BROOKHAVEN BULLETIN
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BROOKHAVEN NATIONAL LABORATORY

Rare K Decay Experiments at the AGS — The Long and the Short of It

Rare K decay — what does this exotic term mean? And why is it preoccupying four teams now running experiments at BNL's Alternating Gradient Synchrotron (AGS)?

To answer that question, let's first look at what it *doesn't* mean. Rare K decay does not mean that Ks are rare in and of themselves. K is simple physics shorthand for the relatively easy-to-produce particle known as a kaon. The AGS is the world's most intense source of kaons (see sidebar, page 2).

If Ks are not rare, then it must be rare for them to decay — right? Wrong.

Kaons are unstable, which means they will decay. Decay is the process by which the constituents that make up particles transform into different, lighter particles.

Kaons are in the meson family, which consists of particles made up of quarks and antiquarks (see flavor chart). A kaon, or K meson, is made of a strange quark and an antiquark, so its tendency is to decay into lighter mesons, usually pions, or pi (π) mesons, made of up and down quarks and antiquarks.

That's the decay mode that led to the discovery of one form of the K meson — the K^0_L, the neutral K-long.

The K^0_L was discovered at BNL's Cosmotron in 1956, by a group from BNL and Columbia University led by Leon Lederman, then of Columbia and now Director of Fermilab. Lederman's team could identify the K^0_L because it often decayed into three pions, as theory had predicted.

A CP Violation

But kaons have also been shown to decay in ways that theory does not predict. In fact, they can decay in a way that defies a basic symmetry principle of physics — CP invariance. CP stands for two attributes of particles — charge conjugation and parity — which were thought to ensure that there is an immutable symmetry to the subatomic world. But CP invariance fails to hold up in one tiny corner of the subatomic world, the so-called "CP violation."

That's what Princeton physicists James Cronin (now at the University of Chicago) and Val Fitch discovered in 1963 at the AGS, when they showed that K^0_L can sometimes decay into only two pi mesons — a CP violation.

This surprising and puzzling result was considered so important that Cronin and Fitch were awarded the Nobel Prize in Physics in 1980.

So, when kaons decay in ways that are not predicted, that is rare. Cronin and Fitch's discovery was the first observed rare K decay — and a harbinger of the crop of experiments now at the AGS (see Rare K Decay chart).

1,000 Times More Sensitive

The present AGS studies, explained Physicist Laurence Littenberg, Physics Department, are also descendants of other rare K decay experiments that flourished about 15 years ago. As the main physics interest moved elsewhere, the once-popular field slowed down.

Said Littenberg, who is in charge of software for rare K decay experiment 787 (E787), "This has led to an opportunity. If you don't do much of a certain kind of experiment in 15 years, you can apply a lot of new techniques when you come back. Now we hope to do experiments that are 1,000 times more sensitive than they were 15 years ago."

Beyond the Standard Model

The primary motivation for these experiments, said Littenberg, "is the physics interest. It's possible that the decay of strange quarks may offer a window into physics beyond the standard model."

The standard model is an overall view of particle physics that has arisen over the 15 years since the last spate of rare K decay experiments. The model represents a consensus of opinion on new particle discoveries and theories that characterize the fundamental consituents of matter and the forces between them.

Although the standard model is the best present theory of elementary particles, it is by no means considered the final word on this subject. There are still a number of mysteries it does not explain, for example, the origin of mass: Why does this particular particle have this particular mass? This and other features of the standard model are simply postulated.

There may well be a more complete theory yet to come, which would go beyond the standard model and explain some of these mysteries. Technicolor and supersymmetry are two examples of such theories that have already been offered.

Three Approaches

"There are several different approaches to probing the standard model," Littenberg said. "One is to make measurements extremely accurately and look for discrepancies between what is and what was predicted.

"Another approach is to keep raising the energy at which you look for something," he continued. "The energy scale for the standard model is good for about 100 billion electron volts. To get comfortably above that region, the Superconducting Super Collider [SSC] was proposed.

"A third approach," summed up Littenberg, "is to look at processes that are forbidden, or at least strongly discouraged, in the standard model — such as rare K decays. If you find that, you would have something new."

Rare K decays are predicted by most theories beyond the standard model. "So, whether or not you find it, it will have a big impact," said Littenberg. Finding a forbidden or discouraged kaon decay points to new physics; not finding such a decay helps to confirm the standard model.

In Forbidden Territory

Three out of the four rare K decay experiments that began their present three-month runs on February 3 at the AGS are searching for forbidden decays. The fourth is looking for a decay that is allowed, but suppressed, by the standard model.

"We were the first rare K decay experiment proposed for the AGS, in 1982," recalled Guest Physicist Michael Zeller, of Yale University, the spokesman for E777. A collaboration of BNL, Yale, the University of Washington and Schweizerishes Institut fur Nuklearforschung, E777 is also the longest-running, having collected its first data in February 1985.

E777 is a search for the forbidden decay of the positively charged kaon, K^+, into three particles: a positive pion, π^+; a positive muon, μ^+; and the negative electron, e^-. The reason the decay mode $K^+ \rightarrow \pi^+ \mu^+ e^-$ is forbidden by the standard model is that it violates what is called lepton flavor.

Generations and Flavor

There are six flavors of leptons and six flavors of quarks — the two families of six particles each prescribed by the standard model (see flavor chart).

Each family is divided into three generations, and each generation contains two flavors of particles. In the standard model, the flavors of one lepton generation simply do not mix with the flavors of another generation.

"We are looking at this lack of lepton flavor conservation," said Zeller. In other words, if $K^+ \rightarrow \pi^+ \mu^+ e^-$, the two lepton decay products — the μ and the e —are lepton flavors from two different generations — and this is what Zeller means by nonconservation.

While the standard model does allow quarks to decay into leptons, the model also says that the second generation muon and the first generation electron should not share the same decay.

Various other models, including technicolor and supersymmetry, do allow lepton flavor violation. In fact, said Zeller, "Technicolor actually predicts it at a sensitivity that we should be able to achieve, if the theory is valid."

Not One in a Billion

In E777's previous two years on line, Zeller said, "We have looked at one billion K decays. Not one has decayed in this mode. Now we're going for another factor of ten — ten billion.

