LNS NEWS

Laboratory for Nuclear Science

M.I.T. Cambridge, Ma.

June 20, 1988 Vol. 6 No. 3

Comings and Goings

Michael Bershadsky is a Sponsored Research Staff member at the Center for Theoretical Physics. Mr. Bershadsky is a particle physicist with interests in conformal field theory and string theory.

Manouchehr Farkhondeh has returned to Bates where he received his Ph.D. in 1984. Manoucher will be working on the polarized source, cryogenic targets, and the out-of-plane spectrometer, preparatory to partaking in experiments requiring successful completion and testing of these units. Two of these experiments are a measurement of the fifth response function of the deuteron and a measurement of the electric form factor of the neutron.

Umberto (Bob) Fazio has returned to the LNS Machine Shop from the Nuclear Reactor Machine Shop.

Samir Jarrah is a Northeastern Coop student majoring in Electrical Engineering and is working at the Computer Center.

Shui-Ngor-Kwan is working at the Computer Center and is a Northeastern Coop student majoring in Electrical Engineering.

Diana Bertozzi has joined the summer clerical staff and has recently completed her first year of college. **Julia A. Sechen** has returned to assist the Purchasing Office for the summer. Julia is entering her senior year at North Carolina State University at Chapel Hill.

William Both will be leaving Bates on June 30 to take an early retirement. Bill has been the RF engineer and leader of the Operations Group.

Michel Garcon has returned to Saclay after several years residence at Bates working on the tensor polarization experiment.

Judy E. Gould a Sponsored Research Administrative Staff member with the Heavy Ion Group terminated on February 29, 1988. Recently Judy received a Master of Arts degree in Counseling Psychology, magna cum laude from Lesley College, Cambridge.

Christopher Maher will be leaving Bates to work at the University of Pittsburgh Super Computing Center.

Bob Terenzoni will be retiring in June after 31 years at the Institute. A farewell luncheon was held in **Bob's** honor at the Danversport Yacht Club on Wednesday, May 25. We all wish Bob "good luck" in his future plans. Thanks to **Jim Grenham** for planning a most enjoyable event.

Noteworthy Notes

An emergency student loan fund in the College of Allied Health Science at the University of Tennessee, Memphis, has been named for **Alice Scott Hitt**, sister of **Elizabeth Scott Hafen**. Dr. Hitt taught chemistry, was organizing a graduate program in the College, and writing a computerized chemistry study program for a MacIntosh when she died of cancer in February. The fund is administered by the University of Tennessee, Memphis, Offices of Development, 62 S. Dunlap, Suite 500, Memphis, Tennessee 38163.

George Sechen, Jr. will be attending Keene State College, Keene, N.H. in September. George is employed at Bates for the summer.

Mario Aloisi's photo appeared in the March 1988 issue of Sports Inc. Magazine. The accompanying article was titled "Concession Deals Changing," and focused on concessions and Sports service facilities. Mario works part-time nights at Boston Garden. **Mario** now has fourteen grandchildren. His fourteenth grandchild was born May 11, 1988 and was named **Brittany**.

Keith Adams, son of **Richard Adams**, graduated from Colby College, Waterville, Maine, cum laude with distinction in Biology.

Wade Sapp received an Independent Activities Period Prize for his IAP Tour of Bates and talk on the "Atom Smasher." Dean Margaret MacVicar donated the funds for this prize to recognize outstanding contributions to IAP.

Chanthini Gonzalez, daughter of Donna Paul, LNS fiscal Office, is 6 1/2 years old and a student at the Rosa Parks Day Care Center in Dorchester. Chanthini is a lady in waiting for the Spanish Festival "Santiago Apostol" held annually in Boston's South End.

Cheryl Murphy of the LNS Purchasing Office and **Joseph Cagnina** were married on February 28, 1988. The ceremony was held at their Woburn home and attended by Joseph's two daughters Karen and Amy Cagnina and Cheryl's sisters Kathy Niborski and Betty Butcher. Kathy surprised her sister by flying in from Detroit, Michigan to be with the bride and groom on their wedding day. The events of that Sunday afternoon came as a big surprise to Joe and Cheryl's families and friends.

The LNS Quarks combined forces with the Space Penguins of the Manned Vehicle Lab to compete in the **Johnson Games**. Thirty-two teams participated in the competition which took place on Saturday, April 23, from 11 a.m. to 3 p.m and was followed by the Athlon Ball that evening. The events were: Tug-of-War, Pentathlon, sack race, relay with four legs and 3 in a sack, Run

Chug (relay chugging soda) Howard Sez (similar to Simon Says), Volleyball, a trivia contest, and the Johnson Squeeze. For the Johnson Squeeze the team formed a compact huddle which was measured in circumference and divided by the number of people.

