"HOT SPOTS, CHAIN EVENTS AND MICRONUCLEAR EXPLOSIONS"

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Previous Speakers at this meeting who have already alluded to Chain Events

- Robert Duncan (Craters Cavities)
- Y.Kim (BEC)
- Akito TAKAHASHI

Speculations on Characteristics of NAE

- **Two decades into the CF/LENR/CMNS era, the mechanism behind these reactions still eludes us!**
- **General agreement that phenomenon occurs on surface, in "special" regions - NAEs by Storms.**
- **One could *speculate* that spatial extant of the NAE could possibly be a single nano particle or a grain.**
- **Reasonable to expect that all NAEs wont be created simultaneously all over cathode surface.**
- **Similarly, once formed, NAEs cant be expected to continue catalyzing reactions for "ever & ever".**
- **The NAEs must have a finite "active" lifetime !**
- **Could this be ns, μs, seconds, hours, days?**

Hot Spots, Chain events, Micronuclear Explosions

- **This line of *speculation* leads us to *postulate* that the LENR phenomenon could comprise of a series of "bursts" of nuclear reactions, each burst composed of "X" nos of nuclear reactions generated by each NAE during its lifetime.**
- **What could be the temporal characteristcs of the reactions *within* a single nuclear "burst"?**
- **Could these individual reactions be "chain correlated" with each new reaction triggered by the previous or other "exotic" agent or particle?**
- **Alternately the entire "X" numbers of reactions could take place simultaneously (coherently?) in a flash… a sort of micronuclear explosion (MNE) !**

REVISIT EARLY BARC STUDIES (1989-90)

- Is there even a shred of experimental evidence to suggest the occurrence of such MNEs?
- Indeed many experimenters in recent times have reported observing "hot spots" (Swartz, SPAWAR group etc) although they have not claimed that these may be attributed to nuclear phenomena.
- However the old timers here will recall that we at BARC had published experimental results indicative of the occurrence of MNEs, within a few months of the F & P announcement!
- Karlsruhe (July '89), BARC 1500 report (Aug '89), ICCF-1 (March '90), FT (Aug '90), Provo (Oct '90)
- Paper appearing in ACS LENR Sourcebook II ('09)

HIGHLIGHTS OF EARLY BARC WORK

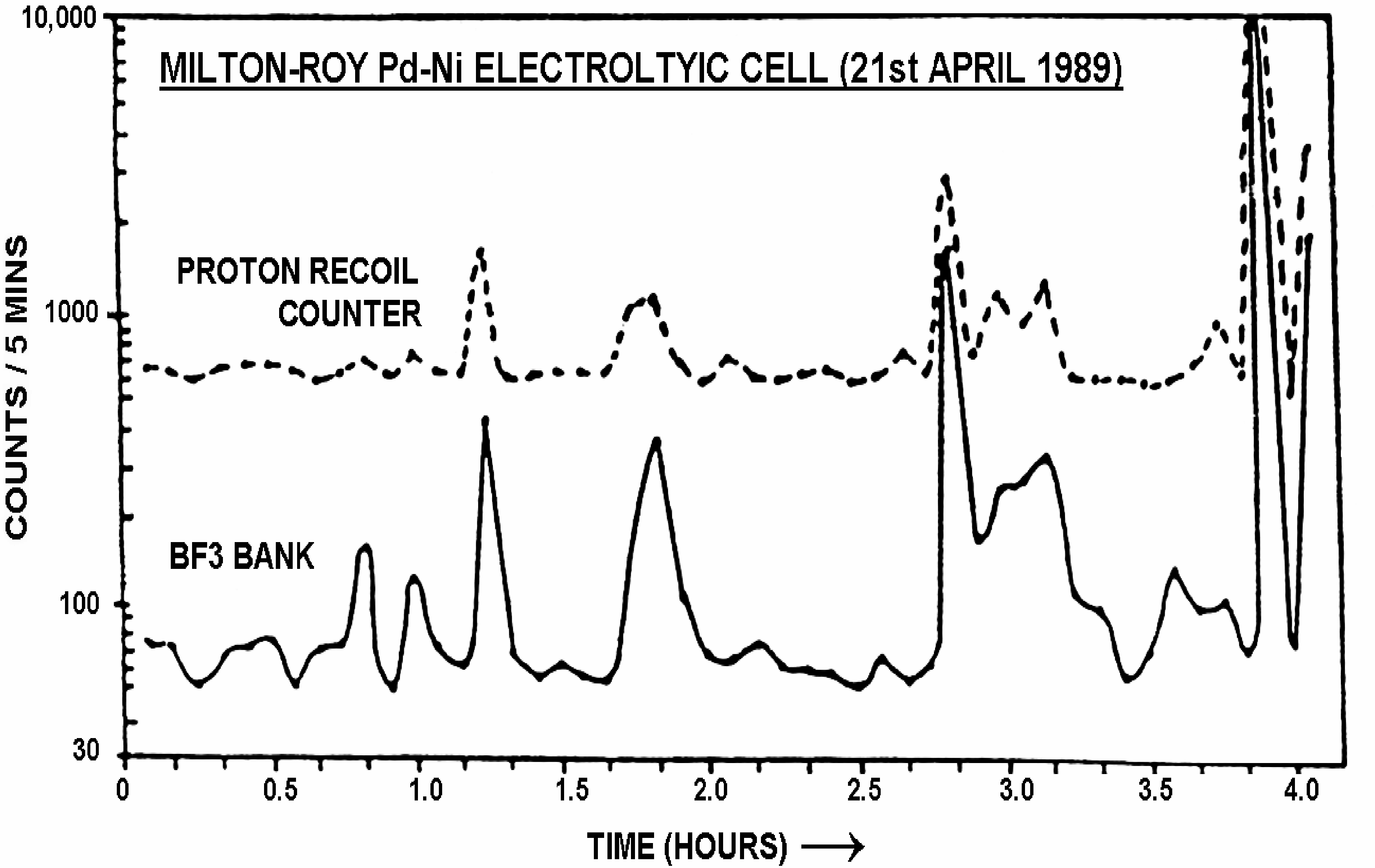
- On March 24th 1989, 12 teams (~ 50 scientists) took up the challenge of verification of the "nuclear origin" of Fleischmann-Pons Effect!
- Within months all teams reported both n & T
- BARC was among first groups to find branching ratio anomaly, (n/T) = ~ $1O^{-7}$
- In the next few projections I recaptulate the various elements of the puzzle that led us to conclude that MNEs could be occurring!
- (Some of these slides were presented already last year at ICCF 14 during my review of the history of Cold Fusion in India !)