(Continued on page 2)

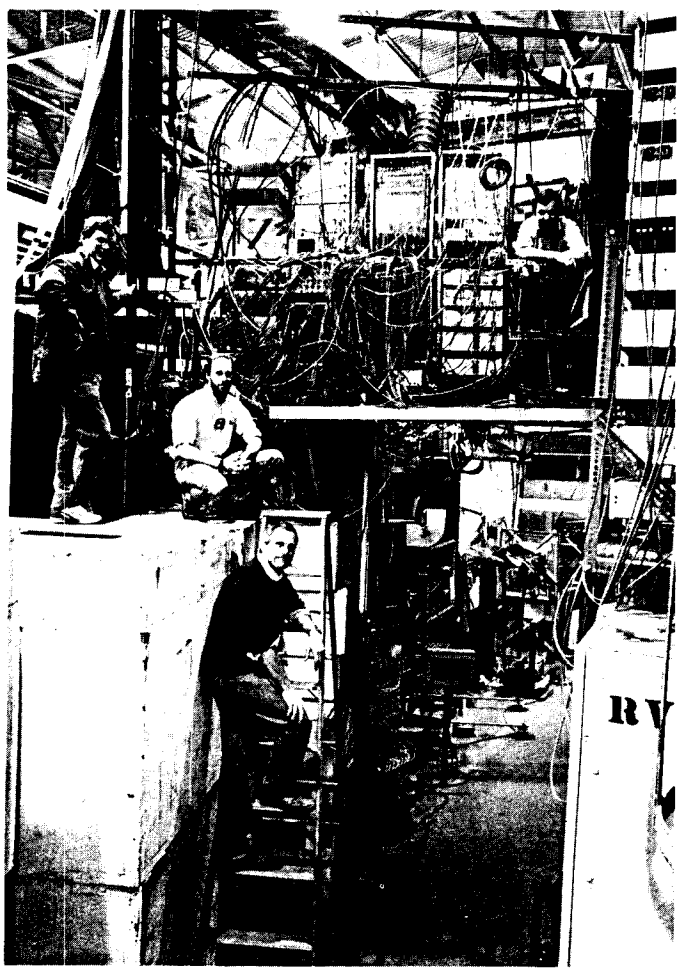
Quark & Lepton Flavors

	Generations I	II	III
*Quark Family	up	strange	top**
	down	charm	bottom
*Lepton Family	electron (e)	muon (μ)	tau (T)
	electron-neutrino (ν_e)	muon-neutrino (ν_μ)	tau-neutrino (ν_T)

* All quarks and leptons have antimatter counterparts.
** Postulated, but not yet discovered.

Some Rare K Decays

Decay Mode	How Rare?	Who's Looking?
$K^0_L \rightarrow \pi^+ \pi^- \pi^0$	allowed	Found at Cosmotron in 1976 by L. Lederman et al.
$K^0_L \rightarrow \pi^+ \pi$	forbidden (CP Violation)	Found at AGS in 1963 by J. Cronin and V. Fitch
$K^+ \rightarrow \pi^+ \mu^+ e^-$	forbidden	E777
$K^+ \rightarrow \pi^+ e^+ e$	rare, but allowed	E777
$K^0_L \rightarrow \mu e$	forbidden	E780, E791
$K^0_L \rightarrow \pi^0 e^+ e$	highly suppressed	E780, E791
$K^0_L \rightarrow \pi^0 \mu^+ \mu$	highly suppressed	E780, E791
$K^0_L \rightarrow e^+ e^-$	highly suppressed	E791
$K^+ \rightarrow \pi^+ \nu \bar{\nu}$	suppressed	E787
$K^+ \rightarrow \pi^+ X^0$	forbidden	E787
$K^+ \rightarrow \pi^+ X^0 X^0$	forbidden	E787



At AGS Experiment 777: (top, from left) Heinz Kaspar, Eric Jagel and Vladimir Chaloupka, and (on ladder) Michael Zeller.

Photos for this story by Mort Rosen.

Intense Gold Beam At The Tandem

During tests performed on Monday, February 22, at the Tandem Van de Graaff accelerator, a pulsed, negative gold beam was produced with a peak intensity of 240 microamperes (μA). This is 40 μA beyond the value of 200 μA specified as the design luminosity for BNL's proposed Relativistic Heavy Ion Collider. Work is continuing to obtain even higher intensities and to optimize the transmission of these beams through the Tandem.

Rare K Decay

(Continued)

If we still don't find it, we'll be backing the new theories into a corner.

"Also, the interaction that would mediate this rare decay would be a new particle. If we get to ten billion, we can say that the particle has a higher mass than 72 trillion electron volts [72 TeV], which is higher than the mass region to be probed by the SSC [a few TeV].

How can E777 and the other rare K decay experiments use the 30-billion-electron volt AGS to probe an energy region higher than that reachable by the proposed SSC? The AGS, after all, has less than 10^3 the energy of the SSC.

Zeller called it, "a quantum mechanics phenomenon. You can violate energy conservation for just a little time. It's like taking money out of the bank that you must get back before the teller notices — and the more money you take, the faster you must get it back. So the more massive the new particle, the less time it has to exist, and the less probability that it will make the decay happen."

In addition to the forbidden decay, $K^+ \rightarrow \pi^+ \mu^+ e^-$, E777 is looking for the rare, but allowed reaction $K^+ \rightarrow \pi^+ e^+ e^-$. In their effort to increase the world sample of this decay, the group had collected 150 events before the current run. "We hope to run to get another 1,500," said Zeller, "for a factor of 50 more sensitivity than the published number. This will enable us to understand the mechanism for this rare decay."

Still a Generation Gap

Like E777, E780 seeks to test the standard model by looking for lepton flavor violation. While E777 is looking for a three-particle decay of a positively charged kaon, however, E780 is looking for a forbidden two-particle decay of a neutral kaon — the same K^0_L discovered at the Cosmotron 32 years ago.

E780, the second-oldest rare K decay experiment at the AGS, began searching for the reaction $K^0_L \rightarrow \mu e$ in February 1987. In this decay, μe is either a muon and an antielectron (a positron), or an electron and an antimuon. In either case, the total charge is zero, like that of the parent kaon.

Physicist William Morse, the BNL spokesman for the Brookhaven and Yale University team that is behind E780, said, "We have looked at 500 million kaon decays since we began, and we have not even seen one example of this. So, as far as we know, the generations still do not mix."

During this, E780's last run, Morse expects to collect 10 billion kaon

(Continued on page 3)

In front of the range stack at AGS Experiment 780 are (from left) William Morse, Robert Adair, Lawrence Leipuner, Henry Kasha and Richard Larson.

The Accelerator of Choice

It's not the only accelerator in the world that produces kaons for experimentation — but it produces the *most* kaons per hour, day after day. That's the main reason why BNL's Alternating Gradient Synchrotron (AGS) has become *the* accelerator of choice for rare K decay experiments.

