



2011 World Materials Summit



# Nuclear Energy Panel

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2011 World Materials Summit & Student Address

# Nuclear Energy

Public Perception Drawback-***Fukushima has altered public acceptance and perception of risk associated with nuclear power***

Critical question that affects nuclear deployment: ***Are nations collectively (or individually) ready to adopt measures to control greenhouse gasses?***

- Benefits
  - High power per unit mass of fuel (less mining, less waste)
  - Fuel is cheap, therefore low operations costs
  - No carbon emission during operation (better for climate change)
  - Significant fuel resource, especially if recycled
- Drawbacks
  - Radioactive waste requires long-term monitoring & control
  - Large plants are costly and take time to build (requires confidence in long-term profits thus desire to maximize plant component life)
  - Safety Concerns-Decay heat must be controlled to protect from fuel failure (e.g., Fukushima station blackout)
  - Unique regulatory regime in each country
  - Single large accident anywhere affects future prospects everywhere



## Overview Thoughts from Panel

- Although the approach of individual countries will differ, nuclear power usage is a likely continued source of energy
  - Examples:
    - Germany versus France & Czech Republic, Japan, China & India
    - Light water reactors, Generation IV reactors
  - The relative public acceptance of risk balanced against energy security, informed by the role of specific public policy approaches, in each country will largely determine the specific national response. ***Informing the public and public policy makers on the importance and relative risks of nuclear energy versus other energy sources is critical to getting an informed decision.***
- Meeting materials challenges is a key technology response to provide “safer” nuclear energy, specifically radioactive material control, extended life plant operation, and safety associated with decay heat removal in the extreme case of station blackouts. Solving these issues, possibly through material science solutions, will improve the ability to convince the public to be increasingly accepting of nuclear energy
- The user facility concept, providing access to high-end capability (test reactors, synchrotron light sources, neutron scattering sources) that can handle radioactive materials is critical and, in conjunction with advanced modeling opportunities, offers a new paradigm for advancing the insight into radiation damage while simultaneously motivating a next generation workforce.



# Likelihood of Nuclear Energy

## Key policy questions

- Do we need to advocate for modern technology, even knowing it comes with an increased cost (e.g., would you let your mom drive down I-95 in a model-T or buy her a modern car with air bags and a hands free phone, given the model-T is paid for)
- Can public policy makers be informed enough to avoid “shifting the scale” during the accident as this shifting leads to the belief that we don’t understand the technology (true for nuclear as well for oil spills and blown up oil fields)
- Can we set international standards of collaboration (visa policy, technical exchange rules under export control, funding opportunities that cross country barriers) to optimize use of resources and to facilitate a common language regarding the technology (e.g., why is the U.S. setting a larger evacuation zone for its citizens in Japan than the Japanese government is setting for its own citizens)
- Can international cooperation be a focus of the study on safer, proliferation-resistant, economic, and waste-minimized reactor systems as embodied in the Generation IV program definition or the fusion programs? How does a commercial company like TerraPower build a Generation IV system working globally?



