

PROCEEDINGS OF SPIE

***Millimeter, Submillimeter,
and Far-Infrared Detectors and
Instrumentation for Astronomy XI***

**Jonas Zmuidzinas
Jian-Rong Gao**
Editors

**17–22 July 2022
Montréal, Québec, Canada**

Sponsored and Published by
SPIE

Volume 12190
Part One of Two Parts

The papers 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. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIDigitalLibrary.org.

The papers 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 these proceedings:

Author(s), "Title of Paper," in *Millimeter, Submillimeter, and Far-Infrared Detectors and Instrumentation for Astronomy XI*, edited by Jonas Zmuidzinas, Jian-Rong Gao, Proc. of SPIE 12190, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510653610

ISBN: 9781510653627 (electronic)

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time)

SPIE.org

Copyright © 2022 Society of Photo-Optical Instrumentation Engineers (SPIE).

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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

**SPIE. DIGITAL
LIBRARY**

SPIDigitalLibrary.org

Paper Numbering: A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE at the time of 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 and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five 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.

Contents

xiii *Conference Committee*

Part One

CMB INSTRUMENTS I

- 12190 02 **Review of radio frequency interference and potential impacts on the CMB-S4 cosmic microwave background survey** [12190-1]
- 12190 03 **SPT-3G+: mapping the high-frequency cosmic microwave background using kinetic inductance detectors** [12190-2]
- 12190 04 **CCAT-prime: design of the Mod-Cam receiver and 280 GHz MKID instrument module** [12190-4]

IMAGERS AND POLARIMETERS I

- 12190 05 **CCAT-prime: the 850 GHz camera for prime-cam on FYST** [12190-7]
- 12190 06 **Broadband kinetic inductance detectors for far-IR observations** [12190-8]

NEW INSTRUMENTS AND CONCEPTS I

- 12190 07 **The Atacama Large Aperture Submillimetre Telescope: key science drivers** [12190-9]
- 12190 08 **The terahertz intensity mapper: a balloon-borne imaging spectrometer for galaxy evolution** [12190-10]
- 12190 09 **EXCLAIM: the EXperiment for Cryogenic Large-Aperture Intensity Mapping** [12190-11]
- 12190 0A **BISOU: a balloon project for spectral observations of the early universe** [12190-12]

CMB INSTRUMENTS II

- 12190 0B **Conceptual design of the modular detector and readout system for the CMB-S4 survey experiment** [12190-16]

OPTICS AND COMPONENTS I

12190 0C **Optical design concept of the CMB-S4 large-aperture telescopes and cameras** [12190-17]

12190 0D **Broadband coated lens solutions for FIR-mm-wave instruments** [12190-19]

COHERENT RECEIVER TECHNOLOGY I

12190 0E **Gal/Xgal U/LDB Spectroscopic/Stratospheric THz Observatory: GUSTO** [12190-22]

12190 0F **5.3 THz MgB₂ hot electron bolometer mixer operated at 20 K** [12190-23]

SPECTROMETERS I

12190 0G **CCAT-prime: the epoch reionization spectrometer for primce-cam on FYST** [12190-26]

12190 0H **On-chip spectroscopic solutions for polarimetric bolometer arrays in submillimeter astronomy** [12190-28]

DETECTORS I

12190 0I **Development of the low frequency telescope focal plane detector modules for LiteBIRD** [12190-30]

12190 0J **A route to large-scale ultra-low noise detector arrays for far-infrared space applications** [12190-31]

COHERENT RECEIVER TECHNOLOGY II

12190 0K **ALMA Band-1 (35-50GHz) receiver: first light, performance, and road to completion** [12190-35]

12190 0L **Design and analysis of the NRC Q-band receiver for ngVLA Band-5** [12190-36]

12190 0M **Extended Q-band (eQ) receiver for Nobeyama 45-m Telescope** [12190-37]