As Laurence Littenberg, who is with AGS Experiment 787 (E787), explained it, "The AGS is the world's best source of kaons, producing the most per second. If you could use the entire beam of the AGS, you could make something like 10^9 kaons per pulse, or about one billion. Of course, not all of these are usable for experiments."

E791's Robert Cousins said, "We thought about doing our experiment at Fermilab," he said, "but the advantage of the AGS was in the number of protons per hour that we can get on our copper target to form kaons."

At both the AGS and the accelerator at the Fermi National Accelerator Laboratory, protons come out of the ring in pulses, and the number of protons per pulse is about the same in both machines. "But they come out about every 2.5 seconds at the AGS," said Cousins, "as opposed to every minute at Fermilab. So Fermilab has more energy, but the AGS is far more intense. And for the production of kaons, it's intensity — not energy — that's important."

The AGS's high intensity kaon beams are in an energy range that allows experimenters to make very fine particle identifications. Because this is uppermost in the mind of those involved with E777, spokesman Michael Zeller said, "For us, the AGS is the only accelerator in the world that can do this job."

— Anita Cohen

E777 — A Sensitive Spectrometer

The experimenters involved in E777 will be able to recognize that the decay $K^+ \rightarrow \pi^+ \mu^+ e^-$ has occurred by detecting an electron coursing through their experimental apparatus. Therefore, for E777 to produce good data, the apparatus must be able to differentiate an electron from a pion to one part in 10^7. This means it can make only one mistake in 10 million events.

To make the spectrometer that sensitive, three detectors — two Cerenkov counters and a lead scintillator shower counter — are used in series to identify the electrons. If all three detectors recognize a particle as an electron, then it probably is one. Said Zeller, "the AGS is the best accelerator for utilizing this technique."

E780 and E791 — Measuring Final State Particles

To determine if $K^0_L \rightarrow \mu e$, E780 and E791 both try to measure everything about the final state particles, to see if one event produced both a muon and an electron.

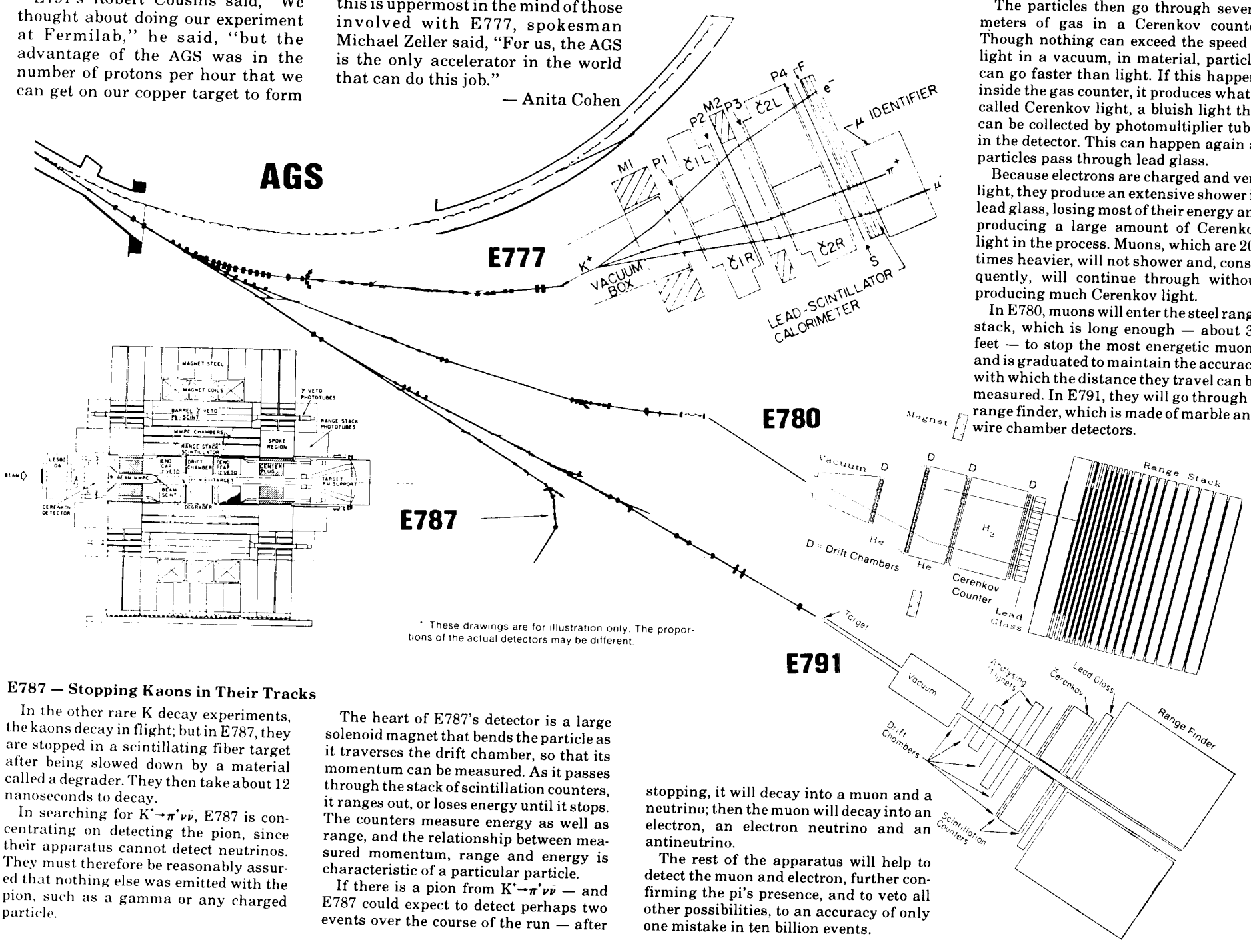
In both experiments, the particles first pass through two drift chambers, which measure their initial trajectories by measuring positions, to better than 0.01 inches.

In E780, the particles' paths are then bent in a powerful electromagnet, in an amount proportional to their momentum, which can thus be measured quite accurately; in E791, two magnets bend the particles twice, and momentum is measured twice, to reduce background. Then the particles' new trajectories can by measured by two subsequent drift chambers.

The particles then go through several meters of gas in a Cerenkov counter. Though nothing can exceed the speed of light in a vacuum, in material, particles can go faster than light. If this happens inside the gas counter, it produces what is called Cerenkov light, a bluish light that can be collected by photomultiplier tubes in the detector. This can happen again as particles pass through lead glass.

