PROGRESS ON THE PULSED FISSION-FUSION (PuFF) PROPULSION CONCEPT. R. B. Adams[1], J. Cassibry[2], K. Schillo[2], [1]George C. Marshall Space Flight Center, Bldg. 4205/118C, MSFC, AL 35812, Robert.b.adams@nasa.gov, [2]University of Alabama in Huntsville, Propulsion Research Center, Huntsville, AL 35899, Jason.Cassibry@uah.edu

Introduction: Funded by a 2013 NASA Institute for Advanced Concepts (NIAC) Phase 1 award, this paper documents the progress in developing a Pulsed Fission-Fusion (PuFF) propulsion system. PuFF compresses coincentric colums of gaseous UF6 and a D-T mixture under a z-pinch configuration. The collapsing pinch compresses the UF6 to criticality, releasing energy to trigger the D-T reaction. There are additional complexities in using a secondard compression wave with an Field Reversed Configuration (FRC) plasmoid.

There are several components to our development. First we have addressed the potiential for reaching the required compression conditions using steady state theory. A 3d fluid solver is under development and is part of this project. Finally we are developing vehicle concepts for both a crewed Mars vehicle and a robotic interstellar explorer.

Steady State Power Balance: For this calculation, we assume that the fission liner thickness is equal to the radius of the spherical fusion core. We approximated the neutron fission cross section as 2 barns, based on the 14.1 MeV neutrons produced by DT and obtained from the ENDF data base. The energy yield per fission reaction was assumed to be 215 MeV. As seen in Figure 2, a fission liner dramatically enlarges the region of net power production by nuclear reactions. The boundary between net power loss and power production is shifted an entire order of magnitude to lower ρR, while temperatures as low as 1 keV are possible. This suggests that pulsed fission/fusion hybrids can reduce the energy required per pulse significantly, by lowering the minimum mass and temperature simultaneously. The significance of this result is that much smaller reactors seem possible, making the feasibility of light weight fusion propulsion systems a reality.

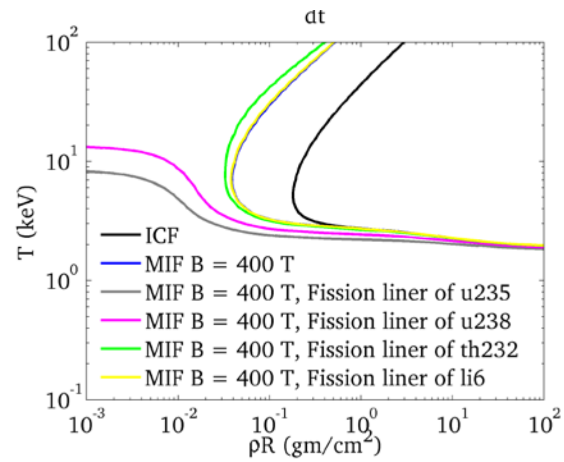

Figure 1. Fission fusion power balance diagram. Regions to the right of each contour represent areas of parameter space in which there is net heating of fission fusion hybrid targets.

Smooth Particle Fluid Solver: We leveraged ongoing work on a new 3D plasma code we are developing called Smoothed Particle Fluid with Maxwell equation solver (SPFMax) to develop a 3D magnetic nozzle modeling capability. SPFMax is a hybrid between a smooth particle hydrodynamic plasma fluid solver and a 3D time dependent Maxwell equation solver utilizing the finite difference time domain method.

Vehicle Concepts: Crewed vehicles to Mars is a long term goal for most exploration programs. We have carried here a concept vehicle using PuFF to carry crew on a round trip to Mars. As expected the PuFF concept greatly enables routine missions to Mars with minimal trip times.

Additionally we carry the ‘stretch’ goal of being able to visit other stars using PuFF. Our methodology is to assume the largest version of PuFF that could be launched with an block II version of the Space Launch System. Additional launches are added for payload, instrumentation, radiator systems, and required fuel. The time to travel for several interstellar targets is then computed.