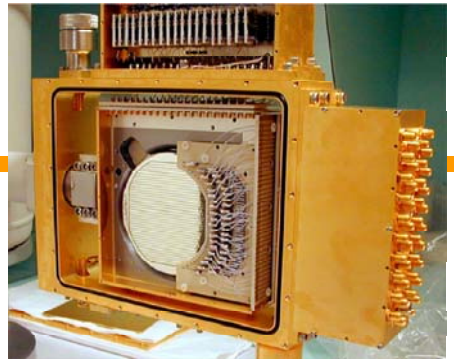


# UT Nuclear Engineering and Next Generation Safeguards


**Prof. Jason Hayward**

**University of Tennessee Nuclear Engineering**

**Oak Ridge National Laboratory**


Nuclear Engineering

# *Overview*

- **Brief overview of UTNE department**
- **Recent participation of NE 403 and 550 at ORNL's Safeguards Lab**
- **New INMM student chapter at UT**
- **New Graduate Certificate in Nuclear Security Science & Analysis to be offered in Fall 2009**
- **Recent safeguards & security research done by UTNE students & faculty**
- **Future research interests related to radiation detection and process monitoring**

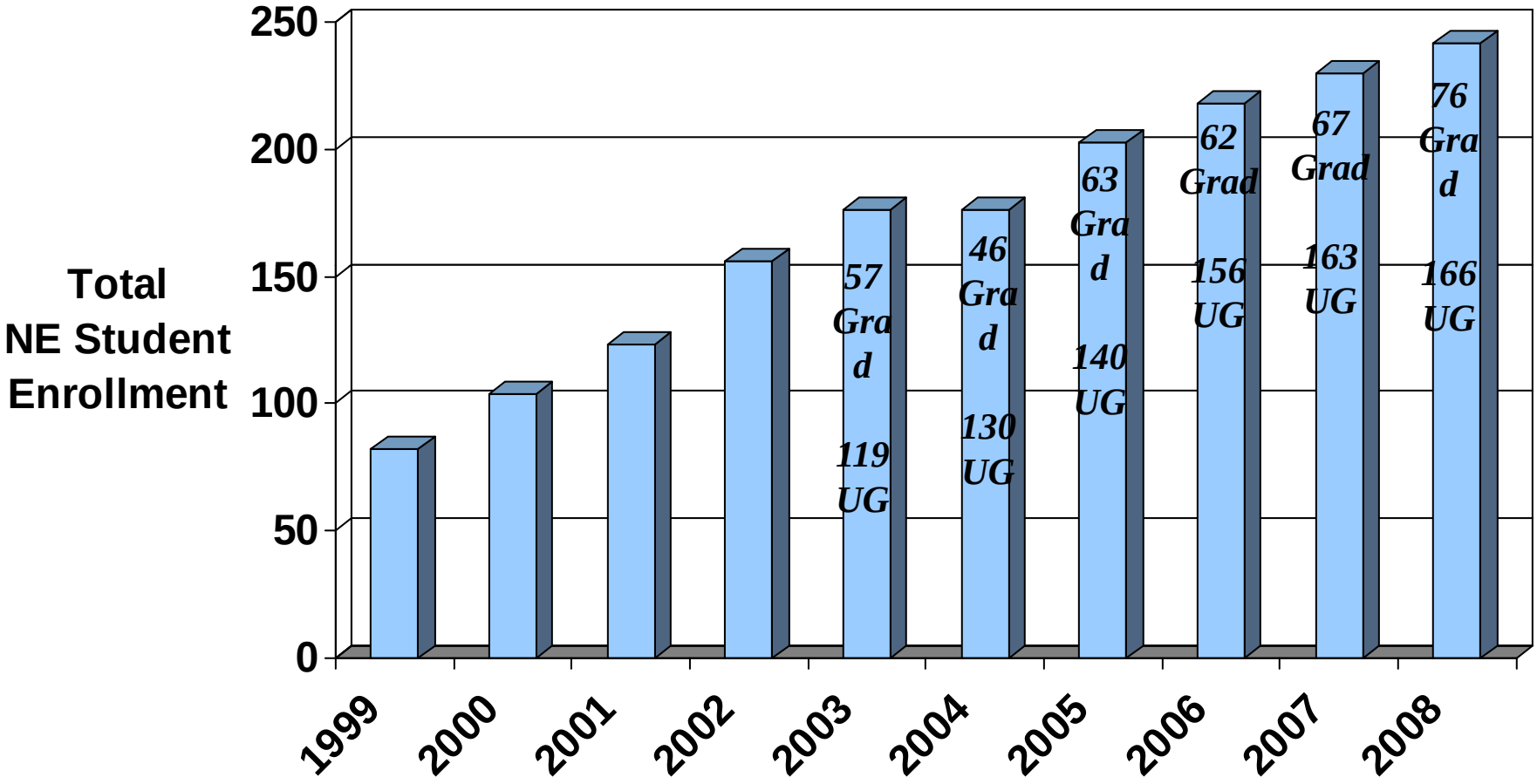
# *Faculty, Staff, and Facilities*

- **Faculty**
  - Hired 4 new faculty members in the past year; UTNE now has 11 Tenured/Tenure Track faculty members
    - 2 of 11 are joint with ORNL (60% UTNE; 40% ORNL)
    - 1 of 11 is joint with IIE (60% UTNE; 40% IIE)
  - 12 research professors; 32 adjunct professors (mostly ORNL)
- **Support Staff: 2 technical, 4 clerical**
- **Pasqua Engineering Building devoted entirely to NE**
- **Several research facilities at nearby ORNL and Thompson Cancer Center available for use by UTNE students and faculty**

# *Student Data*

- **Fall 2008 enrollment: 242 students**
  - 166 undergraduates, 76 graduate students
  - Third largest NE program in the U.S.
  - ~ 95 % U.S. citizens; ~ 18 % female; ~ 5 % minority
  - Grad students
    - ~ 60% fulltime, ~ 30 % distance , ~ 10 % part-time
    - ~ 60% Traditional, ~ 40% Radiological
  - Produced 47 graduates in 2007
- **Produced over 1000 graduates in past 51 years**
- **Graduate program is ranked 11$^{th}$ in U.S. News and World Reports**

# University of Tennessee
# Nuclear Engineering Enrollment




Nuclear Engineering

# *Undergrad and Grad Students at ORNL Safeguards Lab*

- **NE 403: Uranium enrichment, nuclear holdup, AWCC, Coupled-End-to-End Demonstration, neutron time-of-flight transmission measurement (36 students)**
