Plans for PoF V: DESY

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15.05.2025

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DESY.

Summary – directions DESY

- Main drivers are and will be **systems** for experiments in MU and MML
- Develop and built next generation systems (“upgrades”) using new technologies
- Explore possibilities of new experiments with new technologies (dark matter search, atomic clocks, …)
- Explore new technologies (e.g. silicon photonics, quantum sensors…)
- Main trust area will remain solid state detectors (HPADs and MAPs)
- Increased focus on data handling and reduction up stream
- Developing better tools for simulating, prototyping, testing and calibrating detectors

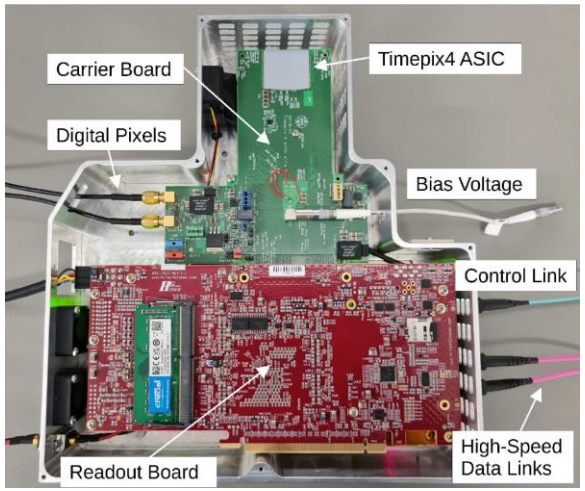
Roadmap for PoF V – Photon Science

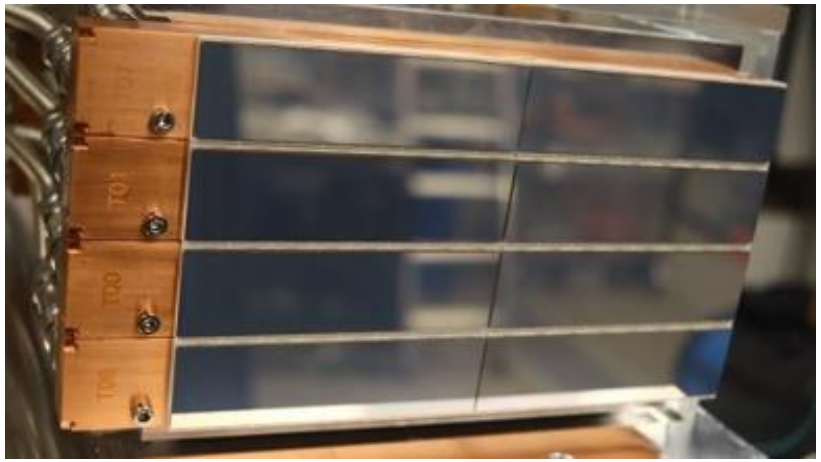
- *New high-speed detectors will be developed and delivered during PoF V, requiring ASIC, sensor and system technologies*

- PETRA-IV synchrotron upgrade – first light planned 2022, detectors currently in development
  - CoRDIA high speed integrating pixel detector
  - TEMPUS timestamping pixel detector
  - High-Z sensors for hard X-ray detection crucial

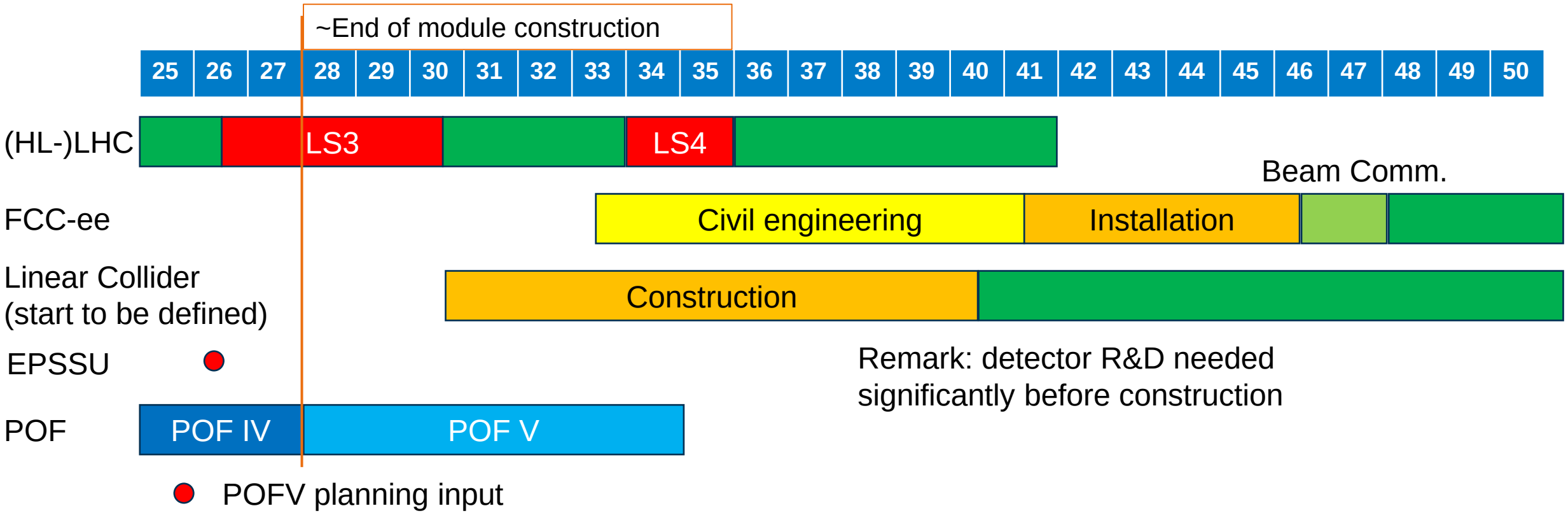
- Eu.XFEL new generation systems in discussion and planning
  - Second generation burst mode pixel detector

- Long term: development towards a 1 MHz imager for CW-XFEL





Roadmap for PoF V – Particle Physics



Gap between LHC upgrades and future colliders makes it possible to go into various experiments.

