DVT Research Group

A joint research group between
Ilmenau University of Technology and
Fraunhofer Institute for Integrated Circuits IIS

Ilmenau, November 12th, 2014

Prof. Giovanni Del Galdo

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The DVT Research Group in a Nutshell

- Founded in 2008 by Prof. Heuberger (currently Director of Fraunhofer IIS)
- Since April 1st, 2012: led by Prof. Del Galdo
- The DVT research group is composed of **two parts**
  - **(1) chair** at Ilmenau University of Technology
  - **(2) department** at Fraunhofer Institute for Integrated Circuits

- Goal: carry out outstanding **fundamental research** and transfer the scientific results into **application oriented projects**

- Personnel
  - at TUI: 8 PhD students, 3 postdocs, 1 researcher
  - at IIS: 1 group manager, 6 employees

Fraunhofer IIS - Locations

- *Erlangen*
  Headquarters
- *Fürth*
  Development Center for X-ray Technology
  Center for Intelligent Objects
- *Nuremberg*
  Localization and Communication
- *Dresden*
  Design Automation
- ***Ilmenau***
  Wireless Distribution Systems / Digital Broadcasting (DVT)
- *Bamberg*
  Supply Chain Management
- *Würzburg*
  X-ray Microscopy

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Technische Universität Ilmenau

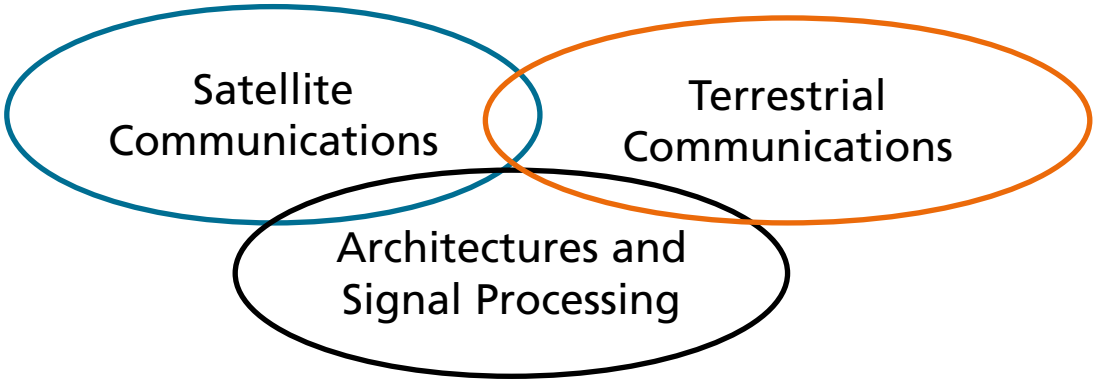
Departments:

- Electrical Engineering and Information Technology
- Computer Science and Automation
- Mechanical Engineering
- Mathematics and Natural Science
- Economics Sciences

Key Numbers:

- 7000 students
- 100 proferssors
- Ilmenau has 26.000 inhabitants

Research topics



- Testing of communication systems and radio devices
  - SatCom-On-The-Move (SOTM) terminals, in Ku and Ka band
  - MIMO terrestrial UE, up to 6 GHz
    - mobile communications
    - Global Navigation Satellite Systems (GNSS)
    - Car-2-Car, Car-2-Infrastructure
    - industrial communications
- Architectures and Signal Processing for Efficient Measurements
  - parameter estimation (e.g. DOA), spectrum sensing
  - x-ray computed tomography, CMOS imaging sensors

Facility for Over-the-air Research and Testing (FORTE)

- The Fraunhofer IIS testing facilities in Ilmenau have been inaugurated in October 2011
- They consists of an antenna tower (50m) and a building hosting the labs

