

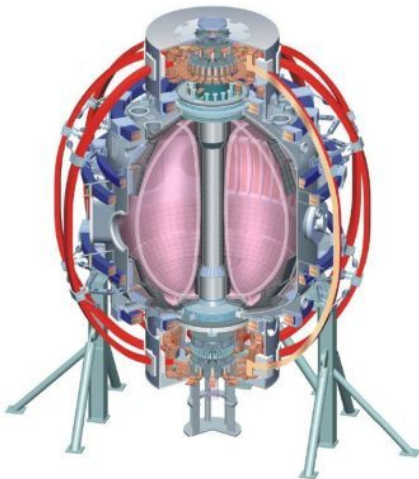
Effects of Biased Electrodes in the Divertor Plate Region of NSTX

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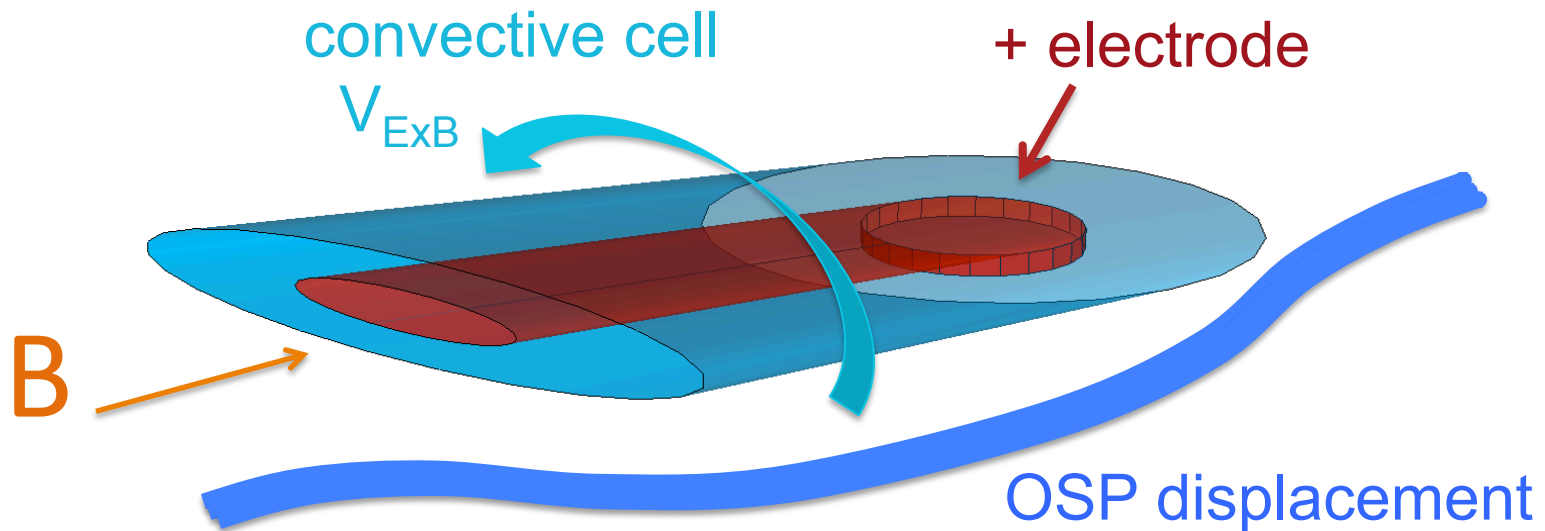


- Motivation
- Experiment
- Results
- Interpretation
- Future plans



Motivation

- Control SOL heat and particle flux to divertor plate by generating convective cells using biased electrodes



