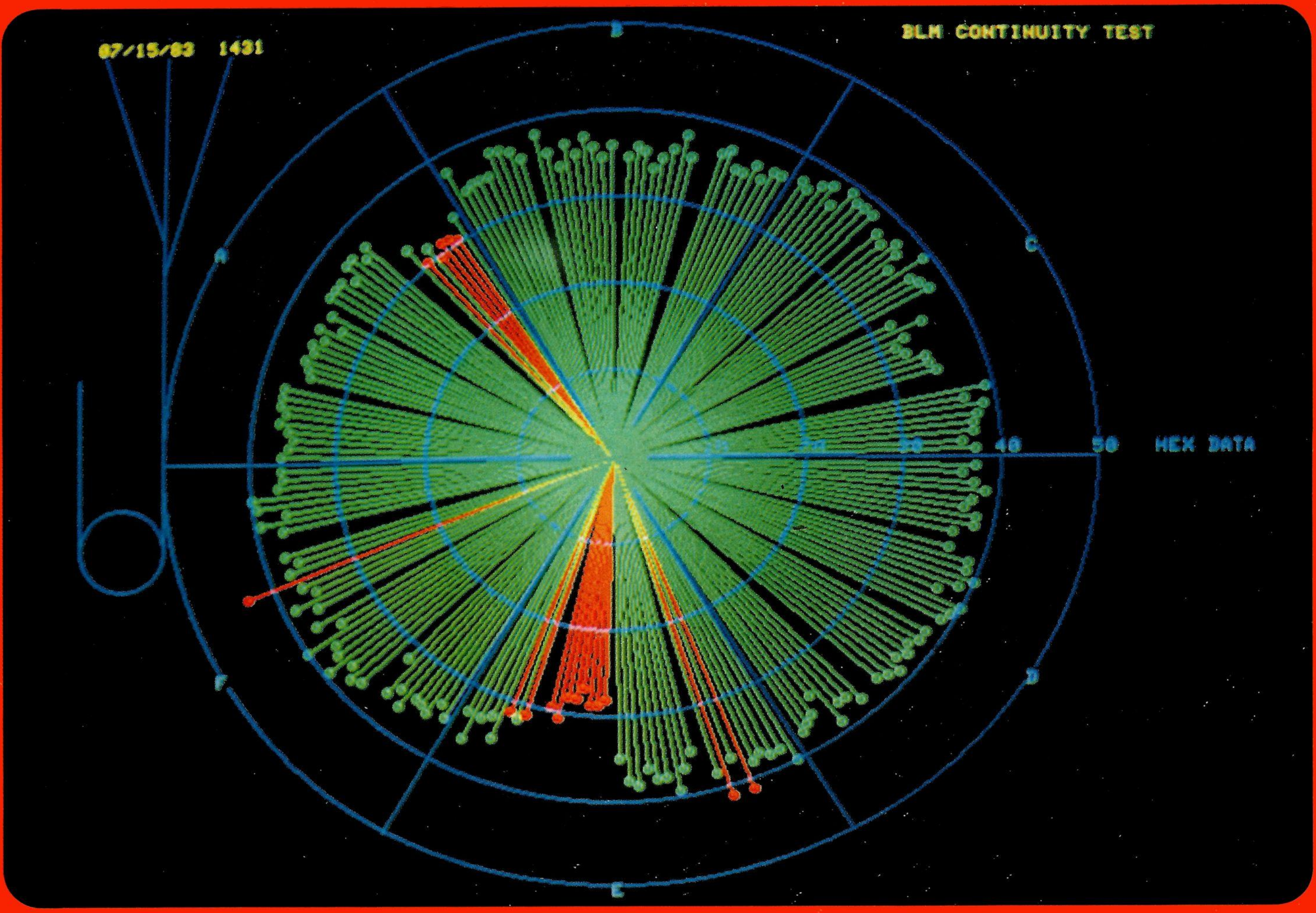
CERN COURIER

International Journal of High Energy Physics



VOLUME 24 JANUARY/FEBRUARY 1984

CERN COURIER

International Journal of the High Energy Physics Community

VOLUME 24 Nº 1 JANUARY/FEBRUARY 1984

Around the Laboratories

Cover photograph: Beam loss monitoring at Fermilab, an example of the sophistication of computer control in modern particle accelerators. See article on page 20.

Laboratory correspondents:
Argonne National Laboratory, USA
W. R. Ditzler
Brookhaven National Laboratory, USA
N. V. Baggett
Cornell University, USA
D. G. Cassel
Daresbury Laboratory, UK
V. Suller
DESY Laboratory, Fed. Rep. of Germany
P. Waloschek
Fermi National Accelerator Laboratory, USA
R. A. Carrigan
KfK Karlsruhe, Fed. Rep. of Germany
M. Kuntze
GSI Darmstadt, Fed. Rep. of Germany
H. Prange
INFN, Italy
M. Gigliarelli Fiumi
Institute of High Energy Physics,
Peking, China
Tu Tung-sheng
JINR Dubna, USSR
V. Sandukovsky
KEK National Laboratory, Japan
K. Kikuchi
Lawrence Berkeley Laboratory, USA
W. Carithers
Los Alamos National Laboratory, USA
O. B. van Dyck
Novosibirsk Institute, USSR
V. Balakin
Orsay Laboratory, France
Anne-Marie Lutz
Rutherford Appleton Laboratory, UK
D. Cragg
Saclay Laboratory, France
A. Zylberstejn
SIN Villigen, Switzerland
J. F. Crawford
Stanford Linear Accelerator Center, USA
W.W. Ash
TRIUMF Laboratory, Canada
M. K. Craddock

Copies are available on request from:
Federal Republic of Germany —
Gerda v. Schlenther
DESY, Notkestr. 85, 2000 Hamburg 52
Italy —
INFN, Casella Postale 56
00044 Frascati
Roma
United Kingdom —
Elizabeth Marsh
Rutherford Appleton Laboratory, Chilton,
Didcot
Oxfordshire OX11 0QX
USA/Canada —
Margaret Pearson
Fermilab, P. O. Box 500, Batavia
Illinois 60510
General distribution —
Monika Wilson
CERN, 1211 Geneva 23, Switzerland

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

The biggest problem of them all

A resurgence of confidence in our understanding of basic processes has led to attention turning once again towards the Biggest Problem — the origins of the Universe.

This new confidence was well demonstrated by a novel and intriguing symposium — 'Large Scale Structure of the Universe, Cosmology and Fundamental Physics', held at CERN last November, organized jointly by CERN and the European Southern Observatory (ESO). It brought together about 200 specialists, mainly from Europe and roughly equally divided between allegiances to particle physics, cosmology and astronomy.

In the cataclysmic conditions of the first few minutes after any 'Big Bang' which formed the Universe, particle physics and cosmology were one and the same.

During the subsequent twenty thousand million years or so, Nature has been much less spectacular and nothing has occurred to match these initial fireworks. Meanwhile the clues left by the Big Bang have mellowed with age. Thus, apart from occasional attempts by geniuses like Einstein and Gamow, the physics of the extremely large and the extremely small have until lately gone their own ways.

Now modern space astronomy promises to overcome the difficulties which constrain earthbound observations. This, together with the appearance of attractive new theoretical ideas, promises a great deal for the future.

The symposium was particularly well timed. The discovery at CERN last year of the W and Z particles which transmit the weak nuclear force showed that the long quest to unify the electromagnetic and weak forces has now borne fruit. The combined electroweak picture is now virtually textbook physics.

High level discussion? At the recent symposium on Particle Physics and Cosmology organized by CERN and the European Southern Observatory (ESO), G. Burbidge of the US Kitt Peak National Observatory (right) confers with ESO Director L. Woltjer.

(Photo CERN 516.11.83)

However for many particle theorists, the excitement of the electroweak picture had died down long ago. Without waiting for its experimental confirmation, these brave souls had dared to attack the next stage of unification — synthesizing the electroweak scenario with the theory of strong interactions, and for good measure throwing in gravity too.

Such 'Grand Unified Theories' (GUTs) naturally encompass enormous ranges of energy, and what happens under laboratory conditions is only a remote corner of their domain. The theories extend out to the extreme temperatures which must have existed in the primaeval fireball of the early Universe. For the 'GUTters', attention has turned away from laboratory experiments towards observations from astrophysics and the implications of the new ideas for cosmology. Thus the formation of the Universe has now become a natural focus of study for both macrophysics and microphysics.

The ideas behind unified field theories were described at the symposium by P. Fayet of Paris. One of the spin-off predictions is the unstable proton, however with the latest data suggesting that the proton half-life is longer than about 10^{32} years, the simplest grand unification schemes look as though they have to be modified. In particular, the decay into a neutral pion and a positron suggested by the 'minimal' grand unified theory is not seen.

One possibility is to construct bigger GUT theories with more free parameters. Fayet also pointed out the advantages of 'supersymmetry' — the extension of conventional assignments of particles with integer and half-integer spins — which offers other channels for proton decay.

Supersymmetry predicts many

new particles (in fact it doubles the number which are thought to exist so far). Intellectually appealing though the theory might be, no signs of these extra particles have yet been seen. However in his introductory talk, D. Sciama of Oxford had suggested that space astronomy might furnish the missing evidence and make supersymmetry respectable.

These (and other) additional particles predicted by unified gauge theories provide new ways of accounting for the vast quantities of 'dark matter' now thought to exist in many galaxies but which are not directly observable. Possible explanations of this dark matter were explored by S. Faber and J. Silk of California.

Directly after Fayet came E. Fiorini of Milan, covering the experimental search for proton decay and other signs of grand unified theories. There has been a great effort in this sector in recent years, and some of the more ambitious new projects are only just starting up. Last year, the Kamioka study in Japan went live, as did a small portion of the detector being built by a Franco/German team in the Fréjus road tunnel.

Presenting the data accumulated so far, Fiorini only awarded an explicit lifetime (some 10^{31} years) to the Kolar Gold Fields experiment in India, the first to produce (1982) a few candidate proton decays. This Indian/Japanese team has now seen a new event of possible interest.

Newer experiments (particularly the giant Irvine / Michigan / Brookhaven study using several thousand tons of water) scan much larger volumes and should be more sensitive. These studies have yet to reproduce the Kolar results and suggest instead that the proton likes to live for longer than 10^{32} years. Clearly these scanty statistics will need time to settle down before a firm proton lifetime can emerge.

Dimitri Nanopoulos energetically described unified field theories and their implications for the early Universe.

(Photo CERN 591.11.83)

Inflation

In his introductory talk, D. Sciama also suggested that the idea of 'inflation' in grand unified theories has given a major boost to cosmology, declaring that it could be the most important development since the discovery of the 3K cosmic background radiation in the mid 1960s. (For a good introduction to these new ideas, see the article by John Ellis and Dimitri Nanopoulos of CERN published in our July/August 1983 issue, page 211.)

Later in the symposium, Nanopoulos energetically described the scenario for this cosmic inflation. The initial fireball (about 10^{-35} seconds after the Big Bang) had a symmetrical vacuum state, and the symmetry of the theory was perfect. Subsequently there was a phase change to the unsymmetrical vacuum (spontaneously broken symmetry). However this phase change did not happen directly. Instead the initial symmetric phase became 'supercooled', so that when the phase change finally came (about 10^{-30} seconds), there was a tremendous release of energy which reheated the fireball to some 10^{14} GeV, giving the fledgling Universe a chance to be 'reborn', and setting off mechanisms which created baryons.

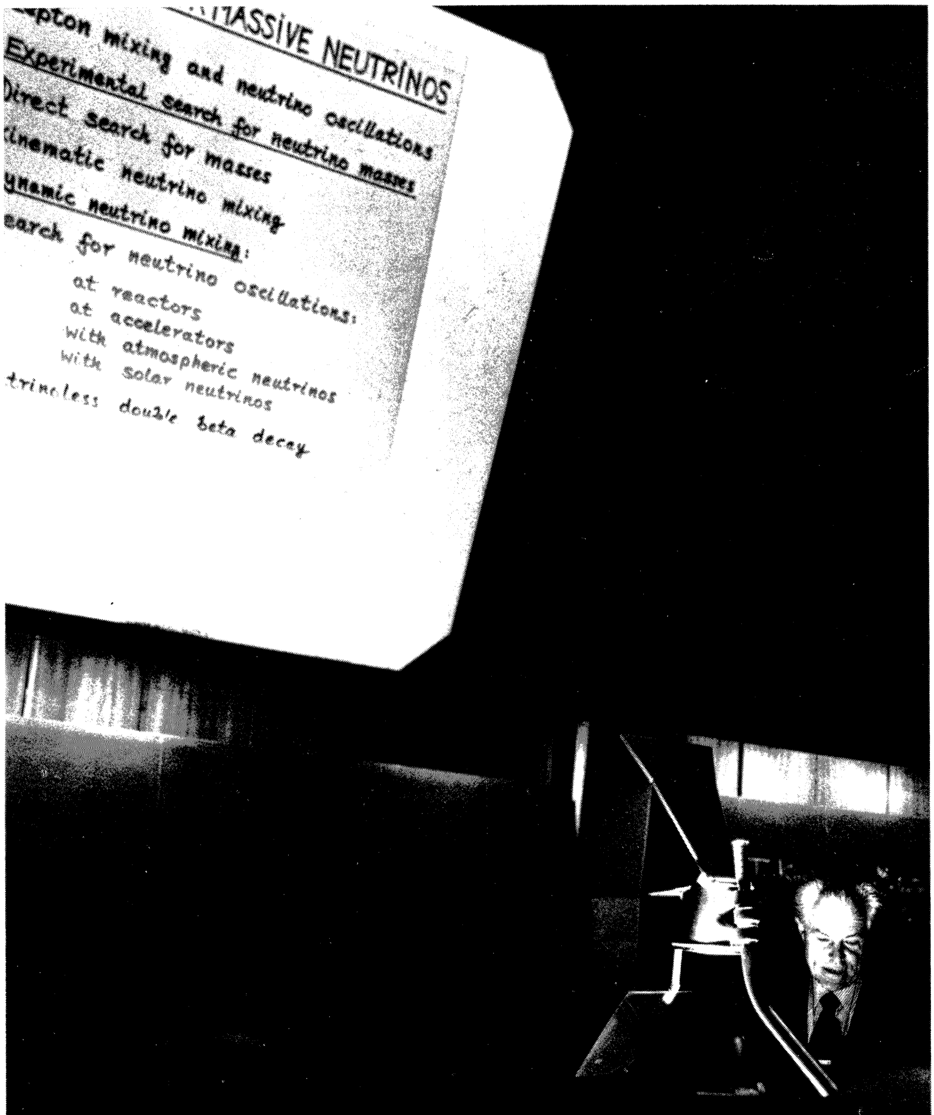
Inflation has a number of appealing features. It provides a natural explanation for the Universe being generally homogeneous, isotropic and flat, while at the same time providing a framework for early quantum fluctuations which might have acted as the 'seeds' of subsequent galaxy formation. Inflation also avoids embarrassment about heavy magnetic monopoles. Such objects, weighing about a microgram — enormous by particle standards — are predicted to be relatively common by non-inflationary theories, but no sign of them has been found.

Without recourse to inflation, the standard Big Bang picture gives abundances of light elements which tie in with observation. Describing the early nucleosynthesis of the first hundred seconds or so of the Universe, J. Audouze of Paris said that it was important to measure these relative abundances accurately.

Despite the appeal of new particles from grand unified theories, neutrinos remain a prolific source of cosmological speculation. The appearance of the Z^0 particle at CERN has enabled particle physicists to claw back the limit on the number of different types of neutrinos from tens of thousands to just twenty! Cosmological arguments from helium abundances are even more restrictive, and infer less than four types, suggesting that the three types 'known' from laboratory experience (electron, muon and tauon) might be all.

R. Mössbauer gave an excellent talk on neutrinos, still the subject of much speculation.

(Photo CERN 584.11.83)



MASSIVE NEUTRINOS

pton mixing and neutrino oscillations

Experimental search for neutrino masses

irect search for masses

inematic neutrino mixing

ynamic neutrino mixing:

earch for neutrino oscillations:

at reactors

at accelerators

with atmospheric neutrinos

with solar neutrinos

trinoless double beta decay

In a masterly presentation for such a mixed audience, R. Mössbauer described recent work to measure neutrino parameters. Cosmology also gives limits on neutrino masses (less than 50 eV), and this year a new measurement from Moscow on the beta decay of tritium has further reduced the room to manoeuvre (electron neutrino heavier than 20 eV — see October 1983 issue, page 308). However Mössbauer stressed the difficulties of such delicate laboratory measurements, and preferred to wait for confirmation by other groups.

The weak interaction sees definite mixtures of quarks, but less clear is the question of neutrino mixing. Mössbauer covered the measurements made so far, carried out over a wide range of neutrino energies. After some initial reports, more recent experiments find no evidence for such 'neutrino oscillations', although there is still a lot of territory to be explored. Mössbauer outlined how such oscillations could account for the perennial discrepancy between the predicted and observed levels of solar neutrinos.

A. Sandage of California described the continuing effort to pin down the basic cosmological parameters. Progress in this field is painfully slow by the standards of laboratory experiments. However opinion on the Hubble constant (which fixes the rate of expansion of the Universe) now seems to be favouring a value of about 50 km per sec per Mparsec. The age of the Universe is also firming up, with about 18 thousand million years as the preferred figure. This ties in with independent measurements from studies of radiochemical elements.

D. Wilkinson spoke on the Universe's background radiation. The detection about twenty years ago of the 3K background signal was a major breakthrough, but there should be other important signals elsewhere in the radiation spectrum. Trying to measure these tiny extragalactic signals, which represent only about a per cent of the total amount of radiation hitting the earth's surface, poses almost insurmountable difficulties. However these are neatly sidestepped by satellite-borne experiments, which hopefully should soon yield incisive new results.

The final day of the symposium opened with a memorable presentation by Stephen Hawking on the quantum mechanics of the Universe. He concentrated on establishing the boundary conditions for this gigantic problem. Without recourse to specific mechanisms and using only attractive plausibility arguments, he showed that a closed quantum Universe can oscillate.

Although this work was not new for the specialists, the underlying message was clear. 'Because of its inherent singularities, classical general relativity predicts its own downfall,' stated Hawking, 'just as the classical picture of the atom was also doomed'.

The meeting merited two closing lectures. For the cosmologists, Martin Rees of Cambridge confessed to finding the symposium an 'unusual experience'. For the particle physicists, John Ellis described particle physics and cosmology as having 'a brilliant past in front of them' — referring to the new common interest in the primaeval Big Bang and its immediate consequences.

The symposium occasionally reflected communications difficulties between macro- and microphysics. The meeting may not have bridged these gulfs in mutual understanding, but it certainly helped to close them. Most of the participants left feeling that they had learned something, however not everyone learned the same things! While there is still a long way to go, the meeting showed that some of the barriers on the way to solving the Biggest Problem may be crumbling.

Report by Gordon Fraser

On the scent of glue

by Frank Close

Soon after the quark model was invented twenty years ago, people realized that it was in trouble. The Pauli exclusion principle ruled out many well known states, in particular the configuration of three identical strange quarks that formed the omega-minus. The very hadron whose discovery had confirmed the Eightfold Way seemingly killed its offspring, the quark model.

In those days, many people were reluctant to accept the idea of fractionally charged quarks which had never been seen. The Pauli paradox suggested that quarks were at best no more than a bookkeeping device, not physical particles. On the other hand some aficionados took the attitude that as these were funny particles then perhaps they obeyed funny rules, and that application of the Pauli principle might involve hidden subtleties.

Today we accept that quarks do obey the Pauli principle, and that the (hidden) subtlety is that each quark flavour (up, down, strange, etc.) can occur in any of three ways, or 'colours'. Thus, for example, if each strange quark in the omega-minus has a different colour, they are no longer identical: Pauli is satisfied; the omega-minus can exist.

The concept of colour has proved seminal in generating a theory of quark forces. Colour appears to be a form of charge, like electrical charge, and a relativistic quantum field theory — quantum chromodynamics (QCD) — has been developed. Its successes in describing high energy hadron interactions are well known. But its application to the study of quark bound states (the hadrons) has raised exciting new problems. A whole host of new hadrons is predicted; 'glueballs', 'hybrids', 'hermaphrodites', 'meiktons' — none of which has yet been seen conclusively, even though the search for them has been intensifying over the last several years. Where have all the flowers gone?

How colour forces work

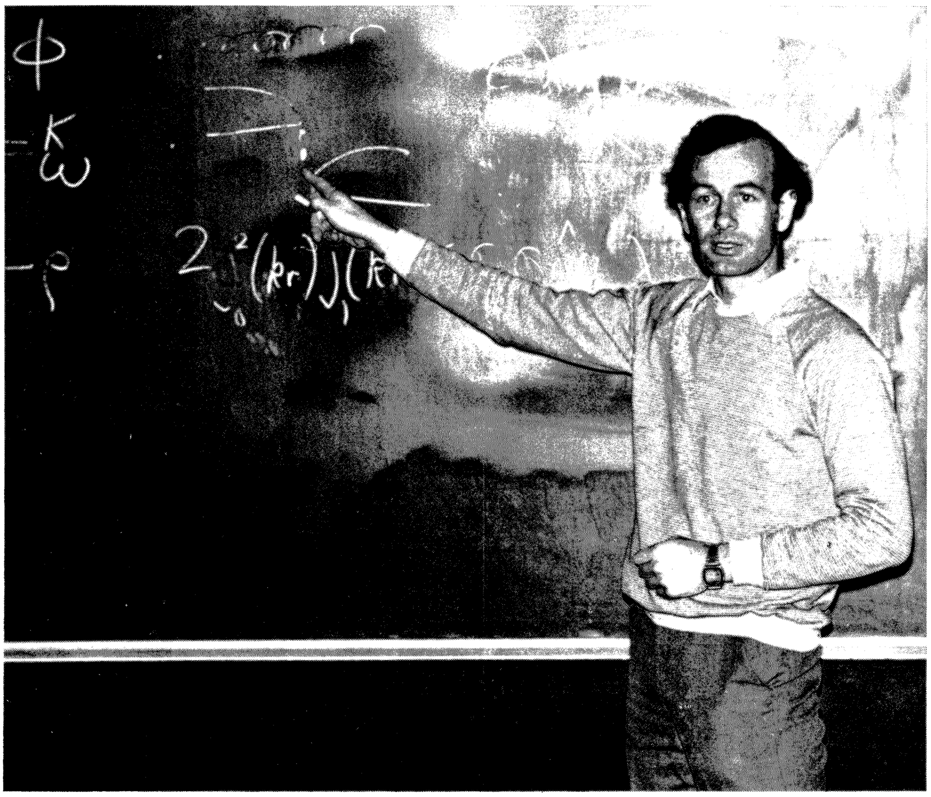
Electrical charges are the sources of electromagnetic forces. As every schoolchild knows, opposite charges attract while like charges repel. Quarks possess electric charge and so feel electromagnetic forces. That is why even electrically uncharged particles like neutrons have electromagnetic interactions; they contain electrically charged constituents. Quarks also have colour and it appears that this is a form of charge whose behaviour in generating forces is analogous to electrical charge except for the important property that, whereas electrical charges are either positive or negative, there are three different varieties of colour. Suppose that quarks carry positive (colour) charge and antiquarks correspondingly carry negative charge. Then the attraction of opposites, such as a red quark and a red antiquark, forms the familiar mesons.