Because electrons are charged and very light, they produce an extensive shower in lead glass, losing most of their energy and producing a large amount of Cerenkov light in the process. Muons, which are 200 times heavier, will not shower and, consequently, will continue through without producing much Cerenkov light.

In E780, muons will enter the steel range stack, which is long enough — about 30 feet — to stop the most energetic muons and is graduated to maintain the accuracy with which the distance they travel can be measured. In E791, they will go through a range finder, which is made of marble and wire chamber detectors.



* These drawings are for illustration only. The proportions of the actual detectors may be different

E787 — Stopping Kaons in Their Tracks

In the other rare K decay experiments, the kaons decay in flight; but in E787, they are stopped in a scintillating fiber target after being slowed down by a material called a degrader. They then take about 12 nanoseconds to decay.

In searching for $K^+ \rightarrow \pi^+ \nu \bar{\nu}$, E787 is concentrating on detecting the pion, since their apparatus cannot detect neutrinos. They must therefore be reasonably assured that nothing else was emitted with the pion, such as a gamma or any charged particle.

The heart of E787's detector is a large solenoid magnet that bends the particle as it traverses the drift chamber, so that its momentum can be measured. As it passes through the stack of scintillation counters, it ranges out, or loses energy until it stops. The counters measure energy as well as range, and the relationship between measured momentum, range and energy is characteristic of a particular particle.

If there is a pion from $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ — and E787 could expect to detect perhaps two events over the course of the run — after stopping, it will decay into a muon and a neutrino; then the muon will decay into an electron, an electron neutrino and an antineutrino.

The rest of the apparatus will help to detect the muon and electron, further confirming the pi's presence, and to veto all other possibilities, to an accuracy of only one mistake in ten billion events.

Rare K Decay

(Continued)

decays. If they see evidence that $K_L^0 \to \mu e$ in these additional decays, Morse said, concurring with Zeller, "A reasonable interpretation would be that there's a very massive new particle that carries a new force that changes the generations. If we don't see it, however, we can say that the mass of the particle that carries the generation-changing thing is greater than 70 TeV — if it exists."

Two Interesting Candidates

E780 researchers are also using their experimental setup to search for two CP violating decays $K_L^0 \to \pi^0 e^+ e^-$ and $K_L^0 \to \pi^0 \mu^+ \mu^-$. "It's very preliminary," Morse said, "but we have two interesting candidates we're looking at — one event of each type of decay mode."

If these candidates stand up to further scrutiny, physicists agree that it will be very exciting. So far, however, none of the other rare K decay experiments has been able to corroborate E780's evidence for these two decays, though both E777 and E791 will continue to search for them during their present runs.

E791 is most likely to recreate E780's findings, if possible, because both experiments are designed to test the same physics. Though E780 has had a one-year head start, E791 began running last May with a completely new beam line and a very sensitive spectrometer that was custom-designed to look for the decay mode $K_L^0 \to \mu e$.

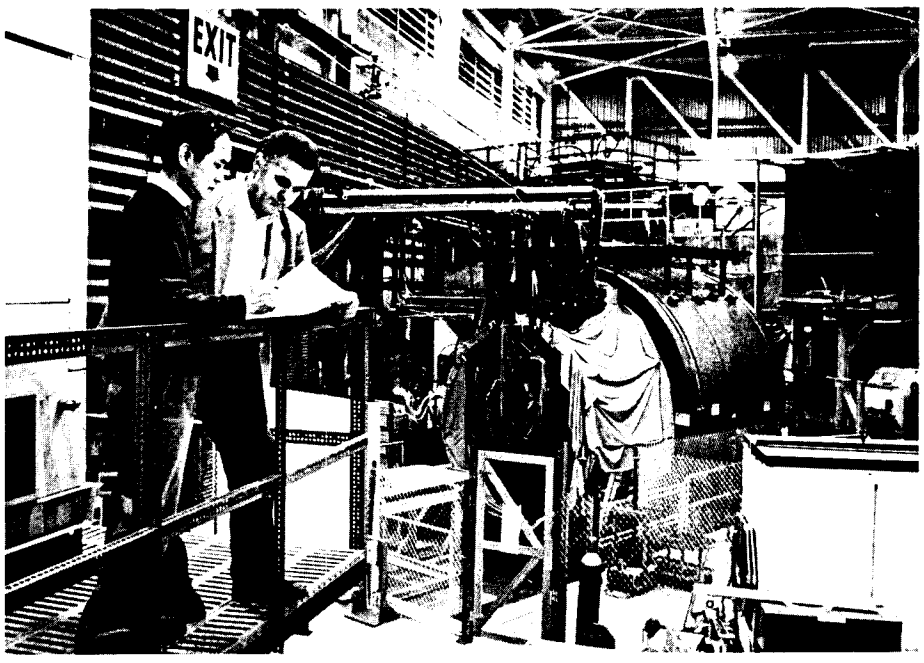
More Precise Results

"After E780 gets results, we will get more precise results," said Guest Physicist Robert Cousins, University of California, Los Angeles (UCLA) one of the experimenters with E791. It is a collaboration between the College of William and Mary; Los Alamos National Laboratory; Stanford University, Temple University; UCLA; University of California, Irvine; and University of Pennsylvania.

In addition to $K_L^0 \to \mu e$, E791 was also designed to search for the rare decay $K_L^0 \to e^+ e^-$. Since the standard model prediction is so low, any evidence of this decay would likely be interpreted as new physics.

Though E791 was designed with two specific decays in mind, Cousins said, "It's so sophisticated we can measure many other things." That's why E791's proposal also indicated the team would search for such other rare decays as the $K_L^0 \to \pi^0 e^+ e^-$ and $K_L^0 \to \pi^0 \mu^+ \mu^-$ decays that may have been observed by E780.

"We haven't seen them yet," explained Cousins, "because these decays are not expected to occur in any of the data we have taken so far. But we will be looking for them in this current run. The next two runs will provide most of our statistics."



Kelvin Li (left) and Ted Kycia at AGS Experiment 787.

Seeking Suppressed Decays

The newest rare K decay experiment at the AGS is E787, a collaboration of BNL, Princeton University and TRIUMF. Spokesman Ted Kycia, a BNL Senior Physicist, said, "The whole detector was assembled over the past five months." Every detector needs some debugging and tuning, so the data that E787 collects during this first run will be largely preliminary.

