



# Physics Beyond Colliders at CERN Update

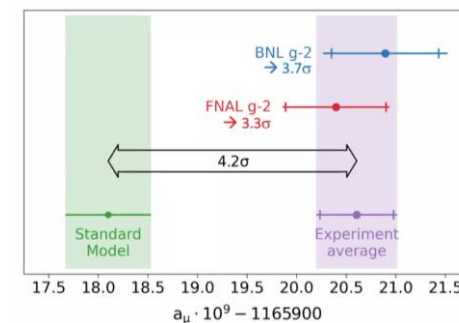
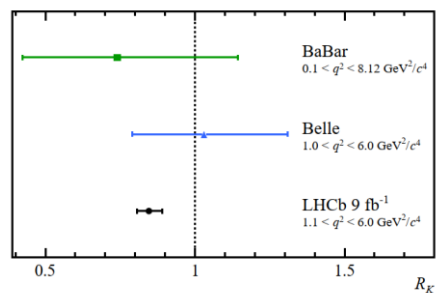
G. Arduini (taking over from M. Lamont), J. Jaeckel, C. Vallée

# ESPP & PBC

- Recognition of the **successful first phase of the Physics Beyond Collider initiative** launched by CERN DG in 2016 with the aim of exploiting the unique capabilities of CERN accelerator complex and infrastructure to enrich and diversify CERN's future scientific programme
- **.....A diverse programme that is complementary to the energy frontier is an essential part of the European particle physics Strategy. Experiments in such diverse areas that offer potential high-impact particle physics programmes at laboratories in Europe should be supported, as well as participation in such experiments in other regions of the world.....**

2020 UPDATE OF THE EUROPEAN STRATEGY  
FOR PARTICLE PHYSICS

by the European Strategy Group





# CERN MTP2020 & PBC

CERN/SPC/1141/Rev.  
CERN/FC/6412/Rev.  
CERN/C490/Rev.  
Original: English  
11 September 2020

**ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE**  
**CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**

*Action to be taken* *Voting procedure*

For recommendation to the Council	SCIENTIFIC POLICY COMMITTEE 319 <sup>th</sup> Meeting 21-22 September 2020	—
For recommendation to the Council	FINANCE COMMITTEE 373 <sup>rd</sup> Meeting 23 September 2020	Chapters I and IV.1: Simple majority of Member States represented and voting (absentees are not counted) and 70% of the contributions of the Member States represented and present for the voting (absentees are counted as votes against) and at least 51% of the contributions of all Member States. Chapter III: Two-thirds majority of Member States represented and voting (absentees are not counted) and 70% of the contributions of the Member States represented and present for the voting (absentees are counted as votes against) and at least 51% of the contributions of all Member States.
For decision	RESTRICTED COUNCIL 200 <sup>th</sup> Session 24-25 September 2020	Chapters I and IV.1: Simple majority of Member States represented and voting (absentees are not counted). Chapter III: Two-thirds majority of Member States represented and voting (absentees are not counted).

**Medium-Term Plan for the period 2021-2025 and Draft Budget  
of the Organization for the sixty-seventh financial year 2021**

GENEVA, September 2020

- Council is invited to:
- approve the overall strategy for the reference period as outlined in Chapter I of this document and elaborated upon in the Appendices (Chapter IV.1);
  - take note of the Resources Plan for the years 2021 to 2025 (Chapter II);
  - approve the 2021 Draft Budget in 2020 prices (Chapter III).

- .....A diverse scientific programme is strongly supported by the 2020 Strategy update, which also recognised the role of the **Physics Beyond Colliders (PBC) study group as the focal point for promoting and channelling new research initiatives**.....
- .....Given the importance of a diverse scientific programme to addressing the outstanding questions in particle physics in a way complementary to high-energy colliders, **PBC activities are funded with an increased budget of 3 MCHF/year in this MTP (up from 1 MCHF/year)**.....



