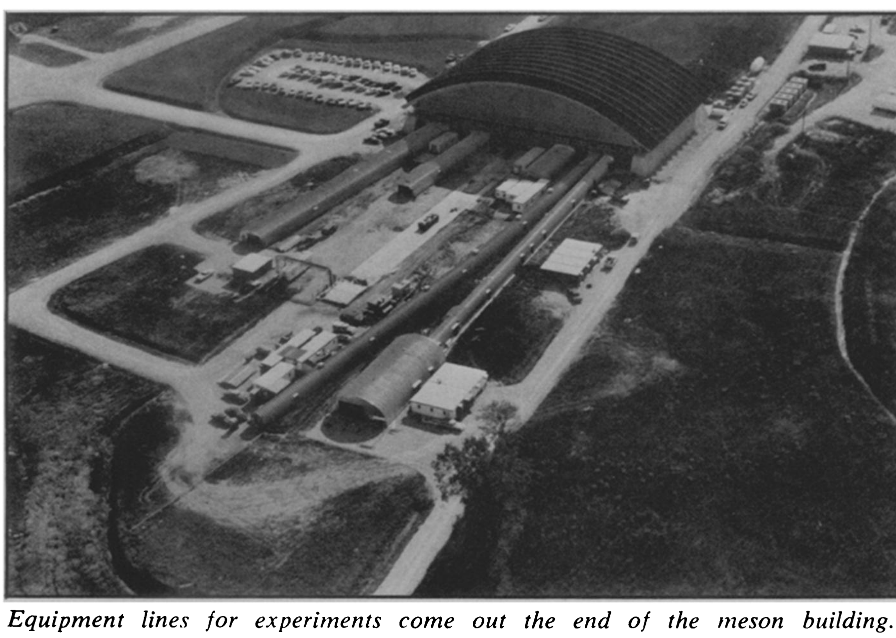
On Location At FermiLab

The set for present and future dramas in particle physics is ready on the Illinois plains. The cast comes from all over the world.

by Dietrick E. Thomsen

Round and round the protons go and then off at left to experimental areas.



Illustrations: FermiLab

Equipment lines for experiments come out the end of the meson building.

The first of a series on the Fermi National Accelerator Laboratory.

The commonplace paradox of particle physics is that to study the very small you need the very large. There was a time when the latest in particle accelerators could comfortably fit into the basement of a classroom building with enough room left over for experiments and maybe some adding machines. In 1974 the latest in particle accelerators, the Fermi National Accelerator Laboratory (FermiLab) located between Batavia and West Chicago, Ill., takes up the area of a respectable municipality. Some of the physicists who were active in the basement laboratory days are still doing experiments. They are the ones who have built the modern installations like FermiLab, but they, like the rest of us, sometimes suffer a little future shock when they contemplate what they have wrought.

The superlatives pile up, and it may be overkill to repeat them, but they give a feel for the place. The main job of accelerating the protons to a top energy that is now 400 billion electron-volts (GeV), and may soon be 500 GeV, is done in a ring about four miles in circumference. The ring shows up plainly on satellite photographs of the Chicago-Milwaukee-Madison region.

The laboratory is administered from a 16-story building shaped like a letter A with curving sides (which everyone calls the "high rise") located at the point where the accelerated protons take off on a tangent from the main ring to go to the experimental areas. FermiLab needs the automobile like Los Angeles. If a physicist wants to go from his office in the high rise to check something at his experiment, he takes his car or a taxi. It's a mile or two. Walking might be healthy, but it wastes time. The constraints that these dimensions apply to accelerator technology would have been unheard of a few years ago. Bunches of protons are ornery things to control, but they must be peeled off the main ring and shot down a mile or more of vacuum tube accurately enough to hit a target that may be only a few thousandths of an inch thick.

There are three main experimental areas with three main beams to serve them. In the center is the neutrino line

—protons struck against a suitable target will make neutrinos, and FermiLab is the most energetic neutrino laboratory in the world. The neutrino line ends at the 15-foot bubble chamber. The purpose of a bubble chamber is to render visible the tracks of particles that may be produced or deviated in an interaction between particles. Neutrinos interact very weakly and therefore seldom with other matter. The large volume of the chamber means that more neutrino interactions can be seen and that they can be seen more completely.

