

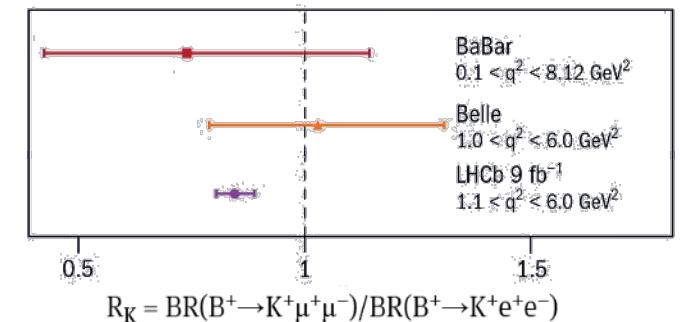
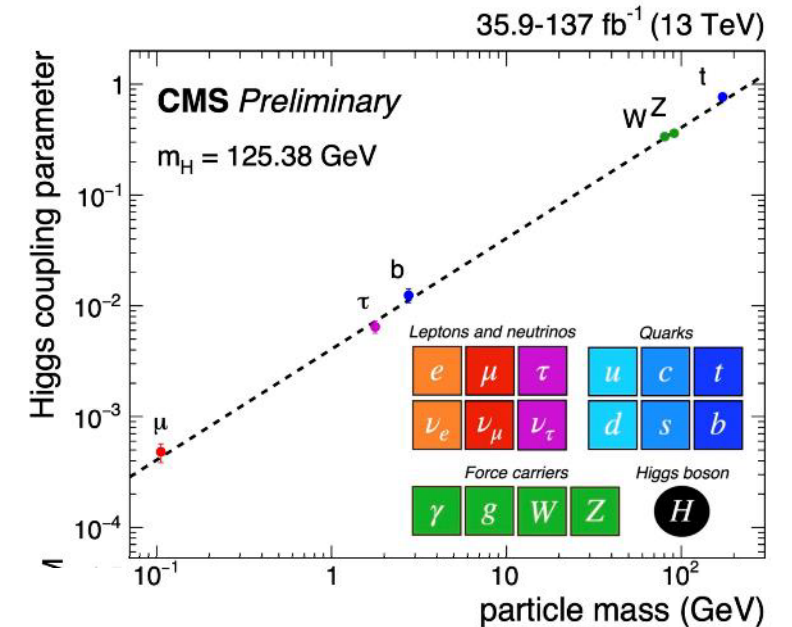
Overview of Particle Physics in Germany

RECFA Visit to Germany, Berlin, April 1st, 2022

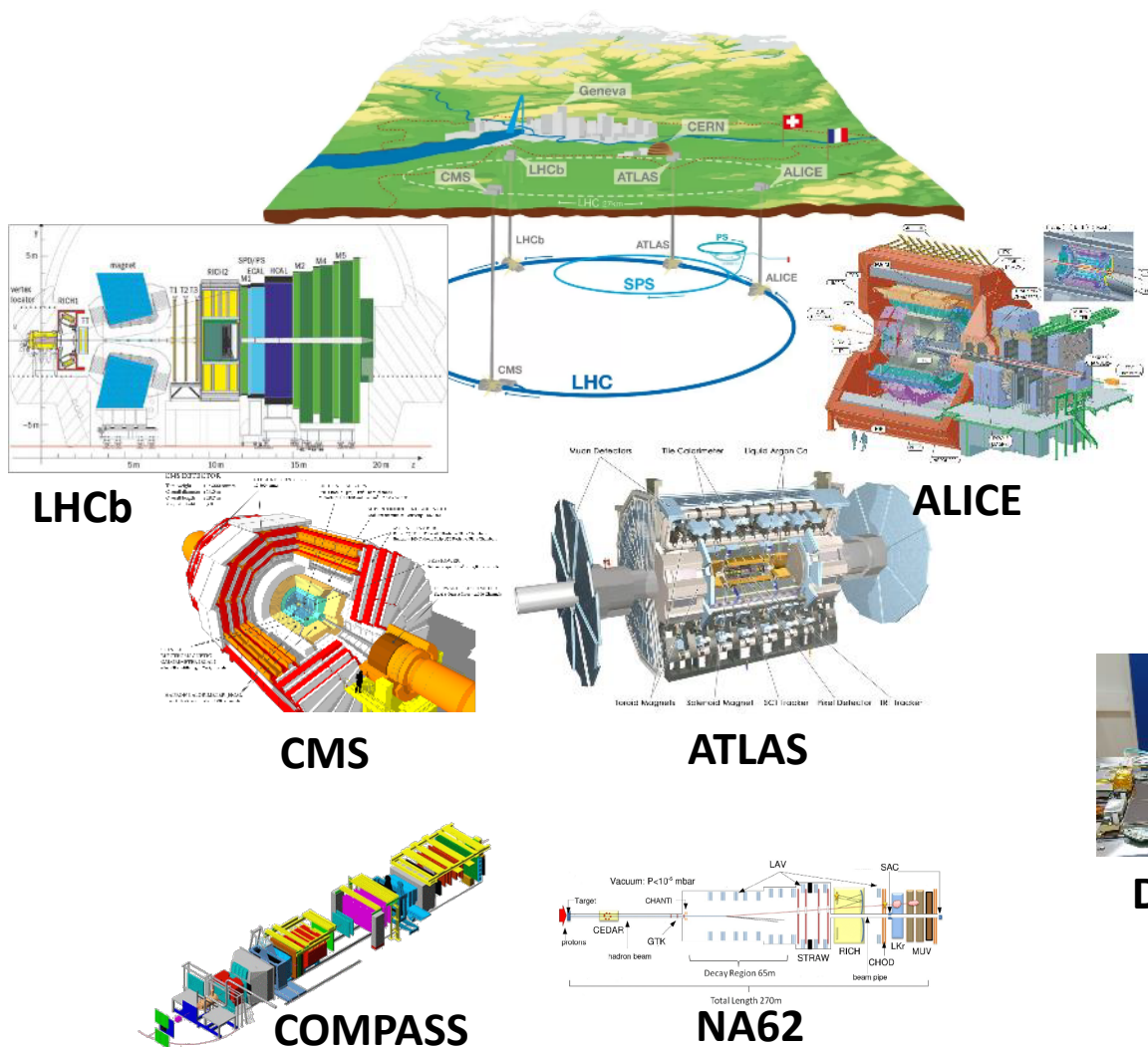
Lutz Feld (RWTH Aachen University)
Chair of Committee for Particle Physics KET

