MT-DTS Highlight 2025

- Development and preparations for production of more than 700 Serenity-S1 boards has been completed

Matter and Technologies – Annual Report 2025

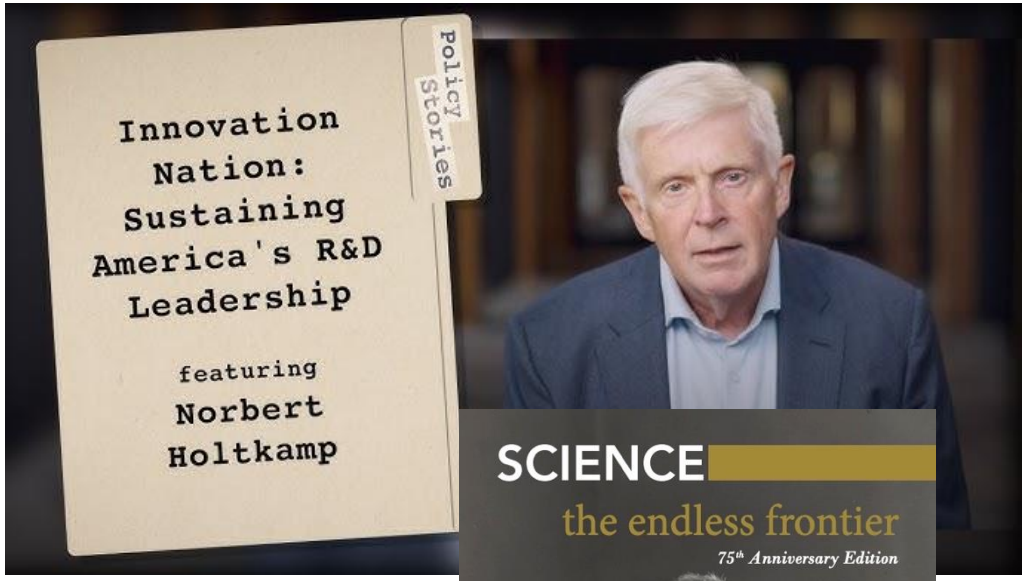
What you ever wanted to ask about Helmholtz, but never dare to

Andreas Kopmann

How to Create, and Sustain, R&D Leadership

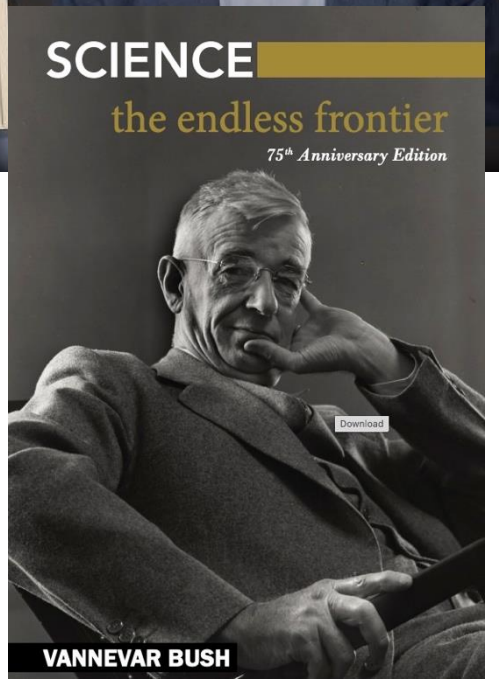
Key characteristics for an exciting work environment, groundbreaking discoveries, and economic growth:

- **Robust government funding** across a spectrum of basic and applied research, including research
- **infrastructure that evolves** in response to emerging needs and technological advances.
- **Industries that leverage ideas** generated as a consequence of government-funded R&D, with protections for intellectual property that allow them to assume the risk of moving technologies to the point of commercial viability.
- **Talented people** with the skills to develop and apply new ideas.
- **International collaboration** in fundamental research that is published in the open literature and subjected to the scrutiny of peers, the test of reproducibility, and further development.



Norbert Holtkamp,

Director FermiLab



1950-2025 - 75 years of

National Science Fondation (NSF)

Helmholtz Association

Helmholtz Association

Mission

The Helmholtz Association contributes to

solving grand challenges

facing society, science and industry by conducting top-rate research in the fields of

- Aeronautics, Space and Transport
- **Earth and Environment**
- **Energy**
- Health
- **Matter**
- **Information**.

KiT contributes to 4 our of 6

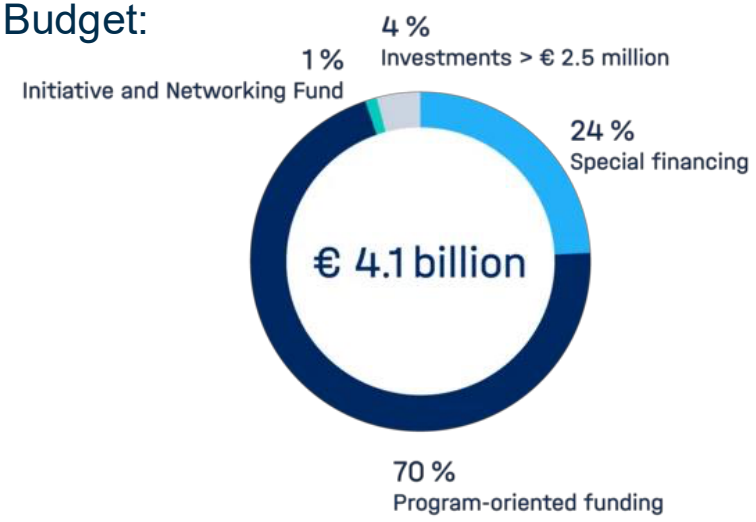
Installation of the inner electrode system inside the KATRIN main spectrometer

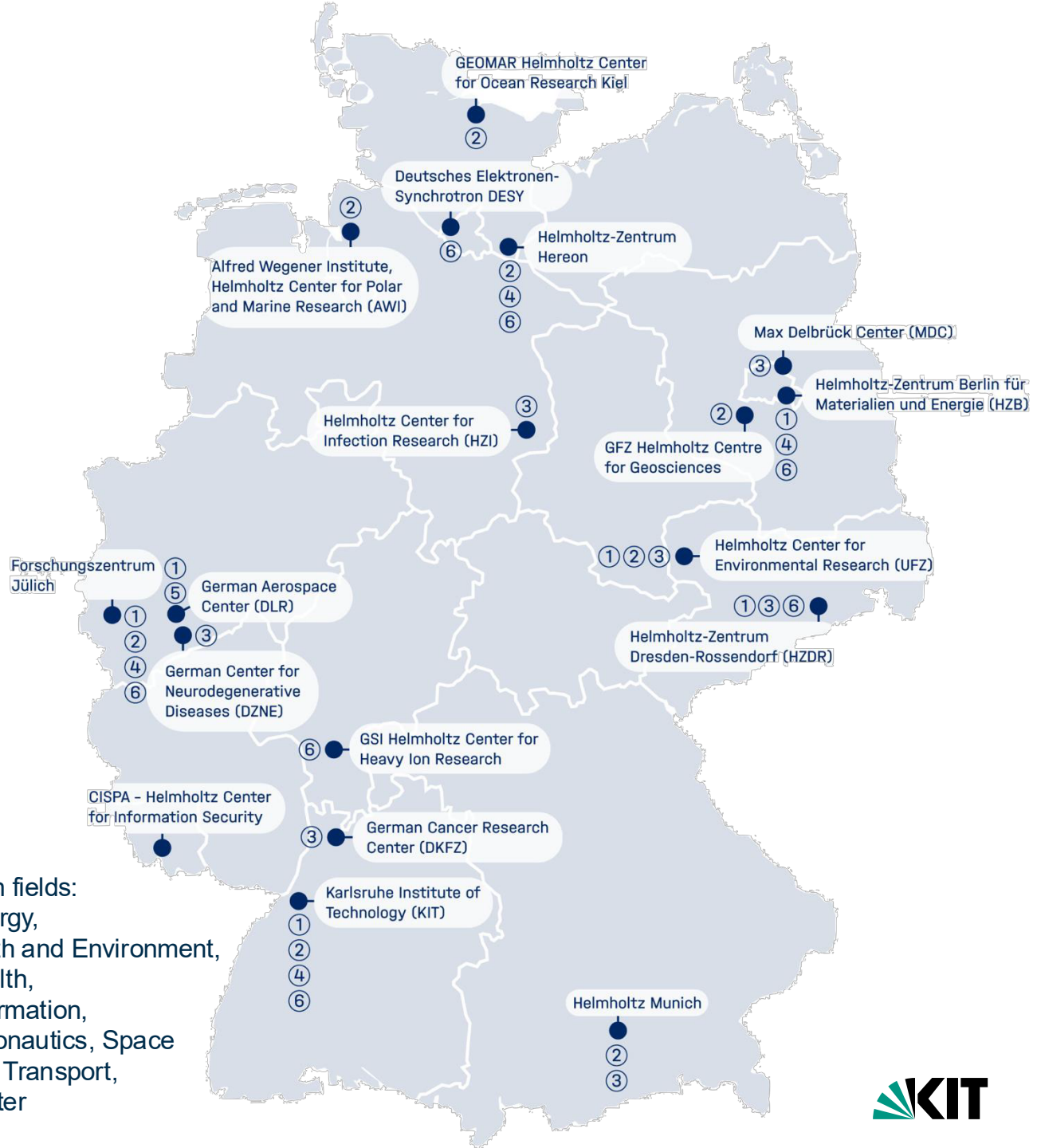
Helmholtz Centers

Helmhotz centers use state-of-the-art scientific infrastructures, especially large-scale equipment such as light sources and satellite systems, laboratories and accelerators.

