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Disruption Physics in NSTX: Halo Currents and Thermal Loading

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2011 & 12 NSTX Research Forum
Macro-Stability breakout session
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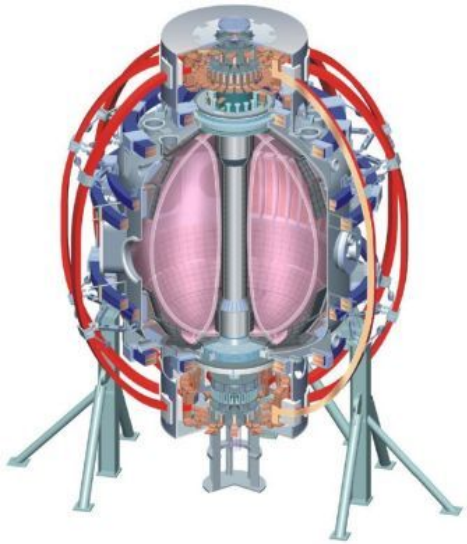

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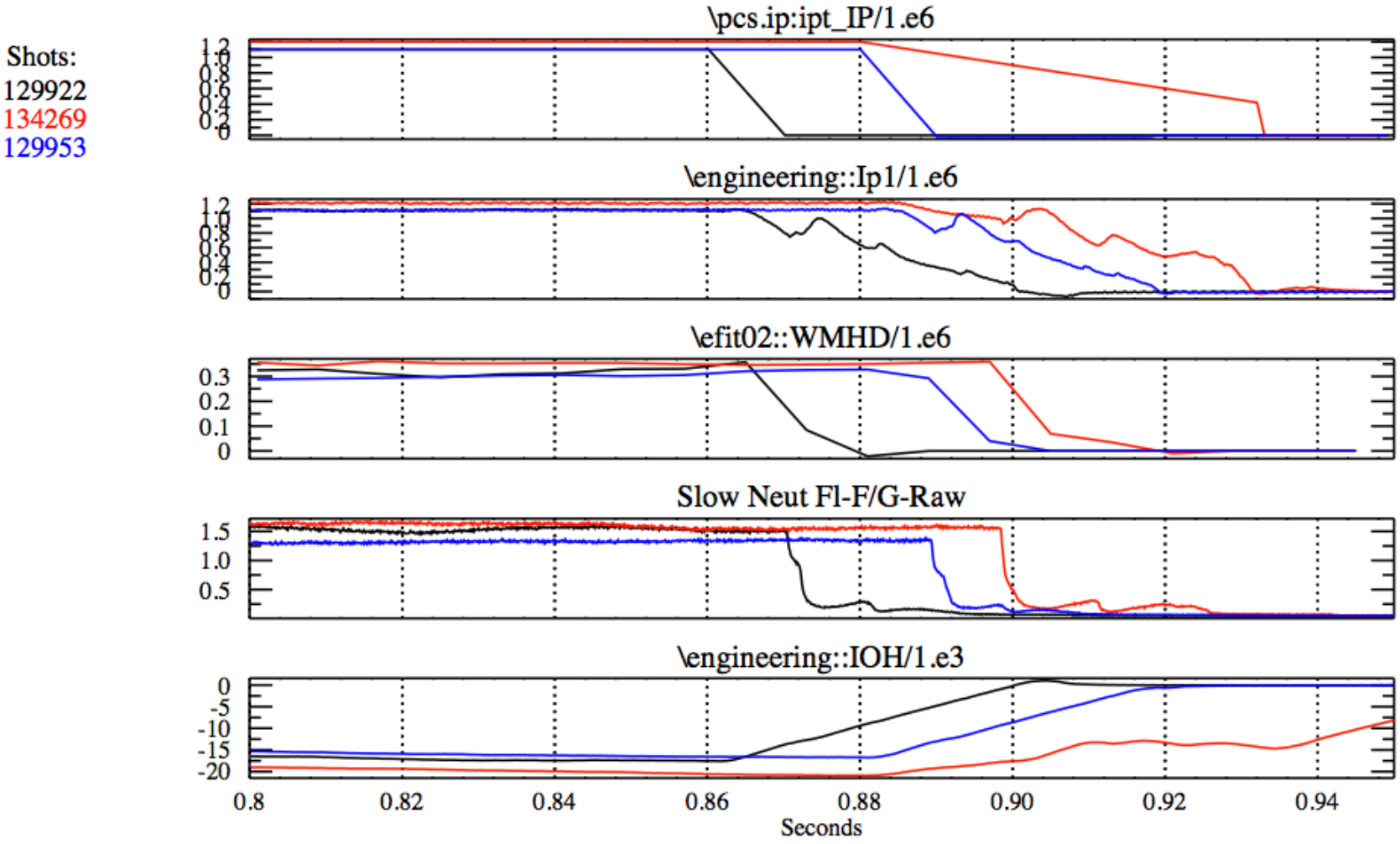
Overview of Proposed XP.

