FERMI NEWS

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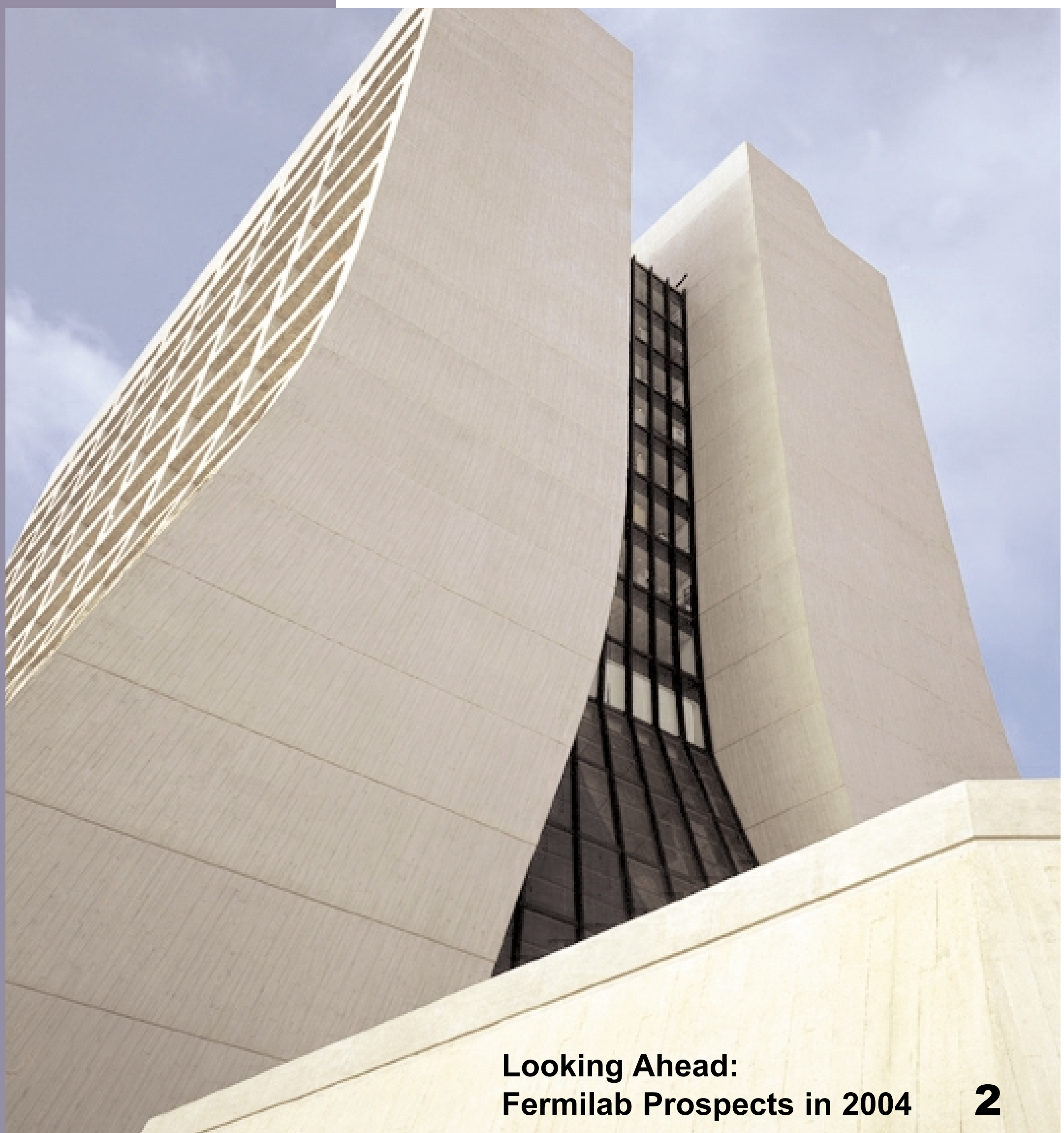

Photo by Fred Ullrich

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INSIDE:

Looking Ahead:

Sure things and long shots from Fermilab's Director

by Michael Witherell

As we approach the New Year it is a good time to predict the future. What will be happening at Fermilab in 2004?

Below are my predictions. Some are pretty sure bets; some are more speculative, and at least one is a long shot. I will let you decide which prediction falls into which category.

The CDF and DZero collaborations will make public many important new results throughout the year, intensifying the competition to be the Result of the Week in *Fermilab Today*. In August, Run II results will make news at the International Conference on High Energy Physics in Beijing.

The Tevatron collider will deliver as many collisions to the experiments as it has in all its previous history, so that the total data sample available for physics will be twice what it is today. The recycler will perform as planned and the beam line for electron cooling of antiprotons will be installed.

It will be a big year for neutrinos at Fermilab. In December we will be starting up the beam line that will send neutrinos to Minnesota. The MINOS collaboration will be producing physics results using atmospheric neutrinos in their far detector, as they tune up to receive Fermilab neutrinos. The MiniBooNE collaboration will have enough events on tape to answer the question of whether there is a fourth light neutrino. Nobody will know the answer yet, however. The Physics Advisory Committee will make recommendations that shape the future of neutrino physics at Fermilab.

> *"One of the experiments will produce a surprising new physics result that will become Fermilab's Result of the Year."*

Photo by Reidar Hahn

Fermilab Director Michael Witherell

The BTeV project will be blessed with exactly what they have been asking for—a whole slew of DOE and Fermilab reviews. By the end of the year they will be near the official launch of the construction project.

The worldwide search to detect dark matter directly will take a big step forward with the first physics results from operation of the Cryogenic Dark Matter Search experiment in the Soudan mine. Similarly, the discussion of the highest energy cosmic rays will revolve around early results with the partially-built Auger observatory.

The Fermilab long-range planning committee will produce its report early in the year. It will be used to guide the direction of R&D toward future projects at Fermilab.

ON THE WEB:

Fermilab:
www.fnal.gov

Fermilab Prospects in 2004

Photo by Reidar Hahn

Fermilab looks forward to striking new advances in luminosity and physics results.

The Sloan Digital Sky Survey will continue to produce impressive results and striking pictures.

The International Technology Recommendation Panel will report its recommendation on the chosen technology for the linear collider, and that recommendation will be accepted. Governments will talk more seriously about how to organize an international linear collider project.

New results from the Tevatron experiments and from the B-factories will show that we do not yet understand everything about the particles made from heavy quarks. Theorists from Fermilab and around the world will engage in a lively debate about their competing explanations of the data.

There will be even fewer workplace accidents at Fermilab than the record-best year we are just finishing, due to the efforts of everyone who works at the laboratory.

