STUDYING RADIOCARBON PAPERS MAY SOLVE THE ENIGMA OF THE RADIOCARBON DATING OF THE SHROUD OF TURIN.

Remi Van Haelst
r.vanhaelst@scarlet.be

Note:
Most data used in this paper are taken from peer reviewed papers, published by radiocarbon experts.
I strongly advice all those interested in a scientific examination of the radiocarbon dating of the Shroud to do the same.

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In Volume 337 N° 6208 of the Nature magazine of 16th February 1989, the results of the radiocarbon dating of the Shroud of Turin were published. The independently obtained results from the laboratories of Oxford, Zurich and Tucson, all using AMS, were statistically evaluated by the British Museum. The conclusion was that the linen of the Shroud of Turin is mediaeval, with at least 95% confidence.

In theory there are FOUR types of distributions. (1)

Distribution	Symbol	Type	Symbolic form.
Normal	Z	Individual observations.	$Z = (x - ù)/\sigma$
Student	t	Sample means	$t = (X - ù)/(s/n^{0.5})$
Chi²	Chi²	Sample variances	$Chi^2 = s^2/(\sigma^2/d.f)$
ANOVA (= Inverted Beta)	F	Ratio of TWO sample variances	$F = S_1^2 / S_2^2$

The statistical analysis, conduced by the British Museum, was made on the basis of a Chi² distribution, in an adapted version by Ward and Wilson.
Strangely, on page 613 one reads that Dr. Leese used ANOVA:

> "The value of d, which lies between the inter- and intra laboratory degrees of freedom was estimated at 5, on the basis of an analysis of variance (ANOVA) on the 12 individual measurements supplied by the laboratories." (2)

In theory, ANOVA is more robust than Chi², certainly when analysing radiocarbon data, obtained by AMS.
The reason for this is that in AMS, each date is the mean of a number of runs, in which are measured a number of targets (or replicates).

In ANOVA, one compares the variability between laboratories with the variability within each laboratory.
The use of ANOVA is approved by NIST. (3)
Example:
Under Table 1 (2) one reads the following remark:
"One anomalous replicate (of 6) obtained for sample for independent measurement O2.2b; if rejected it reduces date by 40 years, final date quoted actually reduced by 20 years."

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Being a graduate chemist, trained to judge industrial laboratory results in the PPM range, I immediately spotted some discrepancies between the 12 individual data in Table 1 and the 3 means given in Table 2.
In reality the Chi² value given as 6.4 is 8.5, a value much greater than the maximal test value 5.99, for the claimed 95 % confidence.
Such a large Chi² value excludes a 95 % confidence.

Nature Table 2 versus computer recalculations.
Ar. 646-+31 Ox. 750-+30 Zu. 676-+24 W. Mean 689-+16 Chi²: 6.4 % SL: 5
Ar 646-+17 Ox. 749-+31 Zu 676-+24 W. Mean 672-+13 Chi² 8.6 % SL:1.4
Computer calculations, based on personal correspondence with Ward & Wilson.
Approved to be correct by Dr. Morven Leese of the British Museum.

Also suspicious are the different values for $-\delta^{13}C$ for samples cut from the same small piece of linen.
In Nature Table 1 is noted Arizona: - 25 Oxford: -27 Zurich: -25.1 o/oo
Note 1 o/oo ^{13}C is many times the whole content in ^{14}C.

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In time several statisticians came to the same conclusion:

The Nature data are not supported by statistical analysis.

Applying Bayes statistics, Andrés Christen used the radiocarbon data for the Shroud as an example. (4)
He concluded: "The dates 795 and 591 are most probably outliers."
In New York (1997), Dr. Marion Scott (Glasgow), a member of the panel on radiocarbon, refused to perform her own EEM ~ EEM calculations, using the Nature data for the Shroud. (5)

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Finally some of the radiocarbon scientists involved agreed with my justified criticism, by correctly assuming that the errors were not large enough to explain an error as large as 1300 years.
But none of them did reply to the simple question:

HOW DID ONE OBTAIN THE CLAIMED 95 % CONFIDENCE?

Because none of the peers did make any remark, the editors of Nature simply refused to comment on my criticism.
Strangely, the same goes for the authorities in Turin.
When meeting Prof. Gonella in Paris (1989), I asked him why he did not spot the wrong Arizona error in Table 2. He never spoke to me again.

