PROCEEDINGS OF SPIE

Millimeter, Submillimeter, and Far-Infrared Detectors and Instrumentation for Astronomy VI

Wayne S. Holland
Jonas Zmuidzinas
Editors

3–6 July 2012
Amsterdam, Netherlands

Sponsored by
SPIE

Cooperating Organizations
American Astronomical Society (United States) • Netherlands Institute for Radio Astronomy (ASTRON) (Netherlands) • Ball Aerospace & Technologies Corporation (United States) Canadian Astronomical Society (CASCA) (Canada) • European Astronomical Society (Switzerland) • ESO—European Southern Observatory (Germany) • International Astronomical Union • Korea Astronomy and Space Science Institute (KASI) (Republic of Korea) • National Radio Astronomy Observatory • POPSud (France) • TNO (Netherlands)

Published by
SPIE

Volume 8452
Part One of Two Parts

Proceedings of SPIE 0277-786X, v. 8452

Millimeter, Submillimeter, and Far-Infrared Detectors and Instrumentation for Astronomy VI,
edited by Wayne S. Holland, Jonas Zmuidzinas, Proc. of SPIE Vol. 8452,
845201 © 2012 SPIE · CCC code: 0277-786X/12/$18 · doi: 10.1117/12.1000040

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:
Author(s), "Title of Paper," in *Millimeter, Submillimeter, and Far-Infrared Detectors and Instrumentation for Astronomy VI*, edited by Wayne S. Holland, Jonas Zmuidzinas, Proceedings of SPIE Vol. 8452 (SPIE, Bellingham, WA, 2012) Article CID Number.

ISSN: 0277-786X
ISBN: 9780819491534

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIEDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc.

The CID Number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID Number.

Contents

Part One

SESSION 1 CURRENT/NEAR TERM CAMERAS AND ARRAYS

Y. Chikada, M. Watanabe, National Astronomical Observatory of Japan (Japan); T. Okuda, Nagoya Univ. (Japan); Y. Kurono, S. Iguchi, National Astronomical Observatory of Japan (Japan)

SESSION 9 CMB INSTRUMENTATION: CURRENT/NEAR TERM

8452 1A **BICEP2 and Keck array operational overview and status of observations** [8452-46]
R. W. Ogburn IV, Stanford Univ. (United States) and Kavli Institute for Particle Astrophysics and Cosmology (United States); P. A. R. Ade, Cardiff Univ. (United Kingdom); R. W. Aikin, California Institute of Technology (United States); M. Amiri, The Univ. of British Columbia (Canada); S. J. Benton, Univ. of Toronto (Canada); C. A. Bischoff, Harvard-Smithsonian Ctr. for Astrophysics (United States); J. J. Bock, Jet Propulsion Lab. (United States) and California Institute of Technology (United States); J. A. Bonetti, Jet Propulsion Lab. (United States); J. A. Brevik, California Institute of Technology (United States); E. Bullock, Univ. of Minnesota (United States); B. Burger, The Univ. of British Columbia (Canada); G. Davis, The Univ. of British Columbia (Canada); C. D. Dowell, Jet Propulsion Lab. (United States) and California Institute of Technology (United States); L. Duband, Service des Basses Températures, CNRS, Univ. Joseph Fourier (France); J. P. Filippini, California Institute of Technology (United States); S. Fliescher, Univ. of Minnesota (United States); S. R. Golwala, California Institute of Technology (United States); M. Gordon, Harvard-Smithsonian Ctr. for Astrophysics (United States); M. Halpern, M. Hasselfield, The Univ. of British Columbia (Canada); G. Hilton, National Institute of Standards and Technology (United States); V. V. Hristov, H. Hui, California Institute of Technology (United States); K. Irwin, National Institute of Standards and Technology (United States); J. P. Kaufman, B. G. Keating, Univ. of California, San Diego (United States); S. A. Kernasovskiy, Stanford Univ. (United States); J. M. Kovac, Harvard-Smithsonian Ctr. for Astrophysics (United States); C. L. Kuo, Stanford Univ. (United States) and Kavli Institute for Particle Astrophysics and Cosmology (United States); E. M. Leitch, The Univ. of Chicago (United States); M. Lueker, Jet Propulsion Lab. (United States) and California Institute of Technology (United States); T. Montroy, Case Western Reserve Univ. (United States); C. B. Netterfield, Univ. of Toronto (Canada); H. T. Nguyen, R. O'Brient, Jet Propulsion Lab. (United States) and California Institute of Technology (United States); A. Orlando, Univ. of California, San Diego (United States); C. L. Pryke, Univ. of Minnesota (United States); C. Reintsema, National Institute of Standards and Technology (United States); S. Richter, Harvard-Smithsonian Ctr. for Astrophysics (United States); J. E. Ruhl, Case Western Reserve Univ. (United States); M. C. Runyan, California Institute of Technology (United States); R. Schwarz, C. D. Sheehy, Univ. of Minnesota (United States); Z. K. Staniszewski, Jet Propulsion Lab. (United States) and California Institute of Technology (United States); R. V. Sudiwala, Cardiff Univ. (United Kingdom); G. P. Teply, California Institute of Technology (United States); K. Thompson, Stanford Univ. (United States); J. E. Tolan, Stanford Univ. (United States) and Kavli Institute for Particle Astrophysics and Cosmology (United States); A. D. Turner, Jet Propulsion Lab. (United States); A. G. Vieregg, Harvard-Smithsonian Ctr. for Astrophysics (United States); D. V. Wiebe, The Univ. of British Columbia (Canada); P. Wilson, Jet Propulsion Lab. (United States); C. L. Wong, Harvard-Smithsonian Ctr. for Astrophysics (United States)

