Undulators for existing and future light sources

In the last several decades accelerator-based light sources have experienced remarkable progress. Currently, light source facilities make up the largest percentage of accelerators built around the world and maintain unquestionable leadership in the multitude of experimental programs in material physics, chemistry, and biology. In the past two decades the primary source of radiation at the majority of light source facilities was from undulators; at free-electron lasers (FELs), undulators are the only source of radiation.

The Advanced Photon Source (APS) at Argonne National Laboratory, along with several other facilities around the world, is at the forefront of developments and building of undulators for the APS storage ring and other light source facilities. In 1998 the APS built the first long undulator line that played a crucial role in the validation of FEL prototype performance in the visible and ultraviolet wavelength ranges. Following that, APS designed and built an approximately 100-m-long undulator line for the first x-ray FEL at Stanford. Recently, a novel undulator for the upgrade of this FEL has been successfully developed and is currently under construction.

During the last decade a significant portion of the APS undulator team's effort has concentrated on the development of superconducting undulators (SCUs). Several planar SCUs and one helical SCU have been designed and built. Three of them are operating successfully at the APS. The superior performance of these undulators has enabled APS users to conduct unique experimental programs. SCUs are integrated into the design of the next generation of the APS storage ring and are being considered for the high-energy upgrade of the Stanford x-ray FEL.

Short CV

E. Gluskin received his M.S. degree in Physics with top honors from Novosibirsk State University, Russia in 1968. He completed his Ph.D. work in the field of x-ray spectroscopy studying the electronic structure of simple molecules and was awarded this degree from the Siberian Branch of the Academy of Sciences in 1974. In 1972, simultaneous with his Ph.D. research, E. Gluskin led the design and construction of the first soft x-ray beamline at the 700-MeV electron-positron storage ring/collider at the Budker Institute of Nuclear Physics in Novosibirsk. From 1972 to 1989 E. Gluskin led the development of the synchrotron radiation instrumentation and research program at this storage ring. He also held the position of Associate Professor at Novosibirsk State University.

In 1990 E. Gluskin joined the construction team of the Advanced Photon Source (APS) at Argonne National Laboratory. Soon after, he assumed responsibility for the design and construction of the APS undulators. Successful completion of the APS construction was followed by the experimental demonstration for the first time of saturation of a free-electron laser (FEL) built by the team co-led by E. Gluskin. In 1999 he became Director of the Experimental Facilities Division and in 2004 was named Director of the Accelerator Division at the APS. Under his leadership the APS team designed and built the first undulator line for the x-ray FEL at Stanford and recently developed a novel undulator for the upgrade of that facility. In the last decade E. Gluskin has led successful developments of novel superconducting undulators; three of these are currently in operation at the APS.

E. Gluskin is a Fellow of the American Physical Society and a Fellow of the American Association for the Advancement of Science.

Long CV

Efim Gluskin

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EDUCATION

Ph.D. in Physics, Siberian Division of Academy of Sciences, Novosibirsk, Russia, 1974

Masters in Physics with top honors, Novosibirsk University, Novosibirsk, Russia, 1968

EMPLOYMENT HISTORY

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS, USA

Argonne Distinguished Fellow, 2009-present
Division Director, 1999-2010
Sr.Physicist/Group Leader, 1998-1999
Physicist/Group Leader, 1992-1998
Physicist, 1990-1992

- Led the design and construction of the Advanced Photon Source (APS) insertion devices. Became the world-recognized leader in the area of developments and utilization of undulators and wigglers. Initiated and completed several innovative projects of unique insertion devices that successfully operated at the APS and other synchrotron radiation (SR) sources.
- Led the design and construction of unique vacuum chambers for insertion devices. This design and innovative technology are widely used at SR sources around the world.
- Led a group of physicists and engineers in the development and successful implementation of the world's first self-amplified spontaneous-emission (SASE) free-electron laser (FEL) saturated in the visible and ultraviolet wavelength regions. Led developments of unique diagnostics systems for the SASE FEL. For the first time made time-resolved critical measurements of spectral properties of SASE radiation.
- Provided technical and management leadership in the design and construction of the undulator line for the Linac Coherent Light Source, the world's first x-ray laser facility built at Stanford.
- Proposed and performed the two-slits, classical Hanbury Brown–Twiss experiment for the first time with SR in the x-ray region.
- Led the successful transformation of the Experimental Facilities Division in the expansion of beamline operations at the APS.
- Led innovative developments of new concepts and designs for the APS accelerator complex.
- Led innovative developments of superconducting devices for the APS and FEL projects

BUDKER INSTITUTE OF NUCLEAR PHYSICS, NOVOSIBIRSK, RUSSIA

Synchrotron Radiation Group Leader at the VEPP-2M electron-positron storage ring, 1984-1989
Senior Physicist, 1981-1984
Physicist, 1978-1981

- In early 70's pioneered technology and research using storage ring synchrotron radiation.
- Measured absorptions spectra of simple molecules in soft x-ray region with record high spectral resolution.
- Measured for the first time the polarization and coherent properties of radiation emitted from the helical undulator.
- Led the team of researchers to utilize 7.5-T superconducting wiggler at the low energy storage ring.
- Developed techniques of characterization of novel multilayer mirrors.
- Developed techniques to calibrate the sensitivity of photodetectors in absolute units.

