Re-Design of Converging Ion Guns for Nuclear Fusion of Advanced Fuels

Marcos Navarro, Brian Egle, Matt Michalak, Gerald Kulcinski, John Santarius, Richard Bonomo
Fusion Technology Institute, University of Wisconsin-Madison

Goal

Increase the reaction rate of the D-D and D-^{3}He nuclear fusion reactions in Inertial Electrostatic Confinement (IEC) devices to the levels required for several non-electric applications of nuclear fusion such as detecting clandestine materials.

Previous Findings

- The Farnsworth-Hirsch fusor reported neutron production rate of 5x10^7 n/s at a cathode voltage of 168 kV and current of 10mA.
- Number of fusion reactions too low for commercial use.
- Mainly used as neutron generators.

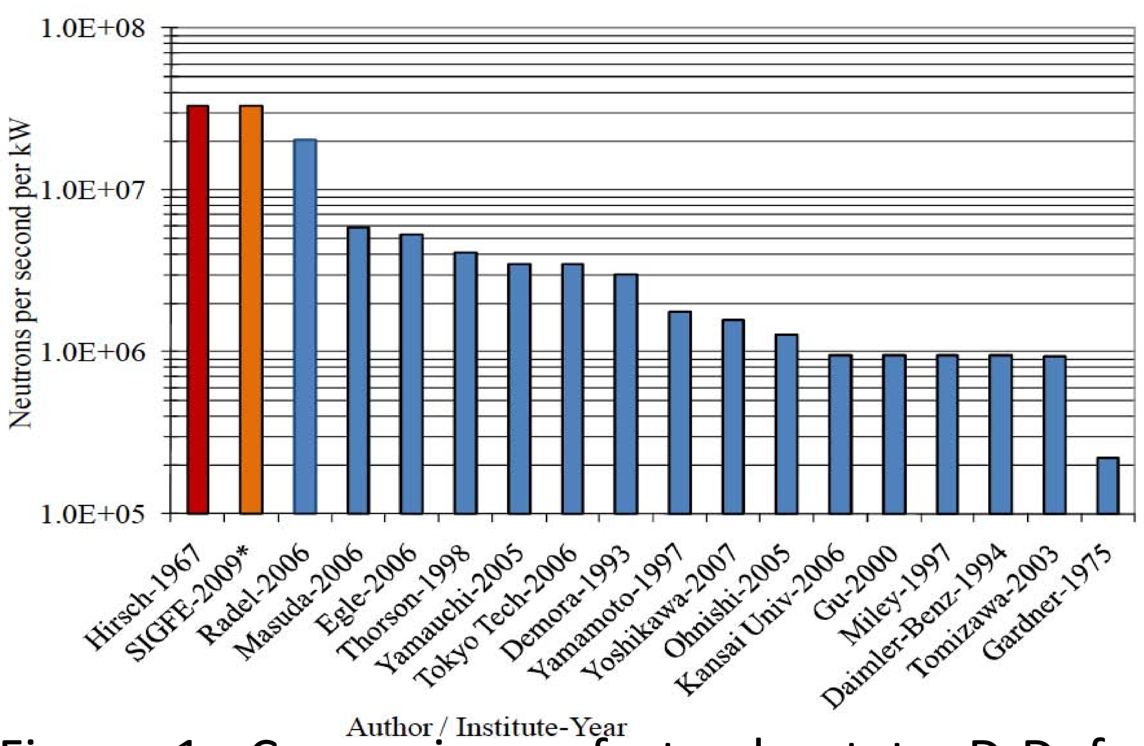

Figure 1. Comparison of steady state D-D fusion neutron rates per kW for various IEC devices.

- Hirsch design holds record for neutron production efficiency.

