Questions from Eugenie Reich to Purdue

4th May 2006

T: 617 354 0329

On slides 2-10 I ask about instances in which the same data were reported in different contexts.

On slide 11 I ask about a number of instances in which his data are not consistent

Publications discussed;

NED v 235 p 1317

Nureth 11 conference paper 258

Multiphase Science and Technology v 19 Issue 3 p 191

Taleyarkhan DARPA Kick Off slideshow of May 2005

PRE v 69 p 036109

Physics of Fluids 17 p 107106

Microphone data are shown in fig 8b of Multiphase Science and Technology v 17 p 191, authored by Taleyarkhan, Lahey, and Nigmatulin.

Xu and Butt are not authors.

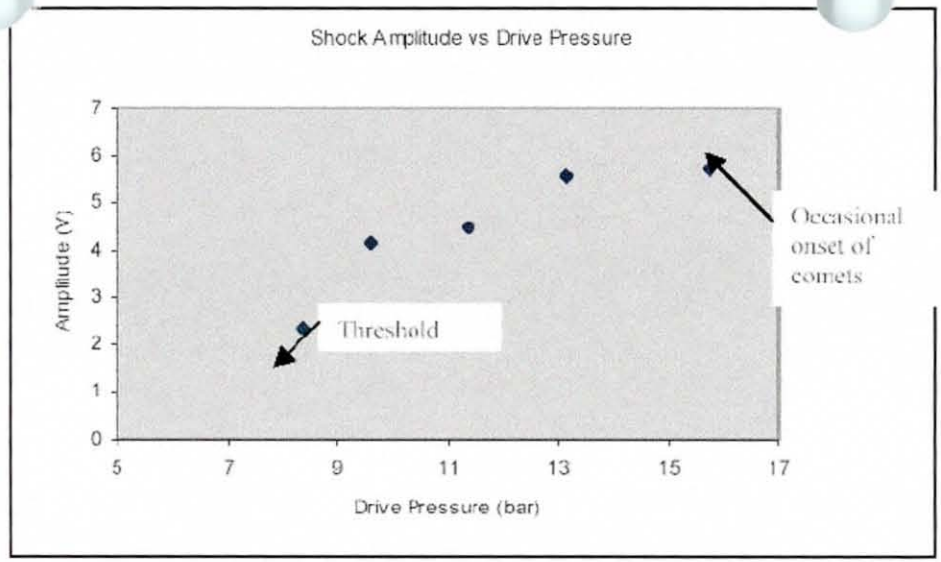


Figure 8b Variation of shock amplitude with drive pressure.

Two microphones are reportedly attached to the ORNL cell shown in figure 3.

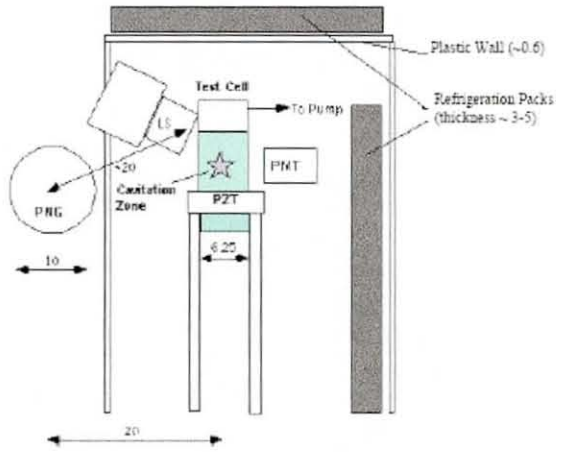
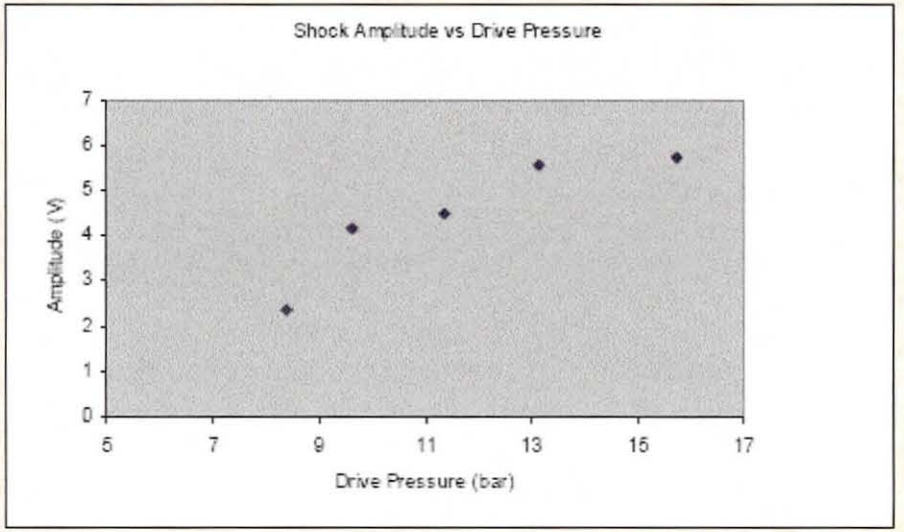
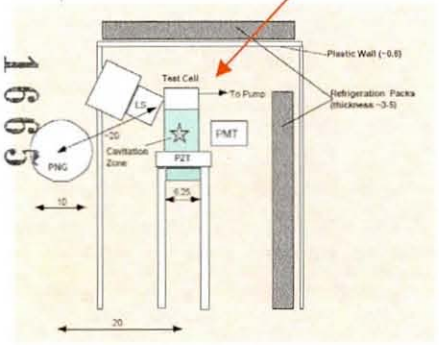


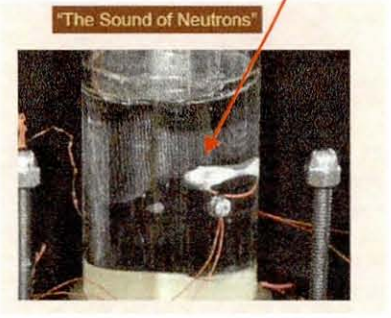
Figure 3 Bubble nuclear fusion experimental setup (for baseline operation the output of the PNG was set to ~ $5x10^5$ n/s)

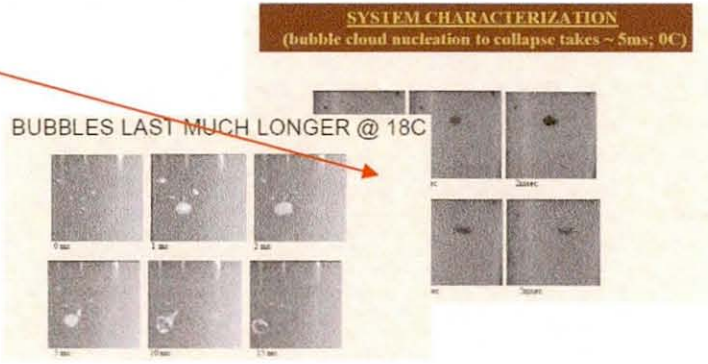
Here are the data again on slide 36 of Taleyarkhan's May 2005 slideshow.



The ORNL cell is on slide 8.
There appear to be two microphones on slide 32
Preceding slides show data from PRE v 63 p 036109







Contextual statements about the cell, as detailed in the MST paper and conveyed by the slides arrangement:

Two microphones were attached (p 199)

The cell could nucleate up to 30 clusters per second (page 201)

The data were taken on "the ORNL experimental apparatus" to which "the" PZT driver was attached (p 195, p199, figure 3)

Data from Taleyarkhan's PRE paper were taken on this cell (p 199, figure 8 and 9 captions)

Microphone data are also shown in figure 8 of NED v p 1317, authored by Adam Xu and Yiban Butt.
Taleyarkhan is not an author.

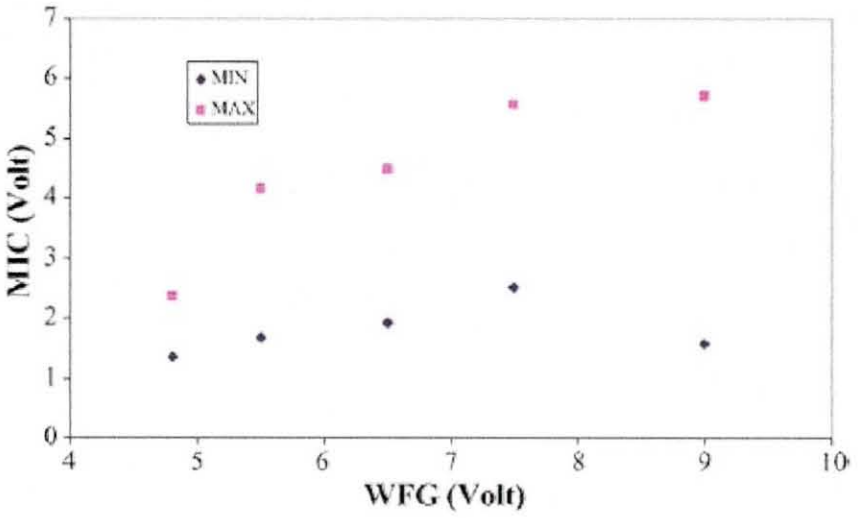
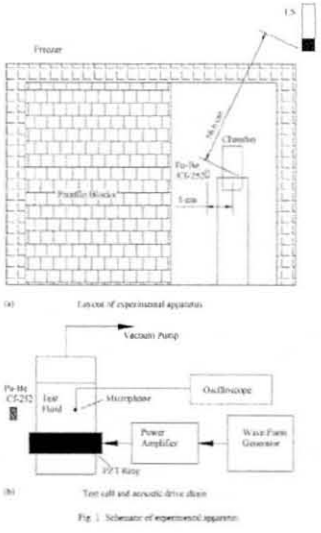


Fig. 8. Amplitudes of microphone signals with increase in drive amplitude.