We also make these facilities available to other researchers in the international knowledge community. (2023: 14,448 users from more than 130 nations)

- 18 centers, legally independent,
  15 Helmholtz Institutes
- Operating in one or more research fields
- Budget:





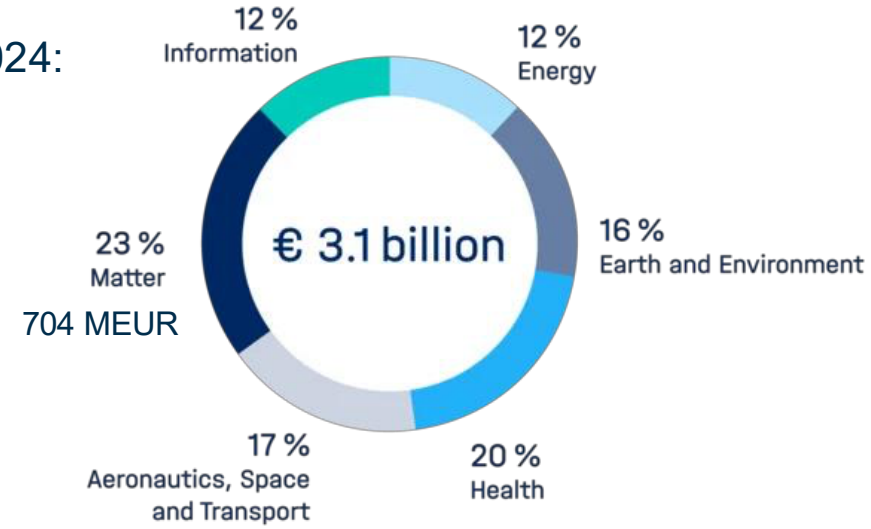
Research fields:

1. Energy,
2. Earth and Environment,
3. Health,
4. Information,
5. Aeronautics, Space and Transport,
6. Matter

Helmholtz Association

The largest research organization in Germany

Budget 2024:



Research field Matter:

Employees: 46.098, 41% scientists

Publication: Nature index 2023

Rank	Institution	FC*
1	Chinese Academy of Sciences (CAS)	2243
2	Harvard University, United States of America	1143
3	Max Planck Society	643
4	University of Chinese Academy of Sciences (UCAS)	636
5	University of Science and Technology of China (USTC)	631
6	Peking University (PKU)	617
7	French National Centre for Scientific Research (CNRS)	614
8	Nanjing University (NJU)	609
9	Zhejiang University (ZJU)	595
10	Tsinghua University	593
11	Helmholtz Association of German Research Centres	531
12	Sun Yat-sen University (SYSU)	492
13	Shanghai Jiao Tong University (SJTU)	489
14	Massachusetts Institute of Technology (MIT)	485
15	Stanford University	474

* Fractional Count = figure taking into account the percentage of authors from the respective institution and the number of affiliated institutions per article. The calaculation assumes that all authors contributed equally to the article, and their sum is 1.0 per article. Count of publications from January 1st, 2023 to December 31st, 2023.

Program-oriented funding (PoF)

- Funding not by center but by research fields, so called “**program-oriented funding**”
- Stable funding for 7 years

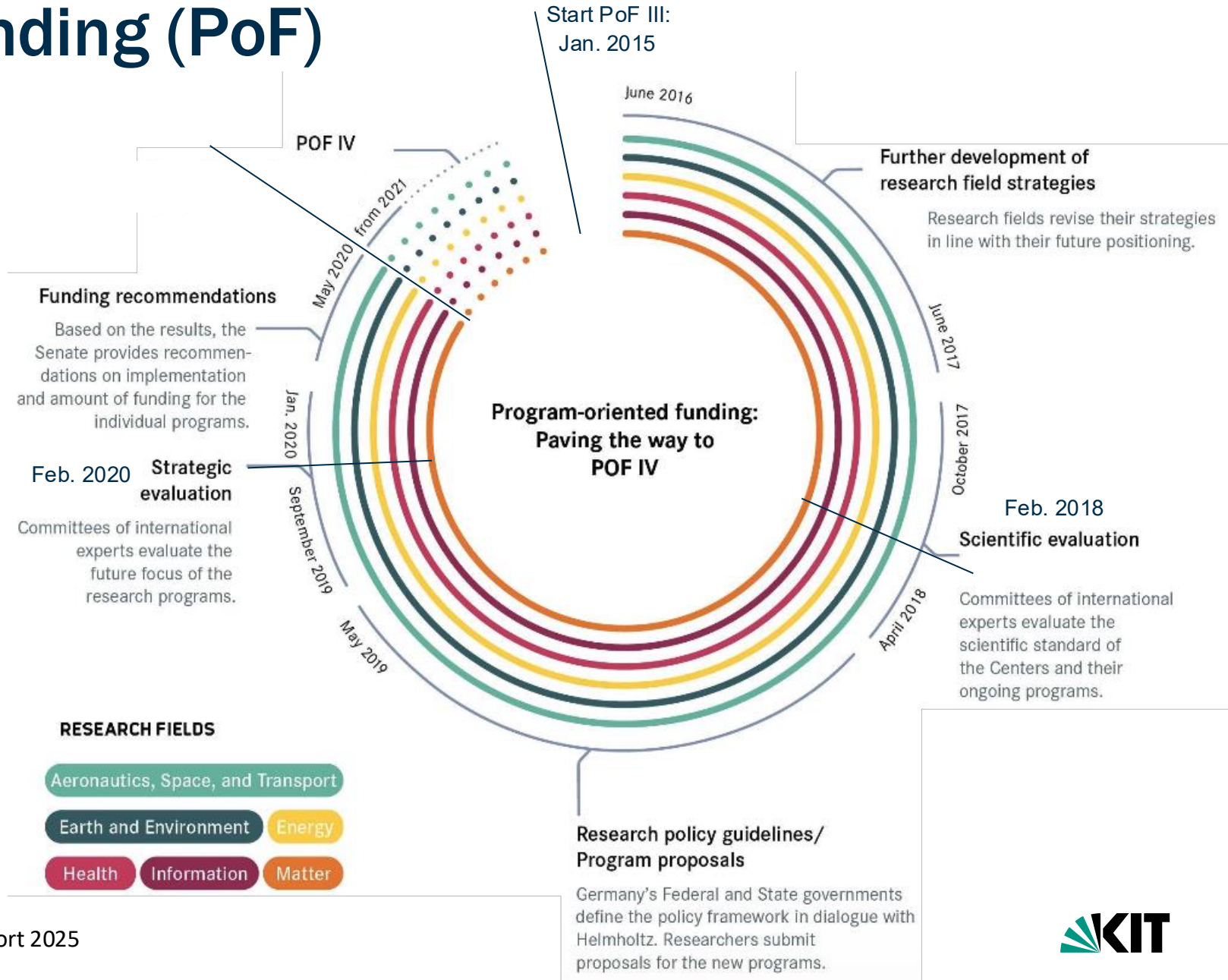
Funding decision in two-step process:

1. **Center-level**: scientific evaluation of the research field progress in individual centers.

   Definition “Startwerte”

2. **Research field level**: strategic evaluation of the research program for the funding period.

   Annual increase of budget bound to evaluation results



Preparations for PoF V

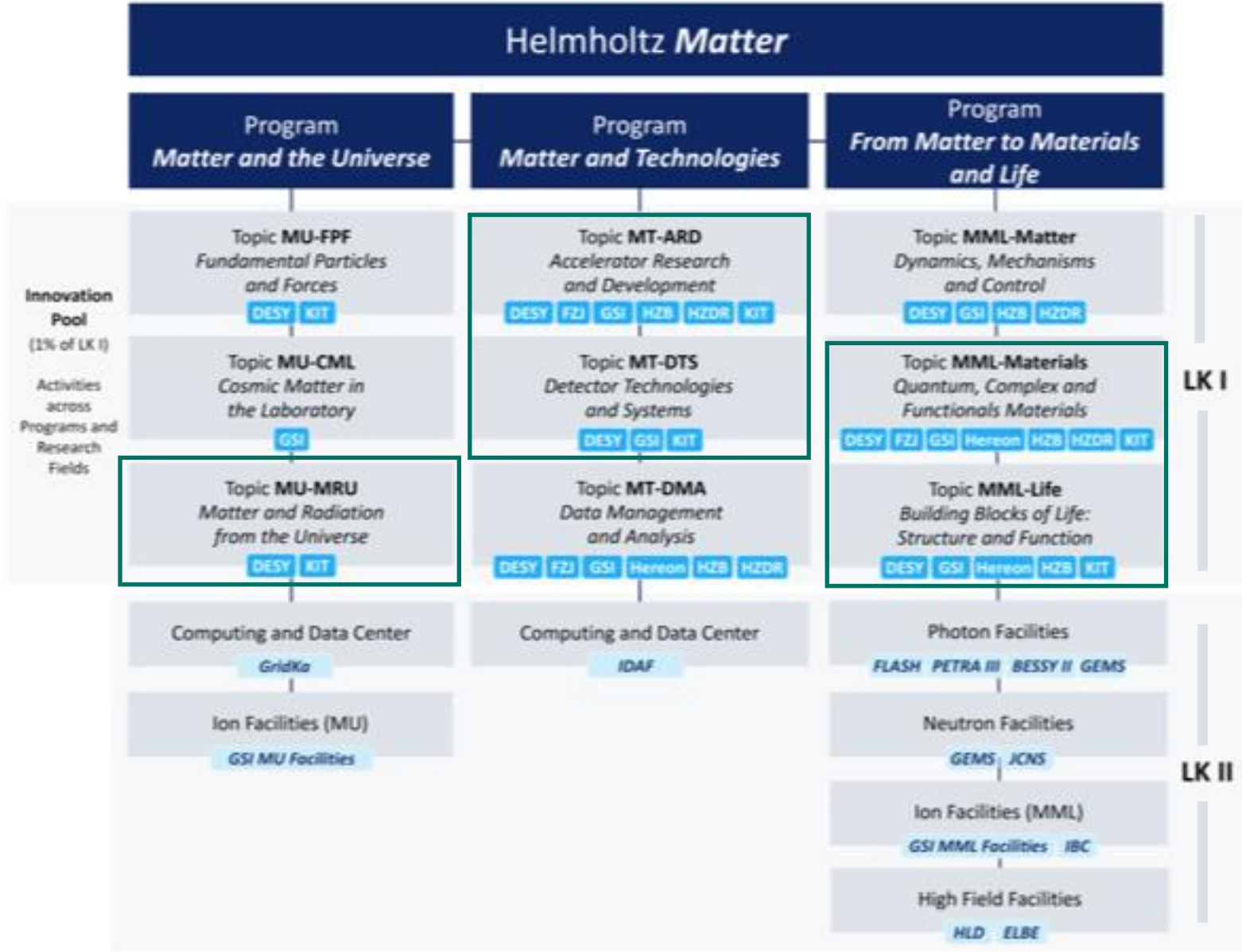
Sep. ´25
Wechsel
Präsident

2023	2024	2025	2027	2028
Vorbereitung Wissenschaftliche Begutachtung (Standards, Gutachtergruppen, Termine, Ablauf)		(1. Halbjahr) Wissenschaftliche Begutachtung	Ableitung und Beschluss Senatsempfehlung für PoF V	Start of PoF V
	Erstellung Status-Reports	Vorschläge Programmanteile und Startwerte	Übergang zu Programmen PoF V	
	Vorbereitung Strategische Bewertung (Standards, Gutachtergruppen, Termine, Ablauf)	Festlegung Programm-struktur und Forschungs-politische Ziele	(Frühsommer) Strategische Bewertung	

