# Nuclear Security & Policy

## Research Activities

R. Scott Kemp

# An Engineering Approach to Policy Research

## Analysis of Technology Policy Choices

Example: Will investing in laser enrichment make proliferation easier?

## Technically Informed Analysis of Policy Issues

Example: What can we reasonably expect to achieve on Iran breakout time?

## Problem-Driven Technology Development

Example: Invent a way to verify a warhead is real without revealing secrets

# The Laboratory for Nuclear Security + Policy

Combines disciplinary expertise from across the institute
nuclear engineering, physics, computer science & artificial intelligence, political science, economics

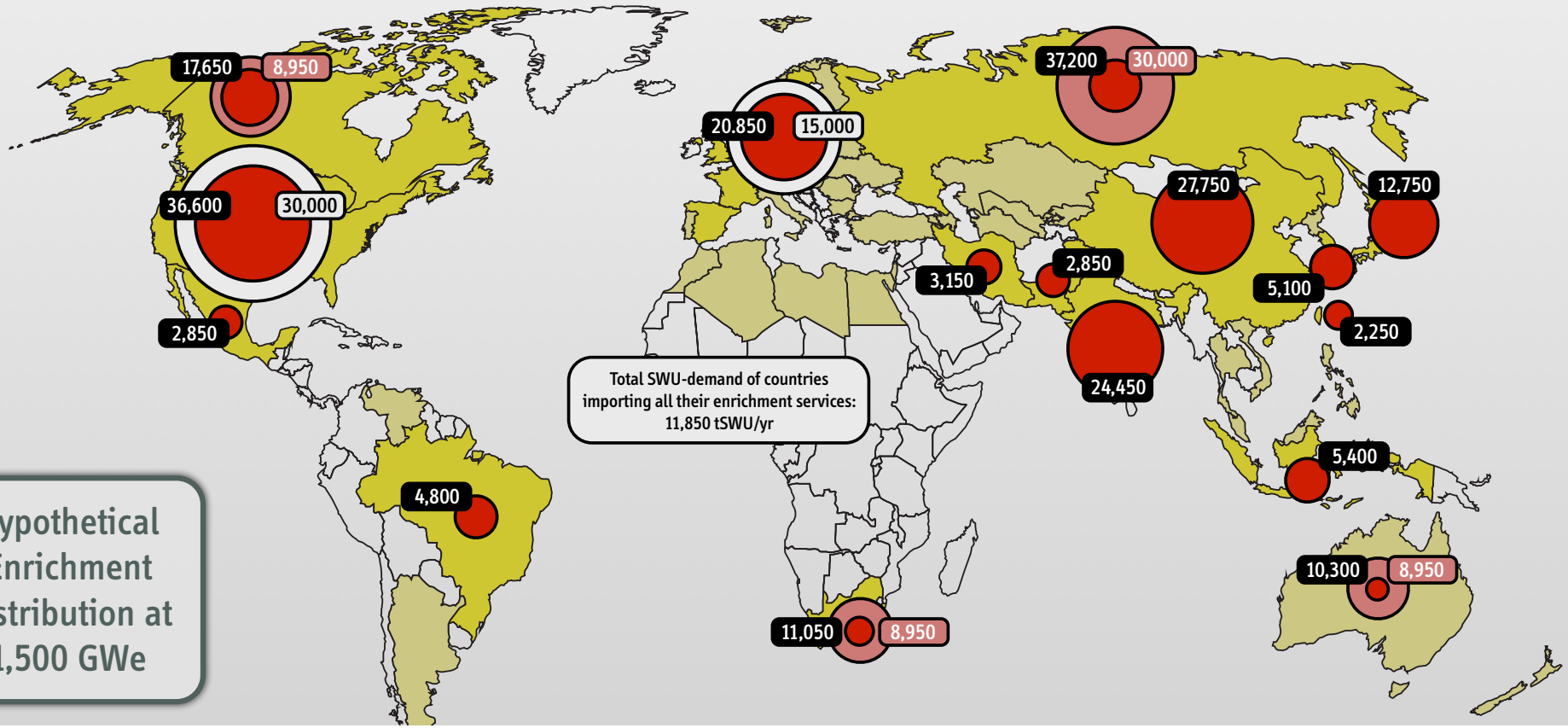
2 lead faculty + 5 associated

8 graduate students

# Major Research Directions

# Managing the Proliferation Consequences of Nuclear Power

- Fuel-supply policies for new nuclear-power countries
- Study game-changing technologies: laser enrichment, new chemex, etc.
- Signals and mechanisms for detecting clandestine activities
- Understanding limits of technology vs. political control

