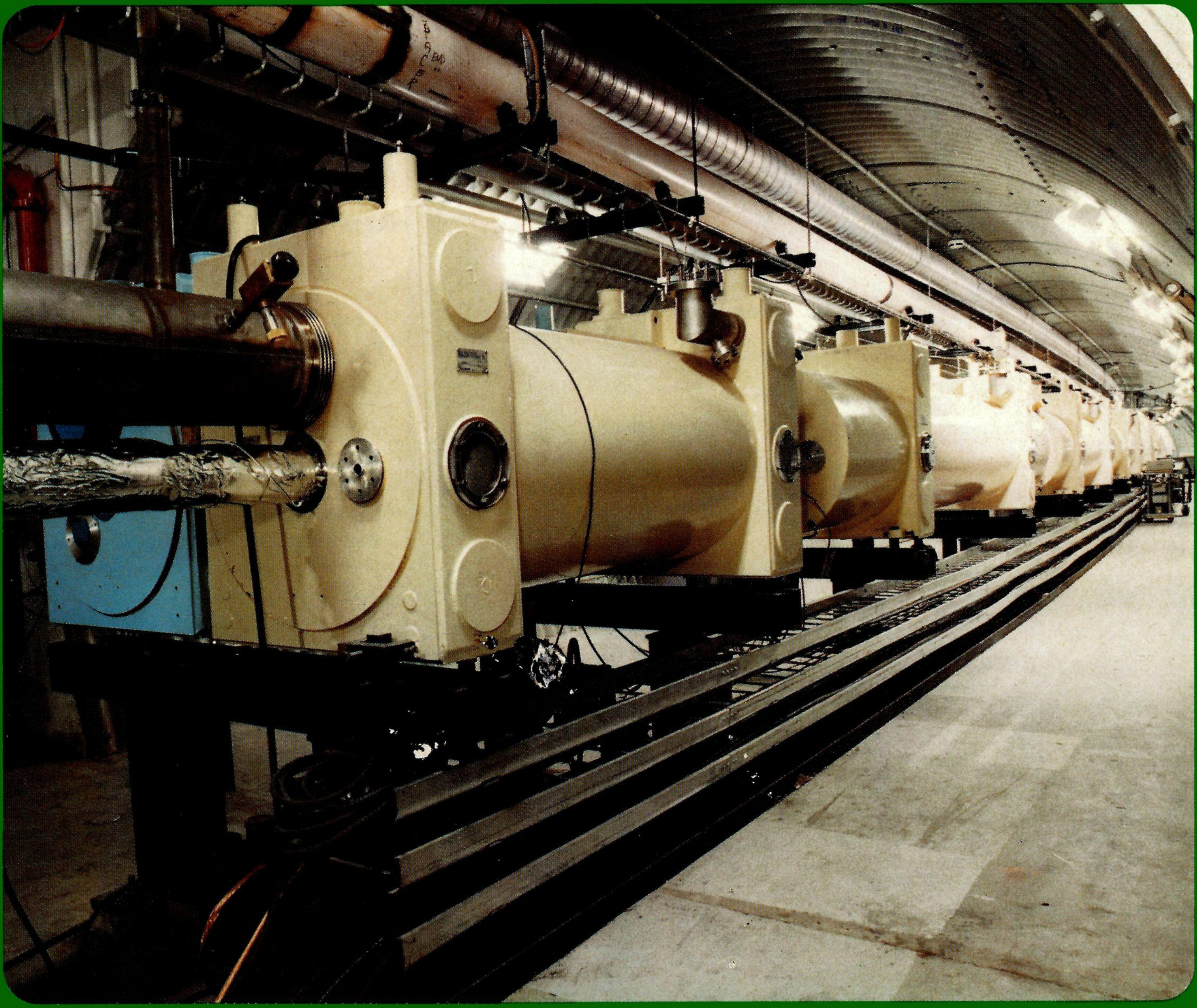
CERN COURIER

International Journal of High Energy Physics



VOLUME 23 6 JULY/AUGUST 1983

CERN COURIER

International Journal of the High Energy Physics Community

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VOLUME 23 Nº 6 JULY/AUGUST 1983

Around the Laboratories

Cover photograph: A full magnet cell of the Brookhaven Colliding Beam Accelerator consisting of six dipoles and two quadrupoles, all superconducting. The cell has been powered to the required field to handle 400 GeV proton beams. One circulating proton beam would pass through the exterior ring, with cream-painted magnets. Just visible on the left is a blue magnet of the other proton ring (Photo Brookhaven).

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

Printed by: Presses Centrales S.A.
1002 Lausanne, Switzerland

Published by:
European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 83 61 11, Telex 23 698
(CERN COURIER only Tel. (022) 83 41 03)
USA: Controlled Circulation
Postage paid at Batavia, Illinois

Particle physics and cosmology

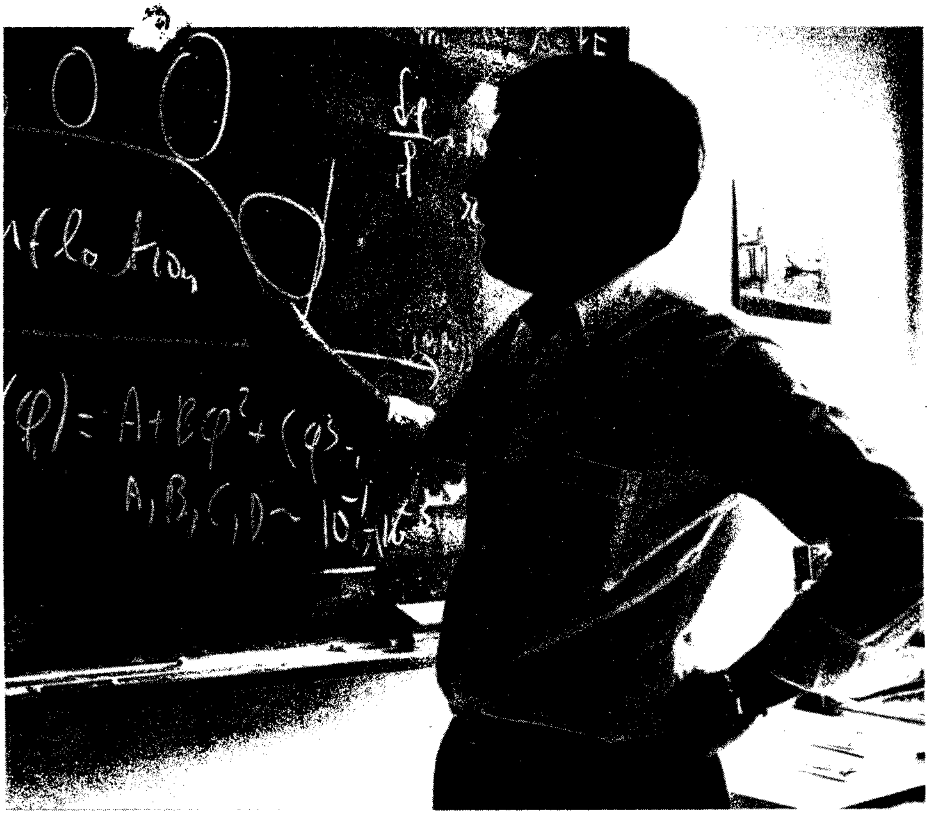
by John Ellis and Dimitri Nanopoulos

The reconciliation of particle physics — the study of the infinitesimally small — and cosmology — that of the infinitely large — is perhaps the ultimate problem that theoretical physicists can dare to attack. Some time ago (January/February 1981 issue, p. 3) we published distinguished cosmologist Stephen Hawking's view of particle physics. Here particle theorists John Ellis (presently at SLAC) and Dimitri Nanopoulos of CERN look through the other end of the telescope and describe how they see cosmology.

At first sight, one might think that these sciences of the very small and of the very large would have very little to say to each other. However, in the past few years the dialogue between particle physics and cosmology has been developing very rapidly. While some particle theorists are now very concerned about observations of light element abundances in distant gas clouds, cosmologists wait with bated breath to know the decay rate of the Z^0 boson. In this article we outline the reasons for this developing symbiosis between microphysics and macrophysics, and trace some of the development in this rapidly changing field.

This rapprochement has been speeded by recent progress within the disciplines of particle physics and cosmology. In the last few years both subjects have witnessed the establishment of a 'Standard Model'. In the case of particle physics this is the gauge theory of the strong, weak and electromagnetic interactions between quarks and leptons which combines Quantum Chromodynamics (QCD) and the Glashow-Salam-Weinberg model. While it describes successfully all data from

John Ellis



Dimitri Nanopoulos

elementary particle experiments, this Standard Model leaves many old questions unanswered and raises many new ones. How many quarks and leptons exist? Why do the masses of elementary particles take their observed values? Why are the strong interactions strong and the weak interactions weak? Theorists take many different directions in their speculative searches for answers to these and other questions. Common features of their speculations include the existence of light particles which are very weakly interacting and hence difficult to produce and detect in accelerator experiments, and the prediction of massive new particles whose production might require an accelerator costing more than the output of all the world's economy. It is natural that impatient theorists should turn for confirmation of their ideas to the only accelerator not subject to budgetary restrictions, namely the 'Big Bang.'

According to the standard Big Bang model of cosmology, one can extrapolate the present expanding Hubble flow of distant objects in the Universe backwards in time, to epochs when the matter in the Universe was much denser and hotter than it is today. Unless some new physics intervenes, this extrapolation may be valid all the way back to a 'Planck' epoch when the energies of the particles in the Universe were of order 10^{19} GeV, at which energies gravitational effects would be important. These energies are likely to have been attained for the first 10^{-43} seconds of the Big Bang, and the Universe would subsequently have cooled as it expanded. In addition to the present Hubble expansion, there are two important pieces of circumstantial evidence for the Big Bang model. One is the observation of the $3K$ microwave background radiation, which is generally believed to be the relic of an epoch when the Universe was over a thousand times smaller and hotter than it is today, and all matter was ionized. The photons in the microwave background are interpreted as relics that escaped when the Universe cooled out of this epoch and the ionized nuclei and electrons combined to form the neutral atoms which populate our familiar world. There is another piece of evidence that the Universe was once a billion (10^9) times smaller and hotter than it is today. This is the observation that about ¼ of the matter in the Universe is in the form of helium 4, while only a few percent could have been manufactured in stars. It is generally accepted that this helium 4 was cooked up from neutron and proton ingredients by thermonuclear reactions in the first three minutes of the Big Bang, along with smaller amounts of other light nuclei. Although there is no direct experimental evidence for the validity of such a leap, these successes of the Big Bang model have encouraged physicists to extrapolate a billion billion (10^{18}) times further back into the Big Bang when typical particle energies were about 10^{15} GeV, almost as a matter of routine.

While the Big Bang theory is very successful, it leaves unanswered many questions and raises new ones. Why is the Universe so old and so large? The original density of the Universe must have been tuned very finely for it to have survived 10^{60} times longer than the Planck epoch and to have expanded to the size it has. Indeed, the Universe is still very 'flat' with a density close to the critical value which would cause it to collapse again in a 'Big Crunch'. Why is the Universe almost homogeneous and isotropic? Domains of the Universe which were causally separated in the past appear to have behaved identically, as inferred for example from the uniformity of the microwave background. On the other hand, where did the small perturbations originate which have led to galaxies and other structures in the Universe today? What was the origin of all the matter in the Universe? The visible matter in the Universe consists of about one proton or neutron for every 10^9 or 10^{10} photons, while there are apparently no large concentrations of antimatter. Is there concealed matter in the Universe in the form of light weakly interacting particle such as neutrinos? The Big Bang theory predicts that there should be about as many neutrinos as there are photons, in which case most of the mass of the Universe could be in the form of neutrinos if they weigh more than a few eV. Have neutrinos played an important role in the formation of structure in the Universe? Massive neutrinos or other light weakly interacting particles might have aided the growth of perturbations in the Universe, including galaxies themselves. How many species of light particle exist? The answer is relevant not only to theorists of galaxy formation but also to calculations of the cosmological nucleosynthesis of helium 4.

This recital of cosmological problems already reveals many important interfaces with particle physics, some of which do not require audacious extrapolations in time or energy. Calculations of cosmological nucleosynthesis are sensitive to the number of particle species weighing less than about 1 MeV, because their thermal energy density could have increased the expansion rate of the Universe during nucleosynthesis, and thereby increased the efficiency of helium 4 production. For this to be below the observational fraction of ¼ by mass, there should not have been more than three or at most four light neutrino-like species. We know already about the electron, muon and tau neutrinos, so there is not much room left. Particle physicists would dearly like this conclusion to be confirmed, as it would answer one of their fundamental questions about the number of quark and lepton species. Cosmology does much better than particle physics experiments in this regard, since the best present experimental limit on the number of neutrinos, coming from J/psi decay, is several hundred thousand! Forthcoming experiments in electron-positron annihilation and in the decay of heavy quark-antiquark bound states (upsilon particles) in particular could improve this limit, as could charged kaon decay experiments albeit with greater uncertainties. However, it may only be observations of the Z^0 decay rate into unobserved neutrals that can confirm the cosmological limit on the number of neutrinos.

