CERN COURIER

International Journal of High Energy Physics

VOLUME 25 9 NOVEMBER 1985

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CERN COURIER is published ten times yearly in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management

Printed by: Cranford Press
Croydon, England.

Published by:
European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 83 61 11, Telex 419 000
(CERN COURIER only Tel. (022) 83 41 03)

USA: Controlled Circulation
Postage paid at Batavia, Illinois

CERN COURIER

International Journal of the High Energy Physics Community

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Cover photograph: The pagoda of the Kofokuji Temple at Nara in Japan, destination of one of the excursions specially arranged for participants at the International Symposium on Lepton and Photon Interactions at High Energies, held in Kyoto in August – see page 377 for a report of the meeting (Photo G. Fraser).

Echoes of a report

Kendrew report opponent John Mulvey – 'A sorry song for Europe'.

Report opponent Erwin Gabathuler – 'another act of scientific barbarism'.

In March 1984, two bodies responsible for science research policy and funding in the United Kingdom – the Advisory Board for the Research Councils (ABRC) and the Science and Engineering Research Council (SERC) – asked for a Committee to investigate the UK's participation in high energy physics in general and in CERN in particular. The enquiry was in the context of continually reduced levels of public sector expenditure in the UK, which have caused severe cutbacks in all non-defence research spending. The Committee, under the chairmanship of Sir John Kendrew, a distinguished molecular biologist, included other scientists, an industrialist and an economist, but no particle physicist. The 150-page report was published on 18 June this year.

The bulk of it is highly complimentary towards high energy physics which it describes as 'enormously exciting, exhilarating and intellectually rewarding'. It is also highly complimentary about the way in which the research is managed and about CERN's role as an international scientific enterprise. To quote UK physicist John Mulvey, 'For the Committee, no praise seemed too high for particle physics research, for the accomplishments of British physicists and for the excellence of CERN'. One of the Committee members, Eric Ash of London's University College, said 'CERN should be regarded as one of the brightest jewels in the scientific crown'.

Despite this fulsome praise, the report ended abruptly with the following major conclusions –

That the UK should remain a Member State of CERN on the present basis until 1989 but should continue its membership beyond 1989 only at significantly lower cost;

The subject is worth pursuing but the proportion of the SERC budget now taken is too high;

UK withdrawal would be a major blow to the science both of the UK and of the rest of Europe with long term detrimental implications for international collaboration;

Progressive reduction of the UK total expenditure on particle physics should attain at least 25 per cent by 1991;

The recommended reductions would still allow the Laboratory to maintain itself at a world class standard;

Irrespective of the present acute financial situation, the overall level of expenditure on the subject is too high.

The report met a great deal of criticism in the UK Press which emphasised the apparent incompatibility between the body of the report and the conclusions.

The Times thundered 'Withdrawal from CERN would be withdrawal from an unusually successful form of European joint-action and of international scientific collaboration. It would mark the effective end of Britain's long and leading contribution to the scientific study of the nature of matter. It would do more harm to the esteem and animal spirits of the scientific community in this country than any good the redistributed funds might do.'

The New Scientist remarked on the report's 'strange lack of consistency' and added 'CERN's worth cannot be measured in Swiss francs, non-stick frying pans, or even in Nobel prizes. Its value lies in the fact that it has long surpassed its aim to bring Europe together. CERN has become a truly international Laboratory. It deserves better analysis and thought than are evident in this report.'

Nature commented 'The decision that there should now be a reconsideration of continued British membership of CERN will further reinforce the impression that the British have concluded that their sceptred isle north of the white cliffs of Dover would be better off on its own.'

Particle physicists in the UK naturally reacted very strongly. Chris Llewellyn Smith of Oxford, who had served as consultant to the Committee, said 'The unsubstantiated contention that a 25 per cent cut in the CERN budget by 1991 is attainable and would allow CERN to maintain itself at a world-class standard is false.' John Mulvey, also of Oxford, concluded a New Scientist article headed 'A sorry song for Europe' with a quote from a West German delegate: 'If Britain followed that course it would be advertising its resignation as one of the West's technologically advanced nations'. Erwin Gabathuler of Liverpool referred to the proposal as 'another act of scientific barbarism towards Europe'.

The European Committee for Future Accelerators (ECFA) tabled its own response: 'ECFA considers that the Kendrew Committee's call for a cut of at least 25 per cent in the CERN budget by 1991 is totally unrealistic, and is in fact incompatible with the Committee's stated aim of ensuring that research of world class standard is continued at CERN.

A cut of 25 per cent in the CERN budget would imply a cut of 50 per cent in the materials budget and the consequential cessation of most experimental activity. This is because the conditions of employment of CERN staff and fixed overheads mean that any cuts would fall on the experimental programme. It is not rational to construct a new facility such as LEP and then to create conditions that preclude its exploitation.

Building LEP within a constant budget is already placing enormous strain on the organization and much essential expenditure on refurbishment and maintenance is being deferred until after the construction period. This backlog must be made up after 1990 in order to maintain the operational efficiency of the accelerators and to minimize safety hazards.

These and other considerations lead ECFA to the inevitable conclusion that CERN will be unable to carry out the research programme for which LEP is being constructed, and maintain its current position of scientific excellence and leadership, unless present budget levels are preserved beyond 1989. ECFA believes that the Member States of CERN should agree its future budgets on the basis of their own scientific priorities and international commitments.'

Meanwhile particle physicists in the UK are marshalling their forces. At a meeting at London's Imperial College on 23 September to discuss the situation, Abdus Salam argued 'should there not have been a Kendrew Report on Defence Research, its performance and its efficiency, at the same time? Should not one have questioned why UK defence research should spend 59.4 per cent of the public R&D budget – and not, say, the 40 per cent the French do, before particle physics is destroyed, just so that the other basic sciences gain one third of one per cent at the end of the exercise?'

The UK Institute of Physics has given its approval to the formation of a new Institute group for high energy particle physics, under the chairmanship of Robin Devenish of Oxford and with Brian Foster of Bristol as Secretary.

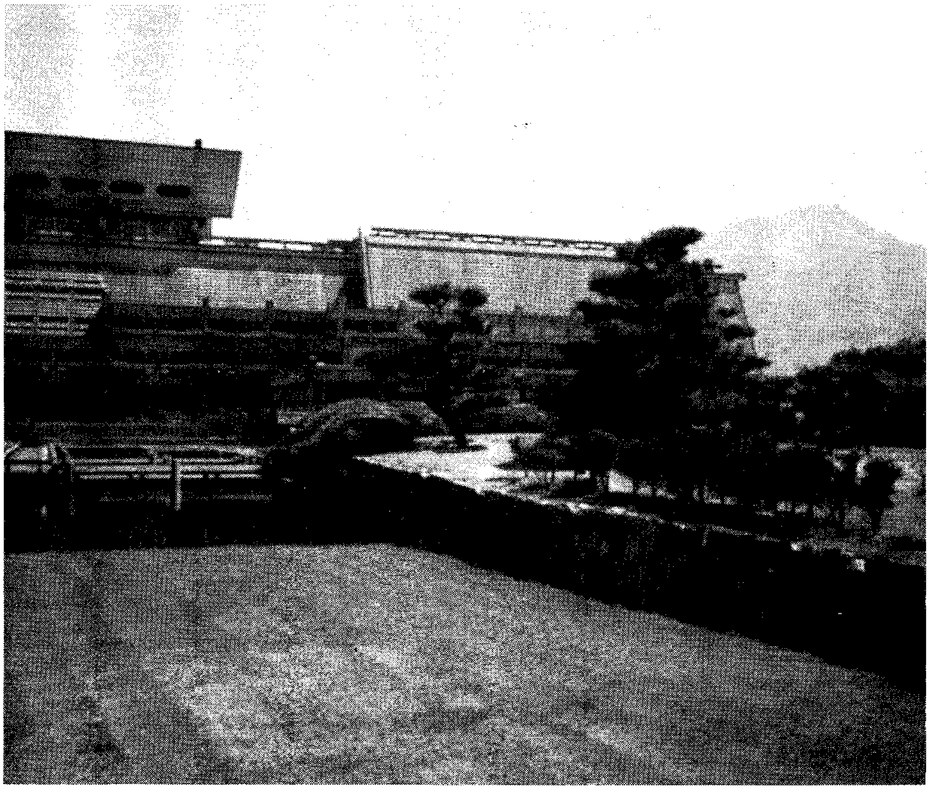
Its first meeting is scheduled for Imperial College, London, on 27 November, where the subject will be 'Particle physics – now and the next ten years'. Speakers will be Peter Higgs on theory, Peter Kalmus on proton-antiproton collider physics, Roger Barlow on electron-positron interactions and Don Perkins on the lepton-nucleon sector. In addition there should be an animated round table discussion on the status of particle physics in the UK. Those wishing to attend should contact Brian Foster at Bristol's Department of Physics.

The report from the Kendrew Committee was endorsed by the SERC and the ABRC in July and is now being considered at UK government level. It is thought likely that the government attitude will be known in advance of the December Session of the CERN Council.

Anomaly Busters II

(Further report)

The Kyoto International Conference Hall, scene of the 1985 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 nonconservation 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 Fréjus 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 Lella 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 Lella, 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.

▲Among 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.

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.

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-Involved 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.

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 – technicolour and 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-

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.

The charming hostesses at the Fujitsu Pavilion at Expo 85.

(Photo G. Fraser)

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.

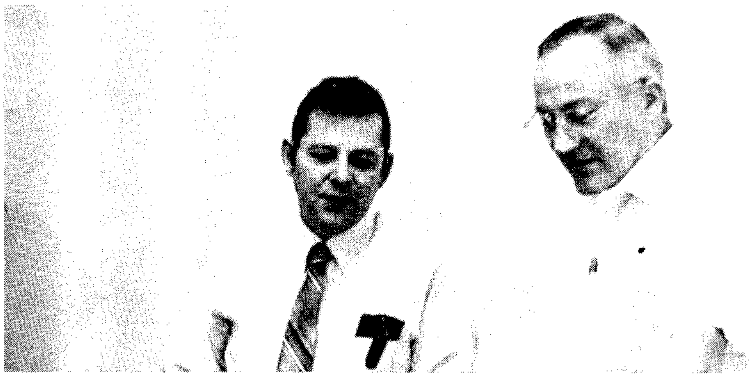
By Gordon Fraser

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, Bjorn Wiik, Alvin Tollestrup, Ron Yourd, Carl Goodzeit, C. -H. Dustmann, Ted Wilson, R. Beuligmann and Bob Diebold.