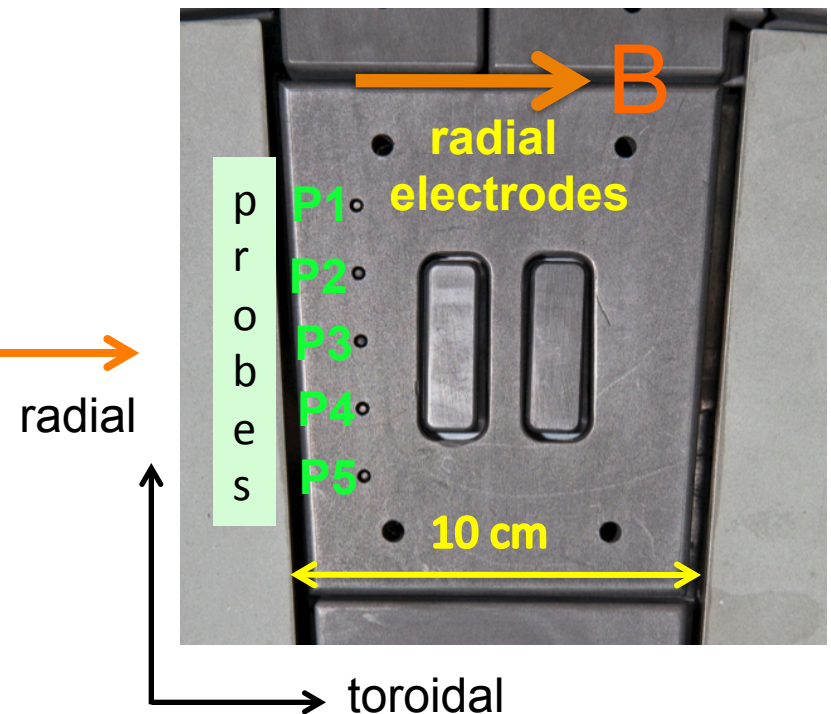
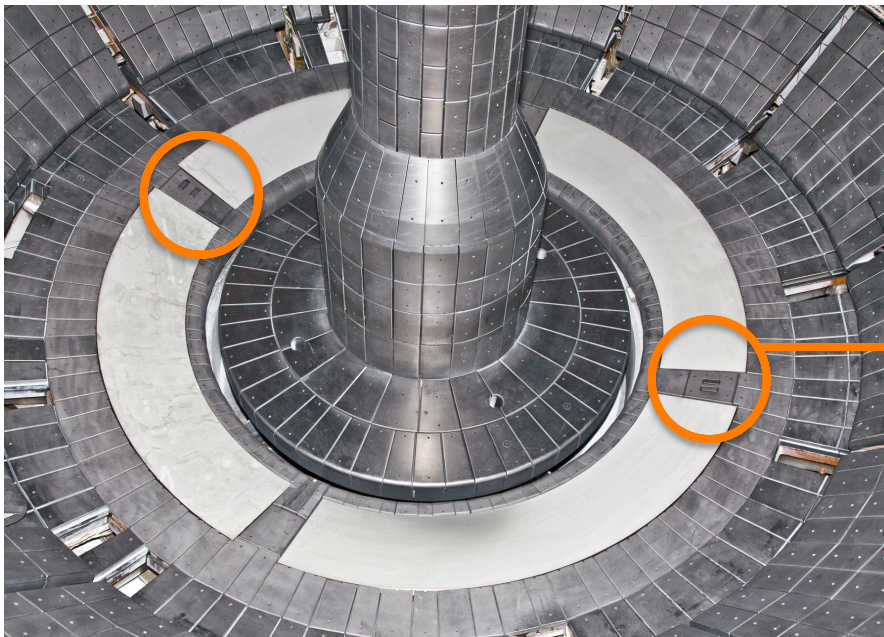
R.H. Cohen and D.D. Ryutov, Nucl. Fusion **37**, 621 (1997)

