

Some Comments on "La simulation des essais nucleaires,"
par M. Rene Galy-Dejean, Rapport D'Information No. 847,
Commission De La Defense Nationale et des Forces Armees,
Assemblee Nationale, 15 decembre 1993.

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by

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INTRODUCTION

Report Statement: "M. Edouard Balladur poursuivait en indiquant: *Pour l'avenir, nous ne signerons aucune interdiction definitive des essais aussi longtemps que nous aurons le sentiment qu'ils sont indispensable a la credibilite technique de notre effort nucleaire.*"

Comment: The relative technical importance of nuclear explosive tests obviously depends on how "notre effort nucleaire" is defined.

If the objective of the French nuclear weapons program is to continue to deploy new nuclear warheads of advanced design, then nuclear explosive tests are indispensable to technical credibility.

If France is willing to depend in the future on its existing, fully-tested designs, then the technical credibility of these weapons can be maintained without nuclear tests.

In this connection, France has conducted more tests for each modern warhead in its current stockpile than any other nation. France is not deficient in this respect in comparison to other countries.

Report Statement: "L'etat d'avancement de nos connaissances scientifiques et techniques d'une part, l'equipment de nos laboratoires d'autre part, en d'autres terms, la mise en oeuvre d'un systeme de simulation connu sous le nom de PALEN plaiaient-ils la France en situation de se passer desormais d'essais nucleaires?"

Comment: This question has no single right answer, and in some respects is the wrong question. The answer obviously depends on what France expects the PALEN system to accomplish.

If the purpose of PALEN is to maintain, and periodically remanufacture, France's stockpile of modern nuclear weapons designs (the TN -70/71,-75, -80/81, and -90 warheads), this goal can be accomplished by the French nuclear weapons experts without conducting further nuclear explosive tests.

If the purpose of PALEN is to assure France the capacity to certify with confidence the performance of new thermonuclear weapons of advanced design without testing, then a large, and possibly infinite, number of nuclear tests will be required first. This is not a "technically credible" goal for a "systeme de simulation."

If the purpose of PALEN is to maintain a "technically credible" cadre of personnel who will be available on short notice to resume the process of developing new thermonuclear weapons, then this goal can be achieved technically without further nuclear tests, but it will cost a large amount of money. The strategic benefit of such a costly program is questionable, and it is not required to maintain a credible nuclear deterrent.

A more appropriate path, for both the U.S. and French programs of "stockpile stewardship," is to accept the technical limitations imposed by a Comprehensive Test Ban, and then to concentrate on careful preservation and analysis of the nuclear and non-nuclear test data base, and the technical base for low volume remanufacture, for those weapons that will remain part of the long-term nuclear deterrent force.

CHAPTER I

Report Statement: "*Peut-on mettre au point un systeme de simulation des essais nucleaires sans proceder, au prealable ou simultanement, a un certain nombre d'experimentations? D'ou je tirerai, par voie de consequence, le caractere que j'ai souhaite donner a la demarche de notre mission d'information. ("Can a nuclear test simulation system be developed without first, or simultaneously, doing a certain amount of testing? This question has determined the way in which I have sought to approach the work of the fact-finding mission.")*

Comment: Once again, this is the wrong question. No system of "simulation" or very low-yield "experiments" can generate the range or complexity of data gained in full-scale nuclear tests, and thus a "nuclear test simulation system" cannot be developed to replace nuclear testing. This is a hopeless task and a prescription for technical failure and endless expenditure of state funds.

In fact, the very phrase "nuclear test simulation system" is misleading, and obscures the fact that calibrated nuclear weapon design codes employ empirical factors derived from nuclear explosive tests, and cannot be modified to incorporate data from new high energy density physics facilities without incurring substantial technical risk.

Rather than trying to "simulate" one's way around the limitations imposed by a test ban, a better approach is to use high resolution radiography and other diagnostic techniques to better assess changes in the "hydrodynamic" (pre-nuclear) performance

of previously tested primary implosion systems, and then use nuclear test validated computer codes to calculate the effects on nuclear performance.

If properly executed, this conservative approach will result in maintaining high confidence in the future nuclear deterrent at a reasonable cost.

CHAPTER II

Report Statement: "Il faut d'ores et deja indiquer que les Etats-Unis sont, vis-avis d'un arret des tirs nucleaires, dans une situation fondamentalement differente de celle de la France car ils maitrisent l'essentiel des techniques de simulation, mises au point grace a de nombreux essais nucleaires. Ayant deja subi un moratoire considere par eux comme desastreux, ils avaient largement anticipe la suspension actuelle. Contrairement a la France qui a decide de suspendre ses essais sans s'y etre preparee et sans avoir suffisamment developpe les systemes de simulation permettant de se passer d'un grand nombre de tirs, les Etats-Unis abordent la periode future avec une grande serenite."

("It should be noted at this point that as far as a suspension of nuclear testing is concerned, the situation of the United States is fundamentally different from that of France, for the U.S. has achieved mastery of most simulation technologies, developed as a result of numerous nuclear tests. Having already experienced a moratorium that it considered to have been disastrous, it had for the most part anticipated the present suspension. Unlike France, which decided to suspend testing without having adequately developed the simulation systems that would enable it to forgo a great many tests, the United States faces the future with great serenity."

