International Linear collider Detector

Letter Of Intent

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CHAPTER 1

The ILD Detector

1.1 OVERVIEW AND PHILOSOPHY

1.2 COIL AND RETURN YOKE

1.3 MUON DETECTOR

1.4 DETECTOR INTEGRATION AND OPERATION

1.4.1 Mechanical Concept

The mechanical design of the ILD detector is shown in figure 1.4-1. The major parts are the five rings of the iron return yoke: 3 barrel rings and 2 endcaps. The central barrel ring carries the cryostat with the solenoid coil in which the barrel calorimeters are installed. The TPC and the outer silicon envelope detectors are also suspended from the cryostat using tie rods.

The endcap calorimeters are supported by the endcap yoke sections which can be moved independently from the barrel sections to allow an opening of the detector at the beam line.

The beam pipe, the vertex detector and the other inner silicon detectors are supported from the support tubes of the QD0 magnets. These sit on pillars outside of the detector and are suspended from the solenoid cryostat using tie rods. A support structure from carbon reinforced plastic supports the beam pipe and the inner silicon detectors.

1.4.2 Detector Assembly and Opening

The ILD detector will be assembled in large parts in a surface building above the underground experimental hall. The pre-assembled sections will then be lowered into the underground cavern using a temporary portal crane. The largest and with 2000t heaviest part will be the central barrel ring with the solenoid coil and the barrel calorimeters installed.

The assembly sequence is shown in figure 1.4-2 and comprises the following steps:

1. the first pillar for the support of the QD0 magent is installed. This pillar needs to be movable in the garage position but will not move on the beam line. The service helium cryostat is also carried by the pillar.

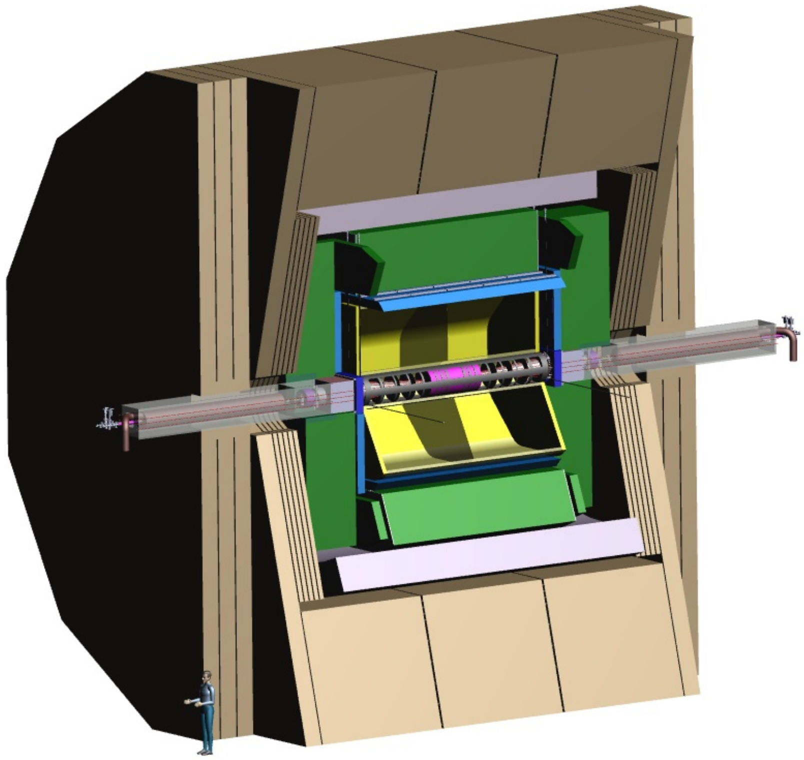

FIGURE 1.4-1. The mechanical design of the ILD detector.

2. the QD0 magnet is suspended from the pillar together with its support structure
3. the endcap yoke is installed
4. the endcap calorimeters are installed and the cables are routed to the outside
5. the first ring of the barrel yoke is installed
6. the central yoke part with the barrel calorimeters is installed, the cables are routed through the slits between the central yoke ring and the other rings
7. the TPC is inserted, the cables follow the routes of the barrel calorimeters
8. the inner part of the detector including the beam pipe and the inner silicon detectors is inserted into the TPC, cables are routed to the outside
9. the barrel yoke is closed
10. the second pillar, QD0 (with support) and the second yoke endcap are installed

Figure 1.4-2 shows the detectors after steps 4, 7 and 10.