The microphone is reportedly attached to a **Purdue** cell operated by Xu and Butt.



Here are the data again in Nureth-11 paper 548 in figure 6.

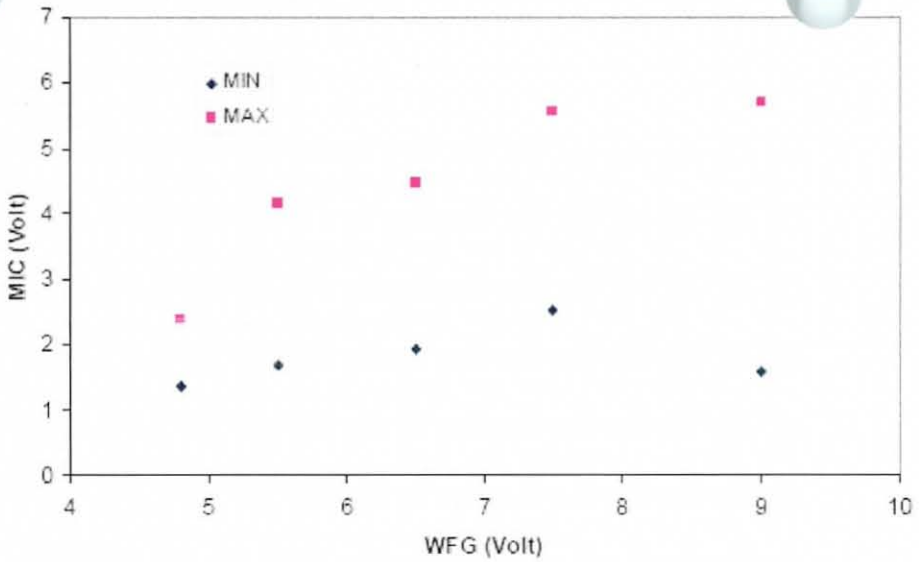


Figure 6: Amplitudes of microphone signals

The map in figure 1 shows the microphone again apparently in a Purdue lab.

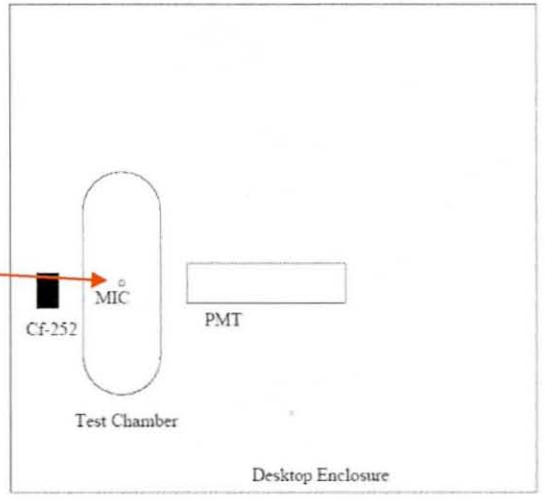


Figure 1: Schematic of experimental apparatus layout (not scaled). Cf-252 – Isotope Neutron Source (0.5 mCi); MIC – Microphone; PMT – Photomultiplier Tube.

Contextual statements about the cell, as detailed in the NED paper:

The cell had one microphone attached (section 5), not two

The cell nucleated <10 bubble clusters per second (section 4 of NED), not 30

The data were taken on a test cell constructed at Purdue (section 4 of NED), not the ORNL apparatus

Below is an overlap of the two sets of microphone data.

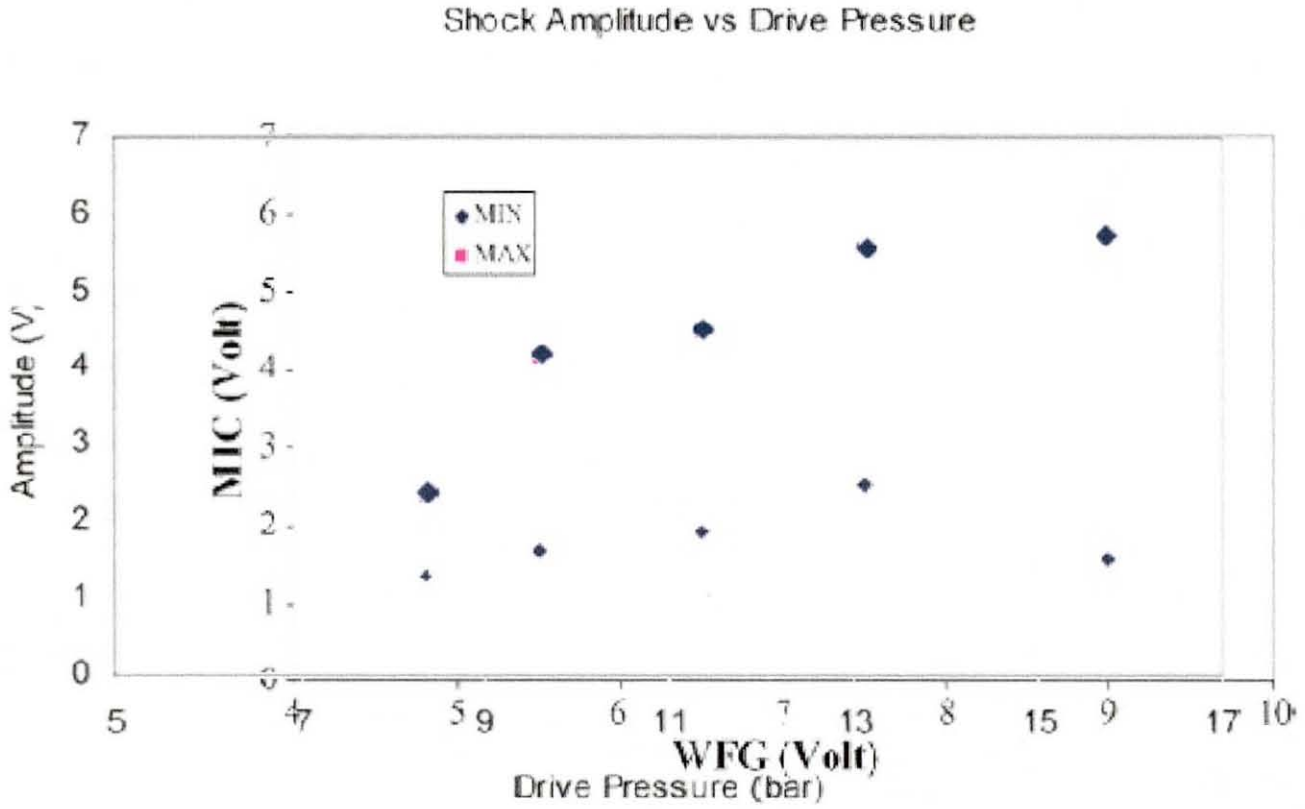


Fig. 8. Amplitudes of microphone signals with increase in drive amplitude

- **E-PRLTAO-96-019605 states that there is considerable variability from experiment to experiment and cell to cell for these kinds of experiments**

Questions:

1. Where were these microphone data taken, in what experimental arrangement, and by who?

2. Why were the data also reported as having been taken in a different experimental arrangement, and by a different set of authors?

3. Why isn't this reuse of data cited in the 4 examples (3 published papers and 1 slideshow) in which this occurred?

Questions on other discrepancies.

The 5ms frame in figure 9 of Multiphase Science and Technology is not the same as the 5ms frame in figure 2d of PRE v69 p 036109, nor as the color frame given in Taleyarkhan's slideshows. This is clearest when the images are magnified and flipped between eg in powerpoint. The MST paper also describes this, saying bubbles move "radially outward". At least two of the three bubble clouds move, so it does not appear color or contrast change alone can account for this. Other frames are identical within minor color and focus changes.

The neutron spectrum in figure 1 of Physics of Fluids v 17 p 107106 contains changes in 4 bins relative to figure 4 of PRE v 69 p 036109 but not in other bins. Rebinning would affect all bins. The PF text also describes this as having an "oscillatory" shape. A primary goal of the PF theory paper is to explain the PRE data.

In a bin-by-bin comparison of SL data in Taleyarkhan's slideshows and figure 7b of PRE v 69 p 036109, it appears that bins 2, 3, 4, are the same while bins 1, 5, 6, 7 differ, while the "corresponding" neutron plots in 7a are identical. It is unclear how a change in analysis could affect some bins and not others

"Confirmatory tritium data" move between *all three* of the following; slideshows, figure 11 of PRE v 69 p 036109, and figure 6 of MST v 17 p 191

Does Purdue have raw data or lab notebooks to support the published or presented figures?

What is the reason for the discrepancies in the reports?

