January/February 2006

ON TARGET

THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY • A DEPARTMENT OF ENERGY FACILITY

Accelerator Division AD
named AAAS Fellow

New Users Group Chair
introduces himself; discusses funding, JLab research impact on nuclear physics

Physicist Kim Egiyan,
recipient of Armenian State Award, shares life, career highlights

Young researchers write
about their scientific research: X. Zheng examines spin identity; K. Slifer studies how spin arises in the nucleon

Pentaquark 2005:
Update on status of search for enigmatic particle

Newsletter goes electronic; this is last paper issue

The On Target newsletter is going completely electronic. This is the last paper issue of the newsletter. The first issue of the e-OnTarget will be posted on JLab's web page before the end of February.

Eliminating the paper version of the newsletter is just one of many cost-cutting moves currently underway across the Lab. "No more printing or postage expenses associated with the newsletter," notes Linda Ware, Public Affairs manager. "In addition, going electronic allows us to produce an issue every two weeks, enabling us to report on more topics and in a more timely manner."

The newsletter will consist of short feature stories and news items highlighting science, safety, technology transfer, and significant events and awards. Many of the items currently found in the Briefs section at the back of the newsletter will migrate to the intranet "Insider" page or the "We Hear That" page. The e-OnTarget will be available in a print-friendly mode for individuals who prefer to read a print version of the newsletter.

Individuals currently receiving the newsletter through the postal system, who wish to receive email announcements regarding posting of the latest electronic issue, may email magaldi@jlab.org to be added to the email notification list.

All staff and users will be emailed the e-version as it becomes available.

By mid-February nearly all work groups had moved into the new CEBAF Center addition (Wing F). The few remaining moves are scheduled to take place before the end of February. Trailer City removal started during the week of Feb. 12.

AAAS announces 2005 Fellows

Accelerator Division AD among newly named Fellows

Swapan Chattopadhyay

Swapan Chattopadhyay, JLab's Associate Director for Accelerators, has been awarded the distinction of Fellow by the American Association for the Advancement of Science (AAAS). The award will be presented at the 2006 AAAS Annual Meeting in St. Louis, Mo., on Feb. 18.

The honor of being named a Fellow recognizes individual AAAS members for their "efforts toward advancing science or fostering applications that are deemed scientifically or socially distinguished." For the year 2005, 376 members were elevated to the rank of Fellow.

Chattopadhyay was cited for his "fundamental contributions to accelerator science, including phase-space cooling, innovative collider designs, and pioneering femto-sources and for mentoring accelerator scientists at facilities worldwide, especially in developing countries." In his position, he is responsible for all aspects of Jefferson Lab's accelerator and Free-Electron Laser (FEL) programs, including research and development, and operations, maintenance and upgrades of the Continuous Electron Beam Accelerator Facility and the Free-Electron Laser. Chattopadhyay leads a team of more than 350 in research of the physics of particles and light beams, forefront electronics, superconductivity, surface science, cryogenics, and computer process control applications.

"What an honor to be recognized by the AAAS for the development of research tools for the world and the rewarding task of mentoring scientists worldwide," Chattopadhyay said.

Founded in 1848, AAAS represents the world's largest federation of scientists and works to advance science for human well being through its projects, programs, and publications. With more than 138,000 members and 275 affiliated societies, AAAS conducts many programs in the areas of science policy, science education, and international scientific cooperation. AAAS publishes the prestigious peer-reviewed journal Science. The tradition of naming AAAS Fellows began in 1874.

Swapan Chattopadhyay received his Ph.D. in Physics from the University of California at Berkeley in 1982. Following a two-year association as Scientific Attaché at CERN (1982-1984), he returned to Berkeley National Lab in 1984, where he made contributions to the Advanced Light Source from its design to commissioning (1984-1992) and was the Founder/Director (1992) of the Center for Beam Physics until his move to Jefferson Lab in 2001.

He has contributed to the development of accelerators in Europe, India, South Korea, Japan, Taiwan, People's Republic of China and North America. He established the first collaboration between Berkeley Lab and Jefferson Lab on the development of FELs based on the superconducting radiofrequency technology. Since 2002, he has served on the Governor's Biotechnology Advisory Board of the Commonwealth of Virginia.

Christoph Leemann
Jefferson Lab Director

Pursuing world-class science, safely

From the Director

Dear Colleagues,

As we begin a new year, I'd like to take this opportunity to highlight the world-class scientific research conducted at Jefferson Lab during 2005. JLab users, along with our own experimentalists have been working to increase our understanding of the nucleus of the atom. The past year has seen the successful completion of a number of critical experiments and the publication of several important peer-reviewed papers as well as articles in publications such as the CERN Courier, Nature and Physics World.

Among the experimental runs, the production run of the Hall A Proton Parity Experiment (HAPPEX II) will yield the world's most precise data on the distribution of charge and current associated with strange quarks in the proton; the Barely Off-Shell Nucleon Structure (BONuS) experiment in Hall B is the first step in discovering how the proton's momentum is distributed among its quarks; and the High Resolution Kaon Spectrometer (HKS) experiment in Hall C, with strong financial support from Japan, dramatically extends our capacity to study strangeness in nuclei. The first experiment using CEBAF began running in November 1995 in Hall C; by the end of 2005, data collection had been completed on a total of 121 physics experiments, and partial data collection had taken place on another eight experiments.

Groundbreaking papers published in Physical Review Letters by JLab scientists and users include:

-- two papers regarding strange quarks in the proton — the exciting G-Zero result, which showed as a function of momentum transfer how strange quarks contribute to the proton's electric and magnetic fields, and a lattice QCD calculation which established a remarkably precise theoretical result for the strange quark's contribution to the proton's magnetic moment;

-- a two-photon exchange correction for elastic electron-proton scattering which clarified the observed difference between the electric form factor extracted from a Rosenbluth separation and that from recoil polarization;

-- a study of polarization transfer in Compton scattering off the proton which established that this reaction directly probes the quark carrying the spin of the proton;

-- a theoretical calculation of the spin-dependent structure functions of protons and neutrons, including their modification by a nuclear medium — a key piece of the 12 GeV science program;

-- and an experiment investigating the transition from the nucleon-meson to the quark-gluon description of the strong interaction in deuteron photodisintegration studies.