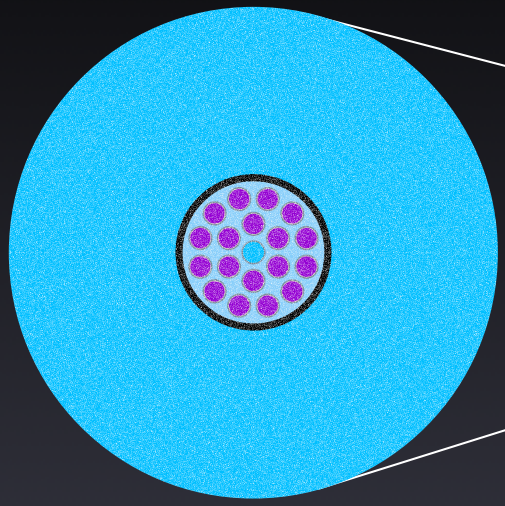


| Country | Ambition | Technology | Expertise | Facilities |
|---|---|---|---|---|
| India | has weapons | Civil | Civil | Civil |
| France | has weapons | Civil | Civil | Dedicated |
| North Korea | has weapons | Civil/research | Civil | Mixed |
| Pakistan | has weapons | Civil/stolen | Civil | Dedicated |
| China | has weapons | Dedicated | Military | Dedicated |
| Russia | has weapons | Dedicated | Military | Dedicated |
| United | has weapons | Dedicated | Military | Dedicated |
| United States | has weapons | Dedicated | Military | Dedicated |
| Israel | has weapons | Mixed | Military | Dedicated |
| South Africa | had weapons | Mixed | Civil | Dedicated |
| Australia | sought weapons | Civil | Civil | Civil |
| Romania | sought weapons | Civil | Civil | Civil |
| Serbia | sought weapons | Civil | Civil | Civil |
| South Korea | sought weapons | Civil | Civil | Civil |
| Switzerland | sought weapons | Civil | Civil | Civil |
| Taiwan | sought weapons | Civil | Civil | Civil |
| Brazil | sought weapons | Civil | Military | Civil |
| Egypt | sought weapons | Civil | Civil | Civil |
| Syria | sought weapons | Dedicated | Imported | Military |
| Libya | sought weapons | Dedicated | Mixed | n/a |
| Iran | sought weapons | Imported | Civil | Civil |
| Canada | sought weapons | Mixed | Civil | Civil |
| Sweden | sought weapons | Mixed | Civil | Mixed |
| Iraq | sought weapons | Mixed | Civil | Mixed |
| Spain | wanted weapons | Civil | Civil | n/a |
| Argentina | wanted weapons | n/a | Military | n/a |
| Algeria | wanted weapons | n/a | n/a | n/a |
| Finland | sought option | Civil | Civil | Civil |
| Germany | sought option | Civil | Civil | Civil |
| Holland | sought option | Civil | Civil | Civil |
| Italy | sought option | Civil | Civil | Civil |
| Japan | sought option | Civil | Civil | Civil |

