in lower regions from the ultraviolet radiation that dissociates them. If Mars and Venus have no iron in their crusts this process would not have happened, and water would have been lost as hydrogen atoms and hydroxyl molecules; however the presence of iron in both planets is generally assumed because of their densities.

An alternative suggestion by A. G. W. Cameron (Yeshiva University) is that earth's magnetic field made the difference; ionized hydrogen and hydroxyl radicals in the ionosphere would have been trapped by interaction with this field. Both the American and Russian probes showed that Venus has no magnetic field, so the solar wind would easily have carried the hydrogen away. —JTS

Radio Telescopes Linked in Southern Hemisphere

Another long baseline radio interferometer is in operation, the first one in the southern hemisphere. The linkup (similar to those described in PHYSICS TODAY, November 1967, page 69) is between two NASA Deep Space Stations in Australia, one near Woomera in South Australia and one near Canberra in New South Wales. Its baseline is more than 9×10^6 wavelengths long at 2295 MHz. Preliminary observations of radio source 3C 273 show that the interferometer has an angular resolution better than 0.008 sec of arc.

The method by which these two telescopes are paired is applicable to any of NASA's Deep Space Stations, so that there is now the possibility of improving resolution still further by the use of pairs of instruments on different continents.

Weston Design: 400-500 GeV From a 200-GeV Accelerator

A bold new design for the 200-GeV accelerator is taking shape at the National Accelerator Laboratory. The strong-focusing synchrotron will be capable of producing 400–500 GeV protons later by addition of power supplies to boost the magnetic field.

The design is not simply a scale-up of the 33-GeV Brookhaven AGS and 28-GeV CERN PS. The beam aperture, magnets and tunnel have all been made surprisingly small; the result is a relatively inexpensive machine with great flexibility and high intensity. It is the first synchrotron to use separated-function magnets and the first to have only an extracted proton beam.

We recently visited the National Accelerator Laboratory (NAL) office in Oak Brook, Ill. and discussed Weston plans with Robert R. Wilson, director, and Edwin (Ned) Goldwasser, deputy director. Unlike typical surroundings for physicists, the office occupies the 10th floor of a Park Avenue-style building. Until recently it resembled an aircraft company, with no partitions and lots of shouting across the room. There are now separate offices, but there is still plenty of shirt-sleeved blackboard talk. And in the middle of it all is a mockup of the accelerator tunnel (3.1 meters wide by 2.4 meters high).

Congress recently approved design money of $7.3 million.

The laboratory submitted a proposal on 15 Oct., and Wilson hopes that construction of the $260-million accelerator will be in the president's budget for FY 1969. If it is, the accelerator could be ready on 1 July 1972 (although Goldwasser feels this should be postponed until the 4th of July).

SUPPORT FACILITIES for 200-GeV accelerator to be built in Weston, Ill.

Accelerator. To allow for an increase in energy at a later date, the accelerator will have a rather large radius—1 km. The magnets are capable of reaching 200 GeV at 9 kG. Later, by increasing the power supply, adding more cooling and perhaps some more rf, the magnets should easily reach 18 kG to make 400-GeV protons and may be able to reach 22.5 kG to yield 500 GeV.

Accelerator experts are impressed with the compactness of the magnets and the tunnel volume to contain the magnets. The 70-GeV accelerator just completed at Serpukhov, for example, has a tunnel with four times the volume. Since magnets and tunnel are the majors costs in building a synchrotron, the Weston design gives a considerable cost saving.

Protons will be accelerated in three stages. A 200-MeV linac (very similar to the one being built to boost AGS intensity) will inject into a 10-GeV booster synchrotron with a 0.075-km radius. The booster will be a rapid-cycling injector. Every time magnetic field intensity peaks, the beam is extracted into the main ring; filling is timed just right so that at each pulse 1/13 of the ring is filled. Once filling is finished the magnetic field in the main ring is raised, and the particles are accelerated to full energy. Although a slow booster would be cheaper and allow for higher intensity, it is not yet well understood (intensity may be limited by space charge). There is still a year to change to a slow

