Report from DESY

Joachim Mnich
PECFA Meeting
13 July 2020

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

DESY in COVID-19

On-site experiments: ALPS II, (Baby)IAXO

Mid-March: DESY was put into reduced operation

- Accelerators stopped and put in safe conditions
- Laboratory not closed but approx. 90% of people in home office

- PETRA restarted in April for some selected Corona-related research projects

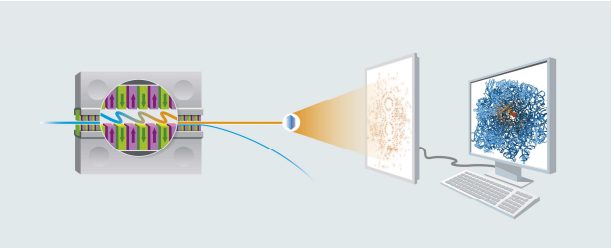
- All other projects continued at somewhat reduced pace
  e.g. ATLAS/CMS upgrades, ALPS II

Since May: all accelerators restarting again

- XFEL, PETRA, FLASH, testbeam
- Today still a large fraction of people are working in home office

Several projects to fight the pandemic:

- structural analysis of biomolecules with PETRA



- AI-based code to assess probability of prior COVID-19 exposure & recovery → likelihood of individual immunity.

- Production of face shields for local health services

- Provision of computing resources for COVID research

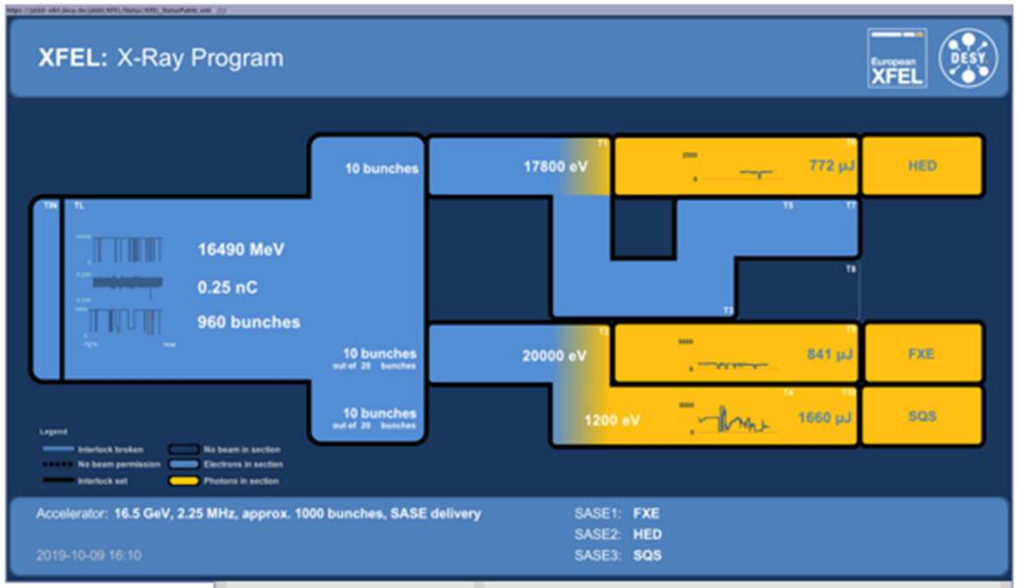
from D. Noelle

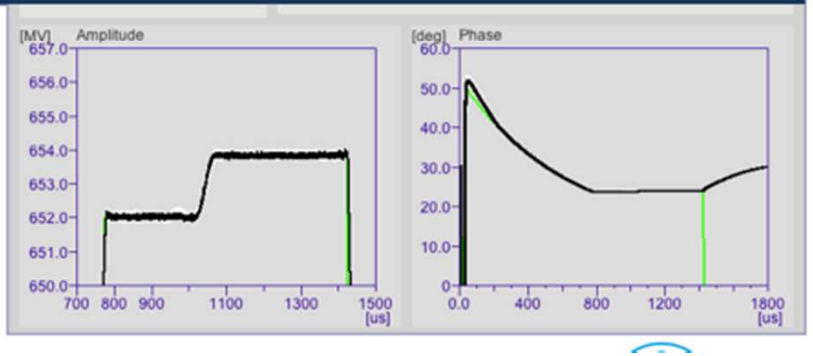
European XFEL

Accelerator has been operated about 7000 hours/year since 2017

Accelerator Operation

- Standard working point 14 GeV
- Maximum demonstrated energy 17.65 GeV
  - Maximum energy ‘out of the box’ 16.5 GeV now is a working point for user operation
- Bunch repetition 1.1 MHz, 2.25 MHz and 4.5 MHz
  - Standard rate changed to 2.25 MHz
- RF Flat-Top 550 – 600 µs
  - ~ 10% needed for feedbacks and SASE2/SASE1 transition
  - Different RF Flat tops allow for independent tuning for SASE1/3 and SASE2
  - Standard is up to 1000 bunches in the LINAC
- Very flexible bunch patterns realized with distribution system
  - Forming the bunch pattern on experiments request.
- Limits by operation constraints by D3 on average power





from D. Noelle / N. Walker

European XFEL

Status in a nutshell

Now in operation ~3 years (since 2017), parallel lasing in three FELs (SASE1,2 & 3)

Maximum electron beam energy 17.6 GeV

- Re-established / checked Feb 2020, sufficient availability margin for 16.5 GeV user operations
- SASE bunch patterns / timing very flexible

LINAC specifics

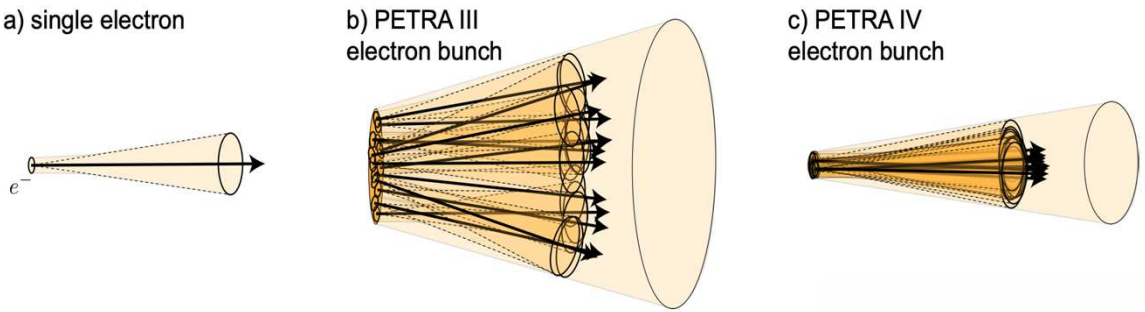
- Max average operational gradient ~23.6 MV/m (spread 15 – 30 MV/m, 22 out of 776 installed SRF cavities detuned)
- Piezo active compensation of Lorentz force (detuning) now on all cavities
  → higher operational gradients, higher availability
  → Very stable system

