INTERNATIONAL LARGE DETECTOR

D B D

ILD Concept group

2012

Editor:

List of Contributors

list of authors

Acknowledgements

acknowledgements

Contents

Chapter 1

ILD Subsystems

Key features of the ILD detector are a very powerful and redundant tracking systems, consisting of a complete Silicon based vertexoing and tracking system, surrounding a large volume high precision time projection chamber, and a highly granular calorimeter. Intense R&D has taken place over the last decade to develop the necessary technologies. ILD presents in many cases more than one technology for a given sub-detector. A distinction is made between options and alternatives: while options have undergone an extensive R&D program and have psased critical proof-of-concept tests, alternatives are included where promising technological developments are envisioned, but are either not yet at a state where they can be proposed to be part of a real detector, or where key components of the R&D have not been done at the time of writing this document.

A connditions for being included as an option has been the technological readiness, as discussed above, but also the ability of the technology to present an integrated concept which shows how a component based on this technology will be integrated into the final detector.

The results of the work shown in this section have to a large extend been obtained by R&D collaboartions which operate largely independent from the ILD detector concept group.

1.1 The ILD Yoke and Coil System

Authors: Francois Kircher, Uwe Schneekloth

1.1.1 Physics Requirements

The physics requirement of the ILD detector call for a high solenoidal field (nominal 3.5 T, maximum 4 T) in the large volume of 6.9 m in diameter and a length of 7.35 m with the following requests:

- Ê In principle high integral field homogeneity. Since this cannot be achieved with anti DID, a precise knowledge of the field at the 10^{-4} level is sufficient.
- Integrated dipole magnet, so called anti DID, to reduce the beam background in the tracking volume
- A fringe field of less than 50 G at $R = 15\,m$ to not magnetically perturb the second detector when in operation.
- An iron instrumented yoke for the detection of muons and for measuring showers escaping the HCAL (tail catching).

In addition, the yoke serves as the main mechanical structure of ILD and combined with the calorimeter should be self-shielding.

1.1.2 Magnet Design

1.1.2.1 Magnet components

- Ê Ê Ê Ê Ê ÊCoil
- Ê Ê Ê Ê Ê ÊYoke
- Ê Ê Ê Anti DiD

1.1.2.2 Magnet main parameters

- Ê Ê Ê Ê Ê ÊGeometrical
- Ê Ê Ê Ê Ê ÊMagnetic
- Ê Ê Ê Ê Ê ÊElectrical

Ê

1.1.2.3 Magnetic field map

Ê

1.1.3 Coil Design

1.1.3.1 Coil main characteristics and parameters

- Ê Ê Ê Ê Ê Geometrical
- Ê Ê Ê Magnetic
- Ê Ê Ê Electrical

Ê

1.1.3.2 Superconducting conductor

- Ê Ê Ê Ê Ê ÊDesign
- Ê Ê Ê Ê Ê ÊReinforcement

Ê

1.1.3.3 Coil technical aspects

- Ê Ê ÊWinding
- Ê Ê ÊMechanical structure

Ê

1.1.3.4 Coil protection

Ê

1.1.3.5 Ancillaries

- Ê Ê Power circuit
- Ê Ê Ê Ê Ê ÊControl and safety systems
- Ê Ê Ê Ê Ê ÊCryogenic plant

1.1.4 Iron Yoke Design

1.1.4.1 Design Considerations

The yoke has several functions. It provides the flux return of the solenoidal field and reduces the outside stray fields to an acceptable level. It is instrumented with detectors for muon identification and tail catching of hadronic showers. The yoke is the main mechanical structure of the detector. The design allows for a fast opening in order to get access to the inner detector components. The ability for access and work in the IR hall during beam operation requires the detector to be self-shielding. In principle, the yoke design is very much based on the CMS detector. The main difference with respect to CMS are the requirements on the stray field and self-shielding, which require an almost hermetic yoke.

1.1.4.1.1 Segmentation For the inner part of the yoke a fine segmentation of the iron was chosen, 10 layers of 100 mm thickness with 40 mm gaps for detectors to be inserted for good muon reconstruction, rejection of hadron background and good performance of the tail catcher (see section **??**). This segmentation is in particular useful for the tail catcher, whereas a similar performance of the muon system could be achieved by arranging the detectors in groups of layers. In addition to the inner fine segmentation, some 560 mm steel plates are added on the outer part mainly to reduce the stray field.

1.1.4.1.2 Fringe Fields During beam operation the IR hall has to be accessible due to the push pull concept. While one detector is in the beam position, assembly or maintenance work has to be done on the other detector. Since all activities in a high magnet field are very cumbersome and potentially dangerous, a field limit of 50 G at 15 m radial distance from the beam line was agreed upon **??**.

Two- and three-dimensional FEM field calculations were done using the CST EM Studio program, varying the thickness and geometry of the iron in the barrel and end-caps until the goal of less than 50 G at 15 m radial distance was achieved. This was obtained with three 560 mm thick steel plates in the barrel and two 560 mm plates in each end-cap in addition to the ten 100 mm thick inner layers. This results in a total thickness of the iron of 2.68 m in the barrel and 2.12 m in the end-caps, respectively. In order to obtain the desired limit, all gaps between the steel plates on the outer radius have to be closed with iron. The only exception are the gaps between the barrel rings and between barrel and end-caps. This space will be needed for cables, cooling pipes and other ancillaries.

It should be noted that the field calculations assume no additional ferro-magnetic material outside the yoke and that the results are at the limit of the accuracy of the FEM calculations.

1.1.4.1.3 Forces The strong magnetic field, maximum of 4 T, introduces large magnetic forces on the end-caps, which were calculated using different FEM programs (CST EM Studio and ANSYS). The largest force, an inward pulling force in the z-direction of about 180 MN, acts on each end-cap, which has to be taken into account in the mechanical design. These magnetic forces are much larger than the gravitational forces, which can be neglected, at least for the end-caps.

1.1.4.2 Barrel Design

Similar to the CMS design, the barrel consist of several, 3 instead of 5, self-supporting independent barrel rings. The solenoid with the central subdetectors is supported by the central barrel ring. Both outer rings can be moved independently along the z-direction. A dodecagonal instead of octagonal shape was chosen in order to reduce the weight and size of the barrel sections. The twelve segments come in two slightly different sizes to avoid segment edges pointing towards the beam line. The average weight of a segment is about 200 t.

- Design
- Deformation and Stress
- Support feet
- Assembly

1.1.4.3 Endcap Design

- Design
- Deformation and Stress
- Assembly

1.1.4.4 Support of Solenoid Cryostat

List of Figures

List of Tables