Homeland Security Task Force Report 2009

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Background & Agenda

- The data report by D. McNabb (D. McNabb, "Nuclear Data Needs for National Homeland Security Program," LLNL tech report UCRL-MI-207715 (2005)) is still the best resource for data needs.
- Here I'll give more of a "state of the union" type report

- Agenda:
  - Overview
  - Securing the (manpower & project) pipelines
  - Case studies in area of detection

Framing The Problem

1. **Safeguards: keeping the stuff out of the wrong hands**

2. **Smuggling detection: finding it if it gets away and keeping it out if you can**

Coast Guard
TSA
Border Enforcement
Customs
…

3. **Response and operations: taking care of the mess if something happens**

FEMA
NEST
1st responders
…

4. **Assessments and attribution: whodunit??**

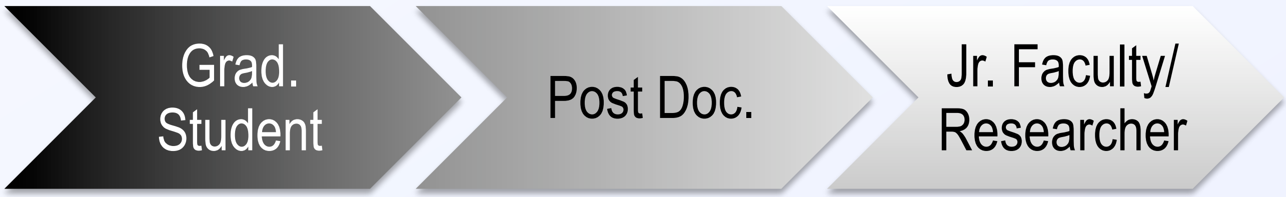
broad and reaches beyond DHS issues:

- Proliferation risks
- Energy infrastructure
- Nonproliferation -- weapons and fuel cycle
- Evaluation of industry-government partnership plans and ideas

FBI, DTRA, NNSA, …

USNDP work addresses points 2 and 4 most directly; I'll focus on point 2

Ensuring technical manpower base (at least at universities) is still a work in progress



SSAA Model

(DNDO - NSF Academic Research Initiative (ARI))

- Targets existing faculty
- As a side effect, trains students & post-docs
- Keep existing programs alive, reallocate existing efforts
- Brings folks into jobs pipeline

