Potential Collaborations on NCSX

with the Compact Toroidal Hybrid (CTH) group, Auburn University

Presented at NCSX Research Forum

Dec. 7-8, 2006

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CTH experiment investigates subset of NCSX research areas

- Integrity of magnetic flux surfaces
- Measurement and reconstruction of magnetic equilibrium
- Low-β current-driven instabilities and disruptions

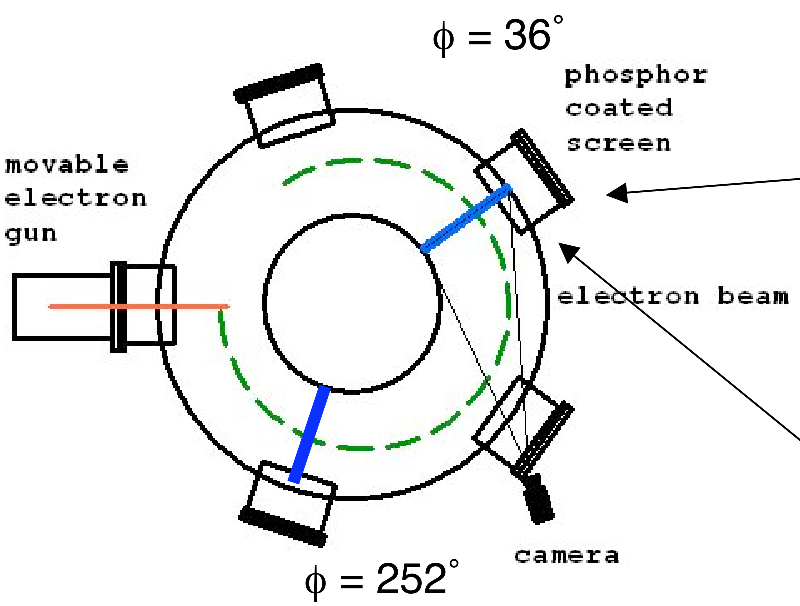
➢ **What are areas in which CTH personnel may contribute to NCSX research campaigns in FY09, FY11, and beyond?**

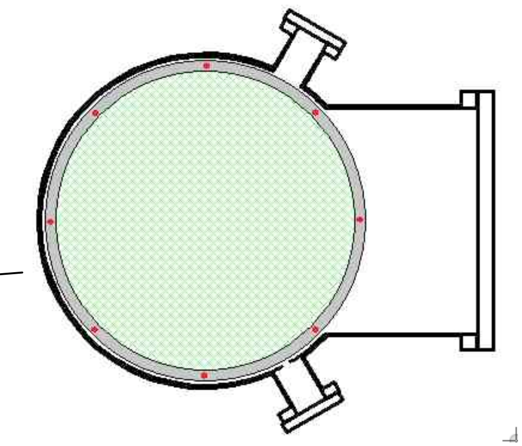
➢ **Are there specific questions for research preparation on NCSX useful to address on CTH?**

Collaborative Research Interests

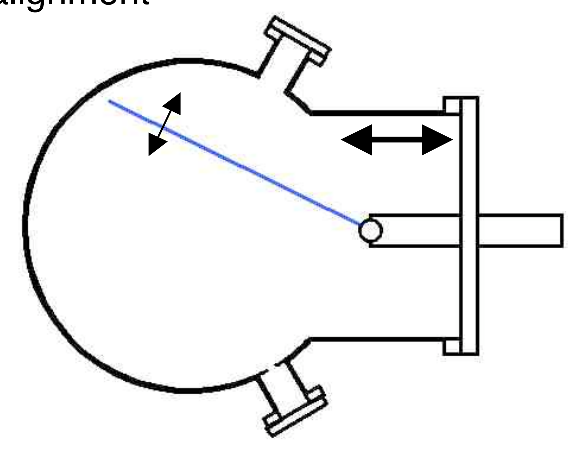
- How to determine/confirm best coil model from field-mapping and other magnetic measurements?
- Can we adequately reduce static islands in the vacuum configuration
- What are effects of (controlled) static islands on both equilibrium and stability?
- Can we identify location (phase) of islands in plasmas?
- Compare predicted LCFS with edge profile measurements.
- How well can we reconstruct current profile from external magnetics, and if we include internal B-measurement (e.g. mm-wave Faraday rotation)?
- Is control of external rotational transform profile robustly effective in avoiding current-driven disruptions?

