PROCEEDINGS

of the 17th INTERNATIONAL SYMPOSIUM

on SPACE TERAHERTZ TECHNOLOGY

Paris, May 10-12, 2006

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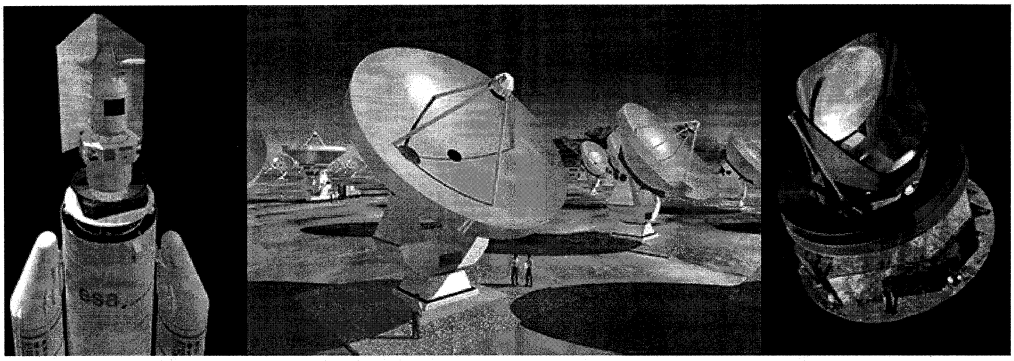
October 2007



