CERN VISIT TO ESTONIA

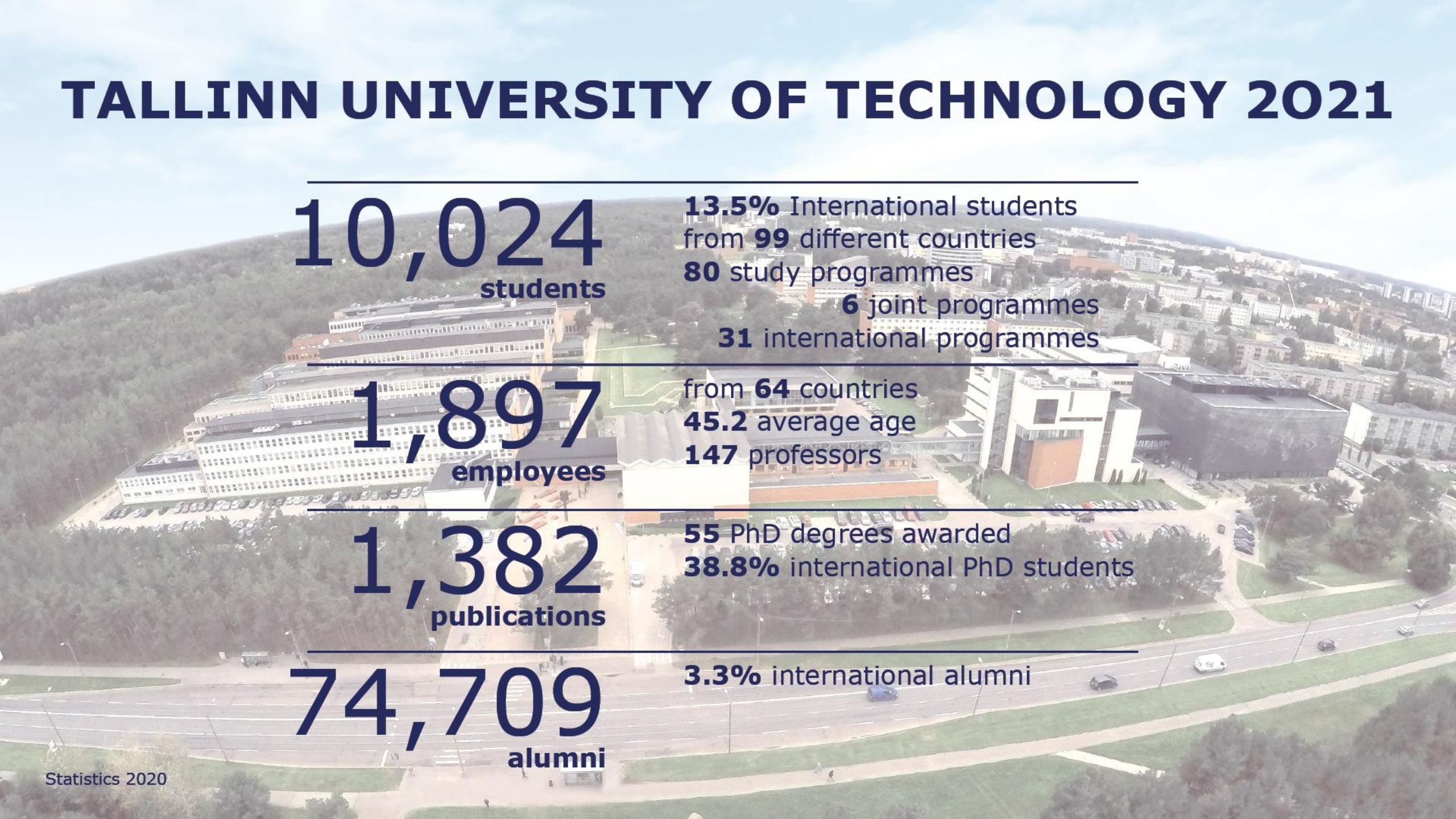
INTRODUCING TALTECH

Sven Illing
Vice-Rector for Entrepreneurship
Tallinn University of Technology

October 11, 2021


TALLINN UNIVERSITY
OF TECHNOLOGY
2021
TAL
TECH

TALLINN UNIVERSITY OF TECHNOLOGY 2021



10,024 students

13.5% International students
from **99** different countries
80 study programmes
6 joint programmes
31 international programmes

1,897 employees

from **64** countries
45.2 average age
147 professors

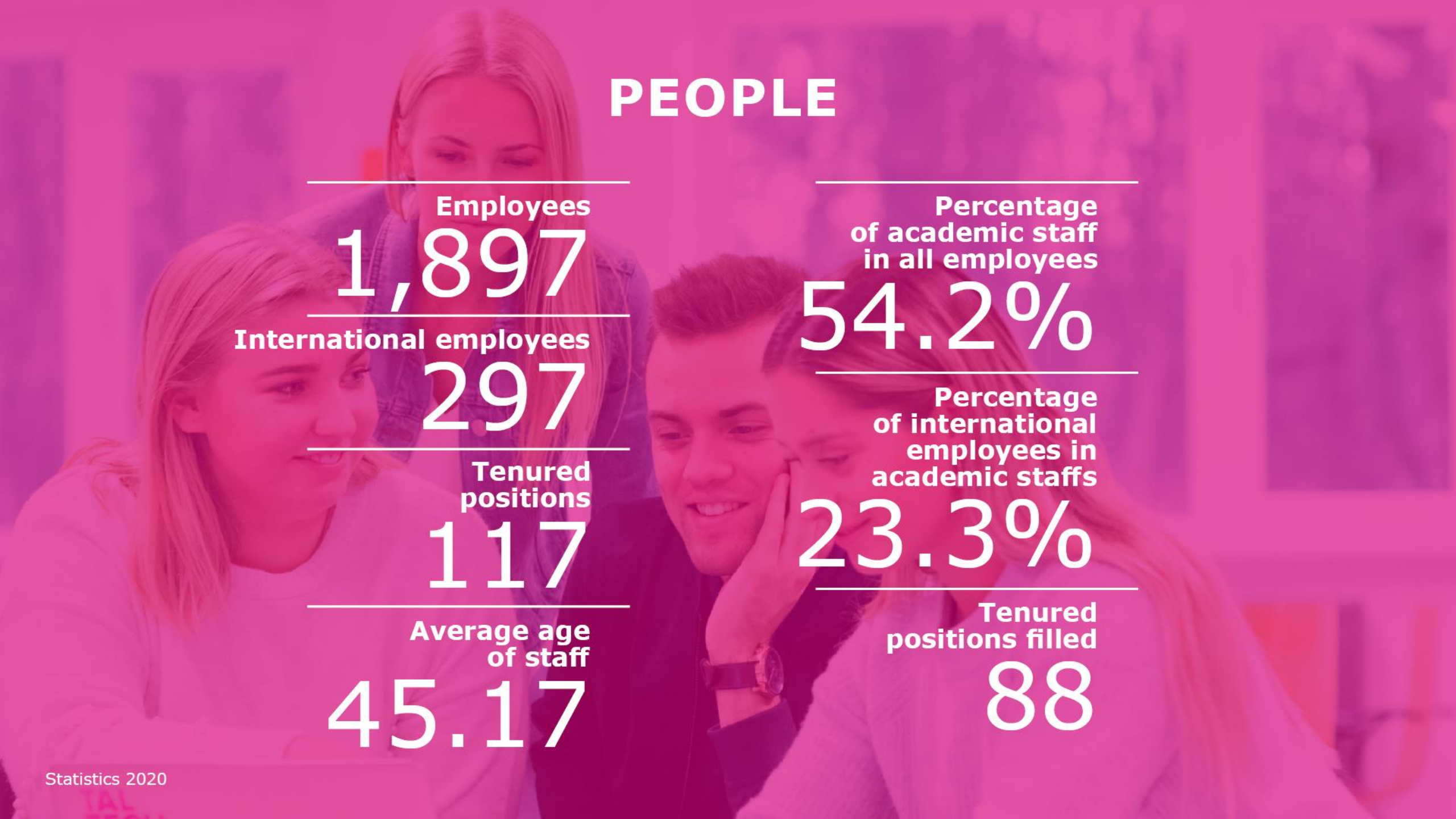
1,382 publications

55 PhD degrees awarded
38.8% international PhD students

74,709 alumni

3.3% international alumni

Statistics 2020



PEOPLE

Employees
1,897

International employees
297

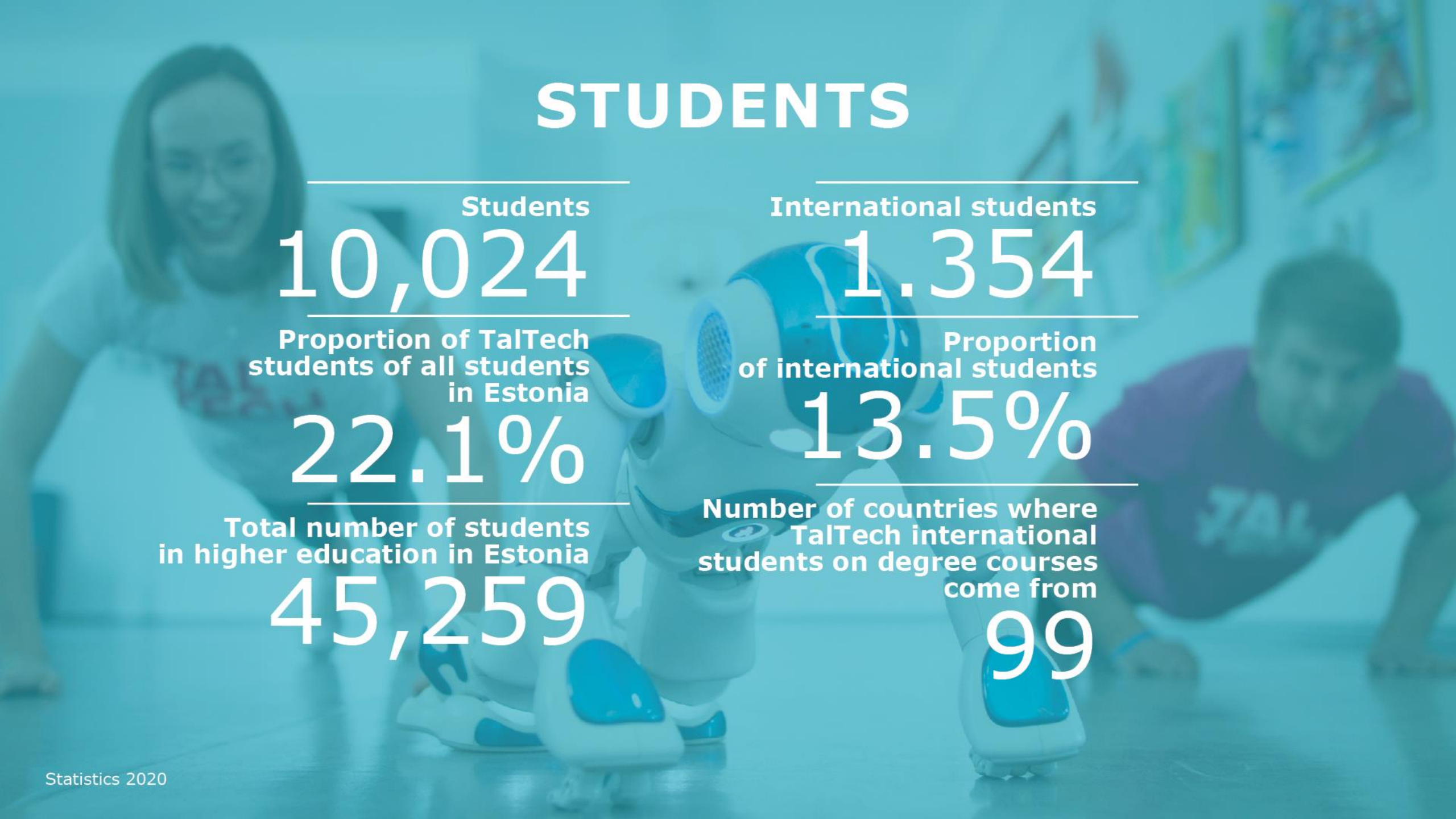
Tenured positions
117

Average age of staff
45.17

Percentage of academic staff in all employees
54.2%

Percentage of international employees in academic staffs
23.3%

Tenured positions filled
88



STUDENTS

Students

10,024

International students

1.354

Proportion of TalTech students of all students in Estonia

22.1%

Proportion of international students

13.5%

Total number of students in higher education in Estonia

45,259

Number of countries where TalTech international students on degree courses come from

