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ILC-CR-0009 Cryogenic Layout

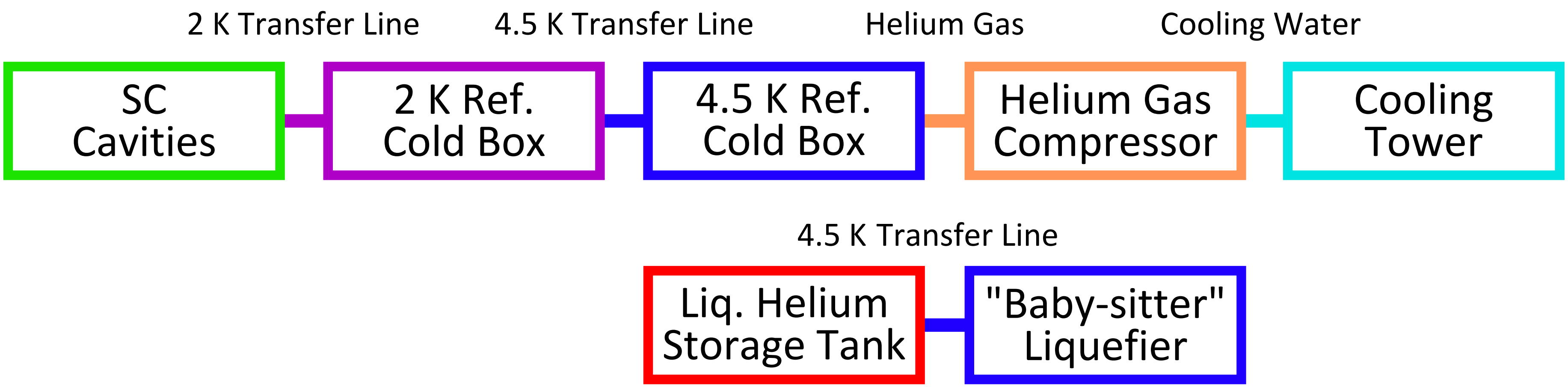
NAKAI Hirotaka, KEK

in collaboration with

Dimitri DELIKARIS, CERN

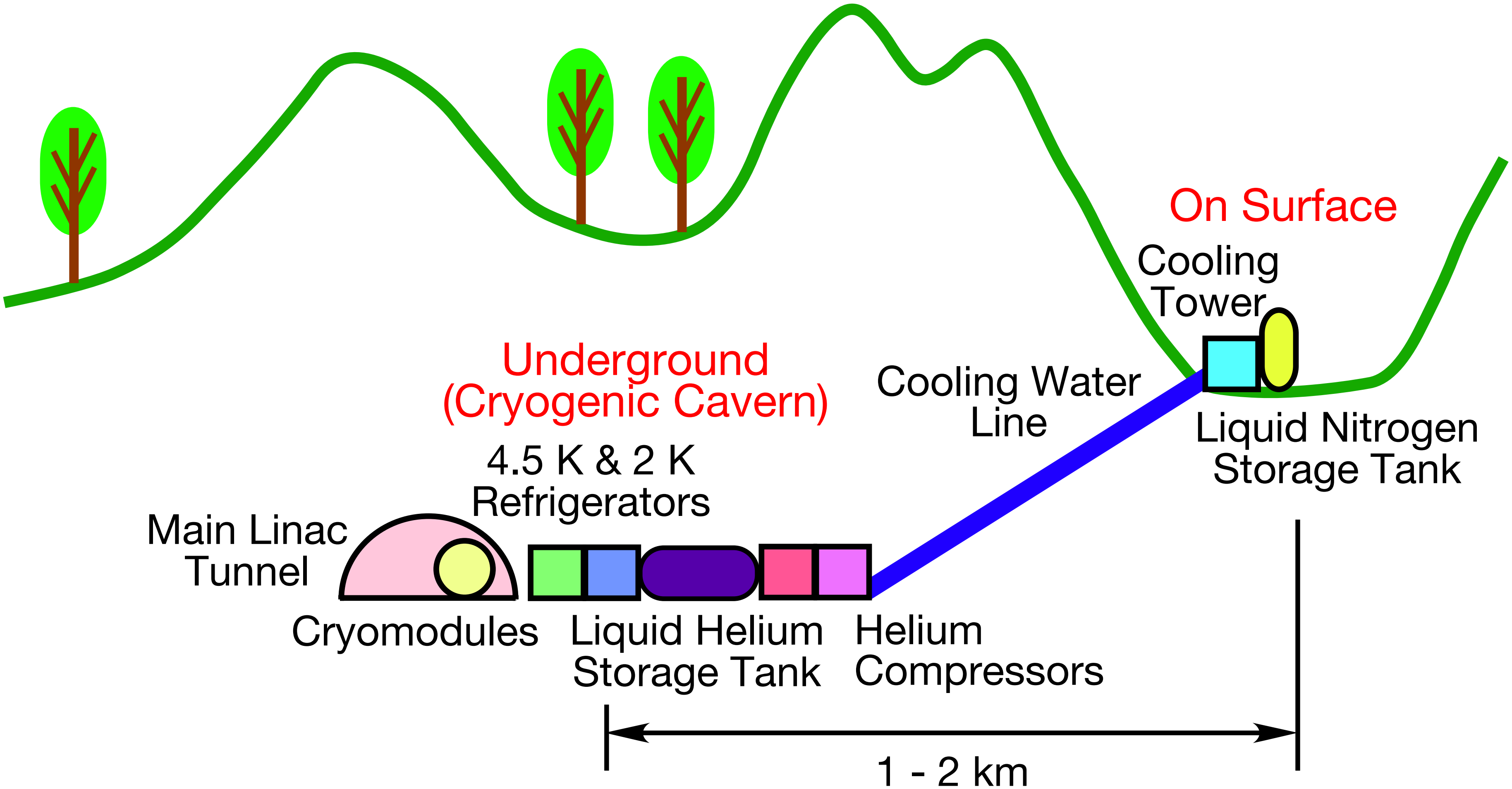
Thomas PETERSON, FNAL

Basic Components of Cryogenic Systems

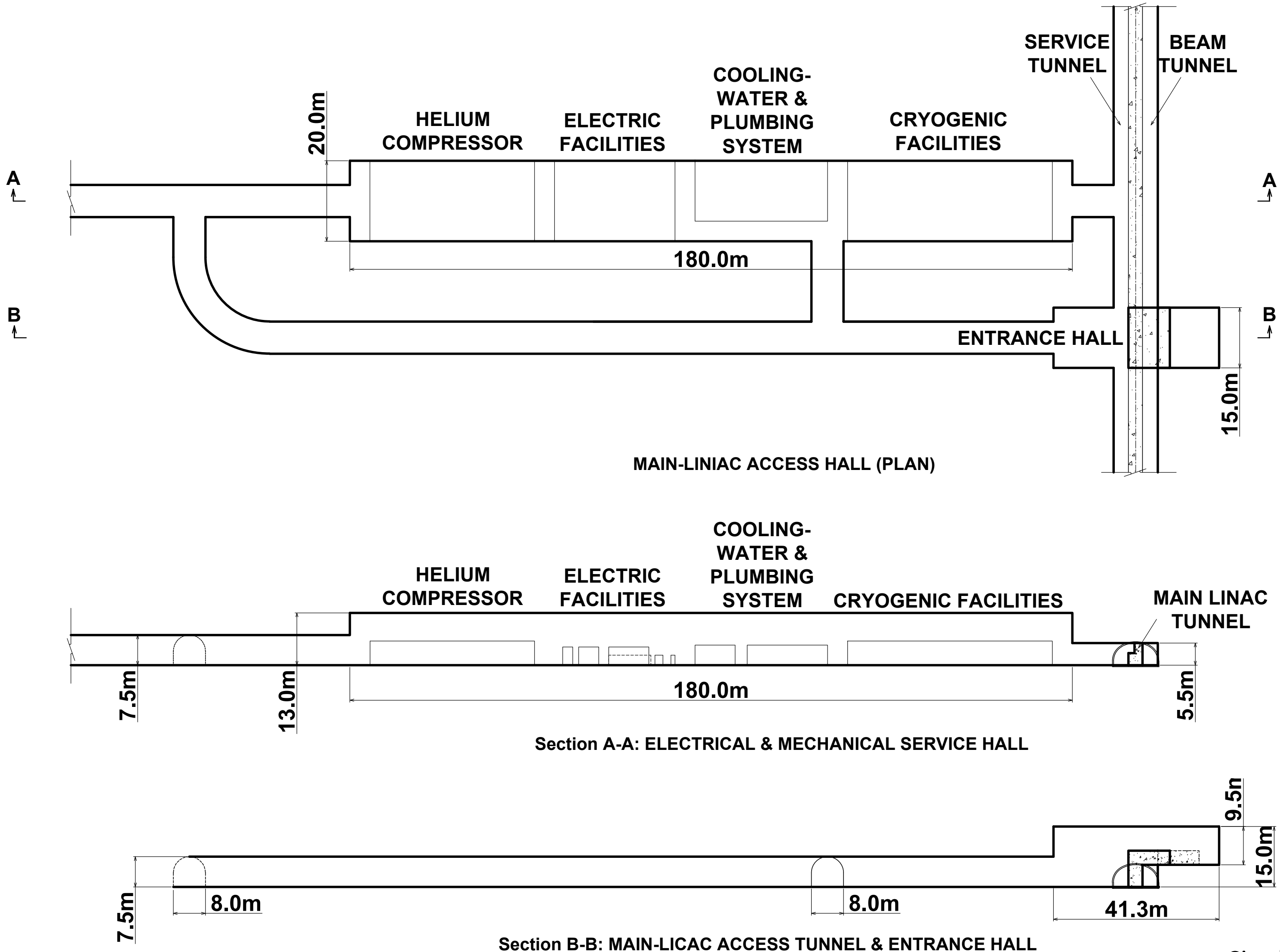


- Shorter cryogenic transfer lines preferred for less heat loads and lower costs
- Heat removal necessary for heat generation at helium compressors as much as consumed electric power (cooling water, cooling towers)
- Liquid helium storage tanks with “baby-sitter liquefiers for long-term shutdowns or at blackouts

Cryogenic Component Configuration in TDR



Typical Access Hall (Cryogenic Cavern)

