

MU Topic 1: Fundamental particle and forces

Outlook

Priscilla Pani (DESY)



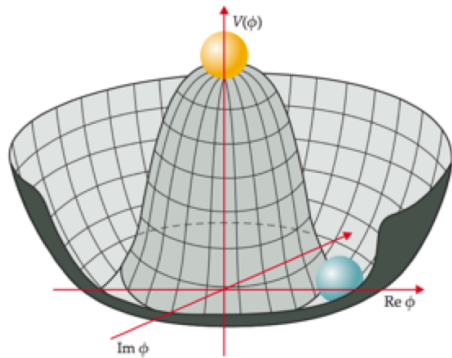
HELMHOLTZ

SPITZENFORSCHUNG FÜR
GROSSE HERAUSFORDERUNGEN

Topic mission and strategy

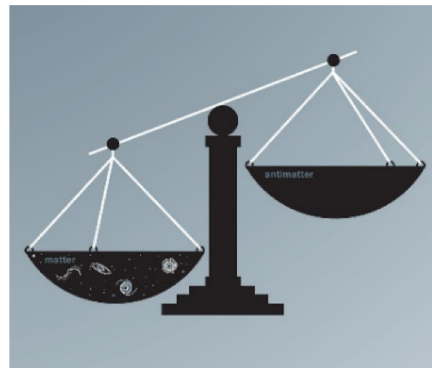
Study the fundamental laws of Nature in our Universe, governed by quantum physics and the dynamics of space-time

Science drivers



What is the structure of the vacuum?

Where did the anti-matter go?



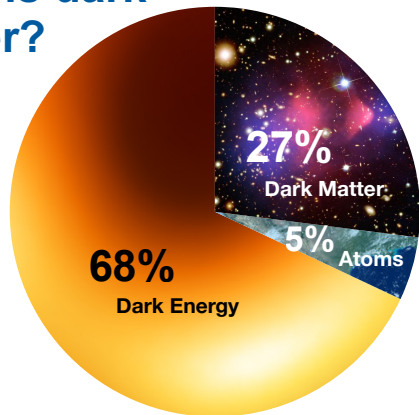
Guiding themes for PoF IV

Higgs and fundamental interactions at high precision

Searches for new particles & phenomena

Cosmology and the dark sector of the universe

What is dark matter?



