Coaxial Helicity Injection Results from NSTX

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ABSTRACT

Coaxial Helicity Injection (CHI) is envisioned as a tool to provide current drive on Spherical Tori wherein the small center column compared to higher aspect tokamaks limits the size of the ohmic transformer. Up to now CHI has been used in two different modes on NSTX. The first is for plasma start-up to provide a target plasma that could be extended with ohmic heating. So far, CHI experiments on NSTX have produced 360 kA of toroidal current using about 25 kA of injector current. These have been sustained for 300ms, but not yet extended with ohmic current drive. The second mode is to modify an already existing ohmic discharge. For this, CHI injector voltage is applied during a lower single null discharge in NSTX. The application of up to 500 V on the CHI injector during ohmic discharges has resulted in modest injector and toroidal currents and small increases in carbon influx and radiated power with no other obvious deleterious effects.

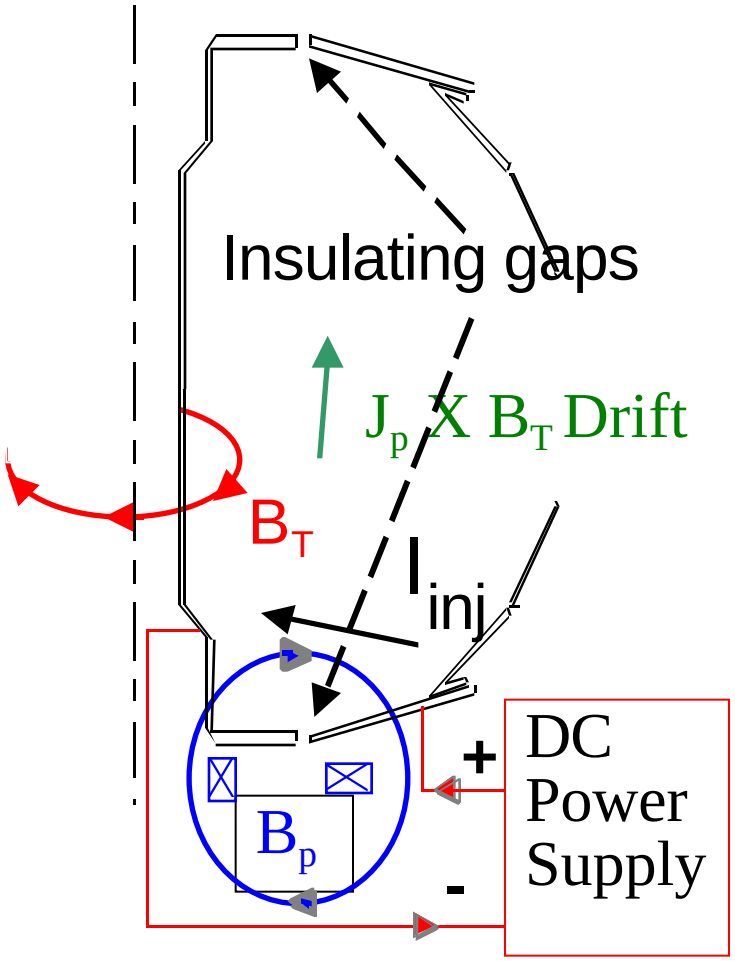
Non inductive current initiation needed for STs

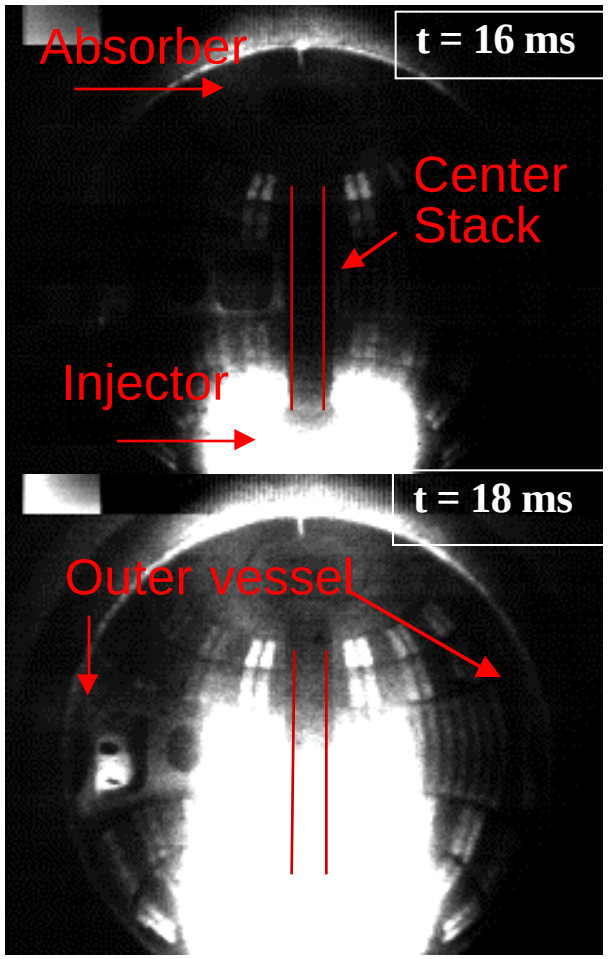
- Demonstrate non-inductive creation of target plasma
- Sustain target plasma by providing edge current drive
- Reduce poloidal flux swing of transformer

Issues

- Mean field flux closure
- Role of magnetic fluctuations

Co-axial electrodes inject helicity into the ST vessel, reconnection processes convert open flux to closed surfaces





