Investigation of Effect on MHD Stability of Error Field Dynamically Generated by Scrape-Off-Layer Current (SOLC)
- A Possible New Direction -

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MHD Science Focus Group Meeting

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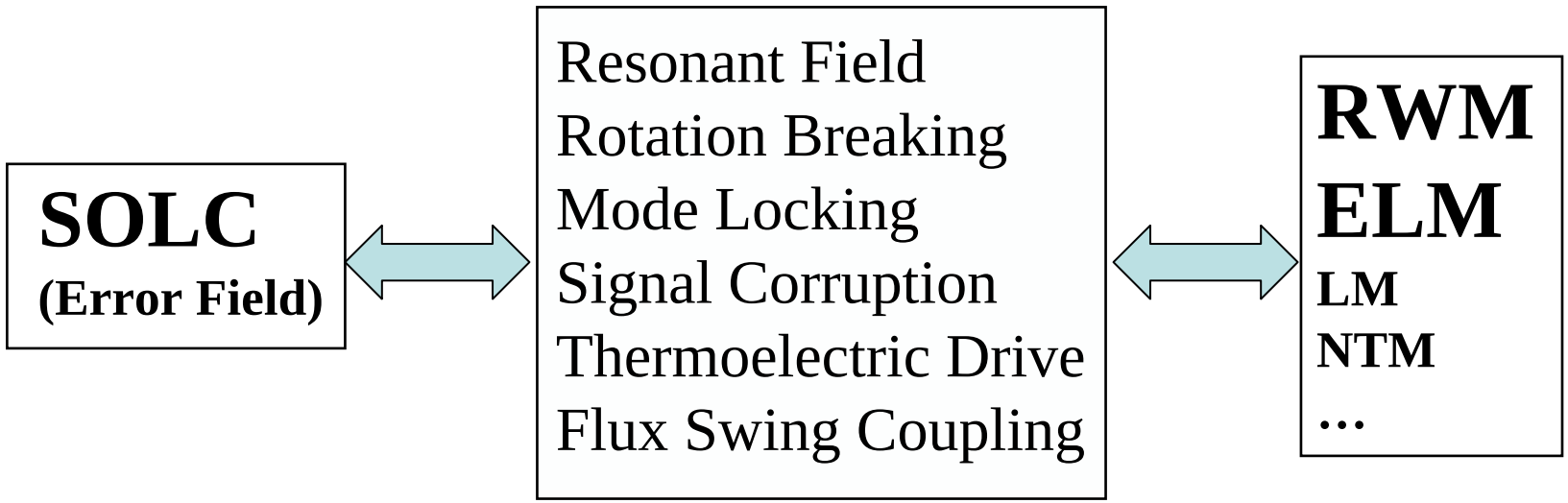
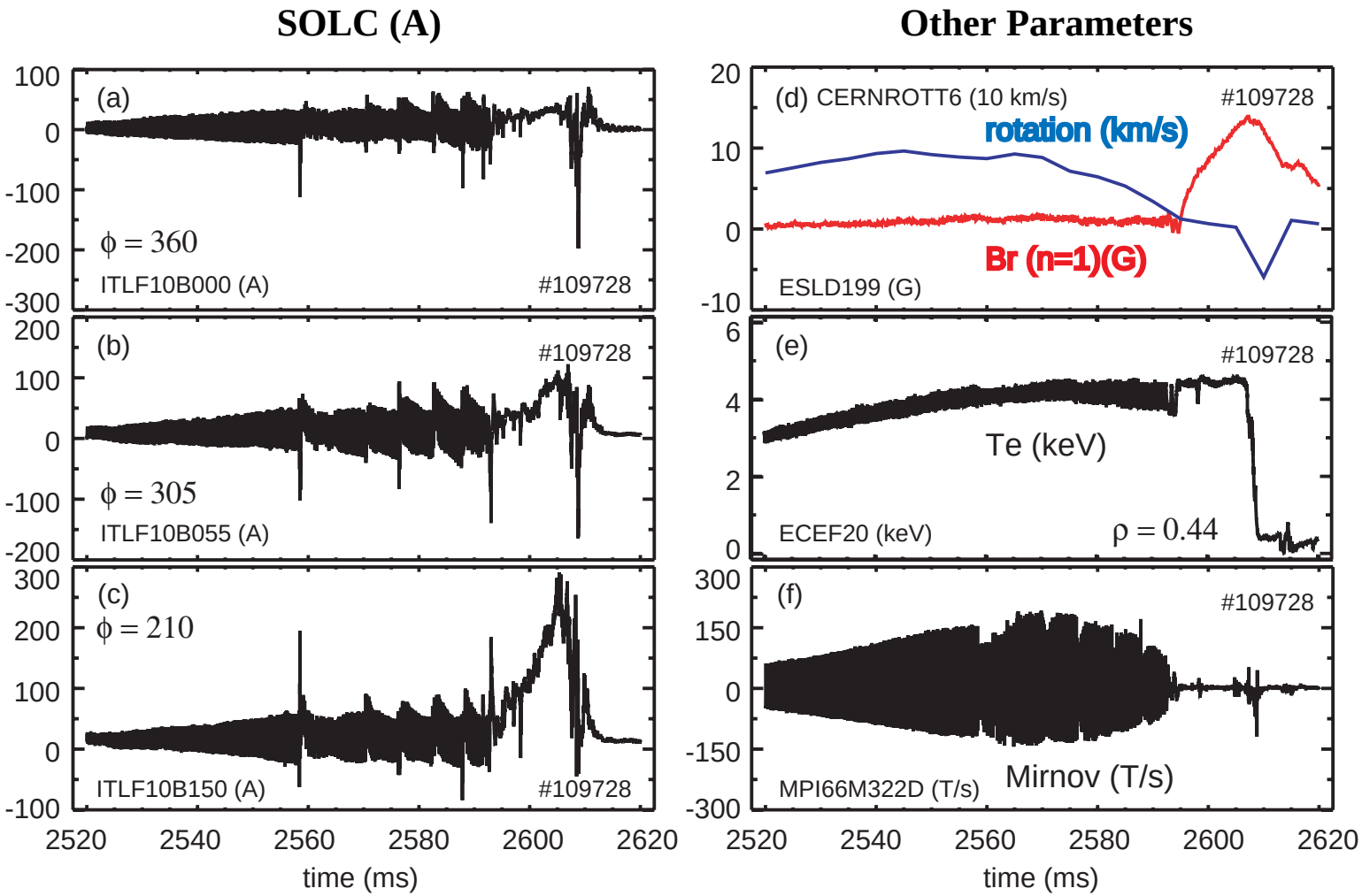
H. Takahashi, et al.
EPS 2005 P4.018
EPS 2003 P3.099
Nuclear Fusion 44(2004)1075
Nuclear Fusion 42(2002)448

