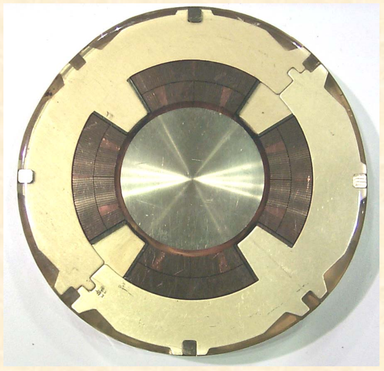
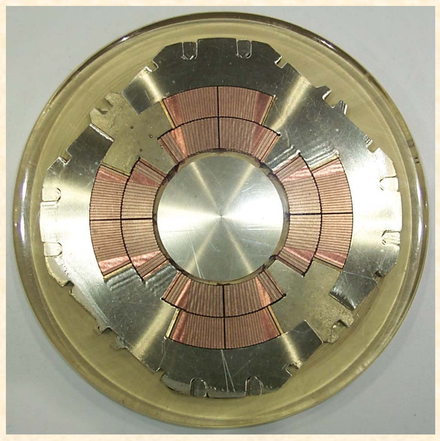
Interaction Region Quadrupoles for the Tevatron (Low Beta Quads)

When a new detector was built for the Tevatron at DO, new interaction region quadrupoles were needed. Tevatron Low Beta Quadrupoles were designed and built at Fermilab to meet this need, in addition to upgrading the luminosity for CDF. These quadrupoles were part of the strategy for increasing the Tevatron luminosity to enhance the discovery potential for the Top Quark.

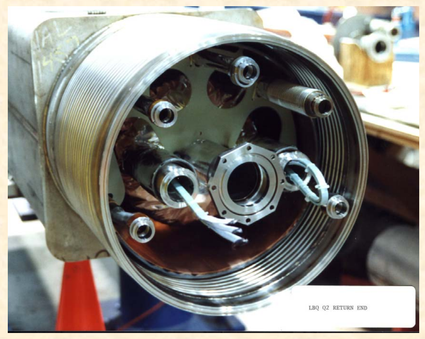


LOW BETA QUAD



LHC IR QUAD

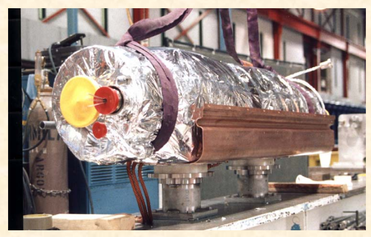
Design and construction took place between 1987 and 1990. The low beta quad design produced a coil with the highest current density and highest peak field on the winding of any quadrupole yet built. They were the precursors to later, even higher gradient quadrupoles. Fermilab is currently manufacturing the interaction region quadrupoles for the LHC, based in large part on the earlier design of the Tevatron Low Beta Quads.



LOW BETA QUADRUPOLE WITH CRYOSTAT

Low Beta Quads were built within Technical Division, primarily in Industrial Building #3. Cable manufacturing was done outside Fermilab, by Lawrence Berkeley Lab and New England Electric Wire, in collaboration with Fermilab personnel. Coil manufacturing, collared coil assembly, yoke, and cryostat were all done in the Industrial area.

LBQ coils during construction.



LBQ with thermal shield and super-insulation during cryostat construction.

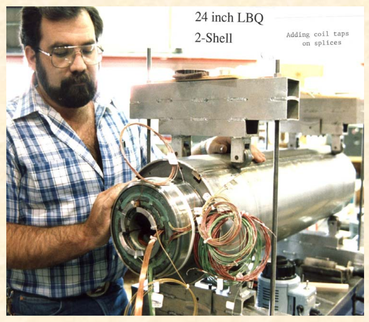
Packaging coils for curing.

LOW BETA QUADRUPOLE CONSTRUCTION

Collared coil entering the yoke and skinning press.

Winding LBQ coils.

LBQ magnet construction contributed to the development of many innovations in magnet technology. The cable measuring process, materials used for cable insulation, end part design configuration, and a unique end support structure were some of the innovations developed during the construction of these magnets. The LBQ was also the first magnet at Fermilab to use a “cold iron” cryostat, instead of the less efficient warm iron style used in the Tevatron. Many of the design features developed during the LBQ construction are still used by today’s state-of-the-art superconducting magnets.



Final wiring and instrumentition.

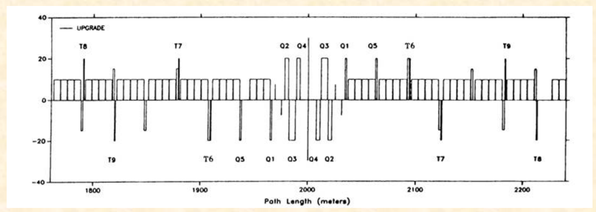
INSTALLATION

LBQ’s were installed in the interaction regions of both the CDF and DO detectors. The lattice design required magnets of several different lengths, each with a different set of operating parameters.

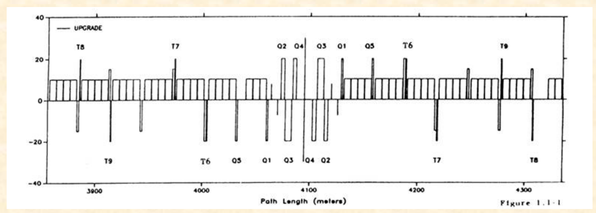
Lattice Designation	Nominal Magnetic Length (m)	Number of Magnets		Excitation Current at 1 TeV (A)	Gradient at 1 TeV (T/m)
		Built	Tested		
T6	0.61	3	3	4832	1.41
T6	0.61	4	3	4832	1.41
Q1/Q5	1.4	12	11	2011/2821	0.58/0.81
Q2	3.35	5	4	4811	1.40
Q4	3.35	5	5	4811	1.40

LBQ Operating Parameters

CDF Lattice



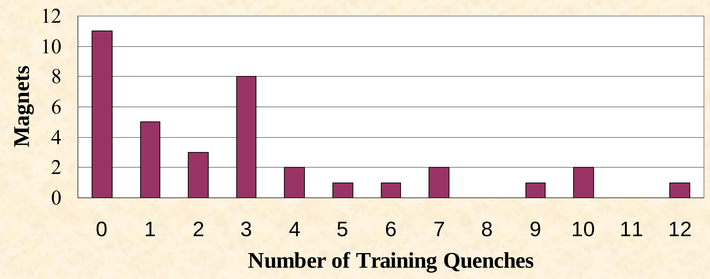
DO Lattice



PERFORMANCE

All Low Beta Quads were tested at Fermilab at operating temperatures before installation. After “training”, all magnets reached the required operating gradient. 24 were installed in the ring, at both the CDF and D0 detectors. They continue to perform reliably in the Tevatron today, and have lowered the β* by nearly a factor of four, which represents a corresponding fourfold increase in luminosity over the original LBQ’s.

Training Quenches to Reach Operating Gradient



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