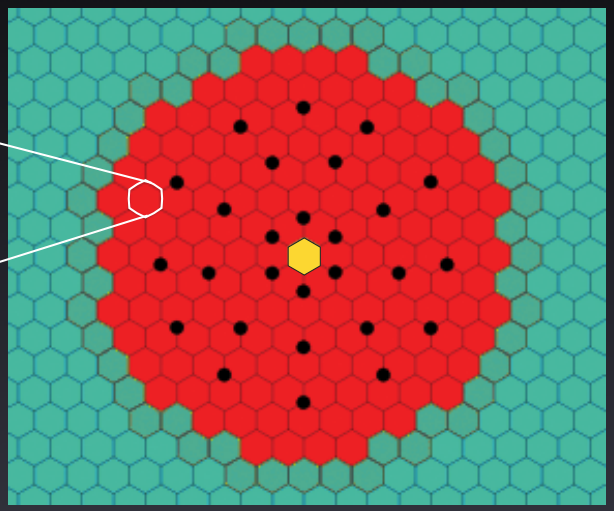
**70 percent of countries that pursued nuclear weapons used their civilian nuclear infrastructure or expertise to do so.**

# Technical Support for U.S. Diplomatic Efforts

# Redesign of Iran's IR-40 Plutonium Production Reactor



CASMO4e infinite lattice element, white walls



Total power: original

Cycle length: original

Power density: original

Plutonium: 1/5 of original

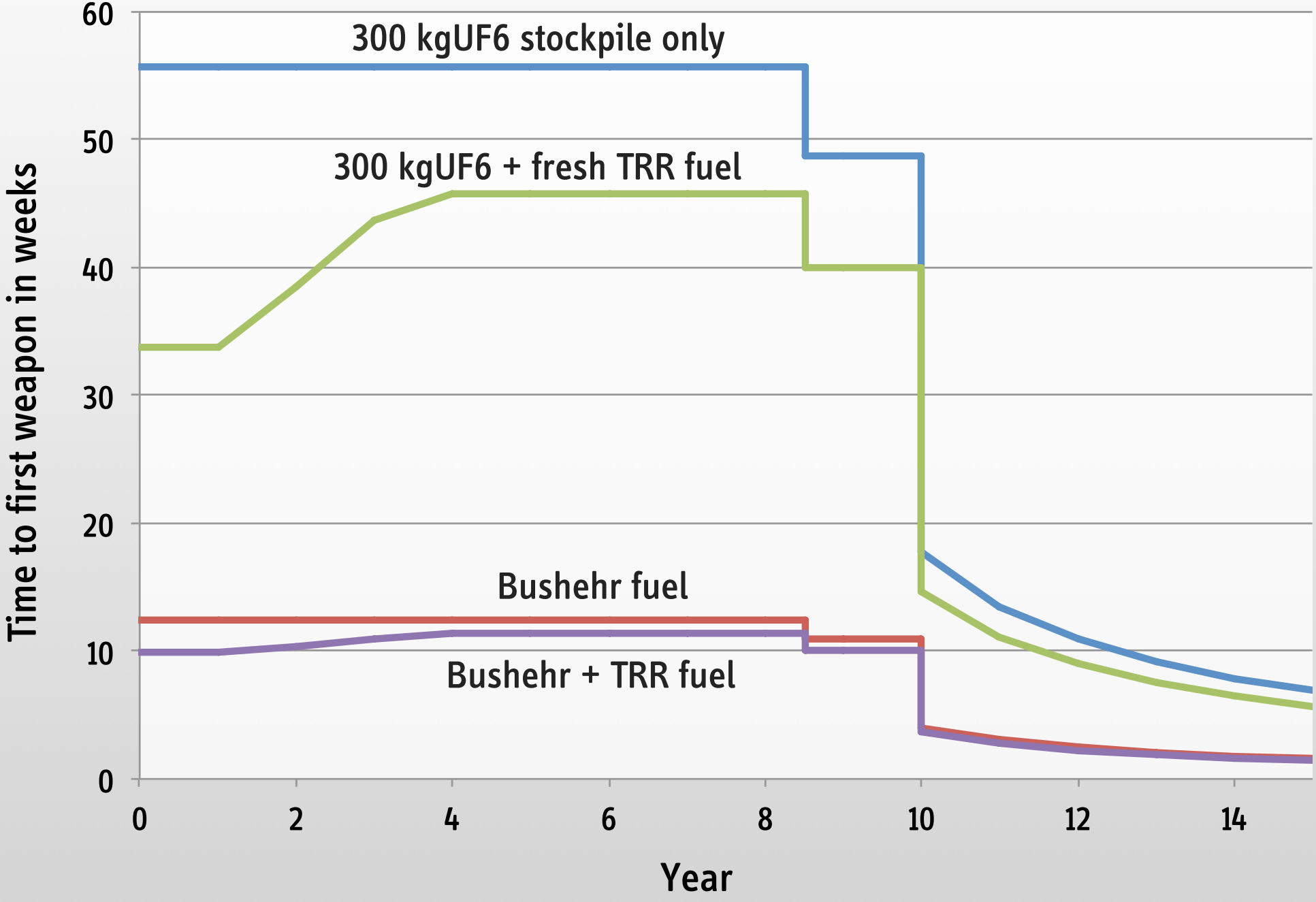
5% LEU dispersion fuel

Empty (96% $D_2O$)

96% $D_2O$ Reflector

R. Scott Kemp, "Two Methods for Converting a Heavy-Water Research Reactor to Use Low-Enriched-Uranium Fuel to Improve Proliferation Resistance After Startup." *Energy Technology & Policy*, vol. 2, no. 1 (January 2015), pp. 39–46.

# Iran's Time to a Nuclear Weapon under the "Iran Deal"
## Exploiting Various Domestic LEU Resources



# Reconstructing DPRK's internal centrifuge-manufacturing capability

## 1. 문제설정

3상리력전동기에 의하여 직접 구동되고 회전체의 아래단은 라선홈을 가진 구면동압베아링에, 웃단은 비접촉자기베아링에 의하여 지지되는 수직형 고속회전기계의 계산략도를 그림 1에 주었다.

그림에서 보는바와 같이 계는 10개의 자유도를 가진다. 여기서 다음과 같은 가정들을 받아들인다.

① 모든 튐성요소들과 점성저항요소들은 선형특성을 가진다.

② 회전체는 불균형을 가지지 않는다.

③ 진동은 미소진동이다.

이러한 가정밑에서 계의 운동에네르기, 포텐샬에네르기 및 발산에네르기는 다음의 식으로 표시된다.