(Photos Dave Jackson)

SUPERCOLLIDER
Magnet decision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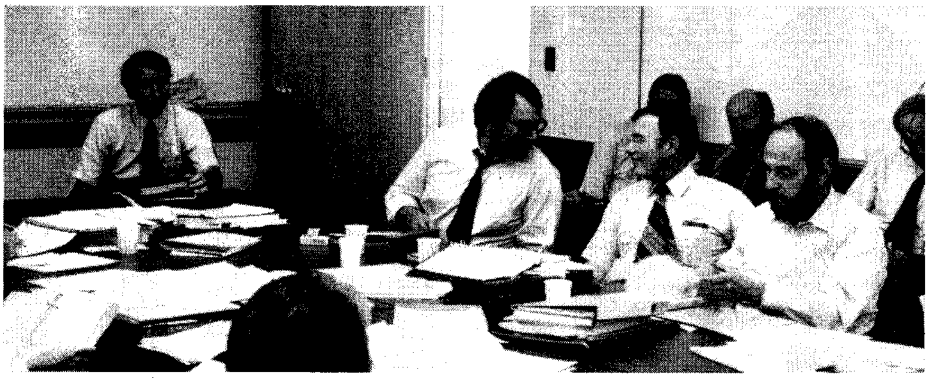
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A very important step in the preparatory work for the US 20 TeV Superconducting Super Collider (SSC) project was taken in September with the selection of the type of magnet to be used for the collider rings. This decision not only allows a concentration 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 radiofrequency 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.

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).

Late news: On 13 October Fermilab (US) achieved its first collisions of proton and antiproton beams, at a record-high total energy of 1.6 TeV (1600 GeV, 800 GeV per beam) and first events were recorded – a fine achievement by both the machine and experimental physicists.

The Texas Accelerator Center concentrated on another approach aiming for simplicity in construction and hence lower fabrication costs. Their design is a low field superferric magnet in which the field configuration is partly determined by the shape of the iron pole pieces. With the enthusiasm and motivation of a new Laboratory, they made quite remarkable progress in developing this concept. Evolving through several pole face and conductor configurations, they built and tested a series of magnets. They also pushed collaboration with industry further than the other Laboratories and had magnets built by General Dynamics.

Since the design field of the superferric magnets is 3 T, the corresponding storage ring is much larger (about 160 km) than for the high field type. The TAC therefore paid a lot of attention to ways of reducing tunnelling costs. In collaboration with the Texas Engineering Experiment Station of A. and M. University, they have started investigating a new tunnelling technique (known as CUTS – Continuous Unitized Tunnelling System) which is a horizontal version of the familiar technique used for the continuous forming of concrete liners such as is used in the building of silos. This development could obviously have important applications outside the field of accelerator building.

There have been several important steps over the past year en route to the final decision. A Technical Magnet Review Panel reported last December guiding the participating Laboratories as to the information that they would need to have in place prior to the decision.They also presented a final report conveying their opinions on technical aspects. An Aperture Task Force studied the particle dynamics of the proposed machine and fed back to the magnet experts the implications for the magnet aperture. Two other task forces were set up by the SSC Central Design Group – a Cost Comparison Task Force, whose role was obvious, and an Operations and Commissioning Task Force whose role was to examine the operational implications of each of the proposed magnets.

Finally a Magnet Selection Advisory Panel was set up under the Chairmanship of Frank Sciulli with Eberhard Kiel, Neal Lane, Michael McAshan, John Rees, E. Parke Rohrer, Alvin Tollestrup, and Bjorn Wiik. There were also three industrial consultants. They met at Berkeley at the end of August and their unanimous decision for the high field magnet was accepted by Maury Tigner, Director of the SSC Central Design Group, who announced the decision on 19 September. This magnet was preferred because of its well understood behaviour and for several relative cost implications of its corresponding ring size.

Much work remains to be done to refine the design and optimize the magnet cost. It is hoped that all the Laboratories will participate in this further work. Meanwhile other preparatory steps towards project authorization have been taken. A 'Siting Parameters Document' was issued in June giving general guidance on the various criteria (both technical and social) which should influence the selection of the site for the Collider. These criteria are helping States keen to be host to the SSC to prepare their proposals.

CERN U(A)pgrading

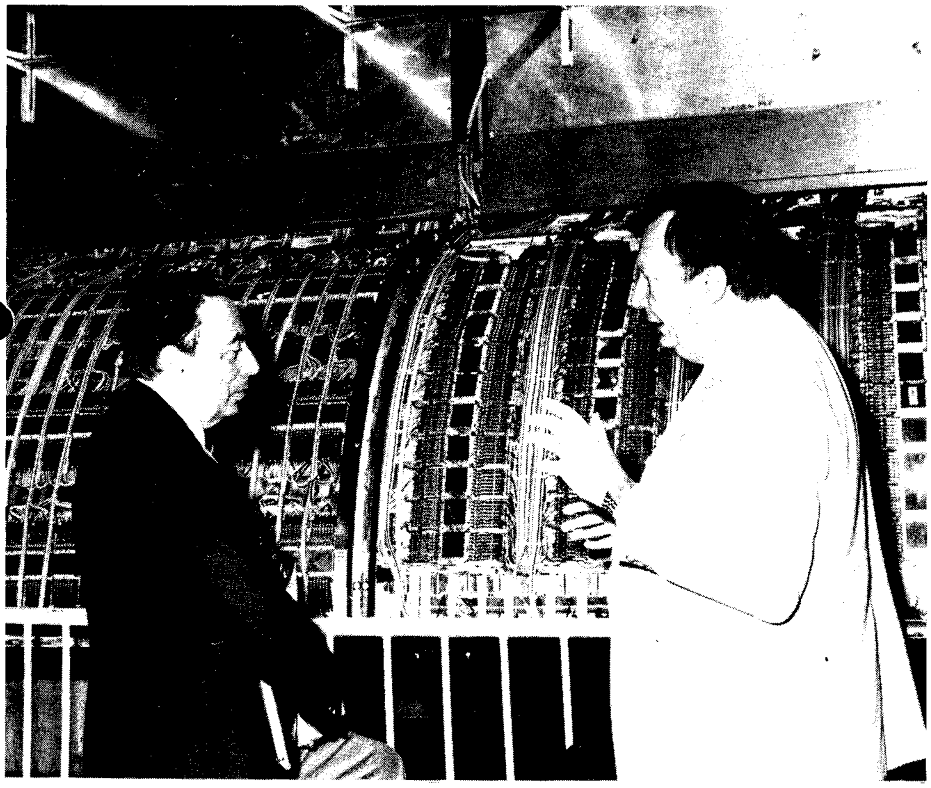
With a sizeable clutch of physics discoveries already to their credit, the big UA1 and UA2 experiments at CERN's proton-antiproton Collider are one of the big success stories of modern physics. Not content with resting on these laurels, both experiments have embarked on major refits to take advantage of the improved collision rates which will be available when the new ACOL Antiproton Collector Ring comes into operation in 1987.

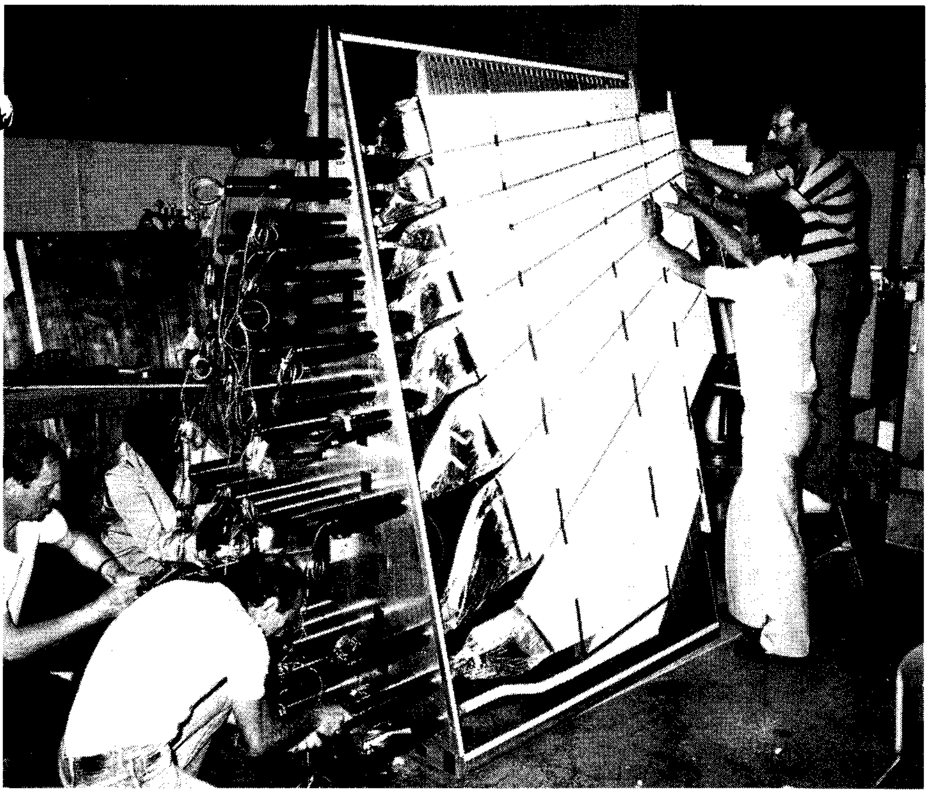
The initial phase of UA1's improvement programme involved installing new muon shielding and detection systems, a new microvertex detector immediately surrounding the beam pipe, and a faster and more powerful data acquisition and triggering system (see June 1984 issue, page 189). These new elements are being run in during the present Collider run, so that further improvements can be carried out during the long Collider shutdown, beginning next year, when the new ACOL ring will be installed.