G. Counsell et al J.Nucl.Mater. **313–316** 804 (2003)

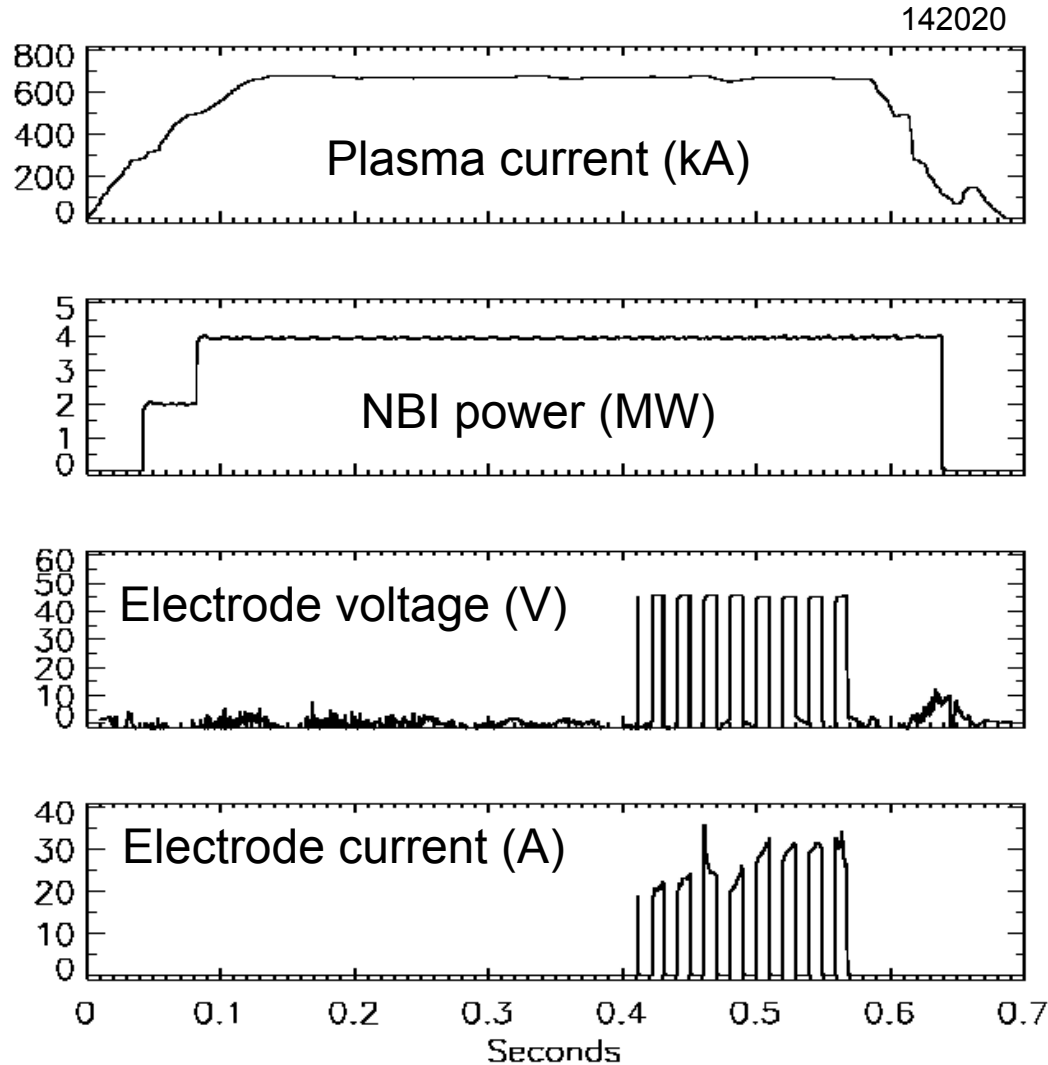
S.J. Zweben et al, Plasma Phys. Cont. Fusion **51**, 105012 (2009)

Experimental Set-up in NSTX

- Two radial electrodes mounted on outer divertor
- Five Langmuir probes mounted next to electrodes
- Fast camera view of electrodes from above with filters