ISSTT 2006

17th International Symposium on Space Terahertz Technology

Paris

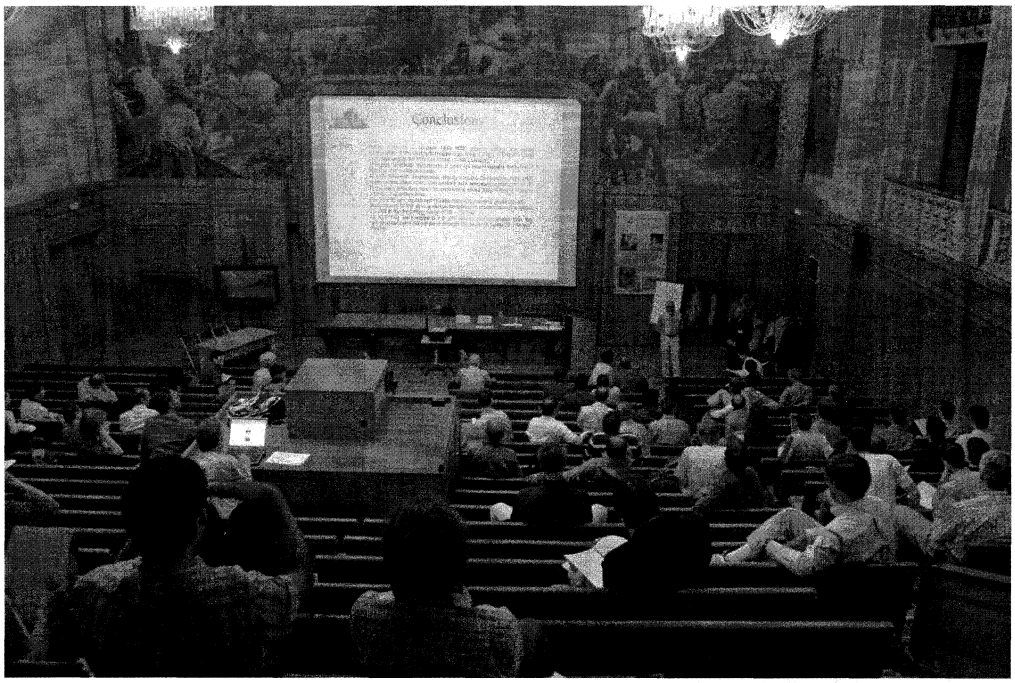
10-12 May

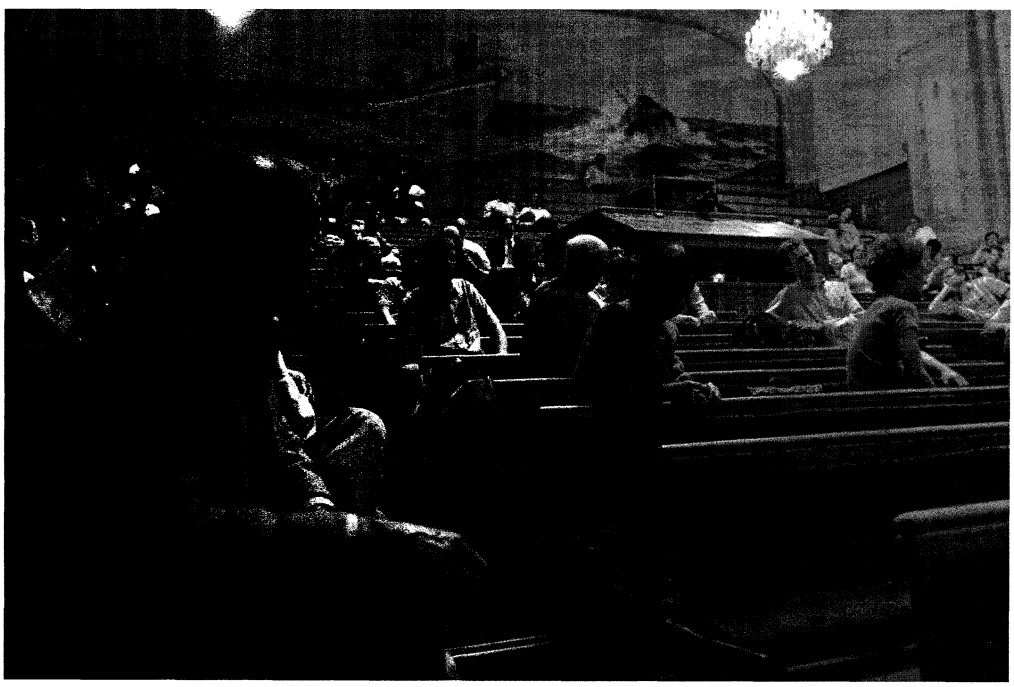
INTRODUCTION

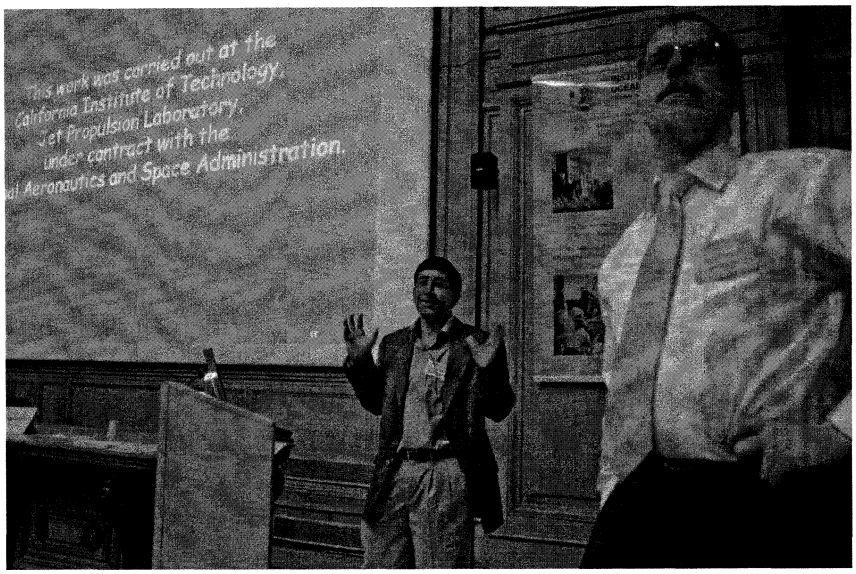
The prime focus of the International Symposium on Space Terahertz Technology is on theory, techniques and applications in the field of space terahertz technology related areas but in reality its scope includes instrumentation for ground-based millimeter and submillimeter-wave radioastronomy. Detectors cooled or un-cooled (SIS, HEB, Schottky mixers, TES, semi-conductor bolometers, KIDs), sources (Gunn sources, frequency multipliers, FFOs, BWO, FIR lasers, photo-mixers and now QCLs), optics (lens, antennas, FSS, diplexers…) spectrometers (AOSs, auto-correlators…) and entire instruments (heterodyne cameras, bolometer arrays, HIFI, Planck,…) are the subject of this annual conference. The first 14 editions of the ISSTT conference were held in the USA. In 2005, the 16th edition was held for the first time in Europe, in Chalmers, Göteborg, Sweden. The 17th International Symposium on Space Terahertz Technology was held at the Institut Océanographique, 195 rue Saint-Jacques, 75005 Paris. The Institut Océanographique is a private institution founded in 1906 by Albert 1er, Prince of Monaco. Located in the heart of the historical center of Paris, near the Luxembourg Gardens, la Sorbonne and the Seine river, it offers an exclusive atmosphere. The entire first floor of the Institut Océanographique was dedicated to the ISSTT 2006. It included the great and the small amphitheaters, the exhibition room and the computer room (called in fact salle du conseil).