2020 user run suspended, but restarting again

Operation hours		**7000 h/year**
E-beam energy	**Nominal**	**14.5 GeV**
	Other	**11.5 GeV, 16.5 GeV**
SASE energy	**S1 & S2**	**5.8—20 keV**
	S3	**0.6—3 keV**
Beam pulse	**max**	**600 μs**
Machine rep rate		**10Hz**
Beam rep. rates		**1.1 / 2.25 / 4.5 MHz**
Bunch charge	**typical**	**0.25 nC**
E-beam stability	**energy**	**< 0.1%**
	transverse	**0.1 σ_{beam}**
	timing	**~25 fs**
Availability (user runs)		
	LINAC	**>90%**
	SASE	**>85%**

Future: PETRA IV

A synchrotron light source at the diffraction limit



Petra IV

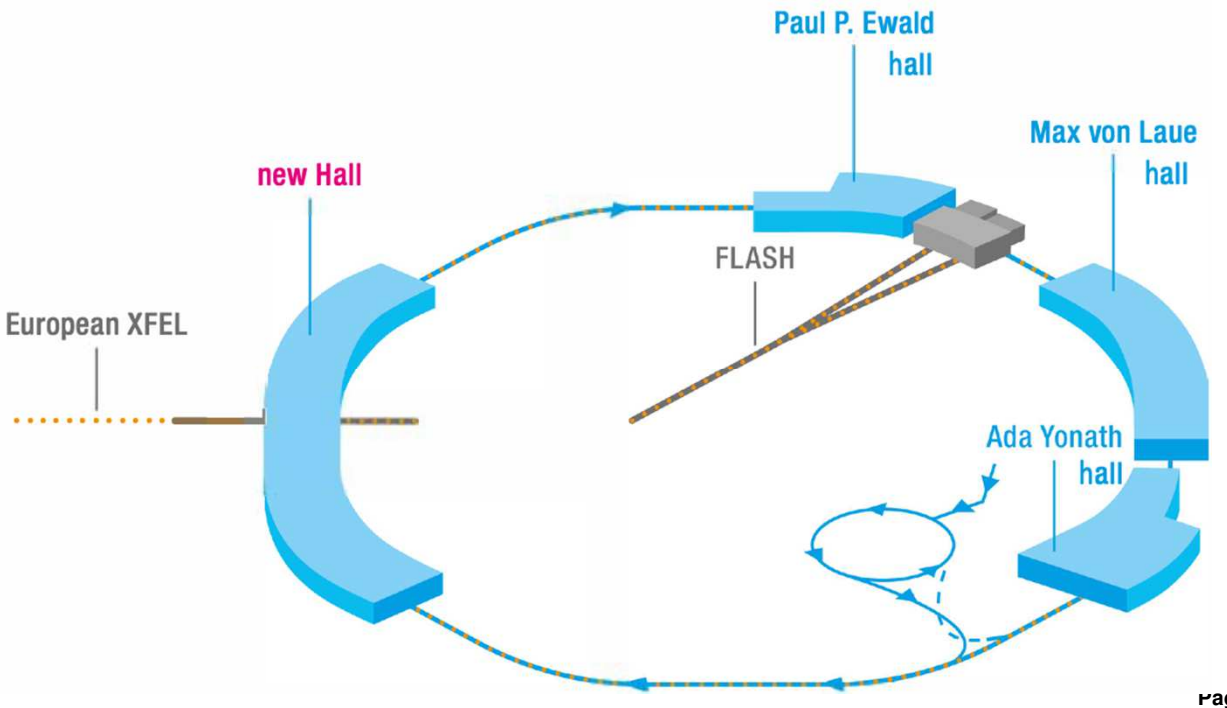
- Synchrotron light source at the diffraction limit
- Storage ring using a Hybrid 7 Bend Achromat (H7BA)
- Upgrade and build new beamlines
- New experimental hall in the west
- CDR published in 2019

New Injector chain

- DESY IV as baseline
- Impact on DESY test beam facility
- Linear Plasma injector as second injector

Current Timeline

- TDR End 2020
- 2025 End Petra III /Start of Construction
- 2027 PETRA IV Startup



KALDERA: A new class of drive lasers for Plasma Acceleration

Science applications need reproducibility and average power

Wim Leemans

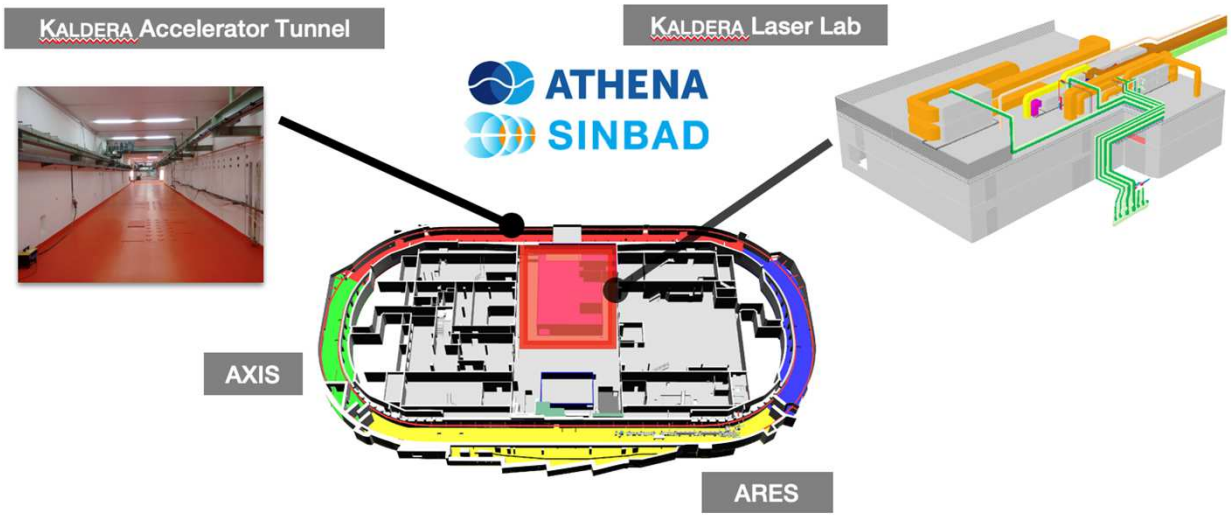
Why?
- Near term: PLASMED X, VUV FEL
- Longer term: injection into PETRA-IV

