Los Alamos National Laboratory

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Addendum To LA-UR 92-1467:

The Relevance of the Los Alamos Meson Physics Facility (LAMPF) to National Goals

A White Paper

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URGENT CONCERNS

The immediate concern is to maintain LAMPF/LANSCE operations and the service the LAMPF/LANSCE community provides to the Nation's science and technology enterprise. The participation and support of this community in developing the case for an advanced spallation neutron source, LANSCE II, and cultivating a similar community of users for LANSCE II is essential. It will take from six to eight years to design and construct the LANSCE II facility. It is essential to maintain a sensible level of research activity at LAMPF/LANSCE during this period.

The goodwill and participation of the LAMPF nuclear science user community has been built up over a period of more than two decades and must be maintained. Once lost this would be irreplaceable. The loss of momentum in research activity would be difficult to recover. The loss of students in the pipeline would be tragic.

The participation of the LAMPF operations staff is essential in accomplishing the transition from LAMPF operations to LANSCE II design to LANSCE II operations. To achieve the above requires a continuing level of activity at least as high as that of FY92.

The additional Department of Defense funding voted by Congress for LAMPF operations and research should be made available as soon as possible. The cost is modest, but the message of determination this action would send to the relevant scientific communities is powerful.

The needs of the Nation's scientific and technological communities would best be served by maintaining LAMPF as a multidisciplinary facility. Care should be exercised not to prejudice the operation of the primary function of such a facility as a neutron source used for condensed matter neutron-scattering studies. Neither should other useful components of a multidisciplinary facility be sacrificed.

INTRODUCTION AND SUMMARY

A number of highly relevant events have occurred since the release in April 1992 of the white paper *The Relevance of the Los Alamos Meson Physics Facility (LAMPF) to National Goals*. These events reinforce the conclusions of that report, which identified three ways in which LAMPF serves the Nation:

•*LAMPF is a unique facility that addresses a wide range of national and technical goals.*

•*LAMPF makes strong contributions to the Nation's science and technology base and to the education and training of its scientists and engineers.*

•*LAMPF provides important benefits to all LANL programs.*

The new events that give even more urgency to these conclusions are: (1) emphasis by Congress the DOE and Laboratory management on the application of LAMPF as the injector for an advanced spallation neutron source, LANSCEII, (2) the new Energy Bill, (3) strong letters from prominent scientists supporting the continued operation of LAMPF and its major programs, (4) a moratorium on nuclear testing, (5) the apparent DOE decision not to provide support toward the construction of a new intermediate energy physics facility in Canada, and (6) a national commitment to supply medical isotopes reliably. In this addendum we discuss the effect that these events have on the earlier conclusions of the white paper. We find, in summary:

•*The broadening and enhancement of the neutron-scattering program by the construction of an advanced spallation neutron source based on the existing LAMPF beam should have highest priority.*

•*The coalescence of scientific opportunities in the materials, biological, and nuclear sciences provided by a balanced use of LAMPF should be pursued vigorously with the purpose of establishing the LAMPF/LANSCE facility as a national center of scientific and engineering excellence.*

NEW CONSIDERATIONS

LAMPF Applications

The emphasis on LAMPF applications, especially the utilization of LAMPF to drive a world-class neutron source for use in the condensed-matter and biological sciences, has apparently struck a responsive chord with the DOE and Congress. Putting this use in top priority with all other uses being secondary would maximize the LAMPF contributions that directly impact industrial competitiveness (See Appendix A of the original White Paper for a list of Industrial Laboratories and Hospitals represented at LAMPF). The application of LAMPF as the injector for an advanced spallation neutron source requires that scientific and technical activity be continued during the transition, or the capability to

maintain and operate the accelerator will be lost along with much valuable research and training.

LAMPF is an ideal driver for a system of time-compression rings that would provide a megawatt or more source of pulsed neutrons produced by spallation reactions. LAMPF produces more than enough protons to drive such a neutron source. A spallation source based on the existing LAMPF beam could be built and operated for a fraction of the cost of a comparable new facility. A spallation source is safe and environmentally benign. The amount of radioactive material resulting from neutron production would be similar to that now produced in the LAMPF beam stop. In the long run, a spallation source is desirable because the waste energy per neutron is one tenth that produced for a fission neutron; hence, more neutrons can be produced in the required small volume in a spallation source such as LANSCE II. Such a facility located at Los Alamos would make the Laboratory an international center for materials science, condensed-matter physics, and structural biology. It would attract a user community to LANL even larger than the existing LAMPF/LANSCE community of about a thousand. It would focus on areas of science perceived to be of paramount importance to the Nation and the Laboratory for the next two decades.