- **NE 550: Nuclear holdup, uranium enrichment, passive and Active Well Counting, In-Situ Object Counting System (ISOCS), 2 labs at UT SMRC**

# *Graduate Certificate Program*

- **Graduate Certification Program in "Nuclear Security Science and Analysis" (NSSA) will be offered starting in Fall 2009**
- **Funded by intelligence agencies through ORNL grant to develop Center for WMD**
- **Main target: All source analysts**
- **Students must take 4 of 8 courses (400 to 600 level)**
- **Topics include: Nuclear fuel cycle, radiation detection and measurement, nondestructive analysis of nuclear materials, health physics, reactor physics, advanced topics in NSSA, nonproliferation policy**
- **In 2nd year, 4 courses will be prepared to be delivered by distance**

# *Certificate Program - 2*

- **Adjuncts who are full time at ORNL will be teaching many courses**
- **Plans to develop M.S. concentrations in NSSA, nuclear materials safeguards, nonproliferation**
- **Prepare students to engage in R&D of new tools and processes related to NSSA**
- **Seeking funding from NRC or other sponsor to develop lab and lecture teaching modules on topics listed below *and* to sponsor equipment for mutual use by UT and by ORNL Safeguards Lab**
  - Process Monitoring for Nuclear Safeguards (lecture + lab)
  - Destructive analysis and nuclear forensics (lecture)
  - Nuclear data for safeguards (lecture)
  - More nondestructive analysis labs for NE 550

# *UT Student INMM Chapter*

- **First meeting in September 2008**
- **Officers elected in November 2008: President, Vice President, Secretary, Webmaster**
- **ORNL Participants: Chris Pickett, Teressa McKinney, Michael Whitaker, Angie Thornton, Ana Raffo-Caiado**
- **Topics: Technical (INMM technical areas overview) and policy (US-India nuclear trade agreement)**
- **Next on the agenda: fund raising, submissions to travel to INMM meetings in 2009, put up chapter website in January**

