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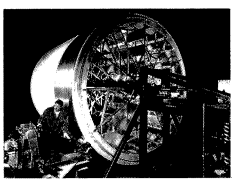

Cover photograph: A technician working on the outer gas vessel for the Time Projection Chamber field cage of the STAR large solenoidal tracking detector, scheduled to begin operation in 1999 at Brookhaven's Relativistic Heavy Ion Collider (RHIC). See January/February issue, page 4.

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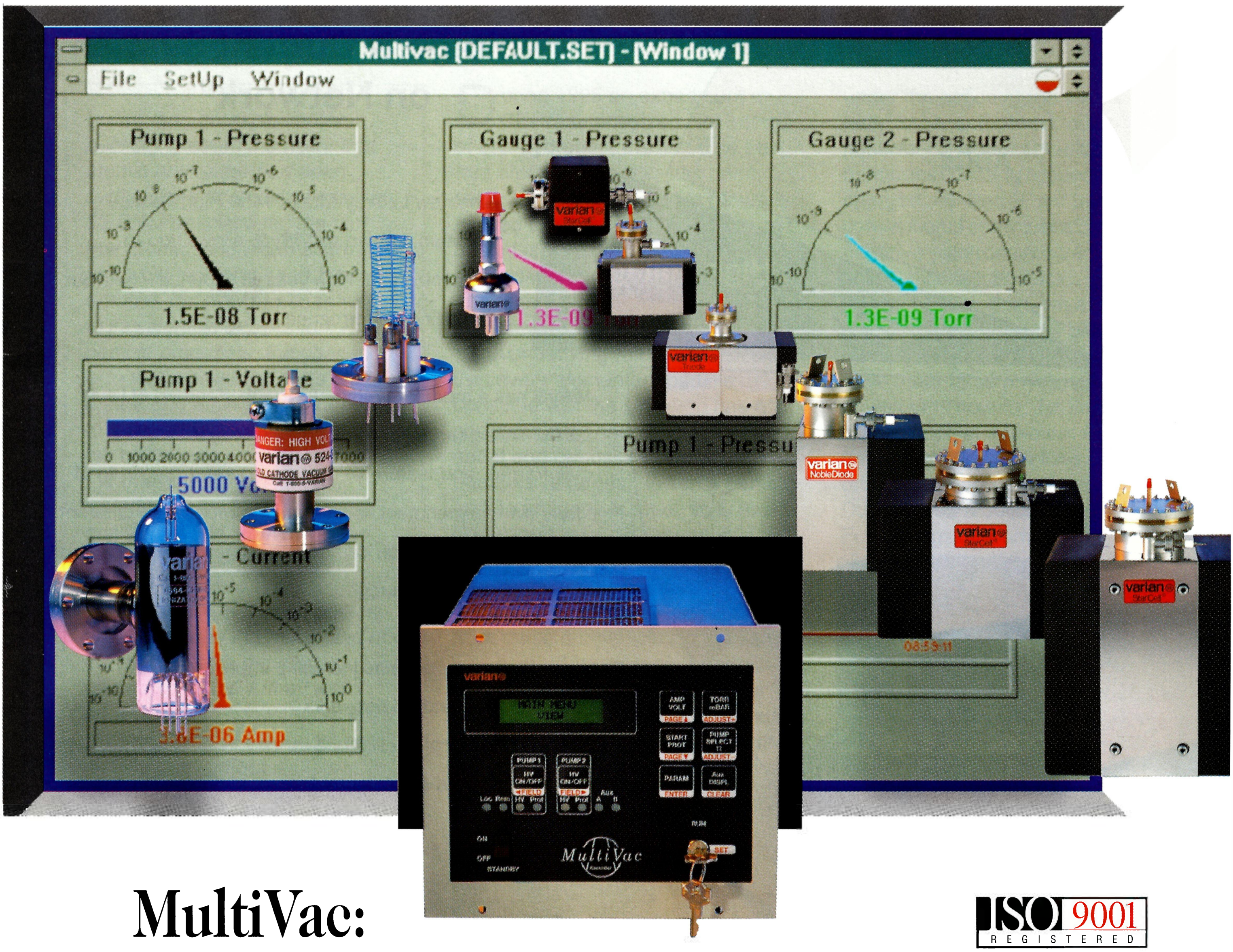

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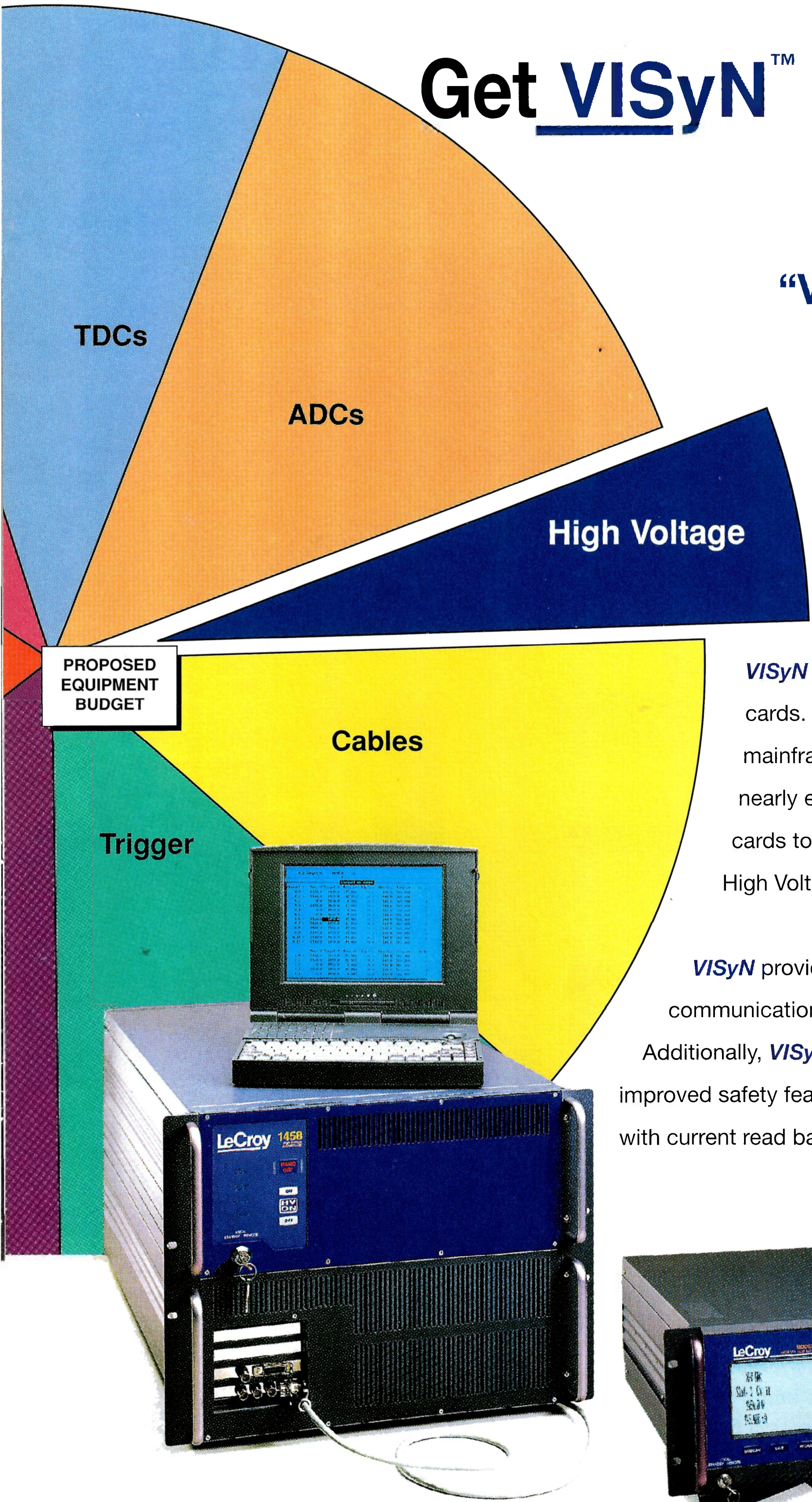

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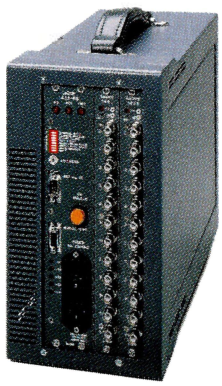

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Atoms of antimatter

In January, an explosion of publicity greeted the news that atomic antimatter had been synthesized in an experiment at CERN. For scientists, the fact that atomic (chemical) antimatter can exist has long been taken for granted, but now the door is open to its scientific exploration. For particle physicists, the challenge is to make precision tests of matter and antimatter symmetry to test that their understanding of the underlying principles is valid.

With everyday language ill-suited to describing the bizarre quantum world, conveying the ideas of particle physics to a general audience is a continual challenge. Even though particle physicists read the more lurid of the mass-media antimatter reports sceptically, they were encouraged to know that at least some aspects of their work are widely appreciated.

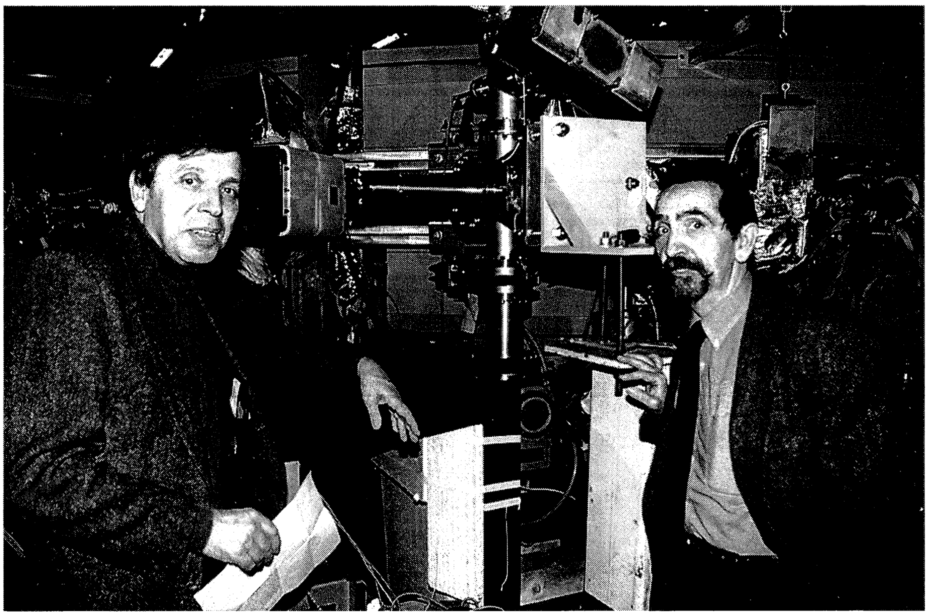
However media suggestions that antimatter could soon be exploited outside the laboratory are absurd. It is just too difficult and expensive to make. Without radical (and as yet inconceivable) improvements in technique, the Universe has not been in existence long enough for any laboratory in it to amass enough chemical antimatter to produce any startling effect.

During 1995 an experiment at CERN synthesized nine atoms of anti-hydrogen, the first time that true atomic antimatter has been seen. While physicists are naturally excited about the discovery, the real business has yet to come - precision spectroscopy to see whether matter and antimatter really behave in the same way.

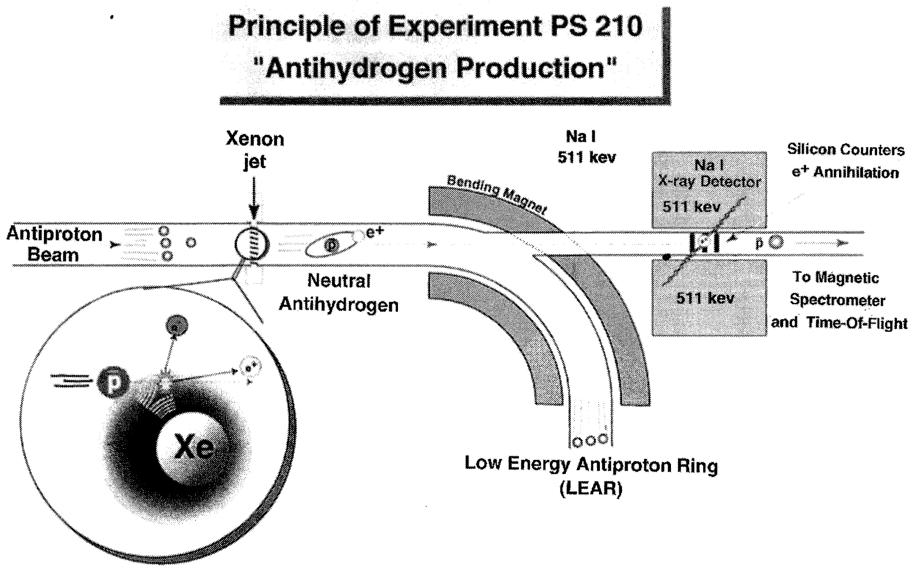
The underlying rules of physics say that every elementary particle constituent of the Universe has a corresponding antiparticle, carrying equal and opposite quantum numbers (charges). When a particle and its antiparticle meet, they most likely annihilate, disappearing in a puff of radiation.

In principle a whole 'mirror' Universe of antimatter could be built up from these antiparticles in the same way as our Universe of ordinary matter is made of particles. If our understanding of physics is correct, then most of the time this antimatter will behave in exactly the same way as the matter we know. For example under the action of the electromagnetic force, anti-atoms, composed of positively charged anti-electrons (positrons) orbiting around negatively charged anti-nuclei, will behave like conventional chemical atoms, where negative electrons orbit around positively charged nuclei.

While the list of known antiparticles has grown steadily, the difficulties of synthesizing such atomic antimatter have meant that physicists have had to wait until now for the first sighting of the simplest anti-atom - antihydrogen, with a lone positron orbiting around a nuclear antiproton. During 1995 a Jülich (IKP Forschungszentrum)/Darmstadt (GSI)/Erlangen-Nürnberg/Genoa (University and INFN)team (spokesman Walter Oelert) working at CERN's LEAR low energy antiproton ring has for the first time constructed antihydrogen. However the experiment only saw the decay products of antihydrogen, and the ultimate goal remains to isolate 'chemical' antimatter.



Walter Oelert (left), spokesman of the PS210 experiment at CERN's LEAR low energy antiproton ring which saw first evidence for chemical antimatter, with Mario Macri, spokesman for the 'parent' JETSET experiment.



Schematic of the CERN antimatter experiment. Collisions between gas nuclei and antiprotons form by-product electron-positron pairs, and if the conditions are right (antiproton and positron velocities very close), the emerging positron can be captured by a neighbouring antiproton to form a neutral atom of antihydrogen. This flies off in a straight line, escaping from the magnetic antiproton orbit of the LEAR ring.

History of antimatter

In 1898 Arthur Schuster in the UK anticipated the existence of antimatter, surmising that there might be atoms with properties exactly opposite to those of ordinary atoms. However the most compelling arguments that antiparticles had to exist emerged from Paul Dirac's work in the late 1920s which reconciled quantum mechanics and special relativity. His electron equations had two solutions, one corresponding to the known electron, the other, with equal but opposite electric charge, to something else.

At first Dirac tried to explain the second solution as the proton, but as this is nearly 2,000 times heavier than the electron, the idea would not work. Other quantum mechanics pioneers, for example Werner Heisenberg, had always been impressed by the power of Dirac's reasoning, but found the unexplained new solutions difficult to swallow. Undeterred, Dirac suspected that his equations predicted the existence of a shadow 'antimatter' world.

Fortunately he did not have long to wait. In 1932 Carl Anderson discovered the positron, the antimatter counterpart of the electron, in cosmic ray tracks. Having sold the idea, the next big antimatter prize was the antiproton, however manufacturing these - which have to be produced as proton-antiproton pairs - requires a big step up in energy. The 2 GeV of rest energy needed to create such a pair requires a beam energy of at least 5.6 GeV, and the Bevatron at Berkeley was built with this goal in mind. When this machine came into operation in 1954, and until the CERN PS came on in 1959, it was the highest energy particle accelerator in the world.

The payoff came almost immediately. In 1955 Owen Chamberlain, Emilio Segré, Clyde Wiegand and Thomas Ypsilantis discovered the long-awaited antiproton, a feat which brought Chamberlain and Segré the 1959 Nobel Physics Prize.

