- accelerate the beam while preserving the small bunch emittances, which requires precise orbit control based on data from high resolution beam position monitors, and also requires control of higher-order modes in the accelerating cavities;
- maintain the beam energy spread within the design requirement of ~0.1 % at the IP;
- not introduce significant transverse or longitudinal jitter, which could cause the beams to miss at the collision point.

### System description

The ILC Main Linacs accelerate the beam from 15 GeV to a maximum energy of 250 GeV at an average accelerating gradient of 31.5 MV/m. The linacs are composed of RF units, each of which are formed by three contiguous SCRF cryomodules containing 26 nine-cell cavities. The layout of one unit is illustrated in Figure 1.3-5. The positron linac contains 278 RF units, and the electron linac has 282 RF units[5].

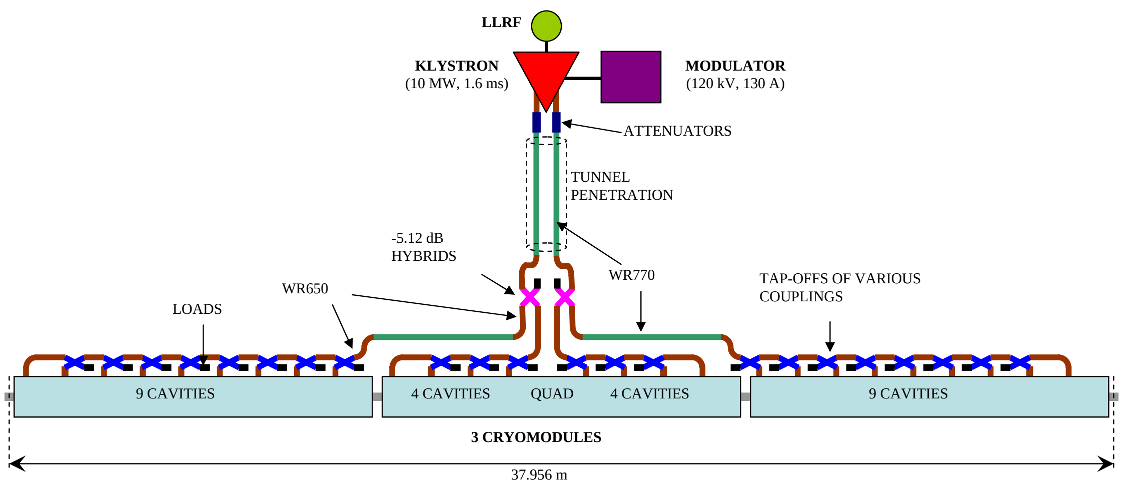


FIGURE 1.3-5. RF unit layout.

Each RF unit has a stand-alone RF source, which includes a conventional pulse-transformer type high-voltage (120 kV) modulator, a 10 MW multi-beam klystron, and a waveguide system that distributes the RF power to the cavities (see Figure 1.3-5). It also includes the low-level RF (LLRF) system to regulate the cavity field levels, interlock systems to protect the source components, and the power supplies and support electronics associated with the operation of the source.

The cryomodule design is a modification of the Type-3 version (Figure 1.2-2) developed and used at DESY. Within the cryomodules, a 300 mm diameter helium gas return pipe serves as a strongback to support the cavities and other beam line components. The middle cryomodule in each RF unit contains a quad package that includes a superconducting quadrupole magnet at the center, a cavity BPM, and superconducting horizontal and vertical corrector magnets. The quadrupoles establish the main linac magnetic lattice, which is a weak focusing FODO optics with an average beta function of ~80 m. All cryomodules are 12.652 m long, so the active-length to actual-length ratio in a nine-cavity cryomodule is 73.8%. Every cryomodule also contains a 300 mm long high-order mode beam absorber assembly that removes

[5] Approximately 3 GeV of extra energy is required in the electron linac to compensate for positron production.

energy through the 40-80 K cooling system from beam-induced higher-order modes above the cavity cutoff frequency.

To operate the cavities at 2 K, they are immersed in a saturated He II bath, and helium gas-cooled shields intercept thermal radiation and thermal conduction at 5-8 K and at 40-80 K. The estimated static and dynamic cryogenic heat loads per RF unit at 2 K are 5.1 W and 29 W, respectively. Liquid helium for the main linacs and the RTML is supplied from 10 large cryogenic plants, each of which has an installed equivalent cooling power of ∼20 kW at 4.5 K. The main linacs follow the average Earth's curvature to simplify the liquid helium transport.

The Main Linac components are housed in two tunnels, an accelerator tunnel and a service tunnel, each of which has an interior diameter of 4.5 meters. To facilitate maintenance and limit radiation exposure, the RF source is housed mainly in the service tunnel as illustrated in Figure 1.3-6.

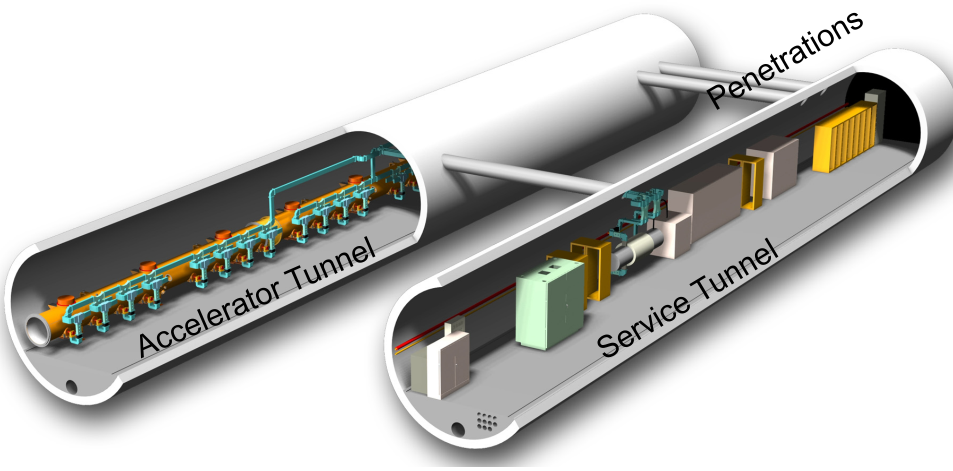


FIGURE 1.3-6. Cutaway view of the linac dual-tunnel configuration.

The tunnels are typically hundreds of meters underground and are connected to the surface through vertical shafts[6]. Each of the main linacs includes three shafts, roughly 5 km apart as dictated by the cryogenic system. The upstream shafts in each linac have diameters of 14 m to accommodate lowering cryomodules horizontally, and the downstream shaft in each linac is 9 m in diameter, which is the minimum size required to accommodate tunnel boring machines. At the base of each shaft is a 14,100 cubic meter cavern for staging installation; it also houses utilities and parts of the cryoplant, most of which are located on the surface.

### Challenges

The principal challenges in the main linac are:

- achieving the design average accelerating gradient of 31.5 MV/m. This operating gradient is higher than that typically achievable today and assumes further progress will be made during the next few years in the aggressive program that is being pursued to improve cavity performance.

[6]Except for the Asian sample site: see Section 1.4.