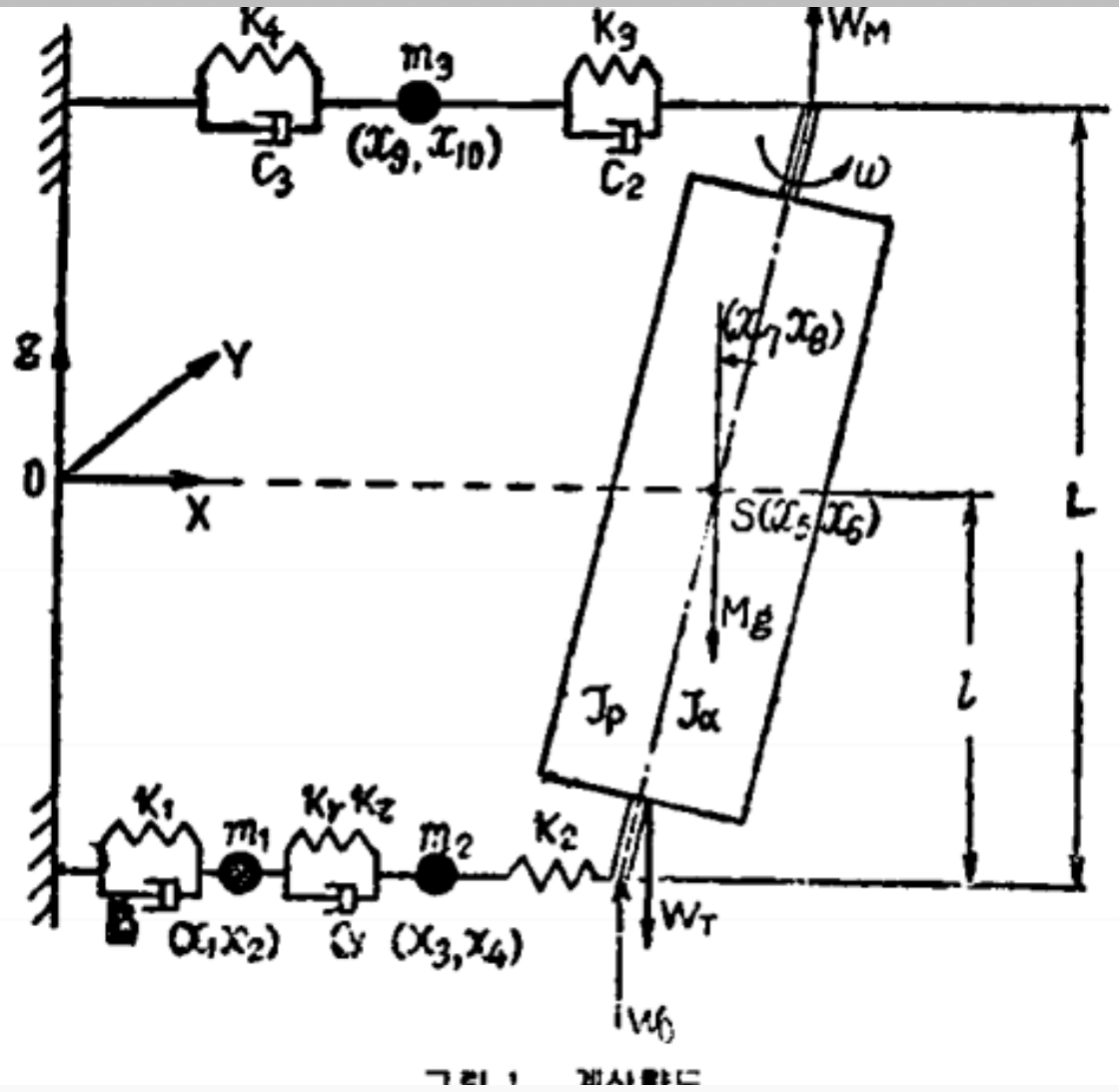