When the initial UA1 design was drawn up, convincing evidence for confined sprays ('jets') of hadrons had yet to be seen. At Collider energies, jet physics has become a key feature. To improve the performance of the detector both for this work and for W and Z physics, the UA1 team is planning a further upgrade with a new fine-grain uranium calorimeter for both hadronic and electromagnetic energy measurement. The detecting medium will probably be a liquid operating at room temperature if a

Carlo Rubbia (right) explains the tracking chamber of the UA1 experiment at CERN to Erich Bloch, Director of the US National Science Foundation. The UA1 detector is undergoing a series of upgrades to exploit improved proton-antiproton collision rates.

(Photo CERN 97.6.85)





safe liquid can be made to work satisfactorily. Successful results have already been obtained with tetra-methyl silane (TMS), but this boils too easily (26.5°C).

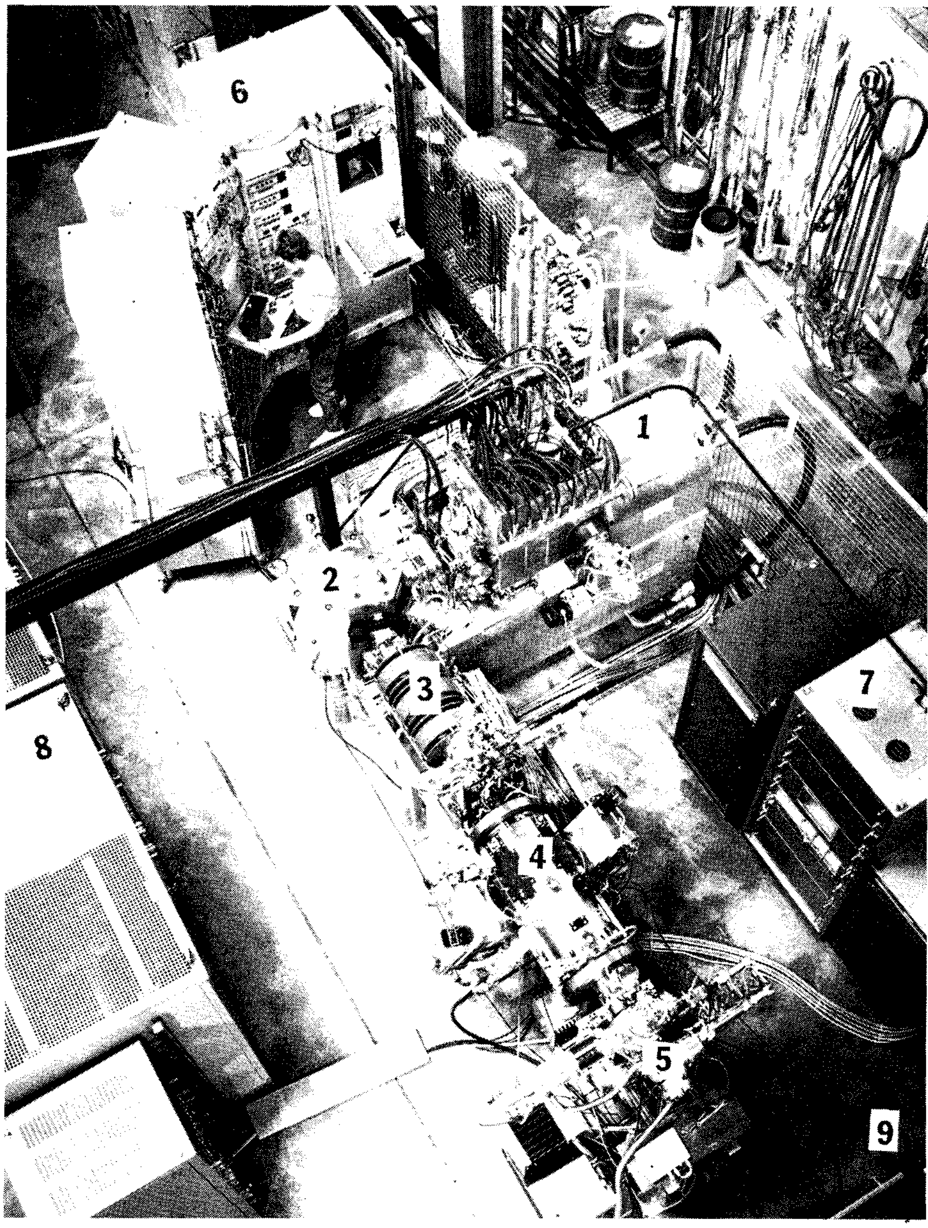
The UA2 detector is likewise undergoing a thorough facelift. A modified collaboration (Bern/Cambridge/CERN/Milan/Orsay/Pavia/Pisa/Saclay) is rebuilding the apparatus to provide better solid angle coverage, especially in the forward zones, and to improve the electron signal. The new UA2 lineup includes members of the Cambridge (UK) team from the UA5 streamer chamber experiment which used to alternate with UA2 for Collider data-taking.

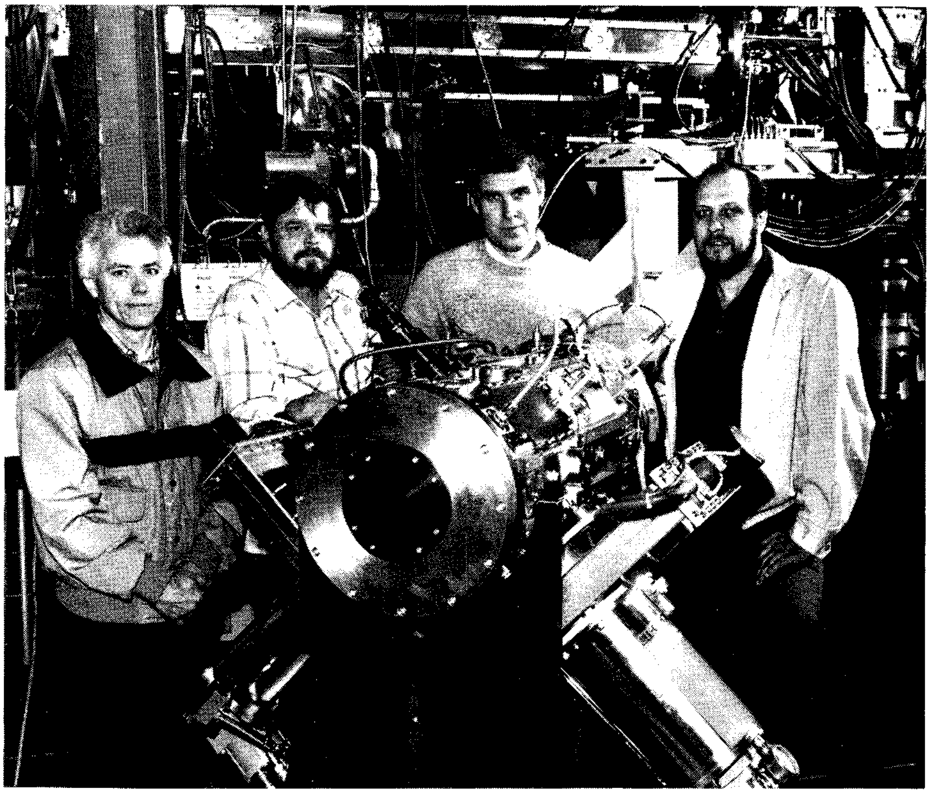
Prototype equipment for the endcaps to close the detector (calorimetry, preshower counters and triggering) have been successfully tested. The main central calorimeter will benefit from new jet vertex detection (the flash analog/digital conversion readout system is already installed), silicon hodoscopes and transition radiation detectors. The use of scintillating fibres is planned to provide a compact good resolution tracking device to make room for the new transition radiation units.

To further increase the power of the detector, the UA2 team is introducing a new data acquisition and triggering system based on the FASTBUS standard and using the new generation of microprocessor-based emulators. The overhaul is scheduled to be complete when the Collider, boosted by the new ACOL ring, switches on again in 1987.

Assembling equipment (calorimetry, to measure energy deposition) for the new endcaps of the UA2 experiment at the CERN SPS proton-antiproton Collider.

(Photo CERN 991.7.85)





Whiff of oxygen

The oxygen ion injector, which will be installed on linac 1 at the CERN proton synchrotron, is seen here undergoing tests at GSI Darmstadt. The indicated components are – 1) ion source from CEN Grenoble, 2) analysing magnet and 3) beam transport from Darmstadt, 4) radiofrequency quadrupole from Berkeley (see below), 5) beam monitor, 6) control unit, 7) ion source generator, 8) ion source power supplies, 9) RFQ generator from CERN.

The tests at Darmstadt went very well. More than 95 per cent of the 80 microamp current of oxygen ions could be transmitted through the injector. The injector is being transferred to CERN and first tests on Linac 1 are scheduled for February of next year. Several experiments to use the ion beams are being prepared and will be covered in a forthcoming article.

(Photo Darmstadt)

A radiofrequency quadrupole has been completed at Berkeley as part of the Berkeley/CERN/Darmstadt collaboration's goal of doing experiments with oxygen 16 ions in the CERN machines. Seen here is the Berkeley RFQ team, left to right, Bob McGill mechanical technician, r.f. engineer Don Howard, design physicist John Staples and project leader Rick Gough.

