THE PULSE

For the Personnel of the Laboratory for Nuclear Science

Volume 5 Number 3 ********** March 1997

http://mitlns.mit.edu/~elsye/pulse.html

BLAST Project at Bates Gets the Green Light from the Department of Energy

The Division of Nuclear Physics of the Department of Energy has approved funding to begin construction of the Bates Large Acceptance Spectrometer Toroid (BLAST) project at the Bates Linear Accelerator Center in Middleton, MA. BLAST, a detector designed specifically to work in conjunction with the new Bates South Hall Ring, will help an international collaboration of 40 scientists to study the structure of protons, neutrons, and light nuclei. The approximate cost of the BLAST project will be $4.5 million and it will take about 4 1/2 years to complete.

Despite the fact that we have known for more than 60 years that atomic nuclei are composed primarily of protons and neutrons, we do not yet understand the detailed structure of the protons and neutrons themselves. It is believed that each contains three "quarks", the fundamental building blocks of most of the observed mass in the universe, but how the quarks and other constituents are arranged has proven to be an important question which is frustratingly hard to answer. The Bates South Hall Ring will provide polarized (spinning) electrons which will strike polarized nuclear targets. Observations of how the relative directions of spinning affect the particles which are produced in the collisions are expected to be especially sensitive to the detailed structure of the protons, neutrons, and light nuclei.

The BLAST detector will consist of an 8-sector copper coil array producing a toroidal magnetic field, instrumented on two sides with particle identification and tracking modules. The design emphasizes proven technology, commercial electronics, and existing data acquisition system software to achieve low cost and a short construction time. The gaseous polarized nuclear targets will be internal to the South Hall Ring to provide very small backgrounds for these precise experiments.

Bates, has served the nuclear physics community for over 25 years. There are currently more than 250 scientists from 11 different countries who use the facility on a regular basis.

Visit the BLAST web site at http://mitbates.mit.edu/~blast/

In This Issue

Seagate Technology Donates Wire Bonder to Electronics Facility

Seagate Technology's Recording Heads Group of Bloomington, Minnesota recently donated a Hughes wire bonder to the Laboratory's Electronics Facility for its work in developing and constructing large, sensitive silicon detector assemblies.

The Hughes 2470-V is an automatic machine for installing wire bonds -- short pieces of aluminum or gold wire, 25μm in diameter, about half the diameter of a human hair. Because of the fine resolution of its stage positioning and the flexible control of its bonding head, the machine can bond wires at very fine pitches down to 100μm and less and, if necessary, install wires at the rate of 2/sec. Thus, it is a machine ideally suited to assembling the silicon sensors and front-end electronics for the Phobos detector: the 120,000-channel front-end system for this detector, as installed, will require about 600,000 wire bonds. Phobos is a detector being built under the leadership of Prof. Wit Busza at RHIC, Brookhaven National Laboratory, New York. "When designing the packaging for a detector such as Phobos, which has severe design constraints in terms of density, speed and allowable power dissipation and which must be built on schedule, we need to choose the right technology and have the right tools to implement that technology. This machine will help us accomplish our goals," said Bernard Wadsworth, the Electronics Facility manager. The WA98 Silicon Pad Multiplicity Detector, which incorporated many of the technological features to be used in the Phobos front-end, was bonded on a Hughes 2470, courtesy of the Opal Group at CERN.

Wire bonds are the entities which connect the I/O bonding pads on an integrated circuit to the 'outside world', that is, to the circuitry in which the chip is embedded. Typically an integrated circuit die -- a square or nearly square piece of silicon which has been processed at a foundry -- is assembled into a package. The package has a lead frame which acts as a transition piece between the technology used in the integrated circuit and the technology of the external wiring: copper conductors etched on a printed circuit board or in the case of a hybrid assembly, the gold conductors which have been screened and fired onto a ceramic substrate. The IC is wire-bonded to the inner ends of the lead frame, and the outer ends of the lead frame are formed to be inserted into an IC socket, or to be soldered directly to the PC board.

