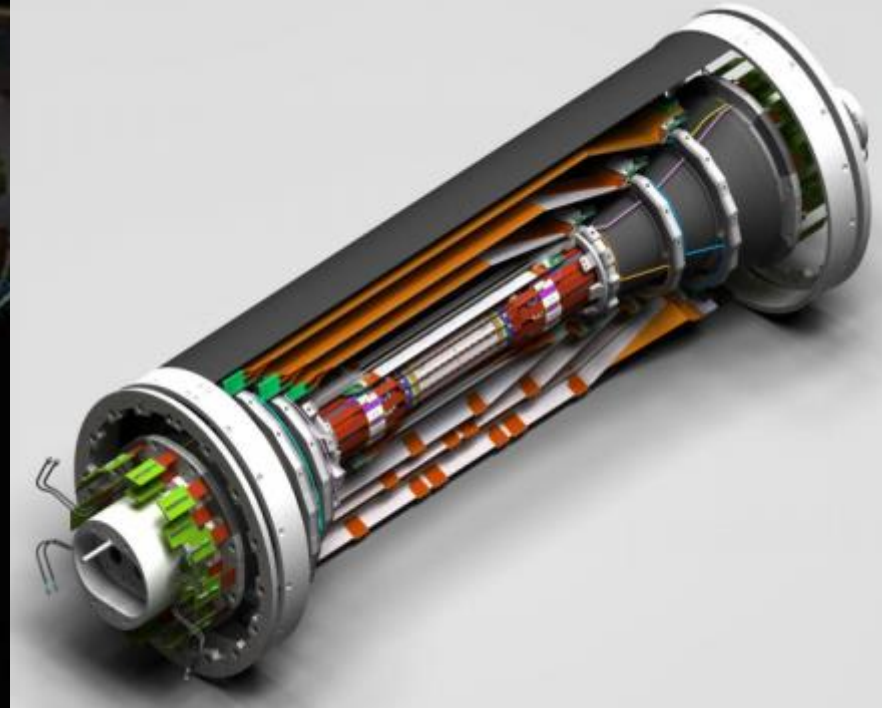
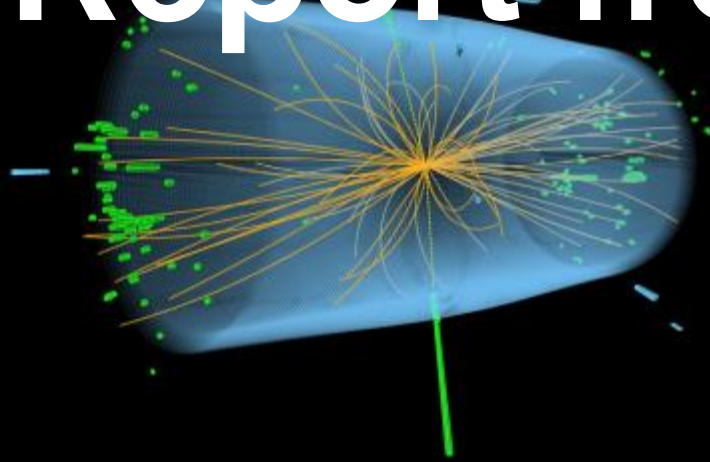
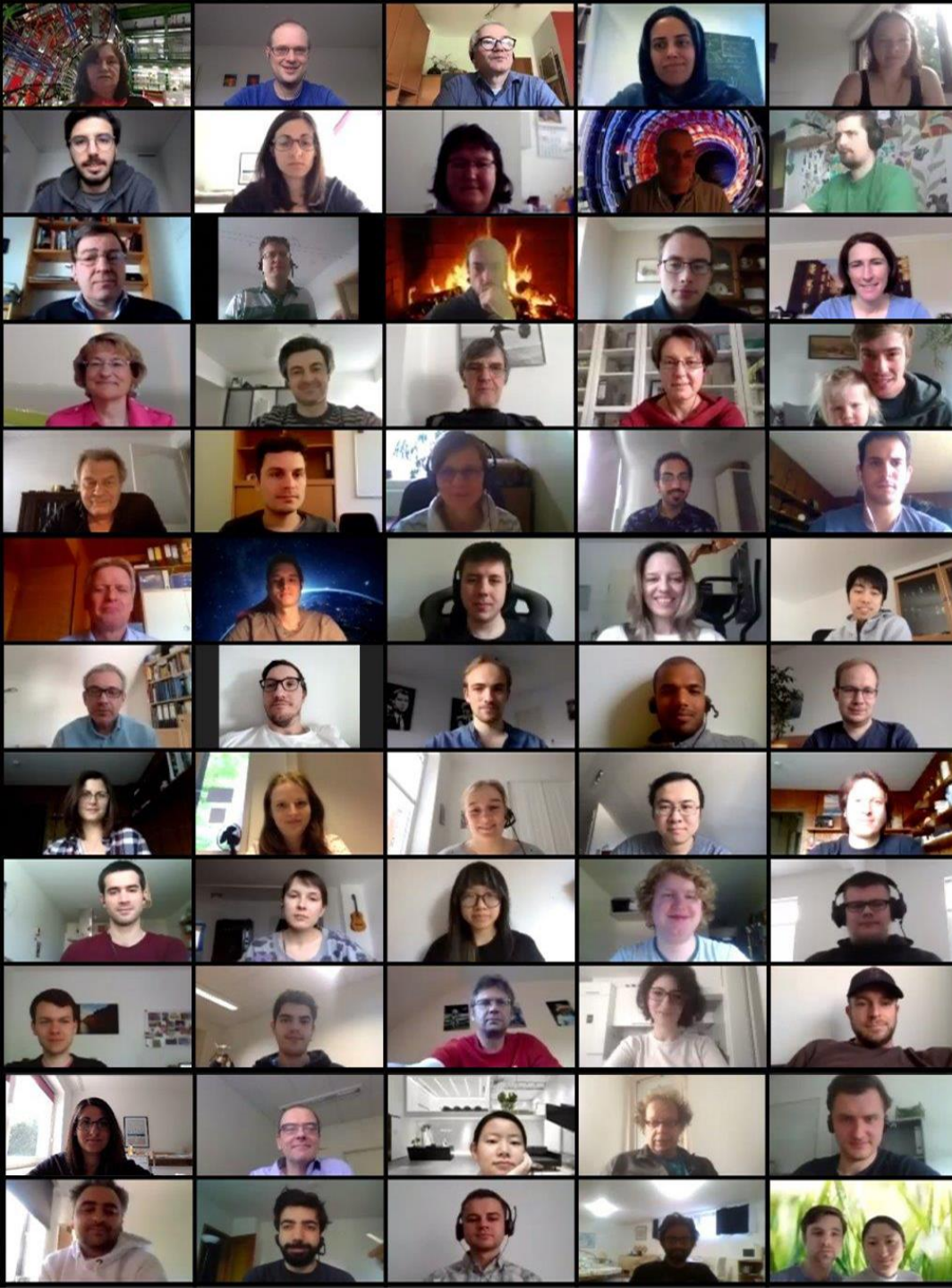


# Report from DESY



Joachim Mnich (DESY)  
Plenary ECFA Meeting  
20 November 2020



- **DESY colleagues coping well with the Covid-19 crisis**
- **The laboratory is operational under strict safety measures and at somewhat reduced pace**
- **Accelerators run, work on detectors going on, workshops open, etc.**
- **A few examples below**



# European XFEL Status

*In operation since 2017, service to experiments at all 6 photon beam lines since beginning of 2019*

**Superconducting linac operation matured, all design parameters achieved**

Maximum energy 17.5 GeV

27000 electron bunches/second in 10 Hz burst mode

Very flexible beam distribution into 3 beamlines with up to 4.5 MHz switching frequency and arbitrary bunch patterns

**Three FELs in parallel operation ( 6 experiments in 12 h shifts)**

Soft X-Ray (SASE 3) : 0.6 – 2.8 keV, up to 10 mJ/photon pulse

Hard X-Ray (SASE1/2): 6 – 14 keV, up to 4 mJ/photon pulse

30 keV demonstrated

**About 6500 hours yearly linac operation**, about 4000 (x3) hours of scheduled photon delivery for experiment commissioning, in-house research, and user service

**COVID-19 caused ‘deep’ shut-down of about 8 weeks**

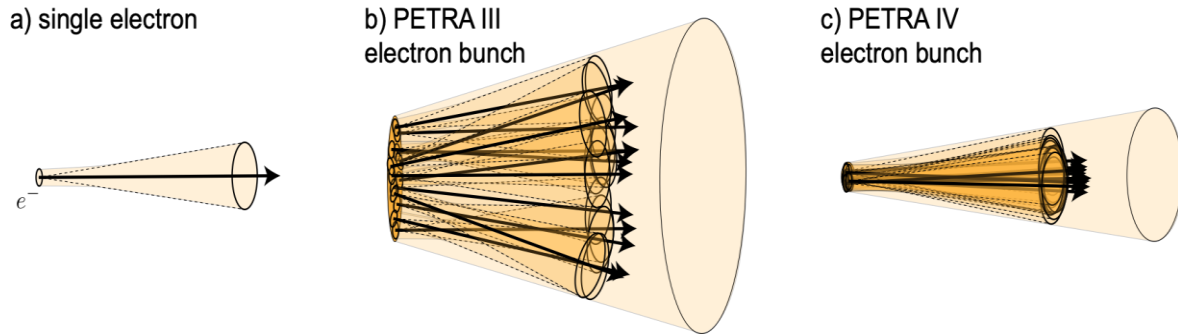
Extended start-up afterwards, back to safe routine operation since summer shut-down 2020



# Future: PETRA IV TDR Underway

*Aiming at project completion beginning of 2027*

- Synchrotron light source at the diffraction limit
- Upgrade and build new beamlines
- New experimental hall in the west
- CDR published in 2019, TDR underway

