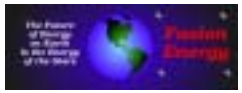


Status of CHI research for plasma start-up

Roger Raman

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Acknowledgments

Thomas R. Jarboe, Brian A. Nelson and the HIT Research Team

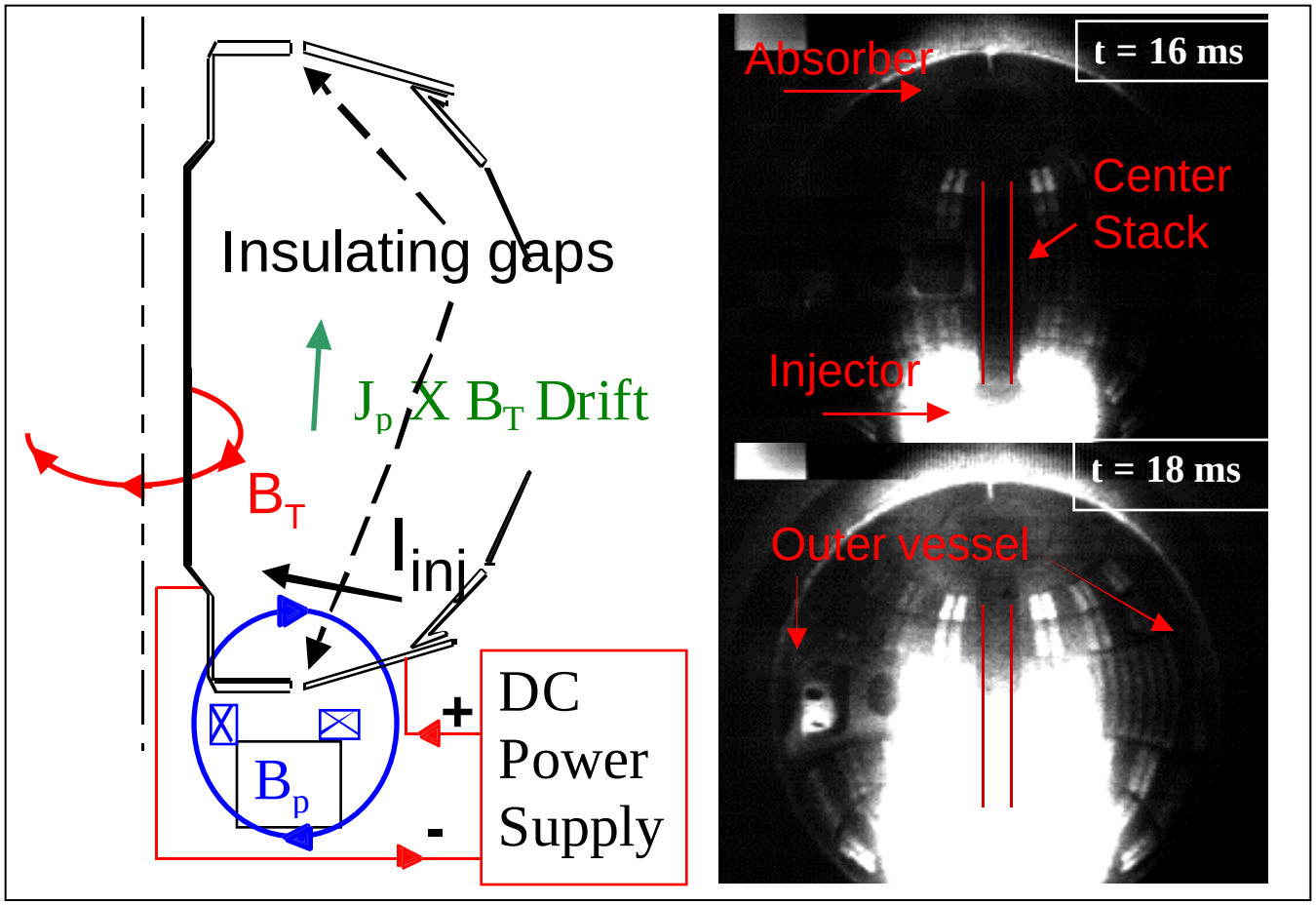
Dennis Mueller, Michael Schaffer, David Gates, Michael Bell, Leonid Zakharov, Steve Jardin and the NSTX Research Team

NSTX Results Review Forum

September 9 to 13, 2002

Princeton Plasma Physics Laboratory, Princeton NJ

Co-axial electrodes inject helicity



Expect reconnection processes to redistribute edge current to the interior, forming closed surfaces

Goals for FY 02 research and issues

- Conduct experiments at higher TF to increase toroidal current, and to study effect on n=1 mode amplitude and frequency – voltage flashovers terminated run

