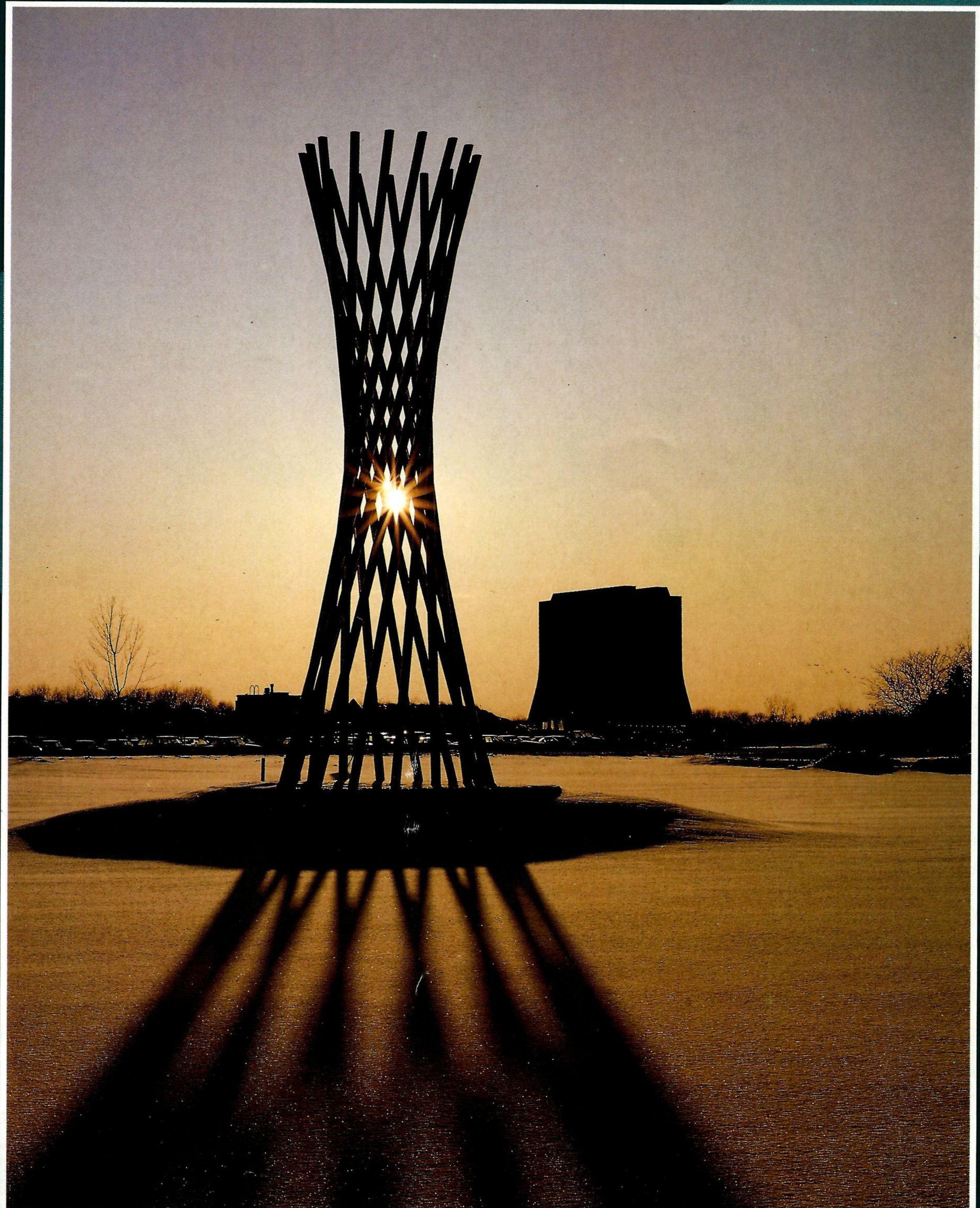
CERN COURIER

INTERNATIONAL JOURNAL OF HIGH ENERGY PHYSICS

VOLUME 34 **4** MAY 1994



Distributed to Member State governments, institutes and laboratories affiliated with CERN, and to their personnel.

General distribution

Jacques Dallemagne
CERN, 1211 Geneva 23, Switzerland

In certain countries, copies are available on request from:

China

Dr. Qian Ke-Qin
Institute of High Energy Physics
P.O. Box 918, Beijing,
People's Republic of China

Germany

Monika Stuckenberg or Kerstin Techritz
DESY, Notkestr. 85, 22603 Hamburg 52

Italy

Mrs. Pieri or Mrs. Montanari
INFN, Casella Postale 56
00044 Frascati, Roma

United Kingdom

Su Lockley
Rutherford Appleton Laboratory,
Chilton, Didcot, Oxfordshire OX11 0QX

USA/Canada

Cyndi Rathbun (B90904 @ FNALVM)
Fermilab, P.O. Box 500, Batavia
Illinois 60510

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

Printed by: Drukkerij Lannoo nv
8700 Tielt, Belgium

Published by:

European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
tel.: +41 (22) 767 61 11,
telex: 419 000 CERN CH,
telefax: +41 (22) 767 65 55

CERN COURIER only:
tel. +41 (22) 767 41 03,
telefax +41 (22) 782 19 06

USA: Controlled Circulation
Postage paid at Batavia, Illinois

Volume 34
No. 4
May 1994

CERN COURIER

Covering current developments in high energy physics and related fields worldwide

On 26 April, the CDF collaboration at Fermilab's Tevatron proton-antiproton collider presented evidence for the long-awaited sixth ('top') quark at a mass of 174 ± 17 GeV. Story in the next issue.

Cover photograph: Tractricious, a sculpture designed by Fermilab founding Director Robert R. Wilson, photographed by Reidar Hahn of the Laboratory's Visual Media Services, in a midwinter sunset with Fermilab's Wilson Hall in the background.

MAKE YOUR BUDGET GO FURTHER...

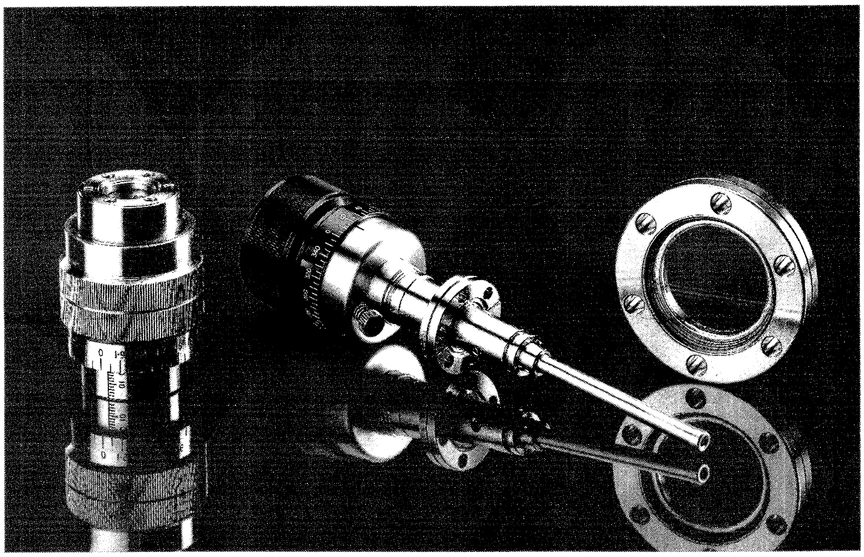
... if you have, until now, postponed purchasing high-quality ultra high vacuum components for financial reasons.

LEYBOLD has rationalised and updated its range of products so as to match market demand more closely, at the same time achieving price reductions of up to 50 % for UHV components – and improving product quality.

Being the leading supplier of vacuum technology and process applications worldwide, LEYBOLD is the most competent partner you could have in the area of UHV systems.

LEYBOLD – The first choice in UHV technology.

Do not hesitate to contact us, just ring:
Germany (+49-221) 347-1234
Switzerland (021) 691 8414



CD-Bonn

181.3.61.11.003.02

LEYBOLD AG

Bonner Strasse 498, D-50968 Cologne, Germany
Leutschenbachstrasse 55, CH-8050 Zürich, Switzerland

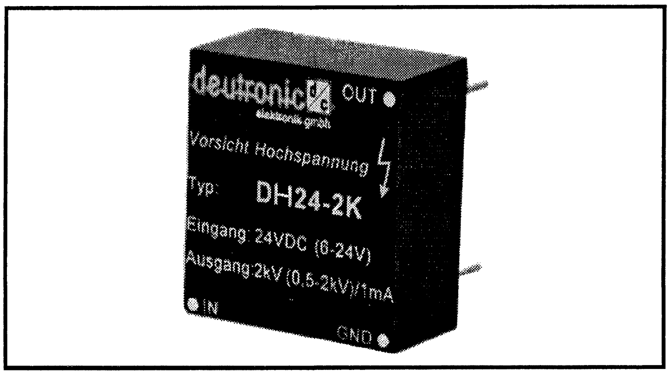
LEYBOLD

Innovative Vacuum Technology

deutronic d/c elektronik gmbh®

Deutronicstr. 5, D-84166 Adlkofen
Tel.: +49-8707/920-0
Tel.: +49-8707/902-34 Sales Dept.
Fax.: +49-8707/1004

High-Voltage DC/DC-Converters
Innovation at a fair price



- **Attractive pricing by delivery from producer**
- **Wide input range 2-12V resp. 2-24V**
- **No minimal load required**
- **Small dimensions (40x40x20mm)**
- **Output voltages up to 3kV**
- **1,5W continuous, 3W peak power**
- **Output proportional to input voltage**
- **PCB-mounting**
- **Small scatter of magnetic field**
- **Positive or negative output voltage**

OUR PRODUCT RANGE:

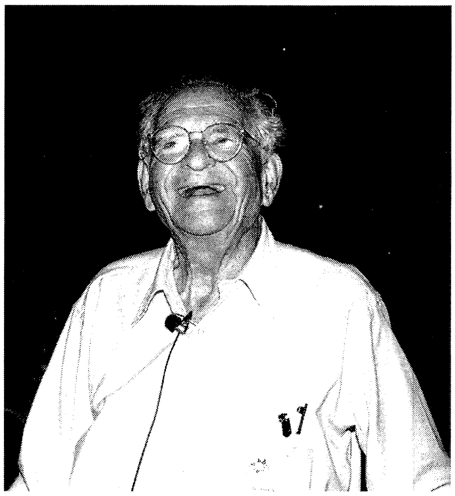
- DC/DC-Converters
- Power supplies in 19" design
- Open frame modules
- External switchers, adapters particular
- High voltage devices
- Power supplies for industrial installation
- Battery chargers
- Power supplies for Telecom-applications

Special devices are our strength.

The development of science this century

1 - from 1900 to World War II
by Victor F. Weisskopf

Victor Weisskopf - 'the tremendous developments that took place in the sixty-six years of my scientific life.'



This is the first in a series of three articles which together are a slightly revised version of a talk delivered at the meeting of the American Association for the Advancement of Science, in Boston, on 14 February 1993, and at a CERN Colloquium, on 5 August 1993, entitled 'Science - yesterday, today and tomorrow'. They describe the tremendous growth of scientific knowledge and insights acquired since the beginning of this century. In a highly abridged form, some of these ideas were used in an earlier CERN Courier article ('Crisis - the Weisskopf view'; October 1993, page 22). Because of the modest size of an issue of the CERN Courier, the text has been repackaged as three articles, each covering an identifiable historical epoch.

My life as an active scientist started in 1928 when I went to Göttingen as a graduate student for a Ph.D. degree under Max Born.
I witnessed the tremendous developments that took place in the sixty-six years of my scientific life. Science has changed its character in many respects, but some of the fundamental attitudes towards the exploration of Nature have remained the same. Having been a physicist, I report mainly about the developments in physics and astronomy, with which I am best acquainted. What happened in other natural sciences will be mentioned in a more cursory way. Three periods of the development of science can be distinguished in our century:

- Period I from 1900 to World War II;
- Period II from 1946 to about 1970;
- Period III from 1970 to the end of the century.

(*The second two periods will be covered in subsequent issues* .)

Divisions of this kind are always somewhat arbitrary since changes are more or less continuous. But there is no question that there were three points in time when great changes in the character of science took place: at the beginning of this century, at the time of the second World War, and during the last two or three decades.

Period I (1900-1945)

The decisive events of the first period have been the conception of the theory of relativity and that of quantum mechanics. Rarely in the history of science have two complexes of ideas so fundamentally influenced natural science in general.

There are important differences between the two achievements. Relativity theory should be regarded as the crowning of classical physics of the eighteenth and nineteenth centuries. The special theory of relativity brought about a unification of mechanics and electromagnetism. These two fields were inconsistent with each other, when dealing with fast-moving electrically charged objects.

Of course, relativity created new notions, such as the relativity of simultaneity, the famous mass-energy relation, the idea that gravity can be described as a curvature of space. But, altogether, the theory of relativity uses the concepts of classical physics, such as position, velocity, energy, momentum, etc. Therefore it must be regarded as a conservative theory, establishing a logically coherent system within the edifice of classical physics.

Quantum mechanics was truly revolutionary. It is based on the recognition that the classical concepts do not fit the atomic and molecular world: a new way to deal with that world was created. Limits were set to the applicability of classical concepts by Heisenberg's uncertainty relations. They say 'down to here and no further can you apply classical concepts'. This is why it would have been better to call them 'Limiting Relations'. It would also have been advantageous to call relativity theory 'Absolute Theory', since it describes the laws of Nature independently of the systems of reference. Much philosophical abuse would have been avoided.

It took a quarter of a century to develop non-relativistic quantum mechanics. Once conceived, an explosive development occurred. Within a few years most atomic and molecular phenomena could be understood, at least in principle. It is appropriate to quote a slightly altered version of a statement by Churchill praising the Royal Air Force: 'Never have so few done so much in so short a time '.

A few years later, the combination

Paul Dirac. His unexpected results were a major influence on the quantum mechanics of the late 1920s and 1930s.

of relativity and quantum mechanics yielded new unexpected results. P.A.M. Dirac conceived his relativistic wave equation which contained the electron spin and the fine structure of spectral lines as a natural consequence. The application of quantum mechanics to the electromagnetic field gave rise to quantum electrodynamics with quite a number of surprising consequences, some of them positive, others negative.

The positive ones included Dirac's prediction of the existence of an antiparticle to the electron, the positron, which was found afterwards in 1932 by C.D. Anderson and S.H. Neddermeyer. Most surprising were the predictions of the creation of particle-antiparticle pairs by radiation or other forms of energy and the annihilation of such pairs with the emission of light or other energy carriers. Another prediction was the existence of an electric polarization of the vacuum in strong fields. All these new processes were found experimentally later on.

The negative ones are consequences of the infinite number of degrees of freedom in the radiation field. Infinities appeared in the coupling of an electron with its field and in the vacuum polarization when the contribution of high-frequency fields is included. These infinities cast a shadow on quantum electrodynamics until 1946 when a way out was found by the so-called renormalization method.