Topic mission and strategy

Guiding themes for PoF IV

Higgs and
fundamental
interactions at
high precision

Searches for
new particles
& phenomena

Cosmology
and the dark
sector of the
universe

Broad theory portfolio

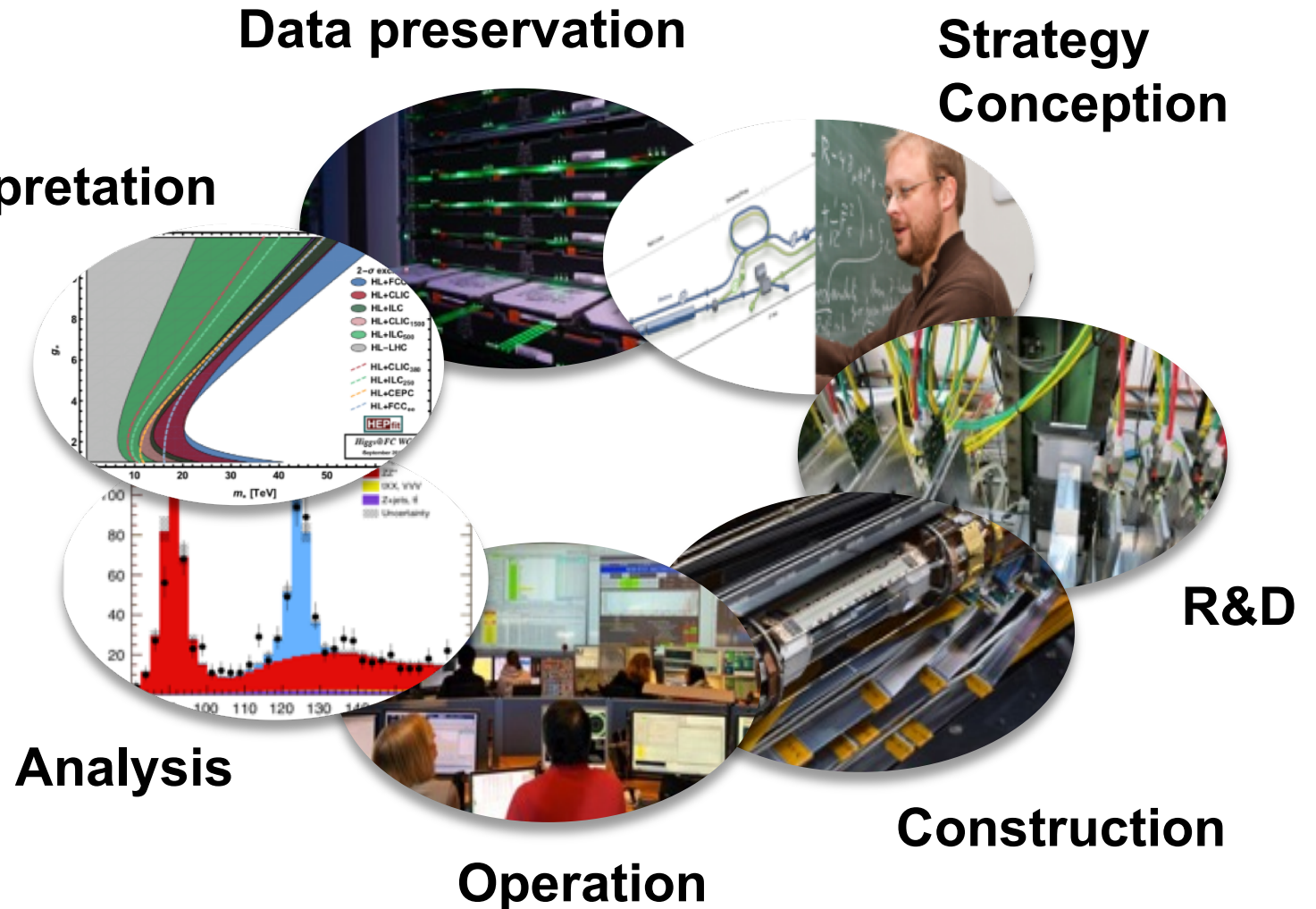
Strong experimental program

- Collider Physics
- Particle Cosmology
- Lattice Gauge Theory
- String Theory

- Off-site experiments:
ATLAS & CMS @CERN,
Belle-II @KEK
- Attractive on-site program:
ALPS-II, Baby-IAXO, LUXE
- Preparation of future
facilities/experiments

Scientific competences ...

- Scientific expertise in the full lifecycle of large and small experiments
- World-leading scientists (3 ERC grants, 2 Emmy Noether groups, 6 Helmholtz YIGs, 9 W2/W3 Professorships)
- Diverse and rich environment (158 scientists, 78 Ph.D. students, 42 nationalities)



... and infrastructures

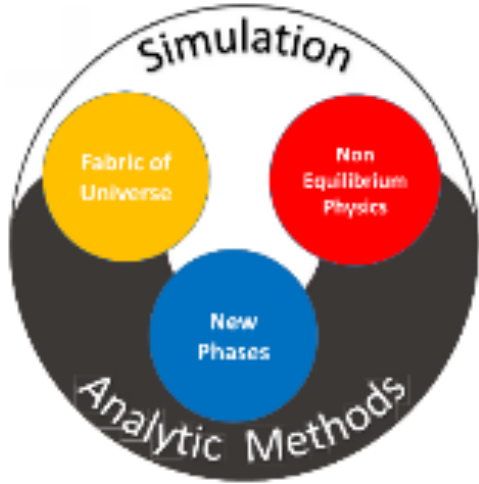
- Enhance infrastructure and system competences for the full lifecycle

Testbeams **M T**



Wolfgang Pauli Center
for Theoretical Physics

Detector Assembly
Facility (DAF)

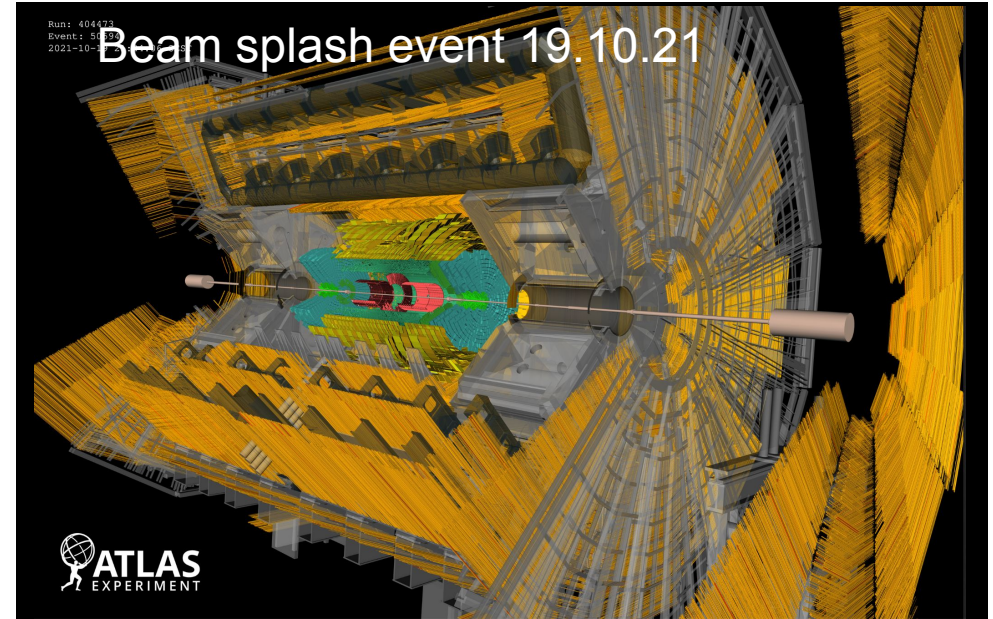


Computing centers:
GridKa, IDAF **M T**



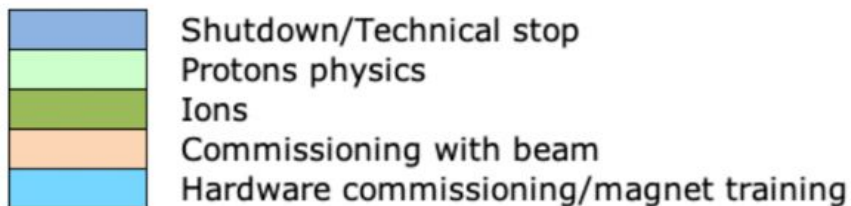
LHC - short term future: Run-3

- Successful beam tests (October 2021)
- Physics collisions expected in 2022
 - centre-of-mass energy target 6.8 TeV
 - max levelled luminosity $2.05 \cdot 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$