99

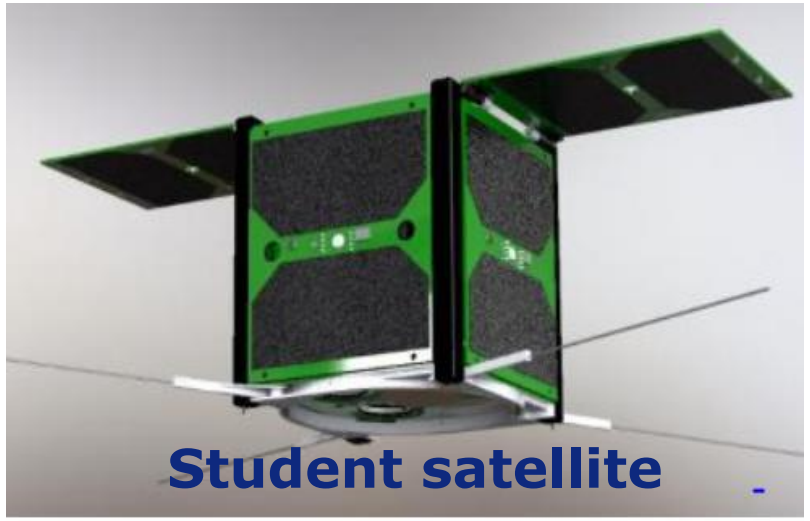
Statistics 2020

STUDENT PROJECTS

Student formula

Iseauto – self-driving car

TAL TECH



Student satellite

Solar car Solaride

RESEARCH & PUBLICATIONS

Number of scientific publications (ETIS)

1,382

Number of high-level (ETIS category 1.1; 3.1; 1.2; 2.1) peer-reviewed scientific publications

1,215

Proportion of publications with international co-authorship (Scopus/SciVal)

62.2%

Number of scientific publications per academic employee

1.65

Number of high-level (ETIS 1.1; 3.1; 1.2; 2.1) peer-reviewed scientific publications per filled academic position

1.45

Top 10 co-publishing countries

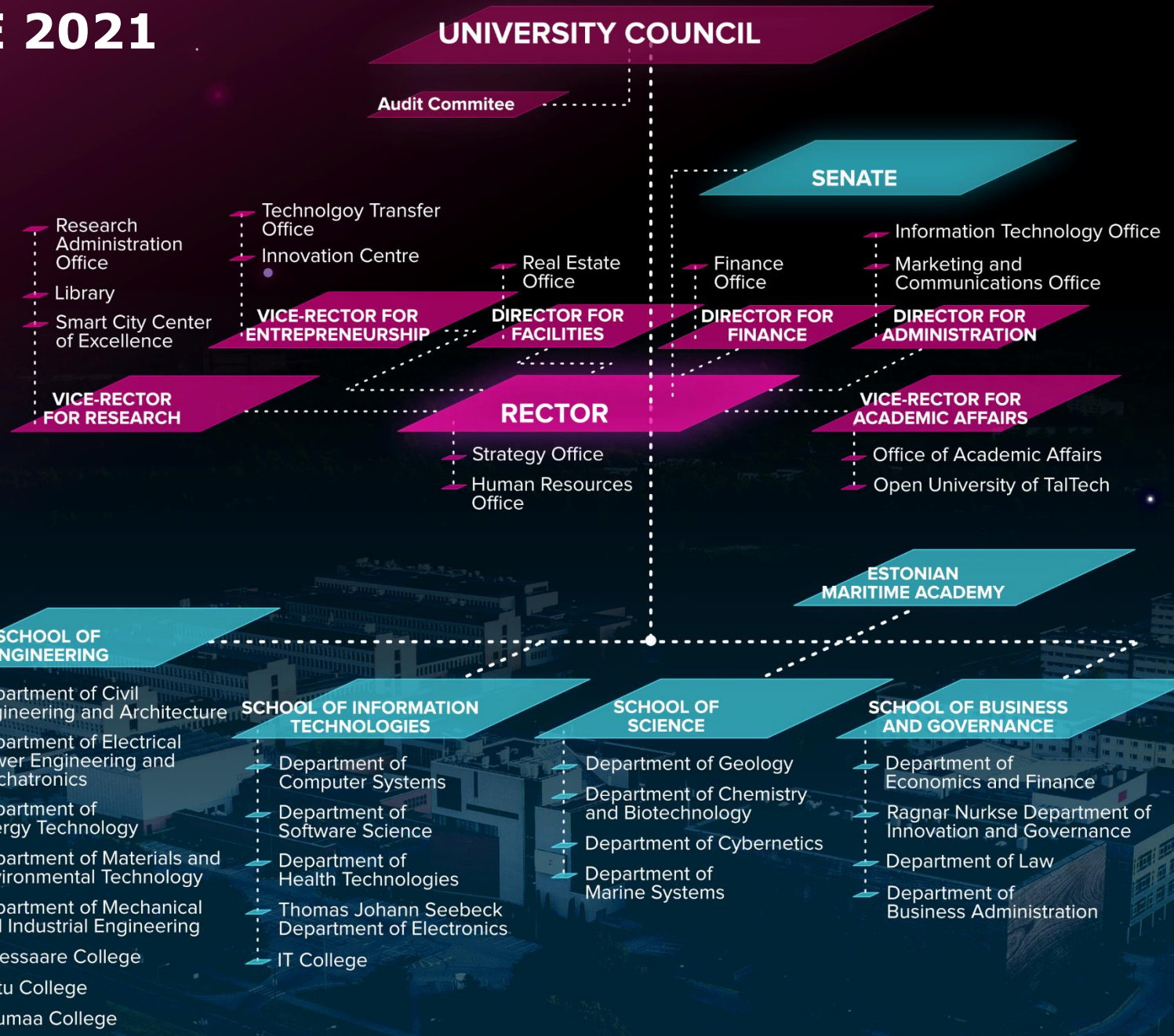
FINLAND, GERMANY, RUSSIA, UK, USA, INDIA, FRANCE, CHINA, SWEDEN, ITALY

Statistics 2020

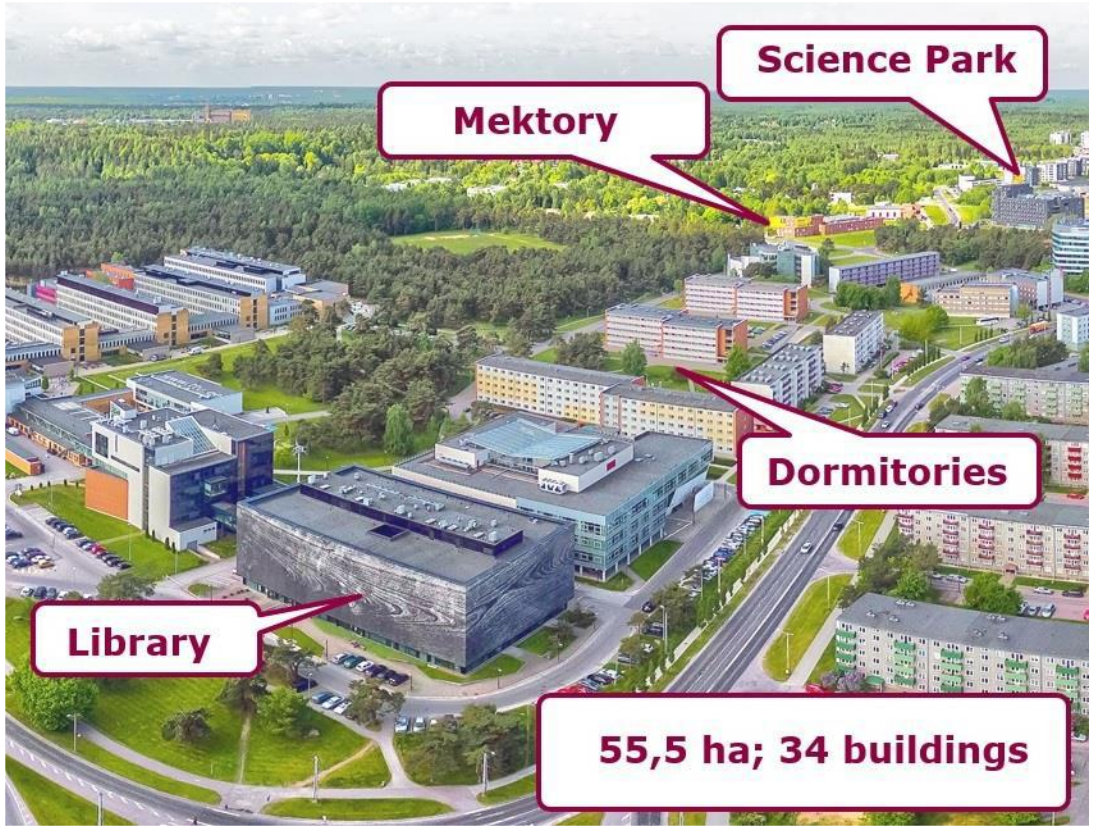
STRATEGIC RESEARCH AREAS

- smart and energy efficient environments
- dependable IT solutions
- valorisation of natural resources
- future governance
- innovative SME-s and digital economy

STRUCTURE 2021



TALTECH – MAIN CAMPUS



+ Estonian Maritime Academy in Tallinn
+ 3 colleges outside Tallinn

TalTech TTO & Innovation Centre Mektory

Science popularization

Technology school
Workshops
Interdisciplinary projects
Technology labs
XR Centre

Promoting entrepreneurship

Startup competitions
Pre-incubation program
Entrepreneurship training
Innovation HUB & Makerlab
Co-working spaces
Hackathons