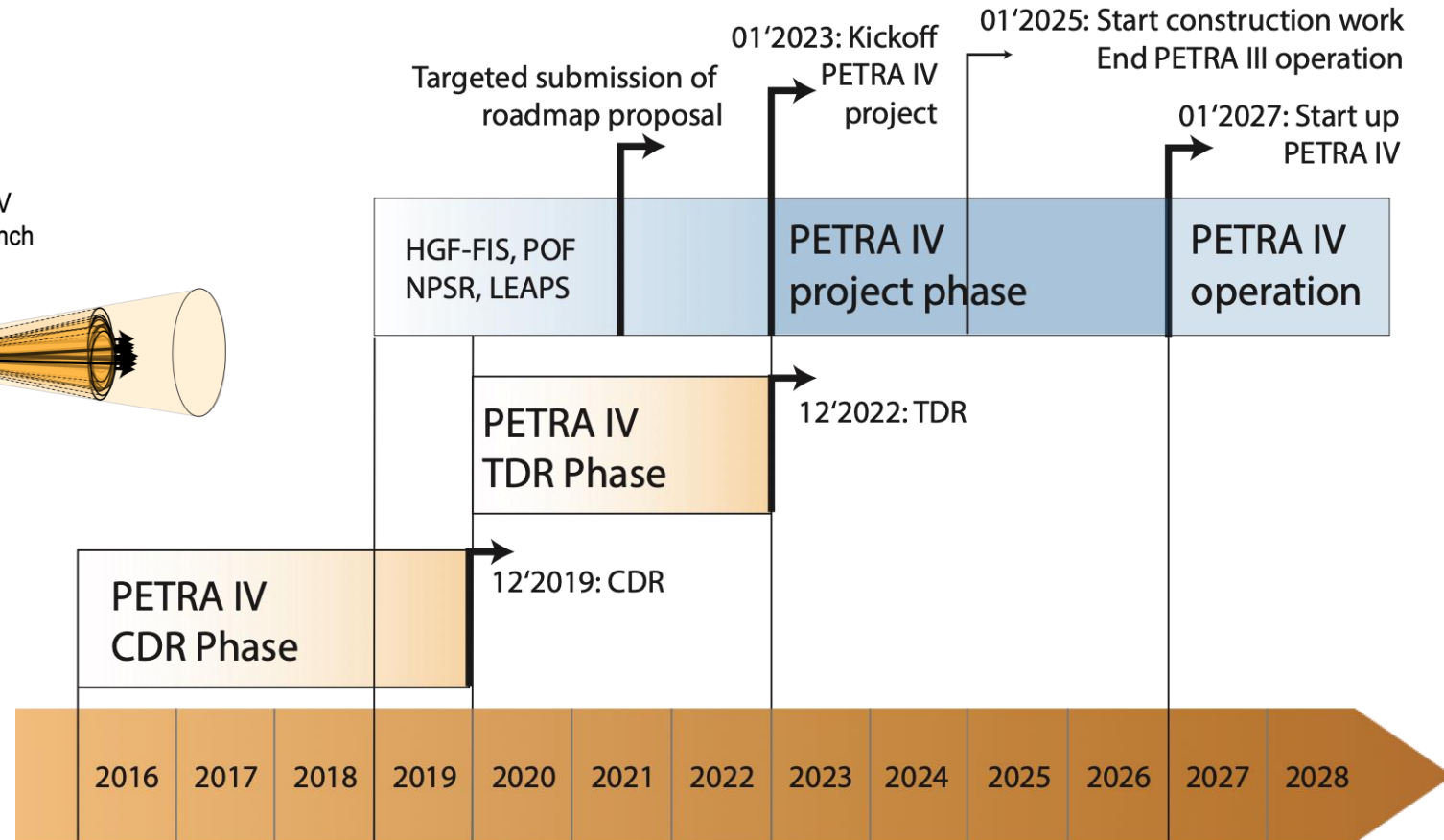


## New Injector chain

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

## Current Timeline

- TDR End 2022
- 2025 End Petra III /Start of Construction
- 2027 PETRA IV Startup



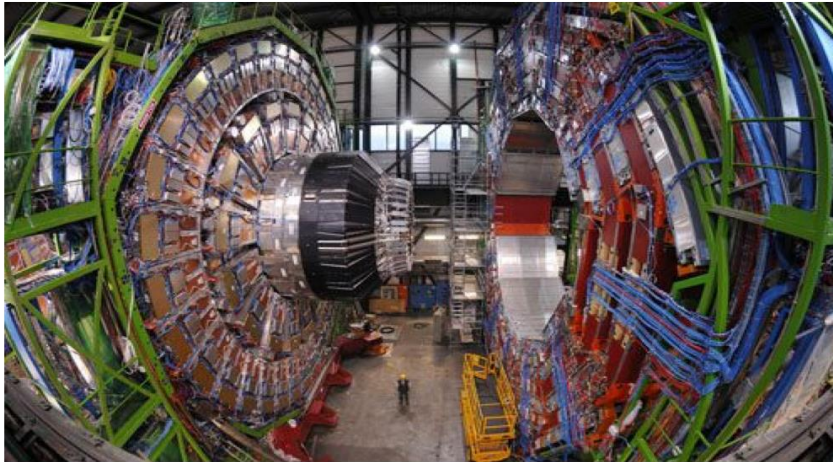


# DESY Particle Physics Strategy

Very successful Helmholtz review in January 2020

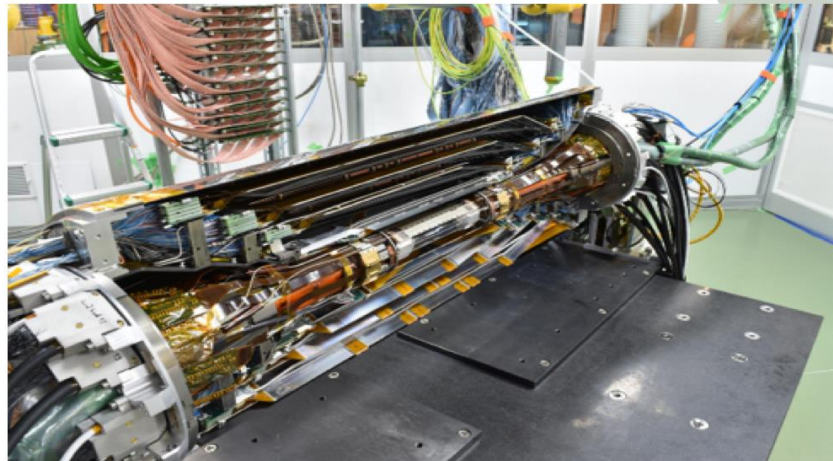
In line with the updated European Strategy

LHC experiments @ CERN



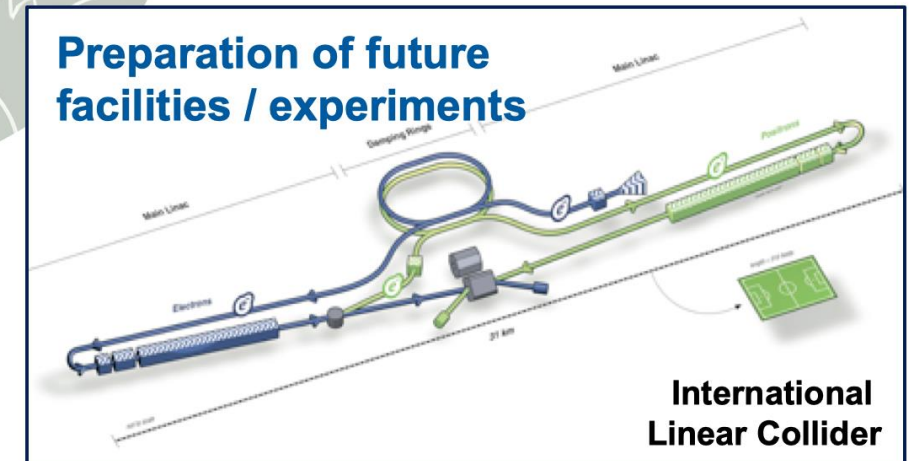
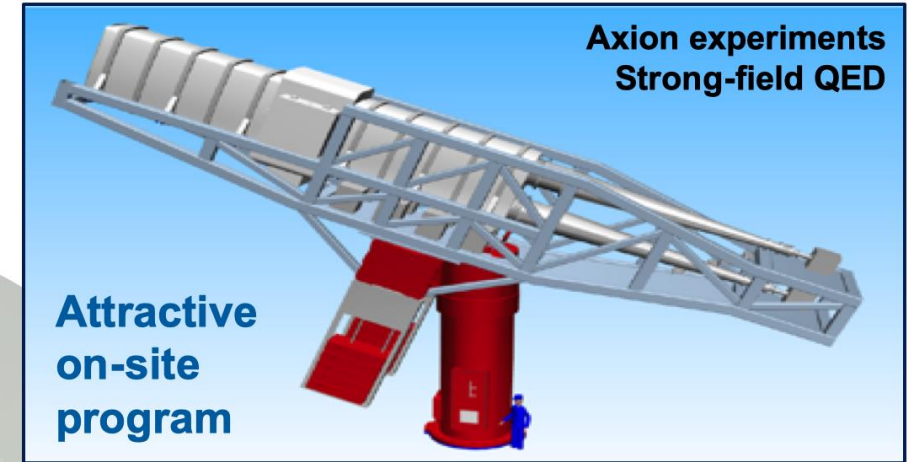
Leading contributions to global collider projects (CERN, KEK)

Belle II @ KEK (Japan)



