NSTX

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Disruption Characteristics with a Warm LLD

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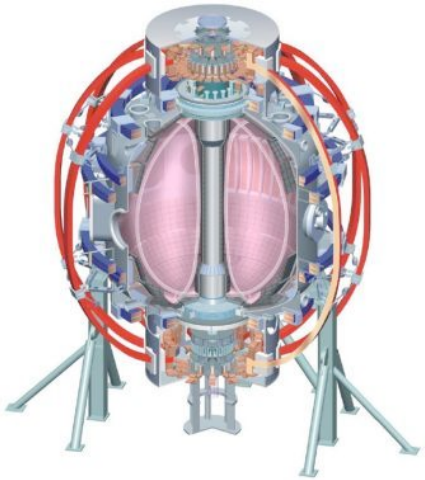
1 Day Allocation in MS TSG
This presentation if for discussion only.

NSTX 2010 Research Forum
LR TSG Breakout Session
Dec. 2nd, 2009



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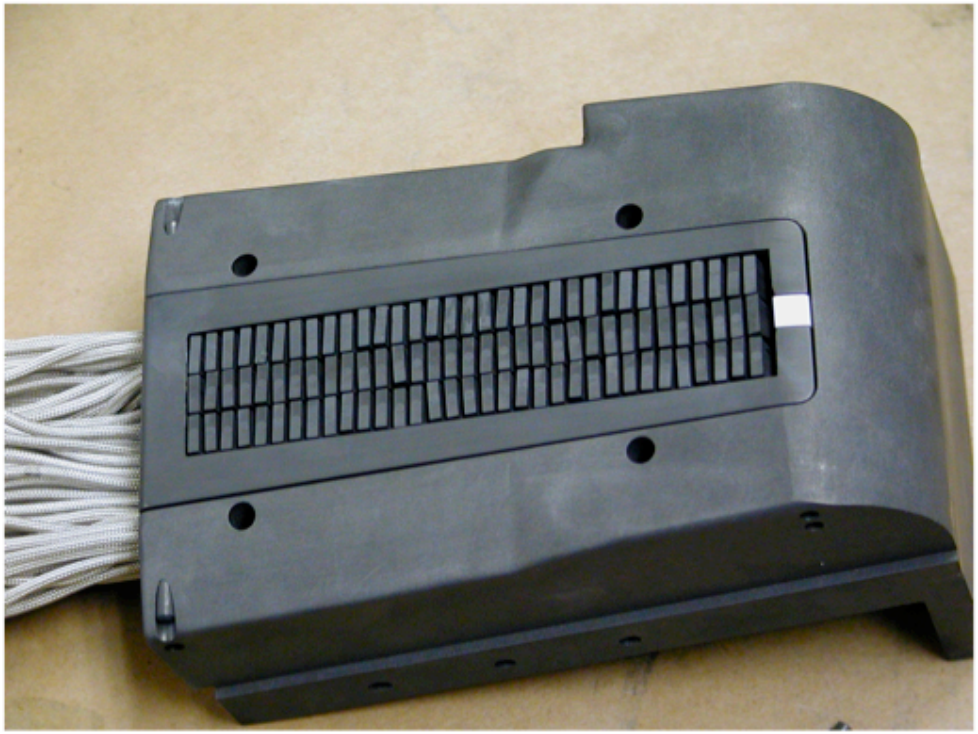
Overview

- Background
  - Halo currents occur when the plasma comes in contact with the vessel/FW/divertor during a vertical displacement event (VDE).
  - These currents cause a vertical JxB force that can break the tokamak.
    - Sideways forces also observed (forces not presently measurable in NSTX).
  - New halo current diagnostics in 2010 should allow improved measurements.
    - Fast IR thermography is a side benefit.
  - Impact of liquid lithium surface on disruption dynamics is important for overall LLD understanding
- Goals
  - Determine how the presence of a hot Li surface impacts the disruption behavior.
    - Low ionization potential of Li may keep plasma cooler, speeding the I_P quench rates and increasing or reducing HCs.
    - Modifications to disruption behavior with recycling/pumping surface (He vs. D_2)
  - Potential side benefits (?): thermal loading, lithium expulsion measurements, evaporative barrier.
- Contributes to
  - Overall understanding of how Li modifies important tokamak physics.
  - NSTX disruption database expansion to include effects of lithium

"Super-Tile" May Also Provide Important Data for HC and CQ Studies

- 99 Pins
  - 33 Rows
  - 3 Columns
- Configurable as 33 triple probes.
- Estimate T_e and n_e in the halo?
- Critical for understanding halo currents.