The presence of three colours makes the possible attractions rather richer than in the simpler electromagnetic case. Just as like charges repel, so do like colours repel. For attractions the rules are generalized slightly; not only can opposites attract, but unlike colours, such as red and blue quarks, can attract under certain conditions. We must take into account the quantum state of the two coloured objects. If it is antisymmetric under exchange of the colour labels, then the coloured objects will mutually attract; if symmetric they will mutually repel.

This subtlety is inherent in quantum chromodynamics (a 'non-abelian' theory). An analogy is the familiar case of nuclear isospin exchange

Frank Close — 'where have all the flowers gone?'

(Photo Rutherford)



forces. Two protons or neutrons are symmetric in flavour and the forces are intrinsically repulsive: a proton and neutron feel a repulsive force when in the symmetric state but the antisymmetric (isoscalar) state is attractive.

The threefold colour forces act in a manner which is an obvious generalization of this. There are three ways that quarks can pair: red and yellow, yellow and blue or red and blue. A third quark will be strongly attracted by a pair only if its colour differs from the initial pair's colours and the quantum state is antisymmetric under the interchange of any pair's colour labels. Thus red-yellow-blue clusters form: protons, neutrons and the familiar baryons exist. Notice that the way the attractions and repulsions work has necessarily forced three quarks, each of a different colour, to be present in the baryon.

A fourth quark brought up to this trio will have the same colour as one that is already there and so be repelled by it. But it will be attracted by the other two, so does attraction or repulsion win? In this case they exactly balance: the attraction only operates between antisymmetric combinations, there is only a fifty-fifty chance that this configuration is present, and, together with the fact that there are two quarks attracting the newcomer and one repelling it, yields a net cancellation. Although this pedagogic example does not explain why colour ionization (existence of free quarks) is forbidden, we can at least see how the systematics of colour forces have generated the observed clusterings of quarks and antiquarks. The hadrons have no net colour, but feel the strong interactions because of their coloured constituents.

Gluons are to colour as photons are to electric charge. Photons transmit electrical forces but do not themselves carry charge. Hence, they voyage freely through space. However the richness of three colours causes the gluons to carry colour. Not only do they directly transmit the forces, but they feel them even while propagating. The spatial behaviour of the colour forces is thus very different from electromagnetism. This leads to a whole new spectroscopy of particles.

Gluons and gluonic hadrons

If gluons carry colour, they can be mutually attracted by the same colour forces that ensnared the quarks in colour-neutral clusters. Thus, one can imagine the existence of bound states of the gluons, originally called gluonic mesons but now widely known as 'glueballs'. There is also the possibility of 'hybrid' hadrons (also called 'hermaphrodites' or 'meiktons') containing both quarks and gluons as excited degrees of freedom.

In the heuristic picture above, a hybrid meson arises when a red quark is attracted by a blue antiquark, for example. These unlike colours attract but are not mutually neutralized; coloured gluons can be attracted by the pair and so neutralize the colour forces. Some, at least, of these configurations are more than mere gauge transformations of conventional quark-antiquark mesons. Thus, an uncoloured quark / antiquark / gluon cluster can form: a hybrid meson. Hybrid baryons have also been predicted. I shall generically refer to glueballs and hybrids as 'gluonic excitations' to distinguish them from their established cousins, conventional quark excitations.

Do we have much hope of producing and then identifying gluonic excitations? A few years ago there was a lot of optimism that the answers to both of these questions was yes. Today there is less certainty about the identification of glueballs, although there still seems to be optimism that they can be readily produced in the laboratory. The discovery of new hadronic states in the 'right sort of experiments' has, perhaps paradoxically, led to this change of opinion. Why?

For nearly a quarter of a century we have studied millions of interactions of pions, protons and other well known particles, and in the process have discovered scores of resonances that have collectively established the quark model of hadronic matter. There is an impressive body of information that indicates that this model is 'correct'. No well established resonances exist that cannot be accommodated in the quark model; the systematics of the hadron masses now have been reasonably well explained by quantum chromodynamics; spin-dependent colour forces between the constituent quarks qualitatively and even on occasion quantitatively describe the pattern of observed energy levels.

These 'classical' experiments have involved beams of quarks and targets of quarks (buried in their parent hadrons), so quark clusters were dominantly produced, especially if one studied the debris in the near forward direction.

To produce glueballs you must either first get rid of the quarks or look in a place where the quarks do not tend to go. The latter approach has recently been employed at CERN, where several groups have been looking at the hadrons produced in the central collision region, in particular at the ISR. The gluons which are generated as the two quark beams brush by could resonate and form glueballs.

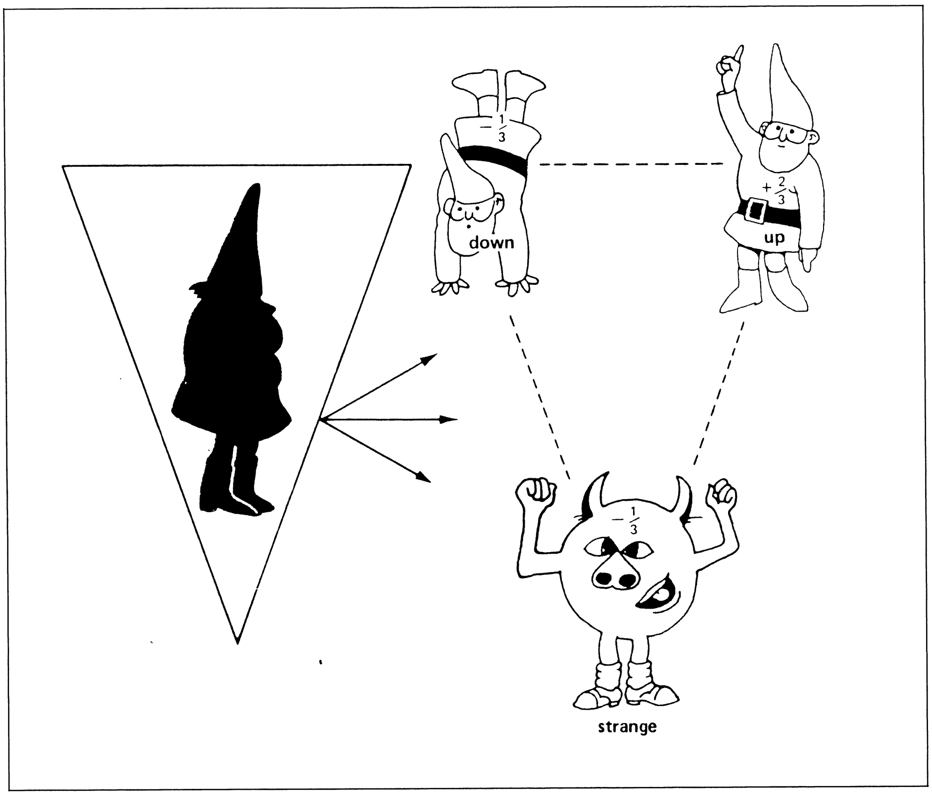
The difficulties here are obvious. Can you be certain that quarks are totally irrelevant in the region under study? Of course, if you were lucky enough to discover two or three prominent structures which had never been seen before elsewhere and they stood out like the famous J /psi, then the world would beat a path to your door. Unfortunately, nature does not yield up such gifts very often. Even when she does, it is not easy to know what you have found.

This is illustrated by what has happened in experiments that destroy quarks. New states have been seen clearly there and theorists have found a new way of generating papers, debating whether these are really the long-sought glueballs or merely excited configurations of conventional quark matter.

These experiments involve electron-positron annihilation at an energy tuned to create heavy mesons such as the J/psi or the upsilon. The J/psi consists of a charmed quark and a charmed antiquark; the upsilon is similarly built from a bottom quark and antiquark. These states survive only as long as the quark and antiquark do not mutually annihilate. When they do, their energy is converted into radiation, photons and/or gluons. The gluons can then form gluonic clusters. This at least is what theory predicts. Decays into a photon plus mesons are particularly interesting. Theory says that one in seven psi decays should be of this form.

About 15 per cent of the psi decays are indeed radiative, so the qualitative suspicion that glue is around appears to be quantitatively validated. If a new state appears in the debris accompanying the photon, then it has good credentials for being gluonic. And new states have been discovered, iota, theta, and last summer the 2.2 GeV two-kaon reso-

The three lightest quarks, as depicted by Frank Close in his book 'The Cosmic Onion' (published by Heinemann Educational Books, London). The numbers indicate the electric charges carried by each quark.



nance seen by the Mark III group at the SPEAR ring (see October issue, page 311). This good news is somewhat clouded by the fact that several well known mesons are also prominent in these data, notably the f(1270), eta and eta prime. Optimists have taken this as proof that the etas do indeed have an intimate relationship with glue and point out that for several years interesting structure has been seen and ignored in the vicinity of the f. This suggests to some that the f may be more than the innocent ideally-mixed quark state we had thought.

The case for gluonic states might have been more clear cut if the states had been better behaved in their decays. The starting guess was that, since gluons have no flavour, their decay products should be uniformly distributed among nonstrange and strange particles. However the iota decays copiously into final states containing kaons (strangeness), but not into other non-strange states. Quite the opposite of 'folklore' expectations for a glueball. Similarly, the theta and the new 2.2 GeV state are both reluctant to decay into lots of pions. Perhaps these states are conventional quark states or just unusual multiquark combinations.

Prompted in part by difficulties with glueballs, theorists have recently been paying increasing attention to the possibility that other manifestations of gluons in spectroscopy might be more amenable to experiment. Particular interest has been focussed on the 'hybrid' hadrons, in which both quarks and gluons occur as excited degrees of freedom.

Their properties have been studied in various ways. In some ('bag') models, the lowest energy states consist of quarks and a single gluon. In others they correspond to excitations of 'strings' between the quarks. A gluon accompanying the quarks permits exotic states whose quantum numbers are otherwise forbidden. Theory gives some hope for certain such states, which although suppressed in radiative decays of J/psis, might be visible in the forthcoming low energy proton-antiproton experiments at the new CERN LEAR ring.

These new states cannot all be theoretically avoided by gauge transformation tricks. The spin-dependent energy shifts that arise from colour forces between the quarks and gluons have been calculated now by various groups and their results agree. The results are reminiscent of what is seen with the well known meson nonet including the pions and kaons.

This has been exploited by some theorists who have shown that the mass pattern of these mesons can be understood at the price of their being rather impure mixtures of quark-antiquark and hybrid states. This possibility is rather harder to eliminate than one might expect. Indeed, in attempts to discredit the whole idea of hybrids, the implications for baryons have been widely investigated during recent months.

While in the case of mesons, hybrids could be hidden in the experimental uncertainties remaining in the field, surely baryon spectroscopy is so well understood that there is no room for a plethora of new states? The results have been rather surprising. First electromagnetic properties: if the proton has a component which consists of quarks in a colour octet with a gluon neutralizing the colour, one would expect that the requirements of the Pauli principle would so upset the quarks' flavour and spin balance that baryon magnetic moment predictions, in particular the famous 3/2 ratio between proton and neutron, would be ruined. In fact it is preserved. Photoexcitation of protons into hybrids has been calculated and seems likely to be rare. Baryon spectroscopy appears safe.

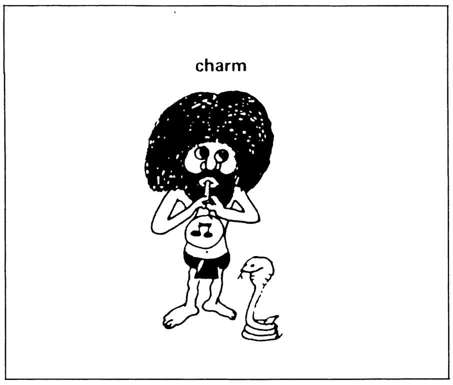
So what are the prospects for establishing the existence of hybrid or gluonic mesons? Theoretical ideas on the expected spectroscopy are converging. For gluonic mesons, all approaches seem to agree that the scalar (vacuum-like) state should be the lightest, somewhere between 0.5 and 1.5 GeV. Other states should be somewhat heavier. The scalar meson has the widest theoretical support, but is not seen in the radiative decays of J/psis, supposedly the best glue factory around. Other gluonic meson candidates are seen instead.

Could the scalar be hiding under the f(1270)? Could it be narrow and down at 600 MeV, and consequently have been overlooked in analyses of two-pion spectra? Are there theoretical problems related to the vacuum? Do the interactions of quarks and gluons radically change the theoretical picture for gluons alone?

This last point in particular is worth facing. Just as some mesons are mixtures of various flavours of quarks, so gluonic mesons might be strongly mixed superpositions of quark and glue components. If mesons are generally very impure mixtures of quarks and gluons, then the search for individual, identifiable, pure gluonic states is in trouble. Instead we may have to look for evidence of an 'overpopulation' of states in certain mass regions, incompatible with the quark model alone. New degrees of freedom such as gluonic excitations would need to be invoked.

In the absence of such a gift of nature there is another strategy that may help identification of states with significant gluonic components. The folklore that gluonic hadrons decay

'Close-up' of the charmed quark.



equally to all flavours is based on the flavour independence of gluon-quark couplings. However this is too naïve. The forces acting on strange quarks are in general different from those on nonstrange quarks. One naturally might expect this to suppress strange particle production relative to the lighter nonstrange; such a phenomenon is well known in hadron physics, and here the folklore says it is easier to produce light quarks out of the vacuum than to produce the heavier strange quarks.

It may be dangerous to assume that this folklore is necessarily applicable to the decays of gluonic states. Indeed, when couplings of gluons and quarks are calculated (in bag models), one finds that the effective coupling strength of a gluon to a quark and antiquark pair can be greater for a strange pair than a nonstrange one. So even if the exchange of a gluon between heavy quarks is suppressed relative to light quarks, the production of a heavy pair can be enhanced in certain cases.

This suggests that gluonic states may preferentially produce strange quarks and antiquarks in their decays, some glueballs and hybrid mesons having important decay channels containing up to four kaons. Conventional bound states of a strange quark and strange antiquark will decay into a pair of kaons, but decays preferring four kaons at the expense of pions would be a rather unexpected phenomenon. Tensor (spin two) glueballs above 2 GeV are expected to contain two gluons, each of which will prefer to generate strange quarks. Thus, phi meson pairs and four kaons could be distinctive signatures. The glueball interpretation of the iota in the bag model requires that it contains one gluon with this preference for strange quarks. Their colour doesn't neutralize, so they cannot emerge as a phi meson, but must separate and end up in different strange hadrons. This is consistent with the apparent fondness for strange particle decays of the various new states seen in J/psi decays.

Three tensor mesons have been claimed in the 'glue-preferred' production of phi meson pairs in negative-pion/proton collisions (see December 1982 issue, page 416), and have not been seen in other channels. In the region just above 2 GeV, a tensor glueball and a hybrid tensor are expected with this 'strange tendency'; excited tensor mesons consisting of a strange quark-antiquark pair are also expected at this mass, and so significant mixing should occur. This could help explain the large decay widths of these candidates.

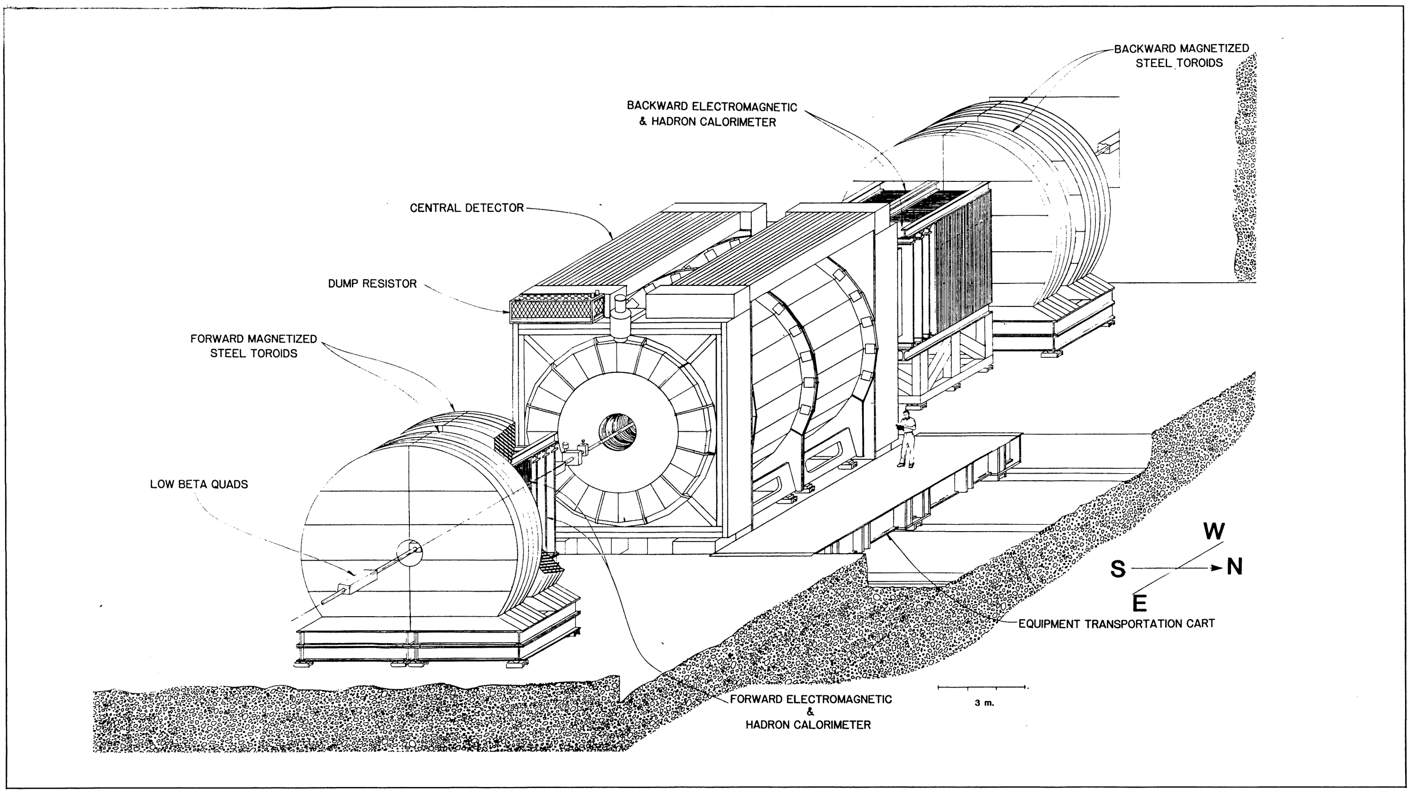
This preference for producing strange particles in gluonic decays may be no more than an artefact of the model. However, if nature does indeed behave this way, then the study of multikaon channels could be profitable.

If structures are seen in these channels and are being produced in processes that are 'gluon-friendly' then there could be a real prospect of establishing gluonic excitation spectroscopy. Proliferation of low-lying pseudoscalars or a prominent metastable state that fits perfectly with prediction are other hopes.

Everyone seems to believe that gluonic states should exist, but to identify them with confidence may require an improved understanding of conventional meson spectroscopy. Given the fundamental role that gluons play in the nature of things, it would be troubling if gluonic states could only be seen by experts in hadron spectroscopy.

(As well as being an expert in hadron spectroscopy, Frank Close of the Rutherford Appleton Laboratory, UK, is a prominent writer and broadcaster on particle physics. His fascinating book 'The Cosmic Onion — Quarks and the Nature of the Universe' has recently been published by Heinemann Educational Books of London.)

Around the Laboratories



Schematic view of the Collider Detector being assembled at Fermilab. First full physics runs are scheduled for 1986, although test runs with a partially completed detector could get under way next year.

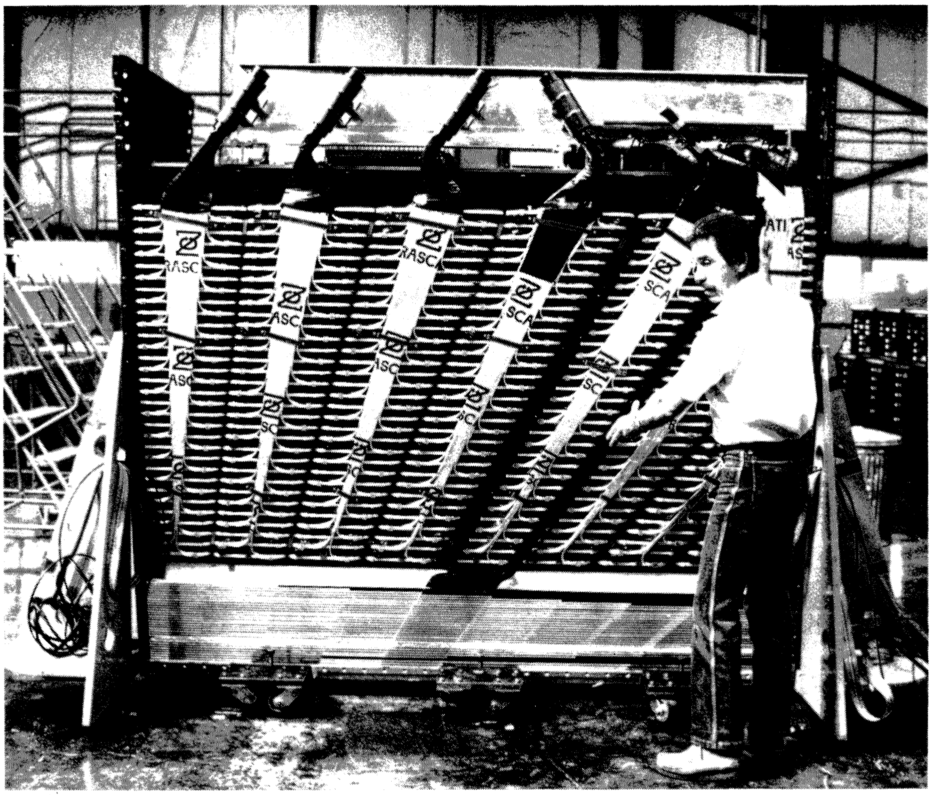
FERMILAB
Collider Detector

A new entry was recently added to Fermilab's list of proposed and approved experiments. The official designation is P-741, and it stands for CDF, the Collider Detector at Fermilab. Behind P-741 are several years of very hard work by the CDF Collaboration, which now includes somewhat over 100 physicists from nine US universities (Chicago, Brandeis, Harvard, Illinois, Pennsylvania, Purdue, Rutgers, Texas A & M, and Wisconsin), three US national Laboratories (Fermilab, Argonne and Berkeley), Italy (Frascati and Pisa), and Japan (KEK, Tsukuba, and Saga).

The primary physics goal for CDF is to study the general features of proton-antiproton collisions at 2 TeV collision energy. On general grounds, it is expected that quark subenergies in the range 50-500 GeV will provide the most interesting physics at the Tevatron Collider. The classic pioneering experiments at the CERN Collider have already demonstrated the richness of the 100 GeV scale in quark subenergies; the inability of current theory to predict with certainty the physics beyond the 100 GeV scale makes the higher energy range of the Tevatron particularly attractive as a place for surprises to be uncovered. Observation of any of the Higgs particles, supersymmetric partners, technicoloured objects, or other things talked about by the theorists would be extremely interesting; finding something completely unexpected would be even more exciting. Rates of W and Z production are expected to be approximately an order of magnitude larger at 2 TeV compared to the 540 GeV of the CERN Collider. The acceptance of the detector is well matched to the kinematic range expected in the 2 TeV hadron collisions.