Summary Recent Runs

Date	Objective	Result
May	XP31: Add CHI to OH	OH target plasmas. Ip decreased whenvoltage was applied.
May	XP-6: CHI for start-up	Implemented TF based arc detection algorithm.
June	XP-6: CHI for start-up TF scan	Produced 300ms discharge at 200kA. 360kA @ 14 times current multiplication. Implemented 10 min HeGDC. Reproduced good n=1 modes, MFIT equilibrium analysis and 300 kA currents.
Aug	XP-31: Add CHI to OH XP-37: OH to CHI	Avoided decrease in Ip, possible increase in Ip. Reproduced high current shots. Absorber arcs. Modified TF based arc detection algorithm to allow TF ramps. Tried "CHI + OH". Obtained 390kA

Development of discharges with 390 kA

Primary results

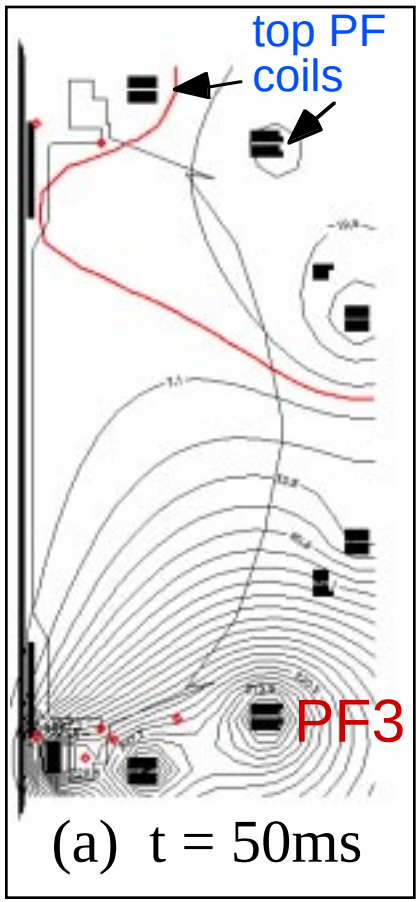
- Up to 390 kA of toroidal current produced at 14 times current multiplication
- Discharges sustained for 330ms

Observations

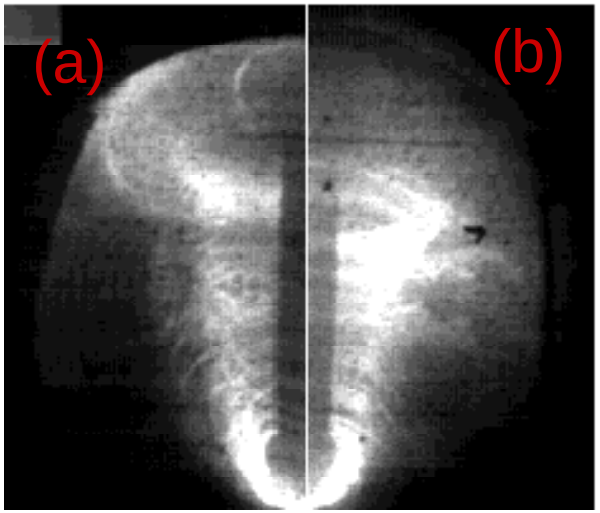
- Evidence for good n=1 oscillations deemed necessary for flux closure (B.A. Nelson G01.007)
- Consistently encouraging MFIT reconstructions (M.J. Schaffer QP1.015)
- Evidence for higher temperature from SXR's (D. Stutman)
- Ion temperature and plasma rotation (M.Nagata, R.Bell, V. Soukhanovskii)

Discharge programming to increase flux closure

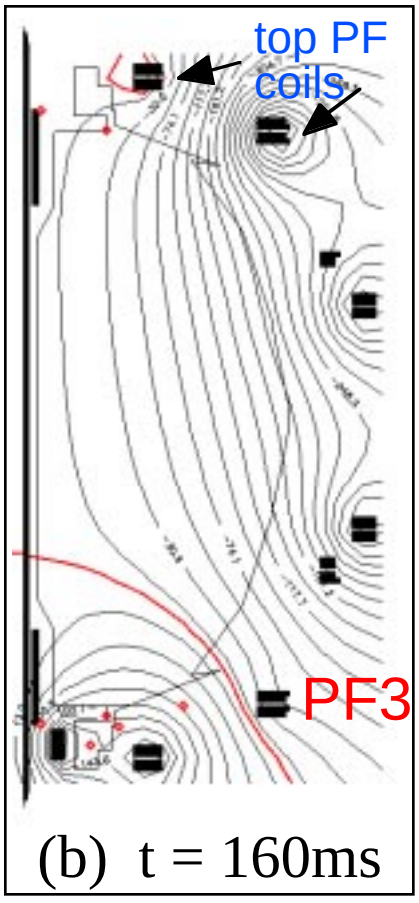
High current configuration ⟶ Preferred configuration



