Civil Engineering Aspects of the Forward Physics Facility

8th Forward Physics Facility Meeting, 21st – 22nd January 2025

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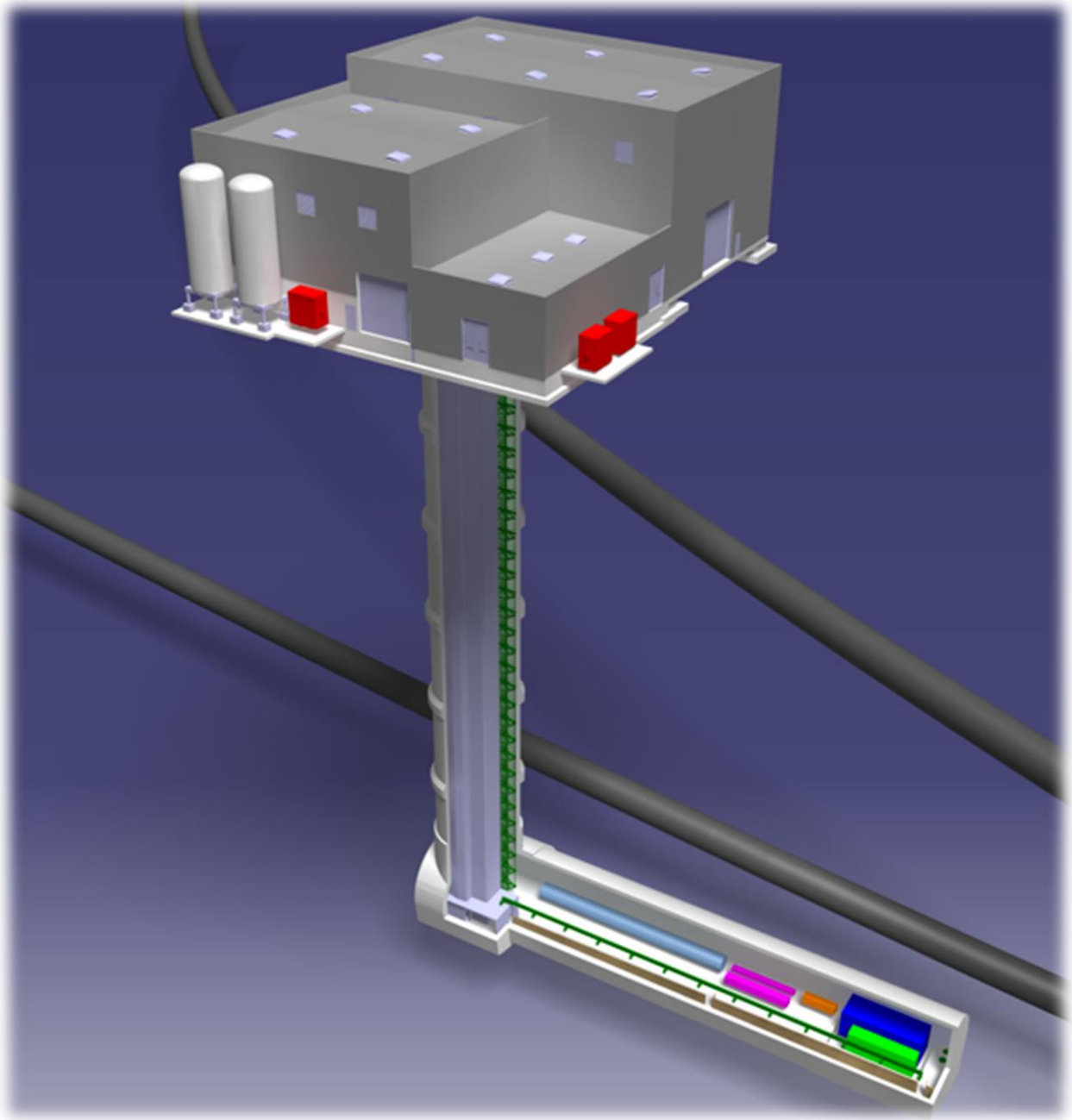
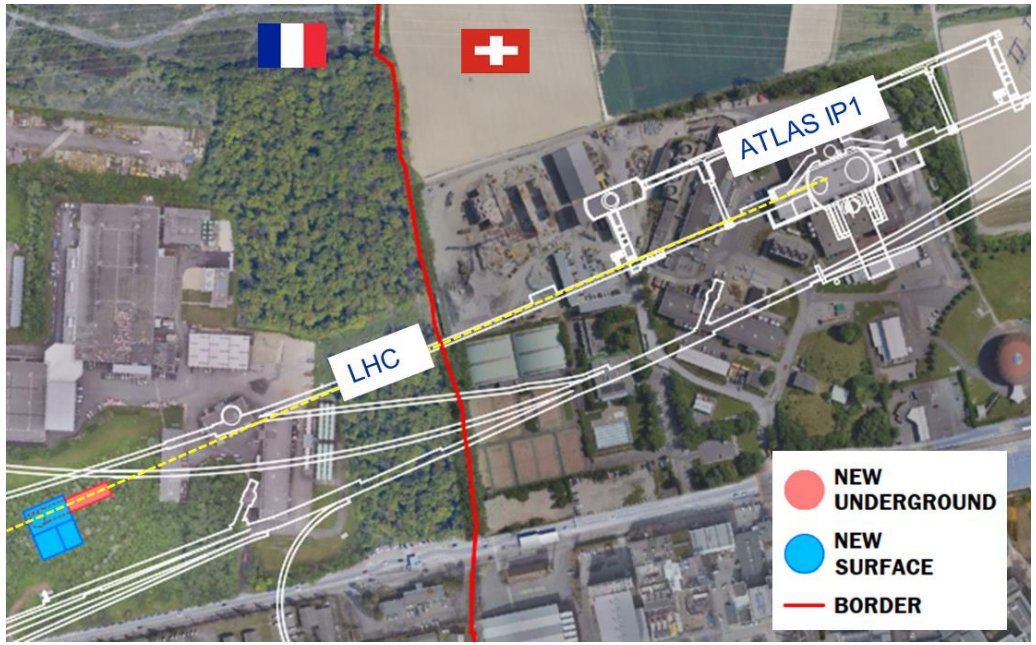
Outline