Typical Plasma Waveforms



Outer strike point (OSP)
near radial electrodes
in these experiments
($R \sim 72-78$ cm)

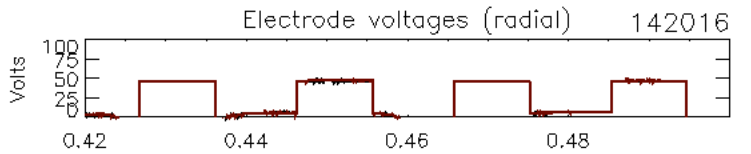
Electrode bias
+50 to 90 Volts

Electrode current
20-40 Amp/electrode

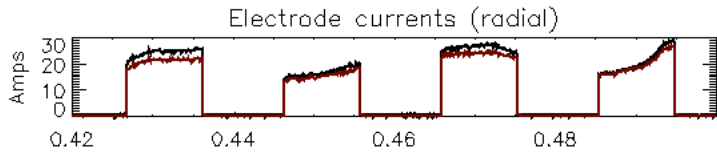
Probe Responses to Biasing

Floating potentials

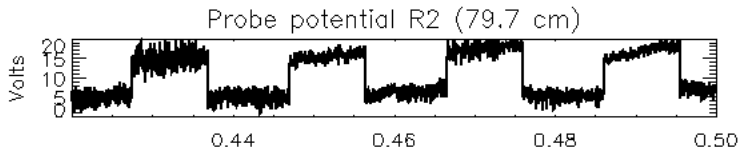
V



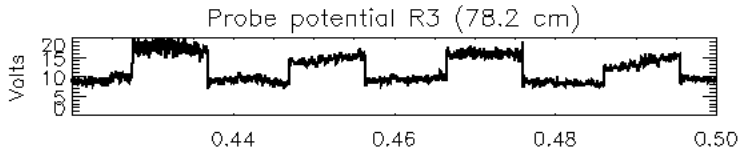
A



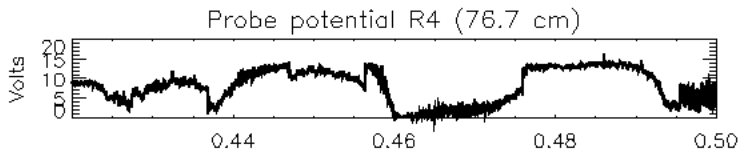
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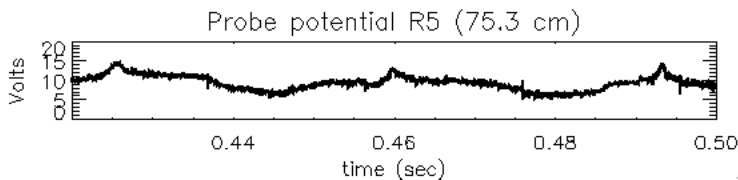
P3



