

Next-Generation Light Sources: Free Electron Laser Research Milestone Experiment Achieved

More than 2,400 scientists come to the Lab's National Synchrotron Light Source (NSLS) each year from across America and around the world. They can testify that this user facility is an unqualified success at what it does: converting energy from a stored electron beam into intense beams of light. These beams of light, ranging from infrared and ultraviolet through x-rays, are used to examine the structure and function of a host of materials.

While synchrotrons have proven to be an invaluable tool, they lack the coherent power available from con-

... experimental results which demonstrate the marriage of the energy reach of accelerators with the finesse of lasers.

ventional laser systems, which in turn lack the energy range of storage rings. This gap between lasers and accelerators was bridged by a BNL/Argonne National Laboratory (ANL) team with the first demonstration of a high gain harmonic generation (HG HG) free electron laser (FEL) at the BNL accelerator test facility (ATF).

In August of 1999, the team described the experimental results which demonstrate the marriage of the energy reach of accelerators with the finesse of lasers.

The proof-of-principle experiment led by Li-Hua Yu of the NSLS was a first step toward development of a new approach to generate very intense coherent hard x-rays. In a coherent source, all elements radiate in synchronism. By analogy, a chorus led by a conductor is coherent; an uncoordinated group of singers, incoherent.

Two Central Concepts

There are two central concepts in the experiment. First is to impose the properties of the laser on the electron beam by "seeding," so the start-up signal is coherent. The second is the

"The important result . . . shows dramatically the potential benefits of a laser-seeded free electron laser."

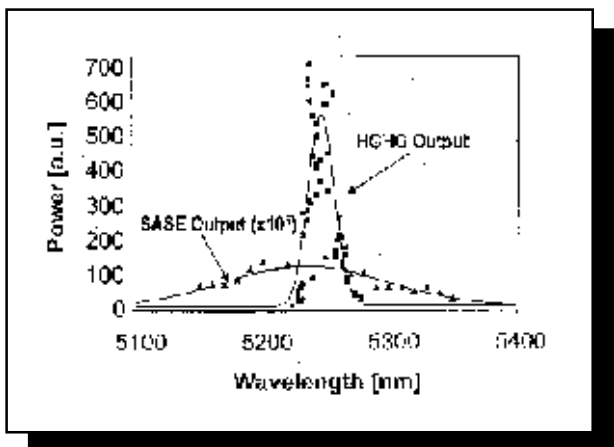
realization that the multiples of the laser frequencies (harmonics) can be generated and amplified in the FEL, which shifts the properties of the laser (such as its stability) to higher frequencies. Another important feature of the HG HG configuration is that it can be achieved in a "single-pass" device, which means that, unlike conventional lasers, it does not require high efficiency mirrors. This will be crucial to projecting high performance laser characteristics into x-ray sources of the future.

Groundwork

Said Yu, "To be able to do this experiment required many people and
(continued on page 3)



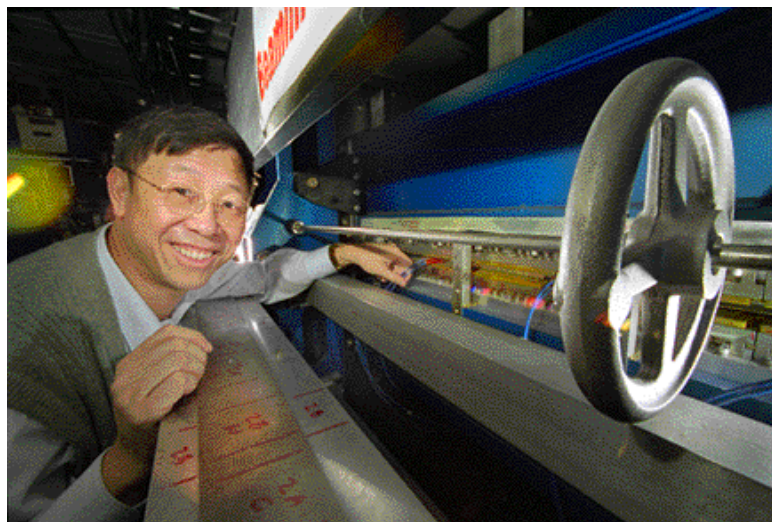
The team on the experiment for the high gain harmonic generation free electron laser included: (from left) Erik Johnson, Bill Graves, Bob Malone, Igor Pogorelsky, Marcus Babzien, Li Hua Yu, Xijie Wang, Lou DiMauro, John Skaritka, Marc Montemagno, Bill Cahill, Bob Harrington, Ilan Ben-Zvi, Sam Krinsky, and Mike Lehecka, all of BNL. Not present were: (from BNL) Jeffrey Aspenleiter, Bill Bambina, Michael Caruso, Walter DeBoer, Pete DeToll, Adnan Doyuran, Rodger Hubbard, Sorin Pop, George Rakowsky, Bob Scheuerer, Don Shea, Lorraine Solomon, Mal Tardd, Martin Woodle, and Vitaly Yakimenko; from Argonne National Laboratory: Sandra Biedron, John Galayda, Efim Gluskin, John Jagger, Vadim Sajaev, and Issac Vasserman.