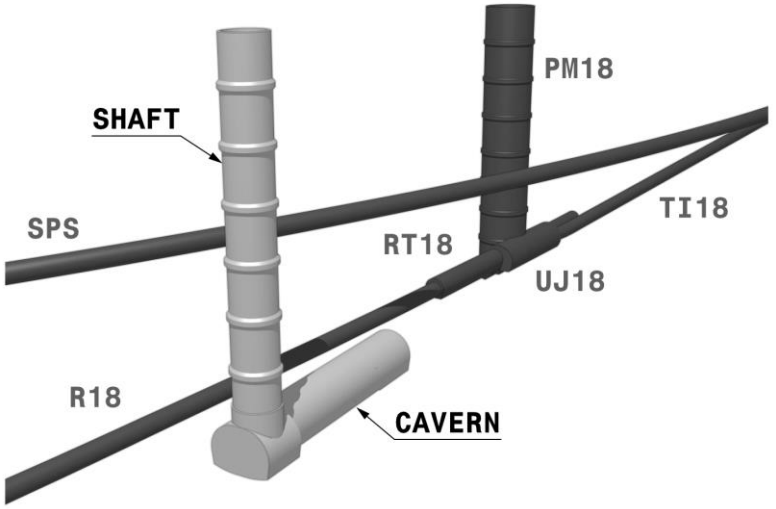
- Overview of Facility
- Site Investigation Works
- Design Update 2024
- Civil Engineering Cost Estimate
- Vibration Study



Project Site

- **Proposed location:** 627m from ATLAS IP1 on the French side of CERN land, 10m away from the LHC tunnel



