FCC-ee large scale project installation planning: challenges & proposals

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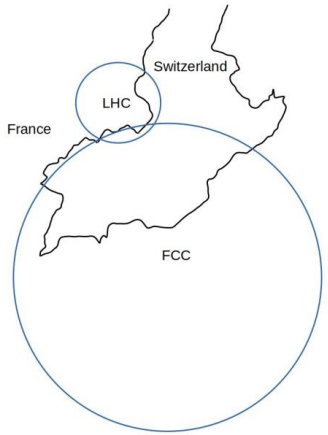
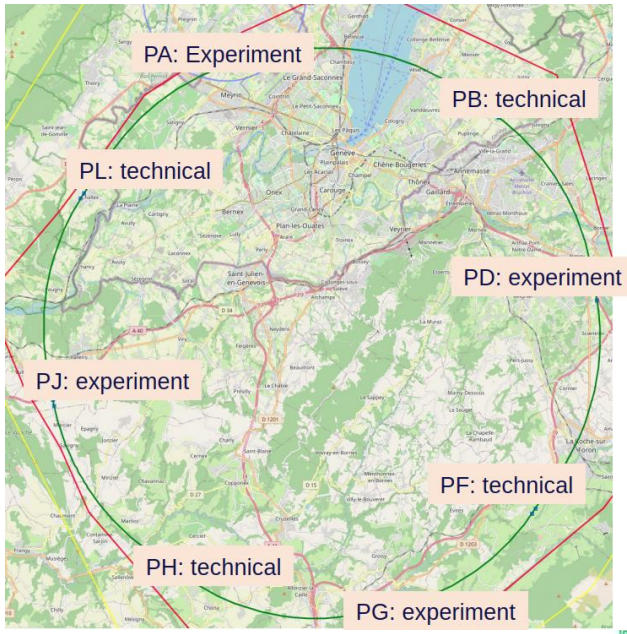
Outline

- FCC study presentation
- Layout and integration evolution
- Civil engineering input
- Equipment to install
- Sector sequence
- Overall planning output
- Overlook

The Future Circular Collider

Multi-stage collider inspired by LEP-LHC program





Courtesy of M. Benedikt

~ 2045 - 2060
90 – 365 GeV

~ 2070 - 2090
100 TeV

FCC-ee | FCC-hh

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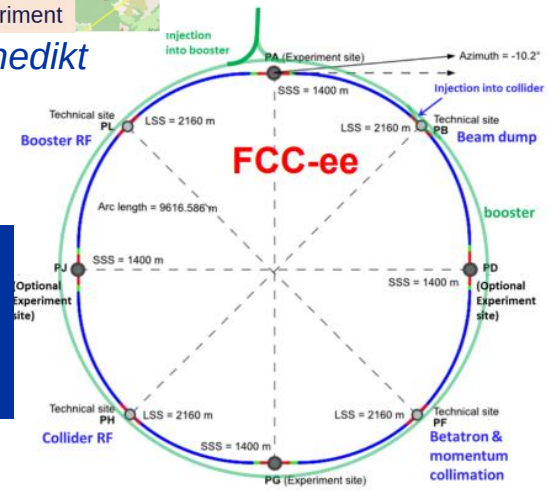
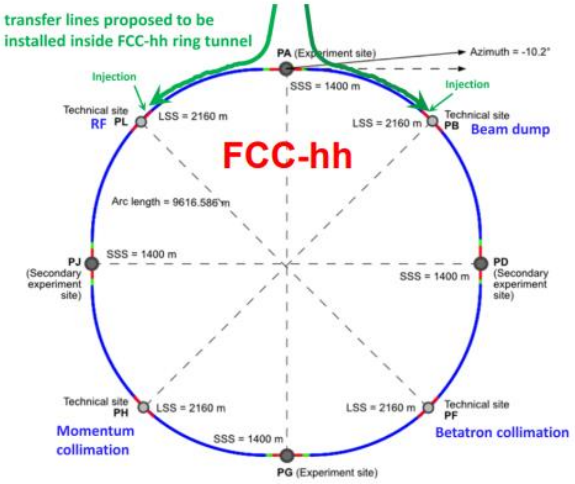


