EPRI/NPD

SUMMARY OF PROGRESS

David H. Worledge

Electric Power Research Institute
Palo Alto, California 94303

International Progress Review on
Anomalous Nuclear Effects in
Deuterium/Solid Systems
Provo, Utah
October 24, 1990

Cold Fusion

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EXCESS HEAT RESULTS AS OF JAN '90

High Levels

Specific Power:	>20 W/cm^3
Power Gain:	2 - 7
Duration:	Minutes to days
Number:	5 labs, >12 cells

Low Levels

Specific Power:	≤20 W/cm^3
Power Gain:	Typically 1.15
Duration:	Days
Number:	11 labs, >40 cells

MANY, MANY, NEGATIVE RESULTS

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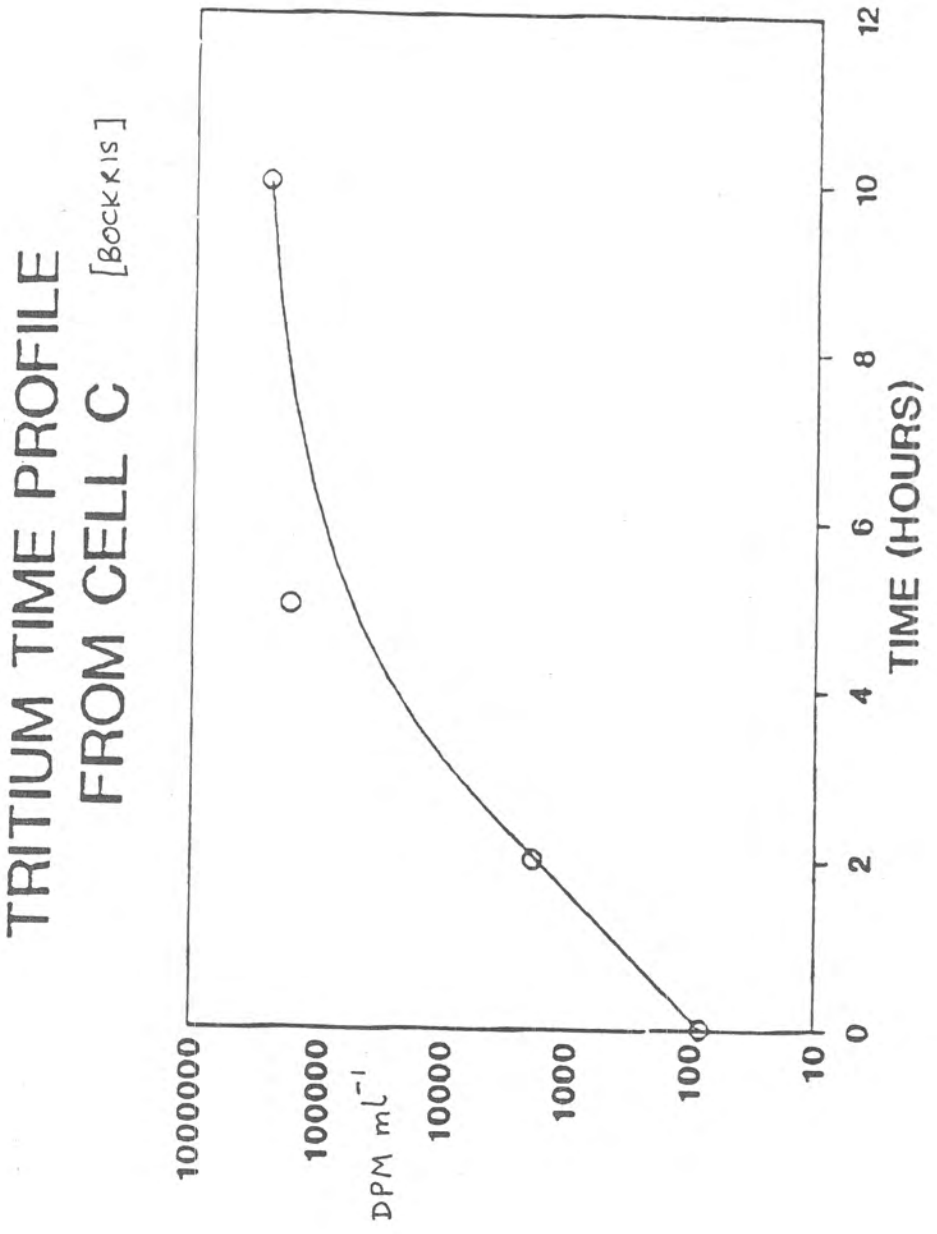
DHW 3/90 - COLD FUSION CONFERENCE