Additionally, the exceptional pentaquark data taken here with outstanding data quality and an order of magnitude better statistics has eliminated several pentaquark candidates.

There have also been many excellent presentations of Jefferson Lab-based physics — in talks, papers and posters presented at APS, PANIC, and other conferences. The complete description of generalized parton distributions (GPDs) — a theory developed by a very small group of theorists, including JLab's Anatoly Radyushkin, was published in Physics Reports. Another major review in Physics Reports, involving JLab staff Rolf Ent, Cynthia Keppel and Wally Melnitchouk, summarized our current knowledge of duality, a major experimental program over the last few years. This type of visibility for our scientific results is vital as it increases the profile of the Laboratory and its work, and establishes us as a world leader in the field.

In the coming year many more important studies are on the schedule, including a measurement of the electromagnetic form factor of the neutron in Hall A, a search for new nucleon resonances and other experiments with the new Frozen Spin Target (FROST) in Hall B's CLAS, and the backward angle run of the G-Zero experiment in Hall C.

In addition to nuclear physics research, JLab scientists and engineers carried out research and devel-

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In their own words

with Users Group Chair Gordon Cates

Gordon Cates

I did my graduate work at Yale working under Vernon Hughes. Vernon was a student of I. I. Rabbi, a luminary in atomic physics, and the inventor of magnetic resonance. While Vernon eventually expanded into electron scattering and related physics, he always retained a fondness for using techniques borrowed from atomic physics in his experiments. Even though I did my thesis at the MIT Bates Accelerator, I received training in both nuclear and atomic physics, and also have a fondness for bringing atomic physics techniques to bear on fundamental nuclear physics problems. Vernon was also the first person to study the spin structure of the nucleon, a subject about which I am passionate to this day.

After Yale I took a job working as a post doc for Will Happer at Princeton. Bill Turchinetz at Bates had pointed out that Will was the guru of new techniques for spin polarizing certain noble gases, including helium-3 (He-3). Will, an atomic physicist, almost didn't hire me because he was afraid I would revert to doing nuclear physics. I told him that if I ended up joining the faculty at Princeton, I probably would, but that while I was his post-doc, I would do what he asked of me. Once I became an assistant professor, I did indeed begin a program in nuclear physics, but Will and I continued to collaborate for the entire 13 1/2 years I spent at Princeton.

The work for which I was probably best known at Princeton, at least until the time I got tenure, were two experiments at SLAC that studied the spin structure of the neutron. These experiments both used a polarized He-3 target, and provide what is still the most precise data on the neutron over the kinematic range that we covered. In the process of developing these targets, however, we learned to produce liter-type quantities of He-3, something that had never been done before. This work played an important role in the invention of a new type of magnetic resonance imaging (MRI) of the lungs, which provides unprecedented resolution. Will Happer and I co-founded a small startup company to commercialize the technology. With no medical school at Princeton, we conducted much of the related research at Duke and UVa.

I first came to JLab in the mid-1990's, as the SLAC program was winding down and JLab was first coming online. Zein-Eddine Meziani and I proposed to study neutron spin structure in the regime where we could observe the way quarks begin to assemble themselves into what we recognize as normal nuclear matter. It was an exciting time, and it quickly became clear that JLab was going to be a wonderful place to work. By the late 1990's I found myself constantly commuting to both JLab and UVa. I fell in love with the Charlottesville area for a variety of reasons including the gorgeous country side, UVa, and the easy two-hour drive to JLab.

Despite being a full professor at Princeton, in the summer of 2000, my wife Laura and I moved to the Charlottesville area (to Gordonsville of all places!) where we live on a 50-acre farm where we raise alpacas and cashmere goats with our children, Gordie and Lynnie. This year I am on sabbatical at JLab and am renting a house in Hampton where I live during the week. I am the current chair of the JLab Users Group Board of Directors, a job that involves, among other things, being an advocate for the users to both JLab management and the funding agencies.

It has been a challenging time for funding issues recently, with lackluster increases for several years, and a

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whopping eight percent cut recommended for nuclear physics in the FY 06 federal budget. Such problems are clearly not lost on our young physicists. We have seen some very talented people decide to leave the field recently as they find themselves frustrated with the situation and the implications that funding limitations has on the job front. Losing young physicists to other fields breaks my heart. And even though I feel their decision is ill motivated in the long run, who can blame them when they run out of patience?

I cannot help but reflect on some of the factors that led me into nuclear physics. When I was nine or ten, I wrote an essay stating that I wanted to be either a scientist or an astronaut. This was a time when the Mercury and Gemini programs often dominated the headlines, and my mom would always let me stay home from school to watch a space launch. When I was not much older, I read a book titled “Atomic Energy”. Again the wonders of nuclear energy were being touted, and I viewed the field of nuclear physics with considerable awe. All of this positive feedback played an important role in drawing me into my current work. Limited funding, with its restrictions on jobs, growth, and new opportunities, can only have a similarly negative effect.

I remain, however, an extreme optimist. In the nearly 30 years since I graduated college, our view of nuclear matter has blossomed in a manner that would have been very tough to anticipate. We have now achieved what are essentially high-resolution pictures of the charge and magnetic currents inside the nucleon. We have established that more than 95% of the mass of protons and neutrons are something other than what we might naively call the mass of the valence quarks. The remainder of the mass includes exotic effects such as quark-antiquark pairs popping in and out of the vacuum, a subject that is being actively investigated by parity-violation experiments. And this is only the beginning. With the 12 GeV Upgrade, the science coming out of JLab will be more exciting than ever before. In many ways I believe that our growth in understanding the nucleon at the beginning of the 21st century can be compared to the growth of our understanding of the atom at the beginning of the 20th century. JLab is key in making this happen.

On the political front, things are starting to turn. The National Academies report, “Rising Above the Gathering Storm”, details how the United States is beginning to fall behind Europe and Asia in the physical sciences and engineering. While a frightening report, it has been embraced by people like Senator John Warner who have quoted from it on the Senate floor while discussing the funding for nuclear physics and JLab.

The President’s FY07 budget represents a significant turn around for which I am cautiously optimistic. The fact that JLab produces roughly 25% of the nuclear physics Ph.D.’s awarded in the United States is not lost on our lawmakers. JLab is very special. Our students are intimately involved in building the apparatus with which they perform their respective thesis experiments.