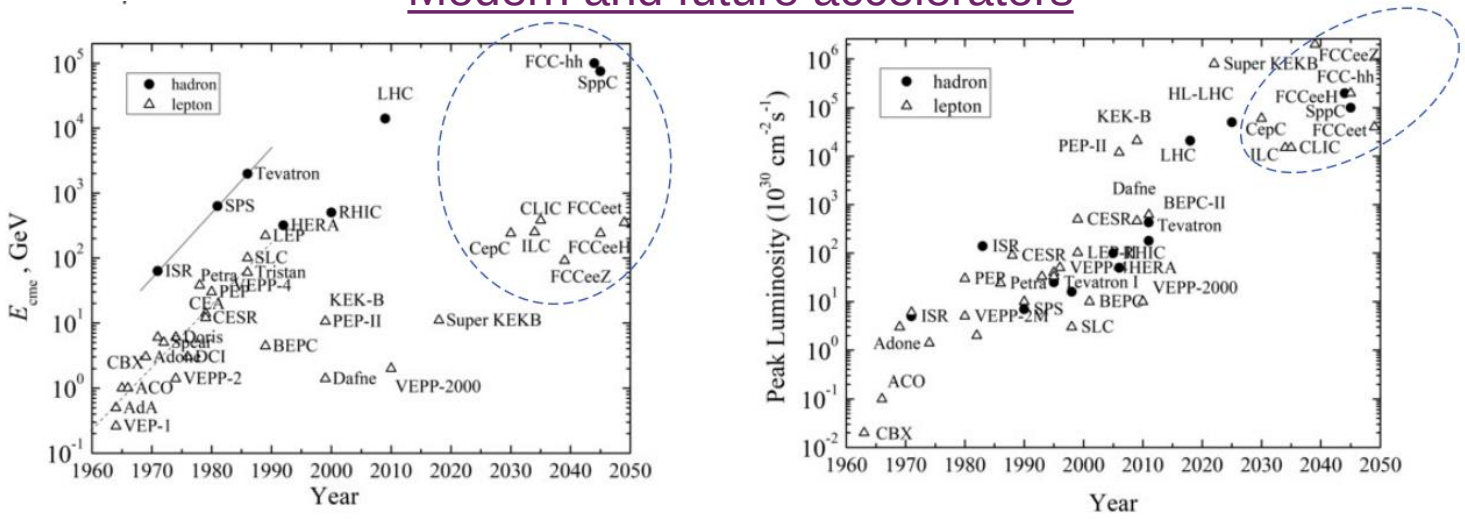


90.7 km with 8 surface points using existing CERN sites and infrastructures

The Future Circular Collider

- **More precision and more energy to sharpen our knowledge and to push the frontier of unknown**