Unlike the other three rare K decay studies, E787 is seeking suppressed decays, rather than forbidden ones. These are predicted by the standard model to occur, but only with very small probability. The probability that a particle will decay through a possible decay mode is called its branching ratio. A low branching ratio indicates a low probability that a particular decay will occur.

Like E777, the primary decay that E787 will search for begins with a positively charged kaon. However, E787 is looking for it to decay into a pion, a neutrino and an antineutrino: $K^+ \to \pi^+ \nu \bar{\nu}$.

"The standard model predicts a very low branching ratio for this decay mode — about 8×10^{-11}," said Kycia. "We will try to get down close to that level with this detector.

A Flexible Detector

"If we detect a higher branching ratio," he continued, "it could be an indication that there is another generation of quarks and leptons. That would be exciting, but, of course, there could be other possible contributors to a higher branching ratio — such as the decay $K^+ \to \pi^+ X^0 X^0$.

"Candidates for X^0 include such particles predicted by current theories as the supersymmetric neutrino, photino or goldstino," continued Kycia, "So if we should detect some events, we'd need to carry out more experiments to pin down the source.

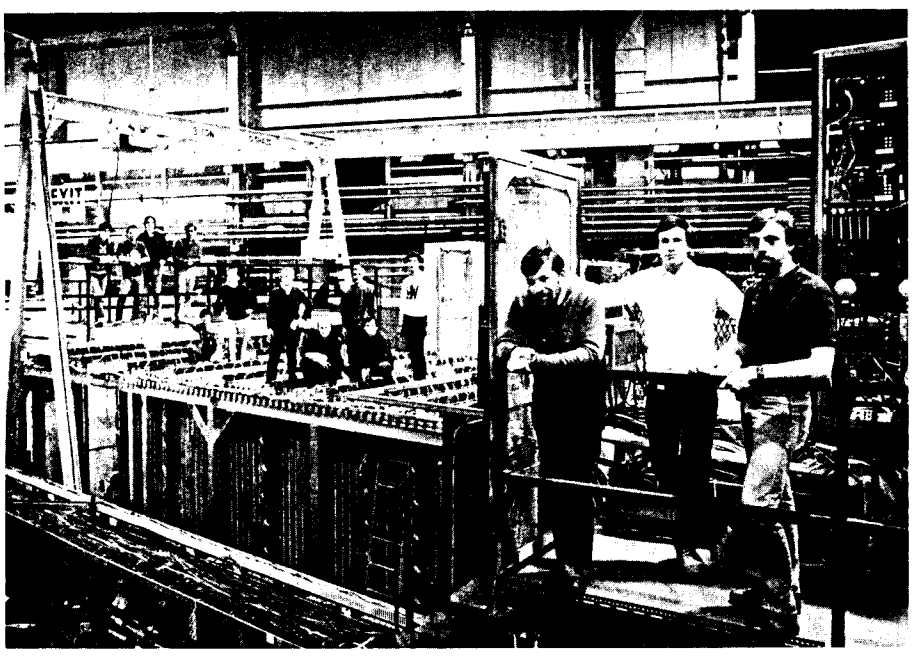
"We should also have the sensitivity of detecting axions, if they exist," added Kycia. E787 will do this by looking for the decay $K^+ \to \pi^+ X^0$, where X^0 is a neutral, light and weakly interacting particle with a sensitivity of 4×10^{-11}, which is several orders of magnitude higher than the present limit. In addition to axions, candidates for X^0 include familons and the scalar Higgs."

Receiving the most attention right now are axions, which are postulated as a way of explaining the missing mass of the universe.

"One possible interpretation for the missing mass is that the world is full of axions, which are not highly interacting, so they have not been observed," continued Kycia. "So we'll conduct that search, and who knows? There could be other surprises. With a detector as flexible as ours, it should be possible to study other K decays."

And that leads to a final definition for the term rare K decay: An opportunity to pursue interesting and revealing physics at the AGS.

— Anita Cohen



Atop the range finder of AGS Experiment 791 are (from left) Chong Zhang, John Ginkel, Joe Stumpo, Chakravarthy Mathiazhagan, Katsushi Arisaka, Morty Eckhause, Ken McFarlane, Rob Whyley, Chris Kenney, Karol Lang and Kurt Biery. To their right are (from left) Wayne Kinnison, David Wagner and Bill Molzon.

Pick a Student

Staff members are invited to review applications to select students to work under their supervision for the 1988 Summer Student and Summer Intern Programs, which will run from June 13 through August 19. Applications will be available for review in Room 2-107, Bldg. 490, Medical Department, from February 17 through March 1. Please enter through the main door and follow the signs.

Guidelines regarding selection of students have been distributed to research department offices. If interested, please contact your department coordinator.

BROOKHAVEN BULLETIN

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ANITA COHEN, Editor
MARSHA BELFORD, Assistant Editor
LIZ SEUBERT, Reporter

35 Brookhaven Ave., Upton, N.Y. 11973
(516)282-2345

A Looke at Lepe Yeare

For three out of four years, a date that falls on a Tuesday one year will fall on a Wednesday the next year. But every fourth year comes leap year, when an extra 24 hours are inserted as February 29 to accommodate the earth's persistent inability to circulate the sun in the 365 days ordinarily allotted.

So in leap year, as March begins, the date that fell on Monday in the preceding year leaps over the usual Tuesday, landing on Wednesday instead, and other days follow suit. And that's been the official pattern in western Europe, at least since Julius Caesar's calendar was introduced, in 46 B.C.

Another pattern that changes with every leap year is the way that people propose marriage. In ordinary years, it is the custom that the male of the species, sparked by glimmering moonlight and the prospect of someone to share the washing up, is the one to drop to one knee before the female of his choice, mumbling, "Dearest, will you marry me?"

In leap year, however, the tradition changes. It's women's turn to be allowed to ask for hand and heart in hope and dread. One old saying of untraceable origin holds that not only may a woman propose during leap year, but on being refused, may claim a silk gown from her reluctant love — unless he can prove that he is already engaged.

Evidence that the saying was taken seriously is found in an Act of the Scottish Parliament in 1288, which says:

"It is statut and ordaint that during the rein of hir maist blissit Megeste, for ilke year known as lepe yeare, olk mayden ladye of bothe highe and lowe estait shall hae liberte to bespeke ye man she like, albeit he refuses to taik hir to be his lawful wyfe, he shall be mulcted in ye sum of ane pundis or less, as his estait may be; except and awis gif he can make it appeare that he is betrothit ane ither woman he then shall be free." (Sic, sic, sic for the spellinge.)