Our cheer summed up our winnings pretty well, **"Like Masters and Johnson we do what we please: We're first in the Sack and first in the Squeeze."** My son Brett was the most proud team member when his entry in the sack race helped lead the team to victory in that event.

We finished in a respectable 15th place. Each team member received a souvenir team tee shirt. We were out there to have a good time and we did. The camaraderie of the team helped to make the day's events enjoyable and worthwhile. Marita and I would like to thank all the members of the Johnson Games LNS Quarks for taking time out to participate.

The teams members were:

Betsy Beise	**Kristina Isakovich**	**Martin Sarabura**
Brian Cole	**Stanley Kowalski**	**George Sechen, Jr.**
Jim Costales	**Eric Kronenberg**	**George Sechen**
Ron Dagostino	**Katya Moniz**	**Sivan Silverman**
Frank Flanagan	**Ernest Moniz**	**Bernard Wadsworth**
Jean Flanagan	**Patty Ryan**	**Dave Woodruff**
Brett Greene	**Nicolas Ryan**	**Terry Yates**

Captain - Marisa Greene
Co-Captain - Marita Filios

--Marisa Greene

Donna Henderson of the LNS Headquarters Office will be entering Mass. General Hospital June 23 for an operation. Donna will be in the hospital for approximately a 3-week stay and then recuperating at home for a month.

News from Bates

Tzong-Shyan Ueng has just received his Ph.D. at the University of Virginia. His thesis was based on data taken at the Bates Center and is titled, "Electron Quasielastic Scattering Production from ^{3}H and ^{3}He."

We are very sad to report the untimely and shocking death of Michael Rodgers in an automobile accident. Mike was an RPI graduate student in residence at Bates, where he was working toward his Ph.D.

We welcome back **Sheila Dodson** from the 3rd Conference on the Intersections between Particle and Nuclear Physics held at Rockport, Maine May 14-19. Sheila worked on the detailed planning of the Conference, coordinating travel, arranging for the Conference office supplies, and assisting the attendees.

Recent group visits to Bates include the North Shore Section of IEEE, whose tour on March 8 was led by **Jay Flanz**, **Ken Jacobs**, and **Dan Tieger**, the Coast Guard Auxiliary Flotilla 403 Personnel were given a CPR course and tour on March 19 by **Dick Keating**, who is also a member of the group; and the Physics Club of Eastern Nazarene College (Quincy), who were hosted by **Ken Jacobs**. Middleton and Danvers Fire Department officers also toured the facility under the guidance of **Gerry Fallon** and **Dick Keating**. The **Radiation Officers** participated in all the tours and we appreciate their cooperation.

--W. Lobar

Professor John Negele has been appointed Associate Director of the Center for Theoretical Physics. He will replace **Professor Jeffrey Goldstone** as Head of the Theoretical Physics Division of the Department of Physics and will represent the Center on the Physics Council. Prof. Negele will begin his new duties on July 1, 1988.

LNS PHYSICS NEWS

June 20, 1988

Deuteron Tensor Polarization in Elastic Electron Deuteron Scatteriing

The experiment was completed in mid-May 1988. The Bates Laboratory delivered a stable and high-intensity electron beam during several run periods. The 850 MeV energy constitutes a new record for the linear accelerator.

This measurement of the tensor polarization observables t_{20} and t_{21} in elastic deuteron scattering allows the separation of the charge and quadrupole form factors of the deuteron on a region of momentum transfer where it will provide a stringent test of various models of the underlying nuclear structure.

Three major technical developments were implemented successfully:

1. A high cooling power liquid deuterium target
2. A deuteron magnetic channel
3. The AHEAD polarimeter based on deuteron-proton scattering.

Turning Up the WIC

For most of SLD (Stanford Linear Detector) the start of magnetic measurements in February represented a beginning -- the first visible activity centered on SLD as a whole detector rather than as a set of somewhat disconnected parts. For the Warm Iron Calorimeter, on the other hand, it's an ending -- the completion of the mechanical installation of the barrel WIC. In order to get to this point, the LNS Counter Spark Chamber Group has built, shipped, assembled, tested and installed 5036 modules in 554 chambers covering a total surface area of about three-quarters of an acre.