JLab is an essential component of nuclear physics in the United States, and producing discoveries that are giving us a new view of nuclear matter. Innovation and discovery of the sort one finds at JLab will be a vital engine behind the technological and economic leadership that I believe will come from the United States over the coming century.

In their own words

with physicist Kim Egiyan

as told to Judi Tull

It is interesting to be given the chance to look back over my life as I approach my 70th birthday, my 50th year in physics and my 20th year in collaboration with JLab.

I grew up in an Armenian village that was what you would call a resort, a place where wealthy people from big cities came to rest and relax. I was always a child of nature; I loved to be outside in the summer — day and night.

I am the fifth child in my family. My parents were working people: father was a carpenter and mother worked on a collective farm. My three brothers and only sister all were very good students in high school, and they taught me to read and write when I was young.

School always came easy for me. In all of my grades, I was first in the class. However, when I became a student of physics at Yerevan State University in 1952, I was shocked to discover that everyone there had been first in their high school classes! The competition was very, very hard, but (maybe because of that) my studies were very successful. I started working at the Yerevan Physics Institute (YerPI) a year before my graduation, and I have been affiliated with it ever since. My current title is Leading Scientist and head of the electro-nuclear program.

My career started in the late-50s with the physics of cosmic rays. However, during that time I read about R. Hofstadter's experiments at SLAC, studying the structure and properties of nucleons and nuclei with high (at that time) energy electrons. I was shocked by the beauty and important results of these experiments. In particular, it was shown that nuclei could be described very well as a simple system of independent nucleons (neutrons and protons). But the question arises, how can nuclei exist as a dilute bound system of nucleons, when long-range attraction between nucleons would lead to their collapse. Therefore the short-range repulsion should exist also. This repulsion should lead to the formation of a few (2, 3) nucleons in very close configurations, which in the '60s we referred to as exotic states. Currently they are called Short-Range Correlations (SRC). This problem fully captured me, and I started to study it.

In the late '60s and first half of the '70s, I organized a small group of young physicists and proposed these studies at YerPI using our electron accelerator with energy up to 6 GeV. We got interesting data; however, these results did not give us direct information on SRCs. The beam parameters of our accelerator were too poor for that. So I started my search to find other scientific centers with better beam parameters.

I looked all over the world. Then in 1979 I heard that an accelerator was going to be built in the United States, and by 1984 I started to think that this lab would be the perfect place for collaboration. When I first proposed the collaboration, I was turned down, partly because the then-Soviet Union already had a big team at Fermilab. But two years later I was granted a trip here to attend a summer workshop on the future of CEBAF's accelerator and physics programs. I returned each summer, and in 1989, the PAC (Program Advisory Committee) accepted our experiments. We drew up the MOU (Memorandum of Understanding) between CEBAF and the nuclear physics community of the Soviet Union. I believe it was CEBAF's first MOU with a foreign country, and I was the spokesman on the Soviet side. After the collapse of the Soviet Union, the collaboration split in to three separate collaborations and from that point to this day our Yerevan-CEBAF collaboration has continued; and I am the spokesman for this collaboration.

In the '90s we were highly involved in developing the CEBAF physics program and in constructing experimental equipment in all three halls. We have three groups of five people — one group in each hall — and we are active partners in the experiments and work on hardware. All three groups are currently analyzing and publishing interesting results. As for me, and my desire to better understand SRCs, we finally obtained direct information about them here, at CEBAF. We "saw" them and measured strengths (probabilities) of 2 and 3 — nucleon SRCs in various nuclei. Experts in our field are discussing these results widely.

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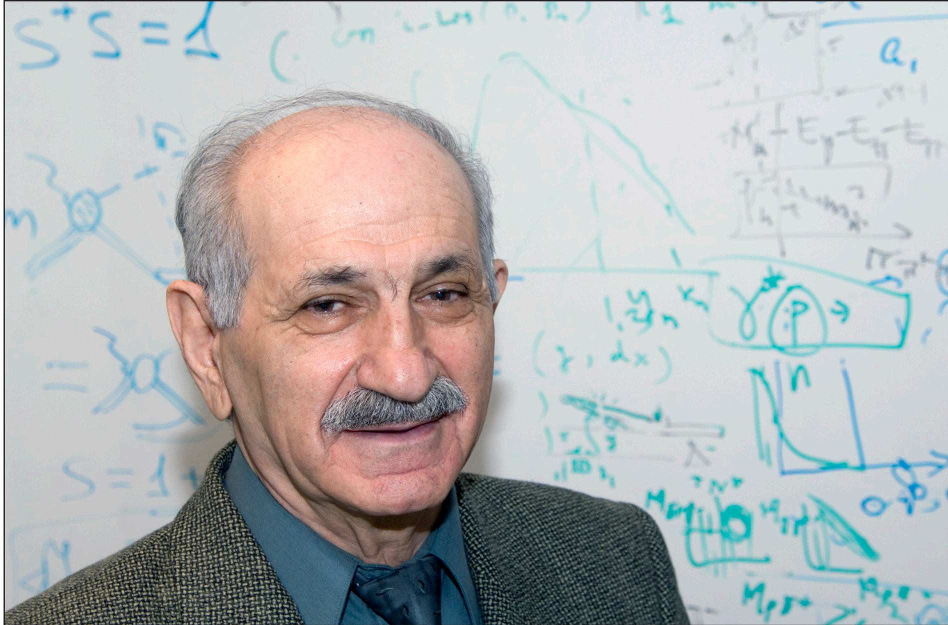

Kim Egiyan earns Anania Shirakatsi Medal

Kim Egiyan poses for a photo in his JLab office. The Anania Shirakatsi Medal (pictured) presented to Egiyan is an Armenian State Award recognizing scientists for notable activities in economics, engineering, natural science and technology, as well as for significant inventions and discoveries. The medal is named after Armenian scholar, mathematician and geographer Anania Shirakatsi (610-685), whose most famous works are Geography Guide, and Cosmography. *(Information from the Republic of Armenia Library website www.president.am/library/eng/)*

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I believe that one of the greatest gifts I've given to science and the world of physics is the young people I have brought along through these years. Many of them have had significant success and I am very proud of them. Two of them work here; four others are at U.S. universities. I continue working with young people. I am currently supervising three "senior" physicists who will defend their Ph.D. work in the next 2-3 years and three graduate students. Last year one of my students defended his Ph.D. based on experimental results obtained in Hall A. Sometimes I feel a main purpose of my life is to be part of a channel for young people to grow in science.

