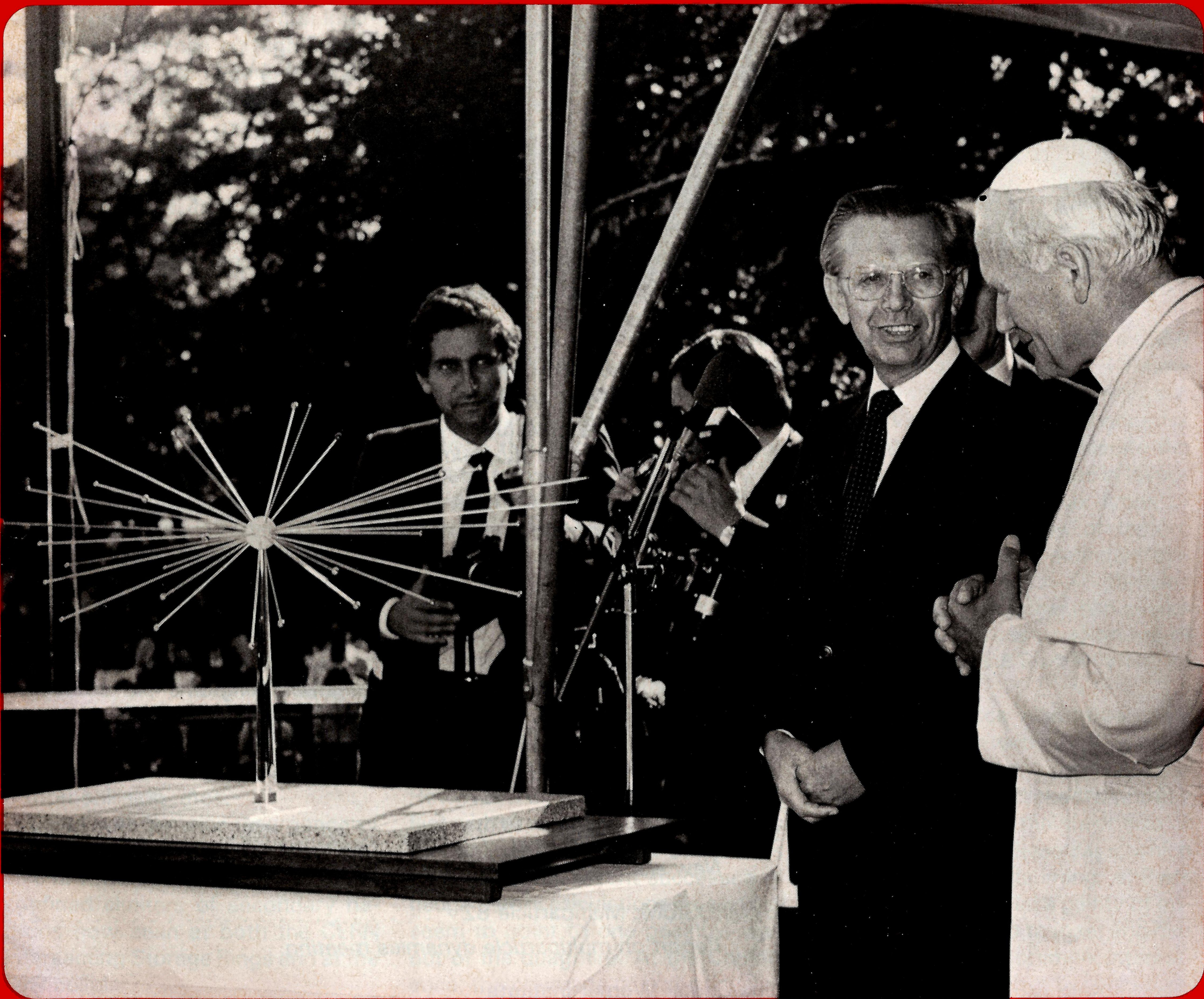
CERN COURIER



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CERN COURIER

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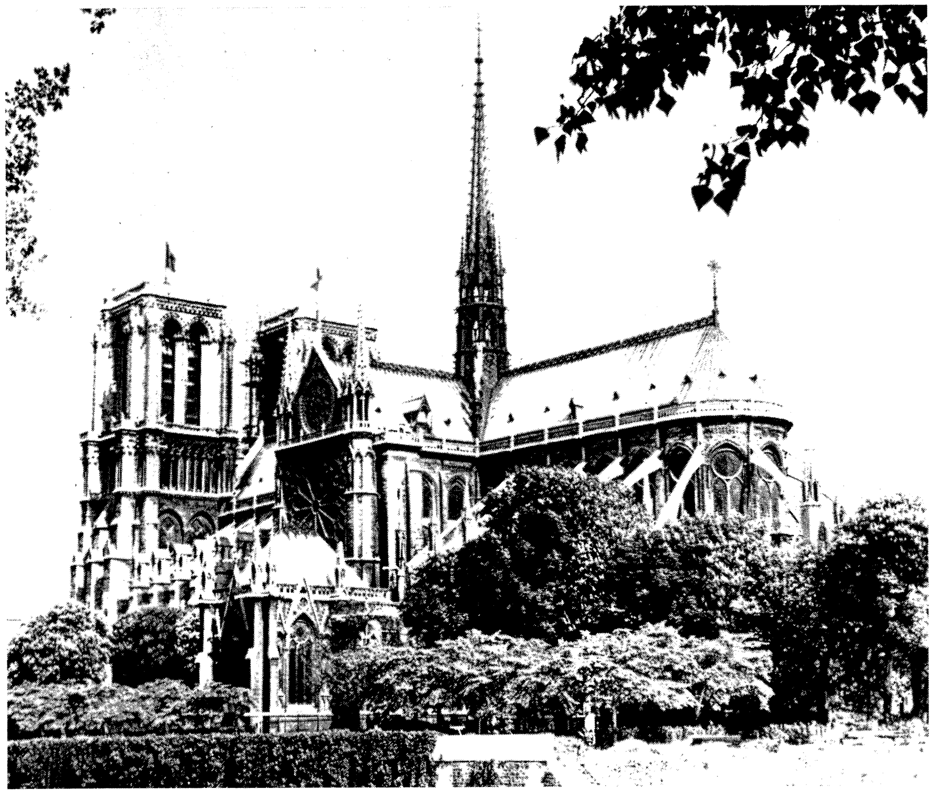
VOLUME 22 N° 7 SEPTEMBER 1982

Cover photograph: During the visit of Pope John Paul II to CERN on 15 June, Director General Herwig Schopper presented him with a representation, made in the CERN workshops, of a high energy proton-antiproton interaction such as is now seen in the SPS collider. The Director General remarked that such phenomena are believed to have been prevalent during the origins of the Universe, a period of vital interest to both science and religion (Photo CERN 218.6.82).

Paris Conference



While this issue was being prepared to go to press, the twenty-first International Conference on High Energy Physics took place in Paris from 26-31 July. Although no unexpected major new discovery was announced, a wealth of new results, data and ideas was presented.

This was the first major international physics meeting to hear detailed results from the newly available 540 GeV record collision energies at CERN's SPS proton-antiproton collider. These energies were previously attainable only in cosmic rays. A plenary session was given over to the physics results from four experiments. These appear to be largely consistent with the cosmic ray findings. A major exception is the unexplained very high charged multiplicity cosmic Centauro phenomenon, which has yet to be found under SPS collider conditions. Comparison of collider results with lower energy data makes for interesting insights. Of course the amount of data recorded by these experiments is still very limited and more advances could result from higher proton-antiproton collision rates.

There was a major resurgence of interest in jet physics, with impressive new evidence for production of confined clusters of secondary hadrons now seen at both the CERN Intersecting Storage Rings and at the SPS collider.

The implications of proton decay, predicted by lofty theoretical aspirations to extend the unification of Nature's different forces, were much discussed. The experimental searches for proton decay, big passive experiments mounted deep underground, now provide an interesting contrast to the conventional experimental scene at the major accelerator centres. More candidate proton decay events were reported, this time from the newly commissioned detector in the Mont-Blanc tunnel as well as the Kolar Gold Fields experiment in India, which reported its first proton decay candidates last year.

While the possible magnetic monopole signal observed recently at Stanford was not reported directly, there was much talk of the continued search for these long predicted magnetic charges. No signals have been seen in other experiments. An idea for proton decay to be catalysed by magnetic monopoles was much discussed in theoretical circles.

Quantum chromodynamics, the candidate theory of quark and gluon interactions, is still labouring uphill. However the theory is not yet in conflict with experiment, even though its predictive power might sometimes be limited. The recent successes of gauge theory calculations on a lattice seem to point to one possible way out of the quagmire. At the Conference, the coverage of non-perturbative QCD was less than initially advertised because of the inability of A. Polyakov to attend.

In mainstream physics, results from electron-positron annihilation and from fixed target experiments with lepton and hadron beams are largely in agreement and generally well understood, although a few corners remain to be tidied up and some explanations found.

The spectroscopy of new particles is filling up nicely, thanks in particular to the experiments at Cornell's CESR electron-positron ring. Lifetime measurements too are converging. There is still no direct evidence for the sixth quark flavour, despite the accumulation of confidence in favour of a theory based on six types of quark and three types of lepton. There is not yet any definitive evidence for glueballs — particles made up of gluons rather than quarks — although there is no shortage of candidate particles from a variety of experiments.

The Conference was impeccably organized. Even with 1200 participants and up to five parallel sessions, everything clicked smoothly into place. Despite the sheer size of this biennial event these days, which many people find daunting, at Paris there was nevertheless plenty of opportunity for people to meet and discuss matters of common interest. As well as the physics presentations, there were sessions on detectors and new machines, poster displays and much, much more. A fuller report of the Paris Conference will be published in our October issue.

(Photo G. Bertin)

The Pope comes to CERN

The Pope addressing CERN staff and their families and many distinguished visitors on the lawn outside the Administration Building.

(Photo CERN 220.6.82)

CERN unaccustomedly bathed in the full glare of international publicity on 15 June when Pope John Paul II chose to include the European Laboratory for Particle Physics on his schedule during a long-awaited visit to Geneva. Closely following his special mission to Argentina during the conflict in the South Atlantic, the Supreme Pontiff's visit to Geneva was arranged around the 2000-delegate International Labour Conference at the Palais des Nations, sponsored by the International Labour Organization.

After arriving at Geneva airport at 8.45 in the morning, John Paul delivered a memorable speech to the Conference. He then embarked on a specially arranged programme which continued almost non-stop right into the evening. During the day, the Pope made a number of speeches, including one at CERN. Each speech touched on a serious issue of vital concern.

His visit was a moment of particular pride for CERN, as Geneva is the home of many other organizations which at first sight could appear more suitable for a papal visit. CERN Director General Herwig Schopper had discovered the Pope's interest in science some time before, when John Paul had addressed a meeting on science and religion in Cologne.

The Geneva visit had in fact been scheduled for 1981, but was postponed after the ugly assassination attempt in St. Peter's Square last year. A papal visit now has to contend with elaborate security precautions, and CERN was no exception. For weeks, the areas of the Laboratory where he was to visit had been the scene of careful preparations to contend with both the papal contingent and the attendant throng of journalists and security men. The Geneva police were responsible for security throughout the visit.

After an afternoon visit to the headquarters of the International Red Cross, the papal Mercedes saloon, flanked by police motorcyclists, swept into the Laboratory entrance at 4.45. John Paul II was greeted by the Director General and representatives of CERN management and of host state (France and Switzerland) authorities. The Pope then embarked on a special tour of the Intersecting Storage Rings, a machine which has produced interesting physics over many years. As well as seeing the ISR installations, he was shown some examples of CERN's technological achievements and was given a short briefing on the LEP project.

At about 5.30, with live television coverage on Swiss TV and speaking in French, he addressed CERN staff, their families, and distinguished visitors assembled on the lawn in front of the Administration Building. In his speech at CERN (a large extract of which is reproduced here), John Paul made some incisive observations on the mutual roles of science and faith in the world today.

The atmosphere at CERN contrasted with the Pope's formal engagements earlier in the day. While elsewhere there had been severely restricted audiences, the atmosphere at CERN was relaxed and homely. The Swiss TV commentator compared the occasion to a 'garden party'. Trying to minimize the public impact of the security arrangements which had been made, the Pope chose to embark on a mini 'walkabout' so that he could be seen by as many people as possible, some of whom had been patiently waiting for several hours for a glimpse of the pontiff. Proud mothers held their young children over the security barriers as he passed.

At about 6 p.m., the Pope got back in his Mercedes and left for a special mass at the vast new Palais des Expositions (Palexpo) next to Geneva airport. The special traffic arrangements meant that the only way to get from CERN to the Palexpo mass in time was to get a ride with the papal party. The Pope had therefore closed his visit to CERN with a special benediction.

Unused to the protocol of such a high level visit, the large team at CERN which had made the painstaking preparations collectively breathed a sigh of relief when it was realized that everything had gone according to plan. However together with the many hundreds of people who had braved the security arrangements to get a first hand glimpse of the Pope, they were left with an indelible memory of the warmth and strength of conviction of their most distinguished visitor.

Speeches

The Pope was welcomed by Director General Herwig Schopper:

'Your Holiness, your presence is a singular honour and a great privilege for the Organization. It is with a particular sense of gratitude, on behalf of CERN, the CERN Council, the Member States and all those who work at the Laboratory either as members of the staff or as visiting scientists, that I warmly and respectfully welcome you to our midst.

All of us are aware of your tireless efforts in establishing contact with men of all conditions: those who toil, those who suffer and those who strive for peace. We have gathered to welcome you, our minds seeking to grasp the deep significance of your visit.

I believe that I am right in regarding your presence as proof of your desire to foster a new relationship between religion and science. Although preoccupied with different aspects of reality, religion and science are nevertheless united by their common pursuit of truth and represent the noblest aspirations of human endeavour. For centuries, however, relations between the Church and men of science were strained and sometimes deteriorated into open hostility. Subsequently, there developed a degree of mutual tolerance which resulted in a period of relative truce, but misunderstandings remained. Today both the Church and the scientific community recognize the need for a far-reaching dialogue in order to create new and fruitful opportunities for mankind.

The time now seems ripe for a dialogue of this kind since it is becoming steadily clearer that objective reality, which Galileo and Newton postulated as the basis of the exact sciences, in no way excludes the existence of a transcendent reality experienced through faith. Both realities can, in fact, coexist. Indeed, current research work in connection with the smallest structures of matter indicates that physical phenomena, the laws of nature and the order of the material universe which they disclose imply an abstract and transcendental interpretation of being rather than purely materialistic.

The task of CERN is to foster the development of physics research as a pure science and to ascertain the fundamental laws governing the existence of the material world. With its complement of some 2300 research workers from all corners of the planet and its own staff, CERN is the largest international laboratory in the world and the supreme symbol of how science can unite humanity and transcend barriers. The Organization is particularly proud to have been chosen as the place from which you address the scientific community as a whole. The impact of your words will extend far beyond the confines of this establishment.'