Comment: This statement greatly exaggerates U.S. "simulation" capabilities, and seriously underestimates France's relative position. Indeed, with the exception of nuclear weapons "effects," which can be faithfully "simulated" over a narrow area for some portions of the radiation spectrum, U.S. nuclear weapons scientists do not even employ the misleading term "nuclear test simulation," and they do not believe they have come anywhere close to constructing "a nuclear test simulation system."

Instead, they talk about different types of "above-ground experimental facilities" that will help to maintain scientific expertise in areas relevant to nuclear weapons design. Many of these desired facilities are not yet constructed, and some of them probably never will be constructed given budget realities in the United States.

It is incorrect to state that the United States "for the most part anticipated the present suspension." In fact, Congress sought to require preparations for a test ban on the Department of Energy beginning in 1988, but the Reagan-Bush administrations strongly resisted such a "Test Ban Readiness Program," and with the exception of a few paper studies, it was never carried out.

The passage of the Hatfield-Exon-Mitchell amendment in September 1992 caught the Bush administration by surprise, and President Bush criticized the amendment even as election year pressures induced him to sign it into law.

The Defense Committee Report is simply wrong on all these points.

Report Statement: "...the United States faces the future with great serenity. France, meanwhile is somewhat paralyzed, allowing the Americans to maintain an undeniable technological advantage and a "dominant position" in the area of nuclear weapons, with all the risks that this might entail for our country in terms of national independence."

Comment: This is a bizarre, even offensive, statement. I cannot comprehend the mentality of those who write such things. France is not in any position to "allow" or "deny" the United States its dominant position in the area of nuclear weapons. This asymmetry derives from the inherent asymmetries between the two societies, from the vastly greater financial and technical resources at the disposal of the U.S. nuclear weapons program, and from the fact that U.S. nuclear weapons reinforce its dominant position in conventional forces.

Moreover, the U.S. (and Russian) nuclear weapons programs represented immoral, grotesque excursions into the domain of nuclear overkill and technological excess. One hopes that there are not many in France who desire to inherit this discredited "dominant position" formerly occupied by the nuclear "superpowers."

More importantly, however, why should anyone in France worry about technological disparities between U.S. and French nuclear forces, or suggest that U.S. nuclear forces pose "risks" to French national independence. In the post Cold-War era, are we now to be considered strategic rivals? What is being implied here? After centuries of friendship between our two nations, and two world wars in which tens of thousands of American lives were lost and billions of dollars expended defending French "independence," this kind of nationalist political posturing over nuclear weapons is offensive and unacceptable. Most Americans would be deeply offended by such statements.

Report Statement: "The Test Ban Readiness (TBR) Program made its first official appearance in Congressional budget documents in 1989. At the time, TBR was just a new name given to the Augmented Test Program (ATP) begun in 1980 by President Carter and continued by President Reagan in 1981....At the request of the U.S. Congress, the TBR program gradually became more clearly defined, focusing on specific experiments coupled with the design and manufacture of simulation resources, all supported by very powerful computers."

Comment: This statement is simply incorrect. Under President Carter, the laboratories did propose an "augmented test program" to address primary and secondary yield scaling, boost variability, and other issues associated with future restrictions on nuclear tests, but most of these tests were never carried out, because the Reagan administration became preoccupied with the engineering development of new strategic offensive systems and the "Star Wars" x-ray laser program, which consumed all the available testing resources.

Moreover, most of these tests did not directly address the issues associated with the Comprehensive Test Ban – such as sensitivity of primary boost performance to the effects of aging on warhead materials, or to changes in manufacturing tolerances and materials – on the theory that the national laboratories should not consent to "prepare" for a treaty to which they were strongly opposed.

In fact, very few preparations for a CTB were undertaken by the DOE weapons complex in the 1980's, and this led Congress to pass the Test Ban Readiness (TBR) Program in the summer of 1988. The purposes of this legislation were as follows:

(1) To assure that the United States maintains a vigorous program of stockpile inspection and non-explosive testing so that, if a low-threshold or comprehensive test ban is entered into, the United States remains able to detect and identify potential problems in stockpile reliability and safety in existing designs of nuclear weapons.

(2) To assure that the specific materials, components, processes, and personnel needed for the remanufacture of existing weapons or the substitution of alternative nuclear warheads are available to support such remanufacture or substitution if such action becomes necessary in order to satisfy reliability or safety requirements under a low-threshold or comprehensive test ban agreement.

(3) To assure that a vigorous program of research in areas related to nuclear weapons science and engineering is supported so that, if a low-threshold or comprehensive test ban agreement is entered into, the United States is able to maintain a base of technical knowledge about nuclear weapons design and nuclear weapons effects (emphasis added).

As evident from the above, Congress did not mandate, and the Department of Energy did not implement, a comprehensive program for nuclear explosive test simulation. Such a program does not exist in the United States.

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On the contrary, U.S. nuclear weapons scientists have always emphasized that thermonuclear weapons design is an "empirical" science, and that the complex "mixing" phenomena that occur in nuclear explosive devices cannot be accurately "simulated" from first principles, but only modeled approximately with heavy reliance on calibration data from actual nuclear explosive tests.

