A General Perspective of the Challenges Associated with Detecting Special Nuclear Materials & Explosives Using Multi-Energy Electron Bremsstrahlung Radiography

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INTRODUCTION

- ScanTech Identification Beam Systems, LLC
- Headquartered in Atlanta Georgia
- Advanced X-Ray Material Discrimination Technology
- 12 Patents Approved
- Core R&D Team Together Since the Early 1990's

SENTINEL IIa

QUAD-RAD Accelerator

SUPER SENTINEL

BACKGROUND

- Balancing Security and Commerce
- The Threat of Cargo Containers
- **Weapons of Mass Destruction**
- **Availability of Nuclear Materials**
- Maritime Cargo Containers
- **Department of Homeland Security**
- **Status of SNM Inspection Program**

FALSE SENSE OF SECURITY

- Radiation Portal Monitors Have Been Deployed
- Use of Polyvinyl Toluene Detectors
- Radiation Detection vs. SNM Identification
- Secondary Screening Procedures
- Handheld Radioactive Isotope Identification Devices (RIID)
- Radiography
- A Problem Remains With Shielded SNM

ADVANCED SPECTROSCOPIC PORTALS

- ASP Program Initiated in 2005
- Develop, Test and Deploy A New Generation Portal Monitor
- Identification of the Type of Nuclear Material in the Container
- Problems with Meeting Performance Specifications
- ASP Monitors Can Not Detect Shielded SNM
- ASP Program Has Not Gone Well and Is At Risk
- Continue to Rely on PVT Portal Monitors

DUAL ENERGY MATERIAL DISCRIMINATION

- Dual Energy Technology Has Been Around For A While
- TSA Advanced Technology X-ray Program
- Purchase and Deploy Several Thousand Systems
- AT Systems Will Be Able To Discriminate Explosives, Flammable Liquids and other Hazardous Materials
- Several Vendors Are Qualifying Systems For Acquisition
- First Awards Have Been Made

ENERGY DEPENDENCE

- Interaction of Radiation With Materials is Energy Dependent

The mass attenuation coefficient of materials in a volume of material is functionally related to the energy of the impinging photons as well as the Z-number of the material,

$$\mu_T = \mu(E, Z_{eff}, \ldots)$$

with the E *beam energy and* μ_T *the mass attenuation coefficient which relates the input intensity to the output intensity of the x-ray beam,*

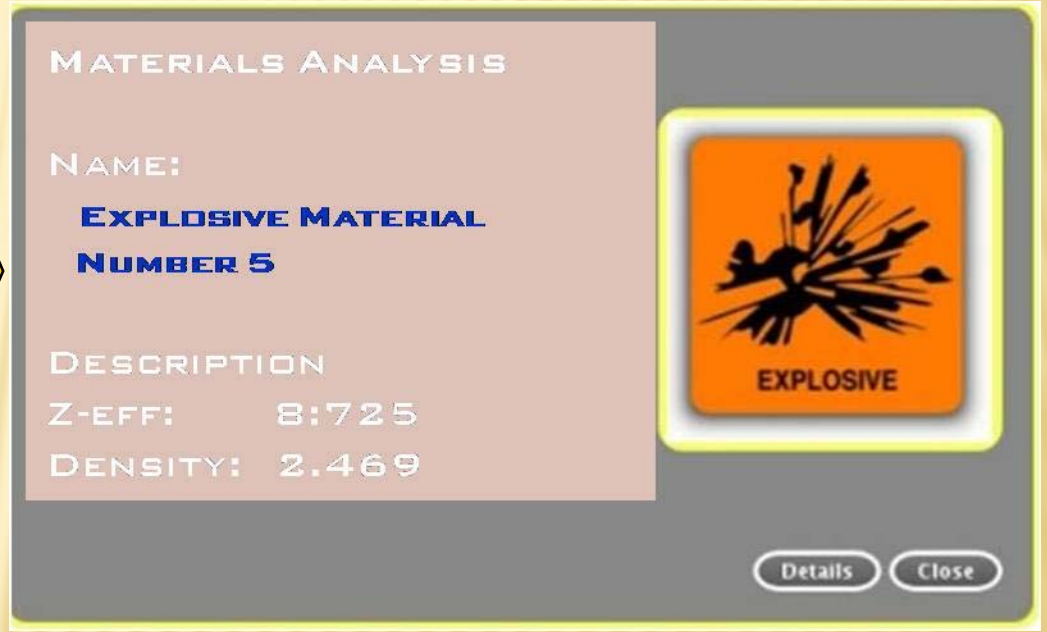
$$I_o = I_i e^{\mu_T L}$$

where I_o *the intensity is measured at the detector,* I_i *is the input intensity of the x-ray beam and* L *is the thickness of the sampled volume.*

