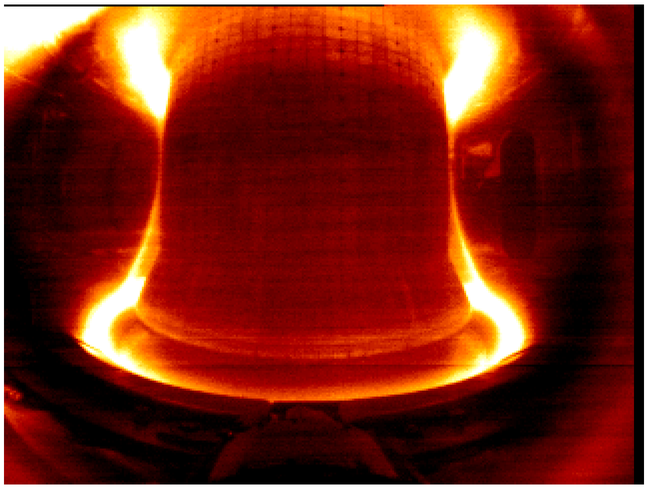
SOL Flows Coupled to the Core as an Explanation for the Up-Down Asymmetry in the L/H Threshold



Presented by M. Greenwald
B. LaBombard , A. Hubbard, J. Rice, J. Hughes

TTF – April, 2004

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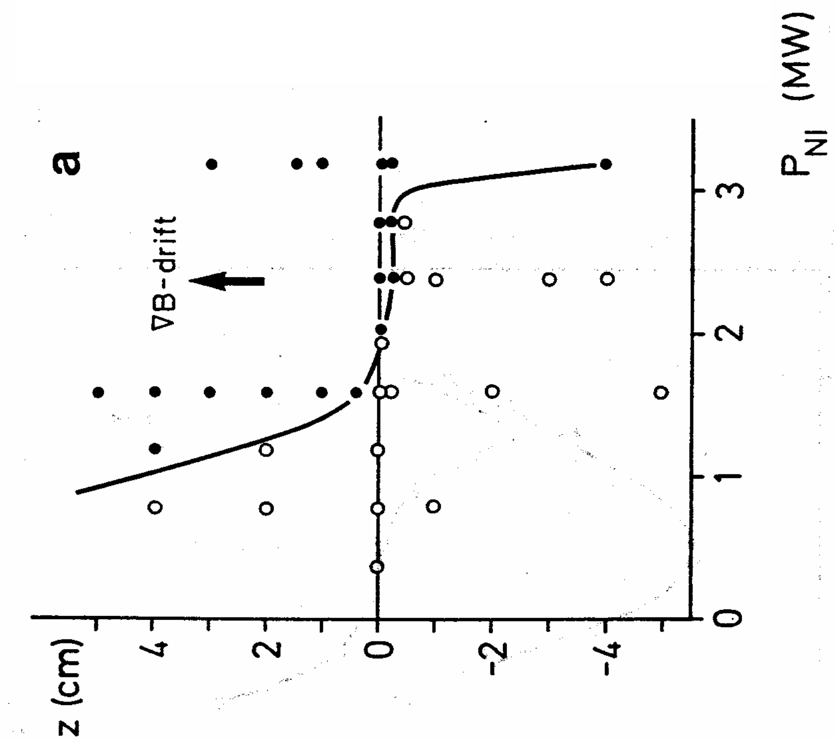
The Effect the ∇B Drift Direction on the H-Mode Threshold is 0th Order and Requires a Robust Explanation

- The L/H Power threshold is typically ~2x higher when ion ∇B drift direction is away from X-point in single null topology when compared to case where ∇B drift direction is toward X-point.
- First reported on Asdex in 1989
- "Universal" result



Asdex 1989

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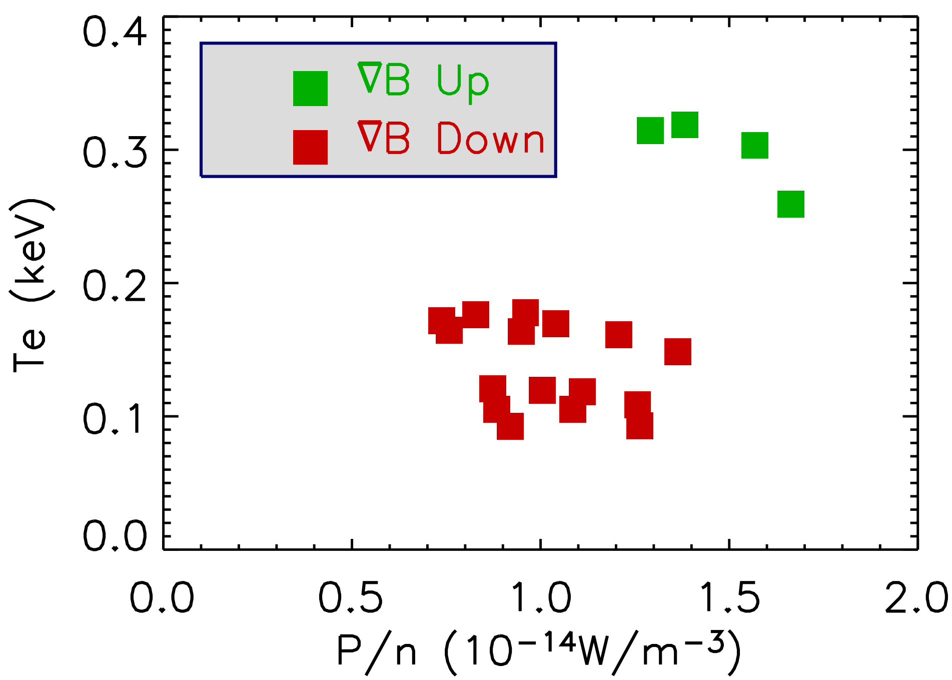
Change is Apparently in Threshold Conditions not in Underlying L-Mode Confinement



