NSTX-U
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Assessment of Equilibrium Field Coil Misalignments on the Divertor Footprints in NSTX-U

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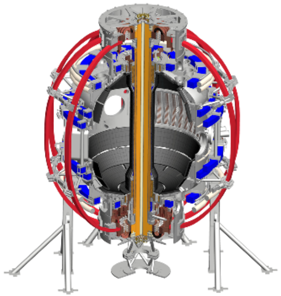
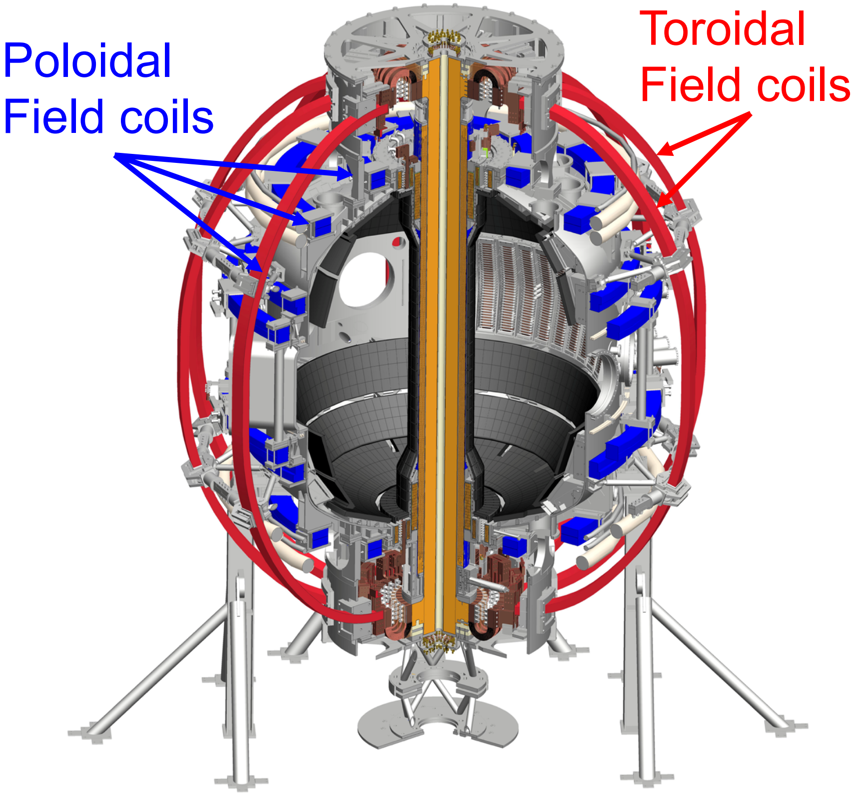
GENERAL ATOMICS

PPPL



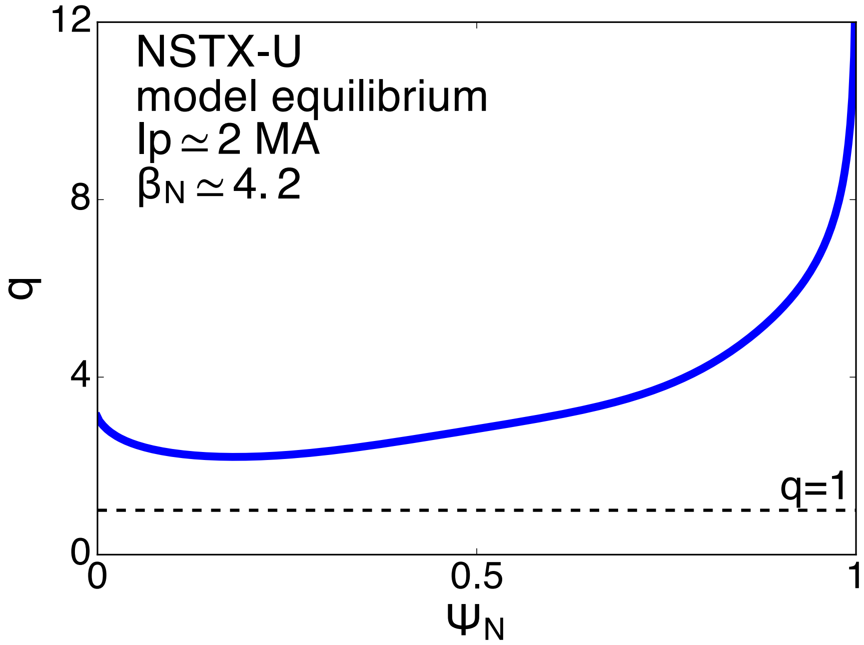
Magnetic field perturbations due to error fields produce complex 3D edge magnetic topologies

