

Proposals for Monitoring and Actively Driving SOLC on NSTX-U for Machine Protection and Performance Extension

- 1. Monitor SOLC for machine protection**
- 2. Compensate for SOLC-generated error field in machine control and equilibrium reconstruction**
- 3. Drive SOLC externally for machine performance extension**

Hiro Takahashi

Princeton Fusion Research LLC

Presented at

NSTX-U Facility Enhancement Brainstorming

February 7-8, 2012



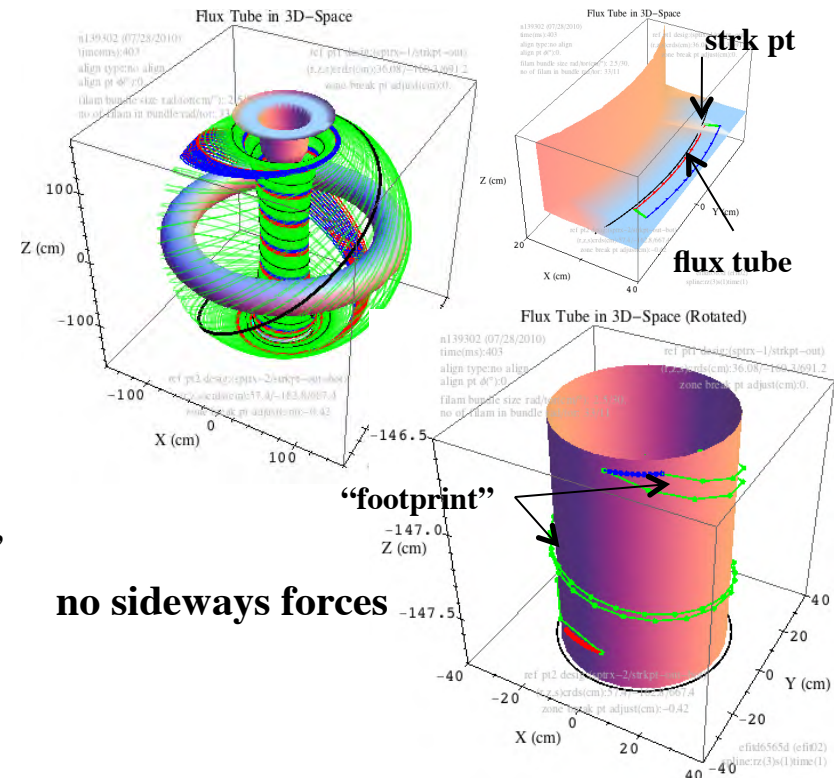
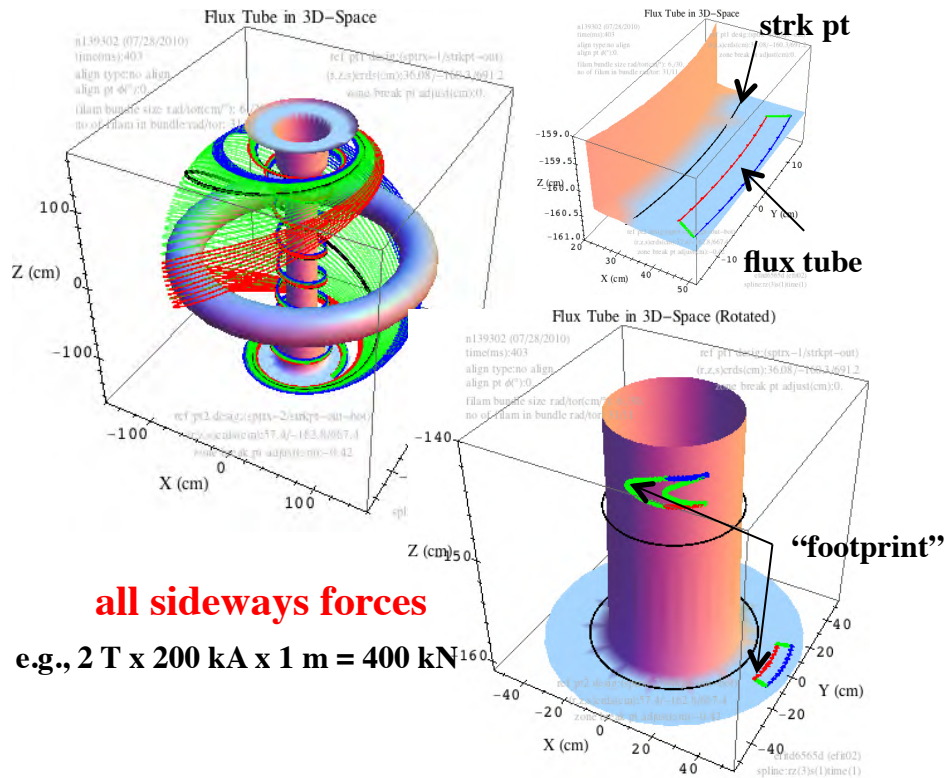
February 8, 2012

