

<http://www.pprc.net/main.htm> (retrieved 4/21/2008)

NUCLEAR FUSION AT AMBIENT TEMPERATURE NOW A REALITY

Abstract

Experiments conducted by Particle Physics Research Company (PPRC), a Los Angeles based company, have conclusively demonstrated low-temperature fusion is achievable, replicable, and sustainable over many hours. This has been accomplished by inducing specific non-equilibrium conditions in partially-deuterided metals using very low input energies in the form of dc currents. In addition to fast-neutron emissions, experiments record energy yields comprising 3-MeV protons and 1-MeV tritons, considered prima facie evidence that fusion is taking place. These results have been recorded over a seven-year period using three types of highly-reliable sensitive detectors. Charged particle emissions have been detected exceeding 400 times background rates. Repeatability of charged particle approaches 80% overall and is expected to reach higher reproducibility when manufactured metal samples (e.g. titanium) have more closely similar properties. PPRC is therefore confident it has invented a validatable trigger for initiating nuclear fusion such that greatly increased yields for commercial applications will ensue. Descriptions of fusion interactions are included below with reaction equations. As a result of the International Conference on Cold Fusion (ICCF-10) held in Boston during October 2003, the technical procedures received wide peer review and acceptance. The two papers can be obtained using the instructions on the last page.

Though arduous developments lie ahead, the ultimate goals for low temperature fusion energy are to

- Reduce the dependence on diminishing oil reserves, particularly during rising energy demands.
- Diminish the need for internal combustion engines of all types, including auto, aircraft and space.
- Reduce atmospheric pollution and enhance the balance of global greenhouse effects.

PPRC feels these can be accomplished by year-end 2007

Introduction

In 1996, while conducting research in an entirely independent area of theoretical physics, Frank Keeney became aware of what appeared a heretofore overlooked electromagnetic field attribute of sub-atomic particles. Further study showed promise of potential energy innovations. By 1997, having been advised the findings might relate to fusion energy, he began experiments in a rudimentary laboratory in Los Angeles, encouraged in achieving low-yield neutron emissions. Later, learning of Keeney's results, Steven Jones, Professor of Physics at Brigham Young University, expressed a willingness to assist using the university's sophisticated neutron and charged-particle detectors located in two underground laboratories. Keeney designed a more promising cell and arranged a contract for Jones to conduct the first experiments in a tunnel lab located near the campus, see Figures 1a and 1b.



Fig. 1a. Jones and Keeney at tunnel lab located in Provo Canyon, Utah. Fig. 1b. Keeney and Jones with first experiment in tunnel lab.

The tunnel lab had a heavy rock overburden to shield background radiations. (Keeney is shown pointing to his first cell in the picture at the right.) The first two experiments, using the same cell, comprised three deuterated copper wires in parallel and the application of a dc current. Since new theory was being tested at this point, yields were as expected, a few neutron counts/hour above background. However, both experiments were successful, uniquely achieving repeatability on the first runs. Other professionals were brought in, allowing innovative metal processing introduced by Consulting Engineer Charles Johnson and computer technology innovations provided by Consulting Engineer David Buehler. Continued results were sufficiently compelling that PPRC solicited investors and raised nearly a million dollars to sustain the research and develop further innovative processes.

After seven years of intensive experiments, PPRC became the first to conclusively demonstrate fusion energy is producible, repeatable, and sustainable over many hours at low (ambient) temperatures and low input energies. Patent applications were applied for in the United States and several other major industrial countries. Foreign international patent applications were filed under the Patent Cooperation Treaty.

The company made its first public disclosure of its fusion yields during three presentations at an American Physical Society's Conference held in Salt Lake City on 5 October 2002. PPRC's two papers are now being published in *World Scientific* and have been submitted to a physics journal, awaiting publication. As with all serious investigators of fusion as an alternate energy, chief among the anticipated applications are reducing the need for internal-combustion engines (ground vehicles, aircraft, and spacecraft), airport and building security devices, medical and many other commercial applications, including independent megawatt power supplies and eventually power plants. With sufficient technical support from other laboratories, it is anticipated this can be accomplished by year-end 2007; this because only low-temperature physics and small input energies are involved. However, because much higher yields are required, new procedures, now proprietary, differ greatly from those detailed below. For example, several designs for the company's first prototype engine are already in place.