8452 1B **Optimization and sensitivity of the Keck Array** [8452-47]
S. Kernasovskiy, Stanford Univ. (United States) and Kavli Institute for Particle Astrophysics and Cosmology (United States); P. A. R. Ade, Univ. of Wales, Cardiff (United Kingdom); R. W. Aikin, California Institute of Technology (United States); M. Amiri, The Univ. of British Columbia (Canada); S. Benton, Univ. of Toronto (Canada); C. Bischoff, Harvard-Smithsonian Ctr. for Astrophysics (United States); J. J. Bock, California Institute of

Technology (United States) and Jet Propulsion Lab. (United States); J. A. Bonetti, Jet Propulsion Lab. (United States); J. A. Brevik, California Institute of Technology (United States); B. Burger, G. Davis, The Univ. of British Columbia (Canada); C. D. Dowell, California Institute of Technology (United States) and Jet Propulsion Lab. (United States); L. Duband, Institut Nanosciences et Cryogénie, CNRS, Univ. Joseph Fourier (France); J. P. Filippini, California Institute of Technology (United States); S. Fliescher, Univ. of Minnesota (United States); S. R. Golwala, California Institute of Technology (United States); M. Halpern, M. Hasselfield, The Univ. of British Columbia (Canada); G. Hilton, National Institute of Standards and Technology (United States); V. V. Hristov, California Institute of Technology (United States); K. Irwin, National Institute of Standards and Technology (United States); J. M. Kovac, Harvard-Smithsonian Ctr. for Astrophysics (United States); C. L. Kuo, Stanford Univ. (United States) and Kavli Institute for Particle Astrophysics and Cosmology (United States); E. Leitch, The Univ. of Chicago (United States); M. Lueker, California Institute of Technology (United States) and Jet Propulsion Lab. (United States); C. B. Netterfield, Univ. of Toronto (Canada); H. T. Nguyen, R. O'Brient, California Institute of Technology (United States) and Jet Propulsion Lab. (United States); R. W. Ogburn, Stanford Univ. (United States) and Kavli Institute for Particle Astrophysics and Cosmology (United States); C. L. Pryke, Univ. of Minnesota (United States); C. Reintsema, National Institute of Standards and Technology (United States); J. E. Ruhl, Case Western Reserve Univ. (United States); M. C. Runyan, California Institute of Technology (United States); R. Schwarz, C. D. Sheehy, Univ. of Minnesota (United States); Z. Staniszewski, California Institute of Technology (United States) and Jet Propulsion Lab. (United States); R. Sudiwala, Univ. of Wales, Cardiff (United Kingdom); G. Teply, California Institute of Technology (United States); J. E. Tolan, Stanford Univ. (United States) and Kavli Institute for Particle Astrophysics and Cosmology (United States); A. D. Turner, Jet Propulsion Lab. (United States); A. Vieregg, Harvard-Smithsonian Ctr. for Astrophysics (United States); D. V. Wiebe, The Univ. of British Columbia (Canada); P. Wilson, Jet Propulsion Lab. (United States); C. L. Wong, Harvard-Smithsonian Ctr. for Astrophysics (United States)