Hubbard 1996

- For fixed conditions (Power, density, current, etc.), edge profiles are similar for both topologies.
- Global power threshold can be recast as condition on local edge temperature or gradient.
- For unfavorable drift direction, threshold Te is about 2x higher

- Size of effect suggests looking for large asymmetries – only occur near separatrix or beyond.

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Thesis

1. Core flows respond strongly to changes in SOL flows
   (SOL flows provide the boundary condition for core flows)

2. The SOL flow responds strongly to changes in magnetic topology.

2a. Explained by strong ballooning character of turbulent transport.

3. This topology dependent boundary conditions for plasma flow may be the explanation for the ∇B drift effect on the H-mode threshold

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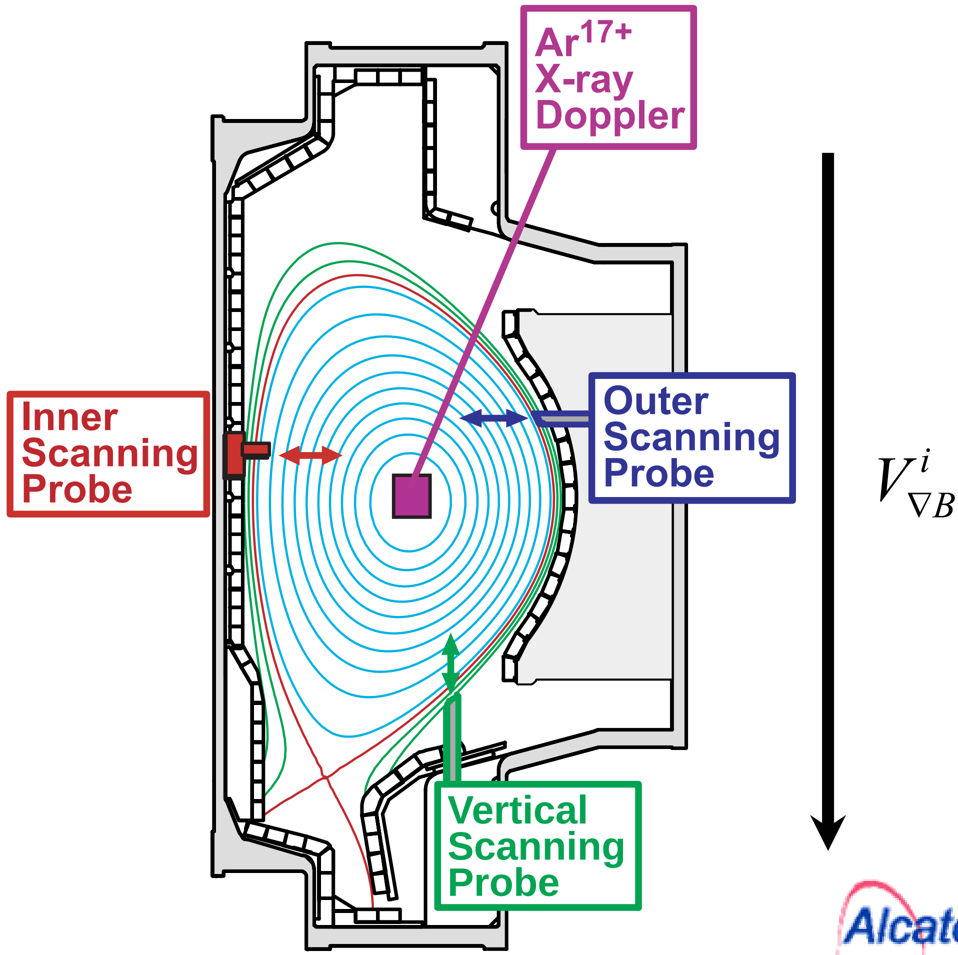
Plasma Heating and Rotation Measurements Without NBI on C-Mod - Provides an Excellent Laboratory to Study These Effects

- Heating is with ICRH + OH
- **Changes in core reflect changes in boundary conditions**
- SOL flows measured at three locations by fast scanning probes
- Core rotation profiles measured passively with high-resolution x-ray spectrometers