For very high density applications, like the Phobos front-end electronics, microelectronic packaging has evolved to 'chip-on-board' or 'chip-on-substrate' configurations leading to the Multi-Chip Module (MCM). In this technology, the integrated circuit die is attached directly to the substrate (there's no room for a package!), and the connections are made by wire bonding directly between the chip's I/O pads and the screened/fired, thick-film conductors on the substrate.

For even higher density applications, chip-scale packaging technologies such as Flip-Chip are being very intensively developed. These technologies are only now being brought into production and will eventually take over from wire bonding, which currently accounts for about 90% of the world microelectronics assembly market.

Seagate's Recording Head Group manufactures and markets advanced read/write heads for disc drives and tape drives, and is recognized as the world's highest volume supplier of magnetic recording heads,

currently producing more than 250 million heads annually. The company's advanced head designs include magneto-resistive (MR) heads, inductive thin-film heads and proximity thin-film heads, which it provides to its own Storage Products Group, as well as other disc drive manufacturers through its OEM marketing effort. The Recording Head Group has been in business for more than 37 years (prior to Seagate's 1989 acquisition it was part of Control Data's Imprimis division), has shipped over half a billion heads since its inception, and employs more than 40,000 people worldwide. In order to meet increasing OEM demand for its recording head components, the company has been steadily increasing its manufacturing space which includes facilities in Minnesota, Northern Ireland, Malaysia and Thailand. Seagate's Recording Head Group is a world leader in the use of sophisticated ion mills for manufacturing precision air-bearing head designs. The company currently produces over one million MR heads per week.

Seagate Technology, Inc. is a leading data technology company providing products for storing, managing and accessing digital information. Seagate product lines include the most comprehensive offering of disc drives and related components, tape drives, and data storage, management and access software. At more than $8.6 billion in revenue for its 1996 fiscal year, Seagate is the largest independent disc drive and components company in the world. Founded in 1979, the company is based in Scotts Valley, California and has offices and manufacturing facilities worldwide.

The MIT Radioactivity Center and the Studies on Radium Dial Painters

The MIT Radioactivity Center

The MIT Radioactivity Center was established in 1934. Part of the mission of the Center was to study the long-term effects of internally deposited radioactivity in human beings. Originally the center functioned on its own, but beginning in 1946 it became a branch of the MIT Laboratory for Nuclear Science and Engineering, which also started in 1946. Even though the Center had studied some dial workers, it was not until 1950 that the Center established as one of its goals to be a central depository for information on radiation poisoning and to study the long-term problems of radium and mesothorium poisoning in human beings . As well as being involved with fundamental studies in biology of the metabolism of calcium and radium in animals and in human beings, the Radioactivity Center was involved with fundamental studies in physics, specifically the properties of nuclei and of the interactions of radiation with matter. The research tool was the cyclotron which was MIT's first "atom-smasher" built in 1938. The group also worked on the development of new types of counters and electronic instrumentation.

During World War II the MIT Radioactivity Center 's cyclotron was a source of supply of radioactive isotopes for research and therapeutic purposes. The cyclotron was in operation, except for a few minor shutdowns, twenty-four hours a day for seven days a week during the war.

From 1950 through 1959 the Center studied a number of high burden radiation cases. The principal means of determining body-burdens was with Geiger-Muller counter and the Evans meter-arc method. By 1965, 426 cases had been measured and many hundred more individuals were located and nineteen bodies were exhumed. (1)

The Radioactivity Center had collaborators from Great Britain, Argonne Cancer Research Hospital, Argonne National Laboratory, New Jersey State Department of Health and the Royal Center Hospital,

London. The work of the Radioactivity Center, one of the first interdisciplinary areas at MIT, was largely supported by the U.S. Atomic Energy Commission.

