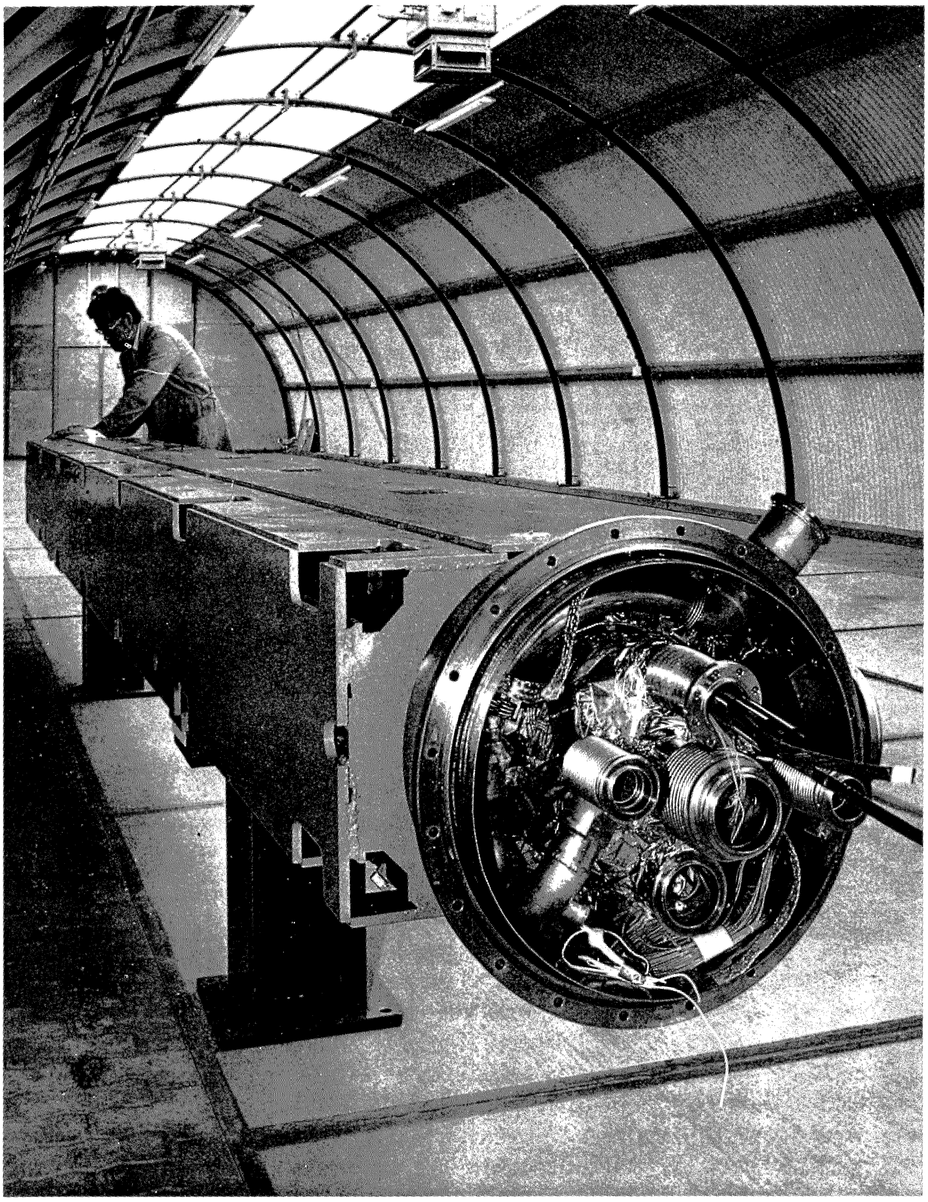
Six-metre superconducting bending magnet for the proposed HERA electron-proton machine ready for tests at DESY.



nets and a 6-metre coil have been tested at DESY and showed good training behaviour and field quality. They reached the so-called 'short sample design qualities' and the required field within only a few quenches. Magnet properties were well above the design values at the required field of 4.53 Tesla.

The new 70-metre tunnel-shaped test-hall has been designed to house two full-length magnet-cells for the HERA proton ring. Each of these cells is composed of six 6-metre bending magnets and two quadrupoles, all superconducting. It will also include correction coils, monitors, full refrigeration and remote controls, and everything needed to simulate the working conditions in the HERA tunnel.

