From the Discovery of Nuclear Fission to Today's Challenges in Nuclear Energy and Nonproliferation

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Women in Engineering
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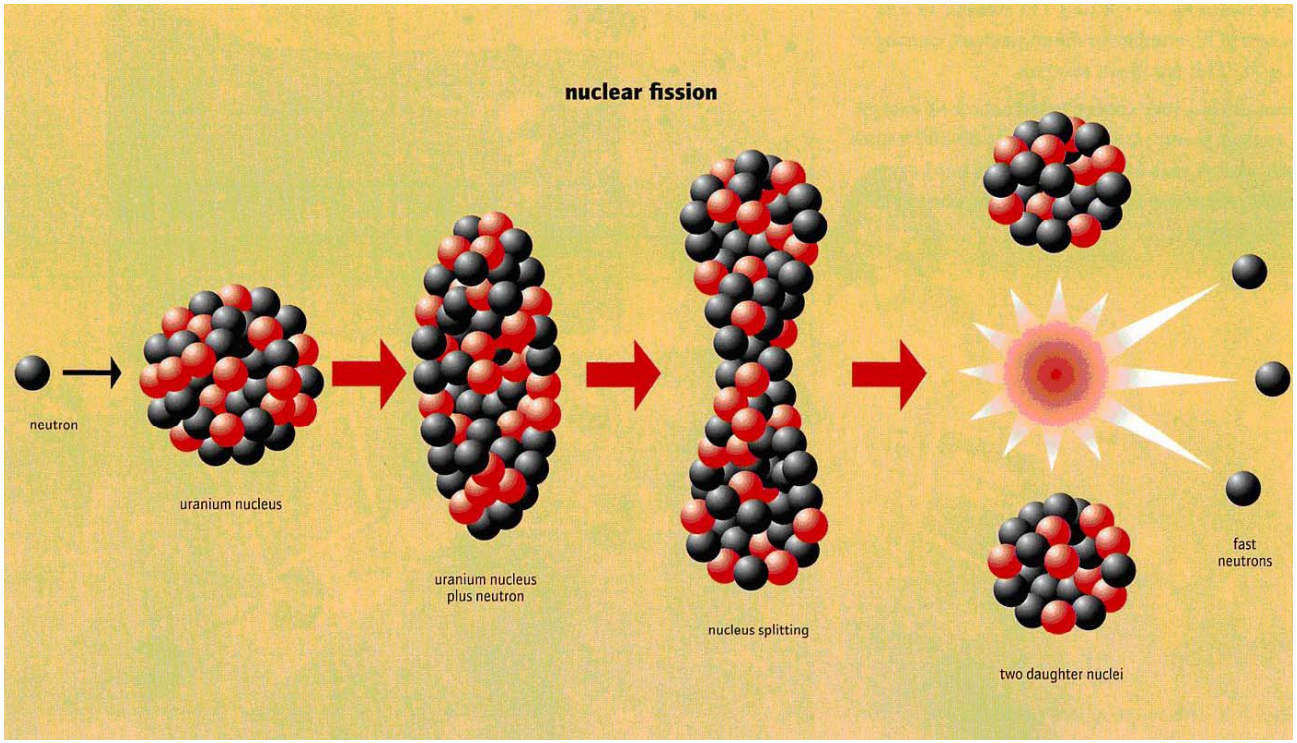
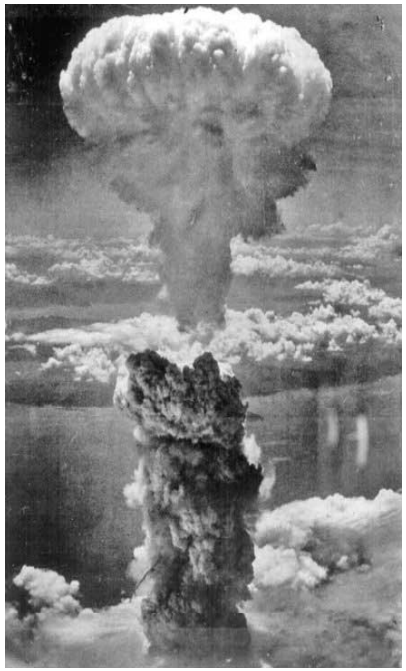
Detection for Nuclear Nonproliferation Group

The Discovery of Nuclear Fission



The Discovery of Nuclear Fission

- One of the most consequential scientific discoveries of the twentieth century: it shaped the world we live in.