For this reason, U.S. nuclear-weapons scientists are extremely cautious about making changes in nuclear weapon designs that have not been "certified" by nuclear explosive tests.

Comments & Background Information

Concerning

- **The U.S. Nuclear Test Ban Readiness Program**
- **Hydronuclear Tests**
- **The National Ignition Facility**
- **U.S. Warhead Safety and Reliability**

Ray E. Kidder

Lawrence Livermore National Laboratory (Ret.)

October 27, 1994

(Views expressed are those of the author and not of his organization.)

NUCLEAR TEST BAN READINESS PROGRAM

Section 1436 of the National Defense Authorization Act for Fiscal Year 1989

Purposes of Program:

(1) To assure that the United States maintains a vigorous program of stockpile inspection and non-explosive testing so that, if a low-threshold or comprehensive test ban is entered into, the United States remains able to detect and identify potential problems in stockpile reliability and safety in existing designs of nuclear warheads.

This purpose is served by the Above Ground Experiments Program (AGEX) that was subsequently established, and by the existing Stockpile Stewardship Program of which AGEX is a part.

(2) To assure that the specific materials, components, processes and personnel needed for the remanufacture of existing nuclear weapons or the substitution of alternative nuclear warheads are available to support such remanufacture or substitution ----- under a low-threshold or comprehensive test ban agreement.

(3) To assure that a vigorous program of research in areas related to nuclear weapons science and engineering is supported so that ----- the United States is able to maintain a base of technical knowledge about nuclear weapons design and nuclear weapons effects.

The purpose of assuring that a "vigorous program of research in areas related to nuclear weapons science" is a principal justification for the proposed National Ignition Facility (NIF).

Hydronuclear Experiments Conducted During the Moratorium on Nuclear testing (1958 - 1961)

"There were 35 hydronuclear [safety] experiments in all at Los Alamos, and a smaller number were conducted at the Nevada Test Site by the Livermore Laboratory. In June 1961, near the end of the program, a criticality experiment was performed at Los Alamos on a modified unboosted weapon design. This experiment produced four-tenths of a pound of fission energy, the highest by an order of magnitude of the entire Los Alamos series." (excerpt from: Robert N. Thorn and Donald R. Westervelt, Hydronuclear Experiments, Los Alamos National Laboratory, Los Alamos, NM, LA-10902-MS, February 1987, p. 6.)

(One-point detonation safety tests can be limited today to far less fission yield than the maximum of four-tenths of a pound referred to above.)

Principal AGEX Facilities

- Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) under construction at Los Alamos.

Stop-motion flash x-ray radiography of above-ground HE-driven implosions and other hydrodynamic phenomena.

- National Ignition Facility (NIF) in pre-construction development phase. Will probably be located in Livermore.

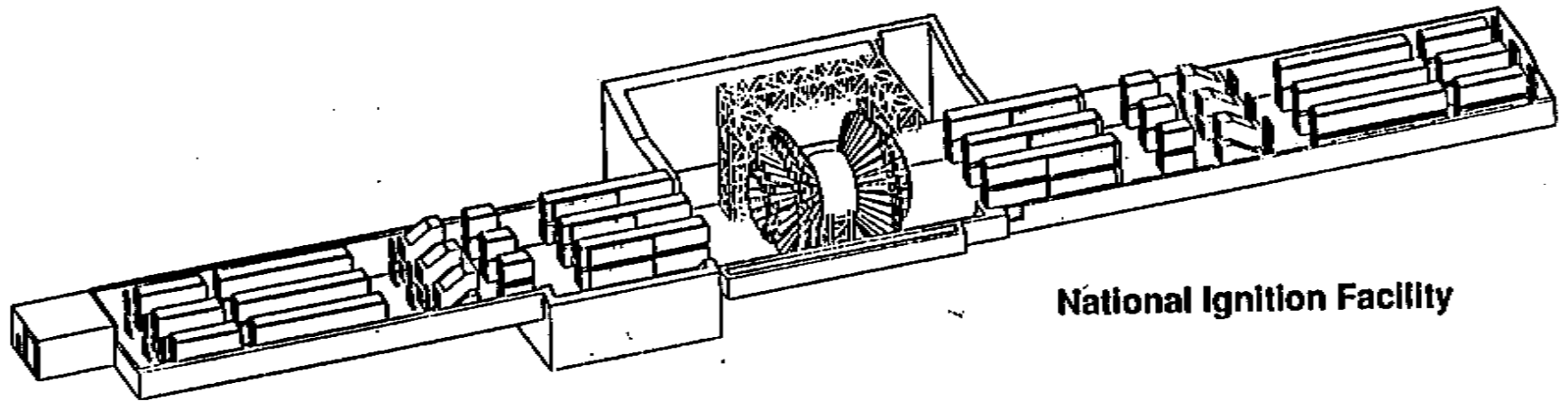
Of these two facilities, DARHT is considered to be of direct importance to Stockpile Stewardship, whereas NIF is of indirect importance (in maintaining a general competence in nuclear weapons science).

For a more detailed description and discussion of the AGEX program see: Philip D. Goldstone, An Expanding Role for AGEX, Los Alamos Science Number 21, 1993.

