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COMMENTS ON AN EXPERIMENT AT YALE ON COLD FUSION

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INTRODUCTION

A brief experiment was conducted at Yale in August 1989 to search for neutron emissions from D_2-gas loaded metals. 103 hours of data were acquired for D_2-loaded samples, and only 28 hours of background runs were performed. We will comment on the experiment based largely on information given in the Yale "Interim Report."[1] Of particular importance is the probability of detecting neutron emissions in such a brief running time. We will show that the probability expression used in the Interim Report is incorrect. A corrected probability calculation is given here using Monte Carlo methods. Then we assess the probability of detecting neutron-bursts in the Yale counter over the data-taking period. We will show that the likelihood of neutron-burst detection in the Yale experiment is low so that the claimed "null" results of the experiment do not contradict the results of Menlove et al. [2] We will also re-examine a possible burst event identified in the Yale experiment.

PROBABILITY EXPRESSION IN INTERIM REPORT WAS INCORRECT

The probability of detecting neutrons from a Menlove-type burst (approx. 20 to 300 neutrons in a 128μs window) must be well-known in order to interpret the data, and indeed to assess the efficacy of the Yale experimental set-up. The Interim Report provides the following probability expression for interpreting the data:

"The most probable neutron multiplicity (M_n) can be calculated from an event of fold (K) using the efficiency for detecting an event of fold (K) given by:

$$\epsilon(K) = M_n * \epsilon(12) * (M_n - 1) * \epsilon(11) * ... * (M_n - K) * \ \epsilon(12 - K) \qquad (1)$$

For neutron source of multiplicity 125 we obtain 100% efficiency for detecting a neutron in each detector (fold=12), and for multiplicity of 20 we have 100% efficiency of detecting 5 neutrons." (Yale Interim Report, pg. 5)

The predictions of 100% efficiency in the Interim Report are dubious and we found that the expression does not represent a proper probability.[3]

When we challenged this expression in the Interim Report, we were given a "corrected" expression for the probability $P_{M,D}(k)$ of getting k hits among D detectors of efficiency ϵ each, when exposed to a burst of M neutrons [4]:

$$P_{M,D}(k) = \frac{M!}{(M-K)!}\frac{D!}{(D-K)!}\epsilon^k\frac{(M-K)}{K!} \tag{2}$$

It is easy to see that the new term $(M-K)/K!$ does not remedy the problems with expression (1): it is itself larger than one for small K and anticipated multiplicity values. Consider the probability of detecting just $K = 1$ hit from $M = 10$ neutrons among the $D = 10$ ring counters in the Yale detector. Then according to equation (2),

$$P = \frac{10!}{9!}\frac{10!}{9!}(0.008)^1\frac{10}{1!} = 8 \tag{3}$$

which is clearly a fallacious 'probability,' being larger than 1 for a multiplicity of only 10 neutrons.

We conclude that the Yale Interim Report and in fact the experimental set-up including needed running times were based to a large extent on an erroneous "probability" formula. Since one of us (SJ) appeared on the Interim report, albeit with a clear disclaimer [1], we feel it a duty to clarify the facts as best we know them.

Seemingly plausible arguments may generate expressions which, when evaluated, normalize to more than 1, or which when compared to a Monte Carlo for the same system give discrepant results, as is the case here. There is no reason to believe that this system might not have an extremely complicated expression for the exact probability. It is at this juncture that a Monte Carlo, properly tested against simple cases, justifies greater confidence than a derived expression. Since a major purpose of the experiment was to look for neutron bursts, it is important that the response to multiple events be properly understood.

DETECTOR-HIT PROBABILITIES FOR NEUTRON BURSTS CALCULATED VIA MONTE CARLO

We have written a Monte Carlo program to compute the probability distributions for various neutron burst multiplicities. The results have been checked for consistency with predictions for simple cases. The calculations assume a central counter of 10% efficiency and 10 ring counters of 0.8% efficiency as described in the Yale 'Interim Report' (see Figure 1). However, we also generated a separate Monte Carlo simulation of the liquid scintillator counter efficiencies including geometrical factors, as we have done for very similar counters used for muon-catalyzed fusion experiments [5]. The results

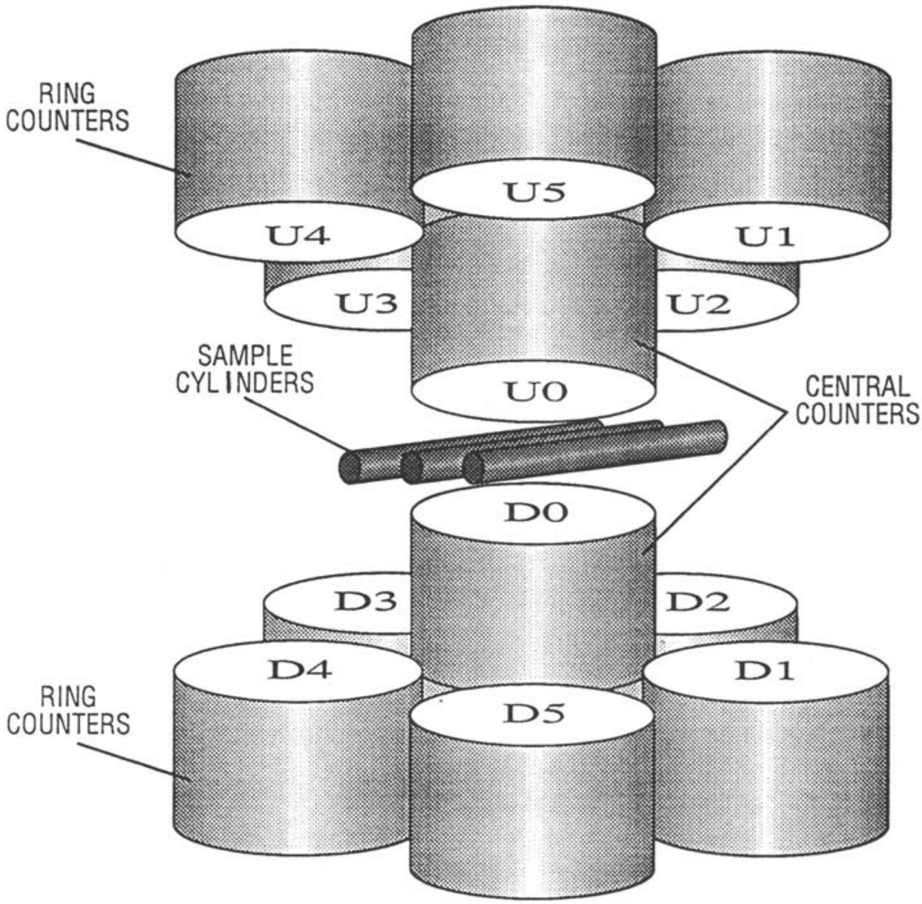

Figure 1. Schematic view of the Yale experiment (August 1989) indicating relative positions of central and ring counters. Liquid-scintillator filled counters were actually five-sided and about 17 cm deep; light guides also had sharp angles. Pulse-shape discrimination was used to help distinguish neutrons from gammas (see Table I).

of this simulation suggest that ϵ_i are approximately 0.5% for ring counters. Furthermore, each detector will have a different efficiency depending on electronic inefficiencies and applied cuts. Thus, the efficiencies $\epsilon_i = 0.8\%$ stated for each ring counter in the Interim Report are suspect. We add a calculation assuming $\epsilon_i = 0.5\%$ for completeness. The Monte Carlo simulation can readily accommodate differing efficiencies for each detector should these be provided by the Yale collaboration as would be proper and more accurate than an unsupported "average" efficiency value.

