Ramona's Plasma Physics Research Concept Summary

1 Introduction
1.1 What is a plasma?

The medical field and biology uses the word plasma to describe blood in the human body (I do not know if they stole the word from us or if we stole the word from them). From now on, I will refer to the physics definition of a plasma which is a hot *ionized* gas. The plasmas I work with are made of deuterium and tritium atoms; deuterium and tritium atoms are like hydrogen atoms but heavier. Figure 1 is a picture of a deuterium atom. The nucleus, center of the atom, contains a proton (P) and neutron (N). The proton has a positive charge (+1) while the neutron has no overall charge. The electron (e) which circles around the nucleus has a negative charge (-1). Therefore when you add the proton and electron charge, the total charge of the deuterium atom is 0. The Tritium atom also has a total charge of zero. The tritium atom is heavier than the deuterium atom because it contains one more neutron in its nucleus.

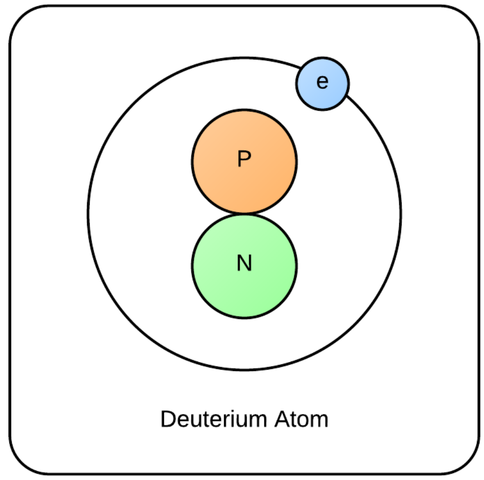

Figure 1: A deuterium atom.

These atoms become *ionized* when they lose their electron; they are then called ions. An atom can lose an electron if it is given enough energy. Once an atom is ionized, the electron is then free to travel on its own instead of around the atom's nucleus. When a Deuterium atom becomes ionized it is called a *deuteron* and when the tritium atom becomes ionized it is called a *triton*. A deuteron and triton are examples of ions.

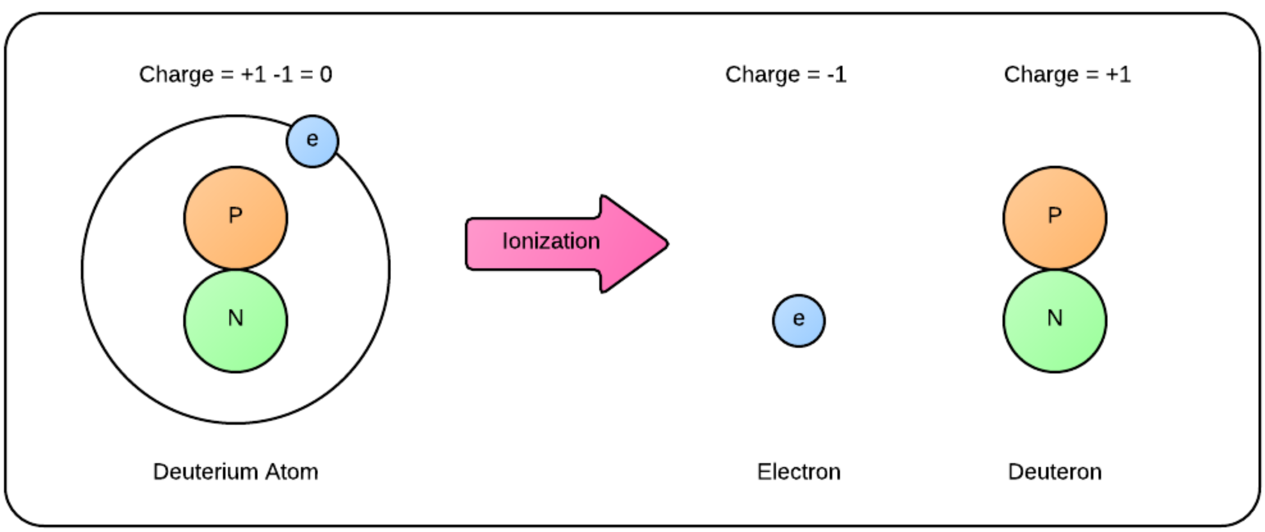

Figure 2: When the deuterium atom becomes ionized, it loses its electron and the deuterium nucleus is called a deuteron.