What?
- GeV-level beams at 1kHz from LP
- FEL-suitable current and energy
- Stability through active feedback
- Technology towards PETRA IV injection

How?
- KALDERA laser with kHz plasma sources

When?
- 2020-2025 phased construction

Parameter	KALDERA
Energy	>3J
Pulse duration	30 fs
Reprate	1kHz
Average power	>3kW



Helmholtz “PoF” Evaluation in January 2020

Competing for funding for PoF IV period – 2021-2027

HELMHOLTZ

RESEARCH FOR
GRAND CHALLENGES

TOPIC 1
Fundamental Particles and Forces

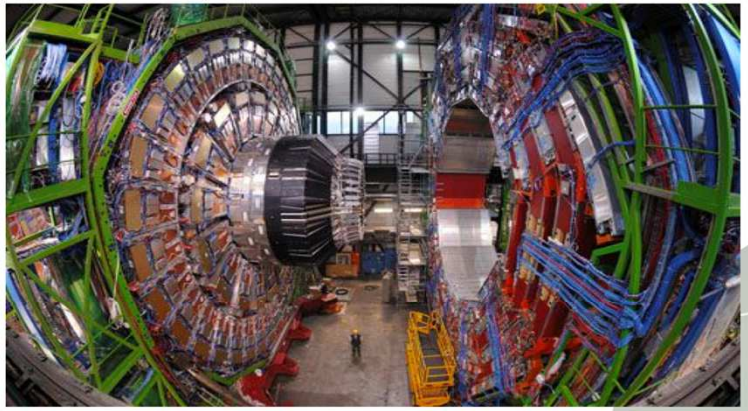
Kerstin Tackmann

DESY. JÜLICH Forschungszentrum GSI HI JENA HELMHOLTZ HIM HELMHOLTZ HZB Helmholtz Zentrum Berlin HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung IPP KIT Karlsruhe Institute of Technology

www.helmholtz.de

Our Strategy – Pillars of Our Program

LHC experiments @ CERN



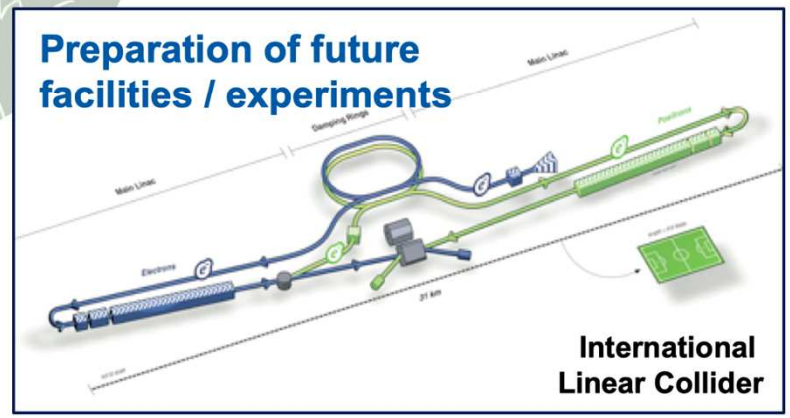
Leading contributions to global collider projects (CERN, KEK)

Belle II @ KEK (Japan)

Broad theory portfolio

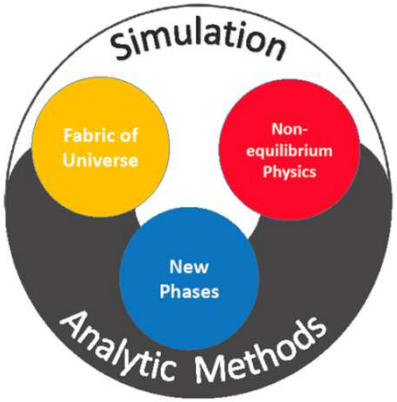
Collider Physics
Particle Cosmology
Lattice Gauge Theory
String Theory

Very positive evaluation result!



The Wolfgang Pauli Centre

Mission



White paper on the future strategy for the Wolfgang Pauli Centre for Theoretical Physics was completed (V. Schomerus, C. Grojean et al.)

5 Interdisciplinary scientific pillars:

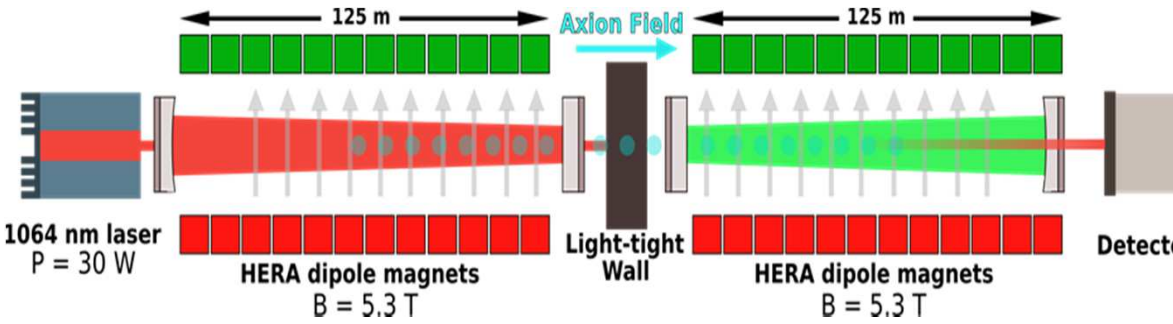
- new phases and phase transitions, non-equilibrium physics, interplay of space-time and matter [Fabric of the Universe], analytic methods, simulation & numerical methods