Parallel to the events in physics during Period I, chemistry, biology, and geology also developed at a rapid pace. The quantum mechanical explanation of the chemical bond gave rise to quantum chemistry that allowed a much deeper understanding of the structure and properties of molecules and of chemical reactions. Biochemistry became a growing branch of chemistry. Genetics was established as a branch of biology, recognizing the chromosomes as carriers of genes, the elements of inheritance. Proteins were identified as essential components of living systems. The knowledge of enzymes, hormones, and vitamins vastly increased during that period. Embryology began to investigate the early development of living systems: how the cellular environment regulates the genetic program. Darwin's idea of evolution was considered in greater detail, recognizing the lack of inheritance of acquired properties. A kind of revolution was also started in geology by A. Wegener's concept of plate tectonics and continental drift. W. Elsasser's suggestion of eddy currents in the liquid-iron core of the Earth as the source of the Earth's magnetism was published at the end of this period, and led to the solution of a hitherto unexplained phenomenon.

The year 1932 was a miracle year in physics. The neutron was discovered by J. Chadwick, the positron was found by Anderson and Neddermeyer, a theory of radioactive decay was formulated by E. Fermi in analogy with quantum electrodynamics, and heavy water was discovered by H. Urey. The discovery of the neutron initiated nuclear physics; the atomic nucleus was regarded as a system of strongly interacting protons and neutrons. This interaction is a consequence of a new kind of force, the 'nuclear force', besides the electromagnetic and gravity forces, and the 'weak force' that Fermi introduced in his theory of radioactivity. Nuclear physics in the 1930s was a repeat performance of atomic quantum mechanics albeit on a much higher energy level, about a million times the energies in atoms, and based on a different interaction. It led to an understanding of the principles of nuclear spectroscopy and of nuclear reactions. Artificial radioactivity, and later nuclear fission and fusion were discovered with fateful consequences of their military applications. One of the most important insights of nuclear physics in this period was the explanation of the sources of solar and stellar energy by fusion reactions in the interior of stars.

Character and sociology of science in this period

I will concentrate on the situation in physics, with which I am mostly acquainted. What is most striking was the small number of experimental and theoretical physicists who dealt with the new developments. The yearly Copenhagen Conferences, devoted to the latest progress in quantum mechanics and relativity, were attended by not more than fifty or sixty people. There was no division into specialities. Atomic and

CES PRESENTS:

CES Technical Training Program

"Hands-on" training sessions are organised in CES headquarters in Geneva on a regular base to help customers integrating quickly and safety their test systems or their DAQ elements. In a few days you will gain months of experience working together with CES systems engineers.
This training program is open to CES customers only.
Participation is limited to 6 persons per session.
Special sessions can be organised for customers receiving their new systems.

Real-Time UNIX VME test systems (3 days)

- Configuration of VME systems
- VME test utilities (VMECHK)
- VME performance measurement utilities
- Introduction to CES test system
- Interrupt handling
- Bus error handling
- Block transfers VME and VIC
- CAMAC drivers CBD 8210 / VCC 2117
- VIC drivers VIC 8250 / VIC 8251

Special session on FASTBUS Interfaces FVSBI 9210, VFI 9214 (2 days)

- The FVSBI and VFI structure
- Operation under LabVIEW III with MAC 7212
- Operation under OS-9 with FIC 8234

OS-9 environment on FIC 8234/43 Disk based and diskless systems (2 days)

- System architecture
- VME test utilities (VMECHK)
- Network configuration
- Disk architecture

Special session on VCC 2117 Intelligent CAMAC Controller (2 days)

- The intelligent CAMAC Controller structure
- Connection through VIC bus
- Connection through Ethernet
- Operation under OS-9
- Operation under Lynx
- Operation under LabVIEW

Equipment available for technical training sessions

VME Monitoring	VMDIS 8004	(VME / VSB)
Processors	FIC 8234	(MC 68040)
	FIC 8243	(MC 68040)
	RAID 8235	(R3000)
FASTBUS Interfaces	FVSBI 9210	
	VFI 9214	
CAMAC Interfaces	VCC 2117	
	CBD 8210	
VME Intercrate Connection	VIC 8250	
	VIC 8251 (reflective memory)	

CES Training schedule

	Lynx / 68040	*Lynx / R3000*	*OS-9 / 68040*	*VCC 2117*	*FASTBUS I/F*
May	25/26/27	17/18/19	10/11	26/27	17/18
June	22/23/24	15/16/17	7/8	23/24	16/17
July	20/21/22	13/14/15	5/6	21/22	14/15

Contact person: Maryse Allard maryse@lancy.ces.ch

CES, at the leading edge in system conception

For any additional information about this product or our complete VIC, VME, CAMAC and FASTBUS line, do not hesitate to contact us.

CES Geneva, Switzerland Tel: +41-22 792 57 45 Fax: +41-22 792 57 48
CES.D Germany Tel: +49-60 55 4023 Fax: +49-60 55 82 210
CES Creative Electronic Systems SA, 70 Route du Pont-Butin, P.O. Box 107
CH-1213 PETIT-LANCY 1 SWITZERLAND

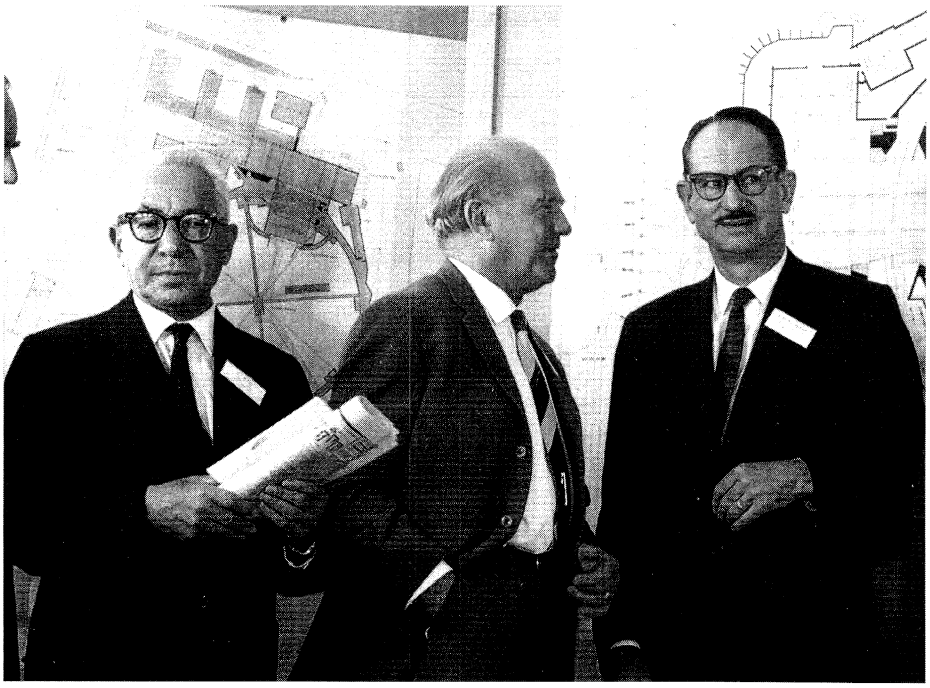
molecular physics, nuclear physics, condensed matter, astronomy, and cosmology were discussed and followed up by all participants. In general, everybody present was interested in all subjects and their problems. Quantum mechanics was regarded as an esoteric field; practical applications were barely mentioned.

The new physics was dealt with at relatively few places. The list of places reveals a dominance of Europe and in particular of Germany. American physicists who wanted to play a leading role in the States were bound to study for a few years in Europe. All this changed rapidly in the early thirties when physics in the USA developed suddenly from being derivative or 'provincial' to becoming central and leading. It was not so provincial in experimental physics considering the decisive experiments of C.J. Davisson and L.H. Germer in 1927 about the wave nature of electrons, and of A.H. Compton in 1923 about the scattering of light by electrons, directly establishing the existence of photons.

The change from being provincial to becoming central was brought about by an internal reorientation of American science spurred by leading American personalities such as G. Breit, E.U. Condon, E.C. Kemble, R.A. Millikan, J.R. Oppenheimer, I.I. Rabi, J. Slater, H.J. Van Vleck and others. Most of these people received some of their education in Europe. The new orientation was helped but not primarily caused by the immigration of prominent German and Austrian physicist-refugees from Hitler. What also helped was the end of German predominance because of the anti-intellectual attitude of the Hitler regime.

Most characteristic of pre-World-War II science were small groups and low costs of research, primarily funded by universities or by foundations and rarely by government sources. Foundations had a great influence on science. Some of the impressive developments of the thirties in biology can be traced to the decision of the Rockefeller Foundation under Warren Weaver to support biology more than other sciences.

Idealism brought people to science. There were not many research jobs and academic positions available and they were not well paid. Anybody who started training for scientific research had to face the possibility of ending up as a science teacher in a high school which, after all, is also a challenging profession. The character of science in the first period can be summarized as a continuation of the intellectual and social tradition of the nineteenth century.

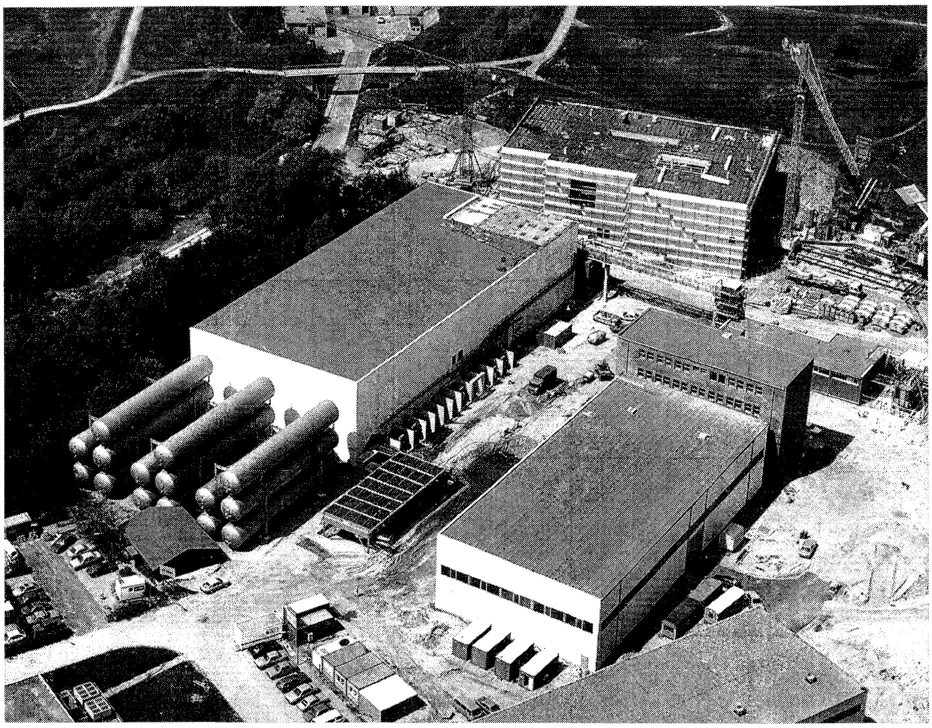


In the 1930s, Europe, particularly Germany, dominated the physics scene with such monumental figures as Werner Heisenberg (centre). However personalities such as Isidor Rabi (left) and Edwin McMillan (right) played a major role in reorienting US physics from a provincial to a central position.

Technological spinoff from accelerators - 1

by Oscar Barbalat

High energy proton physics has brought a major investment in cryogenics. The superconducting magnets for the 6.3 kilometre proton ring of the HERA electron-proton collider at the DESY Laboratory in Hamburg needed the largest helium refrigeration plant ever built in Europe.



Continuing this year's CERN Courier theme of the spinoff and technological derivatives arising from fundamental physics is this series of two articles on the industrial benefits from the central tool of high energy physics - the particle accelerator. It is based on a report initially prepared at the request of the International Committee for Future Accelerators' (ICFA) panel on spinoff from particle physics research (April, page 7).

Accelerator Technologies

Particle accelerator performance depends critically on the underlying technology. Thus the construction of larger, more powerful and more sophisticated accelerators has resulted in technological progress, yielding applications in other areas.

The basic particle accelerator technologies are electrical and radiofrequency engineering, for the powerful electric and magnetic fields needed respectively to accelerate the particles and control the beams.

Superconductivity, with its suppression of ohmic losses, makes the generation of these fields more efficient. With present superconducting materials requiring extremely low temperatures, cryogenics has also become a key accelerator technology.

Beams also need a high vacuum to minimize unwanted collisions. Mechanical engineering appears in the design of nearly every component, while another essential ingredient is the particle source.

Finally, accelerators have led to the development of a variety of monitoring and controlling techniques, both for their construction (high precision survey) and for their operation.

Superconductivity

Large-scale applications of superconductivity have been pioneered by particle accelerator engineers. Improved accelerator performance needed increased magnetic fields and electric fields while keeping the energy consumption within acceptable limits.

This has stimulated the development of superconducting dipole and quadrupole magnets and of superconducting radiofrequency accelerating cavities.

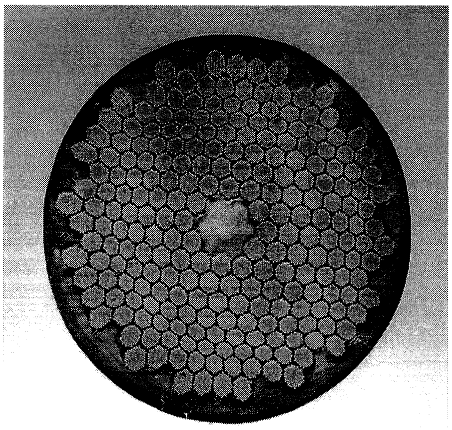
The first superconducting cables (for bubble chambers and nuclear magnetic resonance - NMR - spectrometers) were capable only of d.c. operation. Accelerator requirements seeded the development of superconducting cables for a.c. operation, at the heart of all major ongoing applications. These cables are made of intrinsically stable conductors, twisted thin strands of superconducting wires embedded in a copper matrix and suitable for ramped fields.

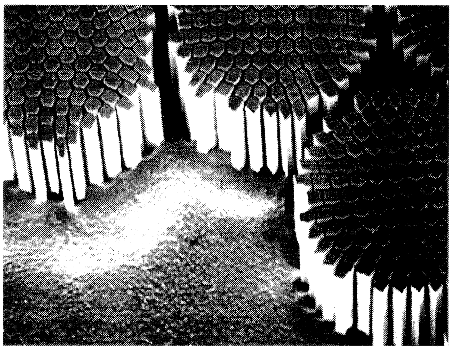
The implementation of a fusion reactor, either based on magnetic or inertial confinement, will probably rely on superconductivity. In the case of magnetic confinement, a net energy gain can only be achieved if the confining magnetic field does not require excessive power. Furthermore, the high magnetic fields permitted by superconductivity may allow the design of more compact machines. ITER, the future large international research tokamak, will be designed around superconducting magnets.

Research on inertial confinement fusion explores several ways of

The physics requirements for high magnetic fields have driven the development of filamentary superconductors. This 1.29 mm diameter wire contains over 28,000 filaments of niobium-titanium (Alsthom Intermagnetics)

Below, a close-up of one of the bundles of 5-micron-diameter filaments.





imploding the fuel pellet. Particle beam fusion systems are based on ideas resulting directly from particle physics research, while the most promising laser system, the free electron laser, also derives from particle accelerator technology.