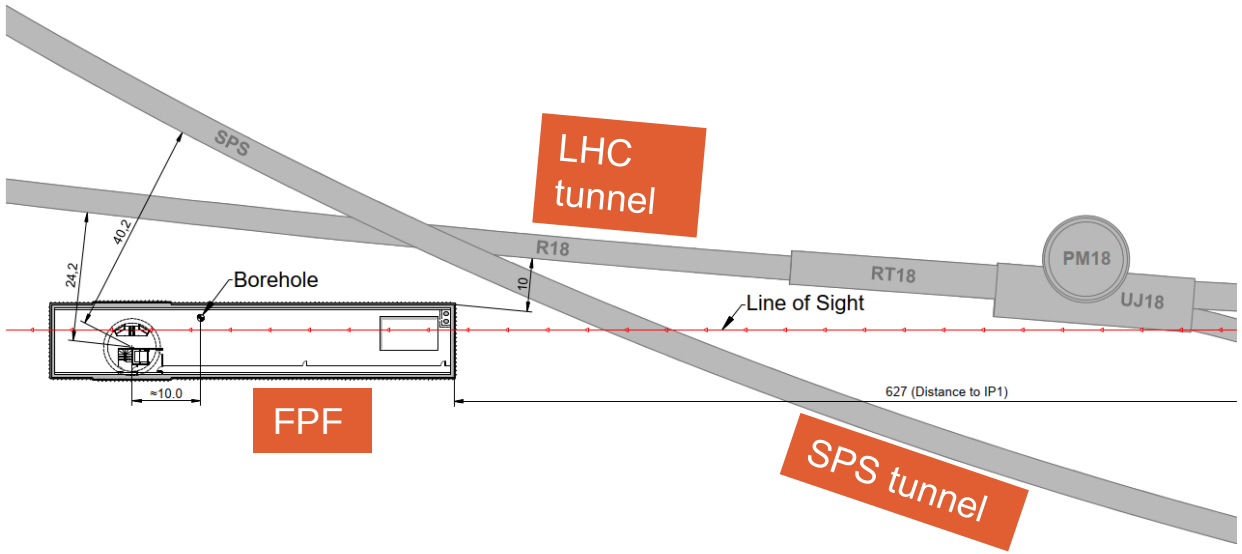


Initial Proposed Design

Purpose built facility

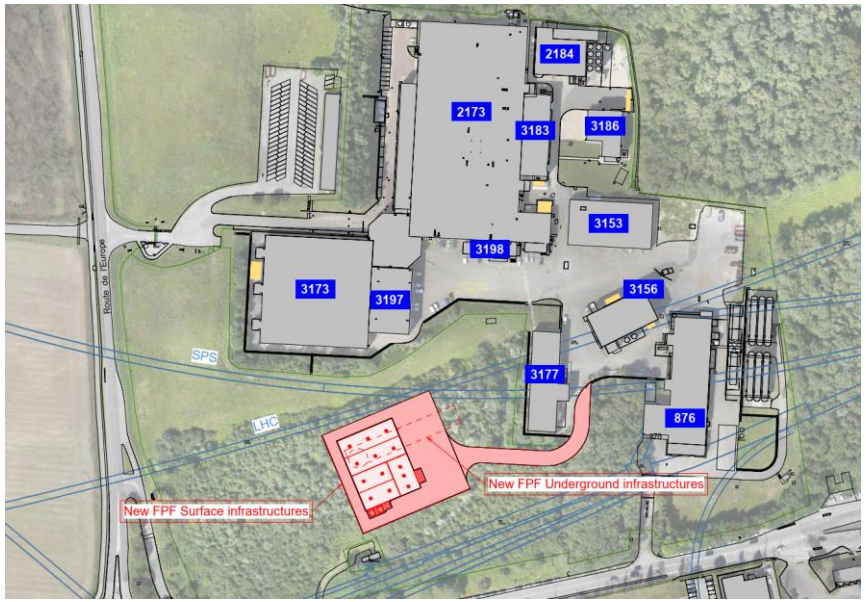
Underground:

- A 75m x 11.8m experimental cavern
- An 84m deep access shaft
- Safety corridor inside the cavern



Above ground:

