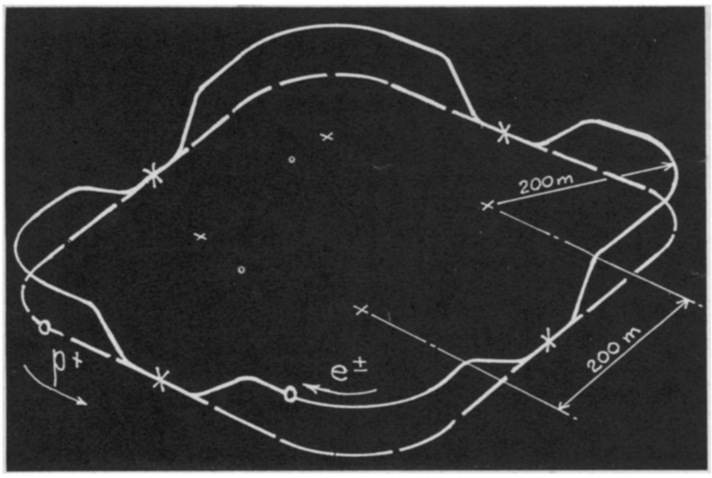
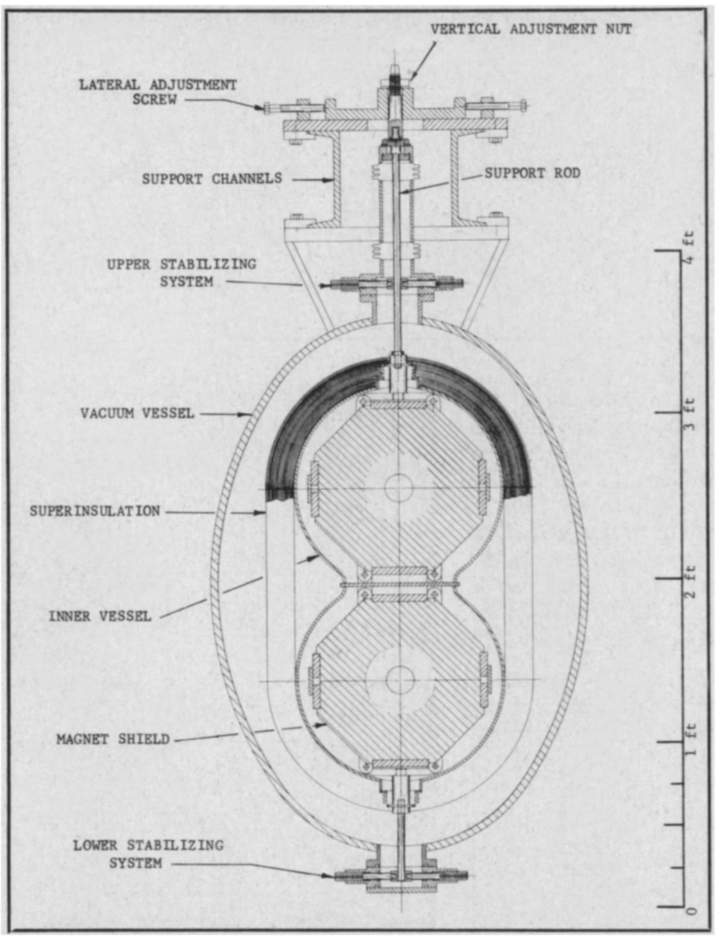


PEP's electron-positron ring would be piggy-backed on its proton ring.

LBL/SLAC

Storage rings: The future of physics

by Dietrick E. Thomsen



ISABELLE's rings would be stacked inside a dewar to keep superconducting magnets cold.