The output of electric power generators has grown considerably in recent decades, performance also having been boosted by improved cooling, allowing higher current densities. However this also produces a rise in ohmic losses and a corresponding reduction in efficiency, prompting a closer look at superconductivity.

Transmission of electric power is another possible application of superconductivity. The prospect of replacing the vast electrical highways feeding large cities by underground superconducting cables is an attractive proposition. Successful tests of a twin-conductor 60 Hz 115 m-long flexible cable transporting triple-phase 1000 MVA at Brookhaven National Laboratory in the 1970s have opened the way to longer transmission lines. Increased environmental consciousness will strongly encourage the development of compact underground power lines.

Another potentially far-reaching application of superconductivity in power engineering is the large scale storage of electricity. Large coal-fired and nuclear power plants are designed to operate close to full capacity. Their efficiency and expected lifetime is decreased significantly if they have to suppress large fractions of their capacity. On the other hand electricity demand has large seasonal, weekly and daily variations. A variety of technologies, ranging from gas turbines to pumped hydroelectricity, are currently used to handle these variations. Reducing unwanted gas emission and the difficulty of finding suitable hydro-storage sites would make new techniques such as SMES (Superconducting Magnetic Energy Storage) attractive.

One of its main advantages is that energy is stored in its electrical form and requires no intermediate conversion from or into thermal or kinetic energy. Reference systems for 5 GVA have been designed in the US and Japan. The feasibility of the concept has successfully been tested in a 30 MJ system installed in 1982 to stabilize the electric power transmission between the Pacific Northwest and Southern California.

High speed ground transportation could also become a large scale application of superconductivity. Prototypes have been demonstrated in Germany and Japan. A 10 ton Japanese test vehicle, using levitation from eddy currents created by an electromagnet moving above a conducting rail, has exceeded 500 km/h. Superconducting coils fulfil the three functions of suspension, guiding and propelling the vehicle.

Research on the application of superconducting magnetic coils for marine propulsion is also underway in Japan and a prototype boat recently has been tested successfully.

Another industrial application of superconductivity is magnetic separation for mineral and scrap metal processing - requiring high magnetic forces over large volumes.

Eddy currents induced by superconducting magnets could slow convection currents during the crystallization process of silicon for semiconductor production. This would lead to more homogeneous crystals and open up the manufacture of larger single chip devices.

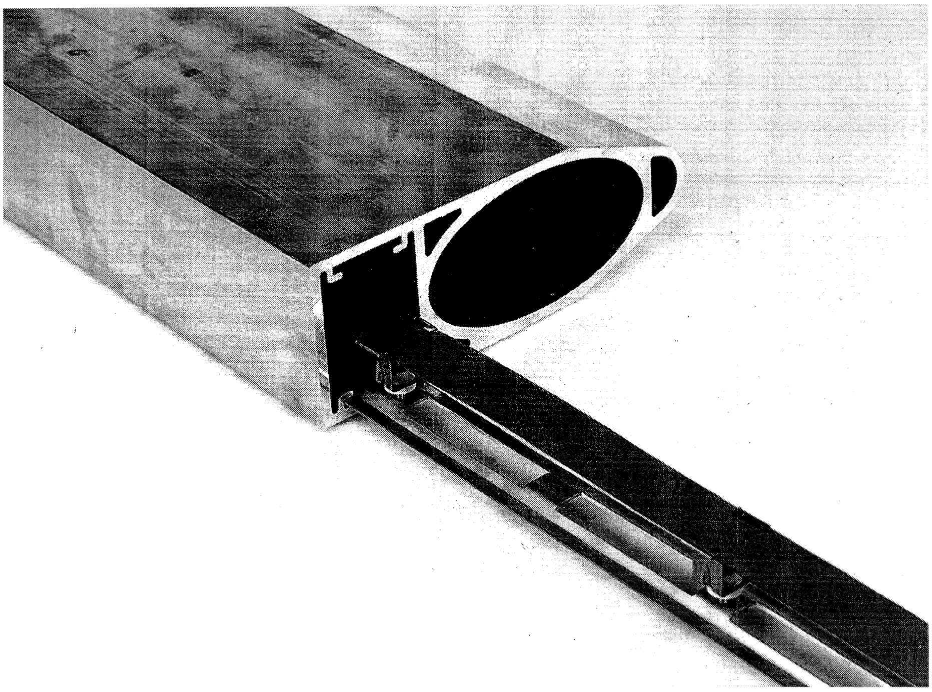
Another avenue worth exploring is ultra-fast computers based on the rapid switching of Josephson diodes.

Superconducting magnets are used all over the world for the characterization and identification of chemical compounds by nuclear magnetic resonance spectroscopy. While some 10 years ago typical systems used magnets in the 5 Tesla range, commercial devices now use magnets operating near 10 Tesla, with correspondingly increased performance.

Superconductivity is also finding applications in medical diagnosis through magnetic resonance imaging scanners, less invasive than classical X-ray diagnosis. Again, performance improvements would follow from higher field magnets.

The high temperature superconductors discovered only a few years ago have not yet found their way into accelerator technology as they can

The construction of CERN's LEP electron-positron collider has pushed vacuum technology. The problems of evacuating a 27-kilometre ring led to the development of a linear non-evaporable getter (NEG) pump using an aluminium-zirconium alloy bonded in powder form on a constantan ribbon, seen here alongside a piece of LEP vacuum chamber.



neither be made into high density current-carrying cables for magnet coils nor deposited on large surfaces for radiofrequency cavities. However, this rapidly developing field is being closely monitored. Any materials breakthrough would open the way to wider applications.

Cryogenics

Cryogenics, the technique of low temperature, goes hand in hand with superconductivity. Classical superconductors operate at a few degrees K, provided by liquid helium cooling. Physicists had become familiar with large-scale low temperature work through the liquid hydrogen bubble chamber, one of the most widely-used detectors of the 1960s and early 70s.

Most superconducting magnets now use niobium-titanium wire and operate at temperatures close to 4.2 K, the boiling point of helium. At this temperature, the field achievable with NbTi is limited to about 6.5 Tesla.

In the quest for higher magnetic fields, superconductors with better magnetic properties, such as niobium-tin, are troublesomely brittle. For its next accelerator project, the LHC proton collider, CERN thus prefers to exploit the improved NbTi performance at lower temperatures (2 K).

Such temperatures offer attractive features: liquid helium becomes superfluid, with an enormous increase in thermal conductivity and reduction of viscosity and much practical payoff.

Cryogenics is applied in other fields, for instance in vacuum and space science and for sensitive instrumentation such as low noise amplifiers and infra-red night vision devices.

The NMR superconducting magnets used both in the laboratory and for medical diagnostics employ cryogenics technology developed for accelerator magnets. What used to be delicate, fragile and complex systems requiring continuous attention have today become a reliable technology.

Another cryogenics outlet is the production through liquefaction of extremely pure gases, useful in any industrial processes (e.g. in the semiconductor industry) requiring extreme cleanliness or purity.

Vacuum and surface science

Particle acceleration requires a good vacuum to avoid scattering the beam on residual gas. Pressures in the region of 10^{-6} - 10^{-7} Torr are generally sufficient for synchrotrons, where acceleration lasts only a few seconds. However storage rings and colliders which must hold beams over several days have more critical requirements, calling for the 10^{-10}-10^{-11} Torr range. Even lower pressures are needed near the detectors to reduce background.

The valuable experience at CERN's Intersecting Storage Rings (ISR) brought considerable progress in this field. The ISR was the first large machine to be operated using the advanced technology of ultra-high vacuum systems (UHV), eventually reaching 10^{-12} Torr. This catalysed the vacuum industry to develop UHV components (e.g. sputter ion pumps, all-metal valves, seals, gauges).

Equally important for UHV systems is the cleanliness of all surfaces. Techniques for cleaning and preparing surfaces - chemical treatments, bakeout and glow discharge to reduce gas desorption - were developed.

The construction of CERN's Large Electron Positron collider (LEP) has further stimulated progress in vacuum technology. Although the vacuum level is less than the ISR, evacuating a 27-kilometre ring posed

special problems. This led to the development of a linear non-evaporable getter (NEG) pump using an aluminium-zirconium alloy bonded in powder form on a constantan ribbon. Another development has been the all-aluminium vacuum chamber with better thermal conductivity and lower residual radioactivity than stainless steel and which can be extruded into complicated shapes.

Other vacuum components have been developed following accelerator experience, particularly where mechanical motion under vacuum is needed. As pressure falls, lubrication is inhibited and friction increases dramatically. Ingenious solutions had to be found for fast closing valves, beam diagnostic devices or shutters and movable sensing electrodes and deflectors.

Vacuum seals have also undergone considerable improvements. Elastomers can sustain neither high radiation nor bakeout at 300-400C, and metal joints have now generally been introduced.

This progress in vacuum technology is finding direct applications in space science and fusion test facilities, and in industry, for example in the technologies for semiconductor manufacture.

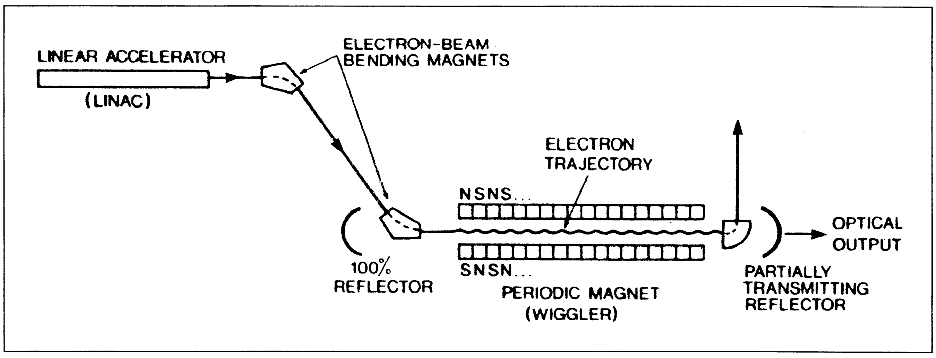
Even when extremely low pressures are not required, for example in surgery, the pharmaceuticals industry or in food preparation and conservation, the extreme cleanliness of UHV systems and their reliability have brought benefits. Cleanliness and special surface conditions are essential for quality and performance in many high technology areas. Vacuum and surface technology therefore play an increasingly important role.

Particle sources

Accelerators require intense sources of electrons and ions. An important application of such sources is the implantation of ions for semiconductor circuit elements. Ion beams are also used in material preparation such as pre-deposition surface cleaning/conditioning and low energy Ion Beam Assisted Deposition (IBAD). IBAD films have remarkable properties (adhesion, hardness, optical transmission, ...). Another important industrial application is the electron beam technique used for precision welding.

Finally the classic applications example is the range of electron tubes used for telecommunications, broadcasting and radar which derive from the cathode-ray tube proto-accelerator devices developed at the turn of the century for basic physics research.

A second article will cover applications in radiofrequency and microwave engineering, mechanical engineering, electrical engineering and power electronics, controls engineering, instrumentation, and surveying and tunnelling.



Another example of high energy physics techniques in action is the free electron laser, invented by John Madey at Stanford in 1971. A light beam is reinforced by synchrotron radiation from electrons passing through a 'wiggler' magnet.

Physics monitor

STANFORD (SLAC) Precision electroweak result

Precision testing of the electroweak sector of the Standard Model has intensified with the recent publication* of results from the SLD collaboration's 1993 run on the Stanford Linear Collider, SLC. Using a highly polarized electron beam colliding with an unpolarized positron beam, SLD physicists measured the left-right asymmetry at the Z boson resonance with dramatically improved accuracy over 1992. Combining the two measurements yields the world's most accurate single determination of the weak mixing angle, $\sin^2\theta_W = 0.2294 \pm 0.0010$.

(The weak mixing angle dictates how the two neutral carrier particles of the underlying electroweak theory combine to form the physical photon, which carries the electromagnetic force and is massless, and the Z, which carries the weak nuclear force, and at 91 GeV is the heaviest known particle.)

The sixfold improvement in accuracy is due to increased luminosity (50,000 Zs compared to 11,000 in 1992), higher polarization (63% compared to 22%) and much improved systematic errors. Use of "flat" SLC beams (2.6 by 0.8 micrometers at the collision point) is largely responsible for the luminosity improvement. An almost threefold increase in the electron beam polarization resulted from an intensive effort involving SLAC, Wisconsin and Berkeley physicists to develop high-polarization photocathodes using gallium arsenide crystals with "strained lattices" (July/August 1993, page 5).

The SLD determination of the asymmetry parameter using a polarized electron beam is a straightforward measurement whose errors are still dominated by counting statistics. The systematic error in this measurement (which has dropped to 1.7% from 3.6% in 1992) is due mainly to the uncertainties in measuring the SLC polarization using a Compton polarimeter, situated close to the SLC interaction point.

But the 1993 SLD run was not without its surprises. Testing the spin transport through the SLC arc to evaluate an expected chromatic effect on the polarization measurement, an SLD group was confronted by a large discrepancy between the polarizations measured with the Compton polarimeter and with a diagnostic Moller polarimeter at the end of the two-mile SLAC linac. Finally, after some furious head-scratching last fall, these physicists stumbled across a Russian paper that helped resolve the quandary. The momenta of electrons in the inner shells of the iron and cobalt atoms in the Moller target had spuriously increased the apparent beam polarization by about 10% - an effect previously ignored in Moller polarimetry. With this finally understood, the discrepancy vanished and the SLD collaboration published its electroweak results.

The value of $\sin^2\theta_W$ extracted from the combined 1992-93 SLD asymmetry measurements is smaller (by more than two standard deviations) than the present LEP value, 0.2322 ± 0.0005, an average of 29 different measurements based on some 8 million Zs seen from 1989-3.

This offset between the LEP and SLD electroweak results is reflected on the corresponding interpretation in the context of the Standard Model. With the sixth ('top') quark not yet confirmed, consistency arguments dictate where this quark can sit if the Standard Model is to survive intact. Using LEP data alone, the top mass is 165 ± 22 GeV, while a global fit to all world data yields $178 \pm 9 + 17 - 20$ GeV.

Excitement is high as the next round of SLD experiments begins this June. With at least 100,000 events expected and a beam polarization of about 75 percent, the error on the final result should be halved. With LEP precision improving too, the next year will certainly be interesting for electroweak physics.

** K. Abe et al, SLAC-PUB-6456 (April 1994), submitted to Physical Review Letters.*

Standard Model parameters

The Standard Model - an amalgam of the current electroweak and quark pictures of basic physics - is increasingly constrained on all sides by new precision results.

In addition to the new electroweak asymmetry measurement from the SLD detector at Stanford's SLC linear electron-positron collider, fresh constraints come from several other directions. At CERN's LEP electron-positron collider, some 3 million Zs were collected in 1993, adding to the 5 million seen from 1989-92, while at Fermilab's Tevatron proton-antiproton collider, the CDF experiment has set a new value for the mass of the W, the electrically-charged counterpart of the neutral Z, at 80.38 ± 0.23 GeV, and the companion D0 experiment provides a new 'floor' of 131 GeV below which the top quark mass cannot go.

(The June issue will include a major feature of the Standard Model by physics writer Christine Sutton.)

Megascience forum

The increasing complexity and cost of major scientific projects such as proton colliders, space observatories and space probes amply merit the accolade of 'Megascience' or even 'Gigascience'. With scientific challenges straining the human and financial resources available, the funding and management of such projects cries out for international collaboration.