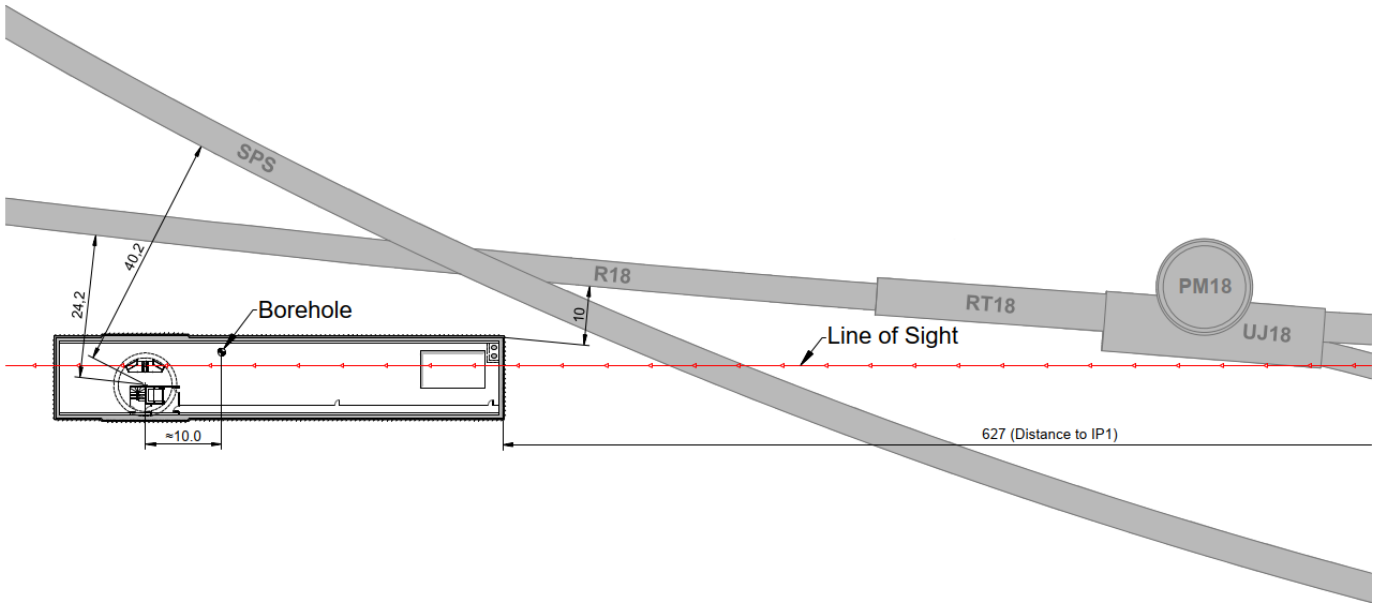
- Access building
- Electrical building
- Cooling & Ventilation building



Forward Physics Facility
Site Investigation Works

- A single new core was drilled the full depth of the proposed shaft, ~100 m deep.
- Shaft located 24m from LHC and 40m from SPS

Position marked by CERN survey team



Forward Physics Facility

Site Investigation Works

- Drilling machine in place

- Works started

- Core samples

Site Investigation Works
Results and Recommendations

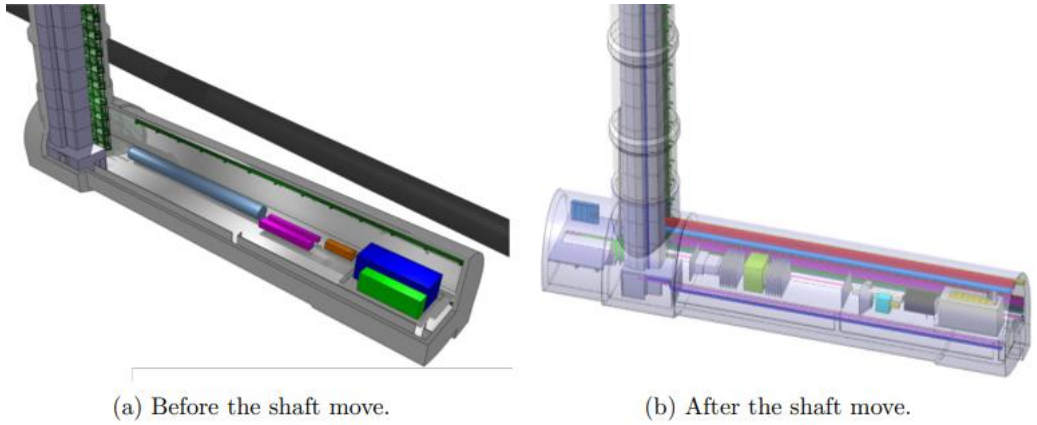
Results	Recommendations
Ground found mostly competent for tunnelling purposes.	N/A
Signs of hydrocarbons were found in the soft sandstone at depths between 84 and 90 m.	1) Excavation material contaminated with liquid hydrocarbons will require specific spoil management. 2) Underground tunnels and works in contact with soils contaminated with hydrocarbons will require specialised waterproofing membrane.
Foundations of the surface buildings will sit within competent moraine.	N/A
No water table has been identified. Overall the ground is not very permeable.	N/A
Vertical swelling test carried out showed a high swelling potential.	Swelling pressures to be considered during the design of the final lining.
Slight elevation of fluoride levels shown in the existing backfill material.	Existing backfill material will need to be disposed of at appropriate facilities.

SUMMARY

- The results of the site investigation were broadly positive
- Favourable ground conditions noted and no water table identified.
- Correct management of hydrocarbons, fluoride, and swelling potential still needed
- can be addressed during the design phase.

