ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

CRPP

Convective cells and blob control in a simple magnetized torus

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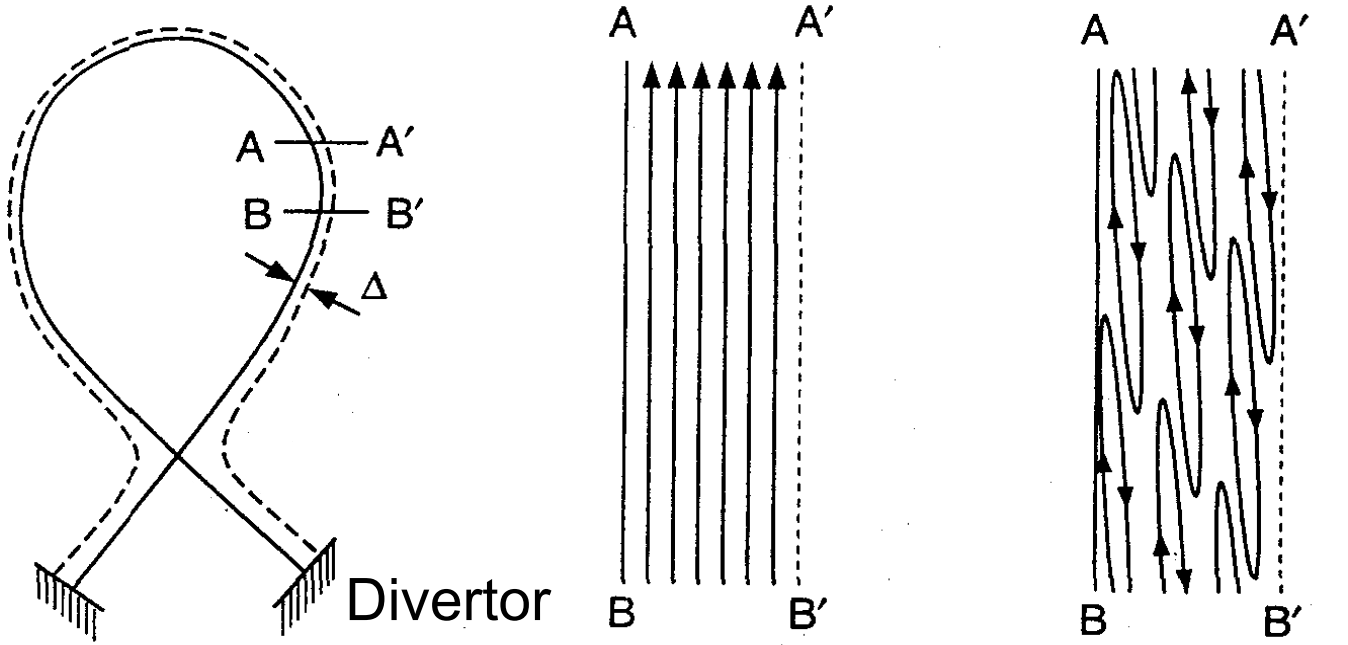
Motivation for toroidal/poloidal asym. biasing

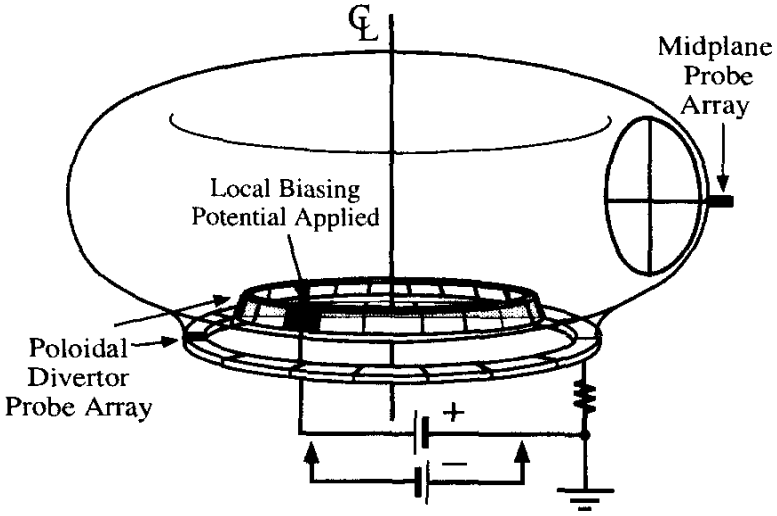
Idea[1] : induce convective motion in the Scrape-Off Layer (SOL) to increase its width and reduce peak heat loads on the divertor