- Two disruption scenarios have been identified for study.
  - Scenario #1: Deliberate VDE with large halo currents and local heat loads.
  - Scenario #2: Centered major disruption at very high stored energy.
- Deliberate VDEs will be made to test physics of heat load dynamics and halo current rotation.
  - Stored energy scan to test whether the HC rotation scales with the diamagnetic frequency.
  - Divertor gas injection to test whether HC (n=0 and n=1) can be suppressed, divertor heat loading reduced.
- Major disruption with minimal pre-disruption energy loss.
  - Instabilities like RWMs and locked tearing modes other have large "pre-disruption" energy loss, large vertical motion before final TQ and CQ.
  - Study a recently noted high-W_{MHD} scenario with reliable, very rapid TQs.
  - Relevant to upgrade given the larger stored energy in that device.
- Both cases:
  - Study spatial, temporal dynamics of the divertor loading.
    - And compare to the core plasma energy loss
  - Study halo current rotation dynamics.
- Contributes to: MDC-15, DSOL-24

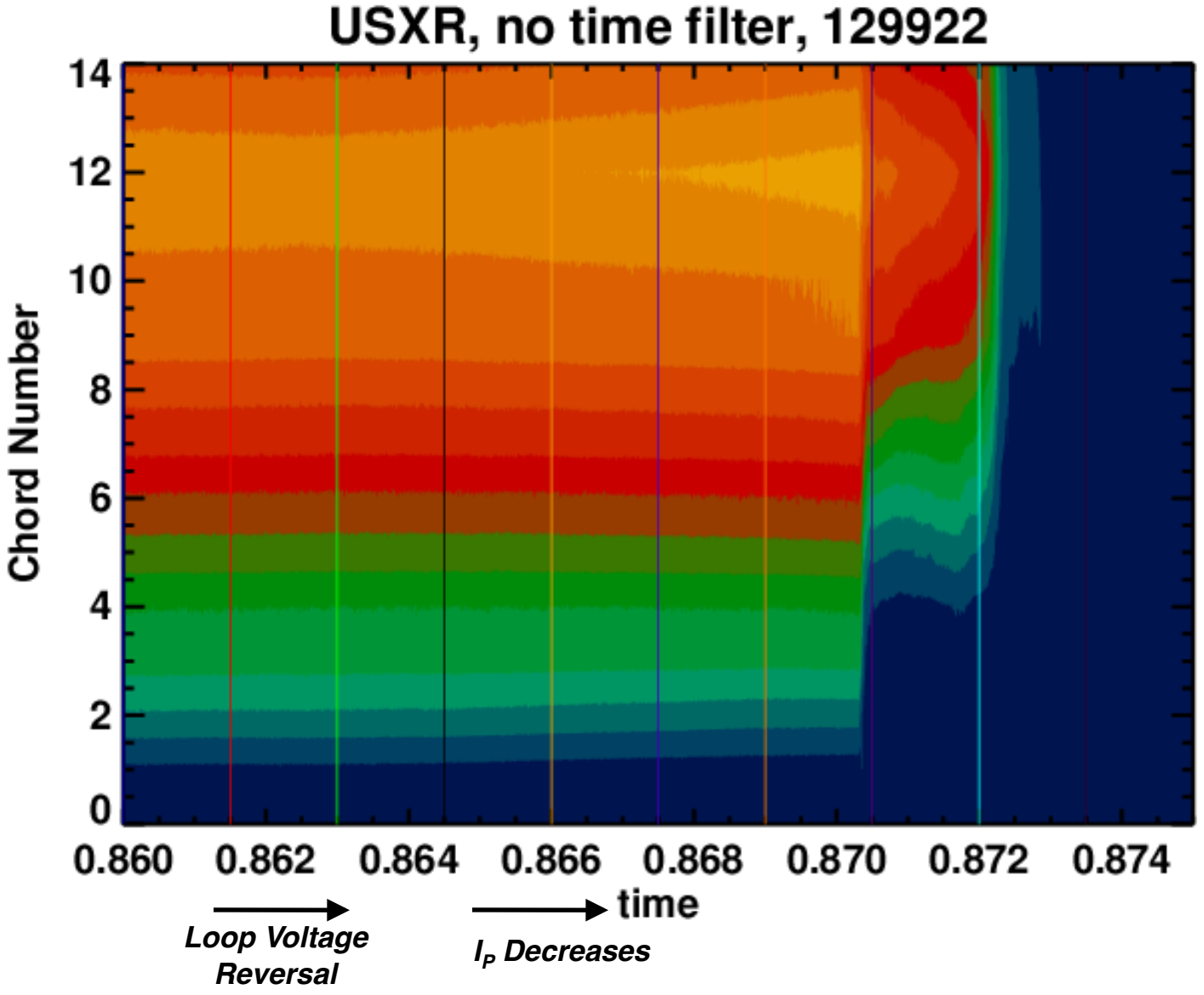
We have Recently Noted Class of High Energy Disruptions With Rapid Energy Loss

