CHI Experiments in NSTX*

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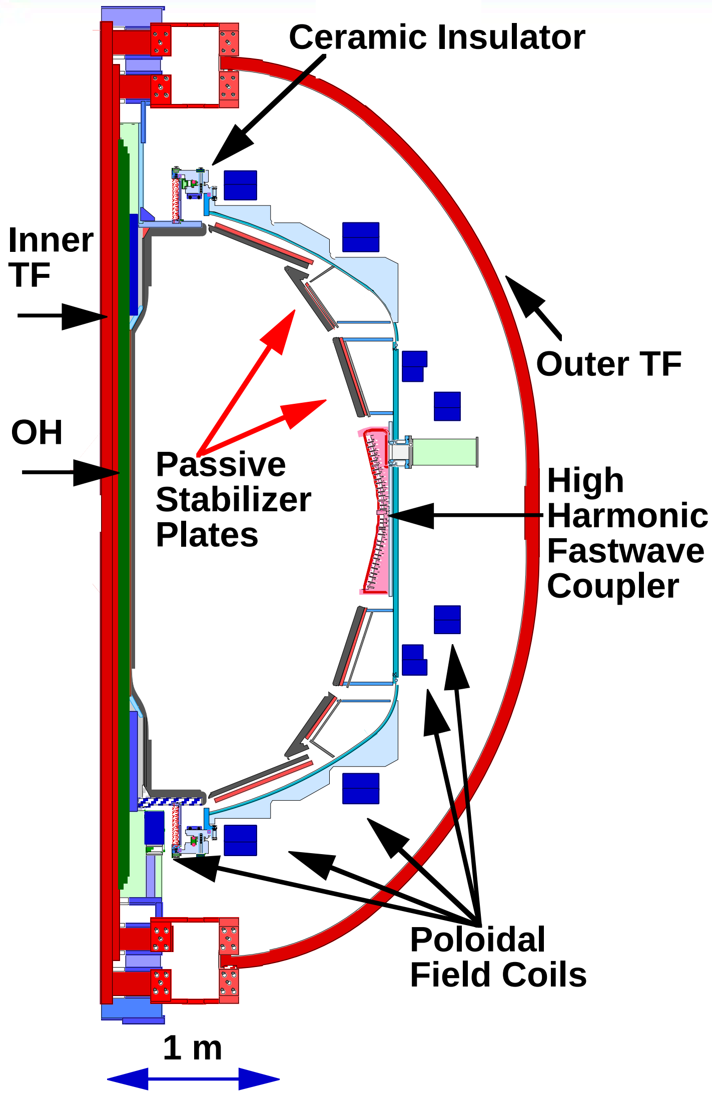
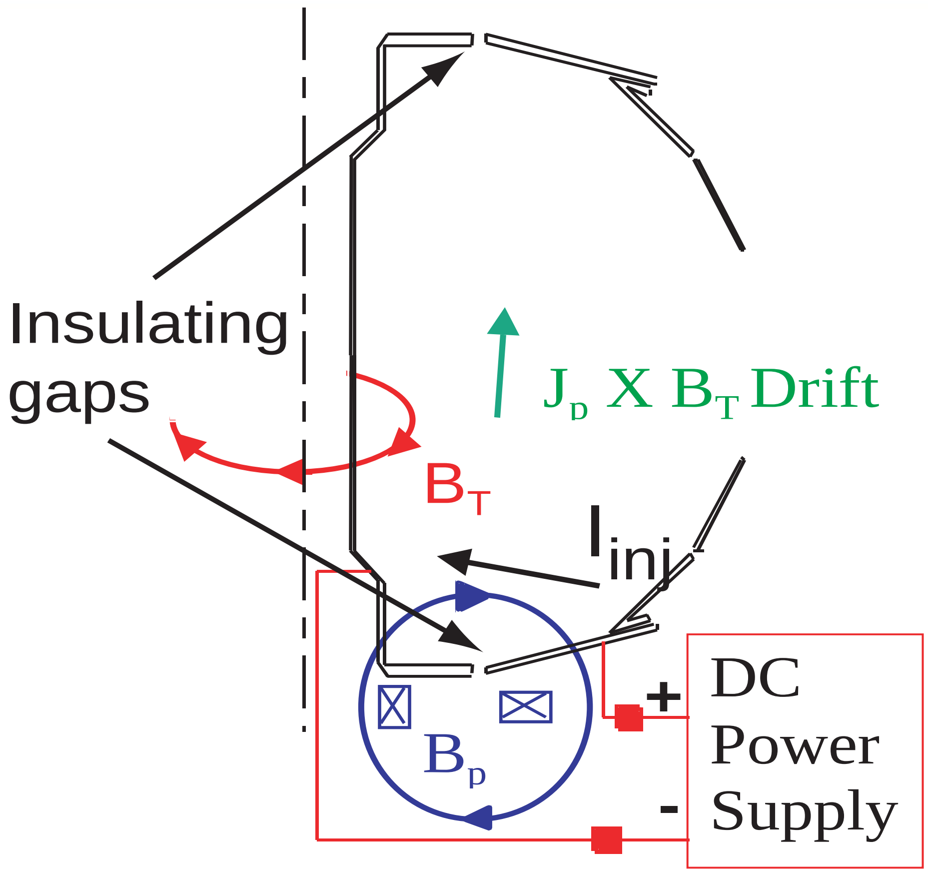
NSTX Is Designed to Explore Low Aspect-Ratio Toroidal Confinement

