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DARPA

HIVER* Electrochemistry Energy Project Update

***(^{2}H-Pd-Li V**ersatile-modeling & **E**valuation of **R**esults**)**

Presented to:

ARPA-E LENR Workshop

Presented by:

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Employees of NSWC Indian Head Division

- 21/22 Oct 2021 -

LENR Field Issues & Potential Solutions

- Lack of acceptance of thermal (heat) results
  - Many calorimeter designs
  - Need academics from top research universities
- Lack of acceptance of nuclear (particle) results
  - Additional detection schemes
  - Multiple, redundant, detectors
- Lack of acceptance of RF coupling to heat/particles
  - Wider listening band
  - Rigorous hypotheses / potential causes
- Lack of transparency by researchers
  - Every group has limitations: even our own presentation today
  - Get patents if necessary; then publish results
  - Openly discuss alternate (prosaic) explanations for anomalies
    - No need to cherry-pick results
- Until this field is an accepted research area, no one group will succeed
  - Rising tide of scientific merit will lift all boats

SPECIAL SECTION: LOW ENERGY NUCLEAR REACTIONS

Cold fusion: comments on the state of scientific proof

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Early criticisms were made of the scientific claims made by Martin Fleischmann and Stanley Pons in 1989 on their observation of heat effects in electrochemically driven palladium–deuterium experiments that were consistent with nuclear but not chemical or stored energy sources. These criticisms were premature and adverse. In the light of 25 years further study of the palladium–deuterium system, what is the state of proof of Fleischmann and Pons' claims?

Keywords: Cold fusion, Fleischmann, Pons, scientific proof.

Introduction

THE question under discussion is whether the phenomenon known as cold fusion has been proven to be existent or non-existent. This is an important question, for if real, the possibility exists that cold fusion might become a meaningful primary energy source with few of the disadvantages associated with the power sources that we have available to us today. One expects science to be able to rationally investigate and determine answers to questions such as this. Having studied this phenomenon almost full time for the past 25 years, I will state my preliminary conclusion up front and then proceed with a more nuanced discussion. Whatever it is and by whatever underlying mechanism it proceeds, the accumulated evidence strongly supports the conclusion that nuclear effects take place in condensed matter states by pathways, at rates and with products different from those of the simple, isolated, pairwise nuclear reactions that we are so familiar with in free space (i.e. two-body interactions). The implications of this statement are profound and we will proceed with caution on the basis of validation of the envisaged new science.

Discussion

Occasionally, with decreasing regularity, one hears statements to the effect that 'Cold fusion has been proven to not exist or to have been based on errors'. Almost always the words 'long ago' are appended. Never are examples of error given at any level of scientific sophistication. If pressed the authority of experts in the fields of nuclear or particle physics are invoked, or early publications of null results by 'influential laboratories' – Caltech, MIT, Bell Labs, Harwell. Almost to a man these experts have long ago retired or deceased, and the authors of these early publications of 'influential laboratories' have long since left the field and not returned. The issue of 'long ago' is important as it establishes a time window in which information was gathered sufficient for some to draw a permanent conclusion – some time between 23 March 1989 and 'long ago'. Absurdly for a matter of this seeming importance, 'long ago' usually dates to the Spring Meeting of the American Physical Society (APS) on 1 May 1989. So the whole matter was reported and then comprehensively dismissed within 40 days (and, presumably, 40 nights). From what we now know is this sensible? Has pertinent new information and understanding developed over 25 years of further study been examined with the wisdom of hindsight? What is the status of these early null results?

Several questions lie on the table of increasing scientific interest and technical importance. Do nuclear processes ever occur at all in metallic lattices? If yes, do these occur by means differently than two-body interactions in free space? Before Martin Fleischmann and Stanley Pons' fateful press conference on 23 March 1989, most who had thought about it would have argued that nuclear processes can be caused or observed to occur on or beneath the surface of solids, but take no advantage from it. The size and timescales of atom–atom and inter-nuclear interactions are so vastly different that the chemical and physical state in which a nuclear process occurs was generally considered to have no influence over the nuclear reaction mechanism, rate or product distribution. The only case considered computationally for the involvement of materials in the nuclear process[1] was the tunnelling interaction of two like charged particles, which is strongly distance-dependent. The thinking was that the palladium lattice used by Fleischmann and Pons in their experiments might (somehow) confine deuterons sufficiently closely to 'meaningfully' (see note 1) increase the tunnelling cross-section. This popular line of reasoning ignored following three crucial details.

(1) At maximum loading of deuterium (D) into palladium (Pd), the centre-to-centre distance between adjacent

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CURRENT SCIENCE, VOL. 108, NO. 4, 25 FEBRUARY 2015 495

