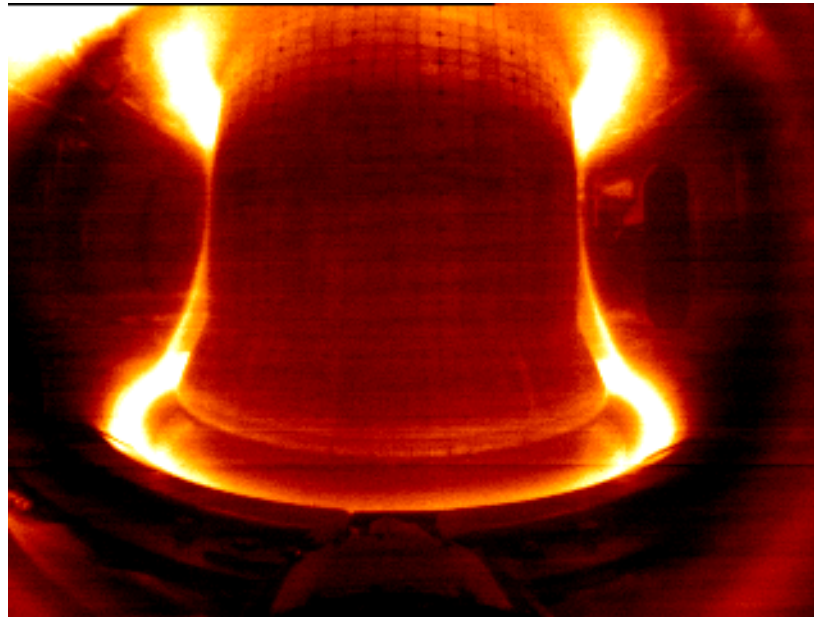

**ROTATION, SOL FLOWS AND THE TOPOLOGY DEPENDENCE
OF THE H-MODE THRESHOLD**



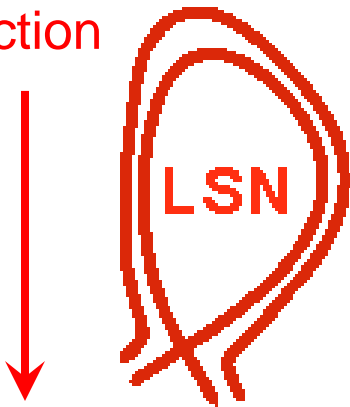
M. GREENWALD, A. HUBBARD, B. LABOMBARD, J. RICE

APS – NOVEMBER, 2004

SAVANNAH, GEORGIA

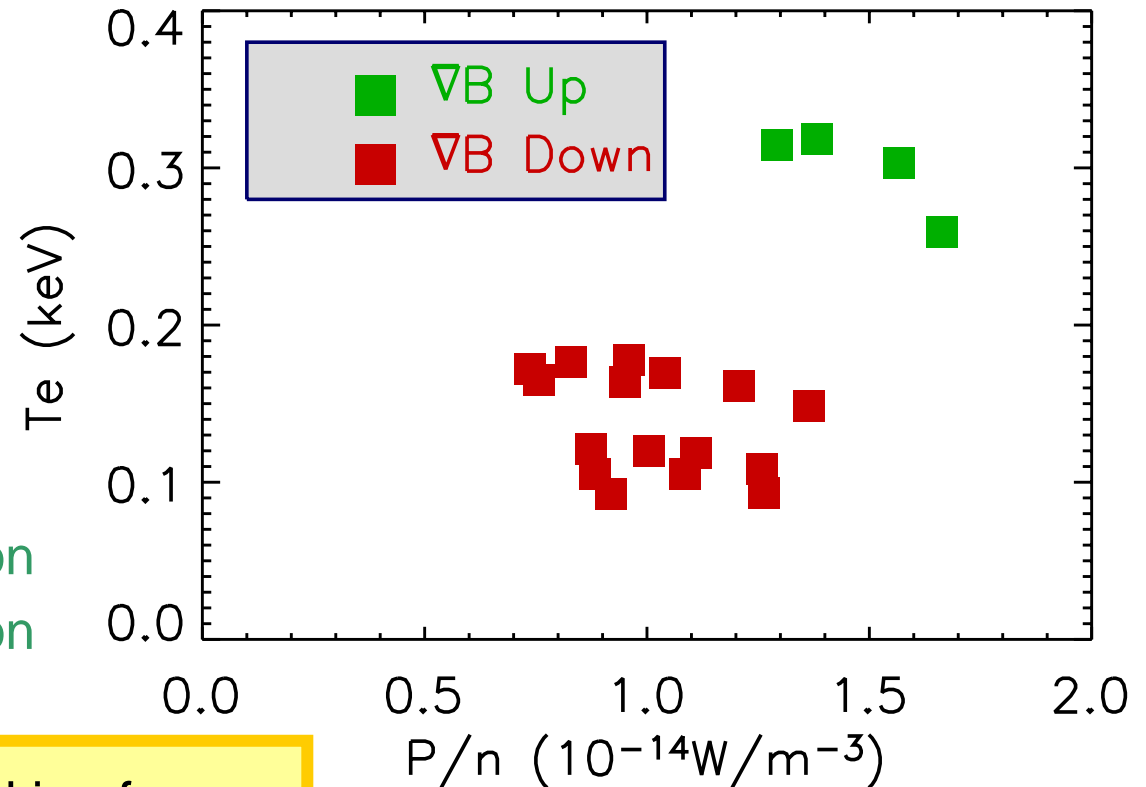
The Effect the ∇B Drift Direction on the H-Mode Threshold is 0th Order and Requires a Robust Explanation