Broad theory portfolio

Collider Physics  
Particle Cosmology  
Lattice Gauge Theory  
String Theory

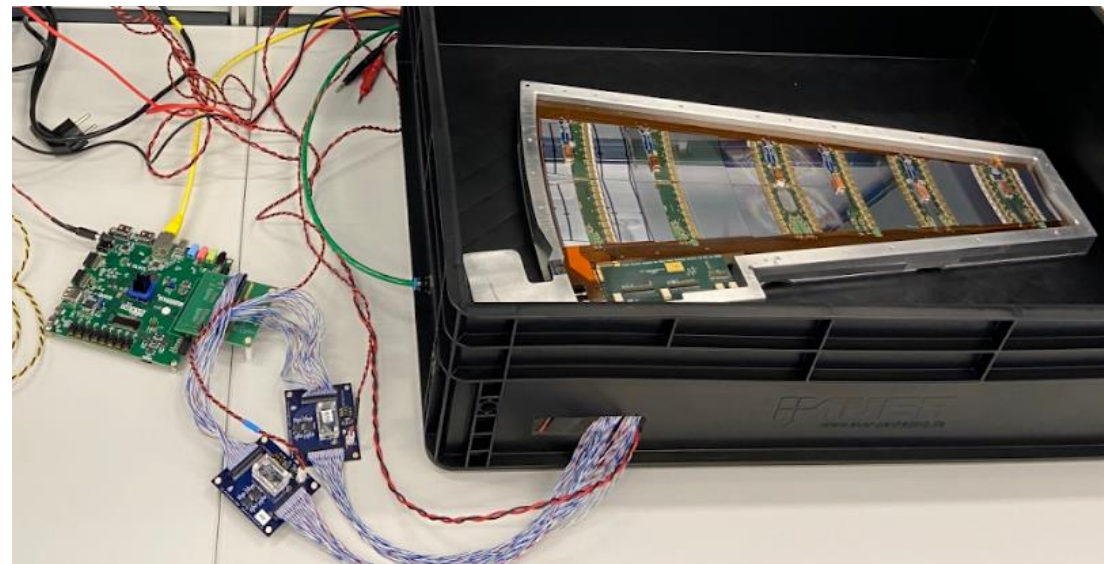


# ATLAS High-Lumi Upgrade

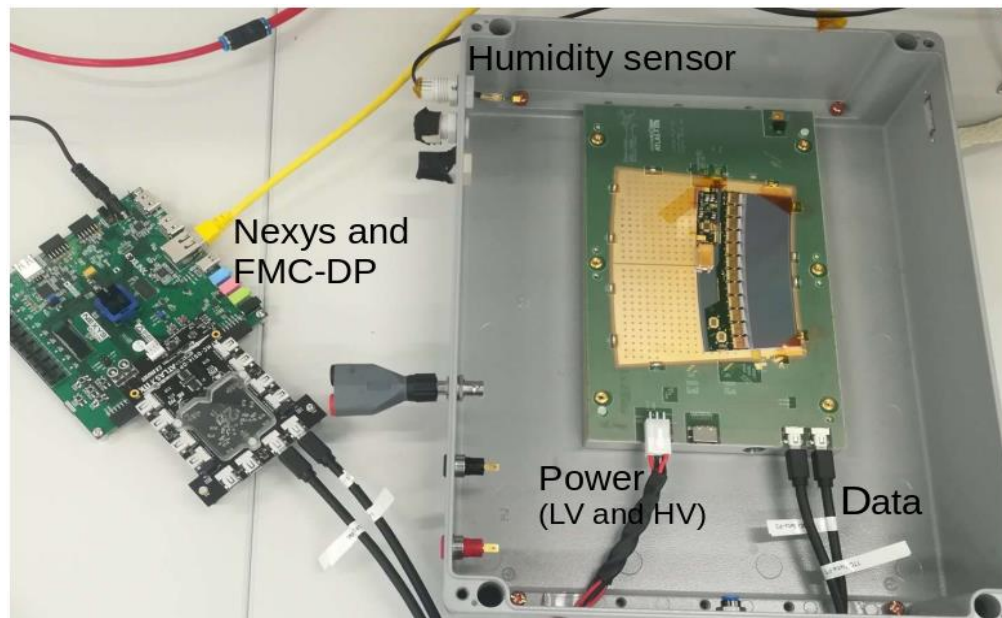
*Important steps towards final modules*

**Full petal side with strip modules built (partially with dummy sensors)**

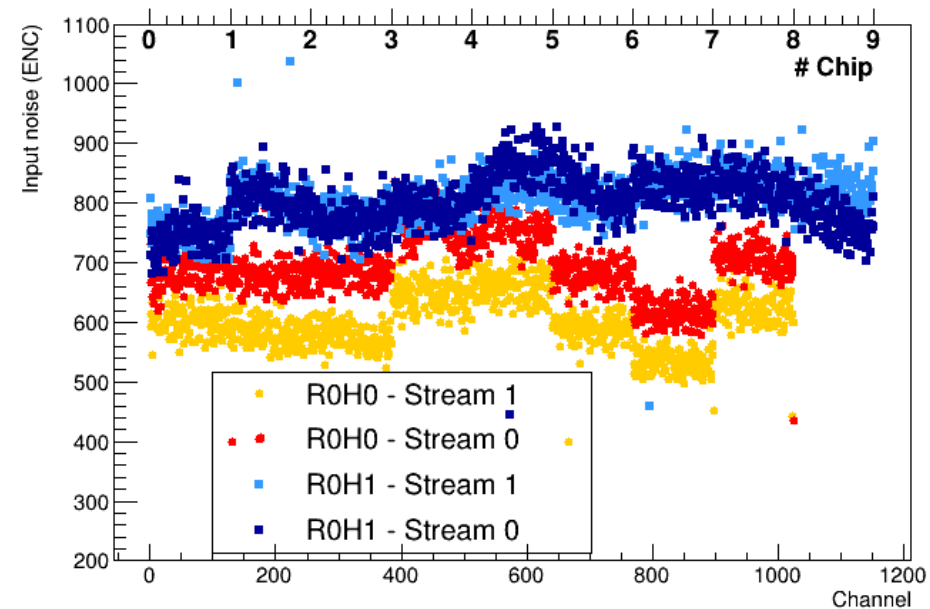
- Successful simultaneously communication with all modules
- Measured noise for all the modules within specifications
- First module with final chip-set built at DESY



Full petal with all module types (prototype readout chip)



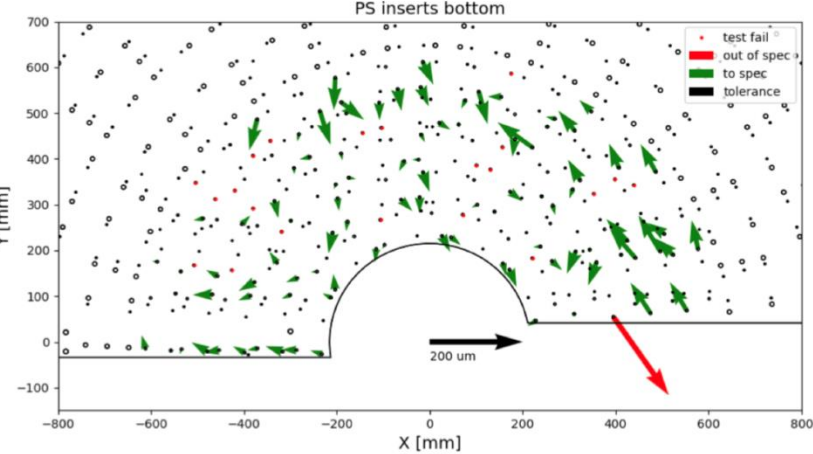
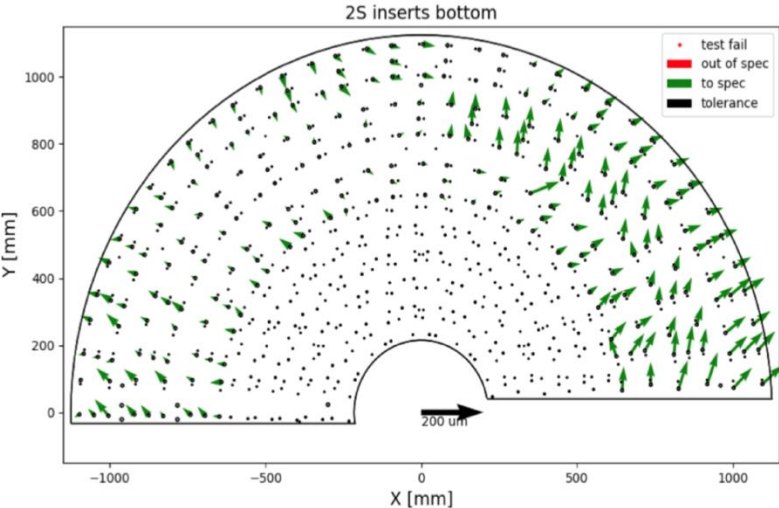
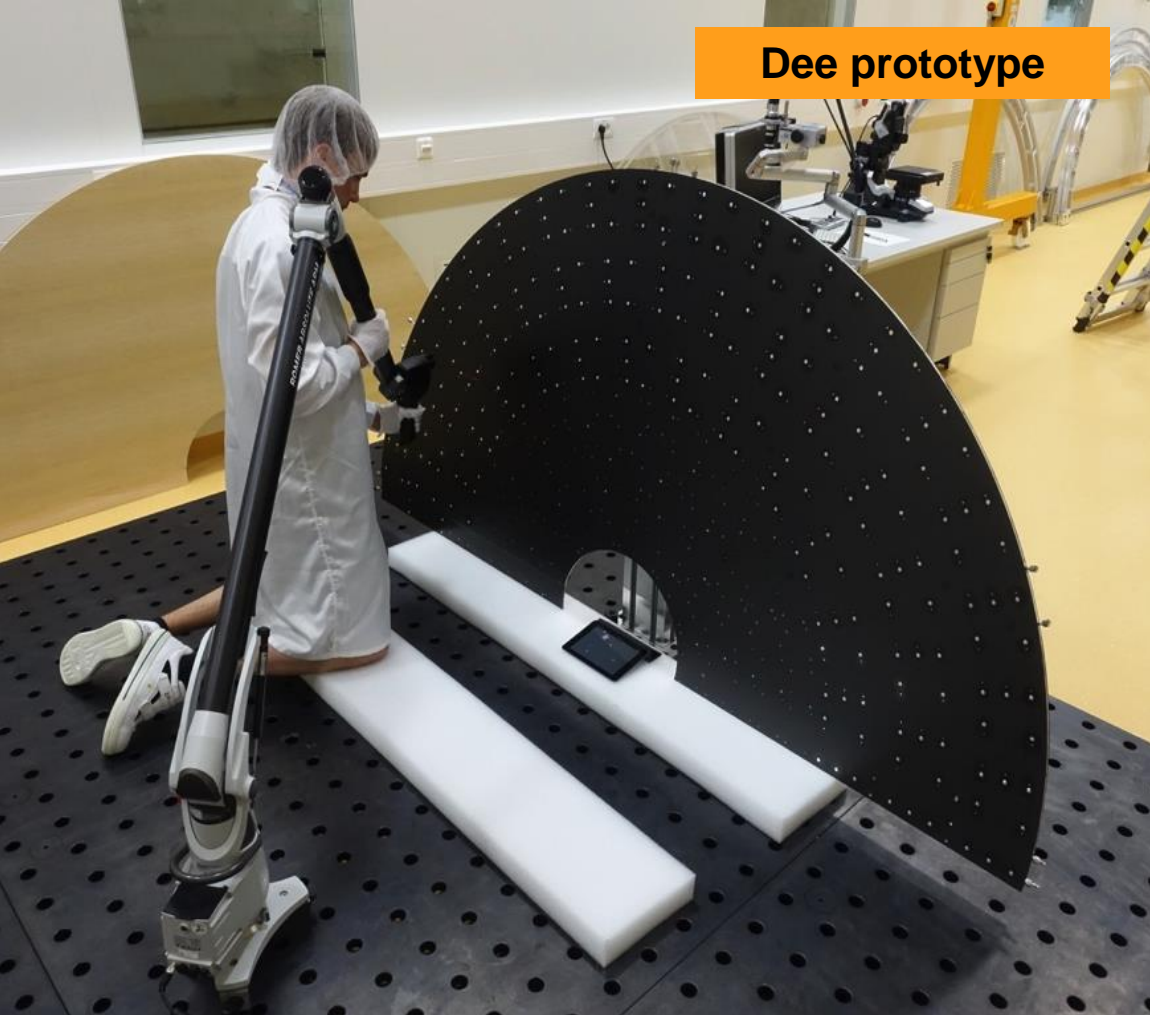
End-cap strip module with final chip-set





# Dee Prototype for Tracker Upgrade

Full activity in DAF in 2020, despite Covid-19 pandemic



Metrology of Dee: Inserts are mostly positioned within 200 µm tolerance (green arrows); only one outlier (red arrow)

# CMS HGICAL @ DESY

## Endcap Calorimeter Upgrade for LHC Phase 2

### SiPM-on-Tile technology where radiation levels permit

- common r/o ASIC for Si and SiPM: HGCROC
- **spin-off from CALICE**

### Development of tile modules

- active elements with ASIC, DCDC, SiPMs, scintillator

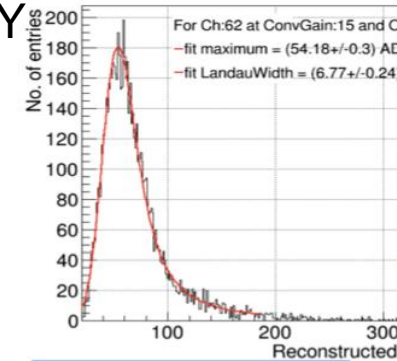
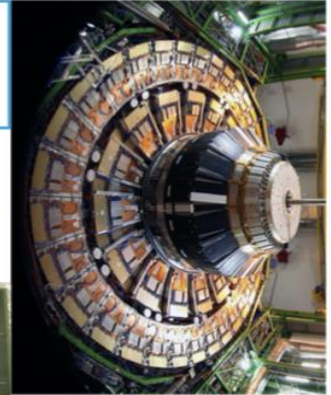
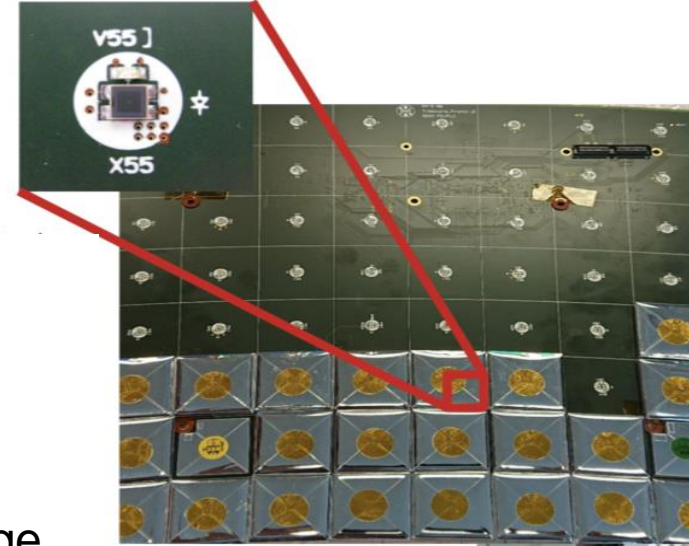
### Tile module prototype in the DESY Testbeam