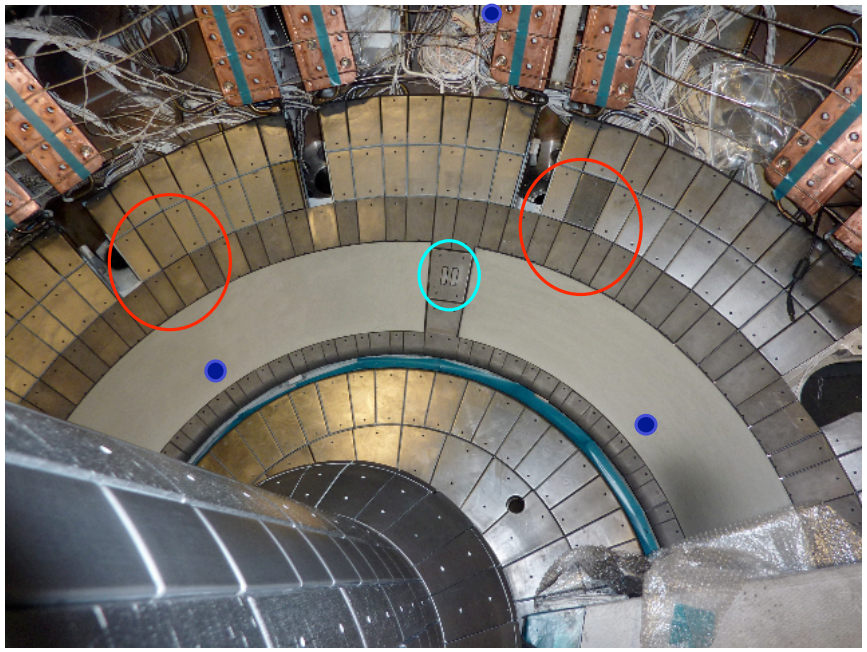
Halo Current Measurement Toroidal Coverage Expanded for 2010

