A Fusion Product Instrument to Study Plasma Instabilities Supporting the Development of an Experimental Fusion Power Plant

Fusion research can supply our need for safer, cleaner, large-scale energy production facilities. A deeper understanding of nuclear fusion reactions and the physics of plasmas (hot ionized gas) is necessary to make fusion energy production a viable alternative energy source. A confined plasma equilibrium state is required to create and sustain the nuclear fusion reactions necessary to provide energy. Therefore plasma instabilities negatively affecting equilibrium becomes a vital research focus. Magnetohydrodynamic (MHD) instabilities in the plasma can displace plasma toroidal surfaces (of constant plasma current, temperature, pressure, and magnetic flux) thereby compromising equilibrium. Studying plasmas, however, with temperatures greater than the sun requires great ingenuity. Fortunately, a group of successful magnetic fusion devices called spherical tokamaks use magnetic coils and high currents to create toroidal and poloidal magnetic fields to confine a plasma in a torus (donut) shape within the tokamak without touching its walls. Several heating methods, of particular interest is the Neutral Beam Injection (NBI) of energetic ions, bring the plasma to operating temperatures.

Charged products from fusion reactions in the plasma follow trajectories dependent upon the magnetic field configuration of the plasma. Energetic protons and tritons (charged products from the deuterium-deuterium (DD) reaction) are not confined as they have a gyroradius larger than the radius of the plasma itself allowing them to quickly leave the plasma and hit the tokamak wall or a well-placed instrument, my instrument. Product emission profiles (where the product is created in the plasma and at what rate) are of great importance in validating theoretical models of MHD instabilities as well as how the plasma transports neutral beam ions deteriorating plasma efficiency. After the NBI, my research will determine the time-dependent charged fusion emission product profile from the DD reaction.

In support of the International Thermonuclear Experimental Reactor (experimental tokamak fusion power plant), component test facility magnetic fusion devices are transitioning to higher plasma densities and therefore increased nuclear fusion reaction rates. The need for new techniques to study these plasmas (especially neutral beam ion transport effects on plasma equilibrium) without losing time resolution will be met by my instrument, which will actually have increased resolution with higher DD reaction rates. I will design, construct, assemble, and install a prototype instrument (see Figure 1) in the Mega Amp Spherical Tokamak at the Culham Centre for Fusion Energy for initial testing and data collection in 2013.

I am excited to present my research contribution to Edwin and Marion Link's legacy. As a scientist I hope to follow in the father of flight simulation's footsteps (though I trade in an airplane for a tokamak) of innovation and fostering future scientists.

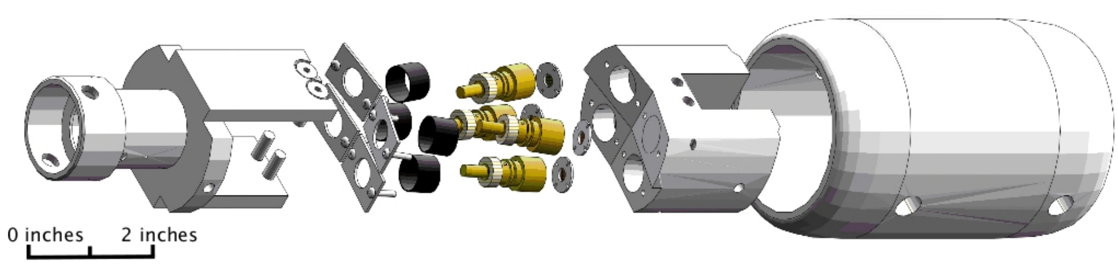

Figure 1: My instrument design concept.