The calculated probabilities of various ring detector hit multiplicities for bursts of 20, 50 and 125 neutrons are listed in the Appendix; results are summarized in Figures 2 and 3. Tables in the Appendix consist of probabilities for detecting from 0 to 10 ring-detector hits assuming various imposed conditions on multiple hits in both the central and ring detectors. 10,000 events, or bursts, of specified multiplicity were generated and the number of single and multiple hits for each counter accumulated. Tables for both 0.8% and 0.5% efficiencies (labelled 'ei'), and deadtime fractions ('ddtm') of 0, 0.1, and 1, were computed to include the effects of possible electronic and gate inefficiencies.

If a detector has already been hit, subsequent hits have a probability of 'ddtm' of being accepted. The ring-hit probabilities are normalized to the total number of bursts. In addition to probabilities for N hits, the accumulated probabilities for N hits or greater are also shown. The expectation value for number of hits is shown at the foot of the table. In order to check the Monte Carlo for the simple case of having K detectors hit by exactly 1 neutron, and no other hits, given a burst of M neutrons and D detectors of efficiency ϵ, we use the probability expression

$$P_{M,D,\epsilon}(K) = \binom{M}{K}\binom{D}{K} K!\epsilon^K(1-D\epsilon)^{M-K} \qquad (4)$$

where $\binom{M}{K}$ is the usual binomial coefficient.

Equation (4) is evaluated under the column labelled 'predict'. The criteria that the equation assumes are: the center counters 'not required', and ring counters are 'only', and 'ddtm' = 1.0. We find good agreement between predictions of (4) and corresponding Monte Carlo calculations (Appendix), an important check.

Each neutron was allowed to hit *only one* each of ring and central detectors. Thus the actual system may have a somewhat greater probability for multiple events due to multiple scattering. The probability for double hits in counters for moderate-sized bursts is not insignificant.

The deadtime of the pulse-shape discriminators was stated [4] as 90ns. With an event gate of 10 μs [1], this would imply an inefficiency of ≈ 0.01. If neutron bursts are narrower than the event gate, the inefficiency could increase to a maximum of 1.0 ('ddtm'= 1) for burst durations of 90ns or less. We do not know the length of bursts; indeed an objective of the experiment was to be prepared to evaluate burst durations.

Note that for large multiplicities there are non-negligible probabilities for detecting more than one neutron in a detector. (See Figure 2.) In fact, for ddtm=1, the probability of two hits in one detector is exactly the probability of one hit each in two detectors.

With these results in hand, let us revisit a few statements in the Yale Interim Report [1]. The report states that the probability for detecting 5 neutrons (assume 2 central and 3 ring) out of a burst of 20 to be 100%. In contrast, the actual probability for <u>not</u> detecting *any* neutrons in ring counters would be

$$P_{20,10,0.008}(0) = (1 - 0.08)^{20} = 18.9\% \tag{5}$$

which is an obvious contradiction to the Interim Report. The Monte Carlo predicts a value of 18.4% for $P(0)$ (in good agreement with prediction (6)) and a probability of about 13% for getting hits in 3 or more ring detectors with such a burst. Furthermore, the probability for detecting a burst of 125 neutrons in <u>all</u> ring counters is less than 5%, rather than 100% as stated erroneously in the Interim Report, an enormous discrepancy. Predictions from the Monte Carlo are contrasted with those in the Interim Report in Figures 2 and 3.

REEXAMINATION OF CANDIDATE BURST EVENT USING CORRECT PROBABILITIES

The Interim Report mentions one event which has characteristics of a moderately large neutron burst (See table 1). In this case, partially-deuterided titanium materials (Ti-662 alloy, see ref. 2) were warming from liquid nitrogen temperature. At a temperature of approximately -10^{o}C, where bursts are reported at high frequency by Menlove et al. [2], an apparent burst occurred in that both central counters (UO and DO) fired along with hits in three ring counters, U1, U3 and U5. Pulse-shape analysis showed that each of the 5 hits was consistent with incident neutrons (not gammas, etc.), as duly reported in the Interim Report. The energy deposited in 3 counters is consistent with neutrons of 2.5 MeV energy. Central counter DO registered 3.3 MeV and ring counter U4 registered 4.4 MeV of energy, but these energies could well represent double hits in the counters following a neutron burst.

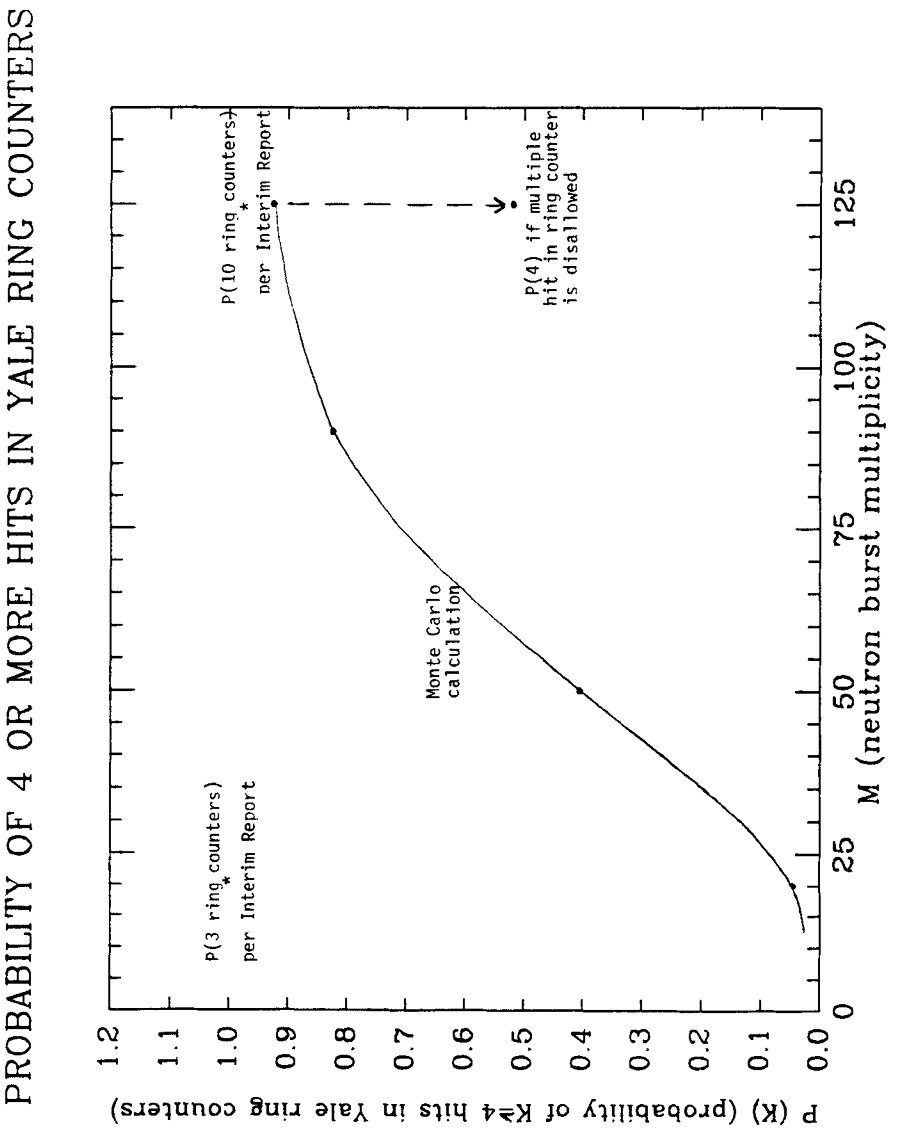

Figure 2. Probability of four or more signals from among ten ring counters (each having neutron detection efficiency 0.008) as a function of number of neutrons in burst, as predicted by Monte Carlo calculation. Note that the Monte Carlo simulation yields burst-detection probabilities which disagree with conclusions in the Yale Interim Report [1].