I think I have had much success in my scientific and educational career and this was recognized in 2004 when I received the Medal of Anania Shirakatsi from the President of Armenia, the highest award in science in my country. I am one of only 142 people to receive it. I am very proud of this, not only because it came from the President, but because my home Institute made the initial nomination, which means that the people working with me recognize my achievements.

I was likely the first Armenian citizen to visit this area in 1986. No Armenian families lived around here during the first period of our collaboration. Now we have a community named the Tidewater Armenian Community, a group of about 50 people. The core of this community is made up of physicists at JLab and their families. We gather once a month at Saints Constantine and Helen Greek Orthodox Church to hear a liturgy given by Father Hovsep, a priest from St. James Armenian Church in Richmond. I hope one day the community will have its own church.

I am here with my family. I have two sons; they are both physicists and are both in the United States. Hovanes graduated from William and Mary (he was the first young Armenian to obtain his Ph.D. in high energy physics from a U.S. university) and did his post-doc work at CEBAF. My other son, Gagik, is a graduate student in Detroit. I have a granddaughter, Ofelia, the sweetest person in the world, who was born in the U.S. and is a U.S. citizen (may be a future president of this country). My wife Elionora, a physician, is here and always is with me. We are part of our community — trying to keep our national traditions and customs. We have great help and support from all levels of JLab management, from physicists, engineers and technicians. We have made many good friends among individuals and families within the Lab and the community at large. Working conditions at the Lab are ideal, and America is a unique, sweet country where everyone has an opportunity to find himself.

I am very happy to be here. But my heart is in my small, mountainous Armenia. I am in the second year of a three-year stay here as a visiting scientist. While I do not know what will happen when my time is up, one thing is clear, I will continue to work in physics right up until the last minute. I will not retire, no!

Spin Identity

Researchers grapple with fascinating phenomenon of spinning quarks in the nucleon

Xiaochao Zheng

by Xiaochao Zheng

Spin is an essential and fascinating phenomenon in the physics of elementary particles. Ever since spin was first defined by Goudsmit and Uhlenbech in 1925, it has played a dramatic role in elementary particle physics, sometimes refuting theories and at other times supporting them. During Experiment E99-117 at Jefferson Lab, an international collaboration consisting of more than 80 physicists from 22 institutions and led by Jian-Ping Chen (JLab), Zein-Eddine Meziani (Temple Univ.) and Xiaochao Zheng (then a Ph.D. student at M.I.T.), collected precision data on the spin of the neutron. Results from this experiment provide evidence that our current understanding of spin is not totally valid.

In high-school physics lessons, nucleons simply consist of three quarks. A more complete picture includes these three so-called valence quarks, plus a sea of quark-antiquark pairs that pop in and out of the vacuum, and gluons exchanged between quarks. Experiments where both the electron beams and the target spins are polarized can provide information about how quarks' spins are oriented inside the target proton or neutron, helping us to understand the fundamental structure of matter and the strong forces holding it together. In the early 1980's people thought that the quarks' spin should contribute a majority of the proton spin. But in 1987, the pioneering spin experiment by the European Muon Collaborations at CERN showed that the sum of the spins carried by the quarks in a proton add up to only about one-eighth of the proton's spin. This "proton spin crisis" triggered tremendous efforts to further study the source of spin of protons and neutrons. Now after 20 years of study, we know that the nucleon spin comes not only from the spin of quarks, but also from the quarks' orbital angular momentum, and from the angular momentum of gluons, the particles that hold the quarks together.

Therefore, one attractive place to study the nucleon spin structure is the valence quark region, where the nucleon can be viewed as being made of only three valence quarks, while other components — gluon, strangeness (s quarks) and other sea quarks — are scarce and the nucleon is relatively easier to study. In particular, it is expected when a valence quark carries a majority of the nucleon energy, it should have negligible orbital angular momentum (OAM) and its spin should align to the nucleon's spin.

Since the nucleon is primarily made of two flavors of valence quarks, the up (u) and the down (d) quarks, it is necessary to combine information from both protons and neutrons to decompose the nucleon spin into different valence quark flavors. Due to the lack of precision neutron data, the valence quarks' spin orientations have not been explored until recently. Experiment E99-117 collected, for the first time, precision data on valence quarks' spin distribution in the neutron.

The experiment ran in Hall A from June 1 to Sept. 29, 2001. In the experiment, a polarized beam of electrons was sent into a polarized helium-3 (He-3) target. This target was used because the He-3 nuclei is made of one neutron and two protons with

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Science benefits society

Magnetic moment leads to breakthrough in medical imaging

The spin of a particle describes its intrinsic angular momentum. It allows the particle to have a magnetic moment, and in the presence of a magnetic field it tends to orient itself along or opposite to the field direction just like a small magnet. It is this feature that allowed medical physicists to invent magnetic resonance imaging (MRI), a technique that reads the small magnetic signals from either protons inside the human body or a particular nuclei being introduced into the body for diagnostic purposes. The much higher spatial resolution and sensitivity of this technique provided a breakthrough in medical diagnostics.

Determining how spin arises in the nucleon

by Karl Slifer

In scattering experiments, the momentum transferred to a nucleon target from the incident electron is a primary characteristic of the interaction. Large momentum transfer reactions probe the fundamental quarks and gluons (collectively known as partons) that make up the nucleon.

At this high-energy scale, the scattering occurs over a very short time and spatial extent within the nucleon. The partons thus have little time to interact before the incident electron departs. As an analogy, consider a high-speed bullet shot through an apple: The apple retains its basic shape and characteristics for some short time after the bullet has passed. This is because the reaction has not had enough time to propagate throughout the apple. By examining the trajectory of the scattered bullet, an observer could learn something about the innards of the apple, whether it had a hard or soft core, for example, but not much about the whole apple.