Technicians, surveyors, physicists, engineers, and other specialists will work together in the tunnels to renew and upgrade the accelerator complex during the annual shutdown. This work will make it possible to deliver more luminosity, increase proton intensity, start up NuMI, and operate the accelerators more reliably.

People from all over the laboratory will rise to the challenge of providing the administrative and technical support needed to do the great science discussed above.

One of the experiments mentioned above will produce a surprising new physics result that will become Fermilab's Result of the Year.

The Fermilab budget for fiscal year 2005 will be 10 percent greater than this year.

Around the Lab:

A look ahead from spokespersons, project managers and division and department heads

Accelerator Division

The progress made during the shutdown—major improvements in all the machines including the Recycler, the driving force behind the shutdown—has me eagerly anticipating 2004.

In the Tevatron, major jobs included alignment and cold lifts of the magnets, and reducing impedance by putting liners in the injection Lambertson magnets. Results have already shown in the startup. Improvements are also expected from damper installation in the Main Injector. The Booster had some modifications to a dogleg orbit bump to reduce beam losses from the beam encountering imperfect magnetic fields as it crosses into and out of the dogleg magnets.

In the Antiproton Source, the installation of motorized quadrupole stands, alignment improvements, and cooling improvements were major work list items. These changes will increase the antiproton accumulation rate. Perhaps the best news of all is from the Recycler. Resolving Recycler vacuum issues was the key for the shutdown, and the effort was very successful. The Recycler will make a major contribution to the delivered luminosity in the coming years. Electron cooling will be installed in the Recycler in approximately a year. After that, the Recycler with electron cooling will be integrated into operations.

The Accelerator Division also made good progress on installing the NUMI beam line during the shutdown. More work remains for the 2004 shutdown, and we expect to deliver the first beam to NUMI in early 2005. *—Roger Dixon*

DZero

Early in 2004 we expect to have reprocessed all data recorded in 2002 and 2003, meaning old data has been run through the latest and best reconstruction program, giving better tracking efficiency, better b-tagging efficiency, and so on. This was made possible by our bringing online remote reprocessing centers at a number of sites around the world—France, Germany, UK, the Netherlands and Canada. The significant increase in computing capability will show up in improved results for the 2004 spring conferences.

Photo by Reidar Hahn

We are pushing hard to exploit all the data that we now have and additional data from 2004. Our new top-mass measurement technique will give much improved precision to Run II data. We are hot on the trail of single top production, which has never been seen so far. We have a strong B-physics group, eager to exploit the detector's new capabilities to study B_s mixing and other heavy flavor physics. And we are keen to make precise measurements of W and Z bosons, high momentum jets and photons, and to exploit our Forward Proton Detector to understand diffractive phenomena.

We are also searching hard for evidence of physics beyond the standard model. Our increased dataset, higher collider energy and improved detector capabilities already have us exploring unknown territory. We are setting the tightest limits on new particle production—but what we really want is not to set limits, but to see something unexpected. We don't know whether this will happen in 2004, but there's no reason why not.
—John Womersley, Jerry Blazey

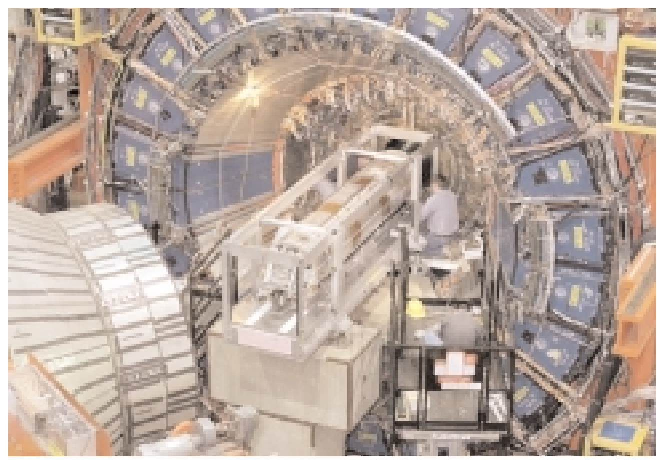


Photo by Reidar Hahn

CDF

String theories predict extra Z-like particles. The signatures are especially clean in CDF and we are looking very hard at the data now. The highest energy jets will probe distance scales down to 10^{-19} meters. This is the flagship measurement of QCD: Does the quark or gluon have structure?

CDF has submitted the X (3872) particle to Physics Review Letters. Next up: studying its properties, especially those that complement Belle. The X is huge in CDF compared to Belle, offering a good chance of finding new particles.

CDF will contribute to the measurement of the angle gamma by measuring the B_s—>KK/B_d—>pi pi branching ratio, and combining this with the CP asymmetry from Babar and Belle for B—>pi pi. We will measure the top dilepton cross section on the full 220 pb^{-1} by the summer. We separately measure the W+ jets cross section with 3 or more jets as another measure of the top cross section. These two methods should agree, a powerful test for new physics. The study of top kinematics offers another exciting prospect new physics.

Fermilab Prospects in 2004

We plan to measure the top mass in several different ways, and to meet the challenge of measuring the W mass. Improved top and W masses improve constraints on the standard model Higgs. We will push beyond Run I limits in completing our initial analysis for the Higgs from supersymmetry. We will complete the search for the doubly charged Higgs H^{++} on 220 pb^{-1}. The Standard Model Higgs is beyond our reach for some time, but there may be surprises—theorists think there may be a relation between the Higgs field and dark energy.

CDF moves toward the world wide CDFGrid, with a workshop planned in January, and with computing available for data analysis in Taiwan, Japan, Korea, Canada, UK, Germany, and the U.S. outside Fermilab. *—Nigel Lockyer, Luciano Ristori*

Neutrinos

NuMI/MINOS: In early 2004 the construction of the NuMI conventional facilities will be completed. Installation will continue in the three main areas here at Fermilab: completing work in the Main Injector Tunnels during the 2004 shutdown; completing installation of the NuMI target station at MI-65; starting and completing installation of the MINOS detector and absorber. The MINOS far detector at Soudan will continue to collect atmospheric neutrino data while awaiting beam. The NuMI project is somewhat ahead of schedule. With a little luck we will stay that way, and begin commissioning the completed beamline and detectors with protons from the Main injector in December 2004. *—Greg Bock*