- custom SiPMs from Hamamatsu in thermally conductive package
- injection-moulded tiles from Russia, automatically wrapped at DESY
- first particle signals with HGCROC

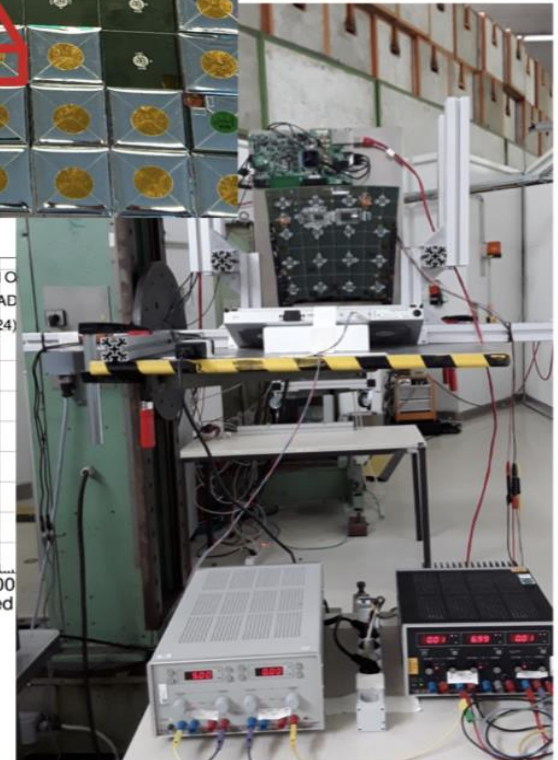
### Development of production procedures

- reflector foil handling, tile wrapping, module assembly
- following successful applications for Russian funds, prepare for tile module assembly at DESY with Russian groups
- preparations at DESY on-going

2 mm<sup>2</sup> SiPM  
with white reflection area  
for better light coverage



MIP spectrum





# Axion Experiments @ DESY

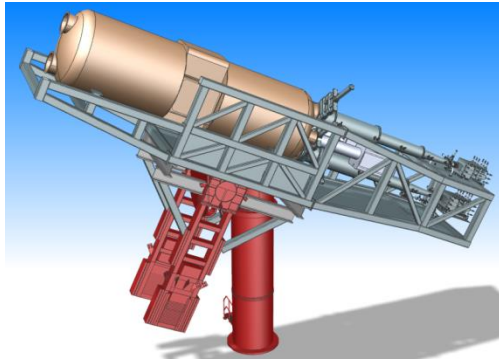
Purely with ALPS II, solar with BabyIAXO, or galactic with (i)MADMAX



## ALPS II (shining light-through-a-wall)

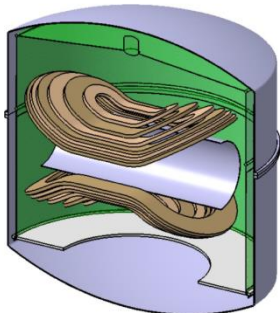
24 modified superconducting dipoles from the former HERA proton accelerator installed in a straight section of the HERA tunnel.

Commissioning of high finesse long baseline optical cavities will start early 2021.  
First data run in autumn 2021.



## BabyIAXO (solar axions)

Ready to start construction, different options for sites at DESY.  
Funding nearly secured, MoUs under preparation.  
Expect to start data taking in 2025.



## (i)MADMAX

Would be located in the iron yoke of the former HERA experiment H1.  
Decided to go for an intermediate stage iMADMAX first.

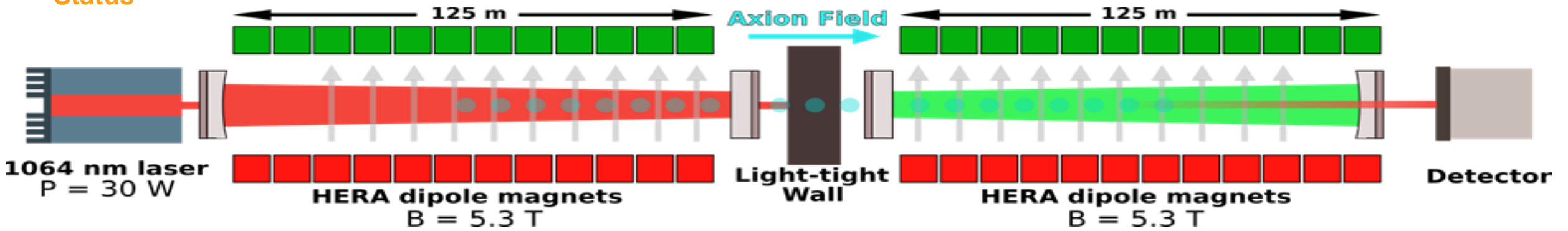
# ALPS II: Last Magnet (of 24) at HERA-North





# ALPS II

Status



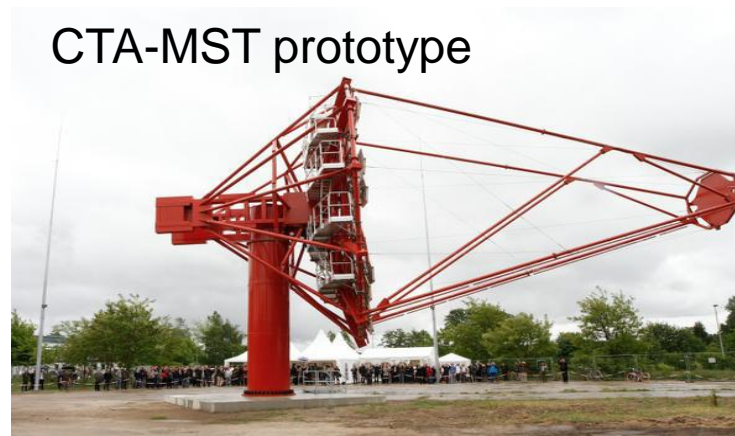
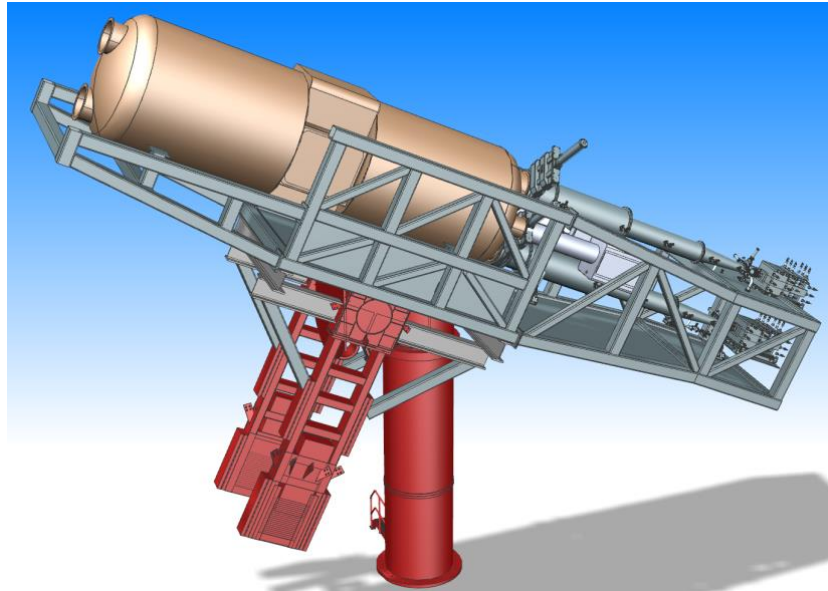
## ALPS II schedule:

March 2021: close vacuum system, start of optics commissioning

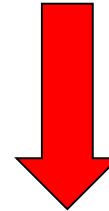
October 2021: dipoles ready for operation, start of axion search

# International Axion Observatory

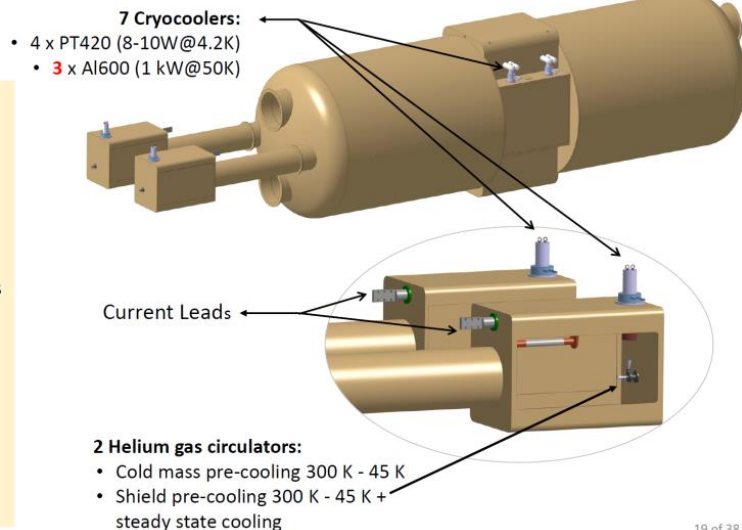
Towards BabyIAXO



CTA-MST prototype



BabyIAXO support



19 of 38

## BabyIAXO figure of merit:

$$(\text{field-strength} \cdot \text{length})^2 \cdot \text{aperture} \approx 242 \text{ T}^2\text{m}^4 \approx 0.1 \cdot \text{IAXO} \approx 10 \cdot \text{CAST}$$

## Status:

- R&D and design well advanced
- Ready to start purchase of long-lead items.
- DESY funding secured.
- Positive discussion with CERN on design & construction of the magnet (draft MoU).
- Site at DESY still unclear due to PETRA IV preparation planning.