SENTINEL II – DUAL ENERGY AT CHECKPOINT SYSTEM

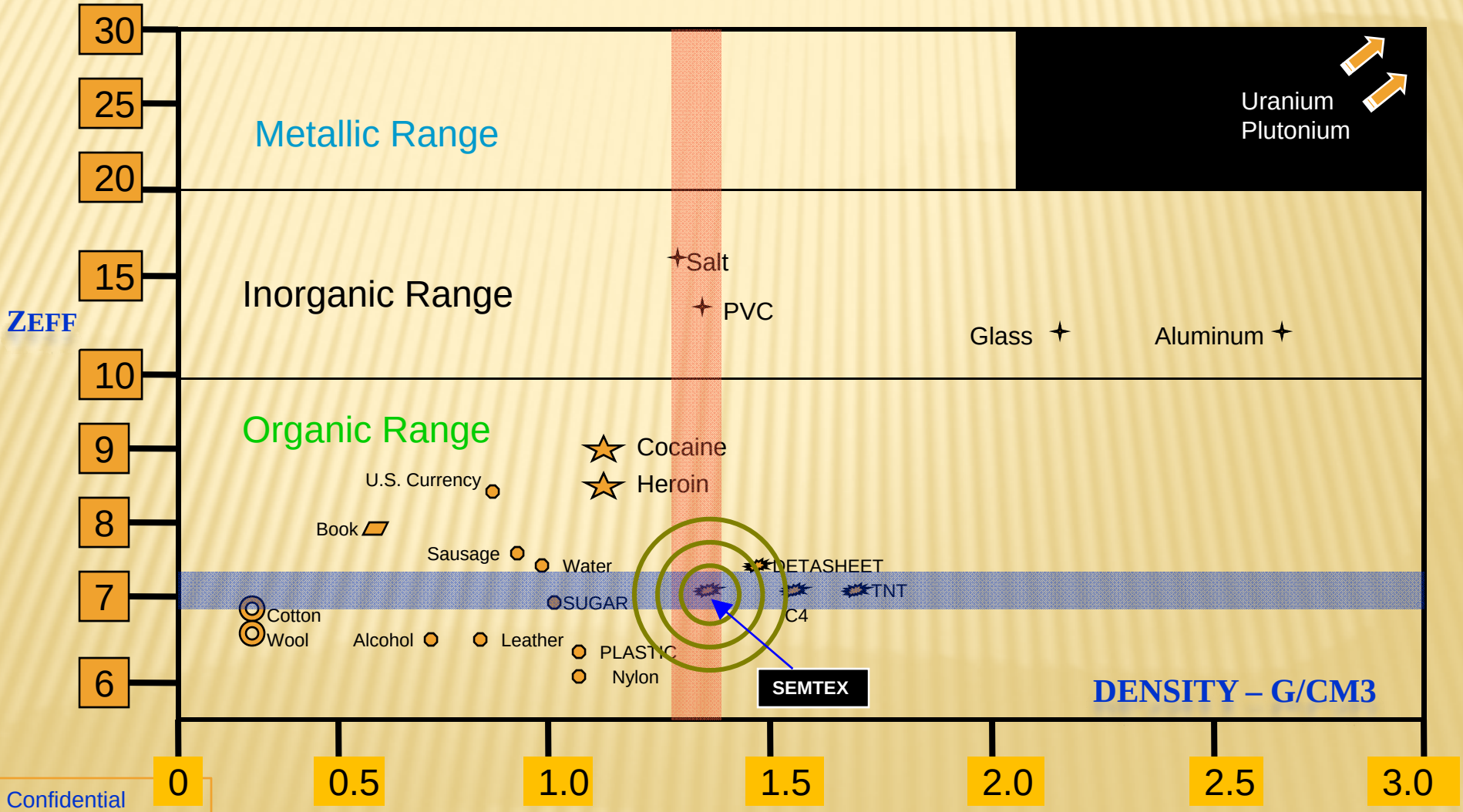
SENTINEL II


Materials Analysis
EXPLOSIVE
Details
Close


MATERIALS ANALYSIS
NAME:
EXPLOSIVE MATERIAL
NUMBER 5
DESCRIPTION
Z-EFF: 8.725
DENSITY: 2.469
EXPLOSIVE
Details
Close

SIMPLIFICATION

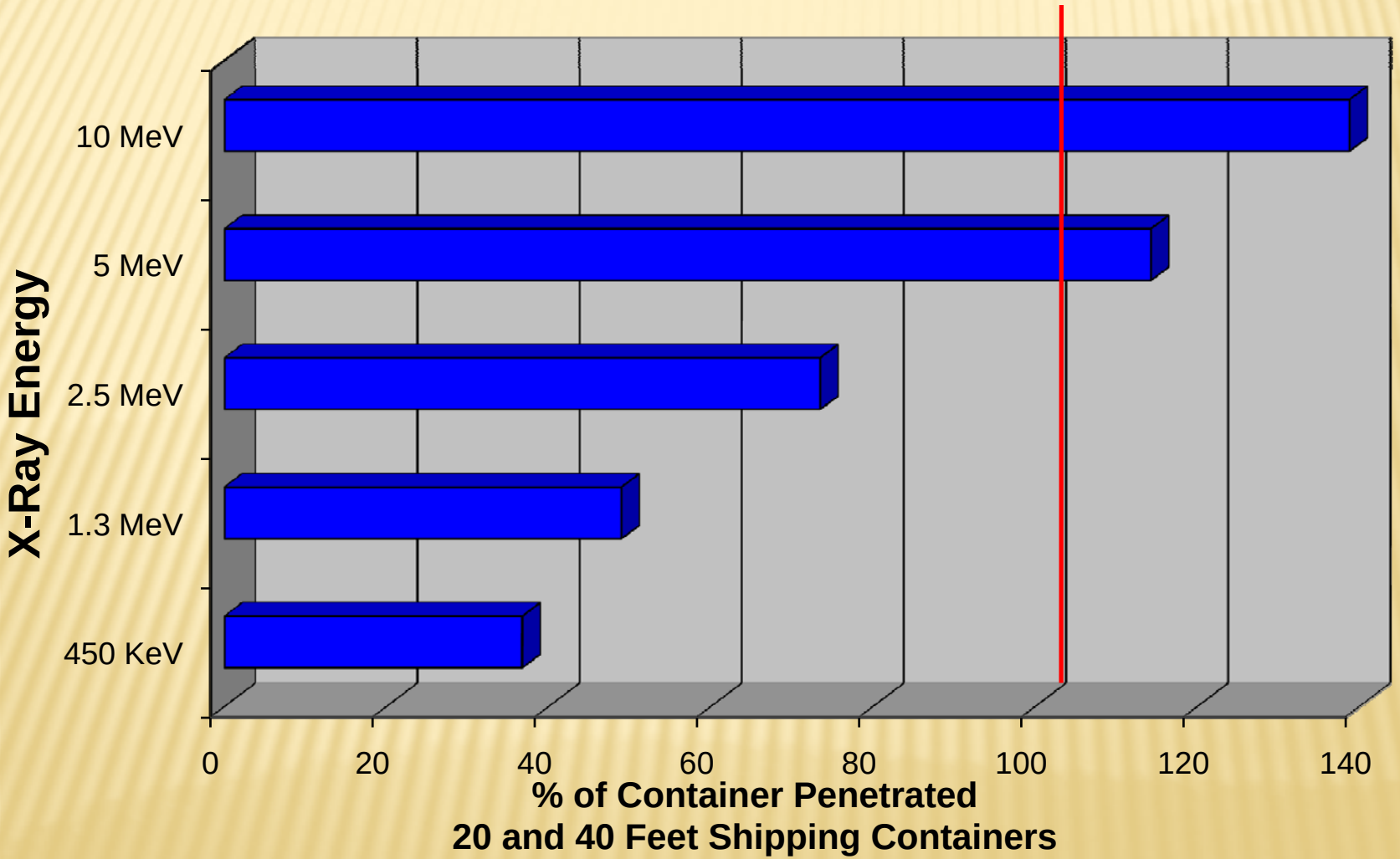
Dual-energy X-Rays are used to determine Effective Atomic Weight vs. Mass Densities of discriminate materials and identify threats.



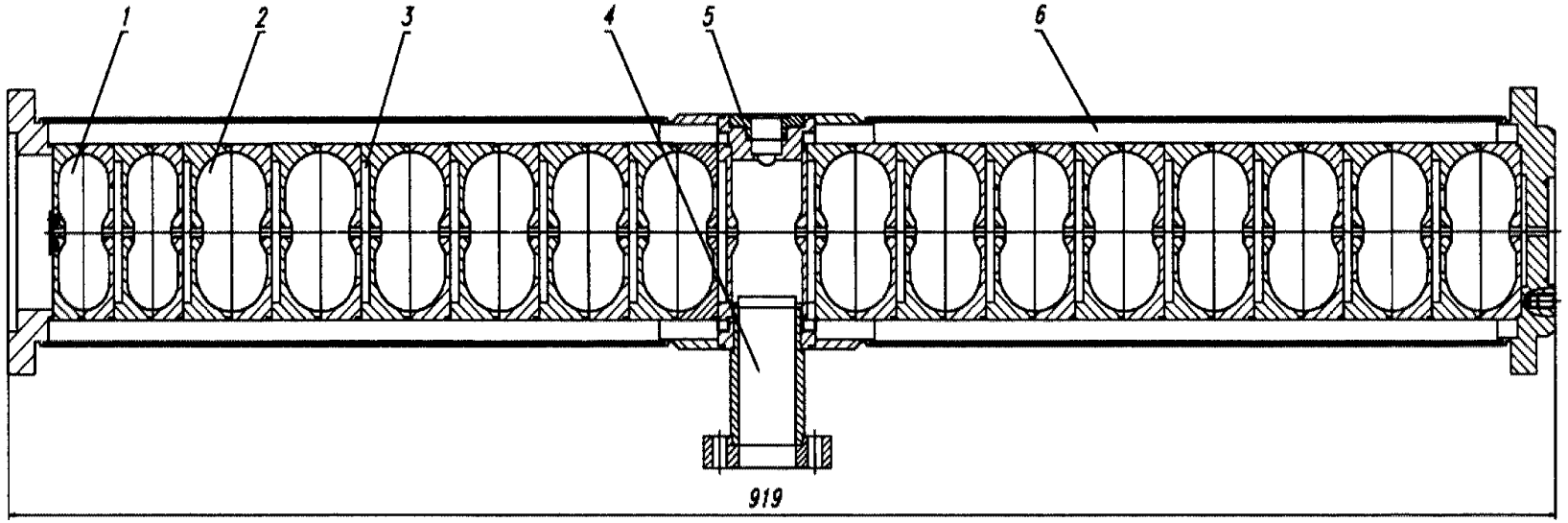
HIGH ENERGY VERSES LOW ENERGY

- Similar Progress Has Been Slow For Cargo Systems
- Several Factors Contribute To This:
  - Need high energy X-rays (i.e. 4 to 10 MeV)
  - Electron beam accelerator or electron LINAC required (i.e..bremsstrahlung radiography)
  - Very stable dual energy (i.e. less than 1% pulse-to-pulse variation)
  - Compensation for low interaction cross sections (i.e. you must be able to measure very small changes in intensity at the detector)
  - Very fast pulse rates
  - Noise is an issue (i.e. background radiation, thermal transients, electronic, etc.)

