Performance Improvements of the UW IEC Device HELIOS for ^3He-^3He Fusion

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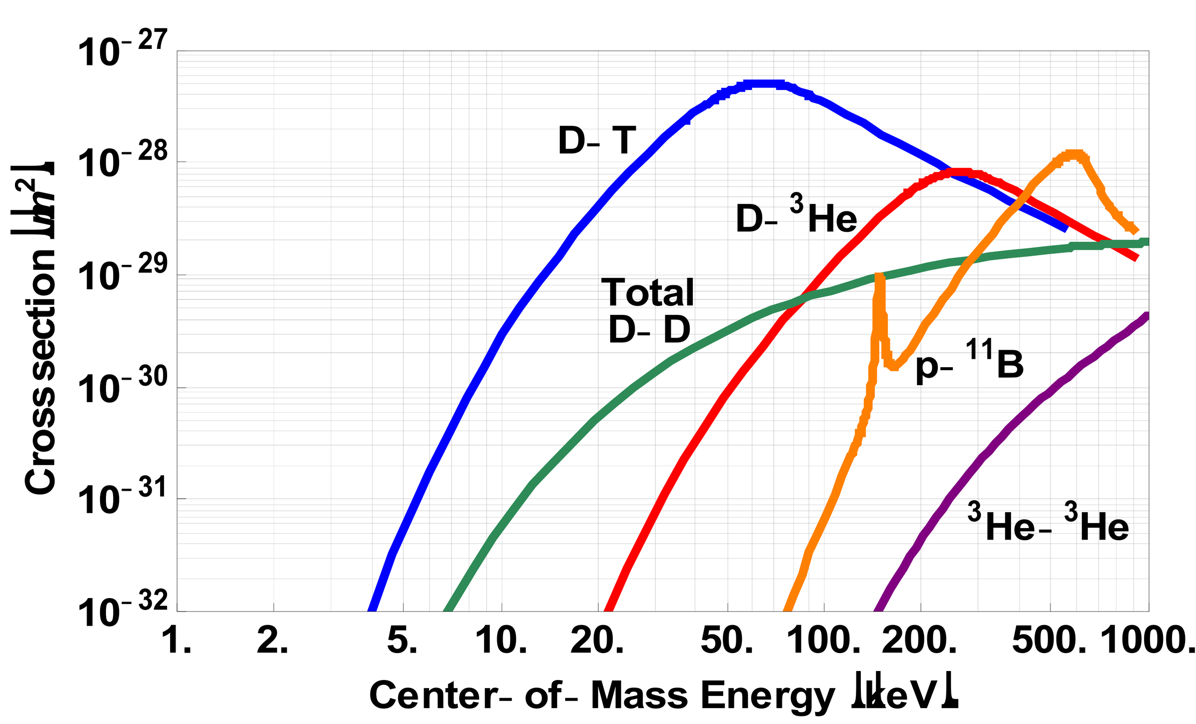
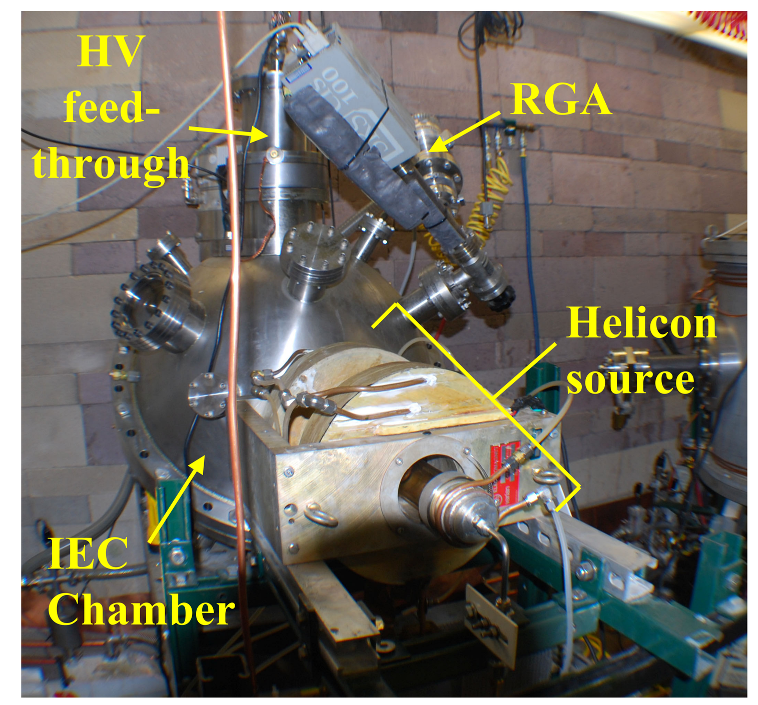
Motivation