BARC ELECTROLYSIS EXPERIMENTS (1989-90)

Division	Cathode: Matl	Geom	cm2 Area	Anode	Neutron Yield	Tritium Yield	n/T Ratio
1 Desalin *	Ti	Rod	104	ss pipe	3.10^{+7}	$1.4\ 10^{+14}$	2.10^{-7}
2 Neut. Phy.*	Pd-Ag	Tubes	300	Ni Pipes	4.10^{+7}	8.10^{+15}	5.10^{-7}
3 HWD *	"	"	300	"	9.10^{+7}	$1.9\ 10^{+15}$	5.10^{-7}
4 HWD *	"	5 Disks	78	Porus Ni	5.10^{+4}	4.10^{+15}	$1.2\ 10^{-9}$
5 Anal.Ch.@	Pd	Hol.Cyl.	5.9	Pt Mesh	3.10^{+6}	$7.2\ 10^{+13}$	4.10^{-8}
6 ROMg @	"	Cube	6.0	"	$1.4\ 10^{+6}$	$6.7\ 10^{+11}$	$1.7\ 10^{-4}$
7 ROMg @	"	Pellet	5.7	"	3.10^{+6}	4.10^{+12}	1.10^{-4}
8 App.Chem @	"	Ring	18	"	$1.8\ 10^{+8}$	$1.8\ 10^{+11}$	1.10^{-3}

Electrolyte : * 5M NaOD @ 0.1M LiOd

NEUTRON COUNT "SPIKES" DURING RUN NO.1



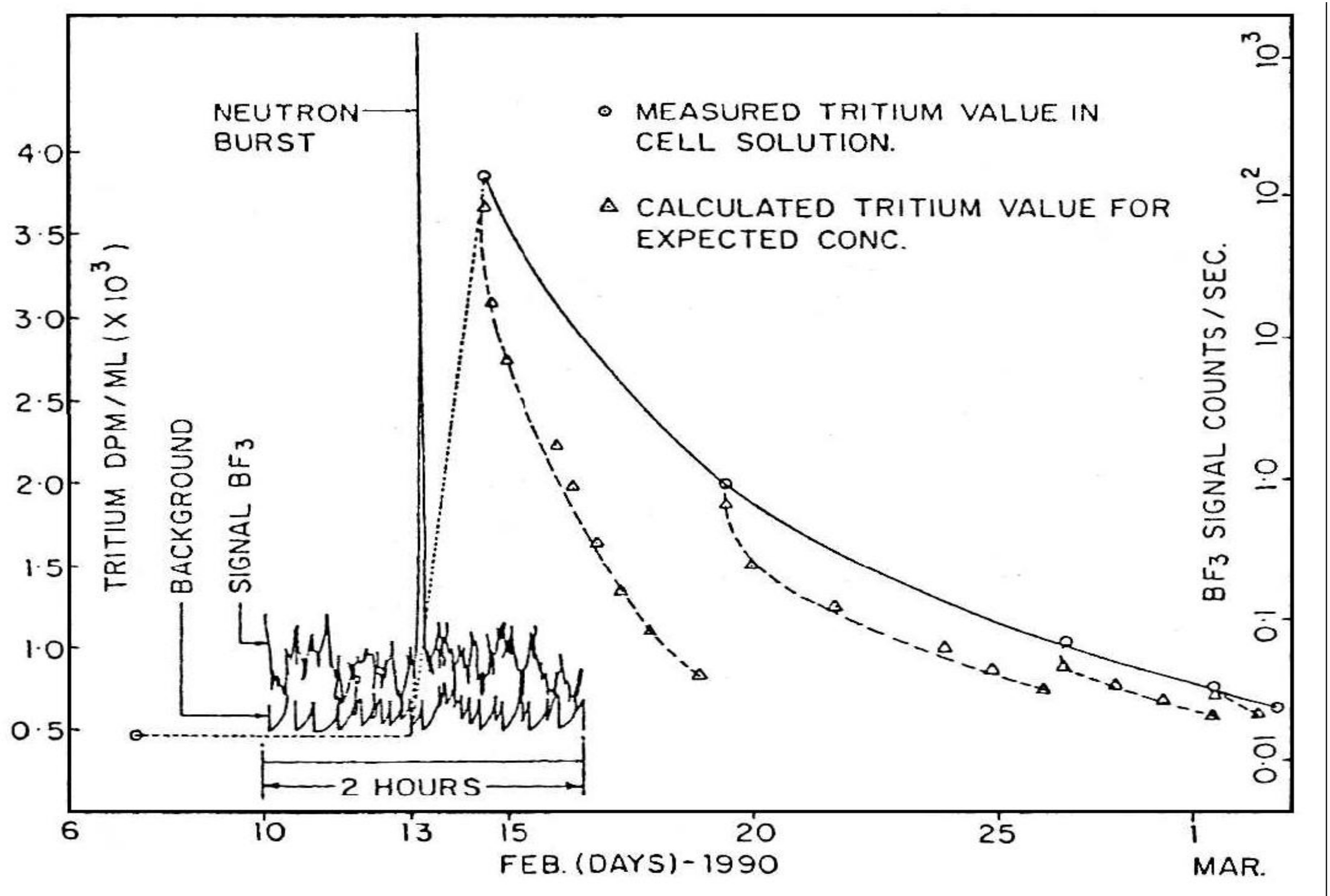
BARC FINDING # 1

- **Neutron to tritium ratio (n/T) ~ 10^{-7} ***
- **This basically means that on an average, one neutron is emitted for every 10 million tritons !**