Technology Transfer

Coordination with Companies
IP protection & technology commercialisation

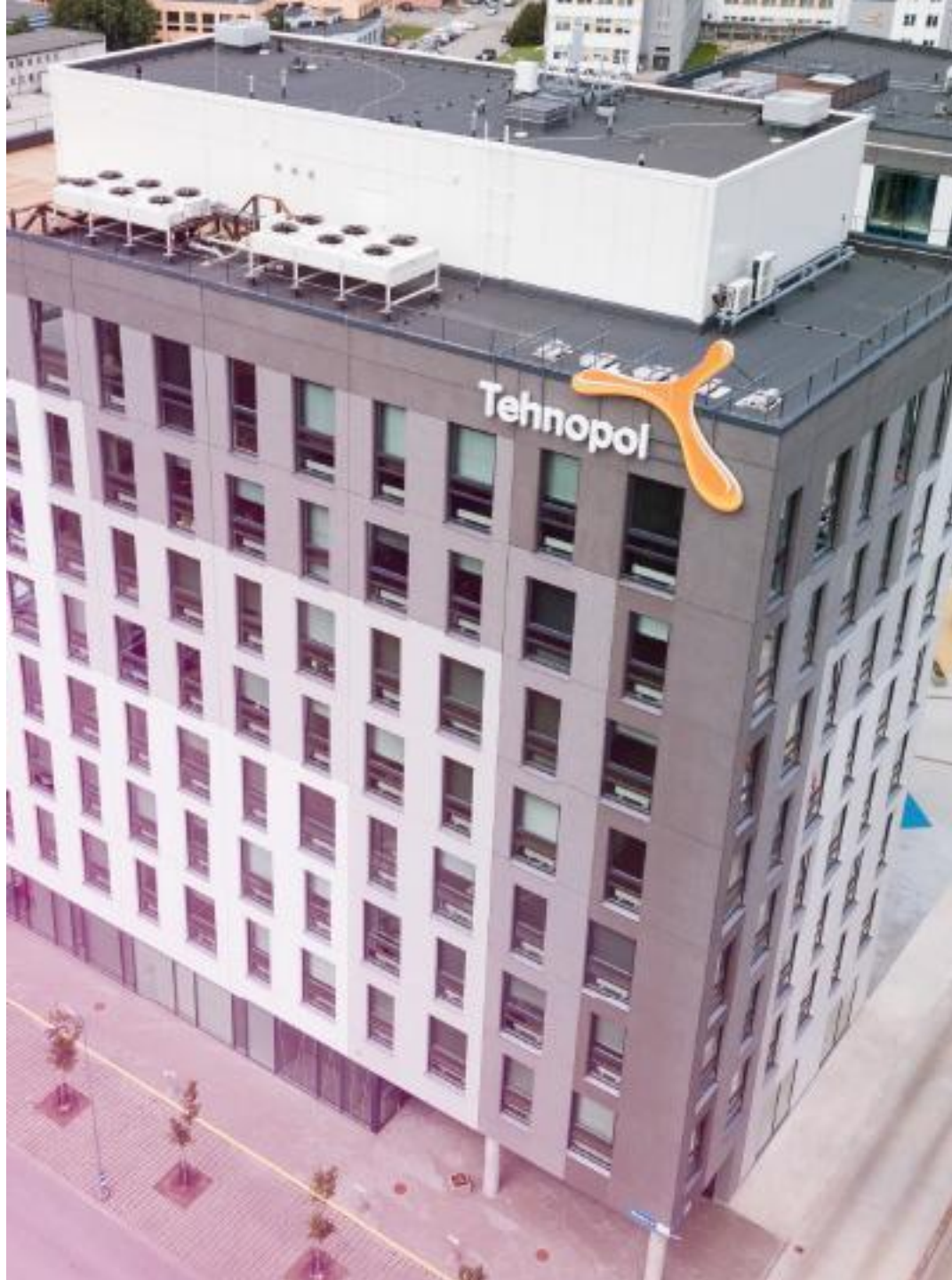
Demo centre

University success stories
Research achievements
Conference Centre

TECHNOPOL SCIENCE PARK
BIGGEST IN THE BALTIC STATES

- Founded in 2003 by TalTech, City of Tallinn & Republic of Estonia
- Located next to TalTech campus
- Home to more than 200 tech companies, incl Microsoft (former unicorn Skype), Fujitsu, Starship, Cybernetica
- Business development services
- Incubation services
- Start-up events
- Network of mentors

TAL TECH



ESTONIAN STARTUP UNICORNS

Wise
$15B

Skype
$8.5B

Bolt
$4.8B

Playtech
$1.8B

Pipedrive
$1.5B

ID.me*
1.5B

Zego *
$1.1B

*** co-founder from Estonia but no company or R&D centre in Estonia**

ON THE WAY TO BECOMING UNICORNS

TAL TECH

Skeleton Technologies

Glia

Monese

Veriff

Starship Technologies

UNIVERSITIES – TECH-TRANSFER AND DEEP TECH SPIN-OFFS

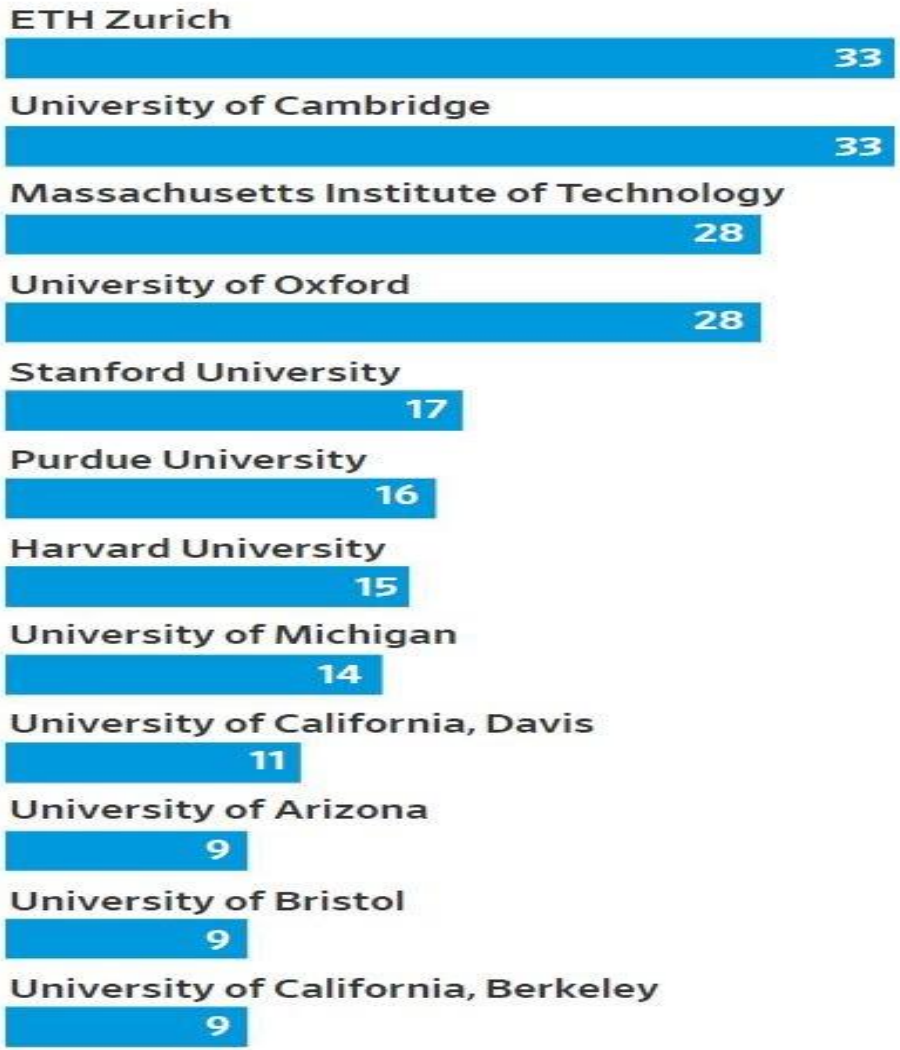
- Europe strives to have more technology companies and be globally competitive.
- Society expects universities to contribute– more technology transfer from universities to society.
- TalTech and University of Tartu are collaborating to foster spin-off creation.

How many spin-offs come out of top universities?

Albert Ltd.

Einstein's alma mater, ETH Zurich, is a world leader in creating companies from innovations.

Spinout leaders over past 12 months



"It was all quite unorganized," he recalled of the founding, during an era when many professors shunned links to business. "There were certainly conflicting opinions on how to deal with university-industry relations."

Catholic University of Leuven now touts Materialise as a pioneer among its fast-growing list of spinouts. Leuven's region, Flanders, has created a €117 million ($128 million) fund, imec.xpand, to help bankroll university spinouts and other startups.

Today, universities from Scandinavia to Bavaria scour their labs for potential startups. France has created a national network to commercialize academic innovations. And universities across Southern and Eastern Europe are trying to catch up.

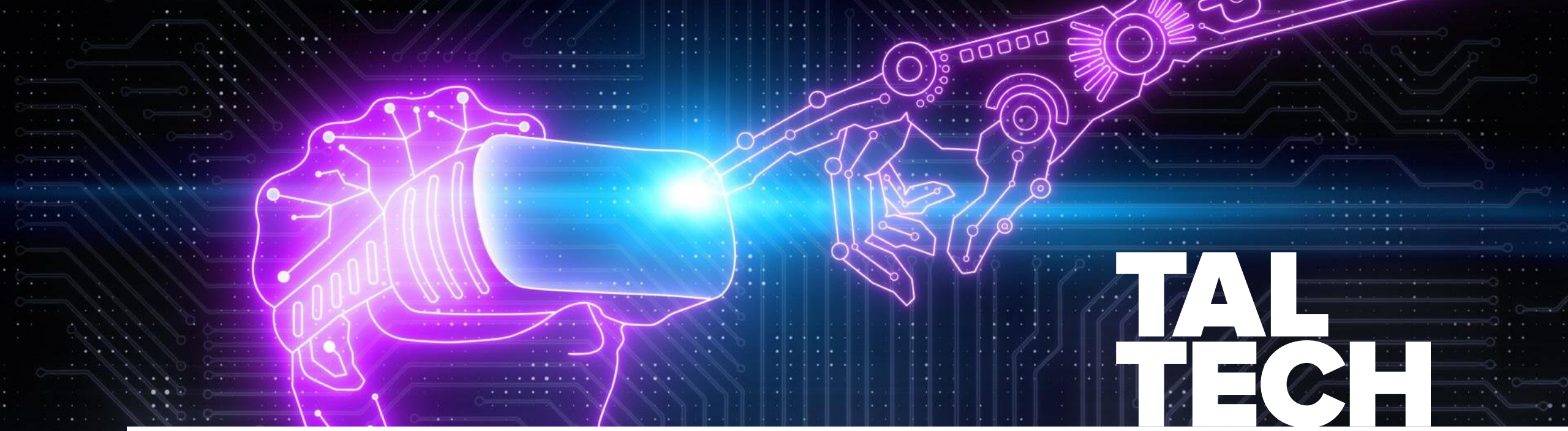
Prestige and public benefit motivate universities more than financial returns, said Thierry Heles, editor at Global University Venturing. Funding for lab

TalTech is looking forward to collaborate with CERN to further science, education, technology transfer & entrepreneurship.

