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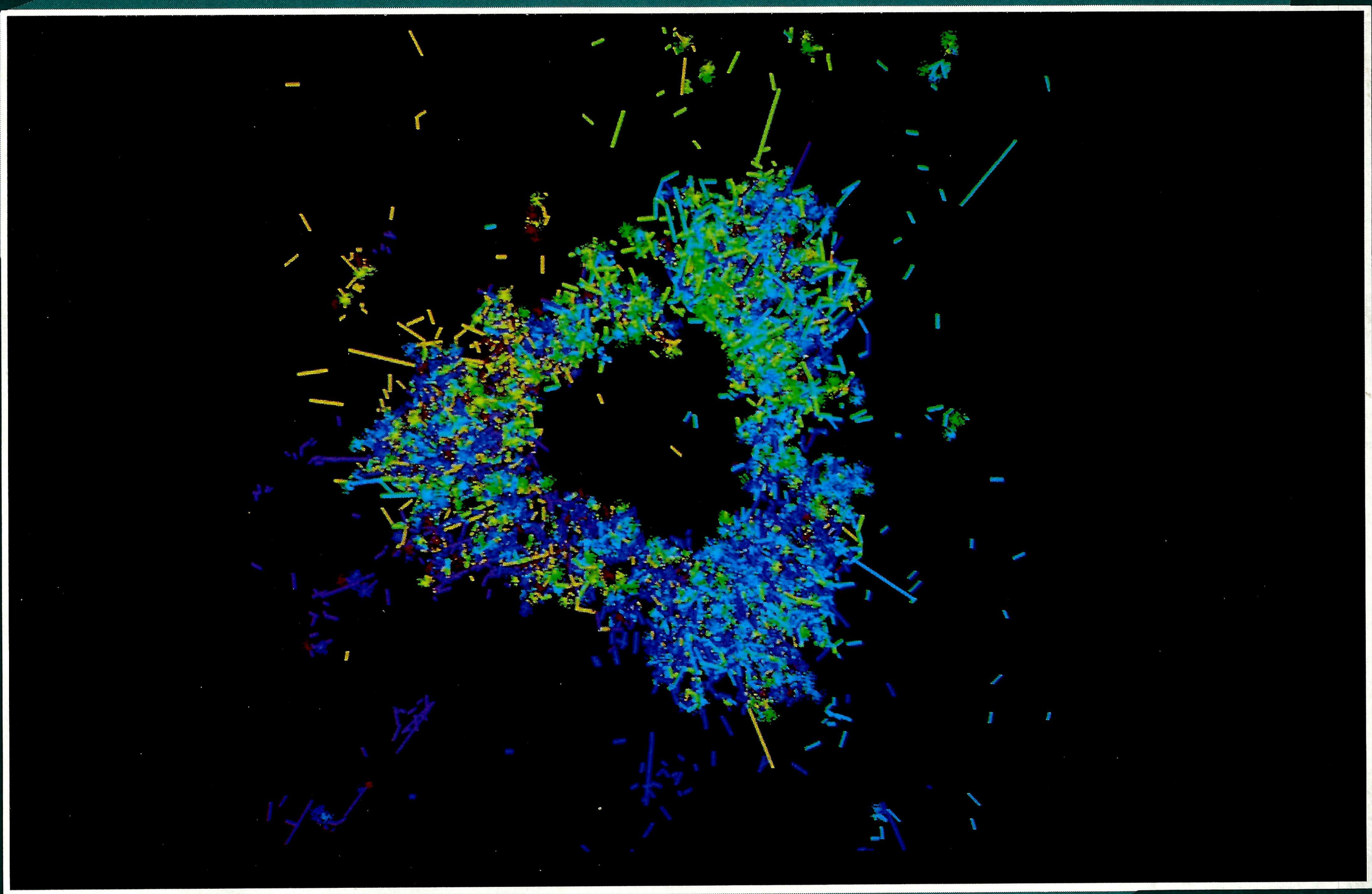

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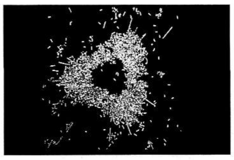
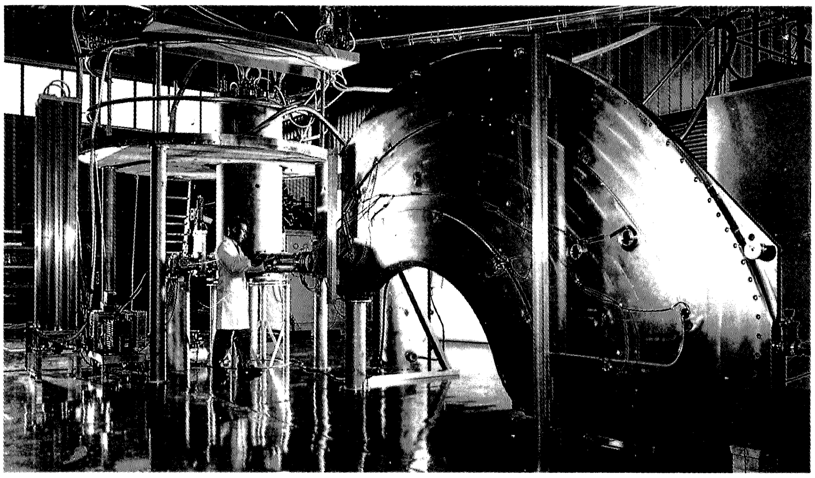
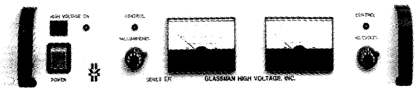


Cover photo: Making elementary particles visible - simulation of the proton's three quark structure by Eyal Cohen of ArScimed (see page 14).





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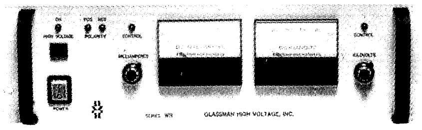

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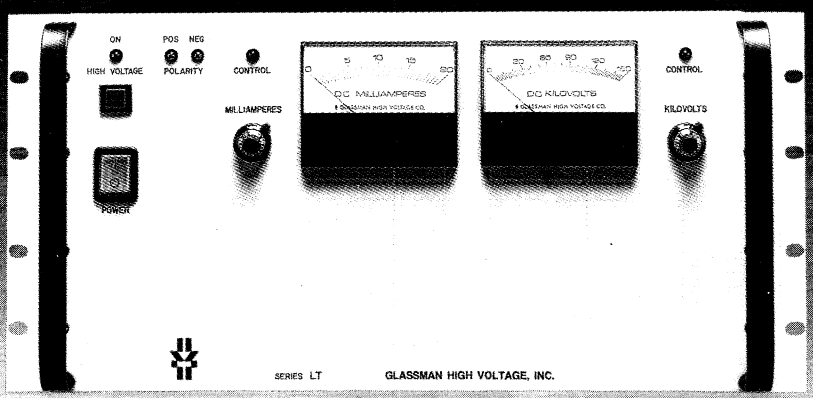

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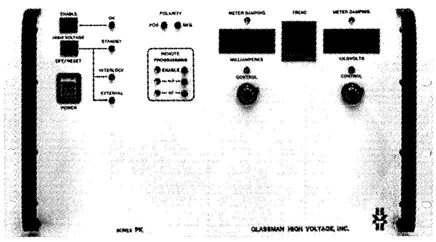

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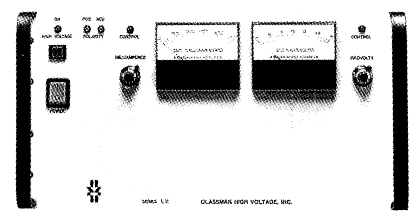

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US recommendations

Now published are the recommendations of a report commissioned in the wake of the dramatic cancellation of the US Superconducting Super-collider (SSC) project last October, when the US Secretary of Energy requested a long term programme to pursue the most important high energy physics goals, with specific recommendations for expanded international collaboration.

These recommendations could mark a turning point in the history of modern particle physics. With the demise of the SSC, CERN's LHC proton-proton collider becomes the best opportunity for attacking the highest energy frontier, and this is now acknowledged.

Chaired by Sid Drell, what came to be known as the 'Future Vision' subpanel of the High Energy Physics Advisory Panel (HEPAP) makes a series of conclusions and recommendations in the executive summary of its extensive and careful report. (The full report includes a summary of the current US scene with which regular CERN Courier readers will already be familiar.)

Conclusion 1

"We have inherited a great tradition of scientific inquiry. The field of particle physics has made dramatic progress in understanding the fundamental structure of matter. Recent discoveries and technological advances enable us to address such compelling scientific issues as the origin of mass, the underlying cause of the preponderance of matter over antimatter, and the nature of the invisible matter that accounts for up to 90 % of the mass of the universe.

Recommendation 1

As befitting a great nation with a rich and successful history of leadership in science and technology, the United States should continue to be among the leaders in the worldwide pursuit of the answers to fundamental questions of particle physics.

Conclusion 2

To sustain excellence in the US high-energy physics programme for two decades and beyond, three elements are essential :

- a flexible, diverse, and dynamic ongoing research effort to address scientifically compelling questions. This implies effective use and timely upgrades of domestic accelerators, an active programme of non-accelerator-based inquiries and strong support for university groups,
- vigorous studies to develop and master the technologies for future accelerators and detectors, and
- significant participation at the highest energy frontier, for which the best current opportunity beyond the (Fermilab) Tevatron is through international collaboration on the LHC at CERN.

Conclusion 3

A temporary and modest bump of $50M/year in the total funding for three financial years from 1996 through 1998, followed by a return to a constant-level-of-effort budget at the level of the President's proposed budget, would revitalize the ongoing research and sustain it through the construction years of the two upgrades at Fermilab and SLAC (Stanford). Within the budget profile, it would be possible to reverse the 1995 cut in the research (operations plus equipment) budget, permitting its restoration to the 1994 level in buying power for productive use of investments made to date, and to initiate significant participation in building the LHC, with the level of commitment growing slowly until financial year 1997 and reaching its full level in 1999.

Recommendation 2

The subpanel recommends that the federal government commit itself to a budget for the Department of Energy's High Energy Physics programme that provides constant-level-of-effort funding plus a $50M/year bump for three years, starting in FY1996, to implement the following:

- Productive use of existing domestic facilities and their ongoing upgrades, including support for the university-based researchers, and flexibility to pursue new ideas.
- Significant participation in the LHC accelerator and detectors, both to provide research opportunities at the energy frontier and to ensure that US physicists remain integrated in the international high-energy physics community.
- Enhanced effort in accelerator research and development, in preparation for a strong role in creating the accelerators of the next century.

Recommendation 3

Given the above three-year supplement and a commitment to support at no less than constant-level funding thereafter, the subpanel recommends that the US government declare its intention to join other nations constructing the LHC at CERN and initiate negotiations toward that goal. Participation in the LHC should be endorsed with a timely decision of support. This will enable the high-energy physics community in the United States to take full advantage of this opportunity and to maintain momentum in the collaborations that have been forming in the hope of applying to the LHC the expertise and technology developed for the SSC and its detectors.

Recommendation 4

The government should give serious consideration both to restoring earlier practices of full authorization at the start of major scientific construction projects and to introducing budget cycles of two or more years.

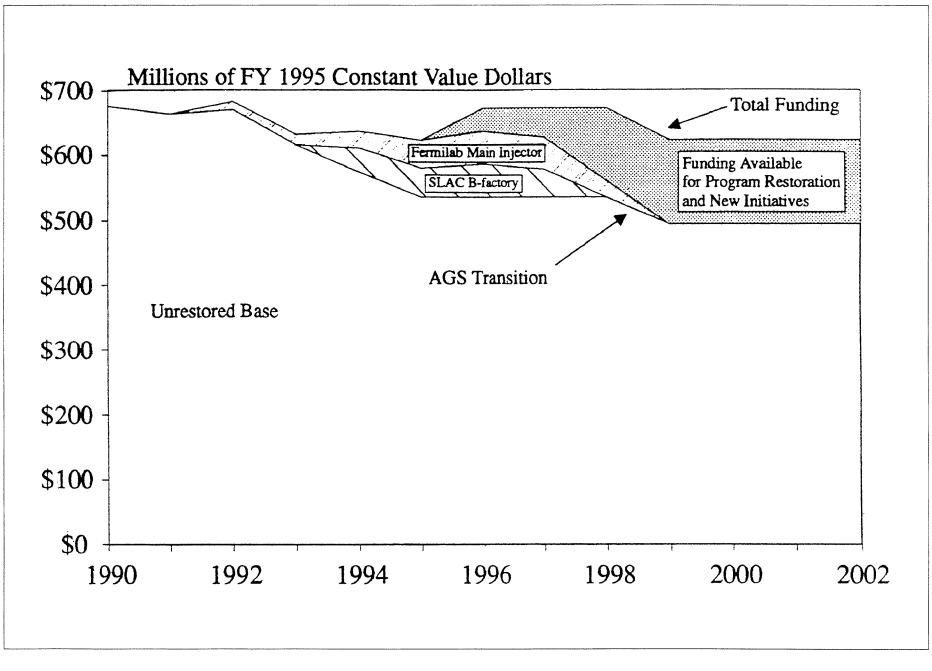
Conclusion 5

We emphasize that the main purpose of the temporary $50M budget bump is to strengthen the existing programme. Without a three-year, $50M/year supplement in 1996, the current US programme would suffer continued damage. The programme's scope and flexibility would be further diminished, and ongoing commitments would be stretched out. This conclusion is independent of US involvement in the LHC.

We do not believe that this problem should be addressed by continued proportional budget decreases at each of the laboratories and in each area of the programme. We do believe that new priorities would have to be set that would likely call for sacrificing important parts of the US programme, in order to preserve quality and productivity in what survives. The inevitable consequences will be continued loss of vitality in the current programme and further discouragement to the new generation entering the field.

As argued earlier, the commitment to initiate effective collaboration at LHC has little impact on the need of the current programme for roughly $50M, up front, to redress its needs. Also the planning assumption of a constant-level-of-effort budget for the future provides sufficient flexibility for effective LHC involvement. This budget scenario may necessitate some delays in making a sizable US contribution to the LHC, and may reduce the total commitment, but it should not close the door. We must find a way to do the most important things, the LHC is one of them."

The summary concludes with some ideas on how to exploit the existing SSC infrastructure and facilities, which could be used as a centre for US participation in CERN's LHC.



The Drell sub-panel's budget proposal for the US high energy physics programme from 1995-2002, showing funds earmarked for the ongoing Fermilab Main Injector and SLAC B-factory projects, and with a proposed $50 million 'bump' over three years for programme restoration and new initiatives, including US participation in CERN's LHC proton-proton collider.

The development of science this century

3 - from 1970 to the near future
by Victor F. Weisskopf

The changes in the character and sociology of science during the last decades

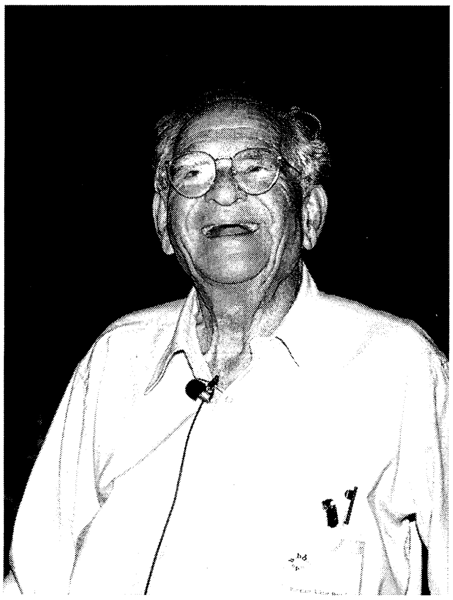
This is the final article in a series of three which together are a slightly revised version of a talk delivered at the meeting of the American Association for the Advancement of Science, in Boston, on 14 February 1993, and at a CERN Colloquium, on 5 August 1993, entitled 'Science - yesterday, today and tomorrow'. Together 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 restrictions of a single issue of the CERN Courier, the text has been repackaged as three articles, each covering an identifiable historical epoch. The first, covering the period from 1900 to World War II, was published in the May issue, page 1. The second, extending from 1946 to about 1970, appeared in the June issue, page 9.

This period covers the time from about 1970 to the present and perhaps to the near future. The amazing scientific developments of Period II continued during the third period, yielding many important results, such as the development of Quantum Chromodynamics. It introduces a new type of field between quarks that keeps them together, whose quanta are the gluons; the discovery of the so-called J/psi particle which consists of a charm quark and its antiparticle; the inclusion of the quark structure of nucleons explaining some detailed nuclear properties; experiments with heavy-ion collisions to study highly excited states of nuclear matter; the nuclear magnetic resonance with its numerous applications in medicine and material science; 'single atom' physics, where experiments with one atom could be performed; the chemistry of 'Bucky balls' that are compounds of many carbon atoms, and the investigations of atomic clusters, units that are intermediates between molecules and solids; much progress was achieved in developmental biology studying how the activities of a gene are regulated, restricted or enhanced, whatever serves the functioning or the growth of an organism.

However, the vigour of basic science diminished because of a number of circumstances. It is the main topic of this section. Serious questions arose in this period in the lay public, in congress and government agencies, and also within the scientific community. Why should presently non-applicable basic science be supported when some of it requires extraordinary high costs? This question was bound to arise at a time of dwindling financial resources. The economic downturn in the USA and Western Europe began around 1970.