Institute of Nuclear Materials Management
INMM

Nuclear Engineering

# *UT Nuclear Engineering Research Overview*

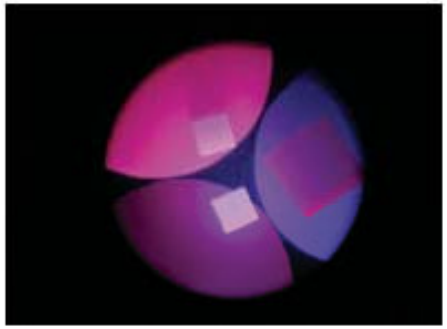
- **UTNE Research Focus Areas**
  - Instrumentation and Controls
  - Reactor Physics and Design
  - Reliability and Maintainability
  - Reactor Safety and Thermal-hydraulics
  - Space Radiation Protection
  - Radiation Detection and Safeguards
  - Nuclear Criticality Safety
  - Health Physics
  - Medical Physics

- **Research Collaboration with Centers of Excellence**
  - Maintenance and Reliability Center
  - Scintillation Materials Research Center
  - Thompson Cancer Survival Center

- **Strong ORNL Research Collaboration for Nearly Five Decades**
  - 2 faculty members have joint appointments with ORNL
  - Several ORNL staff members serve as part-time faculty members

# *Relevant Research Interests*

- **Online monitoring of nuclear materials diversion in enrichment and reprocessing facilities**
- **Advanced integration and control**
- **Gamma-ray and neutron-based detection and imaging systems for fissile material detection and characterization**
- **Development of tools for non-destructive analysis of nuclear materials**
- **New scintillation detector development for security applications**
- **Position-sensitive detector development**
- **Monte Carlo simulations for detector and detection system design**
- **Nuclear data for next generation safeguards**



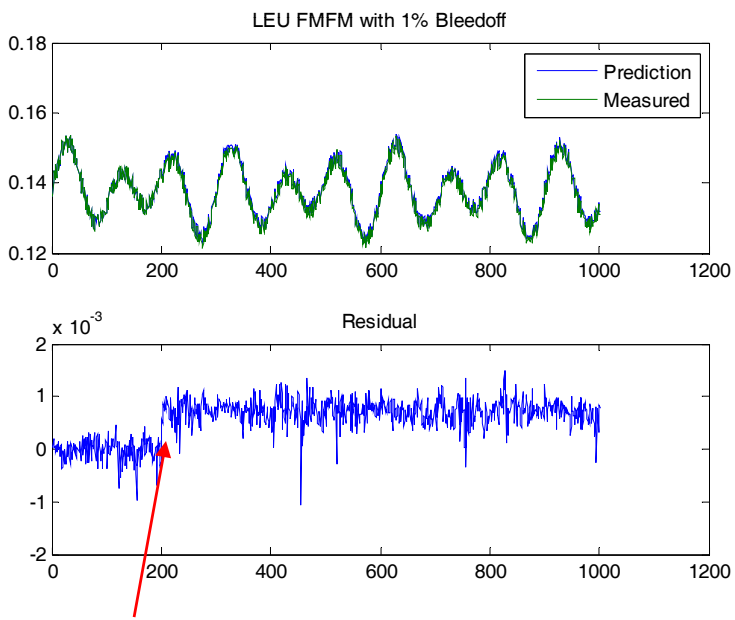
# *UTNE Student Safeguards Work*

- **W. Hines and J. Henkel, "Process online monitoring techniques applied to safeguards monitoring"**
- **J. Mihalczo, B. Grogan, Fieldable Nuclear Materials Identification System**
- **J. March-Leuba, T. Copinger, B. Upadhyaya, et al., "Enhanced algorithm for full-time traceability measurements in a $UF_6$ flow loop"**
- **S. Saavedra, J. Cates, Evaluation of $LaBr_3$:Ce for Safeguards Use**
- **J. Mihalczo, J. Bevins, Modeling of passive detection for arrays of uranium at Y-12**
- **Other UTNE seniors doing Safeguards work at ORNL:**