The interesting thing about plasmas is that because they have moving ions, the gas has electric and magnetic properties. We create plasmas in our laboratories so we can study their properties to find out how they behave.

1.2 Fusion Reactions vs. Fission Reactions

Nuclear *fission* reactions involve releasing energy through splitting a heavy atom (like uranium) into lighter atoms. These types of reactions are the basis for today's nuclear power plants and reactors. On the other hand, nuclear *fusion* reactions involve releasing energy through fusing (or joining together) two light atoms (like deuterium) into one heavier atom. Figure 3 and Figure 4 show two possible outcomes for a nuclear fusion reaction between two deuterons.

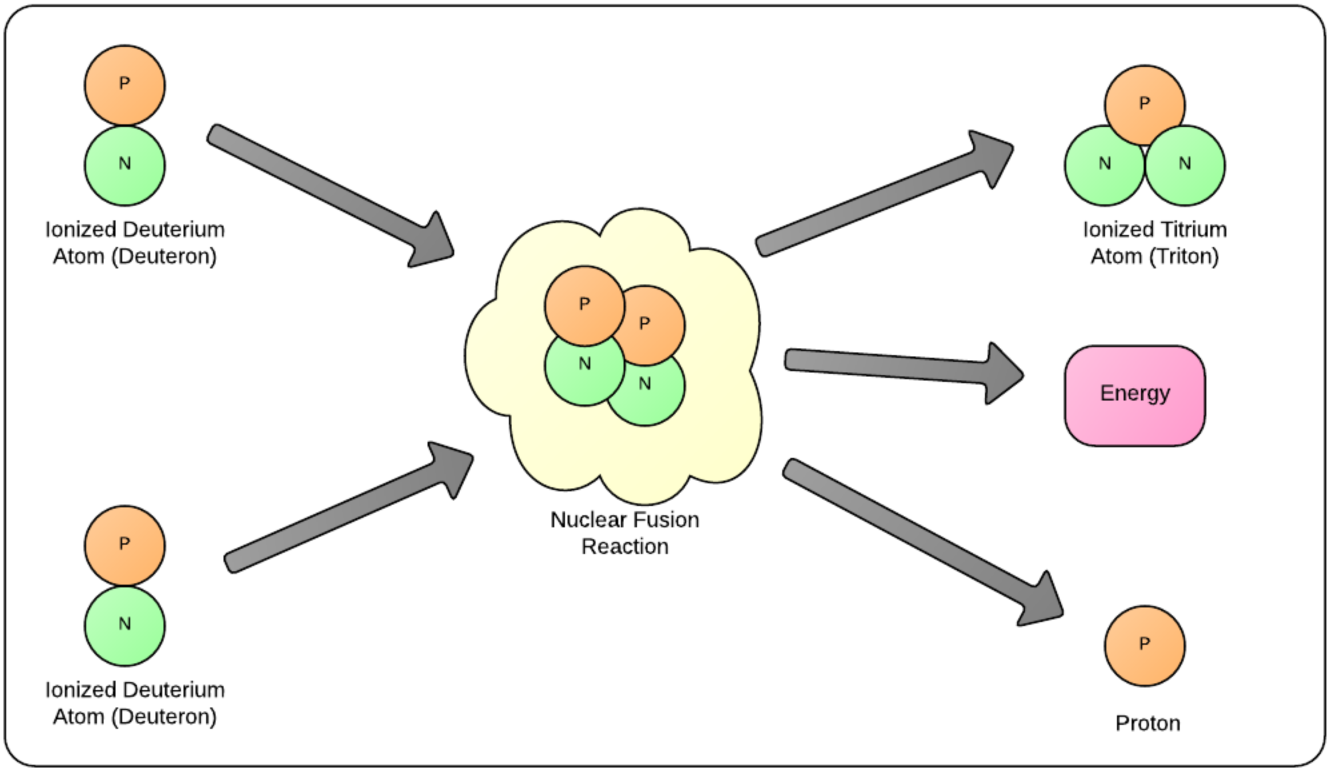

Figure 3: This is a nuclear fusion reaction between two deuterons.

It is more difficult to make fusion reactions occur than it is for fission reactions to occur (which is why power plants based on fission were developed). However, nuclear fusion reactions produce more energy than nuclear fission reactions. This is one of several reasons why current fusion energy research focuses on the development of a power plant based on fusion reactions. Fusion reactions create less radioactive waste which is better for the environment. There is also a larger fuel source on earth for fusion reactions than for fission reactions (for example deuterium can be extracted from saltwater in the ocean). Additionally, in current fission power plants, if certain conditions are not maintained there is a danger of uncontrollable chain reactions, which can cause a meltdown or plant explosion. In a fusion power plant, if certain conditions are not maintained then fusion reactions cannot occur (meaning no meltdowns).