The Radium Dial Painters

The radium dial painters were mainly women who worked in watch factories painting dials on watches and clocks. Radium is a by-product of uranium ore and is found in nature. The dials were luminous and glowed in the dark because they were painted with radium. In order to obtain a fine point the women licked their paint brushes. In some cases the women eagerly licked the brushes because they were told that the radium would add to their vitality and improve their complexion. But a New York dentist, Dr. Theodore Blum noticed that some of his patients had a high incidence of necrosis of the jaw and that most of these patients were dial painters from a local factory. (2) Necrosis is radiation induced soft-tissue and bone. When it develops it causes pain, disability and even death. (3) In 1924 Blum published a paper in the *Journal of the American Dental Association* on the toxicity of radium.

Later Frederick L. Hoffman, M.D. also suggested that radium produced necrosis of the jaw. (4) At the same time that Blum and Hoffman were working on the medical problems, Katherine Wiley, secretary of the National Consumers League Chapter in New Jersey, reported to Florence Kelley, General Secretary of the League (an organization that tried to improve working conditions for women) that the Board of Health in Orange County, New Jersey, had asked the League to investigate "an unusual coincidence of sickness and death among girls employed by the United States Radium Corporation." Four girls were dead as a result of necrosis of the jaw and anemia and eight others were desperately ill. The symptoms resembled phossy jaw of the early 1900s. Phossy jaw was caused by phosphorus poisoning in the match industry. Wiley had visited the radium dial plant, as had the Department of Labor. Both found working conditions to be satisfactory. Plant management told them that the paint contained no phosphorus and that the paint consisted of a small amount of radium. Wiley was told that neither were toxic. Management said that it was poor dental hygiene that caused the dental problems and that the deaths were a coincidence. (5)

Wiley did not know that the U.S. Radium Corporation had asked Dr. Cecil Drinker of the Harvard School of Public Health to study the plant. Drinker found paint all over the work area and all over the dial painters. He also found out that the dial painters had recently been told not to lick the brushes, a clear indication that the company knew something was wrong. Drinker believed that radium was the cause of the illnesses. The report that Cecil and Katherine Drinker (his wife and colleague) wrote had been seriously altered and the report stated that "every girl is in perfect condition."

The company then sought the advice of Dr. F.B. Flinn of Columbia University. Flinn stated that "I believe we are justified in arriving at the conclusion that an industrial hazard does *not* exist in the painting of luminous dials." But the problems continued. One woman had worked as a dial painter for only 3 years and yet had already required 20 operations on her jaw. Another wore a back brace because of the extensive destruction of her spine. (6) At first it was only the women in the New Jersey company, but then two died in a Connecticut watch factory.

Florence Kelley continued to be concerned about the problem of radium poisoning and together with Dr. Alice Hamilton of the Harvard School of Public Health decided to increase public awareness by holding a conference on the subject of radium poisoning. Eventually Kelley was able to schedule a talk by Dr. Charles Norris, the Chief Medical Examiner for New York City. Norris spoke about several women who had died of radium poisoning. The publicity from the Norris talk then helped Kelley and Hamilton to set up a conference on radium poisoning. Soon after that in 1925 Dr. Harrison Martland, medical examiner of New Jersey and his co-workers brought about drastic changes in the radium industry because they confirmed five deaths from radium poisoning and estimated the average radium-dial painter might well ingest, over a five-year period, one thousand micrograms of radium. (7)

Research on the Radium Dial Painters at the MIT Radioactivity Center

In 1958 Samuel D. Clark, M.D. of the MIT Radioactivity Center published an article in the The *Journal of the American Medical Association*. The article

was entitled, "Where are the Cases of Radium Poisoning? A Plea for Assistance." The article stated that about 2000 of the luminous dial painters from the early 1920's were still living and many of them in good health.