Since the basic processes are expected to involve quarks, gluons, leptons, and photons, it is important to measure as much about these particles as possible. The beautiful CERN collider results on jets demonstrate that the quarks and gluons are manifested as clean, narrow jets of hadrons. CDF has chosen shower counters and hadron calorimeters in a tower geometry to detect jets. Leptons are characterized by single particles that have different interactions in the various detector components of CDF. Charged particle tracking in a magnetic field, shower counter and hadron calorimeter response, and penetration through many interaction lengths of material are the techniques planned for detecting electrons and muons. Neutrinos are observed by missing energy and momentum; good coverage

Side view of one of the 50 wedge modules for the central part of the collider detector.



with active detectors and a minimum of inert cracks are called for to 'see' neutrinos. Photon detection is achieved with finely segmented shower counters and the absence of a charged track. This calls for minimizing the amount of material in the tracking region of the detector, between the collision point and the shower counters.

The required granularity is a very complicated issue, with large economic implications. The approach taken by CDF was to provide enough calorimeter towers to just resolve the jets without being able to measure reliably every particle within a jet. The detector is organized into three major pieces, the Central Detector and Forward / Backward Detectors on either side. These are centred around the (superconducting) Tevatron beamline in the BO collision area; major parts of the data acquisition and trigger electronics as well as the on-line computer systems reside in the control rooms of the BO assembly area. The Main Ring (conventional magnets) beam is brought over CDF in a special 'overpass'.

The basic philosophy of the detector is to surround the interaction region with charged particle tracking detectors, followed by shower counters for electron and photon detection and then backed by hadron calorimeters to measure the total energy of hadrons directed at a given region of the detector. Muon detectors are placed outside the hadron calorimeters to measure penetrating charged particles.

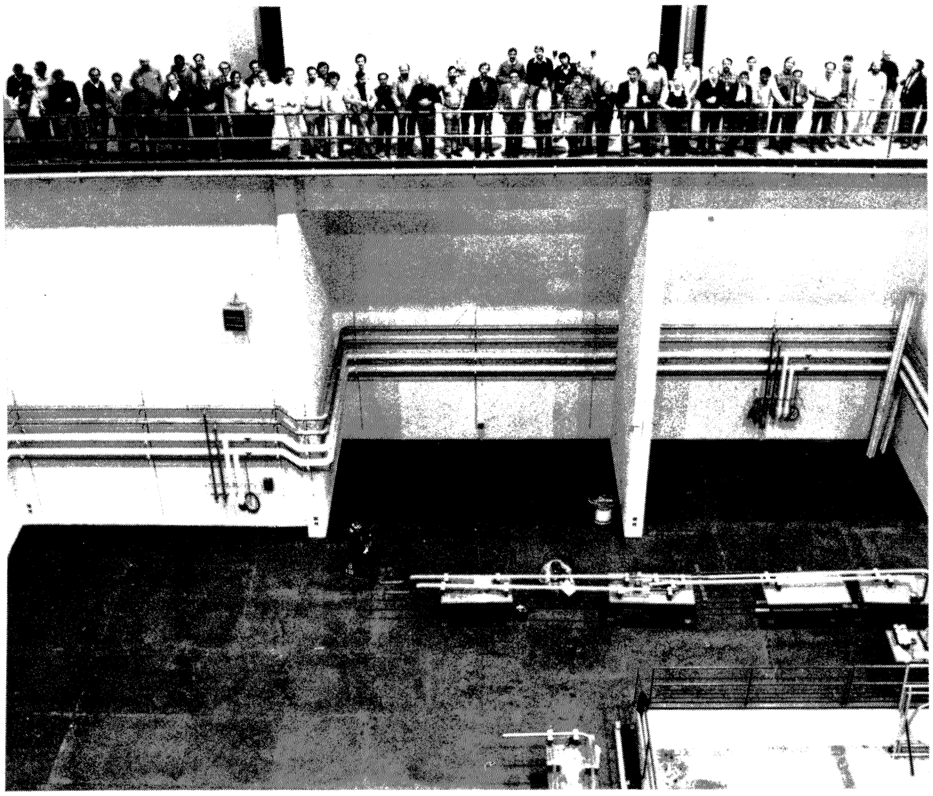
The interaction region is expected to be needle-shaped, less than 1 mm in diameter and roughly 1 m long. Particles produced at right angles to the interaction region pass in sequence through a thin-walled beryllium vacuum chamber, a set of small atmospheric pressure time projection chambers to give crude tracking with simple and fast tracking algorithms, the central tracking drift chamber to provide a momentum measurement of charged particles in the 15 kG magnetic field of the Central Detector, the thin superconducting coil of the solenoid magnet, the central shower counters, the central hadron calorimeters, and finally, the central muon chambers. At smaller production angles, the particles may pass through the end-plug shower counters and the end-wall or end-plug hadron calorimeters. Particles produced between 2 and 10 degrees pass out of the central detector through a hole in the end plug and enter the forward (or backward) shower counters and hadron calorimeters. Small angle muons will be detected and momentum analysed by magnetized iron toroids and muon tracking chambers in the Forward / Backward Detectors.

Most of the tracking systems are based on gas-filled drift chambers operated at atmospheric pressure. The central TPC system uses the excellent tracking ability of the time projection chamber geometry to provide a simple 'snapshot' of the charged particles in an event and to find the event vertex. The Central Tracking system is a modification of the JADE (DESY) arrangement of sense wires, compensated for the strong magnetic field, where more than 80 sense wire layers will be hit by each large angle track. Longitudinal position will be measured primarily by small angle stereo wires, but some charge-division layers are provided for triggering. The muon tracking chambers use charge division readout for one of the coordinates.

Silicon micro-strip detectors will be installed over a limited part of the interaction region to provide precise vertex measurements for identifying

Last October, physicists contemplated a barren BO building, erected to house the Fermilab collider detector. Components for the detector are fast coming in from all over the US, from Italy and from Japan.

(Photos Fermilab)



decays of particles containing heavy quarks.

The Central Detector is organized into 50 wedge-shaped modules (see opposite). The Central Shower counters, Central Hadron calorimeters, and End Wall calorimeters use plastic scintillators to sample ionization. In the shower counters, the plastic scintillators are sandwiched with sheets of lead. Steel plates provide the dense material and mechanical structures for the hadron calorimeters. To improve the position resolution of the Central Shower counters, a gas-filled counter with anode wire and cathode strip readout is placed in the lead-scintillator stack near the shower maximum point. The Central Muon chambers are placed in the last gap of the hadron calorimeter.

The removable end plugs of the solenoid magnet are fitted with gas-filled proportional counters made from specially developed resistive plastic tubes that use cathode pads for read-out. Lead sheets are interspersed with the chambers in the shower counters and the flux-carrying iron of the end plug is segmented for the hadron calorimeter. The shower counters and hadron calorimeters in the Forward / Backward detectors use very similar techniques.

At the heart of the solenoid magnet is a 3 m-diameter, 5 m-long superconducting coil that is being built in Japan. The total thickness of the coil is about one radiation length. The return yoke for this magnet is the main structural component of the Central Detector. As mentioned previously, the end wall and end plug regions of the yoke are instrumented with hadron calorimeters; the rest of the yoke is not instrumented. The entire Central detector, magnet and calorimeters, moves together as a single piece on multi-ton rollers when the detector is moved between the collision hall and assembly areas of BO.

There are more than 60 000 channels of detector information in CDF. The job of sampling and recording all this information is enormous. The basic philosophy is to mount the front-end amplifiers and sample-and-hold circuits as close as possible to the detector components. A multiplexed system was developed to read out the majority of the analogue signals locally and to transmit digital results to data acquisition electronics located in the counting rooms. FASTBUS was chosen as the medium for data acquisition and other large-bandwidth CDF digital communications.

A multi-level trigger system is planned. The basic interaction rate is expected to be roughly 50 000 Hz. Different trigger levels operating at different degrees of complexity will reduce this rate to approximately 1 Hz for logging on conventional magnetic tape for off-line data analysis. Three trigger levels are contemplated. Level 1 must decide to keep an event for digitization and further analysis within one crossing of the beams (every 7 microseconds). Analogue trigger signals derived from the front-end electronics provide information to the Level 1 trigger. This level will reduce the trigger rate by approximately one order of magnitude. Energy deposited in shower counters and hadron calorimeters, and muon tracking hits will form the basis for the Level 1 trigger. Patterns of energy deposition, high-transverse momentum tracks associated with muon hits, large missing momentum and other similar inputs will be used by the Level 2 trigger to reduce the rate to several hundred Hz. Several beam crossings may have to be lost before the Level 2 trigger

Fermilab Users Executive Committee — 1983-1984: Left to right — seated: Stewart Loken — Berkeley, Frank Taylor — Northern Illinois, standing: Alexander Dzierba — Indiana, Robert McCarthy — Stony Brook, Ernest Malamud — Fermilab, Maris Abolins — Michigan State, Lee Holloway — Illinois, William Carithers Jr. — Berkeley, Carl Bromberg — Michigan State, Kenneth Young — Washington, Roger Dixon — Fermilab, Carol Wilkinson — Wisconsin, Joseph Lannutti — Florida State.

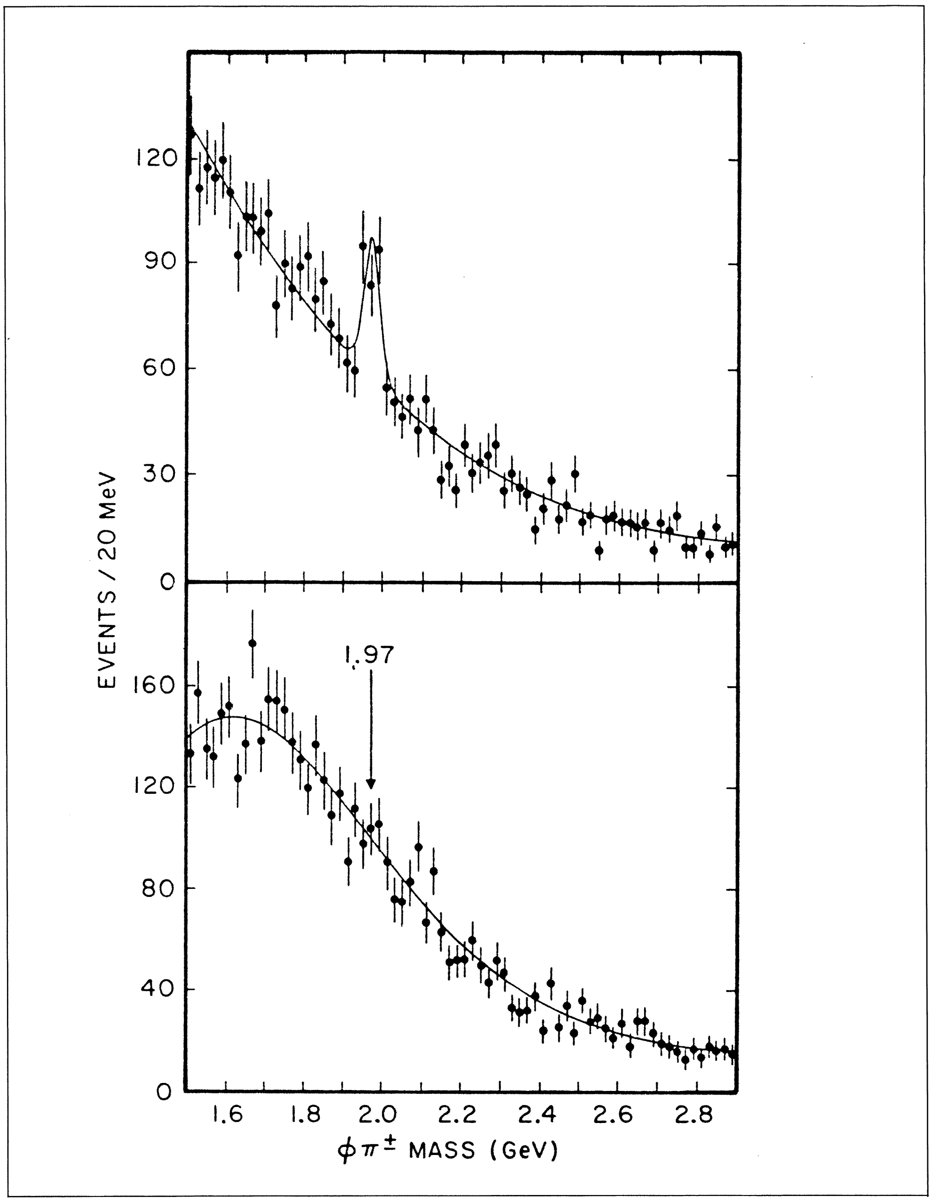
(Photo Fermilab)

reaches a decision. At this stage, the full event information is available to the data acquisition system and dedicated processors will make 'software' cuts to reduce the trigger rate to the data logging level. This is known as Level 3. The control, monitoring, and calibration of CDF will be handled by a system of VAX computers.

All of the major detector systems have undergone extensive R & D and prototyping. Production lines for many of the components are operating. For example, all of the scintillators for the central hadron calorimeters (some 30 tons of scintillator!) have already been cut on a computer-controlled laser machine at Frascati and have been wrapped with wave shifter fingers at Pisa. The Italian group has also finished all of the light guides for this system. With the aid of a computer-controlled plasma torch, the Purdue machine shop has completed over one-half of the steel modules for the Central Hadron calorimeters. The solenoid coil is being wound at the Hitachi works in Japan. Various production lines have been set up at Tsukuba, Argonne, Berkeley, Harvard, and Illinois. Phototubes are under production tests at Rutgers. Trigger modules are being built at Chicago and calibration equipment is being assembled at Pennsylvania. Analysis and event simulation software is being written at Fermilab, Brandeis, and elsewhere. Detector R & D is taking place at Texas, Wisconsin, and Fermilab. Heavy steel transfer carts and toroids are under production at Wisconsin. Massive parts of the solenoid magnet are appearing at Fermilab. Major efforts in frond-end electronics, data acquisition electronics, and on-line software are taking place at Fermilab. The list goes on and on!

One of the most interesting activities is the final assembly of the Central Detector wedge modules. This work involves the coordination of component fabrication taking place all over the world, precision assembly of the modules, and preliminary calibration and systems tests using cosmic rays and radioactive sources. The scintillators and light guides for the hadron calorimeters arrive from Italy along with Italian technicians who install them in the steel modules fabricated at Purdue. Shower counters using Japanese scintillator and wave-shifter are stacked and machined at Argonne before being transferred to Fermilab. Muon chambers arrive from Urbana to be mounted on the modules. Finally, the whole contraption must be made to fit together and to be light-tight before it is wired up to its front-end electronics and tested. All of this must be done for each of the 50 wedge modules for CDF.

Top, the spectrum of the phi meson plus pion combination seen in the CLEO detector at the Cornell CESR electron-positron ring, showing the clear F meson signal at 1970 MeV. The phi mesons are picked up from their decay into two kaons. Bottom, using kaon pairs away from the phi mass makes the signal disappear.



Getting under way is an extensive programme of testing and calibration of production shower counters, hadron calorimeters and tracking chambers, using Tevatron beams. If all goes well, there will be a preliminary test run of the partially completed detector with colliding beams of low luminosity in 1985. Most of the central and forward calorimetry should be in place, but it is unlikely that the complete tracking, trigger, and data acquisition systems will be available until the full physics runs begin in 1986.

CORNELL
CLEO's F

The CLEO (Cornell / Harvard / Ithaca College / Ohio State / Rochester / Rutgers / Syracuse / Vanderbilt) collaboration working at the CESR electron-positron ring at Cornell has found an F meson candidate in a new decay mode and at a lower mass than previously observed. The charmed F meson is the strangeness-carrying partner of the D mesons, and consists of a charmed quark bound with a strange antiquark.

Although observations of D mesons are routine, the F meson has remained elusive. A DASP (DESY) electron-positron annihilation experiment and a more recently CERN photon experiments utilizing the Omega spectrometer provided the strongest F evidence. The Omega experiments gave the F mass as 2020 ± 15 MeV.

The F meson can be observed through the weak decay of its charmed quark into a strange quark. The decay modes most accessible to experimental detection are those in which the new strange quark and the original strange antiquark combine to form either an eta or a phi meson, with a few pions being produced by the weak decay of the charmed quark. The previous experiments have relied on detection of one or more pions along with an eta, observed through its decay into two photons. In the CLEO detector, the phi-pi mode was observed by reconstructing the phi from two charged kaons.

Phi-meson candidates were identified from combinations of oppositely charged tracks interpreted as kaons. A clear phi signal above a substantial background was observed in the two-kaon mass spectrum. Charged kaon pairs, consistent with the phi mass, were selected for further analysis. They were combined with other charged particles, assumed to be pions, to give a phi plus pion mass spectrum, and the mass peak at 1970 ± 5 MeV has a width consistent with the experimental resolution. No mass peak is observed if two-kaon masses above or below the phi are used to create the phi-pi mass spectrum. This underlines that the observed peak is due to phi mesons and not background combinations.

Further evidence that this enhancement is the F meson comes from examining its production and decay. In background electron-positron annihilation, charmed quark production accounts for 40 per cent of the event rate. The momentum fraction (momentum/beam energy) distribution of F events agrees with those of D events measured earlier by CLEO. Also, the product of the F production rate and the relative occurrence of the phi-pi decay is one-third of the product for D^0 production followed by decay to kaon plus pion, in good agreement with a simple quark counting argument.

Angular distributions of the two kaons and the pion further support the proposition. The phi meson has spin 1, the pion has spin zero, and the F meson should have spin zero. These assignments lead to two characteristic angular distributions, which are in good agreement with the data in the peak, after subtracting background.

This observation of an F signal at 1970 MeV in the phi-pi spectrum was announced last summer and has been confirmed by the ARGUS experiment at DORIS (see December 1983 issue, page 423).

DESY
45 GeV — and still topless!

Late in the evening of 9 December, the champagne was broken out at DESY. The PETRA electron-positron storage ring passed from 44.98 GeV total energy to 45.01, thus surpassing the 45 GeV design value for the PETRA improvement programme which began back in 1982. From 37.2 GeV, the energy was nudged to 40.2 towards the end of 1982, and reached 43.19 last July (see October 1983 issue, page 311). To achieve 45 GeV, the PETRA r.f. power and the number of accelerating cavities were eventually doubled.

To run at 45 GeV, all the available space is filled by accelerating cavities. There are now 112 of them working at 500 MHz, with a total of 672 cells. In addition, 24 cavities running at 1 GHz with a total of 152 cells are used to improve the acceleration process. This 1 GHz system is used at lower energies to increase the bunch length.

The energy required to run this system amounts to about 17 MW (from the mains) of which 9.6 reach the cavities. Since they are not superconducting, the cavities' losses are high — only about 1 MW is finally used by the beam to compensate for emitted synchrotron radiation. These energy losses underline the potential usefulness of superconducting cavities for handling high energy electron beams.

At the DESY Theory Workshop — Gerhard Mack and Harry Lehmann (right).

(Photo DESY)

Theory workshop

Concentrating on the common ground between current theory and experiment, the annual Theory Workshop is now a traditional event in the DESY calendar. The sixth such workshop, held a few months ago, explored the new jet information culled from the summer conference season. However the number of outstanding questions in this area still appears to exceed that of clear answers.

The organizing committee, L. Stodolsky (chairman), K. Schilling (deputy chairman), H. Joos and T. Walsh had in the back of their minds a comparison of simple models with standard quark-gluon gauge theory (QCD). However, it became clear that the qualitative successes of QCD have so shaped our thinking that simple models don't generate much enthusiasm any more. On the other hand quantitative tests of QCD are only at an accuracy of about 20 per cent, which leaves much theoretical and experimental work to be done.

Discussion of observed jet structure was fuelled by comparison of results from proton-antiproton collisions and electron-positron annihilation. Although mainly gluon jets are studied in proton-antiproton collisions at the CERN Collider and quark-antiquark jets in electron-positron interactions, the jet similarities are nevertheless striking. However K. Fialkowski mentioned that multiplicity of different types of jets at medium energies could differ.

For a quantitative explanation of jet structure, the theoretical input to describe the transition from quarks to hadrons is lacking. 'Preconfinement' — a candidate theoretical bridge between initial quark and final hadron states — was described by A. Müller.

In practical models, intuitive ideas dominate. Whether jets are independent, or are connected by a colour string, or whether their fragmentation into hadrons is soft, hard or even a thermodynamic process, and what influences these models have on the experimental determination at the quark-gluon coupling constant could not even be solved by a lively round table discussion (H. Meyer, H. Ochs, A. Ali, S. Ellis, G. Gustavson, K. Kowalski).

Luckily nature has given us heavy quarks! During their transition from quarks to mesons most of the quark energy stays with the heavy flavour. It is therefore possible to identify heavy quark jets and to measure their fragmentation, their weak coupling and many other things. The heavy t-quark has not yet been found up to a PETRA energy of 43 GeV, but the chances of finding it at the CERN Collider were extensively discussed by P. Zerwas.

The bound states of heavy quarks are of great interest for theorists. About ten upsilon states have been seen so far and many of the photon and pion transitions between them have been observed. Both the charmonium and bottomonium (upsilon) states can be surprisingly well described by inter-quark potentials, while the pure QCD predictions are a bit fuzzy. For a really quantitative test of QCD, the smaller distances of toponium spectroscopy might help, as would improved calculations on a lattice (which could soon be available).

The situation is even worse with the QCD predictions on gluon matter (talks by E. Bloom and K. Johnson). Here, theoretical models compete with calculations of the glueball spectrum from lattice QCD approximations.

While much of the Worskhop was concerned with experimental findings and their implications, the coverage of lattice gauge theories was more theoretical in flavour. Although errors of a factor of 2 or 3 are quoted for these calculations, the brave numerical attempts to reproduce the observed hadron spectrum from scratch are impressive.

Progress in this field came with larger computers and more computing time, which allowed larger lattices to be treated and the inclusion of fermions. Recently the first numerical results from improved lattice approximations by the late K. Symanzik were published. The lattice field is obviously the scene of much activity.

E. de Rafael spoke on QCD Sum Rules which combine perturbation theory and dispersion relations to give hadron (and quark) mass spectra. This is an alternative approach to lattice calculations. Comparison of its results with experiment gives the same accuracy as other QCD tests.

De Rafael illustrated our relationship with QCD by a parable about a farmer and his cow: a farmer (the physicists) has a beautiful white cow (QCD) of which he is justly proud. This cow provides good milk, but the farmer still has to learn how to make quality cheese!

BROOKHAVEN
Heavy ion proposal

With the apparent demise of the Colliding Beam Accelerator (CBA) project as initially envisioned and with growing interest in high energy heavy ion physics, Brookhaven has decided to push for a new heavy ion facility.