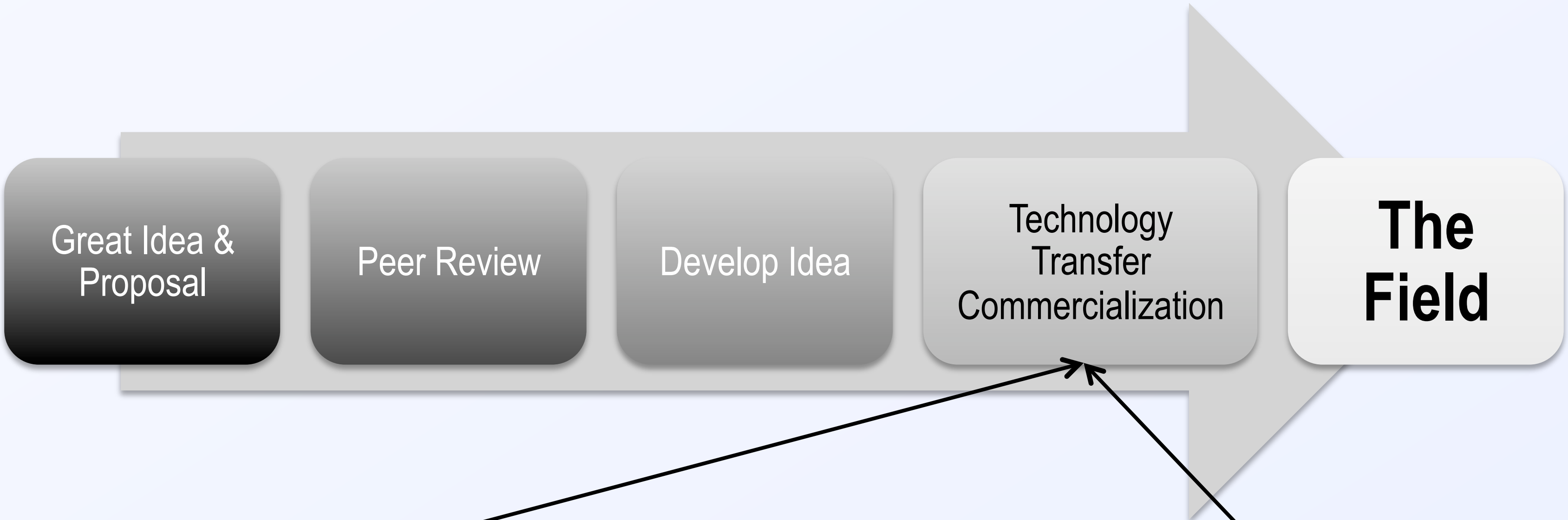
RIKEN/BNL Fellow Model

(See R. Vogt's Homeland Task Force Report 2008)

- Bring new faculty in
- Train students to lesser extent
- Start new programs
- A place to go at the end of the jobs pipeline

Manpower at universities solidifying, but growth will be difficult
National labs get funding from other areas and are not as constrained

Technology Life Cycle in DHS was rushed until recently; still heavily tilted toward commercialization rather than development



"The objective of the FutureTECH™ Program is to establish mutually-beneficial partnerships with the private sector, national laboratories, university community and other Research and Development (R&D) organizations to develop technologies/capabilities that address the long-term needs of the Department and its stakeholders."

"The SECURE™ (System Efficacy through Commercialization, Utilization, Relevance and Evaluation) Program leverages the experience and resources of the private sector to develop fully deployable [i.e., technology readiness level nine, (TRL-9)] products and/or services."

(Source: DHS Science & Technology page (http://www.dhs.gov/files/scitech.shtm))

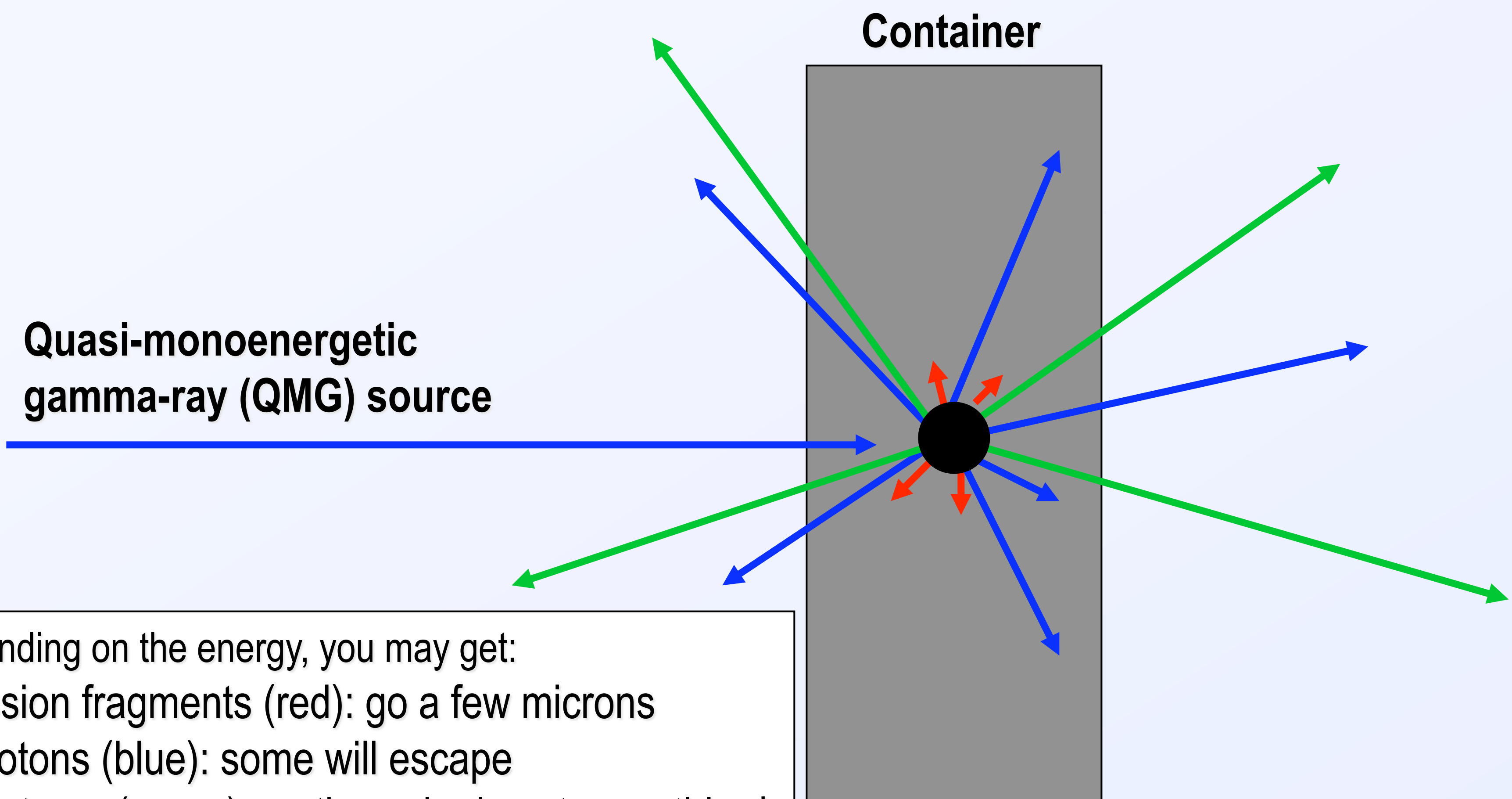
Fortunately there are many more avenues of funding to pursue