8452 1C **The POLARBEAR experiment** [8452-48]
Z. D. Kermish, Univ. of California, Berkeley (United States); P. Ade, Cardiff Univ. (United Kingdom); A. Anthony, Univ. of Colorado at Boulder (United States); K. Arnold, Univ. of California, Berkeley (United States); D. Barron, D. Boettger, Univ. of California, San Diego (United States); J. Borrill, Lawrence Berkeley National Lab. (United States) and Univ. of California, Berkeley (United States); S. Chapman, Dalhousie Univ. (Canada); Y. Chinone, High Energy Accelerator Research Organization (Japan); M. A. Dobbs, McGill Univ. (Canada); J. Errard, G. Fabbian, Lab. Astroparticule et Cosmologie, CNRS, Univ. Paris 7 (France); D. Flanigan, Univ. of California, Berkeley (United States); G. Fuller, Univ. of California, San Diego (United States); A. Ghribi, Univ. of California, Berkeley (United States); W. Grainger, Science & Technology Facilities Council (United Kingdom); N. Halverson, Univ. of Colorado at Boulder (United States); M. Hasegawa, K. Hattori, M. Hazumi, High Energy Accelerator Research Organization (Japan); W. L. Holzapfel, J. Howard, Univ. of California, Berkeley (United States); P. Hyland, Austin College (United States); A. Jaffe, Imperial College London (United Kingdom); B. Keating, Univ. of California, San Diego (United States); T. Kisner, Lawrence Berkeley National Lab. (United States); A. T. Lee, Univ. of California, Berkeley (United States); M. Le Jeune, Lab. Astroparticule et Cosmologie, CNRS, Univ. Paris 7 (France); E. Linder, Lawrence Berkeley National Lab. (United States); M. Lungu, Univ. of California, Berkeley (United States); F. Matsuda, Univ. of California, San Diego (United States); T. Matsumura, High Energy Accelerator Research Organization (Japan); X. Meng, Univ. of California, Berkeley (United States); N. J. Miller, Univ. of California, San Diego (United States); H. Morii, High Energy Accelerator Research Organization (Japan);

Institute of Technology (United States) and Jet Propulsion Lab. (United States); C. L. Pryke, The Univ. of Chicago (United States); C. Reintsema, National Institute of Standards and Technology (United States); J. E. Ruhl, Case Western Reserve Univ. (United States); M. C. Runyan, California Institute of Technology (United States) and Jet Propulsion Lab. (United States); R. Schwarz, C. D. Sheehy, Univ. of Minnesota (United States); Z. Staniszewski, California Institute of Technology (United States) and Jet Propulsion Lab. (United States); R. Sudiwala, Univ. of Wales (United Kingdom); G. Teply, California Institute of Technology (United States); J. E. Tolan, Stanford Univ. (United States) and Kavli Institute for Particle Astrophysics and Cosmology (United States); A. D. Turner, Jet Propulsion Lab. (United States); R. S. Tucker, California Institute of Technology (United States); A. Vieregg, Harvard-Smithsonian Ctr. for Astrophysics (United States); D. V. Wiebe, The Univ. of British Columbia (Canada); P. Wilson, Jet Propulsion Lab. (United States); C. L. Wong, Harvard-Smithsonian Ctr. for Astrophysics (United States); W. L. K. Wu, K. W. Yoon, Stanford Univ. (United States) and Kavli Institute for Particle Astrophysics and Cosmology (United States)

