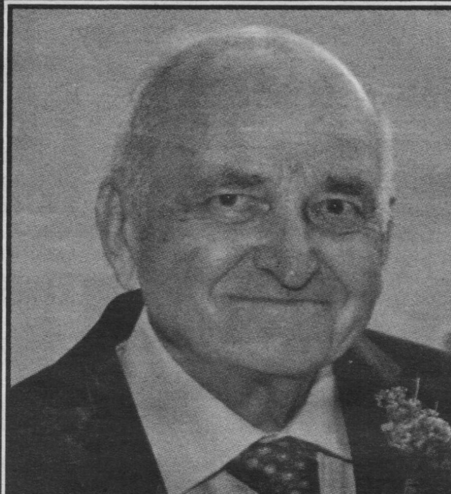
Robert Edward Chrien

Robert Edward Chrien, a senior physicist who retired from BNL's Physics Department on July 31, 1998 after more than 40 years at the Lab, passed away on October 7, 2016. He was 86 years old.

His daughter, Elizabeth Zarrilli, sent this family photo:

The following obituary was published in the Long Isand Advance on October 13, 1916:



Robert Edward Chrien

Robert Edward Chrien, age 86, of Bridgeport, CT (formerly of Bellport, New York), beloved husband of Susan V. Chrien, passed away peacefully on October 7, 2016.

Robert was born in Cleveland, Ohio on April 15, 1930 to the late Fredrich and Anna Goraz Chrien. He was a graduate of Rensselaer Polytechnic Institute and obtained a Ph. D. from Case Institute of Technology. He met his wife, Susan, at Dr. Martin Luther Evangelical Lutheran Church where they were married in 1953.

Robert worked as a senior physicist at Brookhaven National Laboratory in Upton, New York where he did research on nuclear physics and intermediate energy physics. He served as group leader for these two research areas. He also spent two years working as a Brookhaven representative at the Atomic Energy Laboratory in Chalk River, Ontario, Canada. He was a fellow of the American Physical Society and the American Association for the Advancement of Science.

His research included fundamental research on gamma rays from the capture of neutrons by nuclei and interaction of mesons with the nucleus. He led a team at Brookhaven that produced large numbers of doubly strange nuclei and studied their properties. He discovered second order nuclear transitions – the emission of two simultaneous successive gammas from neutron capture.

Robert was a long time member of Our Savior's Lutheran Church in Patchogue, New York. He served for many years as treasurer of the South Bay Art Association, President of the Citizens Council and President of the Bellport Community Action Committee.

Robert and his wife, Susan, moved to the Watermark Retirement Community in Bridgeport, CT in 2011. Robert became involved in the Residence Council and enjoyed teaching a popular "Science in the News" lecture at the Watermark University. He became a member of Salem Lutheran Church and would regularly attend services there.

His longtime passions include a love of classical music, reading, traveling and spending time with his children and grandchildren. He enjoyed going to the theatre, the symphony and book study groups. Every summer, Robert and his wife would spend a week of culture and retreat at Chautauqua Lake where they indulged their tastes for music, art, theatre, lectures and food. He enjoyed keeping in touch with friends from his past and would regularly visit friends and family whenever he traveled.

He is survived by his wife Susan and children Robert E. Chrien (wife Elisabeth) of Los Alamos, NM, Katherine S. Chrien (husband Harry Rogers) of Annapolis, MD, Elizabeth Zarrilli (husband Frederick) of Fairfield, CT and Thomas G. Chrien (wife Nadine) of Rancho Palos Verdes, CA. He will be greatly missed by his grandchildren Jennie (husband Steve Simpson), Natalie, Naomi, Jonathan, Zachary, and Justin.