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TRITIUM RESULTS AS OF JAN '90

High Levels

Experimental Count:	10^4 - 10^8 dpm/ml
Sample/background:	10^2 - 10^6
Duration:	Hours to days?
Number:	7 labs, >22 cells

Low Levels

Experimental Count:	10^2 - 10^4
Sample/background:	3 - 100
Duration:	Hours to days?
Number:	8 labs, >13 cells

MANY, MANY, NEGATIVE RESULTS

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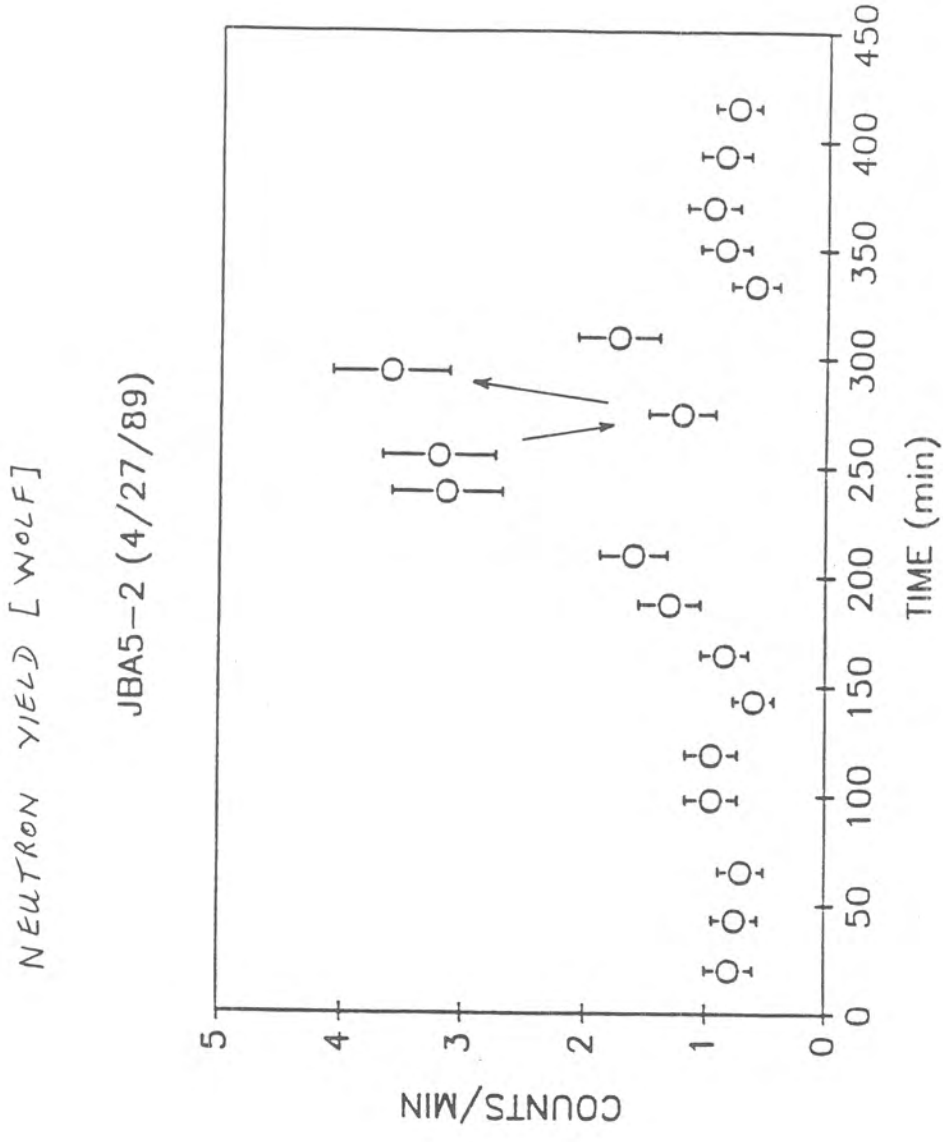

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NEUTRON RESULTS AS OF JAN '90

Random

Experiment/background:	3 - 1,000
Duration:	Minutes - hours
Number:	3 labs, 11 cells

Bursts

Neutrons/burst:	20 - 300
Burst length:	~120 μsec
Duration of bursts:	Hours

MANY, MANY, NEGATIVE RESULTS

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TRITIUM *vs* HEAT *vs* NEUTRONS