To synthesize atomic antihydrogen means bringing together artificial sources of antiprotons and of positrons - neither of which exist naturally. In addition, antihydrogen, like its matter counterpart, is only stable at low energies. Once the 'temperature' exceeds about 14 electronvolts (140,000 degrees), hydrogen and antihydrogen dissociate (ionize) into their component particles.

In our cool everyday world, atomic hydrogen can exist quite happily. However in the high energy conditions needed to create antiprotons, any chance positrons are immediately ripped from the antiprotons before atoms have time to form.

To make antihydrogen requires two things - a lot of antiprotons, and a way of 'cooling' them to low enough temperatures that antihydrogen does not immediately evaporate into its component particles.

The world's first antiproton 'factory' is at CERN, where since 1980 a complex of specially built machines has provided dense beams of antiprotons for physics experiments. With these antiprotons, CERN was able to operate the SPS proton-antiproton collider which in 1983 discovered the W and Z carriers of the weak nuclear force.

Another feature of CERN's antiproton programme is the LEAR low energy antiproton ring, in action since 1983, which slows the particles down to explore proton-antiproton annihilation at lower energies.

LEAR was in fact designed with the possibility of antihydrogen production in mind! Antihydrogen atoms, being electrically neutral, could escape the magnetic clutch of the normal antiproton orbit of the LEAR ring: exit windows were incorporated in the ring's straight sections, while the bending magnet design ensured that any such particles would not be blocked.

The experiment

The CERN antihydrogen experiment uses apparatus originally built for 'JETSET', an experiment by a Bari/CERN/Erlangen-Nürnberg/Freiburg/Genoa/Illinois/Jülich/Oslo/Uppsala collaboration (spokesman Mario Macri) which collides the LEAR antiproton beam with a jet of gas to search for new particles formed in the proton-antiproton annihilations. The widely-acclaimed gas jet technology developed by JETSET is vital to the antihydrogen experiment.

In 1992 Stan Brodsky of SLAC (Stanford) pointed out that collisions between gas nuclei and antiprotons can also form by-product electron-positron pairs, and if the conditions are right (antiproton and positron velocities very close), the emerging positron could be captured by a neighbouring antiproton to form a neutral atom of antihydrogen. These ideas were initially pursued at LEAR by Michel Chanel, Pierre Lefevre and Dieter Möhl.

After encouraging hints were seen using the JETSET apparatus, some of the team installed new detectors downstream of the jet target. The new experiment used a jet of a heavy gas, xenon, to boost the production rate.

Antihydrogen is difficult to detect directly, because the antiatoms immediately annihilate with their matter surroundings. Passing them through thin silicon detectors (which 'strip' away the positron) immediately dissociates the antihydrogen back into an antiproton and a positron. However the two particles remain in close proximity and the trick is to pick up the tell-tale simultaneous antiproton/positron pairs which have escaped from the normal antiproton orbit of the LEAR ring. The nine antiproton atoms each remained intact for some 40 billionths of a second, travelling some ten metres. They were carefully sifted out from 23,000 counts, with particular care being taken to eliminate 'rogue' counts due to antineutrons.

Experiments at LEAR and elsewhere have long studied antiprotonic atoms, where, instead of an electron, a negatively-charged antiproton orbits round a conventional nucleus. With the orbit of the heavy antiproton passing much closer to the nucleus than that of an electron, comparing the spectroscopy of the antiprotonic atom with its conventional counterpart gives important information on nuclear effects. However these compact atoms are inherently unstable as eventually the antiproton is captured by the nucleus.

The LEAR ring is to be closed at the end of this year, but to continue CERN's antiproton capability, an idea by Stephan Maury and Dieter Möhl is being studied to adapt the Antiproton Collector (AC). This ring, commissioned in 1987, handles the wide momentum spread of the 'raw' antiproton beam. The new scheme would cater for experiments trapping antiparticles and antimatter in electromagnetic 'bottles' and provide detailed comparisons of the behaviour of matter and antimatter.

The world's other antiproton factory is at Fermilab, where a new experiment, E862, a Fermilab/Irvine/Penn State/SLAC collaboration, will soon produce antihydrogen by passing an 8.9 GeV antiproton beam through a gas jet target.

One hundred years to the day

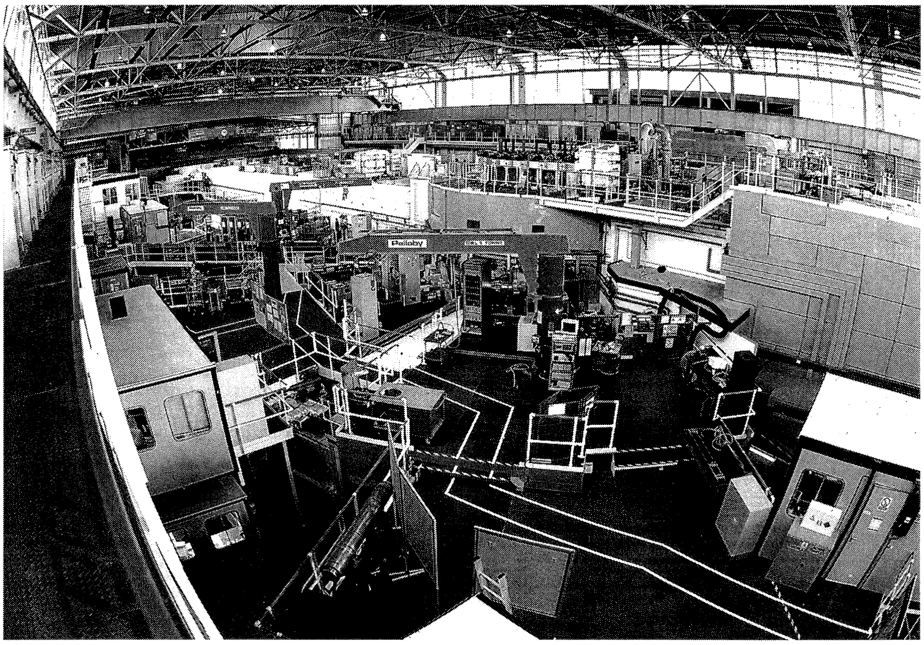
The recent discovery at CERN of antihydrogen caught the attention of the media more than any other physics development in recent years. The CERN press release which started the bandwagon rolling went out on 4 January. Broadcast over the Internet via the World Wide Web, it made prime time TV and headlines all over the world the following day. Curiously, one hundred years previously, Wilhelm Röntgen in Würzburg mailed the news of his dramatic new X-ray discovery on 1 January. With no Internet, the first press report was carried in the Wiener Presse of 5 January 1896. By 16 January, the news had crossed the Atlantic to reach the New York Times. The news of a mysterious 'all revealing radiation' went on to produce about a thousand newspaper reports that year.

Accelerators in action: Spallation neutron sources

Fish-eye view of the experimental hall at ISIS at the UK Rutherford Appleton Laboratory, the first pulsed spallation neutron source for which a major accelerator was specifically built. Operational since 1985, ISIS is the most intense, best instrumented, and most productive installation of its kind.

Recently-developed high-current proton accelerators have features which make them attractive as research neutron sources. Medium energy protons readily generate neutrons in high heavy element targets, producing intense neutron beams which are being used in a broad range of basic and applied condensed matter studies. Providing cold, thermal and epithermal neutrons, spallation neutron sources have already contributed much to the sciences and are set to extend and complement reactor-based investigations into the future.

In this article, Jack Carpenter of Argonne describes the requirements for producing these neutrons and how this is accomplished. A second article, to be published in the next issue of the CERN Courier, will cover the wide range of scientific applications to which these neutrons are put. Together, they form an important supplement to the special July/August 1995 issue of the CERN Courier - 'Applying the Accelerator'.



Accelerators as slow neutron beam sources

Neutrons have been an essential tool in science since their discovery in 1932. Beginning soon after, scientists made increasing use of slow neutrons for studying the structure and dynamics of condensed matter on atomic, molecular, and macromolecular scales. In 1994 C. G. Shull and B. N. Brockhouse shared the Nobel Physics Prize for their pioneering developments of neutron diffraction and inelastic scattering techniques at reactor neutron sources starting in the 1940s and 1950s.

Recently, proton accelerators of increasing power provide proton-driven pulsed spallation neutron sources that present new capabilities for condensed matter research.

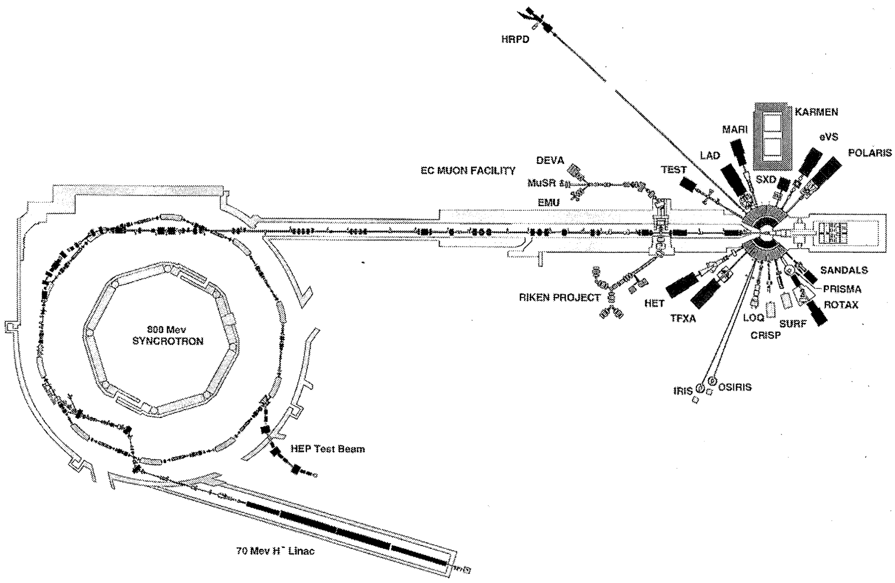
Above a few hundred MeV, most proton energy is lost through nuclear rather than electronic interactions. In targets large enough to exhaust the hadronic cascade, the multiple production - 'spallation' - process sets in; a representative figure is 45 emerging neutrons per proton for 2.2 GeV protons incident on a thick target of tantalum.

The neutron yield is nearly proportional to the proton beam power. The yield and the neutron production and power density distributions are relatively insensitive to the energy. These factors, as well as the consideration that proton losses in the acceleration process are easier to control if the desired beam power is accomplished by low current and high energy, lead to choices of proton energies of up to a few GeV for proton-driven spallation neutron sources.

Targets are compact, a few litres in volume, to produce the highest possible neutron fluxes. Most of the neutrons produced are "evaporation" particles with energies of 1-2 MeV. The small fraction of high energy "cascade" neutrons produced by direct intranuclear collisions necessitate a heavy shield.

The mass of the neutron (1 Amu) implies that neutrons accumulated in thermodynamic equilibrium at common temperatures - "thermal" neutrons of 0.025 eV - simultaneously have wavelengths comparable to interatomic distances and energies comparable to excitation levels of importance in condensed matter.

The ISIS synchrotron (left) serves a star-like array of experimental stations (seen also in the accompanying photograph).



Their unique magnetic interactions and nuclear scattering properties make such slow neutrons powerful probes for determining the structure and motions of atoms and molecular-scale aggregations of matter. "Moderators" of hydrogenous material near the source slow down the primary neutrons to useful energies.

There are three types of spallation sources. "Short pulse" sources (SPSs) based on proton pulses of less than about 1 microsecond, "long-pulse" sources (LPSs) based on proton pulses of hundreds of microseconds, and steady sources based on continuous beams or ones with high frequency microstructure, irrelevant after moderation.

Steady sources, much like research reactors, require large heavy water moderators. SPSs are the most general and employ small (0.5 litre) moderators with high proton density, such as water. Moderator and time-of-flight instrument considerations dictate SPS pulsing frequencies 10 to 60 Hz, and are the only one of the three spallation source types to accomplish efficient, high resolution spectroscopy using neutrons up to some 10 eV. LPSs have only relatively recently come under consideration.

Once, it was thought that the advantage of spallation sources is in the production of "epithermal" (above 0.025 eV) neutrons. Indeed, this is true of the SPSs, but all three types moreover make effective use of cryogenic moderators that also produce intense beams of "cold" neutrons.

The main features of the three types of spallation sources differ in detail. SPSs have a negative hydrogen ion (H^-) source and linac and employ stripping injection into a storage ring using a full energy linac or rapid cycling synchrotron (RCS) with a moderate energy linac. All operate with single turn extraction and in first (h=1) or second harmonic (h=2). New designs have multiplexed extraction to two target stations.

An LPS can operate on the direct beam with the macrostructure (duty cycle around 10%) of a moderate-energy proton linear accelerator; H^- is not necessary. To date the only long pulsed neutron source in operation is the pulsed reactor IBR-2 (not accelerator-driven) at Dubna. However, concepts for accelerator-based LPSs have been worked out; furthermore, auxiliary LPS target stations are compatible with SPS facilities.

As accelerator technology improved in the 1970s, medium energy, high-current proton machines developed which can readily produce copious neutrons by spallation reactions, and a new category of neutron source, the pulsed spallation neutron source, emerged.

These had their beginnings in the ZING-P and ZING-P' prototypes at Argonne in 1973 and 1975. Similar facilities were soon in place at Los Alamos in 1977, where the first installation was called WNR, in 1985 to become LANSCE, and now re-named Manuel Lujan Neutron Scattering Center. KENS at the Japanese High Energy Laboratory, KEK, opened in 1980. The present IPNS at Argonne started operating in 1981. The first pulsed spallation neutron source for which a major accelerator was specifically built was the British ISIS, 1985, by far the most intense, best instrumented, and most productive installation of the new generation.

Under construction are a pulsed/steady-state spallation source at the Institute for Nuclear Research, Troitsk, Russia, and a steady-state spallation source, SINQ, nearing completion at the Paul Scherrer Institut in Switzerland. A number of studies for new machines have been pursued over the years seminal among which was the Canadian ING study (1965); then came IPNS-II at

(SPS = "Short pulse" sources)

Table 1. Existing pulsed neutron sources

Name, Type	Location	Beam Power, kW, Beam Energy, MeV	Startup Date
KENS, SPS	KEK, Japan	3.5, 500	1980
IPNS, SPS	Argonne, US	7.0, 450	1981
MLNSC, SPS	Los Alamos, US	50., 800	1985
ISIS, SPS	Rutherford Appleton Lab, UK	160., 800	1985
IBR-2, (long-pulsed reactor source)	FLNR, Dubna, Russia	2000. (total reactor power)	1984

Table 2. Spallation neutron sources under construction

Name, Type	Location	Beam Power, kW, Energy, MeV	Expected Startup Date
SINQ, Steady	Paul Scherrer Institut, Switzerland	1000., 590	1996
IN-06, SPS and Steady	Institute for Nuclear Research, Troitsk, Russia	300., 600	1996 possible

Table 3. Proposals under development and consideration

Name, Type	Location	Beam Power, MW, Beam Energy, GeV	Status
AUSTRON, SPS	Austria	0.2 → 0.4, 1.6	Documented, Reviewed
ESS, SPS	Europe	5.0, 1.34	Outline Report Complete
IPNS Upgrade, SPS	Argonne, US	1.0 (→ 5.0?) 2.0	Documented, Reviewed
ISIS Target II, SPS	Rutherford Appleton Laboratory, UK	0.16 → 0.24, 0.8	Concept Under Development
JHP n Arena, SPS	KEK, Japan	0.5 → 1.0, 2.0	Concept Established
LPNS, LPS	Los Alamos, US	1.0, 0.8	Concept Under Development
NGNS, SPS	Los Alamos, US	1.0 (→ 5.0?), 0.8	Documented, Reviewed
ORSNS, SPS	Oak Ridge, US	1.0 (→ 5.0?), energy to be determined	Concept Under Development
PSNS, SPS	Brookhaven, US	5.0, 3.6	Documented