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Team Overview

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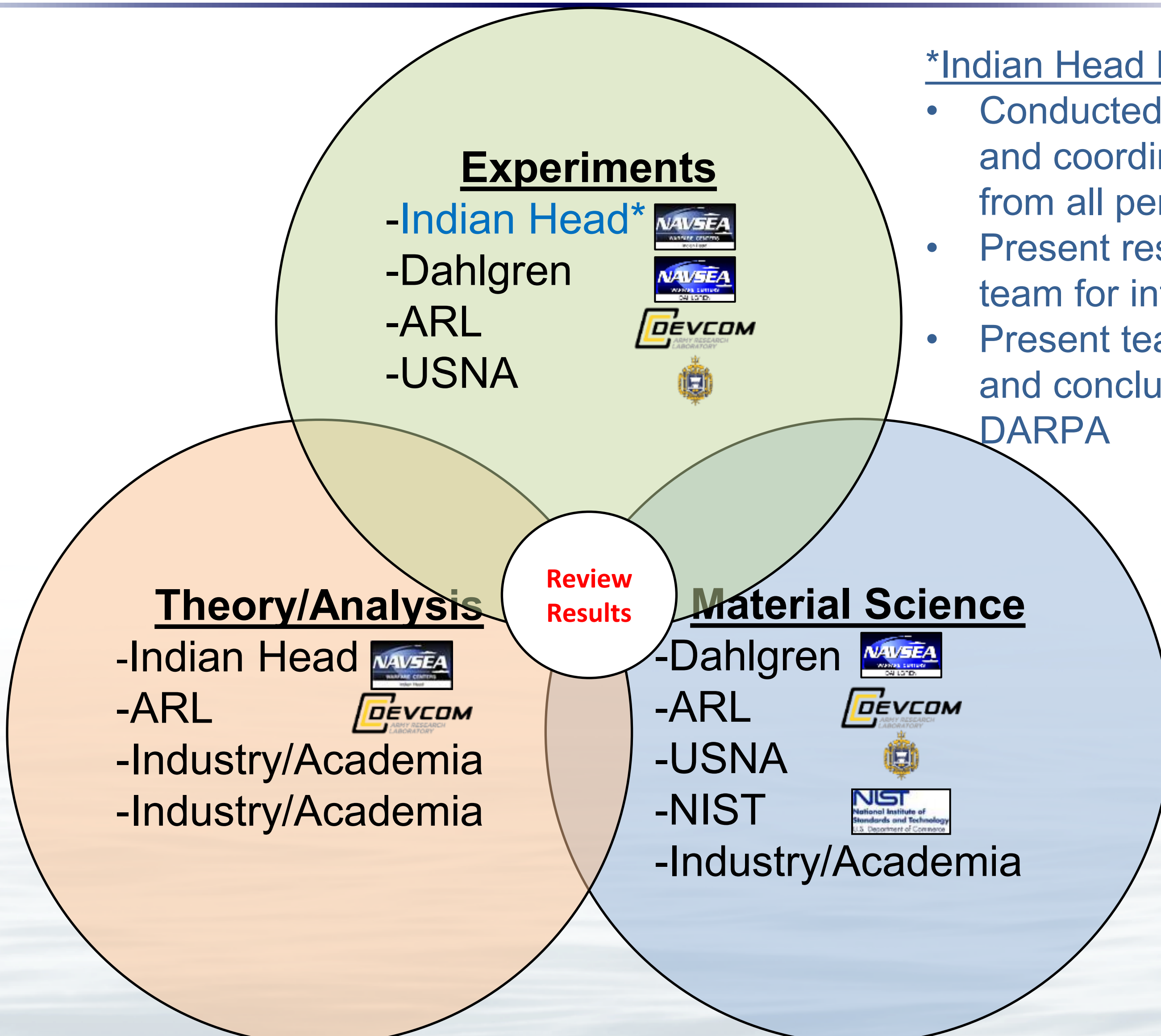

*Indian Head Roles

- Conducted experiments and coordinated results from all performers
- Present results to entire team for internal review
- Present team's results and conclusions to DARPA

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Navy IP: Basis for Experimentation

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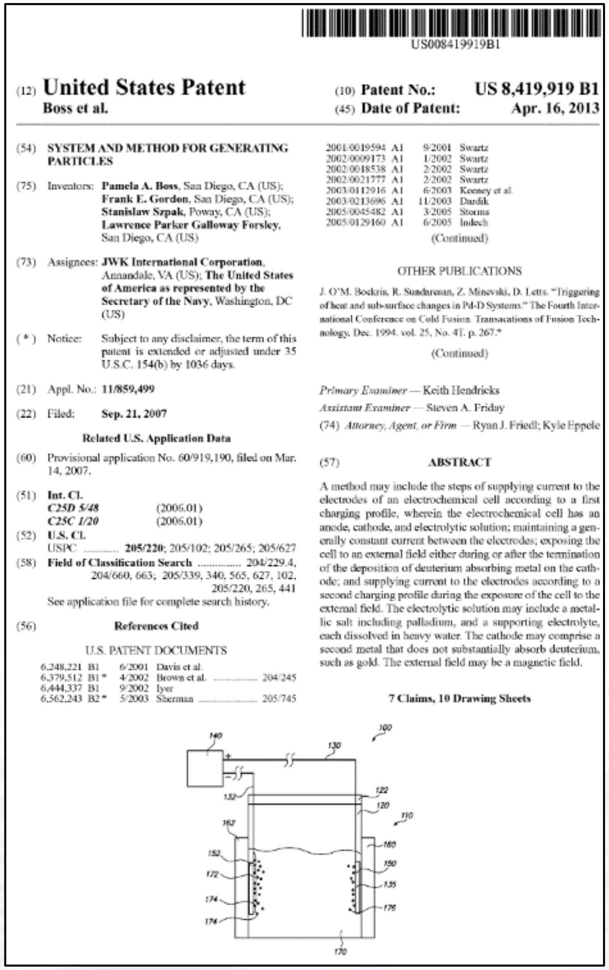

US008419919B1

(12) **United States Patent**
Boss et al.

(10) **Patent No.: US 8,419,919 B1**
(45) **Date of Patent: Apr. 16, 2013**

(54) **SYSTEM AND METHOD FOR GENERATING PARTICLES**

(75) Inventors: **Pamela A. Boss**, San Diego, CA (US); **Frank E. Gordon**, San Diego, CA (US); **Stanislaw Szpak**, Poway, CA (US); **Lawrence Parker Galloway Forsley**, San Diego, CA (US)

(73) Assignees: **JWK International Corporation**, Annandale, VA (US); **The United States of America as represented by the Secretary of the Navy**, Washington, DC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1036 days.

