

# Detection of Highly Enriched Uranium Using a Pulsed IEC Fusion Device

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US-Japan Workshop
May 23, 2007

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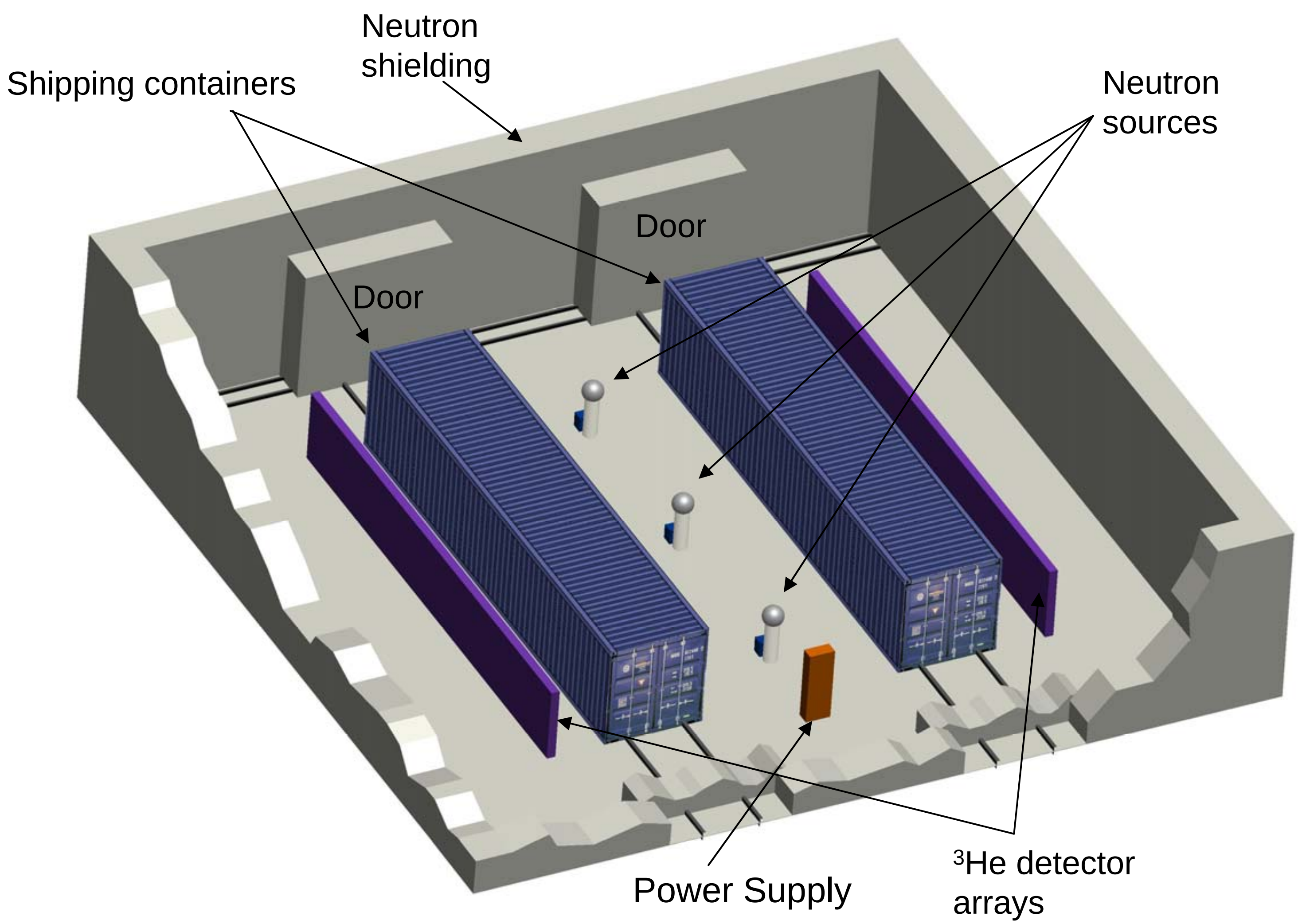
# Outline

- Motivation for pulsed IEC research
- Description of HEU detection method
- Progress of pulsed IEC development
- HEU detection results
- Conclusions

# Motivation for Pulsed IEC-based Fissile Material Detection Research

- There have been at least 150 incidents of nuclear smuggling in past decade, half involving special nuclear material (IAEA)
- 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
- Developing technology for the detection of HEU has become a priority for the US Department of Homeland Security
- IEC technology can provide high fluxes of D-D or D-T neutrons for long lifetimes