3 of the 4 largest disruptions in the last 4 years (in terms of stored energy just before disruption)



Disruption occurs soon after loop voltage is reversed
No Leading RWM, tearing mode lock, no vertical motion before TQ…
…is a unique scenario.

USXR Analysis Shows that the Heat is Lost in Two Steps, Very Rapidly

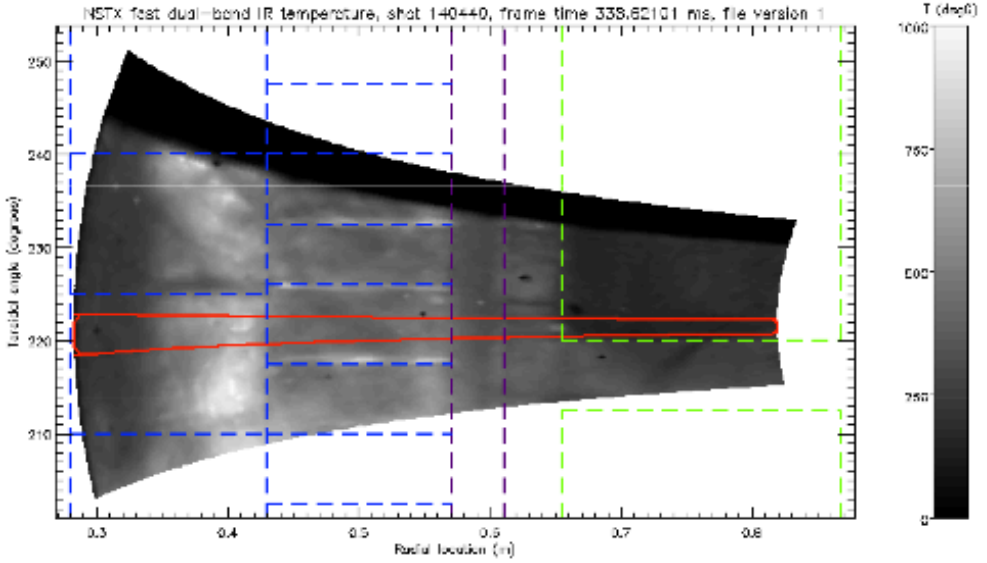