Takahashi NSTX Brainstorm

Field-line Structure Affects Sideways Forces on Center Stack

**low-shear
retains asymmetry**

**high-shear
destroys asymmetry**

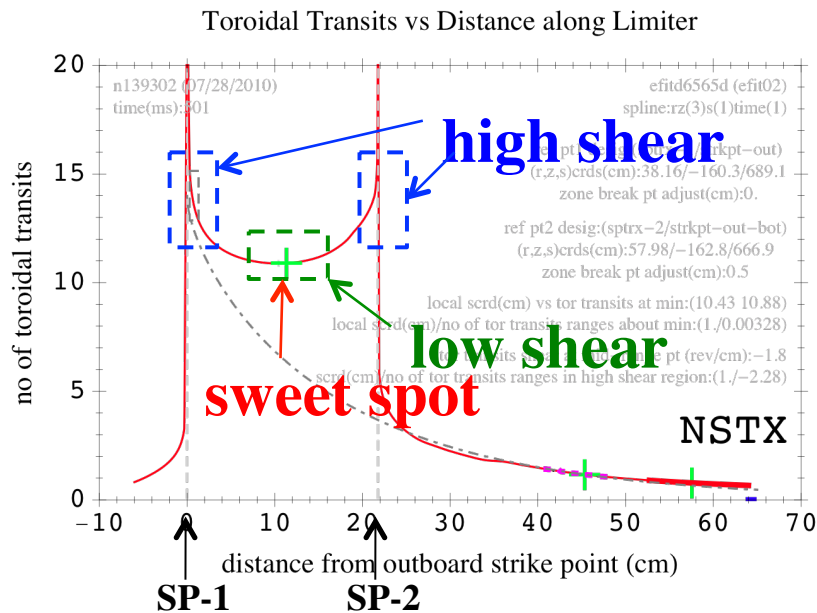


Narrow (~ 30 deg) rotating peaks have been observed; stationary narrow peaks could elude detection by a sparse sensor array.

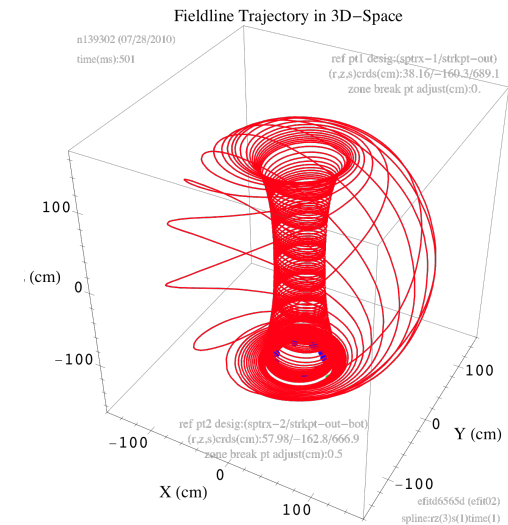
Important to monitor where SOLC flows.

