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Science in National and International Security: The Role of Physics in Non-Proliferation and Counter-Terrorism

Ed Hartouni
N Division
Lawrence Livermore National Laboratory

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Outline of this talk:

A reminder of the V. Bush's vision: The Endless Frontier

The changing nature of threats to national and international security

Science and Technology, example application

Future prospects and challenges

My apologies in advance for the necessarily brief treatment I will give to the many interesting and important topics related to this subject.

OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT
1530 P Street, NW.
Washington 25, D.C.
JULY 25, 1945

DEAR MR. PRESIDENT:

In a letter dated November 17, 1944, President Roosevelt requested my recommendations on the following points:

(1) What can be done, consistent with military security, and with the prior approval of the military authorities, to make known to the world as soon as possible the contributions which have been made during our war effort to scientific knowledge?

(2) With particular reference to the war of science against disease, what can be done now to organize a program for continuing in the future the work which has been done in medicine and related sciences?

(3) What can the Government do now and in the future to aid research activities by public and private organizations?

(4) Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war?

It is clear from President Roosevelt's letter that in speaking of science that he had in mind the natural sciences, including biology and medicine, and I have so interpreted his questions. Progress in other fields, such as the social sciences and the humanities, is likewise important; but the program for science presented in my report warrants immediate attention.

In seeking answers to President Roosevelt's questions I have had the assistance of distinguished committees specially qualified to advise in respect to these subjects. The committees have given these matters the serious attention they deserve; indeed, they have regarded this as an opportunity to participate in shaping the policy of the country with reference to scientific research. They have had many meetings and have submitted formal reports. I have been in close touch with the work of the committees and with their members throughout. I have examined all of the data they assembled and the suggestions they submitted on the points raised in President Roosevelt's letter.

Although the report which I submit herewith is my own, the facts, conclusions, and recommendations ar
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necessarily brief, I am including a
committees.

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Respectfully yours,
(s) V. Bus

THE PRESIDENT OF THE UNITED STATES,
The White House,
Washington, D. C.

Vannevar Bush provides recommendation of regarding the science enterprise in the post-war United States.

Recall that the Trinity test took place on July 16, 1945, the bombing of Nagasaki on August 6 and of Hiroshima on August 9. Japan surrendered on August 15, 1945.

"The pioneer spirit is still vigorous within this nation. Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation an the individual are great. Scientific progress is one essential key to our security as a nation, to better health, to more jobs, to a higher standard of living, and to our cultural progress.

Respectfully yours,

(s) V. Bush, Director

THE PRESIDENT OF THE UNITED STATES,
The White House,
Washington, D. C.

Physics & Advanced Technologies N Division

SCIENCE - THE ENDLESS FRONTIER

"New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create a fuller and more fruitful employment and a fuller and more fruitful life."--
FRANKLIN D. ROOSEVELT
November 17, 1944.

SUMMARY OF THE REPORT

SCIENTIFIC PROGRESS IS ESSENTIAL

Progress in the war against disease depends upon a flow of new scientific knowledge. New products, new industries, and more jobs require continuous additions to knowledge of the laws of nature, and the application of that knowledge to practical purposes. Similarly, our defense against aggression demands new knowledge so that we can develop new and improved weapons. This essential, new knowledge can be obtained only through basic scientific research.

Science can be effective in the national welfare only as a member of a team, whether the conditions be peace or war. But without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world.

Chapter 3 SCIENCE AND THE PUBLIC WELFARE

Relation to National Security

…attack on London was finally defeated by three devices developed during this war and used superbly in the field. V-2 was countered only by the capture of the launching sites.

The Secretaries of War and Navy recently stated in a joint letter to the National Academy of Sciences:

This war emphasizes three facts of supreme importance to national security: (1) Powerful new tactics of defense and offense are developed around new weapons created by scientific and engineering research; (2) the competitive time element in developing those weapons and tactics may be decisive; (3) war is increasingly total war, in which the armed services must be supplemented by active participation of every element of civilian population.

To insure continued preparedness along farsighted technical lines, the research scientists of the country must be called upon to continue in peacetime some…

The changing nature of the threats to national and international security: the rise of asymmetric threats from non-national adversaries

The three points made by the Joint Chiefs quoted in V.Bush's "Endless Frontier" report:

> **"(1) Powerful new tactics of defense and offense are developed around new weapons created by scientific and engineering research; (2) the competitive time element in developing those weapons and tactics may be decisive; (3) war is increasingly total war, in which the armed services must be supplemented by active participation of every element of civilian population."**

do not reflect the contemporary situation. Groups with large resources are able to pose serious threats to national and international security. Strategic threats heretofore have focused on "symmetric" nation states. Asymmetric threats pose nation states against sub-national groups.