8452 1H **The POLARBEAR-2 experiment** [8452-53]
T. Tomaru, M. Hazumi, High Energy Accelerator Research Organization (Japan); A. T. Lee, Univ. of California, Berkeley (United States); P. Ade, Cardiff Univ. (United Kingdom); K. Arnold, Univ. of California, Berkeley (United States); D. Barron, Univ. of California, San Diego (United States); J. Borrill, Lawrence Berkeley National Lab. (United States); S. Chapman, Dalhousie Univ. (Canada); Y. Chinone, High Energy Accelerator Research Organization (Japan); M. Dobbs, McGill Univ. (Canada); J. Errard, G. Fabbian, Lab. Astroparticule et Cosmologie, CNRS, Univ. Paris 7 (France); A. Ghribi, Univ. of California, Berkeley (United States); W. Grainger, Cardiff Univ. (United Kingdom); N. Halverson, Univ. of Colorado at Boulder (United States); M. Hasegawa, K. Hattori, High Energy Accelerator Research Organization (Japan); W. L. Holzapfel, Univ. of California, Berkeley (United States); Y. Inoue, The Graduate Univ. for Advanced Studies (Japan); S. Ishii, Univ. of Tsukuba (Japan); Y. Kaneko, Univ. of Tokyo (Japan); B. Keating, Univ. of California, San Diego (United States); Z. Kermish, Univ. of California, Berkeley (United States); N. Kimura, High Energy Accelerator Research Organization (Japan); T. Kisner, Lawrence Berkeley National Lab. (United States); W. Kranz, Univ. of California, Berkeley (United States); F. Matsuda, Univ. of California, San Diego (United States); T. Matsumura, H. Morii, High Energy Accelerator Research Organization (Japan); M. J. Myers, H. Nishino, Univ. of California, Berkeley (United States); T. Okamura, High Energy Accelerator Research Organization (Japan); E. Quealy, C. L. Reichardt, P. L. Richards, D. Rosen, Univ. of California, Berkeley (United States); C. Ross, Dalhousie Univ. (Canada); A. Shimizu, The Graduate Univ. for Advanced Studies (Japan); M. Sholl, Univ. of California, Berkeley (United States); P. Siritanasak, Univ. of California, San Diego (United States); P. Smith, Dalhousie Univ. (Canada); N. Stebor, Univ. of California, San Diego (United States); R. Stompor, Lab. Astroparticule et Cosmologie, CNRS, Univ. Paris 7 (France); A. Suzuki, Univ. of California, Berkeley (United States); J. Suzuki, High Energy Accelerator Research Organization (Japan); S. Takada, Univ. of Tsukuba (Japan); K. Tanaka, High Energy Accelerator Research Organization (Japan); O. Zahn, Lawrence Berkeley National Lab. (United States)

SESSION 11 CMB INSTRUMENTATION: NEW DEVELOPMENTS II

8452 1J **The Primordial Inflation Polarization Explorer (PIPER)** [8452-55]
A. Kogut, NASA Goddard Space Flight Ctr. (United States); P. A. R. Ade, Cardiff Univ. (United Kingdom); D. Benford, NASA Goddard Space Flight Ctr. (United States); C. L. Bennett, Johns Hopkins Univ. (United States); D. T. Chuss, NASA Goddard Space Flight Ctr. (United States); J. L. Dotson, NASA Ames Research Ctr. (United States); J. R. Eimer,

