Summary of Coaxial Helicity Injection (CHI) Experiments in NSTX FY 01

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Contributors

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Non inductive current initiation needed for STs

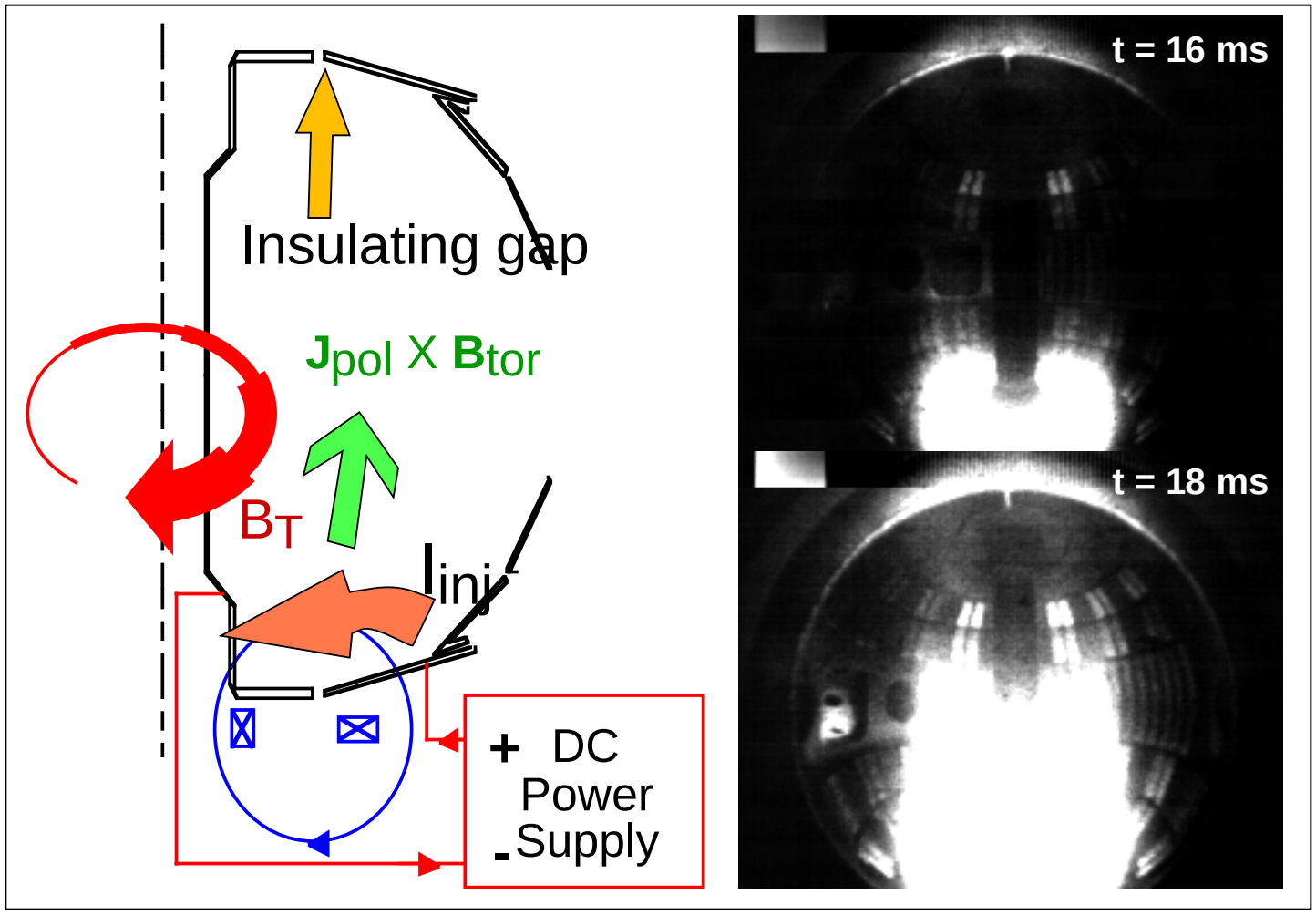
- Demonstrate non-inductive creation of target plasma
- Sustain target plasma by providing edge current drive
- Reduce poloidal flux swing of transformer

Main issues of the year

§ 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 of FY 01 CHI Run

Date	Objective	Result
May 24	XP31: Add CHI to OH	OH target plasmas. Ip decreased after voltage was applied.
May 25 (> 3pm)	XP31: Add CHI to OH XP6: PF1AU arc suppression test	Ip decreased after voltage was applied. LDGIS problem.
May 29	XP-6: CHI for start-up	LDGIS timing problem. Implemented TF arc detection algorithm.
June 25 (> 3:30pm)	XP-6: CHI for start-up	Engineering system debugging until about 3:30pm. Produced 300ms discharge at 200kA.
June 26	XP-6: CHI for start-up, TF scan	TF ramp not possible. 360kA @ 14 times current multiplication. Implemented 10 min HeGDC. Tried CHI at 0.45T, incomplete (not enough time).
June 27 (> 4pm)	XP-6: CHI for start-up, TF scan	Current Rogowski repaired until 4pm. Reproduced good n=1 and MFITs and 300kA currents.
Aug 1	XP-31: Add CHI to OH	Avoided decrease in Ip.
Aug 2 (3:30 to 7pm)	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.
Aug 3	XP-37: OH to CHI	Spent 3 hours on water interlock & CHI ground fault problem. Moved to 15min HeGDC. Modified TF arc detection algorithm to allow TF ramps. Obtained 5 shots on "CHI + OH". Obtained 390kA.