*** *Confirmed since by many groups!***

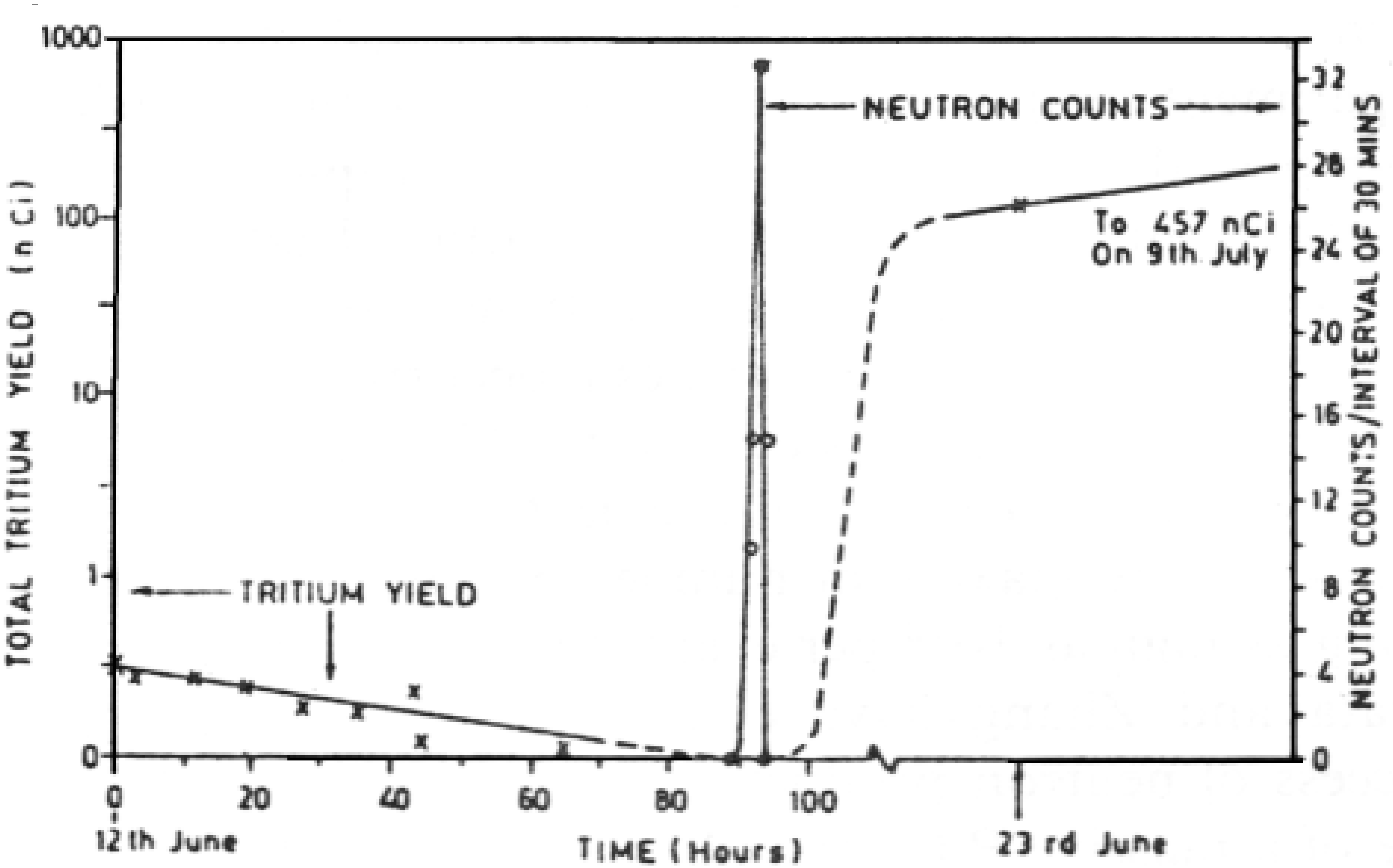
NEUTRON SPIKE & TRITIUM OUTPUT(ROMG CELL)