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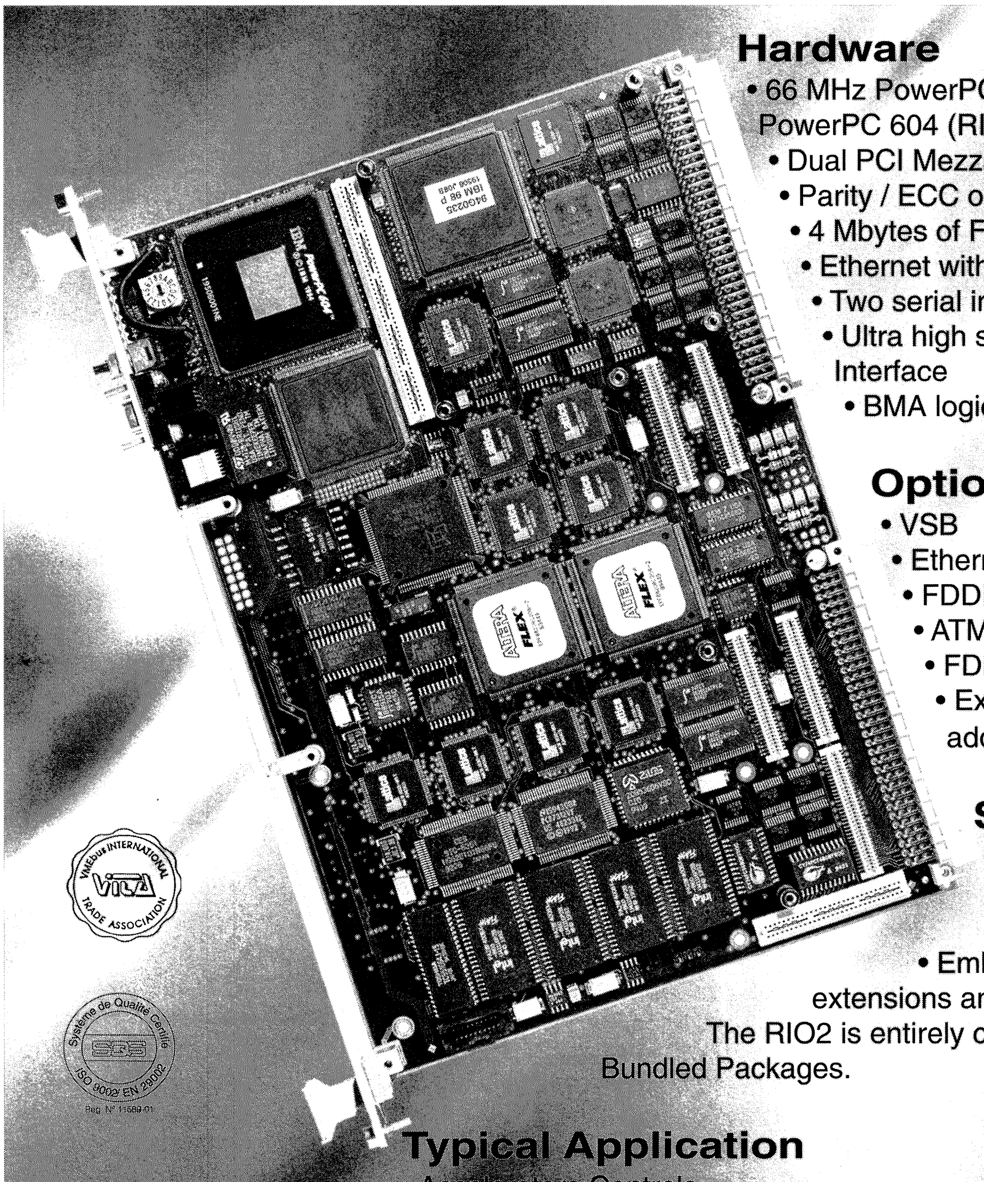

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CREATIVE ELECTRONIC SYSTEMS

Argonne, SNQ in Germany, and KENS-II in Japan, none of which led to a constructed facility, but nevertheless provided important data and design experience.

Now under study supported by the Commission of the European Community is a new installation, the European Spallation Source, ESS (March 1994, page 15). ESS is based on a pulsed proton accelerator delivering a time-average 5 MW of beam power, 30 times that of ISIS. Another current study for a new, multipurpose installation, AUSTRON, somewhat more powerful than ISIS, was recently completed in Austria. The study of a Long Pulse Neutron Source has recently been launched at Los Alamos. Other studies are underway at Argonne, Brookhaven and Oak Ridge in the US and at KEK as a part of the Japan Hadron Project. Some of these studies allow for power upgrading.

As developments stand, there is consensus among developers that 1-MW sources of any of the three types can be built now. However, there is less than full consensus about the most appropriate configuration of accelerator systems. Targets for the 1-MW source require only straightforward engineering but experience to date indicates that the lifetime of solid targets will be only a few months. The highest-yielding target material (uranium) and most effective moderator material (solid methane) are unpractical at the 1-MW level.

Questions as to radiation damage, thermal-elastic shock, and radiation-enhanced corrosion, as examples, remain to be worked out for higher power targets. It is possible to stop a beam of any power if it is sufficiently spread out. However, this spread has to be minimized to maintain the attractive, compact features of the spallation source. At 5 MW, time-average thermal neutron fluxes in spallation sources will be comparable to those in the highest-flux research reactors, 10^{15}n per sq cm per sec. Instantaneous, peak fluxes could be about two orders of magnitude higher.

The applications instrumentation has special features. Research-oriented slow neutron sources of any type can support tens of instruments, all operating independently and simultaneously. A typical neutron scattering instrument costs some $1-5 million and stays in place for about ten years, more or less unchanged.

Typical experiments last a few days, consisting of numerous runs of minutes or hours duration, as thermodynamic variables or compositions are varied in sequence, and are staffed by one or only a few scientists.

Hundreds of independent experiments are completed each year at each of today's sources, with hundreds of visiting scientists appearing on a clockwork schedule. These numbers will be in the thousands in any of the newly-proposed sources. Sources operate 24 hours per day in weeks-long cycles, but operation must be highly reliable. Any interruption of more than a few hours commonly means the failure of an experiment. Thus, if the community of users is to be well served, operational reliability must exceed about 90%. Present experience spans this figure.

This short run/high turnover pattern resembles that of synchrotron light sources, which support very similar experimental programmes. However this pattern differs markedly from that of particle physics experiments, with their long lead times and requirements for long runs.

By J. Carpenter

Smaller than a quark?

Almost one year after the historic formal announcement of the discovery of the sixth ('top') quark by experimental teams at Fermilab's Tevatron proton-antiproton collider, comes speculation that data from the CDF Tevatron experiment may hint at a new type of particle behaviour, possibly due to a still deeper layer in the substructure of the Universe, particles even smaller than quarks and gluons. Story in the next issue.

ALICE in quarkland

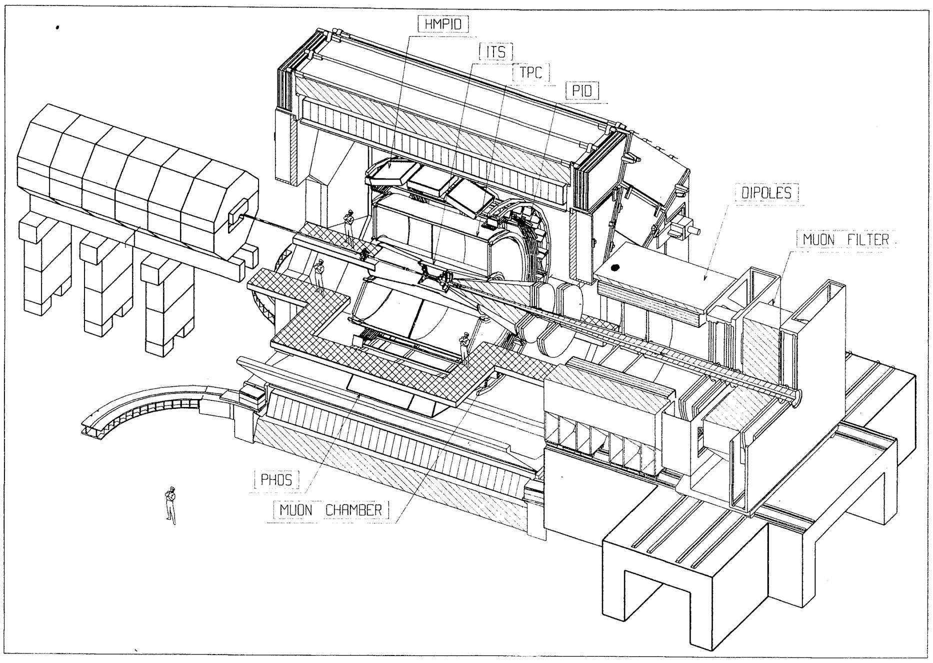
Another LHC experimental milestone

This month we publish the third in a series of articles marking the publication of full Technical Proposals for experiments at CERN's LHC collider.

The main thrust of LHC physics will be the study of proton-proton collisions, covered by two major experiments, ATLAS and CMS, who presented their Technical Proposals in December 1994 (June 1995, page 5). After recommendations from a specially-augmented CERN Research Board, both experiments have recently been approved. (However certain financial matters remain to be resolved.)

ALICE is designed to study heavy-ion collisions in the LHC, raising the energy stakes for this branch of physics from today's maximum of 17 GeV/ nucleon collision energy at CERN's SPS to 5.5 TeV/nucleon. The intermediate ground will be studied at the Brookhaven National Laboratory near New York with the Relativistic Heavy Ion Collider, RHIC. RHIC will collide gold ions at 200 GeV/nucleon starting in 1999.

ALICE's Technical Proposal was submitted on 15 December 1995.



The two main components of the ALICE detector for heavy ion beams at CERN's LHC collider are clearly visible in this cutaway drawing. The central detector will be built inside the existing solenoid of the L3 experiment at the LEP electron-positron collider. The forward muon spectrometer, on the right, will measure the spectrum of heavy-quark resonances.

In the classic children's stories, Alice was the little girl who chased a white rabbit down a hole to find herself transported to a magical world. At the LHC, ALICE (A Large Ion Collider Experiment) will be pursuing new states of matter instead of white rabbits, but the wonderland to be found could be every bit as new and exciting as that of Lewis Carroll's invention.

ALICE is the third collaboration to submit a technical proposal for CERN's LHC collider after ATLAS and CMS, the big general purpose detectors which will spearhead the LHC physics thrust (June 1995, page 5). While the higgs boson search is high on the ATLAS/CMS agenda, ALICE, however, has different goals in mind. The LHC will continue CERN's tradition of diverse beams, being able to accelerate not only protons, but also the high energy beams of lead ions currently in use by SPS experiments. It is this capability which ALICE is designed to exploit as the LHC's only dedicated heavy-ion experiment.

The idea of building a dedicated heavy-ion detector for the LHC was first aired at the historic Evian meeting, "Towards the LHC Experimental Programme", in March 1992. From the ideas presented there, the ALICE collaboration was formed, and in 1993, a Letter of Intent was submitted (July 1993, page 4).

High-energy heavy-ion collisions provide a unique laboratory for the study of strongly interacting particles. The field theory of quarks and gluons - quantum chromodynamics (QCD) - predicts that at sufficiently high energy densities there will be a phase transition from conventional hadronic matter, where quarks are locked inside nuclear particles, to a plasma of deconfined quarks and gluons. The reverse of this transition is believed to have taken place when the Universe was just 10^{-5} seconds old, and may still play a role today in the hearts of collapsing neutron stars.

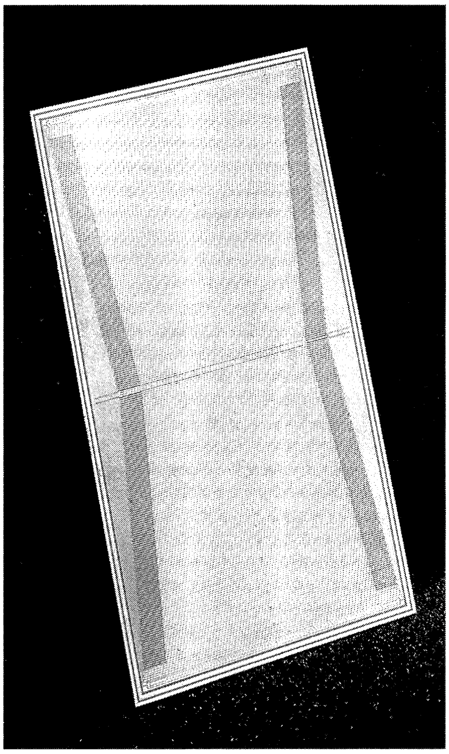
A similar phase transition is believed to have given rise to the higgs mechanism, responsible for particle masses. Although higgs particles should be produced at the LHC, the phase transition which created them is beyond the reach of experiments. The QCD phase transition which ALICE will study is the only one of this kind accessible in the laboratory.

The feasibility of this kind of research was clearly demonstrated at CERN and Brookhaven with lighter ions in the 1980s. Today's programme at these laboratories has moved on to heavy ions, and is just reaching the energy threshold at which the phase transition is expected to occur. This physics reach will be extended at the RHIC heavy ion collider at Brookhaven, scheduled to come into operation in 1999. The LHC, with a centre-of-mass energy around 5.5 TeV/ nucleon, will push the energy reach even further, exceeding even the highest energy densities seen in cosmic ray nucleus-nucleus collisions.

ALICE is bringing members of CERN's existing heavy-ion community together with a number of groups new to the field drawn from both nuclear and high-energy physics. By LHC standards, the collaboration is modest, comparable in size to one of today's experiments at the Large Electron Positron collider, LEP. The ALICE collaboration has 565 members from 26 countries. Countries outside the CERN membership play an important role, with 245 physicists taking part.

By LHC standards, the detector is of moderate proportions, being based on the current magnet of LEP's L3 experiment. (The change in scale from LEP to LHC is reflected in the fact that L3 is the largest detector in operation at LEP!) When LEP switches off, the L3 magnet will be left in place whilst ALICE is installed. LHC beams will pass through the magnet slightly off-centre, 30 cm higher than the current LEP beams. The total cost of the detector will be in the region of 120 MCHF.

Prototype of a silicon drift detector developed by the DSI collaboration (supported by the Italian INFN), in the framework of development work for the ALICE Inner Tracking System. These detectors feature true two-dimensional readout with a small number of readout channels by measuring the drift time of the charge cloud produced by the crossing particle and its centroid at the array of readout anodes. Spatial resolution is of the order of 20 microns in both directions. The low anode capacitance allows excellent energy resolution. The drift field, parallel to the detector surface, is generated by on-board electrodes.



Because the physics of the quark-gluon plasma could be very different from that of ordinary matter, the ALICE detector has been designed to cover the full range of possible signatures, whilst being flexible enough to allow future upgrades guided by early results.

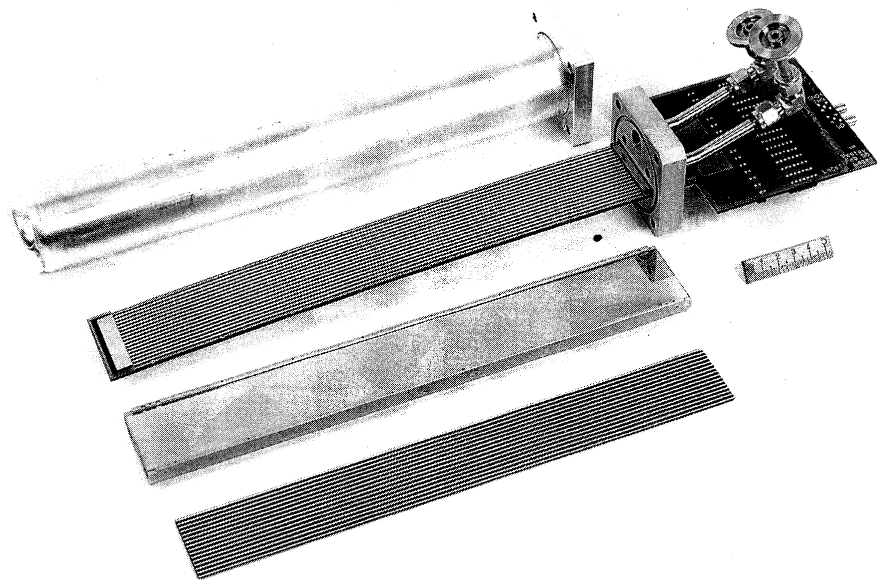
The detector consists of two main parts, a central detector, embedded within the magnet, and a forward muon spectrometer included as an addendum to the Letter of Intent in 1995. The set-up is completed by zero-degree calorimeters located far downstream in the machine tunnel, to intercept particles emerging very close to the colliding beams.