# IEC Fusion-Based HEU Detection Concept




Source: Greg Sviatoslavsky

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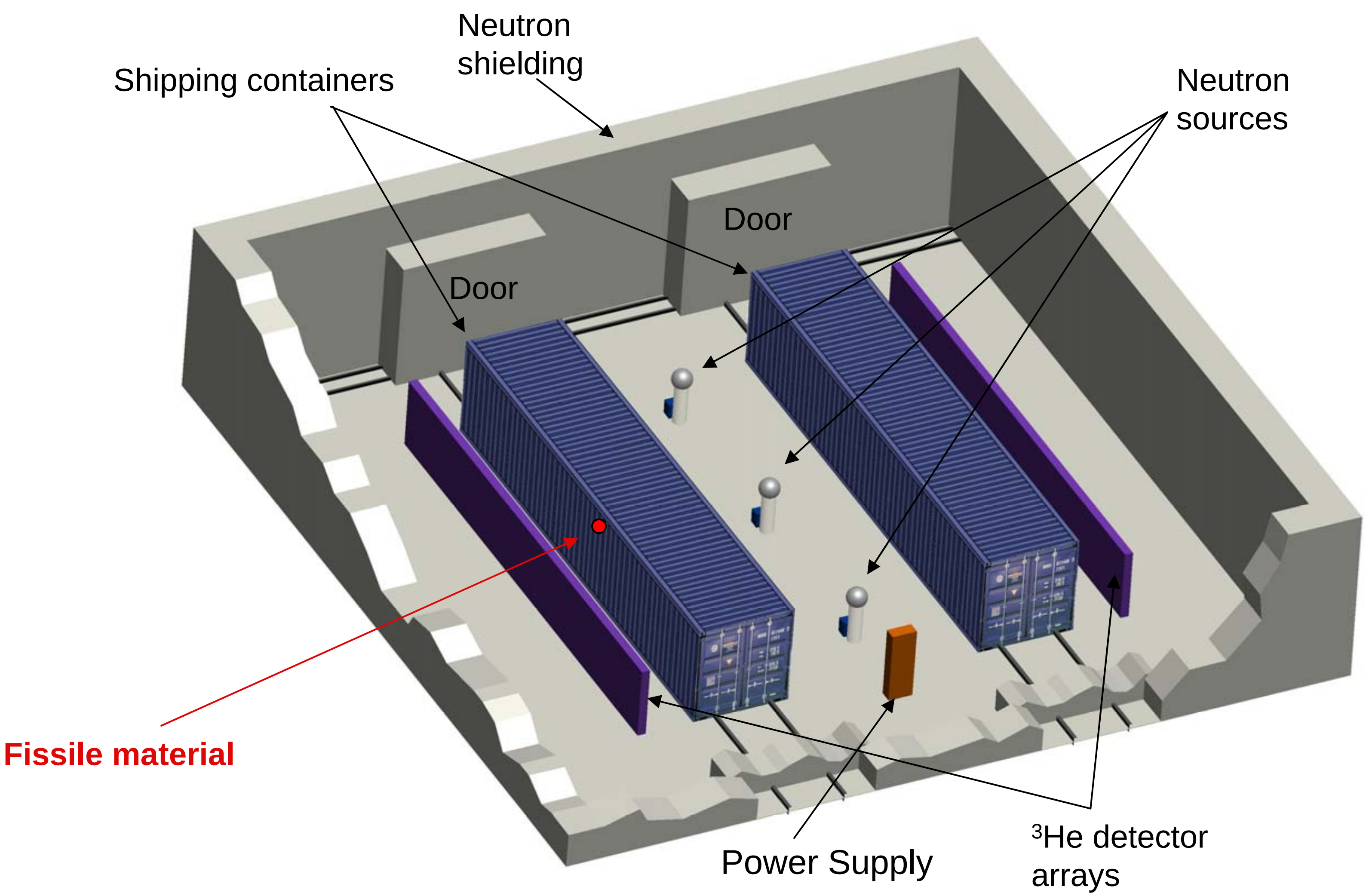
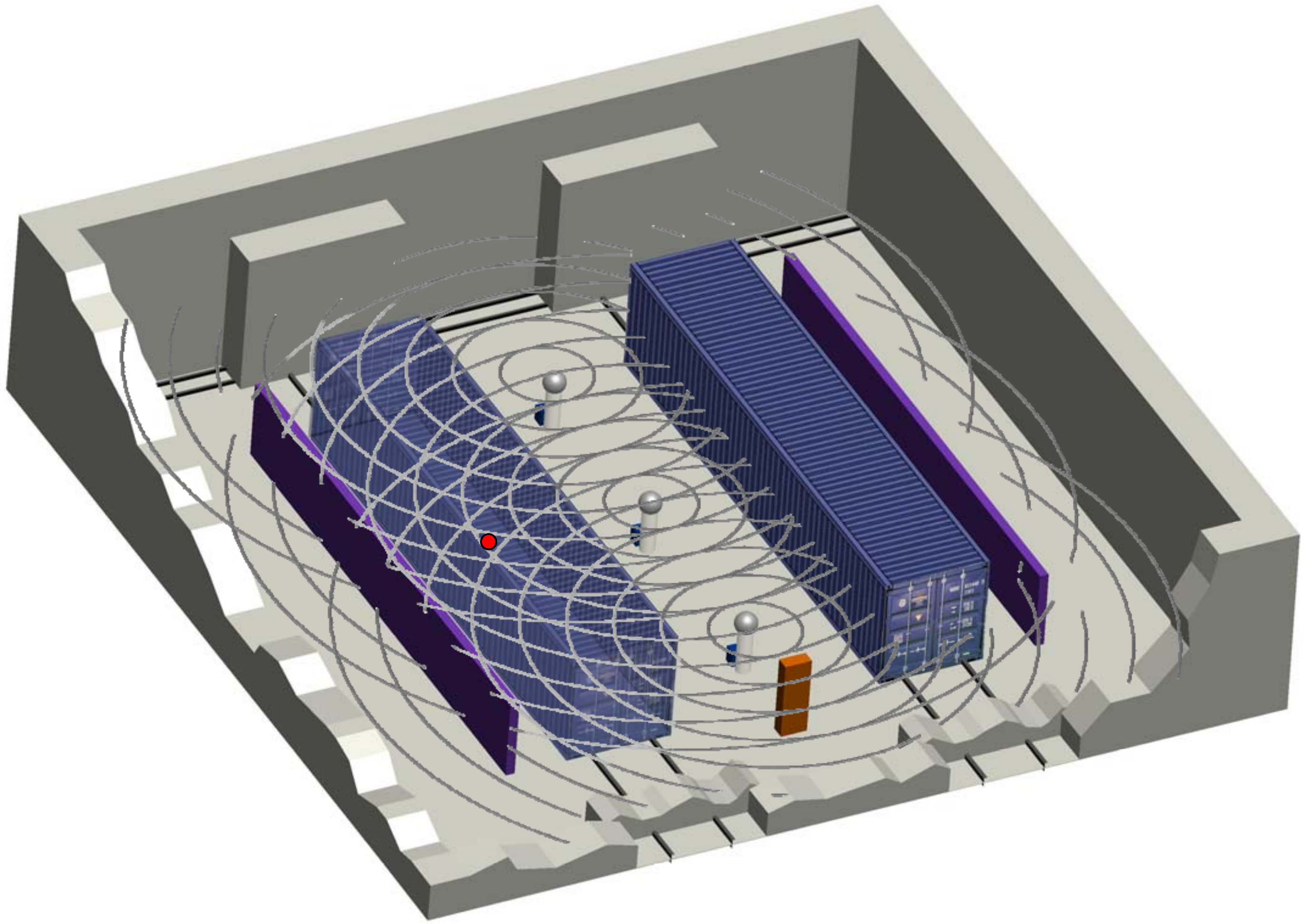