(21) Appl. No.: **11/859,499**

(22) Filed: **Sep. 21, 2007**

Related U.S. Application Data

(60) Provisional application No. 60/919,190, filed on Mar. 14, 2007.

(51) **Int. Cl.**
C25D 5/48 (2006.01)
C25C 1/20 (2006.01)

(52) **U.S. Cl.**
USPC **205/220**; 205/102; 205/265; 205/627

(58) **Field of Classification Search** 204/229.4, 204/660, 663; 205/339, 340, 565, 627, 102, 205/220, 265, 441
See application file for complete search history.

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(Continued)

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Assistant Examiner — Steven A. Friday
(74) *Attorney, Agent, or Firm* — Ryan J. Friedl; Kyle Eppele

(57) **ABSTRACT**

A method may include the steps of supplying current to the electrodes of an electrochemical cell according to a first charging profile, wherein the electrochemical cell has an anode, cathode, and electrolytic solution; maintaining a generally constant current between the electrodes; exposing the cell to an external field either during or after the termination of the deposition of deuterium absorbing metal on the cathode; and supplying current to the electrodes according to a second charging profile during the exposure of the cell to the external field. The electrolytic solution may include a metallic salt including palladium, and a supporting electrolyte, each dissolved in heavy water. The cathode may comprise a second metal that does not substantially absorb deuterium, such as gold. The external field may be a magnetic field.

7 Claims, 10 Drawing Sheets

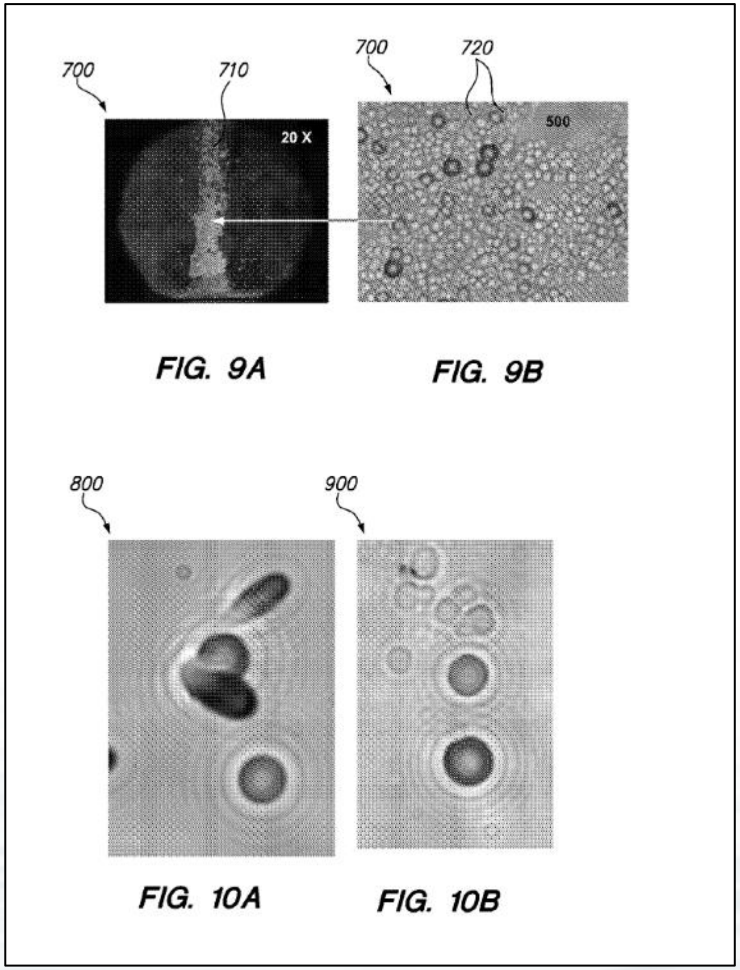

FIG. 9A FIG. 9B

FIG. 10A FIG. 10B

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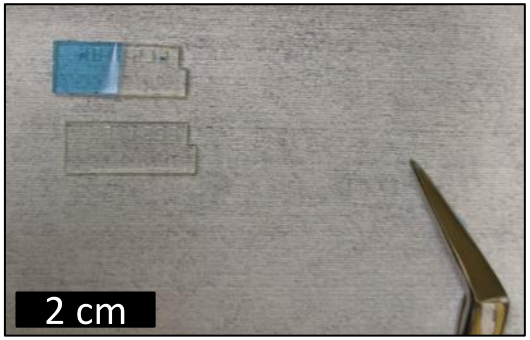
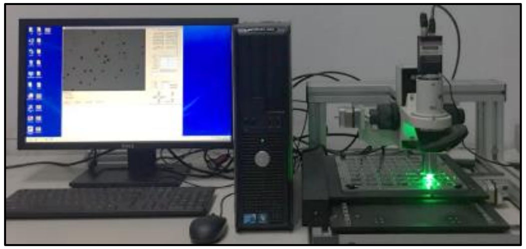
Background: CR-39 Solid-State Nuclear Particle Detector

- Solid-state integrating nuclear track detector
  - CR-39 = Polyallyl diglycol carbonate (plastic)
  - $C_{12}H_{18}O_7$
- Sensitivity & Efficiency
  - Protons (p), ^{3}He, Alphas (α)
    - 0.1 MeV – 10+ MeV, ~100% [1]
  - Neutrons (n)
    - Secondary scattering only, <0.1% [1]
- Scanning
  - Automated or manual