In electron scattering, high momentum transfer reactions can be treated with a dramatically simplified theoretical approach, because the parton interactions are largely ignored. There is, in fact, a long and impressive history of investigation in this kinematic regime at labs like SLAC and CERN, which has helped to form our current understanding of the nucleon's structure.

In a low momentum transfer reaction however, the partons behave collectively as a nucleon. To continue the earlier analogy, consider a pellet shot from a BB gun with much less energy, which simply bounces off the outer skin. In this case, a clever observer could learn something about the global properties of the apple, its mass for example, but not much about what is inside. Likewise, in low momentum transfer electron scattering, only the gross properties of the nucleon are seen. The characteristics of the partons within are not observed.

At this time, nuclear physicists have collected lots of information about the global properties of the nucleon and also about the individual characteristics of the partons. But we don't know exactly how to join these two pictures. JLab is uniquely positioned with one foot on the edge of the high momentum transfer region and the other on the edge of the low energy region. Experiment E94-010 took advantage of this fact to measure the extended Gerasimov-Drell-Hearn sum rule. "GDH" is one of the only spin-dependent observables that can be measured at arbitrary momentum transfer and can also be calculated by theorists from first principles.

Even more importantly, it has previously been measured at very high momentum transfer, and is also being investigated at very low (zero) momentum transfer by independent experiments. Observing how the GDH sum evolves in the intermediate range will be an important first step in understanding how partons form nucleons, and specifically how the nucleon's spin is formed from the partons and their interactions. High precision neutron data from this experiment and complementary proton data from Halls B and C have helped to stimulate a tremendous theoretical response, resulting in a series of international conferences dedicated to the GDH sum.

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Karl Slifer

Science benefits society

Technology developed for experiment leads to new type of MRI capability

The spin exchange optical pumping technology developed for the polarized target has led to some amazing medical imaging breakthroughs. Traditional MRI (magnetic resonance imaging) techniques detect signals from hydrogen, which is found abundantly in human tissue, but is absent in the open cavity of the lung. Enterprising collaborators realized that helium-3, when inhaled, would enable excellent imaging of human lungs during MRI, while avoiding the risk due to radiation exposure necessary in other forms of tomography.

Update on research

The state of the pentaquark

by Kandice Carter

When data hinting at the existence of an exotic particle dubbed the pentaquark was first announced, it set the scientific world on fire. Physicists were excited, because the pentaquark could reveal information about how ordinary matter is glued together; the science-interested public was intrigued, because the pentaquark represents an entirely new form of matter never seen before — a rearrangement of nature's basic building blocks.

But recent experimental and theoretical evidence has somewhat dampened the excitement that followed the first announcements. Some of the initial data that seemed to suggest the reality of the pentaquark have now been revised, and kinematically similar experiments with higher statistics have produced null results.

This was the situation faced by pentaquark researchers who visited JLab for the Pentaquark 2005 Workshop Oct. 20-22. Two and a half days of sessions laid out the current state of pentaquark research from the theoretical and experimental perspectives. Workshop attendees were encouraged by the increasingly better quality of data and data analysis that research in pentaquarks has fostered. JLab has led the way in these advances. High quality beam from CEBAF and the unique equipment in the experimental halls have allowed researchers here to achieve far better kinematics in pentaquark research than anywhere else. JLab researchers have also developed new statistical tools to improve data analysis. While it's unclear what the final verdict will be, the work has already proved interesting and informative.

A Brief History

The smallest building blocks of ordinary matter consist of quarks and the associated gluons that "glue" quarks together. There are six flavors of quarks: up, down, strange, charm, bottom and top. Each flavor of quark also has an opposite — the anti-quarks (up anti-quark, down anti-quark, etc…). Most quarks come in groups of two or three, and are routinely found bound together by strong force gluons as two-quark mesons or three-quark baryons such as protons and neutrons. However, current understanding of the theory of Quantum Chromodynamics (QCD), which describes quark-gluon behavior, says it is possible for quarks to show up as a five-some in the aptly named pentaquark.

Very few attempts were made to find the pentaquark until recently. In a 1997 theory paper, Maxim Polyakov, Dmitri Diakonov and Victor Petrov, from the Petersburg Nuclear Physics Institute in the Russian Federation, predicted the mass of a pentaquark dubbed the "Theta-plus." The theorists predicted that the mass would be confined to a relatively narrow range, which would stand out in a graph of data as a narrow spike, or peak. What's more, this pentaquark was predicted to contain three different flavors of quarks: two up quarks, two down quarks and a strange anti-quark. The presence of the strange anti-quark should make the particle uniquely identifiable, giving it a property called "strangeness." Spurred by this prediction, experimenters began hunting for the particle.

The first pentaquark sighting was announced by researchers from SPring-8, a large synchrotron radiation facility in Japan, in spring 2003. They found hints of the particle while mining data sets taken for other experiments. That same year, researchers from JLab's Hall B, the Alikhanov Institute for Theoretical and Experimental Physics (ITEP) in the Russian Federation and the ELectron Stretcher and Accelerator (ELSA) in Germany, announced that they, too, might have spotted tantalizing hints of the Theta-plus in data previously taken in other experiments. Even better, these experiments quoted high sigma values — values obtained through statistical calculations that quantify how likely it is that the result is accurate. These announcements sparked researchers' imaginations.

However, they all suffered from relatively low statistics (a very small number of potential pentaquarks amongst a large number of other particles that could confuse identification). Further,

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the pentaquark masses pinpointed by these experiments didn't match — some seemed to center at 1520 MeV, while others were closer to 1550 MeV. To clear up the matter, dedicated pentaquark searches with high-statistics measurements and additional theoretical predictions were needed.

A Matter of Statistics

A short time later, the first high-statistics searches for the pentaquark began reporting results. None of these efforts revealed a pentaquark in the region where one was expected, and none of the higher-statistics, higher-precision searches for pentaquark partners, such as a Hall A experiment aimed at finding the Theta-plus-plus, came back positive.

Theorists also began weighing in on the subject, performing new calculations for pentaquark production mechanisms and probabilities. Some theorists even employed lattice QCD calculations. However, few found possible pentaquark states that could be easily identified with current experimental capabilities. What's more, authors of some of the original pentaquark papers began refining their sigma values. Careful reevaluations of the data and statistical methods led them to choose more conservative methods of calculation. The result was a smaller margin of confidence in the original results. Still, the results stood untested by dedicated measurements.