These data (left) demonstrate the striking difference between High Gain Harmonic Generation (HG HG) and Self Amplified Spontaneous Emission (SASE) Free Electron Laser (FEL) experiments conducted on the same equipment. The graph plots power (in arbitrary units) against wavelength (in nanometers) and shows that the energy spread of the HG HG FEL is much smaller and the overall gain higher. The SASE result is multiplied by one million (10^6) to be on the same scale as the HG HG result. The SASE experiment could achieve the same power level if the amplifier were three times longer, but the energy spread would still be greater than that of the HG HG device.

351st Brookhaven Lecture

Li-Hua Yu Talks About Milestone Experiment



To describe and explain the breakthrough research leading to the "High Gain Harmonic Generation Free Electron Laser Results," Li-Hua Yu, National Synchrotron Light Source (NSLS) Department, will give the 351st Brookhaven Lecture, on Wednesday, January 19, at 4 p.m. in Berkner Hall.

Yu will be introduced by NSLS Deputy Chair and Free Electron Laser Manager Sam Krinsky.

Yu, who led the proof-of-principle experiment at the Accelerator Test Facility (see accompanying story), joined BNL in 1982. His research on various topics including free electron lasers and closed orbit feedback system for the storage rings. He received his Ph.D. in physics from the State University of New York at Stony Brook in 1984 and since then has been working at NSLS.

Refreshments will be offered before and after the lecture. To join the lecturer at dinner at a restaurant off site that evening, contact Kathy Lovero, Ext. 7188, by noon on that day.

RHIC Start-Up Delayed

The start-up of the Relativistic Heavy Ion Collider (RHIC), BNL's newest and largest accelerator, will be delayed by three months and is now scheduled to begin in February. The first experimental run is planned in May, after detailed systems tests.

The delay is primarily due to repairs of deformed beam pipe bellows at certain locations around the ring. During last summer's commissioning run, the beam in the Blue Ring had to be steered around an obstruction. This obstruction turned out to be a piece of bent metal sheathing inside a bellows connection between adjacent beam-tube sections.

Upon inspection, technicians
(continued on page 2)

New DOE Initiative



RHIC

(cont' d)

Upon inspection, technicians found that this was the result of distortions that occurred during high-pressure testing of parallel running tubes, which carry liquid helium to cool the superconducting magnets. The deformities were diagnosed as a systemic problem around both the Yellow and Blue Rings, and so an extensive repair job was undertaken.

Thomas Ludlam, Deputy Associate Director for High Energy and Nuclear Physics, said that such a delay is not unusual, given the complexity of the machine.

The \$600 million RHIC construction project began in 1991 and was completed last summer. Designed to recreate under laboratory conditions the state of the Universe just after the Big Bang, RHIC is expected to enable about 1,000 physicists from worldwide to do experiments to explore matter as it existed at the beginning of time.

While the delays may cut the collider's first experimental run from 28 to 25 weeks, Satoshi Ozaki, Associate Laboratory Director for RHIC, said that a final decision on this has not yet been made.

The RHIC team will start cooling down the machine at the beginning of February, with the goal of beginning ion collisions in March or April, and experiments in May.