What the Atomic Energy Commission had requested was that the dial workers be studied by the Center in order to obtain a clearer picture of what the future might bring in terms of radiation poisoning. Many of the files on the dial workers from the U.S. Department of Labor had been destroyed and some of the files from the U.S. Public Health Service were lost in a flood. The goal of the Radioactivity Center was to be a "central catalogue for recording all cases of chronic irradiation poisoning in human beings by certain internally deposited alpha emitters." The information would be available for further study and correlation of such items as the amount of internally deposited radioactivity, shortening of life span, susceptibility to other diseases, and incidence of bone changes and tumors. (8)

Physicians were asked to be on the lookout for following symptoms:

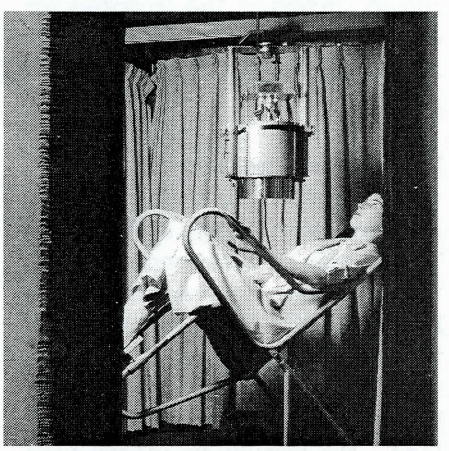
(1) Spontaneous fractures without evidence of neoplasm at the site of the fracture. (2) Osteogenic sarcomas which may develop 25 or more years after exposure to radium. (3) Neoplasms of the paranasal sinuses which may appear many years after exposure to radium (9). (4) Also dial painters had unusual trouble with their teeth, loosing them at an early age and have a long convalescence after extraction. (10)

Physicians were also told that cases would be registered with the Radioactivity Center and that the Center would work closely with the physician listing the patient and that all contacts would be made through the reporting physician.

Radium Dial Companies were asked for help

Next the Radioactivity Center tried to gain the confidence of the companies where the dial painters had been previously employed. Some of the companies of course, had gone under with the publicity of the deaths of some of the workers, but some were still in business. At first the companies were fearful of any further scandal but finally released the names of the people receiving compensation due to radium poisoning. When no bad publicity followed the companies were more willing to give information and to work with the Radioactivity Center.

View into the heavily shielded (8' armor plate) counting room of the 'control background facility' Measurements were made here with extremely sensitive radioactive counting apparatus, under conditions which enabled the detection of extremely small amounts of radioactivity in the human body.



Finally a breakthrough came, and several hundred names were given to the Radioactivity Center. "When we locate a former dial painter, we ask her to recall, if possible the names of some of the individuals who worked with her. Many times she can remember one or two names, and frequently she remembers what happened to them or has some clue as to where they are living at the present time. One case may lead to another." (11)

The next problem was of course getting the dial painters to come to MIT for testing. An interviewer was sent to the individual's home and the project was explained in greater detail. Most of the dial painters came into MIT without too much insistence.

The Tests

The participants were put up in a hotel for the night and the next day they were tested by physicists. There were two tests. The first was to test for radon and thoron in the expired air. This test was accomplished by having the participant breathe aged air from a tank through a tightly fitting mask into a special flask. Another test was done in a room with low background, here the total body burden of gamma-emitting isotopes by means of a very sensitive scintillation counter system. This method would detect the radium in the entire body. After spending time with the physicists the participant would then go to the Medical Department where they were given a complete physical examination, X-rays of selected bones, blood samples were drawn and urine tested. The results were then given to the family physician.

An example of a case history follows a 30-year old women, entered the hospital complaining of painful feet on walking. Fourteen years

ago, when she was 16 years old, she began painting luminous numbers on watch dials, and has continued to be employed doing the same work. For the first seven years her lips touched the brush, however for the past seven years the painting has been done with glass pens, under far better hygienic conditions. Five years ago, she began to notice aching in the right ankle when walking, and two years ago the right foot was put into a plaster jacket for one year. One and half years ago, the pain started in the left hip. Four years ago she first had trouble with her jaw. It became swollen and three teeth were subsequently pulled, and the upper jaw remained swollen for several months. Five months ago a tooth dropped out of the right upper jaw. About six months before entrance, radium was first detected in her body. (12)