Energy Bill

Congress has passed an Energy Bill that acknowledges that nuclear energy is an important option for the U. S. It seems likely that no matter what course the U. S. follows, significant parts of the world will increase their reliance on nuclear energy. For the sake of our physical safety, as well as our economic security, it behooves the U. S. to play a leading role in assuring that the nuclear energy enterprise is conducted safely and responsibly, worldwide. For this, the U. S. needs continuity of competence in nuclear science, a high level of accomplishment in nuclear technology, and a meaningful commitment to the education and training of nuclear technologists. The past contributions of LAMPF to these arenas are second to none. They should continue.

Accelerator Transmutation of Waste (ATW)

This subject was addressed in the main white paper, but its importance and relationship to LAMPF/LANSCE requires reiteration.

Of great concern in the use of nuclear power is the disposal, in an environmentally benign manner, of the spent fuel products. The long-lived actinide and fission-product isotopes present a difficult long term storage problem. A very attractive way to overcome this problem would be to transmute the long-lived radioactive isotopes into more benign species. LAMPF offers great potential as a prototype for the study of the ATW concept. An upgraded high-energy LAMPF linear accelerator can be used to produce copious amounts of neutrons (A 1-milliamp 800-MeV proton beam impinging on a heavy-element converter will produce about 2×10^{17} neutrons per second). If chemically separated reactor waste is placed in such a high neutron flux, the neutrons will transmute these undesirable isotopes. This is the ATW approach to the problem of long-lived high-level waste. The obvious attraction of ATW is that neutrons would only be delivered when

desired, and the production of neutrons could be quickly and safely stopped by shutting down the accelerator. Detailed studies of ATW have been carried out and the general approach appears feasible. This concept was developed at Los Alamos and will use LAMPF/LANSCE II for crucial tests to demonstrate the technical feasibility.

Medical Uses

Approximately 10% of all medical diagnostic procedures require the use of radioisotopes. The represents some 10 Million procedures per year at a U.S. sales volume of $200M for radioisotopes. In addition to the commercial medical radioisotopes (which are dominated by the non U.S. supplied 99Mo/99mTc) there is a rapidly growing medical research effort to develop new, tailored radio pharmaceuticals for diagnostic and therapeutic applications.

As detailed in the original White Paper, LAMPF provides a significant portion of these emerging radioisotopes. The extensive existing infrastructure at Los Alamos is capable of the required chemical processing and shipment of the isotopes to the medical community. The upgraded LAMPF/LANSCE II facility will operate with high reliability at least nine months of the year in order to satisfy the needs of the neutron scattering program. This operating schedule would greatly enhance the effectiveness of isotope production and could provide a cost-effective manner of satisfying a significant portion of the Nation's medical research isotope requirements.

National Defense

The post-cold-war world will result in major changes in the operation of the nuclear weapons community. U.S. policy is to phase out nuclear testing, using the remaining proposed 15 tests for safety and reliability verification of our nuclear arsenal. Innovative techniques will have to be developed that will permit addressing nuclear-weapons physics issues involved in a non-testing environment.

LAMPF maintains a continuing commitment to apply it's unique capabilities to National defense. Previous defense-related contributions have included: neutron cross section determinations of non stable species, particle-induced electronic vulnerability and lethality studies in military systems and measurements of the neutron spectrum produced by proton-irradiation of weapons components. Applications such as these will be continued and expanded with future studies that would make use of the unique combination of fast burst pulses and high particle fluence available that are available now and will be enhanced at the LANSCEII facility. For example, studies show that as many as 5×10^{15} neutrons can be produced in sub microsecond pulses. These fluences are sufficient to simulate effects introduced in weapon environments. Monte Carlo simulations suggest that anomalies and asymmetries in very dense structures can be probed with high energy proton beams that are available at LAMPF.