Agency	Opportunities	Caveats
NSF	DNDO-NSF Academic Research Init. (ARI); Explosives and Related Threats: Frontiers in Prediction and Detection (EXP)	University focus; “small”
DHS	HSARPA; DNDO (Transformational & Applied Research Directorate)	Still widget focused
National Nuclear Security Administration	Non-proliferation (NA-22); Nuclear Risk Detection (NA-23)	Usually gotta know somebody who knows somebody ... (they do issue calls though)
DTRA	Basic Research for Combating Weapons of Mass Destruction Service Call; see http://www.dtra.mil/	

Detection

- Strategies: need probe that penetrates & gives unique signal
  - Active interrogation
    - Charged particles too easily absorbed
    - Neutrons scatter off everything, but …
      - Can fiss in SNM giving correlated neutron (& γ) emission (LLNL)
      - Thermal n's give unique primary γ's & γ cascades: EGAF project (LBNL, LLNL, Budepest)
    - γ's: NRF & photofission (TUNL, LLNL, BNL, …)
  - Passive detection: use environment to provide probe, e.g.
    - cosmic rays (mainly μ's) (BNL,LANL)
    - ν's (LLNL)
- Need to model detection system
  - GEANT or MCNPX
  - Physics modules at http://nuclear.llnl.gov/