Favorable ion drift direction



Unfavorable ion drift direction

Power and Temperature at Threshold



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

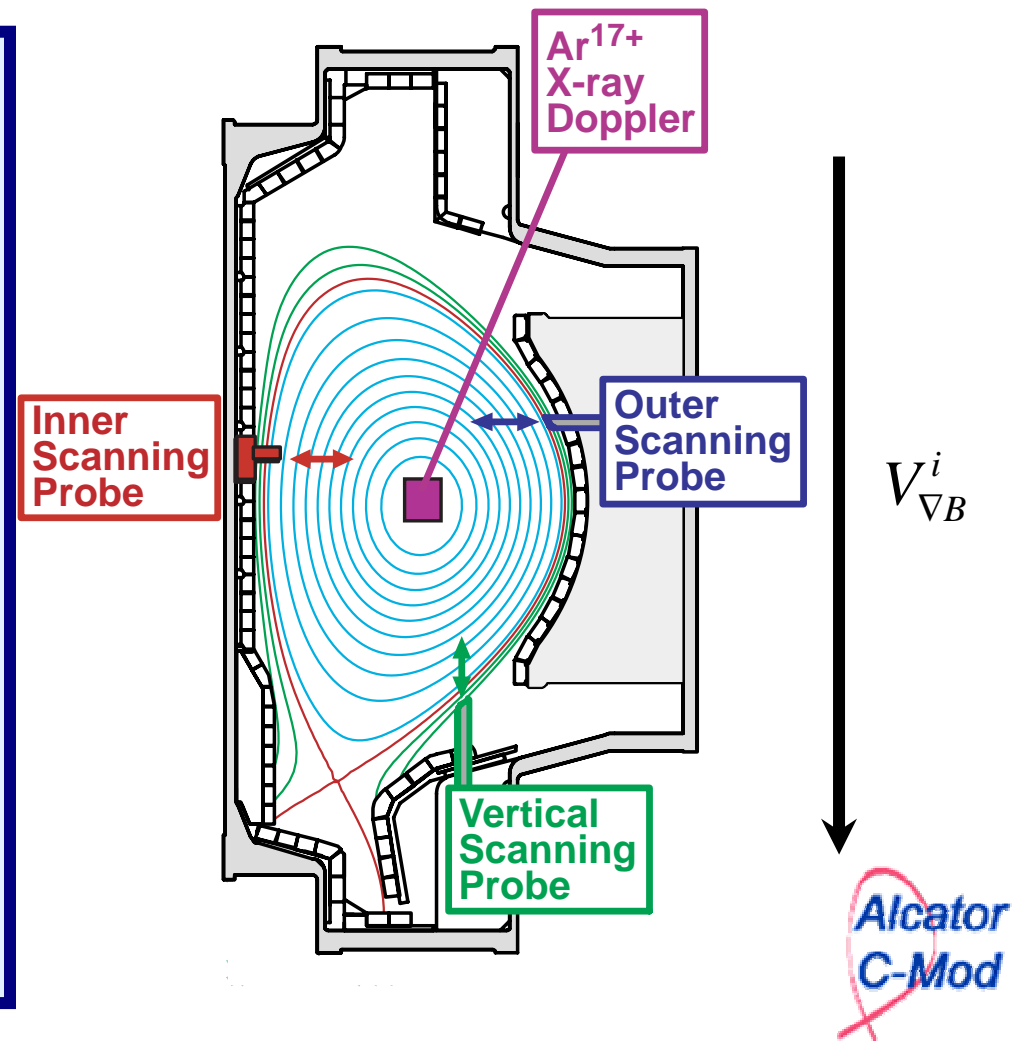
Hubbard 1996

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 and momentum transport – not sources
- SOL flows measured at three locations by fast scanning probes
- Core rotation profiles measured passively with high-resolution x-ray spectrometers

