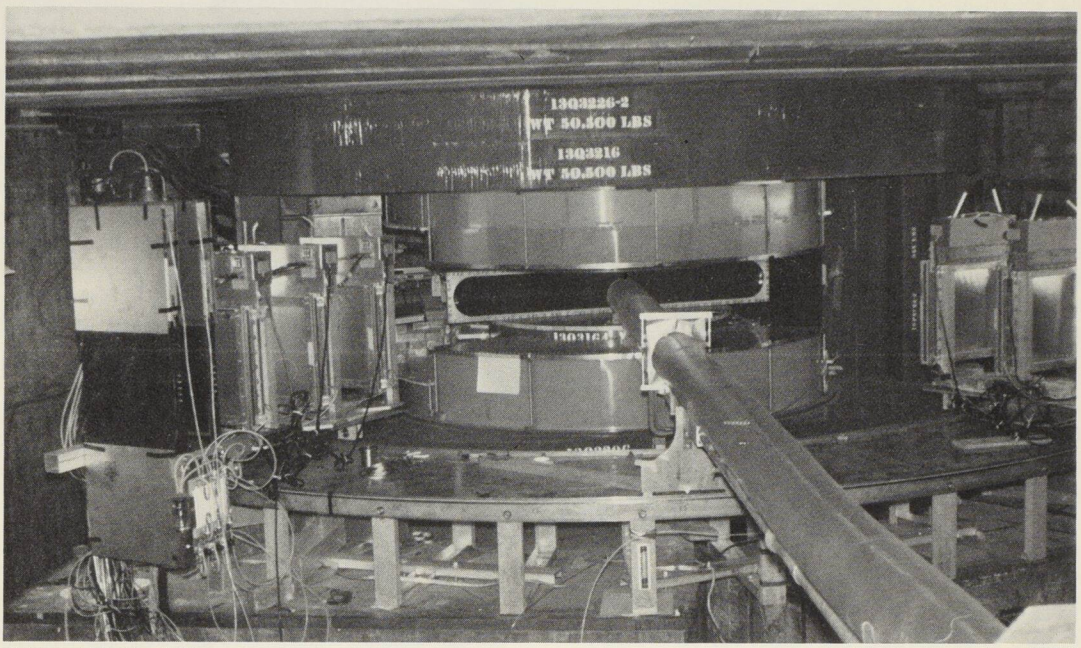
High energy physics -
Exploring the quantum jungle

Productive research in particle physics is predicated on the availability of progressively more powerful accelerators. Although the cost of such installations is prohibitive and the economic consideration alone would probably preclude participation by Canada in high energy physics research, a combination of scientific expertise and technological ingenuity has made possible the prosecution of an active research program in this area.



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A cyclotron magnet used at the Berkeley experiments as an analyzing magnet. Particles passing between the poles are deflected by the magnetic field through different angles according to their mass. Detectors (seen to the left and right) can be placed at the appropriate angles to the beam line to intercept the desired particles.

Un aimant cyclotron utilisé, au cours des expériences faites à Berkeley, comme aimant analyseur. Les particules qui passent entre les pôles sont défléchies par le champ magnétique suivant des angles en fonction de leur masse. Les détecteurs (à gauche et à droite) peuvent être placés selon des angles appropriés par rapport à l'axe du faisceau pour intercepter les particules choisies.

The high energy physicist follows William Blake's suggestion — to see the world in a grain of sand — to its logical conclusion, examining the properties of matter in the most fundamental form, the infinitesimally small particles which constitute atomic nuclei and the many others into which they become transformed. It seems at first sight paradoxical that the studies of such particles involve the use of such massive installations as the Fermi National Accelerator Laboratory's Batavia accelerator in Illinois or the two-mile long Stanford Linear Accelerator in California. These machines, truly enormous in size, energy and cost, have come a long way from the first cyclotron of E.O. Lawrence (pioneer physicist in nuclear research), a modest table-top model, built more than 30 years ago.

What is the resolution of this paradox? Why such mighty sledgehammers to crack such tiny nuts? Mr. E.P. Hincks of the National Research Council of Canada's Division of Physics explains: "There are several reasons for the continuing growth in accelerator energy (and hence, size). The one most frequently cited is that if you want to probe the size and structure of a particle, the effective wavelength of the energy you use to look at the particle has to be small compared to the size of the particle — if the wavelength is too large then you do not get any resolution — the wave will not 'see' the particle. Now, small wavelengths mean high energies and as people have progressed from the study of molecules through atoms to the study of the nuclei of atoms, and then to the study of the particles that constitute these nuclei, with the particles getting smaller and smaller, so the requirement has been for progressively higher energies." Accelerator energies are measured in electron volts (eV), an electron volt being the energy imparted to an electron by a potential difference of one volt. For the high energy physicist, accelerator energies in excess of several thousand million electron volts are required. Canada's most powerful machine is the 500-million electron volt (500 MeV) TRIUMF (TRI University Meson Facility) located in British Columbia and, as Mr. Hincks points out, is regarded by physicists as "a low-to-intermediate energy machine, not really powerful enough for high energy work." (By way of comparison, the accelerator at the Fermi Laboratory has a diameter of 1.2 miles [2 km] and can produce beam energies of the order of 400 GeV — that is four hundred thousand million electron volts).

The cost of such an installation is prohibitive and the economic consideration alone would probably preclude participation by Canada in high energy physics research. That this is not the case is demonstrated by a group of researchers from NRC and Carleton University together with mobile laboratories used by the research team in their visits to the large accelerator facilities in the United States.