EFFECTIVE PENETRATION



EXAMPLE S-BAND ACCELERATING STRUCTURE



S-band accelerating structure

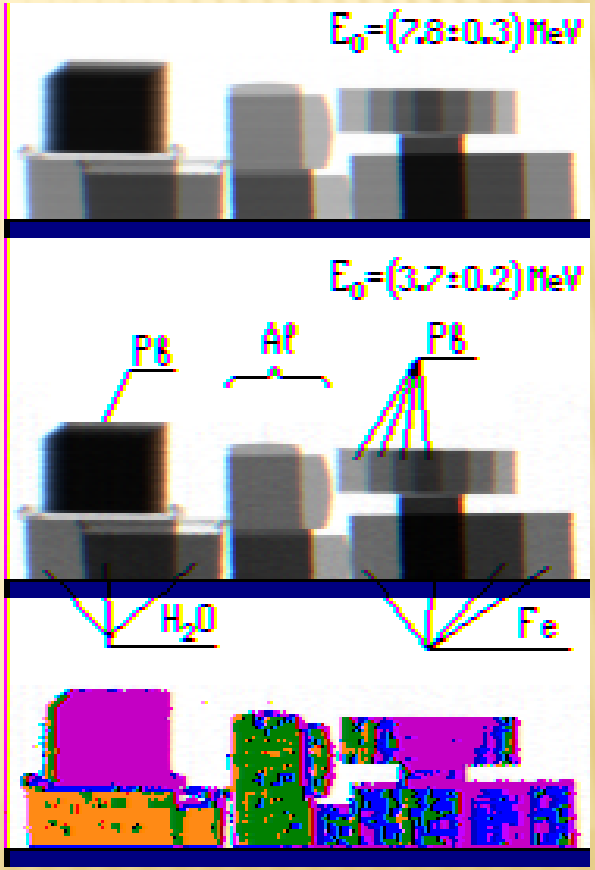
1 - Bunching cell
2 - Accelerating cell
3 - Coupling cell
4 - waveguide
5 - RF probe
6 - water cooling casing

CARGO ADVANCED AUTOMATED RADIOGRAPHY

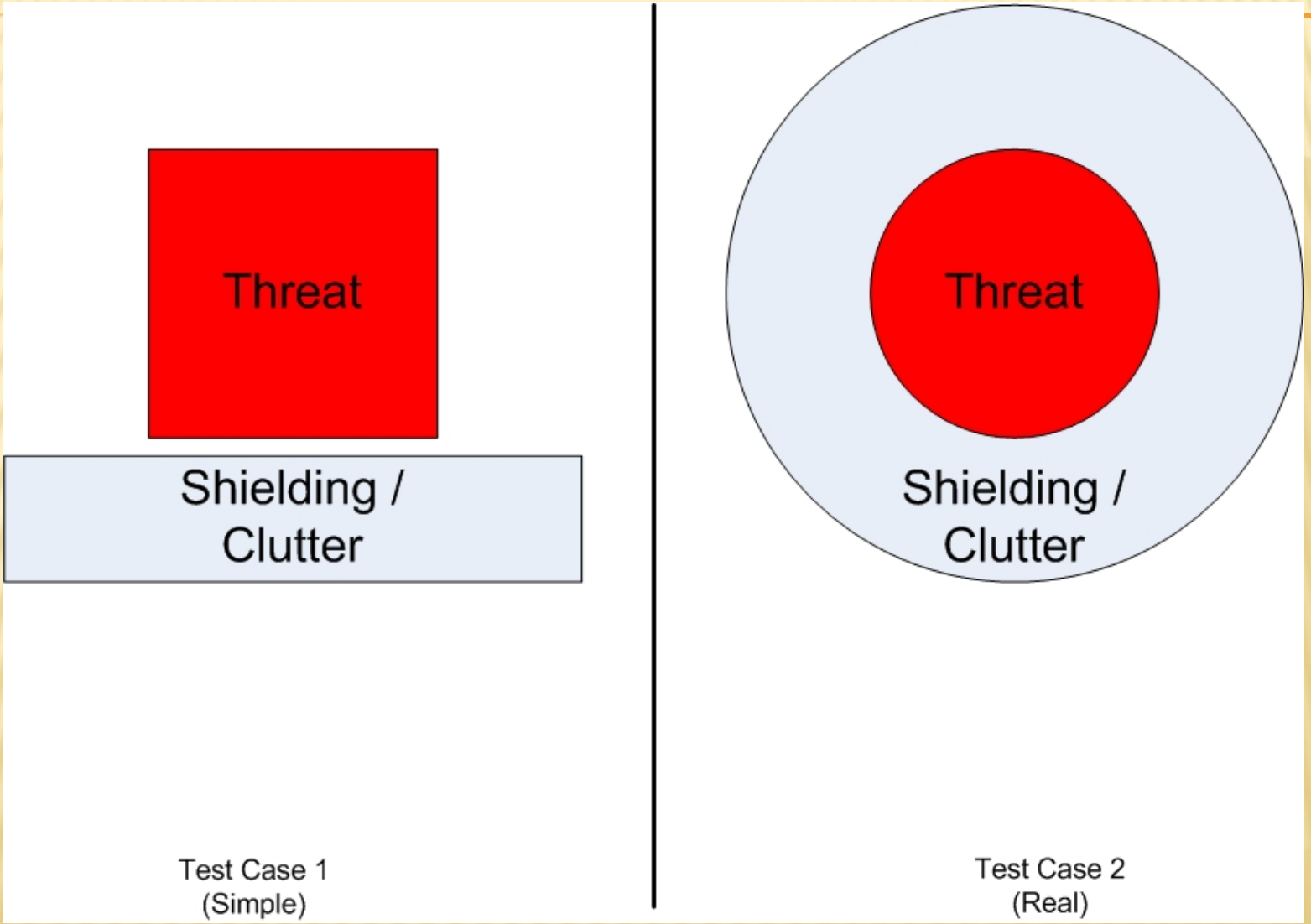
- CAARS Acquisition Initiated in 2005
- Develop, Test and Deploy A Material Discriminating Cargo Inspection System
- Sister Program to ASP – Rapid Design, Prototype and Deploy
- Focus on Identification of Shielded Nuclear Material
- Three Vendors Selected in September 2006
- Required To Design and Build Prototype in 2 Years
- All Failed and Program Cancelled in 2007
- Moved Back Into Research and Development