Development of discharges for plasma start-up

Primary goal

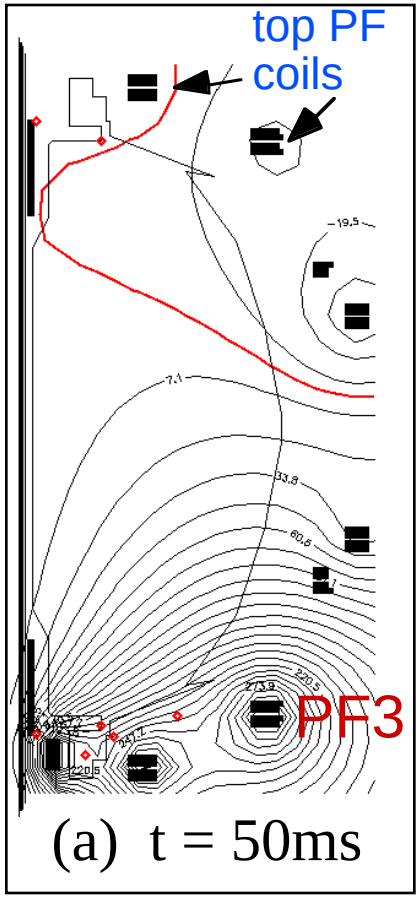
- Up to 390 kA of toroidal current produced at 14 times current multiplication
- Discharges sustained for 330ms

New observations

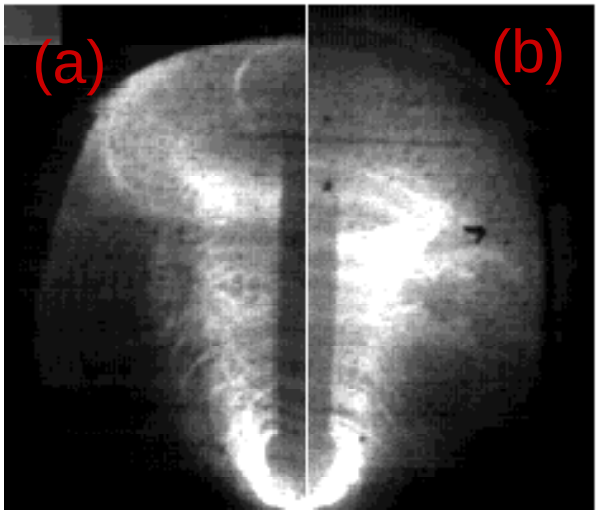
- Evidence for good n=1 oscillations deemed necessary for flux closure (B.A. Nelson's presentation)
- Consistently encouraging MFIT reconstructions (M.J. Schaffer's presentation)
- Evidence for higher temperature from SXR's (D. Stutman)
- Ion temperature and plasma rotation (M.Nagata, R.Bell, V. Soukhanovskii)

Discharge programming to increase flux closure

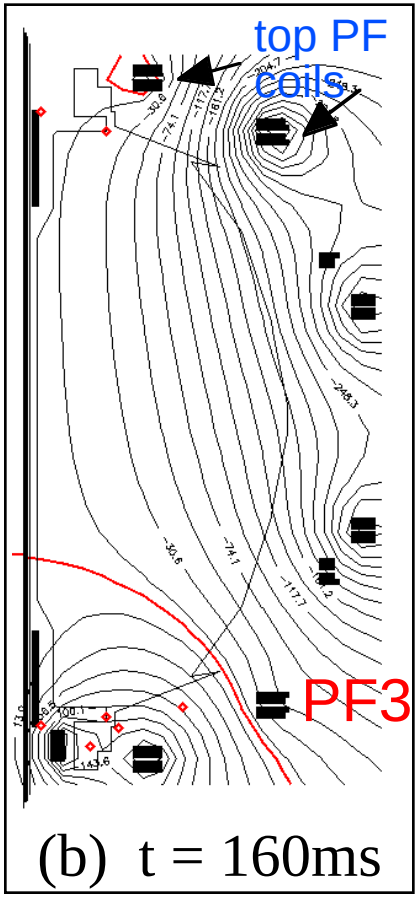
High current configuration ⟶ Preferred configuration