## Mandate of the "Physics Beyond Colliders" Study Group

(Revised January 2021)

### Context

The PBC study was launched in 2016 to explore the scientific potential of the CERN accelerator complex and infrastructure for projects complementary to high-energy frontier colliders, and to provide input to the European Particle Physics Strategy Update (EPPSU). The EPPSU deliberations were supportive of PBC studies, and recommended an enhanced collaboration of CERN with other laboratories in Europe and beyond. As a consequence, the CERN Directorate wishes to maintain the PBC study group as a long-term activity, with a mandate and organization updated to take into account the EPPSU recommendations.

### Scientific goal

The main goal of the Study Group remains to explore the opportunities offered by CERN's unique accelerator complex, its scientific and technical infrastructure, and its know-how in accelerator and detector science and technology, to address today's outstanding questions in particle physics through initiatives that complement the goals of the main experiments of the Laboratory's collider programme. Examples of physics objectives include dedicated experiments for studies of rare processes and searches for feebly interacting particles. The physics objectives also include projects aimed at addressing fundamental particle physics questions using the experimental techniques of nuclear, atomic, and astroparticle physics, as well as emerging technologies such as quantum sensors, that would benefit from the contribution of CERN competences and expertise. The study group will primarily investigate, and, where appropriate, provide support to, projects expected to be sited at CERN. The study group may also examine ideas and provide initial support for contributions to projects external to CERN. The study group is also expected to act as a central forum for exchanges between the PBC experimental community and theorists for assessment of the physics reach of the proposed projects in a global landscape.

### Organization

The group will continue to be led by three coordinators representing the scientific communities of accelerator, experimental, and theoretical particle physics. The coordination team reports to the CERN Directorate. The coordinators will update the PBC working group structure to reflect the updated PBC mandate and input from the community.

The PBC study group will act as CERN's initial portal for new ideas which may come in spontaneously or through specific calls launched by the PBC coordination team. The group will facilitate and support an initial evaluation of the relevance and technical feasibility of the ideas in a global context, and will regularly inform the CERN scientific committees (INTC, SPSC or LHCC) about their findings. Where appropriate, oversight of PBC studies will be passed to the relevant CERN scientific committee once they are adequately mature for scrutiny and review of possible implementation.

