it as "Germany's Apollo."

All the way to perihelion, Helios's components have stayed within about 3 degrees of temperature of its designers' predictions, a remarkable accomplishment considering its previously unsampled environment. Even the antenna wires, almost the only noninsulated bits, were right on the money. One magnetometer, mounted outboard on a boom to measure the interplanetary magnetic field, is slightly warm, possibly due to solar radiation's changing the color of its insulation, but its data are reportedly good and it shows no signs of cooking.

The data themselves are harder to come by. German officials have decreed that no results will be discussed until all of the Helios scientists have met to make a joint presentation at an international scientific meeting in Bulgaria in June. One researcher, mentioning the not-particularly-surprising fact that Helios had detected earth's considerable radio noise for about 30 days after launch, felt compelled to request anonymity in disclosing the "revelation."

But even the questions are fascinating. In 1969, for example, the IMP-8 satellite, orbiting the earth, detected radio emissions from the direction of the sun only moments after the eruption of several solar flares. Yet the radio waves seemed to spring into being more than 45 million kilometers out from the sun. Somehow the plasma waves driven outward by the flares trigger radio waves that don't appear until two-thirds of the way to Mercury's orbit. Why? Only Helios is close enough to tell.

One of the probe's major innovations is a device called a "shock memory" which automatically stores all the instrument readings taken for 15 seconds after *and before* it is triggered by the passing wave front of a solar flare. The recorded data, which are taken at a much higher ratio than Helios transmits information, can then be slowed down and played back to earth at the more leisurely transmission speed.

Helios has a lot of friends in the sky, although much farther from the sun, which together enables solar phenomena to be studied at different positions in space. The IMP-8 satellite includes azimuth information as well, while another called Hawkeye records elevation angles along with its data. Combined with Helios, they provide what amounts to a stereoscopic view of the sun and its environs.

On Dec. 8 Helios B is scheduled to be launched on a path similar to the 95-day solar orbit of its predecessor. If the present probe's temperature readings stay on their predicted curves, Helios B may go as much as 900,000 kilometers closer to the sun. □

Colliding beams, the future of physics

Particle physicists and the accelerator-building specialists who work with them have made storage-ring facilities for colliding beams of elementary particles work in spite of some initial dubiety. Now they are strongly fascinated with them. This is apparent not only from the attention storage rings got at last week's 1975 Particle Accelerator Conference in Washington but also from the choices made by those who hope to build new accelerators in the near future. In the United States and Western Europe at least, it's almost all colliding beams.

The reason for the fascination is economy of energy. When two beams of accelerated particles collide head on, all the energy they carry is available for the formation of new particles and other processes that physicists want to study. In the earlier type of accelerator a single beam of particles is sent against a stationary target. There much energy is invested in forward motion. One of the basic laws of physics is conservation of momentum, which means that the momentum before the collision must remain the same after, so the forward motion continues in the same amount as before, and a good deal of energy is withheld from interesting processes. Two beams of equal and opposite momentum stop each other cold when they collide—the total momentum in the system is zero—so all the energy is available for other things. (In practice not quite. To engineer the thing the beams have to be made to cross at a slight angle, but still the saving is tremendous.)

Up to now storage rings have come in two varieties—electron-positron and proton-proton—because the technology for accelerating and storing the two kinds of particles is different, but there is nothing really to stop accelerator builders from adding a proton ring to an electron-positron facility or vice versa. This is proposed in a few of the projects under consideration, and it would give the opportunity for proton-electron or even proton-positron collisions, an experiment that ought to reveal hitherto unreachable ultrafine details of the proton's structure.

West European physicists have floated suggestions or made detailed plans for four new colliding-beam facilities, three basically electron-positron and one proton-proton. American physicists' hopes include two electron-positron facilities and two proton-proton. What may be planned in Eastern Europe is not known. A representative from the Soviet Union was invited to the symposium, but none came.