Updated Design 2024

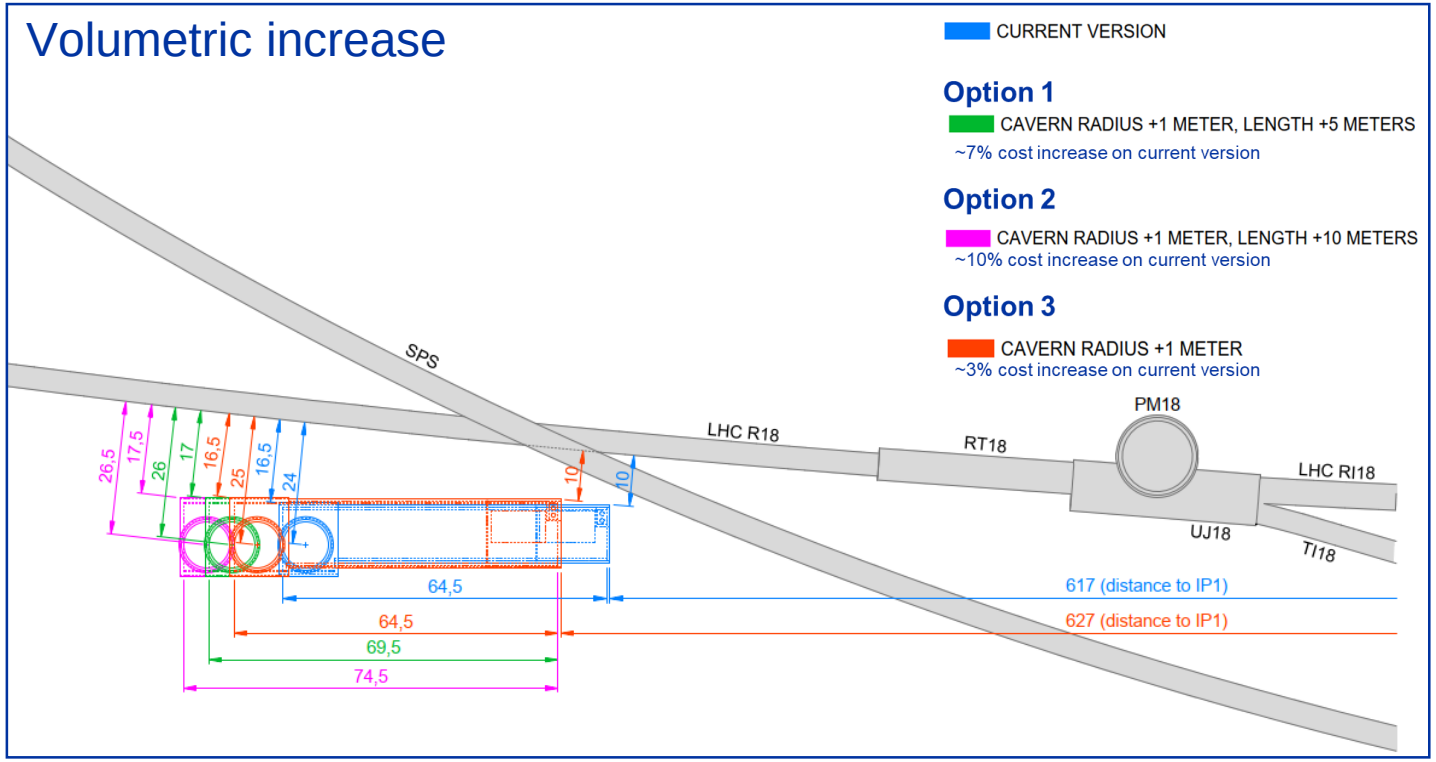
Relocation of shaft



(a) Before the shaft move.

(b) After the shaft move.