# Updated Mandate

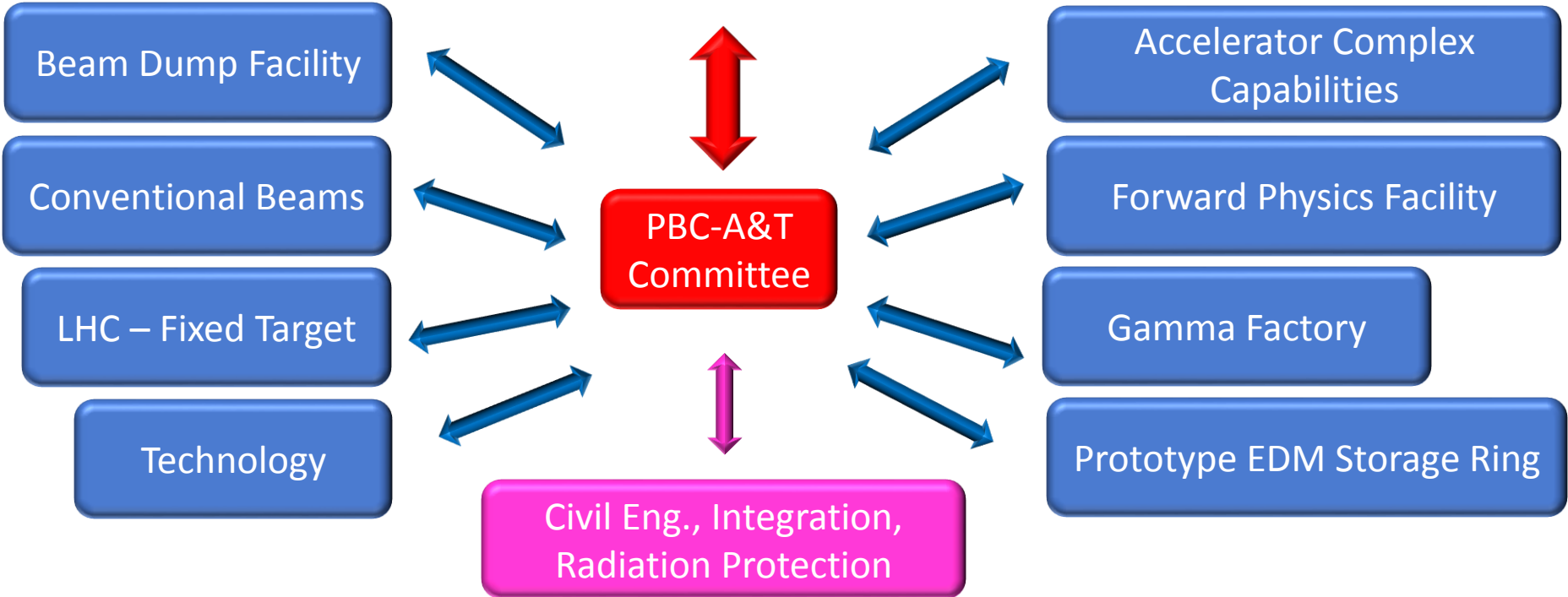
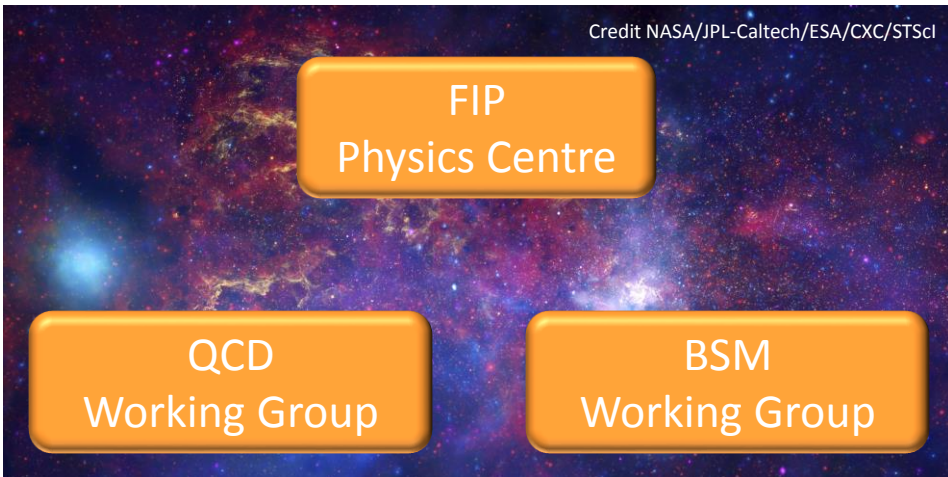
- **Complementarity to the goals of the main experiments of the Laboratory's collider programme**
- **Supporting projects using experimental techniques of nuclear, atomic, and astroparticle physics as well as emerging technologies such as quantum sensors benefitting from CERN competence and expertise**
- **Central forum for exchanges between PBC experimental community and theorists to assess the physics reach of proposed projects in a global landscape**
- **CERN's initial portal for new ideas, facilitating and supporting the evaluation of their relevance and technical feasibility**
- **Informing regularly the CERN scientific committees of its findings, passing the oversight of the studies to them once they are mature for scrutiny and review for implementation.**