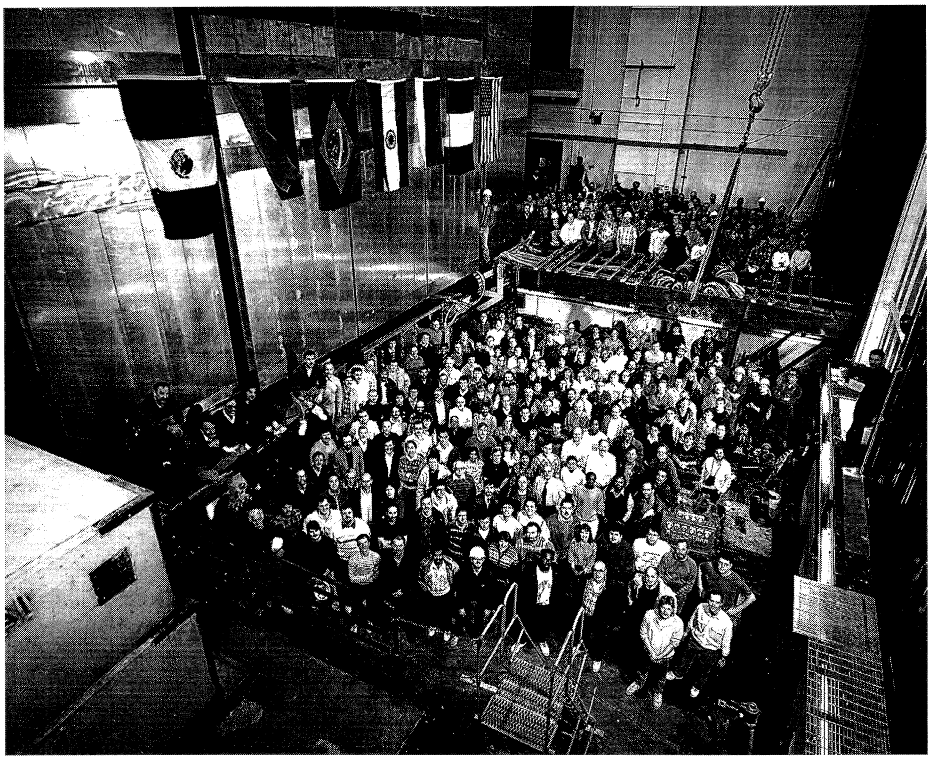
Also in the last two decades, a growing awareness arose of environmental problems such as: the possible global warming by the greenhouse effect; the reduction of the ozone layer protecting us against ultraviolet radiation; the deforestation, intended for commercial interests and for increase of arable areas, unintended by a polluted atmosphere; the deterioration of soil, water and oceans; and finally the population explosion in the developing countries. All these problems need further scientific and technical exploration. Is the greenhouse effect really going to raise the temperature and by how much? How dangerous are toxic substances? Why did the ozone layer diminish so fast? What are the reasons for the deterioration of soil and water? New ways to produce non-polluting power sources should be found, new methods of birth control should be discovered. For all this and similar problems, scientific input will be necessary.

Victor Weisskopf - the aim of competition should be the quality of work and not national pre-eminence.



This is why applied science received increased financial support from government agencies and from foundations. In addition, young scientists are more attracted than before by societal tasks; some of them are eager to contribute to improving the situation. We observe also a change of the aims of applied science; it is less directed towards innovation for business, industry and the military, but more towards re-

Some of the D0 team at Fermilab. Large-scale collaboration has become one of the features of today's major experiments.



search concerning the environment.

Evidently the environmental problems cannot be dealt with solely by natural science: physics, chemistry, and biology. There are also economic, social, political, and psychological aspects that are perhaps even more important as far as the realization of proposed measures is concerned. In the developed world, economic difficulties will arise. The developing world will refuse to fight pollution of its own industrial development by correctly blaming the industrial nations for producing by far the largest part of pollution. This is not an excuse: it also produces pollution of its own ... In fact, developed countries have a deeper sense of environmental protection than developing countries. It is essentially a matter of education.

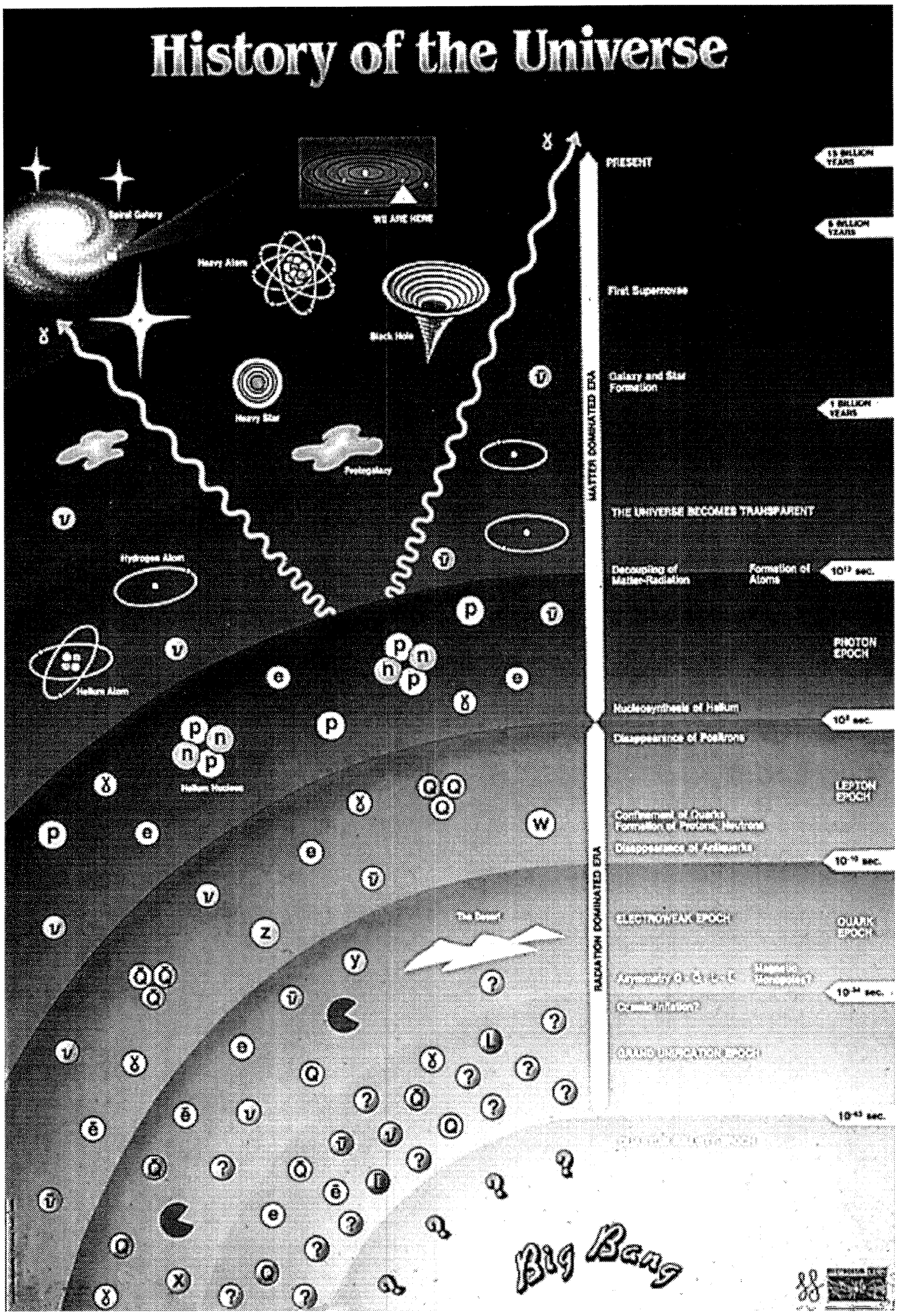
These circumstances require interdepartmental collaboration between natural scientists and social scientists of all sorts. Such collaborations already exist today at several places and, hopefully, there will be more in the future. It brings natural scientists increasingly in touch with economic and political problems, not to get more financial support but to work for the common good. All this is very desirable but there is no denying that it is detrimental to presently non-applicable basic science.

What are the reasons to keep on with basic science, even if it is presently not applicable? It is necessary today to be aware of these reasons in order to prevent an inordinate cut in political and financial support. There are cultural and intellectual values. Basic science embodies a spirit of inquiry and discovery for its own sake. It is a search for the 'why and how' in Nature. It tries to answer unsolved questions. It finds new behaviour patterns of Nature. It is necessary to cultivate that spirit because it also serves as inspiration to applied science.

Here is an instructive quote by M. Polanyi (Personal Knowledge, University of Chicago Press, Chicago, 1958, p. 182.) 'The scientific method (meaning basic science) was devised precisely for the purpose of elucidating the nature of things under more carefully controlled conditions and by more rigorous criteria than are present in situations created by practical problems. These conditions and criteria can be discovered only by taking a purely scientific interest in the matter which again exists only in the minds educated in the appreciation of scientific value. Such sensibility cannot be switched on at will for purposes alien to its inherent passion.'

Basic and applied science are interwoven; they are like a tree whose roots correspond to basic science. If the roots are cut, the tree will degenerate.

Another intellectual value is the role that basic science plays in the education of young scientists. It fosters a kind of attitude that will be most productive in whatever work the students will finally end up with. Experience has shown that training in basic science often produces the best candidates for applied work. Basic science also has ethical values. It fosters a critical spirit, a readiness to admit 'I was wrong', an antidogma attitude that considers all scientific results as tentative, open for improvements or even negation by future developments. It also engenders a closer familiarity with Nature and a deeper understanding of our position and role in the world nearby and far away. Basic science provides political values: it is (or should be) a supranational collective enterprise that brings people together



The increasing common ground between modern particle physics, cosmology and astrophysics and the resulting insights into early history of the Universe have a strong popular appeal.

across national, racial, and ideological boundaries. The aim of competition should be the quality of work and not national pre-eminence.

Unfortunately, a few cases of scientific fraud have lately received a lot of publicity. It led to doubts as to the high ethical standards of science. Actually, it is astonishing how rarely cheating or intended false claims occur in science, compared to other human activities. Any important scientific result is or will be checked by other groups working in similar fields. It is dangerous to risk one's reputation by false claims. Of course, unintended wrong results are frequently published but they are soon eliminated by further research.

The value of basic science has lost its attraction during the last decades. Since the seventies, support for basic research has strongly decreased; it can no longer be pursued as effectively as in the decades before. Typical examples from the USA: the National Science Foundation, which was founded for the support of basic science, is switching over to supporting applied research. The same shift occurred in the National Institutes of Health. Similar tendencies could be noted in Europe. The 'traditional' basic sciences, such as particle physics, basic nuclear physics, and astronomy are suffering more than biology and some new basic fields, such as research in chaos, in complexity and also in neuroscience, because the latter fields are more applicable than the traditional ones. Strangely enough, astronomy and cosmology suffer less than particle and nuclear physics; there is an innate interest of the public for these sciences because they deal with questions near to religious concerns, such as the whence and whither of the Universe. Particle physics tries to hang onto the coat tails of cosmology to get more support since its results are needed to get some insights into what happened in the first three minutes of the Universe's existence.

There are many good reasons for the support of a presently non-applicable basic science, but the question remains: how much should be spent for the support? Should it be supported on the level of the heyday between 1946 and 1970? Certainly, that degree of support produced an enormous harvest of applicable and non-applicable insights. Do we need so many results in such a short time? What is the right amount of support and what is too little? These questions are very hard to answer. It is questionable whether the lavish support given in the post-war decades needs to be maintained to obtain benefits from basic science. On the other hand, the support must not be reduced to an extent that would make certain promising fields of basic science wither away and prevent young people from entering them.

A typical case of that kind is the present status of particle physics in the USA, because of the decision to halt construction of the giant accelerator in Texas, called the Superconducting Super Collider (SSC). It was a vast project at a cost of 12 billion US dollars. Europe faces a similar situation with its somewhat more modest plan for a proton collider. When such projects are given up or considerably slowed down, particle physics is in danger of losing the critical number of people working in the field. Unfortunately, much too little effort was spent on planning an international machine to which all interested parties would contribute. Nationalism and regionalism brought particle physics into the awkward situation that Europe and the USA made independent plans to build similar giant machines. Science policy is a difficult subject when financial means are on the decline.

The scientific community must also be blamed for the growing abandonment of the spirit of basic science. There are symptoms of nationalism, as in the too often used argument that we must remain top nation in a given field. Furthermore, over-specialization has a negative influence on the spirit of science. I.I. Rabi (Science, The Center of Culture, The World Publishing Company, New York, 1971, p.92) expressed it succinctly: 'Science itself is badly in need of integration and unification. The tendency is more the other way ... Only the graduate student, poor beast of burden that he is, can be expected to know a little of each. As the number of physicists increases, each speciality becomes more self-sustaining and self-contained. Such Balkanization carries physics, and, indeed, every science further away from natural philosophy, which intellectually is the meaning and goal of science .'

Much too little effort is devoted by scientists to explaining simply and impressively the beauty, depth, and significance of basic science, not only its newest achievements, but also the great insights of the past. This should be done in books, magazine articles, television programmes, and in school education. The view should be counteracted that science is materialistic and destroys ethical value systems, such as religion. On the contrary, the ethical values of science should be emphasized. Finally, it would help to point out the positive achievements of applied science, the contribution to a higher standard of living, and the necessity of more science to solve environmental problems.

It looks as if we are facing a more pragmatic era, concentrating on applied science. Perhaps the end is nearing of the era of one hundred years full of basic discoveries and insights under the impact of the Theory of Relativity and that of Quantum Mechanics. Even so, we will always need basic research based on the urge to understand more about Nature and ourselves. Let me quote a slightly altered paragraph from my own writings (Science 176 , 138, 1972). 'All parts and all aspects of science belong together. Science cannot develop unless it is pursued for the sake of pure knowledge and insight. It will not survive unless it is used intensely and wisely for the betterment of humanity and not as an instrument of domination by one group over another. Human existence depends upon compassion and knowledge. Knowledge without compassion is inhuman; compassion without knowledge is ineffective.'

Technological spinoff from accelerators - 2

by Oscar Barbalat

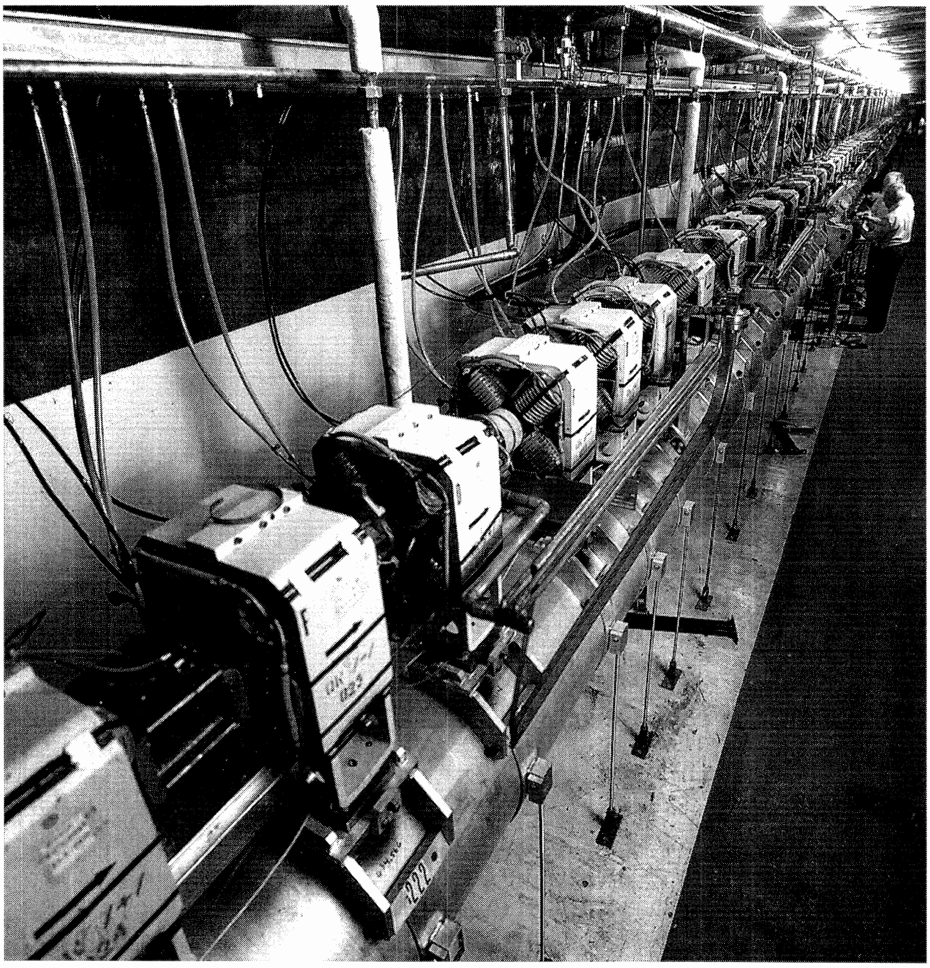
This is the second of two articles on the technological benefits arising from the central tool of particle physics - the particle accelerator. It is based on a report initially prepared at the request of a special panel set up by the International Committee for Future Accelerators (ICFA). The first article appeared in the May issue, page 6.

Radiofrequency and microwave engineering

Particles are accelerated by high frequency fields in structures, usually tuned resonant cavities or travelling wave structures which have a high quality (resonance) factor, attaining high accelerating fields to be reached with reasonable energy expenditure. A similar technology is also used to separate particles into beams of different momenta by transverse high frequency fields.