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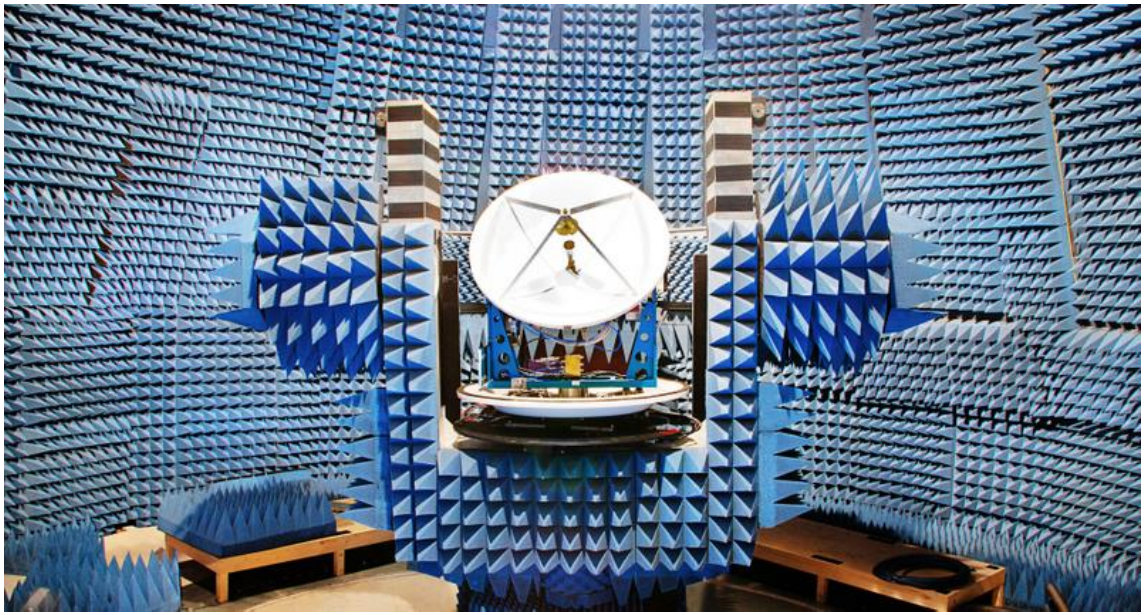
FORTE: Number, Figures, Facts

- Build: 08/2010 – 09/2011
- Architects: staab Architekten GmbH, Berlin
- Project leader : Fraunhofer / Headquarters in Munich
- Companies involved in the construction: 30
- Floor space: 221 m^2
- Budget:
  - Approx. 4 M€
  - Financing
    - Project funding from DLR, Ministry of Thuringia
    - Base funding from Fraunhofer IIS

Facility for Over-the-air Research and Testing (FORTE)

Research platform: »SatCom«

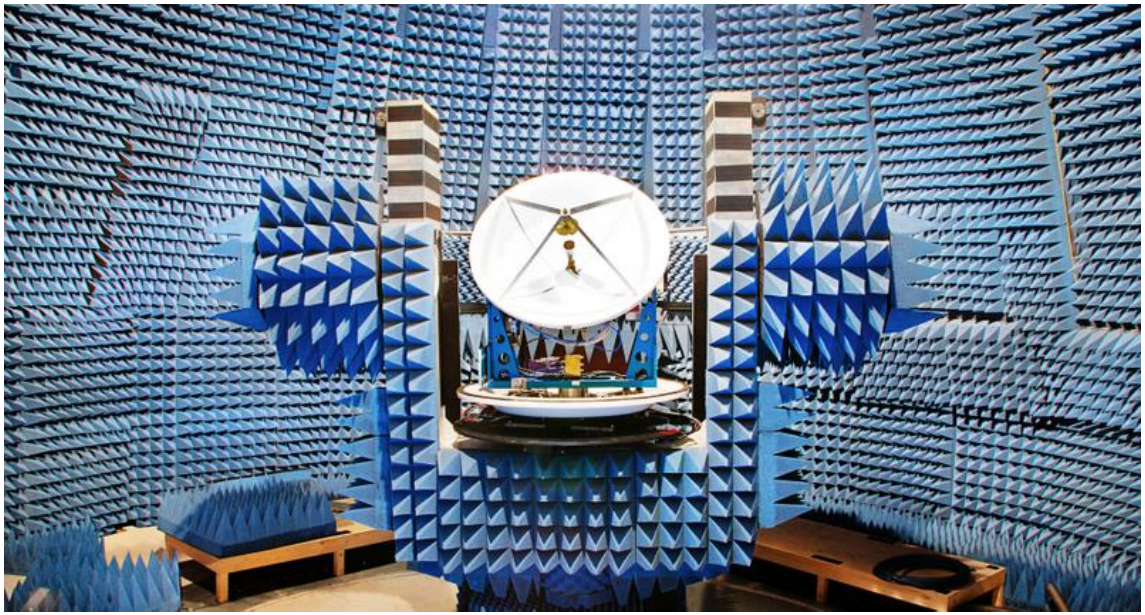
- Goal: to test SatCom-On-The-Move (SOTM) terminals by emulating a satellite connection for arbitrary scenarios (e.g. movement, shadowing) in Ku and Ka band



