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FIRST GENERATION FINAL FOCUSING SOLENOID FOR NDCX-I

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November 9, 2011

FINAL FOCUSING SOLENOID

Figure 1(a) shows a sketch of the prototype final focus solenoid (FFS-1G), or 1st generation FFS. In order to limit eddy currents, the solenoid winding consists of Litz wire wound on a non-conductive G-10 tube. For the same reason, the winding pack was inserted into an electrically insulating, but thermally conducting Polypropylene (Cool-Poly[®] D1202) housing and potted with highly viscous epoxy (to be able to wick the single strands of the Litz wire). The magnet is forced-air cooled through cooling channels. The magnet was designed for water cooling, but the cooling jacket cracked, and therefore cooling (beyond natural conduction and radiation) was exclusively by forced air. Figure 1(b) shows a field profile taken during initial tests. Table 1 represents summarized main magnet parameters.

Though the *design* operating point was 8 Tesla, for the majority of running on NDCX-I it operated up to about 5 Tesla. This was due mostly from limitations of voltage holding at the leads, where discharges at higher pulsed current damaged the leads. Generation 1 was replaced by the 2nd generation solenoid (FFS-2G) about a year later, which has operated reliably up to 8 Tesla, with a better lead design and utilizes water cooling. At this point, FFS-1G was used for plasma source R&D by LBNL and PPPL. The maximum field for those experiments was reduced to 3 Tesla due to continued difficulty with the leads and because higher field was not essential for those experiments.

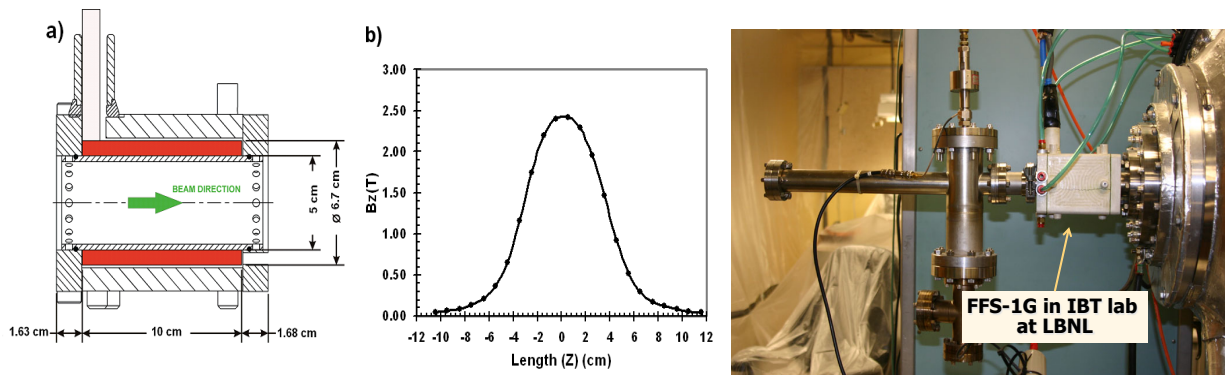


Figure 1. (a) A sketch of final focus solenoid and (b) characteristic magnetic field profile. (c) Photo (A. Anders, LBNL) of the FFS-1G in the IBT lab at LBNL.

TABLE 1. Parameters of the final focus solenoid (FFS).

PARAMETER	VALUE
Maximum solenoid field	8T
Effective field length	10.15 cm
Winding pack id and od	5.1 cm and 6.7 cm
Wire specification	24 strand gauge 20 AWG, heavy build insulation MW80-155 deg., profiled to 1cm x 0.16 cm, wrapped in Nomex paper
Number of turns	32 (8 turns/layer)
Coil resistance	$7.75 \times 10^{-3} \Omega$,
Coil inductance.	$2.80 \times 10^{-5} \text{ H}$
Epoxy specification	Ctd-101k
Stored energy	5.9 kJ
Max. Voltage across magnet	2.4kV
Max. Current	21.3 kA
Pulse length	784 ms

(Above table from PAC 2007 paper, P.K. Roy et al.)

PULSER FOR THE FINAL FOCUSING SOLENOID

The pulser is a SCR-switched capacitor bank which produces a half-sine current waveform. The pulse width is ~800us and a charge voltage of 3kV drives ~20kA through the magnet producing ~8T field.

8T Final Focus Solenoid Pulser (3kV, 20kA)