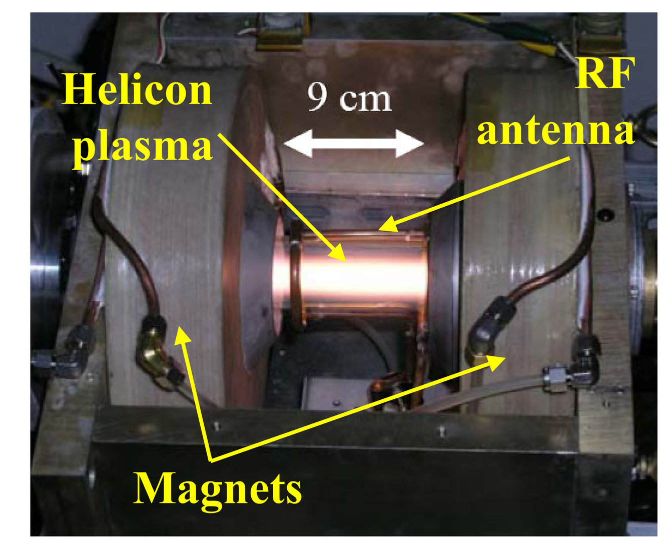
Neutron rate per watt of fusion (including major side reactions)	
Reaction	Neutrons/s/W (MeV)
D-T	3.6×10^{11} (14.1)
D-D	8.6×10^{11} (2.45)
D-^{3}He	2.3×10^{10} (2.45)
^{3}He-^{3}He	negligible

- $^3He(^3He,2p)^4He$ reaction produces virtually no neutrons, and all reactants and products are stable
  → nuclear power with no long-lived radioactivity
- Research can yield better understanding of the reaction, with relevance to nuclear & solar physics.
- Techniques can be developed and applied to other advanced fuels that require high ion energies, e.g. p-^{11}B.



Experimental setup





Source: G.R. Piefer

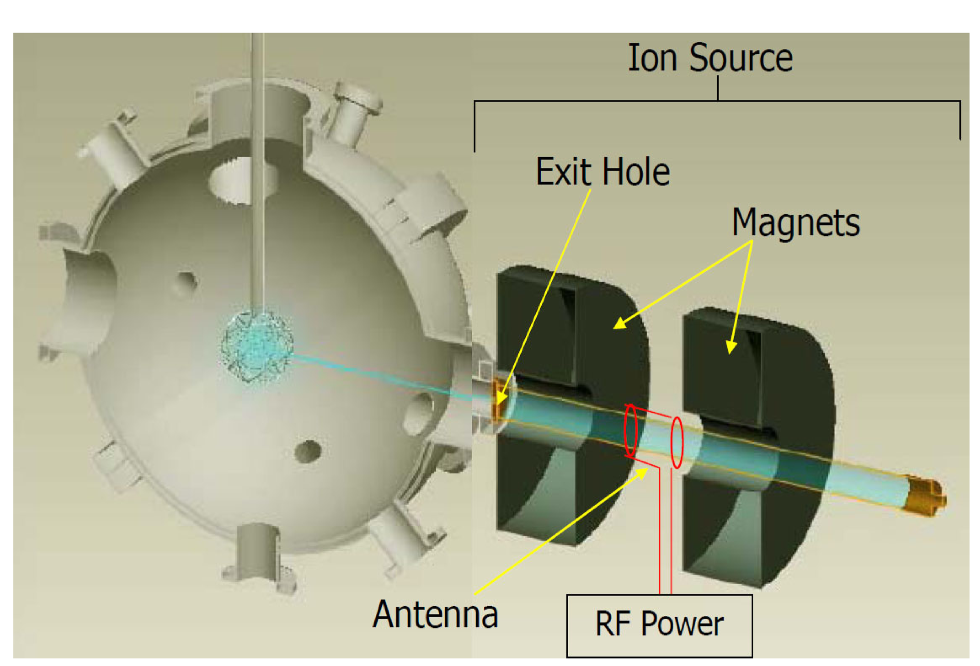
Improvements

Voltage

- A campaign is underway to reach higher voltages in HELIOS, taking advantage of the new 300 kV power supply, with the goal of increasing the ion energy and thus the ^{3}He-^{3}He fusion cross section.
- A high voltage feed-through with walls made of non-conducting materials will be implemented, removing paths where arcing to grounded surfaces can occur.
- The boron nitride stalk has been upgraded to a more robust design to minimize local electric fields, according to experience on the HOMER device and simulations.