Drive SOLC for Performance Extension

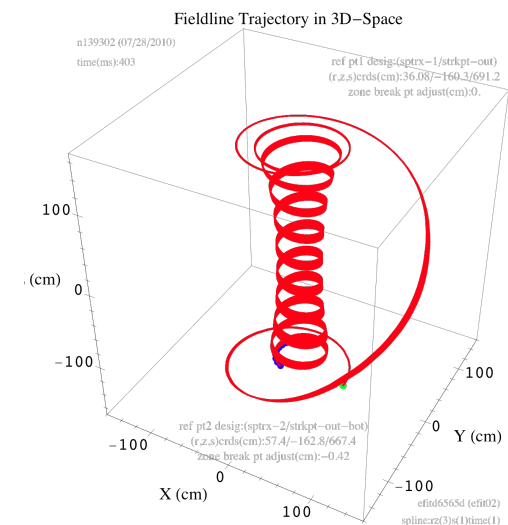
Toroidal Transits Executed by a Field Line



Wide Band



Narrow Band



- Create **stochastic** field via 3D field caused by narrow-band SOLC driven at sweet spot for:
 - On-demand **ELM Trigger** to expel impurity from long steady-state (density) discharges.
 - Possible extension to **runaway mitigation** method.
- Improve **vertical stability** (n-index) at high aspect ratio via 2D field generated by SOLC driven in high-shear regions.

From APS '11



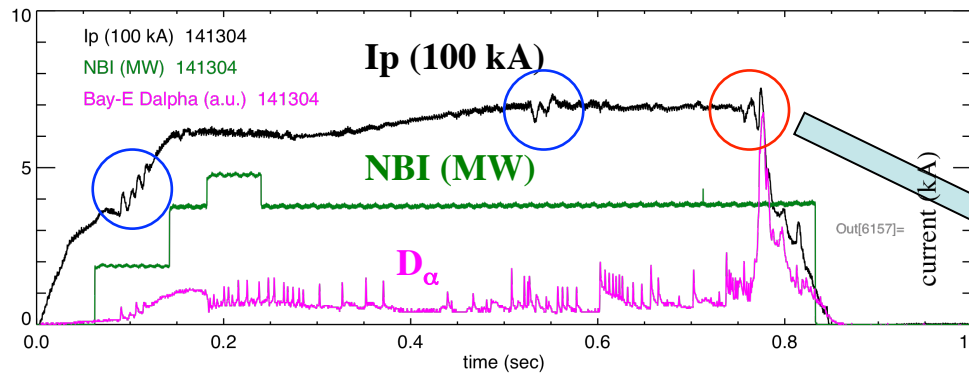
February 8, 2012

Takahashi NSTX Brainstorm

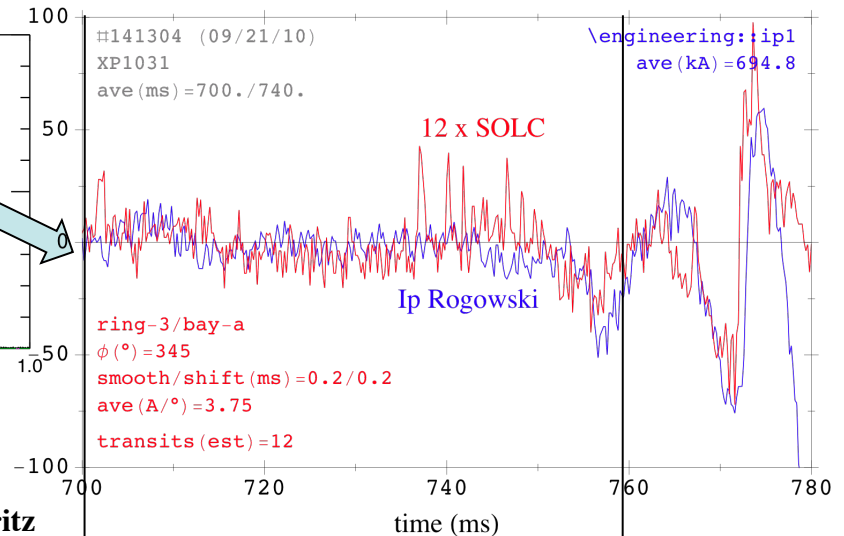
3

Compensating Magnetics for SOLC May Help Performance

Discharge Overview



Toroidal Current (Deviation from Mean) vs Time



A commonly observed I_p signal behavior just before disruption may be traced to SOLC, not to true plasma current.