11 mm Cyl. Pd Pellet cathode -13th Feb 1990



NEUTRON SPIKE & TRITIUM YIELD DURING RUN NO. 2

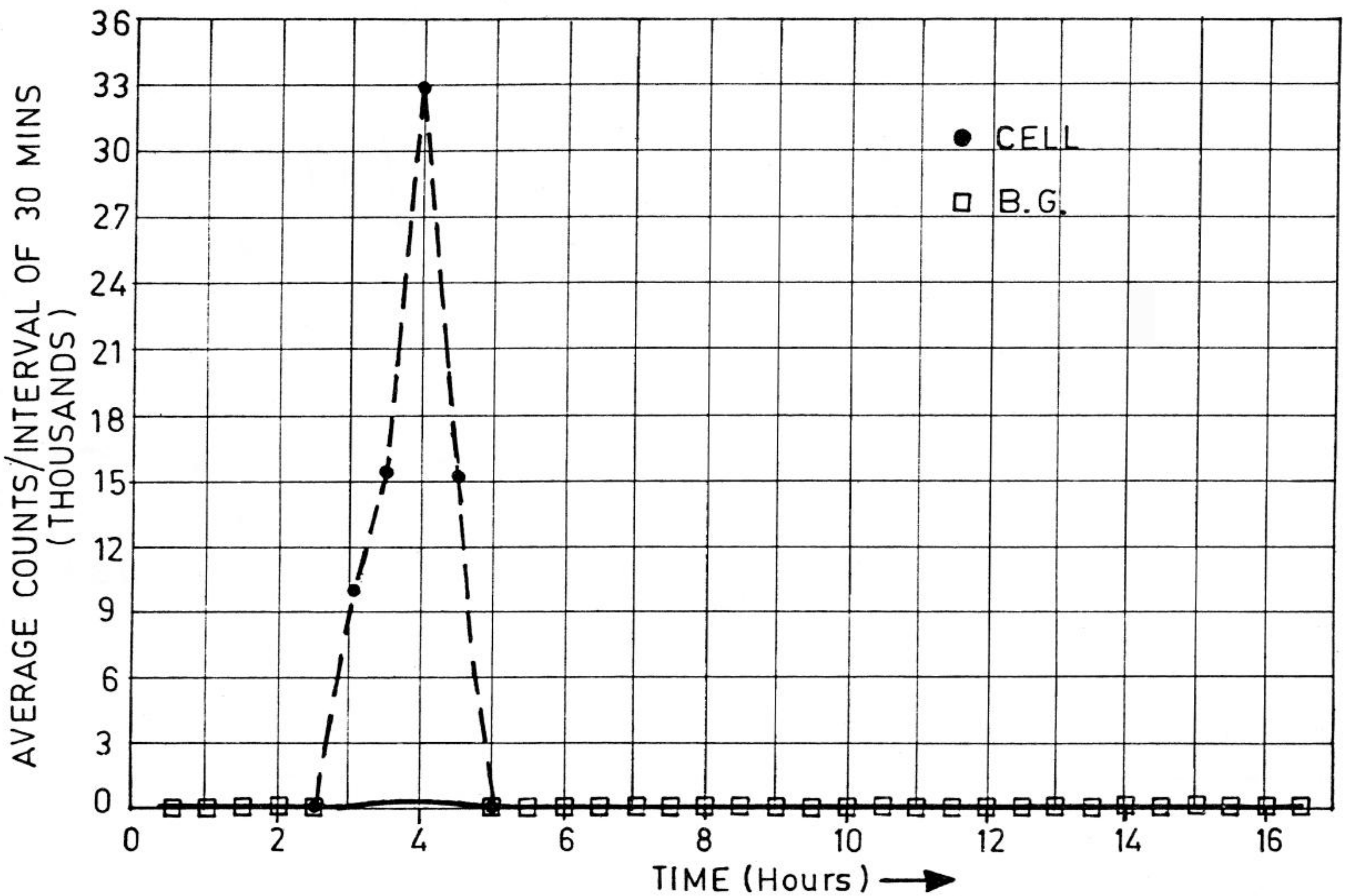
(Milton-Roy Cell - 12th June 1989)



MILTON ROY CELL : NEUTRON SPIKE EPISODE

50 HRS AFTER CURRENT PUT OFF (16th June 1989)

Multiplicity Distribution also Measured



BARC FINDING #2

- **Production of neutrons and tritium appears to be connected in some way.**
- **The fact that we detect neutrons first and tritium later is because electrolyte samples are taken only periodically for tritium assay!**
- **They could have appeared at the same time or one could have "closely" followed the other.**
- **But since tritium is more prolific, reasonable to speculate that one neutron is generated for every 10^7 tritons *through some very low probability secondary reaction!***

"Observation of High Multiplicity Neutron Emission Events from Deuterated Pd and Ti Samples"

(I was led to think e along these lines since my Masters thesis 25 years earlier had been on "Neutron Density Fluctuation Studies in Zero Energy Reactor ZERLINA" – in a field called "Reactor Noise Analysis"!)

INVESTIGATION OF STATISTICAL CHARACTERISTICS OF NEUTRON EMISSION

- ***Are the neutrons emitted one at a time in a random fashion following Poisson distribution?***
- ***Or are there neutron "bursts" wherein many neutrons are emitted in a bunch implying chain reaction events ?***
- **Experimental method exploits fact that the slowing down time of fast neutrons in moderator assembly surrounding a thermal neutron detector is ~ 30 μs!**
- **Hence two or more neutrons from same event get separately detected.**

ANALOGY OF NEUTRON SOURCES

- Am-a-Be source throws out one neutron at a time following Poisson statistics whereas Cf-252 spontaneous fission neutron source produces several neutrons (3 to10) at a time.
- In safeguards field Plutonium content of sealed packages detected through its Pu-240 isotopic content using multiplicity distribution measurements.
- Theory and techniques well developed.

Theoretical Considerations
For Poisson Distribution (Random)

- If N_o = count rate due to random events
- and t = counting time interval (say 20 ms)
- For case when $N_o t << 1$
- $N_o t$ = prob. of registering 1 count
- $(N_o t)^2/2!$ = Prob of registering 2 counts
- $(N_o t)^3/3!$ = Prob of registering 3 counts

  ………………………………..and so on.
- Note that prob of higher order multiplicities rapidly diminishes !!

Burst Events

- **Now let us suppose, superimposed on random background, there are :**
- **s number of burst events/sec with**
- **v number of neutrons in each burst and**
- **Ɛ = efficiency of neutron detection**
- **Then the contribution of burst events to total count rate is "svƐ"**

Theory For Burst Events (Binomial Distribution)

- For $\nu \gg 1$ and $\varepsilon \ll 1$
- Prob P_r of detecting r neutrons out of ν that are produced is given by
- P_r.......$[(\nu\varepsilon)^r/r!]e^{-\nu\varepsilon}$
- This expression peaks for multiplicities (r) whose magnitude is close to the product $\nu\varepsilon$
- Thus if $\nu\varepsilon \sim 4$, the probability of detecting a mutliplicity of 4 is actually higher than that of obtaining 3!