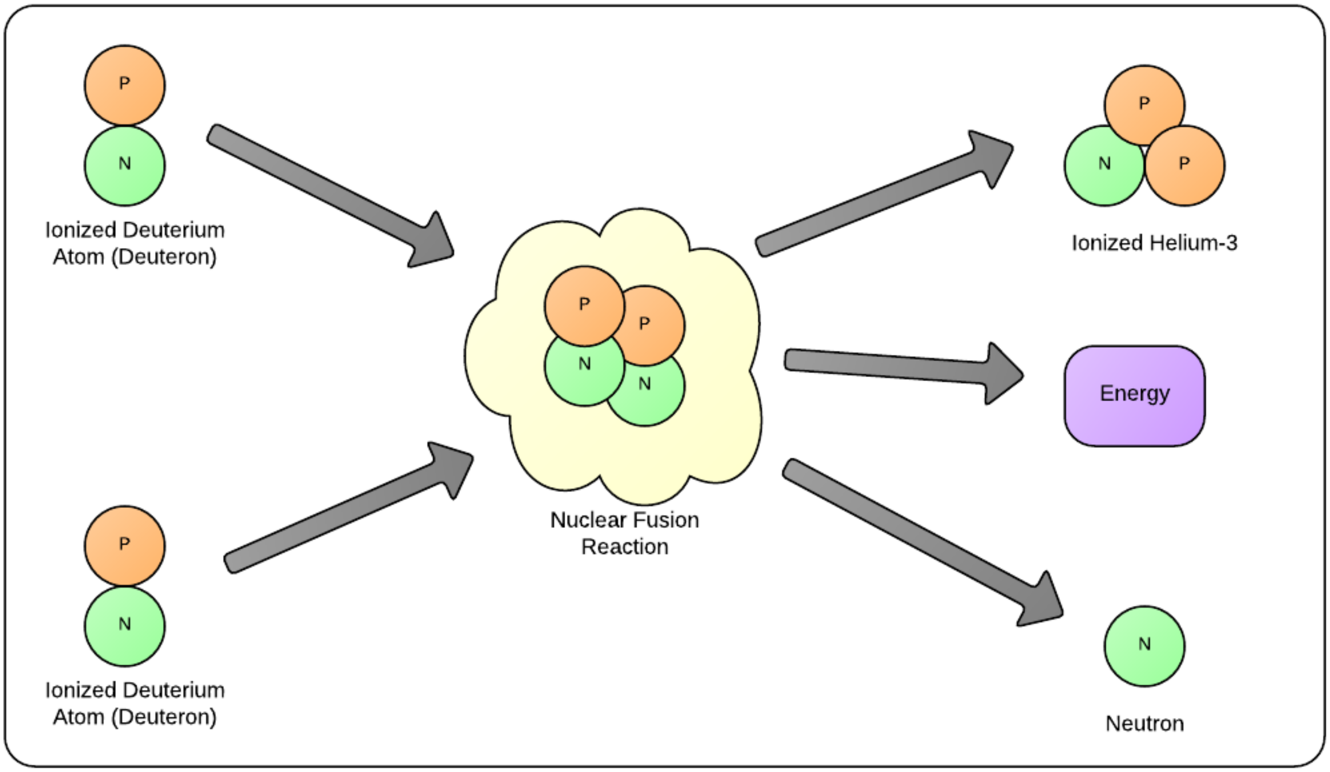

Figure 4: This is the other nuclear fusion reaction which can happen between two deuterons.

1.3 Confining large plasmas in a laboratory

Today, a powerful sources of energy (to provide electricity) comes from nuclear fission power plants. However, due to the nature of nuclear fission reactions, the nuclear fission power plants produce radioactive waste (which is hazardous to the environment and to people) and have a potential for dangerous accidents.

