the request for a fifth representative. The Confederation of British Industry has requested that its representative Mr John Gilby, be renominated and is awaiting a reply.

The situation of the science and public interest representatives is, however, considerably less clear. They are directly appointed by the DES but there appears to be no set procedure governing these appointments beyond "usefulness to the group". Ravetz has certainly been useful, but he has also not shrunk from expressing his opinions, and he may have been seen by some close to GMAG to be 'rocking the boat'.

According to one DES spokesman, the public interest representatives are the ones most likely to change "because the scientific specialists are a small group to choose from", but he expects that the overall "mixture of representatives" will remain the same—except that possibly a lawyer will be included on GMAG for the first time. As to who at the DES is responsible for the changes on GMAG, several sources indicate that Shirley Williams, the Education Secretary, is taking a direct and personal interest in the new appointments. However, her advisers on GMAG remain in the shadows and do not appear to include GMAG's existing members.

All this might be unimportant if it were not symptomatic of how GMAG handles its external relations. And external relations are important to a body whose decisions can affect the competitiveness of British biotechnology industry overseas. In this context, it is obviously desirable to get GMAG's standards accepted and applied by other countries. Unfortunately GMAG does not appear to communicate effectively with foreign scientific organisations. There is a strong feeling among some European scientists that GMAG could provide greater leadership in Europe by revealing more details of its work. As Dr Ravetz argues: "in about a year an American GMAG could be established that would operate in public and be easily accessible to foreign scientists. If that happens, the British GMAG would probably be ignored rather than be viewed as a model for all the world".

A. J. McClelland

Difficulties at PETRA worry designers of Europe's next accelerator

PETRA, the world's biggest storage ring for colliding electrons with positrons, is not behaving quite as expected, writes **Konrad Guettler**

THE European Committee for Future Accelerators (ECFA) convened its technical panel on the design of LEP —Europe's proposal for a 70 to 100 GeV electron and positron storage ring —in Rome recently, only to hear that the machine of which much LEP design has been based (West Germany's 19 GeV PETRA) is encountering difficulties.

Although PETRA started up very smoothly, ahead of schedule, and soon achieved beams of long lifetime, its luminosity (which determines the rate at which experiments can be done) is at present a factor of 100 or so below design. The profound worry is that the scaling up of parameters from lower energy machines, such as the 10 GeV DORIS and SPEAR, to the very much higher energies of PETRA or LEP may in fact not be straightforward, or indeed possible at all. It is still early days for PETRA but a large investigation program on both the technical and the theoretical side has now been launched both at DESY and by ECFA.

Nicola Cabbibo, a particle theorist at Rome University, and CERN are directing the attempts at increasing theoretical understanding of the observed beam properties. The main effects are the following:

- the maximum beam-beam tune shift 'ΔQ' is much less than its design value. ΔQ is the major factor, apart from the stored particle current, determining the machine luminosity, ie the number of interactions that take place at an intersection in unit time. The tune shift is a measure of the non-linear transverse forces between colliding bunches. All the existing machines turned out to have the same limiting value; and this ΔQ had also been assumed for PETRA and for LEP.
- Fast beam instabilities occur at various stored currents and appear to depend on the accelerating radio-frequency voltage. The circulating beams induce currents in the vacuum chamber walls and these wall currents create fields which interact directly with the beam. They can alter the normal betatron and synchrotron frequencies of the beam and thus cause instabilities.
- The accelerated bunches are larger than expected. (This affects the long-term beam stability.) Bunch lengthening is again due to the short-range fields induced by the bunch in the wall. It leads to a wider energy spread within the bunch and can lead to head-tail instabilities.

There was a lot of concern at Rome that there was inadequate knowledge of beam dynamics at high energies. But a lot of experience is accumulating about. high energy electron-positron machines and there was a widespread hope that while machine physicists have encountered very tricky problems indeed, they are unlikely to lead to profound revisions in the approach to LEP.

Since ECFA's Rome meeting, PETRA has run continuously and machine physicists have now pushed the beam current to a maximum of 18mA per bunch, almost up to the 20mA limitation design value. The previous current limitations have been overcome by changing the injection optics to the type also proposed for LEP. The present aim is for fast injection and a high beam intensity, and only later will PETRA go for higher energy, and hopefully, higher luminosity. The latest machine runs at a centre-of-mass energy of 16 GeV have yielded 1-2 hadronic events per nanobarn cross-section per day—which can be compared with 20-100 events at DORIS. This is not a very high luminosity; but the DESY machine physicists are confident about increasing it. Higher energies have to wait till next year when additional accelerating cavities will be switched in. □

Keeping down the cost of LEP

HIGH-ENERGY physicists have become very aware of current financial constraints, and are paying a great deal of attention to reducing the cost of LEP, without diminishing its physics potential. CERN has estimated the construction cost of a 70 GeV LEP to be a little over 1,000 MSF, which is almost the same as the SPS proton accelerator built at CERN a few years ago. No decision about the project has been taken, but ECFA hopes to present a detailed design study to the CERN Council by the end of 1979.

The physics interest in LEP is focussed on the maximum energy of the machine. Lepton physics at high energies centres around the role of the intermediate vector bosons, the charged W^+ or W^- and the neutral Z°.

