IT'IS FOUNDATION 2019

Cover: Animal (Rat and Pig) High-Resolution Anatomical Models for Dosimetry Research

TWO DECADES OF INNOVATIVE RESEARCH

At the end of November 2019, we proudly celebrated our 20th anniversary with a bombastic party that featured cleverly designed acts performed by groups from the entire workforce. These acts demonstrated very well the highly dynamic and innovative environment that has prevailed at the IT'IS Foundation – and at Z43 as a whole – over the last 20 years. Click here to watch some impressions of the party. After celebrating as if there were no tomorrow, the IT'IS team is now looking forward with optimism and enthusiasm to the next exciting decade!

Our history can be viewed as two very distinct parts: During the first 10 years after its inception in 1999, IT'IS successfully established itself as the leading research competence center and trusted technology partner in near-field measurement and simulation technologies and in electromagnetic (EM) risk assessments. During the second decade, our core competencies were further expanded to encompass computational life sciences (CLS), in particular to applications in precision medicine. Today, more than 50% of IT'IS funding supports medical research activities, leading to many new collaborations and key publications over the years (see Page 15).

One key achievement certainly was the release of the Virtual Population (ViP) anatomical models combined with advanced tissue models and breakthroughs in computational multiphysics solvers – the world's first – that are sufficiently powerful to handle the continually increasing resolution and functional features of the models.

The ViP success prompted pursuit of the ambitious goal to develop technologies capable of performing advanced simulations directly in a web-browser rather than at desktop workstations. Parts of these developments are already being used in the o²S²PARC project funded by the US National Institutes of Health (NIH).

In recent years, additional visibility has been achieved with (i) breakthroughs in computational neuromodeling; (ii) the qualification of our implant evaluation tools as the first Medical Device Developmental Tool by the US Food and Drug Administration (FDA) and (iii) research on mm-wave technologies that resulted in a series of land-mark papers (see Page 15) and empowered Z43 partner SPEAG to innovate unique solutions for compliance testing of 5G devices. The latest achievements of all Z43 activities are provided four times a year in our Newsquarter (click here to subscribe).

Looking towards the future, we are confident that the Foundation's unique knowledge base and infrastructure can be leveraged to provide solutions for 6G and beyond, with further applications possible in the fields of precision medicine, material sciences, and more. Our forward-looking spirit is demonstrated by our investment in additional premises (see Page 13) to expand our workspace. Furthermore, with the founding of the TI Solutions AG on the last day of 2019 by IT'IS/Z43 members jointly with our colleagues at MIT, Harvard Medical School and Imperial College London, we are diving deeper into the research on non-invasive brain and peripheral nerve stimulations.

Our successes would not have been possible without the unrelenting dedication of our gifted staff, who continue to expand the boundaries of knowledge. Equally important has been, and continues to be, the consistent support, encouragement, and insightful counsel of our Board Members (see Page 4). We remain most grateful for the shared vision at the turn of the millenium of ETH presidents Olaf Kübler and the late Jakob Nüesch as well as Profs. Wolfgang Fichtner, Peter Niederer, Albert Kündig, and Quirino Balzano, which was fundamental to the establishment of IT'IS.

We are equally grateful for the support of the large number of public agencies and commercial sponsors for funding many of our projects (Page 9).

As we embark on the journey into the next decade, we will further continue to build on existing core competencies in EM and computational life sciences to leverage our distinctive capabilities into intersecting research areas and to continue our mission in shaping the future through research for decades to come.

