Superconductivity for Future Particle Accelerator Project ILC

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Today (August 20), the International Committee for Future Accelerators (ICFA) announced at a scientific conference in Beijing that the planned **International Linear Collider (ILC) is to be realized in superconducting technology**. This decision is of great importance for DESY and its international partners, since they developed this technology together and successfully tested it at the TESLA Test Facility (TTF) in Hamburg. The ILC is the next major project of particle physics. No decision has yet been taken on the realization and site of the facility. As the next step, particle physicists will now join forces to develop the technical design of the project as rapidly as possible.

The ICFA committee, which represents particle physicists worldwide, thus decided between two possible technologies that have been developed in America, Asia and Europe during the past 12 years. The two technologies differ mainly in their accelerating structures, the so-called cavities. These accelerate the particles to high energies before they collide. The cavities can be normal conducting and are then operated at room temperature ("warm" version), or superconducting with an operating temperature close to absolute zero ("cold" version).

"With this technology decision, worldwide particle physics has made a major step forward toward the future – a step in which the true success really is the international agreement," commented Albrecht Wagner, Chairman of the DESY Directorate, today at a press conference of the International Institute of High Energy Physics (IHEP) in Beijing. "Without the worldwide endorsement of one of the two viable technologies, realization of the ILC project would be unthinkable. Of course, DESY takes note of the technology decision with special pleasure. For what was a technological vision ten years ago has now become reality. This is the result of the joint efforts of DESY and its international partners – the TESLA Collaboration, which decisively improved the performance of superconducting accelerating cavities."

A future linear collider for high-energy electrons and their antiparticles, the positrons, will open up unique opportunities to address the 21st-century agenda of central questions about the fundamental nature of matter, energy, space and time, and about dark matter, dark energy and the existence of extra dimensions. The technology decision now allows the next big step to be taken on the way toward that major project of particle physics. The linear collider will complement the Large Hadron Collider (LHC) at CERN, a proton accelerator which will start operating near Geneva in 2007. Regardless of the site where the new research facility will later be built, particle physicists from accelerator centers and university institutes from America, Asia and Europe will now begin working together on the technical design study for the international linear collider.

The Helmholtz center DESY had decided to participate in the ILC in any case even before the technology recommendation – even had the linear collider not been realized in the superconducting technology favored by DESY and its international partners. "With this recommendation it becomes clearer how DESY could make useful contribution to the ILC," says Wagner, "because we here at DESY are currently preparing the European X-ray laser XFEL, which will also be based on the TESLA technology. The XFEL will be realized in Hamburg and Schleswig-Holstein starting in 2006. Its construction will provide a testing ground for many aspects of the ILC." (X stands for "X-ray", FEL for "free-electron laser".)

The two technological concepts for an electron-positron linear collider with collision energies in the range from 500 to 1000 billion electronvolts (GeV) differ mainly in the following points: At 1.3 gigahertz (GHz), the operating frequency of the accelerating cavities of the superconducting version lies in the “L-band” region. The normal conducting version operates at a frequency of 11.4 GHz in the “X-band” range.

A tunnel length of up to 40 kilometers is foreseen for the L-band version, whereas up to 30 kilometers are needed in the X-band case. The X-band technology requires a second tunnel running parallel to the actual collider tunnel to house the klystrons that generate the radio frequency accelerating fields.

Thanks to superconductivity, nearly all the radio frequency power is transmitted to the particle beam in the L-band technology, around one third of it in the X-band case.

Unlike the L-band version, the X-band technology can accommodate higher accelerating fields and thus higher collision energies without the need to increase the length of the linear collider. – In order to reach the collision rates required for electron-positron research, both particle accelerators have to be erected and aligned with extremely high precision in the interaction region. Here, the two technologies differ in their requirements regarding the alignment precision: For the L-band collider it is around half a millimeter, whereas the X-band collider needs a precision of a few hundredths of millimeters.

In November last year, the International Committee for Future Accelerators (ICFA) – the highest committee in particle physics, in which new accelerator projects are discussed and put to vote – had charged the International Technology Recommendation Panel (ITRP) it had appointed to recommend one of the two technologies. Within only eight months, the panel comprising experts from America, Asia and Europe had then thoroughly assessed the two technologies, weighed their respective advantages and drawbacks and finally recommended the superconducting technology for the future linear collider.

"Both the 'warm' X-band technology and the 'cold' superconducting technology would work for a linear collider," said Barry Barish of the California Institute of Technology, Pasadena, USA, who chaired the ITRP. "Each offers its own advantages, and each represents many years of R&D by teams of extremely talented and dedicated scientists and engineers. At this stage it would be too costly and time consuming to develop both technologies toward construction. The panel had our first meeting in January 2004 and started our evaluation of the two technologies. The decision was not an easy one," said Barish, "because both technologies were well advanced and we knew the selection would have significant consequences for the participating laboratories."

George Kalmus, an ITRP member from the UK's Rutherford Appleton Laboratory, explained the cold technology: "The superconducting technology uses L-band (1.3 GHz) radio frequency power for accelerating the electron and positron beams in the two opposing linear accelerators that make up the collider," Kalmus said. "The notable feature of this machine is the use of pure niobium cavities for the accelerating structures of the collider. These cavities at their operating temperature have almost no electrical resistance; that is, they become superconducting. When this occurs, the transfer of power from the drive klystrons to the electron and positron beams becomes highly efficient. The proposed collider would occupy a tunnel of up to 40 km long with the experimental areas located at the midpoint, where the electrons and positrons collide."

The ICFA committee unanimously followed the recommendation of the ITRP on August 20 in Beijing and thus endorsed the choice of the superconducting technology for the ILC.

Source: DESY