Further, the weapons used are not "high tech". They may incorporate widely available materials (which exist because of the high tech nature of commerce).

9/11 and Homeland Security

Terrorism: "The unlawful use or threatened use of force or violence by a person or an organized group against people or property with the intention of intimidating or coercing societies or governments, often for ideological or political reasons."
http://www.bartleby.com/

The attack of September 11 utilized the international transportation infrastructure. Aircraft were used to accomplish the destruction of the World Trade Center towers.

One of the national responses to this attack was the formation of the Department of Homeland Security.

A fictional scenario which is its title :"Sum of all fears"

Published in 1991 by Tom Clancy, some aspects of the plot do not seem far fetched in the light of 9/11.

Synopsis:
An Israeli tactical nuclear weapon is recovered and comes into the possession of a terrorist organization. Disenfranchised weapons scientists recycle its weapons grade ^{239}Pu into a new weapon. The weapon is shipped to the United States clandestinely, using the international shipping infrastructure. The weapon is exploded at the Superbowl taking place in Denver. The explosion creates an international crisis pitting the US against Russia. Escalation to full scale nuclear war is averted by properly attributing the origin of the device.

While many of the plot devices had been considered and addressed, for instance the international non-proliferation programs of the DOE, the use of the international shipping infrastructure received renewed attention in the post-9/11 era.

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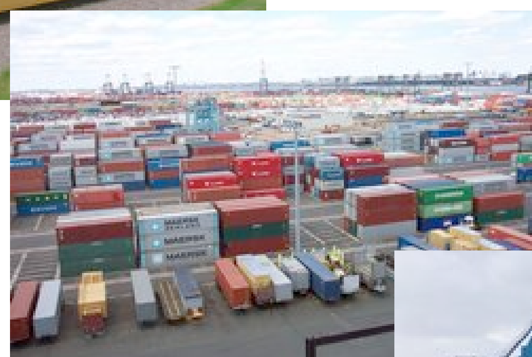
Intermodal transportation



Manufacturer produces goods and ships

Shippers consolidate loads locally and ship to central ports

Containers are consolidated at port

Ships loaded bound for market ports

Ships unloaded at market ports

Containers sorted for shipping

Distributed to major market regions

Containers shipped for local distribution

2003 ranking American Association of Port Authorities (AAPA)

`http://www.aapa-ports.org/`

CONTAINER TRAFFIC (TEUs, 000s)			
RANK	PORT	COUNTRY	TEUs
1	Hong Kong	China	20,499
2	Singapore	Singapore	18,411
3	Shanghai	China	11,280
4	Shenzhen	China	10,615
5	Busan	South Korea	10,408
6	Kaohsiung	Taiwan	8,843
7	Los Angeles	United States	7,149
8	Rotterdam	Netherlands	7,107
9	Hamburg	Germany	6,138
10	Antwerp	Belgium	5,445
11	Dubai	United Arab Emirates	5,152
12	Port Kalang	Malaysia	4,840
13	Long Beach	United States	4,658
14	Quingdao	China	4,239
15	New York/New Jersey	United States	4,068
16	Tanjung Pelepas	Indonesia	3,487
17	Tokyo	Japan	3,314
18	Bremen/Bremerhafen	Germany	3,190
19	Laem Chabang	Thailand	3,181
20	Gioia Tauro	Italy	3,149
21	Tianjin	China	3,015
22	Ningbo	China	2,772
23	Guangzhou	China	2,762
24	Tanjung Priok	Indonesia	2,758
25	Manila	Philippines	2,552
26	Algeciras	Spain	2,516
27	Yokohama	Japan	2,505
28	Felixstowe	United Kingdom	2,500
29	Xiamen	China	2,331
30	Nhava Sheva	India	2,269

Total for 50 ports in 2003: *207,081,000 TEU's*

TEU = Twenty foot Equivalent Unit
20'x8'x8.5' 17,500kg max payload (0.53 g/cm^3)
40'x8'x9.5' 24,000kg (0.36 g/cm^3)

~$0.20/kg shipping cost

The average rate of container traffic at the Port of Los Angeles in 2003 was 14 TEUs/minute

Average for 50 ports: 8 TEUs/minute

Maximum: 39 TEUs/minute

Minimum: 3 TEUs/minute

Statement of the "problem": protect from the illicit transport of special nuclear materials.

