ILD and a Platform Based Push-Pull Detector Motion System

DRAFT V2

K. Buesser[1], C. Clerc[2], M. Joré[3], B. Krause[1], A. Petrov[1], U. Schneekloth[1], K. Sinram[1], R. Stromhagen[1], A. Petrov[1], Y. Sugimoto[4], T. Tauchi[4]

[1]DESY, [2]LLR, [4]LAL, [5]KEK

1 Introduction

The ILD detector concept has chosen a platform based motion system as the preferred solution for a realisation of a fast and reliable push-pull system. This note summarises the requirements and boundary conditions that lead to that decision. In addition the dependency of the actual ILD design on a platform is shown, required modifications if the motion system would be changed are discussed.

2 Context and Boundary Conditions

2.1 Detector Assembly

The RDR baseline of the ILC foresees that the detectors will be pre-assembled on the surface into large sub-assemblies fully equipped with detector technologies and readout electronics. The large sub-assemblies should then be lowered into the underground experimental hall similar to the way CMS has been built. The advantages of this procedure is that the time scales of the accelerator and detector construction are largely decoupled and that the required size of the underground hall and the crane capacity requirements are reduced substantially.

As ILD has a similar design than CMS, it was natural to follow the assembly philosophy of CMS as well. Figure 1 shows the stages of the proposed assembly procedure for ILD. The largest and heaviest part is the central yoke barrel ring (No. 6 in Figure 1) that carries the cryostat with the solenoid coil, and the barrel hadronic and electromagnetic calorimeters. Also the TPC will be supported from this centre piece.

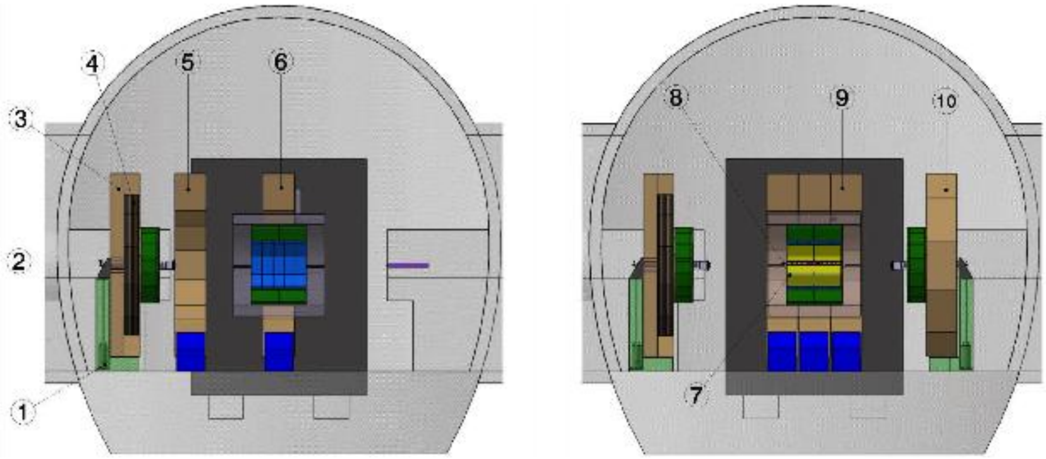

Figure 1: ILD assembly stages; the numbers give the order of assembly.

2.2 Detector Opening

The ILD concept foresees an opening of the detector not only in the parking position, but also when the detector is on the beamline. The endcaps could be moved along the beam direction on airpads and allow limited access to the inner detector parts. Figure 2 and Figure 3 show the opening situation in both cases.

