

After LEP?

Work for the LEP electron-positron Collider at CERN continues to drive ahead with the aim of achieving first colliding beams in the 27 kilometre tunnel towards the end of 1988.

However LEP is far from being the last word in CERN's long term plans. A clue was already in the 'EP Design Study'... by the adoption of a beam height of only 80 cm, there is enough room left (in the tunnel) for the installation of a second machine at a later stage...'

A workshop, organized by the European Committee for Future Accelerators (ECFA) and CERN in March 1984, examined the feasibility of a hadron collider in the LEP tunnel (see June 1984 issue, page 185).

There the idea emerged for a ring of superconducting magnets, installed above the LEP ring, to collide protons together (or protons with antiprotons) at as high an energy as possible.

Since this meeting, considerably more work has been done to firm up the ideas for the new Collider:

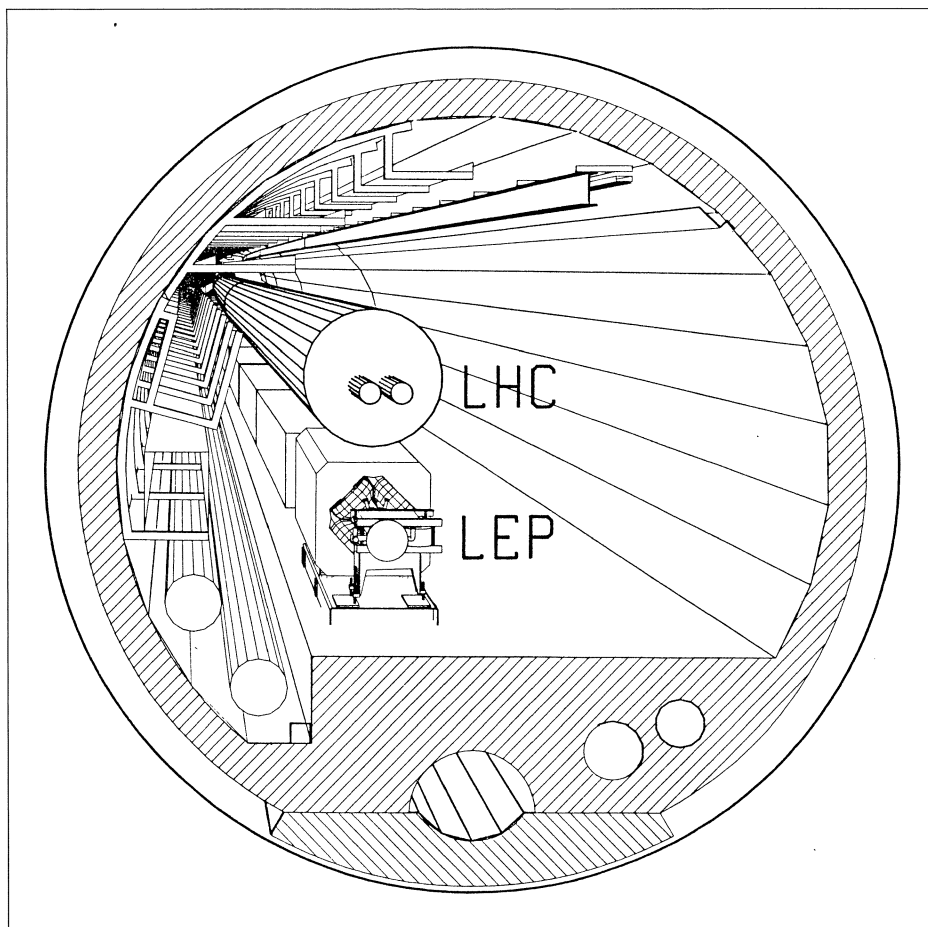
- determining the best configuration for the proton-proton option and establishing its advantages over a realistic proton-antiproton option;
- assessing collisions between the electron beam of LEP and one proton beam;
- designing a complete section of the machine;
- making tentative designs of superconducting magnets providing between 8 and 10 tesla, and working out a European magnet development programme towards this goal;
- outlining where and how the various types of collisions could be exploited in the LEP tunnel.

