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SOLENOIDAL DETECTOR NOTES

CONCEPTUAL DESIGN FOR A SUPERCONDUCTING TOROID

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Conceptual Design for a Superconducting Toroid

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Introduction

By having a toroidal magnetic field in the forward angle region, momenta of forward-going muons can be measured more accurately than by using the solenoid central tracker alone. Such a capability can substantially increase the detection efficiency and momentum accuracy for multimuon events which are likely to be important in SSC experiments, such as Higgs $\rightarrow Z^{\circ}Z^{\circ} \rightarrow \mu^{+}\mu^{-}\mu^{+}\mu^{-}$.

If this toroidal field is obtained using iron magnetized to 1.8 Tesla, a 5 meter path length in iron will allow momentum measurement to no better accuracy than dp/p = 10%. This limitation is due to multiple Coulomb scattering in the iron. A possible alternative choice is to generate the toroidal field by using a superconducting coil, as was pointed out several years ago by Jones[1]. In this talk, I shall present a status report on the conceptual engineering design of such a superconducting toroid. Its measurement accuracy is limited by multiple Coulomb scattering to about 2.5%, and is also very well matched to the accuracy expected for central muon tracks in the solenoid tracker system.

Specifications

The specifications which defined the physics design requirements are listed in Table 1. These were chosen on the basis of (SDC) detector designs which were under consideration several months ago. In a current (EOI) SDC

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design which is shown in Fig. 1, the toroid distance from the interaction point is 14 m, rather than the 11 m used here. However, most engineering features of this conceptual design should also be applicable to superconducting toroids whose specifications are not too different from those in Table 1.

Design Goals

Next I shall briefly describe the status of the conceptual design work which is being done by John Purcell and Lew Creeden of Advanced Cryo Magnetics, Inc. They have used the specifications of Table 1, and have designed a magnet of conservative mechanical and electrical properties, low cost, and simple fabrication. In addition, they have attempted to avoid the use of new technology which would require extensive R&D work.

Design Features

The principal features of the Advanced Cryo Magnetics design are: the use of aluminum stabilized Nb Ti conductor that is bath cooled, fabrication of almost the entire structure from welded aluminum plates, and the use of carbon fiber loops to carry the axial magnetic forces. Fig. 2 shows the geometry of the coil and the aluminum shells which form the helium vessel, as well as of the heat shield and the vacuum vessel.

The carbon fiber tension loops run parallel to the axial (beam) direction, and support the outward axial magnetic pressure which is felt by the upstream and downstream ends of the coil. This magnet has a complicated topology and considerable effort was devoted to specifying practical, low-cost assembly procedures.

Table 2 shows some of the parameters of this conceptual design.

Cost

Cost estimating work is still underway, so that only a very preliminary result of ten million dollars (± 30%) per toroid can be given now.

Future Work

The completed conceptual design work and cost estimating information will be documented soon in a report from Advanced Cryo Magnetics, Inc.

Before proceeding to more detailed engineering work on a superconducting toroid for the SDC detector, three steps should be taken:

1. This design and cost estimate should be scaled up to the most recent (EOI) dimensions and field integral.
2. Physics and cost trade-offs between using a forward superconducting toroid as opposed to using a forward iron toroid should be evaluated by the SDC collaboration.
3. A comparison with other proposed superconducting toroid designs, such as those using forced-cooled superconductors, should be made.

These three steps can hopefully be completed in time to allow more detailed toroid engineering design work to begin within the next six months.

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Reference

1. L. W. Jones, Snowmass 1986 Proceedings, P462.

Table 1

Physics Specifications for Advanced Cryo Magnetics Design

Inner radius	1 m
Outer radius	5.5 m
$\int Bdz$ at inner radius	10 Tesla meter
Distance from i.p.	11 m
Pseudorapidity coverage	1.5-3.0
Total thickness near outer radius	$\lesssim$ 3 R.L.
Total thickness near inner radius	$\lesssim$ 6 R.L.

Table 2

Parameters of Advanced Cryo Magnetics Conceptual Design

Length in z direction	3.3 m
Field at inner radius	3 Tesla
Stored energy	130 MJ
Operating current	7000 Amp
Conductor size	0.39 x 2.0 cm^2
Ampere turns	15×10^6
Conductor length	32000 m
Cold weight	98,000 lb
Warm weight	28,000 lb
Liquid helium volume	15,000 liter