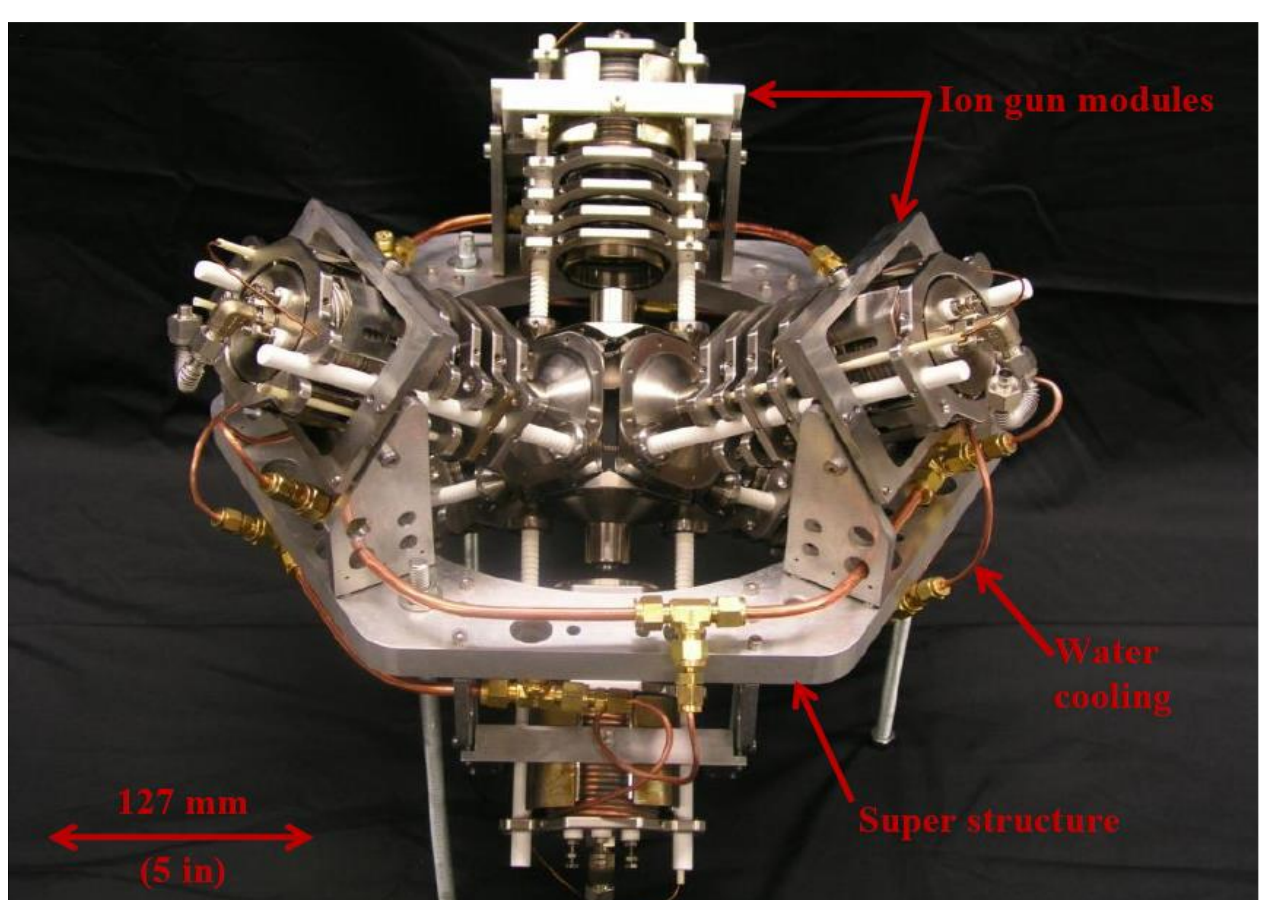

Figure 2. Internal Components of the Six Ion Gun Fusion Experiment (SIGFE).