(a) t = 50ms

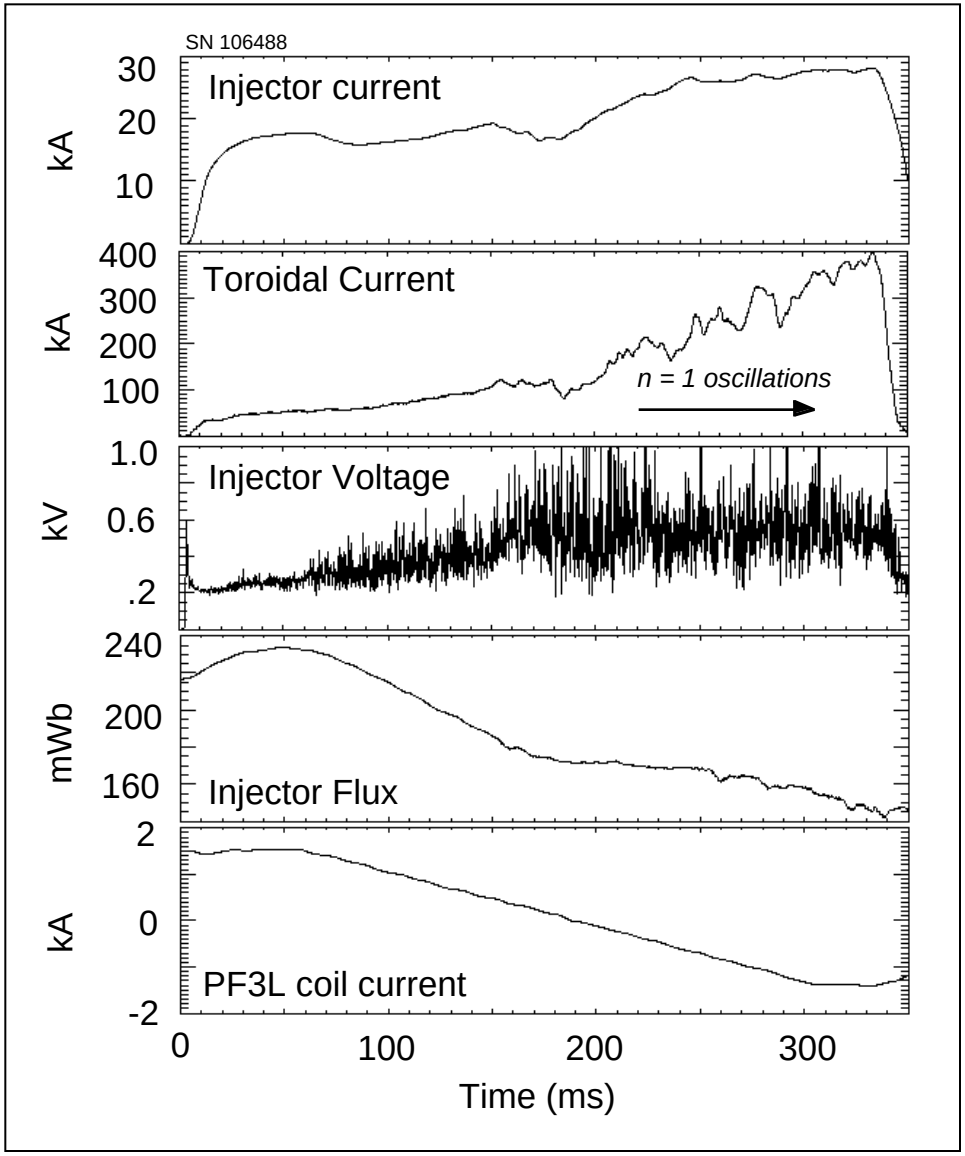


- Reverse current in PF3
- Increase current in top PF coils
- Increase vertical field

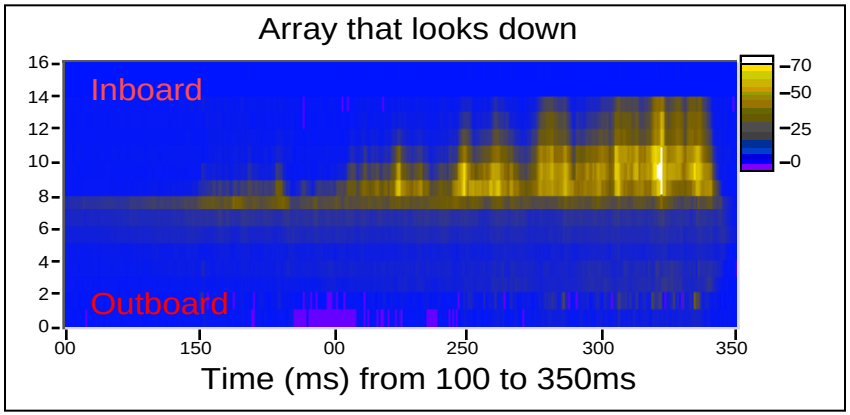


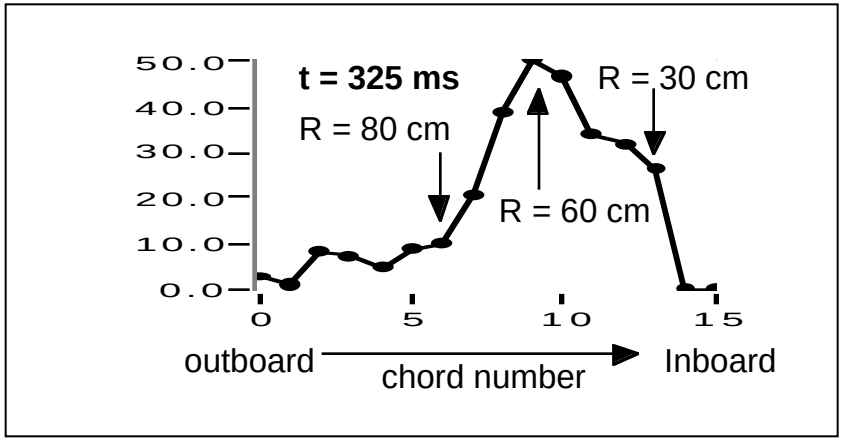
(b) t = 160ms

Obtained 390kA with a current multiplication of 14



Soft x-ray profiles (E > 100 eV)