The Experiments

Neutron Yields. During neutron emission experiments, advantage was taken of a highly sensitive detector designed by Dr. Howard Menlove at the Los Alamos National Laboratory, later granted to BYU. The detector and electronics are shown in Figures 2a and 2b.

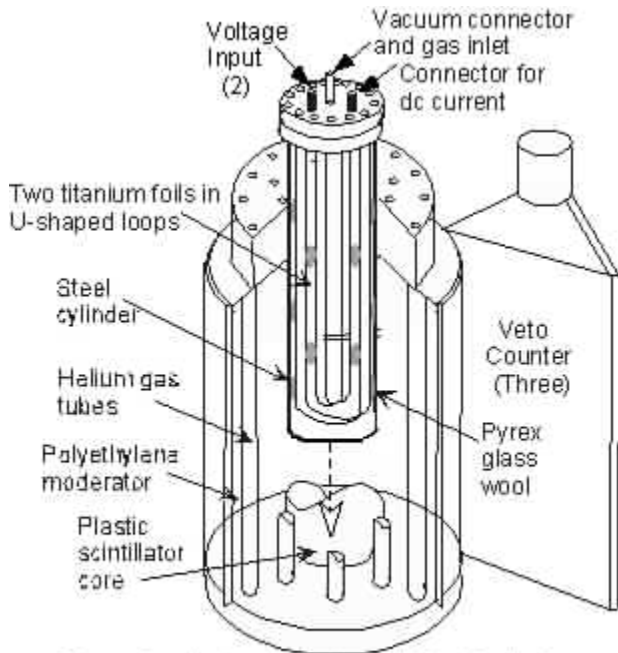


Figure 2a. Neutron Detector with Test Cylinder (enlarged) with Foil Inserted.

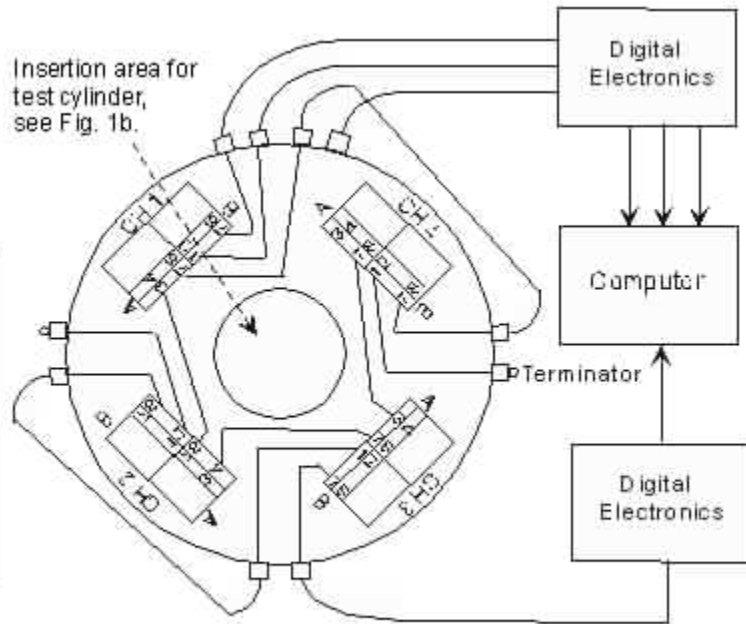


Figure 2b. Top view of neutron detector with 15 helium-3 filled proportional counters in two separate rings.

These experiments involved the hydrogen isotope deuterium, the gas embedded in titanium foils. Neutron yields were evidenced over many hours. Background readings were subtracted from recorded data to ensure accurate yields and correct analysis of statistical significances. These first energetic particle experiments successfully detected neutrons using pre-processed and partially-deuterated metals (both copper and titanium) subjected to the innovative non-equilibrium conditions. Control experiments were performed to ensure no emissions were evidenced under the same conditions when using non-deuterated foils. The specific physics of the fusion reactions are



(d deuteron, n neutron, 1 MeV = one million electron volts.)

To obtain the detailed paper *Neutron Emissions from Deuterated Metals*, see end of document.

Charged Particle Yields. The second experiments are considered important because they produced the highest yields. They also involved condensed matter in the form of small titanium

foils under the same conditions, but using a photo-multiplier tube (PMT) detector and associated electronics to record charged-particle (proton) emissions in the 3 MeV range. The physical setup is shown in Figure 3.