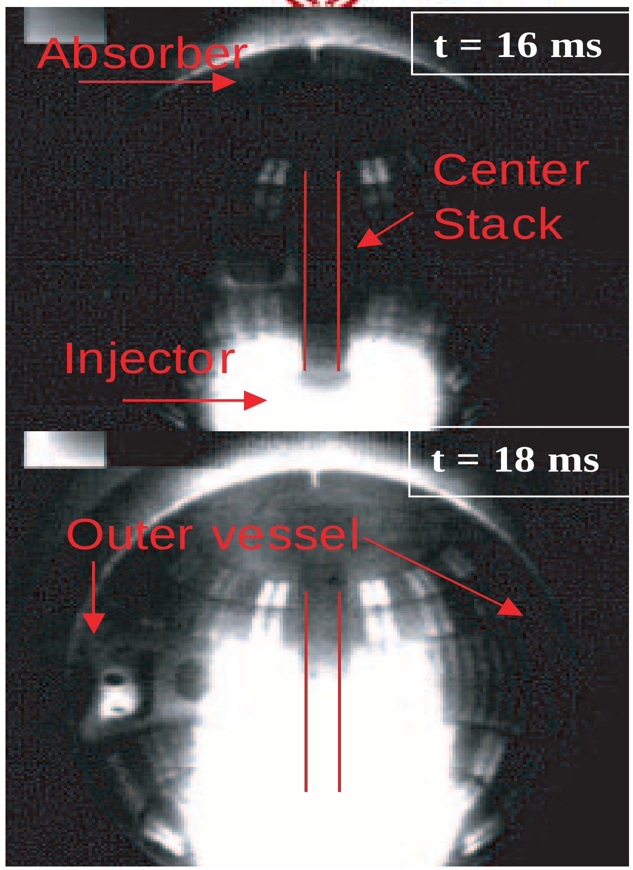


Parameters

Major Radius	} ⇒ A ≥ 1.27
Minor Radius	
Elongation	2.5
Triangularity	0.8
Plasma Current	1.5 MA
Toroidal Field	≤0.6T
Heating and Current Drive	
Induction	0.6Vs
NBI (100keV)	7 MW
HHFW (30MHz)	6 MW
CHI	0.4MA
Pulse Length	1 s