Understanding nature at the fundamental level

- **Higgs** discovery opened a new window to the fundamental laws of nature and to many of the open questions of particle physics
- Tantalizing hints for **flavour violation** in b quark decays
- Strong evidence for **physics beyond the standard model**: neutrino masses, matter-antimatter asymmetry, dark matter, dark energy
- **accelerator-based experiments** are a proven and indispensable key driver of fundamental science
- **LHC** and **SuperKEKb** are today's workhorses
- **HL-LHC** is the next big step
- the leap **beyond HL-LHC** needs to be prepared today
- **German particle physics community is fully engaged**



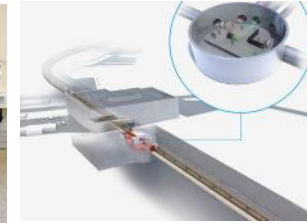
Focal Points of Particle Physics in Germany



**Grid-Computing
Data Science**



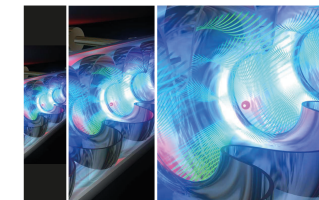
Theory



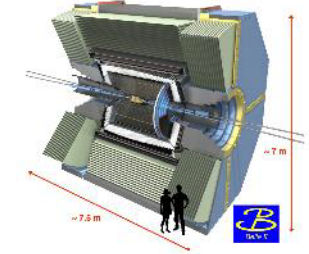
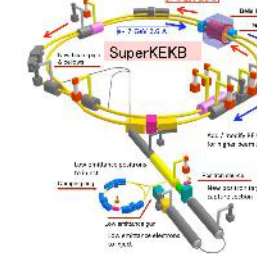
ALPS II



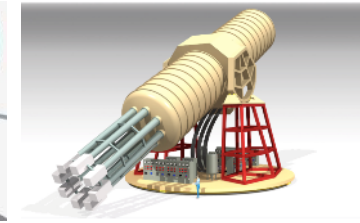
Detector R&D



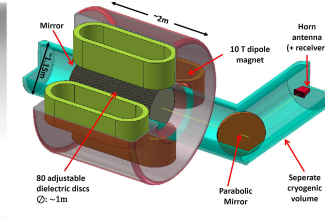
Accelerator R&D



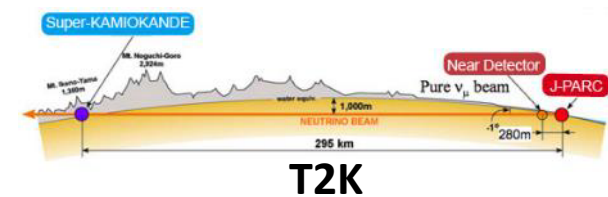
BELLE II



IAXO



MADMAX



T2K



DUNE

Focal Points of Particle Physics in Germany

collaborating institutions

7xUni + DESY + KIT + GSI + MPI

7xUni + DESY + MPI

4xUni + MPI

5xUni + GSI

Grid-Computing
Data Science

25xUni + DESY + GSI + MPI

7xUni + DESY + MPI

BELLE II

LHCb

3xUni + DESY + KIT

14xUni + DESY + MPI

ALICE

Theory

ALPS II

IAXO

MADMAX

CMS

ATLAS

20xUni + DESY + KIT + GSI + MPI

2xUni
 $\mu 3e$

2xUni
T2K

Near Detector
J-PARC
Pure ν_μ beam
280m

4xUni

COMPASS

1xUni

NA62

Detector R&D

9xUni + DESY + KIT + GSI + MPI

Accelerator R&D

1xUni + X

DUNE

Particle Physics Institutions in Germany

- **Universities**

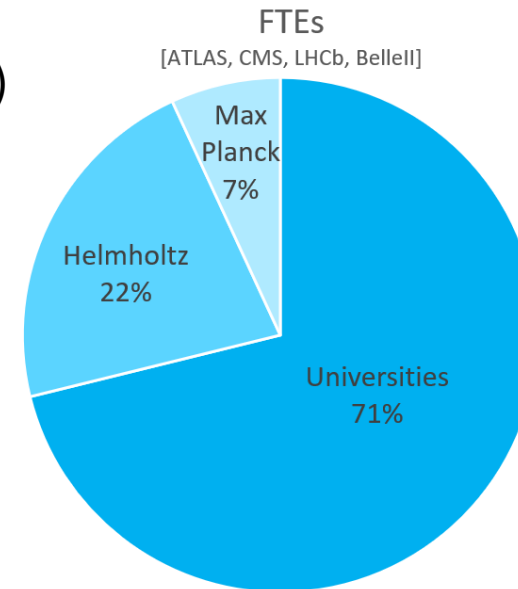
- 25 Universities
- ~150 Professors and junior research group leaders
- typically 130 PhDs completed per year in our field

- **Helmholtz Research Centres** [talk by B. Heinemann]

- DESY at Hamburg and Zeuthen (national hub for HEP)
- KIT, Karlsruhe (also a University)
- GSI, Darmstadt (heavy ion, hadron & nuclear physics)
- more centres contribute on specific topics, like CASUS, Görlitz (HZDR, GPU applications)

- **Max Planck Society** [talk by A. Caldwell]

- MPI for Physics, Munich
- HLL Semiconductor Lab
- MPI for Nuclear Physics, Heidelberg



Community Organisations

Committees elected by their community, build consensus on strategy and scientific program, coordinate outreach activities

Particle Physics KET

- **LHC: ATLAS, CMS, LHCb**
- **Belle II**
- **Neutrinos at accelerators**
- **Fixed target experiments**
- **Axion Searches**
- **Theory**

[this talk]

Hadron & Nucl. Physics KHuK

- **LHC: ALICE**
- **ISOLDE, COMPASS**
- FAIR experiments
- Hadron physics
- Nuclear structure
- **Theory**

[talk by Tetyana Galatyuk]