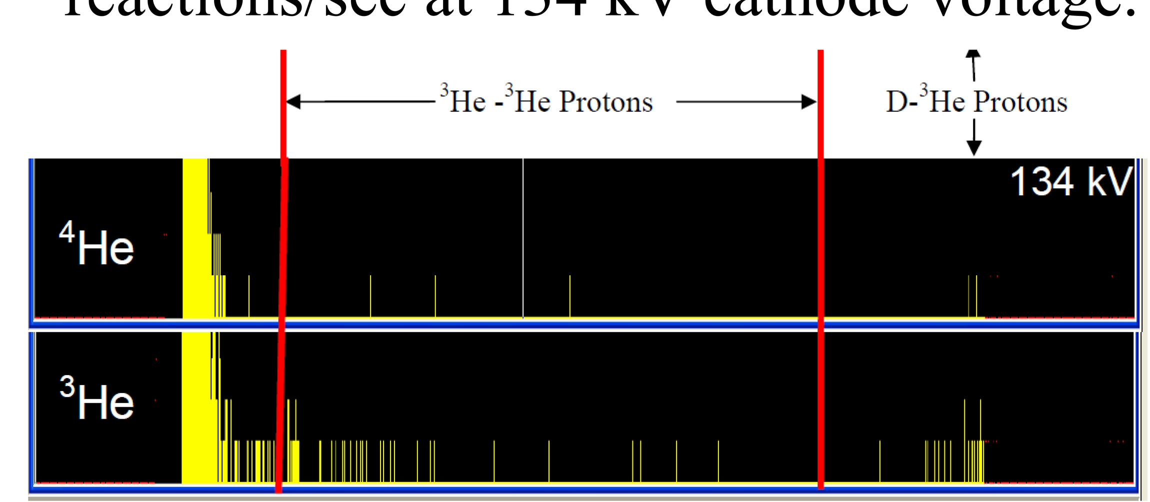
Previous work

- Piefer (2006): ^{3}He-^{3}He protons first detected in an IEC experiment: HELIOS, a spherical device, designed to operate at ~0.2 mTorr using an external helicon ion source.



Source: G.R. Piefer

- The current record ^{3}He-^{3}He rate is 1.1×10^3 reactions/sec at 134 kV cathode voltage.

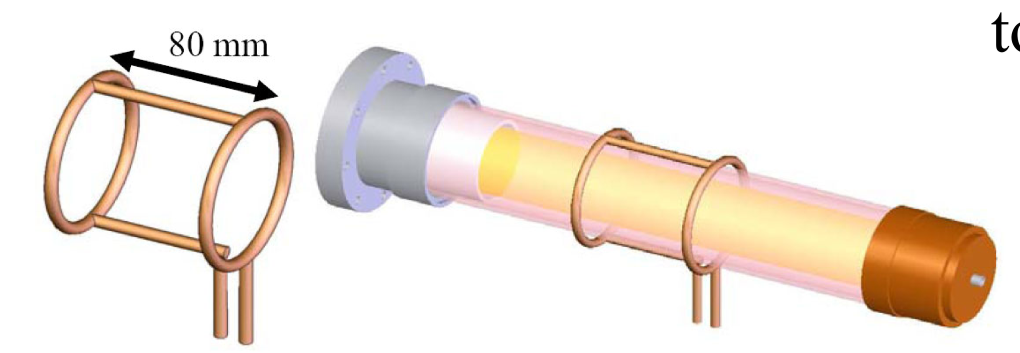


Source: G.R. Piefer

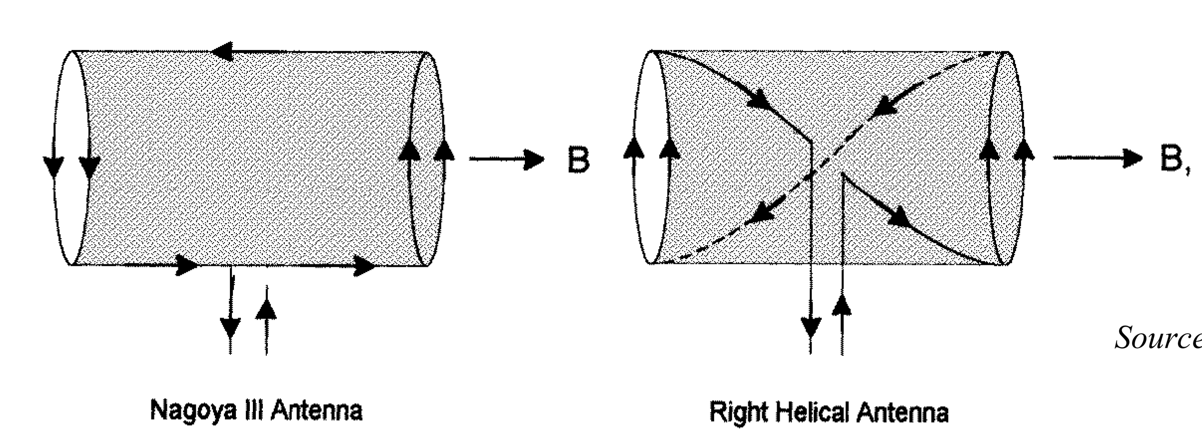
Improvements, cont.

Current

- The maximum ion current measured from the helicon ion source is 12 mA, while the theoretical maximum is ~600 mA. The ion source will be upgraded to improve performance.
- The magnetic field near the aperture is likely deflecting ions into the walls, and space charge effects defocus the ions significantly. To prevent this, a new extraction system will be designed to focus the ions into the chamber.
- The current ion source uses a Nagoya III antenna. This will be changed to a right helical antenna, a design known to preferentially excite the m=+1 helicon mode, which is the most efficient for plasma production.



Source: G.R. Piefer



Source: D.G. Miljak & F.F. Chen

- Helicon sources with a non-uniform magnetic field, using only the magnet downstream of the antenna, have been shown to yield higher plasma densities, which will be tested in this setup.
- Structural changes such as quartz-to-metal seals and improved accessibility are also planned for the source system, for better alignment and reproducibility.

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