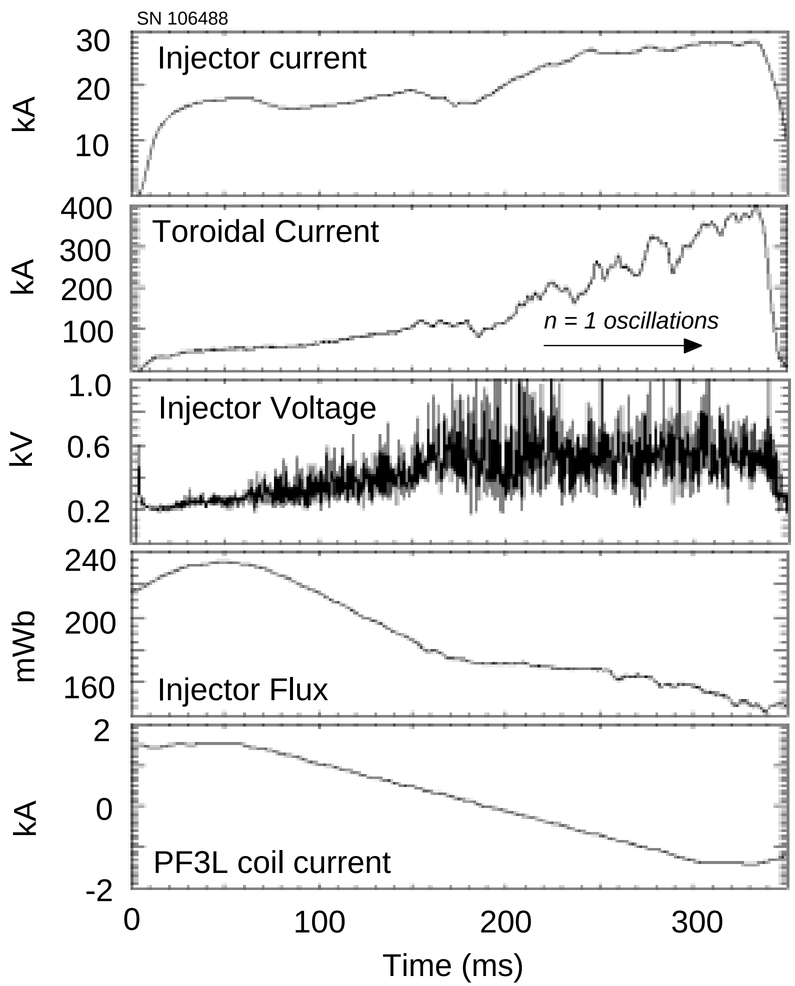
Investigating Coaxial Helicity Injection (CHI) for Initiating Toroidal Plasma Current



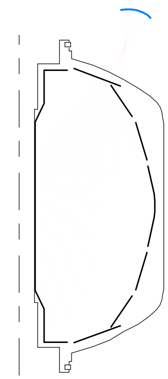


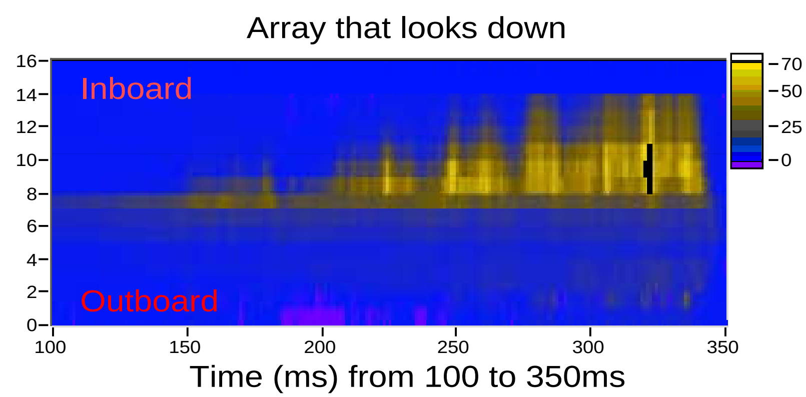
- Inner, outer lower divertors act as electrodes to inject helicity
- Magnetic reconnection can convert open to closed flux

Obtained 390 kA Toroidal Current for Injector Current of 28 kA



- Array of soft x-ray detector sensitive to E_γ > 100eV detect emission from inboard midplane region