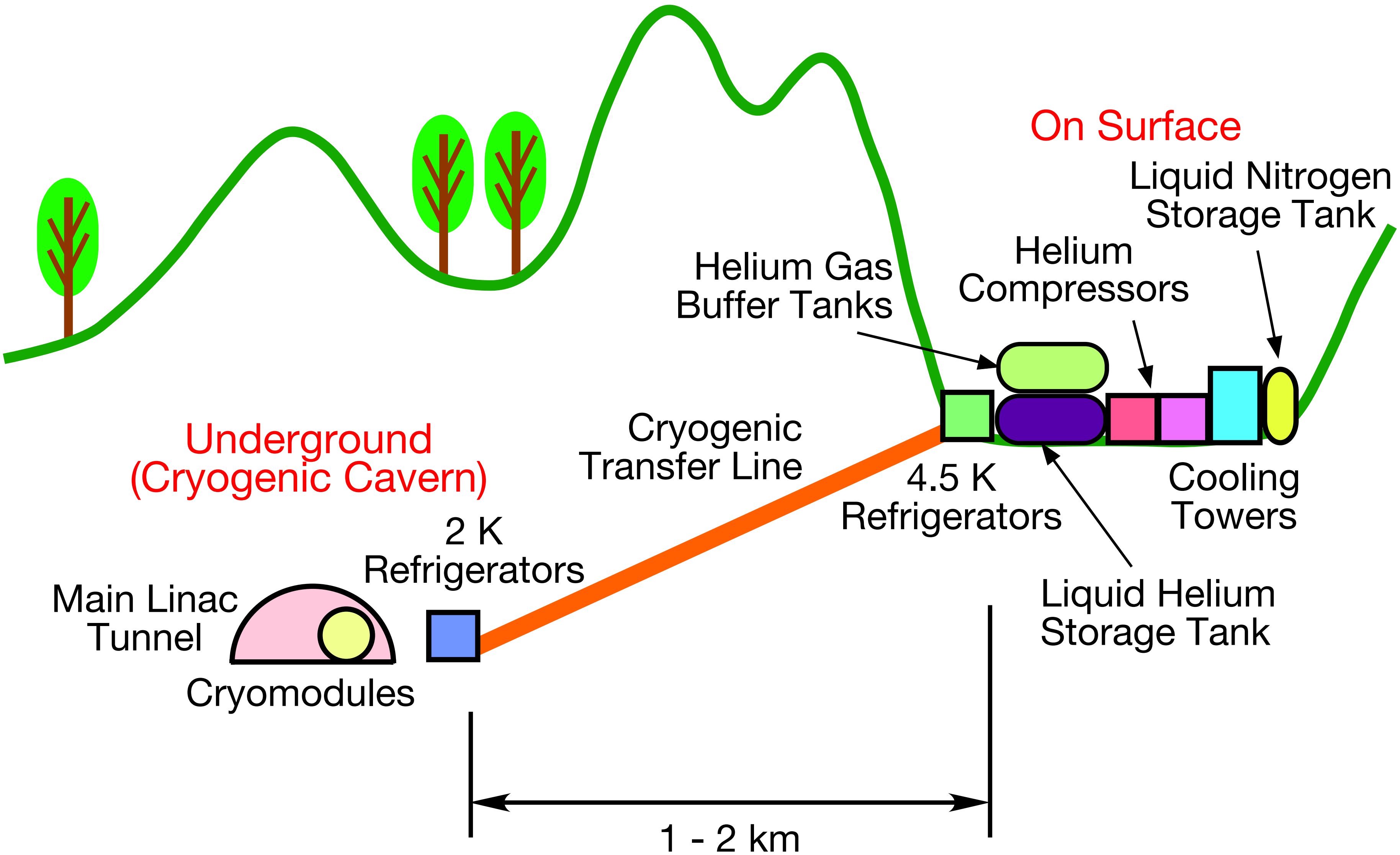


Cited from ILC-TDR

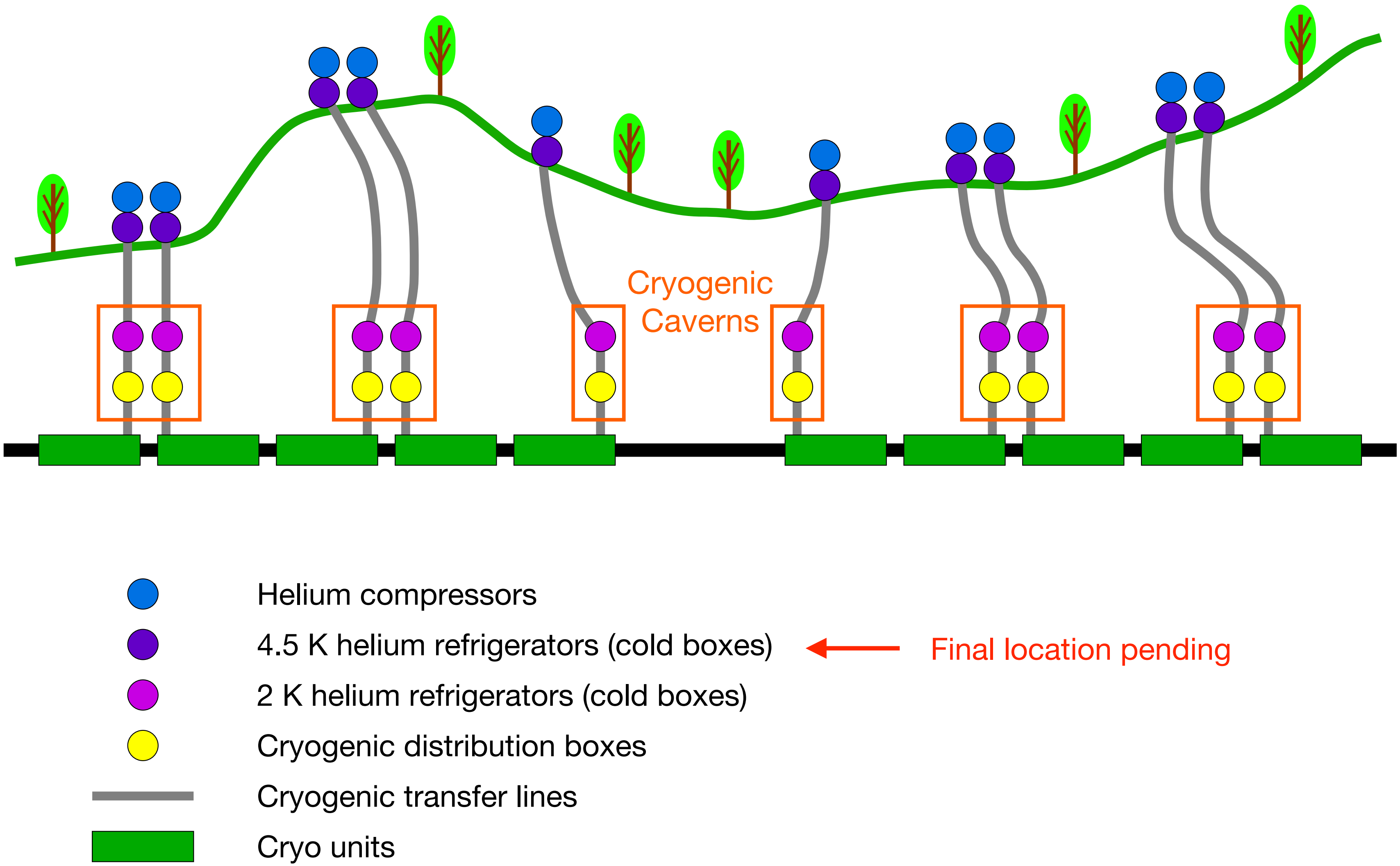
Points of Consideration

- Scenic conservation and environment protection (noise and mechanical vibration)
- Construction costs
- Storage of liquefied gases underground restricted (CERN and FNAL)
- Mechanical vibration of helium compressors affects beams
- Heat removal from helium compressors (cooling towers)
- Radioactivation of helium can be ignored (from past measurements at CERN and FNAL)
- Shorter 2 K transfer lines preferred
- Accessibility for daily checks and accidents response
- Helium buffer tanks required for stable operation of cryogenic systems (liquid helium storage tanks close to 4.5 K helium refrigerators)

Current Cryogenic Component Configuration



Current Cryogenic Plant Configuration



Discussions

- Long cryogenic transfer lines up to about 2 km required in current configuration
- Location of 4.5 K refrigerators still under discussion
- Quantitative discussions on cryogenic configuration suggested