His Holiness Pope John Paul II

'I would like to thank you for the welcome you have given me. The wonders you have shown and explained to me, in so far as I could understand them, have given me a better idea of what has been CERN's main task for almost thirty years. More than two thousand scientists from a hundred and forty universities or national laboratories come here to use installations for particle physics research which could never have been provided from the national resources of the individual Member States. CERN is therefore the main European centre devoted to fundamental research into the composition of matter and is one of the largest laboratories in the world in this field.

You are, above all, research workers. As scientists and technicians you work together for a cause beyond any selfish interest, that of pure research, whose sole purpose is to further scientific knowledge. To do this, you need the instruments capable of reaching very high energies that are available to you here, namely the particle accelerators and the intersecting storage rings. But your guiding star is your passion for discovery.

I should like to emphasize the special features of the working atmosphere at CERN — the wide participation, the attitude of co-operation and the openmindedness. They are a great credit to your Organization. Even the site of your laboratory is symbolic, lying as it does across the frontier between French and Swiss territory. You also welcome scientists from East and West, from countries with very different political outlooks. You all work together as a team, serving the same field of research, and this gives your work a truly international dimension. One of science's greatest merits can be seen here in action — its power to unite men.

Let me dwell on the specific nature of the research in which you are engaged. It aims to explore in increasing detail the basic structure of matter, what may be called the infinitely small, at the frontier of what can be quantified in the microcosm; atoms, electrons, nuclei, protons, neutrons, quarks... In short, you are attempting to decipher the secrets of matter, its composition, its fundamental energy. That is why not only all scientists but also all thinking people who reflect on these problems and all mankind, are interested or at least concerned — it is after all part of their own mystery that is being revealed.

I say 'part', for in the face of the immensity and complexity of what remains to be discovered, you are, as genuine scientists, filled with humility. Is matter made up of fundamental indivisible components? What forces govern their interaction? The answers to these questions seem to retreat as you advance.

Furthermore, these questions raise other questions yet more fundamental for the sum of human knowledge, on the frontiers of the 'exact sciences', the natural sciences, or even beyond, in the realms of philosophy. Your research pinpoints these questions to be put to philosophers and the faithful: What is the origin of the universe? Why do we find order in nature?

There was a time when some scientists were tempted to take refuge in an attitude imbued with 'scientism', but that was a philosophical choice rather than a scientific attitude, as it tried to ignore other forms of knowledge; this tendency now seems to belong to the past. The majority of scientists admit that

The Pope with Director General Herwig Schopper and Vice-President of CERN Council U. Vattani (right) during a visit to the Intersecting Storage Rings.

(Photo CERN 555.6.82)

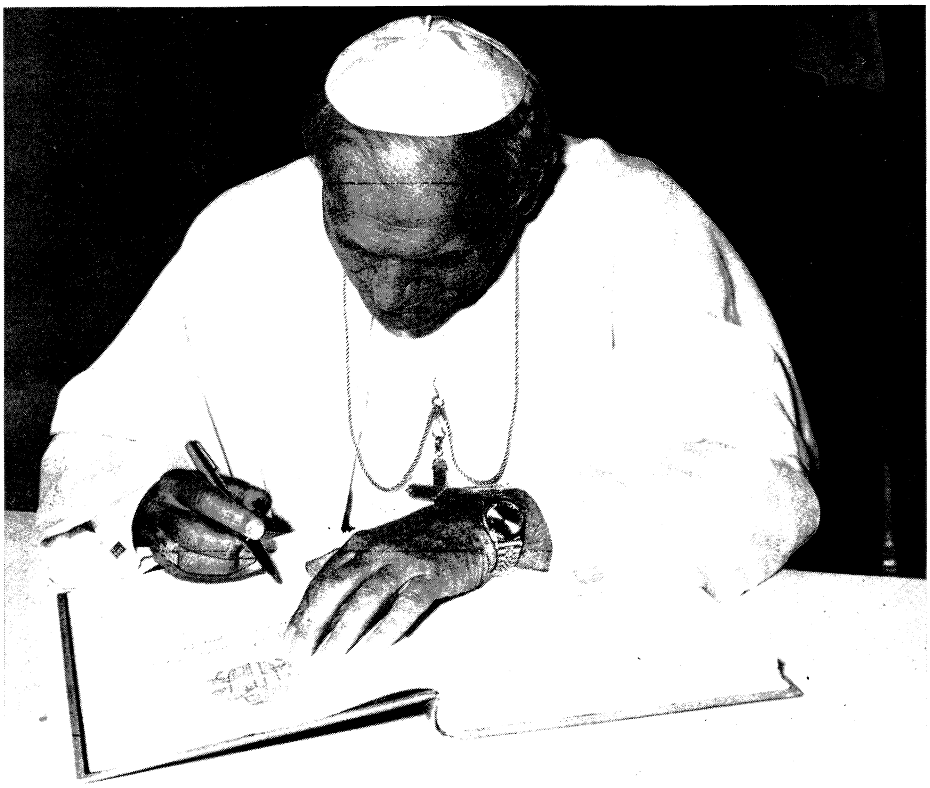
the natural sciences and the scientific method based on experiments, whose results can be repeated, cover only part of reality or rather reflect a particular aspect of it. Philosophy, art and, above all, religion which is knowingly inspired by a transcendental revelation, perceive other aspects of the reality of the universe and of mankind. Pascal spoke, in another sense it is true, of three orders of greatness in man, the greatness of power, the greatness of intelligence and the greatness of love, each infinitely exceeding the other, and specified as their beginning and end that Other who is the Creator, Father of all men, for 'man is infinitely more than mere man'.

You too demonstrate the greatness and mystery of man. The greatness of his power of investigation, his reason, his capacity to attain greater truth, his will to commit himself selflessly to a long and disinterested quest. You demonstrate his mystery too. But perhaps the awe-inspiring novelties of pure research into the nature of matter are less important finally than the poignant novelty of man's attitude and his feeling of insignificance beside these discoveries. How different is the scientific picture of the world to-day from that of our fathers, and that of their predecessors in the great human community. At the same time, let me as a believer simply say what continuity there is in God the Creator's design who made man 'to His own image and likeness', giving him 'dominion' over the whole world which he created out of love and at which the author of the first book of the Bible, Genesis, never ceases to marvel: 'God saw all the things that He had made and they were very good' (Genesis 1,4).

As physicists, you have to use your energy and skill according to the

The Pope signs the CERN 'livre d'or', specially decorated with the papal insignia for the occasion.

(Photo CERN 197.6.82)



scientific methods of the natural sciences. As men, you cannot avoid asking yourselves these other fundamental, existential questions to which I have referred and which are answered by the wisdom of philosophy and faith. I hope that you also do research in this area, for, as you know, these fields are not opposed to each other but rather coexist in harmony. I would have you be receptive to the fullness of truth.

Love of truth, sought with humility, is one of the great forces capable of bringing the men of today together across the different cultures. Science is not opposed to humanism or mysticism. All genuine knowledge opens the way to the essence of life and all truth can become universal. Accordingly, I have recently established in Rome a Papal Cultural Council, in the belief that this fundamental reality unites mankind, and it was my explicit wish that the Council should be open to all scientists and all research centres. You can understand how pleased I am that CERN is open to all those who wish to take part in its research, even if they are not members of its staff. True research, like culture, builds up human communities regardless of frontiers.

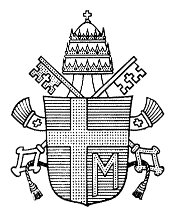
Let me in conclusion refer to the possible applications of your research even if they are not directly connected with your work, your responsibilities and the purpose of this laboratory. History has shown that the discovery of new phenomena leads in time to wondrous applications that are often completely unexpected. Your Member States and their governments and technicians already no doubt follow your research with an interest that is all the greater because they anticipate exploiting them intensively sooner or later. What applications can be expected to stem from the knowledge of the structure of the atom and the possibility of its decomposition?

Men may use their knowledge for better or for worse. The best use will be to serve mankind and its development, in the fields of health care, food resources, sources of energy and protection of the environment. The worst use would be the destruction of the ecological balance, the creation of dangerous levels of radioactivity and, worst of all, the production of instruments of destruction which in power and quantity are already exceedingly dangerous.

We are faced with a great moral challenge — we must harmonize the forces of technology, born from science, with the forces of conscience. 'Conscience must be mobilized!' The cause of mankind will be served if science and conscience go hand in hand. In other words, great attention must be paid to how man uses these discoveries, and his motivation when making the choice.

The Church has spoken often enough of the danger of atomic weapons so I shall not dwell on this subject here. However, even when nuclear energy is used for peaceful purposes the Church hopes, together with so many men of good will, that all the implications of nuclear energy will be fully studied – for instance, the impact with regard to radioactivity, genetics, pollution of the environment, storage of nuclear waste — that the safeguards will be rigorous and that the public will be adequately informed on these problems. The Holy See has a permanent representative at the International Atomic Energy Agency in Vienna in order to make plain its interest in the peaceful and safe use of nuclear energy.

That is not your direct responsibility. However, you are more aware than others of what is at stake and consequently it behoves you particu-



Sa Sainteté Jean-Paul II
mardi 15 juin 1982

Joannes Paulus PP. II

larly to spread information on these matters and above all to inform those responsible for the technical applications, urging them to ensure that the results of scientific research, however remarkable they may be, are never turned against man and are used only for the common good by men and women inspired with the greatest love for mankind.

In conclusion I want to make a wish. It is that scientists in their profession may be constantly aware of the transcendence of mankind in the world and of the transcendence of God over man, and that their actions may be guided by their awareness of the universal significance of their own discipline and the universal significance of brotherly love, a yearning for which was instilled in us particularly by Jesus. I would like to repeat the appeal I made at UNESCO: 'Yes, the future of man will depend on his culture! Yes, world peace will depend on the predominance of the spirit! Yes, peace for man in the future will depend on love.'

Reply by U. Vattani, Vice-President of CERN Council

'We who are associated with this Institution, whose purpose it is to conduct scientific research of a strictly peaceful nature, have followed your message with the greatest interest, based as it is on the view that science is 'one of the paths to follow in the disinterested search for truth'. This indeed is the aim to which physicists are steadfastly dedicated and in CERN's laboratories is transformed into daily reality.

That is why everyone was so moved by the way in which you have presented and analysed these ideas, and we feel particularly honoured that you should have chosen CERN as the place from which to broadcast your message to the world. On behalf of all those present, on behalf of the Laboratory, its staff, its Council and its Member States, I have the honour to express to you our deep gratitude. All of us — physicists, engineers, technicians, administrators, diplomats and politicians alike — have reaped great benefit from your words as well as strong encouragement to pursue our collective research activities in a spirit of quiet conviction and humility.'

Physics in collision

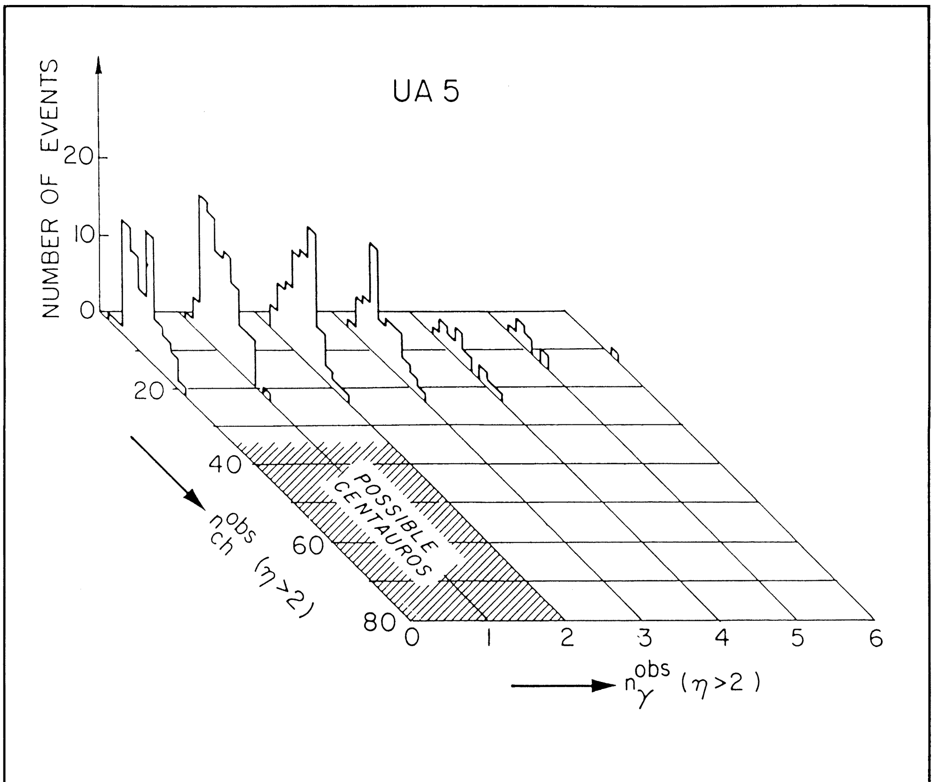
The 2nd international conference 'Physics in Collision' took place in Stockholm from 2—4 June. Some 160 delegates from all over the world gathered together to learn and to discuss about the most recent results from proton-proton, proton-antiproton and electron-positron colliders. The first conference in this series was held in May 1981 in Blacksburg, Virginia, and next year's meeting is scheduled for Lake Como, Italy.

The importance of basic fundamental research was stressed by Jan-Erik Wikström, Swedish minister of education and cultural affairs, in his opening address. It is sufficient to state, said Mr. Wikström, that the quest for knowledge of the structure of matter is part of our culture and thus pure science is an inevitable part of cultural activities. He could also promise to Swedish scientists an increase of the support of basic science for the next fiscal year.

Hard scattering processes, in which two constituents scatter or interact, was the subject of the first talk by Norman McCubbin. Recent results from the CERN Intersecting Storage Rings were reviewed. It has recently become possible to study proton-antiproton interactions at the ISR and a comparison with proton-proton interactions was made by Maurice Jacob. Differences on the few percent level are expected and observed for the dominant hadronic features. More sizable effects are expected to show up when the luminosity is increased enough to study lepton pair production, elastic scattering etc.

Much time was devoted to the most recent results from the experiments at the CERN SPS proton-antiproton collider. Although no new data has been taken since last December, substantial progress has been made in the analysis of the

Presented at the Stockholm conference were these results from the UA5 experiment at the CERN SPS proton-antiproton collider. For selected events (pseudorapidity greater than 2), the observed charged particle multiplicity is shown for different numbers of produced photons. The region which would be populated by Centauro events (many charged particles and few photons) is shown shaded, showing that no Centauro behaviour is seen at 540 GeV.



different experiments. Martti Pimiä summarized the status of the UA1 experiment and showed that the transverse momentum spectrum of charged hadrons follows closely theoretical predictions up to 10 GeV (see June issue, page 178). Qualitative agreement has been observed with cosmic ray experiments in that the transverse momentum spectra are steeper for events with lower multiplicity. Correlations are observed, both of long and short range.