Two of the West European electron-positron proposals, one in England and one in West Germany, appear to be most viable at the moment, according to Kjell Johnsen of the CERN laboratory in Geneva. The third, in Italy, has run into heavy weather from the Italian funding authorities, but the Italian physicists are keeping the idea alive in the hope of some kind of possible international funding.

The British project, planned for the Rutherford Laboratory and called EPIC, and the German, planned for the Deutsches Elektronen-Synchrotron at Hamburg and called PETRA, are basically similar as is to be expected in machines of the same generation built for the same general purpose. Both aim for between 10 billion and 20 billion electron-volts (10 to 20 GeV). EPIC would collide two 14-GeV beams, PETRA two 19-GeV beams. Currently operating e-p machines are all under 5 GeV per beam. Both would be large squared-off ovals about two kilometers across. Rings of that size cause siting problems in the densely populated areas where the two laboratories are located, and the solution in both cases is identical: run the new ring around the existing laboratory buildings. (European physicists drool with envy when they see the lavish grounds of American accelerator laboratories.)

The Italians, who were among the earliest to start storage rings, first with Ada (*Anello d'accumulazione*, Italian for storage ring) and now with the currently operating Adone (*Ada* plus the suffix *one*, meaning the same only bigger), one of three few-GeV e-p machines in the Western world, floated a proposal for a Superadone to collide two 10-GeV beams. But it got such a bad reception from the Italian science funders that further planning is much discouraged.

Johnsen stresses that particle physics in Europe is a matter of international cooperation even where strictly nationally funded and managed laboratories such as these are concerned. Ironically the result of that cooperation is likely to be that only one of these proposals will ever be built.

CERN already has one set of colliding-beam rings for protons. They are fed protons up to 30 GeV by the existing Proton Synchrotron. CERN is now building a Super Proton Synchrotron, a 400-GeV machine, which will be the counterpart to the machine of the same energy at the Fermi National Accelerator Laboratory in Illinois. Some planning has been done for storage rings to take 400-GeV protons from that. Two possibilities are under study, one with normal magnets, one with superconducting magnets. Both would be huge, the normal option requiring two rings

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8,300 meters across, the superconducting option requiring 6,130-meter rings. Nevertheless, cramped as CERN is in the Meyrin suburb of Geneva, there is a site for such things just north of the SPS. An electron ring might be added too.

The American proposals were presented by Victor Weisskopf of Massachusetts Institute of Technology, who was a little surprised at being chosen. Even though he recently served as chairman of a committee on the subject, he is a theoretician, and he suspects he was chosen because he has the necessary "don't-know-how." Since he wanted to tell the symposium why new accelerators are necessary (more about that in a later article), he simply listed the American proposals: an electron-positron ring (2 times 8 GeV) at Cornell University; PEP an electron-positron ring (2 times 15 GeV) with a proton ring (200 GeV) at either Stanford or Berkeley; POPAE, two proton rings (400 GeV) with an electron ring at FermiLab; ISABELLE, proton-proton rings (200 GeV) at Brookhaven National Laboratory.

Fixed-target machines are more or less in abeyance. An energy doubler is being worked on at FermiLab, and one was proposed for the CERN SPS but rejected as not a big enough step. This brushes the tera-electron-volt (thousands of GeV) range. The Soviets are believed to be planning a 2 to 5 TeV machine with superconducting magnets. Other physicists think of that range but not too specifically at the moment.

As Johnsen puts it: "There is a great variety of exciting possibilities to choose from." But the result is likely to be "not what physicists would like, but what society will stand." Nevertheless, he says "We who belong to the rich part of the world have a special responsibility to basic research." □

Zap it with a microwave plasma

In dark, quiet storerooms all over the United States, toxic chemicals lie waiting. These obsolete nerve gases and banned herbicides and deadly industrial by-products wait, sealed in their gray metal cannisters, for some method or machine that can destroy them safely. The waiting might be almost over now, following the refinement of the microwave disintegrator.