"With a great many of the commissioning goals accomplished during last summer's run, and all known deficiencies of the system remedied, we are very optimistic that we will achieve colliding beams and be ready for data-taking fairly quickly this spring," Ozaki said.

RHIC's start-up problems have been addressed swiftly. Since September, about 200 of the bellows have been replaced and their connections braced and other modifications made to ensure safe and reliable operations.

For example, technicians replaced 56 valves in the refrigerator and added additional filters to trap contamination from returned gas. Also to be installed before start-up are approximately 100 power supply units, which adjust magnet strength at beam intersections. The power supplies have been delayed because the manufacturer had not met the RHIC design specifications.

Meanwhile, RHIC has been ahead of schedule in meeting environmental standards, as it is the first DOE Office of Science project and the first Long Island-based facility to be registered to the International Standardization Organization 14001 Environmental Management System.

ISO 14001 is an internationally recognized standard that provides a framework for defining and preventing potential environmental impacts, and for monitoring, communicating and improving performance.

Ludlam concluded, "The extended shutdown has provided the experimenters with a window of opportunity for installation, testing and tuning of components that will make this year's running potentially much more effective than it would have been had we started, as originally planned, in November or December of last year. In terms of physics output, this could well offset the delayed start-up."

— Diane Greenberg

BNLers, Be Your Own Boss — With Help From DOE



Around the sign for the new DOE Small Business Development Center (SBDC) are: (from left) Judith McEvoy, Director, SUNY Stony Brook SBDC; Tim Drawridge, DOE Contract Specialist; Michelle Stark, Business Advisor, DOE Brookhaven Group (BG) SBDC; Jeffrey Waxweiler, CEO, APACE, Inc. of Hauppauge; Lucille Wesnofske, Associate Director, SUNY Stony Brook SBDC; & Robert Gordon, Director, Business Management Division, DOE/BG.

To be one's own boss tops many people's wish list. If starting your own business is your goal, this opportunity for expert assistance could be for you.

A partnership between the Department of Energy (DOE) and New York State has established a Small Business Development Center (SBDC) on BNL's site at the DOE Brookhaven Group. The SBDC provides a range of services to existing and emerging small businesses. It also is a first-of-a-kind at a DOE site.

"This center, with all it has to offer, will be a great benefit to the community, BNL and DOE," said Robert Gordon, Director of DOE's Business Management Division at BNL. "By assisting new and existing small business firms, this new Center contributes to the growth of small business on Long Island. And, BNL will have more potential supply sources."

At the SBDC, a wide range of products and services awaits the business community — business plan development and small business start-up assistance, organizational structuring,

& Small Disadvantaged Businesses (SSDB) program in what is now the Procurement & Property Management Division received a DOE national award for success in creating small business opportunities. BNL has several programs that were created for small businesses. For example, BNL's SSDB Liaison Officer has an open-door policy to assist small, small disadvantaged, and women-owned businesses to become viable. Also, the Technical Assistance Program in the Office of Economic Development & Technology Transfer offers a unique opportunity to businesses needing to solve technical problems. Under this free program, BNL provides its staff expertise to a business for up to a week. Also, the Cooperative Research & Development Agreement (CRADA) program in the Technology Transfer Office enables BNL to enter into partnerships with industry to work on projects that are of mutual benefit.

The new DOE Center's doors opened in November, and its counselors have been meeting almost continually with individuals from the community and from BNL. Interests vary — some clients explore the potential for self-employment and others seek funding opportunities.

The new DOE SBDC office is a satellite of a larger SBDC program located at the State University of New York at Stony Brook, under the auspices of the Office of the Vice President for Economic Development, Yacov Shamash. The Stony Brook Center has been in existence for over 12 years, employing seven full-time professional advisors and two support staff. In addition, a full-time advisor is located at the Long Island University satellite office in Southampton. Since its inception, the Stony Brook Center has assisted over 7,500 clients, achieved over \$91 million in economic impact, created more than 2,057 jobs, and saved more than 700 existing jobs.

"We are hopeful for similar success at the newest SBDC site," said Gordon.

The DOE SBDC is currently staffed with one advisor who provides one-on-one, confidential counseling for the growth of a business. The Center is open weekdays, except Thursday, 8:30 a.m. to 4 p.m. All visits are free. The Center is housed within the DOE Building 464 on 53 Bell Avenue. For information, call 631-344-2393 or e-mail sbdcdoe@bnl.gov. Walk-ins are welcome, but appointments are recommended to ensure that ample time is put aside to assist you.