Such increased internationalism can be built from the bottom up, seeking partners for each new scientific venture, or can climb on existing international infrastructures.

International contacts between scientists are excellent, particularly in the physics and astronomy sectors. The concrete achievements of CERN and other international scientific organizations, often in a glacial political climate, demonstrates what can be achieved. But such pioneering collaboration profits from parallel politico-economic empathy.

In this context, the influential intergovernmental Organization for Economic Cooperation and Development (OECD) has recently established its 'Megascience Forum', chaired by P. Tindemans, Director of the Division of Higher Education and Science of the Netherlands Ministry of Science and Education. 21 of the 24 OECD member states participate in this forum to give advice to their governments. For this exercise, Russia, an OECD non-member state, participates as an observer. Four meetings of the forum have been held so far.

(Founded in 1960, the OECD - which groups nations with advanced market economies - sets out to improve economic and social conditions in its own area while stimulating relations with developing countries and generally boosting world trade. While its major concerns are economic and financial, science and technology have been identified as areas of particular concern.)

Using expert panels, Megascience reports have been prepared on deep drilling, astronomy, global change research and oceanography. Reports currently under study or planned include synchrotron radiation sources and neutron beams, high energy physics, and supercomputing.

As well as ascertaining future prospects and sounding the views of the scientific community, the Forum wanted to look at existing mechanisms for the selection of elementary particle physics priorities and for international collaboration.

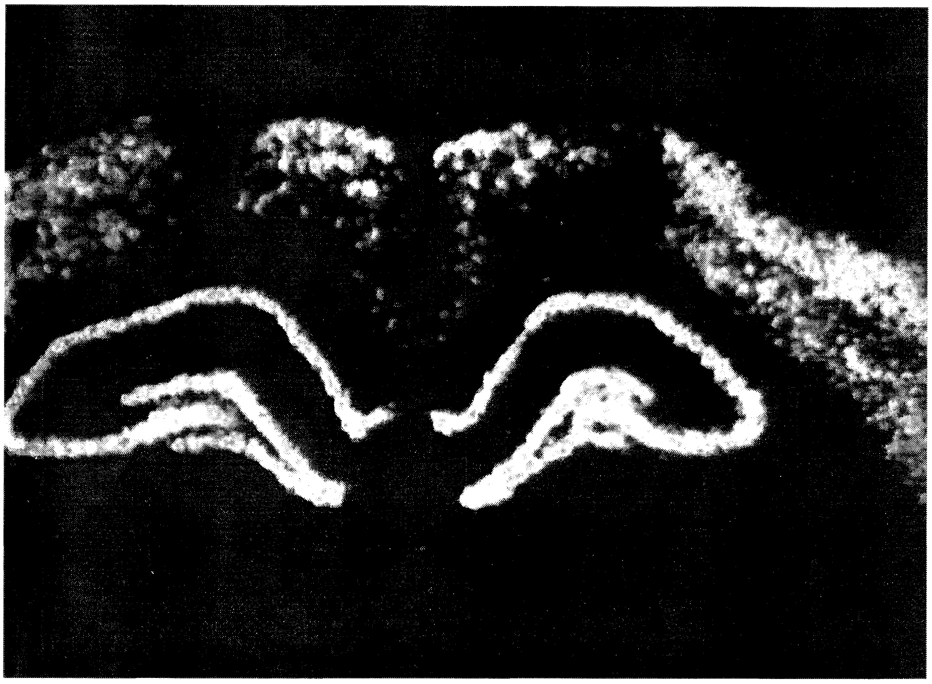
The Megascience Forum also recommended that two additional documents be produced, one placing elementary particle physics in the broader context of nuclear physics and astrophysics, and the other reviewing, from the point of view of governments, possible future mechanisms for selecting priorities and international cooperation. An extensive report is tabled for discussion at an expert meeting in May at the Swiss Paul Scherrer Institute.

The Megascience consultant for high energy physics is former French delegate to CERN Council P. Petiau, while the regional consultants are W. Willis and S. Wojcicki for the US, ECFA Chairman G. Flügge and A. Donnachie for Europe, S. Yamada for Japan and M. Danilov for Russia.

At their first meeting, they agreed on the overall outline for their eventual report, taking into account the extensive work already done in the context of international advisory groups such as ICFA, the International Committee for Future Accelerators.

The concrete achievements of CERN and other intergovernmental scientific organizations are role models for international collaboration.

Scintillating fibres in action. A high resolution CCD beta radio imager using a proximity focused image intensifier coupled to a CCD to pick up light from scintillating fibres has produced this frontal section of a rat brain. This has already given new insights into the role played by genes in memory.



DETECTORS
Scintillating fibres

In the continual search for improved detection techniques, new materials are continually proving profitable. A good example is scintillating plastic fibres - tiny transparent threads sometimes finer than a human hair which transmit light.

The narrowness and flexibility of these fibres was a major breakthrough for endoscopy - non-invasive techniques for viewing the otherwise inaccessible in surgery or machine inspection. In a more sophisticated form, these fibres find ready application in communications technology, where the goal is to transmit information rather than electrical power, replacing conventional and unwieldy current-carrying wire conductors.

In particle physics, fibres have long been used to take the tiny scintillations produced when high energy particles hit fluorescent materials and 'conduct' them to photosensitive detectors some distance away.

A newer application is in tracking, using an array of fibres as a sensitive target, where the pattern of produced light helps reconstruct the trajectory of the particle.

A pioneer large fibre tracker was built in the mid-1980s as part of the upgrade programme of the UA2 detector at CERN's proton-antiproton collider. A cylinder containing 60,000 fibres, each 1 millimetre across, greatly improved the reconstruction of the complex collisions taking place inside the detector.

Among ongoing projects, an important fibre application example is the Chorus experiment, which along with the Nomad detector will exploit from this year the new neutrino beams at CERN (November 1991, page 7).

Chorus will catch its neutrinos in an 800-kilogram block of photographic emulsion. To localize the interaction for subsequent emulsion scanning, the outgoing tracks will be picked up immediately downstream in arrays of fibres. The resulting light will be amplified, as in UA2, by multiple stages of image intensifiers feeding CCDs for final readout. Put end to end, the two million individual fibres used in Chorus would stretch across five thousand kilometres. (Meanwhile the UA2 readout systems have been recycled for the WA98 heavy ion experiment at CERN.)

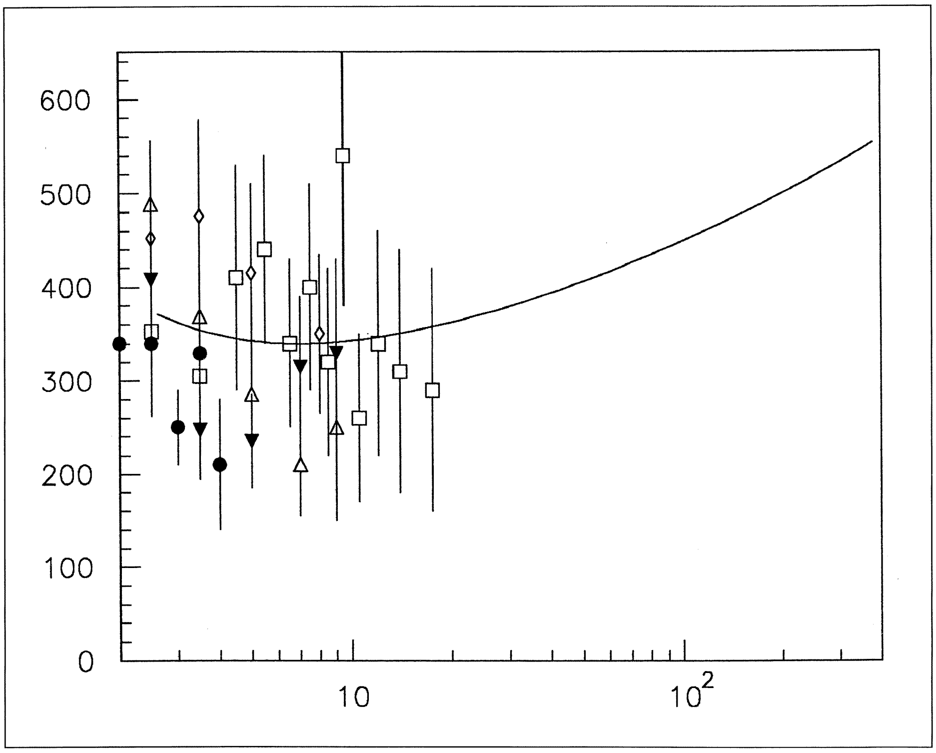
An alternative fibre tracking readout technique has been developed in the US by Muzaffer Atac. This Visible Light Photon Counter is based on a Rockwell solid state photomultiplier with a gain of 20,000 but its 7K operating temperature demands a cryogenic environment. This technique was initially proposed for an upgrade of the D0 detector at Fermilab's Tevatron proton-antiproton collider, and for use at the ill-fated SSC Superconducting Supercollider.

Fibre techniques are also being developed at CERN in the context of the Italian-funded LAA scheme. To cope with the higher interaction rates of tomorrow's physics, fused fibre bundles have been developed with diameters of several millimetres, containing thousands of individual fibres. Special dopants amplify the scintillation, reducing 'cross-talk' between neighbouring fibres, while readout is handled by new image intensifiers based on a single silicon diode.

With fibre tracking now well established in particle physics, the next stage could be new spinoff applications. For instance a group of French physicists (IPN Orsay/Paris) has been developing commercial instruments based on scintillating fibres and image intensifiers aimed mainly for biology, an applications target picked out by Georges Charpak.

A high resolution CCD beta radio

The photon-photon reaction rate (cross-section) showing the data collected so far by a range of experiments and its expected extrapolation into the region to be covered by LEP working at higher energies.



imager, whose main components are a proximity focused image intensifier coupled to a CCD, has also been developed, the device being self triggered by the intensifier's anode pulse. With samples carrying a suitable radioactive tracer, such as sulphur 35, a resolution of 15 microns is achieved, with the image built up a hundred times faster than conventional emulsion-based recorders.

Another instrument, the scintillating optical fibre imager, is designed to handle a much larger sample area. The radioactive sample is immediately above two orthogonal layers of fibres and the resulting light read out from the ends of the fibres at the edges of the layers. This technique is more powerful than X-ray methods and can be used in geology and other applications as well as biology.

Tale of two photons

A very profitable spinoff from electron-positron collisions is two-photon physics. Rather than the electron and positron interacting directly via an exchanged photon, two virtual (transient) photons, one from each particle, get tangled up.

With new electron-positron colliders appearing on the scene, a topical meeting on two-photon physics - 'From DAPHNE to LEP 200 and beyond' - held from 2 - 4 February in Paris, in the premises of the Ministry of Higher Education and Research, was particularly timely. Some 60 physicists, both experimentalists and theorists, participated, with some thirty speakers.

The meeting (sponsored by IN2P3-CNRS, DAPNIA-CEA and Collège de France and organized by J. Parisi of Collège de France and F. Kapusta of LPNHE Paris) was motivated by the ongoing or planned building of new electron-positron colliders covering a wide spectrum of energies and expected to have, as a common feature, a luminosity (a measure of their collision rate) of some 10^{33} cm^{-2} s^{-1}, much higher than machines of the previous generation. Their integrated luminosities of the order of 10^{40} cm^{-2} should considerably boost two-photon physics.

The first part of the meeting was devoted to DAPHNE, a machine of total energy 1 GeV presently being built at Frascati, with its detector (KLOE) and a tagging system planned for two-photon experiments. Prospects for two-photon physics include the production of charged and neutral pion pairs near threshold, as well as of low-mass resonances. Calculations of the pion pair production by two photons at low energy were presented by several theorists using different approaches.

The second part of the meeting was devoted to machines of somewhat higher energy - a Tau/Charm Factory of total energy 3 - 6 GeV that might be built somewhere in Europe, and the B Factory for Stanford (SLAC). Two-photon physics at the Stanford B Factory and its detector (BABAR) could open up meson spectroscopy (up to and including charmonium) and examine the kinematic behaviour of resonance production, where quantum chromodynamics (QCD) has made interesting predictions. There are particular implications for the production of quark-antiquark mesons having non-zero orbital angular momentum, as well as the production of gluonic mesons ("glueballs").

LEP 200 - the energy upgrade of CERN's LEP collider - was the subject of the third part of the meet-

CZECH REPUBLIC AT CERN

7 - 10 JUNE 1994

Geneve, 7/6-10/6/1994
Czech Industrial Exhibition at CERN
Czech Industrial Exhibition organized by TECON, Ltd. Prague
in co-operation with
the Confederation of Industry of the Czech Republic
with patronage of
the Czech Ministry of Industry and Trade
and the Czech Government Committee for Co-operation with CERN.

ATEKO, a.s.
Resslova 956
501 87 Hradec Kralove
Czech Republic
Phone:++42-49-615311
Fax:++42-49-613203

Refrigeration systems, heat exchangers, reverse osmotic stations, environmental technologies, for instance: oil removing from waste water, cryogenic recovery of volatile components from the air, expansion turbines and, with partner PBS turbomachinery

AVIKO, a.s.
Jinonicka 80
158 00 Praha 5
Czech Republic
Phone:+42-2-523041
Fax:+42-2-551002

Special single-purpose machines, assembly lines, equipment for dimension measuring, checking of surface and sorting

CVUT Praha
Czech Technical University
Zikova 4
166 35 Praha 6
Czech Republic
Phone:+42-2-2431 0372
Fax: +42-2-2431 1042

CVUT coordinates its activities in the various fields related to its six faculties: Civil Engineering, Mechanical Engineering, Electrical Engineering, Physical Engineering and Nuclear Sciences, Architecture, and Transportation Sciences. CVUT has a wide experince in real time control application of AI methods - expert system FEL-EXPERT, satellite navigation -NAVSTAR system, sensor systems, digital filters, environmental technology (e.g. waste deposits and surface and groundwater quality), biotechnology, cryogenic processes, fluids dynamics problems, new materials, tools and technology, automation and robotics, designs of machines and devices for industries, and multimedia systems.

Gity, s.r.o.
Marianske nam.4
617 00 Brno
Czech republic
Phone:+42-5-43212378
fax:+42-5-43211036

Design, delivery and installation of computer and telecommunications networks with integrated services. Sale of active and passive components for data networks. Testing and monitoring of networks.

ICM - Innovation Centre of Micronics
Novodvorska 994
142 21 Praha 4
Phone:+422-4761111
fax:+422-4607480

Detectors for charged particles registration, integrated circuit CMOS (ASICs), chemical sensors, microwave devices, special semiconductor devices

KABLO Kolín
Havlickova 432
230 94 Kolin IV.
Czech Republic
Phone:+42-321-518
Fax:+42-321-20639

Wiring conduits, flexible and rigid, for the electrical and mechanical protection of electrical installations
Light weight wiring plastic conduits, junction boxes and square conduits (together with necessary accessories); armoured metal wiring conduits
Heat resistant enameled wires (Cu dia 0.18-0.90 mm) up to 155°C and 180°C
Special materials as the NEUTROSTOP, shielding fittings which can be used for shielding the neutron radiation of nuclear reactors, X-ray sources, etc.
Available production technologies:
Mould presses, extrusion presses, tube welding machines, shaping presses for steel sections, enamelling furnaces.