The inspection must take place on ALL containers.
The time for inspecting a single container must be no more than 1 minute.
The inspection cannot alter the commercial value of the cargo.
The inspection cannot injure stowaways.
Desire both a high probability of detecting the specific illicit cargo and a low probability of a false detection.

This is a variant of the "how to detect a needle in a haystack" question which scientists ask all the time, especially in particle physics and nuclear physics experiments:

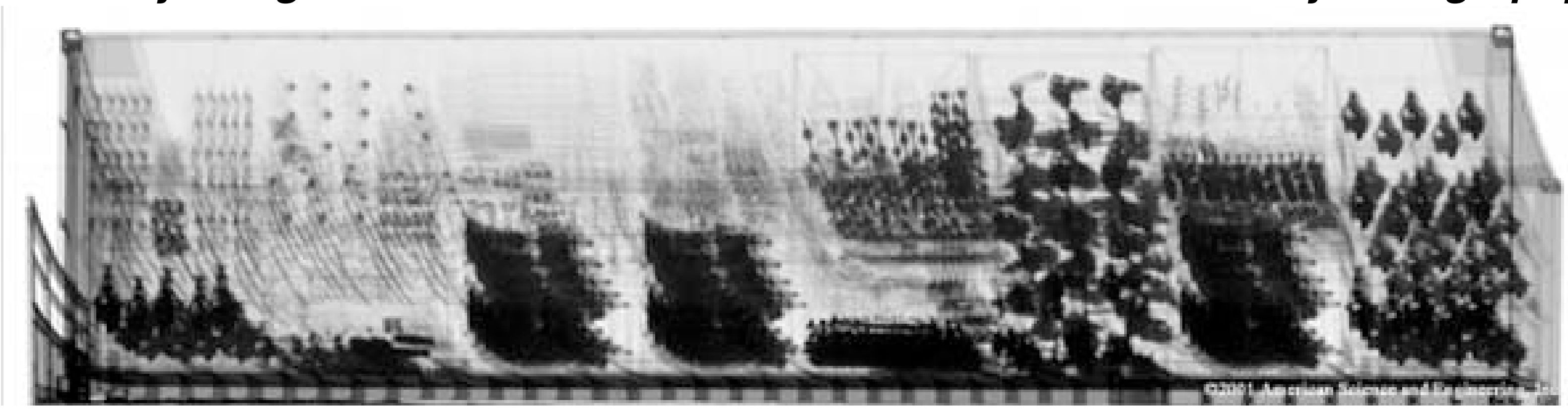
How do you find the very rare occurrence of something in a huge background of common occurrences which are similar?

The methodology of doing basic science is applicable to the "inspection problem"

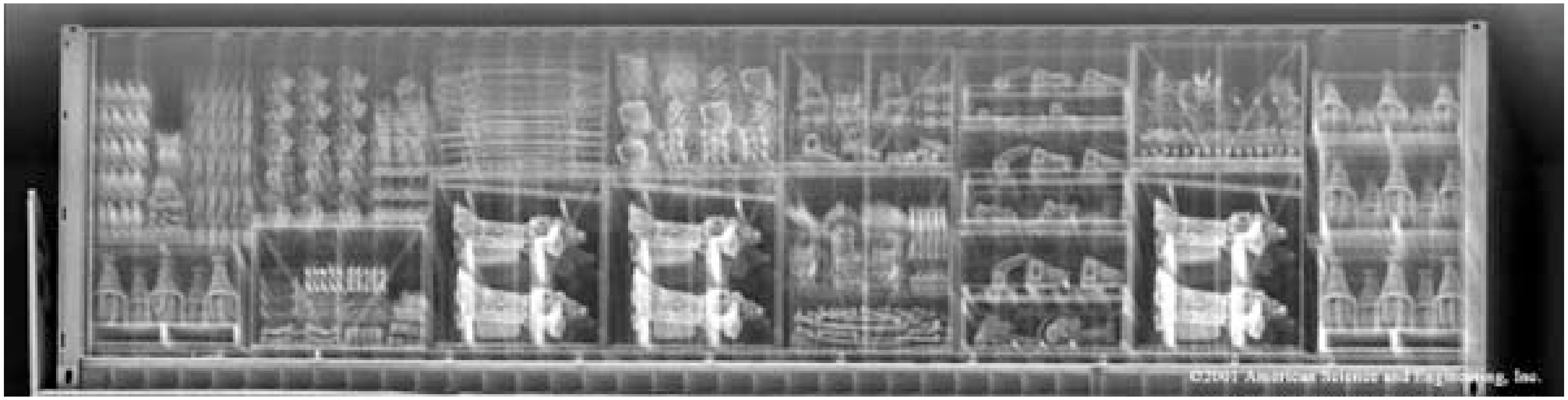
Just look inside?