The end of the barrel installation, though only just past the halfway stage in terms of channel numbers, represents a watershed for the WIC.

The barrel chamber production line stretched across the Atlantic, with the basic components -- graphite coated PVC profiles and copper-clad Glasteel readout electrodes -- produced in Italy and put together in California with a stop in Illinois for stringing. Considering the formidable logistical problems, it is a great tribute to all the contributing institutions that the finished chambers kept rolling off the end of the line more or less on schedule.

The endcap chambers differ in several details of construction from the barrel. The PVC extrusions are made and painted in Italy as before, but the remainder of the construction is all done at the LNS-MIT Campana factory near Batavia, Illinois.

The Glasteel sheets are routed using the Gerber machine at Fermilab. As a result, several of the production facilities used for the barrel have now closed, notably the chamber lamination factory at SLAC and the Glasteel routing facility at Perugia. The production of coated profiles has recently been restarted to provide a stock of spare modules so that we can afford to risk some in a new life test.

Although the WIC can now boast of being the first SLD detector group to 'complete' an installation, the pressures of the SLD schedule have not lifted. Since the advent of magnetic measurements temporarily prevented electronics installation in the barrel, we are now processing endcap chambers.

In the endcap chambers, the modules comprising a chamber are not glued directly to the Glasteel sheets, but are housed in secondary PVC sleeves, so that a faulty module can be slid out and replaced at any stage. Modules and 'empty' chambers are shipped separately, and the modules go through an extensive period of acceptance testing at SLAC before being inserted into chambers. Finally each completed chamber is cosmic-ray tested using the old MAC data acquisition system at PEP region 4 before being approved for installation.

Both module acceptance and chamber cosmic-ray tests take place in the MAC area, which is 28 feet wide. It is therefore a fact of some importance that the endcap chambers and their supporting racks are 29.5 feet long (9m), in contrast to the 7m barrel chambers. To add to the confusion, for various technical reasons the connectors on the endcap chambers are different from those on the barrel chambers. These facts have occasioned much scratching of heads, drawing of floor plans, construction of cable adapters and cleaning out of MAC-related antiques (what am I bid for several dozen assorted chunks of machined aluminium?). However, fitting quarts into pint pots is becoming a WIC speciality, and we are confident that everything will go in eventually. The longer chambers have already caused the Campana factory to diversify into heavy engineering, with the construction of a longer trailer and assorted chambers and module storage racks.

Almost all the modules required for the north endcap are now at SLAC, as are the first three planes of chambers. However, the present focus of construction work is on the so-called 45^o chambers, which are destined to be attached to the arches and the doors to complete the muon coverage. (The 45^o refers to the polar angle that the chambers are intended to cover, not to their orientation!).

These require rather more construction effort from SLAC than the standard endcap chambers, since they go on the outside of the detector and must therefore be encased in steel boxes to prevent enraged engineers from damaging them when they get in the way. It seems to be a fact of SLD life that everything gets in the way sooner or later. The first eight of these have already been delivered to the MAC area for cosmic ray testing.

Meanwhile the installation of the barrel chambers has also led to the first detailed consideration of how the completed WIC should be commissioned and debugged. At present the chambers have no electronics, but this will be remedied soon. The high voltage distribution boards are already available and the first 20 pre-production strip readout boards have been delivered to Pisa for testing. A prototype of the pad electronics, designed and built at LNS, has been tested at SLAC, and the hybridization of this in progress.

The principal R&D remaining in the WIC is the search for alternative gas mixtures. The recent increase of interest in this subject has been sparked (no pun intended!) by the imminence of commissioning, and indirectly by the fire at Fermilab. The canonical Iarocci tube gas of 75% isobutane, 25% argon is extremely flammable, and therefore unsuited to commissioning work when the full SLD safety systems may not be in operation.

A recent suggestion (Aachen report PITHA-87/16) that pure CO_2 may be a suitable gas naturally produced a great deal of excitement in the WIC group. Unfortunately two groups of WICkers (LNS/Campana and SLAC) independently failed to reproduce these results. Work on almost-pure-CO_2 mixtures, however, has yielded an extremely promising candidate of CO_2/argon/isobutane in the proportion 88:2:10. This mixture is almost non-flammable and in fact seems to yield a slightly better resolution than the standard gas mixture. WIC groups at Perugia and SLAC are presently working on fine-tuning the proportion of argon. We expect to start a life test with this gas on March 1 with about 400 modules.

