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Singapore skyline – a report of this year's major physics meeting features on page 1 (Photo G. Fraser).

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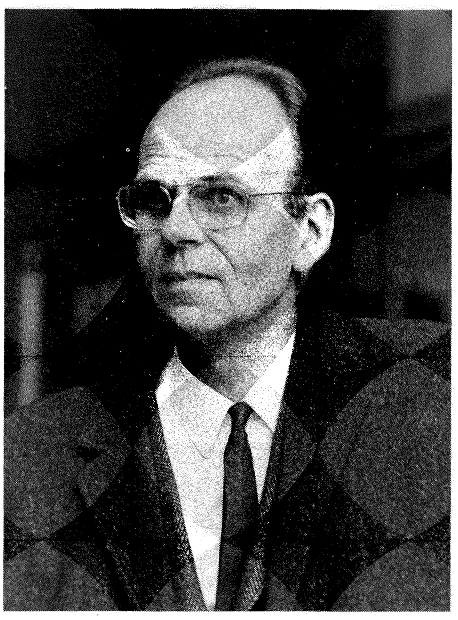
Léon Van Hove 1924-1990



Léon Van Hove, eminent Belgian theoretical physicist and Research Director General of CERN from 1976-80, died on 2 September, only eighteen months after a special symposium at CERN marked his 65th birthday and his formal retirement from the Organization to which he had contributed so much.

After training in mathematics he made fundamental contributions to field theory, statistical mechanics and phase transitions, crystal structure, and neutron scattering as a tool to study condensed matter. For this work he was awarded the US Dannie Heinemann Prize in 1962. He had been working in Utrecht when Viktor Weisskopf invited him in 1961 to lead CERN's Theory Division, succeeding M. Fierz, who was moving to Zurich to take the chair vacant after Pauli's death in 1958.

Van Hove played a major role in establishing the reputation of CERN's Theory Division as a world forum for particle physics ideas. With these theorists working alongside high energy experimenters, he stressed the importance of phenomenology in the quest for new understanding. With his background in statistical physics, Van Hove saw the mass of off-resonance particle production data from bubble chambers, previously discarded, as being ripe for exploitation.

In 1971, Van Hove moved to Munich after Werner Heisenberg retired as Chairman at the Max Planck Institute for Physics and Astrophysics.

In the early 1970s two CERN Laboratories existed side by side – the original Meyrin (Switzerland) site and the new Prevessin (France) campus of the 400 GeV SPS proton synchrotron. In 1976 these sites were formally amalgamated, with John Adams as Executive Director General and Van Hove as Research Director General.

Under his guidance, the research programme at the SPS flourished, while monumental decisions were taken to go for the proton-antiproton collider, with two big experiments. Van Hove took a special interest in this project, which went on to bring unprecedented honours to CERN and propel the European Laboratory to the forefront of the world research stage. His Research Director General mandate also saw the proposal for the LEP electron-positron collider and initial ideas for its experimental programme. His coordination helped the project receive its rapid consensus approval from the physics community.

Subsequently his vision and experience were widely sought in other European research committees, but with more time available for physics he returned to full-time research with new vigour, making important contributions to current thinking on the behaviour of quarks and gluons under extreme conditions and the interpretation of results from experiments using high energy ion beams. He also contributed significantly to the analysis of multiple particle production, where he had been invited to report at the recent Singapore meeting, but had to be replaced by his collaborator A. Giovannini.

With the convergence of ideas from particle physics, cosmology and astrophysics, he helped establish the joint CERN/European Southern Observatory (ESO) Symposia on Astronomy, Cosmology and Fundamental Physics as a regular platform. His own powers of synthesis were the source of valuable guidance in this area.

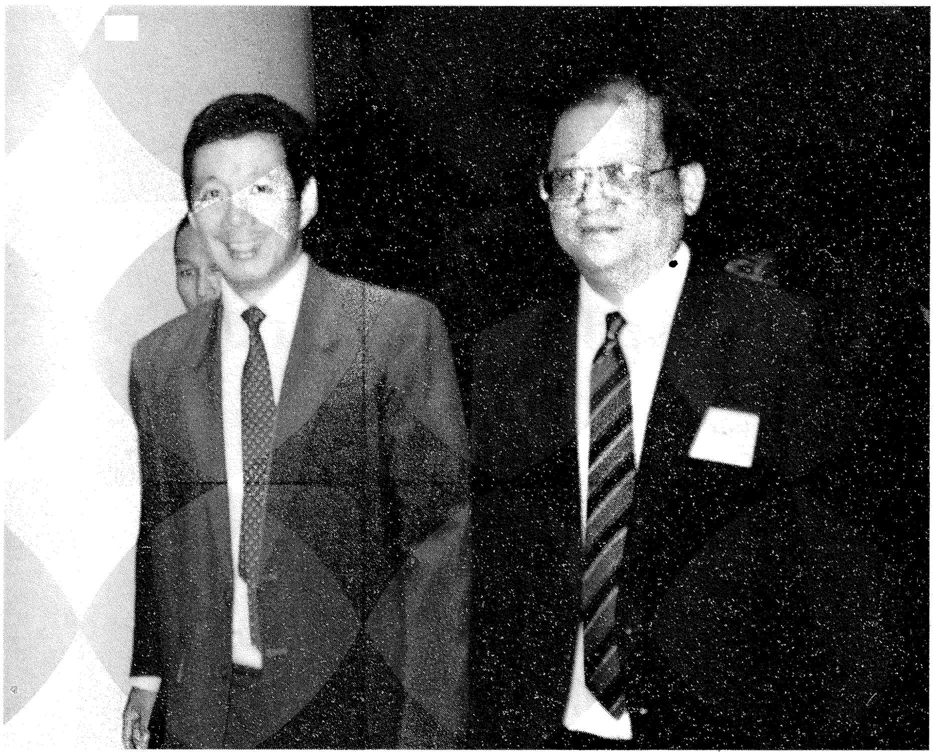
At ease in French, Flemish, German and English, and with a university career spanning several countries, Van Hove was a cultured European. His penetrating insight was frequently evident in major conferences, where his objective comments and conclusions would frequently reorient muddled thinking and provide a real focus for attention.

Earlier this year, he was invited to give the Nishina Memorial Lecture in Tokyo, where in one of his final public appearances he spoke on 'Particle Physics and Cosmology – New Aspects of an Old Relationship'. Put in a more general context, his concluding remarks mirrored his own disciplined attitude to science – 'a redeeming feature in the midst of so much speculation is the slow but tenacious high quality work being done by observational .... and experimental physicists, while phenomenological theorists carefully evaluate results and confront the various interpretations, the only way to advance in the difficult quest for new ...... knowledge of lasting significance'.

Other tributes will appear in a forthcoming issue.

Singapore's double festival

The 25th International Conference on High Energy Physics in Singapore from 2-8 August was opened by Singapore Trade and Industry Minister Lee Hsien Loong (left), seen here with K.K. Phua, Chairman of the Conference Organizing Committee.



Coinciding with celebrations for the nation's 25th anniversary, the 25th International Conference on High Energy Physics, held in Singapore from 2-8 August, was itself a double festival, with the Standard Model of contemporary physics and CERN's new LEP electron-positron collider providing the twin themes.

At the Stanford Lepton-Photon jamboree last summer, Stanford's SLC electron-positron linear collider just pipped LEP to the post for the first examples of Z particles – the electrically neutral carrier of the weak nuclear force – produced by electron-positron annihilation.

One year down the line, Singapore rapporteur Friedrich Dydak, covering electron-positron Z physics, was able to present an avalanche of new data – some 500,000 Zs intercepted by LEP's four big experiments – Aleph, Delphi, L3 and Opal. This solid block of new information reinforces the Standard Model, the two-sided picture of particle physics with the electroweak unification of electromagnetism and the weak nuclear force on one hand, and the field theory (quantum chromodynamics – QCD) of quark-gluon interactions responsible for the strong nuclear force on the other.

Already looking impregnable at the previous Rochester meeting in Munich in 1988, when LEP was still under construction, the Standard Model now reigns supreme. Given the task of updating the Standard Model at Singapore, rapporteur Cecilia Jarlskog of Stockholm enthused over the richness of this picture rather than despairing over the absence of new information.

Delegated to look beyond the Standard Model, Moscow's Lev Okun could have despaired, but didn't. With little laboratory evidence to show, he nevertheless played two strong cards; 'Dark Matter'- the realization that the Universe must contain more than can be seen directly – and the multiplicity of arbitrary parameters which plague the Standard Model itself. Alone, these two strong hints suggest that there is a deeper physics encased in the hard shell of the Standard Model.

Another big question mark hangs over the Higgs mechanism, the spontaneous symmetry-breaking which endows the electroweak vacuum with special properties and gives particles their mass. Vital to the smooth running of the picture, the Higgs mechanism is nevertheless unknown and unexplored. Undaunted, Jarlskog awarded the Higgs sector a delicate tropical orchid for its attractiveness. Less appreciative was summary speaker J.D. Bjorken, awarding the Higgs a durian – a large, unsightly tropical fruit of dubious taste banned from Singapore hotels and the subway because of its nauseating smell.

With the four LEP experiments each providing separate contributions, the Singapore parallel sessions on electroweak Z physics, on heavy quark production, on jets and fragmentation and on particle searches provided a fat chunk of LEP material. For the plenaries, the contributions from the four experiments were distilled into the historic review by Dydak and a detailed review of jet physics and QCD by CERN's Maurice Jacob.

The road to LEP Z physics had been well prepared by some 1500 theoretical papers which examined the 'radiative corrections' the numerous subtle mechanisms which contribute to electron-positron interactions at these energies. The knowledge of the Z mass is limited mainly by the remaining

Nearly time to start. Friedrich Dydak of CERN (left), who opened the Singapore plenary sessions with a milestone talk on new results in electron-positron Z physics, checks his watch with session chairman J.-E. Augustin.

30 MeV (in 90 GeV) uncertainty in LEP's energy calibration.

While the shape of the Z resonance is now well determined, and the number of neutrino families now fixed as 2.89 ± 0.10, Dydak emphasized that there is still room for further improvement in precision tests of the Standard Model. And the 1989/90 harvest of Zs is only a foretaste of things to come – the plan is to catch more than three times as many Zs next year.

The wealth of LEP data is completely in line with all other Standard Model measurements, so that consistency arguments give a lever on the unseen but long-awaited sixth ('top') quark, which now appears to lie at 137 ± 40 GeV.

With little new physics to report, it is nevertheless a sign of progress when the top quark mass can be ballparked with such confidence. Two years ago this quantity was anyone's guess, (although initial measurements of B particle mixing had hinted that it might be high), while quantitative suggestions followed from the initial precision fixes on the Z mass at Stanford's SLC linear collider and at LEP one year ago.

Additional progress is visible in measurements of the coupling strengths of the weak force. Where only recently the overlap from different experiments gave a fuzzy picture, these couplings have now been pinpointed by LEP.

Most of LEP's Zs decay into hadrons, and the experiments see about 20 per cent of these producing the fifth ('beauty' – b) quark, in line with expectations. Aleph and L3 look at the mixing of electrically neutral B mesons (containing the b quark) to extract a value for the mixing parameter in line with earlier determinations from the ARGUS experiment at DESY's DORIS electron-positron ring and the UA1 experiment at CERN's proton-antiproton collider.

These initial measurements of B particle mixing had provided the first hints that the top quark could be heavier than expected. With the new limits from the LEP experiments, the heavy top quark becomes a way of life, and the mixing measurements gain respectability.

Aleph gets a lifetime for B particles of 1.28 x 10^{-12} seconds, in line with the previous world average of 1.13 x 10^{-12}. Studies of charm production are well underway, while Opal compares different light quark (u and d) properties from a sample of photon production.

The LEP data provides a fresh source of information on QCD effects. The underlying QCD coupling strength is expected to 'run' – to depend on energy – and Z measurements at LEP provide a new benchmark. Awaiting a precision analysis of LEP hadronic Z information, and with the individual interactions of constituent quarks and gluons themselves invisible, QCD details have to be inferred by studying the production of jets – well-defined emergent sprays of particles. Analysis of these jets also shows the characteristic three-gluon vertex of QCD, when a single gluon 'breaks up' into two.

Earlier, jet analysis was topological, with the shape of the jets being the main criterion, but this is now complemented by energy correlations between jets, while comparison of the production levels of different numbers of jets gives an independent measurement.

Jets and QCD rapporteur Maurice Jacob (right) with Delphi experiment spokesman Ugo Amaldi.

One focus at Singapore was 'intermittency' – possible inter-particle correlations causing more particles to be produced in some directions. While there have been suggestions of such effects from electron-positron annihilation at lower energies, the numbers of produced particles at LEP energies, as measured by the Delphi experiment, were in line with conventional scaling ideas and provided no evidence for intermittency.

Reporting on electron-positron physics at lower energy machines, Kazuo Abe of the Japanese KEK Laboratory indicated that even here multiplicity fluctuations could be reproduced by standard recipes without resorting to new physics.

At still lower energies, Zhi-Peng Zheng of Beijing reported that the Chinese BEPC machine was performing well, with the BES spectrometer having intercepted several million J/psi decays, with many more and a collision energy increase scheduled for next year.

A lot of attention at LEP has been given to looking for new particles – and while nothing has yet been seen, a lot of territory can be now excluded in the continuing hunt. A 'minimal' Higgs (which few people thought would have been the case anyway) has been excluded below 40 GeV, all the way down to zero mass, and no sign has been seen of additional compositeness. The long-awaited 'supersymmetric' particles - quantum statistics mirror images of those presently known - have still to make an appearance.

Complementary information comes from the experiments at CERN and Fermilab's proton-antiproton colliders. At CERN, the UA2 study has extended its results on jet production, where it sees a combined W/Z peak above the QCD background. With the W particle, the electrically charged carrier of the weak nuclear force, out of reach at LEP until 1994, hadron colliders remain the sole source of W input. Combining the results from UA2 (May, page 3) and from CDF at Fermilab, rapporteur Lee Pondrom suggested a W mass of 80.13 ± 0.30. Comparison of W and Z measurements from these colliders with precision Z information with LEP provides stringent tests of the Standard Model, all passed with flying colours.

Hadron collider experiments have traditionally been consumers of structure functions – the measured distributions of quarks and gluons inside nucleons – but this could change, suggested Pondrom. The CDF study has looked at charge asymmetries in W production, useful for comparing the structure functions of different types of quark.

While the cast-iron lower limit for the top quark mass from CDF is 89 GeV, the electroweak limits point to the region between 100 and 200 GeV. Of all existing experiments, CDF is the place where the top quark is most likely to show up, and Pondrom lingered over a remote point on the scatter plot.

In the structure function sector, where in the past there had been some uneasy disagreements between the data coming from different sources, rapporteur Frank Close described how a consensus agreement among the contributing groups had helped to resolve these differences. When selecting structure function data, Close warned users to look for a 'sell by date' and not to use old information.

In conclusion, summary speaker J.D. Bjorken pointed to many recent physics revolutions – industrial, with plans to build so-called particle 'factories'; sociological, with experimental collaborations becoming larger and wider reaching; and technological – and looked forward to a 'physics revolution' which will eventually topple the Standard Model.

By Gordon Fraser

Hosting Rochester

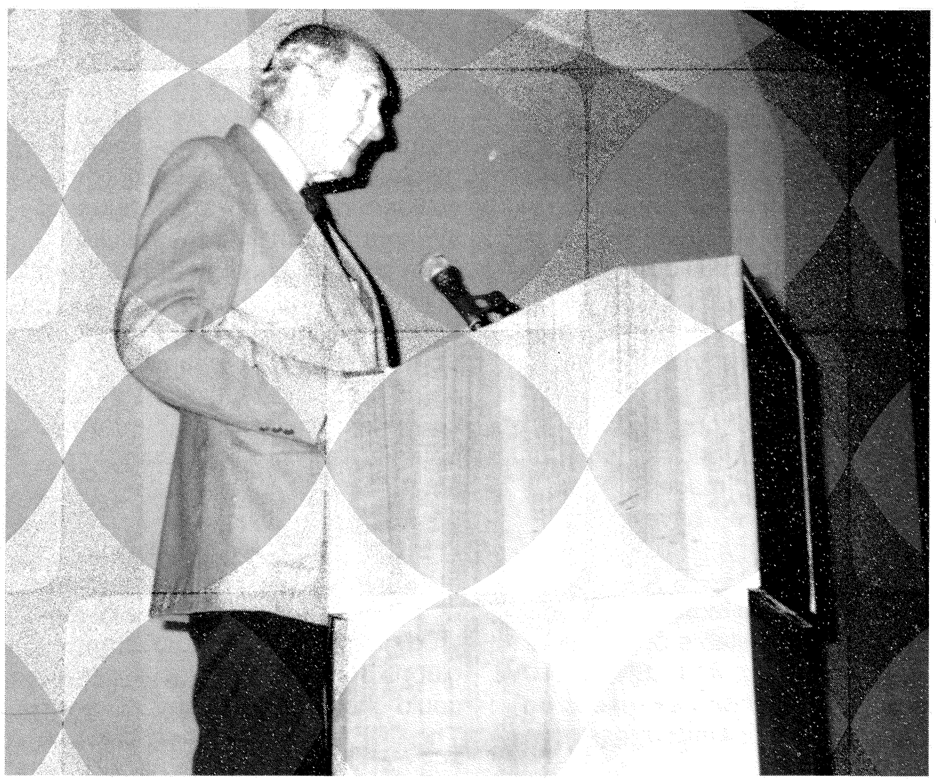
Hosting the biennial 'Rochester' conferences, catering for the various needs of a thousand or so physicists from all over the world, is no easy job. When Singapore was proposed as the 1990 venue, this was only the second time in the 40-year history of the Rochester conferences that the big meeting would be held outside of traditional venues in Europe, the US and the Soviet Union (the 1978 meeting was held in Tokyo).

Under the chairmanship of K.K. Phua, the Singapore organizers attacked their objectives with the enthusiasm, imagination and vigour which has helped this tiny country make such a major impact on the world scene in a short time. Introducing the meeting and welcoming delegates, Singapore Trade and Industry Minister Lee Hsien Loong announced a major new move to attract world scientists and technologists to a new 'Science Habitat'.

Rochester pioneer Robert E. Marshak, in a special session marking the 25th Rochester meeting and a 40-year anniversary, recalled the initial idea which attracted 50 researchers to Rochester, New York, and sketched the subsequent evolution of the meetings into the biennial series attracting many hundreds of scientists from all over the world.

The current Rochester pattern includes many parallel streams over the first few days, providing plenty of scope for detailed discussion and interaction. Subsequently, the material covered in the parallel streams is pulled together in major plenary sessions. Despite the active and well-attended parallel sessions at Singapore, the plenary audience numbered about 500, roughly equivalent to the population of just one LEP experiment, and considerably smaller than at previous meetings, possibly the result of improved physics communications, the continued dominance of the Standard Model, and the distance to Singapore.

The next meeting in the series will take place in 1992 in Moscow.



Robert Marshak looks back over 40 years of 'Rochester' meetings.