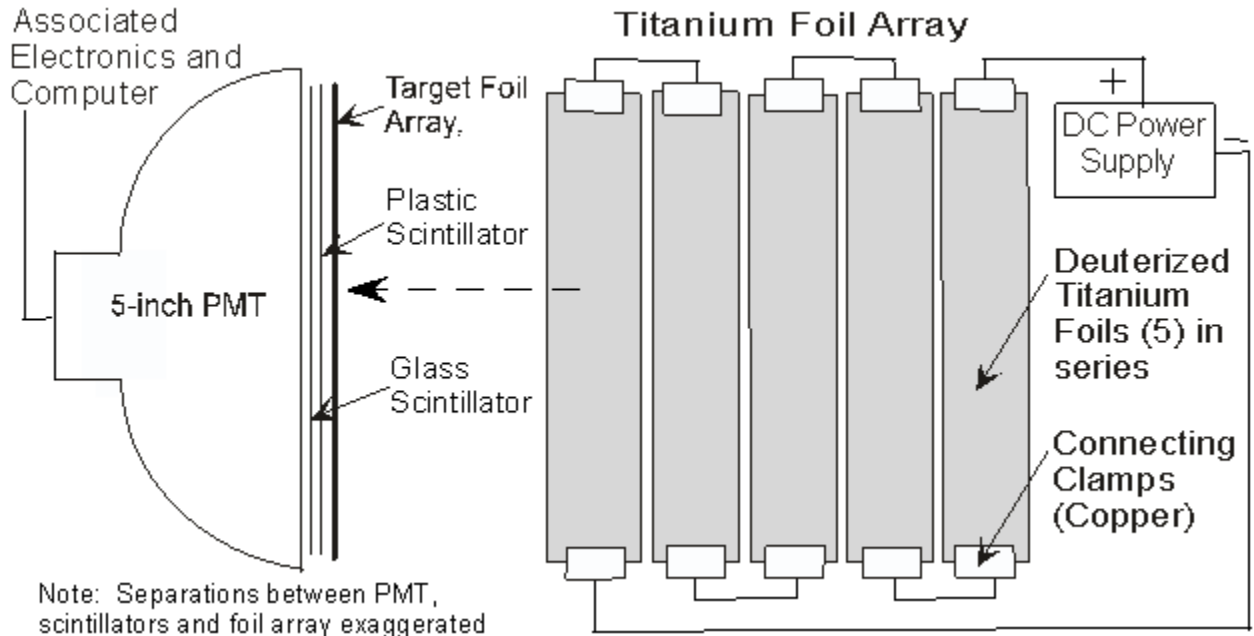


Figure 3. Foil Array and Charged Particle Spectrometer System

This charged-particle spectrometer incorporated a 0.0078 gm/cm^2 (76- μm) thick plastic scintillator adhered onto a thicker glass scintillator (0.375 gm/cm^2) which was glued onto the face of a 12.7-cm diameter PMT. The detector was housed in a light-tight box equipped with electrical feed-throughs. PMT pulses were digitized at 100 MHz over a 160 μs window. Pulse-shape analysis allowed us to distinguish narrow plastic pulses from glass pulses which are broader in time. When a particle passed through the plastic into the glass, the resulting combined pulse was broad and therefore interpreted as a glass pulse. The integrated area under the pulse reflects the light output of the scintillator(s) which corresponds to the energy of the incident charged particle. The plastic scintillator has a non-linear response in that the light output depends on particle energy and identity.

The composite spectrometer is also an effective cosmic-ray veto counter. Nearly all cosmic rays entering the plastic scintillator must also pass through the glass scintillator, producing a characteristic broad (glass-like) pulse seen by the PMT. Cosmic ray pulses were therefore identified and efficiently eliminated. This dual-scintillator counter is a novel detector having the advantage of achieving large-area charged-particle detection conveniently.

Background readings were subtracted from recorded data as described for the neutron experiments. Highest proton yield was 2170 counts/hour, but could be much higher by connecting more PMTs in series. Control experiments were also performed as noted above. The titanium foils were of small area, about 1x5 inches each and .025 mm thick, assembled in five-foil arrays.

It was found that the emissions were nearly 80% reproducible, sufficient to be verified by other physicists or laboratories having available to them a similar PMT detector and using PPRC's technology delineated in the referenced paper. The company is continually focusing on updating these processes to increase fusion output yields, repeatability, and maintaining input energy at low levels for enhancing efficiency.