PRL v96 p34301 fig 3

(blue data removed for clarity)

Counts = -6

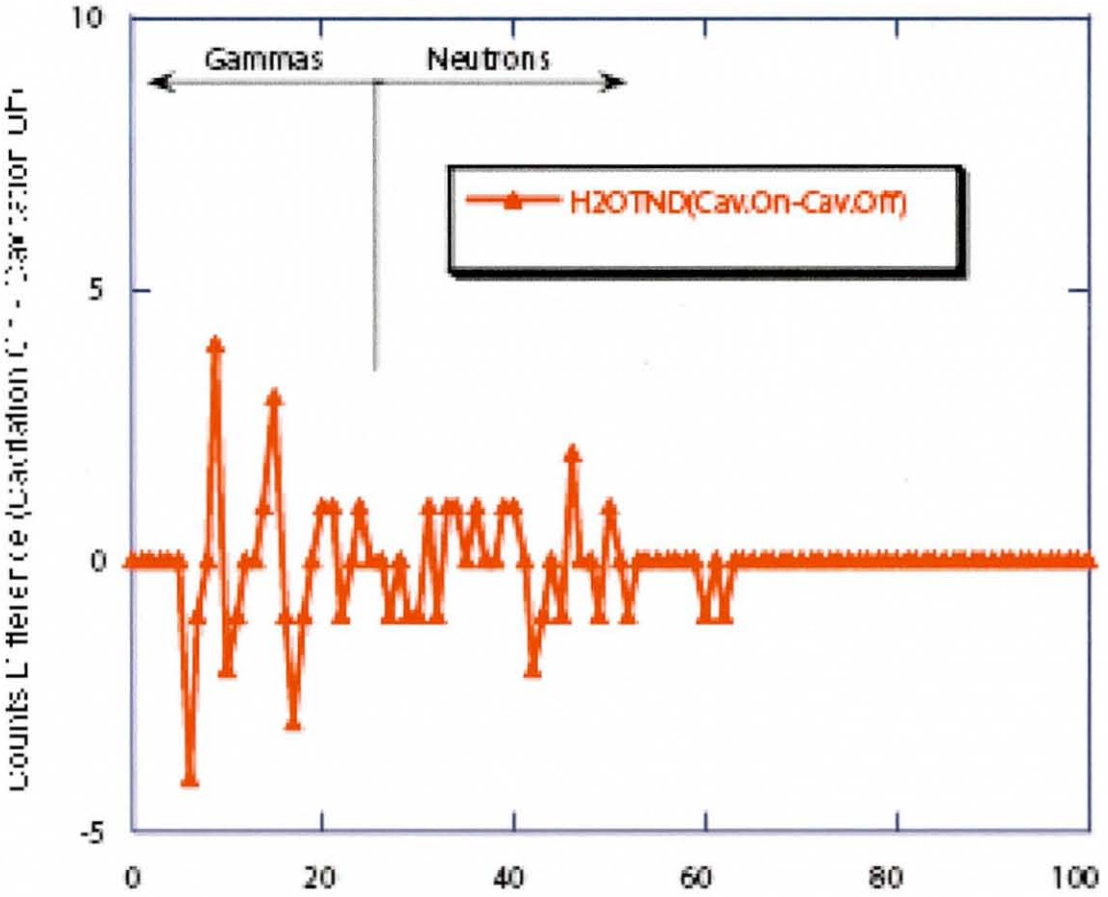


FIG. 3 (color online). Changes in counts from Neutron-Gamma Spectra for D_2O and H_2O with self-nucleation and BF_3 detector (counts for cavitation Off/On = 37/39 for D_2O-UN; = 39/44 for H_2O-UN).

PRL supplement fig 6b

E-PRLTAO-96-019605

"the raw data"

Counts = -5

(also consistent

with fig 6a)

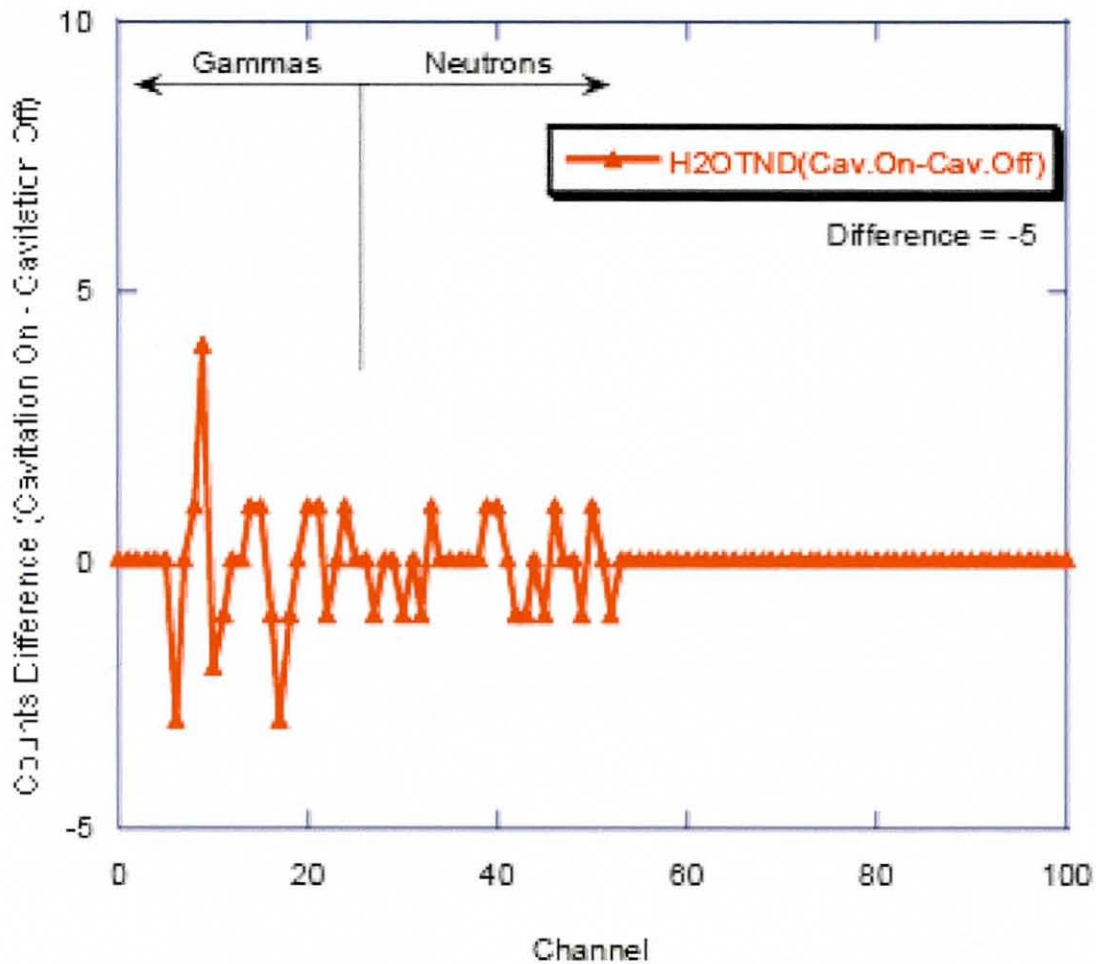


Figure 6a,b Neutron-Gamma Spectra for H_2O with self nucleation and BF_3 detector. Data represent a total of ten (10) runs in 5 cycles (each cycle conducted over a span of 300 s first with cavitation on and then for 300 s with cavitation turned off). Total time = 3,000 s.

Why is it that extra data points appear in the published paper that are not in the raw data?

The work reported in this manuscript was supported by the State of Indiana (Purdue University). The initial suggestions for utilizing deuterated benzene and for striving to conduct experiments without use of external neutrons were made by Professor W. Bugg, Professor L. Riedinger, and Dr. W. Madia, and are most appreciated. The in-depth advice and ongoing technical assistance and cross-checks provided for successful conduct of this study by Dr. JaeSeon Cho of Oak Ridge National Laboratory are gratefully acknowledged and appreciated. The timely support provided by Purdue University's Radiological and Environmental Management services group for conduct of experiments, Dr. Roger Stevens of Spectrum Techniques, Dr. Charles Hurlbut of Eljen, Inc., Ed Bickel of Channel Industries, and Luke Carr of Landauer, Inc., discussions on track detectors with Professor R. Fleisher as well as the insightful review and comments from Michael Murray of BWXT-Y12 are acknowledged.

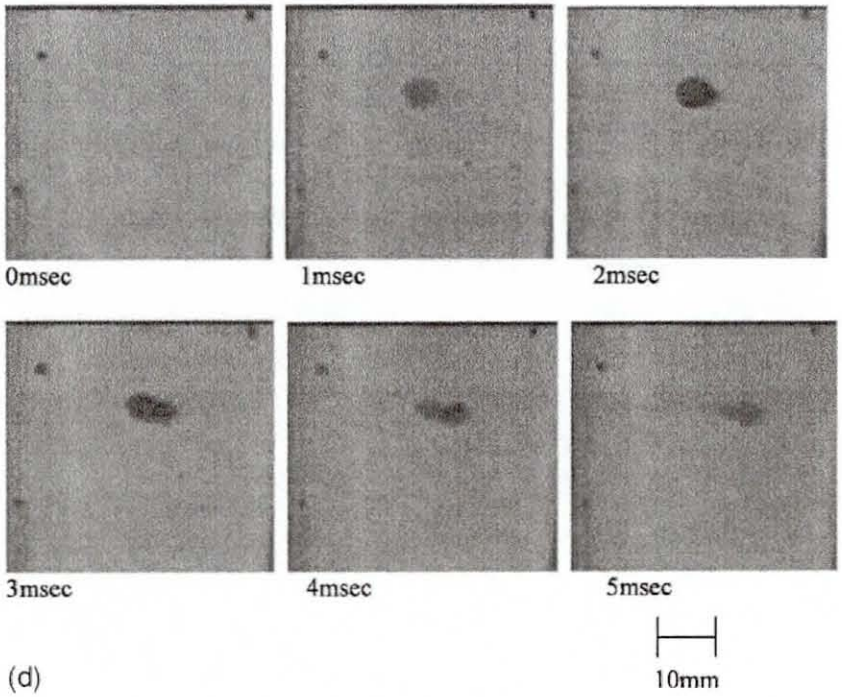
The above acknowledgment section makes no mention of the use of department of defence funding. Does this mean that no DARPA funding was used for equipment, supplies, travel, salaries, nor anything else relevant to the conduct of this experiment?

If this is an omission, why wasn't it corrected after being pointed out to Taleyarkhan several months ago?

