§78. Proposal for the Operation of CHI on QUEST

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During FY2015, the assembly of the CHI capacitor bank, CHI snubber system, and the CHI gas injection system was completed. During early March 2016 these were shipped to Kyushu University. During March 2016 the operation of these systems was tested at the QUEST facility by operating them with a LabView based control system. We are now making final preparations for conducting CHI experiments on QUEST later this year.

1. Introduction

Methods for starting a plasma discharge in a spherical tokamak (ST) without reliance of the center solenoid are essential for the validity of the ST concept. These methods could also simplify and reduce the cost of tokamak-based systems and make them more economical by eliminating components that are not needed during steady-state operation. There are a number of new and important studies that would be possible on QUEST. These are: (a) Benefits of high-power ECH for CHI discharge initiation and heating of CHI plasmas, (b) impact of an all metal wall configuration for reducing low-z impurities, and (c) development of a simpler electrode configuration that is much more suitable for a fusion reactor as described in the Reference [Raman, et al., Fusion Science & Technol., **68** (2015) Pg. 674]. All these objectives are well aligned with the long-term mission of QUEST to develop steady-state fusion reactor technologies. This report describes progress during 2015 and the near-term plans for CHI on QUEST.

2. Experimental Systems for CHI

CHI on QUEST[1] will be powered by a 20 mF, 2 kV capacitor bank capable of generating up to 30 kA of peak injector current. The system triggered by two ignitrons, each connected to 2-3 capacitors. This dual trigger capability would provide greater control over the injector voltage waveform pulse, as on NSTX. Fig. 1 is a photo of the CHI capacitor system taken during the tests conduced at QUEST during March 2016. The capacitor bank is identical in size to the system used on NSTX/NSTX-U for transient CHI studies.

The gas injection assembly is based on the system used on HIT-II and NSTX. It allows pressurized gas from a 1-2 cc plenum to rapidly empty into the vessel through ports that direct the gas from the groundside electrode to the divertor electrode plates. Gas in injected using fast acting pneumatic valves that have about a 2 ms response time, from two different toroidal locations. Fig. 2 shows the internals of a box that contain some of the valves needed for operation. Not shown here are the fast valves mounted on ports on the vacuum vessel.

At each of the three current feed locations below the electrode/divertor plate assembly, a low inductance snubber based on 32 μF, 5kV capacitor will be used to suppress transient voltage spikes that can occur during CHI operations. The primary ground for CHI will be the QUEST outer vacuum vessel.

These systems are now in the process of being connected to the QUEST device to enable CHI experiments later this year.

3. Experimental Plans

The initial objective, during 2016, on QUEST is to initiate the CHI discharge, initially by using high values of the injector flux. This ensures that the resulting discharge remains near the injector region, allowing other optimizations to be carried out to ensure that the discharge initiates reliably. This would be followed by gradually growing the plasma into the vessel, to demonstrate reliable discharge imitation and current multiplication factors.

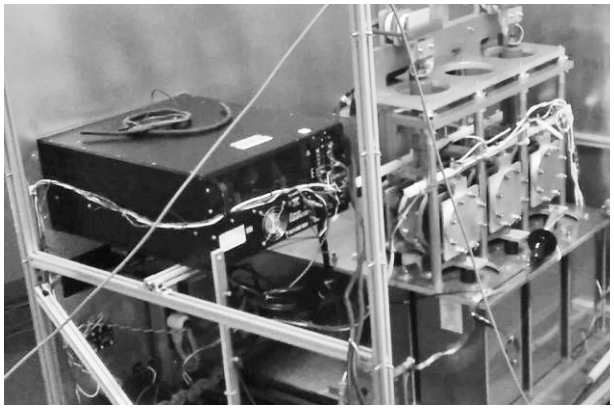

Fig. 1: Photo of the QUEST CHI capacitor bank internal components including a 2kV Glassman Power Supply, and control electronics to enable remote operation of the capacitor bank.

Fig. 2: Control box for activating one gas valve. Not shown here are the trigger system and the fast valves.

Summary

Considerable accomplishments during FY15 include the assembly and testing of supporting systems needed to operate CHI on QUEST. These are the capacitor bank system, fast gas injection system, and the voltage snubbing system.

[1]R.Raman *et al.*, ISTW2015