The meson line ends in a building that might be taken for a small factory. Half a dozen or more experiments share its floor. The experiments are long—some of them stick out the back of the building. They are cramped together and interleaved. Often, says a staff member, only the experts (that is, those who put the stuff there) know which experiment a given piece belongs to.

The equipment for tracking these very-high-energy particles has to be large—interlaced arrays of hodoscopes taller than a human being, spark chambers the size of a truck, Cerenkov counters in a box the size of a small room, huge pieces of shielding.

Question: Where do old battleships go when it's time for them to fade away? Answer: FermiLab, where they bury them. A long time ago physicists discovered that the armor plate from warships was an excellent radiation shield. Other laboratories took bits and pieces. FermiLab takes whole ships.

The electronics that it takes to operate, record and compute these experiments truly boggle the mind. Shelf on shelf, it fills Portakamp trailers all over the place. Most of it has to be put together *ad hoc*.

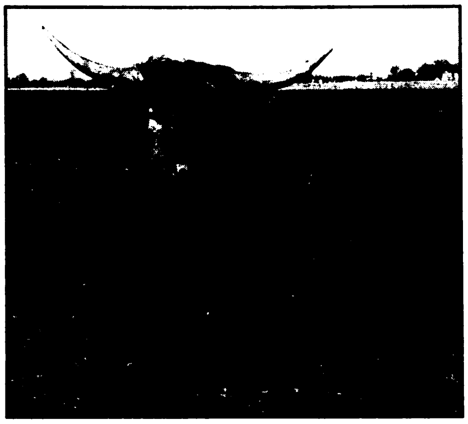
The proton area does not have a single large building. It is a labyrinth of underground passageways and pits, and if one didn't have a guide that knew the place, one would desperately wish for Ariadne's ball of string. In one of its experiments is a relic: A magnet that was part of Enrico Fermi's cyclotron when he was working toward the first nuclear bomb is used as a beam analyzer. It seems very fitting—and it shows

Oh, give me a home where the proton beams roam
A Prairie Within the Proton Ring

The corn is not green at FermiLab in early October; it is brown. The ears stand heavy on the stalks. No one seems to know why the farmer who rents the land hasn't harvested his crop.

The scene at this laboratory that boasts the absolute latest in particle-physics equipment is often extremely bucolic. The combination of old-time Illinois flatland rurality and the newest 20th-century science can be incongruous at moments. If the laboratory should need a really long neutral-particle beam line, says Richard A. Carrigan, one of the staff, it would run right through the cornfield. Until then the farmer rents and plants. Other neighboring farmers rent other pieces of FermiLab land for cropping and grazing.

Meanwhile the laboratory itself is getting into the livestock business in a serious way. It started with the famous herd of bison, which we have mentioned before. Lately the laboratory has been given a herd of Scottish Highland cattle. They come from Mr. and Mrs. James Bannister of St. Charles, Ill., for whom the herd was growing too large. They look a little strange to one used to Jerseys, Holsteins or Aberdeen-Angus. The Highlanders are long-horned shaggy beasts with physical resemblances to bison and musk oxen. They are a hardy breed, and it may prove possible to winter them on the range in regions too far north for the usual kinds of American beef cattle to stand the cold.


Scottish Highlanders peacefully graze.

FermiLab also has a flock of deer inhabiting its woods, who sometimes take breakfast with the bison. There is a flock of quail and a couple of swans, who inhabit a pond appropriately titled Swan Lake. "People hear you're doing this, and they give you things," says a staff member.

All of this leads the mind to wonder what the landscape looked like even before the 19th-century introduction of European style husbandry—the primeval Illinois prairie. There is precious little of it left, and that thought leads to a unique use for the otherwise fallow land in the center of the main accelerator ring: FermiLab plans to establish it as a restored piece of prairie. Robert Betz, professor of biology at Northeastern Illinois University, and Ray Schulenberg, a naturalist at the Morton Arboretum, are advisers to the project.