Dual-Coincidence Emissions. The third experiments we consider perhaps the more significant for it was not their purpose to produce higher yields, but to identify the emitted particles and their energies during fusion. These experiments were recommended by physicists visiting our laboratory who suggested we verify emissions were exhibiting specific particles (protons and tritons), and simultaneously emitting such that their actual energies could be recorded. It was felt this would be more acceptable to the scientific community than emissions of light using the PMT. The physical setup is shown in Figure 4.

ative processes to increase fusion output yields while maintaining input energy at low levels.

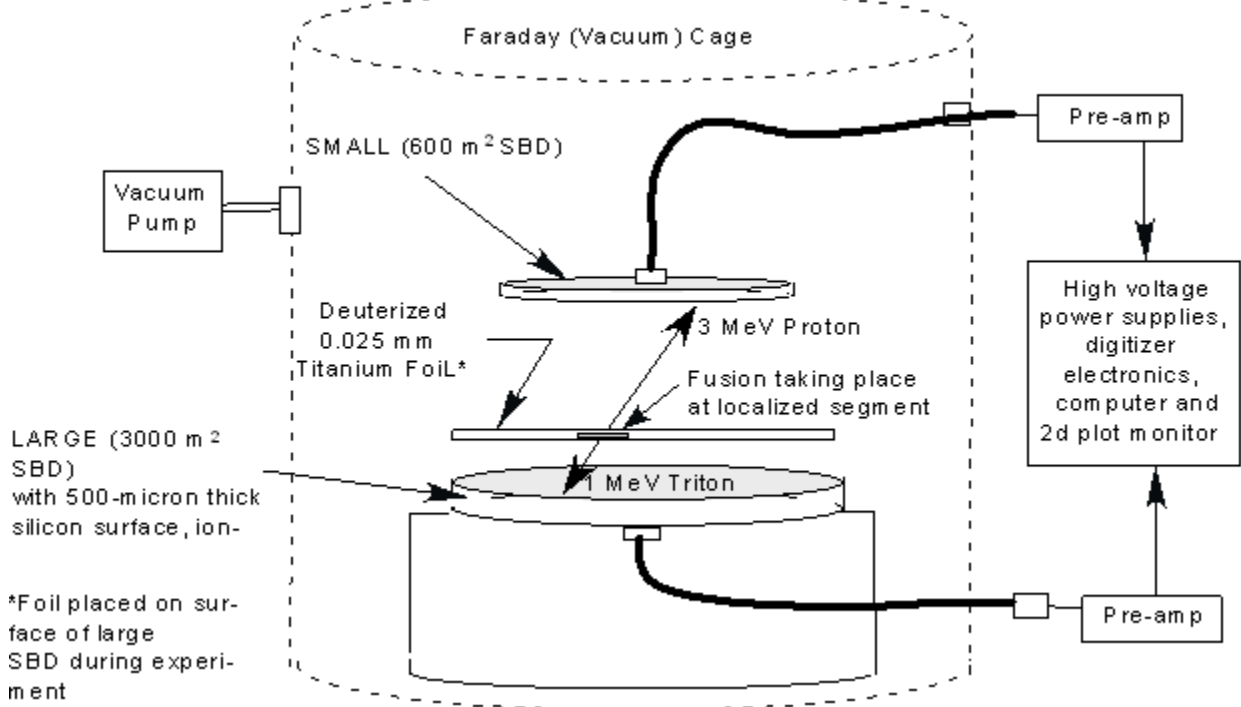


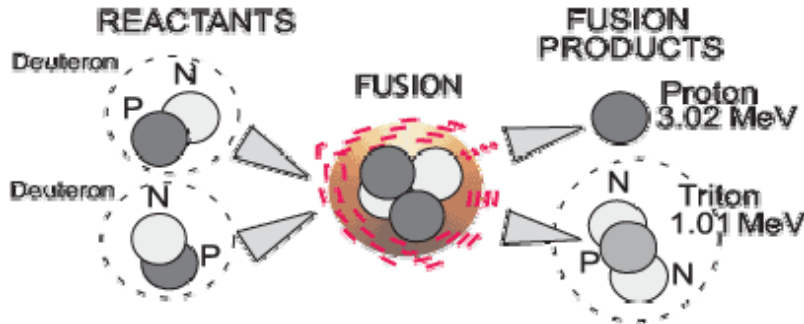
Figure 4. Coincident Proton/Triton Fusion Evidenced Using Two Ion-implanted

Surface Barrier Detectors. Not shown, foil placed on O-ring of lower detector.