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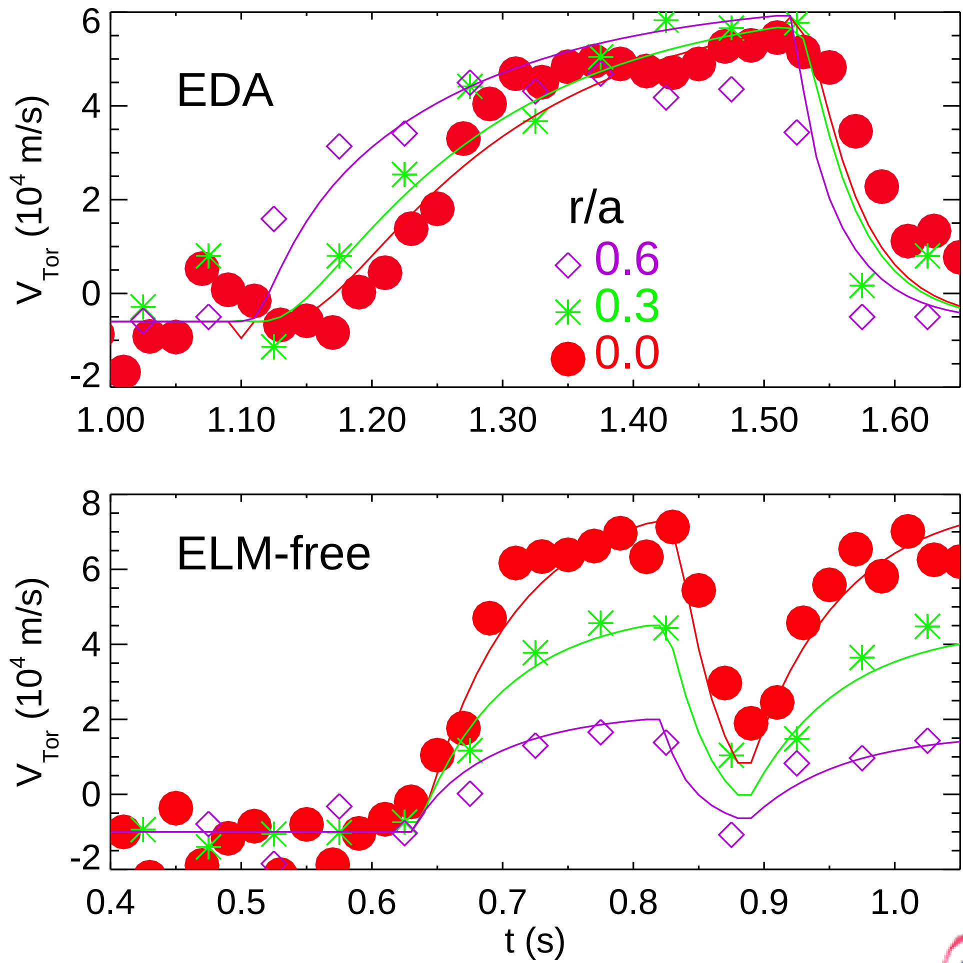
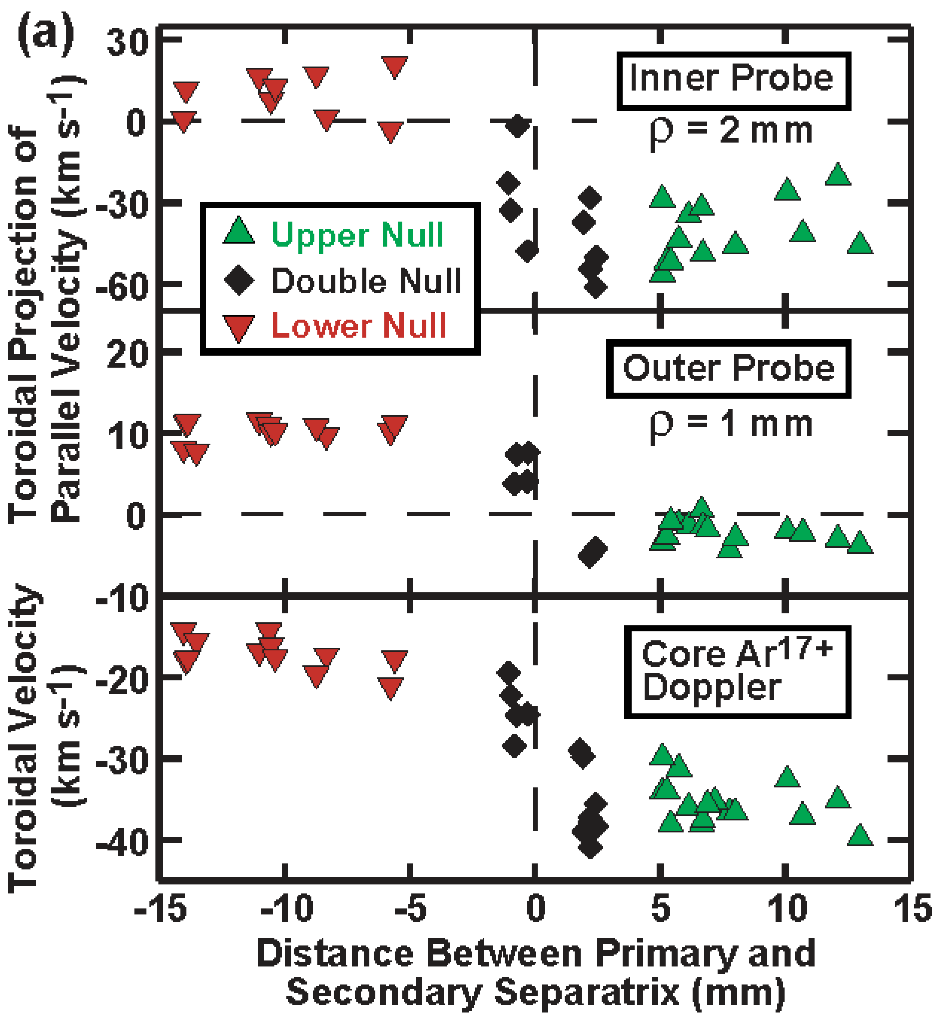
Momentum Is Observed to Be Transported From Outside Inward Into Core

- Core rotation responds to change in edge – L/H transition
- Momentum is observed to diffuse and convect inward.