THANK YOU!

SVEN ILLING
VICE-RECTOR FOR ENTREPRENEURSHIP

WWW.TALTECH.EE



SMART INDUSTRY CENTRE (SMARTIC)

Tauno Otto

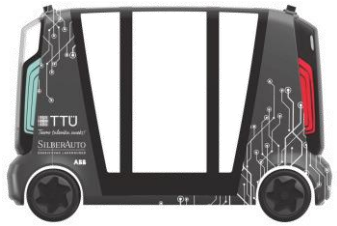
Professor / Department of Mechanical and Industrial Engineering
Head of Development / School of Engineering
Tallinn University of Technology

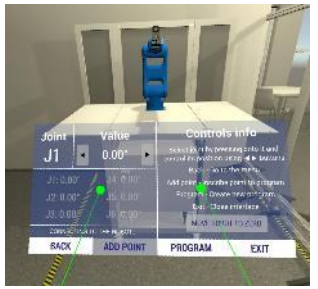
05.11.2021

SMART INDUSTRY CENTRE (SMARTIC)-INTEGRATOR OF DIFFERENT INDUSTRY 4.0 TECH

http://smartic.ee/

Our ultimate goal is to connect all laboratories and devices through single simulation, which can be controlled and managed in real time.





SELF-DRIVING CARS

3D PRINTING

INDUST-RIAL **ROBOTICS**

DIGITAL TWINS & **VR/AR**

SMART GRID SOLUTIONS

PREDICTIVE MAINTE-NANCE & **MONITO-RING**

TAL TECH | TALLINNA TEHNIKAÜLIKOOL

UNIVERSITAS TARTUENSIS 1632

Eesti Maaülikool EMU Estonian University of Life Sciences

SmartIC

Photos by : Raivo Sell, Vladimir Kuts, Yaroslav Holovenko, Kristo Karjust, Dmitri Vinnikov

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

INNOVATION FOSTERING IN ACCELERATOR SCIENCE AND TECHNOLOGY (I.FAST)

- H2020 project started May 2021
- Many accelerator parts that require repairing can benefit from the advantages of using AM. The extreme operating conditions of modern particle accelerators have a strong impact on many complex components that are worn or damaged by thermal fatigue cracks or any other reasons. They can be refurbished by removing the damaged volume and depositing the missing volume of material according to an AM approach.
- The technical feasibility of using AM technologies will be studied by RTU in collaboration with PoliMi. CERN, CEA, CNRS, INFN and TalTech will provide actual data and experience.

- https://ifast-project.eu/

MOBILE ROBOT BOXBOT FOR PRODUCTION LOGISTICS

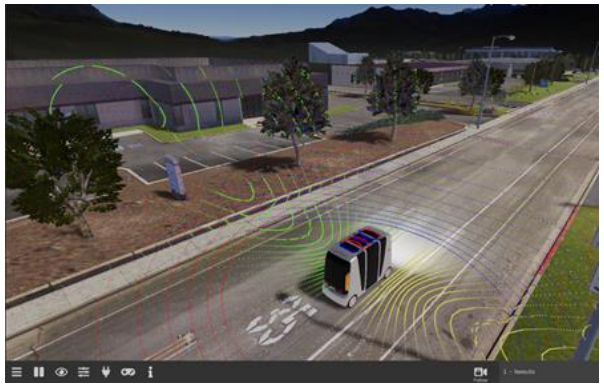
The universal production logistics mobile robot platform Boxbot (versions 1.0 2019 and V2.0 2020) developed at the Department of Mechanical and Industrial Engineering has created a digital twin in addition to the physical mobile robot.


Controls
W A S D - movement
LMB - interact
Use mouse to look around

AUTONOMOUS SELF-DRIVING VEHICLE - ROBOT BUS ISEAUTO

Tasks:

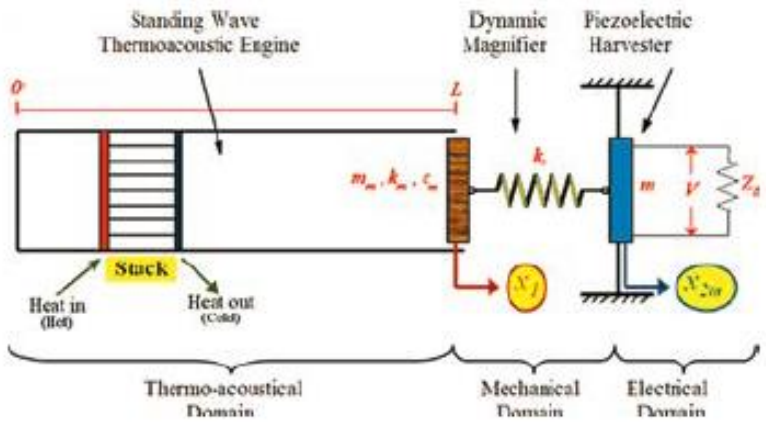
- Robot bus development, artificial intelligence and autonomy;
- Remote control, sensor integration and calibration;
- Communication between vehicles and infrastructure, artificial vision and a smart city;
- Simulations, security assessment, verification and validation;
- Large-scale pilot projects for self-driving vehicles and smart city solutions.

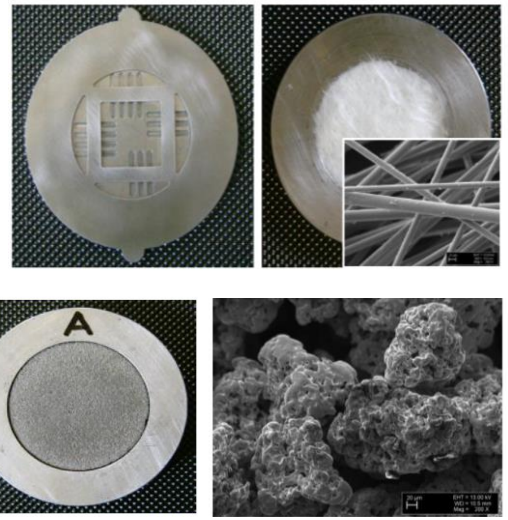


TALLINNA

NEW MICRO-STRUCTURED ACOUSTIC MATERIALS AND NON-LINEAR ENERGY HARVESTING

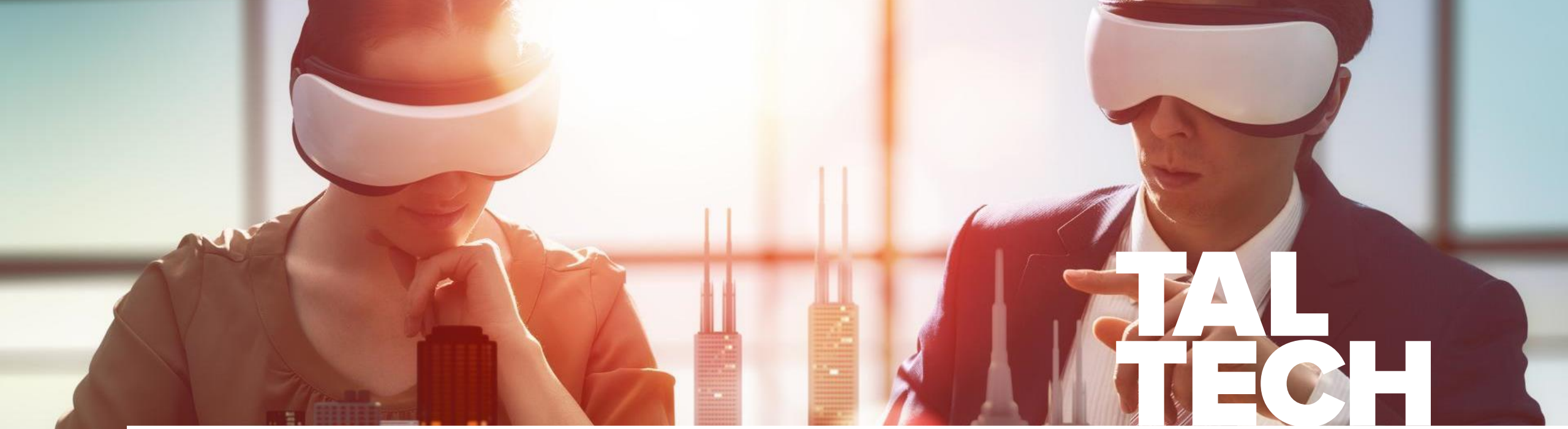
- The main objective of the investigations is to develop highly effective and high-tech acoustic materials for a wide field of applications.
- Traditional porous materials (wool, textile, organic absorbers can deteriorate over time, pollute the surrounding medium by radiating small particles and be potentially harmful.





Test rig to determine acoustic parameters of micro-structured materials at high flow speed and high temperature (a) and Schematic of acoustical to mechanical power conversion and final energy harvesting (b)

Photo of the Micro-grooved element and of traditional glass fiber wool (a) and sintered metal powder sample and magnification 50X (b)



THANK YOU!

tauno.otto@taltech.ee

For more info:

www.smartic.ee

05.11.2021

POWDER TECHNOLOGY
MATERIALS FOR AGRESSIVE ENVIRONMENTS

Renno Veinthal
Professor, Head of Department
Department of Materials and Environmental Engineering

11.10.2021

ADVANCED POWDER TECHNOLOGY LAB

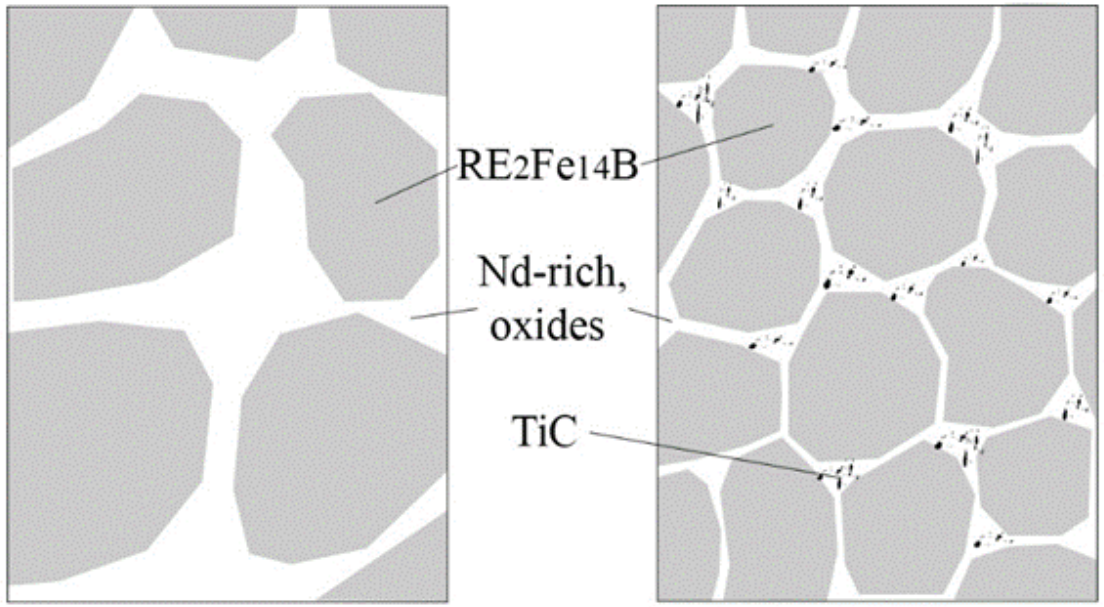
- TiC, Cr_3C_2, ZrC based cermets for niche applications (applications needing high temperature with corrosion, light weight, impact wear etc.)
- Multimodal reinforcement: mixing of different hard phase types (WC, Cr_3C, TiC, VC, TaC, NbC, etc) for increased wear resistance
- Modification of binder phase (Fe, Ni, Cr, Mo etc) to increase the resistance to corrosive environments and thermal shocks.
- Reactive sintering of carbide based composites with improved properties
- Hot isostatic pressing for complex shapes (near net-shape). Possibility to combine with additive manufacturing of the capsule