— Liz Seubert

Arrivals & Departures

Arrivals

Joseph R. Cuccia Jr. ..... Physics

Departures

This list includes all employees who have terminated from the Laboratory, including retirees:

Harold L. Justice ..... Sfgrds. & Sec.

Talent Show Tomorrow

Entrants ranging from six to 18 years of age will take the Berkner stage on Saturday, February 27, to participate in a Talent Show sponsored by the Afro-American Culture Club in celebration of Black History Month.

At 7 p.m., Master of Ceremonies George Grigg Jr. will begin introducing the first of the 32 scheduled acts. The top three will receive monetary awards, and all performers will receive certificates of participation.

All tickets are $3 and may be purchased in advance from: April Donegain, Ext. 2459; Mary Durham, Ext. 7143; Frances Ligon, Ext. 3709; Bruce Penn, Ext. 7213; or Public Affairs, Ext. 2345.

Hospitality News

Guest speaker Vivian Aronson will discuss weaving and spinning, at the next Hospitality Committee morning get-together, which will be held Tuesday, March 1, at 9:30 a.m., in the Brookhaven Center.

We would like to have you join us for this interesting demonstration. Spouses of Laboratory employees and guests are welcome. Please come and bring the children. Babysitting will be provided free of charge. Coffee, tea and danish will be served.

Quilting Classes

Two-hour quilting classes will be held Wednesday evenings, from 7 to 9 p.m., in the Recreation Building in the apartment area on site.

Instructor Linda McKnight has requested that each participant bring the following items to each class: pencil, ruler, sharp scissors, needles, thread (preferably quilting thread) and fabric. If you do not have any fabric, you may purchase some from McKnight at the time of the class.

Cafeteria Menu

Week of February 29

Monday, February 29

Beef noodle soup	(cup)	.75
	(bowl)	.95
Meatball stroganoff over rice		2.85
Pork & cabbage crisp w/1 veg.		2.95
Julienne salad plate (lite-weight)		2.25
Hot deli: Roast turkey breast	(bread)	2.75
	(roll)	2.85
	(hero)	2.95

Tuesday, March 1

Navy bean soup	(cup)	.75
	(bowl)	.95
Roast top round of beef au jus & 1 veg.		3.05
Italian cheese ravioli w/garlic toast		2.75
Seasonal fresh fruit plate (lite-weight)		2.25
Hot deli: Grilled Reuben sandwich		2.85

Wednesday, March 2

Southern vegetable beef soup	(cup)	.75
	(bowl)	.95
Shrimp fried rice w/1 veg. (lite-weight)		2.85
Beef Burgundy ragout over noodles		2.95
Hot deli: Pastrami	(bread)	2.75
	(roll)	2.85
	(hero)	2.95

Thursday, March 3

Beef barley soup	(cup)	.75
	(bowl)	.95
Hunan chicken w/1 veg.		2.85
Skinless baked chicken w/1 veg. (lite-weight)		2.85
Deluxe pizza	(slice)	1.25
Hot deli: Roast beef	(bread)	2.75
	(roll)	2.85
	(hero)	2.95

Friday, March 4

Seafood gumbo	(cup)	.75
	(bowl)	.95
BBQ spareribs w/1 veg.		2.95
Moussaka w/1 veg.		2.95
Baked fresh fish w/1 veg. (lite-weight)		2.85
Hot deli: Corned beef	(bread)	2.75
	(roll)	2.85
	(hero)	2.95

Softball

Any new teams that would like to join the Softball League for the 1988 season should contact Sharon Smith, Ext. 3995, no later than Friday, March 4.

PC User Group

The next meeting of the PC User Group will be on Wednesday, March 2, at 10 a.m., in the Applied Math Seminar Room, Bldg. 515. Jerry Wilnecker of I/O Tech, Inc., will give a presentation on interfacing PCs to the IEEE-488 bus, an 8-bit parallel bus for instrumentation.

Bowling

Red/Green League
C. Bohnenblusch rolled a 230, N. Combatti 223, K. Asselta 216, J. Morris 213/202/605 scratch, T. Prach 213, H. Arnesen 209, E. Sperry 208, M. Guacci 201, C. Scarlett 200.

White League
High games were bowled by Paul Callegari 233/227/640 scratch series, Ken Riker 221, Joe Ferrante 217, Jim Petro 202.

Pink League
Renie Rosati had a 190, Maryann Reynolds 185/168, Kathy Folkers 167.

Purple League
Sharon Smith bowled a 224, Dick Adams 220, Ed Sperry 210, Bob Jones 201, Sharon Moore 198.

Basketball

Standings as of February 18

First Game

Penetrators 53		Knicks 62	
J. Cyr	18	W. Cummings	16
R. Tonkyn	13	L. Walcott	14
T. Abbott	10	M. Lawrence	11
T. Comstock	5	Q. Harrison	11
R. Domenech	5	T. Mendez	6
F. Johnson	2	G. Thompson	2
		T. McGill	2

Three-point shots: Cummings, Domenech, Harrison, Walcott

Second Game

Runaways 45		Hollywood 56	
G. Shepherd	14	G. Mack	16
G. Dunmore	11	E. Meier	12
S. Gilbert	10	K. Hester	11
J. Desmond	8	J. Ripka	6
P. Johnson	2	L. James	6
		B. Turner	4
		B. Gunther	1

Three-point shots: Gilbert, Shepherd (2)

Third Game

Celtics 53		Longshots 44	
O. Aliefendioglu	12	T. Mayo	22
P. Ratzke	10	J. Garrison	12
J. Gaeta	10	F. Malone	4
C. Edwards	9	S. Springston	4
A. Ratti	6	J. Wells	2
P. Browne	4		
M. Fulkerson	2		

Three-point shots: Aliefendioglu, Garrison (2), Ratti

Scoring Leaders	Averages
Q. Harrison	16.57
T. James	16.33
W. Cummings	14.57
J. Cyr	13.00
E. Meier	12.29
P. Johnson	12.14
T. Comstock	11.71
F. Thompson	11.67
S. Gilbert	11.43
G. Mack	11.43

Classified Advertisements

Placement Notices

The Laboratory's placement policy is to select the best-qualified candidate for an available position, with consideration given to candidates in the following order of priority: (1) present employees within the department and/or appropriate bargaining unit, with preference to those within the immediate work group; (2) present employees within the Laboratory as a whole; and (3) outside applicants. In keeping with the Affirmative Action plan, selection decisions are made without regard to age, race, color, religion, national origin, sex, handicap or veteran status.