Facility for Over-the-air Research and Testing (FORTE)

Research platform: »SatCom«

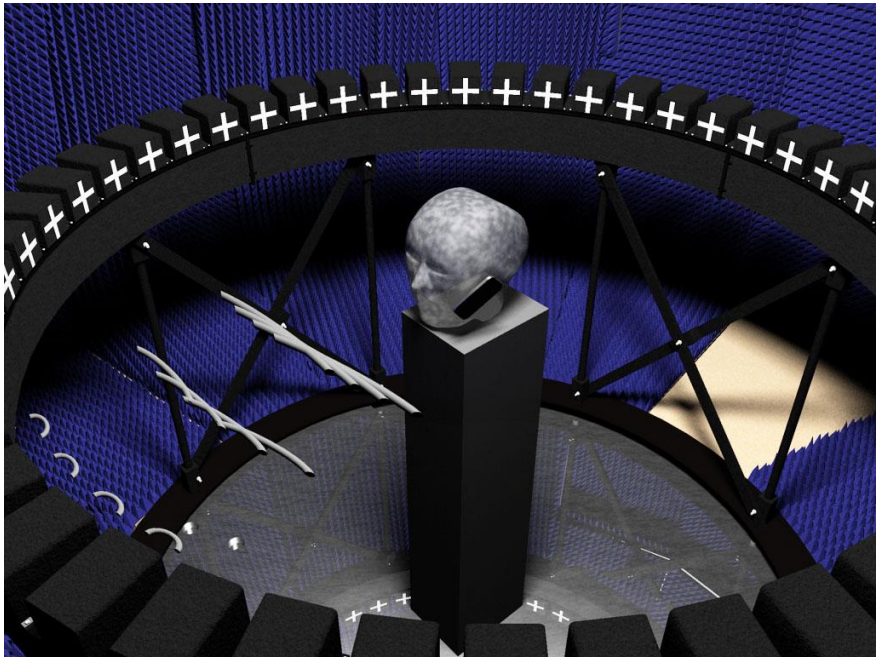
- For more information and a video explaining how the research platform works please visit: www.iis.fraunhofer.de/forte



Facility for Over-the-air Research and Testing (FORTE)

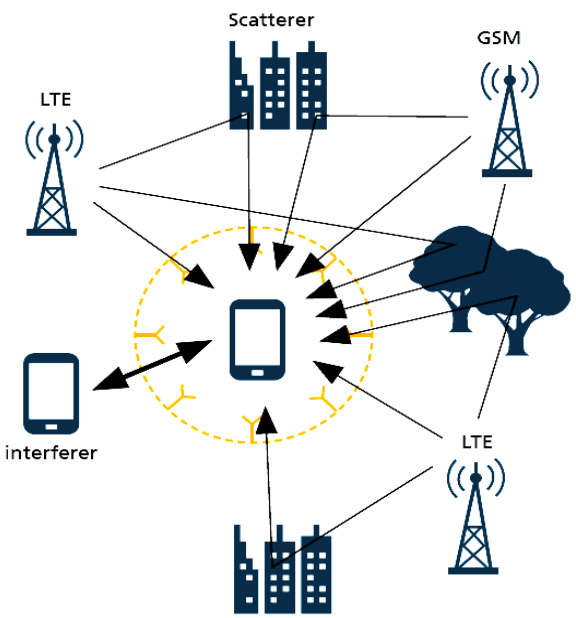
Research platform: »MIMO-OTA«

- Goal: to realize a »universal« Over-The-Air testing system by emulating arbitrary time variant spatial channels and by employing wave field synthesis