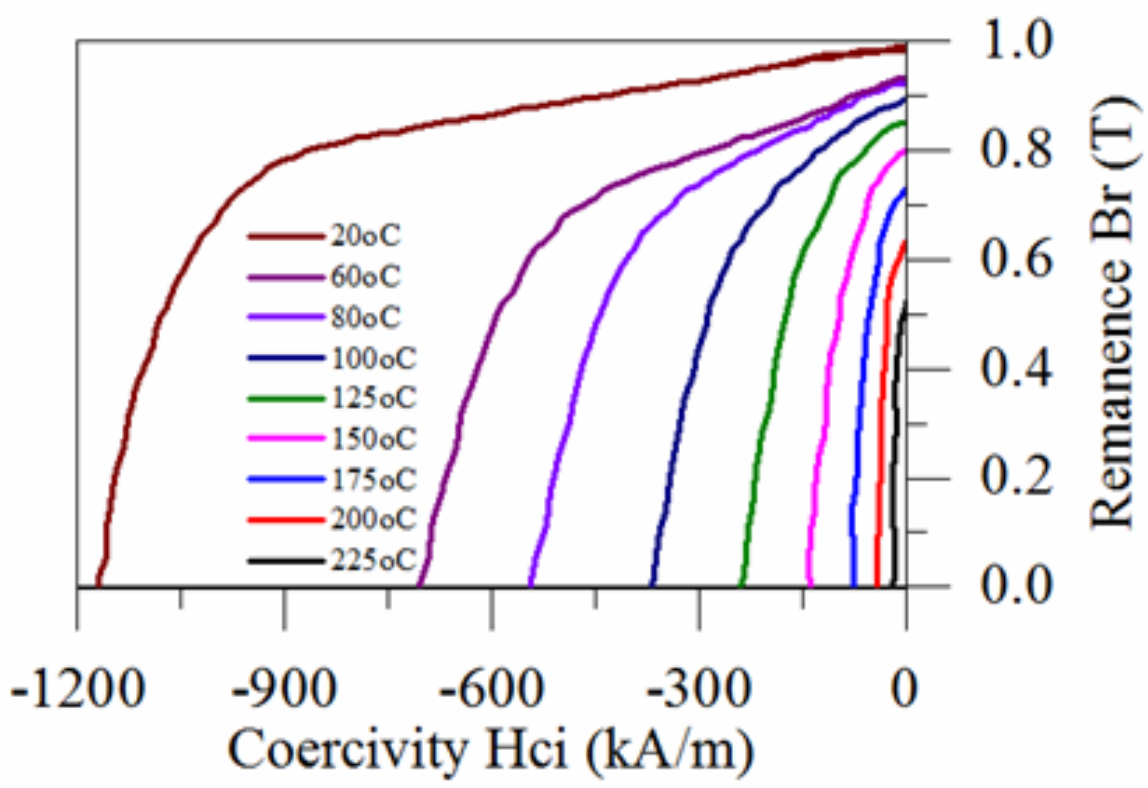
SPS PROCESSING OF MATERIALS

- Sintering: Spark Plasma Sintering FCT HP10 SPS
- Glove box integrated model, applicable to oxygen sensitive powders (e.g. Carbide or metal nanopowders, NdFeB magnets)
- Maximum processing temperature: 2200^{o}C
- Fast heating and cooling;
- Pressure up to 100 MPa with WC-Co moulds

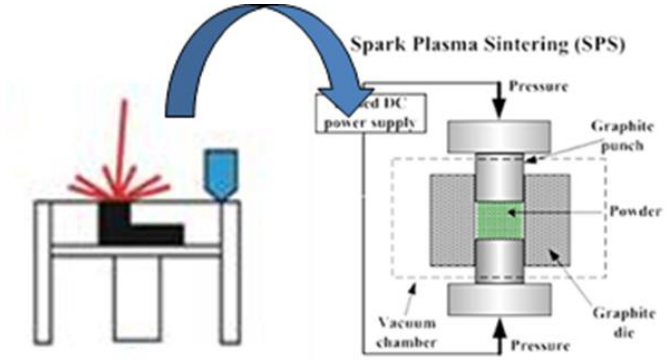
RARE EARTH MAGNETS

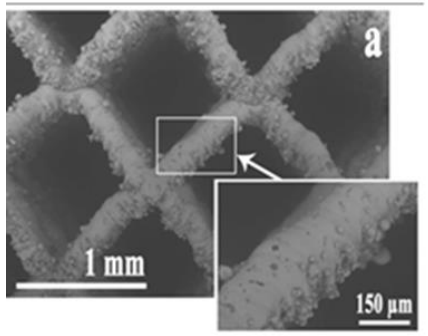
- Substituting critical elements in Neodymium – Iron – Boron magnets

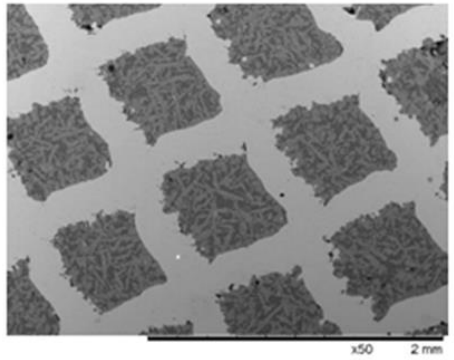


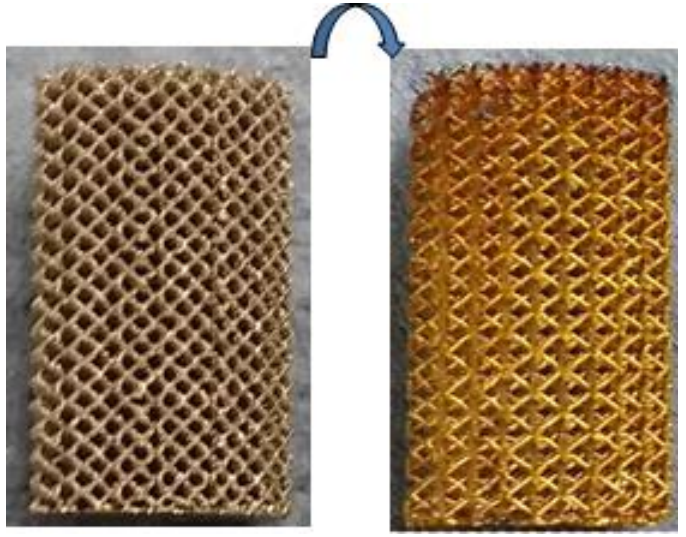


3D PRINTING FOR METAL DERIVED CERAMICS + INFILTRATION









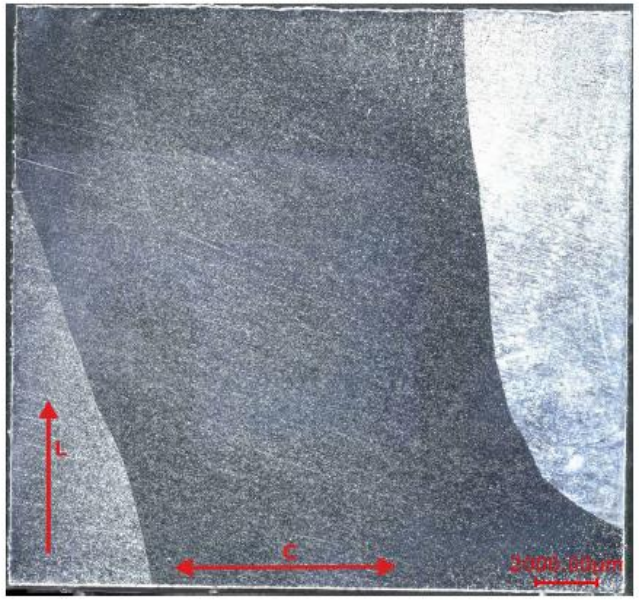
- Carbide and nitride ceramics with high shape complexity can be obtained, not possible by any other method.
- Application in high-temperature, corrosive atmospheres, eg. as insulators or dampers
- Printed open porous lattice structures will be infiltrated to produce solid materials with tailored mesostructures

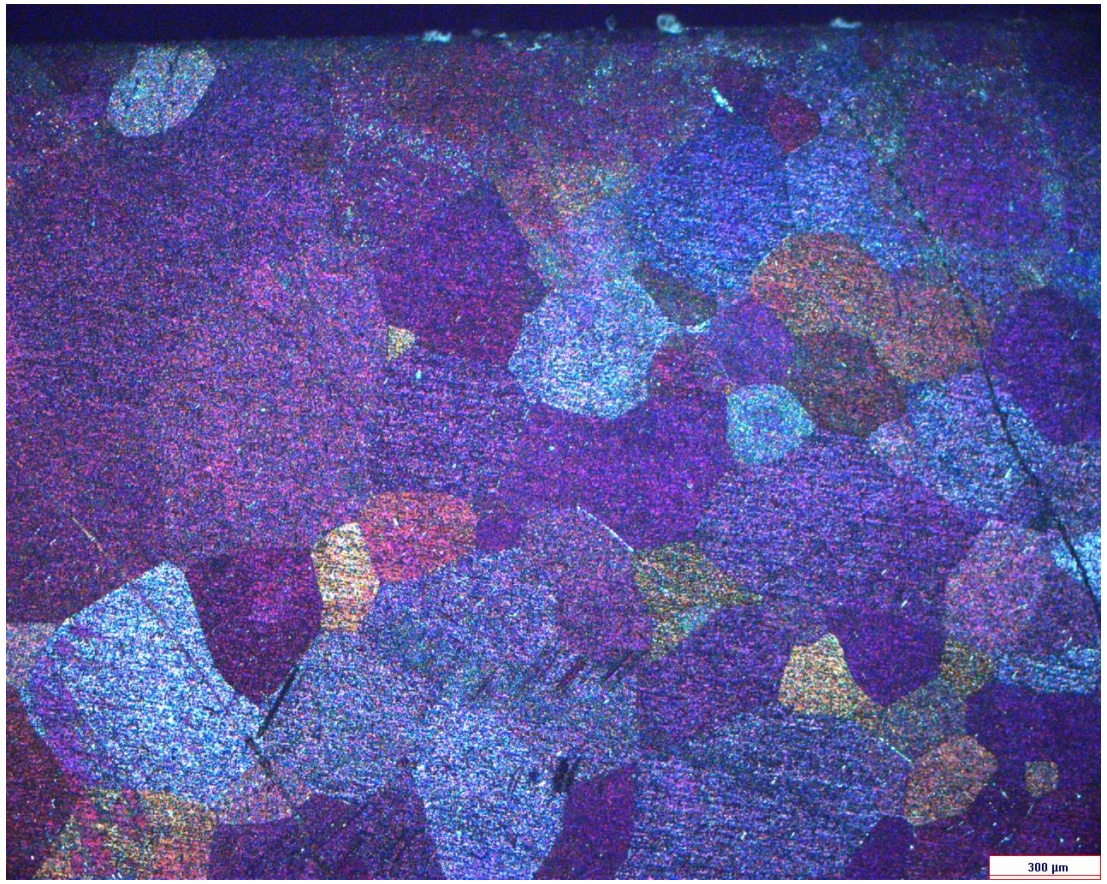
COLLABORATION OFFER ON NIOBIUM DEVELOPMENT