One feature of heavy-ion collisions which is well known is the large particle multiplicity arising from head-on collisions. At the LHC, such central collisions are expected to occur around 100 times per second, producing about 50,000 particles each time, several thousand of which will fall within ALICE's acceptance. The relatively low interaction rate allows the detector to be built with a simple trigger selecting only head-on collisions from the LHC's 40 MHz beam crossing rate.

One of the greatest challenges of heavy-ion physics is to pick out the individual tracks from the dense forest of emerging particles. ALICE's tracking system has been designed for safe and robust pattern recognition within a large volume solenoid producing a weak field. The L3 magnet with a field of 0.2 tesla is ideal for the purpose.

The Inner Tracking System, ITS, consists of six cylindrical layers of highly accurate position-sensitive detectors from radii of 3.9 cm to 45 cm extending to ±45°. Its functions are secondary vertex recognition, particle identification, tracking, and improving the overall momentum resolution. The different layers are optimized for efficient pattern recognition. Because of the high particle density in the innermost regions, the first four layers provide position information in two dimensions. The first two layers are silicon pixel detectors, and the second two are silicon drift detectors. The two outermost layers will be composed of double sided silicon micro-strip detectors. The complexity and importance of this device is reflected in the number of institutions responsible for its production: Bari,

Under study for the ALICE particle identification system is the Pestov spark counter technique, single-gap gas filled parallel-plate devices giving a timing resolution of less than 50 picoseconds. Pestov counters will be the preferred choice if it can be demonstrated that reliable manufacture and operation are possible for the large-area system required.
(Photo Achim Zschau, GSI)



Catania, CERN, Heidelberg, Kharkov, Kiev, Nantes, NIKHEF, Padua, Rez, Rome, St. Petersburg, Salerno, Strasbourg, Turin, Trieste, and Utrecht.

Central tracking is completed by a Time Projection Chamber, TPC, being built by Bratislava, CERN, Cracow, Darmstadt, Frankfurt, and Lund. Proven technology has been chosen to guarantee reliable performance at extremely high multiplicity. The drawbacks of this technology are high data volumes and relatively low speed. The TPC occupies the radial region from 90 cm to 250 cm, and is designed to give a rate-of-energy-loss resolution of better than 7%. It will also serve to identify electrons with momenta up to 2.5 GeV/c.

Two different technologies are under study for the last sub-detector to cover the full azimuthal angle, the particle identification system, PID. Pestov spark counters, single-gap gas filled parallel-plate devices, are being investigated by Darmstadt, Dubna, Marburg, Moscow-ITEP, Moscow-MePHI, and Novosibirsk, whilst parallel plate chambers, PPCs, are being developed by CERN, Moscow-ITEP, Moscow-MePHI, and Novosibirsk. The final design is expected to be complete by the end of 1998. The PPCs are less demanding to construct and operate, but the Pestov counters give a timing resolution of less than 50 pico-seconds, some four times better than PPCs. Pestov counters will therefore be the preferred choice if it can be demonstrated that reliable manufacture and operation are possible for the large-area system required.

A second particle identification device for higher momentum particles, the HMPID, is included in the design as a single arm device above the central PID. A ring-imaging Cerenkov (RICH) detector is the preferred option, being developed by Bari, CERN, Zagreb, and Moscow-INR. However, an organic scintillator approach being pursued by Catania, and Dubna has not yet been ruled out.

Below the central barrel region of the detector is another single-arm device, the photon spectrometer, PHOS, to measure prompt photons and neutral mesons. It is being prepared by Bergen, Heidelberg, Moscow-Kurchatov, Münster, Protvino, and Prague using scintillating lead tungstate crystals developed in the context of CERN's generic detector R&D effort.

Zero-degree calorimeters, ZDC, will be positioned 92 m from the interaction point to measure the energy carried away by non-interacting beam nucleons, a quantity directly related to the collision geometry. These are calorimeters of the spaghetti type, with quartz fibres as the active medium. Their construction is the responsibility of Turin.

Another forward detector, the forward multiplicity detector, FMD, will be embedded within the solenoid with the purpose of providing fast trigger signals and multiplicity information outside the central acceptance of the detector. Innovative micro-channel plate detectors are under consideration by Moscow-Kurchatov and St Petersburg, with conventional silicon multipad detectors as a back-up.

The forward muon spectrometer, FMS, is a major addition to the original design as specified in the Letter of Intent. It was included to measure the complete spectrum of heavy-quark resonances, which are expected to provide a sensitive signal for the production of a quark-gluon plasma. The first section of the spectrometer is an absorber placed inside the solenoid about 1m from the interaction point. This is followed by a large 3 tesla dipole magnet outside the solenoid containing 10 planes of tracking stations. A second absorber and two further tracking planes provide muon identification and triggering. Teams from CERN, Clermont-Ferrand, Gatchina, Moscow-Kurchatov, Moscow-INR, Nantes, and Orsay are working on a more detailed design for the FMS, which is expected later this year.

Triggering is the responsibility of Birmingham and Kosice. Proton-proton mode and ion-ion mode have different trigger requirements. In proton-proton mode, a minimum bias trigger is required, whilst for ion-ion collisions, the trigger's function is to select on collision centrality. A level-zero trigger decision is made at around 1.2 microseconds based on centrality information from the FMD. At level-one (2 microseconds) this is supplemented by the ZDC. A dimuon trigger from the FMD also contributes to level-one. The final level-two trigger decision is made after further processing at 100 microseconds.

The architecture of the ALICE data acquisition system is determined by the relatively short heavy-ion runs foreseen for the LHC, roughly 10% of each year's running. The collaboration will have ten times as long to analyse the data as they have to collect them, and so a high-bandwidth system is envisaged in order to collect as much data as possible in the time available. CPU-intensive operations such as event filtering and reconstruction will be performed offline. Data acquisition is the responsibility of Budapest, CERN, and Oslo.

If all goes to plan, installation of ALICE should begin as soon as the L3 experiment is decommissioned and removed from the experimental area. According to the current LEP schedule, this should be around October 2001, leaving the ALICE collaboration two years to install and commission their detector, ready to set off in pursuit of a plasma wonderland with the first LHC beams in 2004.

CEBAF - on-line for physics

After a decade of design, R&D, construction, and commissioning, the Continuous Electron Beam Accelerator Facility (CEBAF) superconducting radiofrequency accelerator, Newport News, Virginia, is on-line for experiments to bridge the quark and hadronic descriptions of nuclear matter.

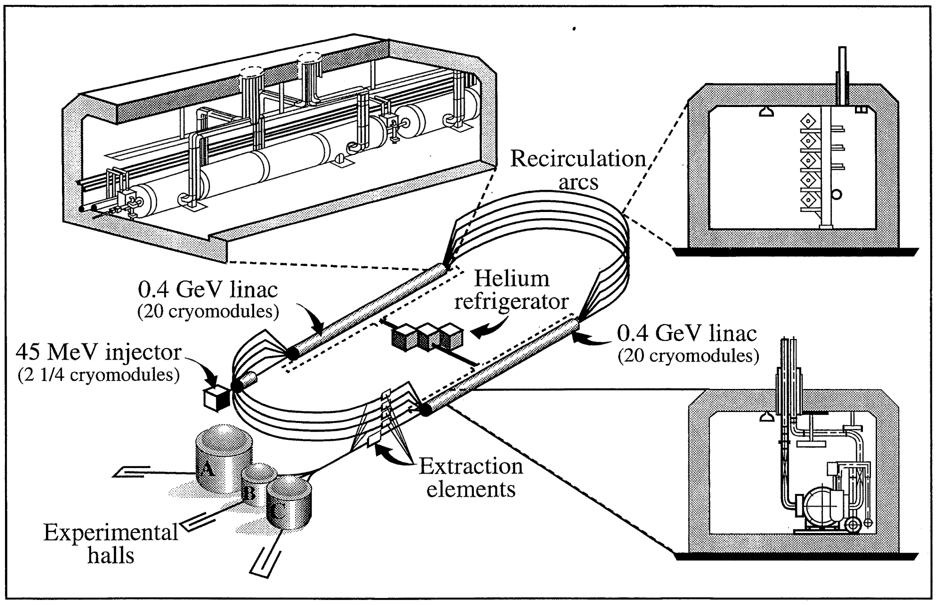
Following a commissioning period that included extended five-pass continuous wave (cw) operation at the 4 GeV design energy, the first of 76 presently approved experiments began on November 15 in Hall C. In the words of spokesman Don Geesaman of Argonne, "The accelerator is running better than any new accelerator I've ever seen, and better than most mature accelerators I've seen."

Initial machine performance was indeed encouraging, with superconducting radiofrequency (SRF) performance the highlight. Before the holiday shutdown, cavity gradient averaged above 6 MeV/m, 20% over specification, and the average cavity Q of 5×10^9 was twice specification. The world's largest 2 K refrigerator - source of half the world's superfluid helium - supported superconducting operation with greater than 99% availability.

Emittance exceeded its 2×10^{-9} m design goal; energy spread at 2.8×10^{-5} exceeded its 10^{-4} baseline specification, nearly reaching its 2.5×10^{-5} design goal. Three interleaved, independent-current bunch trains can be sent from the injector through the machine, and any one can be extracted from any pass. The adoption of EPICS (Experimental Physics and Industrial Control System) is clearly paying off. With two linacs, nine recirculation arc beamlines, and over 2200 magnets, machine complexity is comparable to that of CERN's LEP electron-positron collider. Up time was above 80%.

The presently approved experimental programme consists of 1282 days of beam time in the three experimental halls, or roughly three years of full simultaneous running. The spectrometers in halls A and B will become operational later this year. The programme represents the

Schematic of the Continuous Electron Beam Accelerator Facility (CEBAF) superconducting radiofrequency accelerator, Newport News, Virginia, now on-line for experiments. The electrons are accelerated to the 4 GeV design energy in successive passes through two 0.4 GeV antiparallel linacs linked by five recirculation arcs. The accelerator serves three experimental areas.



efforts of 542 scientists from 114 institutions in 20 countries; roughly 25% of the researchers are from outside the US.

To begin creating a fundamental understanding of strongly interacting matter, the experiments bridge from quarks to hadrons to nuclei, much as experiments in the 1930s bridged from electrons to atoms to molecules. CEBAF's programme begins at an "atomic" level where quarks and gluons make up simple hadrons like protons and pions, and proceeds to a "molecular" level where these "atoms" build up complex nuclei.

A brief history of CEBAF

A consensus concerning the need for a GeV-energy cw electron accelerator developed circa 1980. By 1985, with leadership from James McCarthy of the University of Virginia, the CEBAF accelerator was planned and approved as a pulsed room-temperature linac with a stretcher ring to lengthen the beam into an essentially continuous one.

Meanwhile, attractive SRF technology had matured at Cornell, and CEBAF Director Hermann Grunder called for a technology reassessment. In early 1986, after a conceptual design study led by Christoph Leemann, the present multipass SRF design was adopted. This led to the recruitment of Ron Sundelin and others from Cornell.

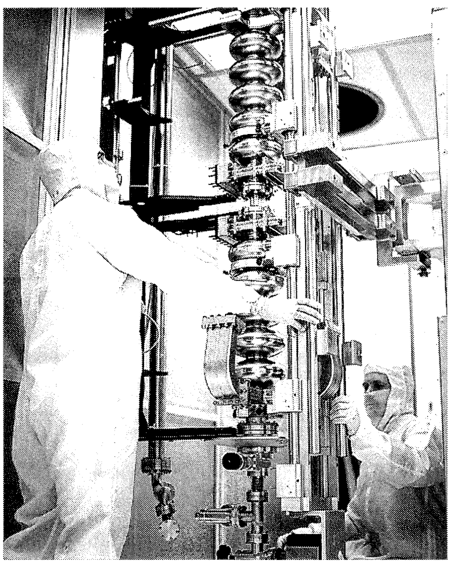
By 1989 construction was well underway, with Beverly Hartline as project manager. Operational tests of partial accelerator configurations began in the injector in 1990, and continued to expand incrementally thereafter through the linacs and arcs, interwoven with installation work. Commissioning of the fully installed machine began in May 1994, with single-pass pulsed beam delivered to Hall C for spectrometer calibration in July.

Over the next year the recirculation arc beamlines were progressively studied and tuned. In May 1995, five-pass beam at a nominal 4 GeV was delivered to Hall C. By early November, optics setup improvements had dramatically enlarged the transverse and momentum apertures, enabling stable and reliable cw operation.

Physics programme

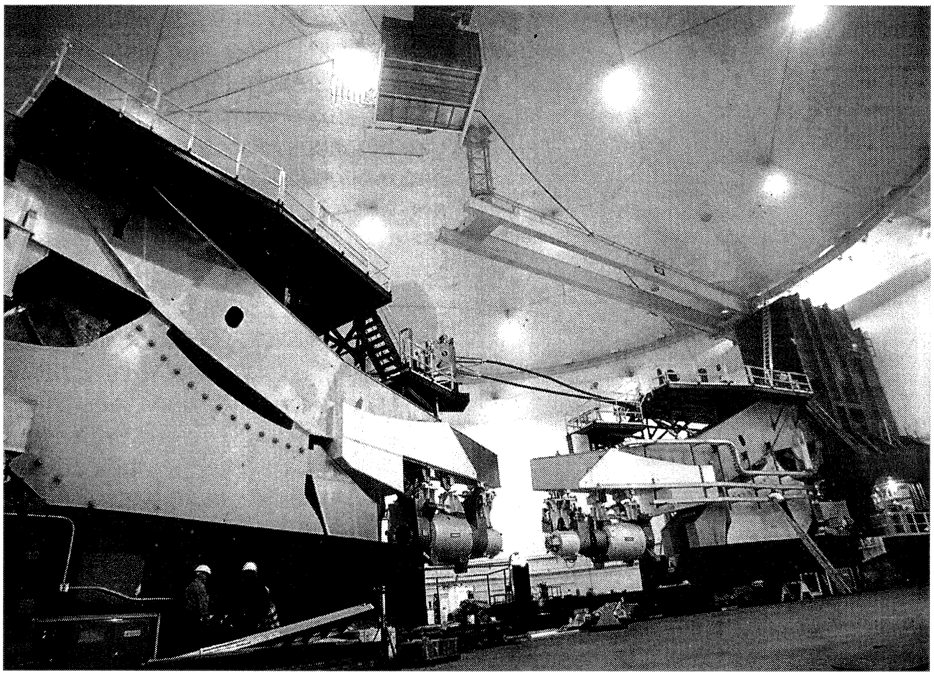
To build the first scientific bridge, some CEBAF experiments will seek to elucidate the quark and gluon structure of the basic hadrons. In one kind of experiment, an electron will simply scatter off the quarks inside an isolated nucleon, revealing the quarks' spatial distribution. In another, the electron will transfer energy to a quark, thereby knocking a proton or neutron into one of their excited "atomic" levels.

Just as ordinary spectroscopy has been an incisive tool for studying the



Superconducting radiofrequency accelerating cavities are the key element in CEBAF. Cavity performance has attained an average gradient above 6 MeV/m, 20% over specification, with the average cavity resonance factor, Q, of 5 x 10^9 double that of the specification.

The high precision 4 GeV magnetic spectrometer in CEBAF experimental hall A.



electronic structure of atoms, "quark spectroscopy" will reveal basic details of the quark structure of matter, helping delineate the effective degrees of freedom in operation in QCD - quantum chromodynamics, the field theory of quarks and gluons - at low energies where simple perturbative methods break down.

In particular, it has been known for 30 years that the baryon family seems to behave as though baryons are made of three massive spin-1/2 quarks - quite surprising from a QCD perspective, where the basic mechanism looks like nearly massless asymptotically free quarks. The experimental study of QCD leads to such simple low-energy structures is vital to achieving a qualitative understanding of strong interactions.

Once the proton and neutron are understood, a firm foundation will finally become possible for our understanding of the nucleus, now based largely on empirical models analogous to the early pictures of molecules with atoms as elementary subunits. Modern chemistry and molecular physics are based on the underlying electron theory; in the future it will be possible to connect nuclear physics to the underlying quark theory.