Depending on the type of machine, the frequencies involved range from a few Megahertz to several Gigahertz. While fixed frequency systems are suitable for the accelera-

The developments for higher power and duty cycle at the two-mile Stanford Linear Accelerator Center (SLAC) machine brought significant improvements in the technology of the klystron microwave generators which produce this radiofrequency power.



tion of electrons, which are already fully relativistic in the MeV energy range, variable frequency systems are necessary to handle the onset of relativistic effects in proton and ion acceleration.

In circular machines, each time the beam goes round it receives an energy boost from the radiofrequency system. For proton machines this can be done with equipment developed for radio and television broadcasting. However this is not the case for linear accelerators through which the beam passes only once, or for large electron rings in which considerable synchrotron radiation losses must be compensated.

In particular, the developments for higher power and duty cycle at the two-mile Stanford Linear Accelerator Center brought significant improvements in the technology of the klystron microwave generators which produce this radiofrequency power. While radar, where this technology was born, in general is not unduly concerned with power efficiency, this becomes a decisive factor for the operation of a large research installation using many Megawatts of mains power. This development has been extended to other applications areas, such as free electron lasers (producing light from electrons) with longer pulse lengths.

In a high energy electron ring such as LEP, the performance limit is set by synchrotron radiation losses. While superconducting radio-frequency techniques reduce inherent losses, synchrotron radiation losses, which increase as the fourth power of beam energy, must be overcome. This has stimulated the development of continuous wave high power radiofrequency generators. For LEP, a 1 MW klystron designed to operate at 353 MHz has been developed by industry with an efficiency approaching 70%.

High power klystrons are also of interest to the fusion community for plasma heating. Accelerator technology is also used for the same purpose to produce neutralized particle beams.

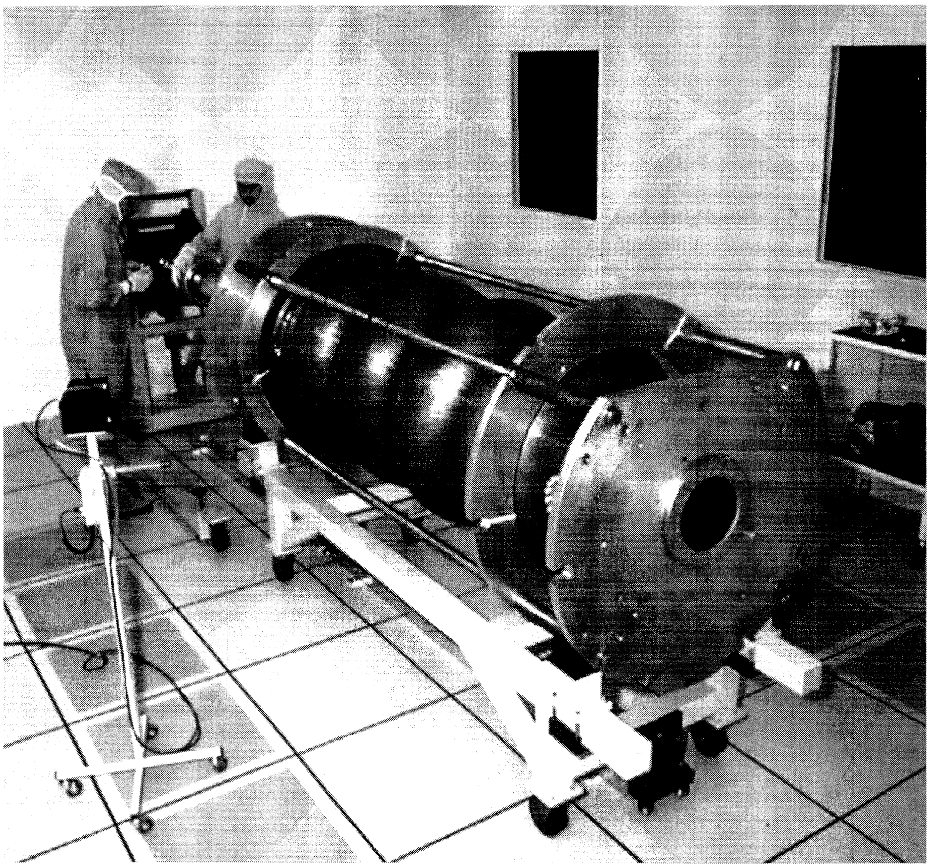
While accelerating systems normally work at a single frequency or in a narrow band, the advent of stochastic cooling, which has to handle particles moving with an extremely wide range of velocities, brought a requirement for broad band amplification and power output over the GigaHerz frequency range. Without entering into the theory, it is sufficient to say that the increase in the number of particles to be cooled requires a corresponding increase in the bandwidth of the correction signals necessary to achieve the cooling. This has led to the development of field effect transistor amplifier modules capable of delivering several kilowatts in a 1 to 3 GHz frequency band.

Mechanical engineering

The construction of particle accelerators involves many facets of mechanical engineering and has advanced the state of the art in several areas.

In colliders, the particle detectors must be placed as close as possible

Preparing a superconducting radiofrequency accelerating cavity for its sputter-coating of niobium. Special technologies like chemical polishing and hydroforming developed to build accelerator cavities have been taken over by industry for general manufacturing. (Photo CERN IT 65.08.90)



to the vacuum tube in which the beam circulates. The beam should not interfere with the vacuum and the metallic vacuum pipe ideally should not attenuate the products of the collision event. The solution was the design of thin shells which minimally interact with the collision products while preserving the vacuum.

Accelerators or some of their subsystems close to experiments require many unconventional materials such as lithium and beryllium because of their low atomic weight, ceramics and epoxy resins which are both good electrical insulators and radiation resistant, ferrites for their high frequency behaviour, plexiglass for its light-guiding properties, and many others. More common materials such as copper, aluminium or stainless steel must be shaped, machined and welded into difficult shapes while preserving high vacuum even under cryogenic conditions.

Materials have to be hyper-clean to avoid vacuum degeneration by outgassing and to ensure stability under high voltages and electric fields. Sophisticated techniques such as photoengraving, electroforming and chemical and electrochemical polishing are used for demanding requirements.

Special technologies like chemical polishing and hydroforming developed to build accelerator cavities have been taken over by industry for general manufacturing. Electron beam welding (itself an early application of electron beam technology) has been successfully refined to manufacture niobium cavities and, with local vacuum, to join the aluminium plates for the windings of one of the large LEP detector magnets.

Accelerator components often require a special coating. This thin film technology is also widely used to create a conducting or resistive metallic film on a variety of substrates resistant to high temperature and radiation ('kapton', quartz, alumina).

While remote handling is essentially a child of the nuclear industry, additional features such as pressure feeling feedback (providing a 'touch' feeling to a video picture) or spools suitable for long sections of fibre optics cable have been introduced to cope with the special problems of particle accelerators. Some of these developments have attracted interest for the maintenance of nuclear reactors or in offshore drilling rigs.

Accelerator requirements may generate applications in sometimes unexpected fields. An example is the use in shipyards of a vehicle designed for CERN for moving heavy precision magnets without deforming them. This allows shipyard components to be cut and machined in the workshop rather than in situ, with an appreciable gain in quality and cost.

Electric engineering and power electronics

Powering large accelerator magnets makes demands on heavy electrical engineering. In a synchrotron, the guiding magnetic field has to be increased in step with the energy of the particles. Once the maximum energy is reached, the magnetic field must be held constant to one part in 10^5. The power converters must be able to adjust the current while achieving a cycle-to-cycle reproducibility of 10^5 to 10^6. The pulsed magnets of large synchrotrons need power swings of hundreds of MW.

With the power for large accelerators taken from the public power grid, a novel scheme of reactive power compensation has been developed to minimize resulting voltage fluctuations on the grid.

With increasing power requirements for accelerators, power conversion efficiency has become essential. Converters must operate in two different modes - acceleration, during which all the converters must be synchronously ramped and operate to within an error of 10^{-4}; and the subsequent steady state of physics data-taking, which demands a precision of 10^{-5}.

While high performance power units are based on conventional thyristor line-commutated power supply modules, for the numerous intermediate and low power units (from 40 kW downwards), the more efficient switched-mode scheme can be used. Modular units with switching currents of 2000 A at 40 kHz have been constructed, opening up a new power range.

Particle accelerators require not only accurate and stable d.c. or ramped power converters, but also intense and fast pulses which must be triggered with high precision and very low jitter to ensure beam transfer timing with nanosecond accuracy.

This has led to the development of pulse generators and improved industrial thyratron switches and spark gaps. The quest for improved high power and high speed switches has also stimulated the study of plasma processes such as the pseudo spark, which may have promising applications in high power devices and as a new particle beam source.

Direct current transformers developed to measure the intensity of accelerator beams are now produced by industry for high accuracy current monitoring.

Controls engineering

Because of their size and their myriad of delicate subsystems and components (magnets, power converters, microwave tubes, vacuum pumps, valves, ...), large particle accelerators have stimulated the development of real time distributed computing systems. This acquired expertise is also used in other large facilities such as fusion research devices.

In this field, the numerous software developments include Remote Procedure Calls - a procedure with its parameters, instead of being executed in the initiating computer, is transmitted and executed in a different machine. This application was driven by the need for a control room operator to access equipment controlled by a separate specialized computer located several kilometres away, and is applicable to a wide variety of distributed computer problems such as distributed databases or mail systems.

Another application is in artificial intelligence. Work in collaboration with CERN on distributed expert systems finds applications in the power industry for power line monitoring and fault diagnosis.

The stringent requirements of accelerators also provide a unique testbed for software producers to subject their products to extreme conditions.

On the hardware side, the man-machine interface in complex control rooms has vastly improved. Control rooms were traditionally filled with rows of racks, each directly wired to the monitoring and control of a discrete subsystem. This arrangement has been replaced by computer-

The LEP control room at CERN. Because of their size and their myriad of delicate subsystems and components large particle accelerators have stimulated the development of real time distributed computing systems.
(Photo CERN CO 24.5.91/19)

driven operator consoles accessing any part of the process.

An associated development was the touch panel, a CRT screen where the equivalent of a classical push-button control panel is displayed as identified squares, activated by touching the appropriate screen area. The display changes as the operator passes to other processes so that the whole system can be controlled from just one console. Some of these concepts have attracted interest elsewhere, in particular in the design of electrical power plants.

Instrumentation

The monitoring and control of particle accelerators needs information, often with very high precision, on beam intensity, position, transverse and longitudinal profile, losses, etc. A large number of instruments have been developed, based on a variety of basic physical processes (electrostatic and electromagnetic induction, ionization, secondary electron emission, synchrotron light generation, Cherenkov and transition radiation) often using sophisticated signal processing and display techniques. For watching the evolution of processes detectors and devices (fast imaging solutions, e.g. the streak camera) have been extended and refined to give picosecond resolution.

Many of these instruments, for example an ingenious technique for measuring d.c. beams, have already found their way into industrial or medical equipment.

Survey and tunnelling

The components of large accelerators require precision alignment over long distances (to say 0.1 mm over of tens of kilometres). A number of accurate survey instruments and methods have been developed which have gone on to be used in major civil engineering projects. An example is the construction of the 27-kilometre ring tunnel for LEP. Its curvature had to be kept rigorously constant because any deviation would have led to unacceptable synchrotron radiation emission, jeopardizing the performance of the machine. This project attracted wide interest from tunnel builders, especially for the subsequent major project, the Channel tunnel linking the UK and France.

Another interesting development has been 'geological radar', based on electromagnetic sensoring to determine the nature of the rock and detect obstacles ahead. This method, together with suitable data acquisition and treatment tools available on modern radiofrequency measurement devices (network analyzers), is now used as a commercial instrument.

A low frequency device (5-100 MHz) is being considered for use on the boring machines for the new transalpine tunnels in order to give advance warning on geologically difficult or dangerous underground water areas.

This technology has considerably benefited from experience with wideband stochastic cooling systems developed for the storing and accumulation of antiprotons.

The components of large accelerators require precision alignment over long distances (to say 0.1 mm over of tens of kilometres). A number of accurate survey instruments and methods have been developed which have gone on to be used in major civil engineering projects. A good example is the geodesy for the 27-kilometre LEP ring. (Photo CERN X596.7.83)

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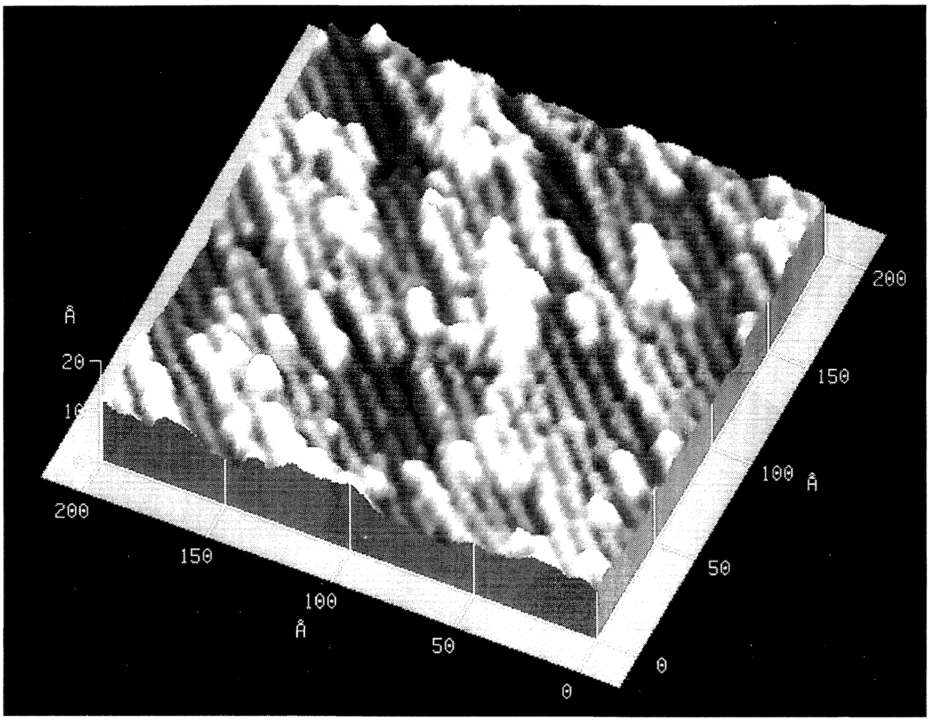
Making elementary particles visible

by Eyal Cohen
ArSciMed (art, science, media)

A Scanning Tunneling Microscope (STM) image of gallium arsenide. The STM has revolutionized our view of the microworld. (Photo France Telecom/CNET Paris B/ Bagneux Laboratory/Park Scientific Instruments)



Ever since the days of the ancient Greek atomists, the notion that matter is made up of tiny fundamental elements has dominated the history of scientific theories. Elementary particles (and now strings...) are the latest in this chronological list of fundamental objects.

Our notions of what a physical theory should be like, and what precisely "matter is made up of..." really means, have evolved with the years, undergoing a profound revolution with quantum mechanics. Physics is now dealing with scales that are many orders of magnitude smaller than wavelengths of visible light, and quantum mechanics implies that macroscopic intuition is totally irrelevant at those scales. The layman, however, keeps insisting that "seeing is believing".

One of the greatest scientific inventions of all times, the microscope, allows the scientist to show what he or she is talking about, thereby suspending natural disbelief. The public of this generation is no longer disoriented by images coming from sources other than visible light, which extend the range of our vision. We are flooded with X-ray or infrared pictures, ultrasound and NMR, to name just a few. We have all even seen a microwave picture of the universe. The electron microscope, and more recently the Scanning Tunneling Microscope, are therefore as effective as their predecessors in convincing that what they show is real.

The Scanning Tunneling Microscope (STM) has, in fact, brought the atom down to earth. It is no longer that mysterious unattainable spirit it was until several years ago. The interpretation of an STM image is far from being straightforward: the dots in the picture are not real objects, and the picture represents a tedious procedure of data collection and reconstruction, not an instantaneous flash. But that does not seem to be an insurmountable mental obstacle. What is important is that the image respects the basic concept of space.

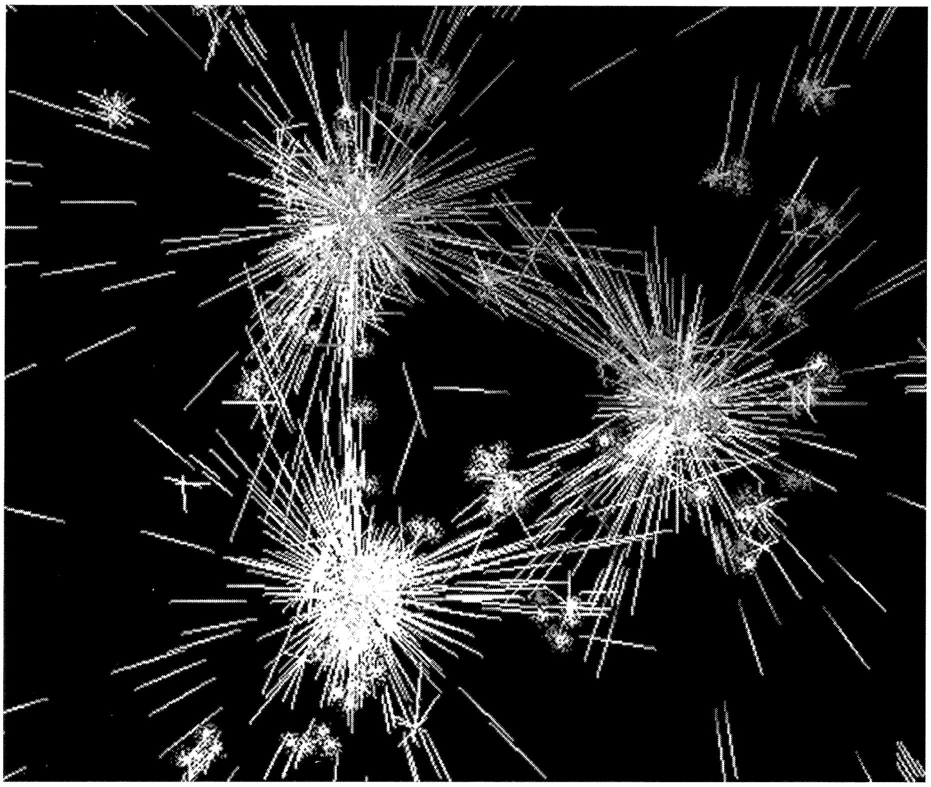
The accumulated weight of overwhelming experimental evidence confirming the quantum theory of the atom since the beginning of this century has not had the same impact on the public as several of the recent well-publicized STM images. This, in my opinion, is due to the non-spatial aspect of the individual pieces of data collected previously.