TABLE I

Expected Frequency Distribution of Counts for Poisson and Bunched Neutronic Events for Typical Sets of Parameters

Multiplicity Of counts	Frequency of Counts in 20ms Intervals for 10^5 samples					
	Poisson Events		Bunched Events ($S=10^{-2}$ per sec)			
	N_0=0.3 cps	N_0=3.0 cps	$\nu = 100$ $\varepsilon = 0.005$ $S\nu\varepsilon = 0.005$	$\nu = 100$ $\varepsilon = 0.015$ $S\nu\varepsilon = 0.015$	$\nu = 500$ $\varepsilon = 0.005$ $S\nu\varepsilon = 0.025$	$\nu = 500$ $\varepsilon = 0.015$ $S\nu\varepsilon = 0.075$
0	99940	99402	99992	99984	99980	99980
1	60	597	6.1	6.6	4.00	0.07
2	$\sim 10^{-2}$	1.7	1.5	5.0	5.1	0.3
3	$\sim 10^{-9}$	$\sim 10^{-2}$	0.2	2.5	4.2	0.8
4	$\sim 10^{-9}$	$\sim 10^{-5}$	0.03	1.0	2.6	1.5
5	$\sim 10^{-13}$	$\sim 10^{-8}$	0.003	0.33	1.3	2.2

TABLE II

Frequency Distribution of Background counts in Two Detector Banks

Counting interval 20 ms
Total counting time 63 hrs

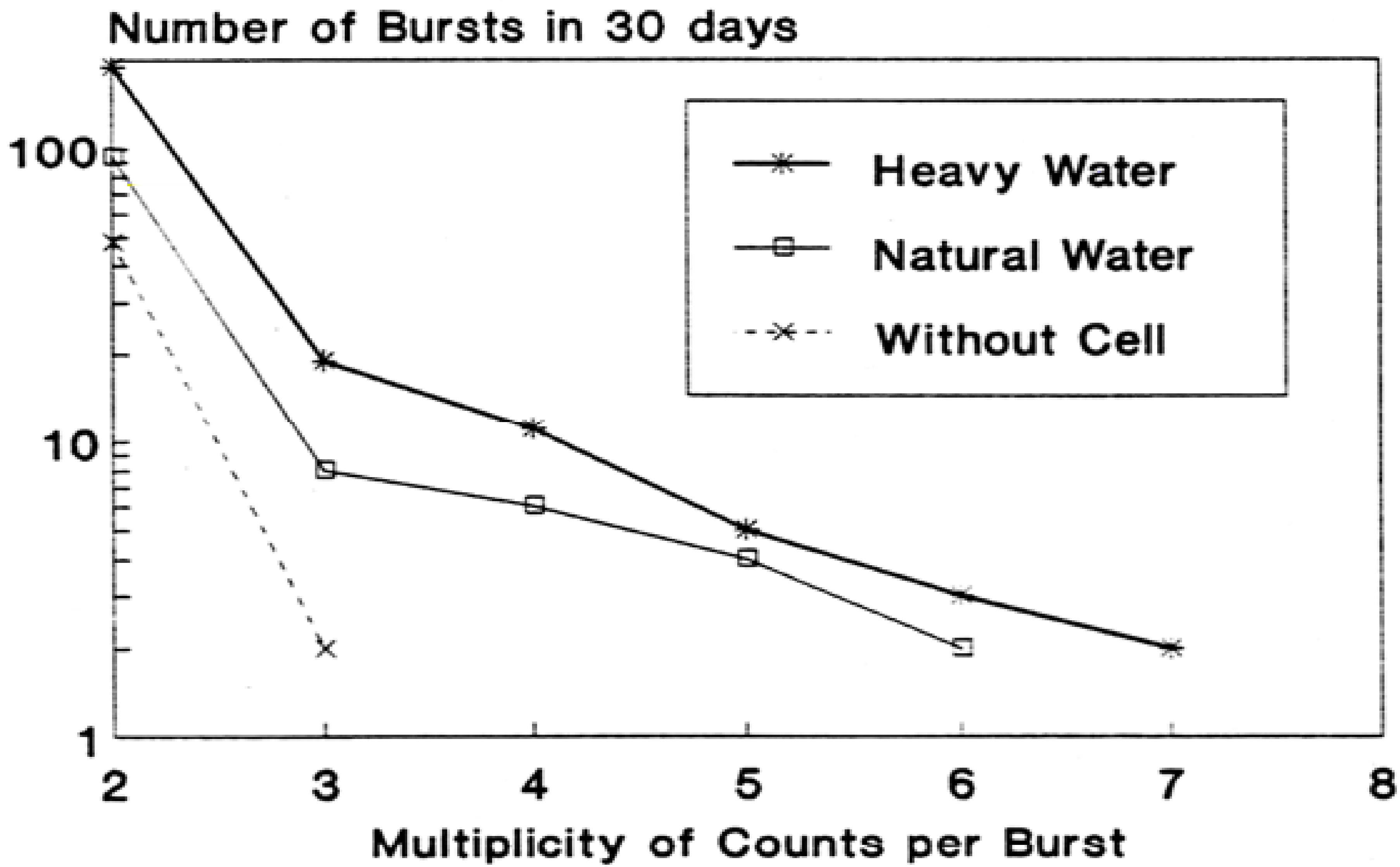
Multiplicity of counts	Frequency	
	BF_3 Bank	He^3 Bank
0	750035	743948
1	339	6413
2	1	14
3	0	0
4-20	0	0
N_0	0.023cps	0.43cps
$N_0\tau$	5×10^{-4}	0.0086

TABLE II: MULTIPLICITY DISTRIBUTION OF NEUTRON COUNTS IN 10 ms INTERVALS
(Milton-Roy Electrolytic Cell: Friday 16th June 1989)