Thus a second major scientific goal of CEBAF is to understand the structure of the nucleus from the quark level. Some experiments will examine this structure by measuring the distribution of charge and magnetization in various nuclei at very small distances. Others, with unique capabilities for detecting many particles simultaneously, will search for overlapping protons in the nucleus by studying processes in which many particles are knocked out by a single electron.

Another aspect of the quark structure of nuclei could be revealed by simply discovering situations in which the standard proton-plus-neutron picture breaks down. For example, within a nucleus, a proton's properties should be modified, as are an atom's in a liquid. CEBAF is particularly well suited to observe such distortions.

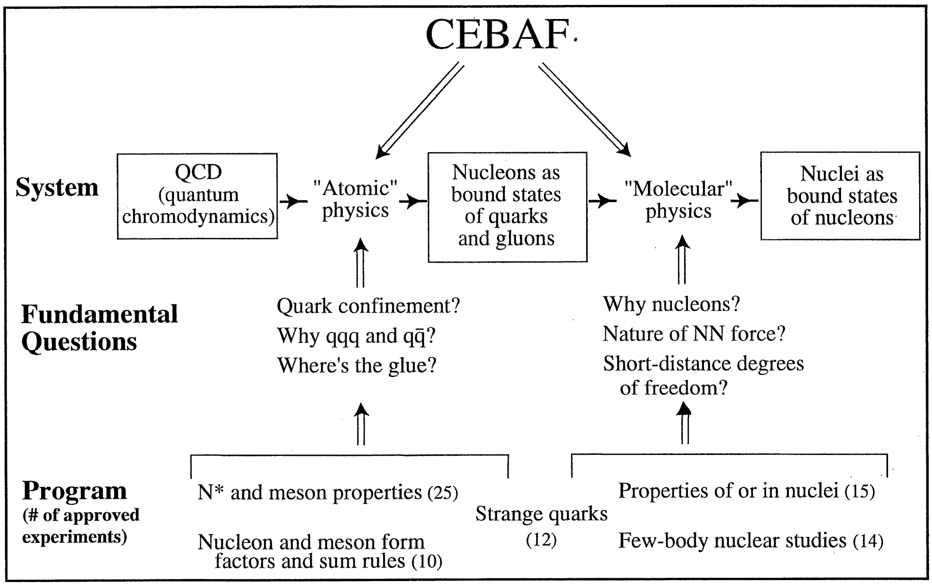
In pursuing these two main goals, it will be essential to explore a number of areas where little is now known. For example, while the proton's mass is largely gluonic in origin, only quark excitations have been discovered so far in its spectrum of excited states. The existence and spectra of new excited gluonic states of matter will provide fundamental information on the origin of confinement.

Another example, from the "molecular physics" of the strong interaction, is the role of mesons in producing interhadronic forces. Since the proton and neutron have constituents in common, a part of the nucleon-nucleon interaction must arise from constituent quark exchange as distinct from meson (quark-antiquark) exchange. To explore the importance of the mesonic "cloud" around the nucleons, some experiments will measure the nucleons' strange-quark and antiquark content by means of their contributions to charge and magnetization distributions.

Outlook

Besides continuing to improve accelerator performance, near-term challenges are to finish fitting out experimental Hall A and Hall B, to begin two-hall and then three-hall simultaneous operations, to commission polarized-beam operation, and to exploit the excellent accelerating cavity performance for energies above 4 GeV. For the longer term, SRF spinoff applications and a substantial accelerator energy upgrade are in prospect.

The CEBAF experimental programme looks at the quark 'atomic physics' - the way quarks form nuclear particles - and quark 'molecular physics' - the way these nuclear particles group together as atomic nuclei.

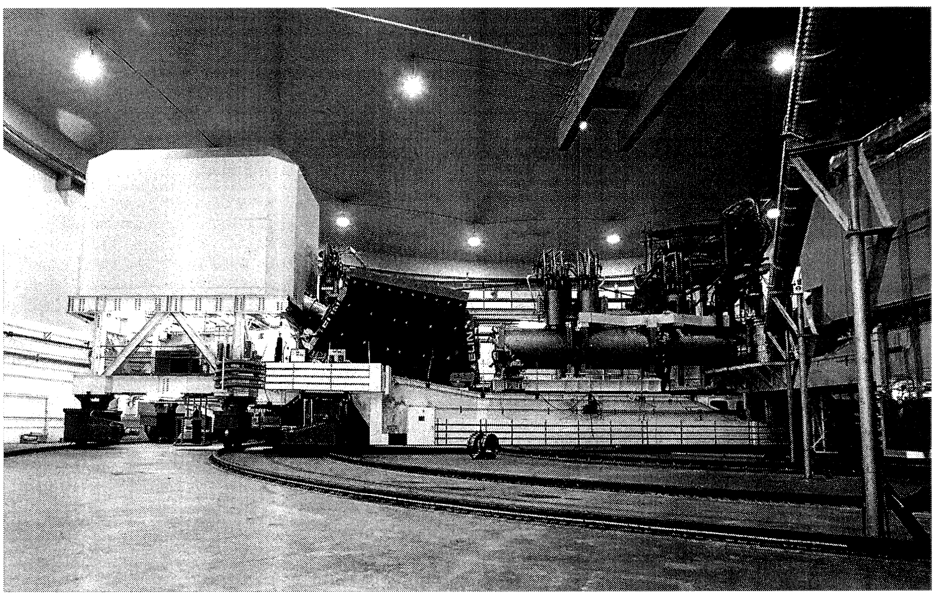


In the early 1990s, high-technology industries identified a need for high-average-power, wavelength-tunable free-electron lasers (FELs) "driven" by CEBAF-type SRF linacs (September 1994, page 20). Especially in the deep ultra-violet, such devices could be cost-effective for material-surface processing and micromachining. Defence applications are also under study. A FEL programme is underway at CEBAF with both civilian and navy funding. Participating manufacturers include DuPont, 3M, Xerox, IBM, Newport News Shipbuilding, and Northrop Grumman.

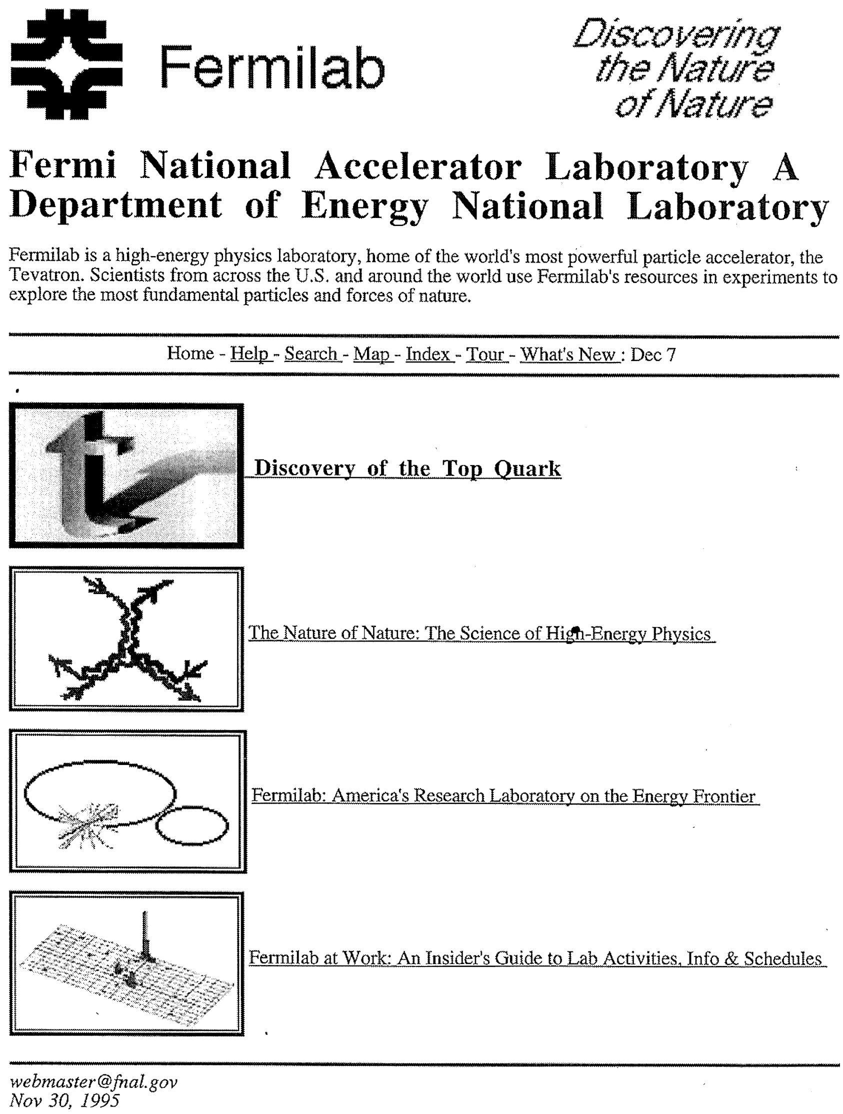
FEL spinoff efforts take place within the larger context of developing SRF for future physics. Three key features of SRF at CEBAF support the prospect of an 8 GeV energy upgrade. The recirculation arcs, where small bending radii would have limited energy transport due to synchrotron radiation, are laid out for up to 16 GeV. The number of passes, originally planned to be four, was changed to five early on reducing the number of cryomodules needed then, but freeing up space for higher-gradient cryomodules. Now, with cavity and cryomodule performance improvements in development, the laboratory is looking toward eventually adding five high-gradient cryomodules to each linac.

With such an extension of its energy, CEBAF's physics reach would be expanded to include the pure quark-like structure of the nucleons and mesons via precise measurements of the unpolarized and polarized valence-quark structure functions, appropriate baryon and meson transition form factors, and hadronization in the duality regime.

The high momentum 6 GeV magnetic spectrometer in CEBAF experimental hall C.



Around the Laboratories


Fermilab

Discovering the Nature of Nature

Fermi National Accelerator Laboratory A Department of Energy National Laboratory

Fermilab is a high-energy physics laboratory, home of the world's most powerful particle accelerator, the Tevatron. Scientists from across the U.S. and around the world use Fermilab's resources in experiments to explore the most fundamental particles and forces of nature.

Home - Help - Search - Map - Index - Tour - What's New : Dec 7

Discovery of the Top Quark

The Nature of Nature: The Science of High-Energy Physics

Fermilab: America's Research Laboratory on the Energy Frontier

Fermilab at Work: An Insider's Guide to Lab Activities, Info & Schedules

webmaster@fnal.gov
Nov 30, 1995

Fermilab's home page (URL: http://fnnews.fnal.gov/) is a widely admired example of effective presentation on the World-Wide Web.

Web offset

The World-Wide Web was conceived at CERN to allow particle physicists easy access to information wherever they happened to be. It has taken the world by storm, and been hailed a telecommunications revolution. From Stockholm to Kathmandu, daily newspapers publish Web editions, and by the end of 1995, the number of Web servers had grown to nearly 75 000. But has the original objective been achieved? Has the Web changed the way that physicists conduct their work?

The answer is a resounding "Yes". At particle physics laboratories the world over, information about accelerator schedules and performance is posted on the Web. Experiments use the Web to distribute draft papers, carry meeting announcements and minutes, and to publicize their work. The much-admired Fermilab home page has even made it into the Netscape "What's Cool" list, along with the CIA and MTV.

At CERN, event pictures from the recent Large Electron Positron collider (LEP) 130 GeV run were on the Web just minutes after they were recorded. All four of the LEP experiments, ALEPH, DELPHI, L3, and OPAL are finding innovative uses for the Web, often using password-protected areas away from the public domain.

ALEPH has "hyperized" all of its reconstruction software and documentation in a system christened Light (LIfe cycle Global HyperText). So, for example, a click on a subroutine call in the source code takes you to that routine's documentation. Analysis software and simulations will soon be added to this package, which will eventually include job submission templates so that a full ALEPH analysis can be conducted through a Web interface.

L3's paper review process is now entirely Web-based. Draft papers are put on the Web and announced in a news item. The Web page also includes information about authors, review schedules, and deadlines for comments. Any L3 physicist anywhere in the world can consult draft papers on the Web, and express his views. After final approval, papers are moved to the L3 public Web page, and submitted to a journal for publication in a more traditional form.

OPAL has developed a Web-based link with Thorn EMI Electron Tubes. The idea is to speed up the development phase of a new sub-detector currently being installed. An exacting quality control procedure for Thorn EMI photomultipliers has been implemented at CERN, and the results are posted on a password-protected area. There, they are consulted by Thorn EMI, and fed back into the company's own quality control procedures. Both OPAL and Thorn EMI have benefited.

As a result of the test database being simultaneously available to OPAL and Thorn EMI, the company has been more directly involved with its client. The benefit to OPAL comes from faster development of the new sub-detector.

The two general-purpose experiments preparing for CERN's next big accelerator, the LHC, are the first to grow up in the Web era. Both ATLAS and CMS are building up complete information reservoirs on the Web. At CMS, text files are submitted to the reservoir by electronic mail. A number of keywords included in the subject line is interpreted by the system which then stores the file where it belongs and puts in all the necessary hyperlinks automatically. For more complex documents, such as pictures, the e-mail contains a pointer to the document. ATLAS has all information since 1993 on the Web, with automatic features for storing, archiving and accessing internal documentation.

Physicists working on the SLD experiment at the SLC linear collider, SLAC, Stanford sign up for their shifts on the Web, and some shifts are even run through the Web. SLD has developed a data browser which allows collaborators around the world to check the quality of data as they are taken. Offline shift crews use this browser to check the data remotely.

Accelerator groups also make full use of the Web's capabilities. At CERN, machine schedules are kept up to date, and during running, the status pages of the SPS and LEP are revised every machine cycle. This information, only available before via television screens around the Laboratory, can now be seen from anywhere in the world.

Lecture notes on accelerator physics for CERN Summer Students are publicly available complete with figures and diagrams. Contributions to LEP performance workshops and the biennial European Particle Accelerator Conference can be composed and submitted using Web templates. Papers received in this way are compiled into proceedings for publication in paper and electronic forms.

And what of the future? One day, perhaps not too far off, night shifts could become a thing of the past. CERN experiments could be controlled through a Web interface by physicists from the United States or Japan whilst Geneva sleeps. But physicists at CERN will still be the ones to answer the 4am call-outs; there will always be some problems that even the Web can't solve.

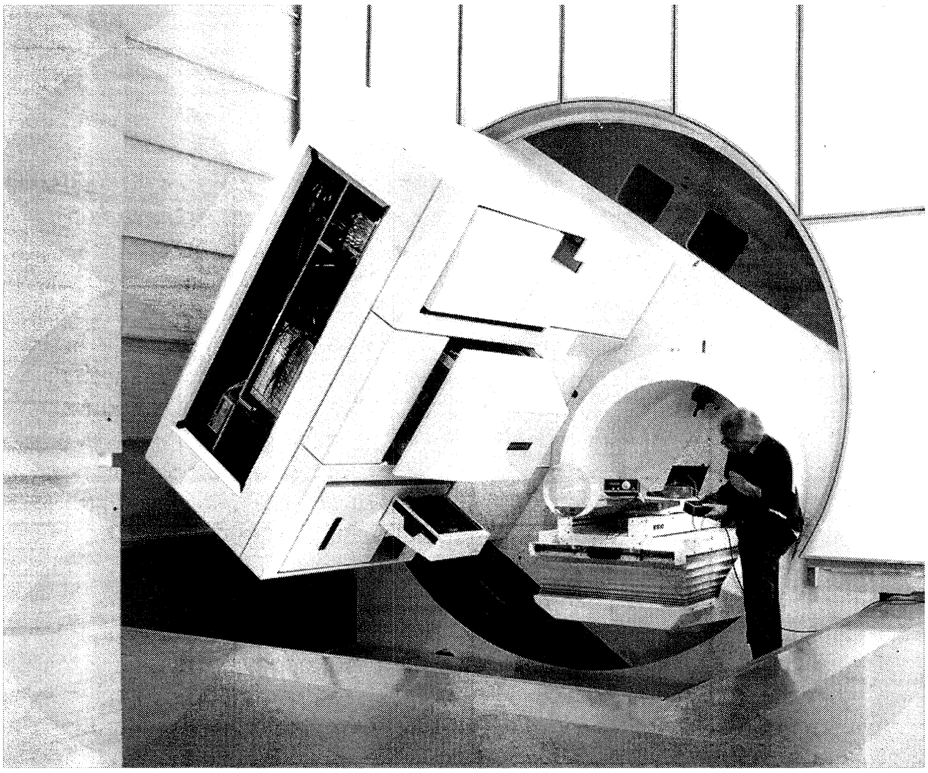
All of CERN's public WWW sites are accessible through the CERN Welcome page at http://www.cern.ch/BigWelcome.html

VILLIGEN
New proton therapy facility

On 30 January, the Swiss Paul Scherrer Institute in Villigen, together with the future collaboration of users from the national and international specialist medical community, formally inaugurated an impressive new proton beam cancer therapy facility, said to be the first of its kind in the world.

