Liquid Krypton Gamma Detector & Neutron Imaging

Matthew Krupcakle
Liquid Krypton (LKr) Gamma Ray Detector

• Objective
  – Gamma energy less than 12 MeV
  – Rapid decision-making
  – Minimal integration (pulse) time

• Application
  – Spectral analysis for isotope identification
  – Rapidly scan cargo for IEDs and nuclear materials
Gamma Ray Scintillation Detector

- Radioactive source decays and emits a photon
- Photon interacts with the matter to produce electrons
  - Photoelectric effect, Compton Scattering & pair production
- Electrons collect in photomultiplier tube (PMT)
- Current/voltage pulse height proportional to initial electron and gamma energy
LKr Scintillation Detector Design

- $^{85}\text{Kr}$ Beta Decays
- Optimal Dimensions
- Xenon Doping
  - Reduces scintillation pulse decay time
  - Increases energy resolution

Simulated gamma spectrums for LKr Detector
LKr Detector

Outside vacuum chamber

Side cross section view of LKr detector with gamma ray shower and small PMTs

Side view cross section

Back cross section
SoftWare for Optimization of Radiation Detectors (SWORD)
SWORD Events

- CAD-like interface
- Monte-Carlo simulation using GEANT 4 simulation engine from CERN

2.22MeV Photon Beam - No filter

2.22MeV Photon Beam - Nonzero charges
10.8 MeV Photon Beam
Neutron Imaging

• Associated Particle Imaging (API) technique
  – Deuterium-Tritium nuclear reaction
Neutron Imaging

• $\alpha$ particle hits position-sensitive detector
  – Direction and time of neutron emission
• Neutron interacts with target material
  – Produces gamma ray
Medical Application

Dose in rem:
\[ H = 1.6 \times 10^{-5} \frac{n}{r^2} \]
\[ \{ n - \text{neutrons/sec} \} \]
\[ r - \text{cm} \]
\[ \sigma_{\text{Fe}} \approx 3.1 \text{ barns} \]

5_rems Max \( \Rightarrow \) 30 sec exposure