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1. Document Identification and Proposed Disposition:
The Status of USITER Diagnostic Port Plug Neutronics Analysis Using Attila
By: Russell Feder, et. al. Submitted to: Proceedings of the American Nuclear Society (ANS) 2013 Winter Meeting, Washington, DC (November, 2013)

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______ 3. Return of document is necessary.

______ 4. In order to meet a publication schedule or submission deadline, patent clearance by ____________________ would be desirable.

__✔__ 5. This document discloses no possibly patentable subject matter.

______ 6. This document describes an invention reported as Contractor Docket No. ________ Princeton Univ #:____________DOE Case No_________.

______ 7. An invention is disclosed for the first time on pages(s) _______________.

______ 8. Remarks:

Signed: Cecelia T. O Brien Digitally signed by Cecelia T. O Brien DN: cn=Cecelia T. O Brien, o=Princeton Plasma Physics Lab, ou=Best Practices and Outreach, email=cobrien@pppl.gov, c=US Date: 2014.05.08 12:25:25 -05'00' Date: 05/07/14

To: **Initiator of Request**
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9. No patent objection to above identified release.
10. Please defer release until advised.
11. Document returned herewith.

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The Status of USITER Diagnostic Port Plug Neutronics Analysis Using Attila

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INTRODUCTION

USITER is one of seven partner domestic agencies (DA) contributing components to the ITER project. Four diagnostic port plug packages (two equatorial ports and two upper ports) will be engineered and fabricated by Princeton Plasma Physics Lab (PPPL). Diagnostic port plugs as illustrated in Fig. 1 are large primarily stainless steel structures that serve several roles on ITER. The port plugs are the primary vacuum seal and tritium confinement barriers for the vessel. The port plugs also house several plasma diagnostic systems and other machine service equipment. Finally, each port plug must shield high energy neutrons and gamma photons from escaping and creating radiological problems in maintenance areas behind the port plugs. The optimization of the balance between adequate shielding and the need for high performance, high throughput diagnostics systems is the focus of this paper. Neutronics calculations are also needed for assessing nuclear heating and nuclear damage in the port plug and diagnostic components. Attila, the commercially available discrete-ordinates software package, is used for all diagnostic port plug neutronics analysis studies at PPPL.

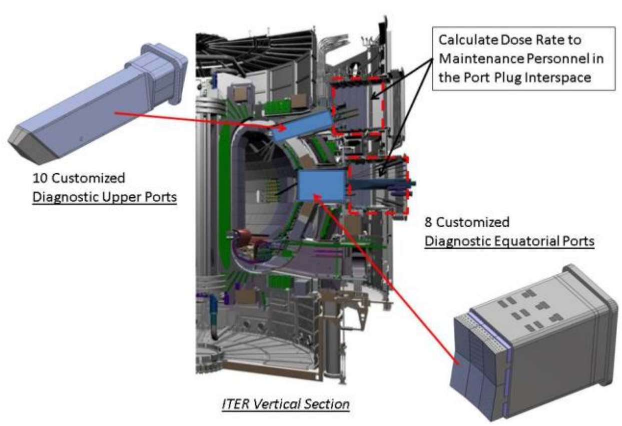

Fig. 1. This vertical section through the ITER Vacuum Vessel and Cryostat highlights the location of the Upper and Equatorial diagnostic port plugs.

ITER PORT PLUG NUCLEAR SHIELDING REQUIREMENTS

Nuclear shielding design in the diagnostic port plugs is primarily driven by the specification for the shut-down dose rate in the port plug interspace. The interspace is the room behind the ports where maintenance personnel can enter to work on the back of the ports. The ITER requirement for interspace dose is 100 μSv/hr 10 seconds after shut-down. The term "shut-down" refers to the end of ITER life after all planned 500 MW and even some 700 MW experiments. This is very conservative but also provides a built-in safety margin for the neutronics calculations.

Dose is calculated using ICRP-74 flux-to-dose conversion factors. Ultimately acceptable levels of Occupational Radiation Exposure (ORE) will need to be demonstrated based on some realistic maintenance scenarios. At this time most interspace equipment design is too conceptual to accurately predict ORE.

THE ATTILA ANALYSIS PROCESS

All calculations documented in this report were performed using Attila-8.0.0 furnished by Transpire, Inc. of Gig Harbor, Washington (www.transpireince.com). The USITER port plug engineering team runs Attila-Severian (the parallel-processing version) on the "Jassby" scientific computing cluster at Princeton Plasma Physics Lab. Jassby uses a total of 96 2.6 GHz processing cores with a total of 768 GB of shared memory. This allows for rapid neutron and photon transport calculations.

Neutron and photon transport calculations in Attila use FENDL-2.1 processed for discrete-ordinates transport to contain 175 neutron groups and 46 gamma energy groups. Currently to help expedite the transport calculations a "few group" FENDL library has been prepared with 46 neutron groups and 21 gamma photon groups. Activation and depletion calculations in Attila use FENDL-2.1 as well as a module called FORNAX. The FORNAX module of Attila uses the neutron transport flux solution to calculate the build-up and decay of radioisotopes in the model structures.

SIMPLIFIED APPROACH TO EQUATORIAL PORT PLUG NEUTRONICS

The ITER organization provides a global neutronics model to unify calculations across the DAs. In order to expedite parametric port plug shielding calculations a simplified approach is taken as shown in Fig. 2.