Pulsed Operation of the UW-IEC Device

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THE UNIVERSITY of WISCONSIN MADISON

Outline

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

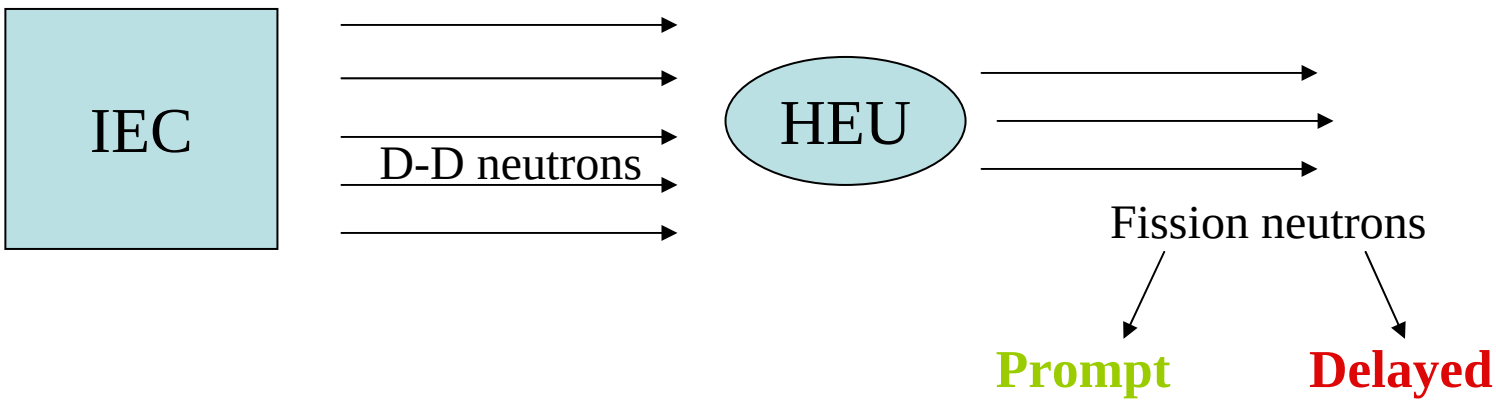
Importance of Research

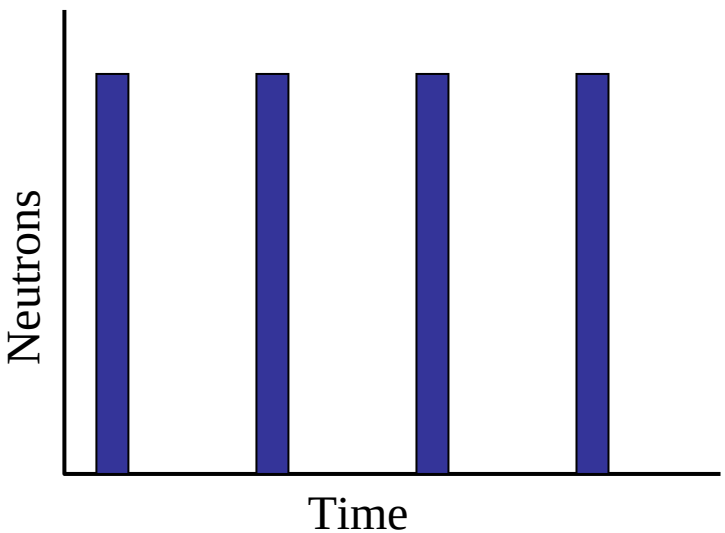
- There have been at least 150 incidents of nuclear smuggling in past decade (IAEA)
- Half involve enriched uranium or plutonium
- As little as 16 kg of HEU or 6 kg of Pu can be used to produce a 20 kiloton weapon, even with low technology levels
- Border security is a proven safeguard, but technology 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

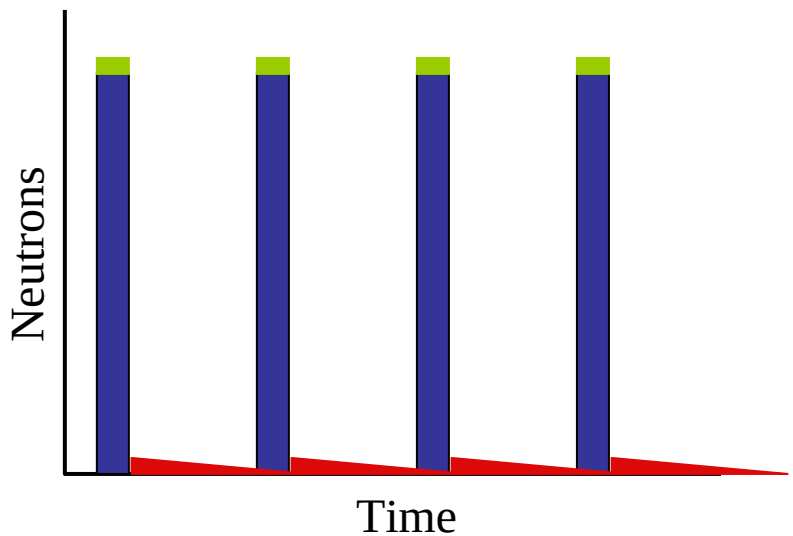
There are Two Categories of Non-Destructive Special Nuclear Material Detection