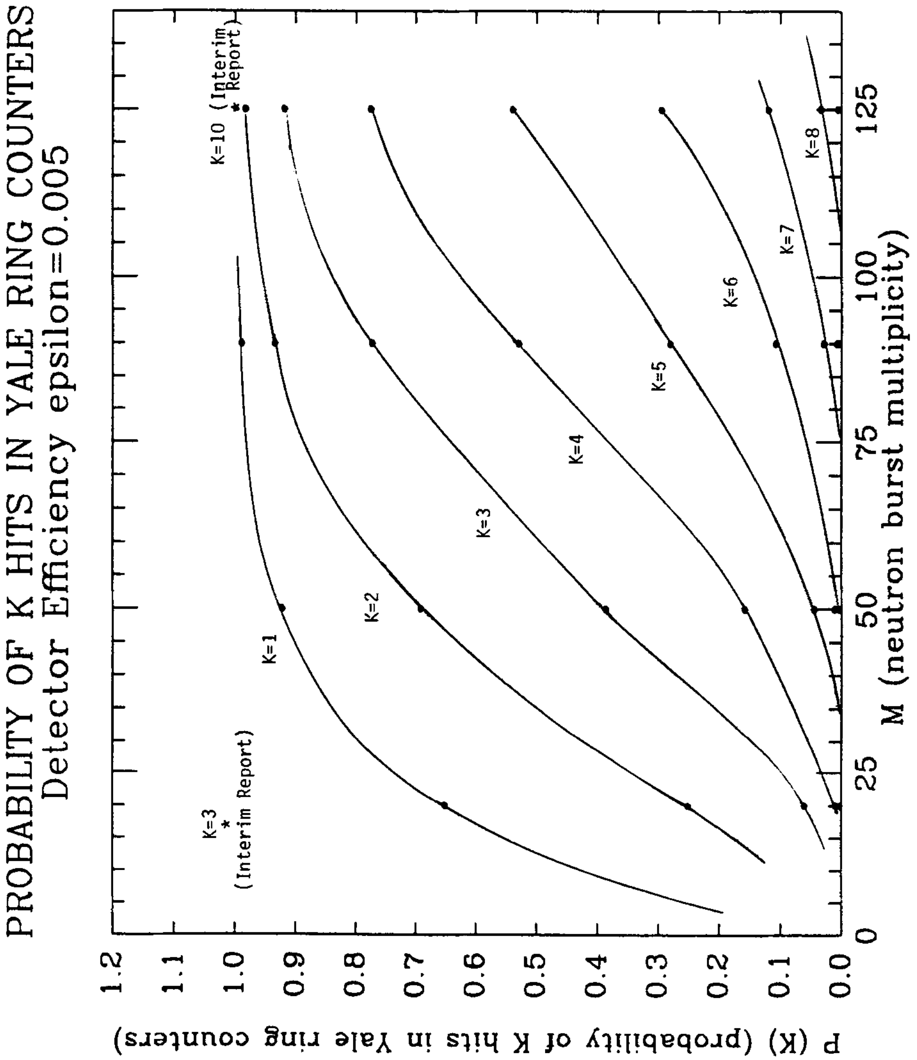

Figure 3. Probability of 1 to 8 hits in ring counters (assuming neutron-detection efficiency of 0.005 each) as a function of neutron burst size, as predicted by the Monte Carlo simulation described in text. Multiple hits in ring counters are allowed here.

Table I: Summary of High Fold Events
(Replicated from Yale Interim Report)

Detector	Energy Deposited (MeV)	Time of Flight (nsec)*	Pulse Shape	Detector	Energy Deposited (MeV)	Time of Flight (nsec)*	Pulse Shape
Five-fold event in background Run 40:				Five-fold event in data Run 45:			
UO	2.8	0.0	n	U0	1.8	0.0	n
U2	0.9	3.7	n	U1	1.1	-17	n
U4	0.9	3.7	n or γ	U3	0.6	3800	n
U5	4.4	-2.4	n or γ	U5	4.4	-18	n
D2	1.5	N/A	n	D0	3.3	N/A	n
Five-fold event in background Run 51:				Six-fold event in data Run 61:			
U3	0.4	N/A	n or γ	U1	0.6	N/A	n
U4	2.0	N/A	n	U4	0.4	N/A	n
U5	4.4	N/A	n or γ	D0	5.4	N/A	n or γ
DO	0.9	0.0	n or γ	D2	1.6	740	n or γ
D1	1.5	3.7	n or γ	D4	1.1	1.2	n or γ
				D5	4.2	1000	n

*N/A: Timing is not available between upper and lower counters (D) due to insufficient electronics [4].

This event has the earmarks of Menlove-type neutron burst in magnitude and timing. Yet it was dismissed in the Interim Report as a cosmic-ray induced event because:

> "...the probability for a double hit in a ring counter is estimated to be of order of 0.2%, see below. We thus can conclude based on the energy deposited in the ring detectors that these events are consistent with background events. In fact inspecting the time scale and energy deposited in detectors U5, U1 and U0 we may conclude that the event of Run 45 include one neutron that does triple scattering including one large angle scattering from detector U5 to its neighbor detector U1, and then immediately followed by a small angle scattering into the central detector U0 lying below the ring detectors (thus yielding to negative time of flight). From our data we deduce an upper limit on neutron bursts from our cells to be smaller than 27 neutrons with 98% confidence (3σ)."[1]

Thus the burst candidate event was rejected because the probability of a double-hit in a ring counter was thought to be only 0.2%. It would be interesting to calculate for comparison the probability of neutron "triple-scattering" resulting in multiple signals in three separate counters, as argued above, along with two other counters showing neutron-like signals in the same event as occurred here.

However, the probability of a double hit in a ring counter arising from a burst of neutrons is not as small as claimed in the Interim Report. There are 10 ring counters in which a double-hit could occur and the neutron multiplicity could be large. The probability for a double hit depends on the burst multiplicity, individual detector efficiencies, electronics deadtimes, and on timing between neutrons. Monte Carlo techniques are good for analyzing situations such as this, and the results of Anderson's Monte Carlo study suggest that the probability for double hits given in the Interim Report is far too small. (See Appendix and Fig. 2).

Applying the results of the Monte-Carlo study for the Yale set-up, we find that a burst of 50-neutrons has a probability of a few percent to 25% (depending on actual detector efficiencies and deadtimes; see Appendix A) of producing the hit pattern of this event, including a double-hit in one ring counter. This is not negligible for a paper trying to set 3σ upper limits. A problem associated with the low (0.005-0.008) efficiencies of ring counters is that unfolding the initial multiplicity from the detected multiplicity is ill-defined. Thus, the event could represent a burst of ≈ 100 neutrons with a still higher probability of double-hits. Furthermore, bursts this large have a high probability ($\gtrsim 50\%$) of triggering one of the large cosmic-ray veto counters (as did occur) since there was no shielding placed between these veto counters and the titanium-deuteride test samples.