Kovohute Rokycany, a.s.
Zeyerova 285
33728 Rokycany
Czech republic
Phone:+42-181-2813
Fax:+42-181-4320

Wrought semi-manufactured products of copper, nickel and their alloys (sheet, strip, rod, tube and wire), and plain bearings and bushings.

MFF UK
and
VAKUUM Praha
Faculty of Mathematics
and Physics,
Charles University
Ke Karlovu 3
121 16 Praha 2
Czech Republic
Phone:+42-2-8576 2327
Fax:+42-2-6641 5095

The physical research at the Charles University is concentrated mostly at MFF UK. VAKUUM Praha, a private company, was formed to support experimental facilities of MFF UK and to apply the results of research.
MFF UK participates in research projects of nuclear and particle physics, solid state and low temperature physics, electronics and vacuum engineering, optics, macromolecular physics and computer science.
The involved activities resulted in such products as radonmeters, gas sensors, thin film coatings, and a variety of optical components.
VAKUUM is manufacturer of UHV small chambers and components, subsystems and mechanical parts of analytical vacuum devices, microwave tubes and ion getter pumps, which are delivered to universities and research laboratories.

Meopta Prerov, a.s.
Kabelikova 1
750 58 Prerov
Czech Republic
Phone:+42 641 54 1111
Fax:+42 641 52 662

Enlarging apparatuses, projectors, telescopes, riflescopes, objectives, medical apparatuses, measuring apparatuses and optical elements for their assembly, measuring microscopes and scale lenses, surveyor's aids, free optic parts, glass and fragile materials working - special single purpose machine for planar and spherical optics.

Nuclear Research Institute s.r.o.
250 68 Rez
Czech Republic
Phone:+422 685 7519
Fax:+422 685 75 67

The development, design and manufacture of mechanical and electrical equipment for in-pile as well as out-of-pile scientific experiments (material testing, corrosion tests, irradiation experiments, remote control handling etc.)

POLDI STEEL Ltd.
Prumyslova 1343
272 62 Kladno
Czech Republic
Phone: +42-312 -4868
-2843
-803
fax: +42-312 -6853
-5269
-4823

Special engineering tool and stainless steels according to specifications based on any internationally renowned standard. All basic grades of stainless steels (austenitic, martensitic, ferritic and dual-phase types) used in nuclear engineering (especially bars and forgings for reactor control systems, rounds and billets for the manufacture of seamless steam generator tubes and rods for the manufacture of welding wires and electrodes.
Borated stainless steel for spent fuel storage of both "wet" and "dry" types (bars, sheets and plates) are available.

PRECIOSA Co.
Preperska 1447
511 11 Turnov
Czech Republic
Phone:+42-436-22752
Fax:+42-436-22323

Scintillation materials and detectors, laser rods and other laser components, crystal based precise optics and mechanics, medical instruments and devices.

SILEKTRO, s.r.o.
Vodickova 30,
111 70 Praha 1
Czech Republic
Phone:++42-2-2421 60 18
-2421 58 24
Fax:++42-2-231 50 70
Contact person:
Mr. Jan Hlavácek

Technical project documentation,
special power supplies distribution with protection of electronic devices against
pulse overvoltage; uninterruptible power supplies (U.P.S).

SKODA Group, Ltd. Comp
Tylova 57,
316 00 Plzen
Czech republic
Phone:(+4219)215 1111
Fax:(+4219) 22 19 85

ŠKODA

Metallurgy - steel, grey iron and non-ferrous metal castings, forgings and crank-shafts
Transport engineering - electric locomotives and other rail vehicles, wagons, trolley buses, electromobiles
Heavy current electrical engineering-electric generators, transformers, circuit breakers and other electric apparatus, electric motors
Power engineering - steam turbines up to 1000 MW output power, nuclear reactors, burn-out fuel containers
Heavy engineering - machine tools, rolling mills, sugar-cane mills, equipment for foundries; hydraulic presses, industrial furnaces, gear boxes

Strojexport PTA, a.s
Vaclavske namesti
110 00 Praha 1
Czech Republic
Phone:+42-2-24032866
fax:+42-2-24032479

STROJEXPORT PTA a.s.

Building construction, underground works, stainless steel, rapid steel turning tools, fittings, electrical material, cables, switches scintillators, etc.
Participating with:

Kablo a.s. Kladno
Prumyslova, P.O.Box 15
27 257 Kladno
Phone:+42-312-4871
Fax:+42-312-6854

PURECERAM
Sportovni 430
50 009 Hradec Kralove 9
Phone:+42-49-25521
Fax:+42-49-25414

SVUSS, a.s.
190 11 Praha 9 - Bechovice
Czech Republic
Phone:+42-2-743233
Fax: +42-2-742078

SVUSS

R&D in thermo, aero, fluid and mechanical engineering, heat and mass transfer, power generation, energy conservation.
Expert services in vibration and noise reduction; thermohydraulic, aerofluid and LBB tests, verification of structural integrity.
Design and production of miniturboaggregates and its parts, ultrasonic nondestructive defectoscopic systems, vacuum-compresor, medical instruments, pressure and ultrasonic gauges, aircondition systems with heat pipes.

TMP-Telekomunikacni montaze Praha
Senovska 434
182 03 Praha 8
Czech Republic
Phone:+42-2-8590264
Fax:+42-2-8590284

Design, delivery, installation, testing and putting into operation public telephone exchanges (analogue, digital), private automatic branch exchanges, transmission systems, trunk cable routes (metallic, optical), radio relay links for telephone, TV and data, local cable networks, intramural wiring, local area networks, wide area networks, structured cabling systems (AT&T Systimax SCS)

VOD AVCR
Skalova 89
511 01 Turnov
Czech Republic
Phone:+42-436-22718
Fax:+42-436-22913

OPTICAL DEVELOPMEMT WORKSHOP of the Academy of Sciences of the Czech Republic.
Custom made optics - crystal optics, laser optics, astronomy optics, X-ray optics, thin films.
High precision products from glass, crystals, ceramics, metals

VSST Liberec
Technical University of Liberec
Halkova 6
461 17 Liberec
Czech Republic
Phone:+42-48-21073
fax: +42 48 27383

Faculty of Textile Sciences offers a free capacity in the broad area connected with the application of textiles and fibrous composites and the application of computer based methods for data treatment, quality assessment and industrial application.
The available selected research results are: new STRUTE textiles applicable as thermal and sound insulations as substitutions for polyurethane foam (the textiles are manufactured), the utilization of basalt fibres for the application in high temperature resistant fabrics, a system of microelectronic piezoelectric resonators and filters design.

VUES Brno
Mostecka 26
657 65 Brno
Czech Republic
Phone:+42-5-453 21 112
Fax:+42-5-452 11 144

Special electric machines and complete drives up to 1 500 kW according to the requirements of customers; high-speed motors, electrical dynamometers and complete measuring stands with dynamometers; special DC and AC generators, power supply sources and starters for the aircraft industry; servomotors with permanent magnets with electronic supply for drives with high dynamics and precision; DC and AC traction motors and drives; synchronous and induction generators up to 1 500 kVA; power supply sources with internal combustion engines.

ZDAS a.s.
Strojirenska 6
591 71 Zdar nad Sazavou
Czech Republic
Phone:+42-616-413 6498
Fax:+42-616-21740

The Metallurgical Plant manufactures casting of steel and nodular cast iron and open-die forgings of steel. Steel casting are made with weight ranging from 20 kgs to 25000 kgs/pc. Castings of nodular cast iron with weight ranging from 20 kg to 8000 kgs/pc.
Open-die forgings with weight from 20 kgs to 9000 kgs. Products of the Metallurgical Plant are delivered rough and/or finish machined. Various products for mechanical engineering, power engineering, metal working, metallurgy, transport, civil engineering etc. according to customer needs.

Organized by

TECON, Ltd.
Narodni 35
110 00 Prague 1
Czech Republic
Phone:++42-2-24212042
Fax:++42-2-24226549
Contact person:Ms.Dagmar Trkalova

Consultancy, training programmes, public relations, UNIDO-Czech Republic Joint Programme for Co-operation in Metallic Industries

In cooperation with

Confederation of Industry of the Czech Republic
Mikulandska 7
113 61 Prague 1
Czech Republic
Phone:++42-2-249 156 79
Fax:++42-2-297 896
Contact person: Mr.Pavel Dzida

Industrial and employer association comprising over 1000 companies and organizations operating in various industrial branches.

Designing and construction

Communicatio Humana - C.H. Expo,Ltd.
Senovazne namesti 20
110 00 Prague 1
Czech Republic
Phone:++42-2-24223645
Fax:++42-2-24221858
Contact person: Ms.Jaroslava Funkova

Company specialised in organizing exhibitions and trade fairs.

Bookshelf

ing. There, two-photon physics potential includes the production of heavy flavours, violent electron-photon scattering, and jet production. This work has many theoretical implications.

The final part of the meeting was given over to the prospects offered by a future linear electron collider of very high energy (some 500 - 1000 GeV total energy). This type of machine would be used either as such, or after conversion into a photon-photon or a photon-electron collider. Such a conversion would use Compton back-scattering of either or both electron beams on a laser, yielding a photon beam of approximately the same energy and intensity as its "parent" electron beam. Each of these three options has its own physics implications.

With the non-electromagnetic behaviour of the photon still little understood (September 1993, page 22), the meeting showed how increased luminosity from new machines would open up a more systematic study of the interactions of highly virtual photons.

Conceptual Foundations of Modern Particle Physics, by Robert E. Marshak (World Scientific, ISBN 98 102109 81)

Particle physics really began as an independent scientific discipline after the Second World War. Robert Marshak was one of its pioneers on the theoretical front, starting out his career with important contributions on meson theory (together with Hans Bethe). The life of Marshak, who died in December 1992, was intimately interwoven with the post-war development of particle physics. His work on weak interaction theory was an important step towards the formulation of the V-A theory, the main pillar on which the modern electroweak theory rests erected. He is also remembered as the founder of the biennial 'Rochester' conference series (March 1993, page 24).

Particle physics pioneers Robert E. Marshak (left, 1916-1992) and Maurice Goldhaber. Marshak completed his book 'Conceptual Foundations of Modern Particle Physics', now available from World Scientific, just before he died.

Just before his death Robert Marshak finished writing his book on the concepts of particle physics. The book starts out with an historical account of the development of the field. He divides it into the startup period (1945-60) - the period of meson physics, the physics of strange particles, parity violation etc; the heroic period (1960-1975) when the Standard Model of the electroweak and strong interactions was developed; and finally the period of consolidation and speculation (since 1975).

Marshak's recollection of the development of particle physics represents a personal view, worth reading by young researchers, although it does not attempt to provide a complete picture.

After the historical chapter Marshak introduces the reader to the basics of quantum field theory (space-time symmetries, global internal symmetries and their breaking, gauge symmetries). Later he turns to a description of QCD and the gauge theory of the electroweak interactions. A whole chapter is devoted to the problems related to anomalies.

In the last part of the book Marshak discusses various hypotheses of unifying the strong and electroweak interactions, especially the various facets of the SO(10) theory, followed by a long discussion of the fermion generation problem and of preon models. The book concludes with an extensive description of topological effects in gauge theories (instantons, solitons, index theorems etc.).

Marshak's book cannot be regarded as a textbook, but rather a personal account of the theory of elementary particles, given by one of its founders. The first part of the book, fairly easy to read, could also be used as an introduction to the theory of elementary particles. On the other hand the second part is rather specialized and is suitable only for experts in particle theory, searching for theory beyond the Standard Model. It could be that this part constitutes, as T.D. Lee writes in his introduction, "a legacy that will impact on the course of the future development of particle physics".

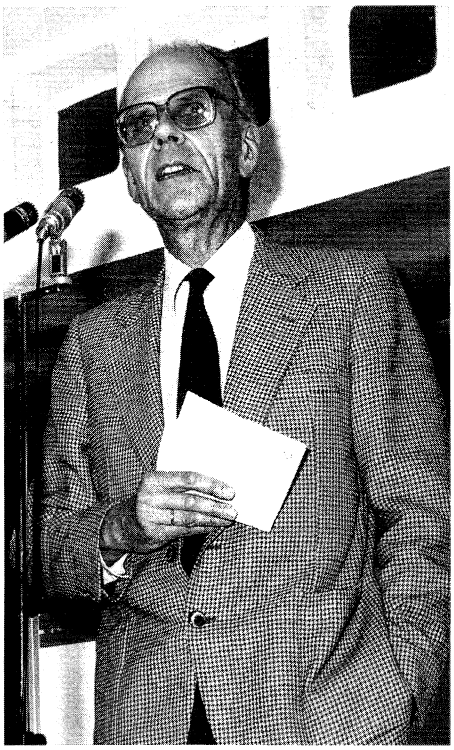
Harald Fritzsch, University of Munich

Scientific Highlights in Memory of Leon Van Hove, Edited by F. Nicodemi (World Scientific, ISBN 98 102139 99 1)

This book collects the contributions for a meeting in October 1991 in Naples under the auspices of the Istituto Italiano per gli Studi Filosofici to commemorate the life and scientific achievements of Leon Van Hove, distinguished theorist and CERN Research Director General from 1976-80, who died in 1990. The articles span Van Hove's scientific contributions and his involvement in European scientific policy and education.

His early scientific work, with contributions to mathematics, statistical mechanics and neutron physics, is covered by A. Messiah and L. Michel, with an appraisal by A. Martin. Among Van Hove's best known research papers is his analysis of neutron scattering data to explore the structure of dense systems and magnetic materials in terms of pair correlation functions. This and its later applications are reviewed by A. Messiah, who also collects some interesting memorabilia from the years they spent together at Princeton, where Van Hove also had a fruitful collaboration with G. Placzek.

Leon Van Hove - scientific highlights



L. Michel undertakes the task of explaining in its full generality the predictions of Van Hove singularities in the phonon dispersion relation for periodic systems. The functional relation between the frequency and wave vector characterizing elastic waves in crystals plays a central role in the explanation of their thermodynamic, acoustic and optical properties. The existence of these singularities was a consequence of applying a beautiful mathematical theory of M. Morse to physics. Van Hove derived his results by showing that they were inevitable consequences of the global topology of the first Brillouin zone of the periodic lattice. This pioneer work used powerful global analysis techniques to unravel concrete physical properties.

For this impressive body of achievement, together with his study of low dimensional phase transitions and non-equilibrium statistical mechanics, he was awarded the prestigious Danny Heinemann Prize of the American Physical Society.

Although during his years in the US he had already worked on high energy physics themes, on his arrival at CERN he became more concerned with these problems (as A. Martin reminds us): Coulomb effects in pion-nucleon scattering, generalized Pomeranchuk theorems, high energy consequences of the quark model, etc.

In later years he became interested in multiparticle production, multiplicity distributions in hadronic final states, the quark-gluon plasma and the deconfining transition, the negative binomial distribution, simplified parton shower models, etc. These topics, his contributions and consequences are reviewed by A. Giovannini. These subjects were dear to Van Hove, providing in his own words "a meeting ground between particle and statistical physics, a dialogue between theory and experiment.".