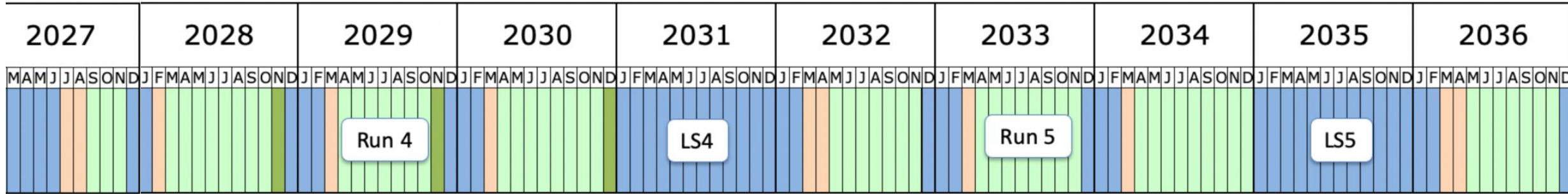
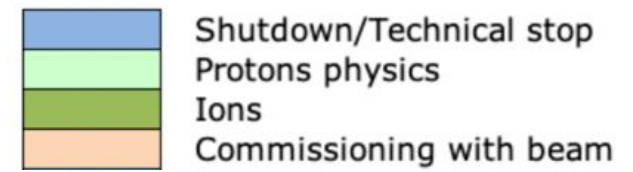
today

In 2019 the decision was taken to extend Run 3 by a year and for LS3 to start in 2025. Impact of coronavirus pandemic reflected in the extended hardware commissioning and magnet training foreseen for 2021.



<https://lhc-commissioning.web.cern.ch/schedule/LHC-long-term.htm>

LHC - long term future: HL-LHC



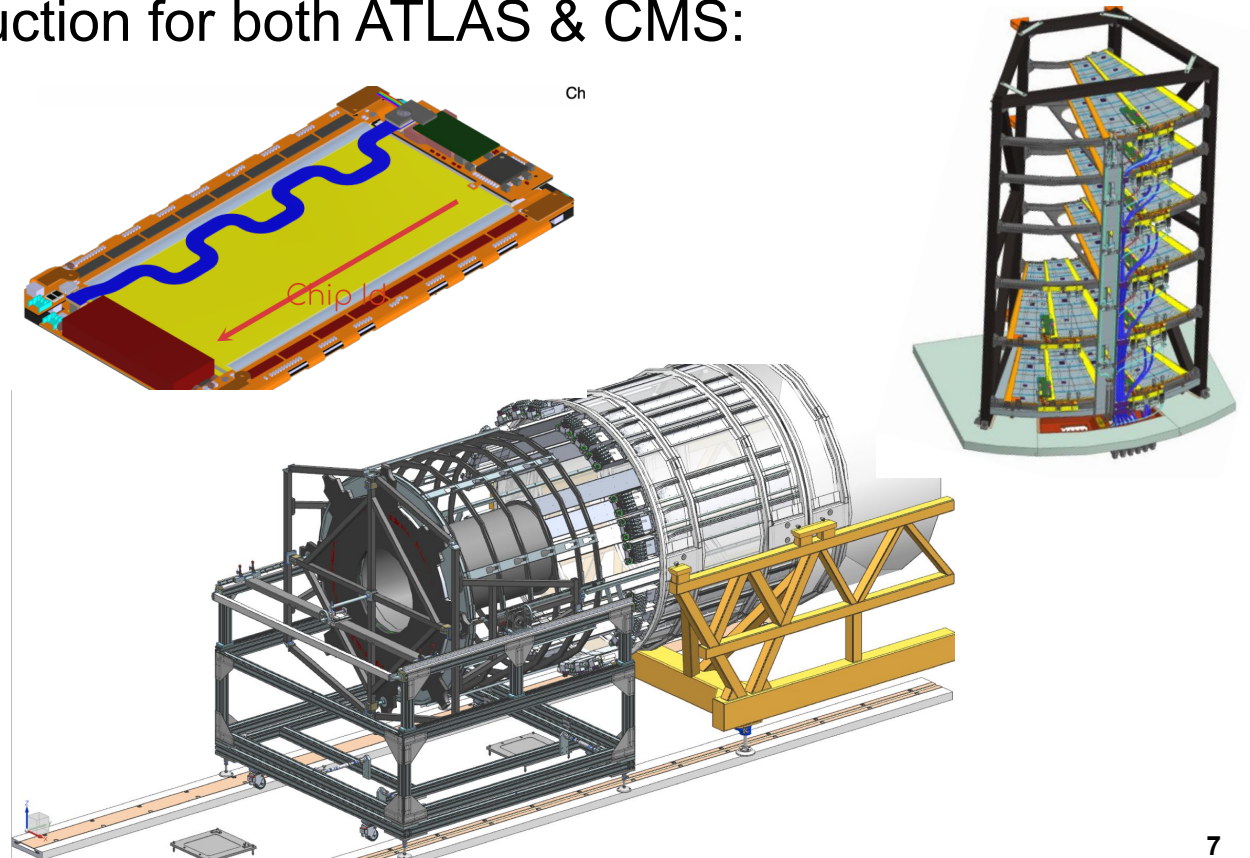
• Excellent progress in tracker end-cap construction for both ATLAS & CMS:

- Module production
- Tracker structures assembly
- Quality assessment tests

• Preparation of physics programme:

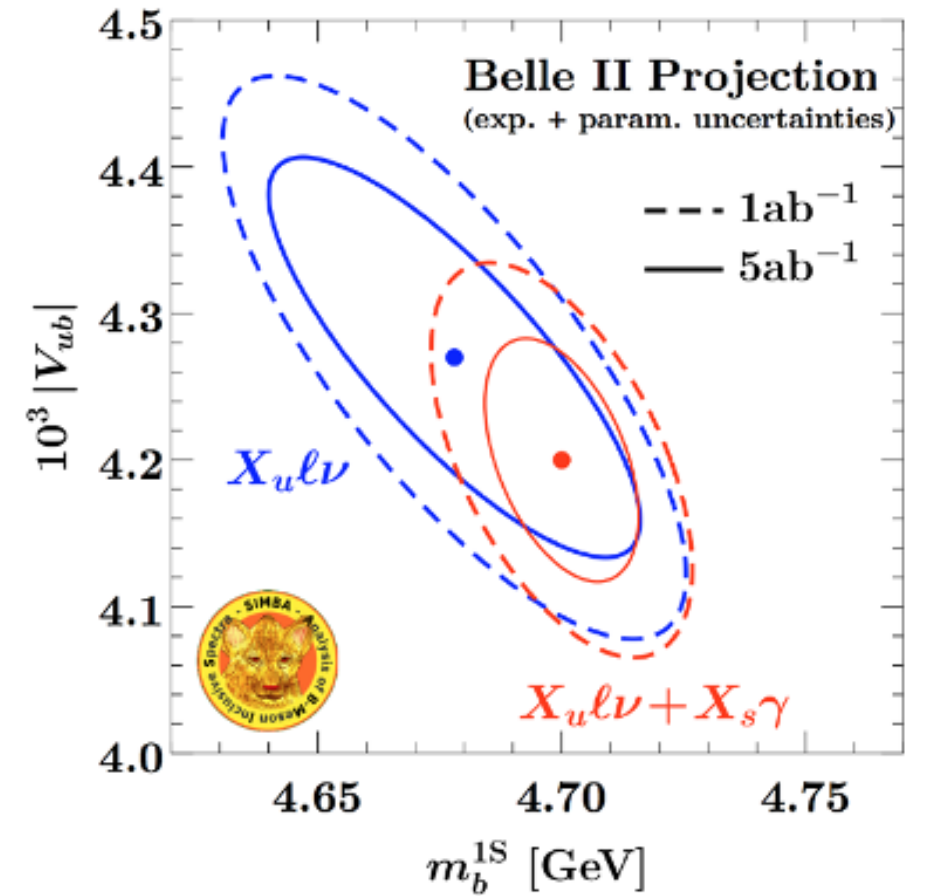
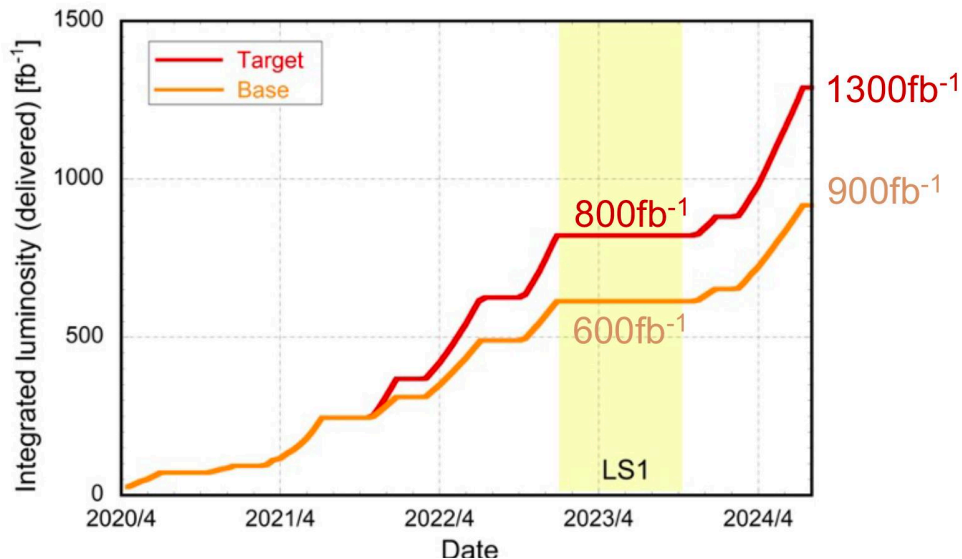
- Rare processes
- Higgs properties
- Dark Matter

TOGETHER
WITH
THEORISTS



Belle - II perspectives

- Operation, calibration and maintenance of the Pixel Vertex Detector
- Extensive Physics program:
 - Lepton flavour universality tests in tau physics
 - Global analysis of inclusive B-decays
 - Dark sector searches

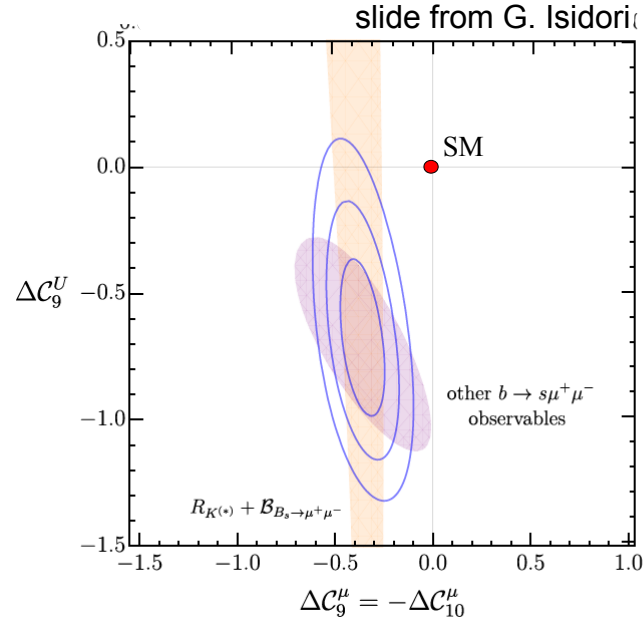
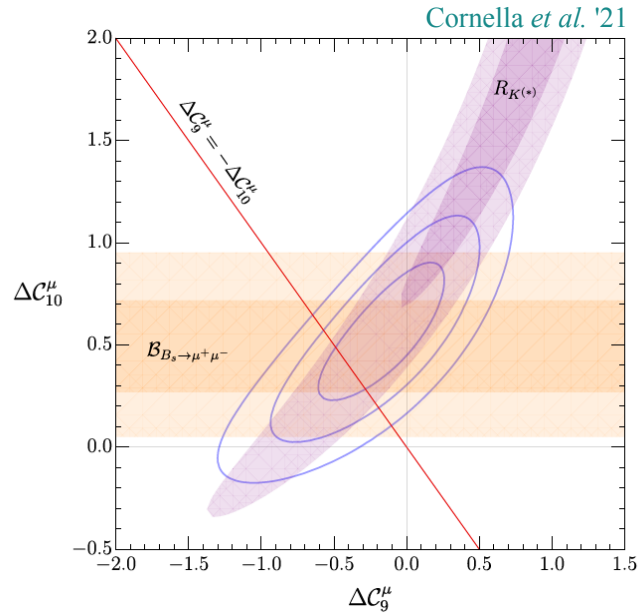