On the other hand, this event could possibly represent a cosmic-ray spallation event of, say 30 neutrons, although such an explanation is complicated by the fact that the timing between neutrons extends over 3.8 μsec. Observe that timing of signals for high-multiplicity <u>background</u> events in Table I is just a few <u>nanoseconds</u>, consistent with cosmic-ray-induced spallation origin. We conclude that the low probabilities for burst detection coupled with low statistics in an environment with significant cosmic-ray flux combine to preclude definitive interpretations of such events. The result remains inconclusive.

Scrutinizing this event is important since in such a relatively short experiment as this, one might expect only one burst (or less) as we shall see in the next section. In any case, this event represents a neutron-burst-like event in which 3 ring counters and both central counters were hit and suggests that the upper limit arguments in the Yale report cited above are overstated.

BURST EVENTS EXPECTED AT YALE BASED ON LANL RESULTS

The Interim Report states that any bursts larger than 27 neutrons would have been seen with 98% confidence. [1] This conclusion is based on faulty probability arguments as we have seen: it is grossly overoptimistic (See Figs. 2 and 3).

Using burst-detection probabilities based on our Monte Carlo calculations, we would judge that a burst of 90 or more neutrons would have an 80% probability of generating 4 or more hits in Yale ring-counters (3 ring-counter hits were in evidence in the event discussed above), generously assuming the efficiency of each ring counter to be 0.8% and allowing for double-hits. (See Figure 2.) The neutron detectors used at LANL had moderated neutron-detection efficiencies ranging from 21% to 34%, so that bursts of $\geq$90 neutrons would have >98% probability to record 4 or more hits.[2] However, such large bursts are rare in the experiments conducted at LANL: Table II shows that only 15 bursts of 90 or more neutrons were detected in 9125 hours of running with 36 cylinders. The average mass of partially-deuterided titanium was about 84 g per cylinder, whereas in the Yale experiments, about 184 g average was used in each run [ref. 1, table II]. Putting these factors together, we may estimate the number Y of bursts of $\geq$90 neutrons expected at Yale:

$$
\begin{aligned}
Y = {} & [15 \text{ bursts of } \geq 90 \text{ neutrons each at LANL}] \\
& \text{X } 103 \text{ hours at Yale/ } 9125 \text{ hours at LANL} \\
& \text{X } 184 \text{ g at Yale/84 g at LANL} \qquad (6) \\
& = 0.4 \text{ bursts expected at Yale in 103 hours running.}
\end{aligned}
$$

The probability of detecting a burst with 0.4 events anticipated is: P = 1 - exp (-0.4) = 0.33.

Let us consider the Interim Report case of bursts of 27 or more neutrons. There are 31 such bursts recorded in the LANL/BYU data [2], so that

$$
\begin{aligned}
Y = {} & [\ 31 \text{ bursts of } > 27 \text{ neutrons each at LANL}] \\
& \text{X } 103 \text{ hours at Yale/ } 9125 \text{ hours at LANL} \\
& \text{X } 184 \text{ g at Yale/ } 84 \text{ g at LANL}
\end{aligned}
$$

Table II

Starting date (Mo/d/y)	Sample Number	Number of source Neutrons[a]	Burst cycle (time)[b]	Total time (h)[c]
Active samples				
4/28/89	Ti-1	127, 136, 85, 76	3(75), 3(75), 4(80), 4(80)	180
5/6/89	Ti-6	258, 179, 121, 70, 15, 127, 94	4(92), 5(110), 5(110), 6(116), 7(140), 8(164), 9(188)	336
5/19/89	DH-1	55, 15, 15, 27	1(48), 2(55), 2(72), 2(78)	264
6/2/89	DD-2	12, 85, 15, 15, 39, 142, 18, 30	0(15), 0(25), 1(48), 1(49), 2(97), 2(97), 2(99), 3(123)	300
6/20/89	Ti-14	15, 91, 12, 24	2(48), 2(72), 4(96), 5(120)	200
6/28/89	Ti-16	24, 24, 12, 15, 18, 15, 15, 109, 18	1(50), 2(72), 2(72), 3(96), 4(144), 5(145), 5(146), 7(150), 8(310)	420
7/7/89	DD-5	12, 279, 130, 88, 48	6(312), 6(312), 6(313), 6(313), 6(314)	620
7/18/89	Ti-19	88, 15	1(50), 6(216)	350
8/18/89	Ti-22	55, 97	2(72), 3(98)	288
8/11/89	Ti-23	19, 23, 19	0(10), 1(82), 5(226)	260
8/8/89	Ti-24	35, 119, 16, 16, 16, 15, 15	0(24), 2(144), 2(144), 3(168), 3(169), 3(171), 6(216)	316
8/29/89	Ti-30	280, 13	6(312), 8(408)	480
9/11/89	Ti-31A	86, 34	7(336), 7(336)	500
9/12/89	Ti-32	23, 35	1(2), 1(19)	380
Borderline samples				
5/16/89	Ti-10	12, 15	6(96), 7(122)	240
6/9/89	DH-4	21	2(120)	200
6/12/89	Ti-13	24	1(28)	140
8/22/89	Ti-25	32	3(72)	280
8/24/89	Ti-28	17	2(28)	250

Inactive samples (Ti)	Run h[c]	Pd samples	Run h[c]	H_2 controls	Run h[c]
				$Pd-H_2$	110
Ti-2	120	Pd-1s	110	Ti-27	220
Ti-3	100	Pd-3s	90	Ti-29	216
Ti-4	108	Pd-4s	120	Ti-31	62
Ti-5	91	Pd-5L	110	Ti-35	630
Ti-7	84				
Ti-8	120				
Ti-9	132				
Ti-11	168			SS + Ti	2600
DD-3	156				
Ti-12	260				
Ti-15	210				
Ti-17	280				
Ti-18	170				
Ti-20	260				
Ti-21	212				
Ti-26	330				
Ti-36	320				

[a] The bolded source neuron values corresponded to the burst occurring between −100°C and 0°C during warmup from LN temperature.
[b] The designation 3(75) represents a burst during cycle 3, 75 h after loading the D_2 gas.
[c] The time represents the total sample measurement time.

$$= 0.77 \text{ bursts expected at Yale,} \tag{7}$$

so the probability of detecting one burst is P = 1-exp(-0.77)= 0.55. Thus, even dramatically relaxing the constraint on burst size observable in the Yale detector, we find only a ≈55% probability of seeing a burst in the duration of the Yale experiment. This probability is consistent with a comment on the experiment in reference 7.

It has been argued [4] that we should compare just the data-collection times accumulated while the titanium cylinders were warming up, since most bursts occurred during warm-up at Los Alamos [2]. We disagree with this approach since deuteriding usually proceeds slowly in our titanium samples which were annealed at less than 300°C [2,5] so that the "soaking" time is important. Nevertheless, we will re-do calculation (6) for completeness:

Y (warm-up time only) = 15 bursts at LANL >90 neutrons

x 20 warm-up hours at Yale/400 warm-up hours at LANL (approx.)

x 184 g at Yale/ 84 g at LANL (average)

= 1.6 bursts expected,

so detection probability is P = 1 - exp (-1.6) = 80%. (8)

There are other factors which should be mentioned as we attempt to compare the two experiments fairly. The time gate over which the systems were sensitive to neutron detection was considerably longer at LANL. The LANL detectors were active for 128 μs, whereas the time gate at Yale we estimate at 20 μs, but in any case substantially less that the LANL gate. The Interim Report also notes that about seventeen (17) hours of data collection were spent on samples prepared by Brookhaven National Laboratory, which were distinct from the titanium materials used at LANL. Thus, if we include a factor for the event gate difference since the duration of burst events is unknown, or reduce the hours spent at Yale to just those using LANL-type samples, then the burst-detection probability at Yale becomes even **less** than evaluated above.