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After some extended correspondence with Prof. Hedges & Dr. Ramsey (Oxford) and Prof. Jull (Tucson) the matter was solved on the basis of a paper by Burr et al. (5)
Here is explained how the AMS facility of Tucson is continuously monitored to keep the deviation of the AMS machine within the limit of 0.3 % Random Machine Error (RME).
For RME values > 0.3, the unit is stopped for tuning up and eventually repairs.
Between March and August 2005, the Arizona facility was stopped FIVE times, because of RME Values > 0.3 % .
To test the AMS facility, in BLIND, series of 8 standard samples are measured 6 times, under the same conditions.
To show the power of ANOVA, I asked Prof. Jull, to give me access to these data. Studying the Burr paper, I was surprised to learn how variable AMS measurements are and how easily samples can be contaminated.
The ^{14}C counts vary between 14000 ~ 24000, while the ratio $^{14}C/^{13}C$ vary between 16 ~ 24. Note that the normal ratio is 1.1×10^{-10}
Using statistical analysis and error reduction (7 & 8) the 48 data in Table 2a, one obtains a number of coefficients ranging from 0.9821 till 1.0156.
In theory, a positive ANOVA analysis should result in an F value BELOW the F value for 6 x 8 measurements at 95 % confidence.
These data, in function of the inter- and intra- degrees of freedom are given in statistical tables.
At 95% confidence, for 8 runs with each 6 measurements, with a degree of freedom {inter (8 – 1) and intra (48 – 8)} the MAXIMUM F value is 2.73.

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The ANOVA analysis of the measurements of the 48 standard samples, as given by Burr resulted in a POSITIVE F value of 1.3 < 2.73.
Prof. Jull was very pleased with the result and agreed that ANOVA could be a useful tool in analysing radiocarbon data.

Then I analysed the following set of 48 data.

8630	8817	8701	8842	8951	8820	8804	8700
8689	8945	8601	8799	8966	8734	8803	8732
8631	8985	8818	8961	8853	8749	8618	8661
8632	8885	8572	8889	8901	8839	8812	8710
8764	8848	8788	8794	8771	8771	8778	8767
8793	8813	8662	8743	8865	8908	8840	8650

Sum

52150 53293 52141 53028 53308 52821 52655 52219 Total = 421606

Total squared sums:

$52150^2 + 53293^2 + 52141^2 + 53028^2 + 52821^2 + 52655^2 + 52219^2 = 22220661816$

Total of 48 squared data:

$8630^2 + 8689^2 +$ ---------- $8767^2 + 8650^2 = 3703662222$

Determination of the coefficients

Number of runs = 8 Number of targets pro run = 6 Total of data = 48

Factor A = $421606^2/48$ = 3703159834

Factor B = 22220661816/6 = 3703443636

Factor C = = 3703662222

ANOVA DF

Between = 3703443636 – 3703159834 = 283801 / 7 = 40543

Residue = 502387 – 283801 = 218586 / 40 = 5465

Total = 3703662222 – 3703159834 = 502387 F = 40543/5465 = 7.4

Note: The RESIDUE should be equal to the total VARIANCE for the 8 runs.

Conclusion: The ANOVA test 7.4 >> 2.73 is NEGATIVE.

Note: Today, there are several websites, giving direct ANOVA results.
One only needs to enter for each run: the number of targets, the means and standard deviation.
In no time, the computer gives the F value and the Probability level.
Because % ^{14}C data are log-normally distributed, small errors are possible.

To my surprise, Prof Jull asked me where I got this information, for normally no laboratory will give this kind of information.
Then I told Jull that I used the EIGHT original Shroud data, obtained by Arizona, multiplied by the 48 coefficients, given by Burr in table 2b.
As a professor, Jull replied: "I have to give you marks for perseverance.
The data used by you are correct. To day we should perform much better."
Alas, Burr did not answer my questions.

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Studying a paper by Hodgins, Butters, Ramsay and Hedges (9) I learned that contamination of "dead wood" as old as 55.000 years, by acid and enzyme hydrolysis may cause significant enrichment in ^{14}C.

Acid treatment:
One obtained 42 µg of pure carbon, containing 21.5 -+ 0.3 % 14C.
Enzyme treatment:
A: One obtained 15 µg of pure carbon, containing 144 -+ 7.4 % 14C
B: One obtained 320 µg of pure carbon, containing 5.6 -+ 0.3 % 14C.

Note:
This paper shows clearly, that sample contamination by modern carbon is not excluded.
The same phenomenon was already noted by Lloyd Currie, writing in NIST.
He also analysed the Nature data, explaining the variability of the data for the Shroud, by the irregularity of ^{14}C concentration, due to atmospheric disturbances. (10)
Analyzing NIST dust samples SRM 1649a , different rates in ^{14}C in char and soot were found. In material from the "Dent Mammoth" one found ^{14}C values between 2500 and 4000 counts.
He announced "near future" ^{14}C measurements, based on a real isotopic mass balance.

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