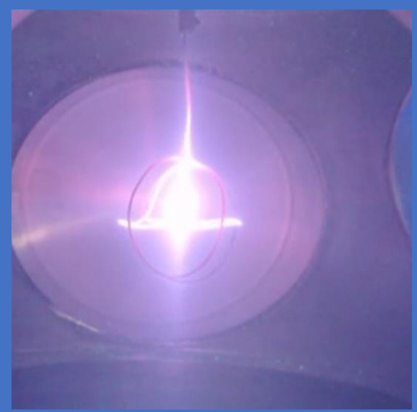
Summer 2021

Engineering an IEC Fusion Device

Ouyang Du
University of Puget Sound



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Ouyang Du, Brett Klaassen Van Oorschot

Department of Physics, University of Puget Sound

Background

Nuclear fusion occurs when two atomic nuclei hit each other with enough energy that they combine. To overcome the repellent force atomic nuclei, have on each other inertial electrostatic confinement (IEC) fusion devices accelerate ionized gas particles towards the center of a fusion chamber by producing a strong electric field (E-field). The E-field is created by supplying a strong negative charge to a spherical grid-like cathode in the center of the reaction chamber. This field accelerate the positively charged nuclei towards the center, where the atoms can speed past the large gaps in the cathode grid and collide with each other to create fusion[1].

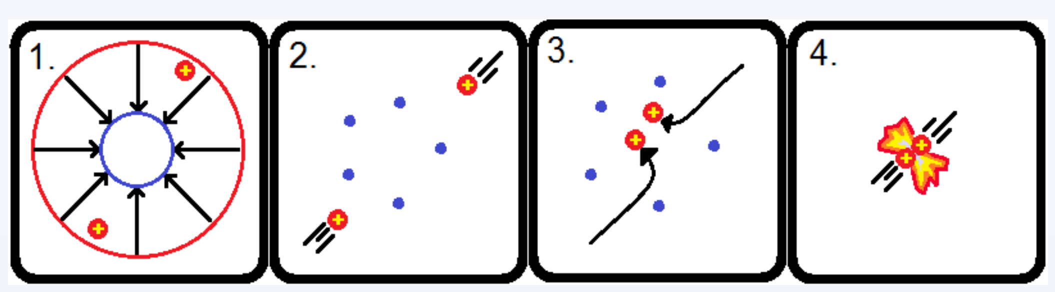

Figure 1: A depiction of how the IEC Fusion device works[2]

Panel 1: E-field attracting ions to the cathode
Panel 2: Ions accelerating towards the cathode
Panel 3: Ions passing through the gaps of the cathode
Panel 4: Collision

Objective

Our goal is to produce an safe IEC reactor with the capability of maintaining deuterium fusion(deuterium being an isotope of hydrogen with a proton and neutron within its nucleus).

The nuclear reaction we hope to achieve is shown in the diagram below

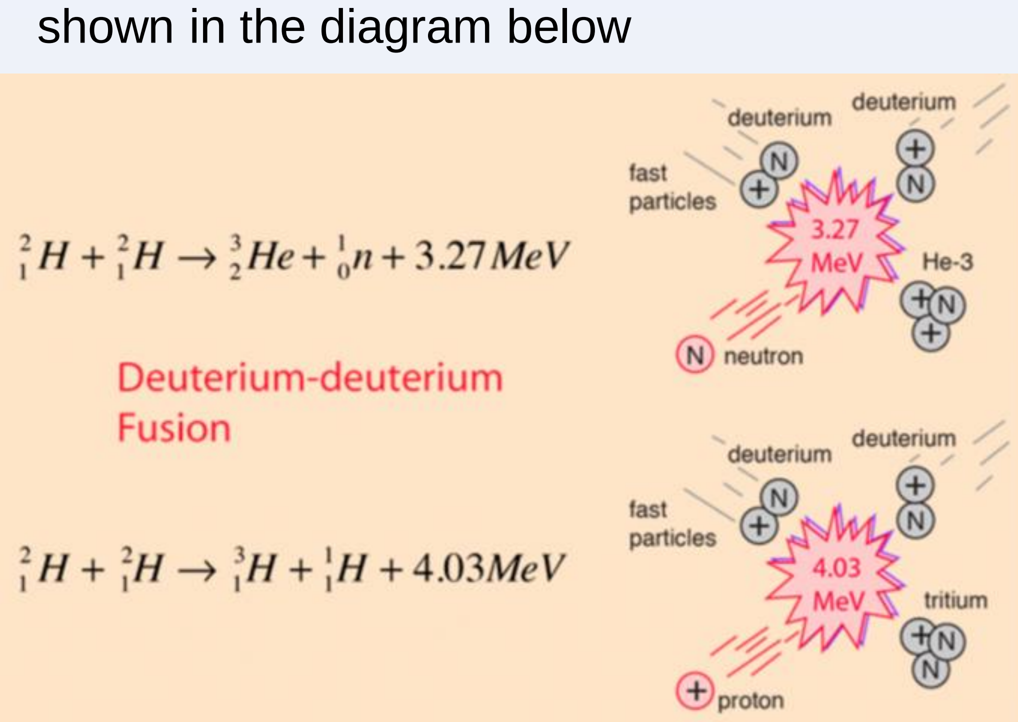

Figure 2: Deuterium Fusion into Helium, Neutron, Tritium, & Protium [3]

Components

The University of Puget Sound IEC Reactor consists of a vacuum chamber, two vacuum pumps, a negative high-voltage power supply, a cathode, deuterium gas tank, and a precision leak valve.

