Prof. Sara Pozzi  
Dr. Marek Flaska  
Dr. Shaun Clarke  
Dr. Syed Naeem  
Alexis Poitrasson-Rivière (GSI)  
Kyle Polack (GSI)  
http://www-ners.engin.umich.edu/labs/dnng/

Requirements:  
- Personal laptop (can be shared if needed); MCNP5/MCNPX and MCNPX-PoliMi RSICC licenses (please request them ASAP at http://www-rsicc.ornl.gov/); MATLAB access  
- Class attendance is mandatory

Textbooks and study materials:  
3. MCNP5/MCNPX and MCNPX-PoliMi manuals  
4. Course handouts and notes

Grading:  
60% laboratory reports  
20% laboratory presentation  
20% final exam (17-Dec-12, 16.00)

All laboratory reports are due at the start of class on the specified due date. Late reports will be penalized 10% for every day past the deadline.

NOTE: Lab reports are limited to 10 pages. Any content past page ten will not be read.

Honor Code:  
Laboratory experimental work is collaborative. However, all data analysis and report writing is to be done individually. The laboratory presentation will be a collaborative assignment. The final exam will be completed individually.

Office Hours (GSIs):  
Times: Tuesday, Thursday 1:00 – 2:00 p.m.  
Room: ERBII 1213  
E-mails: alexispr@umich.edu  
          kpolack@umich.edu

Format:  
Weekly lectures, 2 hours per week on Mondays.  
5 laboratories (4 measurement labs and 1 simulation lab). Laboratory meets during scheduled class period on Wednesdays.
Syllabus (Lectures are shown in bold)

**Week 1**
Nuclear nonproliferation; homeland security
Introduction to the physics of nuclear fission (Knoll Ch. 1)
- Spontaneous/neutron induced fission
- Fission chain multiplication, Rossi alpha
- Neutron and gamma-ray sources (PANDA Ch. 11)
- Neutron and gamma-ray multiplicities
- Delayed neutrons and gamma rays
- Special nuclear material (plutonium and uranium)

**Weeks 2-3**
Introduction to Monte Carlo simulations for nuclear nonproliferation applications
MCNP5/MCNPX, MCNP-PoliMi (*MCNP5 manual Vol. 1 Ch. 1*)
Passive detection of nuclear materials
- Neutron measurement techniques
- Gamma-ray measurement techniques

**Laboratory 1: Introduction to Monte Carlo Simulation Techniques (3 weeks), due 10 October**
1.1: Gamma Spectroscopy with MCNPX
1.2: Gamma Spectroscopy with GEANT4
1.3: Gamma Spectroscopy Validation Measurement

**Weeks 4-11**
Detectors and safeguards instruments (PANDA Ch. 14)
- He-3 detectors, gamma-ray detectors (Knoll Ch. 14.III.B.6 and Ch. 12, PANDA Ch. 17)
- Liquid and plastic organic scintillation detectors – fast-neutron scattering (Knoll Ch. 8.1.A, 8.1.B and 15.III)
- Boron-loaded and lithium-glass scintillators – neutron collisions and capture mechanism (Knoll Ch. 14.II.F and 15.II.A.2)
- Pulse-shape discrimination between neutrons and gamma rays (Knoll Ch. 8.1.C, and 15.III.B.6)
- Cross-correlation and bi-correlation measurement techniques

**Laboratory 2: Gamma-Ray Enrichment Measurements (2 weeks), due 24 October**
2.1: Uranium Enrichment Measurement
2.2: Enrichment Measurement Analysis using MCNPX (or GEANT4)

**Laboratory 3: Organic Liquid Scintillator Measurements (2 weeks), due 14 November**
3.1: Simulation of Neutron Pulse Height Distributions from Liquid Scintillators with MCNPX-PoliMi (or GEANT4)
3.2: Liquid Scintillator (EJ-309) Calibration and PSD Development
3.3: Measurement of Mixed Neutron/Gamma-ray Pulses using a Liquid Scintillator

**Laboratory 4: Time-of-Flight Spectroscopy (3 weeks), due 28 November**
4.1: Time-of-Flight Simulations with MCNPX-PoliMi (or GEANT4)
4.2: Time-of-Flight and Cross-Correlation Measurements with $^{252}$Cf
4.3: Time-of-Flight Characterization of a D-D Source
Weeks 12-13
Active interrogation nuclear materials
- Active interrogation with neutron sources
- Active interrogation with photon sources
- Photonuclear physics overview

Laboratory 5: Active Interrogation with a Bremsstrahlung Source (2 weeks), due 11 December
  5.1: Simulation of bremsstrahlung photon sources
  5.2: Simulation of active photon interrogation of HEU

Week 13
Presentations and final exam preparation
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<td>Course Introduction and Intro to MC + Dice Example</td>
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<td>Radiation Safety Training</td>
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<td>Lab 1.1 - Introduction to MCNP</td>
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<td>Lab 1.2 - Introduction to GEANT4</td>
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<td>DNNG Measurement System Intro</td>
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<td>Wed, 26-Sep-2012</td>
<td>Lab 1.3 - Validation Measurement (NaI)</td>
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<td>Mon, 01-Oct-2012</td>
<td>Sources, Materials, and Gamma-Spec Enrichment Measurement</td>
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<td>Wed, 03-Oct-2012</td>
<td>Lab 2.1 - Enrichment Measurement (HPGe)</td>
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<td>Neutron PHDs and MCNPX-PoliMi Intro</td>
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<td>Lab 3.1 - Neutron Pulse Height Distribution Simulation</td>
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<td>Lab 3.2 - Liquid Scintillator (EJ309) Calibration and Pulse Shape Discrimination</td>
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