Research field Matter

- MU-FPF: High-energy physics *Mainly DESY*
  Experiments ATLAS + CMS
- MU-CML: Nuclear physics *GSI*
  Experiments FAIR, ALICE
- MU-MRU: Astroparticle physics *KIT*
  Experiments Auger, KATRIN, … *DESY-Zeuthen*
  IceCube, CTA

- MML: dominated by operation and construction of research facilities



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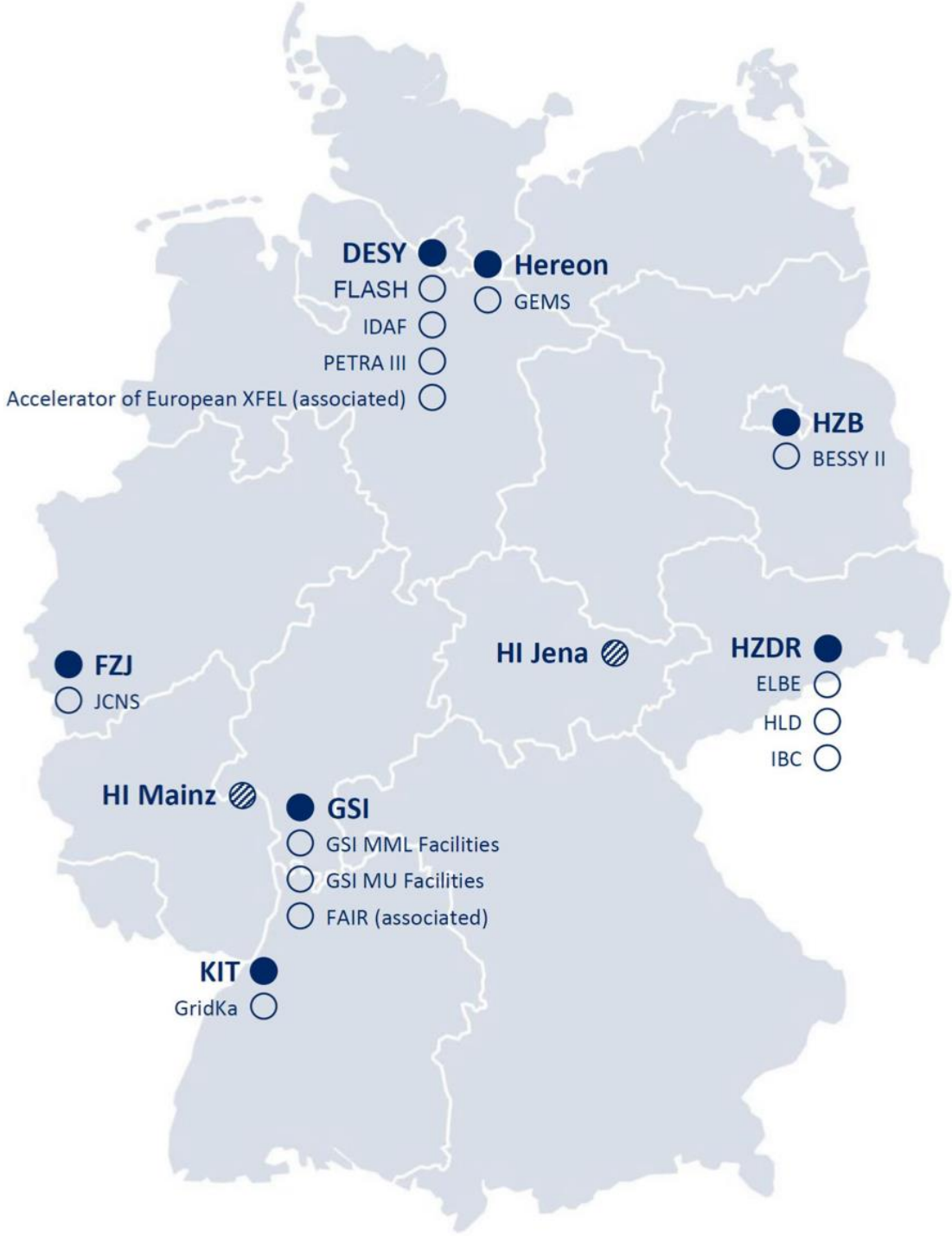


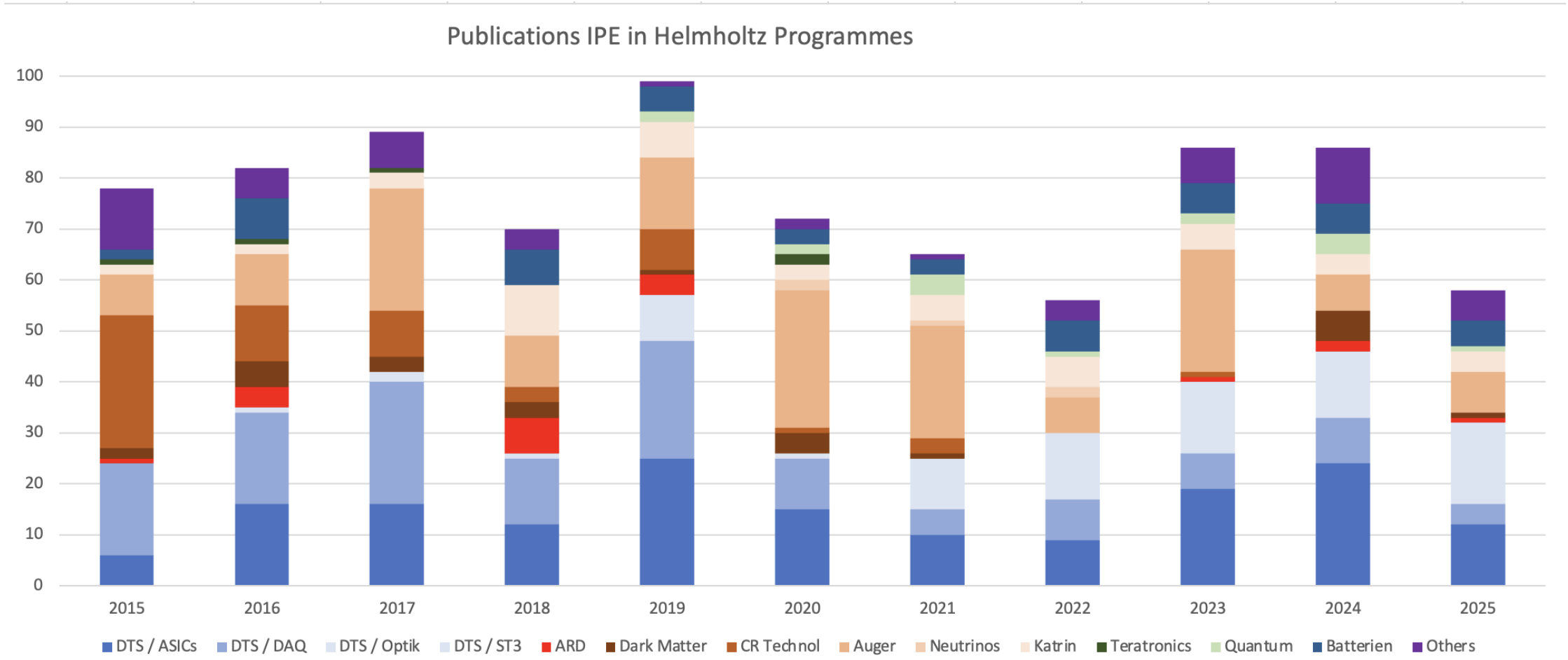
Program duties in 2025

- Helmholtz is monitored annally
  - Progress report
  - Performance indicators
- 4 regular meetings with the vice president for research

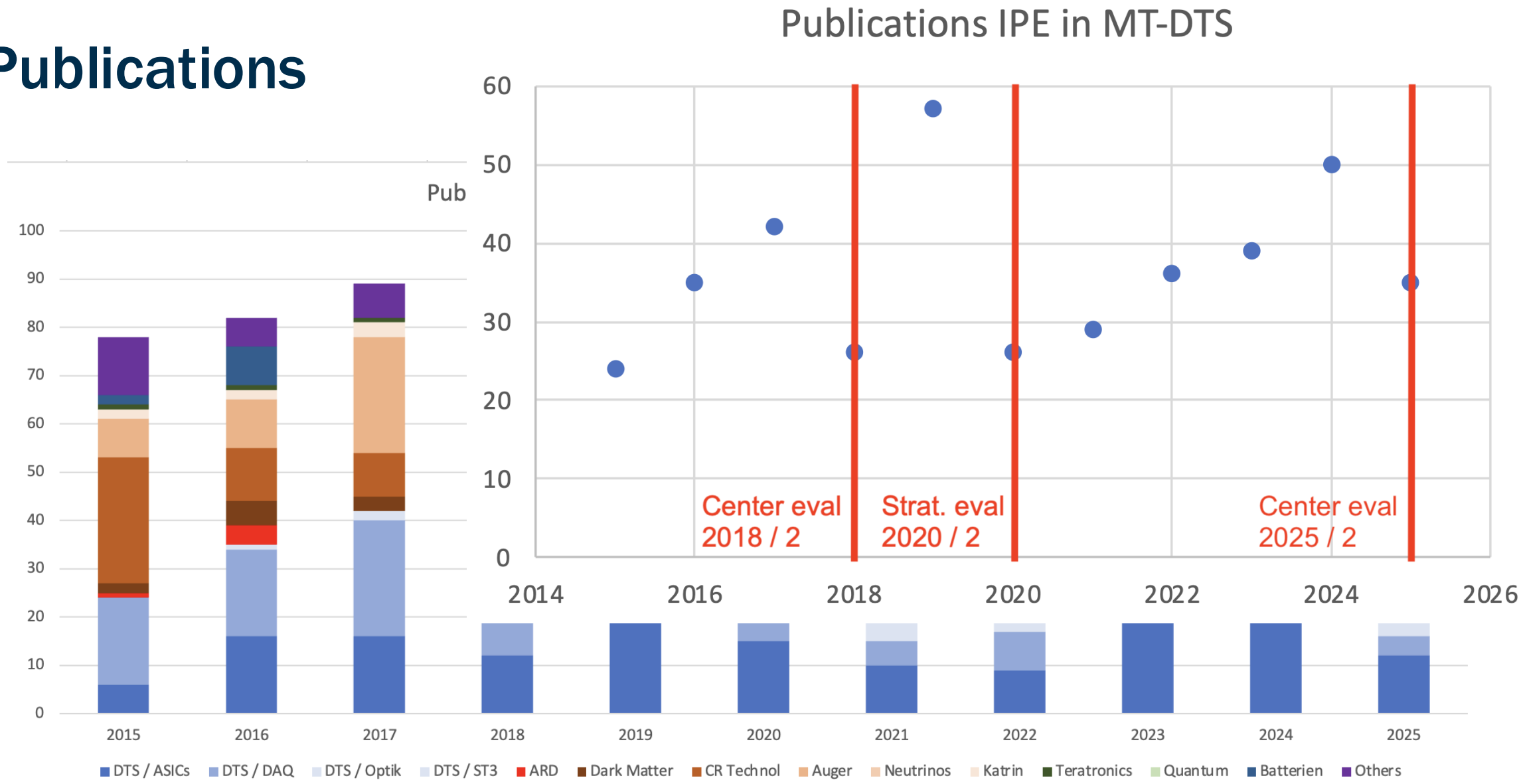
- Long-term planning of the funding cycle
  - 2025: Evaluation + Program proposal