- On-site program: e.g. LUXE, BabyIAXO, dark matter searches.
- Smaller experiment contributions: e.g. Belle II vertex upgrade

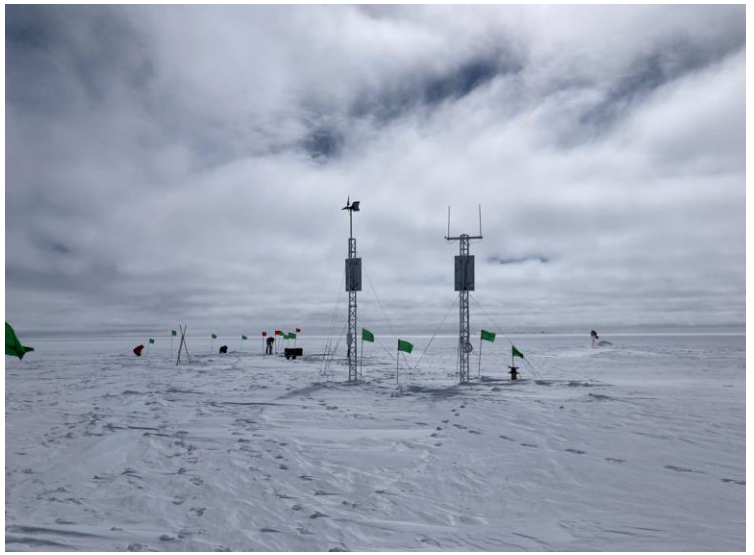
Roadmap for PoF V – Astroparticle

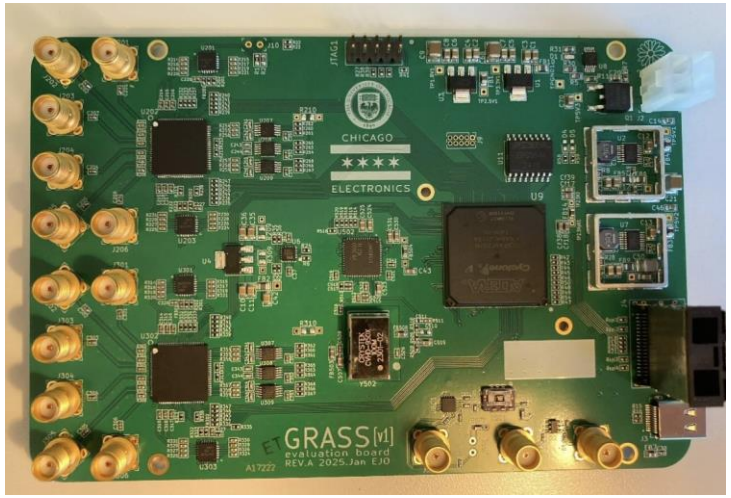
- *R&D towards a variety of projects in MU*

- Icecube Gen-2 and future neutrino observatories
  - Modernisation of DAQ for low power consumption, intelligent triggering (ML) and reconfigurability