(a) t = 50ms

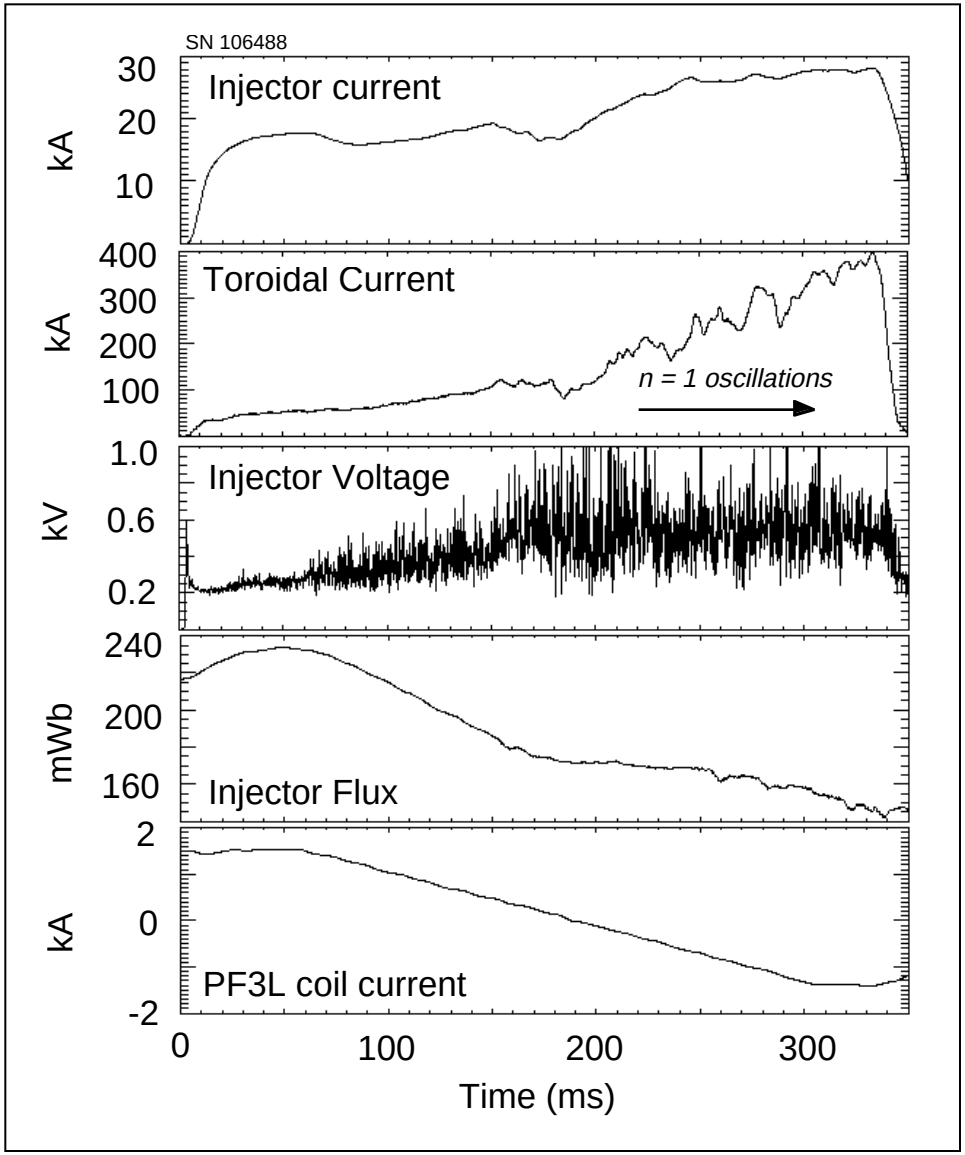


- Reverse current in PF3
- Increase current in top PF coils
- Increase vertical field

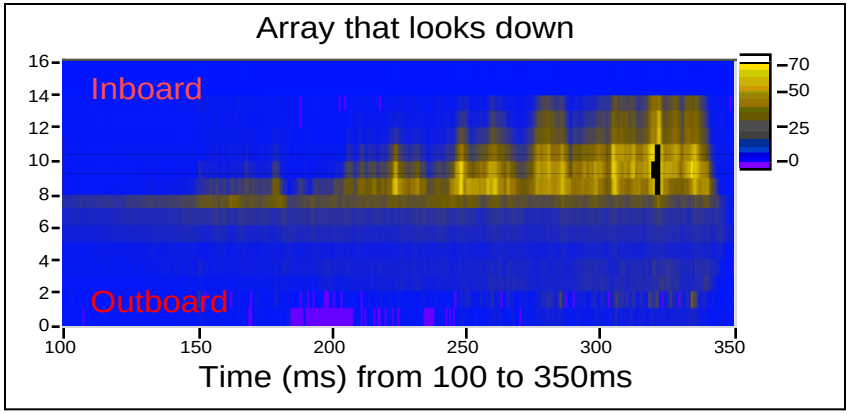


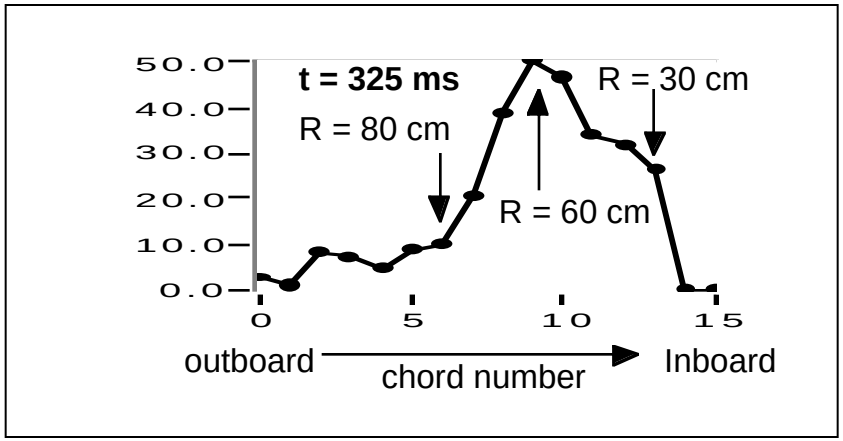
(b) t = 160ms

Obtained 390kA with a current multiplication of 14



Soft x-ray profiles (E > 100 eV)





