Securing a Strong Workforce for the Next Generation of Reactors

THE UNIVERSITY OF
TENNESSEE
KNOXVILLE

DEPARTMENT OF
NUCLEAR ENGINEERING

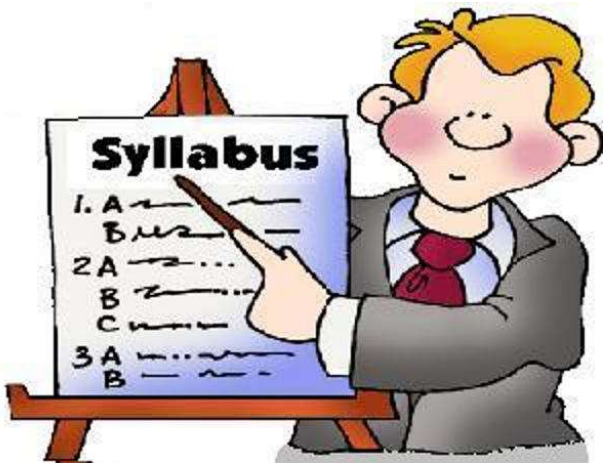
3/16/2022

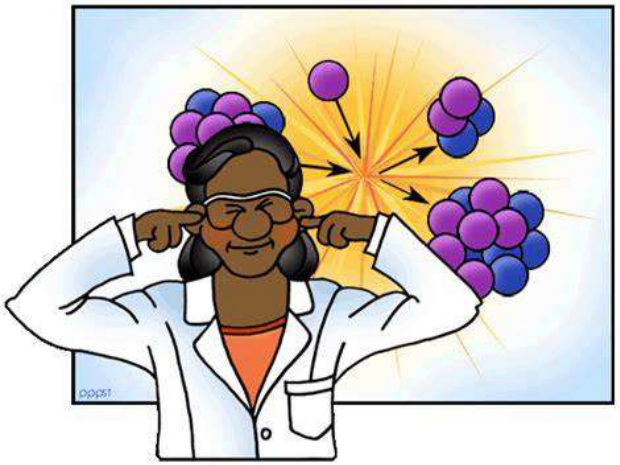
Study Nuclear Engineering: Save the World

NUCLEAR ENGINEERING

Outline/Thoughts

- What are the educational resources that can be focused?
  - –Faculty
  - –Curriculum
  - –Research
  - –Facilities





UTNE Department Overview

- Department **founded in 1957, and is the first NE Department in the US.**
- Offer BS, MS, PhD degrees in two tracks
  - Traditional nuclear power engineering
  - Radiological engineering (health physics and medical physics)
- Undergraduate Student Demographics:
  - 40% Out of State
  - 98% US Citizens
  - 20% Female
  - 37% Non-white
- Close relationship with ORNL and Y-12
- Large NE Department:
  - #1 in PhD Students (ASEE 2020)
  - #2 in BS Students (ASEE 2020)
- Scholarly NE Department
  - #3 in Scholarship (Academic Analytics)
  - #4 in Federal Research Expenditures/FTE (ASEE 2020)

Upon Graduation:

- ~50% go to graduate school

New NE Faculty

Vlad Sobes

Research Interests
- Nuclear Data with a particular interest in the application of Artificial Intelligence
- Sensitivity/Uncertainty (S/U) analysis methods

Previous Appointment
- Research Scientist, Oak Ridge National Laboratory

Education
- PhD, Nuclear Science and Engineering, Massachusetts Institute of Technology

Sandra Bogetic

Research Interests
- Numerical methods for neutral particles
- Applications in reactor design, shielding, and nuclear security and nonproliferation

Previous Appointment
- Postdoctoral Researchers at Lawrence Livermore National Laboratory

Education
- PhD Nuclear Engr. University of California, Berkeley

Livia Casali

Research Interests
- Fusion: experimental and computational modeling, leads Core-Edge Integration at GA
- Impurity seeding, diverter optimization, edge core modeling, etc.