- 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

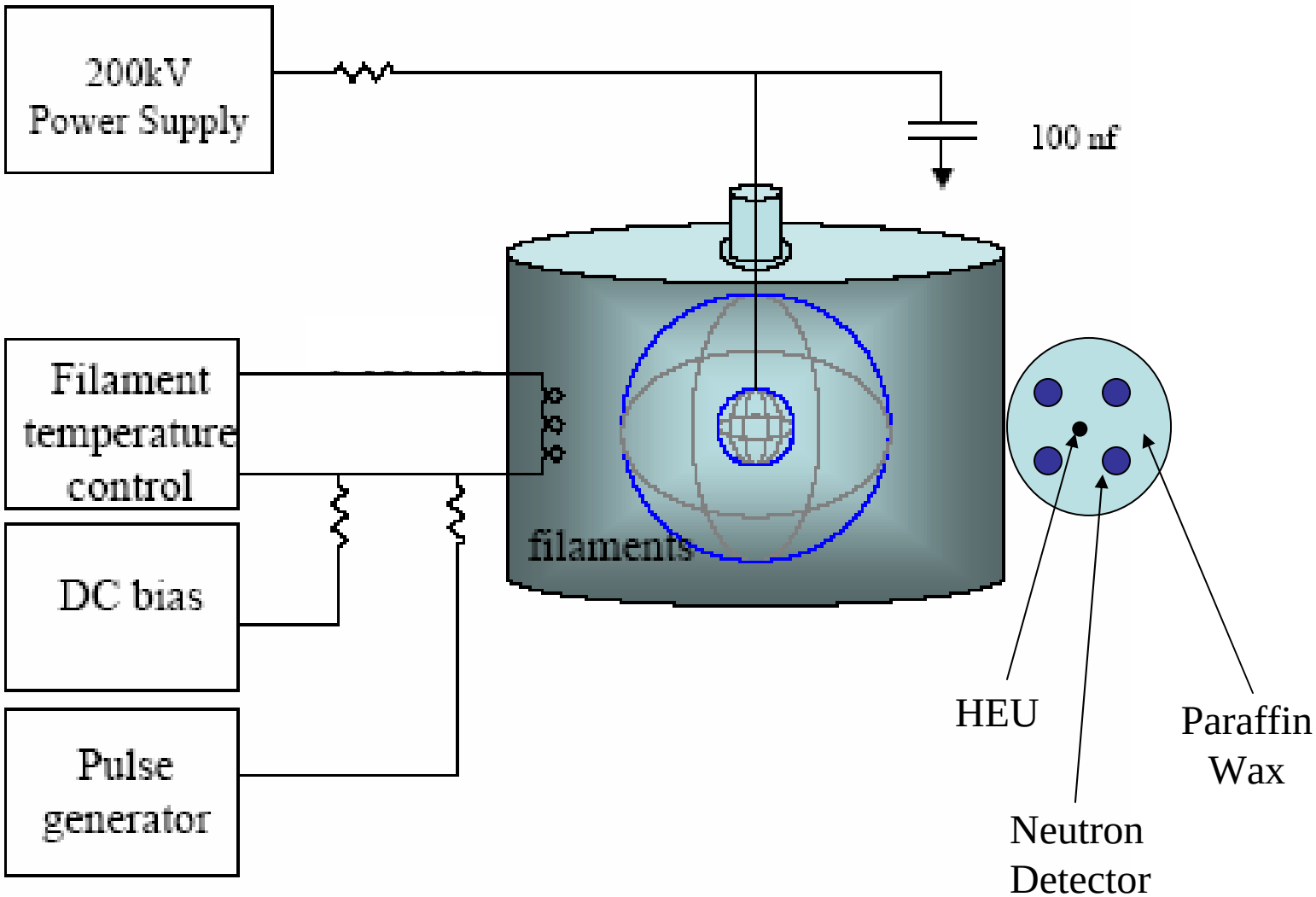
UW Concept for Active Detection of HEU







Initial Design Uses Ion Source to Generate Pulses



Pulse Video

- Video taken at 80 kV, 0.3 Pa D_2, 500 mA pulse current

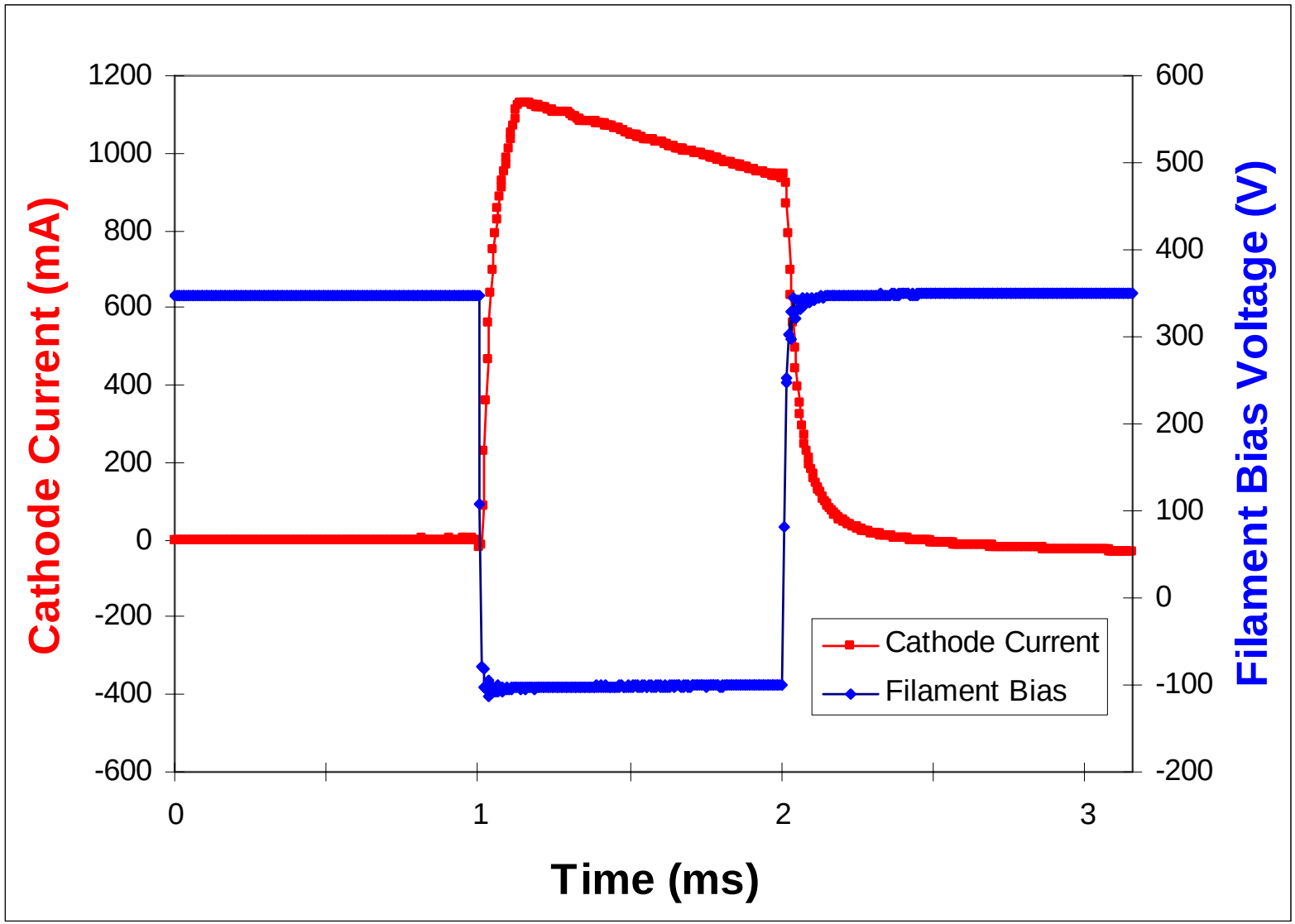