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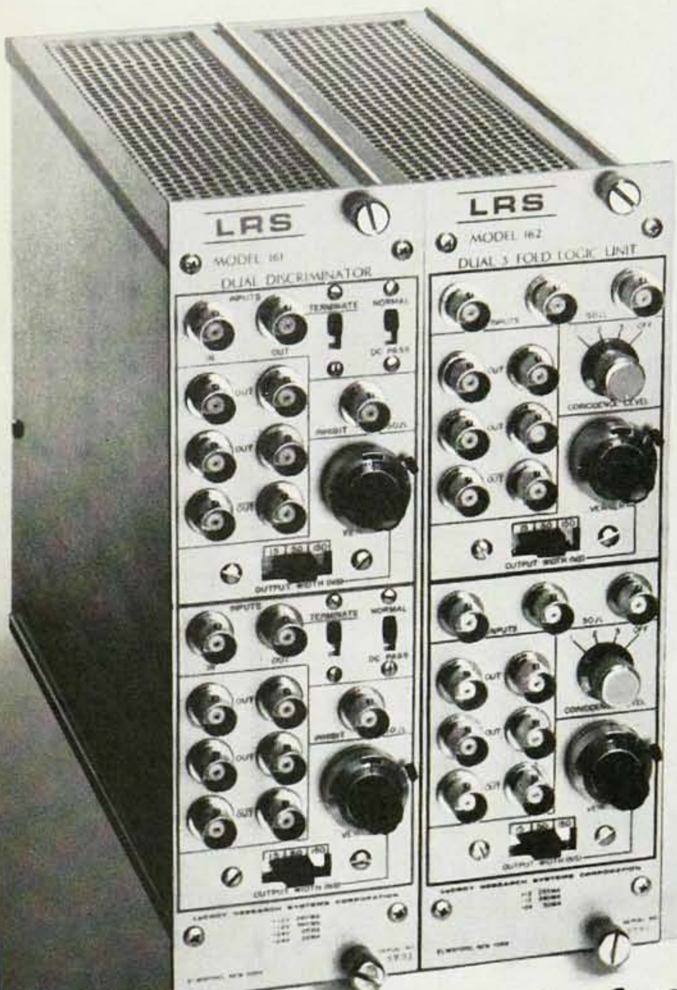