The situation for elementary particles is much worse. Rutherford's alpha particles probed the nucleus of the atom in 1911, and present-day accelerators go deep inside the nucleons, but they are not "microscopes" in the good old-fashioned sense of the term. Worse still, accelerators tend to destroy the object of their observation, leaving dozens of pieces of debris flying around. And if this is not bad enough, the debris are particles not in any way more elementary than the ones they came from. Does that mean that the accelerator is the wrong way to study elementary particles, or conversely that there is no possible visual representation of the sub-atomic world? The answer to both questions is no. Quantum mechanics is rich enough to accommodate both approaches.

The Atom, First Quantization and Quantum Mechanics

In quantum mechanics, particles are "smeared" in space. Moreover, the quintessential Heisenberg uncertainty principle implies that dual quantities, such as position and momenta, cannot be accurately determined at the same time. If we equate pictures with positions, the

A simulation of the proton's quarks.......



first statement suggests that they must be somewhat smudged, and the second indicates that their animation will suffer from the "drunkard" effect, i.e. particles moving in a rather disorderly fashion. The above statements are often presented negatively. "Quantum mechanics cannot be visualized", some would even say. Examined more closely, this does not seem to be a persuasive argument.

First, not all systems are substantially smeared, and even when they are (such as in the STM pictures), there is a nice touch of mystery to it. Second, let us not forget the elastic concept of scale. When we depict particles, we obviously blow up space by factors of at least 10^{13}. When we animate them, we slow time by factors of about 10^{10}. For illustrations, the Planck constant governing the "drunkard" effect can also be scaled at will without causing too much confusion.

Quantum mechanics speaks the language of wave functions, solutions of the Schrödinger equation. That is therefore the first thing one would like to visualize in a synthetic, or computer-generated image. The wave function is a complex, multi-dimensional (one for each internal quantum number) function of a multi-dimensional space (d^N for N particles in d-dimensional space) and of time. Displaying all this information on a two-dimensional screen is not an easy task. In fact, it is in general impossible. One is forced to choose a subset of the available information, such as a scalar function. Scalar functions are easy to display using shades of grey (typically 2^8 per pixel).

For the display of electrons in a quantum atom, a possible choice of function is the electric charge density, proportional to the probability of finding an electron at a given point in space. This choice has the advantage of conveying the "cloudy", or probabilistic, aspect of quantum mechanics. Its main disadvantage is the fact that in stationary energy eigenstates the probability functions do not vary with time, and the dynamics of the system are hidden. What we do in our animations to solve this problem is introduce a time dependent perturbation in the form of a small charge attached to the exploring "camera".

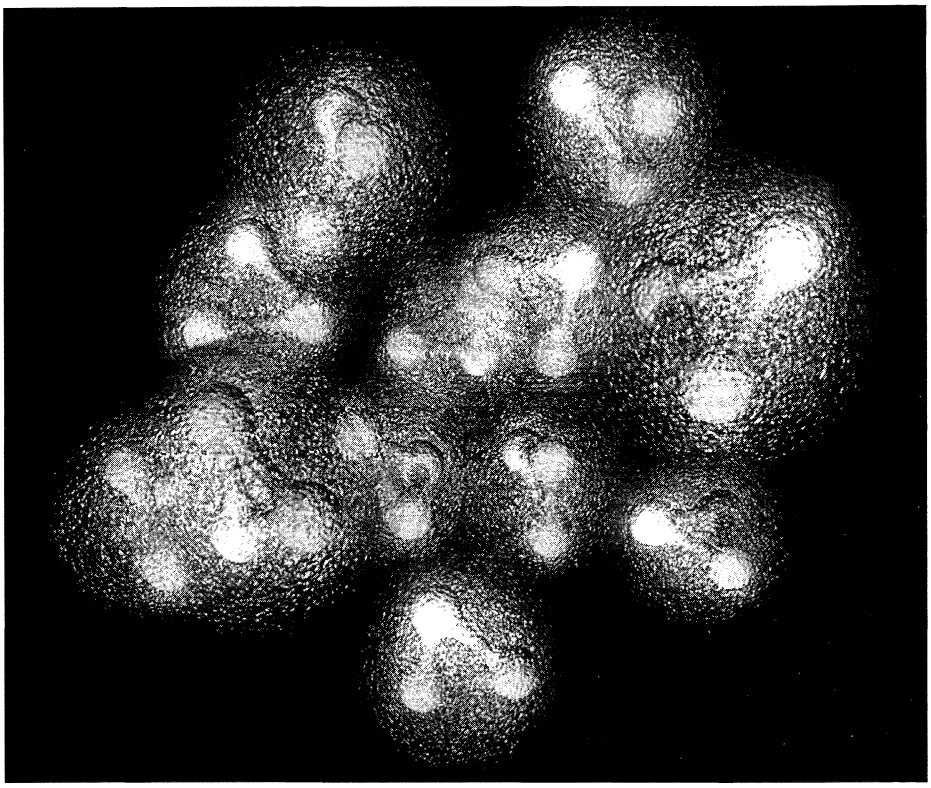
Colour (typically 2^{24} values per pixel) may be used to enliven the visual aspect of the scalar function or, more interestingly, to represent internal quantum numbers. Time evolution is then depicted by colour flow, as well as brightness variations.

The probability density is by no means the only possible choice of observable. Other scalar functions (such as the potential) may be used as well to illustrate other aspects of the system. Some choices stress the particle-like representation, while others stress the wave-like structure. Dynamics are sometimes best illustrated by vector functions (such as the electrical- or probability current density), displayed with the help of little arrows.

Elementary Particles, Second Quantization and Quantum Field Theory

Following the historical development of quantum mechanics, we should now introduce quantum field theory, a theoretical framework allowing particles to emit and absorb others. While initially developed, under the name of Quantum Electrodynamics (QED), to describe the interactions of electrons and photons,

...a nucleus of carbon.......



its effects are much more pronounced when applied to the strong interactions. The building blocks of the corresponding field theory, Quantum Chromodynamics (QCD), are quarks and gluons. They are constantly produced and annihilated inside hadrons, but can never be observed in isolation. The underlying dynamics of this confinement process are not yet well understood. Elucidating such a cryptic theory is the ultimate challenge of visualization. Ironically, this is precisely where invisibility is the subject matter.

Feynman diagrams are by far the predominant visual tool in the domain of elementary particles. It is hard to imagine the field without them. Unfortunately, in their simplest form they correspond to the less intuitive momentum space (as opposed to space-time) representation of the theory. In addition, Feynman diagrams are only a perturbative tool, while the structure of hadrons is a highly non-perturbative phenomenon.

As a first step towards a satisfactory visualization tool of quantum field theories, we developed a simple method based on a "gedanken" measurement process, which locally probes the virtual particle composition of the wave function. As in quantum mechanics, the observation process projects out one of the components of the wave function, according to a calculable probability distribution. Once an observation has been performed, the system is again left on its own till the next one comes along.

The animations created this way look a lot like "living" Feynman diagrams: particles follow crooked lines (due to the uncertainty principle), until they emit or absorb other virtual particles.

The main disadvantage of this approach is that the measurement needed for such an intimate probe perturbs the system in a fundamental way. The pleasant feature is that animations can be performed even when nothing is known about the physical properties of the theory apart from its governing equations. The value of these animations as simulations of physical systems is in these cases very limited, but it does turn out to be a useful popularization and pedagogical tool, and may lead to further insight.

Based on our visualization method we created some computer animated films:

® "Generating a Proton", describing the hadronization process out of three valence quarks,

® "Not so Elementary, the Proton", a voyage through the electron cloud around the atom, and into the proton.

The simulations portrayed in the films treat thousands of virtual particles, experiencing tens of thousands of interaction events. They demanded weeks of computing time on Silicon Graphics workstations.

The general public seems to be rather interested in the intricacies of the world of elementary particles, as we found from the popularity of our animations. The deepest pedagogical impact, as well as entertainment value we experienced to date, is however in the emerging domain of virtual reality. This technology, allows interactivity as well as total immersion in a magical realm.

Our virtual reality piece "HEUS" (Hot Early Universe Soup) recreates a quark-gluon plasma environment, the state of the universe a millionth of a second after the big bang. The interactive viewer can navigate in a pre-computed data base, or, in other words, fly among the particles. He or

CERN Courier contributions

The Editor welcomes contributions. As far as possible, text should be sent via electronic mail.

The address is courier@cernvm.cern.ch

Plain text (ASCII) is preferred. Illustrations should follow by mail (CERN Courier, 1211 Geneva 23, Switzerland).

Contributors, particularly conference organizers, contemplating lengthy efforts (more than about 500 words) should contact the Editor (by e-mail, or fax +41 22 782 1906) beforehand.

Correction

The caption accompanying the photograph in the June issue (page 32) illustrating the Director-General's discussions during his recent visit to China, with government representatives, was incorrect. The photograph used was not taken during Professor Llewellyn Smith's discussions with the President of the Peoples' Republic of China Jiang Zemin, as stated in the caption, but at his meeting with Qiao Shi, Chairman of the Standing Committee of the National People's Congress of China. Our profound apologies to all concerned.

she may choose a virtual particle to ride, and follow it to its fate, which in general arrives quite fast. The particle emits others and changes identity, or disappears in an annihilation process. The fun ends with the formation of hadrons from the quarks, anti-quarks and gluons. For thousands of viewers, HEUS was the first encounter with particle physics.

Today's visualization technology is already capable of enhancing scientific literacy, and contributing to physics education. It has proven to be an indispensable analysis tool in experimental high-energy physics, and has replaced the tons of computer listings in virtually all domains of science and engineering. Abstract mathematicians are also slowly succumbing to its charm. We hope that with some more effort and creativity, and perhaps even more powerful computers, images will find their natural inspirational role in theoretical elementary particle physics as well.

References

E. Cohen, Computer Physics Communications 70 (1992) pp 441-446, and Europhysics News 23 (1992) pp 163-166.

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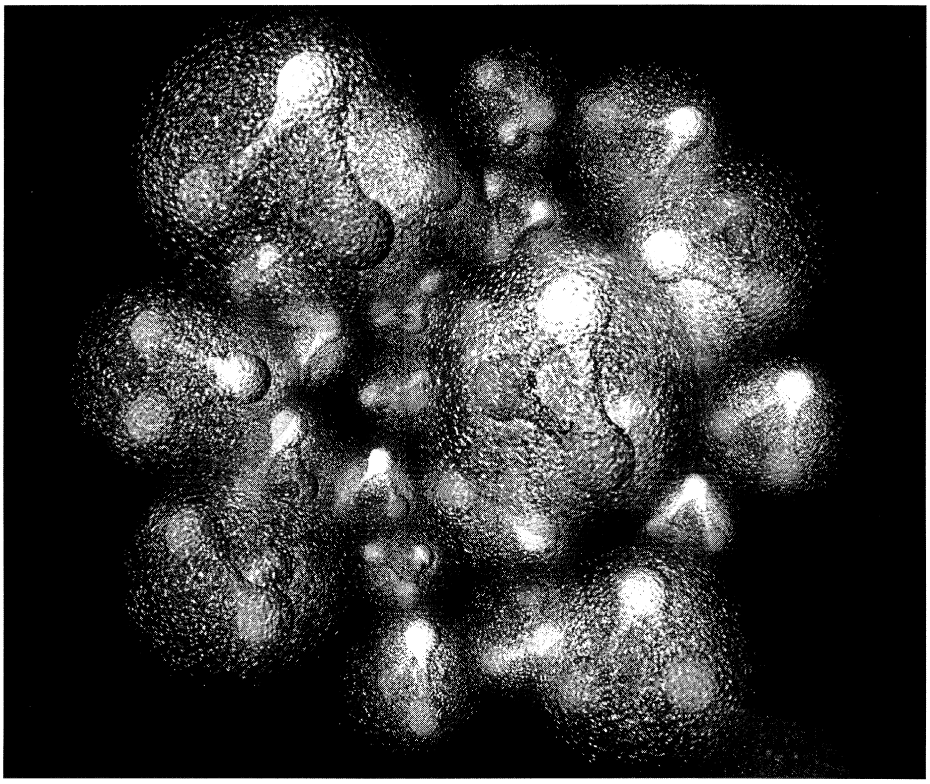
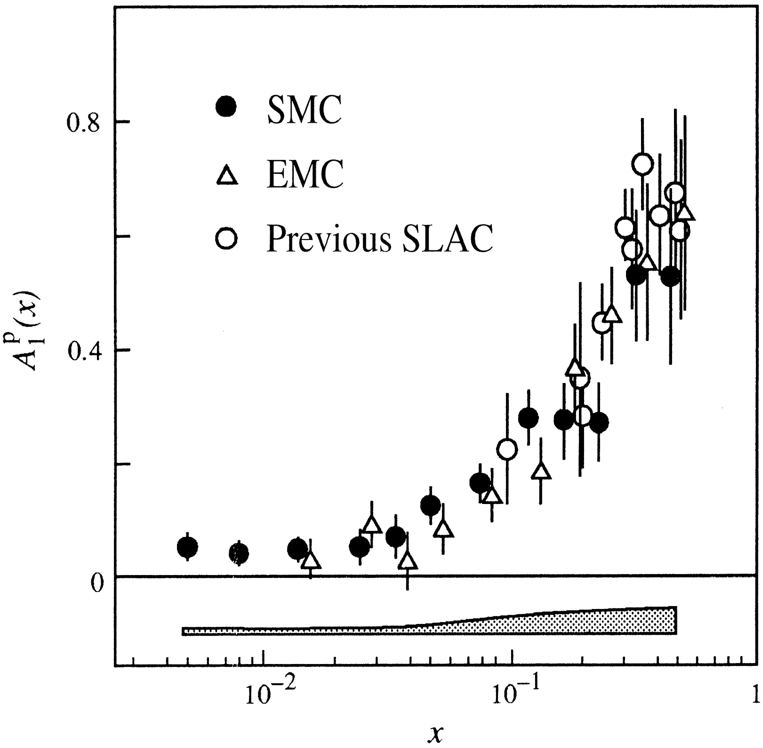
After physics research at SLAC, Harvard, the Weizmann Institute, and the French CEA, in 1989 Eyal Cohen founded ArSciMed in France. After developing visualization tools for the fundamental interactions of nature, the company went on to produce computer graphics films. These have been shown in scientific laboratories, science museums, the Seville World Expo, and in several television programmes. The film "Not so Elementary, the Proton", directed by Eyal Cohen, was awarded third prize in the research category at the "Imagina 93" Festival in Monte Carlo, and Special Mention Cum Laude at the Prix Leonardo Festival in Parma. The first public installation of the virtual reality piece HEUS (Hot Early Universe Soup), was in Karlsruhe, Germany, during the ZKM Multimediale 3 Festival. It will be shown again in Aubervilliers, near Paris, during October 1994.

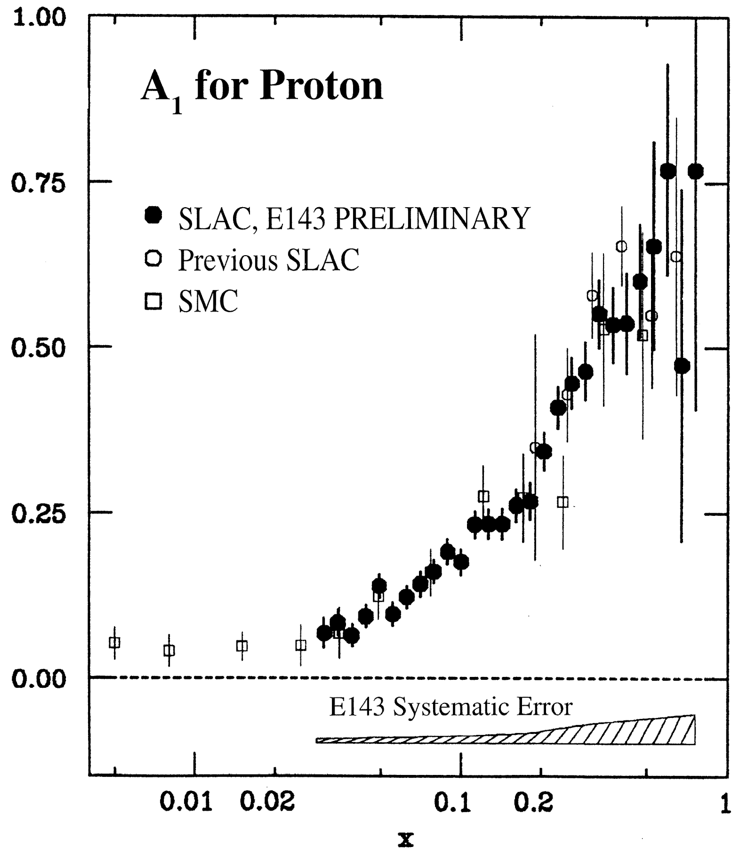


.....a nucleus of silicon........

