PF1B Benefits for Transient CHI (R. Raman, 3 December 2016)

For Transient CHI the primary parameter that determines the maximum closed flux current that can be generated in a ST is the magnitude of the injector flux. By knowing how much magnetic flux links the positive and negative electrode, one can place a limit on the maximum possible closed flux current that can be generated in a device.

The magnitude of the injector flux available from PF1CL is about 200mWb. PF1BL provides an additional ~75mWb. Recent simulations with TSC show that if PF1BL is used (in addition to PF1CL, the current generated by CHI could be increased from ~400kA to over 600 kA (Fig. 1).

It is important to note that for Transient CHI on NSTX-U, PF1CL is the primary coil, PF1BL is not essential; however PF1B is a very important coil for the reasons described below.

1) Non-inductive current ramp-up: The present NSTX-U plan is to generate 400kA of closed flux current using Transient CHI, and then to ramp-up this current to ~0.8 to 1MA. If the initial target current that can be generated on NSTX-U could be increased to ~600kA, then requirements on current ramp-up are much easier.
2) ST-FNSF designs: The divertor coils on a ST-FNSF would be located much farther away from the plasma than on NSTX-U. On NSTX-U, the PF1CL coil is ideally located near the injector gap, and PF1BL is located much farther away from the gap. Thus, experiments that study the current generation potential using only PF1CL, only PF1BL, and with both coils (all on the same machine) contribute to the understanding of divertor coil positions in future devices.
3) Snow Flake and Super X-divertor configurations: These configurations are well suited for transient CHI, because these configurations require a number of divertor coils to control the divertor flux pattern. These coils can also be used to generate the CHI injector flux. Understanding the PF1BL/PF1CL synergism on NSTX-U would again allow us to better predict CHI capability in these advanced divertor configuration devices.
4) Touch base with NSTX results: The present PF1B coil is located in approximately the same location as the PF1BL on NSTX, so it allows for a direct comparison of the NSTX results as the electrode configurations on NSTX-U are changed (metal divertor and divertor cryo pumping).
5) Back-up coil to PF1CL: In the even of an issue with PF1CL, PF1BL can be used for transient CHI.

Because of these reasons, it is desirable to retain some PF1BL capability on NSTX-U; for example, by reducing the physical size of the present PF1BL coil.

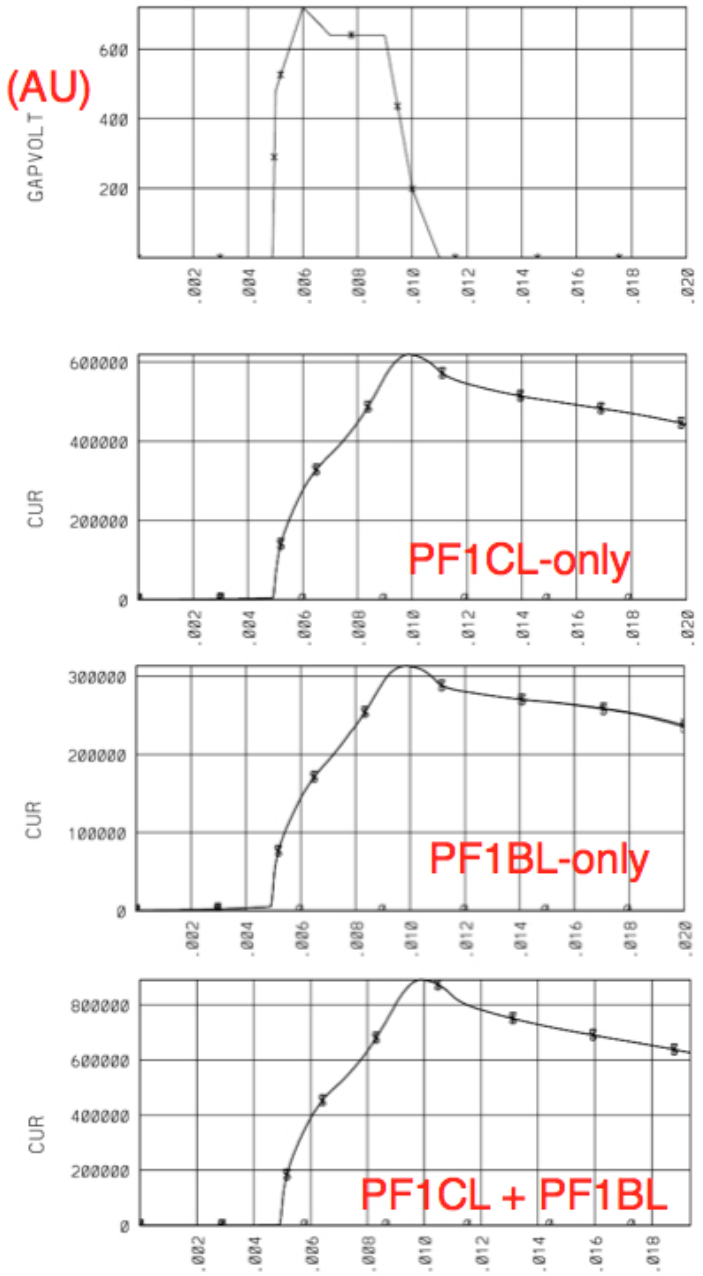

Fig 1: Top: Voltage programming in these TSC simulations for all configurations is the same. Time axis is in seconds. Comparison of toroidal current generation potential for operation with PF1CL-only (16kA – 20 turns), PF1BL-only (13kA – 24 turns – with the top of the coil lowered by 5cm from its present position), and with both coils.