E-beam mapping for accurate coil modeling





ZnO phosphor-coated wire mesh w/ LED's at edge for alignment



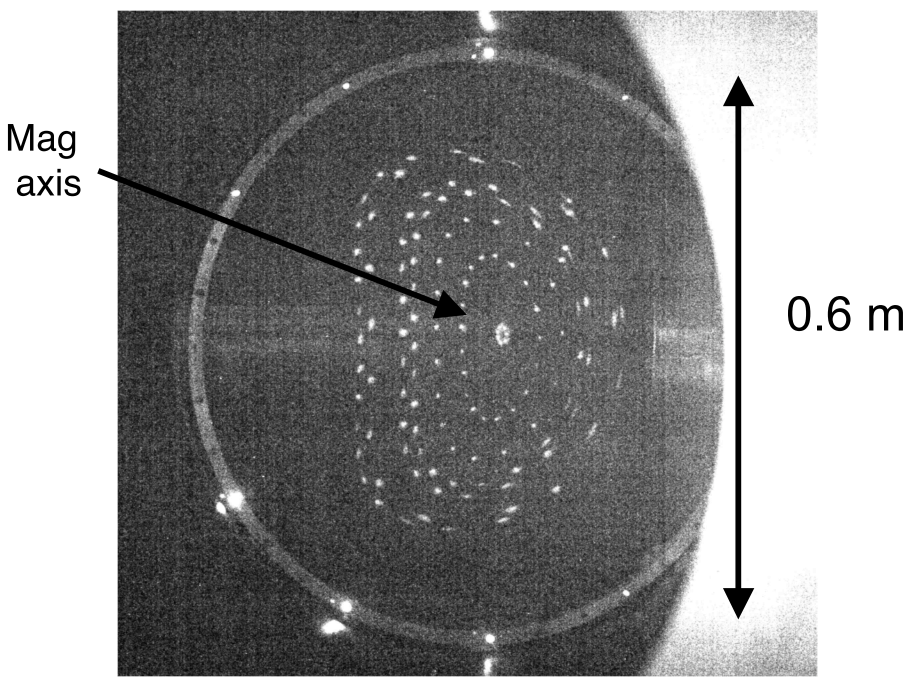
Movable phosphor-coated wand

Entire set-up (gun, screen, camera) was rotated toroidally by two field periods to test for n>0 deviations in equilibrium.

CTH exhibits good flux surfaces

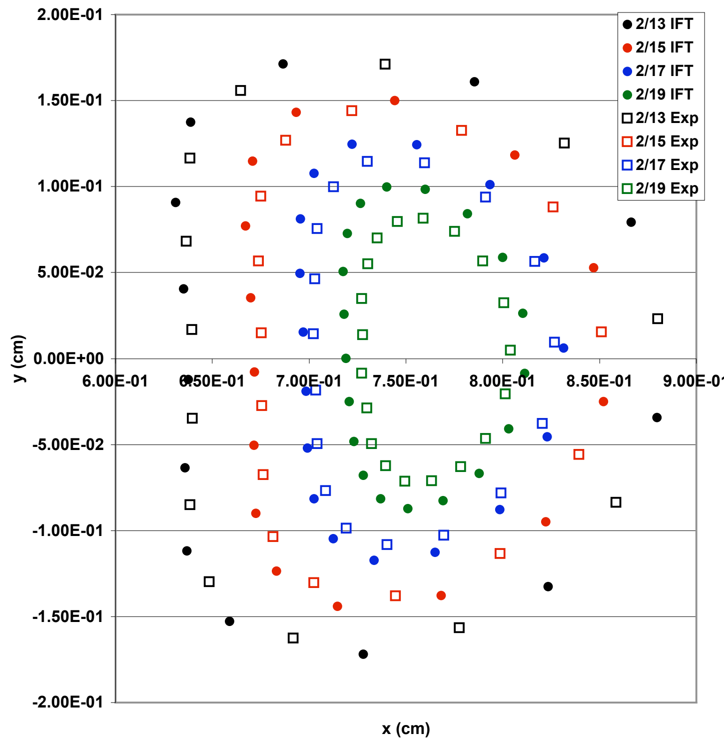
Low rotational transform (iota_edge ≤ 0.2) with zero auxiliary toroidal field