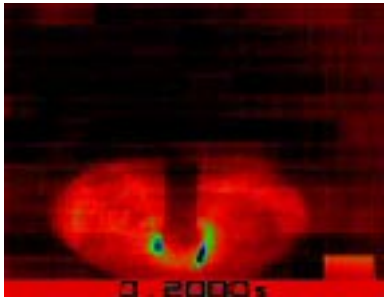
D. Stutman

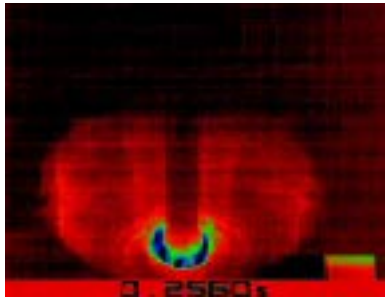
Discharge programming successfully implemented

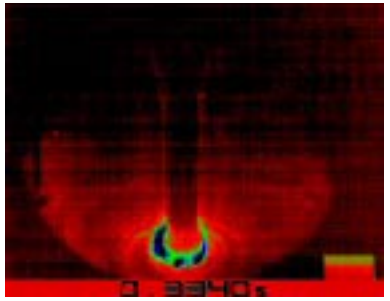
t = 200 ms

t = 256 ms

t = 334 ms



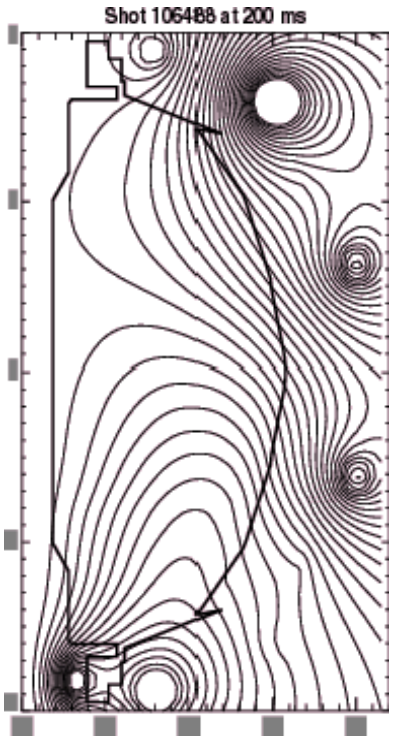


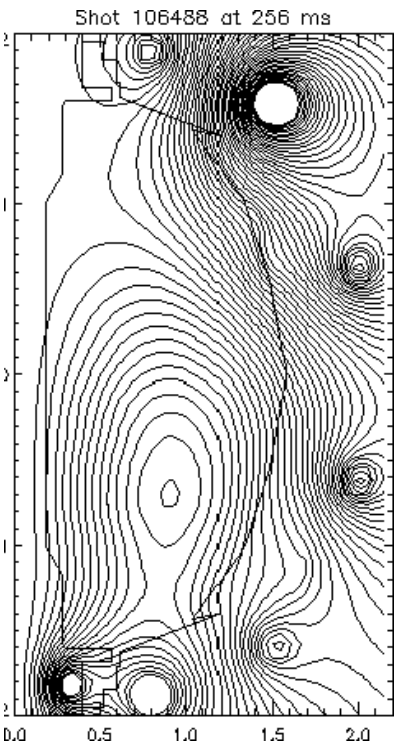


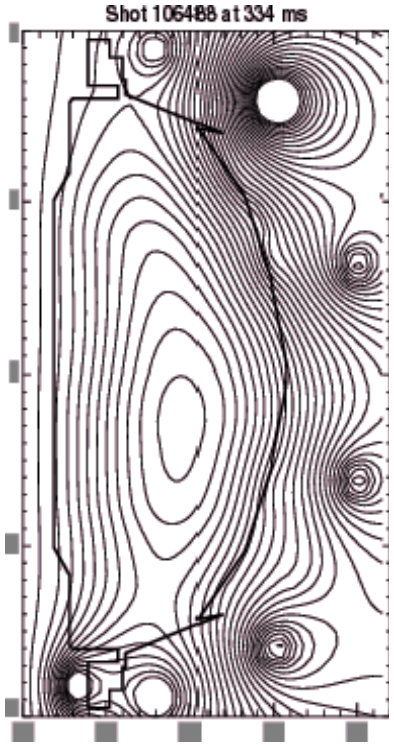
SN 106488

Fast Camera

(R. Maqueda *LANL*)