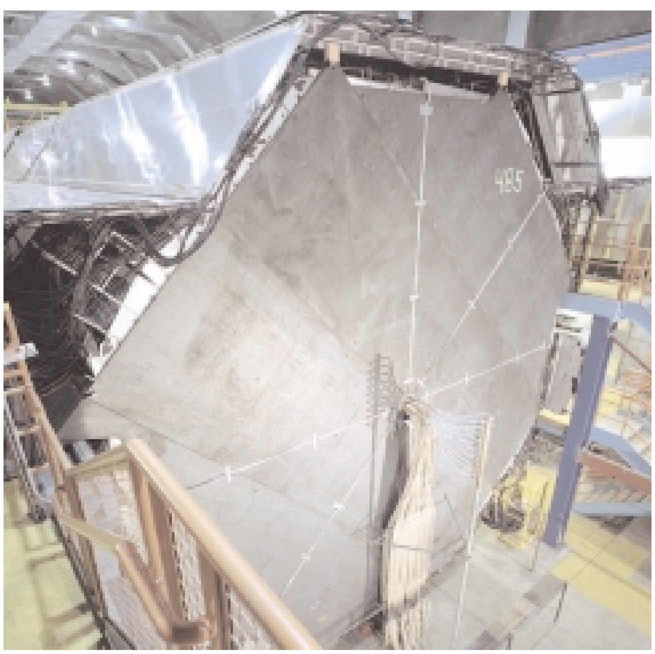


Photo by Fred Ulrich

MiniBooNE: MiniBooNE should surpass the 5M neutrino events milestone, which brings us halfway to our goal. Also, we should have non-oscillation physics results available on charge current quasi-elastic scattering, neutral current pizero production, and neutral current elastic scattering. We're expecting our oscillation physics results to be ready in the summer of 2005. *—Bill Louis*

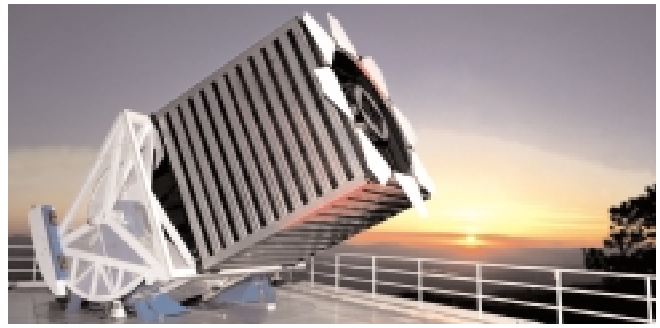


Photo by Fred Ulrich

Astrophysics

Pierre Auger Observatory: The Pierre Auger Observatory is beginning a large expansion. We have deployed over 200 surface detector stations and hope to have nearly half of the array (800) by the end of 2004. By June of 2004 we will have half the observatory's 24 fluorescence telescopes operational. By the end of 2004 we expect to have a data set that will allow a meaningful comparison of results with those of the AGASA array in Japan. *—Paul Mantsch*

SDSS: The Sloan Digital Sky Survey's second public data release will be made late in March 2004, comprising 3300 square degrees of imaging data and 360,000 object spectra. There will be an SDSS Collaboration meeting in Las Cruces in March 2004. The last one was at Fermilab at the beginning of October 2003. The SDSS is planning for a major presence at the American Astronomical Society meeting in Dallas in June 2004. We have requested a special session on multi-wavelength studies of galaxies. *—Rich Kron*

CDMS: The Cryogenic Dark Matter search (CDMS II) experiment is currently taking data in the Soudan underground mine in northern Minnesota. By January, 2004, our first tower of 6 detectors will have accumulated sufficient exposure to improve our sensitivity to weakly-interacting massive particles (WIMPs) by an order of magnitude compared with CDMS I. After some small improvements, we will then turn on our second tower of detectors and run until the summer of 2004, with the expectation of further improvements in sensitivity and the hope to see a signal. Meanwhile, more detectors are being made and tested for backgrounds. During the summer, we will warm the apparatus to room temperature and install as many low-background detectors as we can. After a commissioning period, the full experiment will begin running and continue through 2005. *—Dan Bauer*

Theory

The work on this floor tends to be less programmatic than in other departments. However we do have hopes. From the experiments we all hope for something completely unexpected and inexplicable, which would really challenge us. Failing that we would settle for a heavy Z boson, a signal for supersymmetry or strange behavior of the top quark. Members of the department will be working hard to interpret the data from experiment. The more programmatic efforts include (but are not limited to) lattice QCD, (working primarily on semileptonic B and D decays and B_s mixing) QCD Monte Carlo, (where people are working on NLO Monte Carlo's for general processes). *—Keith Ellis*

the **role** of **science** in the **information society**

CERN, Geneva, 8-9 December 2003

CERN conference addresses issues raised by developing information and communication technologies

by Judy Jackson

Dr. Nolwazi Mbananga from South Africa has a dream that one day electronic kiosks will allow South Africans in remote rural areas to use the Internet for access to improved medical care. Her Royal Highness Maha Chakri Sirindhorn, Princess of Thailand, hopes that her efforts to bring computer access to children in rural schools, people with disabilities and people in prison will improve life for the disadvantaged in her country. A computer scientist from Azerbaijian who did not wish to be identified believes that increased use of the Internet by citizens of his country may help to fight government corruption.

Her Royal Highness Maha Chakri Sirindhorn, Princess of Thailand

The computer that Ms. Vaira Vike-Freiberga, now president of Latvia, and her husband donated to the University of Latvia while in exile in Canada during Soviet rule is now at work creating an electronic archive of the thousands of folksongs that are central to Latvia's cultural identity.

Dr. Onno Purbo of Indonesia and his students are on a mission to create a national network of Internet cafes to bypass government inaction and bootstrap access to the Internet for citizens of Indonesia. Ismail Serageldin, director general of the Library of Alexandria, the world's oldest library, believes we are standing at the threshold of a revolution in information technology and the organization of knowledge and that we must be willing to think of radical change.

Dr. Onno Purbo of Indonesia

Dr. Nico Stehr, Center for Advanced Cultural Studies in Essen, Germany, doubts that the Internet will prove a panacea against government corruption and exploitation. Dr. Folaju Olusegun Oyebola of Lagos, Nigeria has created the West African Doctors' Network, an online resource for physicians faced with some of the most daunting medical challenges on the planet. Dr. Esther Dyson the founding chair of the Internet Corporation for Assigned Names and Numbers, wants individual scientists to get involved with ICANN but cautions that the organization has limited ability to bridge the digital

ON THE WEB:

RSIS:
http://rsis.web.cern.ch/rsis/index.html

CERN:
http://public.web.cern.ch/public/

Dr. Esther Dyson, the founding chair of the Internet Corporation for Assigned Names and Numbers

divide. Tim Berners-Lee, inventor of the World Wide Web, thinks it is useful to take time out now and then to think about where the information age is headed.