The UA2 data was presented by Peter Jenni. Inclusive eta meson production at 90° was estimated to be 0.55 that of neutral pions, and no significant signal of direct photons was observed. Preliminary data was presented on inclusive charged particle production at 90° as was an upper limit on the production of free quarks.

Working together with the UA2 is the UA4 experiment and their results were presented by Bertus Koene (see also page 271). Antiproton-proton elastic scattering has been measured in the squared momentum transfer range from 0.05 to 0.20 GeV^2 with a behaviour which extrapolates nicely from lower energies. They also gave a first preliminary result on the antiproton-proton total cross-section of 66 ± 7 mb at the newly available collision energy of 540 GeV (see page 271).

David Ward summarized the most recent results from the UA5 experiment. New data were presented on production of photons and of strange particles. The excess of photons over charged particles in the central region can be explained by assuming an eta to neutral pion ratio of about 30 per cent. The inclusive strange particle spectra showed average transverse momenta significantly higher than at lower energies. This could be due to an increase in charm production.

The last talk on collider results was given by Narendra Yamdagni who compared event structure in collider and cosmic ray experiments. One of the most exciting results seen in cosmic ray experiments is the so-called Centauro phenomenon, events in which a large number of secondaries are produced but with no or very few photons. The results obtained so far by the UA5 experiment show no evidence for such phenomena at 540 GeV. One may speculate that the threshold for the production of such strange events has not yet been reached.

J. D. Bjorken started the second day's talks by trying to answer 'what have we learnt about hadronic interactions from colliders and cosmic rays?'. He stressed the importance of measuring jets at the collider and indicated the possibility of observing quark-gluon plasma in collisions between uranium nuclei.

The production and decays of states containing heavy quarks were covered in two talks. Lucien Montanet reviewed heavy flavour production in hadronic collisions. A large number of experiments aim at detecting both charmed states and open beauty. Results from electron-positron colliders on the decays of heavy flavour states were reviewed by Thomas Ferguson. With the increasing statistics available on D-mesons, a number of branching ratios have been measured and compared with theories. Semileptonic decay of the charmed lambda baryon has now been seen. The calculated lifetime of B-mesons, containing one beauty quark, is even shorter than that for charmed mesons, less than 10^{-13} s, and only upper limits are available. Semileptonic and more exotic decays were reviewed.

A review of two-photon physics

was given by Susan Cooper. In her conclusions she stressed that this particular field is alive and doing well at electron-positron rings. In particular, the first results on the photon structure function are very successful. In addition to the well-established particle states made up of quarks, there may exist pure gluon bound states, usually called gluonia or glueballs. Experimental evidence for such states were reviewed by Elliott Bloom. Two possible states are the iota (1440) and theta (1640) and preliminary results were given.

Murdock Gilchriese presented new results on the physics on the upsilon region. The new results presented were on a search for new narrow states, leptonic branching ratios, and hadronic and electromagnetic transitions between different upsilon states. The importance of increasing the luminosity of the electron-positron machines was stressed. A review on electroweak effects in electron-positron reactions by Beate Naroska ended the second day. She concluded that the presence of weak neutral currents is clearly established in annihilation into muon pairs, with dominance of the axial vector coupling, whereas the situation is less clear in the experimentally more difficult annihilation into tau pairs.

The last day was mostly devoted to jets, with results from PEP and PETRA and a theoretical review. Horst Oberlack reviewed jet studies at PETRA and could report on a small average charge carried by jets in two-jet events, on four-jet production and that the present estimate of the strong coupling constant somewhat depends on the type of fragmentation model used. Jonathan Dorfan reported that data taken so far at PEP has been with a total collision energy of 29 GeV. Most data has been taken with the Mark II detector. The talk included discussions of scaling violations, energy correlations, heavy quark fragmentation and results on the tau lepton.

Bo Andersson, in his review on jet fragmentation, pointed out that the experimentalists do not see partons but 'big fluffy hadrons', and one should compare angular energy flow on the partonic and the hadronic level. The concluding lecture 'Is there a desert behind mountains' was given by Chris Llewellyn-Smith, who pointed out that the present arguments for a desert, with no new physics between currently available energies and approximately 10^{14} GeV, rest on a tower of untested — but appealing — ideas. There are many alternative theories which predict instead a lot of new physics.

(Report by Per Carlson. Some more recent physics results were subsequently presented at the Paris meeting. A detailed report will follow in our October issue.)

The second international 'Physics in Collision' conference held in Stockholm from 2—4 June coincided with the celebrations for Gösta Ekspong's 60th birthday. He came from Uppsala to the newly created chair in physics at the University of Stockholm in 1960. He is a frequent visitor to CERN, where his duties have included being Chairman of the Scientific Policy Committee (1972—74).

A line-up of speakers at the recent Stockholm 'Physics in Collision' conference: left to right, B. Andersson, J. Dorfan, N. Yamdagni, P. Jenni, S. Cooper, D. Ward, M. Pimiä, C. Llewellyn-Smith and L. Montanet.

(Photo Sten Hellman)

Around the Laboratories

CERN
More 540 GeV proton-antiproton results

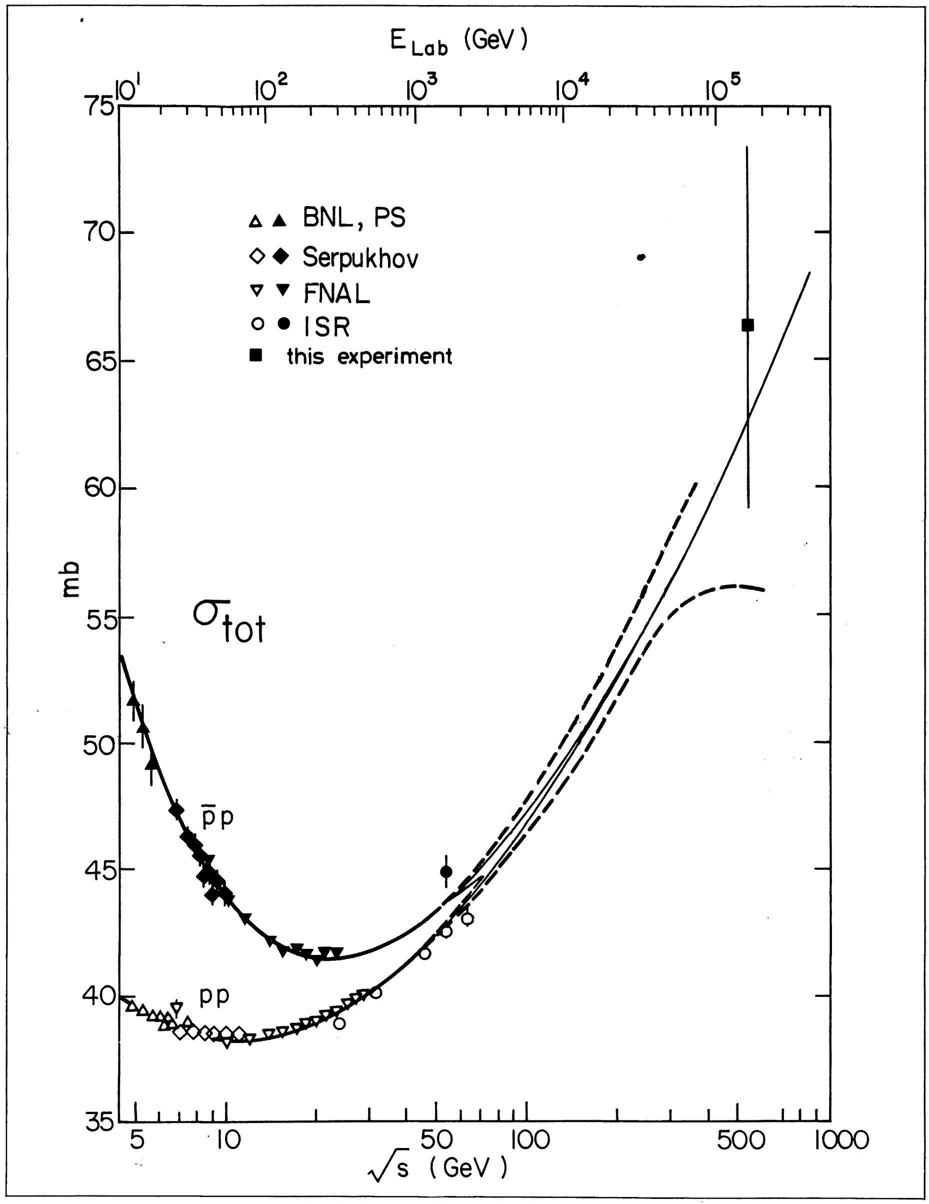
While the experiments at the SPS proton-antiproton collider hope to find bigger fish, routine measurements of the elastic scattering of protons and antiprotons provide a valuable insight into the general behaviour of the proton (and antiproton) at these newly available energy levels.

After its initial survey of particle production, the UA5 streamer chamber was removed from the underground 'cathedral' at LSS4 to make way for the UA2 spectrometer. This intersection area is also the home of the smaller UA4 experiment (Amsterdam / CERN / Genoa / Naples / Pisa). Unlike the bigger general-purpose detectors, UA4 is a dedicated experiment to measure elastic and inelastic interactions using detectors housed in narrow forward cones, complemented by information from the inner detector of UA2.

The forward UA4 detectors for elastic scattering exploit the 'Roman Pot' technique, used so successfully at the Intersecting Storage Rings to make a similar study of small angle elastic scattering in a new energy region. In this technique, detectors are mounted inside moveable sections of the beam pipe so as to intercept the narrow cone of slightly deflected (low momentum transfer) particles. The UA4 Roman Pots were made by the Experimental Areas Group of SPS Division. UA4 measures forward inelastic scattering with the help of specially constructed drift chamber telescopes.

First UA4 results, coming from data taken in the first SPS collider runs late last year, cover elastic scattering in the squared momentum transfer range 0.05 to 0.19 GeV^2. Elastic scattering in this kinematical range is characterized by a 'b parameter' which gives the observed exponential falloff, and is proportional to the square of the effective size of the colliding particles. The parameter increases from 13 GeV^{-2} at the maximum energies available at the Intersecting Storage Rings (the highest previously attainable laboratory energies) to 17 GeV^{-2}, and shows that the proton (and antiproton) are getting bigger at these newly available energies.

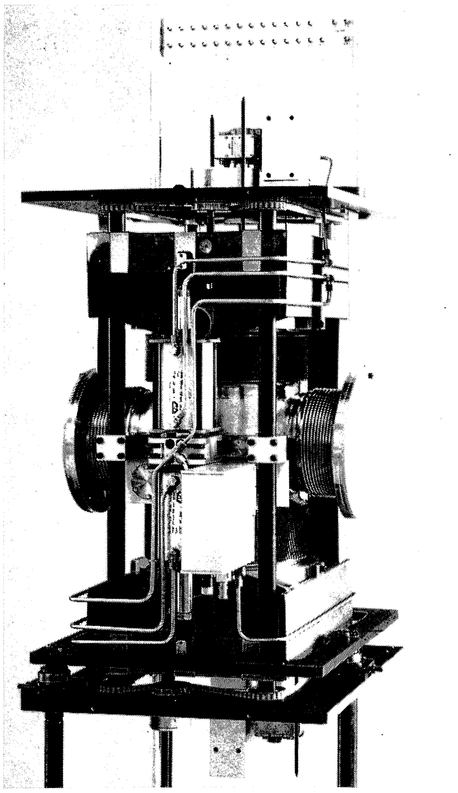
In addition, the UA4 experiment is able to provide a first indication of the total proton-antiproton reaction rate (cross-section) in this newly available energy range. This is done by making simultaneous measurements of the elastic and inelastic reaction rates. The so-called 'optical theo-



Total reaction rate (cross-section) of proton-proton and proton-antiproton collisions plotted against collision energy. On the extreme right is the new result from the UA4 experiment at the CERN SPS proton-antiproton collider, showing how the cross-section continues to increase with energy.

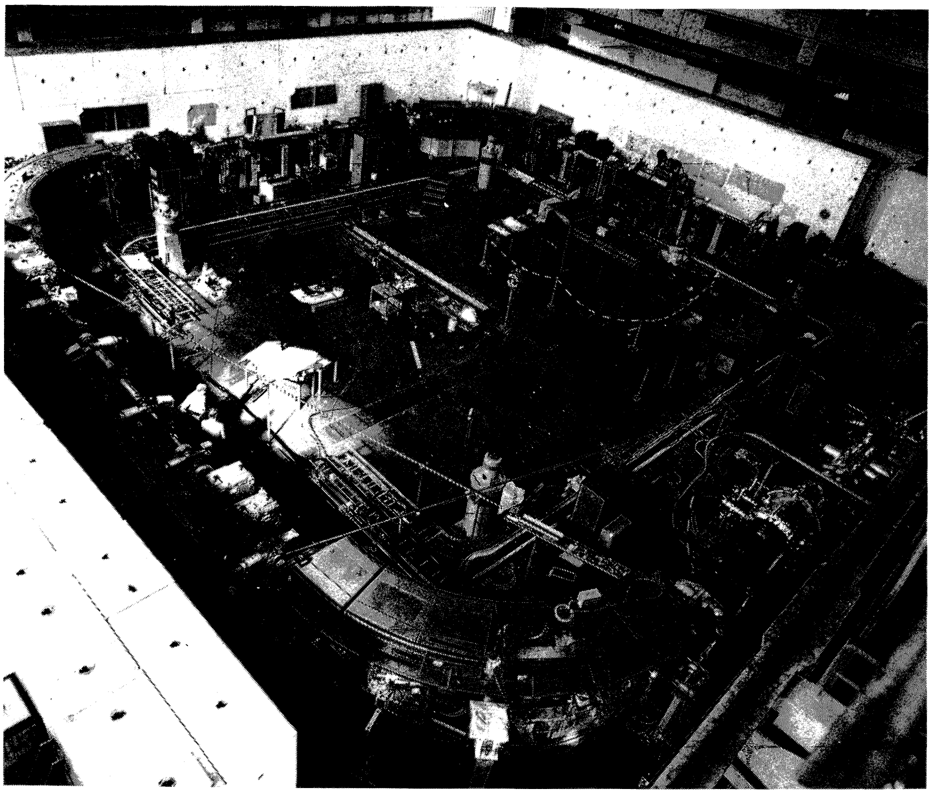
The apparatus of the UA4 (Amsterdam/CERN/Genoa/Naples/Pisa) experiment at the SPS proton-antiproton collider. This uses the 'Roman Pot' technique so successfully exploited for measuring small angle elastic scattering at the CERN Intersecting Storage Rings. Left and right are the flanges for connection to the SPS beam pipe. Above and below are the pots and the mechanism to move the detectors towards the beams.

(Photo CERN 15.4.81)



The LEAR Low Energy Antiproton Ring at the CERN PS, which recently had its first circulating beams (of protons). The programme of low energy antiproton experiments should soon get under way.