P4



P5



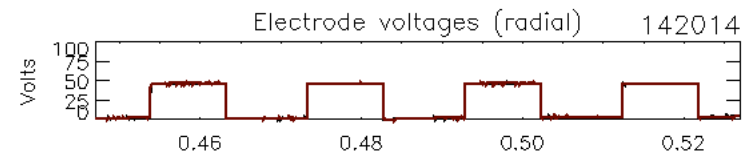
top

electrode

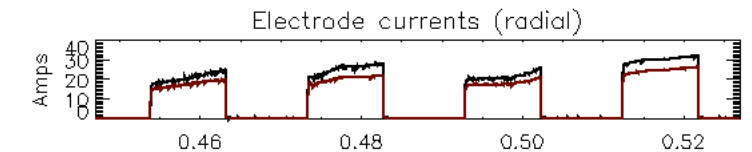
bot

probe currents

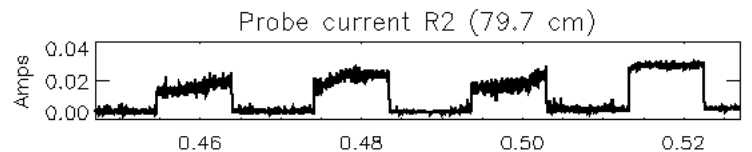
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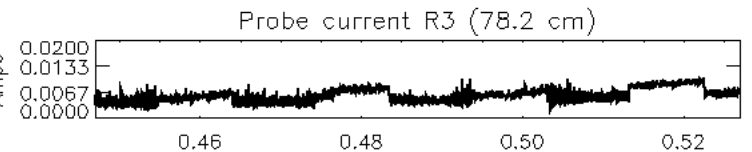
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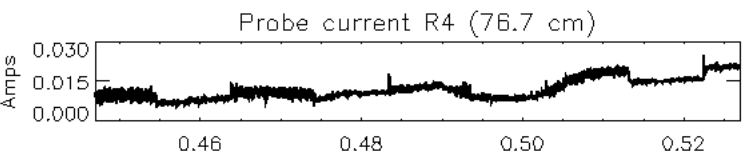
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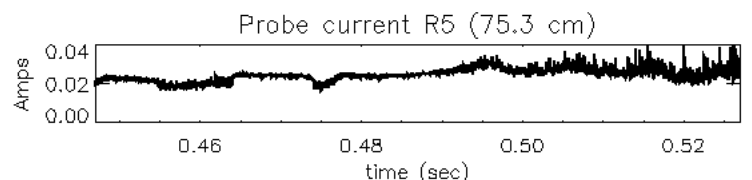
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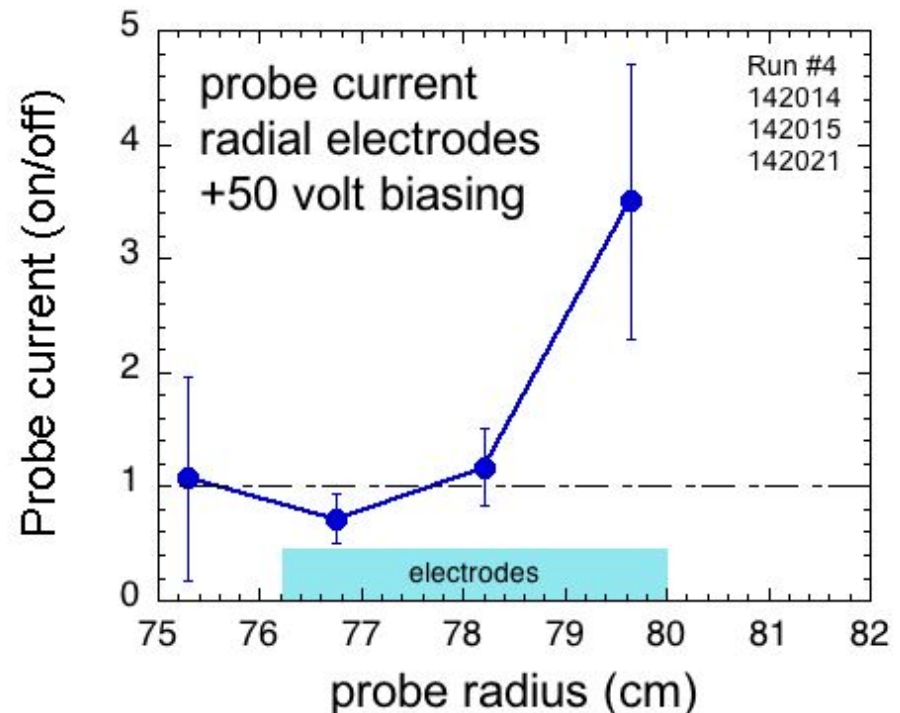
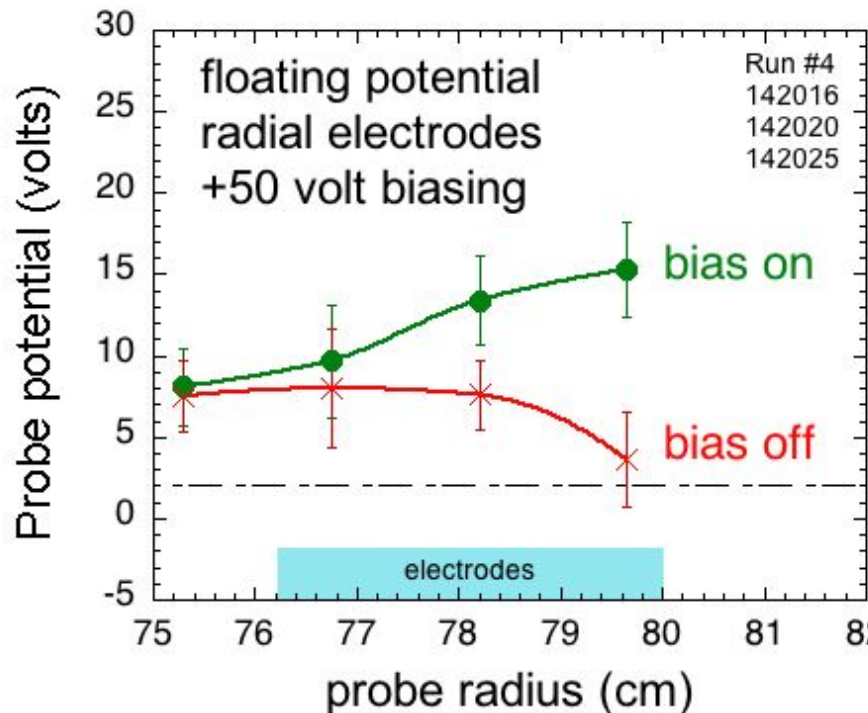