The princess, the president, the computer scientist, the librarian, the Web guru and about 400 others had come to CERN, the European Laboratory for Particle Physics in Geneva, for a two-day conference on the Role of Science in the Information Society. The conference, organized jointly by CERN, UNESCO, the International Council for Science, and the Third World Academy of Sciences, took place on December 8 and 9 as a lead-up to the United Nations World Summit on the Information Society in Geneva December 10-12. The U.S. particle physics community contributed a working science grid demonstration and an exhibit from QuarkNet, the first project to integrate grid-based activities into the physics classroom.

CERN Director Luciano Maiani told delegates that the organizers felt that the voice of the scientific community should be heard at the World Summit for several reasons. Basic science made possible the technologies that gave birth to the information society, Maiani said, and scientific research will influence future developments of the information society "from new electronic devices to the future architecture of the Internet, for example through the sharing of distributed computing resources via the Grid." Finally, the scientific community has the potential to empower scientists from regions hitherto largely excluded from scientific research, to create a "science sans *frontières*," or science without borders.

But what, if any, is the role of science in bridging the widening information and knowledge gap between the developed and developing world? A recurring question at the conference concerned the potential of information and communication technologies, or ICTs, themselves to address social, economic, educational and information inequities that divide rich and poor nations. Will it be possible, for example, asked Essen's Stehr, for developing nations to "jump the queue" and enter the information age directly, without passing through the stage of industrial development that has characterized the history of developed countries?

"Technology itself does not ensure the successful use and application of digital data," said Santiago Borrero, Secretary General of the Pan-American Institute for Geography and History. "Information technology, infrastructure and connectivity do not necessarily equate to information access and a real bridging of the digital divide."

Santiago Borrero, Secretary General of the Pan-American Institute for Geography and History

Photos courtesy CERN

Summing up the conference, Maiani told delegates that "several general themes have emerged as guidelines and have received clear support at RSIS: that fundamental scientific information be made freely available; that the software tools for disseminating this information be also made freely available; that networking infrastructure for distributing this information be established worldwide; that training of people and equipment to use this information be provided in the host nations; that general education is an indispensable basis for the Information Society."

As for predicting the future of the information age, Berners-Lee pointed out the near impossibility of making accurate projections for information technology. Will science make Dr. Mbananga's dream of medical kiosks in Africa a reality? Bring cheaper bandwidth to Indonesian students? Help West African doctors fight AIDS or shine light on government corruption in former Soviet republics?

"It may be that a breakthrough by a couple of unknown high-school students will have more influence on the future of ICTs than all the conferences put together," Berners-Lee said. Nevertheless, he concluded, "the fact that we're all thinking about it together may mean this conference has succeeded already."

Colloquium Series

The subject is science, traditionally speaking

by Mike Perricone

The history of the science colloquium (from the Latin, "to talk together") probably extends back as far as the history of science itself.

"The colloquium is a very traditional thing that I think goes back to the dawn of time," joked physicist Dick Carrigan, whose own history at Fermilab, goes back to the autumn of 1968, or nearly the dawn of time for the laboratory. "The colloquium may have come to us through the academic traditions in Germany. When I arrived here, there was either a colloquium already in place or things were coming together for one. There has been a regular colloquium held everywhere I've ever been in physics, from the biggest place to the smallest. It's a way to get people thinking and to shake things up a bit."

Carrigan is a longtime organizer of the Fermilab Colloquium Series on Wednesday afternoons. But apparently, it took a while to shake things into place at the early days of the National Accelerator Laboratory.

In June 1973, then-Deputy Director Ned Goldwasser wrote a memo to Art Roberts in the Physics Department (now the Particle Physics Division) saying, "the weekly colloquium did not provide, as well as it should, the Laboratory's central, general physics gathering point. This series will probably be commenced on a regular basis next September or October." Roberts countered: "As you know, I didn't appoint the present colloquium committee; my predecessor did." Roberts then appointed John Peoples to chair a new colloquium committee, and the Wednesday afternoon gathering began to evolve into a fixture of the lab culture.

"Actually, 1973-74 was pretty chaotic around here with Wilson Hall not yet completed," said Peoples, who went on to serve as the lab's third director from 1988 to 1999. "We were searching for the right venue. The conference rooms in the Village were small. I remember we put folding chairs on the cement floor in Ramsey Auditorium before it was finished, but the auditorium was too big. Even a couple of hundred people would get lost in Ramsey Auditorium. When Wilson Hall was topped off, and when the One West conference room was completed, the Colloquium was able to settle in on a regular basis."

ON THE WEB:

Fermilab Colloquium—current schedule and past years:
www-ppd.fnal.gov/EPPOffice-W/colloq/colloq.html

Visual Media Services streaming video:
www-visualmedia.fnal.gov/VMS_Site/s_videostreaming.html

Fermilab photos

Some early Colloquium speakers: (top row from left) Chemist C. Ponnamperuma (1980), University of Maryland, offered his speculation that the genetic code employed by earth life may, in fact, reflect a universal chemistry. Astronomer and astrophysicist Margaret Burbridge (1980), University of California-San Diego, spoke on chemical abundance in stars of various types; she is co-author of the renowned work by Burbidge, Burbidge, Fowler, and Hoyle (familiarly known as B2FH) on "Synthesis of the Elements in Stars." N.S. Dikansky (1977), of the Budker Institute in the Soviet Union, spoke on electron cooling. Dikansky is now Rector of Russia's Novosibirsk State University. Among the Nobel Prize winners offering Colloquium presentations: (bottom row from left) Christian DeDuve (1974, medicine) spoke in November, 2003 on "Singularities in the Origin and Evolution of Life." Former URA President Norman Ramsey (1989, physics) spoke in February, 2003 on "Scientists in Times of War." Lab director emeritus Leon Lederman (1988, physics), will speak in March, 2004.

The series strives for a mix of physics and non-physics, at both the expert and general public levels. The topics have ranged from weather on brown dwarf stars to the physics of the blues, from semiconductor spintronics to Native American artifacts found at the lab. Current Colloquium chair Michael Albrow also noted striking parallels offered by two Colloquium presenters from very different fields on consecutive weeks.

"Andrei Linde, one of the originators of the inflationary theory of the Big Bang, spoke on how the universe—or the part of the universe we see—originated 13.7 billion years ago from a singularity, a speck billions of times smaller than a single proton," Albrow said. "The next week, Christian De Duve, a Nobel Laureate in medicine (1974), spoke on the singular origin of life: how all the life we know originated about four billion years ago with the first self-replicating molecule in some primeval 'soup' of organic molecules. One week, the origin of the universe from a single point, and the next, the origin of life from a single molecule, in presentations from two very distinguished scientists."