Astrophysics at Fermilab

Several years ago, Fermilab, with the aid of David Schramm of the University of Chicago, began to forge closer links with astrophysicists and thereby celebrate the intellectual unity of particle physics and the cosmological origins of creation. For the past year, there has been an active astrophysics seminar, with many astrophysicists visiting the Laboratory for extended stays. All these efforts have now culminated in the establishment of an astrophysics group at the Laboratory.

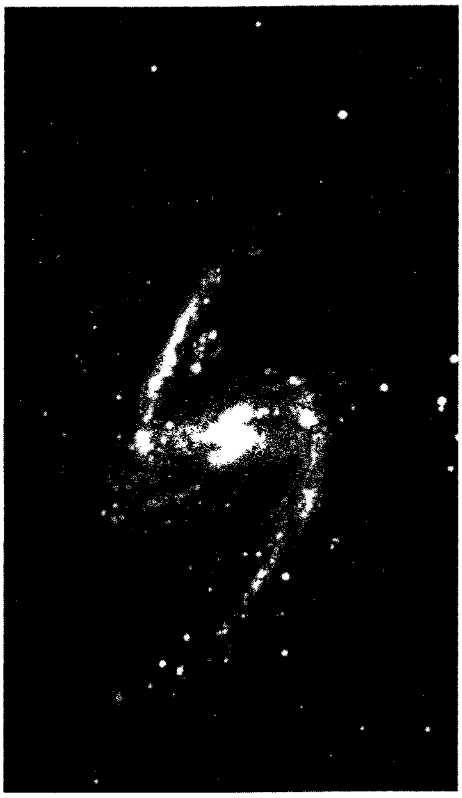
This was the result of a successful application to NASA for a grant to fund such a group. (The particle physics research at Fermilab is supported by the US Department of Energy.) In September, four astro-particle physicists will be in residence at the Laboratory — Edward (Rocky) Kolb, Michael Turner, Keith Olive, and David Seckel, with Schramm continuing to be present several days a week. Alex Szalay will be joining the group in June 1984. The group is preparing a workshop — 'Inner Space — Outer Space', to be run next Spring. Office space for the new group is being prepared adjacent to the existing Fermilab theory area.

Neutrinos lighter than 1 MeV would have had difficulty decaying or annihilating after nucleosynthesis without messing up astrophysical or cosmological observations such as that of the microwave background radiation. If they are indeed stable, their masses must be less than about 100 eV, or else their mass density would exceed observational limits on the density of the Universe. Since the best experimental limits on the muon neutrino and tau neutrino masses are about 300 keV and 200 MeV respectively, this cosmological limit is quite an advance! Recently there have been indications that the electron neutrino may weigh about 30 eV. If so, it would have profound cosmological implications. Neutrinos would be the dominant form of matter in the Universe, and their gravitational perturbations could have been the precursors of galaxy formation. They might enable some theories of galaxy formation to be reconciled with the smoothness of the microwave background radiation. These 'adiabatic' perturbation theories in which matter and radiation vary together are those favoured by the grand unified theories of baryosynthesis which we will meet later. In the absence of massive neutrinos they would be disfavoured by comparison with 'isothermal' perturbations according to which the microwave background is naturally smoother. Some recent astrophysical observations can be interpreted as favouring the model of adiabatic perturbations with massive neutrinos, according to which galaxies should be arranged in 'pancakes' and 'strings'. Particle physicists are not the only ones anxious to hear news about neutrino masses from new experiments, such as those using the low energy neutrino beam at CERN.

There may be other light neutral weakly interacting particles cluttering up the Universe. Many theories based on supersymmetry predict the existence of light neutral gravitinos, photinos and 'shiggses', the supersymmetric partners of gravitons, photons and Higgs bosons respectively. These might have been less copious than neutrinos during nucleosynthesis and at the present day, and could weigh up to 1 keV. In this case they would have aided the formation of individual galaxies and might be responsible for missing mass on galactic scales. Stable neutral particles weighing more than a few GeV are also compatible with cosmology, since most of them would have annihilated before cosmological nucleosynthesis. Evidence for such heavier neutral particles can be searched for at the CERN proton-antiproton collider and in electron-positron annihilation.

So far we have mainly discussed interfaces between particle physics and cosmology involving epochs of the Big Bang for which there is observational evidence. Now we will start extrapolating back before cosmological nucleosynthesis. When the Universe was about 10^{12} times smaller and hotter than it is today, it is believed to have made the transition from a plasma of quarks and gluons to the familiar hadrons. It is possible that perturbations and shock waves generated during this transition may have triggered the formation of galaxies. Experiments on the quark-hadron phase transition would therefore be very interesting for cosmologists as well as to astrophysicists speculating about the existence of 'quark stars'. Such experiments may be feasible with future heavy-ion accelerators.

Extrapolating two or three orders of magnitude further back, we come to the epoch when the Glashow-Salam-Weinberg unified gauge theory of the weak interactions made the transition to the low energy and temperature broken phase that we know today. Before this epoch, the Standard Model of elementary particles would have been an exact symmetry, and further extrapolation necessarily involves speculation about further stages in the unification of the fundamental particle interactions. We have already mentioned the possibility of supersymmetry. Many of the most interesting ideas about the fundamental cosmological problems introduced earlier involve speculations about the grand unification of the strong, weak and electromagnetic interactions.



The Standard Model is unsatisfactory because of its untidy structure with three independent gauge group factors: $SU(3) \times SU(2) \times U(1)$, each with its own gauge coupling. Ultimately one would like a theory with a universal gauge coupling. There are many other aspects of particle physics which are not explained within the Standard Model. For example, why the electric charges of the electron and proton are equal and opposite to one part in 10^{20}, as is evidenced by the undetectability of electrostatic attractions or repulsion between different galaxies. Also, the Standard Model gives no hint of a connection between quarks and leptons, which is suggested by their appearance in three or more generations of particles with similar masses. At first sight, the unification of strong and weak interactions looks very difficult because the magnitudes of their couplings are so different. However, the renormalization group has enabled particle theorists to calculate how these couplings vary with the energy of the experiment in which they are measured. Since they change logarithmically with the energy scale, the energy at which the strong and weak couplings would come together if no new physics intervenes is astronomically high, namely about 10^{15} GeV. Fortunately, this energy scale is significantly less than the Planck scale of 10^{19} GeV at which quantum gravity effects become important, so it might be possible to neglect gravity in a first attempt at unifying the strong, weak and electromagnetic interactions. The simplest such grand unified theories (GUTs) are based on the symmetry group SU(5).

In all such theories, the embedding of the electric charge in a non-Abelian group implies that charges are quantized, and hence that the charges of the electron and proton are exactly equal and opposite. This step also implies the existence of magnetic monopoles, of which more anon. The weak neutral current mixing parameter (the Weinberg angle) is calculable in GUTs, and the prediction of simple models agrees with the experimental data. Quarks and leptons are arranged in common multiplets of the GUT group, which implies relations between the quark and lepton masses. For example, if there are only six quarks, the tau lepton mass of about 1.8 GeV implies a beauty quark mass of about 5 GeV in minimal GUTs, in agreement with experiment. Thus GUTters have a stake in the cosmologists' suggestion that there may only be three neutrinos and hence three generations containing only six quarks. Since GUTs put quarks and leptons into the same multiplet, they expect new interactions to cause quark-lepton transitions which can lead to baryon decay. In the simplest models, the dominant nucleon decay modes are expected to give a positron and a pion, with a lifetime of order 10^{30} years. A recent experiment has not yet found this decay mode, but GUTters are not disheartened since in supersymmetric GUTs the most natural prediction is antineutrino and a kaon, a mode which has not yet been examined exhaustively.

When we apply GUTs to cosmology we must extrapolate back to an epoch 10^{18} times hotter than that of nucleosynthesis. What do we find there? When a poetess hears that all matter should decay, she wonders how it was born. GUTs enable quarks and hence baryonic matter to be synthesized in preference to antimatter in a natural realization of an idea due to Sakharov. Interactions which violate baryon number conservation, as well as charge conjugation and charge-parity conservation, can take an initially symmetric Universe into a state with more matter than antimatter as soon as they drop out of thermal equilibrium. A natural GUT scenario is the out-of-equilibrium decays of superheavy GUT bosons or fermions. The synthesis of a quark asymmetry does not work if the GUT scale is much less than about 10^{14} GeV. Around the time of the quark-hadron phase transition, all the antiquarks will be annihilated by quarks to form mesons, photons and leptons, and the small surplus of matter survives to become the matter visible in the Universe today. It is natural to speculate whether the required charge-parity violation may be related to that observed in the neutral kaons, but this seems unlikely. However, many GUTs which predict a large enough matter-antimatter asymmetry also predict that the neutron electric dipole moment may be large enough to be observed soon.

First ESO-CERN Symposium

Another example of the growing collaboration between particle physicists and cosmologists is the organization this year of the first European Southern Observatory (ESO) — CERN symposium on the large scale structure of the universe, cosmology and fundamental physics. It will be held at CERN from 21-25 November. Among the highlights and scheduled list of speakers are (some details are still provisional) — electroweak unification by P. Darriulat of CERN, unified field theories by P. Fayet of Paris, experimental tests of unified field theories by E. Fiorini of Milan and G. Giacomelli of Bologna, dynamical parameters of the universe by S. Faber of Santa Cruz, clusters by J. Oort of Leiden, galaxy formation by Ya. Zeldovich of Moscow, neutrinos by R. Mössbauer, nucleosynthesis by J. Audouze of Paris, observational evidence for the evolution of the universe by L. Woltjer of ESO, unified field theories and the early universe by A. Linde of Moscow, and quantum gravity by S. Hawking of Cambridge, together with an introduction by D. Sciama of Oxford and Trieste, and concluding talks by J. Ellis of SLAC and M. Rees of Cambridge.

The aim of the symposium is to establish the status of knowledge and to provide a forum for interdisciplinary discussion. Equal time will be given to formal lectures and to general discussion on each topic. A distinguished list of Chairmen and discussion leaders is being drawn up.

The audience will be composed of about equal numbers of astrophysicists and particle physicists, and will be limited to about 150. Participation is by invitation only, and those definitely interested in participating should write to one of the chairmen of the organizing committee before 31 July — Prof. G. Setti, ESO, Karl-Schwarzschildstrasse 2, D-8046 Garching b. München, West Germany; Prof. L. van Hove, CERN, Theory Division, 1211 Geneva 23, Switzerland.

This was some cosmological good news from GUTs, and now comes some bad news. The grand unified monopoles are a great embarrassment, since conventional Big Bang cosmology makes it difficult to understand how less than one monopole could have been created in every causally connected volume during the GUT era. Since monopoles do not annihilate very efficiently, this suggests there should be many more monopoles around today than are allowed by limits on the mass density in the Universe and by the persistence of galactic magnetic fields. Furthermore, it has recently been discovered that grand unified monopoles may catalyze baryon decay at a fierce rate which is incompatible with observations of neutron stars unless the monopole flux is very low. This monopole problem helped set theorists thinking about cosmological inflation.

The breaking of GUT symmetry at a temperature of about 10^{15} GeV occurs through a phase transition. It is possible that the cooling Universe might have stuck in a false vacuum with large energy and supercooled. The vacuum energy would have caused the Universe to expand exponentially in a De Sitter phase until the phase transition was completed. This exponential expansion could have explained the present large size of the Universe, as well as why it is almost flat, with a mass density very close to that required to terminate the expansion with an eventual Big Crunch. Unfortunately, in the original version of this inflationary Universe it was difficult to understand how the phase transition could be completed in an orderly way with few inhomogeneities and monopoles.

However, it was subsequently realized that if the GUT Higgs potential were quite flat, each bubble of the true vacuum would expand exponentially after it was formed. Sufficient expansion would mean that our entire Universe could have originated from a single bubble, and that the closest monopole would probably be more than 10^{10} light years away. At first it seemed likely that such a bubble Universe would be very flat, homogeneous and isotropic, much like the surface of a balloon that has been inflated. When theorists studied the spectrum of perturbations in such a new inflationary Universe, they discovered that they were almost independent of distance scale, as is favoured by astrophysical observations. Unfortunately, the magnitude of the perturbations was much too large. Furthermore, making the GUT Higgs potential flat enough for inflation required a fine tuning of parameters which is unnatural in conventional GUTs.

Both of these problems can be avoided in supersymmetric theories which allow the magnitude of the perturbations and the flatness of the potential to be adjusted at will. Although these adjustments are technically feasible, they become progressively more precise as the temperature of the phase transition falls further below 10^{19} GeV. For this reason, it is interesting to consider the possibility of primordial inflation occurring before the GUT phase transition, in which case monopoles may not be much rarer than the present astrophysical limits. Further development of the primordial inflation scenario requires tackling gravity, which is another long adventure.