Using photonuclear reactions to probe containers

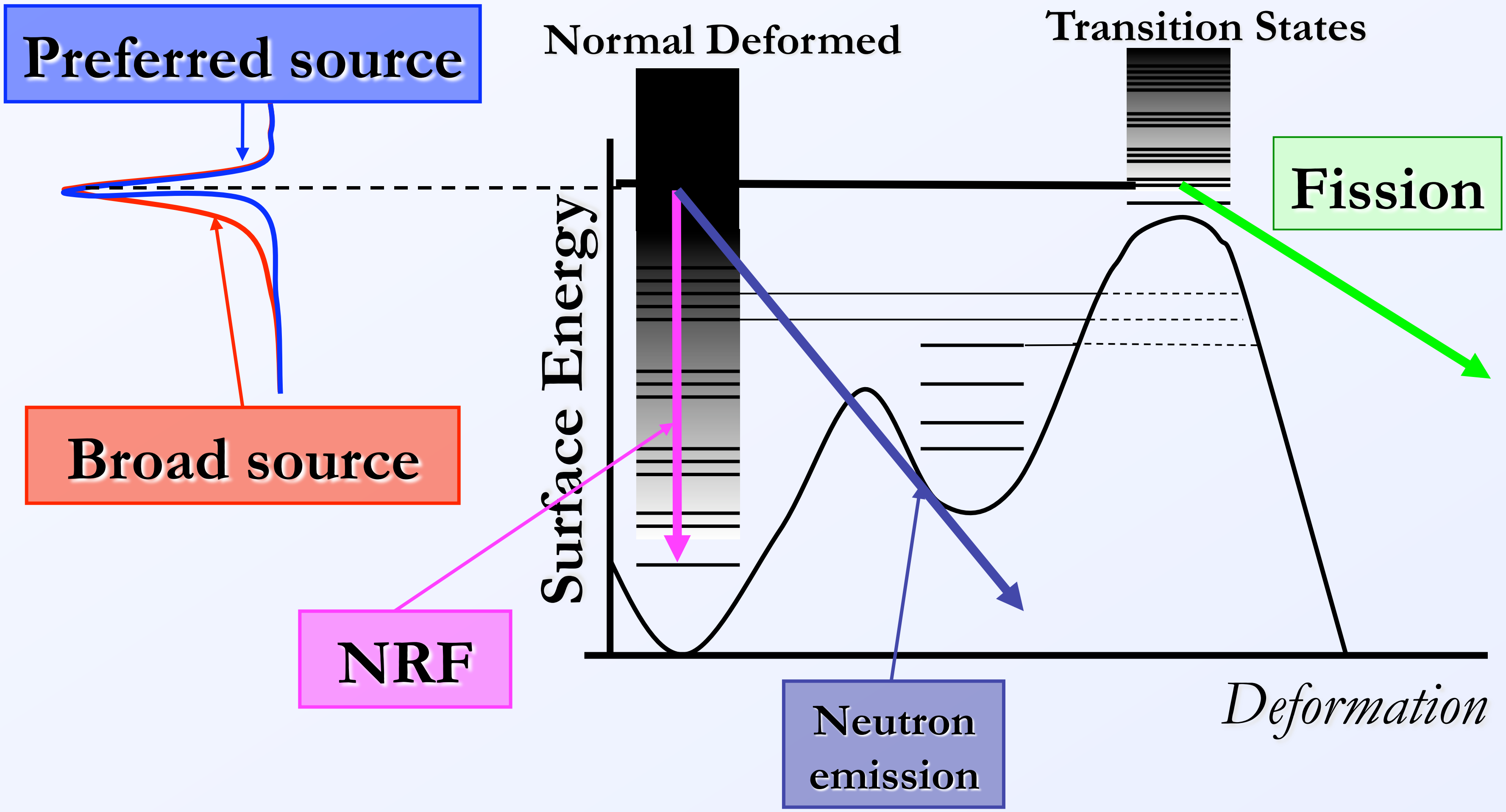


Depending on the energy, you may get:

- Fission fragments (red): go a few microns
- Photons (blue): some will escape
- Neutrons (green): go through almost everything*

Idea: tune QMG to resonances of interest and measure the signature for materials of interest

Photonuclear reaction picture



Our interest is mainly (but not exclusively…) NRF and photofission

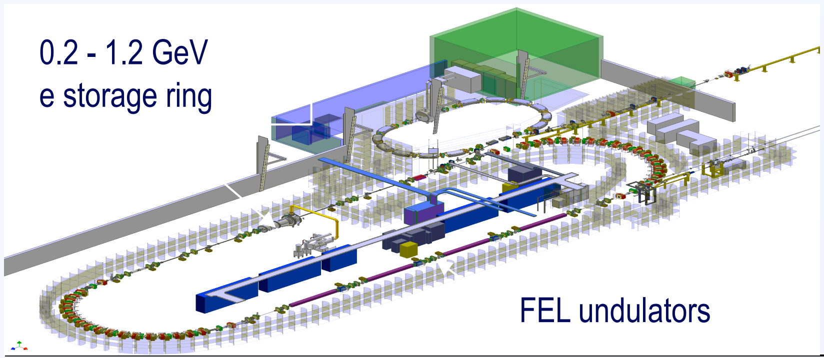
Photonuclear data needs

- We are looking at ways to use monoenergetic gamma-ray sources to probe cargo containers
- Monoenergetic source-based applications rely heavily on the microscopic details of nuclei.
- Nuclear Resonance Fluorescence Needs
  - Cross-section data for NRF states in SNM.
  - Spins and parities of the NRF states.
  - Dominant backgrounds for monoenergetic sources are elastic processes.
    - e.g. Delbruck, Thomson, Rayleigh
    - Need simulation codes with all pertinent processes and data.
- Photofission Needs
  - Neutron anisotropy and energy is important for both photofission and photo-neutron production.
  - For many nuclei of interest, the energy is above the photodisintegration threshold, *a.k.a* neutron production.
  - Little known about the transition states above the barrier.
  - Branching ratios are important.