The main ring is about four miles in circumference and encompasses about a square mile of land. It could thus comfortably encircle many a small town. At the moment a 10-acre section has been plowed and prepared for the first planting, which will take place next spring. Gradually the area of authentic prairie flora will be extended until the whole plot is covered, and the prairie is able to reseed itself. One of the things that makes the main-ring territory ideal for prairie reconstruction is that it is surrounded by water, the channel that brings cooling water to the accelerator's magnets, so that it can be safely burned off now and then. Periodic fires are an important element in prairie ecology. They are a severe natural selector that winnows out the true prairie mix of species.

On three autumn weekends 125 volunteers recruited from FermiLab and surrounding communities by the lab's Prairie Restoration Committee scoured the highways and byways for seeds for the project. The appropriate plants still exist, mostly in marginal areas where the plow never went, such as the edges of the railroad tracks or in carefully preserved patches such as a 10-acre tract in the Morton Arboretum. One hundred and fifty pounds of grass seed and miscellaneous amounts of flowering species are needed to start the project, and many more will be needed in succeeding years. It will take about a decade to fully set the prairie up.

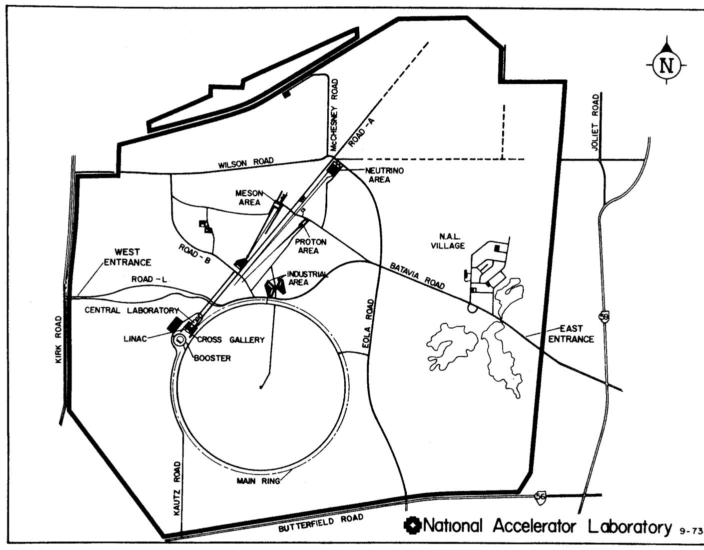
Appropriate prairie fauna will also be introduced, starting with insects and working up possibly to the bison. There are, however, no plans for teepees or covered wagons. Disneyland it isn't, though visitors are expected and welcome. Many come now on Sunday to see the animals.

—Dietrick E. Thomsen

that particle physicists can be string savers.

Up to now they have been experimenting with primary particle beams up to 400 GeV and secondary beams in the hundreds of GeV. The maximum primary energy expected from the accelerator's present state is 500 GeV. To get it they are having to build particular impedance-matching circuitry between the accelerator and the power supply. A special transformer installed in this arrangement blew up in the spring. It has been repaired and will be reinstalled in November. By sometime in December 500 GeV is expected.

The physicists won't stop there. They are already at work on a system to double the energy of the main ring. And then their eyes gleam with a future project called POPAE (Protons on Protons And Electrons), a giant storage ring and colliding beam facility that will lead to supercolossal energies.