TOGETHER
WITH
THEORISTS

Belle - II perspectives

- Operation, ca
- Vertex Detect
- Extensive Ph
- Lepton flav
- Global ana
- Dark secto

+ flavour anomalies



Conservative fit using “clean obs.”
only [$\Delta C_i^\mu = C_i^\mu - C_i^e$]:

4.6σ significance of NP hypothesis
 $\Delta C_9^\mu = -\Delta C_{10}^\mu$ vs. SM

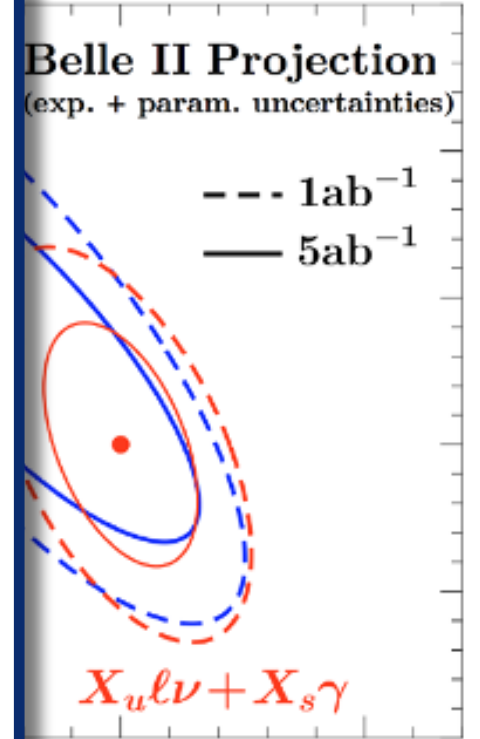
>> 5σ with current best estimate
of charm contrib

Alguero *et al.* '19
Ciuchini *et al.* '20
Li-Sheng Geng *et al.* '21
Altmanshofer & Stangl '21

3.9σ global significance of NP
(*very conserv. estimate*)

Lancierini, GI,
Owen, Serra, '21

within FPF: U. Nierste et al



4.70 4.75
 $\sqrt{s_b}^{1S}$ [GeV]

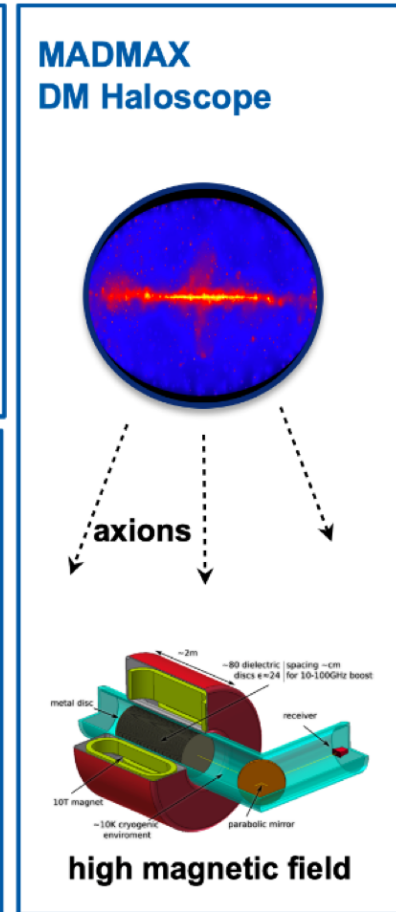
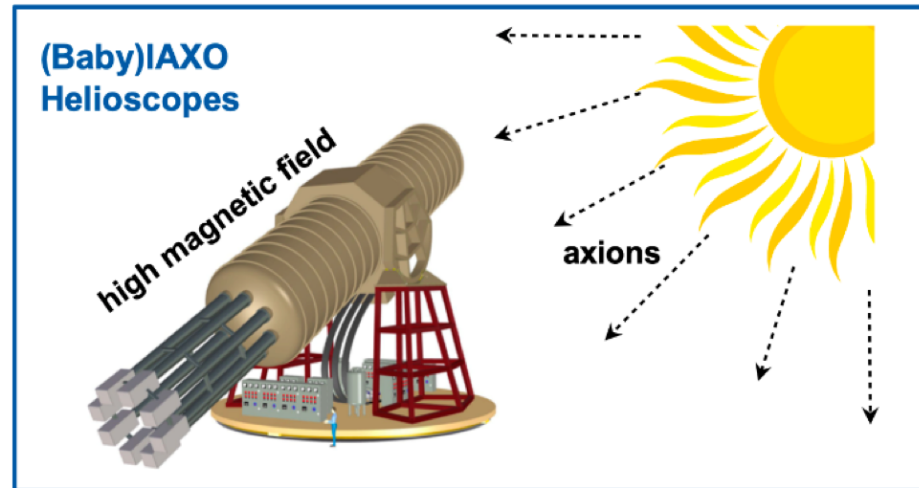
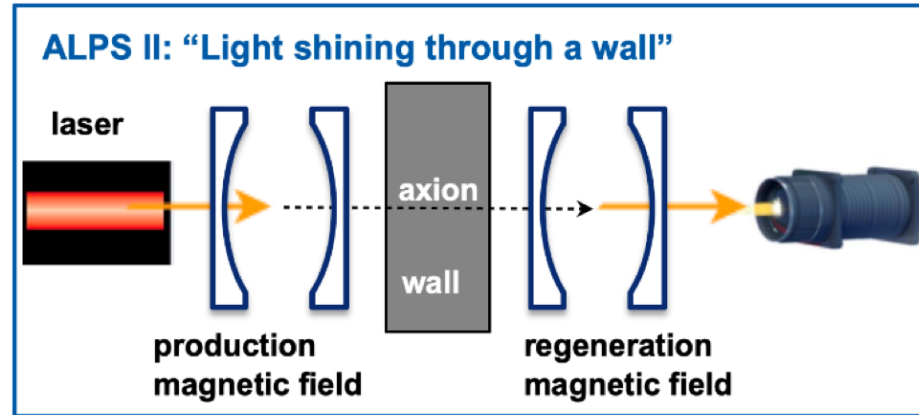
TOGETHER
WITH
THEORISTS