DUAL ENERGY MATERIALS DISCRIMINATION

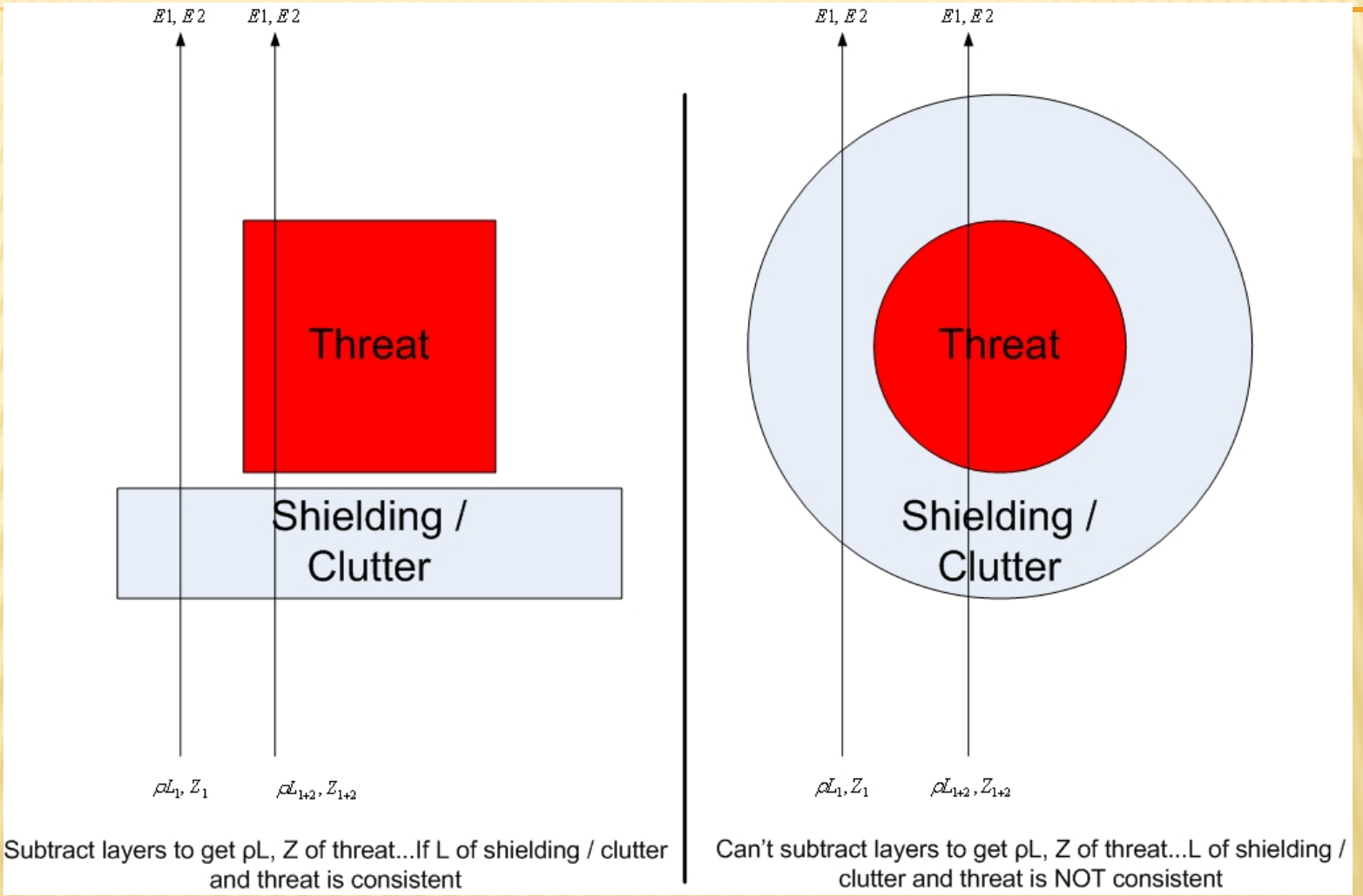
- Single energy inspection cannot discriminate between lead (Pb), aluminum, water or steel in a wedge test
- Dual energy inspection provides the ability to differentiate between materials



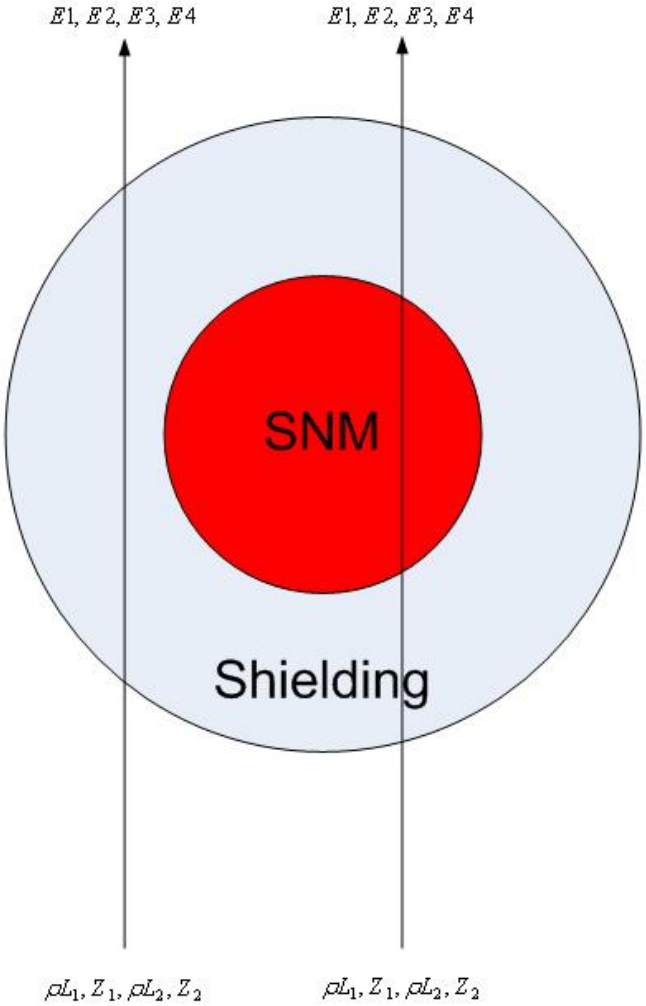
THE PROBLEM



THE PROBLEM



THE SOLUTION

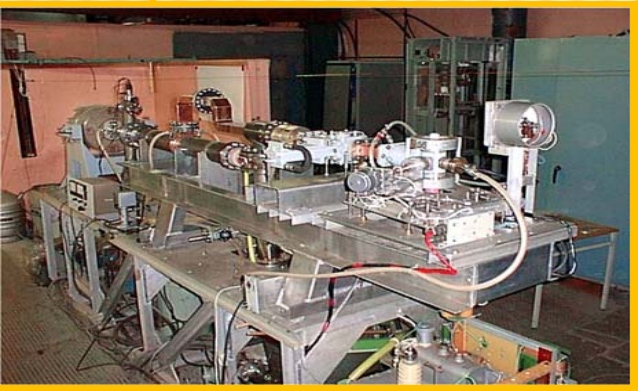


With four energies one can solve directly for ρL, Z of shielding and SNM…Independent of L of shielding and SNM
If more layers...Use more energies

POST 9/11 CAPABILITY & DEVELOPMENT

IBS was formed in 2002 to commercialize technology and manufacture products

Energy Level	2002 – 2003	2003 - 2006	2007 – 2010	2010 - Future
	INSPECTOR	**LEU 8**	**ALL SECURE/CAARS**	**NEXTGEN**
	Design Only	Test Accelerator	Prototype IV	Early Design
	Hi-Energy 10 MeV	Hi-Energy 8 MeV	Hi-Energy 10 MeV	Hi-Energy 10+ MeV
	Dual Energy	Manual Dual Energy	Multiple Energy	Multiple Energy
	Dual Plane	Single Plane	Single Plane	Multiple Plane
H	High Throughput	Low Throughput	High Throughput 30+	Very High Throughput 120
i	Material Discrimination	High Z Demo	Improved Processing	Photo-fission Processing
g		Improved Processing	High Z Optimization	WMD Optimization
h				Material Discrimination
	Full scale geometry	Detector Array Test Bed	Full scale geometry	Full scale geometry