At present two types of bending magnets are being prepared for these tests. The main difference between the two designs is that in one type the iron used to return the magnetic flux is independent of the coils and is placed outside the cryostat (warm iron — DESY design). In the other type the iron is inside the cryostat and is also used to help withstand the stress caused by the current-carrying coils (Brown-Boveri design). Four magnets of each type are being prepared for comparison tests and the final decision will be made next year.

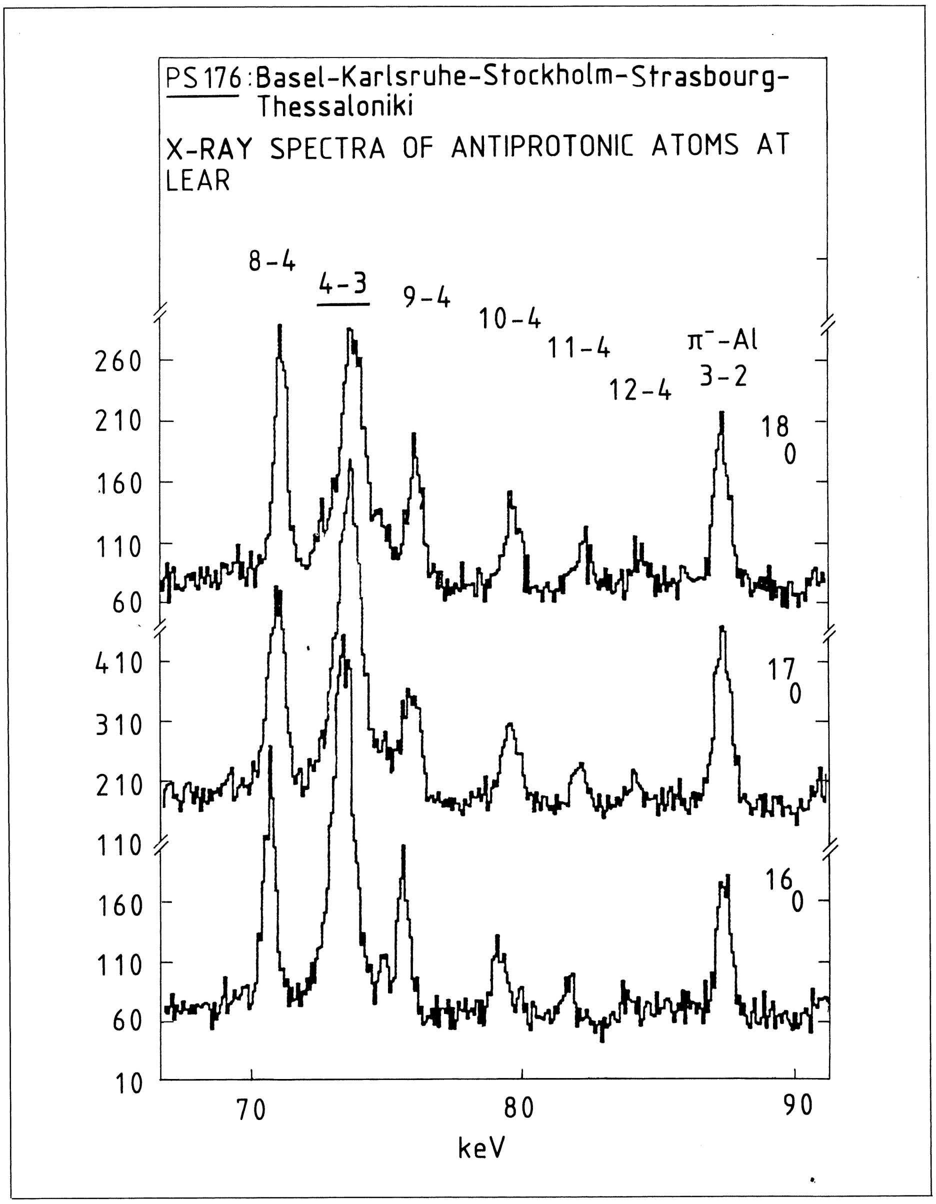
In both HERA dipole projects the beam pipe is kept at low temperature. Superconducting correction coils are wound around the vacuum tube and cooled with liquid helium. These coils are being developed in collaboration with NIKHEF in Amsterdam. A one-metre correction coil prototype, built at NIKHEF, has already been successfully tested, and the first full size correction coil is being built by Dutch industry.