# PBC Workshop (1-4 March 2021)



- 9 sessions:
  - Introduction: EPPSU recommendations and updated PBC mandate
  - QCD
  - Gamma Factory
  - **Quantum Sensors**
  - BSM
  - Accelerator studies
  - **Forward Physics Facility @ LHC**
  - Long Lived Particle Searches @LHC
  - **New Ideas**
- Close to 500 Registered participants: ~100 connected for each session

# Organization – 2021





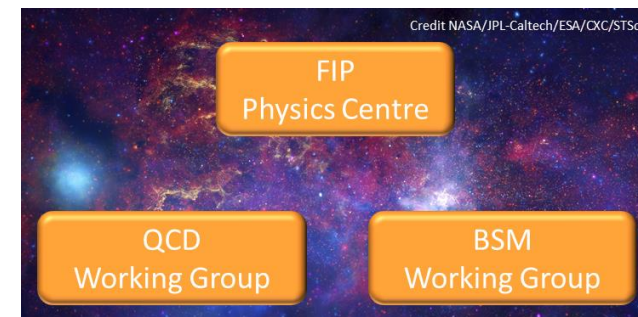
# Physics Working Groups

- **QCD WG:** NA61 (2D scan and very low energy), AMBER (programme with RF-separated beams), LHCb-FT (LHCSpin, double crystals), ALICE-FT, NA60++
- **BSM WG:** NA64(h) and NA64( $\mu$ ) phase 2, NA62++/KLEVER(High-I  $K^{+,0}$  beams) and NA62-BD (post-LS3), SHADOWS, SHiP, TauFV, AWAKE++ (with SHiP@CNGS), LHC-LLP (FASER phase2, FORMOSA, Flare), MATHUSLA, ANUBIS, CODEX-b, Neutrino projects (ENUBET/NuTag), AION, Gamma Factory, EDM Prototype ring, Fundamental Physics at AD/ISOLDE/nTOF
- **FPC (FIPs PHYSICS CENTER):** A panel of theorists covering a large spectrum of new theoretical directions, representatives of worldwide FIPs-related experimental communities, LHC-LLP group, beam dumps outside CERN, axions, DM direct detection, quantum sensors, neutrino experiments, astro-particle and cosmology, representatives of the FIPs-related experiments of the PBC BSM group