Previous Appointments
- Staff Scientist General Atomics

Education
- PhD Max Planck Institute for Plasma Physics, Germany

High Impact Practices

(National Survey of Student Engagement--NSSE)

Community Based Learning (student society 55%)

Study Abroad On Hold

Formal UTNE Curriculum

Undergraduate Research (64%)

Minor (58%)

Senior Design (100%)

Internships and Co-Op (45%)

Q: Where are the high-impact practices located?

A: Experiential co-curricular

George Kuh, *High Impact Practices: What are they, who has access to them, and why they matter*. (AAC&U, 2008)

Nuclear Engineering Related Minors

A Minor in Nuclear Engineering increases knowledge, expertise, and employability. (58%)

Concepts of Cybersecurity Minor

- ECE 461 - Introduction to Computer Security
- ECE 462 - Cyber-Physical Systems Security
- *NE 362 - Numerical Methods and Fortran*
- *STAT 251 - Probability and Statistics for Scientists and Engineers**
- *NE 351 - Nuclear System Dynamics, Instrumentation, and Controls*

(1)

Nuclear Decommissioning and Environmental Management

- NE 404 Nuclear Fuel Cycle
- *NE 433 or NE 233 Principles of Health Physics*
- CE 340 Construction Engineering and Management I
- *NE 406 Radiation Shielding*
- NE 542 Management of Radioactive Materials

(3)

Reliability and Maintainability Engineering Minor

- *NE 401 - Radiological Engineering Laboratory*
- NE 483 - Introduction to Reliability Engineering
- NE 484 - Introduction to Maintainability Engineering
- *STAT 251 - Probability and Statistics for Scientists and Engineers**
- *NE 351 - Nuclear System Dynamics, Instrumentation, and Controls*

(3)

Nuclear Safety Minor

- NE 360 - Reactor Systems and Safety
- NE 402 - Nuclear Engineering Laboratory
- *NE 486 - Nuclear Licensing*
- *NE 421 - Introduction to Nuclear Criticality Safety*

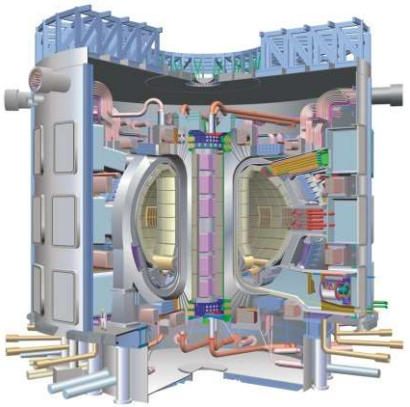
(5)

(2 MSE, 1 Math, 1 AERO, 1 BIO, 1 Physics)

- **Can be fulfilled by proper selection of technical electives and will not require additional courses.**

Advanced Nuclear Research Areas

- **Nuclear Reactor Fuels and Materials**
  - Accident tolerance
- **Nuclear I&C, Reliability, and Safety**
  - Advanced reactor automation
- **Nuclear Fuel Cycles**
  - Cradle to grave: Decommissioning
- **Advanced Modeling and Simulation**
  - Improving nuclear data
  - Safety analysis
- **Radiation Detection and Measurement**
  - Supporting safeguards and non-proliferation
- **Nuclear Fusion Technology**
  - Plasma–Material Interaction



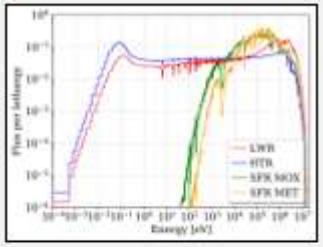
New Engineering Complex

- Goal: Provide ***state of the art*** Nuclear Engineering facilities with **unique** research capabilities
- 228,000 GSF at $129M
- Opened for classes in August 2021.
- 23 New NE Laboratories including LINAC, Radiochemistry Teaching Lab, FNS,…

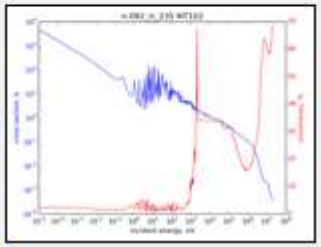
Fast Neutron Source Experimental Facility

John Pevey, Vlad Sobes, Ondrej Chvala, Wes Hines

Fast Reactor Cross Section Needs



Fast flux cross sections for materials used in advanced reactors have high uncertainties resulting in more conservative design which will make plants more expensive and less competitive.



