the first neutron would be started. The third random number was calculated to determine where on the z-axis in the body the first neutron would be started. Once this starting point for the first neutron was determined, three more random numbers were calculated to determine the initial direction of the neutron. More random numbers were then calculated to determine how far the neutron would go in each material and what interactions the neutron would have with other atoms. When the first neutron was either absorbed or, with a small probability, escaped from the defined geometry, the next neutron was started from a random location in the body with an initially random direction. By repeating this process, one neutron was followed at a time until the maximum specified number of neutrons was reached. The calculations reported here ran 30 million neutrons for which 55 billion random numbers were calculated. Calculations generally took 6 to 13 hours on my home desktop computer.

The MCNP computer code has been developed over the past six decades by a development team at the Los Alamos National Laboratory in Los Alamos, New Mexico. It is used in many countries around the world, probably with several hundred individuals using it on a regular basis. It has been verified to be accurate by comparison of calculated results to the results of nuclear experiments. These comparisons have included thousands of experiments in hundreds of facilities. This verification process has proven to the United States Department of Energy and the Nuclear Regulatory Commission that when it is run correctly, the MCNP computer code is accurate within an acceptable uncertainty.

Slide 29

This slide shows a three-dimensional picture of how Jesus' tomb was modeled in the MCNP computer code. Archeologist Leen Ritmeyer indicates that over 1000 tombs have been excavated in the Jerusalem area, so we know how Jesus' tomb was probably configured. Cut into limestone, it would have a small entrance door with a high threshold. Inside would be the "pit" where people could stand up, with benches cut into the limestone on the left and right sides, and at the back, on which to place a body. According to John 20:4-8, after the resurrection, John outran Peter to the tomb. John then knelt down outside the tomb, looked through the open entrance and saw the linen wrappings. According to Leen Ritmeyer, this indicates that the linen wrappings were on the back bench. John must have knelt down well back from the entrance to allow enough light to enter the tomb. From that vantage point, John could not have seen the side benches, only the back bench. So I modeled the body of Jesus in His burial shroud lying on the back bench. His head was placed to the right simply because most people are right handed. The tomb was modeled in MCNP with a limestone thickness of 100 cm for the floor, ceiling, and walls, except that the front wall had a 45 cm thickness. A circular stone with a radius of 70 cm and a thickness of 30 cm was placed in front of the entrance. The face cloth was probably located on the side bench not too far from Jesus' head, based on my calculated results.

<u>Slide 30</u>

Slide 30 shows a side view of the body lying on the back bench. Only a small portion of the floor, ceiling, and walls is shown. Simple geometrical shapes were used for the body and shroud for ease of modeling and to minimize the time taken by the calculations. The head, which is to the right, is modeled as a rectangular box. To the left of the head, the chest, abdomen, and arms are together as one rectangular box. The two legs are modeled separately, each as a sloping box. This also applies to the feet. The feet pointed down and the head was in a forward position due to rigor mortis. The burial shroud was configured as an open box around the body, open at the feet.

<u>Slide 31</u>

Slide 31 shows a top view of the body with the head to the right. The shroud is shown as an open box around the body.

<u>Slide 32</u>

The following describes the conditions assumed for the calculations that produced the results to be shown starting on slide 34. The number of neutrons emitted from Jesus' body in the tomb was normalized to 3.04 x 10^{18} in order to produce an average C^{14} date of 1260 AD at the sample region. This number of neutrons is required to produce enough neutron absorptions in N^{14} in the shroud to change the C^{14} date from 30 AD to 1260 AD at the sample location. These neutrons were assumed to be emitted as the body disappeared. Since MCNP can not do a time dependent calculation, the disappearance of the body was subdivided into ten time steps with 10% of the neutrons emitted in each time step. These ten time steps were then recombined to produce the one set of results that will be shown starting in slide 34. Each neutron was assumed to be emitted from a random location in the body.

Slide 33

Each neutron was also assumed to be emitted in a random initial direction with an initial energy of 0.0253 electron volts (eV). An electron volt is a unit of energy. One electron volt is the energy that an electron, with its negative charge, would acquire if it were to fall across a voltage difference of one volt. A neutron with its energy equal to 0.0253 electron volts is at a very low energy. A neutron at this energy is essentially in thermal equilibrium with the atoms around it when the atoms are at room temperature. Thus, these neutrons are not emitted with any additional energy, but are essentially left behind as the rest of the body disappears. The last assumption was that the inside wall of the tomb next to the feet was a distance of 20 cm from the feet. This distance affects the results because the limestone wall reflects neutrons back into the tomb.