The WPC building:

- Approx. 170 persons from DESY theory and Hamburg University
- Open space and communication areas
- Seminar rooms
- „Research hotel“

Searches for Axions @ DESY

On-site experiments: ALPS II, (Baby)IAXO



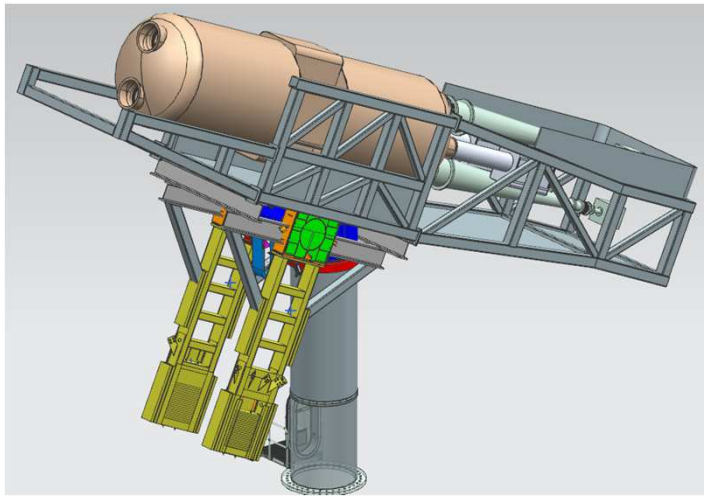
1.) ALPS II: light-shining-through-the-wall experiment
– based on 24 HERA dipoles

Relevant components:

- Magnets: 24 dipoles straightened & tested
- Laser and optics
- Detection scheme
- Infrastructure
- 2020: installation of experiment progressing well

Searches for Axions @ DESY

On-site experiments: ALPS II, (Baby)IAXO



2.) BabyIAXO – a prototype for IAXO
testing all components and probing new axion parameter space

Main components

- Magnet (CERN)
- Drive and support (DESY)
- X-ray optics (LLNL, INAF, ESA)
- Detectors (IRFU, Zaragoza, Bonn, Heidelberg)
- BabyIAXO will re-use the tower of the CTA-MST prototype (Berlin-Adlershof).

CTA prototype moved to the former ZEUS hall at HERA

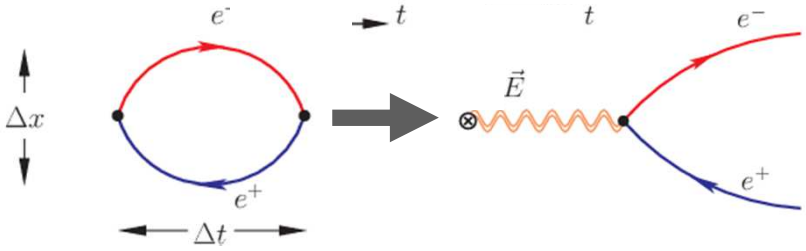
April 2020

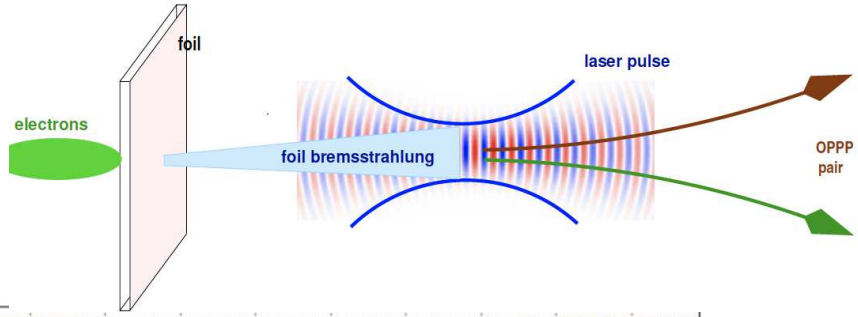
BabyIAXO could be ready for first data in 2024

LUXE

Colliding High-Energy Photons / Electrons With Intense Lasers

J. Schwinger: *On Gauge Invariance and Vacuum Polarization*, Phys. Rev. 82 (1951) 664



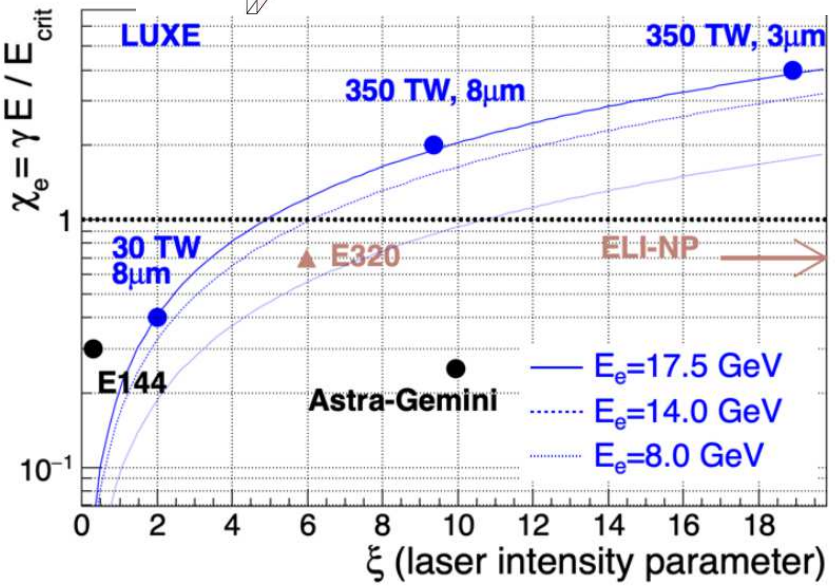


Long-standing prediction (1930s) that vacuum is unstable in background of static electric field when field approaches "critical field"

$$\varepsilon_{crit} = \frac{m_e^2 c^3}{\hbar e} \simeq 1.3 \cdot 10^{18}\ \mathrm{V/m}$$

Critical field has never been reached experimentally. Can now be reached by using high-power lasers - shown to be equivalent to static field.