Prof. Niels Kuster

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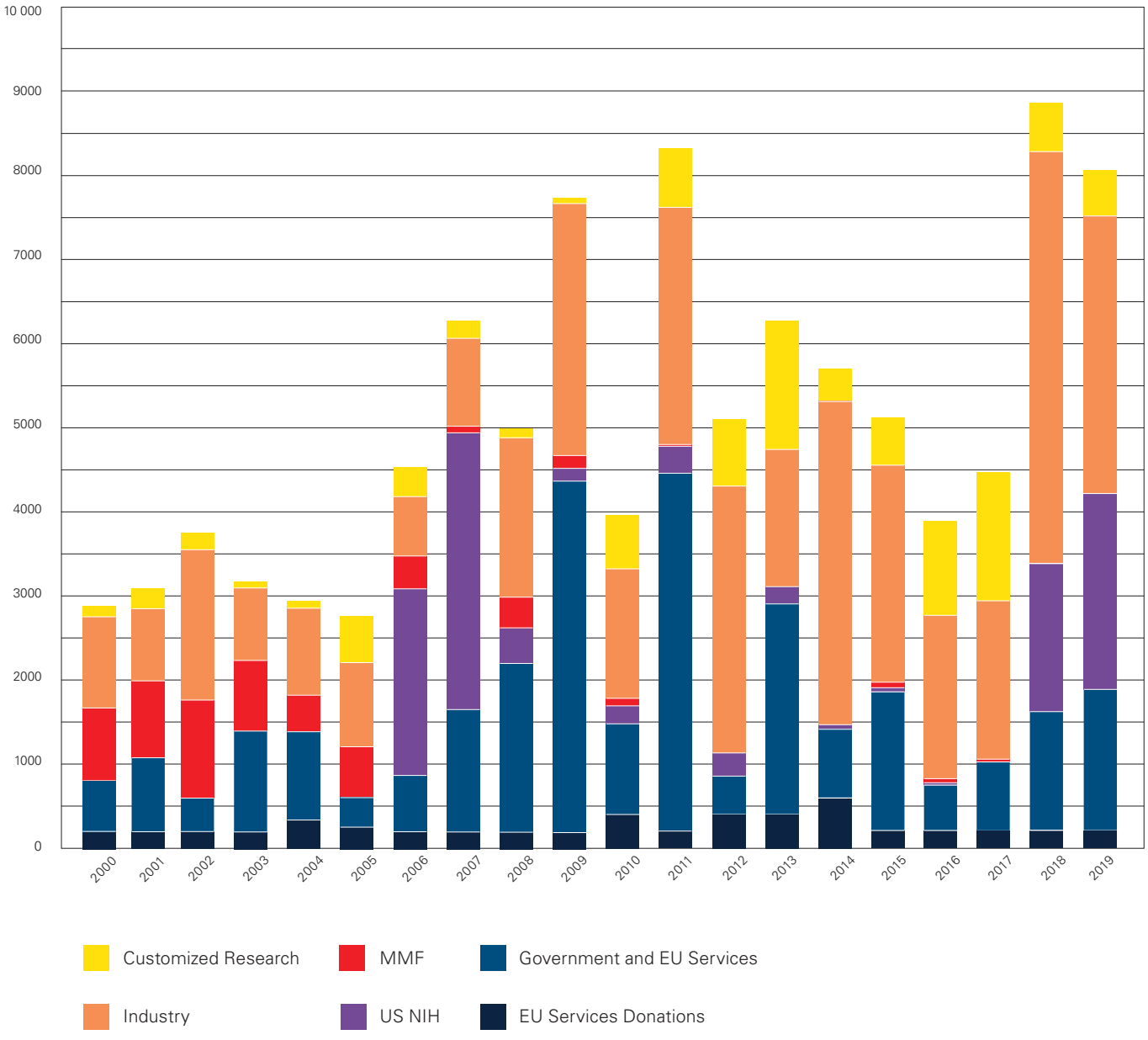