**BabyIAXO data taking could start 2024/25**

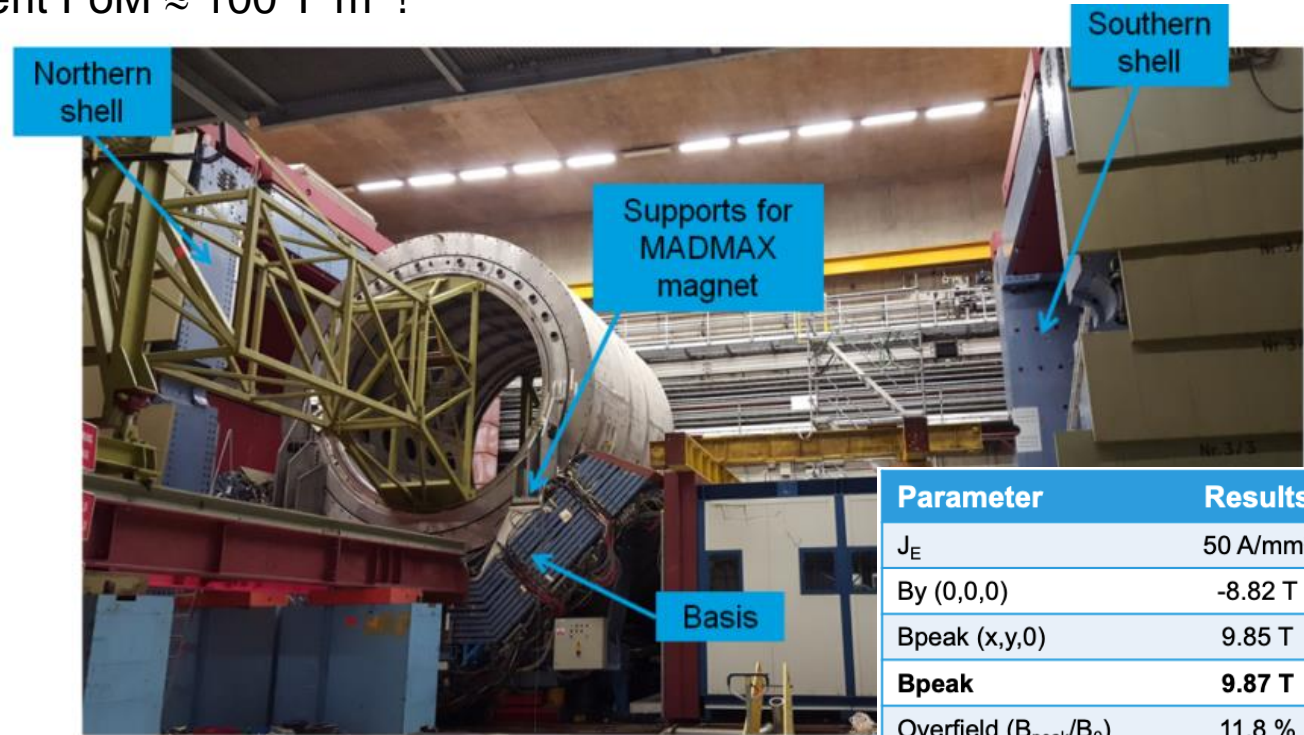
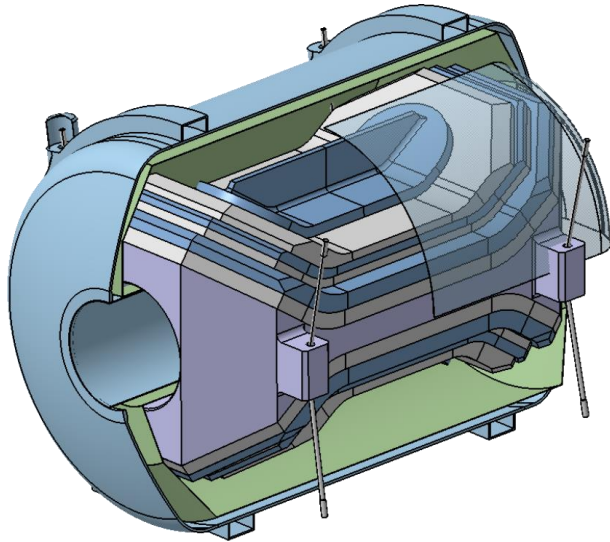


# Magnetized Disk and Mirror Axion eXperiment MADMAX

## The magnet challenge

Unique approach to look for dark matter in an theoretical favored region not accessible with other techniques:

- Place a “booster” of up to 80 dielectric disks of 1 m<sup>2</sup> in a 10 T magnetic dipole field.
- Main challenge: magnet design for figure of merit FoM  $\approx 100 \text{ T}^2\text{m}^2$ !



### Status:

- Design study for magnet successfully concluded.
- “Booster” and detector R&D ongoing.
- Test of booster in CERN’s MOPURGO magnet (1.6 T) in 2022
- MADMAX would be sited in the iron yoke of the H1 experiment in the HERA North hall.

**Data taking could start 2026/27.**

Parameter	Results
$J_E$	50 A/mm <sup>2</sup>
$B_y(0,0,0)$	-8.82 T
$B_{\text{peak}}(x,y,0)$	9.85 T
<b><math>B_{\text{peak}}</math></b>	<b>9.87 T</b>
Overfield ( $B_{\text{peak}}/B_0$ )	11.8 %
<b>FoM</b>	<b>94.4 T<sup>2</sup>m<sup>2</sup></b>
H+ / H- (Z = 0.0 m)	-0.9 % / 5.0 %
<b>Energy</b>	<b>482 MJ</b>
<b>Volume</b>	<b>4.435 m<sup>3</sup></b>
<b>Length</b>	<b>5.0 m</b>

## International Collaboration

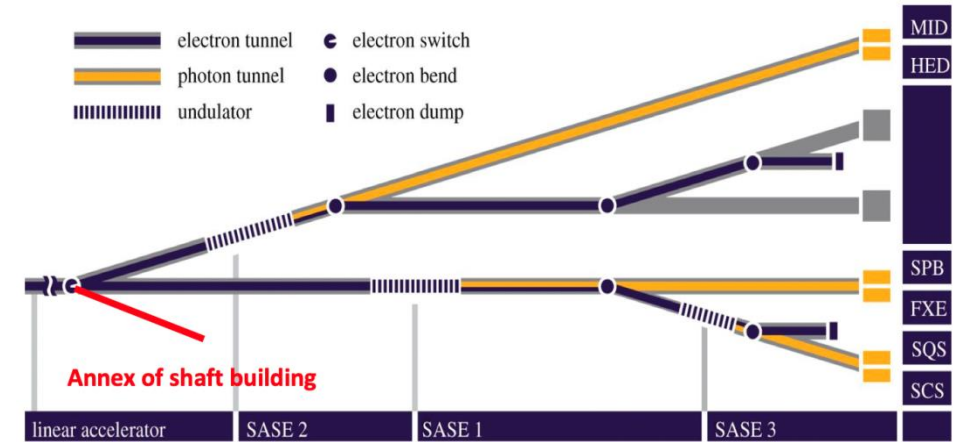
Currently 38 people with 13 institutions – and growing:

- 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), Kiev (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





# The Wolfgang Pauli Centre (WPC)

## Progressing towards construction

- WPC:** bundle theory efforts in particle physics, cosmology, astroparticle physics, ultrafast, cold and condensed matter physics, mathematical physics,
- comprising all DESY theory in Hamburg and Zeuthen + (inter)national partners.
  - Mission: foster interdisciplinary research addressing fundamental challenges;
  - Scientific evaluation of the WPC strategy completed – summary of reports compiled in agreement with the reviewers.

### The WPC building:

- Approx. 170 persons from DESY theory and Hamburg University
- Open space / communication areas, seminar rooms, „Research hotel“
- MoU DESY and Hamburg University in preparation

### Hamburg Prize for Theoretical Physics 2020 awarded to Prof. Valery Rubakov

- Due to the Covid-19 pandemic, the award ceremony (originally scheduled for 11 Nov 2020) and the WPC symposium (planned 11-13 Nov) postponed to November 2021 (dates to be fixed).

### Wolfgang Pauli Centre – Executive Summary

C. Grojean<sup>1</sup>, C. Herrmann<sup>2</sup>, K. Jansen<sup>3</sup>, R. Santra<sup>4,5</sup>, V. Schomerus<sup>1</sup>, G. Sigl<sup>6</sup>, M. Thowart<sup>5</sup>, K. Beernaert<sup>1</sup>, M. Habermehl<sup>1\*</sup>

#### 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 interdisciplinary scientific pillars. Two of these pillars represent theoretical research within the two clusters of excellence “Quantum Universe” (QU) and “CU: 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 foreses 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 activities 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.





# DESY II Testbeam Facility

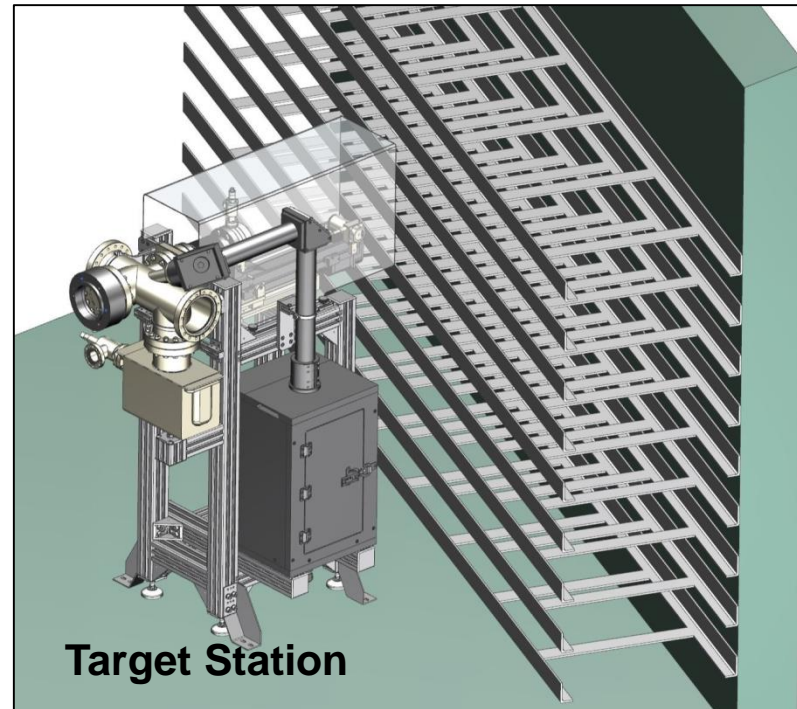
## Highlights and improvements

### Improvements

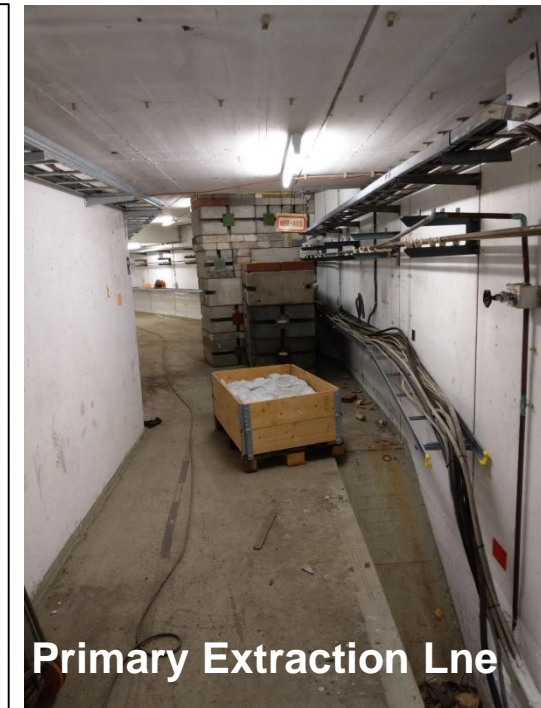
- New target stations for even higher availability
- Primary Extraction beam line  
Preparations are on-going in the old extraction line to DORIS

### Education and outreach

- Successfully hosted the EDIT 2020 detector school
- In collaboration with CERN hosted the 2020 BL4S edition
  - Again 197 team with 1400 high school students from 47 countries applied
  - Two winning teams from Berlin and Geneva
  - Remote participation by Geneva group
- Teacher Education programme in October 2020  
Enables high school teachers to conduct experiments at the test beam



Target Station



Primary Extraction Line



EDIT2020



BL4S



# DESY II Testbeam Facility

## Status 2020 and outlook 2021

DESY II has been again running again very smoothly: 99.5 % availability

### The DESY II Test Beam facility

Fully booked until the Covid-19 shutdown on 18 March  
Successful restart on June 1<sup>st</sup> in a Corona-safe mode

- Reduced team sizes, distancing measures, improved hygiene
- Rescheduling a lot of test beam slots to maximize beam for the community
- Employing remote-access tools