Astroparticle Physics KAT

- **Dark Matter**
- **Neutrino properties**
- **Cosmic rays**
- Gamma-ray astrophysics
- **LE&HE neutrino astroph.**
- Nuclear astrophysics
- Gravitational waves
- **Theory**

[talk by Uli Katz]

Accelerators KfB

- Accelerator R&D** and operation for
- photon science
 - **particle physics**
 - nuclear physics

[talk by Marc Wenskat]

Young High Energy Physicists Association yHEP

[talk by V. Lang]

Research Clusters (BMBF-ErUM-FSPs)

[see talks by U. Husemann & S. Hansmann-Menzemer]

- coordination of collaborations on large experiments
- ALICE, ATLAS, CMS, LHCb + Belle II + FAIR experiments

Data Science and Computing *[see talk by M. Schumacher]*

- **PUNCH4NFDI** (within national research data initiative)
- **DIG-UM** community organization
- **ErUM-Data-Hub** connecting different communities

ErUM-LHC Office (founded in 2020) *[see talk by U. Bilow]*

- joint outreach of German participation in LHC experiments
- foster connections to industry + workshops for PhD students and postdocs

Terascale Alliance

- annual meeting of the particle physics community
- lively program of workshops and schools

Funding Structure

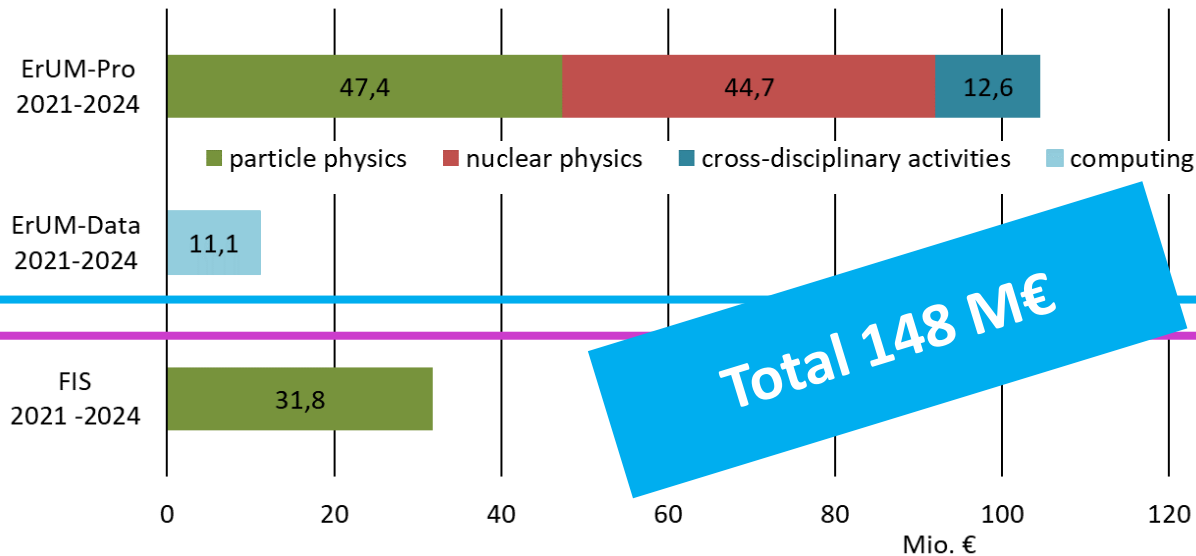
	Base Funding		Project Funding				
	Federal Government (BMBF)	States ("Länder")	BMBF ErUM + FIS (3 year cycle)	DFG	EU	Helmholtz Association (7 year cycle)	Max Planck Society
Universities	•	• • •	• • •	• • •	•		
Helmholtz Centres	via Helmholtz Association 90:10			•	•	• • •	
Max Planck Institutes	via Max Planck Society 50:50		•	•	•		• • •
CERN	245 MCHF/a 21%						

- BMBF funding schemes enable Universities to participate in long-term projects like LHC
- BMBF and DFG funding lines are complementary
- EU: mainly AIDA/AIDA-2020/AIDAinnova and ERC grants (1-2 per year)

BMBF Funding of University Groups 2021-2024

Project Funding (ErUM-Pro and ErUM-Data)

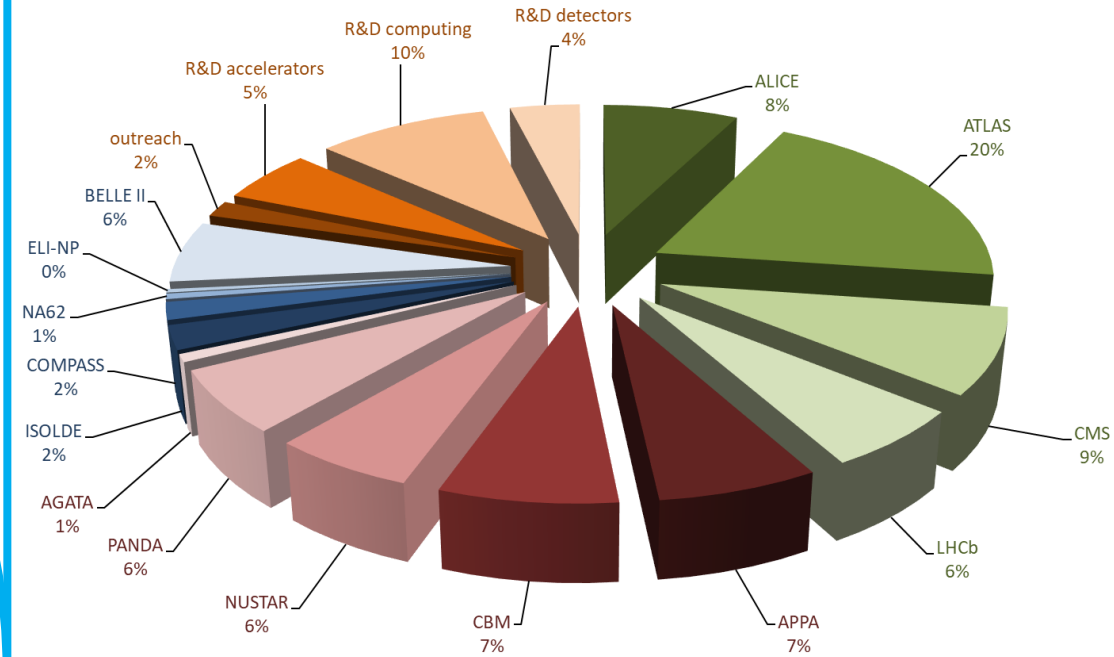
- complemented by significant University funds