Benefitting from recent advances in laser technology
Relevant to various astrophysical phenomena



DESY & EU.XFEL are uniquely suited to perform this experiment

LUXE Colliding High-Energy Photons / Electrons With Intense Lasers

International Collaboration

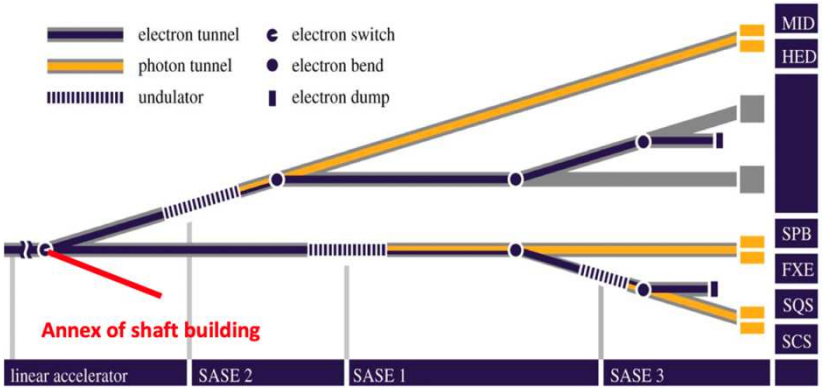
Currently 38 people with 13 institutions – and growing:

- Tel Aviv University, Tel Aviv (Israel)
- Max Planck Institute for Structure and Dynamics of Matter, Hamburg
- Deutsches Elektronen-Synchrotron (DESY), Hamburg
- Institute for Nuclear Research NASU (KINR), Kiew (Ukraine)
- Weizmann Institute of Science, Rehovot (Israel)
- Helmholtz Institut Jena, Jena
- University College London, London (UK)
- Albert-Ludwigs-Universität Freiburg, Freiburg (Germany)
- University of Plymouth, Plymouth (UK)
- Universität Hamburg, Hamburg
- Queens University Belfast, Belfast (UK)
- Friedrich Schiller Universität Jena, Jena
- AGH, Cracow (Poland)

Discussions ongoing with
Marseille, Orsay und Saclay (France), Gothenburg (Sweden),
Skoltech (Russia), Padova (Italy)

Preparing CDR by the end of the year

- **Will include initial (low-cost) and ultimate design**



Towards a global strategy for particle physics

Every three years, the International Committee for Future Accelerators (ICFA) organises a seminar on "Future Perspectives in High Energy Physics". This is a four-day international exchange of information concentrating on plans for future facilities in the field of particle physics. This by-invitation-only meeting has 250 participants, including directors of most of the world's major laboratories in our field, senior particle and accelerator physicists, and government science officials from several countries.

ICFA has chosen to have the next seminar, to be held from 4-7 October 2021 in Berlin, Germany. The focus of the seminar will be on the global future of accelerator-based particle physics.

The 13th ICFA Seminar on Future Perspectives in High -Energy Physics is organised by the Deutsches Elektronen-Synchrotron DESY.

ICFA Seminar 2020: location defined!

The 13th ICFA Seminar will take place at the "Berlin-Brandenburgische Akademie der Wissenschaften" in downtown Berlin, Germany.

berlin-brandenburgische
AKADEMIE DER WISSENSCHAFTEN

Contact address

In case of questions concerning the ICFA seminar, don't hesitate to contact the organisers.

Thank you!

ALPS installation movie:

20200709_141224.mp4

Contact

DESY. Deutsches Elektronen-Synchrotron

Joachim Mnich
DESY Director for Particle Physics

www.desy.de

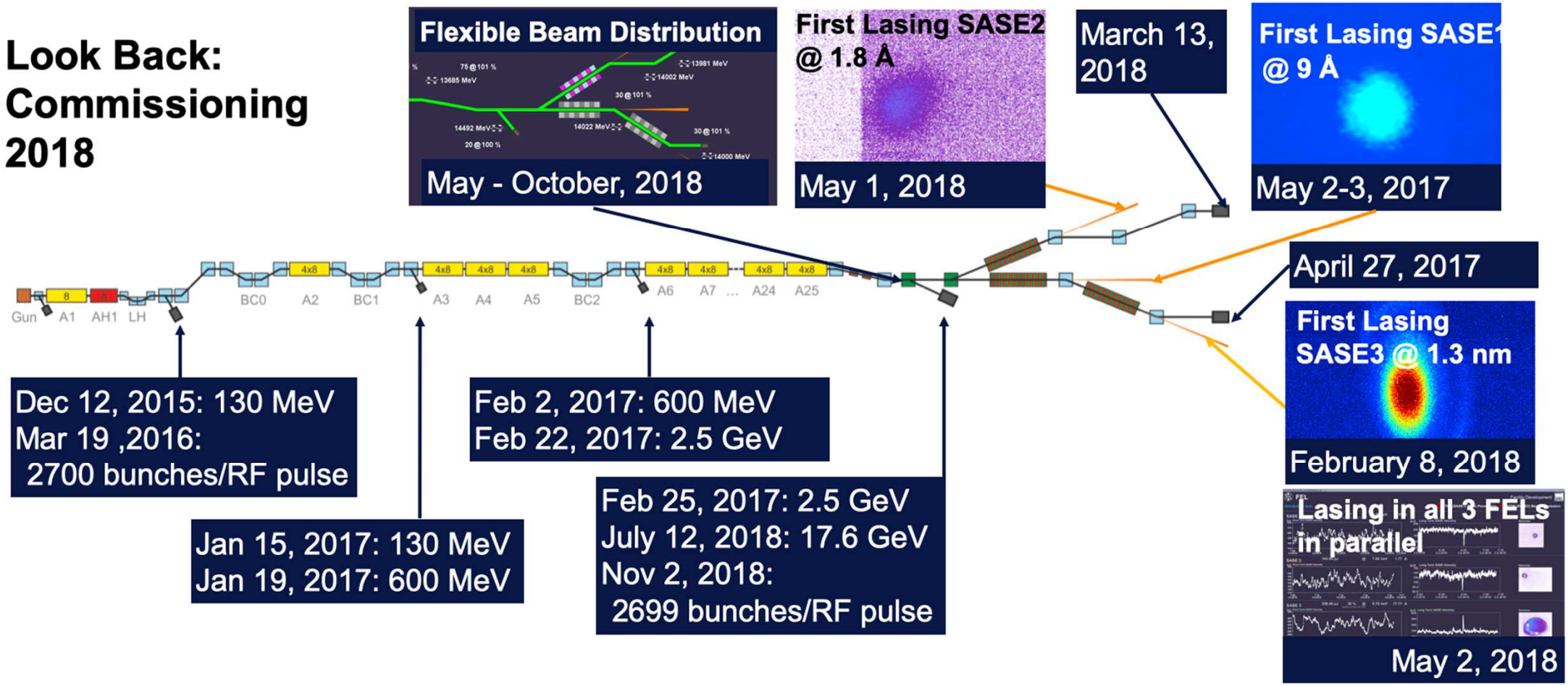
Joachim.Mnich@desy.de
(+49) 040 8998 1921 / 3023