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	AS ↑ to AS ↓	12,0µs	2,4µs	1,40µs
	AS ↑ to GK ↓	12,0µs	2,7µs	1,85µs
	AS ↑ to next AS ↑	244,0µs	14,3µs	5,00µs
FWD	GK ↑ to AS ↑	2,5µs	0,6µs	0,08µs
	AS ↑ to DS ↑	4,4µs	0,7µs	0,45µs
	DS ↑ to DS ↑	4,4µs	1,0µs	0,50µs
	AS ↑ to AS ↓	12,0µs	2,4µs	1,40µs
	AS ↑ to GK ↓	12,0µs	2,7µs	1,85µs
	AS ↑ to next AS ↑	244,0µs	14,3µs	5,00µs
FRDB *40 words*	Block setup time	8,7µs	3,0µs	1,7µs
	First DS ↑ to last DS(t)	27,0µs	9,6µs	10,4µs
	Repetition time	408,0µs	25,0µs	19,3µs
FRDB *1024 words*	Block setup time	8,7µs	3,0µs	1,7µs
	First DS ↑ to last DS(t)	27,0µs	9,6µs	10,4µs
	Repetition time	408,0µs	25,0µs	19,3µs
FWDB *40 words*	Block setup time	8,8µs	3,0µs	1,7µs
	First DS ↑ to last DS(t)	33,0µs	11,7µs	9,1µs
	Repetition time	271,0µs	26,7µs	18,1µs
FWDB *1024 words*	Block setup time	8,8µs	3,0µs	1,7µs
	First DS ↑ to last DS(t)	867,0µs	306,7µs	230,0µs
	Repetition time	1100,0µs	320,0µs	239,0µs
FRDB	SS = 2 cleanup time	4,1µs	3,7µs	8,5µs
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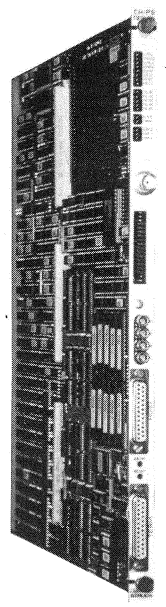

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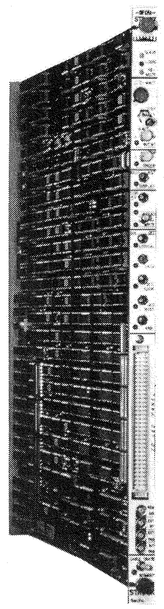

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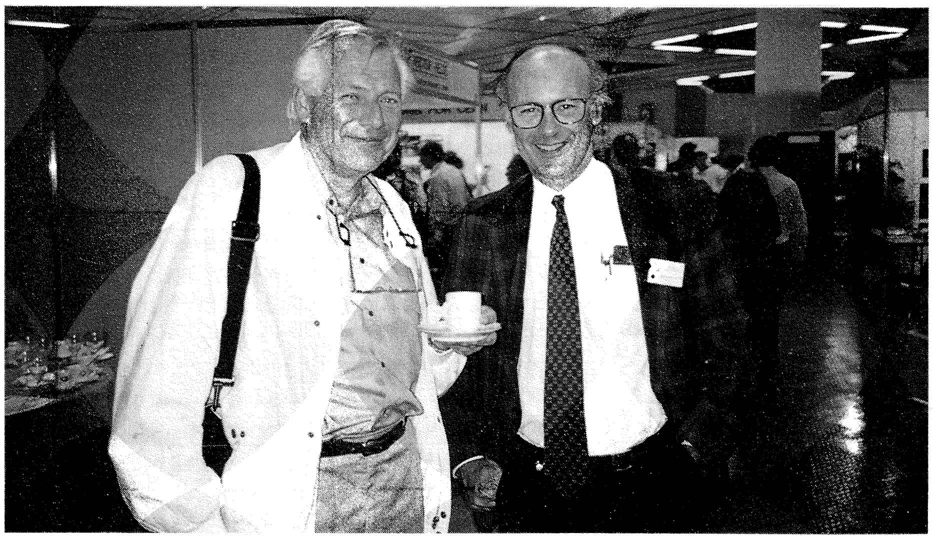
EPAC in Nice

At the European Particle Accelerator Conference in Nice, Organizing Committee Chairman Gunther Plass of CERN (left), and Local Organizing Committee Chairman Pierre Mandrillon.



The signpost to the accelerator future points in several directions, and the second European Particle Accelerator Conference (EPAC), held in Nice from 12-16 June provided a good opportunity to survey the terrain ahead.

Building on the experience of the first EPAC, held in Rome in 1988, the organizers planned for a large meeting and were rewarded with 800 participants. In parallel, the involvement of industry, with a comprehensive 44-strong exhibition, prompted many speakers to refer to the symbiosis of accelerators and industry.

The main raison d'etre of high energy accelerators has always been, and still is, particle physics research. In the first invited paper Maurice Jacob of CERN enthusiastically outlined the progress so far and the hopes that theorists placed in future accelerators. An accelerator is like a time machine that goes back to the very first moments of the Big Bang – the greater the energy, the higher the temperature and the further back in time it can go.

The three-stage EPAC programme began with reviews of the major working accelerators, continued with oral and poster presentations covering the full extent of accelerator R&D, and culminated with the big machines of tomorrow – the HERA electron-proton collider now being completed at DESY, Hamburg, and the plans for the big proton-proton colliders, LHC at CERN and SSC in the US.

Electron machines have traditionally taken longer to reach their design levels than their proton counterparts. However in less than a year, CERN's new LEP electron-positron collider, has already equalled, or exceeded, design values for separate parameters that would yield the design luminosity were it not for an unexpectedly low threshold for the beam-beam effect.

In Japan, the TRISTAN electron-positron collider has successfully installed superconducting cavities to reach 32 GeV per beam and experience will be closely followed for the superconducting cavity energy boost for LEP (May, page 1).

Stanford's SLC linear collider cannot compete with LEP as a Z factory, but finds specialized physics niches with polarized electrons, while also serving as a unique testbed for the next generation of linear colliders. Stanford's bid for the 'Next Linear Collider' (NLC) with 0.5 to 1 TeV beams needs a final focus compression factor of three hundred compared to thirty for the present SLC. This particular problem is being attacked, with a the Final Focus Test Facility currently under construction at Stanford.

There is an ongoing effort at many Laboratories on advanced accelerating techniques for the next generation of linear electron machines, but there is a general consensus that the first to appear will have quasi-conventional accelerating structures. Starting at low frequency with about 20 MV/m superconducting structures at 1.5 GHz or copper at 3.6 GHz would be closest to the existing technologies. This route implies brute force of numbers and economy of scale to offset the lack of a new technology. Stepping up to around 100MV/m with a copper structure, klystrons are discussed for 7 GHz, free electron lasers for 19 GHz and a two beam accelerator scheme at 30 GHz, the latter option being followed at CERN in the CLIC study.

With new linear colliders still some way off and LEP believed to be the highest energy circular electron machine feasible, it is not surprising that 'electron-positron factory fever' has taken hold. Factories have been proposed for producing phi, beauty or tau/charm particles, but in all cases it means delivering a hundred times the collision rates currently achieved. This challenge is set by the particle physicists who require tougher tests for the Standard Model.

Maury Tigner identified 13 studies being carried out in seven countries with energies in the range 1-11 GeV. Whatever the outcome, these factories are unlikely to become as widespread as the ubiquitous synchrotron light source. Tigner believed that only one machine could conceivably be built in the US and even that may never materialize. The most popular choice is the Asymmetric (energy) Beauty Factory, but the asymmetry is the main stumbling block to achieving the high luminosity. The term 'energy transparency' has consequently appeared to cover efforts to make the beams appear symmetric, but the list of requirements is becoming so long that one speaker suspected unequal energies might be ruled out.

The compact synchrotron light source is another example of lateral development in the electron world. HELIOS, the compact source being custom built for lithography by Oxford Instruments for IBM, is close to delivery after some problems with its two 180-degree superconducting dipoles. The second generation is now being discussed, the main emphasis being on reducing cost by lowering the injection energy and replacing the bulky injection linac with another 'table top' accelerator, the microtron.

A possible upgrade of CEBAF from the current 4 GeV to 16 GeV was mentioned in response to a question from the floor, indicative of the need to design for higher energies in any future facility of this type.

Almost ten years after initial operation of such a machine at CERN, there is now a sense of maturity in the proton-antiproton collider field. With friendly rivalry more than compensated by close collaboration, the present situation was covered by a joint CERN/Fermilab review. Both machines are well understood and their operation is essentially resonance limited. Stochastic cooling has the stamp of an established technique, with contributions on design refinements for kickers and pickups. The main future interest is the cooling of heavy ions for CERN's LHC.

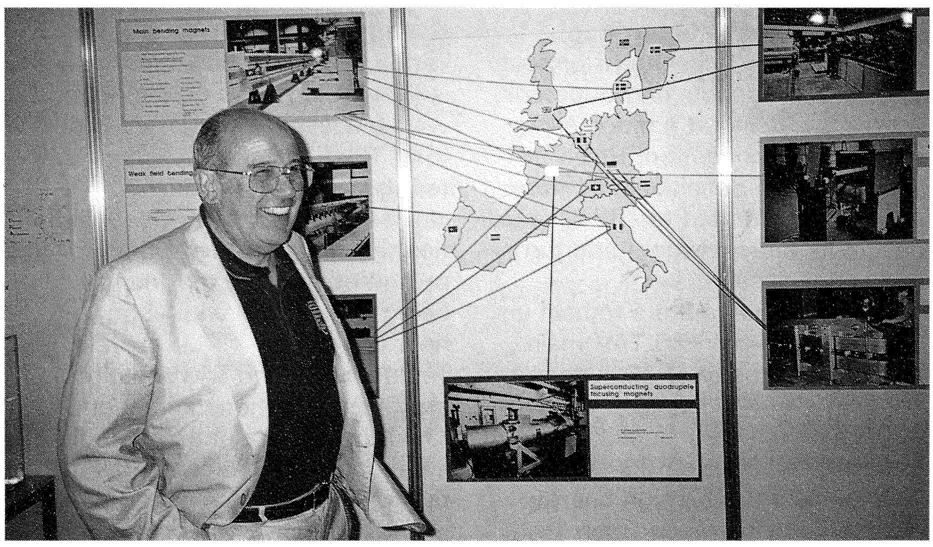
In contrast with the proton scene, where polarized particles are again part of the local scenery, polarized electrons are still hotly debated for machines like LEP. Although the theoretical understanding has improved and the ability to explain observations with the SMILE program is considered as a significant breakthrough, reviewer D. Barber still concluded with the appeal 'Any ideas?'.

The physics interest for light and heavy ions is moving to higher energies where RHIC at Brookhaven is preparing to open up new energy horizons. Before testing a full cell of superconducting magnets, changes were made to the lamination thickness and to the cryostat. Magnet production will be in industry and is planned for 1993-6.

At low energies, there is considerable interest in the radiotherapy applications of light and heavy ions. This was underlined by joint sessions with a parallel medical conference and a visit to the 'Centre Antoine- Lacassagne' (CAL) where the Medicyc medical cyclotron is presently being installed.

Protons and ions deposit their energy in a small volume at a precise depth in tissue (known as the Bragg peak). Heavy ions however are somewhat less efficient in this respect and deposit some energy beyond this region due to fragmentation.

A spin-off of accelerator technology which attracted considerable interest was a Japanese proposal to transmute long-lived radioactive waste into short-lived waste by high energy proton-induced spallation. The basic idea has been aired before, but advances in accelerator technology are making such a nuclear waste 'incinerator' a feasible proposition. A conceptual design with a 1.5 GeV 10mA proton linac is challenging but far from impossible, and is certain to be followed with interest.



Emilio Picasso of CERN in front of CERN's EPAC exhibit. The involvement of European industry in ongoing accelerator R and D work is one of CERN's big success stories.

Malika Meddahi's contribution to LEP beam dynamics formed part of the EPAC poster session.

The review of the UNK high energy project at the Soviet Serpukhov Laboratory reported accelerated progress since 1987, although the start of installation of the superconducting magnets is not foreseen before the end of 1992.

The ongoing big projects were left for the conference finale, where Bjorn Wiik opened with a presentation of HERA. This project for 820 GeV protons colliding with 30 GeV electrons was authorized in 1984 and commissioning will start this autumn. With DESY's electron traditions, the electron ring and injector chain were completed and commissioned well in advance of the attack on protons. For the main HERA ring most of the superconducting dipoles have been delivered. With production running 20% faster than anticipated, deliveries will soon be complete, with installation not far behind.

It was then the turn of the world's largest accelerator project, the US Superconducting Supercollider, SSC. Being at a much earlier stage in its conception, Helen Edwards had no definitive hardware to show and turned to site-specific design features, magnet aperture and schedules.

The main parameters remain unchanged with twin 20 TeV main rings, a luminosity of 10^{33} per sq cm per s, and an injection energy of 2 TeV. Higher luminosity may be obtained by reducing the bunch spacing to 5m. The high energy booster (already bigger than any existing machine) and the main rings would be superconducting with dipole fields of 6.4T and 6.55T respectively.

The emittance budget through the 5-element injector chain assumes a 20% dilution per machine. The main magnet now has a 5cm aperture and Bob Palmer is leading a task force to design the definitive dipole. The changes also include a wider cable, a vertically split yoke and a modified cryostat. The testing and installation schedule is geared to collider commissioning in October 1998.

For CERN, Giorgio Brianti described the design for the multipurpose LHC collider, which would be able to accept ions as well as protons. Its protons could also collide with LEP electrons, giving a total energy of about five times that of HERA. Geneva. Preparations at CERN are now in full swing, the objective being formal project approval in 1992.

With 10 Tesla dipoles the beam energy of 8 TeV can be reached with a luminosity in excess of 10^{34} per sq cm per s, and the intensity of 10^{11} particles per bunch is well within present operational limits. The kinematics of the electron-proton option are more favourable with a lower proton energy and it is likely that 55-60 GeV electrons will be collided with 2 TeV protons. For ions the intra-beam scattering and charge-exchange processes are important and luminosities would be far lower than for the proton option, the maximum figure being about 10^{28} with about a 6 hour lifetime.

Ongoing R and D work centres on the superconducting magnets. The arcs will use niobium-titanium superconducting technology at 2K, but for the low-beta quadrupoles niobium-tin at 4K is being seriously considered. Collaborations between CERN and European industry have been an outstanding feature of this project, with some 30 firms now involved on various aspects of the project*. Bids have been received to build the eight two-in-one dipoles needed for a 100m test string for 1992 and orders will soon be placed.

Quadrupoles, also of the two-in-one type, are being designed by Saclay. The dipole/sextupole lumped corrector is being developed by a British company, Tesla, in collaboration with the Rutherford Appleton Laboratory. In total about 1800 dipoles and a corresponding number of quadrupoles would be required.

As well as capitalizing on the existing CERN infrastructure, there is the added attraction of little expenditure on the low technologies of 'pouring concrete and digging rock', with the high technology aspects attracting European industry on an unprecedented scale.

Concluding the meeting, EEC Director General for Science, Research and Development Paolo Fasella, speaking on 'Scientific Collaboration in Europe', assured the scientific and industrial communities that the EEC was closely following the progress in the high technology of accelerators, and was consequently ready to help. He cited earlier programmes such as ESPRIT and described the present FRAMEWORK channel for EEC aid (CERN already benefits with money for CERN Fellowships). An open invitation was extended to formulate requests for assistance on behalf of valid scientific projects, where the accelerator community should not be short of suggestions!

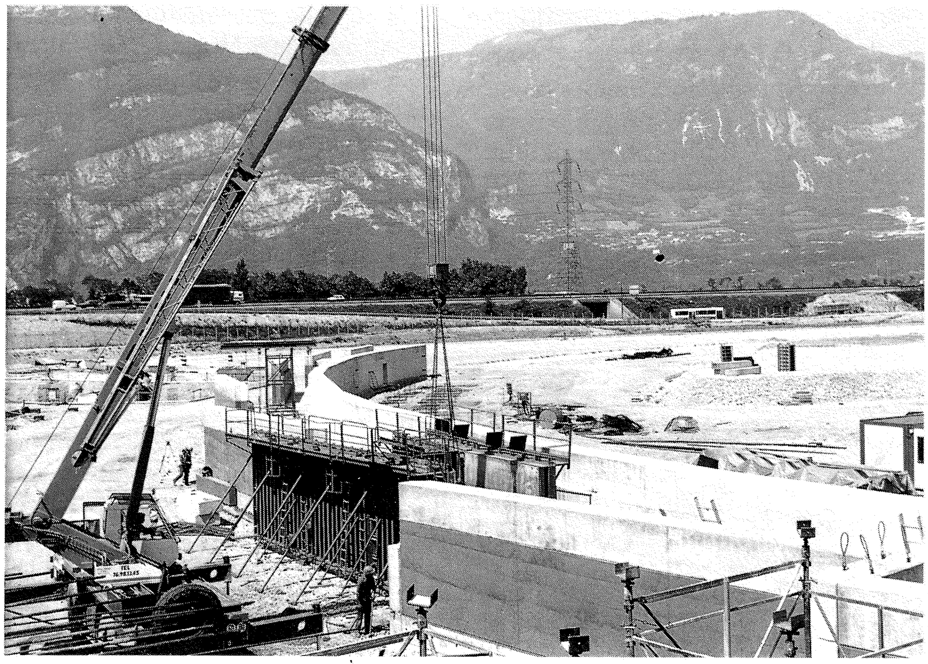
By Philip Bryant

* See page 17

European Synchrotron Radiation Facility starts to take shape

Construction work for the European Synchrotron Radiation Facility (ESRF) at Grenoble

Photo A.M. Freund, A Childeric



Highly visible on the approach to Grenoble from Lyon, the 280,000 square-metre European Synchrotron Radiation Facility site is fast becoming a prominent local landmark.

Based on a series of studies (dating from 1977) and on the detailed preparative work of the ESRF team, the first set of buildings is approaching completion on-site. Elsewhere throughout Europe the manufacture of machine components is reaching the final stages.

The eleven 'Founding Father' countries (France, Germany, Italy, Great Britain, Spain, Switzerland, Belgium, Denmark, Sweden, Norway, Finland) contribute to the construction and subsequent operation of a storage ring for 6 GeV electrons or positrons to be used as a high brilliance X-ray source and of 30 equipped beamlines.

Inside the storage ring will be a 200 MeV linear accelerator for electrons (and possibly an electron-positron converter and a 400 MeV positron linac) to feed the particles into a booster synchrotron where their energy is raised to 6 GeV at 10Hz repetition frequency, for injection into the storage ring. The storage ring will be operated in single bunch or multibunch mode.

The energy of the storage ring was chosen at 6 GeV, to meet the specifications for high flux and high critical energy (19.2 keV X-rays from the 0.8 T bending magnets and up to 14.4 keV in the first harmonic of undulators), and for a wide tunability range of undulators. The horizontal emittance of the ESRF has been specified at 7 nm.rad, and the vertical emittance one order of magnitude smaller. Performance would thus improve over existing dedicated synchrotron radiation sources by one to two orders of magnitude.

The ESRF lattice is the result of optimizing emittance and energy requirements, with the additional constraints of a circumference not exceeding 850 m, of a large number of straight sections for the installation of insertion devices, and of low sensitivity to errors. The Chasman-Green type lattice has 32 6-m straight sections, 29 of which can accommodate insertion devices (two are needed for the radiofrequency accelerating cavities and one for the injection from the booster synchrotron).