R. Raman, D. Stutman

Absorber Arcs Occur on most CHI shots

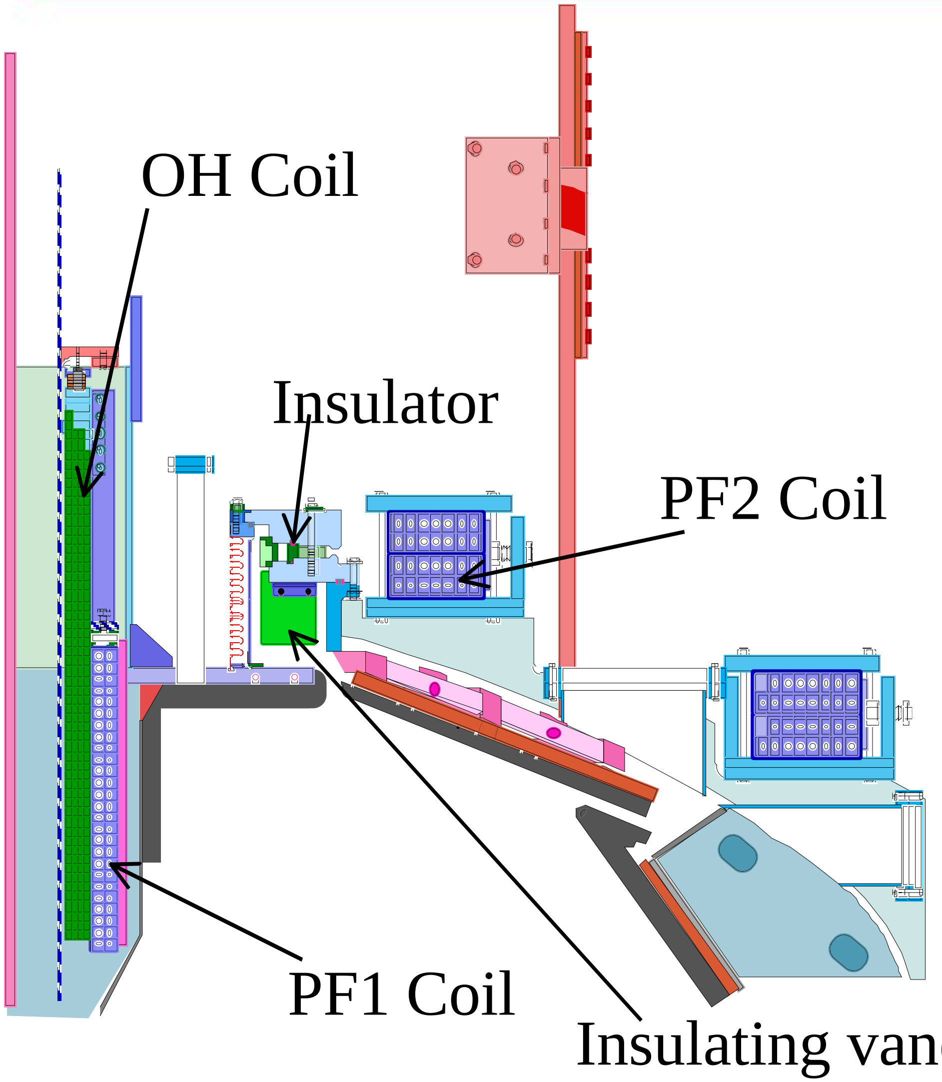
Note image is rotated 180°

- Arcs across the gap at the top of the machine occur on nearly all CHI shots (Absorber Arcs)
- ExB during CHI drives plasma toward the absorber