Part Two

POSTER SESSION

8452 3A **Feedhorn-coupled TES polarimeter camera modules at 150 GHz for CMB polarization measurements with SPTpol** [8452-120]
J. W. Henning, Univ. of Colorado at Boulder (United States); P. Ade, Cardiff Univ. (United Kingdom); K. A. Aird, The Univ. of Chicago (United States); J. E. Austermann, Univ. of Colorado at Boulder (United States); J. A. Beall, D. Becker, National Institute of Standards and Technology (United States); B. A. Benson, L. E. Bleem, The Univ. of Chicago (United States); J. Britton, National Institute of Standards and Technology (United States); J. E. Carlstrom, C. L. Chang, The Univ. of Chicago (United States) and Argonne National Lab. (United States); H. Cho, National Institute of Standards and Technology (United States); T. M. Crawford, A. T. Crites, The Univ. of Chicago (United States); A. Datesman, Argonne National Lab. (United States); T. de Haan, M. A. Dobbs, McGill Univ. (Canada); W. Everett, The Univ. of Chicago (United States); A. Ewall-Wice The Univ. of Chicago (United States); E. M. George, Univ. of California, Berkeley (United States); N. W. Halverson, Univ. of Colorado at Boulder (United States); N. Harrington, Univ. of California, Berkeley (United States); G. C. Hilton, National Institute of Standards and Technology (United States); W. L. Holzapfel, Univ. of California, Berkeley (United States); J. Hubmayr, National Institute of Standards and Technology (United States); K. D. Irwin, National Institute of Standards and Technology (United States); M. Karfunkle, R. Keisler, The Univ. of Chicago (United States); J. Kennedy, McGill Univ. (Canada); A. T. Lee, Univ. of California, Berkeley (United States); E. Leitch, The Univ. of Chicago (United States); D. Li, National Institute of Standards and Technology (United States); M. Lueker, California Institute of Technology (United States); D. P. Marrone, The Univ. of Arizona (United States); J. J. McMahon, Univ. of Michigan (United States); J. Mehl, S. S. Meyer, J. Montgomery, The Univ. of Chicago (United States); T. E. Montroy, J. Nagy, Case Western Reserve Univ. (United States); T. Natoli, The Univ. of Chicago (United States); J. P. Nibarger, M. D. Niemack, National Institute of Standards and Technology (United States); V. Novosad, Argonne National Lab. (United States); S. Padin, The Univ. of Chicago (United States); C. Pryke, Univ. of Minnesota (United States); C. L. Reichardt, Univ. of California, Berkeley (United States); J. E. Ruhl, B. R. Saliwanchik, J. T. Sayre, Case Western Reserve Univ. (United States); K. K. Schaffer, School of the Art Institute of Chicago (United States); E. Shirokoff, California Institute of Technology (United States); K. Story, and The Univ. of Chicago (United States); C. Tucker, Cardiff Univ. (United Kingdom); K. Vanderlinde, McGill Univ. (Canada); J. D. Vieira, California Institute of Technology (United States); G. Wang, Argonne National Lab. (United States); R. Williamson, Kavli Institute for Cosmological Physics (United States) and The Univ. of Chicago (United States); V. Yefremenko, Argonne National Lab. (United States); K. W. Yoon, National Institute of Standards and Technology (United States); E. Young, Univ. of California, Berkeley (United States)

8452 3C **Performance of the SCUBA-2 dry dilution refrigerator: 4 years of operation at the JCMT** [8452-122]
D. Bintley, J. T. Kuroda, E. G. Starman, S. Craig, Joint Astronomy Ctr. (United States); W. S. Holland, UK Astronomy Technology Ctr., Royal Observatory (United Kingdom) and Institute for Astronomy, Univ. of Edinburgh, Royal Observatory (United Kingdom)

8452 3D **The high altitude qualification tests of the cryogenic and vacuum system for ALMA** [8452-123]
A. Silber, European Southern Observatory (Germany)

Conference Committee

Symposium Chairs

Mark M. Casali, ESO—European Southern Observatory (Germany)
Kathryn A. Flanagan, Space Telescope Science Institute (United States)

Symposium Cochairs

Gillian S. Wright, UK Astronomy Technology Centre (United Kingdom)
Luc Smiard, National Research Council Canada (Canada)

Conference Chairs

Wayne S. Holland, UK Astronomy Technology Centre (United Kingdom)
Jonas Zmuidzinas, California Institute of Technology (United States)

Conference Program Committee

Sarah E. Church, Stanford University (United States)
Jian-Rong Gao, SRON Netherlands Institute for Space Research (Netherlands) and Delft University of Technology (Netherlands)
Kent D. Irwin, National Institute of Standards and Technology (United States)
J. Anthony Murphy, National University of Ireland, Maynooth (Ireland)
Albrecht Poglitsch, Max-Planck-Institut für extraterrestrische Physik (Germany)
Karl-Friedrich Schuster, IRAM-Domaine University de Grenoble (France)
Gordon J. Stacey, Cornell University (United States)
Christopher K. Walker, Steward Observatory, The University of Arizona (United States)

Session Chairs

1 Current/Near Term Cameras and Arrays
Wayne S. Holland, UK Astronomy Technology Centre (United Kingdom)

2 Transition Edge Sensors: Array Design and Performance
Jian-Rong Gao, SRON Netherlands Institute for Space Research (Netherlands)