Then, at the American Physical Society April 2005 meeting, Raffaella De Vita, a staff scientist at Italy's Istituto Nazionale di Fisica Nucleare (INFN) in Genova and a JLab CLAS collaborator, presented the results of a high-precision measurement by Hall B researchers of the same reaction that the SAPHIR collaboration at ELSA in Germany announced had produced a pentaquark. The JLab team, whose data contained two orders of magnitude better statistics, found no evidence of the pentaquark.

Two months later, another dedicated, high-precision search for pentaquarks repeating JLab's first pentaquark search with a factor of 10 higher statistics also came up negative. The researchers think a statistical fluctuation combined with a poor early understanding of background reactions in the experiment added up to a ghost signal masquerading as a potential pentaquark. Volker Burkert, Hall B Leader, credits the second run for providing a better understanding of the background and eliminating the ghost.

Andrew Sandorfi said in his presentation at Pentaquark 2005, "So far, there are few peaks, but lots of statistics." And more statistics are coming in every day. Marco Battaglieri, a staff scientist at Italy's INFN in Genova, a JLab CLAS collaborator, and a member of the team that repeated the SAPHIR measurement and analysis, reported another null pentaquark result in a different reaction channel at Pentaquark 2005.

Valery Kubarovsky, a researcher affiliated with Rensselaer Polytechnic Institute and JLab's CLAS collaboration, followed up with another null result for an ultra-high statistics search for the doubly charged Theta-plus-plus. The STAR collaboration at Brookhaven National Lab's Relativistic Heavy Ion Collider may have seen such a state.

Blind Alleys

Marston Bates, a zoologist whose research on mosquitoes led to an understanding of how yellow fever spreads, once remarked, "Research is the process of going up alleys to see if they are blind."

While negative results in the hunt for the pentaquark may seem discouraging, they're still a solid step in the right direction. Without these efforts, scientists would never know if these particles existed. This is especially important since ruling out the presence of possible subatomic particles is just as important as finding new ones. Whether positive or null, each result brings us closer to an understanding of the stuff the universe is made of.

In Memoriam

JLab mourns loss of Scott Myers

Scott Myers

Accelerator Operator Scott H. Myers, 33, passed away at home surrounded by his family on Oct. 1, 2005, after a long and courageous battle with brain cancer. Born in Buffalo, N.Y., he had been a Peninsula resident for the past five years and had been a JLab accelerator operator for approximately 5 years.

He earned his master's degree in nuclear physics in 1998 from Florida State University and was a member of Warwick United Church of Christ, Newport News. Myers is survived by his parents, Huston and Barbara Myers of Rotonda West, Fla.; sister, KelliAnn Winkowski and her husband, Raymond, of York, Pa.; companion, Daniel Cuevas of Newport News; and many aunts, uncles, cousins and friends. Pastor Michael O'Christiansen conducted the funeral service celebrating Scott's life Oct. 4 at the Warwick United Church of Christ. Interment followed at Peninsula Memorial Park.

Scott's fellow accelerator operators hold many special memories of their friend. "Scott was a wonderful asset to the operations group and Jefferson Lab," says Mike Epps, Deputy Group Leader for Operations. "He was a friend and brother who is truly missed. In addition to being a senior accelerator operator and a crew-chief-in-training, Scott worked on several different projects outside the control room. These included writing documentation related to practical ARM (assigned radiation monitor) survey factors, developing and maintaining the video digitizer system, and providing diagnostic development — in particular, developing the linear CCD array project."

"Scott looked forward to coming to work and always came in wearing a smile, even when he knew he was facing an uncertain future," recalls Harry Fanning, Crew Chief. "Coffee was an important part of that day and he was always willing to throw on a fresh pot. His favorite coffee cup was his trusty Marvin the Martian (a Warner Bros cartoon character) mug. He loved that mug, and would not start his day without it. One day his trusted mug broke and he almost lost his will to drink coffee. However, within a week there was a brand new Marvin the Martian mug ready for the task and balance was restored to the Force! (Anything Star Wars, new or old, was a source of enthusiasm for him.)"

"Scott was a huge Buffalo Bills fan and always knew the scores for not only his team but the scores & stats for the teams that his fellow crew members liked as well. Sometimes this would be to his delight when a certain Miami Dolphin's fan would show up knowing the team didn't quite make the cut that weekend. (Scott hated the Dolphins even though, or perhaps because, he was an FSU graduate.)"

"He loved listening to music and one of his favorite groups was Depeche Mode," Fanning adds. "Scott liked to check up on his old campus. When there was a quiet moment on shift he would quickly take a look at the campus via Florida State University's building cameras to see students rushing to and from class or to check on the status of a favored faculty website. It could be 3 a.m. and he would grab a quick peek of his Alma Mater via the campus cameras. 'Good memories' he would say. That and an occasional 'Oh-My-God!' that could startle a quiet crew only to find out 'They left the water fountain on in the quad!' at FSU."

"Scott's friendly demeanor is the part of him we all miss. He would always strike up a conversation with the crews or include himself in a topic of debate. But, no matter how hot the debate may have gotten he would let it slide and be the same old Scott before the next meeting. That is if you didn't take the [Buffalo] Bill's name in vain," Fanning remembers with a smile.

"We all, and especially our Machine Control Center and Operations crews, will miss Scott Myers and his talents dearly," says Swapan Chattopadhyay, Accelerator Division Associate Director.

In Memoriam

JLab mourns loss of Melissa Holloway

Melissa Holloway

Longtime Jefferson Lab Occupational Medicine Nurse Melissa T. Holloway, 52, passed away Oct. 3, 2005. Melissa and her husband Edward resided in Poquoson. She joined JLab's staff in 1990 and handled the medical training programs, including CPR/AED (cardiopulmonary resuscitation/automated external defibrillator) training and provided support to the range of activities managed by Occupational Medicine.

"I worked with Melissa for more than 15 years and I miss her very much," comments Dr. Smitty Chandler, JLab's Occupational Medicine Director. "She was an unusually kind person. I never heard her make a cruel or inconsiderate comment about anyone. She was a 'people person' through and through. Melissa cared about others in an absolutely sincere manner. She had tremendous empathy for others, which is a primary reason why she was such an excellent nurse. She derived great joy from her family."