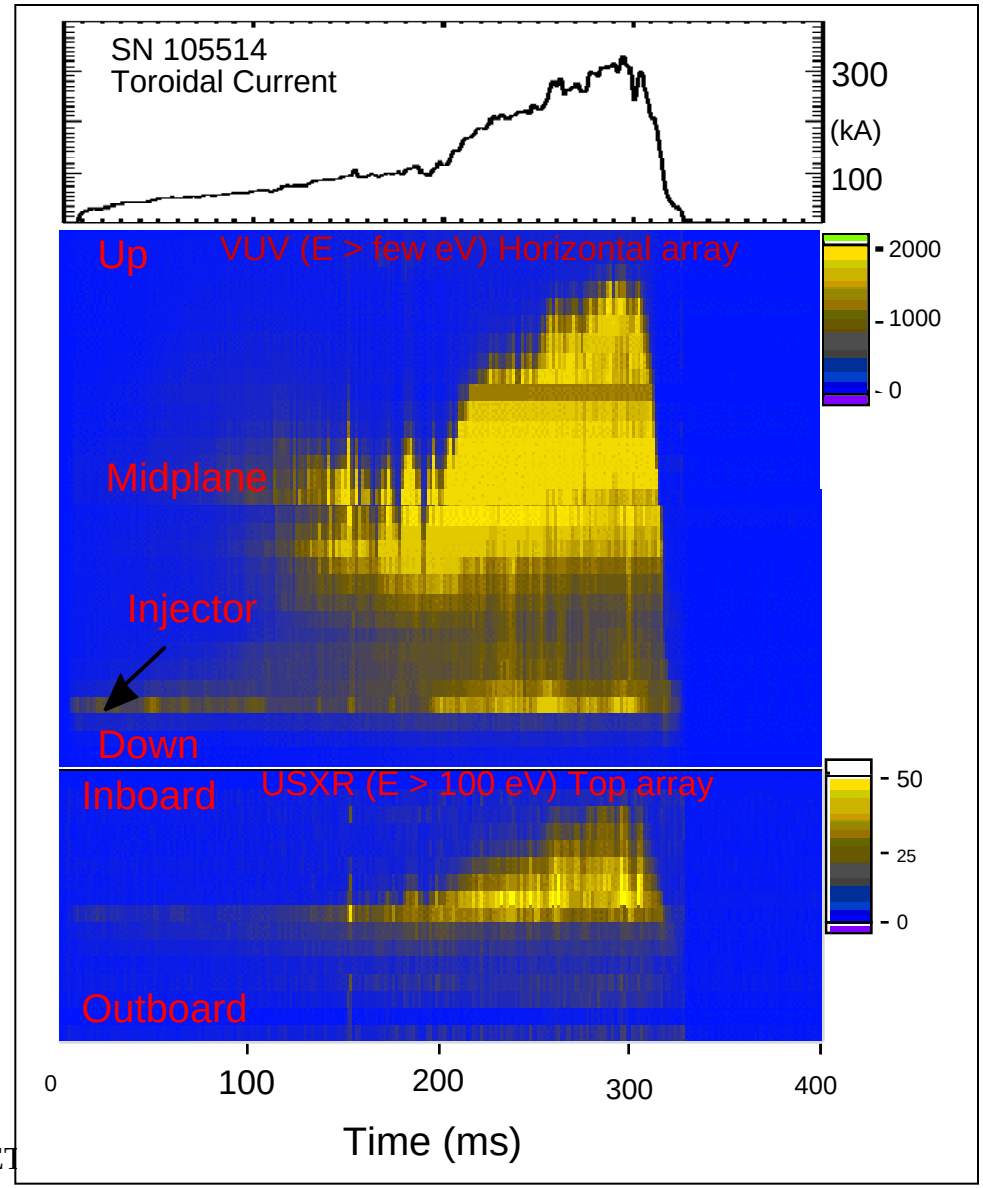


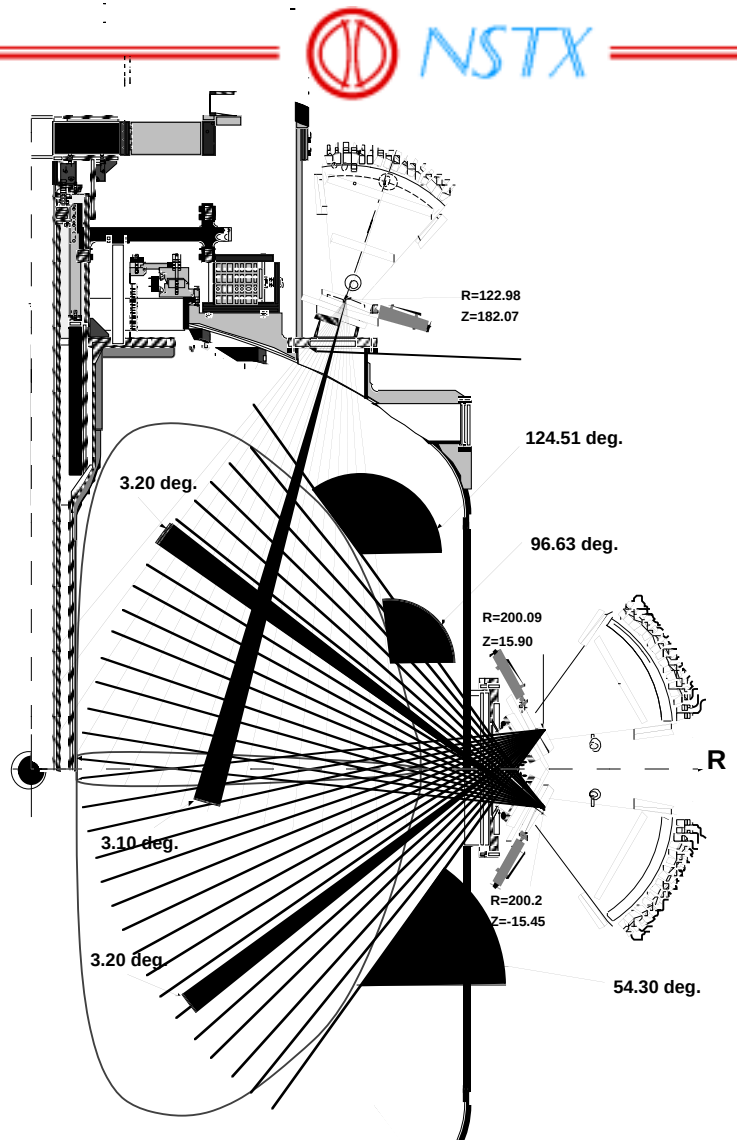


MFIT

(M. Schaffer *GA*)

