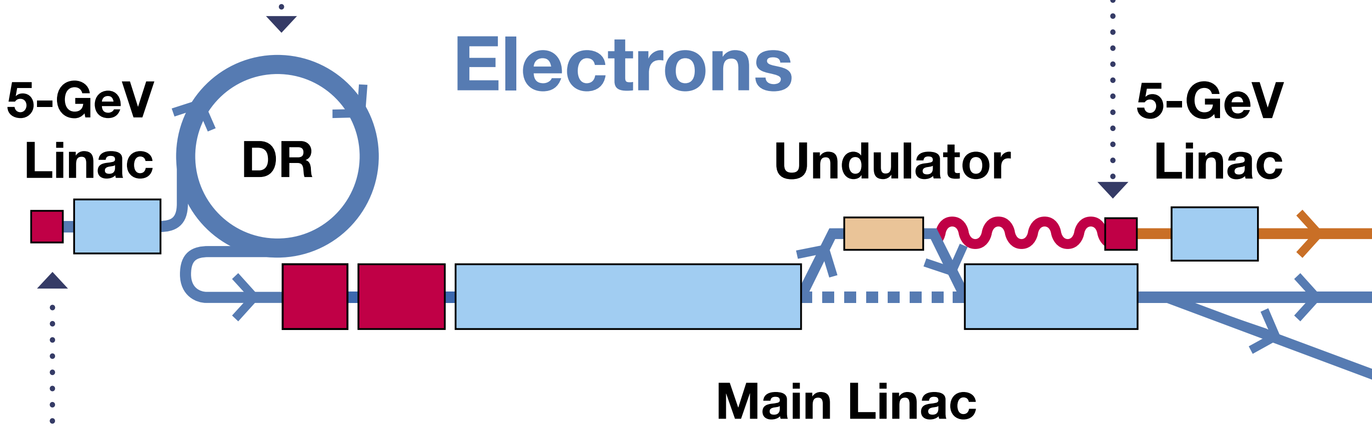
deconstruction: ILC design

Supersymmetry. Dark matter. Extra dimensions. Scientists have proposed the International Linear Collider (ILC), a next-generation project designed to smash together electrons and their antiparticles at a higher-than-ever energy, to learn more about these and other mysteries of the universe. The ILC Global Design Effort team, which includes 63 scientists and engineers from around the world, has agreed on the baseline configuration for the roughly 30-kilometer-long, 500 billion-electronvolt (GeV) particle collider.

Escaping the source, the electron bunches lack the high density needed to produce lots of collisions. In the 6-kilometer-long damping ring, the electron bunches traverse a wiggler, an electromagnetic device that causes the beam to “wiggle,” leading to a more uniform, compact spatial distribution of particles. Each bunch spends roughly two tenths of a second in the damping ring, circling it 10,000 times before being kicked out. Dipole magnets keep the particles on track, bending the beam around the ring. Quadrupole magnets focus and shape the beam. Exiting the damping ring, the bunches are six millimeters long and thinner than a human hair.

Positrons have the same properties as electrons but the opposite electric charge. To produce these antimatter particles, scientists will send the electron beam through an undulator. Magnets within the undulator bring the beam into gentle wavelike motion, causing the electrons to emit lots of light particles (photons) in the forward direction. Just beyond the undulator, the electrons return to the main accelerator while the photons hit a titanium alloy target, producing positrons. A 5-GeV accelerator shoots the positrons to the first of two positron damping rings.

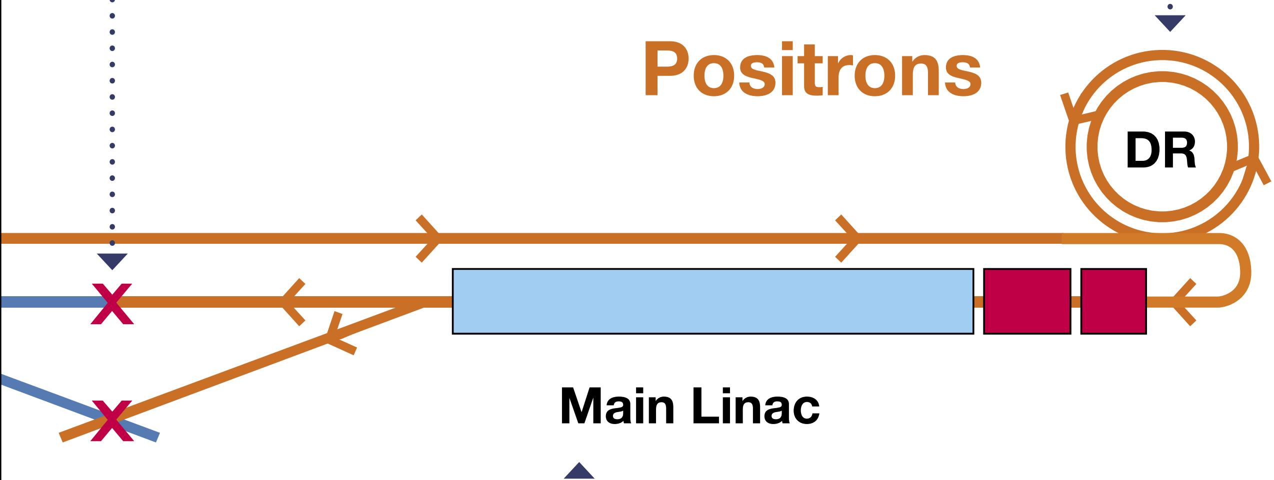


To produce electrons, high-intensity pulses of light from a titanium-sapphire laser hit a target and knock out electrons. The laser emits 2-nanosecond “flashes,” each creating billions of electrons. An electric field “sucks” each bunch of particles into a 250-meter-long linear accelerator that speeds up the particles to 5 GeV.

Two main linear accelerators, one for electrons and one for positrons, accelerate bunches of particles toward the collision area. Each accelerator consists of 8000 superconducting cavities nestled within a series of cryomodules. The modules use liquid helium to cool the cavities to -271°C, only slightly warmer than the coldest possible temperature. Alternating electric

Bam! Traveling toward each other at 99.9999999998 percent of the speed of light, electron and positron bunches collide at 500 GeV, an energy beyond anything current electron-positron colliders produce. Physicists anticipate discovering new particles and forces that will provide clues regarding the existence of extra dimensions, dark matter, and supersymmetry. The baseline configuration of the ILC provides for two collision points, offering space for two detectors. Working like gigantic cameras, detectors use state-of-the-art particle identification technology to record the particles escaping each collision.

The ILC has two identical positron damping rings, located in one tunnel. Why are there two when the ILC has only one damping ring for electrons? Going around in circles, positrons emit light. Hitting the interior of the beam pipe, the light sets free electrons that disturb the positron beam. To limit the build-up of this "electron cloud," scientists can put only half as many positron bunches in a damping ring as electron bunches. Hence two positron damping rings with 6-kilometer circumference are necessary to accommodate the same number of positrons as electrons.



fields "push and pull" the particles through the cavities, accelerating them to 250 GeV. Two 12-km-long tunnel segments, about 100 meters below ground, house the two accelerators. An adjacent tunnel provides space for support instrumentation, allowing for the maintenance of equipment while the accelerator is running.

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Graphic: ILC Global Design Effort

Drawing not to scale