Rice 2003

Core Rotation Shows Same Topology Dependence as SOL



LaBombard 2004

- Change in core flows with topology is in same direction and same magnitude as SOL flows
- Core flows exhibit the same extreme sensitivity to edge topology! – each mm counts
- SOL flows are near sonic on high-field side.

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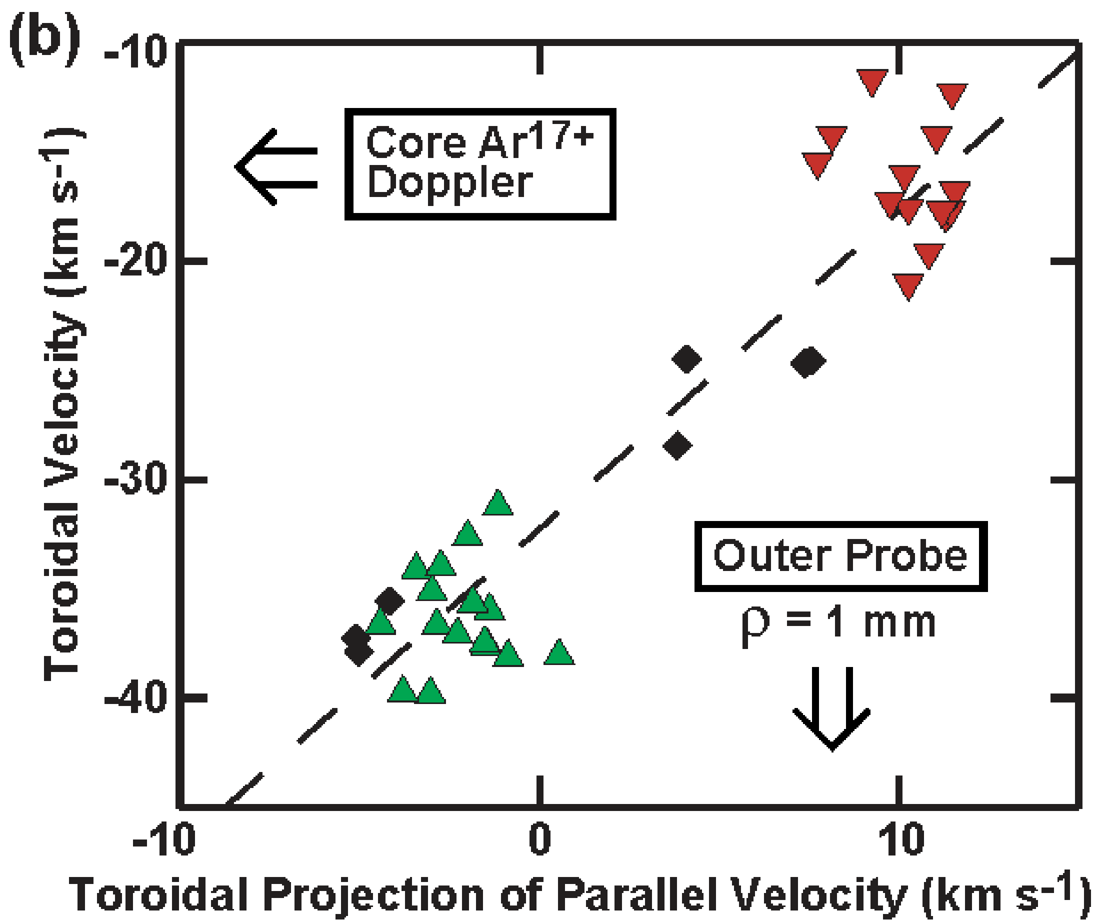
Core and SOL Flows are Well Correlated



- Note: Core and SOL flows track but are **not** identical

So… What is the origin of SOL flow?