We should also consider the sensitivity of the Yale experiment with regard to uncorrelated-neutron production, as opposed to burst events. Like bursts, episodes of random-neutron production were rare in the Los Alamos experiments. Two significant episodes are recorded in ref. 2, occurring in 1703 hours of running. Thus we estimate:

$$\begin{aligned} Y' &= [\text{2 random-neutron episodes at LANL}] \\ &\quad \times \text{103 hours at Yale / 1703 hours at LANL} \\ &\quad \times \text{184 g at Yale / 84 g at LANL} \\ &= 0.26, \end{aligned} \tag{9}$$

so the likelihood of seeing one such neutron-emission episode during the short Yale experiment is small.

The probabilities evaluated above (relations 6-9) are not in contradiction with one neutron-burst candidate or even with zero events in the Yale experiment. We conclude that the Yale experiment was too short to make a definitive statement regarding the veracity of the LANL/BYU results. But longer running times alone would not suffice to remedy weaknesses of the Yale experiment [3]. A better test is planned using the Kamiokande detector in Japan [8] which has the distinct advantage of being 1000m underground so as to preclude cosmic-rays. Neutron-like background counts are much lower than at Yale while neutron-detection efficiencies approach 20%. The experiment will run several weeks and should be completed by summer 1991.

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Appendix Probabilities for Ring-detector Multiplicities

burst = 20 neutrons, count=10000 ei=0.008, e0 = 0.10, 10 dets ddtm=0.10

	Center: ignore,			any			sngl			
Ring:	any	sngl	only	any	sngl	only	any	sngl	only	predict (ign,only)
Probability for exact ring multiplicity										
0:	0.1838	0.1873	0.1838	0.1596	0.1629	0.1596	0.1412	0.1441	0.1412	0.1887
1:	0.3593	0.3604	0.3558	0.3165	0.3173	0.3132	0.2744	0.2753	0.2715	0.3282
2:	0.2839	0.2824	0.2793	0.2502	0.2489	0.2461	0.2200	0.2187	0.2162	0.2440
3:	0.1298	0.1282	0.1267	0.1131	0.1117	0.1103	0.1009	0.0995	0.0984	0.1018
4:	0.0365	0.0352	0.0350	0.0320	0.0308	0.0306	0.0278	0.0269	0.0267	0.0263
5:	0.0061	0.0059	0.0059	0.0058	0.0056	0.0056	0.0053	0.0051	0.0051	0.0044
6:	0.0005	0.0005	0.0005	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0005
7:	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
8:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
accumulated probability for n or more ring hits										
0:	1.0000	1.0000	0.9871	0.8776	0.8776	0.8658	0.7699	0.7699	0.7594	0.8939
1:	0.8162	0.8127	0.8033	0.7180	0.7147	0.7062	0.6287	0.6258	0.6182	0.7052
2:	0.4569	0.4523	0.4475	0.4015	0.3974	0.3930	0.3543	0.3505	0.3467	0.3771
3:	0.1730	0.1699	0.1682	0.1513	0.1485	0.1469	0.1343	0.1318	0.1305	0.1331
4:	0.0432	0.0417	0.0415	0.0382	0.0368	0.0366	0.0334	0.0323	0.0321	0.0313
5:	0.0067	0.0065	0.0065	0.0062	0.0060	0.0060	0.0056	0.0054	0.0054	0.0049
6:	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003	0.0005
7:	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
8:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Expected Multiplicity:										
	1.4967	1.4838	1.4869	1.4992	1.4858	1.4890	1.5024	1.4888	1.4924	1.4007