Oral presentations

Oral presentations took place in the great amphitheater only. The duration of the oral presentations was 15 minutes including questions.







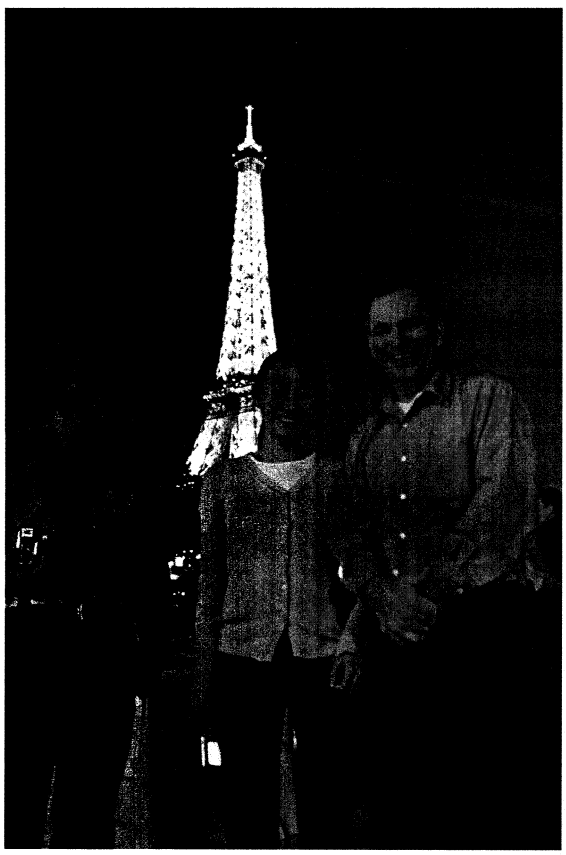
Poster presentations

Poster sessions took place in the small amphitheater and the exhibition room located next to each other. At the entrance of each room a board indicated which posters were displayed. Posters were in vertical format up to A0 size (84x119cm). The poster session were introduced by two thirty-minute oral presentations. Dr. Jian-Ron Gao presented the first poster session while Dr. Eribert Eisele and Dr. Imran Mehdi presented the second session.

Reception at the Observatoire de Paris & Gala Diner

On Wednesday May the 10th from 18:30 to 20:00, the attendees and accompanies were invited to a reception at the Observatoire de Paris , 77 avenue Denfert Rochereau, 75014 Paris, located at only 15 minutes walk from the conference hall. Dr. Daniel Egret, director, welcomed the participants. A visit of the 17th century building was organized and an aperitif with Champagne was offered.