The Results and Treatment

In the early stages after exposure radium is scattered throughout the body and is loosely held, later it is excreted at a less rapid rate. In the later stages the bones hold onto the radium more tightly than at first. (13) For many of the dial painters the results were negative, but it was important to have them as a control group. In individuals with over one microgram in their system it was found that usually difficulties were observed. A common finding was the history of spontaneous fracture of a long bone or the patella. Laboratory testing rarely showed anything wrong with the blood. Frequently the x-rays would show a "peculiar mottled effect in the skull." Many of the people who followed a dormant period of twenty-five or more years after the initial deposit of radium develop a syndrome of deafness, visual disturbances, severe pains around the face and back of the eyes. When x-rayed or studied neurologically nothing was found, however when autopsy was performed "neoplastic infiltration around the pituitary, often extending along the optic and the trigeminal nerves was found. Microscopic examination almost invariably showed a carcinoma arising from the lining membrane of the paranasal sinuses." (14)

The participants in the MIT program were treated by putting them on a low calcium diet and a thyroid extract. This raised the radium excretion and helped to clear the body of radium. Participants were also given magnesium gluconate to help the participants excrete radium. (15)

Summary

The Radioactivity Center at MIT was a pioneering group in nuclear medicine as well as basic physics research. It is important to keep in mind also that the group provided the isotopes for experiments at many of the local hospitals and for other areas at MIT.

In 1970 the Radioactivity Center, was conveyed to the Center for Human Radiobiology at Argonne. The center had defined the radium base line for residual body burden (1932-1941). This helped to provide standards for plutonium, radiostrontium, and other bone-seeking internal emitters. (16) No radiation injury was detectable below the body burden recommended by Evans. In large doses alpha radiation from skeletal deposited radium and mesothorium in humans results in osteoporosis, dense bone necrosis, spontaneous fractures, bone sarcomas, and carcinomas of the paranasal sinus and mastoids. The group built the first cyclotron for medical purposes, developed numerous kinds of equipment for studying nuclear physics. The cyclotron was also used by Martin Deutsch in his discovery of positronium. Positronium is a short-lived association of an electron and a positron bound together in a configuration resembling the hydrogen atom.

The work with the dial painters contributed to our knowledge of the effects of long term radiation on human beings. Although many of the dial painters were healthy, there were others who had illnesses that were caused by radiation poisoning. The studies by the Radioactivity Center were extremely well documented. The Radioactivity Center made many contributions to the nuclear medical, but the group also helped to establish standards. Evans wrote many articles that were aimed at the general public. For example in 1946 he wrote an article for the Atlantic Monthly, "The Medical Uses of Atomic Energy." His articles were clear and precise, as was his work and the accomplishments of those who worked of the Radioactivity Center.

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Favorite Recipes from IAP 1997

Chinese Chicken Slaw

1-Boneless Chicken Breast
1/4 cup of water
1/4 cup of soy sauce
1 1/2 cups of Red Cabbage sliced
1 cup of carrots (Julienne)
1 can of water chestnuts
1 cup of green onions (scallion) shredded
1 cup of Chinese noodles
1/4 cup of sugar
1/2 cup of oil
1/3 cup of white wine vinegar
1/2 tsp of ginger

Combine soy sauce and water and bring to a boil. Add chicken and simmer 25 minutes. Drain, cool and cube. In a bowl combine chicken and vegetables. Mix sugar, oil and ginger. Pour over mixture and chill. Add Chinese noodles.

Submitted by
Lauren Saragosa

Nana's Scones

1/4 cup butter
1/4 cup honey
1 1/2 cups buttermilk
4 cups flour
6 tsp baking powder
1 tsp salt

Mix together, flour, baking powder, salt and set aside. Cream together honey & butter. Gradually add flour mixture & buttermilk. Mix thoroughly. Divide dough into five pieces and roll out each piece on floured board (~1/2" thick). Cut into shapes. Cook on hot (ungreased) griddle. Flip over when bottom is slightly brown. Approx. 3-4 minutes each side.