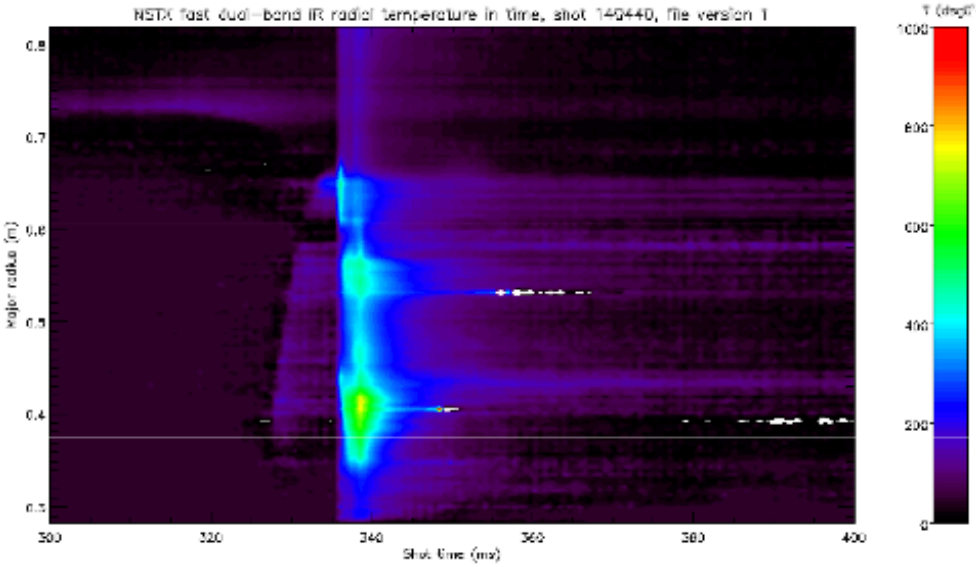
May provide an ideal scenario for studying disruptive heat transport through the SOL

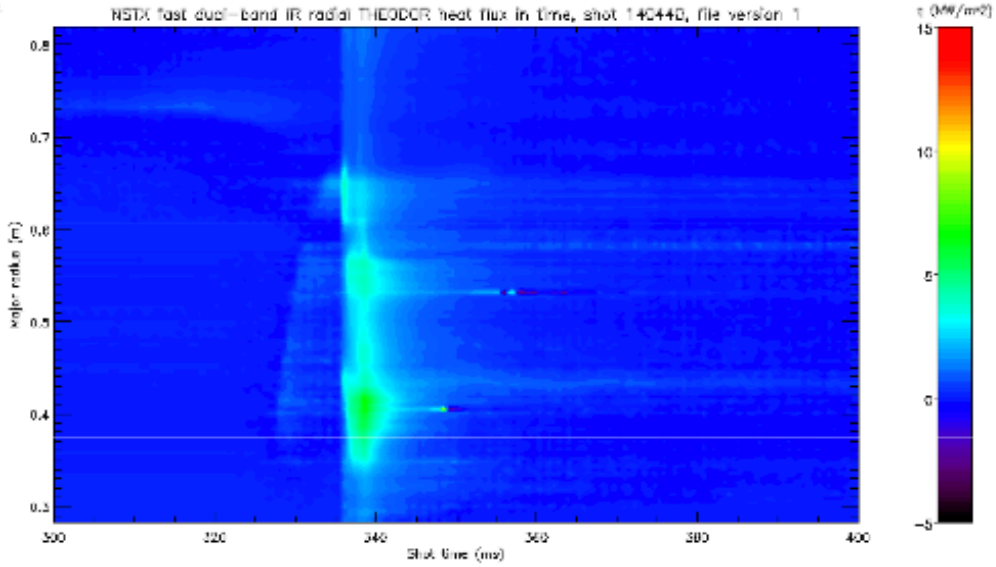
What fraction goes to the divertor? Is it spatially and temporally distributed. How large is the heat foot print compared to the steady state profile?