"Apart from her occupational-health nurse role we at the Lab knew so well, Melissa had a passion for emergency medical services," adds John Kelly, JLab Emergency Manager. "I suspect she was known to virtually everyone in the state who has certification as an instructor in the field. At one time or another, they probably were taught by her."

"She made many useful contributions to JLab's emergency planning and the conduct of our drills and exercises. Her talents included a flair for moulage — applying a realistic looking, simulated injury to a 'victim' to heighten realism and help medical personnel see what they are treating during a drill," Kelly recalls. "It takes time and precision to make an injury look real. I recall an emergency exercise years ago that was based on a simulated boiler-room explosion and building fire in the VARC. Melissa spent hours moulaging a volunteer who truly looked like an authentic trauma victim. The Newport News emergency responders were impressed, to say the least. And who was the patient volunteer? Her husband Edward."

"Melissa regularly volunteered to be the stand-by nurse for many of the Lab's special events such as open houses and run-a-rounds. She just liked people, and she liked being there when help was needed. She was a good listener, very giving, and generous in her compassion for others' medical problems. Her 'fingerprints' are all over Jefferson Lab, and I miss her greatly."

Melissa graduated from Poquoson High School in 1971 and earned her degree as a registered nurse from Thomas Nelson Community College in 1979. Before coming to Jefferson Lab, she worked at Riverside Regional Hospital, Williamsburg Community Hospital and Mary Immaculate Hospital. Holloway was a certified instructor for Basic Trauma Life Support, Advanced Cardiac Life Support and Cardio Pulmonary Resuscitation. She was an Emergency Medical Cardiac Technician for the State of Virginia and a member of the Poquoson Rescue Squad, serving as captain for five years and as a representative on the Peninsula Emergency Medical Services Council.

One line in her obituary read: "Melissa gave so much to so many people while serving in the medical profession … her kindness will long be remembered." The numerous remembrances and eulogies posted on the Daily Press Obituary web site by family, friends and co-workers recalling her passion, strength, kindness, and loving and giving nature are a testament to that statement.

Surviving Melissa is her husband of 34 years, Edward Farrell Holloway Sr.; son, Edward Farrell Holloway Jr. and wife, Brook, of Newport News; one grandson, Brian Devin Lapp, and one granddaughter, her namesake Victoria Melissa Holloway; one brother, Benny Topping and wife, Irina, of Yorktown; one sister, Carolyn Kurtz and close friend, Steve Devan, of Yorktown; her father-in-law, Russell Holloway of Poquoson; one sister-in-law, Regina Holloway McVaugh of Yorktown; and many nieces and nephews.

Spin Identity: Spinning quarks in the nucleon...

Continued from page 8

their spins anti-aligned with each other, hence most of the helium-3 spin comes from the neutron. Electrons scattered from the target were detected in Hall A's two High Resolution Spectrometers (HRS). The nucleon spin asymmetry was formed by comparing the counts of scattered electrons for opposite electron beam helicity states and then corrected for the helium-3 nuclear effects.

When we combined the experiment's neutron results with previous data on the proton, we found that while the spin of the valence up quark is aligned parallel to the proton spin, this is not true for the valence down quark. This new result disagrees with our previous expectations and indicates that valence quarks' OAM is not negligible for the kinematic region explored at JLab. On the other hand, predictions from relativistic constituent quark models, which takes into account the quark OAM through relativistic effects, agrees well with the new data. Extensions of this measurement are being planned as one of the "flagship" experiments for the upgraded JLab. The doubled beam energy (12 GeV) will allow a test of our understanding of the nucleon spin at a cleaner valence and more energetic region.

Determining how spin arises in the nucleon...

Continued from page 9

Experiment E94-010 (spokesmen G. Cates, J.P. Chen and Z.-E. Meziani) ran during the last three months of 1998 in Hall A and measured the polarized spin structure functions of the neutron. This international collaboration involved more than 100 physicists from 32 different institutions and led to 5 Ph.D.s. We evaluated the extended GDH sum as a function of momentum transfer, and found a smooth but dramatic transition from the value previously measured at high energy. Intriguingly, at the lowest measured energy of this experiment, where QCD-based calculations are available, our data is at odds with the expectation from theory. This has presented a significant challenge to the theorists, and should help to refine our understanding of the neutron's spin. From the data, we were also able to evaluate the size and strength of the quark-gluon interactions.

To gain access to the neutron, the collaboration built the JLab polarized helium-3 target. Free neutrons decay on average in about 15 minutes, but are stable within a nucleus such as helium. Helium-3 was chosen because it consists of two protons and a single neutron. When polarized, the protons align themselves in such a way that their spin-dependent properties nearly cancel, leaving the single unpaired neutron. The E94-010 target is the highest luminosity polarized target in the world, and by providing a convenient source of highly polarized neutrons, it has opened up an exciting new avenue of polarized studies at JLab.

From the Director...

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opment work with technologies that enable, or are offshoots of, the Lab's nuclear physics program. The Institute for Superconducting Radiofrequency Science & Technology fabricated and tested accelerating cavities made from single-crystal niobium. This new process could reduce the cost and assembly time of record-breaking accelerator cavities, which could be added to existing accelerators to increase capability, such as JLab's 12 GeV Upgrade, or to build new, more powerful accelerators, such as the International Linear Collider (ILC). The successful commissioning of the superconducting linear accelerator for DOE's Spallation Neutron Source in Oak Ridge, Tennessee — built by JLab — marked a major milestone in the large-scale application of SRF technology and capabilities.

Jefferson Lab's Free-Electron Laser achieved 10 kilowatts (at 6 microns) of infrared laser light and was selected by R&D Magazine as one of the 100 most technologically significant new products of 2005. A positron emission mammography (PEM) device designed and developed by the Detector and Imaging Group imaged breast cancer tumors with a sensitivity rivaling that of whole-body PET imaging systems, while requiring a shorter imaging time and a lower radiation dose. Jefferson Lab has become an incubator for many exciting and potentially beneficial research projects with benefits for society including defense, improved medical diagnostics, industrial and commercial applications, homeland security, and health and safety.