A memorial service will be held next spring at Salem Lutheran Church, 3160 Park Avenue, Bridgeport, CT. In lieu of flowers, please make donations to his church. Funeral arrangements by the Redgate – Hennessy Funeral Home, 4 Gorham Place, Trumbull, CT 06611. To send online condolences, please visit www.redgatehennessy.com

The following highlights from Robert Chrien's years at BNL appeared in the Brookhaven Bulletin:

on August 15, 1997 –

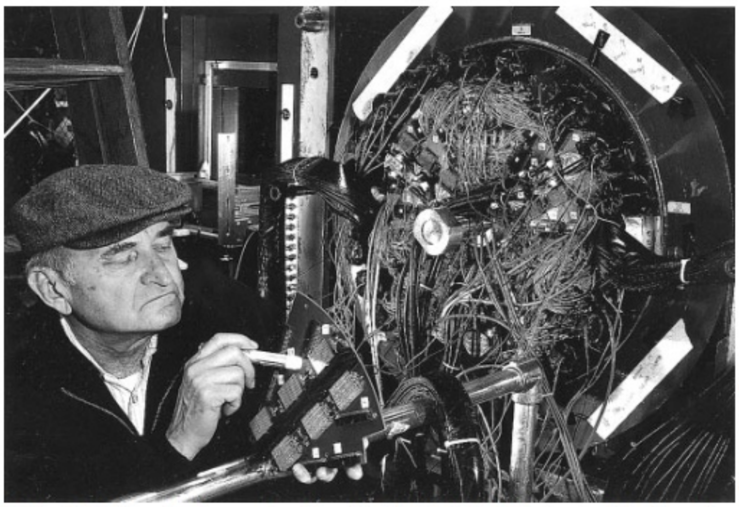
Strange Interactions May Reveal Perfect Symmetry at the AGS

If anything's strange about E906 at the Alternating Gradient Synchrotron (AGS), then the researchers hope the strangeness may be double.

But that's not strange because these experimenters are studying interactions between particles containing strange quarks, looking for the H-dibaryon and other particles containing two units of the quality physicists call strangeness.

Quarks, thought to be the fundamental constituents making up the particles in the nucleus of an atom, come in six "flavors": In addition to the strange quark, there are the up, down, charm, bottom and top quarks. A baryon is a particle containing three quarks, and the H-dibaryon, predicted by theorists to be formed of a symmetrical arrangement of two strange, two up and two down quarks, could be an example of matter in its most stable state.

Armed with the AGS kaon beam — the world's most powerful beam of kaon particles — at the D6 beam line, and a new detector system, the E906 collaboration of scientists from Japan, Germany, Russia and the U.S., including BNL, hopes to obtain new information on strange baryons, which may also lead to evidence of the existence of the six-quark H-dibaryon.



Roger Stoutenburgh

Robert Chrien is shown beside the Cylindrical Detector System designed for AGS Experiment 906 by Joe Nakano, INS-Tokyo.

"To do the experiment, we use the kaon beam at beam line D6 to create nuclei that contain two strange hyperons," said Robert Chrien, a senior physicist in the Physics Department and cospokesman for the experiment. "Hyperons are what we call baryons that have at least one of their three quarks in a flavor other than up or down. The AGS D6 kaon beam is exactly suited to creating the lightest hyperon, the lambda, which consists of an up, a down and a strange quark. Once you have two lambdas in a nucleus, interactions between these strange baryons may occur. One outcome may be H-dibaryon formation."

Chrien explained that the way to observe the doubly strange lambda-lambda interactions is to watch for a sequence of two pions appearing at the same time. In E906, the pions would appear in the interactions after the kaon beam hits a beryllium target, if a nucleus containing two lambda hyperons decays to an ordinary, non-strange nucleus.

If no sequence of two pions appears, it means that the lambdas could have fused together to form the H-dibaryon. If, on the other hand, the pions ap-

(continued on page 3)

Strange Interactions (cont'd.)

pear, that would be decisive evidence against the existence of the H. "Either way, the results will be interesting," Chrien said.

To detect the pions, Joe Nakano of INS-Tokyo, a student of E906's cospokesman, Tom Fukuda, designed and engineered the Cylindrical Detector System (CDS), an extremely compact set of particle detectors. Other experimenters playing a major role in the experiment include Adam Rusek of BNL's Physics Department and Toru Tamagawa, University of Tokyo, who is developing the analysis codes used for the particle tracking in the CDS.

The CDS has been designed to provide the maximum amount of information on the hyperons that decay in the experiment, Chrien explained. "The entire device, with all its associated electronics and phototubes, fits into a magnet of overall dimensions 110 by 110 by 130 centimeters, with a 20-centimeter beam hole. The compact, cylindrical design maximizes the efficiency with which kaon-induced reactions can be studied."