The Department of Energy is preparing for a glass laser inertial confinement fusion ignition facility

NIF

The National Ignition Facility



National Ignition Facility

number of beams

**12 - 18 beamlines
(200 - 300 beamlets)**

energy

1-2 MJ @ 0.35 μm

peak power

500 TW

intensity

500-2000 TW/cm²

pulse length

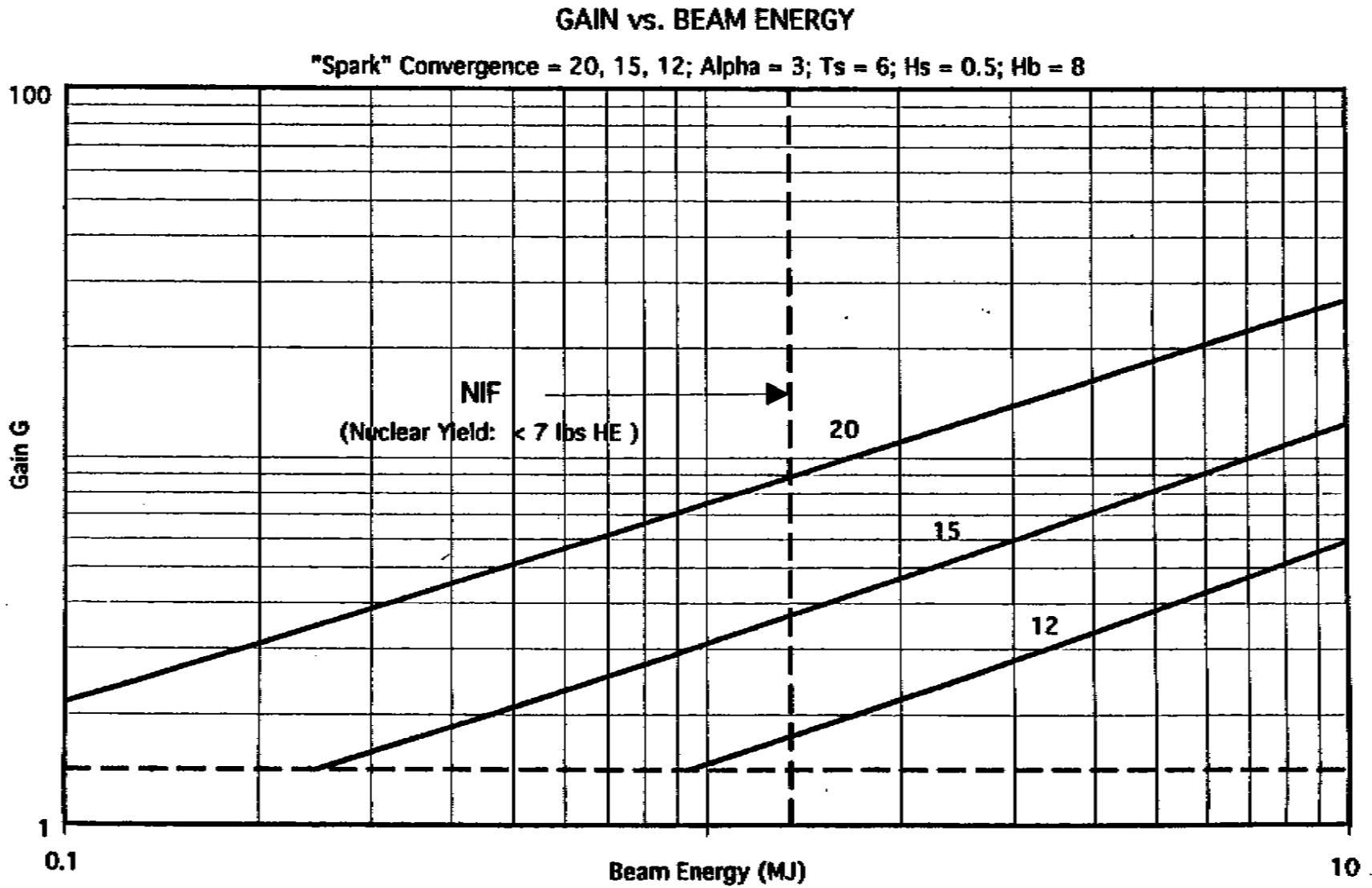
< 20 ns

beam-to-beam power balance

10% rms

pulse shape dynamic range

**> 50:1 (continuous)
> 10:1 (picket fence)**



NATIONAL IGNITION FACILITY (NIF) Proposed Areas of Research

Physics Research:

Super-powerful point-source of 14 MeV neutrons*:

Neutron Pulse-Energy: 10 - 20 megajoules

Pulse duration: ~ 50 picoseconds

Source diameter: ~ 100 microns

Opacity and equation of state measurements

Atomic physics, x-ray laser studies

Electron-positron relativistic plasma physics*

Radiation transport, high temperature hydrodynamics

Nuclear Weapons Science:

Radiation-driven implosion

Thermonuclear ignition and explosion*

**Electric Power Generation and Fissile Fuel Breeding
with Inertial Confinement Fusion (ICF)**

(*) Assumes ignition and modest energy gain (> 20)

KD-1 gives French ICF work a burst of energy

By Don Johnston

Last week's approval of the first phase of the National Ignition Facility by Energy Secretary Hazel O'Leary was celebrated in a rather surprising place — the Centre d'Etudes de Limeil-Valenton in France.

