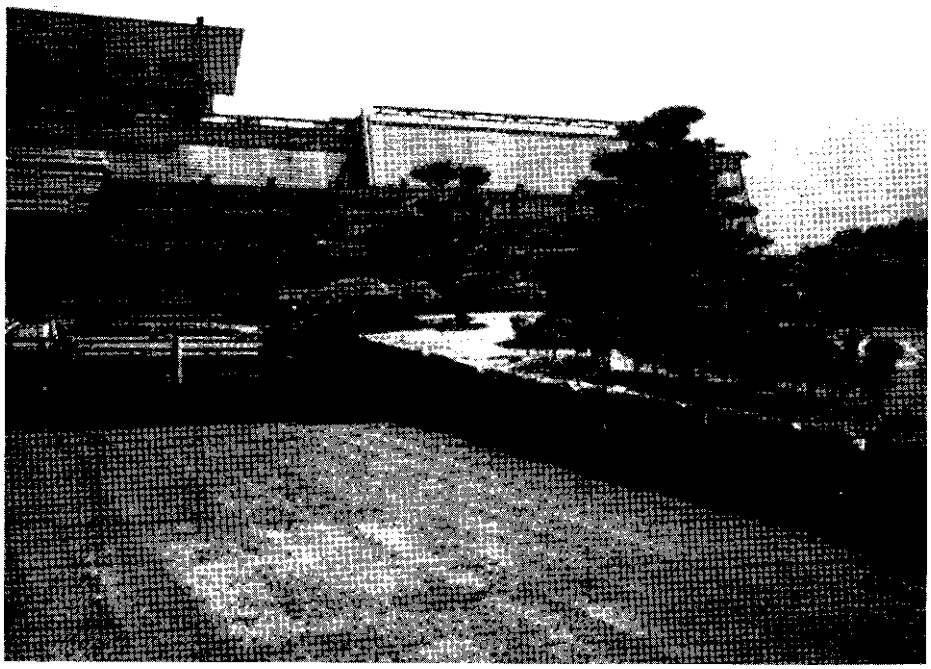
Anomaly Busters II

(Further report)

The Kyoto International Conference Hall, scene of the 7985 International Symposium on Lepton and Photon Interactions at High Energies.



'Reports of the death of the Standard Model have been greatly exaggerated/ observed Roy Schwitters of Harvard, paraphrasing Oscar Wilde for a summary of the International Symposium on Lepton and Photon Interactions at High Energies, held in Kyoto, Japan, from 19-24 August.

'1984 had been the year of the anomaly/ continued Schwitters, reeling off an inherited list of unexplained physics. Then came Kyoto 1985 and, according to Schwitters, the 'anomaly busters'. 'Perhaps the only outstanding physics question is the "dark matter" of the Universe,' he ventured, confessing to 'satisfaction' in the accumulated evidence in favour of the Standard Model (electroweak interactions plus the conventional quark/gluon field theory of nucleons).

The anomaly busters had struck on the first day .of the Kyoto meeting with Yoji Totsuka of Tokyo speaking on baryon number nonjjonservation and 'related topics'. The unstable proton is a vital test of grand unified pictures pulling together the electroweak and quark/gluon forces in a single field theory.

For several years, large underground passive experiments have been searching for signs of the unstable proton, and confidence has ebbed and flowed. Perhaps surprisingly for some, Totsuka concluded that there is 'no compelling evidence' for proton decay. The candidate events seen so far are not clean enough and the accompanying neutrino background is too high, he claimed. However he was not pessimistic, calling for an investment in more data from improved experiments.

Totsuka's 'related topics' included the unexplained muon pulses seen by some underground proton decay experiments scanning the sky in the direction of the star Cygnus X-3 (see September issue, page 264). Although nothing to do with baryon number nonconservation, this effect had nevertheless become a major physics talking point during recent months and warranted coverage. Totsuka was of the view that scans by underground experiments in the Frejus tunnel (France) and the Kamioka mine (Japan), in an admittedly different exposure time, do not reproduce what was seen earlier by the Soudan (Minnesota) and NUSEX (Mont-Blanc) studies, an opinion not universally shared.