- ”Special” requests and opportunities
  - Investment planning
  - Innovationpool projects
  - …

Publications



Publications



Scientific evaluation at KIT

Evaluation panel

Chair:

Rolf Heuer

MT-DTS reviewer:

Philip Patrick Allport, chair ECFA detector panel

In the MT parallel session:

Angeles Faus-Golfe, Rhodri Jones, Ubaldo Iriso, Lia Merminga,

Pascale Ehrenfreund (only MT-ARD),

Jodi Cooley, Phil Allport (both only MT-DTS)

Chair of the panel

First name	Family name	Affiliation	Country
Rolf	Heuer	CERN - European Organization for Nuclear Research	Switzerland

Members of the panel

First name	Family name	Affiliation	Country
Pascale	Ehrenfreund*	International Space University	France
Johanna	Stachel*	Ruprecht-Karls-Universität Heidelberg	Germany
Philip Patrick	Allport	University of Birmingham	UK
Amber	Boehnlein	Thomas Jefferson National Accelerator Facility	USA
Jodi	Cooley	SNOLAB	Canada
Jorgen	D'Hondt	Vrije Universiteit Brussel	Belgium
Angeles	Faus-Golfe	CNRS - Centre National de la Recherche /IN2P3 à IJCLab	France
Ubaldo	Iriso	ALBA Synchrotron	Spain
Rhodri	Jones	CERN - European Organization for Nuclear Research	Switzerland
Sarah	Köster	Georg-August-Universität Göttingen	Germany
Michael	Krisch	European Synchrotron Radiation Facility (ESRF)	France
Nikolitsa	Merminga	Fermi National Accelerator Laboratory	USA
Alexander	Moewes	University of Saskatchewan	Canada
Jan-Erik	Rubensson	Uppsala Universitet	Sweden
Anthony	Van Buuren	Lawrence Livermore National Laboratory	USA
Carlos E. M.	Wagner**	University of Chicago	USA

Agenda

Monday 24.02., day 1

14:00 – 15:15

MT plenary session

- *MT-DTS*, Andreas Kopmann 15 + 15 min

17:45 – 19:15

Strategic topics

- *Talent management and diversity*, with Andreas Kopmann
- *Cooperations, technology + knowledge transfer*, with Frank Simon, as LHCC chair
- *Digitization and sustainability*

Tuesday 25.02., day 2

09:00 – 12:30

Visit of research infrastructures

- *MT show & tell*

14:00 – 17:30

MT parallel session

- *Semincoductor sensors, ASICs and interconnects*, Ivan Peric 7 + 7 min
- *Quantum sensors and readout of cryogenic sensors*, Sebastian Kempf 7 + 7 min
- *High-performance DAQ systems*, Timo Muscheid 7 + 7 min
- *Impact and strategy*, Frank Simon 10 + 10 min

Evaluation results

- Selected slides from the evaluation, annotated with review results
- Recommendations
- Grading

"… the creation of new scientific knowledge … is crucial for Europe ..."

"The development of enabling technologies has been recognized as an overarching theme at KIT" (initial notification)

"Collaboration between the programs is visible at KIT" (initial notification)

Competences at KIT

Semiconductor sensors, ASICs and packaging

- HVMAPS
- Scouting technologies
- Silicon photonics

→ Ivan Peric
MT parallel session

"Impressive"
"Most promising technology"
"strengthen microelectronics in Germany"

HVMAPS prototype for the Mu3e pixel detector

Quantum sensors and readout of cryogenic devices

- Metallic Magnetic Calorimeter (MMC), design and production
- Scalable readout

→ Sebastian Kempf
MT parallel session

"World-leading"
"Scalability remarkable"
"Disruptive technology"
"Establish foundry-like services"

MMC detector: world record in energy resolution of 1 eV

Scalable high-performance DAQ systems

- Programmable electronics (FPGA)
- Fast links
- Parallel programming for CPU and GPU
- Trigger and signal processing

→ Timo Muscheid
MT parallel session

"Essential"
"Key strength"
"Attract engineers early in their careers"

Serenity boards: Tb/s data processing

Science systems for

- High-energy physics
- Astroparticle physics
- Beam physics
- Photon science

ECHo readout system for 800 MMCs

High-tech infrastructures – new capabilities

"Great facilities"
"Detector innovation platform is needed, excellent review, win for Helmholtz and academia"

Clean-room facilities for

- quantum sensors and readout — operation 2025
- electronics packaging — 1 out of 2 production centers for CBM/STS

KIT clean room center KCOP — operation 2026

- 50 MEUR invest
- 2 detector technology clusters

Excellent research facilities for unique detector systems

Detector technology clusters in the Helmholtz program:

Competence Center for High-resolution Superconducting Sensors (HSS)

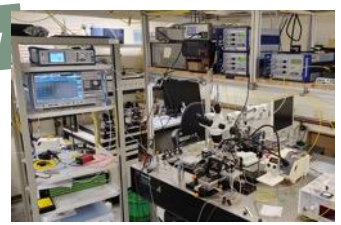
Electronic Interconnect & Packaging Center (AVT)

KIT ASIC and Detector Laboratory (KIT-ADL)

Further laboratories for:

new

Cryogenic readout systems



Silicon photonics

Ultrasound tomography

Proton irradiation

Training excellent scientists

Doctoral school KSETA

- Training physics and technology experts

MU MT

International training:

- Scientific collaborations
- Double degree program with UNSAM, Argentina

Results (21-23):

- 18 doctoral researcher finished
- 118 publications

MT-DTS attracts the best talents

Helmholtz Doctoral Award

2022

Nick Karcher
Readout superconducting sensors

Richard Gebauer
Qubit control
RF Information

both now in industry

2023

Martin Angerer
Electronics packaging
Helmholtz Enterprise
Field study fellowship

Postdoc
U British Columbia

"Link between physics and technology is crucial"
"Attract engineers early in their careers"
"Helmholtz university is a unique selling point"

2021 Faraday Cup Award

Meghana Patil
Ultrafast beam diagnostics

now in industry

2023 UNSAM Engineering School Award

Luciano Ferreyro
Readout super-conducting sensors

Postdoc
Argentina

Collaborations

Our research is embedded in a broad international network

"Internationally highly visible"
"Effective support of interdisciplinary science"
"Aligned well with relevant international detector roadmaps"

Member of international scientific collaborations

- Focus: technologies and design
- KATRIN, CMS, LHCb, CBM, …

ECFA detector R&D roadmap

- Leading roles in definition and implementation
- Broad activities in *semiconductor detectors, quantum sensors, calorimetry, electronics and on-detector processing*

Collaborating with DESY and GSI

- Common developments, Helmholtz Innovation Pool projects

Strategic partnership with
U Heidelberg, ITeDA / UNSAM Argentina

Embedded in the KIT center KCETA

Transfer activities with industry

Network for quantum technologies

- e.g. qSolid - 25 German institutions from science and industry working on a quantum computer

Findings and recommendations

The scientific **productivity and international recognition** of the group is **very high** and the programme breadth is remarkable given the stated staff and budgetary resources."

"The detector development and facilities together provide **key enabling technologies** for the MU projects."

"Environments where radiation hardness is critical, the technology used by ALICE has significant limitations and **HVCMOS** […] is widely seen as the **most promising technology** to address these"

"The design of cutting-edge high-bandwidth and low-latency **data acquisition systems** in support of KATRIN, KARA (including beamlines), CMS and other experiments, is another **key strength** at Helmholtz and KIT"

Recommendations:

- "Contribute with liquid Xenon + photodetector to DRD2 + 4"
- "HSS is world-leading - broad scoping exercise of more potential application areas is proposed"
- "Special attention should be made to staffing levels in the areas of microelectronics design and DAQ development"
- "Early interactions between experimental particle physicists, detector physicists, engineers and assembly technical experts are particularly important"

Grades MT-DTS

Rating contribution to the topic Detector Technologies and Systems (DTS)

Scientific achievements and impact				
X Outstanding	☐ Excellent	☐ Very good	☐ Good	☐ Fair
Originality and innovative potential				
X Outstanding	☐ Excellent	☐ Very good	☐ Good	☐ Fair
International standing and competiveness				
X Outstanding	☐ Excellent	☐ Very good	☐ Good	☐ Fair

Explanations

Scientific achievements and impact

- The **detector capabilities and internationally recognised expertise** in a broad range of sensor and microelectronics design, interconnect technology, array construction and advanced read-out system development are **truly internationally leading**.

Originality and innovative potential:

- The R&D on **HV-CMOS and high-resolution superconducting quantum sensors are world-class** with a large range of opportunities for further potential applications, including possible commercial exploitation.