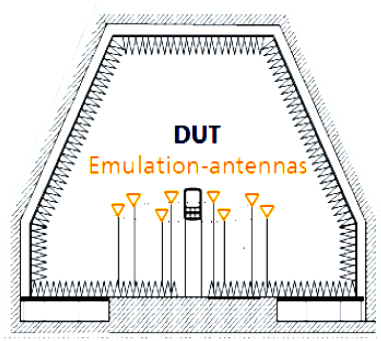


Research Activities »OTA*in*VEE«

- Over-The-Air testing in a Virtual Electromagnetic Environment
  - emulate all features of the electromagnetic field relevant for the Device under Test (DuT) within a confined anechoic chamber
    - Advantages:
      - reproducibility via a controlled environment
      - no interference to and from deployed systems
      - arbitrary scenarios can be realized
      - time-variant frequency-selective spatial channel



Emulation



OTA in VEE

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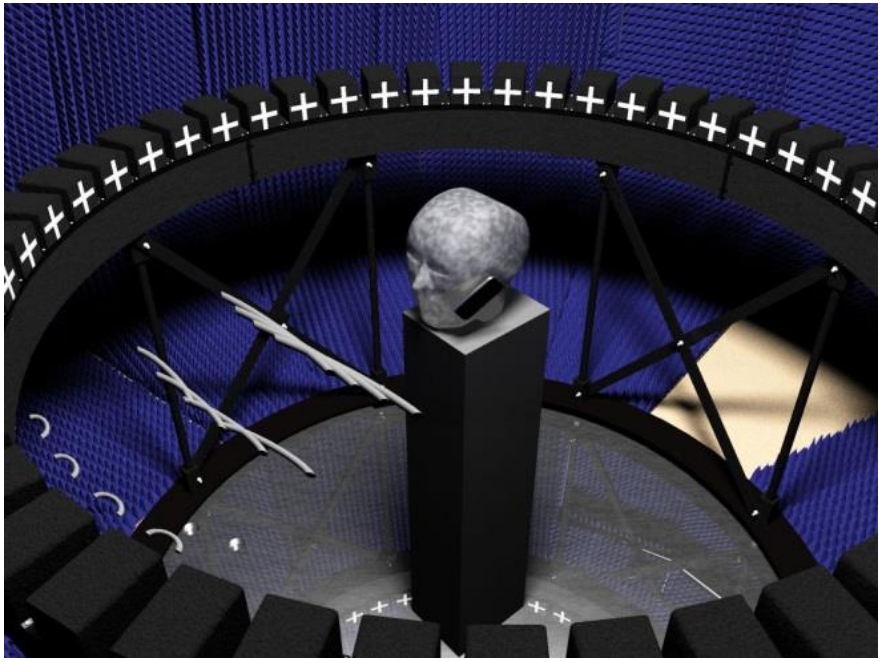
Research Activities »OTA*in*VEE«

- Over-The-Air testing in a Virtual Electromagnetic Environment
  - Mobile communication systems (LTE, LTE-A, UMTS, 5G)
  - Cognitive radio systems
  - Global navigation systems
  - Industrial communication systems
  - C2I (car to infrastructure), C2C (car to car) systems