- Error fields significantly alter the properties of the heat and particle flux distributions on the divertor target plates.
- Error fields can lead to heat loads on undesired regions of the machine.
- Physics of footprints still not fully understood.
- Source of intrinsic error fields is for example a misalignment of the equilibrium coils.
- This work is focused on possible NSTX-U equilibrium coils misalignments.



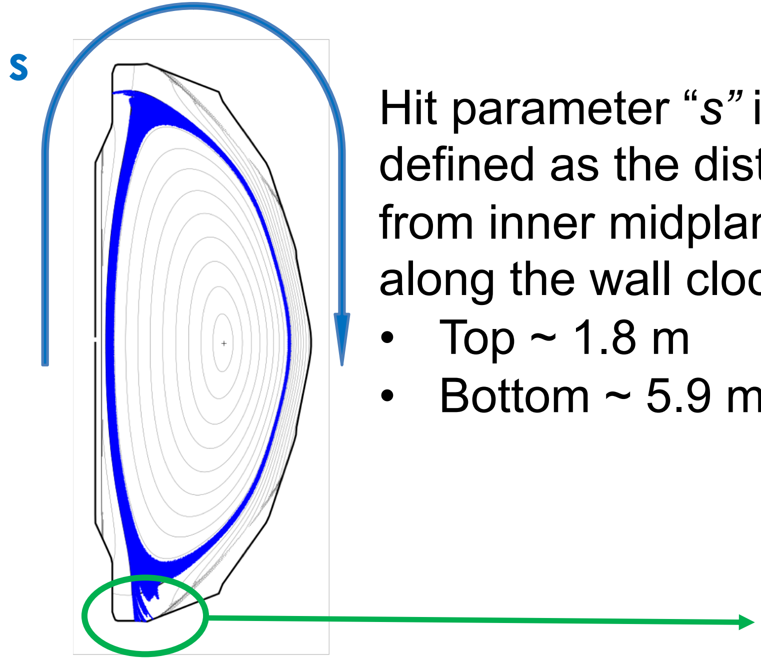
The perturbed equilibrium due to a coil misalignment is computed with the MHD code M3D-C1

- For each simulation one coil is shifted (tilted) by 1 mm (1mrad).
- The field line tracing code TRIP3D uses the M3D-C1 perturbed equilibrium to estimate the magnetic footprints.
- The simulations are linear so shift/tilt magnitude can be varied in TRIP3D.
- Lines launched from the plasma to study the fraction of lines going to the divertor.
- Lines followed from a divertor plate to the other to study plasma penetration.