- Usually heat without tritium
- Tritium* <0.1% of heat when concurrent (Bockris)
- Neutrons* $\leq 10^{-12}$ of excess heat
- Neutron to tritium ratio:

Wolf	Texas A & M	7×10^{9}
Krishnan	BARC A1	5×10^{-9}
Nayar	BARC A2	1×10^{-9}
Claytor	LANL	1×10^{-9}
		1×10^{-9}

* assumes 4 MeV/event

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Summary (March 1990)

- Tritium
  - Strong signal
  - Contamination ?
  - Extremely non-reproducible
- Neutrons
  - Close to background
  - Cosmic ray interference ?
  - Becoming reproducible
- Heat
  - Few % power excess
  - Chemical source not identified
  - Not reproducible

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EPRI Strategy

- Seek existence or write-off proof with nuclear diagnostics
- Improve quality/reproducibility in nuclear experiments
  - Search for tritium contamination
  - Control experiments in electrolysis for tritium
  - Lower cosmic ray, solar and other neutron background (Jones, Wolf, Menlove)
  - ^{4}He assay on Pons Pd
  - ^{4}He assay on University of Hawaii Pd
  - $^{3}He/^{4}He$ assay on sub-ocean lava - University of Hawaii
  - $\Delta E/E$ particle identification (Cecil)
- Study the excess heat and associated physical circumstances
- Promote collaboration, integration of experiments and results

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Little Changed from January 1990

- Pd/electrolytic and Ti/gas load predominate
- Positive and negative findings continue (fewer negatives?)
- Vast differences in quality; improving
- Tritium unreproducible; small amounts common
- Neutron random rates
- Low repeatability of high multiplicity neutrons
- Timing and triggering of neutron spikes
- Few X,γ or He observations

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Areas Changed Since January 1990

- Improved reproducibility of
  - low multiplicity neutron spikes
  - random neutrons
- Neutron observations survive changes in detectors, environments, research groups
- New charged particle observations
- Tentative identification of particles as tritons
- Metallurgical influences and batch to batch variations
- D/T behavior in Pd becoming ~~clearer~~ BETTER KNOWN; tritium contamination puzzles

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Tritium Contamination

- Wolf (Texas A&M) found low levels (~20 times b/g) in stock Pd
  - 2 positive out of 100 samples
  - 1 positive from H_20 cell cathode run for 2 months with no T in electrolyte (had been annealed)
- Wolf extrapolates to all tritium findings (even 10^6 X b/g at Texas A&M and BARC)
- No credible contamination route for higher levels?
- Foul play unlikely (Los Alamos spiking tests)

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New Nuclear Claims

- Hubler (NRL) claims charged particle (5MeV tritons?) from $T_i D_x$ - non reproducible
- Cecil (CSM) observed ~40 bursts of charged particles, 50% reproducible from TiD_x ($\lesssim$ 5MeV tritons)
- Arzhannikov (INP. Novsibirsk) observed random N from chemical reactions (Redox) involving Pd and Pt - tentatively supported by Wolf and Jones (Pd)

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Reproducibility = Confidence

- Many occurrences
- > 50% success rate
- Time correlation with experimental parameter(s)
- Concurrent measurement of background
- Adequate number of blank controls
- Adequate number of hydrogen controls
- Change to detector of same type
- Improve signal to noise ratio
- Change laboratory/environment esp. electric noise, humidity
- Change to diverse detector type
- Concurrent, diverse detectors correlate
- More than one research group confirm results

Plus

- Systematic and random errors
- Appropriate expertise

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Pd Electrolysis

- How can low T contamination exit cathode sometimes, not others?
- Low T contamination in 3 cells
- Deliberate T in Pd goes to gas experimental T in electrolyte
- Some T early in electrolysis, some delayed
- Low random N early or with Δi
- N spikes correlate with cell transient?
- Random N energy ~2.5 MeV (one Ti) - also 6-7MeV?
- $N : T = 10^{-8\pm1}$
- Large random N bursts in some experiments
- Low random N not caused by cosmic rays
- Many cases of neutron spikes and random emission

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Ti/Gas Loading

- N spikes ⟶ temp transient
- N spikes ⟶/ cosmics
- Virtually no E_n for spikes (Pd spikes too)
- Random n from Ti ? ?
- Charged particles $E \lesssim$ 15 KeV (Pdel)
- Charged particles $E \lesssim$ 15 KeV AND 5MeV major constraint to theory
- Early Taniguchi particles could not have been 5 Mev T; unlikely as d+d protons