The purely scientific contributions to this volume also include articles on hierarchical structures (E.R. Caianello), magnetic translation groups (S. Fubini), the fundamental symmetries of string theory (G. Veneziano), and electron holography (by Van Hove's son Michel).

The remaining articles describe Van Hove's impressive contributions to scientific policy. As Research Director General of CERN he played an important, active, and inspiring role in shaping the future of the Laboratory. His interest and contributions to the SPS and LEP programmes are reflected in articles by E. Picasso (LEP: A Big European Project) and F. Bonaudi (The Antiproton Saga at CERN: 1976-1984). These projects, which helped

lead Europe back to world high energy physics supremacy, are among the finest examples of the impact of international cooperation in basic science. The fascinating story of the conception, construction and achievements of these projects are skilfully (and delightfully) told.

We also learn of Van Hove's activities in the European Space Agency (R. Bonnet), the Max Planck Institute (where he was director after Heisenberg retired in 1971), the European Joint Research Centre (J.P. Contzen) and the European Science Foundation (J. Goormaghtigh). These articles portray a man deeply committed to the advancement and teaching of science. He was aware very early of the social accountability of scientists in modern times, and he played an active role in making sure that political decisions regarding the funding of science should be in harmony with the critical judgement of leading scientists. Consensus in the scientific community is a crucial ingredient towards the successful completion of a big project.

Throughout the book we glimpse the strong personality of this remarkable European, with his deep and eclectic knowledge of physics, his social awareness, his high standards as a scientist and as a human being, and his unfailing commitment to fostering science and international relations.

The book ends with the moving words of his wife Jenny, and the complete transcript of an interview with V. de Alfaro in 1989 on the fascinating discussions Van Hove had with Einstein at Princeton. To find out what Einstein told the young Van Hove, read the book.

Luis Alvarez-Gaume, CERN

International collaboration

In the remarshalling of particle physics effort and resources in the aftermath of the decision last October to cancel the US Superconducting Supercollider (SSC), CERN's LHC project for a proton-proton collider in the 27-kilometre LEP tunnel continues to provide an international focus.

In the US, the 'Future Vision' subpanel chaired by Sid Drell has had several meetings and continues to receive input. So far, collaboration with CERN in work towards the LHC accelerator and its detectors is seen as providing a window of opportunity for US scientists while capitalizing on the valuable progress made for the SSC. At the same time, adequate funding should be assured so that all current US projects in the pipeline get completed.

On the other side of the world, a major meeting between Indian and CERN scientists took place in Bombay from 7-9 March to discuss in detail Indian participation in LHC. CERN was represented by Research Director Walter Hoogland and Particle Physics Experiments (PPE) Division Leader Jim Allaby, together with several senior scientists from the CMS and ALICE experiment collaborations and from the LHC machine group.

On the Indian side, participants included R. Chidambarm, Chairman of the Atomic Energy Commission, V. Singh, Director of Bombay's Tata Institute of Fundamental Research, A.N. Prasad, Director of the Bhabha Atomic Research Centre, Bombay, D.D. Bhawalkar, Director of the Centre for Advanced Technology, Indore, V.S. Ramamurthy, Director of the Institute of Physics, Bhubaneshwar, and Bikash Sinha, Director of the Variable Energy Cyclotron Centre, Calcutta. In all, there were nearly 60 Indian participants.

Several talks covered CERN activities, the physics expected from the CMS and ALICE detectors, various programmes in the framework of the Detector Research and development Committee (DRDC), and the status of the LHC machine. High energy accelerator-based activities in India in electron-positron, proton-antiproton and heavy-ion interactions were summarized by Indian scientists, as were developments in accelerator technology at the Centre for Advanced Technology and the Bhabha Atomic Research Centre.

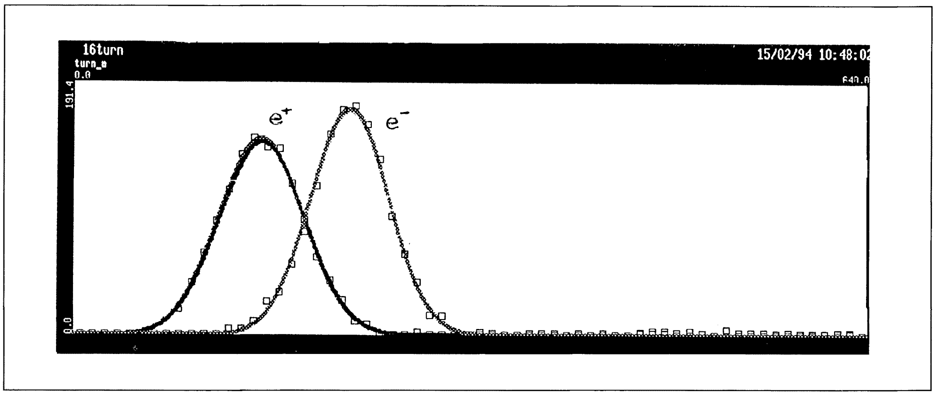
The discussions revealed great enthusiasm and interest of the Indian high energy physics community in contributing significantly to all facets of CERN's LHC programme.

A cooperation agreement between CERN and India's Department of Atomic Energy (DAE), encompassing scientific and technical cooperation in CERN research projects was signed in 1991. The aim of the recent meeting was to extend this cooperation to include Indian participation in LHC and the necessary protocol is being prepared.

CERN
LEP from one year to the next

In the cold light of January and the traditional winter machine shutdown, CERN's LEP electron-positron collider team traditionally reviews the achievements of the previous year and looks forward to the year to come. This year the LEP Performance Workshop covered four major themes each lasting one full working day, followed by a half-day summary.

The main themes were - general performance improvements; performance at injection energy; performance at the standard operating energy around the Z resonance; and with the LEP2 scheme advancing to double the beam energy and allow production of W particle pairs, performance at this higher energy.



Prototype hard X-ray solid state detectors measure bunch sizes of LEP's electron and positron beams.

General performance improvements

Steering a beam round a 27-kilometre ring paradoxically requires pinpoint precision. Continuing painstaking work reveals fresh sources of error which have to be compensated if machine performance is to continue to improve.

At the previous year's workshop, a proposal had been launched to calibrate the offset in the beam pickups with respect to the centres of the quadrupoles. Results obtained during 1993 demonstrated the feasibility and accuracy of this technique and even indicated some large offsets at critical regions - a mighty 1.6 mm at the superconducting quadrupoles around point 2. New couplers are being installed to steer beams smack through the centres of the critical quadrupoles.

A new alignment technique developed during the year, combined with the offset calibration described above, will also pay dividends.

Survey work has revealed its sorry tale of self-misalignment due to forces in the machine. Although almost microscopic, errors of geological, thermal and climatic origin have to be carefully removed. This year's vertical realignment requires moving 120 quadrupoles.

During the discussions a proposal emerged for "controlled misalignment" - running with the wind so that during physics the alignment actually improves, based on an idea proposed a few years ago by Rainer Pitthan of Stanford (SLAC) while working on LEP.

Particularly tricky this year is having to take account of the continuing modifications for higher energy running, which will require careful recommissioning work even for low energies.

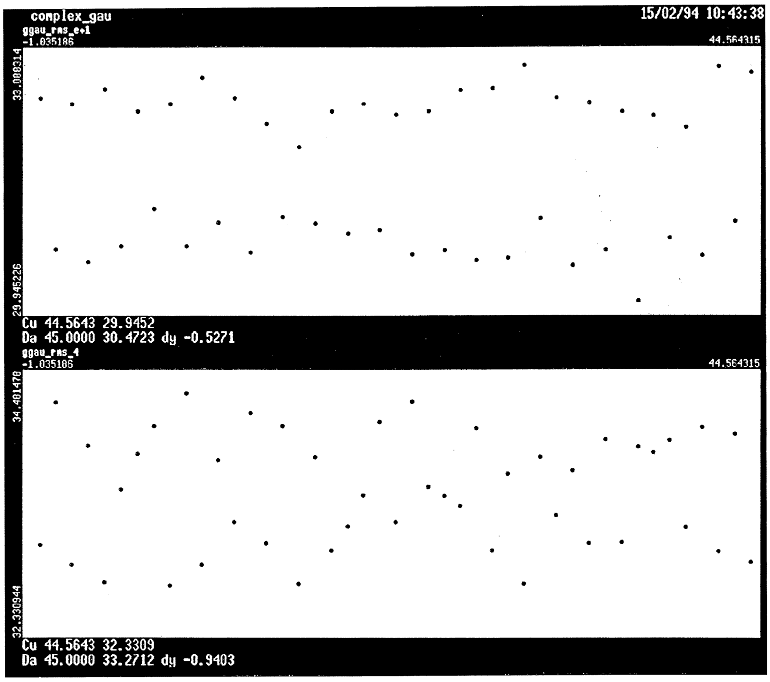
Development work leans heavily on simulation. The magnetic model of LEP is now sufficiently accurate up to sextupole fields, however the knowledge of higher multipoles is not as good and this limits the predictability of nonlinear effects. Fortunately these fields have been shown to have little effect.

The model for computing the dynamic aperture - the simulation region in which beam behaviour is stable - has been significantly improved. Although the results have confirmed previous results with the simpler model, a possible loss mechanism has emerged. There was a strong recommendation that this work should continue as priority and if possible in collaboration with other laboratories.

There was general agreement that an additional 9th bunch for beam monitoring during physics runs would open up new possibilities, allowing important measurements to be made during physics coasts. Machine studies in 1993 showed that the scheme works. However the "9th" bunch should in fact occur ahead of the 8th so that injection is possible. The implications of this 9th bunch on the detector triggers have yet to be discussed.

New beam instrumentation planned for this year should provide accurate measurements of the relative displacements of the electron and positron bunches at the interaction point and thereby greatly facilitate luminosity optimization. Other innovations include more accurate and reliable measurements of tune values, and new beam loss detectors to detect small particle losses from the tails of the distribution. It will also be possible to automatically approach the beam with the collimators until some small amount of beam loss is detected. This automatic "find beam" facility will allow faster and more accurate collimator positioning.

The very useful streak camera, previously requiring specialist operation, is now available for general use. This device allows on-line measurement of beam motion and size in all directions. Synchrotron radiation and



X-ray picture of antisymmetric quadrupole oscillations of two counter rotating LEP bunches due to their beam-beam effect.

beam monitoring techniques are continually being improved.

The possibility of many orbit measurements during the ramp and subsequent "squeeze" (beam compression) would allow the closed orbit to be corrected on a run-to-run, feed-forward basis. During stable physics runs it is now possible to automatically correct the orbit back to a "golden" value.

Injection

At injection from the SPS, the fundamental limitation to the LEP bunch current is due to the transverse mode coupling instability. During 1994 it will be possible, at least during machine studies, to increase the extraction energy from the SPS from 20 GeV to about 22 GeV. Detailed work continues on how to overcome this inherent problem, including the use of wiggler magnets to modify the bunch length.

Around the Z

At the standard LEP operation energy around the Z resonance, accurate energy measurements are of prime concern. Most of the time the precision of these measurements is not yet limited by statistics. Halving these errors (currently about 3 MeV in 100 GeV) would have immediate physics benefits, while the extension of LEP physics into the B particle sector would bring new demands.

Doubling the number of bunches with the pretzel scheme has yielded a 50% increase in average luminosity. Optimization is difficult in that there are around 40 variables and only few observables - empirical "golden orbits" produce the highest luminosities. 1993 pretzel experience revealed a list of effects, not all of which are yet understood.

LEP, unlike other colliders, showed significant particle population in the horizontal tails of the circulating bunches. This is being studied in a small collaboration between CERN and SLAC which will also compare the results with measurements made under identical conditions.

Boosting the luminosity (collision rate) is a continual warcry at LEP.

In this quest a fundamental obstacle is the maximum bunch current which can be collided - one of the beam dimensions becomes too big for the available aperture. This "beam-beam limit" typically occurs at bunch currents of around 0.35 mA with pretzel and 0.50 mA without - significantly less than can be accumulated at injection.

With all possible luminosity cards having been played, the only hope for a significant further increase is by substantially increasing the number of bunches. Schemes of 18 and 36 bunches with pretzel have been looked at, but some of these have fundamental problems.

The most recent idea to be studied is bunch trains with zero crossing angle. In this scheme the bunches at the centre of the experiments collide head-on while the bunches which interact in the straight sections around the interaction points are vertically separated so as to reduce the beam-beam effect. This scheme remains the most likely candidate to allow a significant luminosity increase both for Z and for W pair running and will be given maximum priority for machine studies in 1994.

Polarization and energy calibration

A prerequisite for energy scanning in 1993 was a significant level of polarization under machine conditions close to physics. This was accomplished early in the year and the energy scan began just after the technical stop in June. The beam energy was regularly calibrated by resonant depolarization and the energy of the electrons and positrons compared. During the year a record polarization level of 57% was measured.

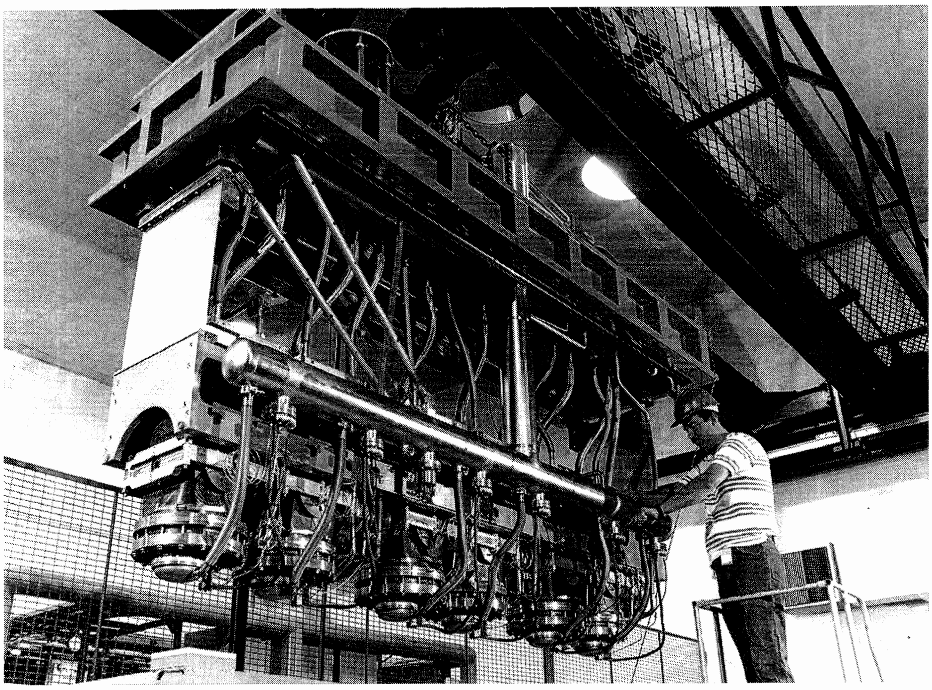
Detailed analysis showed that the beam energy was drifting at some 1.5 MeV/hour due to tidal effects and about 1 MeV/hour for other unknown reasons. There were also large (about 20 MeV) unexplained "jumps" in the beam energy which are being investigated. To help resolve this problem, a proposal was made to attempt to operate LEP with the polarization tunes and with the solenoid compensation during physics data taking, allowing continuous measurement of the beam energy. In any case the energy calibrations must continue at the rate

of at least one calibration every few weeks.