Upgrade Funding (FIS Framework, national Roadmap)

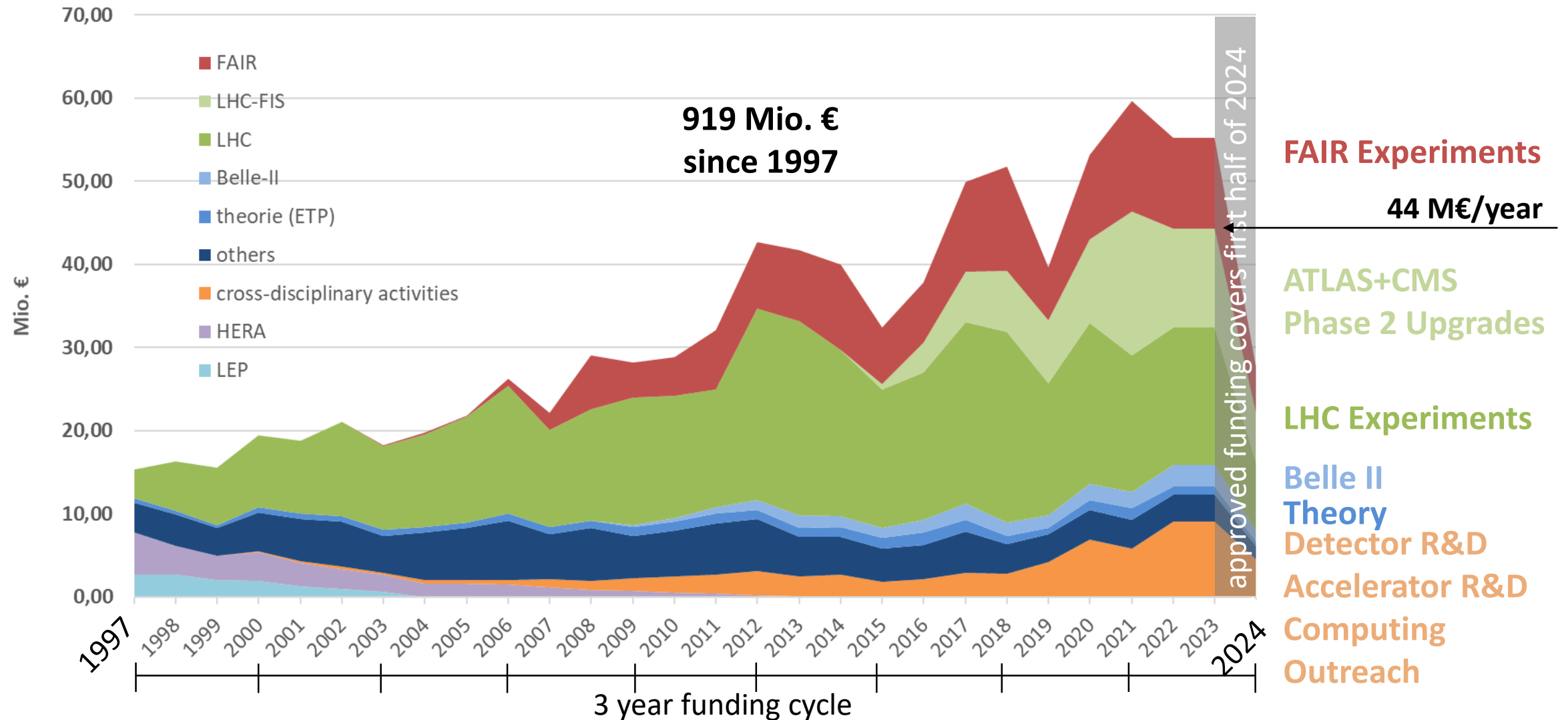
- special contribution to HL-LHC upgrades of ATLAS and CMS
- 103,8 M€ total (2016-2027), recently increased by 13,8 M€**

ErUM funding for 3 years (2021-2024): 116 M€



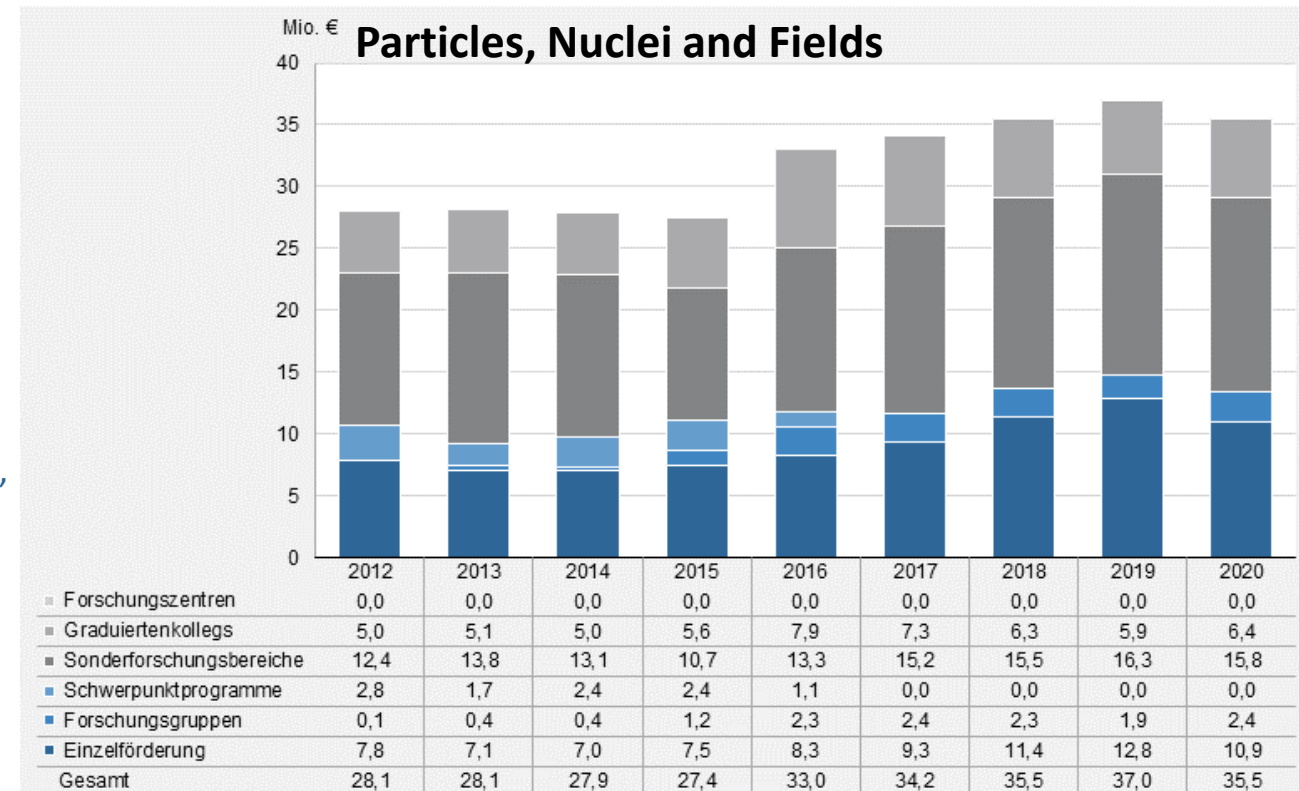
including 4.9 M€ for experiment-related theory

