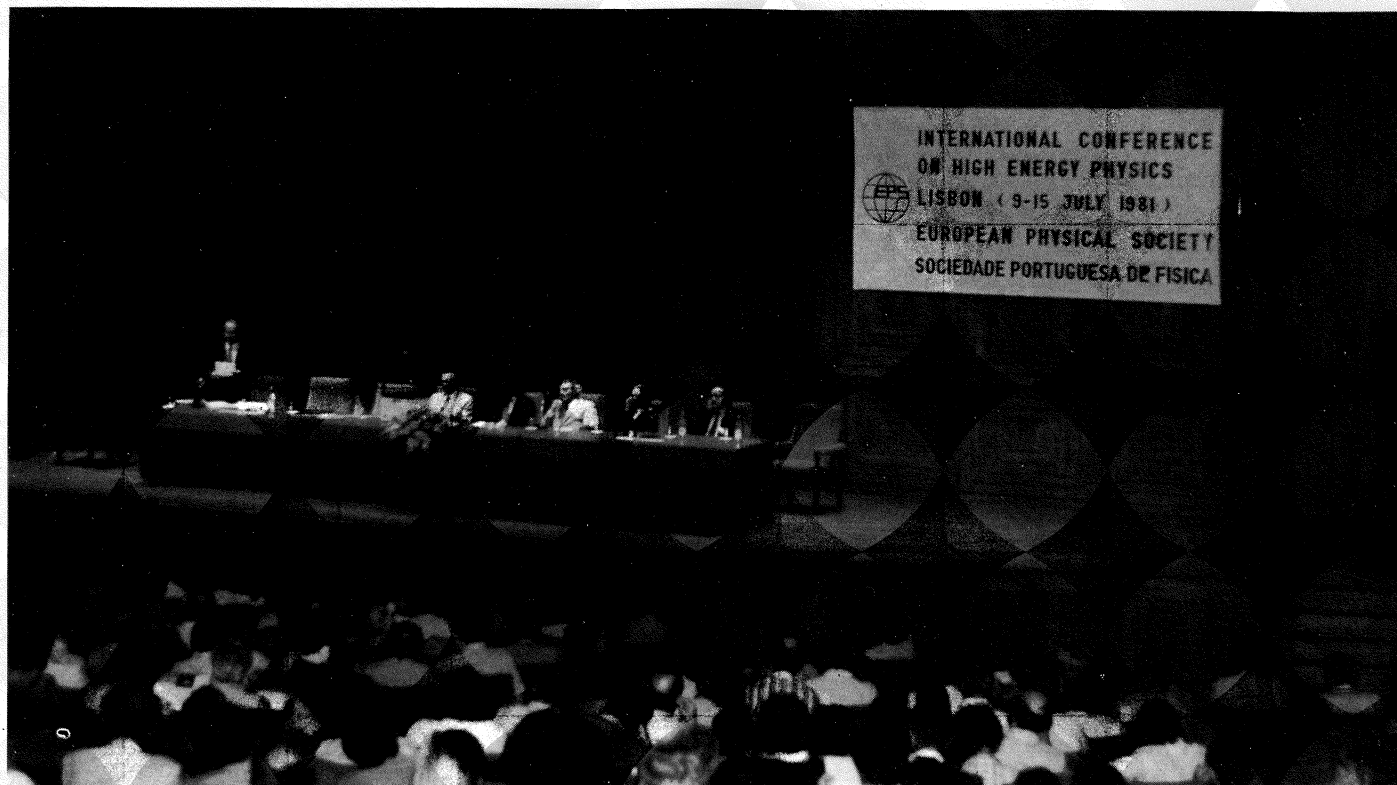


Lisbon Conference

Bragança Gil, President of the Portuguese Physical Society, addresses the Lisbon conference.

(Photo A. Amor)



Although no major physics discoveries were announced, the European Physical Society's International Conference on High Energy Physics, held in Lisbon from 9–15 July, was significant in that it showed the emerging pattern of physics for the 1980s.