Volumetric increase



Design changes were captures in the FPF PBC Note in July 2024

Civil Engineering Cost Estimate

Ref.	Work Package	Cost [CHF]	Percentage of the CE Works
1.	Underground Works	12,392,344.00	35%
1.1	Preliminary activities	1,845,000.00	5.2%
1.2	Access shaft	4,424,143.00	12.5%
1.3	Experimental Cavern	6,123,201.00	17.3%
2.	Surface Works	6,727,231.00	19%
2.1	General items	720,776.00	2.0%
2.2	Topsoil and earthworks	702,227.00	2.0%
2.3	Roads and network	796,122.00	2.3%
2.4	Buildings	4,508,106.00	12.8%
2.4.1	Access building	2,224,786.00	6.3%
2.4.2	Cooling and ventilation building	1,497,350.00	4.2%
2.4.3	Electrical Building	563,689.00	1.6%
2.4.5	External platforms	222,281.00	0.6%
3.	General items	11,815,899.00	33.4%
4.	Miscellaneous	4,397,504.00	12.4%
	TOTAL CE WORKS	35,332,978.00	100.0%

Assumptions

1. Services not included
2. Technical galleries not included
3. Cranes not included
4. Access building as a conventional steel portal frame structure with cladding, only one floor
5. CV Building as a reinforced concrete building, only one floor
6. Finished floor level at 450m ASL
7. Sectional doors not included
8. Unit costs are based on a combination of Hi-Lumi (2018), Faser (2018), SPS Tunnel eye enlargement
9. Inflation figures have been taken dating from 2017-T4, with 2021 as the benchmark year

- Latest cost estimate from September 2024 following enlargement of cavern by 10m and 1m radius
- Previous costs were reviewed by external consultants, and adjusted according to advice
- Findings from site investigation has been incorporated
- Inflation since last (2021) estimate
- Previous declared cost estimate was 27.5MCHF

Estimation class 4
Expected accuracy range: L: -10% to -20%
H: +20% to +30%

Vibration Studies

Are vibrations or tunnel movements from the FPF excavation works problematic for beam operations (LHC or SPS)?

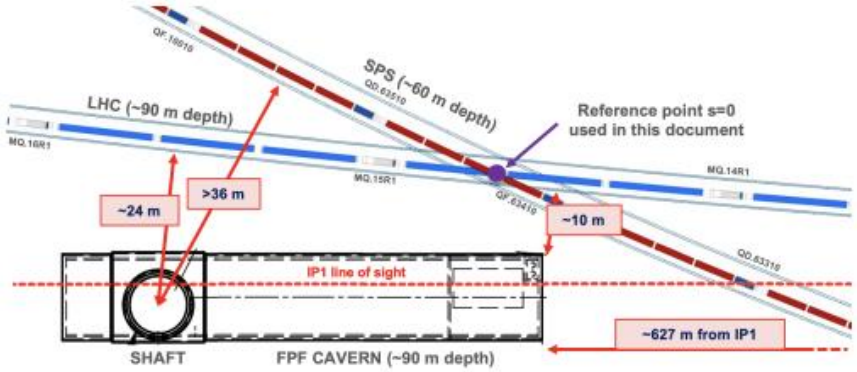
If so this will cause significant constraints on when the FPF could be realized

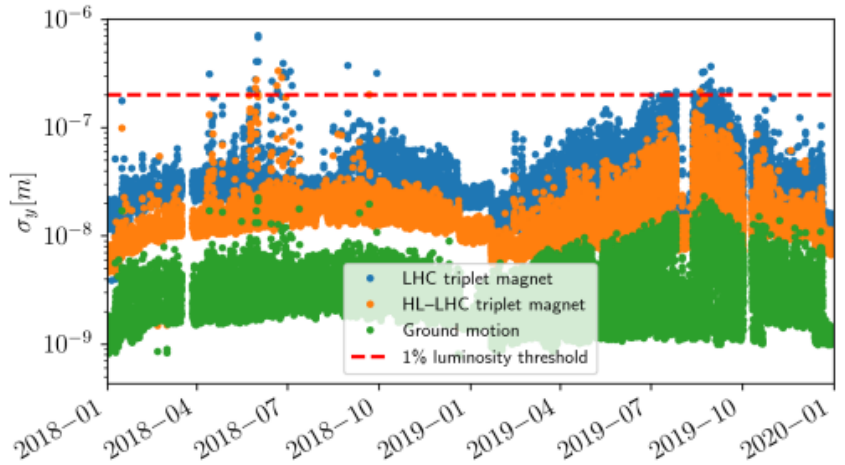
Studies on this led by Davide Gamba (beam physics) with input from different CERN technical groups

Considered:

- Effect of vibrations on beam losses and beam dumps in LHC/SPS
- Effect of excavation on static tunnel movements

