Proceedings of the Fifteenth International Symposium on Space Terahertz Technology

Gopal Narayanan, Editor
University of Massachusetts, Amherst, MA

April 27-29, 2004
Hotel Northampton
Northampton, Massachusetts
PREFACE

On behalf of the Organizing Committee, I wish to thank all of the authors and the presenters who have done a wonderful job of making this Symposium successful and productive. The 15th International Symposium on Space Terahertz Technology was organized by the University of Massachusetts, Amherst, and was co-sponsored by the IEEE Microwave Theory and Techniques (MTT) Society, and by the Electromagnetics Division of the National Institute of Standards and Technology (NIST).

Forty-four abstracts were accepted for oral presentation, and twenty-eight papers were accepted for poster presentations. We also had three invited talks at the beginning of each day. The breakdown of the accepted abstracts in terms of the broad technology category is as follows:

- Hot Electron Bolometers: 15
- SIS Technology: 11
- LO Sources: 8
- Direct Detectors: 11
- Terahertz Systems: 13
- Optics and Related Technologies: 14

All of the accepted papers that have been submitted on time have been included in the proceedings. Only a handful of papers were not submitted and they have been replaced with the accepted abstracts. Online proceedings of the conference are also available at [http://www.stt2004.org](http://www.stt2004.org).

I would like to take this opportunity to thank people who helped in the organization of this symposium. Pamela Poissant and Denise Parent in the Department of Astronomy at UMass helped tremendously in the administrative aspects of the symposium. Barbara Keyworth, Dept. of Astronomy helped arrange the reception. Karen Werner provided invaluable help, especially in the compilation of the submitted abstracts, and in computer support for the conference. Financial support from NIST and Millitech, Inc. are gratefully acknowledged. Special thanks go to our technical review committee listed below for helping to review all the submitted abstracts. I also want to thank our dedicated team of staff member and graduate student volunteers who were on hand to make the event a success.

Gopal Narayanan  
(UMass, Amherst)

**Organizing Committee**  
- Gopal Narayanan  
- Neal Erickson  
- Eyal Gerecht  
- Grant Wilson  
- Sigfrid Yngvesson

**Technical Committee**  
- Al Betz  
- Jack East  
- Tony Kerr  
- Erik Kollberg  
- Harvey Moseley  
- Antti Raisanen  
- Edward Tong  
- Chris Walker  
- Nick Whyborn

Please note the dates and location for the 16th International Symposium on Space Terahertz Technology to be held in 2005:

**May 2-4, 2005**  
Chalmers University of Technology, Göteborg, Sweden.  
(http://www.mc2.chalmers.se/conferences/ISSTT)  
Organizers: Jan Stake, Harald Merkel, Victor Belitsky, and Erik Kollberg.)
15th International Symposium on Space Terahertz Technology

Invited Talks

0.1 James Webb Space Telescope, SAFIR, SPECS, and the future of Space Astronomy
John C. Mather¹, Dan Lester², and Harold Yorke³
1 NASA’s Goddard Space Flight Center Greenbelt, MD
2 Astronomy Department, University of Texas, Austin
3 Jet Propulsion Laboratory

0.2 Development status of Herschel-Heterodyne Instrument for the Far-Infrared (HIFI)
Nick Whyborn¹, Thijs de Graauw¹, Emmanuel Caux², Tom Phillips³, Juergen Stutzki⁴
1 SRON
2 CESR, Toulouse, France
3 Caltech
4 KOSMA, Koln

0.3 The Submillimeter Array Antennas and Receivers Raymond Blundell¹
1 Harvard-Smithsonian Center for Astrophysics

1. Session 1: HEB Mixers 1
Session Chairs: Dr. Sigfrid Yngvesson, UMass and Dr. Erik Kollberg, Chalmers

1.1 Optimization of HEB mixer for the Herschel Space Observatory
S. Cherednichenko¹, P. Khosropanah¹, T.Berg¹, H. Merkel¹,
E. Kollberg¹, V.Drakinskiy², B. Voronov², G. Gol'tsman²
1 Chalmers University of Technology
2 Moscow State Pedagogical University, Moscow