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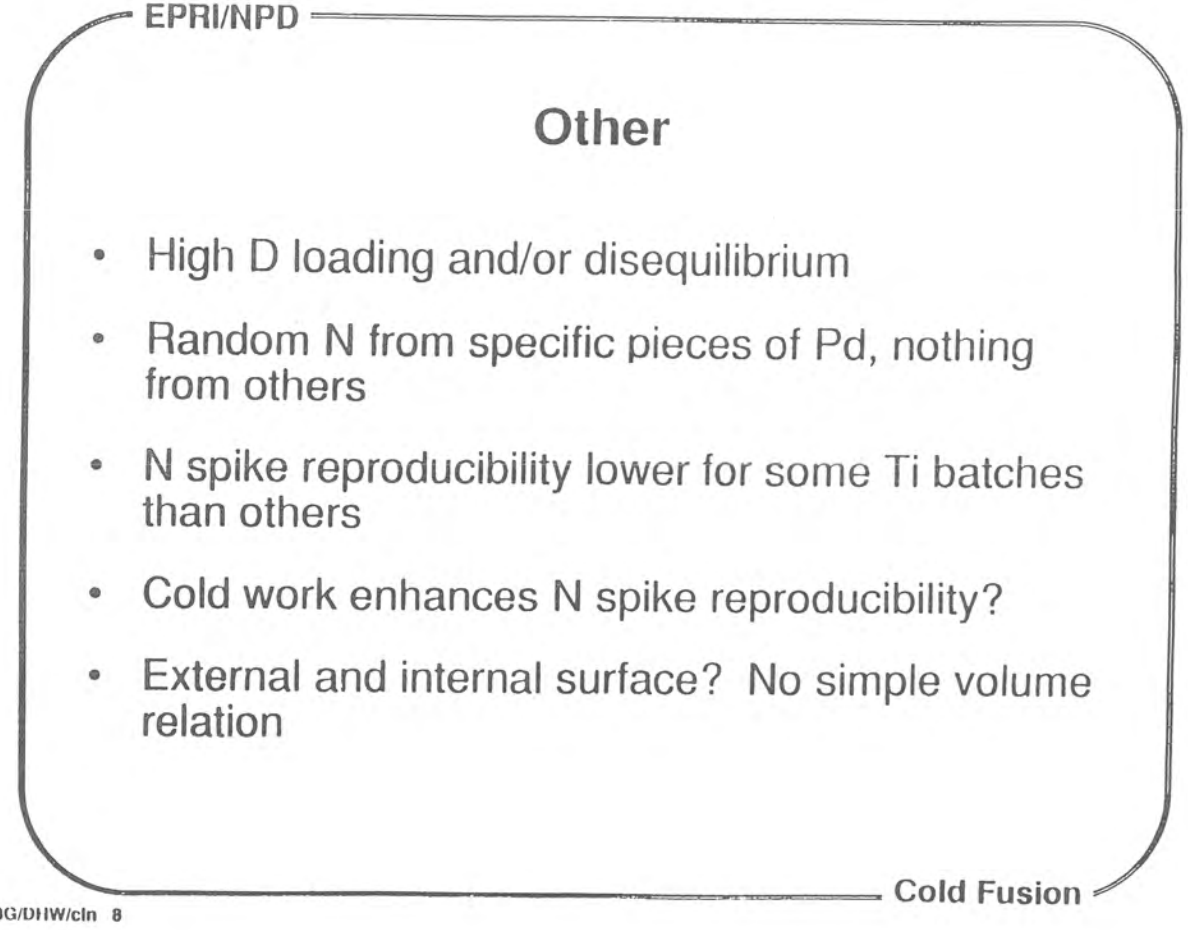

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Steps Needed

- Better tritium/Pd models including porosity/crack formation
- Ti/gas - N spike experiments need diverse detectors, preferably concurrent
- Random electrolytic N need lower background
- Ti/gas - tritium measurements plus controls
- Ti/gas - particles need $\Delta E/E$ identification and track recording
- Electrolysis with thin Pd cathode wall repeated with $\Delta E/E$
- Continue ^4He assays on Pd, perform on Ti

LOOK IN THE GAS

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Conclusions

- Not normal d+d
- Very little guidance yet to theory
- Many experiments are greatly improving in quality
- Many rather different experiments giving similar pattern of results
- Very clear there is extremely good scientific work being done (also this was a "scientific" meeting)
- Funding Agencies: This is a legitimate field that needs support

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