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financial planning, loan information assistance, and access to public and private capital sources, as well as training programs (workshops and seminars). The Center maintains a comprehensive library, provides referrals to consultants and service providers, offers export assistance, and is linked by computer to the other 20 SBDCs across the state. Introductions to DOE and other federal agency purchasing organizations are also provided. This makes BNL an ideal location for the Center.

"BNL plays a significant role in the regional economy as a purchaser of supplies and is a leader in working with small business," Gordon said. "Now it can also be a mentor for emerging businesses."

In 1999, more than 65 percent of BNL's contracts were awarded to small businesses. Also in 1999, BNL's Small

Microcomputer Club Java Presentation

On Thursday, January 20, the BERA Microcomputer Club will sponsor a presentation by Dave Stampf, who programs in Java for the Relativistic Heavy Ion Collider and the Advanced Technology, Applied Science, and Biology Departments.

Stampf will talk on "Java — Fun at the Cutting Edge of Programming," in Berkner Hall, Room C, from noon to 1 p.m. All are invited, bring your lunch.

For more information, contact Club President Steven Stein, Ext. 5694, or visit <http://www.bnlmcc.bnl.gov>.

Omnipoint Demo 1/18

Omnipoint Communications will be in Berkner Hall on Tuesday, January 18, 10 a.m.-2:30 p.m., with special rates for BNLers buying digital PCS wireless services on Omnipoint's GSM network.

Service plans include free caller ID, voice mail, SMS messaging, and FOX News headlines. Plans range from \$15.99 monthly with free phone, to 40 free minutes at \$17.99 monthly, or to 250 minutes, with unlimited weekend calling for the year of the contract at \$27.99 monthly. Call Richard Gall at (631) 343-5900.

Noon Recital January 26, Ensemble Performs Early Scottish Tunes



Rachel Begley

At noon in Berkner Hall on Wednesday, January 26, the Orpheus Caledonius ensemble will perform a collection of 18th-century Scottish tunes. The musicians are directed by Rachel Begley, recorder; and include Jennifer Griesbach, harpsichord; Motomi Igarashi, viol; and Christopher Morrongiello, lute.

Popular tunes in Scotland at that time evidence crosscurrents of both folk and classical music. A study in contrasts, from the most plaintive of ballads to the most raucous of dances, the program will include works by Barsanti, Bremner, Gow, Oswald, and Thomson.

Orpheus Caledonius is a new ensemble of some of the most exciting emerging players of early music. Director Begley, a New York-based English recorder virtuoso, assembled the group from colleagues from Canada, Japan and the US. The group's diverse instrumentation — with wind, bowed and plucked instruments, together with a keyboard — provides an ever-changing tapestry of sound.

Noon recitals are free and open to the public. Bring a lunch and come and go as you please.

Experiment (cont'd)

specialized equipment coming together at the right time.”

The ground was prepared by the theoretical work of Yu and Sam Krinsky (see L.H. Yu, *Phys. Rev. A* 44, 517B, 1991). By 1989, it had become clear that FELs could generate intense radiation at deep ultraviolet (DUV) and even shorter wavelengths.

Yu recalled that interaction with the Chemistry Department’s Louis DiMauro and Michael White showed that the intense UV radiation would have significant applications in many fields. This stimulated much interest from potential users and machine builders, resulting in several national review committees which endorsed investments in FEL research and development for short-wavelength FELs.

“At the same time,” continued Yu, “Ilan Ben-Zvi and his ATF team developed the high brightness electron beam that would be required for such an FEL.”

It had become clear by that time, Yu said, that a proof-of-principle experiment should be conducted in the infrared region before proceeding to an ultraviolet (UV) FEL. Such a small-scale experiment could demonstrate the essential physics. With the high power carbon dioxide laser of the ATF to provide the seed source, the parameters of the experiment were quickly established. The collaboration then called venerable equipment out of retirement and built some new hardware to complete the experiment successfully.

The next step in the development of high gain harmonic generation will take place at the DUV FEL facility managed by Erik Johnson.