International standing and competiveness:

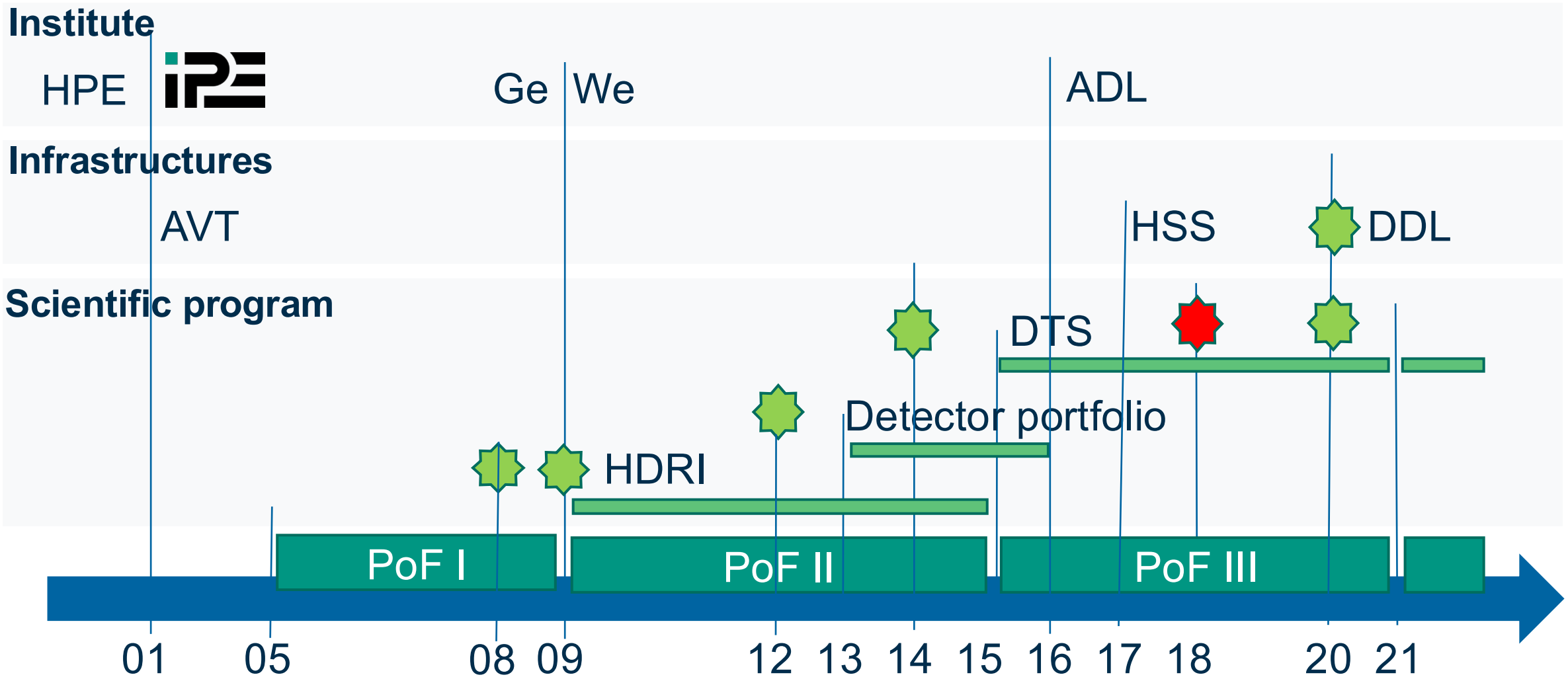
- The group has very strong participation in a number of the **world‘s most ambitious** particle/astro-particle **physics experiments, clear leadership** within many of the **international R&D collaborations** addressing the particle physics detector roadmap recommendations.

Preparations for PoF V

2

Short history of IPE in PoF

The long way to become an institute …



MT-DTS in PoF V – 2028 - 2034

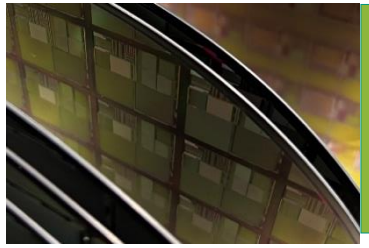
3rd funding period for MT, clear development visible

Themes:

1. **PoF III – Community building** with a broad portfolio of technologies
2. **PoF IV – Focus on sensor, integration and prototypes**
   Invest in dedicated detector infrastructures
   Proposal for the Helmholtz Distributed Detector Laboratory (DDL)
   Pioneering new concepts, strong participation in Innovationpool projects
3. **PoF V – Realization of next generation experiments** = harvest
   Strengthening photon science instrumentation
   by merging MML and MT-DTS @ KIT

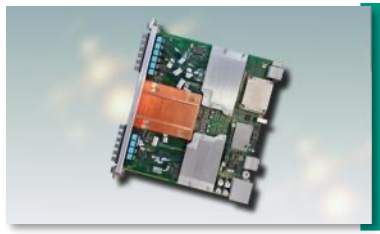
Structure of MT-DTS

From PoF IV



Detection and Measurement
Intelligent & compact granular detectors with high space and time resolution

ST1



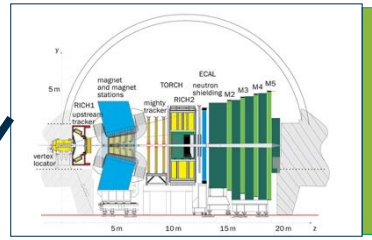
System Technologies
Critical technologies for coping with the data deluge

ST2

Science Systems
Build & characterize demonstrator systems ready for science

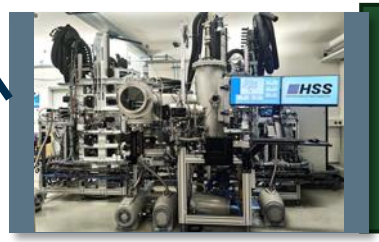
ST3

to PoF V



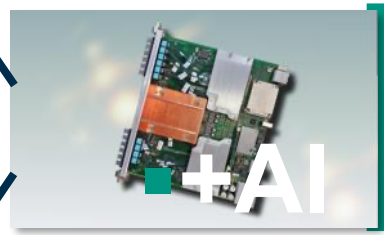
Sensing and Detecting Technologies
Realize intelligent and compact granular detectors with high space and time resolution

ST1



Quantum Technologies
Establish highly pixelated quantum sensors with ultimate energy resolution

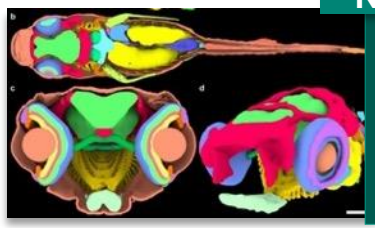
ST2



System Technologies
Build sustainable detector systems and cope with drastically increasing data rates

ST3

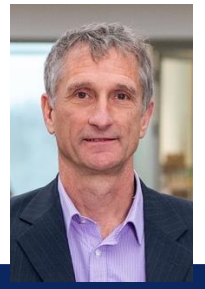
New



Detection Methods
Integrate advanced detector systems into multidimensional modalities for scientific discovery

ST4

Structure of MT-DTS + governance



Changes from PoF IV

- New speaker
- New topics:
  - Quantum technologies
  - Detection methods
- Both initiated by KIT

Detector Technology and Systems (DTS)

Speaker: Silvia Masciocchi (GSI), Heinz Graafsma (DESY), **Frank Simon (KIT)**
Center contact: Cornelia Wunderer (DESY), Christian Schmidt (GSI), **Andreas Kopmann (KIT)**

ST1

Sensing and Detecting Technologies

Simon Spannagel (DESY)
Michael Deveaux (GSI)
N.N.

"Develop versatile sensing technology to realize intelligent, next-generation detector modules for extreme environments"

ST2

Quantum Technologies

Steven Worm (DESY)
Peter Micke (HI-Jena)
Sebastian Kempf (KIT)

"Establish large scale, high energy resolution quantum detectors and explore new quantum sensing technologies"

ST3

Systems and their Technologies

Moritz Guthoff (DESY)
Piotr Gasik (GSI)
Andreas Kopmann (KIT)

"Combine novel technologies into sustainable detectors and highest-rate data processing systems."

ST4

Detection Methods

David Pennicard (DESY)
N.N. (GSI)
Clemens Heske (KIT)

"Integrate advanced detector systems into multidimensional modalities and AI-assisted methods for scientific discovery."

Structure of MT-DTS + governance

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ST1

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Michael Deveaux (GSI)
N.N.

"Develop versatile sensing technology to realize intelligent, next-generation detector modules for extreme environments"

ST2

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"Establish large scale, high energy resolution quantum detectors and explore new quantum sensing technologies"

ST3

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Andreas Kopmann (KIT)

"Combine novel technologies into sustainable detectors and highest-rate data processing systems."

ST4

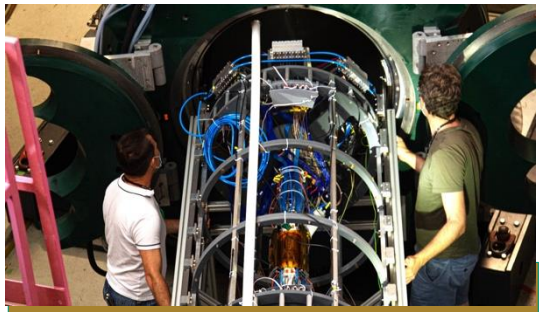
Detection Methods

David Pennicard (DESY)
N.N. (GSI)
Clemens Heske (KIT)

"Integrate advanced detector systems into multidimensional modalities and AI-assisted methods for scientific discovery."

MT-DTS teams in PoF V at KIT

- Three research teams
- Cross-cutting technologies, synergies



Large-scale detector systems, sensors, interconnects and silicon photonics for high-energy physics

Simon / Peric

Superconducting quantum sensors for astroparticle physics and dark matter searches, X-rays, ...