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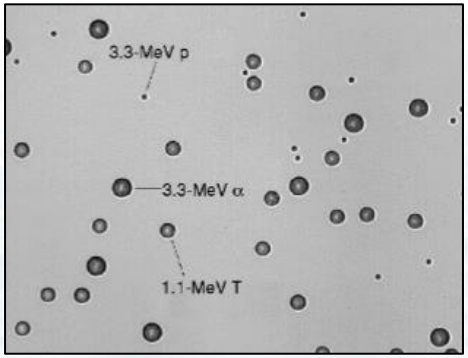

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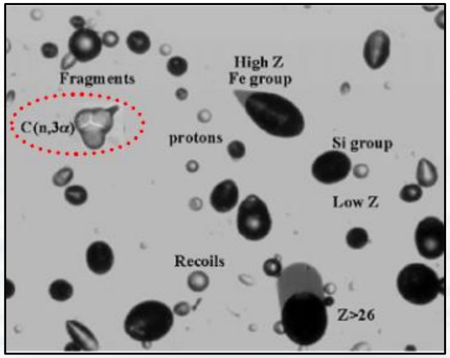

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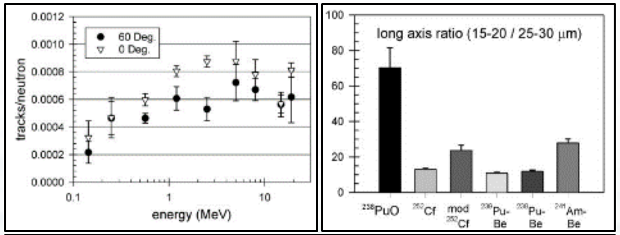

[1]Georgetown University, Radiation Medicine Department, 3970 Reservoir Road NW, Research Building Room E202A, Washington, DC 20057-1482, USA
[2]Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831-6480, USA
[3]Washington Hospital Center, Radiation Safety, 110 Irving Street NW, Washington, DC 20010-2975, USA
[4]University of Ioannina Medical School, Medical Physics Department, Ioannina 451 10, Greece
[5]Los Alamos National Laboratory, MS G761, P.O. Box 1663, Los Alamos, NM 87545, USA

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CR-39 Accuracy in Electrochemical Environments?

- Typical environments
  - In air
  - Ambient conditions
- Sources for material damage / pitting during electrochemistry
  - Heat?
  - Ion bombardment?
- Control experiments?
  - CR-39 in hot electrochemical experiments (next slide)
  - ^{230}Th 4.7 MeV α source in air (below)

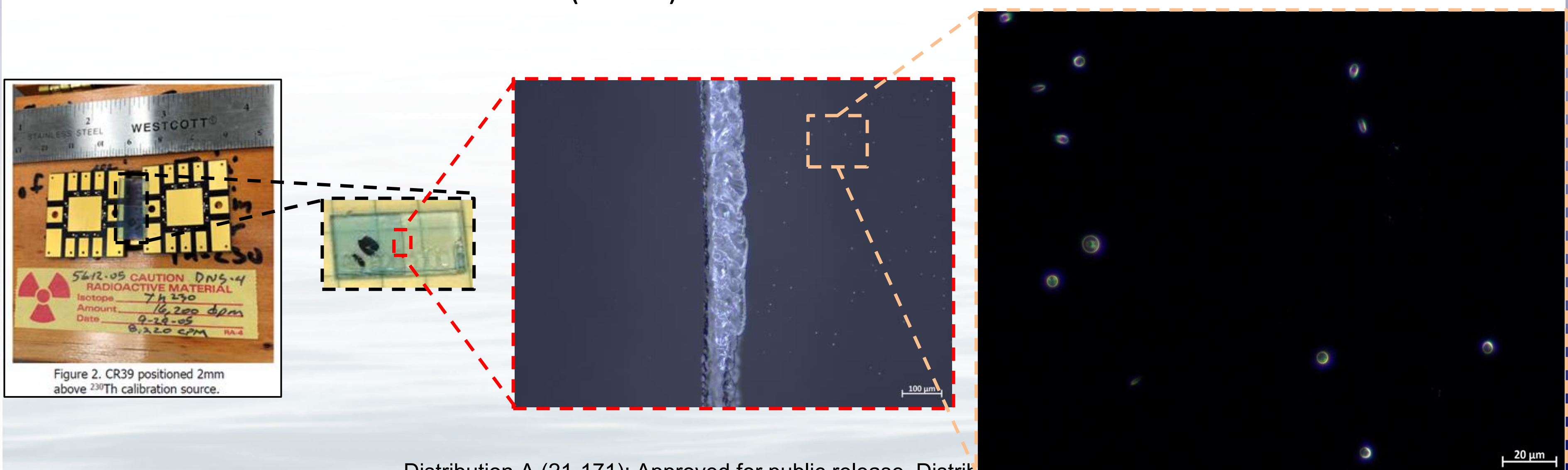
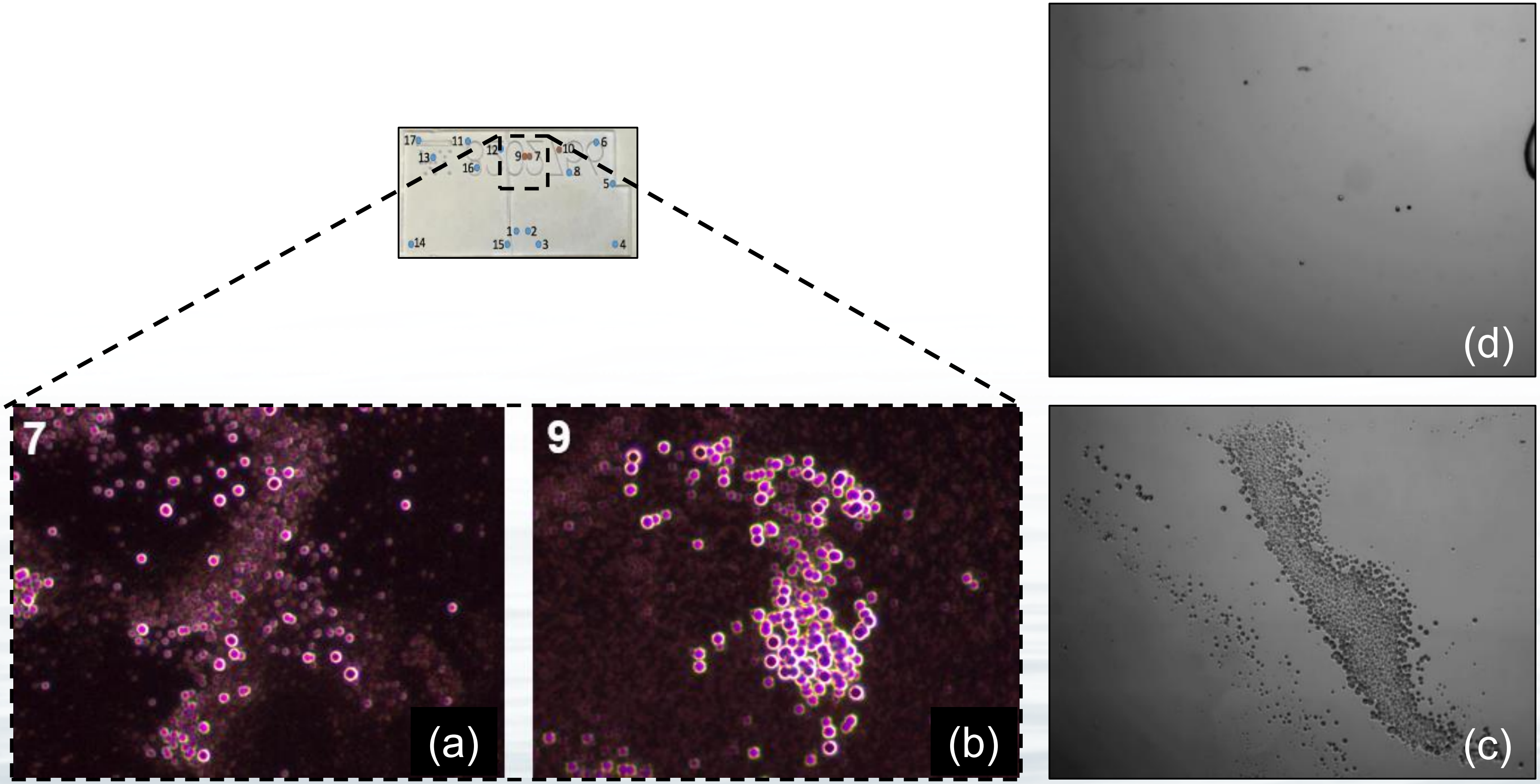