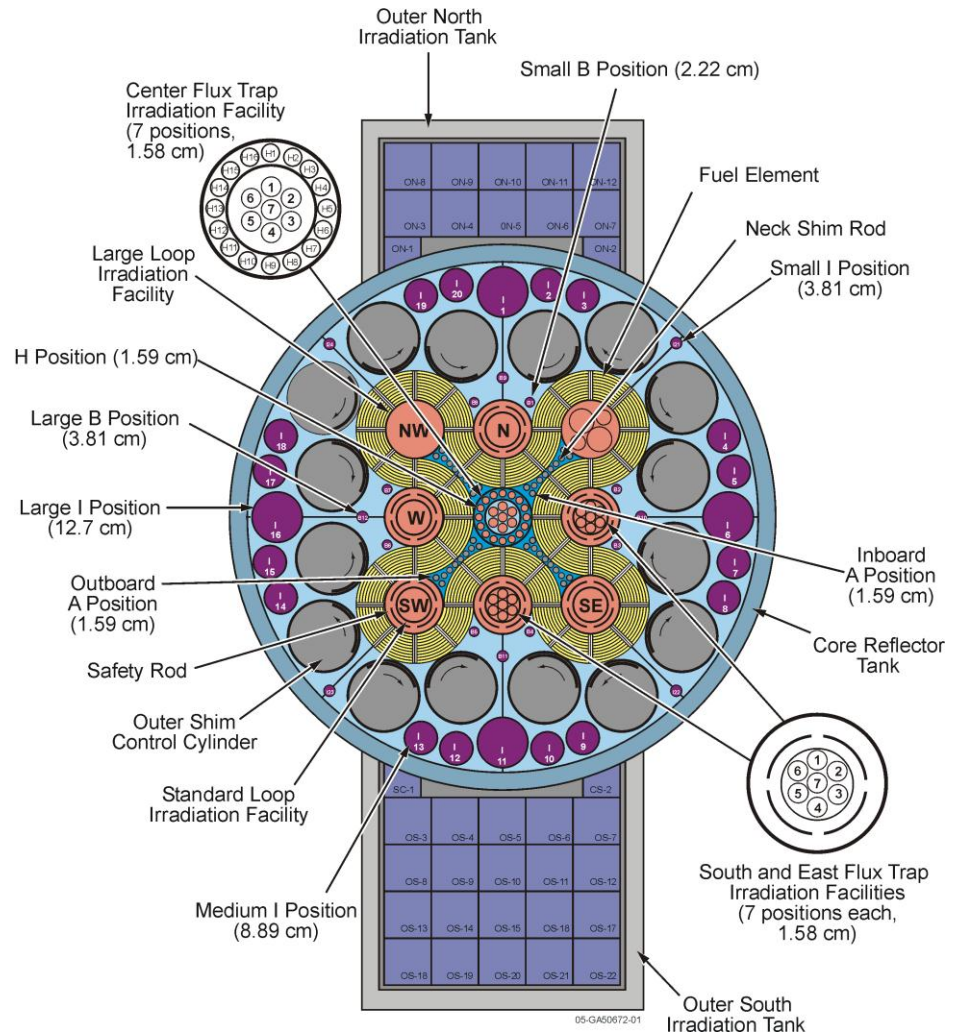
## Material Science Challenges

- Public policy makers typically balance the opinion of technologists who advocate a technical solution (you) and the general public (my mom) who benefit and are affected by the technology choice.
- Informing public policy makers of the ability of material science to mitigate challenges of nuclear energy has the ability to change the balance of that decision, specifically if you change the state of the technology. Examples:
  - Developing a waste form that contains radioisotopes to an acceptable level
  - Providing material science solutions that meet safety requirements for extended lifetimes, including LWR and Generation IV systems. Generation IV systems such as sodium systems have been shown to be inherently safe against loss of cooling but are still too expensive to compete with LWRs, advanced materials may reduce costs
  - Developing cladding materials (e.g., other than zirconium-base materials) that mitigate hydrogen explosions while minimizing changes to reactor operations
  - Continuing non-proliferation research as an international imperative (assay, detection, proliferation resistant fuel cycles) to the safer deployment of nuclear systems
- Access to a fast(er) neutron source is critical for both future advanced fission and fusion system development