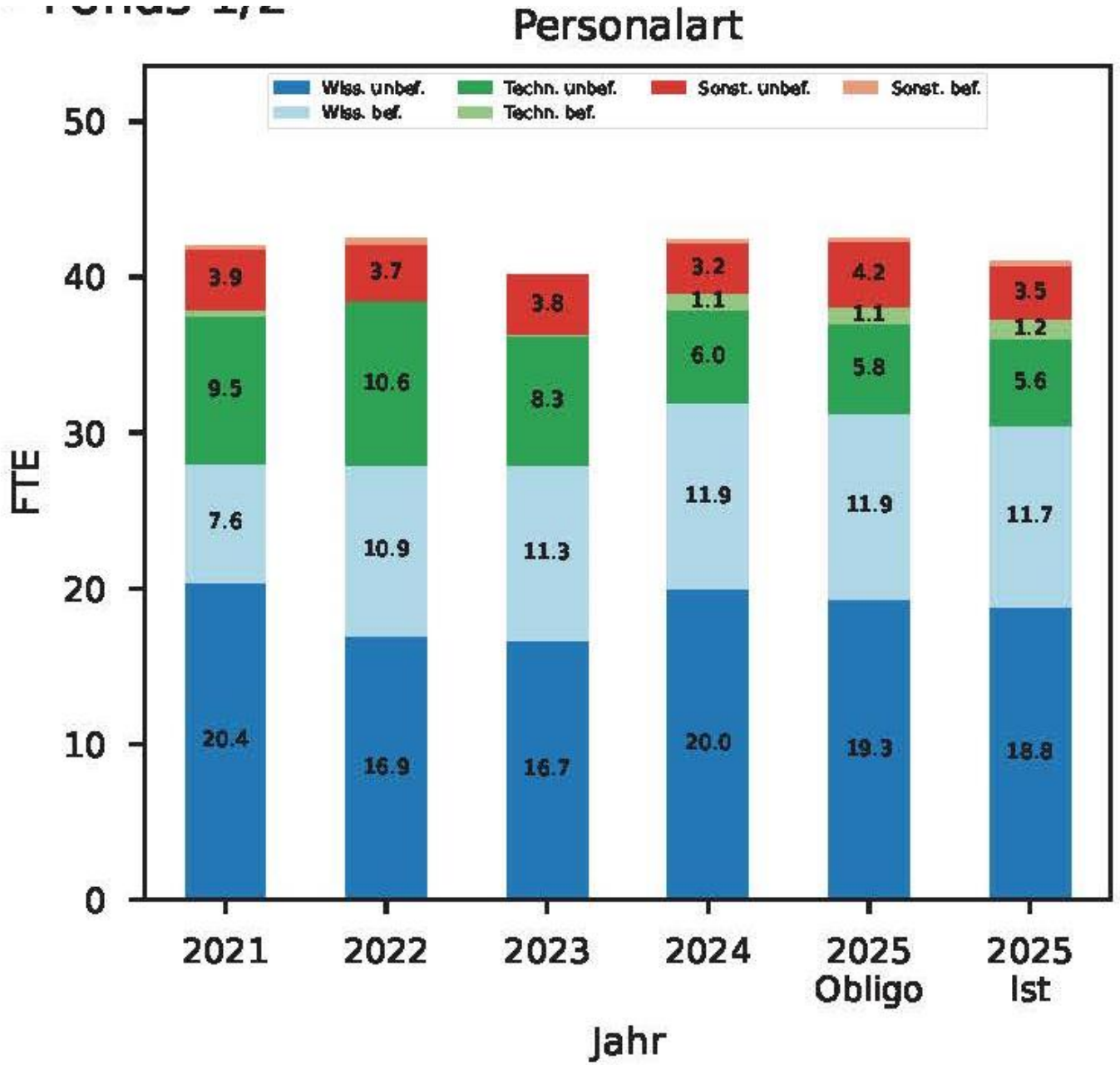
- Space-based detectors for MeV gammas
  - Development of tracker + crystal calorimeter system design
  - Development of strips and/or MAPS for tracker

- Next-gen CTA cameras capturing light flashes from air showers
  - Replacement of classical PMTs by SiPMs
  - Electronics for MHz trigger rates with lower power and size