BMBF ErUM Funding of University Groups since 1997



DFG Funding for University Groups

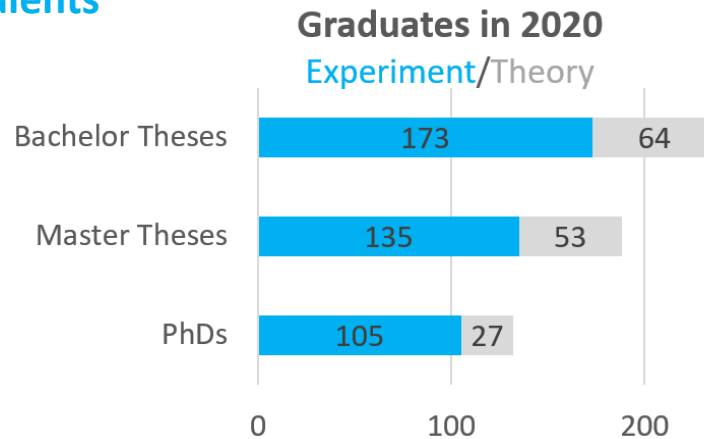
- **complementary to BMBF funding**
i.e. no funding of experiments at large research infrastructures
- **funding instruments** include
 - 6 Research Training Groups, often theory + experiment
 - Aachen, Münster, Darmstadt, Freiburg, Heidelberg (2)
 - several Collaborative Research Centres, mainly theory
 - 8 Emmy Noether Junior Researchers
 - Aachen, Bonn (2), Dresden, Hamburg (2), Munich (2)
 - 1 Research Unit
 - Heidelberg (Mu3e)
- **in addition, administered by DFG**
 - 3 Clusters of Excellence
 - Hamburg, Mainz, Munich



Survey of German Particle Physics Community

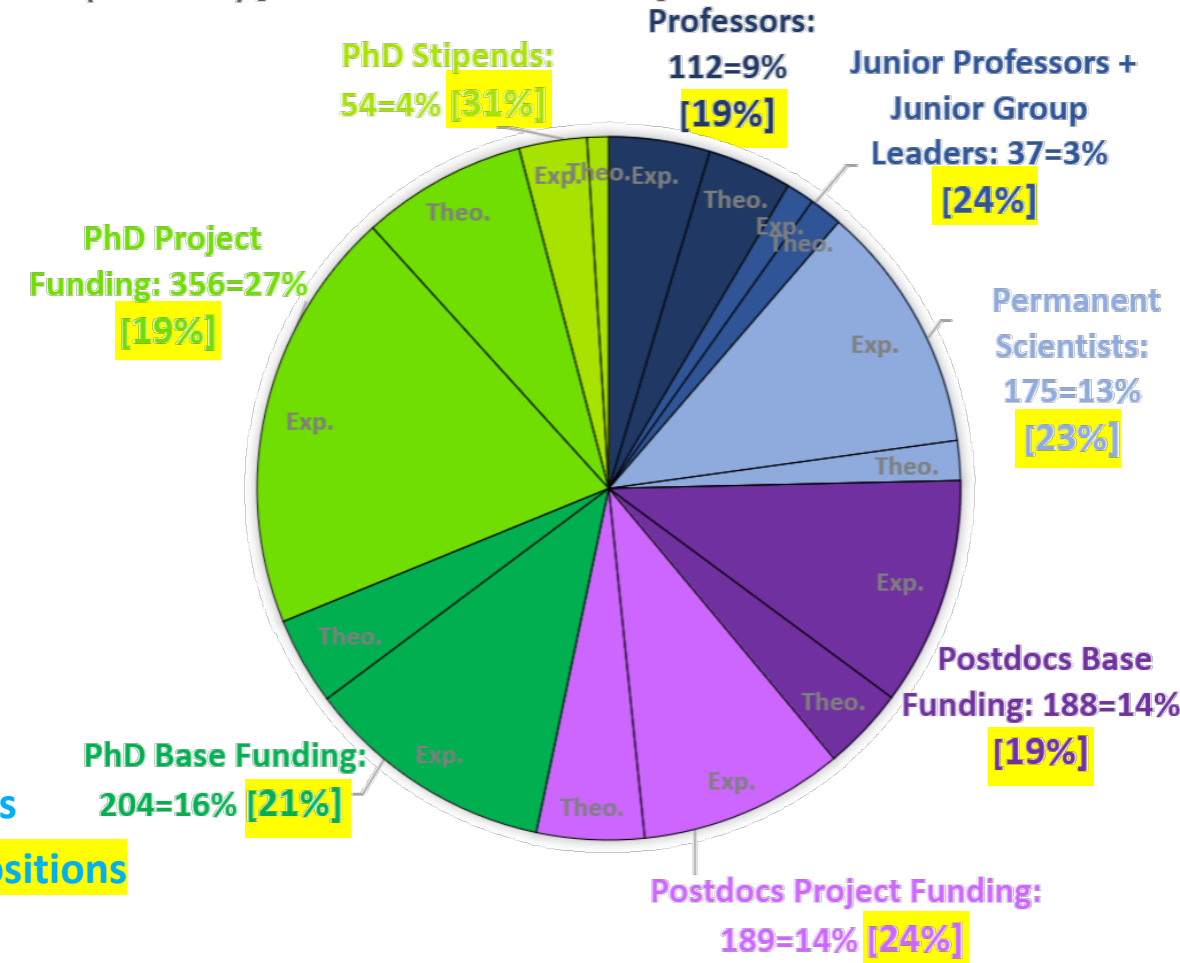
- **Community Survey** (reporting date Jan 2021)
 - Universities, Helmholtz, Max Planck
- **Head-count:** 939 experiment + 376 theory = 1315 total
 - 47% PhD students
 - 29% Postdocs
 - 24% Professors, Junior Group Leaders, permanent Staff