(Photo Berkeley)

KEK
Amiable AMY

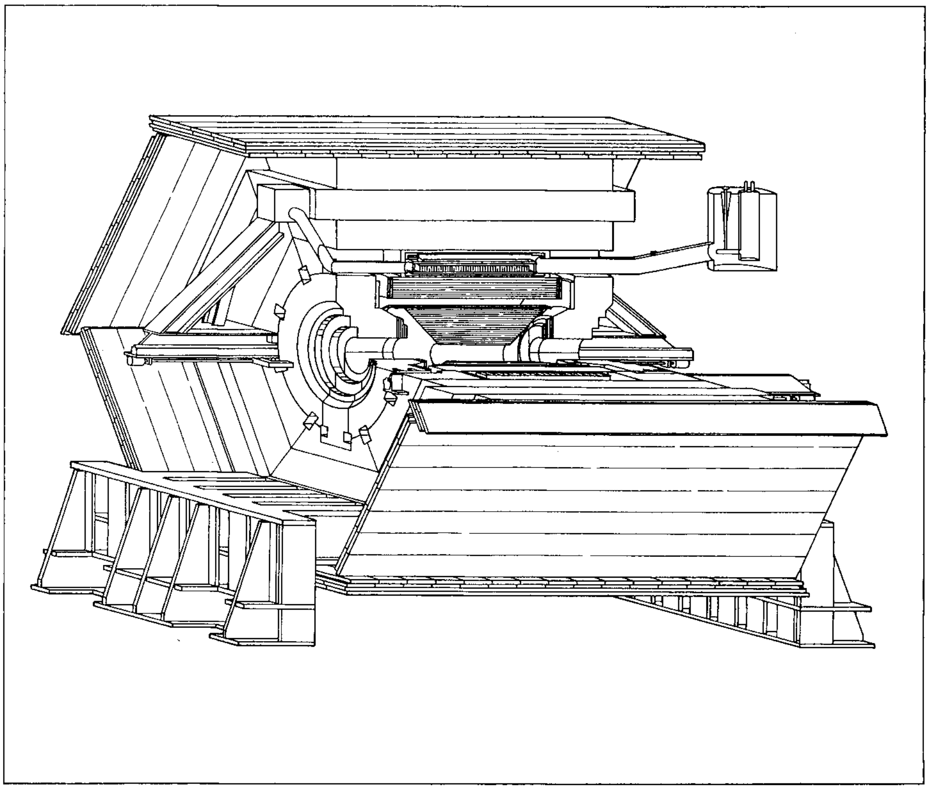
The big VENUS and TOPAZ experiments appeared on the scene relatively early as part of the grand plan for the TRISTAN electron-positron collider now being built at the Japanese KEK Laboratory (see October issue, page 325). Then in 1982 letters of intent were invited for experiments to use the remaining two beam collision points available in the TRISTAN machine.

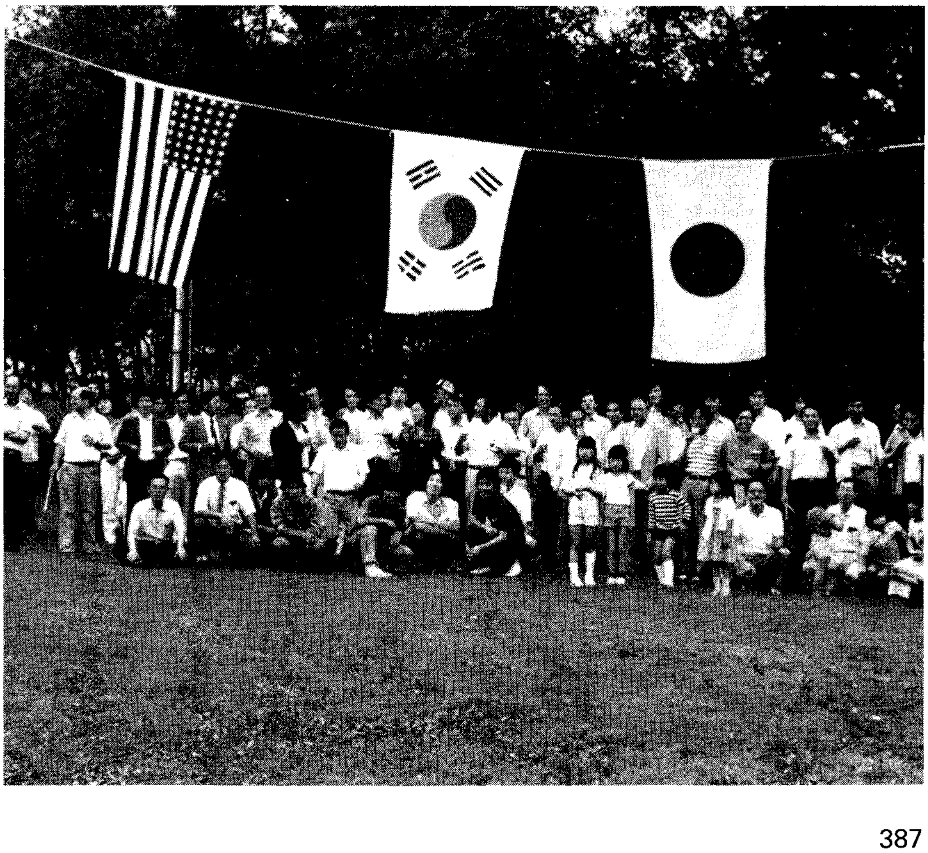
One outcome is AMY, a Japan/US/Korea/China collaboration, which along with the Collider Detector Facility (CDF) at Fermilab, is one of the major examples of US/Japan collaboration in particle physics. While CDF is a much larger project, the level of Japanese collaboration in AMY is higher (50 per cent versus about 15 per cent in CDF).

A modest detector by some present day standards (overall weight 750 tons and a height of 5.5 m), AMY is about five times smaller than the two big detectors being assembled at KEK. However this does not dampen the enthusiasm or lower the physics horizons of the team exploiting this compact high resolution lepton detector.

To achieve good resolution in such a relatively small detector, an internal magnetic field of 3 T will be supplied by a superconducting magnet using thick 8 cm copper clad winding, so that only muons will be of interest outside the magnet yoke. Two layers of iron shielding outside the magnet will purify the muon signal.

The compact high resolution lepton detector AMY now being constructed by a Japan/US/Korea/China team for use at the TRISTAN electron-positron collider at the Japanese KEK Laboratory. Inside the 3T superconducting magnet will be a high resolution drift chamber, with muon detectors outside the magnet and the subsequent iron shielding.





Fourth of July AMY style, with Koreans, Japanese and Chinese joining the traditional US Independence Day celebrations.

Focusing quadrupoles penetrating deep into the detector's forward regions will also ensure that AMY benefits from maximum collision rates of electrons and positrons, which could attain several times the level seen in the other experimental areas.

Immediately surrounding the collision region will be the cylindrical tracking chamber (KEK and Rochester) being assembled in the KEK workshops. A special hexagonal geometry has been designed to exploit the high magnetic field, and the 32 000 wires between an internal diameter of 30 cm and an outer diameter of 130 cm promise a resolution down to about 100 microns.

Outside the tracking chamber in the final version of the detector will be xenon X-ray counters fitted in a 10 cm radial gap to pick up the synchrotron radiation from electrons. However this will probably not be ready for the initial runs, when trigger counters supplied by Beijing will be used.

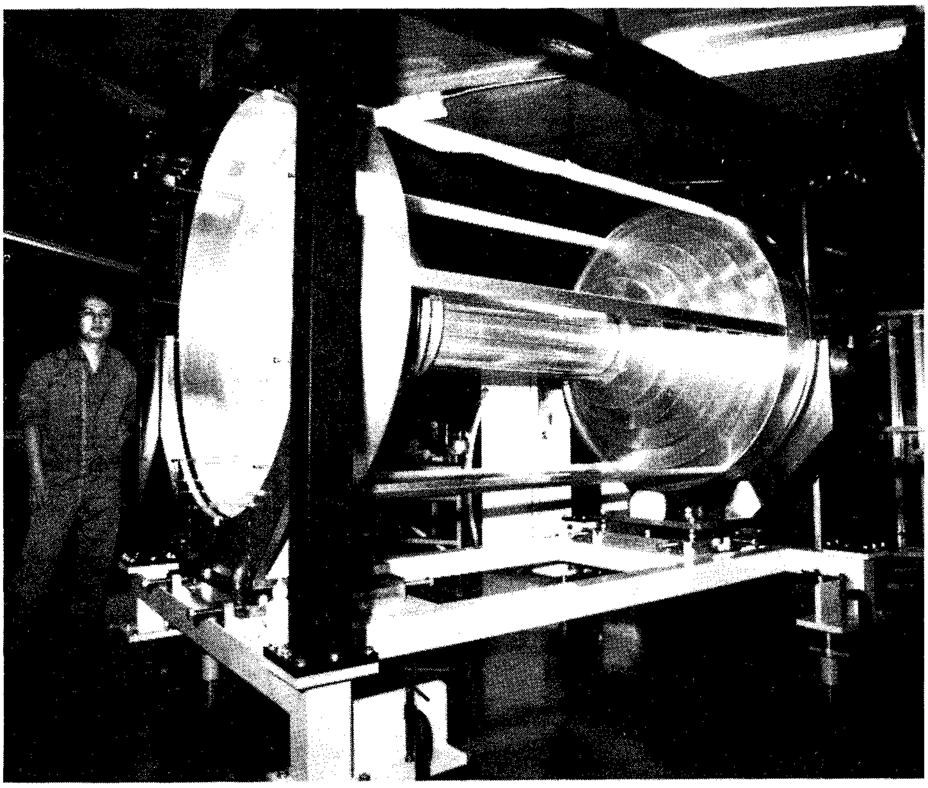
Immediately inside the magnet will be the (lead and plastic) electromagnetic shower counter, the responsibility of a Virginia Polytechnic/Rutgers/Davis sub-collaboration.

The outer muon chambers, supervised by Louisiana State and Tokyo Institute of Technology but built in the KEK workshops, will be arranged in four layers.

Most of the forward space normally reserved for endcaps will be taken up by the beam focusing quadrupoles, but veto counters will be fitted to provide some particle coverage in these regions.

As well as being compact and multinational, AMY also differs from the two big TRISTAN experiments in the relative high use of facilities and skills available in the KEK workshops. Many of the components for VENUS and TOPAZ are supplied by Japanese industry.