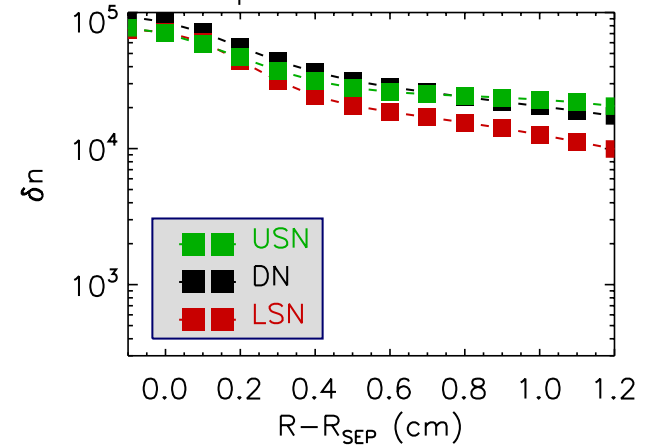
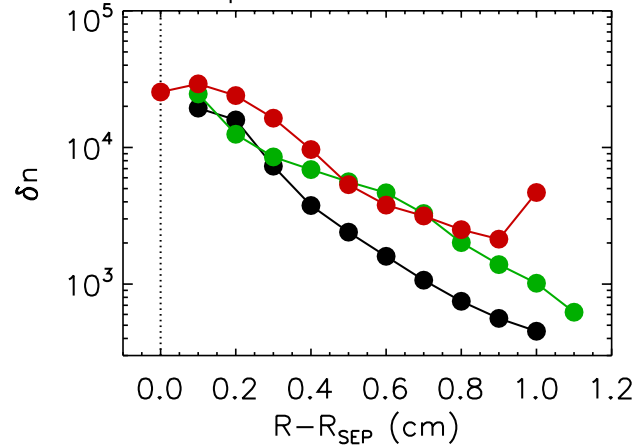


PLASMA FROM BALLOONING TRANSPORT FLOWS ALONG FIELD

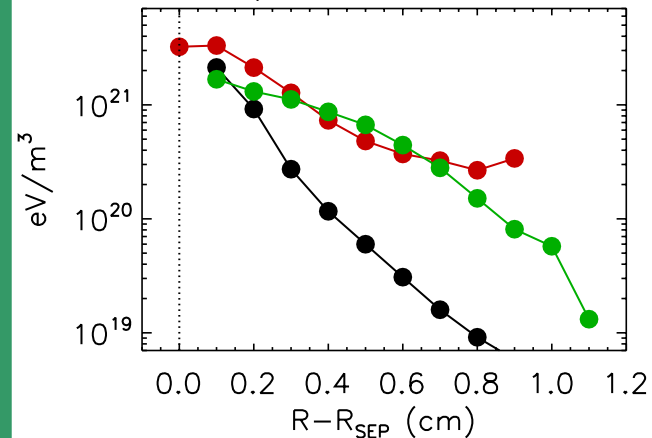
LINES TO POPULATE HIGH-FIELD SOL

- Much higher fluctuation levels (\perp transport) on low field side – ballooning
- When high-field side is connected (SN), shows similar plasma density
- When not connected (DN), no plasma
- For SN, symmetrizing flows are responsible for high-field plasma

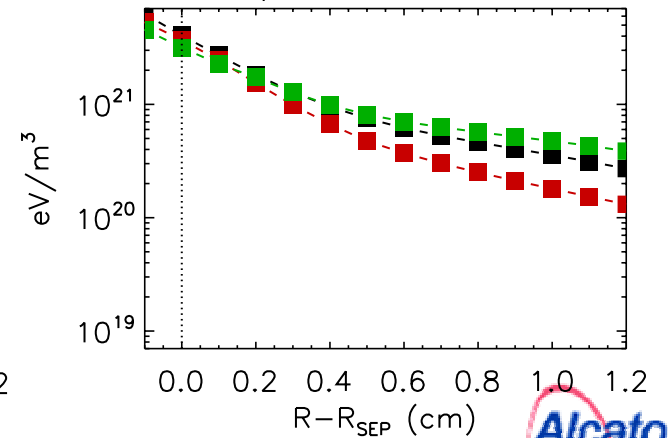
Inner Midplane Fluctuation Levels Outer Midplane Fluctuation Levels