The need for a stored beam lifetime of some 10 hours could impose the use of positrons, instead of electrons. (Positrons repel positive ions created in the residual gas, thus avoiding the ion trapping which is detrimental to the stability of electron beams.)

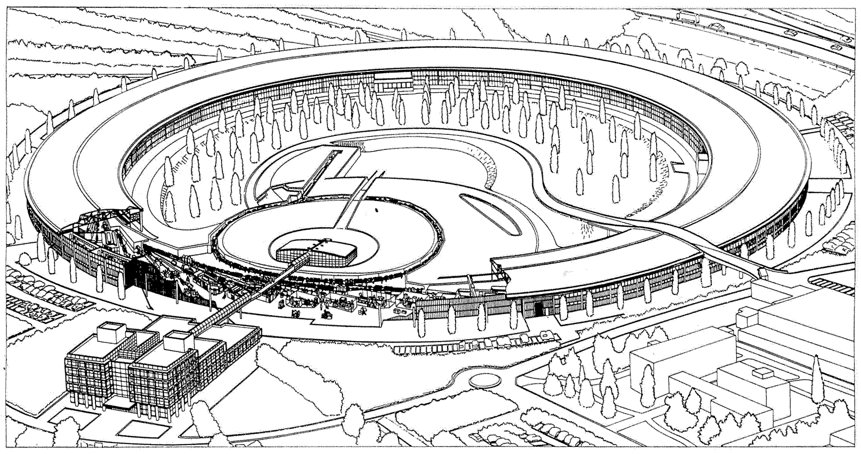
In principle, synchrotron radiation can be drawn from insertion devices to be placed in 29 of the straight sections and from 29 of the 64 bending magnets.

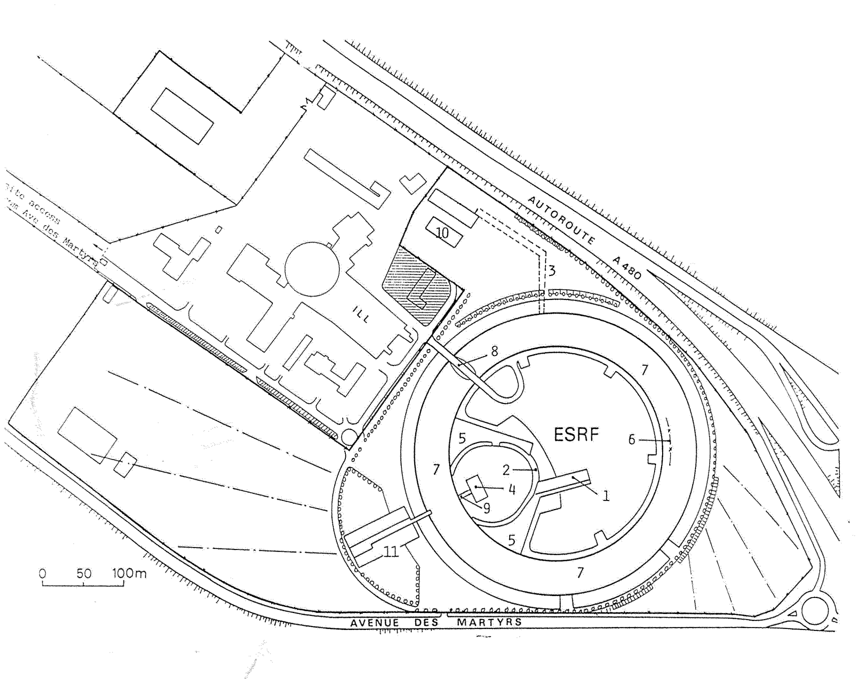
Present planning foresees 26 beamlines on insertion devices and four on bending magnets. A first group of at least seven beamlines shall be operational for external users in mid-1994; within the following 12 months 11 more beamlines should be commissioned. Three new beamlines will then be put into operation each year, up to the total of 30 by 1998. The facility will be operated and made available to users from the contracting countries free of charge, on the basis of scientific merit.

Present status and further planning

Excavation work was completed during 1989. Construction of the accelerator buildings, the storage ring tunnel, the annular experimental hall and some adjacent technical buildings started this February. In February 1991, the accelerator buildings will be ready, but since civil engineering work for the buildings will be completed some time before that, pre-installation activi-

Artist's view of ESRF buildings





ties might start up ahead of time.

The electron part of the Preinjector is already completed and will be installed as soon as the building is available. All equipment of Transfer Line 1 is currently being manufactured, and commissioning is expected in the middle of next year.

More than three-quarters of the Booster Synchrotron equipment have been ordered. The planning for delivery of the injector components foresees installation starting in November, in parallel with the Linac. The detailed design of Transfer Line 2 is ready, and most of the capital costs have already been committed.

About half the Storage Ring equipment has been ordered. A sophisticated system for fast vertical realignment was adopted in the course of construction in 1988 to take account of ground settlement. For the radiofrequency system it was decided to take full benefit from the system developed by CERN for LEP which is altogether almost perfectly adapted to requirements, and to contract out the delivery of a turnkey r.f. transmitter from industry. All major vacuum chambers and the ion pumps have been ordered.

Installation should start by next February. Present installation estimates allow one full year for total assembly (160 girder modules) and subsequent hardware tests. Thereafter provision has been made for a 10 month commissioning period.

The technical options for the Beam Front Ends are finalized, and the call for tenders will be issued in the next months. Hardware and

Outline of the buildings: 1 Preinjector, 2 Injector, 3 Technical Gallery, 4 Control, 5 Technical Buildings, 6 Storage Ring, 7 Experimental Hall, 8 Road Bridge, 9 Foot Bridge, 10 Utilities, 11 Central Building.

ARGONNE Groundbreaking for Advanced Photon Source

In June, the US Argonne National Laboratory celebrated groundbreaking for the Advanced Photon Source, the 7 GeV electron machine planned for the next generation of US synchrotron radiation X-ray research. Report in the next issue.

software for the Machine Control System is already sufficiently advanced for the first application programmes to have been written and partly tested.

The ESRF beamlines have been selected after a wide-ranging discussion with the European synchrotron user community and with advisers from the USA and Japan. The corresponding chapter of the Foundation Phase Report (FPR) was written after a meeting of prospective users in September 1986. Once the FPR was accepted and the ESRF formally established, the first 18 priority beamlines were selected after a second Users' Meeting in March 1989 and subsequent discussions of ESRF's Science Advisory Committee.

The first eight beamlines, for most of which the design phase is well under way, are: Microfocus – Materials Science Wiggler – Laue Protein Crystallography – High Brilliance Undulator – High-Energy X-Ray Scattering – Circular Polarization – Surface and Interface Diffraction – Dispersive EXAFS. A further two are left open, while the next eight beamlines shall also cater for fields of high interest, such as inelastic scattering, Mossbauer diffraction, magnetic scattering, X-ray topography, and many others.

Obviously the 30 'public' beamlines are far from exhausting the potential of the machine, especially for the bending magnet sources. The ESRF is receiving and considering proposals from groups of users intending to build additional instruments at ESRF with independent funding, the so-called Collaborating Research Groups (CRG).

Considerable progress in X-ray optics and detectors and on mechanical stability of the source and the beamlines is necessary to meet the unprecedented brilliance of the X-ray beams to be produced by ESRF's sources. At present, research and development efforts in ESRF's Experiments Division are concentrating on these challenges.

Main Parameters of ESRF's Storage Ring

Energy 6 GeV

Current (multi-bunch mode) 100 mA

Current (single-bunch mode) 7.5 mA

Circumference 844.39 m

Lattice Chasman-Green

Dipoles 64

Quadrupoles 320

Sextupoles 224

Bending field 0.86 T

Number of straight sections 32, out of which 29 are available for insertion devices

Free-length of straight sections 6 m

Number of Bending Magnet Ports 26 at 20 keV, and 16 at 10 keV

Radiofrequency 352 MHz

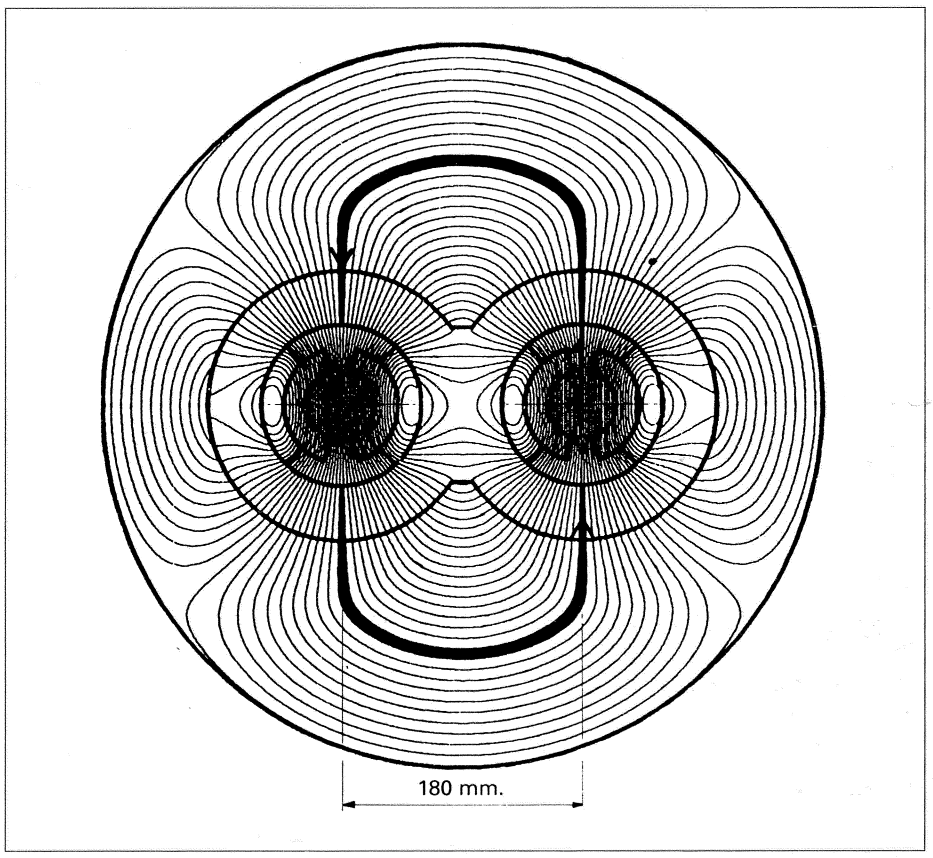
Approximate beam lifetime 10 h

Rms bunch length 16-50 ps

Beam dimensions (h/v) at various source points (10 % coupling): low beta (wiggler) 0.068/0.047 mm; high beta (undulator) 0.412/0.090 mm; Bending magnet 0.187/0.128 mm.

Physics monitor

A field map of the superconducting dipole design for the LHC proton collider for CERN's LEP tunnel, showing the 'two-in-one' design with the two beampipes held in a single cryostat.



HIGH FIELD MAGNETS
Niobium-titanium and beyond

To guide proton beams at tomorrow's higher energies – for the LHC project in CERN's existing LEP tunnel, and for the US Superconducting Supercollider (SSC) construction project – accelerator physicists are pushing for more powerful magnets.

In addition to these big new proton colliders, stronger focusing lenses are needed, particularly for new linacs, and higher fields will also be necessary for hybrid colliders, where electron linacs will shoot at proton rings. Special magnets attaining 15 or even 20 Tesla would be required in the proton rings to reduce beam emittance by synchrotron radiation and enable narrow proton beams to reach sufficient luminosity with sophisticated electron linacs.

Bjorn Wiik stressed these points in his introduction to the two-day workshop on 'High Field Dipoles beyond Niobium-Titanium' held at the DESY Laboratory in Hamburg in July, reminding participants also that experience so far for the superconducting proton ring being built for the HERA electron-proton collider at DESY has already demonstrated that niobium-titanium technology is mature, even on an industrial scale.

The HERA-type design (coils around the beam-pipe, mechanical support collars and cold iron return) has gone on to become widely adopted, but reaches its natural limit for dipole construction using niobium-titanium near 10 Tesla. This is now well understood and has been demonstrated with several test magnets developed in a collaboration between CERN and Italian supplier Ansaldo. A similar geometry was used with niobium-tin in a collaboration between CERN and Elin (Austria) which reached a record field for this kind of magnet of 9.45 Tesla (September 1989, page 5).

CERN's proposed LHC collider in the LEP tunnel envisages 10 T fields with a double aperture carrying the two beam pipes for the proton beams inside a single cryostat. Four contracts have been placed with European firms for the development of one-metre double aperture niobium-titanium magnets with a view to placing further orders for full-scale ten-metre prototype units. Using superfluid helium at 1.8K instead of conventional 4.2K cryogenics provides the necessary additional potential. First results from the one-metre models are expected soon.

The Hamburg meeting began with an outlook review on superconducting materials by D. Larbalestier (Wisconsin), followed by several presentations on wire manufacturing techniques. The afternoon was devoted to magnetization effects, forces in high field dipoles and niobium-tin winding experience. Measurements of the effect of stress on this conductor at different Laboratories were discussed the next morning, followed by a report on recent developments by R. Fluekiger (formerly Karlsruhe, now Geneva).

S.L. Wipf from DESY (who, with A. Asner and B. Wiik, organized the meeting) presented possible methods to overcome the present limitations. Warm superconductors at low temperature (withstanding fields of over 20 Tesla) and some unusual geometries were examined.

A vital superconducting parameter is the critical current density, when, for a given temperature and magnetic field, the superconductor 'quenches'. This current density decreases with the applied field (for a fixed temperature), eventually falling to zero. For filamented niobium-titanium wire this happens around 11 Tesla at 4.2 K and 15 Tesla at 1.8 K.

Higher fields in dipoles (over about 10 Tesla) need other materials, like niobium-tin, more amenable than niobium-titanium at these fields. Even though it is very brittle, niobium-tin can be used to make filamented wires and coils provided that the superconducting substance is generated in the finished cable in a chemical diffusion reaction induced by maintaining the system at over 600 degrees C (red heat) for about a week.

Coils are usually 'reacted' in this way after being wound, using the 'wind and react' procedure. Besides the winding of the coils, electrical insulation of the cables poses severe problems. All materials incapable of withstanding the heat treatment have first to be 'burned out'.

Small solenoids using niobium-tin have been produced by various companies, attaining up to 20 T (July/August, page 26).

It is also possible to do the operations in the reverse order – 'react and wind'. The brittle reacted niobium-tin cable must then be treated very carefully during the subsequent winding process – stress and bending must be kept within defined limits – but no baking is necessary afterwards. This method is proposed for very large coils in fusion projects.

Reacting technology seems to be reasonably well understood, but is obviously not easy for mass production of bigger magnets, so the conventional and cheaper niobium-titanium route will continue to be used wherever possible.

Several techniques have been developed for niobium-tin – the 'Bronze Route' (Vacuumschmelze, Hanau, Germany), the 'Modified Jelly Roll' (TWCA, Albany, US), the 'Internal Tin Process' (IGC, Waterbury, US) and the 'Powder Tube Technique' (ECN, Petten, Netherlands). All these methods can provide reasonable wire (from 0.8 to several mm in diameter with filaments in a metallic matrix).

Another promising material is the 'Chevrel Phase' ($PbMo_6S_8$), however much work remains to be done, and would benefit from user encouragement.

Highest fields could be achieved with high temperature superconductors used at low temperatures. However known materials cannot stand high currents and extremely thick layers of conductor would be needed.

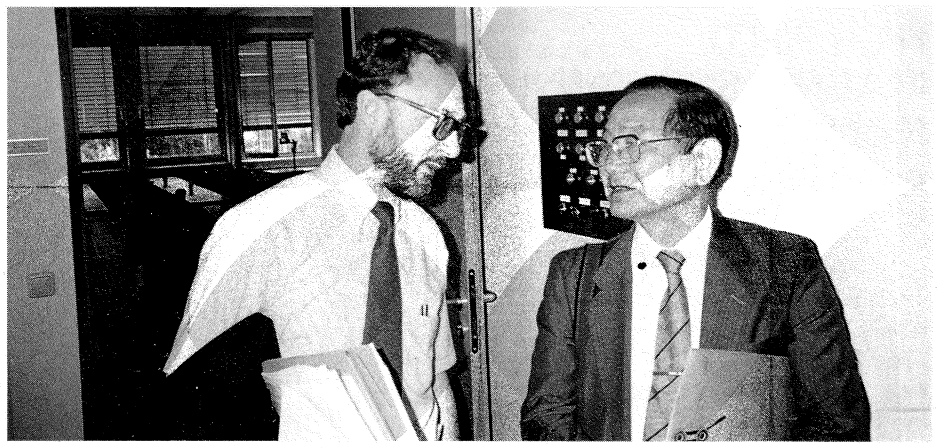
For accelerators, magnetization of the superconducting material is a serious problem, particularly at low fields (persistent current effects). The considerable injection field distortions need special attention (April, page 15).

Accurate measurements show that current through niobium-tin cable deteriorates seriously if stress is applied – effects of more than 50% appear long before any permanent deformation is caused. Compression in coils reaches levels as high as 100 Megapascal (ten kilograms per sq mm) and studies are continuing.

To most participants it was clear that niobium-tin used in conventional geometry is limited to about 13 Tesla. This field is lower than that obtained in solenoids because of the reduction of the critical current density of the filamented wire by winding stresses and mechanical movements.

The ideas presented at the Workshop show that there are still a lot of possibilities to explore to reach higher fields. However such new developments need a long lead time. Niobium-titanium and niobium-tin were known 25 years ago but only now are the industrial techniques being perfected.

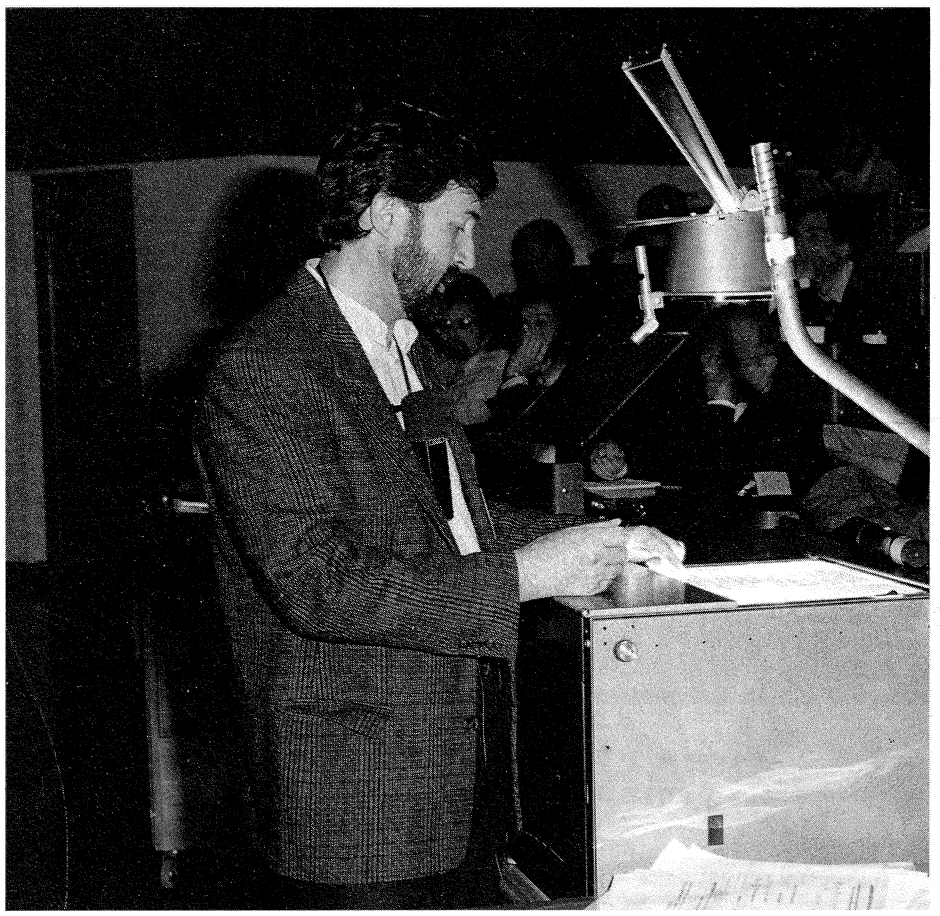
From Pedro Waloschek



David Larbalestier of Wisconsin (left) with Fujio Irie of Kinki (Japan) at the workshop on high field magnets held in July at the German DESY Laboratory in Hamburg.