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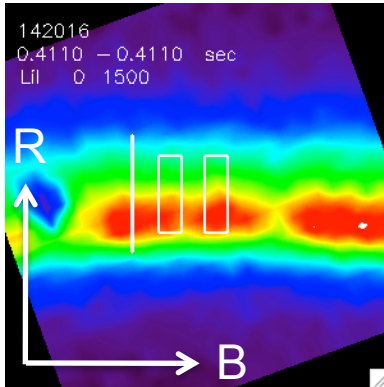
Biasing Changes Probe Profiles

- Floating potential increases at large-R half of electrodes
- Biasing increases probe current at large-R of electrode

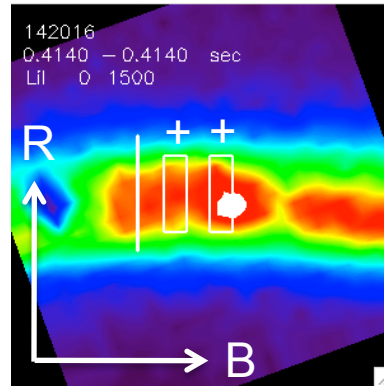


Camera Views of Electrodes (Lithium I)

“bias off”

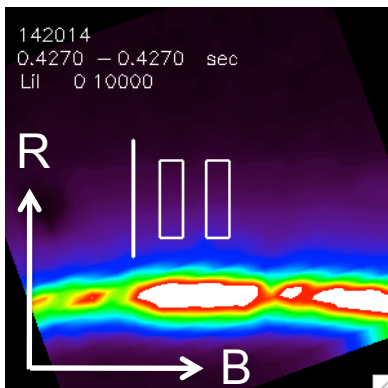


“bias on”