Current Status

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

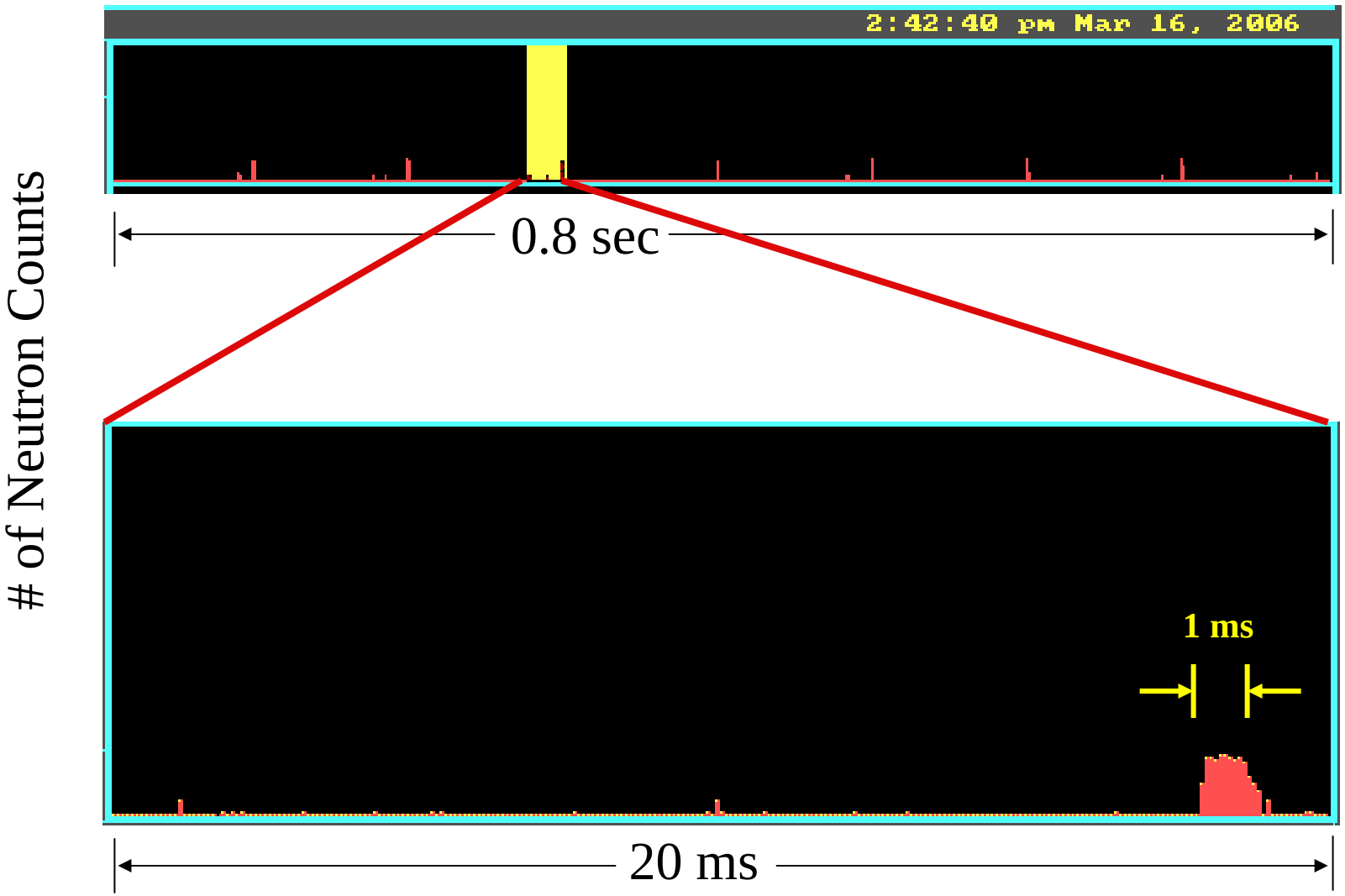
- Shortest Pulse: 10 μs
  - Cathode current: ~70 μs
  - With “flat top” current: 200 μs

- Max Neutron Rate During Pulse to Date:
  - 1.5×10^9 n/s (80 kV, 3 A, 0.38 Pa D_2)