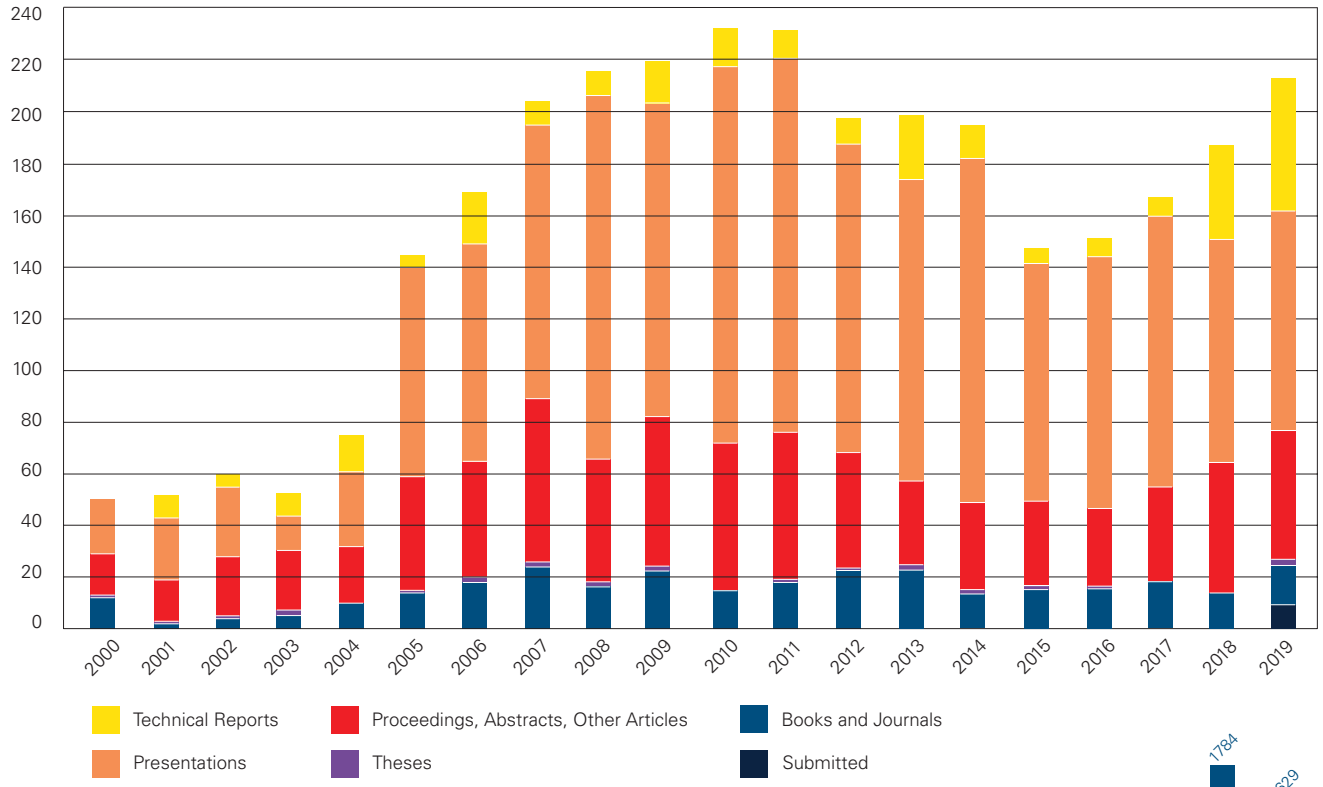
Level of Funding (in 1000 CHF)