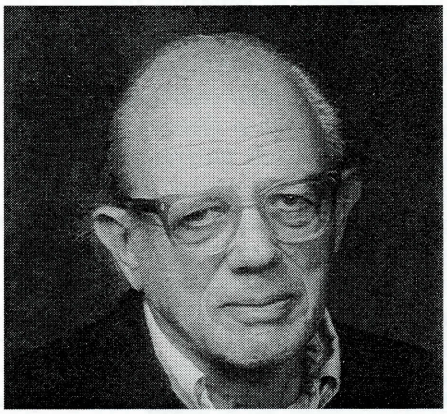
Submitted by
Heidi Demers

Pudding Delight

2 pkgs. Stella D'Oro anisette sponge cookies
2 pkgs. chocolate pudding
2 pkgs. vanilla pudding (I use the "cook" kind, I think it tastes better)
1 lge Cool Whip or fresh whipped cream

Slice each cookie in half length-wise and line bottom of 9x13 pan. Prepare both pkgs. of vanilla pudding and cover cookies. Add another layer of cookies then prepared chocolate pudding. Cover with waxed paper and cool. Spread the cool whip over the top and serve.

Submitted by
Dot Bertrand



Congratulations to Feshbach on his 80th Birthday

Institute Professor Herman Feshbach celebrated his 80th birthday on February 2, 1997. His pioneering contributions to theoretical nuclear physics have deeply influenced the development of nuclear science over the last half-century. He has played a seminal role in the development of the optical model, the unified theory of nuclear reactions, the concept of doorway states, the statistical theory of nuclear reactions, the multiple scattering theory of high energy reactions, the recoilless formation of hypernuclei, the boundary condition model for nucleon-nucleon interactions and the interacting boson model of nuclear structure.

Feshbach's comprehensive two-volume textbook, "Theoretical Nuclear Physics" is the definitive modern work on nuclear structure and reaction theory. The classic two-volume textbook co-authored with Morse, "Methods of Theoretical Physics" is known to every physicist as the standard reference on mathematical physics. These and other distinguished and influential scientific achievements have been recognized, among other honors, by Professor Feshbach's receipt of the 1986 National Medal of Science, the T.W. Bonner Prize in Nuclear Physics of the American Physical Society and his election to the National Academy of Science.

Beyond his research accomplishments, Professor Feshbach has made outstanding contributions as an educator and academician. In over fifty years of service to MIT, he founded the Center for Theoretical Physics in 1967, served as its director from 1967 to 1973, served as physics departmental head for a decade, was appointed Cecil and Ida Green Professor of Physics in 1976 and became Institute Professor in 1983. In addition to his continued contributions to MIT and his own writing, Professor Feshbach has served as an editor of the journal *Annals of Physics* since 1957 and is the editor of the series of books *Contemporary Concepts in Physics*. He has been President of the American Academy of Arts and Sciences and is a member of the board of editors of *Daedalus*, the academy's journal.

Professor Feshbach continues to contribute extensively, both nationally and internationally, as a scientific advisor, leader and statesman of science. He served as a member and chairman of the Nuclear Science Advisory Committee that advises the U.S. Department of Energy and the National Science Foundation on nuclear science from 1979-1983. From 1984 to 1990 he was Chairman of the Commission on Nuclear Physics for the International Union of Pure and Applied Physics. He is a former President of the American Physical Society and a past-chairman of both the APS Division of Nuclear Physics and the APS Panel on Public Affairs.

John Negele

***********Close Out Sale***********

****

We have a few t-shirts and sweatshirts left. We will sell the t-shirts for $3 and the sweatshirts for $5 while they last!