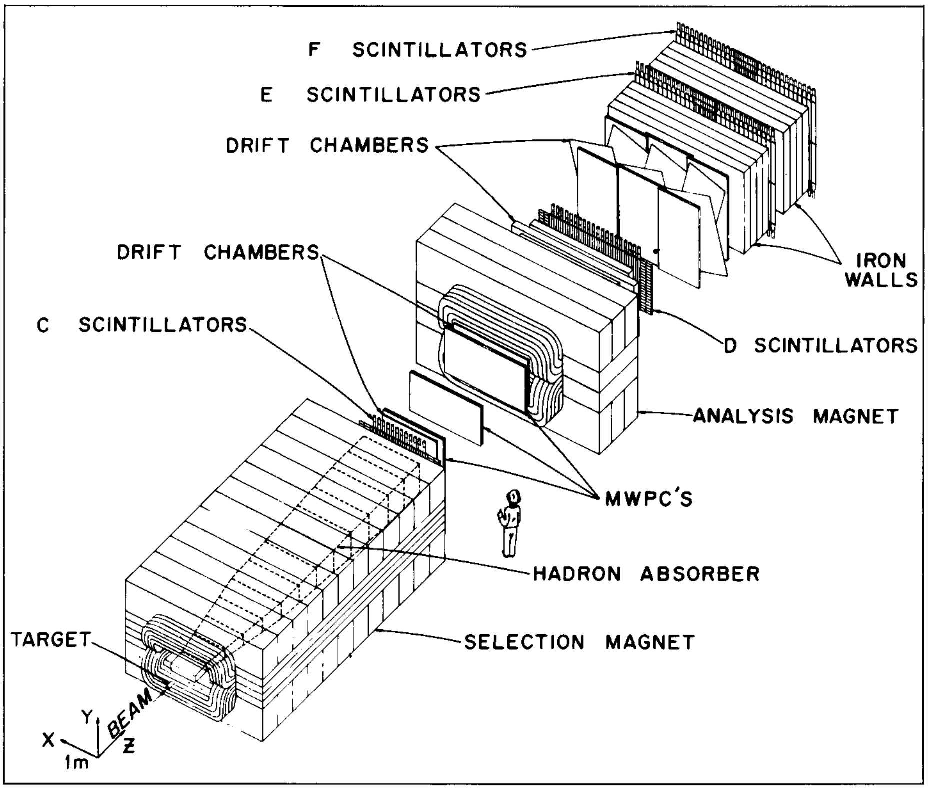
Far from being discouraged by seeing bigger detectors and other machines with higher energy, the AMY team sees a great opportunity to search for new physics. The top quark is still not excluded in the TRISTAN energy range, which could be a promising place to look for signs of any further generation of quarks and leptons which might exist.



The central tracking chamber for AMY under construction in the KEK workshops. Fitted with 32 000 sense wires arranged in a special hexagonal geometry, the detector should be able to resolve down to about 100 microns.

Physics monitor

...e Chicago/Fermilab/Iowa/Princeton experiment at the Fermilab Tevatron looks at the forward muon pairs focused by a selection magnet.



Probing the pion

A transient (virtual) photon, produced deep inside a particle collision, can provide a sharp 'X ray' of the particles which produced it. Such photons, materializing as lepton pairs, are copiously produced when an antiquark from a beam particle annihilates with a quark in a target nucleon.

Lepton pairs have been a fruitful source of new resonances (J/psi, upsilon, Z°), but it is the background lepton pairs, away from the resonances, which reflect the behaviour of the transient photons and open up the inner structure of the colliding particles.

This 'Drell-Yan' mechanism (named after the two pioneering physicists) was originally formulated in 1970, but has been considerably refined by incorporating new ideas from quark/gluon field theory (quantum chromodynamics – QCD) which were unknown fifteen years ago.

With beams of nucleons, the only antiquarks available to annihilate with the quarks of the target nucleons come from the additional dressing of the beam particles ('sea quarks'), supplementing the valence quarks. However when beams of pions are used, valence antiquarks are available, so that muon pairs are produced more readily than with nucleon beams.

This provides a powerful means of probing the structure of the pion, a commonplace enough particle, but which is difficult to use as a fixed target for other particle beams.

Several years ago, experiments at CERN (CERN/Collège de France/ Ecole Polytechnique/Orsay/Saclay) and at Fermilab (Chicago/Princeton) exploited this technique and made the first measurements of the quark structure (structure function) of the pion. In addition, these (and other) experiments tested the Drell-Yan picture, and found in particular that the muon pair signal was consistently higher than the predicted value, requiring the introduction of an empirical 'K factor'. This quantity has never been well understood, and many theorists consider that the complexity of the quark interactions requires something more than just a numerical factor to get things right.

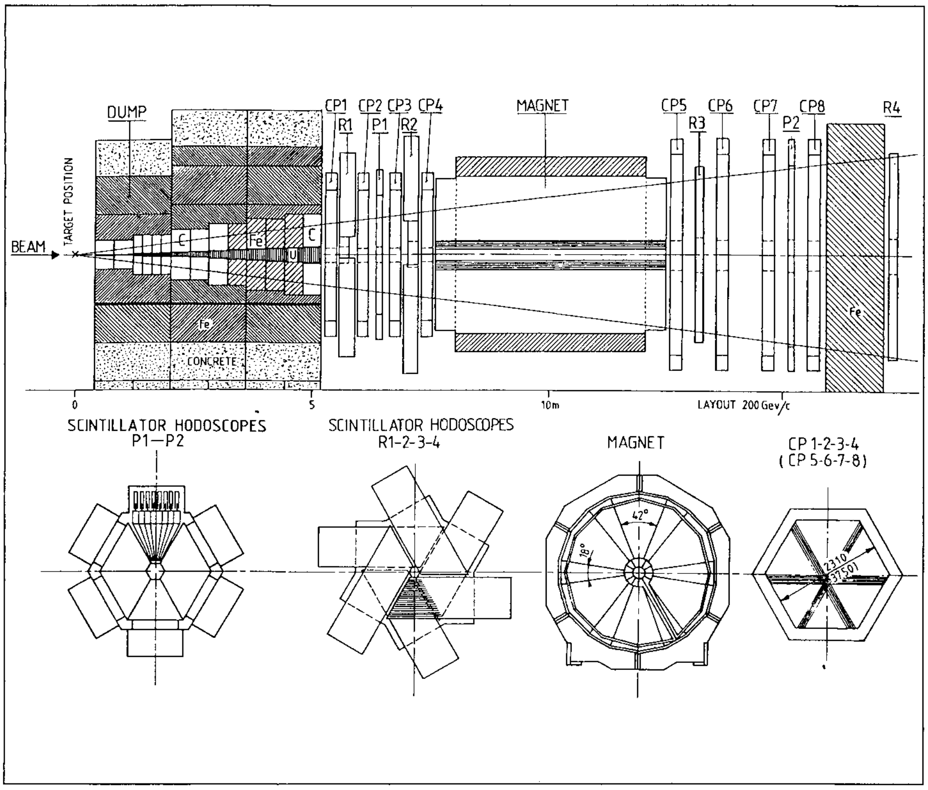
Meanwhile a new generation of experiments was prepared. At CERN, the NA10 (CERN/Naples/Palaiseau/Strasbourg/ETH Zurich) team set out to exploit the very intense pion beams (up to several 10^9 pions per pulse) available from the 450 GeV Super Proton Synchrotron.

The initial batch of data, from 155 000 194 GeV negative pion interactions and producing muon pairs heavier than the J/psi resonances, has yielded incisive results (see April issue, page 104), and further data from 140 and 300 GeV pion beams should shortly be available.

John Rutherfoord of Washington, the speaker on this topic at the recent major Lepton-Photon meeting at Kyoto (see page 377), described NA10 as having some 'pretty data'.

For muon pairs lying between the J/psi region and the upsilon resonance band, the results are in good agreement with the previous experiments. Using the most up-to-date QCD calculations, the uncertainty in the knowledge of the

The CERN/Naples/Palaiseau/Strasbourg/ ETH Zurich experiment at CERN studies muon pairs produced by high intensity pion beams.



sea quark dressing of the pions means that the predicted and observed muon pair spectra become compatible, dispensing with the need for a K factor.

However for heavier muon pairs, above the upsilon region, a K variable, depending on kinematics, rather than just a numerical constant, is required to bring the theoretical and observed distributions into line. The quark structure of the pion is also seen to evolve, the changes being larger than anything which can be attributed to uncertainties in the input quantities. Thus the results from running with 140 and 300 GeV pion beams are eagerly awaited.

Many of the problems of quark calculations stem from the intrinsic difficulty that the quarks are not free, but are bound tightly inside nucleons or other particles. However the measured quark structure of the pion shows that a quark in a pion can carry more of the total momentum than can a quark in a proton.

The aim of the new Chicago/Fermilab/Iowa/Princeton study at the Fermilab Tevatron is to look specifically at the forward production of muon pairs. According to the measured quark structure of the pion, under these conditions the pion antiquark takes up most of the total pion momentum. Thus a laboratory particle, at least kinematically, becomes a close approximation to a quark (of course the quantum numbers of a pion and a quark are different).

In this experiment, a 'selection' magnet upstream of the large aperture magnetic spectrometer focuses heavy muon pairs. This magnet was built from steel and copper recycled from the main ring magnets of the Argonne Zero Gradient Synchrotron. During the first running period of the Tevatron, data was taken using an 80 GeV pion beam derived from 400 GeV protons, and a 255 GeV beam from 800 GeV protons.

Three effects are seen with these 'quarklike' pions, in the angular distribution of the muon pairs, in their average transverse momentum, and in the pion structure function itself. These effects tie in with QCD calculations (by E. Berger and S. Brodksy) which take into account the fact that the annihilating quark and antiquark are contained in a nucleon and a pion.

This is encouraging, as not only is the internal structure of the pion unfolding, but the first steps are being taken to understand it.