As an initial step, Brookhaven has proposed to the US Department of Energy (DOE) a project to provide a link between the Tandem Van de Graaff and AGS proton synchrotron facilities, and the AGS will be modified to accelerate heavy ions. If approved on the schedule requested, this project will be completed in 1985 and used for physics research soon after. Eventually, it could be combined with a Relativistic Heavy Ion Collider to be located in the CBA tunnel. Construction of such a collider could start in 1986 and be completed by 1989, at a cost of approximately $200 million.

This choice of a new direction for Brookhaven's future was based primarily on the recognition that there is an increasing interest in accelerating heavy ions to relativistic energies.

This area of physics has received enthusiastic support from DOE's Nuclear Science Advisory Committee, and the Laboratory has recently submitted a Relativistic Heavy Ion Collider feasibility study to DOE.

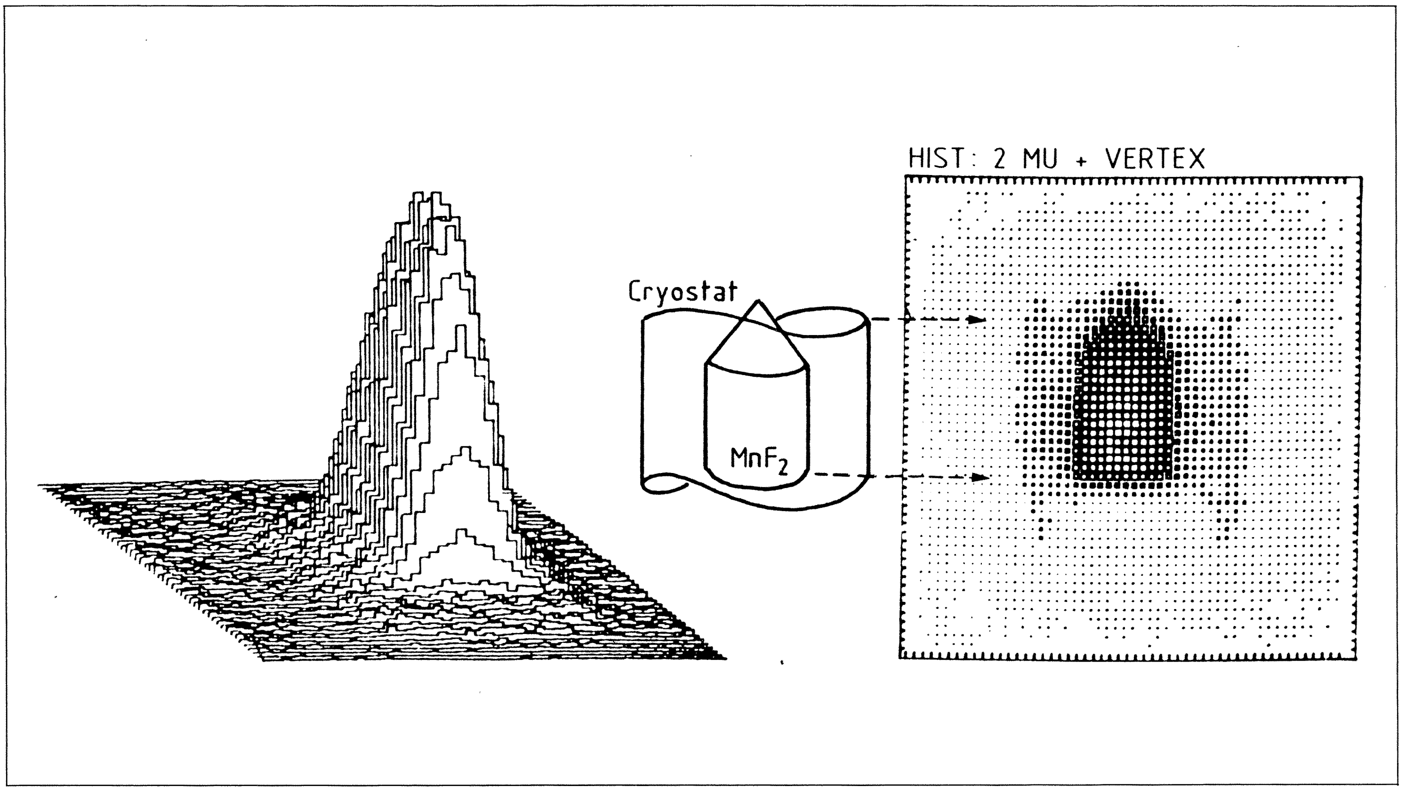
To prepare a detailed design proposal for this collider, a task force has been named by Paul Reardon, Associate Director for High Energy Facilities. Mark Barton will serve as chairman and Harald Hahn as technical coordinator.

AGS intensity records

The Alternating Gradient Synchrotron has achieved substantially higher intensities in recent months. Peak intensities have been as high as 1.6×10^{13} protons per pulse and average intensities over an eight-hour shift of up to 1.5×10^{13} have been attained, improvements of about 50 per cent over 1982.

These performances are a result of the switch to negative hydrogen ion injection in late 1982, and of some

Wire chamber image of a single crystal (about actual size) in its cryostat. Monitoring muon decay in space as well as time using such detectors promises to open new applications for muon spin rotation research.



operational upgrades in the AGS r.f. acceleration system. The injection of negative hydrogen ions, with a stripping foil at the injection point to create the proton beam, is now standard at many proton accelerators. It overcomes limitations on the phase space brightness of the beam at injection, clearing the way for exploration and correction of other intensity-limiting effects.

Initial stimulus for the operational r.f. improvements came from Daniel Boussard of CERN, who during a short visit to Brookhaven last summer introduced a beam loading compensation system. This removes beam-induced transient excursions of the r.f. system during the initial beam capture, increasing the capture efficiency and promising higher intensities.

After further adjustments in the r.f. system and increasing the injected linac current, the physics programme is now reaping the rewards of record intensities. The AGS staff are eternally grateful to Daniel Boussard for his timely contribution.

The AGS injection energy is still 200 MeV. Just where is the 'space charge limit' to the machine's intensity? Judicious improvements to the fundamentally capable and robust accelerator continue to pay significant dividends. There is strong optimism that further careful work will eventually push the AGS' average intensity to near 2×10^{13} protons per pulse, twice the design value envisioned 10-15 years ago!

CERN

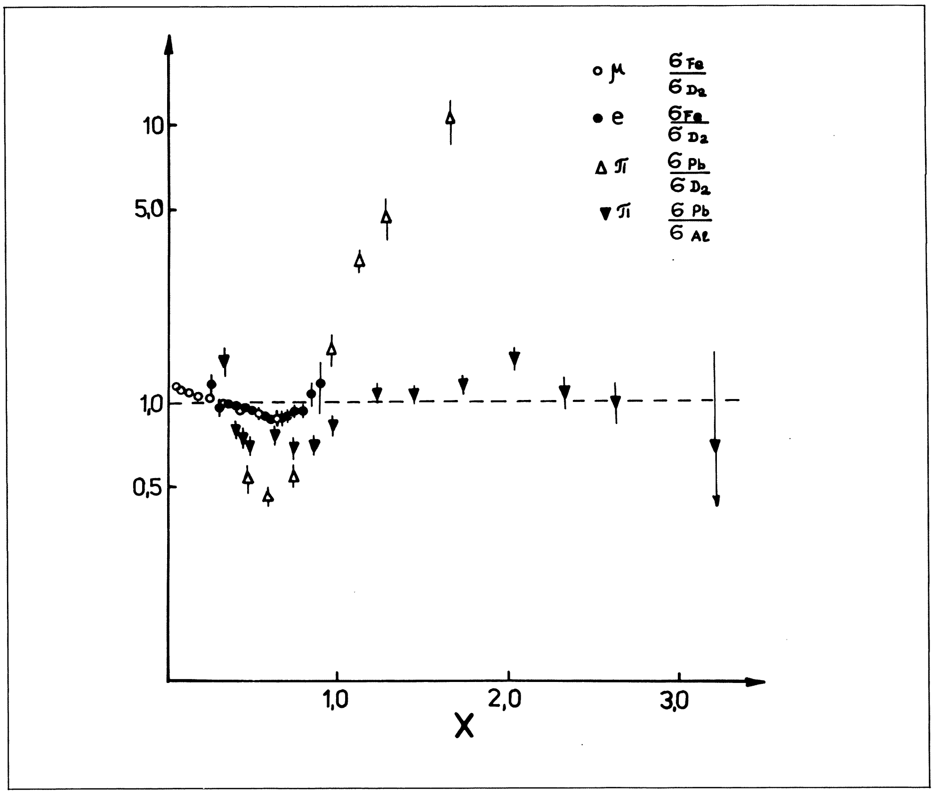
More from muon spin rotation

The technique of muon spin rotation (muSR) is establishing itself as a major physics tool. Multidisciplinary teams of scientists are making use of it in experimental programmes at CERN and at SIN (Switzerland) in Europe, at KEK in Japan, at TRIUMF in Canada and LAMPF in the US.

In less than a decade, these physics programmes have covered a lot of ground, much of it new, and there is no shortage of prospective new clients to swell the ranks of the muSR community. In particular, muSR at major centres like CERN profits from the availability of know-how in technology and instrumentation.

At CERN, muSR physics is based on the faithful 600 MeV synchrocyclotron (SC), using muon beams derived from the forward decay of pions in flight. The present community involves scientists from Sweden, the UK, Italy, West Germany and France, as well as CERN.

The technique involves bringing a beam of polarized positive muons to a stop in a suitable target, where the



Variation in quark structure in nuclei with momentum fraction, x, as measured in different experiments. The ratio of effective nucleon cross-sections reflects the underlying quark structure (structure functions). The round data points are from deep inelastic experiments at CERN and SLAC, and the triangles from nuclear scattering at Dubna, measured under the conditions ('limiting fragmentation') which probe the constituent quark behaviour. The observation of structure for x greater than one implies 'superfast' quarks carrying the momentum of more than one nucleon.

trapped muons precess in the local magnetic fields before decaying. The emission of positrons in these decays is dictated by the laws of weak interactions, and their signals, conventionally monitored by scintillator telescopes, reflect the behaviour of the trapped muons.

For many purposes, a positive muon can be likened to a very light proton, so that 'chemically', the muon and the proton can be considered isotopes of the same element. The accessibility of muons to measurement through muSR provides a good window on the underlying properties of the sample.

The study of metals demands very low temperatures (down to the millikelvin range) and extremely pure samples. Studies at CERN have shown how muons are 'trapped' at impurity sites. Detailed studies of the diffusion steps leading to trapping and of the muon impurity configurations are under way. After this and other groundwork, studies of magnetic materials have gained momentum, and new magnetization behaviour has been seen which poses problems for theorists. In other substances, the onset of paramagnetic behaviour at the Curie temperature has been found to be less abrupt than once had been believed.

In many materials, the stopped muons can pair with electrons to form 'muonium' — a hydrogen-like atom with a muon, rather than a proton, as its nucleus. Like hydrogen, these atoms are highly reactive and can be used as probes of organic compounds.

A range of muonic organic radicals has been studied, and reveal interesting behaviour, both in the underlying properties of the sample and in an explicit comparison of muonium and hydrogen behaviour.

Development work in instrumentation has also paid dividends. A wire chamber detector has been developed at CERN which enables muon decay to be monitored in space as well as time. In conventional muSR detectors, the muon precessions are monitored by looking at the rate of positron decays picked up in a particular direction. This is prone to uncertainties due to beam impurities and other background effects.

The new detector correlates the observed positron trajectories with the muon decay vertex using coincidence techniques. First results have been gratifying, giving greatly increased rejection of spurious events.

Thanks to the cryogenic expertise at hand, muSR experiments at low temperature have already become something of a speciality at CERN. In addition, a new high pressure system has been developed for measurements on samples exposed to up to 14 kbar. First experiments will soon get under way.

Far from growing complacent and self-satisfied at its achievements so far, the muSR community is canvassing for extra support to cater for the growing list of potential users knocking at the door.

DUBNA
Quarks in nuclei

Until recently the structure of nuclei in terms of independent quarks was explored by studying nuclear reactions with large momentum transfers. Recent results from high energy muon experiments at CERN (see November 1982 issue, page 362) made it possible to obtain information on the nuclear quark structures (structure functions) in a hitherto inaccessible region of momentum fractions, x. These striking results, confirmed by the SLAC experiments on deep inelastic scattering of electrons on nuclei (see April 1983 issue, page 90) indicate that there is a significant difference between the nucleon's quark structure in nuclei and in free space.

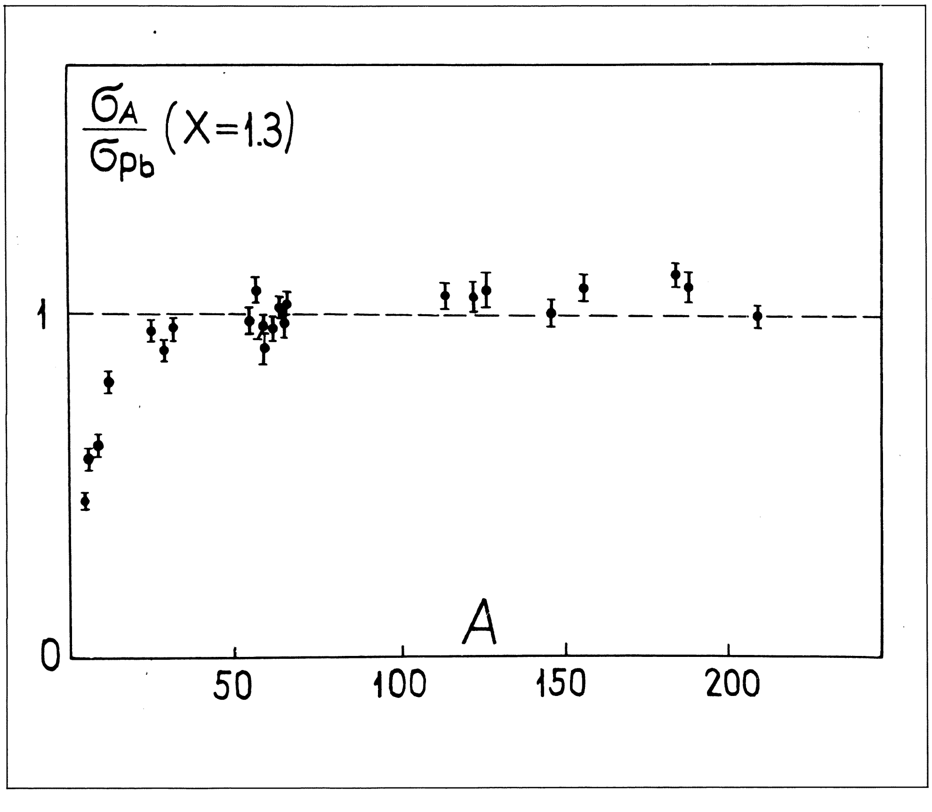
At Dubna, the data on the quark structure functions of nuclei obtained in relativistic nuclear physics (under suitable conditions — 'limiting fragmentation') have been compared with the data on deep inelastic scattering of leptons on nuclei. The CERN and SLAC data for deuterium and iron and the Dubna data for deuterium and other nuclei show that in the momentum fraction region between 0.5 and 1, the appropriate reaction rate on heavier nuclei is less than that on deuterium. Comparing the data from different nuclei shows that in this kinematic region, ratios of nucleon reaction rates (hence structure functions) go as the (x-1)/3 exponent of the ratio of atomic masses, and it will be interesting to test this in future experiments.

The region x greater than 1 ('superfast' quarks) is of special interest and has been probed in nuclear physics experiments at the Dubna synchrophasotron. Superfast quarks carry the momentum of a group of nucleons and are thought to come from multiquark states which exist in nuclei along with the nucleons.

These multiquark configurations are the result of fluctuations of quark plasma and the nucleus is viewed as a system near the critical point for the transition of nuclear matter into quark plasma.

The ratio of structure functions for various nuclei to that of lead for momentum fraction 1.3 is found to be independent of atomic mass number above 50. However for mass numbers less than 20 the structure function ratio decreases with mass. This implies that not only in deuterium, but in all the lightest nuclei, the quark configurations differ from each other and strongly differ from those in heavy nuclei.

Measured at Dubna for x=1.3 (superfast quarks), the nuclear quark structure relative to that of lead does not vary much above atomic mass 50. However for lighter nuclei, the relative structure changes significantly. This implies that not only in deuterium, but in all light nuclei, the quark configurations differ both from each other and from what is seen in heavier nuclei.



(From material supplied by A.M. Baldin.)

CONFERENCE

Computers and accelerators

In September of last year a Conference on 'Computers in Accelerator Design and Operation' was held in West Berlin attracting some 160 specialists including many from outside Europe. It was a Europhysics Conference, organized by the Hahn-Meitner Institute with Roman Zelazny as Conference Chairman, postponed from an earlier intended venue in Warsaw. The aim was to bring together specialists in the fields of accelerator design, computer control and accelerator operation.

The debates about the appropriateness of computer applications in accelerators are now long in the past and the discussions at the Conference were on the details of how to get optimum use rather than on any questions of principle. The computing power which can be bought per dollar continues to increase dramatically and the major restraints on applications are not related to the limitations of the computers themselves but rather to the ability to develop the necessary software programs. It is software which has become the dominant cost factor.

Because of the increased computing power, there is a new level of sophistication in control and operation. For example, rather than the operator adjusting individual machine elements, he can work directly on the machine parameters — Q value, chromaticity, etc. — with the computer taking charge of all the corresponding modifications.

Simulation programs to track beam through magnet systems are very much in vogue and can now incorporate collective effects, beam instabilities etc. Such simulations are particularly useful in storage ring operation where, rather than risk losing precious stored beams, it is important to be able to judge the effect of changes before actually implementing them in reality. These abilities enable machines to be 'modelled' at the computer, independently of the hardware, in a much more thorough way than before. The damping ring for the linear collider at SLAC is a recent example where models simulate the effects of errors and investigate correction schemes.

There are differences in the programs developed at the different Laboratories (such as MAD, SYNCH and TRANSPORT) and some coordination, to standardize input structures and to incorporate the most modern techniques, is very desirable.

The advent of cheap microprocessors seems to have completely closed the debate on distributed versus central computing power in accelerator control. The only discussion concerns the extent to which distributed power should go for there are still arguments as to whether 'central' duties of the control system should be in the hands of one or two large computers. One related possibility for the future is whether the present type of 'mobile' consoles, which can be wheeled round the machine so as to have local control while working on individual machine components, will be replaced with hand-held units.

While thinking of the future an entertaining possible development is the use of voice to transmit instructions to the computer system. Though this is feasible even now, there is some apprehension that a chance juxtaposition of words in a discussion about the weather between machine operators could inadvertently dump the beam.

The Conference was considered very successful and it may well be repeated in a few years' time to survey the developments in the intervening period. These are likely to be considerable and Sir John Adams pointed out that there could be a few new challenges. With the possible advent of huge new machines, like the Superconducting Super Collider proposed in the USA, construction and maintenance may well have to be done by robots. Teaching these robots what to do should keep computer experts quiet for some time.

The International School-Seminar on Heavy Ion Physics, held last year in Alushta (Crimea, USSR) and organized by the Dubna Joint Institute for Nuclear Research, opened with a report 'Prospects for the development of heavy ion physics' by G.N. Flerov, JINR Nuclear Reactions Director. Right is seminar chairman P. Kienle of Munich.

CONFERENCE

Heavy ion physics at intermediate energies

More than 150 physicists from 16 countries gathered in Alushta (Crimea, USSR) for the 1983 International School-Seminar on Heavy Ion Physics organized by the Joint Institute for Nuclear Research (Dubna).

An impressive survey of progress in experimental research and topical theoretical problems in the field of relativistic heavy ion physics was given in reviews by A. M. Baldin (Dubna) and V. I. Man'ko (Moscow), as well as in a number of contributions.

However most of the 60 papers presented were devoted to studies with heavy ions at low and intermediate energies, from 3 to 100 MeV/nuc. Extensive research in this energy range has become possible with the advent of many fine accelerator facilities such as UNILAC at Darmstadt, the four-meter isochronous cyclotron U400 at Dubna, Super-HILAC at Berkeley, GANIL and SARA at Caen and Grenoble in France, the tandem NSF facility at Daresbury and others.

At the School main emphasis was placed on the synthesis of new elements of the Periodic Table. Nowadays the efforts of the experimenters are aimed at producing novel elements beyond 107 by near-barrier ('cold') fusion reactions which might lead to compound nucleus formation with excitation energy as low as 15-20 MeV.

The results of recent experiments of this type were presented by P. Armbruster (Darmstadt) and Yu.Ts. Oganessian (Dubna). The reaction chromium 54 on bismuth 209 was first tried by Oganessian and co-workers at Dubna in 1975 to synthesize element 107. The observed fission tracks pointed to the production of element 107, but no further identification of the created element was carried out. In 1981 experiments performed by Münzenberg and his colleagues at Darmstadt used the same reaction and were able to unambiguously identify the reaction products. The detected nuclide ^{267}107 (see May 1981 issue, page 164) showed that only one neutron was evaporated from the compound nucleus — in contrast to earlier assumptions. Stimulated by the success using this reaction process ('cold fusion') experiments were recently carried out at Darmstadt and Dubna to synthesize element 109 by the reaction iron 58 on bismuth 209.

At Darmstadt during a 12-day experiment with 3 beam energies, the

GANIL (France) Director C. Detraz (left) with Yu. Ts. Oganessian of Dubna, head of the School-Seminar Organizing Committee. Detraz gave a report on the GANIL heavy ion experimental programme.

(Photos JINR Dubna)

irradiation at 5.15 MeV/n with a beam dose of 3×10^{17} produced one correlated event chain of alpha-decays and fission that was very probably due to the production and decay of the isotope A = 266 of element 109. At Dubna a much higher beam intensity of 5×10^{13} pps was available. In experiments aimed at detecting the spontaneous fission of the isotope $^{266}109$ and/or its alpha-decay products, particularly $^{258}105$, leading after electron-capture to the fission of $^{258}104$, no fission track has been found with beams of iron 58 at bombarding energies up to 5.5 MeV/n that could be attributed to the formation and the decay of $^{266}109$. The Darmstadt result is compatible with a cross-section of 2×10^{-36} to 4.6×10^{-35} cm^2 at 67% confidence level, whereas the upper limit for the production cross-section was set at about 5×10^{-37} cm^2 by the Dubna group.

The problems of manufacturing element 109 have led to studies of the possible limitations of such fusion reactions for producing compound nuclei. This is closely bound up with the production of superheavy elements (SHE). Joint Darmstadt / Berkeley experiments at the Super-HILAC and UNILAC have looked hard for SHE evidence, but not all possibilities have yet been tried.

The lack of SHE evidence so far in experiments using accelerators contrasts with the evidence from cosmic rays. According to Perelygin (Dubna), in meteoritic samples of 700 tracks of heavy cosmic ray nuclei, six tracks have been detected which are 1.5 to 1.8 times longer than usual. The unambiguous identification of their origin is quite complicated. A direct indication that they are due to superheavy nuclei could be the detection of the spontaneous-fission tracks just at the point where a cosmic ray, presumably a superheavy nucleus, had been stopped.