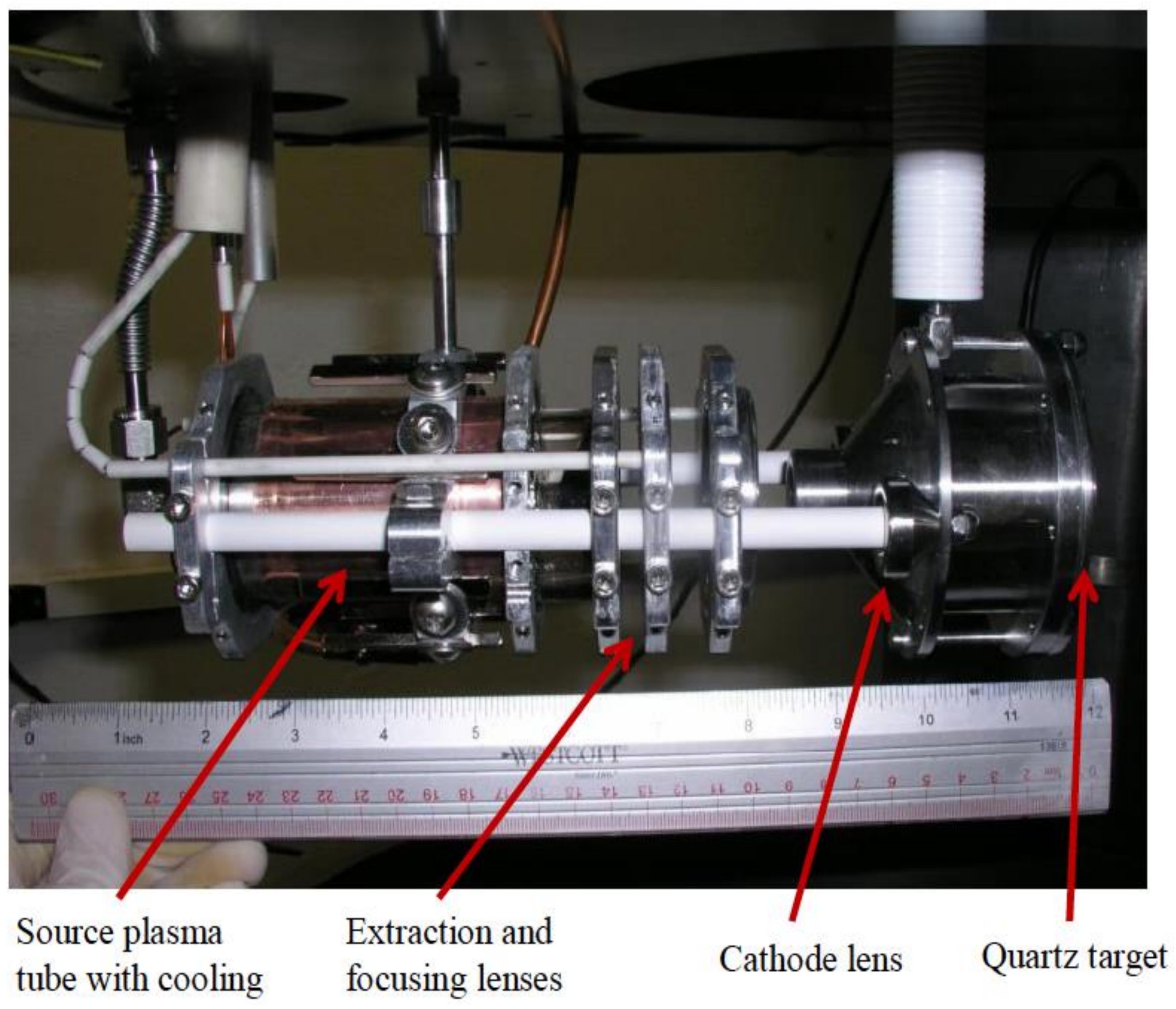

Figure 3. Picture of the prototype ion gun.

Experimental Approach

•Cathode voltages range from -50 kV to -150 kV, currents from 2-30 mA and chamber pressures from 10^2-10^3 μTorr.

•Data gathered required the use of neutron detectors, Fusion Ion Doppler Shift (FIDO) diagnostic, two separate proton detectors and optical cameras.