According to NSLS Chairman Michael Hart, “The important result reported by Yu and his collaborators shows dramatically the potential benefits of a laser-seeded FEL, as contrasted with the self-amplified spontaneous emission approach, or SASE, which BNL has explored and is being pursued at other laboratories.”

The SASE approach does not use a seed laser or harmonics, and the beam it produces does not have the quality that the seed laser provides (see diagram on page 1).

“The challenge will be to see if the HGHG technique can be extended into the hard x-ray range, in the development of a practical, next-generation source of x-ray light,” summed up Hart. “Investigation of this question will be the cornerstone of our continued effort to develop FEL science and technology.”

For a description of the experiment and how previously used instrumentation was rebuilt with a new NSLS dispersive magnet for this occasion, attend the 351st Brookhaven Lecture (see page 1); see also the lead article in the NSLS Newsletter, November 1999, <http://www.nsls.bnl.gov/Pubs/NewsLtrs.html>; and the ATF Web page, <http://www.nsls.bnl.gov/AccTest/AEHG.html>.

United Way, Best Year Ever!



At a breakfast celebrating the conclusion of this year’s United Way campaign on January 7, Campaign Chair Patti Bender of the Plant Engineering (PE) Division and Lab Director Jack Marburger revealed the final tally: \$130,722 — topping the goal by more than \$20,000 and making this year’s campaign the most successful in BNL history:

- Pledges and contributions from 22 percent of employees accounted for \$118,955 of the total.
- Contributions from 35 alumni, retirees and others added \$2,866 more.

Several new programs had significant impact as well:

- A Chinese Auction/Holiday Raffle, held under the direction of Gail Brown, Department of Applied Science, raised \$1,621 in just 2 days.
- Fifty-six BNLeers worked a total of 173 hours as volunteers at soup kitchens, food pantries and local hospitals.
- In addition to the value of this

volunteer work, BSA compensated these workers’ time by donating \$3,640 to the campaign.

- And, because the program was so successful, Marburger and Brian Sack, Assistant Laboratory Director for Finance & Administration agreed to an additional BSA matching donation of \$3,640.

One of the Lab’s best success stories came from PE. Last year, contri-

\$130,722 — topping the goal by more than \$20,000

butions from 7.1 percent of the 384 PE employees provided \$3,522 for the United Way. This year, participation rose to 33.2 percent of PE, garnering \$12,261 for the service agencies needed by so many Long Islanders.

Said Bender, “PE management and IBEW Local 2230 leadership worked



Above, Joe Buscemi (left), President, IBEW Local 2230, congratulates Eugene Barrow of the Plant Engineering (PE) Division on his first-prize raffle win. At left (from left): Joe Buscemi, Ed Murphy, PE Manager; Bob Aikman, PE, third-prize winner; Patti Bender, this year’s Campaign Chair; and Tirre Farmer, last year’s Chair. together to increase our division’s participation this year. It made a big difference.”

With support from Joe Buscemi, IBEW Local 2230 President, Ed Murphy, PE Manager, held a party and raffle with prizes donated by BSA for all PE employees who had contributed to the campaign financially or by volunteering their services. The first prize of a color TV/VCR was won by Eugene Barrow, and Bob Aikman won a CD player (see photos above).

“It was tremendously gratifying to participate in such an outstanding campaign,” said Marburger. And speaking on behalf of BSA, he said, “We are prepared to do it again next year.”

Next year’s chair will be Beth Blevins, Director’s Office, who co-chaired this year’s campaign. She will be joined by Susan Monteleone, Department of Advanced Technology, who will head the campaign in 2002, as well as Brown. — Karen McNulty

Arrivals & Departures

Arrivals	
Stanko Brankovic	Appl. Science
Sailesh Chopra	Physics
William C. Elliott	Biology
Thomas L. Kash	Medical
Xin Li	Chemistry
Saskia Mioduszewski	Physics
Marvin A. Schofield	Appl. Science
Departures	
Mulki R. Bhat	Adv. Technology
Paul J. Klotz	Appl. Science