Integrated luminosity (delivered) [fb⁻¹]

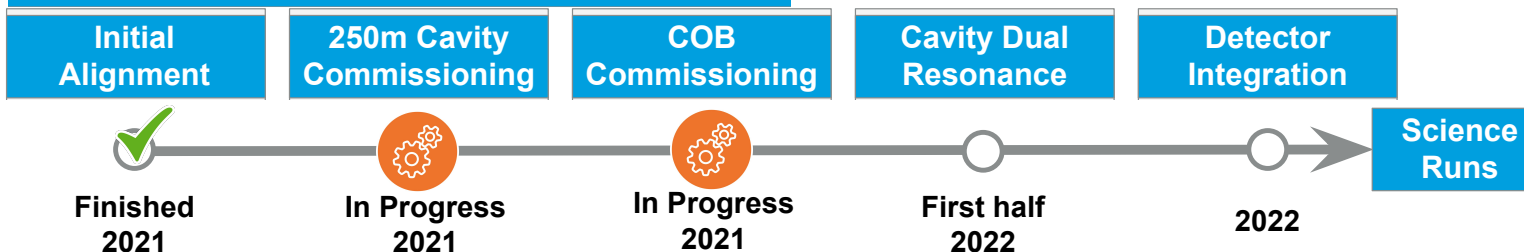
1500
1000
500
0
20

On-site experiments: ALPS-II & beyond

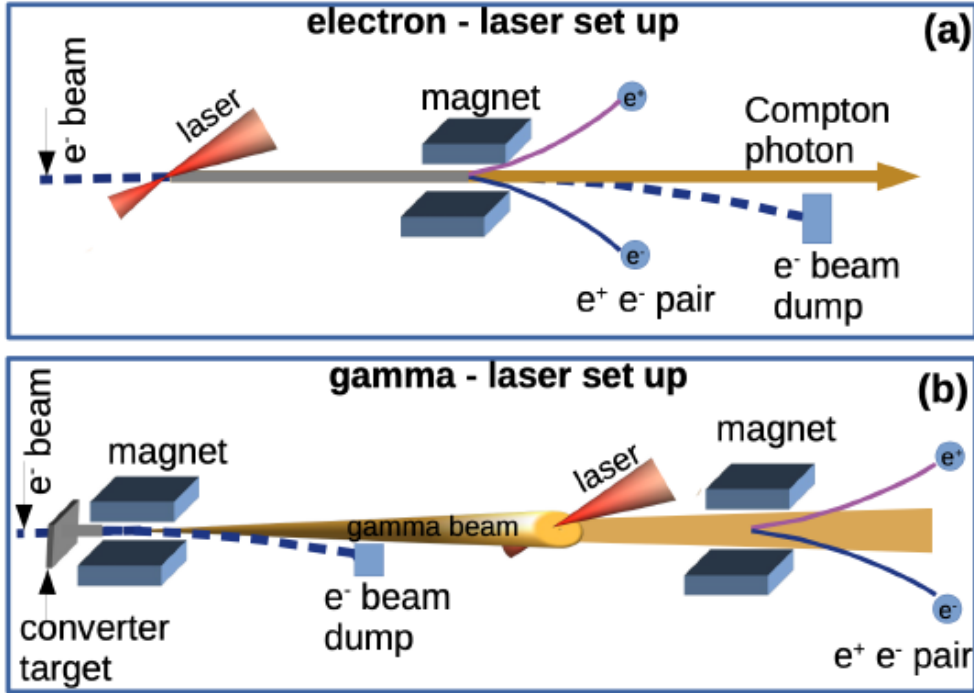
- Towards Axions/ALPs observation
- ALPS-II experiment on schedule, physics harvesting coming soon!
- prototypes for IAXO (babyIAXO at DESY) and MADMAX (at CERN) under construction, expect scientific results by 2024/2025



