FERMILAB-Proposal-893

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E-893 (Strait) Design and Construction of Interaction Regions at the CERN Large Hadron Collider (LHC)

Fermilab
(BNL, LBL)

Status: *No Data Yet*

Fermilab, Brookhaven National Laboratory and Lawrence Berkeley Laboratory have formed a collaboration to contribute to the design and construction of the Large Hadron Collider (LHC) which will be built at CERN. The US efforts will focus primarily on the interaction regions (IRs), with the US taking significant responsibility for the design and construction of at least two, and possibly all four IRs. (Other contributions will include special twin-aperture dipoles for the RF straight section and superconducting cable R&D and testing.) Fermilab will work exclusively on the IRs and is leading this effort. The current status is that an Interim Implementing Arrangement for this collaboration is almost ready for signature by CERN and US laboratories.

The layout shows one half of an IR. It consists of four strong (>200 T/m), large aperture (70 mm) superconducting quadrupoles (Q1-Q3), which focus to beam at the interaction point (IP), and two dipole magnets, one single-aperture (D1) and one twin-aperture (D2) which bring the beams from their separated orbits into collisions at the IP. The dipoles are superconducting at two of the four IRs and are conventional magnets at the other two. The US Laboratory Collaboration will supply all of the superconducting magnets shown in the layout.

Fermilab will design and build the high-gradient quadrupoles which are the centerpiece of the IR project and are among the most challenging magnets required for the LHC. Figure 1 is a cross-section of the magnet currently under design. These magnets are required to operate at an unprecedentedly high gradient, at least 50% higher than the Low Beta Quadrupoles in the Tevatron Collider. Their field quality must be excellent over a large fraction of the aperture, since under collision conditions these quadrupoles are expected to be the main determinant of the dynamic aperture of the LHC. In addition, these magnets will be subject to substantial heating due to the interaction of secondary particles from p-p collisions at the interaction point. The development, construction and testing of these very challenging quadrupoles will ensure that Fermilab and the US HEP program remain at the cutting edge of superconducting accelerator magnet technology. No matter what technology is used to build future higher energy colliders, it is certain that they will require quadrupoles of the highest possible gradient in their interaction regions. Thus this project looks forward to machines beyond the LHC as well as to the LHC itself. In addition, these quadrupoles, or ones very much like them, can be used to upgrade the Tevatron Collider. New quadrupoles will be required for the mini-collider region being considered for

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C0, and stronger quadrupoles at the CDF and D0 interaction regions will be able to free valuable space for improved shielding, beam instrumentation and forward detectors that may be required as the Collider luminosity grows.

The R&D program for the high gradient quadrupole is well underway. As we design the new quadrupole, we are also using several models of the existing Tevatron Low Beta Quadrupoles as a test bed for new design ideas, and we have entered into collaborations with industry and other Labs to develop improved superconducting wire that will ensure that the quadrupoles can reach the highest possible gradient. We will begin winding the first coils for the new high gradient quadrupole in the spring of 1997 and the first model magnet will be completed later in the year. The quadrupole development program is the base around which we will build a broader superconducting magnet R&D program looking at high-field or low-cost magnets for use in proposed future hadron or muon colliders.

In addition to building the quadrupoles themselves, Fermilab, together with the other labs in the collaboration, intends to take major responsibility for all aspects of the interaction region construction, from the interaction point out through the beam separation-recombination dipoles. This includes the construction of cryostats, cryogenic feed boxes, power lead boxes, and the integration of these and other components into the CERN accelerator system. This level of responsibility requires that we be involved in the accelerator physics as well as the technology of the IRs. Preliminary discussions have taken place among the accelerator physics groups at Fermilab, CERN and the other US Labs, and several areas of potential collaboration have been identified. Since the middle of 1995 we have had a physicist stationed at CERN working with the group responsible for all of the LHC insertions, and smooth working relations are being established. We have already made significant contributions to the design of absorber systems (shown in the layout) which are necessary to limit the beam heating of the magnets. By taking this global approach to the design and construction of the LHC IRs, we have an excellent opportunity to be deeply involved in a forefront hadron collider project and to begin to build the sort of global collaboration that will be necessary to build future colliders beyond the LHC. Our work on the advanced accelerator physics and technology of the LHC, together with our continuing efforts to improve the Tevatron Collider, will maintain and improve our position as accelerator builders at the energy frontier, a position essential if we aspire to lead the construction of future colliders.

