White Paper for University of Washington Collaboration with the QUEST-ST in Japan to develop long-pulse, steady-state current drive and support simplification of the Tokamak concept

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Tokamak research has made tremendous progress during past decade suggesting that it could be a viable fusion reactor concept. Further simplification of the concept, such as the elimination of components not required during steady-state operation, and methods to increase the steady-state current drive efficiency would further increase the likelihood of a tokamak-based power reactor.

Plasma start-up using Coaxial Helicity Injection (CHI)[1] is one method for eliminating the solenoid. Considerable progress has been made in this area to suggest that this is a viable method for solenoid-free plasma startup in a tokamak. [2] [3] [4] This proposal for collaboration with the QUEST-ST in Japan is to explore the different installation concepts of CHI systems in a tokamak and to study each of their potential benefits to a next step ST or tokamak and eventually for a device such as the FNSF.

Recent thinking[5] on new ways to implement CHI capability suggests that it may be possible to provide useful edge current drive after CHI has formed the initial start-up plasma. Driving edge current with good confinement requires an all metal system to minimize the effects of low-Z impurity radiation in the plasma edge. In addition it is highly desirable to have an efficient source for electron heating. QUEST is well equipped in both these areas. It is an all metal system with 100 kW of ECH heating (projected to increase to 1MW during the next few years). This puts QUEST in an ideal situation to test and more fully develop CHI capability for both start-up and steady-state current drive purposes.

We have since the 2008 IAEA meeting discussed this possibility with the QUEST team members. QUEST management has now given us approval to conduct a detailed design study to investigate the feasibility of a CHI system installation that incorporates these new ideas. This design work will be completed by May 2012.

The QUEST group will then make a decision on whether to proceed with the CHI upgrade, which will enhance their steady-state research program. A factor that would strongly influence their decision will be commitment from the University of Washington group to ensure that CHI will work as well on QUEST as it did on HIT-II and NSTX. This is due to the time and cost involved in the CHI system installation by Toshiba, the company that built QUEST.

An international collaboration with QUEST will enhance our program in the following manner.

1. The full potential of CHI will be studied on QUEST as it is an all metal system with high power ECH capability (both these capabilities did not exist on HIT-II and do not exist on NSTX)

2. The new CHI geometry we will test on QUEST would make it easier for the installation of CHI systems on next step STs and Tokamaks

3. Validation of extended MHD simulations of CHI with neutral dynamics and ionization physics. This requires a graduate student and part time of a professional.

4. We will attract graduate students for Ph.D. research on QUEST to further develop the CHI physics and technology. To ensure that CHI does work well on QUEST, R. Raman will assume primary responsibility with strong active support from Tom Jarboe.

To support these activities and for possible addition of a Thesis related diagnostic on QUEST, we anticipate that the international collaboration cost for the University of Washington part of the activity would be about $290k/year for 6 years.

References

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