Key Players in the Discovery of Fission

Ernest Rutherford
1871 - 1937
Nobel prize:
1908 chemistry

Enrico Fermi
1901 - 1954
Nobel prize:
1938 physics
First nuclear reactor
1942

Otto Hahn
1879 - 1954
Nobel prize:
1944 chemistry

Irene Curie

Ida Noddack

Lise Meitner

Key Players in the Discovery of Fission

The first researcher to achieve nuclear reactions was **Ernest Rutherford.**
But he did not believe in large scale production of energy by nuclear reactions.
He called this idea a “moonshine”.

Several mistakes were made in the process of discovering fission.
Interestingly, it was the men who made mistakes, and the women who corrected them !

Uranium fission with slow neutrons was obtained by **Enrico Fermi in 1932-33**.
However, Fermi did not understand that he induced fission. He thought fission of uranium was impossible.

Irene Curie

Ida Noddack

Lise Meitner

The First Idea of Fission

Ida Noddack

A German physicist, **Ida Noddack,** criticized Fermi's conclusion that the uranium nucleus could not split and she published a paper in 1934 that provided an interpretation of Fermi's experiment in terms of the breakdown of the uranium nucleus.

No one believed her. Fermi considered the possibility but concluded that the breakup of the nucleus was not possible. The reason for his conclusion was the wrong mass values found in the literature at the time.

Otto Hahn and **Fritz Strassman,** were also working on experiments on uranium fission and were able to achieve fission in Berlin, 1938, and were able to measure fission products. They still did not understand that fission had occurred.

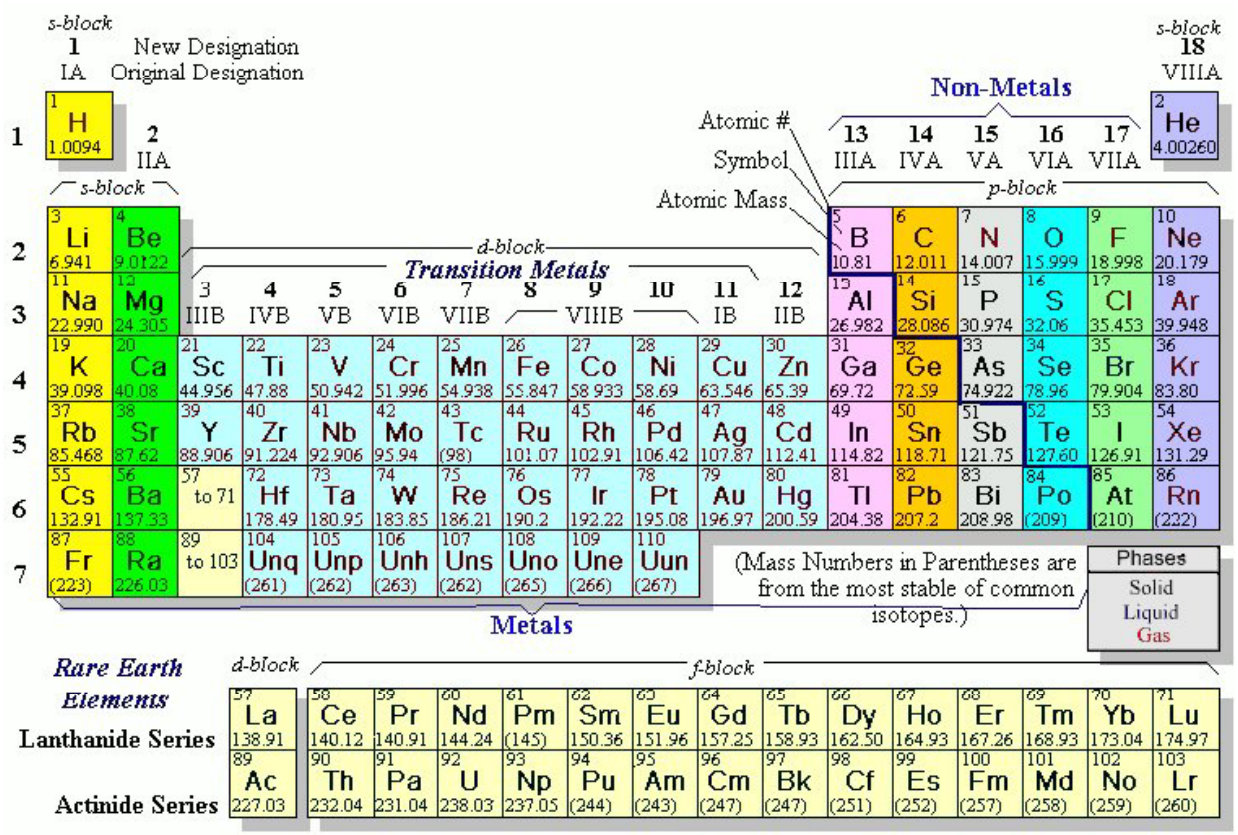
Work on Neutron Bombardment of Heavy Nuclei