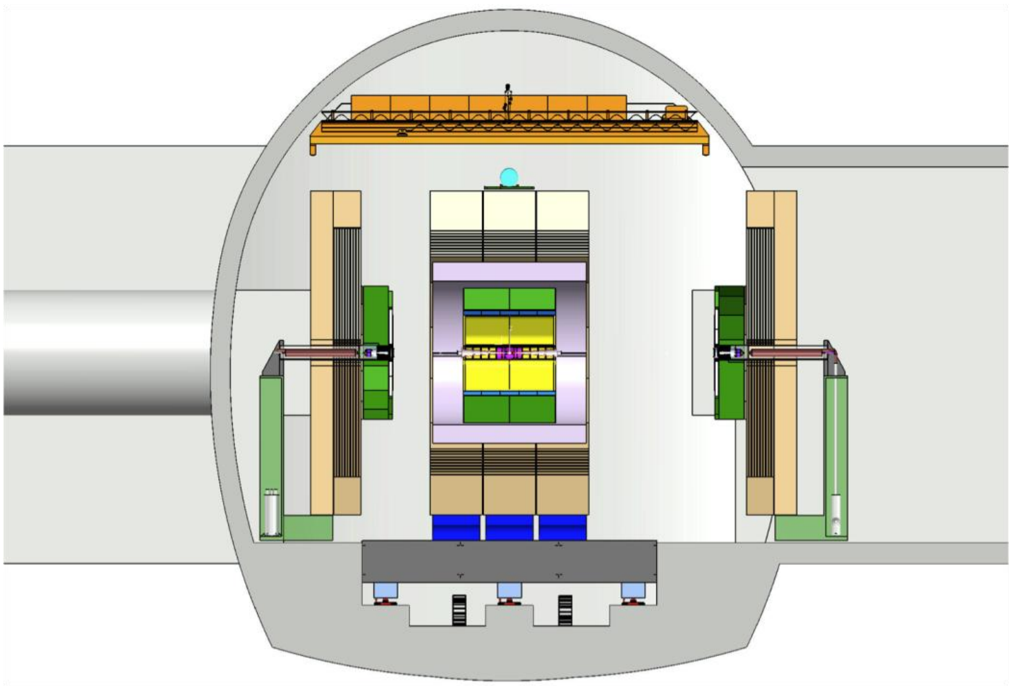

Figure 2: Opening of the detector in the parking position

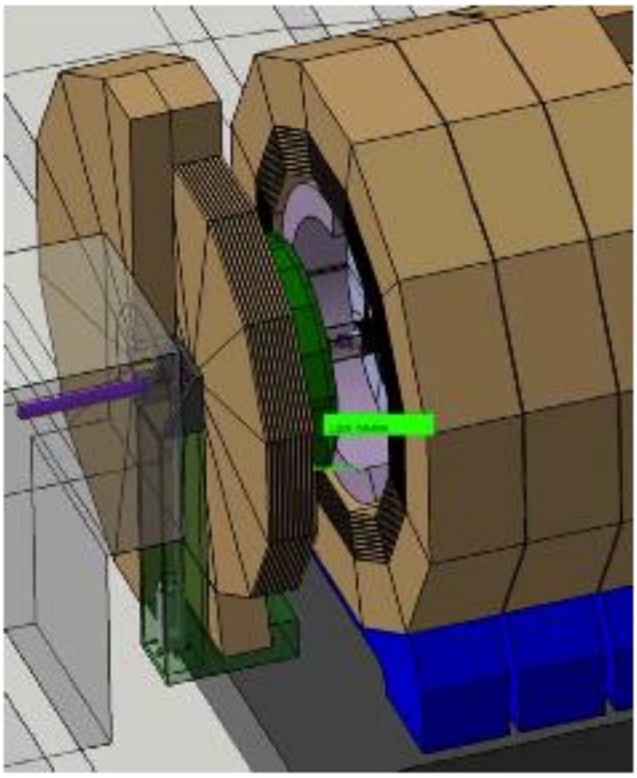

Figure 3: Opening of the detector in beam position.

3 ILD decision for a platform

It has been decided rather early in the design process of ILD to follow a platform concept for the push-pull movement. The decision has been first triggered by concerns of the designers of the CMS solenoid coil – which is very similar to the proposed ILD magnet – about moving the coil while it is cooled down to superconducting conditions. But as the warm-up and cooling times of the coil are in the range of several weeks, a rapid push-pull system is relying on the ability to move the coil cold. The platform was seen as the best solution to keep the vibrations of the coil during the movement of the detector to minimum levels. Then it was soon recognized, based on actual experience when opening CMS, that the use of a platform would greatly reduce the risk of damaging the inner detectors or the beam pipe during a push-pull movement due to relative displacement between yoke sections at the beam level.