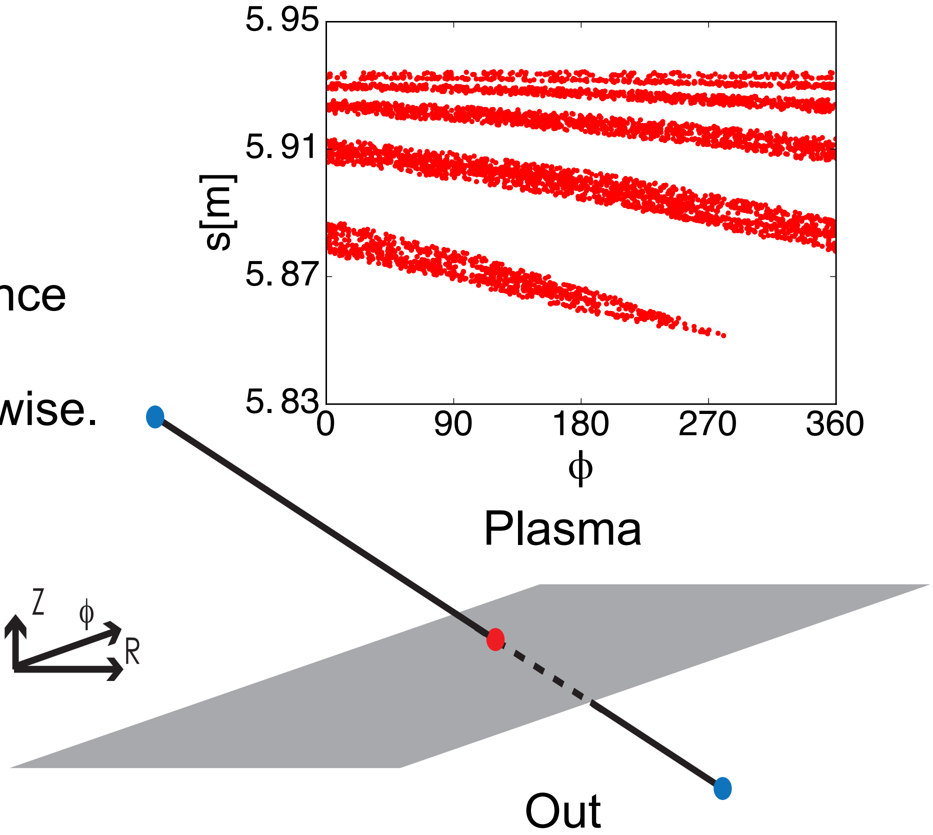
Footprints are estimated using the last step inside and first step outside the limiter and the limiter itself

Poincaré plot of the region with lines that exit the plasma



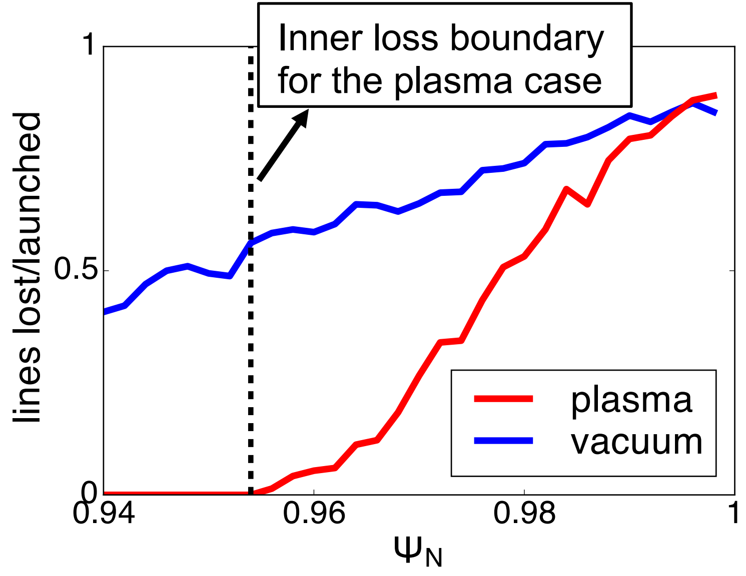
Hit parameter "*s*" is defined as the distance from inner midplane along the wall clockwise.