The experiment will run until 1998. "E906 is one among many experiments that can best be done at the AGS," emphasized Chrien. "The AGS program is of special interest to our Japanese collaborators, who are considering the construction of a 50-billion-electron-volt [GeV] version of the AGS, which operates at 33 GeV for protons. The new device, the Japanese Hadron Facility, will enable them to continue the research we pioneered at the AGS into the 21st century. The AGS is now serving as a vital bridge to the next generation of experiments, so it is important to our Japanese colleagues as they prepare for the future."

— Liz Seubert

on August 31, 2001 –

BNL's AGS Produces First Significant Number Of 'Doubly Strange Nuclei'

Strange physics has taken a great leap forward at BNL, where physicists have for the first time produced a significant number of "doubly strange nuclei" — nuclei containing two strange quarks.

Strange quarks are one of the six types or flavors of quark believed to make up the particles in the nucleus of an atom. Studies of doubly strange nuclei will help scientists explore the forces among these particles, particularly within what is called baryonic strange matter, in which the quarks are confined to baryons, which contain three quarks. In addition, studying doubly strange nuclei may contribute to a better understanding of neutron stars, the superdense remains of burnt-out stars, thought to contain large quantities of strange quarks.

"This is the first experiment to produce large numbers of these doubly strange nuclei," said Adam Rusek, Collider-Accelerator (C-A) Department, who, with Robert Chrien, Physics Department, and Tomokazu Fukuda of Osaka, Japan, is a co-spokesperson for the collaboration. Rusek explained that the whole experiment was conceived and planned by Fukuda, who first had the apparatus designed and built in Japan, then brought the experiment to BNL to use the world's cleanest and most intense kaon beam — produced at the Alternating Gradient Synchrotron (AGS).

Collaborating on the experiment are 50 physicists, representing 15 institutions in six countries. They describe their findings in an upcoming issue of *Physical Review Letters*. Two collaborators, Joe Nakano and Toru Tamagawa, are from the University of Tokyo. Other BNL collaborators on this "strange" research are: Philip Pile, C-A, and Richard Sutter, Physics.

Four previous experiments conducted over the past 40 years in the U.S., Europe, and Japan have produced one such nucleus each, with varying degrees of certainty.

In the current publication, which is based on data taken in 1998, the collaboration describes 30 to 40 events out of several hundred produced. "That's enough events to begin studies using statistical techniques," Rusek said.

With the ability to produce appreciable numbers of doubly strange nuclei, "BNL is now the best place in the world to study this strange matter," said Morgan May, who leads BNL's strangeness nuclear physics program.

(continued on page 2)

At the AGS with the cylindrical detector system for the doubly strange nuclei experiment are: (front, from left) Adam Rusek and Robert Chrien, (back, from left) Sidney Kahana, Philip Pile, and Morgan May.

Doubly Strange Nuclei

(cont'd.)

Strange creations

To create these doubly strange nuclei, the researchers used the AGS beam of negatively charged kaons to strike a beryllium target and interact with its protons, causing some of the energy to convert into new strange quarks. These quarks then regroup to form a variety of particles, some of which continue to interact.

Occasionally, a structure containing a proton, a neutron, and two lambda particles — each composed of one up, one down, and one strange quark — is formed. This double-lambda structure, with its two strange quarks, is the observed doubly strange nucleus.

Look for pions

Detecting the formation of this strange species is no easy task. It is like finding a subatomic needle in a particle-soup haystack. For one thing, many other species are produced in the collisions.

Plus, the scientists cannot see the double lambda structure directly. Instead, they look for pions, a subatomic product that the lambdas emit as they decay in less than one billionth of a second.

Furthermore, to infer that the pions came from a nucleus containing two lambdas, there must be two pion decay signals at very specific energies.

From the analysis, the researchers concluded that several hundreds of lambda-lambda particles were produced.

"The most important part is eliminating all the other possible explanations for these events," said Sidney Kahana, a BNL Physics theoretical physicist. "We're left with this double lambda species as the only explanation."