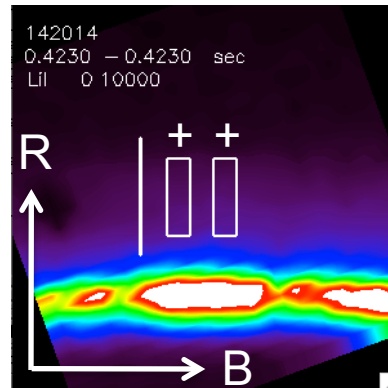


Outer strike point at electrodes:
Large-R half of electrode glows

“bias off”



“bias on”

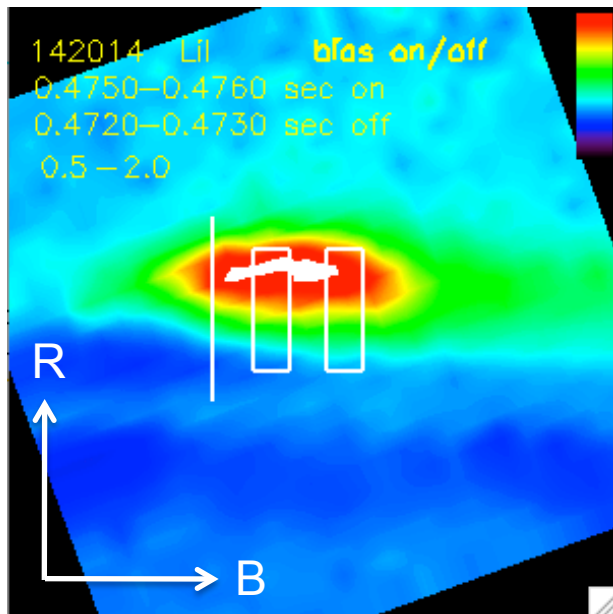


OSP ~ 3 cm below electrodes:
OSP not deflected by electrodes

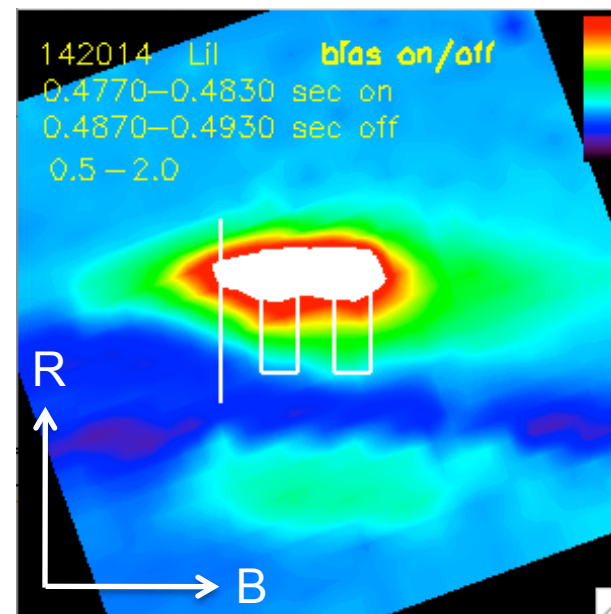
Ratio of Bias-on to Bias-off Images

- Light emission increases by ≥ 2 at large-R half of electrodes at turn-on of bias (± 1 msec) and steady-state (± 6 msec)

bias turn-on (1 msec)



bias steady state (6 msec)