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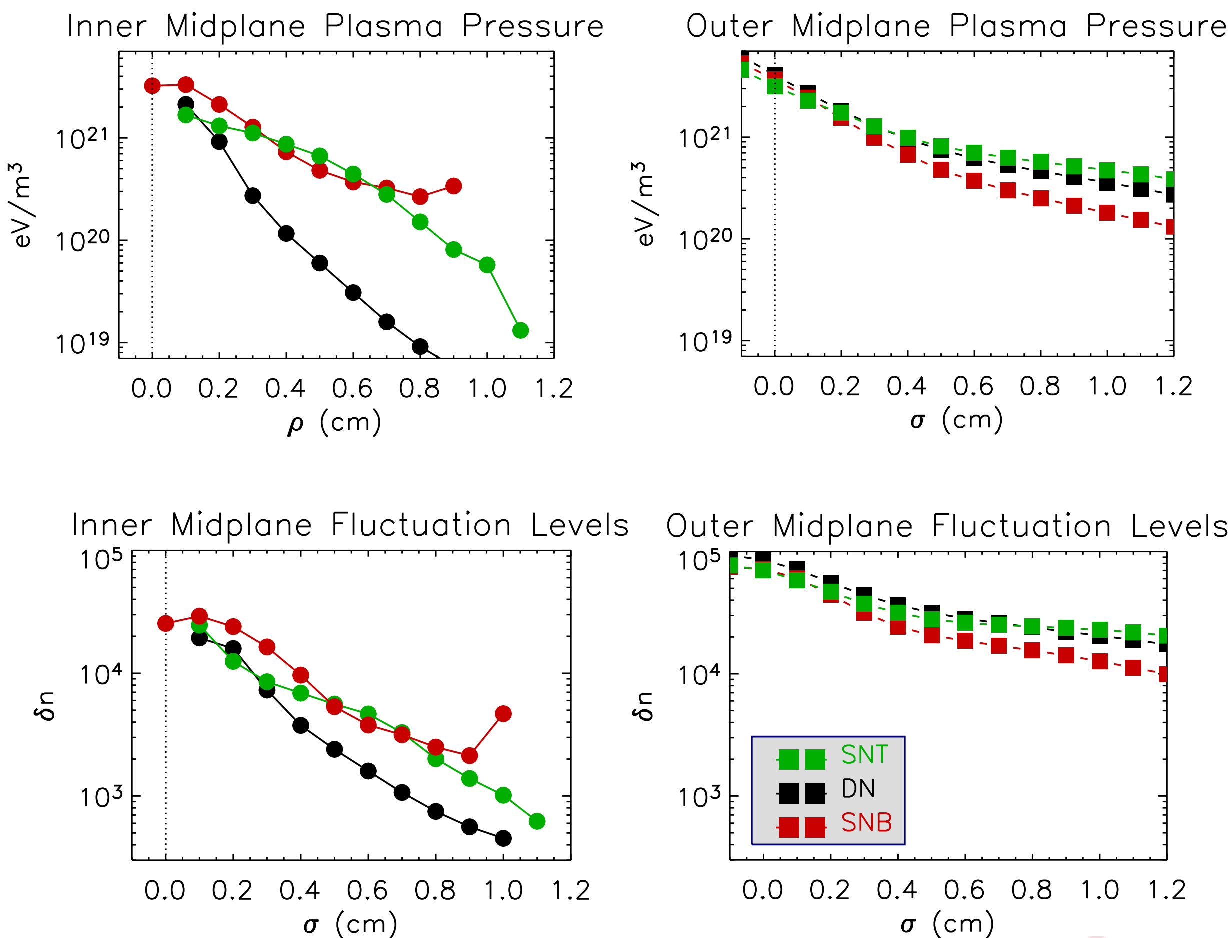
Plasma From Ballooning Transport Flows Along Field Lines to Populate High-Field SOL

- Much higher fluctuation levels (⊥ transport) on low field side – ballooning
- When high-field side is connected (SN), shows similar plasma density
- When not connected (DN), no plasma
- So for SN plasmas, symmetrizing flows are robust feature of SOL



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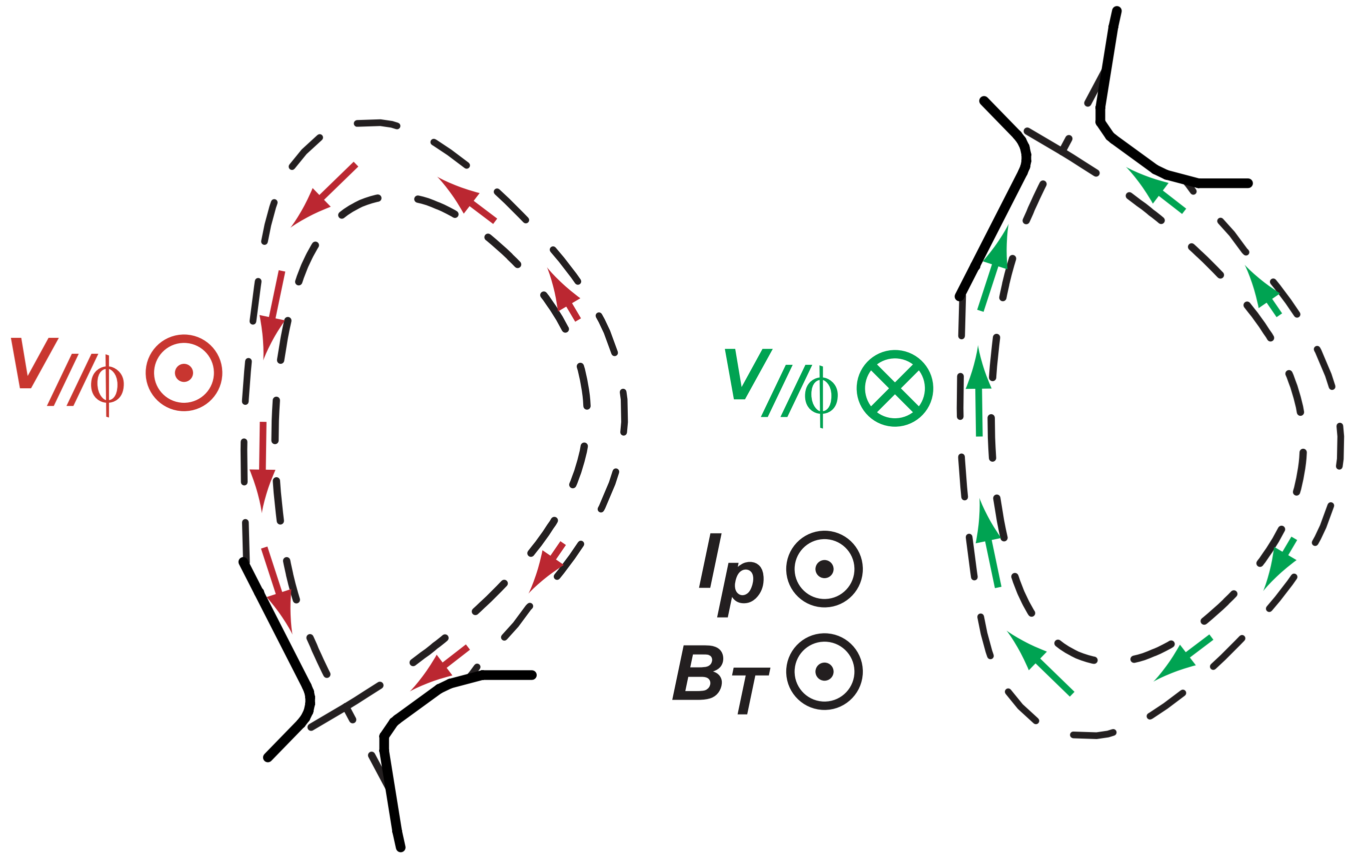
Symmetrizing Flows Driven By Ballooning Transport are Co or Counter Depending on Topology