Radiotherapy - irradiation by special beams - is one of the most effective weapons to combat malignant cancers, and the increased precision given by proton beams provides special benefits. Using proton beams from PSI's 600 MeV cyclotron, degraded to some 200 MeV and

The gantry of the new proton cancer therapy facility at the Swiss PSI Laboratory, which will soon be taking its first patients.



using a specially designed spot-scan system, the treatment is designed to provide a precision 'beam scalpel' attack on the tumour, with minimal damage to surrounding tissue.

First patients will be treated at PSI this spring, referred by clinics and major hospitals after consultation with PSI radiotherapy specialists according to well-defined procedures.

PSI also offers Optis, using lower energy proton beams to treat eye tumours. This has handled over 2,000 patients from across Europe. Over 500 patients with deep tumours have also been treated using PSI's PIOTRON superconducting multiple pion beam facility.

Providing special beams for cancer therapy is a big success story in the application of particle accelerators. The special July/August 1995 issue of the CERN Courier illustrated X-ray, neutron and proton therapy. Another possibility on this scene is the use of heavy ion beams, where a new facility has been established at the GSI heavy ion Laboratory, Darmstadt (January/February issue, page 16).

BROOKHAVEN RHIC spin initiative - US-Japan collaboration

RIKEN President Akito Arima and Brookhaven Director Nicholas Samios at the signing ceremony of the RIKEN-Brookhaven collaboration agreement. 25 September 1995.

Brookhaven's Relativistic Heavy Ion Collider (RHIC) is moving into the final phases of construction. The first look at gold beam collisions in the ultra-relativistic energy regime is scheduled to take place in the spring of 1999, and the research programme is taking on an added dimension through a recently-signed collaboration agreement between Brookhaven and Japan's RIKEN Laboratory (November 1995, page 1).

As a result of this collaboration, RHIC will be not only the world's highest energy collider of heavy ions, but also the highest energy collider of spin-polarized proton beams for physics research.

During the past several years, a world-wide group of scientists, including theorists as well as experimentalists, has developed a proposal to utilize the two large RHIC detectors, STAR and PHENIX, for spin-related measurements using high-intensity beams of polarized protons in RHIC.

The AGS Alternating Gradient Synchrotron which will be the RHIC injector, has a long history of accelerating polarized protons, and studies have shown that the RHIC lattice, with some additional components, can accelerate, store and collide polarized beams from the AGS.

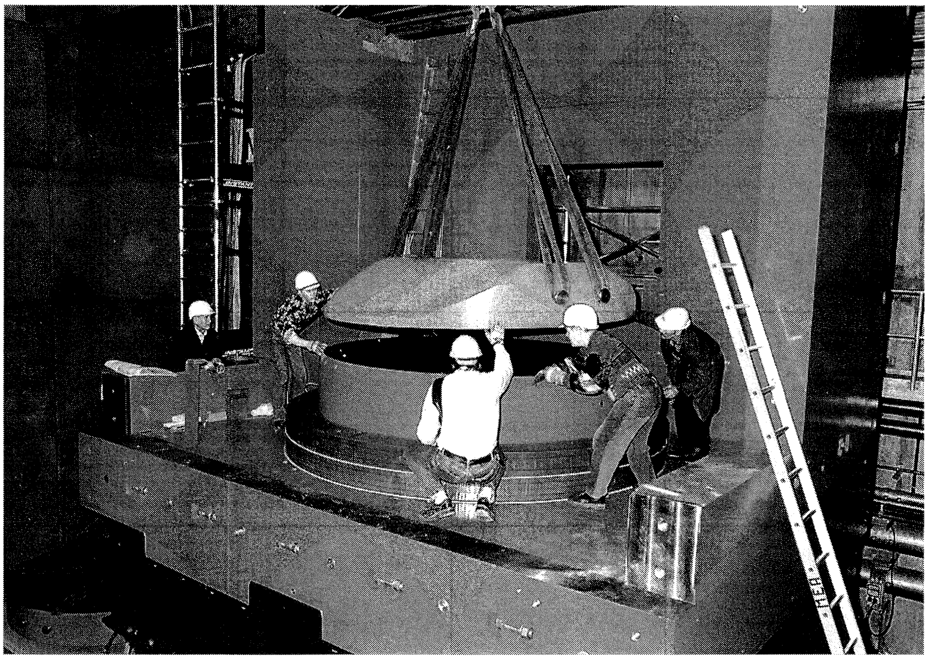
A luminosity of 2 x 10^{32} per sq cm per s is achievable, with 70% polarization at 250 GeV per beam. Meaningful data runs of 8-10 weeks per year will be possible, making a minimal impact on the machine's primary mission of colliding heavy ion beams.

With the continuing development of this possibility, the entire collaborations for both STAR and PHENIX have decided to incorporate the spin programme into their research agendas. The newly initiated collaboration between RIKEN and Brookhaven will provide two billion Japanese yen (about $20M) over a five-year period to implement the spin capability.

Specifically, RIKEN will fund the fabrication and installation of specialized dipole magnets (Siberian snakes and spin rotators) needed to preserve and manipulate the spin axes of polarized protons through acceleration and storage in RHIC, and will also provide an additional spectrometer for muon measurement in the PHENIX detector.

As presently planned, the spin physics programme will focus on measurement of longitudinal and transverse spin interactions to probe the nucleon spin structure through hard-scattering collisions of the quark and gluon constituents. Deep inelastic electron and muon experiments at SLAC (Stanford) and CERN have pioneered the study of the spin structure of the quarks and antiquarks inside protons and neutrons.

A major new experiment begins to take shape for the HERA machine at Hamburg's DESY Laboratory. Here technicians install the iron yoke, supplied by the Efremov Institute, St. Petersburg. Particles will reach the detector through the 'window' seen in the background. (Photo Heike Thum-Schmielau)



The high energy hadronic interactions accessible to RHIC will complement these studies by examining the spin content of gluons and sea quarks in the kinematical range accessible through direct photon and inclusive jet production, as well as W and lepton-pair (Drell-Yan) signals. The large RHIC detectors, designed to handle particle multiplicities of many thousands in heavy ion collisions, are robust enough to handle the high luminosity collision rates in proton beams as well.

RIKEN (Rikagaku Kenkyusho), or the Institute of Physical and Chemical Research, is a semi-governmental research institute supported by the Japanese government's Science and Technology Agency. Established in 1917, RIKEN, like Brookhaven, is a multi-purpose laboratory, with research programmes ranging from nuclear and particle physics to the life sciences.

With the agreement signed in September by Brookhaven Director Nicholas Samios and RIKEN President Akito Arima, the RHIC spin initiative is on firm footing, and the stage is set for a major new undertaking in the study of the fundamental structure of hadrons and nuclei. It is expected that the RIKEN-funded spin capability for RHIC will be completed when the machine is ready to turn on in 1999.

Tom Ludlam

The article on industrial applications at Brookhaven's tandem accelerator (November 1995, page 2) pointed out how this radiation environment can simulate the conditions of outer space for testing spacecraft semiconductor equipment. The illustration showed the results achieved with a Samsung 16 Megabit DRAM. Unfortunately the 'Megabit' went astray in the accompanying caption, thereby drastically underestimating the significance of the result - the 16Mbit memory chips will be the largest ever used in space. We apologize for the error.

DESY
HERA-B begins to take shape

Now taking shape at the West experimental hall of the HERA superconducting proton ring at Hamburg's DESY Laboratory is the big HERA-B experiment, in which the HERA proton beam will be fired into a target (June 1995, page 20).

The first major item of equipment to appear is the 580-tonne spectrometer magnet. The 34 elements of the iron yoke, supplied by the Efremov Institute, St. Petersburg, were transported to Hamburg as six truckloads.

Installed behind the proton-gas interaction point, the spectrometer magnet uses coils from the Argus experiment, which stopped taking data at DESY's DORIS electron-positron collider in 1992.

Once the magnet is installed, specialists will study its influence on the nearby HERA beam.

RUTHERFORD APPLETON
ISIS proton intensity record

The ISIS pulsed neutron source at the UK Rutherford Appleton Laboratory (see page 4) has completed its most successful run to date in style. During the past year over 600 experiments were performed by

Physics monitor

university and industrial teams from the UK, Europe and beyond in fields as diverse at high temperature superconductivity, drug delivery, surfactant chemistry and residual stress in engineering components.

The successful implementation of two new servo systems (stabilising the ion source current and controlling the radial beam position prior to bunching) by ISIS accelerator physicists allowed the accelerator to operate with high efficiency at a mean current of 200 microamps. ISIS is now, by more than an order of magnitude, the most powerful pulsed spallation source in the world today and is seen as setting the direction for future neutron sources in Europe, Japan and the United States.

Annual theory meeting

Meanwhile a regular RAL highlight is the annual theory meeting, when the national particle theory community packs the 200-seat Lecture Theatre and enjoys three days of topical talks. As usual there was an experimental talk; this time John Thompson described the preliminary results from the first increase in energy at CERN's LEP electron-positron collider (January/ February, page 1).

Former head of RAL theoretical physics Roger Phillips celebrated his official retirement by delivering a superb review of neutrino physics. Formal theory was covered by Paul Townsend and Shimon Yankielowicz, who discussed membrane theory and duality. Ikaros Bigi talked on b-physics while different aspects of QCD were covered by Keith Ellis, Mike Teper, Mike Pennington and Brian Webber. Helmut Satz discussed how colour deconfinement may be detected in nuclear collisions.

Most-cited high energy physics papers

There is no official 'best seller' list of physics papers, but the number of times a published paper is subsequently referred to is one indicator of its scientific impact. Hrvoje Galic of the Stanford Linear Accelerator Centre (SLAC) has carefully analysed these citations.

High-energy physicists are blessed with many useful resources on the World Wide Web: The Los Alamos e-print archives (Ref. 1), Particle Data Group documents from Berkeley (Ref. 2), the Durham-RAL HEPDATA system (Ref. 3), the CERN preprint depository (Ref. 4), to mention just a few. SLAC Library offers several high-energy physics databases managed under SPIRES, the most popular being the HEP-PREPRINT database (Ref. 5).

This database, a joint project of the SLAC and DESY libraries, contains more than 300,000 entries with extensive bibliographic descriptions of high-energy physics preprints, e-prints, and journal articles. It also has pointers to viewable versions of many thousands of articles in Postscript depositories worldwide.

One of the unique features of this database is the citation search, with citations collected from the 8,000 - 10,000 preprints received annually by the SLAC Library. Since 1974, HEP-PREPRINT has tracked the number of times a published high-energy physics journal article has subsequently been cited. E-prints citations are also counted.

The accompanying table based on the HEP-PREPRINT citation data displays 'hot topics' - journal articles with the most citations in the last three years. A second table of 'all-time favourites' - articles with the most citations in the last two decades - will be published in the next issue.

The tables reflect the situation on December 31, 1995. While interesting, the total number of citations is not the only criterion of the value of a scientific paper. Theoretical fashion clearly plays a role and makes some themes temporarily more popular. Experimental work is grossly undercited, probably because important results seem to be considered 'common knowledge' by the majority of non-experimentalists, and the use of convenient 'catch-all' references to the Review of Particle Properties. Papers published in smaller or non-English-language journals are generally less available and less cited. Finally, the database only collects citations found in preprints, and many otherwise important citations from non-preprinted articles are not included.

'Hot topics' - Most-cited papers of the past three years

The list of high-energy physics articles that have collected the most citations in the last three years is a good indicator of what is "hot" in the field today. Hard experimental results, the continuing search for physics beyond the Standard Model, quark calculations and a concomitant need for detailed phenomenology, and astrophysics and cosmology all figure prominently.

In a category of its own is the Review of Particle Properties, the high energy physicists' 'telephone directory', whose two editions (1992 and 1994) themselves have more than 1,000 citations each - a real

Table 1
High energy physics articles with the most citations between January 1, 1993 and December 31, 1995 - the 25 papers with the most citations in the last three years, based on the number of citations in the SLAC-SPIRES database.

In a category of its own:

a) Review of Particle Properties
Particle Data Group (K. Hikasa et al.)
Phys. Rev. D45 (1992) S1
1154 citations

b) Review of Particle Properties
Particle Data Group (L. Montanet et al.)
Phys. Rev. D50 (1994) 1173-1823
1030 citations

Other most cited papers:

1) Supersymmetry, Supergravity and Particle Physics
H.P. Nilles
Phys. Rept. 110 (1984) 1
486 citations

2) The Search for Supersymmetry: Probing Physics Beyond the Standard Model
H.E. Haber , G.L. Kane
Phys. Rept. 117 (1985) 75
450 citations

3) Structure in the COBE DMR First Year Maps
COBE Collaboration (G.F. Smoot et al.)
Astrophys. J. 396 (1992) L1
426 citations

4) Weak Decays of Heavy Mesons in the Static Quark Approximation
N. Isgur , M.B. Wise
Phys. Lett. B232 (1989) 113
407 citations

5) The Lund Monte Carlo for Jet Fragmentation and Electron-Positron Physics: JETSET Version 6.3, an Update
T. Sjostrand, M. Bengtsson
Comput. Phys. Commun. 43 (1987) 367
404 citations

6) Comparison of Grand Unified Theories with Electroweak and Strong Coupling Constants Measured at LEP
U. Amaldi, W. de Boer, H. Furstenau
Phys. Lett. B260 (1991) 447
400 citations

7) Weak Transition Form Factors Between Heavy Mesons
N. Isgur, M.B. Wise
Phys. Lett. B237 (1990) 527
387 citations

8) Implications of Precision Electroweak Experiments .... and Grand Unification
P. Langacker, M-X. Luo
Phys. Rev. D44 (1991) 817
383 citations

9) Asymptotic Freedom in Parton Language
G. Altarelli, G. Parisi
Nucl. Phys. B126 (1977) 298
371 citations

10) A Model of Leptons
S. Weinberg
Phys. Rev. Lett. 19 (1967) 1264
363 citations

11) QCD and Resonance Physics. Theoretical Foundations
M.A. Shifman, A.I. Vainshtein, V.I. Zakharov
Nucl. Phys. B147 (1979) 385
360 citations

12) Dynamical Model of Elementary Particles Based on a Analogy with Superconductivity. I.
Y. Nambu, G. Jona-Lasinio
Phys. Rev. 122 (1961) 345
337 citations

13) CP Violation in the Renormalizable Theory of Weak Interaction
M. Kobayashi, T. Maskawa
Progr. Theor. Phys. 49 (1973) 652
333 citations

14) Particle Creation by Black Holes
S.W. Hawking
Commun. Math. Phys. 43 (1975) 199
331 citations

15) Chiral Perturbation Theory to One Loop
J. Gasser, H. Leutwyler
Ann. Phys. (N.Y.) 158 (1984) 142
329 citations

16) Computation of the Quantum Effects due to a Four-Dimensional Pseudoparticle
G. 't Hooft
Phys. Rev. D14 (1976) 3432
305 citations

17) Chiral Perturbation Theory: Expansions in the Mass of the Strange Quark
J. Gasser, H. Leutwyler
Nucl. Phys. B250 (1985) 465
302 citations

18) An Investigation of the Spin Structure of the Proton in Deep Inelastic Scattering of Polarized Muons on Polarized Protons
EMC Collaboration (J. Ashman et al.)
Nucl. Phys. B328 (1989) 1
298 citations

19) On String Theory and Black Holes
E. Witten
Phys. Rev. D44 (1991) 314
295 citations

20) Neutrino Oscillations in Matter
L. Wolfenstein
Phys. Rev. D17 (1978) 2369
295 citations

21) The Lund Monte Carlo for Jet Fragmentation and Electron-Positron Physics: JETSET Version 6.2
T. Sjostrand
Comput. Phys. Commun. 39 (1986) 347
291 citations