→ many young talents



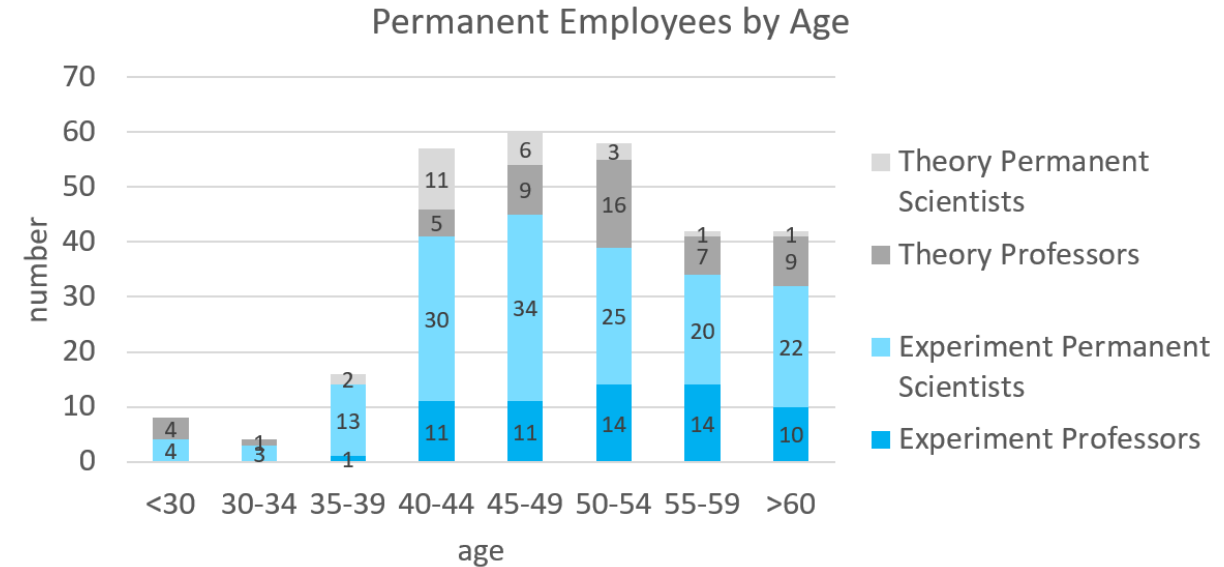
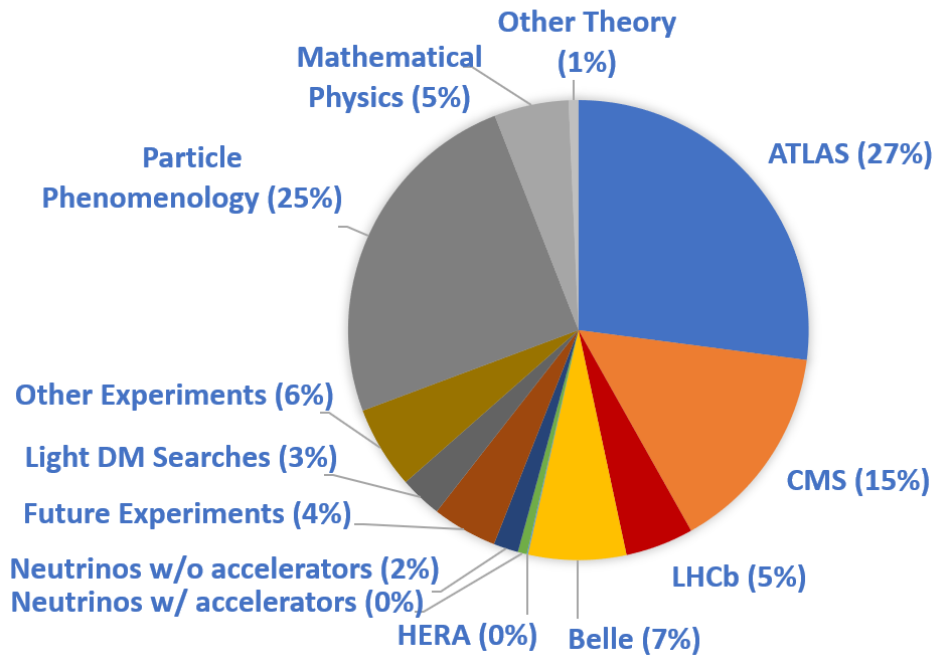
- 54% base funding + 46% project funding
- 50% internationals in PhD+Postdocs, 25% in permanent positions
- **22% women each in PhDs, Postdocs, and leading/permanent positions**
 - up from ~10% in permanent positions in 2014!
 - for comparison: 24% female bachelor graduates (in 2020)

PERSONPOWER IN PARTICLE PHYSICS (JAN 2021) [PERCENTAGE OF WOMEN]



Survey of German Particle Physics Community (II)

