ALTERNATIVES TO THE SUPERCONDUCTING SUPER COLLIDER

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The debate over the Superconducting Super Collider has given the public a false impression that people who oppose the SSC are opposed to particle physics in general. I happen to be a supporter of particle physics and an opponent of the SSC. Let me briefly explain why.

Continued progress in particle physics requires a succession of new machines responsive to rapidly changing theories and rapidly changing technologies. Nobody is wise enough to guess what will be the important questions and the important tools ten years ahead. Every new machine is a gamble. If we build the SSC, it might turn out to be a glorious success or it might turn out to be a flop. In either case, we will want to build other machines to carry on from where the SSC stops. Unfortunately, the SSC is an end rather than a beginning. It does not offer much hope of further development. It does not incorporate a new idea. I am afraid that it may be a trap, tying our particle physicists to an old technology and barring the way to newer and more powerful alternatives.

What are the alternatives? I do not claim to be an expert on accelerator design, but I see a tremendous promise in linear electron–positron colliders. There are many reasons why linear electron–positron colliders may be a better gamble than the SSC.

▷ Electron–positron collisions are usually cleaner and scientifically more illuminating than hadron collisions. Our existing electron–positron colliders SPEAR and CESR have been outstandingly cost-effective, as measured by major scientific discoveries per dollar invested. In the TeV range, the advantage of easier diagnostics is likely to favor electron–positron colliders even more strongly.

▷ In electron–positron colliders the full machine energy is available in elementary interactions, whereas in the SSC the energy is shared among quarks and only a fraction of the machine energy is available.

▷ The technology of future accelerators must move toward high luminosity as well as high energy. High luminosity demands tiny interaction volumes and extreme accuracy of focus and timing. All these requirements are pushing us in the direction of optical laser fields rather than radiofrequency fields for acceleration.

▷ The substitution of laser for radiofrequency fields could in principle allow a drastic reduction in the length of linear accelerators. To take a rough example, a joule of laser energy in a 3-nanosecond pulse focused into a 10-micron spot produces an accelerating field of 50 GeV per meter. Nobody knows yet how to use such fields efficiently for acceleration. But we might reasonably gamble some fraction of our efforts on the chance that we can learn how to build an electron–positron collider with linear accelerators giving us 10 TeV per kilometer.

▷ The technology of free-electron lasers is advancing rapidly and is giving us experience in handling interactions between intense electron and laser beams. A laser-driven electron–positron collider is in essence only a free-electron laser working backwards. The problems of beam instability are similar whether we are trying to push energy from electrons into photons or from photons into electrons.

▷ If laser acceleration works well in the domain of linear electron–positron colliders, there is no reason why it should not also be applied to hadron colliders. We might then be able to build a linear hadron collider with the performance of the SSC, but much smaller and cheaper.

▷ The great virtue of electron–positron collider technology is that it can be pursued incrementally. Our aim should be to build cost-effective machines with high luminosity at a variety of energies, able to respond quickly to the various opportunities that new discoveries will create.

All these arguments in favor of linear electron–positron colliders may turn out to be wrong. Likewise, the arguments in favor of the SSC may turn out to be wrong. A prudent gambler places his bets so that no matter what happens, he stays in business. If a decision to build the SSC means that we give up the aggressive pursuit of laser acceleration and other innovative technologies, then the SSC may become as great a setback for particle physics as the space shuttle has been for space science. A vote against the SSC need not be a vote against particle physics.

I am grateful to the editors of PHYSICS TODAY for an advance copy of the article "New Particle Acceleration Techniques" by Andrew Sessler (January, page 26). Sessler does not agree with me. His article is an authoritative survey of linear electron–positron collider technology. Anybody with a serious interest in alternatives to the SSC should read it. ■

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