Heavy ion beams of low and intermediate energies are a powerful tool for producing new nuclei very far from beta-stability. Fruitful studies of the properties of such nuclei have been carried out using the laser spectroscopy methods, subject of a comprehensive review by E.W. Otten (Mainz); some results were presented also by O. Klepper (Darmstadt) and I.N. Izosimov (Leningrad). Having high resolution and sensitivity, laser techniques working on-line with mass separators for radioactive beams have allowed the systematic studies of spins, moments and charge radii of nuclei in long isotopic chains extending far from the beta-stability line. Twelve long chains have been investigated by laser spectroscopy for various elements, including a total of about 200 radioactive nuclei.

The studies of the properties of nuclei far from beta-stability have led to the discovery of new modes of radioactive decay. (At Darmstadt, proton radioactivity — see October 1981 issue, page 357, and more recently at Berkeley, the beta-delayed two-proton decay from aluminium 22.) Lively discussions on the future prospects for proton radioactivity studies followed the talks by S. Hofmann (Darmstadt), Yu. N. Novikov (Leningrad), O. Klepper (Darmstadt) and V.I. Goldansky (Moscow).

R. Spohr (Darmstadt) presented an impressive talk on the studies and applications of nuclear tracks produced by accelerated heavy particles in solids. He considered the use of small angle scattering of neutrons and X-rays for observing the diameter and length of latent tracks, the manufacture of single-pore membranes (up to 20 cm^2 in area, with a pore diameter of say 5 microns) for measuring deformability of individual red blood cells, and heavy-ion lithography for observing microscopic density deviations (e.g. in biology). For applications in microelectronics, he discussed the prospects of nuclear track etching for generating well defined surface textures as well as for producing strongly emitting surfaces for cold cathodes, etc. The discussions that followed the talk confirmed once more that heavy ion beams offer a unique precision instrument for microproduction of material surfaces, with numerous promising applications.

CERN Council approves antiproton improvements

At its December session under the Presidency of Sir Alec Merrison, the CERN Council gave its support to a programme of improvements to the CERN antiproton project. In 1983, the CERN proton-antiproton collider was the scene of the epic W and Z particle discoveries, and CERN is extremely keen to sustain its lead in this physics for as long as possible. This calls for more intense antiproton beams, higher collision rates (luminosities) and improved detectors. Such a programme should keep CERN's nose in front even during the initial years of operation of the Fermilab proton-antiproton collider (see page 11), before Fermilab's higher design luminosities and collision energies take over.

However the necessary financial and manpower resources to implement this CERN improvement programme were extremely difficult to find at a time when the Laboratory is so heavily committed to the construction of LEP while sustaining a broad physics programme for 2600 researchers. A proposal to assemble these resources was patched together by squeezing further savings from the already tightly-stretched CERN budget (particularly by extending machine shutdowns), by retaining bank interest which would normally have been returned to Member States, and by other manipulations involving new money coming in from the new Member State, Spain.

After long discussion, the Member State delegations were able to agree on a variant of the proposal. Very much in keeping with the tradition of CERN and despite the severe economic difficulties being experienced, the Member States confronted the problems in a positive spirit and energetically sought ways to strengthen CERN's scientific programme.

At this Council session, Spain took its place as CERN's thirteenth Member State. The Spanish delegates — J. Rojo and J.A. Ruiz Lopez Rua — were warmly welcomed by Sir Alec Merrison.

During the session, Sir Alec was re-elected President, while A. Pappas and J. Rembser were elected Vice-Presidents. For the Scientific Policy Committee, D. Perkins was elected Chairman, P. Falk-Vairant and E. Lohrmann re-elected members, while A.N. Diddens (Amsterdam) and L. Maiani (Rome) become new members.

Council approved the reappointment of Bas de Raad as SPS Division Leader (for three years) and Alan Wetherell as Experimental Physics Division Leader (for six months, to give time to find a successor). Horst Wenninger becomes Experimental Facilities Division Leader for three years, succeeding Adolf Minten.

President of CERN Council Sir Alec Merrison in the chair for the December Council meeting.

(Photo CERN 362.12.83)

People and things

Groundbreaking for the new SLC machine at Stanford. Left to right, Chairman of the Stanford University Board of Trustees William R. Kimball, SLAC Director 'Pief' Panofsky, and wielding the shovel, US Energy Secretary Donald Hodel. SLC Project Director John Rees is hidden behind Hodel. Later this year, Panofsky hands over the SLAC directorship to Burt Richter.

(Photo Stanford)

Groundbreaking at Stanford

31 October 1983 saw the official groundbreaking for the new Stanford Linear Collider (SLC). At the ceremony, US Energy Secretary Donald Hodel said '. . . these projects, frankly, cannot be started with knowledge that we will find what we seek or what we expect to find. And many of them cannot be started in the high energy physics area with any assurance that something will come out of the project that will pay for itself. I want to reaffirm here today the commitment we have to the proposition that high energy physics, that science and technology, at the frontiers of human knowledge, is in and of itself something that we wish to pursue, not because we can identify cost-benefit outcomes which prove that it was a good economic investment, but because we believe that we see mankind at its exalted best when we see pursuit of knowledge for knowledge's sake.'

Major international meetings

This year's International Conference on High Energy Physics takes place in Leipzig, East Germany, from 19-25 July. The organizer is Prof. K. Lanius, Institut für Hochenergiephysik, Platanenallee 6, DDR-1615 Zeuthen, East Germany.

Also sponsored by IUPAP is next year's International Symposium on Lepton-Photon Interactions, which will take place in Kyoto, Japan, from 19-24 August 1985. Organizer is Prof. J. Maki, Research Institute for Fundamental Physics, Department of Physics, Kyoto University, Kitashirakawa Oiwake, Kyoto-606, Japan.

Spin symposium

The sixth international symposium on high energy spin physics will be held at the University of Luminy, Marseille, from 12-19 September. Both parallel and plenary talks are planned, with the first day including specialized workshops on the acceleration and storage of polarized particles in large machines, on phenomena in intermediate energy nucleon-nucleon scattering, and on theory and experiment on high energy spin effects. Those interested in participating should write as soon as possible to J. Soffer, Centre de Physique Théorique, CNRS Luminy, Case 907, 13288 Marseille Cedex 9, France.

The Nuclear Physics Sub-Committee of the UK Institute of Physics is organizing a conference on Nuclear Structure Physics, to be held

Members of CERN's Spanish community celebrate their country's rejoining CERN, bringing the total number of Member States to thirteen.

(Photo CERN 653.11.83)

at the University of Bradford, UK, from 11-13 April. Further details from the Meetings Officer, Institute of Physics, 47 Belgrave Square, London SW1X 8QX, UK.

The Proceedings of the International High Energy Physics Conference held at Brighton (UK) last July are now available, price 15 pounds sterling, from the Library, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire OX11 0QX, UK. Prepayment is required. Full marks to all concerned for the speedy publication of this 900-page tome.

CERN COURIER Index 1983

As in the previous year, the Index to the 1983 editions of the CERN COURIER is not being distributed with copies of the journal. Copies are available on demand from Monika Wilson, CERN/DOC, 1211 Geneva 23, Switzerland. Please specify whether you want the English or French version of the Index.

Kurt Symanzik

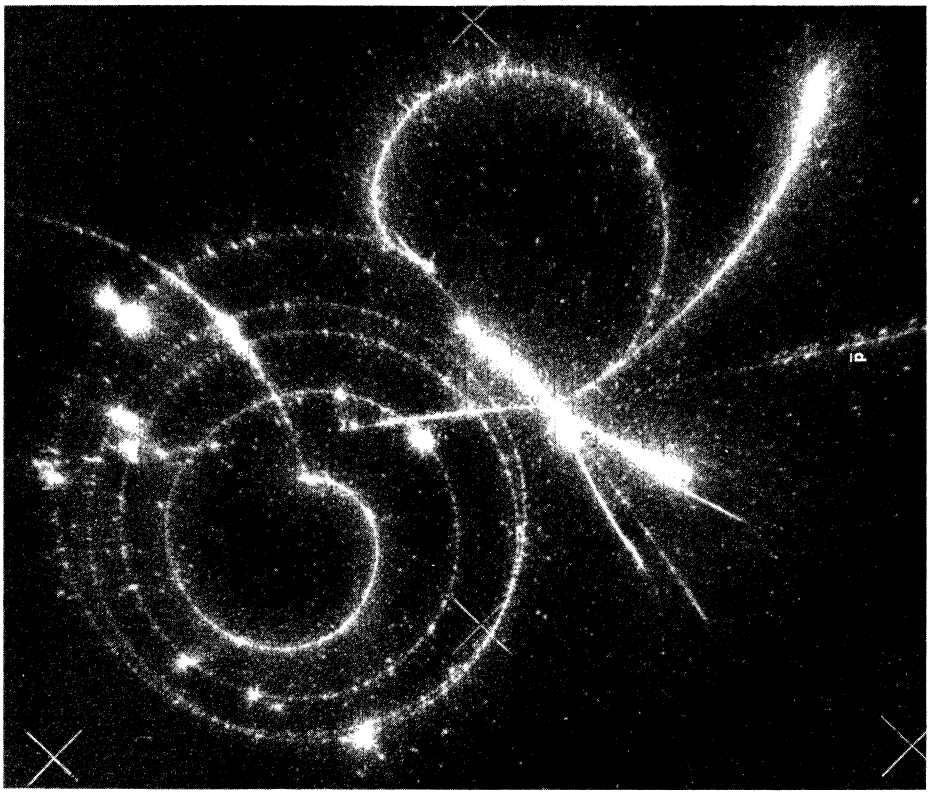
As announced briefly in our previous issue (December 1983, page 433), theoretician Kurt Symanzik died in Hamburg on 25 October 1983, one month before his 60th birthday.

For particle physicists, his name is primarily linked with the Callan-Symanzik equation, which de-

At the end of November, the LEP Pre-Injector Group and the civil engineering contractors threw a party to mark the completion of the building to house the LEP Injector Linac (LIL) at CERN. Here LEP Project Director Emilio Picasso addresses the throng assembled in the future klystron gallery.

(Photo CERN 629.11.83)

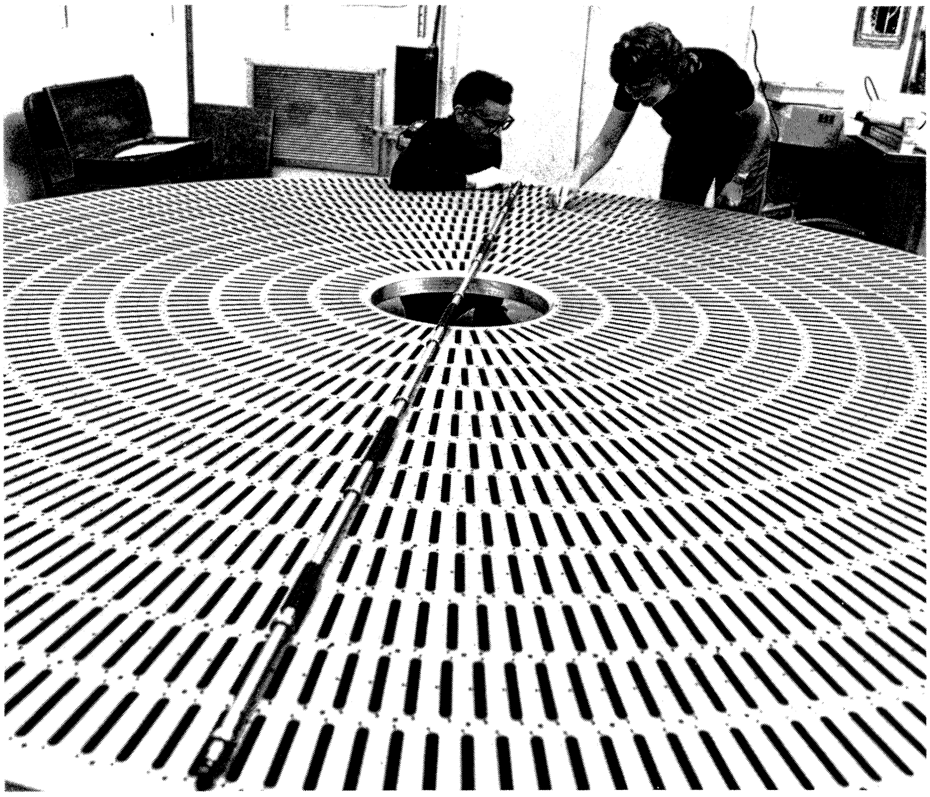
Streamer chamber photograph of a low energy antiproton interaction seen by the Dubna / Frascati / Padua / Pavia / Turin group working at LEAR, CERN's new Low Energy Antiproton Ring. The incoming 600 MeV/c antiproton track is on the right. The experiment has so far amassed 20K photographs with the chamber filled with helium and 7K with neon in a study of the interactions of low energy antiprotons with different light nuclei. The fiducial cross-marks seen in the photograph are 280 mm apart.



scribes high energy behaviour in quantum field theory. Its application to quark fields leads to 'asymptotic freedom' – viewed in a small enough region of space-time, quark interactions become relatively feeble.

Symanzik's brilliant work on many aspects of quantum field theories began when he was still a student. Later, in the sixties, he discovered euclidean field theory and with it a relation between quantum field theory and statistical mechanics, on which modern Monte Carlo calculations in lattice gauge theories are based.

After his studies, first in Munich and then with Heisenberg in Göttingen, he worked from 1955 to 1961 at various institutes in Europe and the USA. After two years at CERN (1961-2), he became Professor of Mathematical Physics at the Courant Institute (New York). From 1968, he had the position of a Senior Scientist at DESY and was professor at the University of Hamburg. In 1981 he received the Max Planck Medal, the highest distinction of the German Physical Society. Until a few weeks before his death, Professeur Symanzik had been actively working on a problem in quantum chromodynamics.

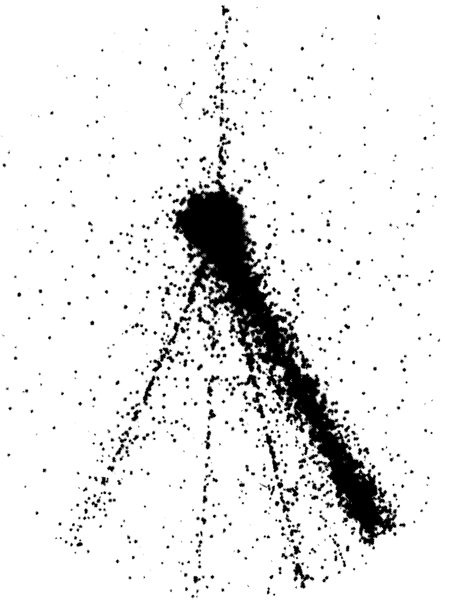


The Mark II detector, currently at the PEP electron-positron ring at SLAC, is to be upgraded for operation at the new SLC linear collider. One of the endplates for its new drift chamber is seen here being inspected by Gail Hanson (right) and Charlie Hoard. The chamber was designed to have excellent momentum resolution in a 5 kilogauss magnetic field, good solid angle coverage, ease of pattern recognition and high tracking efficiency, and energy loss measurement to aid electron identification. This is accomplished with 12 layers of multi-sense-wire cells. There are approximately 6000 sense wires in the chamber.

(Photo Stanford)

Bare uranium

Bare uranium nuclei — uranium atoms with all 92 electrons removed — have been produced at the Berkeley Bevalac. (Uranium ions were first produced in the Bevalac in 1982.) Uranium injected from the Super-HILAC (Heavy Ion Linac) already has 68 electrons missing, and the remainder are stripped off by passing the accelerated beam emerging from the Bevatron through a metallic foil. Any uranium ions with remaining electrons can be swept away by a magnetic field.



A 10 GeV pion from a SLAC test beam interacts to produce four high energy secondaries in a fibre optic plate scintillator active target being developed by the University of Notre Dame for use in Tevatron experiment E-687 (photoproduction of charm and beauty). This test used an 18 millimetre diameter, one centimetre thick, terbium-doped glass target composed of 15 micron diameter fibres. The background dots are due to the dark emission of single photoelectrons during the seven millisecond image intensifier gate used with this slow scintillator. To directly observe charm and beauty decays, a cerium-doped glass with a time constant of about 80 nanoseconds will be used.

Workshop on Detectors for Relativistic Nuclear Collisions

A Workshop will be held from 26-30 March at the Lawrence Berkeley Laboratory. It will focus on the requirements for the next generation of detectors that will be needed to search for the production of the quark-gluon plasma in central high energy nucleus-nucleus collisions. Detectors for both fixed target and collider geometries will be considered. For further information contact L. S. Schroeder, Building 70, Room 319, Lawrence Berkeley Laboratory, Berkeley, California, 94720, USA.

After co-chairing the working sessions which established a programme of collaborative effort in high energy physics, James E. Leiss, Associate Director of the Office of Energy Research in the US Department of Energy, and Madame Gu Yu, Adviser to the Chinese Academy of Sciences, signed a joint US/Chinese agreement at a ceremony at Stanford University.

(Photo Stanford)

STANFORD LINEAR ACCELERATOR CENTER OF STANFORD UNIVERSITY

announces an opening for the position of

ASSOCIATE DIRECTOR, TECHNICAL DIVISION

The Stanford Linear Accelerator Center (SLAC) is a major high energy physics research laboratory operated by Stanford University under contract with the U.S. Department of Energy. SLAC's Technical Division consists of groups that are responsible for operating and maintaining the large electron accelerator and colliders; for advanced research and development in the fields of accelerator physics and engineering; and for the general provision of technical services to the rest of the laboratory. The Associate Director, Technical Division, has primary responsibility for the leadership and management of this program under the general direction of the Laboratory Director.

Candidates for the position of Associate Director, Technical Division, must have had extensive and widely recognized experience as practicing scientists in the field of accelerator physics. The laboratory is seeking a person who is willing to play a strong leadership role in the years ahead.

The intended starting date for this position is 1 October 1984; the actual date can be a matter of negotiation. Applicants should submit a curriculum vitae, together with the names of at least three references, to Professor W.K.H. Panofsky, Chairman, Associate Director Search Committee, Bin 80, SLAC, Stanford University, P.O. Box 4349, Stanford, California 94305. SLAC is an equal employment opportunity employer.

SLAC

NEUTRINO PHYSICIST

Los Alamos National Laboratory invites applications for a high-level position in the Medium Energy Physics Division, to participate in and provide oversight for the experimental program in neutrino physics at Los Alamos.

Candidates should have a PhD. in Physics and a strong record of accomplishment, as demonstrated by publication of research, in particle and/or nuclear physics, with emphasis on the study of neutrino detection and interactions.

The Laboratory is operated by the University of California for the U.S. Department of Energy and offers competitive salaries and a full range of employee benefits. The beautiful mountain location in Northern New Mexico provides exceptional recreational activities. The school system is excellent, and the community offers a casual, relaxed lifestyle.

Screening will begin in March, 1984, but later applications will be welcome until the position is filled. Applicants should send a complete resume and three references, in confidence, to:

Richard O. Garcia
Personnel Administration Division, DIV-84-F
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

University of California
Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

An Affirmative Action/Equal Opportunity Employer: Women, Minorities, Handicapped and Veterans are urged to apply.

UNIVERSITY OF LONDON

Chair of experimental particle physics tenable at Imperial College of Science and Technology

The Senate invites applications for the above Chair. The Professor appointed will be responsible for leading the High Energy Nuclear. Physics Group within the Department of Physics, a group which undertakes research in experimental particle physics.

Applications (ten copies) must be received not later than **10 February 1984** by

The Academic Registrar,
University of London,
Senate House, London WC2E 7HU,

from whom further particulars should first be obtained.

UNIVERSITY
OF
MARYLAND

High Energy Physics Group is looking for a

HIGH ENERGY PHYSICIST

to take on major responsibilities for the hadron calorimeter being built for the OPAL detector at LEP in CERN.

Expected to spend time both at CERN and at Maryland. Five year appointment beginning in 1984. Salary commensurate with experience.

Complete résumé with three references should be sent to

Prof. George A. Snow
DOE HEP Contract Director
Dept. of Physics and Astronomy
University of Maryland,
College Park, Md. 20742 USA

U. of Maryland is an equal opportunity/affirmative action employer.

POSTDOCTORAL APPOINTMENT
LOS ALAMOS NATIONAL LABORATORY
Los Alamos Meson Physics Facility (LAMPF)

The experimental nuclear chemistry group at LAMPF is accepting applications from postdoctoral candidates. The appointment is for one year, renewable for a second and pays a stipend amount of $26,220.00 to $27,600.00 per annum (depending upon research experience). Employee benefits include paid incoming travel, moving expenses, and 24 days annual vacation. Candidates no more than three years past the Ph.D. in nuclear chemistry or nuclear physics are invited to apply. The appointee will join our research program in pion-induced reactions in complex nuclei. This program includes, but is not limited to, studies of pion single and double charge exchange, a single and multiple nucleon removal, pion absorption, and pion production. Candidates experienced in on-line counter techniques and computer-based acquisition systems are particularly being sought.

For information, call Bruce Dropesky at (505) 667-4372.

To apply, please send resume in confidence, by January 15, 1984.

Madeline Lucas, Div-84-I
PERSONNEL DIVISION
Los Alamos
National Laboratory
Los Alamos, NM 87545

University of California
Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

The Laboratory is operated by the University of California for the Department of Energy. Our beautiful high-country mountain location provides a relaxed, casual lifestyle, a pollution-free environment, and ample recreational activities.

An Affirmative Action/Equal Opportunity Employer: Women, minorities, veterans, and handicapped are urged to apply.

Research With High Energy Heavy Ions

Brookhaven National Laboratory

The Physics Department at Brookhaven National Laboratory invites applications for positions in the heavy ion research group. The Laboratory is planning a 15 A•GeV heavy ion facility that utilizes the Double Tandem Accelerator as injector and the Alternating Gradient Synchrotron as main accelerator for fixed target nucleus-nucleus collisions. The group will generate a new research program centered at this facility in collaboration with outside users.

Applicants with backgrounds in nuclear or particle experimental physics will be preferred. Appointments will be made at both postdoctoral and scientific staff levels, depending on the successful applicants' experience. Send applications to:

A.Z. Schwarzschild
Chairman, Physics Department
Brookhaven National Laboratory
Associated Universities, Inc.
Upton, Long Island, N.Y. 11973

An Equal Opportunity Employer m/f

bnl
Brookhaven National Laboratory
Associated Universities Inc.

ACCELERATOR PHYSICIST OR ENGINEER

The Physics Division of the Oak Ridge National Laboratory is seeking a physicist or engineer to join the staff of the Holifield Heavy Ion Research Facility as accelerator physicist for the Oak Ridge Isochronous Cyclotron.

Primary initial responsibilities of this position include routine and long-range beam development, analysis of ion motion in the cyclotron, development of improved components, long-range facility development, and operator training and certification. The position requires the ability to work on a wide variety of problems and skill in interpersonal relations. Opportunities exist for assumption of management responsibilities.

Applicants with a Ph.D. degree or equivalent experience in physics or engineering will be considered. Although experience in accelerator design and operation is desirable, applications are also solicited from individuals with experience in experimental nuclear physics, large magnet technology (conventional and/or cryogenic), and computer based computational techniques. U.S. citizenship is required.