New names for old mesons

The Particle Data Group collates information on particle properties from experiments carried out at Laboratories all over the world and brings out regular editions of its 'Review of Particle Properties' – the particle physicists' handbook.

Twenty years ago, the Group introduced a new convention for naming baryons (half-integer spin particles), which has gone on to become standard. This contrasts with the mesons (integer spin particles), which use an alphabet soup of largely uninformative names, some particles with related quantum numbers having very different names, while other disparate particles have inherited confusingly similar labels.

People and things

It is easy to invent logical and consistent naming schemes, however it is unpleasant and confusing to have to learn lots of new names. Thus having considered schemes of various degrees of radicalism (and having exposed part of the physics community to them) the Particle Data Group now ends up with a set of new names. The exception is the celebrated J/psi, which has such a monstrous name that nearly everybody wants to keep it!

Under the new meson scheme, the quantum numbers (spin, parity, isospin, etc.) and the quark content define the names. The spin is indicated by subscript, except for the spin zero, negative parity (pseudoscalar) and spin one, negative parity (vector) particles, where the subscript is omitted.

For mesons which are not bound states of quarks and antiquarks (such as 'glueballs'), the quantum numbers (when non-exotic) determine their names, just as for quark-antiquark bound states. This seems appropriate since such states will be difficult to distinguish from quark-antiquark ones and will likely mix with them.

A difficulty arises with related isospin singlet particles (eta and eta prime, omega and phi, f and f prime). For the lightest such states, the existing conventions will be followed. Primes are being reserved for use in these cases, so the old habit of using primes to denote radial excitations has been dropped.

Many familiar names stay – pi, eta, rho, omega, eta prime, phi, J/psi, chi, upsilon, etc. Some names undergo minor changes: $A_2(1320)$ for example, becoming $a_2(1320)$, while others get a complete face-lift, $S^*(975)$ becoming $f_0'(975)$.

For mesons containing strange and other heavy quarks, the heavier of the two quarks provides the label – K for a strange quark, D for a charmed quark, B for beauty and T for top. A letter subscript is added for the lighter quark, unless it is 'up' or 'down'. Thus the F (charm/strange) meson becomes D_s. Another subscript gives the spin (again omitted for pseudoscalar and vector mesons). Finally a superscript asterisk is added for states with 'normal' spin-parity assignments from a quark model picture (zero plus, one minus, two plus, etc.). Thus the names K, K^*, D, D^* and B do not change, but K^* (1430) becomes K_2^* (1430), L (1770) becomes K_2 (1770), etc.

The new scheme admittedly can lead to cumbersome notations, but not for states that are likely to be common. To facilitate the transition, the Particle Data Group will use both the old and the new meson labelling schemes for a few editions of the Review of Particle Properties.

From Matts Roos

On people

Ian Butterworth, presently Research Director at CERN, has been appointed Principal of Queen Mary College, London, from 1 August 1986.

Gustav-Adolf Voss, leading figure on the world particle accelerator scene and Vice Chairman of the DESY Directorate since 1973, has been awarded the German Federal Service Cross (Bundesverdienstkreuz) 1st Class. The award comes in recognition of his work in developing and constructing storage rings, in particular the PETRA electron-positron collider at DESY, and for his contributions to accelerator physics and technology. At present Gus Voss is responsible for the civil engineering and for the 30 GeV electron storage ring of the new HERA proton-electron collider now under construction at DESY. He is also a member of the Working Group on the scientific and technological

CERN Research Director Ian Butterworth, soon to become Principal of London's Queen Mary College.

Hans Hoffmann – from UA1 at CERN to the DESY Directorate.

long-term future of CERN, chaired by Carlo Rubbia, and is chairman of CERN's LEP Machine Advisory Committee.

On 1 September Hans Falk Hoffmann took over from Wolfram Schoett (who returned to the Federal Ministry of Research and Developments BMFT, Bonn) as one of the five members of the Directorate of the DESY Laboratory in Hamburg and as leader of DESY's Z-Division (Central Data Handling, Developments and Operations).

Hans Hoffmann is well known at CERN, where for several years he played a key role as technical coordinator for the big UA1 experiment, and has served as Secretary of the LEP Experiments Committee. He is however no stranger to DESY, where he had worked with the 'Bonanza' Group at the DORIS electron-positron ring.

Input from ECFA

The European Committee for Future Accelerators (ECFA) meets in plenary session twice a year. At the meeting at CERN earlier this year, ECFA Chairman Jean Sacton described the trend towards even greater internationalization of particle physics research and how arrangements have been completed to allow the exchange of observers between meetings of Plenary ECFA and the US High Energy Physics Advisory Panel (HEPAP).

The ECFA Chairman had attended a recent meeting of HEPAP in Washington, at which the programmes of all the major high energy physics Laboratories had been discussed, and he had the unusual experience of appearing before a hearing of the US House of Representatives' Committee on Science and Technology accompanied by representatives of CERN and DESY. After brief presentations on ECFA, and the European US and Japanese programmes, there had been a lively discussion, mainly directed towards the possibilities for interregional collaboration.

ECFA was delighted to learn of Portugal's impending membership of CERN, and was encouraged by the measures being taken to expand that country's activities in particle physics (see September issue, page 263).

A decision had been taken previously to form an ECFA committee, chaired by G. Coignet of LAPP, Annecy, to study the work on new techniques for particle acceleration and to act as a forum for the exchange of ideas. It is hoped that the Committee will include laser and plasma experts as well as accelerator physicists.

One of ECFA's main preoccupations was the Kendrew Report in the UK, and the resolution appearing on page 376 was passed unanimously.

ECFA's sub-group V on links and networks has a long record of effective contributions to its credit, and its present chairman, J. Hutton of Rutherford Appleton summarized the results of its latest initiative – a European Networkshop held in Luxembourg in May. For the first time, it included experts from national PTTs and from other scientific disciplines. The principal outcome was the decision to set up working groups to study topics in more detail – message handling, X25 protocols, file transfer and full screen editing, for example. The participants also hope that they have added a new acronym to our vocabulary –

On 3 September Queen Beatrix of the Netherlands, accompanied by Prince Claus, visited CERN. Here CERN Director General Herwig Schopper supplies the necessary introduction as Queen Beatrix meets Dutch accelerator physicist Simon van der Meer (back to camera), who shared the 1984 Nobel Physics Prize with Carlo Rubbia.

(Photo CERN 39.9.85)

RARE (Reseau Académique pour la Recherche Européene) – a newly-formed association to oversee this activity.

The plenary ECFA meeting closed with a brief account by the Chairman of the first meeting of the Working Group on the Scientific and Technological Long-term future of CERN, chaired by Carlo Rubbia (see July/August issue, page 241). The Group has set up three sub-groups to examine (a) hadron collider and electron-proton options for the LEP tunnel; (b) large linear colliders and new techniques for particle acceleration; and (c) physics and instrumentation.

From ECFA Secretary Derek Imrie

ESO/CERN Symposium on Cosmology, Astronomy and Fundamental Physics

After the success of the ESO (European Southern Observatory)/ CERN Symposium on Cosmology, Astronomy and Fundamental Physics, held at CERN in November 1983, the second Symposium is to be held at ESO, Garching bei München, West Germany, from 17 to 21 March next year.

The advertised aim of the Symposium is to establish the status of knowledge and provide a forum for discussion among people from different disciplines. Thus equal time will be devoted to formal presentations and to general discussion on each topics, with roughly equal numbers of participants (limited to about 150 overall) from the astrophysics and particle physics sectors.

The list of confirmed speakers already includes 1984 Physics Nobel Prizewinners Carlo Rubbia (Experimental Status and Prospects of Particle Physics) and Simon van der Meer (Prospects for Future High Energy Accelerators), and 1983 prizewinners W. Fowler (Age of the Observable Universe in Inflationary Cosmology) and S. Chandrasekhar (Possible Astronomical Implications of Singularities in General Relativity). Other topics include 'dark matter', superdense matter, high energy gamma sources, cosmic background radiation, neutrinos, galaxy clustering...

Those with a definite interest in participating would write to one or other of the Chairmen of the Scientific Organizing Committee before 15 December: G. Setti, ESO, Karl-Schwarzschild-Strasse 2, D-8046 Garching bei München, West Germany, or L. Van Hove, CERN, TH Division, 1211 Geneva 23, Switzerland.

International cooperation in science

'All honour to science which explores the Universe and solves its mysteries. All honour to it as it examines the constitution of life. All honour to it as it elucidates the working of the mind-body organism. All honour to it as it seeks to alleviate pain. All honour to it as it enlarges the providence of the earth and all honour to it as it ensures better communications between human beings and societies.'

With these words, UN Secretary General Javier Pérez de Cuellar opened the Conference on South-South and South-North Cooperation in Sciences, held at the International Centre for Theoretical Physics (ICTP), Trieste, Italy. The Conference brought together 234

In September A. M. Petrossyants, Chairman of the USSR State Committee for the Utilization of Atomic Energy passed through CERN. He is seen here (with cap) at the Annecy/Belgium/Los Alamos/Serpukhov experiment which is covered by the CERN/USSR agreement on collaboration in particle physics.

(Photo CERN 207.9.85)

delegates from 63 countries, with the objectives of identifying science projects in which cooperation is potentially profitable, to examine possibilities of financial support, and to strengthen international ties.

Speakers included ICTP Director and President of the Third World Academy of Sciences Abdus Salam, Director General of the International Atomic Energy Agency Hans Blix, UNESCO Assistant Director General I. Kaddoura, A. R. Khane as Secretary General of the United Nations Industrial Development Organization, Sir John Kendrew as President of the International Council of Scientific Unions, and Fermin A. Bernasconi as Director General of the Intergovernmental Bureau for Informatics.