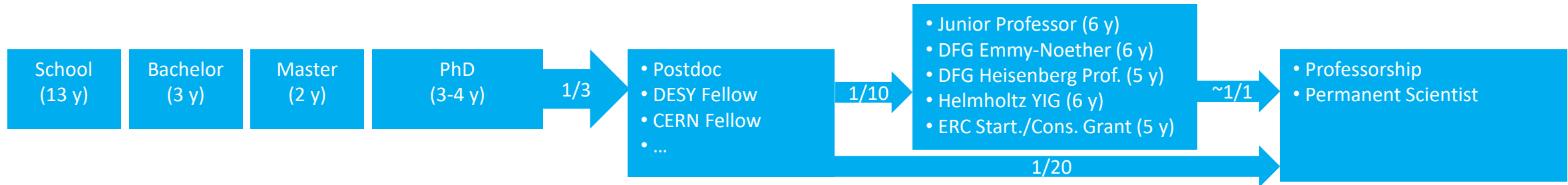
FTE PER EXPERIMENT OR THEORY BRANCH



8-10 permanent positions per year to fill

- Strongest contributions to LHC experiments and Belle II
- Healthy program of selected smaller scale experiments
- Very strong particle phenomenology

The talent pipeline: Education & Career Development



“Netzwerk Teilchenwelt” (KONTAKT Project)

[see talk by Uta Bilow]

offers various opportunities to make contact with particle physics early on during school and university education

PhD students

- **supported** through e.g.
 - **Graduate Schools**
 - **Maria-Laach-School**, further national & international **schools** (e.g. Terascale Alliance Schools [1] on Detectors, Statistics, Machine Learning, etc., HASCO School [2], etc.)
 - **workshops** on Science Communication, Leadership, Networking and Self-Presentation in Science organized by the ErUM-LHC Office
- KET and KHuK recommended in 2020 to **pay PhD students a 2/3 postdoc position** (was mostly 1/2 before)
 - was implemented in funding period starting 2021, but no extra funds available → reduction of number of BMBF funded PhD positions by roughly 25%
 - this reduction needs to be compensated for

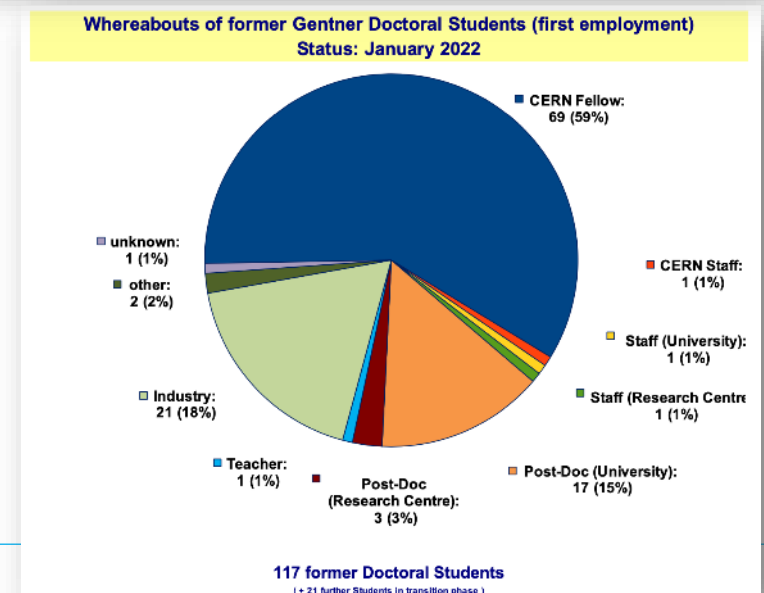
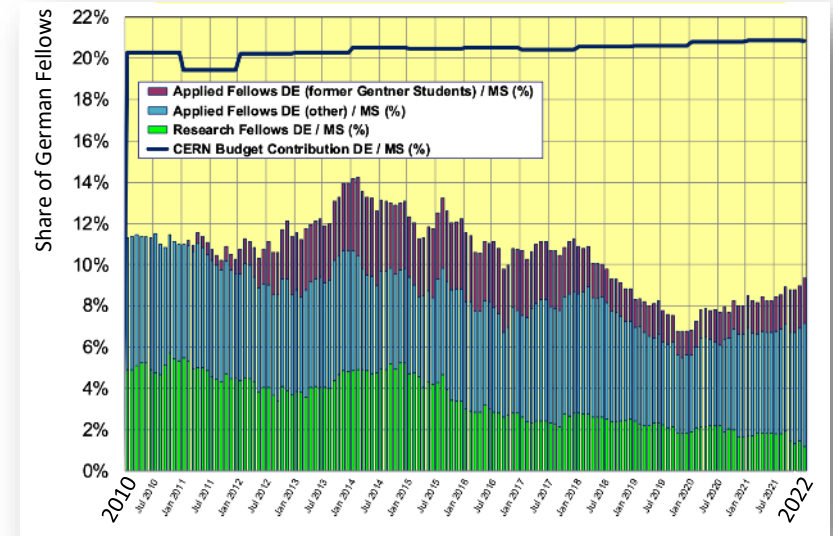
[1] https://www.terascale.de/schools_and_workshops/ [2] <http://hasco.uni-goettingen.de>

Postdocs

- **many options**
- **Junior positions are highly competitive** (6-7 per year)
 - high probability to obtain a permanent position afterwards
 - in many cases allowed time after PhD is limited
→ Fellowship has to be the first Postdoc position
- **Habilitation**
 - additional qualification path at the Universities

German colleagues at CERN

- **German colleagues hold many leading positions at CERN**
 - see following talks
- **Our share in CERN Staff, Fellows, and Students is 7.3%, considered very low** compared to Germany's contribution to the CERN budget of 20.3% in 2021.
 - strongest imbalance in technical, IT and administrative groups, but also in fellows (9%)
 - CERN and BMBF have set up a bilateral working group to reduce imbalance
- **Wolfgang Gentner scholarship for technical doctoral students at CERN**
 - **funded by BMBF** since 2007, 1.8M€/year, funding for 36 months
 - **currently 40 German PhD students at CERN, 32 of which are Gentner**
 - 16.7% of all technical PhD students at CERN are German
 - 37% of active Gentner PhDs are female
 - 60% stayed at CERN as Fellows, 10% became Staff after fellowship
 - **important part of the talent pipeline, should be continued**