  - Cryogenics - T. Okamura
  - Civil engineering - M. Miyahara
- Operation procedures
  - Procedures before and after long-term shutdowns
  - Recovery procedure at sudden blackouts
- Safety policies
  - Who establishes?
  - How do we establish?
  - Cost for safety

Summary

- No question about compressors (+ cooling towers) and storage tanks (+ “baby-sitter” liquefiers) on surface
- For change request, compressors (+ cooling towers) and storage tanks (+ “baby-sitter” liquefiers) on surface can be proposed at this stage
- Location of 4.5 K refrigerators kept pending for further study (their location underground in the figure for the change request at this stage)

Change Request

Contents of Change Request

Introduction

Advantages of the Proposed Cryogenic Component Layout

1) Operation Considerations
   - Mechanical vibration and noise from compressors
   - Large amount of cryogens underground prohibited at some accelerator institutes
   - Heat removal from helium compressors
   - Accessibility to cryogen supply and daily check
   - Radioactivation of helium
2) Schedule Considerations
3) Cost Considerations

Disadvantages of the Proposed Cryogenic Component Layout

1) Natural Environment Conservation
2) Cost Consideration

Figure 1. Schematic cryogenic layout described in TDR.
Figure 2. Schematic cryogenic layout proposed in this change request with the 4.5 K refrigerator location kept pending for further study.

Introduction

Introduction

The cryogenic system for the ILC consists of various components, such as cold boxes, compressors and transfer lines of cryogens. Baseline layout of the cryogenic system described in TDR was determined with the primary focus on the conservation of nature at the mountainous candidate site for ILC. Almost all cryogenic components has been considered to be installed in the cryogenic caverns next to the main linac tunnels about 100 meters below the ground level. Only the cooling towers for the cooling water of the helium compressors may be installed on the surface for easier heat removal, as shown in Figure 1.