Travel restrictions lead to a lot of cancellations starting in September

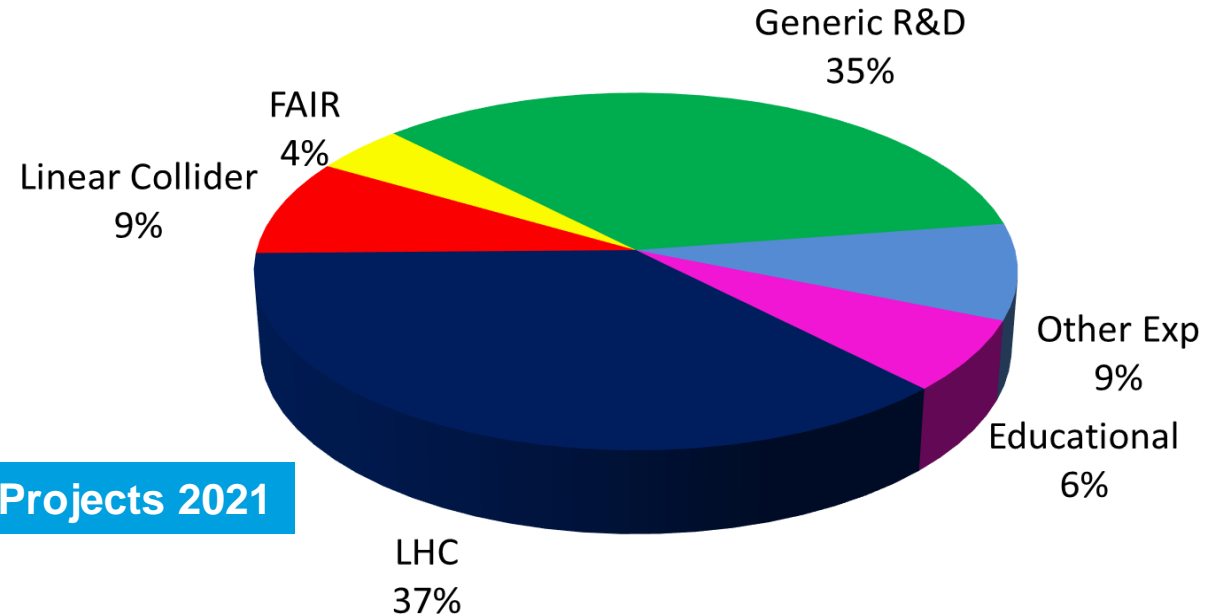
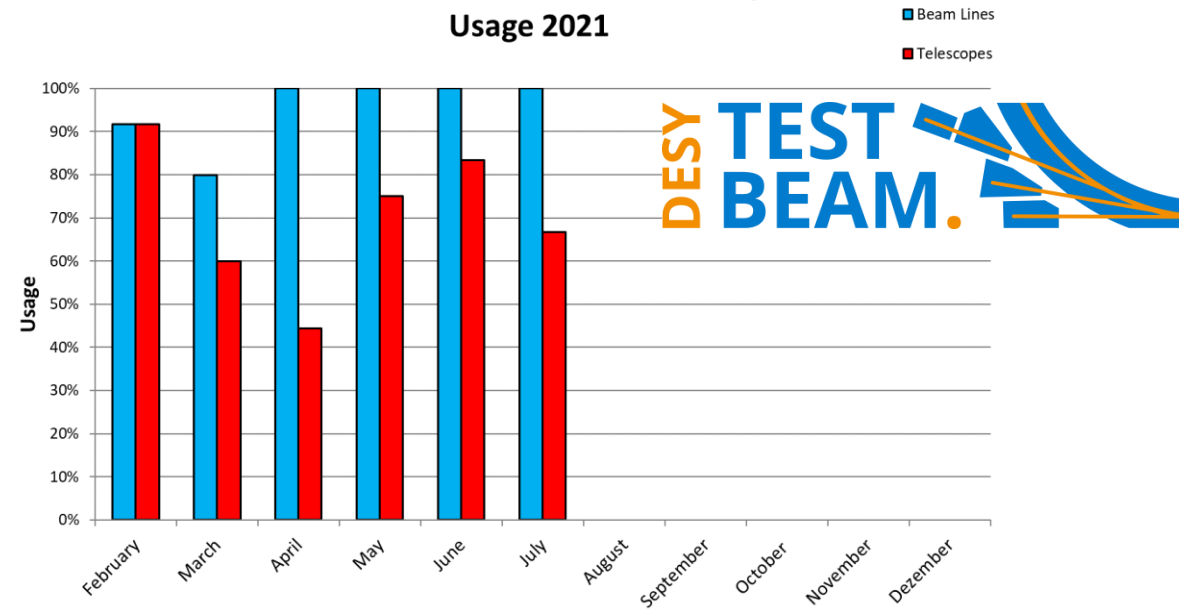
- Use of facility down to 66 %

2021: Again almost fully booked

- Early slots not as popular, lots of groups fear travel restrictions
- Telescopes remain popular, >80% of the request want to use a telescope

## DESY-II Test Beam Facility

Usage 2021



Projects 2021

13th ICFA Seminar on

# Future Perspectives in High-Energy Physics

<https://icfa2020.desy.de>



**Postponed by one year  
New date: 4-7 October 2021**

**Invitation through RECFA members  
Will start early 2021**

[Home](#)

[Timetable](#)

[Practical information](#)

[Registration](#)

## 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.



## Contact address

In case of questions concerning the ICFA seminar, don't hesitate to contact the [organisers](#).



# Thank you!

## Contact

**DESY.** Deutsches  
Elektronen-Synchrotron

[www.desy.de](http://www.desy.de)

Joachim Mnich  
DESY Director for Particle Physics

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

# Backup



# 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 $\mu$ s
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 $\sigma_{\text{beam}}$
	timing	~25 fs
Availability (user runs)		
	LINAC	>90%
	SASE	>85%

# KALDERA

DESY embarking on new class of drive laser

3kW average with >100 TW peak at 1 kHz

Why?

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

What?

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

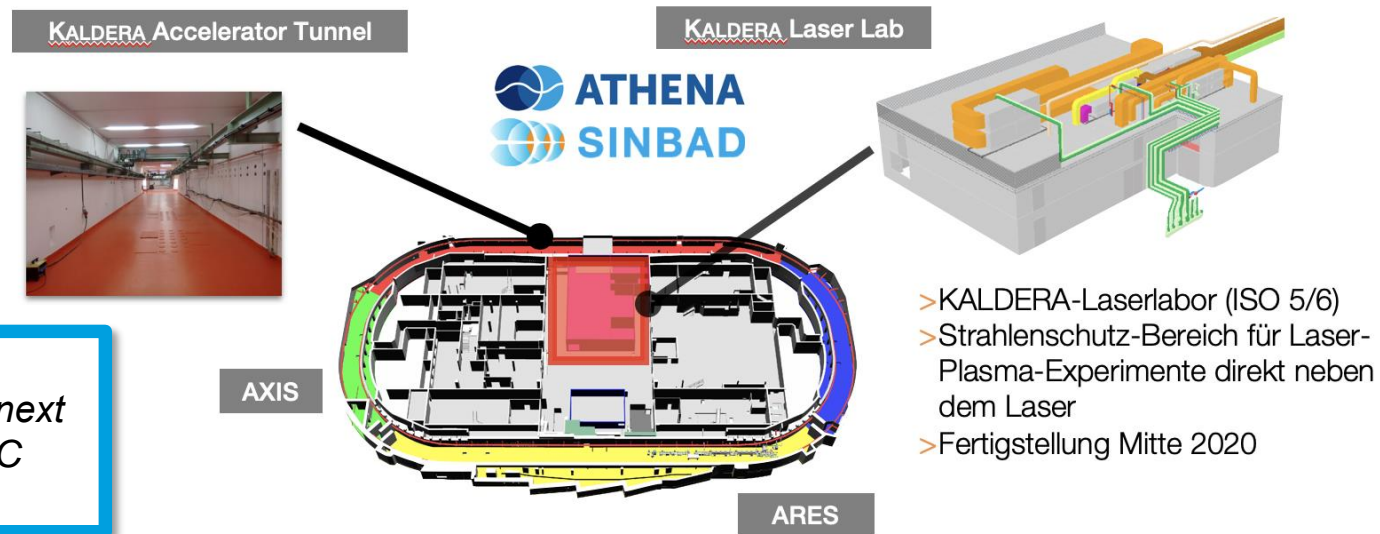
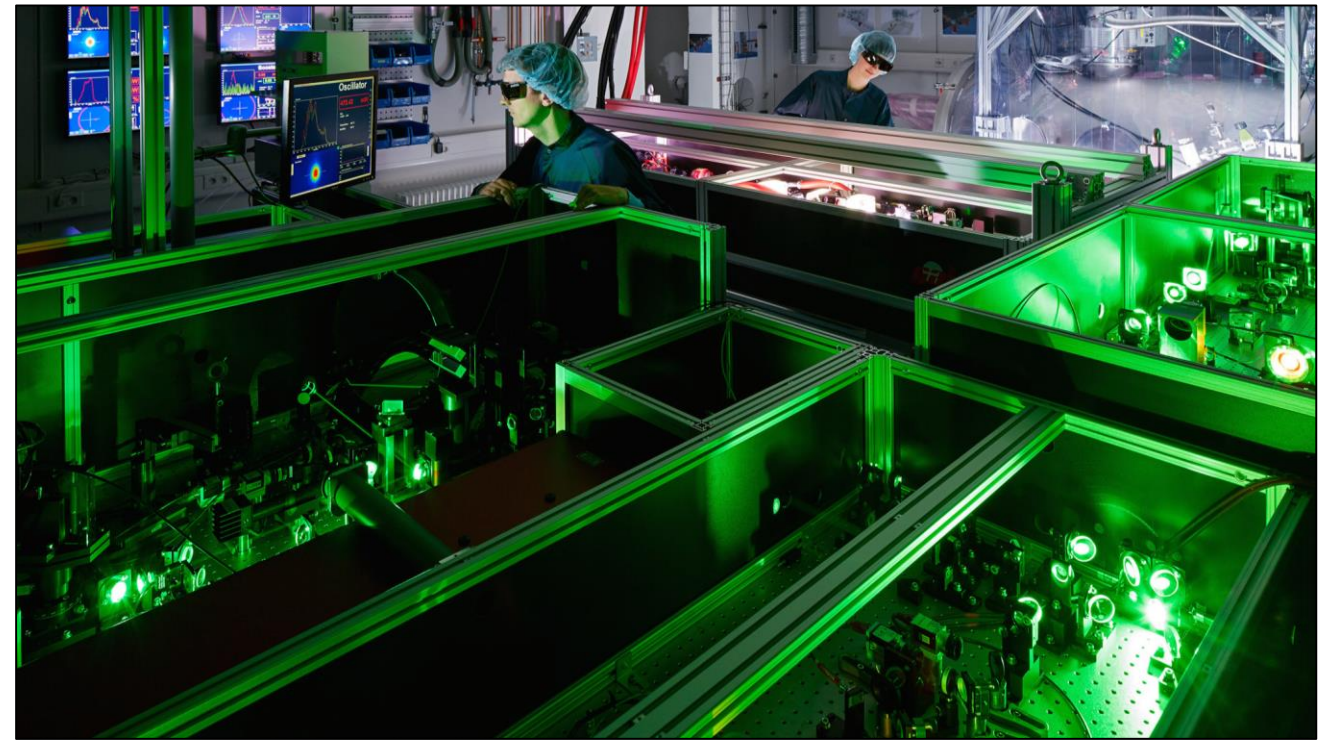
How?