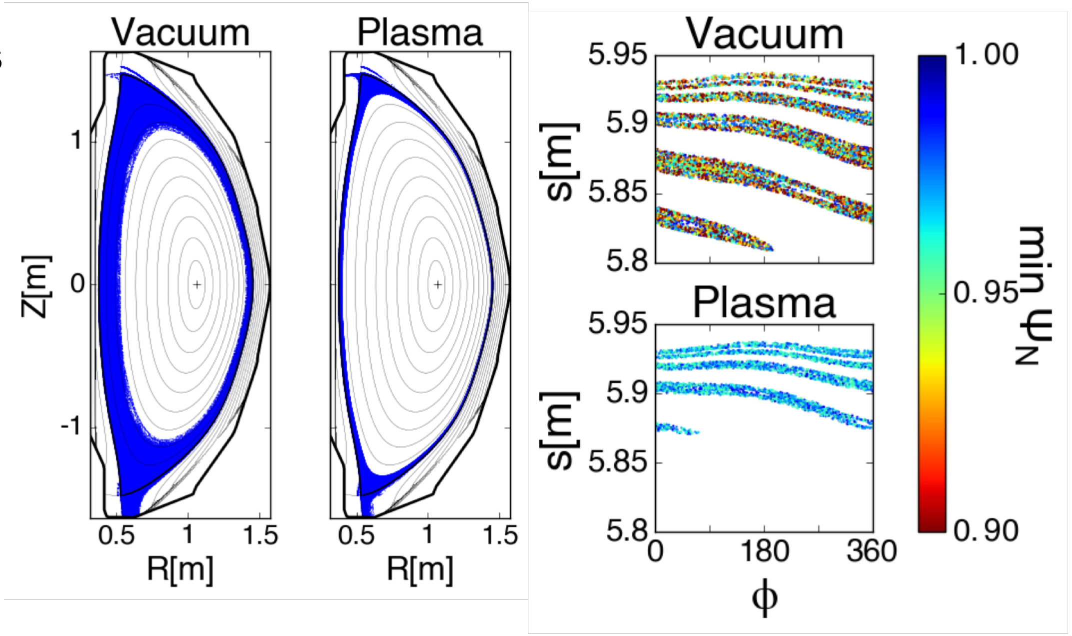
- Top ~ 1.8 m
- Bottom ~ 5.9 m



Including the plasma contribution in the simulations, the outer footprints size is reduced by more than a factor of 2

Neglecting the plasma contribution results in a field line loss of 50% at $\psi_N \simeq 0.95$, the inner field line loss boundary when the plasma response is included