Still to come in 2004: Chris Morris of Los Alamos National Laboratory offers a talk on Jan. 7 with implications for national security, "The Use of Muons for Scanning Cargo." February offers the potential for a synergy similar to the "singularity" presentations of Linde and De Duve, with J. D. Bjorken speaking on "The Classification of Universes" followed a week later by Spencer Wells of the National Geographic Society on "The Past Within Us: Tracing our Genetic History."

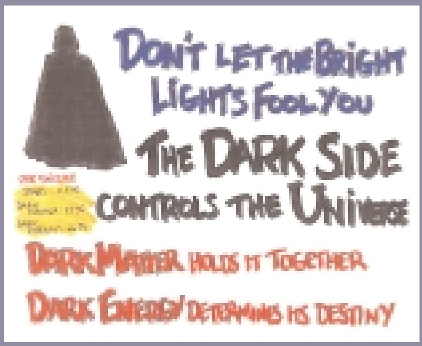
And in March, Nobel Laureate and Fermilab director emeritus Leon Lederman will again bring his distinctive style—and humor, no doubt—to Wednesday afternoon in One West.

The Fermilab Colloquium Series is open to the public (enter at the west gate for security check and badging). The 2004 schedule is available on the Web, where more than 100 presentations have been archived and are available through streaming video on the website of Fermilab's Visual Media Services.

(Special thanks to lab archivist Adrienne Kolb for unearthing the early memoranda)

Are We Ready for

Cosmologists, theorists focus on the connection with particle physics



Graphic courtesy of Michael Turner

ON THE WEB:

University of Chicago Astronomy Department
http://home.uchicago.edu/~bsjohnso/

Rice University Astronomy Department
www.owlnet.rice.edu/~rlentz/astro201/intro.html

Physics Today
www.physicstoday.org/vol-56/iss-4/p10.html

by Elizabeth Clements

I used to be under the belief that Darth Vader was the culprit behind dark energy. And while I'm not completely abandoning my naive notion, recent discussions with leading cosmologist Michael Turner and theoretical physicist Joe Lykken may have convinced me otherwise.

It's a Mystery

Simply put, dark energy is a mystery. The expansion of the universe is accelerating, and theorists believe that dark energy is the driving force behind it. Evidence shows that dark energy makes up approximately 70 percent of the universe, meaning 25 percent is dark matter and 4 percent is matter made of atoms.

"Dark energy is the most important problem and deepest mystery in all of science," Turner said. "We are talking about the expansion of the universe speeding up. Everyone understands that it should be slowing down because of gravity. What is going on? The simple answer is that we don't have a clue and that is what makes this so much fun."

But what is dark energy? How does it behave? Why is it there? If dark energy is anything, it is the driving force that leads to questions with very few answers. And that is where Fermilab comes in.

The Higgs, Supersymmetry, and Extra Dimensions

Both cosmologists and theoretical physicists believe that dark energy has a fundamental connection to particle physics. "Particle physics is all about understanding the fundamentals of matter, space, time and energy," Turner said. "Dark energy appears to be a fundamental feature of space."

But how can a particle accelerator help solve the mystery? Lykken believes that experimental discoveries of the Higgs particle, supersymmetry and extra dimensions may provide some clues about the physics behind dark energy.

"If the Tevatron were to discover supersymmetry (and there is a good possibility that it will), we would have a great chance to learn something about dark energy," Lykken said. "Dark energy is a very long-term project, and nobody said that understanding it was going to be easy. On the particle side, we need the Large Hadron Collider and the Linear Collider. New telescopes, such as Supernova/Acceleration Project's satellite telescope, are also necessary."

Turner agrees that accelerators alone cannot solve the dark energy puzzle. "We need both accelerators and telescopes," he said. "Accelerators can play a role by testing the role of supersymmetry, and telescopes can play a role by looking out in space and back in time to map out the expansion history, telling us how this cosmological speed-up occurred."

The Dark Side?

The distant white dwarf supernova, SN 1997ff, exhibited less red-shift than expected, indicating that the expansion of the universe was speeding up.

The Evidence

In 1998, a team from Lawrence Berkeley Laboratory, led by Saul Perlmutter, and a team of scientists from around the world, led by Australian astronomer Brian Schmidt, announced that the expansion of the universe appears to be accelerating. The two teams found that a distant supernova was fainter than expected, indicating that the expansion of the universe was speeding up rather than slowing down.

"We know that the expansion of the universe is accelerating," said Lykken. "But matter does not make the universe accelerate. It makes it slow down. There must be something else making the expansion speed up."

Since 1998, the number of observed supernovae has increased dramatically, and the evidence for dark energy has only gotten stronger. In February 2003, the Wilkinson Microwave Anisotropy Probe produced a map of the cosmic microwave background. The WMAP analysis indicates that atomic matter makes up 4 percent of the universe, dark matter makes up 23 percent, and dark energy makes up 73 percent. In October 2003, the Sloan Digital Sky Survey independently confirmed this data, bolstering the case for dark energy.

"This is all the smell of good science," said Turner. "Scientists always like to have independent confirmation of the same data—the more independent the better. Dark energy is not a discovery that is too good to be true."

Lykken added, "The Standard Model makes up only four percent of the universe, and those principles don't explain things like dark energy. There is a whole universe out there, and that's great. Instead of being an old science, we found out that particle physics is a new science. I don't know anybody that is resisting dark energy any more."

The Destiny of the Universe

Before dark energy, physicists believed that gravity would eventually cause the universe to collapse. Now that physicists know the universe is speeding up, the destiny question is wide open.

"If the universe continues to accelerate, its fate is not very attractive," said Lykken. "In the end, the universe will be dominated by dark energy, and we will all dilute away. I would like to find a much more disastrous way for the universe to end."

Turner agrees that if the universe continues to accelerate, its fate is bleak.

"We will only see a handful more galaxies, which makes a great argument for funding astronomy now," he says. "It may not be possible in a billion years. On the other hand, the destiny question is wide open, and discoveries at Fermilab could change this conclusion."

Up, Up, and Away

With SNAP, Fermilab signs on for NASA-DOE Joint Dark Energy Mission

When the Supernova Cosmology Project and the High-Z Supernova Search announced in 1998 that the universe is accelerating, *Science* magazine called it the Breakthrough of the Year. Some think the finding validates Einstein's abandoned cosmological constant.