Here are some photographs of bubbles presented in papers authored by Rusi Taleyarkhan in 2004 and 2005. One of the frames goes missing, but, the captions look ok.

are the photos the same?

PHYSICAL REVIEW E 69, 036109 (2004)



(d)

(d) Images of bubble cloud nucleation to collapse for tests with C_3H_6O (3 °C).

(Images taken at rate of 1000 frames per second and 1/2000 second shutter speed.)

Multiphase Science and Technology, Vol. 17, No. 3, pp. 191-224, 2005

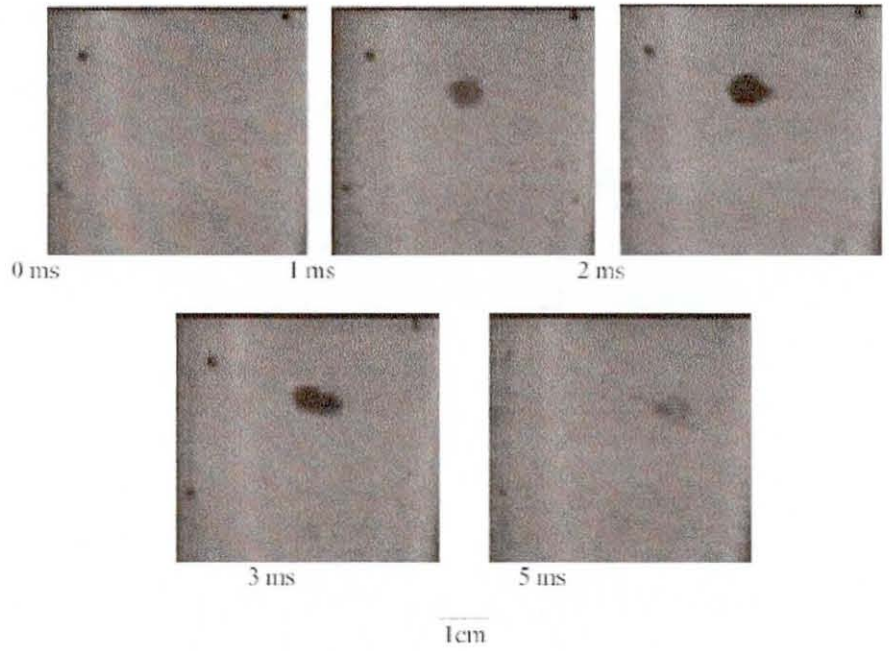
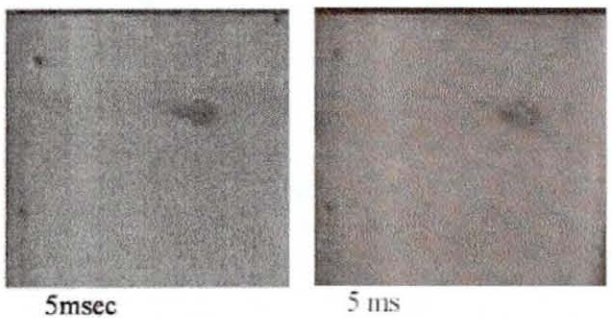


Figure 9a Images of bubble nucleation to collapse for tests with Acetone (3°C).

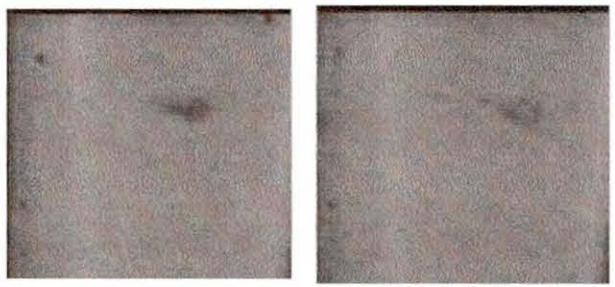
This slide concentrates on the frame captioned 5ms.

Left is PRE.

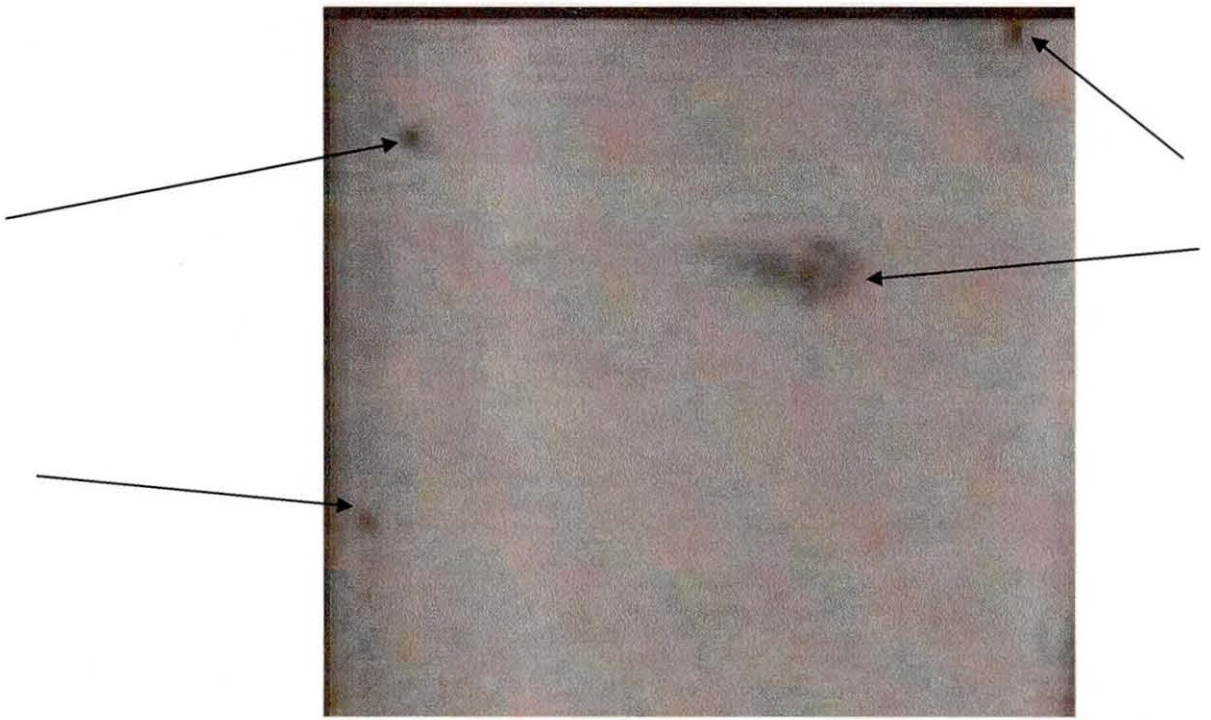
Right is Multiphase Science and Technology



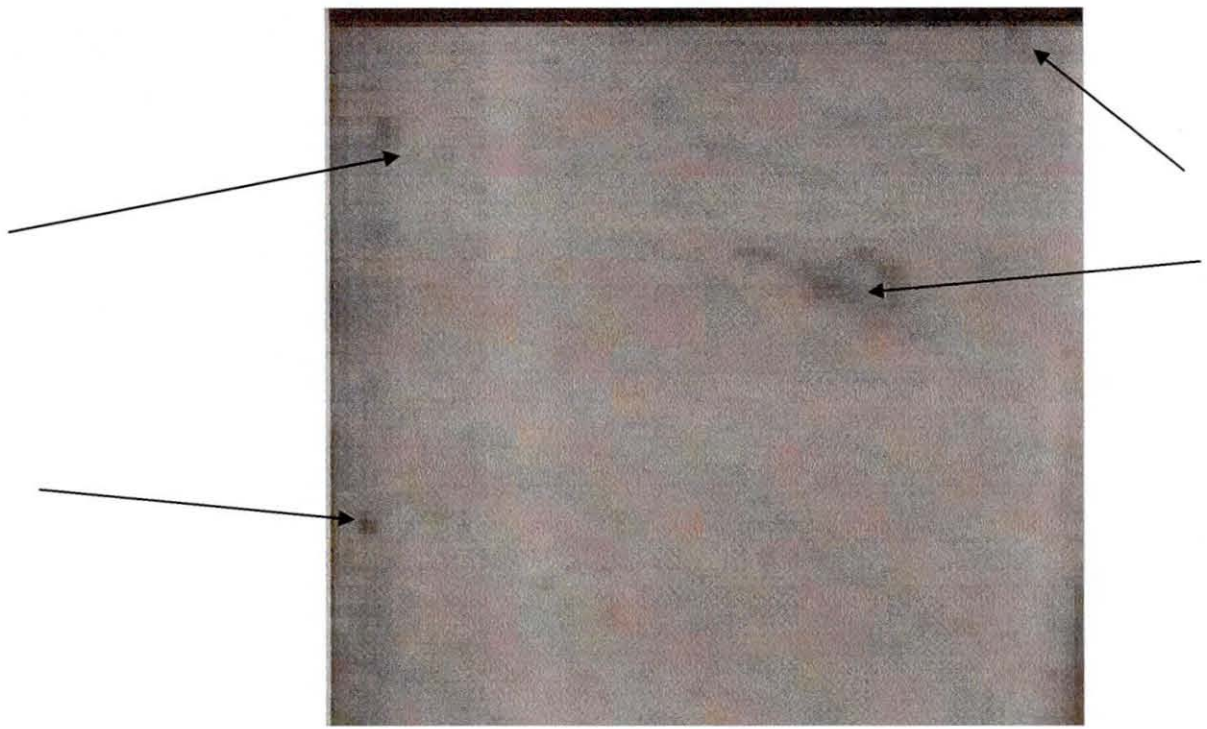
In this slide, the PRE photo is replaced with the equivalent color one from Taleyarkhan's May 2005 slideshow. It's possible to flip between this slide and the previous one to get some idea how the image changes when they go from black and white to color.