The second day of the meeting started with an eagerly awaited talk by Carlo Rubbia on the continuing search for new physics at the CERN proton-antiproton Collider. The intrinsic interest of the accumulated data sample had been greatly increased by the Collider run earlier this year with energies being ramped (briefly) up to 450 GeV (see May issue, page 131).

The accumulated data shows as yet no evidence for so-called 'Centauro' events - cosmic ray interactions seen to produce very high levels of charged particles. However Rubbia could point to multiplicity results from the UA5 streamer chamber experiments (see also October issue, page 335) and to new indications from UA1 which show that the production of confined showers ('jets') of hadrons becomes more prolific at higher energies (more than tripling over the range 200 to 900 GeV). This, according to Rubbia, warrants continuing the search.

Said to be the largest wooden building in the world, the Todai Temple's Hall of the Great Buddha at historic Nara was on the itinerary of one of the excursions specially arranged for participants at the Kyoto Lepton-Photon meeting.

Jet activity accompanying W and Z particles now looks very much as expected, after some suspicion last year that this might not be the case. A handful of anomalous jet plus electron plus neutrino events reported last year by UA2 now looks more in line with the Standard Model.

Rubbia then turned to the controversial subject of 'monojets' - proton-antiproton collisions seen by the UA1 detector producing a jet of hadrons at large transverse momentum accompanied by the missing energy indicative of a neutrino or other invisible particle. As well as having more data, UA1 has relaxed a missing energy 'cut', which makes the monojets less distinct.

Rubbia pointed to events which can be clearly ascribed to decays of the heavy tau lepton, but indicated that a few additional monojet candidates might not be firmly caught in the Standard Model net.

John Ellis of CERN (speaking on the prospects for supersymmetry), was of the view that the number of observed monojet events is 'compatible with background processes'. Schwitters also chose to account for the monojet signals in terms of tau decays, pointing out an interesting example of role-reversal which had arisen in recent meetings, with theorists (normally the gold-diggers) frantically working out background levels while the experimenters indulged in supersymmetry calculations!

By comparing the observed signals of muon pairs carrying equal electric charge with those carrying opposite charge, UA1 is also trying to establish whether there is any mixing between neutral particles carrying the beauty quantum number (analogous to the mixing seen with the neutral kaons).

Rubbia's final topic was the preliminary evidence for the sixth 'top' quark seen in the production of widely separated jet pairs and an electron or a muon, accompanied by missing energy (see September 1984 issue, page 263). These are suspected to come from the decay of a W boson into a top quark and a bottom antiquark (or vice versa, depending on the charge of the W). According to Rubbia, the top quark candidates still cluster around a mass of 40 GeV.

Jon Rosner of Chicago, speaking the next day on heavy quarks, believed that the top quark has still to be found, and urged the Collider experiments to fix limits. Schwitters argued that the 30-50 GeV range for the top is possible, but 'not established', and hoped that scheduled detector improvements would help achieve better signal to noise ratios. He pointed out that the candidate top yield looks too high for all the events to be accounted for by W decay, and that Z decays might also be present.

After Rubbia, Luigi Di Leila from CERN took over for the more conventional results coming from the Collider. The figures now coming out from W and Z production are reaching a level of precision which ties in well with results from lower energy experiments, giving a universal value for the electroweak mixing parameters. The production of Ws and Zs looks very much as expected, allowing room for only a few additional neutrinos beyond the three types presently known, a result also pointed out by Rubbia.

'Fragmentation' or 'hadronization' (the way hadrons are produced from the colliding quarks and gluons) looks softer in the Collider than what is seen in electron-positron annihilation or at lower collision energies (CERN Intersecting Storage Rings). This suggests, said Di Leila, that the Collider's jets emanate mostly from gluons rather than quarks, a result underlined by a method developed at UA1 for explicitly comparing quark and gluon jets.

Another recent first from the Collider is the observation by UA2 of single photons coming from the electromagnetic interactions of quarks. The production level agrees with theory.

Gracing the Meson 50 Symposium in Kyoto in August was Madame Yukawa, widow of Hideki Yukawa who proposed the meson theory of nuclear interactions half a century ago.