Each week, the Personnel Office lists new personnel placement requisitions. The purpose of these listings is, first, to provide open placement information on all non-scientific staff positions; second, to give employees an opportunity to request consideration for themselves through Personnel; and, finally, for general recruiting purposes. Because of the priority preference policy stated above, each listing does not necessarily represent an opportunity for all candidates. As a guide to readers, the listings are grouped according to the anticipated area of recruitment.

Except when operational needs require otherwise, positions will remain open for one week following publication date.

For further information regarding a placement listing, contact the Employment Manager, Ext. 2882.

LABORATORY RECRUITMENT - Opportunities for Laboratory employees only.

2800. HFBR USER COORDINATOR - Requires an AAS degree or equivalent, substantial knowledge of Laboratory policies and procedures, demonstrated organizational abilities and experience in administrative functions. Will be responsible for processing HFBR user proposals and coordinating these efforts between users, the review committee and Participating Research Teams. In addition, will organize meetings and workshops, handle budgets and perform secretarial duties for small group. Excellent oral and written communication skills are required as well as the ability to organize and edit materials for a user newsletter. Director's Office.

OPEN RECRUITMENT - Opportunities for Laboratory employees and outside applicants.

2801. ACCOUNTING POSITION - Requires AAS in accounting, BS preferred, a minimum of 2 years' working accounting experience, and excellent communication skills. Responsibilities will include assistance in various areas of General Accounting, i.e. A/R, inventories, capital equipment and other accounting analyses. Fiscal Division.

2802. CONTRACTS POSITION - Requires a BS degree in a technical field and significant experience in all phases of procurement with an emphasis on contract preparation, price analysis and administration. Will be responsible for drafting RFP's, developing contract modifications, evaluating proposals, and analyzing cost and man-hour estimates. Contracts and Procurement Division.

2803. ENVIRONMENTAL CHEMIST - Requires MS/PhD in analytical and environmental chemistry and several years of related experience with analytical instrumentation. Will provide technical assistance and overview for all non-radiological aspects of S&EP's analytical chemistry program. Responsibilities also include the development and implementation of new procedures and applicable EPA programs to meet regulatory permit requirements. Familiarity with RCRA and other EPA regulations, industrial hygiene and EPA sample analysis techniques required. Safety & Environmental Protection Division.

Motor Vehicles & Supplies

77 MERCURY MARQUIS - 122k mi., $300; 2 Mich. radials, 215-75R/15, 2 steel snows, 225-75R/15, $50/pair. Sam, Ext. 4023 or 929-3721.

SNOW TIRES - 2, 195-14, low miles, $15/ea; tire for 100cc dirtbike, brand-new, $20. 924-3082.

77 PEUGEOT 604 SEDAN - rare, extras, new parts, needs some work, asking $2,100. Ext. 3653 or 878-8541.

81 RABBIT - 4 speed, new clutch, clean in/out, am/fm cass. 281-4507, 6 p.m.-9 p.m.

82 DATSUN 200SX - 5 speed, a/c, loaded, 99k mi., excel. cond., asking $2,600. John, Ext. 7770 or 4480.

73 BUICK - good cond. Ext. 4496 or 878-1584 eves.

VW PARTS - rebuilt cylinder heads, new Weber carb., assorted studs, $100 takes all. Fred, Ext. 4407 or 4435.

80 HONDA ACCORD - 2 dr., 5 speed, 71k mi., excel. cond., $1,300. 744-6668 after 6 p.m.

76 TOYOTA COROLLA - runs well, $400 neg. Ext. 3836.

80 MUSTANG - w/Chevy 305 cu. in., 450 h.p. motor, new tranny, motor, rear, asking $5,700. John, Ext. 5222 or 698-5701.

86 CAMARO - red, w/black int., V6, 44k mi., loaded, Kenwood stereo system, $7,500. John, 727-3673.

78 PONTIAC GRAND PRIX - 8 cylinder, 301 engine. Frank, Ext. 2314 or 567-5131.

77 CHEVROLET BLAZER - 4wd, a/c, new tires, K-5 Cheyenne pkg., 4" lift, $3,500. 369-2535.

57 FORD DEL RIO RANCH WAGON - good cond., $2,900. Ext. 2385.

85 NISSAN PICKUP - 4x4, king cab, ST pkg., mint cond., extras, $8,500. Ext. 4241 or 732-4577.

CHEVY VEGA - bad trans., rest OK, good for parts, $50. Ernesto, Ext. 3869 or 475-7569.

85 TOYOTA COROLLA - Sport Coupe, excel. cond., a/c, p/s, am/fm stereo, 5 speed, 44k mi., $5,900. 758-2544.

78 PONTIAC GRAND PRIX - needs windshield, motor runs well, body good, $1,850. 286-3334.

86 IROC-Z - red/black, T-tops, louvers, a/c, cruise, p/s, p/b, p/w, much more. 727-1412 after 6 p.m.

68 CAMARO PARTS - doors, truck int., more, some free. Steve, Ext. 2310 or 929-6877.

81 JEEP WAGONEER LTD - tan/wood, V8, 4 dr., 4wd, full power, a/c, sunroof, $6,500. 475-3407.

83 BUICK REGAL - excel. cond., a/c, p/s, am/fm, beige landau top, asking $5,800. Ext. 2964.

75 FORD GRANADA - V8, a/t, a/c, 4 dr., runs well, $400. Greg, 399-1258.

82 CHEVETTE L/S - damaged, many excel. parts, 45k mi., best offer over $300. Dave, 281-0062.

65 DODGE DART - best offer. Ext. 2314 or 567-5131.

Boats & Marine Supplies

12' ALUMINUM BOAT - good cond., $300; outboard motor, Mercury, 9 h.p., new pump, $350. 924-3082.

16' ALUMICRAFT - good fishing boat, needs some work, $125. Ken, 289-8212.

WANTED - 26' Polaris Sloop, inboard, gas, any cond. Ext. 3339 or 286-3393.

16' BOWRIDER - rebuilt, 70 h.p., trailer, canvas, many extras, good cond., asking $2,200. Dan, Ext. 2075 or 737-8124.

22' SEAFARER SAILBOAT - 1974, 3 sails, Volvo outboard, full keel, asking $4,000. Fred, Ext. 4407/4435 or 499-1214.

22' MARATHON WEEKENDER - 1986, 170 h.p., Mercruiser, Shoreline trailer, stand-up head, full galley, extras, $16,500. Ext. 3341 or 981-9474.