1.2 NbN phonon cooled Hot Electron Bolometer Mixers with improved interfaces: Noise temperature and LO power requirement
J.J.A.Baselmans¹, M.Hajenius¹,², J.R. Gao¹,², A. Baryshev¹, J. Koo¹,
T.M. Klapwijk³, P.A.J. de Korte¹, B. Voronov³, and G. Gol'tsman⁴
1 Space Research Organisation of the Netherlands (SRON)
2 Delft University of Technology
3 California Institute of Technology
4 Moscow State Pedagogical University
1.3 Stability measurements of a NbN HEB receiver at THz frequencies
T. Berg¹, S. Cherednichenko¹, V. Draksinskiy¹, H. Merkel¹, E. Kollberg¹, J.W. Koo²
1 Chalmers University of Technology
2 California Institute of Technology

1.4 Development of NbN Terahertz HEB Mixers Coupled Through SlotRing Antennas
Eyal Gerecht, Dazhen Gu, Xin Zhao, John Nicholson, Fernando Rodriguez-Morales, and Sigfrid Yngvesson¹
¹ National Institute of Standards and Technology
2 University of Massachusetts, Amherst

1.5 Phonon-cooled hot electron bolometers on freestanding 2µm Si₃N₄ membranes for THz applications
Pedro Muñoz, Sven Bedorf, Michael Brandt, Thomas Tils, Martina Wiedner, Martin Brüll, Netty Honingh, Karl Jacobs
KOSMA, Köln

1.6 The role of quantum noise in terahertz receivers
Sigfrid Yngvesson¹, Erik Kollberg²
1 University of Massachusetts, Amherst
2 Chalmers University of Technology

2. Session 2: SIS Mixers
Session Chair: Dr. Edward Tong, Harvard-Smithsonian Center for Astrophysics

2.1 The ALMA Band 6 (211-275 GHz) Sideband-Separating SIS Mixer-Preamplifier
A. R. Kerr¹, S.-K. Pan¹, E. F. Lauria¹, A. W. Lichtenberger², J. Zhang², M. W. Pospieszalski¹, N. Horner¹, G. A. Ediss¹, J. E. Effland¹, R. L. Groves¹
¹ National Radio Astronomy Observatory
2 The University of Virginia, Charlottesville

2.2 A Fixed-Tuned Integrated SIS Mixer with Ultra-Wideband IF and Quantum-Limited Sensitivity for ALMA Band 3 (84-116 GHz) Receivers
S.-K. Pan¹, A. R. Kerr¹, M. W. Pospieszalski¹, E. F. Lauria¹, W. K. Crady², N. Horner, Jr.¹, S. Srikanth¹, E. Bryerton¹, K. Saini¹, S. M. X. Claude², C. C. Chin², P. Dindo², G. Rodrigues², D. Derdall², J. Z. Zhang¹ and A. W. Lichtenberger¹
¹ National Radio Astronomy Observatory
2 Herzberg Institute of Astrophysics
3 University of Virginia, Charlottesville
2.3 Low noise 1.2 THz SIS mixer for Herschel radio observatory
A. Karpov, D. Miller, F. Rice, J. A. Stern, B. Bumble, H. G. LeDuc, J. Zmuidzinas
1 California Institute of Technology
2 MDL, Jet Propulsion Laboratory

2.4 Development of the Band 3 and 4 mixer units for HIFI
1 SRON
2 Delft University of Technology

2.5 Waveguide-type all-NbN SIS mixers on MgO substrates
Masanori Takeda, Yoshinori Uzawa, Akira Kawakami, Zhen Wang, and Takashi Noguchi
1 Kansai Advanced Research Center
2 Nobeyama Radio Observatory

3. Session 3: Direct Detectors 1
Session Chair: Dr. Albert Betz, University of Colorado

3.1 Arrays of Bolometers for Far-infrared and Submillimeter Astronomy
1 NASA Goddard Space Flight Center
2 NASA Ames Research Center
3 JPL/Caltech
4 University of Chicago, Yerkes Observatory

3.2 A 90GHz Bolometer Camera Detector System for the Green Bank Telescope
1 NASA / Goddard Space Flight Center
2 University of Pennsylvania, Philadelphia
3 SSAI, Lanham
4 GS&T Greenbelt
5 NIST / Boulder
6 NRAO, Green Bank
3.3 Frequency Selective Bolometers - Progress and Projections  
G.W. Wilson\(^1\), T.C. Chen\(^2\), E.S. Cheng\(^3\), D.A. Cottingham\(^4\), T.M. Crawford\(^5\), T. Downes\(^5\), F.M. Finkbeiner\(^6\), D.J. Fixsen\(^4\), D.W. Logan\(^1\), S. Meyer\(^7\), T. Perera\(^7\), E.H. Sharp\(^7\), and R.F. Silverberg\(^8\)  
1 University of Massachusetts, Amherst  
2 Global Science and Technology, NASA/GSFC  
3 Conceptual Analytics, Glenn Dale, MD  
4 NASA/GSFC  
5 Univ. of Chicago, Chicago  
6 SSAI, Greenbelt