ON THE WEB:

Lawrence Berkeley National Laboratory
http://snap.lbl.gov/

NASA
http://universe.gsfc.nasa.gov/

by Matthew Hutson

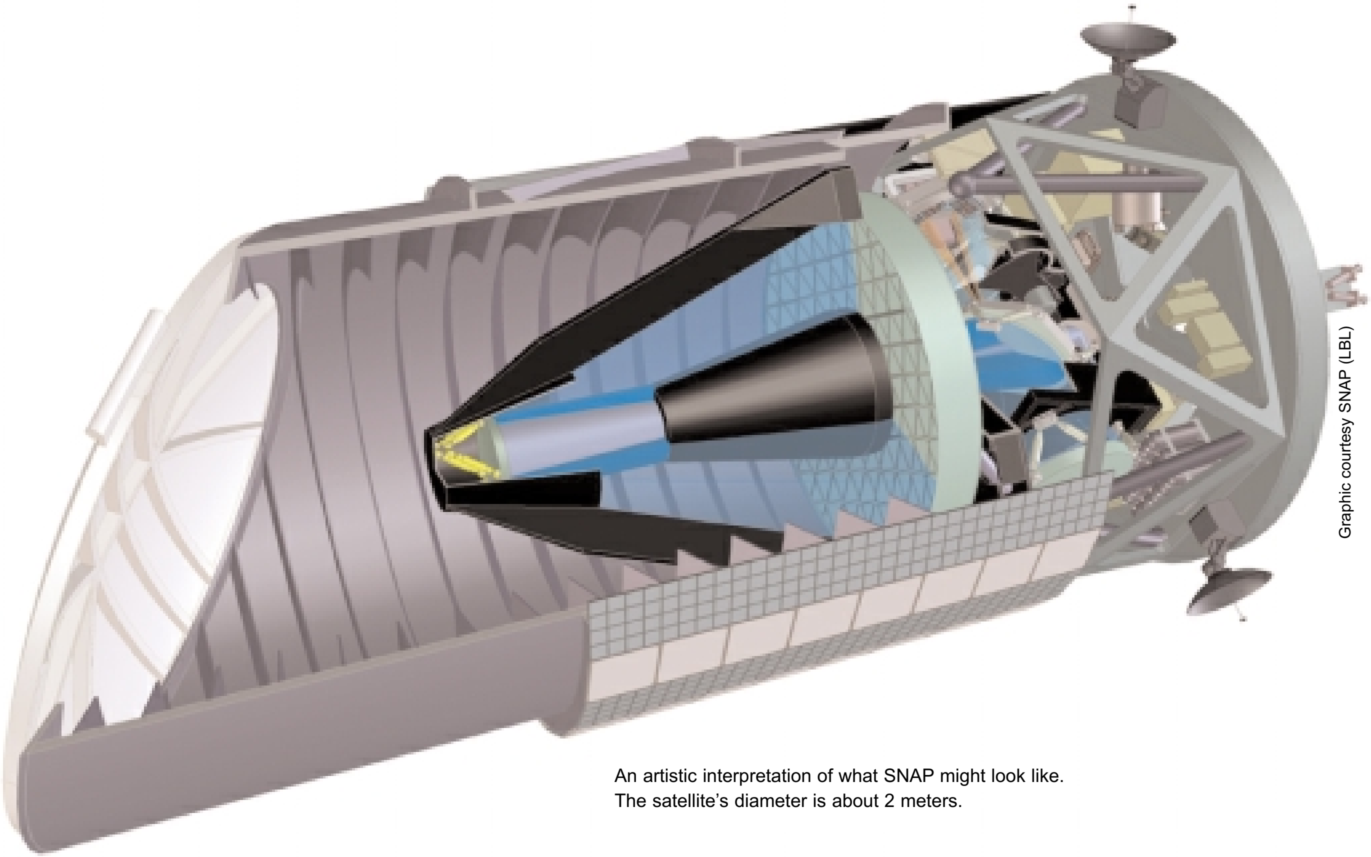
Fermilab is moving up in the world, literally. The "Accelerator" in the lab's full title refers to the acceleration of subatomic particles, but it's expanded its horizons, so to speak. Fermilab's latest collaborative project, if approved, will investigate the acceleration of entire galaxies. The Lawrence Berkeley National Laboratory-led SuperNova/Acceleration Probe, with the snappy acronym SNAP, aims to measure the mysterious dark energy fueling the universe's increasingly rapid expansion.

The proposed SNAP satellite would discover and measure the properties of thousands of distant supernovae moving away from Earth and let scientists reconstruct the history of the universe's growth. Fermilab theorist and SNAP collaborator Scott Dodelson said, "If it wasn't for the experiments, cosmology just wouldn't be that exciting." But thanks to a slew of new experimental techniques, the world of cosmology has entered a new era.

A Little History

Measuring the velocity (based on redshift) and the distance (based on brightness) of type Ia supernovae gives a good picture of the universe's expansion history. In 1998 Saul Perlmutter's Supernova Cosmology Project at Lawrence Berkeley National Lab, and another collaboration called the High-Z Supernova Search, used plots of these supernovae to look back in time and show that the universe's expansion is actually accelerating. For lack of a better understanding, theorist Michael Turner dubbed the mysterious accelerating force "dark energy."

To search for the explanation for dark energy, cosmologists need better measurements of how it has evolved over time. Using the Hubble Space Telescope plus several terrestrial telescopes, the SCP has now plotted over 50 supernovae, but the next generation of precision measurements requires new instruments. The HST can only detect a handful of supernovae in the time devoted to this project, and the atmosphere hampers ground-based observations by absorbing light coming from supernovae at redshifts above z=1 (or 7 billion light years away). In 1999 Perlmutter decided that only a dedicated space-based telescope could give them the required capabilities, and his group began designing SNAP.



Graphic courtesy SNAP (LBL)

An artistic interpretation of what SNAP might look like.
The satellite's diameter is about 2 meters.

SNAP has many prime selling points. With a 2-meter aperture, it would see very faint supernovae. The half-billion-pixel digital camera covering one square degree of sky at a time (considered "wide-field") would discover large numbers of the explosions, which occur in each galaxy about once per century. Near-infrared detectors would pick up light at wavelengths beyond the visual spectrum, extending the telescope's reach to z=1.7, mapping the expansion history of the universe over the last 10 billion years. A spectrograph would analyze each event in enough detail to provide a thorough characterization of each supernova (a "supernova CAT-scan"). And on-board filters giving data in nine wavelength bands would account for any dimming due to galactic dust. No single supernova has undergone all of these measurements before, and SNAP would analyze 2000 of them a year.

In addition to studying type Ia supernovae, the probe would also analyze type II supernovae, survey galaxy clustering, and compile unprecedented measurements of a phenomenon called gravitational lensing whereby matter—even dark matter—in the line of sight of more distant objects will distort their images. There's also a concept that Pelrmutter calls "not so innovative but cute to look at": an integral field unit spectrograph that would produce a 3-dimensional data cube with the x and y coordinates making up two dimensions, and wavelength making up the third.