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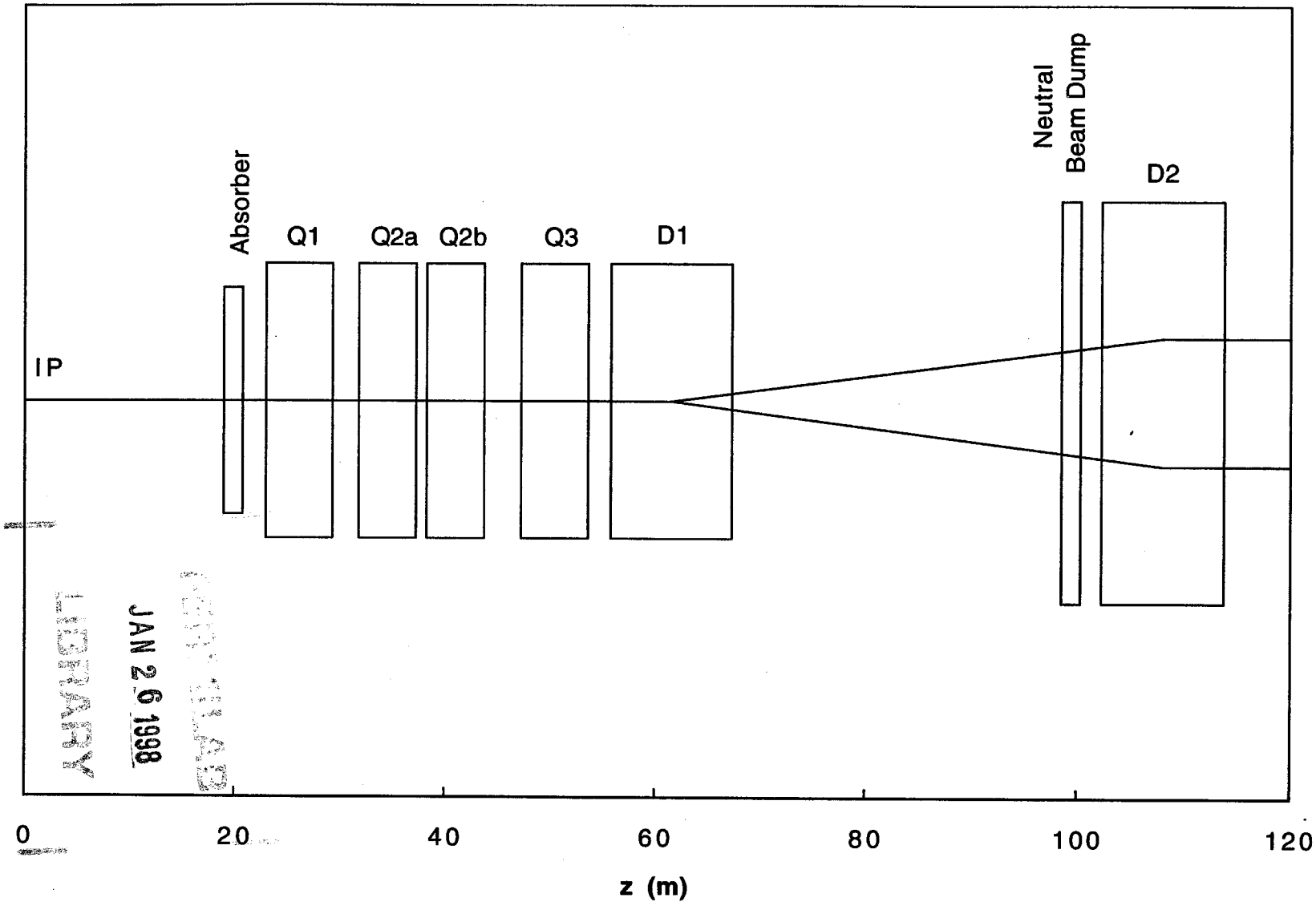

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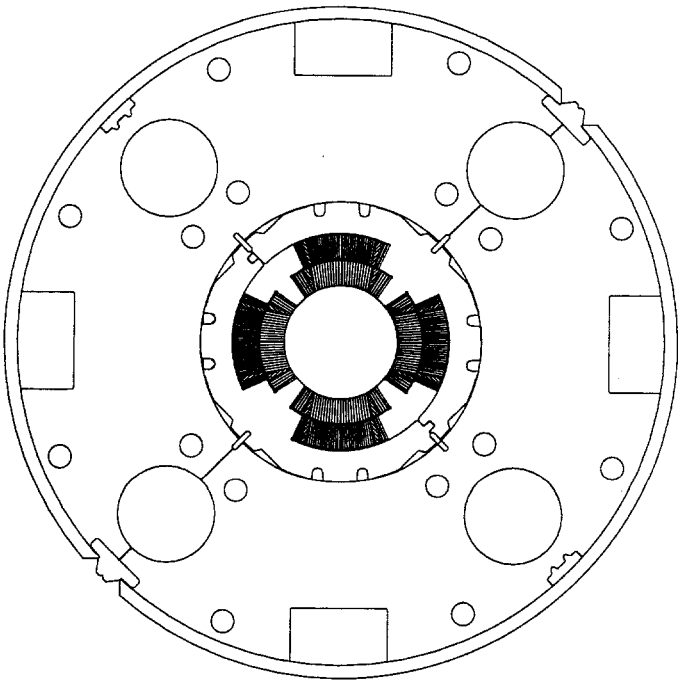

Figure 1. Cross-section of the LHC interaction region quadrupole currently under development at Fermilab.

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