It should be mentioned that the conditions described on this slide and the previous slide are not the only solution that solves the three mysteries on slide 24. It is expected that other solutions will exist, but they have not yet been calculated.

Slide 34

The following results were calculated for the conditions described on the previous two slides. This slide shows the calculated distribution of neutrons in the tomb along the midline of the body on the linen below the body. The top curve shows the neutron distribution including neutrons of all energies. The three lower curves show the neutron distributions for neutrons of various energies. The location where the samples were cut from the shroud for the C^{14} dating is the second point from the left. The y-axis for this point reads about 1.2×10^{14} neutrons per cm^2 whereas the value at the peak is about 1.28×10^{15}, which is about ten times higher. With the head modeled to the right and the feet to the left, this peak in the neutron distribution occurs at about the center of mass for the body. Notice that there is a very significant slope in the calculated neutron distribution at the second point from the left, where the samples were cut from the shroud.

Slide 35

In the process of calculating the neutron distribution in the last slide, MCNP also calculated the neutron absorption in the N^{14} in the shroud under Jesus' body along the midline of the body. The distribution of neutrons absorbed in the N^{14} in the shroud peaks near the center of mass of the body, with the peak being about ten times greater than the neutron absorption at the location where the samples were cut from the shroud, i.e. at the second point from the left. This distribution of neutrons absorbed in N^{14} in the shroud can be used to calculate the distribution of C^{14} dates that would be obtained for each point if cut from the shroud and sent to a dating laboratories.

Slide 36

Slide 36 is the result of this calculation. The C^{14} dates shown in this distribution apply to the shroud below the body along the midline of the body. The second point from the left is normalized to 1260 AD, the average value of the three laboratories, by the choice of 3.04×10^{18} neutrons to be released from the body. But notice that the curve goes up to about 8500 AD near the body's center of mass. This of course is far into the future. Thus, if we could get a sample along the backbone of the dorsal image below the top of the abdomen, the computer calculation predicts that the dating laboratory would date that sample to about 8500 AD. The scientists making this measurement would probably initially be bewildered, thinking that a C^{14} date into the future is impossible, but they would eventually conclude that the Shroud of Turin, at some point during its existence, had experienced a significant absorption of neutrons in the N^{14} in the linen.

Slide 37

If we take the calculated results for the leftmost four points on the previous curve and calculate a best fit curve between them, i.e. a least squares polynomial equation ($y = 0.0236x^3 + 1.2639x^2 + 38.944x + 975.92$), the result is the magenta curve in this slide. This curve, which is based on the hypothesis that neutrons were released from Jesus' body, goes through the three data points very nicely. Thus, the hypothesis that neutrons were released from Jesus' body in the tomb explains the slope across the three C^{14} values reported by the three laboratories.

Slide 38

The MCNP calculations reported values for neutron absorption in N^{14} in linen. Values were reported for linen in a region just above the left side bench and just above the right side bench, and in the shroud surrounding the body on the back bench. The values for the back bench included four regions for the shroud below the body, for the shroud to the right of the body, for the shroud above the body, and for the shroud to the left of the body. The neutron absorptions in N^{14} were counted, i.e. tallied, in rectangular regions that were larger than the tally regions used for the results shown in the previous four slides. For each of these large tally regions, the number of neutron absorptions in N^{14} reported by MCNP was used to calculate the C^{14} date that would be obtained by a dating laboratory.

Slide 39

This shows the resulting C^{14} dates for a piece of linen, such as the face cloth, just above the left or right side benches. It also shows the C^{14} dates for the shroud as it wraps around the body on the back bench. These values are probably too small to see so sections of this data will be shown starting in slide 41.

Slide 40

The one sigma uncertainty in these C^{14} dates obtained from the MCNP runs was also calculated. By running 30 million neutrons in the MCNP calculations, very low statistical uncertainties in the calculated C^{14} dates were obtained. These calculated uncertainties are in units of years. The one sigma uncertainty for most of the C^{14} dates on the side shelves are about five years. The one sigma uncertainties for the shroud around the body are less than 13 years on the dorsal side and less than 10 years on the rest of the shroud.