W pair energy

Operating LEP at energies approaching 100 GeV per beam (instead of 45) is a new game. For the experiments, data will accumulate much more slowly - 16 W pairs in the same luminosity 'bite' which gives 30,000 Zs. However with new W channels opening up above the minimum threshold, high energy dominates over luminosity for the initial physics scan.

Accurate energy calibration is a continual requirement, but with the resonant depolarization scheme usually used at the Z level suffering at higher energies, other schemes have to be found. Studies of luminosity optimization continue in parallel with the push to install the superconducting accelerating cavities to boost the LEP beam energies.



One of three accelerating sections of Argonne's superconducting injector linac being lowered into its cryostat.

ARGONNE Uranium-beam upgrade of ATLAS

The superconducting heavy ion linac ATLAS at Argonne National Laboratory is now operating routinely for ions over the full range of the periodic table.

In its original form, which went into operation in 1978, ATLAS was a superconducting linac using a small (8.5 MV) tandem electrostatic accelerator as injector. Because of the limitations of the tandem, the ion species that could be accelerated above the Coulomb barrier around 5 MeV per nucleon were restricted to the nuclear mass range below about 100, whereas by the mid-1980s it was clear that some of the most interesting physics required the heaviest projectiles. This need has now been filled by replacing the tandem with a Positive Ion Injector (PII) - an electron cyclotron resonance ion source on a 300kV platform coupled to a 12MV superconducting drift-tube-type linac, a concept first described at the 1984 Linac Conference at Seeheim, Germany. This system was the first use of an ECR source at high voltage and the first application of superconducting resonators for the acceleration of very low velocity ions.

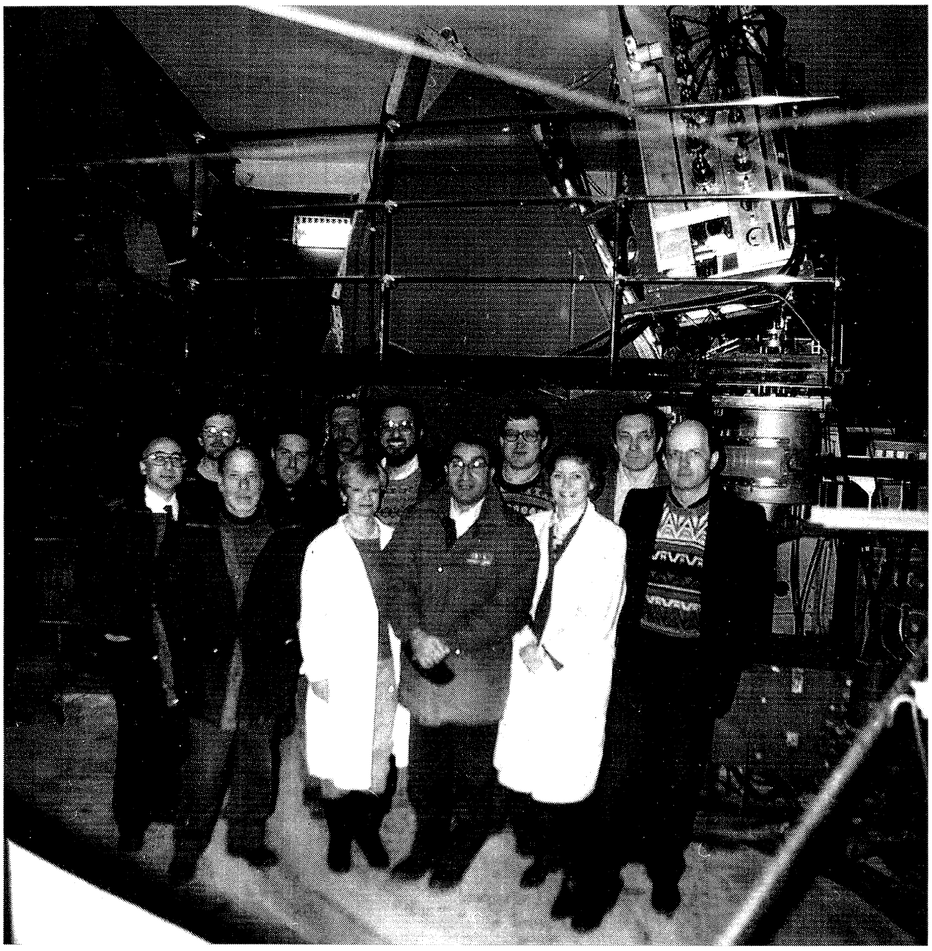
The injector linac is formed by an array of 18 superconducting niobium four-gap structures, independently phased. Four different types (sizes) of structures are needed to accelerate the heaviest particles (charge/mass ratio around 0.1) from velocities (β) around 0.008 to greater than 0.043 those of light. These structures, of which three classes operate at a frequency of 48.5 MHz, make use of a technology developed by Ken Shepard for the main part of the ATLAS linac, including housings of a composite material of niobium explosively bonded to copper.

The main technical challenges for PII were:

- to bunch the very slow ions from the source into pulses less than 0.3ns wide at the first accelerating structure;
- to accelerate them without unduly degrading beam quality;
- to avoid beam loss through defocusing through radiofrequency acceleration at low velocity; and
- to achieve phase control of the resonators.

All of these problems were solvable. About 60% of the initial beam is bunched into 12.125MHz pulses 0.3 ns wide by a two-stage system consisting of a 4-harmonic buncher on the voltage platform (β= 0.0015) followed by a 24.25MHz buncher at the entrance to the linac (β=0.008).

The Russian-Italian collaboration of Moscow's Institute for Nuclear Research and INFN, Catania near the CLAMSUD pion spectrometer and the proton linear accelerator beamline at the Moscow Meson Factory. Left to right: F.Riggi, A.Zhuravlev, D.Nicotra, R.Barbera, Yu.Gavrilov, M.Golubeva, G.Pappalardo, A.Palmeri, F.Guber, T.Karavicheva, A.Kurepin, V.Tiflov.



The effects of transverse defocusing are controlled in the difficult low-velocity end of the linac by a superconducting solenoid after each accelerating structure, by alternating-phase focusing in the first structure, and by velocity focusing caused by the extremely rapid increase in velocity in the first few structures. The result is 100% beam transmission.

Similarly, the compact geometry leads naturally to the preservation of longitudinal beam quality if the linac is properly tuned; indeed, the longitudinal emittance for the beam from PII is only about 20π KeV-ns even for the heaviest ions, a new standard of excellence. In short, all of the design goals for the PII have been achieved with almost no changes in the original design.

The new injector has had an immediate impact on the ATLAS experimental programme. Whereas previously the most-used projectiles were species such as sulphur 36 and nickel 58, now ions from throughout the periodic table are routinely accelerated.

Perhaps the most notable example is a major experiment aimed at understanding the mysterious peaks found in the energy spectra of positron-electron pairs produced when two very heavy nuclei interact at energies near the Coulomb barrier, as reported some years ago by groups working at the Unilac at GSI, Darmstadt.

The positron-electron experiment (APEX) at ATLAS, just now fully operational, is an Argonne/Chicago/Florida State/Michigan State/Princeton/Queen's/Rochester/Yale/Washington collaboration.

The newly completed APEX detector measures with high efficiency both the energies and the emission angles of coincident positron-electron pairs, and a large-solid-angle heavy particle detector measures the characteristics of coincident nuclear-reaction products.

The uranium beams available on target are 5 particle nA for projectiles with energies below 6.5 MeV/A, the energy range thought to be of interest. Because of the high efficiency of the detector, the large beam current, and the continuous wave character of the beam, the APEX counting rate is at least ten times that of previous experiments. Hopefully this improved performance will allow the mystery of these positron-electron events to be unraveled.

TROITSK
Moscow Meson Factory's linear accelerator in action

1993 was the first operational year of the full length linear accelerator of the Moscow Meson Factory (MMF). The proton beam energy was increased from 247 to 423 MeV, limited by the number of klystrons on hand. The design goal is 600 MeV and 500 microamps.

With the beam loss monitoring system under computer control,

particle losses in the main (disk and washer) part of the linac have been minimized to three parts in ten thousand at the pulse current of 17 mA, and the average beam intensity increased in turn up to 50 microamps.

With many improvements in radiofrequency power supply, beam diagnostics, and automatic control systems, together with a new beam tuning method, the MMF linac in 1993 provided 3190 hours of stable operation, despite budgetary difficulties. 40% of this time was devoted to experimental physics at beam energies between 250 and 420 MeV, and another 40% was spent on isotope production at 160 MeV. The rest was used for accelerator physics and beam quality improvements. With the main experimental hall for the storage ring and secondary beams not complete, a small experimental area was constructed at the exit of the accelerator tunnel .

Two dipole magnets and three quadrupoles deflect and focus the primary proton beam to the experimental installations. Three additional quadrupole doublets at the end of accelerator match the beam from the accelerator with the proton channel. The beam is focused on the target to a spot about 3 mm across. Special beam diagnostics include three profile detectors, a magnetoinduction detector and a Faraday cup.

The first experiment ready for data-taking measures the energy dependence of pion production on nuclear targets. Its main purpose is to solve the long-standing puzzle of a narrow resonance structure in proton-induced pion production on medium nuclei near 350 MeV proton energy. A narrow (only 7 MeV width) resonance was observed with low energy pions by an INR-JINR collaboration in Dubna and at Saclay, but has not been confirmed in recent work at TRIUMF.

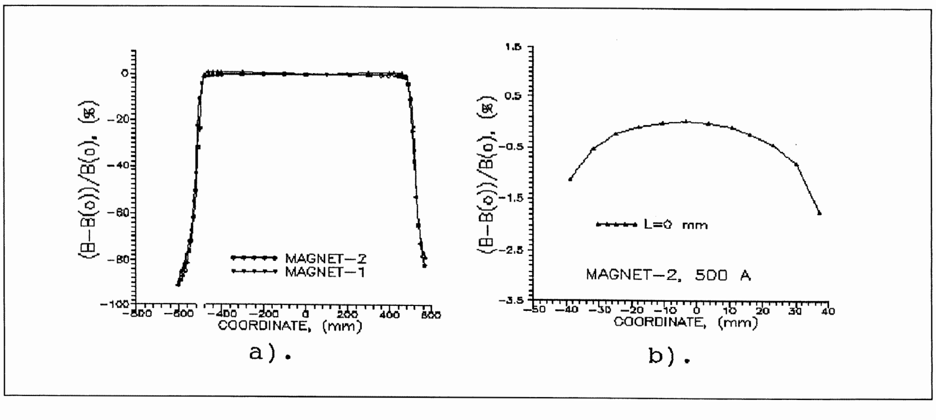
For the measurements of pion spectra, two detector systems are installed. The first is the CLAMSUD pion spectrometer developed by INFN, Catania, Italy. Covering a large solid angle (30 msr), with high momentum acceptance (±20%) and good momentum resolution (0.2%), it has a very short mean trajectory of only 1.66 m. Several planes of drift chambers and scintillators are used in a focal plane. Improved particle identification is supplied by four time-of-flight detectors. The pion spectra at several momenta will be measured in 1-2 MeV proton energy intervals for several nuclear targets near 350 MeV, taking advantage of the smooth energy variation provided by phase adjustment of the accelerator.

The second detector system is the range telescope with 12 semiconductor detectors developed by Moscow's Engineering Physical Institute, followed by 14 scintillators. This system is able to measure pion energies up to a few MeV. It can also measure nuclear fragmentation by protons, and the first helium 3 and helium 4 spectra were obtained during the latest run. This year more than 1000 hours are scheduled for physics measurements.

A new powerful radioisotope production facility began operating at the intense MMF 160 MeV beam . The shielding water cooling system and control system are adjusted for target bombardment with a beam current of more than 100 microamps. INR, in collaboration with TRIUMF, has developed a new method of strontium 82 production using thick rubidium targets. This radionuclide is used for Positron Emission Tomography in medical diagnostics. Germanium 68, cadmium 109 and sodium 22 were also supplied for medical and technical applications.

ITEP MOSCOW Spectrometer for export

In the framework of an official collaboration between Moscow's Institute for Theoretical and Experimental Physics (ITEP) and the German GSI heavy ion Laboratory, Darmstadt, a high energy heavy ion spectrometer



Longitudinal (a) and transverse (b) magnetic field distributions in the ITEP Moscow spectrometer magnet recently supplied to the GSI heavy ion Laboratory, Darmstadt.

IMPERIAL COLLEGE
University of London

Research Associate Positions in High Energy Physics

The High Energy Physics Group at the Blackett Laboratory, Imperial College, London has vacancies for two Research Associate Positions.

The group has programmes with the ALEPH experiment at LEP, the ZEUS experiment at HERA and with preparations for the CMS experiment at the LHC. Involvement with the B-factory at SLAC is also probable. The group has a strong tradition for both analysis and detector development, particularly the development of silicon-based micro detectors and their associated electronics.

ALEPH activities concentrate on the heavy flavour area, preparations for LEP2 and the construction of a new silicon vertex detector. Within ZEUS structure function analyses and heavy quark processes are emphasised. The Imperial group is a leading one in CMS; activities include the tracking area with particular emphasis on signal processing and read out, R & D into techniques for electromagnetic calorimetry and investigation of the requirements for good CP violation physics in the B sector.

The positions are for an initial period of two years. The starting date will be by negotiation between 1 July 1994 and 1 January 1995.

Salary, according to age, in the range £15,735 - £20,989 including London allowance.

Applications comprising a curriculum vitae, a list of publications and the names and addresses of two referees should be sent by Monday, June 6 1994 to:

Professor P J Dornan, Blackett Laboratory, Imperial College
Prince Consort Road, London SW7 2BZ, England.

Late applications will be considered until the positions are filled.

The College is striving towards Equal Opportunities

People and things

designed and manufactured at ITEP has been delivered to GSI and is now available for joint experiments.

The spectrometer was developed for 300 MeV/nucleon argon 17+ and argon 18+ beams in experiments probing the high energy density of matter at GSI's SIS heavy ion synchrotron.

The main purpose of the spectrometer is to provide the energy loss measurements of heavy ions in gold and aluminium targets. The energy losses of the beam reflect the time evolution of the target density.

The spectrometer consists of two 12.3 Tesla.metre H-type dipole magnets and two vacuum chambers. The top and bottom chamber walls are of soft magnetic iron, giving a magnetic field density of some 15 T at 500 A in the 50 mm gap.

ITEP Moscow is looking to provide similar such equipment.

Magnet parameters

Bending angle	7.5 degree
Magnetic rigidity	12.3 Tm (vacuum gap)
Radius of curvature	8 m
Air gap	80 mm
Vacuum gap	50 mm
Pole width	170 mm
Pole length	1000 mm
Total length	1285 mm
Number of windings	144
Maximum current	535 A
Weight	3.5 T

Vacuum chambers

Vacuum pressure (tested) 10^{-6} torr	
Gap (vacuum)	50 mm
Total length	1440 mm
Weight	65 kg

On her visit to CERN in August 1982, UK Prime Minister Margaret Thatcher is seen here accompanied by then CERN Director General Herwig Schopper (right) and Alan Astbury, recently named Director of the TRIUMF Laboratory in Vancouver, succeeding Erich Vogt.
(Photo CERN 116.8.82)

TRIUMF Director

Alan Astbury, R.M. Pearce Professor of Physics at the University of Victoria, British Columbia, and Director of the Canadian Institute of Particle Physics, has been named Director of the TRIUMF Laboratory in Vancouver, succeeding Erich Vogt, who stepped down on 1 April after a 13-year term.