3.4 A Comparison of Device Characteristic of Mo/Au TES Bolometers with Different Normal Metal Bar Geometries  
Johannes G. Staguhn\(^1,2\), Dominic J. Benford\(^1\), S. Harvey Moseley\(^1\), Christine A. Allen\(^1\), James A. Chervenak\(^1\), Thomas R. Stevenson\(^1\), Wen-Ting Hsieh\(^1,3\)  
1 NASA/Goddard Space Flight Center  
2 SSAI  
3 Raytheon ITSS

4. Session 4: Sources 1  
Session Chair: Dr. Gopal Narayanan, University of Massachusetts, Amherst

4.1 Tunable All-Solid-State Local Oscillators to 1900 GHz  
John Ward, Goutam Chattopadhyay, Alain Maestrini, Erich Schlecht, John Gill, Hamid Javadi, David Pukala, Frank Maiwald and Imran Mehdi  
Jet Propulsion Laboratory

4.2 Reliability of cascaded THz frequency chains with planar GaAs circuits  
Frank Maiwald, Erich Schlecht, Robert Lin, John Ward, John Pearson, Peter Siegel, and Imran Mehdi  
Jet Propulsion Laboratory

4.3 AM Noise in Drivers for Frequency Multiplied Local Oscillators  
N. Erickson  
University of Massachusetts, Amherst

4.4 Continuous THz-Wave Generation using Uni-Traveling-Carrier Photodiode  
Hiroshi Ito, Tomofumi Furuta, Fumito Nakajima, Kaoru Yoshino, and Tadao Ishibashi  
NTT Photonics Laboratories, NTT Corporation
5. Session 5: Direct Detectors 2
Session Chair: Dr. S. Harvey Moseley, NASA GSFC

5.1 Photon-counting Superconducting Detectors for Submillimeter Astronomy: Recent Results
J.D. Teufel¹, L. Frunzio¹, M. Shen¹, D.E. Prober¹, R.J. Schoelkopf¹
W.-T. Hsieh², M.J. Li², F.A. Pellerano², G. Schneider²,
C.M. Stahle², T.R. Stevenson², D.E. Travers², E.J. Wollack²
1 Yale University
2 NASA Goddard Space Flight Center

5.2 The CMB Polarization Observer (CLOVER)
G. Yassin¹, P. A. R. Ade², C. Calderon¹, A. D. Challinor¹, L. Dunlop¹, W.
K. Gear¹, D. J. Goldie¹, K. J. B. Grainge², M. J. Griffin², M. E. Jones¹, A.
N. Lasenby¹, B. Maasch², P. D. Mauk², S.
J. Melhuish¹, A. Orlando², L. Piccirillo², G. Pisano², A. C. Taylor¹ and S.
Withington¹
1 Cavendish Astrophysics, University of Cambridge, UK
2 Department of Physics and Astronomy, University of Cardiff, UK

5.3 Detection of 1.6 and 2 THz radiation with a Tunable Antenna-Coupled Intersubband Terahertz (TACIT) detector
G. B. Serapiglia¹, M. S. Sherwin¹, M. Hanson¹, A. C. Gossard¹ and W. R.
McGrath²
1 University of California, Santa Barbara
2 Jet Propulsion Laboratory, Pasadena, California

6. Session 6: HEB Mixers 2
Session Chair: Dr. Eyal Gerecht, NIST

6.1 Quantum Mechanical Mixing Model for Hot Electron Bolometers
Harald F. Merkel, P. Khosropanah, T. Berg, S. Cherednichenko, E.
Kollberg
Chalmers University of Technology

