Division Submission Form

Submission Deadline: March 24, 2017

Instructions to Division Leadership

Please use this form to submit one to three Nuclear Grand Challenges representative of the interests of your Division. These Challenges must be technical issues that need to be addressed to enhance the economic, political, and public acceptability of nuclear technologies.

Division Name

Division Contact Information

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In the following pages, please present each Challenge in the form of a one-sentence question or statement.

Then, in 300 words or less, provide sufficient background information on this Nuclear Grand Challenge and describe why it should be one of the final ANS Nuclear Grand Challenges.

Submit completed form to:

ANS President Andy Klein
grandchallenges@ans.org

Challenge #1

Qualification of advanced materials that can withstand extreme nuclear fusion and fission environments (high temperature, radiation damage and transmutation, helium and hydrogen surface and bulk effects, and compatibility with advanced coolants).

Reason for Selecting Challenge #1

Advanced fission and fusion reactor designs offer many potential benefits but will require new materials to be successful. These advanced reactors have unique challenges that call for materials to resist corrosion when in prolonged contact with liquid salts or liquid metals, remain strong at elevated temperatures in a neutron field, maintain structural integrity when exposed to high fluxes of light ions and high heat flux, resist reaction in a loss of coolant event, and more. Materials must be developed and qualified for each of these areas so that they can be implemented in new reactors.

Materials issues lie at the heart of many of the technology issues that need to be solved. Without advanced materials, adequately qualified so that they can be used in engineering designs, we will never have a viable fusion or advanced fission power plant. This is a multi-faceted challenge that benefits not only nuclear energy research but has application toward many other industries.

Challenge #2

Safely and efficiently fuel, exhaust, breed, confine, extract, and separate tritium in unprecedented quantities.

Reason for Selecting Challenge #2

Tritium management in fusion and fission systems presents a persistent challenge to confine and avoid tritium permeation into undesirable locations. Fusion reactors pose additional challenges in tritium management. Only a fraction of tritium in the plasma will be "burnt up" and converted to helium. Cost effective, high throughput tritium re/processing capabilities need to be developed. In addition, burning plasma fusion reactors will require unprecedented quantities of tritium. As tritium is not found in nature, it must be bred. Scalable systems for breeding and extracting sufficient quantities have not been demonstrated. Since the fusion fuel cycle wholly depends on tritium availability, this is a critical area for the success of fusion energy.

This is a critical issue for the future of fusion energy. Without tritium, there can be no deuterium-tritium fusion (which is the most probable reaction for a fusion power plant). Current tritium system designs are based on extrapolations from simple assumptions or benchtop scale experiments. Tritium is not only important because it is the fuel for the reactor, but it is a critical safety issue. For this reason, we must develop and qualify reliable methods to handle large amounts of tritium.

Challenge #3

Successfully demonstrate significant energy gain in a long pulse or steady-state burning plasma.

Reason for Selecting Challenge #3

The path to viable fusion power from a magnetically confined plasma source requires the creation of a burning plasma. In a burning plasma, the primary heating source comes from the fusion reaction itself. Furthermore, in order to begin to consider the economic viability of a fusion power plant, the reaction must have a significant energy gain, or “Q” factor (ratio of output power to input heating power), in a reaction that is sustained over a time frame of minutes or hours. Construction has begun for an international experiment that aims to achieve this (the ITER tokamak), and numerous privately funded smaller experiments have the potential to make leaps forward toward this goal.

Demonstrating that we can sustain a plasma that produces energy is fundamental and encompasses a great many physics and technology challenges. Furthermore, strategically the world has invested much funding into pursuing this goal, and successfully achieving this challenge will demonstrate that there is a way forward to achieving fusion as a power source.