(Photo CERN 133.7.82)



rem' then enables the total reaction rate to be calculated without knowing the rate of SPS particle collisions (luminosity). Although still preliminary, this data shows that the proton-antiproton reaction rate is still increasing at these higher energies, and fits in with extrapolations from other measurements at lower energies. The obtained values for both the b parameter and the total reaction rate (cross-section) indicate that the size of the proton increases by 15-20 per cent from ISR to SPS collider energies.

LEAR is near

Construction work is now largely complete for the LEAR Low Energy Antiproton Ring, which represents the final phase of CERN's large antiproton project. While the major part of this project is given over to the acceleration of antiprotons, the LEAR ring will slow them down to the 0.1–2 GeV/c range where a wide field of physics remains to be explored in detail.

The LEAR 'ring' is in fact almost square, so as to provide long straight sections for the installation of major items of equipment. Its 80 m circumference is one-eighth that of the neighbouring 28 GeV Proton Synchrotron, and one half of the Antiproton Accumulator (AA) ring. Four sector magnets are placed at the corners of LEAR, with quadrupole doublets in either side, giving long straight sections of 8 m between the doublets. Injection and ejection of antiprotons uses a common septum magnet. The all-metal vacuum system is designed with a view to achieving the same high vacuum levels achieved in the Intersecting Storage Rings (ISR) at CERN. 'Acceleration' is handled by two ferrite cavities. Stochastic cooling equipment has been installed to act on the circulating beams.

CERN's antiprotons are supplied by the AA at 3.5 GeV. This means that the antiprotons destined for LEAR first have to be decelerated to about 600 MeV in the PS. This has already been successfully demonstrated (see June issue, page 179).

Late in July, a first beam of 50 MeV protons injected from the linac was stored in the LEAR ring. The Antiproton Accumulator is undergoing a refit, so no antiprotons were available for these initial tests. LEAR should soon have its first antiprotons.

A wide range of initial experiments has already been approved for fixed target operation at LEAR (see April 1981 issue, page 113). For these initial studies, the decelerated antiproton beams will be extracted. However further options could use co-rotating antiproton and negative hydrogen ion beams, or colliding antiproton and proton beams.

Assembly of the new 12-m Cherenkov counter for the European Hybrid Spectrometer, designed and built mainly by the Junta de Energia Nuclear of Madrid.

(Photo CERN 325.3.12)

Spain rejoining CERN

At the CERN Council Session in June the delegates of the twelve Member States voted unanimously in favour of the reaccession of Spain to the Organization. After ratification of the CERN Convention by the Spanish government and deposition of the 'instruments of accession' with the Director General of UNESCO, Spain will become CERN's thirteenth Member State.

Spain was previously a member of CERN from 1961 to 1968 but withdrew for financial reasons and because there was not a strong enough base of domestic high energy physics research to allow Spanish scientists to make adequate use of the facilities at CERN.

Moves towards re-entry began about two years ago in the context of Spain's determination to increase the national effort in research and development (now running at about 0.04 per cent of the Gross National Product, which is considerably below most other European countries) and Spain's wish for closer integration in Europe.

In the previous era of Spain's membership of CERN a strong experimental physics group was built up at the Junta de Energia Nuclear (JEN) in Madrid. This group is now well equipped with bubble chamber film analysis equipment and is participating in experiments at CERN and DESY (with the Mark J detector). The group participates in three collaborations using the European Hybrid Spectrometer at CERN, having contributed a large forward Cherenkov counter and is building a forward and intermediate hadron calorimeter.

Another group of active physicists is at the University of Valencia. They worked first with emulsions and then with bubble chambers and are now involved in two experiments using the Omega spectrometer at CERN. A third group at the University of Santander works in close collaboration with Valencia and has also been involved in experiments at Berkeley and Fermilab. On the theoretical side an association called Grupo Interuniversitario de Fisica Teorica (GIFT) was set up in 1968 and now involves about 100 physicists (about half of them working on high energy physics problems) in 14 universities. The present total number of experimental physicists is about 40.

The aim is to strengthen the groups at Madrid and Valencia/Santander and to create a group at Barcelona. Other university participants could then be centred on these three strong groups. It is hoped that over about a four year period the expenditure related to the national high energy physics effort in Spain will increase from around 6 million Swiss francs per year to about 16 million while the number of experimental physicists is doubled.

The financial contribution of Spain to the CERN budget will rise to its full amount of 7 per cent over a transition period until 1989. 40 per cent of the Spanish contribution will be used to reduce the contributions of other Member States, while 60 per cent will finance experiments at LEP.

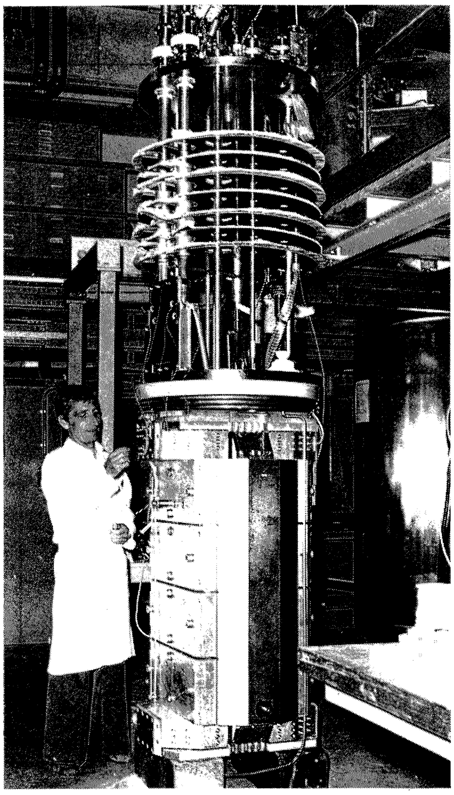
It is a very happy occasion for the high energy physics community to welcome back our colleagues from Spain to CERN and to see European collaboration in science, of which CERN is the finest example, further strengthened.

Looking for vacuum refraction

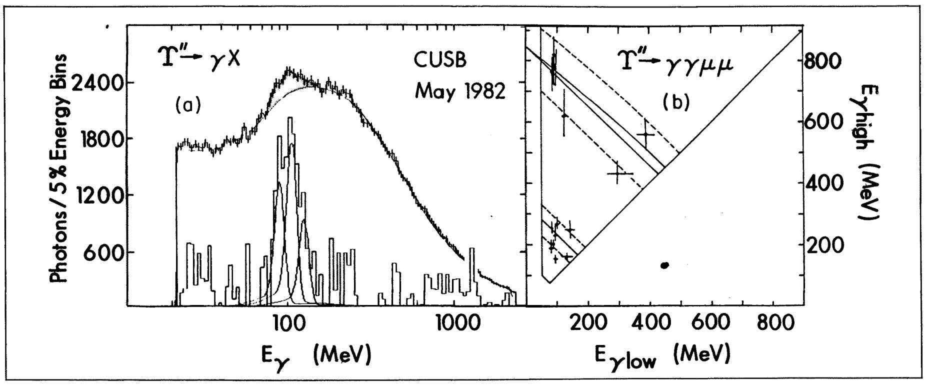
According to classical electromagnetic theory, nothing should happen when light passes through a magnetic field in a vacuum. However this is no longer the case on the quantum

Superconducting dipole which recently attained 7.6 tesla at CERN. A longer version could be used in experiments to look for quantum effects of magnetic fields on polarized light.

(Photo CERN 448.5.82)



Evidence for a new upsilon state from the CUSB detector at the Cornell's CESR electron-positron ring. Left, single photons from radiative decays of an upsilon (3S) show an excess over the expected background. This is due to decays to a new (2P) upsilon state. Right, a scatter plot of the energies of the two photons released when 3S upsilons eventually decay into muon pairs. The data is grouped in two bands corresponding to 3S—2P—2S and 3S—2P—1S upsilon decays.



scale, when photon-photon interactions should make the vacuum doubly refractive (birefringent). A linearly polarized light beam exposed to a magnetic field thus should become elliptically polarized.

However the effect would be extremely small, as the effective refractive indices are only 10^{-21} different from unity. To try to detect these tiny effects due to photon-photon interactions requires a long optical path in a high magnetic field.

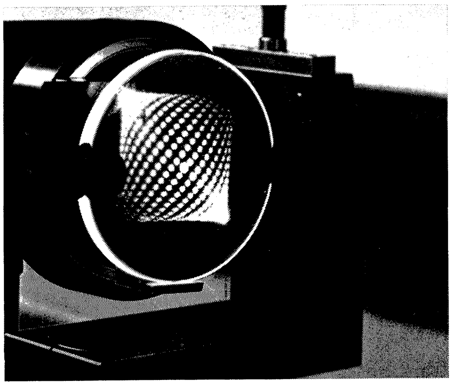
The long optical path can be achieved by a system of mirrors to bounce the light back and forth. These mirrors have to be of extremely high quality to minimize perturbations to the polarized light. The system developed at CERN has demonstrated that the linear polarization of a laser beam can be effectively maintained during multiple reflections to give an optical path length of some 3 km!

To produce the required high magnetic fields, a superconducting dipole magnet has been developed at CERN and has produced a central field of 7.6 tesla. Now this has been demonstrated, work can begin on the construction of a similar, but much longer magnet, for use in the experiment.

The prototype dipole magnet developed at CERN has a bore of 10 cm and overall length 125 cm, and uses niobium-titanium as conductor. The field, thought to be the highest ever attained with this type of magnet, was reached without any training.

The mirror system for the new experiment at CERN to measure the effects of a high magnetic field on the vacuum. By bouncing a laser beam back and forth between mirrors, perturbation-free optical paths of up to 3 km can be attained.

(Photo CERN 314.6.80)



CORNELL
New physics results

The excellent luminosity now available at the CESR electron-positron ring (following installation of mini-beta sections to squeeze the colliding beams) and the features of the two detectors have produced interesting new physics results. In particular, as reported briefly in our July/August issue, the detectors have seen the 'other' charge conjugation upsilons.

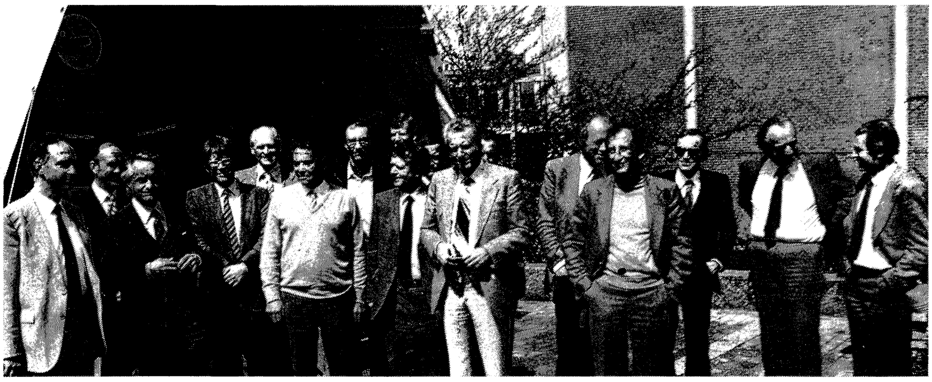
The upsilon particles, discovered at Fermilab in 1977, are understood as heavy (beauty) quark-antiquark pairs. Nowadays most upsilon searches are made in electron-positron annihilation, but the selection rules of these reactions restrict the quark-antiquark configurations which can be produced directly. Other upsilons have to be hunted in the subsequent radiative decays of the parent upsilons. A similar situation occurs with charmonium — charmed quark-antiquark pairs (see March 1981 issue, page 68).

The sodium iodide and lead glass counters of the CUSB detector (Columbia / Stony Brook / Louisiana State / MPI Munich) make for good photon resolution, and so can monitor closely the photons emitted in upsilon decays.

Previously, four upsilon states

Representatives from six countries (Canada, France, Italy, the Netherlands, Norway and the United Kingdom) at a meeting at DESY to discuss international collaboration in the construction of the proposed HERA electron-proton collider. In the background on the left is a mock-up of the HERA tunnel.

(Photo DESY)



were known — three narrow resonances and a wider fourth state which can decay into beauty mesons. All these states consist of a beauty quark-antiquark pair with parallel quark spins and no orbital angular momentum (S-upsilons). However other quark-antiquark states (P-upsilons) should exist carrying one unit of orbital angular momentum. These cannot be formed directly in electron-positron annihilation, but should show up in the radiative decays of S-upsilons. Finding P-charmonium was difficult enough and the lower production rates and higher hadron levels for the heavier upsilon system don't make the hunt for P-upsilons any easier.

P-upsilons have been seen at CUSB using two different techniques. An analysis of the energy spectrum of single photons from 3S upsilon decays shows a net excess over the predicted background, centred around 98 MeV. This signal is interpreted as being due to upsilon transitions from a 3S to a 2P configuration. The photon energy gives the 3S-2P upsilon mass difference.

The second technique involves picking up the two photons from an initial upsilon 3S-2P transition and subsequent decay to 2S or 1S, and a final upsilon decay into two muons. This means that for these events all the particles in the decay chain are observed. The scatter plot of the two photon energies shows two distinct bands, corresponding to photons from 3S-2P-2S or 3S-2P-1S decay chains. The spread and position of the 2P upsilon is the same from the two methods. Meanwhile the two-photon upsilon decays have also been seen by the CLEO (Cornell / Harvard / Ithaca / Rochester / Rutgers / Syracuse / Vanderbilt) group. This experiment has in addition exploited the large solid angle and good momentum resolution of their detector to look at charmed meson production. Theory says that some 40 per cent of the non-resonant hadron production in high energy electron-positron annihilation comes from charmed quarks. A knowledge of how these quarks subsequently 'fragment' into charmed hadrons is vital to further understanding of high energy hadron production. Charmed mesons come in spin zero (D) and spin one varieties (D*), and the CLEO group has measured the production of charged D*s. When complemented by data at other energies, this will provide valuable information on the formation of hadrons from charmed quarks.

DESY
Turning on DORIS-II

During the six months between November 1981 and April 1982, the DORIS electron-positron storage ring was completely rebuilt (see November 1981 issue, page 397).

Originally DORIS was optimized for low energy operation at beam energies below 2.5 GeV. To maximize the space charge limited luminosity at such a small energy, DORIS was built as a two-ring machine with 480 bunches in each ring and two intersection points. After having worked quite successfully for a number of years in this mode, the discovery of the upsilon at Fermilab triggered the first rebuilding of DORIS in 1978: In order to reach the required energies of up to 2 × 5.1 GeV for production of upsilon and upsilon prime particles, DORIS was converted into a single ring with a very much beefed-up r.f. acceleration system and only one positron and one electron bunch. This made it possible for the first time to produce and investigate the upsilon resonance and its first excited level, the upsilon prime, under the much cleaner conditions of an electron-positron storage ring.

But at the upsilon prime, DORIS was at the end of its new range. Magnets originally designed for peak energies of 3.5 GeV saturated so badly, and the power consumption got so large (close to that of PETRA at 18.4 GeV) that a decision was made in March 1981 to 'recycle' DORIS. The main aims were: an energy increase to 2 × 5.6 GeV (so as to reach also the higher excited states of the upsilon and produce beauty mesons); a luminosity increase by at least a factor of 20, mostly through mini-beta interaction regions, a better injection system, and a smoother vacuum chamber to increase instability thresholds; and a drastic reduction of electrical power consumption.