MULTIPLEXING AND READOUT I

12190 ON **Advanced RFSoc readout for space-based superconducting sensor arrays** [12190-43]

DETECTORS II

12190 OO **A robust, efficient process to produce scalable, superconducting kilopixel far-IR detector arrays** [12190-47]

12190 OP **Highly sensitive and wide dynamic range polarimetric detectors arrays in the submillimeter domain** [12190-48]

SPECTROMETERS II

12190 OQ **CONCERTO: a breakthrough in wide field-of-view spectroscopy at millimeter wavelengths** [12190-51]

12190 OR **Development of a cryogenic far-infrared post-dispersed polarizing Fourier transform spectrometer** [12190-152]

12190 OS **Recent developments with Cornell's ZEUS-2 spectrometer at APEX** [12190-53]

POSTER SESSION: DETECTORS I

12190 OT **LiteBIRD low- and mid-frequency detectors: design and status** [12190-62]

POSTER SESSION: MULTIPLEXING AND READOUT I

12190 OU **Phase drift monitoring for tone tracking readout of superconducting microwave resonators** [12190-64]

12190 OV **A simulation suite for readout with SMuRF tone-tracking electronics** [12190-65]

12190 OW **CCAT-prime: RFSoc based readout for frequency multiplexed kinetic inductance detectors** [12190-66]

12190 OX **Development of TRL5 space qualified hardware for tuning, biasing, and readout of kilopixel TES bolometer arrays** [12190-68]

12190 OY **Heterogeneous readout for large superconducting arrays** [12190-69]

- 12190 0Z **The Simons Observatory: complex impedance measurements for a full focal-plane module**
[12190-70]
- 12190 10 **Research on ZCU111 firmware algorithm for multi-science targets** [12190-71]
- 12190 11 **Design and initial performance of the HARDWARE.astronomy Housekeeping (H.aHk) box**
[12190-72]

POSTER SESSION: CMB INSTRUMENTS I

- 12190 12 **The Simons Observatory: development and validation of the large aperture telescope receiver**
[12190-74]
- 12190 13 **The Simons Observatory: mechanical and electrical robustness of the universal focal-plane modules** [12190-77]
- 12190 14 **2022 upgrade and improved low frequency camera sensitivity for CMB observation at the South Pole** [12190-81]
- 12190 15 **PROTOCOLC: an artificial calibrator source for CMB telescopes** [12190-82]

POSTER SESSION: IMAGERS AND POLARIMETERS

- 12190 16 **The ToTEC camera: optical alignment and characterization** [12190-83]
- 12190 17 **The Mexico UK Sub-mm Camera for Astronomy (MUSCAT) on-sky commissioning: focal plane performance** [12190-84]
- 12190 18 **The Mexico UK Sub-mm Camera for Astronomy (MUSCAT) on-sky commissioning: performance of the cryogenic systems** [12190-86]
- 12190 19 **Design of microstrip-line coupled kinetic inductance detectors for near infrared astronomy**
[12190-87]
- 12190 1A **Correlating visual characteristics and cryogenic performance of superconducting detectors**
[12190-89]
- 12190 1B **Readout electronics for kinetic inductance detectors for COSMO** [12190-90]
- 12190 1C **Proper evaluation of spatially correlated noise in interferometric images** [12190-92]
- 12190 1D **CCAT-prime: optical and cryogenic design of the 850 GHz module for Prime-Cam** [12190-93]

Part Two

POSTER SESSION: NEW INSTRUMENTS AND CONCEPTS I

- 12190 1E **Novel nulling spectropolarimeter design for polarization measurement of the cosmic microwave background** [12190-96]
- 12190 1F **Pixel design for FIR/mm/submm astronomy constituted of a set of antenna-coupled superconducting detectors feeding a metamaterial-based lenslet** [12190-97]
- 12190 1G **The Japan-United States Infrared Interferometry Experiment (JUSTInE): balloon-borne pathfinder for a space-based far-IR interferometer** [12190-98]
- 12190 1H **wSMA superconducting diplexer development** [12190-99]