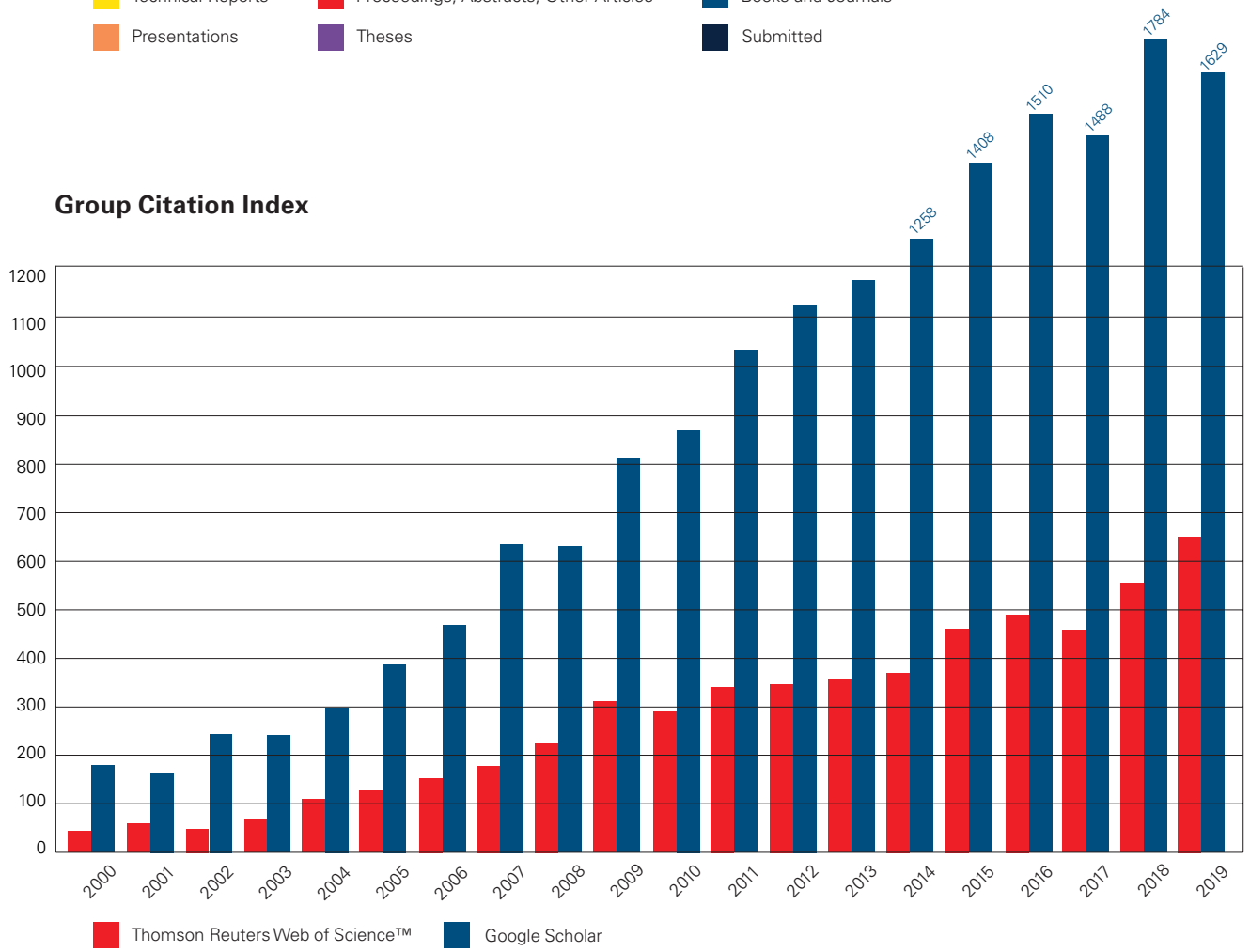


KEY FIGURES

Number of Publications



Group Citation Index



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Medartis AG, CH
ON Semiconductor, CH
Phonak Communications AG, CH
Research and Consulting Co. Ltd., CH
RUAG, CH
SensArs, CH
Schmid & Partner Engineering AG, CH
Swiss Federal Railways, CH
Swisscom, CH
ZMT Zurich MedTech AG, CH
FRONIUS International GmbH, AT
MED-EL, AT
Cochlear, AU
Cardiatis, BE
Dow Silicones Belgium SPRL, BE
iMinds, BE
Mobile & Wireless Forum, BE
Synergia Medical, BE
MicroPort Scientific Corporation CRM, CN
Biotronik, DE
Dialogik GmbH, DE
Dr. Sennewald Medizintechnik GmbH, DE
Draeger, DE
Forschungs- und Technologiezentrum der Deutsche Telekom, DE
Incos Boté Cosmetic GmbH, DE
Kathrein-Werke KG, DE
Pfisterer International AG, DE
Roche Diagnostics, DE
Siemens AG, DE
T-Mobile International AG, DE
TÜV SÜD Auto Service GmbH, DE
Nokia Research Center, FI
SYNOSTE, FI
Healtis, FR
Image Guided Therapy, FR
Orange S.A., FR
Oticon Medical, FR
Sorin CRM/LivaNova, FR
THESS, GR
Istituto Di Ricerche Biomediche "Antoine Marxer" S.p.A., IT
Milexia Group, IT
MEDICO SpA., IT
TILAB SpA., IT
Alnair Labs, JP
Association of Radio Industries and Businesses, JP
Mitsubishi, JP
NTT Communications, JP
NTT DoCoMo, JP
Takeda Pharmaceutical Company, JP
Toshiba, JP
Dymstec, KR
HCTM, KR
GTX Medical, NL
Philips Medical Systems, NL
Vratis, PL
Ericsson Radio Systems AB, SE
Torptronics Engineering AG, SE
Volvo Car Corporation, SE
EMFields Solutions Ltd., UK
Galvani Bioelectronics, UK
IndexSAR, UK
MCL Technology Ltd., UK
Vodafone, UK
York EMC Services, UK
Abbott/St. Jude Medical Inc, US
AGC Automotive, US
AT&T, US
BrainsGate, US
Boston Scientific, US
CranioVation, US
CTIA, US
Exponent Inc., US
Flex, US/SG
GE Healthcare, US
Imricor Medical Systems, US
Intel Corp., US
Mainstay Medical, US
Micro Systems Engineering Inc., US
Microsoft, US
Motorola, US
MRI Interventions Inc., US
National Instruments, US
Nevro Corporation, US
Qualcomm, US
SeboTek Hearing Systems, US
Synopsis Inc., US

** For more information about individual departments, please consult https://www.itis.swiss/who-we-are/partners/*

PROJECTS

EM Technology

TD SENSOR	Development of time-domain near-field field sensor technology
OH4VNA	Development of a miniature optically-fed electrical measurement head for a vector network analyzer
ICEy-RE	Implementation and validation of a novel dual near-field EMC/EMI and radiated emission testbed
WPT/P11	Development of test equipment and software to show compliance with EM safety guidelines of wireless power transfer (WPT) systems