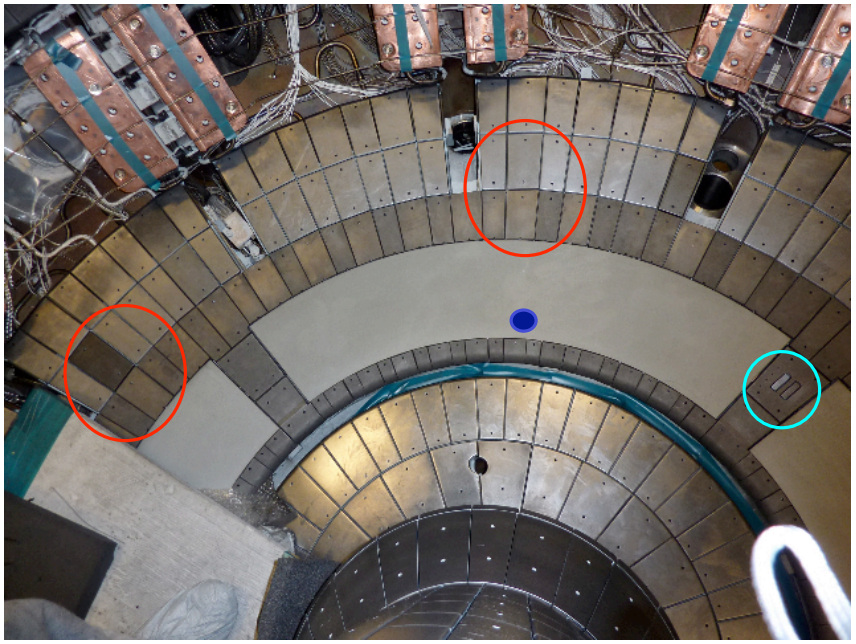
Super Tile

Shunt Tiles

LLD Centerpost Rogowski

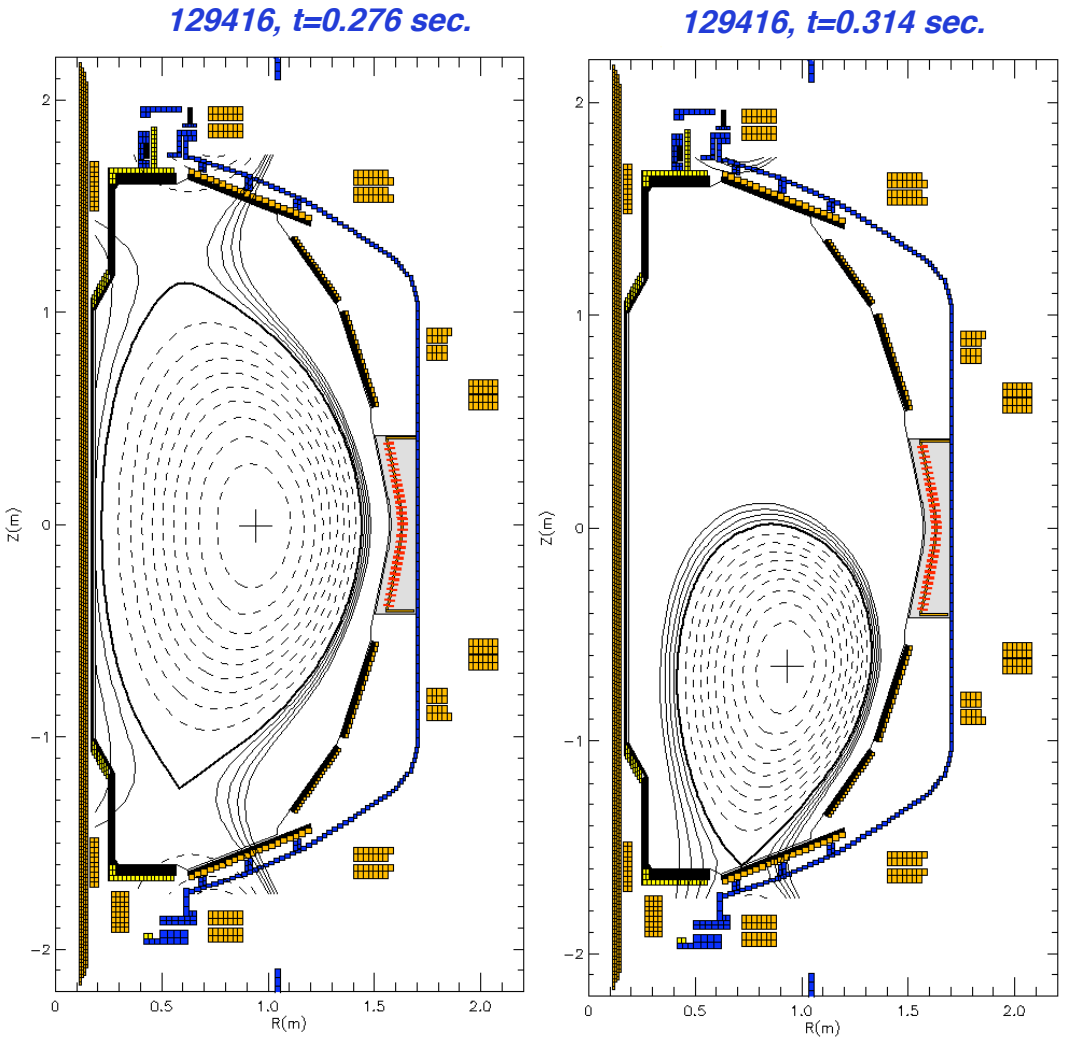
LLD Gap Bias Tiles





Suggested Discharge For These Studies

- Moderate triangularity Ohmic discharge.
- Induce VDE by turning off vertical position control.
  - Force down with an offset voltage on the radial field coils.
- Had been shown to be flexible:
  - Runs in D_2 or He
  - Runs over reasonable range of B_T and I_P (XP-833).
  - Takes 2-4 MW of NBI.
- Tends to land right on LLD.
  - Difficult to make downward VDEs that don't do this.



Run Plan (1/2 day ?)