Interested persons should send their resumes to:

Mr. J. T. Atherton
Ph.D. Employment
Building 4500 N
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

An equal opportunity employer

FIVE YEAR FELLOWSHIP in High Energy and Nuclear Theory

The Nuclear Theory Group of Lawrence Berkeley Laboratory's Nuclear Science Division is seeking a person with outstanding promise and creative ability in the area of Quantum Chromodynamics with applications to nuclear and/or astrophysics problems. The position as Divisional Fellow arises from our interest in ultrarelativistic nuclear collisions and the possible transformation of nuclear matter into a quark-gluon plasma. Both high energy and nuclear theorists are welcome to apply. The appointment is for a five year term with the intention of promotion to a senior staff position.

Applicants are requested to submit a curriculum vitae, list of publications, statement of research interests, and the names of at least three referees to:

Miklos Gyulassy, Chairman, Search Committee, Nuclear Science Division, Mail Stop 70A-3307, Lawrence Berkeley Laboratory, Berkeley, CA 94 720 as early as possible before the closing date, March 31, 1984.

Lawrence Berkeley Laboratory is an equal opportunity/affirmative action employer.

LAWRENCE
BERKELEY
LABORATORY

ASSISTANT PROFESSOR

Experimental or Theoretical Particle Physics

Tenure track position available, Fall 1984 in experimental or theoretical particle physics. A Ph.D. in elementary particle physics (experimental or theoretical) is required. Post-doctoral experience in one of these fields is desirable. All applications received before February 15, 1984 will be considered.

Duties include teaching undergraduate and graduate courses in physics as well as participation in research. There are currently three faculty members in the experimental particle physics group, working on experiments at Fermilab and DESY, supported by a grant from the NSF. In addition, there are two faculty members in elementary particle theory, supported by a DOE grant, working on gauge field theories and their applications to QCD and weak interactions.

The successful candidate is expected to apply for a grant under the «Outstanding Junior Investigator Program» of the DOE.

Send resume and three letters of recommendation to:

Professor J. P. Davidson, Chairman,
Department of Physics and Astronomy,
University of Kansas,
Lawrence, Kansas 66045.

An Affirmative Action/Equal Opportunity Employer. Applications are sought from all qualified people regardless of race, religion, color, sex, disability, veteran status, national origin, age or ancestry.

LARSEN AND TOUBRO ENDOWMENT CHAIR IN NUCLEAR ENGINEERING/SCIENCE

AT

INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY POWAY, BOMBAY-400076, INDIA

This Chair has been created to attract an eminent Nuclear Engineer/Scientist. The appointment is highly prestigious with salary/benefits even better than those of a full Professor of the Institute. Other benefits include subsidised housing on the campus, travel grants in India and consultative practice. Initially the appointment will be for a 3 year period; extension or reduction of the period of appointment is negotiable.

The Institute is looking for a person with established reputation in the field of Nuclear Engineering/Science with some experience in a University/R and D Institute/National Laboratory. The incumbent will be expected to provide leadership in research and development in the nuclear energy field and to interact strongly with the nuclear industries and R and D organisations in India.

Please mail your full biodata within 30 days of the advertisement to Prof. A. K. De, Director.

Weak Interactions – Formulae, Results, and Derivations

By Professor Dr. **Herbert Pietschmann**
Institute for Theoretical Physics, University of Vienna

1983. 9 figures. IX, 202 pages. ISBN 3-211-81783-2
Cloth DM 72,—, öS 504,—

Contents: Some General Mathematical Equations. — The Dirac-Algebra. — Field Operators and Invariant Functions. — S-Matrix, Cross-Sections and Life-Times. — Phase Space Integrals. — Weak Interaction Lagrangian. — Discrete Transformations. — Muon-Decay. — Tau-Decay. — Semi-Leptonic Baryon Decay. — Semi-Leptonic Meson Decays. — Current-Algebra. — Hadronic Hyperon Decay. — Quasi-Elastic Neutrino Scattering. — Deep Inelastic Neutrino Scattering. — Neutral Current Interactions. — Decay of the W-Boson. — Decay of the Z-Boson. — Charmed Particles and Higher Flavours. — Appendices: Comparison between Different Metrics. Limits on Additional S, P, T Interactions from the μ-e Ratio of Hyperon Decays. Some Formulae for e^+e^- Reactions. — Addenda: The Dirac-Algebra. Phase-Space Integrals. Field Operators. Gauge Invariant Lagrangians. Muon Decay. Semi-Leptonic Baryon Decay. Semi-Leptonic Meson Decays. Current Algebra. — References. — Sources.

Springer-Verlag Wien New York

TRIUMF
MESON RESEARCH FACILITY
University of Alberta
Simon Fraser University
University of Victoria
University of British Columbia
Competition No. 418-123

DETECTOR PHYSICIST

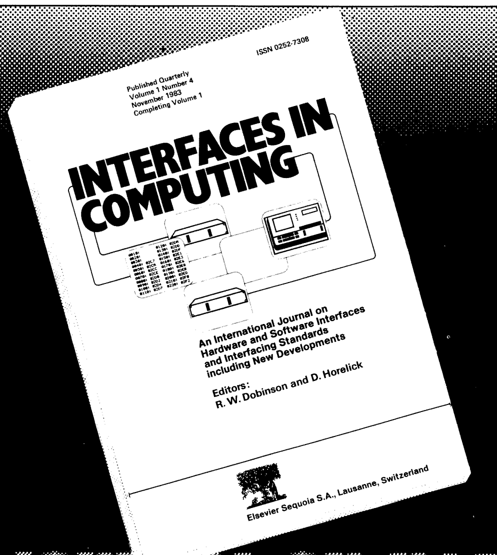
The Experimental Facilities Division at TRIUMF has an opening for a physicist to perform innovative development work in the field of wire chambers, drift chambers and similar devices. Initially, the appointment will be for two years but the position is a continuing one and the successful applicant will be subject to consideration for a continuing appointment.

Candidates should have a recent Ph.D. in physics and at least 3 years of demonstrated experience in the design and construction of gaseous detectors, with several publications in this area. Experience in related areas such as chamber readout systems and data acquisition systems is desirable.

Applications with curriculum vitae outlining experience and research interests, lists of publications and at least 3 letters of recommendation should be sent by March 1, 1984 to:

TRIUMF Personnel (Competition No. 418)
4004 Wesbrook Mall
Vancouver, B.C.
Canada. V6T 2A3

We offer equal employment opportunities to qualified male and female applicants.



ISSN 0252-7308

Published Quarterly
Volume 1 Number 4
November 1983
Completing Volume 1

INTERFACES IN COMPUTING

An International Journal on
Hardware and Software Interfaces
and Interfacing Standards
including New Developments

Editors:
R. W. Dobinson and D. Horelick

Elsevier Sequoia S.A., Lausanne, Switzerland

EDITOR
R. W. Dobinson
EP Division
CERN
1211 Geneva 23
Switzerland

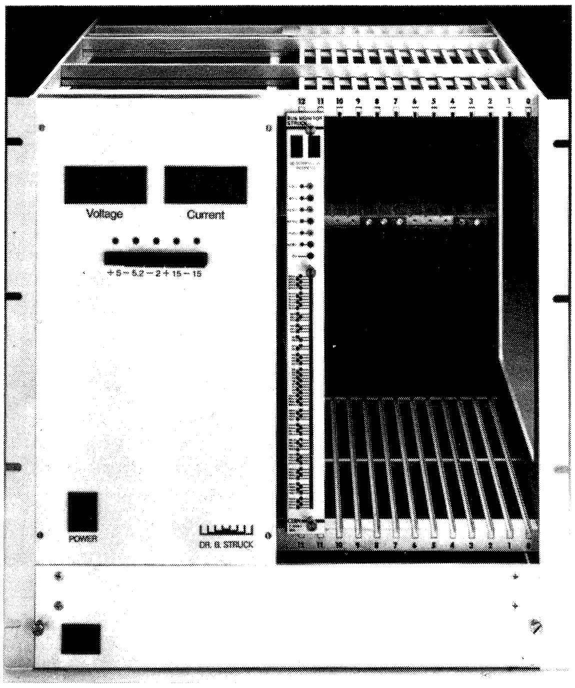
AN INTERNATIONL JOURNAL ON HARDWARE AND SOFTWARE INTERFACES AND INTERFACING STANDARDS INCLUDING NEW DEVELOPMENTS

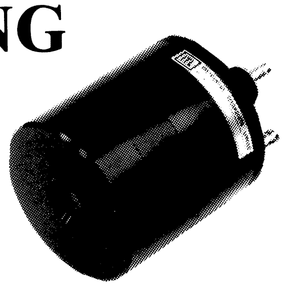
Interfaces in Computing is an international journal designed for production managers concerned with computing technology, system designers, electronics engineers and technicians. Its objectives are to ensure that the users of interfaces are fully aware of available techniques, to identify the needs of users when they are not satisfied by available standards and to demonstrate interrelations between hardware and software interfaces. The journal emphasizes the value of considering hardware interfaces, communications protocols and operating systems interfaces as part of the total system design.

Please ask for a free sample copy

ELSEVIER SEQUOIA S.A.
P.O. Box 851
CH-1001 **Lausanne 1**, Switzerland

8342S


Voltage
Current
+5 −5.2 −2 +15 −15
POWER
DR. B. STRUCK

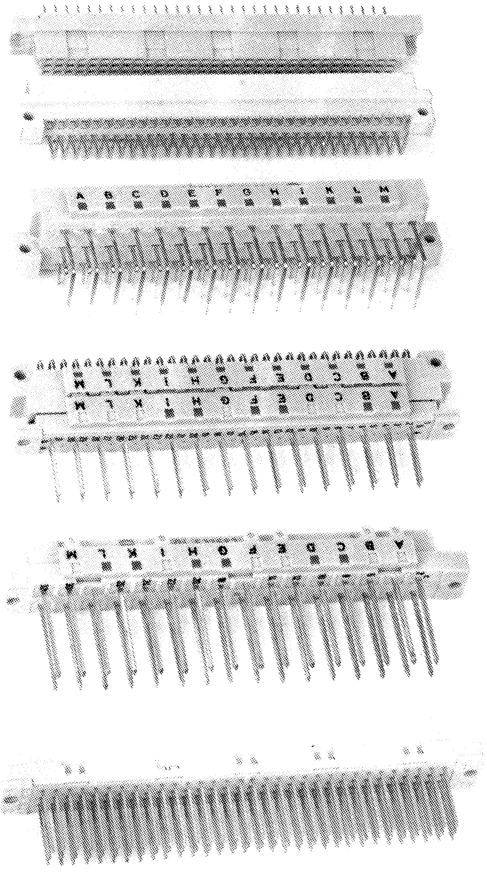


You can rest assured, our Gds A connectors are pretty smart!

So you want the quality to match your requirements? No problem. We keep strictly to the quality classes of the November 1982 draft of DIN 41 612, a new classification which we, incidentally, played a large role in preparing. Standards to be met are now technically sound, established with actual applications in mind. The age of confusion is now past: quality class allocation is now solely determined by defined criteria, whereby the number of mating cycles required and exposure to corrosion predominate.

What standards do YOU specify? Quality class 3 connectors (50 mating cycles) are a new addition to the HARTING range. Of course we can also supply you with male and female connectors in quality classes 2 and 1 (400 and 500 mating cycles respectively) as well as ones for military applications governed by VG 95 324. And because we are always engaged in developing our products further we can now provide you with Types B and C wrap-post and solder-pin connectors in polyester. This material is highly resistant to corrosive solvents and brief exposure to high temperatures. Its combustibility class is UL 94-VO.

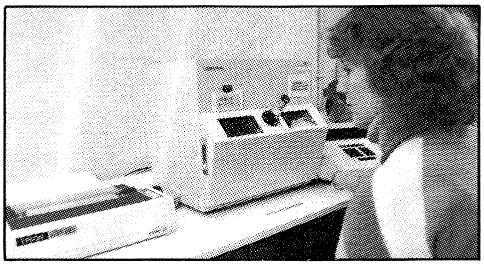
Rest assured, whenever you choose HARTING products you've decided on quality.



HARTING®

HARTING ELEKTRONIK GmbH
Postfach 1140 · D-4992 Espelkamp
West Germany
☎ (0 57 72) 47-1
Tx 9 72 310-11 he d

HARTING – experienced electronic component specialists.

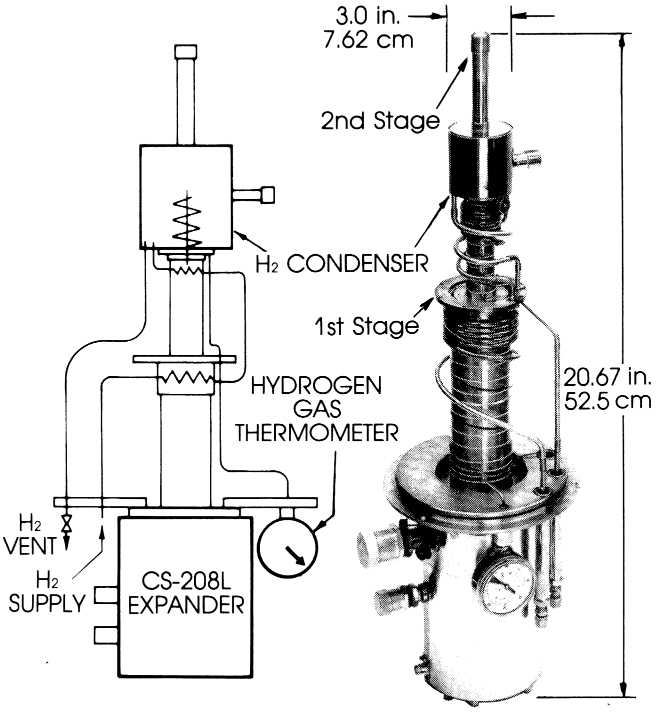


For quality assurance it is necessary to collect a large amount of test data and evaluate it by computer.

Subsidiary companies:
Belgium: N. V. HARTING ELEKTRONIK S. A., Industriezone Doornveld, Schapenbaan, B-1730 Relegem, Phone 02 - 465.42.40, Telex 645 73. **France:** HARTING ELEKTRONIK S.A.R.L., BP 24, F-94121 Fontenay-sous-Bois Cedex, Phone 8 77 - 06 26, Telex 212 583. **Great Britain:** HARTING ELEKTRONIK LTD., Airport Estate, GB-Biggin Hill/Kent TN 16 3 BW, Phone (0 95 94) 7 14 11, Telex 951 68. **Italy:** HARTING ELEKTRONIK S.P.A., Via Como, 2, I-20096 Pioltello (Milano), Phone 02 - 9 240 366, Telex 323 494. **The Netherlands:** HARTING ELEKTRONIK B.V., Mon Plaisir 89 D, Industrieterrein Vosdonk, NL-4879 AM Etten-Leur, Phone 01-608-3 54 00, Telex 5 4 754. **Norway:** HARTING ELEKTRONIK A/S, Nils Hansens vei 13, Bryn, N-Oslo 6, Phone 02-68 75 72, Telex 7 6 399. **Sweden:** HARTING ELEKTRONIK AB, Box 1173, S-163 12 Spånga, Phone (08) 7 507 440, Telex 15 090. **Switzerland:** HARTING ELEKTRONIK AG, Eschenstrasse 2, CH-8603 Schwerzenbach, Phone 01 - 825 51 51, Telex 54 340.

Foreign representatives:
Austria: Burisch Ges. m. b. H. & Co. KG, P.O.B. 24, A-1210 Wien. **Brazil:** ER COMERCIO E INDUSTRIA LTDA, P.O.B. 2456, 30.000 Belo Horizonte MG. **Denmark:** Knud Wexøe A/S, P.B. 35, DK-2840 Holte. **Finland:** SKS Suomalainen Kone Oy, P.O.B. 74, SF-00521 Helsinki 52. **Japan:** Yamaichi Electronics Co. Ltd., 3-chome Shibaura, Minato-ku, Tokyo 108. **South Africa:** Bowthorpe-Hellermann-Deutsch (Pty) Ltd., 80 Mimetes Road, Denver Ext. 9, Johannesburg. **Spain:** Elion S. A., Apartado Postal 7097, E-Barcelona 14. **Bulgaria, CSSR, Jugoslavia, Poland, Rumania, Hungaria:** Gebhard Balluff GmbH & Co., P.O. B., A-2346 Maria Enzersdorf-Südstadt/NÖ.

DISPLEX®
MODEL CS-208LL CLOSED CYCLE REFRIGERATION SYSTEM FOR HYDROGEN LIQUEFACTION



PERFORMANCE SPECIFICATIONS

FEATURES:
- ☆ Designed for hydrogen liquefaction
- ☆ Safe source of liquid hydrogen
- ☆ Avoids handling of bulk quantities of liquid hydrogen
- ☆ Safety vent tube
- ☆ Safety control to maintain liquid hydrogen

CAPACITY:
First Stage - 35 watts @ 77K
Second Stage - 10 watts @ 20K

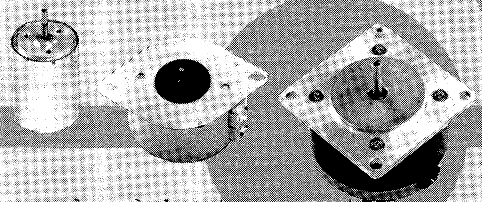
CONDENSING RATE:
0.6 liter/hr.

RECONDENSING RATE:
1 liter/hr.

Air Products and Chemicals, Inc.
Advanced Products Department
1919 Vultee Street
Allentown, PA 18103 USA
Telephone: (215) 481-3927 Telex: 847416

Air Products

Pour des moteurs pas à pas il faut voir le NOUVEAU programme Crouzet



Moteurs pas à pas à aimant permanent 7,5°
deux ou quatre phases, avec ou sans commande, de 21 à 275 mNm. ⌀ 35,5/51/57,5/65 mm.

Moteurs pas à pas hybrides 1,8° ou 3,6°
deux et quatre phases, avec ou sans commande, de 60–3000 mNm.

Et aussi des nouveautés dans la gamme étendue des Moteurs synchrones et courant continu.

Documentation complète à votre disposition.
Si vous recherchez performance et fiabilité à des prix compétitifs, contactez Crouzet.

Crouzet

Crouzet SA
Buckhauserstrasse 24
8048 Zurich, Tél. 01/52 41 20

Un maillon dans le réseau mondial Crouzet.

metallography equipment

- CUTTING
- EMBEDDING
- POLISHING
- CONSUMABLES

Hardeness Testers

- ROCKWELL
- BRINELL
- VICKERS

PRESI

2, av. Hector-Berlioz - 38320 Poisat (Grenoble)
Tél. 76/ 25.32.72 - B.P. N° 4 - Télex 980 709 F

FOR HIGH ENERGY PHYSICS

UP TO 1 x 10^4 GAIN IN VERY HIGH MAGNETIC FIELDS

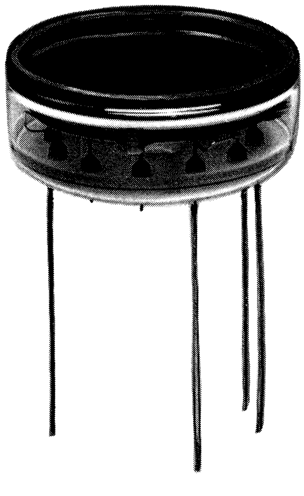
NEW FINE MESH TYPE 10 STAGE PMT

The new R2063 fine mesh tube performs very well in high magnetic fields to about 10K gauss. This unique 2″ tube is the first high quality detector for High Energy Physics to overcome the gain killing effect of magnetic environments.

UP TO 15 GAIN IN HIGH MAGNETIC FIELDS

NEW MESH TYPE, FLAT TRIODE PMT

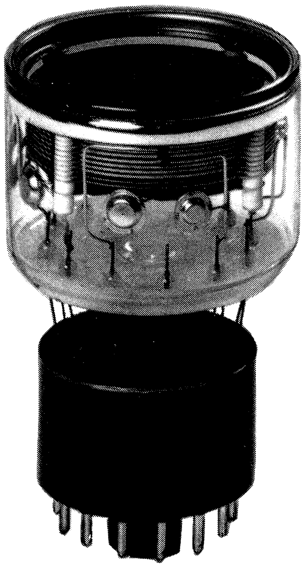
The R2046 mesh type tube provides enough gain (about 15) to preserve your signal while operating in magnetic fields of up to 10K gauss. The compact flat geometry with 3″ diameter permits stacking large numbers of detectors with good volumetric efficiency.



HIGH PULSE LINEARITY AT HIGH COUNT RATES IN MAGNETIC ENVIRONMENTS

MESH DYNODE PMT

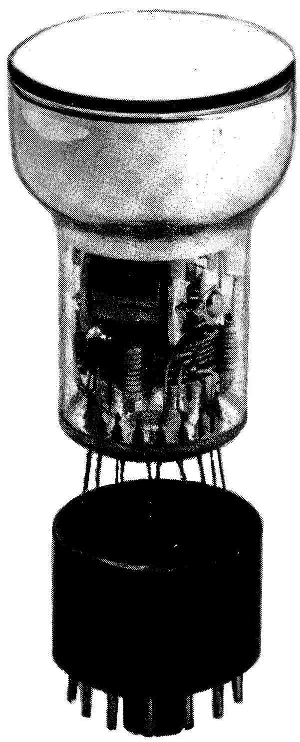
The R1652 combines superior performance in magnetic fields, good gain and high count rate linearity. This 3 inch diameter, head on tube with 9-stage mesh-dynodes uses a new proximity focus design for operation in magnetic fields up to a few hundred gauss.



HIGH ENERGY RESOLUTION AND GOOD PULSE LINEARITY

HYBRID MESH/BOX AND GRID PMT

The R1911-01 uses box and grid dynodes at the front end for high energy resolution and new mesh type dynodes in the final stages for excellent pulse linearity. Pulse linearity of less than 2% deviation at 50 mA 1500 V is significantly better than standard PMT's. This 3″ tube is ideal for physics and medical diagnostic applications because of its reduced length.



CALL OR WRITE FOR DATA SHEETS

HAMAMATSU

HAMAMATSU CORPORATION • 420 SOUTH AVENUE • MIDDLESEX, NEW JERSEY 08846 • PHONE:(201) 469-6640

International Offices in Major Countries of Europe and Asia.