High-Speed LabVIEW Diagnostic Provides View of Pulse Trace

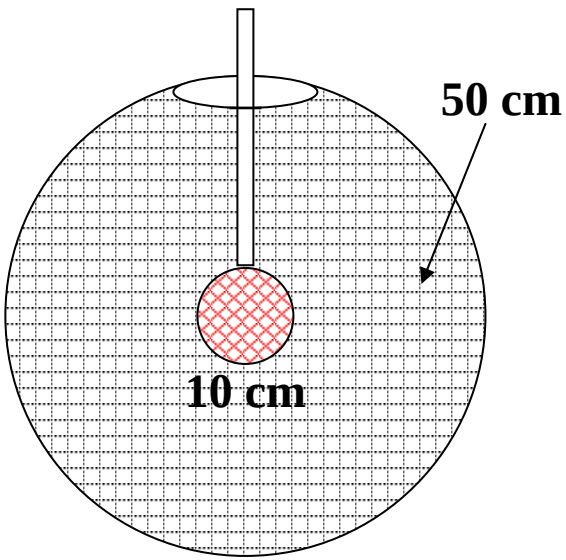


High-Speed Neutron Diagnostics Provide Greater Insight into Pulsed Operation

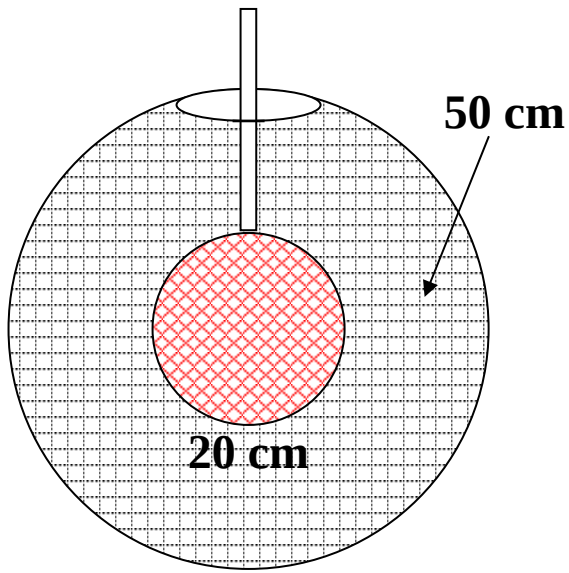


Larger Cathode Yielded Higher Pulse Current and Neutron Rates

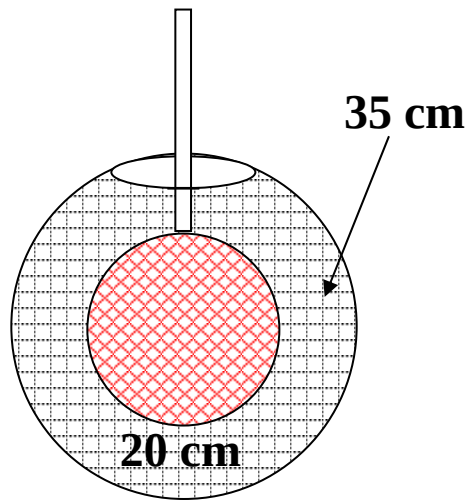
- Pulse current increased by ~20% when switching from 10cm to 20 cm cathode
- Average ion energy is higher
  - Ions encounter fewer neutrals as they are accelerated