Meson 50

This year sees the fiftieth anniversary of one of the turning points of modern physics - the late Hideki Yukawa's meson theory of nuclear forces. A three-day meeting in Kyoto immediately before the big Lepton-Photon Symposium brought together several hundred physicists in a fitting memorial to Yukawa's work. The Symposium's aim was to survey theoretical developments and the applications of meson physics over the past half century, together with coverage of recent advances and an exchange of views on future progress.

kAmong the big names at the Meson 50 meeting in Kyoto was Richard Feynman, seen here (standing) with Yoshio Yamaguchi of Tokyo, who was chairman of the organizing committee of the big Lepton-Photon Symposium held at Kyoto immediately afterwards.

Initial proceedings were given over to reviewing Yukawa's monumental work and to surveying the consequent evolution of physics, including the establishment of meson physics and its applications. Towards the end, attention turned to more speculative topics, with speakers questioning current physics dogma and highlighting unanswered questions, concluding with a look at the possible directions for tomorrow - strings, supercomputers and the cosmos.

Production of hadronic jets in electron-positron annihilations was handled by Hiroaki Yamamoto of Berkeley. Here the valiant struggle continues to account for the observed behaviour by one or other of the hadronization models currently on the market. While the independent fragmentation model now becomes more and more excluded, the cluster and string model candidates might be complementary, rather than competing, concluded Yamamoto.

Nuclear physicist Karl Bergkvist of Stockholm had been invited to present the talk on lepton number (non)conservation and neutrino mass. In this sector, experiments at DESY (ARGUS) and at PEP at Stanford are giving a lead on the mass of the tau neutrino, now estimated to weigh less than about 80 MeV (70 MeV in the case of ARGUS).

Elsewhere in the neutrino sector, there has been in recent years a spate of reports of odd effects. Anomaly Buster Bergkvist went about demolishing them, coming to the conclusion that there is presently 'no evidence' for neutrino oddities.

A report from Guelph, Canada, (see July/August issue, page 241) had suggested signs of a 17 keV neutrino in tritium decay. Several other experiments have now covered this ground and no confirmation has been seen.

Neutrino oddity number two had been the hint of 'oscillations' (mixing of neutrino types) reported last year by the experiment working at the Bugey reactor in France (see July/August 1984 issue, page 244). According to Bergkvist, members of a reactor experiment at Goesgen (Switzerland) are 'sceptical' of the Bugey result. The two sets of data are not compatible, and as the Goesgen limits are more comprehensive than Bugey, Bergkvist ruled that the Swiss study has 'anticonfirmed' Bugey's suggestion.

However the main thrust of Bergkvist's attack was directed against the ITEP (Moscow) results which for some years have been indicating that the electron neutrino must weigh several tens of electron volts. While preparing a similar study in Stockholm, he has made an in-depth study of the ITEP results. Bergkvist left his audience in no doubt of his objections to the ITEP analyses. At Kyoto, there was nobody to argue the case for the Moscow experiment.

New particle searches

High up on the list of 'expected' particles are those named after Peter Higgs and believed to be responsible for mass in the electroweak picture. Despite the great success of this theory, predictions of the Higgs particle mass are notoriously difficult to obtain. The experimental cupboard, too, is bare.

Sachio Komamiya of Heidelberg had the job of covering searches for new particles in electron-positron experiments. Despite all efforts, he concluded that no evidence has been seen for new particles, both expected and unexpected. Searches for free quarks, additional leptons and for 'substructure' (compositeness of quarks) all had drawn a blank.

Turning to his 'shopping list in the minimal supermarket', Komamiya showed a long list of limits gradually being pushed back by experiments at PETRA and PEP. Supersymmetry is still beyond the experimental horizon.

Long hot summer

As well as being unusually hot, this summer in Japan was very busy for physicists. As well as the big International Symposium on Lepton and Photon Interactions at High Energies, held in Kyoto from 19-24 August (some 900 participants), and the 50th Jubilee of the Meson Theory (Meson 50), held in Kyoto from 15-17 August (some 300 participants), there was the Tokyo Institute for Nuclear Study (INS) International Symposium on Composite Models of Quarks and Leptons, held at INS from 13-15 August (some 100 participants in addition to INS physicists), the International Symposium on Polarization Phenomena in Nuclear Physics, held in Osaka from 26-30 August, the International Workshop on Deuteron-Invo/ved Reactions and Polarization Phenomena held in Tsukuba from 22-23 August, and a small historical workshop on the history of particle physics in Japan as part of the US-Japan joint research project. Some participants in the major Japanese meetings this summer went on to other conferences in Seoul (Korea) and in Beijing.