Japanese contribution

"I want to stress the enormous contribution of the two Japanese scientists, Joe Nakano and Toru Tamagawa, from the University of Tokyo, who completed their doctoral dissertations on this experiment," said Chrien.

In addition to his work on the physics and analysis of the experiment, Nakano was responsible for the design, construction, and operation of the cylindrical detector system (CDS), which, Chrien explained, was the crucial measurement element of the experiment.

Toru developed the analysis techniques and simulation codes required to understand the CDS data. He produced results for several calibrations and tests verifying the CDS response, as well as the analysis of the production data.

Two lambda laboratory

Now that the scientists believe they have a reliable method for producing the double lambda species, they would like to produce more so that they can get better measurements of the binding energy, or force of interaction, between the two lambda particles.

"We can use this nucleus as a laboratory in which the two lambdas can be held together long enough to study," Kahana said.

Based on the current data, the interaction between lambdas appears to be rather weak — too weak for the two particles to merge to produce a postulated, six-quark structure called an H particle. But further experiments are necessary, the scientists say.

The interaction between lambdas may also offer insight into the properties of neutron stars, which are thought to contain vast numbers of strange particles, including lambdas. Neutron stars are the only place in the universe scientists believe such baryonic strange matter exists in a stable form.

— Karen McNulty Walsh

on January 14, 2005 –

BNL Scientists Set Upper Limit on Three-Body Breakup of ^{9}Beryllium

Goldhaber's 1952 suggestion results in 2004 experiment

Working on a suggestion from Maurice Goldhaber, four Brookhaven scientists — chemist James Wishart of the Chemistry Department and retired physicists David Alburger, Robert Chrien, and Richard Sutter — have completed an experiment designed to search for a rare splitting mode of a beryllium isotope. Their experiment, published in the December 17, 2004, edition of Physical Review C, *provides the beginning of an answer to a decades-old question.*

The story begins in 1934 when Cambridge University graduate student Maurice Goldhaber began experimenting with "photodisintegration," a technique that uses photons (particles of light) to split nuclei.

Goldhaber applied this technique to many materials, but an isotope of the element beryllium, ^{9}Be, caught his attention.

The ^{9}Be nucleus can be thought of as a clump of three particles: two alpha particles, each containing two protons and two neutrons, and an extra neutron that clings loosely to them. ^{9}Be can be split up in two ways: the two-body breakup, which results in ^{8}Be and a neutron; and the three-body breakup, leading to two alpha particles and a neutron. Both types occur only if the photons have a certain "threshold" energy. In ^{9}Be, the three-body threshold is slightly lower than the two-body.

Goldhaber thought that ^{9}Be would be a good medium for detecting the "three-body force," a theoretical force that occurs only in the presence of three particles. This force would be very weak, trumped by the primary force binding the nucleus, the two-body force. However, measuring a three-body force in ^{9}Be would require observing the three-body breakup of ^{9}Be, and the probability of that, according to theory, was very, very low.

In 1952, Goldhaber, then a scientist at BNL, suggested an experiment to Alburger, who ran the Lab's 3.5 megavolt (MV) Van de Graaff accelerator, used for low-energy nuclear physics experiments. Alburger had studied a fluorine isotope, ^{20}F, and Goldhaber suggested that ^{20}F could be used as a source — i.e., use the photons produced when it decays — to break up the ^{9}Be nucleus. Alburger did in fact observe some neutrons, but these were likely produced by other radiation and his results were ultimately inconclusive.

Decades later, in 1983, a group of Japanese physicists claimed they had observed neutrons from the three-body splitting of ^{9}Be — more neutrons than predicted by theory. Goldhaber wanted to try to reproduce the results, but Alburger thought the Japanese experiment likely contained errors resulting from the radioactive source they had used.

In 2004, Alburger, by then retired, joined Wishart, Chrien, and Sutter to address the problem finally.

"Our aim was two-fold," said Chrien. "We wanted to search for neutrons produced by the three-body splitting of ^{9}Be, but we also wanted to see if the Japanese group's result was due to other radiation from the source. It seemed clear that it would be better to use an accelerator, instead of radioactivity."