LEP results were updated at the Singapore meeting (see page 3).

At the Neutrino 90 meeting at CERN, E. Fernandez of Barcelona gave a compilation of Standard Model results from the four experiments – Aleph, Delphi, L3 and Opal – taking data at CERN's LEP electron-positron collider.



NEUTRINO 90
Shop window for LEP/Underground sunshine

Sixty years after its prediction and 35 years after its discovery, the neutrino, the otherwise invisible particle carrying off 'missing' energy in radioactive beta decay, still provides compelling physics.

The Neutrino 90 meeting held at CERN in June, the 14th in a series which began at the Meyrin Laboratory in 1963, reflected the continued enigma of this puzzling particle. Despite heroic efforts, some basic neutrino properties – mass, flavour oscillation – are so subtle as to elude measurement, and can only be sketched in as experimental limits.

While the 1987A supernova has made neutrino astronomy respectable (May issue, page 18), a much closer extraterrestrial neutrino source – the sun – continues to challenge the ingenuity of experimenters. However Neutrino 90 included first reports from several new telescopes looking for neutrinos and other particles, promising important new insights in the next few years.

A scoop for Neutrino 90 was the first comprehensive batch of data from the four experiments – Aleph, Delphi, L3 and Opal - taking data since August last year at CERN's LEP electron-positron collider. Initial 1989 data quickly showed that the Universe can contain only three types of neutrino (December 1989, page 18). This landmark result showed that physics has room for just three kinds of weakly interacting particles (leptons) – electron, muon and tau, and six types of quark, grouped into three pairs – up and down, strange and charm, bottom (or beauty) and top.

With more than 100,000 Z decays under their belts in 1989 and about twice that number in only the first half of this year's run, the four experiments had polished their neutrino limits, taken a detailed look at weak decays, carefully studied the way the Z (a mediator of the weak force) produces strongly interacting particles (with implications for quark field theory), simplified the scenario for 'dark matter', and pushed up the mass limits for possible new particles. In particular, preliminary results from Aleph and L3, combined with input from other sectors of the Standard Model, ascribed the long-awaited sixth ('top') quark to the mass region between 100 and 180 GeV*.

Neutrinos from the sun

The pioneer study of solar neutrinos – the South Dakota Homestake Mine experiment led by Ray Davis – has now been accumulating data for 20 years. As well as discovering that the observed neutrino signal is only about half what is expected (the 'solar neutrino puzzle'), K. Lande of Pennsylvania pointed to possible ten-year cyclic effects, perhaps correlated to sunspot activity or to solar geometry.

With less data accumulated, but with directional effects giving additional information, the Japanese

Kamiokande underground experiment confirms the solar neutrino puzzle, but does not see marked time variations, claimed spokesman Y. Totsuka.

The puzzle could be resolved by new detecting media picking up more representative solar neutrino information. Newcomers on the scene are two studies using gallium – the Gallex experiment using 100 tons of solution in the Italian Gran Sasso underground Laboratory (May 1989 issue, page 1), and the SAGE Soviet/US effort using 30 tons of metal at Baksan in the Caucasus (June, page 16). Both should soon start providing a new window on solar particles and help disentangle effects due to neutrino properties from those arising from solar mechanisms. Preliminary SAGE results do not rule out a lower solar neutrino flux in the lower energy region.

Introducing the meeting, CERN Director General Carlo Rubbia had highlighted the solar neutrino question and its deep implications for physics. 'If we knew the Kurie plot of the neutrinos emerging from the sun, we would know everything,' he declared. (The Kurie plot is the traditional way of displaying the spectrum of beta decay.)

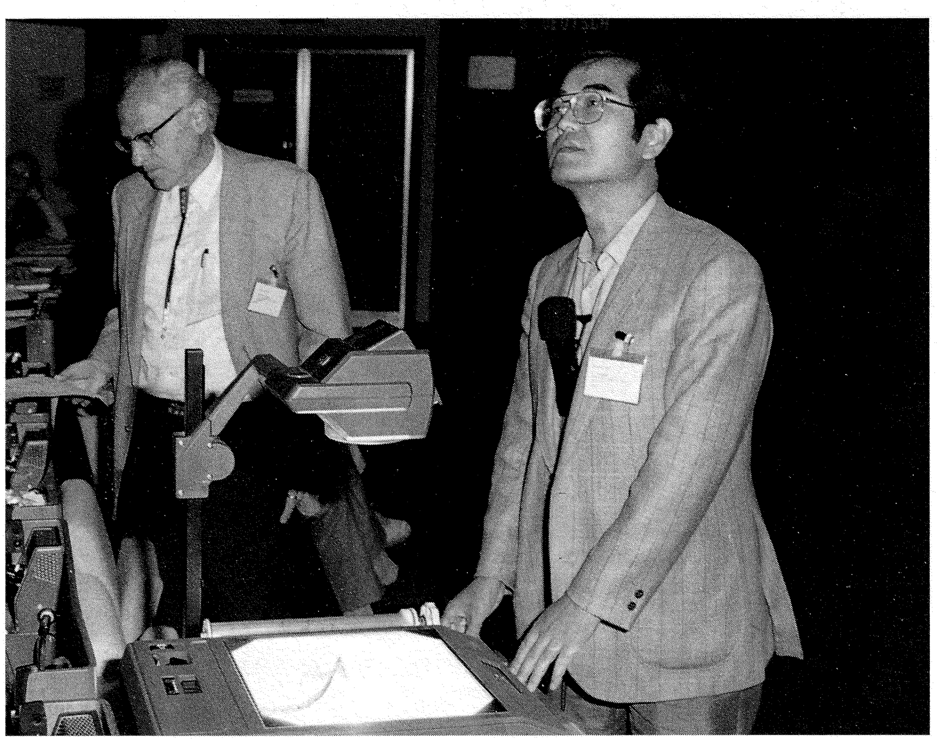
Looking at extraterrestrial muons, rather than neutrinos, is another Gran Sasso study, MACRO, which began operation last year and has intercepted some 800,000 muons from outer space. G. Giacomelli of Bologna described an initial sweep for sharply defined muon sources. Awaiting its first muon 'star', MACRO has correlations with the signals picked up by the Extensive Air Shower array 1400 metres above on top of the mountain.

On the neutrino mass front, precision measurements of tritium beta decay at Zurich and at Los Alamos now give the lightest (electron-type) neutrino even less mass room to move – less than 15.4 and 12.5 electronvolts respectively.

There was a time when big experiments using neutrino beams were the flagships of the fixed target experiment fleet. Now not many of these neutrino flagships remain, but proposals for future experiments have been aired so that high energy neutrino beams do not become history. Alvaro de Rujula reviewed ongoing experiments, together with projects in the pipeline, proposals awaiting a decision, and ideas for discussion. Neutrino oscillations and the detection of the tau neutrino are major goals.

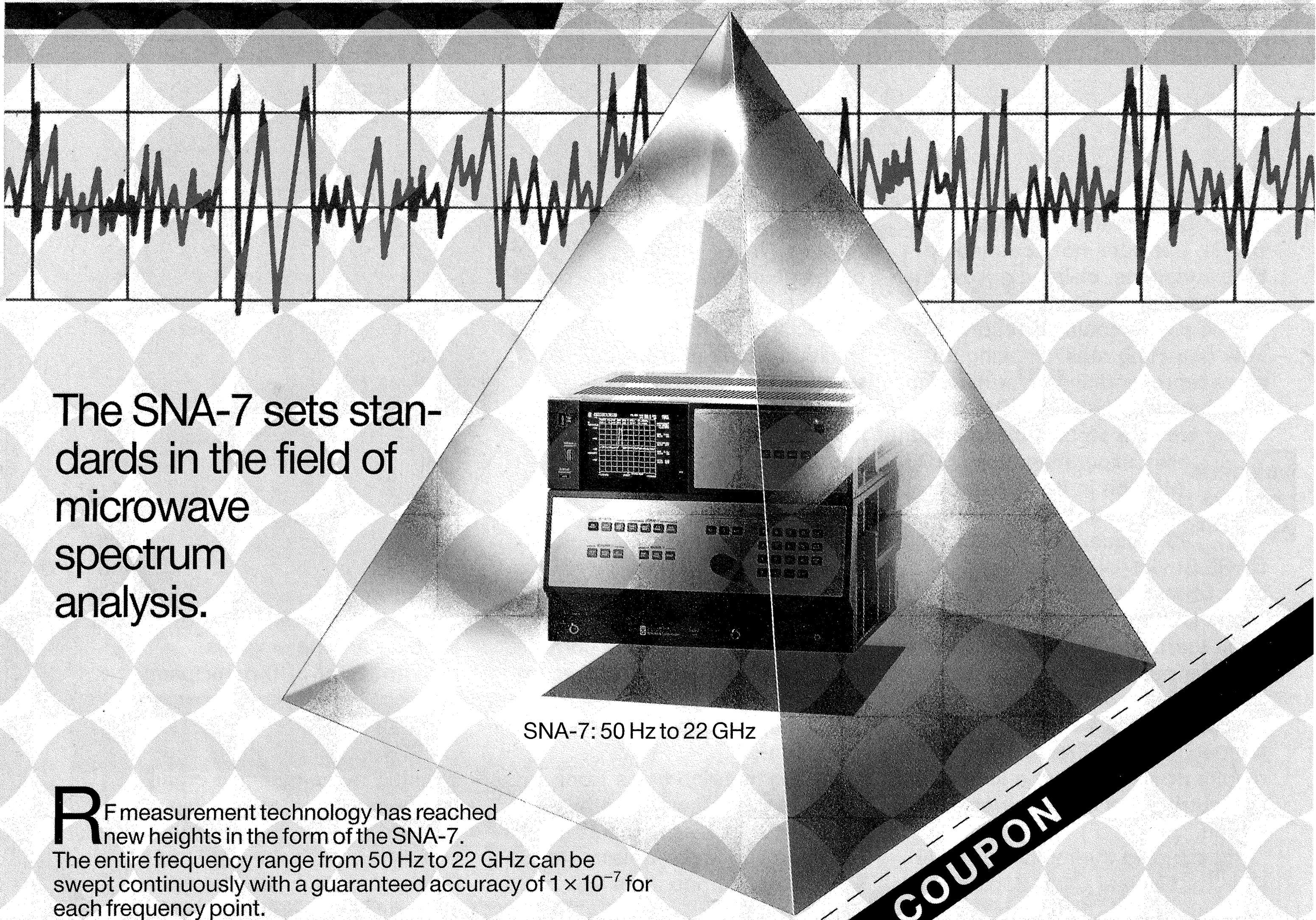
With about 300 participants, Neutrino 90 was a major meeting, but still 'compact' enough to be accommodated on the CERN site, and assisted by imaginative organization under the chairmanship of Klaus Winter. With neutrino pioneers Bruno Pontecorvo, Fred Reines and Jack Steinberger among the participants, the event provided a fascinating snapshot of science's relentless march into the unknown.

With the Standard Model in impeccable shape despite the onslaught of LEP, the 'Higgs mechanism' triggering the symmetry breaking at the heart of electroweak synthesis remains a complete mystery. Guido Altarelli of CERN described the modest region where, according to LEP, the Higgs particle(s) can be excluded. However Carlo Rubbia wagered that supersymmetry could have an important role to play, and looked forward to a 'neutrino and photino' meeting by the year 2000!



Y. Totsuka of Tokyo (right) gave the latest results from the Japanese Kamiokande underground study. Left is Neutrino 90 session chairman, neutrino pioneer Fred Reines.

A new dimension in performance.



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Around the Laboratories

The first cryomodule with four 4-cell superconducting radiofrequency accelerating cavities on its way for installation in the LEP tunnel.

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CERN
Towards LEP 200

In March a cryomodule with four superconducting radiofrequency accelerating cavities operated for the first time in CERN's new LEP electron-positron collider, the result of many years of careful research and development work and an important step on the road to boost LEP energies from their initial level around 50 GeV per beam to above the 82 GeV threshold for production of W pairs (May, page 1).

The advantages of superconducting r.f. cavities for large storage rings stem mainly from the considerably reduced r.f. losses (about a factor of 100,000) and from the increased acceleration fields for CW operation compared to copper cavities.

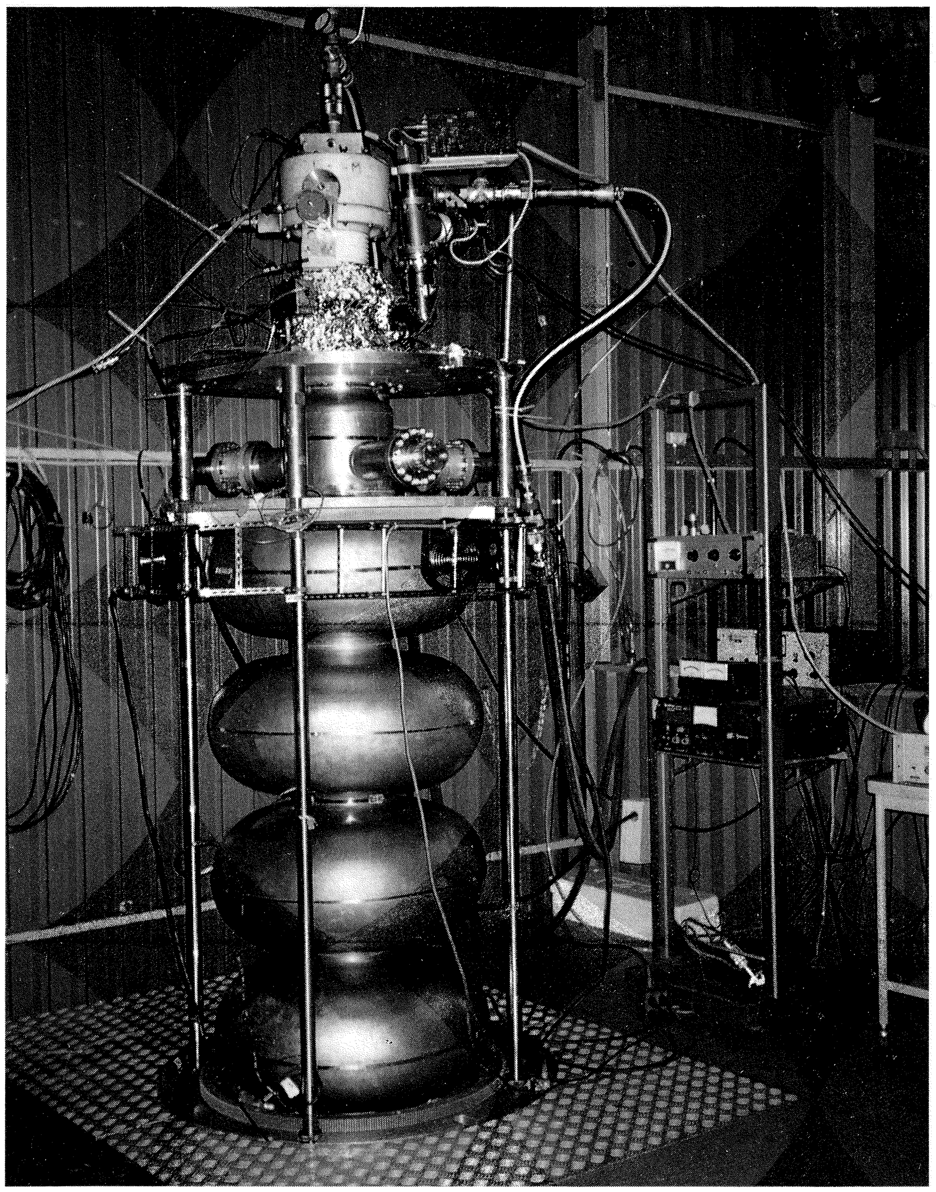
With this in mind, the first studies of r.f. superconductivity were started at CERN in 1979. For a first feasibility study an operating frequency of 500 MHz was fixed. Niobium was chosen as superconducting material, allowing operation at 4.2K, the normal boiling temperature of helium.

Cavities were fabricated with a rounded geometry, favouring surface treatments and reducing resonant electron loading. The development of fabrication and surface technologies in combination with new and powerful diagnostic methods (in particular temperature mapping) rapidly brought acceleration fields and quality factors adequate for LEP.

In 1983 a 500 MHz five-cell niobium cavity was tested in the PETRA storage ring at DESY, Hamburg. This mastering of niobium technology for a large 500 MHz multicell cavity added confidence in going to the (even lower) LEP operating frequency of 353 MHz with the obvious advantage that the existing LEP r.f. generation, distribution and control systems can be used.

A new cavity shape was designed with ports for r.f. power input and higher-order-mode (HOM)

A micron-thick layer of niobium is deposited on a copper 'substrate' cavity by sputtering.



The first LEP year

At the end of August, CERN's LEP electron-positron collider came to the end of a five-month run in which the four big experiments – Aleph, Delphi, L3 and Opal – intercepted 650,000 Z particles.

Before LEP began operation last year, the world supply of Zs - the electrically neutral carrier of the weak nuclear force - was measured in hundreds, and in its first run last fall LEP delivered more than 100,000 of these particles, opening the era of precision Z physics.

LEP performance this year has nudged design levels (July/August, page 9), but has been limited by residual vertical dispersion in the machine and by non-linear beam-beam interactions. The compensation schemes to ensure that the circulating beams are not unduly perturbed by the powerful solenoids of the four experiments have also needed modifications.

With careful attention, LEP experts hope to at least triple the Z score in 1991. This year, the first superconducting radiofrequency acceleration cavities have been tested (this page), the first step on the road to push LEP's energy to the level needed to produce pairs of W particles – the electrically charged weak force carrier. This is foreseen for 1994, by which time the LEP experiments should have accumulated at least five million Zs.

power output at the two beam tubes. In 1985 a first four-cell niobium cavity was submitted to a long-term laboratory test at 7 MV/m, comfortably above the design value of 5 MV/m. In 1987 a first LEP-type niobium cavity was installed in the SPS and operated for more than 10,000 hours.