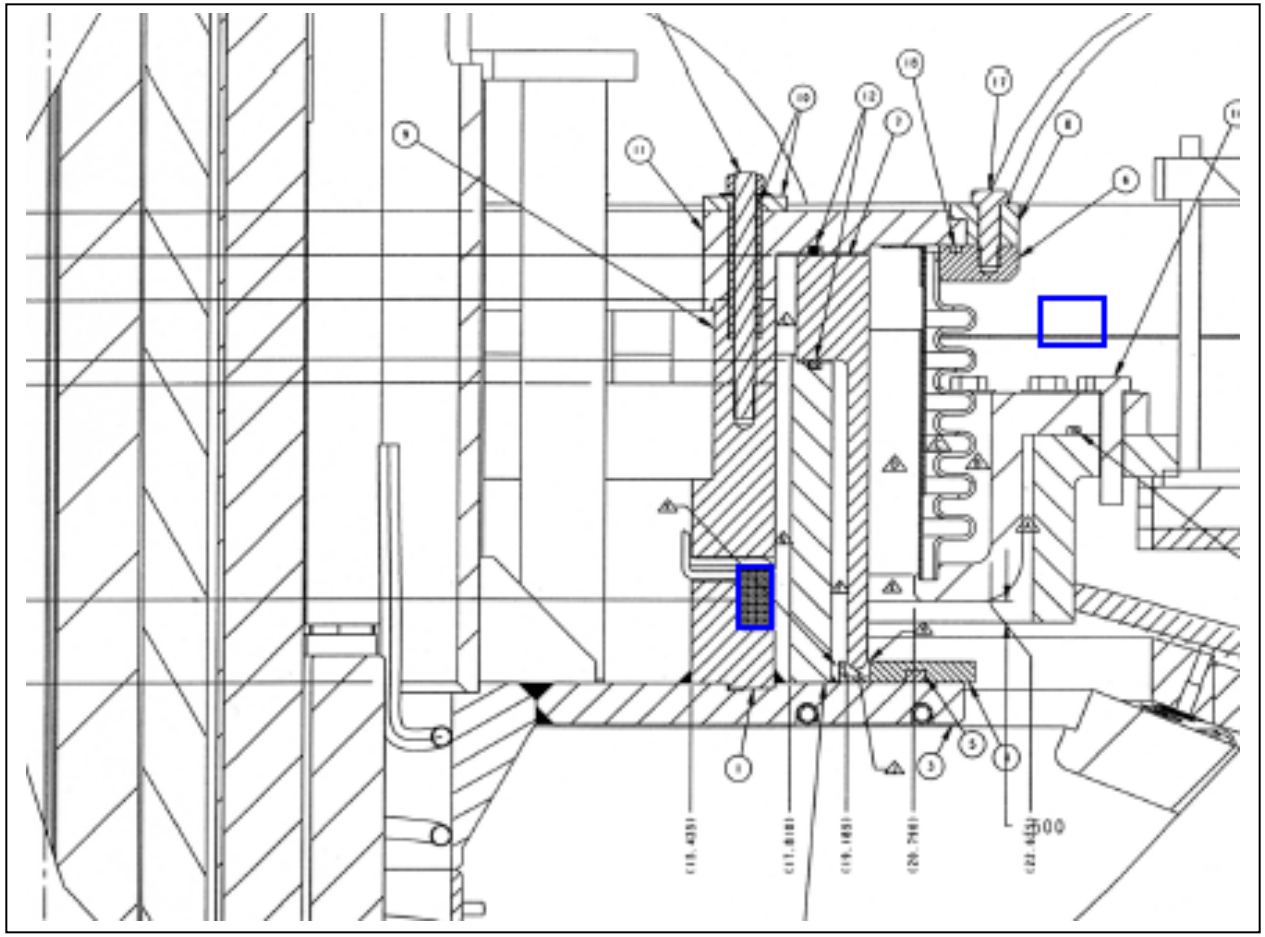
- Measure extent of edge driven current when CHI is added to a LSN discharge – noise pick-up in magnetics

- Implement feedback control for sustaining plasma shape during the high current phase – CHI run postponed until FY03

Needed CHI hardware modification now underway

- Components related to flashover redesigned.
- Improved snubber circuit based on HIT-II and DIII-D experience should suppress voltage excursions in test cell.
- Considerably improved absorber with long ceramic insulator, like on HIT-II.
- HIT-II-like PF absorber field control PF coils being installed.