This is the time to end our study of particle physics and cosmology. We see that it is a vigorous field which is rapidly developing. Many particle theories can only be tested by the Great Accelerator in the Sky, and many cosmologists anxiously await data from particle physics experiments. The dialogue between the very large and the very small will continue to enthral us in the future.

From Galileo to the Z^o

The recent San Remo 'Science for Peace' meeting commemorated the 150th anniversary of the birth of Alfred B. Nobel. An impressive array of eminent scientists flanks the stage.

(Photo R. Pecoraro)

On 3 May an audience of some of the world's leading physicists gathered in a small theatre on the Italian Riviera greeted Herwig Schopper's announcement of the observation at CERN of a first Z^o candidate (see June issue, page 167) with spontaneous applause. The occasion was an international nuclear physics symposium, one of six meetings under the general title of 'Science for Peace' organized with remarkable flair by Nino Zichichi and a scientific committee of Nobel Laureates and heads of research establishments, as part of linked Alfred Nobel and Galileo commemorations at San Remo and in Rome.*

The announcement was greeted by words of praise for CERN from Sheldon Glashow, one of the theoreticians whose ideas now appear vindicated, and from I.I. Rabi who over 30 years ago had helped motivate the creation of a European laboratory to provide 'competition' for American physicists, but not bargaining for quite so much of it. Simon van der Meer was on hand to explain the technique of stochastic cooling which turned the dream of antiproton physics into a reality and made the crucial experiments possible.

Sam Ting's report of key ideas behind experiments on photons, leptons, quarks and gluons naturally turned thoughts towards the big machines now being built, planned or merely imagined, even though Glashow wondered whether we needed another Einstein rather than new accelerators, unless extremely large. The alleged barrenness of the 'desert' no longer seems so forbidding.

Now that LEP had broken the psychological barrier of a 10 km machine, the presentation of current projects in Europe and the USA — a sound programme for the 90s — drifted readily into speculation about even bigger schemes going to the limit of potential means. There was the mirage of the 20 x 20 TeV 'Desertron', and other ideas, such as the ELOISATRON (European Long Intersecting Storage Accelerator) advocated by Nino Zichichi.

In Viki Weisskopf's view new accelerators will be built, because to spend so much on fundamental research is a great feature of our civilization. Just as CERN came to symbolize the scientific 'United States' of Europe, maybe one of the speculative ideas will one day materialize as a Laboratory representing the United Nations of the world of science. Good science also needs good fortune and new sources of funding will have to be found. So it was perhaps appropriate that this Nuclear Physics for Peace symposium took place in the splendid Casino of San Remo. A special session on Science, Peace and Freedom paid tribute to Alfred Nobel's ideals and was a fitting complement to the scientific programme.

As so to Rome — to honour the memory of Galileo Galilei who 350 years ago published his 'Dialogues' which laid the foundations of modern science and, unhappily, brought him into conflict with the Church. When the participants arrived, Italy's capital went wild with joy, normal traffic came to a standstill as flag-waving car processions wound their way through the city and the noise exceeded that bearable by non-Romans. Alas, it was not for the eminent visitors that the crowds rejoiced, but for the local football team who had regained the national trophy after 41 years. The proper welcome was all the more dignified when the 33 Nobel Laureates and about 200

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* 150th anniversary of the birth of Alfred B. Nobel and 350 years since the publication of Galileo's epoch-making 'Dialogues'.

At the Vatican on 9 May, Pope John Paul II greeted participants in an international symposium on 'Galilean Science Today', including (front row, left to right) Gösta Ekspong of Sweden and CERN Director General Herwig Schopper. The symposium marked the 350th anniversary of the publication of Galileo's famous 'Dialogues' — a major milestone in science. After the misunderstandings of the past have now been dispelled, the way is now clear for a fruitful concord between science and faith.

(Photo Osservatore Romano)

scientists from all over the world assembled under Swiss guard in the Sala Regia of the Vatican to be greeted by Pope John Paul II. He reiterated his hope that the dispelling of past misunderstandings and mistrust will lead to fruitful concord between science and faith. Scientists enjoyed great moral influence which should be used in the defence of man and his dignity. The task of scientists was gigantic and noble, and the world expected from them a service worthy of their intellectual capabilities and ethical responsibilities.

The symposium on Galilean Science Today rightly took place in the Barberini Palace in the very room where Galileo often visited his friend who later as Pope Urban VII and Head of the Church came into conflict with him. The very charged sessions provided a wide panorama of modern science where true to Galileo's principles the search for truth was carried out in intellectual humility.

In concluding the symposium, Nino Zichichi called for optimism because, after all, human intellectual power is enormous. Our striving towards a fuller understanding of Nature should lead to a better life in peace and human dignity. More means are needed for research and not for arms because, as should be made known widely, scientists' work is of the greatest value to mankind. These stimulating days of talks and meetings of eminent scientists in the public eye certainly assisted these aims and were a worthy memorial to two great men of science.

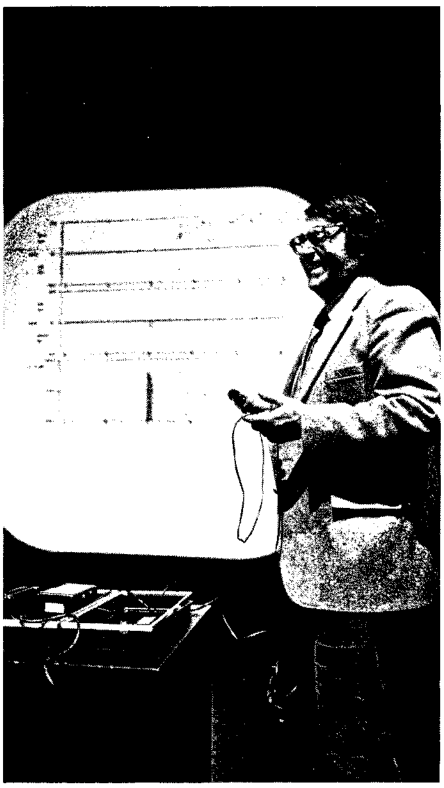
(Report by Simon Newman.)

Around

FERMILAB Annual Users' Meeting

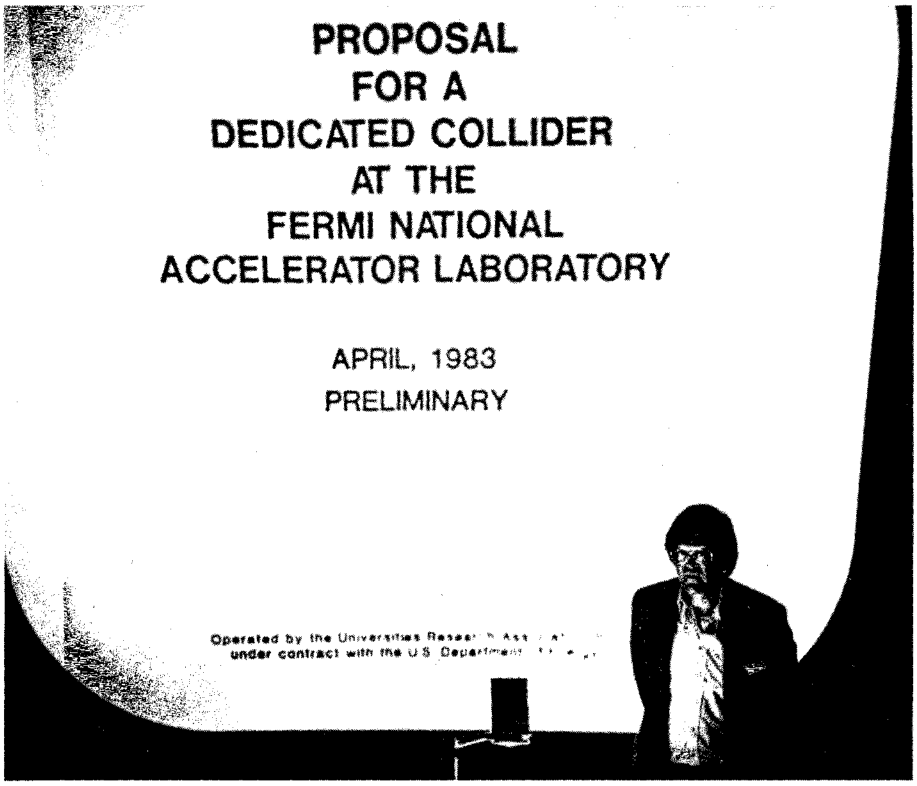
In an atmosphere full of promise a record 370 users met at Fermilab in April for the 15th annual Users' Meeting. The gathering took place in the midst of activities to bring beam through one-third of the Energy Saver (see June issue, page 181)*. Laboratory Director Leon Lederman and his staff reported that the ring was nearing completion and that circulating beam could follow soon. The ebullience of the moment was further

At the recent Fermilab annual Users Meeting, Peter Limon describes progress on the one-third ring beam test for the Fermilab Energy Doubler. As he spoke, beam monitors showed that beam had travelled several hundred feet, but later that day beam was happily passing through the third of the ring to a temporary beam dump.



the Laboratories

James D. Bjorken presents Fermilab's new proposal for a dedicated proton-antiproton collider, reaching collision energies of 4 or 5 TeV. It would fit gracefully into the Fermilab site and use the Tevatron as injector.



PROPOSAL
FOR A
DEDICATED COLLIDER
AT THE
FERMI NATIONAL
ACCELERATOR LABORATORY

APRIL, 1983
PRELIMINARY

**** First full turn of beam around the new Fermilab superconducting Doubler Ring occurred on 2 June, with the ring operating at 100 GeV.***

stimulated by an awareness of the momentous successes in Europe and by the realization that pivotal decisions would have to be made for the United States to regain a leading position in the field.

The two-day programme included talks by Leon Lederman, Universities Research Association president Guy Stever and the Director for Energy Research at the US Department of Energy, Alvin Trivelpiece. Of particular interest to users were presentations by Fermilab personnel on the status of laboratory facilities for the upcoming fixed target programme. Particularly lively discussion ensued after presentations by Ken Stanfield on the experimental areas and by Taiji Yamanouchi about the schedule. Users were characteristically concerned with seeming delays in schedules that prevented their resumption of an active experimental programme as early as possible.

The situation with TeV I, the proton-antiproton collider programme at Fermilab, was aired in talks by John Peoples who described the design and projected construction schedules for the antiproton source, by Alvin Tollestrup who presented a status report on the collider flagship detector for TeV I, and by Dave Johnson who outlined the possibilities for the other interaction region in D0. The inevitable comparisons with the CERN programme had to be made. Reasons for optimism emerged based on higher energy (2 TeV compared with 0.54 TeV) and higher anticipated luminosity, permitting the exploration with higher statistics of 'known' phenomena such as Z^0s and Ws and perhaps opening thresholds to new and unexpected physics.

Al Brenner reported on the Computing Facility at Fermilab and described the present saturated state of the BCyber system. He outlined the schedule for the acquisition of an upgraded system which calls for at least a factor of two more computer power to be installed by Christmas. This new system will take care of the computer needs for only the next two to three years. Brenner emphasized that a new architecture is really needed to accommodate the long-term computing requirements at Fermilab.

A highlight of the meeting was a Friday afternoon session devoted to a discussion of Fermilab options presented to the High Energy Physics Advisory Panel subcommittee on New Facilities (Woods Hole Panel). In a brilliant introductory statement panel chairman Stanley Wojcicki outlined the panel's objective, the method by which it hoped to arrive at its recommendations, and the good news and bad news confronting US particle physics. J.D. Bjorken gave a short summary of the new Fermilab proposal for a 2 TeV on 2 TeV Dedicated Collider (DC) and Maury Tigner summarized the results of a Cornell workshop on a 20 TeV on 20 TeV proton-proton collider, the so-called 'Deserton'. A lively 'Town Meeting' discussion followed.