- KALDERA laser with kHz plasma sources

When?

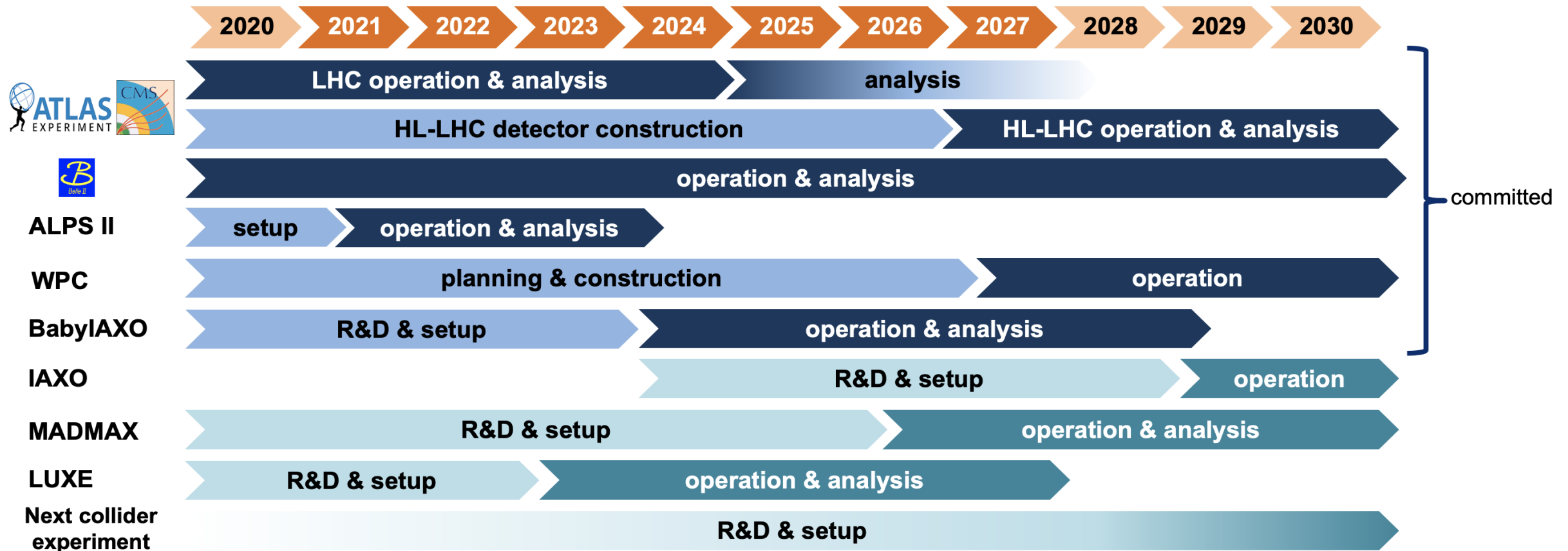
- 2020-2025 phased construction

**MAC October 23-24, 2019**  
*“The MAC congratulates DESY for proposing KALDERA as the next crucial step to turn LPA from a concept to a technology. The MAC fully supports these efforts to take the world lead in this field.”*

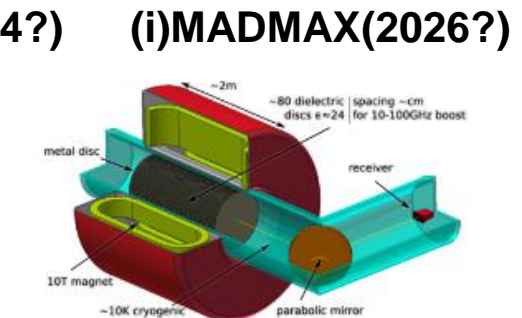
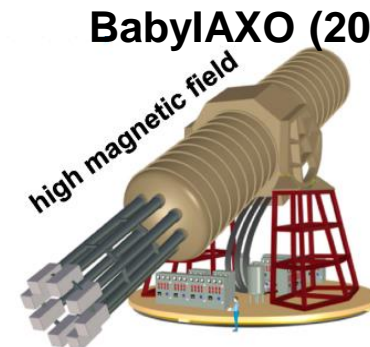
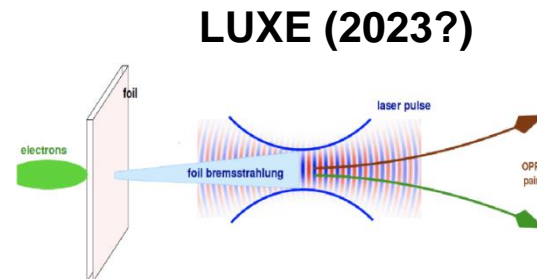




# Timeline of Planning



On-site programme



# HGCAL Tilemodule Centre

## Preparations in progress

### Collaborators from Russia

- to start with 3 people in November
- work on SiPM characterisation and preparation of QC

### Foil cutting

- use ATLAS machine

### Tile wrapping

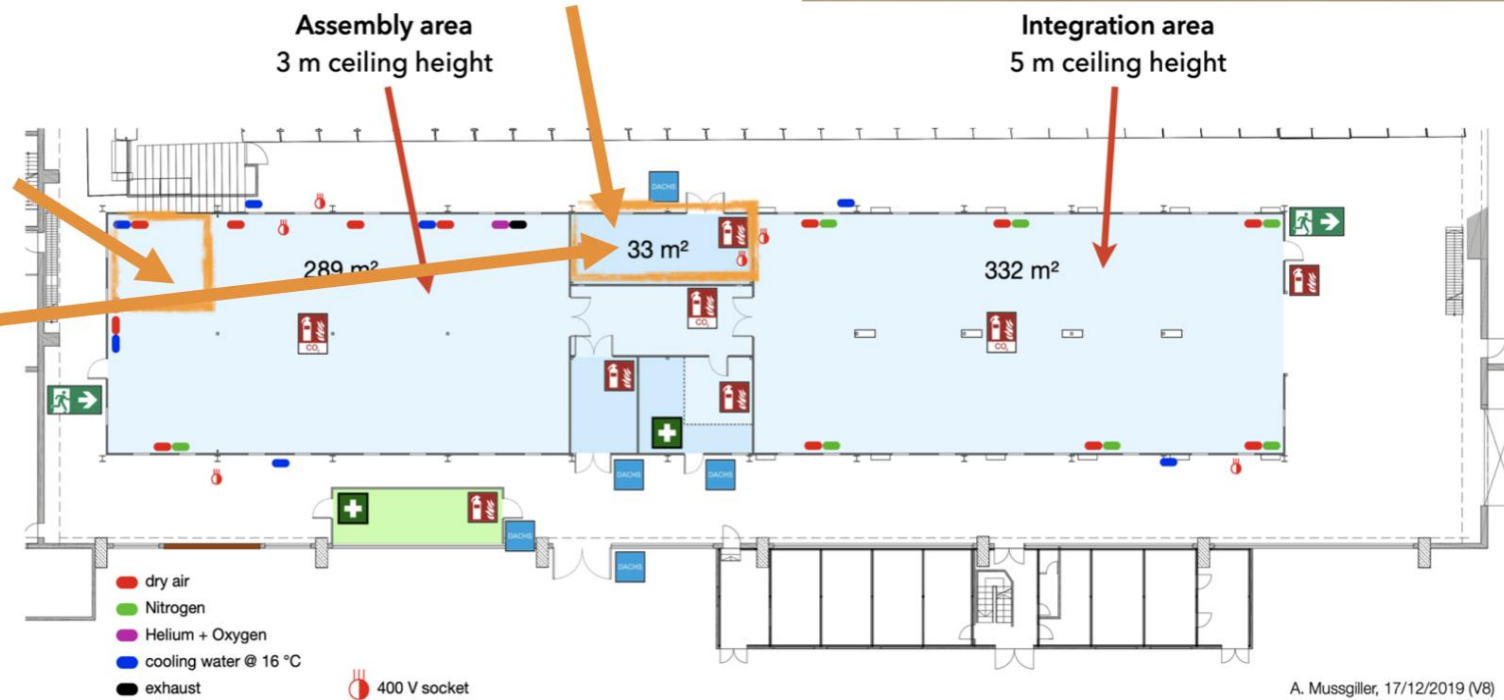
- sound-proof room in DAF

### Module assembly

- room with separate entrance in DAF
- Pick & Place machine delivered

### Cosmic tests

- HERA Hall West



A. Mussgiller, 17/12/2019 (V8)



# DESY Participation in Belle II

## Key roles in all aspects of the experiment

### SuperKEKB + Belle II offer high potential for breakthrough results

- So far accumulated  $74 \text{ fb}^{-1}$  of data for physics analysis
- Recent update of SuperKEKB roadmap: upgrade of final focus system in 2026 → reach  $50 \text{ ab}^{-1}$  by 2031

DESY fully committed to make this project a success by providing unique expertise

### Detector construction & operation: PXD operation & understanding of installed pixel detector, and preparing tests and installation of full detector in 2022

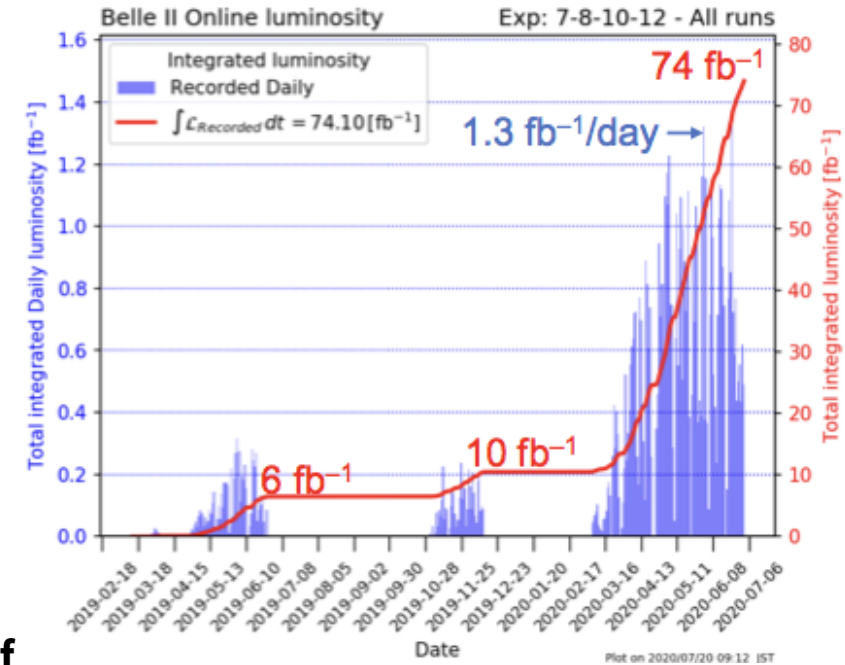
- Strong engagement in machine-detector interface task force to understand and mitigate background issues in sub-detectors and improve lumi performance

**Software and computing:** leading roles in reco&calibration algorithms for tracking+calorimetry, and providing essential tools and services for vital collaborative activities

- Key grid resource contributions for MC, from 2021 onwards Belle II raw data centre, ...