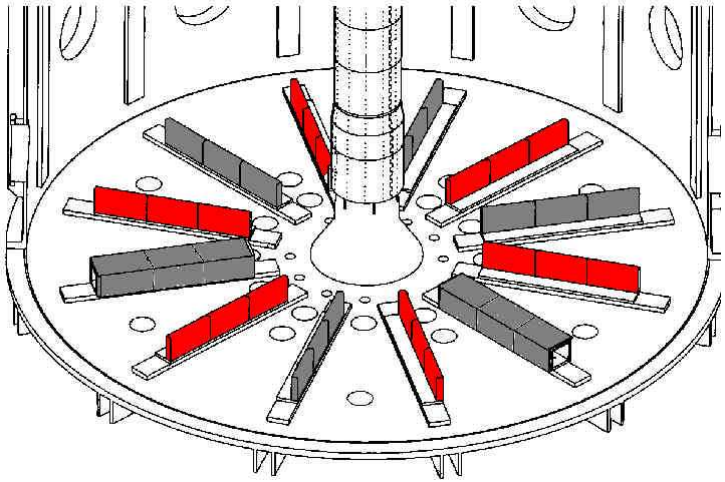
[1] Cohen and Ryutov, NF 1997

Toroidal/poloidal asym. biasing in tokamaks

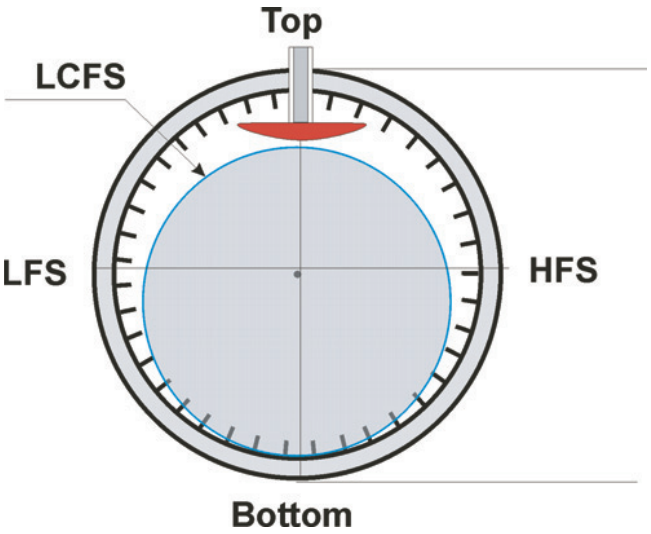
JFT-2M, Hara et al., JNM 1997



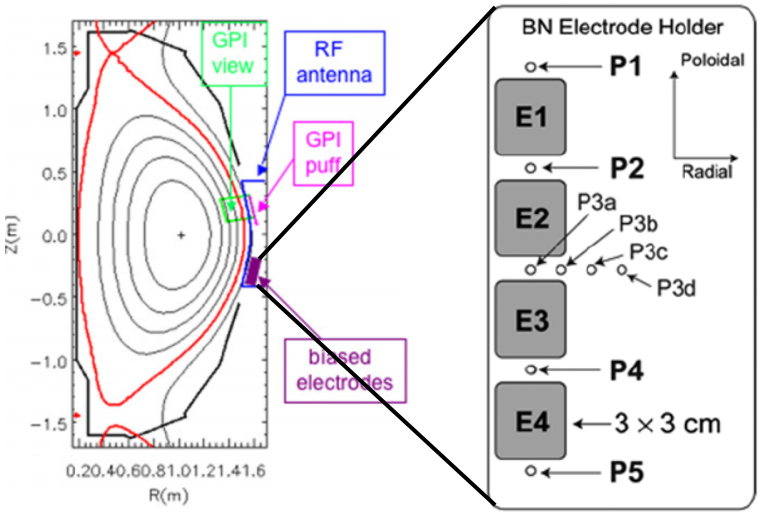
MAST, Counsell et al., JNM 2003



CASTOR, Stockel et al., PPCF 2005

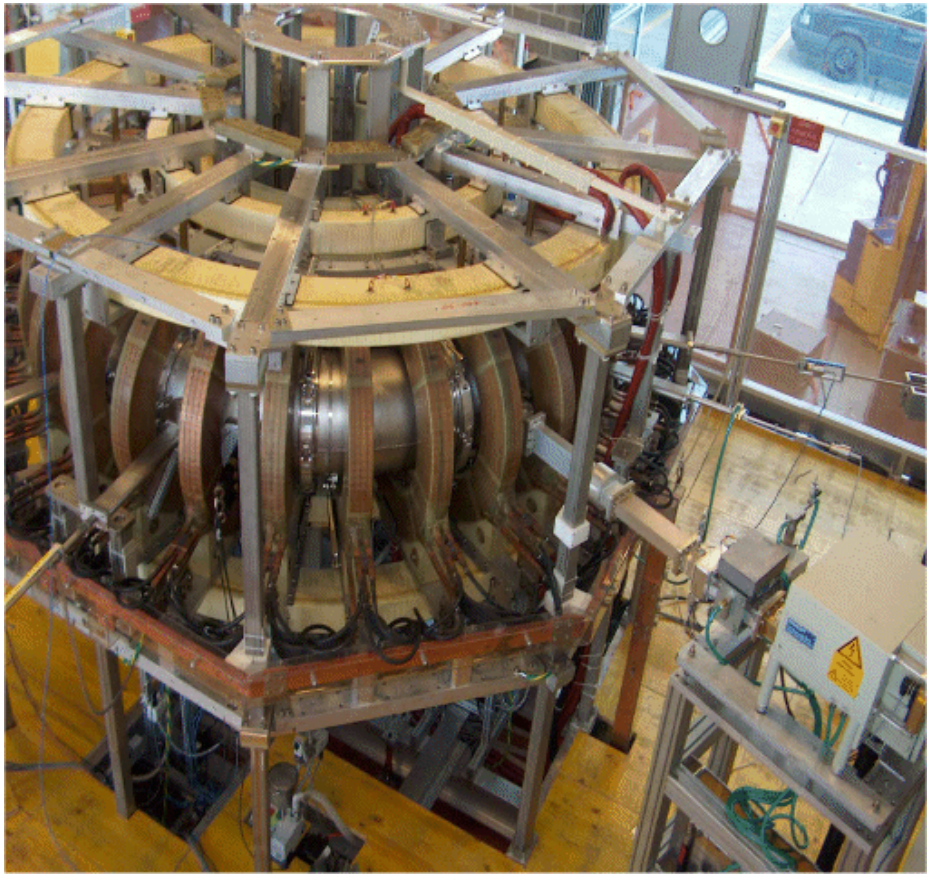


NSTX, Zweben et al., PPCF 2009

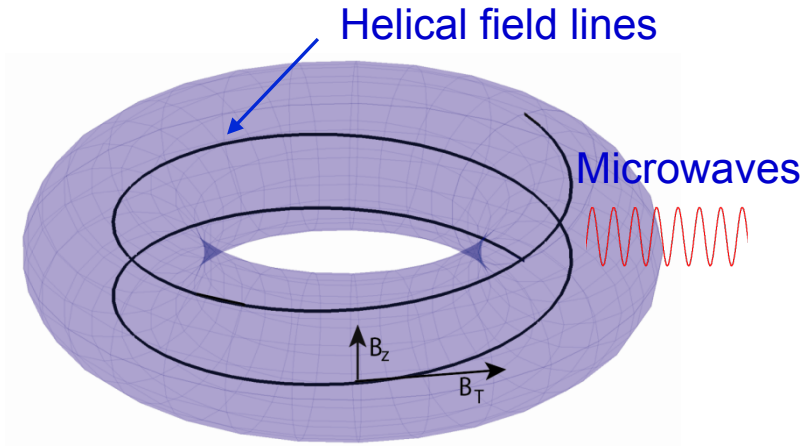


The TORPEX device

- Toroidal device: R=1 m, a=0.2 m
- Open field lines, ∇B and curvature



Fasoli et al., POP 2006



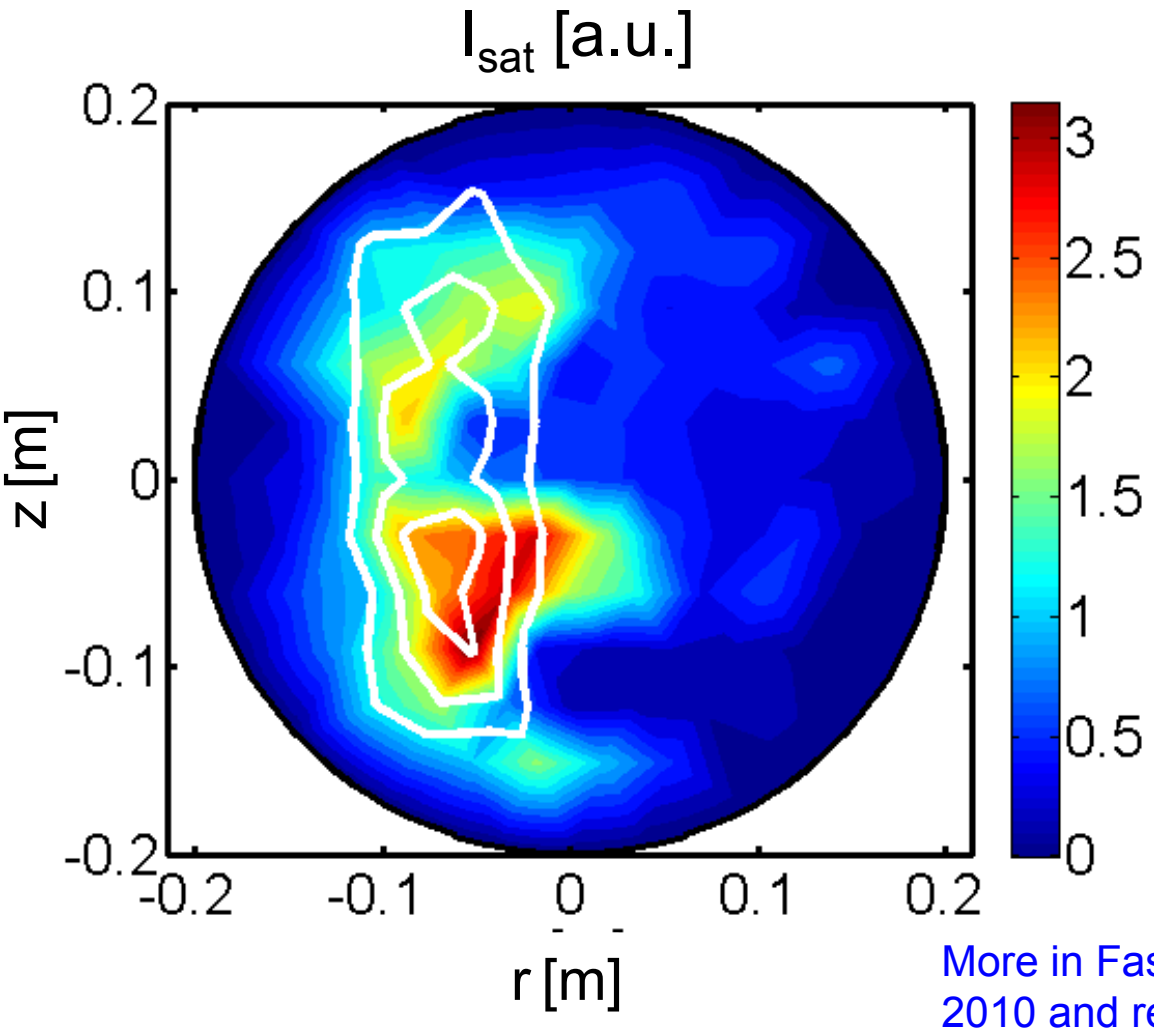
Parameters

$|B_T| \approx 76mT$ $\quad n_e \leq 10^{17} m^{-3}$

$|B_z / B_T| \leq 5\%$ $\quad T_e \leq 15eV$

$T_i << T_e$

Target plasmas
ideal interchange regime, $k_{||}=0$



More in Fasoli et al., PPCF 2010 and references therein

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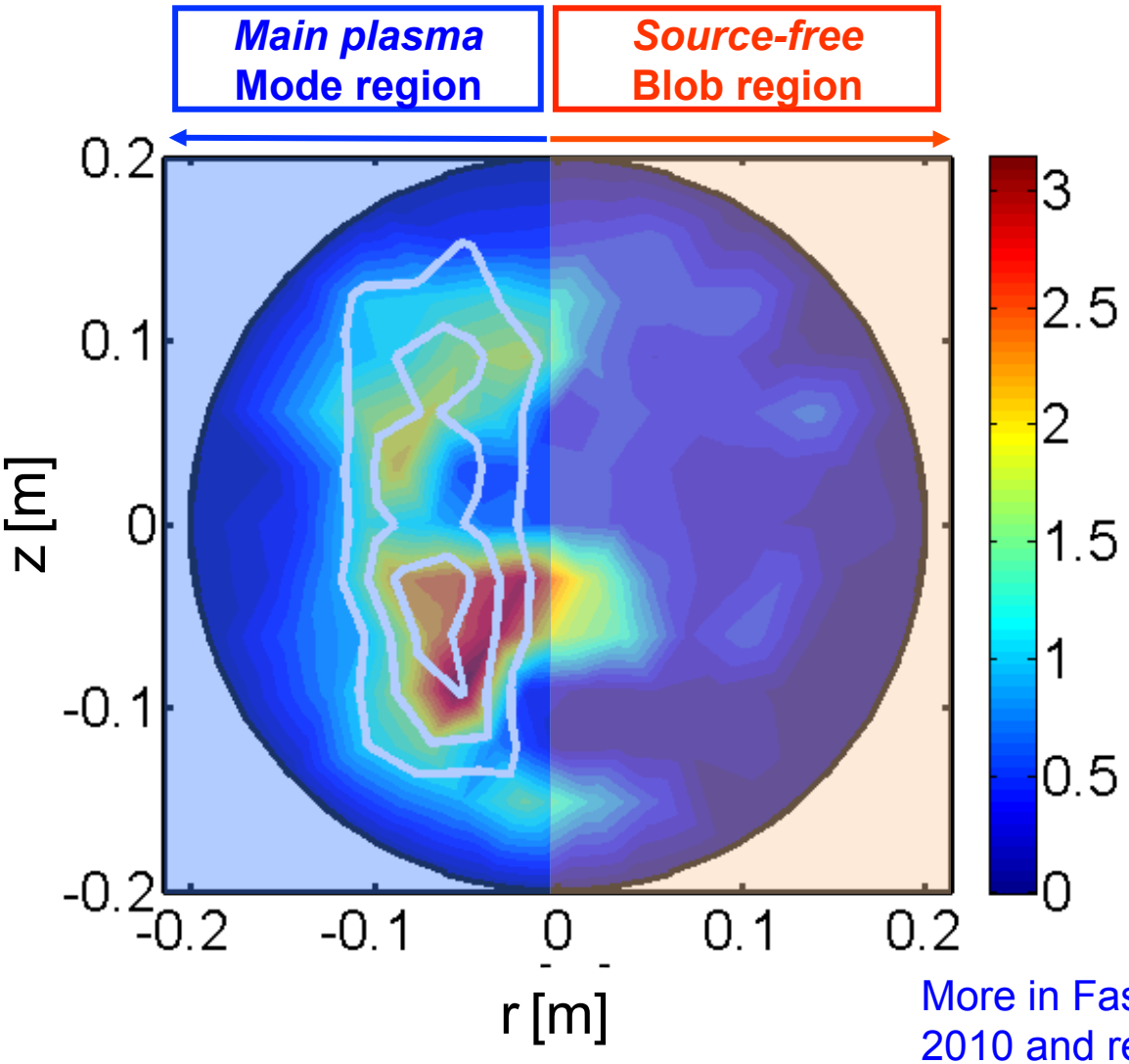
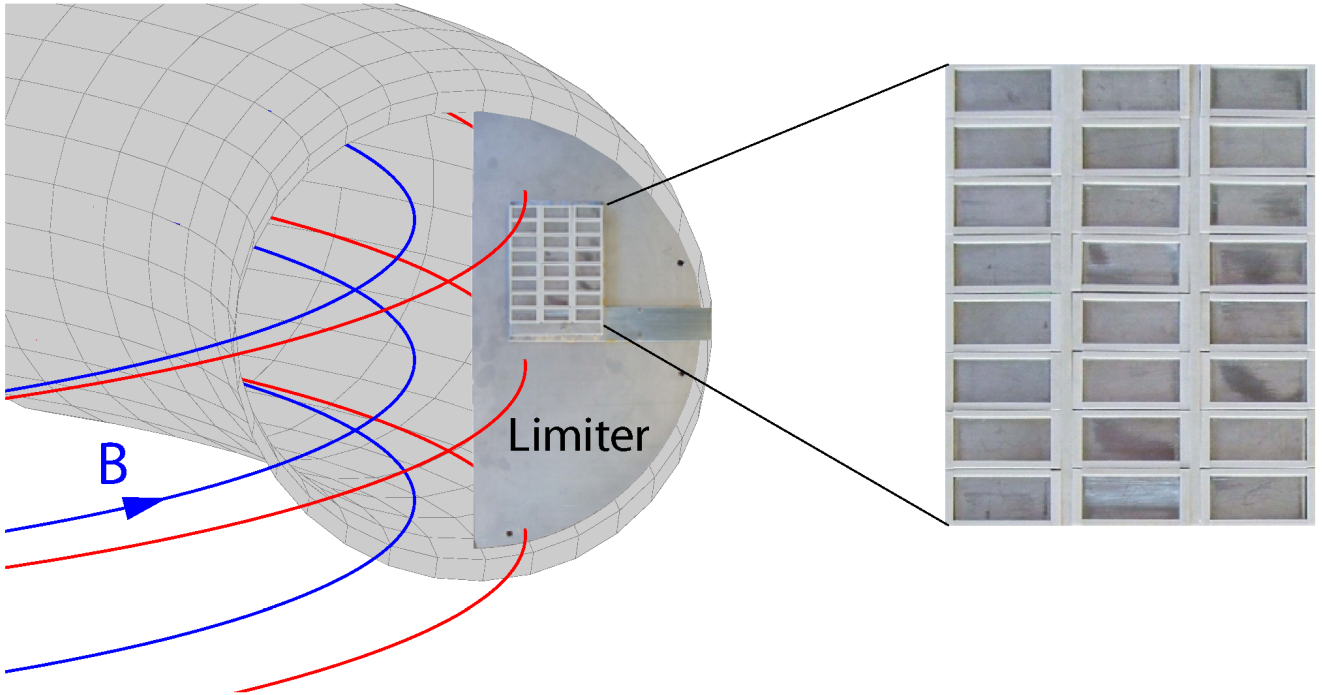


