Approach to Optimizing D-D Neutron Rates in a Linear IEC Device

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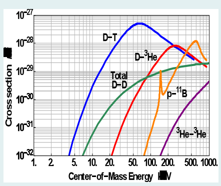
Main Objective

- Characterization the first linear IEC device at the University of Wisconsin-Madison.

D-D Fusion

Neutron rate per watt of fusion (from fuel only)	
Reaction	Neutrons/s (MeV)
D-T	4×10^{11} (14.1)
D-D	9×10^{11} (2.45)
D-^{3}He	2×10^{10} (2.45)

•The D(D,n)^{3}He reaction produces mid-energy neutrons.
•Also produces higher neutron rates than any other fusion reactions.
→ can be used for either Fast or Thermal Neutron Analysis.



•New HV capabilities of the UW-IEC lab will permit exploring D-^{3}He for the linear device.
•Device symmetry will allow for improved studies of charge exchange processes for these fuels.

Linear Device

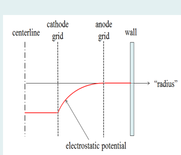
•Inside the chamber, two anode-cathode pairs will oscillate the ions across a target region.

Optimization Parameters	
L_{C-C} (m)	Cathode-Cathode Separation
Δ (m)	Cathode-Anode Separation
V_C (kV)	Cathode High Voltage
P (mTorr)	Chamber Pressure

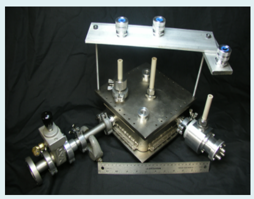
•Preliminary optimization studies for D-D were performed using the VICTER molecular code developed by G. Emmert and J. Santarius[1].

VICTER Simulations

•Basic assumptions going into VICTER[1]:
-Backgroung D_2 gas.
-Planar, cylindrical, or spherical geometry.
-Prescribed electrostatic potential profile
-Ions enter from source region.
-D^+ and D_2^+ ions created in the intergrid and cathode regions by impact ionization, charge exchange, and dissociation of fast ions colliding with the background D_2 gas.
-Collisionless ion motion between interactions
-Daughter products travel at the same speed as parent.



Diagnostics

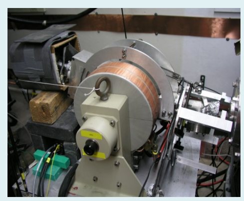


Neutral Particle Analyzer

•Charge exchange processes taking place will be studied with an NPA built by Becerra.
•Neutral particles energies screened are between 5-170 keV, with increasing difficulty in measuring the energy spectrum as pressure goes down[2].

Time of Flight

•The TOF diagnostic improved by Mc Evoy will be used to find the spatial distribution of fusion reactions.
•When using D-^{3}He, , D-D fusion is inevitable and by tuning the TOF, count rates can be separated in the measured proton spectrum.



Spectrometer

•Depending on the fuel used in operation (and HV), a single ended or double ended Langmuir probe and a Newport Oriel LineSpec spectrometer will be used to measure the spatial distribution of of the ion energies, as demonstrated by Khachan[3].

Neutron Detector

•An LND 2530 ^{3}He filled neutron detector is readily available for measurements during operation.
•This detector is calibrated with a Plutonium-Beryllium neutron source.

[1] G.A. Emmert and J.F. Santarius, *Phys. Plasmas* **17**, 013502 (2010).
[2] G. Becerra, "Analysis of Fast Neutral Particles in IEC Fusion Devices," Ph.D. thesis (2014).
[3] J. Khachan, D. Moore and S. Bosi, *Phys. Plasmas* **10**, No. 3 (203).

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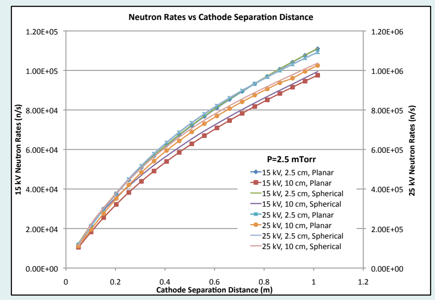
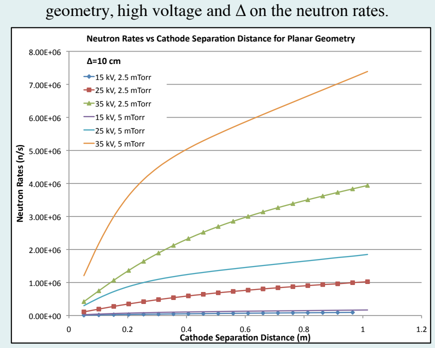
VICTER Simulation Results



•The plot above shows the effect of variation geometry, high voltage and Δ on the neutron rates.



•For planar geometry, higher pressures dominate over larger Δ's, effectively increasing the neutron rates.

Conclusions

- For fixed pressures, the neutron rates don't vary much as a function of geometry, however, at higher voltages (~35kV), these rates reach a saturation point and cease to be a function of Δ.
- At low voltages, no significant change in rates is observed once the pressure is varied.
- Neutron rates increase significantly with pressure and voltage.
- There is a limit to this pressure (observed in previous experiments) before achieving a glow discharge, ~10 mTorr.

Future Work

- Develop a high voltage feed through for the anode-cathode pair configuration.
- Adapt VICTER to run D-^{3}He and validate results using the linear device and HOMER.