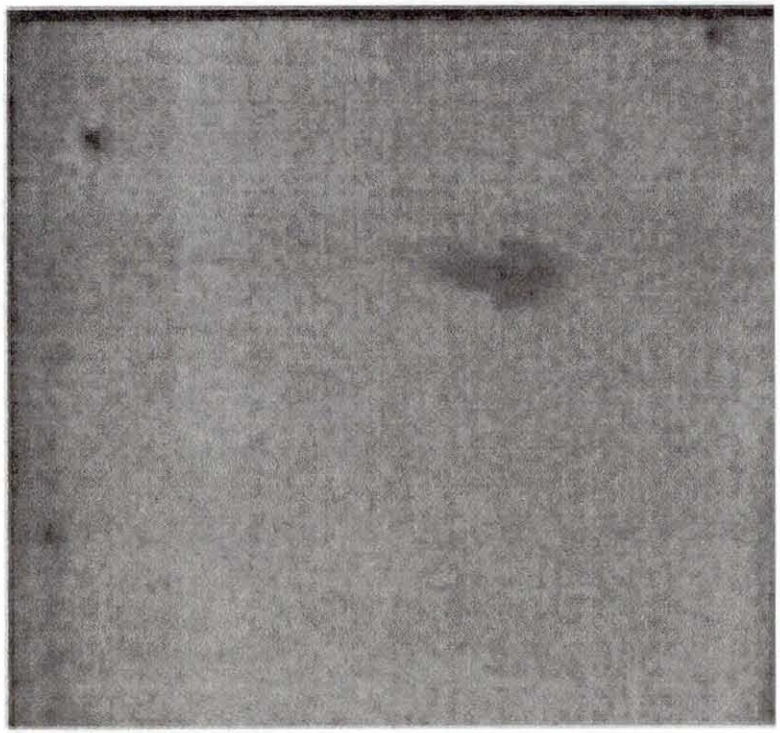
m



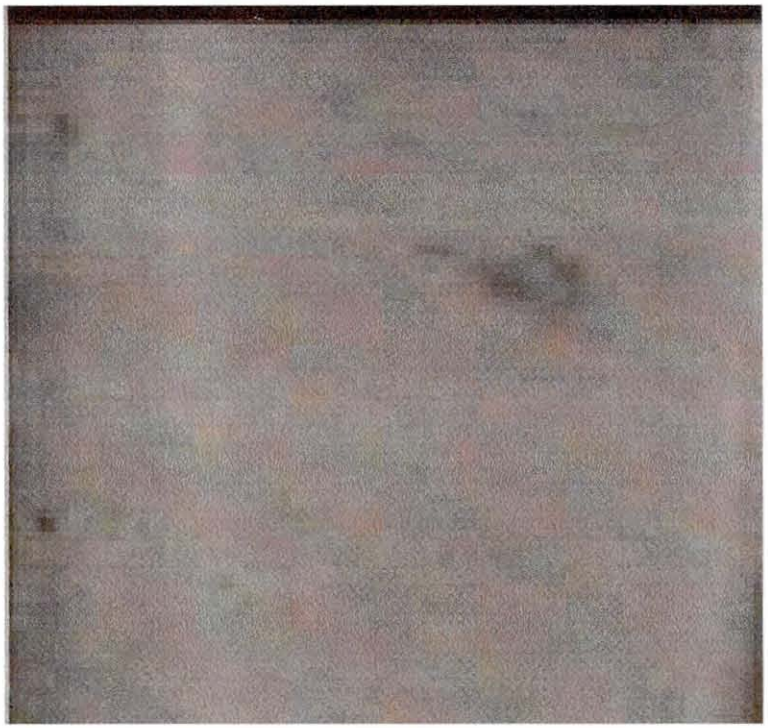
Flip back and forth between this slide and the next one to compare the images. This is the slideshow, the color version of the PRE frame.



Flip back and forth between this slide and the previous one to compare the images. This is the MST frame. Minor contrast or color changes can't account for the change between it and the PRE and slideshow photo.



5msec



5 ms

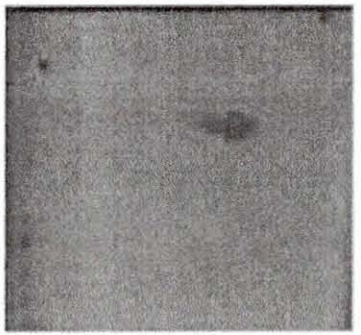
m

Or compare the two published versions. Again, the bubble is bigger, more diffuse, and further to the right, in 2005, than in 2004.

What could motivate these changes? Here's what the authors say.

PHYSICAL REVIEW E **69**, 036109 (2004)

in Fig. 2(d) are typical photographic images of bubble clouds taken 1 ms apart in acetone at ~3 °C. It is seen that the bubble clouds persist in the pressure antinode of the test section for ~5 ms prior to condensing, and reach bubble cloud sizes in the range of ~6 mm in diameter.



5msec

Multiphase Science and Technology, Vol. 17, No. 3, pp. 191-224, 2005

Direct imaging of bubble clusters was conducted using a 1,000 fps digital camera system (with 1/2000 shutter speed). Figure 9(a) shows the bubble cloud history when streaming is largely absent. As seen therein, the ~ 6-7mm diameter bubble clusters nucleated in ~ 0°C temperature liquid persist for about 5 ms before ultimately condensing back in the test liquid. These ~6mm diameter clusters nucleate in the centerline region of the test cell and then are driven radially outwards due to the (acoustic) radiation pressure field. It is important to note that these are bubble clusters, not individual bubbles. Based on the well-known Rayleigh-Plesset equation, it has been shown *(28,30,31)* that the maximum size of an individual bubble under the experiment conditions would be a maximum of ~0.5mm which is about ten times lower than the directly imaged bubble clusters. As seen from Fig. 9(b) at a liquid pool temperature of ~ 18°C, the nucleated bubble clusters persist much longer (lasting for ~ 20 ms). Figure 9(c) shows the formation of a comet-like bubble cloud structure and a sharp drop in neutron production.

5 ms

Between these reports, the authors changed their minds about what happens to the bubbles prior to condensing. In 2004, they thought the bubbles condensed in the pressure antinode of the cell, while in 2005, they thought the bubbles were driven radially outwards. Changing their minds is OK, but changing their data to support their changing view isn't.

PHYSICAL REVIEW E 69, 036109 (2004)

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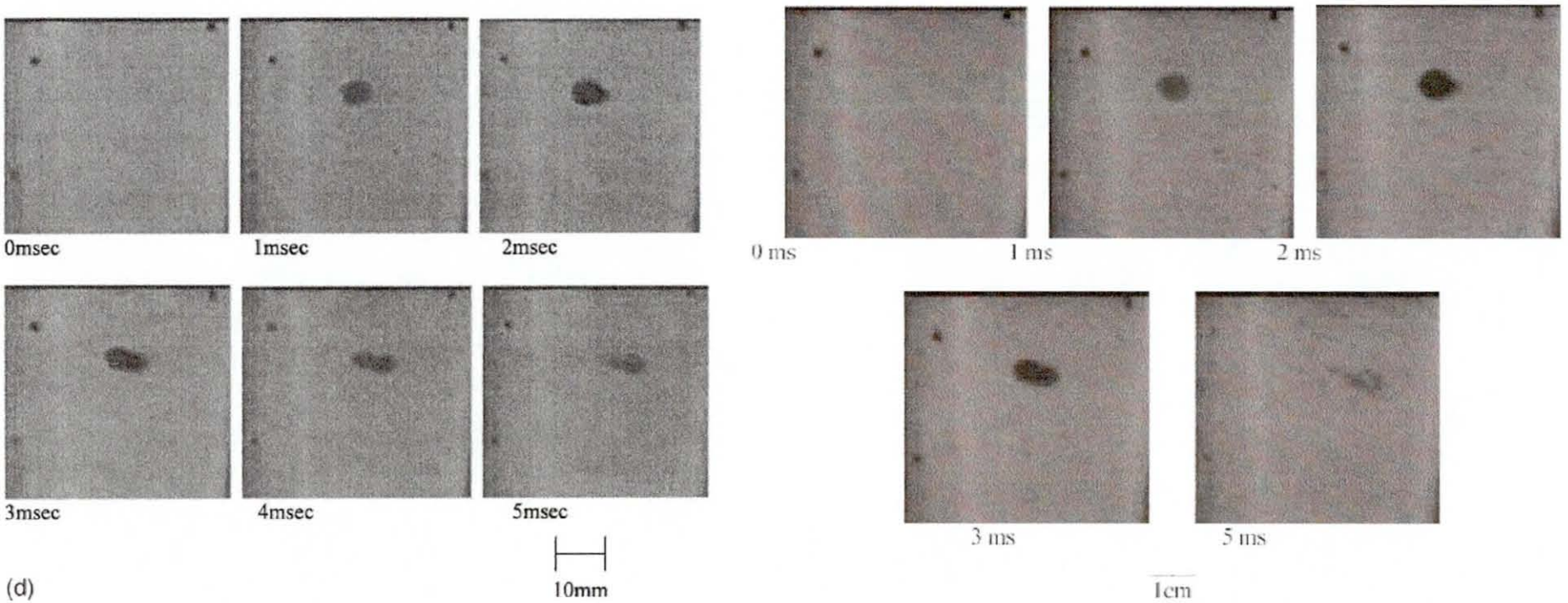


When expressly asked about the differences in the 5ms frame, Taleyarkhan stated by email that the dropping of the 4ms frame was the only difference between these figures.

The caption and text of PF v 17 p 107106, which is premised on explaining Taleyarkhan's 2004 data, claims these figures show the same results. Do they?