Kempf

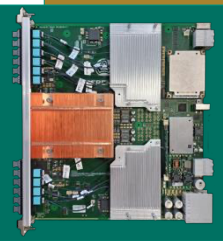
building up in PoF IV

Detectors, instruments and methods for photon science

Baumbach / Heske

formerly MML

- Activities in applications beyond RF
  Helmholtz Matter,
  Technology transfer
- Continuous training of young scientists

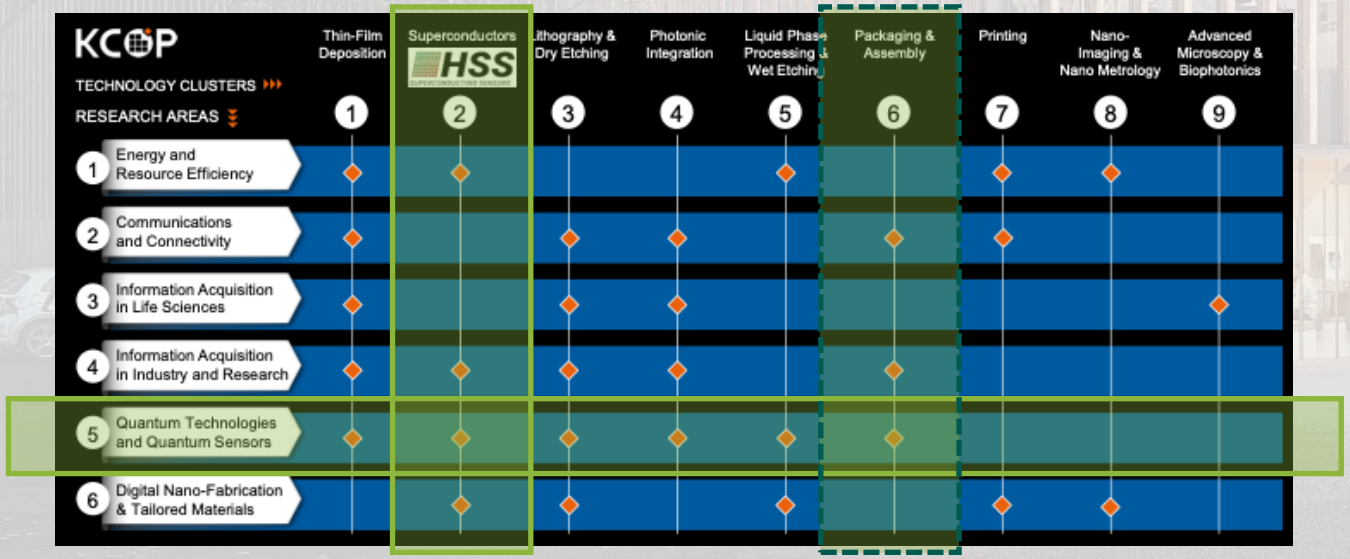


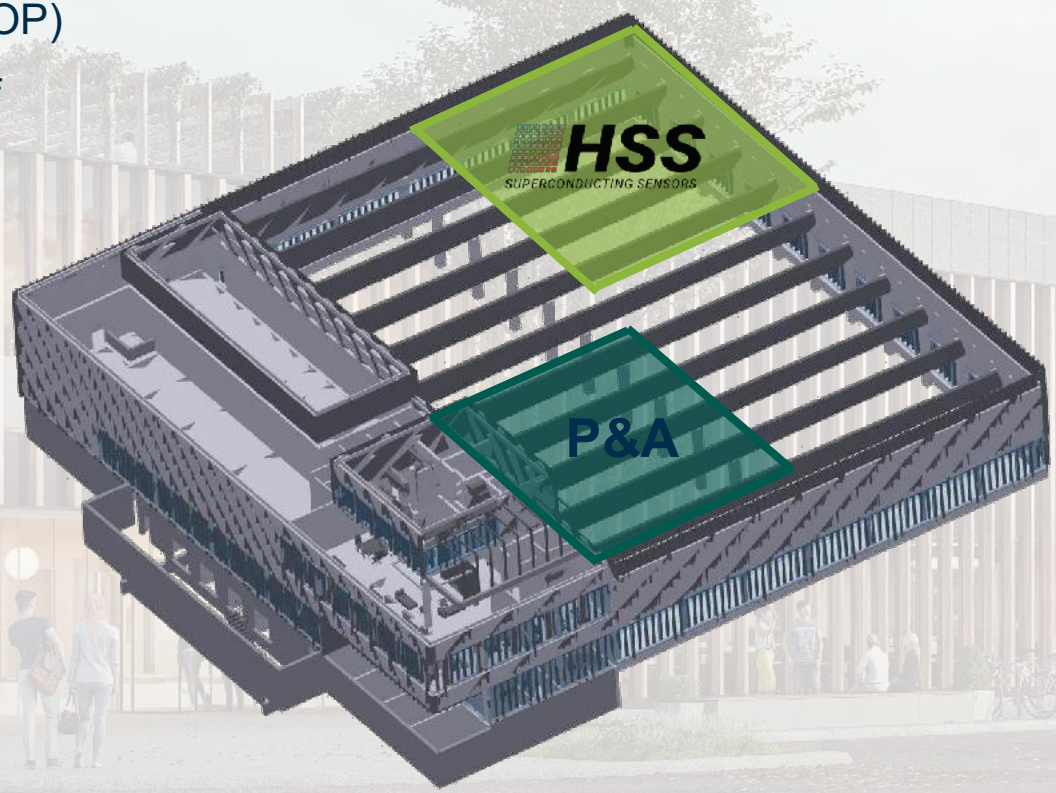
High-performance DAQ systems,
intelligent algorithms for online trigger and reconstruction, AI

KCOP: Karlsruhe Center for Optics and Photonics

Large-scale research infrastructure

- Integration of HSS in Karlsruhe Center for Optics and Photonics (KCOP)
- HSS forms independent technology cluster (TC) and is main driver of research area (RA) “Quantum Technology and Quantum Sensors”
- Close collaboration with TC “Packaging and Assembly (P&A)” (operated by MT-DTS) for sensor module packaging





approval as result of evaluation 2018
start of construction 2021

Competence Center for High-resolution Superconducting Sensors

HSS
SUPERCONDUCTING SENSORS

- Installation is now complete
- Three mayor pillars:
  - Development
  - prototype and batch fabrication
  - applications
- Competes with international facilities: MIT-LL, NASA/GSFC, NIST, …
- Requires **continuous equipment extensions and technology (r)evolutions**

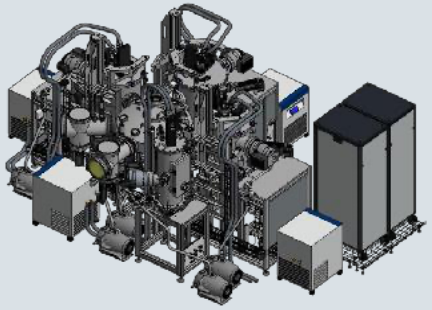
Next: re-location to KCOP

- Technology clusters operated by MT-DTS: TC2 HSS + TC6 Packaging and Assembly (~50% of clean room space)
- **Both are key for PoF V research program**

Photolithography

photoresist processing, direct laser lithography

UHV material deposition cluster



magnetron sputtering, e-beam evaporation, in-situ oxidation, ion-based substrate cleaning

ICP-PECVD

TEOS + silane based insulator deposition

3 x ICP-RIE

F- and Cl-based RIE of metals, dielectrics, and Si

CMP technology

Wafer polishing for multi-layer supercond. structures

Main Activities – Precision Experiments
The wider context

KATRIN++ – R&D phase during PoF V, Operations ~ 2035

- Multi-million quantum sensor array
- Windowless coupling to a room-temperature spectrometer (“cold chicane”)
- Sub-eV resolution to push neutrino mass measurement to ultimate limit

DELight – dark matter detection with superfluid helium, in proposal and R&D phase

- Large-area, large-pixel sensors

BULLKID – dark matter detection with KIDs on silicon, construction of first phase ongoing

- Readout system for 1000s of quantum sensors, complex online triggering for background suppression

XLZD – Dark Matter Detection Collaboration

- Liquid Xenon TPC

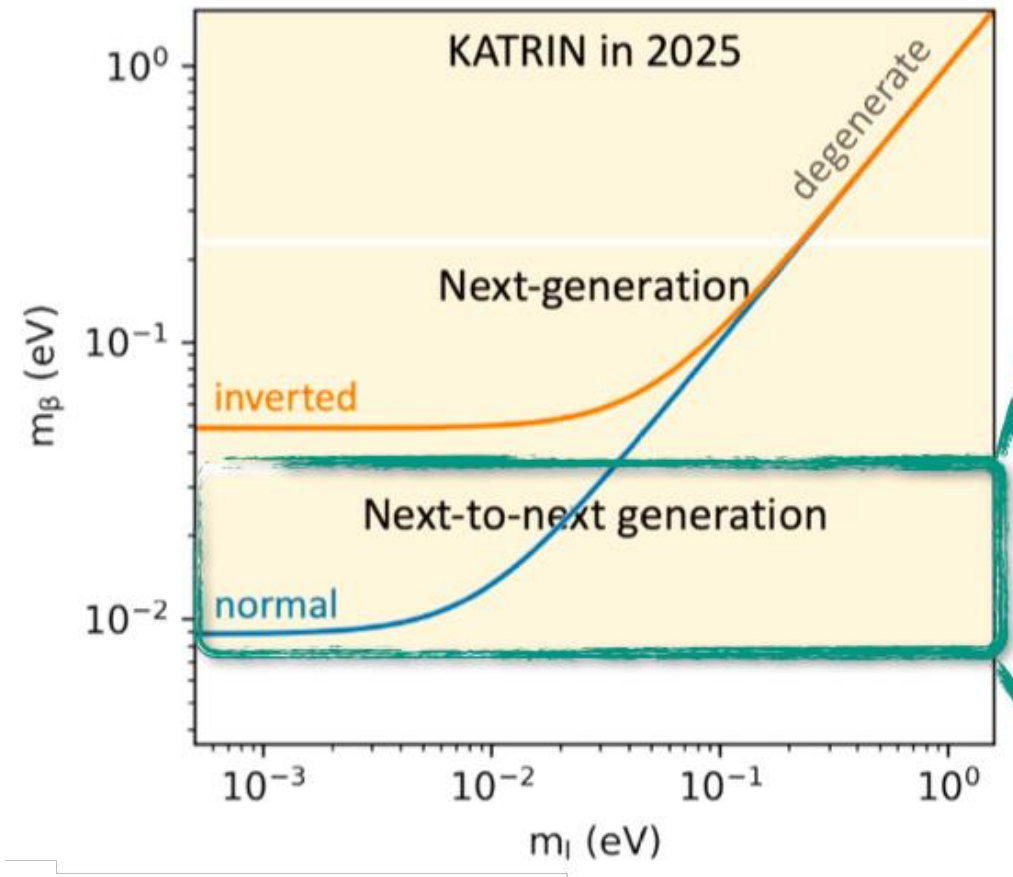
Key technologies

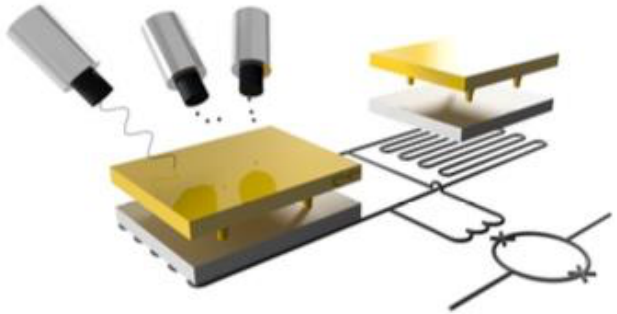
- Quantum sensors, in particular MMCs
  - Achieve sub-eV resolution
  - Operation in magnetic fields
  - Emphasize scaling and large-scale production
- Quantum sensor readout technology
- Liquid Xenon technology