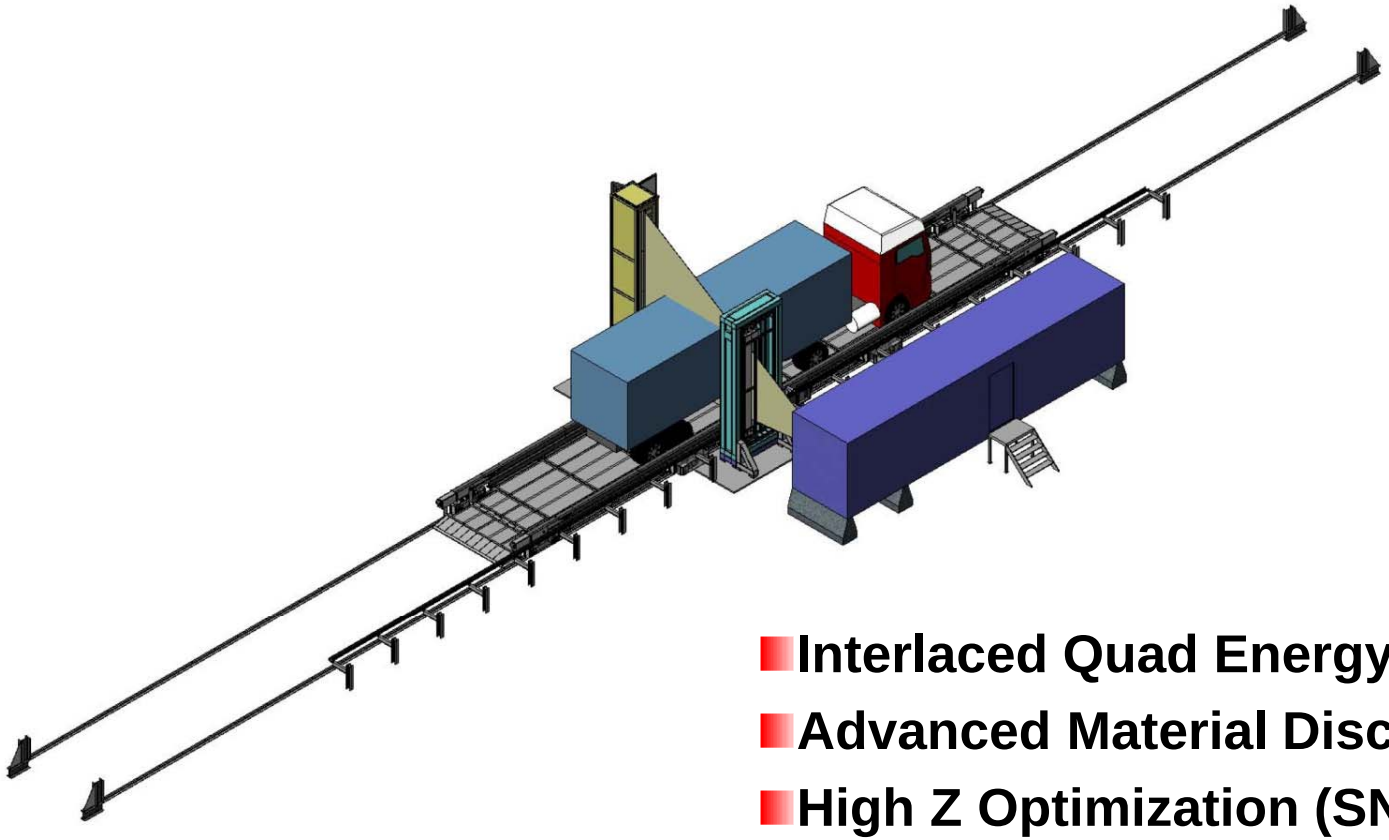


9 MeV – Eual Energy Accelerator - 2001

7.5 Mev Dual Energy Accelerator - 2005

10 MeV Quad Energy accelerator - 2007

ALLSECURE CARGO INSPECTION SYSTEM

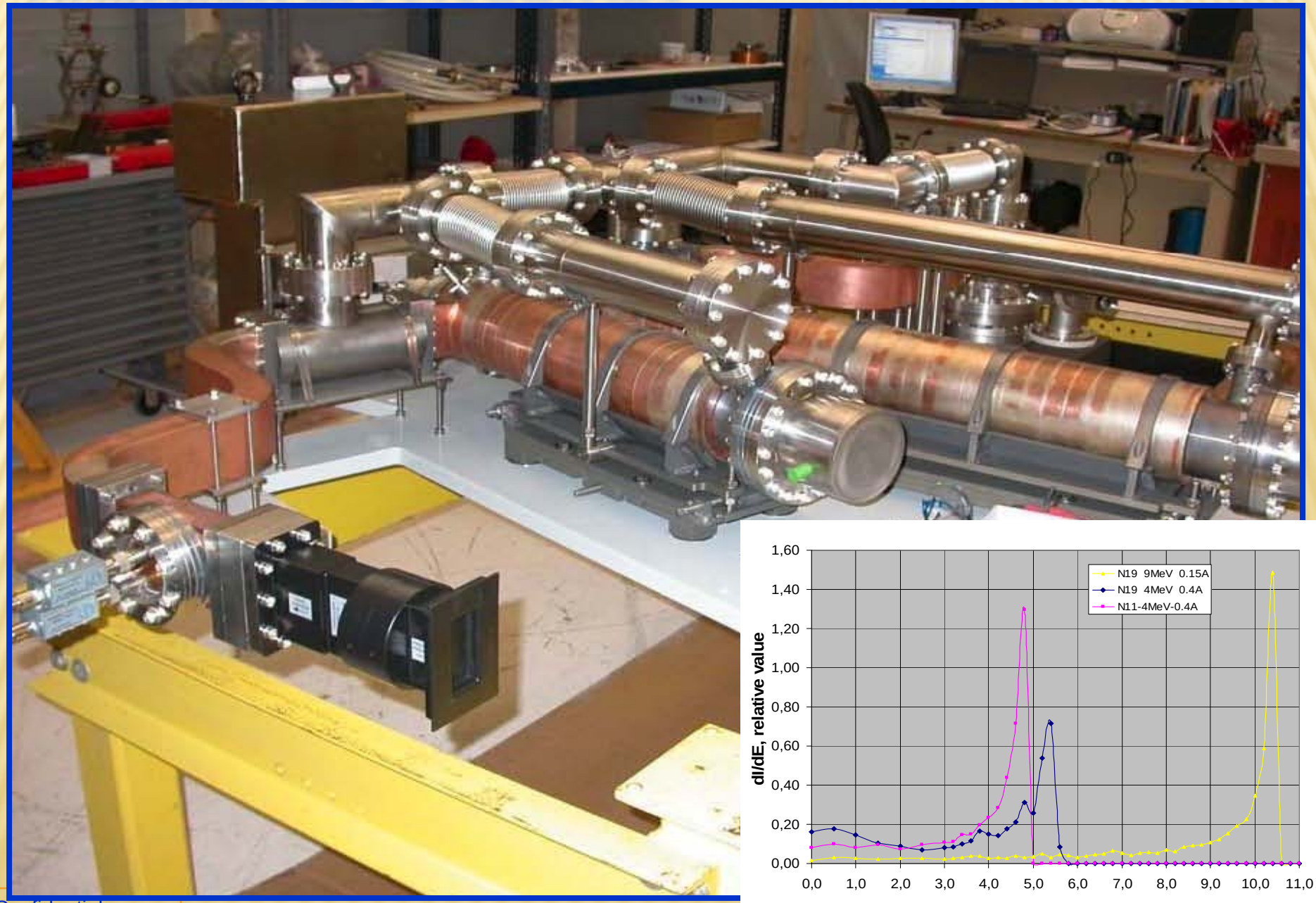


- Interlaced Quad Energy
- Advanced Material Discrimination
- High Z Optimization (SNM)
- In Test-bed Demonstration