Physics monitor

Quark spin puzzle. These spin polarization asymmetries (vertical axis) measured against quark momentum fraction (x) in high energy muon-nucleon scattering at CERN (EMC and SMC) and electron-nucleon scattering at SLAC (previous and new data) confirm that the spins of the component quarks account for only about 30 % of the spin of the nucleon.





NUCLEON SPIN
Enigma confirmed

In 1987 the European Muon Collaboration (EMC - June 1988, page 9) reported results from a polarized muon-proton scattering experiment at CERN which puzzled the particle and nuclear physics communities. Contrary to the prediction of the naive quark model, the EMC found that little of the proton spin seemed to be carried by the spins of the quarks.

An extensive experimental programme was therefore immediately proposed at CERN, SLAC (Stanford) and DESY (Hamburg) to measure the spin structure function of the neutron and to repeat the proton measurement with improved accuracy.

After five years of intense experimental activity, incisive new data have been recently obtained in Europe at CERN and in the United States at SLAC. The situation was summarized recently at the fifth "Conference on the Intersections of Particle and Nuclear Physics", held at the beginning of June in St. Petersburg (Florida). The spin structure has been measured for the proton, the neutron and the deuteron. New CERN and SLAC proton data were presented which confirm, with significantly increased precision, the initial results and underline the enigmatic spin structure of the proton.

Experiments with unpolarized lepton beams and targets average over all the possible orientations of quark spins in the nucleon or nucleus. To measure the fraction of the nucleon spin carried by the quark spins, one must orient the spins of the incoming lepton and of the target nucleon, so that the lepton and nucleon spin are either parallel or antiparallel to each other.

Electron and muon data are complementary: electron data have high statistical accuracy in a limited x-range (momentum fraction carried by the struck quark), while muon data have lower statistical accuracy but extend to significantly lower x and higher momentum transfer (Q^2). Systematic uncertainties are similar. A combined analysis of electron and muon data exploits the relative strengths of the two types of experiments.

Polarized muon-nucleon scattering experiments are carried out at CERN by the Spin Muon Collaboration (SMC), using beams of 100-200 GeV muons. To compensate for the relatively small number of muons in the beam, a very thick polarized butanol target has been designed and built. To cancel to a large extent systematic uncertainties, the target consists of two cells with opposite longitudinal polarizations, inserted in a superconducting magnet of 2.5T. Both cells are 60cm long and 5cm in diameter, separated by 30cm. It is by far the largest polarized target in the world. Nucleon spins are oriented in the direction of the beam by dynamic nuclear polarization and then frozen at 30mK using a helium-3/helium-4 dilution refrigerator. SMC measured the spin structure of the deuteron in 1992 and of the proton in 1993. The measurements on the proton cover now a wide x range, from 0.003 to 0.7 and improve significantly the experimental accuracy of the proton data.

Several experiments are in progress at SLAC. In 1992 the E142 experiment measured the spin structure of the neutron with a helium-3 target in the x range 0.03-0.6. The E143 experiment, which used NH_3 and ND_3 as proton and deuteron targets respectively, took data at the end of 1993. These targets are polarized using the same principle as is used in the SMC target. The E142 and E143 experiments used electron beams of energies up to 30 GeV.

The development of strained gallium arsenide crystals (July/August 1993, page 5) increased the polarization of the electron beam in 1993 from 40% to 90% and made it possible to reach a remarkable statistical accuracy. Proton and deuteron data have been measured by the E143 collaboration in the x range 0.027 to 0.7. As well as impressive statistical accuracy (10^8 events for proton longitudinal spin data) due to the high SLAC electron flux and polarization, systematic uncertainties are reduced by random fast reversals (120Hz) of the spin orientations of the electrons in the incident beam.

The surprising EMC results observed in 1988 are now confirmed with an increased precision by the recent SMC and E143 proton data. The combined analysis of all the existing proton and neutron data show that they are consistent with each other and corroborate to within 10% the theoretical prediction of J.D. Bjorken for the proton and neutron difference.

When quark-gluon field theory (QCD) corrections are taken into account, the analysis of all published data indicates that quark spins account for only about 30% of the nucleon spin. The origin of the remaining fraction of the spin is not yet understood. Taken at face value, the recent SMC and E143 data indicate a significant contribution to the nucleon spin from the strange quarks and antiquarks with a net polarization opposite to that of the nucleon. This disagrees with the predictions of naive quark models, such as those proposed 20 years ago by J. Ellis and R. Jaffe as a benchmark for the subsequent data.

One possible interpretation is a large contribution from the Adler-Bell-Jackiw "axial anomaly" by which a quantum effect destroys a classically conserved current. This effect is expected to be small unless there is a large gluon polarization. The small quark spin fraction and the polarization of the strange quark sea can alternatively be explained naturally in a class of approximate models of QCD in which the spin-1/2 nucleon corresponds to a sort of "knot" in the field of pions (topological soliton). Thus, to understand the spin structure of the proton, one has to take into account an unexpectedly large effect of either the gluon spins or the orbital angular momentum of quarks and gluons.

Publication of the complete E143 results on the accurate comparison of the proton and deuteron is expected in the near future. SMC will take new data on the deuteron this year and on the proton next year. At SLAC, two new experiments, E154 and E155, are planned to measure the proton, the deuteron and helium 3 spin structure in the fall of 1995 with a 50 GeV electron beam, the highest available electron energy. The experimental approach proposed by the HERMES collaboration at DESY, Hamburg, (December 1993, page 16) involves a novel technique based on a polarized atomic gas target in the polarized electron beam circulating in the HERA machine. Its main advantage is the high purity of the polarized atomic gas target, and high statistics. HERMES plans to take its first data next year.

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From 1 April, UK particle physics falls under the jurisdiction of the new Particle Physics and Astronomy Research Council (PPARC). Following closely particle physics and CERN affairs for PPARC are John Walsh (left) and Janet Seed, seen here with Maurice Jacob, CERN Advisor on Member State Affairs, at a PPARC housewarming.

UNITED KINGDOM
Under pressure

While attempting bravely to sustain the legacy left by J.J. Thomson, Rutherford, Chadwick, Cockcroft, Blackett, Dirac and others earlier this century, the United Kingdom, one of the major contributors to CERN, has suffered in recent years from an erosion of the international purchasing power of the pound sterling. At the same time, the national scientific community has squabbled over the apportionment of the research cake.

In recent years, the CERN budget has remained constant in real terms, but the pound has drifted steadily down. In 1984 one pound bought 3.15 Swiss francs, now it gets just over 2. The hypersensitivity which left calculations at the mercy of exchange rate hiccups was cushioned in 1988 by a new method of calculating national CERN contributions, introduced by Chris Llewellyn Smith, now the Laboratory's Director General, using less sensitive input data.

Another major UK influence was the publication of the famous Kendrew Report in the UK (and its CERN offspring, the Abragam Report). A Committee under molecular biologist Sir John Kendrew was convened in 1984 to investigate UK participation in particle physics in general and in CERN in particular. One recommendation was a reduced UK commitment to CERN, but this met with stiff resistance and the idea was buried.

Squeezed by exchange rate pressure on one side and suffering from the Kendrew onslaught on the other, it was the domestic programme which suffered. In 1983 this was around £35 million (in today's prices), but has since fallen to some £21 million. The decade has also seen erosion on the manpower front.

Once the dust from the Kendrew and Abragam reports had settled, UK scientists launched a counter-offensive. The well prepared 'Particle Physics 2000' plan, first published in 1991 and subsequently updated, aims to ensure having the correct resources in place for good UK participation in major long term physics goals - the origin of mass (the higgs mechanism), the pattern of elementary particles, and the nature of dark matter.

During this time, the position of basic science in UK administration has shifted from the Ministry of Education and Science to the Office of Science and Technology, under a Cabinet Minister (currently William Waldegrave of higgs competition fame - January/February, page 19).

From 1 April, particle physics falls under the jurisdiction of the new Particle Physics and Astronomy Research Council under Peter Williams, Chairman of Oxford Instruments, one of the UK's most successful high technology companies and a good example of spinoff from basic science. The Council's annual budget is £181 million, about half of which goes to particle physics (including the UK contribution to CERN).

UK experimental particle physics is almost exclusively conducted overseas, mostly at CERN's LEP electron-positron collider (where UK teams are involved in three of the four major experiments) and DESY's HERA electron-proton collider (both major experiments). In addition there is research and development work for studies at CERN's planned LHC proton-proton collider, where a major effort is being mounted in electronics and triggering. In addition there are ongoing experiments at CERN, DESY, Stanford (SLAC) and the European ILL neutron Laboratory in Grenoble, France, together with several passive neutrino and astrophysics detectors - Soudan in the US, Sudbury in Canada and a home-based dark matter search. Through no wish of its own scientists, the UK has no further involvement with neutrino and muon beams at CERN.

A major national research asset is the Rutherford Appleton Laboratory, established as the site for the 7 GeV Nimrod proton accelerator, commissioned in 1964 as the second highest energy accelerator in Europe after CERN's PS. Since Nimrod's closure in 1978, the Laboratory has become a national particle physics staging post for UK involvement at CERN, at the same time broadening its scope to become a truly multidisciplinary scientific laboratory. Particle physics represents now one-sixth of its activities.

With its significant resources, particularly in high technology and computing, the Laboratory provides invaluable support for UK university groups working at CERN. This channeling and coordination of activities allows even small units to make valuable contributions to major experiments.

Good examples of the Laboratory's expertise are at two opposite extremes of engineering scale - the Microelectronics Support Centre on one hand and the huge superconducting magnets built for the Delphi experiment at LEP and the H1 experiment at HERA on the other.

Aware of the dangers of isolation, UK scientists have several missions. A liaison office set up to foster relations between UK science and industry is working very effectively, while many UK particle physicists put a lot of effort into popularizing their traditionally impenetrable field, giving talks at schools and through media coverage.

(This detailed picture emerged at a recent meeting of the European Committee for Future Accelerators (ECFA) at the UK Rutherford Appleton Laboratory. It is an ECFA tradition to make the rounds of CERN Member States to review the particle physics programme of individual nations.)

High-Energy Gamma-Ray Astronomy: Milagro detector

To study the heavens, astronomers take advantage of most of the electromagnetic spectrum from radio waves (10^{-9} eV) to ultra-high-energy gamma rays (10^{18} eV) to complement their meagre knowledge from the narrow optical wavelength band.

The study of high-energy gamma-ray astronomy has recently been pushed up to several GeV with the EGRET instrument aboard the Compton Gamma Ray Observatory satellite. EGRET utilizes techniques from particle physics - scintillation counters, spark chambers and a sodium iodide calorimeter. EGRET has made an all-sky map that has revealed a surprising view of the high-energy heavens including highly-variable emission from Active Galactic Nuclei (AGN) and from the mysterious gamma-ray bursts (GRB).

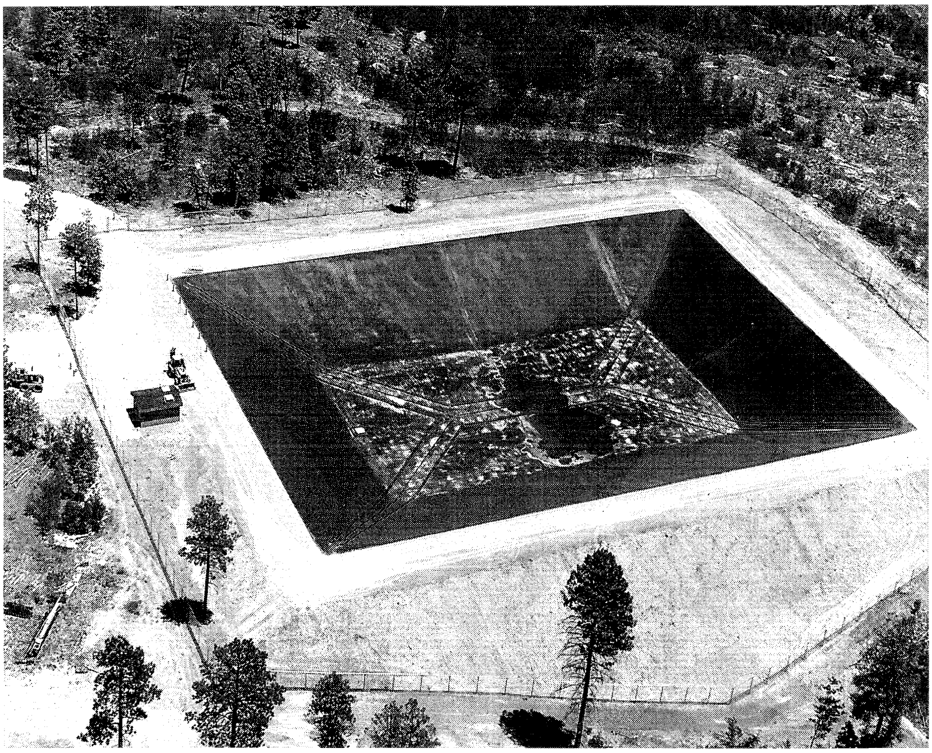
Because the gamma ray flux falls rapidly with increasing energy, extending these studies to higher energies requires much larger detectors than can presently be deployed in satellites. To date, higher-energy measurements have been made with three ground-based techniques: air Cherenkov telescopes (around 1 TeV = 10^{12} eV), air shower arrays (from 10 TeV - 1 PeV = 10^{15} eV), and atmospheric fluorescence detectors (above 10^{17} eV). All of these techniques observe particles produced in extensive air showers that result when cosmic particles interact with the earth's atmosphere. However, of these methods, only air shower arrays are a non-optical technique that can scan the entire overhead sky 24 hours a day. These attributes are important for studying the episodic and variable sources that are so prevalent.

An air shower array consists of scintillation counters sparsely spread over a relatively large area. For primaries above 100 TeV, approximately 10^{4-5} shower particles reach the ground at mountain altitudes. The sparse array samples these particles and the direction of the primary particle is reconstructed by measuring the relative times at which the individual counters are struck. Several large arrays have been in operation for a number of years including the CASA array in Dugway, Utah, the CYGNUS array in Los Alamos, New Mexico and the HEGRA array in the Canary Islands.

Several years ago, there were claims of detected emission above 100 TeV from X-Ray binaries such as Cygnus X-3 and Hercules X-1. However, observations with current, more sensitive arrays have not revealed any further evidence. This does not imply that the earlier observations were incorrect - this is an observational (as opposed to an experimental) science. The more recent measurements have shown that there are presently no bright sources of 100 TeV photons anywhere in the northern sky.

Air Cherenkov telescopes have shown that the steady emission from at least some of the sources detected by EGRET (most notably the Crab and Markarian 421, an AGN) extends up to several TeV. It is important to know if the episodic emission seen by EGRET also extends to higher energies. Air shower arrays, with their continuous all-sky sensitivity, could be used to address this question if their energy threshold could be significantly reduced. The difficulty lies in the fact that the number of particles reaching the ground diminishes

An aerial photograph of the Milagro site. The large pond had been emptied of water at the time this photograph was taken. Note the front-end loader beside the reservoir for scale.



rapidly with decreasing energy.

A group working on the CYGNUS array has invented a new technique for detecting air showers that extends the all-sky, continuous operation attributes of the air shower array to energies as low as several hundred GeV. This new technique uses water as the detection medium. Photomultiplier tubes placed 1-2 metres below the surface of a covered body of water can be used to detect the Cherenkov light produced by tranversing shower particles. Such an instrument can detect virtually every shower particle that reaches the ground. In particular, the water Cherenkov technique is extremely efficient for registering photons via pair production in the first 0.5 m or so of water; photons are the most abundant shower particles reaching the ground. The dense sampling also leads to excellent angular resolution.

A collaboration from the Berkeley, Irvine, Riverside, and Santa Barbara and Santa Cruz campuses of the University of California, from Los Alamos, and from Maryland, George Mason and New York Universities submitted proposals for a water Cherenkov air-shower detector called Milagro. (Milagro, Spanish for miracle, is also the term used to describe a form of religious folk art prevalent in Northern New Mexico). Recently, the US National Science Foundation and the US Department of Energy announced that they will jointly fund the construction of this detector. Considering the difficulty in obtaining funding for new projects these days, perhaps Milagro has been aptly named!

It will be built in an existing man-made water reservoir in the Jemez mountains west of Los Alamos, New Mexico. This reservoir, which measures 60 m x 80 m x 8 m deep, was previously used by a geothermal energy research project at Los Alamos. Milagro will employ approximately 400 8"-diameter photomultiplier tubes in the uppermost (shower) layer, and some 170 photomultipliers in an optically isolated layer at the bottom to identify muons in the shower. In addition, a middle layer of some 170 phototubes will be used to study the characteristics of hadronically-induced showers. Milagro will continuously record approximately 1500 events per second. Because of the continuous operation and the high data rate (over 1 Mbyte per second), the events will be reconstructed on-line before being written to tape.