Inner Midplane Plasma Pressure

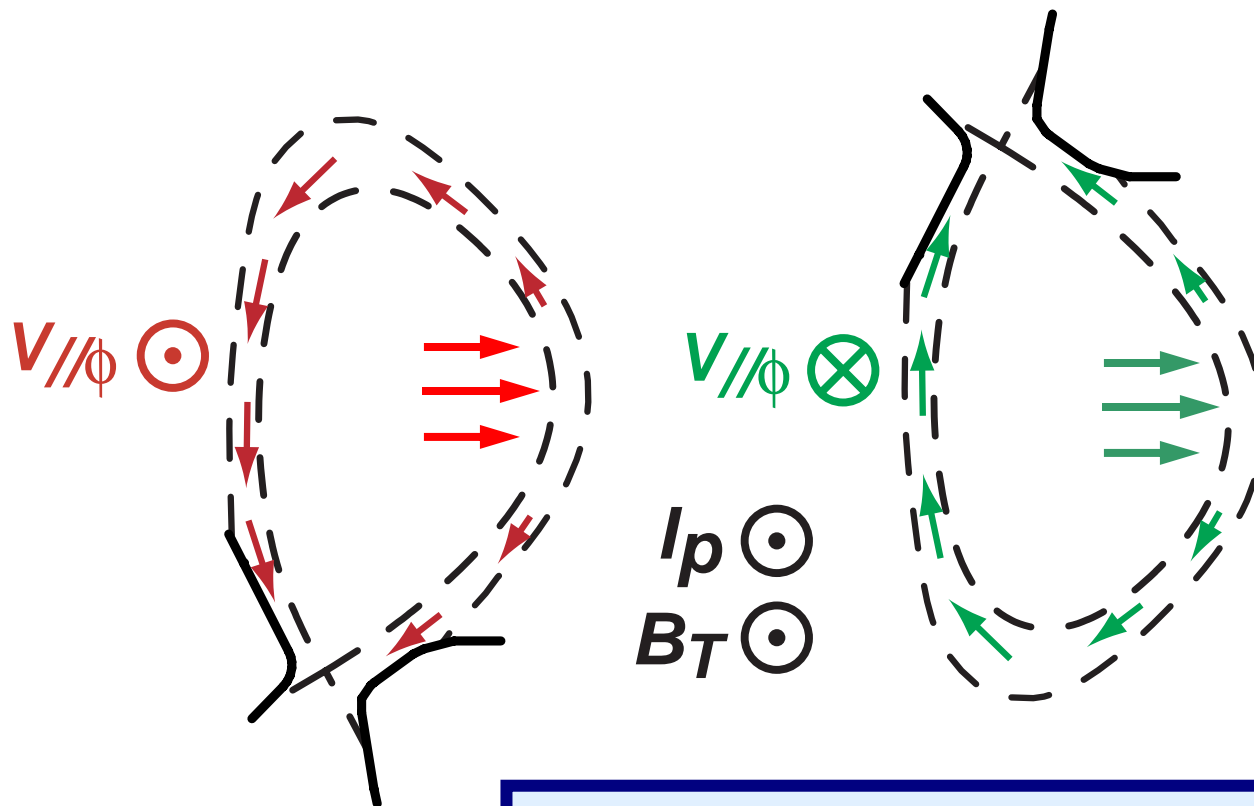


Outer Midplane Plasma Pressure



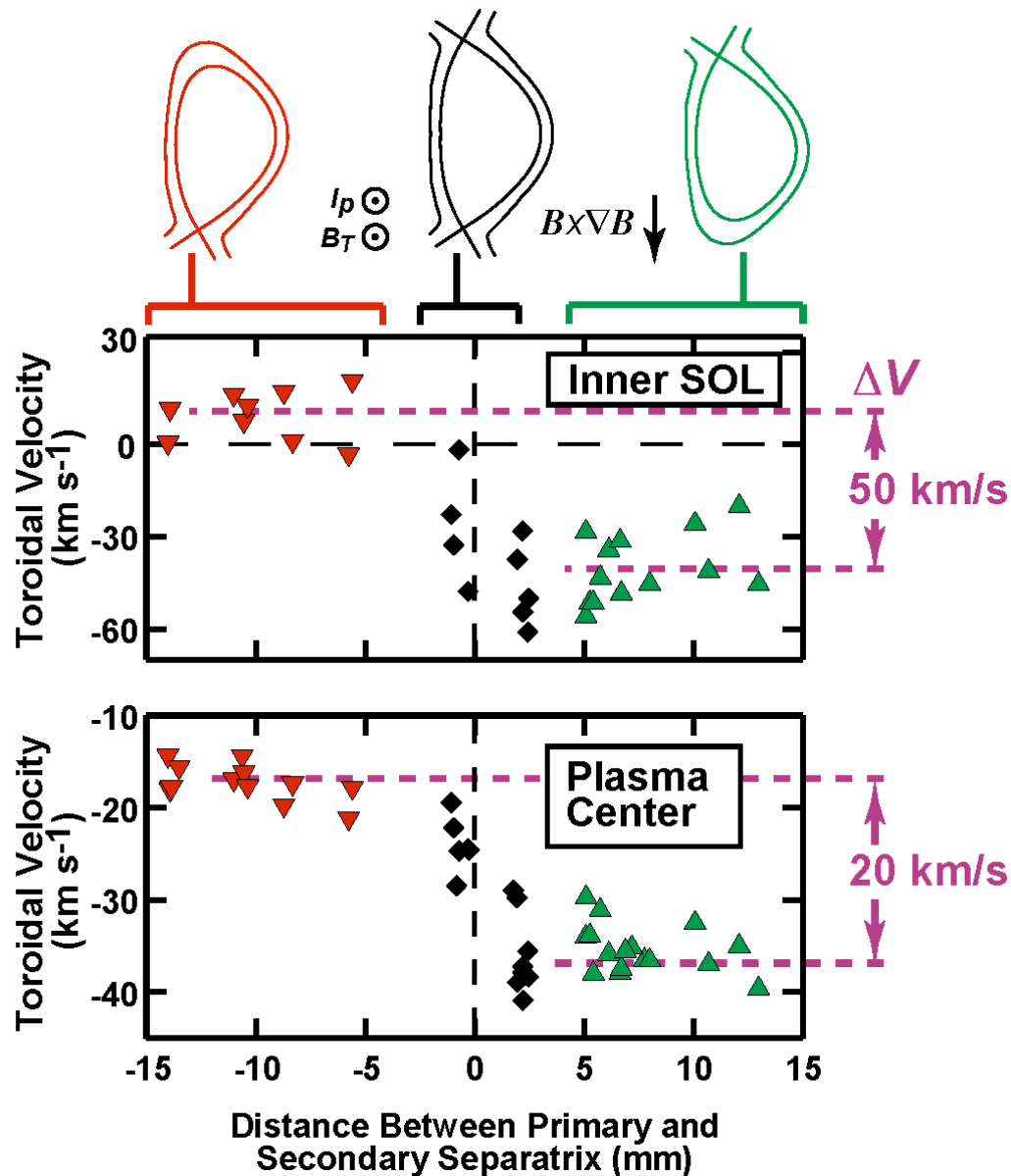
SYMMETRIZING FLOWS DRIVEN BY BALLOONING TRANSPORT ARE CO OR COUNTER DEPENDING ON TOPOLOGY

⊥ transport-driven parallel SOL flows:



These flows are observed with
the inner wall probes

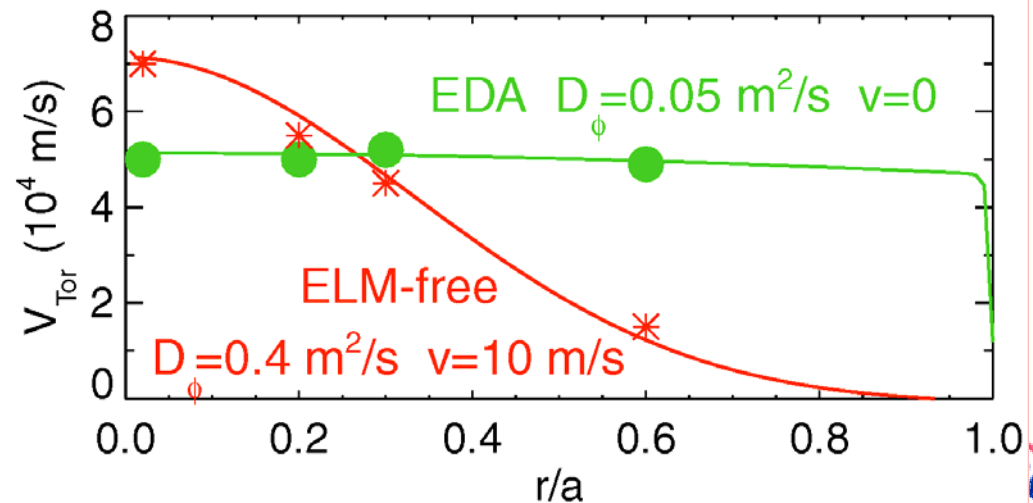
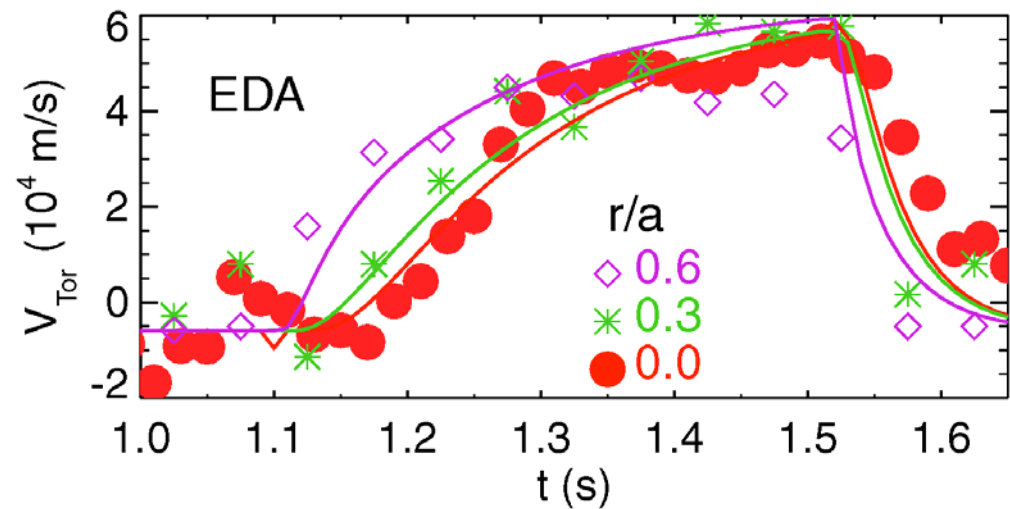
CORE ROTATION SHOWS SAME TOPOLOGY DEPENDENCE AS SOL



- 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.
- Double null balance is critical

MOMENTUM IS OBSERVED TO BE TRANSPORTED FROM OUTSIDE INWARD INTO CORE

- Core rotation responds to change in edge – L/H transition
- Time histories used to obtain transport coefficients.
- Momentum is observed to diffuse and convect inward.