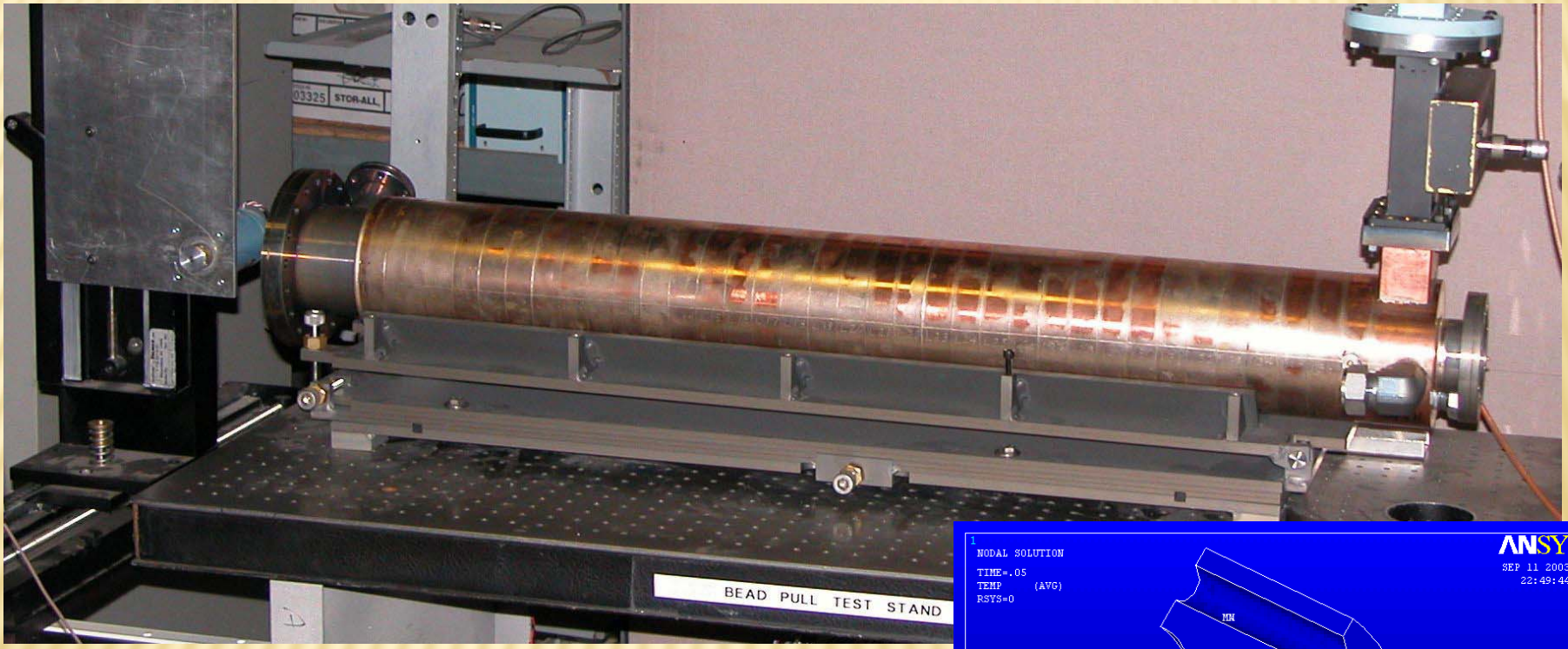
ALL SECURE TECHNOLOGY HIGHLIGHTS

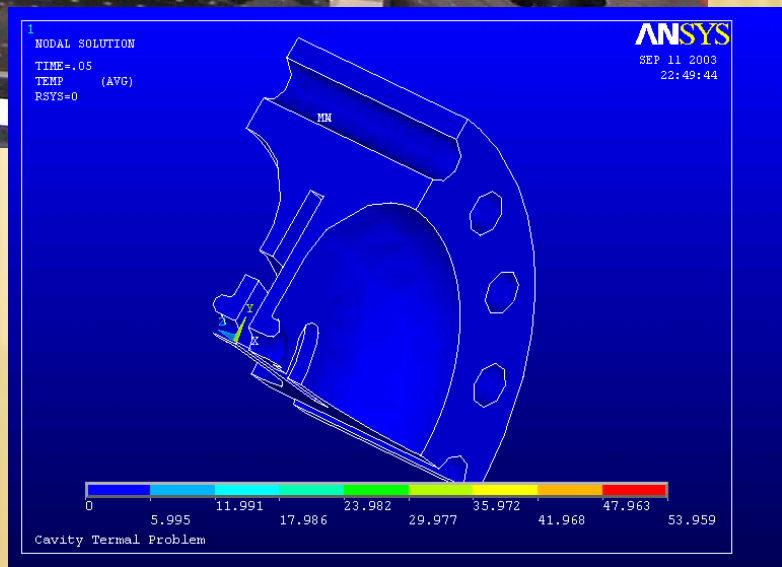
- Full Time Quad-Energy (FTQE) for primary con-ops
- Energy Sweep Mode (ESM) for secondary con-ops
- Adaptive Energy Control (AEC) for energy optimization
- High energy 5 - 16 MeV, low energy 3 - 10 MeV
- High beam pulse energy (6 -14 J)
- Ultra-low jitter system design
- Low loss accelerator design
- Pulse-to-pulse x-ray beam stability better than 1%
- Complete scan x-ray beam stability better than 5%
- Beam pulse length 5 - 10 μsec
- Pulse Repetition Rate (PPR) of each accelerator 300 Hz
- Three and four energy Z analysis method
- Inverse solution Z analysis (ISZ) method