In the meantime, fruitful negotiations on contributions to the HERA project are under way with both physicists and authorities from Canada, France, Italy, Israel, the Netherlands and the United Kingdom.

CERN
Antiprotons in orbit

The LEAR Low Energy Antiproton Ring promised to supply beams of low energy antiprotons of intensities much greater than had ever been available before. And it has. In just a few hours of beam time last year, LEAR experiments were able to log data which would have taken months or even years with conventional antiproton beams.

Already the benefits are being reaped. Some initial LEAR results on the scattering of antiprotons from nuclei were described in a previous



Comparison of X-ray spectra from antiprotonic atoms of different isotopes of oxygen, measured by the Basle / Karlsruhe / Stockholm / Strasbourg / Thessaloniki group working at CERN's LEAR Low Energy Antiproton Ring. On the left, an unperturbed (8-4) atomic transition, and next to it, a strongly attenuated and broadened line (4-3). The attenuation of this line clearly increases with the number of neutrons.

issue (December 1983, page 416). Now a Basle / Karlsruhe / Stockholm / Strasbourg / Thessaloniki (BKSST) team has some interesting results from the X-ray spectra of antiprotonic atoms.

The study of such exotic atoms, in which an atomic electron is replaced by an orbital antiproton or other negatively charged particle, has long been a speciality at CERN.

When antiprotons are brought to rest in a target, they are captured in an outer atomic energy level, but quickly fall down the rungs of the atomic energy level ladder. For each energy level transition, a quantum of radiation is emitted.

Because the antiproton is much heavier than the electron, it orbits much closer to the nucleus than the corresponding electron states. In fact when the antiproton approaches the lowest available atomic energy levels, it can be considered as orbiting inside the inner electrons. Such an atomic system can be viewed as a kind of superheavy hydrogen-like atom, with a heavy nucleus replacing the lone proton of hydrogen, and an antiproton replacing the valence electron.

But there is one big difference. As well as the electromagnetic interactions responsible for ordinary atomic structure, antiprotons also interact with nuclei through the strong force.

These strong interactions become more important as the antiproton approaches the nucleus, and should be measurable by comparing the observed behaviour with that expected from the pure electromagnetic interaction between the charged nucleus and the orbiting particle.

In highly excited states, the orbiting antiproton is still far from the nucleus, and the interaction is purely electromagnetic. However at or near the atomic ground state, the orbit is so small that the antiproton touches, or even penetrates, the nucleus.

These nuclear interactions affect the atomic spectra calculated on the basis of a hydrogen-type atom picture, and the deviations between the observed and 'expected' values should provide important information on the antiproton-nuclear interaction.

These deviations can occur in three ways. The closer the antiproton approaches the nucleus, the more the strong interaction shifts the energy level from its 'hydrogen' position. Increasing nuclear forces also mean that the inner antiproton levels have a greater chance of being annihilated in a nuclear proton or neutron. This has two consequences. When annihilation is still weak, a small fraction of the antiprotons disappear and the ensuing radiative transitions (when the antiproton falls to a lower level) are attenuated. In the lowest level, nuclear annihilation dominates over the atomic cascade. These states are very short-lived, and this shows up as a broadening of the corresponding spectral lines.

Careful measurements of all these effects should provide information on the interaction between the antiproton and the nucleons bound in the nucleus. In addition, comparison of measurements from neighbouring nuclei with the same proton number would show how the antiproton-nucleus interaction changes as one or more neutrons are added. In this way the antiproton-proton and antiproton-neutron interactions could be disentangled.

In classic antiproton experiments at CERN over the years, attempts were made to compare measurements from different nuclei, but statistics were so scanty that the resultant errors were large and conclusions were hard to draw.