DORIS was turned off on 2 November last year. The tunnel was com-

Posing around the last Fermilab Energy Saver dipole cryostat are prominent members of Fermilab's new Experimental Areas Department, with Department Head Ken Stanfield on the extreme left.

(Photo Fermilab)

pletely emptied and a new machine was built and installed by making use of the old parts wherever possible. After six months of rebuilding, measuring and installing the DORIS magnets, and constructing a new vacuum system, new injection lines, and new r.f. and control systems, DORIS was switched on again on 9 May. After five hours of debugging the beam was successfully stored. First accumulation was accomplished two hours later.

Initial luminosity measurements on 1 August gave a figure of about 4×10^{30} cm^{-2} s^{-1}, higher than that achieved with the old DORIS.

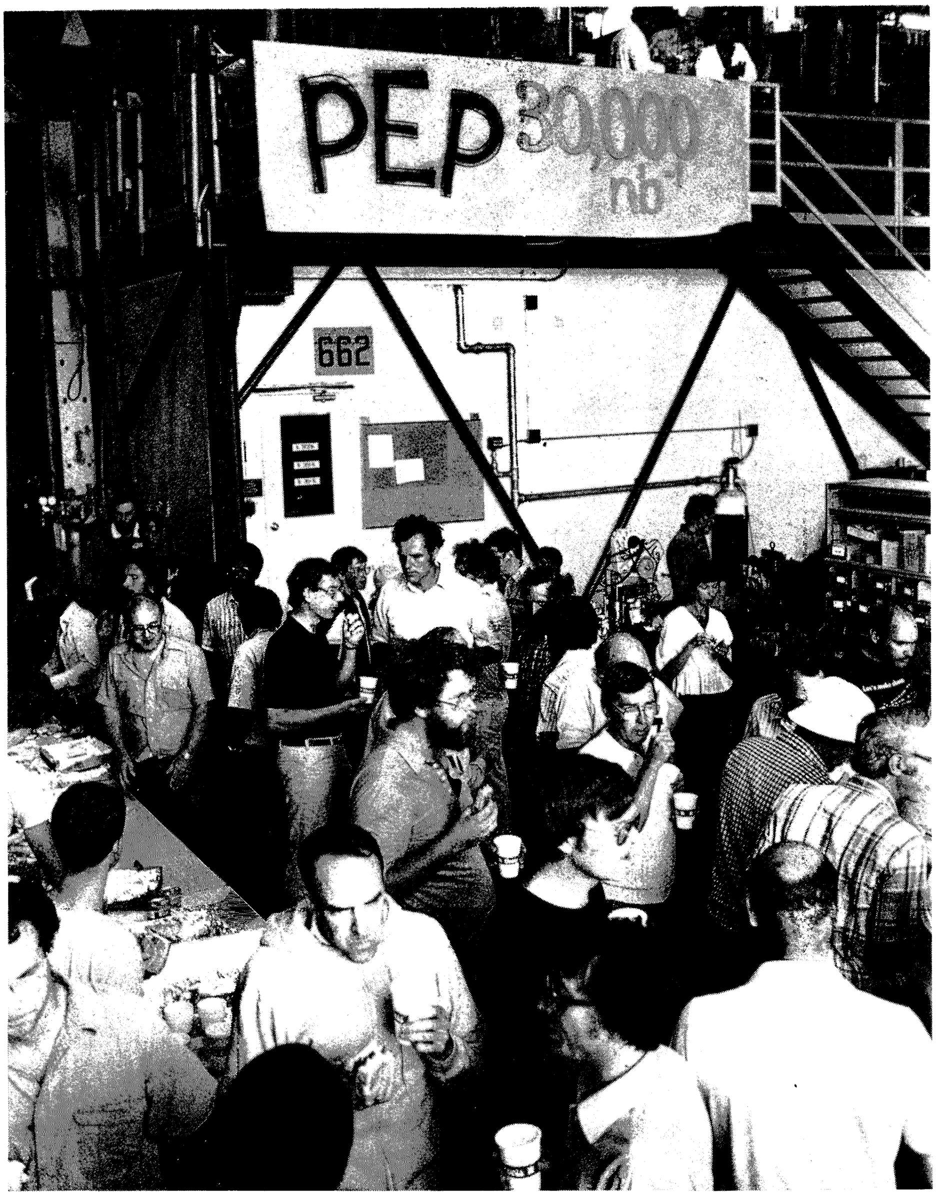
FERMILAB
Successful spring run

Through the efforts of everyone from the US Department of Energy on down, the spring run at Fermilab was extended for two weeks. The additional running was particularly important in view of the extended shutdown that started in June to complete the Energy Saver installation. For this reason the spring run had been crowded with a significant effort to include several waves of experiments. As a result the additional weeks produced much more data-taking than would be indicated on the basis of time alone.

Accelerator performance was excellent during the spring run. A new intensity record of 3.23×10^{13} protons/pulse was set 30 May. Extraction losses were routinely a factor of two lower than a year ago. The superconducting left bend performed smoothly throughout the five and a half month period.

The accelerator was forced to new levels of sophistication because of the demands of the programme. At one point, a 'front porch' gave 1 millisecond, 250 GeV beam to the neutrino experiments preceding the normal one-second flat top interlaced with eleven mini and maxi fast pings. The 'maxi' half of the pings supplied more fast spills to the neutrino experiments, while the 'mini' pings fed the hadron bubble chamber experiments.

In the last few weeks of the spring run two major dimuon experiments with new detectors got their first taste of running. These are E615 (Princeton / Chicago / Iowa State / Fermilab) and E605 (Columbia / Stony Brook / Washington / Fermilab / Saclay / CERN / KEK / Kyoto). The running time on E623, a multiparticle



Celebrations at SLAC after new performance records from the PEP electron-positron ring.

(Photo Joe Faust)

spectrometer experiment, doubled in the last several weeks. This group includes participants from Arizona, Fermilab, Florida State, Notre Dame, Tufts, Vanderbilt and Virginia Polytechnic Institute. Similarly, E400, a new experiment to look for charmed production by neutrons, began to accumulate data. Institutions working on the experiment include Illinois, Colorado, and Fermilab. E619, a collaborative effort involving Michigan, Minnesota, Rutgers, and Wisconsin, measured the sigma zero to lambda hyperon transition magnetic moment in the last portion of the spring run. The same apparatus was used earlier in the running period in the Meson Laboratory. To complete it in this running period and advance the measurement by two years or even make the measurement possible at all, it was necessary to move the equipment to the Proton Laboratory. This type of measurement gives significant insights into constituent quark masses.

Another area where the additional running has been particularly significant is in testing equipment for the Collider Detector Facility. Construction of much of this equipment must be under way before the next opportunity for testing. The Collider Detector Facility involves Harvard, Argonne, Berkeley, Tsukuba, INFN (Italy), KEK, Fermilab, Texas A&M, Chicago, Purdue, Illinois, Wisconsin, and Pisa. Similarly, radiation damage studies on bent crystals for an interesting new possibility for deflecting charged particle beams was completed. This experiment, E660, involves Albany, New Mexico, Fermilab, Chalk River, Dubna, and Strasbourg.

STANFORD
Vintage year for PEP

The PEP electron-positron ring has steadily improved since operations began in 1980, and an operational period early this summer went particularly well. Particle collisions attained record levels, with luminosities exceeding 10^{31}, and with 10 000 inverse nanobarns being accumulated in a month.

This has been achieved by locking onto 'golden orbits', found by trial and error to give higher luminosities than computer calculated ones, even though these orbits look a bit distorted. Other improvements have been made by allowing the operators to tune the machine by the seat of their pants, looking for subtle tuning changes which pay luminosity dividends.

Additional motivation came from generous offers of wine for operators who could achieve more than 500 inverse nanobarns in 24 hours, and for peak luminosity records.

Experiments for SLC

Plans for the proposed new linear electron-positron collider (SLC) at SLAC continue to forge ahead (see January/February issue, page 8). Although there is still a lot of research, development and construction work still to be done for this revolutionary new particle collider, letters of intent for proposed experiments are now being invited.

SLC construction authorization has been requested for the 1984 fiscal year, and a construction schedule proposed leading to completion of the project at the end of 1986. While there are still many questions to be resolved, there is now sufficient confidence in the project to embark on selection of experiments. Present

Right, plan view of the ELSA project at Bonn. The stretcher ring will be placed in a tunnel (4 m below ground level). The 2.5 GeV synchrotron will serve as injector. Two external electron beams (e_1 and e_2) pass through the hall of the 500 MeV synchrotron, which has to be shut down after more than 25 years of operation. Together with a tagging system T_1 the low energy electron beam e_1 will be used for photon nuclear physics (PNP). The high energy beam e_2 will be split: It will produce monoenergetic photons in T_2 for a large acceptance dipole spectrometer (LAS) and will be used for electroproduction experiments (EP). The high energy photon beam (HEP) will be used for photoproduction experiments with polarized photons and targets and for Compton scattering experiments. A synchrotron radiation facility will also be installed.

planning assumes that some 25 million dollars will be available over four years for the first experiments.

The recently published report of the Subpanel on Long Range Planning for the US High Energy Physics Programme of the High Energy Physics Advisory Panel (the 'Trilling Report') has endorsed the project. However the final report was careful to underline the uncertainties in such a novel scheme, and pointed out a number of factors which could affect the luminosity, for better or for worse. In view of these uncertainties, the report recommended against early decisions on new buildings and tunnels to extend the machine's experimental capabilities, and against early authorization of a very large scale detector project.

The SLC project now envisaged involves only a single beam collision point, and a 'push-pull' experimental hall with a centrally shielded vault to house an experiment, and with two large assembly areas on either side.

To propose only one SLC detector is considered inadequate and risky. Although only a single collision area can be considered initially, a suitably constructed experimental hall using 'push-pull' detectors could accommodate two experiments as readily as a two collision area design, although with some sacrifice in the speed with which experiments can be changed.

Thus SLAC is now embarking on a programme leading to approval of two SLC experiments. One of these is expected to be a moderate cost upgrade of an existing detector from the PEP electron-positron ring. The second experiment is seen as being either a rapid special search, or the useful core of a big detector that can be subsequently upgraded, or an upgrade of a second existing PEP detector.

Early physics output from the SLC is considered to be of great importance, and the first detector should have already demonstrated its capabilities. High background counts could provide problems in the initial runs and should be anticipated.

BONN ELSA project

The Physikalisches Institut of the University of Bonn began elementary particle physics with the completion in 1958 of a 500 MeV electron synchrotron, the first in Europe with a strong focussing magnet system. Nearly 10 years later, in 1967, a larger machine of 2.5 GeV came into operation. Both machines have a repetition rate of 50 Hz and a duty cycle of about 5 per cent. They have contributed considerably to our knowledge of photo- and electroproduction in the resonance region.

However many important problems in that area remain unsolved and several new questions have come up in recent years. After 12 years of experiments with the 2.5 GeV synchrotron, a major upgrade is needed to continue the investigations in the field. An improved duty cycle is necessary for new high precision coincidence experiments as well as for a high intensity 'tagged' photon beam. In addition, a slightly increased energy range will cover the resonance region more completely and allow the investigation of excited vector meson states. Such a project is ELSA (short for ELectron Stretcher Accelerator), now under construction at Bonn.

Electron bunches from the existing 2.5 GeV synchrotron will be injected into ELSA every 20 ms and stretched uniformly in time. This scheme allows for a nearly 100 per cent duty cycle up to the highest ejection energy of the synchrotron of 2.3 GeV. In this stretcher mode ELSA will run with a constant magnetic field.

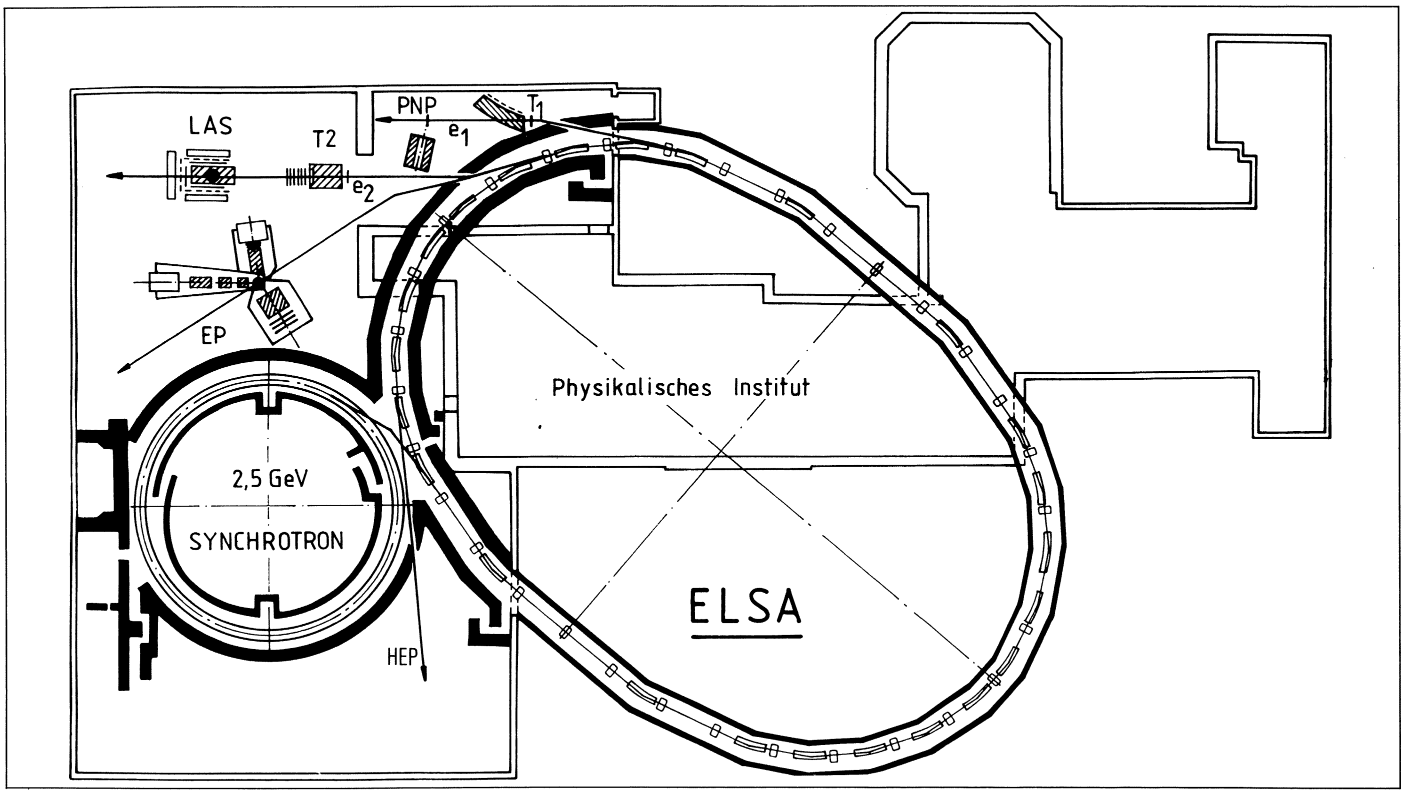
To reach energies beyond 2.3 GeV, ELSA must be operated as an accelerator. The electrons will be injected at 1.8 GeV and accelerated to a maximum energy of 3.5 GeV in about 150 ms. Then the electrons will be stored as in the stretcher mode (for times between 50 and 500 ms) and peeled off for the experiments.