SOLC may account for up to ~10 % of I_p signal in this discharge.

Did this discharge die an unnecessary death because feedback control tried to save the discharge when it needed no saving???

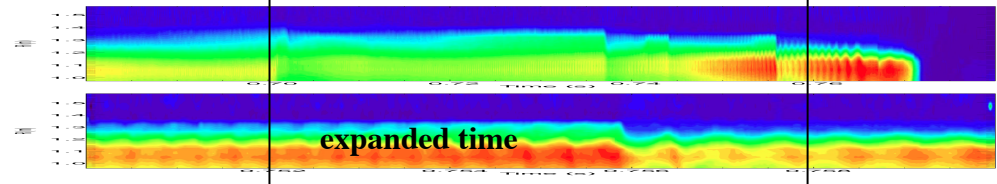
High-performance (parameter-pushing) discharges may be sensitive to control/equilibrium errors.

From NSTX Results Review - MHD, '11



February 8, 2012

K. Tritz



Axisymmetric and/or non-axisymmetric parts of SOLC may affect machine performance:

- Report false plasma current and position
- Sound false alarm for growing MHD modes
- Report false MHD mode phase (*positive* feedback)
- Change vertical stability (n-index)
- Destabilize MHD modes
- SOLC field significant fraction of equilibrium field at measurement points (DIII-D)

