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SHORT-LIVED PARTICLES TANTALIZING MORSELS FOR RESEARCH PHYSICISTS

A relatively new property of matter called charm has an interesting personality.

And tenaciously on its trail are the collaborators of experiment 531. The researchers seek to study charmed particles and how they fit into the whole scheme of physics. "Some properties of matter live forever, such as charge," said Bill Reay, professor of physics at Ohio State University and spokesman for the experiment. "But charm can be destroyed by weak decay."

Other collaborators come from Fermilab, Korea University (Seoul, South Korea); McGill University, Universite D' Ottawa and University of Toronto, all in Canada; and Aichi University of Education (Kariya), Kobe University (Kobe), Nagoya University (Nagoya), Okayama University (Okayama), Osaka University (Osaka), Science Education Institute of Osaka Prefecture, Cosmic Ray Laboratory at the University of Tokyo and Yokohama National University (Yokohama), all in Japan.

If the experimental observations of charmed particles support the elaborate theories put forth to describe subatomic behavior and makeup, then edgy theorists will feel more comfortable and confident that at least they are on the right track. That's one of the reasons why the results of E-531 are being awaited so eagerly and why excitement is high--because preliminary results tend to support the theoretical postulates.

The results from experiment 531--the one featured in the story that begins on this page--were presented at the 1979 International Symposium on Lepton and Photon Interactions at High Energies held last month at Fermilab.

Charm is just not something that someone reaches out to grab. It's elusive and requires careful planning and the assembly of sophisticated detectors to study it. Since charmed particles only die by weak decay, they live a billion times longer than most of the particles known, explained Reay. Most particles die by strong or electromagnetic processes. They die in the time it takes them to travel the diameter of an atomic nucleus.

Because of a charmed particle's ability to hang around a long time, relatively speaking, it can travel the distance from about one-tenth the diameter of a human hair to about one-eighth of an inch before it dies. That's a short distance for high energy physicists to deal with. Most of their detectors which are in fashion do not have the resolution to see such short distances.

How then can experimenters record the lifetime of a charmed particle?

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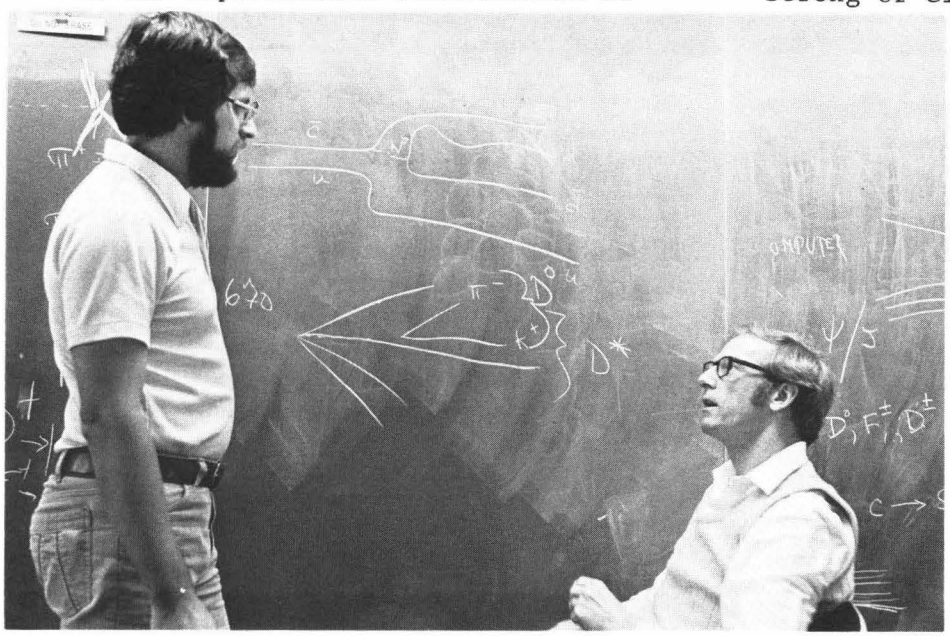

...Ron Sidwell (left) and Bill Reay...

OTHER EMULSION EXPERIMENTS

Two other emulsion experiments also are being run at Fermilab.

