Pulsed Operation of the UW-IEC Device

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Outline

• HEU detection methods
• UW pulsed IEC design
• High-speed diagnostics
• Neutron production characteristics
• Summary and future work
Importance of Research

• There have been at least 150 incidents of nuclear smuggling in past decade (IAEA)

• Half involve enriched uranium or plutonium

• As little as 16 kg of HEU or 6 kg of Pu can be used to produce a 20 kiloton weapon, even with low technology levels

• Border security is a proven safeguard, but technology to detect HEU is not yet available

• Developing technology for the detection of HEU has become a priority for the US Department of Homeland Security
There are Two Categories of Non-Destructive Special Nuclear Material Detection

• Passive and active detection

• Passive detection is unreliable for HEU
  – Low count rates
  – Simple to shield
  – Calorimetry easy to deceive

• Active Detection is more applicable
  – Neutrons or photons
  – Neutrons are highly penetrating in high-Z material
  – Large fission cross-sections
UW Concept for Active Detection of HEU

IEC → D-D neutrons → HEU → Fission neutrons

Prompt & Delayed

Neutrons

Time

5
Initial Design Uses Ion Source to Generate Pulses

- 200kV Power Supply
- Filament temperature control
- DC bias
- Pulse generator
- 100 nf
- HEU
- Paraffin Wax
- Neutron Detector
Pulse Video

- Video taken at 80 kV, 0.3 Pa D₂, 500 mA pulse current
Current Status

- Max Voltage: 110 kV
- Max Pulse Current: 3 Amps

- Shortest Pulse: 10 µs
  - Cathode current: ~70 µs
  - With “flat top” current: 200 µs

- Max Neutron Rate During Pulse to Date:
  - $1.5 \times 10^9$ n/s (80 kV, 3 A, 0.38 Pa $D_2$)
High-Speed LabVIEW Diagnostic
Provides View of Pulse Trace

![Graph showing Cathode Current and Filament Bias Voltage over time](image)
High-Speed Neutron Diagnostics Provide Greater Insight into Pulsed Operation
Larger Cathode Yielded Higher Pulse Current and Neutron Rates

- Pulse current increased by ~20% when switching from 10cm to 20 cm cathode
- Average ion energy is higher
  - Ions encounter fewer neutrals as they are accelerated

Past Configuration

Current Configuration

Future Configuration?
Pulse Current Increases Linearly with Cathode Voltage

**constant source conditions for both experiments**
Neutron Rate Scaled Less Than Linearly With Pulse Current in Initial Design

- Filament power adjusted to change current
- 10 kΩ resistor currently in series with IEC to limit arc current
- Cathode voltage drops accordingly with increased pulse current
- Future design will reduce resistor to 1 kΩ

Data taken at 90 kV (meter), 0.36 Pa D₂
Summary

• Pulsed IEC has been developed that is capable of operation at 110 kV, 2.4 A, 0.37 Pa D₂

• Pulsed neutron rates of $1.5 \times 10^9$ n/s have been achieved during 500 µs pulses

• New diagnostics have provided greater insight to high-speed operation

• Operation with 20 cm cathode has improved pulse current and neutron rates
Future Experiments will Focus on Increasing Pulse Current and Neutron Production

- Generate higher current from filaments
  - Study contributions of individual filaments
  - Add additional filaments
  - Increase negative pulse voltage

- Pull more current into cathode
  - Increase cathode size
    - Recent experiments have looked at 10 cm vs. 20 cm cathodes
  - Replace 50 cm anode with 35 cm anode

- Begin irradiation of HEU samples
  - Detection hardware is available for initial experiments
  - HEU sample should be available in near future
Questions?