Coaxial Helicity Injection

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Princeton Plasma Physics Laboratory

Presentation Outline

- Motivation for CHI
- Summary of experimental runs
- Remaining Phase I activities
- Future plans

Motivation for CHI on NSTX

- ST designs can be simplified by removing solenoid
  - Demonstrate non-inductive creation of seed plasma
  - Sustain seed plasma using non-inductive methods
- Edge current drive during sustained phase
- Save V.s for Ohmic plasmas

CHI Terminology

- INJECTOR: Lower divertor plate region
- ABSORBER: Upper divertor plate region
- INJECTOR CURRENT: Current supplied by PS (no absorber arc)
- TOROIDAL CURRENT: Plasma current + open field line current

CHI Requirements for ST

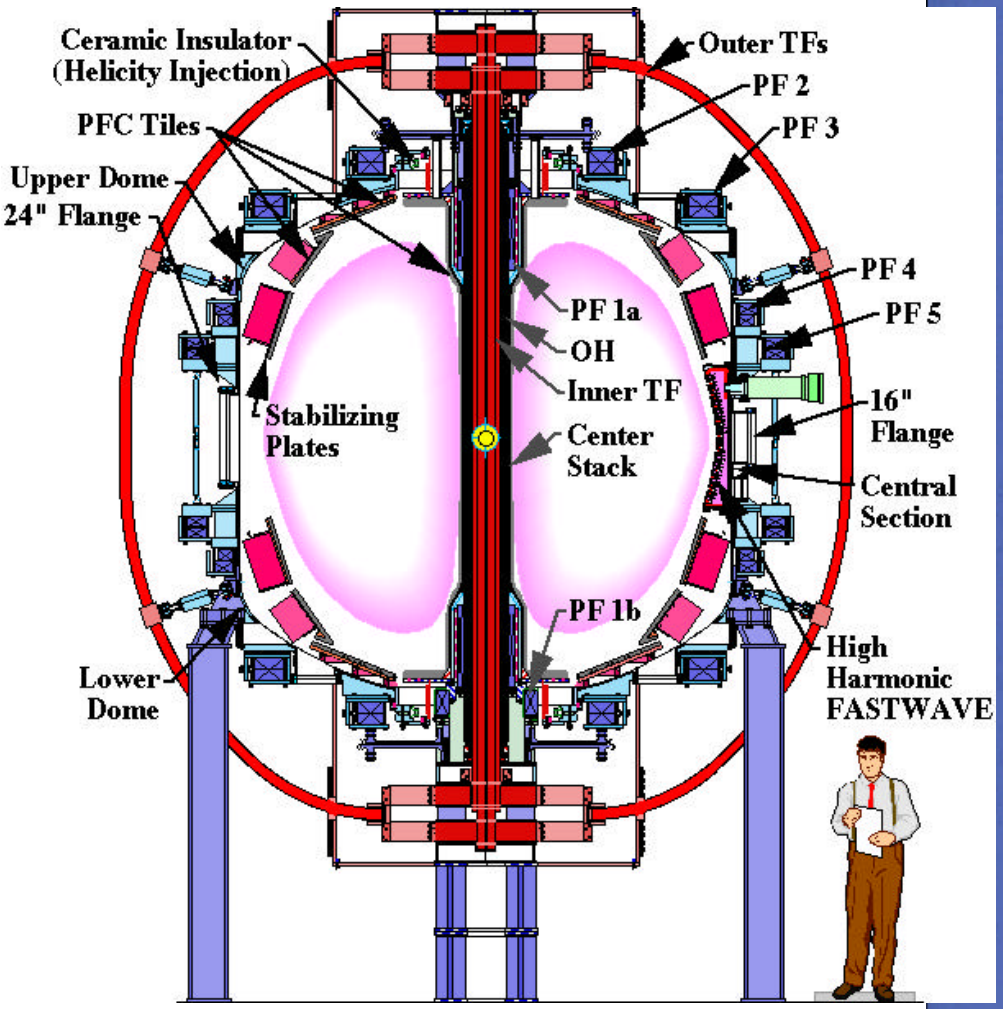
• Injector region where voltage can be applied along poloidal flux penetrating two insulated electrodes in the presence of a toroidal field.

• Confinement region in which the CHI produced plasma can be maintained in equilibrium using PF coils.

CHI on HIT and NSTX

- Injector and absorber regions different
- NSTX volume 30 x HIT-II
- NSTX used high current DC power supplies vs. capacitors on HIT
- ECH Pi on NSTX vs. electron gun and 6kV capacitor on HIT