EM Exposure and Risk Assessment

sXc, sXv, sXh	Development of optimized exposure systems for bio-experiments from static to GHz frequencies
sXv – NTP/NIEHS-II	Development, manufacture, installation, and detailed dosimetry of the exposure systems for the National Institutes of Environmental Health Sciences (NIEHS) *in vivo* follow-up studies
MICEV	Development of metrology techniques to advance inductive power transfer for charging electric vehicles
MIMAS	Development of anatomical models, computational tools, and methodologies to facilitate the safety assessment of metallic implants in magnetic resonance imaging (MRI)

IT'IS for Health

CLS - o^2S^2PARC	Establishment of an interactive, freely accessible online platform for simulating peripheral nerve system neuromodulation / stimulation
CLS - FUS	Transcranial Focused Ultrasound; Sonoknife; Liver motion during FUS interventions
CLS - V&V40	Development of novel concepts for verification and validation of computational life science software platforms and their applications
ViP 4.x	Development of the next generation of high-resolution anatomical models
ViP - NEUROMAN	Functionalized anatomical models for studying EM-neuronal dynamic interactions
ViP - P/VM/M	Development of novel posers, of methodology for enhanced volume meshes of anatomical structures and of a physically-based morphing tool
MRI - MRIneo	Development of MRI exposure risk probability of fetuses and newborns based on local temperature safety considerations
MRI - MRInext	Development of tools to morph anatomical models to patient anatomies for personalized *in silico* radiofrequency exposure assessment
MRI - Implant Safety	Improved procedures and instrumentation for MRI-safety evaluation of medical implants
MRI - ULF NMR	Development of numerically validated MRI coil and electric phantom models, and optimization of neuronal current imaging with ultra-low field nuclear MRI
Cranio	Modeling of craniospinal compliance in humans to advance the understanding of dynamic compliance and its pathophysiologic basis
NeuHeart	Development of a neuroprosthesis to restore the vagal-cardiac closed-loop connection after heart transplantation
PerfusImaging	Establishment of a metrological framework for blood perfusion measurements of impaired heart tissues by means of medical imaging technology
RESTORE	Development of a patient-specific system based on targeted epidural electrical stimulation to restore locomotion in paraplegic patients
PREP2GO	Development of a pre-operative planning system for neuromodulation surgery for spinal cord injury rehabilitation (starting date: April 2020)
HT-KSA/UHZ/ETHZ	Development of novel hyperthermia hardware and treatment planning software for human applications
REPLICATIONS	Validation and mechanistic investigation of modulation-specific cellular EM effects published by Zimmermann *et al.*
RISE	Implementation of a protocol for reaching deep structures by non-invasive brain stimulation to modulate striatum-based learning
DEEP-MCI-T	Development of a novel approach, based on temporal interference stimulation, aimed at deep non-invasive brain stimulation to enhance cognitive functions in mild cognitive impairment and traumatic brain injury
STANDARDIZATION	Participation in regulatory activities (standards committees and governments)

Z43 EXPANDS INTO NEW QUARTERS: MOVING TO THE FRONTLINE!

During the week before Christmas 2018, Niels received a phone-call from his friend Andi Stutz. Andi, together with his sisters Elsa and Maya, are the founders of Fabric Frontline, the famous Swiss luxury brand renowned since the 1980s for its exquisite silk fabrics. "Niels, we nearly forgot you – we are in the process of renting out the former Fabric Frontline premises, but then remembered that you really like our buildings … ". Niels was in Andi's office to sign the contract before he could even finish the sentence.

Fabric Frontline and Z43 have a long history together. After SPEAG moved with IT'IS into Zeughaussstrasse 43 in 2000, Fabric Frontline and SPEAG were the only companies in the red-light district of downtown Zurich that were producing high-quality goods on-site for the world. Andi, known as the *The Silk King*, is the most generous host and the city's most colorful *bon vivant*; the Fabric Frontline buildings at Kräuelgasse 9 / Ankerstrasse 118 were the place to see and be seen.

That telephone call changed Z43: since April 2019, the former creative environment of the Fabric Frontline brand has been providing a new home for the entire computational life sciences team as well as some much-needed additional meeting space, just a stone's throw away from the main headquarters. Investments in the buildings were made with an eye to preserving much of their history by retaining the character of the interieur, including the grand piano, as well as the legendary garden dwarfs. It remains an oasis of calm, a beautiful leafy shaded green zone in the heart of Zurich.

We are very proud that the motivational spirit of the buildings' creative past lives on with Z43!

