§19. Development of Dynamic Simulator for Large Superconducting Magnet System

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Large scale superconducting solenoids installed in the two kinds of detectors (ILD and SiD) with the outer diameter of around 16m will be employed to International Liner Collider (ILC) project. The superconducting solenoids for detectors will be cooled by two phase flow helium. The central region which means the collision point of electron and positron can be regarded as interface between detector and accelerator. That is, boundary between accelerator and detector is composed of crab cavity and final focusing magnets, which are referred to as QD0 and QF1. Especially, QD0 final focusing quadrupole magnets are installed in the detector. These superconducting equipment except detectors have to be cooled by saturated and pressurized superfluid helium. Therefore it is necessary to employ large scale helium refrigerator to generate coolant such as two phase flow of helium, 2p-He, and superfluid helium, p-HeII, s-HeII. In addition, we should consider the cryogenic system for detector and accelerator comprehensively.

In the FY2014, we consider the practical design of cryogenic system for the central region. Fig.1 shows the cryogenic configuration which is focused on the detector and final focusing magnet, QD0. Cold box is located on the detector as shown in the Fig.1 because not only 2p-He and s-HeII should be transferred to detector and both side of QD0s, respectively such that heat load should be reduced as small as possible. To perform this, it is necessary to shorten the transfer tube length. 2p-He is generated in the distribution box which was drawn on the brown in the figure. After that it can be supplied to detector solenoid via current lead box which is drawn on the gray. On the contrary, s-HeII for both side of QD0s can be generated in the 2K refrigerators which are drawn on the yellow and are located both side of detector. In order to cope with pushpull operation which means that detectors move 28 m from collision point to maintenance location, warm flexible tube and cable chains are employed in this system. In this configuration shown in the Fig.1, we have to pay special attention to the vibration of QD0s installed in the detector such that maximum vibration amplitude against both side of QD0s is less than 50nm because cold box and other equipment with vibration source is located on the detector. In order to reduce such kind of vibration source, these equipment had better be located far from the detector. But in this scenario, several serious problems such as reduction of heat load and compensation structure for pushpull operation and production cost should be considered. Fig.2 shows the cryogenic flow diagram for detector and final focusing QD0s. In order to perform optimization of the diagram, we are developing dynamic simulation tool. Fig.3 shows the two phase flow cooing simulation to perform optimal cooling design of detector solenoid with the diameter of around 8m. Flow instability does not occur in the case that inlet void fraction of 2p-He is less than 0.1. So the heat exchanger installed in the distribution box should be designed with this condition.

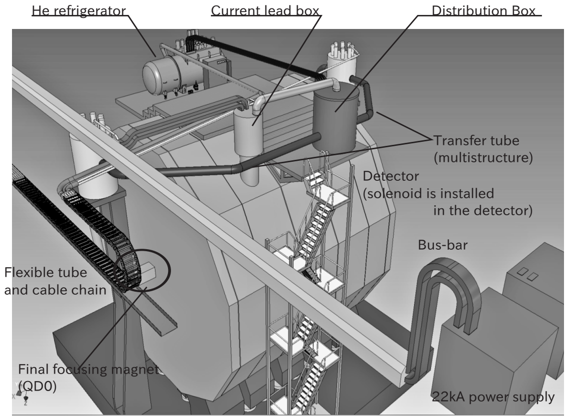

Fig. 1: cryogenic configuration for central region.

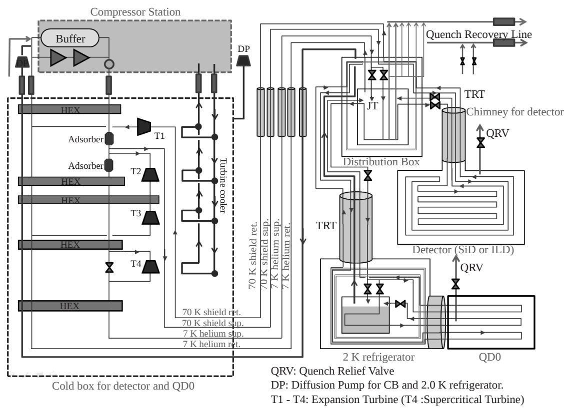

Fig. 2: Schematic cryogenic flow diagram in the central region.

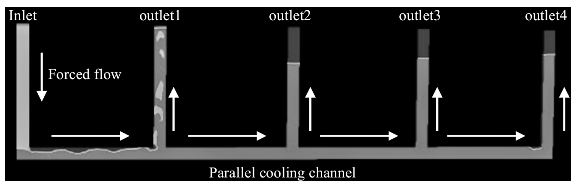

Fig. 3: Simulation results example for 2p-He with parallel cooling channel.