NSTX and HIT-II



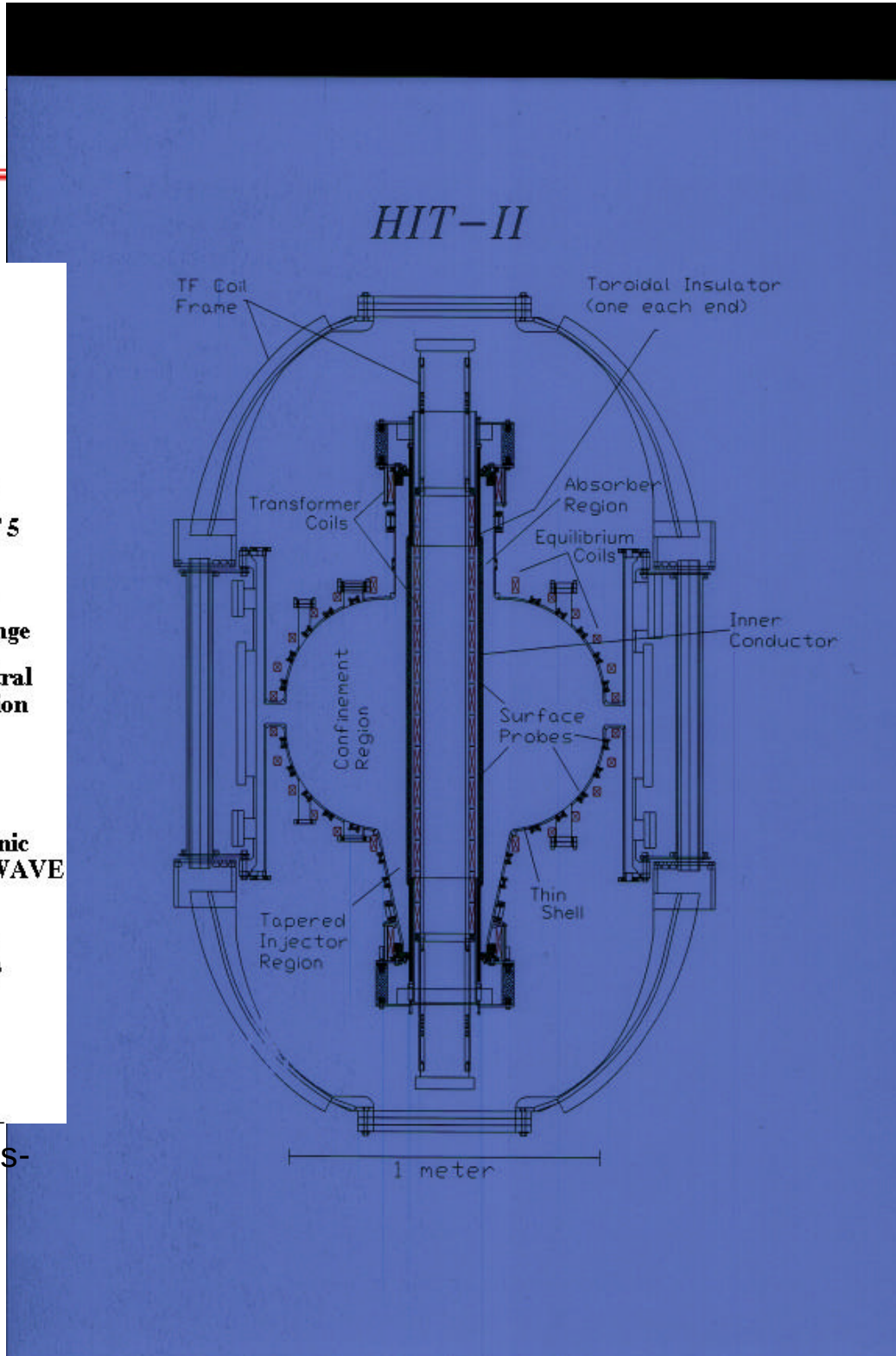
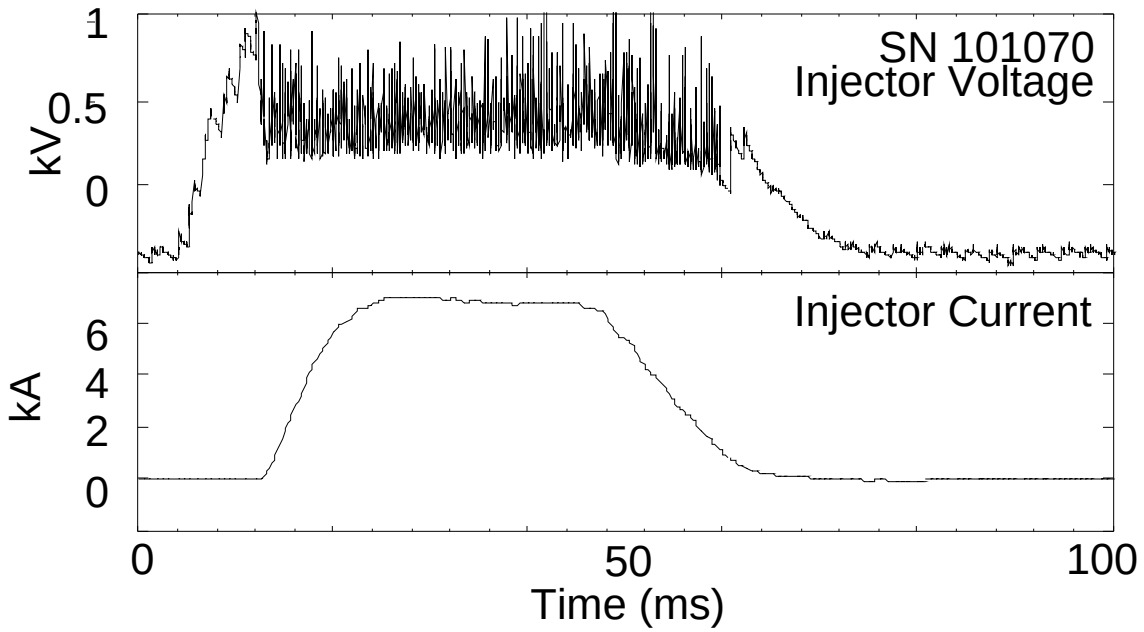


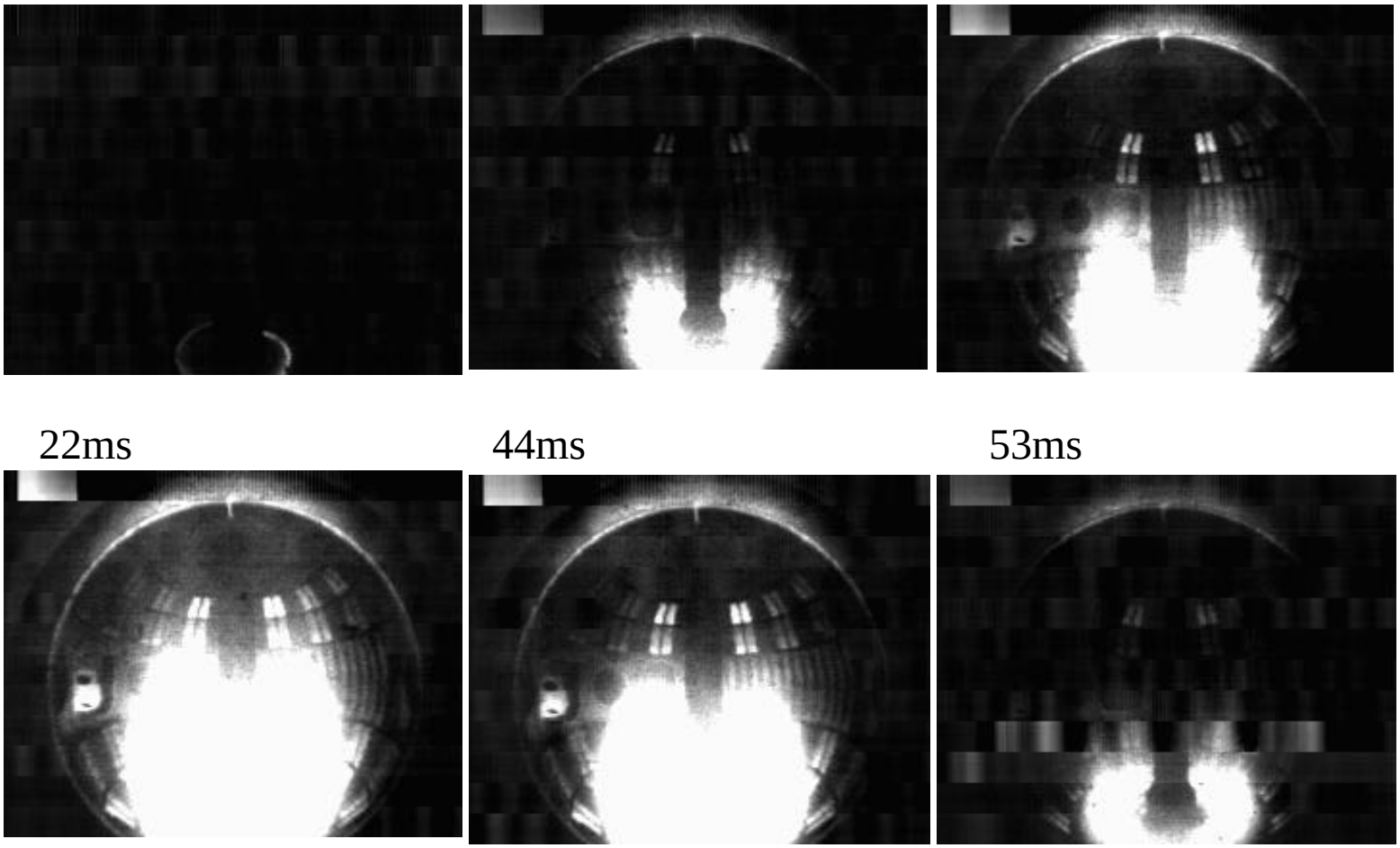
Fig. 1. A schematic of the NSTX device cross-section.