Succeeding discussions on the ILC cryogenic system after TDR, however, reveal some technological and safety issues for the prescribed cryogenic layout in TDR. One of major issues is that at some institutes the cryogen storage underground or in accelerator tunnels is strictly controlled except the accelerator cryostats or cryomodules for the safety reason. The new cryogenic layout, shown in Figure 2, is proposed after several discussions on the cryogenic layout among the cryogenics experts. In the proposed cryogenic layout the main helium compressors and the cryogen storage tanks will be placed on the surface in addition to the cooling towers. Further discussions including various operational and emergency modes may bring more modification of this proposed configuration.

Figure 1. TDR Cryogenic Layout

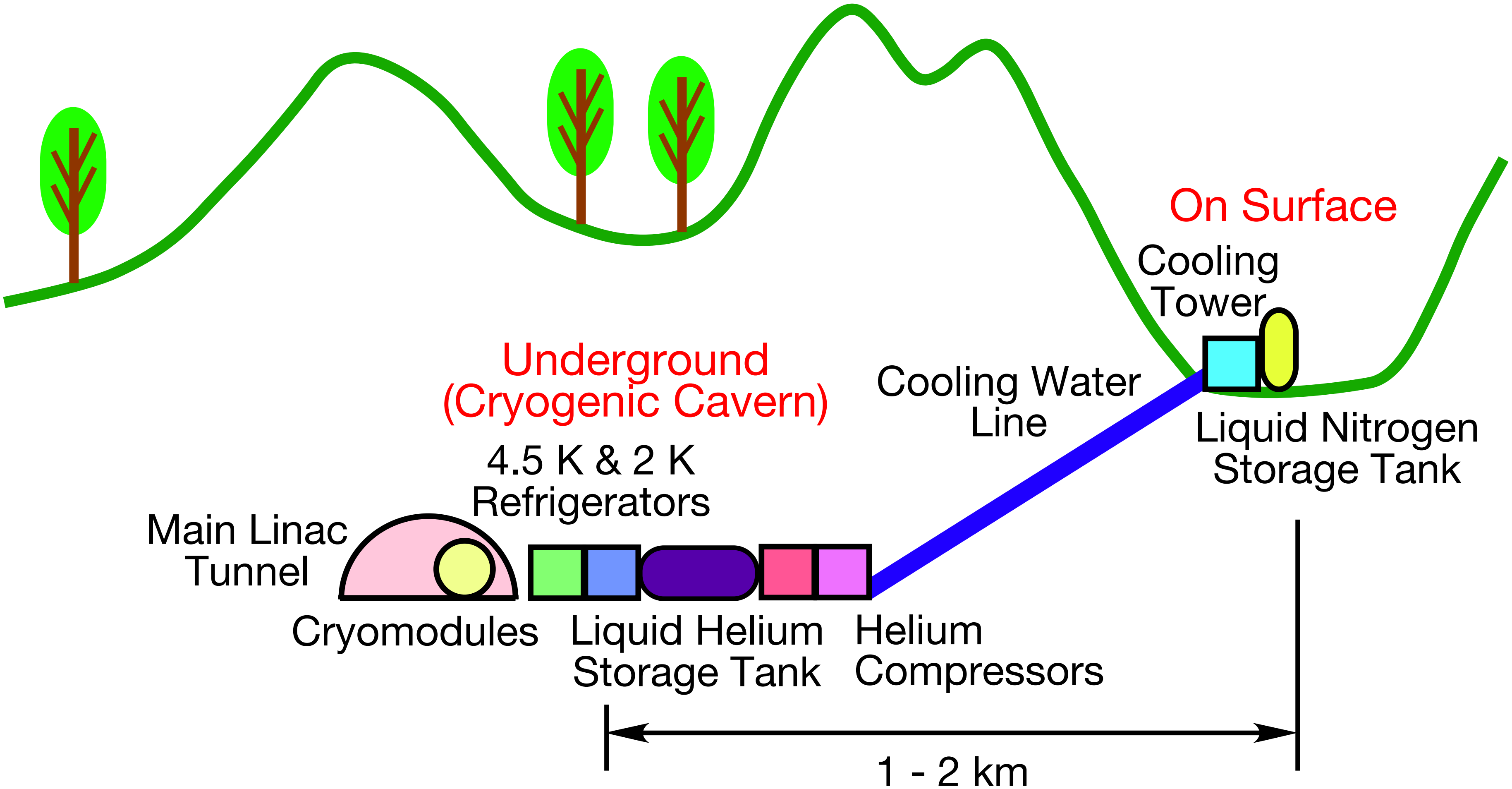
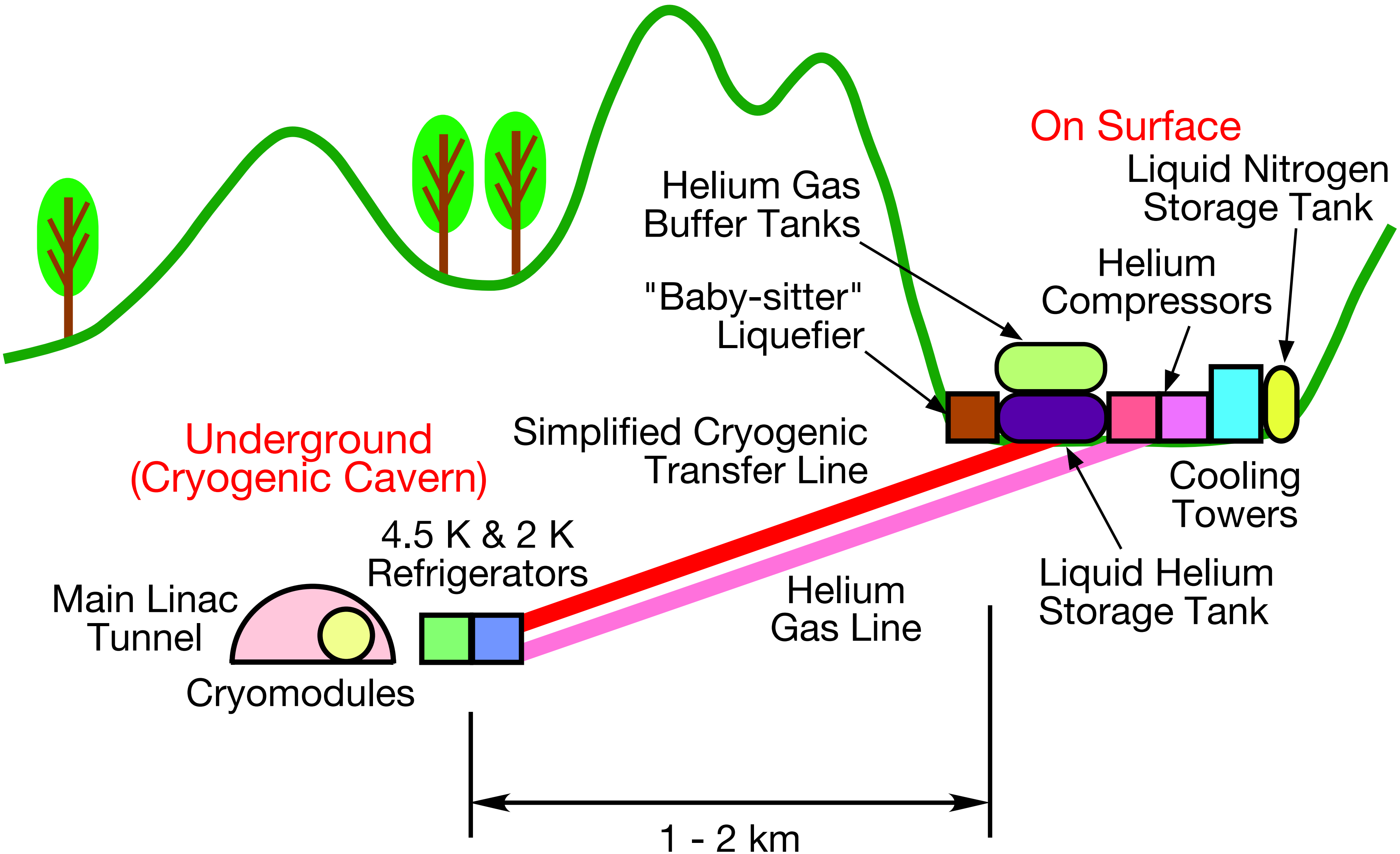


Figure 2. Proposed Cryogenic Layout



Advantages of Proposed Cryogenic Component Layout

Mechanical vibration and noise from compressors

It is pointed out that the mechanical vibration from the helium compressors may interfere in electron/positron beam operation. Hence from the point of view of the ILC operation it should be better not to install the helium compressors near ML tunnels, such as in a cryogenic cavern. Installation of the helium compressors on the surface can make the situation free from this issue.