ALPS II Optics Commissioning Roadmap



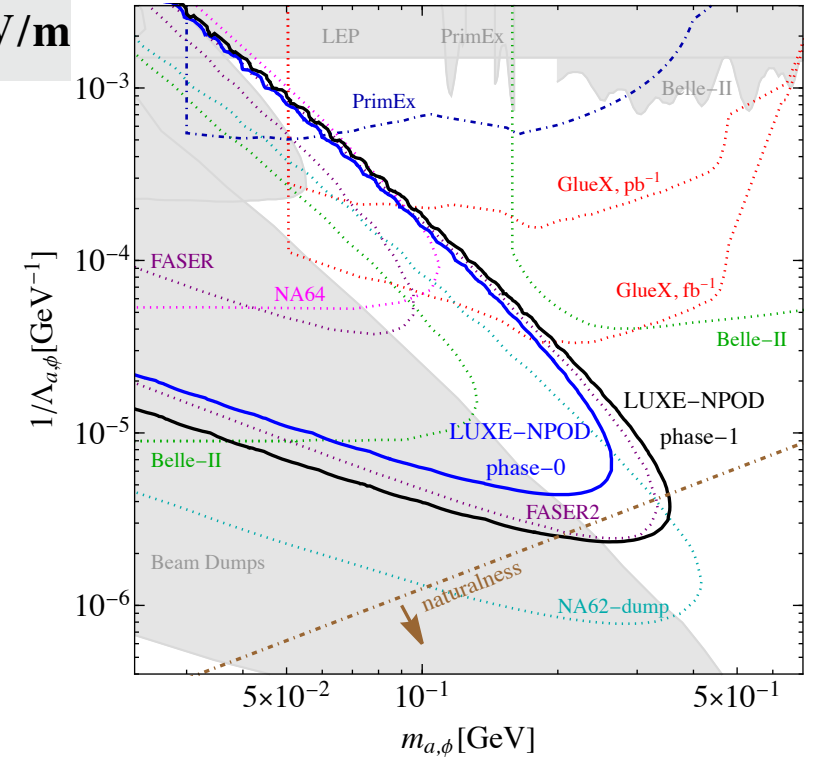
On-site experiments: LUXE



- First time measurement of non-perturbative QED in strong fields (Schwinger critical field)

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

- Discovery potential for axions



- Collaboration of particle, accelerator and laser physicists
- Ongoing infrastructure and detector designs

2022

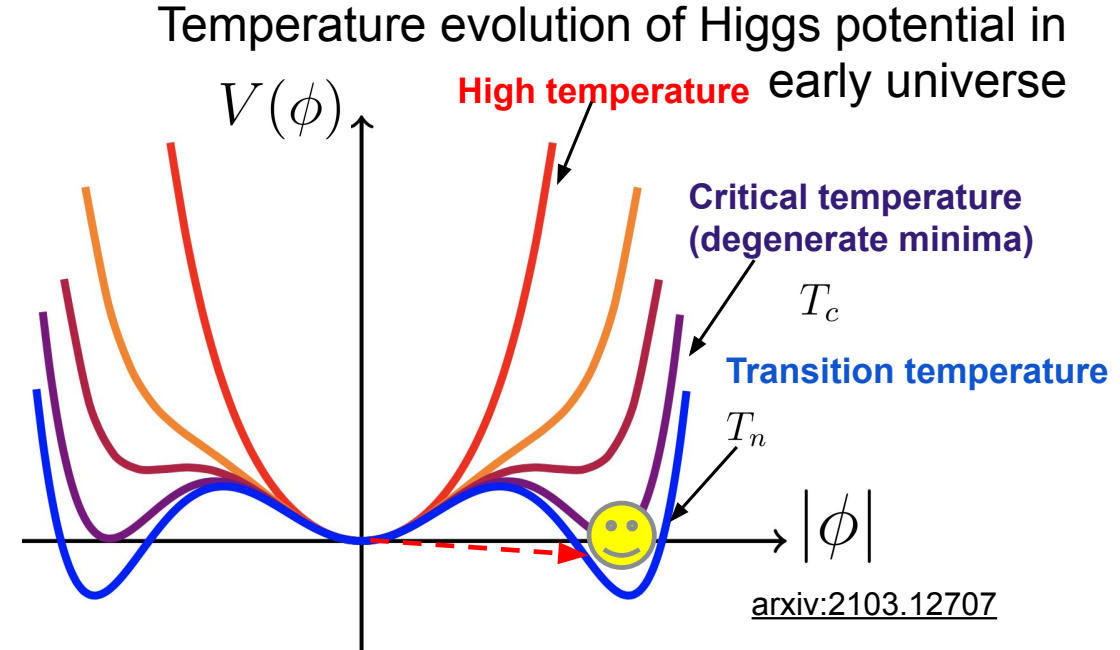
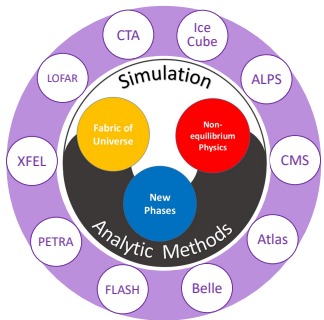
2024

2025-



Theoretical developments

- Building construction for the Wolfgang Pauli Center
- Coherent interfaces between theory and experiments for Higgs physics, B-physics and new particles models
- Cosmological implications of Higgs and dark matter
- Precise predictions for Standard Model physics and beyond