The gala diner was held on the river Seine, on board of the *Bel Ami*, on Thursday May 11th at 20:00 till 23:30.



ORGANIZATION

The Observatoire de Paris, the Université Pierre et Marie Curie, Supélec and the laboratoire AstroParticule et Cosmologie organized the 17th International Symposium on Space Terahertz Technology, ISSTT 2006, at the Institut Océanographique, in the historical center of Paris, on May 10-12, 2006.

The 2006 edition of the ISSTT was patronized by Prof. Pierre Encrenaz and Dr. Jean-Michel Lamarre.

For the review of the abstracts, we would like to thanks the international review committee:

Prof. Thomas Crowe	Dr. Gregory Goltsman	Dr. Harald Merkel
Dr. Heribert Eisele	Dr. Karl Jacobs	Dr. Michel Piat
Prof. Neal Erickson	Dr. Anthony Kerr	Prof. Antti Räisänen
Dr. Jian-Rong Gao	Dr. Imran Mehdi	Dr. Edward Tong

The program of the conference had been arranged by the local scientific committee:

Dr Alain Maestrini (chair)		
Prof. Georges Alquié	Dr. Yan Delorme	Prof. Alain Kreisler
Dr. Gérard Beaudin	Dr. Yannick Giraud-Héraud	Dr. François Pajot
Dr. Annick Dégardin	Dr. Bruno Guillet	Dr. Michel Piat

Local organizing committee at the Observatoire de Paris:

Dr. Gérard Beaudin (chair)		
Michèle Ba-Trung	Alain Germont	Chantal Levivier
Nicole Delhaye	Dr. Bruno Guillet	Dr. Alain Maestrini
Dr. Yan Delorme	Patrice Landry	Djilali Zidani
Dr. André Deschamps	Marie-Claude Lemonnier	

with the help of Dr. Annick Dégardin and Prof. Alain Kreisler, Supélec.

The edition of proceedings of the ISSTT 2006 was arranged by Dr. Alain Maestrini at the Observatoire de Paris.

PAPERS

We accepted one hundred and two (102) abstracts. Forty-nine (49) were accepted for oral presentation while fifty-three (53) were accepted for poster presentation. For this edition of the ISSTT we had two posters sessions that were introduced by two thirty-minute oral presentations. We also had four (4) invited presentations.

SIS and HEB mixer papers represent about 40% of the total number. This underlines the importance of heterodyne detection for radio-astronomy in times where direct detection in the far-infrared makes tremendous progress toward building multi-thousand pixel cameras. New or upcoming ground-based telescopes like ALMA or APEX will use heterodyne receivers up to 950GHz and will require SIS mixers or small arrays of SIS mixers. Several authors presented their work on this type of mixer with an emphasis on side-band separation. In addition, two years before the launch of Herschel, several flight mixers for HIFI were presented. Research on HEB mixers is also a very active field, well represented at the ISSTT, due to the potential of HEB to work at THz frequencies with low noise. Several authors presented their work on THz waveguide HEB mixers or quasi-optical HEB mixers using NbN, NbTiN or MgB2 thin films. The IF bandwidth of HEB mixers is still limited compared to other types of mixers like SIS or Schottky mixers and is the subject of several papers presented at the ISSTT.

Direct detection was well represented at the ISSTT 2006 with a dedicated oral session and a total of 11 papers including posters. Papers on single photon detectors for the far or mid-infrared and papers on instruments and technologies dedicated to CMB science were presented.