burst = 20 neutrons, count=10000 ei=0.005, e0 = 0.10, 10 dets ddtm=1.00

	Center: ignore,			any			sngl			
Ring:	any	sngl	only	any	sngl	only	any	sngl	only	predict (ign,only)
Probability for exact ring multiplicity										
0:	0.3487	0.3712	0.3487	0.3043	0.3240	0.3043	0.0913	0.0976	0.0913	0.3585
1:	0.4017	0.3959	0.3794	0.3537	0.3489	0.3342	0.1055	0.1041	0.0993	0.3774
2:	0.1899	0.1794	0.1735	0.1669	0.1579	0.1523	0.0520	0.0490	0.0472	0.1698
3:	0.0507	0.0458	0.0445	0.0442	0.0395	0.0383	0.0138	0.0125	0.0119	0.0429
4:	0.0083	0.0071	0.0070	0.0074	0.0063	0.0062	0.0028	0.0023	0.0022	0.0067
5:	0.0006	0.0005	0.0005	0.0006	0.0005	0.0005	0.0002	0.0001	0.0001	0.0007
6:	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
7:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
accumulated probability for n or more ring hits										
0:	1.0000	1.0000	0.9537	0.8772	0.8772	0.8359	0.2656	0.2656	0.2520	0.9560
1:	0.6513	0.6288	0.6050	0.5729	0.5532	0.5316	0.1743	0.1680	0.1607	0.5975
2:	0.2496	0.2329	0.2256	0.2192	0.2043	0.1974	0.0688	0.0639	0.0614	0.2202
3:	0.0597	0.0535	0.0521	0.0523	0.0464	0.0451	0.0168	0.0149	0.0142	0.0503
4:	0.0090	0.0077	0.0076	0.0081	0.0069	0.0068	0.0030	0.0024	0.0023	0.0074
5:	0.0007	0.0006	0.0006	0.0007	0.0006	0.0006	0.0002	0.0001	0.0001	0.0007
6:	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
7:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Expected Multiplicity:										
	0.9704	0.9236	0.9343	0.9728	0.9251	0.9350	0.9906	0.9386	0.9472	0.9166

```
burst = 20 neutrons, count=10000  ei=0.008, e0 = 0.10, 10 dets ddtm=1.00
Center:ignore,              any                       sngl
Ring:any    sngl    only    any    sngl    only     any    sngl    only    predict
Probability for exact ring multiplicity                                    (ign,only)
  0:0.1838 0.2159 0.1838   0.1596 0.1879 0.1596   0.0461 0.0545 0.0461   0.1887
  1:0.3593 0.3705 0.3286   0.3165 0.3257 0.2892   0.0938 0.0972 0.0855   0.3282
  2:0.2839 0.2673 0.2418   0.2502 0.2361 0.2138   0.0756 0.0713 0.0640   0.2440
  3:0.1298 0.1134 0.1042   0.1131 0.0988 0.0906   0.0332 0.0279 0.0262   0.1018
  4:0.0365 0.0278 0.0266   0.0320 0.0245 0.0233   0.0090 0.0074 0.0070   0.0263
  5:0.0061 0.0047 0.0045   0.0058 0.0043 0.0042   0.0017 0.0011 0.0011   0.0044
  6:0.0005 0.0004 0.0003   0.0003 0.0003 0.0002   0.0001 0.0002 0.0001   0.0005
  7:0.0001 0.0000 0.0000   0.0001 0.0000 0.0000   0.0001 0.0000 0.0000   0.0000
  8:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
  9:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
 10:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
accumulated probability for n or more ring hits
  0:1.0000 1.0000 0.8898   0.8776 0.8776 0.7809   0.2596 0.2596 0.2300   0.8939
  1:0.8162 0.7841 0.7060   0.7180 0.6897 0.6213   0.2135 0.2051 0.1839   0.7052
  2:0.4569 0.4136 0.3774   0.4015 0.3640 0.3321   0.1197 0.1079 0.0984   0.3771
  3:0.1730 0.1463 0.1356   0.1513 0.1279 0.1183   0.0441 0.0366 0.0344   0.1331
  4:0.0432 0.0329 0.0314   0.0382 0.0291 0.0277   0.0109 0.0087 0.0082   0.0313
  5:0.0067 0.0051 0.0048   0.0062 0.0046 0.0044   0.0019 0.0013 0.0012   0.0049
  6:0.0006 0.0004 0.0003   0.0004 0.0003 0.0002   0.0002 0.0002 0.0001   0.0005
  7:0.0001 0.0000 0.0000   0.0001 0.0000 0.0000   0.0001 0.0000 0.0000   0.0000
  8:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
  9:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
 10:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
Expected Multiplicity:
    1.4967 1.3824 1.4110   1.4992 1.3851 1.4138   1.5039 1.3860 1.4183   1.4007


burst = 50 neutrons, count=10000  ei=0.008, e0 = 0.10, 10 dets ddtm=0.00
Center:ignore,              any                       sngl
Ring:any    sngl    only    any    sngl    only     any    sngl    only    predict
Probability for exact ring multiplicity                                    (ign,only)
  0:0.0167 0.0167 0.0167   0.0167 0.0167 0.0167   0.0167 0.0167 0.0167   0.0155
  1:0.0788 0.0788 0.0788   0.0785 0.0785 0.0785   0.0785 0.0785 0.0785   0.0672
  2:0.1986 0.1986 0.1986   0.1979 0.1979 0.1979   0.1979 0.1979 0.1979   0.1289
  3:0.2673 0.2673 0.2673   0.2663 0.2663 0.2663   0.2663 0.2663 0.2663   0.1435
  4:0.2367 0.2367 0.2367   0.2356 0.2356 0.2356   0.2356 0.2356 0.2356   0.1026
  5:0.1356 0.1356 0.1356   0.1348 0.1348 0.1348   0.1348 0.1348 0.1348   0.0493
  6:0.0522 0.0522 0.0522   0.0516 0.0516 0.0516   0.0516 0.0516 0.0516   0.0161
  7:0.0119 0.0119 0.0119   0.0118 0.0118 0.0118   0.0118 0.0118 0.0118   0.0035
  8:0.0020 0.0020 0.0020   0.0020 0.0020 0.0020   0.0020 0.0020 0.0020   0.0005
  9:0.0002 0.0002 0.0002   0.0002 0.0002 0.0002   0.0002 0.0002 0.0002   0.0000
 10:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
accumulated probability for n or more ring hits
  0:1.0000 1.0000 1.0000   0.9954 0.9954 0.9954   0.9954 0.9954 0.9954   0.5272
  1:0.9833 0.9833 0.9833   0.9787 0.9787 0.9787   0.9787 0.9787 0.9787   0.5117
  2:0.9045 0.9045 0.9045   0.9002 0.9002 0.9002   0.9002 0.9002 0.9002   0.4445
  3:0.7059 0.7059 0.7059   0.7023 0.7023 0.7023   0.7023 0.7023 0.7023   0.3155
  4:0.4386 0.4386 0.4386   0.4360 0.4360 0.4360   0.4360 0.4360 0.4360   0.1720
  5:0.2019 0.2019 0.2019   0.2004 0.2004 0.2004   0.2004 0.2004 0.2004   0.0694
  6:0.0663 0.0663 0.0663   0.0656 0.0656 0.0656   0.0656 0.0656 0.0656   0.0201
  7:0.0141 0.0141 0.0141   0.0140 0.0140 0.0140   0.0140 0.0140 0.0140   0.0040
  8:0.0022 0.0022 0.0022   0.0022 0.0022 0.0022   0.0022 0.0022 0.0022   0.0005
  9:0.0002 0.0002 0.0002   0.0002 0.0002 0.0002   0.0002 0.0002 0.0002   0.0000
 10:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
Expected Multiplicity:
    3.3170 3.3170 3.3170   3.3148 3.3148 3.3148   3.3148 3.3148 3.3148   2.9171
```

burst = 50 neutrons, count=10000 ei=0.005, e0 = 0.10, 10 dets ddtm=0.10

Center:	ignore,			any			sngl		
Ring:	any	sngl	only	any	sngl	only	any	sngl	only	predict (ign,only)
Probability for exact ring multiplicity										
0:	0.0779	0.0820	0.0779	0.0772	0.0813	0.0772	0.0507	0.0532	0.0507	0.0769
1:	0.2298	0.2345	0.2259	0.2284	0.2331	0.2245	0.1546	0.1582	0.1523	0.2025
2:	0.3063	0.3062	0.2978	0.3046	0.3044	0.2961	0.2037	0.2032	0.1977	0.2350
3:	0.2277	0.2238	0.2190	0.2269	0.2231	0.2183	0.1533	0.1511	0.1477	0.1583
4:	0.1141	0.1108	0.1094	0.1136	0.1103	0.1089	0.0751	0.0727	0.0717	0.0685
5:	0.0344	0.0336	0.0330	0.0341	0.0333	0.0327	0.0228	0.0221	0.0218	0.0199
6:	0.0078	0.0072	0.0071	0.0077	0.0071	0.0070	0.0045	0.0043	0.0042	0.0039
7:	0.0018	0.0017	0.0017	0.0018	0.0017	0.0017	0.0015	0.0014	0.0014	0.0005
8:	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0000
9:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
accumulated probability for n or more ring hits										
0:	1.0000	1.0000	0.9720	0.9945	0.9945	0.9666	0.6664	0.6664	0.6477	0.7657
1:	0.9221	0.9180	0.8941	0.9173	0.9132	0.8894	0.6157	0.6132	0.5970	0.6887
2:	0.6923	0.6835	0.6682	0.6889	0.6801	0.6649	0.4611	0.4550	0.4447	0.4862
3:	0.3860	0.3773	0.3704	0.3843	0.3757	0.3688	0.2574	0.2518	0.2470	0.2512
4:	0.1583	0.1535	0.1514	0.1574	0.1526	0.1505	0.1041	0.1007	0.0993	0.0929
5:	0.0442	0.0427	0.0420	0.0438	0.0423	0.0416	0.0290	0.0280	0.0276	0.0244
6:	0.0098	0.0091	0.0090	0.0097	0.0090	0.0089	0.0062	0.0059	0.0058	0.0045
7:	0.0020	0.0019	0.0019	0.0020	0.0019	0.0019	0.0017	0.0016	0.0016	0.0006
8:	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0000
9:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Expected Multiplicity:	2.2149	2.1862	2.1988	2.2158	2.1870	2.1997	2.2140	2.1855	2.1973	2.0226