That is where NIF's French twin, the Laser Mega Joule (LMJ), will be constructed. "We were very glad about that," said Michel Andre, head of the 20-strong delegation of French laser scientists who spent five days this week with their LLNL counterparts at the Lab planning the development of the mega lasers.

This close collaboration is the result of a formal 10-year agreement concluded between the Department of Energy and the French Commissariat d'Energie Atomique (CEA) in July and to be officially signed in ceremonies to be held in

Paris next month.

The agreement represents a "quantum leap from past areas of collaboration," says Howard Lowdermilk, deputy project manager for NIF and host for the visiting scientists. By sharing development costs and assigning areas of concentration, the respective parties aim to save time and money in bringing their projects to fruition by the target date of 2002. "Both sides are optimistic we'll be able to reduce costs," he said.

The approval of Key Decision 1 keeps the two projects at the same stage of development, Andre said. "Only two Labs are at this level of development in the world."

Lowdermilk quickly added "it's our intention to keep it that way."

Franco-American collaboration in laser research is nothing new and has been going on informally for

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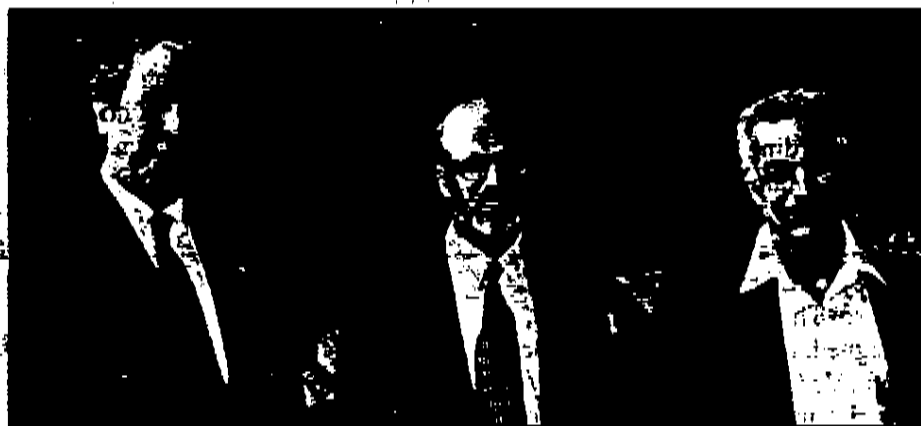


Photo by Bryan Quintard

At the Franco-American laser summit were (from left): Michel Andre, head of the French delegation, Howard Lowdermilk, deputy project manager of NIF, and Marc Novaro, French laser scientist.

FRENCH

continued from page 1

some 20 years. These exchanges were formalized in a three-year 1989 agreement that laid the foundation for the one reached earlier this year.

"There's a substantial French presence on-site. We've been doing joint physics experiments with them on Nova," Lowdermilk said.

"Beamlet is also a good example of how collaboration is working. We've been working together to demonstrate its capabilities."

Andre emphasized the importance of developing close professional and personal ties because of the distance between the two labs. "You have to know the people you work with," he said. "Our languages are different and we have to make sure we give the same sense to the same word. It's important to have trust."

For the last year Marc Novaro, a French laser scientist from Limeil, has been working at the Lab as a liaison with LMJ and Erik Storm, an LLNL plasma physicist and one time head of ICF, has been in France. Storm just returned and Novaro leaves today but will be replaced by two colleagues who will stay for several months.

The French laser project has not met with the kind of criticism NIF has received from anti-nuclear groups, Andre said, explaining that France has long depended on nuclear power for most of its energy needs. If anything, he said, there's public support for LMJ because it provides an alternative to nuclear testing in the South Pacific, for which France has been criticized internationally.

Collaboration is strictly in unclassified work and does not extend to weapons research or classified aspects of ICF, Lowdermilk said, though "as the level of classification goes down, there'll be more collaboration."

Nuclear Tests and Nuclear Yields

NUCLEAR (fission) YIELD in equivalent lbs or tons of HE

- Less than 1/10 lb:

Nuclear detonation safety can be readily assessed. ("One-point safe" if: less than one chance in a million of nuclear yield exceeding 4 lbs when HE is detonated at any one point.)
(No known nuclear detonation safety problems in current U.S. stockpile.)

- Less than 1/4 lb:

Insufficient to melt 5 kilograms of Pu. (No nuclear 'explosion' is possible.)

- Less than 4 lbs:

Of little value to nuclear weapon development by either nuclear or nonnuclear weapon states.

- 10 or more lbs (in 5 kilograms of Pu):

Will begin to exert a a pressure in the megabar range. (Would surely be considered a nuclear 'explosion'.)