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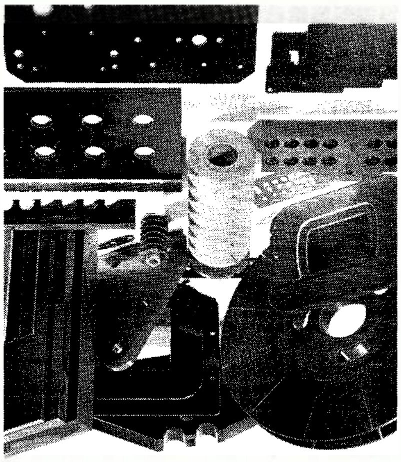

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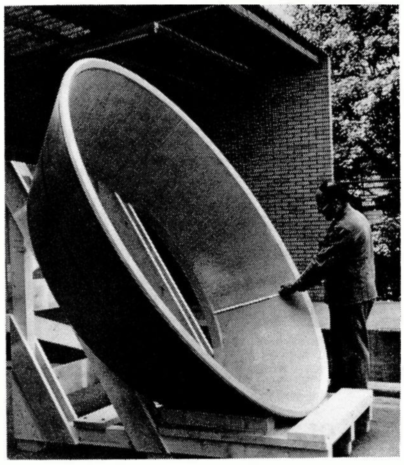

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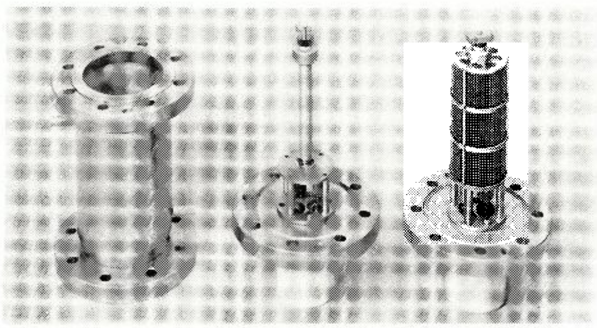

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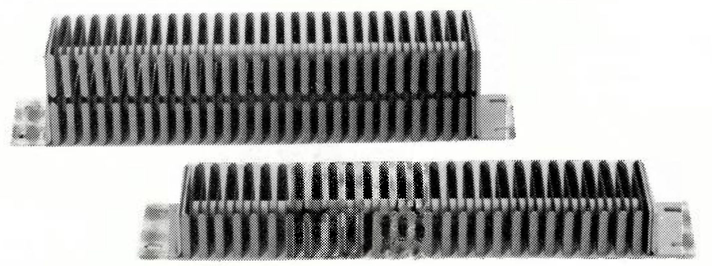


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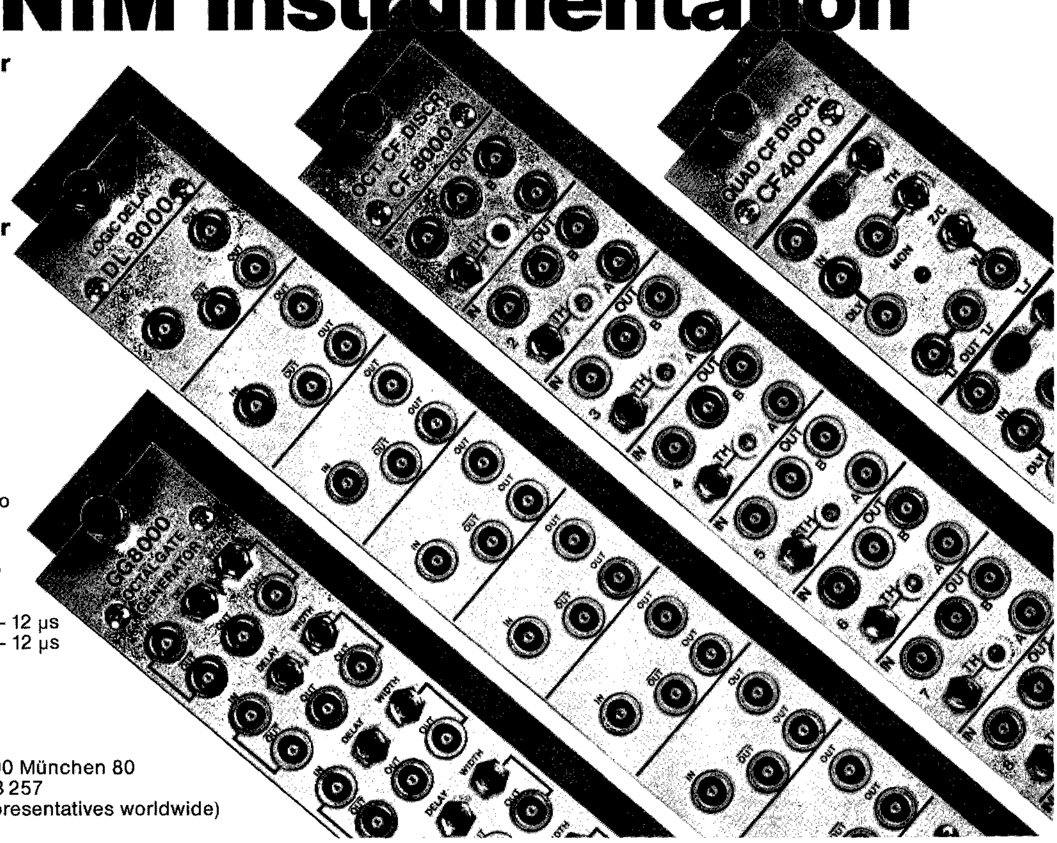

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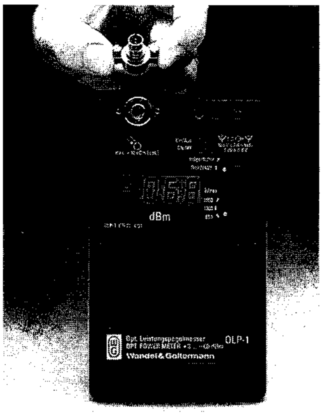

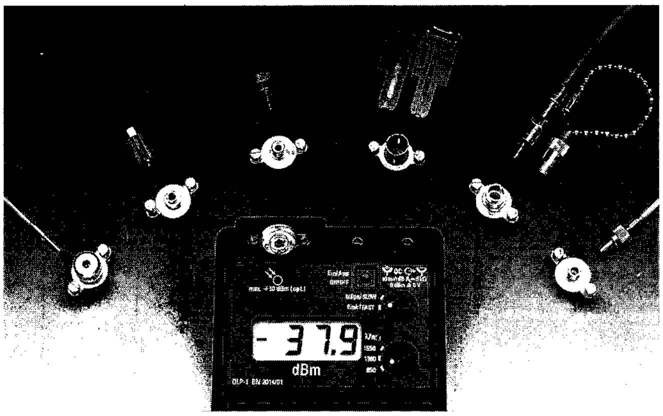

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Can't match the fibre type? Then try the OLP-1. Matches to all standard graded-index-, monomode- and step-index fibres with core diameter ≦200 µm; without the need for switching, adapting or recalibration.
Got to change detectors? Not with the OLP-1. Just turn the switch to measure at 850 or 1300 or 1550 nm.
Difficult to use? The OLP-1 couldn't be simpler to operate: connect up, switch on, and read off the result. Display reads from −60 (−50) dB to +3 dB in one continuous range.
Accuracy is ensured by thermal compensation. No need to wait for things to settle down if the temperature changes!
On the move? As you'd expect, the OLP-1 can be used with dry batteries or a Nicad rechargeable battery; if you need to make long-term measurements there's also a mains adapter/charger. Battery check and auto-off circuits ensure long, trouble-free operation. Why not get to know more about the OLP-1? It can be used for servicing, in the lab. Mains or battery operation.
Fill in the coupon for your copy of the detailed colour brochure and make light work of your problems.

Information Coupon

I would like:
- ☐ a copy of the OLP-1 colour brochure
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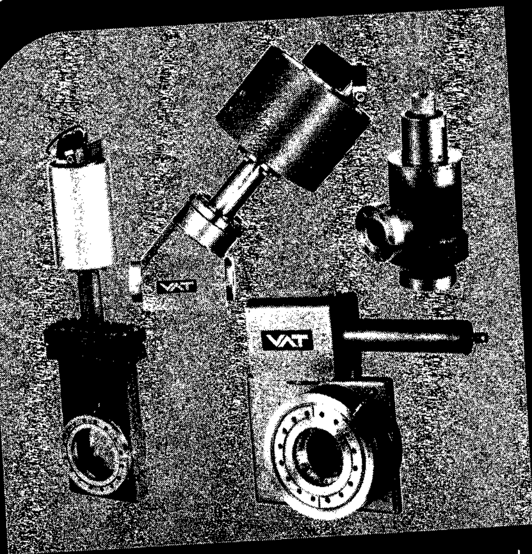