OTA in VEE

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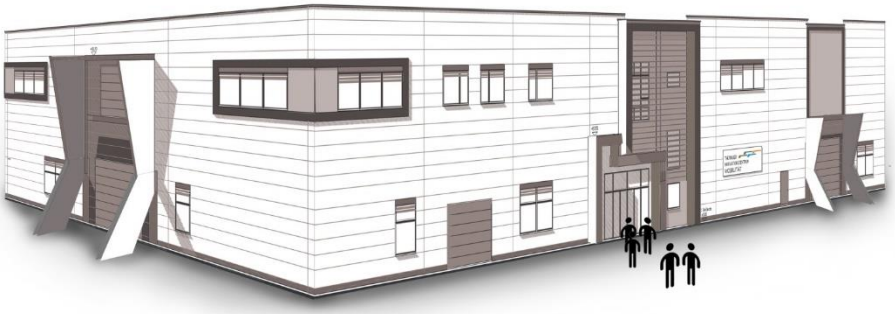
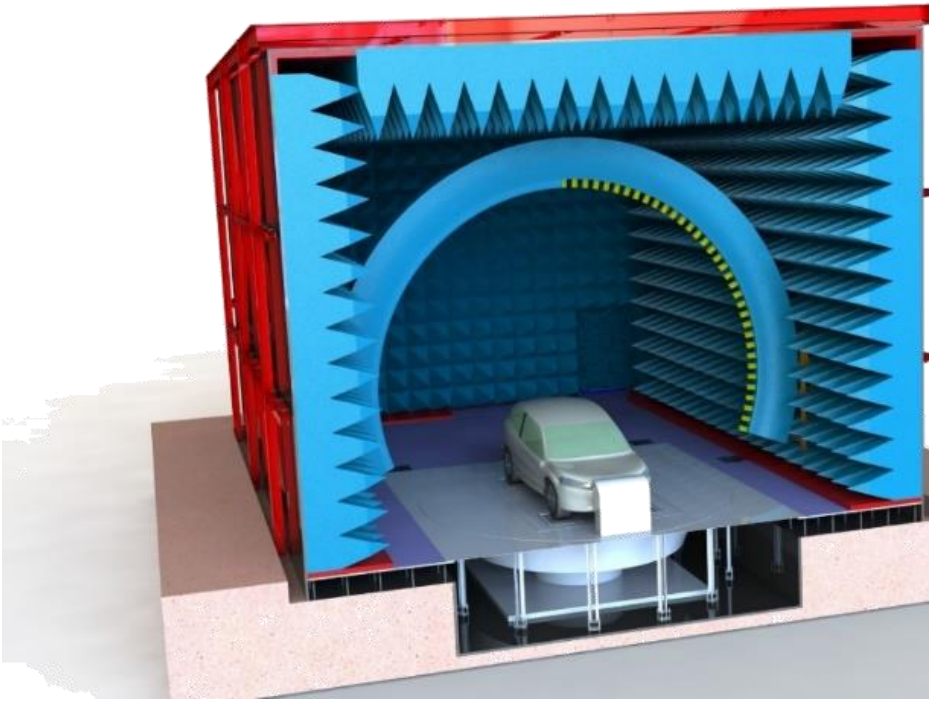
Research Topic »OTA*in*VEE« - VISTA

- Virtual Road – Holistic simulation and emulation concept
  - measurement of vehicular antennas
    main frequency range 400…6000 MHz,
    Extension 70…400 MHz
  - electromagnetic compatibility
    emission, robustness
  - virtual EM environment
    OTA*in*VEE measurements,
    channel emulation
  - drive train measurements
    turntable with dynamometer,
    drive profiles





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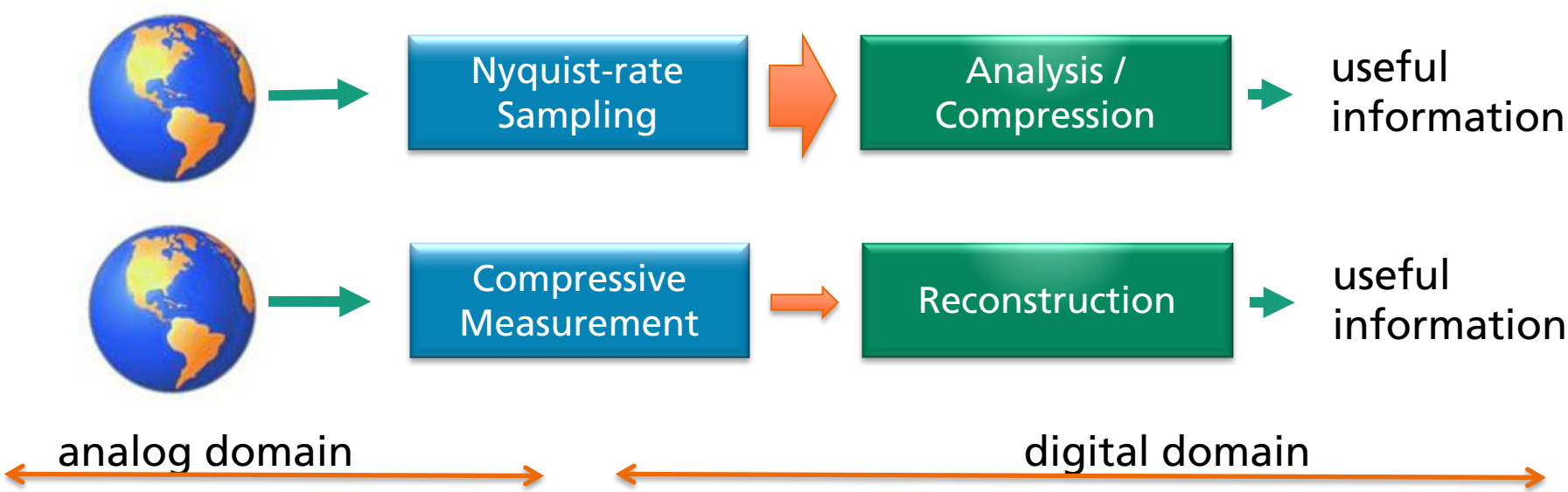
Architectures and Signal Processing for Efficient Measurements

