

Journal of Research

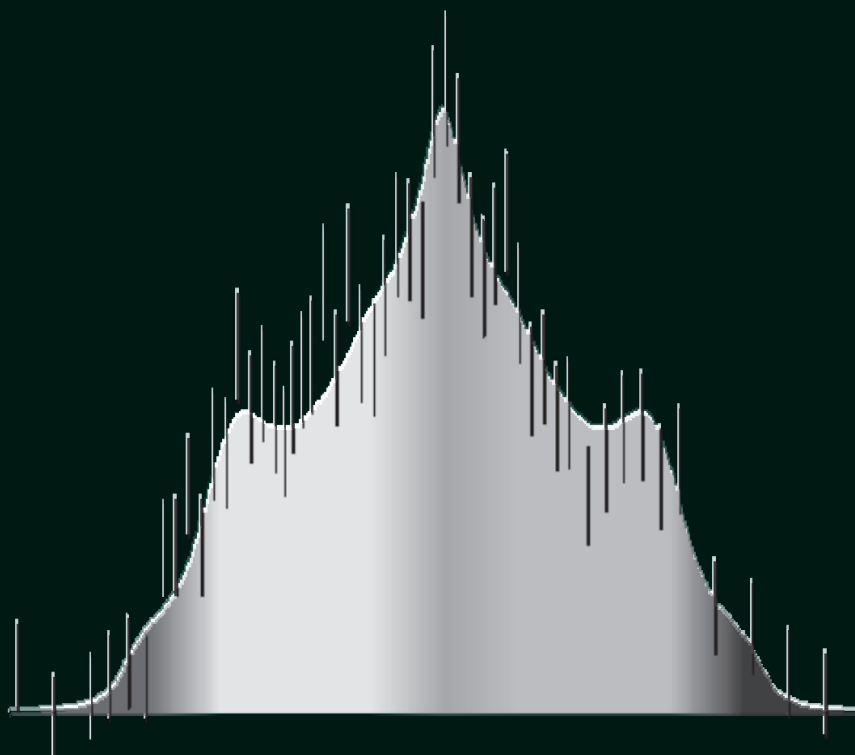
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Special Issue: Applications of High-Precision γ -Spectroscopy



NIST

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NIST, originally founded as the National Bureau of Standards in 1901, works to strengthen U.S. industry’s competitiveness; advance science and engineering; and improve public health, safety, and the environment. One of the agency’s basic functions is to develop, maintain, and retain custody of the national standards of measurement, and provide the means and methods for comparing standards used in science, engineering, manufacturing, commerce, industry, and education with the standards adopted or recognized by the Federal Government.

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¹At Boulder, CO 80303.

²Some elements at Boulder, CO.

Journal of Research of the **National Institute of Standards and Technology**

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Cover: The profile on the cover illustrates the rich data available from high-resolution crystal spectroscopy. The gamma rays for this particular profile were produced in a SrTiO₃ single crystal oriented so that the <100> direction was parallel to the spectrometer axis. Following the emission of a primary gamma ray, the nucleus recoils. A second gamma ray can be emitted while the nucleus is in motion and its energy measured in the lab frame appears to be Doppler shifted. Due to the isotropic emission of the primary gamma rays, a broadening is observed rather than a shift. Because the atoms in the source are arranged in a periodic structure and oriented with respect to the spectrometer, neighboring atoms block certain recoil trajectories. The lifetime of the nuclear level and the inter-atomic potential, as well as the orientation of the source influence the shape of the Doppler broadened profile. This particular profile shows the experimental data and theoretical lineshape of the ⁴⁹Ti Doppler broadened gamma ray with $E = 1498$ keV. [M. Jentschel et al., Nucl. Instr. Meth. B **115**, 446 (1996).]

The *Journal of Research of the National Institute of Standards and Technology*, the flagship periodic publication of the national metrology institute of the United States, features advances in metrology and related fields of physical science, engineering, applied mathematics, statistics, and information technology that reflect the scientific and technical programs of the Institute. The *Journal* publishes papers on instrumentation for making accurate measurements, mathematical models of physical phenomena, including computational models, critical data, calibration techniques, well-characterized reference materials, and quality assurance programs that report the results of current NIST work in these areas. Occasionally, a Special Issue of the *Journal* is devoted to papers on a single topic. Also appearing on occasion are review articles and reports on conferences and workshops sponsored in whole or in part by NIST.