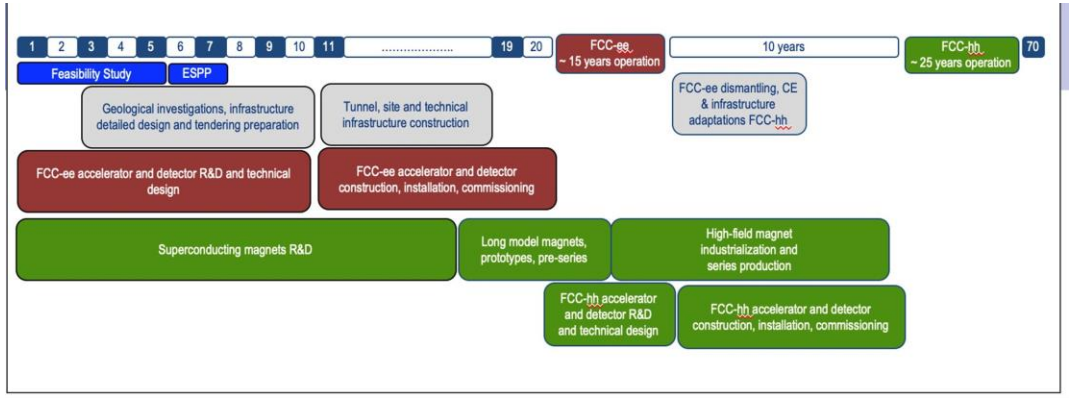
Modern and future accelerators

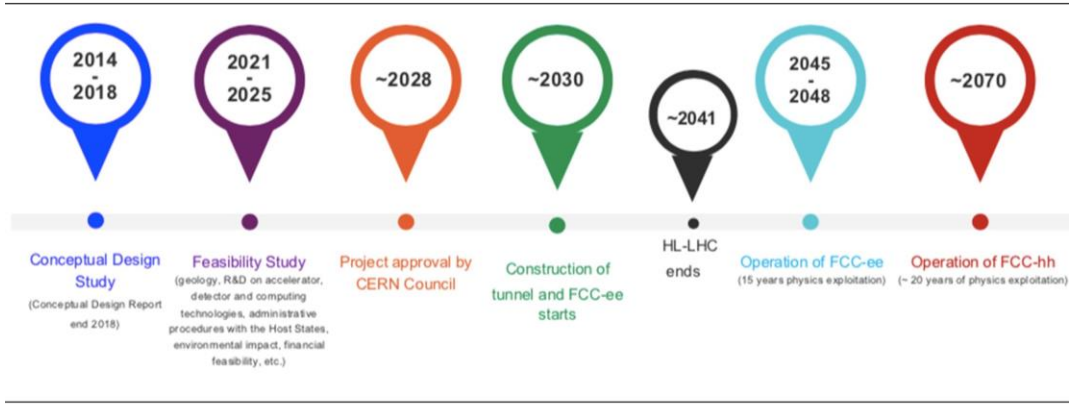


Ref: V. Shiltsev and F. Zimmermann, Rev. Mod. Phys. 93, 015006, 2021.

- **In 2020, the European strategy of particle physics (ESPP) on the long-term plan for particle colliders**
  - An electro-position factory is highest priority
  - Europe should investigate technical and financial feasibility of a future hadron colliders with energy of at least 100 TeV with an electron-position Higgs and electroweak factory as a possible first stage

Milestones from FCC Mid-term review Nov. 2023





1st stage collider, FCC-ee: electron-positron collisions 90-360 GeV
Construction: 2033-2045 → Physics operation: 2048-2063

2nd stage collider, FCC-hh: proton-proton collisions at ≥ 100 TeV
Construction: 2058-2070 → Physics operation: ~ 2070-2095

Main milestones

- Phase I: Conceptual design: end in 2018
- Phase II: Feasibility study from 2021-2025
  → *Mid-Term review end of 2023*
- European Strategy for Particle Physics end of 2027
- Project approval by CERN Council in 2028

Preparatory phase: 2026-2032

Civil engineering milestones

- Study and tendering prior to 2033
- Site preparation of civil engineering areas in 2032
- Start of civil engineering work in 2033

Start of operation

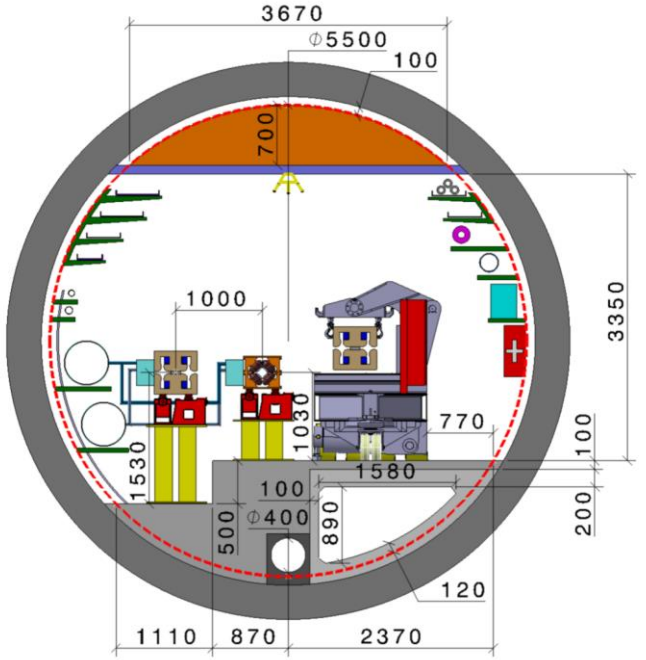
- Foreseen 2045-2048
- **Output date after analysis: 2046**