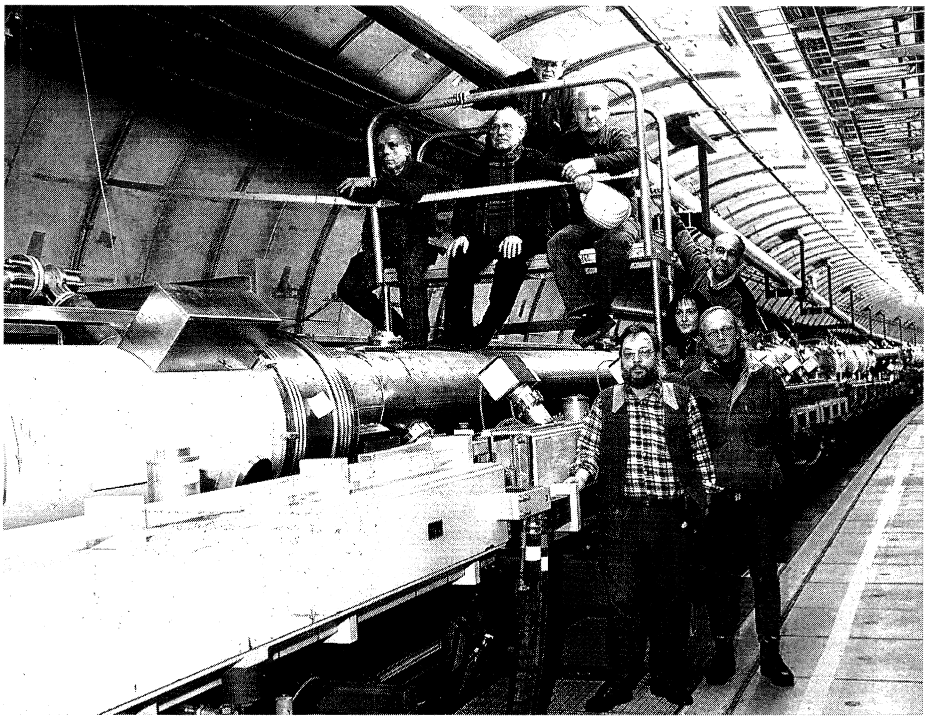
Milagro objectives include:

- the first all-sky map in the 1-TeV region;
- measurement of the energy spectrum of high-energy gamma-rays from the Crab (needed to understand the acceleration mechanism);
- a search for high-energy emission from gamma-ray bursts, where information on the upper end of the energy spectrum of this puzzling phenomenon would be useful and could provide a clue to the distance to the burst;
- observation of emission from active galactic nuclei;
- a highly sensitive search for evaporating primordial black holes;
- solar physics studies including the first determination of the axial solar magnetic field and the first determination of the short-time behaviour of energetic solar flares.

A four-year construction schedule is envisioned with completion expected in 1998. Milagro's unique capabilities will allow an unprecedented view of the heavens. If Milagro lives up to its name, it should uncover new phenomena and gain new insights into our universe.

Around the Laboratories

The spin rotator team at DESY's HERA electron-proton collider. The special spin rotator magnets for the electron ring can be seen to the right.



DESY
Longitudinal electron polarization success

On 4 May the 6.3 kilometre electron ring of the HERA electron-proton collider at DESY, Hamburg, held a longitudinally polarized electron beam, with the individual electrons, spinning like tiny tops, lined up parallel (or antiparallel) to their direction of motion. These longitudinally polarized electrons make the inherent left-right asymmetry of weak interactions easier to see and open the door to new precision measurements.

This is the first time that such a high energy electron beam has been produced - normally electron beams are transversely polarized, with the spins pointing across their direction of motion.

The spin manipulations are carried out using special spin rotator magnets, installed in the HERA ring last winter, and developed under the leadership of the late Klaus Steffen in collaboration with Jean Buon of Saclay. These magnets provide a series of horizontal and vertical kicks which flip the spins but together produce no net deflection of the electron orbit.

Many sceptics had believed that such polarizations would be difficult if not impossible, because of the potential sensitivity of these delicate gymnastics to tiny beam disturbances. The initial run produced a polarization level of 55%.

The spin rotator magnets swing round the natural transverse (vertical) polarization of the electrons - the circulating particles, like compass needles, tend to line up with the magnetic field of the storage ring. However even this natural polarization is at the mercy of depolarization resonances, which tend to push the spins out of line.

The availability of longitudinally polarized electrons is a curtain raiser for the HERMES experiment (December 1993, page 19) using an internal target in the HERA electron beam to study the quark spin composition of nucleons. HERMES will begin taking data next year.

Additional spin rotator magnets will be installed in the HERA electron beam so that the major ZEUS and H1 experiment can also benefit.

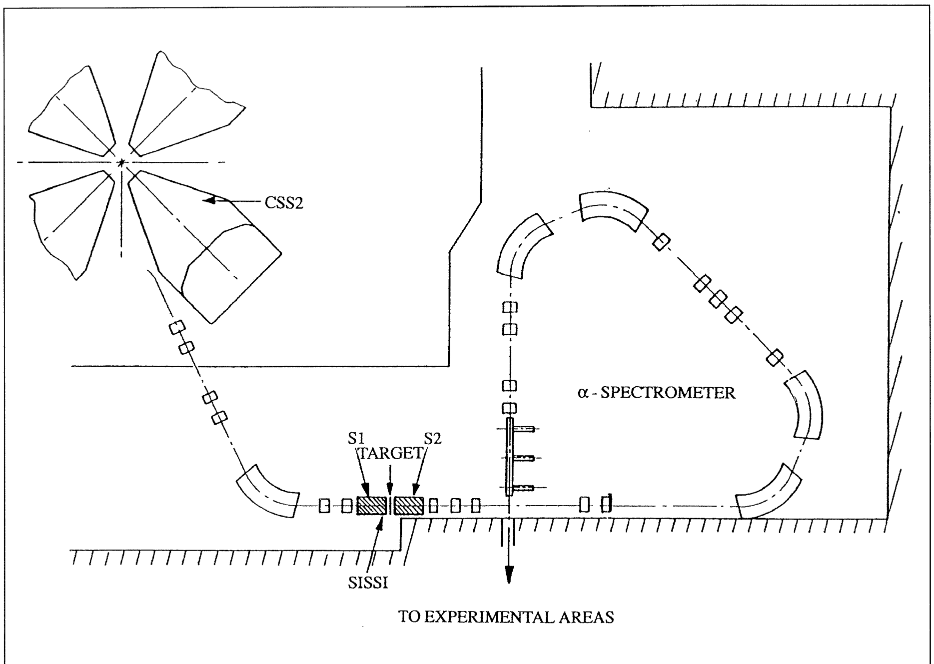
MAGIC NUCLEI
Tin-100 turns up

In the same way as the Periodic Table of chemical elements reflects the successive filling of orbital electron shells, in nuclear physics the so-called 'magic' numbers correspond to closed shells of 2, 8, 20, 28, 50, 82, 126,... neutrons and/or protons. More tightly bound than other nuclei, these are the nuclear analogues of the inert gases.

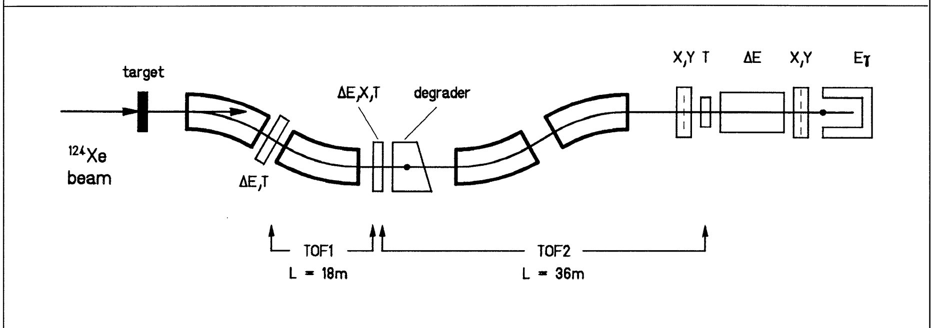
'Doubly magic' nuclei have closed shells of both neutrons and protons. Examples in nature are helium-4 (2 protons and 2 neutrons), oxygen-16 (8 and 8), calcium-40 (20 and 20) and calcium-48 (20 and 28). Radioactive tin-132 (50+82) has been widely studied.

'Wanted' nuclei on this list include oxygen 28 (8 and 20), nickel 78 (28 and 50) and tin-100 (50 and 50). The latter has now been seen in heavy ion studies at the French GANIL Laboratory, Caen, and the German GSI Laboratory, Darmstadt. Although these sightings confirm the expected stability of tin-100, real physics has to await higher intensities.

The production of exotic nuclei by projectile fragmentation of heavy ions was pioneered at relativistic energies at the Berkeley Bevalac and later



Above, at the French GANIL heavy ion Laboratory, the new SISSI secondary ion source at the exit of the second cyclotron increases the yield of interesting ions.



Below, schematic of the FRS projectile-fragment isotope separator at the GSI heavy-ion synchrotron SIS at Darmstadt, Germany. Isotopic separation is achieved by a magnetic rigidity analysis of the fragments in the first and second half of the instrument together with a degrader inserted between the two sections. Fragments are identified with position, energy loss, and time-of-flight detectors installed after the first, second, and fourth dipole stage.

successfully applied at intermediate energies at GANIL, at Michigan State superconducting cyclotron in the US, and at RIKEN in Japan. The GSI heavy ion synchrotron SIS extends this technique to the heaviest nuclei up to uranium.

The GSI experiment was performed between March 10 and April 11, 1994, by a Munich Technical University/GSI collaboration headed by Jürgen Friese of Munich TU, utilizing a 1 GeV/nucleon xenon-124 beam made from isotopically enriched gas.

The key element in this experiment is GSI's FRS projectile-fragment separator, a four-section magnetic forward spectrometer used for spatial separation of the forward-emitted fragments from the primary beam and of selected isotopes from the mixture of other fragmentation products. To achieve this, a thick degrader is inserted in the central focal plane of the spectrometer that allows a separation according to the nuclear charge in addition to the magnetic-rigidity separation according to mass over (ionic) charge. Apart from the spatial separation, the background is further reduced by identifying each fragment event by event with respect to nuclear mass and charge by measuring the energy loss, the time of flight, and the magnetic rigidity of the fragments.

The relativistic energies provided by the SIS synchrotron facilitate an in-flight identification without ambiguities due to different ionic charge states that pose problems at lower incident energies.

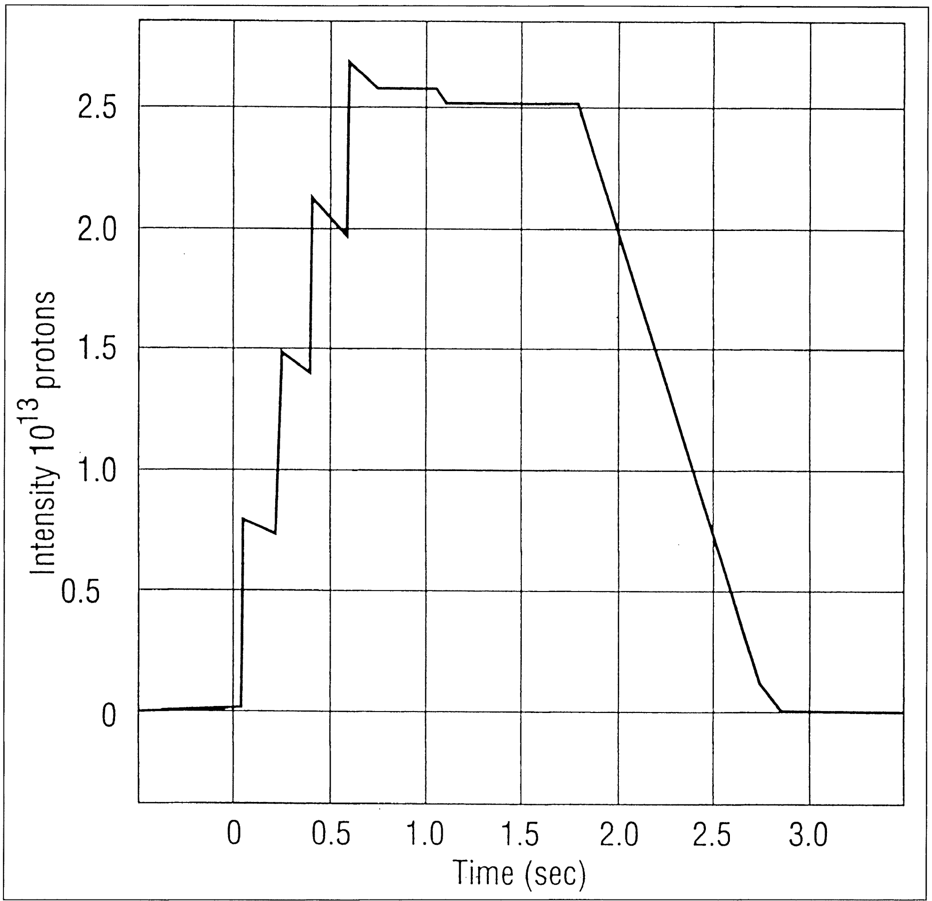
The final run for the production of tin-100 lasted 277 hours during which seven events attributed to this isotope were observed. These event rates are comparable to those observed in the search for the heaviest elements at GSI's UNILAC accelerator - in the 1988 run to confirm the discovery of element 109 (meitnerium) two events were observed in 240 hours of beam time.

In principle, the GSI secondary-beam facility could open up more detailed spectroscopic studies of this and other exotic nuclei. However this requires much higher production rates which can only be provided when SIS can be filled to the space charge limit. For this purpose, a replacement of the old Wideroe prestripper section of the UNILAC injector by a new high-intensity accelerator is currently under consideration.

After a promising initial study last October at the French GANIL heavy ion Laboratory at Caen, the new SISSI (Source d'Ions Secondaires à Solénoides Intense) device close to the exit of the second GANIL cyclotron, in conjunction with the Alpha and LISE3 spectrometers increased the transmission rate.

A 63 MeV/nucleon beam of tin-112 (46^+) from the cyclotrons bombarded a nickel target in SISSI. The momenta of the emerging fragments were analysed in the two downstream spectrometers, and results (time of flight, energy loss and total energy) recorded in a four-element silicon telescope at the final focus of LISE3. The SISSI emittance and Alpha acceptance were well

Fed by the Booster, the Brookhaven AGS Alternating Gradient Synchrotron is producing record intensities. The cycle plot shows how the intensity goes up in four steps as successive Booster bunches are injected at 200 millisecond intervals. As the intensity increases, losses also increase. Transition losses appear at 1.1 seconds. After acceleration to 24 GeV the beam is extracted at a uniform rate for 1 second.



matched. 11 events corresponding to tin-100 were seen in a 44-hour run. Other new neighbouring isotopes (palladium-92 and -93, indium-99, antimony-104) were also identified.

The experiment involved physicists from Warsaw, JINR Dubna, Orsay, Bucharest, GSI Darmstadt, Göttingen and Leuven as well as GANIL. For future studies, the production rate will be boosted by increasing the primary beam intensity and the acceptance of the Alpha spectrometer.

BROOKHAVEN AGS improvements

The new Booster - AGS Alternating Gradient Synchrotron complex is providing beam while machine development to enhance performance also progresses, so far on schedule. In 1991 the Booster turned on and performed as requested - attesting to a successful construction and quality control programme.

In 1992 beam was provided to users while the Booster met most of its operational goals - falling slightly short of its proton intensity goal of 0.5 x 10^{13} protons per pulse (ppp). This would have been inconsequential except that the Booster intensity seemed to be hitting a fairly solid brick wall of undetermined origin. Since the goal for 1993 called for a doubling of the intensity, the situation seemed serious enough to schedule three months (February - April 1993) for Booster development.

In 1993 all the Booster systems were scrubbed and polished until they gleamed. Each procedure was meticulously carried out, documented, recorded, and cross-checked, and every known skill and art was applied. This resulted in a modest 25% gain, but the brick wall, while shifting a bit, remained.

Meanwhile a small group continued to map the stopbands, a programme started one year earlier. A month of careful stopband measurement and correction produced another modest 25% gain.

Refusing to admit defeat, further stopband measurements revealed a surprise problem with skew sextupole fields. There are no skew sextupoles in the Booster and any skew sextupole errors were expected to be small and have no effect on the beam.

The fields were small but turned out to have an unexpectedly large effect. The problem was corrected by winding four small skew sextupoles on existing correction magnets, giving a further gain of 25%. Overall the stopband corrections raised the Booster intensity from 0.65 x 10^{13} to 1.0 x 10^{13} protons per pulse, and the machine is performing just as the books say it should.

With the Booster operating at this level (peak performance was 1.2 x 10^{13} ppp), it was possible to inject four Booster pulses into the AGS and accelerate an AGS record 2.5 x 10^{13} ppp to extraction, easily exceeding the goal for the year of 2.2 x 10^{13}. (The previous AGS record had been 1.9 x 10^{13} from 1986.)

The AGS is limited to 2.5 x 10^{13} ppp by the available radiofrequency power. In a major upgrade, new power amplifiers are being installed for ten radiofrequency cavities which should more than triple the AGS capabilities. Another major new system to enable the AGS to jump rapidly through transition is also being installed.

For the heavy ion programme the Tandem-Booster-AGS complex operates fairly straightforwardly. In 1991 it accelerated silicon ions, and in 1992 increased the silicon intensity by a factor of ten to 9 x 10^{10} ions per pulse (ipp), and accelerated gold ions. In 1993 it accelerated gold with a factor of ten gain in intensity to 3 x 10^{8} ipp.