Defining the Strategy for Particle Physics

Full community was involved through five workshops

- *Future e^+e^- -Collider* (Mai 2016 at Munich, indico.mpp.mpg.de/event/4223/)
- *Future of Neutrino Physics* (Februar 2017 at Heidelberg, www.mpi-hd.mpg.de/neutrinos/)
- *Future non-Collider Projects* (April 2017 at Mainz, indico.him.uni-mainz.de/event/9/)
- *Future Hadron Collider* (Dezember 2017 at DESY, indico.desy.de/event/18276/)
- *Strategieworkshop Teilchenphysik* (Mai 2018 at Bonn, indico.desy.de/event/19892/)

jointly organized by KET, KHuK, and KAT



Priorities of German Particle Physics Community [1], [2]

- successful realization of the **HL-LHC** and full exploitation of the outstanding physics potentials of **HL-LHC** and **SuperKEKB**
- **electron-positron collider Higgs factory** as next international HEP project; Europe, with CERN, should play a leading role in decision making and realization
- CERN should prepare to host the **next hadron collider** at the high-energy frontier
- searches for **axion-like** particle and **weakly interacting** massive or light dark matter particles
- visible European participation in **long-baseline neutrino experiments**
- strong **theory program** is essential both for strategic decisions and for the success of experiments
- development of advanced **accelerator and detector technologies** as well as **computing and software technologies**

in line with the European Strategy update approved by CERN Council in June 2020

[1] https://www.ketweb.de/stellungnahmen/e298526/KET_ESPP_Statement_2018.pdf, [2] <https://www.ketweb.de/stellungnahmen/e304947/KET-Response-final.pdf>

Preparing the Future

- **Under discussion: FCC-ee, CLIC, ILC, and FCC-hh**
 - colleagues from Germany (mainly DESY and MPI) take leading coordination roles in all studies, including the ECFA Higgs, Top & EW Factory Initiative
- **broad interest in the German community** [see talk by J. List]
 - strong expertise in many key technologies (CALICE calorimetry, silicon tracking, TPCs, ..., tools, and theory!)
 - **limited by missing resources**
 - priority on commitments in (HL-)LHC experiments
 - limited funding for (generic) detector R&D
- important next step: implementation of the **ECFA detector roadmap** [see talk by S. Kühn]
- **Future Collider Forum** ^[1]
 - German community exchange
 - 2 workshops (April and October 2021)
- for **accelerator R&D and roadmap** see talk by M. Wenskat

[1] <https://indico.desy.de/event/29446/>, <https://indico.desy.de/event/31420/>

Key Issues

- 1** **preparations for HL-LHC** need full support over the next years
[talk by U. Husemann]
- 2** **computing at HL-LHC** needs a transformation of the current model
[talk by M. Schumacher]
- 3** to fully understand the Higgs and its connections to physics beyond the standard model, we need to **pave the way to a future collider facility**
[talk by J. List]
- 4** **involvement of German groups in studies for future colliders** needs to be strengthened; substantial contributions to the implementation of the **ECFA detector and accelerator roadmaps**
[talks by J. List, S. Kühn, M. Wenskat]
- 5** strong German support for CERN enables **scientific access to the world's leading particle physics laboratory** and should fully bear fruit in CERN's technology transfer, industry contracts, and human resources
[talk by T. Behnke on ILO&TT]
- 6** keep a **good balance between large scale infrastructures and a diverse portfolio of smaller scale experiments**: new physics may hide in different places *[talk by M. Schott]*
- 7** keep improving on fostering **young talents as our most valuable resource** *[talk by V. Lang]*
- 8** **share our science and technology with society** *[talks by U. Bilow and T. Behnke]*




















Summary

- **Particle Physics is shaping our view of the world and has led to ground-breaking advances in technology.**
- **Germany has many strong groups with world-leading competences** very well integrated in the European and world-wide community.
- **COVID:** successful teleworking, but delays in lab work and supplies.
- Leading contributions to the **LHC and HL-LHC experiments** and **Belle II**, supplemented by a diverse program of **selected smaller scale experiments**.
- Particle Physics research in Germany is a **joint effort of Universities, Helmholtz Centres and Max Planck Institutes**, and **CERN**.
- **BMBF-ErUM funding** enables University groups to participate in large scale experiments. FIS funding for HL-LHC upgrades is very important. **DFG** funding is complementary and supports in particular early career researchers. Community is very grateful for strong support!
- Success of **HL-LHC Upgrades and Computing** needs continued attention and support.
- Future plans of German groups are reflected in the European Strategy for Particle Physics. **Participation in studies for future projects needs to be strengthened.**



Backup

KET Picture Book

 <p>Prof. Dr. Kerstin Borras DESY / RWTH Aachen University DPG Fachverbandsvorsitzende</p>	 <p>Prof. Dr. Allen Caldwell MPI-P Munich MPI Director</p>	 <p>Prof. Dr. Klaus Desch Bonn University CERN Council Delegate</p>	 <p>Dr. Michael Dührssen-Debling, CERN KET Member</p>	 <p>Dr. Frank Ellinghaus Wuppertal University KET Member</p>	 <p>Prof. Dr. Lutz Feld RWTH Aachen University KET Chair</p>	 <p>Prof. Dr. Christian Fischer Giessen University KHuK Representative</p>
 <p>Prof. Dr. Erika Garutti Hamburg University KET Member</p>	 <p>Prof. Dr. Beate Heinemann Hamburg DESY Director</p>	 <p>Prof. Dr. Ulrich Husemann KIT Karlsruhe GA Chair</p>	 <p>Prof. Dr. Michael Krämer RWTH Aachen University KET Member</p>	 <p>Prof. Dr. Heiko Lacker Humboldt University Berlin RECFA Representative</p>	 <p>Dr. Valerie Lang Freiburg University yHEP Chair</p>	 <p>Prof. Dr. Manfred Lindner MPI-K Heidelberg KAT Representative</p>
 <p>Dr. Jenny List DESY Hamburg KET Member</p>	 <p>Prof. Dr. Tilman Plehn Heidelberg University KET Member</p>	 <p>Prof. Markus Schumacher Freiburg University KET Deputy Chair</p>	 <p>Dr. Frank Simon MPI P Munich KET Member</p>	 <p>Dr. Marc Wenskat Hamburg University KfB Representative</p>		