With the electroweak theory adequately explaining almost all of leptonic physics and with quantum chromodynamics (QCD) emerging as the theory of inter-quark forces, physicists are confidently looking to broaden their horizons. However the comparison of QCD predictions with experiment still looks sometimes more like an art than a science, and there is a lot of ground to be covered before any QCD textbooks can be written.

Putting QCD problems to one side, new unifications are being suggested to merge the electroweak and QCD pictures, and a new breed

of experiments is emerging to test the predictions of these broader theories. Some experimentalists are turning away from their traditional haunts at high energy accelerators to mount new 'passive' experiments deep underground to search for new phenomena. Theoreticians are striving to use the new insights on the structure of matter to aid cosmologists in their bid to reconstruct the early history of the universe. Gravity too is being fed into the new unification schemes.

Apart from specialized workshops, Lisbon was the first example of a major international meeting which included substantial coverage of passive experiments looking for new behaviour, notably proton decay. Although it is too early for confident new results to be available, the international effort under way in this sector reflects how physicists are beginning to look away from accel-

erators and storage rings.

Another pointer to the future came on the first day of the conference, when CERN Director General Herwig Schopper, in a talk on the future development of European particle physics, indicated the initial success of tests with antiprotons in the SPS (see page 289). He proudly emphasized that this remarkable achievement had been accomplished just three years, almost to the day, since the antiproton project had been formally approved at CERN.

The next day saw the arrival of Carlo Rubbia hotfoot from CERN where only hours before, some evidence for proton-antiproton collisions had been picked up in the forward telescope of the UA1 detector in the SPS ring. This announcement was greeted with spontaneous applause, and conference chairman Giuliano Preparata rushed messages of congratulation to CERN on

The conference opened with R. Barloutaud speaking on the search for evidence of baryon number violation.

(Photo A. Amor)



this 'spectacular success'.

By next year's conference season, passive experiments and the CERN studies of 540 GeV proton-antiproton collisions might have a lot of fascinating new material to report.

Rubbia's talk at Lisbon centred on the objectives of the new physics opening up at the collider. Spotting heavier quark flavours by looking directly for new quark-antiquark bound states might no be easy, and alternative flavour mechanisms would have to be exploited. Assuming of course that they exist at the predicted masses, the long-sought intermediate bosons of weak interactions should not present such problems. High on the experimental agenda is the job of fixing their masses as accurately as possible. If it could be measured, the width of the neutral Z boson would give information on the number of species of neutrino which exist in the universe.

The measurement of this parameter in the collider would be a major breakthrough and would have important implications.

For the possible future development of the collider, Rubbia mentioned the use of polarized protons, already being actively investigated at other machines. Higher luminosities, if achieved, would increase the chances of uncovering more new particles, in particular the Higgs bosons, which are just as fundamental to the underlying theory as the weak bosons. For the longer term, Rubbia touched on the possibility of building a proton-antiproton collider in the proposed LEP tunnel at CERN.

While Rubbia could not report any collider physics, experiments at the Intersecting Storage Rings (ISR) have already had their first look at proton-antiproton collisions, albeit at a lower energy (see June issue, page 196). In the early sessions, Martin Block presented first results from experiment R211 (a Louvain/Northwestern collaboration) which uses the 'Roman Pot' technique. With meagre statistics and using instrumentation resurrected from some of the first experiments carried out at the ISR ten years ago, a first shot at the proton-antiproton total cross-section gives 46 millibarns. Although the errors are, in Block's words, 'still obscene', this suggests that the proton-antiproton reaction rate, like that of proton-proton, is still rising, but might be approaching the proton-proton figure from above. Other ISR experiments also reported initial antiproton results.

In the new department of passive experiments, the conference in fact opened with a talk by R. Barloutaud, who described the motivation behind the range of studies under way or being mounted to search for signs of baryon number violation.