They are E-553 and E-564. Both, like E-531 (see companion story) are investigating charmed particles. However, they are using emulsions different in composition from those being used in E-531. E-553 collaborators are using an Eastman Kodak emulsion, while the experimenters in E-564 are using special cryogenic sensitized emulsion from Russia.

The sophisticated detectors in the three experiments are analogous but not identical with one another, yet they all serve the same purpose--to help experimenters locate the vertexes in the emulsion. The detector arrangement in E-553 is more akin to the detector in E-531. In experiment 564, however, the emulsion, which is both the target and the detector, was placed inside the 15-foot bubble chamber. The chamber is an excellent and visible method of tracing tracks back to the emulsion and finding the vertex of the event. Overall, E-553 and E-564--like E-531--are searching for and studying short-lived particles. Collaborators for E-553 come from Cornell University, University of Houston, University of Lund in Sweden, University of Pittsburgh, University of Sydney in Australia and York University in Downsview, Canada.

Collaborators for E-564 include Fermilab, University of Kansas, University of Washington, Institute of Nuclear Physics in Cracow, Poland, and Institute of Theoretical and Experimental Physics in Moscow, Institute of High Energy Physics in Serpukhov and Joint Institute for Nuclear Research in Dubna, all in Russia.

Because of the success of their initial runs, and the promise of even more impressive results, all three experiments have been approved by Fermilab for more running time, probably sometime in the spring of 1980. Researchers in three experiments are enthusiastic and have expressed their interest in doing more, said John Peoples, head of the Research Division.

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Enter now emulsions.

An old pro for a new job.

They've been around a long time, going back to the days when physicists used emulsions to catch the tracks of cosmic rays for study. Emulsions have that needed property of being able to see short distances and consequently can record the track of a charmed particle. This then is the heart of the E-531 detection system: approximately 3,000 sheets of Fuji emulsion in two sizes.

A single sheet is 600 microns thick. About one half of the sheets are mounted perpendicular to the incident neutrino beam and the remaining half are mounted parallel to it. Those mounted parallel are pure emulsion and are called pellicles. Each emulsion sheet mounted perpendicular to the beam contains a 70-micron thick layer of polystyrene sandwiched between two 300-micron-thick layers of emulsion. (The polystyrene layer adds rigidity to the emulsion sandwich, which has a tendency to deform during developing because of surface tension effects.)

The Fuji emulsion is a slow, ultra-fine grain film analogous but not identical to the emulsion on black and white photography film. However, there the resemblance ends. Regular photographic film can be developed simply and in a short time, but the Fuji emulsion, after it has been exposed to the high energy particles, must be treated with tender loving care.

First, the exposed emulsion sheets were transported by motor vehicle to the Canadian collaborators. (Shipping the emulsion by air would expose them to an unacceptable quantity of cosmic rays. They would contaminate the emulsion with unwanted tracks.) The Canadian experimenters then meticulously and slowly--it takes a week--developed the emulsions to reveal the particle tracks. Clumps of silver mark the path a high energy particle took through the emulsion.

After developing, the emulsion can now be safely handled and examined. Most of them were shipped by air to Japan, where they are extensively being studied. Some remain in Canada to be studied, and some