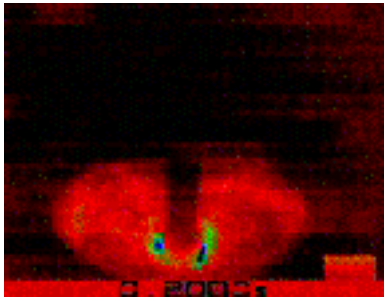
D. Stutman

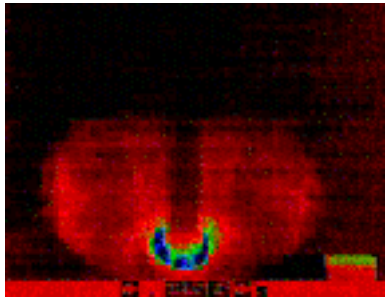
Discharge programming successfully implemented

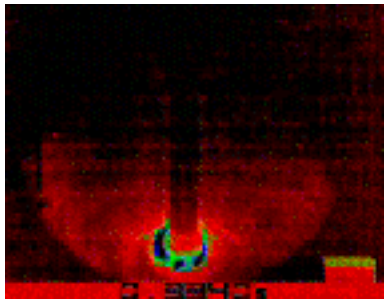
t = 200 ms

t = 256 ms

t = 334 ms



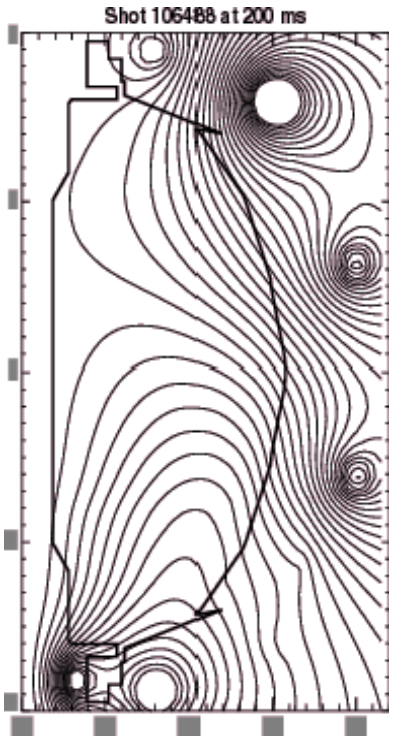


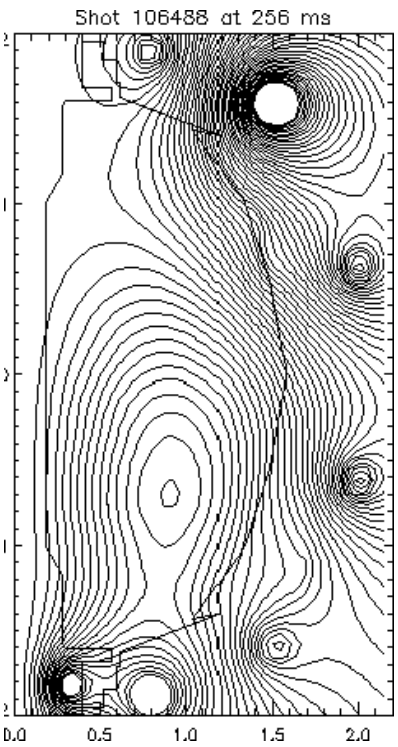


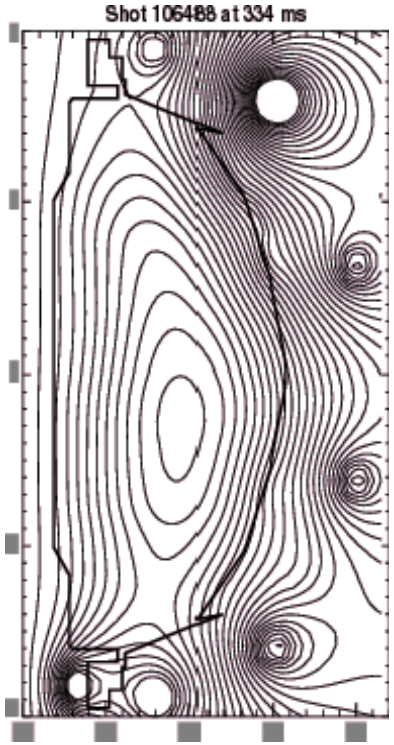
SN 106488

Fast Camera

(R. Maqueda *LANL*)