The experiment, supported by the Office of Basic Energy Sciences within the DOE Office of Science, was performed at the Chemistry Department's 2-MV Van de Graaff, run by Wishart. The researchers directed the accelerated electrons at a gold target embedded within the beryllium blocks. As the electrons struck the gold nuclei, they produced "bremsstrahlung" — German for "braking radiation" — a spray of photons with varying energies. These were the source photons. Detectors surrounding the beryllium recorded any neutrons that emerged.

At the Chemistry Department Van de Graaff are (from left) Richard Sutter, David Alburger, James Wishart, and Robert Chrien.

Roger Stoutenburgh D0450193

The scientists took measurements using photons with energies above the three-body threshold but below the two-body, allowing them to see neutrons produced by the three-body split only.

They detected far fewer neutrons than the Japanese group had done and concluded that the group's result must have been due to neutrons produced by background photons, not source photons. So the present experiment set an upper limit on the number of neutrons resulting from the three-body splitting of beryllium.

The four researchers agreed that this experiment is a wonderful example of how good science can be done for nearly nothing. For example, they had used discarded detectors from the High Flux Beam Reactor, leftover electronics from the Alternating Gradient Synchrotron, and a supply of beryllium blocks from the Lab's former Nuclear Energy Department.

In the future, Alburger, Chrien, Sutter, and Wishart may attempt to make improvements to the experiment that could increase the detection rate of three-body neutrons.

"We are grateful to Maurice for suggesting this research problem and providing continual encouragement along the way," Chrien said. "And we also thank Stephen Howell and Harold Schwarz of the Chemistry Department for their assistance." — Laura Mgrdichian

on December 18, 2009 –

Roger Stoutenburgh D5041109

Roger Stoutenburgh D5061109

High-School Seniors Win 'Discovery' Art Prizes

Robert Chrien (right), President of the BNL Art Society, awards a 2009 "Discovery" prize to Terence Corrigan for his mysterious and compelling painting entitled "Unzipped." The artwork depicts elements of a portrait with two zippers incorporated into the space as part of the picture to symbolize the character waiting to be found by the onlooker who looks under the surface. This artwork is a perfect metaphor for the research done by scientists as they attempt to uncover the secrets of nature.

Kayla Forman (right) wins a 2009 "Discovery" prize from BNL for her striking photograph of a boy at an open door leading him from a sunlit country scene to a dark, seemingly unknown interior — a strong metaphor for "discovery." Forman took the photo in Nuevo Amanacer, Nicaragua, where members of a fund-raising humanitarian club in her school travel twice yearly to provide aid. She will return there in February and see Jackson, the subject of her photo. "I can't wait to tell him about the awards he has won!" she says.

Brookhaven Science Associates (BSA), the company that manages BNL, awards the Discovery Art Prize annually to two local high school seniors for artwork best exhibiting the spirit of scientific discovery. The BNL Art Society chooses the prize winners from artworks exhibited at a show for high school seniors held by the South Bay Art Association (SBAA) each November.

This year, two students were awarded the Discovery Prize: Terence Corrigan and Kayla Forman, both of Northport High School. At the BNL Art Society Art & Crafts show held in November in Berkner Hall, the winning artworks were accorded the place of honor. Robert Chrien of BNL's Physics Department, President of the BNL Art Society, congratulated the winners and presented them with a certificate and a $500 savings bond.

Forman will continue to develop her gift for photography by studying art and will also focus on the liberal arts as her major in college. Corrigan, however, has decided teaching art will be his future career. He hopes to attend either Syracuse University or Penn State University. Both these talented students won additional prizes for their work from SBAA — Forman won a special award for her photo, and Corrigan was one of three students who, each judged on three artworks of which one was his Discovery prize winner, was awarded one of only three SBAA art scholarships.

Said Robert Chrien, BNL Art Society President and SBAA Treasurer, "The excellent standard of the high school seniors' artworks makes it very difficult to choose the winners, and the art teachers of all the participating students are to be congratulated. Special congratulions go this year to Terence's teacher, Margaret Minardi, and Kayla's teacher, Tara Pillich. Both our winners produced outstanding work that promises much for the future."

— Liz Seubert