Expo 85

Tsukuba Science City, home of an impressive list of Japanese national and commercial research centres, including the KEK High Energy Physics Laboratory, was also the scene of the mammoth Expo 85, which from 17 March to 16 September this year attracted millions of visitors from all over the world. Its theme was 'Dwellings and Surroundings - Science and Technology for Man at Home', and many of the big names of industry - IBM, Fujitsu, Mitsubishi, etc. - had mounted imaginative and striking exhibits. A continual message was the quest of science to probe the unknown, and in particular the infinitely small, so that generations to come would reap the harvest of new knowledge. The IBM exhibit, for example, highlighted the TRISTAN high energy machine nearing completion at nearby KEK. At Expo 85, Big Science was hailed at Man's Great Benefactor. No questions asked.

Several theoretical speakers underlined that despite the apparent unchallenged position of the Standard Model, it has too many free parameters to be the ultimate theory of Nature. There is a list of alternatives, basically divided into two camps: supersymmetric models of various kinds or composite models with quark substructure. The naturalness of the Standard Model points to new physics right round the corner/ observed Schwitters.

CERN theoretician John Ellis was cast in the role of supersymmetry high priest, and surveyed the short but turbulent history of searches for supersymmetric particles at the CERN Collider. After some initial optimism last year in missing energy events, 'the background had struck back', he said. Optimism revived during the brief 'gluino wars', but Ellis pronounced that what is now seen is 'compatible with background'. 'May God give us supersymmetry,' concluded Ellis and paraphrasing St. Augustine, 'but not yet'.

Alternatives to supersymmetry - technicolourand composite models - were described by Michael Peskin of Stanford. He was not as pessimistic as Komamiya as regards the limits of possible substructure within the quark, and stressed that until all forces are understood, as opposed to 'just unified', searches for new particles should continue. This could pay off in 'dramatic' new effects in the TeV region.

Ed Thorndike of Rochester covered the decays of heavy particles. Most of the decays of the tau lepton are 'just as they ought to be', but some still remain to be identi-

fy *charming hostesses at the Fujitsu Pavilion at Expo 85.*

(Photo G. Fraserj

fied. Turning to the decays of particles carrying the beauty quantum number, the world average lifetime of these weak decays as measured at electron-positron machines is about one picosecond, and comparing the yield of strange and unstrange quarks in these decays is still a hazardous affair. Overall, the data allow little room for movement in the (Kobayashi-Maskawa) six-quark model.

Carlo Caso of Genoa dealt with the production of these particles in hadronic experiments, where the observation of beauty particles in an emulsion experiment at CERN (see July/August issue, page 238) gives a somewhat shorter beauty quark lifetime, less restrictive for the six-quark model.

Charm physics was handled by Thorndike and by Rosner, who surveyed the impressive results from the Mark III detector in the Stanford SPEAR ring. The gas jet experiment which took data just before the closure of CERN's Intersecting Storage Rings showed just how closely this method can fix narrow bound states. The ARGUS experiment at DESY's DORIS II ring has found evidence for an additional heavy charm meson at 2420 MeV.

Opening the meeting with a talk on lepton-hadron reactions, Frank Sciulli of Columbia indicated how new data from the CERN/Dortmund/Heidelberg/Saclay/Warsaw neutrino experiment now ties in with the big Fermilab counter results, making the world picture of neutrino information much more coherent.

The 'EMC effect' (variation in the quark structure of nucleons with different nuclei - see September issue, page 270) is now well-established over a range of kinematical conditions, but the exact behaviour is still blurred in some places (small fractional momentum). Neutrino studies have yet to attain the level of precision required to see the effect, reported Sciulli.

Alfred Mueller of Columbia reviewed the current status of techniques in quantum chromodynamics (QCD - quark/gluon field theory), including the area of the EMC effect, indicating that QCD has a lot to tell us about the physics of quarks, and even nucleons. However he concluded with a fairly lengthy 'wish list' to increase the predictive power of this as yet immature field theory.