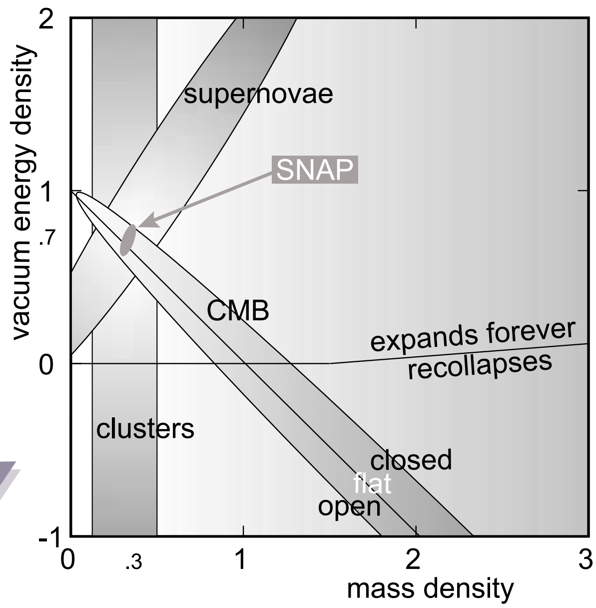
DOE and NASA Team Up

In April 2002 the National Research Council sponsored a report entitled "Connecting Quarks with the Cosmos" from the Committee on the Physics of the Universe, led by theorist Michael Turner. The report made seven recommendations, including one specifying that "NASA and DOE work together to construct a wide-field telescope in space to determine the expansion history of the universe and fully probe the nature of dark energy."

The two organizations took the recommendation seriously and teamed up to form the Joint Dark Energy Mission, or JDEM. A dark energy mission also fit directly into NASA's new Beyond Einstein program, designed to study the Big Bang, dark energy, and black holes, including plans for two space-based observatories, three space probes, plus other programs. The probes will launch every 3 years beginning in the next decade. One probe has been designated a dark energy probe.

In October 2003, DOE and NASA released a proposal outlining how they will work together on the JDEM collaboration. NASA will do the space mission management. The dark energy investigation, including scientific payload and investigation, will be a Primary Investigator-led effort. In three years NASA and DOE will choose the winning scientist-led team for JDEM.

Up,



Graphic courtesy SNAP (LBL)

Mass density and vacuum energy density as ratios of the "critical density" needed for a flat universe. Evidence from three types of experiments converge on a universal mass density of .3 and an energy density of .7, for a total of 1.0. Clusters: measurements of the abundance of galactic clusters. Supernovae: redshift measurements of receding supernovae by groups like the Supernova Cosmology Project and High-Z. CMB: measurements of the cosmic microwave background by COBE, BOOMERanG, DASI, and WMAP. SNAP: the predicted results and accuracy of SNAP.

SNAP is a contender. In November, NASA selected five mission concepts to fund for further study. Three of them involve SNAP, one is for technology development, and one involves a project called DESTINY, led by Jon Morse at Arizona State University.

JDEM has brought together the two very different cultures of NASA and DOE. NASA for example, uses large contractors to do much of the work and places a small team of scientists at the top of a project. DOE, on the other hand, uses large self-organizing collaborations of scientists, who lead the project. Kathy Turner, Program Manager in the Office of High Energy Physics at DOE's Office of Science says that a precision instrument like a dedicated dark energy probe requires everyone to work closely, in a hands-on fashion: If you change widget A, will it change the science? But the mission size, and the need to go into space, require that they work in a different mode.

"Neither DOE nor NASA could do the project alone," she said.

Paul Hertz, the Program Scientist for Beyond Einstein at NASA Headquarters, added: "There are a huge number of cultural conflicts, but they don't keep us from working together well."

Both organizations gained important insight from recent collaboration on SLAC's Gamma Ray Large Area Space Telescope.

"The GLAST collaboration has been a wonderful learning opportunity for both of us," said Hertz. "We understand each other's way of doing business now." Such cooperation indicates a new spectrum of possibilities as the two cultures learn to combine their strengths.

In November the Secretary of Energy Spencer Abraham, released "Facilities for the Future of Science: A Twenty-Year Outlook." JDEM tied for third place in scientific importance and readiness for construction.

Fermilab Steps In

In January 2003, Fermilab made a request to become part of SNAP. In November, SNAP invited Fermilab to join the collaboration. Fermilab will contribute work from 16 scientists, part-time or full-time, to the 80 or so scientists already in the collaboration: 11 astronomers, astrophysicists, and cosmologists; and 5 high-energy and accelerator physicists. The Fermilab team, led by Peter Limon and Steve Kent, includes five subgroups. Albert Stebbins heads the Science and Simulations group, Kent heads the Calibrations group, Chris Stoughton heads the Software group, John Marriner heads the Electronics group, and Tom Diehl heads the Radiation Shielding group.

Fermilab began preliminary work on the project 18 months ago. Diehl has been working on the radiation shielding for about a year. The shield must block visible light, infrared heat and cosmic rays. When Diehl designed shielding for DZero, each bus-sized shield weighed 110 tons, but for this project he cannot go above 20 kilograms.

"The best we can do is not make things worse" by turning the cosmic rays into particle showers, Diehl said.

Steve Kent and Doug Tucker are working with LBL's calibration team to account for all of the systematic errors that might alter the brightness of the supernovae. Their experience with Sloan will help them avoid certain mistakes.

"Once a satellite is launched," Kent said, "you have no opportunity to go back and fix or change anything. A big advantage of space, fortunately, is that one does not need to look through the earth's atmosphere with its variable clouds, haze, and dust that afflict ground based observations."

The SNAP satellite would collect more than 100 gigabytes of data each day.

"This requirement would be significant for a land-based system but represents an enormous challenge for a satellite," Marriner said.

The Electronics group evaluates the memory technologies, data compression algorithms, and computing hardware required to record the data, compress it, and send it back to Earth.

Each area of electronics R&D has its own special hurdles. The group is exploring flash memory chips, which don't require power to store data but in the past have shown poor radiation tolerance. They're pushing outside the realm of traditional data compression algorithms and testing novel schemes for prescaling data to reduce the amount of bits sent to the ground. So far, their computing chips have shown a high sensitivity to radiation. The computing systems must be light, and they must be efficient enough to require little power, and robust enough to survive bombardment from cosmic particles.

Limon sees SNAP fitting into a potential long-range plan as Fermilab extends its areas of research into space. SNAP could become a flagship project.

"We have a worldwide reputation for excellence in experimental cosmology," Dodelson said. "Fermilab is not only an accelerator lab. It is really a fundamental physics lab. I see this as completely consistent with Fermilab's mission."

Further, the lab's role in the Sloan Digital Sky Survey has provided experience in astronomy and cosmology, as well as the science and techniques of wide-field astronomical observations.

