CONTACT: **Brian LaBombard**
Phone: 617-253-7264

FOR IMMEDIATE RELEASE
September 23, 2010

How big is the 'footprint' of a fusion plasma?

Fusion plasmas contact their container walls primarily along a narrow 'footprint' – a concern for reactor designers. Recent experiments yield insight on what sets its size.

Plasma physicists are clever. They build "magnetic bottles" to hold and isolate extremely hot, dense plasmas inside a vacuum vessel. This thermal insulation has proven quite effective, allowing plasma temperatures in excess of 100 million C to be attained – conditions under which the nuclei fuse and release energy. Reactor designers have adopted this scheme as the basis for building electrical power plants. In particular, a "tokamak" device – a torus or donut-shaped magnetic bottle – is been found to perform very well. This magnetic insulation comes with a catch, however. Heat that leaks out the bottle becomes focused into narrow channels as it streams along magnetic field lines in adjoining boundary layers. This produces narrow "footprints" on wall surfaces. The smaller the footprint, the more intense the heat flux becomes.

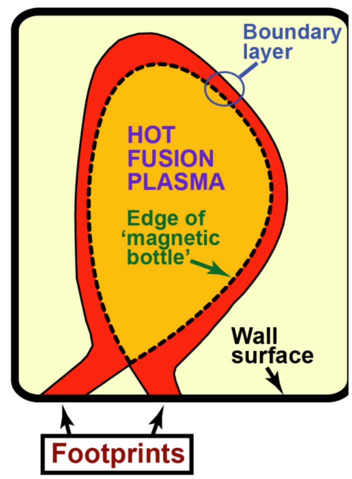

Fig. 1 - Heat escaping a fusion plasma tends to focus into narrow "footprints."

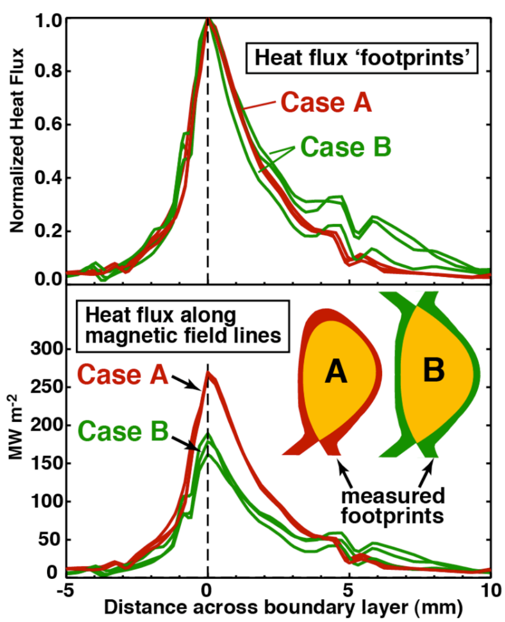

Fig. 2 – Reducing magnetic field line length by a factor of 2 (case B) yields no change in the heat flux footprint's shape near its maximum.

In fact, the intensity can easily exceed the power handling ability of present technologies. But, physicists have answers for this as well, at least in part: shape wall surfaces and operate in regimes that promote radiative losses. Yet, no one knows if these schemes will be adequate for a power-producing fusion reactor because a fundamental question remains: What underlying physics sets the size of the footprints seen in fusion plasmas?

Recent experiments performed in the Alcator C-Mod research tokamak† have uncovered important clues, including behaviors that appear counter-intuitive at first. One prevailing model holds that, as the length of the magnetic field line becomes longer, the footprint should get wider; the heat has more time to spread out before it encounters a wall surface. To test this model, Alcator C-Mod prepared two plasmas: one with the usual footprints (Fig. 2, case A) and one with an additional set of footprints (Fig.2, case B), each having half the field line length. No significant change in footprint shape was seen. In other plasmas, field line lengths were varied by changing how tightly they twist around the torus – changing the ratio of plasma current to toroidal magnetic field strength does that trick. Again, the field line lengths did not matter (Fig.3).

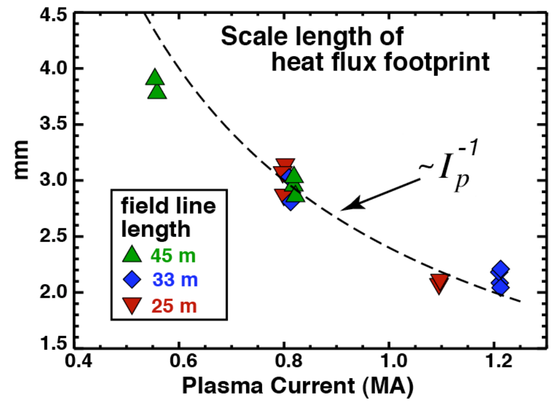

Fig. 3 – Scale length of heat flux footprints are found to be independent of magnetic field line length. They depend instead on parameters that effect plasma pressure gradients in the boundary layer, such as plasma current (I_p).

These data are part of a growing body of evidence that self-regulatory heat transport mechanisms are at play, which tend to clamp the width of the heat flux profiles at a critical scale-length value. This scale length in turn depends on parameters that control the magnitude of plasma pressure gradients in the boundary layer, such as plasma current (Fig.3), and whether oscillatory modes are present.

---

†Experiments performed in coordination with DIII-D and NSTX tokamaks in support of a Joint Research Target established by the US DoE Office of Fusion Energy Sciences.

Contacts: B. LaBombard, 617-253-7264, labombard@psfc.mit.edu
J.L. Terry, 617-253-8637, terry@psfc.mit.edu

Abstract: JI2.00004

Scaling of the power exhaust channel in Alcator C-Mod

Session JI2: Edge and Divertor Physics
2:00 PM–5:00 PM, Tuesday, November 9, 2010
Hyatt Regency Hotel - Grand Ballroom CD