Figure 2. CR39 positioned 2mm above ^{230}Th calibration source.

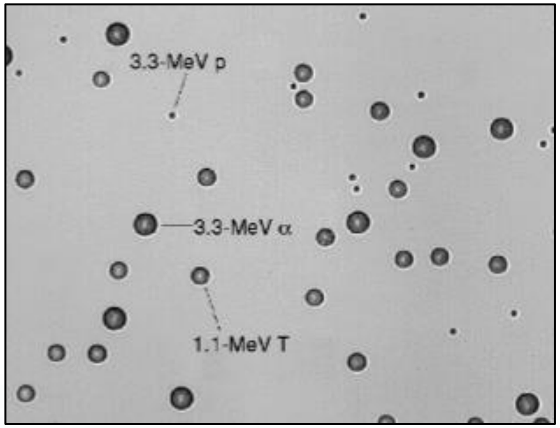
Sample CR-39 Results

- Industry/academic partners analyzed CR-39 chips post-experiment
- Two partners working independently found tracks across multiple separate experimental runs (a)-(c); a relative lack of nuclear tracks on control runs (d)



CR-39 Comparison w/Literature

- Difficulties
  - Etch conditions?
  - Qualitative comparison: morphology
  - Quantitative comparison: measured diameter/depth



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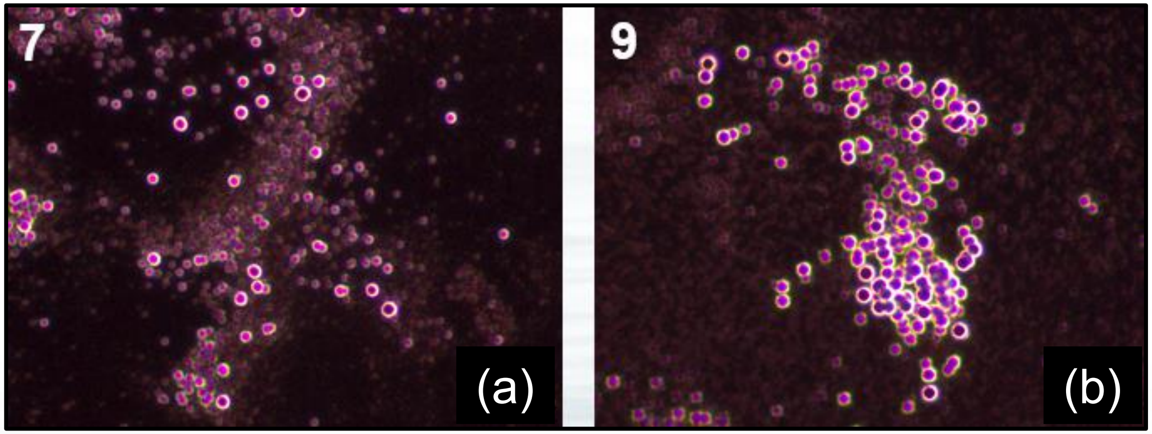