This initial talk was supplemented later in the conference by a session on proton decay searches, chaired by Abdus Salam, who has provided significant motivation for these experiments. In his introductory remarks, Salam emphasized the long-term implications of this work. Rather than being an ad hoc series of short-term studies, he advocated that this type of physics should develop into a regular long-term effort, and indicated in no uncertain way that funding arrangements should take this into account. If the proton is indeed found to be unstable, then its exact decay modes could have serious implications for the future of high energy physics machines. Certain decays, because of the mass-scale involved, could mean that this new physics would be inaccessible to conventional high energy machines.

In the proton search session, the results from the Japan/India collaboration at the Kolar Gold Fields were presented (see July/August issue, page 253). However no new events could be reported to supplement the three proton decay candidates recorded up to the end of April. Another detector, weighing 31 tons, has begun operation 2000 feet underground at the Soudan site in Minnesota. Embarrassingly quickly, this detector has recorded an event which could be interpreted as proton decay. However the group prefers at this stage to explain it away as multiple scattering.

Another feature of the conference was that, unlike the more recent European biennial particle physics meetings, Lisbon included parallel sessions. With a total of some 700 participants (significantly less than the conferences held in recent years in Madison, Geneva and Tokyo), the parallel sessions were fairly compact and gave a workshop feel to the first

Herwig Schopper spoke on the future of European high energy physics, and was able to reveal the first successes at CERN with tests at the high energy proton-antiproton collider.

(Photo A. Amor)

few days, with plenty of opportunity for discussion, public and private.

On the other hand, the physics which had to be covered ranged over a wide field, so that the parallel sessions included valuable 'mini-rapporteur' talks which brought together results from several experiments. For the plenary sessions, the organizers had included two types of talks – review papers presented after the appropriate parallel sessions, and invited speakers deemed to be worth hearing. Despite this imaginative organization, there were a few topics, like the structure of the weak current, which slipped off the map during the plenary sessions.

Another praiseworthy feature was the reappearance of sessions on experimental instrumentation. Once a regular adjunct to these international meetings, this important corner of particle physics has had no regular international forum in recent years. At Lisbon, these parallel sessions covered particle detectors and data handling. While contributions on particle detectors were naturally well covered by the experimental physicists, data handling has become something of a speciality, and despite some brave attempts, the coverage of this sector was not really representative.

As a European meeting, it was only natural to encounter a preponderance of European data, dominated by results from CERN and DESY. Nevertheless, the scarcity of US contributions was a bit disappointing. A notable exception was the nice talk by P. Franzini on the results obtained at Cornell's CESR electron-positron collider. There was also some news from Fermilab, but less from the PEP electron-positron collider at SLAC. One had the impression that SLAC was keeping some good things up its sleeve for the Bonn Lepton/Photon meeting.



A not altogether unexpected confrontation was the disagreement between two experiments using the Split Field Magnet at the CERN ISR. While Antonino Zichichi's Bologna / CERN / Frascati group sees signs of a beauty baryon at 5.5 GeV, an Annecy / CERN / Collège de France / Dortmund / Heidelberg / Karlsruhe / Warsaw collaboration sees nothing (see June issue, page 207). After much debate, the issue remained unresolved.

In the high energy electron-positron sector, it was DESY's PETRA ring which dominated, with luminosities at record levels and with data from JADE, PLUTO, TASSO and Mark-J now being supplemented by results from CELLO. At Lisbon, the meagre PEP data which was presented underlined the PETRA findings.

Hadron production in electron-positron annihilation is supposed to

be a good test bed for QCD, and in certain cases agreement between theory and experiment is quite good. However devil's advocate arguments can be proposed which challenge this. The behaviour seen in gluon jets seems to be similar to that of quark jets, although there could be a systematic broadening. Baryon production in electron-positron annihilation seems to be unexpectedly high.