Starting from this assumption, the ILD detector concept has been developed to its present design. The main advantages of the platform are:

- A complete decoupling the push-pull moving system from the detector proper
- A much reduce risk to the detector during a push-pull movement
- Reduction of vibrations during movement
- Keeping the inter-alignment of the detector parts and therefore reducing the calibration requirements
- Movement in two directions and rotation possible, if the platform is running on air pads
- Fast alignment of the detector axis to the required precision of +- 1mm

- Decoupling of the floor behaviour from the detector mounting, thus avoiding changes of the load distribution onto the different individual detector supports due to long-term and - during the push-pull operation - short-term ground motion
- Best compatibility with the ILD detector assembly and opening procedures

4 Alternatives to a Platform

ILD in its present design is relying on a platform. If the platform concept would be abandoned, other measures need to be found to keep the major detector parts (i.e. the yoke rings and endcaps that carry the inner detectors) together during the push-pull operations.

The SiD solution of having the barrel ring as one rigid piece supporting the endcaps during the movement is not applicable due to the shear size of ILD.

Independent support of the yoke rings, including the endcaps, during the movement would result in the risk of misalignment of the detector subsystems. Deviations in the movements of the yoke rings could result from unevenness in the motion system or different settlement behaviour of the hall floor. It is our understanding that a massive rigid frame construction around the yoke rings and the endcap would be needed to ensure a tight and common movement of the detector. Though we assume, that such a frame could be designed, it imposes other risks to the detector. These risks have not been evaluated in necessary details and require a full design study with a new concept of ILD.

4.1 Implications of Outer Detector Frame

The implications and the design of an outer detector frame have not been studied for ILD so far. However, as this frame should also reduce relative movements at the beam level it would have to be, by force, large and obstructive.

Possible implications range from questions on the distribution of forces during detector movements, the possible transfer of forces from detector elements via the frame to other parts, ~~possible~~ changes in the detector envelope, changes in the magnetic fringe fields, and issues with access to subdetectors for maintenance.

4.1.1 Distribution of Forces during Detector Movement

A platform would mediate the forces applied for the movement of the platform/detector system from the points where the detector is attached to the platform. If there would be no platform, but a solution with an outer frame that is moving on rails, only few support points will have contact with the rails or the floor. The forces to move the detector must be applied at that points which holds the risk of introducing shearing forces to the full system. On a platform, the moving forces could be applied anywhere to the platform, while the resting points of the detector on the platform will not be affected directly by the movement itself.

4.1.2 Transfer of Forces

The magnetic forces on the yoke endcaps are in the order of several 10s of kt weight equivalent. In the present ILD design, the yoke rings that are pressed together at well-defined hard stops, distribute these forces. An outer frame that clamps together the yoke rings needs to be rigid enough, to make sure that the detector parts stay aligned during movement and also during magnet operation. It must be ensured, that this frame does not transfer shearing forces - e.g. stemming from misalignment of the frame and the yoke – between the detector parts. Especially any misalignment of the inner detector parts would result in the need for longer calibration data taking. A detailed study of these effects is needed.

4.1.3 Detector Assembly and Envelope

A massive steel frame that clamps the yoke parts together would be a major item that brings additional weight to the system. The outer envelope of the detector would be larger, which might have an effect also on the required beam height in the detector hall. The already problematic difference in beam height for ILD and SiD could be increased even further.

In addition, the assembly procedure of ILD would need to be re-designed. The frame would need to be constructed around the detector after the major pre-assembled parts have been lowered into the underground hall. The procedure and especially the time scale of this has not been studied. As additional underground working time would be needed.

If the option to open the detector endcaps also in the beam position should be retained, the support of the endcaps from the outer frame needs to be studied in detail.

4.1.4 Subdetector Access

In the present ILD design, it is rather easy to open the detector endcaps or even to move the yoke rings as shown in Figures 1-3. Therefore access to subdetector elements and to cable paths is provided for maintenance work relatively uncomplicated. An outer detector frame would by design hold the yoke rings together and therefore block any longitudinal movement. This means that for a longitudinal movement of the yoke rings, the detector frame needs either to be partially disassembled or it must be designed from the first place to allow the yoke ring movements, e.g. by using a complicated rail system. These delicate operations pose mechanical constraints on such a frame that have not been studied yet and deserve their own detailed design study.

4.1.5 Magnetic Fringe Fields

The magnetic field of ILD has been designed to carefully meet the boundary conditions given in the Interface Requirement Document. The fringe fields of the detector need to be kept below 50G in a distance of 15m from the detector axis to allow the second detector in the parking position unrestricted access. A steel frame around the iron yoke will change the fringe fields of the detector. Figure 4 shows the result of a simulation of the magnetic fringe field where a steel floor plate has been assumed to be under ILD. It can be seen that significant fringe fields will be induced in steel arrangements that close to the detector. Therefore we assume that a steel frame around the detector will have a significant impact on the magnetic fringe fields as well. This impact needs to be studied carefully to make sure that the requirements can be met.