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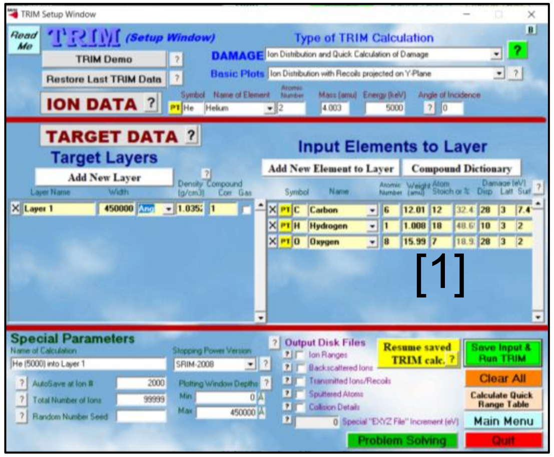
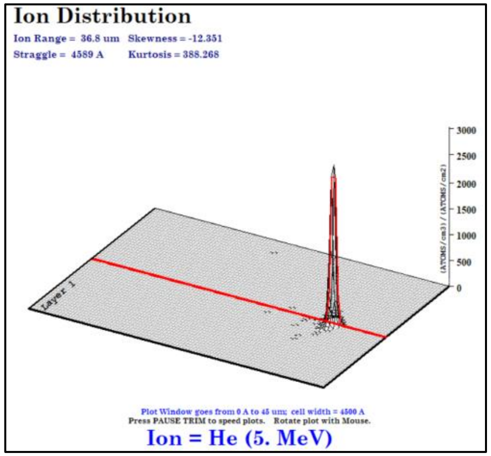
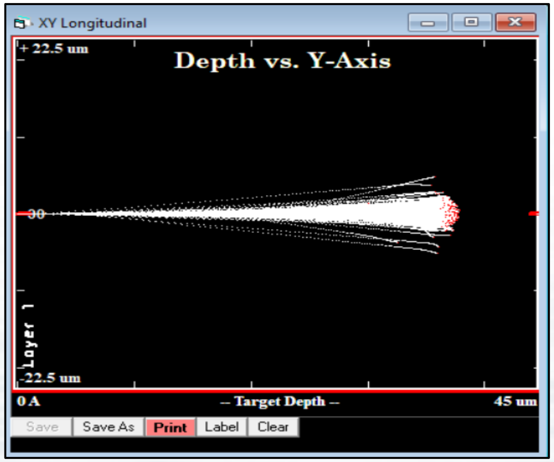
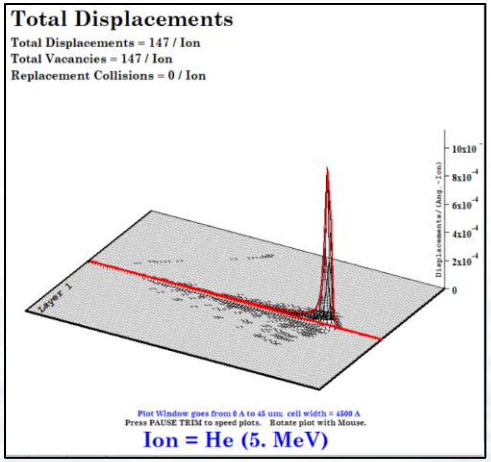
α-Particle Transport Through Matter









α-Particle Transport		
Energy	D_2O	CR-39
1 MeV	6 µm	4 µm
5 MeV	37 µm	29 µm

[1] Keiji ODA, et al. , Application of CR-39 Track Detector to Neutron Spectrum Measurement , Journal of Nuclear Sci & Tech, 28[7], pp. 608-617 (July 1991).

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Neutron Detector Results

Oct 2020

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2 Run 27 $\bar{x}$ = 5.91 n = 692	3
4	5 Background Count $\bar{x}$ = 5.89 n = 2861	6	7 Run 28 $\bar{x}$ = 6.33 n = 695	8		
11 Background Count $\bar{x}$ = 5.90 n = 2407	12	13 Run 30 $\bar{x}$ = 6.14 n = 693	14			

3.9σ
p ~= .00005
< $\frac{1}{20{,}000}$ chance

$$z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

2.3σ

Jan 2021

10	11	12 Background Count $\bar{x}$ = 6.00 n = 3511	13	14	15 Run 32 $\bar{x}$ = 6.12 n = 1814	16 Background Count.. $\bar{x}$ = 6.38 n = 3206
17 ...cont...	18	19	20 Background Count $\bar{x}$ = 6.12 n = 3624	21	22	23 Run 33 $\bar{x}$ = 6.87 n = 2401

10.9σ

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Neutron Results vs. NJ Background