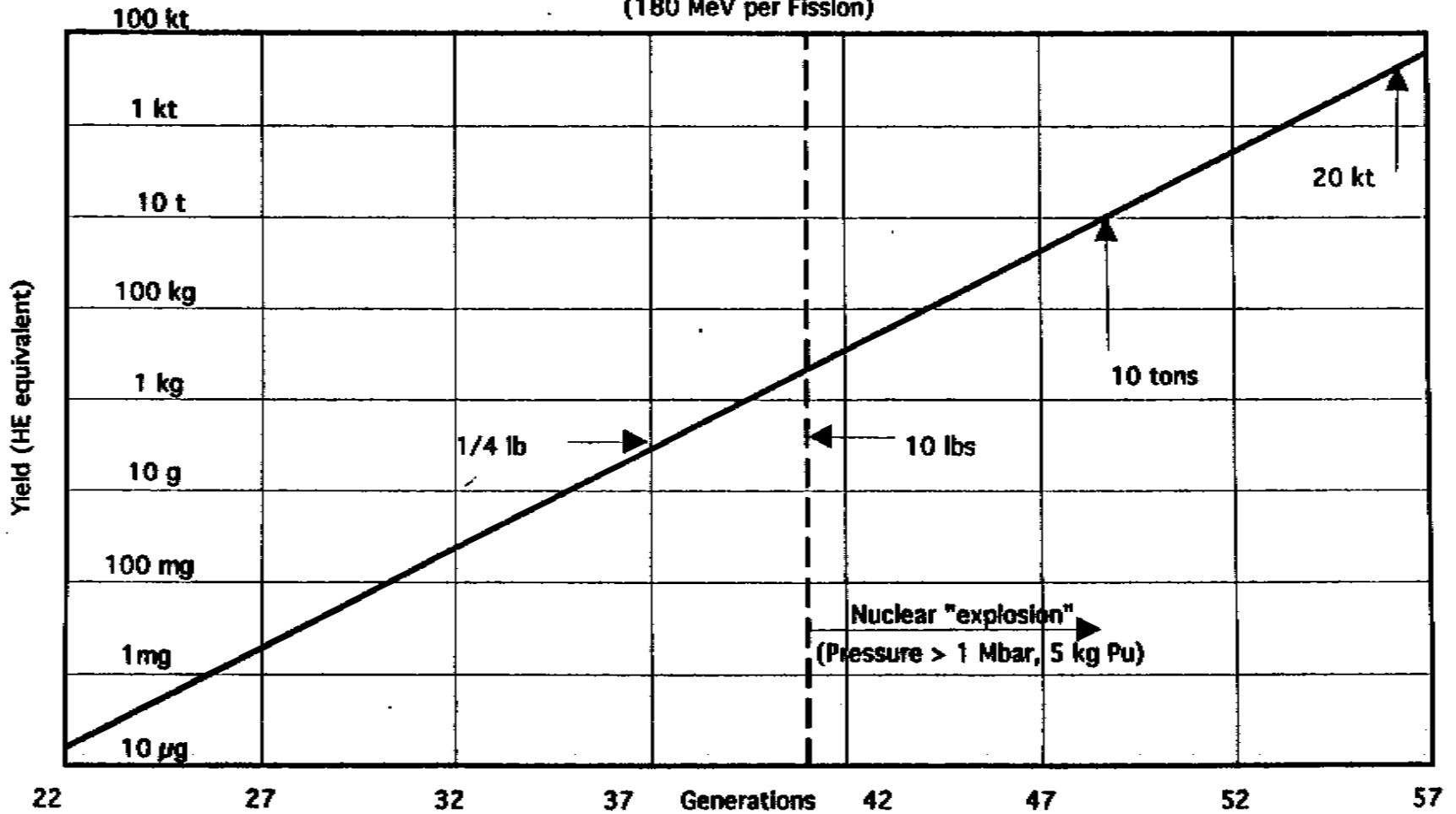
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- 10 tons:

Would be of very substantial value to a proliferator in checking and correcting computer codes, reducing yield uncertainty, verifying performance, and reassuring "the boss". (Could not be detected and identified as a nuclear explosion by seismic means, even if fully coupled to the seismic medium.)

Would begin to be of value to nuclear weapon states.

Appendix C
These pages were given to those we met in Paris

YIELD vs GENERATIONS OF FISSION (180 MeV per Fission)