Backup

from D. Noelle

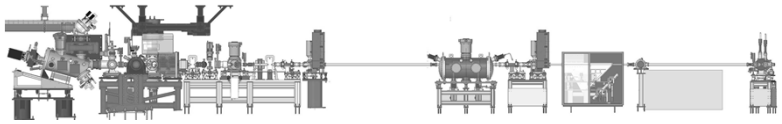
European XFEL

Timeline



Powering an FEL, Injection into state-of-the-art storage ring, novel endstation modalities, medical applications are DESY goals for advanced accelerator builders

Stable, reliable generation of high quality beams to ensure machine availability



2019

Demo-FEL (LUX) operational

- Demonstrate that LPAs can power FEL
- Long term runs (week or more)

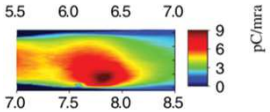
2021

Simulation studies for PETRA-IV injection

- Injection energy, bunch length, charge,....

Laser plasma accelerators

- Up to 8 GeV
- Dechirper, plasma lenses, low emittance
- 29 hr stability run (Maier et al.)



2023

2025-2027

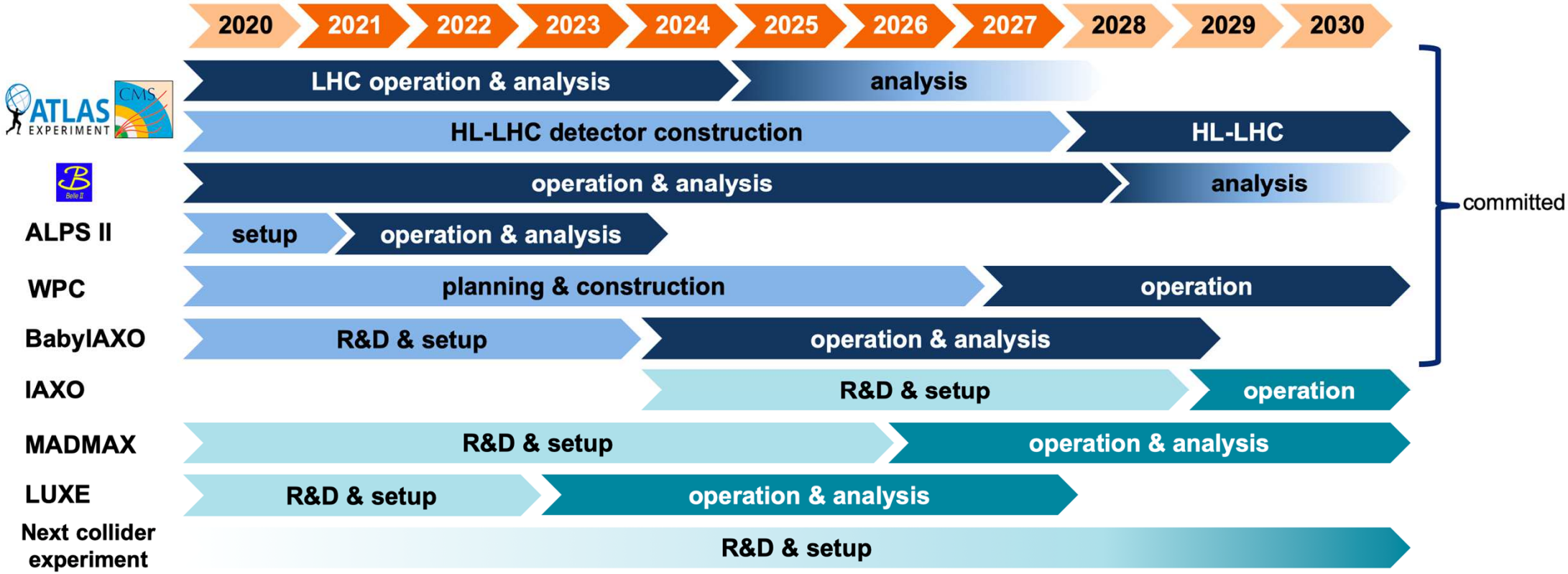
2nd Injection system development for PETRA-IV: LPA based

KALDERA operational

- Multi-kW laser
- kHz operation of LPA
- Feedback control
- Long term stability runs

Also: medical initiatives with PLASMAD-X, radiation biology using REGAE/ARES/PITZ and international collaborators

Timeline of Planning



Result of the Evaluation

We are rated as outstanding

Recommendations

- The strong leadership position of Helmholtz in Fundamental Particles and Forces should be fully supported.
- Flexibility to be able to respond to future strategic directions in the field should be retained.