Experimental Runs: November 9, 1999 (1 day)

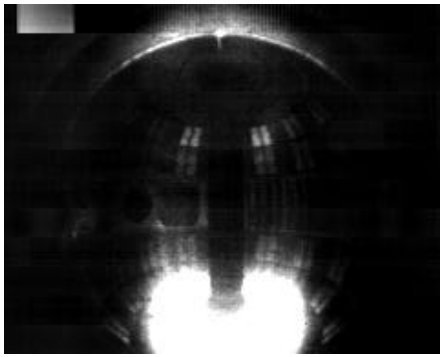
- Operated with 75mOhm series resistor & 2 - PS in parallel
- Started with 16mTorr vessel pressures
- Produced stable 40ms discharges



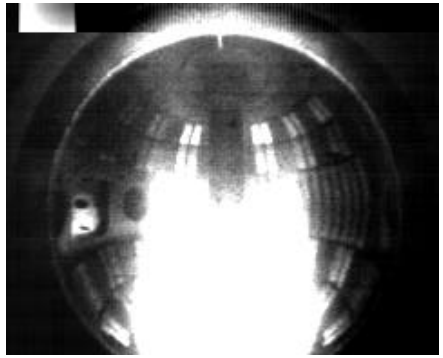
CHI discharge evolution (R. Maqueda, LANL)