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Note From the Chief Editor

Dear Reader,

Those of you who are familiar with the *Journal of Research of the National Institute of Standards and Technology* have no doubt noticed our new cover. The Board of Editors of the *Journal* and I thought that the start of the year 2000 was an appropriate time to change our appearance and to incorporate on the cover a photograph or other illustration relevant to NIST and its work.

A brief description of the photograph or illustration will be found on the back of the title page. We hope that you find these of interest.

Barry N. Taylor
Chief Editor

*Applications of High-Precision γ -Spectroscopy
Papers Presented at the July 1998 Workshop
at the University of Notre Dame*

Preface

This Special Issue of the Journal of Research of the National Institute of Standards and Technology contains papers from an international workshop on the Applications of High Precision γ -Spectroscopy held on the campus of the University of Notre Dame, July 1-3, 1998. These applications extend from the study of nuclear level-schemes, level-lifetimes, and fundamental constants to investigation of atomic collision cascades, and the location of impurities in solids. Problems lending themselves to such investigations are seen to arise in astrophysics, nuclear, atomic, and condensed matter physics. The techniques and facilities used in these various applications range from semiconductor ionization spectrometers to crystal diffraction instruments while the measurements are carried out at accelerators, nuclear reactors, and/or spallation sources. The goal of this workshop was to provide a forum for the discussion and exchange of ideas on the present use and future developments of High-Precision γ -Spectroscopy.

The format of the workshop included a number of longer invited talks followed by contributed papers on a given topic with ample time allotted for discussions. This gathering included some 53 participants from 10 countries. Their numerous contributions can be seen in the following Program listing, and in the papers included in this Special Issue. A similar gathering had taken place previously on October 4-7, 1992, at the Institut Laue-Langevin (ILL) in Grenoble, France, where there were 60 participants coming from 12 countries. The changes in the scope and perspective between these meetings show increased diversity in the range of applications, a higher level of spectroscopic performance, extension of high resolution spectroscopy to higher energies, increased sophistication of the modeling procedure, and the practical realization of several opportunities whose potential could only be glimpsed at the time of the Grenoble meeting.

The very successful programs of γ -Spectroscopy at the ILL and elsewhere had certain limitations in the range of accessible energies, available resolution, and measurement accuracy. A new impetus in this area was provided by the successful development of GAMS4, a double-flat-crystal spectrometer operated as a joint facility at the High Flux Reactor of the ILL. The concept for the instrument was developed and tested at the National Institute of Standards and Technology [NIST—previously the National Bureau of Standards (NBS)] in the early 1970s. The earliest work was done with long-lived, relatively low-energy sources activated in the NBS reactor. There it was shown that high-resolution, high-accuracy γ -ray spectroscopy could be realized by a transmission geometry, two-crystal instrument, calibrated from first principles, and guided by laser-based angle interferometry.

The move to ILL was motivated by the need for prompt, high-energy, high-intensity sources available at the High Flux reactor with its higher neutron fluxes, and the possibility of having an in-pile source. The implementation, further development, and expansion of this concept at ILL was carried out through the joint and dedicated efforts of Ernest Kessler (NIST), Geoffrey Greene (NIST), M. Scott Dewey (NIST), and Hans Börner (ILL) in spite of the fact that the United States of America was not and is not a member of the ILL consortium of users. This long-standing collaboration between NIST and the ILL, involving significant sharing of the needed financial and human capital investments, has enabled the developments evident in this Special Issue on Applications of High-Precision γ -spectroscopy. While a significant portion of the papers included in this Special Issue result from the use of GAMS4, future benefits of a curved double-crystal spectrometer (GAMS5) seem very promising.

