Madrid Physics Conference

problems of creating and maintaining the necessary low emittance beams now seem to be mastered.

Conclusion

The meeting concluded with a review of the work of the International Committee for Future Accelerators (ICFA) by its chairman, Yoshio Yamaguchi, and by succinct reviews by former KEK Director Tetsui Nishikawa and former SLAC Director 'Pief' Panofsky.

Nishikawa estimated that simply to sustain all operating and proposed accelerator projects requires about ten times more accelerator physicists than are currently available!

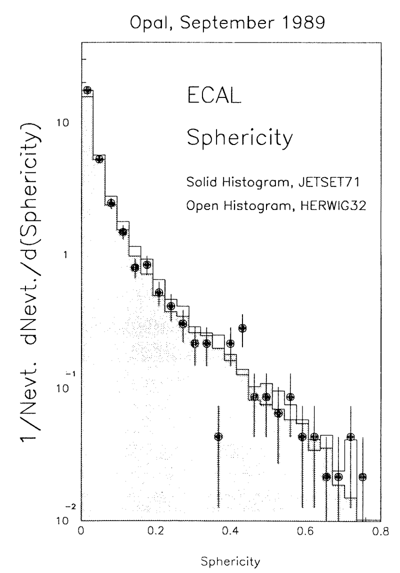
Panofsky saw the approach of a new watershed in the exponential growth of particle collision energies over the past fifty years. The next generation of machines, such as the SSC and the new linear colliders, have 'exhausted the capacity of our present knowledge', and he called for an increased proportion of resources to investigate new ideas to keep the exponential growth on its traditional steady upward track.

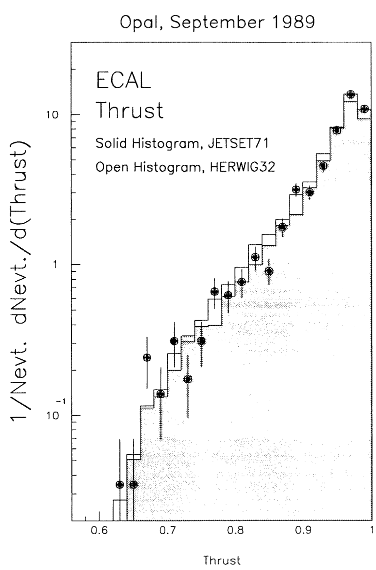
Hard on the heels of the Lepton-Photon Symposium at Stanford in August (October issue, page 1) came the International Europhysics Conference on High Energy Physics in Madrid from 6-13 September. With the two meetings held so close together, there was much overlap in the physics reported, although some teams were able to use the extra month to present new results. A notable example was the Mark II team working at Stanford's SLC linear collider, who presented new limits on the number of allowed neutrinos (see page 1).

The Madrid meeting attracted about 600 participants from all over the world. An initial three days of parallel sessions followed by four days of plenary talks could cover the field in depth and in breadth.

The Local Organizing Committee included physicists from the two Madrid Universities, Autónoma and Complutense, as well as from the Spanish Research Council (CSIC). The Conference opened with short addresses by C. Lopez, Rector of the Universidad Autónoma de Madrid and Chairman of the Local Organizing Committee, and P. Pascual, scientific advisor to the Minister of Education in Spain, who both expressed their satisfaction on seeing this major meeting organized in Spain so soon after the country has rejoined CERN as a Member State and at a scientifically historic time, with CERN's new LEP collider coming into operation.

Thus the parallel sessions began with a special two-hour survey of three of the four LEP experiments and their results from the LEP pilot run. J. May (Aleph), U. Amaldi (Delphi) and A. Michelini (Opal) surveyed the status of the experi-





The Madrid 'Europhysics' conference on high energy physics in September gave a foretaste of things to come at LEP, with multihadron production in Z decays, as seen by the Opal detector. The histograms are simulations of quark 'fragmentation' into hadrons.

ments, their plans for the near future and the results obtained so far. Opal was able to present multihadron production rates by the Z, the electrically neutral carrier of the weak nuclear force, as well as some jet shape distributions, in good agreement with models of quark 'fragmentation' into hadrons.

A wealth of new experimental results and theoretical investigations emerging from the 15 parallel sessions was summarized in the plenaries. These sessions began with short addresses by R.A. Ricci, President of the European Physical Society, and W. Bartel (DESY), Chairman of the EPS High Energy Physics Division.

A new EPS prize for outstanding work in high energy physics was awarded for the first time, going to Georges Charpak (CERN), who received his medal from R. Salmeron (Ecole Polytechnique), former Chairman of the HEP Division of the EPS. Replying, Charpak emphasized the importance of detector developments and pointed out the consequent spinoff ties between particle physics and other fields of science, particularly medicine and biology.

LEP Project Leader Emilio Picasso reviewed the history of the new machine, and its physics debut on 13 August with the first Z reported by the Opal collaboration only minutes after the start of the pilot physics run.

A. Hutton (Stanford) described the history of Stanford's SLC Linear Collider and looked at the problems encountered with this new type of machine. However things are now well under control, and early next year a polarized electron source will be installed to boost SLC's physics potential.