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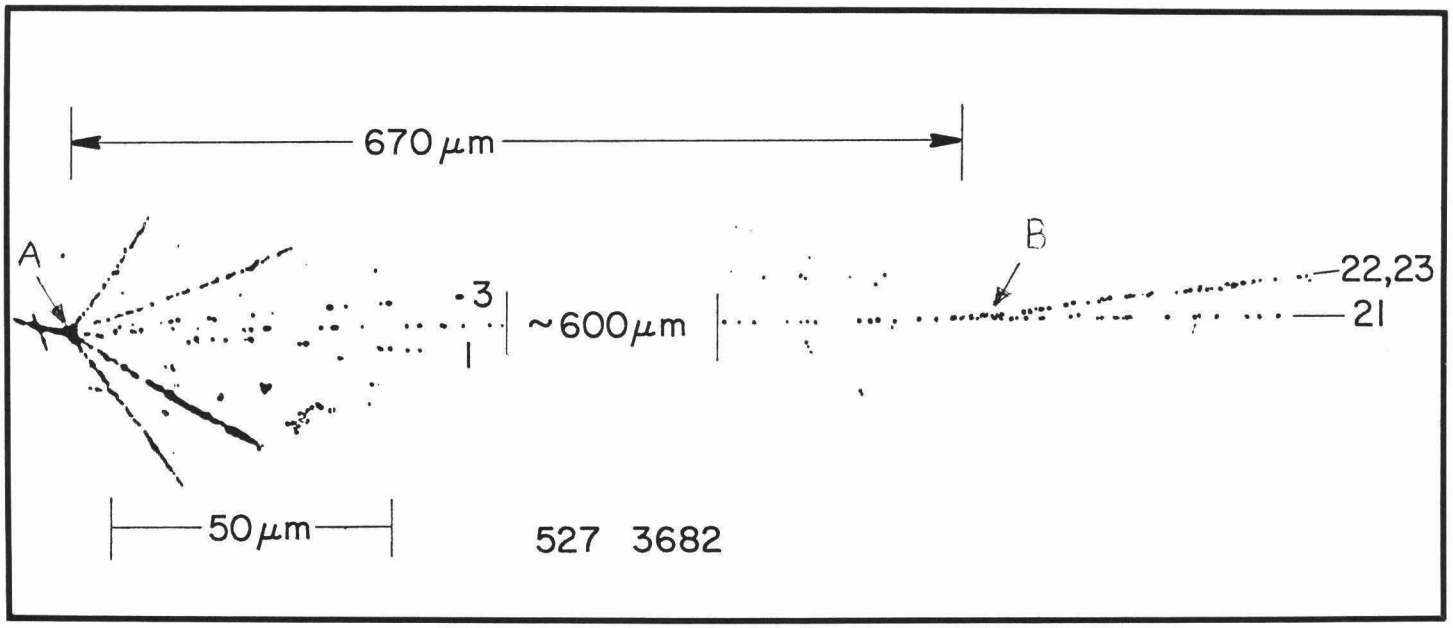

One of the events being evaluated by the E-531 collaborators. At the left, a neutrino, moving from left to right, strikes a nucleus in the emulsion sheet at point A. The neutrino does not leave a track. The struck nucleus literally explodes into nuclear fragments, shown by the heavier tracks going off at wide angles. However, the experimenters are more interested in the fainter tracks. These were created by particles produced by an interaction with a nucleon, such as a neutron or proton. Do these tracks change character? Tracks 1 and 3 (not fully shown) continue in a straight line. But the track that runs from point A to point B dies at point B, 670 microns downstream from the disintegrated nucleus. This track, physicists say, was made by an F-meson charmed particle traveling at nearly the speed of light. It decayed into four particles, three of which left tracks 21, 22 and 23. (Tracks 22 and 23 are side-by-side in the vertical plane of the paper and not easily seen as two tracks.) The fourth particle did not make a visible track. Three of these four fragments have been identified as pions. By determining the characteristics of the fragments, the experimenters can then describe the particle that gave birth to them.

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were returned to Fermilab for evaluation.

That search for the track of a charmed particle is not easy.

Imagine placing a sheet of emulsion under a 100- to 150-power microscope and looking for the desired event. Only a miniscule portion of the emulsion in a limited plane is visible under the microscope. And then with thousands of sheets waiting to be searched...

Well, a random search is just not practical. It would take an inordinate amount of time. The investigators must first have a fairly good idea of where to look. They use two approaches, explained Ronald A. Sidwell, senior research associate at Ohio State University and deputy spokesman for E-531.

--They predict where the vertex (point of interaction) is located and then scan that general area. This is known as volume scanning.

--They follow the track in from their elaborate spectrometer until they reach the vertex. This technique is twice as efficient as volume scanning, Sidwell said. It's 80 percent efficient at finding neutrino interactions.

The spectrometer in a sense is the magic wand that points the way to the sought after vertexes. It's a multi-ton behemoth that occupies cubic meters of volume, yet it's an ingenious, sensitive

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eye that helps the researchers see the particles from the event and trace their trajectory back to the vertexes in the emulsion, which itself is both a target and a detector.