In this reaction the low-temperature fusion process may include nucleon transfer reactions as



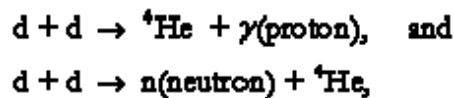
(p proton, t triton) where a neutron is transferred from one deuteron to the other, but without necessarily forming an intermediate excited helium-4 nucleus. The fusion processes in this invention begin and end at low temperatures. By this is meant that the reactants initially have kinetic energies less than 500 eV. These can be illustrated schematically as



Two deuteron particles, each having one proton and one neutron, fuse to produce a charged proton and a charged triton (the latter having one proton and two neutrons).

These experiments involved silicon ion-implanted detectors (I-ID). In this arrangement, actual particle energies were recorded, e.g., protons near 3-MeV where one electron volt is energy equivalent to only 1.6×10^{-19} Joule. Also recorded were tritons near 1-MeV energy levels, the levels according to their depths in the foil. The experiments were successful on the first attempt and are highly repeatable, close to 80%.

Since the above are so easily repeated (reproduced), we continue to analyze the reaction and the data to enhance understanding of this new technology. At this date the results are also being published in *World Scientific* and have also been submitted to a physics journal. This fusion trigger is now sufficiently reproducible and of statistical significance to be considered successful. The $d + d$ reaction noted above is not the only effective fusion reaction, for example there are



and numerous other interactions which are well documented, their reaction equations and descriptions too numerous to include here.

To obtain the detailed paper *Charged Particle Emissions from Deuterated Metals*, see end of document.

Verification

In August of 2000, prominent physicists, Dr. Graham Hubler from the U.S. Naval Research Laboratory and Dr. Peter Hagelstein from the Massachusetts Institute of Technology, were invited to review the experiments and results in our two underground laboratories. These physicists were chosen because of their considerable expertise in theoretical and experimental fusion research. They expressed confidence that fusion at ambient temperature had indeed been achieved. Because the charged-particle emissions using photo-multiplier tubes did not directly identify or record specific particle energies, it was they who recommended the experiment illustrated in Fig. 4.

In order to ensure validation, the company has published the procedures for the purpose of allowing the scientific community to read firsthand – and to read first, prior to media announcements. It is anticipated that the procedures will be subjected to strict review by referees, peers knowledgeable in the field, giving the papers rigorous but fair appraisal. This will provide a welcomed opportunity for national laboratories, private laboratories, universities and corporations interested in alternate energy to validate the results and contribute to enhancing energy yields. The review of this work, at the International Conference on Cold Fusion (ICCF-10), held in October 2003, was published in the conference proceedings, followed by a peer-review conducted by the Department of Energy in August 2004. Both reviews greatly enhanced the credibility of the work. A published review by the Department of Energy is also anticipated.

Objectives and Benefits

Many scientists justifiably hold the view that only when atomic particle outputs are confidently replicable can the devices producing fusion energy outputs be successfully engineered for commercial uses. It is therefore among the chief objectives of these inventions to reveal and exploit the nature of the atomic, nuclear, and metallurgical phenomena developed as described above. Consistent replicable and efficient results at varied power input levels are required to ensure returns-on-investments. Chief among these is to produce a non-fossil fueled prototype

engine by year-end 2007.

As noted, deuterium is plentiful in seawater, fresh water, ice, even snow. The deuterium form of hydrogen is available in a ratio one out of every 7000 hydrogen atoms, and is easy to separate from saltwater. Thus it is a *renewable alternate energy source*. *Of great significance, fusion of atomic particles and/or light nuclei produce more energy for a given amount of material than virtually any other known energy source. It has been reported that one cubic mile of seawater, utilized efficiently, could produce as much energy from deuterium as all the world's oil reserves combined.*

Development is underway to produce useful engines of all types. It has been estimated that because of its potential efficiency, *the content in one liter of deuterium could provide 500 liters of petrol*. In addition, (over a longer time period), multi-watt power supplies and plants of mega-megawatt outputs of great efficiency could be constructed so that non-radioactive commercial power can be generated more cheaply and in more localized areas, *diminishing the requirements for vast power grids*. For example, it is estimated that a power plant producing 1500 megawatts would use only about 400 grams of deuterium and about 600 grams of tritium per day. Once achieved, this would obviate the great concern for diminishing oil reserves worldwide, of particular significance to countries having little or no oil resources of their own, the major importers being the U.S., China and Japan in that order. There is also the issue of promoting clean atmospheric conditions and the serious need of improving the balance of earth's greenhouse effects. In addition to the aforementioned applications, certain fusion energy devices will permit an extraordinary list of other practical applications. It is difficult to ascertain the incredible commercial, aerospace, military, social, economic and political effects that production of fusion energy will have from such readily available and inexpensive deuterium resources.