The Bonn Institute has built two synchrotrons so far, and students have made important contributions in the design and construction. This fruitful tradition will be continued with ELSA. A construction time of three years seems to be realistic.

With ELSA the present research will be extended to multiparticle final states. The study of these reactions

ELSA parameters

circumference	164.4 m
length of one cell	10.3 m
dipole bending radius	10.84 m
bend of a dipole	15 degrees
max. magnetic field	1.1 T
energy loss per revolution at 3.5 GeV	1.22 MeV
number of cavities	2
r.f. frequency	499.67 MHz
circulation frequency	1.82 MHz
installed r.f. power	250 KW



in photoproduction requires a tagged photon beam to determine the initial state kinematically. Such a tagging system can only handle limited intensities and the corresponding loss of counting rates has to be compensated for. Therefore a very good duty cycle and a detector system with large solid angle coverage (also under construction) are essential in order to achieve meaningful event yields.

It is also intended to store and accelerate polarized electrons in ELSA. A new source for polarized particles has been built and will be installed at the 2.5 GeV synchrotron.

SYMPOSIUM
Multiparticle 82

The thirteenth symposium in the successful series on multiparticle dynamics was held from 6—11 June in the picturesque North Holland village of Volendam. While originally confined to hadron-hadron interactions, multiparticle dynamics is now of interest in all types of particle collision. Results on proton-antiproton collisions at CERN, both in the SPS and the ISR, are a talking point wherever particle physicists meet, and Volendam was no exception (see page 268). Also prominent at Volendam were ultrarelativistic effects in nucleus-nucleus collisions (this ground had previously been covered at the Bielefeld meeting — see July/August issue, page 223). However the main aim of this year's meeting was to review the common features of hadrons produced in different types of collision (lepton-lepton, lepton-hadron and hadron-hadron).

Striking similarities in the behaviour of hadron production in all these collisions ('jet universality') are seen for hadron jet energies in the range 10—15 GeV. The rate of increase of mean transverse momentum with produced hadron energy near 10 GeV appears to be faster for electron-positron annihilation and forward lepton-hadron scattering than for hadron-hadron and backward lepton-hadron scattering. This may be due to the effects of diquarks and/or because of the increased complexity of hadron-hadron interactions. A large amount of data has now been collected on jet universality, but more knowledge on strangeness flow is required, and the general search for systematic differences should be continued.

Quark-parton models, using results from hard constituent scattering, do indeed explain soft hadron-hadron collisions. These models are now becoming very refined. Now in a suitably modern disguise, Regge poles have recently made a revival, this time as a property of hadron constituents rather than of hadrons themselves.

While all observations appear to be consistent with quantum chromodynamics, it is difficult to prove or disprove that this is the correct theory of strong interactions.

Equally important as the many results presented in sometimes heavily loaded sessions were the opportunities for discussions and personal contacts.

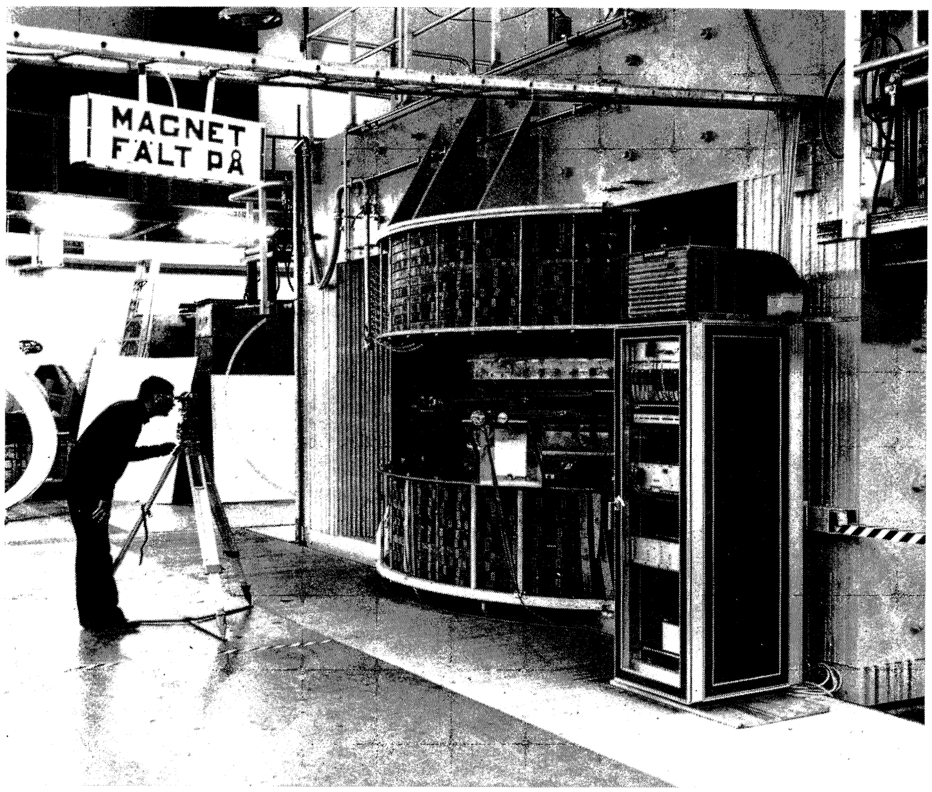
A consensus view was that the interest over the next few years will turn to hadron-hadron collisions at the highest available energies, and to the special particle production properties of kaon beams. Interesting results are expected at next year's conference, most likely to be held at the Davis campus of the University of California.

(We are grateful to Wolfram Kittel for providing us with the material for this report.)

The Gustaf Werner Institute

Magnetic field measurements under way at the rebuilt 200 MeV synchro-cyclotron of the Gustaf Werner Institute at Uppsala in Sweden. The performance of the machine is being greatly improved to support a programme of research in nuclear physics and many other disciplines.

(Photo GWI)



Around the CERN Member States there are many research centres, predominantly based in the universities, which are playing an important role in their national educational and research programmes. They benefit from involvement in the frontier science and technology which is encountered in Laboratories such as CERN and this stimulus helps to sustain their intellectual and technical standards. The broad interface with their national systems achieves a cross-fertilization of different disciplines and spreads the excellence which comes from their national programmes and which is further nourished by involvement with the international Laboratories.

This month we present the Gustaf Werner Institute in Sweden as an example of a national centre which has developed a fine nuclear physics research programme in its own right and has extensive involvement in the high energy physics research at CERN. Many of the techniques learned in these two areas are helping research and practical applications in other fields of science at the Institute.

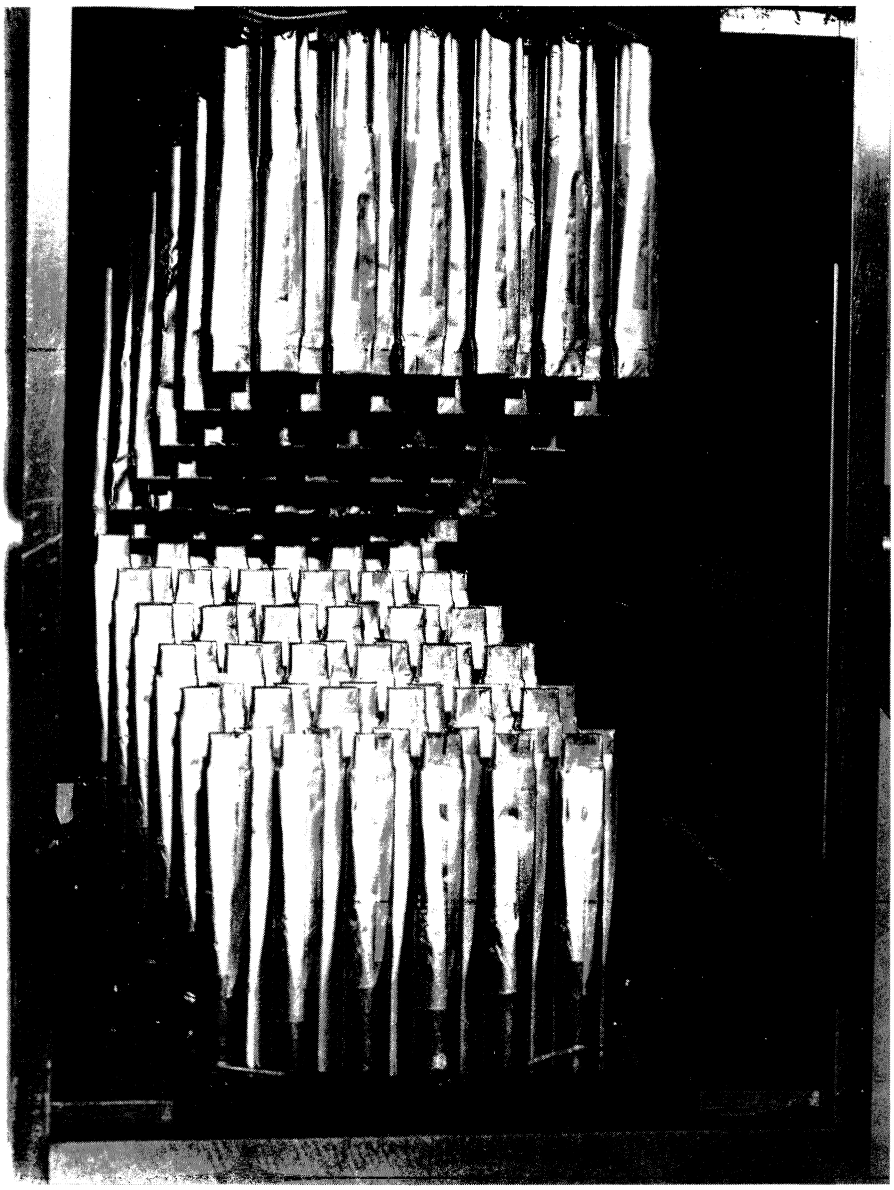
The Gustaf Werner Institute is situated centrally on the campus of the oldest University in Scandinavia at Uppsala in Sweden. There are chairs in high energy physics and physical biology and research groups in physics, chemistry, biology and medicine. Ionizing radiation, its production and use are the common research interests.

In the 1940s, The Svedberg (awarded the 1926 Nobel Prize for his work in colloidal chemistry) became interested in the effects of radiation on proteins and other macromolecules. Aided financially by Gustaf Werner, owner of a Swedish textile company, he initiated the planning of a new accelerator. This came at the time when the principle of phase stability was invented, making it possible to accelerate particles beyond 10 MeV which was the practical limit of old cyclotrons. It was therefore decided to build a synchrocyclotron with the highest possible energy within the available funds.

The first beam of 185 MeV protons was obtained in 1951 and for a while Uppsala had the highest particle energies in Western Europe (surpassing IKO in the Netherlands and Harwell in the UK which had 50 and 170 MeV respectively). With this experience behind them, Uppsala accelerator physicists participated in the construction of the CERN synchro-cyclotron with the magnet as their main responsibility.

Among the scientific highlights in the history of the Institute was the first direct observation in 1956 of proton energy shells in nuclei. These were found in detailed measurements of (p,2p) reactions from light nuclei. In 1957 radiation surgery and cancer therapy using 185 MeV protons were introduced. Protons of this energy have a range of 24 cm in tissue and are therefore well suited for medical applications. For example, radiation surgery was successfully made on 30 patients suffering from Parkinson's disease and other brain disorders. In the early 70s it was found that pions were produced in proton-nucleus collisions leading to discrete nuclear states. Since then this type of nuclear reaction has been studied in many laboratories.

The accelerator was shut down in 1977 for a complete reconstruction. The flat-pole geometry has been changed to a three sector spiral ridge geometry to make possible a radially increasing magnetic field while maintaining axial focussing. With this new field configuration, protons starting at a frequency of 25 MHz reach a final kinetic energy of 200 MeV at a fre-



One of the scintillation counter arrays prepared at the Institute for installation in the high energy muon beam at CERN. Each of the 144 scintillators has a 2 cm² cross-section facing the beam.

(Photo CERN — 149.12.81)

quency of 23 MHz. The earlier frequency range (33-26 MHz, supplied by a rotating condensor) resulted in an extracted beam of 185 MeV. The new accelerator will have electronically tuned broad-band amplifiers for the acceleration of protons. Other heavier particles can be accelerated in the cyclotron-mode with constant frequency. Intensities of between 10 and 100 μA will be obtained depending on the particle accelerated and the chosen energy. The new properties are far superior to those of the old machine which gave only protons of a fixed energy and extracted beam intensities a thousand times smaller.

The accelerator was, to a large extent, built by the staff of the Institute. There was consultancy help from CERN, particularly for the design of the radiofrequency system and for the extraction channel, as well as help with the components for the magnet system from the local industry Scanditronix. Assembly of major components and detailed magnetic field measurements are now in progress.

Final government authorization for the experimental areas was given at the end of 1981. One large hall for physics and a smaller one for biomedical projects will be constructed. The total area is about 1800 m². The halls will be located 7 m below the ground and will receive beams from the accelerator hall 5 m further down.

There is a considerable interest in using the accelerator. Letters of intent have been received for 27 physics projects and 70 projects in chemistry, biology and medicine. These latter projects demand much less time and space than the physics projects, but nevertheless a separate experimental area is foreseen for the non-physics sciences.