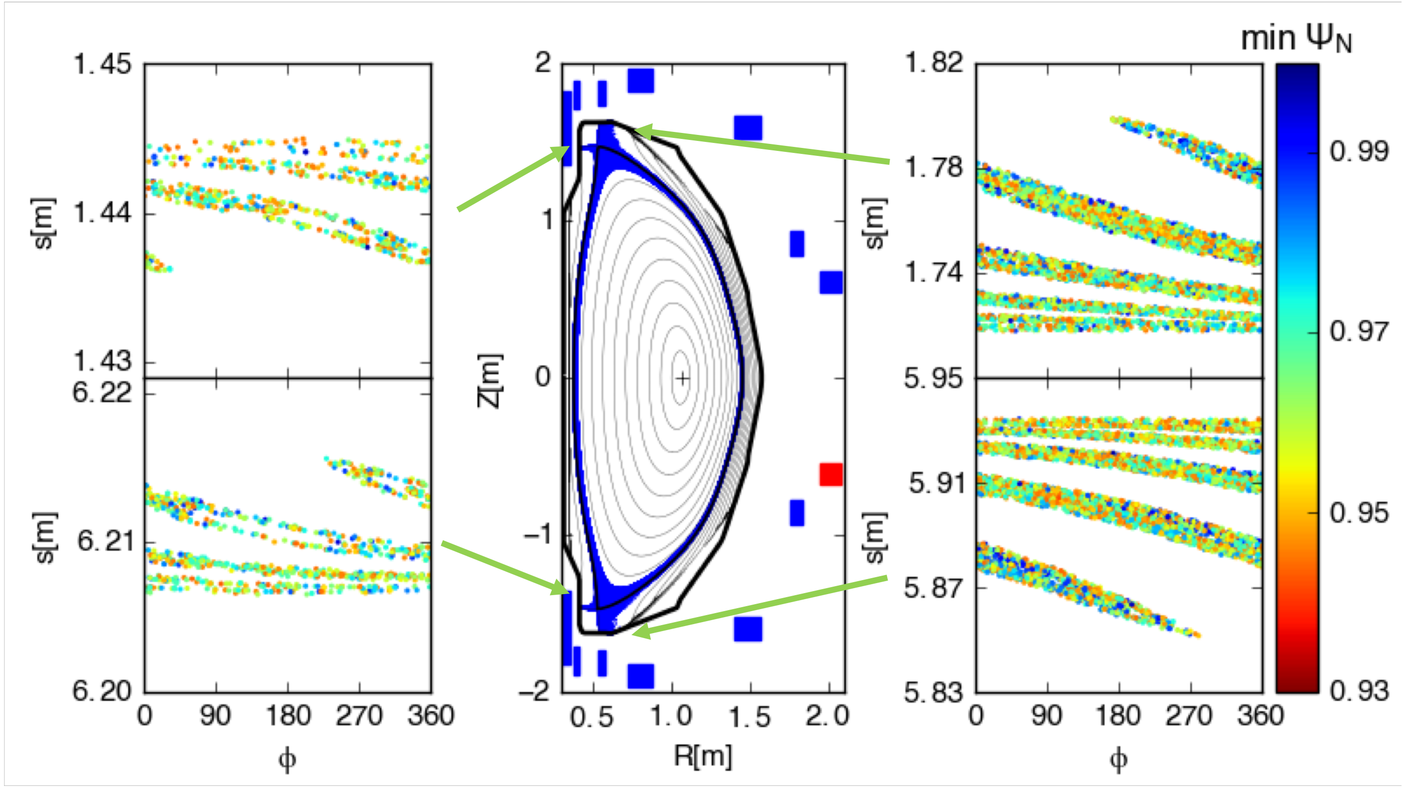




Poincaré plot of the region with lines that exit the plasma.

In the rest of the talk plasma response always included.

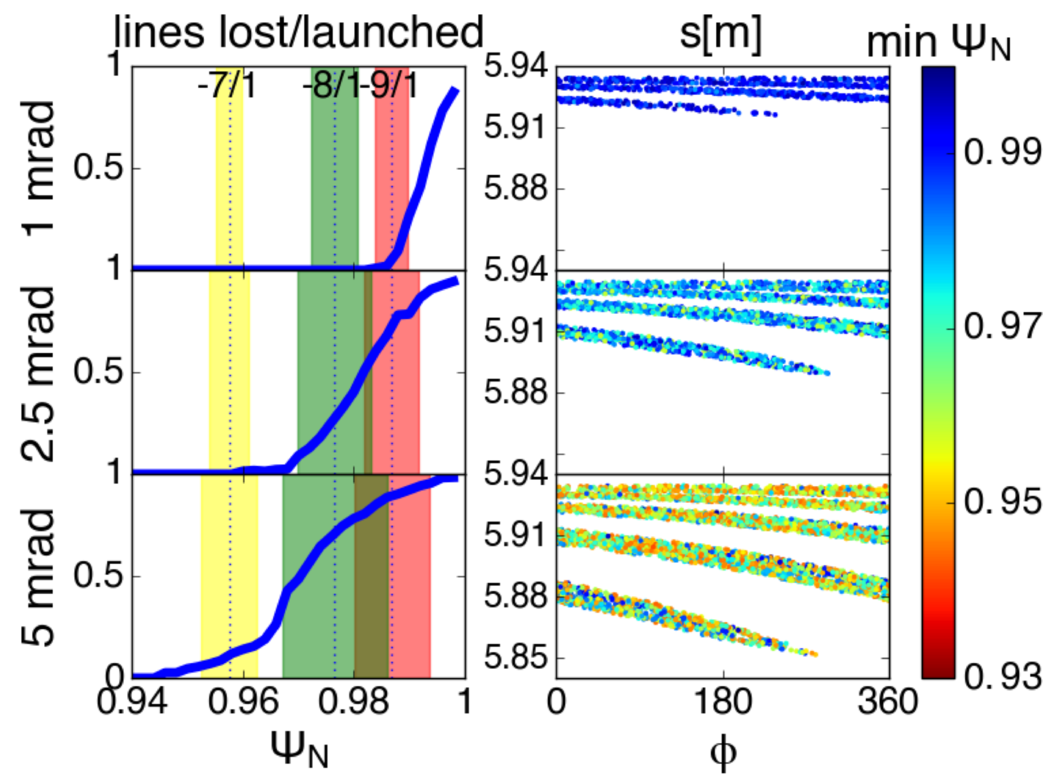
5 mrad tilt of the PF5 coil produces 8 cm wide footprints on the outer divertor plates