More in Fasoli et al., PPCF 2010 and references therein

Biasing setup on TORPEX

- Array of 24 electrodes
- Each can be biased individually and the current can be measured



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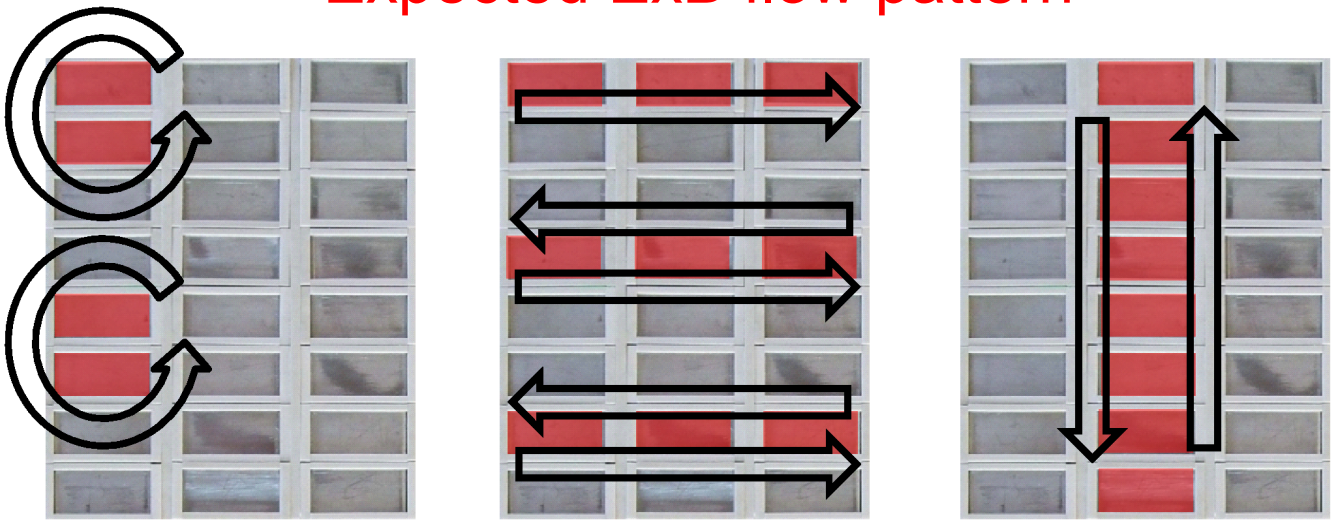
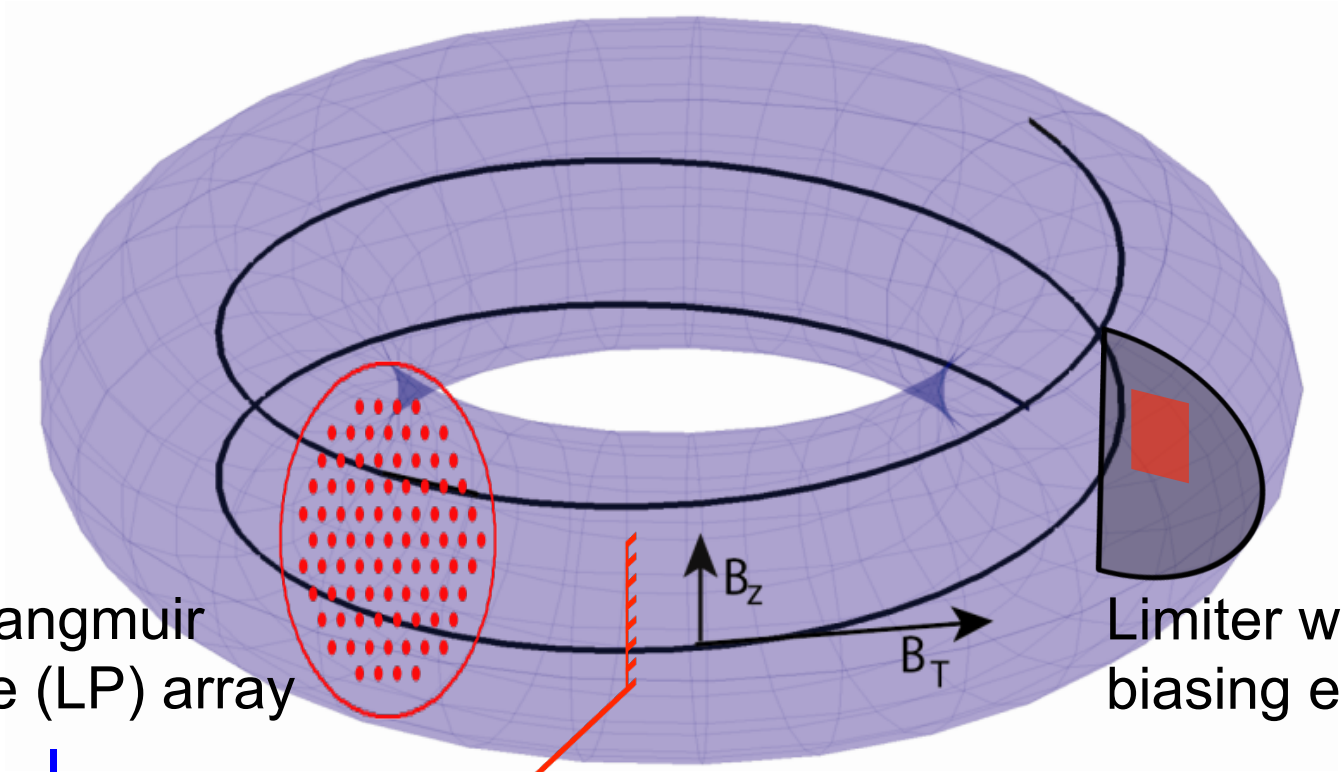
Expected ExB flow pattern



What is in practice the effect of biasing on blobs and time-averaged profiles?