Source: Greg Sviatoslavsky

# Pulsed Fusion Neutrons Induce Fissions within the Shipping Container



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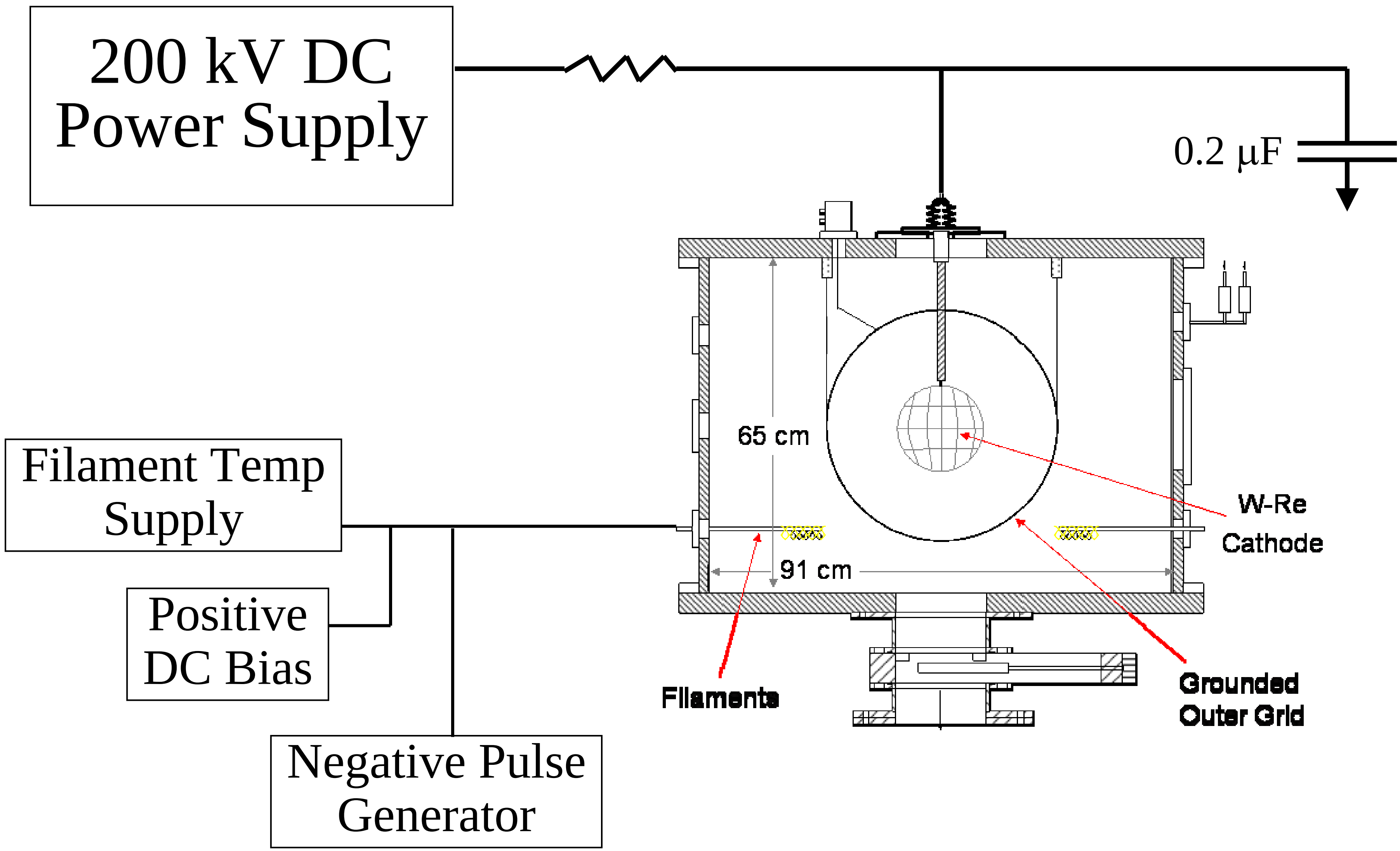
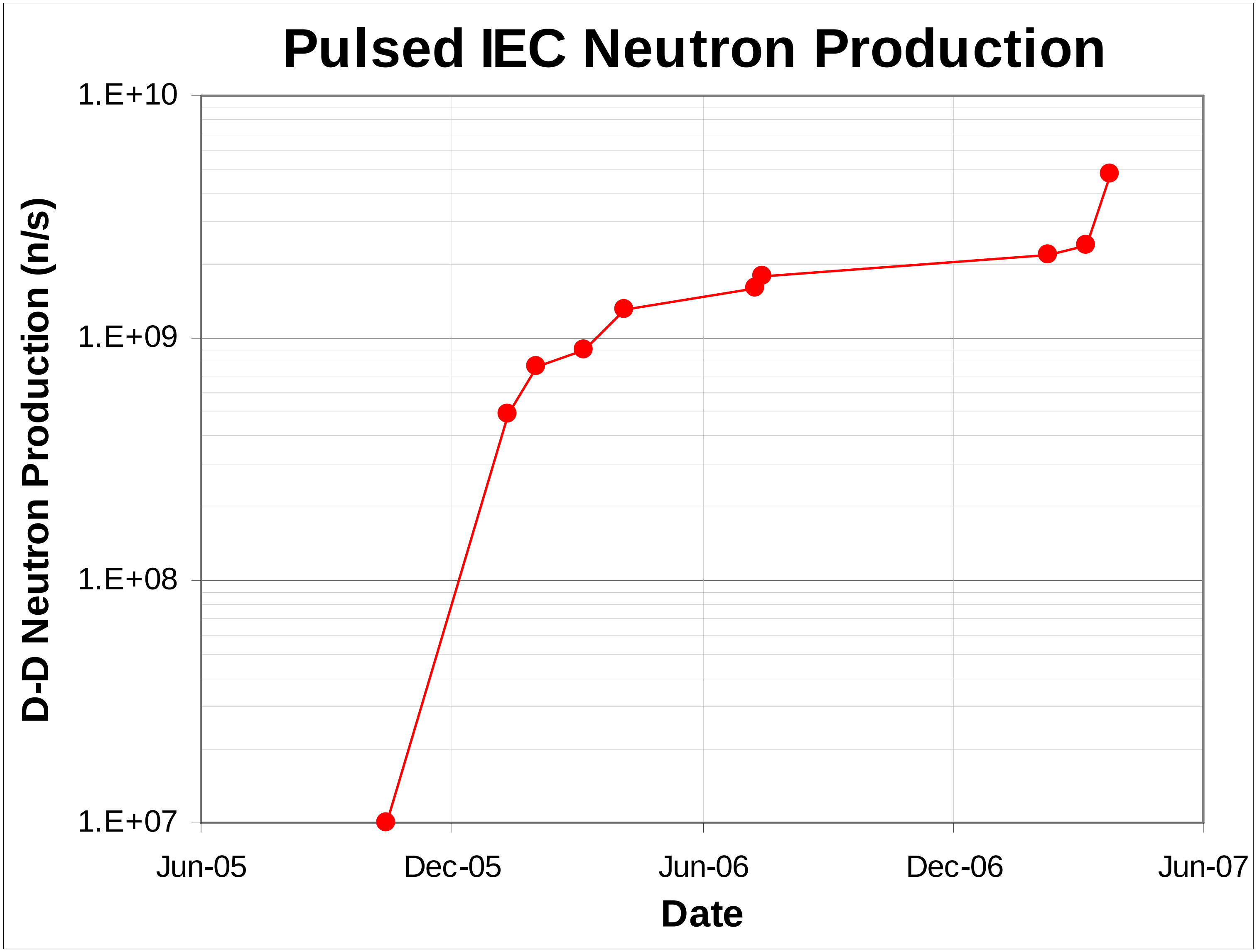
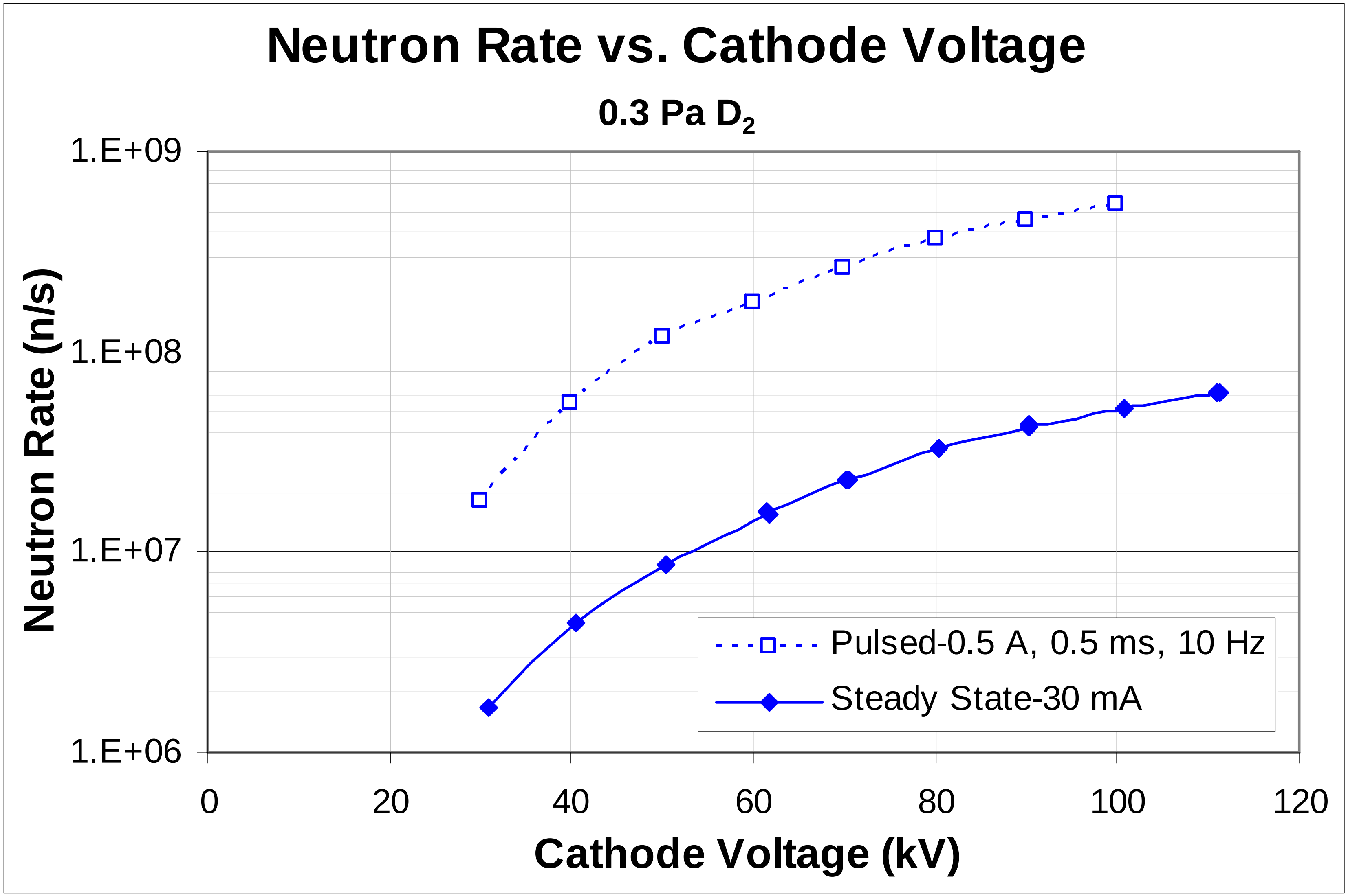
# Wisconsin Design Uses Ion Source to Generate Pulses