All in all, 1987 was a productive -- if hectic -- year for the WIC group, and so far 1988 looks set to be at least as busy. On the other hand, we can point to the barrel WIC as the first detector component to be in place in SLD. If the commissioning proceeds on schedule, in a few months we should be able to describe it as the first detector component to be working in SLD!

--Susan Cartwright*

*reprinted with permission from Susan Cartwright and William Ash, <u>SLC Newsletter #29</u>, 1 March 1988.

Susan Cartwright is a Sponsored Research Staff member with the **Counter Spark Chamber Group** at SLAC.

The Search for a Quark-Gluon Plasma

A relatively new area of interest in nuclear physics is the experimental study of nuclear matter at high densities and temperatures. According to Professor Robert J. Ledoux experiments which may produce such matter by colliding heavy nuclei together have made some recent advances. Statistical model calculations of quantum chromodynamics (QCD) predict that hot, dense nuclear matter, when compressed to an energy density about ten times that of ground state (normal) nuclear matter, may undergo a deconfining phase transition. Under such conditions the individual quarks which are normally bound tightly into the nucleons may move relatively freely in a volume large compared to that of a nucleon. This many body state of quarks and gluons is called a quark-gluon plasma (QGP). The fundamental goal of the research is to produce a QGP and use it to study QCD.

Experiments in this field currently use accelerators originally designed for protons to accelerate ions and collide them with fixed targets. At Brookhaven National Laboratory,(Upton, N.Y.) the Alternating Gradient Synchotron (AGS) currently provides silicon beams at energies of 14.5 GeV/nucleon. At CERN, (Geneva, Switzerland) the Super Proton Synchotron (SPS) provides sulfur beams at energies up to 200 GeV/nucleon. The best energy for stopping (in the center of mass) colliding heavy nuclei is thought to be somewhere between these two energies. Such collisions might produce extended nuclear matter with very high baryon densities. At higher collision energies, it is expected that there will be a region of lower baryon density, but very high energy density, which might lead to a QGP. One way of increasing the energy densities over large volumes is to increase the mass of the colliding nuclei. Thus, Brookhaven is building a new AGS booster that can accelerate gold ions to 12 GeV/nucleon, and CERN is planning a 180 GeV/nucleon lead injector for the SPS.

Unfortunately, these proton accelerators all have single magnet rings, which are sufficient for colliding beams of countercirculating protons and antiprotons because the beams are oppositely charged. Colliding countercirculating ion beams, which are always both positively charged, requires a double magnet ring. The nuclei in all the experiments discussed above collide with fixed targets, and hence their center of mass energy is much less than the beam energy in the lab frame. Theorists have calculated that even the highest energies available at the SPS may be too low to produce a QGP. To solve this problem, a machine called the Relativistic Heavy Ion Collider (RHIC) has been planned. To be located at Brookhaven, it would provide countercirculating 100 GeV/nucleon gold ion beams by the mid 1990's This would mean 10 times the center of mass energy per nucleon than that available at the SPS. However, funds for construction of this machine have not been approved. (For more information on the accelerators see "Search and Discovery," Physics Today, March 1988).

Ledoux explained that there are several problems that must be surmounted before a QGP can be detected. First, as already explained, the energy densities of the collisions must be increased. It is estimated from data obtained in experiments at the AGS that energy densities of about five times that of ground state nuclear matter have been produced. The energy density of ground state nuclear matter is approximately .15 $GeV/fermi^3$. CERN has achieved an energy density of about 2 $GeV/fermi^3$. This is believed to be right around the value necessary to produce a QGP. Another problem is that the transition to a QGP may not exist at all. Finally, if it does exist, the QGP may be difficult to distinguish from a very hot, very dense hadronic gas. This means that it is not definitely known whether or not there is a detectable difference between the observable degrees of freedom of quarks and gluons in the QGP, as opposed to those of the pions and nucleons of a hot hadron gas.

It is this latter area that recent experiments have been yielding some clues. It was suggested in 1986 that a possible signature of the early stage of the QGP would be the "melting" of J/psi particles. As an example, in a plasma of electrons and positive ions, bound states (atoms) are prevented from forming by electromagnetic "screening." It is thought that a QGP would, in a similar manner, screen the color force that binds quarks. Since the J/psi is a combination of a heavy charmed quark and a heavy anticharmed quark, many would be dissolved by the QGP, and the number of J/psi particles observed should be less in a head-on collision, where the chances of forming a QGP are higher than in a glancing collision. One experiment at CERN, which used oxygen beams at 200 GeV/nucleon, has seen exactly this effect. However, Ledoux cautions that there may be other explanations for this suppression, such as rescattering of J/psi's in the surrounding nuclear matter.