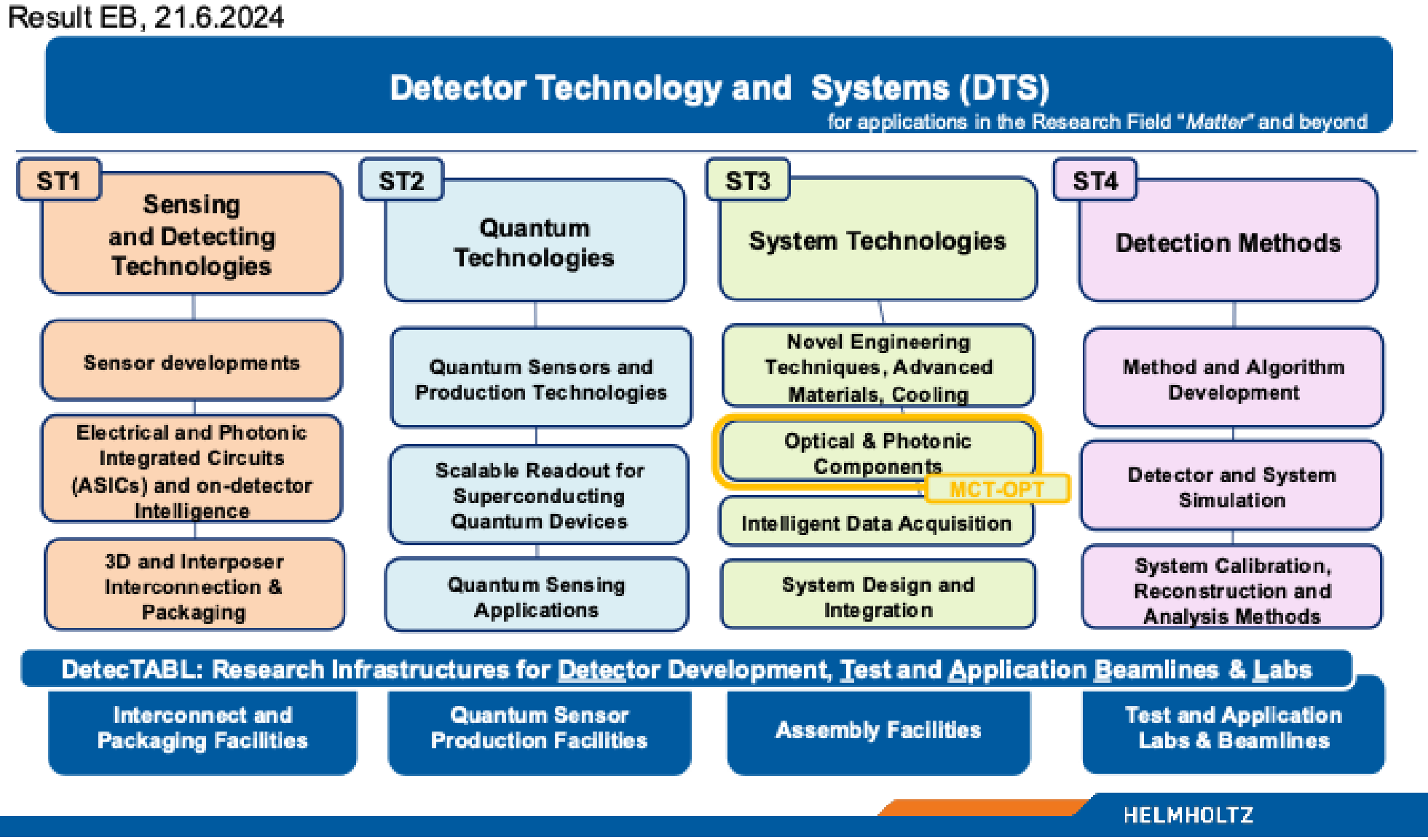


Numbers



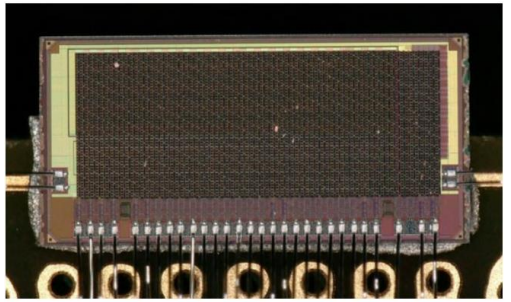
ST 1: 14 FTE
ST 2: 6 FTE
ST 3: 18 FTE
ST 4: 5 FTE

ST1 – Sensing and Detecting Technologies

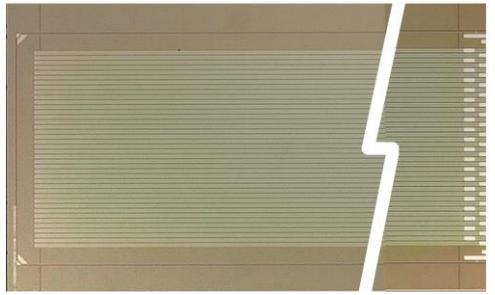


ST1 - Sensor developments

- 65nm MAPS development for next generation Vertex detector based on Tangerine developments.
  - Octopus project in DRD3
- CMOS Strip sensors for cost effective tracking.

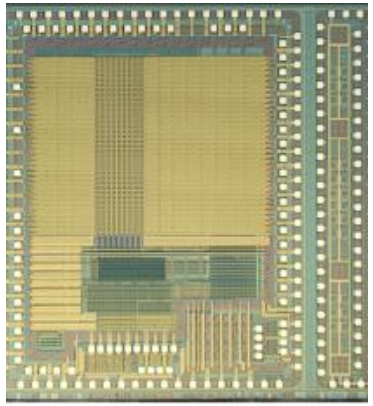


Tangerine
H2M sensor



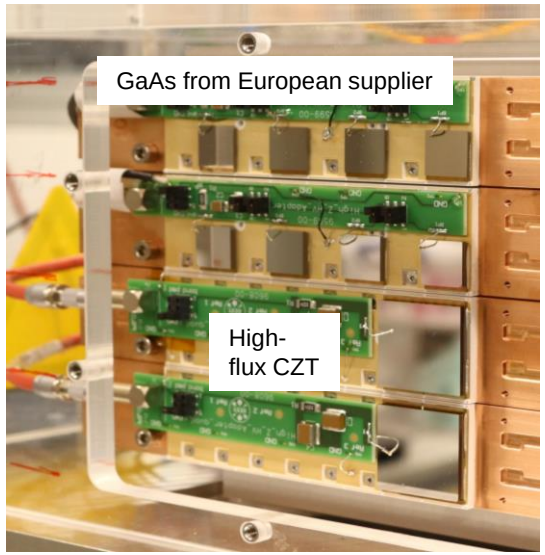
Passive CMOS
strip sensor

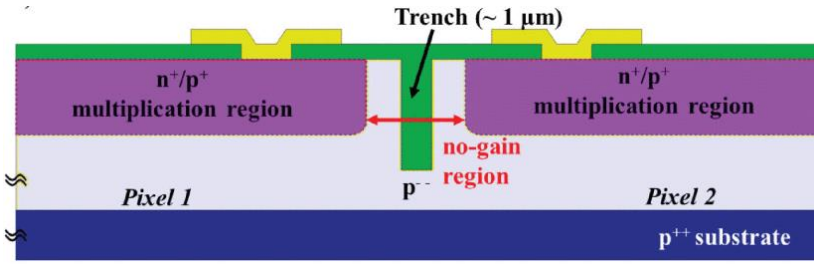
- Further development of MALTA (radiation hard MAPS in 180nm)
- Further development of DECAL (MAPS for calorimeters)



MALTA 3

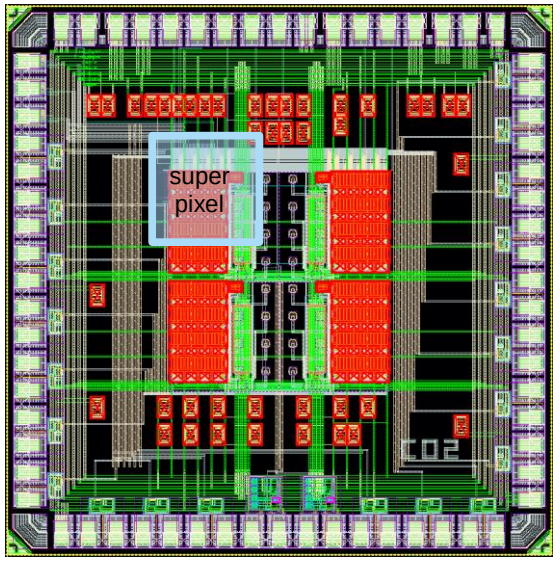
- High-Z materials for hard X-rays. (CZT and Perovskites)
- LGADs for soft X-rays.