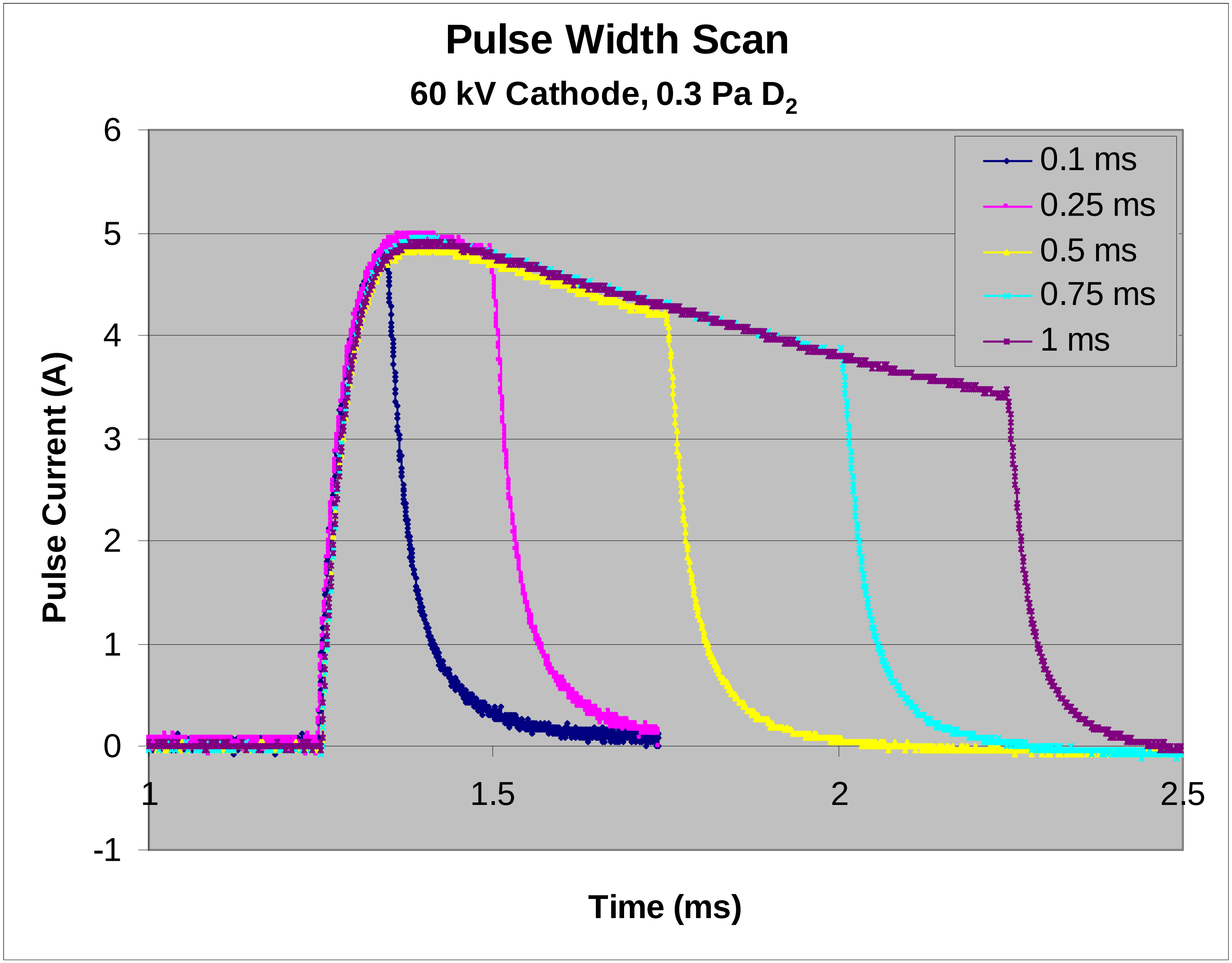
# Significant Progress has been Made Over the Past Two Years