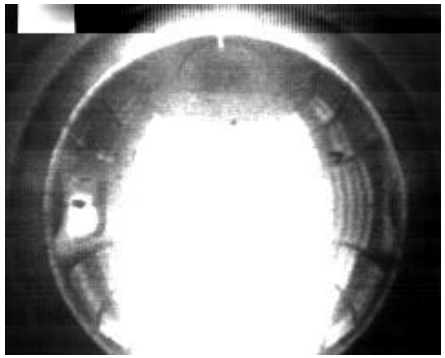
Current multiplication



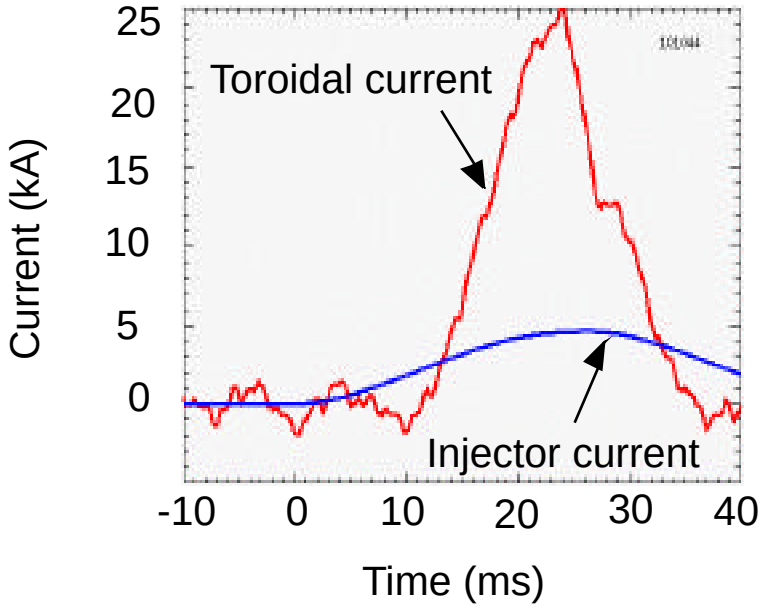
16ms



18ms

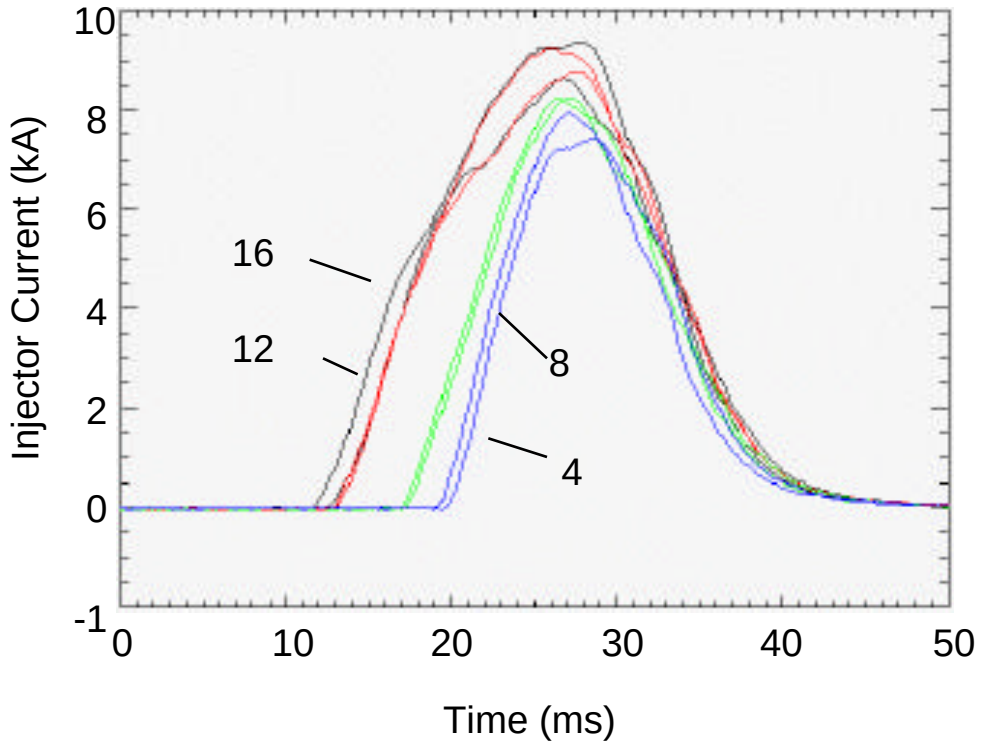


20ms



- CHI systems successfully introduced on NSTX
- First measurement of CHI produced current on NSTX
- Current multiplication of 4 achieved

Injector impedance at low pressure



- Fast gas puff system injects gas in the injector region
- Small change in current as pressure is lowered
- 4mTorr pressure compatible with divertor operation
- Further improvements possible

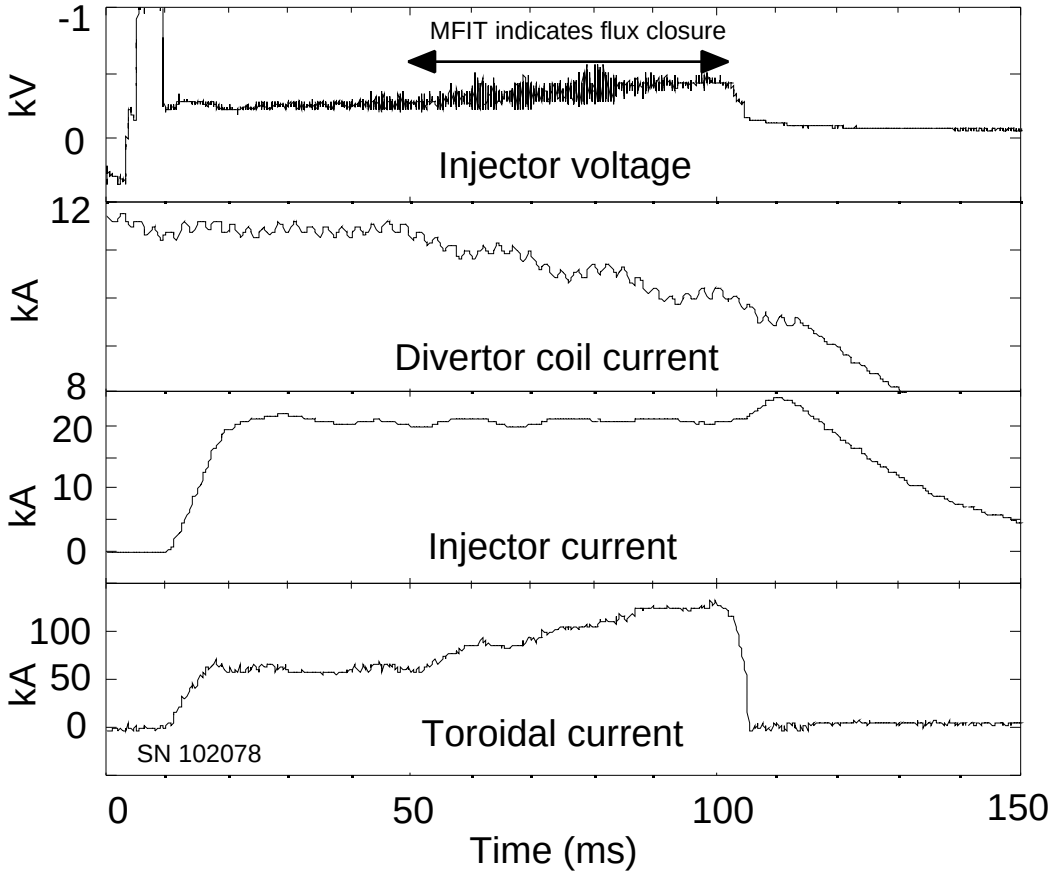
December 1999 (2.5 days)

- Operated with one PS, removed 75mOhm resistor
- 80ms discharges @ 16mTorr (Dec. 17)
- 50kA of toroidal current @ 4mTorr (Dec. 17)
- 40kA of toroidal current @ 2mTorr (Dec. 20)
- Initiated experiments on vertical position control (Dec. 20)
- Obtained discharges @ 1mTorr (Dec. 21)

January13 and 14, 2000 (1.5 days)

- Operated with 2 - PS and no resistor
- Eliminated spurious absorber arcs
- Produced 130kA of toroidal current using 20kA of injector current @ 3mTorr
- Produced 130ms discharges

Long pulse discharge (Jan 21)