To advance the exchange of scientific information, JLab hosted 11 large scientific conferences, workshops and meetings — attended by 1,100 participants — during 2005 on topics ranging from Semi-Inclusive Reactions to Energy-Recovering Linacs and the Coordinated Theoretical-Experimental Project on Quantum Chromodynamics (CTEQ).

Jefferson Lab provides unique research capabilities with CEBAF and its experimental halls, the Free-Electron Laser and medical imaging that put us at the forefront of nuclear science and laser research. Jefferson Lab scientists and users produce incredible science on a regular basis, a fact in which we can all take pride. Continuing the exciting programs in science and technology at the Lab requires not only our dedication to scientific excellence, but to operational excellence as well, particularly in the area of safety. The success of our programs will mean little if it comes at the expense of any one of our colleague's health, and in a competitive funding environment, the Lab cannot afford even one mishap. Supporting our science programs takes the attention and efforts of all of us and we must dedicate ourselves every day to excellence in safety performance in order to ensure that our science and technology programs remain healthy and productive in the coming year and beyond.

Milestones
for Oct.-Dec. 2005

Hello

Anthony Bavuso, Control System Computer Scientist, Accelerator Division

Lorelei Carlson, Front Desk Receptionist, Administration Div.

Willie Durosseau, RadCon/IH Waste Technician, Enviornment, Health &Safety Div.

Nina Farrish, Human Resources Consultant, Admin. Div.

Michael Gericke, Hall C Post Doctoral Fellow, Physics Div.

Jade Johnson, Human Resources Assistant, Admin. Div.

Dennis Turner, Accelerator Operator, Accel. Div.

Michael Sprouse, Mechanical and Controls Inspector/Evaluator, Admin. Div.

Mike Klopf, Terahertz Post Doctoral Fellow, Accel. Div.

Goodbye

Sherri Powers, Sr. Budget Analyst, Chief Finance Office

Kelly Mannsfeld, Associate Director of Admin. Div.

Michael McCrea Sr., Machinist, Accel. Div.

Spring Science Series kicks off Feb. 21

The 2006 Spring Science series kicks off at 7 p.m. on Tuesday, Feb. 21, in the CEBAF Center auditorium with astronomer, teacher and author Jeffrey Bennett from the University of Colorado (Boulder) presenting "The Scale of the Universe." If you could hold the Sun in your hand, where would we find the planets and other stars? Bennett will take a virtual trip across the universe, in both space and time, which will fascinate and amaze his audience.

One of the many projects Bennett has been involved in is "Voyage: A 1-to-10 Billion Scale Model Solar System" that opened in 2001 on the National Mall in Washington, D.C. (just outside the northeast corner of the National Air and Space Museum). For more information about Bennett and his work, visit www.jeffreybennett.com/. Also, available for purchase following the lecture will be autographed copies of Bennett's latest children's book "Max goes to Mars."

Then on Tuesday, March 21, Louis Bloomfield, professor of physics at the University of Virginia, will examine "How Things Work." He will offer the audience an introduction to the physics and science in everyday life; and examine objects from our daily lives, focusing on their principles of operation, histories, and relationships to one another. For additional information about Bloomfield, visit http://rabi.phys.virginia.edu/HTW/.

The presentations begin at 7 p.m. in the CEBAF Center auditorium. The lectures are free and open to anyone interested in learning more about science; they last about one hour and include a question and answer period at the end. For security purposes during Science Series events, enter at JLab's main entrance (Onnes Dr.). Everyone over 16 is asked to carry a photo ID and security guards may inspect IDs, bookbags, purses and vehicles.

Reaching out to youth in need; baker's dozen bikes donated to Toys for Tots!

Christiana Grenoble and Larry King, Accelerator Division, thank everyone at JLab who supported the 2005 Toys for Tots drive. "Seeing the generosity of the people we work with all year long really gets the holidays off to a proper start," King said. "I'm sure your donations have made the holidays of many families quite a bit happier this year!" This is the fourth year that staff in the Test Lab collected donations to buy children's bikes for the Toys for Tots drive; and each year the outpouring has gotten bigger. Each 20" bike was assembled and included a helmet and bike lock. U.S. Marines handling the local Toys for Tots program picked up the bikes and other toys during JLab's Children's Holiday Party, Dec. 10. Special thanks to Larry's son and Santa's Little Helper (aka Ned King) for bike assembly, set-up and tire inflation assistance!

Determine JLab status during, after severe weather

If there is a delayed opening or JLab closure due to severe weather, there are three primary ways for employees, users and contractors to get current information on JLab's operating schedule. For updated, recorded messages, call the main phone number, (757) 269-7100, which can handle up to 16 calls simultaneously; or call the JLab Status Line, (757) 232-2000, which can receive up to 20 calls at a time; or visit the JLab website (www.jlab.org/) where weather closing or delay information will be posted as a banner message. JLab closing/delay information is also given to local TV and radio stations but JLab cannot guarantee that the information will be aired.

If after checking these avenues you are still uncertain about going to work, call your supervisor. If your supervisor has specifically informed you that you are designated as "essential personnel" for a weather-related event, be alert for special instructions. All others — employees, users and contractors — are subject to closure status instructions and shouldn't return to JLab before the time specified.

The Lab's procedures for winter storms are posted in the EH&S Manual, Appendix 3510-T4 under the heading "Winter Storms." (www.jlab.org/ehs/manual/PDF/3510T4SevereWeather.pdf)

The Lab's Administrative Manual (section 207.08.D.2) contains policy regarding taking leave due to a weather emergency and states: "Employees, who, on their own, decide that weather conditions preclude their attendance or requires their early departure, may take vacation leave provided they obtain the advance approval of their supervisor."

TIAA-CREF offers retirement counseling sessions

The 2006 spring schedule for individual counseling sessions with Anthony Kohlrus, TIAA-CREFF senior individual consultant, is posted. This is an opportunity for JLab employees to discuss the current status of their account, investment strategy and retirement goals with Kohlrus, according to Doug Roeder, Compensation and Benefits. The dates available are: Thursday, March 16; Thursday, April 13; Thursday, May 11; and Thursday, June 15.

To sign up for an appointment go to www://tiaa-cref.org click on Meetings/Counseling and follow the menu or you may call 800-842-2008. Sessions will be held in VARC (Bldg. 28), room 40A.

ON TARGET

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