# Fusion Cross-Sections Increase with Increased Ion Energy



# Shorter Pulse Widths Generate Higher Intensity Pulses



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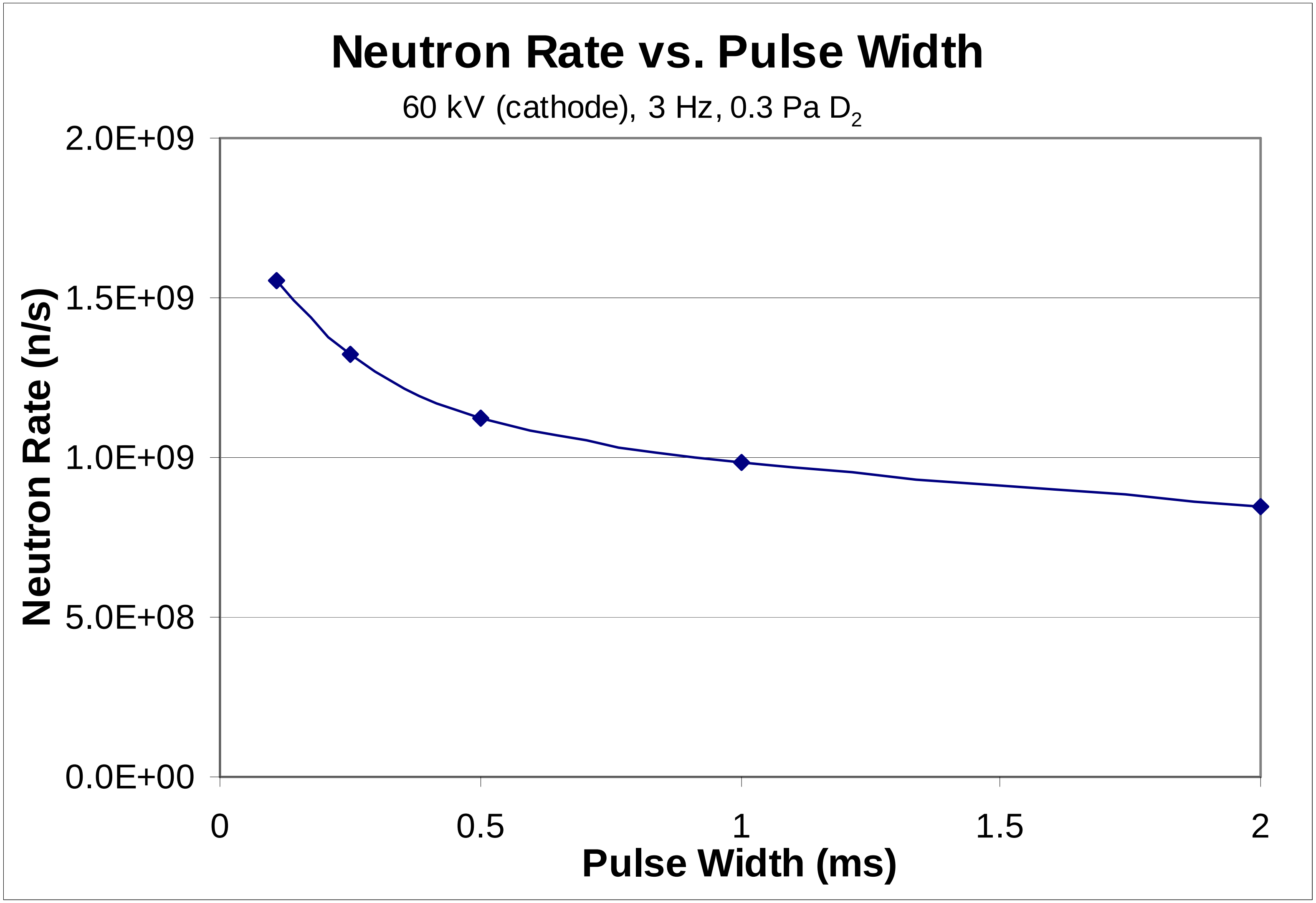
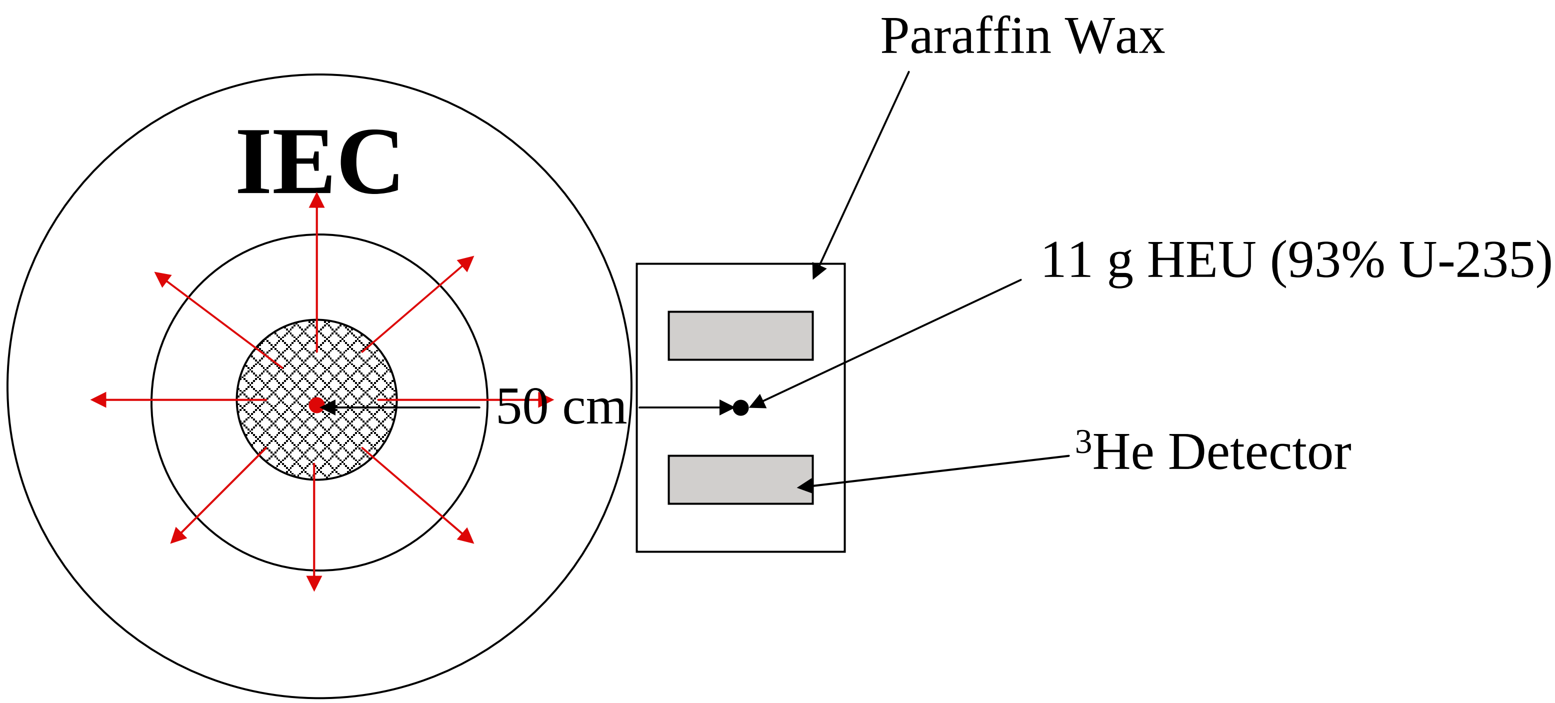


# Pulsed IEC Capability Has Reached Levels Sufficient for Near-Term Application Research

- Max Cathode Voltage: 120 kV
- Max Pulse Current:
  - Deuterium:  6 Amps
- Max D-D Neutron Rate: $4.7 \times 10^9$ n/s
  - (96 kV , 5 A, 0.33 Pa)
  - (110μs pulse width, 5 Hz)