SOLC May Interact with MHD through 'Multiplexed-Feedback'



SOLC Can Be Resonant Even in Rotating Plasma

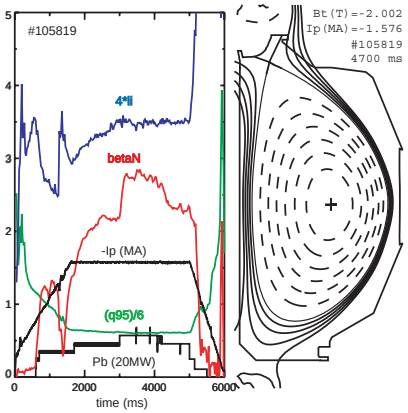
Entraining, Breaking, Locking, Growth, and Thermal Collapse



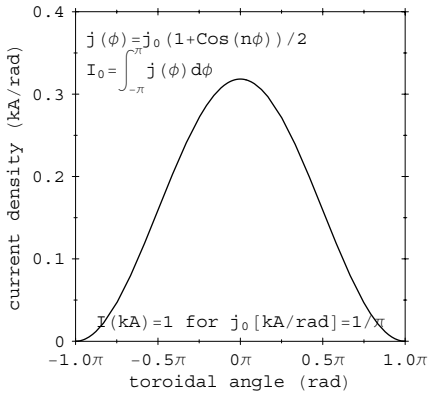
H. Takahashi, et al.
Nuclear Fusion 44(2004)1075

Non-axisymmetric SOLC Grows before Thermal Collapse

SOLC Generates Helical Field (Model Calc)



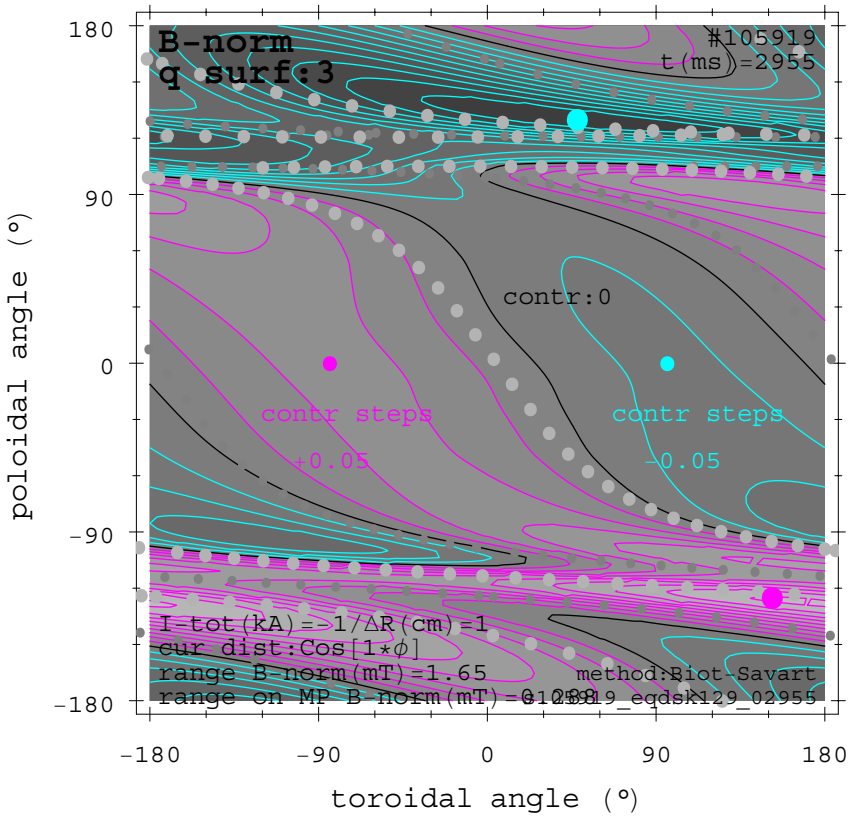
Only equilibrium used, *not* measured SOLC



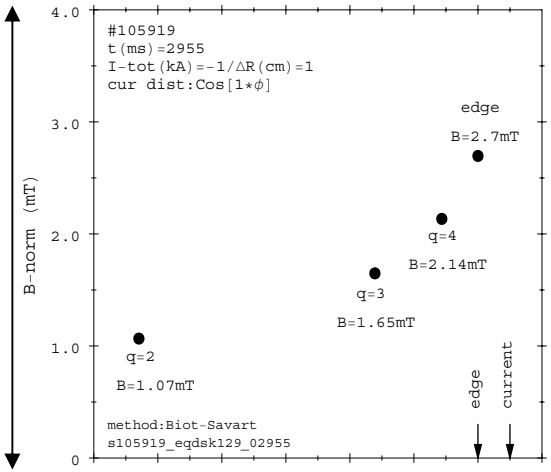
SOLC toroidal variation (assumed)

Field Normal to q=3 Surface Generated by *Unit Sheet Current (1 kA)* (*Not* Measured Values)