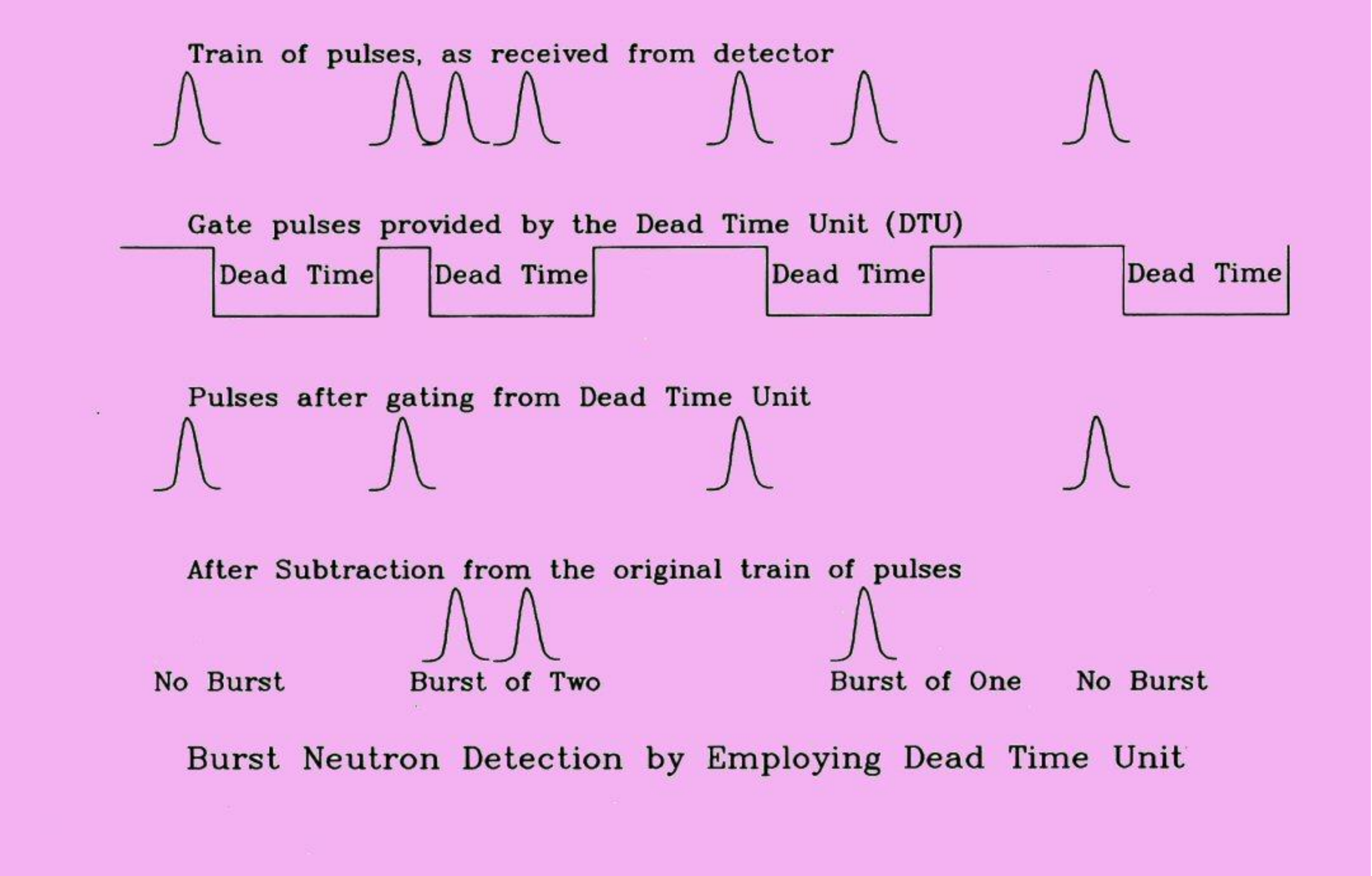
Time	BF_3 Counter Bank (Signal)															^{3}He Counter Bank (Background)		
(Hrs)	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	1*	2*	3*
18.55	124	21	4	1	-	-	-	-	-	-	-	-	-	-	-	2	1	-
19.00	54	9	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
19.05	335	54	7	2	1	-	-	-	-	-	-	-	-	-	-	4	-	-
19.10	320	82	10	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-
19.15	243	13	4	-	1	-	-		-	-	-	-	-	-	-	5	-	-
19.20	315	35	3	1	-	-	-	-	-	-	-		-	-	-	4	-	-
19.25	295	24	-	1	-	-	-	-	-	-	-	-	-		-	5	-	-
19.30	492	51	3	2											-	4	-	-
19.35	447	42	2	1	-	-	-	-	-	1	-	1	-	-	-	9	-	-
19.40	104	13	4	-	-	1	-	-	-		-	-			-	5	-	-
19.45	355	49	1	1	-	1	-	-	-	-	-		-	-	-	33	1	-
19.50	395	99	16	2	-	-	-	-	1	-	-	-	-	-		22	3	-
19.55	55	24	7	33	2	1	1	1	1	1	2	2	1	-	5	6	2	-

(*) Starred numbers represent the multiplicity of counts obtained in a single 10 ms interval. The respective frequency of occurrence (per 1000 gated intervals) is given in the corresponding column below.

FREQUENCY DISTRIBUTION OF BURST COUNTS INTEGRATED OVER 30 DAY PERIOD (ICCF-5)



PRINCIPLE OF DEAD TIME TECHNIQUE



CONCLUSIONS OF “n” MULTIPLICITY STUDIES

- Approximately 20 % of neutrons produced could be attributed to high multiplicity events wherein > 20 neutrons are generated per burst!
- Although balance 80% of neutrons detected were single neutron detection events that still does not prove they were in fact emitted only as singles!
- For example if 10 neutrons emitted in a sharp burst, even a set up with 10% neutron detection efficiency will not be able to detect multiplicity!

POSSIBLE REASONS FOR NON OBSERVATION OF MULTIPLE NEUTRON EMISSION BY OTHERS

- **Q: How come no one else has observed bunched neutron emission ?**
- **Ans : *No one has attempted!***
- **When neutron detection efficiency is as low as 1%, even if 100 neutrons are emitted in a single sharp bunch, you will still detect it only as a single neutron event;**
- **If 10 counts are registered during a one minute interval, it could imply (for 1% efficiency) either**
- **there were 1000 single neutron emission events**
- **or *there may have been 10 burst events each of which emitted 100 neutrons !***