burst = 50 neutrons, count=10000 ei=0.008, e0 = 0.10, 10 dets ddtm=0.10

Center:	ignore,			any			sngl		
Ring:	any	sngl	only	any	sngl	only	any	sngl	only	predict (ign,only)
Probability for exact ring multiplicity										
0:	0.0167	0.0193	0.0167	0.0167	0.0193	0.0167	0.0111	0.0125	0.0111	0.0155
1:	0.0788	0.0845	0.0763	0.0785	0.0842	0.0760	0.0523	0.0563	0.0510	0.0672
2:	0.1986	0.2083	0.1906	0.1979	0.2075	0.1899	0.1311	0.1379	0.1259	0.1289
3:	0.2673	0.2668	0.2498	0.2663	0.2659	0.2489	0.1807	0.1799	0.1687	0.1435
4:	0.2367	0.2334	0.2198	0.2356	0.2323	0.2187	0.1608	0.1591	0.1499	0.1026
5:	0.1356	0.1286	0.1221	0.1348	0.1278	0.1213	0.0910	0.0862	0.0818	0.0493
6:	0.0522	0.0464	0.0451	0.0516	0.0458	0.0445	0.0339	0.0303	0.0290	0.0161
7:	0.0119	0.0106	0.0105	0.0118	0.0105	0.0104	0.0083	0.0070	0.0070	0.0035
8:	0.0020	0.0019	0.0019	0.0020	0.0019	0.0019	0.0011	0.0011	0.0011	0.0005
9:	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0000
10:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
accumulated probability for n or more ring hits										
0:	1.0000	1.0000	0.9330	0.9954	0.9954	0.9285	0.6704	0.6704	0.6256	0.5272
1:	0.9833	0.9807	0.9163	0.9787	0.9761	0.9118	0.6593	0.6579	0.6145	0.5117
2:	0.9045	0.8962	0.8400	0.9002	0.8919	0.8358	0.6070	0.6016	0.5635	0.4445
3:	0.7059	0.6879	0.6494	0.7023	0.6844	0.6459	0.4759	0.4637	0.4376	0.3155
4:	0.4386	0.4211	0.3996	0.4360	0.4185	0.3970	0.2952	0.2838	0.2689	0.1720
5:	0.2019	0.1877	0.1798	0.2004	0.1862	0.1783	0.1344	0.1247	0.1190	0.0694
6:	0.0663	0.0591	0.0577	0.0656	0.0584	0.0570	0.0434	0.0385	0.0372	0.0201
7:	0.0141	0.0127	0.0126	0.0140	0.0126	0.0125	0.0095	0.0082	0.0082	0.0040
8:	0.0022	0.0021	0.0021	0.0022	0.0021	0.0021	0.0012	0.0012	0.0012	0.0005
9:	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0000
10:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Expected Multiplicity:	3.3170	3.2477	3.2773	3.3148	3.2453	3.2747	3.3204	3.2513	3.2772	2.9171

```
burst = 50 neutrons, count=10000  ei=0.005, e0 = 0.10, 10 dets ddtm=1.00
Center:ignore,              any                       sngl
Ring:any    sngl    only    any     sngl    only     any     sngl    only     predict
Probability for exact ring multiplicity                                       (ign,only)
 0:0.0779 0.1108 0.0779   0.0772 0.1100 0.0772   0.0023 0.0033 0.0023   0.0769
 1:0.2298 0.2759 0.2013   0.2284 0.2744 0.2000   0.0075 0.0094 0.0066   0.2025
 2:0.3063 0.3056 0.2356   0.3046 0.3036 0.2341   0.0100 0.0095 0.0076   0.2350
 3:0.2277 0.1952 0.1572   0.2269 0.1947 0.1569   0.0067 0.0058 0.0044   0.1583
 4:0.1141 0.0839 0.0716   0.1136 0.0835 0.0713   0.0034 0.0023 0.0020   0.0685
 5:0.0344 0.0221 0.0194   0.0341 0.0219 0.0192   0.0007 0.0003 0.0003   0.0199
 6:0.0078 0.0052 0.0045   0.0077 0.0051 0.0044   0.0000 0.0000 0.0000   0.0039
 7:0.0018 0.0013 0.0011   0.0018 0.0013 0.0011   0.0000 0.0000 0.0000   0.0005
 8:0.0002 0.0000 0.0000   0.0002 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
 9:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
10:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
accumulated probability for n or more ring hits
 0:1.0000 1.0000 0.7686   0.9945 0.9945 0.7642   0.0306 0.0306 0.0232   0.7657
 1:0.9221 0.8892 0.6907   0.9173 0.8845 0.6870   0.0283 0.0273 0.0209   0.6887
 2:0.6923 0.6133 0.4894   0.6889 0.6101 0.4870   0.0208 0.0179 0.0143   0.4862
 3:0.3860 0.3077 0.2538   0.3843 0.3065 0.2529   0.0108 0.0084 0.0067   0.2512
 4:0.1583 0.1125 0.0966   0.1574 0.1118 0.0960   0.0041 0.0026 0.0023   0.0929
 5:0.0442 0.0286 0.0250   0.0438 0.0283 0.0247   0.0007 0.0003 0.0003   0.0244
 6:0.0098 0.0065 0.0056   0.0097 0.0064 0.0055   0.0000 0.0000 0.0000   0.0045
 7:0.0020 0.0013 0.0011   0.0020 0.0013 0.0011   0.0000 0.0000 0.0000   0.0006
 8:0.0002 0.0000 0.0000   0.0002 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
 9:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
10:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
Expected Multiplicity:
   2.2149 1.9591 2.0325   2.2158 1.9597 2.0338   2.1144 1.8464 1.9181   2.0226
```

```
burst = 125 neutrons, count=10000  ei=0.008, e0 = 0.10, 10 dets ddtm=0.00
Center:ignore,              any                       sngl
Ring:any    sngl    only    any     sngl    only     any     sngl    only     predict
Probability for exact ring multiplicity                                       (ign,only)
 0:0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000 0.0000 0.0000   0.0000
 1:0.0003 0.0003 0.0003   0.0003 0.0003 0.0003   0.0003 0.0003 0.0003   0.0003
 2:0.0042 0.0042 0.0042   0.0042 0.0042 0.0042   0.0042 0.0042 0.0042   0.0016
 3:0.0255 0.0255 0.0255   0.0255 0.0255 0.0255   0.0255 0.0255 0.0255   0.0045
 4:0.0785 0.0785 0.0785   0.0785 0.0785 0.0785   0.0785 0.0785 0.0785   0.0083
 5:0.1736 0.1736 0.1736   0.1736 0.1736 0.1736   0.1736 0.1736 0.1736   0.0105
 6:0.2520 0.2520 0.2520   0.2520 0.2520 0.2520   0.2520 0.2520 0.2520   0.0091
 7:0.2481 0.2481 0.2481   0.2481 0.2481 0.2481   0.2481 0.2481 0.2481   0.0054
 8:0.1516 0.1516 0.1516   0.1516 0.1516 0.1516   0.1516 0.1516 0.1516   0.0021
 9:0.0559 0.0559 0.0559   0.0559 0.0559 0.0559   0.0559 0.0559 0.0559   0.0005
10:0.0103 0.0103 0.0103   0.0103 0.0103 0.0103   0.0103 0.0103 0.0103   0.0000
accumulated probability for n or more ring hits
 0:1.0000 1.0000 1.0000   1.0000 1.0000 1.0000   1.0000 1.0000 1.0000   0.0423
