

2018 CONFERENCE ON LABORATORY INSTRUCTION BEYOND THE FIRST YEAR

BALTIMORE, MD, USA JULY 25-27, 2018

EDITORS

MELISSA EBLÉN-ZAYAS

ERNEST BEHRINGER

MARTA DARK MCNEESE

ELVIS GENESTON



Editors

Melissa Eblen-Zayas
Carleton College
Department of Physics & Astronomy
1 North College St
Northfield, MN 55057
USA

Email: meblenza@carleton.edu

Ernest Behringer
Eastern Michigan University

Email: ebehringe@emich.edu

Marta Dark McNeese
Spelman College

Email: mldark@spelman.edu

Elvis Geneston
LaSierra University

Email: egenesto@lasierra.edu

Published under the terms of a Creative Commons Attribution 3.0 license:
<https://creativecommons.org/licenses/by/3.0/>

You are free to:

- Share, copy, and redistribute the material in any medium or format
- Adapt, remix, transform, and build upon the material for any purpose, even commercially.

Provided you give attribution (include the original article's title, author(s), proceedings citation, and DOI), provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

TABLE OF CONTENTS

Acknowledgements

Conference Overview

Peer reviewed papers

Graphical Approach to Multi-slit Interference Analysis

Patricia Allen

Case Study on How to Develop 3D Labs with Theoretical, Experimental, and Computational Goals

Ashley R. Carter

Lessons Learned from Five Years of Student Self-directed Experimental Projects in the Advanced Lab

Melissa Eblen-Zayas and Ryan C. Terrien

Particle Physics with Low Cost SiPM Based Detectors

Brett Fadem

Fluorescence Correlation Spectroscopy (FCS) Module for Advanced Undergraduate Laboratories

Nancy R. Forde, David Lee, and John Bechhoefer

Introducing Students to Nonlinear Model Fitting with Jupyter Notebooks Through a Quantitative Diffraction Experiment

Jerome Fung and Lauri Wardell

Uncertainty Propagation in Modern Physics Lab

George Hassel, Darren Broder, and John Cummings

Polarization Studies of 3D Photonic Crystals Using Transmission and Reflection Experiments

Michael Hennessey, Dimitri Lezcano, Shabbir M. Mian, Giuseppe Carnicella, Tecla Arcidiacono, Valentina Robbiano, and Franco Cacialli

A Lab to Detect Radio Pulsars Using a Remotely Accessed 18-Meter Radiotelescope

Norman Jarosik and Daniel Marlow

Fourier Transform Spectroscopy in the Visible Range

Jenny Magnes and Tyler Hatch

CAEN Educational: Nuclear and Particle Physics Experiments

Cristina Mattone, M. Antonello, M. Locatelli, V. Arosio, L. Malinverno, S. Lomazzi,
and R. de Asmundis

Think First, Act Later - A Course Structure for Improving Student Designed Experiments

Nathan D. Powers, Dallin S. Durfee, and David D. Allred

Limits of Precision in the Balmer Lines Spectroscopy Lab

Timothy Roach

ACKNOWLEDGMENTS

At the 2018 Conference on Laboratory Instruction Beyond the First Year of College (BFY III), sponsored by the Advanced Laboratory Physics Association (ALPhA), 130 members of the advanced lab community as well as representatives from 15 vendors gathered to share effective lab curricula, teaching methods, and experiments. These Proceedings provide documentation of some of the 41 posters and 56 workshops that were presented as part of the conference.

This marks the second time that the Conference on Laboratory Instruction Beyond the First Year of College has published a peer-reviewed Proceedings. The Proceedings' on-line submission and review process were supported by Lyle Barbato, who provided significant support in making sure that everything ran smoothly. We thank Lyle for his effort and the excellent work that he does. In addition, this volume would not be possible without all of the referees who volunteered their time and expertise to review the papers submitted for publication in the Proceedings.