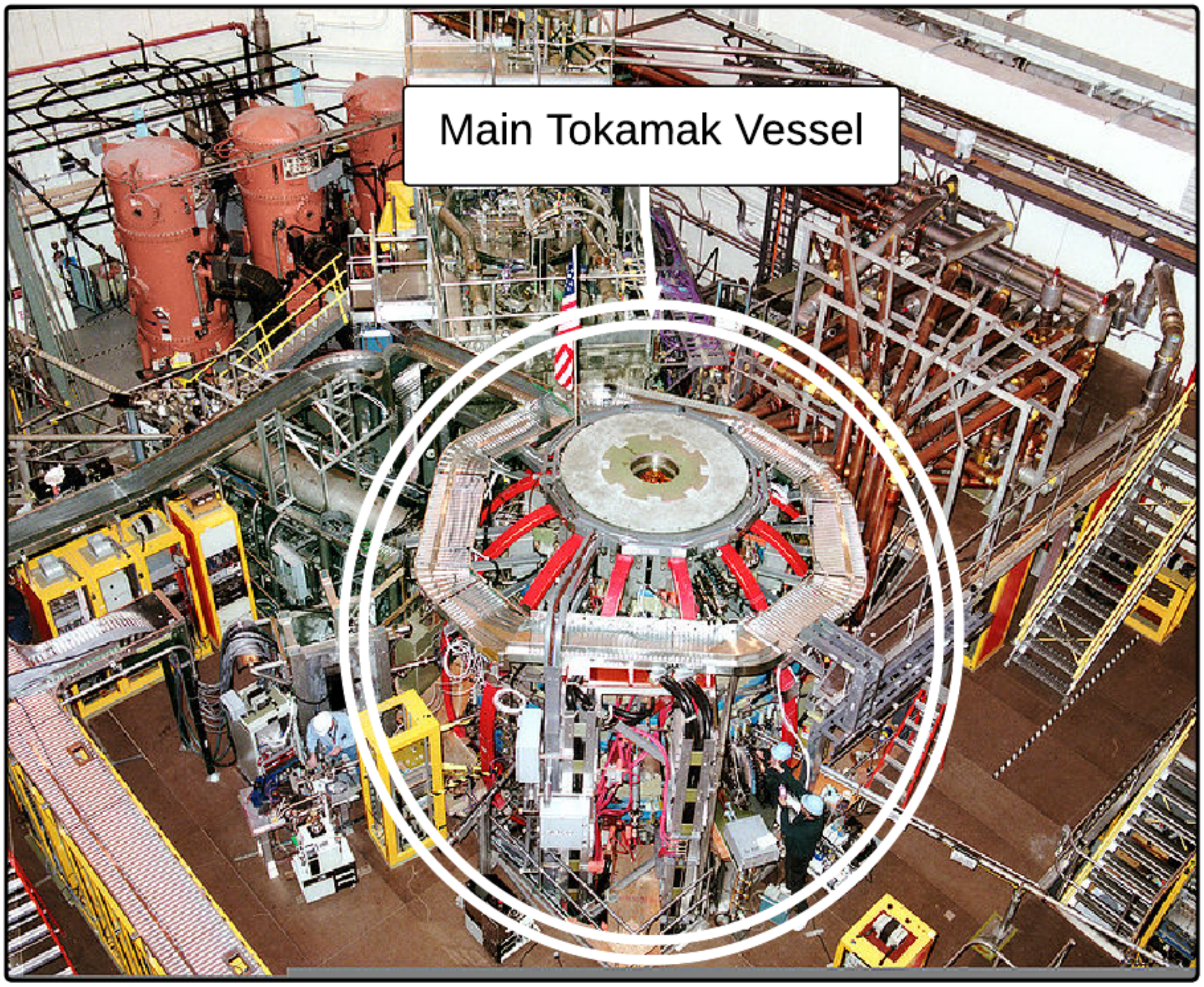

Figure 5: The National Spherical Torus Experiment at the Princeton Plasma Physics Laboratory is located in New Jersey. The tokamak vessel which houses the plasma