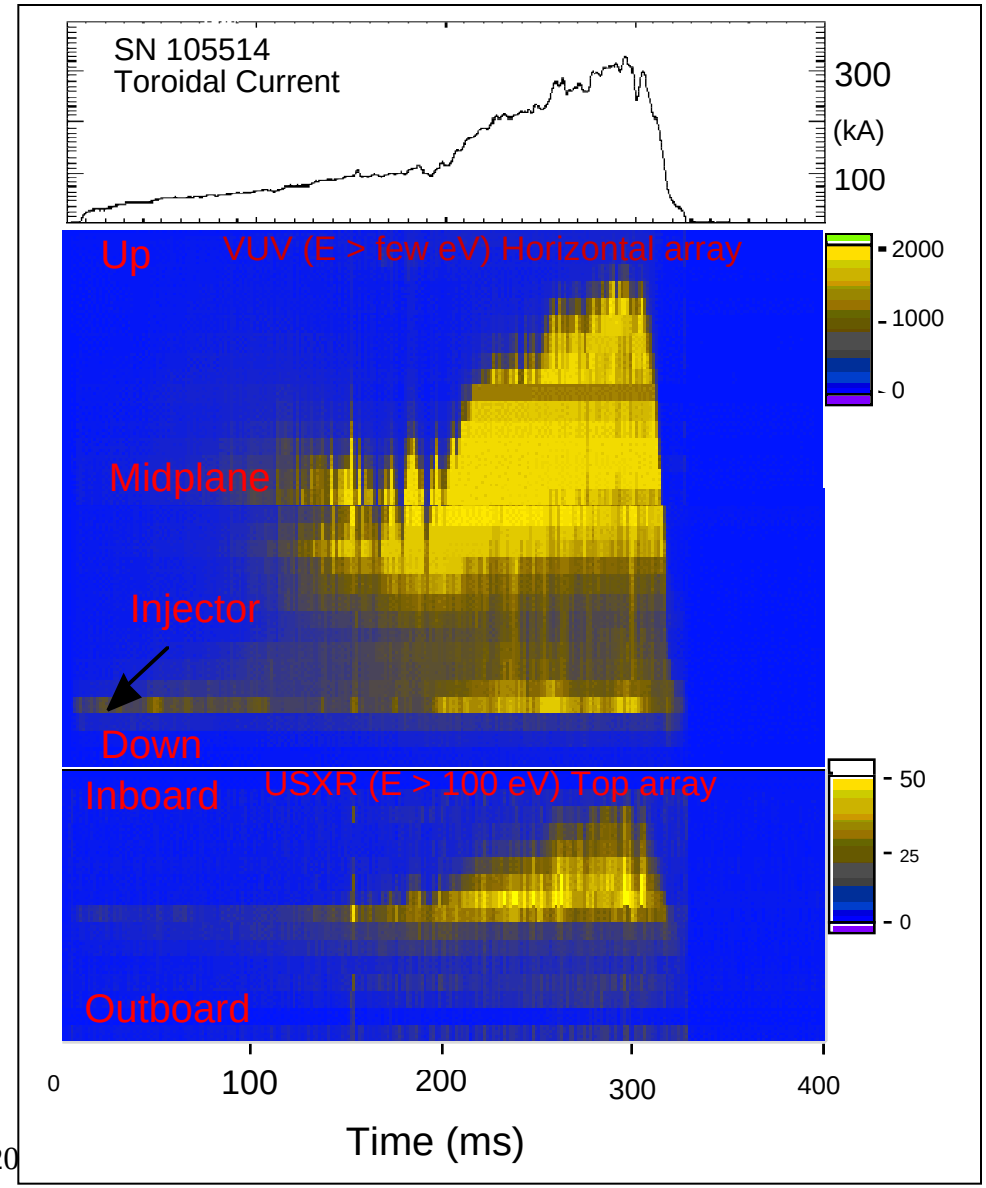


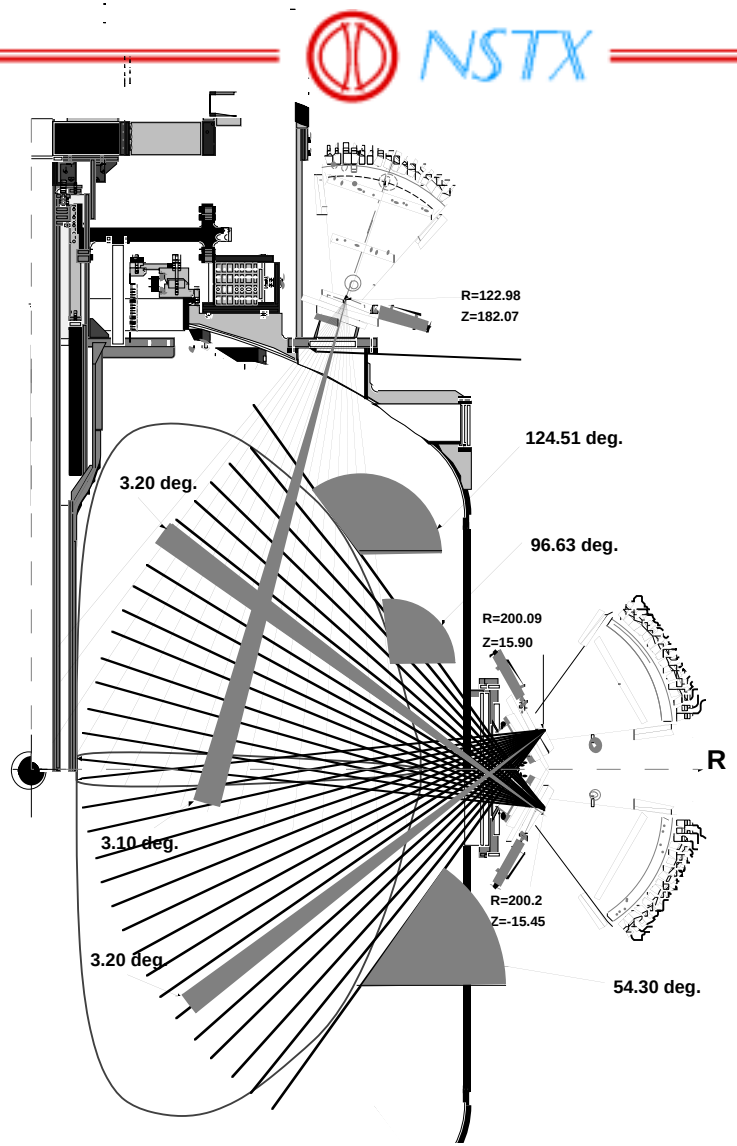


MFIT

(M. Schaffer *GA*)