There was a relatively small number of papers on sources, 16 in total. QCLs are the subject of an increasing interest for THz local oscillators since their performances improve at a rapid pace. Photo-mixers now provide enough power for pumping SIS mixers at millimeter wavelengths. These two technologies were well represented at the ISSTT 2006. On the contrary, traditional fundamental sources like Gunn diodes or sources based on frequency multiplication were less represented at the ISSTT 2006 than in previous editions.

Several papers on novel devices and technologies like carbon-nanotubes detectors, non-linear metamaterials or MEMs were presented at the conference and a short oral session was dedicated to them. Schottky mixers, correlators, submillimeter-wave heterodyne cameras, THz heterodyne instruments, measurements of the dielectric constant of materials at submillimeter-wavelengths,... were the subject of an important number of papers, 27 in total, classified in the categories "devices, receivers, imagers and spectroscopy". Several of them could also have been presented in other categories.

The number of papers per category is the following:

- *SIS papers :* 12 oral presentations + 9 posters
- *HEB papers :* 9 oral presentations + 12 posters
- *Direct detection :* 8 oral presentations + 3 posters
- *Sources :* 6 oral presentations + 10 posters
- *Novel devices & technologies for THz :* 5 oral presentations + 1 poster
- *Devices, receivers, imagers and spectroscopy :* 9 oral presentations + 18 posters

SESSION INDEX

DETAILED SCIENTIFIC PROGRAM

(Only the presenting author is indicated)

Wednesday 10 May 2006

09:00-09:30 **Conference Opening by Prof. Pierre Encrenaz.**

09:30-10:15 **Invited Speakers Session. Chairperson: Dr. Gérard Beaudin**

Dr. JM Lamarre, Observatoire de Paris, LERMA, "The HFI instrument for Planck"

Dr. Ulf Klein, ESA, ESTEC, "Future Satellite Earth Observation Requirements and Technology in Millimetre and Sub-Millimetre Wavelength Region"

10:45-12:00 **Oral session n°1: "SIS 1".**
Chairpersons: Dr. Jian-Rong Gao & Dr. Karl Jacobs

WE1-1 Kerr: "A Superconducting 180° IF Hybrid for balanced SIS Mixers"
WE1-2 Tong: "Theory of Series-Connected Distributed SIS Mixers with Ultra-wide Instantaneous Bandwidth"
WE1-3 Justen: "RF and IF couplers for a sideband separating SIS waveguide mixer for 345 GHz focal plane array"
WE1-4 Mena: "Side-band-separating heterodyne mixer for band 9 of ALMA"
WE1-5 Karpov: "1.4 THz SIS mixer development for radio astronomy"

12:00-12:30 **Poster session n°1 presentation by Dr. Jian-Rong Gao**

14:00-15:30 **Poster session n°1**

P1-01 Banik: "VO2 TES as Room Temperature THz Detectors"
P1-02 Camus: "Design of coplanar stripline duplexer for two-band bolometric detection integrated in large arrays of bolometers"
P1-03 Karasik:"A Phonon-Cooled Nb Direct Detector for SubMM Imaging and Spectroscopy"
P1-04 Shi: "Characterization of the Performance of a Quasi-Optical NbN Superconducting Hot-Electron Bolometer mixer"
P1-05 Gao: "Direct comparison of sensitivity between a spiral and a twin-slot HEB mixer at 1.6 THz"
P1-06 Hedden: "Characterization of Diffusion-Cooled Hot Electron Bolometers for Heterodyne Array Receiver Applications"
P1-07 Drakinskiy: "Gain bandwidth of THz NbN Hot Electron Bolometer Superconducting Mixers on thin SiO2 /SiNx membrane"
P1-08 Drakinskiy: "16 Pixel HEB Heterodyne Receiver for 2.5 THz"
P1-09 Dauplay: "Unexpected Frequency Shift on Membrane Based Double-Slot and Double-Dipole HEB Receivers"
P1-10 Semenov: "Does the Bandwidth of a Hot Electron Bolometer depends on the Local Oscillator Frequency"
P1-11 Rodrigues-Morales: "Optimal Coupling of NbN HEB THz Mixers to Cryogenic HEMT IF Low-Noise Amplifiers"
P1-12 Baselmans: "Influence of the direct response on the heterodyne sensivity of hot electron bolometer mixers"
P1-13 Merkel: "Quantum Noise in Hot Electron Bolometers"