Following the example of other recent meetings, the theorists rallied behind the flag of 'superstrings', which are being heralded as hot contenders for the ultimate Theory of Everything (see June issue, page 185). Michael Green of London's Queen Mary College gave a memorable explanation of the relevance of superstring and related ideas to the current problems of particle physics.

By its very nature, the Lepton-Photon Symposium with its slant on basic interactions sidesteps some areas of particle physics, becoming an appealing forum for fundamental issues. The topicality of the Kyoto meeting was increased by the welcome decision of the organizers to bring in topics of interest which on the surface have little or nothing to do with the Lepton-Photon label.

Thus apart from Green on superstrings, there was Joseph Silk of California on galaxy formation, Claudio Pellegrini of Brookhaven on the prospects for future accelerators and detector specialist Georges Charpak of CERN on the outlook in his line of business. Almost a complete afternoon was given over to a presentation of the current status of big machine construction throughout the world, with Boyce McDaniel acting as spokesman for the US, Herwig Schopper speaking for CERN, Volker Soergel for DESY, Tetsuji Nishikawa for Japan, Zhu Hongyuan for Beijing, and N. Tyurin for Serpukhov.

Sponsored by the International Union of Pure and Applied Physics, the Science Council of Japan, the Physical Society of Japan and the Japan World Exposition Commemorative fund, supported by Tokyo's Institutes for Nuclear Study and Cosmic Ray Research and by the Japanese KEK Laboratory, and hosted by Kyoto's Physics Department and Research Institute for Fundamental Physics, the Symposium was a model of efficiency and intelligent organization. The Organizing Committee, chaired by Yoshio Yamaguchi of Tokyo, and the Local Organizing Committee, chaired by Kozo Miyake, are to be congratulated on providing a programme in keeping with the fine cultural tradition of the historic city of Kyoto.

By Gordon Fraser

Around the Laboratories

At the meeting of the SSC Magnet Selection Advisory Panel at Berkeley in August: 1. Panel Chairman Frank Sciulli, left, with Russ Huson who did much work in driving along the low field, superferric magnet development at the newly formed Texas Accelerator Center.
2. At the table (left to right) are Ron Yourd, Peter Limon, Maury Tigner (Director of the SSC Central Design Group) and Eberhard Keil.
3. An attentive audience: (left to right) John Rees, Bjom Wiik, A/vin Tollestrup, Ron Yourd, Carl Goodzeit, C -H. Dustmann, Ted Wilson, R. Beuligmann and Bob Diebold.

(Photos Dave Jackson)

SUPERCOLLIDER
Magnet decision

A very important step in the preparatory work for the US 20 TeV Superconducting Super Collider (SSC) project was taken in September with the selection of the type of magnet to be used for the collider rings. This decision not only allows a concentration of effort on the selected magnet type but also has impact on many other aspects of the machine design. In particular it carries in its wake the determination of the machine circumference with its implications for site selection and for tunnelling costs. There are implications for many other machine components, such as the racjiofrequency system, and with all these machine features now more firm, a more precise cost estimate can be made.

Four Laboratories played major roles in preparing the necessary information to take the magnet decision - Berkeley, Brookhaven, Fermilab and the newly-formed Texas Accelerator Center. The first three eventually collaborated on what became known as the high field or conductor-dominated design. Their magnet aims for a 6 T field (in fact, given the steady improvements in the quality of niobium-titanium superconductor in recent years, this design figure was raised to 6.4 T not long before the magnet decision) and the field quality is dictated by the configuration of the current-carrying superconducting cable. For 20 TeV proton beams this field level implies a storage ring of about 90 km.

1.

2.

3.

The research and development work on the magnet was divided amongst the three collaborating Laboratories. At Berkeley the emphasis was on the improvement of the superconducting cable and the construction of some short magnets. At Fermilab (the home of the superconducting Tevatron) the emphasis was on the cryogenic systems, since it is hoped to reduce the heat load of the SSC magnets by a factor of at least five by comparison with the Tevatron magnets, and on some tests of 'dry winding'of the magnet coils. At Brookhaven a series of longer magnets were built and in July a 4.5 m demonstration magnet of the high field design was successfully tested. Since then three other 4.5 m magnets have also surpassed the design specification (see October issue, page 332).