is circled in white. The tokamak is over two stories tall and all of its supporting components take up an entire building.

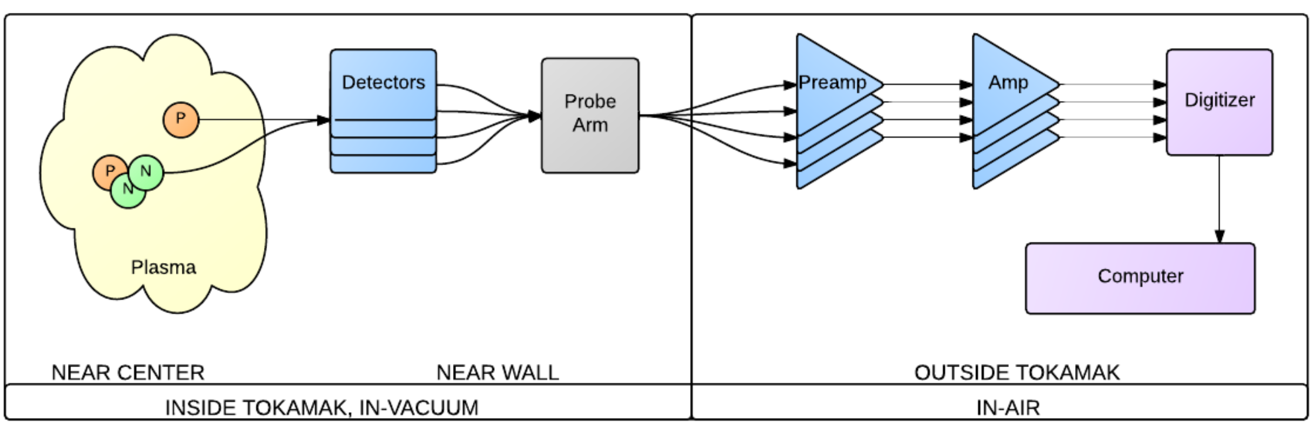

Figure 8: Data acquisition schematic.