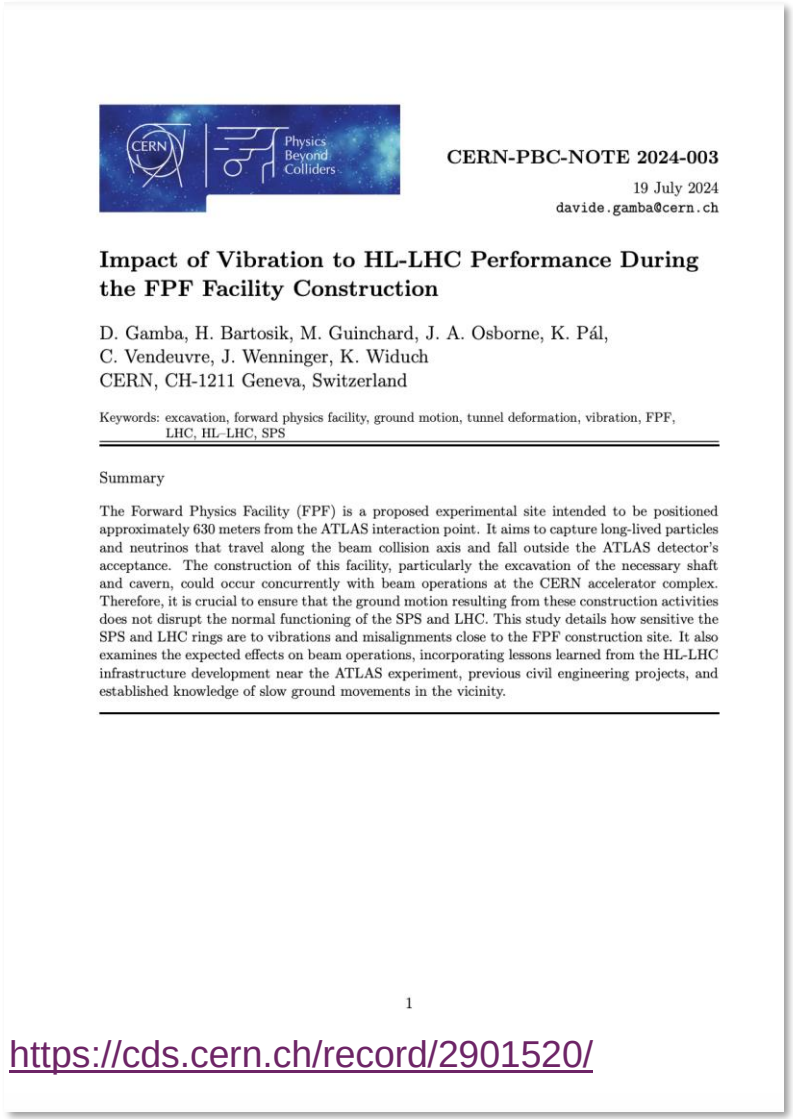
Lots of useful information from studies and measurements related to excavation of HL-LHC galleries close to ATLAS/CMS in 2018 and during LS2





Vertical rms ground motion (green)measured at IP1 in the (3 - 100 Hz). Amplified using simulated HL–LHC (orange) and measured LHC (blue) triplet magnet transfer functions.

Vibration Studies



CERN-PBC-NOTE 2024-003

19 July 2024

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Impact of Vibration to HL-LHC Performance During the FPF Facility Construction

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Keywords: excavation, forward physics facility, ground motion, tunnel deformation, vibration, FPF, LHC, HL-LHC, SPS

Summary

The Forward Physics Facility (FPF) is a proposed experimental site intended to be positioned approximately 630 meters from the ATLAS interaction point. It aims to capture long-lived particles and neutrinos that travel along the beam collision axis and fall outside the ATLAS detector's acceptance. The construction of this facility, particularly the excavation of the necessary shaft and cavern, could occur concurrently with beam operations at the CERN accelerator complex. Therefore, it is crucial to ensure that the ground motion resulting from these construction activities does not disrupt the normal functioning of the SPS and LHC. This study details how sensitive the SPS and LHC rings are to vibrations and misalignments close to the FPF construction site. It also examines the expected effects on beam operations, incorporating lessons learned from the HL-LHC infrastructure development near the ATLAS experiment, previous civil engineering projects, and established knowledge of slow ground movements in the vicinity.