Technical Problems have limited operational space

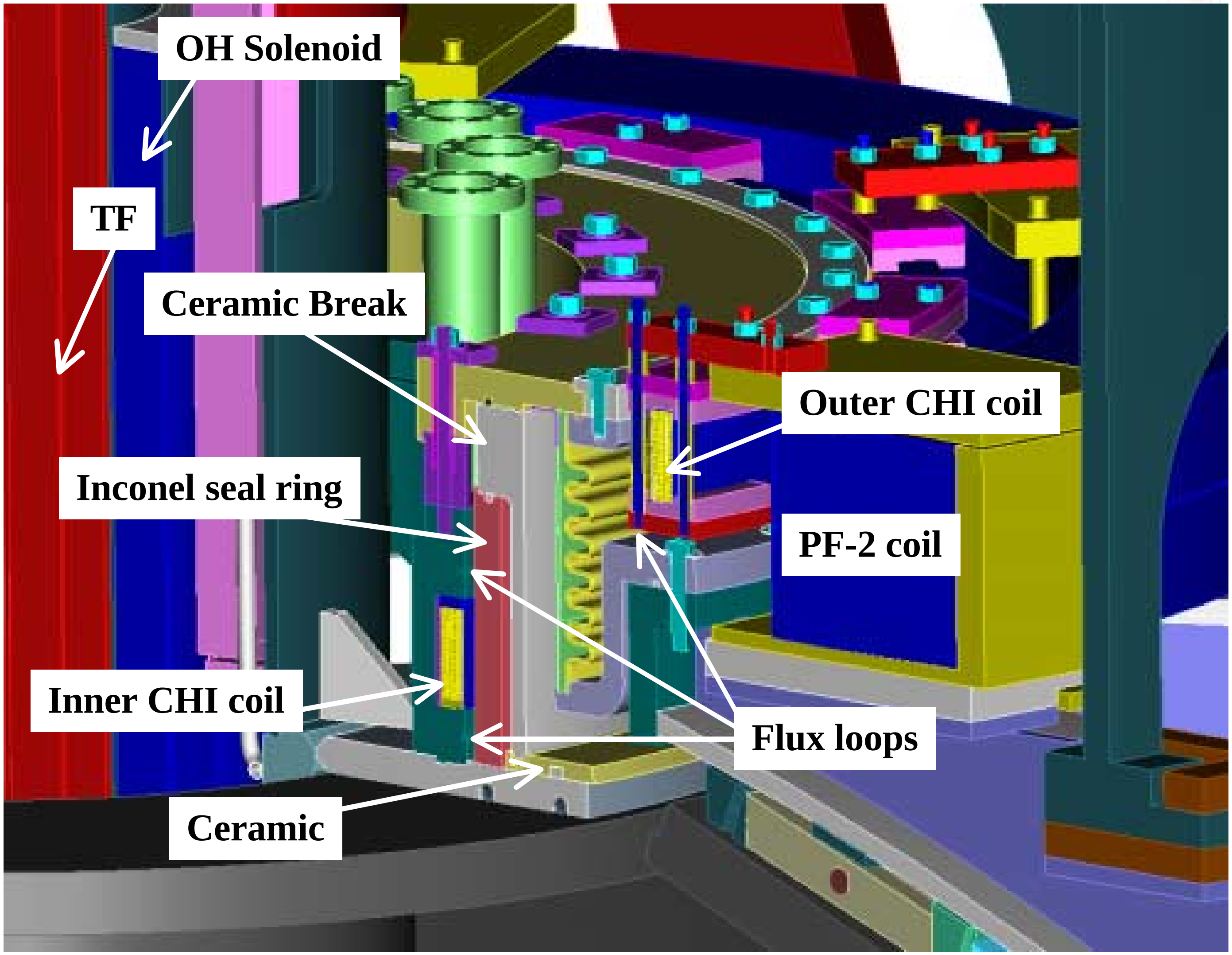
- An operational regime that minimizes the frequency of absorber arcs and /or delays their occurrence has been developed
  - Exploration of other scenarios is problematic.
- In addition to arcs inside the vessel, arcs in power cables external to the vessel have occurred
  - System routinely tested to 3kV.
- Both absorber and external arcs must be avoided.