# MCNP Model Accurately Predicts Time-Dependent Neutron Behavior



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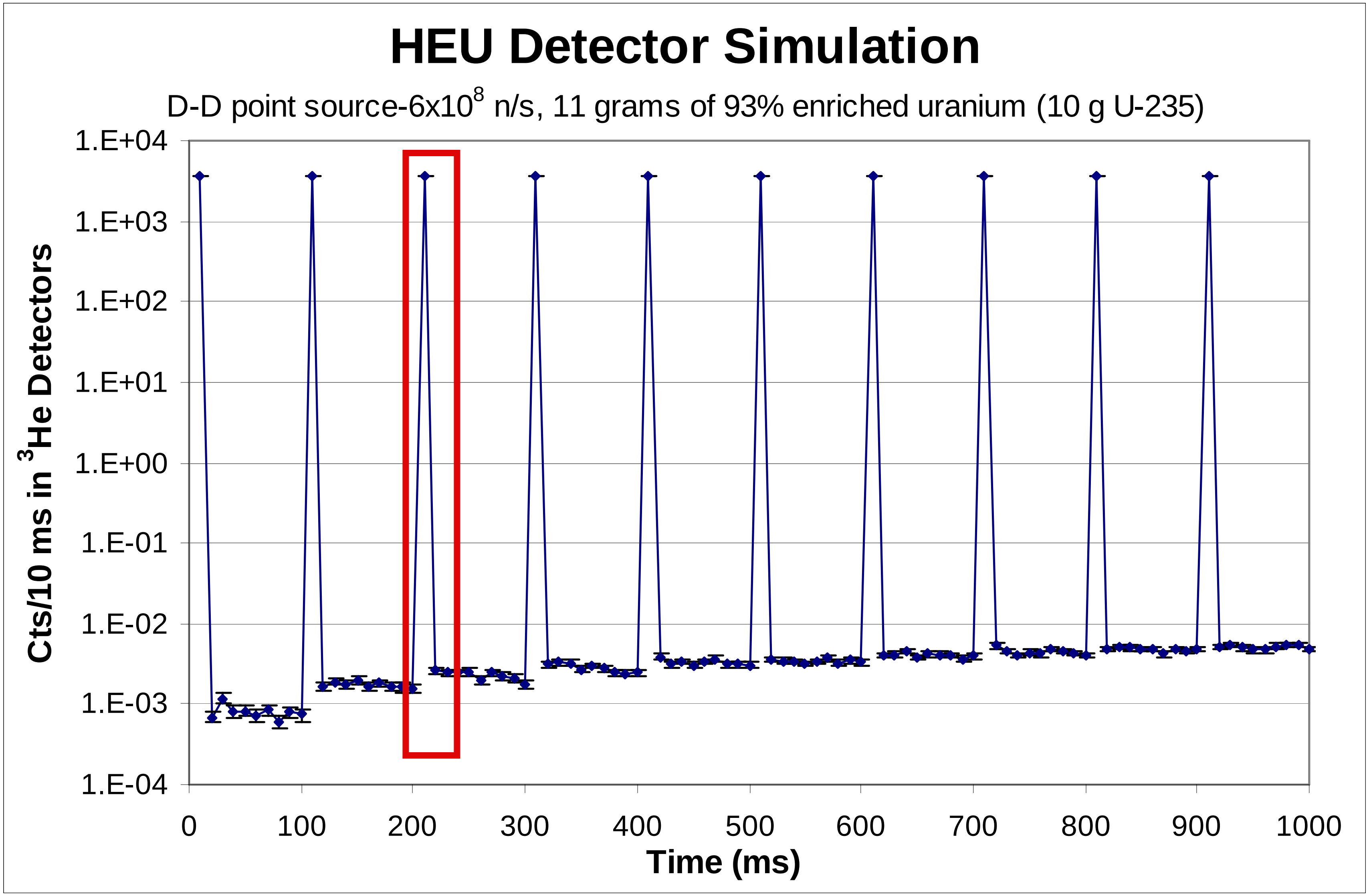
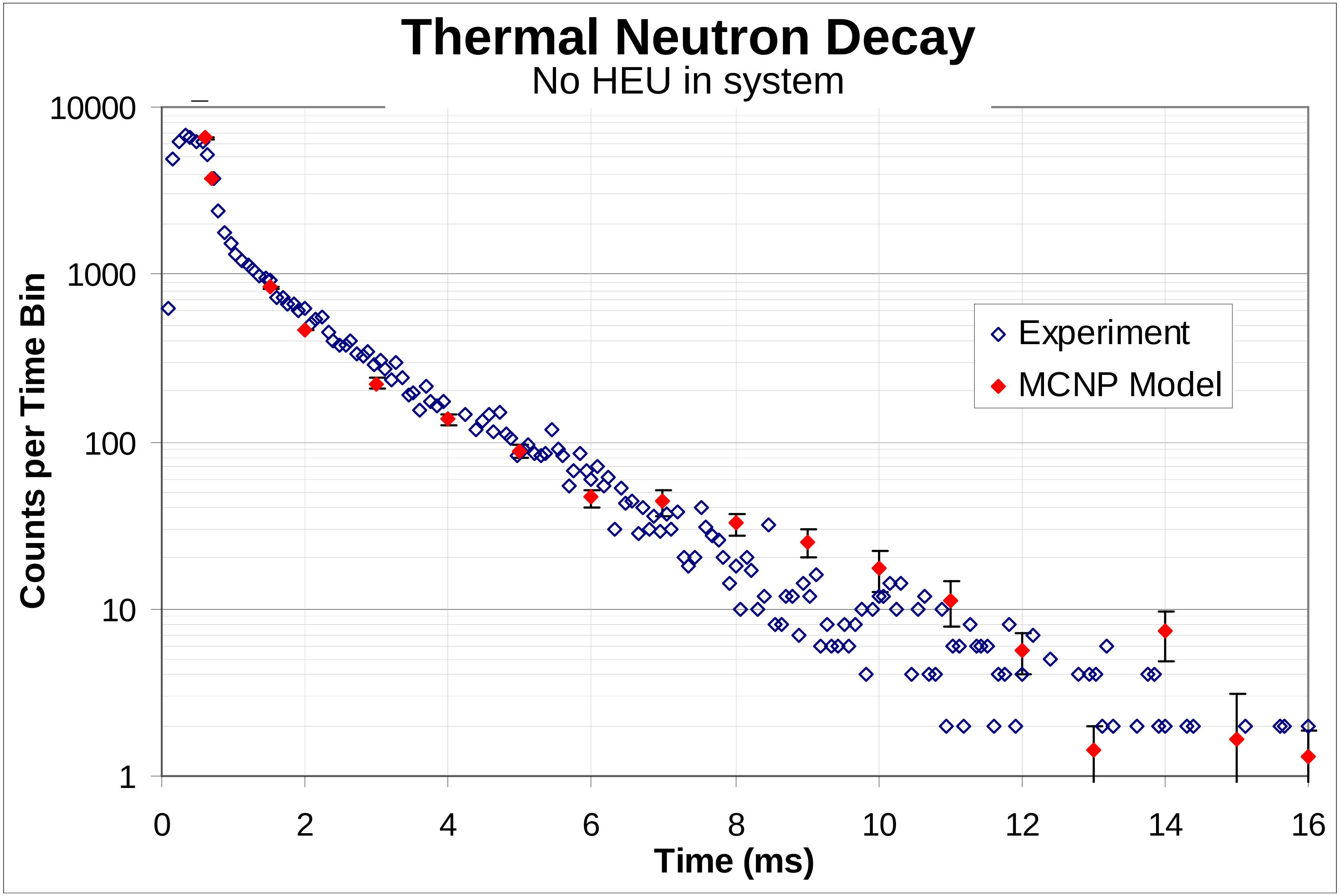
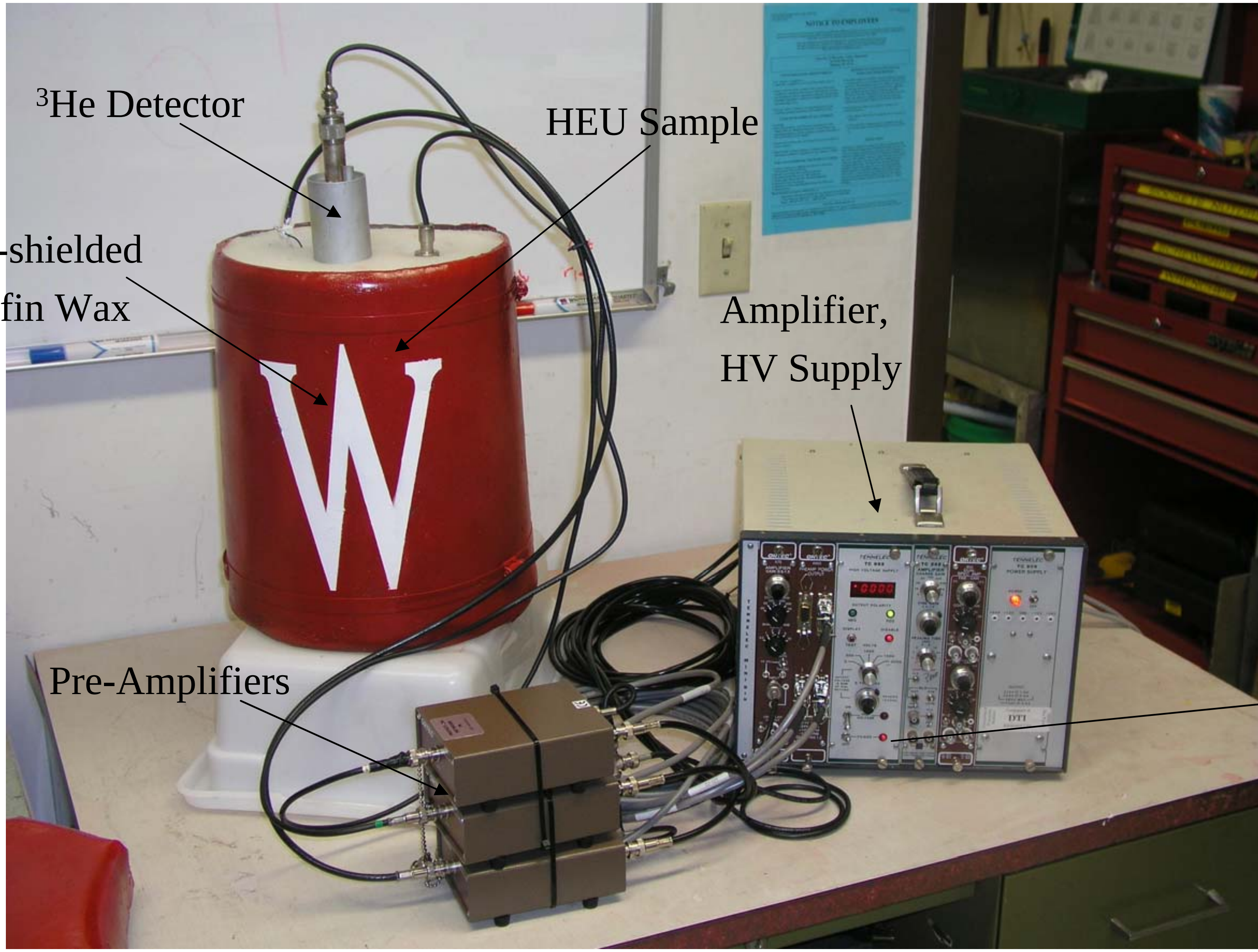