Hamamatsu Photonics K.K., 1126 Ichino-cho, Hamamatsu, Japan, 0534/34-3311 • Hamamatsu TV Europa GmbH, Postfach 1140, D-8031 Seefeld 1, W. Germany, 08152/7705

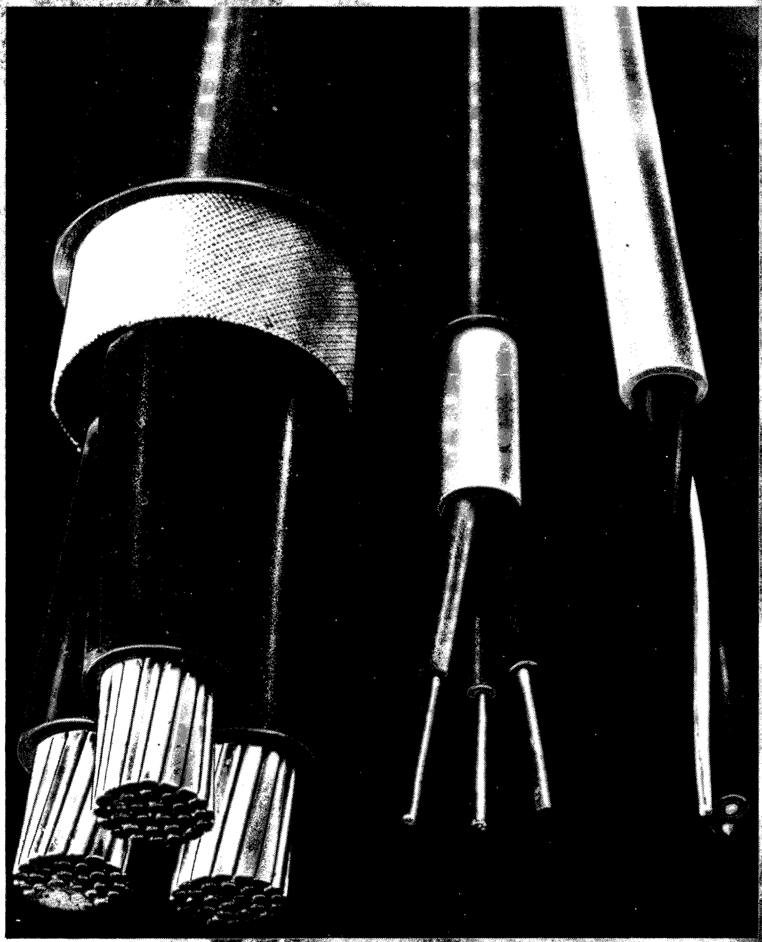
IL MURO DEL FUOCO

ALBERGHI, CINEMA, TEATRI, MUSEI, SCUOLE, OSPEDALI

L'elenco potrebbe allungarsi quasi all'infinito: sono luoghi dove improvvisamente può sprigionarsi un incendio con i rischi che ne conseguono.
Noi abbiamo pensato alla sicurezza di persone e cose vincendo il fuoco con una nuova linea di cavi:

FP 200; AFUMEX®, RETOX®.

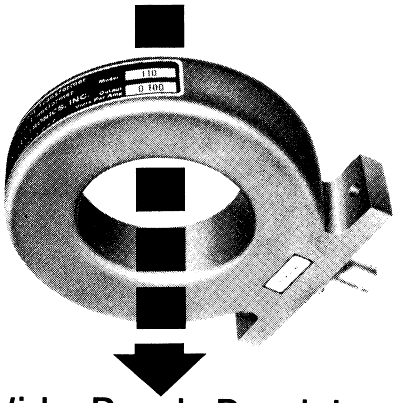
FP 200 continua a funzionare anche nel fuoco, consentendo l'alimentazione di luci di sicurezza, allarmi, apparecchiature antincendio.
AFUMEX® non propaga l'incendio, non emette fumo e gas tossici e quindi non causa panico e danni alle persone.
RETOX® non propaga l'incendio e anche se emette fumo riduce notevolmente l'emissione di sostanze corrosive, evitando gravi danni alle attrezzature e agli impianti.

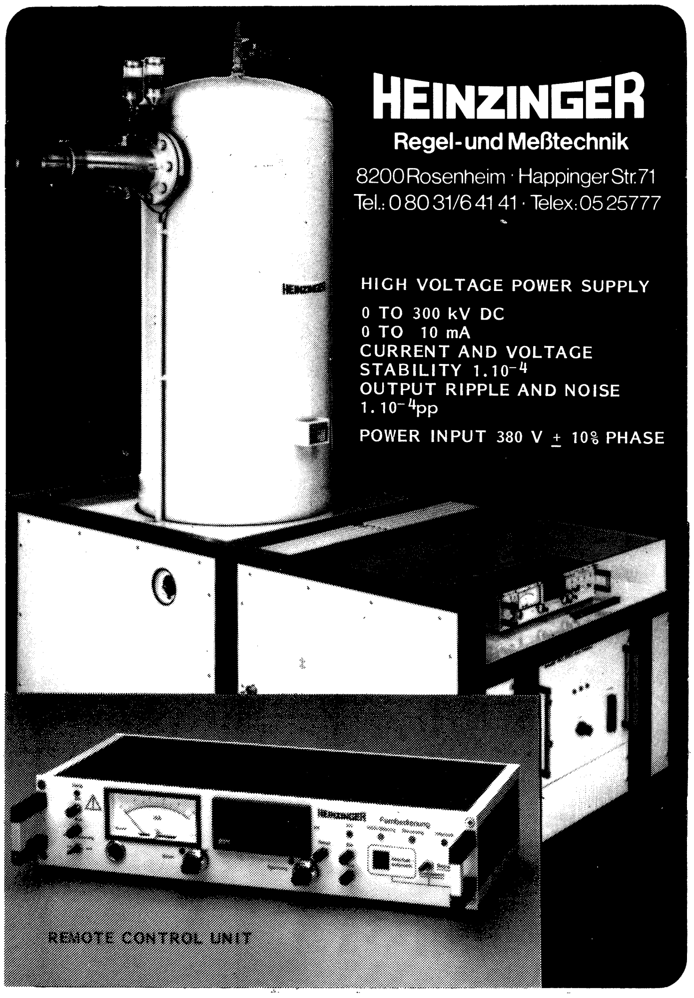


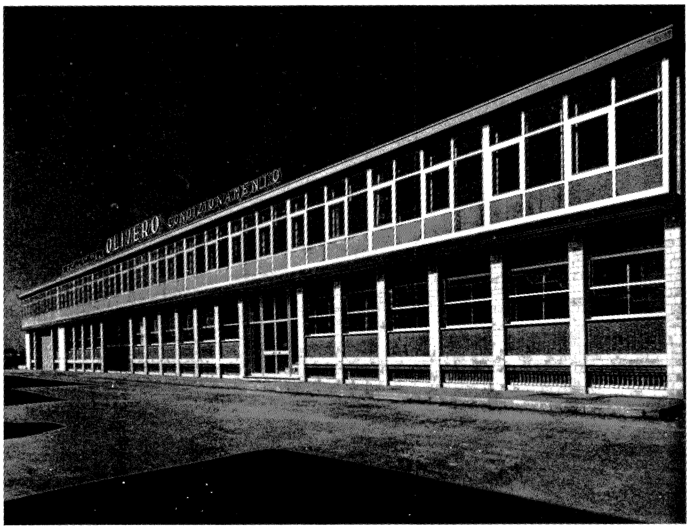
PIRELLI

Società Cavi Pirelli spa
Gruppo Mercato Generale - Viale Sarca, 202 - 20126 Milano - Tel. (02) 64421 - Telex 310135 PIREMI I


CRAMAL 20




REMOTE CONTROL UNIT



Heating, ventilation and air conditioning systems for civil and industrial facilities.

Sanitary, firefighting systems and overpressure units.

Fan coils systems for industrial building or combined systems for office building or dwelling units.

Fumes and vapors exhaust systems, ventilation systems for workshops, factories and tunnels.

Refrigeration systems for general industrial users.

Different systems for nuclear industry including air and fluids treatment and distribution.

Heat exchangers.

Pressure vessels.

Filters for collection of foreign matters contained in fluids.

Heat technology equipment approved by ISPESL – RINA – LLOYD REGISTER – BUREAU VERITAS.

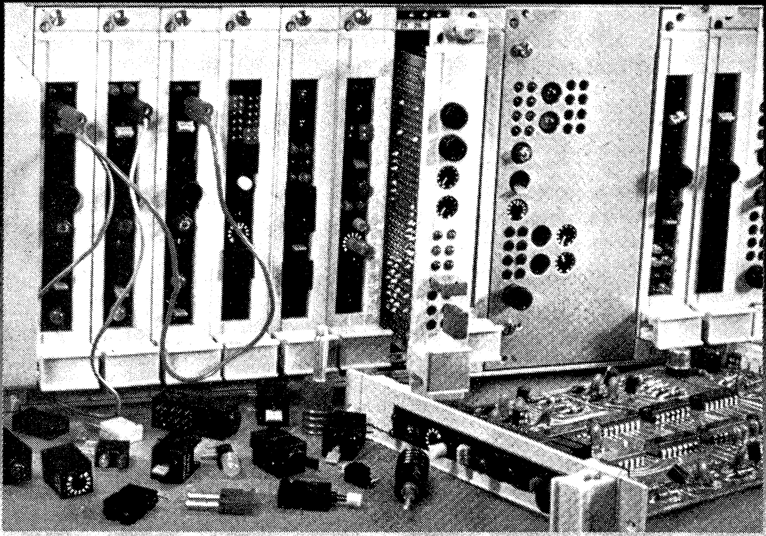
OLIVERO

DOMENICO s.r.l.

Head Office: C.so Orbassano, 402/14-10137 Torino
Tel.: 30.96.666 (5 lines in automatic selection)
Telex: 221.530 OLIDO I

Système de composants pour plaques frontales

Eléments d'affichage et de contrôle à souder sur plaques



Le système FEL de MENTOR comprend les éléments les plus divers pour plaques frontales. Grâce à ces composants d'affichage et de contrôle à souder directement sur les circuits imprimés, les plaques frontales peuvent être munies de toutes les fonctions habituelles tout en gardant un aspect net, compact et rationnel, et même être construites selon votre propre conception.

- LED avec ou sans résistance
- LED de cadran ou symboles
- 7 segments, matrice à 5x7 points et affichages hexadécimaux avec logique intégrée
- Potentiomètre et trimmer
- Commutateurs rotatifs, interrupteurs à touche et à coulisse
- Interrupteurs codeurs à 2 touches
- Boutons-poussoirs avec ou sans LED
- Jacks d'essai et de commutation
- Porte-fusibles et interrupteurs principaux.

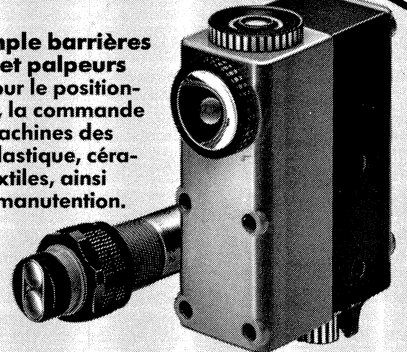
Un catalogue détaillé sur le système FEL est à votre disposition.

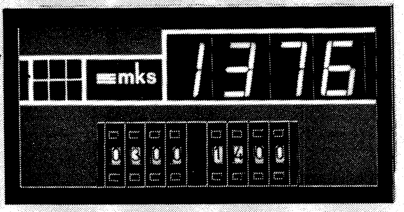
MENTOR

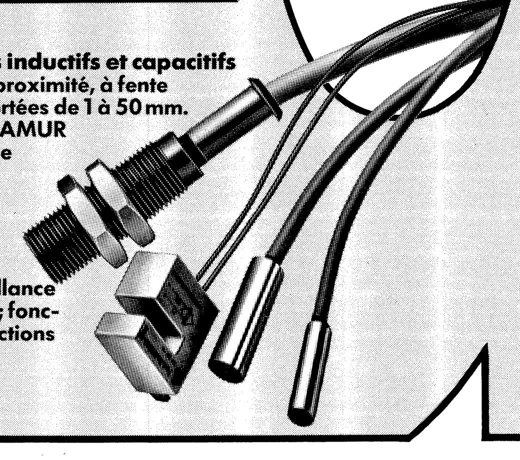
Th-5.3/82

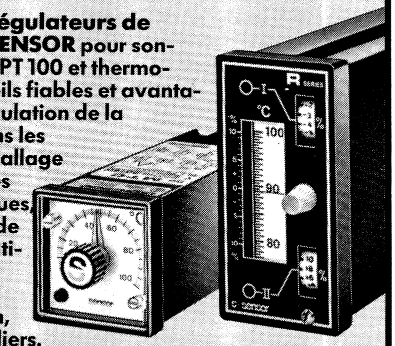
Kurt **Hirt** AG

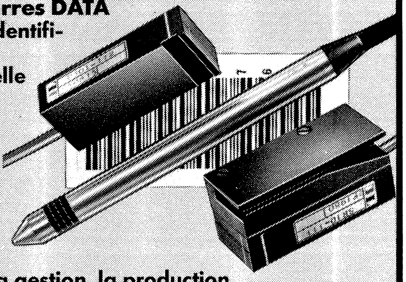
8050 Zurich - Boîte postale - Thurgauerstr. 74 - Tél. 01 / 302 21 21 - Tx 823 417

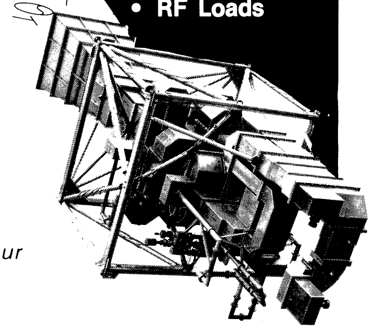



mks
1376









RF TECHNOLOGY
Components and
Engineering

- Monopulse Comparators
- Pressurization Systems
- Microwave Absorbers
- Coax and Waveguide
- Waveguide Switches
- Open Wire Switches
- Coax Breakaways
- Coaxial Switches
- Phase Shifters
- Stub Tuners
- DC Breaks
- Combiners
- RF Loads

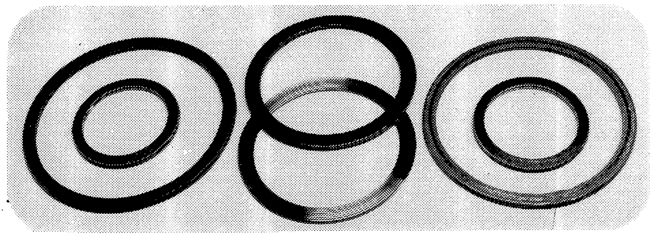
Contact Dielectric for all your RF needs from mW to MW.

DIELECTRIC COMMUNICATIONS
A UNIT OF GENERAL SIGNAL
Tower Hill Road • Raymond, Maine 04071
Tel.: (207) 655-4555 • 800-341-9678
TWX: 710-229-6890

Rivaflex Gaskets
with Rivatherm foil

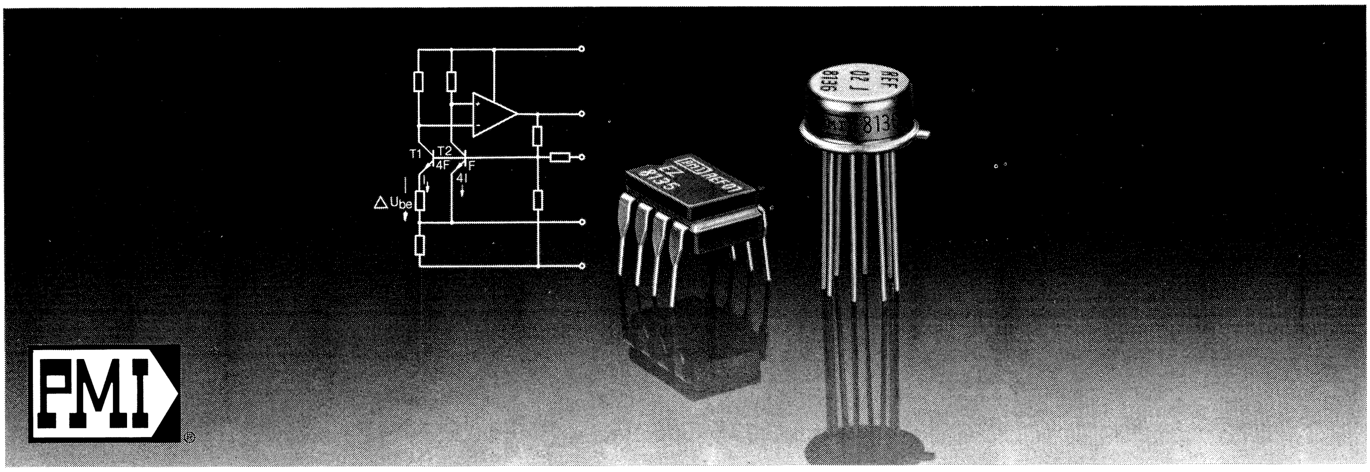
New!

Grooved Gaskets
with covering layer of Rivatherm foil



Kempchen may deliver to you.
We are specialized in all gasketing problems. Our laboratones are always in charge of finding new solutions for your gasketing problems.
Our engineers shall be pleased to consult you; please contact them.
Kempchen: optimum solutions for gaskets, packings and compensators.

kempchen-Weber AG
CH-4349 RHEINSULZ
Telefon 064 64 17 51 · Telex 982 265 kwa ch



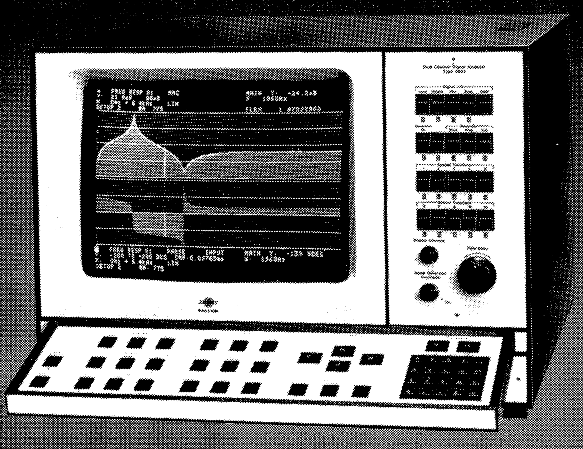
ASSURE LONG-TERM SYSTEM ACCURACY WITH PMI PRECISION VOLTAGE REFERENCES

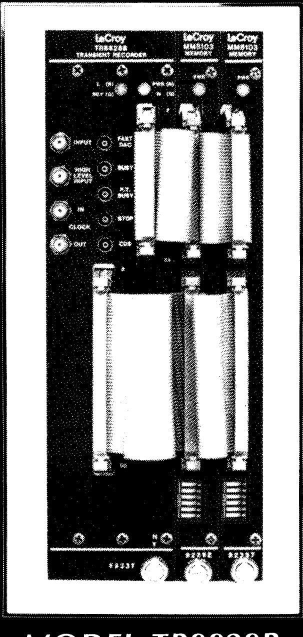
Absolute accuracy, temperature coefficient, and long-term stability of the reference element determine often the overall precision – and recalibration period – of your system.

PMI fully integrated references are designed for the optimized combination of these three key parameters. They don't use Zeners, but tightly controlled matched transistors for band-gap principle implementation, on-chip thin-film resistor trimming for minimum temperature drift, and an op-amp for convenient 5 or 10 Volt output. Especially convenient for system calibration is the possibility to adjust output voltage over a ±3% range, without impairing any of the guaranteed specs. Very low idle current, but high load capability are other attractive features. And for the highest requirements, we offer lot-tested, long-term stability **guaranteed** versions. Ask for the detailed data sheets!

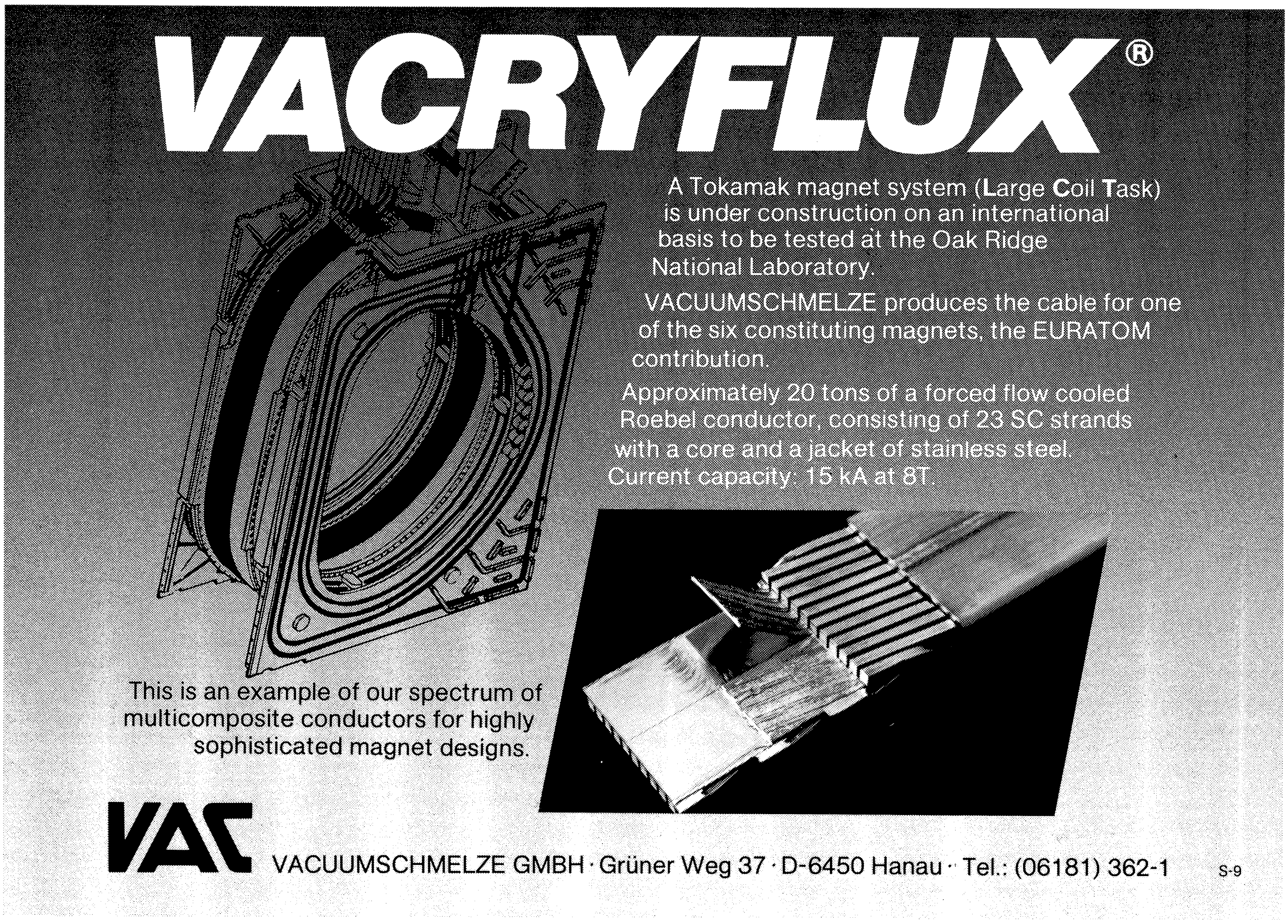
Bourns (Schweiz) AG, 6340 Baar
Tel. 042 / 33 33 33 Telex 868 722

PMI Precision Monolithics Incorporated
A BOURNS SUBSIDIARY
STA. CLARA CALIFORNIA






10n
10n
+K
47
+K
22



VACRYFLUX®

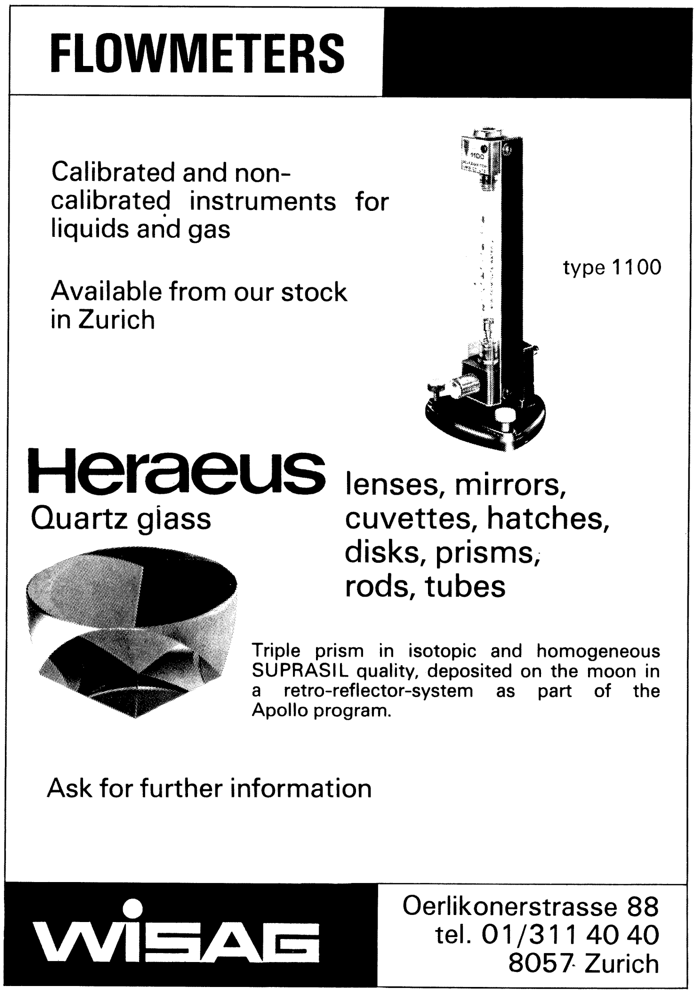
A Tokamak magnet system (**L**arge **C**oil **T**ask) is under construction on an international basis to be tested at the Oak Ridge National Laboratory.