PHYSICAL REVIEW E **69**, 036109 (2004)

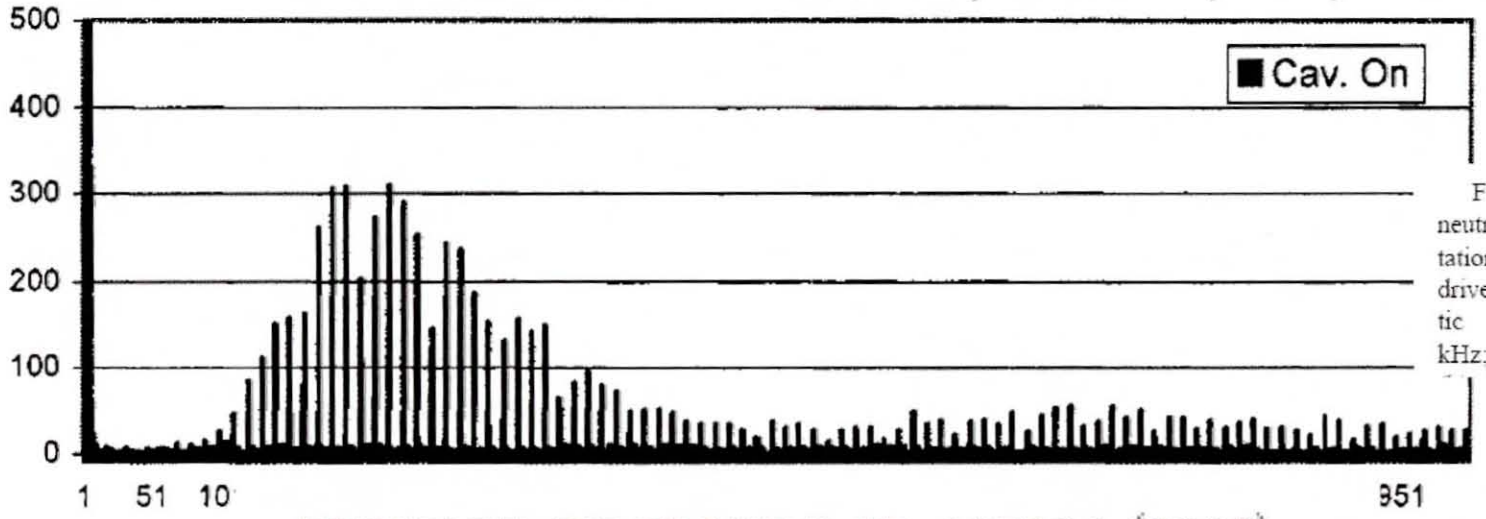


FIG. 4. (a) Time spectrum of neutron counts for tests with cavitation on (C_3D_6O at 0 °C; PNG drive frequency ~ 200 Hz; acoustic forcing frequency = ~ 19.3 kHz; time channel width = 5 μs).

PHYSICS OF FLUIDS **17**, 107106 (2005)

(a)

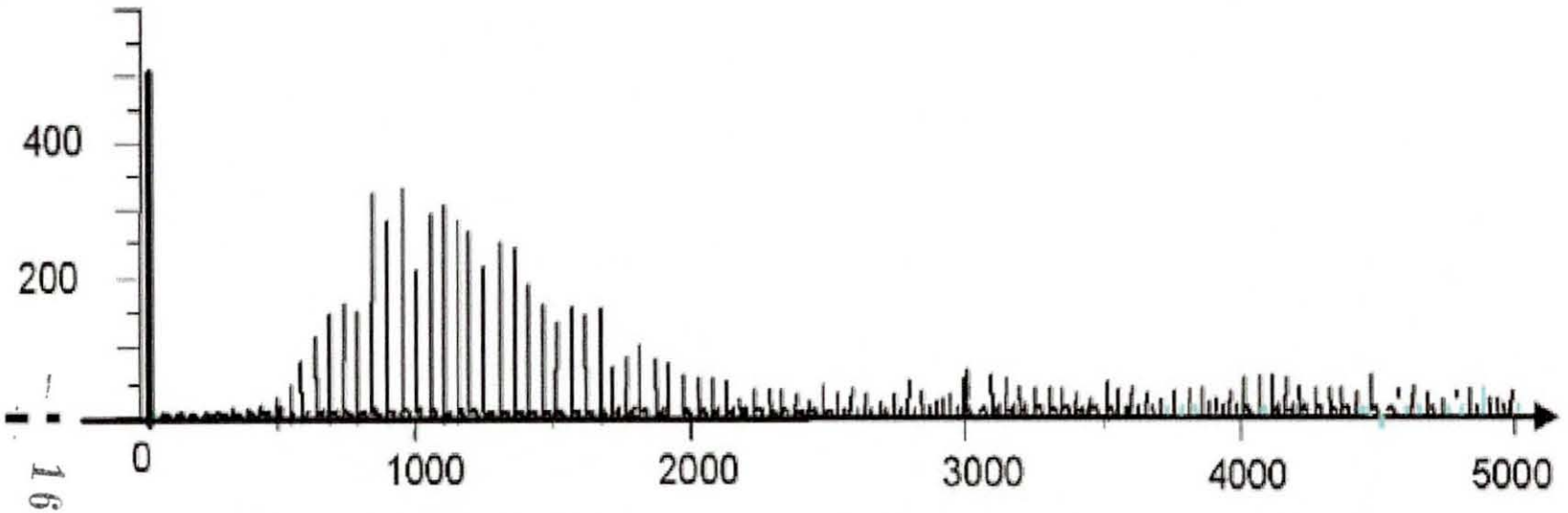
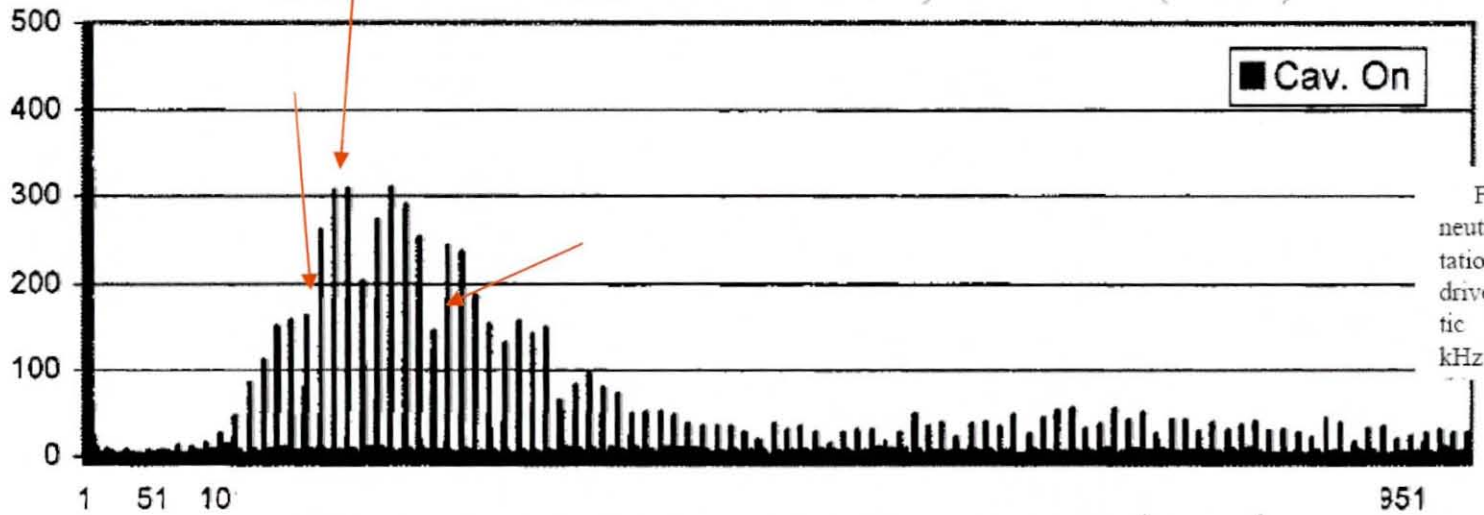


FIG. 1. (Color online). Schematic sequence of events during the ORNL bubble fusion experiments [Taleyarkhan *et al.* (Refs. 1 and 2)].

1686

It looks like around 3 peaks have changed. But why?

PHYSICAL REVIEW E **69**, 036109 (2004)



(a)

FIG. 4. (a) Time spectrum of neutron counts for tests with cavitation on (C_3D_6O at 0 °C; PNG drive frequency ~ 200 Hz; acoustic forcing frequency = ~ 19.3 kHz; time channel width = 5 μs).