Past Configuration

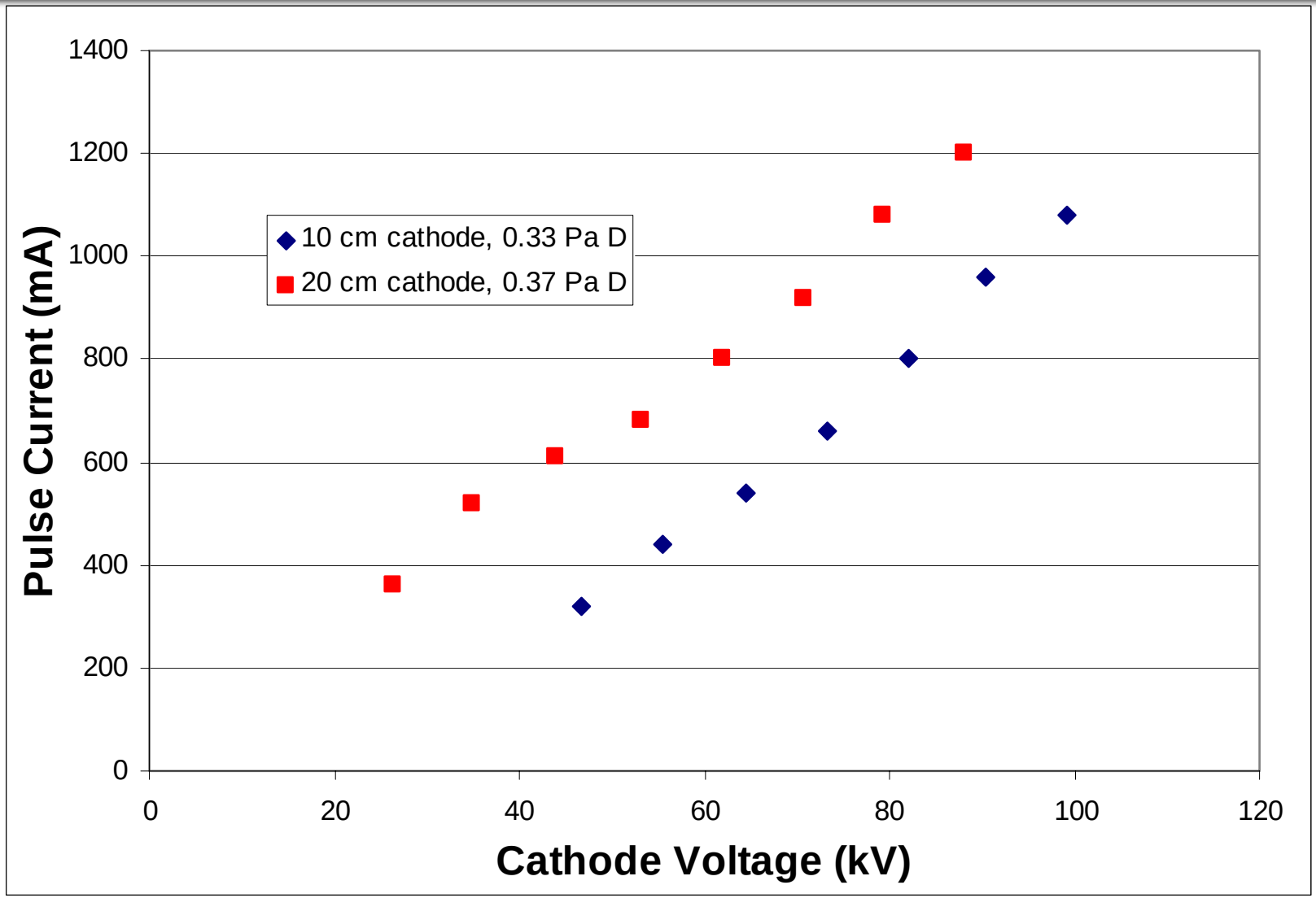


Current Configuration



Future Configuration?