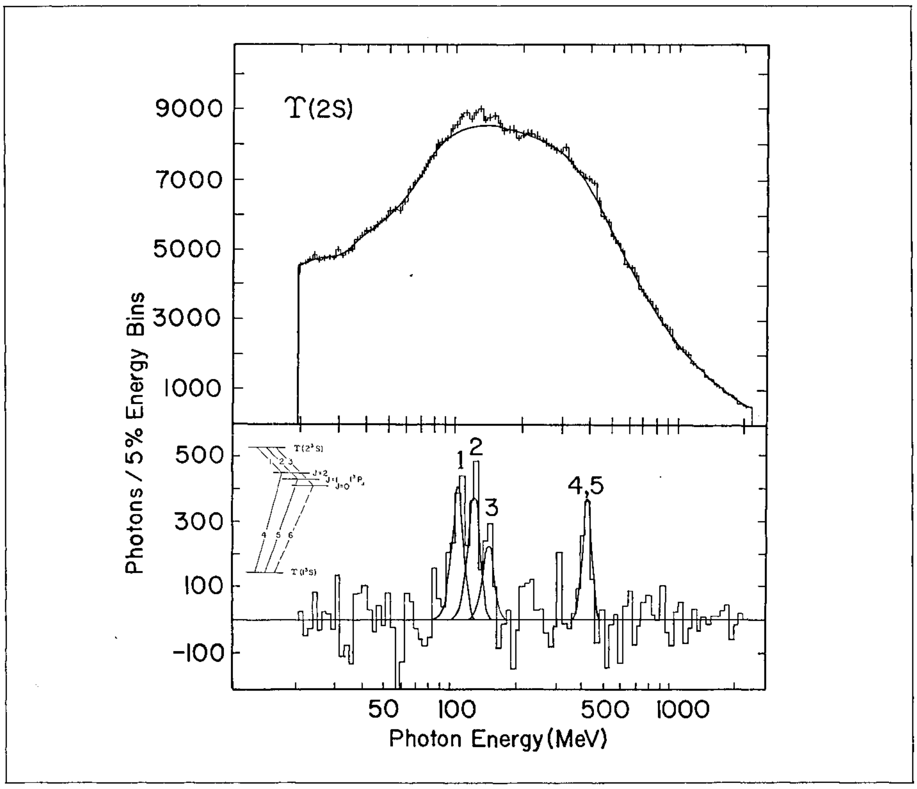
In his talk on Saturday regarding the Department of Energy's Fiscal Year 1984 Science Budget, Alvin Trivelpiece said nothing to dispel mounting optimism by pointing out that the climate for basic research in Washington is good, both major parties would identify themselves as friends of basic research and the administration is open to suggestions for major new initiatives in science.

Some of the new physics that may be studied with the new machines was summarized by Martin Perl of SLAC who gave a talk entitled 'The Status of Lepton Searches', a speciality of his for which he received the 1982 Wolf prize for physics, an honour he shared with Fermilab Director Leon Lederman. The conference ended with an interesting discourse on computing and its ramifications by 1982 Nobel laureate Ken Wilson of Cornell. He argued persuasively that we must look to the revolution in microprocessors to provide the basis of an industrial recovery. Moreover, he presented a scenario whereby the funding of the 'Desertron' could be effectively obtained from computer and electronics companies without having to look to the US federal government. On this euphoric note attendees dispersed to continue their preparations for the imminent Tevatron era.

CORNELL
More upsilons

The CUSB group working at the CESR electron-positron collider has added three new particles to the upsilon family. The upsilons are understood as beauty quark-antiquark bound states with parallel quark spins (triplet states, carrying also orbital angular momentum. So-called P states carry one unit of orbital angular momentum, while S states have none. The CUSB group has now observed the ground state P upsilons in radiative decays of the first excited S upsilon.

Evidence for three new upsilon states from the CUSB detector at Cornell's CESR electron-positron ring. Top, single photons from radiative decays of 2S upsilons show an excess over the background. Below, the background-subtracted spectrum, showing how well it is fitted by three photon lines at 149, 128 and 108 MeV, corresponding to the three states of the 1P upsilon. The 427 MeV signal is due to the (merged) 1P to 1S decays.

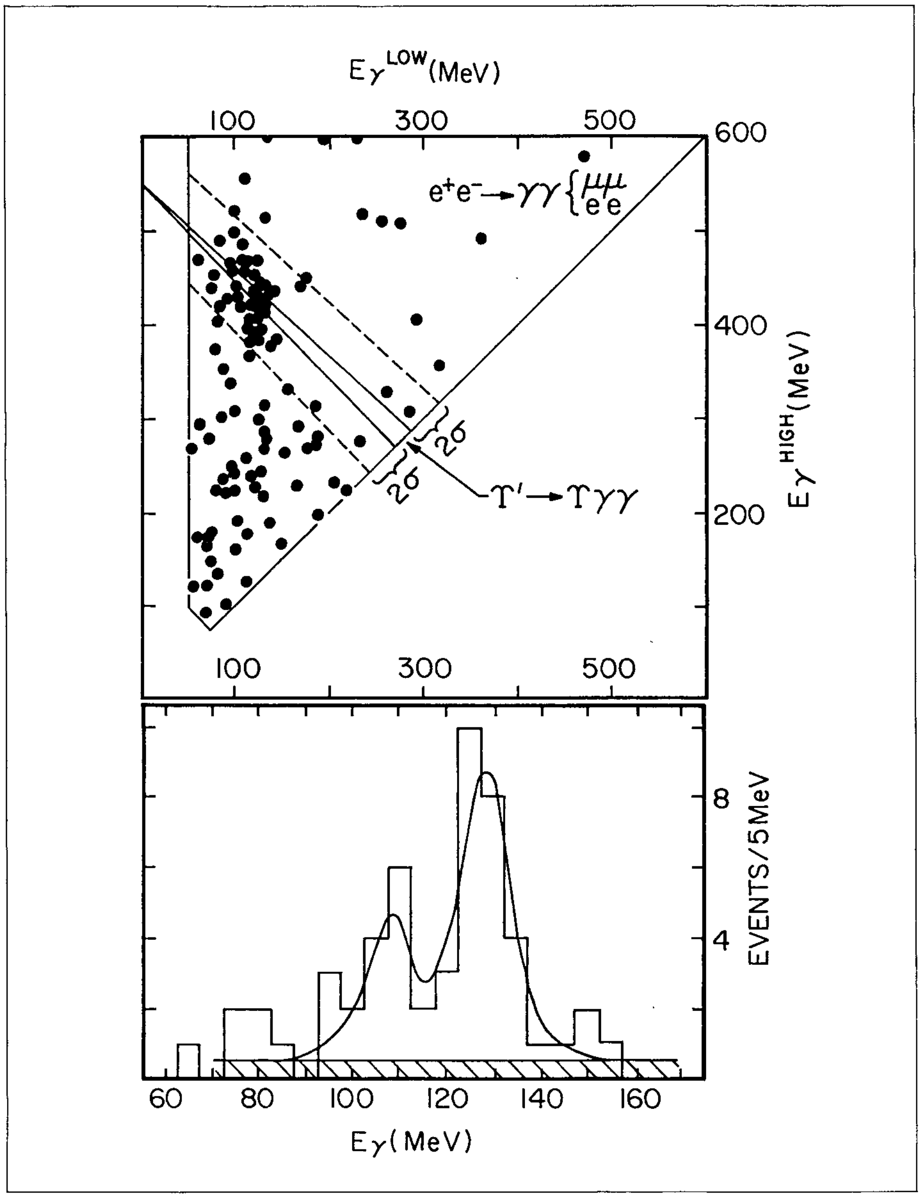


The four lowest lying S upsilons are relatively easy to observe since they carry the same quantum numbers as the photon and are directly produced in electron-positron annihilations. Many other bound states are expected to exist but they must be produced indirectly. In fact, the upsilon spectrum is far richer in bound states than the analogous charmonium system, although the search is more difficult due to higher multiplicities and lower production rates. The first excited P upsilons (2P) were observed at CESR with the CUSB sodium iodide and lead glass calorimeter last year in radiative decays of the second excited S upsilon (3S) — see September 1982 issue, page 274.

The CUSB group has also studied upsilon 2S radiative decays to search for the lowest lying P upsilon (1P). This task was expected to be more difficult, despite the higher production rate of 2S particles, because the rates for electric dipole transitions were expected to be significantly smaller than the 3S to 2P transitions. During a run from December 1982 to March 1983, 30 inverse picobarns of integrated luminosity were collected and 150 000 2S upsilon events were detected. The 2S events were analysed with the same two techniques that were successfully employed for the 3S events.

The first technique involves an analysis of the inclusive (single) photon spectrum from upsilon 2S decays. A broad prominent excess over background is visible in the region from 90 to 160 MeV. Another smaller, yet statistically significant, narrow peak is observed at 427 MeV. The interpretation of the lower energy signal as being due to radiative transitions from the 2S to the 1P upsilons is supported by a number of observations. The excess from 90 to 160 MeV is much wider than the detector resolution and has been fitted by three photon lines at 149, 128, and 108 MeV, corresponding to the three states of the 1P. These three lines are produced in the ratio expected for electric dipole transitions from 2S to 1P states. Both the centre of gravity of 9 900 MeV for the 1P mass, and the measured branching ratio of 16 per cent agree with predictions. The expected lines for decay of the 1P to the ground state (1S) are observed (merged together) at 427 MeV which

Top, the scatter plot of the photon energies of the two photons for the upsilon 2S-1P-1S decay chain. The 1S is detected by its decay into two electrons or two muons. The solid diagonal lines show the 2S-1S upsilon mass difference on which the decay photons should cluster. Below, the spectrum of the lower energy photon has prominent lines at 107 and 128 MeV. Because of the small branching ratio involved, the third line, near 150 MeV, is suppressed and does not show up.



is consistent with the 2S-1S mass difference.

The CUSB group has used a second independent analysis technique to search for the 1P states. This technique involves the simultaneous observation of the two photons in the decay chain 2S-1P-1S. The first photon comes from the 2S-1P decay, the second from the 1P-1S decay. The 1S is detected by its decay to two electrons or two muons. In this analysis all four final state particles are observed in the detector.

Events with only two photons cluster at energies of 120 and 430 MeV in the scatter plot of the two photon energies. The sum of these energies has a nice peak at the energy corresponding to the 2S-1S mass difference, after properly accounting for the recoil energy. This agrees with the hypothesis that these events are produced via 1P intermediate states. Two lines at 107 and 128 MeV are prominent in the spectrum of the lower energy photon; the third line near 150 MeV is not expected to be visible in this sample of double radiative transitions due to the small branching ratio for the decay of the appropriate 1P state.

The remarkable agreement in the energies and branching ratios of the low energy photons obtained from these two distinct analyses is reassuring.

With these latest additions, the upsilon family now includes ten members. The spectroscopy provides valuable new information with which to test the theories describing the binding forces between quarks.

ORSAY/CERN Progress with LEP Injector Linacs

At CERN, construction work is under way near the PS for the tunnels to house the injector linacs for the new LEP electron-positron collider. These LEP Injector Linacs (LIL) are covered by a formal agreement between CERN and the French Orsay Laboratory, signed in March last year.

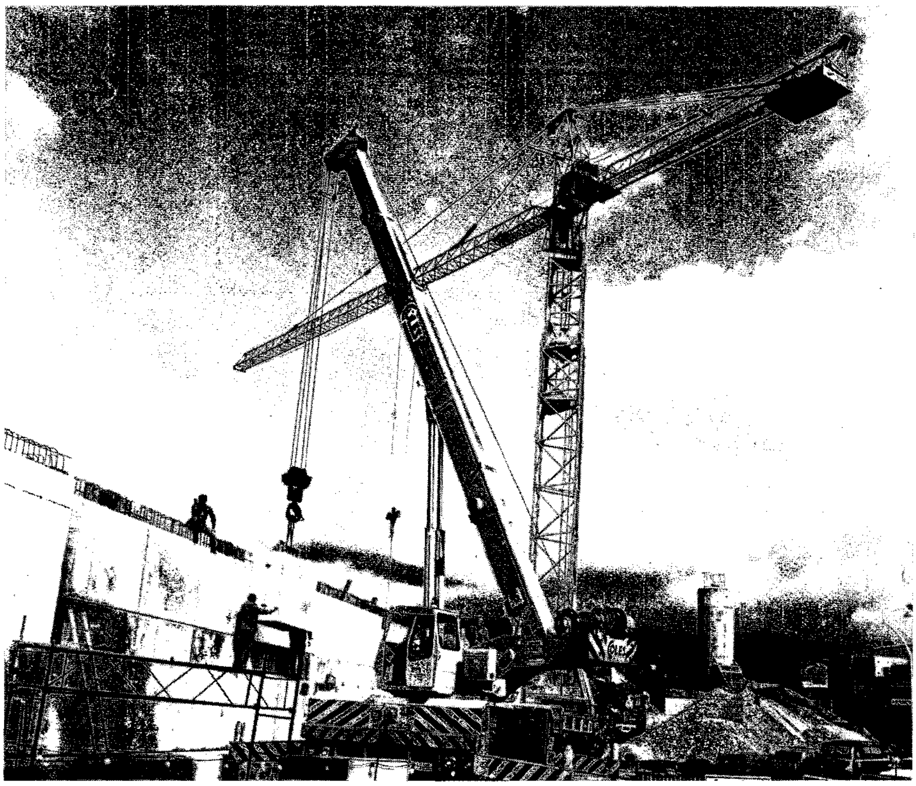
An important decision concerning the thinking behind the linac project was also taken at about that time. Following discussions in the 'LEP Machine Advisory Committee', it was decided to fit the linacs with a pulse compression system (storage cavities, as in SLAC's SLED project), thus reducing the original nine klystron-modulators to six.