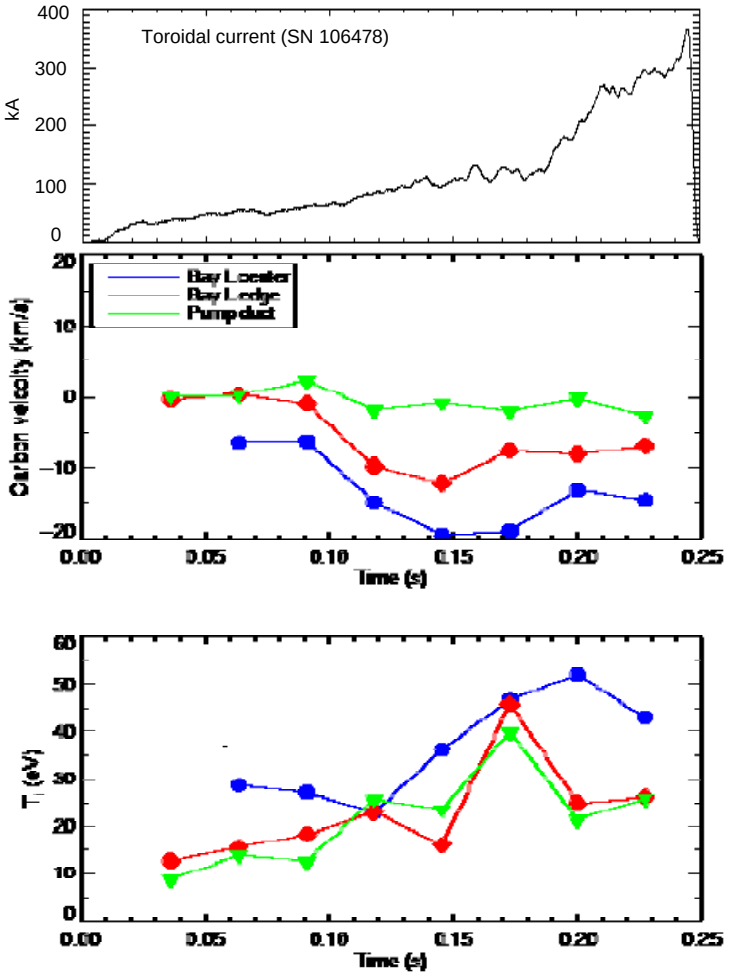
VUV emission extends to fill chamber

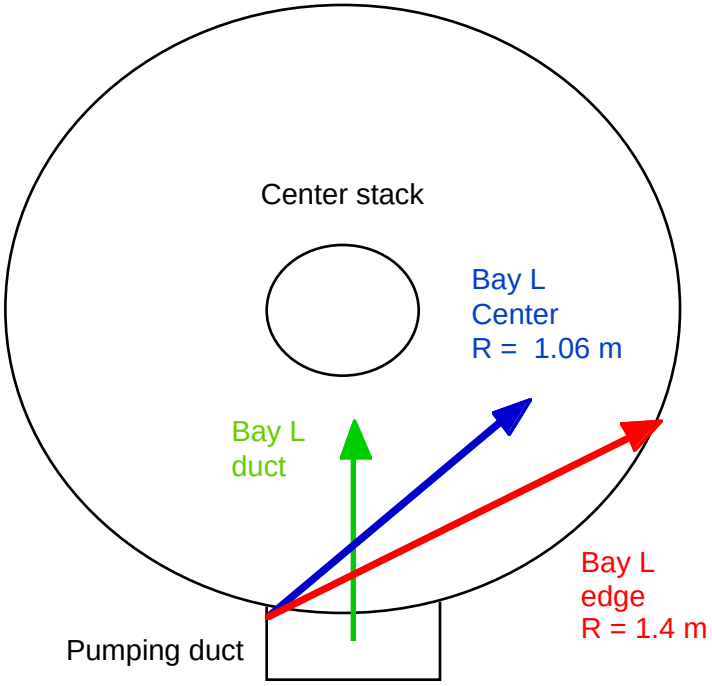




D. Stutman (Johns Hopkins Univ.)

Ion Doppler CIII Ion temperature and edge plasma rotation





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

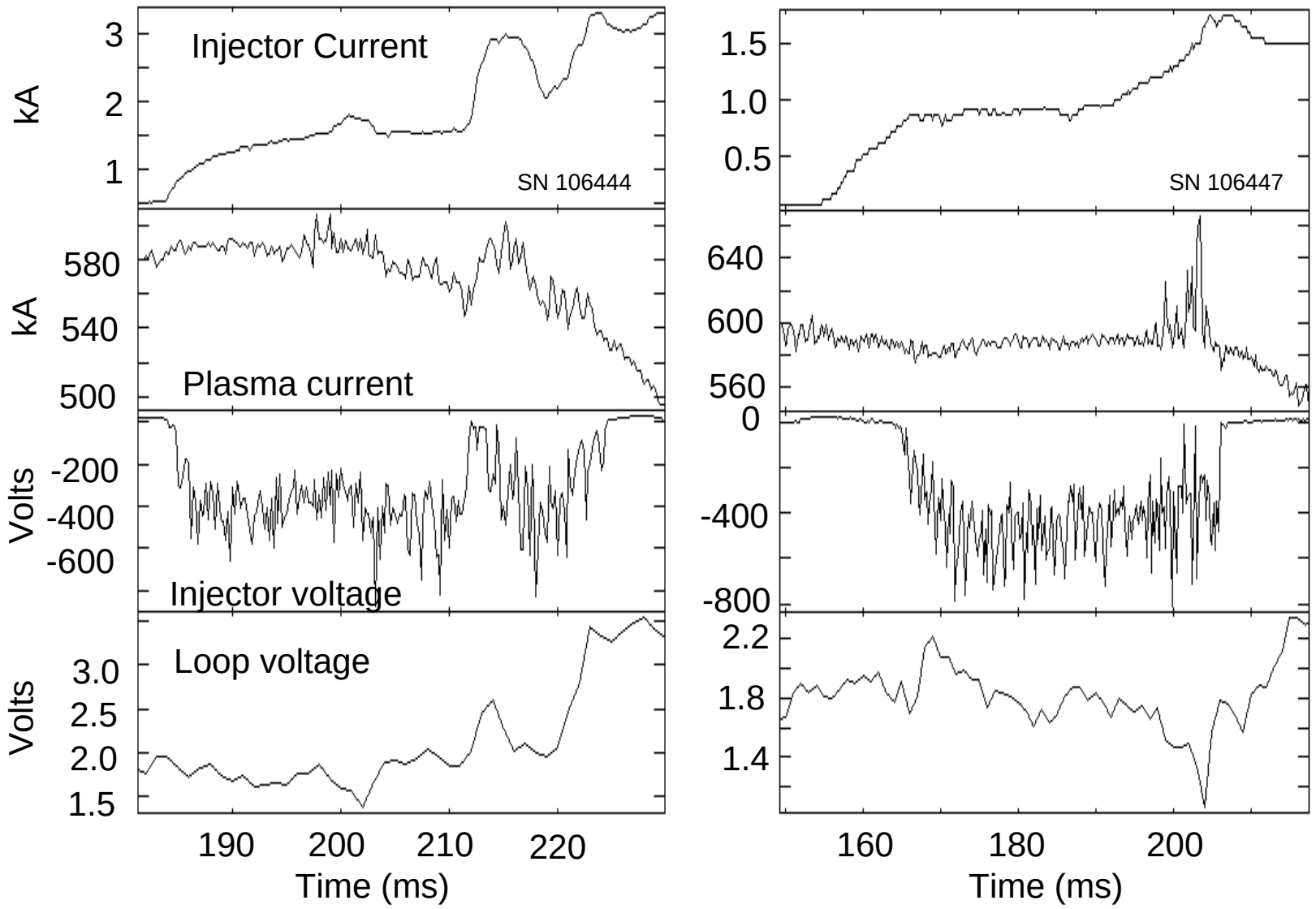
Add CHI to Ohmic