The Editors thank:

Patricia Allen, Ashley Carter, Anne Cox, Brett Fadem, Nancy Forde, Jerome Fung, Elizabeth George, George Hassel, Herbert Jaeger, Joseph Kozminski, Jenny Magnes, Daniel Marlow, Mark Masters, Cristina Mattone, Michele McColgan, Shabbir Mian, Nathaniel Powers, Timothy Roach, Jonathan Skuza, Ryan Terrien, Kurt Vandervoort, Lauri Wardell.

We hope these proceedings are useful in continuing to build the advanced lab community in physics.

Melissa Eblen-Zayas
Ernest Behringer
Marta Dark McNeese
Elvis Geneston

CONFERENCE OVERVIEW

2018 Conference on Laboratory Instruction Beyond the First Year (BFY III)

The theme of this conference -- “3D Physics: Integrating Experiment, Theory, and Computation” -- was inspired by both the 2014 *AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum* and the more recent 2016 *AAPT Recommendations for Computational Physics in the Undergraduate Curriculum*. The former emphasizes the essential role of laboratory instruction in developing students’ physics knowledge and experimental abilities in addition to many transferable skills such as modeling, design, troubleshooting, innovation, and communication. The latter recognizes the fundamental role of computation in the current practice of physics, whether to enable data acquisition, perform data modeling and analysis, or communicate results. Implementing elements from both sets of recommendations may be done efficiently by integrating the three major areas of physics – experiment, theory, and computation – in excellent advanced laboratory experiments.

As at previous BFY conferences, invited talks, workshops, breakout sessions, and posters provided opportunities for participants to share their ideas and expertise regarding specific experiments, assessment practices, developing an effective BFY laboratory curriculum, and approaches to cultivating broadly transferable skills in our students. The conference also provided time and space to discuss community-building at the local and national level. The 2018 BFY conference provided an opportunity for the advanced laboratory community to share ideas and knowledge, learn new techniques, ask questions, and plan for the future, so that we can continue to construct positive instructional laboratory experiences for our students and for ourselves. We thank all those who participated and contributed toward the success of the conference.

Organizers:

Joseph Kozminski, Lewis University (co-chair)
Mary Lowe, Loyola University Maryland (co-chair)
Ernie Behringer, Eastern Michigan University
Ashley Carter, Amherst College
Marta Dark McNeese, Spelman College
Melissa Eblen-Zayas, Carleton College
Khalid Eid, Miami University Ohio
John Essick, Reed College
Elizabeth George, Wittenberg University
Catherine Herne, SUNY New Paltz
Natasha Holmes, Cornell University
Heather Lewandowski, University of Colorado
Melanie Lott, Denison University
Mark Masters, Purdue University Fort Wayne
Lowell McCann, University of Wisconsin River Falls
Randy Peterson, University of the South
Vanessa Preisler, University of La Verne
Gabe Spalding, Illinois Wesleyan University
David Sturm, University of Maine

Jeremiah Williams, Wittenberg University
Benjamin Zwickl, Rochester Institute of Technology

The organizing committee of BFY III thanks the following people for their indispensable assistance in making this conference a reality:

Lyle Barbato and Bruce Mason (ComPADRE); Tiffany Hayes, Bob Hilborn, and Beth Cunningham (AAPT); and the Proceedings Editor, Melissa Eblen-Zayas, and Co-Editors Ernie Behringer, Marta Dark, and Elvis Geneston.

We especially thank our hosts, the Loyola University of Maryland Physics Department. We are also grateful for financial support from the National Science Foundation, the Advanced Labs Physics Association (ALPhA), and our participating vendors and sponsors: the American Association of Physics Teachers (AAPT), CAEN SpA, Cambridge University Press, ID Quantique, Jasper Display Corporation, Keithley – A Tektronix Company, Keysight Technologies, Klinger Educational Products, Liquid Instruments, MathWorks, Modus Medical Devices, Nanosurf Inc., Oxford University Press, PASCO Scientific, Photron, Quantum Experience Ltd., Qubitekk, Inc., Spectrum Techniques, and TeachSpin Inc.