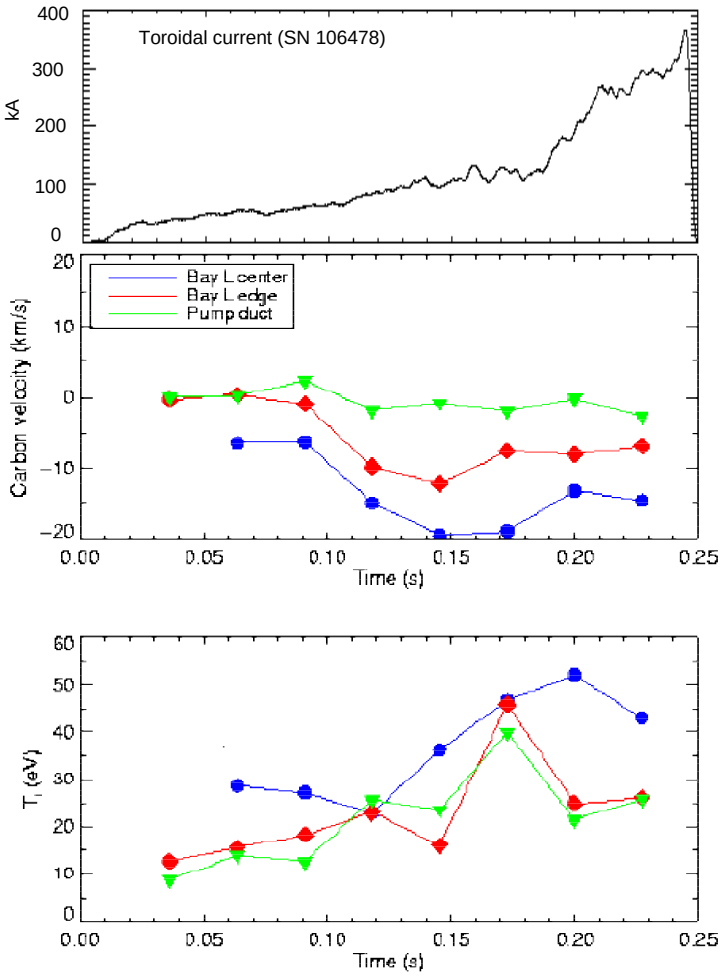
VUV emission extends to fill chamber

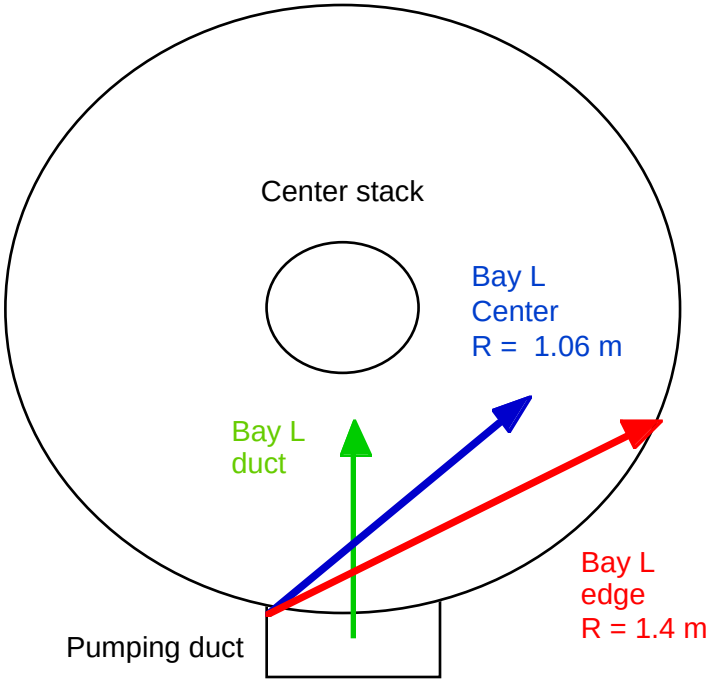




D. Stutman (Johns Hopkins Univ.)

CIII Ion Doppler measured rotation consistent with HIT-II





Time resolution : 26 ms

Direction of rotation: clockwise
(same as on HIT-II)
Rotation speed ~ -10 to -20 km/s