Absorber design considerably improved



Good progress with CHI modeling effort

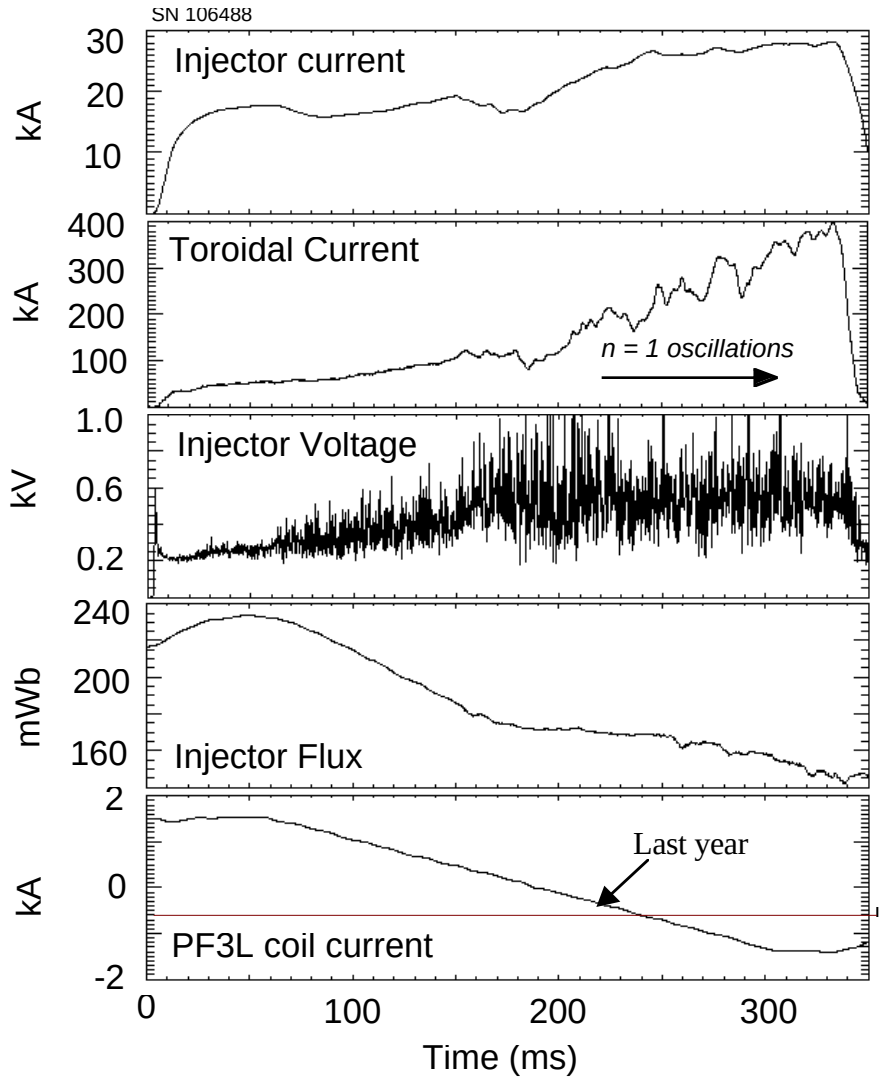
ESC: Equilibrium code developed by Leonid Zakharov (PPPL), adapted for CHI type plasmas and includes capability for current flow on open field lines and in the private flux region. Allows good reconstruction of CHI discharges.

TSC: Code developed by Steve Jardin. Several simulations conducted to gain familiarity with the code. Code will be used for specific CHI start-up discharge simulation for FY 03 CHI assisted plasma start-up.

3DMHD: Code developed by Xianzhu Tang (LANL) to understand CHI physics (presentation today at this forum)

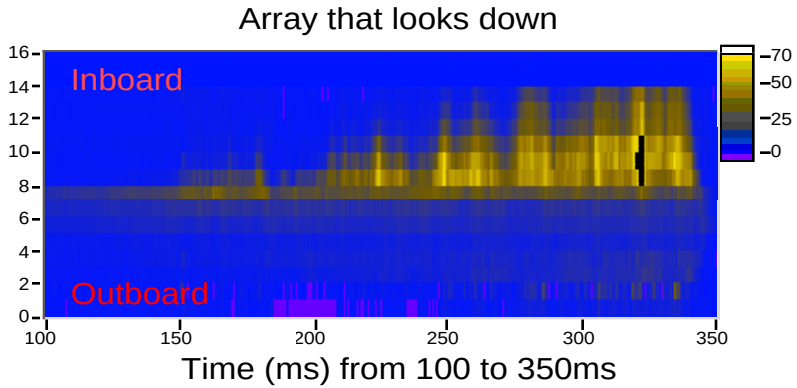
EFIT: Modified for CHI by Michael Schaffer and Lang Lao (GA) – presentation today at this forum.

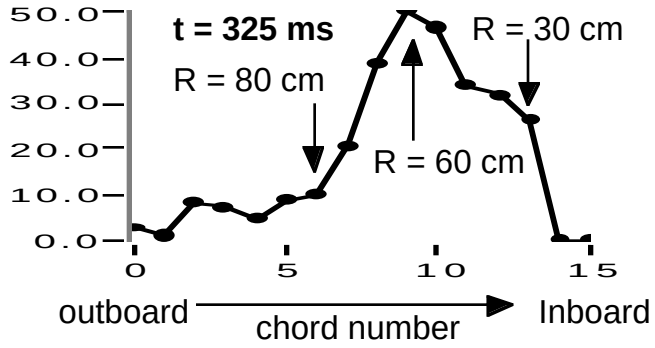
High current discharge from FY01 reconstructed by ESC