Strongly connected to implementation of ECFA Detector R&D roadmap:

- DRD5 – Quantum Technologies
- Possibly in addition:
  - DRD2 – Liquid Detectors
  - DRD4 – Photon Detectors

KATRIN++

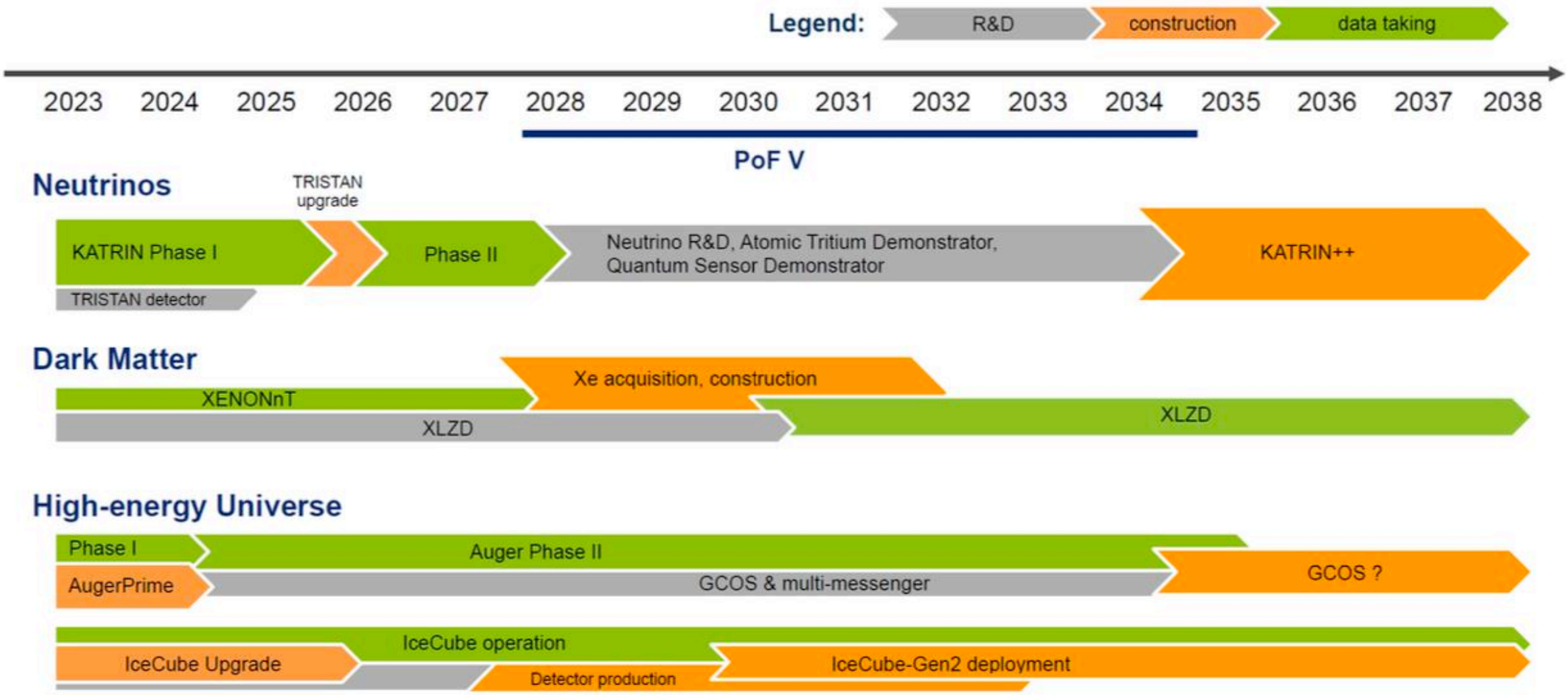




detector challenges related to KATRIN

- detection of electrons
  (backscattering, charging effects)
- large-scale detector array (10-100 cm^2 sensitive area)
- outstanding energy resolution at 18.6 keV ($\Delta E/E < 10^{-4}$)
- operation in large magnetic background fields (mT….T)
  (resilience to magnetic fields)
- interface cryogenic detector to warm spectrometer

MU-MRU / Astroparticle physics – Roadmap



Main Activities – Photon Science
The wider context

Creation of unique and challenging experimental environments for the development of novel detection approaches

- HIKA as first phase beamline BL23 at PETRA IV
- Beamlines and labs at KARA within the Clusters for
  - Spectroscopy (X-SPEC beamline)
  - Scattering (NANO beamline)
  - Imaging (IMAGE and HIKA beamlines)
- Multidisciplinary KIT research infrastructure for natural and engineering sciences
- Complementary experimental stations at low-emittance photon facilities
- Radionuclide Materials Observed with Soft X-ray Spectroscopy (ROXS) at X-SPEC

Key technologies

- Quantum-sensor based calorimetric superconducting detectors
  - High rates & harsh environments
  - Operation in magnetic fields
- AI-supported beamline concepts for autonomous large-scale digitization and analysis of 3D morphology
- Automated beamline operation
- Bragg (de)-magnifiers

KIT's new activities in MT-DTS

- KIT proposes to strengthen MT-DTS by further contributions in ST1-3 and in a fourth subtopic, jointly with DESY
  - ST4 will support system conception, design, characterization, and application
- KIT's beamlines and labs will extend the DTS "Research Infrastructures" portfolio
  - System implementation and application tests as important steps in technology development

Main Activities – High Energy Physics
The wider context

LHC Phase IIb Upgrades – LS4 2034-35

- LHCb MightyTracker and Upstream Pixels: HVCMOS MightyPix Sensor
- ALICE3 Main Tracker modules – packaging and interconnects

EIC – Construction start 2026

- HVCMOS AstroPix sensor for highly granular ECAL

Next CERN Flagship – CDRs/TDRs early 2030ies, Operations from ~2045

- Ambition to contribute significantly to one experiment:
  - Calorimetry
  - Tracking
  - DAQ / data transmission

CMS, Belle II

- DAQ operation & development (CMS HGCAL, Tracker; Belle II PXD, possible Belle II upgrade)

Key technologies

- Semiconductor sensors, in particular HVCMOS
- Silicon photonics
- Packaging, interconnect technology
- High-performance DAQ, on- and off detector processing, system design
- High-speed links, intelligent front-ends

Strongly connected to implementation of ECFA Detector R&D roadmap:

- DRD3 – Semiconductor Sensors
- DRD6 – Calorimetry
- DRD7 – Electronics and On-Detector Processing
- Possibly in addition
  - DRD8 – Mechanics & Cooling

Detector development for LHCb@LHC

LHCb phase IIb upgrade: *pushing the limits of time and space resolution, data rates*

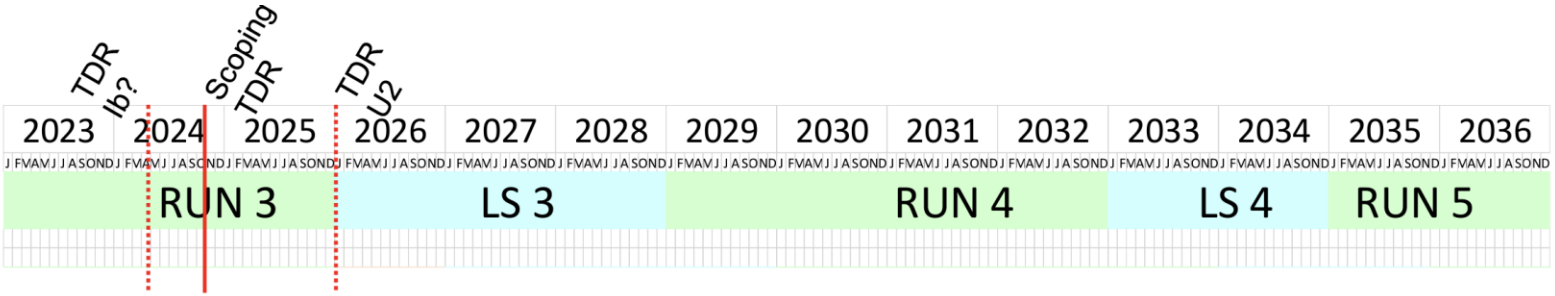
KIT highlights:

KIT-ADL technology currently baseline for one mayor system: 6 layers of HV-CMOS sensors MightyPix,
18 m^2 in total

Strong expertise in electronics packaging at IPE

Grand challenges:

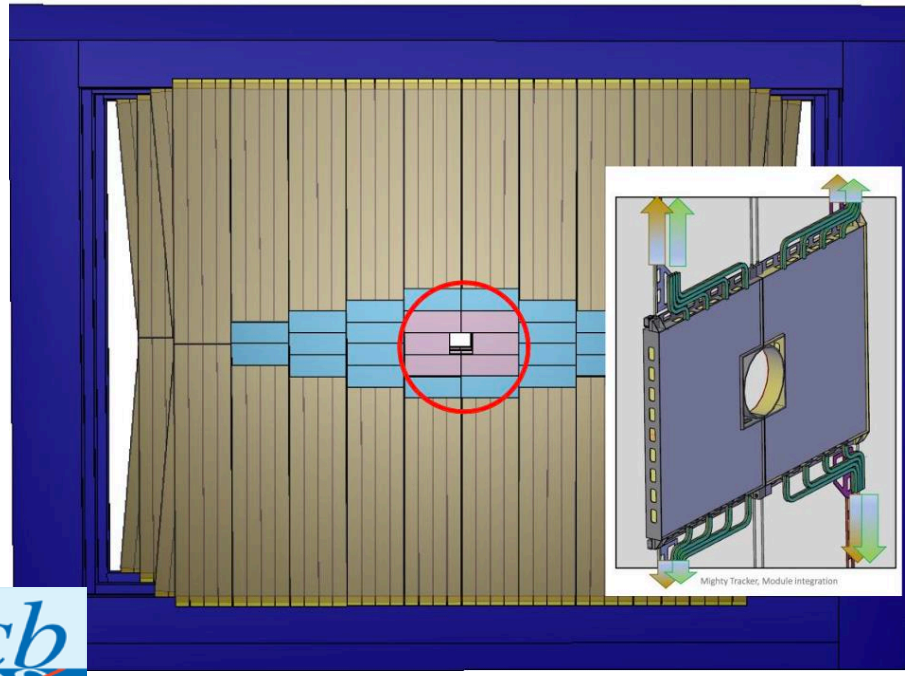
Flavour Physics, probing the standard model



TDR being prepared in the next years

Collaborators welcome: an opportunity for a leading role in the upgrade

Long-term commitment and resources needed to enable adoption of technology by collaboration.