Work over the past two years concentrated on the design study of various prototypes, like the heavy current injector, the prototype modulator and the prototype cross-section, and on calculations of beam dynamics. Now it has taken a fresh direction, and specifications are being drawn up for the calls for tender for the various linac components.

The high current injector (the initial 200 MeV electron linac) consists of a triode gun operating at 90 to 100 kV followed by a 30 MeV standing wave buncher. The equipment has been assembled at Orsay's Linear Accelerator Laboratory to test the characteristics of the transmitted beam. This testing station (see May 1982 issue, page 147) has virtually reached its design performance. In the latest tests, charges of 50 nanocoulombs or more have been successfully accelerated at the buncher output at various pulse widths (e.g. 5 A, 10 ns).

The characteristics of the microbunches produced agree with the calculations — a phase extension of the microbunches around the peak of the r.f. wave of 10° for 50 per cent of the accelerated particles and 24° for 80 per cent of them. The width of the energy spectrum is 11.5 per cent for 80 per cent of the accelerated particles.

A modulator-klystron assembly from the Orsay linac was modified to provide an r.f. pulse width of 4.5 μs, compatible with the filling time of the bunching section. The long pulse of this assembly has made it possible to test the pulse compression system for LIL. Here, there is a SLED-type operating mode borrowed from SLAC in which part of the long pulse is stored in low-loss storage cavities and then abruptly re-emitted in a very short time (virtually the same as the accelerating section filling time). At a constant peak power supplied by a klystron, the effect of this is to increase the peak power supplied to the sections. In other words, for a given acceleration gradient, it is possible to power more sections with the same modulator-klystron assembly. The saving made has led to the name 'LIPS' (LEP Injector Power Saver) for the LIL version.



Construction work under way at CERN for the LEP Injector Linacs (LIL). Assembly work for the linacs should start next spring and first beams could be accelerated at the end of 1985.

(Photo CERN 316.5.83)

The spherical storage cavities were built by CERN and taken to Orsay for the successful tests. The initial r.f. pulse of 23 MW, 4.5 μs, was transformed into a shorter pulse with an average power of 50 MW for 1 μs but with a peak at 115 MW. LIPS will now become the official version of the LIL r.f. power supply, and results in a total saving of three modulator-klystrons.

A prototype LIL modulator has been set up at Orsay. It provides a long 4.5 μs, 280 kV, 300 A pulse intended to power a klystron with a peak power of 35 MW. Design performance has been reached and the modulator, in its virtually final version, is now undergoing power life tests. The prototype klystrons will be acceptance-tested at Orsay using a prototype modulator.

Various prototype LIL accelerating cells were roughed out and then machined at the beginning of 1982. This permitted the testing of diamond cutting tools and the measurement of the r.f. characteristics. Thereafter, 45 cells were machined, assembled and brazed to provide a three-stage prototype section 1.5 m long. An additional section of 13 cells corresponding to the ninth linac step has also been assembled but not brazed. Apart from the measurement of the overvoltage coefficient, which turned out to be 10 per cent below expectations, the r.f. and mechanical characteristics are excellent. Two types of input and output couplers have been successively developed. The couplers finally chosen are now being subjected to further measurements in order to obtain dimensions which are as close as possible to the final ones and to gain full knowledge of the fine matching adjustments.

The design studies on beam focusing in the low-current 600 MeV electron-positron linac have resulted in a FODO-type solution in which the quadrupoles are arranged around the sections. The first two sections of the 600 MeV linac, however, are focused by long solenoids. The heavy-current linac makes use of triplets fitted between the sections.

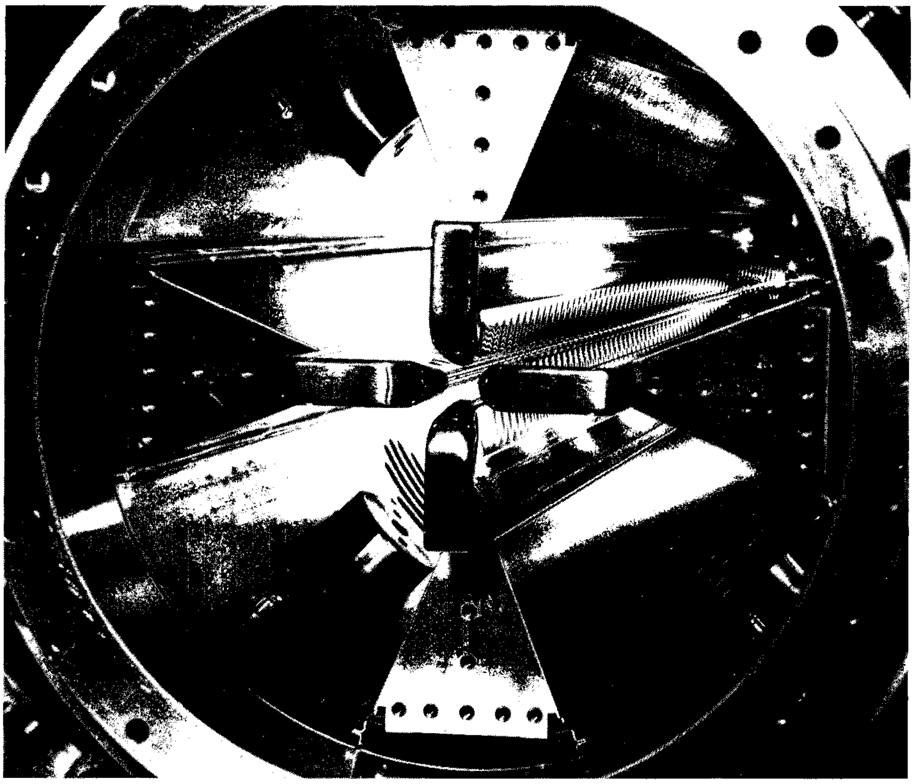
By now, a large number of the calls for tender for the LIL components have been issued and several contracts have been placed. The first production section and modulator are due for delivery at the beginning of 1984.

It should be possible to accelerate the first beams at the end of 1985. The full LEP machine is now scheduled to come into action in the second half of 1988. (See page 228 for other LEP news.)

CERN
Nuclear beams

Several major Laboratories are looking at the possibility of doing experiments with high energy nuclei, accelerated in machines designed to handle protons. Machines in Germany, France and the US are already providing beams of lower energy nuclei. Experiments using these beams, and other studies using particle beams on nuclear targets, have provided tantalizing hints of new behaviour.

Especially compelling is a search for the so-called 'quagma', or quark-gluon plasma, a new state of matter expected to have different properties than conventional nuclear matter.



The interior of the radio-frequency quadrupole (RFQ) recently tested successfully at CERN. Such preinjector units are seen as playing an important role in any future projects to accelerate heavy ions at CERN.

(Photo CERN 19.3.83)

At CERN, an idea has now been accepted in principle to mount an experiment using beams of oxygen 16 ions accelerated in the 28 GeV 'proton' synchrotron. This machine is no stranger to exotic beams, having provided deuterons and alpha particles and antiprotons. For the future, it is also scheduled to supply electrons and positrons for LEP.

The main problem in accelerating heavier ions in an existing machine, designed to handle other particles, usually occurs in the linac. To be accelerated, the particles must appear between the drift tubes in step with the oscillating fields in the linac tanks. This depends on the charge to mass ratio of the particles and the strength of the fields.

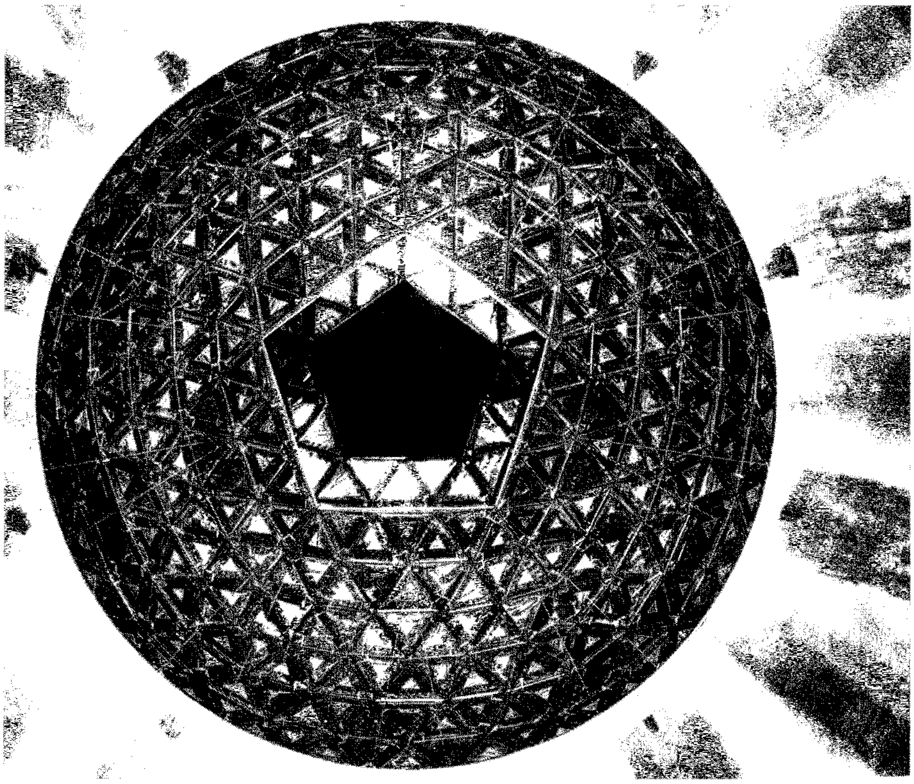
The old PS linac (which is alongside the new one and is still available for accelerating particles) can operate with fields about a third higher than for normal proton operation. This makes it possible to accelerate oxygen ions carrying six positive charges. These ions would then pass through a stripper foil at 12.5 MeV per nucleon to completely strip away the remaining two orbital electrons, leaving just the oxygen 16 nucleus.

Some r.f. gymnastics remain to be done, but in principle there would be no problem in accelerating the completely stripped ions in the synchrotrons. The four-ring Booster would be used prior to injection into the PS ring since it would give higher intensities. It also keeps the r.f. gymnastics out of the PS ring, which will have many other tasks on its hands.

Ion intensity is important, and serious attention to optimizing ion source and proposed radiofrequency quadrupole (RFQ) preinjector will be necessary. RFQs have demonstrated

Unusual view of the 'Plastic Ball' detector (a Berkeley/Darmstadt collaboration) used in heavy ion studies at the Berkeley Bevalac. The idea is to move this to CERN for higher energy studies.

(Photo LBL)



their ability to provide a potentially highly efficient replacement for conventional preinjectors (see May 1980 issue, page 108). Also the existing proton beam monitors would not be sensitive enough for the ion beams and the beam monitoring system will need development.

For the oxygen 16 beams, the energies of interest are in the range 7-13 GeV per nucleon. Berkeley and Darmstadt are prepared to provide an ion source and RFQ pre-injector. Experiments would use the 'Plastic Ball' detector, currently used in heavy ion experiments at the Berkeley Bevalac, together with a streamer chamber.

Over the years, the PS has become more a source of particles for other CERN machines, so that the experimental areas it can serve are now limited. The streamer chamber would require a large vertex magnet such as has been relocated recently in the West Experimental Area. However, this area has no direct link to the PS, being served by beams from the big 450 GeV SPS Super Proton Synchrotron.

For the oxygen 16 experiments, the beams from the PS would be fed into the SPS, which would act as a gigantic transfer line and swing the beam round to point in the required direction.

If the ions are to be injected into the SPS anyway, it is only natural to contemplate their acceleration as well. In principle fully stripped oxygen ions at about 7 GeV per nucleon could be fed in and accelerated up to about 225 GeV per nucleon. However, no decision on this possibility has been taken at this stage, and it remains as an option for 1986 and beyond.

The interest in heavy ion experiments at CERN was reflected in the recent SPS fixed target workshop (see January/February issue, page 8), where a lively stream of parallel sessions and subsequent summaries covered the potential use of nuclear beams and targets for the SPS.