Irene Curie

Either alone or in collaboration with her husband, **Jean Curie**, **Irene Curie** did important work on natural and artificial radioactivity, transmutation of elements, and nuclear physics; she shared the Nobel Prize in Chemistry for 1935 with him, in recognition of their synthesis of new radioactive elements.

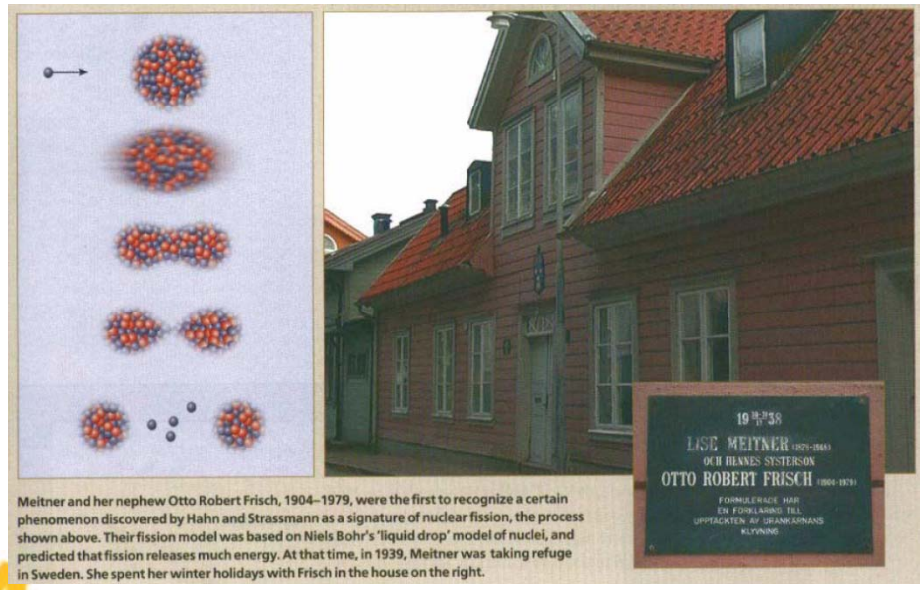
Their work was summarized in their joint paper *Production artificielle d'éléments radioactifs. Preuve chimique de la transmutation des éléments* (1934).

Looking for a Heavy Isotope



The Discovery of Fission

The explanation, based on the theory of the nucleus, was given by another woman physicist, **Lise Meitner.** She was a refugee in Sweden, Stockholm, from Austria. On the morning of Christmas Eve (24 December) 1938, she was visiting with her nephew Otto Frisch in a town near Göteborg, Sweden. While riding on skis, she found the theoretical explanation for fission (the word “fission” was invented just then) and even estimated the amount of energy released in fission.



Meitner and her nephew Otto Robert Frisch, 1904–1979, were the first to recognize a certain phenomenon discovered by Hahn and Strassmann as a signature of nuclear fission, the process shown above. Their fission model was based on Niels Bohr's 'liquid drop' model of nuclei, and predicted that fission releases much energy. At that time, in 1939, Meitner was taking refuge in Sweden. She spent her winter holidays with Frisch in the house on the right.

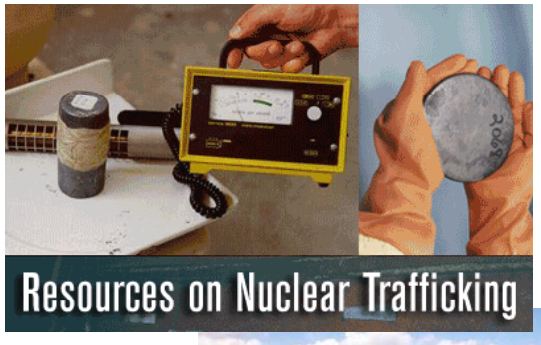
After the War, Otto Hahn received the Nobel prize alone for the discovery of fission**. Lise Meitner** never received that recognition. This fact is still discussed today.