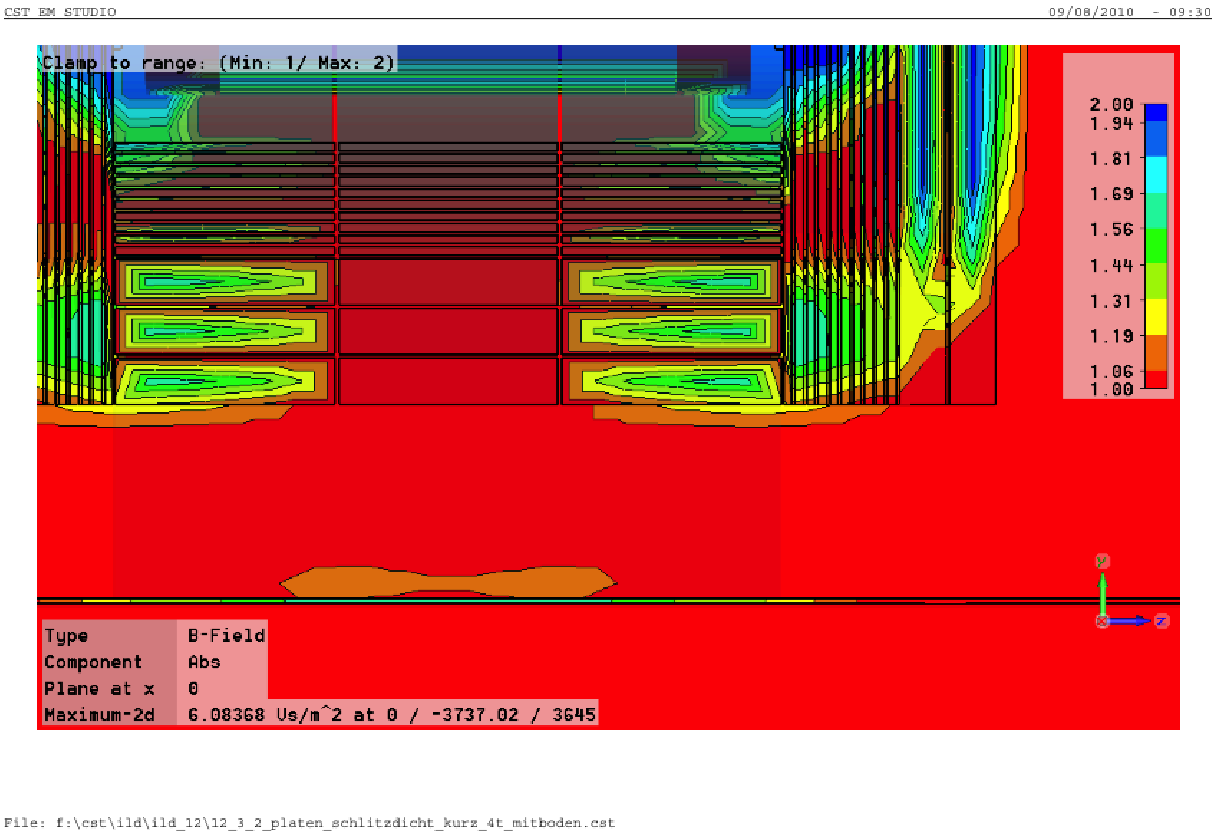

Figure 4: ILD magnetic fringe field with iron floor.

5 Conclusion

The present ILD design is relying on the use of a concrete platform for the detector motion system. If this concept should be abandoned and replaced by a rail based motion system, detailed design studies and important modifications are needed. A support frame structure needs to be developed that hold the detector rings together during the motion, not only at the ground level but also at the beam level. In addition this frame has to retain the strong forces that apply during the operation of the solenoid magnet. In addition the possibilities to access the detector on the beam or in the parking position need to be ensured. Tough it seems not impossible to find such a solution, it would require significant design changes to the ILD detector. On the other hand the advantages a platform would bring, among them the decoupling of the ground floor behaviour from the detector mounting, the fast alignment possibilities of the whole detector complex, the reduction of vibrations and shear forces during the detector movements meaning in the end the reduction of the risks to the detector during a push-pull operation seem large enough to question the need of the design work for another solution.