INFRASTRUCTURE

Dosimetric, Near-Field, and EMC/EMI Facilities

Semi-Anechoic Chamber

This shielded, rectangular chamber has the dimensions 7 × 5 × 2.9 m (L × W × H). It is equipped with a reflecting ground plane floor, and half of its walls are covered with electromagnetic absorbers. The chamber contains an integrated DASY52NEO system and can be utilized for all research activities involving dosimetric, near-field and far-field evaluations, the optimization and synthesis of handheld devices, body-mounted transmitters, implants, desktop applications, micro-base and pico-base station antennas, exposure setups, calibration procedures, EMI tests, MRI safety tests, compliance testing of implants, etc.

Two Reverberation Chambers

The Blue and NIEHS reverberation chambers have the dimensions 4 × 3 × 2.9 m and 3.7 × 2.2 × 2.7 m (L × W × H), respectively. Both chambers are equipped with two mechanical stirrers and provide controlled and consistent environments for EM emissions and immunity testing, as well as shielding effectiveness and susceptibility testing of electromagnetic equipment.

Facility for Dosimetric Compliance Testing

IT'IS shares with Schmid & Partner Engineering AG a facility that meets the requirements for dosimetric evaluations. The documentation of Class C accreditation has been completed.

Technical Equipment and Instrumentation

Spectrum and Network Analyzers

1 HP 8753E Network Analyzer, 30 kHz–6 GHz
1 HP APC 85033B Calibration Kit
1 Rohde & Schwarz FSP Spectrum Analyzer, 9 kHz–30 GHz
1 Rohde & Schwarz ZVA24 Vector Network Analyzer, 10 MHz–24 GHz
1 Rohde & Schwarz ZVA50 Vector Network Analyzer, 10 MHz–50 GHz
1 Rohde & Schwarz ZV-Z52 Calibration Kit
1 Copper Mountain R60 Vector Reflectometer
1 Keysight E5061B Vector Network Analyzer, 5 Hz–1.5 GHz

Signal Generators and Testers

3 Agilent 33120A, Waveform Generators
1 Agilent 33250A, Waveform Generator
1 Agilent E8251A Signal Generator, 250 KHz–20 GHz
3 Anritsu 3700A
2 Anritsu MG3700A
1 HP 8647A, Signal Generator 250 KHz–1000 MHz
1 Rohde & Schwarz CMU200
1 Rohde & Schwarz CMW500
1 Rohde & Schwarz CTS55, Digital Radio Tester
1 Rohde & Schwarz SMIQ02B, Signal Generator
2 Rohde & Schwarz SML02, Signal Generators
1 Rohde & Schwarz SML03, Signal Generator
1 Rohde & Schwarz SMT06, Signal Generator
1 Rohde & Schwarz SMU200A, Signal Generator
1 Rohde & Schwarz SMY02, Signal Generator

DASY, cSAR3D, DAE, EASY4MRI, MITS, PiX, Phantoms, Resonators

1 INDY (3 year old child head) Phantom
1 ISABELLA (6 year old child head) Phantom1 SPEAG ASTM Phantom
2 SPEAG DAE4, Data Acquisition Electronics
1 SPEAG DAE4A, Data Acquisition Electronics
2 SPEAG DAE4ip, Data Acquisition Electronics
4 SPEAG EASY6 DAE, Data Acquisiton Electronics
4 SPEAG DAEasy4MRI, Data Acquisition Electronics
2 SPEAG DASY52 NEOs
1 SPEAG EASY4MRI
1 SPEAG EASY6
2 SPEAG ELI4 Phantoms
1 SPEAG HAC RF Extension
1 SPEAG HAC T-Coil Extension
5 SPEAG cSAR3D (2 Flat, 1 Left Head, 1 Right Head, and 1 Quad)
1 SPEAG SAM V6.0 Phantom
1 ZMT MITS 1.5 with ELIT Phantoms
1 ZMT MITS 3.0 with ELIT Phantoms
2 ZMT Dual Cylinder Phantoms
1 ZMT MITS Gradient v1
1 ZMT MITS Gradient v2
1 ZMT PiXE64
1 ZMT MITS-HFR1.5
1 ZMT MITS-HFR3.0
3 SPEAG SHO V2 RB, RC, and RP OTA Hand Phantoms
1 SPEAG ICEy-EMC and -mmW