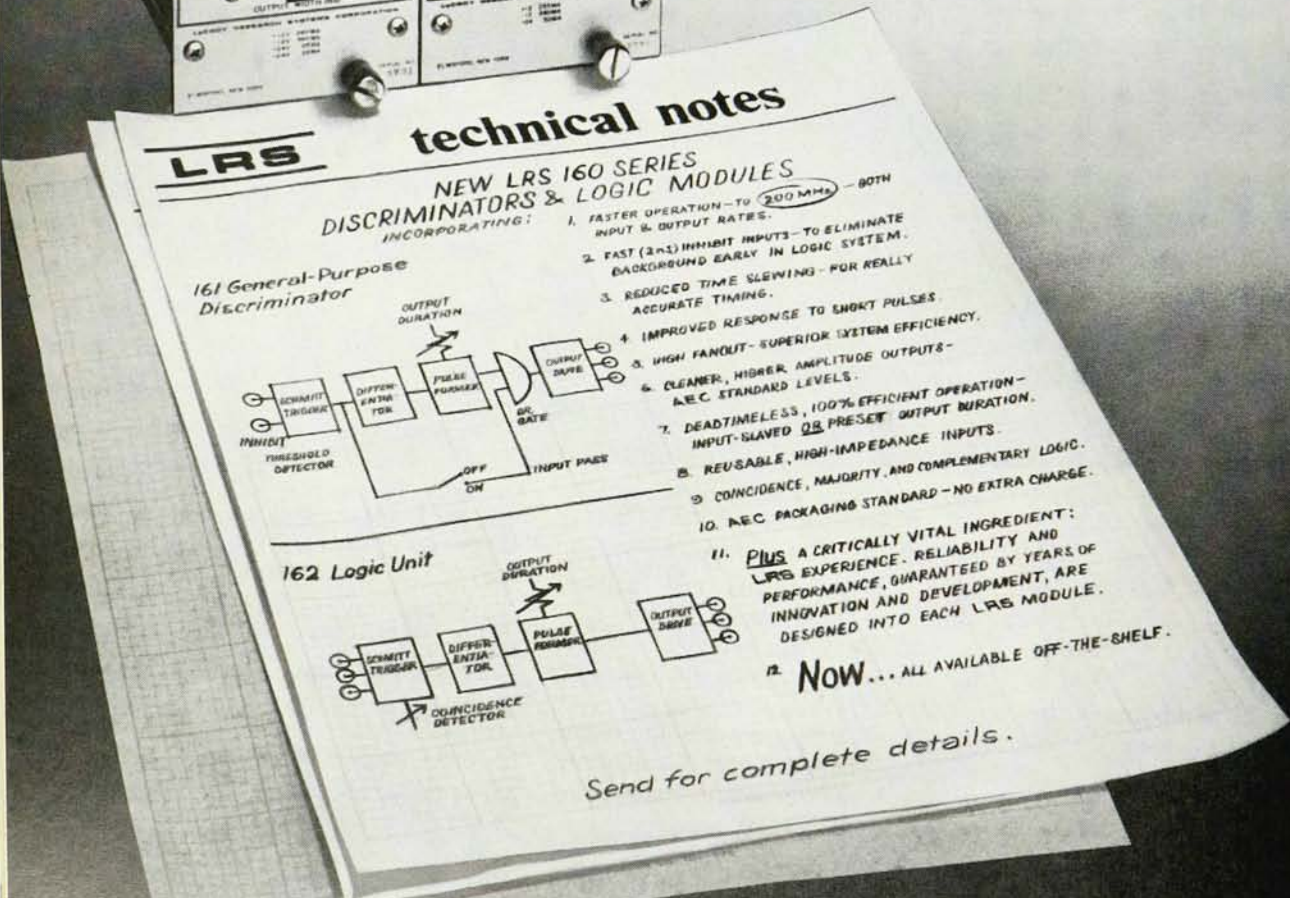

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booster, Wilson remarked, if someone comes up with a feasible design.

The main ring has six sextants, each with one long straight section (54 meters) and one medium straight section (29 meters). Within each sextant 14 unit cells are arranged; a unit cell consists of eight bending magnets with parallel pole tips to keep particles moving in a circle and two quadrupole focusing magnets, one to focus the particles and a second to defocus them (to produce a net strong-focusing action).

Magnets. Even though the idea of separating the jobs of bending and focusing is an old one, the NAL machine is the first synchrotron to achieve strong focusing this way. Other synchrotrons have combined the functions into one kind of magnet whose pole profile is shaped to produce a field gradient radially. The merits of separated-function magnets have come to the fore over the past couple of years largely through the efforts of Gordon Danby of Brookhaven.

We asked Wilson what decided his NAL team to use separated-function magnets. He noted that they wanted to have a machine that could go to very high energy; that means very high magnetic fields. In combined-function magnets the field gradient is produced by having pole tips close together on one side and far apart on the other. Where pole tips are close the iron tends to saturate. But with parallel pole tips a higher magnetic field is possible. The AGS runs at about 13 kG; saturation occurs slightly higher. The Weston magnets may be able to go as high as 22.5 kG, to produce 500-GeV protons.