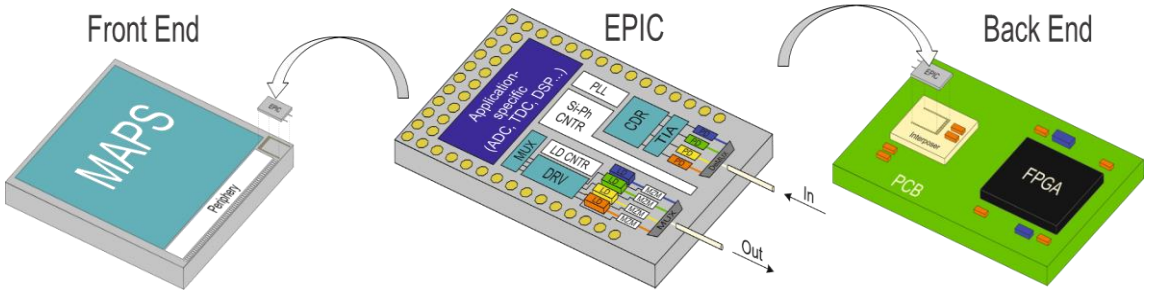


ST1 – ASICs / 3D andInterposers

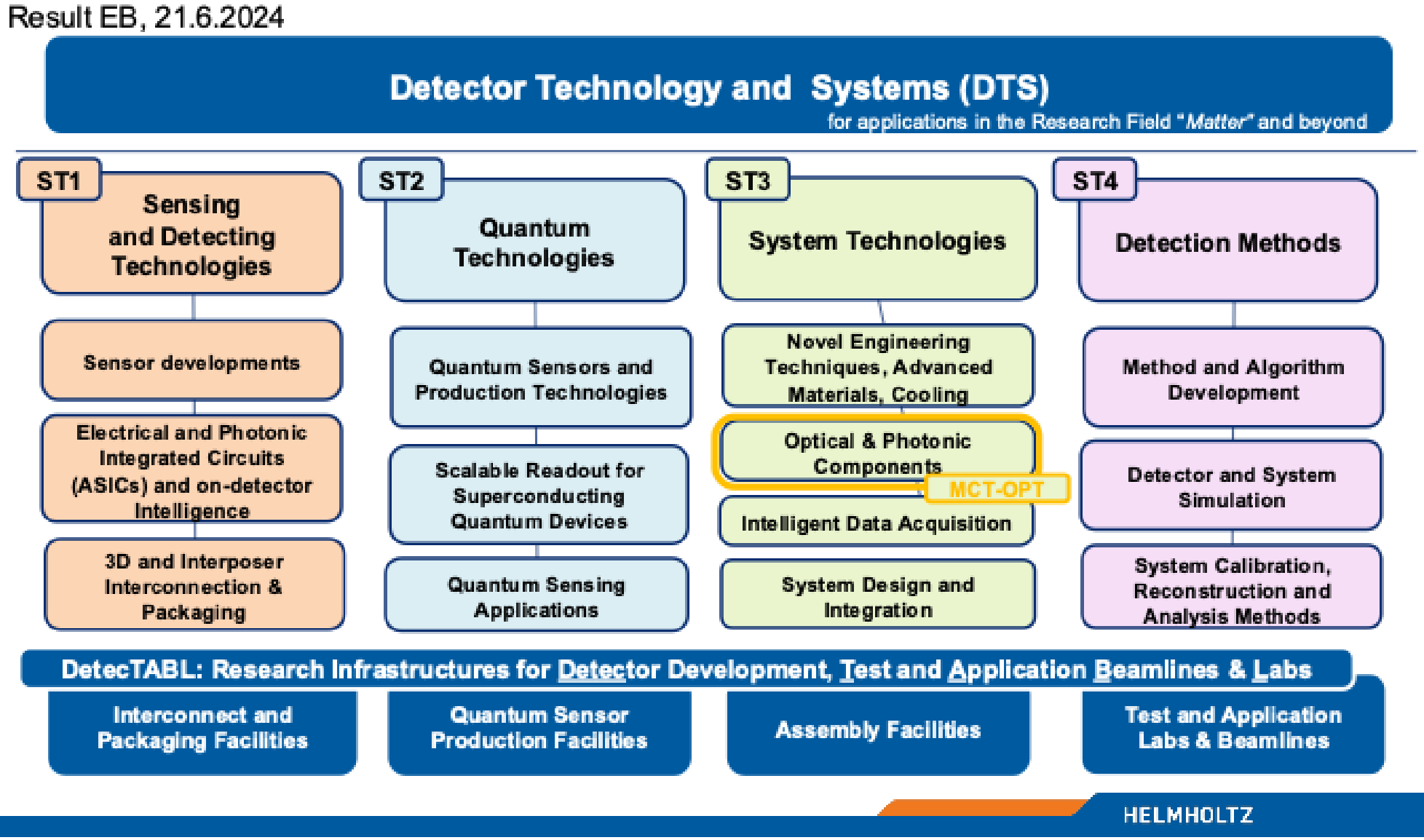
- **Electrical and Photonic ICs & on detector Intelligence**
  - CoRDIA: 65nm CMOS ASIC for 150 kHz high-dynamic range imaging
  - Further ASIC developments based on CoRDIA for burst mode an MHz frame rates.
  - Interest in smaller feature sized ASICs for increased on detector intelligence.
  - PIC Transceiver based on GFoundry 45nm silicon photonic CMOS
    - Technology investigations SoPhie Innopool. Also part of DRD7
    - Getting technology application ready in PoF V