Results

- In a defocused mode, SIGFE matched experimental results of the Hirsch device.

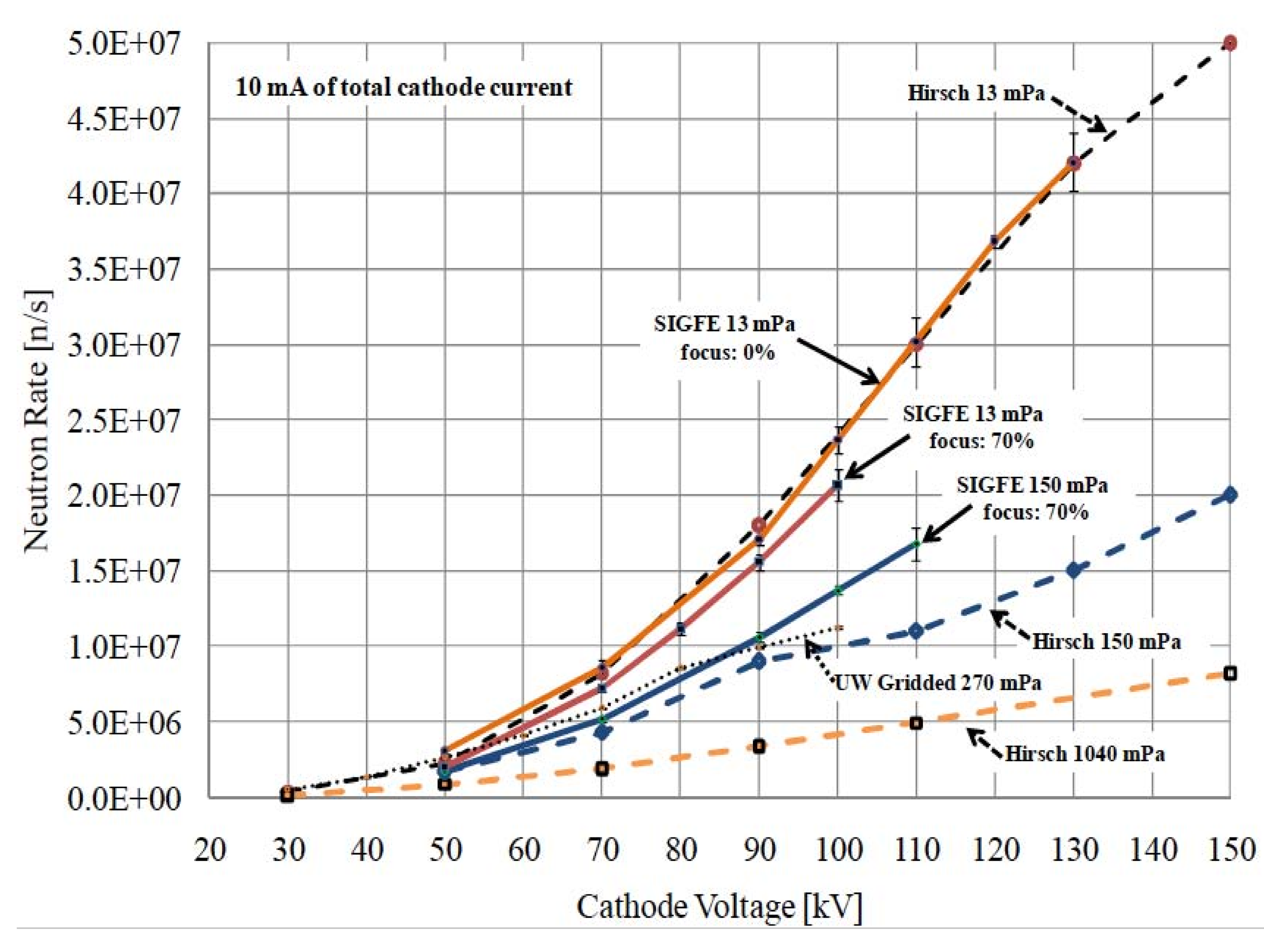

Figure 4. Experimental Neutron Production Rates vs Cathode Voltage at various pressures for D-D reactions.