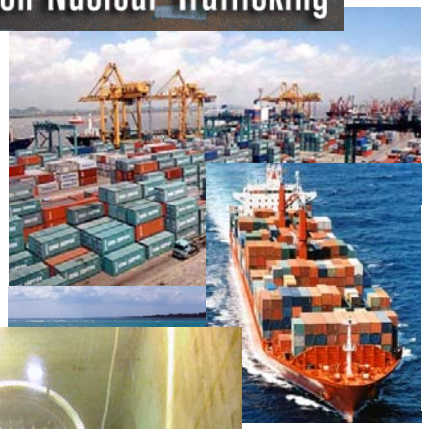
National Security, Nuclear Nonproliferation, and Safeguards

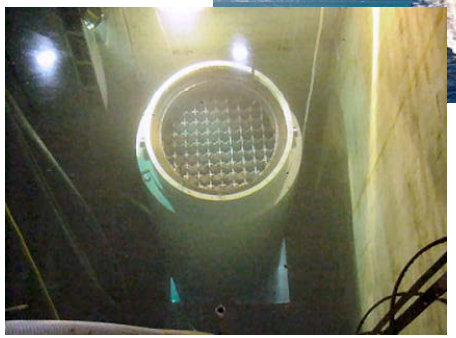
- Today, there is a need to detect, secure, and dispose of nuclear and radiological materials

- The possibility that terrorists might acquire and use nuclear weapons is an urgent and potentially catastrophic challenge to global security

- The resurgence of nuclear power requires advanced materials control and accounting techniques for nuclear fuel reprocessing in order to prevent diversions, ensure safety, and reassure the international community







Detection for Nuclear Nonproliferation Group

Newly established group at the University of Michigan

Group Members

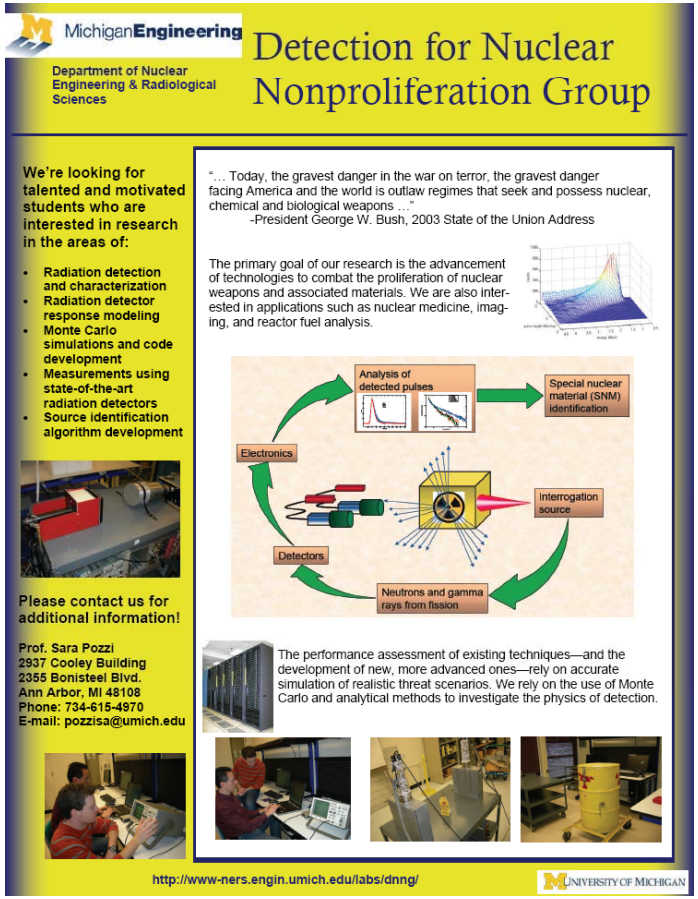
- Marek Flaska, Assistant research scientist
- Shaun Clarke, Postdoctoral researcher
- Eric Miller, Graduate student
- Jennifer Dolan, Graduate student
- Ben Maestas, Graduate student
- Mark Bourne, Undergraduate student
- Scott Ambers, Undergraduate student
- Bill Walsh, Undergraduate student
- Lu Huang, Undergraduate student
- Ben Dennis, Undergraduate student
- Paul Stanfield, Undergraduate student