Slide 41

These are the calculated C^{14} dates for the left side of the shroud on the back bench. All of these dates are normalized to the average experimental value in the sample region of 1260 AD. This 1260 AD value was calculated for a small tally region – the second point from the left in slides 34 to 36. This tally region used for normalization to the 1260 AD experimental value was smaller than the tally regions shown here, so that the 1260 date is a smaller region within the 1317 AD value shown in this slide on the dorsal side of the cloth along the body midline at the far left side below the toes of the body.

Slide 42

This slide shows calculated C^{14} dates for the right side of the shroud. Notice that the C^{14} dates go up to 8459 AD for a sample point below the center of mass of the body on the dorsal side. The values highlighted in yellow are the C^{14} dates around the body at that point.

Slide 43

If you take the values highlighted in yellow in the last slide and wrap them around a cut through the body, then the values in this slide result. The colored section represents a cut through the body at the maximum value on the dorsal side. The values under the body go up to 8459 AD along the backbone, are about 4600 AD on the right side next to the wall, go up to 4048 AD above the center of the body, and are about 3600 AD on the left side away from the wall. If the head had been modeled to the left in MCNP with the feet to the right on the back bench, then these values would be switched left to right, so that the left side would be next to the wall at about 4600 AD and the right side would be away from the wall at 3600 AD. The side next to the wall receives neutrons reflected back from the limestone wall so that more neutrons are absorbed in N^{14} in the linen that is next to the wall.

Slide 44

Slide 44 shows the C^{14} dates calculated for a piece of linen such as the face cloth lying anywhere on the left bench. The Sudarium of Oviedo, traditionally believed to be the face cloth of Jesus referred to in John 20:7, was C^{14} dated to about 700 AD. The highlighted regions in this slide show where the face cloth could have been placed on the left bench to obtain a C^{14} date of about 700 AD. Regions were chosen for yellow highlighting within $\pm$ 50 years of this 700 value, i.e. within a C^{14} date range of 650 to 750 AD.

Slide 45

Slide 45 shows the C^{14} dates calculated for a piece of linen such as the face cloth lying anywhere on the right bench. The highlighted regions in this slide show where the face cloth could have been placed on the right bench to obtain a C^{14} date of about 700 AD, i.e. within a C^{14} date range of 650 to 750 AD.

In the burial process, the people in the tomb would probably have gone through the following sequence:

1. They would have laid down the back side of the burial shroud on the back bench.
2. Jesus' body would have been laid down on this section of the shroud on the back bench.
3. The face or head cloth would have been removed from his head, folded up and laid aside.
4. The remaining section of the shroud would have been moved over His head and laid down on the front side of His body.
5. The side strip, which had previously been cut from the main shroud, may have been wrapped around the body at the elbows to keep the arms down for modesty. This might have been done to overcome the effects of rigor mortis.
6. The burial shroud would have been tucked in around the body.

Notice in this process that the person in the tomb working on the burial, perhaps the apostle John, would have been standing at the back bench facing the body when he removed the head cloth. It would have been most natural for this person, after taking off the head cloth, to fold it up (John 20:7) and lay it down on the side bench immediately to his right. This is exactly where the MCNP calculations predict that linen at that location would have a C^{14} date of about 700 AD, the very C^{14} date measured for the Sudarium of Oviedo. If Jesus' head was on the left side of the back bench, then all calculated C^{14} dates would be exchanged left to right.

<u>Slide 46</u>

The C^{14} dates fall off rapidly as you move along the centerline of the right bench from the back of the tomb toward the front of the tomb. The reason for this is shown in slide 46. The neutron distribution that results from Jesus' body emitting neutrons in the tomb is much higher over the back bench (110 to 160 cm in slide 46) and falls off rapidly as you move toward the front of the tomb (-110 cm in slide 46).

<u>Slide 47</u>

Some have suggested that an earthquake at the time of the resurrection (Matthew 28:2) caused neutrons to be emitted in the limestone of the tomb, which caused neutrons to be absorbed in N^{14} in the linen, which then caused the Shroud of Turin to give a C^{14} date to the Middle Ages. According to this concept, the neutrons were emitted in the limestone of the tomb rather than in Jesus' body. It was rather simple to test this concept in the MCNP calculations. The only requirement was to switch the neutrons from being emitted from random locations in Jesus' body to random locations in the limestone walls, floor, and ceiling of the tomb. Calculations were run from an initial neutron energy of 0.0253 electron volt (eV) up to 1.0 million electron volts (MeV). The resulting neutron distribution inside the tomb was calculated to be very uniform over this entire range.