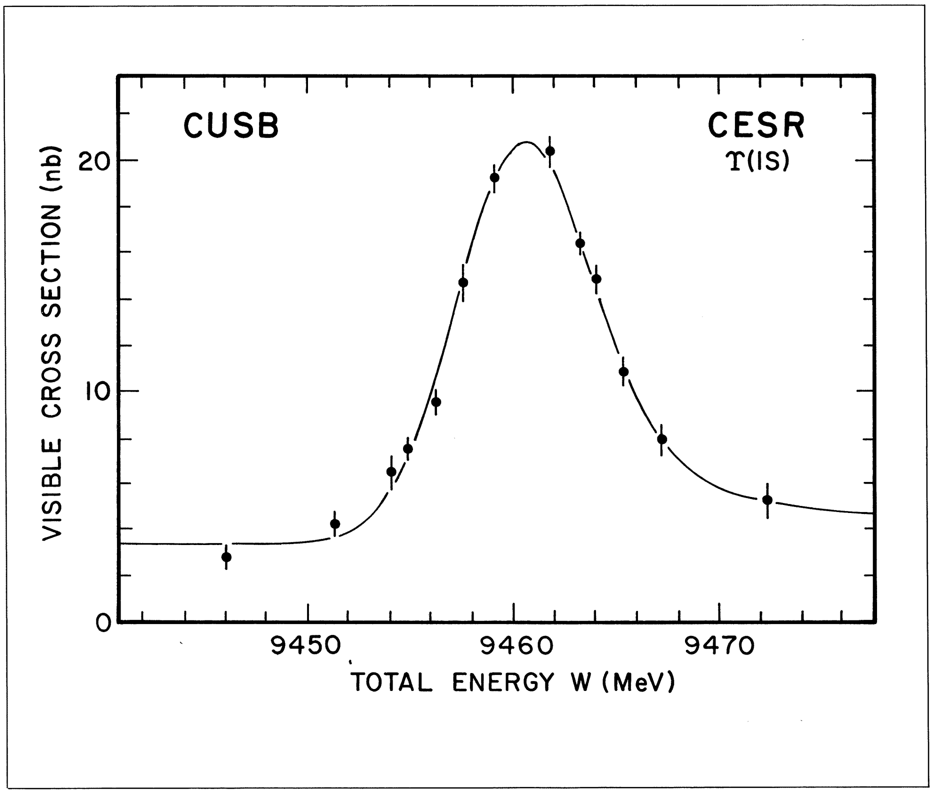
But LEAR soon changed that. With LEAR, the BKSST group was able to amass sufficient data in the brief 1983 run to provide a first look at the differences in atomic antiproton spectra from several neighbouring isotopes of oxygen.

Although final results have yet to be calculated, systematic effects are already clearly visible. These measurements will surely provide important new information on nuclear interactions, and will also complement the data coming from nuclear scattering using electron beams (see page 64).

But the termination of the atomic cascade does not necessarily spell the end for the antiproton. There is a slight chance that the antiproton picks up a nucleon from the nuclear surface and produces a state deeply bound by the strong force, emitting a high energy photon. Such evidence for 'baryonium' states has been found by the same group in previous (pre-LEAR) studies of antiprotons stopped in hydrogen and helium targets (see March 1983 issue, page 55). This time the detector was again searching for these energetic photons. As yet no evidence has been found, but the search (by a Basle / Stockholm / Thessaloniki sub-group) continues.

Other LEAR experiments are looking at antiprotonic hydrogen, and will provide the parameters of the basic antiproton-proton interaction. This will also be vital information for the heavier atomic studies.

In the months ahead, we can be sure of lots more interesting physics results from the experiments at LEAR.



The upsilon production rate measured by the CUSB detector at the Cornell CESR ring, using the resonant depolarization method, giving a precise value (9459.97 ± 0.11 MeV) for the upsilon mass.

CORNELL
Fixing the upsilon mass

The mass of a heavy vector (spin one) meson is one of the few quantities in high energy physics that can be measured with the precision that is routine in other areas of physics. These measurements, made in electron-positron storage rings, exploit the polarization of the beams resulting from the emission of synchrotron radiation, and the spin precession due to the anomalous magnetic moment of the electron.

This technique, called resonant depolarization, has been used at SPEAR (Stanford) to measure the psi mass, and at Novosibirsk to measure the phi, psi and upsilon masses. New measurements of the upsilon masses from Novosibirsk, DORIS