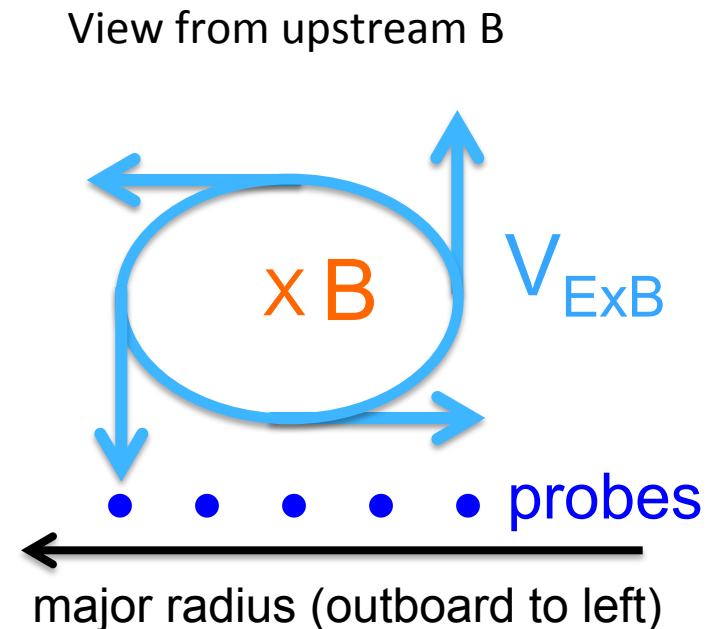
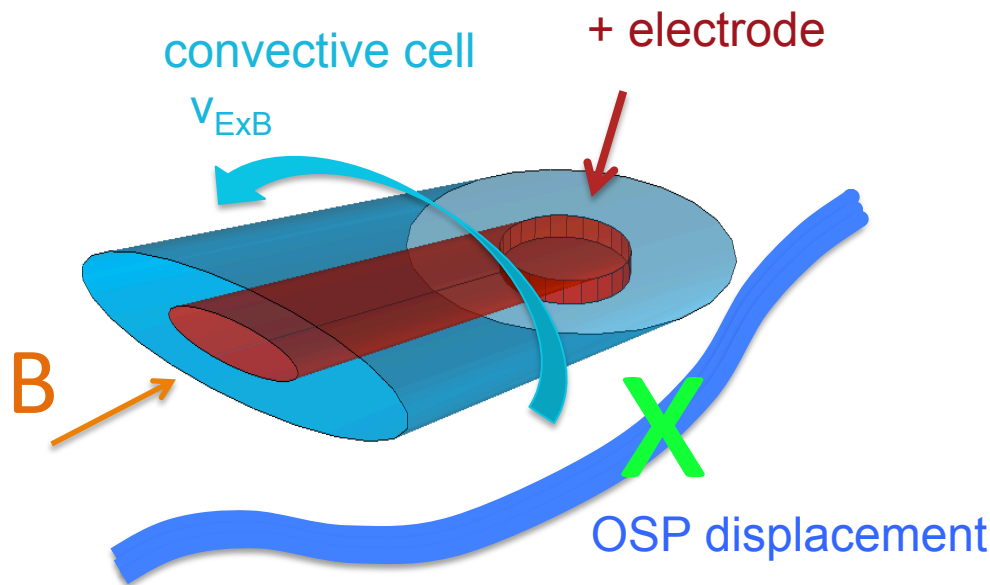


Summary of Experimental Results

- When OSP was near electrodes, positive biasing caused an increased in local density at large-R half of electrodes
- When OSP was ~ 3 cm inboard of electrodes, biasing did not move nearby OSP location
- When OSP was $\sim 10-15$ cm inboard of electrodes (not shown) no effects of biasing were seen in nearby probes
- No non-local effects observed in any other diagnostics

Qualitative Interpretation of Results

- Expected convective cell $E \times B$ motion moves plasma downward into divertor at large- R and upward at small- R probes
- Could possibly explain increase in density at large- R probes, but a quantitative model can not be constructed yet



Future Directions

- Quantitative modeling of 3-D potentials and transport effects should be done including effects of neutrals, finite ion orbits, turbulence, rotation, flux tube geometry along B, etc.
- Relevant biasing experiments were done on TORPEX (Theiler et al PRL '12), and could be used to validate such modeling
- Next tokamak step could be a larger area electrode (~ 1 kA) with better diagnostics. e.g. larger probe array, IRTV
- Alternatively, local cold gas puffing might be able to generate divertor convective cells (also Cohen/Ryutov 1997)