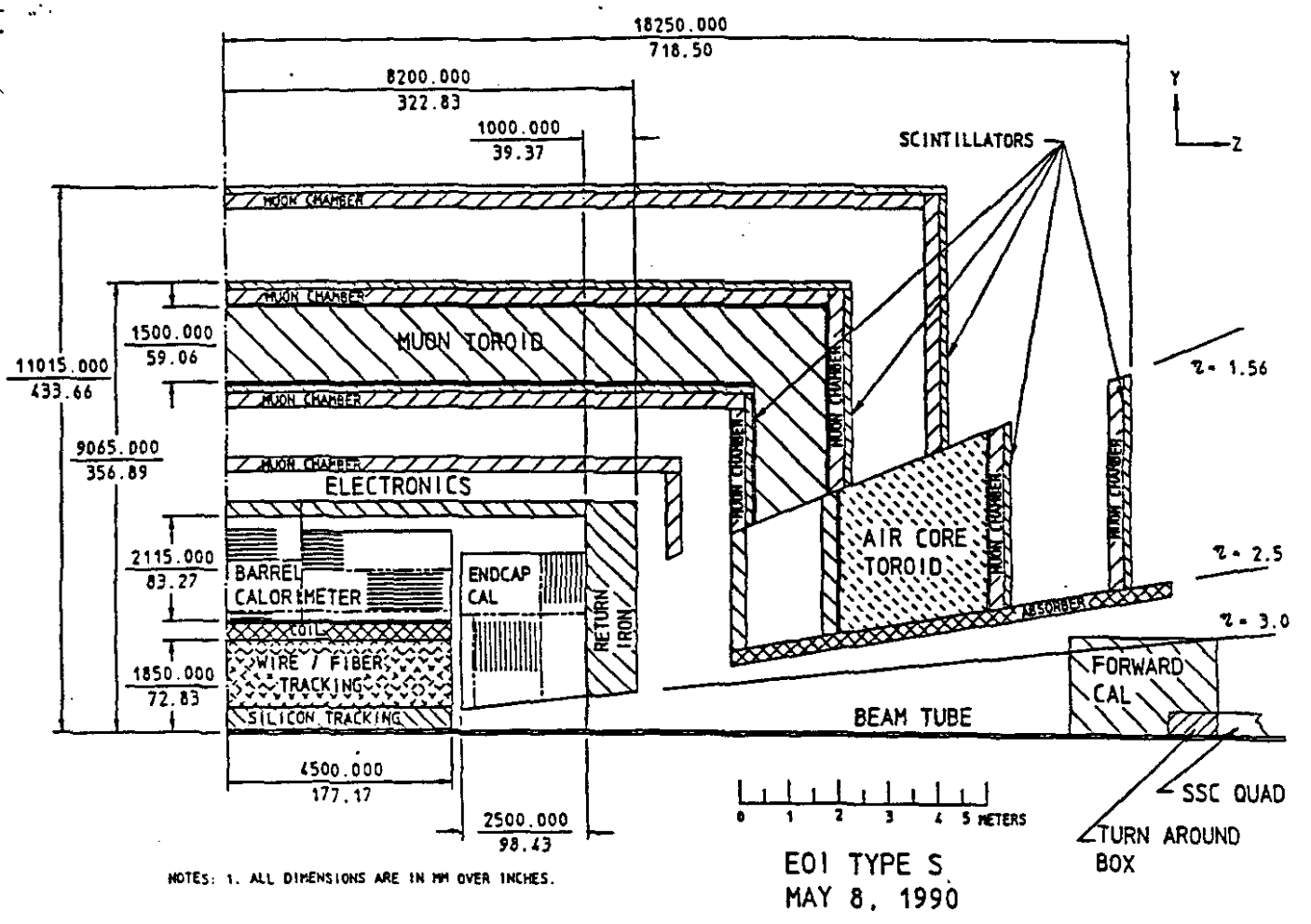

Fig. 1. SDC detector, with a superconducting air core toroid at 14 meters, covering η = 1.5 to 2.5.

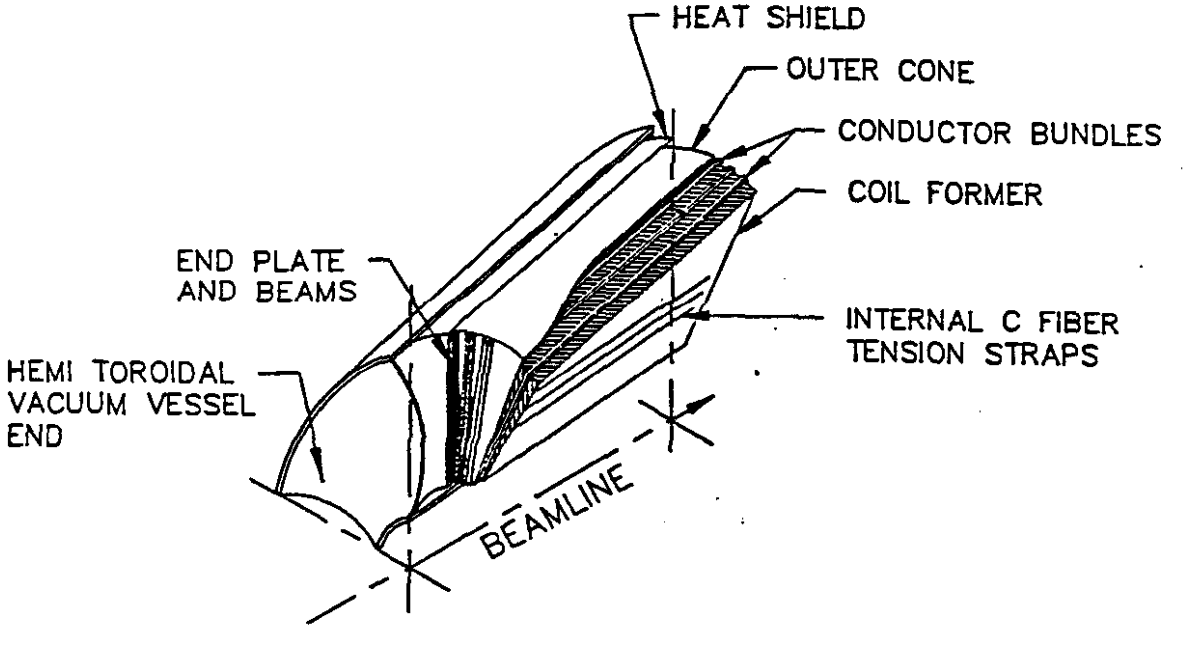

Fig. 2. The air core toroid designed by Advanced Cryo Magnetics, Inc.