After the discovery of the upsilon at Fermilab and the subsequent investigation of upsilon fine structure at DORIS, the energy region covered by the CESR ring has enabled the CLEO and CUSB experiments to specialize in the upsilon region. In particular, the fourth upsilon, which is much broader than its lighter counterparts as it can decay strongly, gives a handle on the threshold for the production of naked beauty. Franzini indicated that

In parallel with the Lisbon Conference, a high energy physics exhibition was organized by CERN and Portuguese physicists to communicate with the local population. It was held in the Instituto Superior Tecnico from 8-19 July and attracted an impressively large number of visitors. They were able to see many models communicating physics ideas, to hear talks on modern physics and to learn about CERN, its role and its research equipment.

(Photo CERN 298.7.81)



the lightest beauty meson should be seen at about 5.25 GeV. This is in line with Zichichi's candidate beauty baryon, with its extra quark, at 5.5 GeV. The characteristics of the upsi-lon decays seen at CESR suggest charm as the favoured decay channel of the beauty quark.

There has been an upsurge of interest in the apparent similarities in the hadron spectra from different types of experiment. The R415 Bologna / CERN / Frascati group uses a technique of subtracting out leading protons to leave a hadron spectrum which has many broad features in common with what is seen in electron-positron annihilation. These similarities are also found in other types of reaction, notably 70 GeV kaon-proton data from the BEBC bubble chamber reported at the conference.

After all these years, the lifetime of charmed particles is still a talking point. At Lisbon, the emergence of new results from the specially built high resolution bubble chambers at CERN, from emulsion experiments at Fermilab and from the hybrid system at SLAC together show that the difference between the lifetimes of the charged and neutral charmed mesons might not be as marked as was once thought. The neutral particle now appears to live for about a third as long as the charged one, a result which is still of interest to theoreticians. The situation is still being confused by occasional events, perhaps due to more exotic particles, giving very different lifetimes.

Charm signals at the ISR are now plentiful. By comparing the observed enhancements with the smooth spectra of other particle combinations, the established selection rules provide an impressive verification of the charm signals. However the reconciliation of the calculated

charm production rates with the observed relative numbers of electrons and pions is a problem which worries some people. Using conventional models, the calculated charm production rates can overtax the observed levels of produced electrons.

Covering the field of hadron spectroscopy, Frank Close indicated how the different levels of hidden strangeness are now emerging (in some cases years after their charmed counterparts). However everything is not yet cut and dried and the labelling of many states has to be settled. Glueballs — states made of gluons but no quarks — have long been expected, and occasional candidates are put forward. Sam Lindenbaum reported on an enhancement seen in the spectra of phi meson pairs, doubly forbidden by conventional selection rules, which could be a candidate glueball.

Baryonium — exotic bound states coupled to baryon-antibaryon pairs — were also once expected on theoretical grounds. After several encouraging initial sightings some years ago, the experimental evidence for baryonium has grown more and more scanty. If baryonium is not yet dead, its recovery now would be very remarkable.

Elsewhere in the hadron area, the dip in the elastic proton-antiproton spectrum (see July/August issue, page 246), was mentioned several times. This appears at the same momentum transfer as the dip in the proton-proton spectrum, but at much lower energies. In this context, it was interesting to learn from Roy Rubinstein of a new Fermilab result which shows a dip in the scattering of 200 GeV pions off protons at a squared momentum transfer of 4 GeV^2 . Besides its possible relationship with other diffraction-type effects, the existence of a dip this far



Paula Fernandes models the Lisbon t-shirt.

(Photo A. Amor)

out is interesting in itself.

At Madison last year, a talking point was the absence of jet-like structure and the unexpectedly large high transverse momentum hadron yields over the full coverage of the NA5 experiment at the SPS (Bari / Cracow / Liverpool / Munich / Nijmegen collaboration — see also May issue, page 155). These effects are still very much there, and are now supported by minimum bias data from experiment R807 (Brookhaven / CERN / Copenhagen / Lund / Rutherford / Tel Aviv), and from the Split Field Magnet, both at the ISR.

These results have to be reconciled with previous reports of fairly clean jet structures using single particle triggers. In addition, these new results are not just extrapolations of the soft behaviour seen at lower transverse momenta. Something new could be happening. In particu-

lar, the high hadron yields have interesting implications for the big detectors being prepared for high energy proton-antiproton colliders.