DISTRIBUTION OF EXPLOSIVE YIELDS AT NTS: 1980 THROUGH 1984

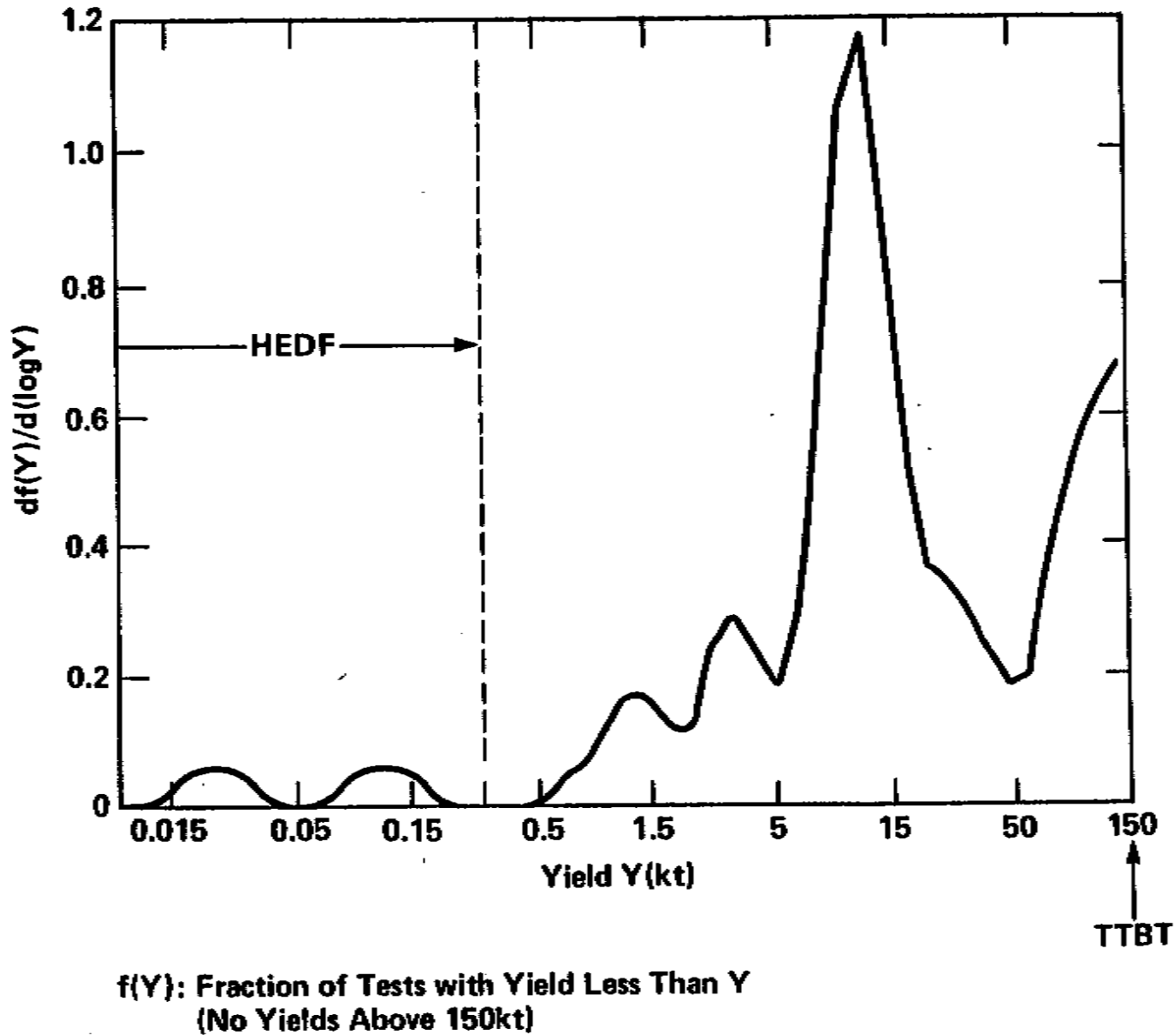


Figure 1

THERE IS A LARGE GAP BETWEEN AGEX PARAMETER SPACE AND THE WEAPONS RANGE

Appendix C

These pages were given to those we met in Paris

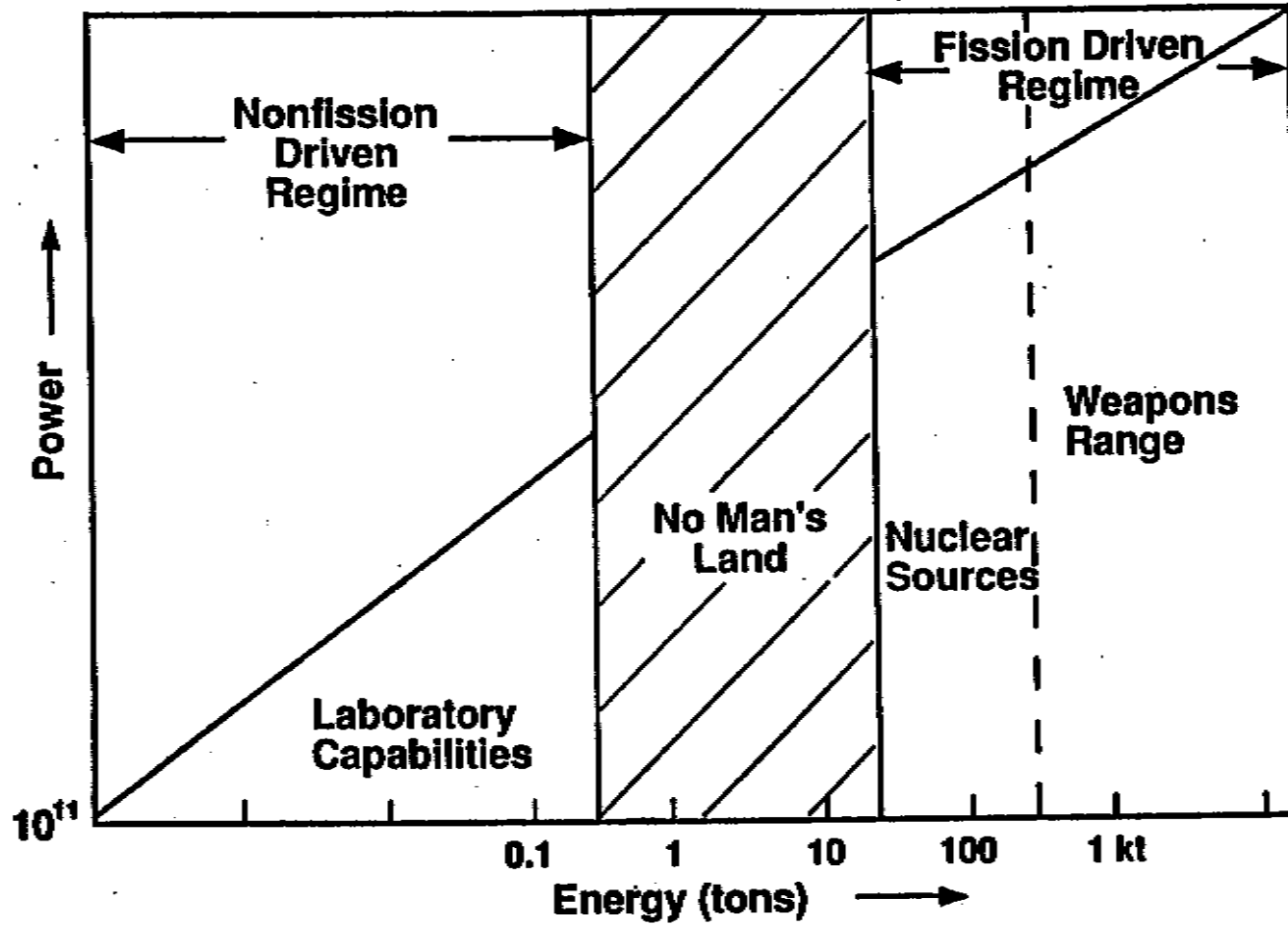


FIGURE 1

WARHEAD SAFETY RATINGS
(U.S. Enduring Stockpile)

		Entered Stockpile	Safety Rating
B61-10	Tactical Bomb	1990	B
W88	Trident II D5 SLBM	1990	C
W87	MX Peacekeeper ICBM	1986	A
B61-7	Strategic Bomb	1986	B
W80-0	Cruise Missile, SLCM	1984	B
B83	Strategic Bomb	1983	A
W80-1	Cruise Missile, ALCM	1982	B
B61-4	Tactical Bomb	1980	B
W78	Minuteman III ICBM	1980	C
W76	Trident I, II C4 SLBM	1979	C

A: ENDS, IHE, FRP

B: ENDS, IHE

C: ENDS

ENDS: Enhanced Nuclear Detonation Safety

IHE: Insensitive High Explosive

FRP: Fire Resistant Pit

(The W78 Minuteman III warheads are scheduled to be replaced with W87 MX Peacekeeper warheads.)

President Clinton declared the U.S. stockpile of nuclear weapons to be both SAFE and RELIABLE when he elected to extend the Congressionally-mandated moratorium on U.S. nuclear weapons testing that would otherwise have ended on July 1, 1993.⁽¹⁾

SUMMARY & CONCLUSIONS

There should be no doubt in anyone's mind that the detonation of ten kilograms of high explosive constitutes an "explosion". That amount is said to have been used in the recent terrorist attack on a bus in Tel Aviv that destroyed the bus and killed twenty-two people.

Nuclear explosions with yields less than ~10 tons are not of much use to the further development of U.S. nuclear weapons . (Much larger yield tests would be needed to reliably predict the performance of new boosted-fission weapons, for example.) This is presumably also the case for the other declared nuclear weapons states. An explosive yield of 10 tons (1000 times the Tel Aviv explosive yield) clearly represents an extremely powerful explosion.