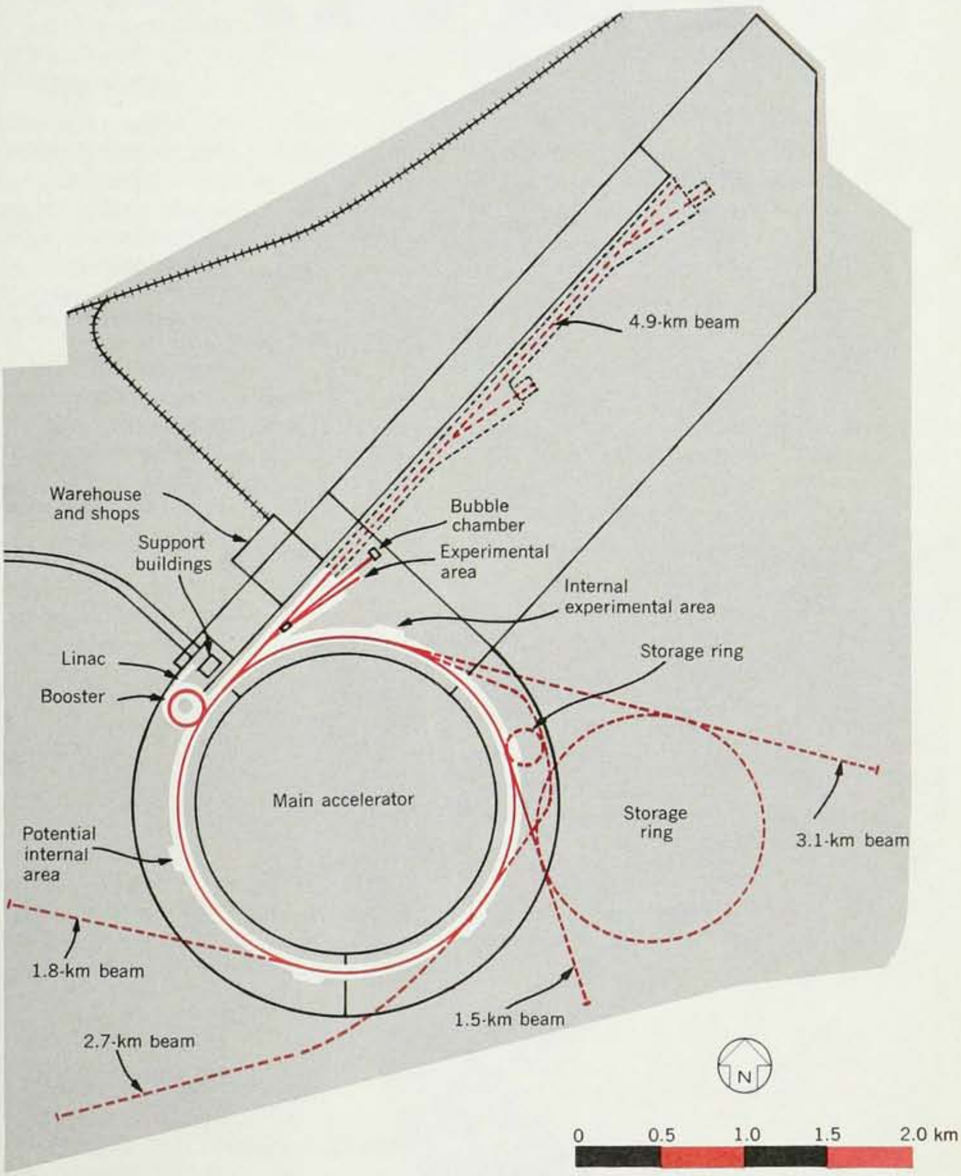
Each of the 744 "window-frame" bending magnets will be 6.3 meters long, but they will have two kinds of apertures, one 5.0 cm × 10.0 cm and the other 3.8 cm × 12.5 cm; the variation is to allow for the characteristic undulations of a strongly focused beam.

The synchrotron is expected to produce 1.5×10^{13} protons/sec or 5×10^{13} protons/pulse. Magnets are being designed to allow for an intensity of 10^{14} protons/sec since at 200 GeV, Wilson feels, some cross sections may become so small that higher intensity will prove more desirable than higher energy.

The accelerator will be pulsed every three to four seconds: 0.8-sec filling time, 1.6-sec rise time, 0- to 1-sec flattop and 0.6-sec descent time. For counting experiments the flattop keeps the coincidence circuits from being jammed.

Once the accelerator is finished, Weston physicists have the option (if they have the money) to add a small storage ring or a large one. To do the former, one can build a bypass to a small storage ring that is filled with 50–100-GeV protons. Then one can inject half of the particles back into the main ring, accelerate them to 200 GeV, and then let them collide with the other half of the protons (moving in the opposite direction) back in the storage ring. A large storage ring can be built by adding another external proton beam.

Experiments. Because the NAL machine will have an intensity about ten times as high as the accelerators at CERN, Brookhaven and Serpukhov, it became clear that a conventional beam arrangement would not do. Typically in a circular accelerator, one extracts a beam by flipping a metal target into the beam when it is at full energy. All kinds of secondary particles come off, Goldwasser explained, and people arrange their apparatus in



MASTER PLAN for 6800-acre Weston site. Dotted lines are future possibilities.

Quiz for Big-Computer experts.

Part 1:

1. Open ended time-sharing PDP-10's are being delivered. Other companies delivering time-sharers are________.

2. Complete time-sharing software is now being delivered with the PDP-10 hardware. Others delivering completely integrated hardware / software time-sharing systems are________.