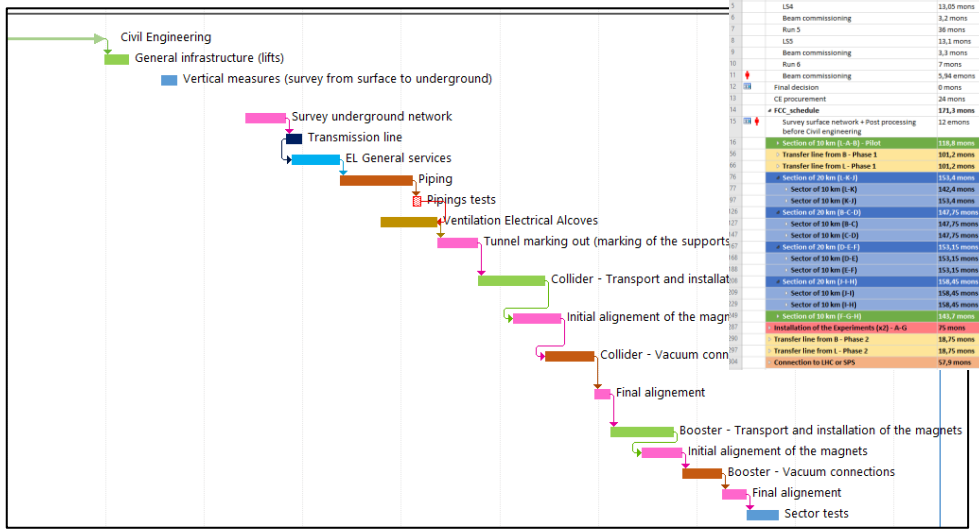
Courtesy of F. Gianotti, FCC Week 2023

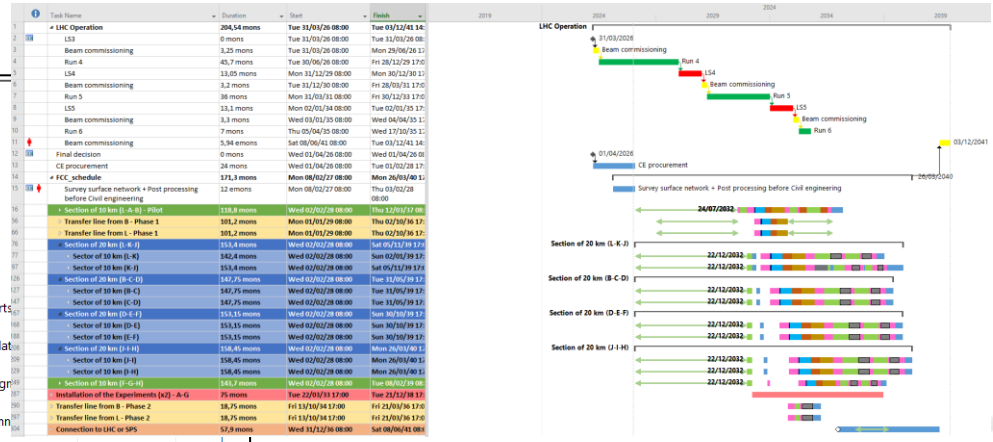
FCC-ee in 2018

First planning version in Phase I

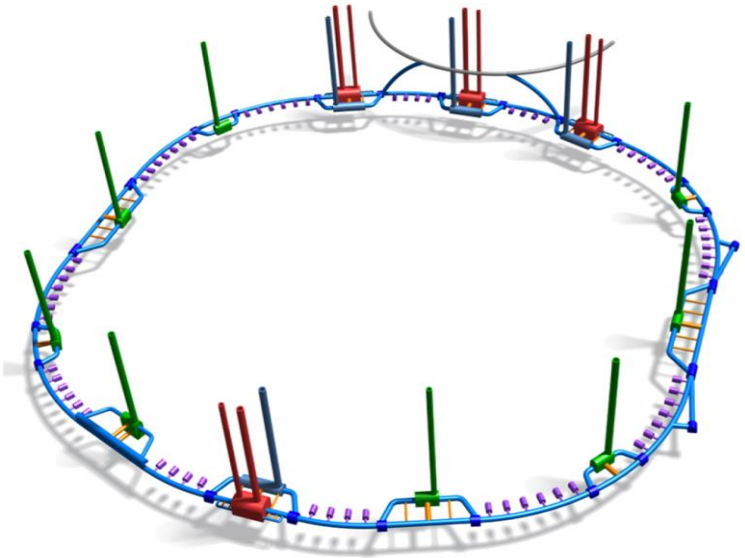
- Horizontal configuration of booster and collider
- 12 shaft access points
- 97.75 km tunnel