Metallographic analysis

- Similar grain dimensions in all directions
- No porosity
- No segregations
- No defects

- Hardness: 41 HV10





TALLINN UNIVERSITY OF TECHNOLOGY

TALTECH.EE/EN

ADVANCED POWER ELECTRONIC SYSTEMS AND COMPONENTS

Dmitri VINNIKOV
Research Professor, Head of Power Electronics Group
Department of Electrical Power Engineering and Mechatronics
Tallinn University of Technology

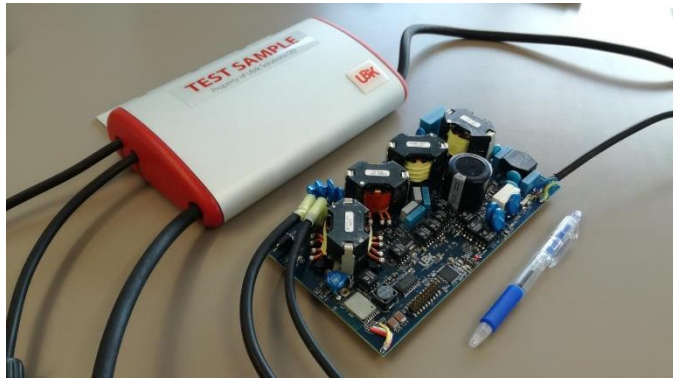
05.11.2021

POWER ELECTRONICS GROUP OF TALTECH

POWER ELECTRONIC SYSTEMS FOR RENEWABLE ENERGY APPLICATIONS

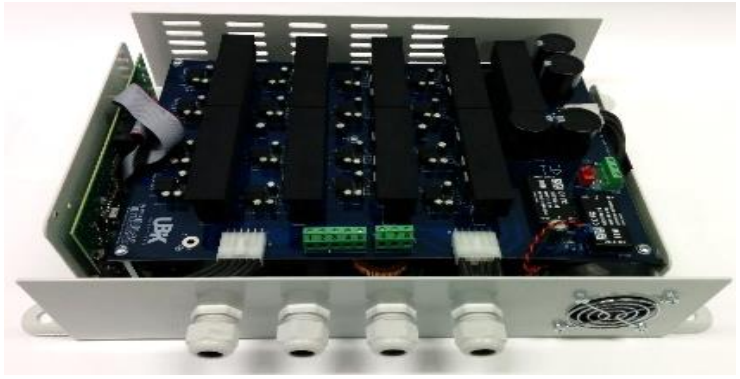
- *PEG is one of the frontiers of the latest advances in the topic of high-performance photovoltaic (PV) converters incl. string inverters and PV module-level power electronics*
- *Over 10 Patents and Utility Models; US patent on advanced DC-DC converter and control is currently commercialized as the Optiverter® - first in the world hybrid of PV power optimizer and microinverter*
- *Joint product development with Estonian cleantech start-up companies Ubik Solutions and MicroMasch Eesti OÜ*

OPTIVERTER® - Smart Grid Ready Shade-Tolerant PV Microinverter



- *Input 8…60 VDC, output: 230 VAC, 50 Hz, 350 W*
- *Compatibility with different types of PV modules*
- *Global MPPT, ultimate shade-tolerant performance*
- *Wi-Fi based integrated communication gateway (IEEE 802.11 b/g/n)*

Smart Grid Ready "Full-SiC" PV String Inverter with Ancillary Services Support



- *Input: 300…800 VDC, output: 400 VAC, 50 Hz, 3.5 kW*
- *"Full-SiC" design, switching frequency 100 kHz*
- *On-Grid and Off-Grid operating modes*
- *Enhanced power quality control algorithms*
- *Converterless integration possibility of battery storages*

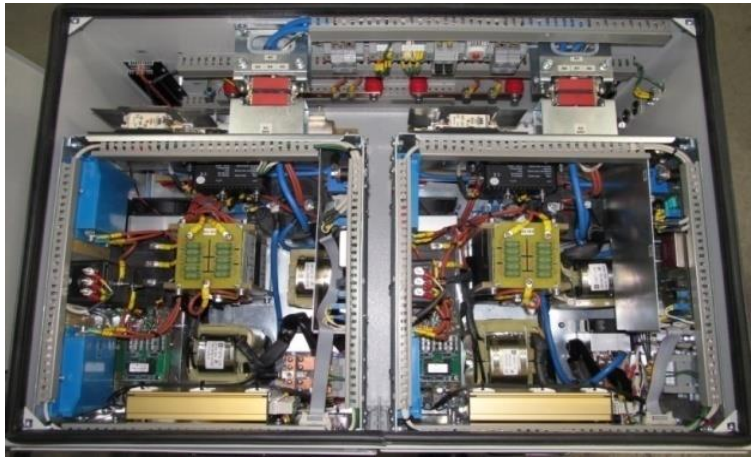
Power Conditioning Unit for Fuel Cell Back-Up Power Systems

- *Input: 35…64 VDC, output: 400 VAC, 50 Hz, 10 kW*
- *Modular design, interleaving control of cells*
- *On-Grid and Off-Grid operating modes*
- *Enhanced power quality control algorithms*
- *Converterless integration possibility of battery storages*

POWER ELECTRONIC SYSTEMS FOR ELECTROMOBILITY

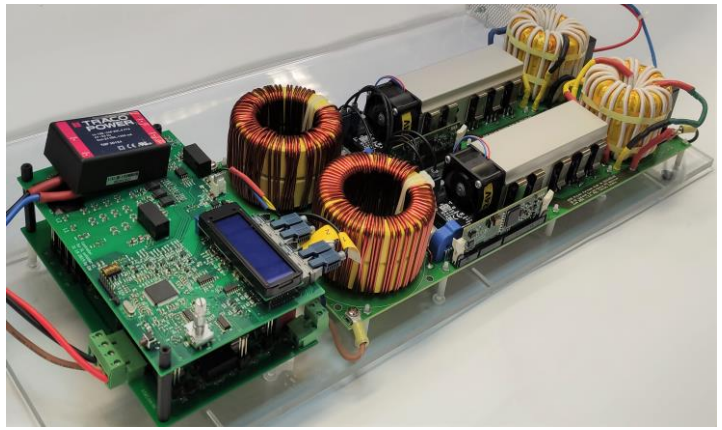
- *Traction and auxiliary converters for light rail vehicles (trams)*
- *High-voltage IGBT-based converters for electric and diesel-electric locomotives and/or trains*
- *Fast charging systems for EVs*
- *Stationary battery energy storage systems*
- *Remote control, diagnostics and data communication systems*
- *Joint product development with Estonian companies TET-ESTEL AS and MicroMasch Eesti OÜ*

10 kW Rolling Stock Auxiliary Power Converter APC-10-1.5k



160 kW Traction Converter TVM1 for Light Rail Vehicles

5 kW Electrolytic Capacitorless EV Battery Charger



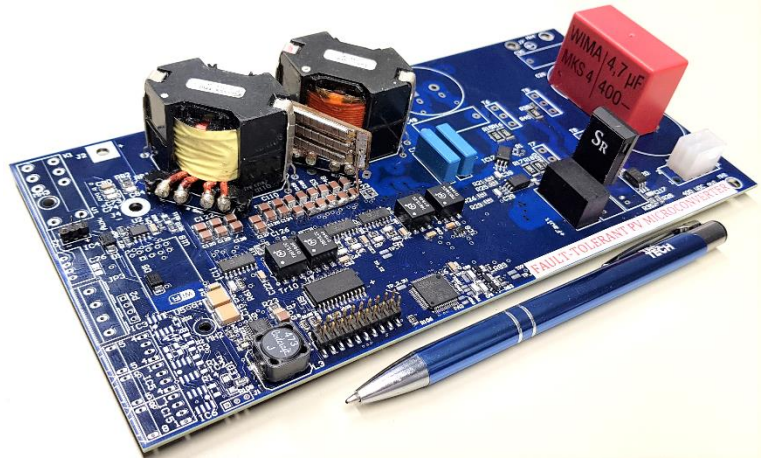
TAL TECH

- *Microprocessor control and self-diagnostic system*
- *Modular designn for quick repair and maintenance*
- *Energy saving control algorithms*
- *Enhanced reliability and fault tolerance*

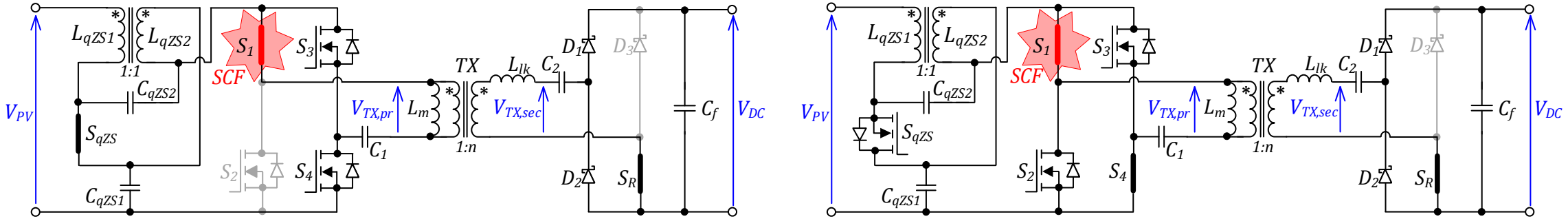
- *Input: 3x400 VAC, 50 Hz; output: 330…470 VDC*
- *Modular design with high-grequency isolation*
- *No grid filter and bulky DC-link capacitors*
- *Enhanced power quality control algorithms*
- *Simplified control with reduced number of sensors*

FAULT-TOLERANT POWER CONVERTERS

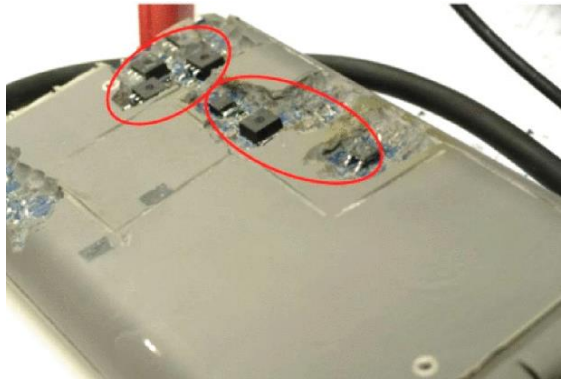
- *Target: mission-critical applications, like more electric aircrafts, medical, etc.*
- *Novel solution: fault-tolerant dc-dc converters with minimum redundancy*
- *Know-how: first in the world methodology for wear-out damage estimation*
- *Several technology demonstrators at TRL5-6*



