Fraunhofer HHI
Jahresrückblick 2021

Freunde des HHI

Berlin, 18. November 2022

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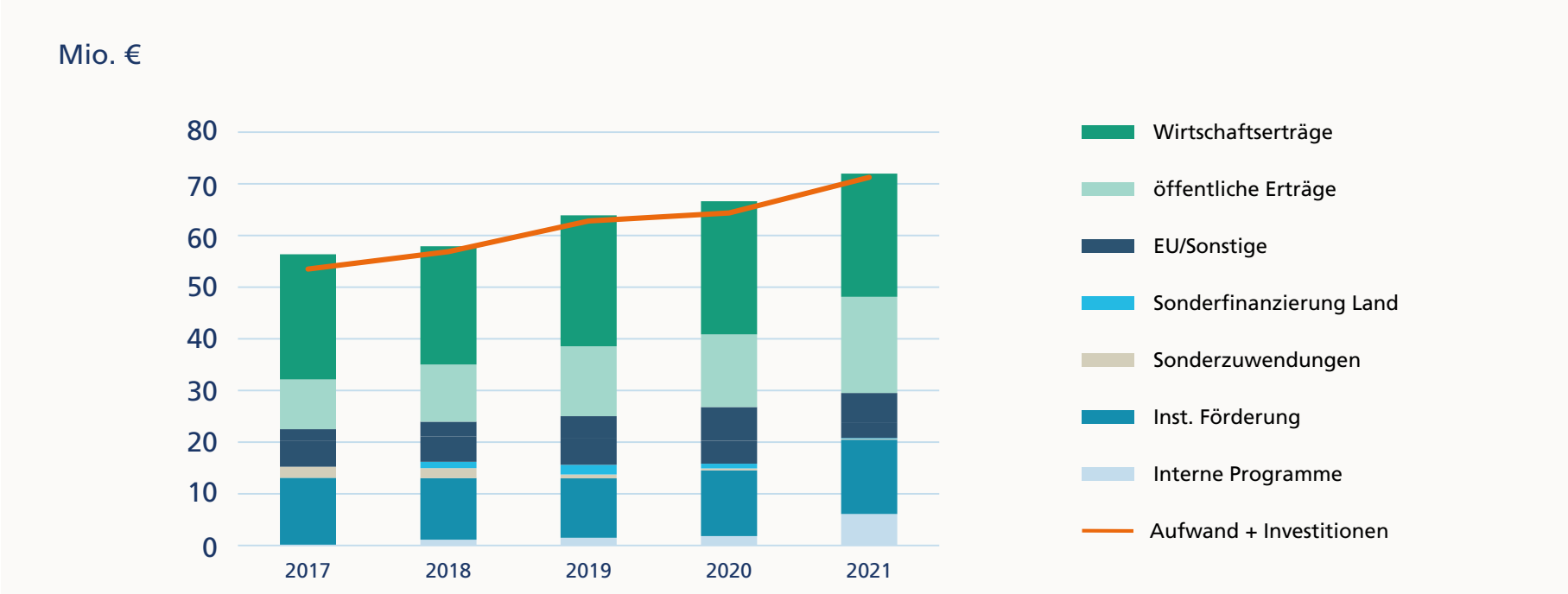
Budgetentwicklung 2021

Stabiles Wachstum auch im zweiten Pandemiejahr



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Personalentwicklung - Köpfe HHI gesamt

Stammpersonal

2017
Stammpersonal
331

2018
Stammpersonal
339

2019
Stammpersonal
365

2020
Stammpersonal
358

2021
Stammpersonal
389

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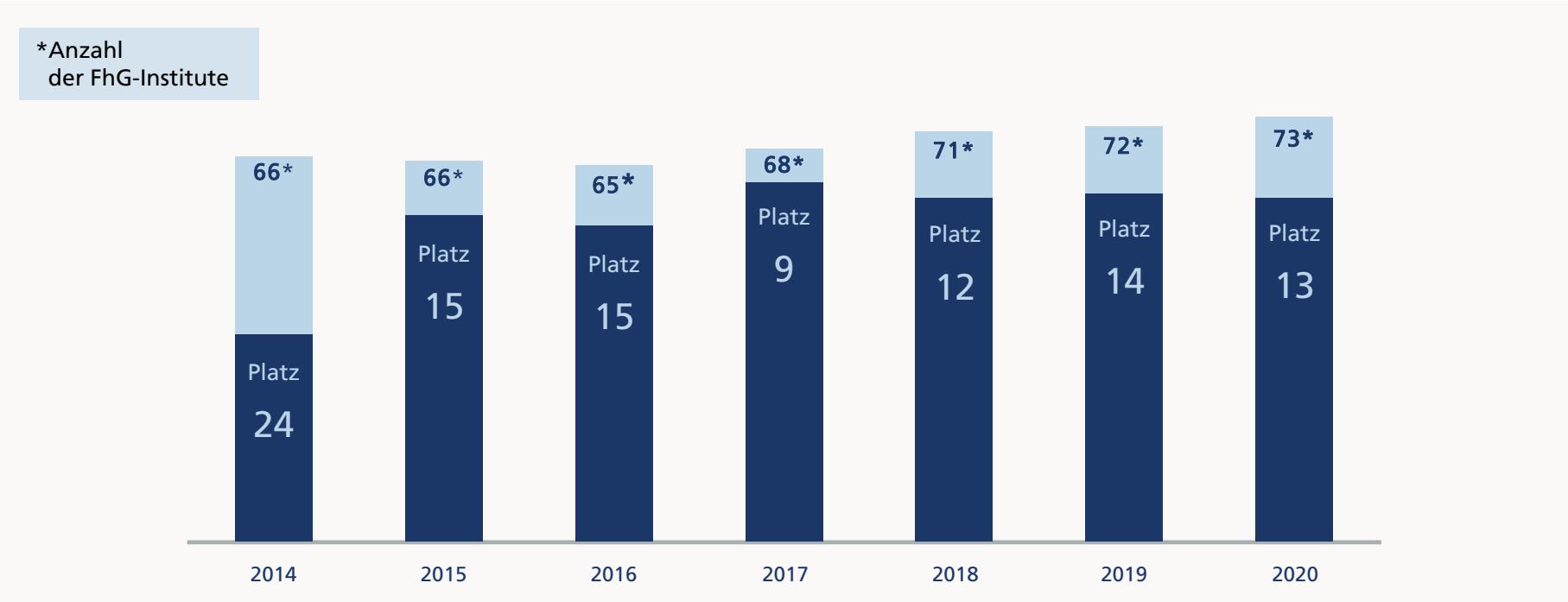
Wissenschaftliche Exzellenz

HHI auf Platz 13 unter allen Fraunhofer-Instituten



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Photonic Networks and Systems (PN)

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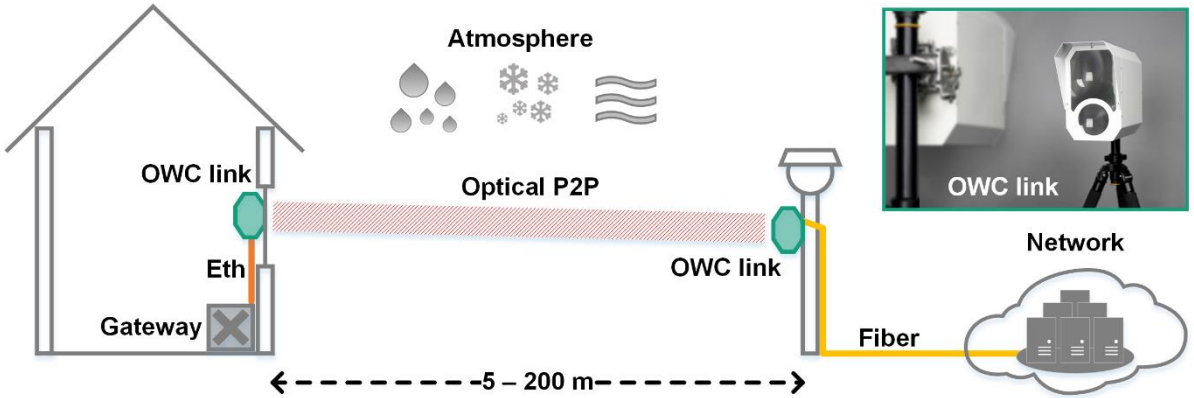
Wireless-to-the-Home with Deutsche Telekom

LiFi Link for last hop to the home

- Bridge last meters to customers with wireless link
- Communication possible through insulation glass
- +1 Gbit/s @ 100 m