6.2 Superconducting Hot-Electron Bolometer Mixer for Terahertz Heterodyne Receivers
Alexei D. Semenov¹, Heinz-Wilhelm Hübres¹, Heiko Richter¹, Konstantin
Smirnov², Gregory N. Gol’tsman², and Boris M. Voronov²
1 DLR Institute of Planetary Research, Berlin
2 Moscow State Pedagogical University
<table>
<thead>
<tr>
<th>Session 7: Poster Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 Design and Characterization of a Sideband Separating SIS Mixer for 85-115 GHz</td>
</tr>
<tr>
<td>V. Vassilev, V. Belitsky, C. Risacher, I. Lapkin, A. Pavolotsky, E. Sundin</td>
</tr>
<tr>
<td>Chalmers University of Technology</td>
</tr>
<tr>
<td>Institute of Applied Physics RAS, Novgorod, Russia</td>
</tr>
<tr>
<td>7.2 ALMA Band 6 Cartridge Design and Performance</td>
</tr>
<tr>
<td>NRAO</td>
</tr>
<tr>
<td>* Institut de Radio Astronomique Millimétrique</td>
</tr>
<tr>
<td>7.3 Design Considerations of a Two-Distributed-Junction Tuning Circuit</td>
</tr>
<tr>
<td>Yoshinori UZAWA¹, Masanori TAKEDA¹, Akira KAWAKAMI¹, Zhen WANG¹, and Takashi NOGUCHI²</td>
</tr>
<tr>
<td>1 Kansai Advanced Research Center, Japan</td>
</tr>
<tr>
<td>2 Nobeyama Radio Observatory</td>
</tr>
<tr>
<td>7.4 Sideband-Separating SIS Mixer at 100GHz Band for Astronomical Observation</td>
</tr>
<tr>
<td>S. Asayama¹, K. Kimura², H. Iwashita², N. Sato², T. Takahashi³, M. Saito¹, B. Ikenoue¹, H. Ishizaki², N. Ukita¹</td>
</tr>
<tr>
<td>1 National Astronomical Observatory of Japan</td>
</tr>
<tr>
<td>2 Osaka Prefecture University, Japan</td>
</tr>
<tr>
<td>3 Nobeyama Radio Observatory, Japan</td>
</tr>
<tr>
<td>7.5 A Dual Polarization Sideband Separation SIS Receiver for the Large Millimeter Telescope</td>
</tr>
<tr>
<td>Gopal Narayanan, Ron Grosslein, Vikram Kodipelli, Vern Fath, Don Lydon, and Prachi Deshpande</td>
</tr>
<tr>
<td>University of Massachusetts, Amherst</td>
</tr>
</tbody>
</table>
7.6 Design of a Balanced Waveguide HEB Mixer for APEX 1.32 THz Receiver
M. Pantaleev, D. Meledin, A. Pavolotsky, C. Risacher, and V. Belitsky
Chalmers University of Technology

7.7 New Results on Bistability Effects in HEB Devices
Dazhen Gu, Yan Zhuang, Sigfrid Yngvesson
University of Massachusetts, Amherst

7.8 Bandwidth Measurements on HEB Mixers at Terahertz Frequencies Using Sideband Generators as well as Two Lasers
University of Massachusetts, Amherst
University of Massachusetts, Lowell

7.9 Ultimate Performance of a Cold-Electron Bolometer with Strong Electrothermal Feedback
Leonid Kuzmin, Chalmers University of Technology

7.10 Noise Temperature Measurements of NbN phonon-cooled Hot Electron Bolometer Mixer at 2.5 and 3.8 THz
Moscow State Pedagogical University

7.11 Superconducting Single Photon Detectors Array based on Hot Electron Phenomena
1 Moscow State Pedagogical University
2 IBM T.J. Watson Research Center

7.12 Compact 1.6-1.9 THz local oscillator as stand-alone unit for GREAT
1 KOSMA
2 RAIUB, Universität Bonn

7.13 Improving the Efficiency of Quasi-optical Analysis and Design of Terahertz Systems
Marcin L. Gradziel, David White, J.A. Murphy, S. Withington
1 National University of Ireland Maynooth, Ireland
2 Department of Computing, Institute of Technology, Dublin, Ireland
3 Cavendish Laboratory
7.14 Instrument for Measurements of HEB Receiver Noise Temperature with Cold and Hot Loads Internal to the Cryostat
R. Zannoni, S. Yngvesson
University of Massachusetts, Amherst

7.15 Modal Analysis and Experimental Study of High-Order Mode Contribution to Standing Waves in Quasi-Optical Systems
Willem Jellema, Stafford Withington, Neil Trappe, J. Anthony Murphy, Wolfgang Wild
1 SRON
2 Cavendish Laboratory
3 National University of Ireland, Maynooth
4 Kapteyn Institute

7.16 Integrated versatile radiometer
Anders Emrich, Omnisys Instruments AB

7.17 Regarding Atmospheric and Mechanical Stability Requirements of (LO-Pumped) Mixers
J. W. Kooi, R. Schieder, J. Baselmans, M. Hagenius, A. Baryshev, R. Hesper
1 California Institute of Technology
2 University of Koln
3 SRON
4 Kapteyn Astronomical Institute, Univ. Groningen
5 Delft University of Technology