However specific jet patterns still appear, an example being the three-jet structure at a three per cent level reported by the Columbia / CERN / Oxford / Rockefeller group at the ISR.

Other new results from the ISR came from alpha particle collisions (see May issue, page 163). Latest analysis shows that the atomic mass number dependence in alpha-proton collisions is more gentle than that of alphas on alphas.

There was the now almost traditional contrast of results from different experiments searching for the fractional electric charges in matter which might be indicative of free quarks. While G. Morpurgo in Genoa still sees no effect in iron, W. Fairbank at Stanford repeatedly sees

Ever helpful — the conference secretariat.

(Photo A. Amor)

fractional charges in niobium. Although this apparent incompatibility is always handled by the parties involved, in public at least, with consummate good taste, the continual disagreement is now a serious problem, and ways are being sought to resolve it (see page 301). However it should be remembered that the techniques of the two experiments are very different, and, as Fairbank commented, 'if you dig in the mountains and find gold, it does not mean that you can dig on the beach and find gold'.

In neutrino physics, once the glamour spot of particle physics conferences, there was little to report. The possibility of neutrino oscillations — the mixing of different kinds of neutrinos — has cooled off since last year, when it was a hot topic.

Scattering experiments with different kinds of lepton beams provide a powerful probe of hadronic structure, and the computation of the quark composition of nucleons through their structure functions has developed into a minor industry. Results from a range of experiments using electron, muon and neutrino beams appear to be in broad agreement, although there are some points to be resolved. However the structure function game seems to be getting very complex and the extraction of parameters from the mass of experimental data is not straightforward. At Lisbon, the CHARM neutrino experiment (WA 18) from CERN added its contribution to the structure functions available for consultation. There was some debate on the relatively low value of the QCD parameter given by the NA 4 muon scattering experiment (Bologna / CERN / Dubna / Munich / Saclay) at CERN. Because of the kinematical range covered, this low value did not cause too much distress.

Peter Landshoff was scheduled to



cover the current theory of the universe on one hour, and succeeded by confining his attention mainly to the successes (or otherwise) of QCD. The quantitative formulation of this theory is still very shaky and the calculational techniques do not inspire confidence. Landshoff reeled off a long list of effects in need of an explanation, and remarked 'if the situation seems muddled, it is because we are muddled'. He pointed out the growing interest in diquarks as a reaction unit. For about ten per cent of the time, it looks as though it is a diquark, rather than a quark or an antiquark, which is picked up from the vacuum by an interacting particle.

In contrast, G. 't Hooft concentrated on pure QCD theory and emphasized the possible complexities of the formalism. Whatever its calculational difficulties, QCD is the right theory, according to 't Hooft. 'What else is there?' he asked, and assured his audience that the complete solution of QCD would provide plenty of employment.

The pure theory review talks were compressed towards the end of the conference, and provided a refreshing change of emphasis after the experimentalists' inevitable preoccupations with statistics and parametrizations. At least the theorists usually make do with far fewer transparencies per unit time than

their experimental colleagues.

Despite its formidable title, Bruno Zumino's talk on the efforts to produce 'grand' and 'super' unified theories was enlightening. He explained that in the current jargon, 'grand' refers to attempts to merge electroweak theory with QCD, while 'super' theories go a giant step further and try to pull in gravity as well.

Richard Feynman, sadly absent from the international conference scene for several years, was originally billed as giving the concluding talk. Although he was indeed the final speaker, he described his own theory of quantum chromodynamics rather than trying to summarize what had been said by everyone else. Whatever the outcome of his theory, it was instructive to watch the great man's highly individual way of handling formalism.

Perhaps the hottest topic of all at Lisbon was the weather, with the mercury climbing towards the 40 degree C mark during the second week — among the highest temperatures ever recorded in Lisbon. Fortunately the superb conference rooms in the Gulbenkian centre were equipped with some of the best air conditioning in town.