"X-ray" cargo?

Transmission x-ray radiography

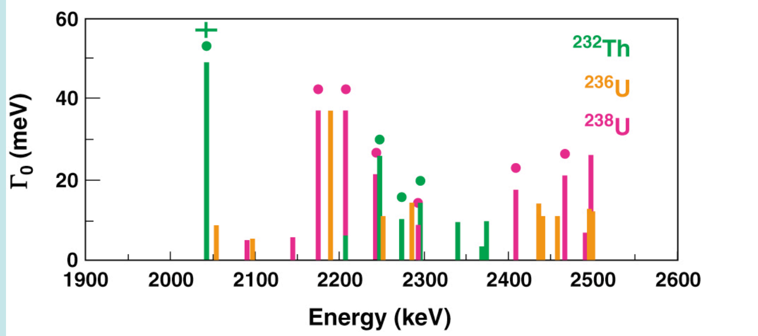


Backscatter x-ray radiography



We can detect *high density* items in the cargo, we cannot specify the isotopic composition of the high density items using x-rays.

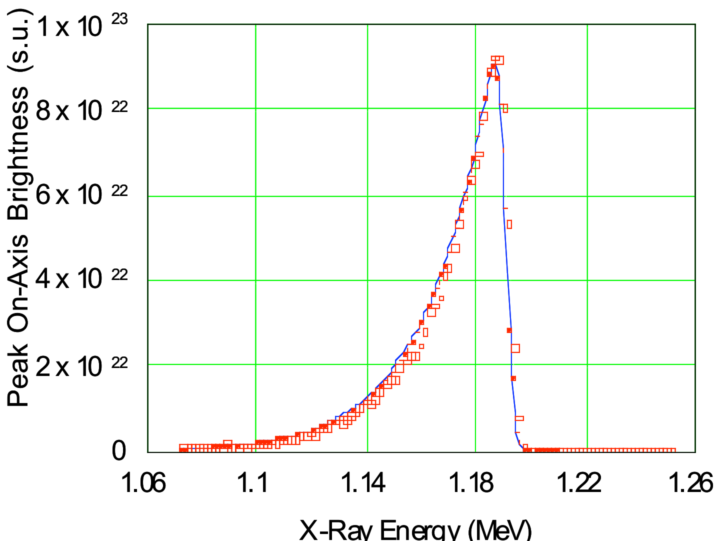
Nuclear Resonance Florescence (NFR) - a highly specific isotope signature.