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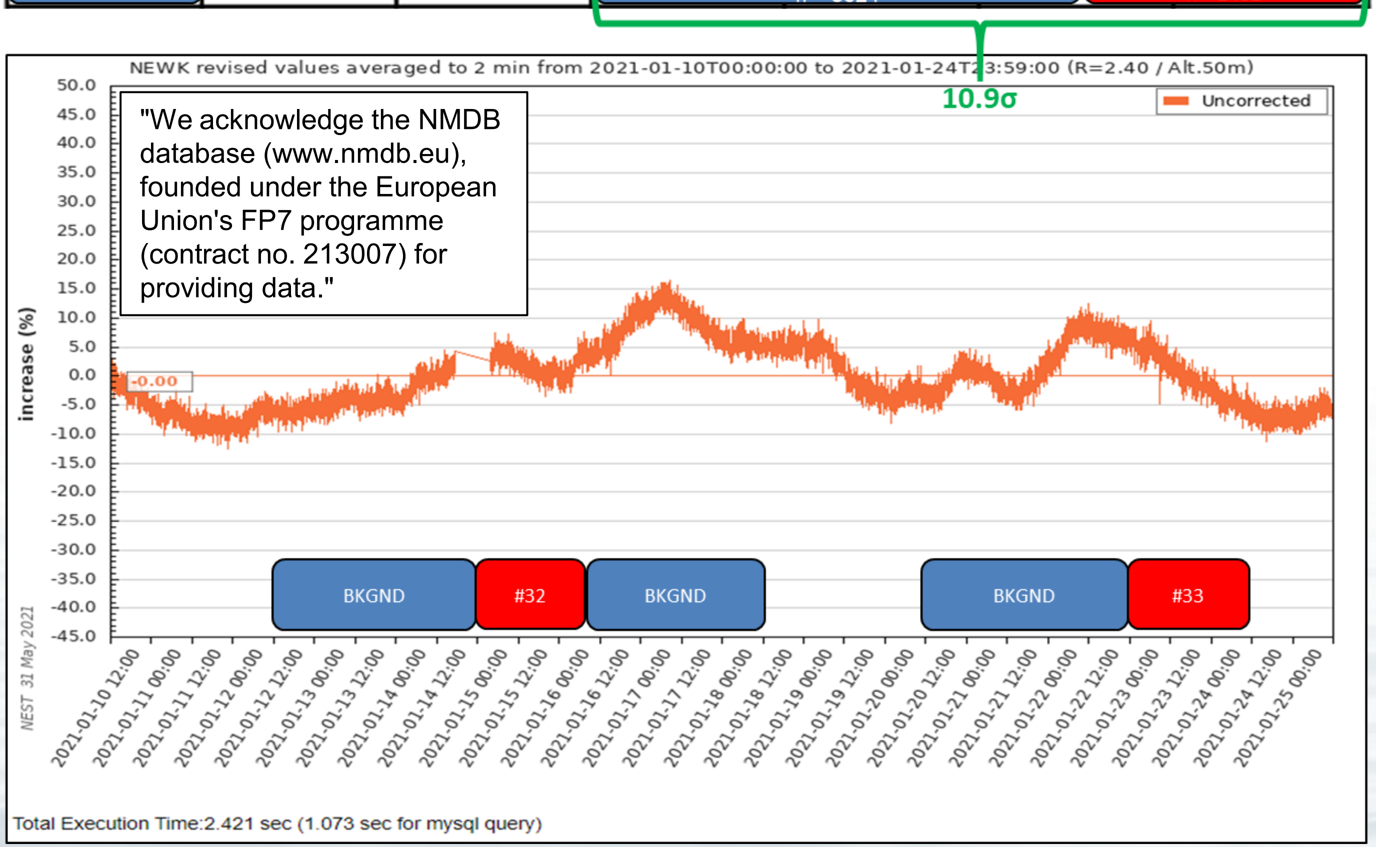
Jan 2021

10	11	12	13	14	15	16
		Background Count $\bar{x}$ = 6.00 n = 3511			Run 32 $\bar{x}$ = 6.12 n = 1814	Background Count.. $\bar{x}$ = 6.38 n = 3206
17	**18**	**19**	**20**	**21**	**22**	**23**
...cont...			Background Count $\bar{x}$ = 6.12 n = 3624			Run 33 $\bar{x}$ = 6.87 n = 2401



2.45 MeV n and H(n,γ)D Modeling

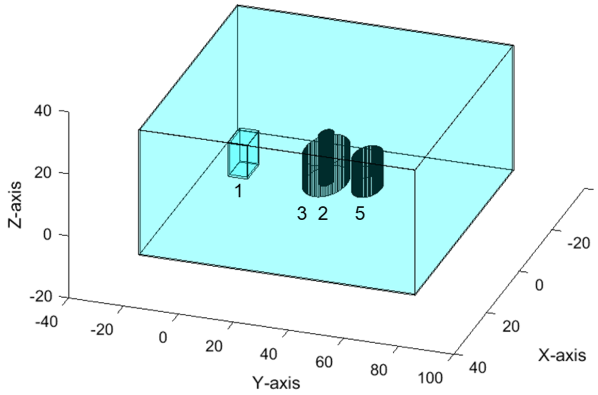


Figure 1. Simulation geometry (cm scale): lucite filled D_2O chamber (1) with ^3He detector (2) surrounded by HDPE (3) and NaI gamma detector (5).

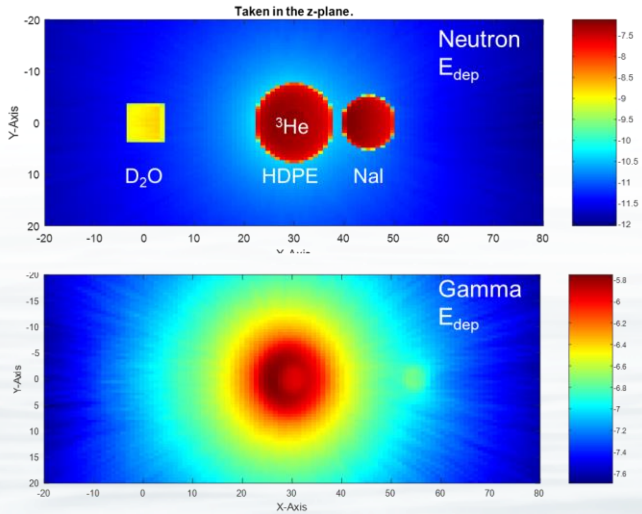


Figure 2. Energy deposited (MeV/g) in materials: (a) Neutron energy deposited in D_2O and HDPE (C_2H_4) surrounding ^3He detector. Neutrons also reach the NaI behind HDPE; (b) Gamma energy isotropically emitted from HDPE and deposited in NaI detector and D_2O.