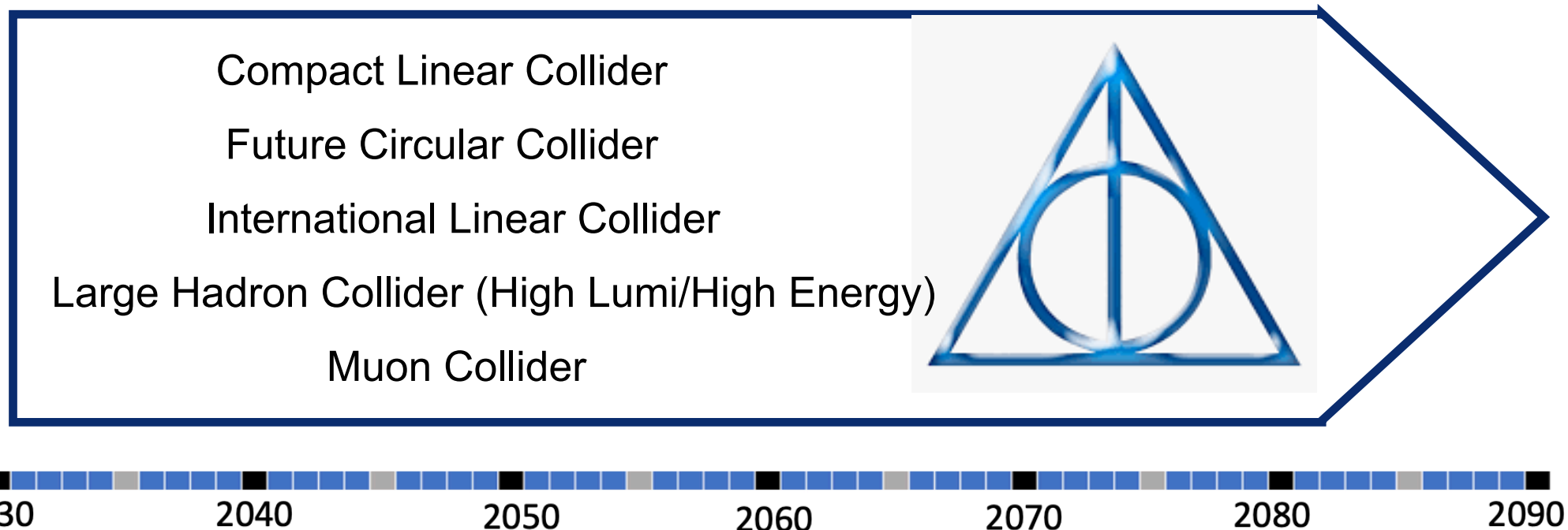


1st order EW phase transition

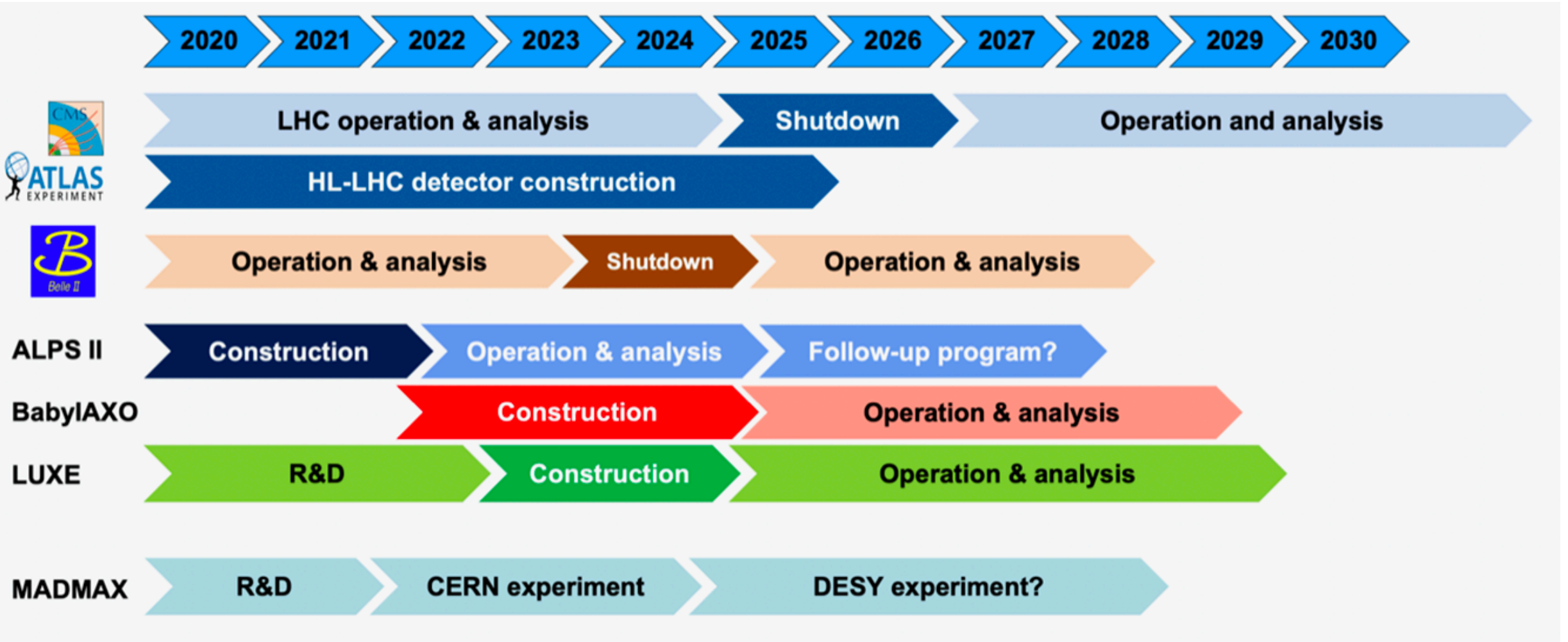
- ➔ matter-antimatter asymmetry (baryogenesis)
- ➔ Collider “smoking gun”: N2HDM
 $A \rightarrow Z h_2/h_3$
- ➔ Stronger transition = stronger LHC signal!

Future global colliders

- Continue long-term contribution to the European Strategy for Particle Physics
- Creation of a community forum supporting future collider activities in Germany:
 - Foster the interactions (experiment and theory, detectors and accelerators)
 - Identify and exploit synergies



Conclusions



Looking forward to the exciting scientific program ahead!

**Vielen
Dank**

Kontakt

DESY. Deutsches
Elektronen-Synchrotron

www.desy.de

Vorname Name

Abteilung

E-mail

Telefon