The development of niobium cavities continued with the construction of four more cavities (two at CERN and two in industry). These were assembled, installed and initially tried in the testbed for the LEP copper cavities before being installed as a basic four-cavity module near LEP's interaction region 2, using a standard LEP r.f. system slightly modified for the specific needs of s.c. cavities and a cryogenic system based on a modified (ISR) liquefier.

Despite the fact that initial oper-

ation was considerably restricted by the physics programme, design acceleration fields in the individual cavities were reached rapidly and no major detrimental effects on beam behaviour were observed, so that the cavities can now be used for routine operation in LEP.

As well as the niobium cavities, a second line of development used a thin (microns) layer of superconducting niobium deposited on a copper cavity, with the Meissner effect giving a penetration depth of only 0.05 microns in the niobium. This gives several advantages over cavities fabricated from niobium sheet – thermal stabilization of localized surface defects is increased by the higher thermal conductivity of copper (about a factor of ten), r.f. losses are typically halved, and in addition the use of copper considerably reduces cavity costs. After a detailed exploration of sputtering methods and their parameter range, this method was finally applied very successfully to four-cell LEP cavities.

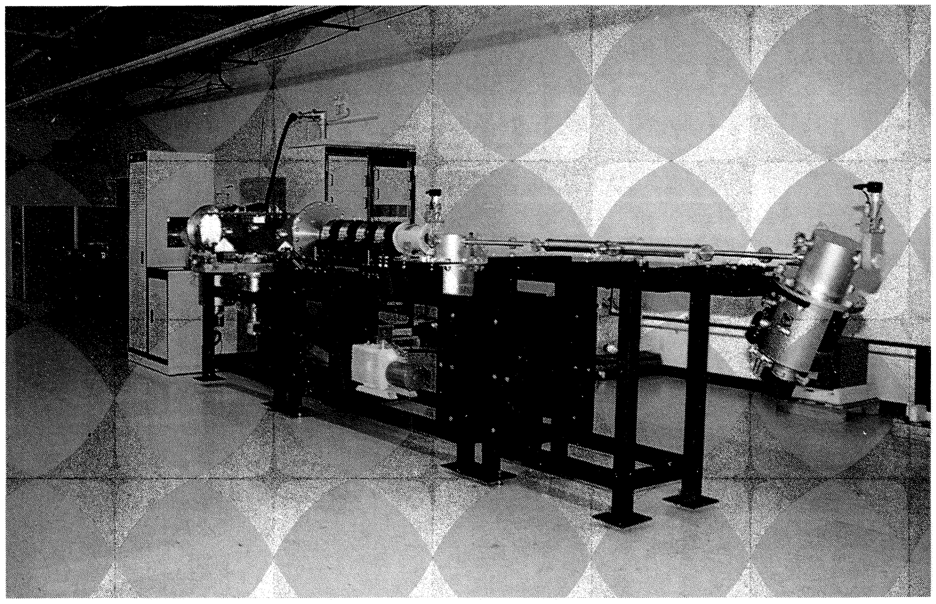
In 1989 SPS asked for more superconducting cavities for accelerating electrons and positrons to higher injection energies for LEP. In a crash programme the niobium cavity was replaced by a module of two niobium-copper LEP-type cavities, which has participated routinely in SPS operation since March.

The operation of superconducting cavities in an accelerator requires many specific auxiliary items like cryostats, r.f. couplers and frequency tuners. A new modular type of cryostat with good accessibility to all critical parts of the cavity system was developed and proved its worth for the assembly of cavities under clean (dust-free) conditions and for a fast replacement or repair of cavity parts.

Radiofrequency power couplers and HOM couplers were developed and tested, and development work is continuing in the push for higher LEP beam intensities. A novel tuning system with no moving parts gained its roadworthiness certificate during operation in the SPS and LEP.

The need for homogeneous and clean inner cavity surfaces – one of the biggest challenges – has fostered the development of special facilities at CERN like a large electron beam welding plant using an 'internal' electron gun, a fully automated installation for chemical surface treatments, a rinsing plant using high-purity, dust-free water, large clean rooms for cavity assembly, and magnetron sputtering for depositing niobium on LEP-type cavities. The fabrication of cavity systems is gradually being handed over to industry. For the upgrading of LEP, a first batch of 20 niobium cavity systems has already been ordered; eight niobium-copper cavities will be constructed as a test series in CERN, enabling the 32 first cavities to operate in LEP by the end of 1991.

The very successful operation of niobium-copper cavities paved the way for the next stage. 160 such cavities will be ordered from industry (with an option for 64 more), so that in 1994 LEP experiments should be able to see the first examples of W production.



The 1.85 MeV radiofrequency quadrupole (RFQ) built by AccSys Technology of California for calibrating the BGO crystals in the L3 experiment at CERN's LEP electron-positron collider.

RFQ for BGO

One of the key elements of the giant L3 detector at CERN's LEP electron-positron collider is its electromagnetic calorimeter, composed of 11,000 bismuth germanate (BGO) crystals manufactured in Shanghai, providing precise energy measurements of electromagnetic particles from less than 100 MeV to more than 100 GeV.

To maintain performance, the crystals must be continually calibrated and recalibrated. After five years of development at Caltech, a solution was adopted using a 1.85 MeV radiofrequency quadrupole (RFQ) to provide a pulsed beam of negative hydrogen ions. These ions are neutralized in a nitrogen gas cell, drift through L3's magnetic field, and bombard a lithium target, giving 17.6 MeV radiative capture photons to calibrate all of the crystals to better than 1% in one to two hours.

The RFQ was built by AccSys Technology, Inc. in Pleasanton, California (who among other things have also supplied the injector for the proton therapy synchrotron built at Fermilab for the Loma Linda Medical Centre), while the ions are produced by a special volume ion source developed at Berkeley. The L3 system, using the RFQ and a special beam pipe and target, will be completed and tested by the AccSys and Caltech groups, working together with physicists from the World Laboratory.

The RFQ will be shipped to CERN in October and installed in the L3 detector next February. The RFQ beam, starting 12 metres from the target, will be focused to a 2 cm-diameter spot on the target, mounted next to the inner track detector, inside the BGO endcap.

The RFQ calibration technique has also been extended, using a fluoride crystal target, to produce high intensity bursts of photons that can simulate a single high energy photon (to 40 GeV equivalent) in each crystal for each pulse, promising a precision of 0.4% in a few minutes, of interest for the next generation of large proton-proton colliders.

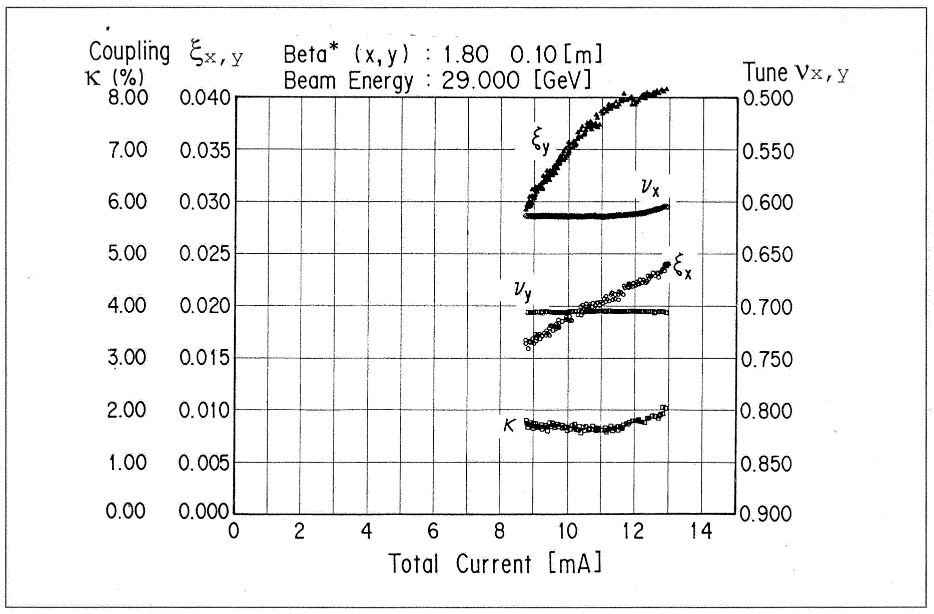
This work for L3 has been funded by the World Laboratory, by the US Department of Energy (DoE) through Caltech, and by a DoE Small Business Innovation Research grant to AccSys.

Meanwhile the L3 experiment has been completing its final BGO endcap modules, consisting of 3200 crystals covering the forward-backward region, to be ready for running at LEP next year.

KEK
Boosting TRISTAN

Ever since the TRISTAN electron-positron collider at the Japanese KEK Laboratory was commissioned in May 1987, the highest priority has been given to boosting beam energy for a rapid survey of quark-lepton physics in the new energy region.

Thus the radiofrequency power steadily increased every year. In particular, a full set of superconducting cavities (32 five-cell units) was installed in two stages, turning the TRISTAN Main Ring into 'a circular linac' with all of the four straight sections filled with accelerating cavities. Collision energy reached 64GeV in the fall of 1989.



Machine parameters for the TRISTAN electron-positron collider at the Japanese KEK Laboratory, displayed as a function of total beam current (betatron tunes, Greek nu; beam-beam parameters, xi; and vertical-horizontal emittance ratio, kappa). Recently the maximum of 0.04 for xi-y, the vertical parameter for the strength of the beam-beam interaction, was found to be too restrictive.

TRISTAN covers an interesting energy region where the electromagnetic and weak interaction significantly overlap in producing quarks and leptons. In addition, non-annihilation mechanisms also play important roles in particle production.

Aiming at high precision studies of all these interactions, TRISTAN has entered on a new phase, emphasizing high luminosity (high collision rate). The big question was whether it was possible to achieve high luminosity with a machine having so many radiofrequency cavities!

In February, a collision energy of 58 GeV was chosen so as to satisfy the physics needs and at the same time keep a large enough margin of r.f.power to permit considerable frequency shift to reduce beam emittance and guarantee stable operation, even under partial r.f. failure.

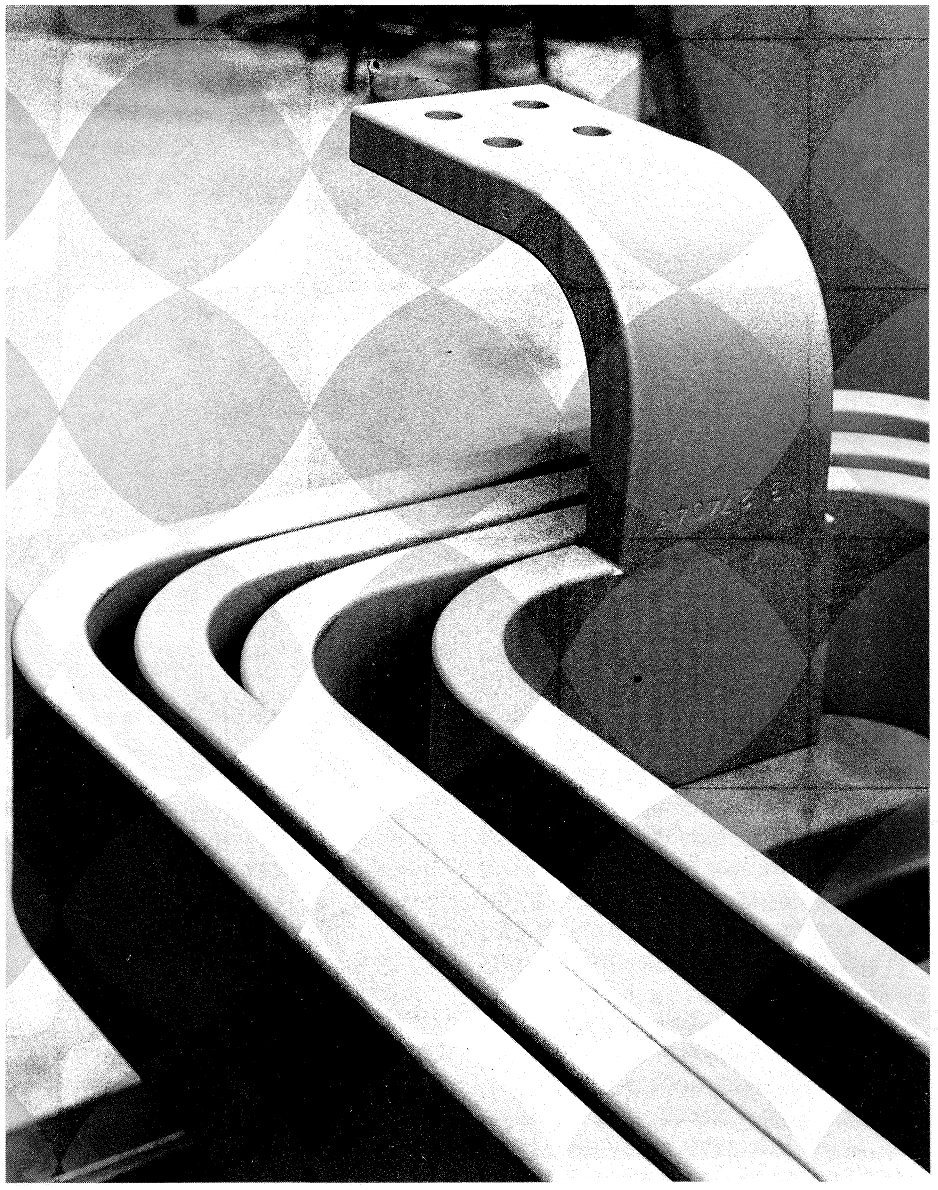
To establish the best operating point, r.f. accelerating voltages were carefully balanced across each collision point to equalize the betatron tune (frequency of transverse oscillation in units of the rotational frequency) to within 0.002 between the electron and positron beams.

With complaints from experimental groups about luminosity imbalances, horizontal and vertical amplitude functions were corrected and relative beam position was finely adjusted at each collision point using electrostatic beam separators. An annoying beam background persisted at one of the collision points for some time when a smaller beam pipe (10cm diameter) was used. A careful study with beam masks revealed that a quadrupole magnet was misplaced, and realignment not only decreased the synchrotron x-ray background, but also facilitated machine tuning.

A drift has been observed in TRISTAN's beam orbits, requiring frequent adjustments. Prior to injection, a pilot beam bunch is circulated, and vertical closed orbit is

This four-turn design for the coils to power the magnets for Fermilab's proposed Main Injector ring would give rapid ramping.

(Photo Fermilab)



measured and automatically readjusted to within 60 microns. With automatic orbit adjustment, this kept the specific luminosity (luminosity divided by beam-current product) as high as 0.3 x 10^{30} per sq cm per sec per milliamp sq, maintaining the vertical-to-horizontal emittance ratio less than 2%. The horizontal emittance itself was also halved (170nmrad) by shifting the r.f. frequency up by 2.5kHz. Beam loss during energy ramping has been minimized by preserving the constant betatron tune and beam orbits.

As a result of these and other efforts, accelerator performance has steadily improved, and the strength of interaction between colliding bunches, as represented by the beam-beam parameter, has reached 0.04 in the vertical direction. It is now possible to accumulate 0.5 inverse picobarns/day/experiment. In five months (March-July), less three short scheduled shutdowns each of about ten days, the VENUS detector recorded 31 inverse picobarns, with ten and twenty per cent less by AMY and TOPAZ respectively. This integrated luminosity is already comparable to those accumulated in the past.

During the scheduled shutdown which began in August, superconducting quadrupoles will be installed at four intersections to squeeze the beams from the present 1.8m and 0.1m to 0.9m and 0.05m to double the luminosity.

Since the total beam current has been limited to below 13.5mA because of a temperature rise in higher-mode coupler of the superconducting cavities, all the couplers are to be replaced, which should eventually boost luminosity to the level of an inverse picobarn per day.

FERMILAB III

The total ongoing plans for Fermilab are wrapped up in the Fermilab III scheme, centrepiece of which is the proposal for a new Main Injector (July, page 4). The Laboratory has been awarded a $200,000 Illinois grant which will be used to initiate environmental assessment and engineering design of the Main Injector, while a state review panel recommended that the project should also benefit from $2 million of funding.

Alongside the Main Injector in the Fermilab III package is the facelift for the linac (May, page 9) and improvements to the Laboratory's front line facility, the superconducting Tevatron, and to the antiproton supply.

By lowering the cryogenic operating temperature, the Tevatron should approach the 1 TeV energy for which it was named. The necessary cold compressors are gradually being introduced.

For proton-antiproton collider operation, a total of 22 electrostatic separators will eventually be installed for the next run (in 1991) to triple the collision rate (reaching a luminosity of 5 x 10^{30} per sq cm per s). Further performance increases should follow from increasing the number of bunches in the colliding beams from six to 36.