There has always been a strong relationship between LAMPF and defense programs. With reduced reliance on nuclear testing, this relationship will become even more

important as we continue our stewardship of safe, credible, and reliable weapons systems for the Nations defense.

Continuation of Nuclear Physics Programs at LAMPF

Many prominent scientists familiar with the contributions of LAMPF to nuclear physics and to the nuclear physics community urge strongly that the LAMPF facility be continued. The following citations support this position:

From Professor Hans A. Bethe, Nobel Laureate, to Senator Domenici (24 July 1992):

... My main interest is nuclear and particle physics, in which LAMPF has been a leader. They have done outstanding work on studying the properties and action of pions, the most important particles holding the nucleus together. They are uniquely qualified for the study of the elusive neutrino. Recently they have shown that the weak force shows up surprisingly strongly in certain states of complex nuclei by violation of parity, giving new insight into nuclear structure, ...

... An important part of LAMPF is LANSCE, a very intense pulsed neutron source driven by the LAMPF beam. Neutrons are powerful tools in exploring the structure of materials, ...

... Los Alamos is widely recognized as a national treasure. Nuclear weapons, until now the central responsibility of Los Alamos, are declining in importance, a development that we greatly welcome. But the difficult transition for Los Alamos to peaceful products should not be made more difficult by closing down its important research laboratory, LAMPF.

From Professor Edward Teller to Senator Domenici (23 July 1992):

... In my field, which is pure and applied science, I see continuing accomplishments in many places of excellence in our country, but there are only few organizations where pure science and applied science interact strongly and productively. One of these is Los Alamos, and the LAMPF facility is one of the links between these two endeavors....

... In connection with pure science, LAMPF has produced a world record in the number of available particles of well-defined property which carry the name Neutrinos. Neutrinos play a great role in the clarification and understanding of the next problems that physics is facing.... By measuring the properties of the neutrinos, LAMPF has contributed to one of the most interesting problems of astrophysics....

... For machines of this kind [the Superconducting Supercollider]*we will have to wait many years. In the meantime, LAMPF plays an important role in moving science forward in helping to educate scientists and to give information why and how to construct the ever more expensive high energy machines....*

From Sir Denys Wilkinson, F.R.S., to Louis Rosen (25 November 1992):

... it seems little short of farcical that the very existence of one of the world's premier scientific facilities should be threatened by the requirement to make a marginal budgetary saving; that, surely, cannot be the right way to manage science.

From Sir Denys Wilkinson, F.R.S., to Siegfried Hecker (30 November 1992):

... I know a lot about LAMPF at first hand and as a member of the international community of scientists working in the relevant field(s).... There is just one point from my earlier letter [to Louis Rosen, passed along to Siegfried Hecker] *that, before I begin, I feel that I should now re-emphasize: that is the unique place that LAMPF occupies in the US programme in respect of nuclear and particle physics; it is the bridge: it is the only place in the US that, on a regular and routine basis, brings together experts in both the nuclear and particle fields. Those fields have historically tended to drift apart from their common origins. Yet, if we are to aspire to a uniform and internally consistent understanding of nuclear Nature from quarks to the heaviest elements we must preserve some forum within which all the relevant considerations can be brought together and within which we may attempt to weave the seamless robe. That, and nowhere else within the US, is LAMPF; there is literally nowhere else where, within a single institution and research community, such overlapping nuclear and particle expertise is to be found or will be found....*

LAMPF is a truly priceless asset, still unique in many respects, and furthermore, capable of very significant development and extension in many ways, should that be desired.... To terminate LAMPF's nuclear work at such a stage of high productivity and high promise would be greeted by the international community with blank incredulity and regarded as an act of intellectual vandalism without precedent.

OPPORTUNITIES

Effective use of National Resources

It is a natural and effective use of national resources to build the new LANSCE II facility utilizing the existing LAMPF/LANSCE infrastructure. Not only is the requisite accelerator technology in place at Los Alamos, but the experience in target design as well as the technical and scientific backup are present. Moreover, the intense neutron flux generated by such a source would enhance further crucial investigations of the Los Alamos initiative to transmute radioactive waste (ATW).