Title: Collaborative Research: ARI-MA: Nuclear Data Measurements on Actinides Using the High Intensity Gamma-ray Source

Orgs: Duke University, U. of North Carolina at Chapel Hill and NC A&T State University

High Intensity Gamma-ray Source (HIγS) at Duke University: the γ-ray beam is produced by Compton backscattering inside the FEL optical cavity



The nearly monoenergetic polarized high-intensity γ-ray beams at HIγS are used to:

1. Search for low-spin states in ^{238}U and ^{235}U at energies above 3 MeV with sensitivities to Γ_γ down to 1 meV; *important for developing technologies to scan cargo for specific nuclei*
2. Measure γ-ray attenuation coefficients at 3 to 50 MeV to accuracies better than 1%; typical present uncertainties are 2 to 3%; *important for improving image reconstruction and material quantification*
3. Develop techniques and instrumentation for measuring photoneutron and photofission reaction cross sections

Technical Approach

- Nuclear resonance fluorescence (NRF) technique is used to search for strongly excited states in uranium isotopes and in nuclei of shielding materials.
- Emitted γ-rays are detected in a set of large volume HPGe detectors.
- γ-ray attenuation coefficients are determined with high precision in γ-ray transmission measurements.
- New neutron detector technologies are developed.
- Simulations are performed using modern Monte Carlo codes.

Schedule

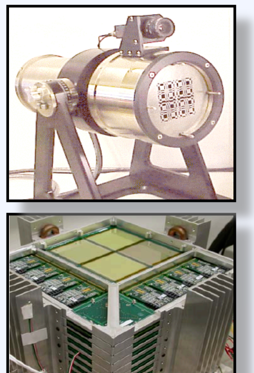
- Search for high intensity transitions: experiments on $^{235,238}U$ from 2 to 5 MeV are completed and data analysis will continue in 2010;
- Attenuation coeff. measurements will continue in 2010;
- R&D on photo-neutron and photo-fission measurements will continue;
- Extensive simulations of applicability of NRF technique will be undertaken;

Team

- C.R. Howell, A. Tonchev and W. Tornow, Duke Univ.; H.J. Karwowski, Univ. of NC at Chapel Hill; R.S. Pedroni, NC A&T State Univ.

Gamma-ray Imaging Detector Evaluation

High-fidelity, quantitative evaluation of gamma-ray detectors for realistic non-proliferation applications



Project Team: Doug Wright, Larry Hiller, Kareem Kazkaz, David Lange, Karl Nelson

Mission Relevance & State of the Art

- Success leads to decisions on which technologies should be pursued to satisfy mission needs, prior to lengthy and costly detector development.
- No process exists for head-to-head prediction of detector performance for specific scenarios.
- *Applies to high priority, high-level portfolio requirements for gamma detection for HEU, plutonium, and stand-off detection. Combines imaging and spectral analysis.*