Measurement setup



2D Langmuir probe (LP) array

➡ V_{fl}, I_{sat}

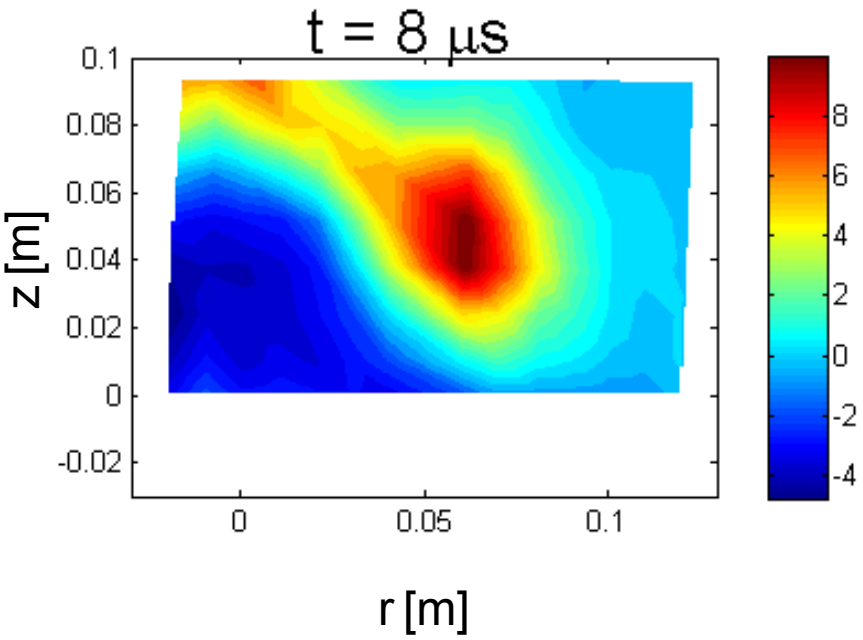
Limiter with biasing electrodes

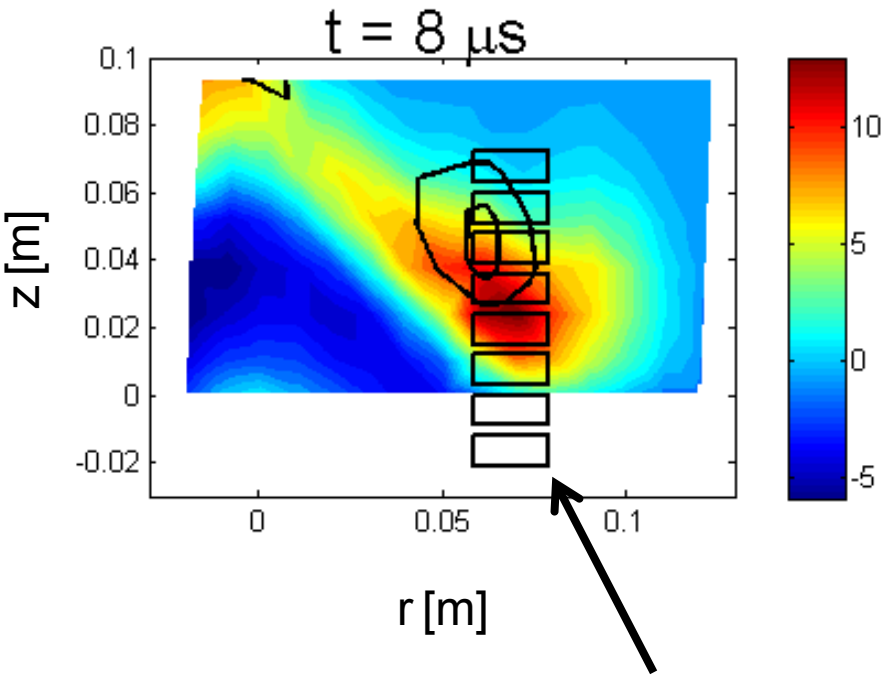
Movable 1D LP array

➡ V_{pl}, V_{fl}, I_{sat}

Control of blob vertical velocity

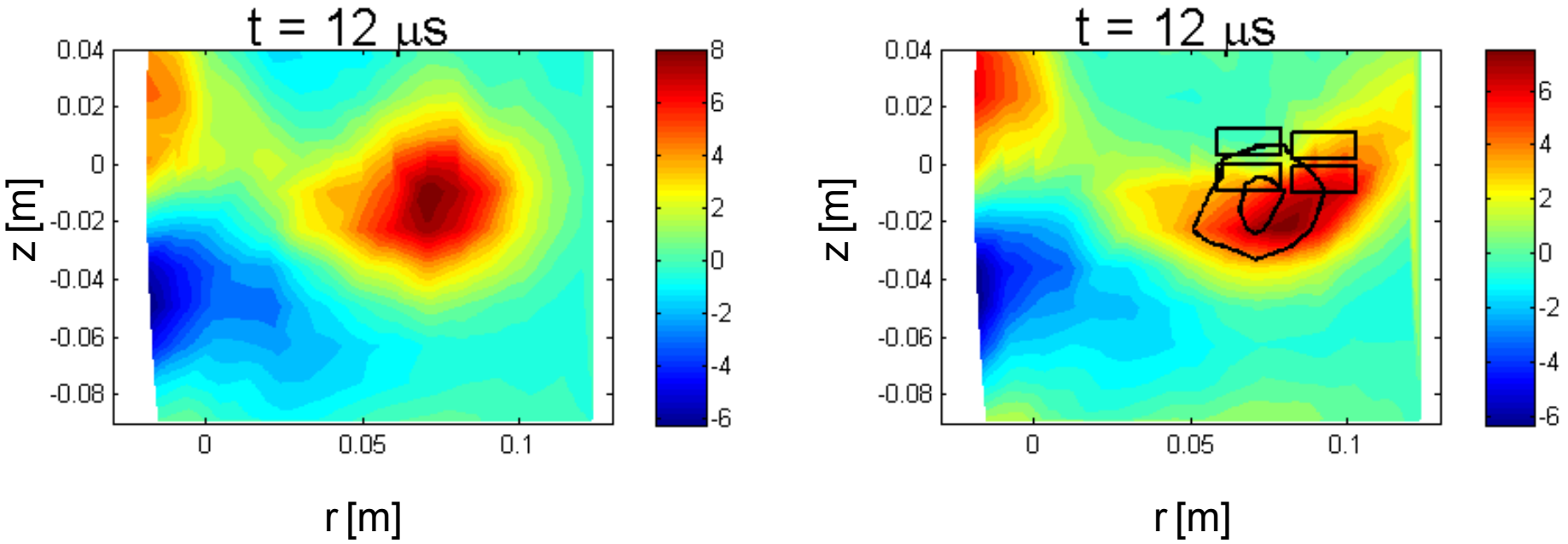
$\tilde{I}_{sat}$ [a.u.]





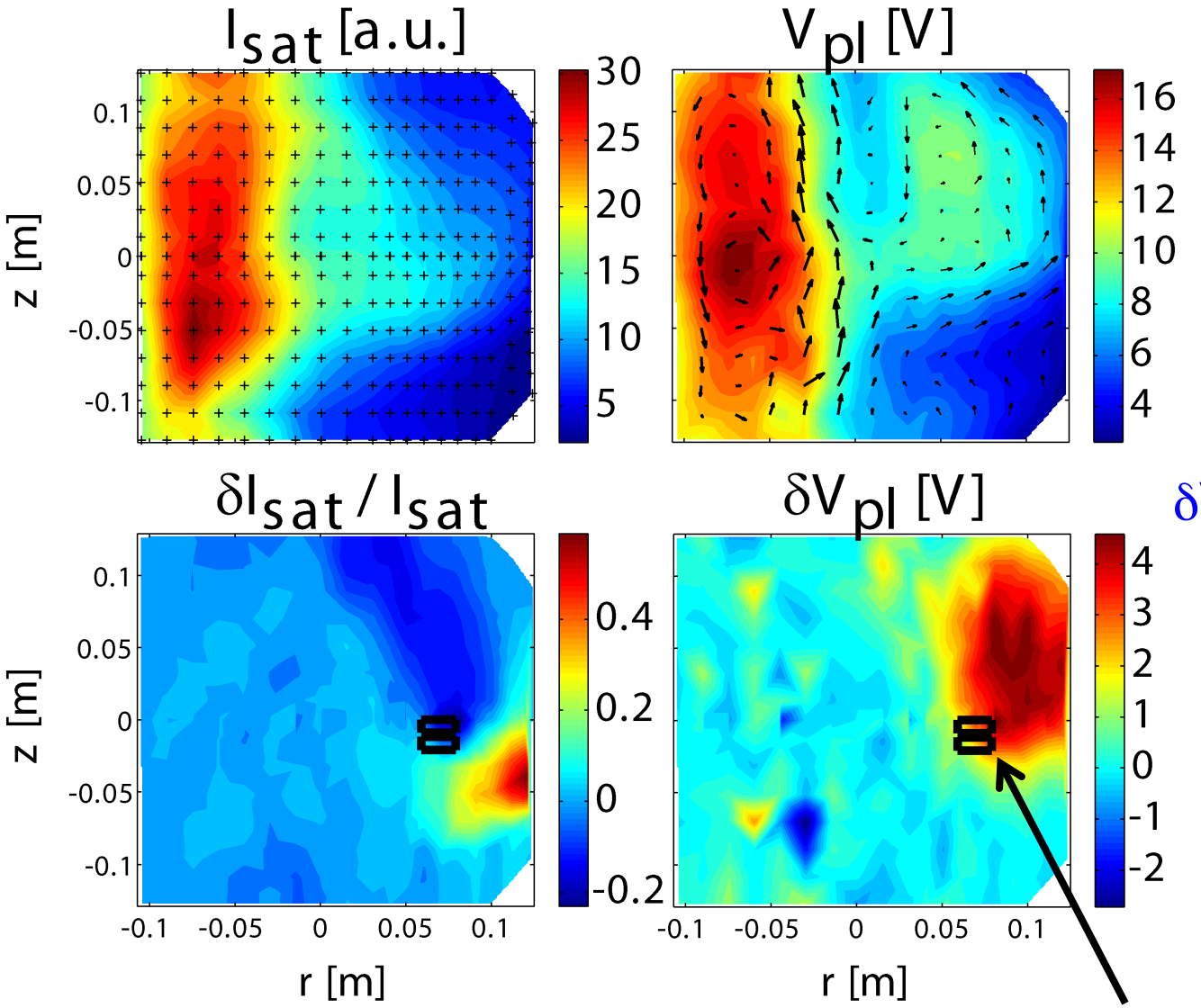
Control of blob radial velocity

$\tilde{I}_{sat}$ [a.u.]



Vblob: ≈ 1200 m/s → 2200 m/s

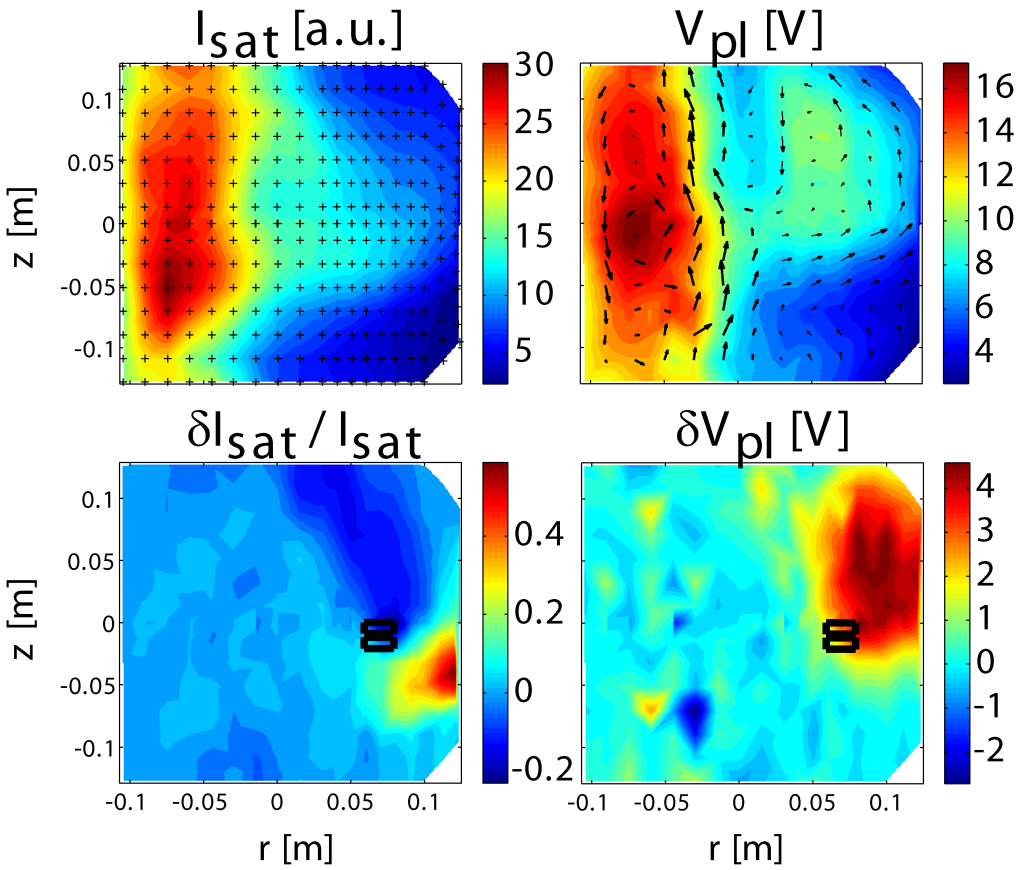
Effects on time-averaged profiles



$\delta V_{pl} \equiv V_{pl}$(bias on) – V_{pl}(bias off)