Exploiting the colliding beams, the CDF detector operated in the one-year run ending last June for the first time with its complete configuration. Triggering and offline data handling will be substantially improved to cope with the planned Tevatron collision rate increase, while hardware improve-

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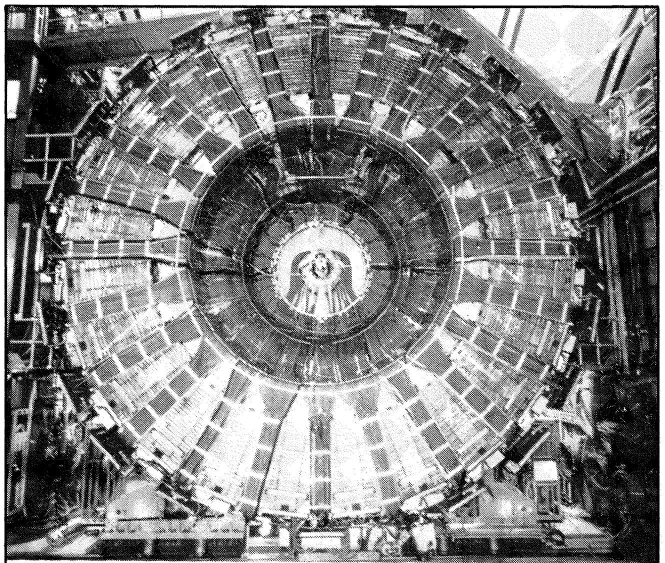

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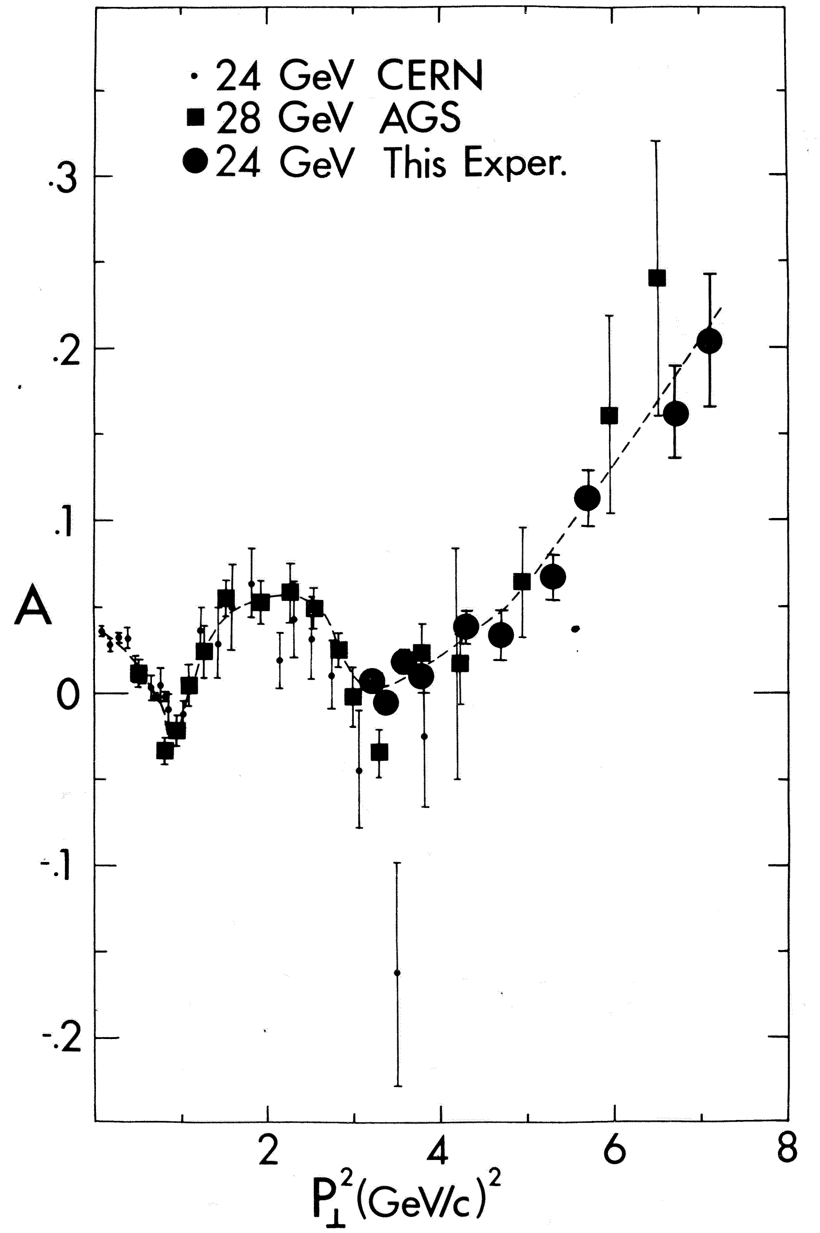
NE·TECHNOLOGY

MEASURING UP TO THE FUTURE

Left-right asymmetry versus transverse momentum for polarized (spin oriented) proton-proton elastic scattering. The large effect seen at the Brookhaven AGS and now confirmed is a challenge for quark-gluon field theory.*



ments in the pipeline include a silicon microvertex detector, improved central tracking, more muon shielding, and increased muon coverage.

Meanwhile the D0 detector is being readied for its first taste of colliding beams (March, page 6). Here again a series of upgrades is planned to take full advantage of increased Tevatron performance – new central tracking and improved electronics.

The challenges of the increased collision rates could provide a valuable testbed for the next generation of proton colliders, as well as hunting for the long-awaited sixth 'top' quark.

On the fixed target front, first generation Tevatron experiments are now all busy, and the possibility of 150 GeV beams from the new Main Injector has sparked a wave of proposals which will be aired later this year. One of these is a high precision, high sensitivity programme of neutral kaon physics, while two others involve neutrino beams – one for an improved measurement of the electroweak mixing angle and for a systematic study of nucleon structure, the other to search for oscillations between muon- and tau-type neutrinos. Beams would also have to be supplied for testing SSC-related equipment.

BROOKHAVEN
Spin result underlined

A recent experiment looking at violent proton-proton elastic scattering confirms, with high precision, earlier data which puzzled many theorists. Most pictures of strong interactions based on perturbative quark-gluon field theory (Quantum Chromodynamics, QCD) suggested that spin effects should disappear with energy and as the collisions become more violent.

Six years ago a Michigan team led by Alan Krisch found a large left-right asymmetry in violent (high transverse momentum) proton-proton elastic scattering at the 28 GeV Brookhaven Alternating Gradient Synchrotron (AGS – September 1984, page 273), a result which provided valuable fuel for the viewpoint that spin is an essential aspect of particle behaviour which does not get averaged out in the high energy wash.

However with production levels quite small and the statistical errors in the experiment fairly large, there was some doubt about the reliability of this surprising result.

Thus the Michigan team embarked on a quest for a better polarized (spin-oriented) proton target. The idea was to build a polarized target with much more cooling power, allowing about four times more beam intensity without boiling the liquid helium. They switched from their conventional helium-3 target, which operated at a temperature of 0.5K in a 2.5T magnetic field, to a helium-4 target with more cooling power (because of the larger heat of vaporization).

Unfortunately such evaporation refrigerators are very inefficient below about 1K. In the complex but successful dynamic nuclear polarization technique invented some

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thirty years ago by Anatole Abragam (College de France) and Carson Jeffries (Berkeley) the proton polarization usually grows with the ratio of the magnetic field to the temperature. In an attempt to keep the proton polarization near its earlier value around 50 per cent, the Michigan team commissioned Oxford Instruments to construct a superconducting 5T magnet with a field uniformity of one part in ten thousand.

Earlier work at CERN and elsewhere had shown that impressive levels of dynamic nuclear polarization could be produced in beads of frozen ammonia, a substance which is also highly resistant to the radiation damage which plagues other polarized target materials such as alcohols.

The Brookhaven target proved very efficient, and was used for almost three months in a high intensity AGS proton beam, with the polarization rapidly reaching 96% after each radiation-damage-removing anneal, and averaging 85%.

The dominant feature of the 24 GeV proton-proton elastic scattering spin data is a rapid increase in the left-right asymmetry at high transverse momentum. With the threefold improvement in precision, it is unlikely that the variation from zero symmetry is a statistical fluctuation. Spin theorists are calling for a rethink of basic principles.

Fireworks for RHIC

The fourth workshop on experiments and detectors for Brookhaven's Relativistic Heavy Ion Collider (RHIC), held at the Laboratory early in July, brought together nearly 200 soon-to-be RHIC users for an intensive week of discussions, with working groups focusing on the preparation of letters of intent for experiments. These letters, due on 28 September, are the first step towards the first round of experiments for the new collider.

As well as seven main working groups, each developing its concept for a RHIC detector, participants also looked at implementation issues, including the configuration of the existing experimental halls, machine questions such as possible luminosity upgrades, and the plans for detector R&D.

The meeting took place amid celebrations for the 4 July Independence Day holiday, and as fireworks lit the skies in surrounding communities, workshop participants toiled into the night. The heavy demands of today's physics research schedule allowed no respite – most participants had commitments to experiments scheduled at Brookhaven's AGS machine, which completed its May-June heavy ion run two days before the workshop began, or at CERN's SPS, where preparations were getting underway for this summer's ion run. This left a narrow midsummer slot for a major meeting.

The detector concepts being developed for RHIC, like their fixed-target experiment predecessors, seek to characterize events in terms of global characteristics, such as particle multiplicity and the angular distribution of energy, for on-line selection. A wide range of measurement strategies is being proposed to search for signatures of new states of matter and to study their properties in an environment where tens of thousands of particles may be produced.

Edward Shuryak offered an overview classification of experiments into three kinematic regions: 1 – physics of hadronic matter, with studies of very soft pions, leptons, photons and resonances, interferometry measurements and precise measurements of transverse momentum spectra and resonances; 2 – quark-gluon plasma physics, with measurements of hadronic spectra, continuum dileptons, direct photons at transverse momenta of 1 –5 GeV, and J/psi and upsilon suppression; 3 – hard scattering phenomena, spectra of hadrons with transverse momentum above 5 GeV, jets, and direct photons.

Nearly all the ideas discussed at the workshop lead to large, complex detectors whose final design and construction need a substantial R&D effort. This began two years ago through funds for heavy ion research made available by the US Department of Energy's Director of Nuclear Physics, and a detector development programme for RHIC detectors began last year, with funding for ten proposals emerging from a review by a Detector Advisory Committee (January/February, page 11).

At this summer's workshop these projects received a mid-term assessment. After presentations by each group, the Detector Advisory Committee met to consider recommendations for R&D funding in the coming fiscal year, with the Laboratory having declared its intention to devote approximately two million dollars of RHIC R&D funds to detector development.

At the closing session of the workshop, Tom Ludlam, speaking for the RHIC Project management, announced that a portion of these funds (one-third to one-half) would be committed, on the basis of the Committee's recommendations, to continuation of the ongoing projects. The remainder of the R&D funds will be committed after the

letters of intent have been received and reviewed, opening the door for new ideas from the letters of intent. This also signals a shift in emphasis of the R&D effort from its initial, rather generic scope, towards specific RHIC experiments.

The discussions included, for the first time, extensive consideration of the role of hard scattering processes in RHIC experiments, and the requirements for making such measurements in high energy nucleus-nucleus collisions. While the characteristics of excited hadronic matter produced in these collisions are mainly displayed by near-thermal radiation of 'soft' particles, a decade of experience with high transverse momentum phenomena at elementary particle colliders suggests that hard scattering of quarks and gluons will also take place in the nuclear collisions at RHIC.

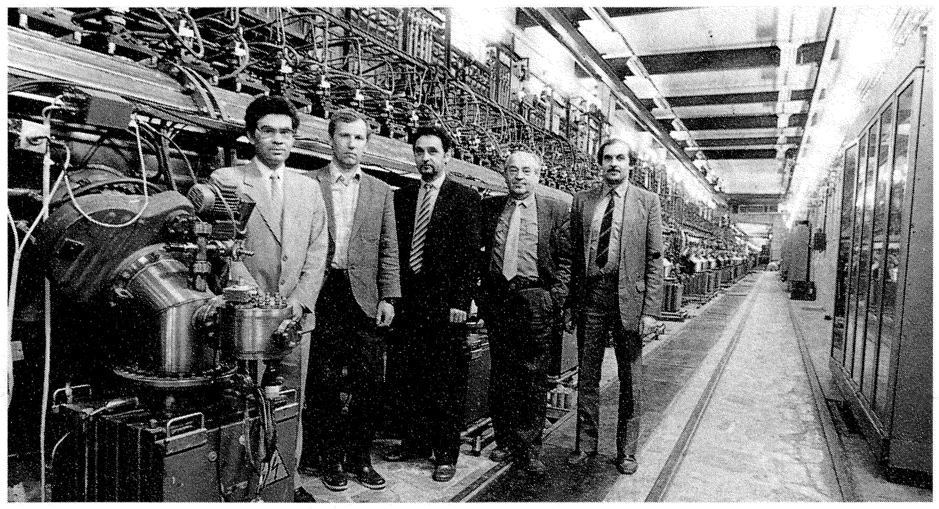
These events show up as jets or single photons with transverse momenta of many GeV, and their measurement in nuclear collisions can provide an important experimental link between quark-gluon mechanisms and the soft processes which characterize hadronic matter at the phase transition temperature.

By tagging jets in RHIC collisions it should also be possible to study the rate at which the 'scattered' quarks lose energy travelling through the large volumes of colliding nuclei, in effect studying the transparency of high density nuclear matter – including a plasma state – to a beam of high energy quarks.

Hard scattering processes are rare. The growing interest in jet measurements, as well as the study of heavy resonances such as the J/psi and upsilon through their leptonic decay modes, has led to a strong push by several groups to consider the highest possible RHIC collision rates. As outlined in the Conceptual Design Report, there are several possible roads towards eventual upgrades of the design luminosity, 2 x 10^{26} per sq cm per s for gold beams at the top energy.

These options, which could ultimately increase the luminosity by more than an order of magnitude, and their implications for detectors, were the subject of many discussions with accelerator physicists. In the closing session, RHIC Project Head Satoshi Ozaki emphasized the Laboratory's intention to pursue these options, and urged that detector designs should bear this in mind.

At the week's end, seven working groups reported on the status of their detector designs and their plans for developing these into letters of intent, in parallel with the start of RHIC construction this fall. These letters will be reviewed by the Program Advisory Committee which meets November 8, 9 and 10. After that, decisions on detector R&D funding will be announced, as will the procedures and timescale for the submission of RHIC proposals.



A group from the Soviet Institute for Nuclear Research Accelerator Physics Division near the Alvarez part of the new linear accelerator of the Moscow Meson Factory now under construction. Left to right – P.N. Ostroumov, A.V. Feschenko, V.L. Serov, S.K. Esin, L.V. Kravchuk.

MOSCOW
First 100 MeV at Meson Factory

In April protons were accelerated for the first time to 100 MeV at the linear accelerator at the Moscow Meson Factory of the Institute for Nuclear Research, now nearing completion at Troitsk, 40 km south of Moscow.

The linac was designed by the Moscow Radiotechnical Institute and the Institute for Nuclear Research to accelerate protons and negative hydrogen ions, unpolarized and polarized, to 600 MeV. Initial total current will be 0.5 mA with the pulse current 50 mA and pulse duration 10^{-4} s at a repetition rate of 100 Hz.

The accelerator consists of the injector system, the initial part (Alvarez type) taking the energy to 100 MeV (5 cavities with drift tubes) operating at 198.2 MHz, and the main part with maximum energy 600 MeV (27 disc-and-washer cavities) at 991 MHz. Energy regulation is designed to be stepwise below 160 MeV and then continuous up to 600 MeV, with

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A special feature of the accelerator is the high intensity RFQ injector of polarized protons presently under development. The polarized proton source with the atomic beam is expected to produce pulsed current up to 3 mA at 15 keV and 90 per cent polarization. Rapid reversal of the polarization is foreseen without significant change of the beam intensity and polarization level.

The 750 keV proton injector has been installed and checked at 10 Hz. However a 1 Hz pulse repetition rate is maintained during the tuning procedure to decrease irradiation.

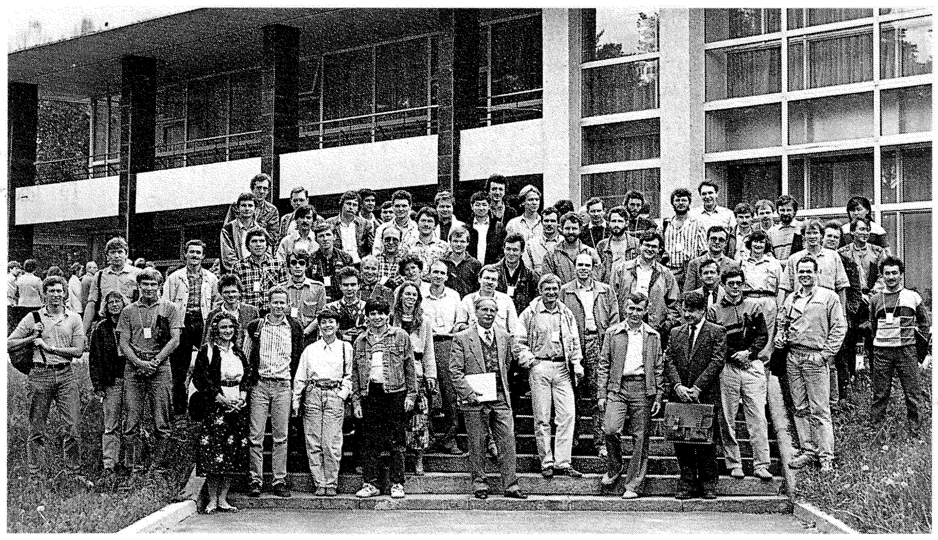
Last year the proton beam of 110 mA pulse current was injected into the first accelerating cavity and accelerated to 20.5 MeV. The first cavity gave pulse currents of 29 mA and 46 mA without and with prebuncher respectively, reasonably close to the design values.

Tuning of the complete initial part of the accelerator with beam began in April, when 100 MeV protons were obtained for the first time. The output pulse current of 10 mA (without prebuncher) has been already reached, while pulse parameters are expected to approach design values by the end of this year. Losses in the whole initial part of the linac are encouragingly small.

Equipment for the main part of the accelerator (from 100 MeV to 600 MeV) is installed and partially tested. By the end of this year, 160 MeV protons are expected and will be extracted to a small adjacent experimental area. The acceleration to the maximum energy of 600 MeV is planned for next year.

Completion of the linear accelerator for the Moscow Meson Factory will provide a valuable facility for experiments in particle-, nuclear- and solid state physics with high intensity primary and secondary beams of protons, pions, muons and neutrons. Construction of the experimental hall and the manufacture of equipment for beam channels, the proton storage ring and experimental installations is underway.

This year's Soviet Summer School in Dubna saw a significant level of international participation, which the organizers hope will establish a tradition.



SOVIET UNION
Summer school goes international

The traditional annual Soviet Summer School, held in June in Dubna on the banks of the Volga, this year had international participation for the first time. Initiated by Moscow's Physical Engineering Institute and the Joint Institute for Nuclear Research, Dubna, the school has rotating themes, with the accent this year on developments in high energy physics.

The latest results from CERN's LEP electron-positron collider (F. Dydak, CERN and Yu. Kamyshkov, ITEP Moscow) provided a natural focus for discussion. V. Khoze (Leningrad) looked at detailed quark field theory (QCD) tests which will emerge, while V. Telegdi looked forward to physics with polarized beams.

M. Danilov (ITEP) covered new results from B-mesons (carrying the fifth – beauty – quark) and outlined prospects for B factories. Soviet plans for such factories - for tau/charm as well as B mesons – were outlined by A. Skrinsky (Novosibirsk) and Yu. Alexakhin (JINR).

Further QCD developments were covered by Yu. Dokshitzer (Leningrad) while M. Khlopov (institute of Applied Mathematics) examined the growing links between particle physics and cosmology.

Turning to the future, L. Okun (ITEP) looked for physics beyond the Standard Model. Plans for the next generation of proton-proton colliders – LHC at CERN and the US Superconducting Supercollider, SSC – were outlined by K. Eggert (CERN) and M. Marx (Stony Brook). For the experimentalists, C. Fabjan (CERN) examined detector implications for these machines.

The School's Organizing Committee, Chaired by B. Dolgoshein, hopes that the international debut of the school will go on to become a tradition.

FRASCATI Phi factory

The Istituto Nazionale de Fisica Nucleare (INFN), responsible for Italian research in nuclear and particle physics, has approved the construction of a phi-factory at Frascati National Laboratory.

The phi-factory, with twin intersecting electron-positron rings providing very high luminosity (collision rate), revives the Frascati tradition of electron storage rings, dating back to the pioneer AdA machine in the early sixties, and which continued with Adone.