P1-14 Scherer: "Physics of ultra-thin NbN films for phonon-cooled Hot-Electron-Bolometers"
P1-15 Kreisler: "Fabrication and characterization of ultrathin PBCO/YBCO/PBCO constrictions for further application as hot electron bolometer terahertz mixers"
P1-16 de Lange: "The Band 3 and 4 Flight Model mixer units for HIFI"
P1-17 Baryshev: "Design and development of a 600-720 GHz receiver for ALMA Band 9"
P1-18 Shitov: "Development of balanced mixers for ALMA Band-10"
P1-19 Grimes: "Analysis of subharmonic SIS mixers using SuperMix"
P1-20 Teipen: "Analysis of the influence of Current Density Jc and DC-Quality Q on Mixer Performance around 700 GHz for more than 50 measured SIS-Mixers"
P1-21 Navarrini: "Test of 1 mm Band Turnstile Junction Waveguide Orthomode Transducer"
P1-22 Gulevich: "Generation of THz radiation with the use of Vortices located in Jefferson ring"
P1-23 Febvre: "Ultrafast superconducting digital circuits and Interfaces for analysis and processing of microwave electrical signals"
P1-24 Boussaha: "Study of Josephson Electrodynamics in Parallel Arrays of Superconductive Junctions for Submm-Wave Local Oscillator Applications"

16:00-17:55 **Oral session n°2: "Direct detection".**
Chairpersons: Dr. Gregory Goltsman & Dr. Anders Skalare

Invited talk by Dr. Philip Mauskopf, University of Wales, Cardiff, UK, "Transition Edge Superconducting detector arrays for a 40-200 μm spectrometer on the SPICA telescope"

WE2-1 Karasik: "Ultralow NEP in the Hot-Electron Titanium Nanobolometers"
WE2-2 Vystavkin: "To the sensitivity estimation of transition edge sensor bolometers for submillimeter waveband radiation detection operating at super low temperatures"
WE2-3 Morozov: "Single photon counting detector for THz radioastronomy"
WE2-4 Matsuo: "Direct detection and interferometer technologies in terahertz range"
WE2-5 Audley: "Prototype Finline-coupled TES bolometers for CLOVER"
WE2-6 Piat: "Precise measurement of CMB polarisation from Dome-C: the BRAIN experiment"

Thursday 11 May 2006

09:00-10:00 **Oral session n°3: "Novel Devices & Technologies for THz". Chairpersons: Dr. Wojtek Knap & Dr. Peter Siegel**

TH1-1 Yngvesson: "Microwave Detection and Mixing in Metallic Singe Wall Carbon Nanotubes and Potential for a New Terahertz Detector"
TH1-2 Lee: "RF-to-Millimeter-wave Conductivity Spectra of Single-Walled carbon Nanotubes"
TH1-3 Foulon: "Terahertz non linear metamaterial"
TH1-4 Schicke: "Niobium SupraMEMS for Reconfigurable Millimeter Wave Filters"

10:30-12:00 **Oral session n°4: "SIS 2". Chairpersons: Dr. Anthony Kerr & Dr. Karl Schuster**

TH2-1 Vassilev: "A 211-275 GHz Sideband Separating SIS Mixer for APEX"
TH2-2 Heyminck: "The APEX 345GHz/460GHz 7-pixel heterodyne array"
TH2-3 Huggard: "Focal Plane Heterodyne SIS Receiver Array with Photonic LO Injection"
TH2-4 Claude: "Performance of the Band 3 (84-116 GHz) receiver for ALMA"
TH2-5 Serizawa: "A 385-500 GHz Balanced Mixer with a Waveguide Quadrature Hybrid Coupler"
TH2-6 Kamikura: "A 385-500 GHz Sideband-separating (2SB) SIS Mixer Based on a Waveguide Split-Block Coupler"