$j_{SOLC}(\phi) = j_0(1+\cos(\phi))/2$ where $j_0 = 1/\pi$ kA/rad



4 mT

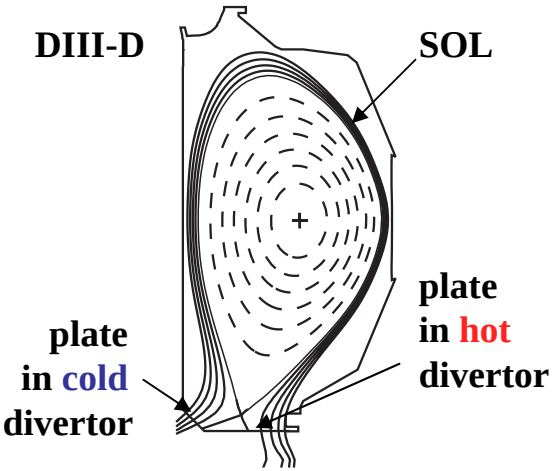


14 cm

Peak B_{norm} (mT) per *unit sheet current* (1kA)

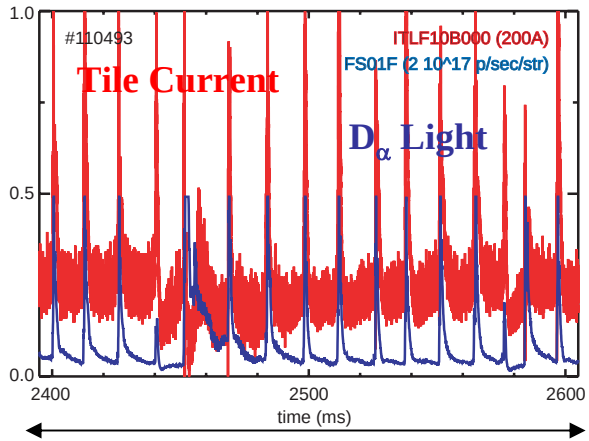
SOLC Non-axisymmetric during ELM Spike…

SOLC Thermoelectrically Driven



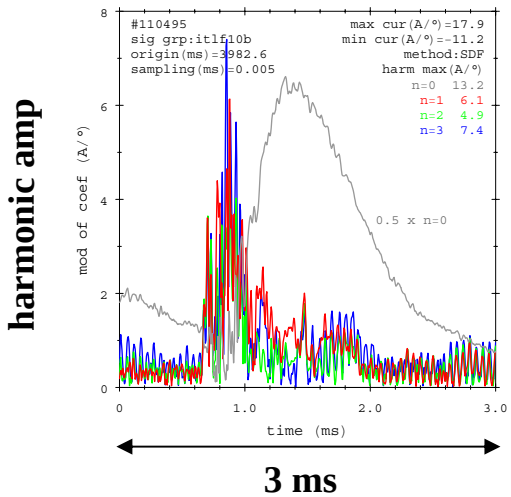
Current Flows in SOL When ELMs Occur

(Harbour, Contrib. Plasma Phys., 1988)