- no low-order rational surfaces => no islands
- Low aspect ratio configuration achieved



Composite photo of measured flux surfaces

Magnetic axis localized to within several mm



Comparison of model from IFT (closed symbols) w/ expt. (open symbols)

Small deviations from design investigated by least-squares fitting

Alter coil model by varying coil parameters in optimizer in IFT line-following program;

- least squares fit of differences between multiple experimental **magnetic axis** positions and computed results.

- includes B_{EXT},poloidal coil positions and currents, helical coil winding law

  Example: Helical coil winding law (ϕ tor. Angle; θ pol. Angle)

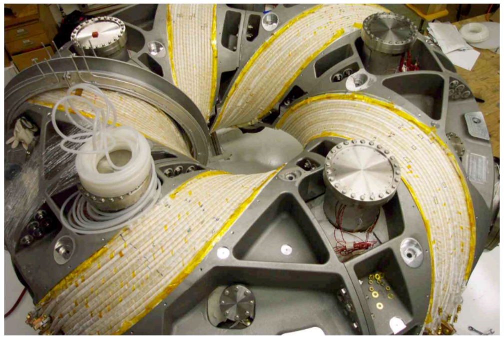
  $\phi = 2/5\ \theta + \beta_1 \sin\theta + \beta_2 \sin 2\theta$

  $r_{COIL} = r_0 + a_1 \cos\theta + b_1 \sin\theta + \ldots$

- perform SVD analysis to identify likely source(s) of error (Hanson/Muñoz)

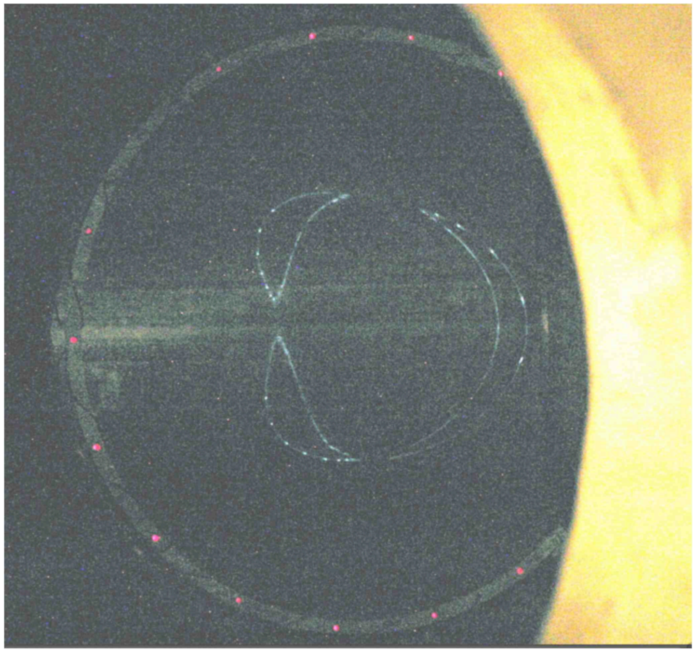
In design, $r_0 = 0.385$ m, $a_1 = b_1 = 0$
Best fit: $r_0 = 0.384$ m, $a_1 = 2.6$ mm, $b_1 = 0.7$ mm