- Scan the configuration, see how Li changes things.
  - "configuration"={Shape,I_P, B_T, Offset Voltage}
  - Most likely scan will be I_P=500,600,700 kA, maybe also B_T=0.4,0.5T
- Repeat each case in D_2 vs. He.
  - Recycling surface vs. pumping surface.
  - Will pumpout result in a hotter plasma in the D_2 case?
- Check the standard things:
  - Are halo currents larger or smaller with Li?
  - Has the current quench duration changed?
  - How do the halo/boundary temperature and density change?
  - Is the VDE growth rate the same?
- Operations/diagnostics issues:
  - How much evaporation required between shots?
    - Can we measure/estimate Li leaving the tray?

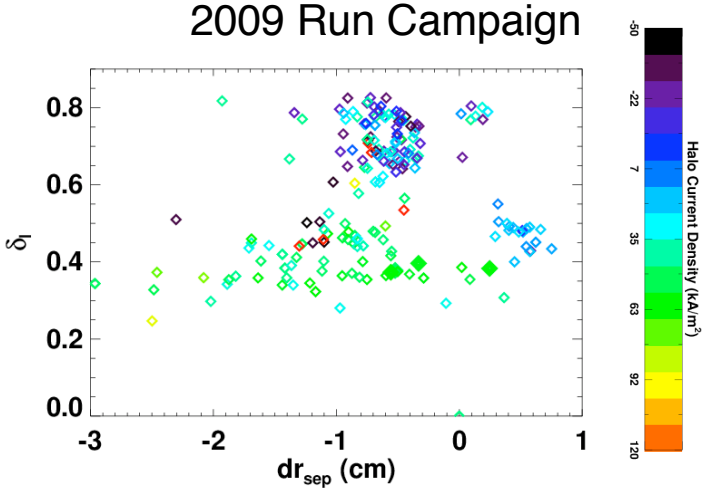
Backup

LLD Will Collect Substantial Halo Currents from Inadvertent VDEs

- Current density measured from shunt tiles in outboard divertor.
- LLD Area is ~1m^2, divided into four quadrants.
  - $A=2\pi R\delta R=2\pi\cdot 0.78\cdot 0.2=1m^2$
- Halo currents of 20-30 kA/segment should be assumed for the rare worst case.
  - Caveat, need to carefully look at the data for these worst cases.

Halo Current Density vs. triangularity and dr_{sep}

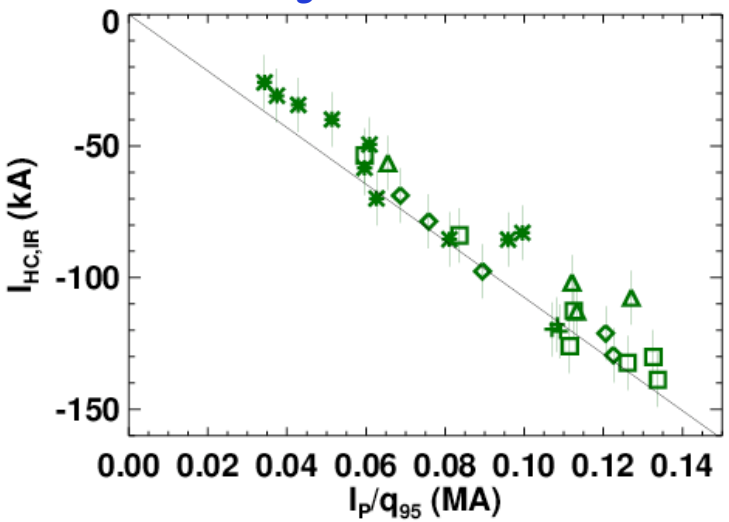
2009 Run Campaign



Strategy for this XP:

- ***Compile statistics for disruption/VDE dynamics during the 1st half of the run.***
- ***Develop baseline for "worst-case" disruptions in 2010.***
- ***Find I_p & B_T combinations that lead to HCs less than the worst case bounds.***
- ***Scans only in this range!***

"Inner Ring" Measurements From 2008



Run Plan (Cold LLD), 1/2 day

- Establish reference discharge: Ohmic 129416 is a template (3 shots)
  - Switch to D_2 in order to be compatible with LLD pumping.
  - Reduce the plasma current to fit in the allowed HC limits
- Complete one or both of the following scans:
  - q_{95} scan via I_P and B_T variations. (5 shots)
  - Downward velocity scan via offset voltage variation. (3 shots)
- May also try a few shots with NBI (3 shots)
  - Test observation in many devices that NB shots have lower HCs than Ohmic.
- Goal: Characterize the HCs
  - TPF vs. HCF for deliberate VDEs.
  - I_P and B_T scaling with more diagnostics (limited in 2008 data set).
  - Achieve good benchmark cases for ITER TA testing.
- This data is useful even without step 2.