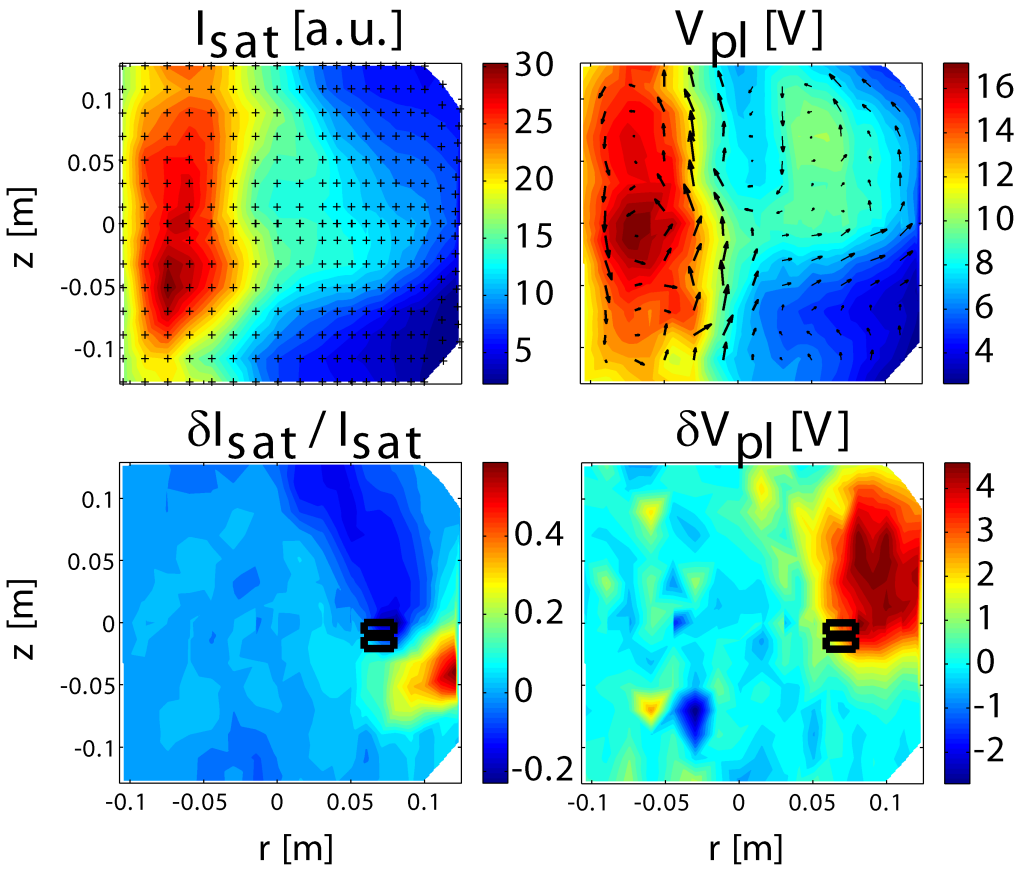
Applied bias: +40 V

Effects on time-averaged profiles



Bias voltage of +40 V on a pair of electrodes produces a convective cell

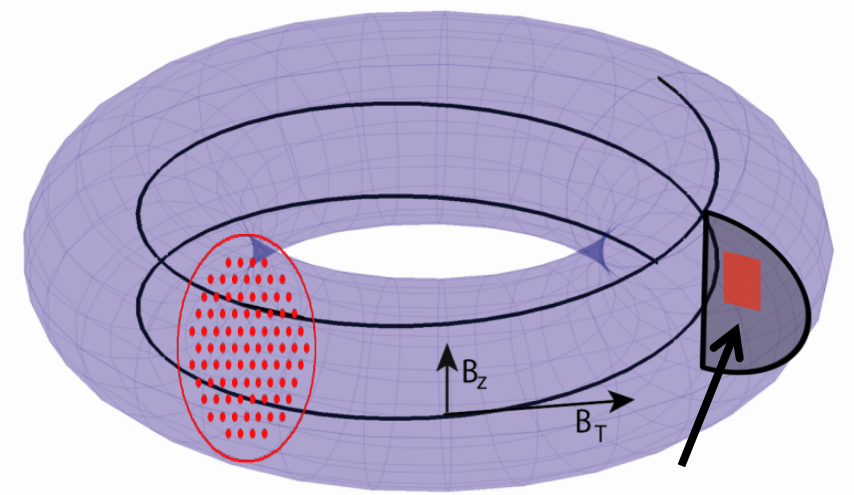
Effects on time-averaged profiles

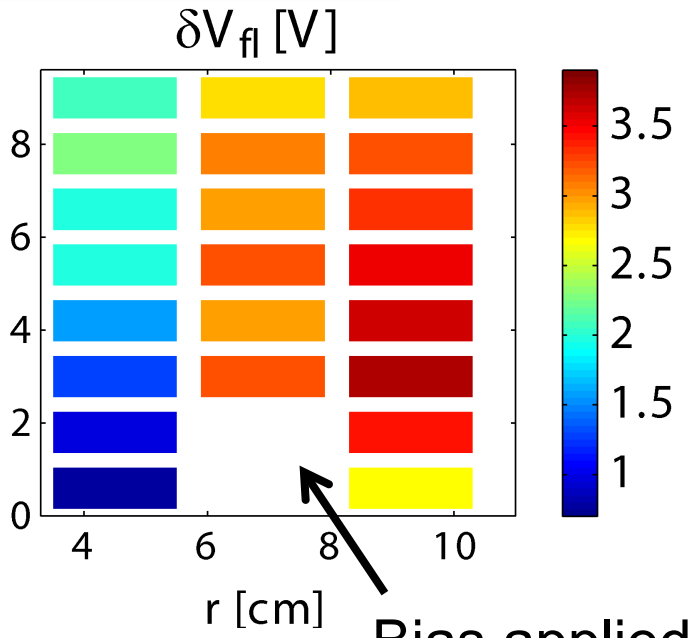


Bias voltage of +40 V on a pair of electrodes produces a convective cell

- What is its structure along B ?
- Why is δV_{pl} shifted w.r.t. the biased flux tube ?
- What limits the magnitude of δV_{pl} ?

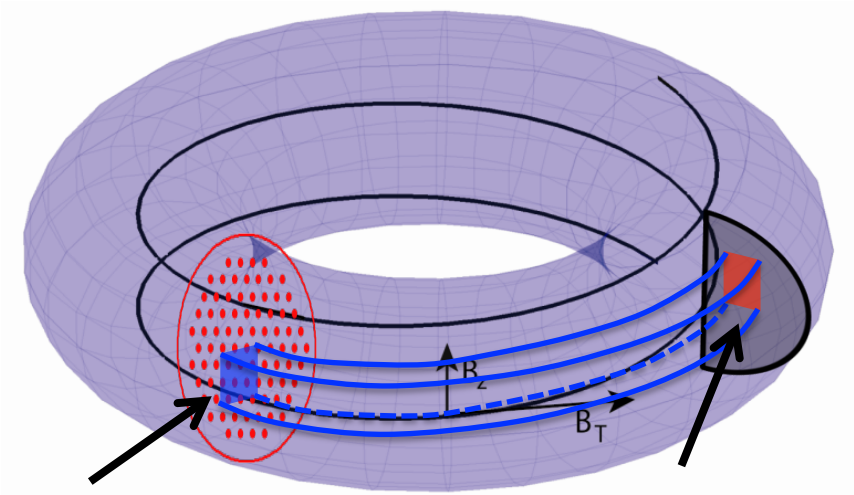
Uniformity of convective cell along B

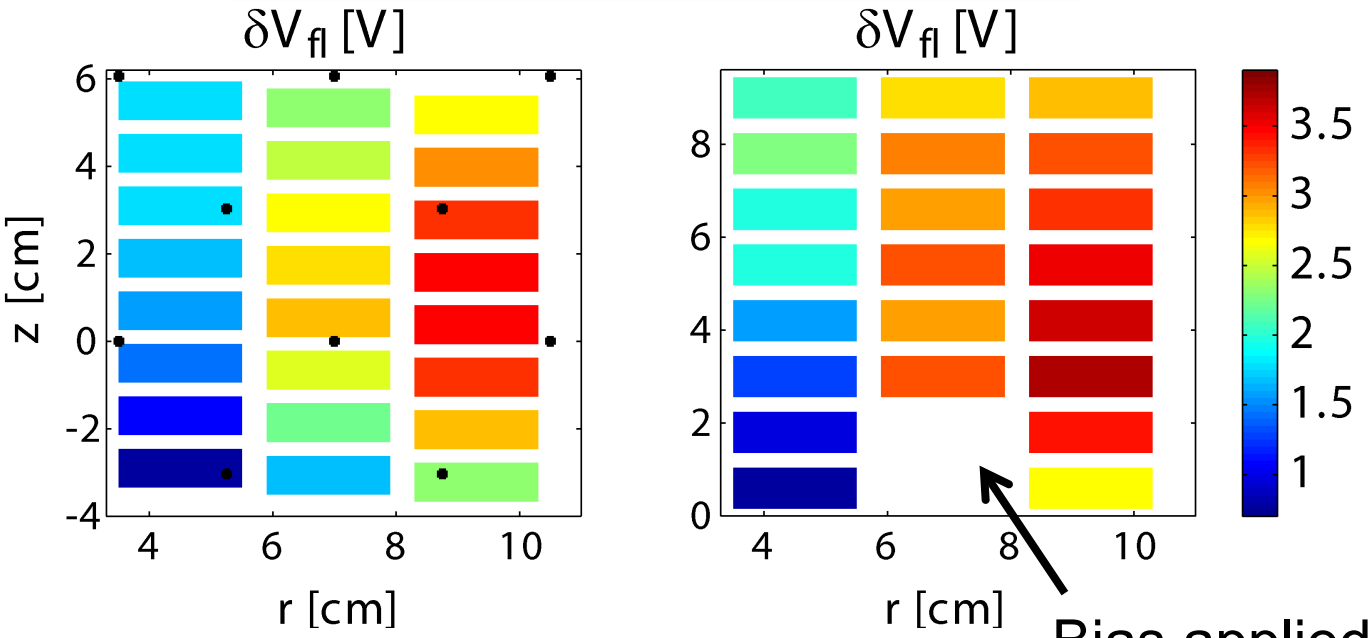




Bias applied to these electrodes

Uniformity of convective cell along B





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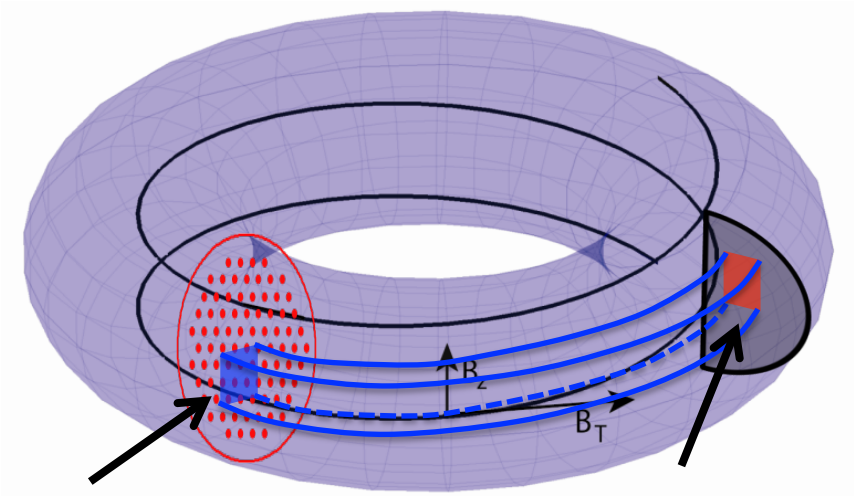