- **3D and Interposer**
  - Wafer bonding as technology of interest.
    - Integration of microchannels
    - Long term: Wafer bonding of sensor + ASIC

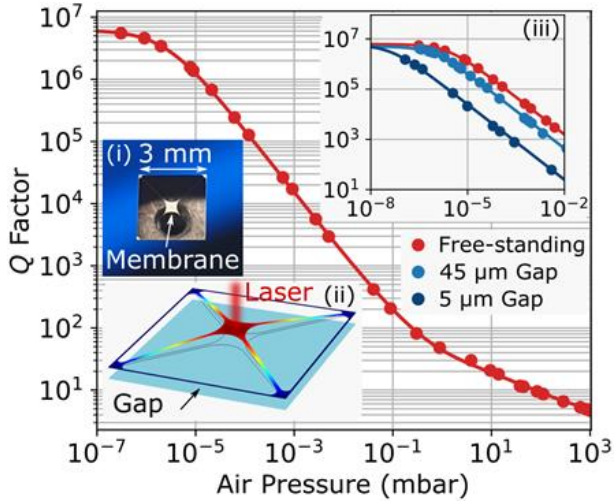


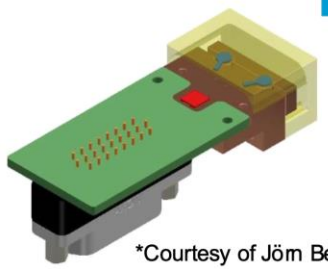
ST2 – Quantum Technologies



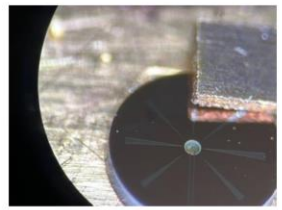
ST2: Quantum technologies

- Currently exploring possibilites of Quantum sensing
  - InnoPool QS4Physics
  - Active member of DRD5
  - Infrastructure for Quantum R&D in Hamburg and in Zeuthen.
  - Part of ERC grant DarkQuantum
- **Quantum Sensor and Production Technologies**
  - Cryogenic Membranes
    - Gas pressure sensor UHV to ambient with gas identification
    - High frequency GW detection.
- **Quantum Sensing Applications**
  - Rare particle searches using Transition Edge Sensor systems.
    - Reaching DM detection limits through ultra low noise
  - Atomic clock-based experiment to search for Ultra-Light Dark Matter