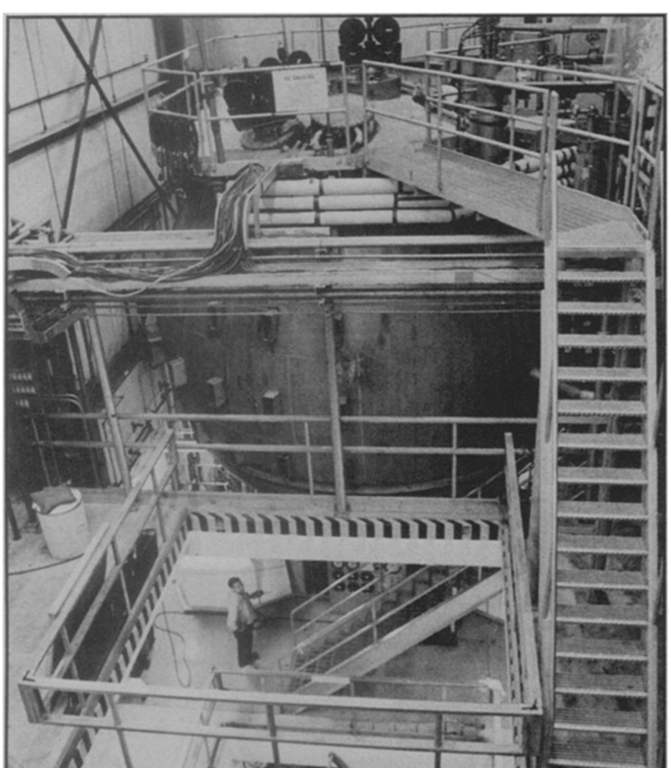
The accelerator's main ring is four miles around, but it looks small compared with the lab's whole territory.

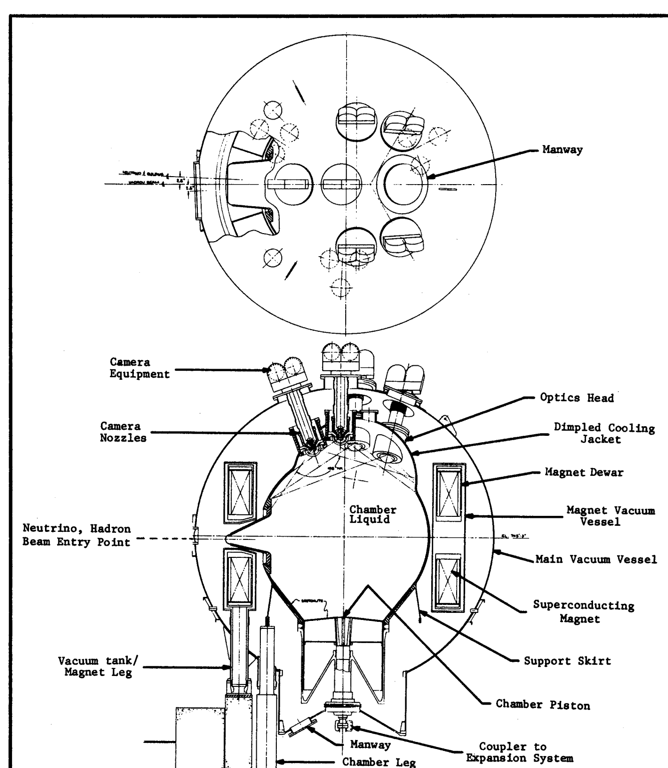
What use is it all? the practical person will ask. It cost a quarter of a billion dollars to build, and it costs millions a year to run. The best justification for such a laboratory is its main purpose: to find out all it can about the structure of matter. It is a cliché to say that no one can tell what benefits that may lead to, but it is no less true for being hoary with repetition.

But there is a second point that deserves emphasis. In doing these experiments scientists are working with technological artifacts of industrial size and pushing them to an accuracy and a fine tolerance not often required in industrial practice. What is learned here about many things—the moving and positioning of large and heavy objects, cryogenic refrigeration of large volumes, evacuation of large volumes and sometimes filling them with touchy substances like liquid hydrogen under high pressure, the capabilities of complex electronic circuitry, etc., etc.—could have industrial uses.

Finally the laboratory is embarked on two projects that could benefit everybody, a superconducting power cable and a superconducting energy storer. The power cable between the substations and the accelerator's main ring is proving incapable of handling the power for the really high energies (which the laboratory's original design didn't foresee). It will be replaced with 500 meters of superconducting cable. If this pilot project works, superconducting cable could be applied to long-distance power transmission, saving large amounts of energy. The energy storer will use the field of a superconducting magnet to store energy temporarily. Its designers hope it will find wide application as a load balancer between maximum and minimum periods of demand on power grids.

At the same time FermiLab is learning interesting and surprising things about the physics of elementary particles. That will be the subject of our next installment. □





Illustrations: FermiLab

It takes three stories to house a 15-foot bubble chamber. Schematic shows what's inside the big steel spherical tank.