R. Raman, NSTX Results Review, Sept. 9, 2002

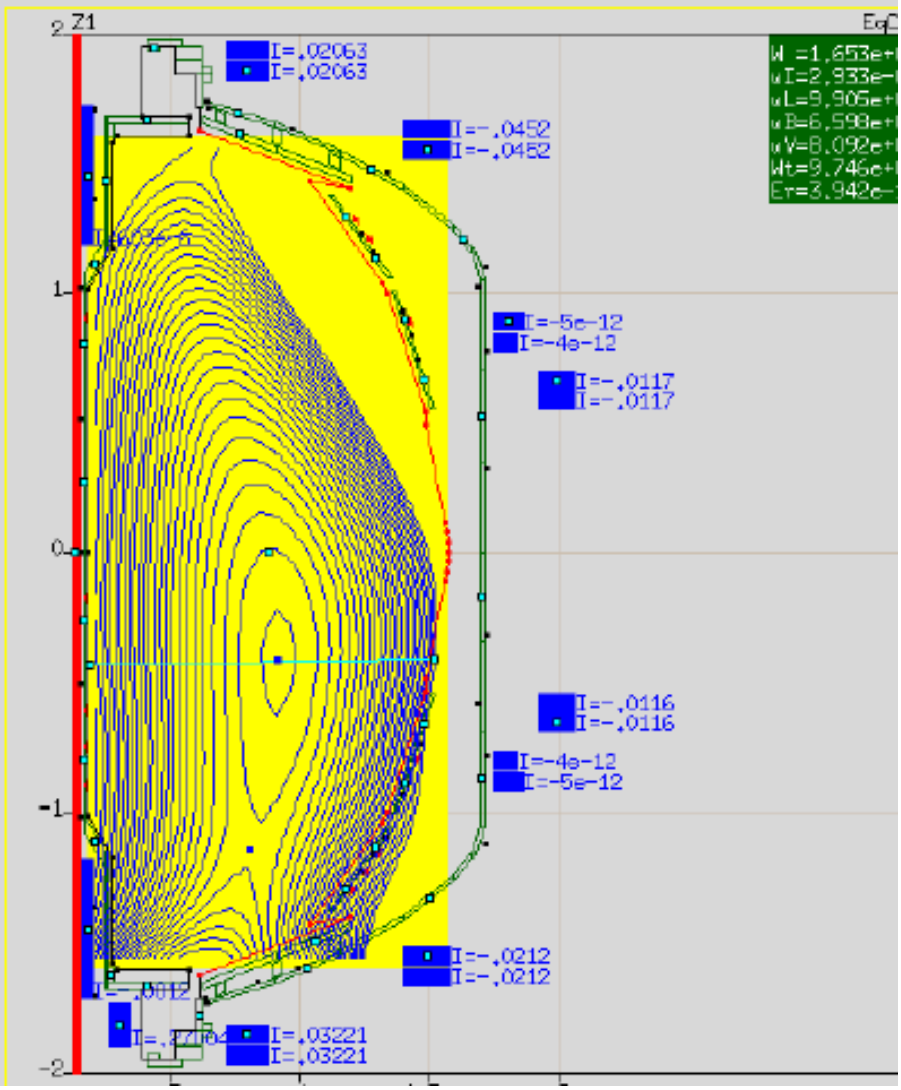
Soft x-ray profiles (E > 100 eV)

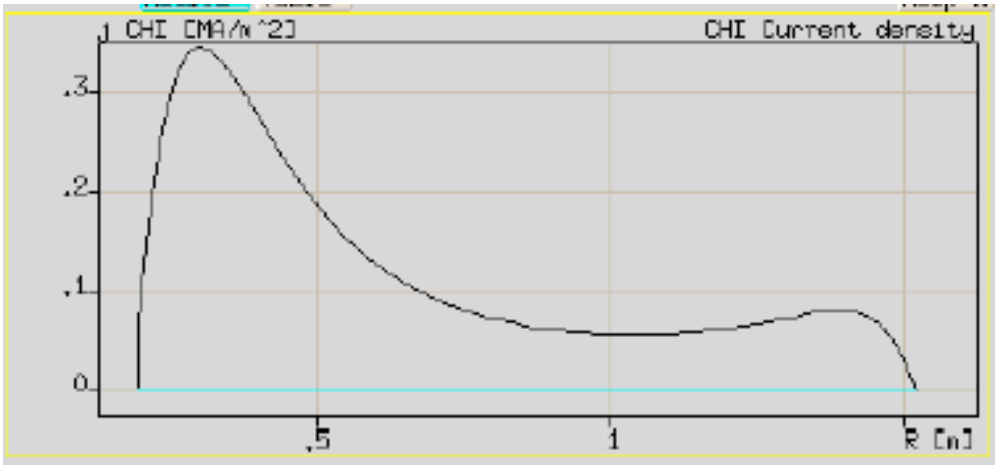




Soft X-ray:
D. Stutman (Johns Hopkins Univ.)