POSTER SESSION: DETECTORS II

- 12190 1I **Simons Observatory focal-plane module: detector re-biasing with bias-step measurements** [12190-103]
- 12190 1J **Design and characterization of new 90 GHz detectors for the Cosmology Large Angular Scale Surveyor (CLASS)** [12190-104]
- 12190 1K **Tolerance analysis of octave bandwidth millimeter-wave planar orthomode transducer** [12190-105]
- 12190 1L **Optical measurements of ultra-sensitive far-infrared TES bolometers with FDM readout** [12190-108]

POSTER SESSION: OPTICS AND COMPONENTS I

- 12190 1M **Cross-slot metal-mesh bandpass filters for far-infrared astronomy** [12190-111]
- 12190 1N **Construction of a large diameter reflective half-wave plate modulator for millimeter wave applications** [12190-112]
- 12190 1O **The ToTEC camera: polarimetric commissioning and performance of the continuously rotating half-wave plate** [12190-113]
- 12190 1P **Novel infrared-blocking aerogel scattering filters and their applications in astrophysical and planetary science observations** [12190-114]
- 12190 1Q **Optical analysis of BISOU: a balloon project to measure the CMB spectral distortions** [12190-115]
- 12190 1R **Optical modeling for the LiteBIRD Medium and High Frequency Telescope** [12190-117]

- 12190 1S **A holographic phase-retrieval method of aperture-field evaluation for bolometer-array-equipped radio telescopes** [12190-118]
- 12190 1T **Modal simulation framework for the design and verification of future few-mode far-infrared spectrometers** [12190-119]

POSTER SESSION: CMB INSTRUMENTS II

- 12190 1U **On-site detector noise characterization of the POLARBEAR-2A receiver** [12190-121]
- 12190 1V **Thermal testing for cryogenic CMB instrument optical design** [12190-126]
- 12190 1W **The optical bread-board models of the LiteBIRD Medium and High Frequency Telescope** [12190-127]
- 12190 1X **Improved polarization calibration of the BICEP3 CMB polarimeter at the South Pole** [12190-128]

POSTER SESSION: COHERENT RECEIVER TECHNOLOGY I

- 12190 1Y **Octave bandwidth receiver technology for radio and millimetre-wave telescopes** [12190-129]
- 12190 1Z **Impedance models for tunable antenna-coupled intersubband terahertz (TACIT) mixers** [12190-131]
- 12190 20 **Electromagnetic performance comparisons of 0.85 THz integrated bias-tee SIS mixers with twin-junction and end-loaded tuning schemes** [12190-134]
- 12190 21 **Wideband cryogenic LNA design for the ngVLA Band-1 receiver** [12190-135]
- 12190 22 **Exhaustive qualification and endurance testing of the 300 GHz frequency doubler of the sub-millimeter instrument of the Jupiter Icy Moon Explorer mission** [12190-136]
- 12190 23 **Atmospheric phase monitoring system evolution for the NOEMA interferometer** [12190-137]

POSTER SESSION: MULTIPLEXING AND READOUT II

- 12190 24 **RF-ICE: large-scale gigahertz readout of frequency-multiplexed microwave kinetic inductance detectors** [12190-139]
- 12190 25 **Development and performance of universal readout harness for the Simons Observatory** [12190-140]

- 12190 26 **Development of TRL5 firmware for tuning, biasing, and readout of kilopixel TES bolometer arrays** [12190-141]
- 12190 27 **Development of frequency domain multiplexing readout using sub-kelvin SQUIDs for LiteBIRD** [12190-143]
- 12190 28 **Digital active nulling for frequency-multiplexed bolometer readout: performance and latency** [12190-144]
- 12190 29 **DAC clipping buffer and data processing for TES readout** [12190-145]
- 12190 2A **Study and development of programming topologies in FPGA for the reduction and analysis of data from heterodyne instruments for radio astronomy** [12190-146]