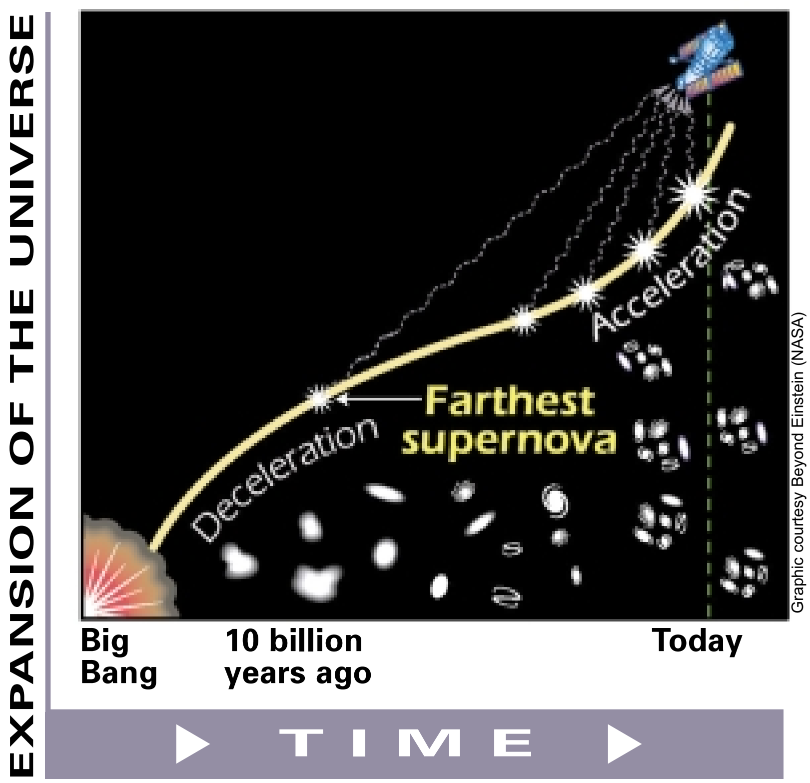
"Fermilab found a lot of new ways to use the wide-field data," Perlmutter said, "and that's a testament to the creativity of the team. It made a natural match."

Limon summarized the three compelling reasons to join the collaboration:

- SNAP offers exciting science, exploring some of the biggest questions in the universe.
- Fermilab has much to contribute. Its team members have expertise in electronics, mechanical and thermal engineering, scientific simulation software, instrument calibration, and reduction of raw data into a form appropriate for analysis.
- The proposed SNAP satellite is an elegant tool for focused research, a space-based wide-area survey of the sky.

The proposed launch date remains 10 years away, but Limon insisted the project really has much more urgency, as the next phase of project evaluation looms just three years away.

"There's a lot of work between now and then," he emphasized.



SNAP will measure the rate of expansion of the universe by looking at distant supernovae as they recede.

F N E E R W M S I

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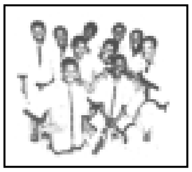
LADYSMITH BLACK MAMBAZO

Saturday, February 14, 2004
Tickets - $27 ($14 for ages 18 and under)



It has been more than fifteen years since Paul Simon made his initial trip to South Africa and met Joseph Shabalala and the other members of Ladysmith Black Mambazo in a recording studio in Johannesburg. Simon incorporated the traditional sounds of black South Africa into the *Graceland* album, a project regarded by many as seminal to today's explosive interest in World Music. Ladysmith Black Mambazo has come to represent the traditional culture of South Africa. Considered South Africa's cultural emissaries at home and around the world, Black Mambazo accompanied the future President Nelson Mandela, and then-South African President F.W. de Klerk, to the Nobel Peace Prize ceremony in Oslo, Norway.

CHOREOGRAPHER'S SHOWCASE

featuring Gus Giordano Jazz Dance, Tommye Giacchino and Gregory Day, Ballroom Dancing

Saturday, March 13, 2004
Tickets - $18 ($9 ages 18 and under)

Founded in 1962 as Dance Incorporated Chicago, the company was the first jazz dance troupe to tour the former Soviet Union in 1974. This focus on jazz dance led to a new name - Gus Giordano Jazz Dance Chicago - and its current mission to develop and preserve the indigenous American art form of jazz dance, thereby creating an awareness of jazz dance as a true artistic expression of American life. More than 40 years since its inception, Gus Giordano Jazz Dance Chicago continues to bring the excitement of American jazz dancing to audiences in countries around the world.

MANYA: A LIVING HISTORY OF MARIE CURIE

Written and performed by Susan Frontzcak

Saturday, April 17, 2004
Tickets- $15 ($8 for ages 18 and under)

Madame Marie Curie (née Maria Sklodowska) - changed our world through her discovery of radium and radioactivity. Through her own passion and perseverance, Marie Curie opened the doors of science to women world-wide. Manya not only celebrates the scientist, but also illuminates the human side of Marie Curie, a woman who felt more daunted by the chemistry of the kitchen than of the laboratory. Whether looking at Marie within her historical context or through the lens of a new millennium, this is a life that challenges our assumptions about what one person can achieve and the responsibilities of science.

Chez Léon MENU

Lunch served from
11:30 a.m. to 1 p.m.
$10/person

Dinner served at 7 p.m.
$23/person

For reservations, call x4512
Cakes for Special Occasions
Dietary Restrictions
Contact Tita, x3524
http://www.fnal.gov/faw/events/menus.html

Lunch — Wednesday, January 7

Cannelloni of Sausage, Pepper & Cheese
Salad of Field Greens with Arugula
Chocolate Pecan Tart

Lunch — Wednesday, January 14

Chicken Satay with Asian Peanut Sauce
Steamed Jasmine Rice
Sauteed Asian Vegetables
Coconut Cake

Lunch — Wednesday, January 21

Rouladen
Egg Noodles with Dill
Linzentorte

Lunch — Wednesday, January 28

Ropa Vieja
Field Plantations
Cornmeal Cake with Raisins & Cherries

Dinner — Thursday, January 8

Seafood Soup
Lemongrass Beef on Skewers
Steamed Jasmine Rice
Stir Fried Vegetables
Ginger Souffle with Chocolate Sauce

Dinner — Thursday, January 15

Lentil Soup with Cumin & Garlic
Roast Leg of Lamb with Arzo
Lemon Napoleon

Dinner — Thursday, January 22

Vol-au-Vents with Mushrooms Duxuelle
Bouillabaisse
Field Greens with Mustard Vinaigrette
Profiteroles

Dinner — Thursday, January 29

Coconut Vegetable Soup
Sweet & Sour Red Snapper
Corn Fritters
Green Vegetables
Pavlova

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