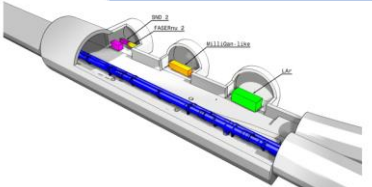
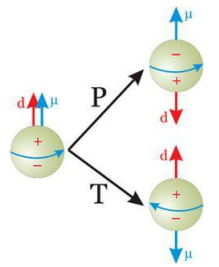
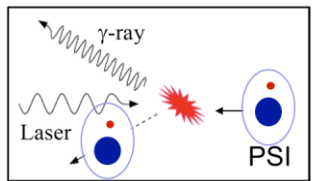
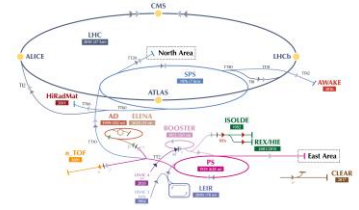
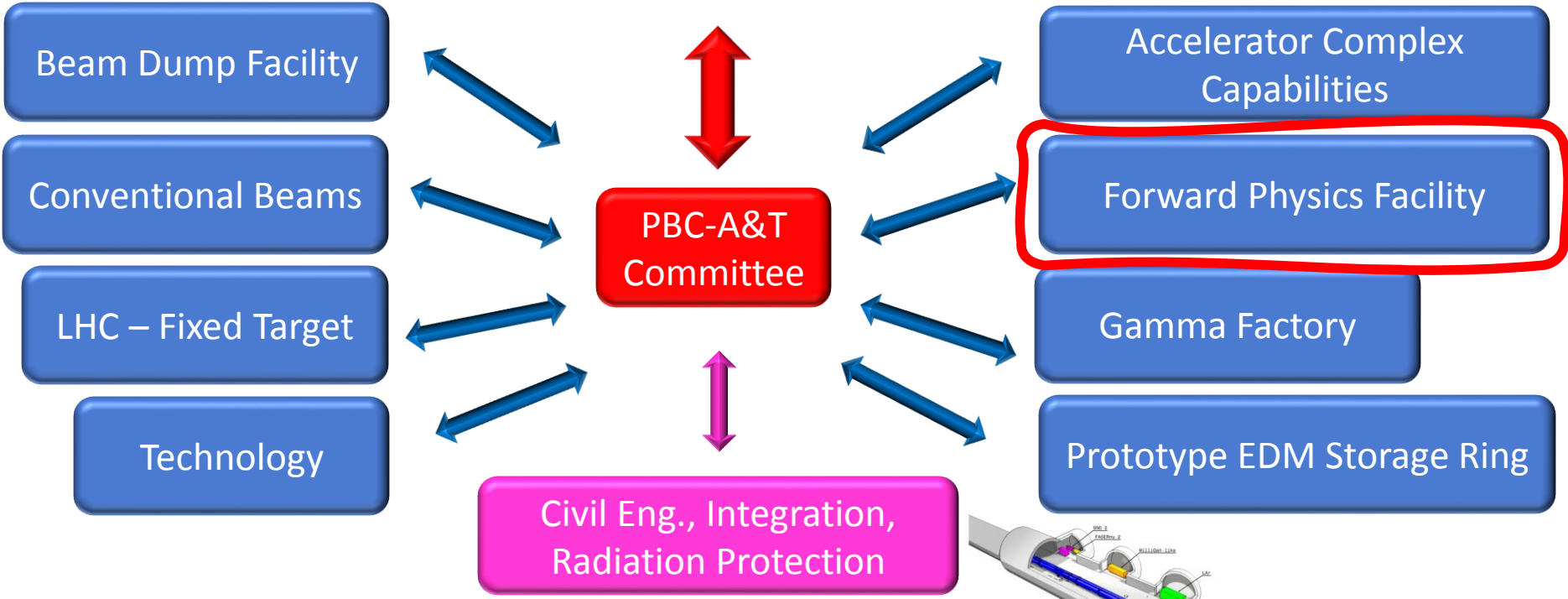
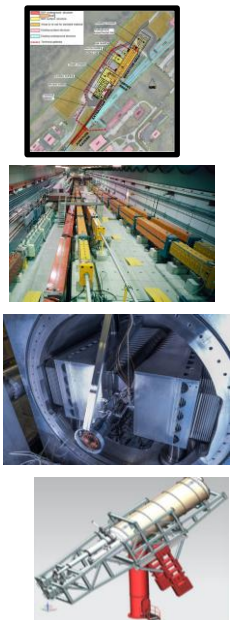
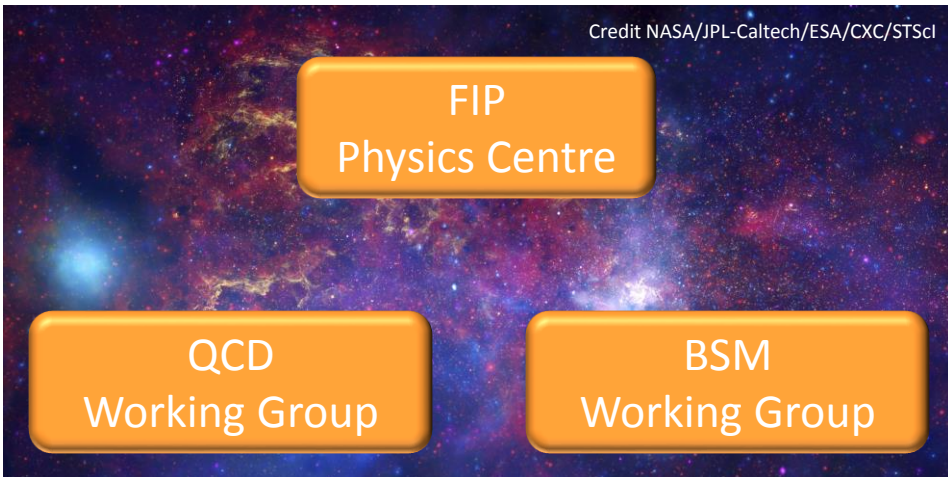
## Representatives of the Forward Physics Facility in the Physics Working Groups