The other interesting observation comes from Brookhaven. Experiment E802 consists of magnetic spectrometer which measures particles produced in 15 GeV/nucleon silicon + nucleus collisions. The E802 is a collaboration of Argonne National Laboratory, Brookhaven, Columbia University, M.I.T., the University of Tokyo, and the University of California. Working at MIT on this project are Professor Lee Grodzins, Professor Ledoux, Dr. Steadman, Dr. Stephans, Dr. Woodruff, Ms. Neal, and 8 graduate students. Data from this detector revealed that the ratio of $K^+/\ ^+$ particles is much higher for the collisions of nuclei than for collision of two protons by a factor of about 4. This is thought to be evidence that the baryon densities in the AGS collisions are very high. Again, there may other explanations. One possibility is that a rescattering of pions through the surrounding nuclear matter could produce kaons, increasing this ratio. This would mean that the result would have nothing to do with the possible transition to a QGP. Theorists are presently trying to calculate whether or not this effect will be significant. Ledoux feels that the results of these two experiments are encouraging and that there is a possibility that quark-gluon plasma may eventually be found.

--David Bitko

This article has been reprinted with permission from the **Undergraduate Newsletter, May 11, 1988**.

7840 BGO Crystals at CERN

On March 28, 1988 the last batch of a delivery of a total of 7840 BGO (bismuth-germanate) crystals to be installed in the central region of the Electromagnetic Calorimeter of the L3 Experiment arrived at CERN.

These crystals have very specific characteristics ensuring that the demands towards the optimum operation of the Electromagnetic Calorimeter are fulfilled. Most important are the high density and the clear transparency of the crystals. The choice of BGO as detector material guarantees that the electromagnetic showers produced by penetrating particles are fully contained in the very compact calorimeter and that the energy of those particles is measured with high precision.

The production of these crystals itself was an excellent example of international collaboration in high energy physics. All high purity GeO_2 which was needed for the crystal production was delivered by the Soviet collaborators in the L3 experiment, namely ITEP Moscow and LNPI Leningrad, to CERN. Here quality controls were performed through the University of Lausanne. This raw material was sent afterwards to the Shanghai Institute of Ceramics (SIC), People's Republic of China, where the BGO crystals were grown. Cutting and polishing of the crystals were also performed in Shanghai using methods and techniques developed by members of the L3 Collaboration from LAPP Annecy.