⊥ transport-driven parallel SOL flows:



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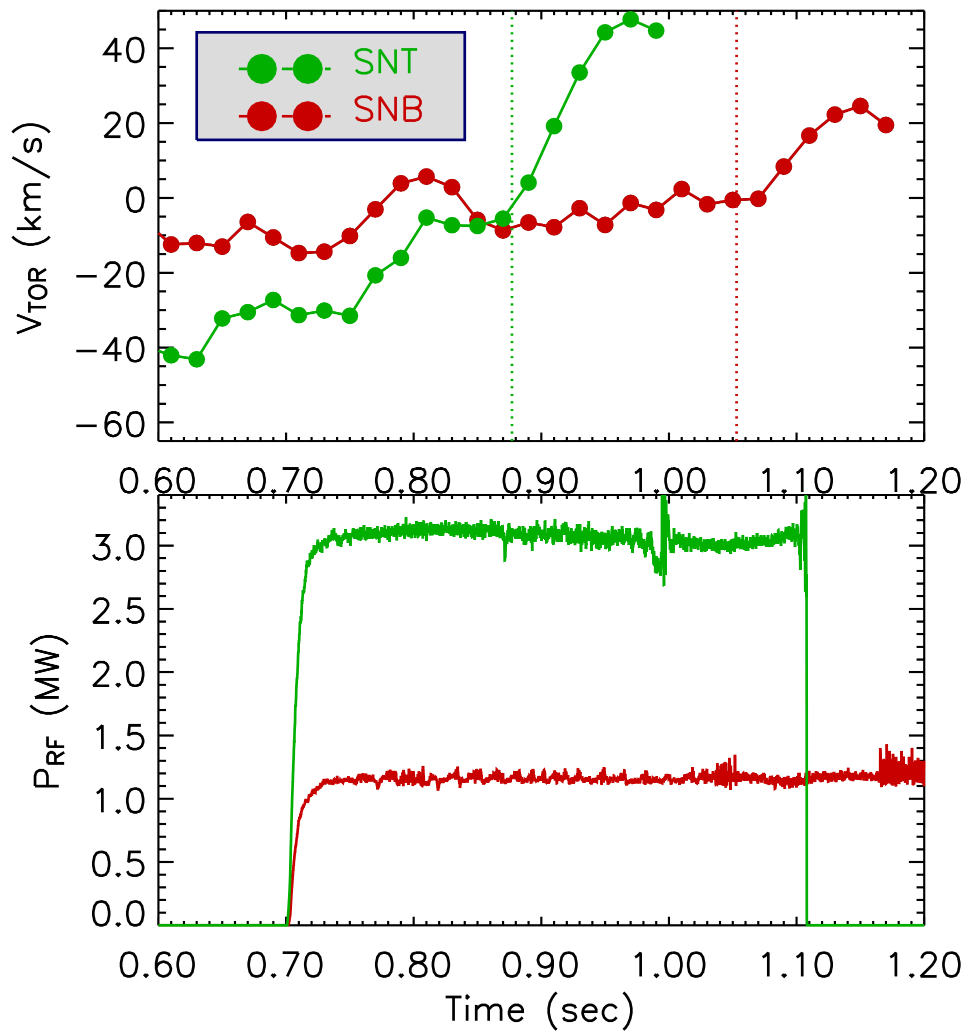
Net Flow is Sum of Two Effects