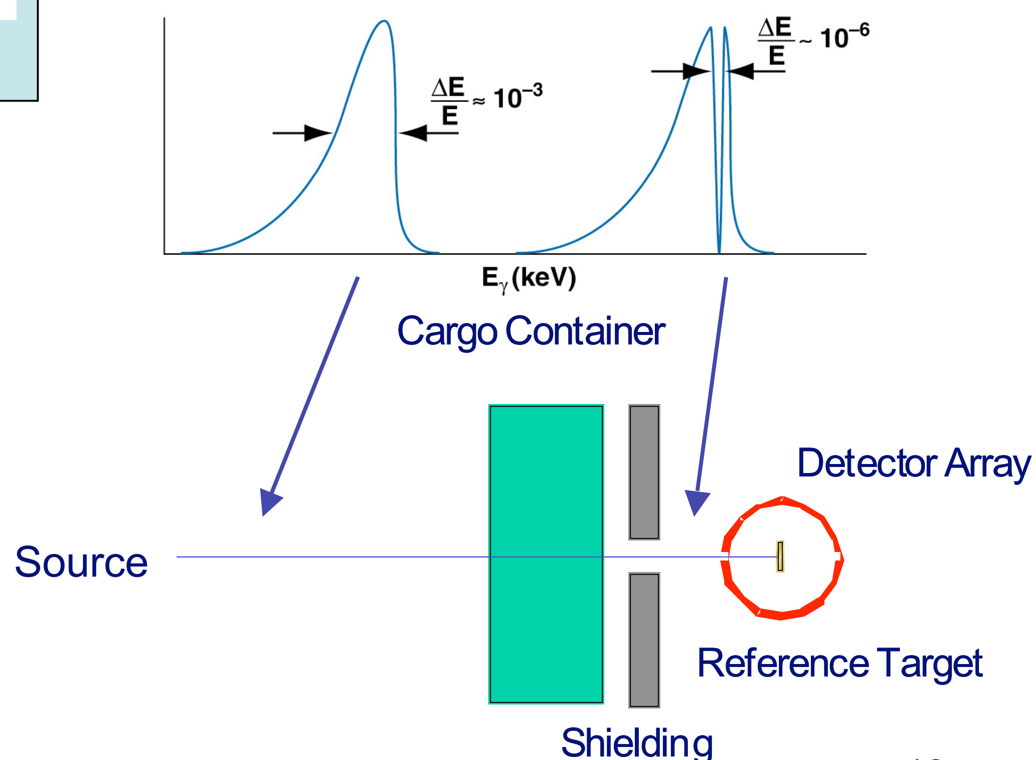


Known resonance energies and widths

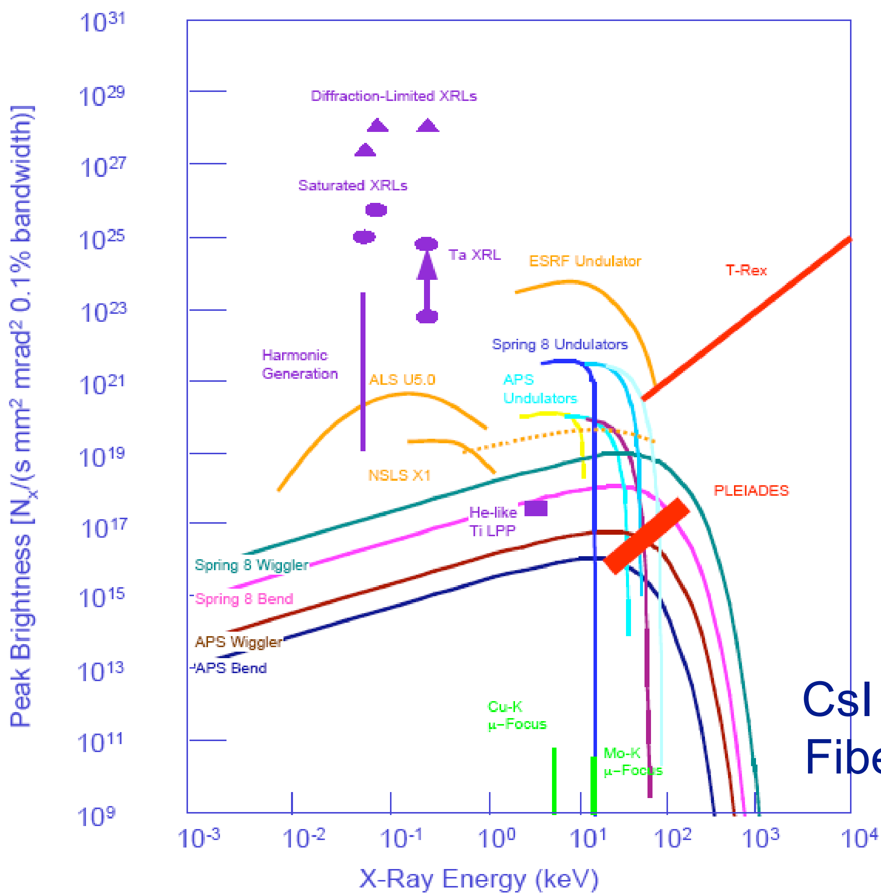
The proposed scheme utilizes a very narrow bandwidth, high brightness gamma-ray source to illuminate a container and determine the presence of a specific isotope.

Narrow bandwidth, bright gamma-ray beams are a possibility borne out of the Inverse Compton Scattering light source program.