Congratulations to:

Dan Cheever on the birth of his son Alexander, born on October 14, 1996

Townsend Zwart on the birth of his son Gerrit Peter, born on December 3, 1996 and for receiving his Ph.D. in January, 1997

Peter Binns on his marriage to Beth Perkins on November 2, 1996

David Barkhuff, from University of Virginia, a student at Bates who received his Ph.D. in September 1996

Welcome

George Antonopoulous - Operations Group

Larry O'Brien - Rehired as the Assistant Group Leader of Accelerator Physics/Operations Group, Bates

Alan Wolcott - RF engineer in the RF group, Bates

Townsend Zwart - Polarized Injector Group, Bates

Promotions

Ken Jacobs - Group Leader for the new combined Accelerator Physics/Operations Group, Bates

Serge Sarkar - Associate Group Leader, Electronics/Electrical Group, Bates

LNS Wins With United Way

The following members of LNS were United Way raffle prize winners.

John Negele - 2 Premium Club Tickets to the Boston Celtics vs Toronto Rapotors Game – April 20

Ed Alvarez - 2 Round-Trip Tickets aboard the Martha's Vineyard Island Queen during 1997 season

Lee Grodzins - Dinner for 2 at the Bisuteki Steak House, Sage Hotel, Cambridge

Next year you too could be a winner Congratulations

Reprinted from The Tech Talk
February 5, 1997

In Memoriam

CHARLES W. BLAKE

Charles W. Blake, 69, of Leander, TX, died on December 30. He was a sponsored research staff member in the Laboratory for Nuclear Science when he retired in 1986 after working at MIT for 34 years. He leaves his wife, Maxine, and a daughter, Susan Blake of Hawaii.

How to Find Comet Hale-Bopp

Beginning the last week of March through the second week of April Hale-Bopp should be visible in both the morning and evening skies. Several hours after sunset, look toward the northwest sky and locate Cassiopeia, the W-shaped constellation on the side of the North Star opposite the Big Dipper. Hale-Bopp will pass between Cassiopeia and the Great Square of Pegasus in late March and will move westward toward the constellation Pegasus in April.

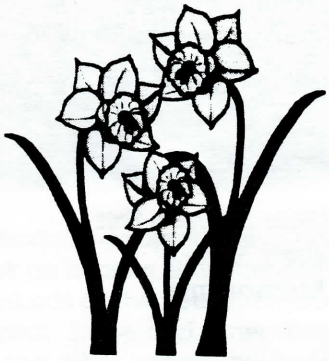
Blue Copies of Purchase Orders

Because of recent changes in the MIT procedures for processing requisitions and purchase orders, the LNS Fiscal Office needs the requisitioner's help to maintain accurate information with current LNS purchase orders. Under the old accounts payable system the blue copy address automatically defaulted to the LNS Fiscal office. However, the current SAP system sends the blue copy of the purchase order to the requisitioner. This effectively removes the LNS Fiscal Office from full access to the proper information associated with a purchase order. It is extremely important that anyone receiving the blue copy of a purchase order forward that blue copy (or a photocopy) to the LNS Fiscal Office in order to have sufficient documentation for the payment of an invoice to a vendor and proper records for an MIT or Government Audit. For anyone ordering items using the e-req system, it is necessary to insert:

"LNS Fiscal Office (26-519)"

in the area which says SEND COPY OF THIS PURCHASE TO: The LNS Fiscal Office needs to receive copies of all purchase orders so that payments to vendors can be done both accurately and promptly. Thank you for your help in this matter.

Join us for an end of winter gathering



Date: Friday, March 21, 1997
Time: beginning at 8:30 a.m.
Place: 26-414

Just make a loaf of your favorite bread or a dozen muffins. Bread should be in the "Quick Bread" category, i.e. Banana, strawberry, zucchini, date nut, etc. Can't cook? Don't let that bother you – can bring the orange juice, cream cheese or butter.

If you plan to join us, please contact Cheryl Cagnina by March 14, at x3-2394 or email cagnina@mitlns.mit.edu

THE PULSE is a publication of the Laboratory for Nuclear Science for the LNS Community.

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If you have any ideas and/or suggestions for new features in THE PULSE please let us know. Address inquiries to Pulse, 26-537.