200 ms

SOLC Toroidal harmonics during an ELM



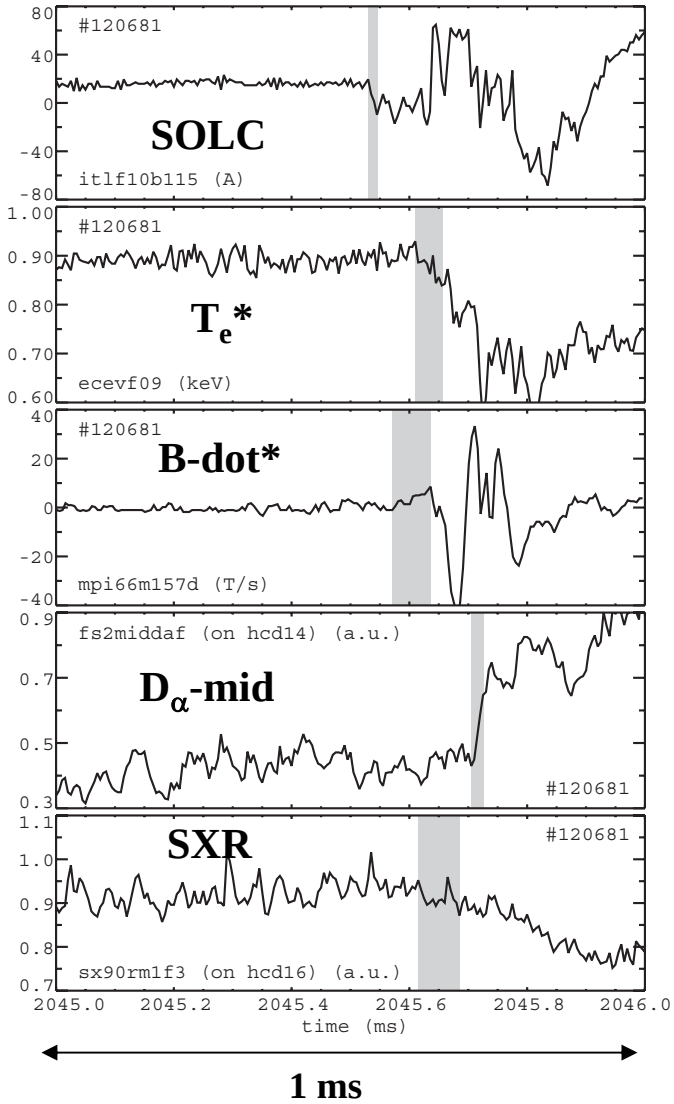
3 ms

SOLC flows in high β discharges, and becomes large and spiky during ELMs.

…and Can Create Error Field

SOLC Onset Precedes Thermal Collapse

ELM2045 H. Takahashi, et al., EPS 2005 P4.018



SOLC onset *leads* edge T_e collapse (by 70 - 120 μsec in this ELM).

SOLC, *at least initially*, is not an effect of heat and particle flux to divertors.

SOLC exceeds ion saturation current - sheath may have broken down.

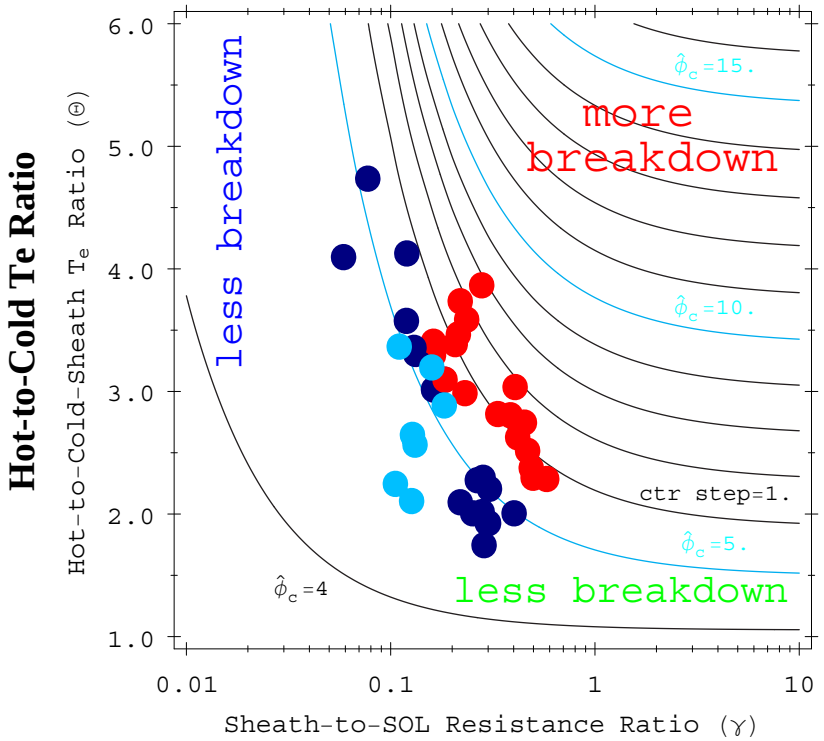
Earliest observed onset in each diagnostic is compared to take spatial variation into consideration.