From CMS@LHC to a Higgs factory

1. Development of 5D reconstruction and trigger algorithms on data; commissioning and operation of DAQ systems
2. Beyond LHC: Shape next generation experiments at a future Higgs Factory (Operation 2040+)
   Goal: towards the end of POF V provide a concrete technical proposal

KIT highlights:

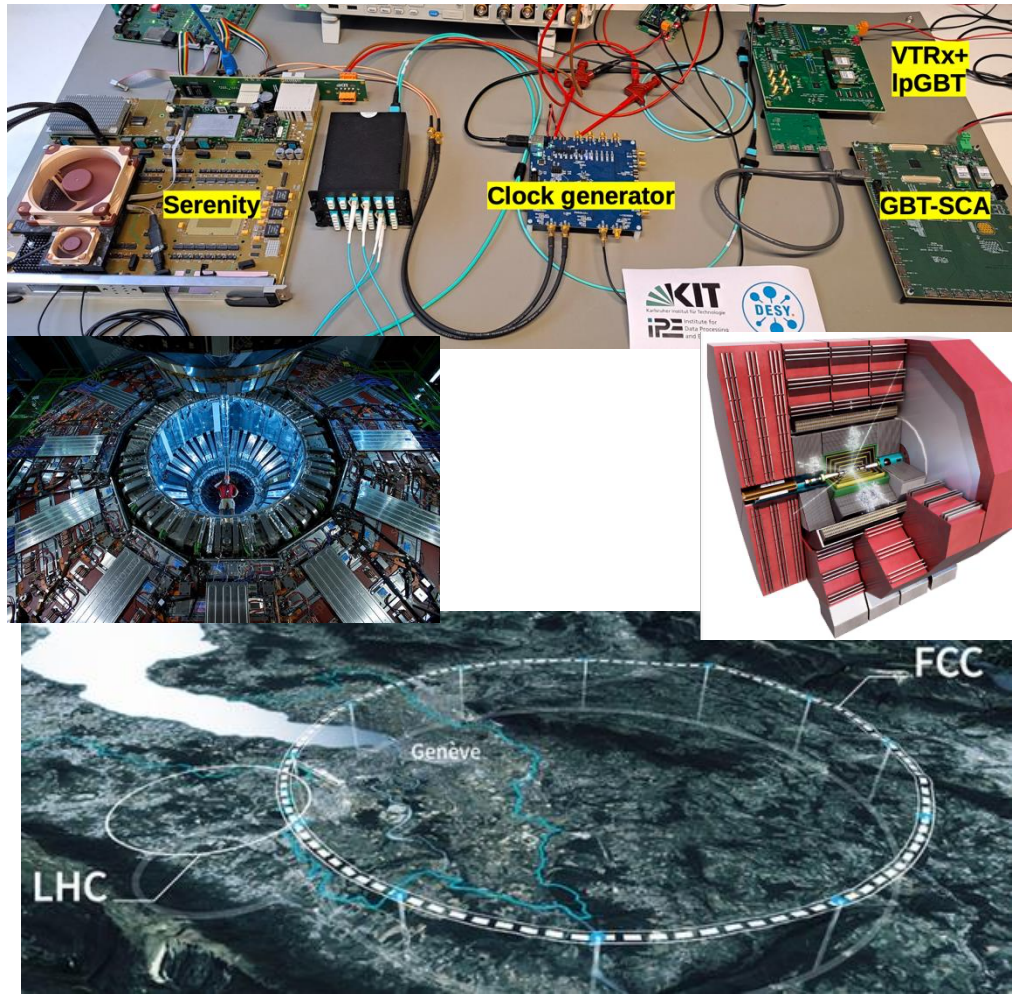
CMS Phase II Upgrade: High-performance DAQ & Trigger, Serenity Board.

- L1TrackTrigger (CORE contribution)
- High Granularity Calorimeter as new activity

Engaged in DRD collaborations (ECFA R&D Roadmap)

Grand challenges:

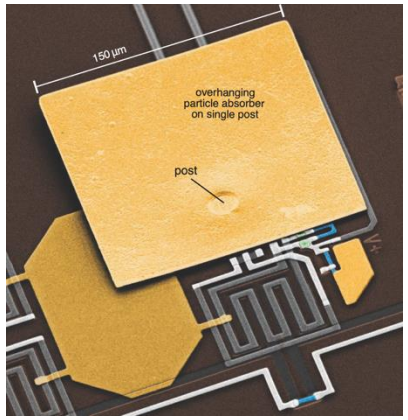
Understanding the Higgs Boson, discovering beyond the standard model physics



Major activities – KIT

	2028 – 2029 – 2030	2031 – 2032	2033 – 2034
ST1	Sensor design finalized for multi square-meter detectors for high-radiation, high-rate environment (e.g., LHCb, EIC)	Establish 2.5/3 D integration technology, integration of silicon photonics in detector assemblies	
ST2	Scaling sensor- and readout concepts to kilo and megapixel sizes, including production and test capacities	Operation of quantum sensors outside of laboratory environment, coupling to warm signal sources, operation in magnetic field	Demonstrators for megapixel quantum sensors (e.g., KATRIN++)
ST3	Demonstrator realized for a no backend DAQ system with on-detector intelligence (e.g. for beam diagnostics)	Development of X-ray optics to realize imaging applications at high luminosity beamlines (e.g., PETRA IV)	Development of an imaging station at a high-luminosity beamline (e.g., HIKA at PETRA IV) Higgs Factory detector concepts
ST4		Operando and KI-supported high-throughput analyses for demonstrators in materials and life science.	Framework for autonomous data quality monitoring, intelligent data analysis, quantum algorithms Advanced online algorithms for highly granular, high dimensional collider data.

PoF V program proposal



Abstract: MT-DTS **drives world-leading innovation** in detection technologies and systems, offering comprehensive expertise **from sensing concepts and component design to full system integration**. […]

Challenges:

- We **design cutting-edge detectors** for next-generation experiments, advancing technology to create highly segmented, ultra-fast, high-resolution and robust systems.
- We **pioneer disruptive technologies** — including quantum sensors, next-generation interconnects, advanced engineering materials, and AI-driven detector systems.
- We **establish key competencies** in detector technologies such as microelectronics, contributing to Germany's and Europe's technological sovereignty.
- We **develop novel methods and concepts** to extract and process maximal information from sensors, and therefore fully exploit the potential of our detector systems.
- We **train the next generation** of scientists and engineers in cutting-edge technologies.

PoF V program proposal – Goals

MAPS for particle tracking: Deliver prototypes based on pixel sensors optimized either for multi-square-meter tracking systems (2030) or for excellent space and time resolution (2032).

Integration and interconnect technologies: Establish access to wafer bonding and 2.5/3D integration technologies, demonstrated via prototypes including integrated silicon photonics (2031).

Quantum sensing technologies: Develop and test new technologies, such as cryogenic and single-ion quantum sensors and optical clocks (2029).

Quantum sensors in experiments: Scale sensor and readout concepts to large pixel counts and areas with suitable production and test capacities. Demonstrate operation in harsh experimental conditions (2030).

Tracking systems: Demonstrate ultralight-weight detector systems, based on semiconductor and gaseous detectors and operated with advanced cooling, powering, and readout concepts for next-generation experiments at accelerators (2030).

Detector system for photon science: Deliver a multimegapixel HPAD X-ray imager, with single-photon sensitivity and adaptive gain, running continuously at 150 kfps (2033).

Detector systems for future collider experiments: Develop highly granular calorimeters and particle tracking concepts, with advanced DAQ systems and on-detector intelligence, towards integration into complete detectors (2035).

Detector stations: Develop a holistic view on modern detector stations, e.g. at photon sources, including simulation, instrumentation, and operational concepts, leading to the realization of an imaging station at a high-luminosity beamline.

Detector facilities: Demonstrate and apply new approaches to the design of detector systems and detection methods, e.g. AI-supported design and high-throughput measurement and analysis, systems optimization, and autonomous operation (2035).

High-Tech Agenda Germany Kompetenzzentrum Chipdesign

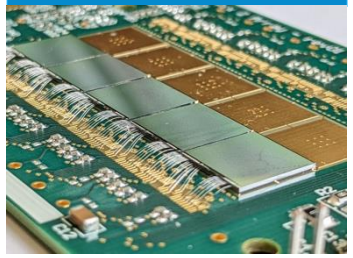
Goals: develop Germany to the European center for chipdesign
connect academic research and industrial demands

1. Spitzen-forschung

Internationale Experten, Mikroelektronik-Designgruppe, Zugang zu Hightech

2. Spin-offs und Transfer

Vernetzung mit der Industrie, Förderung von Ausgründungen



3. Nachwuchs ausbilden

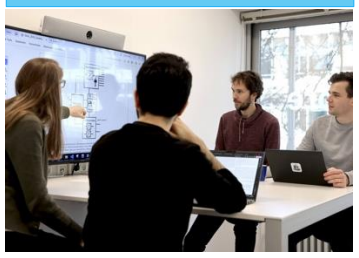
Von der MINT-Förderung zu Promotion und Nachwuchs-wissenschaftlern

4. Forschungs-infrastrukturen

Reinräume für Fabrikation, Integration und Charakterisierung, “open access”

5. Regionale Vernetzung

Beratung und Kompetenz für die Region, Vernetzung mit Universitäten und Hochschulen



What is next?

Strategice evaluation 26.05.-29.05.2026, Berlin

(4 rehearsals: online, Kassel, 2x Berlin)

Participants:

- MT-DTS 12 participants
- KIT team:
  - Frank Simon
  - Andreas Kopmann
  - Sebastian Kempf
  - Clemens Heske

Last results

Berlin 2020: “The program MT is a success story”

DTS	Goals	Work program	Competence & Resources	Impact & Risk
PoF IV	7	7	7	6
	Alignment	Coherence, Management, Cooperation	Competence	Originality
PoF III	6	5	6	5

There is not much room to improve …