The two vacuum pumps can work together to create a pressure of less than 10^{-5} torr. This removes most of the air molecules which allows the deuterium ions in the chamber to move freely and only collide with one another.

Figure 3: Picture of UPS IEC reactor

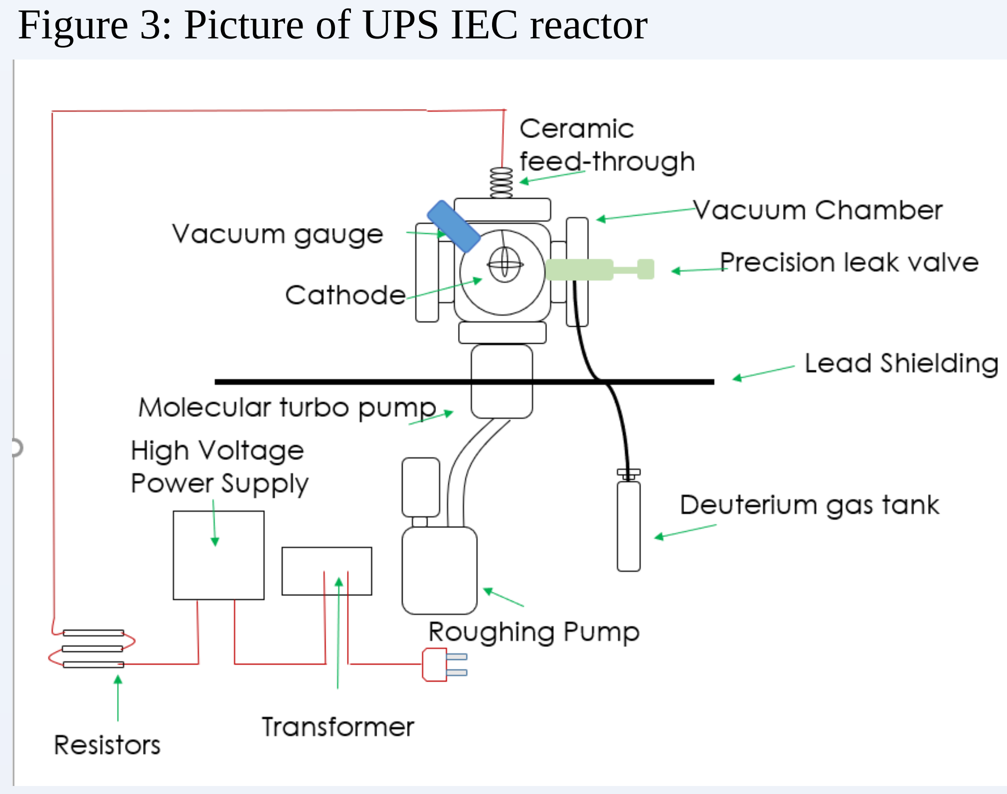

Figure 4: Diagram of UPS IEC reactor

Our high-voltage (HV) power supply is capable of producing a negative voltage up to 60kV with a max current of 16.5 mA. This is more than enough to create fusion. Most IEC reactor operate at a voltage of 20kV and a current of 5mA.
The ballast resistors help protect the high-voltage power supply from current surges. When the gases in the vacuum chamber ionizes, the ions completes the circuit which causes the current to spike. Resistors lower that current and therefore protects the power supply.

Monitors & Controls

LabJack is a data acquisition device that allows us to read and give out electric signals. DaqFactory is a software that can create an interface for an user and the LabJack. Through the combined use of both we were able to connect our IEC reactor with a computer so that remote control and monitoring of the reactor is possible. This way the observer can conduct research in safety behind the radiation shield.