The detector can be opened and maintained in the garage position using the above described procedures. The space required in the garage position is best met with a hall width of at least 30m. This is in contradiction to the underground cavern described in the RDR,

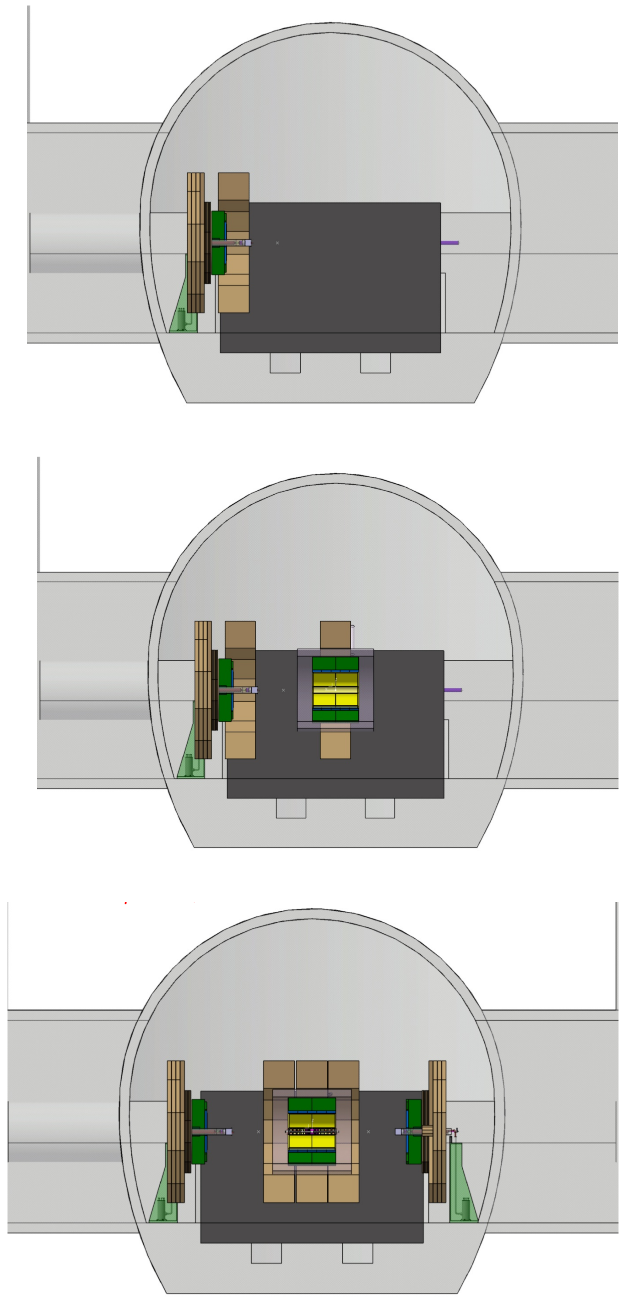

FIGURE 1.4-2. Detector assembly sequence.

which is 25m wide. However, a smaller hall would make proper maintenance of the detector very difficult. As the additional space is only needed in the garage position, a solution with an alcove extending the hall to 30m in that region would be a cost effective compromise.

It is planned to allow the opening of the detector endcaps also at the beam line. As space is limited there due to the machine elements, only limited access can be reached. The QF1 magnet extends to 9.5m from the IP. Additional space is needed for the QF1 cryostat and the flanges between QF1 and QD0. Preliminary studies show that access space of 95cm can be gained between the endcap and the barrel yoke. This would allow limited access to the inner detector for short maintenance actions at the beam line. This will be sufficient as major interventions would anyhow be done in the garage position. The detector would then be pulled out to allow the other experiment to move in and save precious beam time.