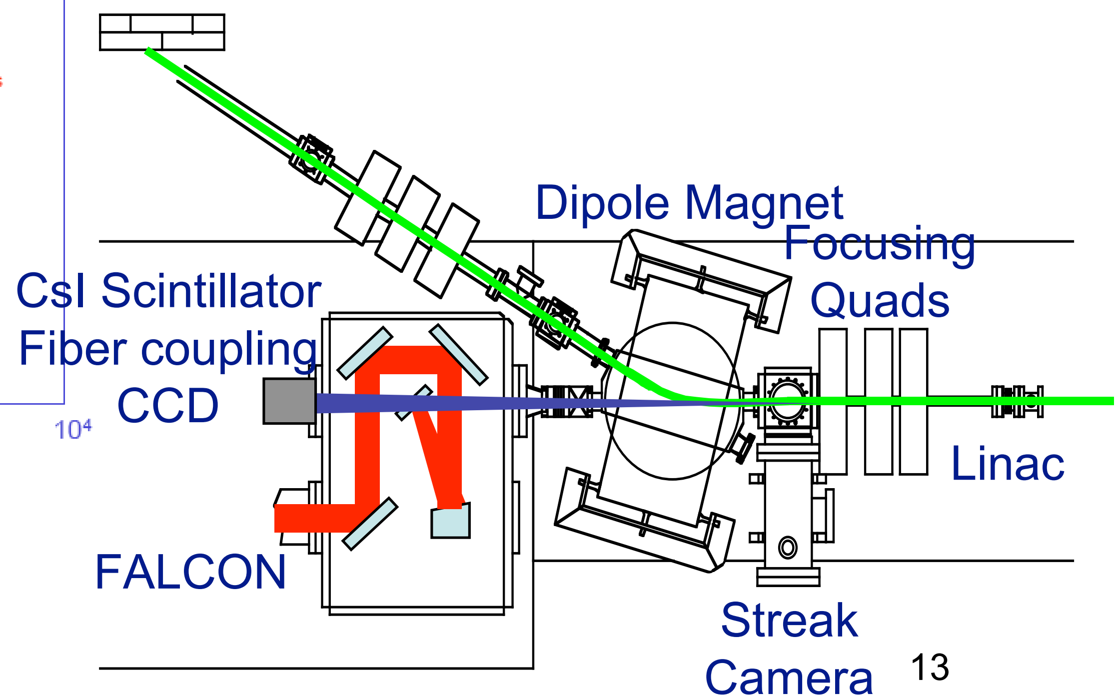


Light Source development at LLNL leads to technology path to produce high intensity gamma-ray light source.



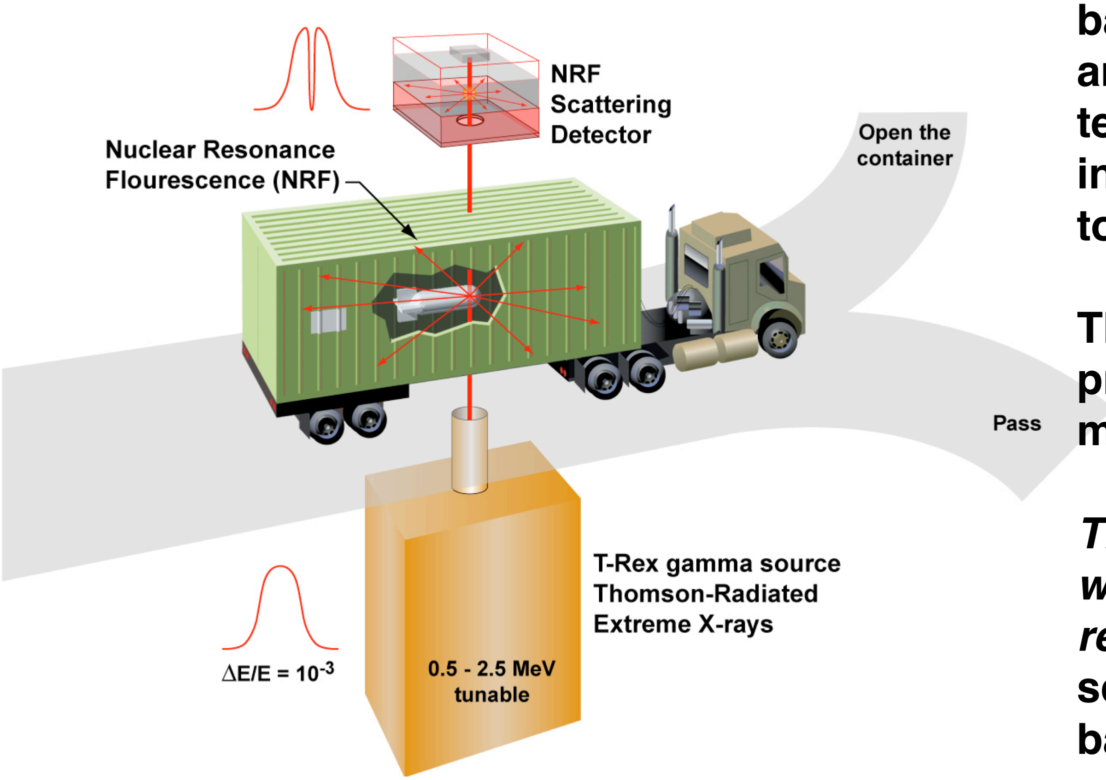
LLNL PLIEADES x-ray source parameters:

Tunable x-ray energy: 15 to 140 keV
Short pulse duration: 300 fs to 5 ps
Collimated: < 10 mrad
Narrow Bandwidth: $\Delta\lambda/\lambda \sim 10\%$
Photon intensity: > 10^7 photons/shot
Brightness: 10^{15} to 10^{17} photons/s/mm^2/mrad^2/(0.1% BW)
Repetition rate: 10 Hz



Ongoing research will determine the effectiveness of this particular method of determining the isotopic composition of material in containers. The enabling light source technologies were developed for other applications from laser and accelerator technologies.