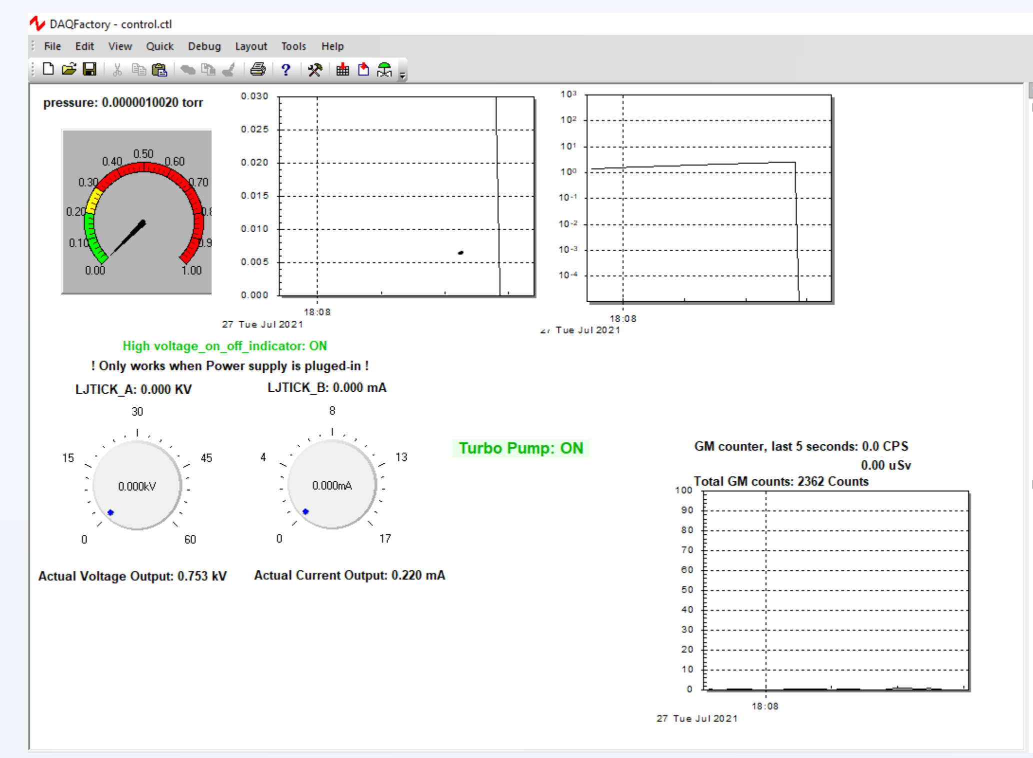

Figure 5: UPS IEC reactor remote controls and monitors

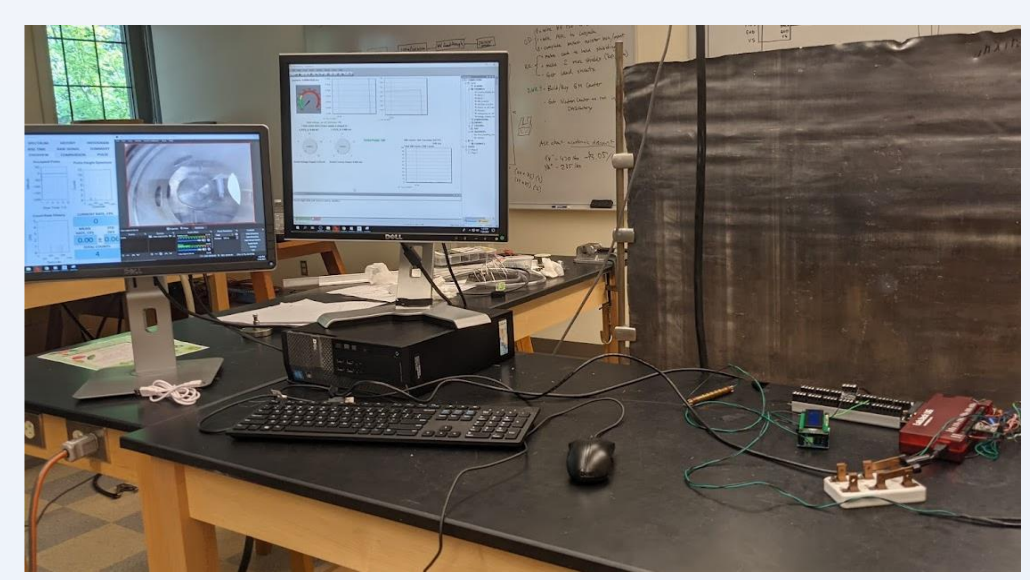

Figure 6: Observer's point of view

Safety

The intensity of x-rays produced by our IEC fusor follows an exponential relationship with the voltage applied through the HV-power supply and even at higher voltages is below the radiation safety limit. The government's radiation limit is 1mSv per year for the general public. Our IEC Fusor operating at 40kV with the ⅛ inch thick lead shielding emits a radiation dose of around 0.006 mSv/hr to a person 2 meters away.

Conclusions

As of summer 2021 our IEC Fusor is capable of creating the correct voltage, current, pressure, and fuel for fusion to occur. However we have not measured any neutron counts, the reasons for which we are uncertain. The two possibilities are either neutrons are being produced but our method of measuring them is flawed or neutrons are not being produced at all. Either way more research and work needs to be done on the IEC reactor before we can be certain that we have achieved fusion.

The UPS reactor offers the opportunities for future research which includes, but not limited to, the study of the plasma, x-ray, and neutron production.

Reference

1. McCarthy, William C, and Daniel L Mucaro. "Development of Economic Spherical IEC Fusion Device." *WORCESTER POLYTECHNIC INSTITUTE*, 2015.
2. Michal Stano, Michal Racko "Experiments on D-D Fusion Using Inertial Electrostatic Confinement (IEC) Device in the Laboratory Exercise on Plasma Physics at the Comenius University" *Acta Physica Universitatis Comenianae*, vol. 53,2016, pp.71-81
3. Nave, R. (2016). Nuclear fusion. http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fusion.html.

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Fusor.net community

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