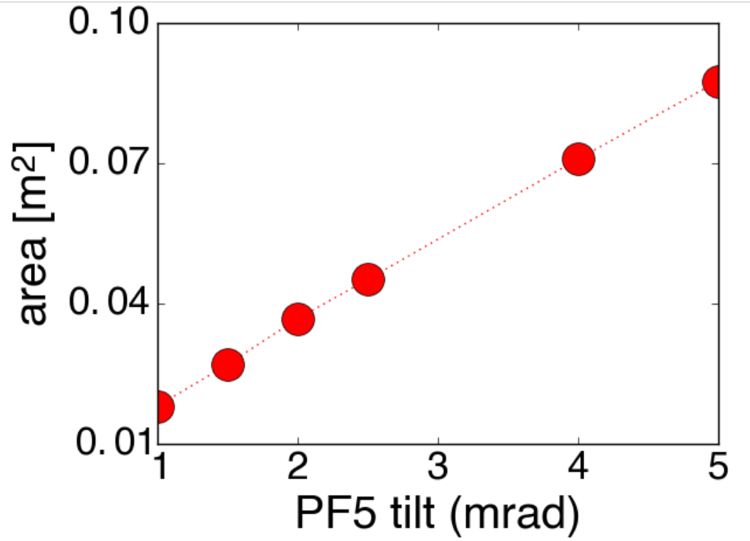
Footprints area

- Outer:
- Upper -> 0.0854 m^2
- Lower -> 0.0876 m^2
- Inner:
- Upper -> 0.0034 m^2
- Lower -> 0.0042 m^2

The footprint area scales linearly with the tilt magnitude

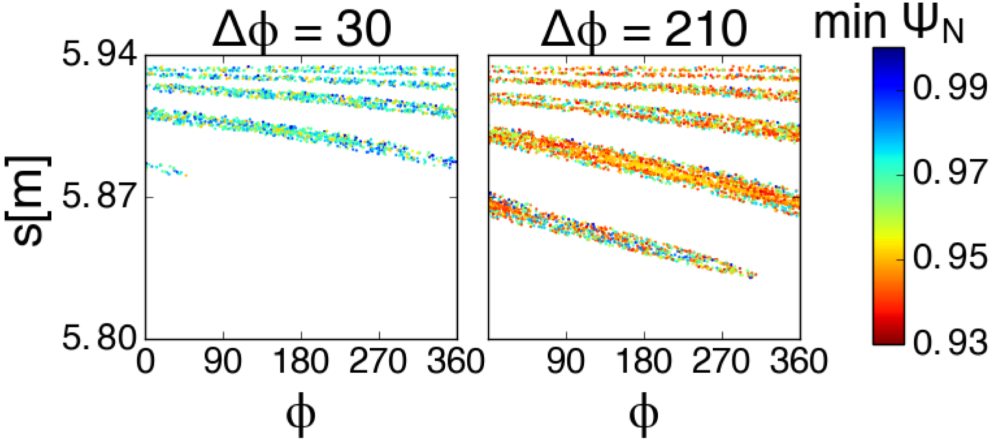


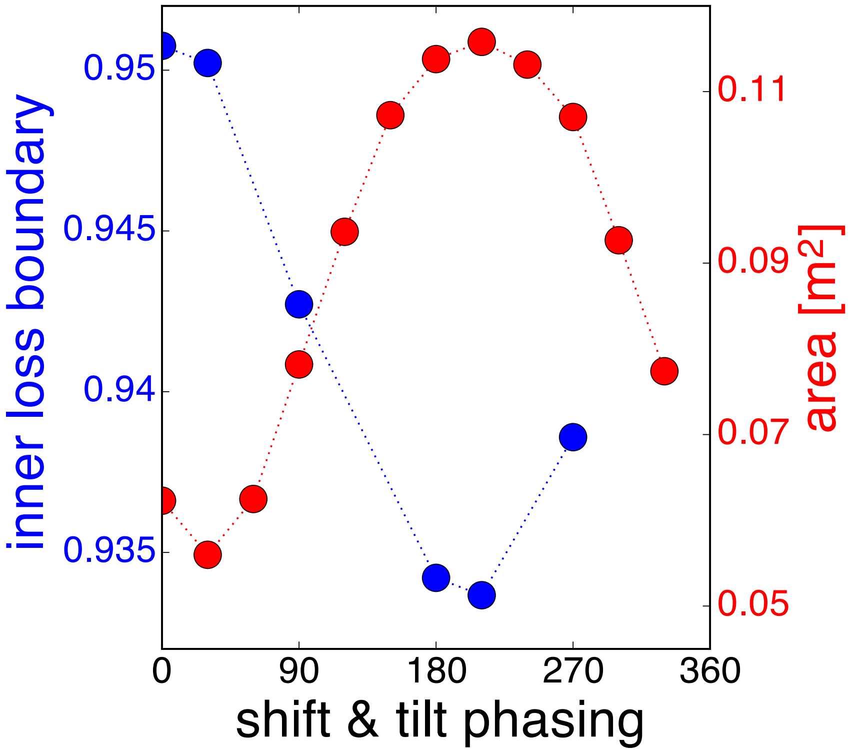
- For 1 mrad tilt the footprint is about 1.8 cm wide, for 5 mrad 8 cm wide
- The larger the tilt, the deeper the lines go in the plasma