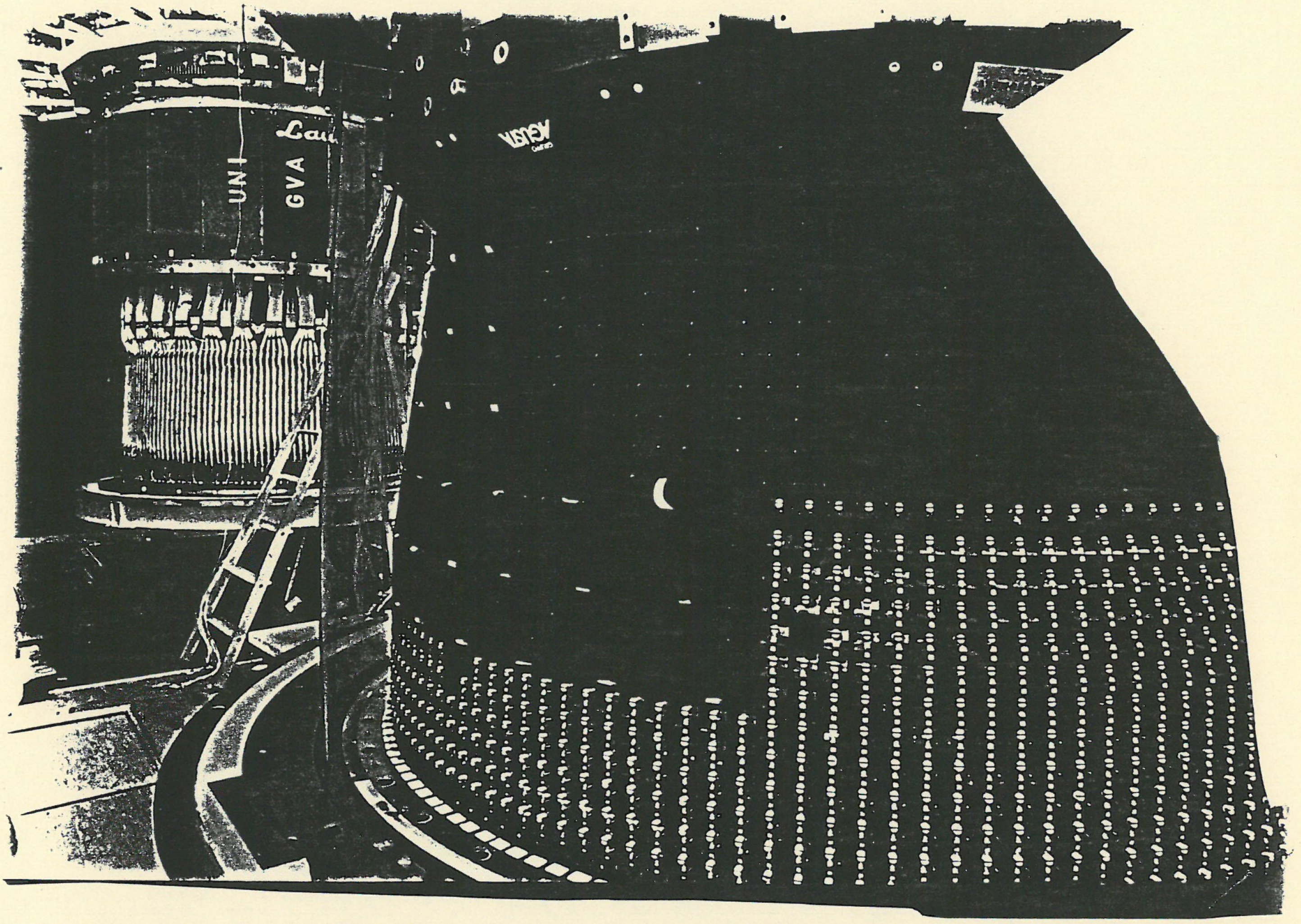
Up to about 400 BGO crystals per month have been delivered by SIC to the L3 Collaboration at CERN. This quantity is to be compared to a few tons of BGO crystals produced per month for high energy physics applications before the L3 project started. The excellent quality and good performance of the BGO crystals produced in collaboration with the Shanghai Institute of Ceramics manifests itself in the fact that essentially all crystals fulfilled the tight optical and mechanical specifications and that the delivery of BGO crystals was completed several weeks ahead of schedule.

Upon receipt at CERN all crystals were subjected to quality controls performed by scientists from CERN, MIT, University of Lyon and LAPP Annecy. After acceptance and adequate preparation all BGO crystals were equipped with large area photodiodes which were glued onto the rear face of the BGO crystals through RWTH Aachen. The prepared BGO crystals were then coated with a highly reflective paint in order to maximize the light to be detected by the photodiodes. In the next step the crystals are inserted into a high precision carbonfibre mechanical support produced by an Italian helicopter company under the supervision of INFN Rome and LAPP Annecy. Afterwards readout electronics developed and produced by Princeton University and University of Lyon were connected to the photodiodes. Installation of the services for the cooling system, built by Lausanne University, and the Xenon lamp monitoring system, built by Geneva University, completes the construction of the Electromagnetic Calorimeter.

The central part of the Electromagnetic Calorimeter consists of two half barrels (see photo). The fully operational half barrels are transported to the CERN X3 test beam where every individual crystals is to be calibrated at different energies. Already in summer 1987 calibration of the first half barrel was carried out at the X3 beam. This summer the second half barrel is scheduled for calibration.

To completely cover the solid angle with an Electromagnetic Calorimeter consisting of BGO crystals, the L3 Collaboration is presently negotiating with the Shanghai Institute of Ceramics on the production of some further 3000 BGO crystals needed for the forward region of the L3 Detector.

--Hans Rykaczewski
L3 Collaboration at CERN



To submit news for the next <u>LNS News and LNS Physics News</u>, send information to <u>LNS News, 26-505 by August 12, 1988.</u>

How about volunteering to do a Personality Profile for us? Surely there is someone in the Lab. that you would like to know more about? Or how about submitting something related to your hobbies or outside interests?

Jean P. Flanagan, Editor
Contributing Editors: David Bitko, Susan Cartwright, Marisa Greene, William Lobar, and Hans Rykaczewski.

Thanks to Dick Adams for his contribution to **Comings and Goings**.