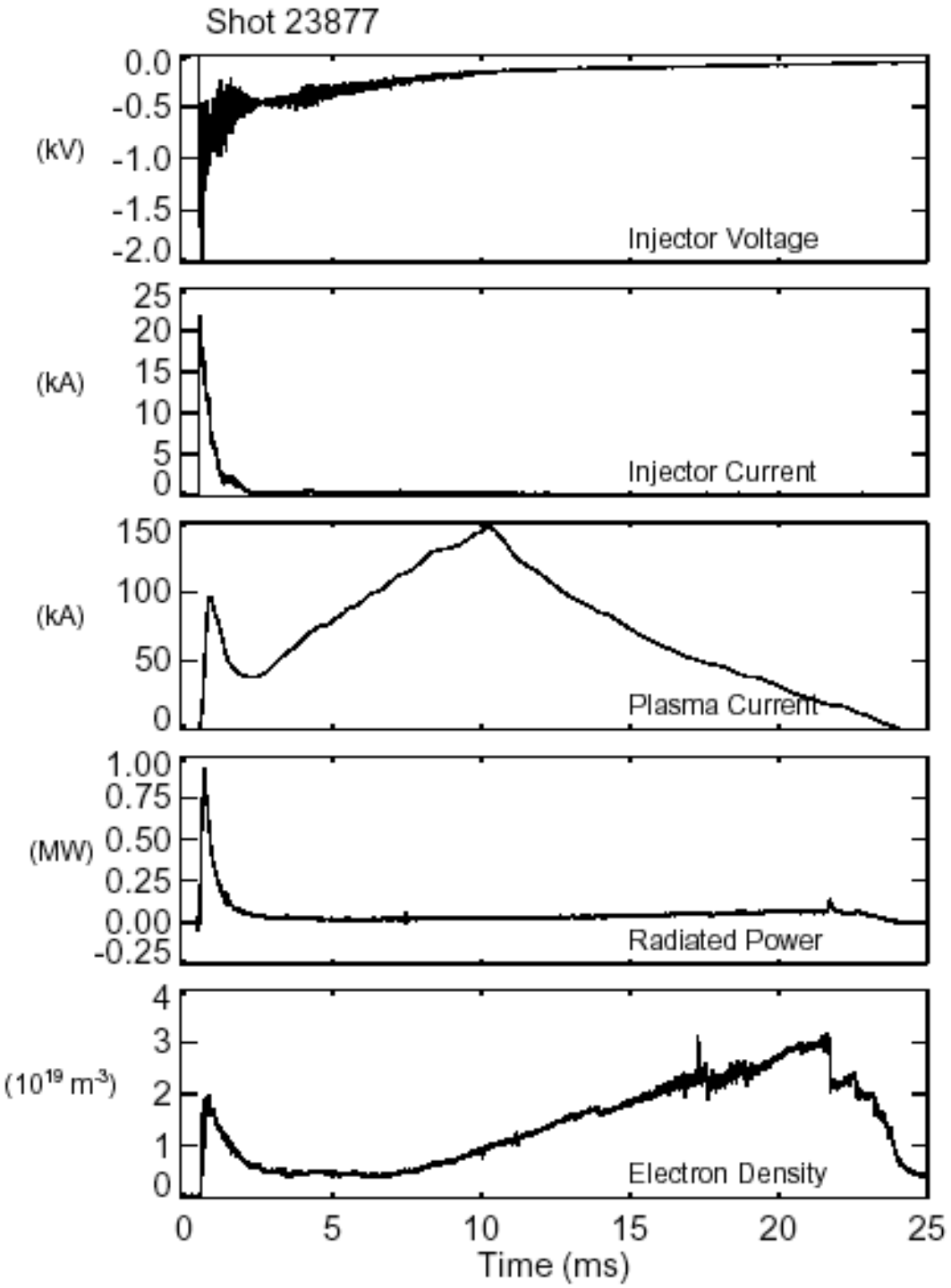
CHI shot 106499 reconstructed by ESC (Zakharov, Raman)





Demonstration of CHI assisted plasma start-up on HIT-II spherical torus

HIT-II



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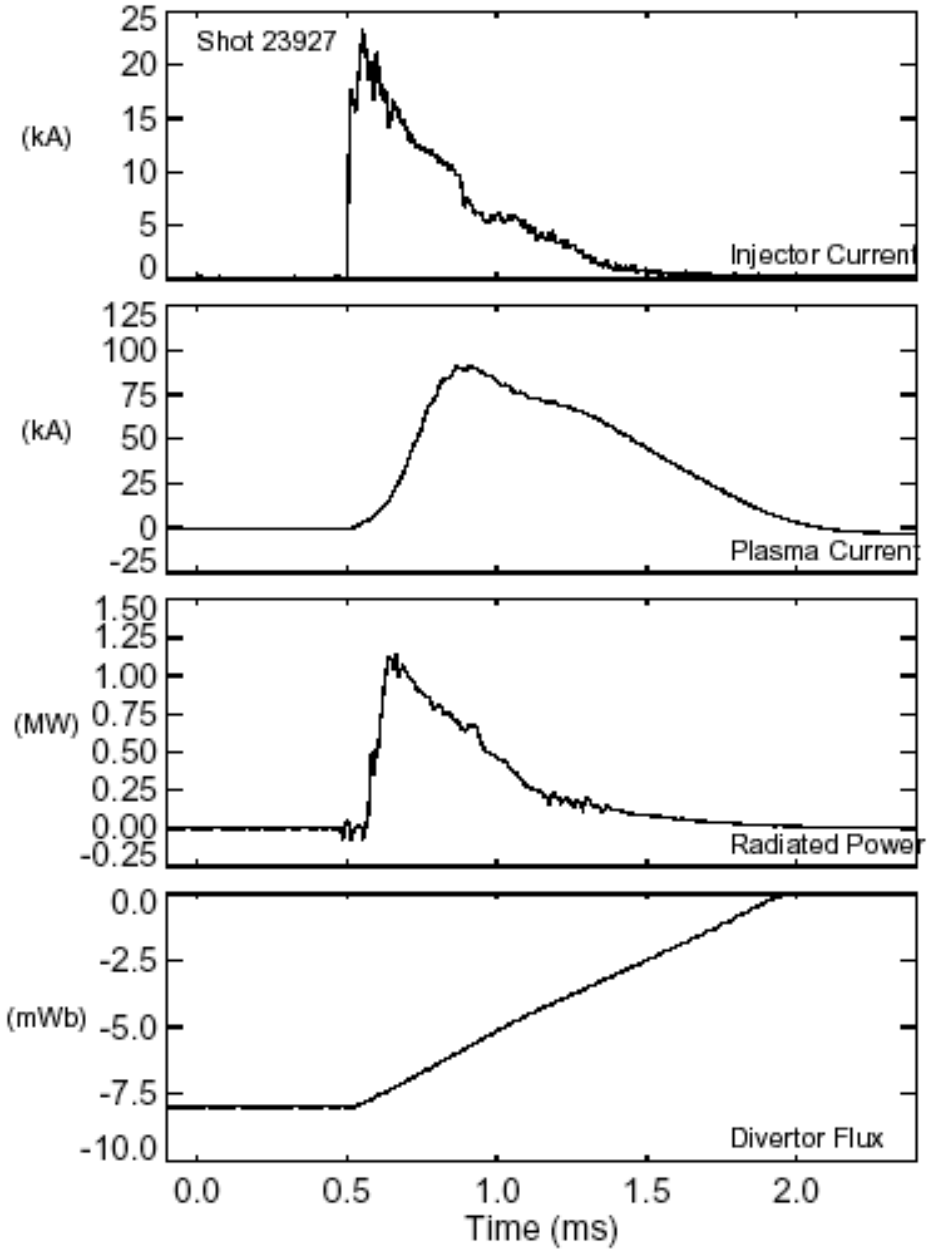
CHI start-up procedure results in closed field-line plasma generation