VACUUMSCHMELZE produces the cable for one of the six constituting magnets, the EURATOM contribution.

Approximately 20 tons of a forced flow cooled Roebel conductor, consisting of 23 SC strands with a core and a jacket of stainless steel. Current capacity: 15 kA at 8T.

This is an example of our spectrum of multicomposite conductors for highly sophisticated magnet designs.

VAC VACUUMSCHMELZE GMBH · Grüner Weg 37 · D-6450 Hanau · Tel.: (06181) 362-1 S-9



FLOWMETERS

Calibrated and non-calibrated instruments for liquids and gas

Available from our stock in Zurich

type 1100

Heraeus Quartz glass

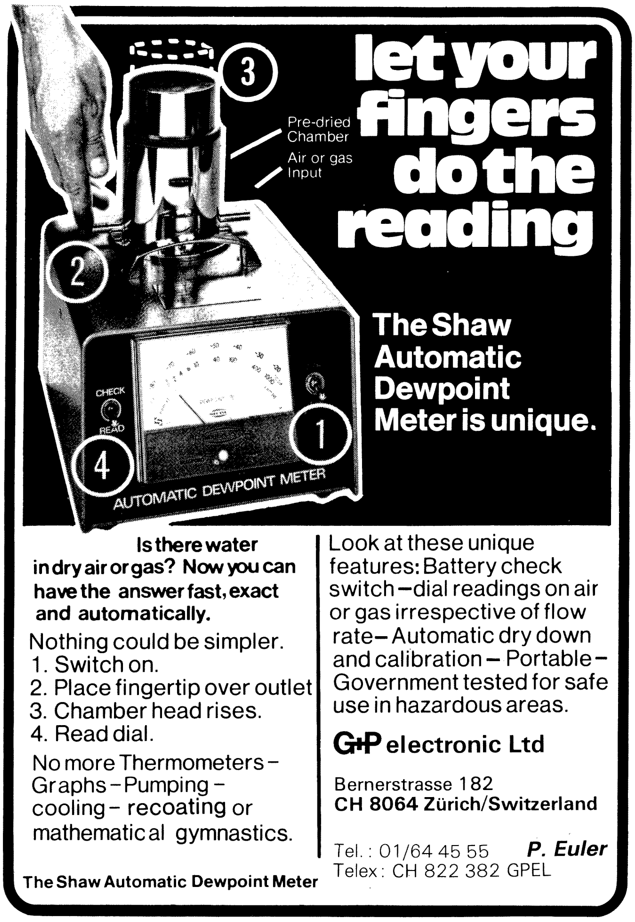
lenses, mirrors, cuvettes, hatches, disks, prisms, rods, tubes

Triple prism in isotopic and homogeneous SUPRASIL quality, deposited on the moon in a retro-reflector-system as part of the Apollo program.

Ask for further information

WISAG

Oerlikonerstrasse 88
tel. 01/311 40 40
8057 Zurich



let your fingers do the reading

The Shaw Automatic Dewpoint Meter is unique.

Is there water in dry air or gas? Now you can have the answer fast, exact and automatically.

Nothing could be simpler.
1. Switch on.
2. Place fingertip over outlet
3. Chamber head rises.
4. Read dial.

No more Thermometers - Graphs - Pumping - cooling - recoating or mathematical gymnastics.

The Shaw Automatic Dewpoint Meter

Look at these unique features: Battery check switch – dial readings on air or gas irrespective of flow rate – Automatic dry down and calibration – Portable – Government tested for safe use in hazardous areas.

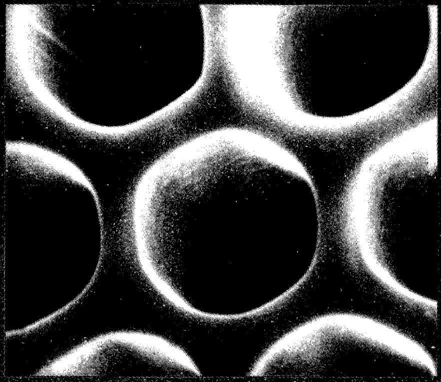
G+P electronic Ltd

Bernerstrasse 182
CH 8064 Zürich/Switzerland

Tel.: 01/64 45 55 *P. Euler*
Telex: CH 822 382 GPEL

IMAGING?

We supply solutions . . .
from X-ray to IR



Detail of microchannel plate.

Philips range of channel multipliers is comprehensive. It's also advanced, as illustrated by the 12.5 μm MCP with its open area of up to 80% . . . just one example of our contribution to progress over the last 20 years.

Used primarily as an amplifying element in image intensifiers, MCPs are also the 'eyes' of particle and VUV radiation satellite experiments.

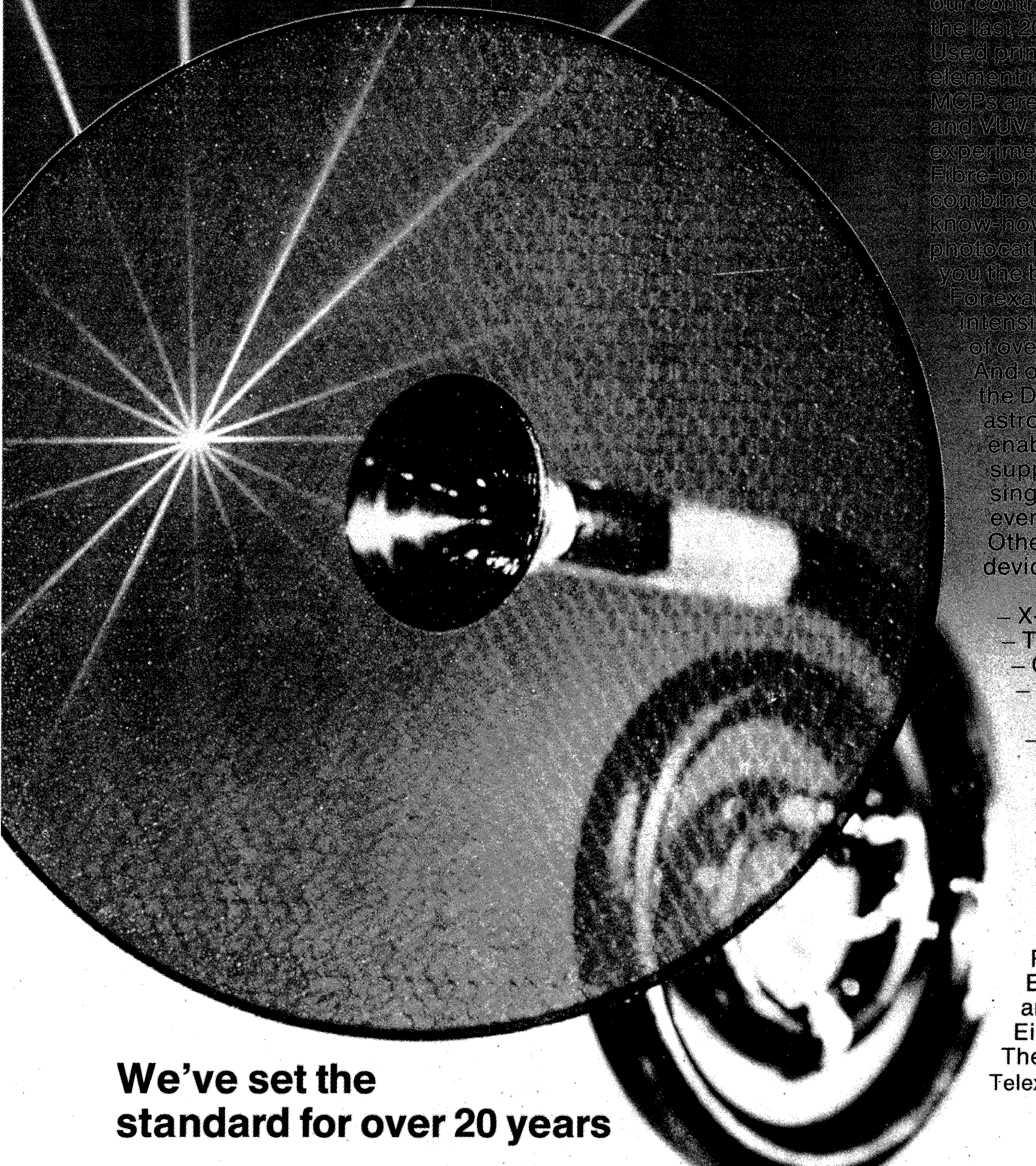
Fibre-optic faceplate technology combined with unmatched know-how in phosphor and photocathode technologies brings you the best in modern imaging.

For example, our XX1380 image intensifier features a resolution of over 50 line pairs/mm.

And our 16" PMT proposal for the DUMAND neutrino astrophysics collaboration enables ^{40}K ocean noise suppression by resolving single- and multi-electron events.

Other Philips advanced devices for imaging include:

- X-ray Image Intensifiers
- TV Camera Tubes
- CCD Imaging Devices
- High-resolution Image Intensifiers
- IR Thermal Imaging Devices



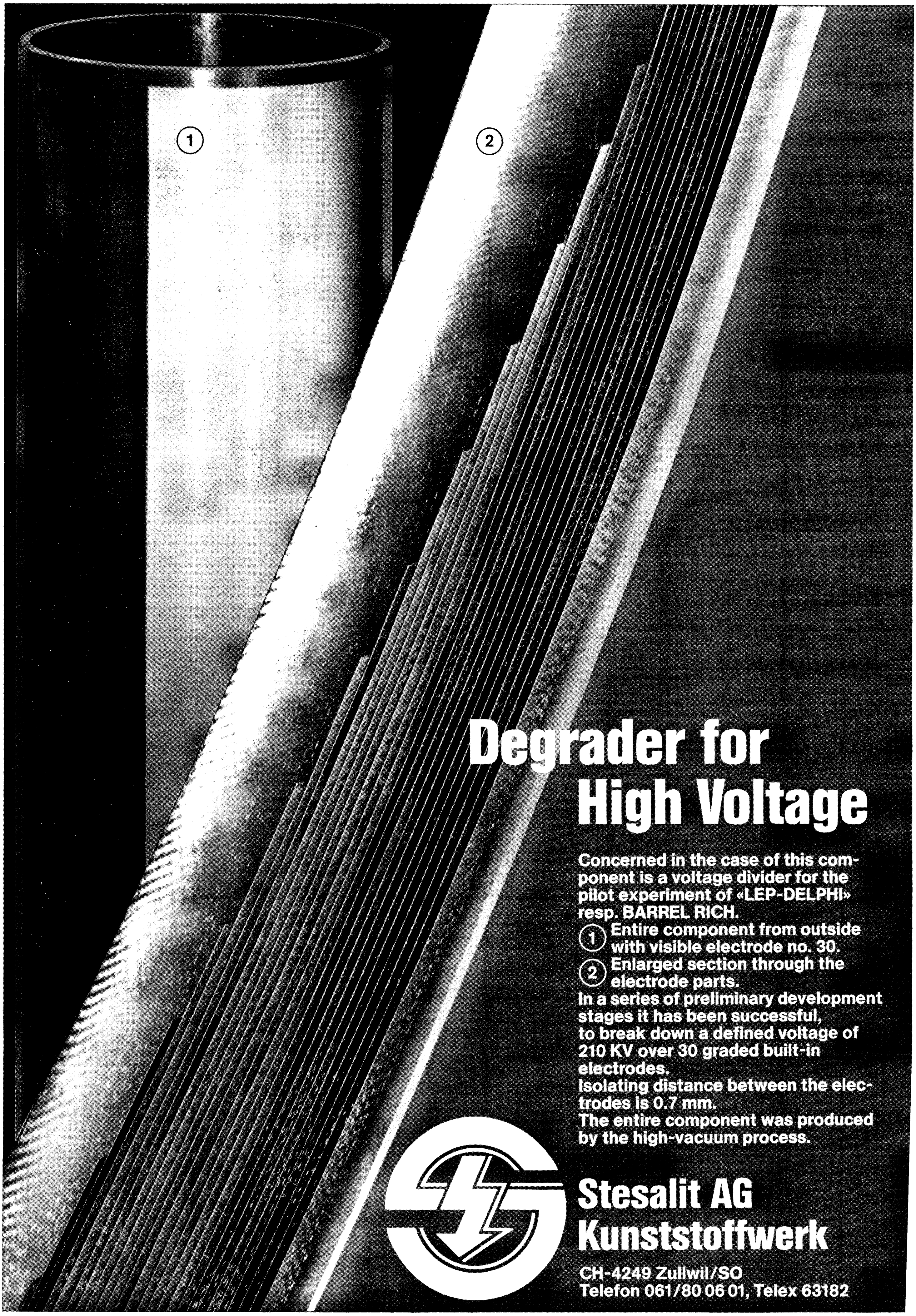
With Philips you therefore get single - stop shopping for all your imaging needs. For more information contact:

Philips Industries,
Electronic Components
and Materials Division,
Eindhoven,
The Netherlands
Telex: 35000/nljeveo

We've set the standard for over 20 years

PHILIPS Electronic components and materials

PHILIPS



Degrader for High Voltage

Concerned in the case of this component is a voltage divider for the pilot experiment of «LEP-DELPHI» resp. BARREL RICH.

① Entire component from outside with visible electrode no. 30.

② Enlarged section through the electrode parts.

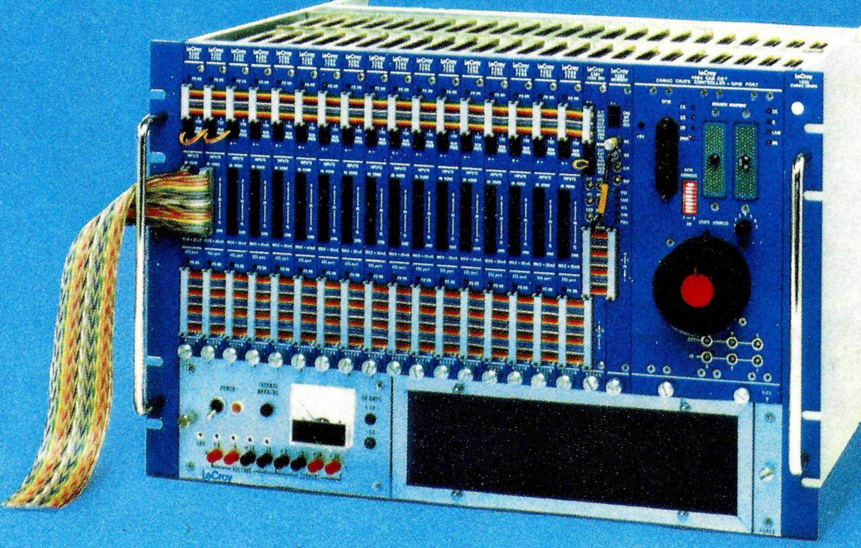
In a series of preliminary development stages it has been successful, to break down a defined voltage of 210 KV over 30 graded built-in electrodes.
Isolating distance between the electrodes is 0.7 mm.
The entire component was produced by the high-vacuum process.

Stesalit AG
Kunststoffwerk

CH-4249 Zullwil/SO
Telefon 061/80 06 01, Telex 63182

Fast Encoding and Readout ADC System

Fast 16 Channel CAMAC ADC
Faster Conversion Time
Fastest Readout Speed



For High Rate Analog Data Acquisition Applications, Real Time Systems, and Second Level Energy Based Triggers

LeCroy introduces the System 4300 Fast Encoding and Readout ADC (FERA), our new high speed, low cost, high density, analog-to-digital conversion system. FERA contains:

Model 4300 ADC—16 channels of charge sensitive ADC's per single width standard module with CAMAC readout or front panel ECL port for 10 MHz data transfer. Available in 9, 10, or 11-bit versions with internal pedestal memory and sparse data scan readout. The 9-bit FERA may be read out in 2.8 μsec after the gate is closed, the 10-bit in 4.8 μsec, and the 11-bit in 8.5 μsec.

Model 4301 FERA Driver—for fan-out of gate, clear, and test signals for a full crate of Model 4300 FERA's. It includes a 12-bit DAC for calibration and testing.

Model 4302 Fast Triple Port Memory—holds 16 K of 16-bit data words. Front panel ECL write port (100 nsec/16-bit word). CAMAC read/write port for access. Private read/write port for the Series 4800 CAB, programmable bit slice CAMAC processors (200 nsec/16-bit word).

Series 4800 Programmable Bit Slice Processors—5 MHz bipolar bit slice processor that executes all instructions including shift, multiply, and external memory access in 200 nsec. Available in Crate Controller or Branch Driver versions with optional GPIB (IEEE-488) port. Includes 4 K x 24-bit instruction memory and 4 K x 16-bit data memory which may be increased to 64 K words with Model 4302 Memories.

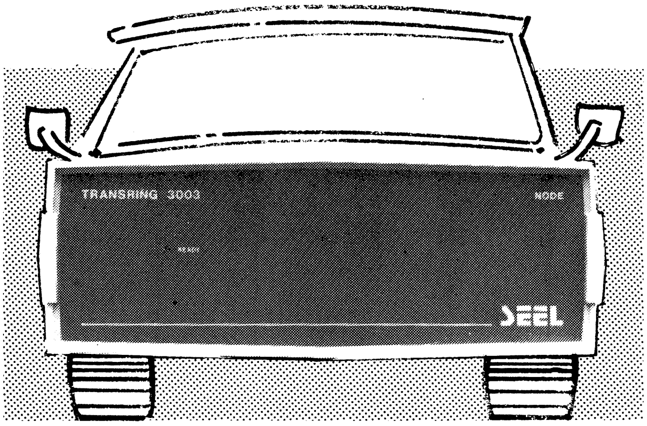
The Model 4300 16 channel FERA combines fast parallel conversion with an optimized readout scheme to achieve an extremely high data throughput rate. For example, 160 channels containing 20% valid data can be digitized into 11 bits, have the pedestals subtracted, and be read out into a memory every 15 microseconds.

The complete system approach permits single ADC modules to be used with existing CAMAC systems, up to multicrate installations with programmable real time data processing.

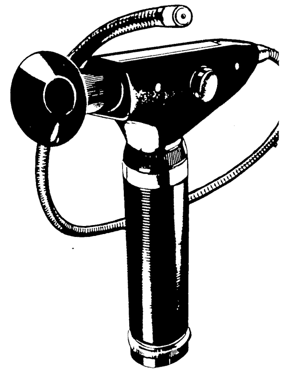
For more information on FERA, contact your local sales representative.

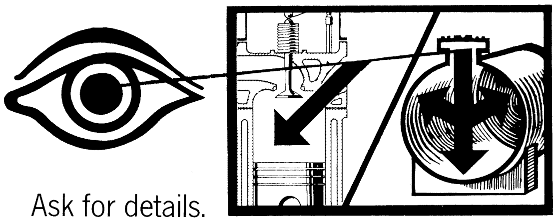
LeCroy

Rue Cardinal-Journet 27, 1217 Meyrin 1-Geneva, Switzerland, 82 33 55. Offices: USA, (914) 425-2000; Heidelberg, W. Germany, (06221) 28192; Les Ulis, France, (6) 907.38.97; Botley, Oxford, England, (0865) 72 72 75. Representatives throughout the world.



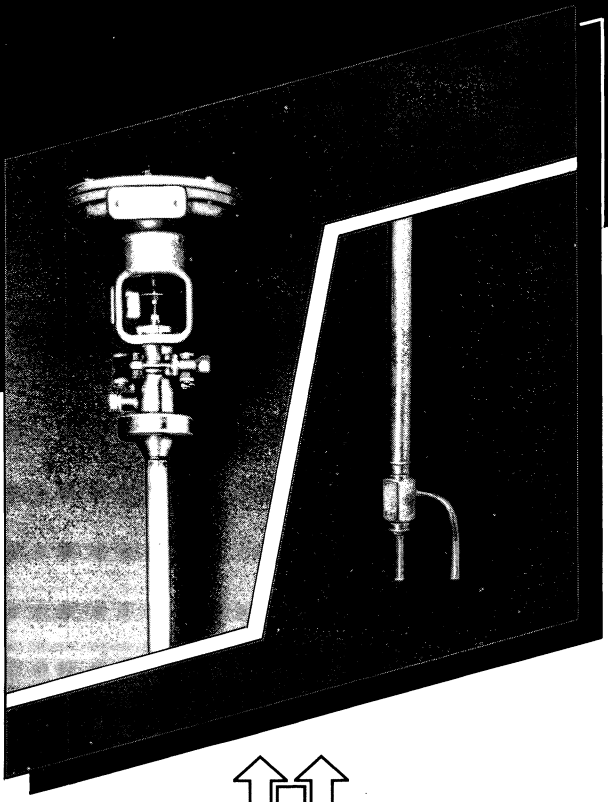
TRANSRING 3003
NODE
READY
SEEL





ABSOLUTE COLD

SUPCRYO®
control valves



SUPCRYO the first range of cryogenic control valve suitable for working temperature at —270°C (liquid helium), very low dispersion of energy, consumption less than 1/10 watt.

Thanks to its external totally tightness and internally double barrier tightness controlled by overpressure. The SUPCRYO is a product exceptionnally reliable.

ADAREG - Advanced technology and Know-how

Complete range of 14 product lines.

ADAREG

ADAR control valves

Z.I. du Prunay - 30, rue J.-P. Timbaud - B.P. 107
78501 SARTROUVILLE CEDEX - FRANCE - Tel.: (3) 915.20.18 - Telex: F 697.717.

Mr ______________________ Firm ______________________

Address ____

______________________ Tel. ______________________

wants ☐ a SUPCRYO documentation ☐ the visit of a technician


8973
Eimac
MADE IN U.S.A.
Eimac
9009/X2062K
Eimac
MADE IN U.S.A.
8974
Eimac
MADE IN U.S.A.