FCC-ee planning for the
Conceptual Design Report



FCC-ee evolution: new integration

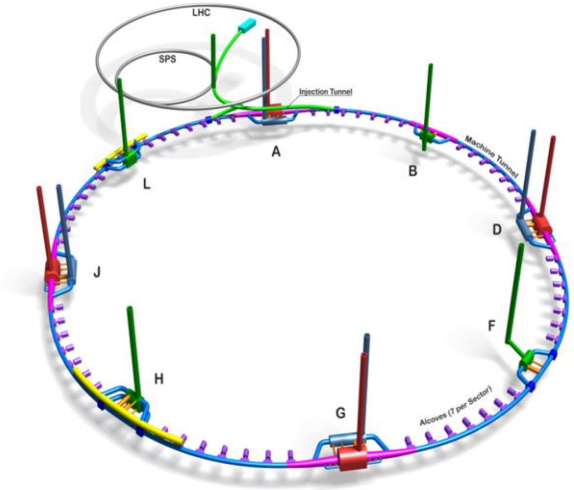
- **Phase II since 2023, new elements to consider:**
  - Reduced number of shaft (12 → 8)
  - 90.7km tunnel: 8 sectors of ~11km

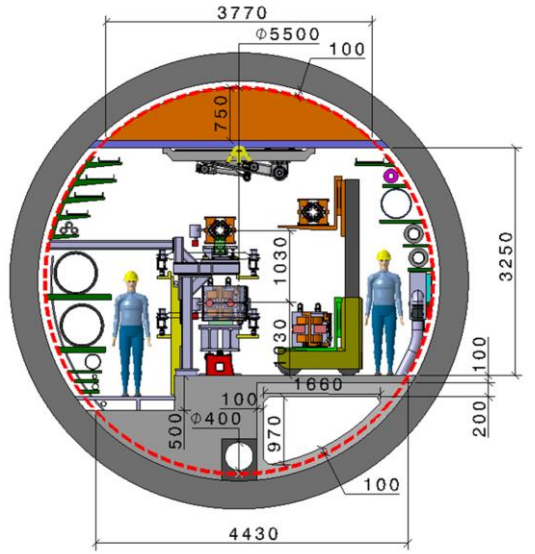
  } Impact on civil engineering schedule

  - New cross section: vertical configuration
  - New equipment specific information

  } Impact on installation

→ Update of the FCC-ee schedule for construction, installation and commissioning

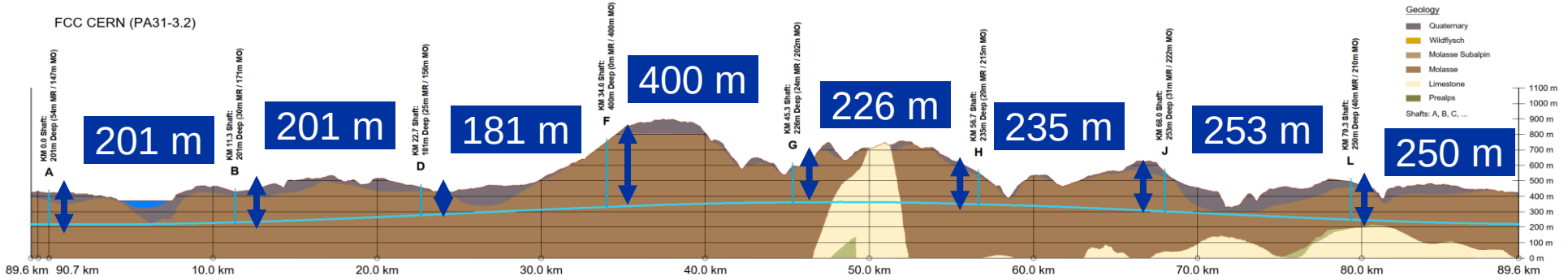




F. Valchkova-Georgieva, J.-P. Corso, and K. Hanke, Challenges and solutions in the integration studies of the future circular collider