Old Absorber Region Design



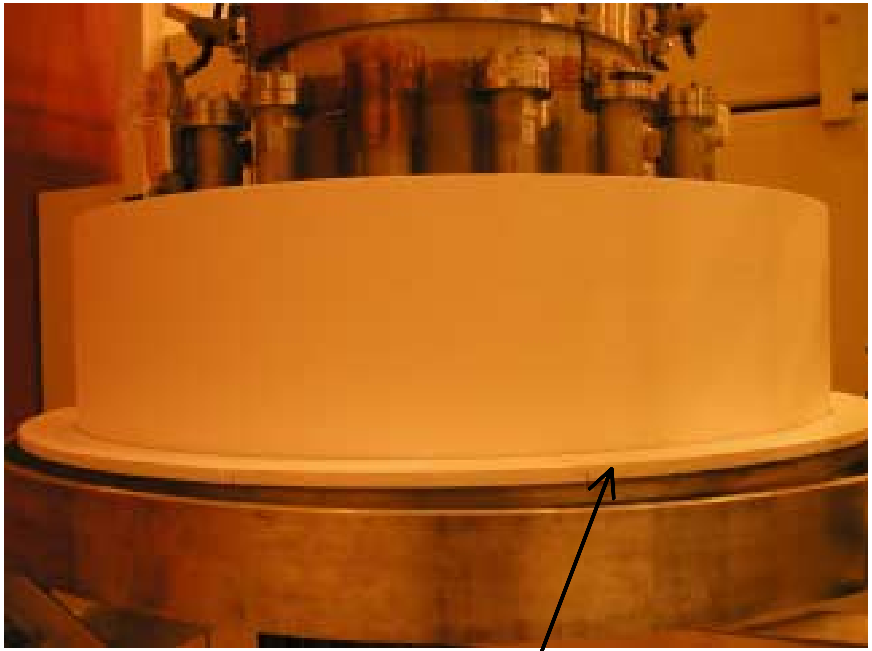
- Insulator on low field side
- Inner and outer vessel can be connected along radial or vertical lines.
- No separate coils to reduce poloidal field connecting inner and outer vessel

New Absorber Design



- Insulator on high field side
- No simple connection path in insulator region
- Coils to produce local poloidal field to reduce stray field from plasma and PF coils, 1kA peak current
- Flux loops to measure field in absorber region will permit feedback

Ceramic Installation



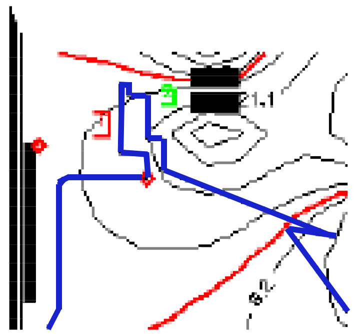
- Alumina Ceramic
- 1.0m (39.37”) OD , 0.91m (35.87”) ID
- 25.15 cm (9.9”) total height
- 6.35 cm (2.5”) between vacuum surfaces

Split ceramic skirt to cover metallic surface

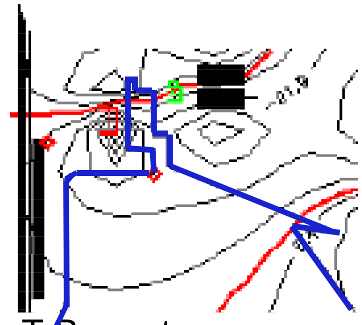
With no plasma, the CHI coils can reduce the flux and field in the absorber region

- Field contours for shot 106488, no Ip, no CHI coil currents
- Flux in gap is -7 to -24 mWb

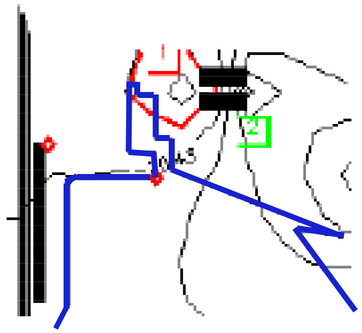
- 1000A in inner and 0A in outer CHI coils
- Flux in gap is -7 to +10 mWb



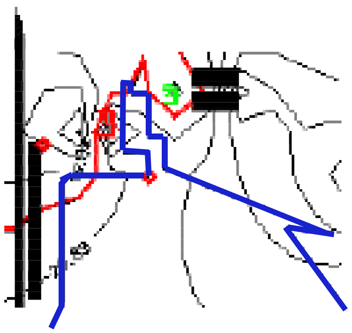
The Br contour value at the gap is -21mT.



The -21mT Br contour moves away from the gap.



The Bv contour value in the gap is -20 mT.

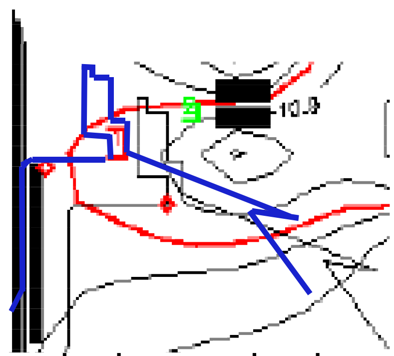


The Bv value near the gap is reduced.