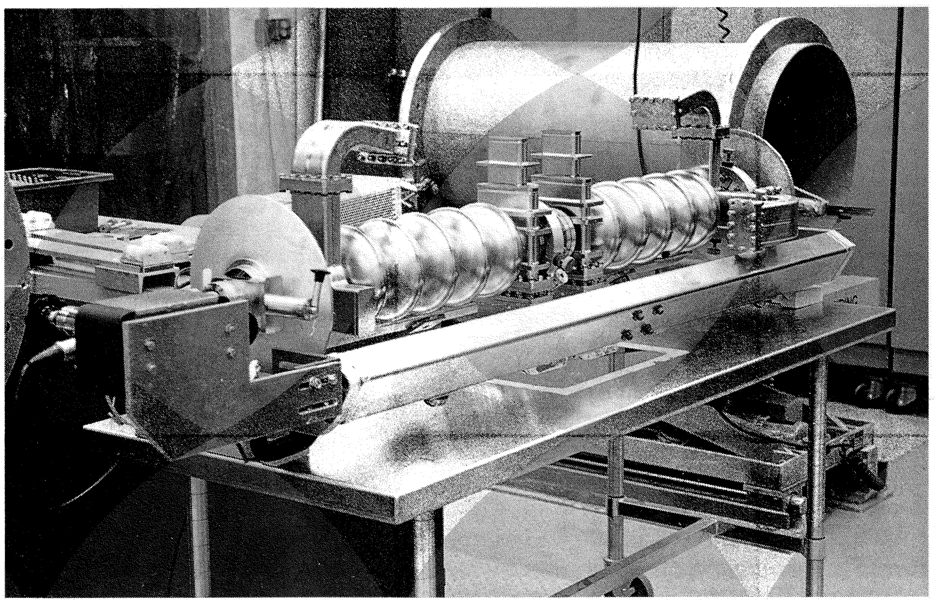
Adone and its injector are to be decommissioned in the next two and a half years, liberating space for the new phi factory, to become operational in five years.

The new machine is planned to span the collision energy range from the threshold for production of pion pairs (280 MeV) through to 1.5 GeV. Luminosity is initially foreseen as 10^{32} per sq cm per s at the phi energy (1020 MeV), rising eventually to 10^{33}. Two interaction regions will be available for experiments.

Obtaining the required luminosity in this energy range will be a challenge: new technical solutions will be explored and all machine parameters will be carefully optimized.

The known properties of phi decays into kaon pairs and into eta mesons plus a photon ensure that the machine will also be a ready source of kaons and other mesons. The various kaon pair combinations generated in phi decays will open up a new window on the poorly understood CP-violation sector (violation of the combined left-right, particle-antiparticle symmetry seen in the decays of neutral kaons).

The first twin superconducting radiofrequency cavity from German supplier Interatom for the Continuous Electron Beam Accelerator Facility (CEBAF) being built at Newport News, Virginia. Initial tests of these cavities have given encouraging results.



CEBAF Accelerating cavities look good

The first assembled pairs of superconducting accelerating cavities from German supplier Interatom for the Continuous Electron Beam Accelerator Facility, Newport News, Virginia, have exceeded performance specifications.

In a May 25 test at CEBAF, a hermetically linked, operationally configured cavity pair surpassed 5 MV/m for accelerating gradient and 2.4×10^9 for the quality factor, Q. At or above the required Q, one cavity reached 8.3 MV/m, the other 11.6 MV/m. At the required gradient, respective Qs were 5.4 and 4.1, both x 10^9.

By mid-June, a total of three pairs had been assembled and tested. Maximum gradients at or above the specified Q averaged 8.53 MV/m, and Qs at the required gradient reciprocally averaged 4.9 $\times 10^9$.

As scheduled, a total of nine production cavities had arrived from Interatom by mid-July. A team headed by Peter Kneisel chemically processes the cavities, assembles them into hermetically sealed pairs, and tests them at 2 K.

Some 320 cavities, immersed in 2-K helium within cryostats, will be used in the 4-GeV, five-pass recirculating accelerator; the injector will use another 18.

The final concrete section of CEBAF's 1.4-kilometre racetrack accelerator tunnel was finished in June, and on July 31, CEBAF's programme of injector 5 MeV testing was completed. At the end of this testing phase, which began early this year in CEBAF's test lab, the injector was operated with con-

Grenoble - Rhône-Alpes - France

The European Synchrotron Radiation Facility is constructing a state of the art storage ring for 6 GeV electrons and/or positrons to be operated as a high brilliance synchrotron radiation source in the field of X-ray from 1994 on.
Financing of the ESRF is shared by 11 European countries.

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RADIATION
FACILITY

In the present build up phase, the European Synchrotron Radiation Facility offers you interesting career prospects and a unique opportunity to develop and apply your skills in an international hi-tech environment in fields as varied as:

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*Scientists are generally on fixed-term contracts (max. 5 years)

who give evidence of relevant education, and who have experience in research institutes, universities or high-tech industries. Candidates with at least some years of experience in a similar situation, or with a professional background combining education and/or experience from one or more of the fields mentioned above are particularly invited to apply.

The working language is English: - knowledge of French is desirable.
For more information about the ESRF, employment conditions and specific vacancies, you can give your name, address and field of professional experience directly to us in Grenoble, and we shall provide you with the information needed, and an "Application Form".

ESRF (Recruitment Officer), Boîte Postale 220, F-38043 Grenoble Cedex.

MEDIA-SYSTEM

Build a Scientific Europe

DATA ACQUISITION SCIENTIST

(Position #PR2154)

The 4-GeV Continuous Electron Beam Accelerator Facility, now under construction in Newport News, Virginia, is searching for staff scientists as members of the group responsible for data acquisition.

The experimental equipment requires state-of-the-art data acquisition systems capable of selecting and analyzing complex events at high data rates. Candidates should have an advanced degree in Physics or Computer Science, with several years of programming experience in the areas of device control, graphical user interfaces, or distributed computing.

We offer a very competitive compensation package and stimulating work environment.

Applicants should submit a curriculum vitae specifying position number and three professional references to: **Employment Manager, CEBAF, 12000 Jefferson Avenue, Newport News, VA 23606.**

CEBAF

The Continuous Electron Beam Accelerator Facility

An Equal Opportunity, Affirmative Action Employer

RESEARCH ASSOCIATE

(SCIENTIFIC PROGRAMMER)

The Department of Physics and Astronomy of The University of Iowa has a position opening for a research associate to work on the experiment ZEUS in Hamburg, Germany.

This position requires a Ph. D. in physics, or an equivalent combination of education and experience, with a strong scientific programming background, a knowledge of DEC operating systems, and knowledge of several different programming languages including FORTRAN and C.

The successful applicant must be willing to relocate to Hamburg, Germany during 1991 or early in 1992.

The tentative starting date wil be beginning 1991 and possibly sooner.

Salary will be commensurate with education and experience. Please apply in writing, including three names of references and their telephone numbers, to:

Professor Usha Mallik
Department of Physics and Astronomy
The University of Iowa
Iowa City, Iowa 52242-1479

The University of Iowa is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

People and things

tinuous-beam currents over 500 microamperes, a factor of 2.5 above the design specification.

The completed programme of injector subsystem tests and development work provided much information about injector operation and performance, as well as delivering beam for extensive studies of radiofrequency control system performance and for characterizing beam diagnostic instruments. Two different schemes for measuring beam bunch length were also tested.

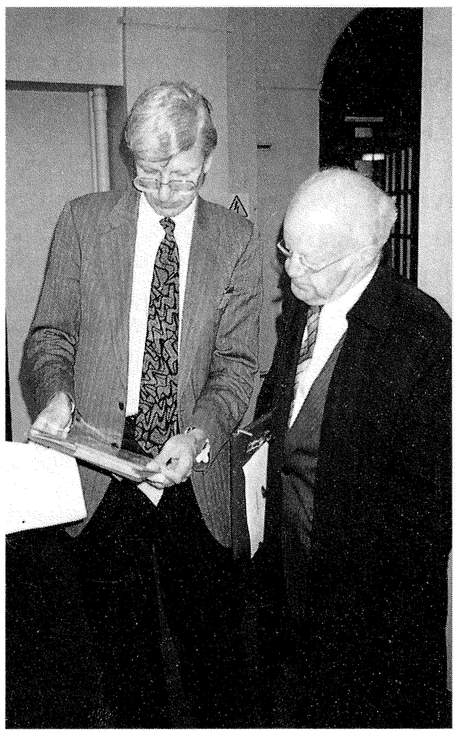
CEBAF's full 45 MeV injector will use two additional 20 MeV cryomodules like those to be used in the 4 GeV recirculating accelerator itself. On August 1, the entire injector was disassembled, and the move to the accelerator tunnel began.

CERN Council

At the June meeting of CERN Council, Director General Carlo Rubbia outlined the plan for the LHC proton collider in the LEP tunnel as CERN's major project for the coming decade. This time the Director General placed the traditional ongoing four-year rolling programme of scientific activities and budget estimates in a wider context, outlining CERN's strategy and programmes up to the year 2000.

With the end of the 1991-4 rolling programme already having to take account of LHC, Council requested the Director General to take the necessary steps immediately so that Member States could come to a final LHC decision in June 1992.

At the same meeting, Pierre Darriulat's term as Research Director was renewed for a further three years.



A July physics conference at Oxford's Clarendon Laboratory marked the 65th birthday of Richard Dalitz, seen here (right) studying the meeting programme with fellow Oxfordian Chris Llewellyn-Smith, currently Chairman of CERN's Scientific Policy Committee. Participants included many colleagues and former students from Dalitz' days at Birmingham and Chicago.

On people

Abdus Salam, Director of the International Centre for Theoretical Physics (ICTP), Trieste, has been awarded the Copley Medal of the UK Royal Society. At ICTP, the Institute's annual Dirac medals have been awarded this year to Ludwig Dimitriyevich Fadeev of Leningrad's Steklov Mathematical Institute and to Sidney Coleman of Harvard. The ICTP's Dirac Medals, instituted in 1985 in memory of P.A.M. Dirac, are awarded every year on 8 August, Dirac's birthday, in recognition of contributions to theoretical physics, but are not awarded to Nobel Laureates or Wolf Foundation Prizewinners.

Gwyn Williams of the US National Synchrotron Light Source, Brookhaven, and his NSLS colleagues Peter Siddons and Carol Hirschmugl, together with Dieter Moeller of Farleigh Dickinson University have been awarded one of this year's prestigious R&D 100 Awards for their work on a wavefront dividing infrared interferometer.

Ions in LEAR

After initial trials of injection and storage of oxygen ions last year, CERN's LEAR low energy 'antiproton' ring has electron-cooled oxygen ions, achieving momentum 'spreads' down to 4 x 10^{-4}, and stacked up to 13.8 x 10^{9} charges at 11.4 MeV per nucleon, with subsequent acceleration taking the ions to 408 MeV per nucleon before extraction for experiments. This ability to store and accelerate dense beams of ions is of interest for radiological research.

The Institute of Particle Physics of Canada

Applications are invited for a position as a Research Scientist with the Institute of Particle Physics of Canada (IPP). Candidates should preferably have three years of post-doctoral experience and a demonstrated record of accomplishment. The Research Scientist appointment is associated with an academic position at a Canadian University and includes the right to hold research grants and to supervise graduate students. Such an appointment may lead to permanence after three years of employment. The current program of IPP includes the following experiments : (i) e^+e^- collisions in the Y region (ARGUS at DESY); (ii) e^+e^- collisions at LEP (OPAL); (iii) e-p collisions at HERA (ZEUS). Future projects under active study include participation in a hadron–hadron collider experiment and a B Factory detector. The choice of experiment and university affiliation will be determined by mutual agreement between the candidate and the IPP. Curriculum vitae and the names of three references should be sent to :

D. G. Stairs, Chairman
The Institute of Particle Physics
Rutherford Physics Building
McGill University
3600 University Street
Montreal, Quebec H3A 2T8
Canada

Applications should be received before 15 November 1990

In accordance with immigration regulations, preference will be given to citizens or permanent residents of Canada

UNIVERSITÉ DE MONTRÉAL

Research Associate Position in Particle Physics

Applications are invited for a Research Associate Position in Experimental Particle Physics for participation in the OPAL collaboration at LEP. The successful candidate will be expected to contribute to the data analysis and to participate in the maintenance, development, and calibration of one of the OPAL subdetectors. Experience in software associated with Monte Carlo simulation and data reduction will be an asset.

The Université de Montréal encourages applications from both men and women.

Candidates should send their résumé and three letters of reference to :

Professor Claude LEROY
Laboratoire de Physique Nucléaire
Université de Montréal
Case postale 6128, Succursale "A"
Montréal, Québec
Canada H3C 3J7

e-mail : LEROY @LPS.umontreal.ca
telefax : (514) 343 6215
phone : (514) 343 6722

The deadline for receipt of applications is 1 November 1990

CARNEGIE MELLON UNIVERSITY

RESEARCH ASSOCIATE POSITION EXPERIMENTAL HIGH ENERGY PHYSICS

The Department of Physics at Carnegie Mellon University invites applications for a Research Associate position in experimental high energy physics to work on the L3 experiment at CERN. The individual who fills this position will be based at CERN. Applicants should submit a curriculum vitae and arrange to have three letters of recommendation sent to :

Professor Arnold Engler
Department of Physics
Carnegie Mellon University
Pittsburgh PA 15 213
USA

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The Max-Planck-Institut für Physik Munich

has an opening for a

Ph.D. Physicist

with experience in low temperature physics

We are looking for an experimental physicist to participate in the development of a calorimeter operating at very low temperatures (30 mK), with the goal of detecting the small nuclear recoil energies caused by the elastic scattering of dark matter particles or low-energy neutrinos. We are especially interested in applicants who have experience in experiment at low temperature physics and the properties of superconductors. The appointment is usually for three years with a possibility of extension. Applications (including a résumé and the names of three referees) should be sent as soon as possible to :

Dr. Susan Cooper
Max-Planck-Institut für Physik
Föhringer Ring 6
D – 8000 München 40
Germany

USERS' CORNER

CERN Experiments Committees restructured

A change in the current structure of CERN's Experiments Committees was approved at the July meeting of the Research Board and will take effect on 1 January 1991. The SPS and PSC Committees will merge into a new body named SPSLC (for SPS and LEAR Committee) which will take care of the particle physics research programme using these machines. Membership of the new Committee will be close to that of the parent bodies, to be gradually modified while current membership runs out. At the same time, a new Experiments Committee, the ISOLDE Committee, will be established. It will deal with ISOLDE experiments as well as with research not pertaining to particle physics conducted at the SPS and LEAR when this is considered appropriate by the SPSLC Chairman.

Detector R and D Committee

An important element in the success of CERN's planned LHC proton collider for the LEP tunnel will be the development of detector technology to exploit the machine's high collision rate. The European Committee for Future Accelerators (ECFA) has set up working groups to make a broad assessment of the detector requirements (May, page 27) and these will report at a meeting in Aachen from 4-9 October.

To make optimal use of the resources available at CERN and to oversee the allocation of valuable test beam time, a Detector R and D committee has been set up along the lines of the existing Experiments Committees.

Its role will thus be to evaluate proposals, particularly for detector system development, and make recommendations to the Research Board for resource allocation. As with experiments, the collaborating institutions, including CERN, are expected to provide their share of the manpower and the financial resources. Detector R and D projects requiring CERN resources, test beams, technical support or computer time are invited to submit proposals.

First chairman is Enzo Iarocci, with Franco Bonaudi as Secretary.

Ilya M. Frank

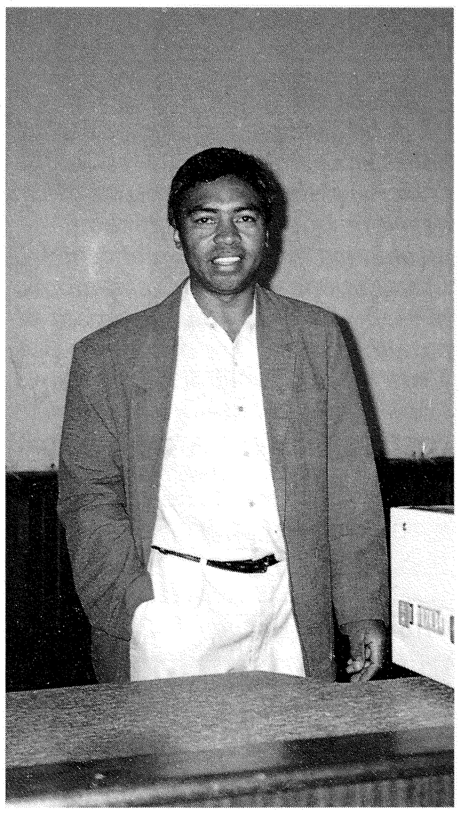
Academician Ilya M. Frank died on 22 June. Recipient of the 1958 Nobel Physics Prize with Pavel Cherenkov and Igor Tamm for their joint development of new detection techniques, he made significant contributions to nuclear and atomic physics, and in the development of pulsed reactors. For more than 30 years he was Director of the Neutron Physics Laboratory of the Joint Institute for Nuclear Research, Dubna, near Moscow.

Otto Kofoed-Hansen 1921-1990

One of the best known Danish physicists from the latter half of this century died on 21 July at his home in Copenhagen. Otto Kofoed-Hansen initially worked as a goldsmith's apprentice before studying physics at Copenhagen. Fascinated by the weak interaction, his first experiments ascertained that the 'missing energy' in beta decay was associated with a corresponding missing linear momentum, thereby underlining Pauli's neutrino hypothesis. UA2 at CERN, the last experiment in which Kofoed-Hansen participated actively, observed exactly the same effect albeit at a momentum roughly nine orders of magnitude higher!

Active in theory as well as in experiments, he covered a wide spectrum of modern physics. Together with Karl Ove Nielsen (recently retired from the University of Aarhus) he carried out in 1950 the first – and for a long time the only – on-line mass separation experiment, a forerunner of CERN's ISOLDE. He was appointed head of

S. Narison opens the QCD-90 meeting at Montpellier, France, in July.



Celebrations at the German DESY Laboratory, Hamburg, for the initial taste of particles in the first completed octant of the superconducting proton ring of the HERA electron-proton collider. In the absence of protons, the test made do with 7 GeV positrons. With installation going well and the last of the 450 nine-metre superconducting dipoles being delivered, the 6.4 kilometre proton ring should be complete by the end of October. The HERA electron ring was completed in 1988 and tested last year.

the Physics Department of the newly established Riso Laboratory in 1956, and was at CERN from 1968 until 1977, where in addition to his research he served as a personal adviser to Director General Willi Jenschtke and from 1969-72 was Chairman of the 'Physics III Committee' responsible for the scientific programme at the Synchro-Cyclotron. After his return to Denmark he maintained close contact with CERN, to which be felt deeply attached and where he was a frequent visitor until a short time ago.

Fermilab Physics Department

At Fermilab, Jeff Appel becomes Head of the Physics Department, Steven Pordes Deputy Head, and Hans Jostlein Associate Head.

History of CERN, Vol. 2

Under the North Holland Physics Publishing imprint, the History of CERN, Volume 1, became available in 1987. This covered the inception of the idea of a European physics Laboratory in the post-war years leading to the establishment of CERN in 1954, and is now supplemented by a second volume, describing the building and early life of the Laboratory. The initial overview in the new book is followed in Part II by a survey of scientific results and technical achievements. The social and political relationships inside the Organization and the interfaces with the European physics community and with Member State representatives are covered in Part III. To conclude, Part IV underlines CERN's uniqueness, pointing out the difference between it and other major Laboratories. The book throws new light on the management of a large organization dedicated to science, with its multiple considerations – scientific, technical, financial, political, personal and institutional. The 900-page volume, by A. Hermann, J. Krige, U. Mersits, D. Pestre and with a contribution by L. Weiss, is priced at $138.50 or Dfl. 270 (ISBN 0-444-88207-3).

