**U.S. DEPARTMENT OF ENERGY**
**NUCLEAR ENERGY RESEARCH INITIATIVE**
**ABSTRACT**

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**PI: John A. Becker** **Proposal No.: 2000-123**

**Institution: Lawrence Livermore National Laboratory**

**Collaborators: Los Alamos National Laboratory**

**Title: Isomer Research: Energy Release Validation, Production and Applications**

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The goal of this applied nuclear isomer research program is the search for, discovery of, and practical application of a new type of high energy density material (HEDM). Nuclear isomers could yield an energy source with a specific energy as much as a hundred thousand times as great as that of chemical fuels. There would be enormous payoffs to the Department of Energy and the country as a whole if such energy sources could be identified and applied to a range of civilian applications.

Despite the potential payoff, efforts in applied isomer research have been rather limited and sporadic. There has been basic research on nuclear isomers since their discovery in 1935 with an occasional hint to tantalize interest in HEDM. In most cases, these hints were refuted by careful examination by other groups.

We believe it is time for the Department of Energy to re-examine its strategy in this area. The potential payoffs are large enough to warrant inclusion of applied nuclear isomer research in the U.S. portfolio of high-risk, high-payoff activities. Our proposal below details a strategy for such a program. It is in direct response to a call for the fundamental science studying nuclear isomers that could be beneficial for civilian application by DOE/NE (LAB-NE-2000-1). There are several key elements of this strategy which we propose for the Department's consideration.

1. Every effort should be made to leverage the strengths in nuclear physics that exist at the DOE National Laboratories. Appropriate collaborations with University groups should be encouraged.

2. A solid base of knowledge about and experimental capabilities in nuclear isomers must be established and maintained. In the current environment, there is a tendency to spend limited resources to refute spurious experimental results. A coordinated program of basic experiments and theory is needed to establish the knowledge base required for civilian applications.

3. While the long-term goal includes amassing significant quantities of any new energy source, the Department should not proceed with such production activities until and unless there is compelling, proven scientific evidence that such a source exists.

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4. The Department needs an independent, expert isomer evaluation capability so that claims of discovery can be checked quickly with the highest precision warranted and policy decision makers are fully and accurately informed.

We believe that the needs of the country can be best met by collaboration among the National Laboratories specializing in nuclear physics research. That collaboration would initially involve Lawrence Livermore National Laboratory and Los Alamos National Laboratory. We propose to form the equivalent of a Virtual National Laboratory on applied nuclear isomer research. The scientific direction of this program will be controlled by the LLNL and LANL co-PIs while LLNL will serve as the administrative lead laboratory for this effort. The collaboration includes nuclear physicists, radiochemists, and atomic physicists with access to unique resources, and it would hopefully become a major element in the Department's arsenal as it attempts to understand the place of applied nuclear isomer research in its overall R&D portfolio. We would expect to also serve as the advocate for appropriate collaborative research from both the University Community, other National Laboratories and from Industry.

The isomer research area is rich with possibilities: we have prioritized several areas likely to be the most rewarding and fruitful for initial experimental and theoretical investigation because these areas directly bear on important issues: can the energy stored in nuclear isomers be released on demand? Is the size of the atomic-nuclear mixing matrix element large enough to be useful? Can we initiate quantal collective release of isomeric energy from a crystal? What is the precise energy of the 3.5 eV level in $^{229m}$Th?

The specific target experiments are:

- X-ray induced decay of $^{178m2}$Hf with a sensitivity $10^5$ times recent work
- NEET: A measurement of the atomic-nuclear mixing matrix element in $^{189}$Os
- Superradiance in $^{93m}$Nb
- TEEN: Nuclear isomer energy release in $^{178m2}$Hf
- Energy and lifetime of the $^{229m}$Th isomeric level at 3.5 eV