Relative timing error of data transmission and acquisition was measured by recording a common reference signal (Te signal needs to be delayed by ~ 10 μs and B-dot signal advanced by ~ 30 μs.

Sheath Breakdown May Initiate ELM Process

Norm Sheath Potential Contours*

H. Takahashi, et al., EPS 2005 P4.018



Sheath-to-SOL Resistance Ratio

ELMing and ELM-free Points Occupy Separate Regions

ELMing State (Red Dots): Just before an ELM in ELMing H-mode Discharge

ELM-free State (Dark Blue Dots): Well before an ELM (Which is Also Shortly after an ELM)

ELM-free State (Light Blue Dots): L-mode Discharge

*Based on a model by: Harbour, Contrib. Plasma Phys. 28(1988)415 and Staebler and Hinton, NF 29(1989)1820

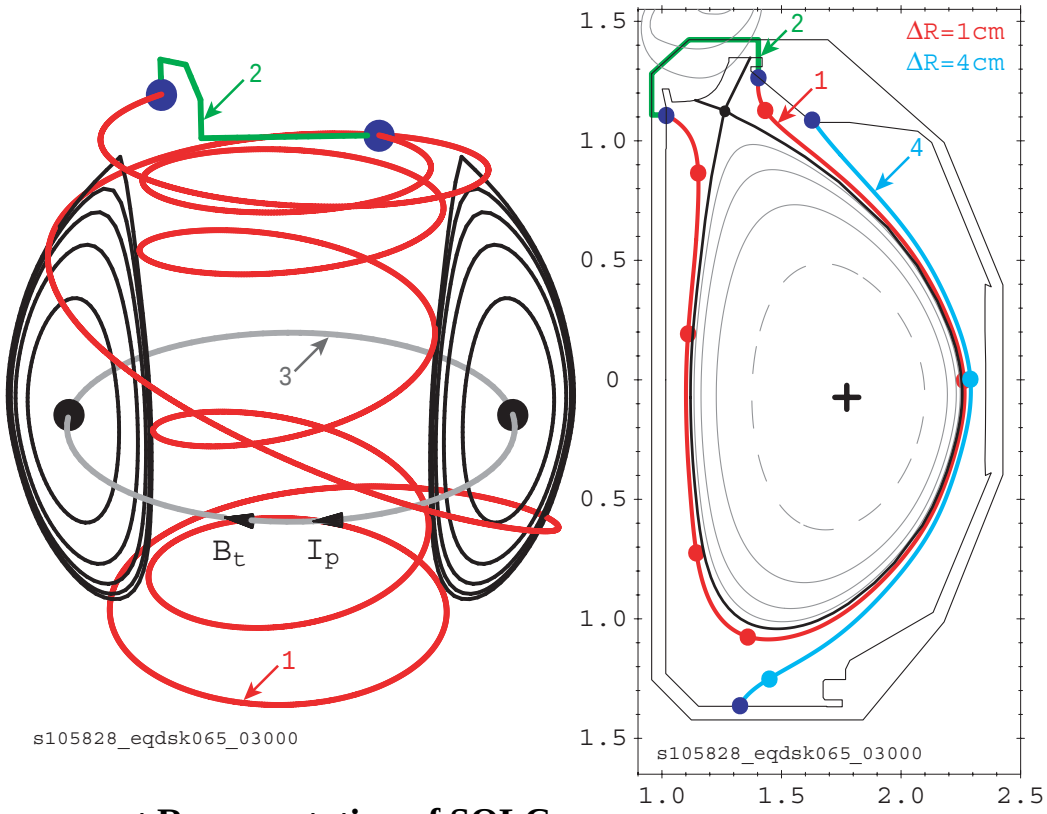
ELMing State at Higher Sheath Potential

Summary

- **SOLC is likely to be entangled with many MHD phenomena, including RWM, ELM, LM, and NTM through multiple channels of feedback relationship.**