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Project LINCNET

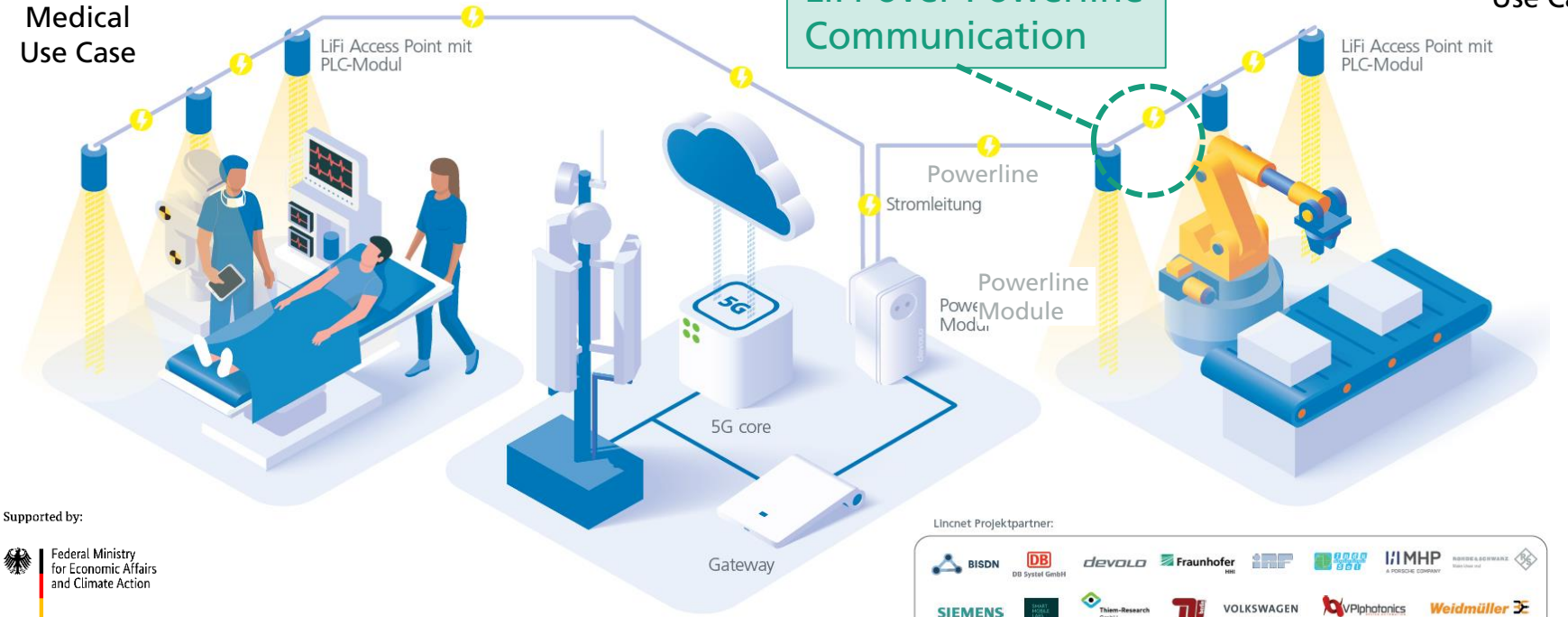
consortium led by: devolo

LiFi from the power plug

Medical Use Case

Industrial Use Case

LiFi over Powerline Communication



Supported by:

Federal Ministry for Economic Affairs and Climate Action

Lincnet Projektpartner:

BISDN, DB Systel GmbH, devolo, Fraunhofer HHI, IMP, MHP, Rohde & Schwarz, SIEMENS, Thiem-Research GmbH, VOLKSWAGEN, VPIphotonics, Weidmüller

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6G over LiFi

Transparent transmission of 6G waveforms

- **6G Requirements**
  - >1 Tbit/s per access point covering larger cell size
  - >10 Gbit/s per user device, cable-like QoS
  - Ultra-reliable, ultra-low latency, support for large number of IoT devices

- **6G over LiFi**
  - Use LiFi to transmit 6G waveforms, similar to fiber optics
  - LiFi offers high traffic density and enhanced security
  - Guaranteed QoS by central coordination
  - Cellular protocols handle impairments of LiFi channels, inter/intra-cell interference

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High-End Lab Equipment: Best Fraunhofer Acquisition 6/21

The success story continues…

Coherent Receiver Frontends

42 HE Racks (~2m)

- Best Fraunhofer acquisition in June 2021
- Project volume: 1.425 Mio. €
- 80 channels, 6.4 TSa/s, 51.2 Tbit/s capacity

Dual-pol IQ-Modulator

IDPHOTONICS

- Upgrade of OMFT prototype to 60 GHz BW
- Up to 110 GBd or 64 QAM
- >30 units OMFT-40, OMFT-60 sold

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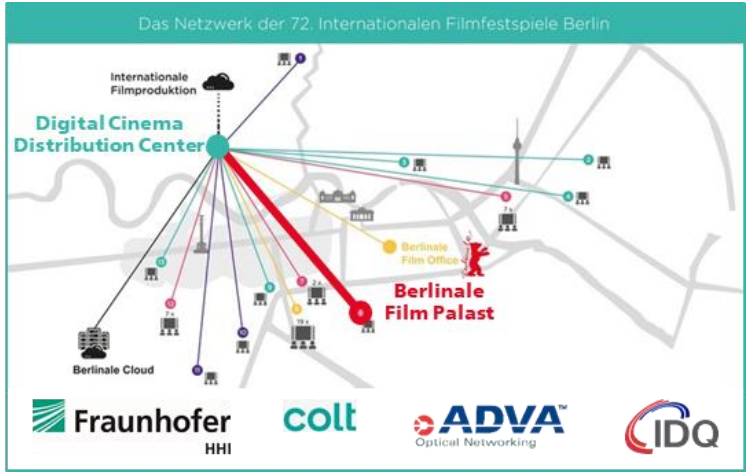
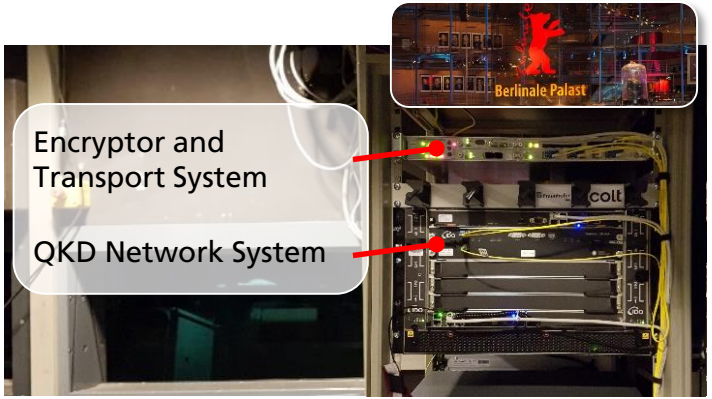
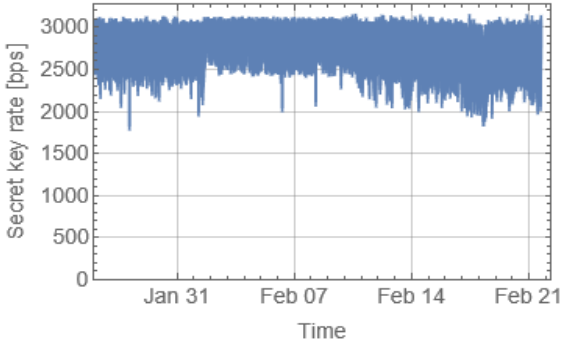
QKD-secured: Berlinale Film Festival 2022







- QKD-secured digital movie distribution during Berlinale 2022
- 37 festival premiere movies with 6 TB of data distributed and protected by QKD

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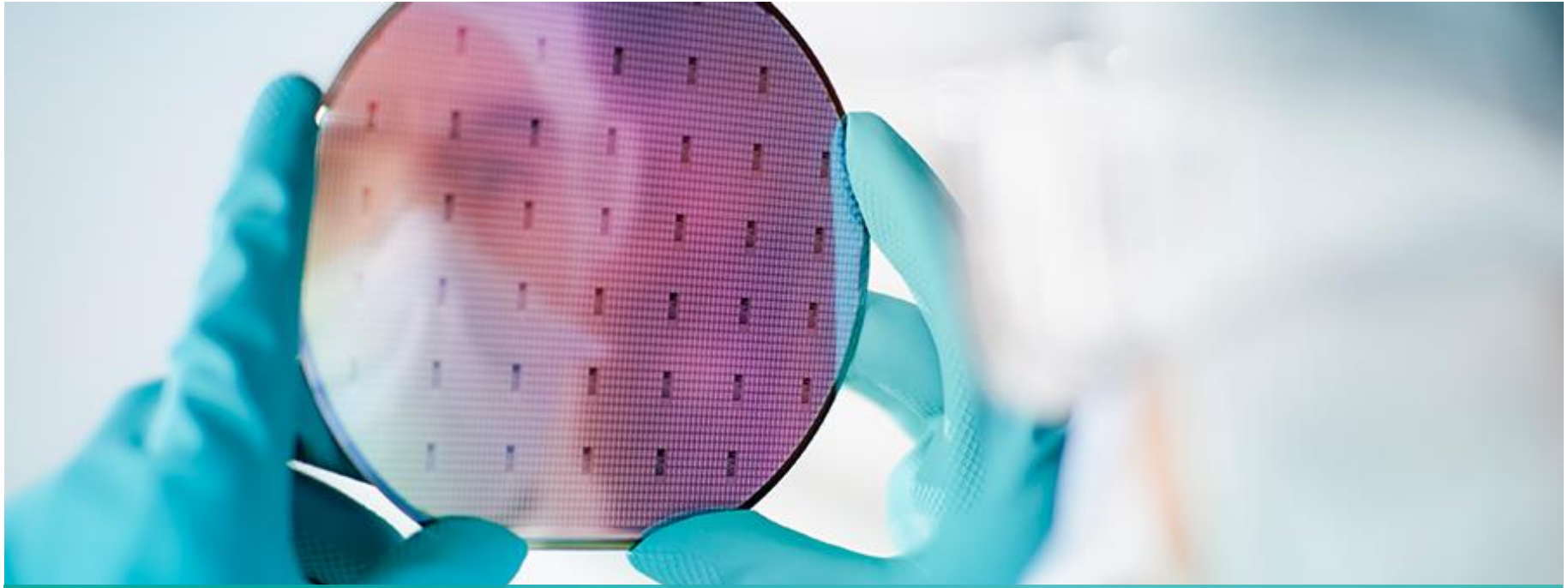

Photonic Components (PC)