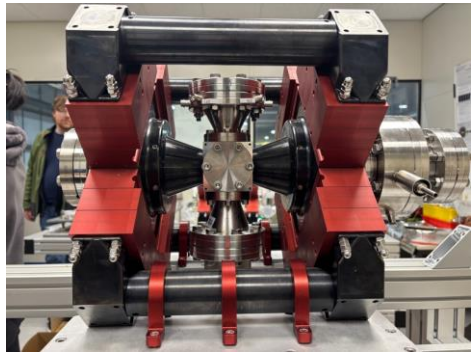




*Courtesy of Jörn Beyer, PTB

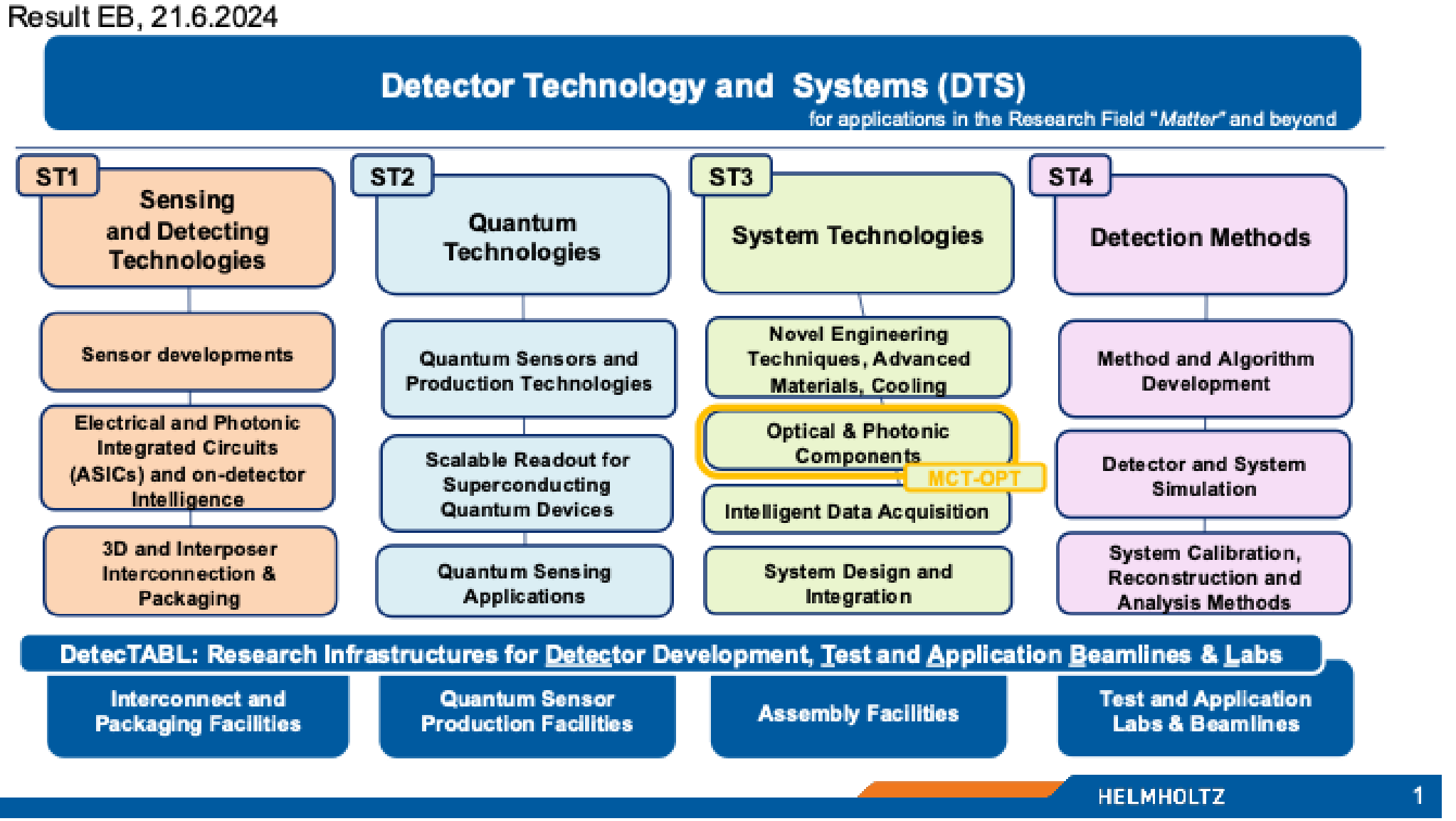


*Courtesy of Adriana Lita, NIST



DESY electron beam ion trap (EBIT)

ST3 – System Technologies



ST3 – System Technologies

Novel engineering techniques, advanced materials and cooling

- Goal – achieve efficient cooling of increasingly fast and intelligent (more power hungry) detectors
  - Trackers and space systems require low material budget
  - X-ray imagers require compact tiled design
  - Some experiments in-vacuum
- Development – microchannel cooling and its integration with sensors / hybrids

Optical and photonic components (?)

- Goal – transfer data to high-bandwidth optical links as early as possible in readout chain, to efficiently increase data rates
- Development – Sophie silicon photonic transceiver project. Currently investigating potential, followed by integration into systems. (But this is in ST1…)