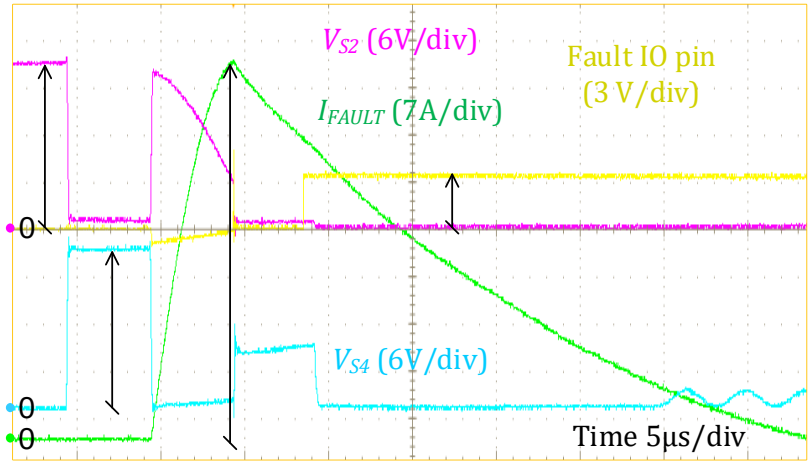
Fault-tolerant PV microconverter: TRL6, 15-65V/350V, 350W, 100kHz, fast fault detection and remedy



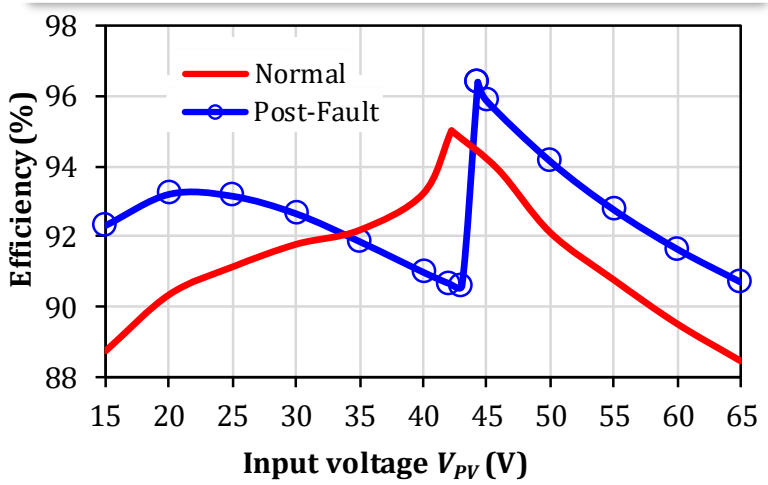
Outdoor applications – unrepairable potted design



Fault detection <10µs



Efficiency differs – redistributed stresses

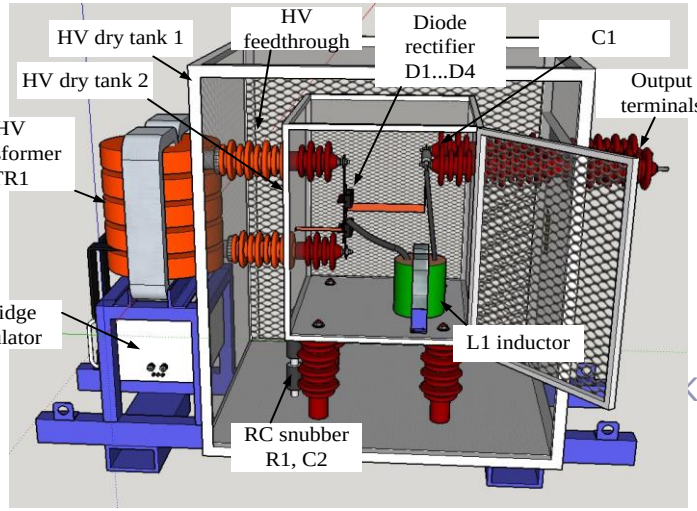


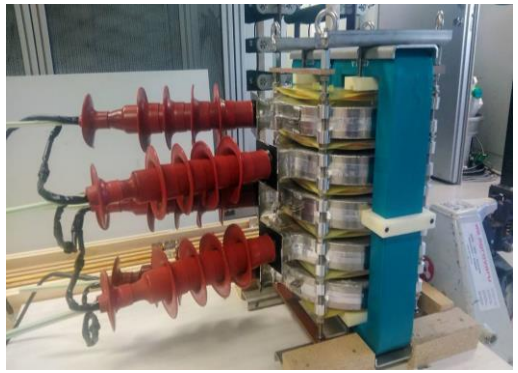
EXPERIMENTAL DRY HV TRANSFORMER FOR ESS IOT/CLYSTRON MODULATORS

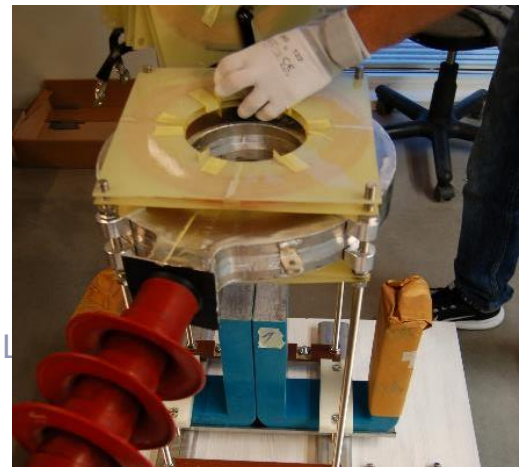
- *Estonian In-Kind Contribution (IKC) to ESS*
- *Interdisciplinary research activities incl. core design, construction of windings, HV connections, cooling, etc.*
- *Industrial partners: MS Balti Trafo OÜ and Energiatehnika OÜ*
- *Technology developed and demonstrated at TRL6*

DESIGN SPECIFICATIONS

- *Input voltage amplitude: 1 kV*
- *Input current amplitude: 500 A*
- *Output voltage amplitude: 10 kV*
- *Pulse power 500 kVA (<4ms)*
- *Modulation: 15 kHz modulated pulses*
- *Isolation voltage: 65 kV*







QUESTIONS

– POWER ELECTRONICS GROUP –

Your Reliable Partner in Power Electronics

POWER ELECTRONICS GROUP

Reliability and fault tolerance of computing systems

Maksim Jenihhin
Associate Professor
Department of Computer Systems
School of IT
Tallinn University of Technology

CERN-TalTech Meeting
11 October 2021

Position in the TalTech structure

- School of Information Technologies
  - Computer Systems
  - Health Technologies
  - Software Science
  - T. J. Seebeck Electronics
- School of Engineering
- School of Science
- School of Business and Governance
- Estonian Maritime Academy

Topic: Reliability of integrated circuits and systems

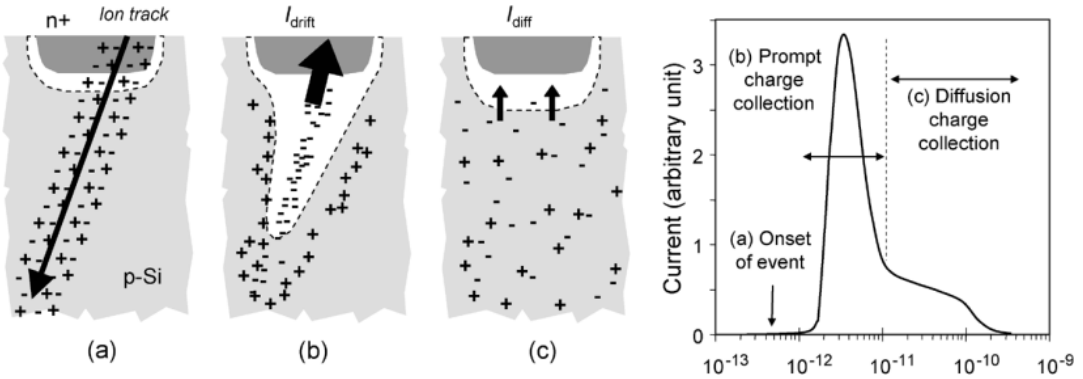
- **Maksim Jenihhin**
- Jaan Raik (Centre for Dep. Computing)
- Samuel Pagliarini (Centre for HW Security)
- Gert Jervan (Professor / Dean for IT)
- Artur Jutman (Testonica Lab OÜ)
- …

TAL TECH

Reliability against (radiation-induced) faults

Faults in the system's chips ("*root of trust*") e.g., CPU/GPU ASICs, FPGAs, …:

- Soft errors (by protons, neutrons…)
  - single-event effect (SEU, SET), single-event multiple effects (nanoscale)
  - usually, transient faults
    - e.g. latch-up/upset in a memory element
- Total Ionizing Dose
  - accumulated exposure to many radiation effects, ~"*ageing*" (permanent faults)
  - atomic displacement
- Not related to radiation, yet nasty faults:
  - FPGA/ASIC design bugs
  - ASIC manufacturing defects/variations
  - ageing