The enabling physics, nuclear resonance florescence states in the 1 to 2 MeV region in actinides, was discovered in the early 1990's by Kneissl, *et al.* in Germany.



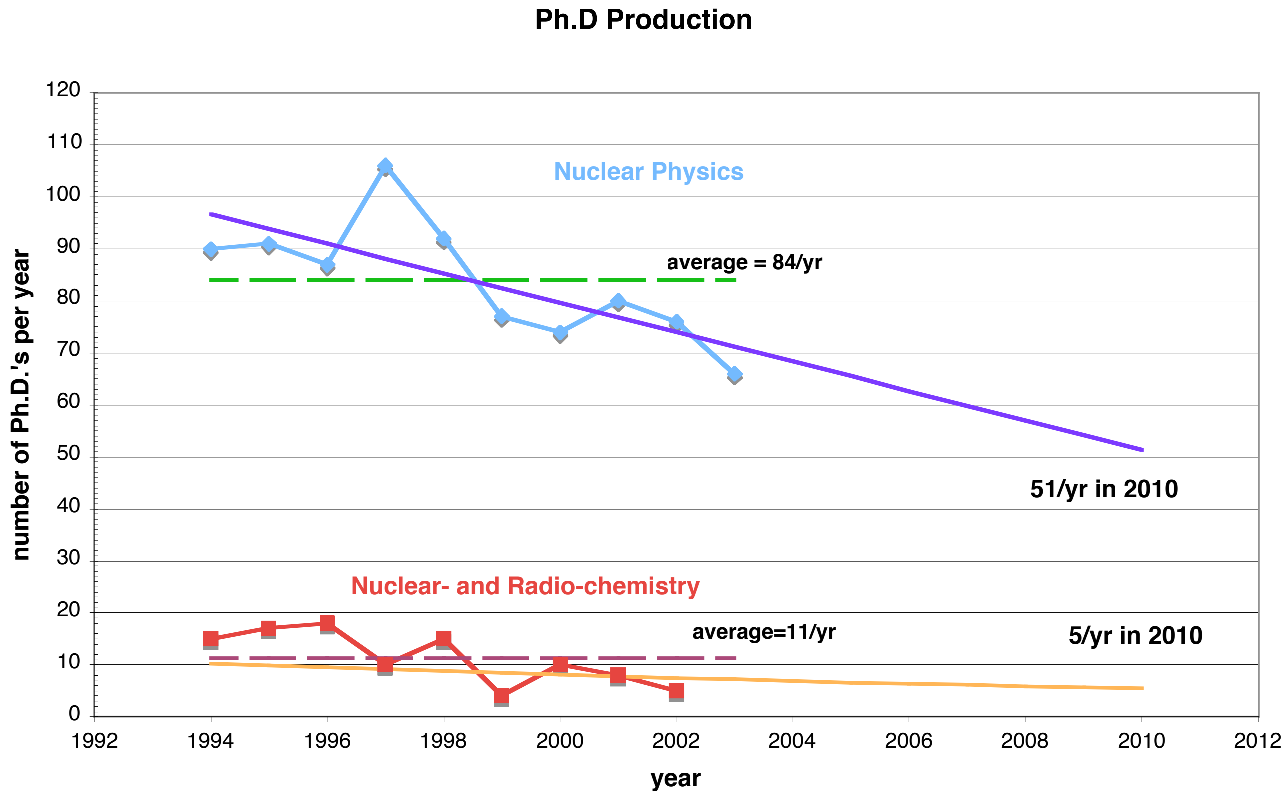
Physicists at LLNL working in basic nuclear physics research, and in laser-accelerator technology development had the ingredients of a possible solution to a national security challenge.

The basic research activity which provided the ingredients was not motivated by the application.