Halo Current Diagnostics in NSTX Have Been Continually Upgraded

3 Rogowskis on the Center Column (pre-2008)

- One rogowski (CSCL1) broken into three segments.
- The other two (CSCL2 and CSCU1) continuous

Arrays of Toroidal Field Sensors (2008)

- Poloidal current flowing in vessel wall
- One array of 6 sensors near CHI gap (Inner Ring)
- One array of 6 sensors between outboard divertor (OBD) and secondary passive plate (SPP) (Outer Ring)

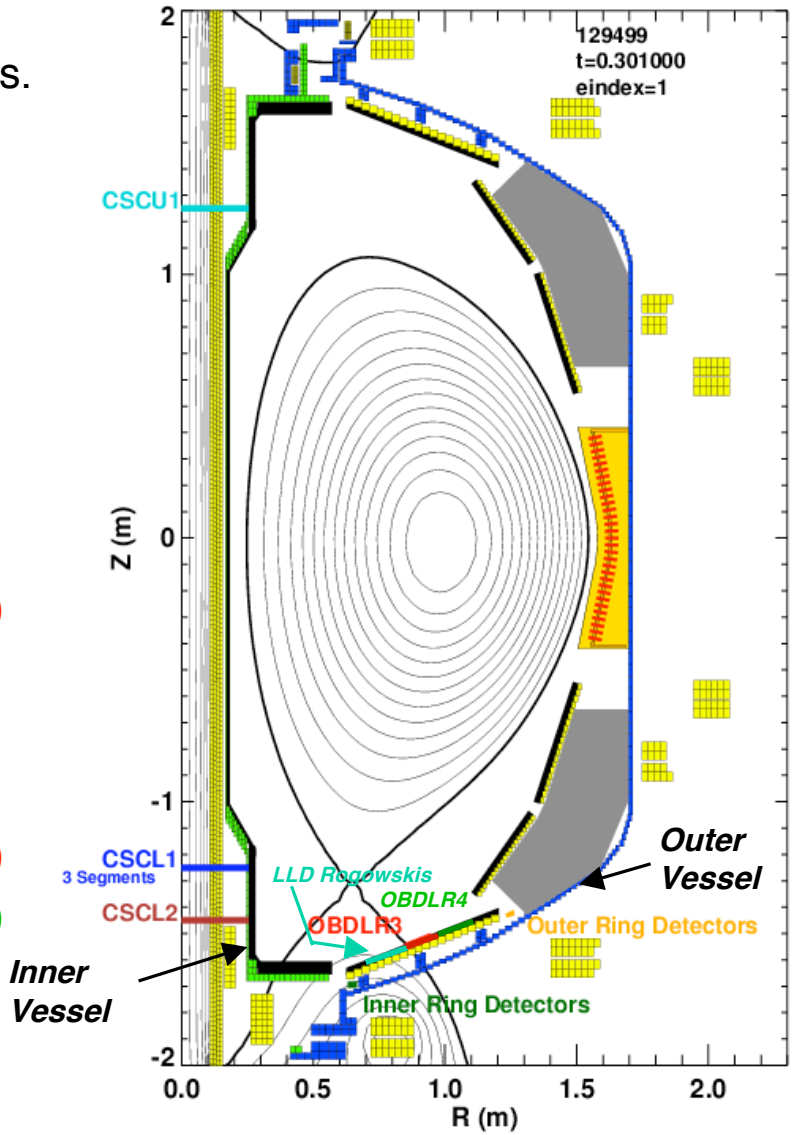
Arrays of Instrumented Tiles (2009)

- 4 Tiles in row 3 of the outboard divertor (OBDLR3)
- 90º Toroidal Separation
- Highly localized measurements of the current

Improved Instrumented Tiles and LLD (2010)

- 6 Tiles in row 3 of the outboard divertor (OBDLR3)
- 6 Tiles in row 3 of the outboard divertor (OBDLR4)
- 4 Rogowskis on the LLD centerposts
- Bias Electrodes in LLD Diagnostic Gap Tiles