Probes

1 METROLAB THM 1176, Magnetic Field Sensor
1 SPEAG AMIDV2, Audio Magnetic Field Probe
1 SPEAG AMIDV3, Audio Magnetic Field Probe
5 SPEAG T1V3LAB, Temperature Probes
1 SPEAG T1V4LAB, Temperature Probes
2 SPEAG T1V3, Temperature Probes
1 SPEAG EE3DV1, E-Field Probes
1 SPEAG EF3DV3, E-Field Probe
1 SPEAG EL3DV2, E-Field Probe for WPT
2 SPEAG ER3DV6, E-Field Probes
1 SPEAG ES3DV2, E-Field Probe
1 SPEAG ET1DV4, Dosimetric Probe
2 SPEAG ET3DV6, Dosimetric Probes
1 SPEAG EU2DV2, Dosimetric Probe
1 SPEAG EUmmW E-Field Probe
1 SPEAG EX3DV3, Dosimetric Probe
4 SPEAG EX3DV4, Dosimetric Probes
2 SPEAG H1TDSx, H-Field Time Domain Sensor and Remote Units
1 SPEAG E1TDSz, E-Field Time Domain Sensor and Remote Unit
1 SPEAG 1RU1PXI TDS Remote Unit
1 SPEAG H1TDSx-ICEy H-Field Time Domain Sensor
1 SPEAG H1TDSz-ICEy H-Field Time Domain Sensor
1 SPEAG E1TDSx-ICEy E-Field Time Domain Sensor
1 SPEAG E1TDSz-ICEy E-Field Time Domain Sensor
4 SPEAG H3DV6, H-Field Probes
3 SPEAG H3DV7, H-Field Probes
1 SPEAG HL3DV2, H-Field Probe for WPT
1 SPEAG HU2DV1, H-Field Probe
1 SPEAG DAK Kit 12/3.5/1.2E
1 SPEAG DAKS-12 Probe
8 SPEAG RFoF1P4MED Probes and 1 Remote Unit
1 Greisinger GMH 5430 Conductivity Meter

Antennas

1 SPEAG D835, Validation Dipole
1 SPEAG D900, Validation Dipole
1 SPEAG D1640, Validation Dipole
1 SPEAG D1800, Validation Dipole
1 SPEAG D1900, Validation Dipole
1 SPEAG D3500, Validation Dipole
1 SPEAG D5GHz, Validation Dipole
1 SPEAG CD835V3, Validation Dipole
1 SPEAG CD1880V3, Validation Dipole
1 SPEAG CD2450V3, Validation Dipole
2 SPEAG PiXitor 64 MHz
1 Log-Periodic Antenna (650–4000 MHz)
2 Generic Phones (835/1900 MHz)
3 SPEAG HAC Dipoles

Meters

3 Agilent 34970A Data Acquisition Units
2 Agilent E4419B, 4 HP 8482A, Power Meters
1 Handyscope HS3 Data Acquisition Unit
1 Handyscope HS4 Data Acquisition Unit
3 HP 436A, 3 HP 8481A, Power Meters
1 Magnet Physik FH49–7030, Gauss/Teslameter
2 Rohde & Schwarz NRP2 Power Meters

Amplifiers

1 Amplifier Research 10S1G4A, Amplifier, 800 MHz–4.2 GHz
1 Kalmus 717FC RF Power Controller, 200–1000 MHz
6 LS Elektronik 24xx Amplifiers
8 Mini-Circuits Amplifiers, ZHL42, 700–4200 MHz
2 Mini Circuits Amplifiers, ZVE-8G, 2–8 GHz
1 Nucletudes ALP336 Amplifier, 1.5–2.5 GHz
2 Ophir 5141, 700 MHz–3 GHz

Other Equipment

8 Maury 1878B, 3-Step Tuners
1 Narda EHP-50 EM Field Probe Analyzer, 5 Hz–100 KHz
1 Narda ELT-400 Magnetic Field Probe, 1 Hz–400 KHz
1 Siemens Universale Messleitung, (0.5) 1–13 GHz
2 SPEAG Dipoles SCC34 Benchmark
1 Thermoconcept THW L2 Thermal Conductivity Meter
1 RFoF4MED-CU Calibration Unit
2 OPUS 20 THI Humidity and Temperature Monitors

Computers

2 Personal Mobile Computing Devices, from Apple, Asus
75 Laptops, from Acer, Apple, Asus, Dell, HP, IBM, Lenovo
83 Desktop Workstations, from HP, Dell, Acceleware, Dalco, custom built
13 High Performance Computing Workstations/Servers, from Dalco, Acceleware, custom built
7 Network Data Storage Servers, QNAP
8 Servers; from Dalco
9 Miscellaneous Peripherals, e.g., network devices, printers, scanners, etc.