1. Topology dependent SOL flows as described above

2. Topology independent component which always increases in co-direction with plasma pressure



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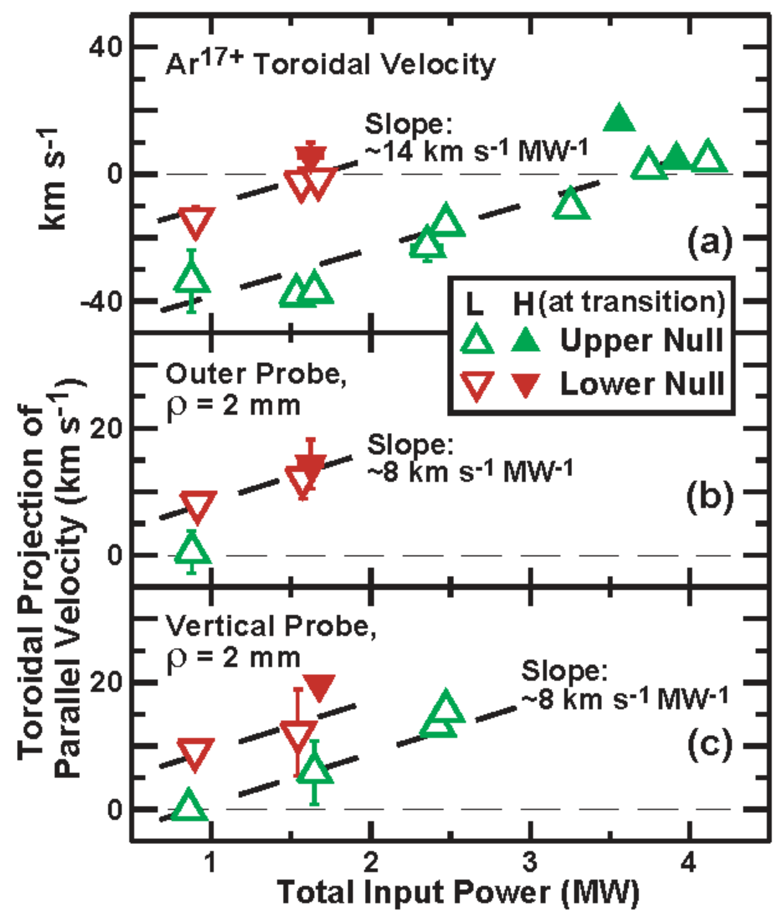
To Reach Given Level of Core Flow (Shear) Requires more Pressure (Power) for Unfavorable Drift Direction

- For particular discharge conditions, L/H transition is reached when core rotation reaches some critical value.
- Relevant physics is likely local shear but measurements not available yet…
- For unfavorable drift direction, starting conditions are farther from threshold in this sense.



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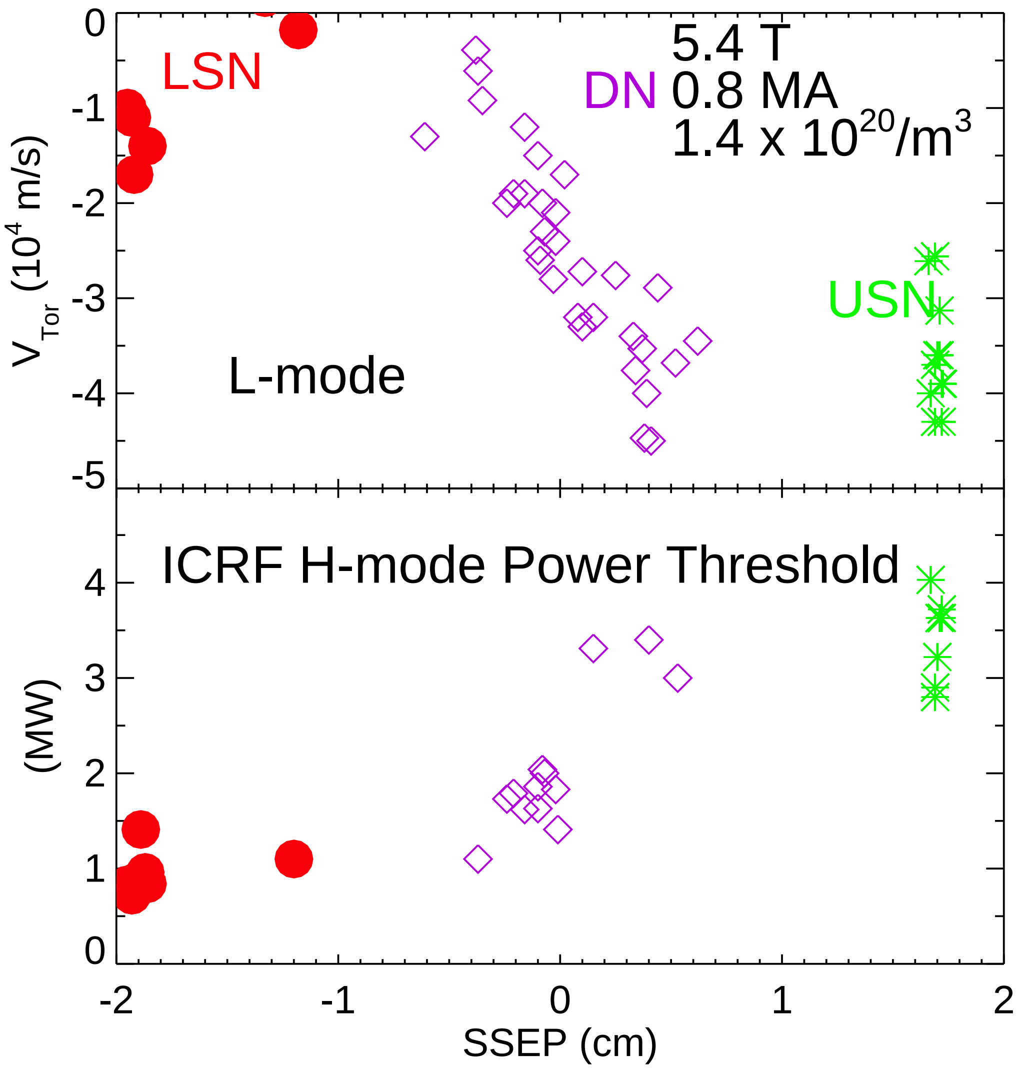
Change in Power Threshold Follows Changes in Flows