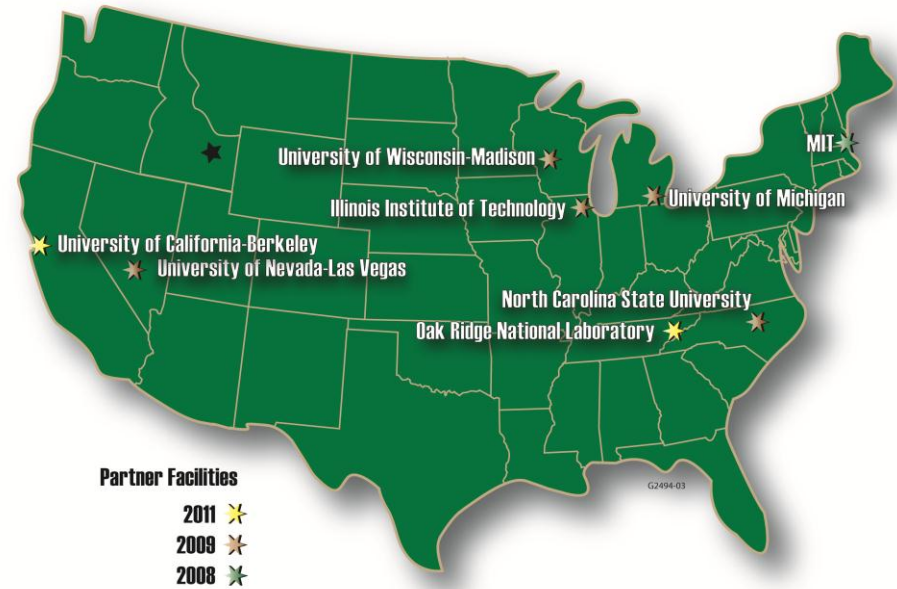
# ATR NSUF

- Mechanical properties
  - Nanoindenter/AFM
  - Small sample mechanical testing
  - Automated micro-hardness tester
- Analysis at micro- and nano-scale
  - FEG-STEM-chemical and structural analysis at the nano-scale
  - Atom Probe-identify single atoms (few in world available for use on radioactive material, none on fuel)
  - Raman spectroscopy-light scattering to understand atomic structure
  - SEM hot stage-real time analysis of changes in structure due to temperature
- Sample Preparation
  - Dual-beam FIB #2
- Fuel Examination
  - Consolidated Fuel Exam Machine feasibility study-would save space in HFEF



# Collaboration

- University Partner Facilities
  - MIT (MIT Reactor)
  - Illinois Institute of Technology (Advanced Photon Source)
  - University of Wisconsin (Characterization Lab for Irradiated Materials)
  - University of Michigan (Irradiated Materials Testing Lab)
  - NCSU (Pulstar Reactor)
  - UNLV (Electron Microscopy Laboratory)
  - UC-Berkeley
  - Collaboration with Oxford University



## National User Facilities:

- **Advanced Photon Source**
- **SHaRE**
- **LANSCE, NIST**

Expansion to include major facilities in France, Japan, China, India, and other countries with significant nuclear research infrastructure would be optimal



# User Facility Concept

- Traditionally, major facilities have resisted accepting the burden of working with radioactive materials. Changing that mindset allows the application of modern material science to nuclear energy materials issues (e.g., modeling and experiment at the same time and length scales)
- The costs of working with radioactive materials is costly so the user facility model allows for anyone with the best idea is allowed access to necessary capability
- Once the U.S. establishes the ability to analyze radioactive materials routinely in user facilities, the next logical step would be to take that international (e.g., routine access to fast reactor irradiation space in India for U.S. scientists and routine access to BES user facilities in the U.S. for Indian scientists)
- Scientists can prove the use of user facilities across funding agencies, proving to policy makers the value, without the need for formal arrangements (DOE NE and DOE BES facilities)
- Mechanisms for international partnerships need improvement
  - Coordinated funding or equipment sharing mechanisms involving international agreements
  - Student exchanges & travel support
  - Removing barriers to export control, & improvements in visa approval time
  - ***Is the ITER (or CERN) model relevant to designing Generation IV systems***



# Key Elements: Nuclear

- To take advantage of the carbon free generation possible through the use of nuclear energy, nuclear systems must continually strive for improved safety, acceptable economics, reduced proliferation, and minimization of the waste stream. Improvements in materials technology, and the subsequent informing of the public and public policy makers of the improvements, is critical to meeting this improvement goal. Of specific note is the need to evaluate, analyze, interpret, and respond, via materials improvements, to the specific safety challenges identified in the Fukushima accident.
- Building active collaborations among the countries performing nuclear research will expedite material solutions. Providing mutual facilitated international access coupling the best scientific ideas with unique capabilities such as test reactors, and synchrotron and neutron scattering sources that can handle radioactive materials, is critical. In conjunction with advanced modeling opportunities, the “user facility” model offers a new paradigm for advancing material performance while simultaneously motivating a next generation workforce.

