UNITED KINGDOM

Under pressure

While attempting bravely to sustain the legacy left by J.J. Thomson, Rutherford, Chadwick, Cockcroft, Blackett, Dirac and others earlier this century, the United Kingdom, one of the major contributors to CERN, has suffered in recent years from an erosion of the international purchasing power of the pound sterling. At the same time, the national scientific community has squabbled over the apportionment of the research cake.

In recent years, the CERN budget has remained constant in real terms, but the pound has drifted steadily down. In 1984 one pound bought 3.15 Swiss francs, now it gets just over 2. The hypersensitivity which left calculations at the mercy of exchange rate hiccups was cushioned in 1988 by a new method of calculating national CERN contributions, introduced by Chris Llewellyn Smith, now the Laboratory’s Director General, using less sensitive input data.

Another major UK influence was the publication of the famous Kendrew Report in the UK (and its CERN offspring, the Abragam Report). A Committee under molecular biologist Sir John Kendrew was convened in 1984 to investigate UK participation in particle physics in general and in CERN in particular. One recommendation was a reduced UK commitment to CERN, but this met with stiff resistance and the idea was buried. Squeezed by exchange rate pressure on one side and suffering from the Kendrew onslaught on the other, it was the domestic programme which suffered. In 1983 this was around £35 million (in today’s prices), but has since fallen to some £21 million. The decade has also seen erosion on the manpower front.

Once the dust from the Kendrew and Abragam reports had settled, UK scientists launched a counter-offensive. The well prepared ‘Particle Physics 2000’ plan, first published in 1991 and subsequently updated, aims to ensure having the correct resources in place for good UK participation in major long term physics goals - the origin of mass (the higgs mechanism), the pattern of elementary particles, and the nature of dark matter.

During this time, the position of basic science in UK administration has shifted from the Ministry of Education and Science to the Office of Science and Technology, under a Cabinet Minister (currently William Waldegrave of higgs competition fame - January/February, page 19).

From 1 April, particle physics falls under the jurisdiction of the new Particle Physics and Astronomy Research Council under Peter Williams, Chairman of Oxford Instruments, one of the UK’s most successful high technology companies and a good example of spinoff from basic science. The Council’s annual budget is £181 million, about half of which goes to particle physics (including the UK contribution to CERN).

UK experimental particle physics is almost exclusively conducted overseas, mostly at CERN’s LEP electron-positron collider (where UK teams are involved in three of the four major experiments) and DESY’s HERA electron-proton collider (both major experiments). In addition there is research and development work for studies at CERN’s planned LHC proton-proton collider, where a major effort is being mounted in electronics and triggering. In addition there are ongoing experiments at CERN, DESY, Stanford (SLAC) and the European ILL neutron Laboratory in Grenoble, France, together with several passive neutrino and astrophysics detectors - Soudan in the US, Sudbury in Canada and a home-based dark matter search. Through no wish of its own scientists, the UK has no further involvement with neutrino and muon beams at CERN.
A major national research asset is the Rutherford Appleton Laboratory, established as the site for the 7 GeV Nimrod proton accelerator, commissioned in 1964 as the second highest energy accelerator in Europe after CERN's PS. Since Nimrod's closure in 1978, the Laboratory has become a national particle physics staging post for UK involvement at CERN, at the same time broadening its scope to become a truly multidisciplinary scientific laboratory. Particle physics represents now one-sixth of its activities.

With its significant resources, particularly in high technology and computing, the Laboratory provides invaluable support for UK university groups working at CERN. This channelling and coordination of activities allows even small units to make valuable contributions to major experiments.

Good examples of the Laboratory's expertise are at two opposite extremes of engineering scale - the Microelectronics Support Centre on one hand and the huge superconducting magnets built for the Delphi experiment at LEP and the H1 experiment at HERA on the other.

Aware of the dangers of isolation, UK scientists have several missions. A liaison office set up to foster relations between UK science and industry is working very effectively, while many UK particle physicists put a lot of effort into popularizing their traditional fields, giving talks at schools and through media coverage. (This detailed picture emerged at a recent meeting of the European Committee for Future Accelerators (ECFA) at the UK Rutherford Appleton Laboratory. It is an ECFA tradition to make the rounds of CERN Member States to review the particle physics programme of individual nations.)

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High-Energy Gamma-Ray Astronomy: Milagro detector

To study the heavens, astronomers take advantage of most of the electromagnetic spectrum from radio waves (10^4 eV) to ultra-high-energy gamma rays (10^{18} eV) to complement their meagre knowledge from the narrow optical wavelength band.

The study of high-energy gamma-ray astronomy has recently been pushed up to several GeV with the EGRET instrument aboard the Compton Gamma Ray Observatory satellite. EGRET utilizes techniques from particle physics - scintillation counters, spark chambers and a sodium iodide calorimeter. EGRET has made an all-sky map that has revealed a surprising view of the high-energy heavens including highly-variable emission from Active Galactic Nuclei (AGN) and from the mysterious gamma-ray bursts (GRB).

Because the gamma ray flux falls rapidly with increasing energy, extending these studies to higher energies requires much larger detectors than can presently be deployed in satellites. To date, higher-energy measurements have been made with three ground-based techniques: air Cherenkov telescopes (around 1 TeV = 10^{12} eV), air shower arrays (from 10 TeV - 1 PeV = 10^{16} eV), and atmospheric fluorescence detectors (above 10^{17} eV). All of these techniques observe particles produced in extensive air showers that result when cosmic particles interact with the earth's atmosphere. However, of these methods, only air shower arrays are a non-optical technique that can scan the entire overhead sky 24 hours a day. These attributes are important for studying the episodic and variable sources that are so prevalent.

An air shower array consists of scintillation counters sparsely spread over a relatively large area. For primaries above 100 TeV, approximately 10^{45} shower particles reach the ground at mountain altitudes. The sparse array samples these particles and the direction of the primary particle is reconstructed by measuring the relative times at which the individual counters are struck. Several large arrays have been in operation for a number of years including the CASA array in Dugway, Utah, the CYGNUS array in Los Alamos, New Mexico and the HEGRA array in the Canary Islands.

Several years ago, there were claims of detected emission above 100 TeV from X-Ray binaries such as Cygnus X-3 and Hercules X-1. However, observations with current, more sensitive arrays have not revealed any further evidence. This does not imply that the earlier observations were incorrect - this is an observational (as opposed to an experimental) science. The more recent measurements have shown that there are presently no bright sources of 100 TeV anywhere in the northern sky.

Air Cherenkov telescopes have shown that the steady emission from at least some of the sources detected by EGRET (most notably the Crab and Markarian 421, an AGN) extends up to several TeV. It is important to know if the episodic emission seen by EGRET also extends to higher energies. Air shower arrays, with their continuous all-sky sensitivity, could be used to address this question if their energy threshold could be significantly reduced. The difficulty lies in the fact that the number of particles reaching the ground diminishes...