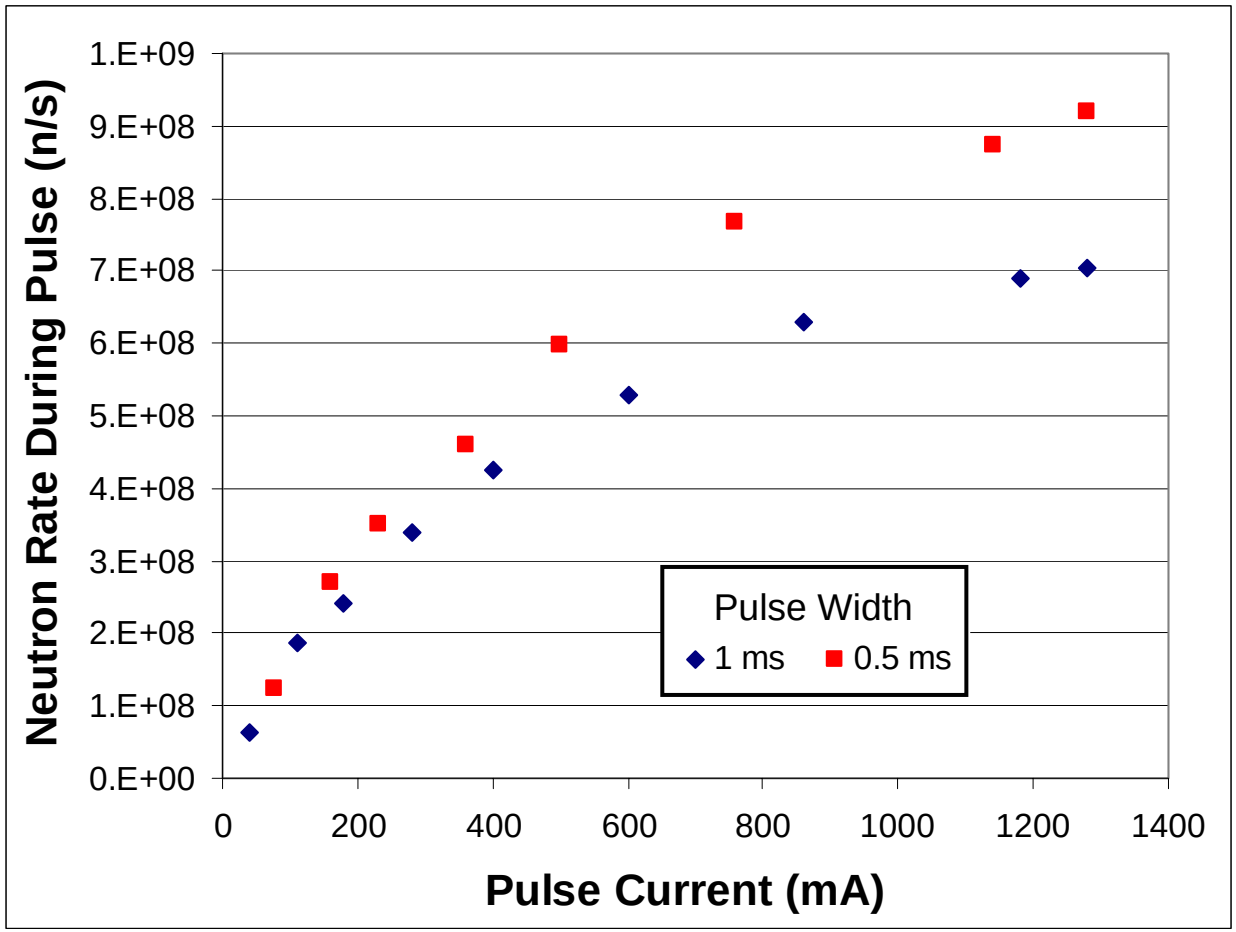
Pulse Current Increases Linearly with Cathode Voltage