The large detector measures both momentum and direction of flight. This information helps researchers identify the particles spewing out from an event. Looking downstream from the location of the emulsion sheets, there comes:

1--A set of drift chambers.

2--An analyzing magnet.

3--A second set of drift chambers.

4--A counter system that measures the time-of-flight of particles and helps identify the particular species, such as pi-mesons, K-mesons and protons, for example.

5--A wall of lead glass blocks that helps determine the position and energy of gamma rays and electrons.

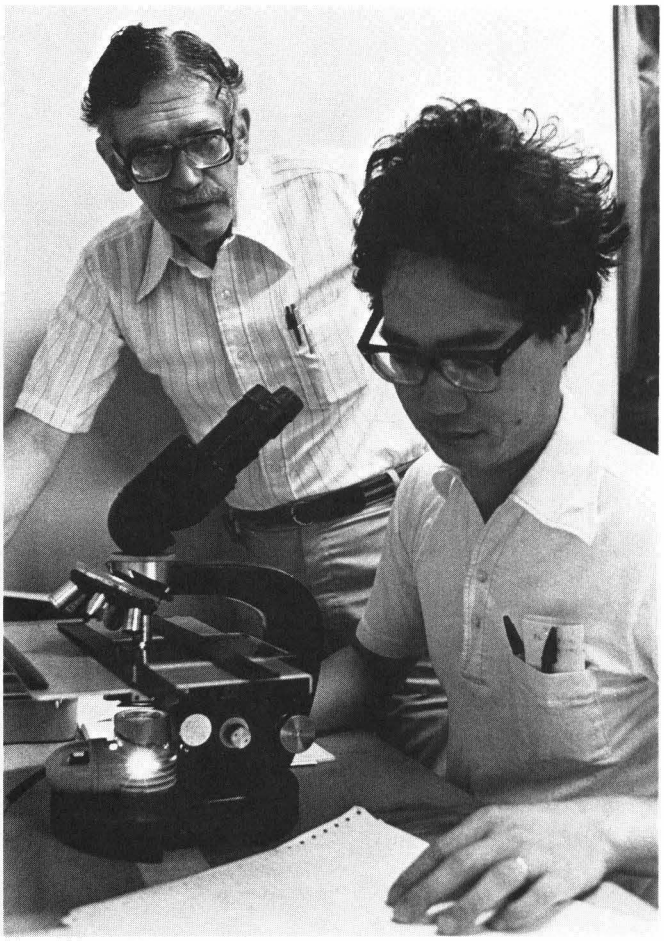
6--A steel calorimeter made up of four-inch thick iron plates and scintillation counters. This calorimeter can detect neutral hadrons, specifically neutrons and kay-long mesons.

7--A muon detector constructed of 300 tons of steel and two planes of scintillation counters. One plane is one-half of the way through the steel and the other one is located at the far end.

One of the more fascinating and absolutely essential components of the overall detector system is the changeable emulsion sheet. Proposed by several E-531 experimenters and developed by Dr. Kiyoshi Niu and his group at Nagoya University, Japan, it is located downstream from the emulsion packets (modules) but ahead of the spectrometer.

The sheet helps researchers more precisely locate the vertexes in the emulsion packets by improving the detector's resolution. As the name changeable implies, the sheet is changed when it accumulates an abundance of particle tracks. After a clean sheet is installed, the physicists have fewer tracks to scan and can more readily find the tracks that interest them as the experiment progresses.

The E-531 collaborators predict the emulsion contains about 2,200 neutrino



...*Examining emulsion sheets under a binocular microscope are Kurt Reibel (left), professor of physics, and Shuichi Kuramata, research associate, both with Ohio State University. The humidity in their laboratory at 32 Neuqua in the Village is maintained at around 80 percent to keep the emulsions from drying out, thus becoming brittle and possibly cracking. The majority of the emulsion analysis, however, is being done by the collaborators in Japan...*

interactions. (The experiment ended its initial run earlier this year at Fermilab, but is scheduled for more beam time next spring.) They expect to find around 1,000 to 1,200 of the events. Their search, of course, is still in its early stages.

At the time this story was written, they had found 400. Of these 400 neutrino interactions, they have located 16 that have "obvious charm decay," said Sidwell. They are multi-prong decays with two, three or four tracks, he added.