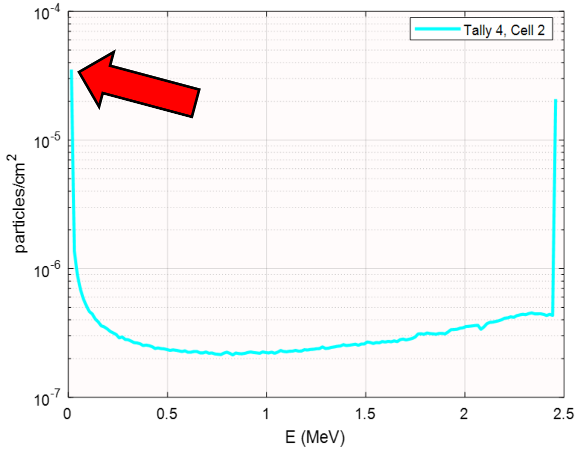


Figure 3. Energy spectrum of neutron flux (#/cm²) in ^3He detector per 2.45 MeV neutron emitted from Pd wire.

~30,000 2.45 MeV neutrons must be emitted in order to trigger one thermal ^3He count.

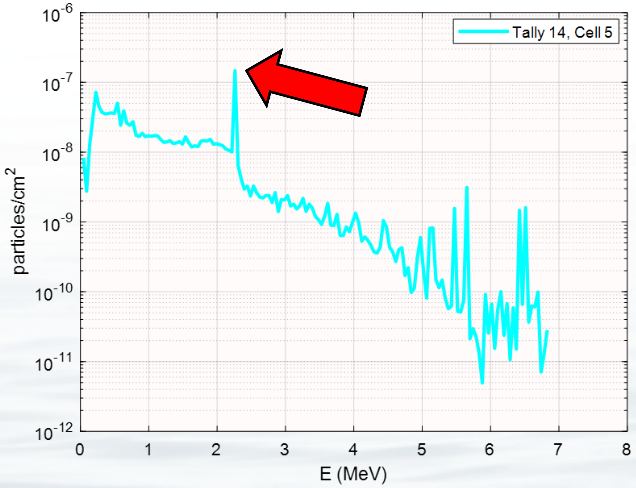


Figure 4. Energy spectrum of gamma flux (#/cm²) into NaI detector, per 2.45 MeV neutron emitted from Pd wire. 45kV resolution.

~7,700,000 2.45 MeV neutrons must be emitted in order to read one NaI count.

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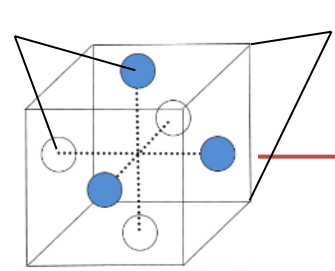
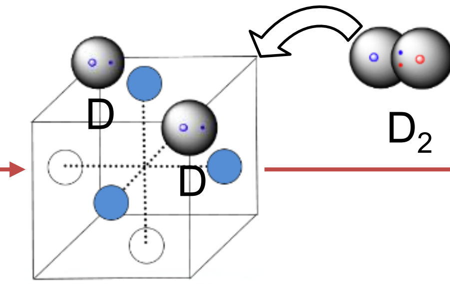
Theoretical Roadmap

$$H\psi = E\psi$$

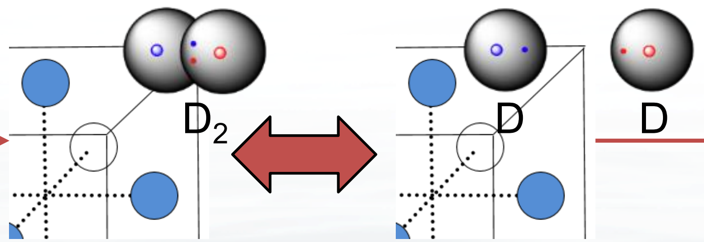
System Modeled with QM DFT



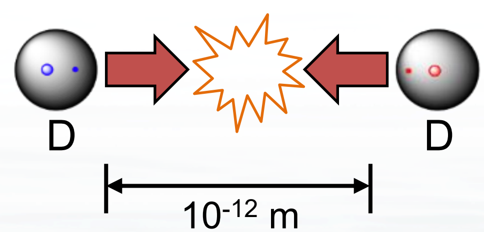
Electrochemically Plated Lattice Structure w/Vacancies



Electrochemical Deuterium Loading in Lattice



Deuterium Parametric Pumping Through Applied DC Current



D-D Reaction Cross-Section Calculated based on DC Pumping and Electron Screening

Exothermic Energy/Particle Release

Conclusion

- Overall team conclusions presented to DARPA
  - This work should continue; much interesting science left to be done
  - Results do not yet rise to level publishable in peer-reviewed nuclear physics journal
    - More work needed on additional nuclear detection schemes
- What's next?
  - Submission of results to peer-reviewed chemistry journal
  - Outside replication studies to determine whether results are repeatable
  - Follow-on work with multiple additional & redundant nuclear detectors
- Mechanisms for collaborating with our team
  - U.S. government:
    - Replication studies by interested labs
  - Non-government entities:
    - Navy Cooperative R&D Agreement (CRADA)
- POC:

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