Robert Baumann, TI, TDRM 2005

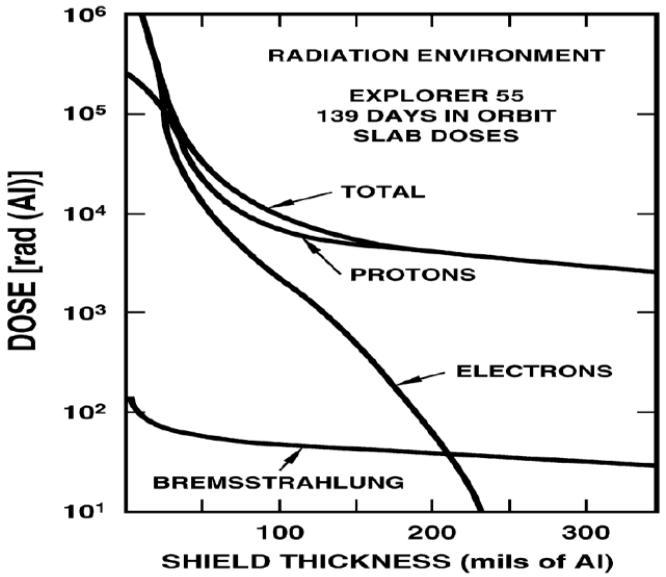
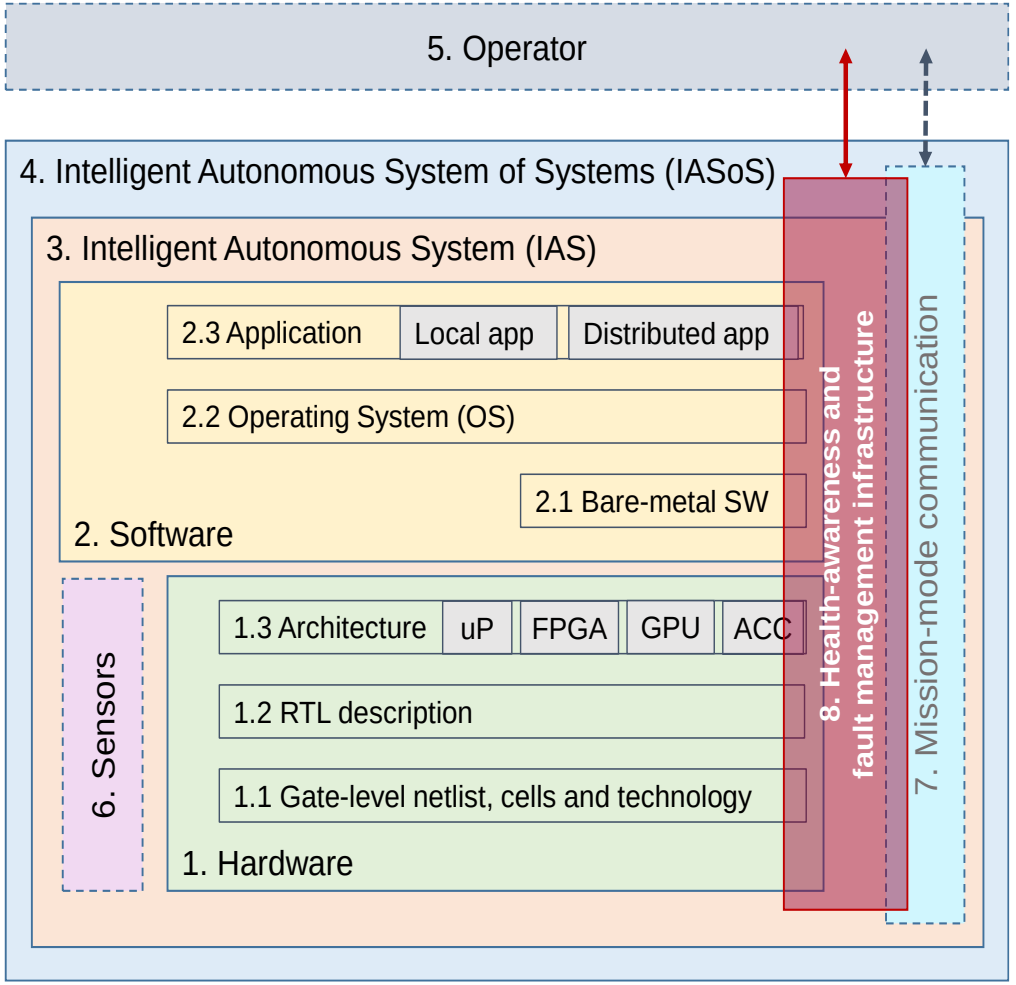


Fig. 6. Contributions of protons, electrons, and bremsstrahlung to total dose as a function of aluminum shielding. The data were taken after a 139-day exposure during the Explorer 55 space mission. (After [11]).

J. R. Schwank, et al, IEEE TNS 2013., doi: 10.1109/TNS.2013.2254722

Relevant research directions

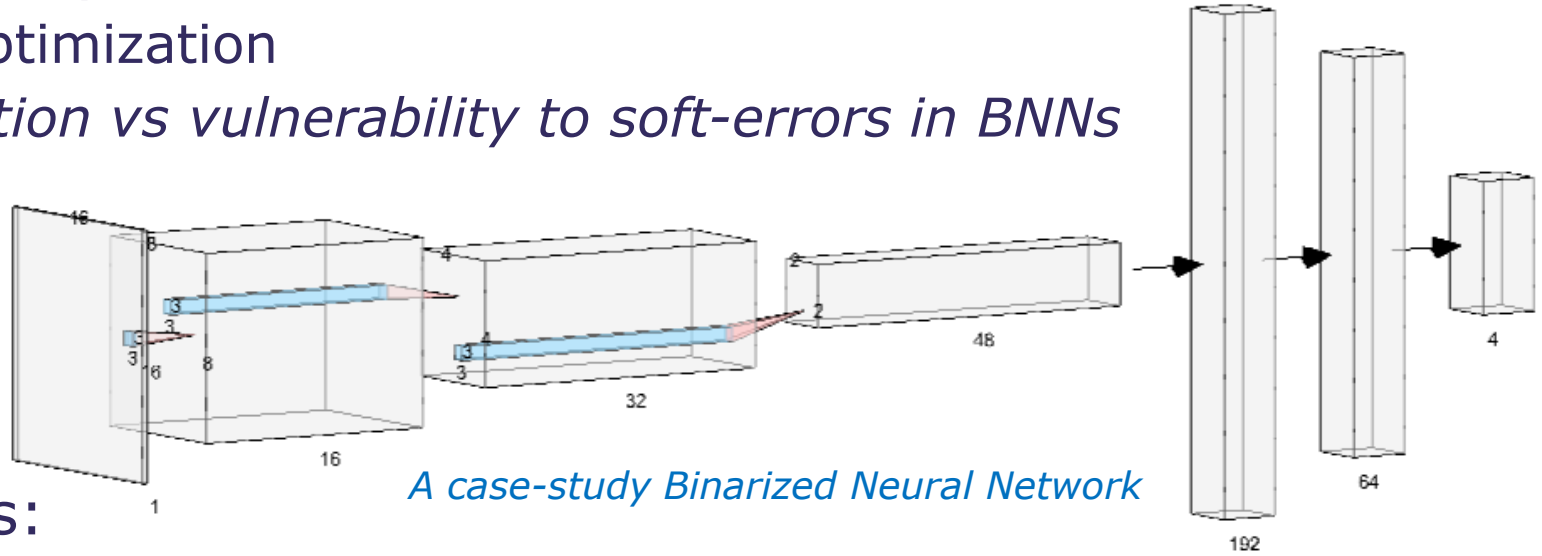
- Compute-efficiency and trust-efficiency
  - reliability for COTS (*commercial of-the-shelf*)
  - cost-efficient reliability
- Cross-layer fault management
  - system "health" awareness
  - from logic-cells to systems-of-systems
- Modelling (faults, diagnostic modelling of circuits and systems, reliability metrics)
- Reliability assessment and enhancement
  - fault injection, fault tolerance/resilience, …
- other selected competencies:
  - debug/verification, functional safety, security, on-line and manufacturing test



A layered view of a computing system

DNNs reliability and AI-assisted solutions

- Reliability of Deep Neural Networks (DNN) hardware accelerators
  - Evaluation of the (intrinsic) reliability
    - NNs architectures (e.g. layers, quantization)
    - platforms (e.g. FPGA, GPU)
  - analytical fault-injections optimization
  - *Example: security optimization vs vulnerability to soft-errors in BNNs*



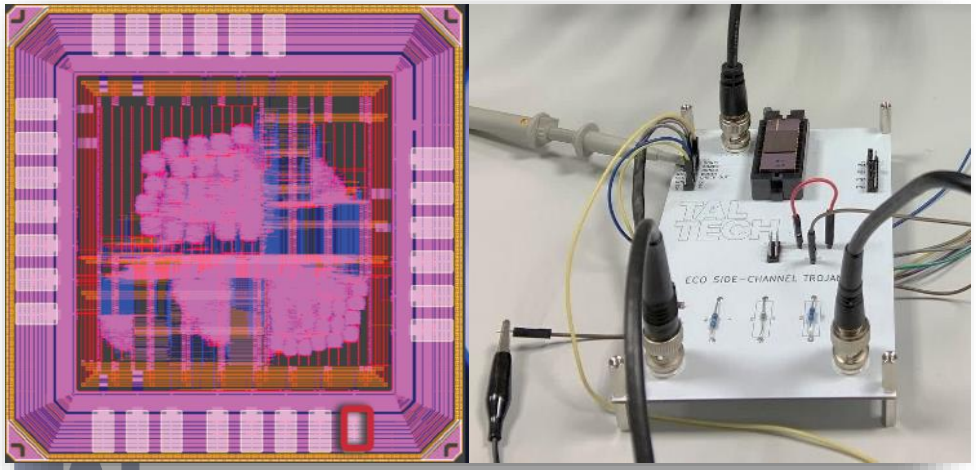
A case-study Binarized Neural Network

- Deep/Machine Learning tools:
  - DL-assisted reliability assessment (with IROC/FR)
  - ML for Electronic Design Automation (EDA) tasks
    - *Example: wafer-level manufacturing test process optimization at Intel, DE*

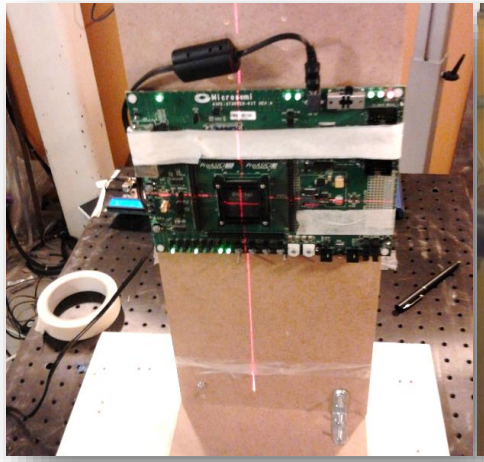
TAL TECH

ASIC design and rad-hard validation

- Notably, Prof. Samuel Pagliarini, Centre for HW Security
- New chip tape-outs every ~6 months (10nm to 650nm technology)
  - design and validation in-house
  - fabrication in Taiwan (TSMC), EUROPRACTICE (Fraunhofer/DE), IHP/DE
- Rad-hard FPGA/GPU/ASIC and SW validation by accelerated testing
  - - Neutron testing at Los Alamos/US and ChipIR/UK; Cobalt testing at IEAv/Brazil



1mm x 1mm crypto ASIC, 65nm CMOS



ProASIC3 FPGA laser guide

Full setup with 7 FPGAs and 2 GPUs

Success in collaboration projects

Selected examples:

- H2020 MSCA ITN **RESCUE** (2017-2021) *Interdependent Challenges of Reliability, Security and Quality in Nanoelectronic Systems*
  - TalTech (M. Jenihhin), IHP, Cadence, Bosch, IROC, Intr.-ID, PoliTo, TU Delft, BTU
- H2020 RIA **IMMORTAL** (2015-2018) *Integrated Modelling, Fault Management, Verification and Reliable Design Environment for Cyber-Physical Systems*
  - TalTech (J. Raik), IBM, DLR, Recore, Testonica, Graz UT, U Twente
- H2020 Twinning **SAFEST** (2021-2023) *Secure and Assured Hardware: Facilitating ESTonia's Digital Society*
  - TalTech (S. Pagliarini), TU Munich, KU Luven, LIRMM, TU Graz
- FP7 STREP **BASTION** (2014-2017) *Board and SoC Test Instrumentation for Ageing and No-Failure-Found*
  - Testonica (A. Jutman), TalTech, Infinion, Aster Tech., UTwente, PoliTo, U Lund, HSHL

Also H2020 TUTORIAL, FP7 DIAMOND, FP6 CREDES, …

TAL TECH

Maksim Jenihhin

Associate Professor
Department of Computer Systems
School of IT
Tallinn University of Technology
maksim.jenihhin@taltech.ee

CERN-TalTech Meeting
11 October 2021