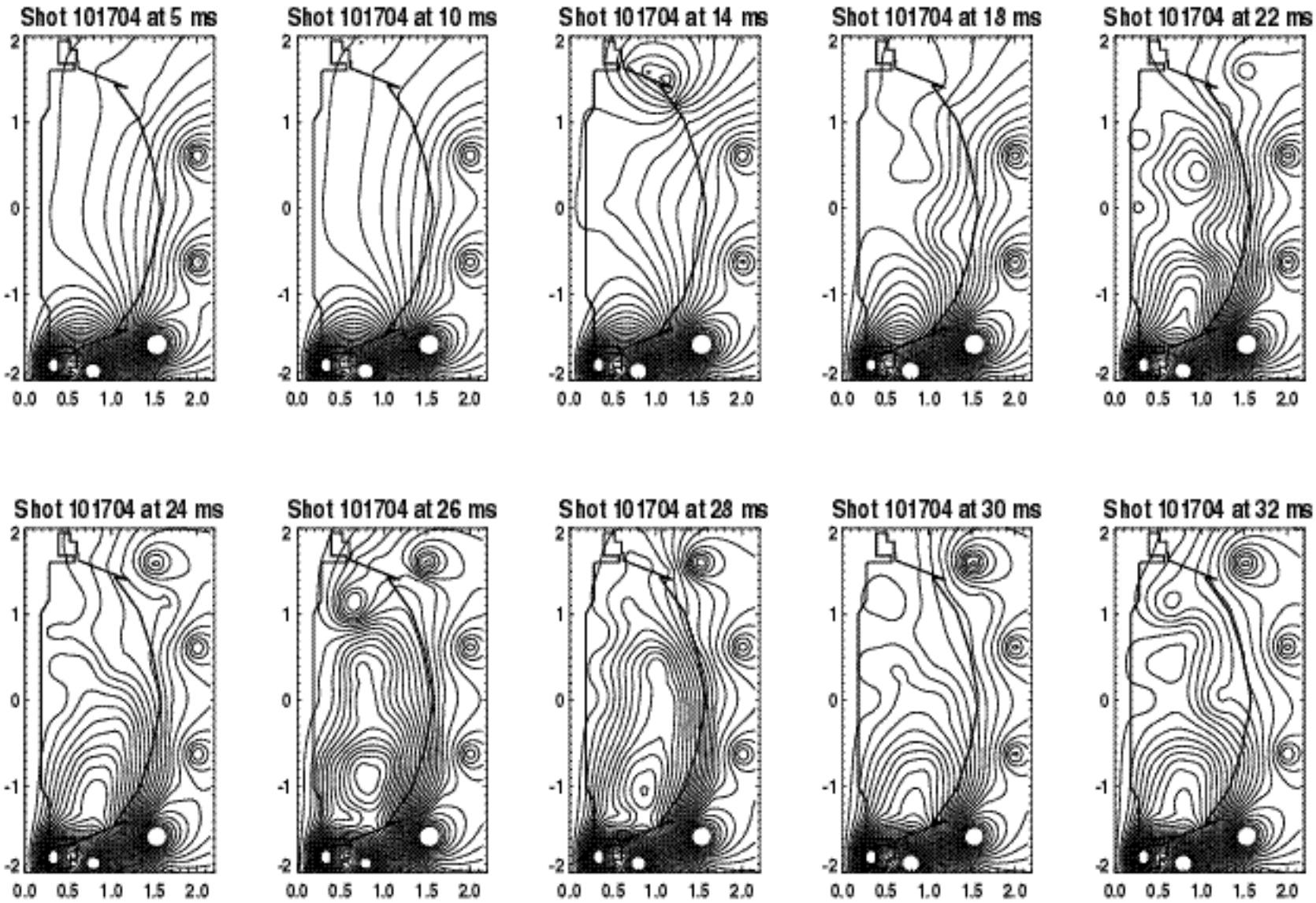


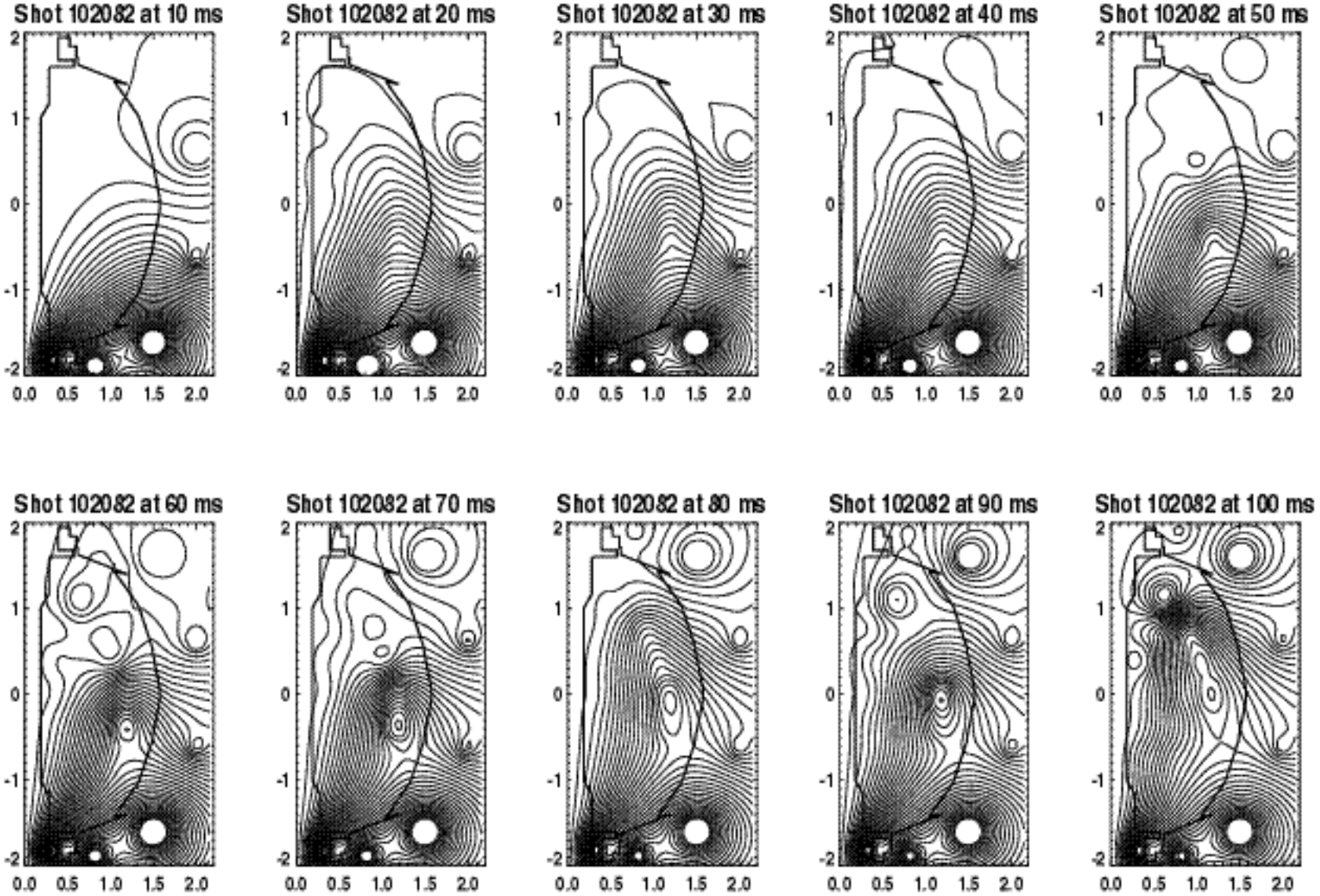
- Start with high Injector flux
- Reduce Injector flux
- Increase Injector voltage
- Vessel pressure ~ 3mTorr

MFIT analysis (M. Schaffer and L. Lao, GA)

- MFIT
  - Calculates best fit to measured magnetic data using plasma ring currents, vessel currents and external coil currents.
  - Does not require closed magnetic surfaces.
- EFIT

- Fits a Grad-Shafranov toroidal equilibrium to magnetic and other data.
- Most of the toroidal current must be on closed magnetic surfaces to get a fit.