In sum the Booster-AGS complex met its goals for 1993. With the major upgrade of its radiofrequency system the AGS should meet its 1994 intensity goals of 4 x 10^{13} ppp using the Booster at its present intensity. Also scheduled for this year

is a Booster proton intensity of 1.5 x 10^{13} ppp. This will call for a steady accumulation of many small improvements, but must be accomplished to meet the AGS goal of 6 x 10^{13} protons per pulse in 1995. For 1996 an order of magnitude increase in the intensity of the gold beam is the objective.
From Ed Bleser

First RHIC magnets successful

Manufactured by Northrop Grumman Corporation, the first dipole for the Relativistic Heavy Ion Collider (RHIC) heavy ion collider was delivered to Brookhaven on May 2, and successfully cold tested (at 4.6 K) on May 9.

Approximately one month prior to this important RHIC milestone, a quadrupole cold mass (coil and yoke), also made by Northrop Grumman, had undergone successful test. The quadrupole will later become part of a so-called CQS package - an assembly which also includes sextupole and trim "corrector" windings.

The operating current of 5000 A corresponds to a field of 3.46 T in the dipole and a gradient of 71.2 T/m in the quad which in turn translate to 100 GeV per nucleon for gold ions. Precise measurements of the magnetic field were input to computer simulation of beam performance which showed that the "field quality" of both magnets were well within tolerances needed for collider operation. Both quench performance and field quality of these first two magnets indicate their suitability for installation in the RHIC tunnel.

The first phase of the contract between Brookhaven and Northrop Grumman calls for 30 dipoles and 10 quadrupoles to be delivered this year. Eventually, 373 dipoles and 432 quadrupoles will be produced by Northrop Grumman for RHIC. Installation in the tunnel is scheduled to begin in 1995.

The Grumman-Brookhaven collaboration began in June 1992, with the signing of the single largest RHIC construction contract. The process of technology transfer was begun when Northrop Grumman engineers and technicians participated in the assembly and test of the last two preproduction dipoles at Brookhaven.

Following that, many physicists, engineers, and technicians from the RHIC Magnet Division travelled regularly to Northrop Grumman to work with their counterparts in the development of tooling needed for magnet manufacture and for consultation during the assembly process. The RHIC magnets represent the first example within the United States of large scale industrial production of superconducting accelerator magnets.

The first dipole magnet for the RHIC heavy ion collider arrives at Brookhaven.

DUBNA-GRAN SASSO Satellite computer link

In April a 64 kbit/s computer communication link was set up between the Joint Institute for Nuclear Research (JINR), Dubna (Russia) and Gran Sasso (Italy) Laboratories via nearby ground satellite stations using the INTELSAT V satellite.

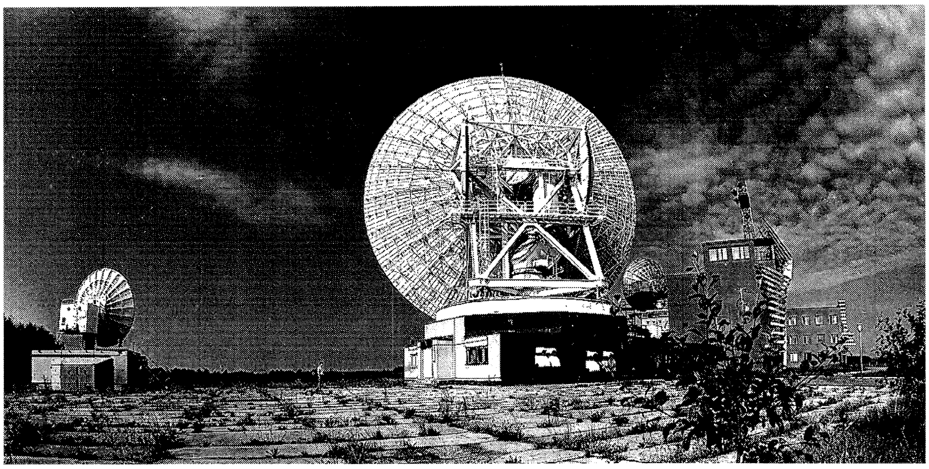
Previously the international community of Dubna's experimentalists and theorists (high energy physics, condensed matter physics, low energy nuclear and neutron physics, accelerator and applied nuclear physics) had no effective computer links with scientific centres worldwide.

Now Dubna physicists get a powerful computer line to the European HEPNET, including CERN as main node, important for effective participation in major experiments where JINR physicists are involved - Delphi, Obelix, and SMC as well as the emerging LHC collaborations. In the reverse direction, the link benefits the close scientific collaboration of Italian INFN groups not only with Dubna but also with Moscow, Novosibirsk, Serpukhov etc.

The establishment the line resulted from an agreement between former INFN President N. Cabibbo and JINR Director V. Kadyshevsky signed at the end of 1992.

Dubna is highly suitable as an entry point for Russia and other JINR member-states because of the nearby major Russian PTT ground satellite communication station. This

The satellite ground station located near Dubna, Russia, forms an integral part of a new computer link between the Joint Institute for Nuclear Research (JINR) and the Gran Sasso Laboratory in Italy.



is linked by powerful land line to Moscow and by satellite channels to Europe, the USA and East of Russia, with JINR's computer centre providing technical backup. In the framework of JINR's computer communication project and the INFN agreement, this link will be upgraded to 2 Mbit/sec. This link and others still being prepared will be available for other Russian and JINR member-state scientific centres.

Bookshelf

John R. Huizenga; "Cold Fusion: the Scientific Fiasco of the Century", Oxford University Press, 1993 (ISBN 019-8558171).

Review by Douglas R.O. Morrison

"Cold fusion is dead, isn't it?" is a question I am often asked. The reply is a strange one, "Yes, scientifically it is dead, but not from a media point of view or from funding"

In 1989 two electrochemists, Martin Fleischmann and Stanley Pons, claimed sustained nuclear fusion had been achieved in a test-tube with a palladium cathode and deuterium, observing excess heat, neutrons and tritium. A series of encouraging confirmations and successively greater excess heat claims were seized on by the world's media.

The US Government set up a panel of some 20 world-class scientists from several disciplines under John Huizenga, distinguished professor of Chemistry and Physics at the University of Rochester. They concluded that there was no present evidence for the discovery of a new nuclear process termed cold fusion. It might be thought that would end cold fusion, but for interesting reasons, it did not entirely.

John Huizenga has written a book describing the curious claims and evidence for cold fusion and has given an excellent explanation of the science involved. This was published as a hardback book of 236 pages, telling the story up to the end of June 1990. Again one might think it was the end of the cold fusion story. Now he has written about what happened in the next two years in a paperback book which contains an epilogue of 51 pages. If you thought the first year was extraordinary, the next two years described in the new edition were even more incredible!

In the main part of the book, the basic science is simply and clearly explained. The number of "miracles" required for each results or theory is described - a "miracle" is a gross violation of previous knowledge and experimental results such as energy conservation. Thus some theories are classified as "triple miracles".

It might be thought that people who claimed to have observed cold fusion would be proud to show their cells actually working, but a remarkable feature was that although the panel announced their visits to laboratories well in advance, they never managed to see a single cold fusion cell working!

In April and May 1989, in an electronic newsletter I compared cold fusion with other examples of Pathological Science such as N-rays. There was a great response from readers. This is one of the major themes of John Huizenga's book. He devotes a chapter to Pathological Science bringing it up to date with stories such as water with memory, as well as some remarkable cold fusion results. The final chapter lists 15 lessons on judging hypothesis, reproducibility, press conferences, publication, secrecy, lobbying, etc. The final conclusion is that "the scientific process works by exposing and correcting its own errors".

In the Epilogue, even more strange happenings are described such as the setting up of a company based on a theory that inside the deuteron, it is possible to create nucleon-antinucleon pairs and their annihilation then gives GeV of energy - a violation of energy conservation! Also at a university in Texas there was a claim to be able to transmute mercury into gold - the alchemists' dream!

Initially proponents insisted that the effect must be nuclear fusion since it happened with deuterium but not with normal hydrogen. However in the

People and things

Epilogue it is shown that the situation has changed now with several groups reporting cold fusion effects with normal light hydrogen!

While most scientists have given up on cold fusion, a small but very active group of mainly non-scientists have become experts at handling the media so that stories of positive results are listed and there is talk of a conspiracy against cold fusion - a well-known tactic of cults. At the same time some influential people have been impressed, and a subsidiary of a Japanese motor car manufacturer has set up a laboratory near Nice for Fleischmann and Pons. Also the MITI organization has decide to allocate $30 million over four years to set up a New Hydrogen Energy institute - they say they do not necessarily believe in cold fusion but wish to explore possibilities.

Overall the book is a fine account of an incredible story that many will find impossible to believe even though it did actually happen - and a few True Believers are still continuing! Well worth reading.

American Physical Society Prizes

Among the 1994 winners of American Physical Society prizes and awards are:

Carl E. Wieman of Colorado for pioneering contributions to atomic physics, including the development of ultra-precise measurements of atomic parity non-conservation and new techniques for trapping neutral atoms;

Richard L. Arnowitt of Texas A&M, Stanley Deser of Brandeis and Charles W. Misner of Maryland for their joint development of a new formalism for general relativity;

Thomas J. Devlin of Rutgers and Lee G. Pondrom of Wisconsin, Madison, for their elegant series of strange baryon experiments at Fermilab;

Yoichiro Nambu of Chicago for his many fundamental contributions, including the understanding of the pion as a signal of spontaneously broken chiral symmetry;

Steven Chu of Stanford for his outstanding work in applying lasers to trapping, cooling and spectroscopy;

Thomas L. Collins (retired) and Gustav-Adolf Voss of DESY for their seminal contributions that led to the development of high luminosity interaction regions for storage rings;

writer Gary Taubes for his book 'Bad Science: The Short Life and Weird Times of Cold Fusion' and other contributions to promoting the public understanding of the relation of physics to society;

Sylvester James Gates of Maryland who receives the new Visiting Minority Lectureship Award for his contributions to theoretical high energy physics;

and Tor Raubenheimer of SLAC for his doctoral thesis research contributions to linear collider beam dynamics.

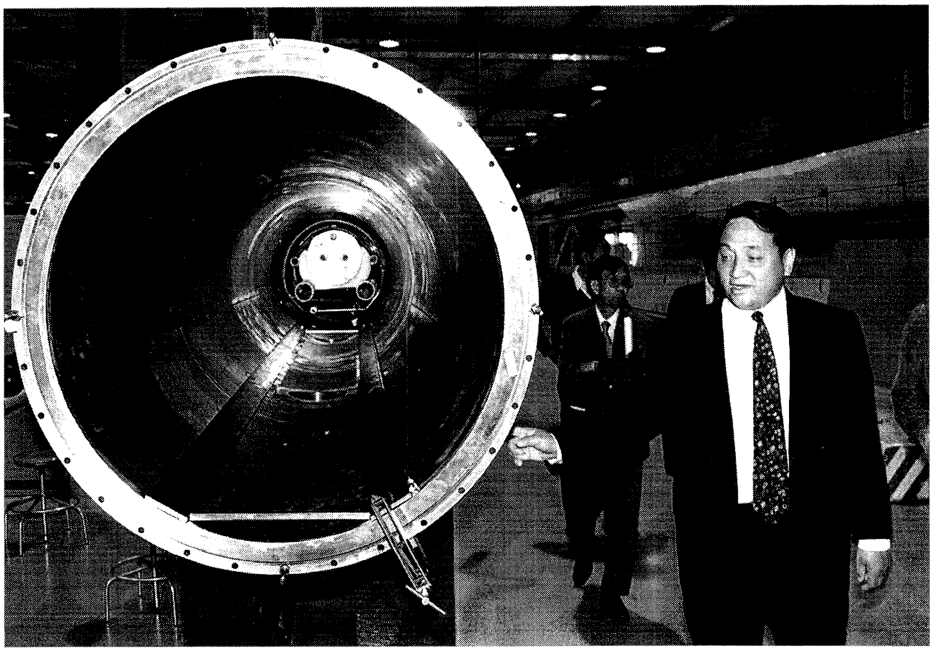
Odd Dahl

CERN pioneer Odd Dahl died in Bergen, Norway, on 2 June at the

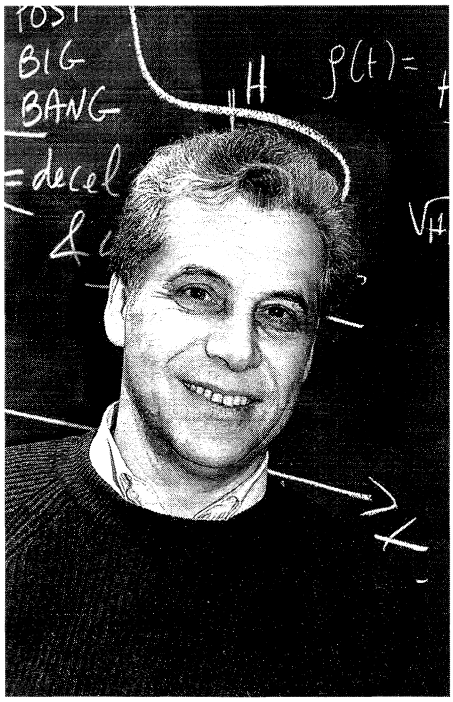
On 24 June at a meeting of CERN's governing body, Council, 17 of CERN's 19 Member States voted in favour of the LHC proton-proton collider as CERN's next major machine. Germany and the UK did not vote for the motion, but with the meeting adjourned, the vote will be continued when Council reconvenes.

During his visit to CERN on 26 May US Ambassador to Switzerland Larry Lawrence (centre) admired the Aleph detector at LEP and met members of the Madison, Wisconsin, group working on Aleph. (Photo CERN 46.5.1994)

Wang Shaoqi, Director General of the International Cooperation Department of the Chinese State Science and technology Commission, admires LHC superconducting magnet equipment during his visit to CERN on 2 May.
(Photo CERN 19.5.94)



From 1 July Gabriele Veneziano becomes Head of CERN's Theory Division, taking over from John Ellis.



age of 95. A tribute will appear in the next issue.

On people

Michel Davier, former Director of LAL, Orsay, receives the Gentner-Kastner prize, awarded jointly by the French and German Physical Societies, for his numerous outstanding experimental contributions to electroweak physics.

TRIUMF reorganization

The new Director of TRIUMF, Alan Astbury, has announced a revised divisional structure with the following Division Heads: Ewart Blackmore (Accelerator Technology), Gerardo Dutto (Cyclotron Operations), Philip Gardner (Technology Transfer), Jean-Michel Poutissou (Science, and Associate Director) and Ian Thorson (Administration).

Joint US/CERN/Japan accelerator course

A joint US/CERN/Japan topical course on accelerator physics and technology will be held on Maui, Hawaii, from 3-9 November, organized by the CERN Accelerator School, the Japanese KEK Accelerator School and the US Particle Accelerator School, and hosted by the University of Hawaii. This novel tripartite venture grew from the biennial joint US/CERN school initiated in 1984.

As well as for those with a professional interest in accelerator physics and technology, the course is also aimed at graduate and postdoctoral students and those working in accelerator-based sciences. It will consist of intensive lectures and courses covering the wide range of accelerator technologies. Further information from USPAS@FNALV.FNAL.GOV or the USPAS office, fax +1 708-840-8500

ITEP school

The XXII ITEP School took place at a picturesque place near Moscow from February 22 to March 2. The tradition of annual ITEP Schools goes back to 1973, but this time the 1994 School was made international, with about 30 students and post-docs from abroad, including FSU countries. The support of the American Physical Society, the International Science Foundation, the Russian Foundation for Fundamental Research and Ministry for Science and Technology allowed prominent lectures to be invited from all over the world.

The main topics were B-meson physics and electroweak interactions with equal accent on theory and modern experimental technique and results. Popular lectures were also given on the theory of the early Universe, supernovae, superstring unification and topological models. Evening sessions were devoted to presentations of the younger partici-

On 28 April the Norwegian Research Board for Science and Technology visited CERN.

pants and included much informal discussions. The scientific programme was complemented by competitions in country skiing, visits to old orthodox monasteries, "troika" rides, night party in the forest and other Russian pleasures. The next ITEP School is scheduled for February - March 1995.