J. Dorfan (Stanford) came with new results from the Mark II collaboration at SLC. Based on a 332-event scan of the Z, they are able to place new limits on the allowed number of light neutrino types (see page 1). It was impressive to witness how well Standard Model calculations tuned at a total energy of 29 GeV could describe hadronic Z decays when extrapolated to 90 GeV.

K. Fujii (KEK) summarized electron-positron collider physics below the Z mass. The experiments at PEP (Stanford) and PETRA (DESY, Hamburg) gave high precision tests of the Standard Model while TRISTAN (KEK, Japan) covered the energy regime up to 60 GeV.

L. Nodulman (Argonne) reviewed the results of the CDF team working at Fermilab's Tevatron proton-antiproton collider. With lots of data from a year of running at a collision energy of 1800 GeV, they have been able to measure the masses of the Z, getting a value centred on 90.9 GeV, compatible with that from SLC, and the companion charged W particle, centred at 80 GeV. No new particles were reported and the threshold for production of the sixth ('top') quark was pushed up to 77 GeV.

J.-M. Gaillard (Orsay), covering the UA experiments at CERN's proton-antiproton collider, came to very similar conclusions. With an impressive list of quark field theory (quantum chromodynamics – QCD) calculations, he confirmed that the Standard Model is in good shape.

The spectroscopy and decay of heavy flavour particles has experimental input from fixed target experiments as well as from storage rings. A review by R. Morrison (Santa Barbara) included a long list of identified charmed and beauty particles. The detailed knowledge accumulated so far can account for 95% of all decays of the D neutral, charmed meson.

There was progress in the physics of the B mesons, containing the fifth (b) quark, where the mixing of electrically neutral Bs is now well established. The Argus (DESY) and Cleo (Cornell) experimental teams have first indications of charmless B decay, with component b quarks decaying directly into u quarks. The evidence comes from the shape of the lepton spectrum in semileptonic decays.

These measurements provide new input for calculating the elements of the (KM) matrix interrelating six kinds of quarks, reviewed by I. Bigi (Notre Dame). According to his evaluation, the violation of charge/parity (CP) symmetry is again open for discussion, with the new result by the E731 experiment at Fermilab based on only a fraction of their data (October issue, page 4). The result from the full statistics is eagerly awaited.

Looking at the electroweak sector of the Standard Model, R. Barbieri (Pisa) pointed out the potential importance of weak radiative corrections (see following story).

The hadronic (strongly-interacting) sector of the Standard Model was reviewed by J. Stirling (Durham), G. Martinelli (Rome) and A. Mueller (Columbia). Stirling looked at evidence in favour of QCD. Helpful in this respect is a resolution of some long-standing disagreement between two series (EMC and BCDMS) of measurements of nuclear quark structure using muon beams, following a reanalysis at Stanford of electron beam data. Mueller, still QCD-ing, tried to resolve the apparent paradox of quarks carrying little or none of the proton spin (June 1988, page 9). Another approach to QCD came from Martinelli, who presented impressive results from lattice calculations which avoid the problems besetting a traditional perturbation approach. An example was a calculation of the electric dipole moment of the neutron. L. Alvarez-Gaume (CERN) looked beyond the Standard Model, particularly in the direction of string theories.

The widespread application of Standard Model predictions was emphasized by M. Rees (Cambridge) who explored links between cosmology and particle physics, and H. Meyer (Wuppertal) reviewing non-accelerator experiments. The relative abundance of different helium isotopes in the universe appears to limit the allowed number of neutrino types to three.

Summarizing, L. Maiani (Rome) emphasized that with everything fitting so well into the Standard Model, there is a need to explore higher energies to understand where the Standard Model comes from. For this, new accelerator techniques are needed to attain these energies, complemented by new detector technologies to withstand high rates and high radiation doses. These aspects were covered by W. Schnell (CERN) and R. Wigmans (LAA Project) respectively.

Non-physics attractions included a memorable concert by Victoria de los Angeles, who delighted the audience with a recital of Spanish songs from the Renaissance to contemporary composers.

From Fernando Barreiro and Wulfrim Bartel

Making corrections correctly

The standard 'electroweak' picture, synthesizing electromagnetism with the weak nuclear force (via the gauge symmetry group SU(2) x U(1)) agrees so far with all experimental results. Despite these impressive successes, it is only a crude overall check of the model since only the results of first-order approximations (perturbations) have been verified.

The importance of radiative corrections in high energy electron-positron physics. For a hypothetical 92 GeV resonance for the Z particle – the electrically-neutral carrier of the weak nuclear force – in a spectrum of pairs of charged muons are shown non-photonic corrections (fine dashed line), the result (dashed line) of adding first order quantum electrodynamics corrections, and the result (solid line) of second order corrections applied to the first curve.

Refined calculations in modern field theory use successively finer approximations (perturbations) from a series expansion of possible interaction mechanisms, including multiple exchanges of the field particles transmitting the forces.

For a model to be elevated to the status of a theory such as quantum electrodynamics (QED), such higher order effects – called radiative corrections – have to be carefully checked by precision experiments.

Although the Z particle – the electrically neutral carrier of the weak force – was discovered at CERN's proton-antiproton collider back in 1983, precision studies of the Z become possible only with the advent of experiments at the new