Shot 102082 at 10 ms
Shot 102082 at 20 ms
Shot 102082 at 30 ms
Shot 102082 at 40 ms
Shot 102082 at 50 ms
Shot 102082 at 60 ms
Shot 102082 at 70 ms
Shot 102082 at 80 ms
Shot 102082 at 90 ms
Shot 102082 at 100 ms
2
1
0
-1
-2
0.0 0.5 1.0 1.5 2.0

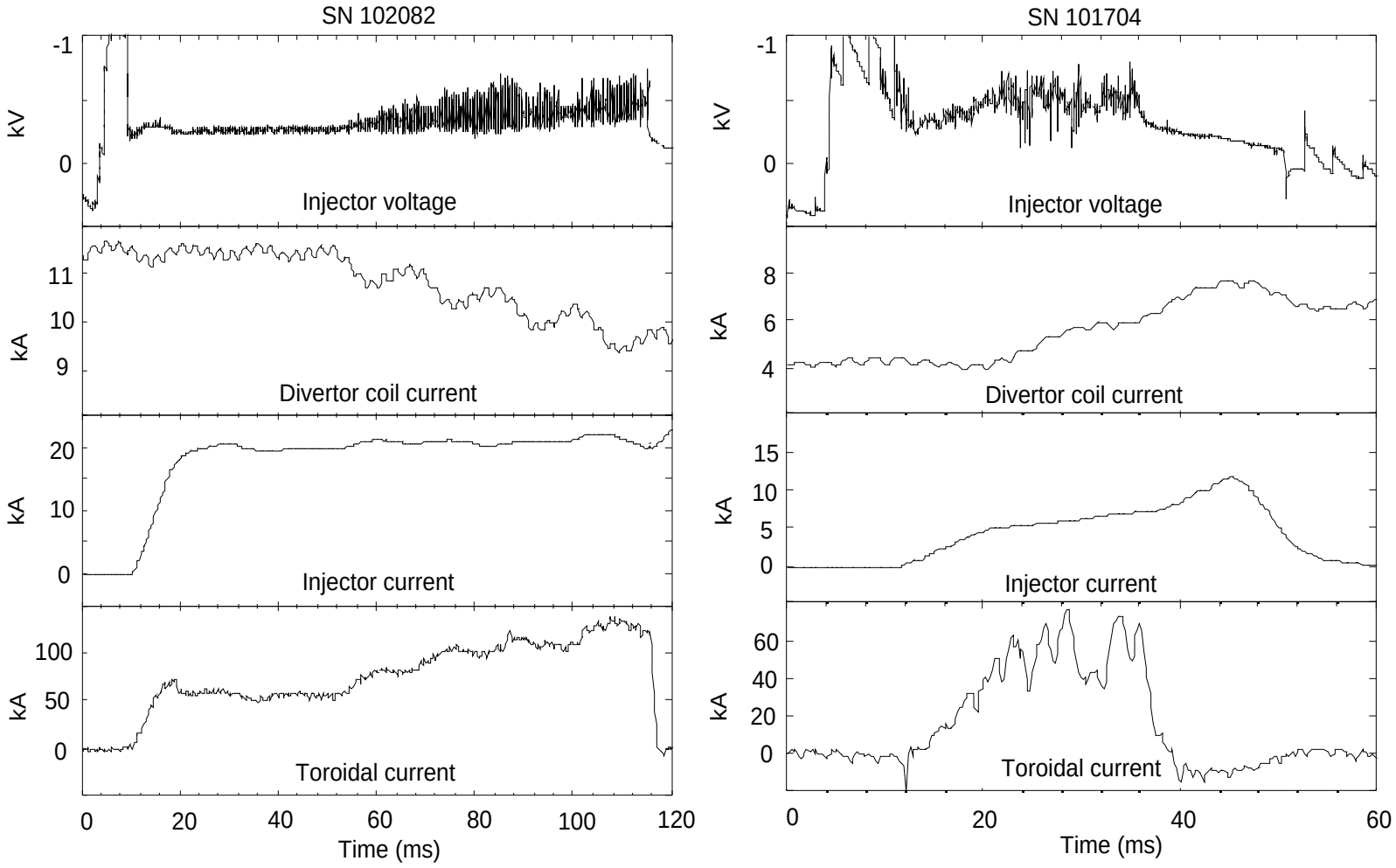
MFIT, EFIT plans (M. Schaffer, L. Lao)

- MFIT will be modified for easy between-shot use by operating personnel.

- EFIT will first be used on "Ohmic + CHI" plasmas.