- Signal acquisition plays a crucial role in a multitude of applications
- Traditionally, sampling is carried out at Nyquist rate
- By exploiting *a priori* information on the signals, it is possible to sample them at a lower rate without loss of information, i.e., the signals are measured in a **compressed domain**



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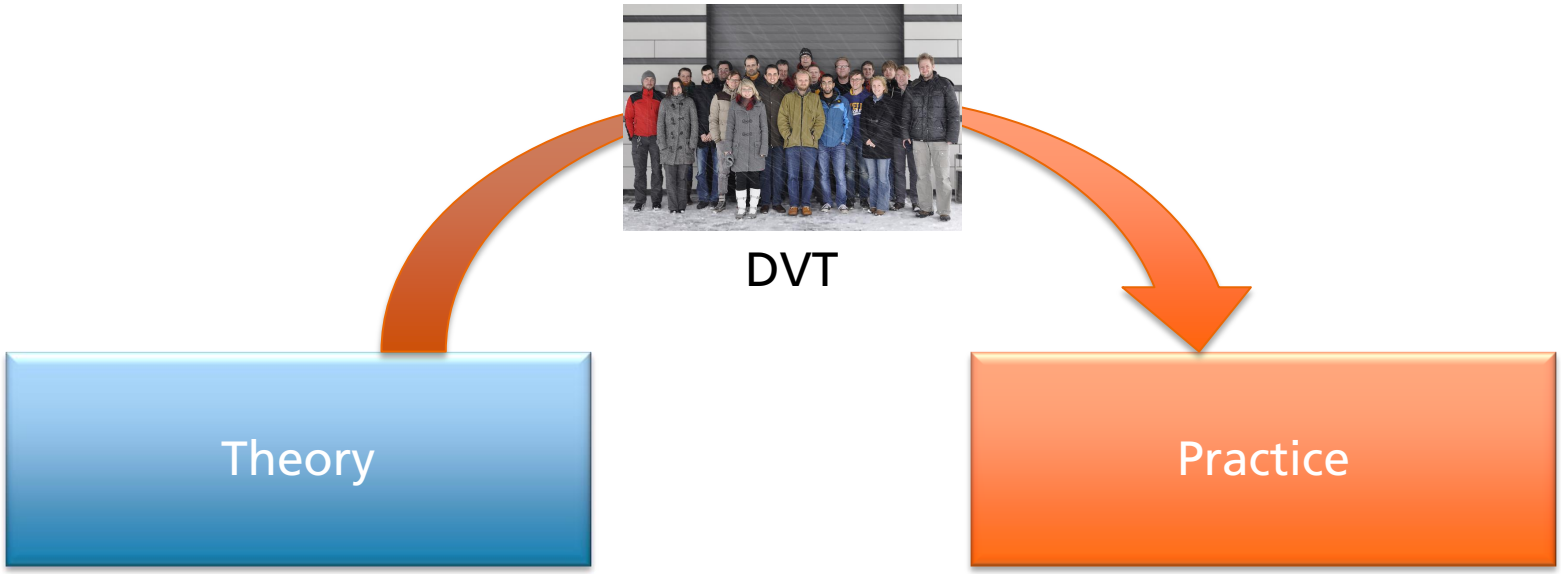
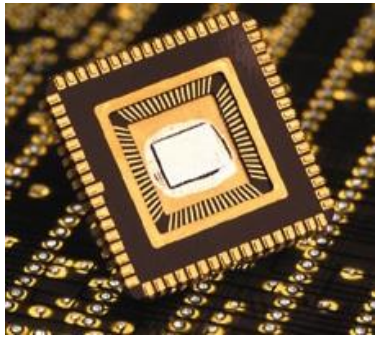
Architectures and Signal Processing for Efficient Measurements