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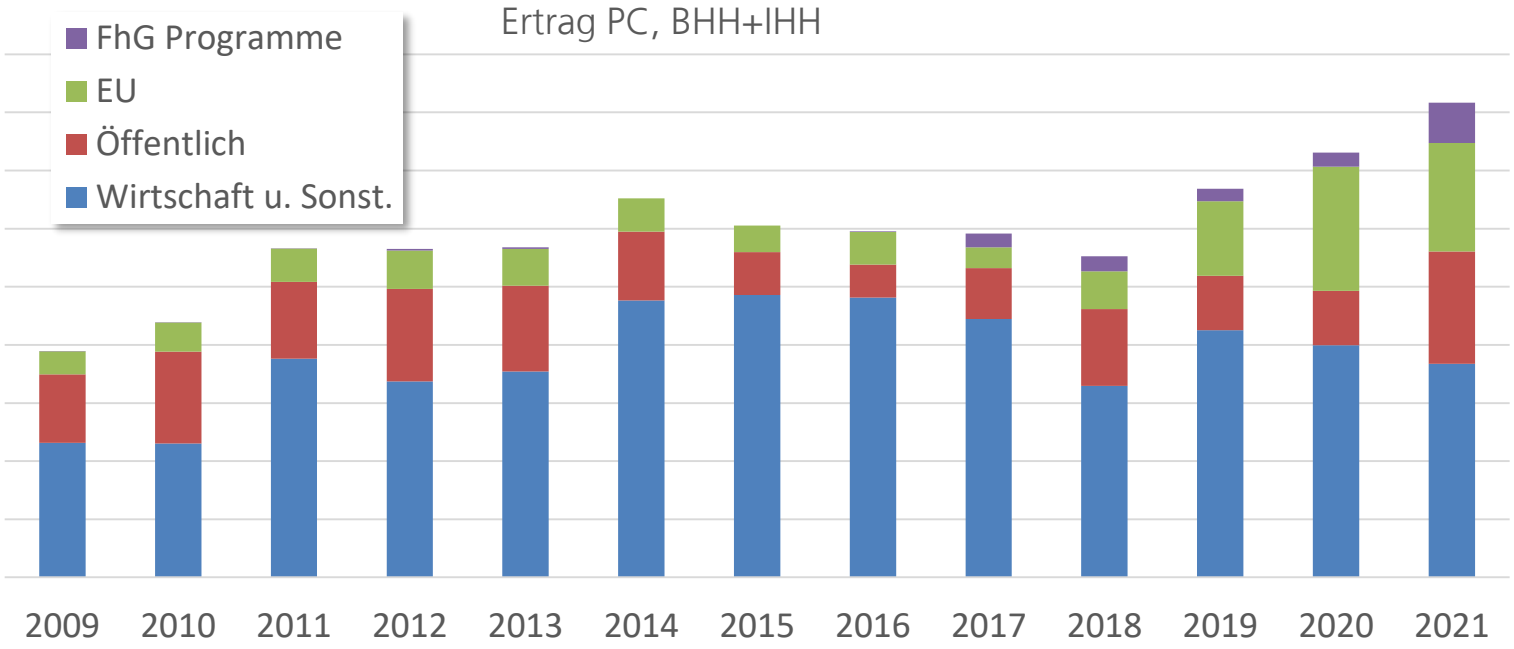
PC trotz Corona weiter gewachsen

2021: Hauptsächlich öffentlicher Invest



Ertrag ohne Regelgrundfinanzierung BHH/IHH, institutionelle Förderung IHH. Stand Sigma Betriebssicht April 2022. Vor HHI-internen Korrekturen.

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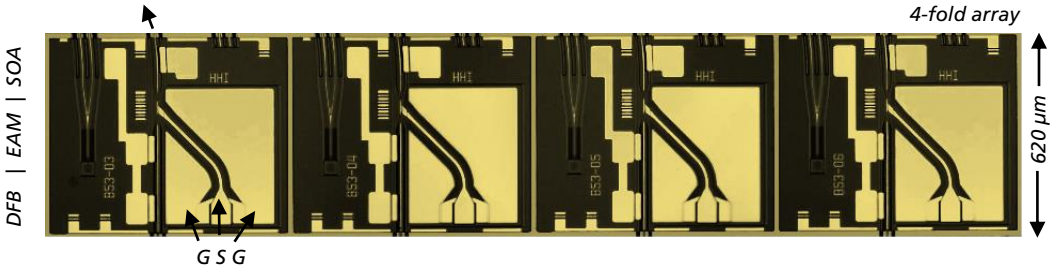
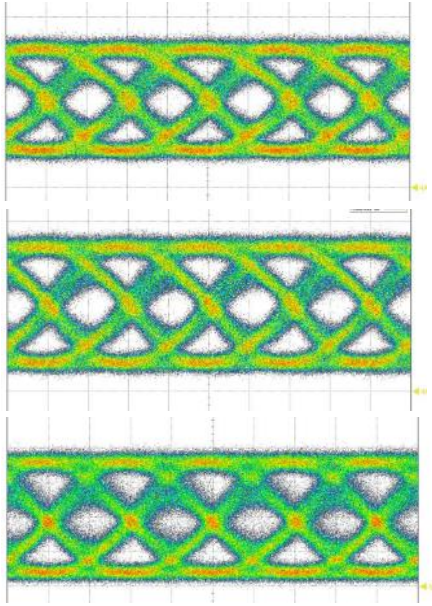
EML Array Chip for uncooled 100 GBd / channel

With integrated amplifier



- High bandwidth & **uncooled** operation
- High output power, power equalization by integrated SOA
- Publication at OFC 2022 - "Uncooled 100 GBd O-Band EML for Datacom Transmitter Arrays"
- Main competitor: Lumentum (Japan): Single EML with 76 GHz bandwidth (50°C)
- Customers: GPU manufacturer (USA), TRX manufacturer (Asia)

100 Gb/s NRZ optical eyes



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Björn Globisch mit Karl-Scheel-Preis ausgezeichnet

Preis der PGzB für herausragende wissenschaftliche Leistung unmittelbar nach Promotion

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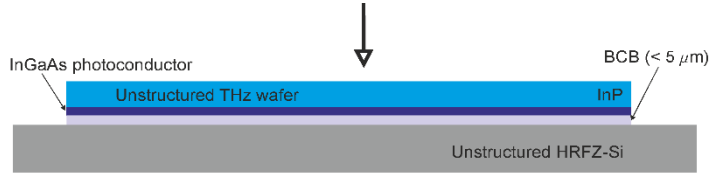
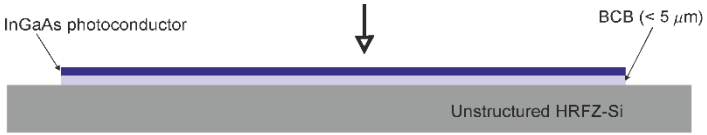
Next generation THz antennas: 10 THz bandwidth

1.2 µm-thin InGaAs membranes on Silicon

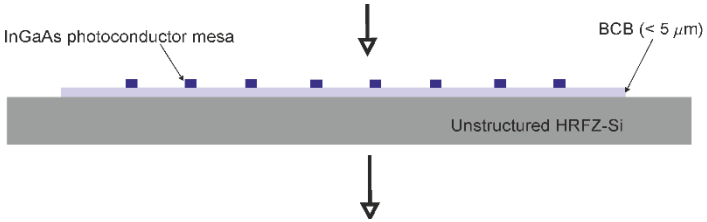
1. Waferbonding: InP on Si



2. Lapping and wet etching

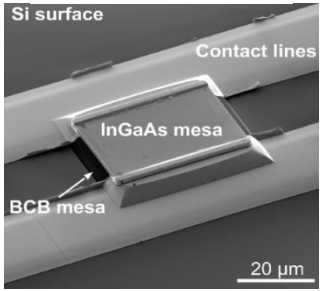


3. Mesa etching + antenna structuring

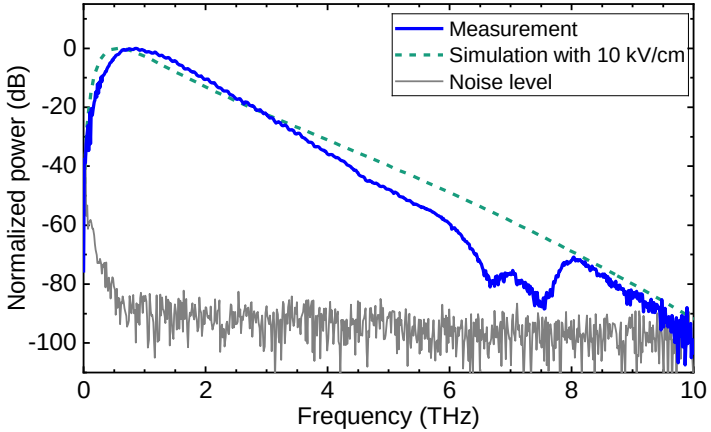


4. Separation of THz antennas

PCM THz antenna



Fiber coupled module



- Wafer scale fabrication process
- First time: Full optical band-width converted to THz

Paper under review in Optics Express

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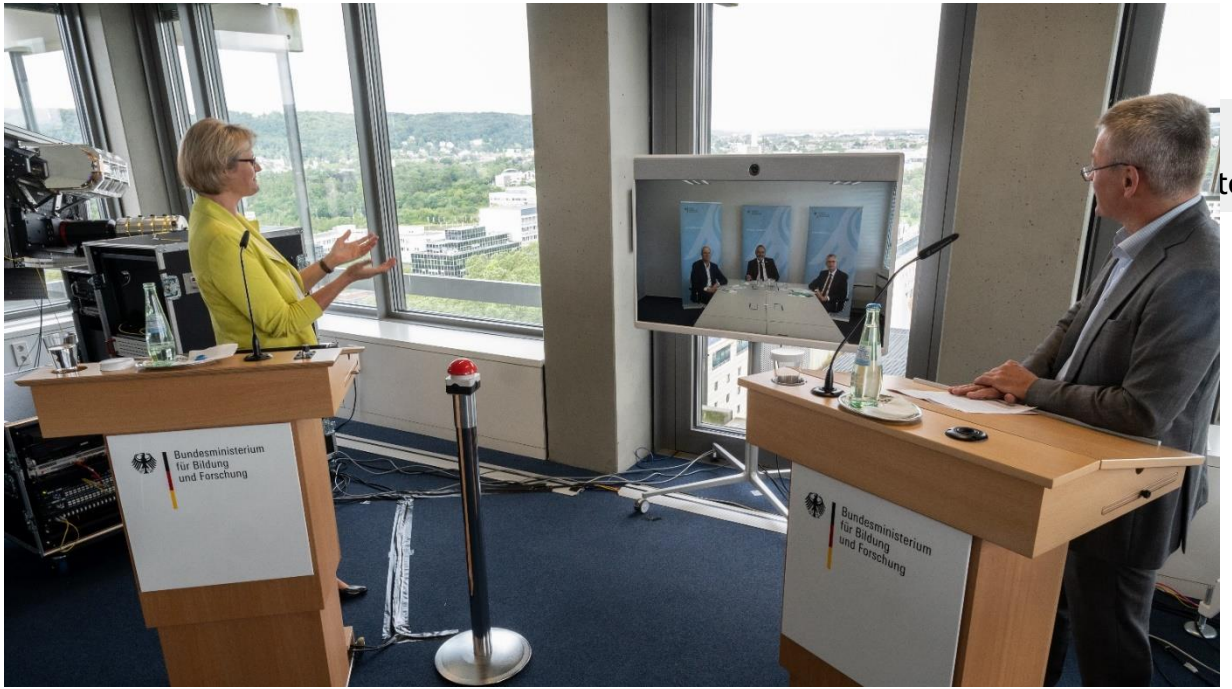
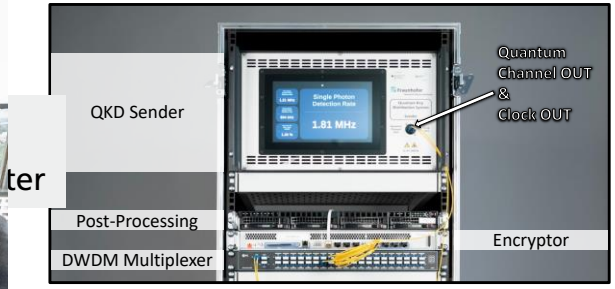
QuNET: Quantum Protected Video Connection