QUADRAD ACCELERATORS

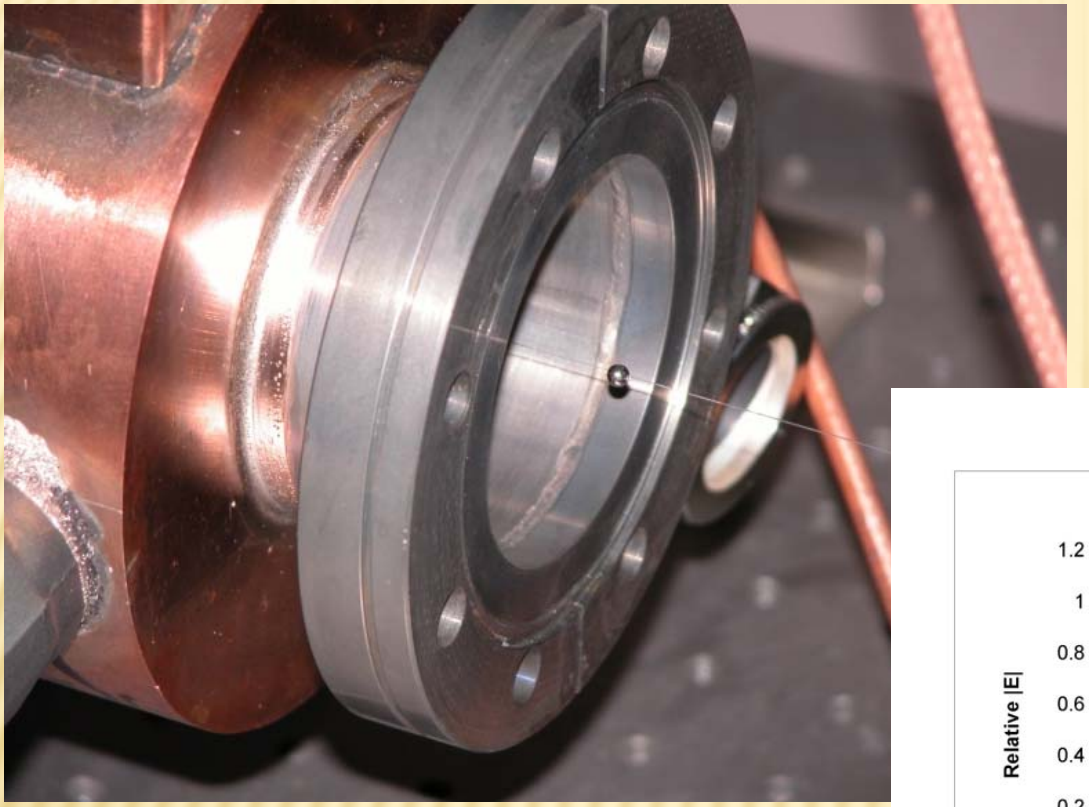


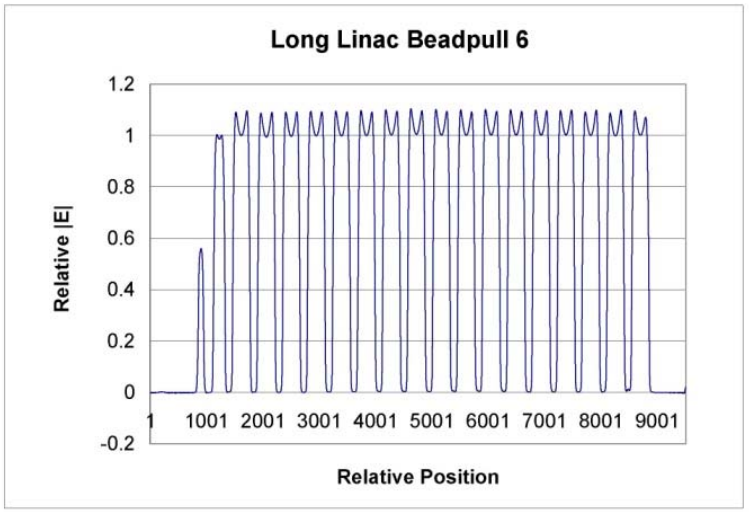
ACCELERATOR STRUCTURE



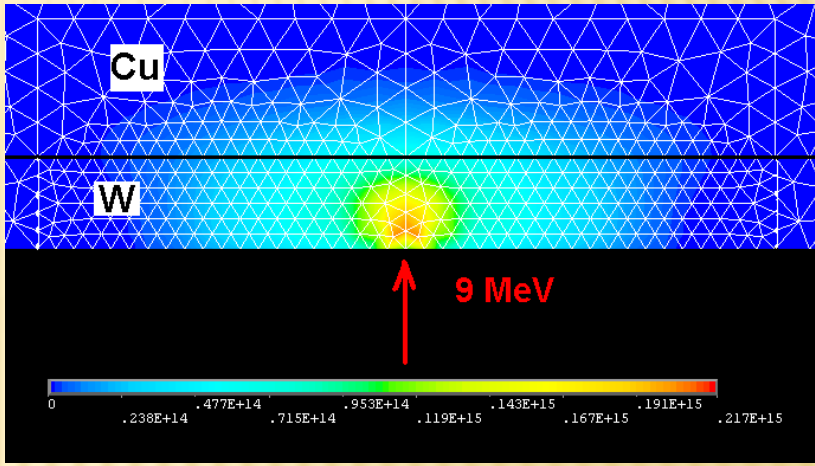


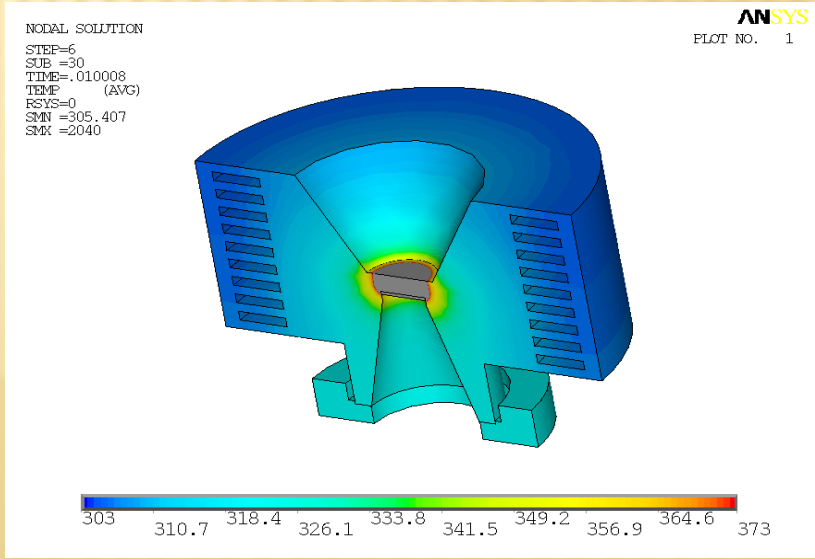
ACCELERATOR BEAD-PULL



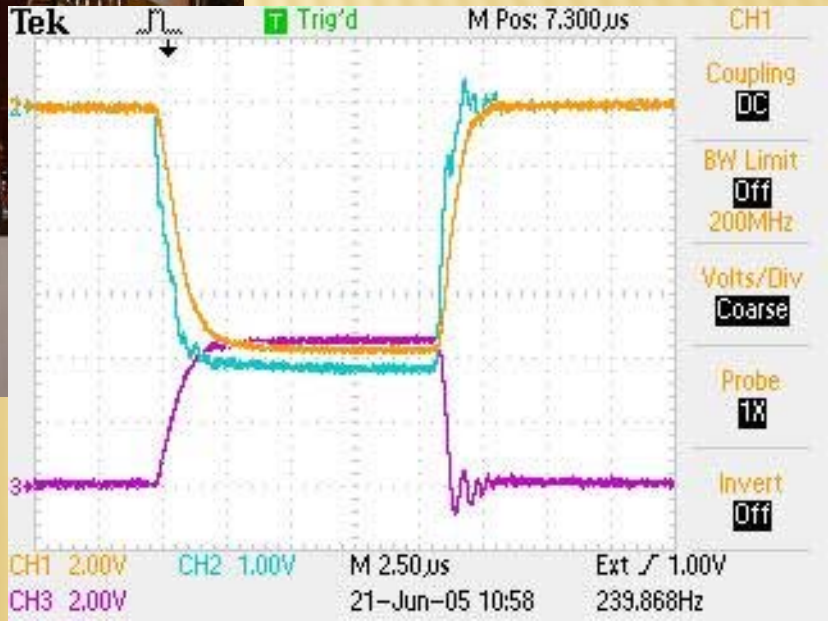


BREMSSTRAHLUNG CONVERSION TARGET





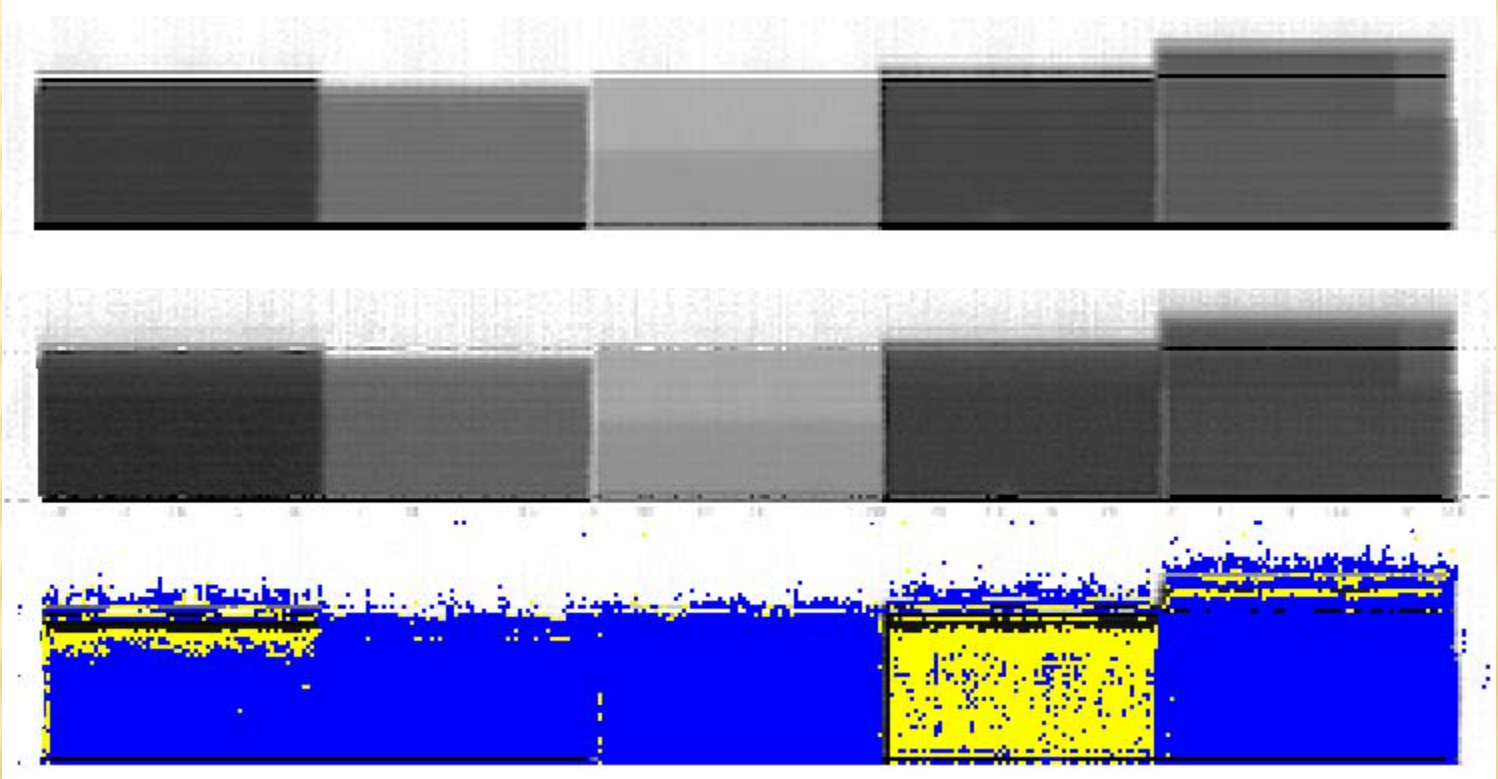
PULSE POWER SYSTEM MODULATOR



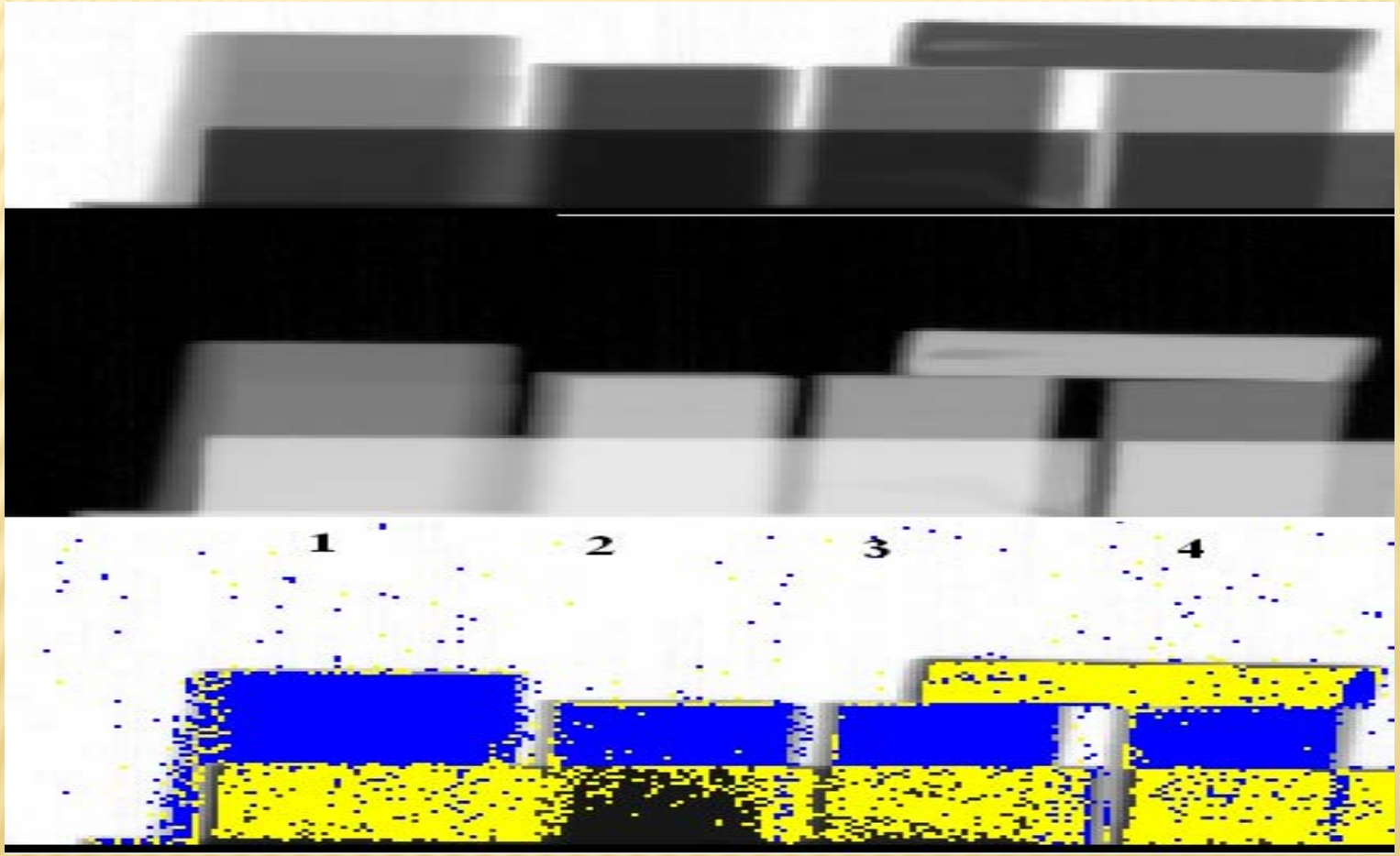
INTEGRATION AND TEST

Z-ANALYSIS TESTING (STEEL, ALUMINUM &LEAD WEDGE TEST)

Z-ANALYSIS TESTING (STEEL AND LEAD WEDGE TEST)



Z-ANALYSIS TESTING WITH STEEL SHIELD (WEDGE TEST)



ALLSECURE CARGO INSPECTION SYSTEM

- 4-10 or 16 MeV
- Interlaced Quad Energy
- Advanced Material Discrimination
- High Z Optimization (SNM)
- 40+ Containers per Hour Throughput
- Ready For Full Scale Pilot Demonstration By December 2011

THE END

THANK YOU

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