Fast IR Camera Demonstrated Ability to Resolve Disruption Heat Loading

- 2-D surface temperature shows significant turbulence
- T, q in t shows interesting pre-collapse signature
- Peak q using THEODOR (α=10,000) shows much (~5-10X) lower value than 1-D C&J
- Fast cooling of the surface shows that incorporation of surface layer physics is essential

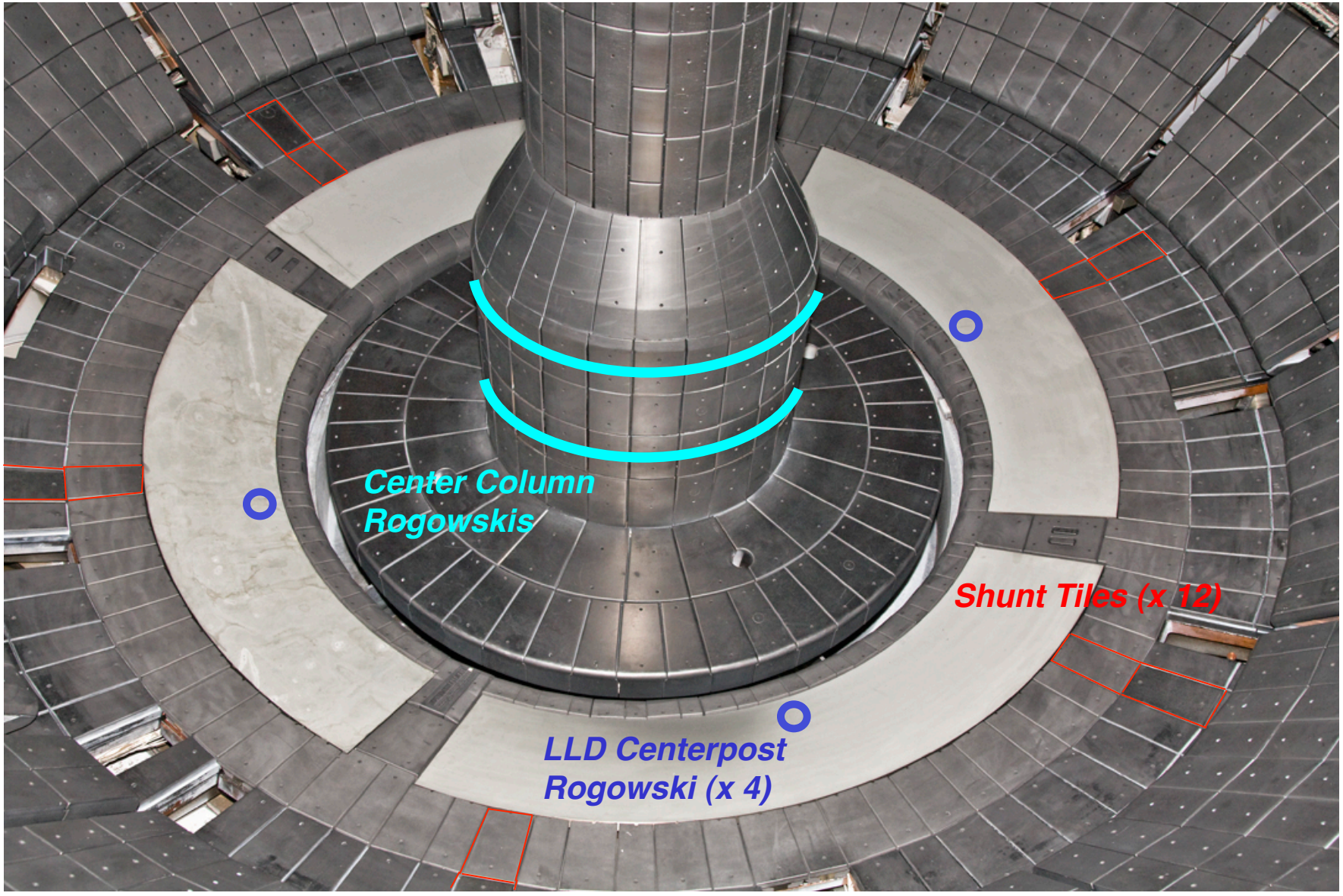






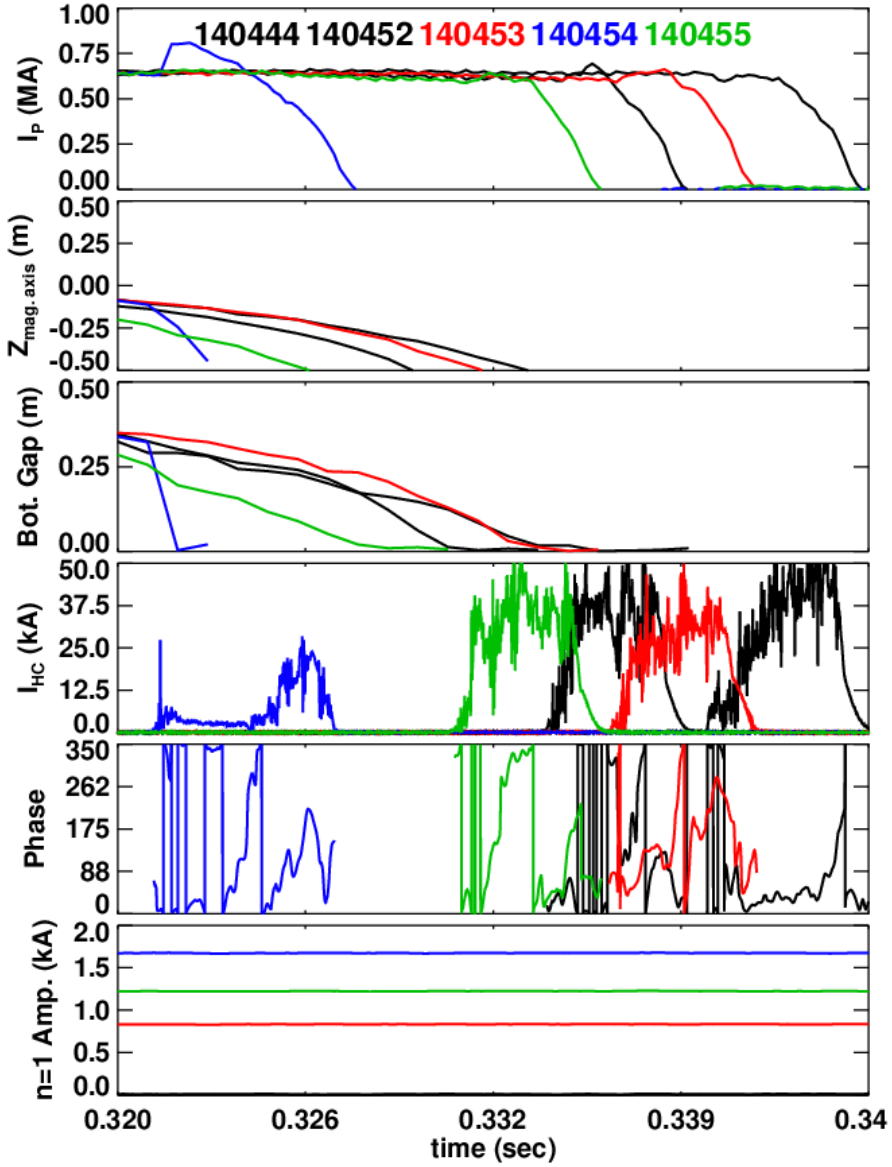
Halo Current Diagnostics Should Be Largely Similar to Those in 2010

Only change: toroidal field detectors near CHI gap were removed due to large melting of stainless covers



Tested Use of n=1 Applied Fields to Reduce Halo Current Rotation

- Deliberate VDEs, driven down, NB heated L-mode.
- n=1 fields applied just as vertical drift is beginning.
  - Large enough to drive a locked mode disruption during the VDE for 140454.
- Halo current pattern rotates in all cases.



Proposed Experiment (1 Day)

- VDE Scenario (2/3 day).
  - Scan stored energy of pre-disruption plasma.
    - See if rotation scales with plasma energy (diamagnetic effect).
    - Heat loading over a range of VDE energy levels.
  - Test impurity gas injection into divertor at time of disruption.
    - Determine if the n=1 HC can be modified by increasing the SOL resistivity.
    - See if heat loading can be similarly reduced.
- Major Disruption Scenario (1/3 day).
  - Study the development of the edge collapse with ME-USXR.
  - Study relative timing of plasma TQ and the divertor loading.
  - Determine/estimate what fraction of energy goes to divertor vs. other surfaces.
    - And how much is the SOL broadened?
  - Time permitting, scan the plasma shape (connection length?) to see how it impacts the divertor heat load.