ST3 – System Technologies

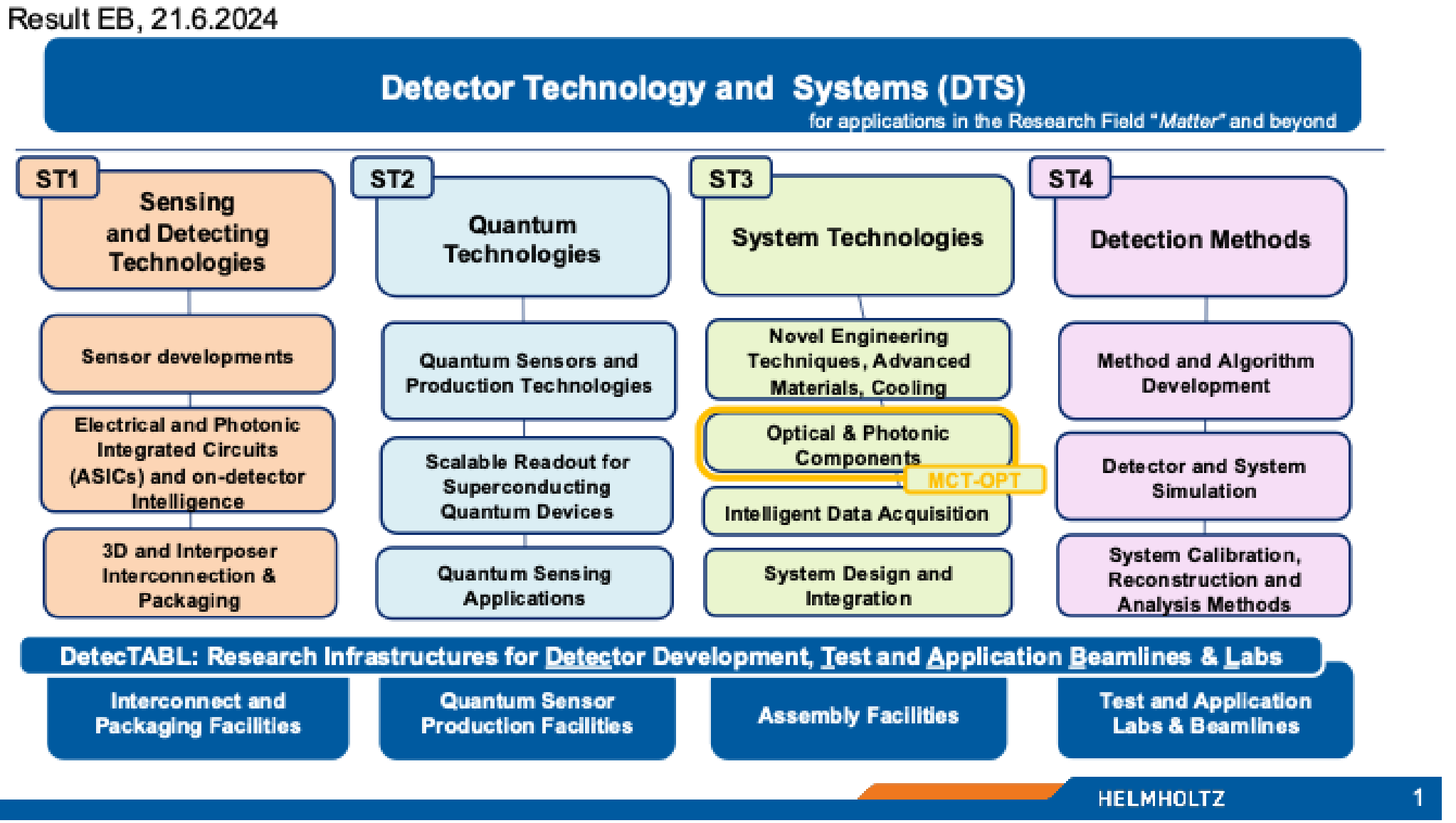
Intelligent data acquisition

- Goal - High-speed data reception from detectors, and processing “close to the detector” (e.g. trigger decisions and reduction algorithms)
- Development - DAQ systems capable of Tbit data rates, using off-the-shelf datacenter accelerator cards for both reception and processing; this is critical to detectors delivered in POF-V
- Development – Icecube DAQ for reduced power consumption and more intelligent triggering and flexibility

System design and integration

- Development and production of tiled X-ray imagers with high-speed ASICs and Tbit data rate DAQ
  - Aim at common system design for TEMPUS, CoRDIA and future Eu.XFEL detectors
- Considering PoF-V development of medium sized particle physics experiments (e.g. BELLE) and local experiments (e.g. LUXE)
- Long-term R&D towards future colliders
- Development of space-based MeV gamma ray detectors with a tracker + calorimeter structure

ST4 – Detection Methods



ST4 – Detection Methods

Method and algorithm development

- Developing flexible DAQ and software for testing and prototyping; e.g. further development of Caribou system with CERN and BNL
- Electron CT with tracking detectors
- Developing data analysis and methods for event-based detectors in photon science

Detector and system simulation

- Start-to-end simulation of detectors and experiments with the Allpix^2 framework

System calibration, reconstruction and analysis methods

- Corryvreckan test beam analysis framework
- Development of common software tools for imaging detector calibration (rather than per-project)

Applying technology to new applications?

Ongoing

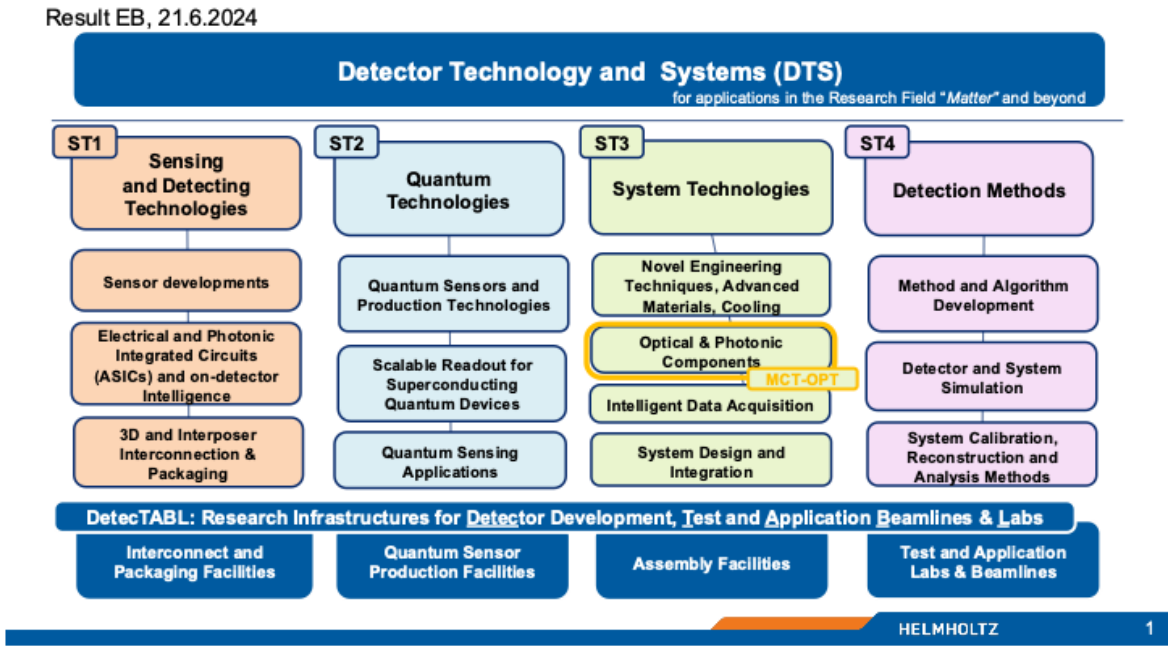
- Medical R&D – dosimetry for ultra-high dose rates during FLASH radiotherapy
  - Already testing technologies at PITZ accelerator, and working with industrial partners (NitroFLASH collaboration)

Under consideration

- Laser-plasma accelerator-driven X-ray sources
  - Pulsed sources like FELs, but with greater energy spread and hence demand for some spectroscopic features
- Plasma diagnostics for fusion
  - Wide X-ray energy range, spectroscopic capabilities, and high-speed operation

Summary

- Represented in all pillars but predominantly in ST1 and ST3
- ST1 – semiconductor sensors and high-speed ASICs for a range of applications
- ST2 – exploring quantum sensing applications, and developing cryogenic membrane sensors
- ST3 covers R&D towards future systems, and engineering of systems to be delivered within POF-V
- ST4 consists of tools for simulating, testing and prototyping detectors, plus exploring some new applications



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