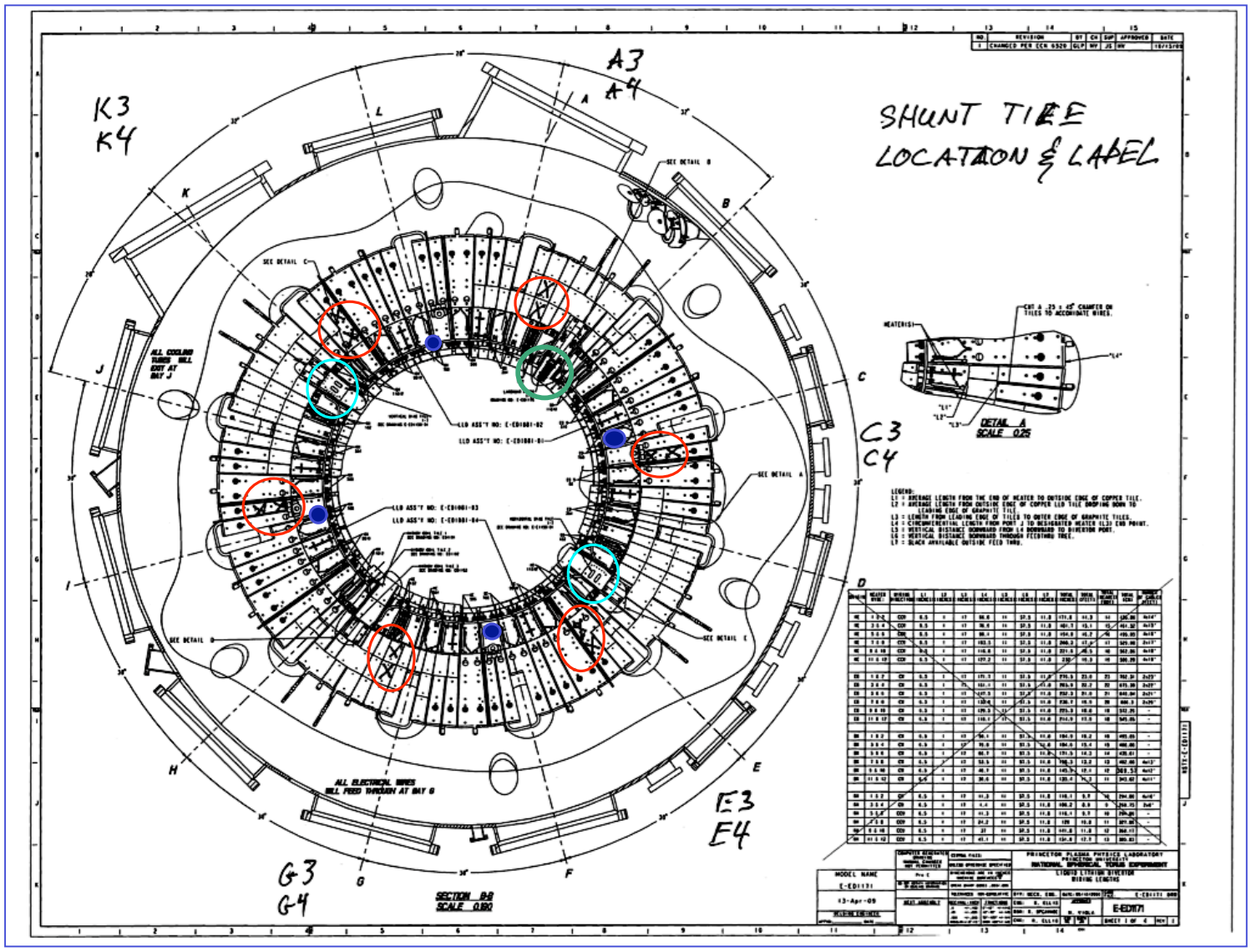
NSTX has isolated inner and outer vacuum vessels.
Only connection between them is via buss-work at the vessel bottom.



Diagnostics

- Halo current detection.
- Fast equilibrium reconstruction.
- Fast visible camera viewing divertor region.
- Fast IR camera viewing the divertor region.
  - New fast TCs?
- USXR (horizontal and a vertical cameras) viewing the lower divertor.
- Triple Langmuir probes in the super-tile for T_e, n_e measurements.

Halo Current Measurement Toroidal Coverage Expanded for 2010



Super Tile

Shunt Tiles

LLD

Centerpost

Rogowski

LLD Gap

Bias Tiles