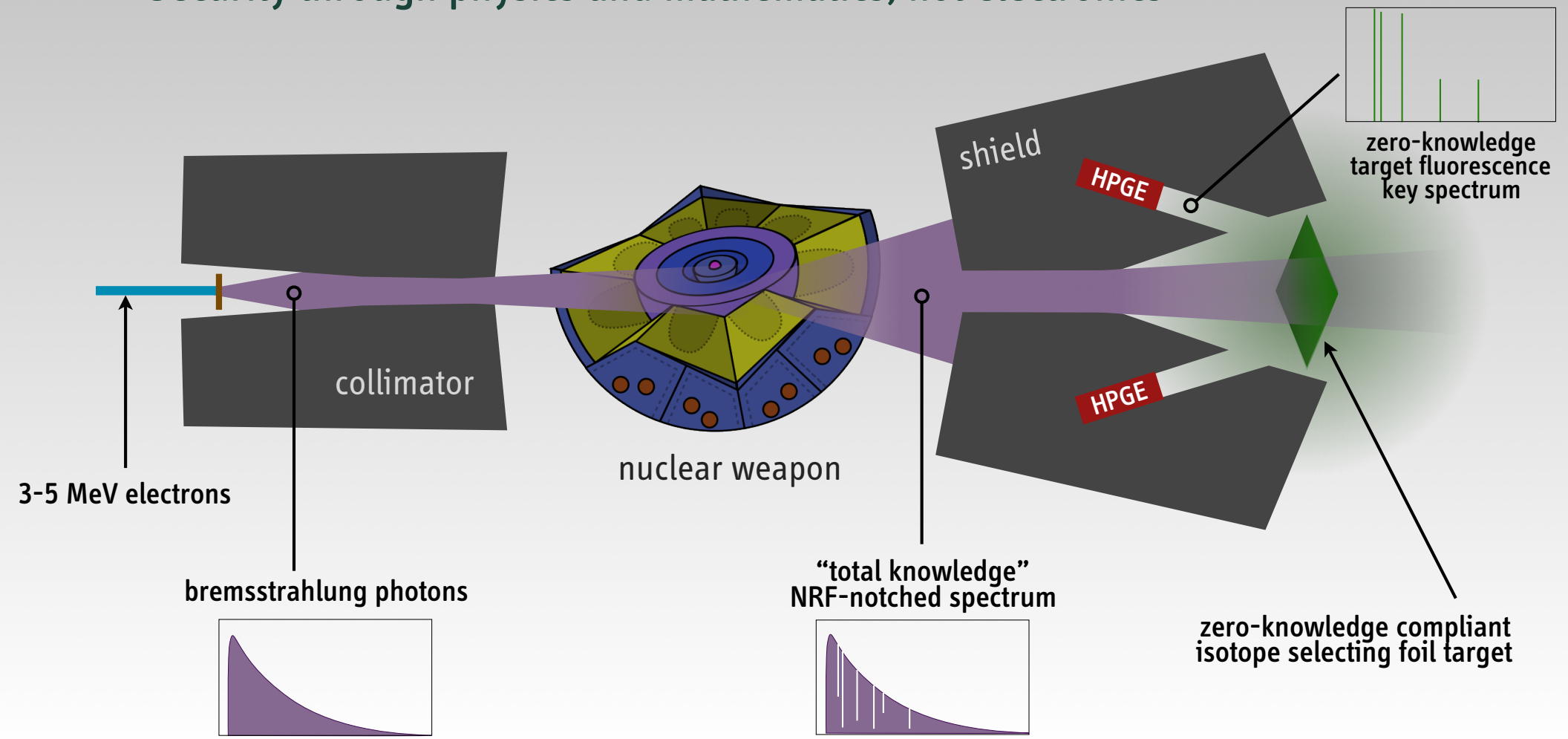