Collaborations - National

- Vladimir Protopopescu, Oak Ridge National Laboratory
- Alan Hunt, Idaho Accelerator Center
- Donald Umstadter, Univesity of Nebraska
- Peter Vanier, Brookhaven National Laboratory
- John Mattingly, Sandia National Laboratories
- Brandon Blackburn, Raytheon
- Andrey Gueorgueiv, Icx Radiation

Collaborations - International

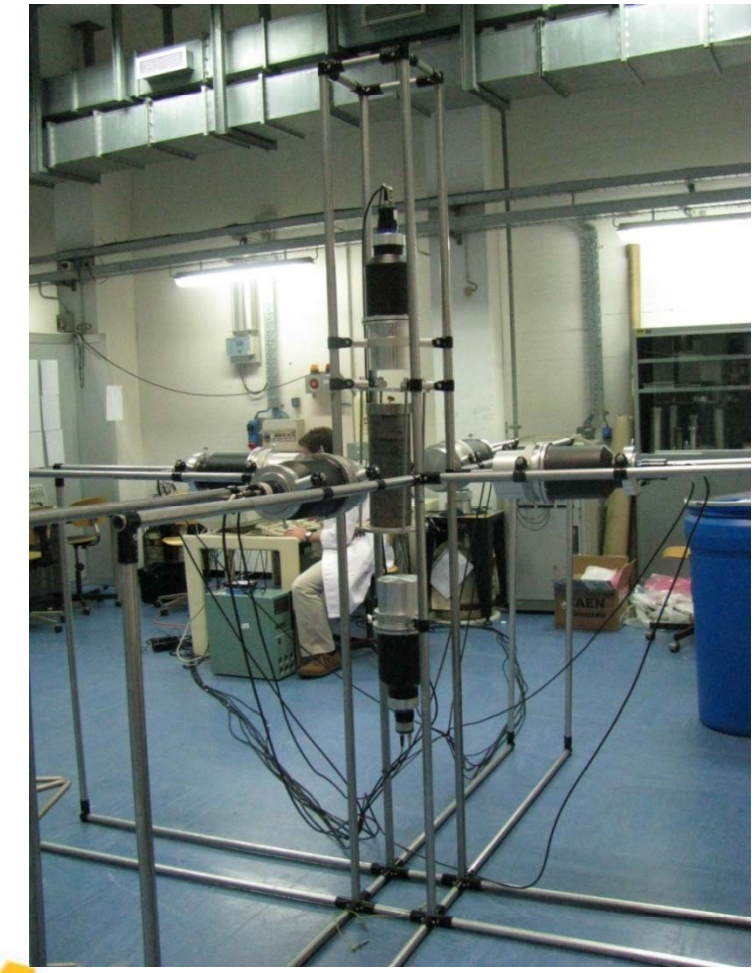
- Imre Pazsit, Andreas Enqvist, Chalmers University of Technology, Sweden
- Enrico Padovani, Polytechnic of Milan, Italy
- Paul Scoullar, Southern Innovation, Australia
- Peter Schillebeeckx, JRC Geel, Belgium
- Senada Avdic, University of Tusla, Bosnia



My in Path in Nuclear

- Milan, Italy
  - Polytechnic of Milan, MS Nuclear Engineering, 1997
  - Polytechnic of Milan, PhD Nuclear Engineering, 2001
- Oak Ridge National Laboratory, Oak Ridge, TN
  - Postdoctoral research fellow, 2002 - 2003
  - Research staff, 2004 - 2006
  - Senior research staff, 2007- 2008
- University of Michigan, Ann Arbor, MI
  - Associate Professor, 2008 - present

Research: Measurements of Plutonium Oxide Samples at the Joint Research Center in Ispra, Italy