7.18 BSMILES - A Balloon borne Superconducting Submillimeter-Wave Limb-Emission Sounder for Atmospheric Research
Yoshihisa Irimajiri, Takeshi Manabe, Satoshi Ochiai, Harunobu Masuko, Takamasa Yamagami, Yoshitaka Saito, Naoki Izutsu, Michiyoshi Namiki
1 National Institute of Information and Communications Technology (NICT), Japan
2 Japan Aerospace Exploration Agency (JAXA), Japan

7.19 ALMA cartridge-type receiver system for Band 4
1 Osaka Prefecture University, Japan
2 Nagoya University, Japan
3 Toyota National College of Technology, Japan
4 National Astronomical Observatory, Japan
5 Mitsubishi Electric Tokki System
7.20 A Dual-Frequency Mixer Array for CHAMP+
R.Hesper¹, H. Schaeffer¹, G. Gerlofsma¹, C. Kasemann², A. Baryshev³
1 Kapteyn Astronomical Institute, University of Groningen
2 Max-Planck-Institut für Radioastronomie, Bonn

7.21 The Large Millimeter Telescope
F. P. Schloerb¹, L. Carrasco²
1 University of Massachusetts, Amherst
2 Instituto Nacional de Astrofisica, Optica, y Electrica, Mexico

7.22 A multi-path Far-infrared and Submm gas cell for spectral tests of Herschel/HIFI
D. Teyssier¹, D. Dartois², D. Deboffle², J.-P. Crussaire², Y. Longval², F. Boulanger², M. Pérault³
1 SRON-Groningen/ESA
2 IAS, Université Paris-Sud
3 LERMA/ENS

7.23 Tunable Heterodyne Mixer using Plasmon Modes in a Grating Gated Double-Quantum-Well Field Effect Transistor
Mark Lee, Michael C. Wanke, and John L. Reno
Sandia National Laboratories

7.24 A Broadband Finline Ortho-Mode Transducer for THz Applications
Christopher Groppi¹, Christian Drouet d’Aubigny², Christopher Walker³, and Arthur Lichtenberger³
1 National Radio Astronomy Observatory
2 University of Arizona, Tucson
3 University of Virginia, Charlottesville

7.25 Chip for autocorrelation spectrometer applications with integrated digitizer
L. Landén, A. Emrich, S. Andersson, J. Dahlberg
Omnisys Instruments AB

7.26 T-shaped Emitter Metal Heterojunction Bipolar Transistors for Submillimeter Wave Applications
Andy Fung¹, Lorene Samoska¹, Jim Velebir¹, Peter Siegel¹, Mark Rodwell², Vamsi Paidi², Zach Griffith², Miguel Urteaga², Roger Malik³
1 Jet Propulsion Laboratory
2 University of California, Santa Barbara
3 RJM Semiconductor
### 7.27 Device Technology for SIS Mixers in the 1-1.5 THz Band

*M. Kroug*, J. Eroms, T. Zijlstra, A. Baryshev, T.M. Klapwijk
1 Delft University of Technology
2 SRON

### 7.28 A Phase-locked Terahertz Quantum Cascade Laser

*A.L. Betz*, R.T. Boreiko, B.S. Williams, S. Kumar, and Q. Hu, J.L. Reno
1 University of Colorado, Boulder
2 Massachusetts Institute of Technology
3 Sandia National Laboratories

### Session 8: Sources 2

**Session Chair: Dr. Neal Erickson, University of Massachusetts, Amherst**

#### 8.1 THz Quantum Cascade Laser as Local Oscillator in a Heterodyne Receiver

1 German Aerospace Center (DLR)
2 NEST-INFM and Scuola Normale Superiore Piazza dei Cavalieri, Italy
3 Cavendish Laboratory, University of Cambridge

#### 8.2 The Study of Harmonic-Mode Operation of GaAs TUNNETT Diodes and InP Gunn Devices Using a Versatile Terahertz Interferometer

*H. Eisele, M. Naftaly, J. R. Fletcher, D. P. Steenson, M. R. Stone*
University of Leeds, Leeds

#### 8.3 THz Spectrometer Based on a Josephson Oscillator and a Cold-Electron Bolometer

1 Chalmers University of Technology
2 Institute of Radio Engineering and Electronics, Moscow
3 Institute of Crystallography, Russian Academy of Sciences, Moscow
4 Moscow State University, Moscow