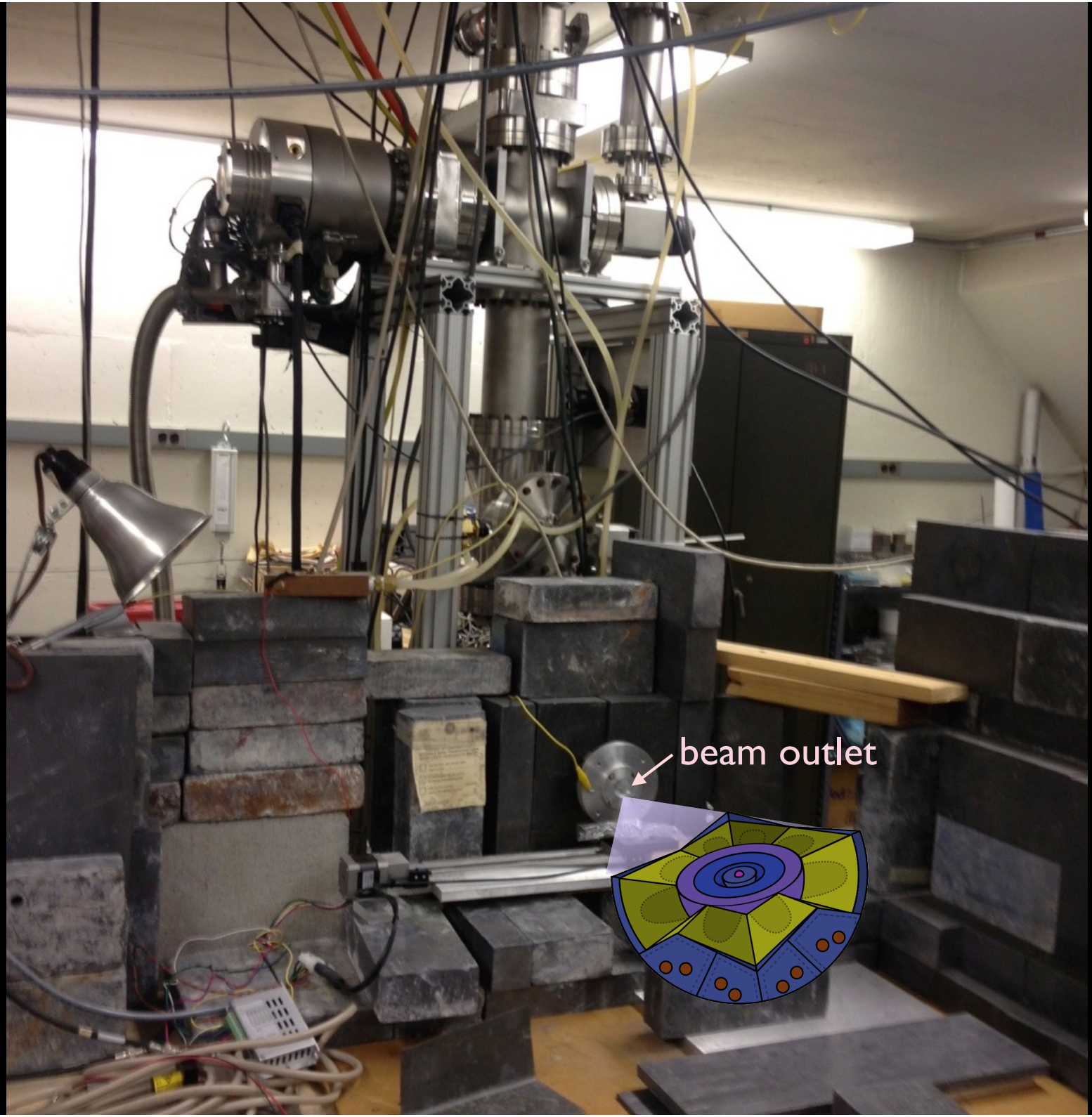

그림 1. 계산략도

# Technology Development for Nuclear Security Missions

# Verification for Nuclear Warhead Dismantlement

- A primary NNSA mission, supported by NNSA's CVT consortium at $3M/5yr
- Based on transmission nuclear resonance fluorescence
- Implements zero-knowledge protocols to protect classified information
- Security through physics and mathematics, not electronics

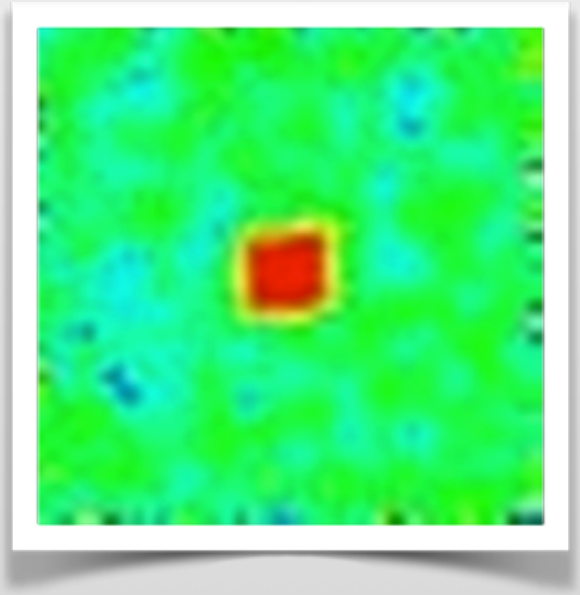



beam outlet


Shielded Tunnels for
Gamma detectors

# Active Detection of Nuclear Materials in Cargo

- Multi mono-energetic interrogation of of cargos
- Discreet lines from isomeric decay of 11B(d,ng)12C
- Active interrogation of shielded cargo without dose of bremsstrahlung



MCNPX simulation of a 100 cc cube of Uranium in a 40 cm Iron block imaged using 4.44 and 15.11 MeV gamma rays

# Recent and ongoing projects at LNSP

Physical cryptographic warhead verification
Epithermal neutron warhead verification
Fundamental of information transport in physical measurements
Technical reconstruction of North Korea's centrifuge program
Monochromatic interrogation of cargo for smuggled nuclear materials
Weapon usability of neptunium
Review of methods for detecting clandestine nuclear installations
Using national fuel stockpiles for fuel-supply security and nonproliferation
Understanding oligopolistic forces in the enrichment sector
Redesign of Virginia Class submarine reactor to use non-weapon grade uranium
Gravitomagnetic detection of clandestine centrifuge facilities
Historical perspectives on how verification confidence is constructed
History of the gas centrifuge programs around the world