 1:1.0000 1.0000 1.0000   1.0000 1.0000 1.0000   1.0000 1.0000 1.0000   0.0423
 2:0.9997 0.9997 0.9997   0.9997 0.9997 0.9997   0.9997 0.9997 0.9997   0.0419
 3:0.9955 0.9955 0.9955   0.9955 0.9955 0.9955   0.9955 0.9955 0.9955   0.0404
 4:0.9700 0.9700 0.9700   0.9700 0.9700 0.9700   0.9700 0.9700 0.9700   0.0359
 5:0.8915 0.8915 0.8915   0.8915 0.8915 0.8915   0.8915 0.8915 0.8915   0.0276
 6:0.7179 0.7179 0.7179   0.7179 0.7179 0.7179   0.7179 0.7179 0.7179   0.0171
 7:0.4659 0.4659 0.4659   0.4659 0.4659 0.4659   0.4659 0.4659 0.4659   0.0080
 8:0.2178 0.2178 0.2178   0.2178 0.2178 0.2178   0.2178 0.2178 0.2178   0.0026
 9:0.0662 0.0662 0.0662   0.0662 0.0662 0.0662   0.0662 0.0662 0.0662   0.0005
10:0.0103 0.0103 0.0103   0.0103 0.0103 0.0103   0.0103 0.0103 0.0103   0.0000
Expected Multiplicity:
   6.3348 6.3348 6.3348   6.3348 6.3348 6.3348   6.3348 6.3348 6.3348   5.1144
```

```
burst - 125 neutrons, count-10000  ei-0.008, e0 - 0.10, 10 dets ddtm-0.10
Center:ignore,              any                       sngl
Ring:any    sngl    only    any    sngl    only      any    sngl    only    predict
Probability for exact ring multiplicity                                    (ign,only)
 0:0.0000 0.0001 0.0000   0.0000 0.0001 0.0000   0.0000 0.0001 0.0000    0.0000
 1:0.0003 0.0013 0.0003   0.0003 0.0013 0.0003   0.0001 0.0004 0.0001    0.0003
 2:0.0042 0.0097 0.0032   0.0042 0.0097 0.0032   0.0014 0.0032 0.0010    0.0016
 3:0.0255 0.0416 0.0211   0.0255 0.0416 0.0211   0.0074 0.0126 0.0061    0.0045
 4:0.0785 0.1138 0.0611   0.0785 0.1138 0.0611   0.0264 0.0361 0.0207    0.0083
 5:0.1736 0.2053 0.1279   0.1736 0.2053 0.1279   0.0543 0.0640 0.0400    0.0105
 6:0.2520 0.2508 0.1764   0.2520 0.2508 0.1764   0.0796 0.0784 0.0570    0.0091
 7:0.2481 0.2173 0.1685   0.2481 0.2173 0.1685   0.0765 0.0699 0.0538    0.0054
 8:0.1516 0.1166 0.0982   0.1516 0.1166 0.0982   0.0472 0.0352 0.0299    0.0021
 9:0.0559 0.0371 0.0341   0.0559 0.0374 0.0341   0.0191 0.0130 0.0122    0.0005
10:0.0103 0.0061 0.0061   0.0103 0.0061 0.0061   0.0032 0.0023 0.0023    0.0000
accumulated probability for n or more ring hits
 0:1.0000 1.0000 0.6969   1.0000 1.0000 0.6969   0.3152 0.3152 0.2231    0.0423
 1:1.0000 0.9999 0.6969   1.0000 0.9999 0.6969   0.3152 0.3151 0.2231    0.0423
 2:0.9997 0.9986 0.6966   0.9997 0.9986 0.6966   0.3151 0.3147 0.2230    0.0419
 3:0.9955 0.9889 0.6934   0.9955 0.9889 0.6934   0.3137 0.3115 0.2220    0.0404
 4:0.9700 0.9473 0.6723   0.9700 0.9473 0.6723   0.3063 0.2989 0.2159    0.0359
 5:0.8915 0.8335 0.6112   0.8915 0.8335 0.6112   0.2799 0.2628 0.1952    0.0276
 6:0.7179 0.6282 0.4833   0.7179 0.6282 0.4833   0.2256 0.1988 0.1552    0.0171
 7:0.4659 0.3774 0.3069   0.4659 0.3774 0.3069   0.1460 0.1204 0.0982    0.0080
 8:0.2178 0.1601 0.1384   0.2178 0.1601 0.1384   0.0695 0.0505 0.0444    0.0026
 9:0.0662 0.0435 0.0402   0.0662 0.0435 0.0402   0.0223 0.0153 0.0145    0.0005
10:0.0103 0.0061 0.0061   0.0103 0.0061 0.0061   0.0032 0.0023 0.0023    0.0000
Expected Multiplicity:
   6.3348 5.9835 6.2352   6.3348 5.9835 6.2352   6.3350 5.9971 6.2474    5.1144
```

```
burst - 125 neutrons, count-10000  ei-0.008, e0 - 0.10, 10 dets ddtm-1.00
Center:ignore,              any                       sngl
Ring:any    sngl    only    any    sngl    only      any    sngl    only    predict
Probability for exact ring multiplicity                                    (ign,only)
 0:0.0000 0.0088 0.0000   0.0000 0.0088 0.0000   0.0000 0.0000 0.0000    0.0000
 1:0.0003 0.0577 0.0003   0.0003 0.0577 0.0003   0.0000 0.0000 0.0000    0.0003
 2:0.0042 0.1548 0.0017   0.0042 0.1548 0.0017   0.0000 0.0000 0.0000    0.0016
 3:0.0255 0.2442 0.0034   0.0255 0.2442 0.0034   0.0000 0.0000 0.0000    0.0045
 4:0.0785 0.2417 0.0074   0.0785 0.2417 0.0074   0.0000 0.0001 0.0000    0.0083
 5:0.1736 0.1701 0.0108   0.1736 0.1701 0.0108   0.0000 0.0000 0.0000    0.0105
 6:0.2520 0.0894 0.0090   0.2520 0.0894 0.0090   0.0000 0.0000 0.0000    0.0091
 7:0.2481 0.0271 0.0042   0.2481 0.0271 0.0042   0.0000 0.0000 0.0000    0.0054
 8:0.1516 0.0053 0.0016   0.1516 0.0053 0.0016   0.0001 0.0000 0.0000    0.0021
 9:0.0559 0.0009 0.0004   0.0559 0.0009 0.0004   0.0000 0.0000 0.0000    0.0005
10:0.0103 0.0000 0.0000   0.0103 0.0000 0.0000   0.0000 0.0000 0.0000    0.0000
accumulated probability for n or more ring hits
 0:1.0000 1.0000 0.0388   1.0000 1.0000 0.0388   0.0001 0.0001 0.0000    0.0423
 1:1.0000 0.9912 0.0388   1.0000 0.9912 0.0388   0.0001 0.0001 0.0000    0.0423
 2:0.9997 0.9335 0.0385   0.9997 0.9335 0.0385   0.0001 0.0001 0.0000    0.0419
 3:0.9955 0.7787 0.0368   0.9955 0.7787 0.0368   0.0001 0.0001 0.0000    0.0404
 4:0.9700 0.5345 0.0334   0.9700 0.5345 0.0334   0.0001 0.0001 0.0000    0.0359
 5:0.8915 0.2928 0.0260   0.8915 0.2928 0.0260   0.0001 0.0000 0.0000    0.0276
 6:0.7179 0.1227 0.0152   0.7179 0.1227 0.0152   0.0001 0.0000 0.0000    0.0171
 7:0.4659 0.0333 0.0062   0.4659 0.0333 0.0062   0.0001 0.0000 0.0000    0.0080
 8:0.2178 0.0062 0.0020   0.2178 0.0062 0.0020   0.0001 0.0000 0.0000    0.0026
 9:0.0662 0.0009 0.0004   0.0662 0.0009 0.0004   0.0000 0.0000 0.0000    0.0005
10:0.0103 0.0000 0.0000   0.0103 0.0000 0.0000   0.0000 0.0000 0.0000    0.0000
Expected Multiplicity:
   6.3348 3.6938 5.0851   6.3348 3.6938 5.0851   8.0000 4.0000 0.0000    5.1144
```