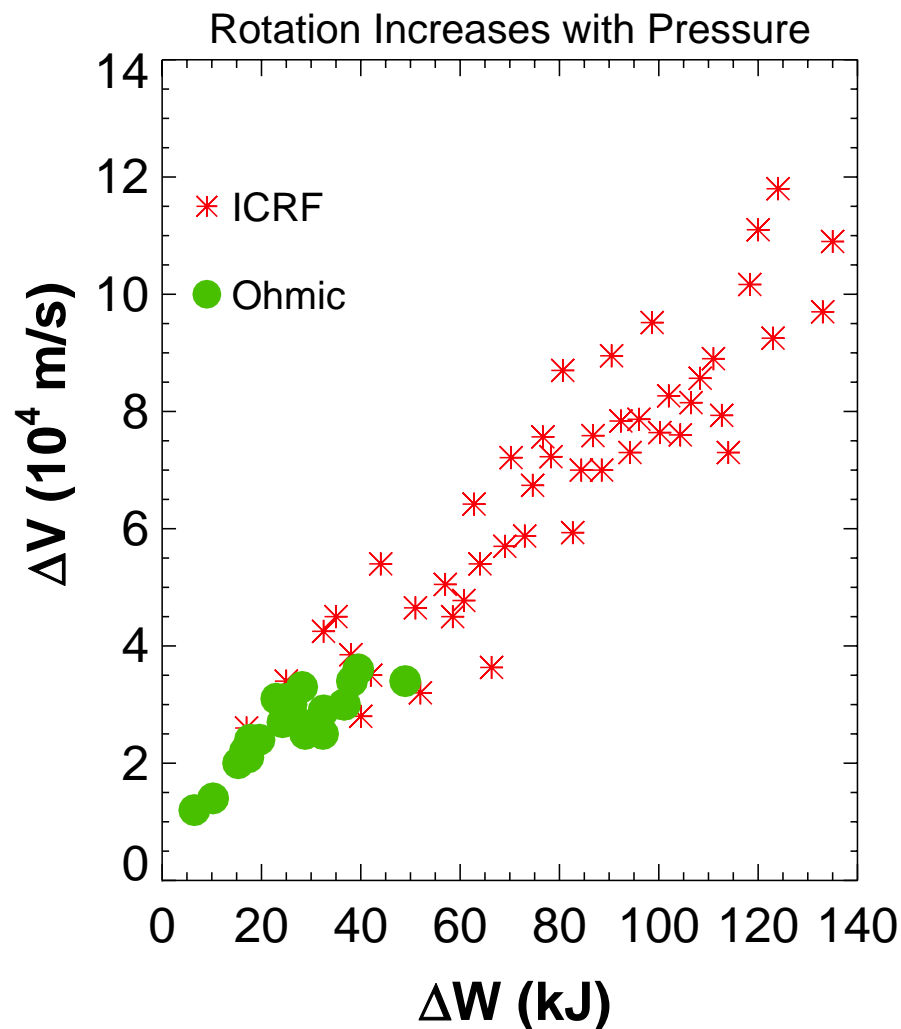


PRESSURE DEPENDENT (TOPOLOGY INDEPENDENT) COMPONENT

ALWAYS INCREASES IN CO-DIRECTION WITH PLASMA PRESSURE

Two “contributions” to the flows

1. Topology dependent SOL flows as described above
2. Pressure dependent rotation in both L and H-Mode
 - Net rotation is Sum of Two Effects
 - (Observed in core and SOL)

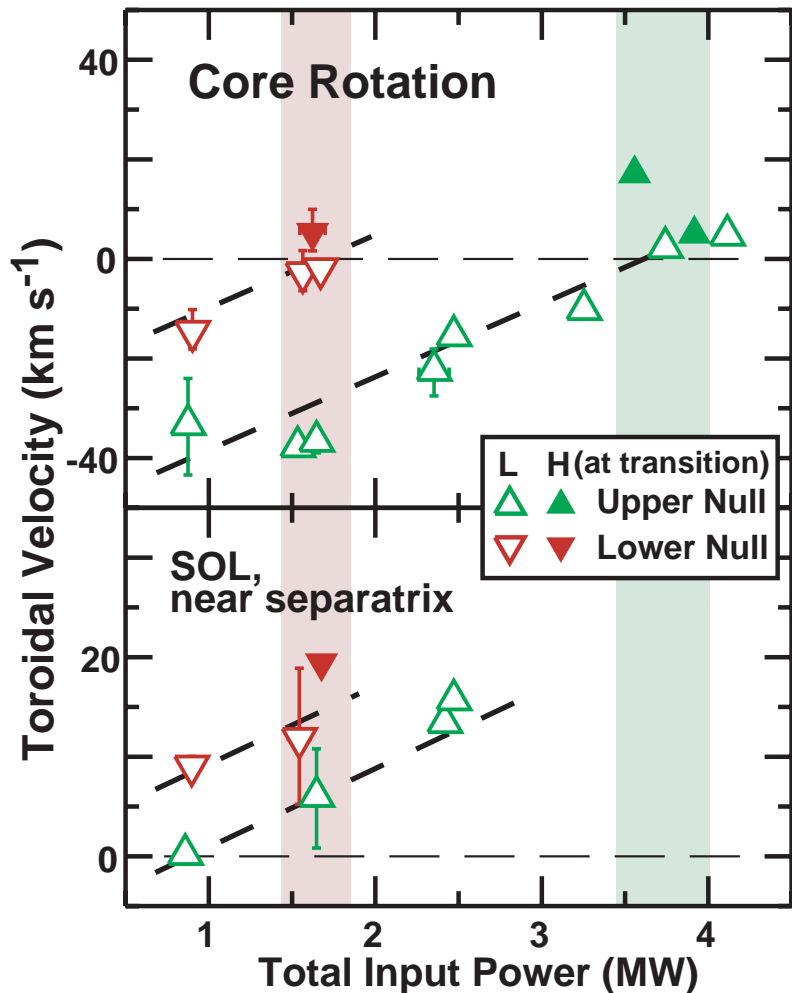


(Plasma Pressure, Power)