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Their masses can be estimated from the 'Weinberg angle' measured in neutrino interactions. At present predictions of the Z° and the W^+ mass are 89 ± 5 GeV and 78 ± 6 GeV, respectively. Single beams of about 45 GeV should be sufficient to produce Z°s in association with other particles but the full machine energy will be required to create a W^+W^- pair.

For technical and cost reasons, the original CERN design study (LEP-70, completed this summer) was optimised for an energy of 70 GeV; but it is now being redone for 80-85 GeV per beam. The size and cost of any such machine increase with its maximum energy, and LEP-70 already had a circumference of about 30 km. However, valuable experience was gained from the LEP-70 design exercise. In particular the cost sensitivity of machine parameters and components can now be assessed more reliably.

Wolfgang Schnell, of the CERN ISR division, has already proposed some interesting ways of reducing the construction cost of the future accelerator. LEP will have more than 2,500 dipole bending magnets to keep the particles on their orbits. The bending power of each magnet is low because too high a track curvature would make the electrons lose too much of their energy by synchrotron radiation. Conventionally, magnets are made by precisely stacking hundreds of thin steel plates and welding them together. But the low magnetic fields required for LEP (to reduce bending, synchroton radiation, and running costs) can be obtained by bonding a smaller number of steel plates in concrete, thereby dispensing with a lot of steel and fabrication cost.

Further, the particle beams have to be refocused repeatedly to counteract the natural tendency of beams to diverge. More than 800 quadrupole magnets are foreseen for this task. A similar number of higher multipole magnets completes the set of tools which allow machine operators to tune the beams and to overcome instabilities. Using anodized aluminium in the manufacture of quadrupole coils, in place of copper, would save much cost and production effort; detailed investigations into the properties of such coils are already under way.

The costliest item of the machine is the radio-frequency system which will accelerate the electron beams. Its components, klystrons and accelerating cavities, stretch over 1.5 km and their total power consumption at 70 GeV will be over 70 MW. About 19 MW of this will simply be lost in synchrotron radiation, a feature which is negligible in all existing proton accelerators. When a bunch of electrons passes through the cavities, it picks up energy from the applied RF power and thus is accelerated. But the four bunches in each beam spend most of their time outside the accelerating cavities, and the applied power is lost. An ingeneous method to reduce these losses is to couple a low-loss mode storage cavity to a set of accelerating cavities. Energy can then be saved by constantly transferring power between the accelerating and storage cavities.

By itself, this scheme would not help on component cost but it would either reduce running cost, or alternatively allow a higher maximum beam energy. superconducting RF cavities is curto become available in a few years' time; they will eventually allow the beam energy to be raised to about 130 GeV. The upper limit is set by the synchrotron radiation power that can be absorbed by the vacuum chamber, and by the field gradient ilmitations in the accelerating cavities. Research into super conducting RF cavities is currently carried out under a joint CERN-DESY programme, and a first test cavity is to be installed into DORIS by the end of 1979. However, it is unlikely that this technology will be sufficiently mastered for mass production for the first phase of LEP.

Great importance is also attached to the planning of experimental installations and facilities. Experience at DORIS and SPEAR has shown that the cost of experimental detectors and associated electronics and computers amounts to a sizeable fraction of the total machine cost. Furthermore, the average number of charged particles produced in an electron-positron annihilation at these energies is of the order of 20. Very complex detectors are required to track that many particles, and to identify them unambiguously. So a major effort must be made to reduce the cost of such devices.

Konrad Guettler

Fermilab looks to the future

David Dickson visits the Fermi National Laboratory and talks to its new director, Dr Leon Lederman (right)

THE past year has not been an easy one for the Fermi National Laboratory)Fermilab) at Batavia, just outside Chicago. Twelve months ago Fermilab's then director, Dr Robert R. Wilson, was pushing hard for the rapid completion of the next phase in Fermilab's development. This is to be the construction of a second ring of superconducting magnets which, with their increased field, will allow energies of up to 1,000 GeV to be reached, twice existing energies.

Last November, frustrated by indications that the Department of Energy would not provide him with sufficient funds for the rapid construction of the Doubler, Dr Wilson threatened to resign if such funds were not included in Fermilab's budget for the fiscal year 1979. But the department stood firm, providing Wilson with only $15 million of the $30 million that he had requested. And in February he resigned as threatened, citing the department's "indecisive and "subminimal" support for the Doubler project.

The whole affair left the US high energy physics community feeling somewhat uncomfortable. Many of those who had admired Dr Wilson's achievements in establishing Fermilab were uncertain about the strategy that he had chosen to adopt. Dr Wilson also left a legacy at the laboratory where many felt experimental programmes had been unfairly squeezed to allow development work on the Doubler to proceed as rapidly as possible.

The task of putting all the pieces back together again now rests with Fermilab's new director, Dr Leon Lederman, whose appointment was announced in October and who takes over the position full-time next 1 June (although already working several days a week at the laboratory). of physics at Columbia University and director of the university's Nevis accelerator. He has also been closely involved with Fermilab since its inception; he was a member of the team which selected the site from over a hundred possibilities in the 1960s, and he also led the investigators who discovered the upsilon particle in the summer of 1977.