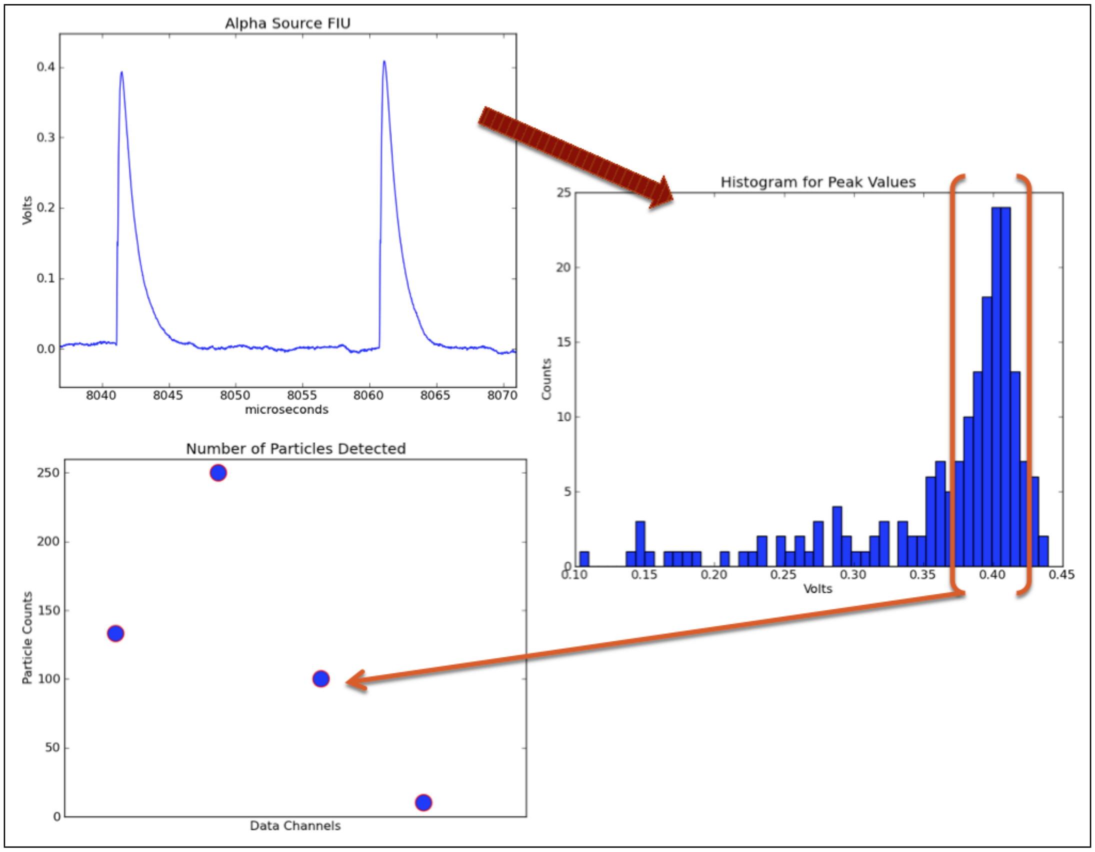

Figure 9: An example of pulses from raw data, which once analyzed will be binned and integrated to reveal particle count rates for comparison to MAST particle yield rates.

References

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[12] An image depicting the poloidal (red, called theta) direction and the toroidal (blue, called phi) directions. Notably absent is the radial coordinate which starts from the center of the tube and points out. 13 September 2006. Made in POV-Ray by Dave Burke. PNG File.

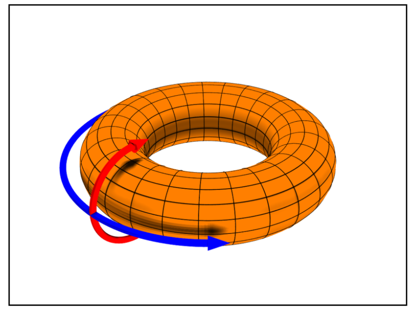

Figure 6: The red line indicates the poloidal direction and the blue line indicates the toroidal direction.[12]

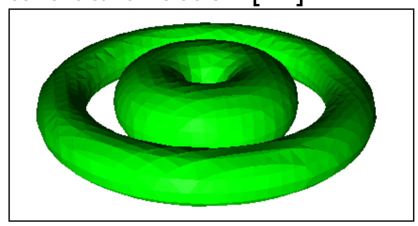

Figure 7: A radially compressed spherically shaped toroidal plasma inside of a conventional toroidal plasma for a visual comparison.