Rating:

Goals	Work Program	Competences and Resources	Impact and Risks
Outstanding	Outstanding	Outstanding	Outstanding

The WPC

The White Paper

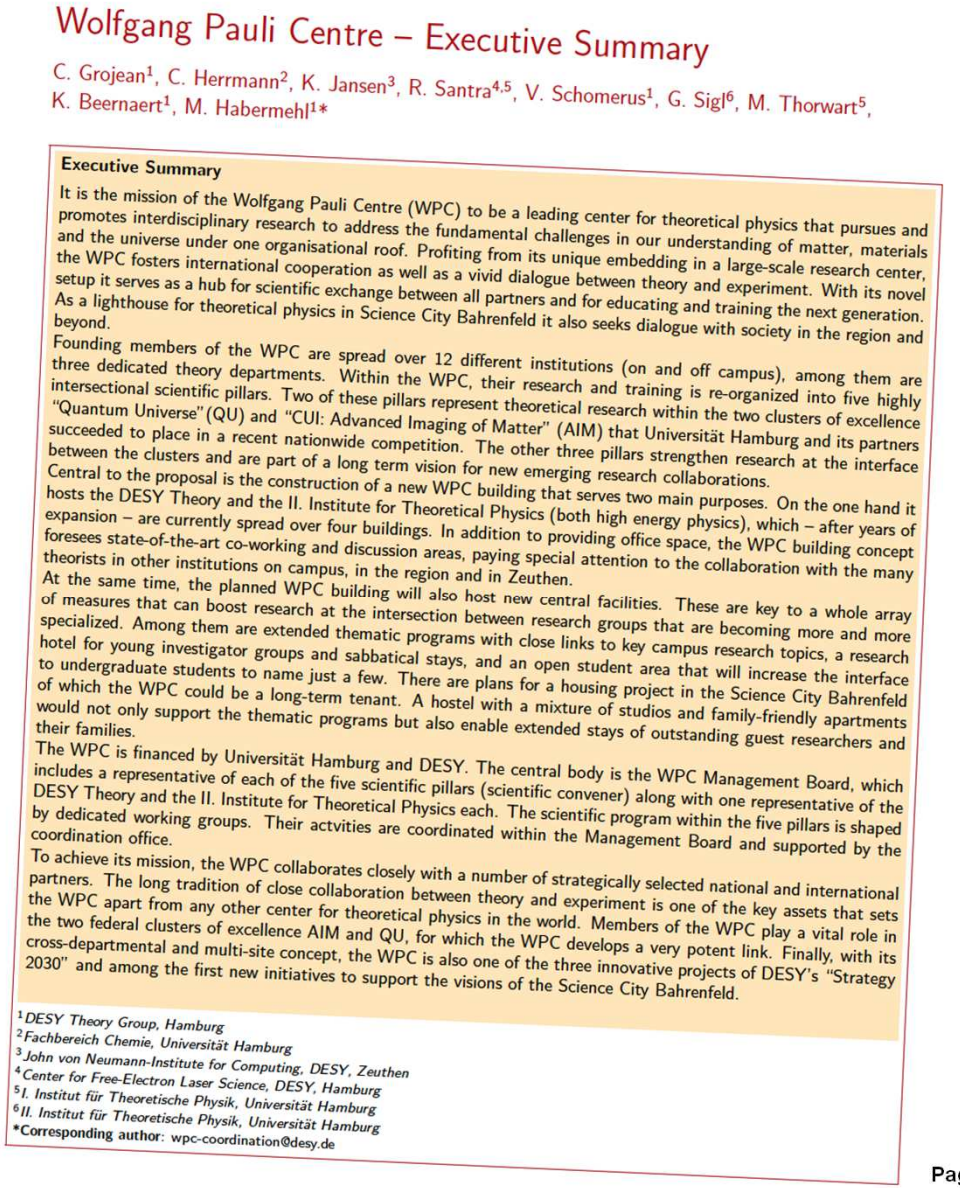
White paper on the future strategy for the Wolfgang Pauli Centre for Theoretical Physics was completed (V. Schomerus, C. Grojean et al.)

5 Interdisciplinary scientific pillars:

- new phases and phase transitions, non-equilibrium physics, interplay of space-time and matter [Fabric of the Universe], analytic methods, simulation & numerical methods

Significant movement in the last year:

- DESY campus development determined construction costs of 20 Mio Euros.
- Financing model based on split 60/40 DESY/UHH agreed by DESY/UHH/BWFG.
- Contracts between DESY and UHH to be drafted in 2020
- International panel of theorists invited to review the strategy paper.



Wolfgang Pauli Centre – Executive Summary

C. Grojean[1], C. Herrmann[2], K. Jansen[3], R. Santra[4,5], V. Schomerus[1], G. Sigl[6], M. Thorwart[5], K. Beernaert[1], M. Habermehl[1]*

Executive Summary

It is the mission of the Wolfgang Pauli Centre (WPC) to be a leading center for theoretical physics that pursues and promotes interdisciplinary research to address the fundamental challenges in our understanding of matter, materials and the universe under one organisational roof. Profiting from its unique embedding in a large-scale research center, the WPC fosters international cooperation as well as a vivid dialogue between theory and experiment. With its novel setup it serves as a hub for scientific exchange between all partners and for educating and training the next generation. As a lighthouse for theoretical physics in Science City Bahrenfeld it also seeks dialogue with society in the region and beyond.

Founding members of the WPC are spread over 12 different institutions (on and off campus), among them are three dedicated theory departments. Within the WPC, their research and training is re-organized into five highly intersectional scientific pillars. Two of these pillars represent theoretical research within the two clusters of excellence "Quantum Universe" (QU) and "CUI: Advanced Imaging of Matter" (AIM) that Universität Hamburg and its partners succeeded to place in a recent nationwide competition. The other three pillars strengthen research at the interface between the clusters and are part of a long term vision for new emerging research collaborations.

Central to the proposal is the construction of a new WPC building that serves two main purposes. On the one hand it hosts the DESY Theory and the II. Institute for Theoretical Physics (both high energy physics), which – after years of expansion – are currently spread over four buildings. In addition to providing office space, the WPC building concept foresees state-of-the-art co-working and discussion areas, paying special attention to the collaboration with the many theorists in other institutions on campus, in the region and in Zeuthen.

At the same time, the planned WPC building will also host new central facilities. These are key to a whole array of measures that can boost research at the intersection between research groups that are becoming more and more specialized. Among them are extended thematic programs with close links to key campus research topics, a research hotel for young investigator groups and sabbatical stays, and an open student area that will increase the interface to undergraduate students to name just a few. There are plans for a housing project in the Science City Bahrenfeld of which the WPC could be a long-term tenant. A hostel with a mixture of studios and family-friendly apartments would not only support the thematic programs but also enable extended stays of outstanding guest researchers and their families.

The WPC is financed by Universität Hamburg and DESY. The central body is the WPC Management Board, which includes a representative of each of the five scientific pillars (scientific convener) along with one representative of the DESY Theory and the II. Institute for Theoretical Physics each. The scientific program within the five pillars is shaped by dedicated working groups. Their actvities are coordinated within the Management Board and supported by the coordination office.