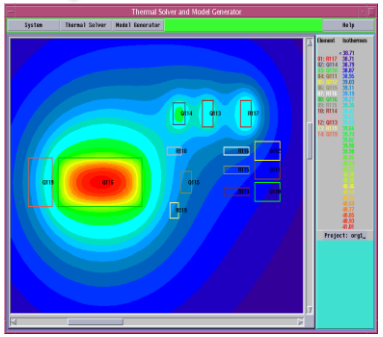


- DVT attempts to bridge the gap between theory and practice
- To do so, we collect sound know-how in the theory and build collaborations with experts close to practical applications

Architectures and Signal Processing for Efficient Measurements

DVT

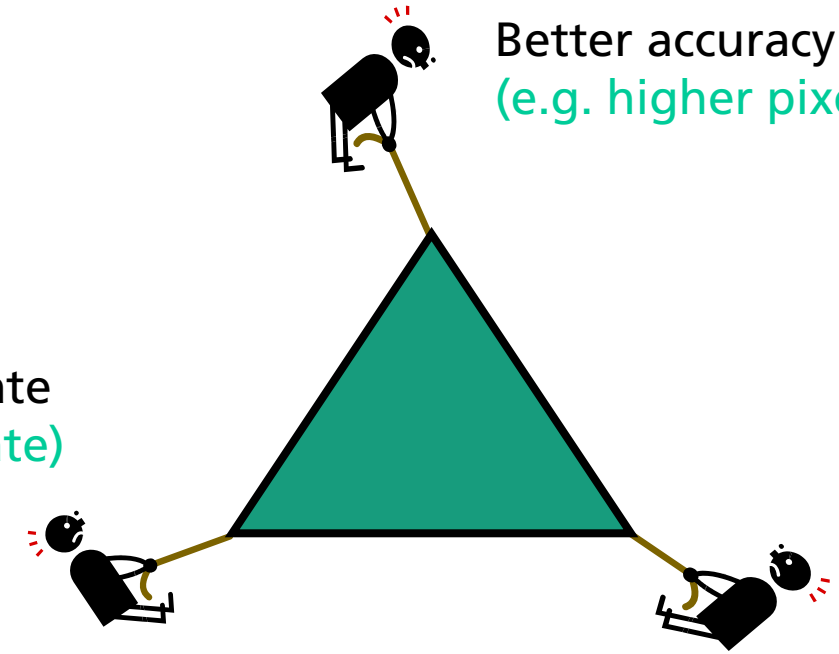




- DVT attempts to bridge the gap between the hardware implementations (e.g. sensors and detectors) and the application-specific signal processing
- Ideally: bring signal processing motivated hardware modifications

Architectures and Signal Processing for Efficient Measurements

- Compared to traditional approaches, by carefully designing the measurement process we have control over the following advantages



Better accuracy
(e.g. higher pixel resolution)

Higher acquisition rate
(e.g. higher frame rate)

Lower data rate
from the sensor
(e.g. fewer samples
per frame)

In parenthesis, an example for an imaging sensor

Theoretical Aspects of Compressive Sensing

Aspects that are not specific to one application field but could potentially be applied to many

- Measurement design
  - design a measurement matrix in the presence of noise (SNR, dynamic range, support recovery, resolution)
  - adaptive measurement design
    - measure next based on the previous (e.g., ROI)
- Sparsity order estimation
  - how to estimate the sparsity order in the compressed domain
  - implications on the measurement design and recovery
- Compressed domain processing (e.g., detection, pattern recognition)
- Structured sparsity
  - tensor description (multidimensional signals, e.g., RADAR)
  - polarization

Thank you for your attention!

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