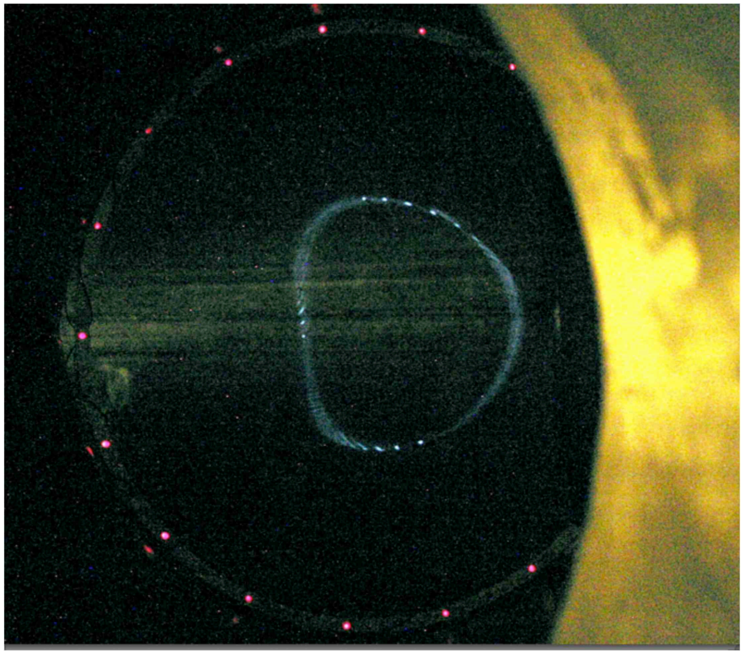
Results also directed us to find flaw in vertical field configuration (0.4% field imbalance)



=> Continuing to validate this scheme

Static island successfully reduced





1/3 island reduced to minimal width by application primary & (orthogonal) secondary corrections

Contributions to field mapping on NCSX

- Provide analysis & modeling
  - Apply validated SVD analysis procedure to NCSX coil model and measurements
  - Use field-mapping results to assist in placement of correction coils, if not already fully designed & emplaced.
  - Suppression of vacuum islands

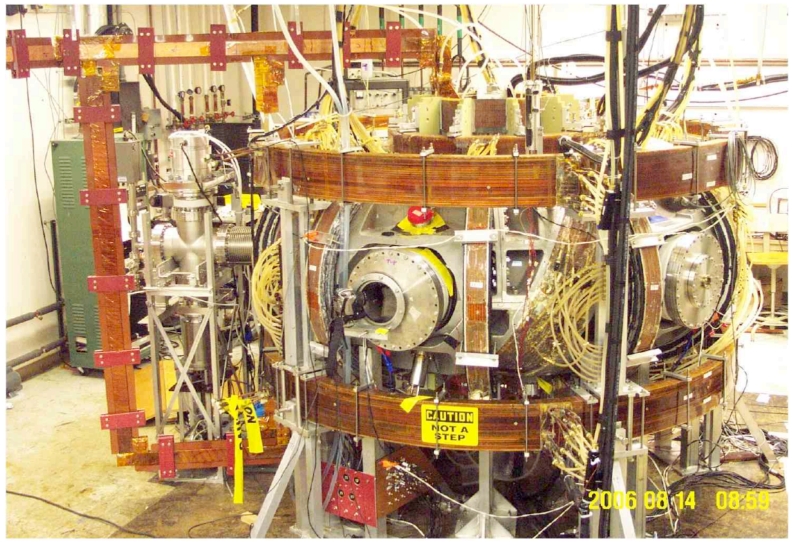
- Provide test-bed for NCSX techniques
  - Can we (or should we) map at pulsed high field (B~0.5 T) to reduce effect of remnant fields?
  - Test techniques for faster, more accurate mapping
  - Possibility of field-mapping at different toroidal locations

- Contribute existing hardware.

Extra

CTH program: field-mapping & ECRH plasmas supplemented by ohmic current

- Easily alternate between field-mapping & plasma operation
- Densities up to 4×10^{18} m^{-3} (ECRH) cutoff attained; higher with ohmic current
- Diagnostics
  - -Segmented Rogowski coils
  - -Flux loops
  - -Diamagnetic loop
  - -Langmuir probes
  - -SXR arrays; 4mm interferometer



5 field periods
R_o =.75 m, $R/\langle a \rangle \geq 4$
$B_o \leq 0.7$ T
$I_p \leq 30$ kA; $\Delta\iota \leq 0.5$
P_{in}= 15 kW ECRH @18GHz