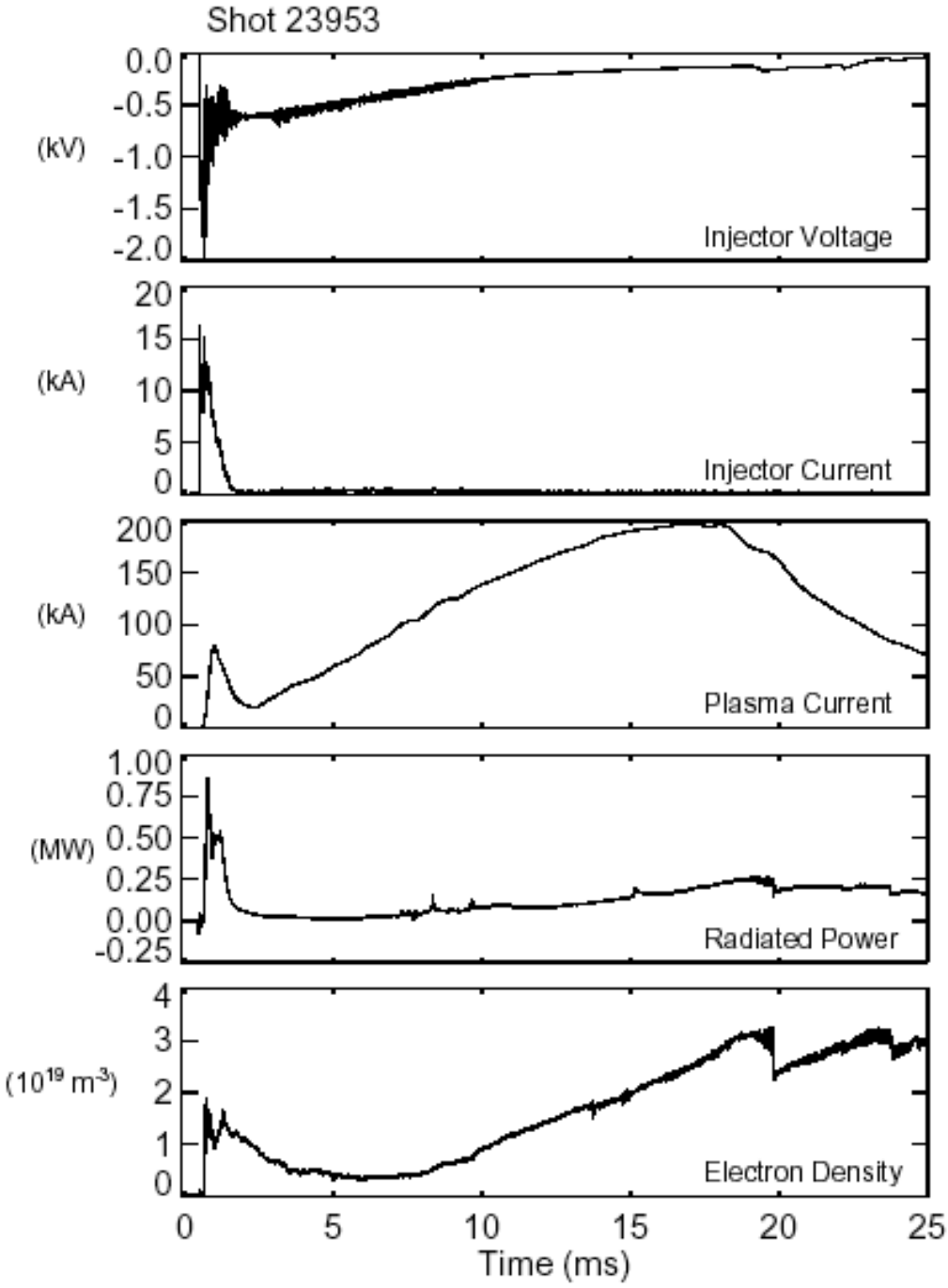
HIT-II



Raman, Jarboe, Nelson

CHI start-up works with a pre-loaded transformer

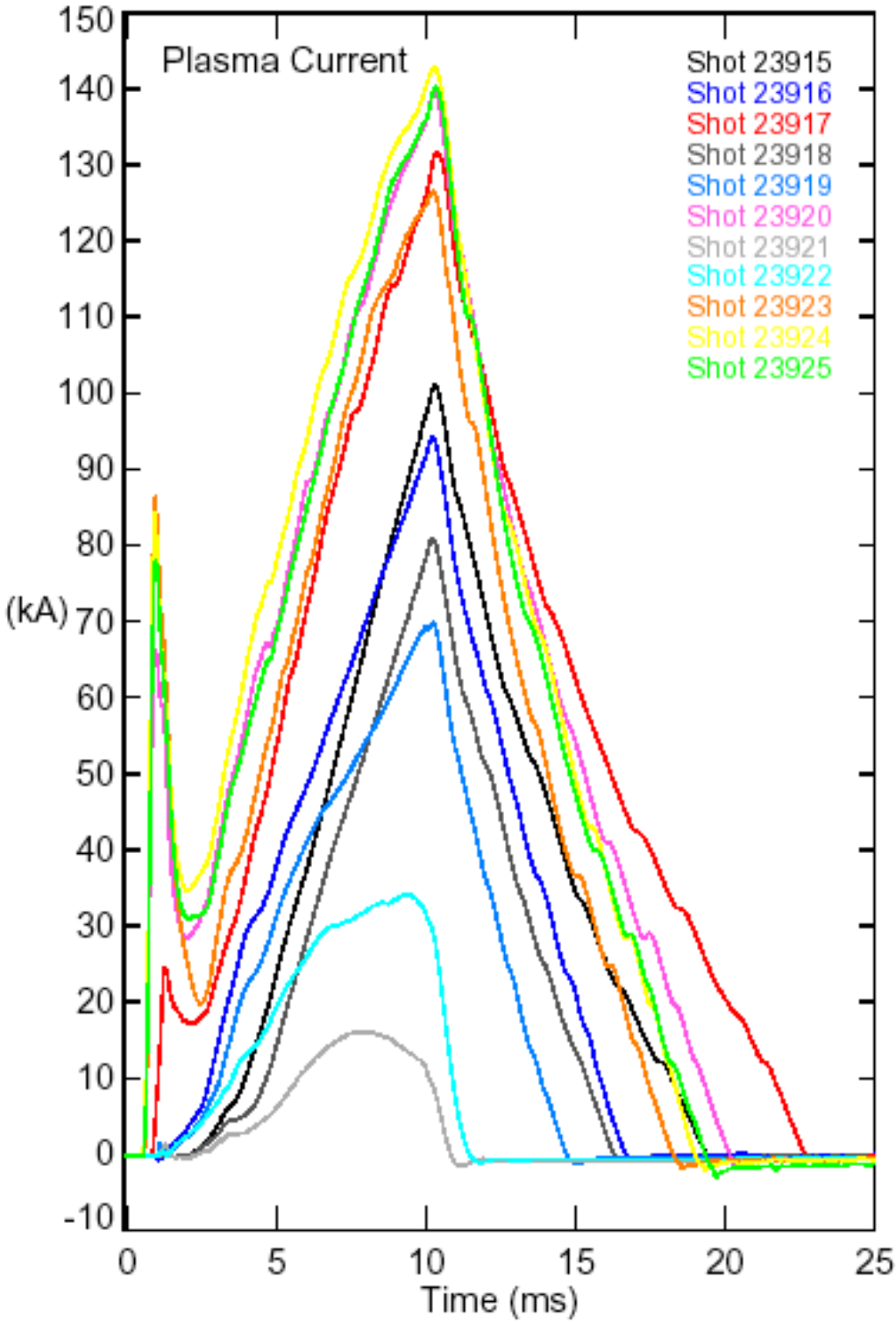
HIT-II



Raman, Jarboe, Nelson

Discharges with CHI start-up assist are robust

HIT-II



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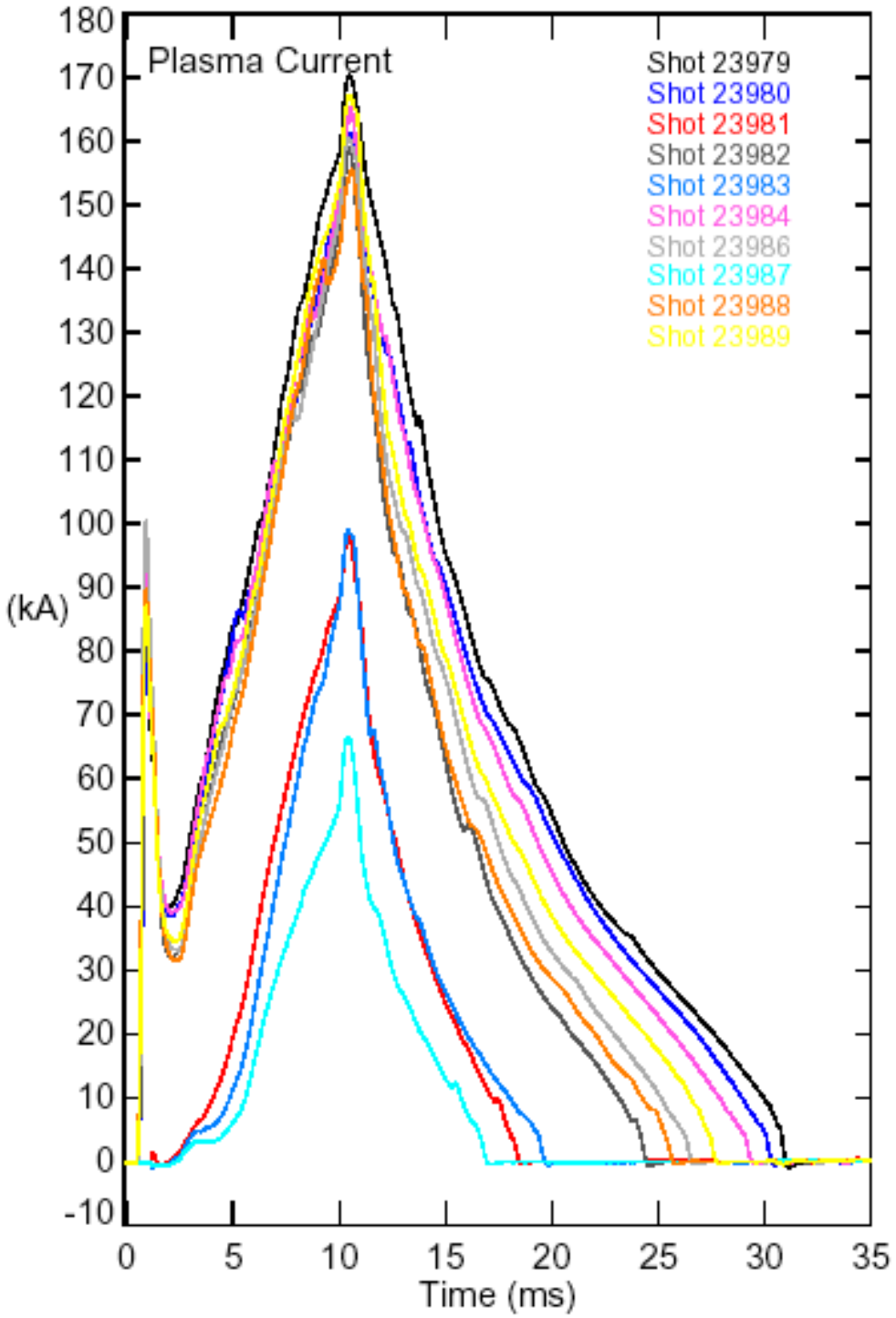
Demonstration of volt-seconds savings with CHI start-up assist on the HIT-II experiment

HIT-II



Raman, Jarboe, Nelson

Methods developed on HIT-II are fully adaptable to NSTX (XP developed for NSTX)

Previous method (technically difficult)	New method (simple method)
Long CHI pulse (~300ms)	Short pulse (< 50ms), much simpler power system requirements for future NSST