12:00-12:30 **Invited talk by Mrs. Nebes on Frequency Regulation and Management introduced by Dr. André Deschamps**

14:00-16:00 **Oral session n°5: "HEB". Chairpersons: Dr. Boris Karasik & Dr. Edward Tong**

TH3-1 Goltsman: "Spiral antenna coupled and directly coupled HEB mixers at frequencies from 1 to 70 THz"
TH3-2 Skalare: "An HEB cross-bar balanced mixer at 1.5 THz"
TH3-3 Jacobs: "1.9 THz and 1.4 THz waveguide mixers with NbTiN HEBs on Silicon Nitride Membranes"
TH3-4 Kooi: "IF Impedance and Mixer Gain of Hot Electron Bolometers and the Perrin-Vanneste Two Temperature Model"
TH3-5 Kuzmin: "Ultimate Cold-Electron Bolometer with SiN Tunnel Junction and Andreev Contact"
TH3-6 Gao: "Can NbN films on 3C-SiC/Si change the IF bandwidth of hot electron bolometer mixers ?"
TH3-7 Cherednichenko: "MgB2 thin film terahertz mixers"
TH3-8 Merkel: "Aging of Hot Electron Bolometers"

16:30-18:00 **Oral session n°6: "Sources". Chairpersons: Dr. Thomas Crowe & Dr. Didier Lippens**

TH4-1 Hu: "Terahertz quantum-cascade lasers as local oscillators"
TH4-2 Hovenier: "Phase lock and free running linewidths of a two color THz quantum cascade laser"
TH4-3 Kimberk: "A photonic Local Oscillator Module for Submillimeter Interferometry"
TH4-4 Eisele: "Performance Improvements in Low-Noise Oscillators and Power Combiners with Harmonic-Mode InP Gunn Devices"
TH4-5 Truscott: "Injection locked self-oscillating mixers for terahertz focal plane arrays"
TH4-6 Hesler: "Multiplier Development for the Upper ALMA Local Oscillator Bands"

Friday 12 May 2006

09:00-09:30 **Poster session n°2 presentation by Dr. Heribert Eisele & Dr. Imran Mehdi**

09:30-10:30 **Oral session n°7: "Devices, Receivers & Instruments". Chairpersons: Dr. Heribert Eisele & Dr. Imran Mehdi**

FR1-1 Schlecht: "A Novel 520 to 600 GHz Subharmonic Biasable Mixer"
FR1-2 Chattopadhyay: "TIP : A Terahertz Interferometer for Planets - A Concept Study"
FR1-3 Erickson: "A very Wideband Analog Autocorrelation Spectrometer"
FR1-4 Withington: "A Modal and Quantum-Statistical Analysis of Imaging Phased Arrays and Interferometric Phased Arrays"