- Noise pick up on magnetics
- 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



D. Mueller

Add OH to a CHI discharge

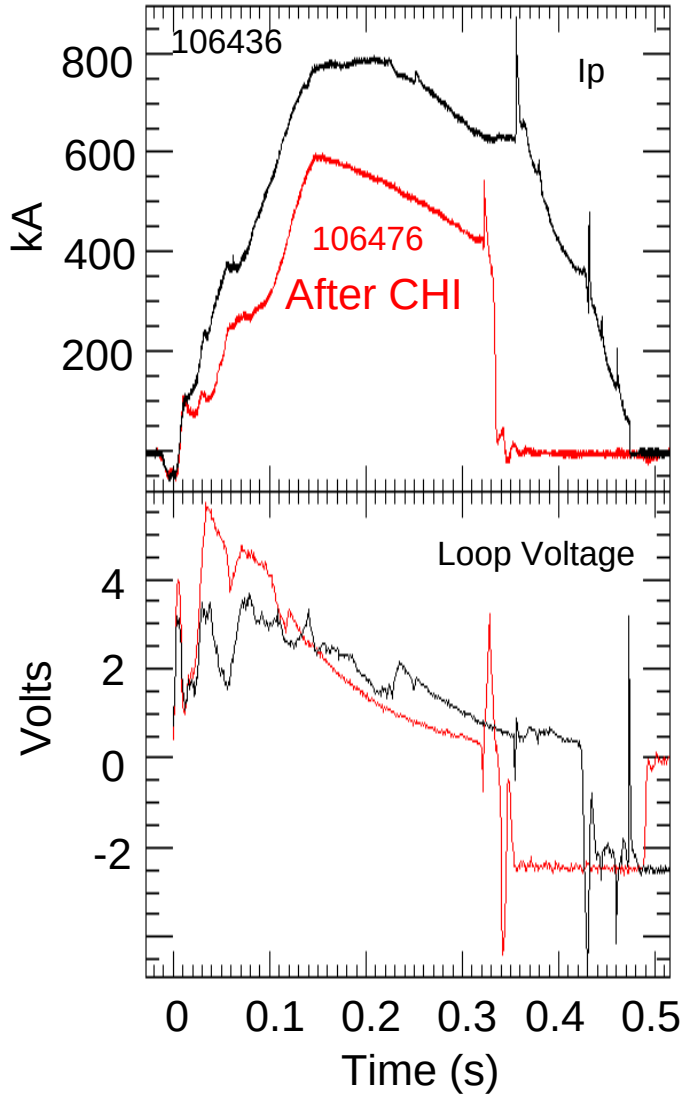
- Very limited data (total 5 shots: 0.5, 1, 1.2, 2 and 4V)
- Statistically insufficient data at low loop voltage (0.5 and 1V)
- Absorber arcs at higher voltage (2 and 4V)