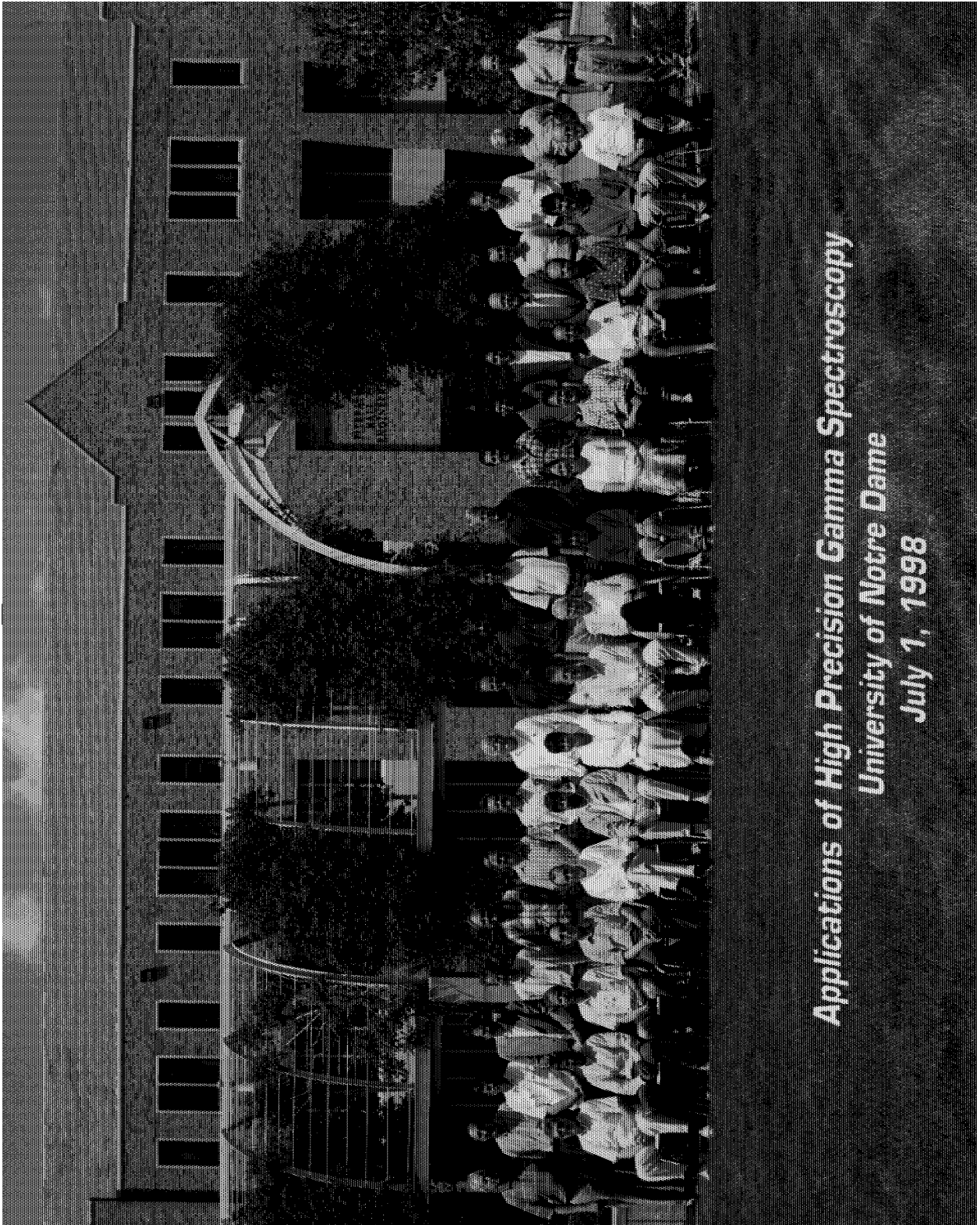
To the extent that the scientific contributors to this meeting have benefited from the capabilities offered by GAMS4, (and may be further benefited in the future by GAMS5), they, and we, are indebted to the successive Directors of the ILL over the past 20 years. Each of these directors, irrespective of his disciplinary perspective, has evidenced a broadly supportive view of the disparate character of the ILL enterprise, allowing it to include even the unusual body of work that is the subject of these proceedings. Finally, we acknowledge the generous financial support of the Graduate School, the College of Science, and the Department of Physics of the University of Notre Dame.