POSTER SESSION: SPECTROMETERS I

- 12190 2B **CCAT-prime: the design and characterization of the silicon mirrors for the Fabry-Perot interferometer in the Epoch of reionization spectrometer** [12190-148]
- 12190 2C **Determining the efficiency of a cryogenic far-infrared diffraction grating spectrometer used as a post-dispersing module for a high-resolution spectrometer** [12190-149]
- 12190 2D **Development of a Fourier transform spectrometer for the calibration of THz on-chip spectrometers** [12190-150]
- 12190 2E **Cryogenic testing towards TRL-5 demonstration of a novel stiffness-compensated, reactionless scan mechanism for the Fourier transform spectrometer of SPICA SAFARI instrument** [12190-151]
- 12190 2F **Design and testing of kinetic inductance detector package for the terahertz intensity mapper** [12190-153]
- 12190 2G **CCAT-prime: the design of the epoch of reionization spectrometer detector arrays** [12190-154]

POSTER SESSION: OPTICS AND COMPONENTS II

- 12190 2H **CCAT-prime: the optical design for the Epoch of reionization spectrometer** [12190-157]
- 12190 2I **Characterization of aerogel scattering filters for astronomical telescopes** [12190-158]
- 12190 2J **A new thermo-mechanical structure design for space qualified close-cycle dilution refrigerator** [12190-159]
- 12190 2K **Impact of the effective thickness from anti-reflective sub-wavelength structures in achromatic half-wave plate design** [12190-162]
- 12190 2L **Laminate polyethylene window development for large aperture millimeter receivers** [12190-164]

12190 2M **Modelling ground pickup for microwave telescopes** [12190-165]

POSTER SESSION: CMB INSTRUMENTS III

12190 2N **Testing magnetic interference between TES detectors and the telescope environment for future CMB satellite missions** [12190-167]

12190 2O **Testbed preparation of a small prototype polarization modulator for LiteBIRD Low-Frequency Telescope** [12190-169]

12190 2P **The Simons Observatory: antenna control software integration and implementation** [12190-170]

12190 2Q **Long-timescale stability in CMB observations at multiple frequencies using front-end polarization modulation** [12190-171]

12190 2R **Wide field high cadence CMB survey designs for Chilean telescopes** [12190-172]

12190 2S **Cosmology Large Angular Scale Surveyor (CLASS): pointing stability and beam measurements at 90, 150, and 220 GHz** [12190-173]

12190 2T **QUBIC: the Q and U bolometric interferometer for cosmology** [12190-186]

POSTER SESSION: COHERENT RECEIVER TECHNOLOGY II

12190 2U **Design of an on-chip integrated 230 GHz dual-polarization balanced SIS receiver for multi-pixel array applications** [12190-175]

12190 2V **Characterization of the John A. Galt Telescope for radio holography with CHIME** [12190-176]

12190 2W **Overview of VLBI instrument for Millimetron space mission** [12190-177]

12190 2X **A compact kinetic inductance travelling wave parametric amplifier with continuous periodic loading structure** [12190-178]

12190 2Y **Demonstration of a 25% bandwidth 520-680 GHz Schottky receiver front-end for planetary science and remote sensing** [12190-179]

12190 2Z **Further optical analysis of the ALMA Band 9 front end for a possible upgrade** [12190-180]

12190 30 **Design of high compression point Josephson junction travelling wave parametric amplifiers for readout of millimetre and sub-millimetre astronomical receivers** [12190-182]

12190 31 **The repair work and future plan for the Auto-Correlation Spectral Imaging System (ACSIS) at the James Clerk Maxwell Telescope (JCMT)** [12190-183]

- 12190 32 **Development of key technologies of the radio astronomy phased array feed digital backend**
[12190-184]
- 12190 33 **The new multi-frequency instrument (MFI2) for the QUIJOTE facility in Tenerife** [12190-185]