Proton-proton collisions

Using 10 tesla dipole bending magnets, collision energies of 17 TeV (17 000 GeV, 8500 GeV per beam) could be achieved with a respectable collision rate (luminosity $10^{33} \text{ cm}^{-2} \text{ s}^{-1}$). A 'two-in-one' aperture solution for the superconducting magnets is recommended for economy and compactness.

It is the relative ease of colliding proton beams (as compared to the difficulties of first making and then handling antiprotons) which promise high collision rates and make the proton-proton option the preferred solution. Despite the need

The designers of the LEP electron-positron Collider now being built at CERN were far-sighted enough to leave enough room for a possible second machine.



to provide a large number of bunches (a figure of 3564 has been quoted), the two proton rings in the LEP tunnel could be filled using CERN's existing 450 GeV SPS machine and its proton supply in only a few minutes and the injection procedure could be activated a short notice. Of course new injection lines would have to be built.

Proton-antiproton collisions

Contra-rotating beams of protons and antiprotons can be handled in the same magnet aperture, as is done in the SPS Collider. This facilitates magnet construction but

provides lower collision rates than the proton-proton option.

For 10 T dipoles giving 16.6 TeV total collision energy the estimated luminosity using CERN's improved antiproton source is $2.7 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$. The introduction of electrostatic beam separators to eliminate unwanted proton-antiproton collisions (as is now done in the SPS) would boost the luminosity to 13.5×10^{30} but bites into the cost savings of the single aperture approach.

Pending further studies, the proton-antiproton option is disfavoured. Proton-antiproton collisions (useful for comparison with proton-proton) could be achieved in one of the apertures of the proton-proton configuration.

Electron-proton collisions

With protons in the upper ring and electrons in the lower, electron-proton collisions are a natural bonus. The radiofrequency power which will be installed to boost the energy of the LEP beams could either be used to maintain the electron beam at its highest energy, or to boost the electron current at lower energy to increase the luminosity.

The total collision energy would thus be between 1.4 and 1.8 TeV (compared with 314 GeV in the HERA Collider now being built at the German DESY Laboratory in Hamburg), and the luminosity between 10^{31} and 10^{32} .

Experiments

Initially, the four LEP experiments would continue to look at electron-positron collisions but would have to get out of the way of the proton beams, when these are in use. For protons, new experiments could be mounted in other areas of the tunnel (the LEP tunnel has eight large vertical shafts). In time, some or all of the LEP experiments could be transformed.

However the production of suitable superconducting magnets for the collider would require a vigorous development programme.

The future seen from Erice

A few specialists have been finding time to think beyond the LEP electron-positron Collider now being built at CERN and the SSC Superconducting Super Collider proposed for the US to the physics needs and accelerator possibilities of the future. Despite the modest effort, a lot of progress has been made in sorting the wheat from the chaff amongst proposed accelerator schemes and in defining crucial features of future machines.

Some of this thinking came together at a seminar on 'New Techniques for Future Accelerators' held in Erice, Sicily, from 12-17 May. It concentrated on linear

electron-positron colliders with beam energies of at least 1 TeV and luminosities of at least 10^{33} per cm^2 per second. Earlier approaches concentrated on reaching accelerating gradients as high as possible (with reduced machine length and cost in mind). This, though still obviously very desirable, now carries less emphasis and other features are more prominent.

Two of these features were confronted by Bob Palmer in one of his usual stimulating talks. They concerned the input to the linacs, where reaching the desired luminosities will need very low emit-

tance beams, and the output from the linacs, where luminosity again dictates concentration of the particle bunches in miniscule cross-sections when they collide.

Emittance should ideally be as low as 10^{-8} but, if this could be slackened off to 10^{-7} , it is not so frighteningly far from what should be achieved soon in the damping rings for the big linear collider nearing completion at Stanford. It could however require bunches spending a long time in damping rings which, to have a reasonable repetition rate, could involve tens or hundreds of such rings. Ugo Amaldi called attention to this problem