BARC FINDING # 3

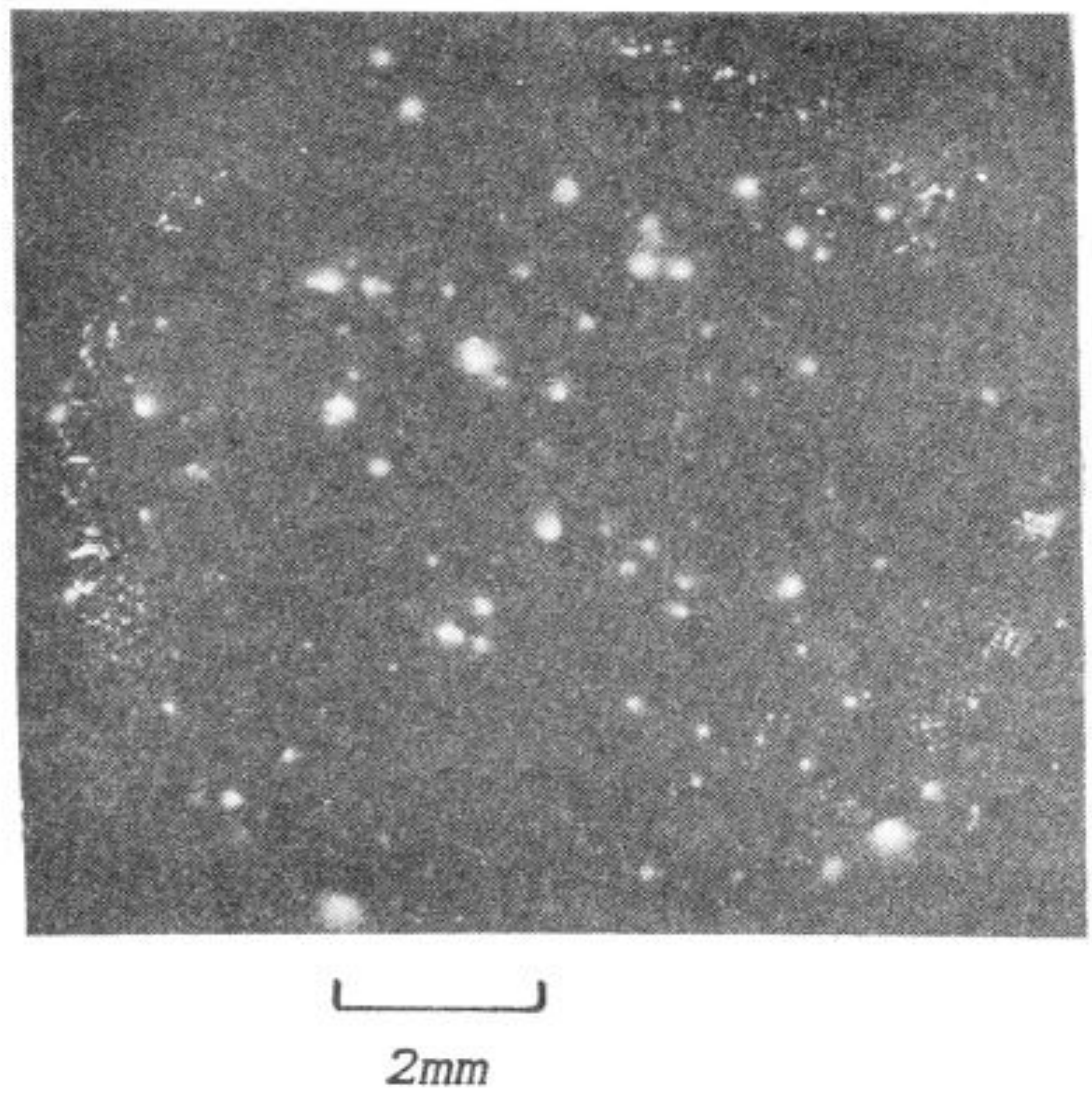
- Neutrons appear to be generated in bursts of 10s to 100s;
- Since n/T is 10^{-7}, it follows that Tritium must in turn be produced in bursts of 10^8 to 10^{10} !
- They are correlated in time; But what about space?

SPOTTY SIGNATURES OF DEUTERATED TITANIUM TARGETS

(Gas/Plasma Loaded)

Autoradiography was used as a very effective tool !