11:00-12:30 **Poster session n°2**

P2-01 Thomas: "A broadband fixed-tuned 380 GHz Schottky-based subharmonic mixer"
P2-02 Rollin: "A Low Noise Integrated Sub-Harmonic Mixer at 183GHz"
P2-03 Siles: "Design of a 400 GHz Schotty Mixer for Hign Performance Operation"
P2-04 Siles: "Design of Heterostructure Barrier Varactor Frequency Multipliers at Millimeter-wave Bands"
P2-05 Maestrini: "A High efficiency Multiple-Anode 260-340 GHz Frequency Tripler"
P2-06 Truscott: "A Design Methodology for Planar Triplers in Coplanar Waveguide on Thick Membranes"
P2-07 Paveliev: "Experimental study of the harmonic generators and detectors, based on superlattices in wide frequency range 600-2200GHz"
P2-08 El Fatimy: "Resonant terahertz detection in InGaAs/AlInAs and AlGaN/GaN - based nanometric transistors"
P2-09 Chimot: "Terahertz emission and detection from ion-irradiated In0.53 Ga0.47As gated at 1.55 μm"
P2-10 Pavlov: "Spectral Characterization of a 2.5 THz Multi-Mode Quantum Cascade Laser"
P2-11 Puetz: "Micromachined Spatial Filters for Quantum Cascade Lasers"
P2-12 Dhillon: "Phase matched frequency mixing between telecom wavelengths and THz radiation in a quantum cascade laser"
P2-13 Torres: "Analysis of the stable two-mode operation of a 4-sections semiconductor laser for THz generation by photomixing"
P2-14 Tignon: "THz generation by optical rectification and competition with other nonlinear processes"
P2-15 Saeedkia: "Theory and Design of an Edge-coupled Terahertz Photomixer Source"
P2-16 Banik: "Catadioptric Microlenses for Submillimeter and Terahertz Applications"
P2-17 Martin: "CFRP Mirror Technology for Submillimeter and Shorter Wavelengths"
P2-18 Martin: "CFRP Structures for Astronomy Applications"
P2-19 Schuster: "Micro-machined Planar THz Optics"
P2-20 Murk: "Characterization of Micromachined Waveguide Hybrids at 345 GHz and 600 GHz"
P2-21 Ward: "New Standards for Submillimeter Waveguides"
P2-22 Hunter: "Quasi-Optical Faraday Rotator Design, Construction and Evaluation"
P2-23 Candotti: "Cross-polarization characterization of GORE-TEX at ALMA band 9 frequencies"
P2-24 North: "Rigorous Analysis of Antipodal Finline Tapers for High Performance Millimetre and Sub-millimetre Detectors"
P2-25 Emrich: "Spectrometers for (sub)mm radiometer applications"
P2-26 Pardo: "Atmospheric opacity above 1 THz: evaluation for the Alma site and for laboratory developments"

P2-27 Constantin: "Terahertz frequency metrology and sensitivity issues in photomixer spectrometer"
P2-28 Nyström: "A Vector Beam Measurement System for 211-275 GHz"
P2-29 Stacey: "Detection of the 205 μm [NII] Line from the Carina Nebula"

14:00-15:00 **Oral session n°8: "Superconductors for Imagers & Detectors". Chairpersons: Dr. Netty Honish & Dr. Jacob Kooï**

FR2-1 Baselmans: "Development of high-Q superconducting resonators for use as kinetic inductance detectors"
FR2-2 Liu: "Development of a 585 GHz One-Dimensional Diffusion-Cooled Nb HEB Mixer Imaging Array Based on the "Reverse-Microscope" Concept"
FR2-3 Gu: "A Two Dimensional Terahertz Imaging System Using Hot Electron Bolometer Technology"
FR2-4 Groppi: "SuperCam : A 64 pixel superheterodyne camera"

15:15-16:45 **Oral session n°9: "THz Spectroscopy & spectrometers". Chairpersons: Dr. Neal Erickson & Dr. Wolfgang Wild**

FR3-1 Constantin: "High resolution terahertz spectroscopy of species of astrophysical interest"
FR3-2 Goy: "Quasi-Optical Characterization of Dielectric and Ferrite Materials"
FR3-3 Yagoubov: "550-650 GHz spectrometer development for TELIS"
FR3-4 Wiedner: "Condor-an Astronomical Heterodyne Receiver at 1.25 - 1.5 THz"
FR3-5 Huebers: "High resolution spectroscopy with a quantum cascade laser at 2.5 THz"
FR3-6 Hajenius: "Heterodyne receiver based on hot electron bolometer and quantum cascade laser for detection of the OH line at 3.5 THz"

16:45-17:00 **Closing of the conference by Dr. Alain Maestrini**