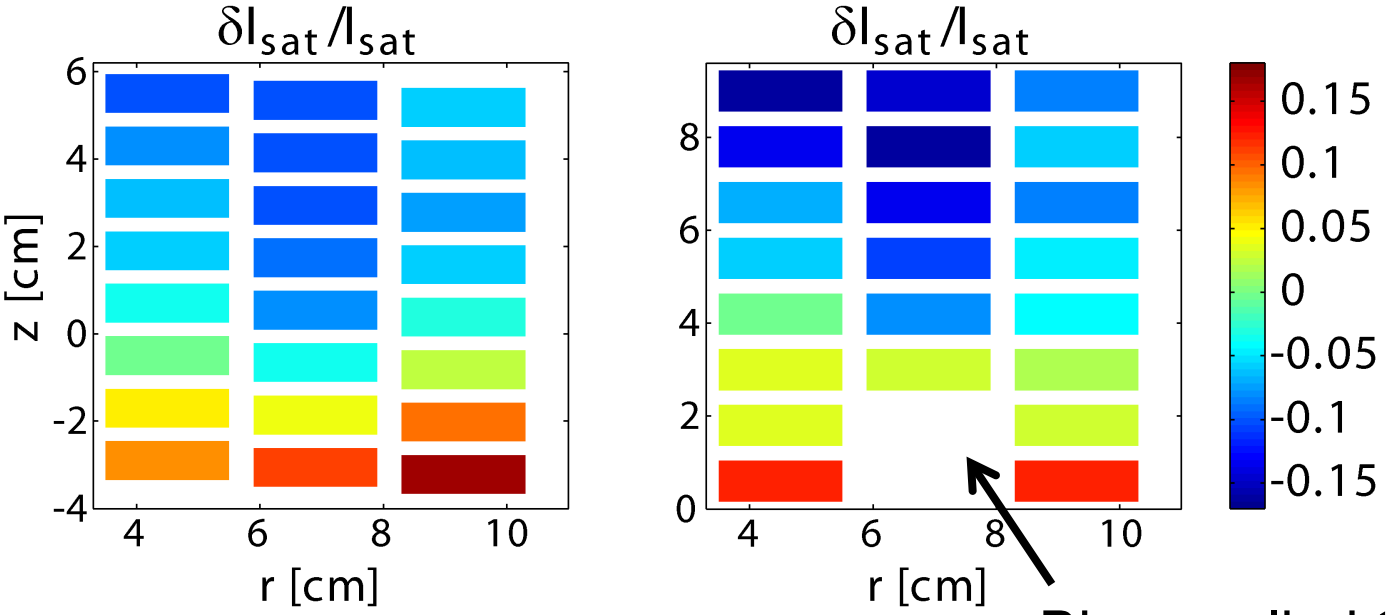

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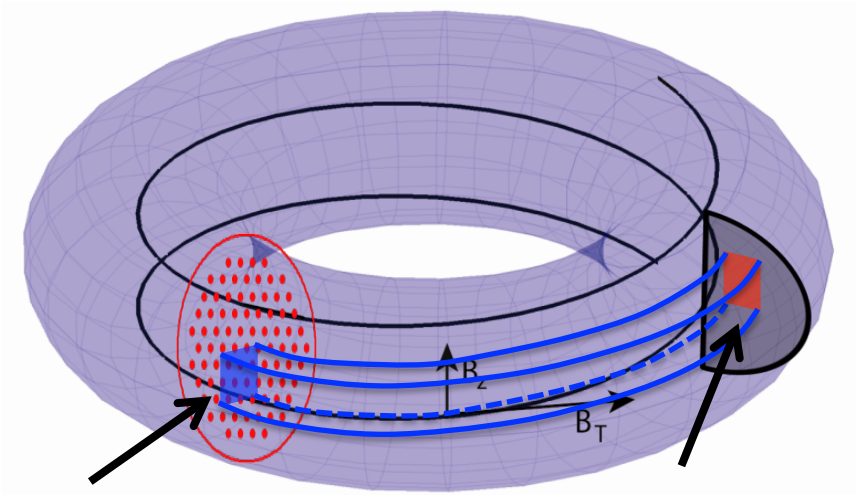
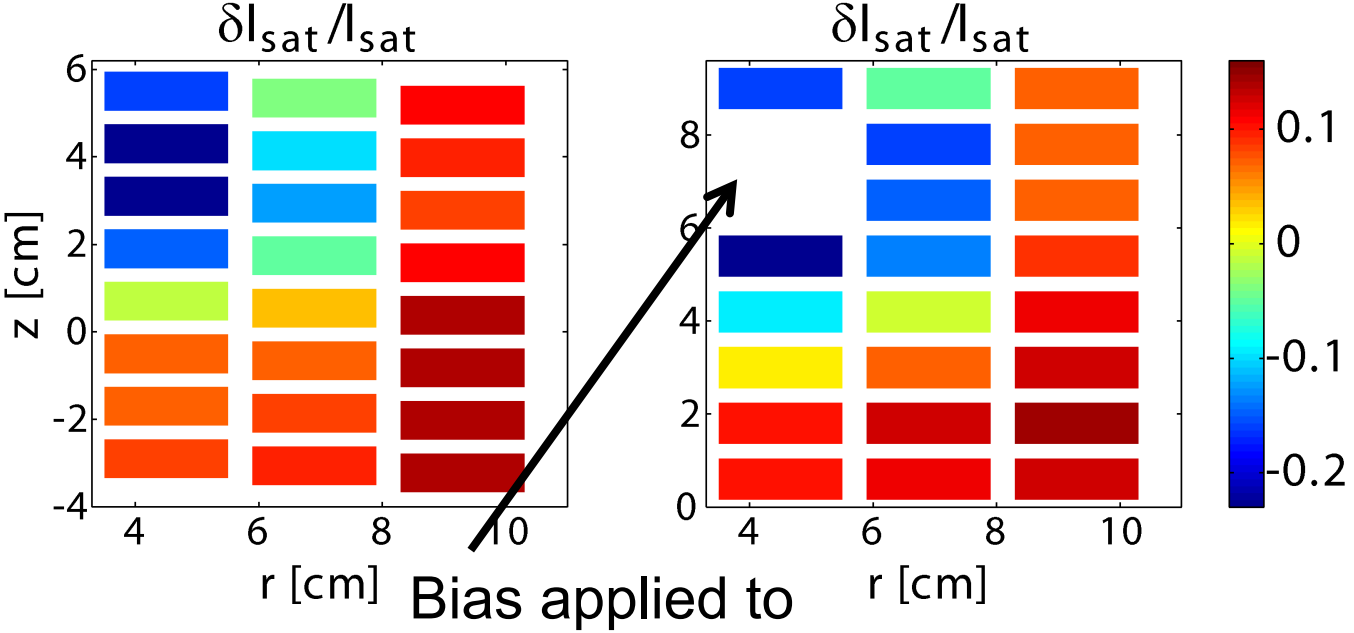
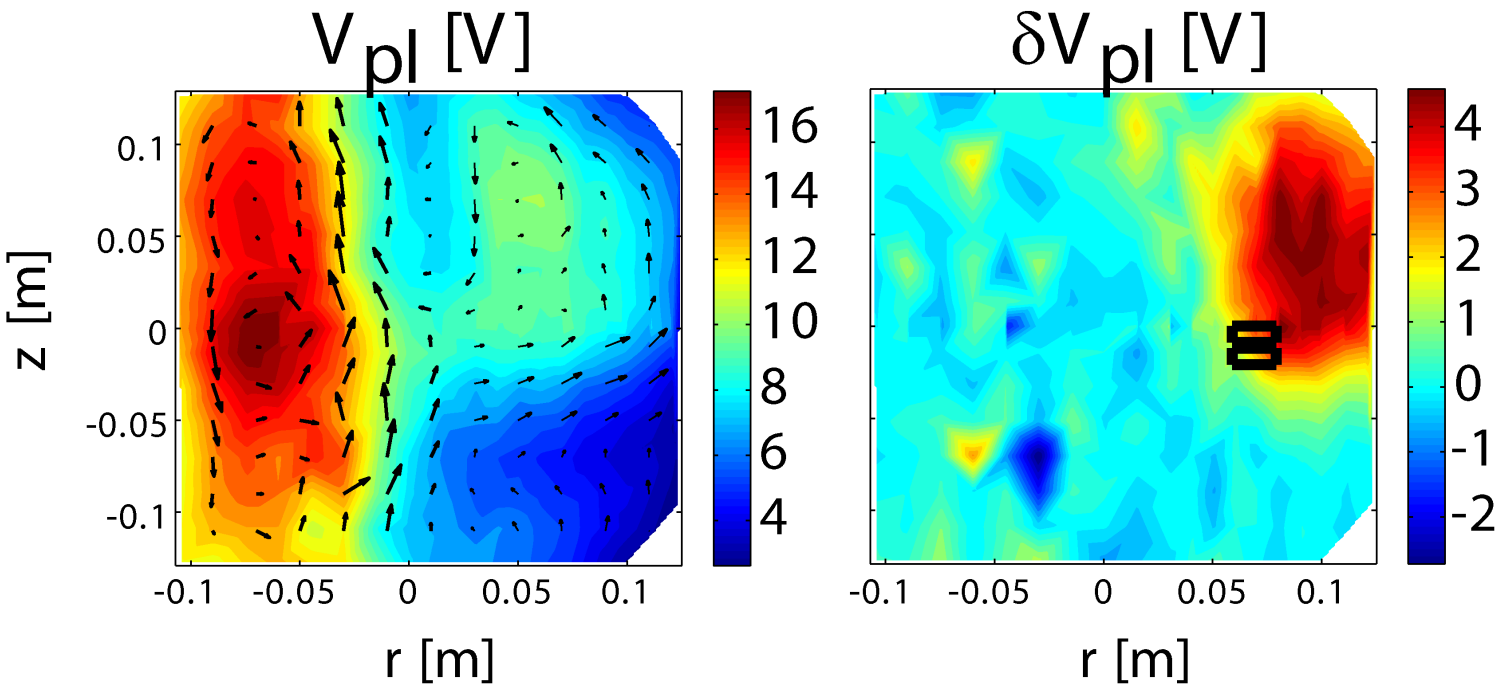