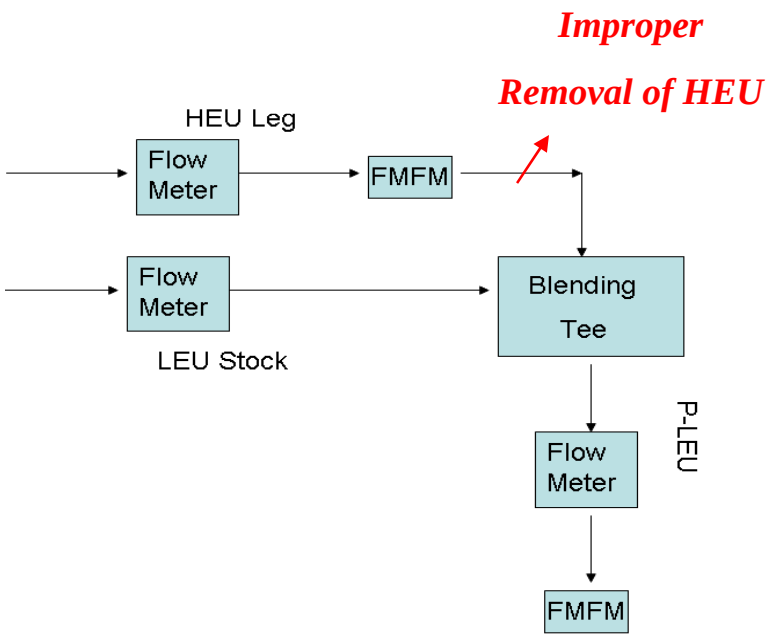
  **K. Pena, P. Brukiewa**

# Process On-Line Monitoring Techniques Applied to Safeguards Monitoring

**OLM techniques use empirical models to monitor a process for anomalous behavior that may be due to equipment malfunction, degradation, or improper operation.**




**Detection results for 1% bleed-off with 1% measurement noise.**



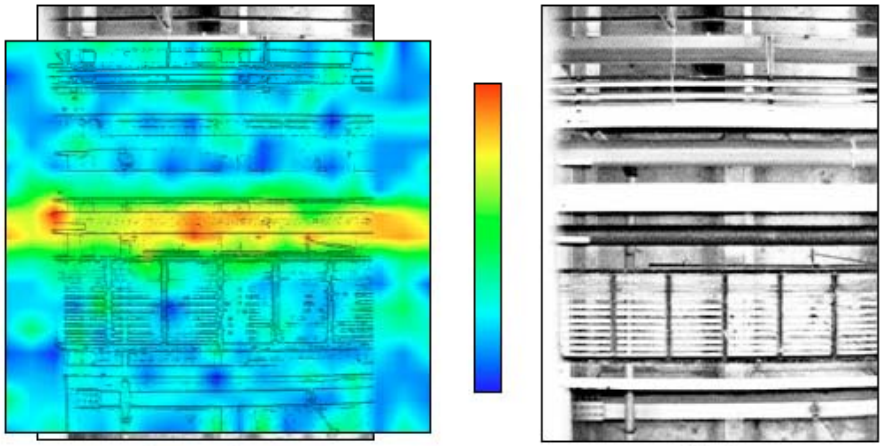

**Blend Down Monitoring System Diagram**

**OLM techniques developed for sensor calibration monitoring are sensitive enough to detect subtle changes in operations when coupled with nuclear radiation measurements.**

Nuclear Engineering

from J.W. Hines

# *Imaging at Processing Facilities*



Gamma ray image

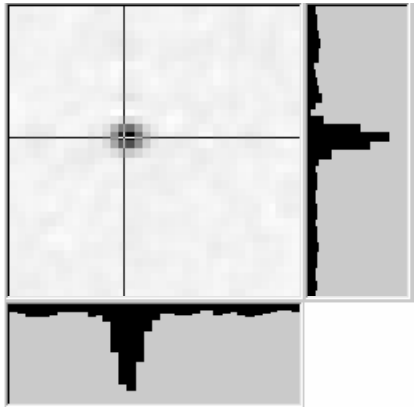
Video image

- **Gamma-ray image taken at K-25 with CsI(Na) based coded aperture imager**
- **Use new system to extract quantitative information, examine materials tradeoffs**



**from K.P. Ziock**

# *Gamma-ray Imaging for Safeguards*



- **Gamma-ray imaging spectrometer (GRIS)**
- **Coded aperture imaging, MURA mask**
- **Position-sensitive germanium**
- **Coaxial Ge in back to increase efficiency**
- **Gamma-ray spectrum at any imaging pixel**
- **Analyze shielding over known source**

# *Summary*

- **UTNE has recently become very involved in safeguards education, including education of undergraduate and graduate students at ORNL Safeguards Lab**
- **Graduate Certificate program in Nuclear Security Science and Analysis is beginning in Fall 2009**
- **UT student INMM chapter is underway**
- **Support to UT from ORNL in Safeguards Area is strong**
- **Sustainable program requires year-round, funded work for students and faculty in safeguards and security**
- **UTNE is excited about opportunity to partner with ORNL in preparing the next generation of safeguards experts and developing next-generation safeguards technologies**