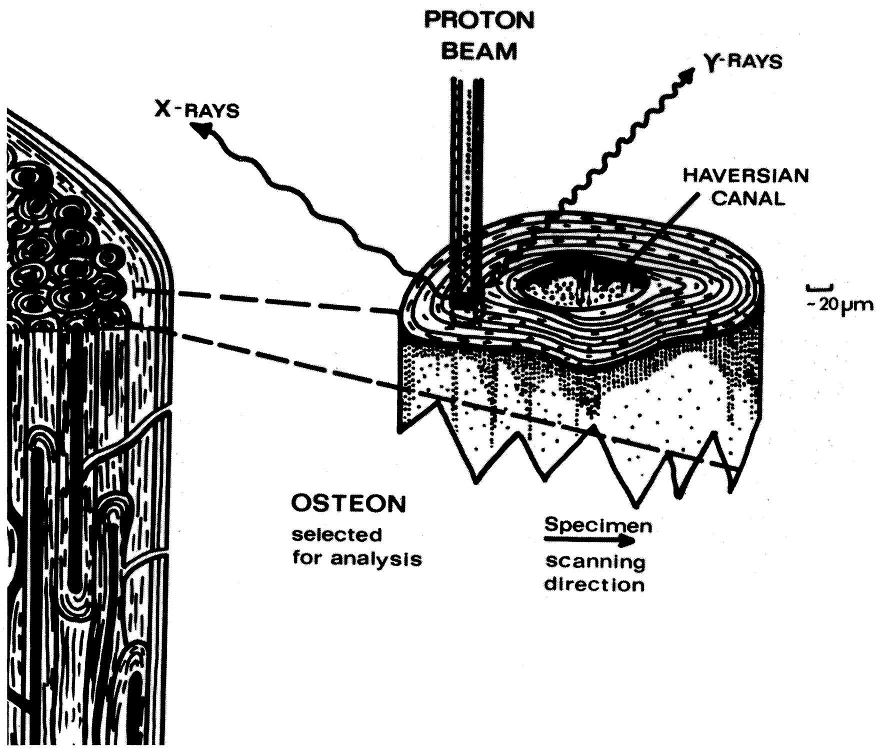
Many of the experiments in intermediate energy physics will use a large 135° spectrometer magnet, equipped with position sensitive detectors. Detectors for photons and neutrons are also being developed. The radiotherapy and radiosurgery programme is being prepared in collaboration with physicians from Uppsala and Stockholm and physicists from ITEP in Moscow (where they have experience in tapping 200 MeV protons from a synchrotron and use similar special beam transport and stereotactic instruments).

In addition to the research using the on-site accelerator, there is an extensive research programme using accelerators and reactors elsewhere. Examples from the present projects give an idea of the research profile of the Institute.

There are two important projects involving electron-positron collisions. For several years, physicists from Uppsala have participated in the development of Ring Imaging Cherenkov (RICH) counters (see March issue, page 49). These new counters are used for particle identification and are being proposed for several high energy experiments.

The other electron-positron project presently in progress involves positrons of very low energies. It makes use of the annihilation reaction to two gammas using a positron camera. This research is a joint undertaking between the Institute's nuclear chemists, the Institute of Chemistry and the University hospital. The Institute is here involved in the production of nuclides, their separation and fixation in organic molecules.

Physicists from the Institute participate within the European Muon Collaboration at CERN in the study of quark and gluon properties by irradiating nuclei with muons. By studying the effects of nuclear matter on their propagation it is hoped to learn



The scanning technique to measure concentrations of lead in bone. The use of this technique is described in the text.

more about these fundamental particles. For these studies it is necessary to detect muons scattered at small angles which remain in the beam region. A trigger system using the information from 450 scintillators placed in four different planes before and four planes after the target will be used. This information will be processed in 50 ns to pick out any difference from a straight beam track. The trigger system is a pilot scheme for the Fastbus project (see March issue, page 54).

In an extensive series of experiments still in progress at CERN and at SIN, Institute physicists participate in the detailed study of muon-induced fission. Several first observations have been made on phenomena related to the mechanism that produces fission and the fate of the muons surviving the fission process.

In theory, interesting results were recently obtained in the study of spin effects in intermediate energy proton scattering from nuclei.

Using the intense low energy antiproton beams which will be available from LEAR at CERN, a CERN/Grenoble/Saclay/Swierk/Uppsala collaboration will study how heavy hypernuclei are formed and how they decay by fission. The lambda particle of the hypernucleus is produced in kaon nuclear interactions after stopping antiprotons in a heavy nucleus. The kaons are among the final products of the annihilation process between antiprotons and nucleons in the target nucleus.

(It is worth interjecting in the midst of our account of the scientific work of the Institute that participation in research at CERN does have particular complications for the more remote universities such as Uppsala. The problems of communication are still, physically and financially, difficult. Even such mundane matters as the cost of travel and transport can have an inhibiting effect on the participation of research centres a long distance away. The determination of the Gustaf Werner Institute to benefit from the research facilities at CERN has all the more meaning because of these difficulties.)

In the cell research laboratory in Uppsala infiltration of different cytostatic substances in tumour cells is studied. The tumour is simulated by a cultivation of cell aggregates, and cytostatics and other tumour-affecting compounds labelled with a radionuclide are given to the medium surrounding the simulated tumour. By means of autoradiography, information on the penetration of the various substances into the tumour is obtained.

Studies are made also on how the fundamental building blocks of living matter, especially the DNA molecule, respond when exposed to ionizing radiation. Too much damage to the DNA can lead to cell death and it is important to learn when this occurs. This knowledge is of importance for understanding the cause of cancer and for optimizing its treatment.

New ways to use slow neutrons in cancer research are developed in collaboration with the Institut Laue-Langevin, Grenoble, and the University of Bremen. Advantage is taken of the fact that boron-10 has a very high cross-section for neutron capture leading to disintegration of the compound nucleus into two heavily ionizing fragments. These fragments are used to trace the location of boron-tagged macromolecules in tissue specimens by means of solid-state detectors. Boron-loaded molecules found to accumulate in tumour tissue may then be used in combination with slow neutrons as tools for selective killing of malignant cells.

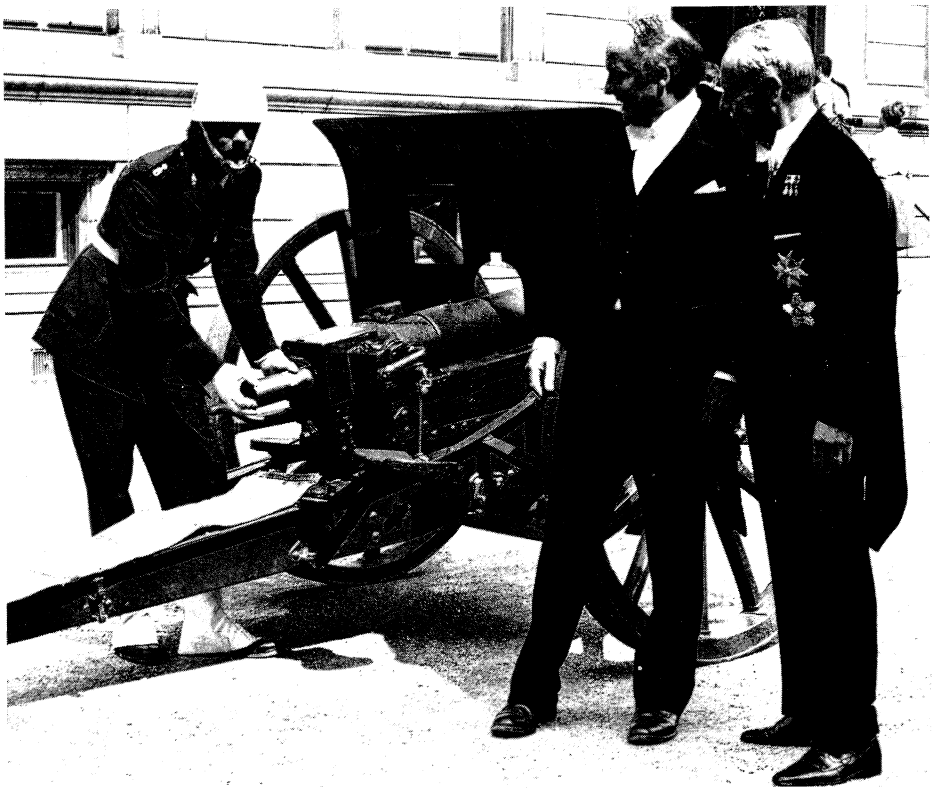
A new method to trace heavy metals in the body based on the PIXE (particle induced X-ray emission) technique has been developed. Heavy metals in the environment are assimilated by man through food, water and air. They are distributed to the visceral organs where severe damage may result. Lead does not, however, remain in the soft tissues but accumulates in the bone. For determination of the lead concentration, autopsy specimens of femur were collected from workers whose exposure to metals had resulted in clinical lead poisoning. The incorporation of lead in compact bone follows the building blocks called haversian systems or osteons, the diameter of which is approximately 200 microns.

For the assessment of the lead distribution within individual osteons, a 6 MeV proton beam, 5 microns in diameter, was used to produce X-rays. From analysis of these X-ray spectra it has been found that lead

People and things

accumulates close to the vascular canal which can be clearly distinguished from the surrounding bone tissue formed as rings. There the lead concentration was found to be 185 ng per g, ten times greater than the level in a man free from occupational exposure.

With the imminent restart of the improved synchro-cyclotron and the involvement in some of the most lively projects at CERN, the Gustaf Werner Institute seems well placed to continue to play an important role in national and international research.



Mats Lemne (right) and Erwin Gabathuler were recently made Doctors Honoris Causa at the University of Uppsala, Sweden. The gun seen here was fired in salute during the ceremony.

(Photo Uppsala)

Joan Bjorken puts the finishing touches to the upper tiers of the cake for the recent 15th anniversary party at Fermilab.

(Photo Fermilab)

On people

Former CERN Director General Sir John Adams was recently elected an Honorary Member of the European Nuclear Society.

On 22 July, CERN Director General Herwig Schopper was awarded the degree of doctor honoris causa of Friedrich Alexander University, Erlangen-Nürnberg. Professor Schopper worked at Erlangen from 1953–7.

At a ceremony on 4 June, Erwin Gabathuler and Mats Lemne were made Doctors Honoris Causa at Uppsala University, Sweden.

Currently research director at CERN, Erwin Gabathuler was previously Leader of CERN's Experimental Physics Division. He played an important role in the formation and development of the European Muon Collaboration, one of the largest experiments currently under way at CERN. This study has proved to be a fine example of how fruitful international scientific collaboration can be. The award came in recognition of his scientific work and his interest in supporting university departments in CERN Member States.

Mats Lemne, county governor of Sweden's Södermanland district, has played a major part in the administration of scientific research in Sweden. After serving as chairman of Sweden's National Atomic Research Council, in 1977 he became chairman of the Natural Science Research Council. He has also contributed significantly to many other Swedish scientific projects. He has served as Swedish delegate to the CERN Council and

During his recent visit to CERN, the Pope was greeted, in Polish, by theorist Jacques Prentki. Born in France, the former Leader of CERN's Theory Division was raised and educated in Poland.

(Photo CERN 175.6.82)

was chairman of the Finance Committee from 1973 — 76. In awarding the doctorate, the Uppsala faculty expressed its appreciation for these important contributions to the furthering of research.

H. Guyford Stever has been elected President of Universities Research Association, which operates Fermilab under a contract with the US Department of Energy.

Jacques Prentki has left his position as Leader of CERN's Theory Division after a six year mandate, and is succeeded by Maurice Jacob. One of the first scientists to work at CERN, Professor Prentki has become one of the prominent figures in the Laboratory, where his leadership and warm personality are highly appreciated. He is also Professor at the Collège de France.

Eugenii Feinberg

As mentioned briefly in our July/August issue, Nicholas P. Samios has been named Director of Brookhaven National Laboratory. Associated with Brookhaven since 1959, he had served as Acting Director following the resignation of George H. Vineyard at the end of last year. Together with Brookhaven Senior Chemist Ray Davis, well known to physicists for his work on solar neutrinos, Samios has recently been elected to the US National Academy of Sciences.

The seventieth birthday of Eugenii Lvovitch Feinberg was marked recently by a special seminar at the Lebedev Physical Institute in Moscow.

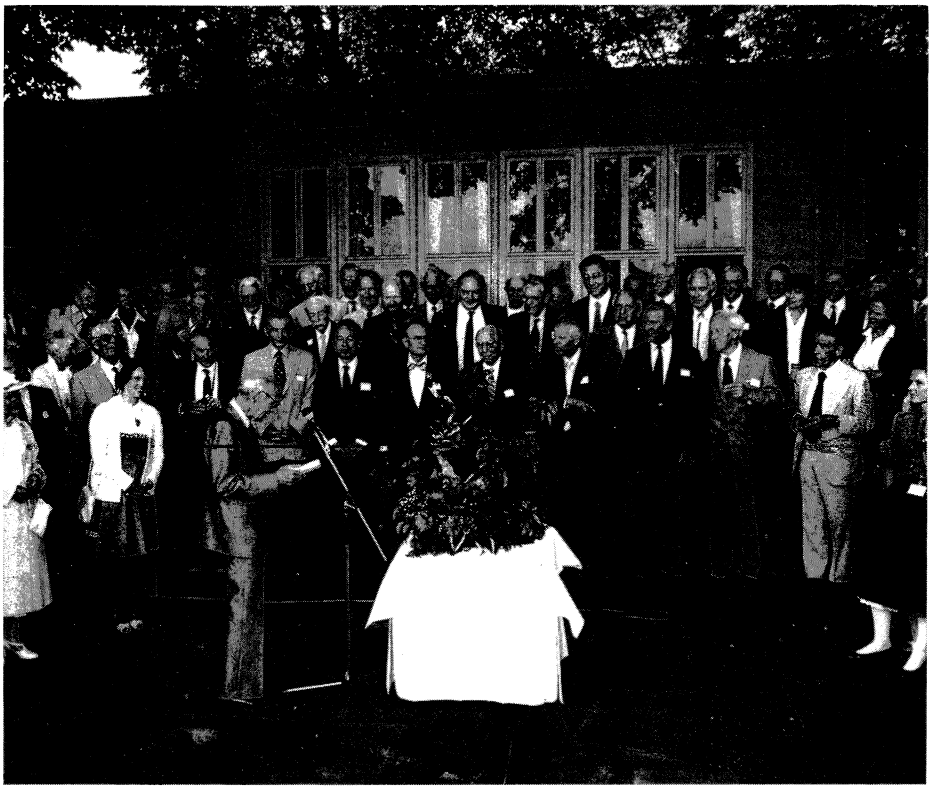
Professor Feinberg is well known for his pioneering theoretical work on inelastic diffraction, the peripheral model for particle production, applications of thermodynamical ideas to inelastic processes, the notion of formation length in hadronic interactions, etc. In addition to this work in particle physics, he has also made important contributions in radio wave propagation and in neutron physics. He has been very influential in high energy physics and cosmic ray studies in the USSR.

His wide range of interests is amply demonstrated by his newly-published book 'Cybernetics, logic and art'. His great intellect, together with an attractive personality and humanistic approach, has won him many worldwide friends.

Professor Feinberg joined the Department of Theoretical Physics at the Lebedev Institute in 1935 and has remained there ever since. He is a corresponding member of the USSR Academy of Science.

Addressing his fellow Nobel Laureates at the traditional Nobel meeting in Lindau, West Germany, is Alfred Kastler, who won the Physics Prize in 1966.

(Photo Kemmer)



been appointed Project Director for the proposed SLAC Linear Collider (SLC).

CERN elections and nominations

At the CERN Council session in June, J. Andersson of Sweden was elected Chairman of CERN's Finance Committee, succeeding K.O. Nielsen of Denmark. Nominated members of the Scientific Policy Committee were J. D. Dowell of Birmingham, UK, C. Jarlskog of Bergen, Norway, and G. Morpurgo of Genoa, Italy. Within CERN, G. Drouet has been appointed Leader of Site and Buildings Division for a period of three years from 1 January 1983, to succeed H. Laporte, who will take over full-time direction of civil engineering work for LEP.