In addition, the collaborators have found 14 one-prong decays, some of which may be the result of charmed particles.

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A track suddenly goes off at a large angle--known as a kink--from its original course. This kink may be the result of a particle being scattered off a nucleus or the decay of a charmed particle. "We need a more detailed analysis to know which is which," said Sidwell.

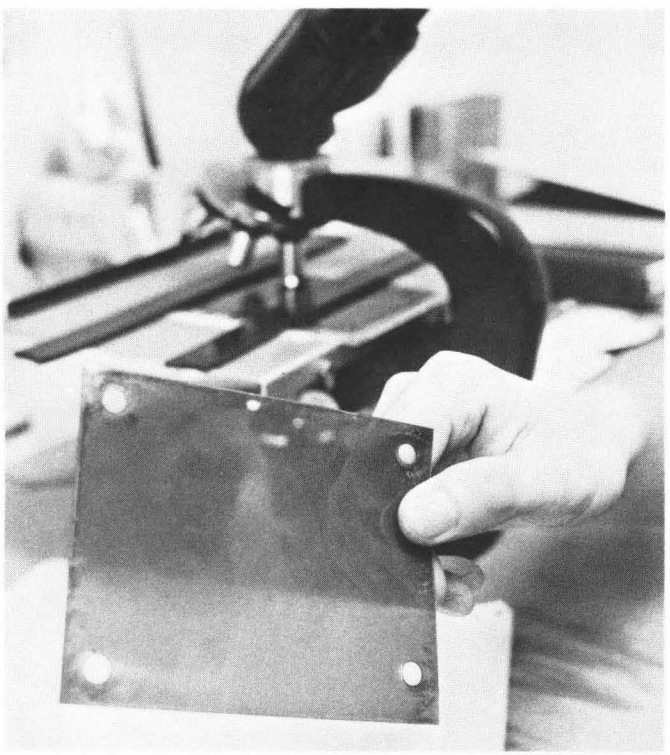
Although very preliminary, reminds Bill Reay, spokesman, the data is revealing some interesting things.

1--The experimenters have found four different kinds of charmed particles in the neutrino interactions.

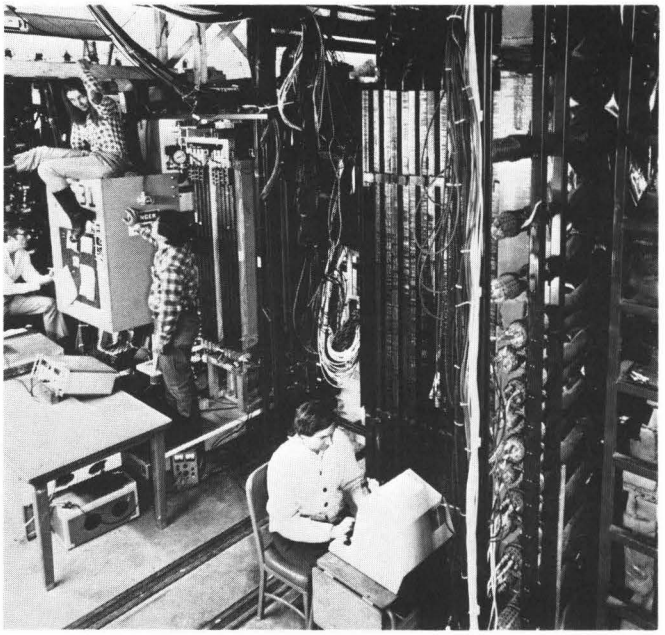
2--Subject to further calibration, there is an indication that D-zero mesons (charge of zero) have a much shorter lifetime than D-plus mesons (charge of one). This is of great interest in the theory of charm and an important input to theorists' interpretation of how strong interactions influence weak interactions.

3--E-531 experimenters also have found an indication of a particle with a charge of two. "It could possibly be a charmed baryon with a charge of two," said Reay. "A long-lived particle of this type has never before been seen."

So there it is, an emulsion experiment that is generating excitement at Fermilab.



...One of the exposed and developed emulsion sheets used in Experiment 531...