DESY
Polarized Beams

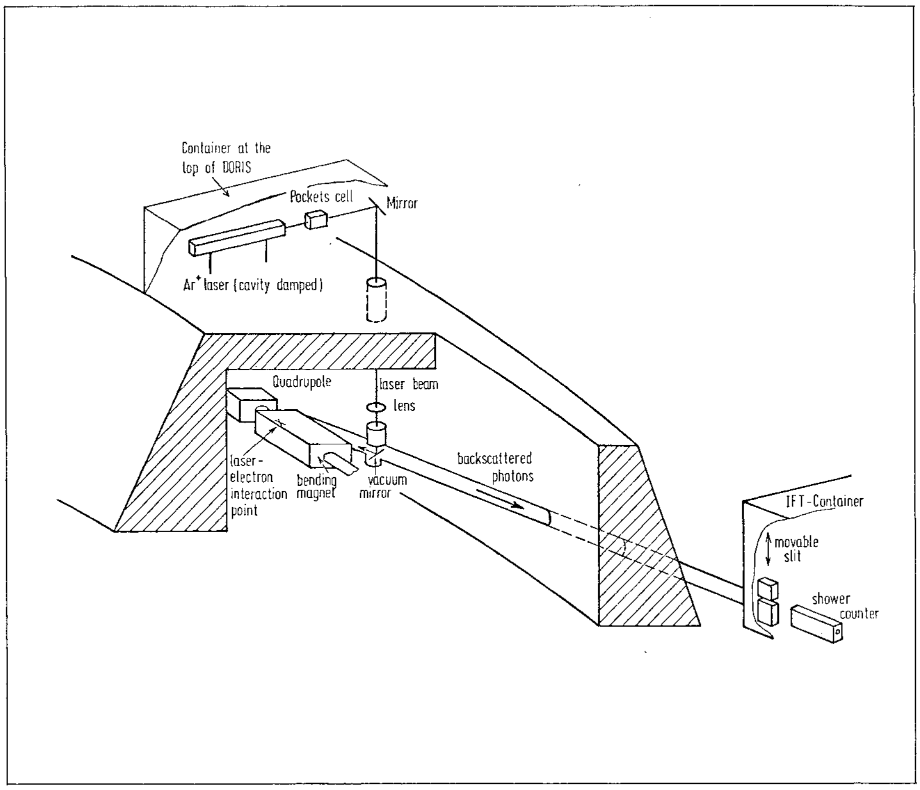
In both electron-positron storage rings at DESY (PETRA and DORIS-II) polarized beams can now be obtained and kept under conditions which seem reasonably well understood. While at PETRA the energy of particles circulating in the machine is currently measured with an accuracy of five significant digits using the depolarization method, the two experiments running at DORIS, Argus and Crystal Ball, have measured asymmetries caused by an 80 per cent beam polarization at the upsilon prime energy.

Beams at PETRA become polarized within twenty minutes and to keep the polarization some loss in luminosity must be accepted. However at DORIS-II the polarization time is only one minute and there seems to be no loss in the excellent luminosity performance of 1000 inverse nanobarns per day.

At the PETRA ring, a device to measure polarization was installed back in 1978. A polarized laser beam is directed against the electrons. The backwards scattered laser photons, which take a large amount of energy from the electrons, are detected in counters along the beam-pipe. The distribution of these photons provides the information needed to calculate the degree of polarization of the beam.

During the last year this procedure has been improved considerably. It is now possible to make a measurement in only one minute. This allows a more or less continuous monitoring

Diagram of the laser polarimeter recently installed at the DORIS-II electron-positron ring at DESY.



of the degree of polarization. Factors affecting the polarization can be quickly recognized and eventually controlled. At present a new laser is being installed which should allow the degree of polarization to be measured in a few seconds.

The early measurements at PETRA have confirmed essentially the expectations for polarization and for several depolarizing effects. Polarization was normally very low and in addition it was different for every fill. The bare PETRA machine destroys its polarization at about the same rate at which it is built up. The lack of reproducibility made it impossible to use polarization for any type of experiment until a reliable method was found for accurate control of the working conditions.

Depolarization is caused by several components and imperfections in a storage ring. However polarization can be enhanced by compensating those components of the vertical distortions which are closest to the main depolarizing resonances. Special beam 'bumper' combinations are used empirically to cancel the main depolarizing effects.

At PETRA, the polarization can be maintained with reasonable luminosity at around 80 per cent. Feedback with fields as low as 0.1 gauss can destroy the polarization. The frequency gives the exact energy of the beam and the accuracy of such measurements is two orders of magnitude better than the natural beam energy spread. This enables other important properties of the beam to be tested, such as the momentum compaction factor, which measures the variation of the accelerating high frequency field with beam energy.

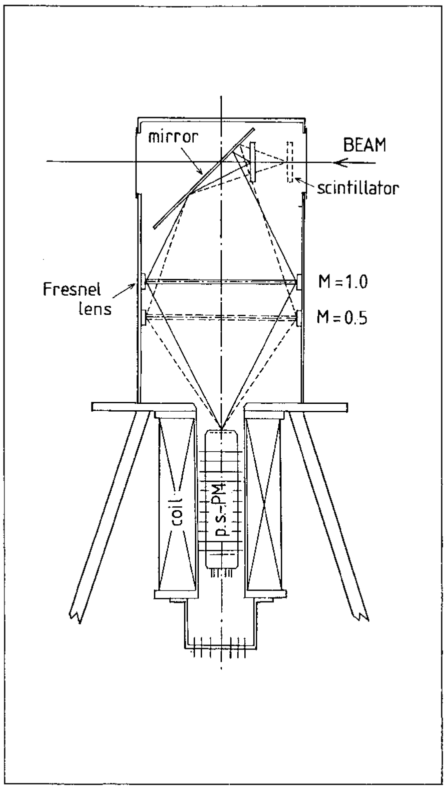
At DORIS-II, the asymmetry of electron-positron annihilation into two photons was measured by both experimental groups at the upsilon prime energy, away from any depolarizing resonance. Both groups obtain a value of 80 per cent, in agreement with measurements using a laser polarimeter.

LAPP (ANNECY)
High resolution hodoscope

Thanks to continual technological advances, scintillator materials have kept their place as one of the main weapons in the armoury of particle physicists.

At LAPP, a new high resolution scintillator hodoscope has been developed which uses a special photomultiplier placed in an axial magnetic field to localize the secondary elec-

Schematic view of the prototype hodoscope using the position sensitive photomultiplier (p.s.-PM, below).



trons. Development work established the optimal configuration of the focusing dynodes, and a prototype was developed in collaboration with Hamamatsu TV.

In this device, the secondary electrons, after amplification by the series of dynodes, are collected on a multianode arranged in a matrix array (see July/August 1980 issue, page 199).

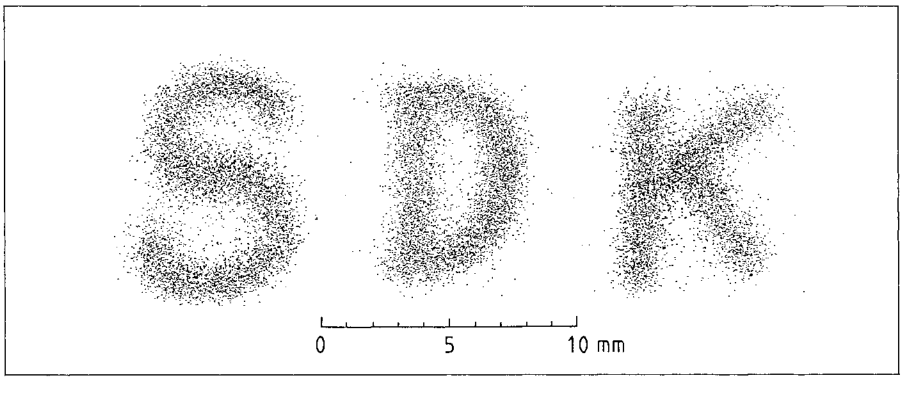
Using this device with 10 mm of scintillator, a prototype hodoscope has been constructed which is able to detect the position of particles in a dense 10 GeV pion beam (from the CERN PS) to better than 1 mm in two dimensions.

The pulse heights were recorded in an on-line computer and the position of the impact point calculated. Subsequent off-line analysis can further improve the recorded image quality.

A lens system has been devised to optimize the performance of the large aperture optics. This also gives the hodoscope the additional ability to 'zoom' up and down the beam. Possible improvements to the optics have also been demonstrated.

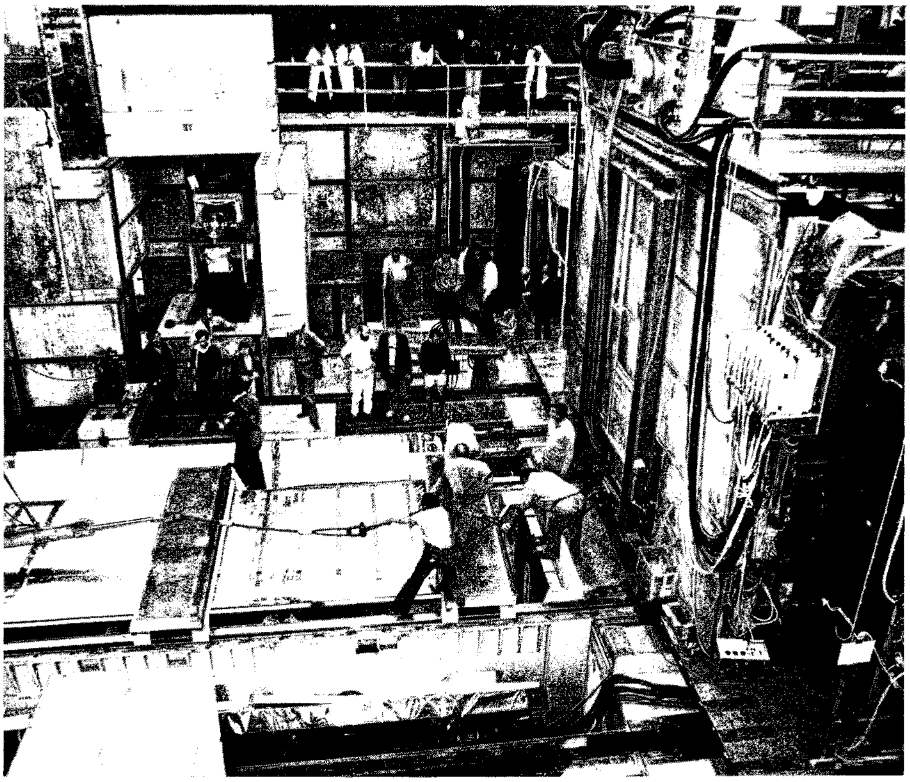
The device, with its technical simplicity and its use of the well established photomultiplier technique, appears to offer certain advantages over gaseous or solid-state detectors. For the future, a fast analog processor is being developed to extend real time calculation capability, and a more sophisticated unit, with a larger multianode, is also foreseen. Applications are foreseen in several areas of particle physics or medicine. For the latter, a hybrid system is being developed using the photomultiplier with an image intensifier so as to provide a larger sensitive surface.

An example of the resolution obtained with the hodoscope, using external defining scintillators in the shape of letters.



Seen here being reinstalled in the PETRA ring at DESY in 1981 is the PLUTO detector, which went on to amass important data from photon-photon collisions. This detector has had a long and illustrious career at both the DORIS and PETRA rings.

(Photo DESY)



CONFERENCE
Photon-photon collisions

Despite being difficult to observe, photon-photon collisions have opened up a range of physics difficult, or even impossible, to access by other methods. The progress which has been made in this field was evident at the fifth international workshop on photon-photon collisions, held in Aachen from 13-16 April and attended by some 120 physicists.

The plenary morning sessions gave overviews of the ground covered since the Paris workshop two years ago. The substantial evolution of the field resulted in some lively afternoon discussion sessions, while in the experimental sessions 27 papers were presented, compared to seven at the Paris meeting.

The photons which collide are bremsstrahlung (radiation) from the circulating particles in electron-positron storage machines. To separate the photon collisions from direct electron-positron interactions, the outgoing electron and/or positron has to be detected, or the events identified by forward/backward missing energy.

The former method requires high electron detection efficiency close to the beam direction, while the latter requires good coverage for charged and neutral hadron detection.

At DESY, the eminent suitability of the PLUTO detector for this work was clearly demonstrated by its contributions to the workshop. It is a little saddening that PLUTO (after being active at the DORIS and PETRA electron-positron rings since 1974) is leaving no ideally equipped successor for two-photon physics. However first two-photon results from the detectors at the PEP ring indicate a very promising programme at SLAC.

Among the topics covered were two-photon production of meson resonances, of muon, hadron and proton-antiproton pairs, and of four charged pions, together with results on the photon structure function (a speciality of this field of physics).

Results from the JADE detector at PETRA provided interesting further information on the relative production levels of charged and neutral rho meson pairs in different charge combinations of four pions. The Crystal Ball detector showed some nice examples of light scattering (elastic photon-photon collisions) through an intermediate eta meson.

Good data on the total photon-photon cross-section looks difficult to come by, and the two-photon reaction may have limitations when used as a probe of quantum chromodynamics (theory of quarks and gluons) through the photon structure function.

On a lighter note, the choice of two possible afternoon excursions confronted the participants with a totally different problem, and provided another success for the organizers when all participants were convinced they made the correct choice!

(Report compiled from material kindly supplied by Egil Lillestol.)