Alan Astbury won the Rutherford Medal of the UK Institute of Physics in 1986 for his role in the UA1 experiment at CERN, where he was Carlo Rubbia's co-spokesman from 1980-3, and in the discovery of the W and the Z bosons. A frequent visitor to CERN, Alan served as Chairman of the Proton Synchrotron Experiments Committee from 1976-8 and was a founding member of the LEP Experiments Committee from 1982-5.

Fermilab people

Tom Nash, former head of Fermilab's Computing Division, becomes the Laboratory's Associate Director for Scientific Technology and Laboratory Information.

Josh Frieman becomes head of Fermilab's Theoretical Astrophysics Group, taking over from Rocky Kolb.

Proton performance at DESY

On 10 March, the DESY III proton machine in Hamburg accelerated for the first time a well behaved nominal design current of 167 milliamps, thanks to a novel longitudinal multibunch feedback system, based on transverse kicker magnets, to

Bulgarian President Zhelyu Zhelev (left) visited CERN on 9 March, where he was greeted by Director General Christopher Llewellyn Smith. (Photo CERN HI19.3.94)

and the afternoons for contributions, both experimental and theory. The symposium is sponsored by the Royal Academy of Sciences through its Nobel Committee for Physics. Information from internet astpart@vana.physto.se.

combat beam instabilities. This imaginative solution overcomes an inherent DESY III obstacle which had long been blocking the route to improved performance.

With a damping time of only 30 milliseconds, the system suppresses awkward beam oscillations which would otherwise interfere with subsequent injection into the PETRA ring, the next stage of proton acceleration en route to proton beams in the HERA electron-proton collider.

Without the feedback system, DESY III proton current had in fact attained a higher level, 180 mA, but only about a third of the particles could be extracted for the subsequent stages of acceleration. The higher proton current should increase HERA electron-proton collision rates.

Eberhard Wieczorek

Eberhard Wieczorek, theoretical physicist in the former Institute for High Energy Physics of the East German Academy of Sciences in Zeuthen, now DESY-Zeuthen, and a Professor at the Humboldt University in Berlin, died in February at the age of 56. He worked on various problems of quantum field theory; much of his work was done in Dubna. He was one of the driving forces behind the annual Ahrenshoop Symposia which provided rare but valuable occasions for East-West German contact.

Meetings

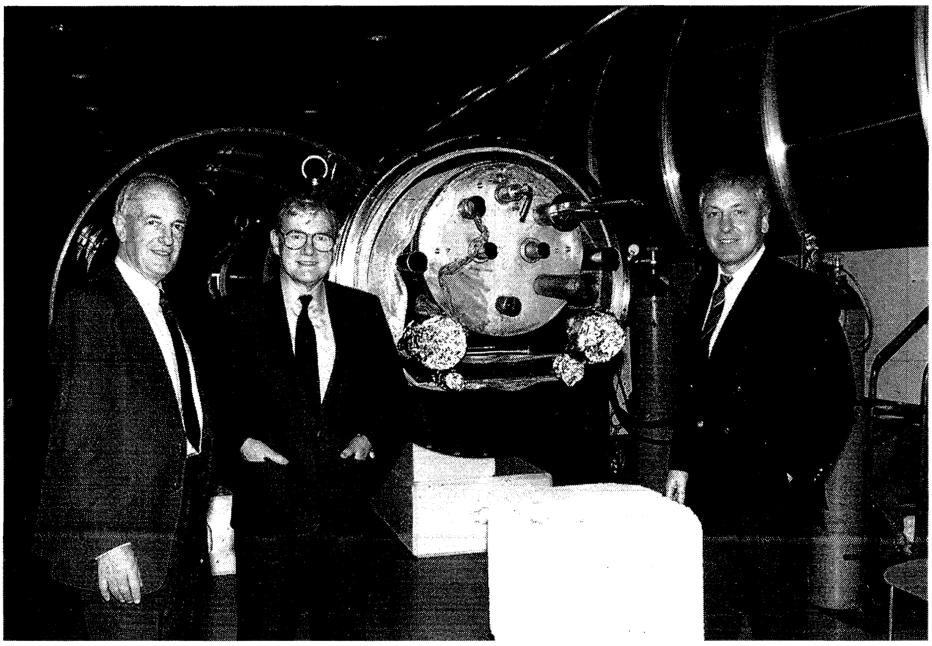
The international workshop "Quark confinement and the hadron spectrum" will be held in Como, Italy, from 20-24 June. Deadline for registration and submission of abstracts is 15 April. Further information: Dr. Nora Brambilla, Dipartimento di Fisica, Via Celoria 16, 20133 Milano, Italy; Phone: +39-2-2392-723; fax: +39-2-2392-480; e-mail: N.BRAMBILLA@MILANO.INFN.IT

A 'Trends in Astroparticle physics' symposium will be held in Stockholm from 22-25 September. Morning sessions will be for invited speakers

Correction

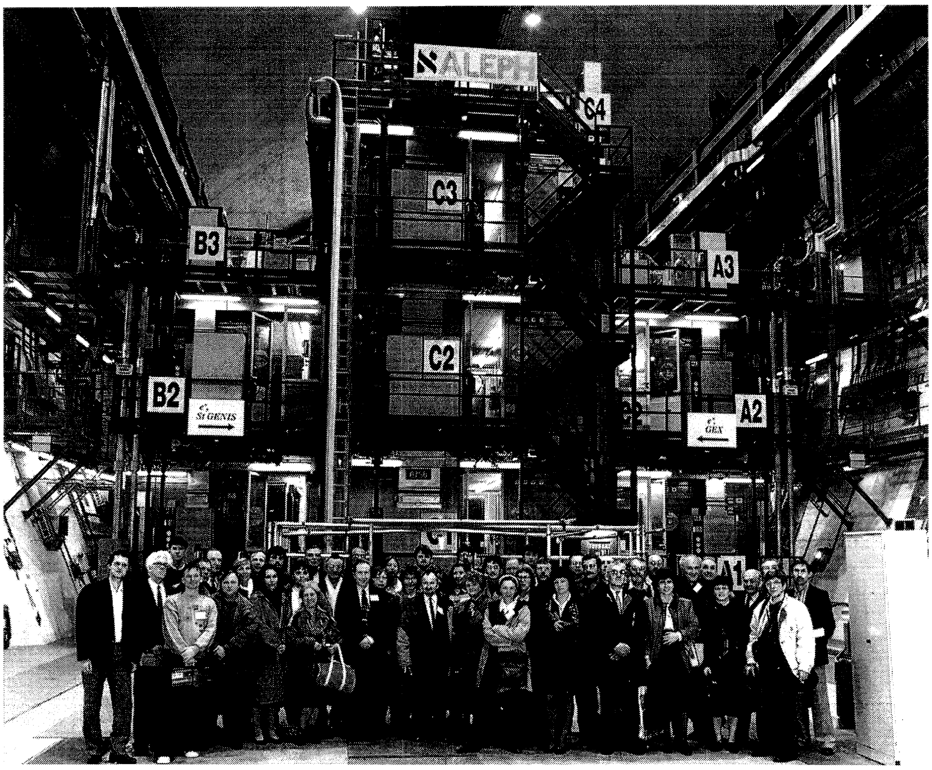
Alert readers soon spotted an unfortunate error in the picture caption on page 23 of the April issue, which in fact showed stochastic cooling pioneer Simon Van der Meer (left) with muon cooling proponent Swapan Chattopadhyay from Berkeley. The picture had been correctly captioned at CERN berore the issue went to press. Our apologies to all concerned.

Visiting CERN on 25 February, Director General for UK Research Councils Sir John Cadogan (centre) admired the large superconducting magnets being developed for CERN's LHC proton-proton collider. With him were CERN's Associate Director for Future Accelerators Lyndon Evans (right) and outgoing Chairman of the UK Nuclear Physics Board A. ('Sandy') Donnachie. (Photo CERN H38.2.94)



Top - Quarks in the Curriculum - physics teachers from Finland and Hungary got together at CERN from 26 February - 1 March. Away from the sessions, their sightseeing included a visit to the Aleph experiment at the LEP electron-positron collider. More Quarks in the Curriculum workshops are planned for teachers from other CERN Member State nations.
(Photo CERN GE8.3.94)

Below - Retiring from CERN, distinguished theorist Sergio Fubini returns to his chair at Torino. Celebrating the occasion with him (second from right) in Torino in February were CERN theory colleagues (left to right) André Martin, Tai Tsun Wu and Maurice Jacob.



External correspondents

Argonne National Laboratory, (USA)
D. Ayres

Brookhaven, National Laboratory, (USA)
P. Yamin

CEBAF Laboratory, (USA)
S. Corneliussen

Cornell University, (USA)
D. G. Cassel

DESY Laboratory, (Germany)
P. Waloschek

Fermi National Accelerator Laboratory, (USA)
J. Cooper, J. Holt

GSI Darmstadt, (Germany)
G. Siegert

INFN, (Italy)
A. Pascolini

IHEP, Beijing, (China)
Qi Nading

JINR Dubna, (Russia)
B. Starchenko

KEK National Laboratory, (Japan)
S. Iwata

Lawrence Berkeley Laboratory, (USA)
B. Feinberg

Los Alamos National Laboratory, (USA)
C. Hoffmann

Novosibirsk, Institute, (Russia)
V. Balakin

Orsay Laboratory, (France)
Anne-Marie Lutz

PSI Laboratory, (Switzerland)
R. Frosch

Rutherford Appleton Laboratory, (UK)
Jacky Hutchinson

Saclay Laboratory, (France)
Elisabeth Locci

IHEP, Serpukhov, (Russia)
Yu. Ryabov

Stanford Linear Accelerator Center, (USA)
M. Riordan

TRIUMF Laboratory, (Canada)
M. K. Craddock

UNIVERSITY OF GENEVA

The Department of Nuclear and Particle Physics has an opening for a position of

RESEARCH ASSOCIATE

to join its group involved in the L3 Experiment at LEP.

The candidate must have a PhD in experimental particle physics and should not be more than 32 years old. This is a non-permanent position limited to a maximum of 6 years, starting October 1st, 1994.

Applications should be sent to :

Prof. P. Extermann
Département de physique
nucléaireet corpusculaire
24, quai Ernest-Ansermet
CH - 1211 Genève 4

The National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU) is exploring the option of increasing the accelerator physics staff. NSCL is the home of the world's first (K500) and highest energy (K1200) superconducting cyclotrons. The laboratory is funded by the National Science Foundation to engage in heavy ion nuclear physics research. MSU is one of the largest universities in the country, with a beautiful campus community adjacent to the state capital of Michigan. Excellent benefits available.

The following areas of expertise are sought:
RF Engineer/Physicist-Expertise in the area of high power (>100kW) if as it relates to charged particle accelerators particularly in the frequency range of 10 to 500 MHz. Experience in one or more of the areas of analyses, design, and implementation of RF drive, feedback, complex high voltage cavities, and accelerating structures is required. A Ph.D. in physics or MSEE or equivalent is required.

Particle Beam Optician-Expertise in the area of magnetic optics as it relates to charged particle beam transport for accelerator systems particularly in the momentum range of 0.01 to 1 GeV/c. Experience in the design of beam transport systems utilizing such computer codes as DIMAD, TRANSPORT, or COSY is required. Experience in the hardware design and commissioning of such systems is desirable. A Ph.D. in physics or equivalent is required.

Cyclotron Physicist/Engineer-Expertise in the area of cyclotron design and operation at both the experimental and computational level is sought. Experience with large computer codes for magnetic field calculations and beam dynamics studies is required. Proven experience in the design and commissioning of cyclotron hardware is required. A Ph.D. in physics or equivalent is required.

Applicants should send resume to Ms. Chris Townsend, Laboratory Administrator, Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824-1321.

Michigan State University is an
Equal Opportunity/Affirmative Action Employer
Women and Minorities are especially encouraged to apply.

CERN COURIER

A unique advertising medium for scientific and technical equipment

CERN COURIER is the internationally recognized news magazine of high energy physics. Distributed to all the major Laboratories of the world active in this dynamic field of fundamental research, it is compulsive reading for scientists, engineers, administrators, information media and buyers. Written in simple language and published simultaneously in English and French it has become the natural communication medium for particle physicists in Europe, the USA, Russia, Japan – everywhere where the fundamental nature of matter is studied.

Published from CERN, Switzerland, it also has correspondents in the Laboratories of Argonne, Berkeley, Brookhaven, Cornell, Fermi, Los Alamos and Stanford in the USA, Darmstadt, DESY and Karlsruhe in Germany, Orsay and Seclay in France, Frascati in Italy, Rutherford in the U.K., PSI in Switzerland, Serpukhov, Dubna and Novosibirsk in Russia, KEK in Japan, TRIUMF in Canada and Beijing in China.

The annual expenditure on high energy physics in Europe is about 1800 million Swiss francs. The expenditure in the USA is about $ 1100 million. There is also considerable expenditure in Russia.

CERN COURIER is the way into all high energy physics research Laboratories. If you have a market in this field, there is no surer way to make your products known than by advertising in CERN COURIER.

All enquiries to:

Europe

Advertising Manager
Micheline Falciola
CERN COURIER
CERN
CH-1211 GENEVA 23
Tel. (022) 767 41 03
Telex 419 000 CER
Telefax (022) 782 19 06

Rest of the world

Laurie Shapiro
Advertising Manager, USA
Gordon and Breach Publishers
P.O. Box 20009
Riverfront Plaza Station
Newark, NJ 07102-0301
Tel.: 201-643-7500 (ext. 228)
Fax: 201-643-7676

Advertisements in CERN COURIER

Format A4 — **Monthly publication**

All advertisements are published in both English and French editions. Second language versions accepted without extra charge.

Space (page)	Actual size (mm) width by height	Cost per insertion (Swiss Francs)			
		1 insertion	3 insertions	5 insertions	10 insertions
1/1	185 x 265	1980	1900	1830	1730
1/2	185 x 130 90 x 265	1170	1100	1040	960
1/4	90 x 130	690	630	590	550

These prices include no entitlement to special placing.

Supplement for:
— one additional colour — 1500 SwF
— 1/2 page — 900 SwF
— Covers:
Covers 2 and 3 (one colour) — 2000 SwF
Cover 4 (one colour) — 2500 SwF
Publication date — 1st of month of cover date
Closing date for positive films and copy — 1st of month preceding cover date
The cost of making films and of translation for advertisements are charged in addition.
Screen (offset) — 60 or 54 Swiss (150 English)
Advertisements cancelled after 1st of month preceding cover date will be invoiced.
These rates are effective for the year 1994.

Inquiries for Europe:
Micheline FALCIOLA / CERN COURIER – CERN
CH-1211 Geneva 23 Switzerland
Telephone: 022/767 41 03 — **Telex 419 000 CER CH**
Telefax 022/782 19 06

Inquiries for the rest of the world: **please see page III.**