- Most of the reactions took place at the walls of the device.
- Less than 0.2% of fusion reactions occurred in a 9.5 mm spherical cavity at the center.

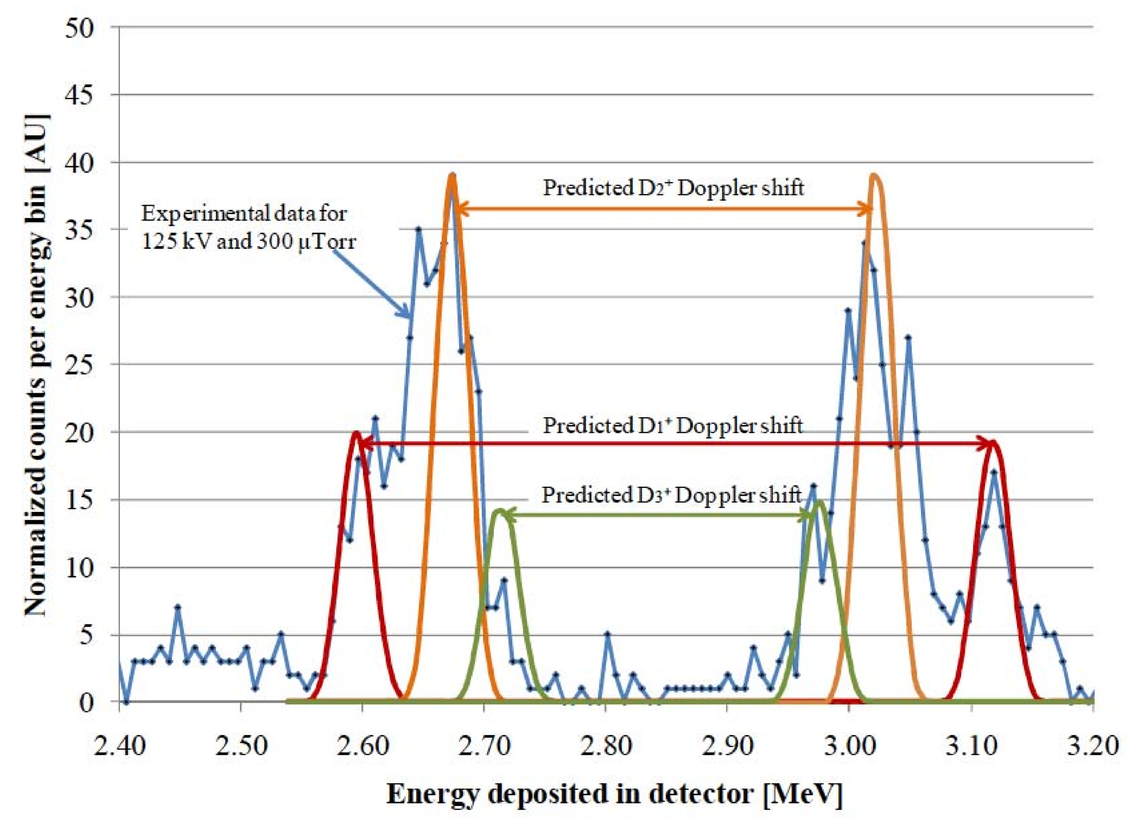

Figure 5. Experimental and predicted fusion proton spectrum of D-D fusion protons Doppler shifted by 125 keV D_1^+, D_2^+ and D_3^+ ions after passing through 8 μm of Al foil.

Fuels for testing:

- D-D
- D-^{3}He
- ^{3}He-^{3}He
- D-T

Planned Research:

- Design ion guns with higher current outputs.
- Balance ion currents.
- Vary fuel configuration to find highest neutron production rates.
- Operate the SIGFE in a pulsed mode.

GERS Annual Poster Session, May 2013

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