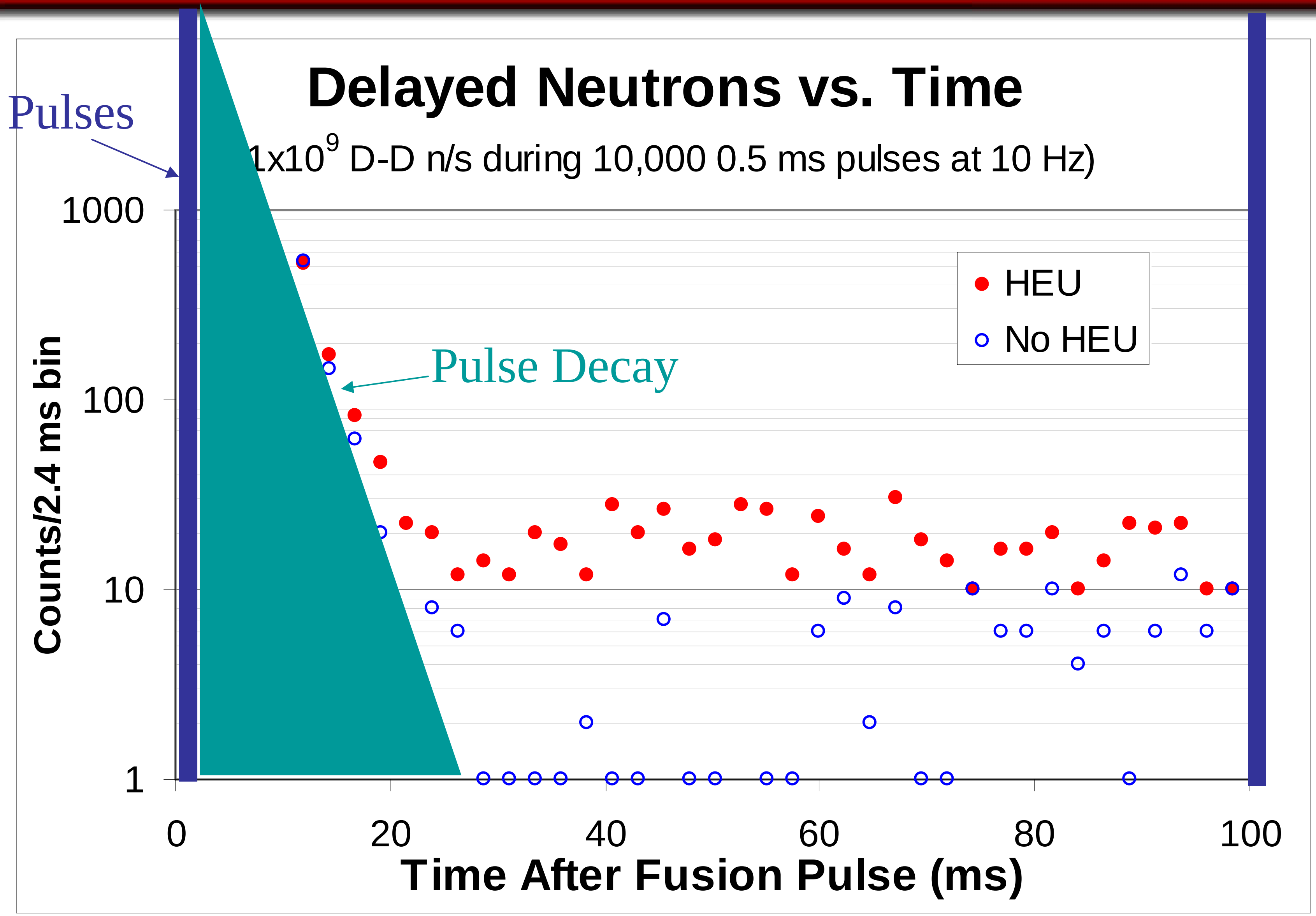
# MCNP Model Accurately Predicts Time-Dependant Neutron Behavior