22) Infinite Conformal Symmetry in Two-Dimensional Quantum Field Theory
A.A. Belavin, A.M. Polyakov, A.B. Zamolodchikov
Nucl. Phys. B241 (1984) 333
291 citations

23) Quantum Field Theory and the Jones Polynomial
E. Witten
Commun. Math. Phys. 121 (1989) 351
289 citations

24) Parton Distributions Updated
A.D. Martin, W.J. Stirling, R.G. Roberts
Phys. Lett. B306 (1993) 145
287 citations

25) Evidence for Top Quark Production in Proton-Antiproton Collisions.....
CDF Collaboration (F. Abe et al.)
e-Print Archive: hep-ex/9405005
Phys. Rev. Lett. 73 (1994) 225
284 citations

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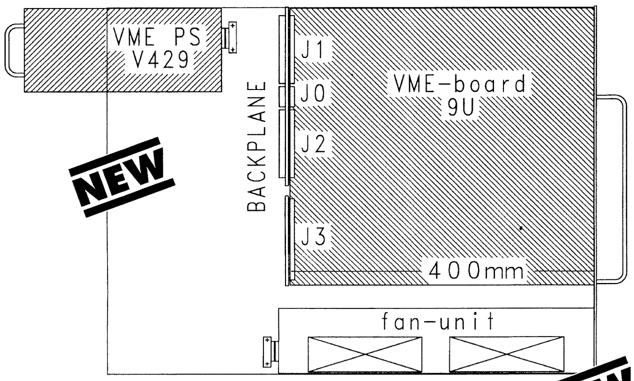

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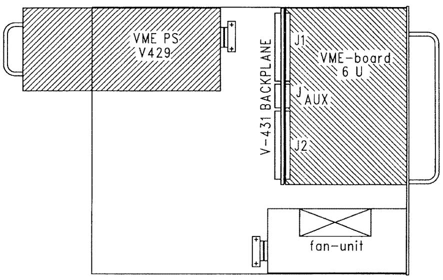
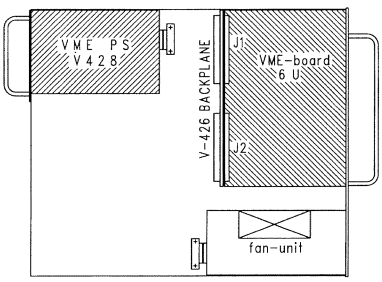


VMEbus-crate CERN-spec. V430



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Applicants should send curriculum vitae, bibliography and a description of research and teaching interest to Professor G. Mitselmakher, HEE Search Chair, Department of Physics, P.O. Box 118440, Gainesville, FL 32611, USA. Please arrange to have your reference letters sent or provide the names of at least three references for the Committee to contact. Applicants with questions may contact the Search Chair by mail or by email at Mitselmakher@phys.ufl.edu or by telephone at 904/392-9237. The deadline for receipt of applications is March 20, 1996.

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tribute to all the experimental physicists whose work was used in the compilation. Yet the Review is more than just a compilation - its selection process and the standard-setting, its review sections and other features, make it an indispensable tool.

It is perhaps sometimes too indispensable, and the dearth of experimental results in the list suggests that the Review of Particle Properties is sometimes a more convenient reference than original experimental papers (which of course are included in the Review).

With the Standard Model so well entrenched, the quest for physics beyond the Standard Model is very much in people's minds. With supersymmetry the top contender for new physics, two substantial review papers on supersymmetry, one by Nilles, the other by Haber and Kane, head the list of journal articles.

Next on the list comes a milestone paper which bridges particle physics and cosmology. The COBE-collaboration's 1992 precision measurement showed the first evidence for structure - the 'seeds of the Universe' - in the cosmic microwave background.

With calculations in the quantum chromodynamics (QCD) field theory of quarks and gluons so difficult, any calculational aid is a boon. Heavy quark effective theory, where only certain quark masses become important, is particularly productive, witness the two classic articles by Isgur and Wise, at positions 4 and 7.

At position 5, Sjostrand's and Bengtsson's simulation program for jet fragmentation physics (the 'Lund model') is a vital tool in the interpretation of experimental data.

At sixth place is another example of the search for physics beyond the Standard Model and reflects in the impact of precision results from CERN's LEP electron-positron collider. The Amaldi, de Boer, and Furstenau tests of the Grand Unified Theories (GUT) at LEP suggested that current data does not extrapolate smoothly to the GUT limit, and that new physics (perhaps supersymmetry) comes into play. Also on GUT phenomenology is a definitive paper by Langacker and Luo at position 8.

Positions 9 through 13 are occupied by several classic and still very influential papers: the 1977 Altarelli and Parisi work on parton physics, Weinberg's 1967 proposal of the electroweak unification (Salam's version, first published in a book rather than a preprint, escapes this analysis), the 1979 Shifman, Vainshtein, Zakharov article on QCD theory and phenomenology, the 1961 Nambu and Jona-Lasinio paper on dynamical generation of particle masses, and Kobayashi and Maskawa's 1973 extension of Cabibbo's mixing to three quarks.

At position 14 is Hawking's 1975 proposal of particle behaviour near black holes. As a pioneer example of quantum mechanics and general relativity working together, this is much referred to by theorists continuing this quest.

More evidence for interest in quark calculations comes from the two papers by Gasser and Leutwyler on chiral perturbation theory at fifteenth and seventeenth places. Between them is 't Hooft's study of instantons and dynamical symmetry breaking, a tentative suggestion which has now become a classic paper.

Although experimental results are implicitly cited in many of the phenomenological papers, the EMC-collaboration paper on proton spin structure (position 18) is the most cited new experimental result in the last three years.

Ed Witten's imaginative ideas are widely admired. His study of two-dimensional black hole solutions in superstring motivated dilaton gravity is at 19th position and his study of topological field theory is 23rd. Another string theory classic, by Belavin, Polyakov, Zamolodchikov is in 22nd place. With superstrings now a theoretical industry, the absence of other string papers is perhaps surprising.

A reflection of the continuing attempts to understand neutrino physics is Wolfenstein's paper on neutrino oscillations and their implications for solar neutrino fluxes (20th position).

Echoing the entry in 5th place is an earlier version of the Lund Monte Carlo by Sjostrand. Also with a strong phenomenological slant is the valuable 1993 Martin, Stirling, and Roberts refinement of parton distributions.

The 1994 suggestion of evidence for top quark production by the CDF-collaboration concludes the list of the 25 most-cited papers of the past three years. Clearly the importance of the top quark discovery will be reflected in subsequent citations listings.

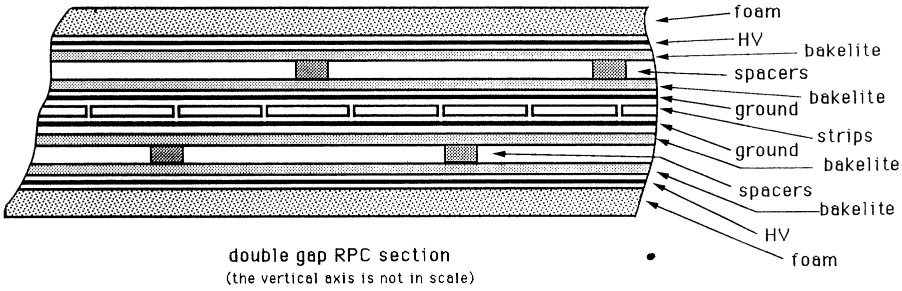
(A more complete version of the table, listing the 50 most-cited articles, is posted at SLAC's Web server - Ref. 6.)

Information from Hrvoje Galic, SLAC Library Databases

References:

1) http://xxx.lanl.gov/
2) http://pdg.lbl.gov/
3) http://cpt1.dur.ac.uk/HEPDATA
4) http://preprints.cern.ch
5) http://www-spires.slac.stanford.edu/find/hep
6) http://www-spires.slac.stanford.edu/find/top40.html

The subject of increasing attention for challenging new instrumentation requirements are resistive plate chambers - gas particle detectors operated, in their initial design, in limited streamer mode, under an uniform electric field. This schematic of a double gap RPC module has two chambers mounted facing each other in the same mechanical structure with independent high voltage and sharing a common readout plane of strips.



Resistive plate chambers

With present and future experiments in particle physics and astrophysics demanding detectors capable of good simultaneous space and time resolution over large areas, resistive plate chambers (RPCs) are prominent among generic detector designs. Interest and progress were reflected at the III International Workshop on Resistive Plate Chambers and Related Detector (RPC95) in Pavia (Italy) last fall.

RPCs are gas particle detectors operated, in their initial design, in limited streamer mode, under an uniform electric field. The accompanying figure shows a schematic of a double gap RPC module, consisting of two chambers facing each other, mounted in the same mechanical structure with independent high voltage and sharing a common readout plane of strips.

Each chamber is composed of two plates of bakelite, a phenolic polymer with high volume resistivity, separated by a 2 mm gap. The outer faces of the bakelite plates are coated with a conductive graphite paint on which the high voltage is applied. Planarity of the plates is assured by PVC spacers.

These detectors have been initially used as veto counters for cosmic radiation in non-accelerator (NADIR) and accelerator experiments (FENICE) and later exploited as muon detectors in large area cosmic ray physics (COVER PLASTEX) as well as in fixed target beauty production experiments - E771 at Fermilab and WA92 at CERN.

The L3 experiment at CERN's LEP electron-positron collider has used some 300m^2 of RPCs as muon trigger. At present RPCs are the approved muon detector baselines for ATLAS and CMS at CERN's LHC proton collider and BaBar at the SLAC B factory.

The increasingly severe environments in which the RPCs are supposed to operate - high intensities, large backgrounds, tight safety requirements,.... - require special attention.

The recent Workshop played an important role in bringing together experts and comparing different experimental approaches on major issues such as working mode (the merits of avalanche vs streamer mode), new electronics for avalanche mode, new freon gases and new resistive materials, wide gap and glass RPCs.

The Workshop was opened by R. Santonico (developer of the first detector) who presented results on 2mm gas gap bakelite RPCs operated with a new ecological freon ($C_2H_2F_4$ instead of the standard CF_3Br) in a low gain gas condition. He discussed operating the RPC in the "avalanche mode", the precursor of the streamer. In this mode the signals are very small and front-end preamplification is needed: on the other hand the operating voltage can be kept below 10kV (where the streamer condition begins to appear) allowing a significant decrease of power dissipation. The collected saturation charge is of the order of 1 pC and typical time distributions have a jitter width of 4.5ns.

The rate capability has already been tested by the ATLAS collaboration (full efficiency up to 1-2kHz/cm^2) with the standard freon but it is hoped that such behaviour can be well reproduced with the new gas.

Interesting results were shown on the behaviour of different gap sizes (2, 5, 6 and 8mm) with melamine electrodes. The measurements, made on small RPCs, show that wide-gap RPCs have smaller dynamic range, leading to small average charge, high rate capability and low power consumption. However the operational voltage is high (16 to 19kV, depending upon the gas mixture used).

The issue of surface treatment of the standard bakelite RPCs was discussed. Internal electrode treatment helps operation with lower current (a factor 4) and noise counting rate (a factor 10) compared to non-treated bakelite electrodes.

Several talks then reported on the use of electrodes made of different material such as plastic (ABS) or glass.

The general feeling emerging from the Workshop was that much effort has gone into understanding the performances of the detector. Ongoing studies are likely to reveal RPC potential and versatility. First order problems have been solved but more systematic studies are needed. There was a consensus that a "new generation" of RPCs (new freons, new front-end electronics) will be able to operate with full efficiency at the high fluxes foreseen at CERN's LHC.

The Workshop was sponsored by the local Istituto Nazionale di Fisica Nucleare, the University of Pavia and the Fulbright Foundation.

From Sergio Ratti, Pavia

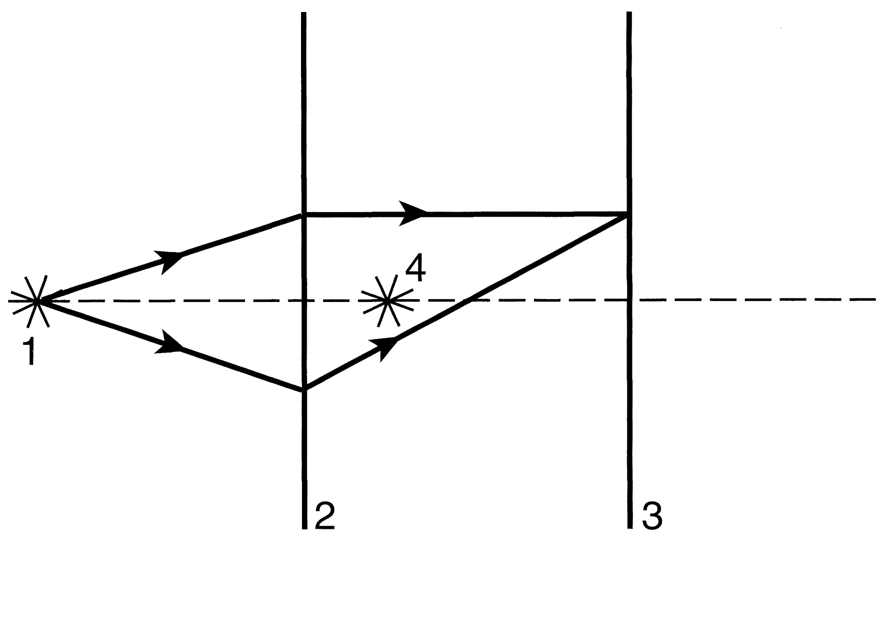
QUANTUM MECHANICS
Now you see it, now you don't

Ever since the development of quantum mechanics in the 1920s as the ultimate description of microscopic objects, great minds have agonized over baffling conundrums which appear to arise when quantum behaviour has to be reconciled with everyday experience. However physicists who eat and drink quantum mechanics dismiss these agonies as unnecessary intellectual masochism. These physicists point out that such conundrums occur because non-quantum mechanical concepts and/or prejudices are imposed on a quantum scenario.

With the behaviour of individual quanta difficult to monitor, quantum physics has often had to rely on imaginary 'gedanken' experiments organized by such intellects as Werner Heisenberg or Richard Feynman. Now a delicate new experiment by an MIT/Innsbruck team using an atomic interferometer underlines the validity of these classic thought experiments.

The classic example of a quantum 'conundrum' is a beam of electrons - particles - passing through two closely separated slits. A screen on the far side of the slits shows the characteristic bands of electron diffraction. In some places on the screen there are many electrons, while in others there are less - the screen is 'dark'. For these dark bands, blocking one slit increases the number of electrons coming through from the other. The electrons clearly behave as waves.

But the electrons are particles, and as such any one electron has to go either through one slit or the other, but not both. How can this be reconciled with the wave-like behaviour?



The ultimate quantum experiment. Electrons from a source (1) passing through a pair of slits (2) form a pattern on a screen (3). Introducing a light source (4) allows one to tell which of the two slits a particular electron has passed through.

In his classic book 'The Feynman Lectures on Physics', Richard Feynman concludes - the electrons arrive in lumps, like particles, and the probability of arrival of these lumps is like the distribution of intensity of a wave. It is in this sense that an electron behaves "sometimes like a particle and sometimes like a wave".

However it is when this wave behaviour is put to the test that 'problems' arise. Feynman proposed an imaginary experiment, with a light source on the far (screen) of the two slits, and placed midway between them. Electrons reflect light, and in this case the reflected flashes show how the electron has passed through the slits. Monitoring the passage of individual electrons in this way would clearly show that they either go through one slit or the other. Blocking one slit does not favour the other. The wave behaviour has somehow been destroyed when the extra light source was brought in to try to follow the electrons. How?

It is another example of Heisenberg's celebrated Uncertainty Principle - the very act of trying to observe what is going on affects what is going on.

In the new MIT/Innsbruck experiment, individual photons (from laser-excited atoms) bounce off sodium atoms as they pass through slits. The experimenters clearly see a change in the diffraction bands, with the band contrast decreasing as the distance between alternative atomic paths increases. As Feynman predicted, the wave picture gradually disappears.