The Laboratory finds itself with a fortunate opportunity to direct the experience developed with LAMPF/LANSCE toward a greatly enhanced research mission in the future. While LANL should press ahead with the development of the new spallation source, two corollary pursuits should be kept in view: First, the new facility will develop unprecedented large fluxes of muons and neutrinos around which can be built a world-class program of pure and applied research without detracting from the primary neutron

application; second, during the transition period of approximately six years that it will take to design and build the new facility, it is imperative to maintain a sensible level of technical and scientific activity. LAMPF provides a test bed to solve the technical problems involved in the design of LANSCEII and there are unique scientific opportunities to be exploited with the investments already made at LAMPF.

Integration and Development of the User Community

The Laboratory brings together three communities of scientists—nuclear, condensed matter, and biological, all of whom have a common interest in the continuing development of the LAMPF/LANSCE relationship.

There is a synergism that occurs for these disciplines because all must solve many new technical problems in order to succeed. For example, magnetic resonance imaging (MRI) for medical diagnosis came from many areas of research. Resonance of nuclei began with particle beam work. The extension to solids from beams was obvious and today is a powerful tool for chemistry. Imaging required first that advanced computers be available for the computations, and this opportunity was first applied to medical work using x-rays (CAT scans). Large superconducting magnets are claimed by both accelerator and materials scientists as originating in their disciplines, but no matter their source, they led to MRI, which is much safer and more accurate than x-ray imaging. All of this history is sprinkled with Nobel Prizes, and the lesson is the same old refrain that fundamental research can be and is useful. The superconducting magnets may soon be replaced by permanent magnets, and again both accelerator and materials people will want credit for this improvement, whose end product, of course, serves biology.

The Laboratory has a proud history of accomplishments of the best people working together to achieve goals. A great deal needs to be done in bringing about user groups in the materials and biological sciences that integrate with the nuclear physics user group in a way that achieves mutual goals. Every effort must be made to put in place an atmosphere conducive to defining and acquiring objectives in this new multidisciplinary domain.

The lines between nuclear physics and the disciplines of biology and materials need not be drawn so sharply as they are for funding purposes at the DOE. The accelerators for all of these disciplines are mostly the same, and the cost of keeping the doors open at LAMPF includes many technical people who are independent of the final experiments. This talent will be lost if a shutdown of even a one or two years occurs.

An integrated community of scientists and engineers working toward common goals in the multidisciplinary arena of nuclear physics and chemistry, accelerator technology, materials science, and biology is attainable at LANL and is consistent with its past experience and its commitment to good management. The excitement of challenges such as this is what drives science and technology of the highest quality.

REALIZATION OF LANSCE II

The scale, time and nature of neutron scattering experiments is different from that of the nuclear science experiments that have been the core of the LAMPF research program. Neutron scattering experiments take less time and tend to use an existing spectrometer system. Thus, a large number of neutron scattering experiments would be conducted at each spectrometer facility each year. These aspects of the neutron scattering program will require that LANSCE II operate a larger fraction of the year with greater reliability than has been the case with LANSCE.

The operation of LANSCE II would use 60 of the 120 pulses per second available from LAMPF. The increased running time and beam reliability would improve the cost effectiveness of the LAMPF nuclear science, atomic physics, radiation damage, and medical isotope production.

The new spallation source now under consideration at Los Alamos is specified to use 1 megawatt of beam power,. This will require modest improvement to the existing accelerator. The accelerator and the storage ring will provide an increase in beam power to 1 megawatt, a factor of 15 times the present operation. Should a superconducting linear accelerator prove necessary, such can be accommodated in the existing tunnel.

The great advantage of an accelerator-based neutron source is the pulsed time structure it provides to the neutron flux, which significantly enhances the efficiency of experiments. In order to optimize the time-of-flight characteristics, two neutron-production targets are being planned, one at 40 pulses per second for epithermal neutrons, and one at 20 pulses per second for cold neutrons. These design features allow the attractive possibility of continuing, without compromise to the neutron-scattering program, the intermediate energy nuclear and particle physics and medical isotope programs at LAMPF.

Important ingredients for securing the LANSCE II program are a technically sound design, emphasizing the best current technology, reliable operation of the present accelerator and neutron source, and strong support and backing from the neutron-scattering user community.

The experience and talent of the physicists and engineers associated with the present LAMPF/LANSCE facilities should be brought to bear on the realization of a new coordinated LAMPF/LANSCE concept.