CHI plans on NSTX for the Fy 04 to 08 period

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CHI has produced substantial toroidal current (390kA with 28kA injected, 330ms pulse)

Discharges produced in the preferred "narrow" footprint case

Substantial work still remains, before a CHI discharge can be transferred over to another current drive system

Current status
Most discharges end in an absorber arcs

Improved Absorber to be installed (July to September, 2002)

New Absorber insulator plus Absorber field control is expected to allow sustained operation at higher currents.

Feedback control of a CHI discharge much more challenging than ohmic discharges.

FY 03 [Characterize CHI discharges and investigate flux closure]:

- Investigate flux closure, by generating a high current long flattop discharge. Characterize the electron pressure profile.
- Improve on the experiments on adding CHI to an Ohmic discharge (D. Mueller) - The purpose here is to begin to develop understanding of feedback control of discharges that also contain a CHI produced edge current component. Since these discharges will initially contain a much larger portion of transformer driven current and will be feedback controlled to start with, modifications to the feedback control system can be made in gradual steps as the portion of the CHI current is increased in gradual steps. Eventually, methods developed here will be used on CHI only discharges that are used for plasma startup.
- Improve EFIT to include open field line and private flux current (M. Schaffer, L. Lao), and ESC in collaborations with L. Zakharov.
- Improve TSC to model CHI discharge evolution (in collaboration with S. Jardin and S.M. Kaye of PPPL).
- Initiate work on 3D MHD modeling using existing codes (X.Z. Tang, LANL).
- Initiate feedback control studies (D. Gates, B.A. Nelson).

FY 04 [Establish feedback controlled operation of a CHI discharge and improve CHI discharges]

- Make full implementation of fast acting poloidal field coils for absorber field control.
- Produce reference-operating conditions in which CHI provides some edge current drive.
- Conduct fast camera measurements to observe edge fluctuations in the CHI current (R. Maqueda, S. Zweben).
- Conduct initial edge probing studies to understand current penetration mechanisms (H. Ji , J. Boedo).
- Conduct initial divertor heat load studies to learn how to maximize the current that flows the long way around the torus and not in the private flux region. Additionally, these studies may lead to improved divertor tile material selection for the NSTX upgrade extension (R. Maingi, H. Kugel, C. Busch).
- Obtain routine EFIT and TSC for CHI only discharges.
- Extend full feedback control to CHI only discharges.
- Heat a CHI discharge using (ECE – if possible) and HHFW.

FY 05 [Establish plasma startup]

- Detailed measurements using edge probe, MSE, Fast Camera.
- Hand off a CHI discharge for operation using the central solenoid.

FY 06 [Physics understanding of CHI discharges]

- Understand mechanisms that lead to closed flux generation based on edge probing studies, MSE measurements, EFIT, TSC simulations and other diagnostics.
- Handoff a CHI discharge for operation using a non-inductive current drive system.

FY 07 [Implement edge current drive]

- Provide some edge current drive during a high current, long pulse discharge.

FY 08 [Integrate CHI with other current drive systems]

- Fully integrate CHI with other current drive systems.
- Finish student thesis work No. 1 started in prior years: "Energy balance in a CHI plasma."
- Finish student thesis work No. 2 started in prior years: "CHI current drive physics."

New engineering tools and improvements needed for the CHI program

Improvement 1:
A very important improvement is higher voltage capability (2kV for the injector PS). This may be quite important for allowing us to couple CHI to HHFW.

Improvement 2:
The tracking distance along the lower insulator(s) surfaces need to be increased.

Improvement 3:
We also need to find a way to quantify the carbon content in a CHI discharge and determine how it changes with reduced injector current (for the same toroidal current). Implementing Improvement No. 1 will help in this regard as for the same toroidal current we will need lower injector current. It will be really good if we can produce 500kA CHI discharges using only about 10kA of injector current. CHI has never been operated in this regime and this will be new territory for CHI and from both a technology and physics point of view this is a direction we would like to move towards.

Related to this is being able to determine the energy balance in a CHI plasma. What fraction is wasted on the divertor plates, what fraction is in the open field line region and how much actually makes it into the core.

Improvement 4:
It would be very useful to know the current path on the vessel structure. We would like to know the poloidal current density into the wall. An array of toroidal-field measuring Mirnov coils could be used. This will tell us where on the wall (poloidally) the current enters and leaves the wall. This will considerably improve EFITs capability to reconstruct a CHI discharge (strongly requested by Jarboe, Schaffer, Paoletti and others).

Improvement 5:
It would be really nice to have an ECH system (as high a power as possible), but at least 500kW. We would like to be able to heat the core of a CHI plasma with this. First we have to establish the reference CHI plasma we would like to use (primarily the toroidal field that is optimum, and the method of ECH application to avoid density limit issues, for example 0.6T discharges and late in the discharge after the initial density has decayed away- This have not yet been established). Since ECH is a much more localized heating system, it will allow us to heat the region where closed flux is forming and will increase the decay time of the current in this region. Also, this is a system we can use routinely without any worry of coupling issues.

Improvement 6:
An engineering study to determine the response time capability of the PF2 and PF3 coil systems and how they can be made as fast as reasonably possible.

CHI related collaboration with other groups

EFIT, ESC reconstructions and TSC simulations
(Mike Schaffer, Steve Jardin, Leonid Zakharov)

Dynamo probe measurements
(H. Ji, J. Boedo)

Edge fluctuation measurements
(R. Maqueda, S. Zweben)

Edge rotation measurements
(M. Nagata, V. Soukhanovskii, R. Bell)

Divertor heat flux, divertor Langmuir probes
(R. Maingi, H. Kugel, C. Busch)