1.4.3 Integration of Subdetectors

1.4.3.1 Mechanical Integration

1.4.3.2 Cabling Scheme

1.4.4 Push-pull Operations

The present ILC baseline design foresees one interaction beamline which needs to be shared by two detectors in a push-pull configuration. While one detector is taking data on the beamline, the other one is parked in its garage position in the same underground hall. Following a - still to be defined - time schedule, the detector on the beam line is moved away to its own garage position to make space for the waiting detector to collect data. This 'push-pull' scenario has never been tested at existing accelerators and poses unprecedented engineering challenges to the detector designs.

The LoI concept groups and the ILC Beam Delivery System group have agreed on a set of Minimum Functinal Requirements [?] which define the boundary conditions for the push-pull operations. Most of these requirements comprise geometrical boundaries, like the size of the underground hall or the limits of the garage position of the detectors. But also physical limits for ionising radiation and magnetic fields need to be defined to allow a friendly co-existance of two detectors in one hall. In addition direct requirements come from the machine itself. As the QD0 final focus magnets will move with the detectors, requirements on alignment tolerances and vibration limits have been defined.

The timescale for the push-pull operation needs still to be defined, but it is clear that the time for the exchange of both detectors needs to be minimised to maximise the integrated luminosity. The full push-pull procedure comprises for the outgoing detector:

- powering down of the detector solenoid
- removing of the radiation shield between detector and hall
- disconnecting all local supplies (cryo, etc.)
- disconneting the beam pipe between the QD0 and the QF1 magnet
- moving the detector out toward its garage position
- connecting local supplies in the garage position

For the incoming detector the procedure is reversed, but additionally needs to include time for alignment and eventually calibration of the detector system at the beam line.

It is envisaged to complete the full push-pull operations on a timescale of a few days. As the full understanding of the challenges require a detailed engineering design of the hall and the procedures, a final evaluation of the push-pull operation for ILD is beyond the scope of this LoI and needs to be studied in the following Technical Design Phase. Nevertheless this section describes our conceptual understanding of the ILD operations.

1.4.4.1 Moving the ILD detector

The ILD detector will be placed on a concrete platform to avoid damages from vibrations during push-pull and also to ease internal alignment challenges. The concrete platform will have a size of approximately 15 $\times$ 20m and needs to be $\approx$ 2.25m thick. Figure 1.4-3 shows the ILD detector on its platform in the garage position and on the beam line.

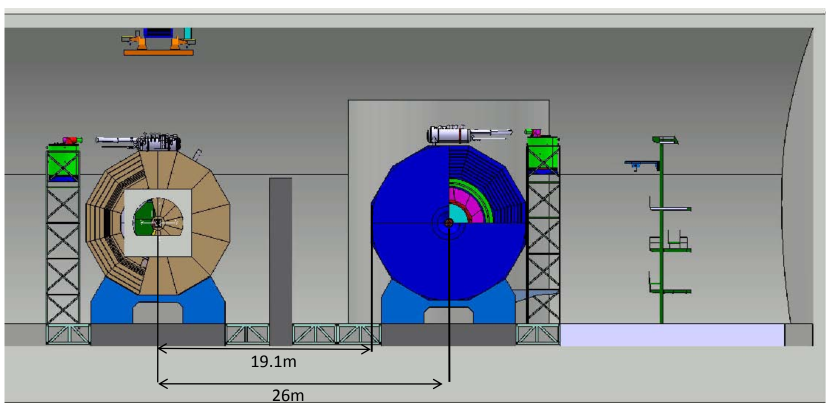

FIGURE 1.4-3. ILD detector in the garage position and on the beam line.

The platform will move on the hall floor using a system of rollers which are the most suitable solution for this one-dimensional movement.

Most supplies for the detector will be provided by using flexible supply lines which move with the platform. As the development of flexible cryogenic supply lines is challenging, the current scheme foresees service cryostats for the QD0 magnet and for the main detector solenoid which provide liquid helium during the movement of the detector. In the garage positions as well as on the beam line, the detector will be hooked up to permanent cryo lines.

The detector elements can be moved on the platform by using either a roller system, or by using air pads similar to the solution CMS has adopted. While the space at the beam line is limited, only the opening of the detector endcaps is foreseen to allow a limited access to the inner detectors. In the garage position more space is needed to allow major maintenance work, e.g. the removal of the TPC. More details of the opening procedures are described in section 1.4.3.2.