Relies on good feedback controlled operation during a steady-state CHI pulse (Equilibrium feedback control for CHI not yet tested on NSTX)	Transient discharge considerably simplifies feedback control requirements 1. CHI pre-programmed phase 2. OH pre-programmed phase, CHI off 3. OH feedback control phase
Absorber and external hardware should be arc-free during 300 ms pulses	Probability of absorber and external arcs decreases as the CHI pulse length decreases
Relies on pressure profile characterization and possible auxiliary heating of CHI plasmas	Details of pressure profile not too important, auxiliary heating may not be needed

Other small NSTX hardware modifications (gas injection, speeding up CHI coils, absorber PF coil activation for absorber field control) will be implemented if needed.

Summary

- CHI start-up works very well on HIT-II.
- CHI start-up on HIT-II is a very robust plasma start-up method.
  (for plasma start-up in a steady-state ST reactor volt-seconds savings is not necessary)
- CHI start-up results in volt-seconds savings, and consistently outperforms inductive-only operation.
- CHI start-up can be used with a pre-charged transformer.
  (therefore it is also applicable to a transient burning plasma ST device)
- Steps needed to implement CHI start-up are now understood, methods developed on HIT-II will be implemented on NSTX early during the Fy 03 run.

It is no longer a question of if CHI start-up will work. It works very well on HIT-II and it will work on NSTX.