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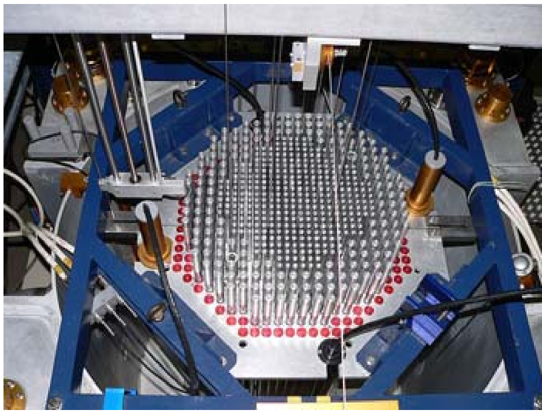
Neutron dance: What happens at the heart of a nuclear reactor?

By Larry Greenemeier | Thursday, April 21, 2011 | 5 comments



As officials in Japan deal with the accumulation of radioactive seawater near the devastated Fukushima Daiichi nuclear power plant in the wake of last month's earthquake and tsunami, the U.S. Department of Energy is investing in fundamental research it hopes can be used to build safer nuclear reactors and avoid reactor emergencies.

The department's Nuclear Criticality Safety Program (NCSP) on Wednesday awarded $1.5 million to researchers at Rensselaer Polytechnic Institute (RPI) in Troy, N.Y., for a new nuclear engineering research program and laboratory dedicated to the careful measurement and analysis of how neutrons interact with different materials around them. Nuclear criticality refers to a sustained nuclear fission chain reaction.

Part of the NCSP's charter is to ensure that nuclear material is stored safely and securely to reduce the threat of a criticality accident, during which an unintended critical reaction releases a dangerous surge of neutron radiation. "Doing this requires calculations of the different scenarios when you store materials," says Yaron Danon, the nuclear engineering professor heading up the research. "Let's say you have a dry cask [of radioactive waste] or you are storing fresh material that hasn't already been used in a reactor. If it's suddenly flooded with water, for example, what will happen?"

Accurate predictions can be made by knowing the basic properties of how the neutrons and gamma rays will interact with the metals, composites and other materials in their surrounding environment. "An analogy: If you want to calculate how an oven will heat, you need to know the heat transfer properties of the materials," he adds. "We are doing the same thing at the level of nuclear interaction."

The hope is that this study of basic nuclear interactions will enable more accurate predictions of energy production and shielding effectiveness in a working nuclear reactor. More specifically, the research is expected to produce data that would, for example, help nuclear scientists and engineers more accurately inventory the amount of fissile material in a given nuclear fuel rod and predict how much energy that rod might release. "This knowledge isn't going to change the design of a reactor dramatically, but it's going to improve it," adds Danon, director of RPI's Gaerttner Linear Accelerator Laboratory.

RPI researchers will use a linear accelerator on campus to produce neutrons for study. The data produced will be available for engineers designing new reactors and facilities as well as those looking at storage issues and disposal of spent nuclear fuel—anyone who deals with neutron interactions with different materials. These probabilities, once measured and validated, will be made public and hopefully used by engineers and scientists around the world as inputs in a wide range of engineering models and simulations.

Image of CROCUS Reactor used for research at the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland courtesy of Rama, via Wikimedia Commons