Reorganization at Fermilab

With the recent conclusion of 400 GeV running in the Main Ring, Fermilab's traditional Meson, Neutrino and Proton Departments have been combined into a single Experimental Areas Department, headed by Ken Stanfield, operating as part of the Research Division under Peter Koehler. In this way the skills and resources of the three experimental areas are pooled in readiness for the new era of TeV (1000 GeV) physics (photo page 276).

Reorganization at SLAC

Burt Richter now holds the new position of Technical Director of SLAC as well as Associate Director of Technical Division, now including the former PEP Division. Greg Loew is Deputy Director of this extended Technical Division. Joe Ballam remains Associate Director of Research Division, which now includes Experimental Facilities Department, transferred from Technical Division. John Rees has been appointed Project Director for the proposed SLAC Linear Collider (SLC).

CERN Preparing for LEP experiments

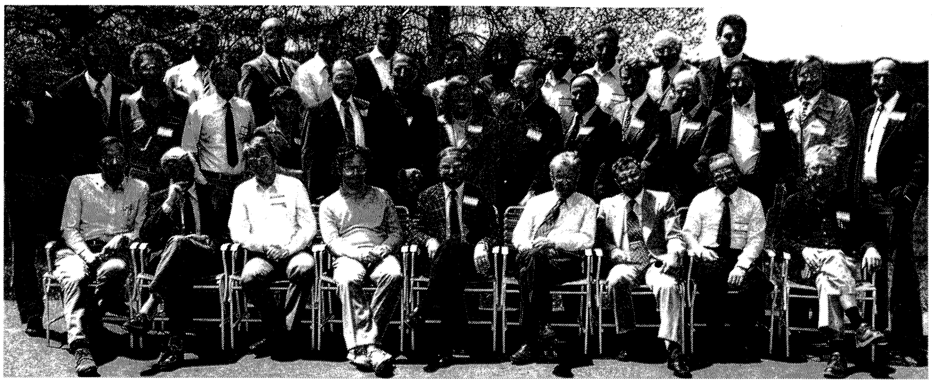
Earlier this year, the first sessions of the new LEP Experiments Committee were held to prepare the way for the selection of experiments for CERN's new electron-positron ring. While Phase I of the LEP project foresees four beam intersection areas, seven experimental groups initially indicated their interest. From these, an optimal choice of experiments has to cater for both as broad a range of physics objectives and as wide a user base as possible. The selection process involves continual feedback so that the initial proposals can be adapted to satisfy additional physics requirements and to minimize overlap of interests, and the collaborations can be extended so that as many physicists as possible will have a chance of joining an active LEP experiment. An initial selection of four experiments has been made. This includes two general purpose detectors, one (ALEPH) considered to be based on advanced technology, and the other (OPAL) using more conventional techniques. The more specialized detectors are DELPHI and Sam Ting's proposal, as yet nameless. Modifications are being suggested for these last two. More details soon.

To celebrate ten years of the four-ring CERN Booster — a four-tier cake and wine of appropriate vintage.

(Photo CERN 126.6.82)

Participants at the recent Workshop on Accelerator Orbits and Particle Tracking Programs, held at Brookhaven.

(Photo Brookhaven)



Ten years of boosting

The tenth anniversary of Booster operations at CERN was celebrated on 7 June. Giorgio Brianti, who had led the construction team, paid tribute to the machine's contributions to the CERN physics programme and to accelerator science (such as the analysis of instabilities by the late Frank Sacherer). He also thanked outgoing Booster Group Leader Helmut Reich, associated with the machine from its beginnings in 1966, and the Booster staff for having adapted the machine to new requirements for the SPS and the Antiproton Accumulator, more than doubling the design intensity en route.

Orbits at Brookhaven

A 'Workshop on Accelerator Orbits and Particle Tracking Programs' took place at Brookhaven National Laboratory from 3—6 May. The workshop was attended by about 50 people, with representatives from the major high energy physics laboratories in Europe and the US

The status of particle tracking programs was reviewed, and the participants had the opportunity of comparing the characteristics of each program, as well as the applications relevant to various kinds of beam dynamics. The need was recognized for aiming at standardized and modular input-output structures, and for improved communications amongst the users and writers.

The beam dynamics process over a relatively small number of revolutions is rather well understood, and several programs were presented which satisfactorily describe the short term situations. The long term behaviour, typically of the order of millions of revolutions, under the effect of random noise, periodic modulations and magnetic non-linearities, is less understood, and stimulated lively discussions both from the theoretical and computational points of view. The workshop ended with reports on the sources of magnetic imperfections in superconducting magnets, on the origin of noise in storage rings, and with discussions on the available experimental results. The need was recognized for collecting more experimental evidence on the effect of magnetic imperfections on the storage ring performance. With the present generations of superconducting storage rings, this topic has great practical relevance, since it impacts on the design and tolerances of the magnets.

Conferences and meetings

The 12th International Conference on High Energy Accelerators will be held at Fermilab from 11-16 August 1983. The programme will include sessions on colliding beam straight sections and on detectors. More information from F. R. Huson, Fermilab, PO Box 500, Batavia, Illinois 60510, USA.

A Workshop on Drell-Yan processes is being held at Fermilab from 7-8 October this year. Emphasis will be given to recent developments in theory and experiments on the production of massive lepton pairs. Those interested in participating should contact Risto Orava, Fermilab, PO Box 500, Batavia, Illinois 60510, USA.

A Workshop on SPS Fixed Target Physics for the years 1984—89 will be held at CERN from 6—10 December. More details next month, or in the meantime from I. Mannelli at CERN.

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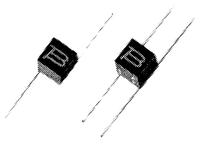

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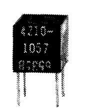

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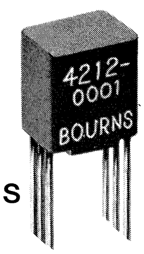

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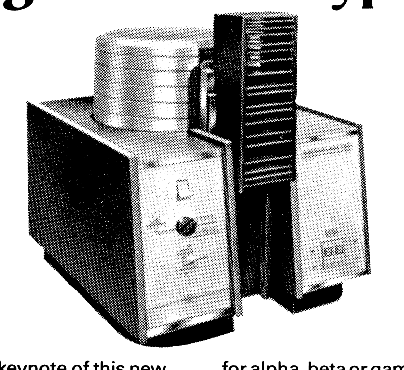

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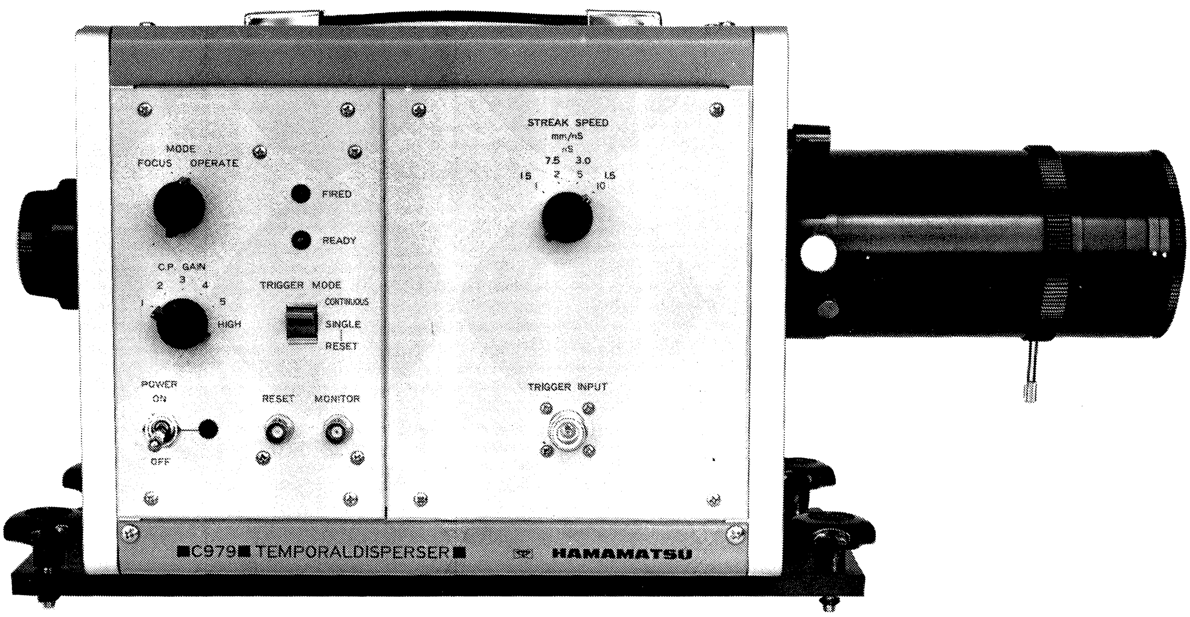

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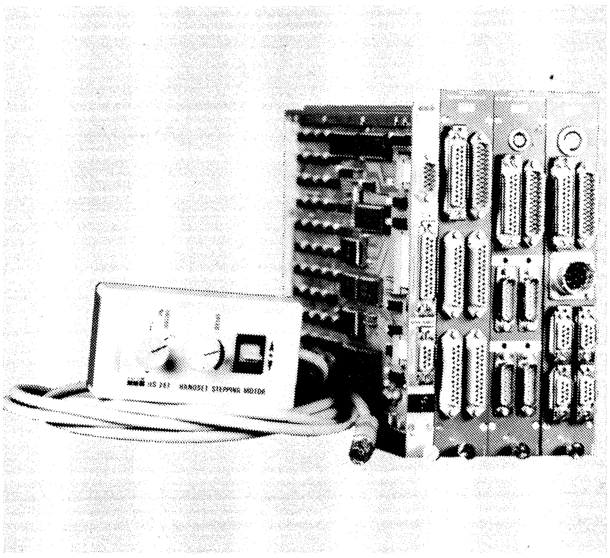

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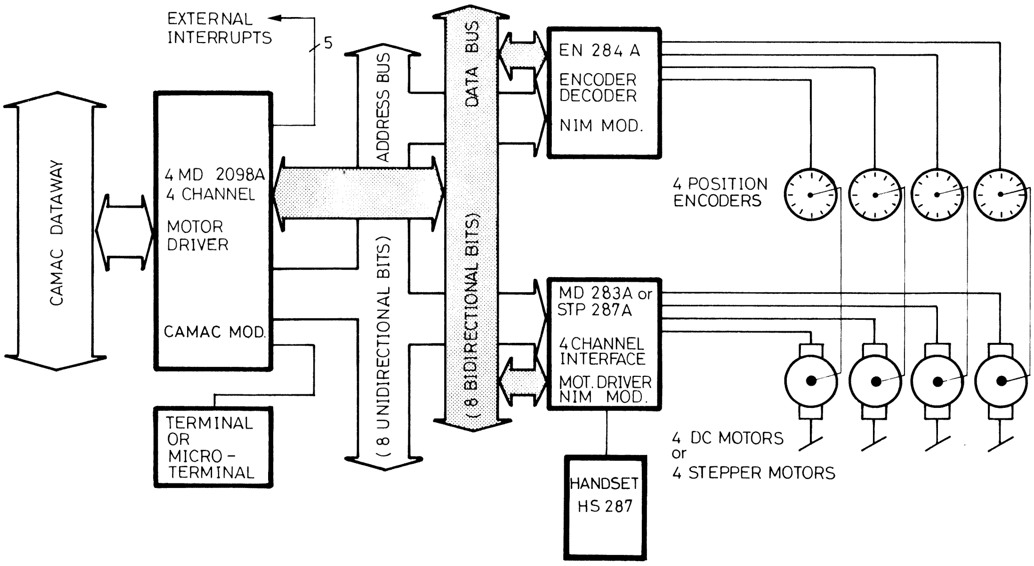

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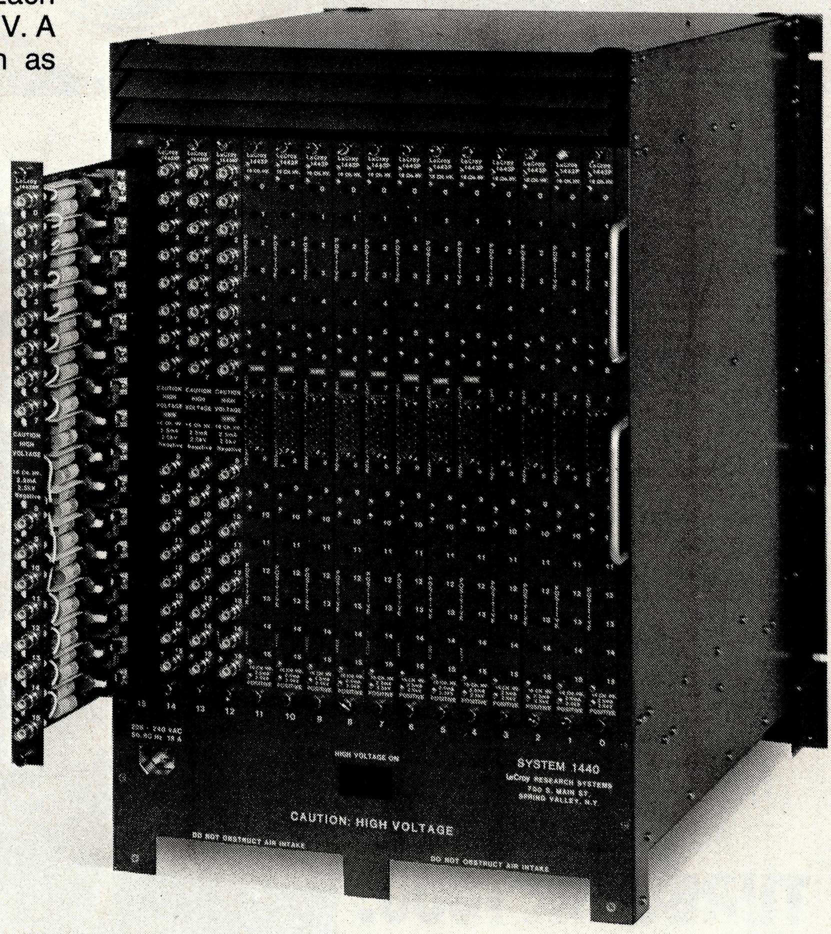

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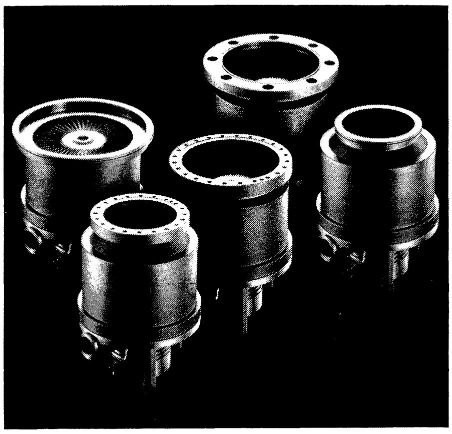

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