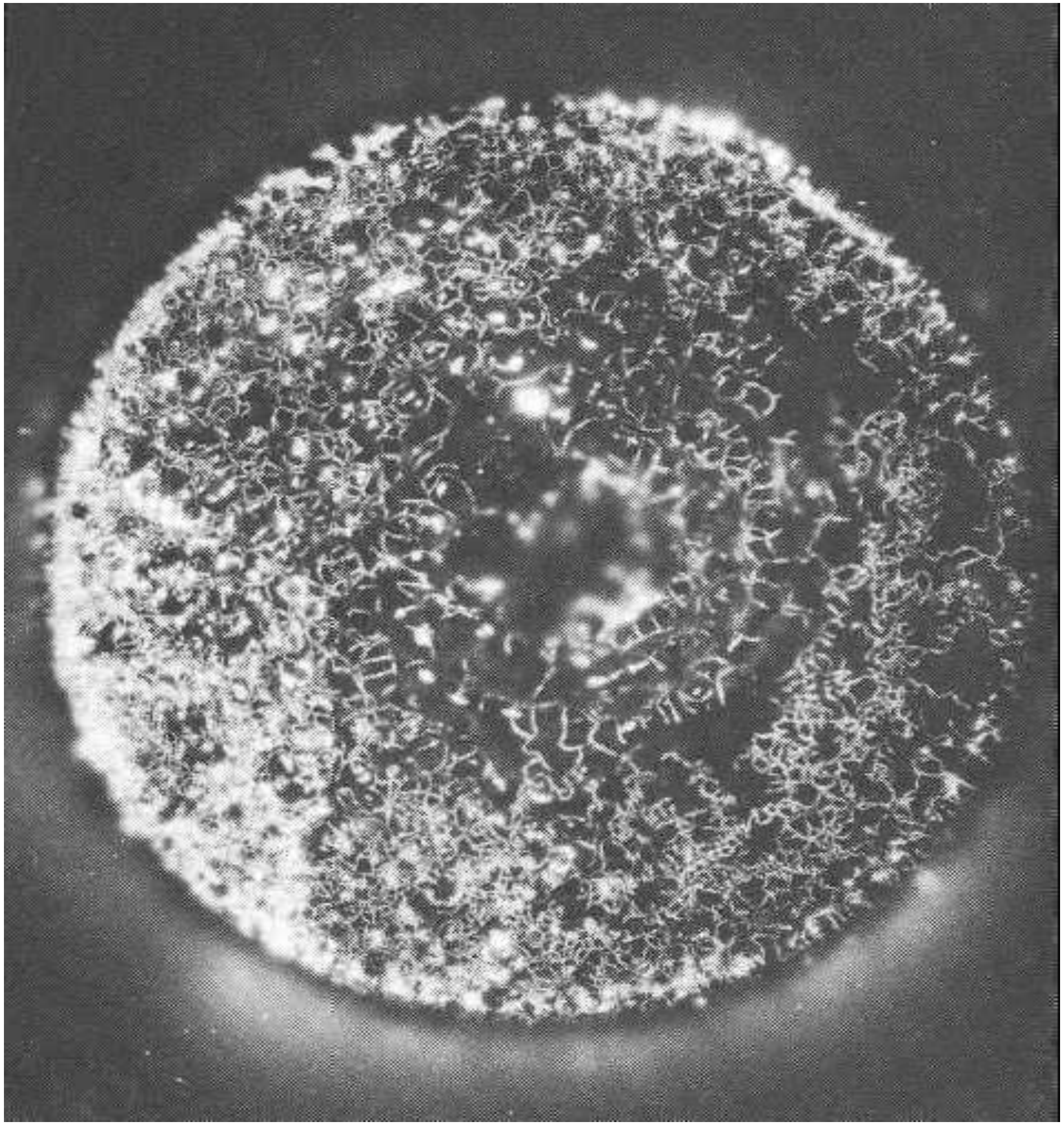
AUTORADIOGRAPH OF Ti DISC TARGET SHOWING ACTIVE SPOTS



AUTORADIOGRAPH OF A DEUTERATED Ti SHAVING INDICATING TRITIUM – CONTAINING HOT SPOTS

(Kaushik, T. C. *et al, Indian J. Technol,* 1990, 28, 667)

AUTORADIOGRAPH OF Ti ANODE OF PLASMA FOCUS DEVICE AFTER DISCHARGE SHOTS



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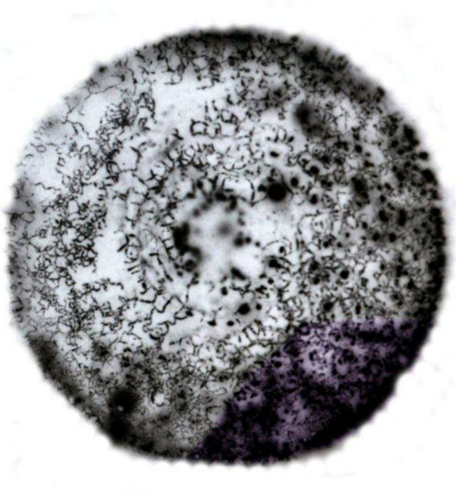

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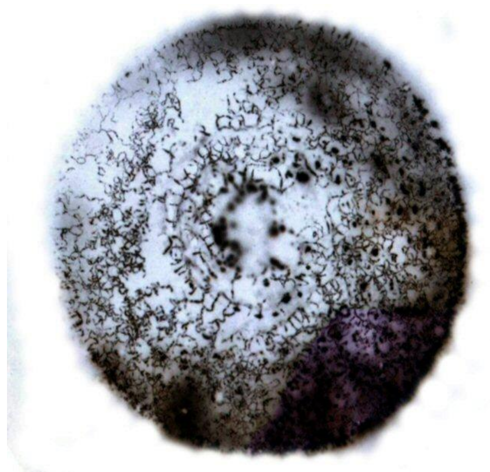

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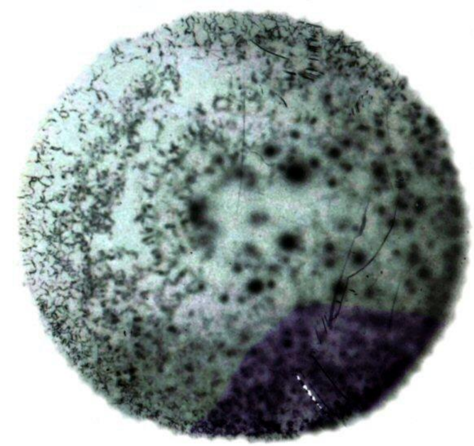

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BARC FINDING # 4

- **In case of titanium targets, tritium is found in cold worked defect sites … hot spots.**
- **These hot spots can perhaps be identified as “NAE” sites.**
- **The generated tritium stays put in same spot for several months! (poor diffusion rate in titanium)**

BARC "FINDING" # 5

- Superimpose finding No.3 on finding No.4, namely that tritium is found in highly localized hot spots which serve as NAE sites, and
- We are tempted to speculate that MNEs could be occurring in a single NAE site or possibly a single nano particle, producing approximately 10^8 to 10^{10} tritons !
- Can we now jump and speculate further that heat producing helium generating reactions also could occur in form of MNEs? Do the temperature hot spots on cathodes give a clue?

ESTIMTIMATED MAGNITUDE OF MNEs

- We thus arrive at the conclusion that at an NAE site somewhere between 10^8 to 10^{10} tritium producing reactions take place in some sort of avalanche type nuclear reaction or MNE (within a time span of nano seconds)
- It is for theoreticians to come up with a mechanism for such chain/MNE events!

CONCLUDING REMARKS

- **My purpose in re-presenting this "*forgotten old work*" is to try and encourage/inspire at least one other group to attempt measurement of neutron multiplicity in an LENR configuration which produces neutrons.**
- **We have seen it in Pd-D2O electrolysis as well as TiD2 gas loaded targets. It would be interesting to see if gas loaded Pd nano powder based devices also generate neutrons; If so they would also become candidates for multiplicity measurements.**
- **Detection of non-Poissonian neutron bursts would imply possible presence of chain events & MNEs.**
- **Cant think of any other nuclear signatures for this.**
- **MNEs, if real, clearly pose challenge to theory!**

THANK YOU !

My apologies for having been a bit too imaginative and speculative today!!