3. Digital's PDP-10 can directly address up to 262,144 36 bit words. It has a 1 usec memory cycle time, a logically complete order code, 7 fully nested programmable interrupt levels, 16 accumulators (15 of which can be used as instantaneous index registers), a high speed, full word multiplexer, and floating point hardware. An equivalent computer might be________.

4. Basic PDP-10's go for as low as $113,000 but most customers usually buy everything they need to solve big problems. The typical PDP-10 time-sharing system actually sells for between $300,000 and $400,000. An equivalent problem solver from another company probably costs________

____

5. General purpose, multi-user PDP-10 systems can handle multiple jobs simultaneously — conversational time-sharing, real-time simulation and control, batch processing. What other computing system can do this?________.

6. How much does it cost?________.

7. **PRIZES:** Part one of this quiz will be followed by part 2 and part 3. What, beside a PDP-10 brochure, do you consider an appropriate prize for answering all questions in the three parts correctly?________And what would you consider an appropriate prize for the man who suggests the most appropriate prize?

____

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So over the years the philosophy has changed. Extracted proton beams have been built at several accelerators. At CERN, for example, a slow beam has been extracted with 80% efficiency, and Brookhaven expects to reach better than 90% when its new slow beam is extracted this month.

The Weston designers hope to get a 95% efficiency. Then all the experiments will be arranged downstream from the extraction point in a straight tunnel that could eventually be 4.9 km long. Present plans call for a beam 1.6 km long that will be switched from the tunnel onto three target stations, which will supply nine beams. More switching points will be added if the method proves successful. If not, external proton beams can be produced in three other places, and internal targeting can be done at one of the long straight sections on either side of the main extraction point.

A 3.7-meter bubble chamber is being built nearby at Argonne National Laboratory, and Brookhaven has submitted a proposal to build a 4.3-meter chamber. AEC has not encouraged Weston to make plans for construction of a large chamber at this time. When the 200-GeV machine starts up, Goldwasser hopes to move an existing bubble chamber to Weston.

While we were talking, Wilson began pulling on a strip of white flexible material. It turned out he was not just exercising his fingers; he was examining a sample of polyethylene-coated nylon that Goldwasser had just brought in. The material is used to make inflatable buildings; Goldwasser feels they might make excellent temporary structures for experiments.

Wilson, who is a sculptor as well as an accelerator builder, is eager to make NAL a beautiful place. He said, "I don't see why there shouldn't be good architecture at a large laboratory, instead of placing buildings helter skelter everywhere. We've tried to pull as many buildings together as possible and put them all together in one. We've put the central building right smack in the center of most activities. It's almost surrounded by the linac, the booster ring and the extraction point."

From a high-rise building (10–20 stories), Wilson feels that the surrounding Illinois prairie becomes quite attractive. (He notes that the altitude on the 6800-acre site is a variable–20% higher during corn season.)

The staff at NAL is still tiny, about sixty people. But help has been coming from engineers and physicists all over the country, especially from Berkeley, Brookhaven, the old MURA laboratory and Argonne. When the laboratory is finished, Wilson expects it will employ 2500 people.

HEKA, SCIENCE AND TECHNOLOGY

ROBERT R. WILSON, director.

Unlike other national laboratories, Weston will do only high-energy physics research. Goldwasser expects that 75% of machine time will be for outside users and the remainder for laboratory staff. Goldwasser noted that one can control the percentage by hiring enough staff to use the machine 25% of the time. But one should not let the percentage get too high. The staff people, in the short-range view, make what appear to be the best proposals. "But young blood is very important; the new ideas that come into the field will not come from a staff that is static within the laboratory. They come from young graduate students that are just growing up in the universities. Unless you reserve a large fraction of the program for them over a ten-year period you'll find that you have a sterile program."

Both Wilson and Goldwasser stressed that they are making a real effort to meet the civil rights problem head-on. The issue, first raised when the accelerator site was being selected, is far from closed. Congress, physicists and the country as a whole will be watching Weston, they feel. Their tentative plans include a program to train Chicago Negroes as technicians, provision of convenient transportation from Chicago to Weston, and encouragement of neighboring communities to provide housing on a nondiscriminatory basis. —GBL □

MOCKUP of accelerator tunnel and magnets is viewed by Edwin Goldwasser, deputy director, Luke Yuan and L. C. Teng.