Between BMBF + BSI in Bonn





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BERLIN

Fiber Optical Sensor Systems (FS)

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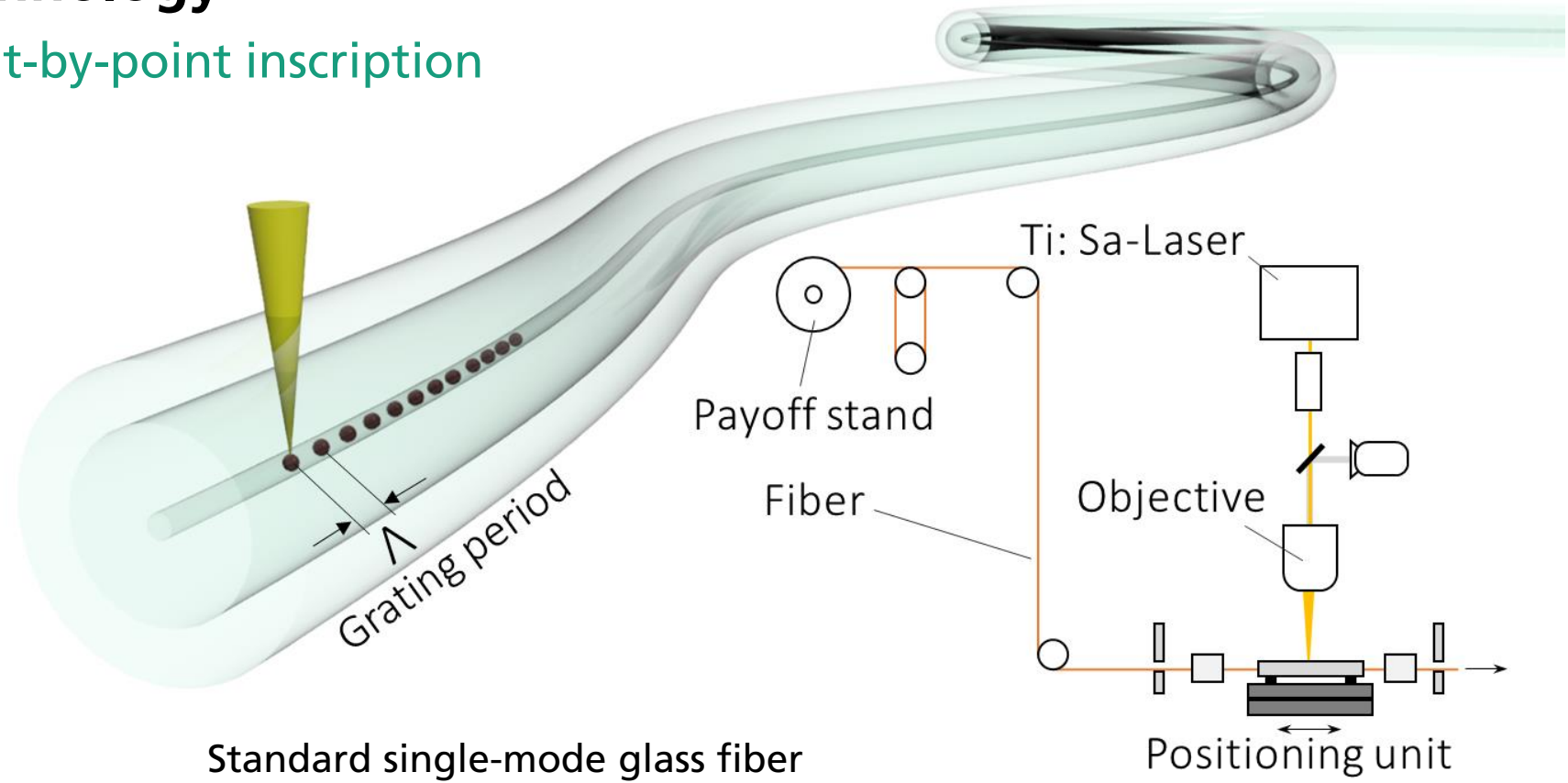
Technology

Point-by-point inscription



Standard single-mode glass fiber

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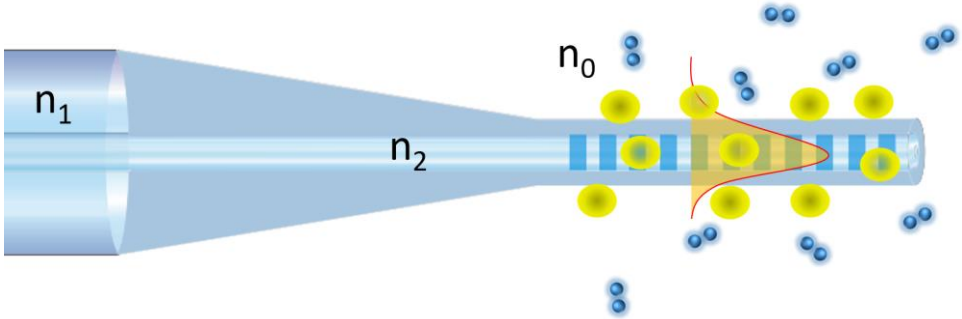
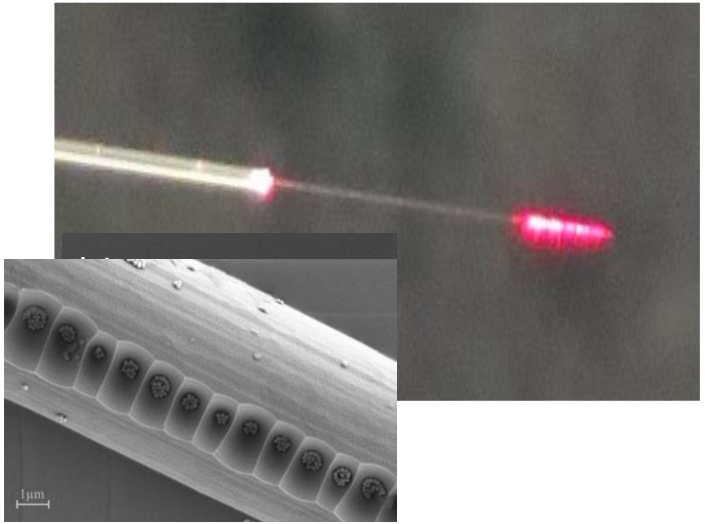
FiberLab: Fiber optical H2-sensors

Evanescent detection of H_2: Fiber optical etched FBG sensor coated with catalytical Pd nano-particles





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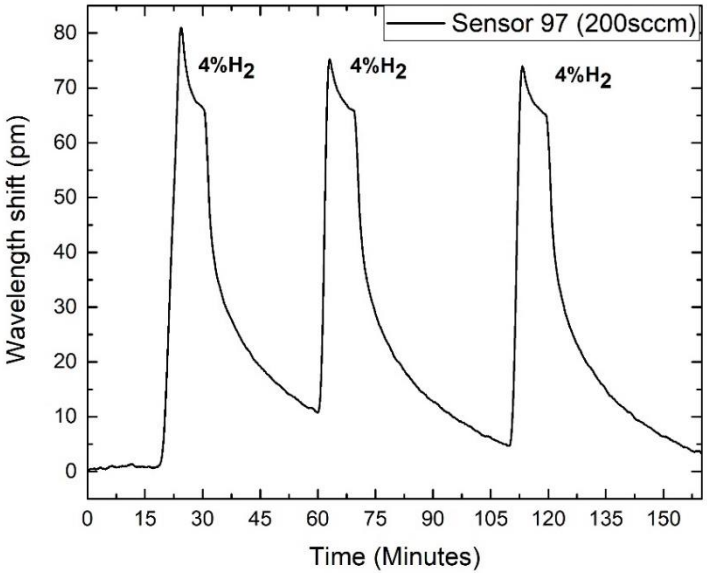
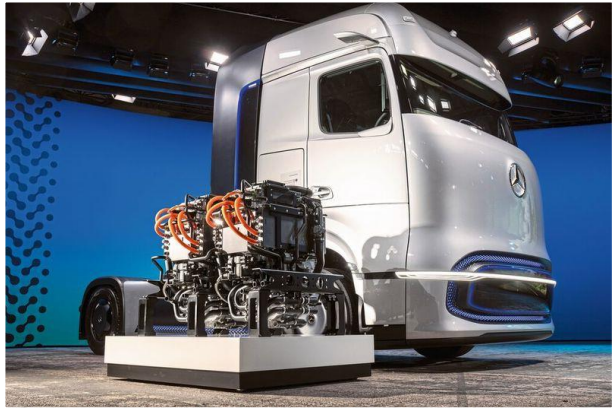
FiberLab: Fiber optical H2-sensors