Bowling

Red & Green League – January 4
R. Deem 269/266/202/737 scratch series, E. Larson 258/253/223/734 scratch, R. Mulderig Jr. 257/246/215/718 scratch, R. Mulderig Sr. 245/208/639 scratch, M. Meier 225/213/633 scratch, J. Meier 225/212/628 scratch, J. Griffin 224/203/609 scratch, J. McCaffrey 213

Purple & White League – January 6
B. Mullany 209/198, J. Meier 208/191, P. Wynkoop 200/193, J. McCarthy 224, G. Mehl 215, C. Rooney 202, K. Riker 200, P. Callegari 197/184, M. Picinich 197/177, P. Kennedy 196, D. Keating 190, J. Alduino 189, K. Hogan 183, C. Johnson 181, M. Addessi 181, M. G. Meier 175, K. Dilgen 174, L. Simes 171

Defensive Driving

The training group of the Safety & Health Services Division will offer a six-hour defensive driving course on Saturday, January 29, 9 a.m.-3:30 p.m., in Berkner Hall, Room B.

The course will be taught by a Metropolitan Life instructor and is open to BNL, BSA and DOE employees, BNL facility-users, and their families, at a cost of \$23 per person. Completing the course gives a 10-percent discount on vehicle collision and liability insurance for three years.

To register, send a check made out to Empire Safety Council, in care of Scott Zambelli, P.O. Box 670, Mount Sinai, NY 11766. All checks must be received by Friday, January 21. So that your registration can be confirmed, include your phone number with your name. For more information, call Zambelli at 249-3000, Ext. 5877 (not the on-site Ext. 5877).

IBEW Meeting

Local 2230, IBEW, will hold its regular monthly meeting on Monday, January 24, at 6 p.m. in the Knights of Columbus Hall, Railroad Avenue, Patchogue. There will be a meeting for shift workers at 3 p.m. at the union office. The agenda includes regular business, committee reports and the president’s report.

Holiday Notes

In observance of Martin Luther King’s birthday, the Lab will be closed on Monday, January 17. There will be no **Bulletin** on Friday, January 21.

In addition, the **Research Library** and the on-site offices of the **Teachers Federal Credit Union** and the **United States Postal Service** will be closed on Monday, 1/17. The **swimming pool** and **gymnasium** will keep normal weekend hours but close on Monday.

The **Cafeteria** will provide weekend service Saturday-Monday, 1/15-17, 7:30 a.m.-2 p.m. daily. The **Brookhaven Center** is closed on Saturdays, and will be closed on Sunday, 1/16, but dinner service will resume on Monday, 1/17, 5-9 p.m.

Softball Captains

A meeting for BERA Softball League Captains will be held at noon on Wednesday, February 2, in Berkner Hall, Room C. To run or nominate someone for the League Board, you must attend the meeting.

All teams planning to play this season should have at least one representative present. Bring preliminary rosters so that a league structure can be determined. Any new team will be placed in the League by the Board.

For more information, e-mail softball@bnl.gov.

BERA Ski Trip

The first BERA-sponsored ski trip of 2000 is scheduled for Wednesday, February 16, to Camelback. Save the date — more information will be forthcoming. Call Andrea Dehler, Ext. 3347, or Bob Marascia, Ext. 7779 for pre-reservations.

January 2000

Don't just resign - Do it!



BNL Food Drive

Pickup Thursday, January 20.
No time to shop? Send personal checks to: BNL Food Drive, c/o R. Kito, Bldg. 460, or D. Wadman, Bldg. 129.

Volleyball

League standings as of January 7			
Open League A		Mixed League 2	
Drill.&Excav. Co.	24-6	Safe Sets	30-0
Shank, Cary&Throw	16-14	Spiked Jello	24-12
Far Side	12-18	Up-Setters	24-12
Death Volley	8-22	Inside Out	25-14
Open League B		Nuts & Bolts	7-26
Late Entry	20-10	Group Sets	6-27
Bumpin Uglier	19-11	Setups	4-29
Monday Nite Live	15-15	Mixed League 3	
The Stars	6-24	Six Samurai	22-2
Mixed League 1		Upton Ups	18-6
I Want Your Sets	19-5	Net Setters	12-12
Set to Kill	16-8	NWO	8-16
Scared Hitless	7-17	Networkers	7-17
Rude Dogs	6-18	Butlers	5-19

BROOKHAVEN BULLETIN

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