On the other hand, the most important of the hydronuclear tests - one-point detonation safety tests - can readily be performed with fissile yields of less than 1/10th lb, an amount that would produce no nuclear explosion at all. Indeed, these tests were not considered to represent a violation of the nuclear testing moratorium of 1958-61.

This suggests that if a CTB were simply defined to ban all nuclear explosions , then nuclear tests with fissile yields large enough to be of value to nuclear weapon states (and nuclear proliferators as well) would be banned, whereas potentially important one-point detonation safety tests could be performed without violating the CTB. (This approach has the further merit that it avoids the contentious definition of a "nuclear explosion", relying on the fact that public perception of what is and what is not an 'explosion' is sufficiently clear without further definition.)

(1) Further information and the author's views concerning the reliability and safety of the U.S. nuclear weapons stockpile can be found in the following Lawrence Livermore National Laboratory Reports:

a) Maintaining the U.S. Stockpile of Nuclear Weapons During a Low-Threshold or Comprehensive Test Ban, UCRL-53820, October 1987.

b) Report to Congress: Assessment of the Safety of U.S. Nuclear Weapons and Related Nuclear Test Requirements, UCRL-LR-107454, July 26, 1991.

c) Assessment of the Safety of U.S. Nuclear Weapons and Related Nuclear Test Requirements: A Post-Bush Initiative Update, UCRL-LR-109503, Dec. 10, 1991.

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