SELECTED PUBLICATIONS 2019

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M. N. Polatoglu. *Development and Optimization of Image-Based Neurostimulation Modelling for Bioelectronic Medicine.* MSc. Thesis, Swiss Federal Institute of Technology, ETH Zurich, September 2019.

W. Kainz, E. Neufeld, W. E. Bolch, C. G. Graff, C. H. Kim, N. Kuster, B. Lloyd, T. Morrison, P. Segars, Y. S. Yeom, M. Zankl, X. G. Xu, and B. M. W. Tsui. *Advances in Computational Human Phantoms and Their Applications in Biomedical Engineering – A Topical Review.* IEEE Transactions on Radiation and Plasma Medical Sciences, 3(1):1–23, January 2019.

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E. Kaniusas, S. Kampusch, M. Tittgemeyer, F. Panetsos, R.F. Gines, M. Papa, A. Kiss, B. Podesser, A. M. Cassara, E. Tanghe, A. M. Samoudi, T. Tarnaud, W. Joseph, V. Marozas, A. Lukosevicius, N. Ištuk, A. Šarolić, S. Lechner, W. Klonowski, G. Varoneckas, and J. C. Széles. *Current Directions in the Auricular Vagus Nerve Stimulation I – a Physiological Perspective.* Frontiers in Neuroscience, 13:854, August 2019.

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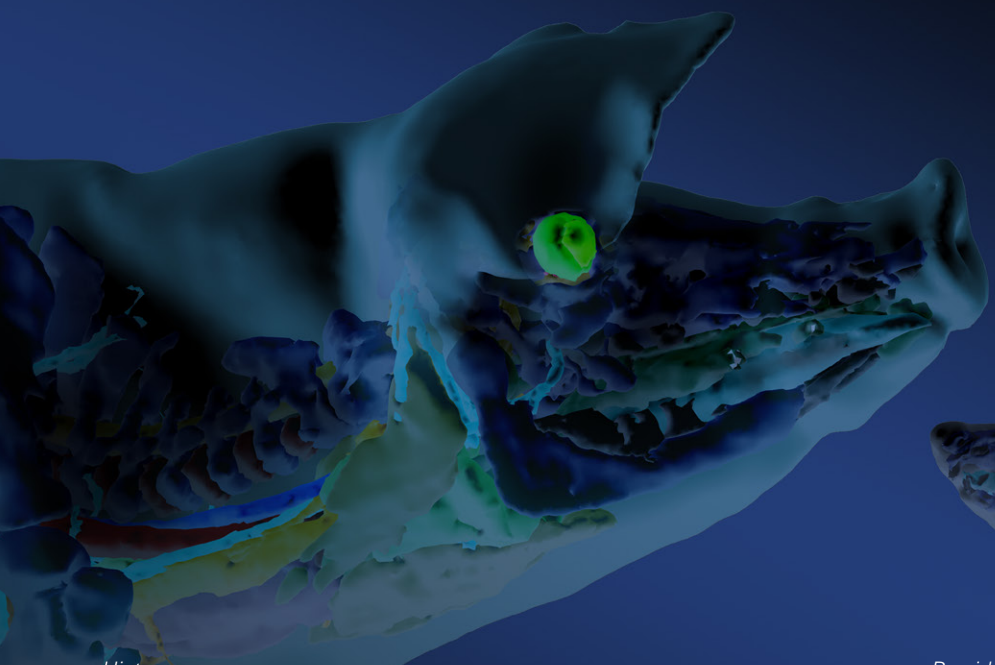
A. Christ, T. Samaras, E. Neufeld, and N. Kuster, *Limitations of Incident Power Density as a Proxy for Induced Electromagnetic Fields,* Bioelectromagnetics, *submitted.*

IT'IS FOUNDATION



History
The IT'IS Foundation was established in 1999 through the initiative and support of the Swiss Federal Institute of Technology (ETH) Zurich, the global wireless communications industry, and several government agencies. IT'IS stands for "Information Technologies in Society".

Legal status
The IT'IS Foundation is a non-profit tax-exempt research foundation.

Mission
The IT'IS Foundation is dedicated to expanding the scientific basis of the safe and beneficial application of electromagnetic energy in health and information technologies.

The IT'IS Foundation is committed to improving and advancing precision medicine and the quality of life of people with disabilities, in particular, through innovative research.

The IT'IS Foundation is an independent research institute.

The IT'IS Foundation provides a proactive, creative, and innovative research environment for the cultivation of sound science and research, and education.

Funding
National and international public funding, research projects sponsored by agencies and industry, and customized research.

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