Bias applied to these electrodes

Position of δV_{fl}: effect of plasma flows



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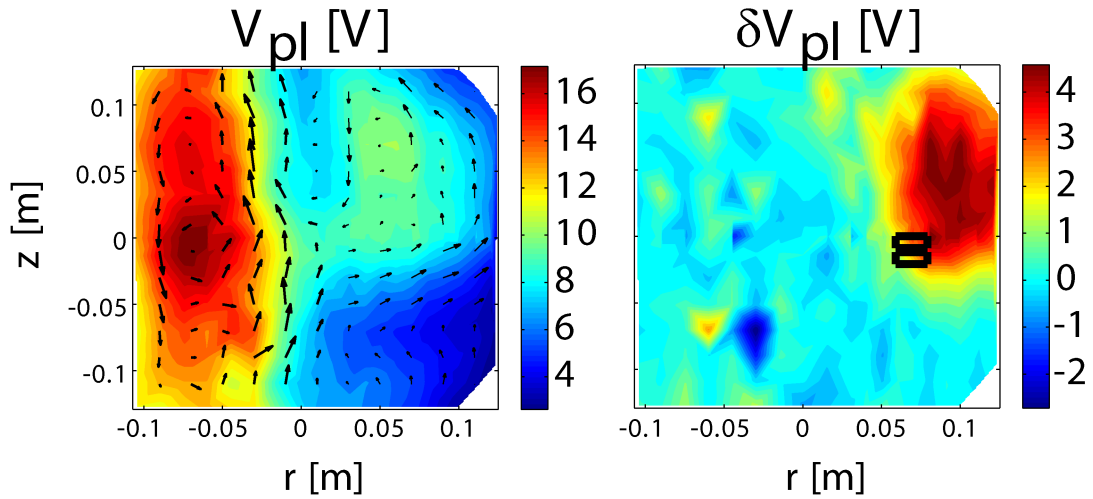

Hypothesis: position of δV_{fl} structure determined by plasma flows

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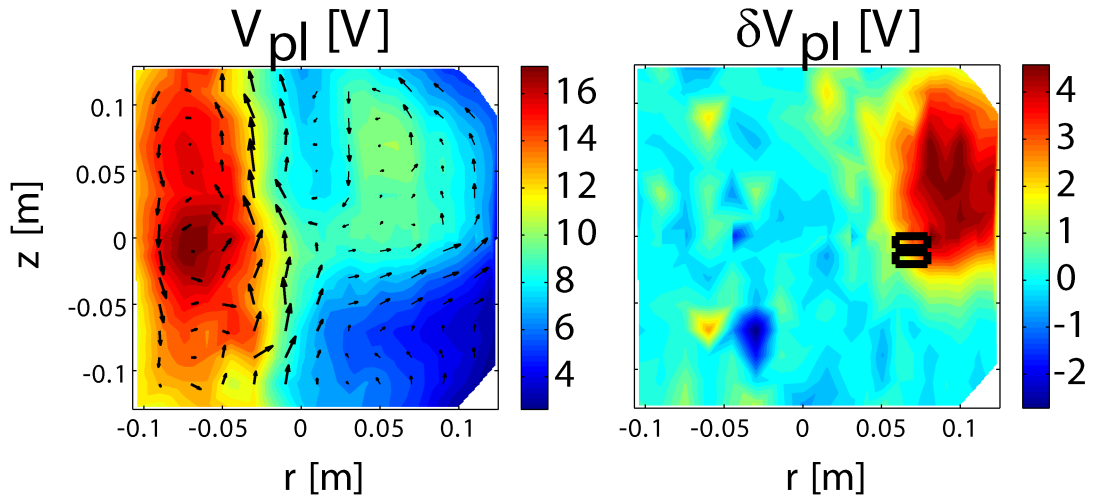

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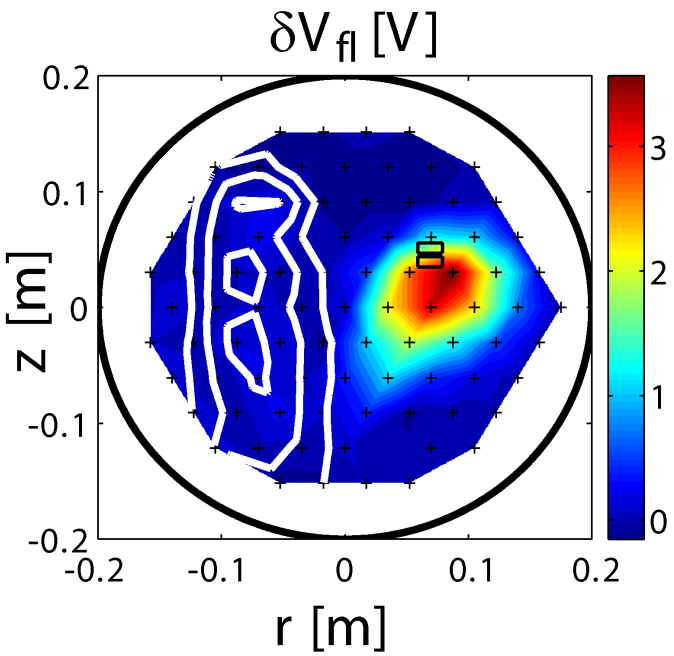

Confirmation by

- reversal of vertical ExB flow (B → -B)

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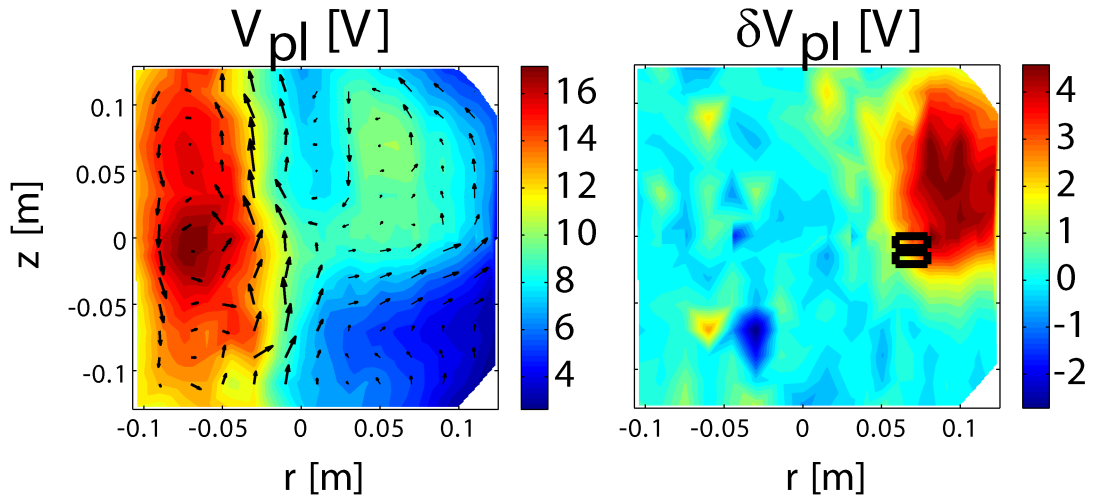

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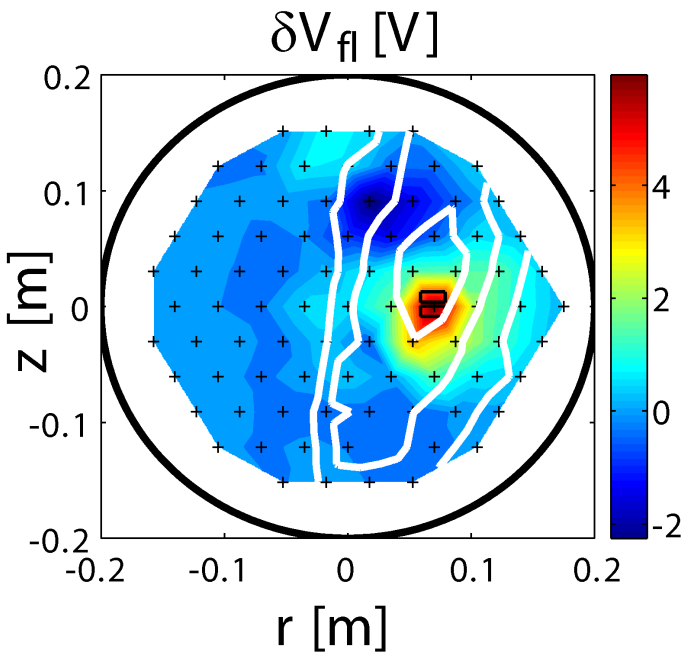

Confirmation by

- reversal of vertical ExB flow (B → -B)
- displacing the plasma radially

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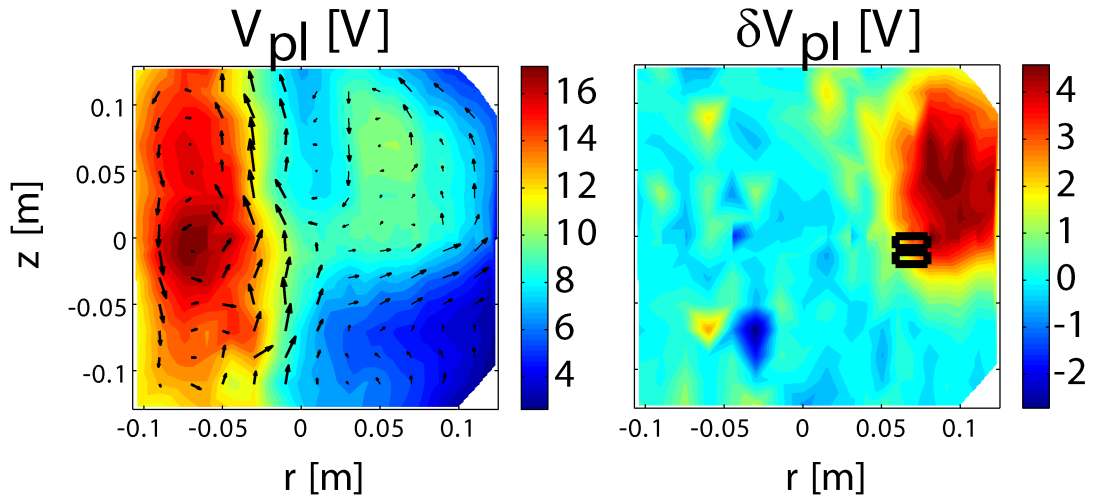

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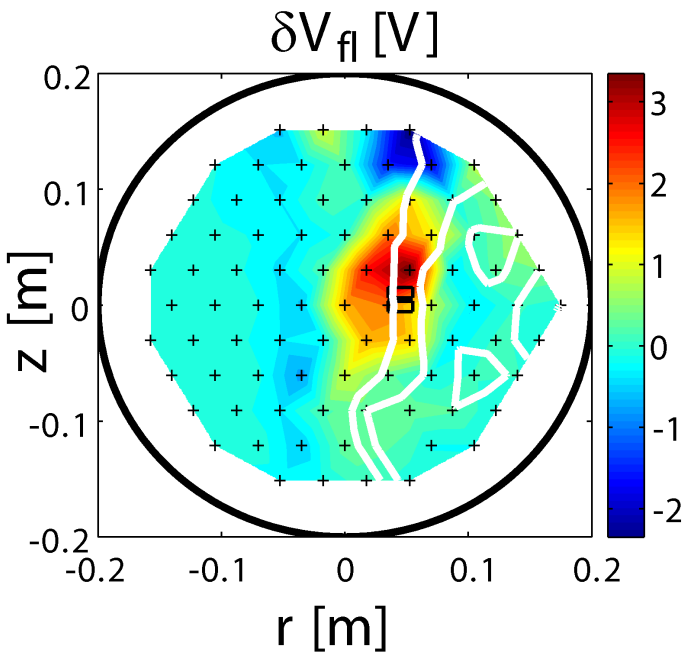