### Physics performance and analysis:

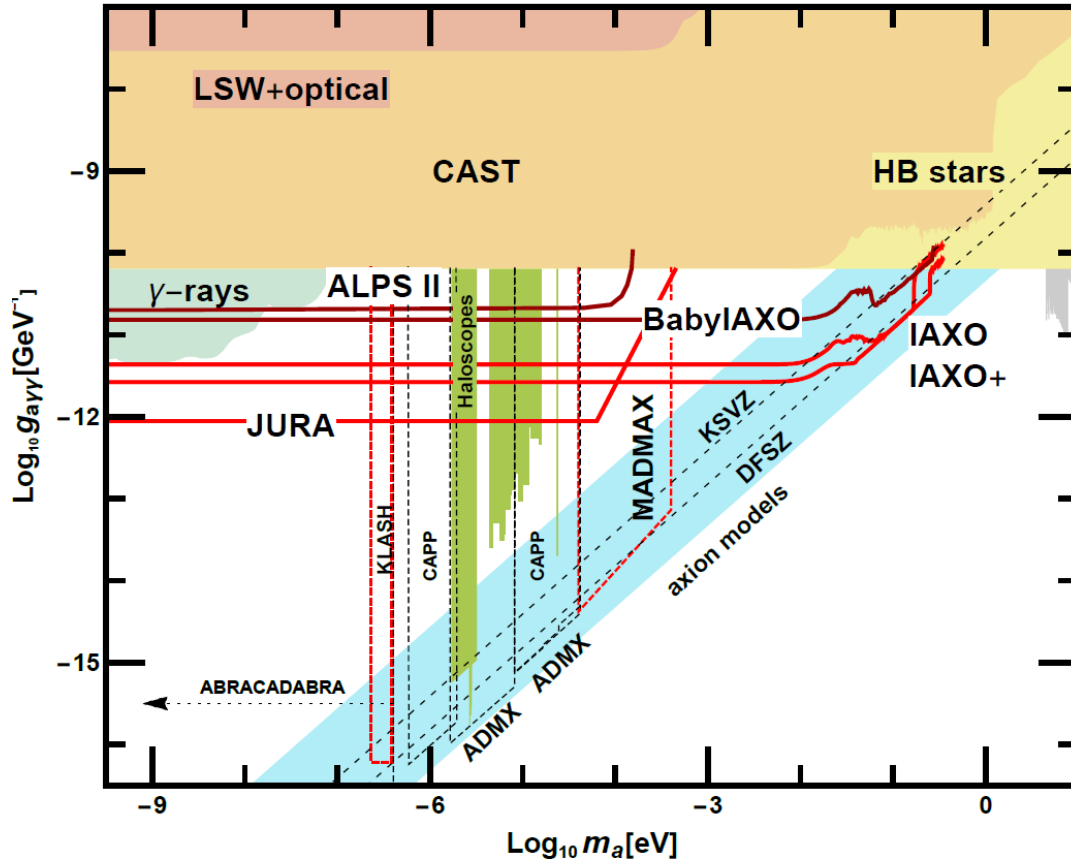
- leading efforts in monitoring and improving detector performance for analysis
- DESY convenors for 4 out of 10 physics WGs, leading contributions to first physics papers.



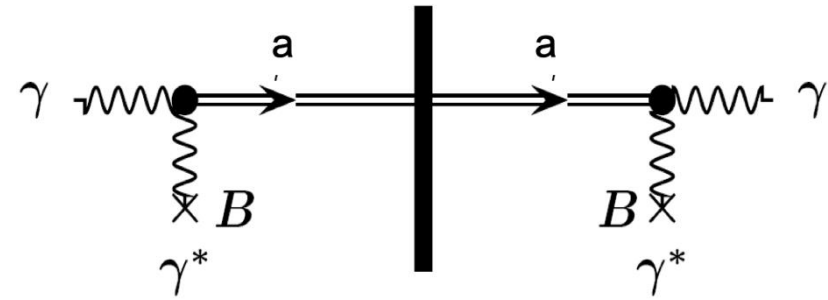
# Axion Physics at DESY

Developing a new focal activity

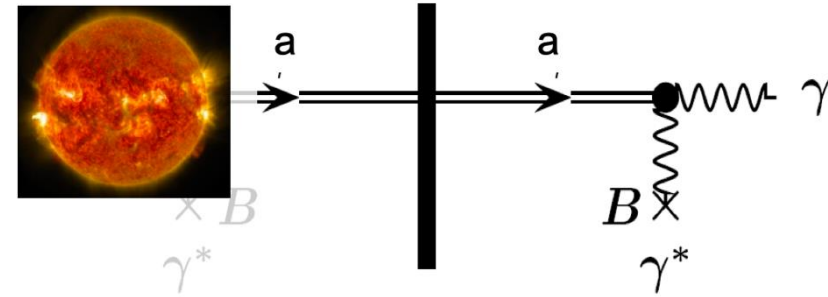
Huge phase space for axions / ALPs with different motivations



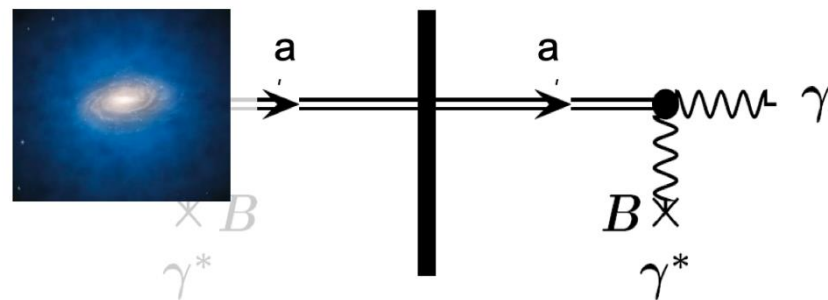
Three detection approaches:



Lab: L-S-W  
ALPS-II



Helioscope  
(baby)IAXO



Haloscope  
MADMAX

DESY involved in all three.



# LUXE („Laser und XFEL“ Experiment)

Colliding high-energy photons/electrons with lasers

**Scientific goal: Probe quantum physics in novel regime**

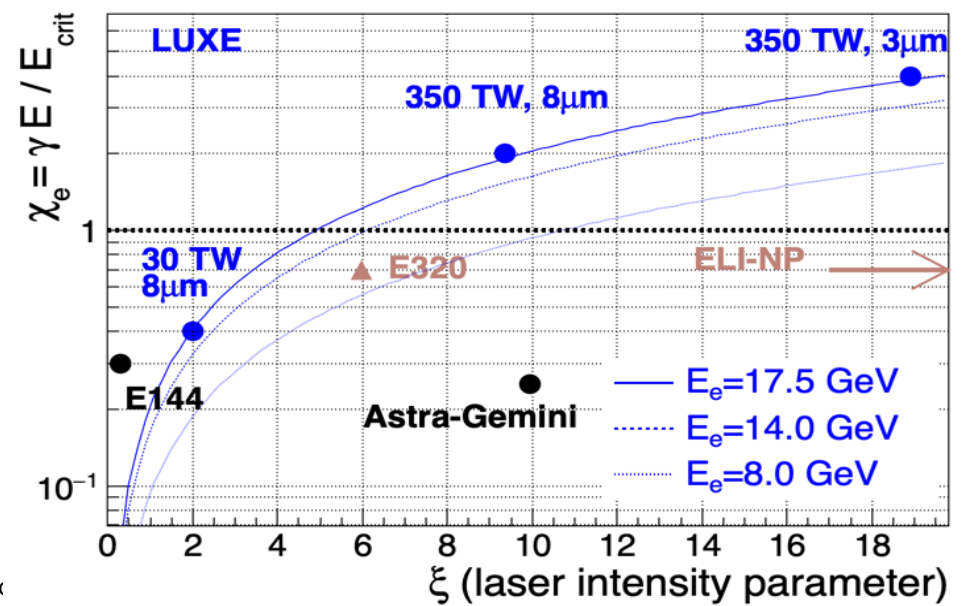
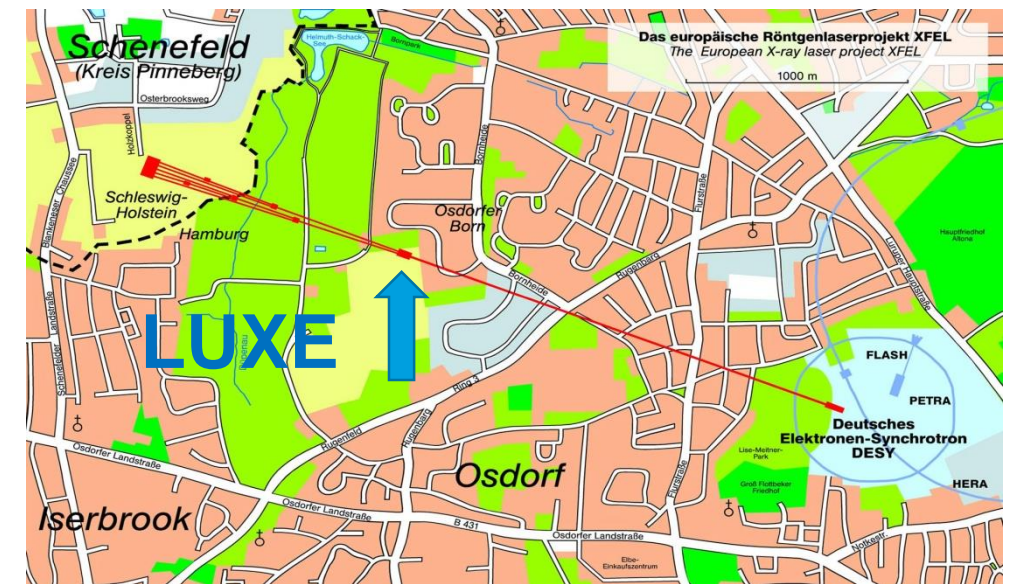
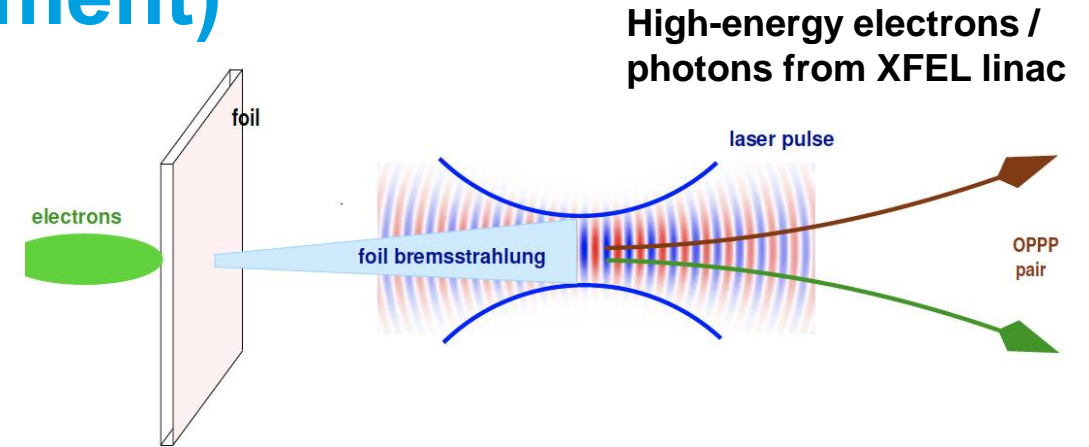
- Observe transition from perturbative to non-pert. Regime; reach Schwinger critical field value for the first time!

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

- Now possible thanks to new laser developments!

**Collaboration of particle, accelerator and laser physicists**

- Recommended by EPPSU; 14 institutions (and growing)



**European XFEL and DESY unique place!  
Conceptual design report (CDR) by end of 2020!**