Robert B. Palmer

People and things

On people

Robert B. Palmer has been appointed Associate Director for High Energy Physics at Brookhaven National Laboratory, and becomes responsible for the research programmes at the Alternating Gradient Synchrotron and the planned Colliding Beam Accelerator. He joined Brookhaven's Physics Department in 1960 and has played an important role in many of Brookhaven's research projects and physics discoveries, including the recent work on new superconducting magnets for use in particle accelerators.

Sharing the 1982 Enrico Fermi Award are Herbert L. Anderson of Los Alamos National Laboratory and Seth H. Neddermeyer of the University of Washington. Established in 1956, the Award is made only in those years when the selection committee deems the nominees to have made exceptional contributions to the field of atomic energy. Anderson was cited for 'his pioneering collaborations with Enrico Fermi in demonstrating the emission of neutrons in fission at Columbia University; for his essential role in constructing the first chain-reacting piles; for his work on the production and the determination of the properties of tritium and helium-3; for his collaboration with Fermi in detecting the first hadronic resonance at the University of Chicago; and for his continuing contributions to understanding the nature of strong and weak nuclear forces.' Neddermeyer was honoured for 'participating in the discovery of the positron; for his share in the discovery of the muon; for his invention of the im-

Good news for LEP

The 'Déclaration d'Utilité Publique' decree for CERN's LEP electron-positron collider has now been signed by the French government, so that the way is now clear for the civil engineering construction of the 27 km ring. It is hoped that work on the tunnel will start soon and first collisions should then be achieved in the second half of 1988.

One of the main aims of this machine is to provide a copious source of Z^0 particles, heavy (about 100 times the mass of the proton) carriers of the weak force. These particles are one of the key predictions of the electroweak theory which unifies electromagnetism with the weak nuclear force.

As well as having French government approval, it was also comforting for the LEP community to hear CERN's announcement of the discovery of the Z^0 (of which the first signs were reported in our June issue). By the beginning of June, five candidate Z^0 events had been found in the CERN SPS proton-antiproton collider (four decays into an electron-positron pair and one into two muons). The particle's mass looks in line with the predictions of the electroweak theory, and thus in line with the LEP design energy. Later this year, a special issue of the CERN COURIER will be given over to these historic discoveries of the W and Z particles.

Carlo Rubbia

Simon van der Meer

plosion technique for assembling nuclear materials; and for his ingenuity, foresight, and perseverence in finding solutions for what at first seemed to be unsolvable engineering difficulties.'

Carlo Rubbia and Simon van der Meer of CERN were awarded the degree of doctor honoris causa by the University of Geneva on 3 June. The awards were in recognition of the important role played by both men in the CERN antiproton project leading to the discoveries of the W and Z particles.

The sixtieth birthday of E.R. Caianiello was the occasion of a physics theory meeting at Amalfi (near Naples, Italy) early in May. It brought together about 60 physicists, and in particular almost all the many collaborators with whom Prof. Caianiello has worked during his many very productive years in physics. He is well known for his formulation of Feynman diagrams using determinants and permanents, and for his contributions to renormalization theory. His scientific interests now include biophysics, and he is also working on the geometrical approach to quantum theory.

Angelo Scribano has been appointed Director of the Italian INFN Pisa Laboratory. Over the years, he has been active in a wide range of experiments using the CERN machines, and is currently also engaged in the Fermilab Collider Detector Facility with a Pisa-Frascati team.

At a physics meeting at Amalfi (near Naples) to celebrate his sixtieth birthday, E.R. Caianiello (right) chats with former collaborator J.A. Wheeler.

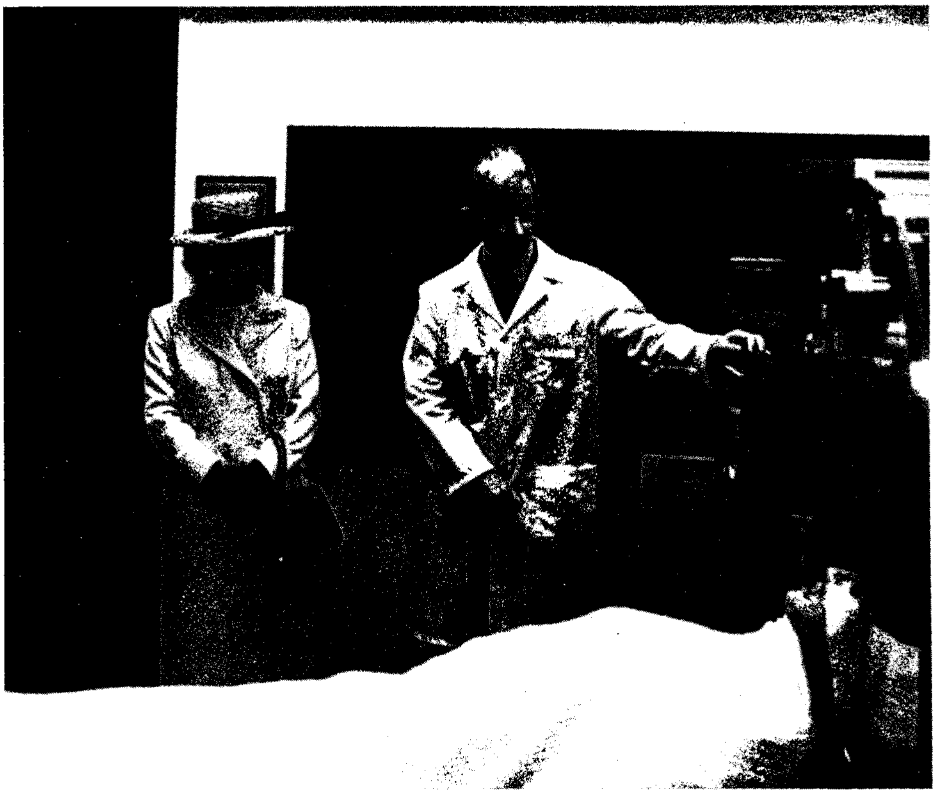
American Physical Society's Division of Particles and Fields

The 1983 Executive Committee has the following membership — Chairman Alfred Mann of Pennsylvania, Vice-Chairman John Peoples of Fermilab, Past Chairman Charles Baltay of Columbia, Secretary-Treasurer Thomas Ferbel of Rochester, and Division Councillor C.N. Yang of Stony Brook, together with Edmond L. Berger of Argonne, Lowell Brown of Washington, Ernest D. Courant of Brookhaven, David Nygren of Berkeley, Thomas A. O'Halloran of Urbana-Champaign and Richard E. Taylor of SLAC.

Changes at TRIUMF

David Axen has completed a successful tour as Associate Director and Division Head for Science and will be returning to teaching at the University of British Columbia and experimenting at TRIUMF and LEAR. His replacement is Peter Kitching from the University of Alberta, who has been active in polarized proton reaction experiments.

Brian Pate retired from a very productive Headship of the Applied Programs Division in September 1982 to become Director of the UBC/TRIUMF Positron Emission Tomography Programme. Joop Burgerjon has taken over as Division Head since then, successfully commissioning the 42 MeV CP-42



Brian Pate demonstrates the Positron Emission Tomograph built at TRIUMF to Britain's Queen Elizabeth II during her recent tour of the University of British Columbia Acute Care Hospital. Short-lived isotopes are supplied direct from TRIUMF via a 2.5 km pneumatic tube.

(Photo: UBC Biomedical Communications)

CERN Director General Herwig Schopper watches as Netherlands Minister of Education and Technology W.J. Deetman signs the CERN visitors' book.

(Photo CERN 39.6.83)

cyclotron for isotope production. In October he will hand over to Richard Johnson, at present better known for his low energy pion scattering experiments measuring neutron and proton radii.

A Technology Division was formed last October with responsibility for Engineering Services, Controls, Electronics and Computers. Its first Head is Kenneth Dawson, a well-known FASTBUS enthusiast from the University of Alberta, who has recently spent some years' leave at Los Alamos.

Neutral currents revisited

In these days of Big Science, making a major discovery is a big step. This is well illustrated by a fascinating article by Peter Galison called 'How the first neutral current experiments ended', published in a recent issue of 'Reviews of Modern Physics' (Vol. 55, No. 2, April 1983). He traces in detail the story behind the discovery of the weak neutral current in the Gargamelle bubble chamber at CERN in 1973, the role played by the big neutrino counter experiment at Fermilab, and the personalities involved.

The SLAC 'Accelepede' won the prize for the best centipede costume in the 7.6 mile 'Bay to Breakers' carnival run in San Francisco in May. The Accelepede consisted of a chain of 33 runners wearing boxes representing SLAC power supplies, connected by beam pipe, and complete with flashing lights and beepers. We hope to be able to publish a colour photograph later this year.

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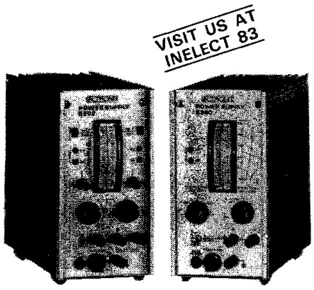

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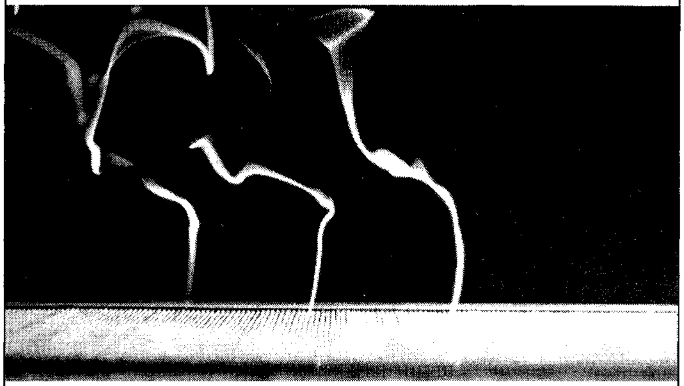

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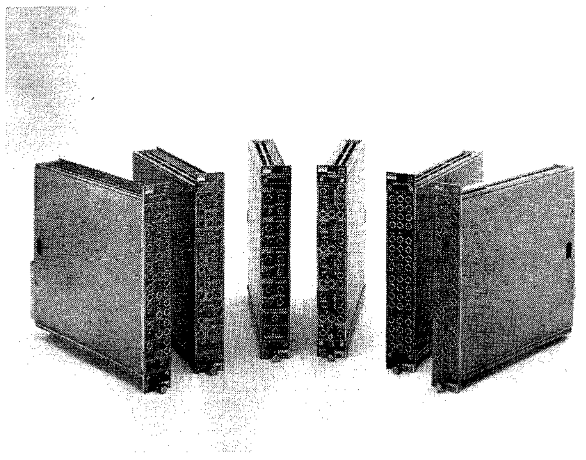

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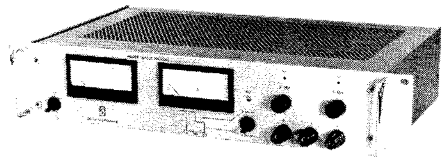

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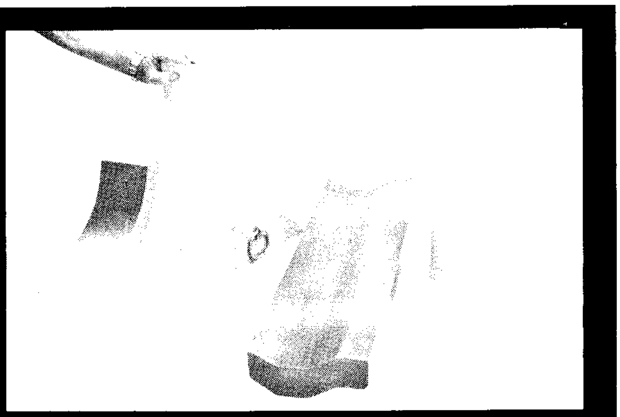

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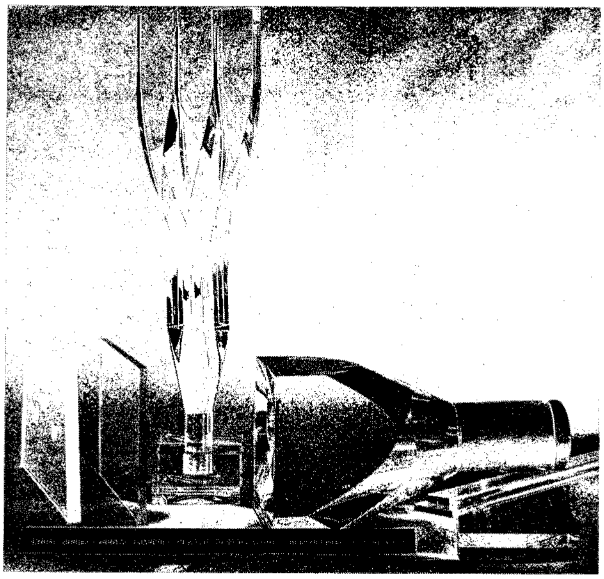