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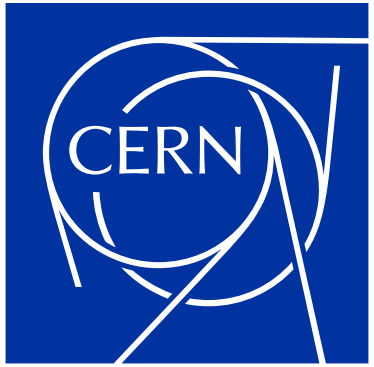
https://cds.cern.ch/record/2901520/

Conclusions:

- Vibration levels / impacts on beam and luminosity production expected to be comparable to those observed during the HL–LHC CE works in 2018 LHC run. No significant effect is expected in the SPS
- No significant tunnel deformations for SPS and LHC tunnels are anticipated
  - Should any arise, likely can be compensated for by orbit correctors or re-alignment
- **Overall, no major disruptions to HL–LHC / SPS performance are expected during the FPF excavation works**
- Specific actions:
  - Detailed structural calculations of the new shaft / cavern will be needed (similar to the studies conducted for the HL–LHC CE works)
  - If FPF excavation activities occur during HL–LHC operations, an alarm procedure to detect excessive vibration levels must be established
    - In the event of excessive vibrations, road headers could be utilized instead of rock breakers as a possible mitigation measure
  - Any ground compaction activity, a known source of strong single-frequency vibration, should be scheduled outside of beam-time periods to minimize disruptions



Thank you!

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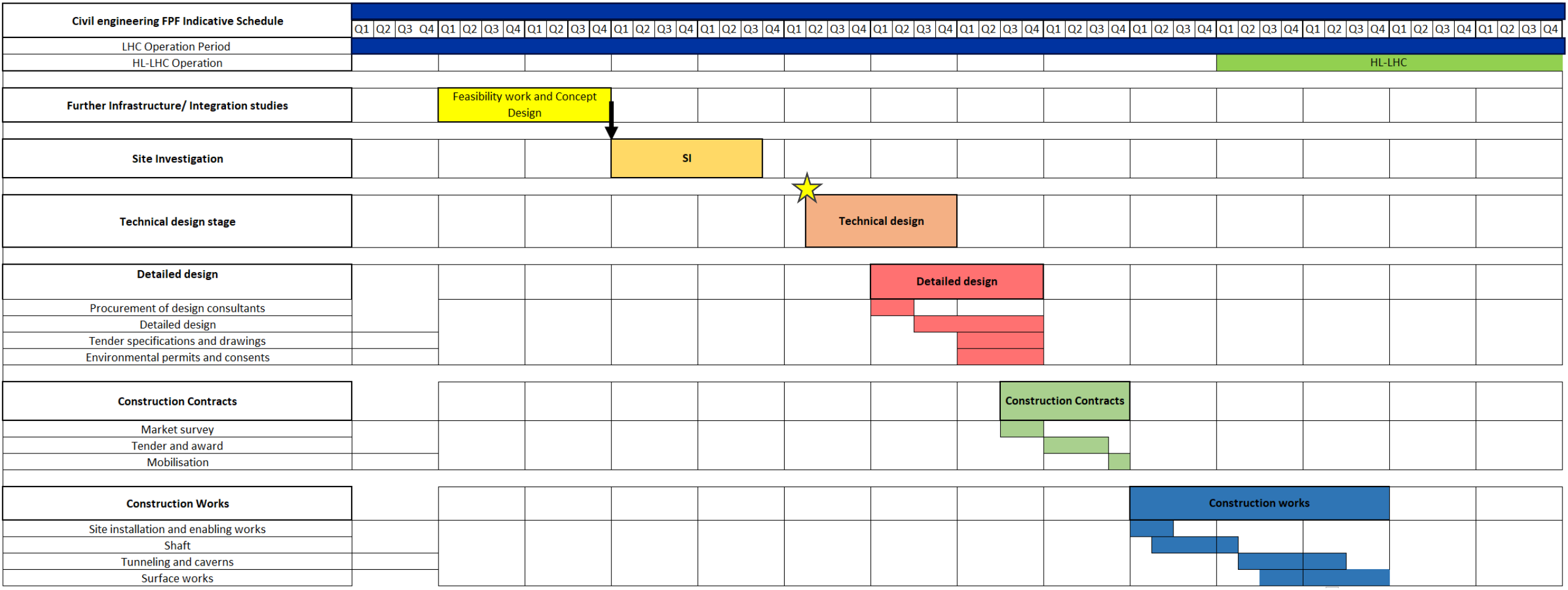
Proposed Civil Engineering Schedule



NB Very early stage estimate for schedule

Design must be frozen before technical design can begin