# Neutron Detector Construction
# Optimized Delayed Neutron Detection

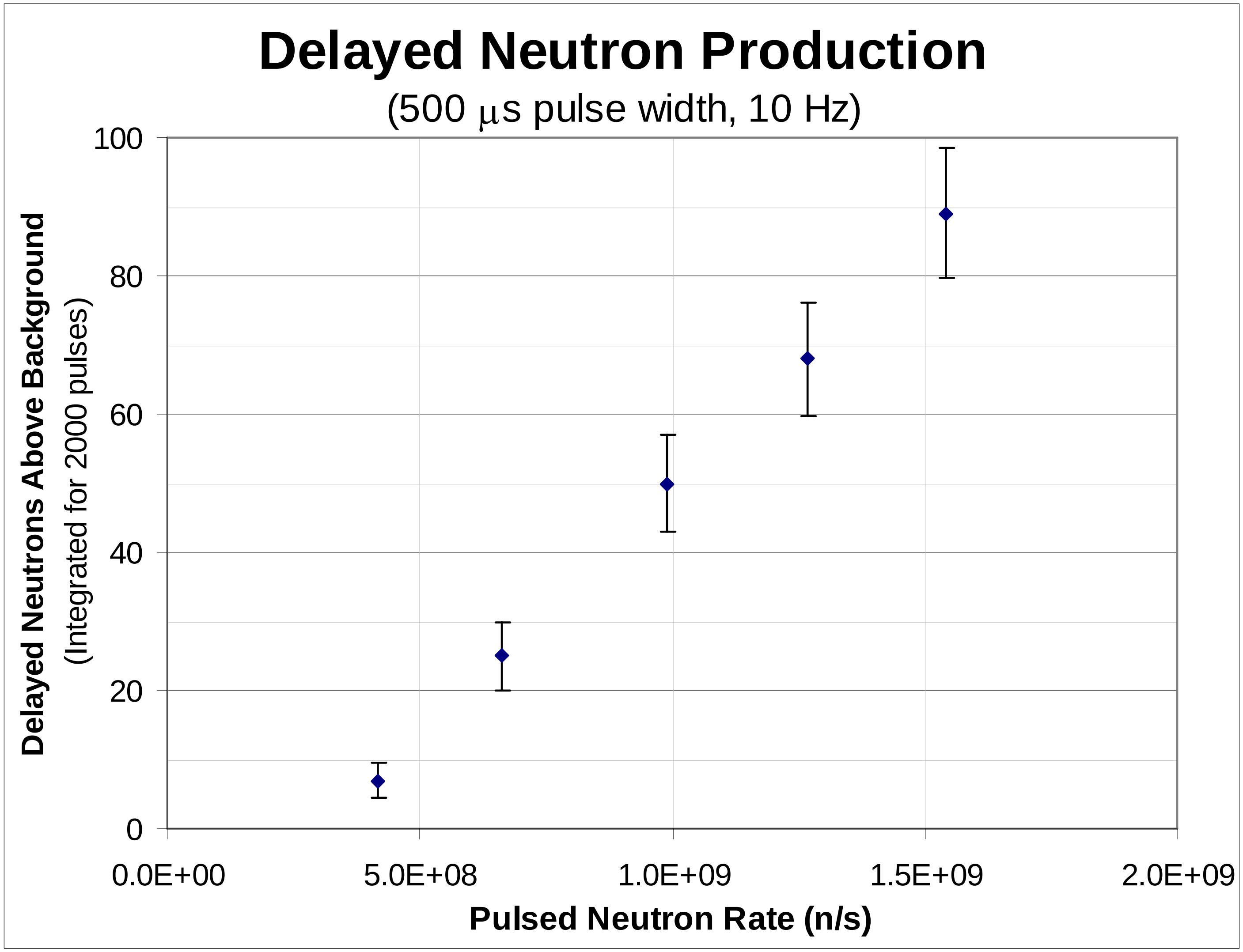


# Pulsed IEC Device has Generated Detectable Levels of Delayed Fission Neutrons



# Delayed Neutron Production Scaled Linearly with Fusion Neutron Rate

- HEU 50 cm from IEC center
- Detectors ~10 cm from HEU



# Conclusions

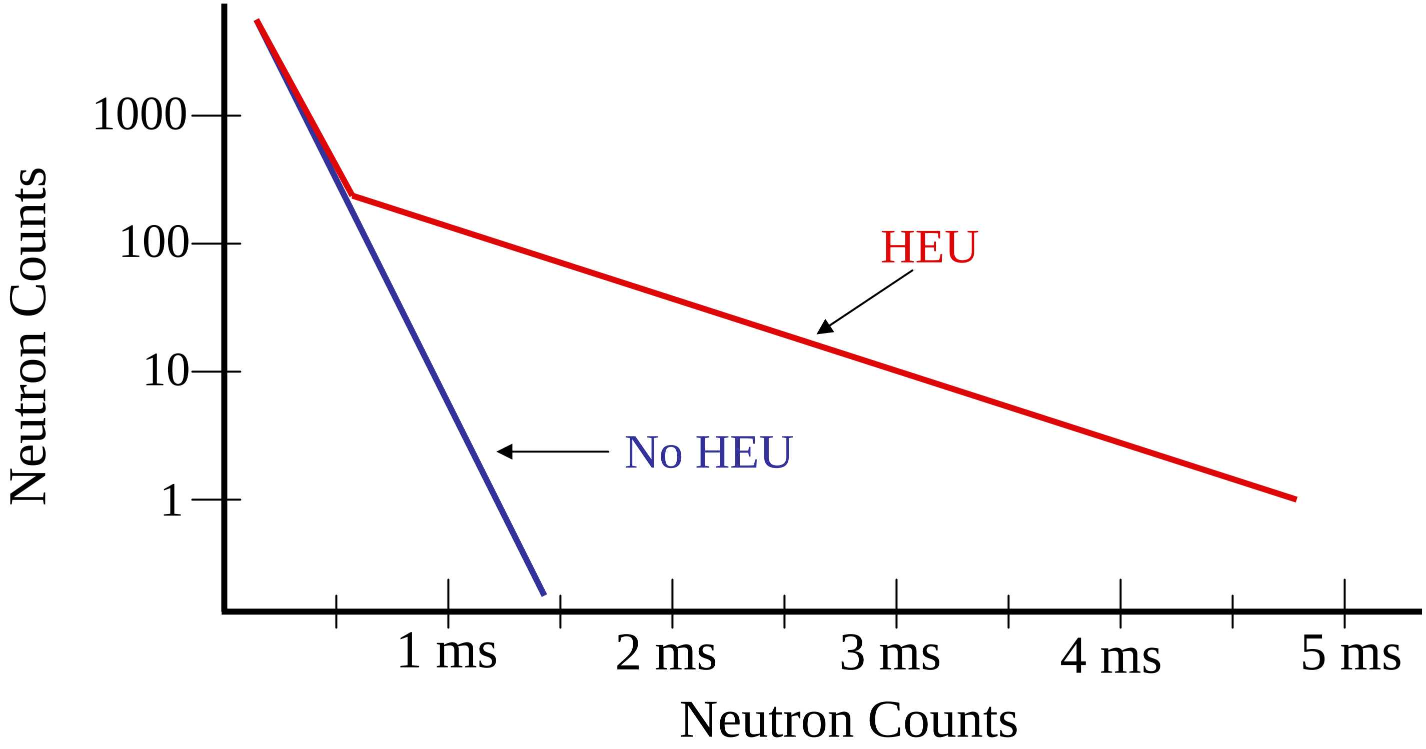
- Numerous improvements were made to the pulsed IEC device:
  - Pulsing circuitry was operated at voltages up to 120 kV
  - Pulsed $D^+$ currents in excess of 6 Amperes were achieved
  - Pulse width studies revealed increased neutron production at shorter pulse widths
- Pulsed neutron production rates as high as $4.7 \times 10^9$ n/s were generated during 110 μs pulses at 5 Hz.

# Conclusions (cont.)

- An MCNP model was developed that accurately models the time-dependent behavior of pulsed IEC neutron production and the associated HEU detection hardware.
  - This model was able to predict the number of delayed neutron counts collected in the $^{3}He$ detectors to within approximately ±10%.
- *Pulsed* D-D neutron production rates as low as $4x10^{8}$ n/s generated in the UW-IEC were used to detect the presence of a 10 gram sample of uranium-235.
  - Delayed neutron production was found to increase linearly with fusion neutron rates.
  - Signal-to-noise ratios as high as 6.2 were found to exist when 65 kV remained on the cathode between fusion pulses.

# Recommendations for Future Work

- Expand HEU detection study to look at effects of geometry and shielding
- Investigate Differential Die-Away technique



# Questions?

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