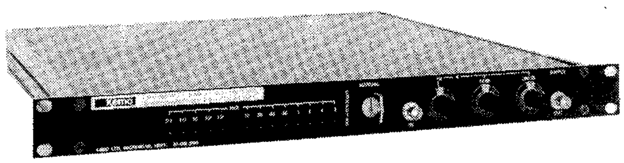

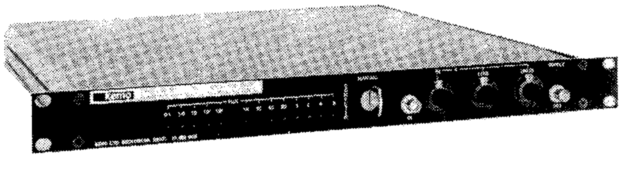

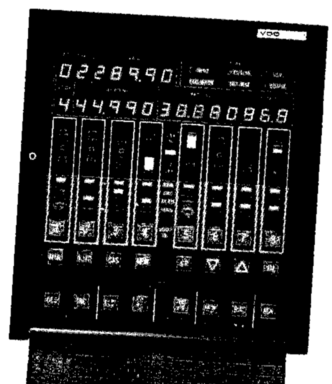

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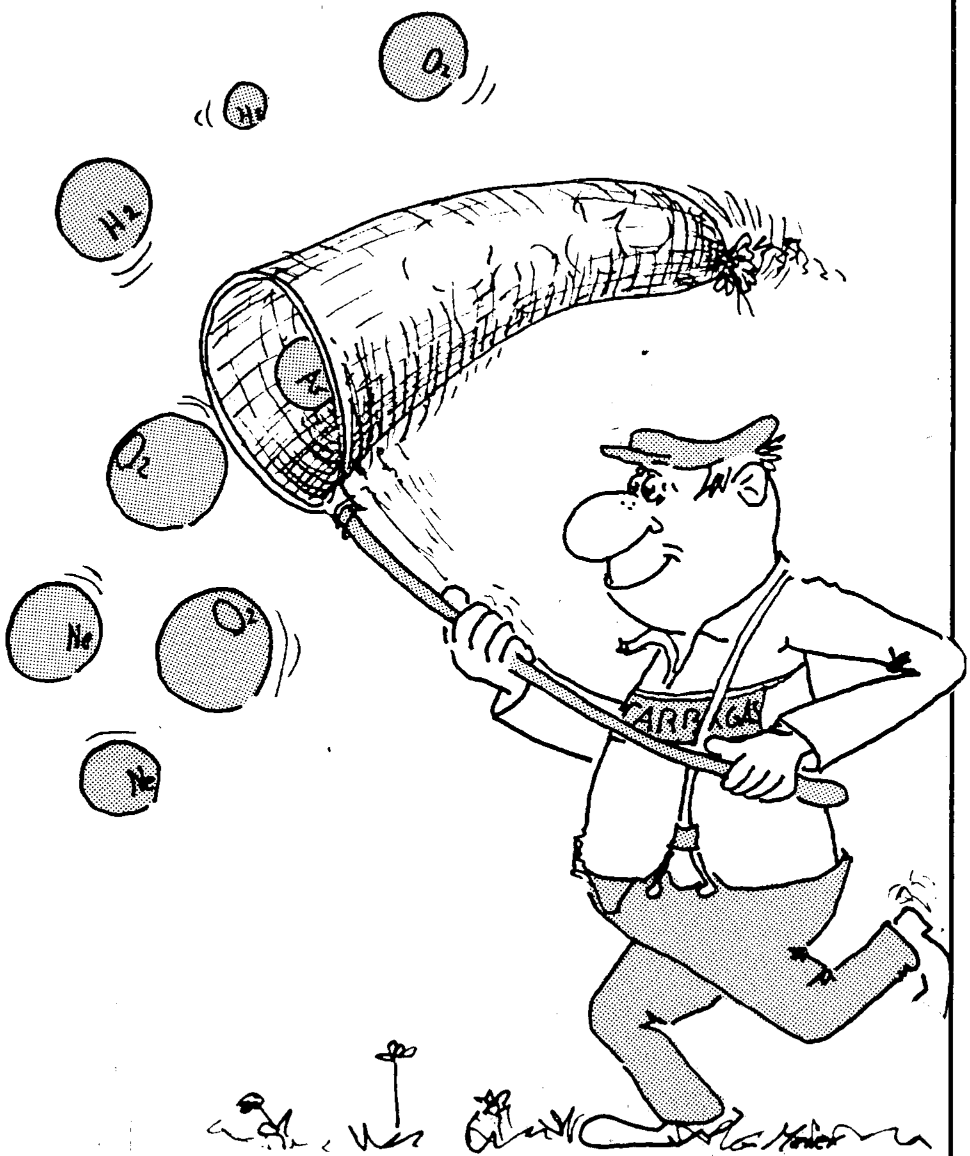

$Al(C_2H_5)_3$	C_3H_6	Kr
Ar	C_3H_8	NH_3
AsH_3	C_4H_6	NO
BCl_3	C_4H_8	NO_2
BF_3	C_4H_{10}	N_2
B_2H_6	C_4H_{14}	N_2O
CF_4	C_4H_{16}	N_2O_4
CH_4	C_5H_{12}	Ne
$(CN)_2$	C_6H_{14}	O_2
CO	C_7H_{16}	PF_5
$COCl_2$	ClF_3	PH_3
COS	Cl_2	SF_6
CO_2	D_2	SO_2
C_2H_2	GeH_4	SeH_2
C_2H_4	HBr	SiH_2Cl_2
C_2H_4O	HCl	SiH_4
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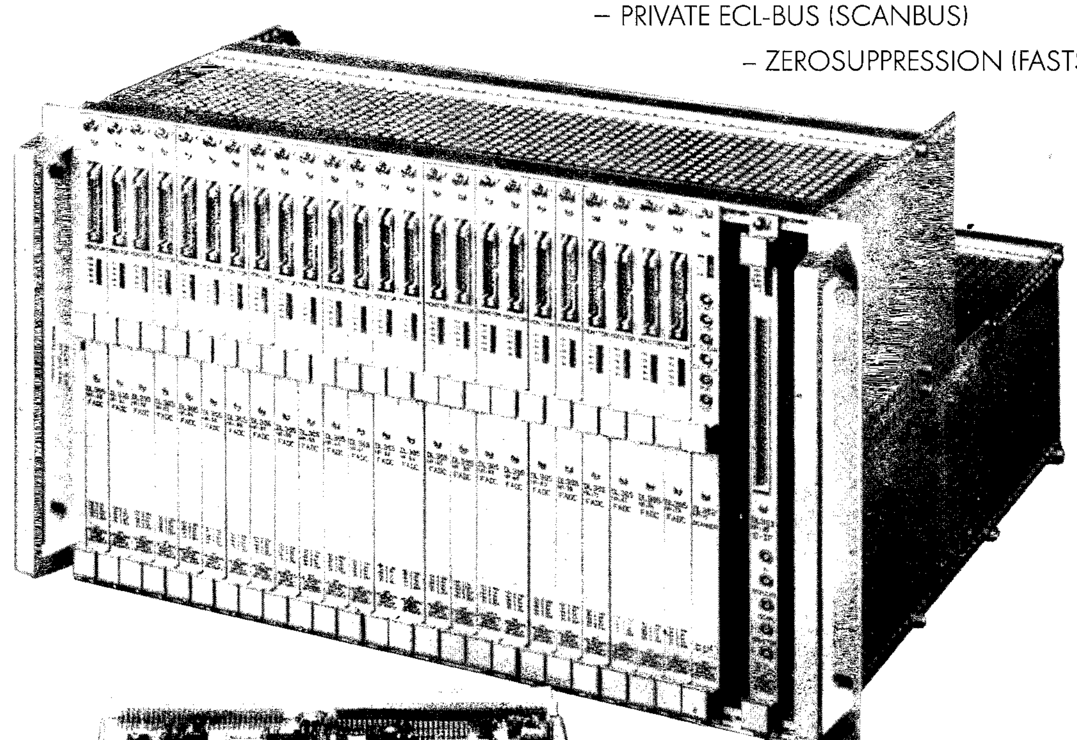

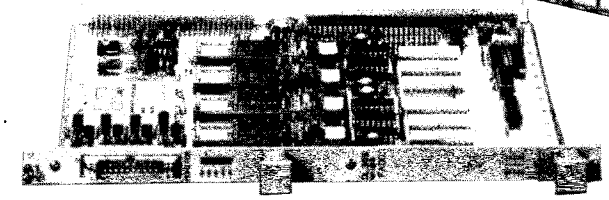

5 GROUPS OF MODULES:

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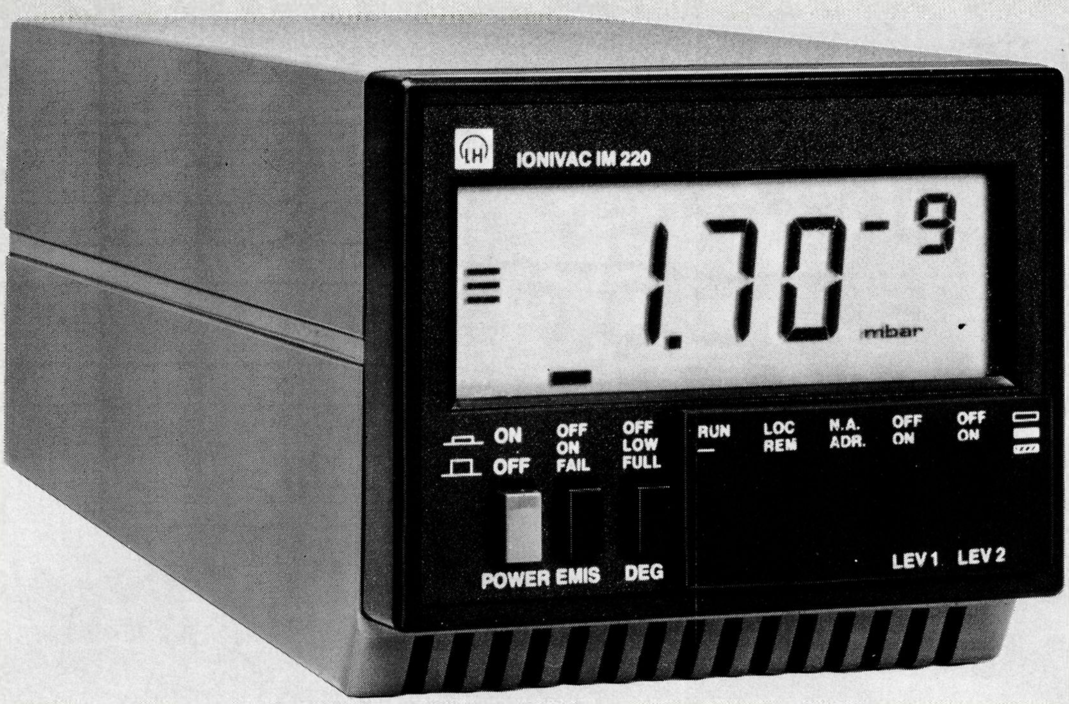
IONIVAC IM 220



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- ■ Additional trend display of pressure changes
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- ■ Measuring range 10^{-2} to 1×10^{-10} mbar

The superiority of the IM 220 over other ionization vacuum gauges is based chiefly on the perfection of its microcomputer electronics in

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