Advertising

Starting with this issue, Gordon and Breach Science Publishers become the advertising representatives for the CERN Courier worldwide except for Europe, where business continues to be handled by Advertising Manager Micheline Falciola. Enquiries should be directed to the appropriate office (see page III).

The CERN Courier welcomes this new arrangement, which should go on to consolidate the journal's pre-eminent position as the 'International Journal of High Energy Physics'.

Princeton University

ELECTRONICS ENGINEER

The High Energy Physics group at Princeton University invites applications for an immediately available Electronics Engineer position. The individual filling this position will lead a group that provides electronics support for ongoing experimental programs at Brookhaven, CERN and Fermilab, and will actively participate in research and development work for the SSC.

Applicants should have a Masters degree in either Electrical Engineering or Physics or the equivalent experience, a background in analog and digital design, and a knowledge of electronics production and packaging techniques (PC boards, PALs, ASICs, and chip design). Interested individuals should send a curriculum vitae and the names of three referees to :

Professor A. J. S. Smith
Physics Department
P.O. Box 708
Princeton University
Princeton
NJ 08544
USA

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UNIVERSITÄT KARLSRUHE

In der **Fakultät für Physik** ist eine Professur (C4) für

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(Nachfolge J. Wess)

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Gesucht werden Bewerberinnen und Bewerber mit dem Arbeitsgebiet Theorie der Elementarteilchen und Relativistische Quantenfeldtheorie.

Die Fakultät für Physik mit ihren beiden Schwerpunkten Festkörper- sowie Kern- und Teilchenphysik bietet vielfältige Möglichkeiten zur Zusammenarbeit, insbesondere mit bestehenden Gruppen der theoretischen und experimentellen Elementarteilchenphysik.

Bewerbungen und Unterlagen über die bisherige Forschungs- und Lehrtätigkeit sowie Sonderdrucke der wichtigsten Publikationen werden bis zum **15. November 1990** erbeten an den Dekan der Fakultät für Physik, Universität Karlsruhe, Postfach 6980, D – 7500 Karlsruhe 1.

Die Fakultät für Physik ist bemüht, den Frauenanteil zu erhöhen, und ermutigt daher besonders Frauen, sich zu bewerben.

RACHAL CHAIR IN HIGH ENERGY PHYSICS
TEXAS A&M UNIVERSITY

Texas A&M University is seeking outstanding applicants in experimental physics for the Rachal Chair in High Energy Physics. This endowed chair is an important component of the expansion of the high energy research program at Texas A&M following the Texas siting of the Superconducting Super Collider. In total seven new faculty positions in experimental high energy physics and four new faculty positions in theoretical high energy physics will be created over the period of the SSC construction.

At present there are six faculty members in experimental high energy physics. Current research includes CDF and DO at Fermilab, MACRO at Oran Sasso, $\mu+e\gamma$ search at Los Alamos, and development of two new detector technologies for SSC. There are at present five faculty members in theoretical high energy physics. Current research includes phenomenology, supersymmetry, superstrings and supermembranes, and astroparticle physics.

Texas A&M is also a major participant in the Texas Accelerator Center. TAC is engaged in advanced accelerator research and technology development. Current projects include linac technology' SSC magnet development, beam dynamics, magnetic resonance imaging, superconducting energy storage and magnetic levitated trains.

The board of Regents of Texas A&M University recently approved the creation of the Laboratory of High Energy Physics at Texas A&M, as a host facility for regional and international cooperation in SSC research. This laboratory will provide a basis of facilities and personnel to support major activity in the development and construction of SSC detectors and in theoretical research related to SSC physics. Applicants should have a record of accomplishment and leadership in contemporary high energy physics' and an interest in developing a major role in research at the Superconducting Super Collider. Please address applications or nominations to :

Professor Peter M. McIntyre
Chairman, Rachal Chair Search Committee
Department of Physics
Texas A&M University
College Station
Texas 77843-4242
USA

Texas A&M University is an Equal Opportunity/Affirmative Action Employer

POST-DOCTORAL FELLOWSHIP IN NUCLEAR PHYSICS

Department of Nuclear Physics
LUND UNIVERSITY

The Photonuclear Research Group at the Department of Nuclear Physics at the University of Lund announces a postdoctoral fellowship open to applicants who within the past three years have completed their PhD examination in nuclear physics. The Photonuclear Research Group is performing experiments with monoenergetic, tagged photons at MAXlab in Lund. This research program involves photodisintegration and photon scattering experiments, mainly in light nuclei, below 100 MeV. At present the experiments include the (γ,p), {γ,n}, {γ,γ}, {γ,γ'} and (γ, pn} reactions as well as (γ,cc') with two charged particles in the exit channel. A major upgrade of the tagging facility is planned during 91/92 with among other equipment a new, improved tagging spectrometer.

The fellowship, granted by the Swedish Natural Science Research Council, is for one year but can be extended to a maximum of two years. It is free of tax and amounts to SEK 130.000.- (US $ 21.000.-) to a European or SEK 135.000.- (US $ 21.900.-) per year to an overseas physicist. Additional support can be obtained for a fellowship holder with children. Applications with curriculum vitae, publiction list and three letters of recommendation should reach

Bent SCHRöDER
Department of Nuclear Physics
Sölvegatan 14
S - 223 62 LUND / Sweden

before December 1, 1990.

HEALTH PHYSICIST

(Position #AR2122)

CEBAF, under construction since 1985 in Newport News, Virginia, will be a world-class scientific laboratory centered around a high-intensity, continuous wave electron beam, which will provide a unique capability for nuclear physics research.

We are seeking a Health Physicist to implement a full operational health physics program for the laboratory. This will involve the provision of the personnel monitoring service, dosimetry, and radioanalysis services; specification and maintenance of instrumentation; monitoring and control of radioactive material; rendering advice and provision of necessary instruction/training on radiation control matters and providing assurance that administrative and automatic safety systems function effectively. Participation in the preparation of project documentation and in the definition and implementation of such safety measures as installed monitors, radiation shielding, barriers and interlocks, controlled areas, and the environmental program.

The minimum qualifications for this position are a science degree or degrees with specialization in health physics. Extensive work experience in operational Health Physics is required. Experience of high energy particle accelerators is preferred. Specialized knowledge of electronics and instrumentation systems will be advantageous. Teaching ability is important.

We offer a very competitive compensation package and stimulating work environment.

For prompt consideration, please send resume, specifying position number and job title to: **Employment Manager, CEBAF, 12000 Jefferson Avenue, Newport News, VA 23606.**

CEBAF

The Continuous Electron Beam Accelerator Facility

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GRENOBLE - France

The ESRF is constructing a synchrotron radiation source in the field of X-rays, to support scientists in the implementation of fundamental & applied research on the structure of condensed matter.

The Computing Services is in charge of the computer supported services for the whole ESRF organization: Central Computer, Office and laboratory Automation Management Information System, Experimental. Data acquisition, C.A.D., and the Machine Central System for the 6 GeV X-ray source.

We are presently recruiting an:

Electronics Engineer

to lead a small group of highly skilled hardware developers in charge of designing fast detector read out systems. Main emphasis will be the development and implementation of image treatment systems for two dimensionnal X-ray diffraction patterns.

Qualifications & experience: Higher education on University level. Proven experience of state-of-the-art digital boards in high speed data-acquisition systems based on the VME bus standard or equivalent. The working language in ESRF is English, Knowledge of French is desirable.

State your name, address and the reference number to us in Grenoble, and we shall provide you with an "Application Form" to be returned to us **before the 31th October 1990**:
ESRF-Personnel Office/ Réf.: 6107/90,
BP 220 - F 38043 Grenoble Cedex.

MEDIA-SYSTEM

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CHIEF MECHANICAL ENGINEER

The Physics Department at Boston University is seeking a Chief Mechanical Engineer to design and perform thermal and stress analysis on mechanical systems for physics research applications. Familiarity with computer-assisted design and analysis required. Facilities include a state-of-the-art machine shop with computer-controlled machines and CAD/CAM system.

Minimum educational background: MA in Mechanical Engineering or equivalent; five years' experience in a research environment.

Please send cover letter, resume, and names of at least three references to: Tom Bagarella, Boston University, Office of Personnel, 25 Buick Street, Boston, MA 02215. An Equal Opportunity/Affirmative Action Employer.

UNIVERSITAS BOSTONIENSIS CONDITA MDCCCLXIX

BOSTON UNIVERSITY

You'll find we have a lot to offer.

Mario Morpurgo

Meetings

The fourteenth biennial Particle Accelerator Conference will be held in San Francisco from 6-9 May 1991. Further information from Conference Chairman Matthew Allen, SLAC, PO Box 4249, Bin 33, Stanford, California 94309, USA.

A Polarized Collider Workshop to be held from 15-17 November at Penn State will discuss the physics case for a polarization option for planned hadron colliders. Further information from Richard W. Robinett, bitnet RQ9 at PSUVM, or directly from the conference node, POLARP at PSULEPS

The IVth Conference on the Intersections between Particle and Nuclear Physics will take place from May 23-29, 1991, in Tucson, Arizona. Further information from Ms. Elaine Zukowski, Building 510F, Brookhaven National Laboratory, Upton, NY 11973-5000, USA, tel (516) 282-3866, fax (516) 282-5820, bitnet HENP at BNLDAG

SSC Conference

The Atlanta Conference on the SSC will be held on the 13-15 November in conjunction with the 1990 Southeastern Section of the American Physical Society (SESAPS) meeting in Atlanta, Georgia. The meeting will focus on industrial and scientific opportunities, covering the status of the project, industry, university and laboratory participation, the development efforts now underway for major detectors and progress toward defining the initial research programme. For information phone Tony Gabriel at (615) 574-6082 (bitnet TAG at ORNLSTC), or William Dunn at (919) 544-4952.

Mario Morpurgo

With the death of Mario Morpurgo on 29 May CERN lost one of its most individual and engaging characters. CERN's founding fathers, of whom Edoardo Amaldi was the prime example, are often cited but there is also a kind of brotherhood of the original builders amongst whom Mario Morpurgo occupied a special place. Morpurgo was not the person to aspire to a position of leadership or power, preferring to cultivate his own interests. Such individuals are rare and without them CERN would not be what it is, would have less value and less character.

Morpurgo came straight to CERN after his studies at Rome and immediately applied his intelligence to the design and construction of conventional magnets. He was quick to recognize that the future lay in strong-current superconductivity at a time when it was just beginning. Although cryogenics was for him a complete 'terra incognita' as it was for bubble chamber builders, he rapidly initiated himself into its mysteries using the facilities of the small laboratory founded and directed by Fritz Schmeissner and was soon able to design the large magnet for the Omega detector. He conceived the idea of extrapolating conventional magnet cooling technology to superconducting magnets, using a forced current of liquid helium under pressure. For this he needed a pump which he himself designed and got his team to build and which is still regarded as a model of its kind. After the inevitable teething problems, Omega was a complete success. Henceforth, Morpurgo was to be an authority in the field of superconducting magnets. He naturally became head of the Cryogenics Laboratory on Schmeissner's departure and contributed to the initial studies for the LHC.

All those who knew Mario Morpurgo found him both paradoxical and endearing. Though fundamentally a loner, he could run a team and earn its respect and affection. His range of knowledge and talents was impressive. In addition to his professional activities as an engineer, he could turn his hand to drawing and painting, in which he displayed considerable talent, and his connaisseurship in art was the admiration of his friends.

Although his caustic wit elicited wariness and even apprehension, he demonstrated unfailing loyalty to his friends. He also had a keen sense of justice and on several occasions intervened vigorously and effectively to combat injustices which had particularly shocked him.

Now he has left us and we will never again see that curious almost Chaplin-like figure of Mario at the far end of some corridor deep in his own thoughts.

May these few lines stand as a testament of friendship from those who knew him and of gratitude from the whole of CERN.

His former colleagues

Italy at CERN

Italian Industrial Exhibition at CERN (Bldg 60)

LIST OF PARTICIPANTS at the Exhibition at CERN

23-26 October 1990

Organized by the Italian Institute for Foreign Trade (ICE)

For further information, apply to

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CH-8005 ZURICH
Tel. 01/271 75 05 Telex 822 635 ice ch Telefax 01/272 54 14

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Please note that NC machine tools are used during processing.

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Au compte d'autrui
Courbement de tuyaux en fer, acier inox, laiton, etc. Travail de tôles. Exécution de pièces sur plan et travaux de charpenterie en général. Soudures en aluminium, acier inox, bronze, cuivre, laiton, etc., avec la possibilité d'obtenir un produit fini destiné à plusieurs secteurs; alimentaire, sanitaire, hospitalier, agricole, zootechnique, de l'automobile, etc.
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Associazione provinciale di Modena

Via Nazario Sauro, 21
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Tel. 059/58 31 11
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Small and medium companies association providing its members with services, advices and trade-union activity.

Association de petites et moyennes sociétés auxquelles l'on fournit services, consultations et activité syndicale.

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Nuclear Section of LABEN S.p.A.:
Development and production of data acquisition systems in the domain of High Energy Physics, by utilizing innovative technologies.

Secteur nucléaire de la LABEN S.p.A.:
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SILENA S.p.A.

Via Firenze, 3
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Tel. 02/923 33 31
Tlx. 32 25 23
Fax. 02/923 32 93

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La ligne de production comprend pré-amplificateurs, amplificateurs, haute tension, codeurs analogiques numériques ultra-rapides, analyseurs multi-canaux pour spectrométrie nucléaire, systèmes pour l'acquisition et le traitement des données nucléaires et contrôlés par ordinateur, systèmes de contrôle d'irradiation Alpha, Bêta et Gamma.

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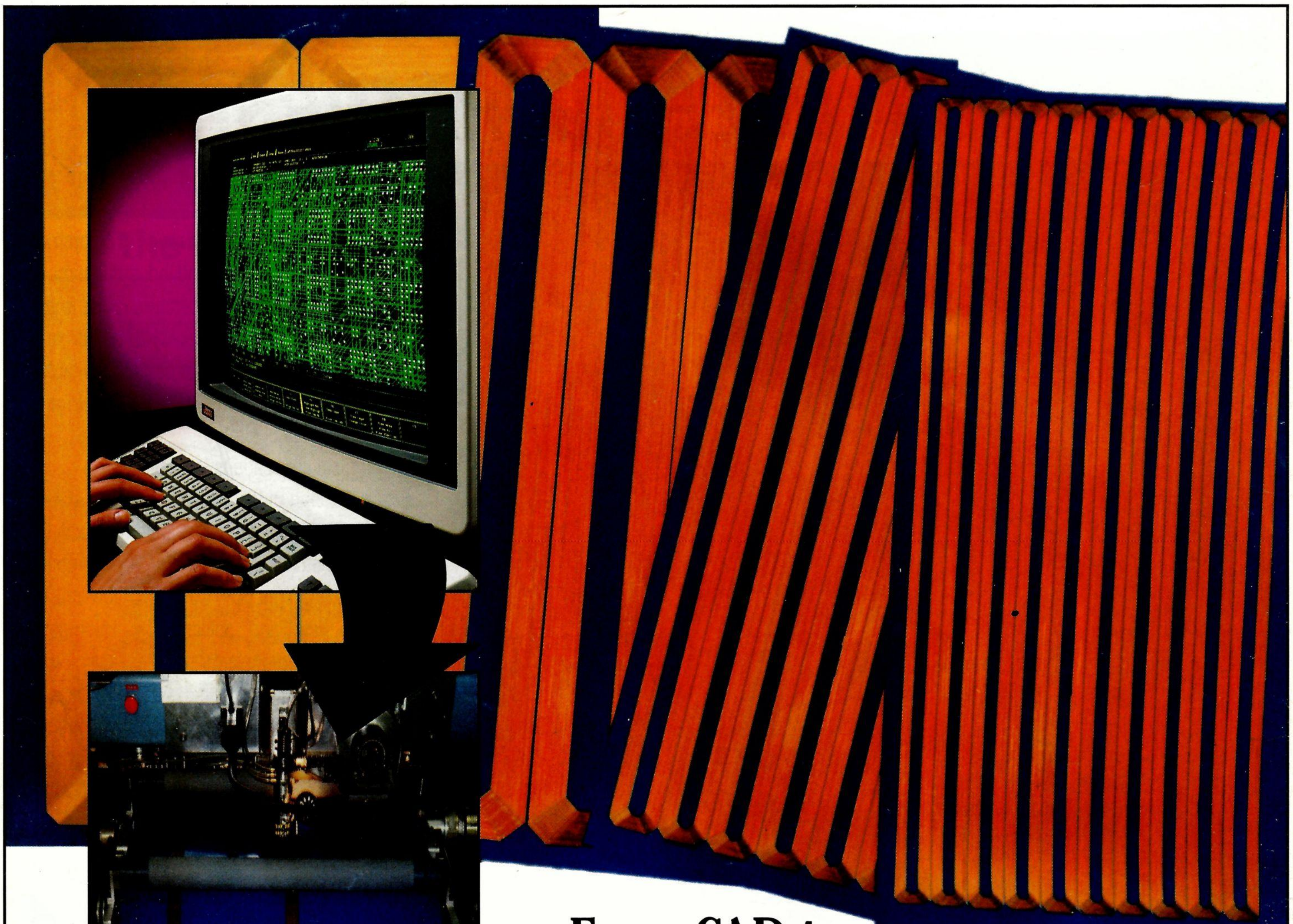

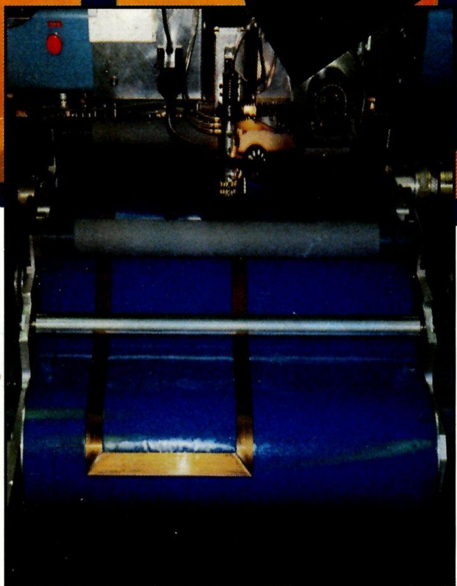

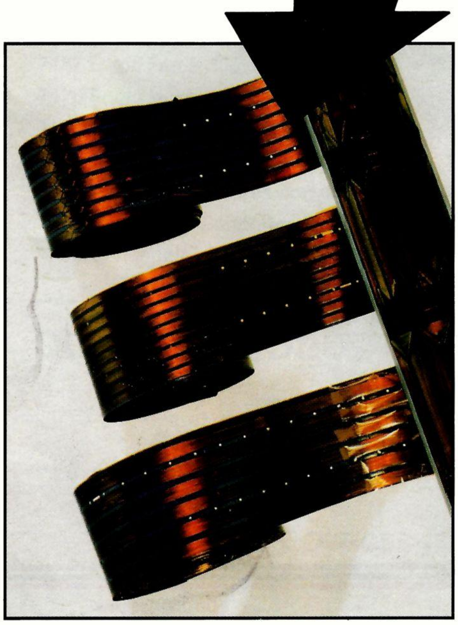

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