This Buck Rogerish-sounding invention is not a hand gun made of kryptonite in a chromium holster. It is instead, an unexciting system of tubes, valves, intake ports and chambers. But it does some exciting things. It was first developed at Lockheed Palo Alto Research Laboratory in 1970 under Defense Department grants for the decomposition of toxic vapors in contained atmospheres, such as nerve gases accidently released in laboratories. A modified version of this original microwave disintegrator is reported in the March ENVIRONMENTAL SCIENCE AND TECHNOLOGY by Lockheed chemists Lionel J. Bailin and Merle E. Sibert and by colleagues Leonard A. Jonas from Edgewood Arsenal, in Maryland and Alexis T. Bell of the University of California at Berkeley.

The modified system uses inert gases or air to carry the toxic substances into a special chamber. The team tested simulated nerve gases (structurally similar compounds that are easier to handle than the real thing) in their modified disintegrator and achieved nearly 100 percent decomposition. And to top that, the breakdown products may be reusable chemicals.

The disintegrator breaks up toxic materials by producing a microwave plasma inside a reaction chamber. This is formed when an inert gas under reduced pressure is bombarded with microwaves. Electrons and other electrically charged particles are bumped off the gas molecules and form a low-temperature plasma. When toxic gases are fed into the system, their chemical bonds are broken by the energetic plasma, and the "pieces" collide and form new hydrocarbons. The structure of these compounds depends on the toxic starting material and the carrier gas, but methane, ethane and chlorinated hydrocarbons are all possible end products.

Although the original research goal was to develop a technique for detoxifying the air in a contained atmosphere, Bailin is more encouraged about using the modified disintegrator on stored solids and chemical vapors. "When air from the room passes through the plasma system along with the toxic gas," he says, "nitrogen oxides are produced which can form corrosive nitric acid." The problem of toxic by-products is circumvented by using inert carrier gases and injecting small amounts of the toxic vapor or solid into the system without air. The team is in the process of enlarging the disintegrator from a 10 cubic-centimeter capacity to a two-liter capacity. This will make it possible, the team hopes, for industries and laboratories to dispose of their stored, toxic wastes safely and inexpensively. Now, only special, high temperature incinerators can be used to disarm some of the compounds, but they are very expensive. The microwave disintegrator would probably cost much less than the incinerators and break down the chemicals more completely, Bailin says. □

Checking clocks to 2 microseconds

Probably the best index of a society's complexity is how carefully it has to measure time. In one famous instance, timekeeping became a matter of strategic national importance, helping the British Navy maintain its mastery of the oceans. In the early 1700's the British government offered 20,000 pounds to anyone who could make a timepiece accurate enough to allow navigators to locate themselves at sea within 30 nautical miles at the end of a six-week voyage. To meet this standard, a clock would have to keep time within three seconds a day, and the prize—for creation of the first "chronometer"—went to a self-taught English carpenter, John Harrison.

Though technological progress of the present age could be dramatized by more spectacular achievements, none provides a more clear-cut measure of sophistication than the very existence of an increasingly large number of people who really do need to know what time it is to within a few microseconds. Last week these people received some good news: The U.S. National Bureau of Standards announced that when it conducted a careful, direct check on the synchronization between its own "Universal Coordinated Time" and the European "International Time Bureau," the two were off by only two-millionths of a second.

Not that anyone was particularly surprised. Indirect checks, involving radio signals between the two time centers in Boulder, Colo., and Paris, France, have been going on for years. Such radio-comparisons have even allowed measurement of the relativistic time lag due to Boulder's higher elevation and weakened gravity—amounting to two parts in 10^{13}. But like most scientists, the world's official timekeepers couldn't resist the urge for side-by-side comparison (and a week in Paris), so a portable atomic clock was carefully transported across the Atlantic.

David Allen, the head timekeeper at NBS, was very pleased with the results of the test, which he calls "totally adequate within what we're trying to do." About a thousand commercial atomic clocks are now in operation, he says, and, at $20,000 apiece have become necessities in several applications, including sophisticated navigation and satellite tracking.

Some submarines, for example, use an ultramodern version of an old Viking technique to measure their position at sea. When lost in darkness or fog, the Vikings would beat a drum and time the interval before an echo was