Ion Temperature ~ 30 - 50 eV
Instrumental error: 4 eV

R. Bell, M. Nagata, V. Soukhanovskii

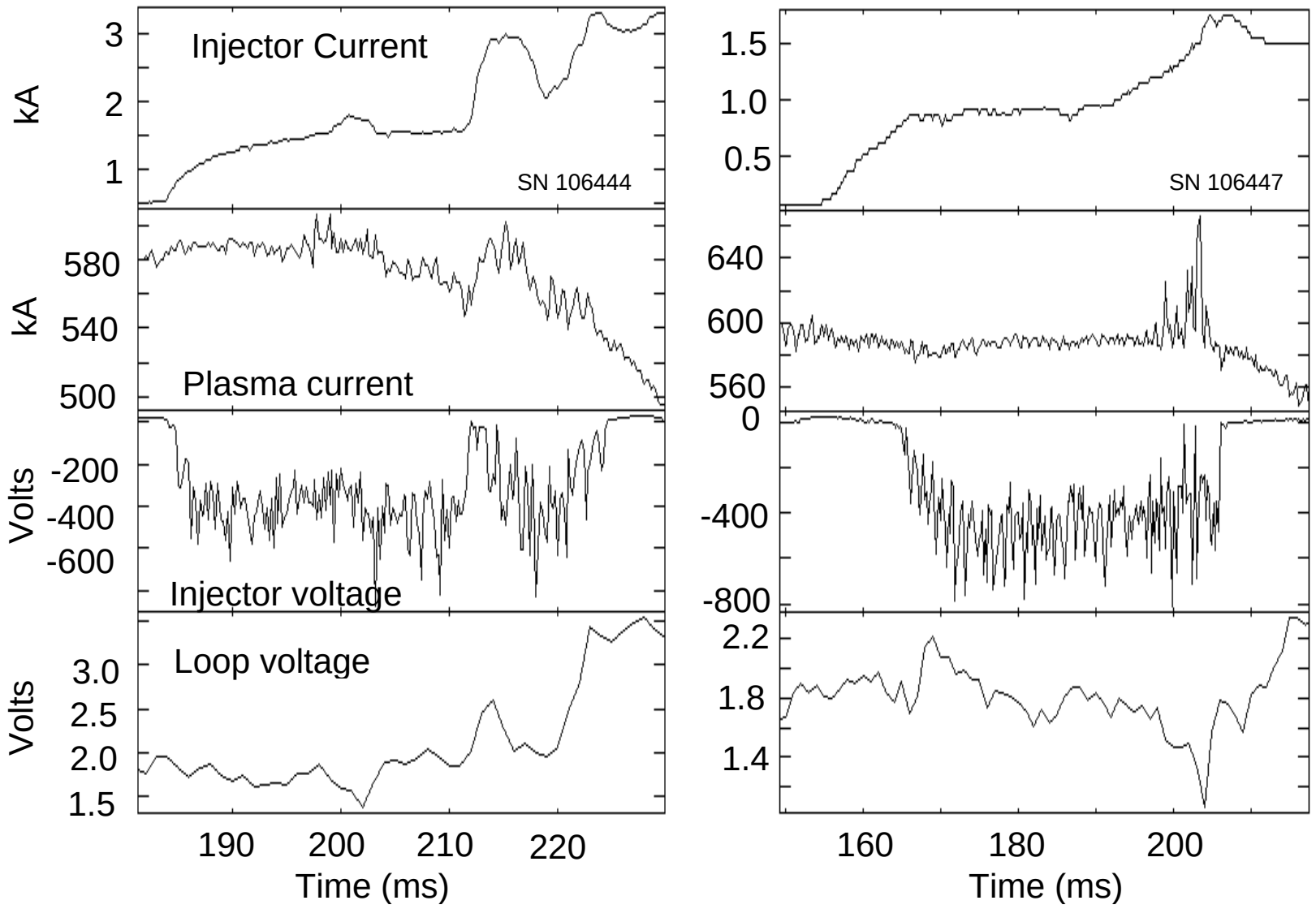
Add CHI to Ohmic

- Noise pick up on magnetics presented problems
- Initial results showed a drop in Ip
  - Better null in absorber region
  - Increased upper triangularity
  - Avoided current driven in absorber region

Needed improvements

- Improve grounding, reduce noise
- Improve plasma shape (lower elongation, higher triangularity)
- Improve gas injection capability in lower divertor