H_2 fiber sensors with catalytical nanoparticles exposed to hydrogen atmosphere





Monitoring of H_2-leakage in hydrogen-driven trucks

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POWER Informationen zur Energiewende
SOLARIFY
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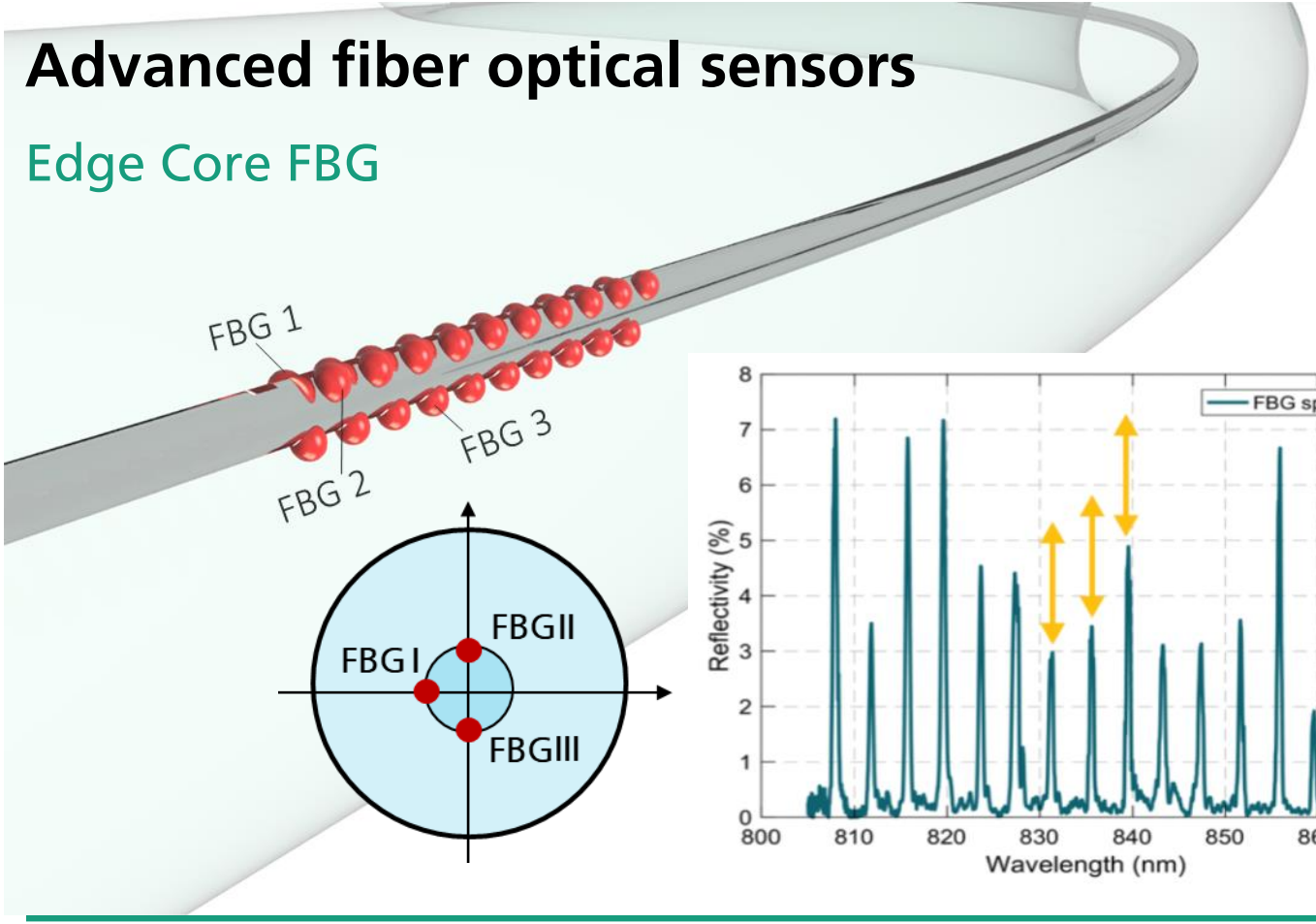
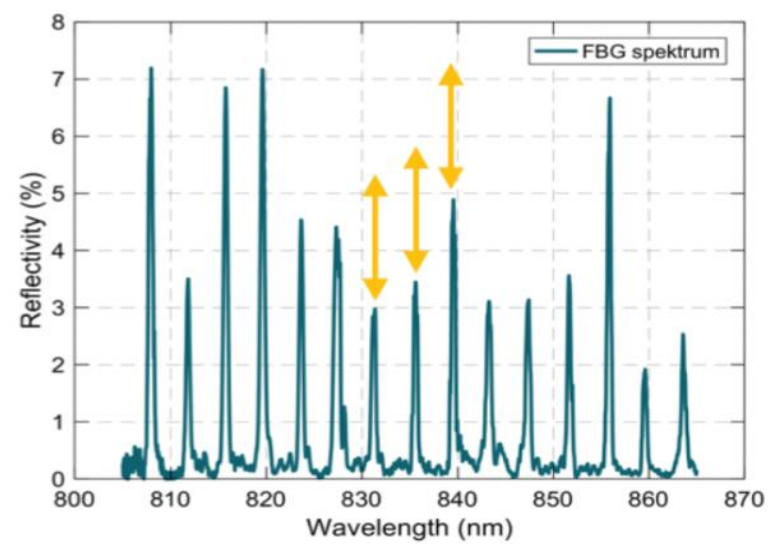
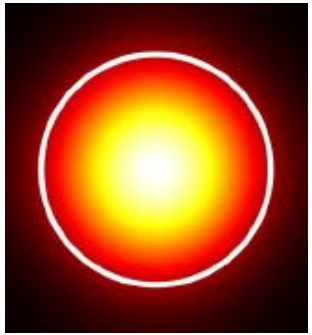
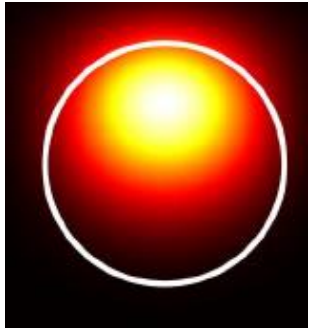
Advanced fiber optical sensors

Edge Core FBG









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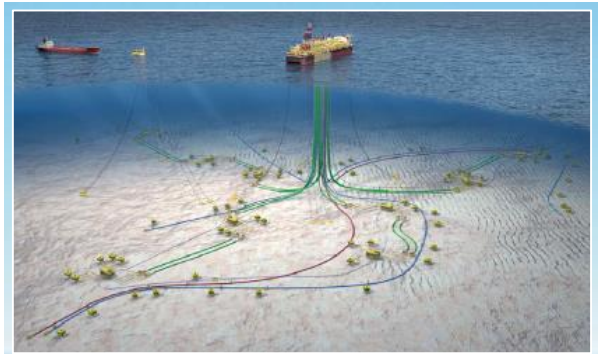
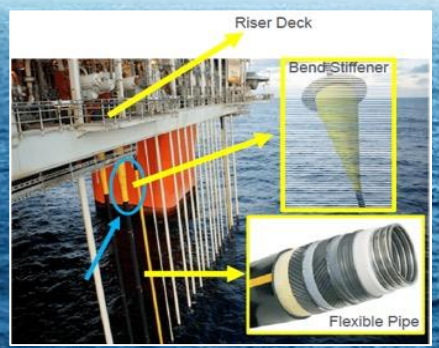
3D Shape Sensing of flexible Tubes in Oil & Gas Exploration

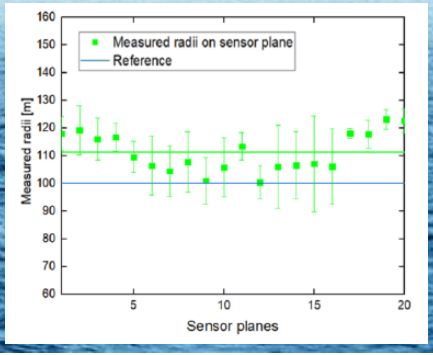
First tests in Brazil – Vitória 08/21

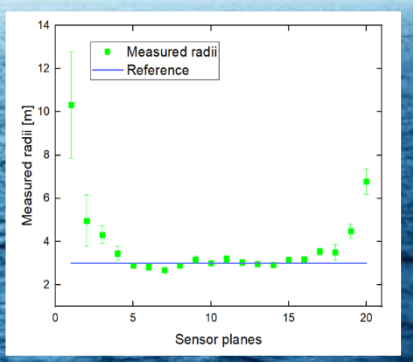


Challenges

- Total length of flexible pipe > 1 km
- Dynamic range of bending radii range from 3 to 2000 m







TechnipFMC

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Thermal abuse test of 120 kWh LIB in transport box

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Vom Erzbergwerk über Industriebrache zum Reallabor

Erzaufbereitungsanlage

1980

Industrie-Ruine

2020

CO_2 –neutrales Reallabor Batterien

2021

Photovoltaik: 20 kWp (50 kWp)

2nd Life LIB Speicher: 85 kWh (250 kWh)

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Wireless Communications and Networks (WN)

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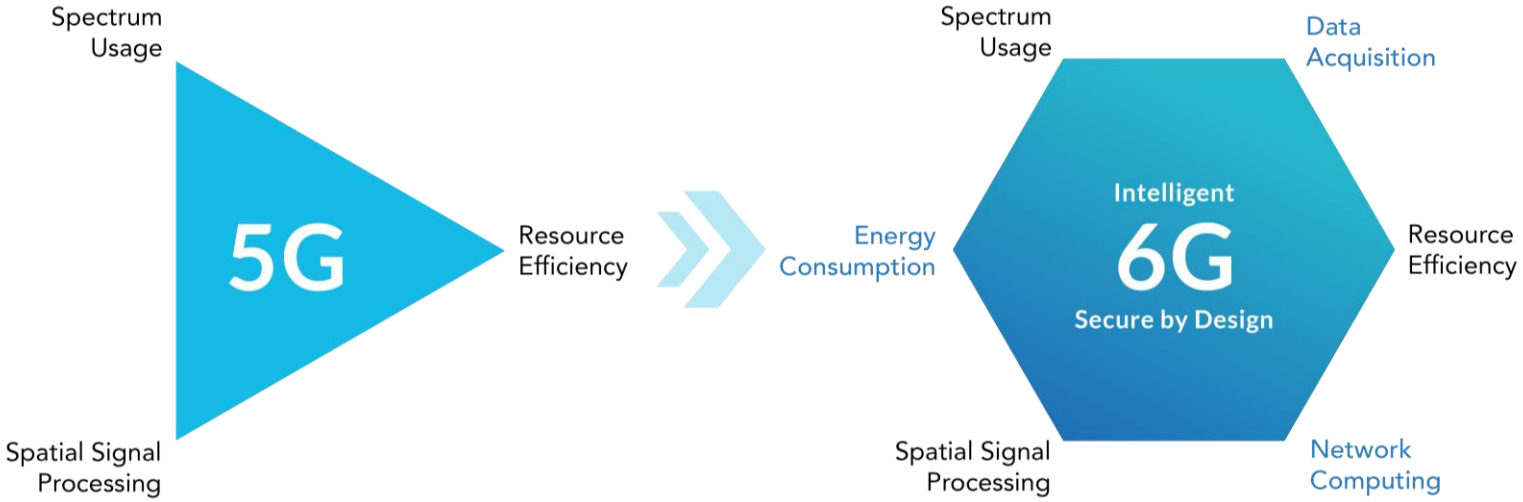
Transition towards 6G