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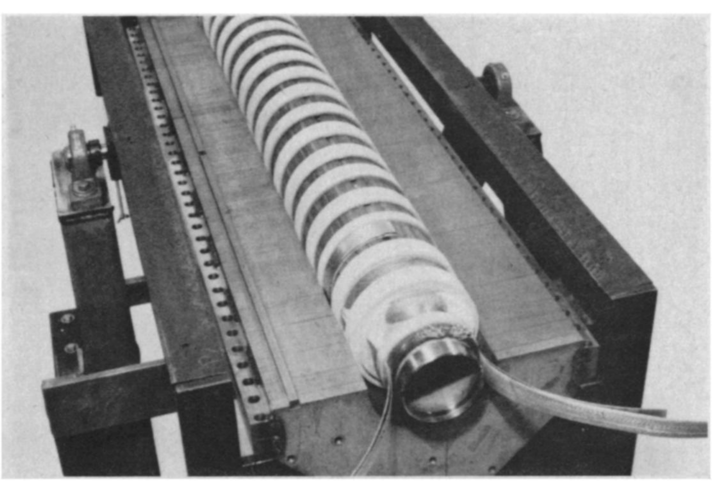

Model of a magnet for ISABELLE.

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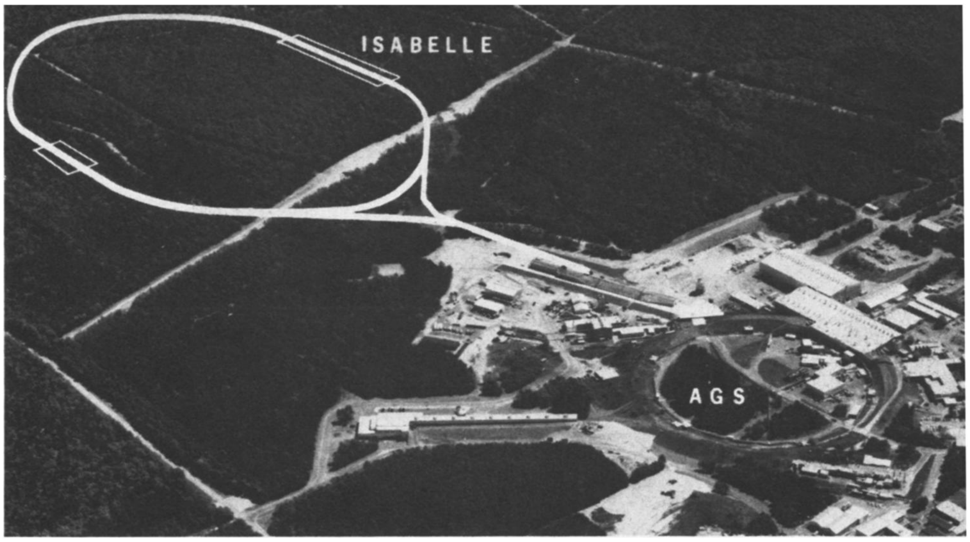
The future of high-energy physics seems to lie in storage rings. The performance of those already in operation, especially the Intersecting Storage Rings at the CERN Laboratory in Geneva, have confirmed physicists' predictions that storage rings would be useful tools and have awakened a desire for more and better ones.

The advantage of storage rings is that they drive together two moving beams of particles, like two cars circling a racetrack in opposite directions and colliding. So all the energy brought by both beams can go to make new particles or do other interesting things in the collision. In the CERN ISR for example, colliding beams of 30 billion electron-volts (30 GeV) provide a total of 60 GeV for use in the interaction. To do the same with a conventional accelerator (a moving beam striking a stationary target) would require about 2,000 GeV. This is far greater than the capacity of the highest-energy conventional accelerator, the one at the National Accelerator Laboratory at Batavia, Ill., which now goes to 300 GeV and hopes to reach 400.

Current plans envision more powerful and more versatile storage rings. Up to now there have been two species of storage rings: those that collide protons with protons and those that collide electrons with electrons. Like milk and meat in kosher cooking, the two have not met. In the future—God and the U.S. Government willing—there will be hybrids. American physicists would like to build at least two storage-ring projects, one on the East Coast and one on the West. The West Coast one is planned as a hybrid; the East Coast one could become one.

The American projects, as well as some European ones, are still in the early planning stages. After all, the CERN ISR, which inspired them, has only just begun operation. But as Wolfgang K. H. Panofsky, director of the Stanford Linear Accelerator Center,

They seem to be the only practicable way to study particles at ultrahigh energy



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ISABELLE would be fed by Brookhaven's Alternating Gradient Synchrotron.

points out, these things have a lead time of about 10 years so it is well to begin planning the next generation even before the current one comes into operation. Needless to say there has been no Government authorization for either project yet, and considering the Government's attitude toward high-energy physics, there are many obstacles in the way. Nevertheless, physicists maintain hope.