### Session 9: Systems

**Session Chair: Dr. Grant Wilson, University of Massachusetts, Amherst**

#### 9.1 Submillimeter SIS Receiver Gain Stabilization

*James Battat, Raymond Blundell, Todd R. Hunter, Robert Kimberk, Patrick S. Leiker, Cheuk-yu Edward Tong*
Harvard-Smithsonian Center for Astrophysics, Cambridge
9.2 The Southpole Imaging Fabry-Perot Interferometer, SPIFI  
Nikola, T.¹, Stacey, G.J.¹, Oberst, T.E.¹, Parshley, S.C.¹, Stark, A.A.²,  
Tothill, N.², Harnett, J.²  
1 Cornell University  
2 Harvard-Smithsonian Center for Astrophysics, Cambridge

9.3 Upgrade to the TREND Laser LO at the South Pole Station  
Sigfrid Yngvesson¹, Eyal Gerecht¹, John Nicholson¹, Fernando  
Rodriguez-Morales¹, Xin Zhao¹, Richard Zannoni¹, Jason Dickinson¹,  
Thomas Goyette², William Gorveatt², Jerry Waldman², Dathon Gholish²,  
Jacob Kooi², Christopher Martin², and Eric Mueller²  
1 University of Massachusetts at Amherst  
2 University of Massachusetts at Lowell  
3 University of Arizona  
4 California Institute of Technology  
5 Smithsonian Astrophysical Observatory  
6 Coherent-Deos, Inc.

9.4 High Resolution Imaging using a 1.5 THz Transceiver  
Jason C. Dickinson, Thomas M. Goyette, and Jerry Waldman  
University of Massachusetts Lowell

Session 10: HEB Mixers 2  
Session Chair: Dr. Daniel Prober, Yale University

10.1 Increased bandwidth of NbN phonon cooled hot electron bolometer mixers  
M. Hajenius¹, J.J.A. Baselmans², J.R. Gao¹, T.M. Klapwijk¹, P.A.J. de Korte¹,  
B. Voronov³ and G. Gol’tsman³  
1 Delft University of Technology  
2 SRON  
3 Moscow State Pedagogical University

10.2 Characterization of NbTiN Hot Electron Bolometer Mixers with Different Lengths  
Denis Loudkov, Edward Tong and Raymond Blundell  
Harvard-Smithsonian Center for Astrophysics, Cambridge

10.3 Ultra-Thin Silicon Chips for Submillimeter-Wave Applications  
R.B. Bass¹, J.C. Schultz¹, A.W. Lichtenberger¹, R.M. Weikle¹, S.-K. Pan²,  
E. Bryerton², C.K. Walker², Jacob Kooi²  
1 University of Virginia, Charlottesville  
2 National Radio Astronomy Observatory  
3 University of Arizona, Tucson  
4 California Institute of Technology
11.1 A Gaussian Beam Measurement Range for MM and Sub-MM Receiver Characterization
M. Pantaleev, V. Belitsky, K. Ermisch, M. Fredrixon, M. Svensson
Chalmers University of technology

11.2 Gaussian Beam Analysis of Relay Optics for the SEQUOIA Focal Plane Array
G. Narayanan
University of Massachusetts, Amherst

11.3 Satellite antenna measurement at 322 GHz using a computer-generated hologram as the focusing element
J. Ala-Laurinaho¹, J. Häkki¹, T. Koskinen¹, A. Lönnqvist¹, J. Mallat¹, A.V. Rääsänen¹, S. Ranvier¹, J. Säily¹, J. Tuovinen¹, V. Viikari¹
1 MilliLab, Helsinki University of Technology,
2 MilliLab, VTT Information Technology

11.4 The Terahertz Atmosphere
S. Paine and R. Blundell
Harvard-Smithsonian Center for Astrophysics, Cambridge

11.5 Characterization and Status of a Terahertz Telescope
D. P. Marrone, R. Blundell, H. Gibson, S. Paine, D. C. Papa, C.-Y. E. Tong
Harvard-Smithsonian Center for Astrophysics, Cambridge

11.6 Design and Verification of ALMA Band 9 Receiver Optics
A. Baryshev¹, R. Hesper¹, K. Wielinga², G. Gerlofsma¹, M. Carter³
1 SRON
2 Mecon Engineering BV, The Netherlands.
3 IRAM