PHYSICS OF FLUIDS **17**, 107106 (2005)

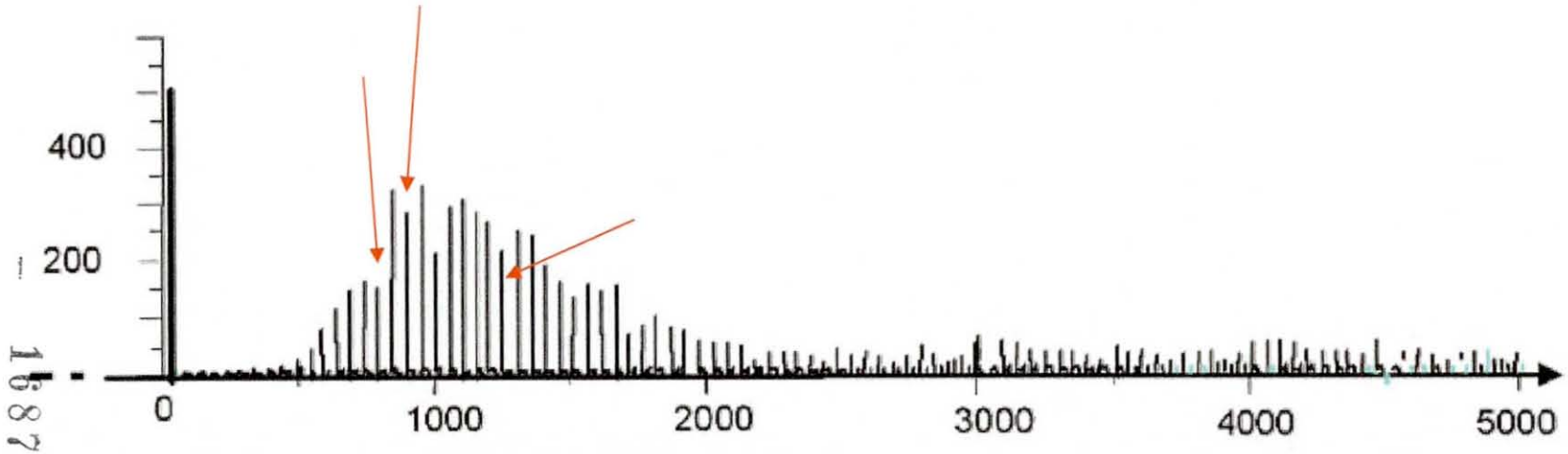


FIG. 1. (Color online). Schematic sequence of events during the ORNL bubble fusion experiments [Taleyarkhan *et al.* (Refs. 1 and 2)].

The authors say…

PHYSICAL REVIEW E **69**, 036109 (2004)

Starting at channel ~100 (500 μs) the neutron counts start to grow significantly to a peak near channel ~180 (~900 μs) and then asymptotically decrease to a lower level around channel ~500 (2 500 μs), reaching values about 10 times smaller than in the peak channels.

PHYSICS OF FLUIDS **17**, 107106 (2005)

As seen in Fig. 1, the neutrons are produced by cavitation not only after the first collapse ($t \approx 40$ μs), but after a dead-time interval of about ten acoustic periods (500 μs), the production of the neutrons resumed and became quasi-periodic during about $n' \approx 40-50$ bubble cluster bounces (see Fig. 1), which were coordinated with the acoustic forcing frequency and SL light emissions. It is interesting to note in Fig. 1 that the intensity of neutron emissions after $n' \approx 40-50$ bounces finally diminishes. This is presumably due to the fact that the Bjerknes force[20] expels the bubble cluster from the acoustic antinode, and condensation of the vapor bubble also occurs in the chilled liquid pool.

Let's take a look at this figure again. In 2004, "the neutron counts grow to a peak and then asymptotically decrease". In 2005, "the production of neutrons became quasiperiodic". While it's okay for description of the data to change, the data shouldn't change as well.

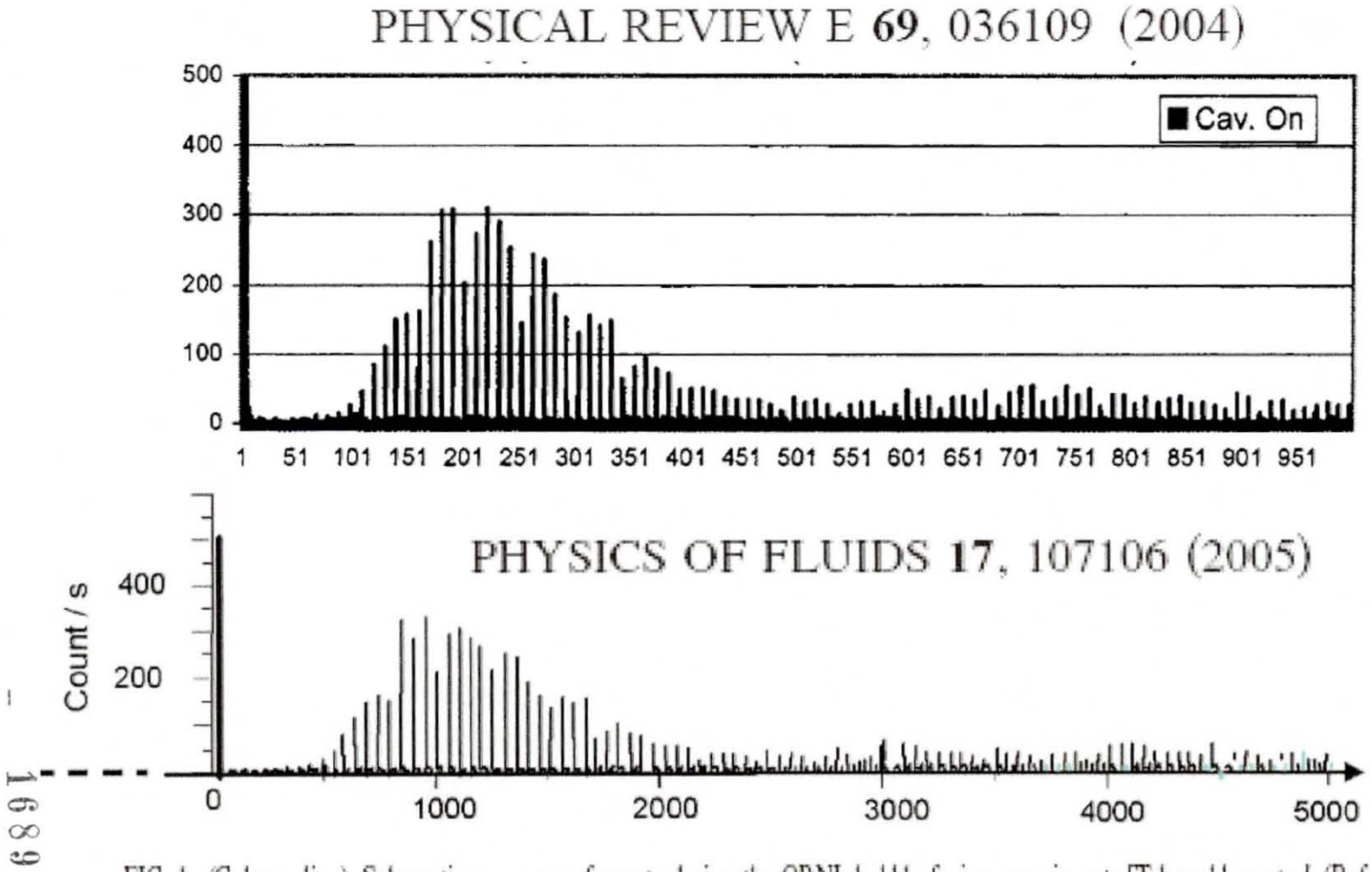
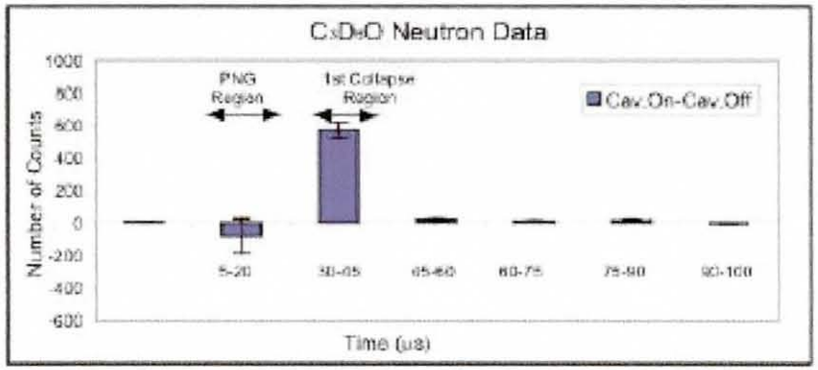
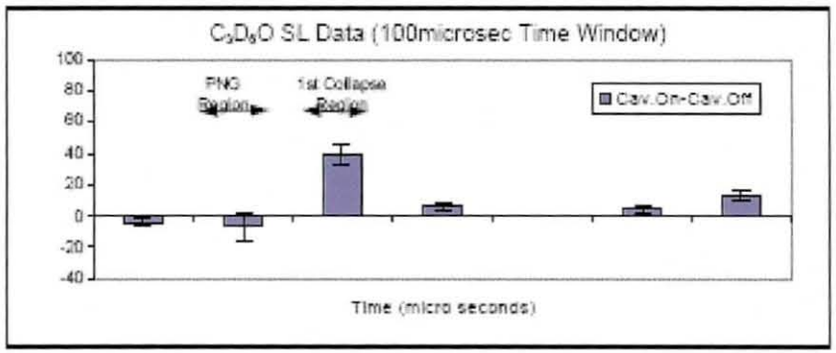


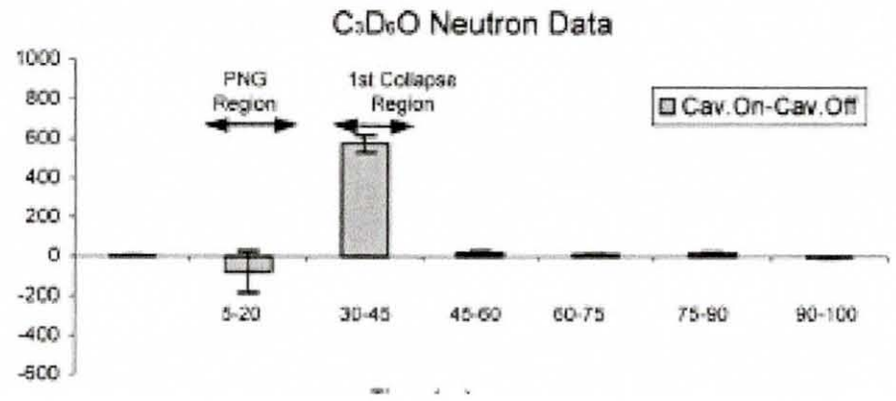
FIG. 1. (Color online). Schematic sequence of events during the ORNL bubble fusion experiments [Taleyarkhan *et al.* (Refs. 1 and 2)].