** "The uncertainties of many parameters are higher than is desired, motivating additional efforts in cross section measurements, improved data evaluations, and data assimilations."*

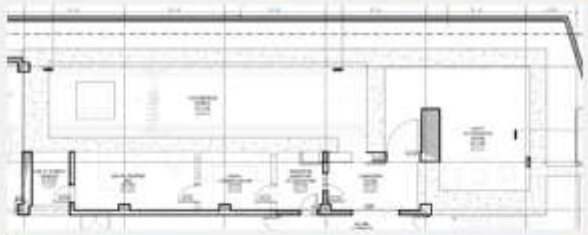
*N. Touran and J. Yang, "Sensitivities and Uncertainties Due to Nuclear Data in a Traveling Wave Reactor," Proceedings of the PHYSOR 2016 Meeting in Sun Valley, ID, May 2016.

Support Fast Reactor Developers

Objectives

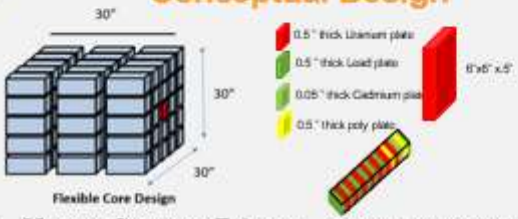
- Deliver to the nation, a Fast Neutron Source experimental facility that supports advanced fast reactor concepts, through improved cross sections and neutronics codes for advanced reactor design and licensing.
- Design, license, construct, and test a flexible facility that can be used to measure nuclear physics properties in multiple specific fast reactor flux spectra: eg. Salt, Lead, or Sodium

New Nuclear Engineering Building

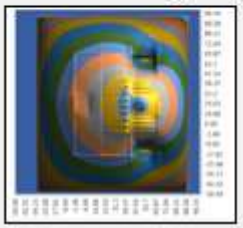


Facility and shielded vaults under construction and opening Summer 2021

Conceptual Design



- Neutron Generator Driven
- Subcritical (k_{eff} = 0.95)
- Thermal-fast coupled system
- Flexible Cassette Design
- Oscillator for Integral Cross Section measurement

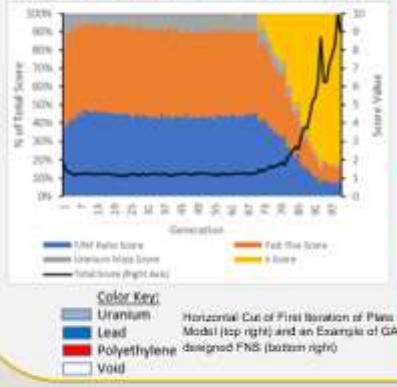


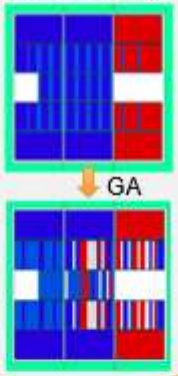
Fast Flux

Thermal Flux

Genetic Algorithm Optimized

Optimize the design of the core for a specific desired neutron spectrum (advanced reactor design) while reducing the required fuel mass from 3500 to 1700 lbs. and increasing flux.





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Pevey J, O. Chvála, S. Davis, V. Sobes, and J.W Hines, "Genetic Algorithm Design of a Coupled Fast and Thermal Subcritical Assembly" Nuclear Technology, Oct. 2019,
DOI: 10.1080/00295450.2019.1666599

Working with Industry