...The E-531 detector network downstream from the emulsion packets. From the left, Bill Reay, Dale Pitman, University of Toronto; Toshio Hara, Osaka City University, Japan; and Mike Gutzwiller, Ohio State University...

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SPECIALTY RESTAURANT CHEZ LEON THRIVING

The Chez Leon, a restaurant featuring specialty menus, continues to be popular among Fermilab employees and users, reports Tita Jensen, the restaurant's congenial chef.

Opened earlier this year and named in honor of Leon Lederman, Fermilab director, the restaurant is in the Users Center, Village. Lunch is served each Wednesday at 12:30 p.m. and costs $4.50. Dinner is served on Tuesdays and Thursdays at 7 p.m. for $8.00. The menu changes each day.

Assisting Jensen is Mrs. Aruna Gupta of India. She is an expert in Indian food, said Jensen. Her husband, Dr. Virenda Gupta, is visiting the Theoretical Physics Department here.

"Mrs. Gupta has extensive experience in catering for home and large outside parties," said Jensen. "While her husband was visiting CERN, she introduced Indian food in a local Geneva restaurant. Her food was a great success."

Reservations can be made by calling 840-3520.

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RICHARD PARRY EARNS DATA PROCESSING CERTIFICATE

Richard Parry of the Fermilab Accelerator Division Safety Group was awarded a certificate in data processing from the Institute for Certification of Computer Professionals (ICCP) for successfully completing the 1979 examination.

The ICCP annually administers the examination in more than 100 testing centers throughout the world. Parry was one of 973 successful candidates out of 2,948 who took this year's examination. ICCP is a not-for-profit organization comprised of eight computer societies for the purpose of testing and certifying knowledge and skills of computer personnel.

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BOOK ON RUSSIA GIFT FROM NICHOLLSES

Gilbert L. and Judith E. Nicholls, a husband and wife scientific team at Fermilab, have given the library a book about Russia.

"Soviet Union, A Geographical Survey" was published by Progress Publishers in Moscow. The Nichollses purchased the volume when they were at the Institute of Nuclear Physics, Novosibirsk, for a three-month collaboration.

He is an electrical engineer with the Accelerator Division and she is a physicist in the Computer Department.

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HELP CREDIT UNION HELP YOU

It's helpful to customers to remind them that the Fermilab branch of the Argonne Credit Union has an important deadline, said Cindy A. Gould, branch manager.

Requests for withdrawals of savings or ready cash loans must be in the branch office by 10 a.m. if the person wants their check the same day. Checks may be picked up after 1 p.m.

The office hours of the credit union at Fermilab are 8 a.m. to 5 p.m. Monday through Friday.

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MAYNARD FERGUSON IN CONCERT AT FERMILAB

Maynard Ferguson, world-famous jazz performer, and his band will give a concert at Fermilab Oct. 12.

The concert will begin at 8:30 p.m. in the Central Laboratory auditorium. Reserved seats are $7 each. For tickets, call the Guest Office, Ext. 3124.

His appearance here is another in the Fermilab Arts Series arranged by the Auditorium Committee.

Those who follow jazz recognize Ferguson as the premier performer on the jazz scene with millions of devoted fans throughout the world. Trumpeter, valve trombonist, instrument designer, leader and composer do not adequately describe his monumental contributions to music. His crest of popularity never seems to falter and album after album of his becomes a hit.

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CANOE RACE THIS SUNDAY

Trophies wait for the winners of Fermilab's fifth annual canoe race.

Even those who come in second will be awarded plaques. The great race--really a fun event--will start this Sunday (Sept. 30) at 1 p.m. at sector F-4 of the Main Ring and will end there.

Contestants can use their own canoes or can rent a canoe from the laboratory for the day at $5. Persons who want to help with the details during the race have been asked to contact Larry Allen, Ext.3721, or Helen McCulloch, Ext. 3126.

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REMINDER ABOUT FIRE PREVENTION WEEK

National Fire Prevention Week will be observed Oct. 7-13, the anniversary week of the great Chicago fire.

The Fermilab Fire Department will show a film on fire hazards common to the laboratory Monday through Friday of that week at 1 p.m. in Curia II, CL2-S.

The department also has four free booklets on a variety of fire safety topics. They will be available in Curia II, but also by calling the fire station,Ext.3428.

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