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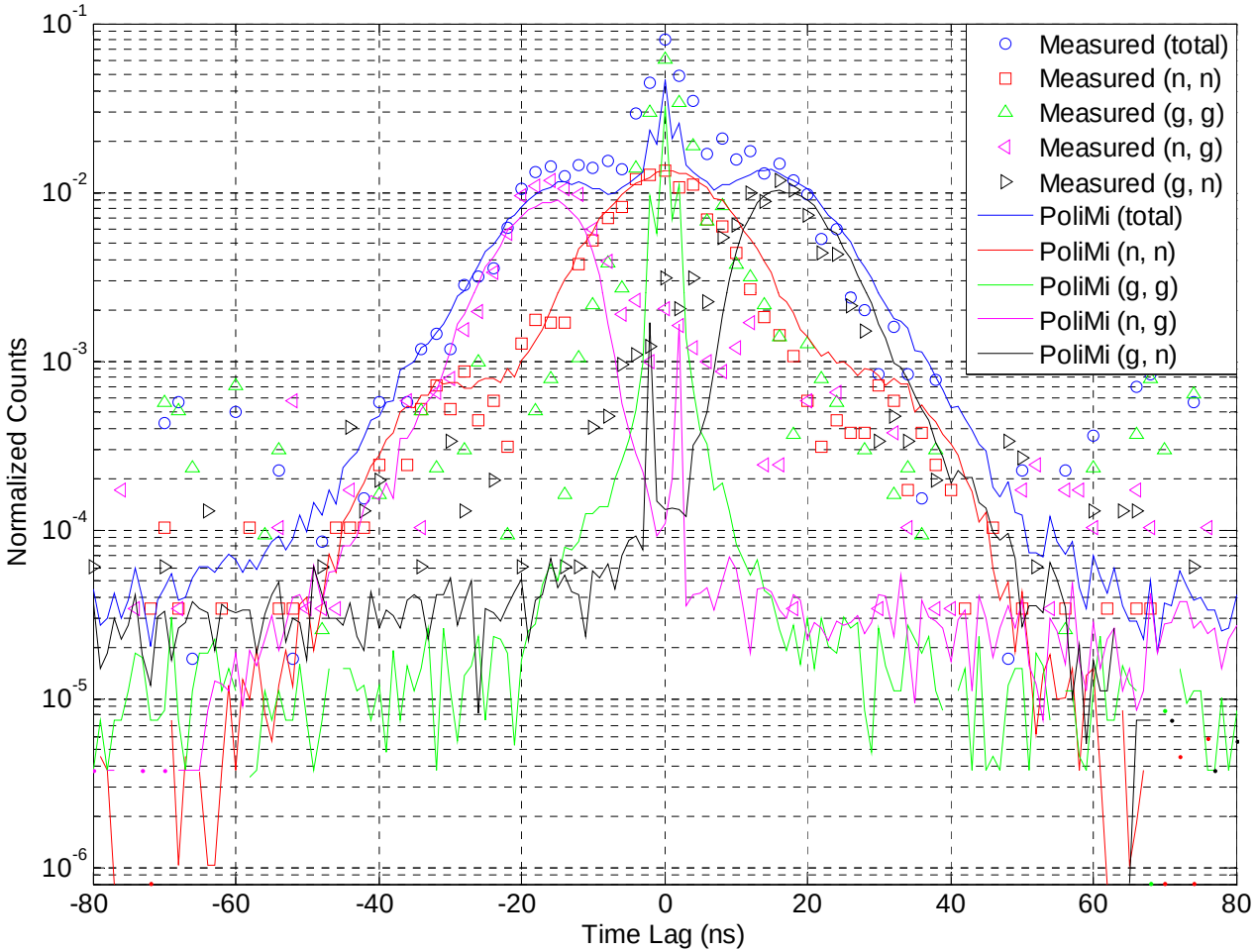

Teaching: Detection Techniques for Nuclear Nonproliferation

- Nuclear nonproliferation; homeland security
- Introduction to the physics of nuclear fission
- Monte Carlo simulations for nuclear nonproliferation applications: MCNP5, MCNP-PoliMi
- Passive and active interrogation of nuclear materials
- Detectors and safeguards instruments

The Second Nuclear Era

Eugene Wigner and Alvin Weinberg

Dr. Alvin M. Weinberg (1915-2006)

- Following the Three Mile Island accident, Dr. Weinberg noted the end of the first nuclear era and expressed his conviction about the emergence of a second nuclear era.
- This second nuclear era will require not only a new generation of reactors with improved safety, reliability, fuel efficiency, but also advanced safeguards and nonproliferation techniques to monitor the nuclear material.

The second nuclear era will only occur with the enthusiastic contributions of the next generation of physicists and engineers.

Women in Nuclear

- There is a rich tradition of women in nuclear

Irene Curie

Ida Noddack

Lise Meitner

It’s up to us to continue the heritage !

References and Contact Information

• Nhu-Tarnawska Hoa Kim-Ngan and Imre Pázsit, The Discovery of Nuclear Fission, Chalmers Reproservice, Goteborg, Sweden, 2007.

• The Discovery of Fission, American Physical Society http://www.aip.org/history/mod/fission/fission1/01.html

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