**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 D_2

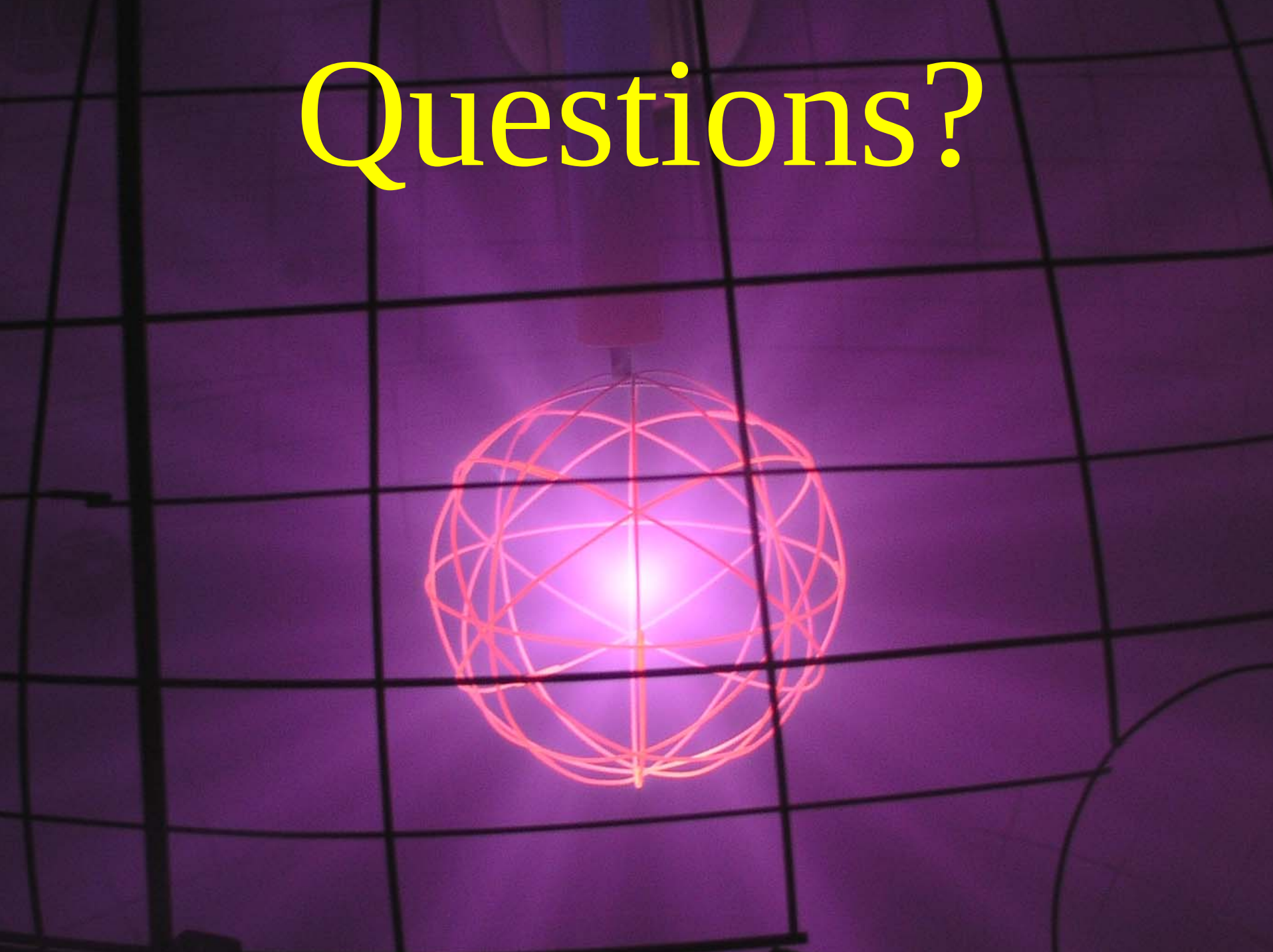
Summary

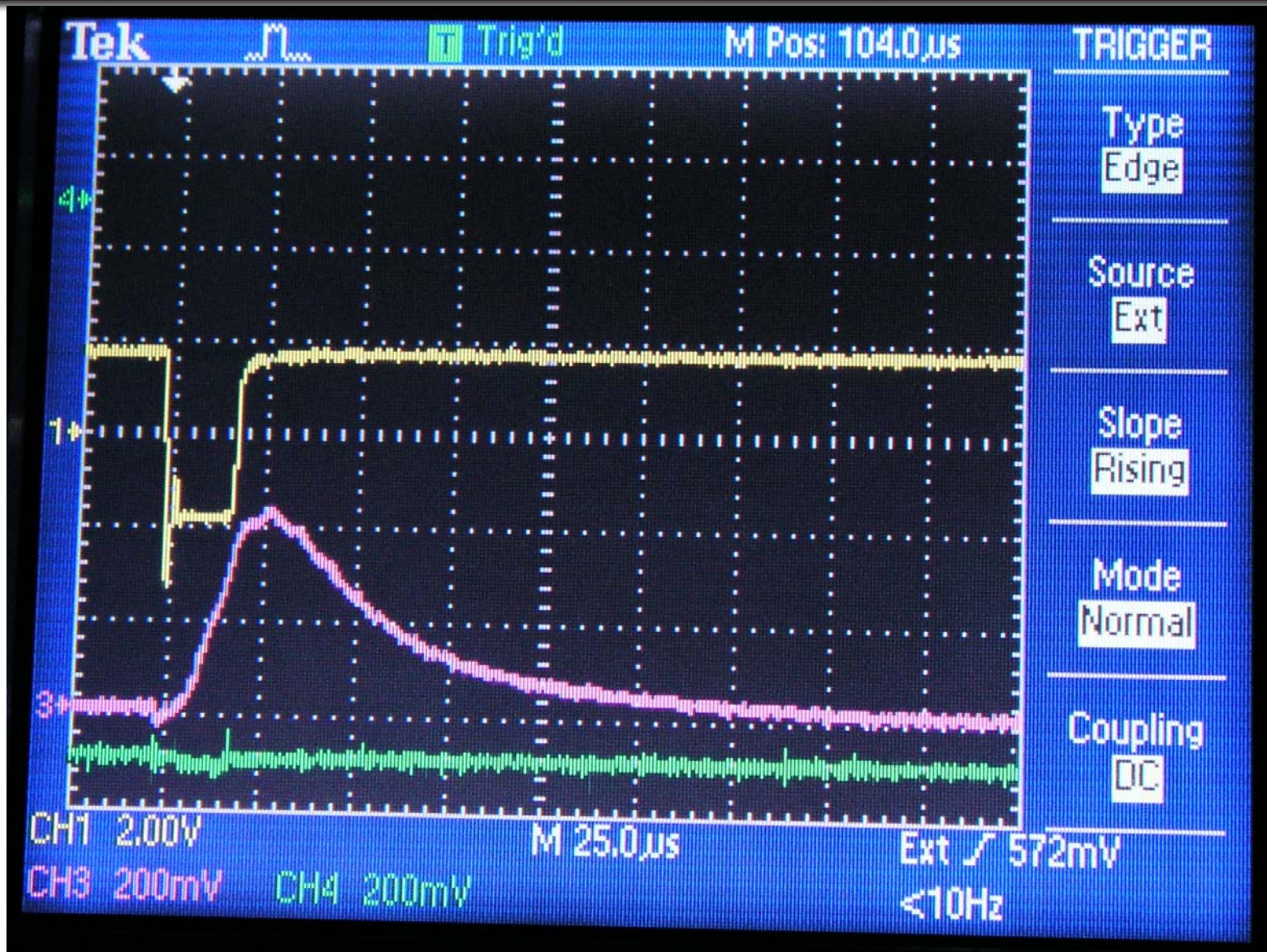
- Pulsed IEC has been developed that is capable of operation at 110 kV, 2.4 A, 0.37 Pa D_2
- Pulsed neutron rates of 1.5×10^9 n/s have been achieved during 500 μs pulses
- New diagnostics have provided greater insight to high-speed operation
- Operation with 20 cm cathode has improved pulse current and 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?




Tek
Trig'd
M Pos: 104.0µs
TRIGGER
Type
Edge
Source
Ext
Slope
Rising
Mode
Normal
Coupling
DC
CH1 2.00V
M 25.0µs
Ext / 572mV
CH3 200mV
CH4 200mV
<10Hz