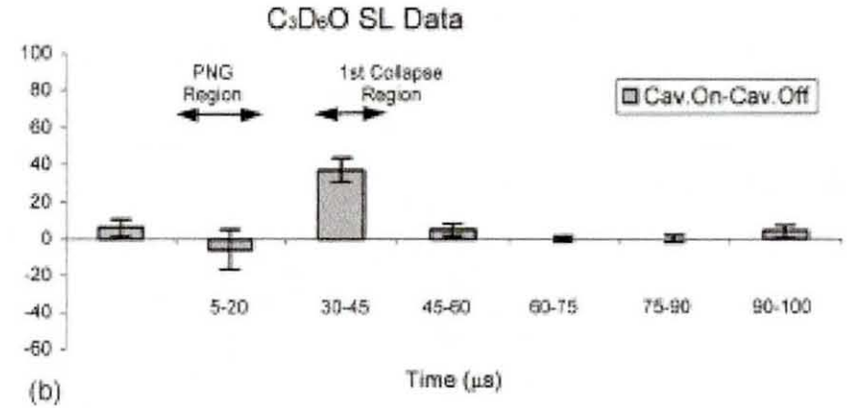
Taleyarkhan's 2004 PRE paper depends on showing neutron and SL data from "corresponding" runs. He shows these data in his slideshows too. Are these the same data, or different?





(Wayne State University Sep 2005, Fermilab June 2004)

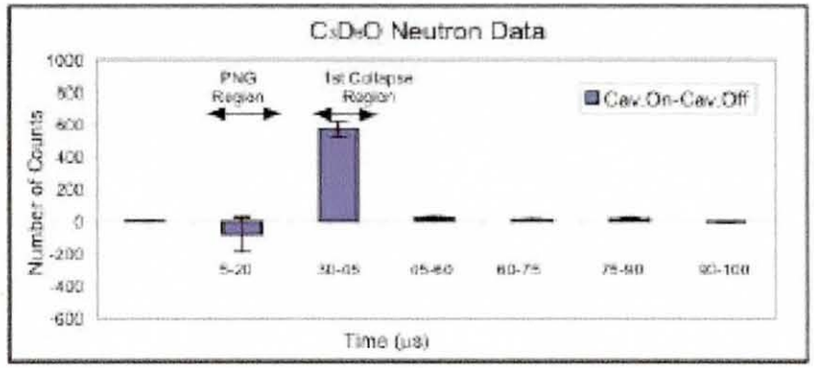


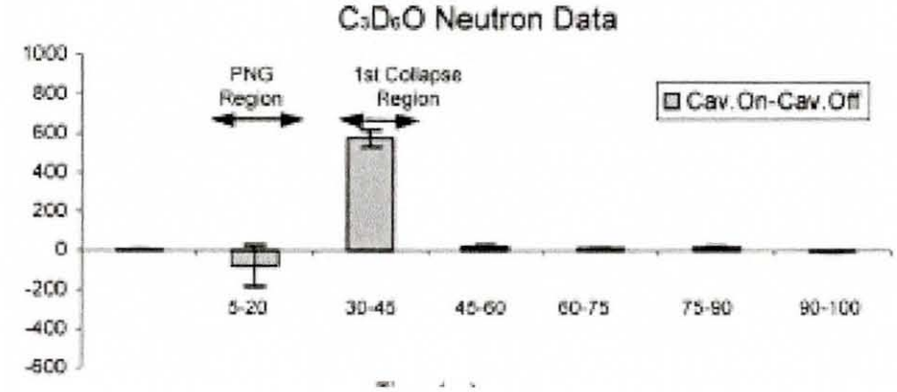


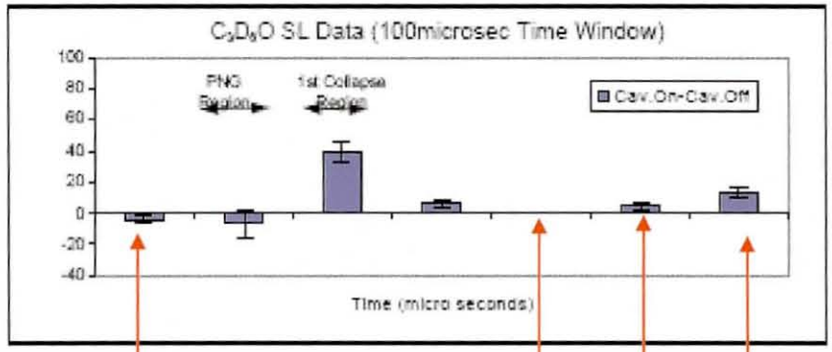
PHYSICAL REVIEW E 69, 036109 (2004)

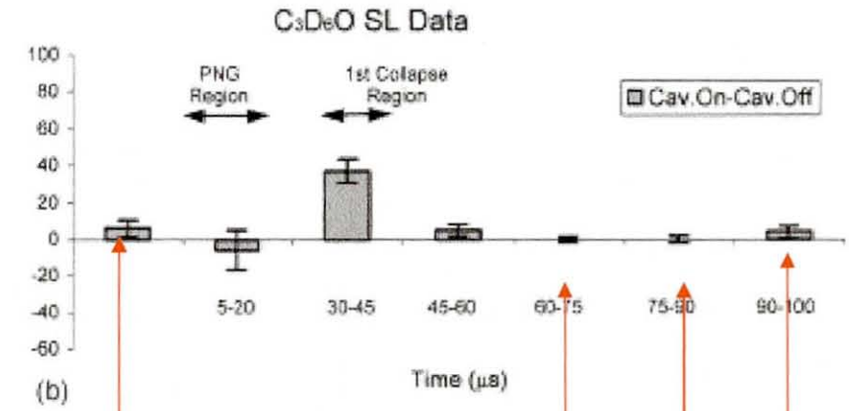
The neutron data are the same

The SL data differ in the 1st, 5th, 6th, and 7th runs, but are identical in the 2nd, 3rd, and 4th runs









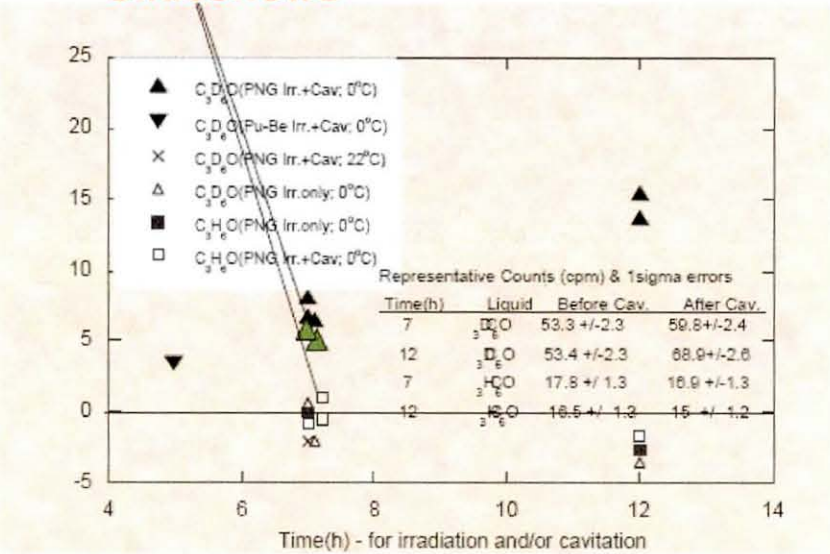
What can explain the combination of partly identical and partly different SL data? Rebinning should affect all bins.

The "confirmatory" control data (empty squares) are plotted differently in all three instances. The confirmatory positive data (blue triangles) are plotted differently in two instances (PRE and MST).

What explains these discrepancies? Taleyarkhan says this is an overlay problem. Why is he overlaying data, rather than plotting it from a central file?

Between the PRE and the slideshows, one control point moves, above the other the same distance as it was previously below. Why?

Slideshows



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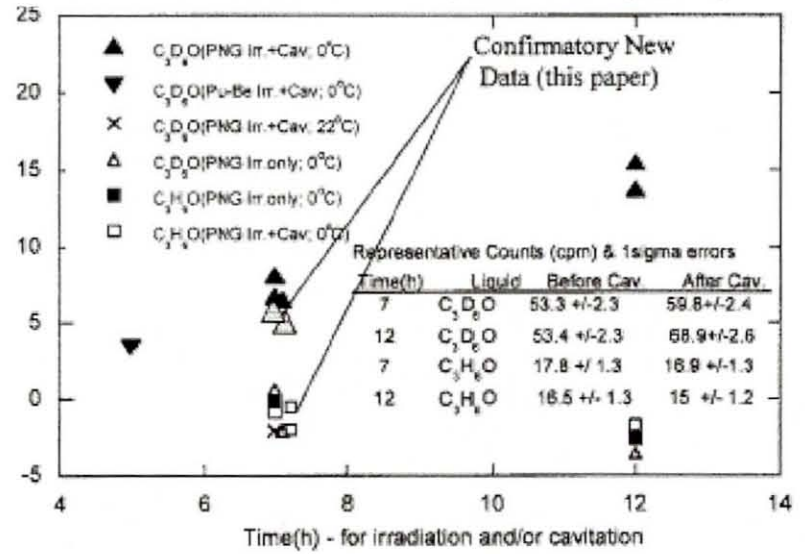

FIG. 11. Confirmatory tritium data together with prior data under similar conditions [1].

Data (Ref. 29)