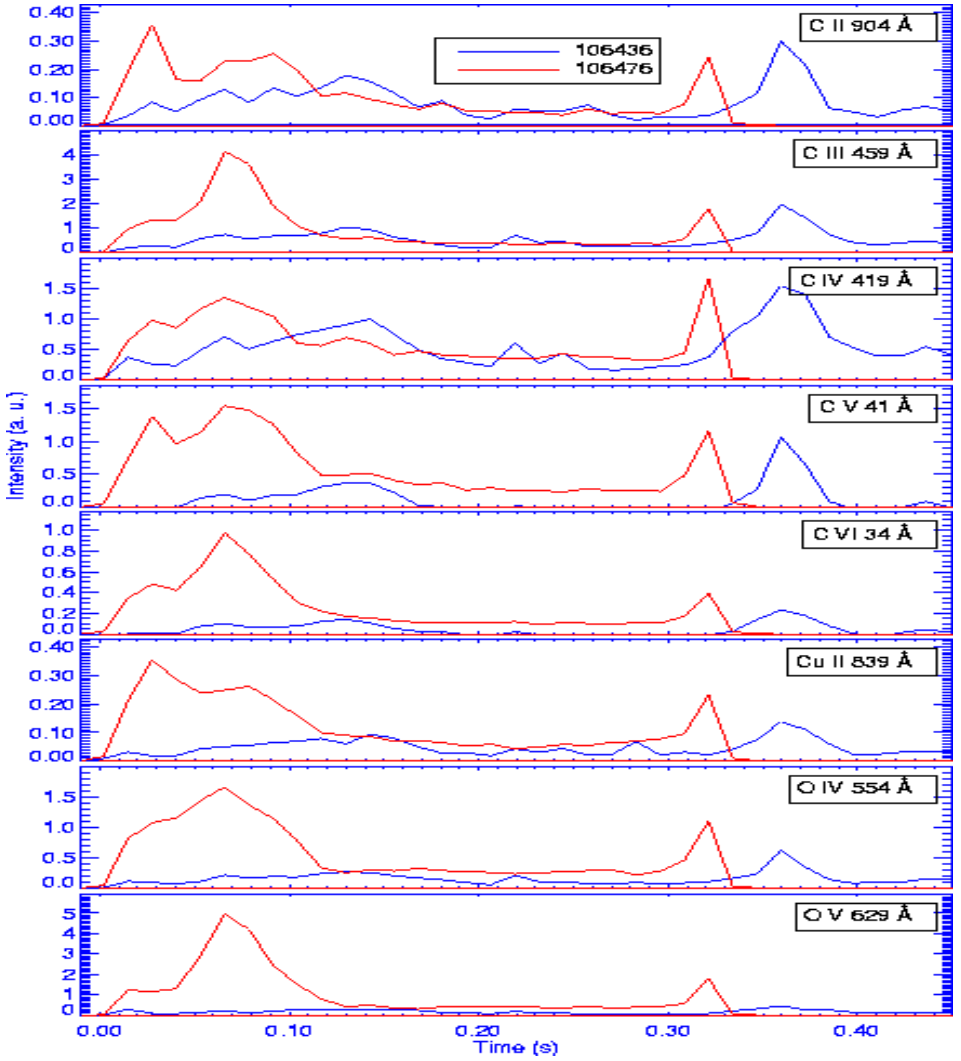
Needed improvements before further tests

- Improved absorber
- Increase toroidal current, test effect of NBI and HHFW

  - Got started on "OH+CHI" and "CHI+OH" but so far results look more like debugging the experiment than like preliminary physics.

Produced Ohmic plasma after CHI without boronization





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

Summary

• Absorber arcs considerably restrict operating parameter space and are a constant threat to run time.

• Recovery after CHI appears easier than previous thought. No carbon contamination on absorber Penning gauge.

• Produced 390kA discharges with 14 times current multiplication in 330ms long discharges. Desirable features observed (n=1 oscillations, MFIT reconstructions, soft x-ray emission).

• Nearly doubled the toroidal current and maintained it at high values in steady state. This is a notable accomplishment for FY 01 in operational physics and it enables the investigation of flux closure and fluctuations.

• Made real progress on flux closure & fluctuations, though we are still far from complete or conclusive solutions.

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