1.4.4.2 Shielding

The ILD detector will be self-shielding with respect to maximum credible accident beam loss scenarios. Detailed simulations show [?] that a proper design of the detector provides shielding which is sufficient to still allow access to the detector hall for professional workers. This is important to fulfil the minimum requirements which need to allow access to the other detector in its garage position during beam operations.

A movable concrete shield needs to fill the gap between the detector and the walls of the underground hall. As this shielding needs to fit both detectors, no engineering effort has been pursued so far to find a detailed design. This has been referred to the Technical Design Phase where it will be studied in collaboration with the second detector concept group. Nevertheless, these kind of shieldings have been used in other accelerator experiments (e.g. at HERA) and pose no conceptual design challenge.

1.4.4.3 Alignment and Calibration

Though the ILD detector will be moved on a platform, the alignment of the detector after being brought to the beam position is not trivial. The functional requirements ask for an alignment accuracy of the detector axis ±1mm and 100μrad after push-pull. The requirements for the QD0 magnet are even tighter: ± 200 μm and 5 μrad. ILD will be equipped with a laser-interferometric alignment system like MONALISA [?]. This system allows for a alignment of both QD0 magnets which are carried by the detector to the ILC beam lines on each side of the hall. In addition the detector itself can be positioned within the required tolerances using this system. The QD0 magnets will be placed on actuators which allow for an independent alignment of the magnets with respect to the detector.

After the alignment of the detector and the commissioning of the beam, some calibration data needs to be taken at the energy of the Z resonance. The internal alignment of the detector can then be done most precise in offline analysis.

1.5 THE MACHINE DETECTOR INTERFACE

1.5.1 The Interaction Region

The interaction region of the ILD detector comprises the beampipe, the surrounding silicon detectors, the forward calorimeters with the masking system and the QD0 magent with its ancillaries and the support structure. The interaction region is shown in figure 1.5-4, figure 1.5-5 shows a blow-up of this region.

FIGURE 1.5-4. Interaction region of the ILD detector. The outer support structure of the magnets and forward calorimeters has been removed on the right side in this picture.

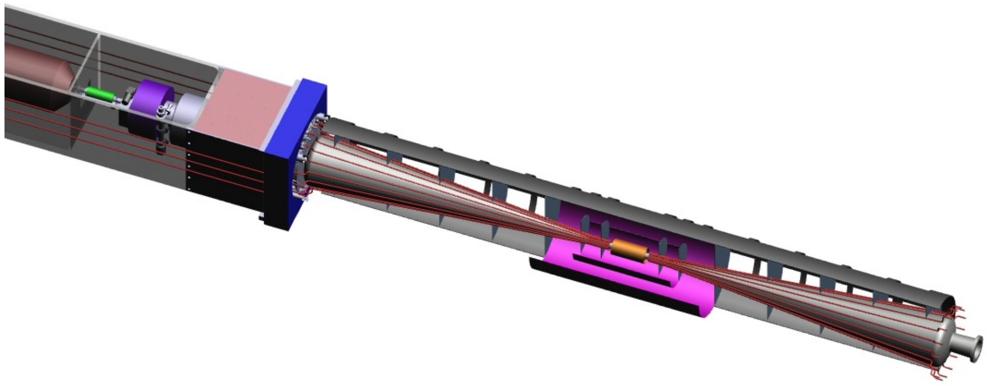

FIGURE 1.5-5. Interaction region of the ILD detector. Shown are the vertex detector (yellow), the SIT (pink), the ECAL plug (blue) with the LumiCal, the LHCAL (light red) and the BeamCal (violet). The routing of the cables is also shown.

1.5.1.1 The Beampipe

1.5.1.1.1 Mechanics

1.5.1.1.2 Vacuum

1.5.1.1.3 Wakefield Losses

1.5.1.2 Masking and Forward Calorimeters

1.5.1.3 Support of the Final Focus Magnets

While the QF1 magnets of the final doublet will stay fixed in its position, the QD0 magnets need to move with the detector during push-pull operation. The magnets are installed in a support structure. Two solutions are under study for ILC. Figure 1.5-6 shows a solution with a support tube with square cross section. The tube is made from 30mm thick stainless steel and is supported from a pillar outside of the detector and carbon fibre tension rods which are suspended from the solenoid cryostat. In this way the detector endcaps can be opened at the beam position without interfering with the magnet alignment. Another solution with a support tube with circular cross section is under study.