Miscellaneous

BIKE - 10 speed, front rim bent, rest in great cond., $25 firm. Billy, 286-0243 after 4 p.m.

MOVING SALE - Patchogue, furniture. 758-7562.

CHEST - Sears, children's, 4-drawer; 3-drawer dresser/changer; double bed, maple finish; ski boots, man's size 11. John, Ext. 5279.

ROUTER - Sears, w/20 cutters, new cond., $45; reciprocating saw, Wren, w/blades, $25. 924-3067.

POOL TABLE - slate, 4'x7', w/accessories, $200; ping pong table, folds, excel. cond., $70. 758-9743 after 6 p.m.

MOLDING - 2⅝" Sprung, painted white, good cond., 190', 25¢/ft. or $40/all. Ext. 2452.

SKIS - woman's 150cm & size 7 boots. Tom, Ext. 5275.

HARD DISK INTERFACE - for PC jr. controller, cables, power supply, uses any drive, $120. Bernie, Ext. 4842.

SCREENS & STORM WINDOWS - wood, 14 each, good cond. Cliff, Ext. 3794.

DIRT BIKE - 1987, KX80, excel. cond. Bob, Ext. 4672 or 929-4753.

IBM PC - 256K, color, two 360K Hayes modem w/Smartcom II, mouse microspooler, $800. Elaine, Ext. 5329.

BRAIDED RUG - oval, brown/orange/white, 4½'x8', cotton, 2 smaller matching rugs, very good cond. 821-1455.

UNDERSHIRTS - Jockey, man's, new V-neck, large 42-44, $3/ea.; D-76 replenisher. Susan, Ext. 4267.

SOUND MOVIE CAMERA - Minolta XL-440 Super 8mm; Cannon PS-1000 sound projector, screen, film splicer, case, all $250. Jim, Ext. 4758.

AQUARIUM - 10 gal., complete deluxe set-up, excel. filter, stand on wheels, 2 lg. fish, instruc. & more, $185 value asking $95. 929-3795.

WEDDING HAT & VEIL - wide brim, beaded, $65. 289-1003 eves.

POLAROID AUTO 250 - w/case, flash, cable release, $35; Aquarius computer w/16K memory, data rec., printer, more, $120 neg. Ernie, 588-4987.

Car Pools

QUEENS - van pool needs one person. Fred, Ext. 3254.

Real Estate

Real Estate advertised for sale or rent is available without regard for the race, color, creed, sex or national origin of the applicant.

For Rent

BELLPORT VILLAGE - 1 bdrm. cottage, no pets, non-smokers, ref. required, couple preferred. Ext. 2700 or 286-7539.

HILTON HEAD, SC - 2 bdrm. condo, sleeps 6, beach, pool, golf, tennis, Feb. & March, $320/wk. Ext. 3147 or 585-9149.

EAST SETAUKET - 3 bdrm. hi-ranch, l/r, d/r, 1½ baths, economical coal stove, patio, in-ground pool, avail. immed., $925/mo. + util. Ext. 3791 or 928-7154.

RIDGE - 2 large bdrm. house, newly refurbished, combined l/r-d/r, walk to private lake, 5 mi. to Lab, $675/mo. + 1 mo. sec. Ext. 4048.

MASTIC PARK - small 1 bdrm. apt., furn., cable, $350/mo. + elec. & 2 mo. sec. 281-7844.

For Sale

WINDHAM, NY - ski chalet, 3 large bdrms., sleeps 10, 2 baths, fp, all appliances. 744-9746 eves.

STONY BROOK - 4 bdrm. cape, quiet street, l/r w/fp, den, d/r, 2 baths, bsmt., office, $189,000 or rent for $1,075/mo. + util. 751-8240 eves.

PATCHOGUE - large 1 bdrm. co-op, 2nd floor, immaculate, w/w, appliances, new kitchen, many closets, a/c, balcony, near all, must see, $69,900. 472-0392 or 472-6922.

PALM COAST, FL - ¼ acre, Greenbelt, approx. 3-5 miles to ocean, 24 miles to Daytona, water & sewer util., great investment, $5k & take over payments, $142/mo. over 8 yrs. Tom Nolan, Ext. 5265 or 7160.

MASTIC - Forge River area, immaculate 3 bdrms., country kitchen, l/r w/fp, 100x175 fenced plot, city water, by owner, $106,000. 273-2349.

SHIRLEY - Tangiers, 4 bdrm. cape, brand-new, full bsmt., oak floors, European cabinets, 100x150 plot. 736-3899.

AQUEBOGUE - 3 bdrm. ranch, f/p, oak floors, beautiful wooded ½ acre, $132,500. 874-2318.

CENTER MORICHES - corner lot, 5 bdrms., 2 baths, full bsmt., 1 car garage, storage, shed, 1 block from bay, 15 min to Lab, choice of 3 school districts, $175,000. John, Ext. 7799 or 874-2932 after 6 p.m.

SETAUKET - north of 25A, hilltop setting, private, 3 bdrm. ranch, 2 baths, open l/r, den w/fp, 2 car garage, patio, beautiful landscaping, $229,000. Ext. 7560 or 689-7494.

NORTH SHIRLEY - 5 bdrm. hi-ranch, 2 kitchens, d/r, l/r, family rm., 3 baths, garage, ½ acre, fenced, 20x20 deck, 9 months old, $155,000. 395-5188 after 5:30 p.m. & wknds.

Wanted

ALUMINUM "JOHN" BOAT - approx. 4'x12', light, complete, good cond. Ext. 3794.

HOUSE TO RENT - 3 bdrm., in SWR school district, for BNL physicist w/family. Ext. 3009 or 2707.

BASEBALL CARDS - any condition. Ext. 3541 or 924-4070.

HOUSE OR APARTMENT - to rent, for approx. 2 months during summer season. Mirek, Ext. 3861.

INFANTS - 3 months old for Ph.D. study of infant memory, involves pleasant play tasks in your home. Ext. 3372.

PARTICIPANTS - to join Jazzercise, on site. Marilyn, Ext. 2259.

CAROLINA RICE UPC LABELS - for church, until March 25, send to Debbie, Bldg. 463. Ext. 3420.

TENNIS BALLS - used, for dogs to play with. Victor, Ext. 2395.

HOME CARE FOR ELDERLY MAN - 4-5 hrs. a day, 3-4 days a week, Brookhaven Hamlet. Jim, Ext. 4040 or 289-0876 or 286-0024.

Ads left out of this issue due to lack of space need not be re-submitted to appear in the next issue.