Noise interference during experiment



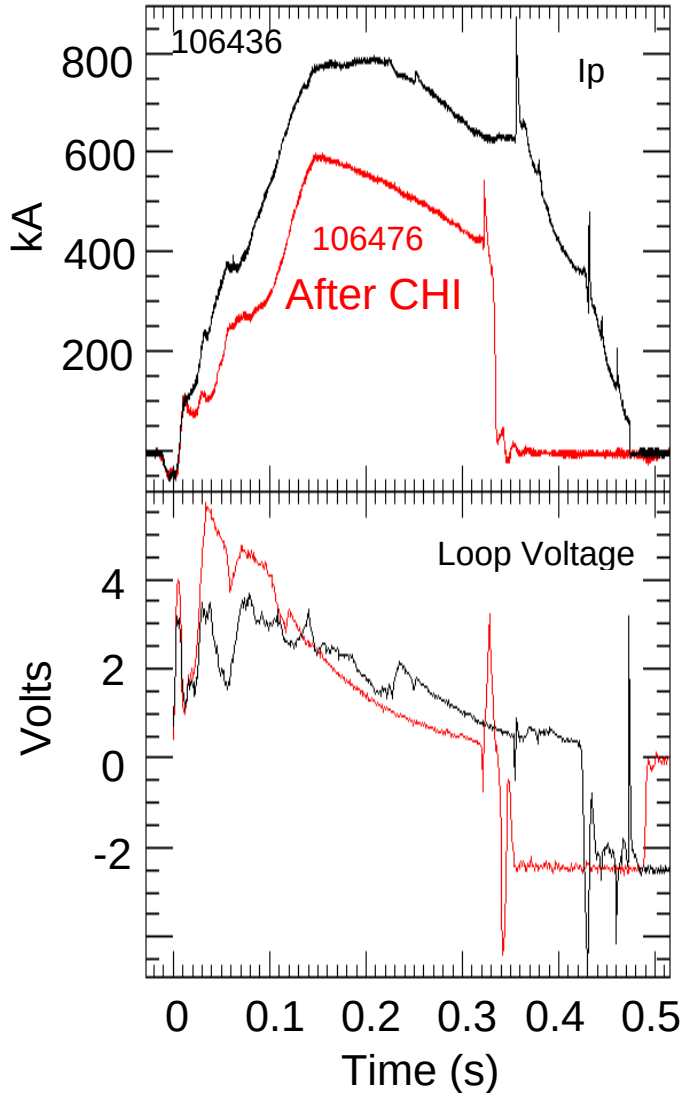
Add OH to a CHI discharge

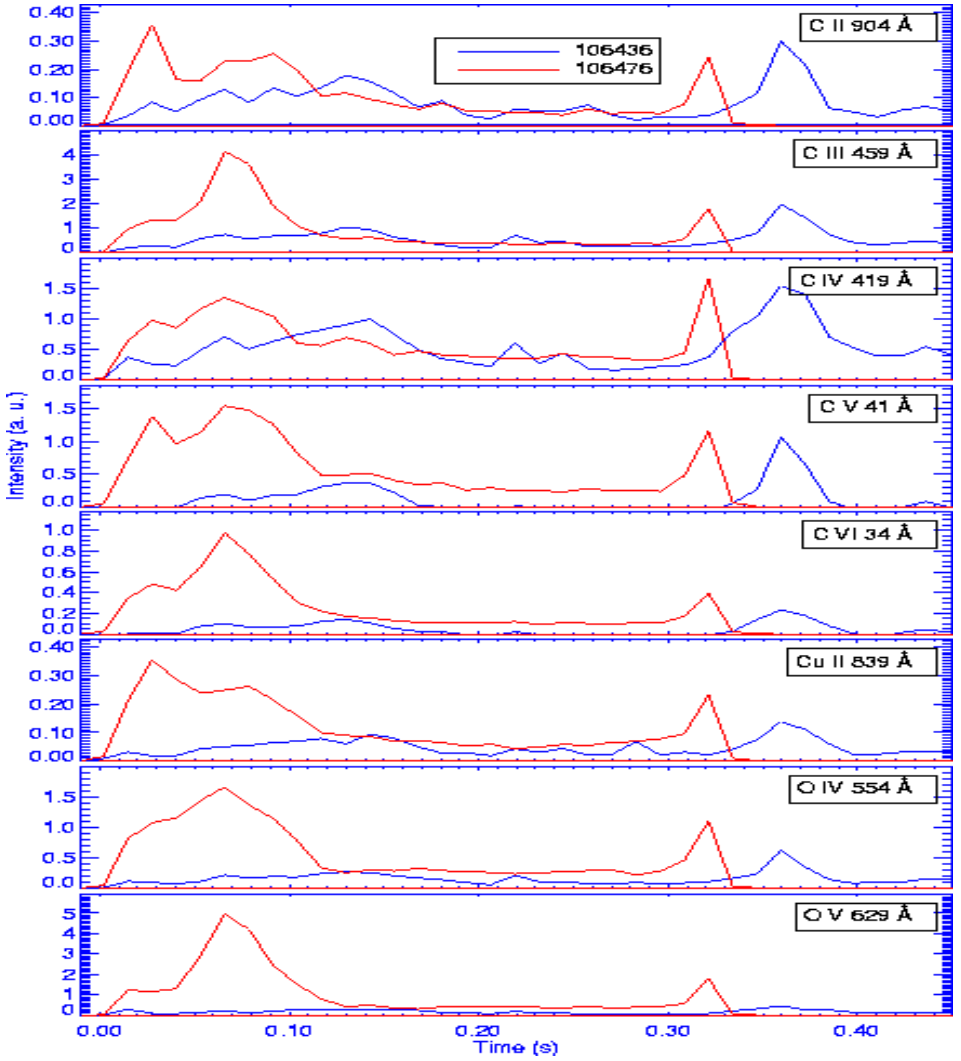
- Very limited data (total 5 shots: 0.5, 1, 1.2, 2 and 4V/turn)
- Statistically insufficient data at low loop voltage (0.5 and 1V/turn)
- Absorber arcs at higher voltage (2 and 4V/turn)

Needed improvements before further tests

- Improved absorber
- Increase toroidal current, test effect of NBI and HHFW
    - Began "OH+CHI" and "CHI+OH" but so far dominated by technical issues which must be resolved before physics experiments can be performed

Produced Ohmic plasma after CHI without boronization





2001 APS - DPP meeting Long Beach, CA

V. Soukhanovskii, R. Maingi, C.H. Skinner

Summary

- Produced 390kA discharges with 14 times current multiplication in 330ms long discharges.
  - Desirable features observed (n=1, MFIT reconstructions and SXR emission)
- More than doubled the toroidal current in the preferred flux configuration.
  - Enables the investigation of flux closure and fluctuations.
- Made real progress on flux closure and fluctuations, though we are still far from complete or conclusive solutions.
  - EFIT reconstructions needed.
- Absorber arcs considerably restrict operating parameter space.
  - Improved hardware design underway.

FY 02 run plans

- Assemble hardware for improved absorber
- Increase toroidal current to 500kA
- Test NBI and HHFW coupling to CHI discharges
- CHI performance versus toroidal field
- Initiate feedback control tests
- Lower elongation plasmas for "OH+CHI" with improved grounding
- EFIT with open field line currents and in private flux region
- Improve TSC modeling of CHI discharge evolution
- Initiate 3-D MHD modeling of CHI discharges