The QD0 magnets are placed in the support structure on actuators and are monitored using an interferometric laser alignment system like MONALISA.

1.5.2 Machine Induced Backgrounds

Machine induced backgrounds have been studied in detail for the ILD detector and its predecessors GLD and LDC. The main relevant background are pairs from beamstrahlung which are produced in the highly charged environment of the beam-beam interaction. The background levels found are well below any critical limit. Table 1.5.2 summarises the expected background levels for several subdetectors for several beam parameter sets: the nominal ILC

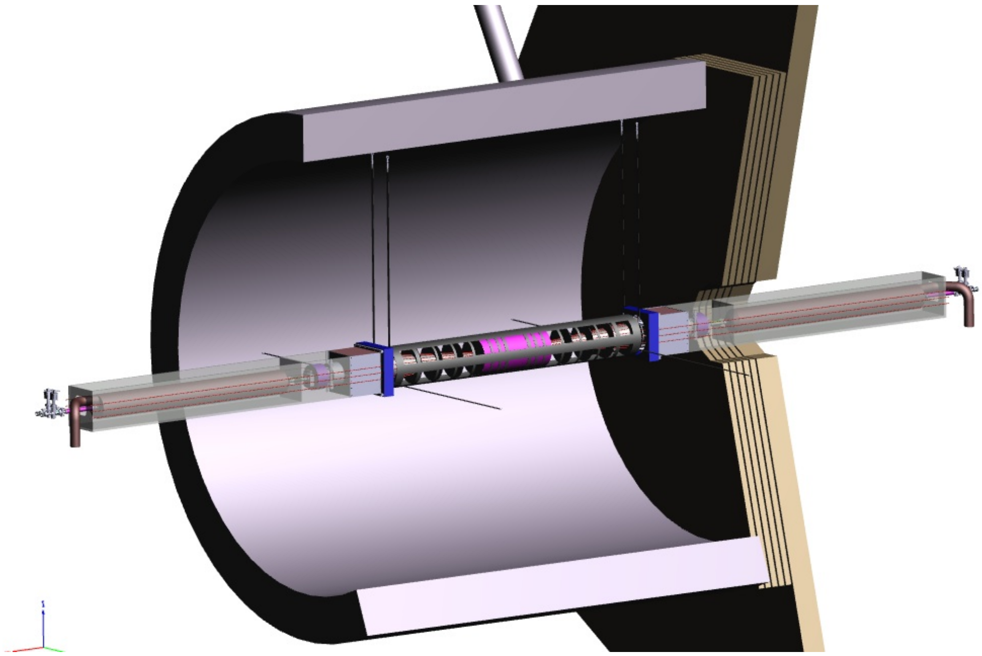

FIGURE 1.5-6. Support of the magnets in the detector. The support structure carries the QD0 magnets and the forward calorimeters. It is supported outside of the detector on a pillar and supended inside from the solenoid cryostat using carbon fibre tie rods.

Subdetector	Nominal 500	Nominal 1000	Low-P	Tolerance
Vertex Detector				
SIT				
FTD				
TPC				
ECAL				
HCAL				

TABLE 1.5-1
Pair induced backgrounds in the subdetectors.

beam parameters for 500 and 1000 GeV cms energy and the Low-P parameter set[1]. Also shown are the detector specific tolerance levels.

1.5.3 Provisions for the Low-P Beam Parameters

Necessary modifications:
- Vertex detector inner layer shorter - or larger radius?
- Beampipe modifications

[1]The Low-P parameter set requires modifications to the baseline detector design which are described in section 1.5.3. The numbers in the table reflect these modifications for the Low-P case.

Larger backgrounds in forward calorimeters

1.5.4 Measurement of Energy and Polarisation

Traditionally the methods of measuring the beam energy and the beam polarisation are also parts of the Machine Detector Interface. As the polarimeters and the energy spectrometers are not a part of the detectors at the ILC but are common facilities in the machine, we will refer here only to the common design efforts [].