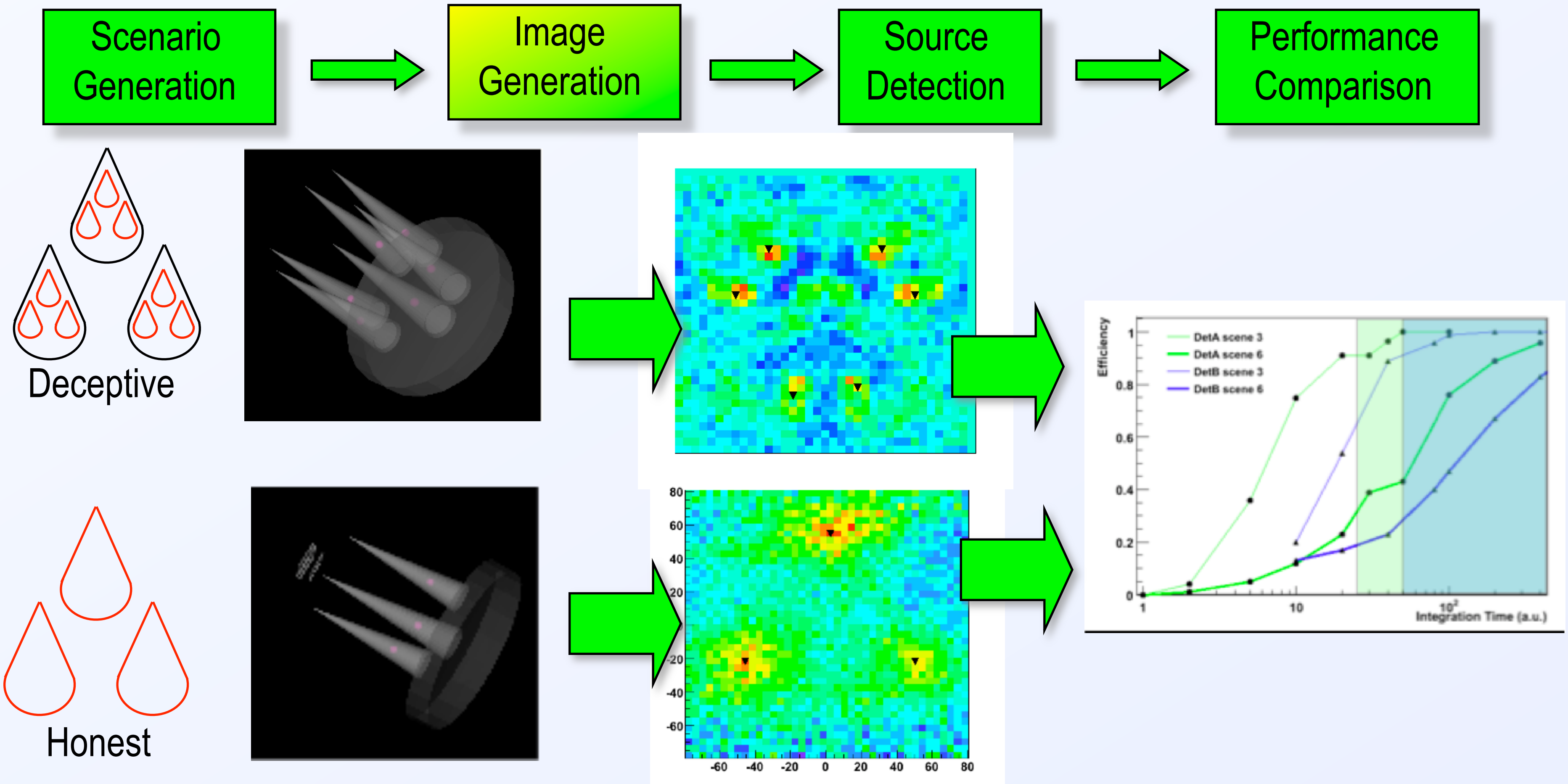
Project Objectives

- Leverage gamma-ray imaging evaluation framework
- Select scenarios in consultation with NA22 management, e.g. warhead counting, multi-lane alarm evaluation at boarder crossing
- Compare detector technologies based on alarm efficiency versus false-positive rate

Cost & Schedule

- Year 1: Workshop with detector experts; Evaluation of application scenarios with multiple technologies, $550K.
- Year 2: Optimization and validation based on refined detector/ scenario concept, $450K.

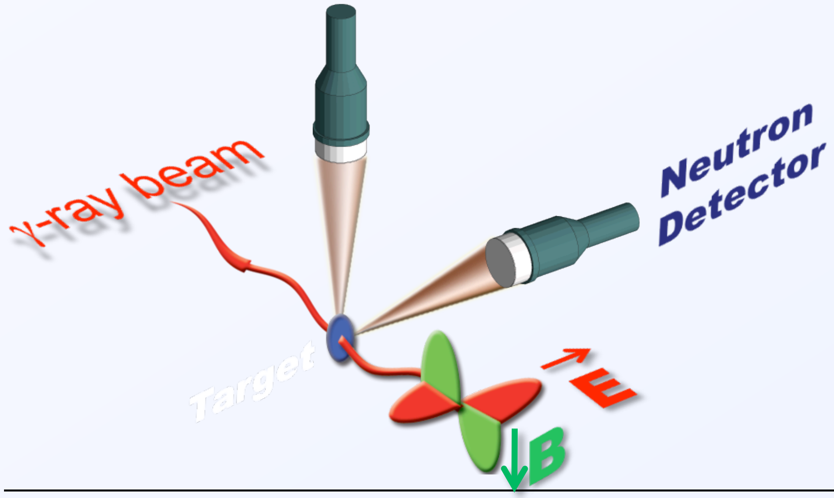
Leverages framework for comparing different detectors in realistic scenarios



Recently completed workshop with technology advocates and now proceeding with quantitative study of realistic application

Title: ARI-MA: Development of a New Method for Interrogating Special Nuclear Materials based Upon Polarized (γ,n) Asymmetries

Org/PI: Duke University and TUNL / Henry R. Weller



Relevance and Goals

Mathematical representations of the results for each isotope will be used in simulations to determine the optimal means for identifying heavily shielded special nuclear materials.