Urgency for Fusion as an Alternate Energy Source

It is well established that most of mankind's energy resources, oil, coal, natural gas, hydro-electric, even nuclear resources, exist in limited supply. Further, most produce a relatively small quantity of energy per unit of given source and raise serious environmental concerns. Because earth's population and energy demands continue to

climb dramatically, and oil reserves are rapidly diminishing, researchers have been vigorously seeking more plentiful, efficient, and environmentally friendly energy sources. Solar power, wind tunnels and other innovations will provide interim power in segmented areas but lack sufficient energy outputs for national and worldwide use.

This has led researchers to consider thermonuclear fusion, the process occurring in the sun, termed "hot fusion", using plasma-type approaches striving to reach extraordinary temperatures within highly confined volumes. However, it has understandably proven discouraging for many highly-competent scientists that producing, controlling, and sustaining fusion reactions in this

manner have proven highly elusive. Although billions of dollars have been invested over many decades of research, to date these efforts have not been sufficiently successful in output/input efficiency to render confidence. Though some intermediate successes have been achieved, some at the international level, the extreme conditions present enormous technological challenges and large energy inputs, demanding in turn extraordinary financial investments. Lack of success and financing have forced many skilled scientists and engineers to reduce or abandon hot fusion research. However, it is anticipated that the experimental results evidenced from fusing of deuterium nuclei at low temperatures as described herein will renew optimism and help to direct attention to the physical phenomena involved.

Advantages and Marketplace

So great is the need for an efficient and inexpensive alternative energy source to replace the world's rapidly diminishing oil reserves that every major laboratory in the U.S., including our government, military, and those in foreign countries, are spending vast sums to develop nuclear fusion energy to replace fossil fuels. PPRC plans, and has designs in place, to take advantage of its present fusion technology to develop a hydrogen-isotope engine prototype for production by manufacturers near year-end 2007. The company therefore considers a most serious and paramount responsibility is to publish and exploit with other laboratories and corporations the innovative processes developed by its inventors.

Because vast supplies of deuterium are available from seawater, and since expensive shipping among nations will be greatly lessened, it is anticipated with confidence these two factors alone will help reduce the great concerns for diminishing oil reserves. There is little doubt on the need to replace fossil-fueled internal combustion engines. The vast potential return-on-investment becomes readily apparent considering the annual market value of fusion-generated engines alone will be many billions of dollars. For example, the present U.S. gross income from internal combustion engines is 2.7 billion and worldwide in excess of 252 billion. This company is therefore aggressively developing advanced designs for greater yields and enhanced efficiencies towards prototype engines.

Joint development and Licensing

The company feels that joint development should be on a basis allowing free ingenuity and collaboration in research and development among participating laboratories and other companies seeking renewable alternate energy resources. PPRC is willing to negotiate its new technology and cooperate in developing all types of commercial and industrial applications, both in the U.S. and abroad. Licensing will also play an important role.

Parties interested in cooperative development, laboratory validation or investment are invited to contact us using the information found at the end of this website.

Acknowledgement

We have many respected physicists acting in experimental, consulting and advisory capacities, most of which are mentioned above. Dr. Ed Cecil of the Colorado School of Mines, a pioneer in fusion research, has also given helpful advice. Dr. Thomas Taylor and Dr. Malcolm Fowler, both associated with the Los Alamos National Laboratory, have witnessed a successful I-ID experiment at our laboratory and will soon be initiating validation of our results. All those mentioned have many years experience in energy research, and have contributed greatly to our progress. In addition, they have added considerable credibility to our work and increased the likelihood of our results being accepted and validated by other professionals among the scientific community. To them we express great appreciation.

For Copies of Technical Papers

The latest updated versions of the two technical papers can be obtained by contacting Frank Keeney at fwk@pprc.net. The titles of these two papers are

Neutron Emissions from Deuterated Metals

Charged Particle Emissions from Deuterated Metals

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