HELMHOLTZ

RESEARCH FOR
GRAND CHALLENGES

Research Field Matter
Matter and Technologies

# MT-DTS-ST2 – System Technologies

Moritz Guthoff, Andreas Kopmann

DTS strategy meeting
January 11, 2024

# Achievements 2021-2023

## From PFB

- MT highlights
  - 2021: Terabit per second processing with Serenity board
  - 2022: readout of cryogenic sensors
  - 2022: reinforcement learning for accelerator control

- Attracting the best talents
  - 7 PhDs, 4 with distinction
  - 2021 Faraday Cup for beam diagnostics
  - 2022 Helmholtz doctoral prize for system to readout of quantum devices
  - 2022 Honorary Prize of the Austrian Ministry of Science
  - 2023 Best paper award IEEE Conference on Network Function Virtualization and Software Defined Networks

# Achievements 2021-2023

## From PFB

- Publications / Open-source Software
  - 2021 6 / 0
  - 2022 13 / 4
  - 2023 11 / 5
- Shared hardware design and production
  - DTS 100G
- Additional funding for
  - ACCLAIM: AI for beam control
  - PANDA MVD DAQ system
  - ALCYONE X-ray dosimeter for space lab
  - Ultrasound computer tomography
  - Cryo electronics lab
- Success in technology transfer

# Achievements 2021-2023

## From PFB

- Contributions:
  - CMS TrackTrigger
  - DAQ system for ECHo
  - Readout CUBIC
  - KATRIN data management
  - Timepix4 readout

  - Silicon photonics design tools
  - Advancing packaging facilities
  - CBM-STS detector cables
  - CMS pixel modules
  - PIXDD ASIC sensor bonding

# MT-DTS working groups

**ST1: Detection and Measurement**
M. Caselle (KIT), M. Deveaux (GSI),
S. Spannagel (DESY)

**ST2: System Technologies**
A. Kopmann (KIT)
M. Guthoff (DESY)

**ST3: Science Systems**
C. Schmidt (GSI)
C. Wunderer (DESY)

**Sensing**
Alexander Dierlamm (KIT-IPE)
Sebastian Kempf (KIT-IMS)
Michele Caselle (KIT-IPE)
Marcel Stanitzki (DESY)
Michael Fiedler (KIT-IPS, U FR)
Simon Spannagel (DESY)

**Advanced Data Transmission**
Karsten Hansen (DESY)
Marc Schneider (KIT-IPE)

**Digital Real-time Data Acquisition and Processing Systems**
Luis Ardila, Oliver Sander (KIT-IPE)
Suren Chilingaryan (KIT-IPE)

**Particle Physics, Hadrons & Nuclei**
Silvia Masciocchi, Christoph Caesar (GSI)
Christian Enss (KIT-IPE, U HD)
Volker Tympel (HI Jena)
Frank Simon (KIT-IPE)

**Photon Science**
Michael Fiederle (KIT-IPS, U FR)
David Pennicard (DESY)

**ASICs**
Ulrich Trunck (DESY)
Ivan Peric (KIT-IPE)
Steven Worn (DESY-Zeuthen)

**Novel Engineering Techniques, Advanced Materials and Interconnects**
Thomas Blank, M. Caselle (KIT-IPE)
Moritz Guthoff (DESY)
Karsten Hansen (DESY)
Christian Schmidt (GSI)

**Astroparticle Physics**
Matthias Balzer (KIT-IPE)
Steven Worm (DESY-Zeuthen)
Andreas Haungs (KIT-IAP)

**Beam Physics**
Michele Caselle (KIT)

# Summary of new topics in PoF V

## List of received and expected project templates

- DAQ
  - Data transfer and reduction for X-ray cameras; receiving and reducing X-ray data using PCs with accelerator cards
  - Real-time data acquisition for ultrasound tomography
- Readout quantum devices
  - DAQ system for KATRIN++ with megapixel quantum sensors
- Computing & Algorithms:
  - Software-defined DAQ
  - Low frequency 3D ultrasound tomography device for highly advanced imaging algorithms
  - Computer Aided Diagnosis using multimodal AI

# Summary of new topics in PoF V

## List of received and expected project templates

- Packaging and interconnect:
  - 3D integration and fast prototyping
  - 3D stacking and interposer technologies
  - Silicon interposer; micro channel cooling for Photon Science detector systems
  - CMUT based ultrasound transducer arrays; application: wearable ultrasound tomography
- Advanced materials:
  - Micro channel cooling
  - Thermal materials for detector applications
  - Novel 3D printing techniques (?)
- Silicon photonics: packaging for 3D-integration, component design, demonstrator
- Silicon photonics for detectors: monotithic approach

# Key applications in PoF V

## From DESY, GSI, HI-Jena, KIT

- Limited funding requires wise focus
- Criteria:
  - Larger interest in the centers
  - Cutting-edge technology
  - Existing pre-work
  - Good effort to impact ration, matching group size
- Example: topics under discussion in KIT
  - Quantum sensors for
    - KATRIN with 1MPixel
    - Cosmology
    - X-ray spectroscopy
- Ultrafast beam diagnostics
- Quantum computing
- Health technologies
- *LHC, FCC detector and DAQ development*

# Foreseeable changes in PoF V

## Trends, new topics, new groups

- Scalable readout system systems for quantum devices will be more requested according with larger sensor production
- Applications fields: sensors, qubits
- Data rates will continue to increase. Need for efficient reduction, trigger, by intelligence (also AI), team up with computing centers
- Silicon photonics: demonstrators will need suitable packaging technologies
- Custom packaging technologies for specific constrains

- There are new groups and topics:
  - Frank Simon, interest in high energy physics, calorimetry
  - Sebastian Kempf, design and production of superconding quantum sensors
  - Cangri Ulusoy, HF technology
  - Professorship on intelligent DAQ systems
  - …

# Detector Technology and Systems (DTS)

**ST1: Detection and Measurement**

- Semiconductor Sensors (and others)
- Cryogenic Quantum Sensors and Production Technologies
- Frontend microelectronics

**ST2: System technologies**

- Intelligent Real-time Data Acquisition and Processing Systems
- Scalable Readout for Superconducting Quantum Devices
- Interconnects, Packaging and Silicon Photonics
- Novel Engineering Techniques, Advanced Materials, Cooling

**ST3: Science Systems**

- Particle Physics, Hadrons & Nuclei
- Photon Science
- Astroparticle Physics
- Beam Physics
- Beyond Matter: Health Technologies, Quantum Computing, …

**Production technologies and characterization**

**Research infrastructures**

- High resolution superconducting sensor development and fabrication center (HSS)
- Detector Test Beams
- Interconnect and packaging centers