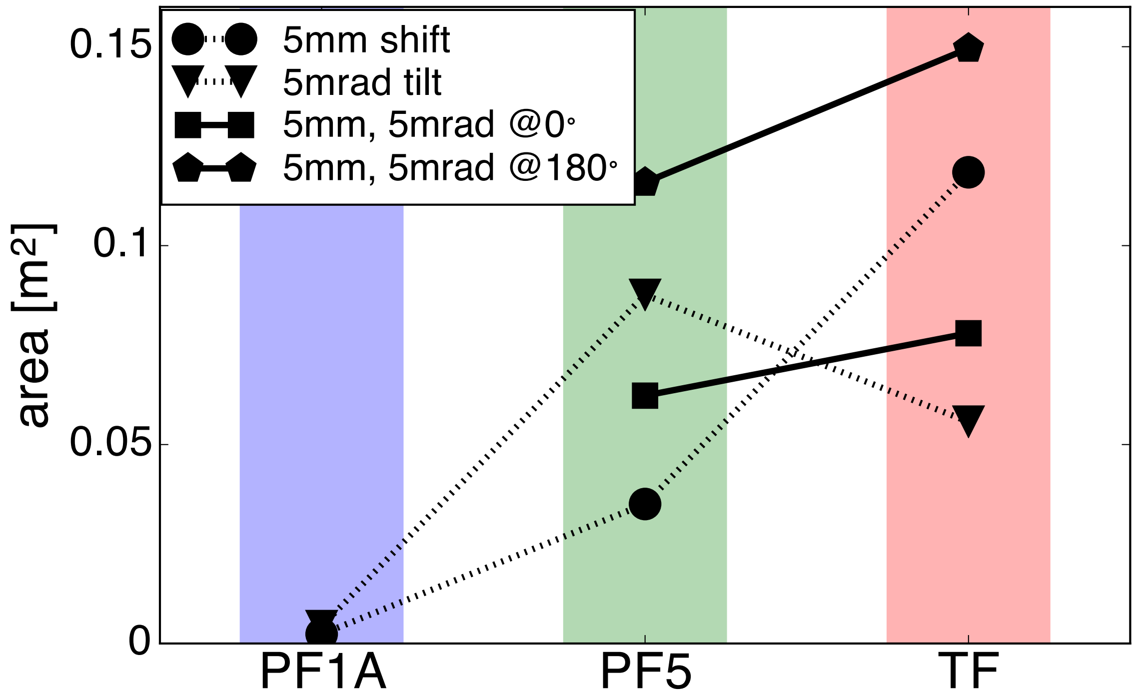
Shift at 30º from tilt direction produces the minimum area, at 210º the maximum

- Combining 5 mm shift and 5 mrad tilt.
- The largest footprint is also that with the deepest field lines.
- The area for a 5 mrad tilt only is ~0.09 m^2





TF coils misalignment produces the largest perturbation



- Misalignment of the innermost PF (PF1A) is negligible compared to the PF5 and TF.
- TF shift produces larger footprints than TF tilt. Vice versa for the PF coils.
- Shift and tilt combinations at 180º produce bigger footprints than at 0º.
- Combinations of shifts and tilts of PF5 and TF are not expected to exceed 6mm/6mrad

Conclusions

- **TRIP3D coupled with M3D-C1 predicts that:**
  - The area of the footprints changes linearly with the misalignment magnitude.
  - The relative phase of the misalignments can bring to larger or smaller footprints.
  - At larger footprints generally correspond field lines that go deeper in the plasma.

- **Next step: Is a large footprint more or less desirable than a small footprint?**
  - Does a larger footprint spread the heat flux on a larger surface, being therefore desirable?
  - Do deeper field lines in the footprints correspond to a larger radiative layer at the edge, that also decrease the heat density on the divertor?

- **Comparisons with experimental data are needed to validate the predictions.**

This work was done using the OMFIT framework.

Disclaimer

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