Richard D. Deslattes
Ani Aprahamian
Special Issue Editors

Applications of High-Precision γ -Spectroscopy

Program

Tuesday June 30, 1998		Session Chair: R. W. Hoff—Lawrence Livermore National Laboratory	
17:00 – 21:00	Reception and Registration		
Wednesday July 1, 1998		14:00 – 14:50	G. Mathews <i>Current Topics in Gamma-Ray Astrophysics</i>
Session Chair: A. Aprahamian—University of Norte Dame		14:50 – 15:30	J. Goerres <i>Nuclear Structure and Galactic γ-Ray Activity</i>
9:00 – 9:50	R. D. Deslattes <i>High-Resolution γ-Spectroscopy: the First 85 Years</i>	16:00 – 16:40	S. Robinson <i>GRID and the Study of Multiphonon States</i>
9:50 – 10:30	E. Kessler <i>Precision Measurements of Fundamental Constants Using GAMS4 I</i>	16:40 – 17:10	F. Bevar <i>Simulations of γ-Cascades and Modeling Atomic Collision Chains</i>
11:00 – 11:40	M. S. Dewey <i>Precision Measurements of Fundamental Constants Using GAMS4 II</i>	17:10 – 17:35	R. de Haan <i>Lifetimes of States in ^{178}Hf</i>
11:40 – 12:20	M. Jentschel <i>The GRID-Technique: Current Status and New Trends</i>	17:35 – 18:00	R. Schwengner <i>Magnetic Rotation in the A=80 Region: M1 Bands in Heavy Rb Isotopes</i>
Session Chair: C. J. Lister—Argonne National Laboratory		Friday July 3, 1998	
4:00 – 14:50	D. D. Warner <i>Nuclear Structure: The Future With Radioactive Beams</i>	Session Chair: D. D Warner—Daresbury Laboratory	
14:50 – 15:20	J. Doering <i>Low-Spin States From Decay Studies</i>	9:00 – 9:50	C. J. Lister <i>How far From Stability Can We Go Using Gammasphere and the FMA?</i>
15:20 – 16:00	R. Kruecken <i>Precision Lifetime Measurements Using the Recoil Distance Method</i>	9:50 – 10:30	S. Yates <i>Electric Dipole Transitions and Octupole-Coupled Excitations in the Spherical Nuclei</i>
16:30 – 17:20	T. Glasmacher <i>High Resolution γ-Ray Spectroscopy With Fast Exotic Beams</i>	11:00 – 11:40	N. V. Zamfir <i>Phonons and Phase Transitions in Finite Nuclei</i>
17:20 – 18:00	C. Y. Wu <i>Sub-Nanosecond Lifetime Measurements Using the Recoil Distance Method</i>	11:40 – 12:10	W. Reviol <i>Measurements of Dynamic Electromagnetic Moments in Neutron-Deficient Nuclei</i>
Thursday July 2, 1998		Session Chair: R. D. Deslattes—NIST	
Session Chair: M. Jentschel—Institute Laue Langevin		14:00 – 14:40	R. Moreh <i>New Nuclear Resonance Photon Scattering Studies of Molecular Adsorption and of Single Crystals</i>
9:00 – 9:40	K. H. Heinig <i>Gamma-Ray Induced Doppler Broadening Measurements With Single-Crystalline Targets (Crystal-GRID)—the Principles</i>	14:40 – 15:20	C. Doll <i>GAMS 5—The New Gamma-Ray Spectrometer in Double-Diamond Geometry at the ILL</i>
9:40 – 10:20	N. Stritt <i>Study of Interatomic Potentials Using the Crystal-GRID Method on Oriented Single Crystals of Ni, Fe, and Cr</i>	15:50 – 16:30	G. Savard <i>High-Accuracy Mass Measurements of Trapped Radioactive Isotopes</i>
10:50 – 11:20	T. Koch <i>Study of Interatomic Potentials in ZnS: Crystal-GRID Experiments Versus Ab Initio Calculations</i>	16:30 – 17:10	D. Seweryniak <i>Studies of Nuclear Structure far From Stability Using Recoil-Decay Tagging and Related Methods</i>
11:20 – 12:00	J. Jolie <i>Neutrino Induced Doppler Broadening</i>		



*Applications of High Precision Gamma Spectroscopy
University of Notre Dame
July 1, 1998*