In slide 37, it was shown that if neutrons are emitted from random locations in the body, then the calculated C^{14} date curve goes through the three C^{14} dates obtained from the three laboratories. But if the neutrons are emitted in the limestone walls, floor, and ceiling then the C^{14} date curve is very horizontal across the sample region so that it passes through only one of the laboratory values. This poor agreement is shown by the plot of the blue line in this slide.

Slide 48

The C^{14} dates for the right side bench are shown in this slide for neutrons emitted in the limestone. These values are for an initial neutron energy of 100 eV. The C^{14} date of 700 AD for the Sudarium of Oviedo does not exist on the right side bench for neutrons emitted in the limestone, as shown here. It also does not exist on the left side bench or on the back bench at this 100 eV initial neutron energy. It also does not exist for any other energy (0.0253eV to 1.0 MeV) that was calculated.

Slide 49

The MCNP calculations indicate that there must be from 8.0×10^{11} up to 9.0×10^{11} neutrons emitted per cm^3 of limestone in the walls, floor, and ceiling of the tomb to produce an average C^{14} date of 1260 AD in the sample region. Individuals who want to promote the idea that the C^{14} date of 1260 AD resulted from neutrons that were emitted in the limestone as a result of an earthquake need to show that an earthquake can produce this level of neutron emission in limestone.

Calculations indicate two other problems with this concept. Neutrons emitted in the limestone do not produce the correct slope of 57 years/cm across the sample region as shown in slide 47, and the C^{14} date of 700 AD is not obtained anywhere in the tomb as shown in slide 48.

Slide 50

Where does the evidence indicate that the neutrons were emitted? They were emitted in the body and not in the limestone.

Slide 51

In summary, the nuclear analysis computer code MCNP was used to show that if 3.04×10^{18} neutrons were released at random locations in Jesus' body, either prior to or during the disappearance of the body, it explains three things: the incorrect C^{14} date of 1260 AD for the Shroud of Turin, the slope of 57 years per cm for the C^{14} dates across the sample region, and the incorrect C^{14} date of 700 AD for the Sudarium of Oviedo.

Slide 52

Explaining these three things by one hypothesis, that neutrons were released from Jesus' body in the tomb, is strong evidence that the hypothesis is true. But additional sampling and testing is required to prove that Jesus' body emitted neutrons in the tomb.

Slide 53

If the MCNP predictions are validated by additional sampling and testing, it would:

1. Prove that neutrons were released from Jesus' body in the tomb.
2. Invalidate the conclusion of the C^{14} dating which indicated that the Shroud of Turin is from the Middle Ages.
3. Indicate that the Shroud of Turin is circumstantial evidence for Jesus' resurrection.

Slide 54

This slide gives my contact information for questions or comments. Thank you for your consideration.

Addendum

The concept in slide 14 of Jesus' body transitioning into an "alternate dimensionality" may need further explanation. Our understanding of the physical world around us has been a very gradual development over many centuries. Physicists first recognized three components of our physical reality: matter, space, and time, consistent with God's creation of the universe in Genesis 1:1 "In the beginning (time), God created the heavens (space) and the earth (matter)." Then they came to realize that matter in particular relationships to space and time can give rise to a very important concept called energy. And at the current time, people are starting to recognize that matter in other particular relationships to space and time can give rise to another important concept - information. For example, all of life exists on this planet because of the information content in its genetic material. But there are basic conflicts in our current understanding of the "laws" by which we observe reality to function. For example, the basic assumptions of general relativity are in conflict with the basic assumptions of quantum mechanics – they can't both be true and apply to all of reality. To help resolve this issue and to answer basic questions such as how the various forces and sub-atomic particles in nature relate to each other and even why matter has weight, that is, to essentially develop a "theory of everything", a branch of modern physics has developed called "string theory." String theorists attempt to resolve these conflicts and answer these questions by extending our concept of reality with its four dimensions, three spatial dimensions (X, Y, and Z) plus one time dimension, into higher dimensionalities containing anywhere from 10 to 26 dimensions. The point is that our perception of our four dimensional reality may be only a small subset of a larger reality. So if the atoms in Jesus' body transitioned, or phased, from our four dimensional reality into an alternate dimensionality within the larger reality, the body could very well give the appearance of disappearing from our four dimensional reality. This may seem very strange to our thinking, but modern physics has been forced to consider these concepts to be possibly true based on how our physical universe operates.