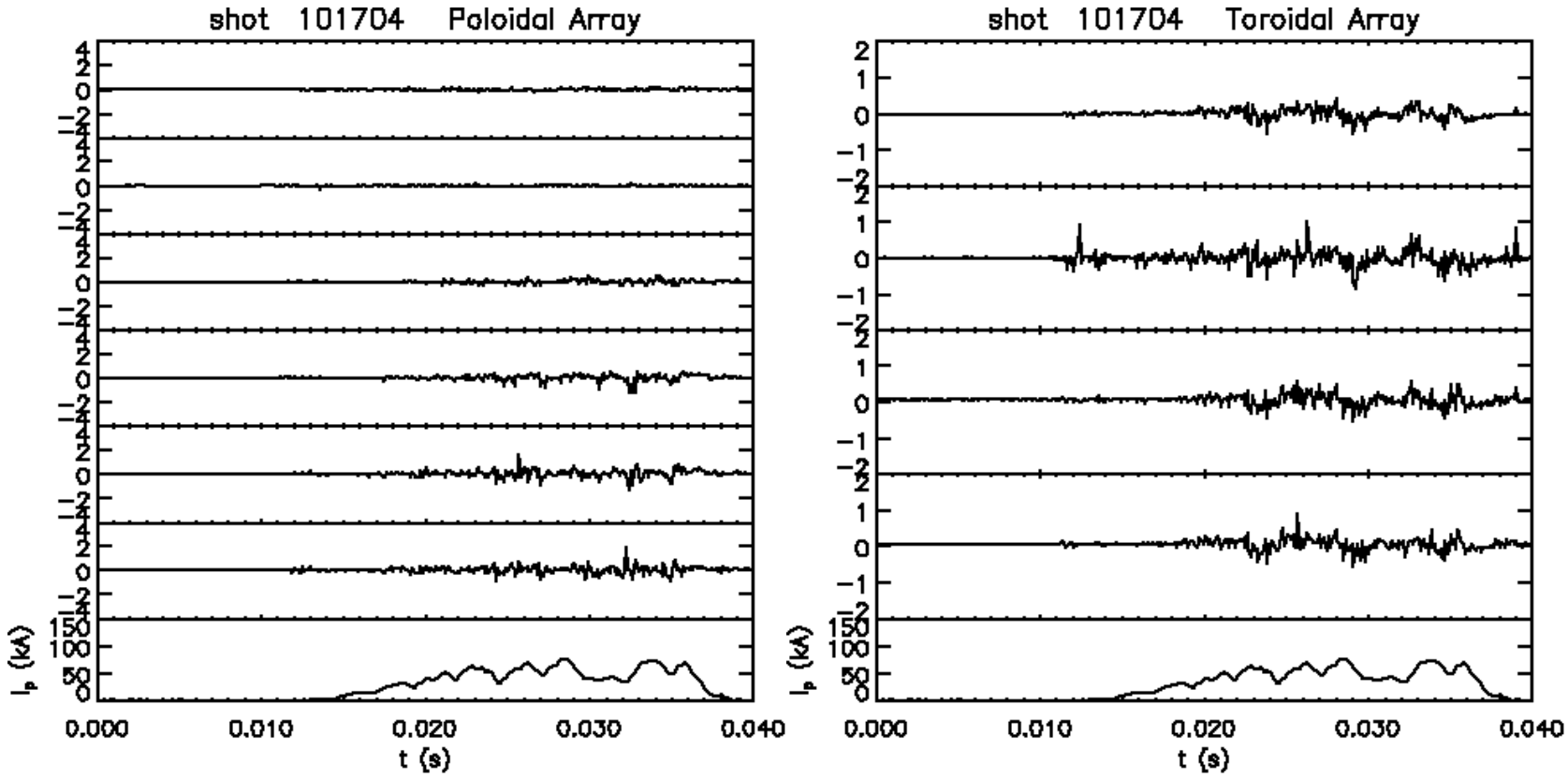
- EFIT will be modified for "CHI-only" plasmas, through more accurate representation of SOL current.

Comparison of Shots 102082 and 101704



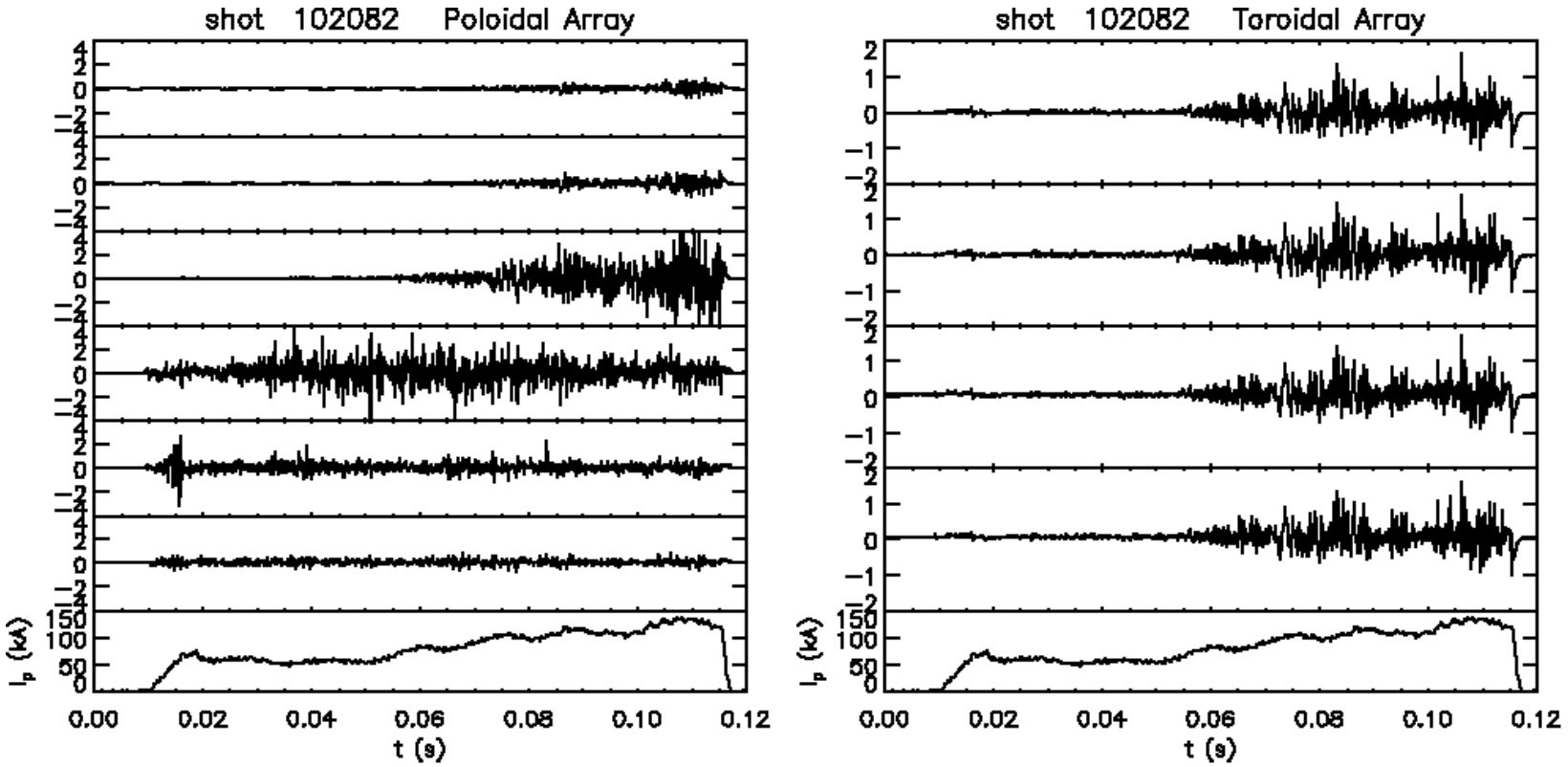
MHD analysis (H. Ji, PPPL)
MHD fluctuations localized in lower half of vessel but toroidally uniform