Extended design dimensions



Speaker

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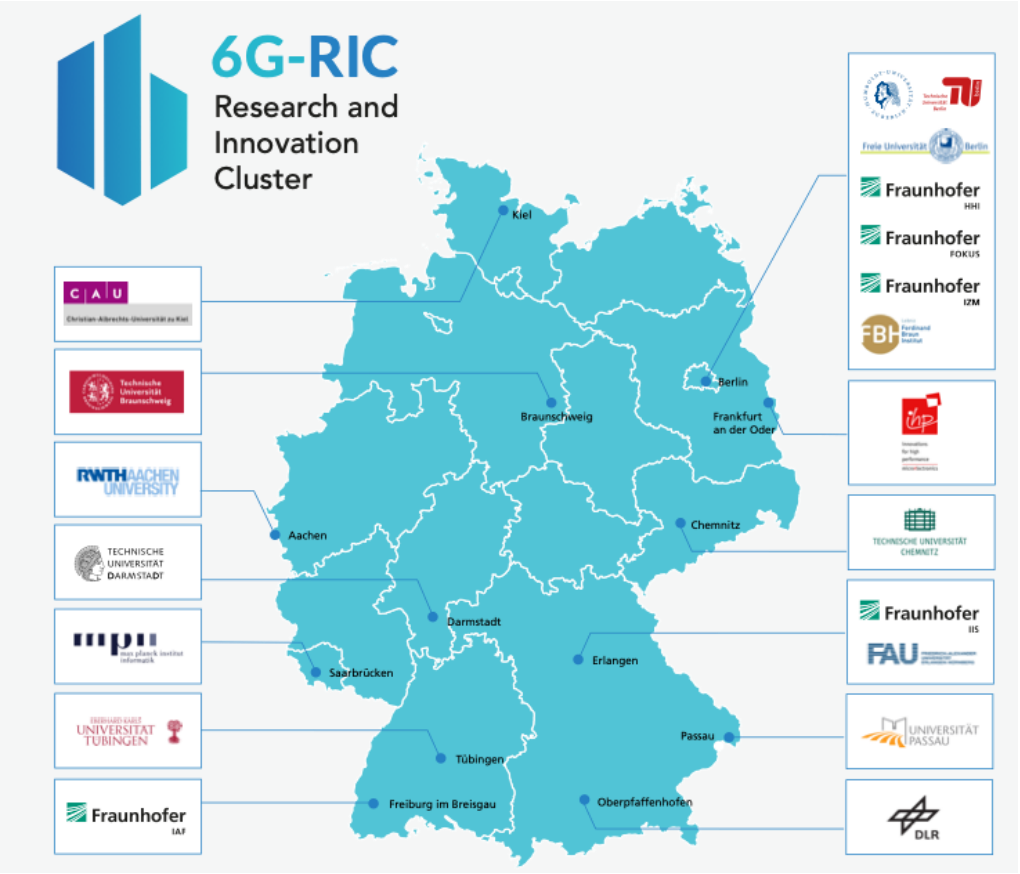
6G-RIC

- **Duration:** 1.8.2021-31.7.2025
- **Funding:** 70 Mio. €
  - Investment: ca. 12 Mio. €
  - Subcontracts: ca. 11 Mio. €
- **Coordination:** HHI



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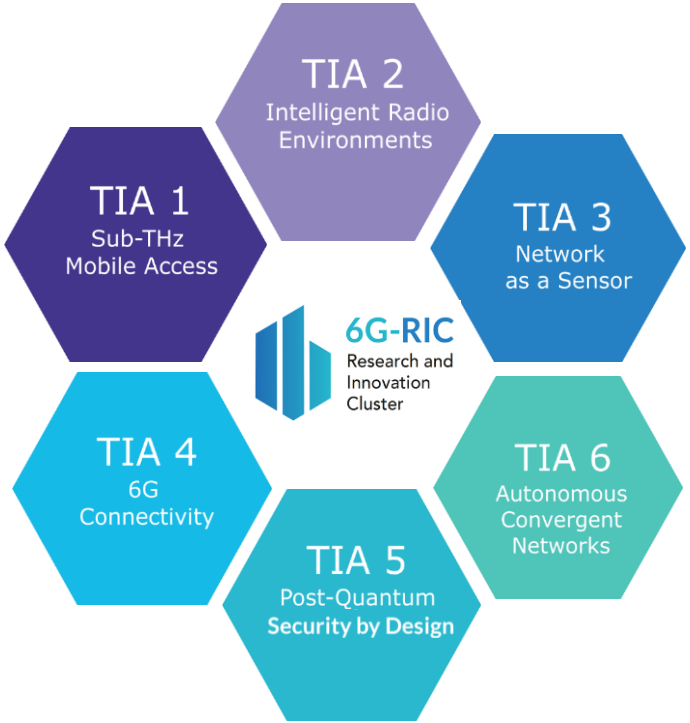
6G-RIC

Definition of Technical Innovation Areas (TIA)



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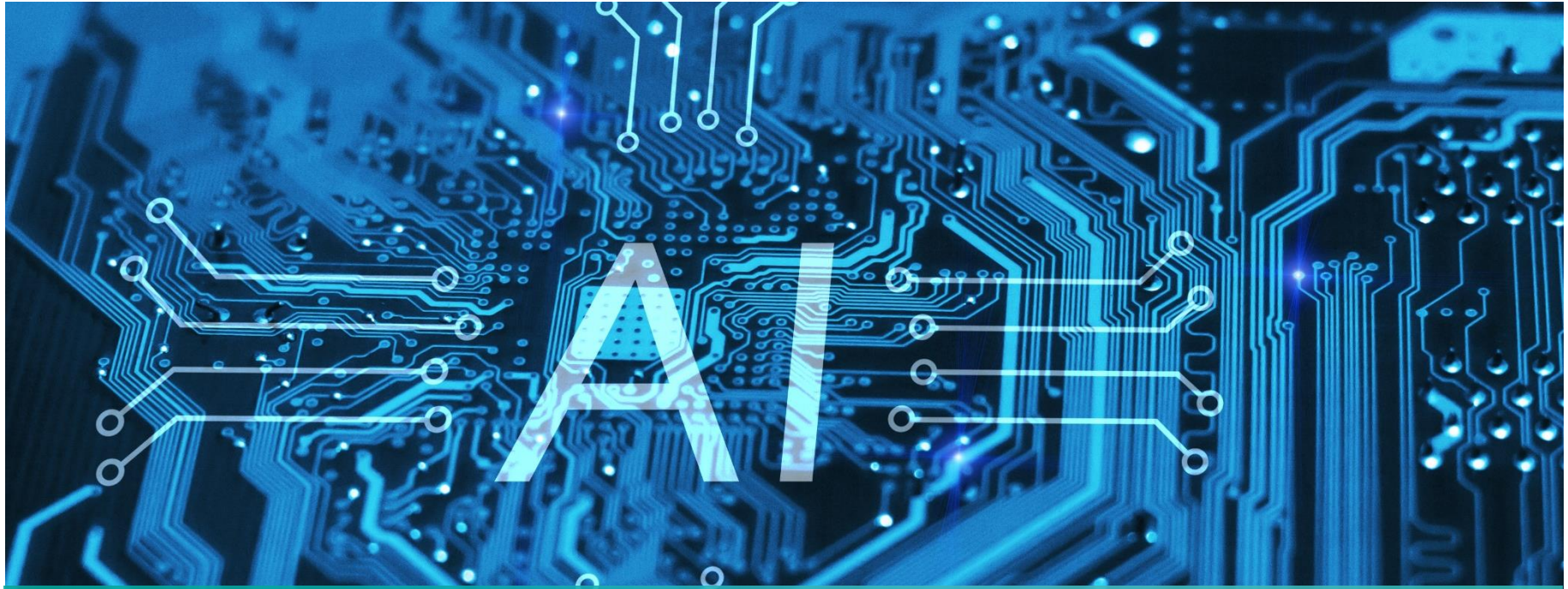

Artificial Intelligence (AI)

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New Professorship

Machine Learning & Communications

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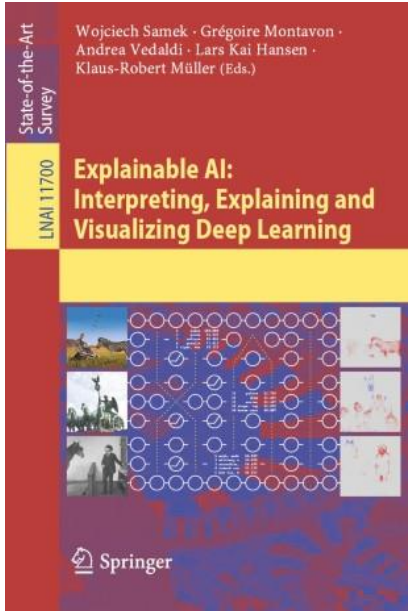
Explainable AI 2.0

New Book, New Research …

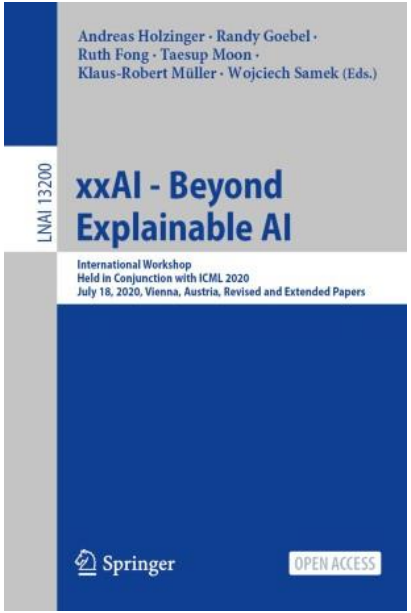
2019



310k

Downloads

2022



New directions in XAI:

- Explain & improve
- Concept-level XAI
- Regression, RL, Unsup. L.
- Non-interpretable domains
- Beyond explaining

…

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Explainable AI 2.0

Limitations of heatmap explanations

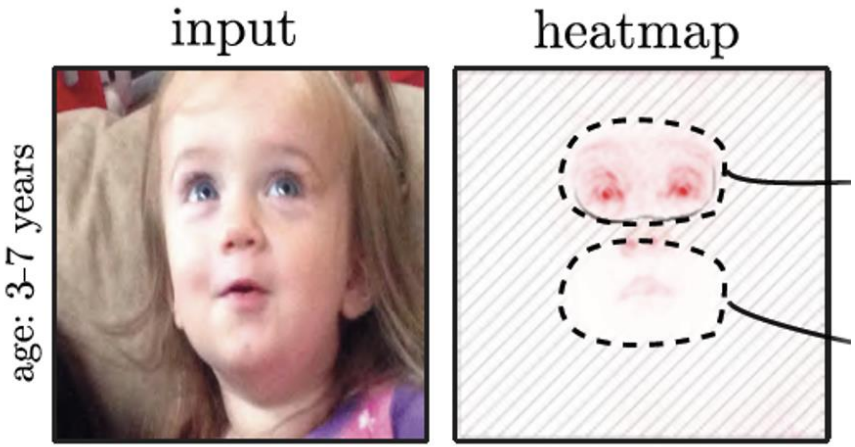
LRP Heatmaps (2015):

- explain *where* the model looks at, not *what* the model is doing.

Limitations:

- we do not learn anything about the model and its representations.

- humans think in terms of concepts, not in terms of pixel-wise values.



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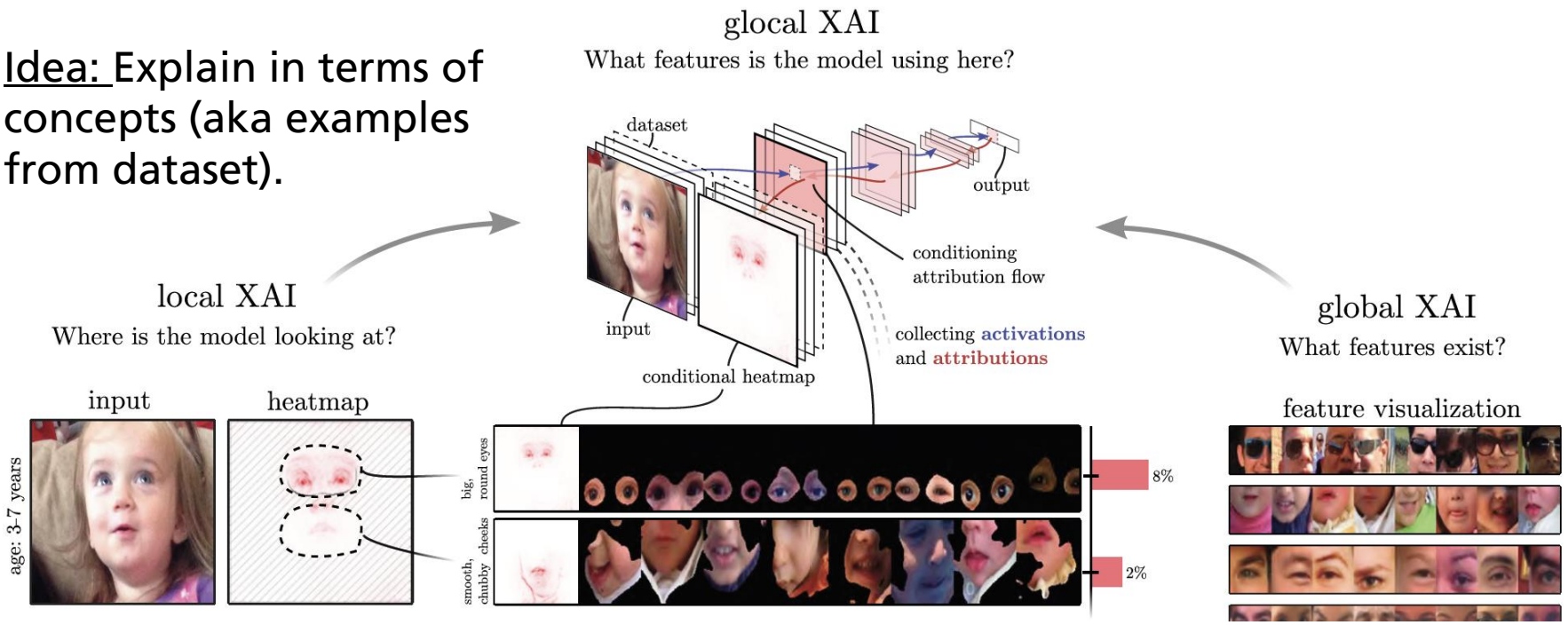
Explainable AI 2.0

Concept Relevance Propagation (CRP)

<u>Idea:</u> Explain in terms of concepts (aka examples from dataset).



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NN Compression and Green AI

Energy-efficient AI project

EEAI

Auf dem Weg zu energieeffizienter künstlicher Intelligenz

Welche Energieeinsparpotenziale bieten KI-Anwendungen?

dena
Deutsche Energie-Agentur

- Quantify energy requirements of AI (data center, distributed setting…)
- Evaluate potential of hardware designs, compression methods, algorithmic tricks to reduce energy
- Demonstrate savings in exemplar applications

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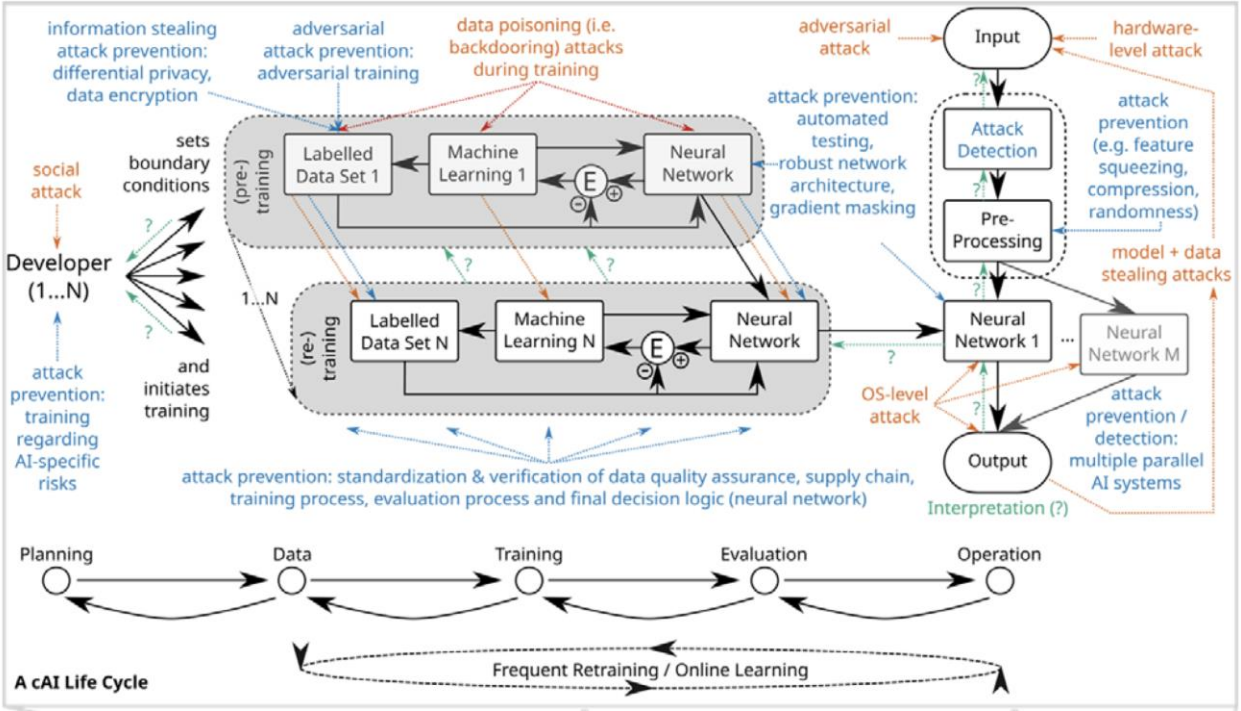
New Topics

Towards Auditing and Certification



Bundesamt für Sicherheit in der Informationstechnik

TÜV VERBAND

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Vision & Imaging Technologies (VIT)

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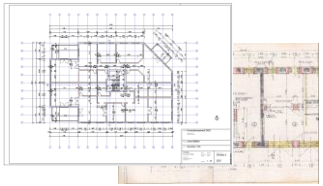
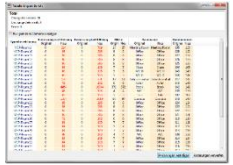
BIMKiT: Digital Twins for Construction Industry



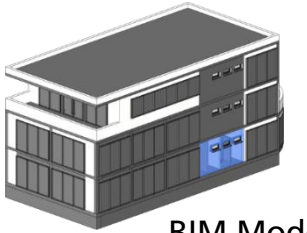
CAD/scanned plans



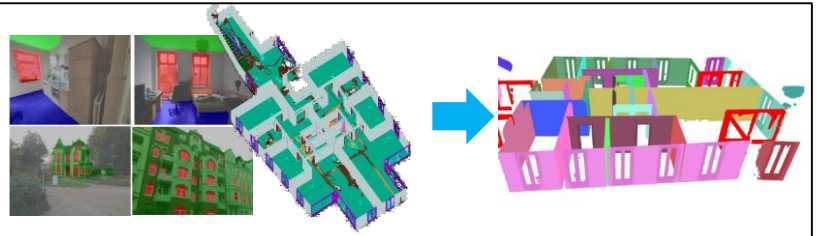
Documents

Point clouds

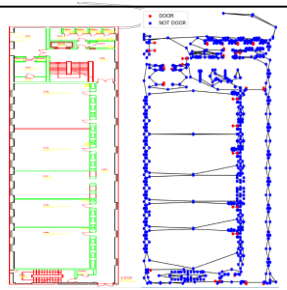
Images



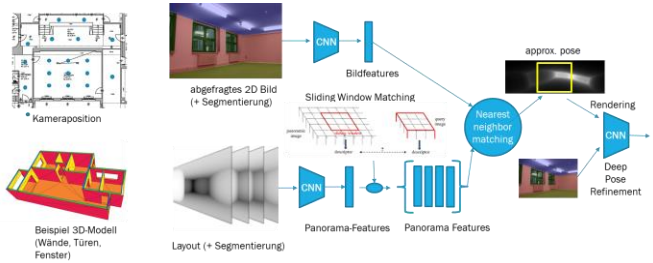
BIM Modell



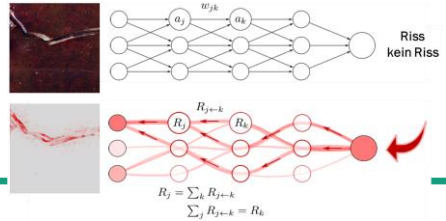
Hybrid Image and Point Cloud Segmentation



CAD Analysis via GNNs



Matching Images and 3D Models



Damage Detection

And many more...