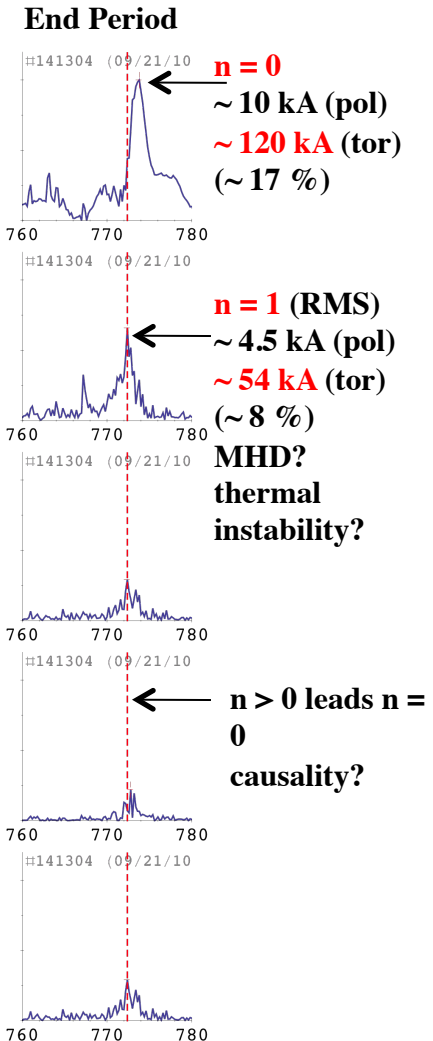
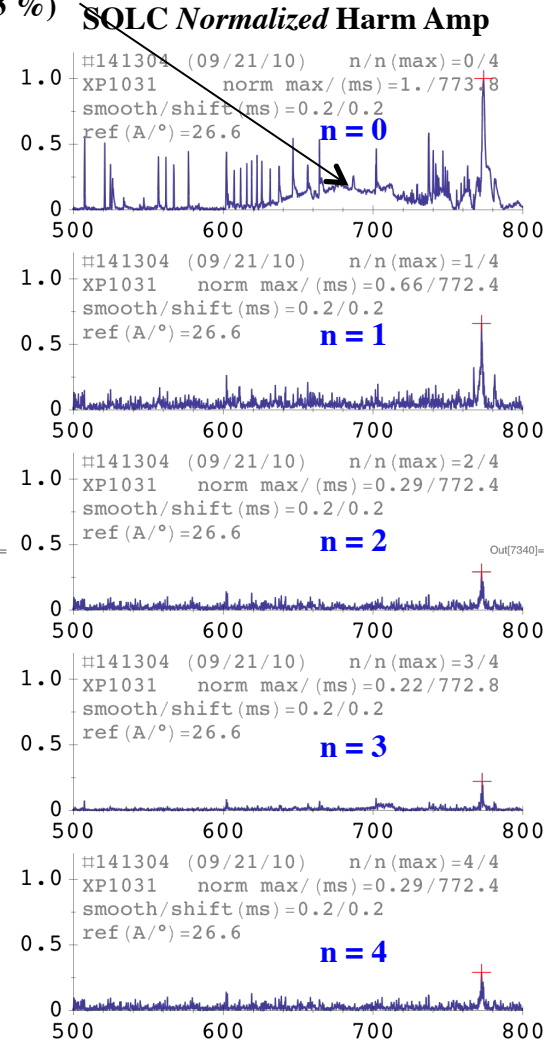
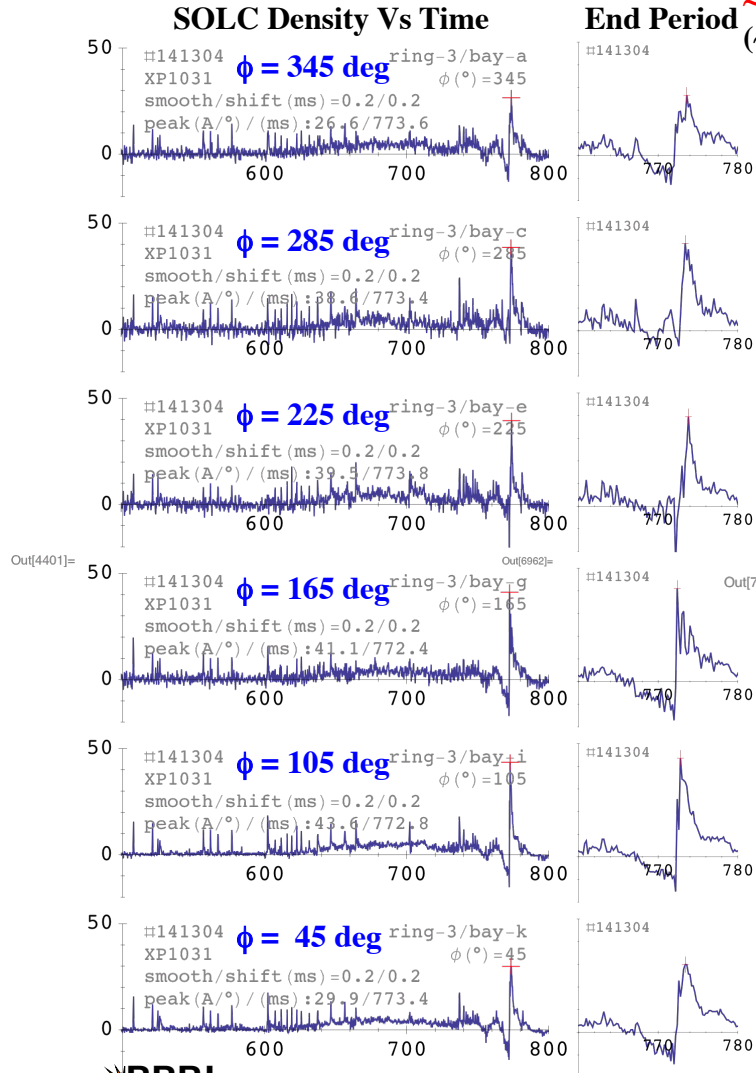
Takahashi NSTX Brainstorm

Large Current Flows in Near SOLC Zones

Toroidal Spatial Variations

n = 0
 ~ 1.9 kA (pol)
 ~ 23 kA (tor)
 (~ 3 %)

Toroidal Harmonic (SVD) Analysis



Summary

- Monitor SOLC signals for delineating **safe operating space**.
- Use SOLC for magnetic compensation in **machine control** and real-time/off-line **equilibrium reconstruction** for improved performance:
 - Tile-current sensor arrays
 - Magnetic sensor arrays
- Create **stochastic** field via 3D field caused by narrow-band SOLC driven at sweet spot for:
 - On-demand **ELM Trigger** to expel impurity from long steady-state (density) discharges.
 - Possible extension to a **runaway mitigation** method.
- Improve **vertical stability** (n-index) at high aspect ratio via 2D field generated by SOLC driven in high-shear regions.