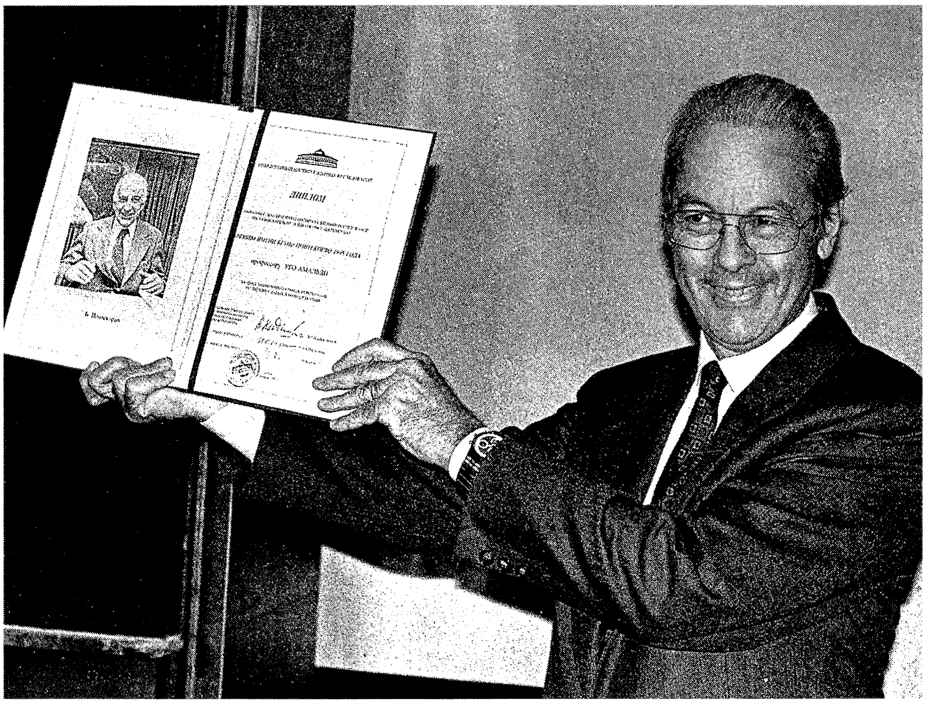
However as the distance between alternative atomic paths decreases, there comes a point (about half the wavelength of the illuminating photons) where the information from the reflections can no longer tell which of two alternative paths an atom has taken. With no artificially introduced certainty, the wave picture remains valid.

Reference

M.S. Chapman et al, Physical Review Letters, Vol. 75, p. 3783 (1995)

People and things

Ugo Amaldi of CERN receives the 1995 Bruno Pontecorvo Prize of the Joint Institute for Nuclear Research, Dubna, Russia, for his experimental contributions to the study of weak interactions.



On people

On 2 February Gerard 't Hooft of Utrecht received a doctorate honoris causa from the Katholieke University, Leuven, Belgium. As well as his famous contributions to theoretical physics, he is honoured for his work in bringing modern theoretical physics to a broad Dutch-speaking audience.

Paul Williams, Chairman and Chief Executive of the Council for the Central Laboratory of the Researchers Councils (CCLRC), which runs the (now combined) UK Rutherford Appleton and Daresbury Laboratories, received the award of CBE in the UK New Year Honours list.

A programme on Pakistan TV recently marked the 70th birthday of Abdus Salam, the only Pakistani ever to win a Nobel Prize (1979). Stricken by a debilitating handicap, he is presently in Oxford, UK.

New Director at Frascati

Paolo Laurelli has been appointed Director of the Frascati National Laboratories of INFN for the next three years, succeeding Enzo Iarocci who held the position for the past six years.

Born in 1947, Laurelli took his Physics degree at Pisa in 1970 with Giorgio Bellettini as advisor in an experiment at the CERN PS. All his experimental work was carried out at CERN, where he was also a Visiting Scientist in 1974 and in 1981. From 1971 - 1978 Laurelli was involved in two ISR experiments: the measurement of the total proton-proton cross-section and of lepton pair production. Then he worked at the SPS on the coherent photo-production of charmed mesons.

As member of the Aleph collaboration since 1983, he became, in 1992, spokesman for the Italian groups, succeeding Lorenzo Foà.

In addition to his interest in the physics of each experiment, Laurelli has also followed the technical development of detectors: in particular he took care of the establishment in Frascati of the "tubificio", where streamer-tube calorimeters are built for many experiments.

At present he is a member of the International Virgo Council, responsible for the Pisa Virgo gravitational interferometer.

A.M. Baldin 70

On 26 February, a special seminar at the Joint Institute for Nuclear Physics (JINR), Dubna, marked the 70th birthday of Academician A.M. Baldin. At Moscow's Lebedev Institute of Physics in the late 1940s, under the guiding influence of such masters as D.V. Skobeltsin, M.A. Markov, P.A. Cherenkov, V.I. Veksler and I.E. Tamm, he made important contributions to the JINR synchro-phasotron project and to theoretical aspects of particle production and nuclear optical anisotropy.

In the late 60s, appointed as director of JINR's Laboratory of High Energies, he opened up the field of experimental relativistic nuclear physics. Under his directorship, the huge and ageing synchrophasotron was converted into a light ion and polarized deuteron machine, attracting wide interest. Its successor, the superconducting Nuclotron, was recently commissioned.

At Dubna, he has always played an additional important role as a leading theorist, introducing fruitful ideas on

Celebrating his 70th birthday in February is A.M. Baldin (right), seen in this archive photo explaining superconducting magnets to the late N.N. Bogoliubov (left), and L.G. Makarov.

particle production and asymptotic behaviour. As a member on the JINR Directorate, his boundless energy and optimism furthers the cause of fundamental science during a time of rapid change in Russia and in the JINR Member States.

In his youth he achieved fame as a mountain climber, gaining a title as Soviet champion.

SLAC Summer Institute

The XXIV SLAC Summer Institute on Particle Physics 'The Strong Interaction from Hadrons and Partons' will be held in Stanford from 19-30 August. Further information from World Wide Web http://www/slac.stanford.edu/gen/meeting/ssi/next/ssi96.html

Meetings

June 19-21, 1996: XVI International Conference on Physics in Collision (PIC'96), Mexico City. Contact Heriberto Castilla, CINVESTAV, Chairman, Local Organizing Committee; Telephone: (52)(5)747-7098; Telefax (52)(5)747-7002; E-Mail: physcoll@fis. cinvestav.mx

Juan Jose Giambiagi

When on 8 January Juan Jose Giambiagi passed away in Rio de Janiero, a guiding light of Latin American physics was extinguished, someone who had shown what a conscientious scientist must and can do in the Third World.

After graduating at Buenos Aires and postgraduate studies at CalTech, he returned to lead the group of Argentinean physicists who, at the end of the fifties, set the tone for the "golden decade". In these few years, physics not only was resurrected in Buenos Aires, but reached heights that could compare with those achieved in advanced countries.

This terminated abruptly in 1966 during the "night of long sticks", when the military occupied the Science Faculty and literally beat up everybody, forcing them through a double rank of soldiers. A large majority of the Faculty resigned, causing the exodus of first-rate Argentinean scientists around the world.

Giambiagi was so shocked that he resolved to stay in Argentina. With a research grant he continued to work at home, in an apartment baptized by his friends as "Instituto Juan Carlos Ongania", after the military dictator who forced its creation by disrupting the University. Together with Bollini - another first-rate Argentinean scientist - he did very good work. During this period they wrote the well-known paper in which they first proposed the dimensional regularization.

When the situation normalized at the beginning of the seventies, he resumed a university professorship at La Plata that, once again, managed to shine in physics. The subsequent wave of repression sent him first home and then out of the country to escape physical danger. He was one of the many Argentinean physicists (part of this second diaspora) who found friendly hospitality in Brazil and contributed to the scientific progress of that country. He worked at the Centro Brasiliero de Pesquisas Fisicas, and for two terms was Director of the Latin American Center for Physics. From this position he continued his relentless effort to encourage the development of Science in Latin America.

He received a large number of rewards and distinctions (from Argentina too once democracy had been reinstalled), acknowledging his scientific stature, his impact as a teacher and his tireless efforts to promote science.

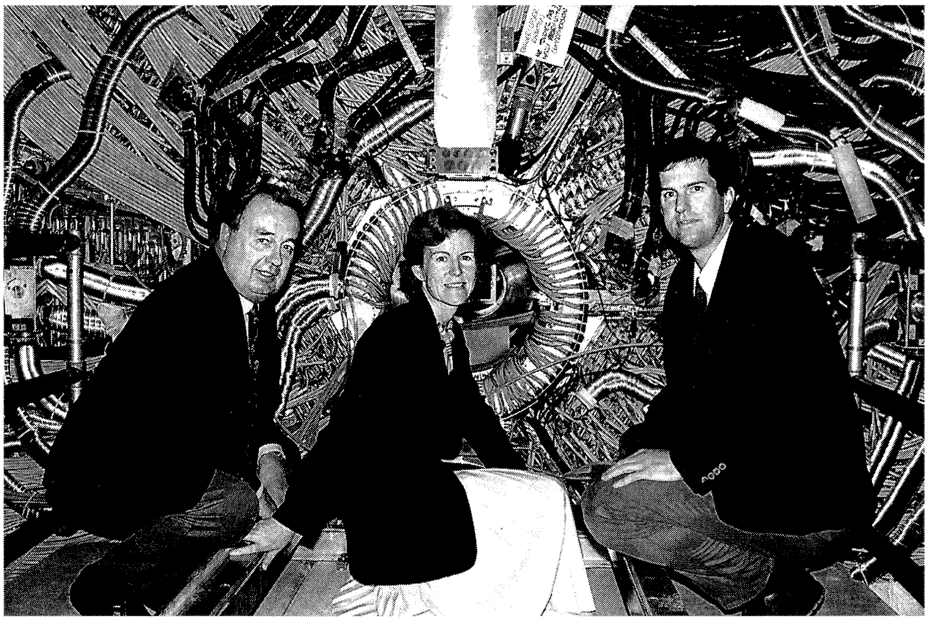
He was scientifically productive up to his last days. Beloved teacher and warm personality, he had many

Czech Minister of Industry and Trade Vladimir Dlouhy (centre) enjoys a ride on the CERN LEP monorail with CERN Council Vice-President and President of the Czech Academy of Science Council of International Cooperation Jiri Niederle (left) and Maurice Jacob, in charge of CERN's relations with Member States. (Photo HI 21 01.1996)

disciples and friends around the world who will remember with emotion his smile and sparkling eyes, which sought to understand and see beyond what was superficial.

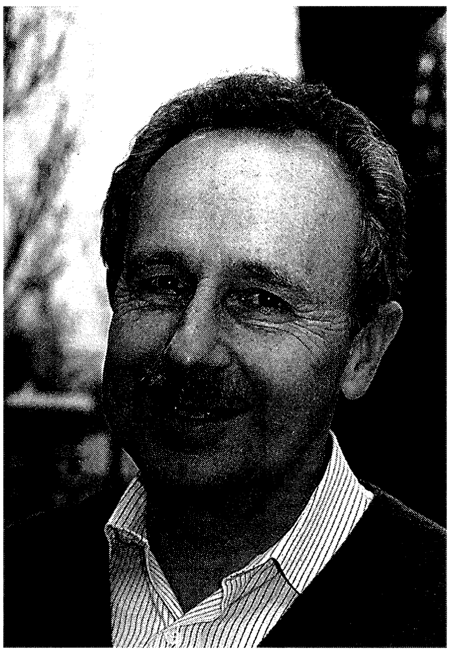
Daniele Amati

(As well as Buenos Aires and Rio de Janeiro, Juan Jose Giambiagi also spent time at Manchester (UK) and at Caltech, where he worked with Murray Gell-Mann. His dimensional regularization paper with Bollini paralleled work done independently by G. 't Hooft and M. Veltman.)

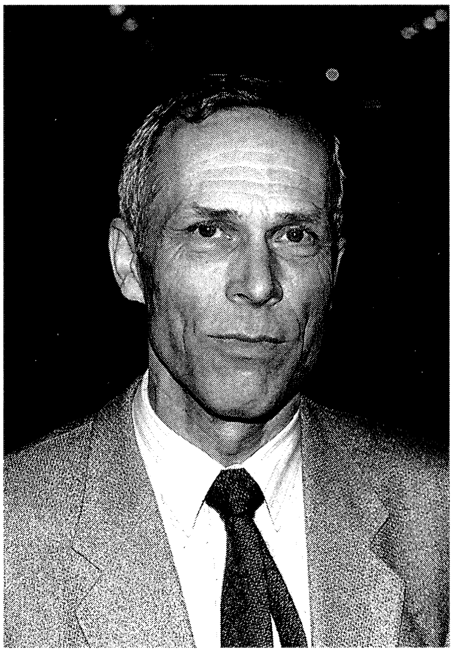


Anne Anderson, Ireland's Permanent Representative to the United Nations and other international organizations in Geneva, at the Aleph experiment at LEP with (right) Roger Forty of CERN and Norman Blackburne, Head of CERN's Directorate Services Unit.

Bo Angerth is the new Leader of CERN's Personnel Division, succeeding Willem Middelkoop.



Dietrich Güsewell is the Leader of CERN's new Engineering Support and Technologies (EST) Division.



CERN Courier contributions

The Editor welcomes contributions. These should be sent via electronic mail to courier@cernvm.cern.ch Plain text (ASCII) is preferred. Illustrations should follow by mail (CERN Courier, 1211 Geneva 23, Switzerland). Contributors, particularly conference organizers, contemplating lengthy efforts (more than about 500 words) should contact the Editor (by e-mail, or fax +41 22 782 1906) beforehand.

TENURE-TRACK FACULTY POSITION
EXPERIMENTAL HIGH ENERGY PHYSICS
THE OHIO STATE UNIVERSITY

The Department of Physics invites applications for a tenure-track faculty position in Experimental High Energy Physics, effective October 1, 1996. Our goal is to expand our High Energy Physics program and to start a group preferably working in hadron collider physics. The successful candidate will lead this effort. Depending on the applicant's qualifications, the appointment will be made at the Assistant, Associate or Full Professor level.

The Ohio State University physics department currently has 46 faculty members covering research areas in experimental and theoretical atomic, molecular, condensed matter, nuclear and high energy physics, and theoretical astrophysics. The experimental high energy group presently consists of six faculty members who are conducting experiments in electron-positron annihilations with the CLEO collaboration and in electron-proton collisions with the ZEUS collaboration at DESY, Germany. Future commitments of our current faculty include proton-proton collider physics with the CMS collaboration at the LHC, and the CLEO-III upgrade at Cornell.

Interested applicants should send a resume, a description of scholarly achievements and research interests, and at least three letters of reference to: Professor Klaus Honscheid, Department of Physics, The Ohio State University, 174 West 18th Avenue, Columbus, OH 43210-1106 USA. Applications should arrive no later than May 1, 1996 to receive full consideration. The Ohio State University is an Equal Opportunity/Affirmative Action Employer. Qualified women, minorities, Vietnam-era Veterans, disabled veterans and individuals with disabilities are encouraged to apply.

RESEARCH ASSOCIATE POSITION
Experimental High Energy Physics
Carnegie Mellon University

The Department of Physics at Carnegie Mellon University invites applications for a postdoctoral Research Associate position in experimental high energy physics. The individual who fills this position will work at the ongoing L3 experiment at LEP and on detector development for the future CMS experiment at the LHC, both on-site at CERN and at Carnegie Mellon. Applicants should submit a curriculum vitae and arrange to have three letters of recommendation sent directly and as soon as possible to:

Professor Helmut Vogel
Department of Physics
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213, USA
e-mail: vogel@cmphys.phys.cmu.edu

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As a senior hardware designer, you must also possess strong system design and related analog, digital and mixed mode design skills. You must be able to design analog front ends. When there are no existing solutions, you will participate and contribute to the specification and design of new custom monolithics. You'll also design high speed digital circuits implemented in discrete logic, programmable logic, FPGAs and gate arrays. Many designs will require use of ECL or other differential, high speed logic. Low noise design skills, good understanding of transmission line theory, printed circuit board layout techniques and high density packaging techniques such as Hybrids, MultiChip Modules and daughter cards also essential.

We require 10+ years experience in design and development engineering, including relevant experience with modular data acquisition products such as VME, CAMAC, FASTBUS or VXI. Five years experience in project or engineering group leadership, some familiarity with C and C programming and a BSEE essential. An advanced degree is preferred.

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