- **Inclusion of SOLC in MHD analysis is a possible new direction to follow.**

Appendix-1 SOLC Flows along Open Field Lines…



Line-current Representation of SOLC

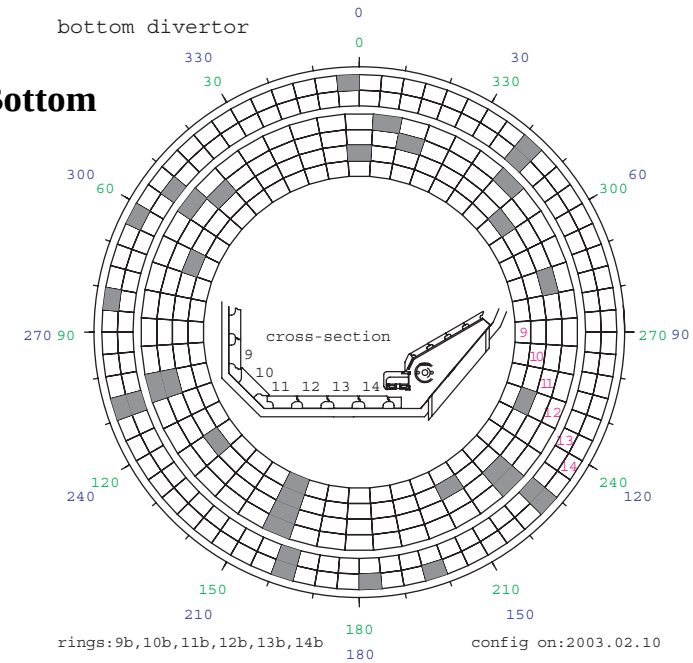
- Actual Current Spread Toroidally and Radially -

Current path varies greatly depending upon radial locations - red and blue curves.

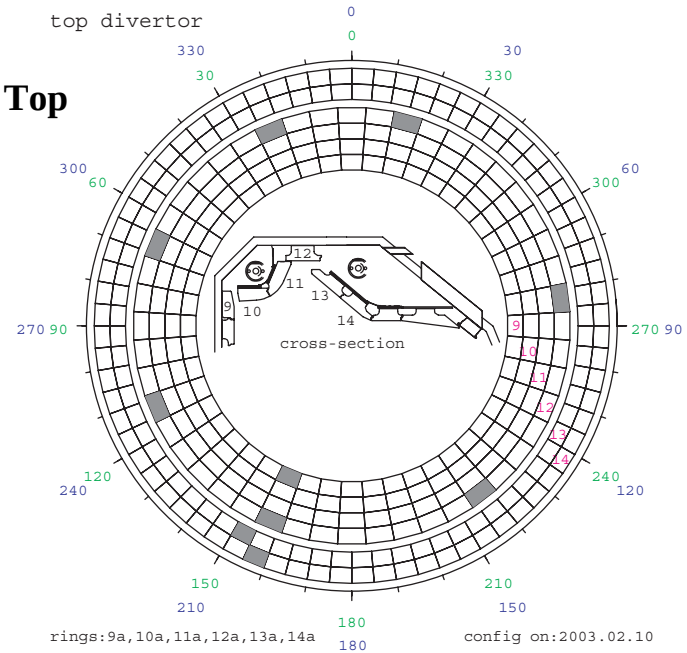
…re-circulates radially, and/or completes its circuit through tokamak structure.

Appendix-2 Sensors Measure SOLC through Divertor Tiles

Bottom



Top



Each shaded divertor tile is instrumented with a resistive-element current sensor, which *sums* current over a significant radial extent.

A narrow SOLC channel may escape detection because < ~ 10 % of tiles in selected tile-rings have sensors.