The West Coast plan is a joint operation of the Lawrence Berkeley Laboratory and SLAC. It is called PEP (proton-electron-positron) and is intended to provide for collisions of protons with electrons and electrons with positrons. It would have two rings, one above the other, the top one storing electrons or positrons up to 15 GeV, the lower holding protons up to 150 GeV. There would be four straight sections where the beams could collide. Planning is still in such a preliminary state that diplomacy can be maintained by showing two site plans, one that shows PEP at Berkeley being fed by LBL's bevatron, the other showing it as Stanford being fed by the SLAC accelerator.

The eastern project is by the Brookhaven National Laboratory and is called ISABELLE. (The first three letters stand for Intersecting Storage Accelerator.) The basic plan for ISABELLE is a proton-proton ring that would take 25 GeV protons from Brookhaven's Alternating Gradient Synchrotron and accelerate them to 200 GeV and then clash them together. Later ISABELLE could also have an electron ring added, which would be supplied by the AGS with 4-GeV electrons and accelerate them to 15 GeV.

European scientists are considering the possibility of using the 300-GeV proton accelerator now under construction at CERN to feed high-energy antiprotons to the existing storage rings, and the possibility in the distant future of adding storage rings to the 300-GeV machine itself. An electron-proton machine is under discussion in Great Britain, and an electron-proton and a proton-proton machine of 250 GeV are mentioned in the Soviet Union.

All these projects will involve improvements in accelerator design such as superconducting magnets to keep the dimensions of the rings reasonable and improved technology for tuning and controlling beams so as to increase their luminosity.

Luminosity is a characteristic related to the number and density of particles in a beam. Together with the cross section for a given interaction it determines how many hits can be expected. Luminosity is even more important than energy in storage-ring design. As Panofsky puts it: "In storage rings you ask what is the minimum luminosity to be considered; in accelerators, what jump in energy is most useful."

With higher luminosity and higher energy, physicists hope to probe farther into the territory where the ISR has been leading them. Up till recently physicists had believed that at least where the hadrons (particles, like neutrons and protons, that respond to the strong interaction that holds atomic nuclei together) were concerned, they had reached a kind of plateau called Asymptopia where the physics and mathematics were getting much simpler. At Asymptopia, crucial quantities such as cross sections stopped depending in complicated ways on the energy of the interaction and in some cases even became constant. Dramatic ISR results have upset some of these expectations (SN: 4/14/73, p. 242), and physicists are no longer so willing to make book on Asymptopia. "The hadrons may surprise us again," says Leon Lederman of Columbia University. Says Sam M. Berman of SLAC: "There may be no Asymptopia."

An important province of Asymptopia was an effect called scaling. Scaling seemed to indicate that electrons in electron-proton collisions were bouncing off point-like particles instead of particles with spatial extent, as protons are known to be. The interpretation is that in these cases the electrons bounce off point-like inner constituents of the proton, which have been named partons.

Suppose scaling isn't true at ultrahigh energies, says Berman. Then we will see a new energy scale for hadronic phenomena where the parton constituents may not be point-like but themselves have spatial extent and form. And we may see a breakdown of common quantum electrodynamics, the theory of electrical behavior in the microscopic world.

The higher-energy, higher-luminosity storage rings would also be very useful for the study of the weak interaction. The weak interaction tends to get overwhelmed by strong-interaction effects at low energies. At higher energies it should come into its own. Perhaps the long-sought intermediate vector boson, the particle theoretically supposed to carry the force of the weak interaction from place to place (SN: 4/1/72, p. 222), will make an appearance. More may be learned about relations between the weak and the electromagnetic interactions. Some theorists now see them as two parts of the same thing.

Thus the physicists have ample reason to want the new machines. As Lederman puts it, they are "driven by the fact that [they] want to see. [They] have a certain passion for what's ahead."

They also have a great deal of hope, despite the present Government's attitude toward high-energy physics. Anyway, the lead time on these things being what it is, perhaps substantial appropriations will not be necessary for several years. Ronald Rau of Brookhaven sums it up by saying: "We hope that NAL is not the last machine in the United States." □