Results will be verified using phantom targets.

The large cross sections for these (γ,n) reactions provide extremely large counting rates leading to short inspection times.

Technical Approach

This project will utilize the high intensity polarized γ-ray beams of the HIγS facility at Duke University.

The ratio of neutrons emitted parallel vs. perpendicular to the direction of polarization of incident gamma-rays will provide a unique signature for the identification of isotopes of interest.

A catalogue of these previously unmeasured ratios along with neutron yields as a function of neutron energy will be established for a large number of isotopes using a range of incident γ-ray energies from threshold to 20 MeV.

Schedule

The detection system will be commissioned in 2010. Data collection for energies between threshold and 20 MeV will begin for ^{238}U, and possibly for ^{208}Pb, in 2010.

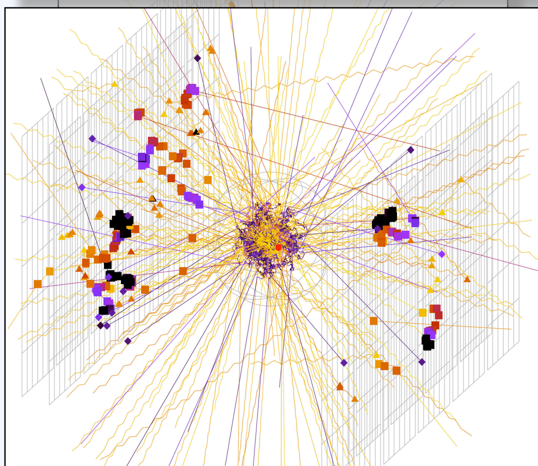
Additional isotopes will be catalogued in subsequent years. An adequate data base will lead to realistic simulations followed by verification using phantom targets.

Team

H. R. Weller, M.W. Ahmed, S. Stave and Y. Wu, Duke University and TUNL.

Targeted modeling gaps of high value to DNDO
All three physics models released on external website: http://nuclear.llnl.gov

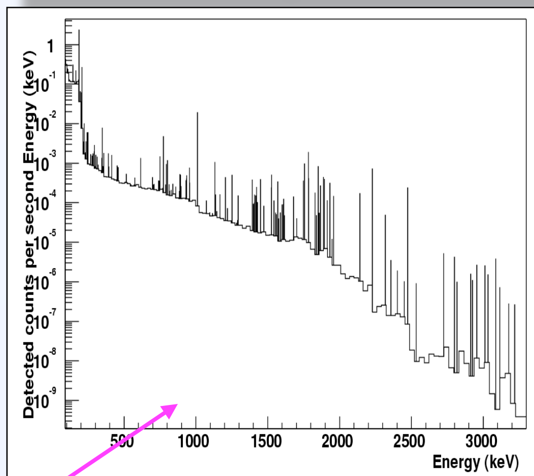
Fission multiplicity



Multiple neutrons and gamma-rays produced from fission

Essential physics for fission-chain detector concept: can detect shielded HEU

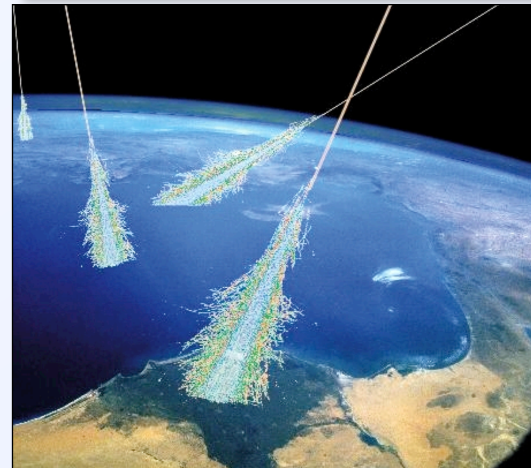
Gamma-ray Emission



Gamma-ray source intensity for aged mixtures of Special Nuclear Material

Source term for SNM in all gamma-ray detection concepts

Cosmic-ray showers



Energetic particles produced in upper atmosphere that reach the ground

Significant background in neutron detection, especially for maritime cargo applications

DHDO 06-08: $1.6M

Interface also provided for MCNP, MCNPX, Geant4, COG

Doug Wright (PI), Dave Brown, John Buyer, Chris Hagmann,Tom Gosnell, Jeff Gronberg, Larry Hiller, David Lange, Jerome Verbeke, Ramona Vogt

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