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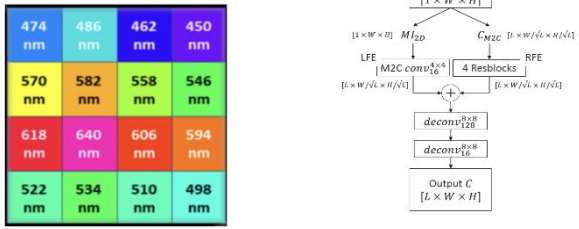
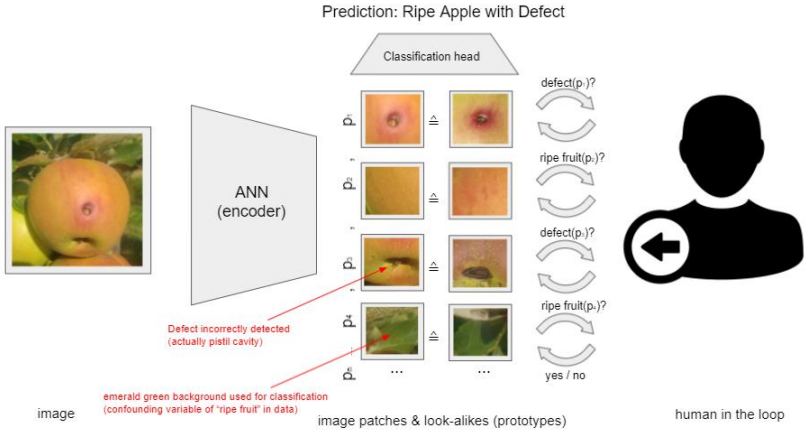
NaLamKi: AI-based sustainable Agriculture

NaLamKI

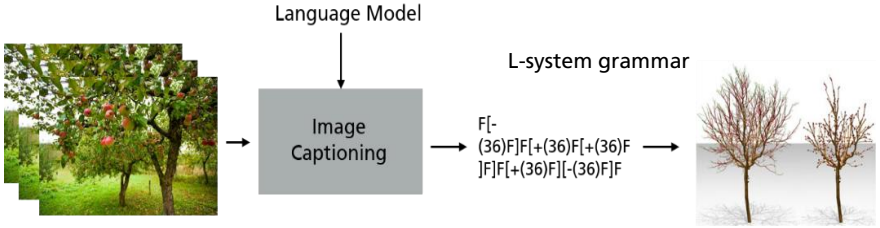
- AI methods for
  - Capturing & prediction of plant growth
  - Determination of plant physiology
  - Prediction of crop yield



Deep Image Restoration for HSI Imaging



Prototype Learning & Human in the Loop



Grammar-based Procedural Plant Modeling

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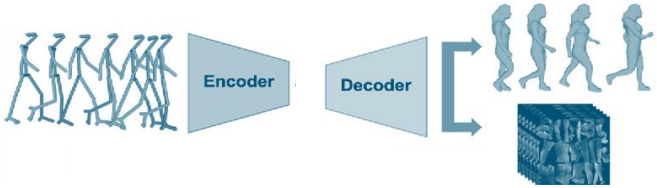
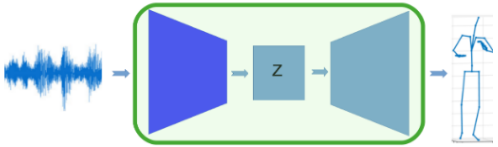
From Volumetric Video to Virtual Humans

Volumetric Video

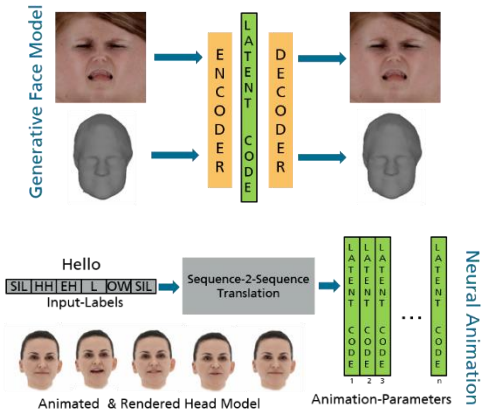
Volumetric Video Animation
Contributions to standards (MPEG, gltf)



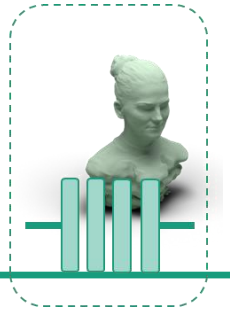
Generative Models (e.g. impl.Representations)



Speech-driven Gesture Synthesis



Generative Face Model &
Text-driven Animation



Neural Shading

W. Paier et al., IEEE CGA 2021
M. Wochel et al., CVPR 2022
A. Zimmer et al., CVM 2022
…

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Video Communication and Applications (VCA)

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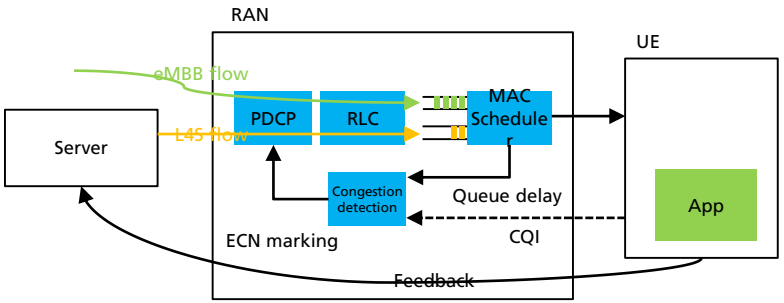
Volumetric Video Streaming over 5G with L4S

- Guaranteed low latency over 5G with L4S
- In cooperation with Dt. Telekom and Ericsson



Demo video for MWC2022

Managed Latency panel at Telekom booth @MWC 2022 with Dr. Cornelius Hellge

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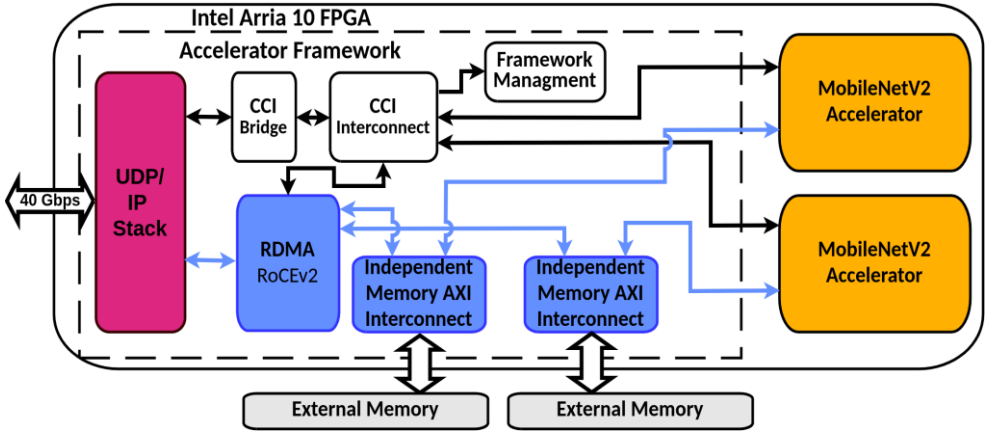
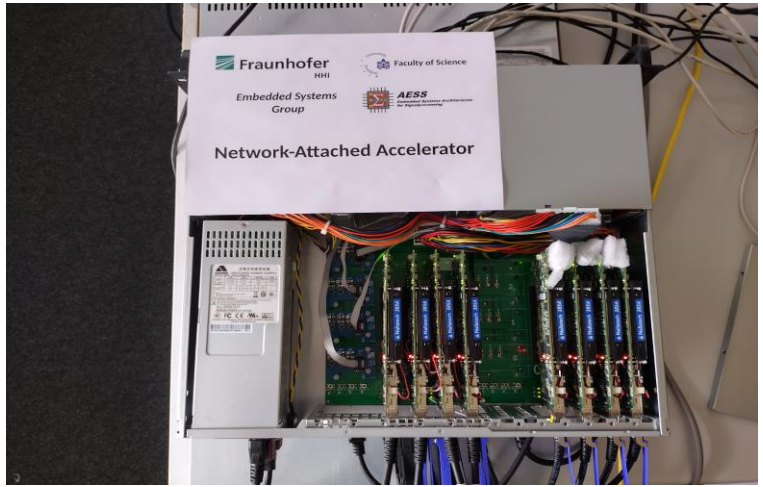
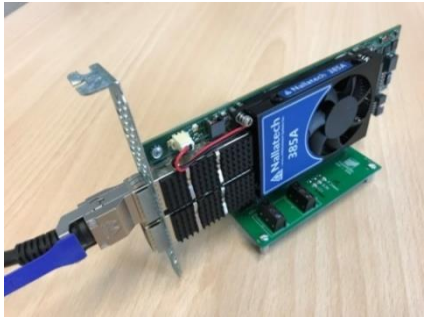
Embedded Systems

NAA – Network attached Accelerator

- ML Accelerator for data center applications
- 40Gbps (100Gbps) Network Stack







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Vielen Dank für Ihre Aufmerksamkeit!

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