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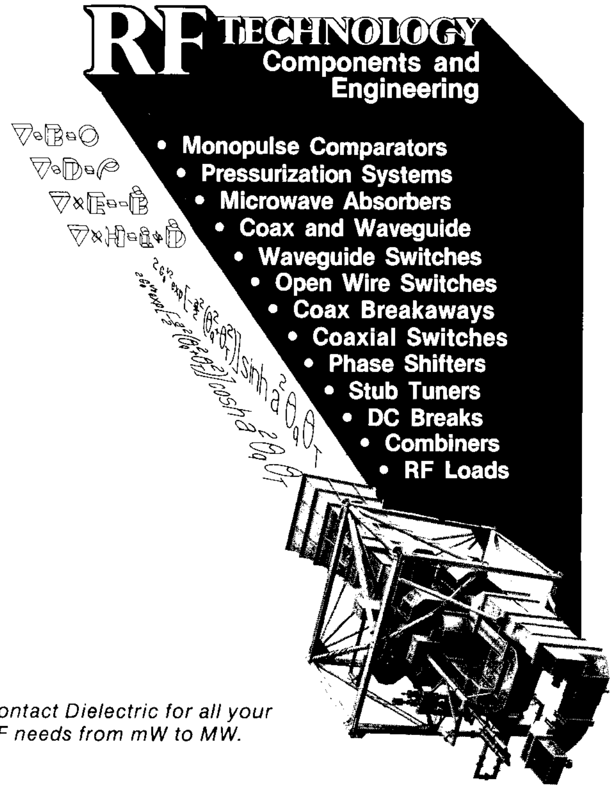

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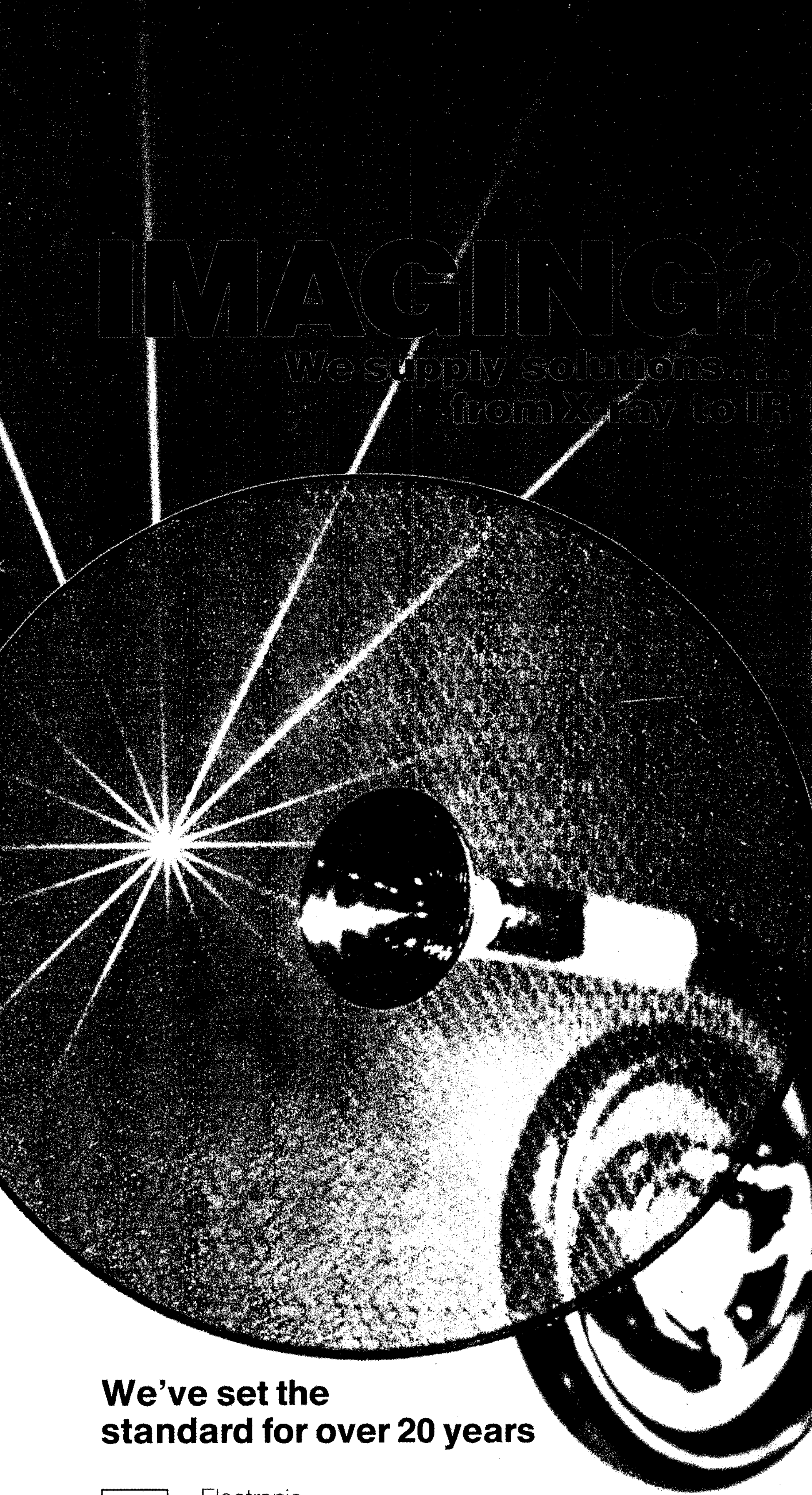

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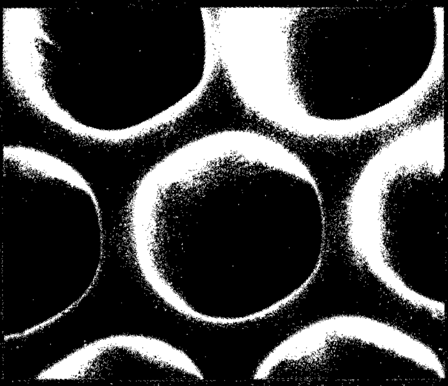

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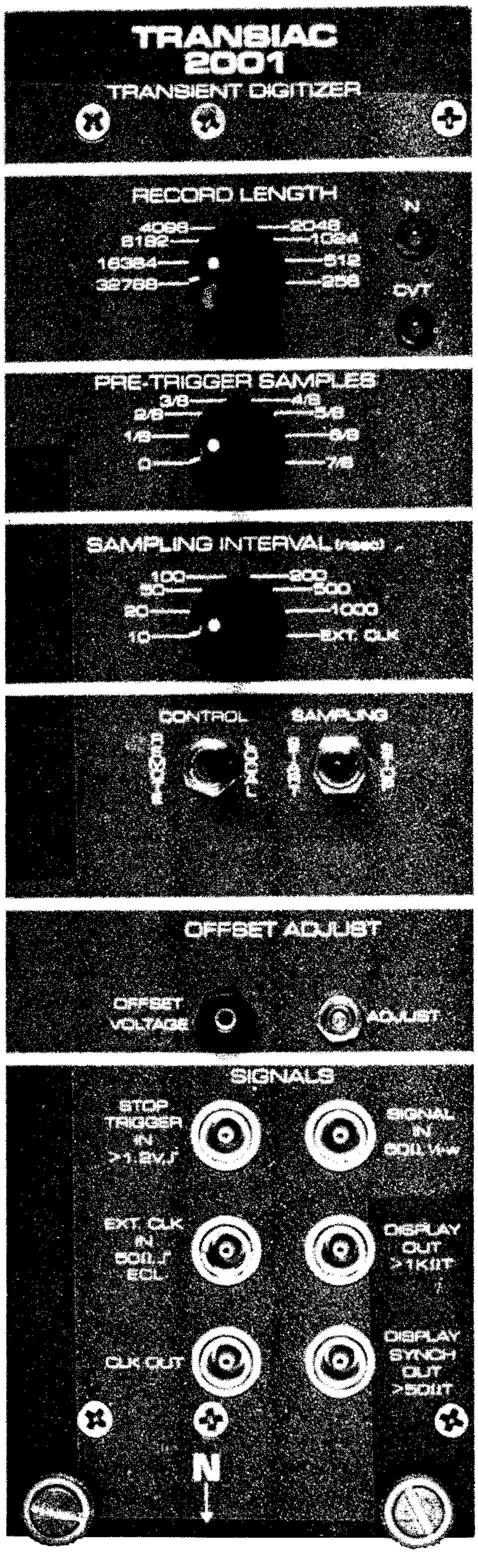

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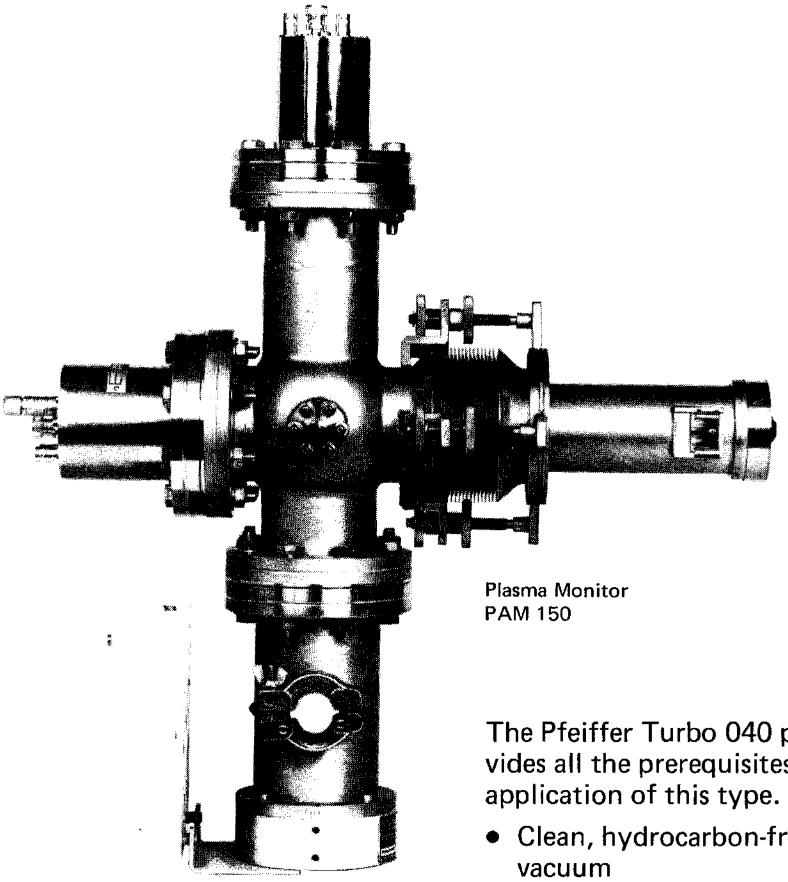

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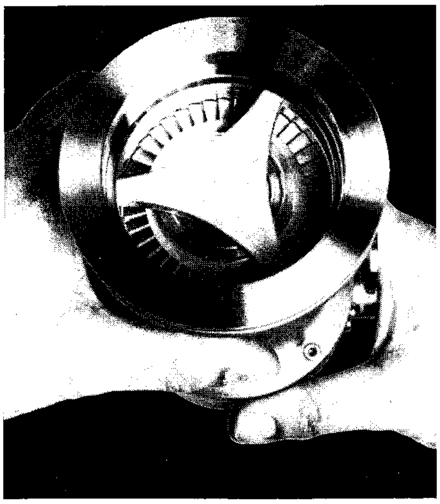

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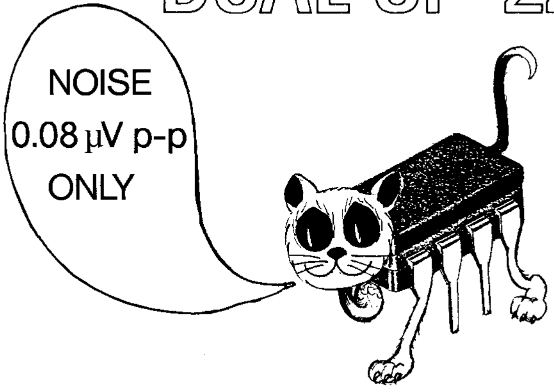

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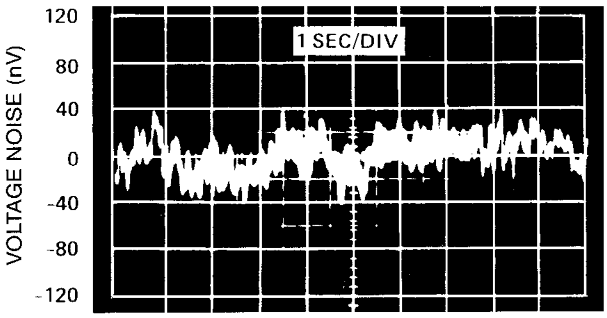

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