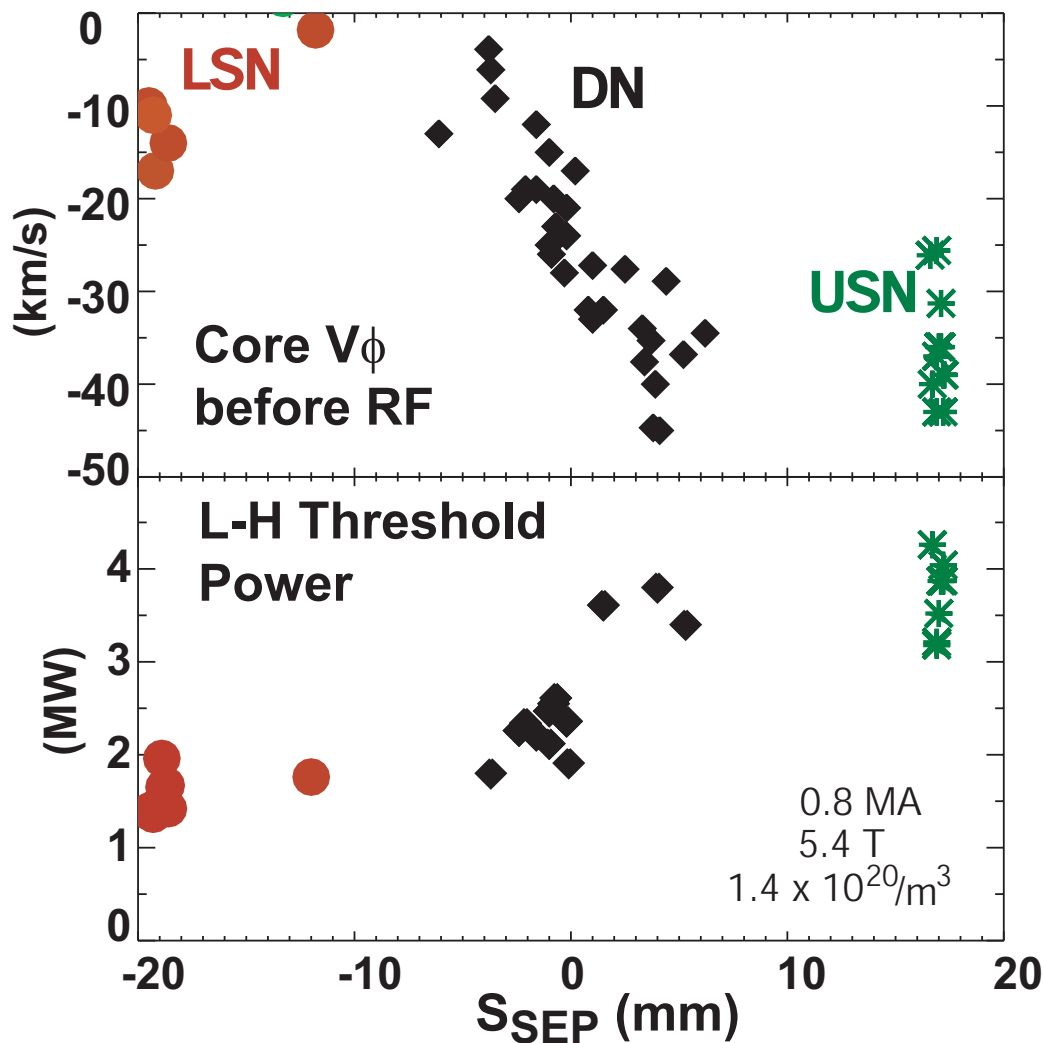


TO REACH GIVEN LEVEL OF CORE FLOW (SHEAR) REQUIRES MORE PRESSURE (POWER) FOR UNFAVORABLE DRIFT DIRECTION

- 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 state.



CHANGE IN POWER THRESHOLD FOLLOWS CHANGES IN FLOWS



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

To SUMMARIZE

1. Significant parallel flows are driven in the SOL as a result of poloidally asymmetric cross-field transport (ballooning).
2. These flows reverse direction with respect to the plasma current depending on whether the x-point is at the top or bottom of the machine.
3. These flows couple to toroidal rotation in the **confined** plasma
4. There is a separate effect in which both the SOL and core flows increment in the co-current direction when the plasma pressure (input power) is increased.
5. So these two effects add or subtract depending on the topology.
6. Plasmas with the ∇B drift in the unfavorable direction have "farther" to go to get to the same state of rotation.

How this works quantitatively with the details of ExB stabilization and such is still unknown.