Optimizing Neutron Production Rates from D-D Fusion in an Inertial Electrostatic Confinement Device

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Background

Motivation

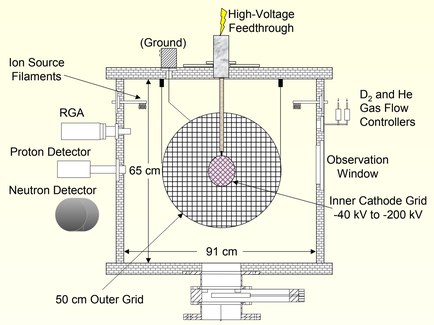
2.45 MeV neutrons produced in a D-D fusion reaction can be used for detection of explosives in suitcases, packages, shipping containers, or other clandestine materials. The University of Wisconsin IEC device has produced D-D neutrons at a rate of 10^8 neutrons/second. These neutron production rates are approaching the levels required for the detection of explosives. This experiment investigated the effect of altering the cathode's size (diameter), geometry, and material composition with respect to the neutron production rate in order to make explosives detection using D-D fusion with an IEC device a near-term reality.

Explosives Detection

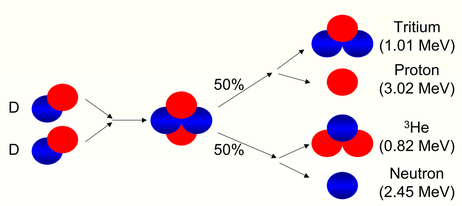
Typical explosive compositions contain low Z material (H, C, N, O) which are not easily detected using conventional x-rays or metal detectors. Composition C-4, a military plastic explosive, is approximately 90% RDX by weight (RDX – $C_3H_6N_6O_6$). Thermal neutron activation analysis can be used for detecting this and other common explosives.

Package Containing 24 – 20g vials of Composition C-4

Inertial Electrostatic Confinement



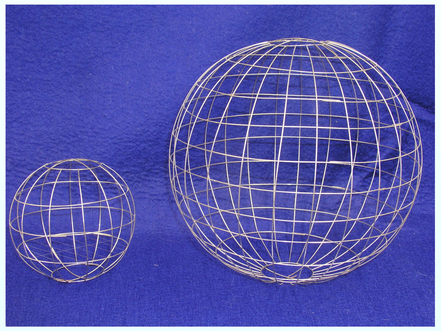
Schematic of the University of Wisconsin IEC Fusion Device



D-D Fusion Reaction

Experimental

Cathode Size

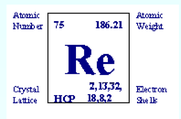

10 cm Inner Cathode Grid Diameter 20 cm Inner Cathode Grid Diameter

Cathode Geometry

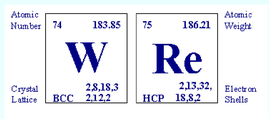
10 cm Symmetric Inner Cathode Grid

10 cm Lat/Long Inner Cathode Grid

Cathode Material

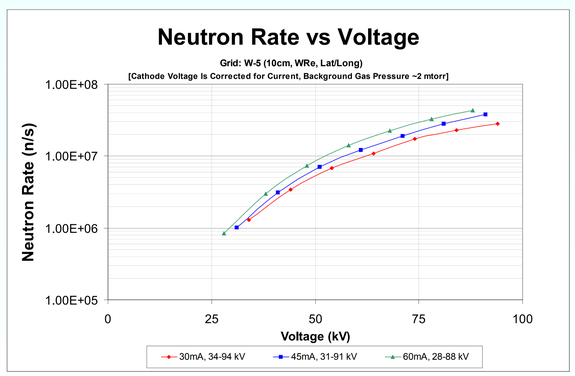


10 cm Inner Cathode Grid (Re)



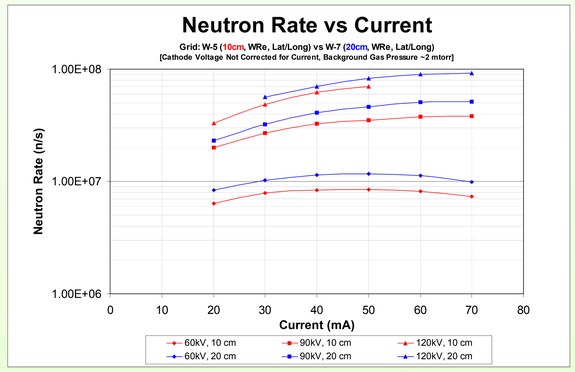
10 cm Inner Cathode Grid (WRe)

Cathode Voltage

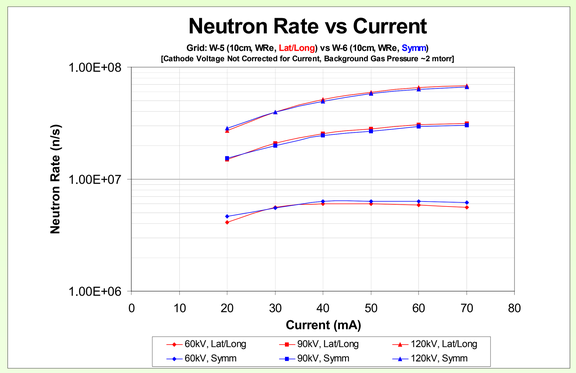


Results

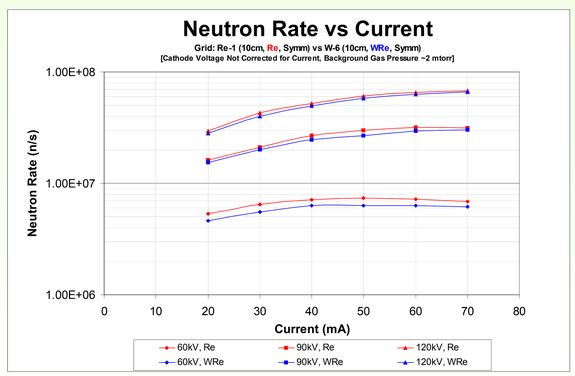
Cathode Size



Cathode Geometry



Cathode Material



Conclusions

Cathode Voltage

Increasing the cathode voltage from 34 kV to 94 kV at a meter current of 30 mA increased the neutron production rate from 1.24 x 10^6 n/s to 2.83 x 10^7 n/s for a constant background D-D gas pressure and a constant cathode size.

Cathode Size

The neutron production rate was found to increase approximately 20% by doubling the cathode's diameter from 10 cm to 20 cm for a constant voltage, background D-D gas pressure, geometry, and material.

Cathode Geometry

No significant difference in neutron production rate was achieved by altering the geometry of the cathode for a constant voltage, background D-D gas pressure, size, and material.

Cathode Material

No significant difference in neutron production rate was achieved by altering the material of the cathode for a constant voltage, background D-D gas pressure, size, and geometry.

Future Work

- Cathode Size: 5, 10, and 20 cm inner grids.
- Impurities: Optimizing neutron production rates by increasing "conditioning" time of the device.
- High Voltage Stalk: Evaluation of additional stalk materials, other than Boron Nitride, for possible improvements in operating stability and operating voltages.

ANS 16th Topical Meeting on the Technology of Fusion Energy, September 14-16, 2004, University of Wisconsin-Madison