NOVOSIBIRSK UNIVERSITY, NOVOSIBIRSK, RUSSIA (simultaneous with appointments at BINP)

Associate Professor, 1986-1989
Assistant Professor, 1980-1986

Courses Taught:
Undergraduate–Classical Mechanics, Electrodynamics, Statistical Physics, Quantum Mechanics
Graduate–Experimental Physics of Synchrotron Radiation

INSTITUTE OF INORGANIC CHEMISTRY, NOVOSIBIRSK, RUSSIA

Physicist, 1972-1978
Ph.D. student, 1968-1972
Advisor to three PhD students: two in Novosibirsk, one at the Illinois Institute of Technology/APS

PUBLICATIONS

Authored over 150 publications in peer-reviewed journals and books, co-authored one book. A short list is provided here.

1. E. S. Gluskin, A.N.Skrinsky et al., "The utilization of synchrotron radiation from the VEPP-2M storage ring for the achievement of high-resolution soft x-ray absorption spectra," The USSR Academy of Sciences Scientific Review, Physical Series **40**(2), 224-230, (1976) (in Russian).
2. E. S. Gluskin, A.A.Krasnoperova "The absorption structure near the L_{II-III} -absorption edge of the chlorine molecule," Proceedings of Vth International Conference on VUV Radiation Physics, Montpellier, France, V.1, 117-119, (1977)
3. E. S. Gluskin, E. M. Trakhtenberg, A. S. Vinogradov "A simple system for elimination short-wavelength synchrotron radiation in the 30Å to 180Å wavelength range," *Nucl. Instrum. Methods* **152**(1), 133-134, (1978).
4. A.S.Artamonov, N.A.Vinokurov, E. S. Gluskin et al., "First experiments with an optical klystron installed on the VEPP-3 storage ring," *Nucl. Instrum. Methods* **177**(1), 247-252, (1980).
5. S. V. Gaponov, N. N. Salashchenko, E. S. Gluskin et al., "Long-wave x-ray radiation mirrors," *Optics Commun.* **38**(1), 7-9 (1981).
6. E. S. Gluskin, A. V. Sokolov et al., "The study of helical undulator parameters as a source for the x-ray holography," Springer Series in Optical Sciences **43**, X-ray Microscopy, 336-343, (1984).
7. E. S. Gluskin, P. M. Ivanov et al., "First experiment with synchrotron radiation from the 75 kG superconducting wiggler on the VEPP-2M storage ring," *Nucl. Instrum. Methods A* **246**(1-3), 41-44 (1986).

8. E. S. Gluskin, S. V. Gaponov et al., “A polarimeter for soft x-ray and VUV radiation,” *Nucl. Instrum. Methods A* **246**(1-3), 394-396 (1986).
9. E. Gluskin, I. McNulty et al., “X-Ray intensity interferometer for undulator radiation,” *Nucl. Instrum. Methods A* **319**(1-3), 213-218 (1992).
10. E. Trakhtenberg, E. Gluskin et al., “The Vacuum System for Insertion Devices at the Advanced Photon Source,” 1995 Particle Accelerator Conference and International Conference on High-Energy Accelerators, Dallas, TX, 2072-2074 (1996).
11. E. Gluskin, “APS Insertion Devices: Recent Developments and Results,” *J. Synch. Rad.* **5**, 189-195 (1998).
12. S. Milton, E. Gluskin et al., “Observation of self-amplified spontaneous emission and exponential growth at 530 nm,” *Phys. Rev. Lett.* **85**(5), 988-991 (2000).
13. S. Milton, E. Gluskin et al., “Exponential gain and saturation of a self-amplified spontaneous emission free-electron laser,” *Science* **292**(5524), 2037-41 (2001).
14. E. Gluskin, N. A. Vinokurov et al., “Optimization of the design for the LCLS undulator line,” *Nucl. Instrum. Methods A* **475**(1-3), 323-327 (2001).
15. E.Gluskin, Development and Performance of Superconducting Undulators at the Advanced Photon Source, Synchrotron Radiation News 28(3), 4-8 (2015).
16. J.Bahrdt, E.Gluskin, Cryogenic permanent magnet and superconducting undulators, NIM in Physics Research, A 907, 149-168 (2018).

PROFESSIONAL ACTIVITIES AND AFFILIATIONS

- Fellow of the American Physical Society
- Fellow of the American Association for the Advancement of Science
- Presented more than 50 invited talks at major international conferences and meetings
- Served on more than 10 international advisory committees for international conferences
- Editor of two proceedings of Synchrotron Radiation Instrumentation and FEL conferences
- Served on the International Relations Committee of the American Physical Society
- Member of the International Advisory Committees for Photon Factory, Japan and Pohang Light Source, South Korea

RESEARCH INTERESTS AND EXPERIENCE

Synchrotron radiation (SR) instrumentation in the vacuum ultraviolet, soft x-ray and hard x-ray regions, including:

- Insertion devices for 3rd and 4th generation SR sources;
- Optical elements and multilayer mirrors;
- Monochromators;
- Optical klystrons and vuv lasers;
- Production and measurement of radiation polarization;
- Absolute photometry and radiometry;
- X-ray absorption and emission spectroscopy;
- Applications of synchrotron radiation to x-ray physics;

Management of a user-oriented synchrotron radiation research facility