***The essential new knowledge was obtained through basic research*; and applied by scientists working in that area of basic research.**

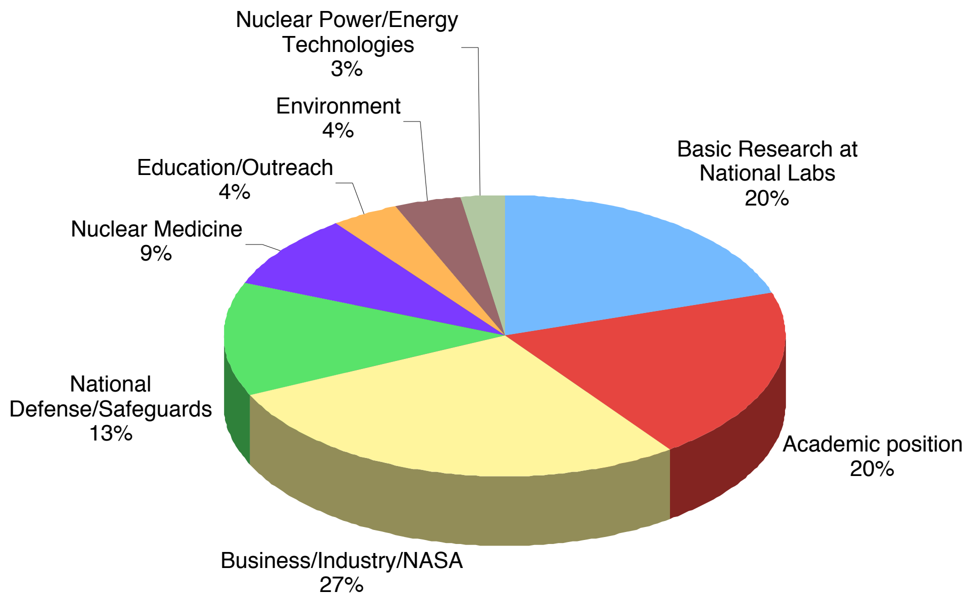
Future prospects and challenges

The application of nuclear science to the radiation detection research and technology development relevant to the national security mission of the DOE and DHS depends on the availability of a workforce trained in nuclear science. The PhD pipeline shows *decreasing* production of PhD's with nuclear science training.



In the next 5 years, LLNL Homeland Security research areas expects to double the number of nuclear scientists engaged in its R&D from 40 to 80.

At the same time the nuclear power/energy technology field is also expected to expand. There is difficulty in finding researchers with the necessary skills to support the increases in Homeland Security R&D.



Nuclear Science Ph.D. careers

Quote from the Augustine Report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*

SECURING THE HOMELAND

Scientific and engineering research demonstrated its essential role in the nation's defense during World War II. Research led to the rapid development and deployment of the atomic bomb, radar and sonar detectors, nylon that revolutionized parachute use, and penicillin that saved battlefield lives. Throughout the Cold War the United States relied on a technological edge to offset the larger forces of its adversaries and thus generously supported basic research. The US military continues to depend on new and emerging technologies to respond to the diffuse and uncertain threats that characterize the 21st century and to provide the men and women in uniform with the best possible equipment and support.

Just as Vannevar Bush described a tight linkage between research and security, the Hart-Rudman commission a half-century later argued that security can be achieved only by funding more basic research in a variety of fields. In the wake of the 9/11 attacks and the anthrax mailings, it is clear that innovation capacity and homeland security are also tightly coupled. There can be no security without the economic vitality created by innovation, just as there can be no economic vitality without a secure environment in which to live and work. Investment in R&D for homeland security has grown rapidly; however, most of it has been in the form of development of new technologies to meet immediate needs.

Human capacity is as important as research funding. As part of its comprehensive overview of how science and technology could contribute to countering terrorism, for example, the National Research Council recommended a human-resources development program similar to the post-Sputnik National Defense Education Act (NDEA) of 1958. A Department of Defense proposal to create and fund a new NDEA is currently being examined in Congress.

CONCLUSION

The science and technology research community and the industries that rely on that research are critical to the quality of life in the United States. Only by continuing investment in advancing technology—through the education of our children, the development of the science and engineering workforce, and the provision of an environment conducive to the transformation of research results into practical applications—can the full innovative capacity of the United States be harnessed and the full promise of a high quality of life realized.

What can be done?

The American Competitiveness Initiative implements some of the recommendations of the Augustine Report.

The Office of Science 20 year facility initiatives contain many proposals important to nuclear physics, e.g. the Rare Isotope Accelerator (RIA).

Better information regarding the nuclear science workforce, especially on future program expansion, e.g. homeland security R&D at the national labs. We do not do a good job forecasting workforce needs.

The National Nuclear Security Agency (NNSA) of the DOE and the Domestic Nuclear Detection Office (DNDO) of the DHS should expand their academic support through programs like the Stockpile Stewardship Academic Alliance Program (SSAAP) of the NNSA.

Auspices Statement

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