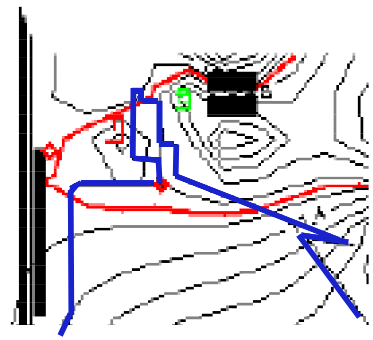
Plasma current reduces the flux and field, but the CHI coils can further reduce them

- Field contours for shot 106488, Ip=400 kA, no CHI coil currents
- Flux in gap is ~ 4 mWb

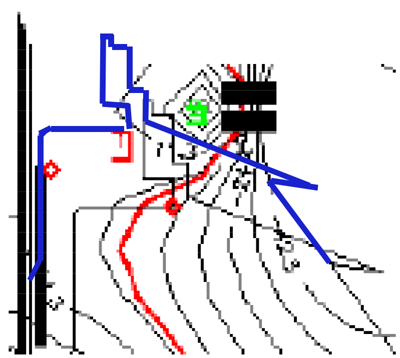
- 200A in inner and -300A in outer CHI coils
- Flux in gap is ~ 1 mWb



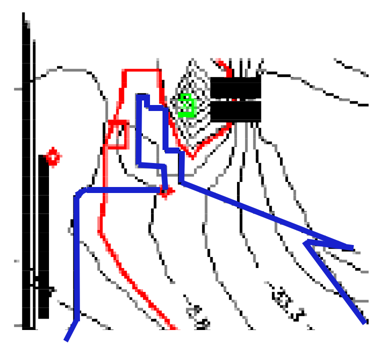
The Br countour in the gap is about -11mT.



The Br contour in the gap is about -5 mT.



The Bv contour in the gap is about 6mT.



The Bv contour in the gap is about -9mT.

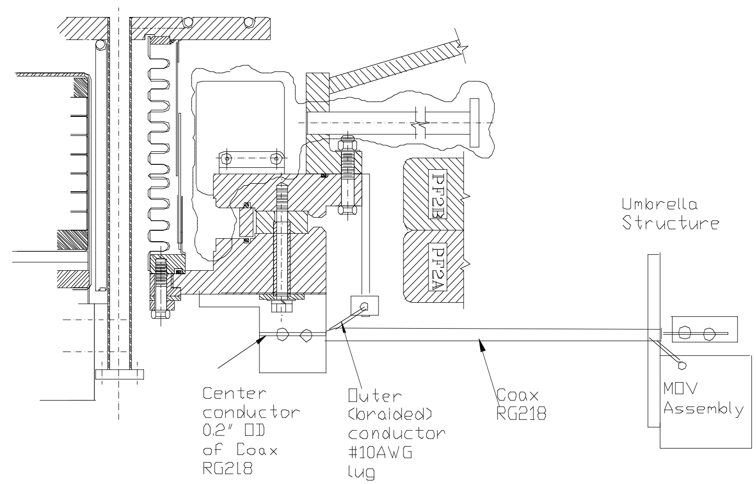
Arcs external to vacuum

PROBLEM

- 1 kV supply
- Hi-pot to 3 kV
- Highly variable plasma load
- Voltage arrestors connecting inner and outer VV through MOVs located ~ 20 feet away
- Voltage spikes > 3 kV

MODIFICATION

- Move MOVs closer to machine, used 18 inches of coax cable
- 4 MOV assemblies in parallel
- Reduced inductance of voltage limiting circuit (0.04 μH)



Insulating gap at bottom of NSTX

Photo of installed MOV assembly

- One of the 4 MOV assemblies
- Each assembly has 30 modules mounted on building steel
- 1kV maximum continuous operating voltage
- Begin conducting at 1.4kV

Significant Improvements to CHI system

- *Redesigned absorber region with large new insulator on the high-field side*
- *New coils to reduce poloidal field in absorber region*
- *Installed new flux loops for use in feedback system to control poloidal field in absorber region*
- *Relocation of MOVs in the voltage surge protection system reduced inductance which should reduce size of voltage spikes*
- *These improvements should permit us to explore a wider variety of operational scenarios without arcs.*