- Core flows (and presumably shear) show remarkable dependence on topology
- Inconsistent results reported with DN may be the result of this extreme sensitivity

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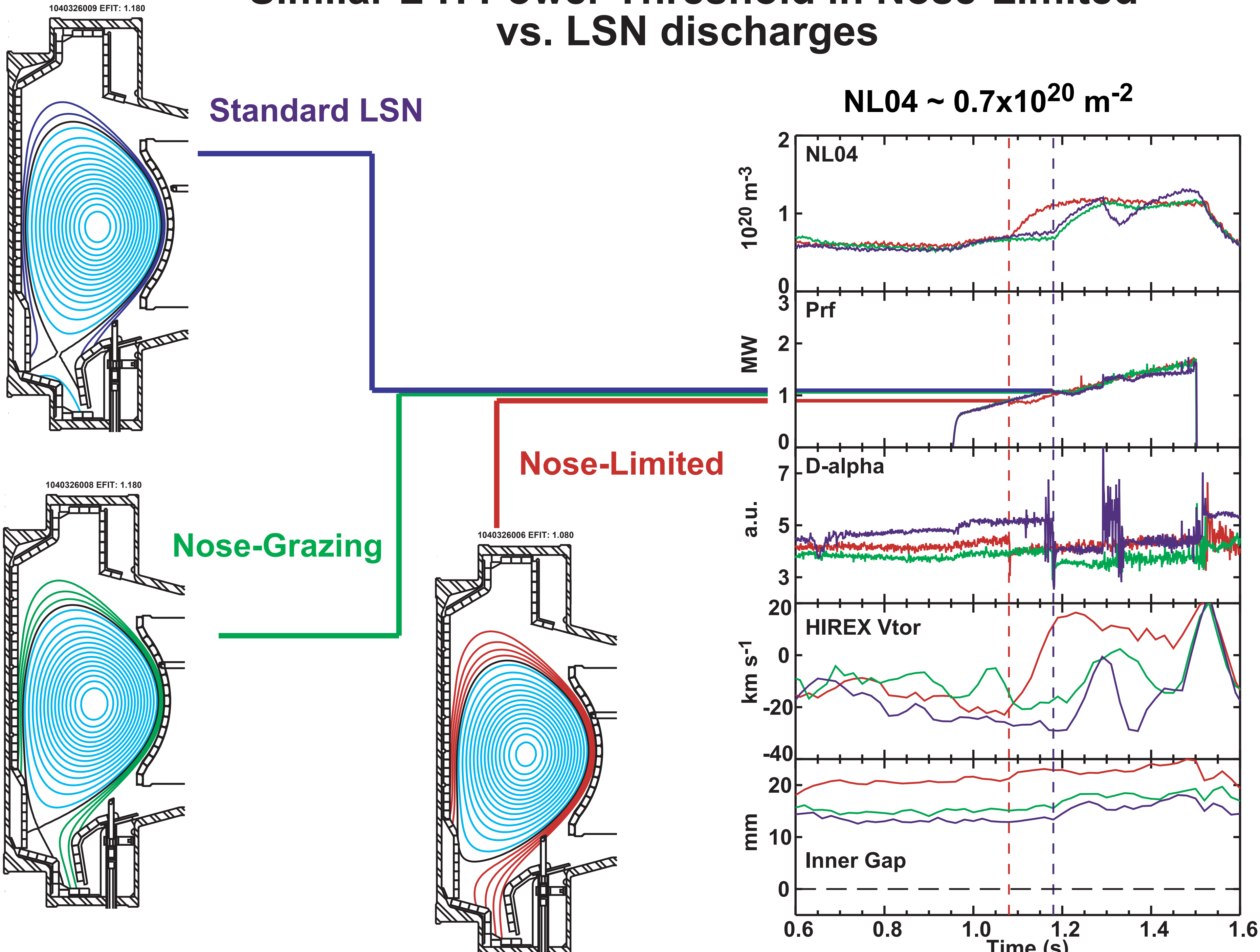
Similar L-H Power Threshold in Nose-Limited vs. LSN discharges



Run Summary - MP#384

Summary

- SOL flows provide the boundary condition for core flows
- Ballooning character of cross-field transport deposits particles on low-field side of plasma.
- Symmetrizing flows populate high-field side
- This topology dependent flow couples across separatrix into core
- Net flow is combination of this effect combined with pressure/power dependent co-current flow
- Thus more power is required to reach same flow conditions for unfavorable drift topology.

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