**BSM:** J. Feng (FPF and FASER 2), A. de Roeck (FORMOSA), S. Trojanowski (FLArE)

**QCD:** F. Kling (forward neutrinos)



# Organization – 2021





# Forward Physics Facility WG

- Building up on the **successful approval & installation of FASER and SND** in LHC with the support of PBC



- Broad Physics Programme covering **several PBC Benchmark Models as well as SM physics with forward neutrinos**

Benchmark Model	Underway	FPF	References
BC1: Dark Photon	FASER	FASER 2	Feng, Galon, Kling, Trojanowski, 1708.09389
BC1': $U(1)_{B-L}$ Gauge Boson	FASER	FASER 2	Bauer, Foldenauer, Jaeckel, 1803.05466 FASER Collaboration, 1811.12522
BC2: Dark Matter	-	FLArE	Batell, Feng, Trojanowski, 2101.10338
BC3: Milli-Charged Particle	-	FORMOSA	Foroughi-Bari, Kling, Tsai, 2010.07941
BC4: Dark Higgs Boson	-	FASER 2	Feng, Galon, Kling, Trojanowski, 1710.09387 Batell, Freitas, Ismail, McKeen, 1712.10022
BC5: Dark Higgs with hSS	-	FASER 2	Feng, Galon, Kling, Trojanowski, 1710.09387
BC6: HNL with e	-	FASER 2	Kling, Trojanowski, 1801.08947 Helo, Hirsch, Wang, 1803.02212
BC7: HNL with $\mu$	-	FASER 2	Kling, Trojanowski, 1801.08947 Helo, Hirsch, Wang, 1803.02212
BC8: HNL with $\tau$	FASER	FASER 2	Kling, Trojanowski, 1801.08947 Helo, Hirsch, Wang, 1803.02212
BC9: ALP with photon	FASER	FASER 2	Feng, Galon, Kling, Trojanowski, 1806.02348
BC10: ALP with fermion	FASER	FASER 2	FASER Collaboration, 1811.12522
BC11: ALP with gluon	FASER	FASER 2	FASER Collaboration, 1811.12522

# Forward Physics Facility WG Mandate



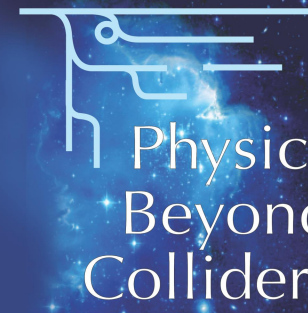
- A Forward Physics Facility at the LHC could house a **suite of experiments enhancing the LHC's potential for both BSM and SM physics** extending the capabilities of the FASER detector installed in the line of sight of the interaction point IP1.
- The Working Group is mandated to provide a **Conceptual Design of the facility** after an analysis of the possible options and taking into account the impact on the LHC Machine during construction and installation and the HL-LHC operational scenario.

**Convener: J. Boyd**

# Forward Physics Facility WG Objectives



- **Determine the experimental set-up** based on the physics requirements identified by the Physics Working Groups.
- Study the possible **civil engineering scenarios**, their **impact on the LHC machine and its infrastructure**, and study the integration of the experiment in the LHC tunnel.
- **Evaluate the performance** based on the expected HL-LHC operational scenario.
- **Conceptual Design Report** of the facility.



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Looking forward to work with you  
Thank you

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