1. Operation Considerations (2)

Large amount of cryogens underground prohibited at some accelerator institutes

The total liquid helium inventory for the ILC cryogenic system is estimated 632000 liters in TDR. For the case of mountainous region site, there will be 10 cryoplants, and hence the amount of 63200 liters of liquid helium should be managed at each cryoplant. Because of the safety reason, the cryogen storage underground or in accelerator tunnels is strictly controlled at multiple accelerator institutes, even if a large ventilation system could be equipped. There is no strong reason against such safety regulation in the ILC cryogenic system.

Heat removal from helium compressors

The AC power consumption at each cryoplant is estimated at 3.2 MW in TDR. This consumption comes mainly from the helium compressors, and hence, the same amount of heat will be generated from the compressors in other words. If the compressors would be installed in the cryogenic caverns, such huge amount of heat should be removed from the cryogenic caverns underground to the surface of the site. If the compressors would be installed on the surface, conventional facilities and techniques can be employed.

Accessibility to cryogen supply and daily check

Large amount of liquid helium should be introduced into the cryoplant at the initial stage. During the operation of the cryogenic system, the safety valves may activate some times by blackouts or by improper operation and so on, and helium gas or liquid helium should be suppled into the cryogenics after the safety valve operation. If the cryogenic system would be installed at the cryogenic cavern, long supply lines for liquid helium and helium gas from the surface to the cryogenic cavern should be prepared. Or, wide roads for big trailers for liquid helium or helium gas cylinders would be required from the surface to the cavern. If the cryogen storage tanks are installed on the surface such situation can be ignored.

1. Operation Considerations (5)

Radioactivation of helium

Radioactivation of helium is reported after some period of superconducting accelerator operation. However, the radiation level of helium is far below the generally allowed limit/ threshold. The issue of helium radio activation can be removed from the discussion on the cryogenic layout.

2. Schedule Considerations

The new cryogenic layout requires smaller area of the cryogenic cavern next to the main linac tunnel because of less numbers of cryogenic components. The construction duration of the cryogenic caverns may become shorter, if the area of the cavern is small. On the other hand, the surface area will become larger and the excavation duration may become longer. The resultant duration of shorter underground construction and longer excavation can be expected shorter in total. Detailed discussion on the schedule consideration will be made among CFS colleagues.

3. Cost Considerations

The same discussion on the schedule consideration can be made also for the cost consideration. The total cost for the cryogenic system seem to be reduced in total, if the new cryogenic layout is selected. Detailed discussion on the cost consideration will be made among CFS colleagues.

Disadvantages of Proposed Cryogenic Component Layout

1. Natural Environment Conservation

Almost all cryogenic components except the 2 K refrigerator cold boxes will be installed on the surface, i.e. at the access points. This means many cryogenic components appear clearly in the natural mountainous areas. The helium compressors and the cooling towers may spread their mechanical noises and vibrations. Water vapor smokes from the cooling towers may be visible and may bring the emotional misunderstanding as radioactive smokes among the residents near the access points. It is important to assess how much noise and vibration can be accepted among the residents, and how the optimum locations for these installation on surface with contribution from natural geology and site shape (such as in valley). It is also necessary to explain to the residents that the cryogenic facilities are radiation-free.

2. Cost Consideration

There are two cooling water lines between the cryogenic caverns and surface in the baseline layout. The lines may employ ordinary steel pipes because of water lines. If almost all cryogenic components would be installed on the surface and only the 2 K refrigerator cold boxes do in the cryogenic caverns, the multi-channel cryogenic transfer lines should be constructed. This transfer line, despite the well-known manufacturing technology, costs much higher than that for an ordinary water pipe.