Fermilab events

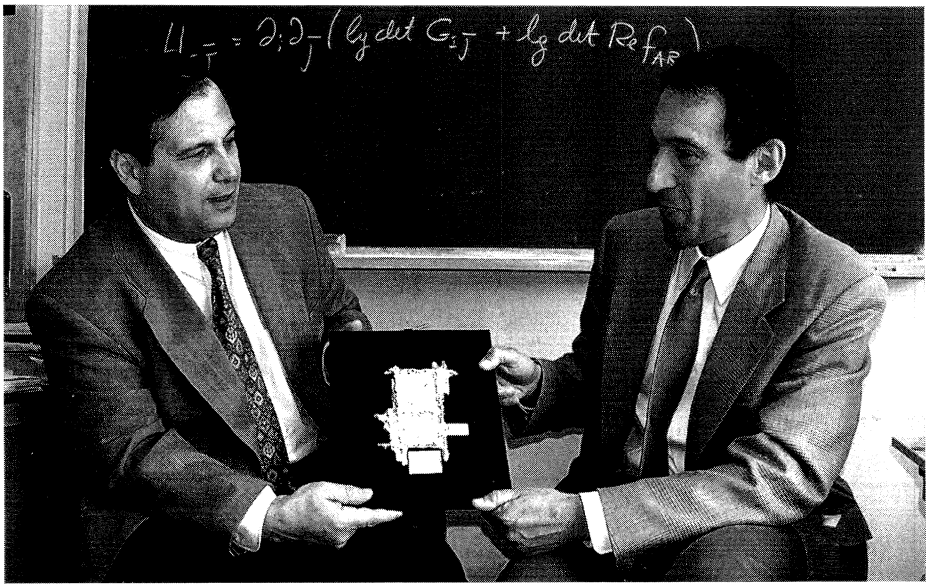
From 22-24 August: Second Workshop on Small-x and Diffractive Physics at the Tevatron; Co-Chairmen: Michael G. Albrow, Fermilab and Alan R. White, Argonne; Scientific Contacts: Michael G. Albrow, ALBROW@FNALV.FNAL.GOV; Alan R. White, ANLHEP::ARW; General Information Contact: Mary C. Burke, ANLHEP::MCB

From 14-16 October: Workshop on the Origin of Fermion Masses and Mixings, Contact: Joseph Lykken, LYKKEN@FNALV.FNAL.GOV

Meetings

The 23rd INS international symposium on "Nuclear and Particle Physics with Meson Beams in the 1 GeV/c Region" will be held from March 15-18 1995 on the main campus of University of Tokyo. The symposium is being organized so as to discuss the present status and future prospects of nuclear and particle physics such as kaon decays, strangeness nuclear physics, meson-nucleus interactions etc. which are closely related to current experimental programs at the KEK 12 GeV PS. Further information; Ms. K. Hata, INS, University of Tokyo, Tanashi, Tokyo 188, Japan, telefax : 81-424620775, e-mail : insymp23@ins.u-tokyo.ac.jp or insvax::insymp23

Together this year in CERN's Theory Division are Sergio Ferrara (left, of CERN) and Daniel Freedman, visiting from MIT, seen here with the prestigious 1993 Dirac Medal of Trieste's International Centre for Theoretical Physics which they both received (with Peter van Nieuwenhuizen of the State University of New York, Stony Brook) for their discovery of supergravity and other major contributions to supersymmetric field theory. Their joint 1976 paper led to an explosion of interest in quantum gravity. The ICTP Dirac Medals, instituted in 1985, are awarded annually on 8 August (Dirac's birthday) for important contributions to theoretical physics by researchers who have yet to win a Nobel or Wolf Prize.



INTERNATIONAL WORKSHOP ON COLLECTIVE EFFECTS IN LARGE HADRON COLLIDERS

The International Workshop on Collective Effects in Large Hadron Colliders will be held in Montreux, Switzerland, from 17 to 22 October 1994, to review and discuss all aspects of collective single-beam and beam-beam effects, in past, existing, and future large hadron colliders. Deadline for expressing an interest in participation is 31 August 1994.

Further information:

Dr. E. Keil, SL Division
CERN
CH-1211 Geneva 23,
Switzerland

Phone: +41 22 767 3426
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LHC94@CERNVM.CERN.CH

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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.

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TWO TENURE TRACK POSITIONS
in Experimental Particle Physics

Department of Physics and Astronomy
University of Victoria

The University of Victoria Department of Physics and Astronomy invites applications for two tenure-track positions at the rank of Assistant Professor. The positions are in the area of experimental particle physics and are bridging appointments to replace faculty who will be retiring in the next five years. Applicants are expected to have an established research record and a commitment to undergraduate and graduate teaching.

The particle physics group is currently participating in the operation and data analysis of the OPAL experiment at LEP 1, rare kaon decay experiments at BNL, tracking detector development at SLAC and LHC RD3 calorimeter research. Future research activities of the group are aimed at LEP 200 with OPAL, the ATLAS experiment at LHC, where a significant hardware contribution is anticipated, and the SLAC B factory. The nearby TRIUMF laboratory affords the opportunity for involvement in the physics program and provides facilities for technological support and test beams for detector development not normally present in a university department.

The University of Victoria is an employment equity employer and encourages applications from women, persons with disabilities, visible minorities, and aboriginal persons.

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents. Others are encouraged to apply but are not eligible for appointment until a Canadian search is completed and no appointment made.

Applications with curriculum vitae, publication list and the names and addresses of at least three referees should be sent to:

Dr. J.M. Dewey, Chair
Department of Physics and Astronomy
University of Victoria
P.O. Box 3055
Victoria, RC V8W 3P6
Canada

Applications will be accepted until 30 September 1994.

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE

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Please remember to let us know in good time. All notices of change of address must be accompanied by old and new addresses. (Include label from magazine wrapper.)

Any enquiries regarding subscriptions should be addressed to:

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IMPERIAL COLLEGE
University of London

Blackett Laboratory

Lectureship in Physics

We are seeking an outstanding experimental physicist with a commitment to the teaching of electronics and instrumentation, to join the staff of the Blackett Laboratry.

The appointee will have research achievements in experimental physics including instrument design. S/he will be expected to pursue an independent programme of research, including the supervision of research students, which fits into the experimental activities of one of the established research groups in the areas of Applied Optics, Astrophysics, Biophysics, Experimental Solid State Physics, High Energy Physics, Laser Optics & Spectroscopy, Plasma Physics, or Space & Atmospheric Physics.

Salary in the range £15,735 to £27,241 including London Weighting.

Applications including a C.V. and the names of three referees should be sent to Miss R. Tuckwell, Blackett Laboratory, Imperial College, Prince Consort Road, London SW7 2BZ, UK by 31 August 1994. For further information phone +44 (0) 71 594 7501, fax +44 (0) 71 225 8869 (or after 25 June +44 (0) 71 594 7892) e-mail r. tuckwell@ic.ac.uk.

The College is striving to be an Equal Opportunities employer

LANCASTER UNIVERSITY

School of Physics and Materials

RESEARCH ENGINEER IN ELEMENTARY PARTICLE PHYSICS

The Lancaster High Energy Physics Group has a Research Engineer's position available. The person appointed will be expected to play a prominent role in developing apparatus for use in High Energy Physics Experiments and in co-ordinating the work of technicians. The development work will be carried out in collaboration with physicists in this department and with other physicists and engineers working in international collaborations. It will be necessary to work with specialists in both electronic and mechanical engineering.

The group is currently involved in developing the forward particle detectors for the ATLAS experiment at the LHC at CERN. Currently it is planned to base these detectors on Gallium Arsenide technology. In addition the group is involved in an experiment at the proposed B factory at SLAC, where opportunities are expected to arise in the development of triggering and data acquisition systems.

The successful candidate is likely to have a degree in an engineering related subject with either some academic/industrial experience in instrumentation or in detector design and construction in experimental elementary particle physics. The post is supported by PPARC and will be for an initial period of 2 years.

For further details and application forms please contact Personnel Services, Bowland College, Lancaster University, Lancaster LA1 4YT (telephone 0524 846549). Applications, naming three referees should be sent to Personnel Services at the above address by 1st September 1994. Further information about this position can be obtained from Prof T Sloan (tel: 0524-593615 or e-mail TS@UK.AC.LANCS.PH.V1).

OPAL at LEP

University College London

Research Fellows

University College London has two vacancies for postdoctoral R.A.s to work on data from the OPAL experiment. At LEP 1 the UCL group is studying the photon structure function, the Z lineshape and the parameters of electroweak theory, as well as searching for the Higgs boson. At LEP 2, from 1996, photon structure function studies with the extra energy and luminosity will give new tests of QCD, tests of electroweak theory will be made in WW production and the Higgs search will be extended to higher mass. the successful candidates will take leading roles in these analyses. **Both positions are funded by PPRAC and are on the 1A scale, with salary between £12,828 and £20,442, according to age and experience; plus £2,134 London allowance.**

Please send your letter of application with a full cv, publications list, and the names and addresses of two referees to Professor David J Miller, Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, UK. (Informal enquiries by e-mail to DJM@UK.AC.UCL.PH.V1).

Working Toward Equal Opportunity

DESY has an opening for a

SENIOR PHYSICIST in experimental particle physics,

at the **DESY-Institute** for High Energy Physics in Zeuthen (Berlin).

A tenured position is offered with a salary equivalent to that of a full Professor (C4 at a German University).

Applications and suggestions of candidates should be sent before **30 September 1994** to
Prof. Dr. B.H. Wiik
c/o DESY, Notkestr. 85,
D - 22603 HAMBURG.

Further information about the position in question can be obtained from Prof. Dr. B.H. Wiik.

University of Copenhagen
Niels Bohr Institute
for
Astronomy, Physics, and Geophysics

Research Assistant or Assistant/Associate Research Professor Position in Experimental Particle Physics

A position as research assistant or assistant/associate research professor in experimental particle physics at the Niels Bohr Institute for Astronomy, Physics, and Geophysics (NBIfAFG) will be open from November 1, 1994.
Experimental particle physics research at the NBIfAFG is conducted at CERN in Geneva, Switzerland. The NBI-Group is involved in the ALEPH and DELPHI experiments at LEP and in the heavy ion experiment NA44 at SPS. In addition to physics analysis in all three experiments the group contributes to the hardware and software of the two LEP experiments. The group is also involved in the preparations of an experiment, ATLAS, at the proposed accelerator LHC at CERN.
While based in Copenhagen, the chosen candidate is expected to work in one of the LEP experiments and particularly in the future LHC experiment. He/she is expected to participate in the University teaching program at all levels. The language of undergraduate instruction is Danish, but English will be accepted.
Applications should indicate which type of position they are interested in, any number is possible. They should also include a *curriculum vitae*, a complete list of publications, copies of scientific publications, and further documentation which the applicant wishes to have considered. Information about teaching experience should alse be enclosed. The material should be submitted in triplicate and should contain a full listing of the items submitted. After evaluation of the applicants' qualifications by a specially appointed Evaluation Committee, its report will be sent to all applicants. The Evaluation Committee may ask for supplementary material, which the applicant then must provide in the requested number of copies.
Information about research plans, facilities and staff may be obtained from Professor Jørn Dines llansen, Niels Bohr Institute, Blegdamsvej 17, DK - 2100 Copenhagen Ø,Denmark; telephone : +45 35325293, fax +45 31421016, E-mail : dines@nbivax.nbi.dk
If no suitable applicant is qualified at the level of associate professor the position will be filled at the level of assistant professor or, if not possible, at the research assistant level. The position will be limited to 2 years if given as a research assitant position, otherwise maximally to 5 years. It will be under a contract as agreed between the Confederation of Professional Unions and the Ministry of Education. The annual salary depends on seniority and ends for associate research professor at a maximum of 340.091 DKK after contributions to the pension scheme, but before tax.
Applications should be made to Acceleratorudvalget, attn. Ms B. Sode-Mogensen, written in English, and mailed to the Ministry of Research, H.C. Andersens Boulevard 40, DK - 1553 Copenhagen V, Denmark. Applications must be received no later than August 15, 1994.

Max-Planck-Institut für Physik (Werner-Heisenberg-Institut) München, Germany

We invite applications from PhD graduates for a postdoctoral position in

Experimental High Energy Physics

The initial appointment is made for two years with the possibility of renewal for up to a total period of five years. The position is available now.
Our group has been engaged in the design and construction of the H1-detector and is actively participating in the data taking at the HERA e-p collider.
We expect that the person appointed will participate in the installation and operation of a neural network trigger for the H1-detector as well as in the exploitation of its physics potential. The location of work will be both at Munich and at the experiment at DESY in Hamburg.
For full consideration, applications must be received by July 31, 1994. Candidates should submit a curriculum vitae and arrange for three letters of recommendation to be sent to:

Prof. G. Buschhorn
Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)
Föhringer Ring 6
D - 80805 München
Germany
(BITNET: GWB@DMUMPIWH)

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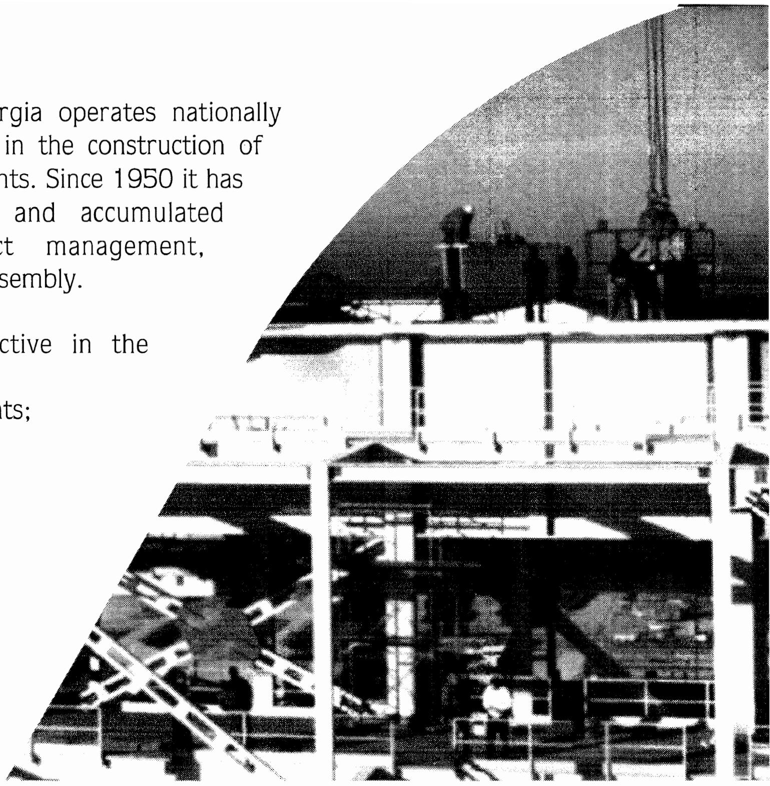

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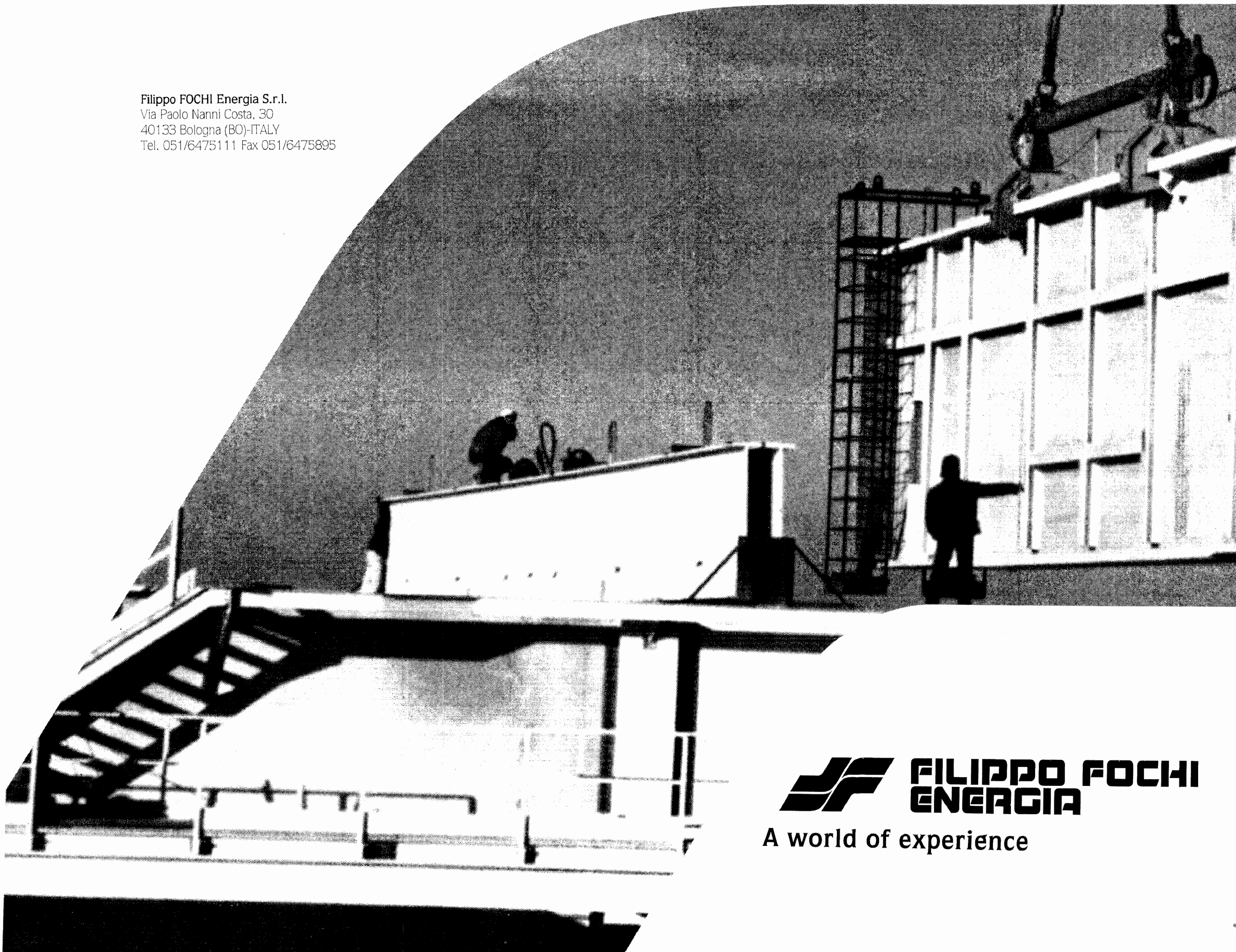

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