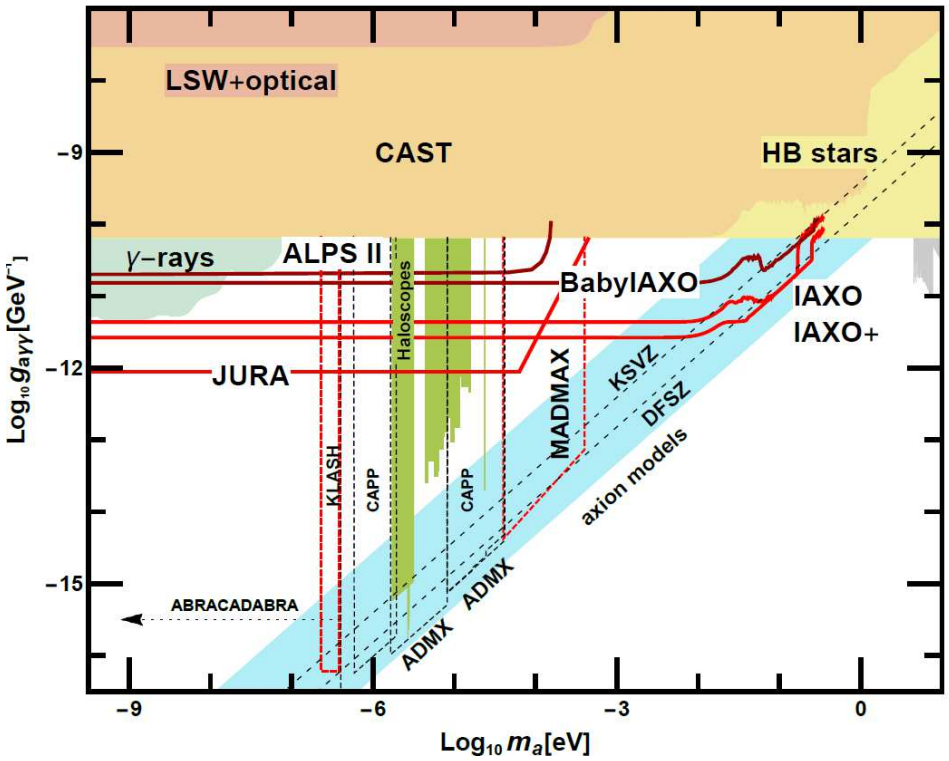
To achieve its mission, the WPC collaborates closely with a number of strategically selected national and international partners. The long tradition of close collaboration between theory and experiment is one of the key assets that sets the WPC apart from any other center for theoretical physics in the world. Members of the WPC play a vital role in the two federal clusters of excellence AIM and QU, for which the WPC develops a very potent link. Finally, with its cross-departmental and multi-site concept, the WPC is also one of the three innovative projects of DESY's "Strategy 2030" and among the first new initiatives to support the visions of the Science City Bahrenfeld.

[1] DESY Theory Group, Hamburg
[2] Fachbereich Chemie, Universität Hamburg
[3] John von Neumann-Institute for Computing, DESY, Zeuthen
[4] Center for Free-Electron Laser Science, DESY, Hamburg
[5] I. Institut für Theoretische Physik, Universität Hamburg
[6] II. Institut für Theoretische Physik, Universität Hamburg
*Corresponding author: wpc-coordination@desy.de

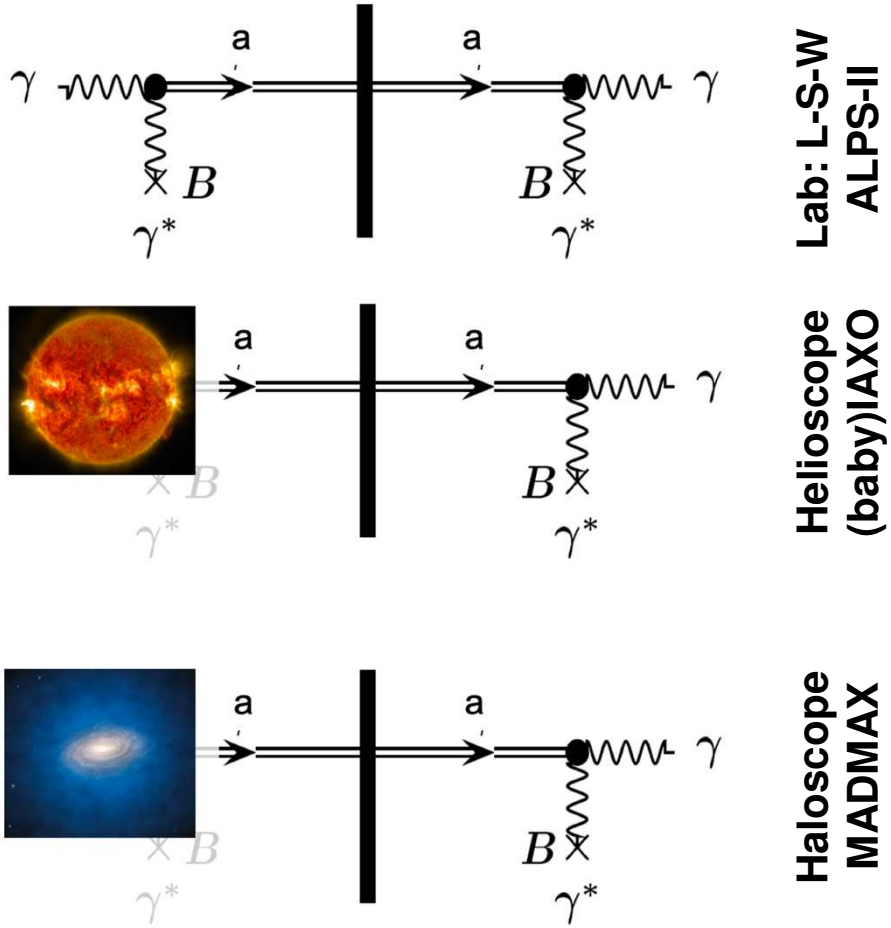
Axion Physics at DESY

Developing a new focal activity

Huge phase space for axions / ALPs with different motivations



Three detection approaches:



DESY involved in all three.