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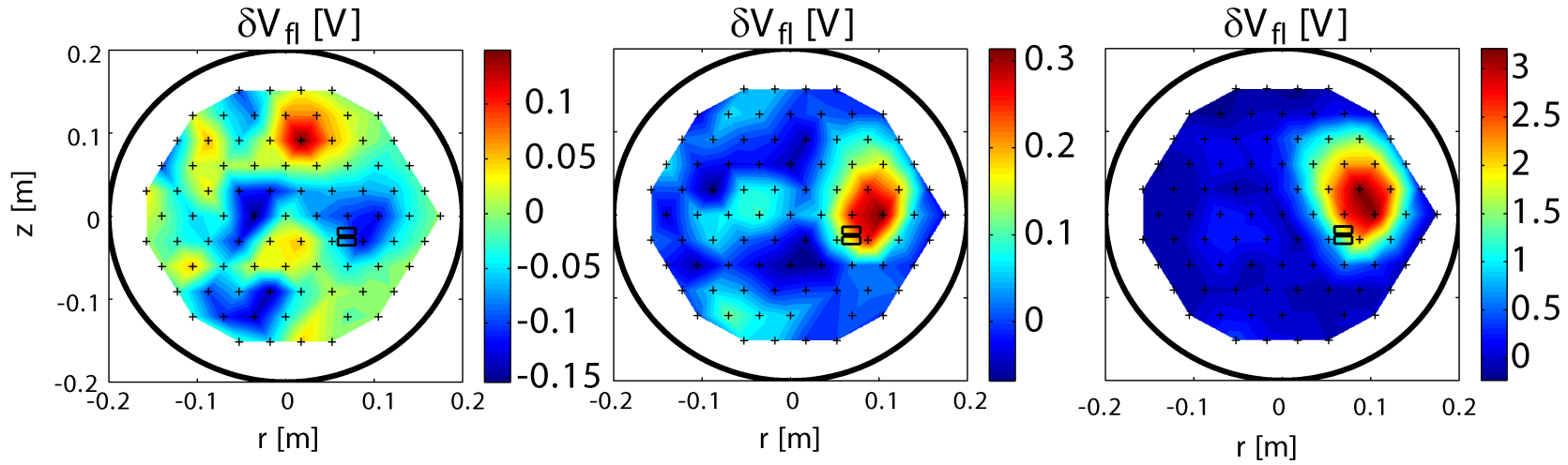
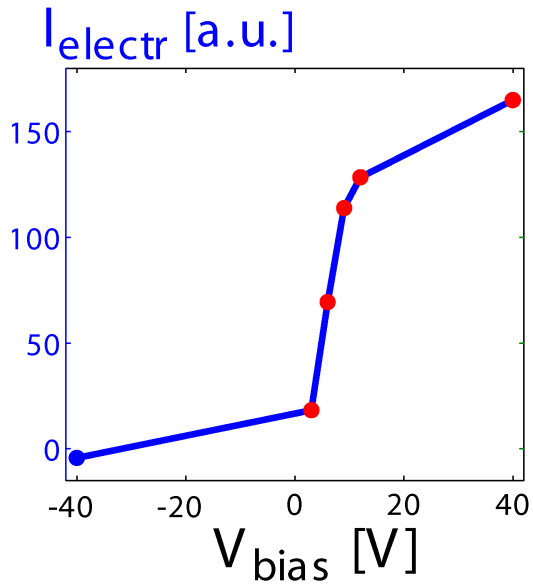
Magnitude of δV_{fl}: scan of bias potential V_{bias}

bias: -40 V +3 V +40V





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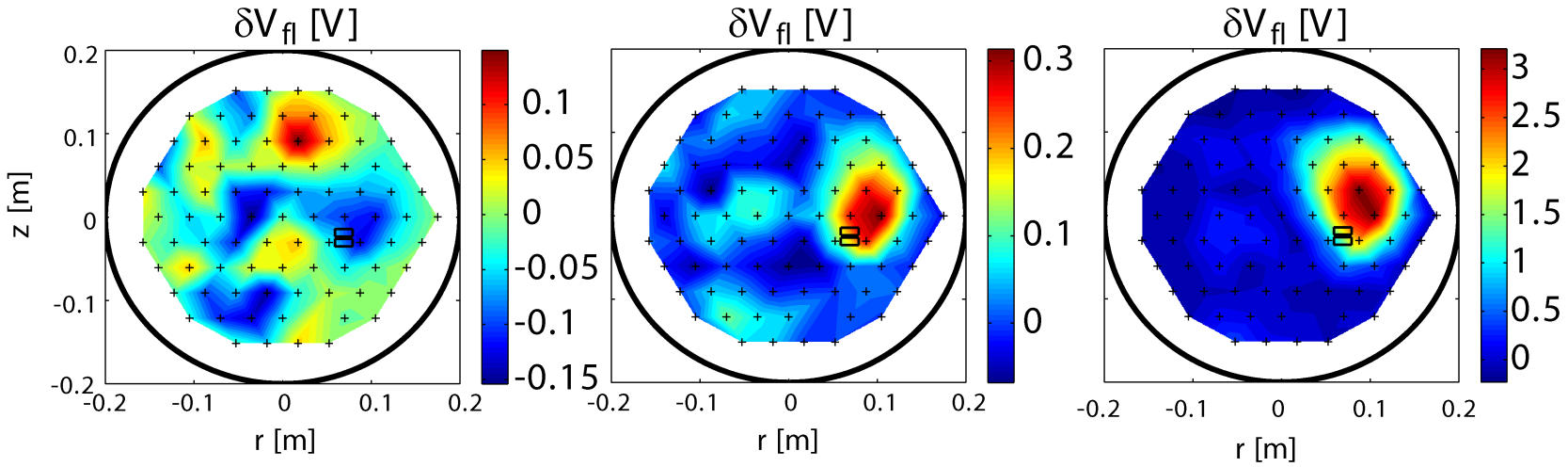

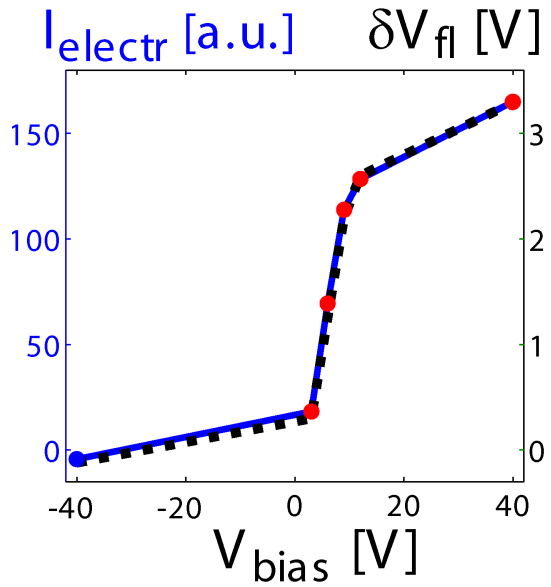

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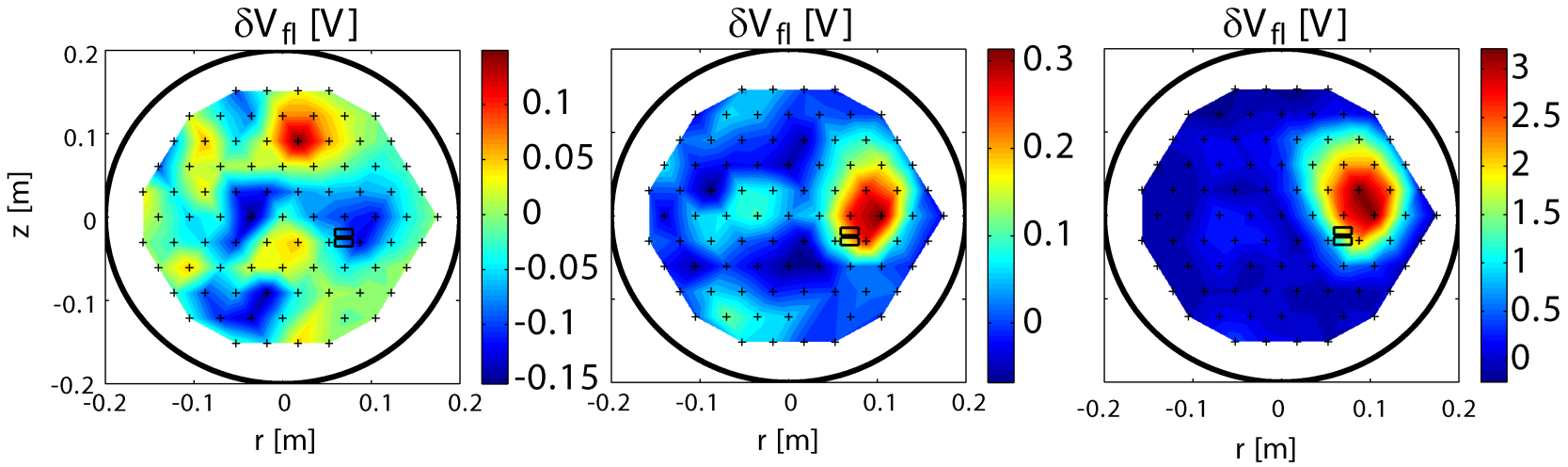

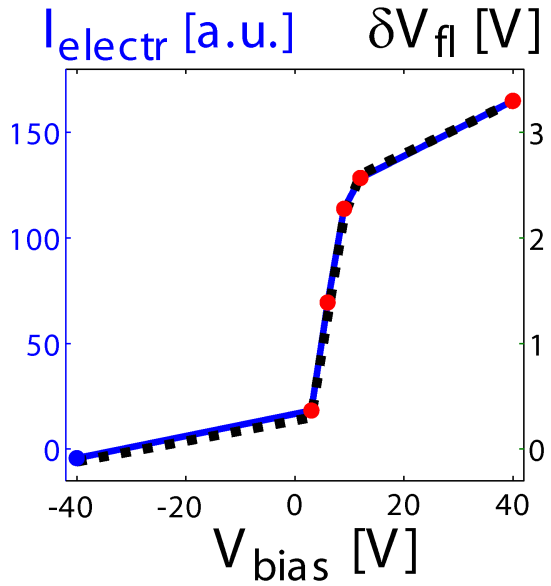

- $|I_{sat}^{ion}| << I_{sat}^{e^-}$
- $\delta V_{fl} << V_{bias}$
- $\delta V_{fl} \propto I_{electr}$

➡ Problem not 1D, cross-field currents important

Main results

- Control of time averaged profiles and blobs using toroidal/poloidal asymmetric biasing
- Both radial and vertical blob velocities significantly modified
- Biasing generates a convective cell that
  - is fairly uniform along B
  - is shifted w.r.t. the position of the biased flux tube due to plasma flows
  - is limited in magnitude (i.e., $\delta V_{fl} << V_{bias}$) due to a high level of effective cross-field conductivity