SN 101704



Distinct features for low and high current phases (H. Ji)

SN 102082



- Current < 50kA: MHD activity is localized in outer bottom
- Current >100kA: MHD activity more uniform except for outboard

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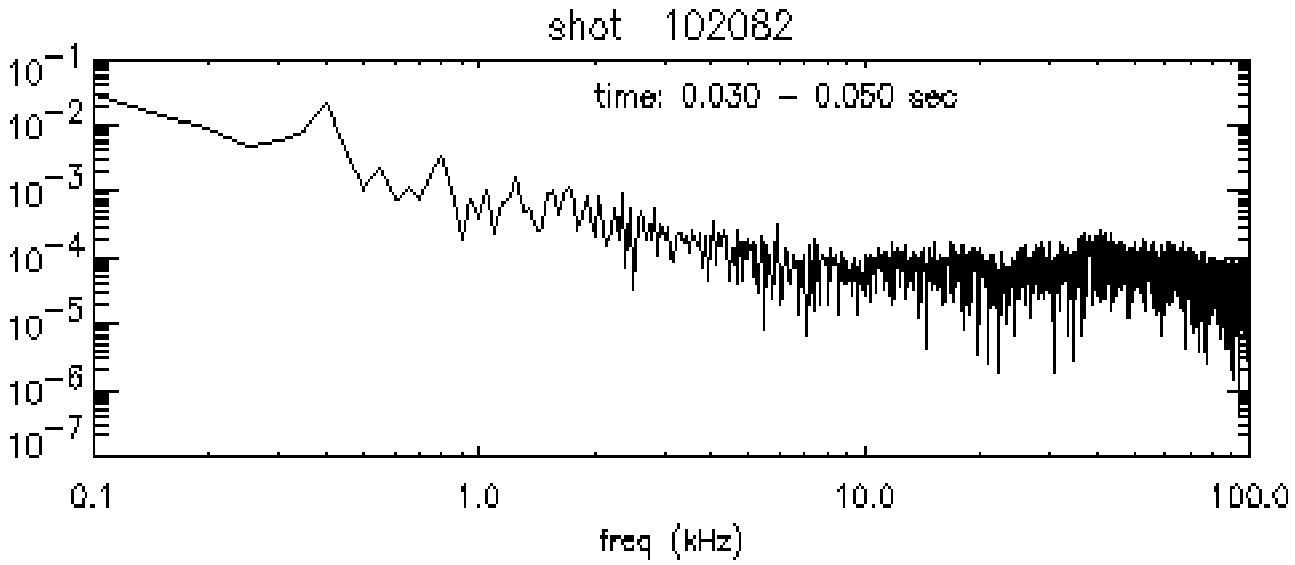
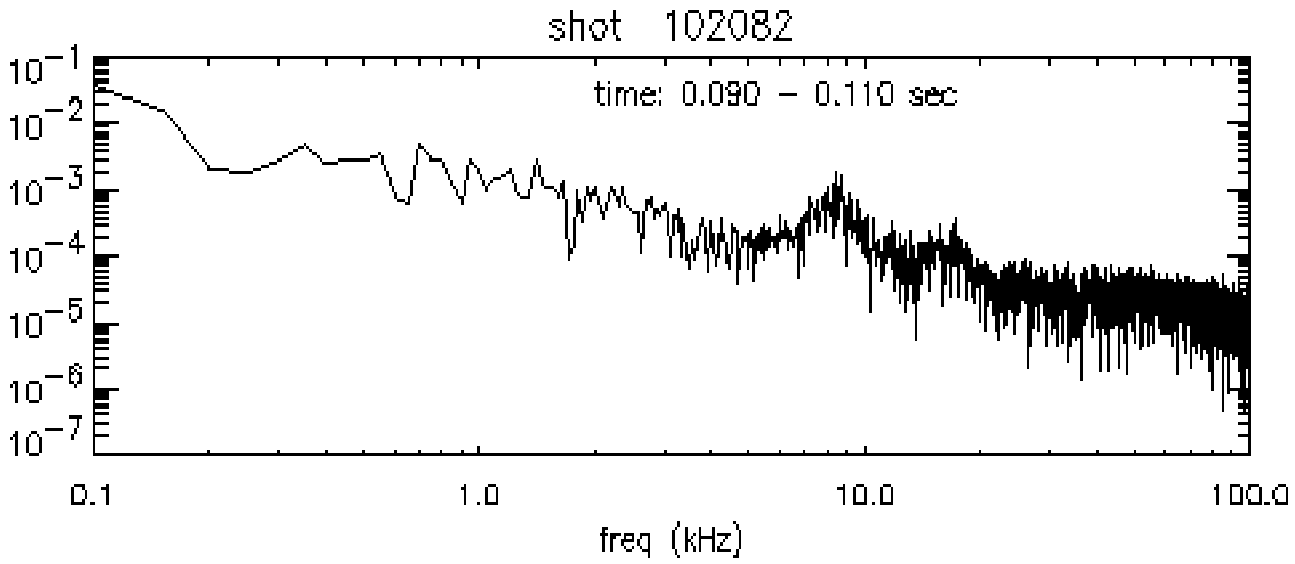
Low frequency (9kHz) coherent mode only during high current phase (H. Ji)

- Mode only in outer Mirnov's





Vacuum flux plots for SN 101704 and 102082 (B.A Nelson)

SN 101704

SN 102082

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Remaining Phase I objectives

- Extend CHI produced toroidal current to 200kA
- Improve vertical position control
- Extend discharges to vessel pressure < 0.5mTorr
- Improve flux closure at higher current
- Initiate experiments on Ohmic + CHI

Summary

- Obtained 20kA injector current for ~ 500V applied
- Obtained 130kA toroidal current
- Obtained current multiplication up to 10
- MFIT shows evidence for flux closure for ~20% toroidal current
- Produced stable high current, long pulse (130ms) discharges
- Demonstrated discharges at 1mTorr
- Operated with both PS without safety resistor