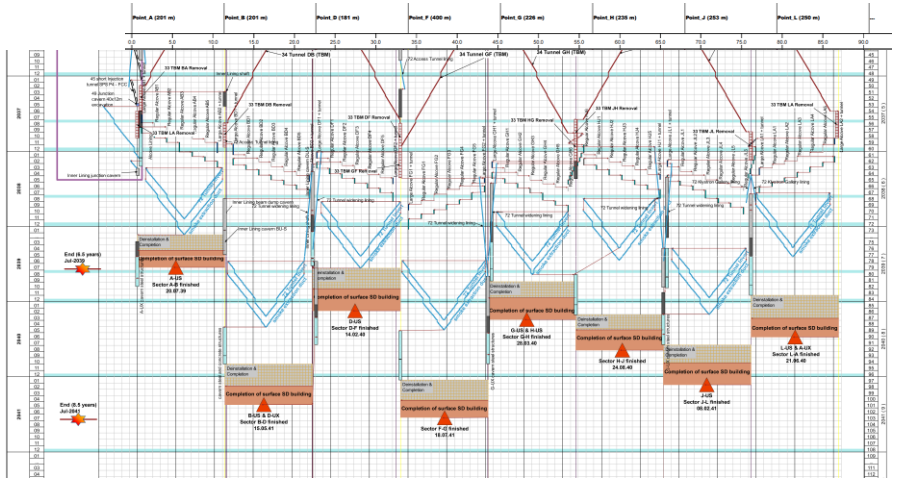
Working Baseline: Civil engineering strategy release

- Underground machine passing through **multiple kinds of geology with 8 access shafts at different depth**



Courtesy of T. Watson

- Civil engineering (CE): from site preparation to tunnel boring
  - 8 [shaft+sector]:
    released in non-sequential order (wrt ground and depth)
  - No access for installation, before the releasing from CE
  - CE activities start in 2032 (site preparation) and end in 2039-2041 (from first sector A-B to the last sector F-G)



FCC-ee equipment to install in the arc

Number of surface sites	8
Surface requirements	~40 ha
LSS@IP (PA, PD, PG, PJ)	1400 m
LSS@TECH (PB, PF, PH, PL)	2032 m
Arc length	9.6 km
Sum of arc lengths	76.9 km
Total length	90.7 km

Initial configuration,
as delivered by civil engineering

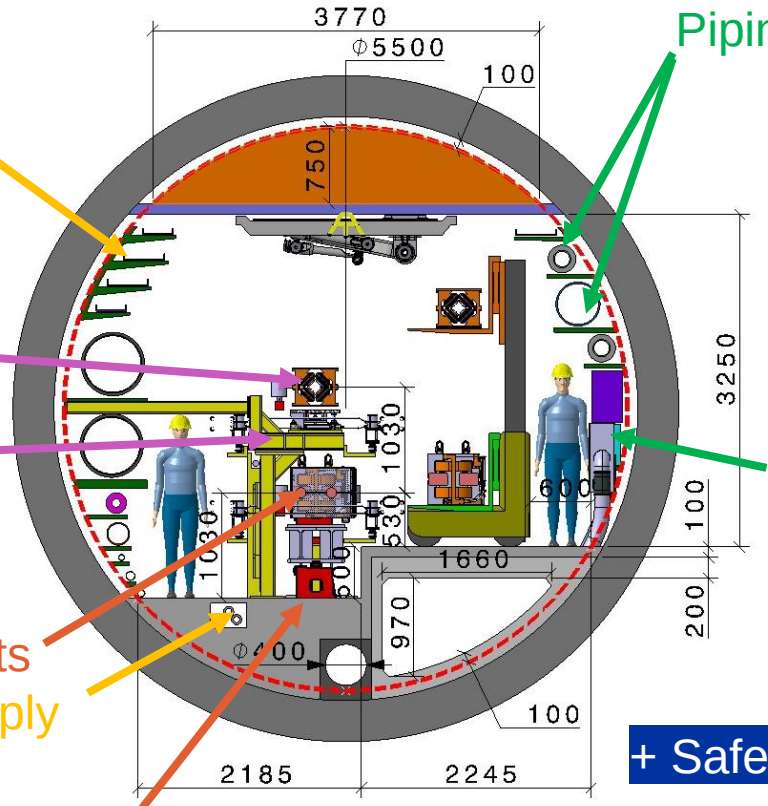
Smoke / He extraction

Fresh air supply

High voltage
cables trench

Drain

Final configuration



Cable trays

Piping

Booster magnets

Booster support

Ventilation
dampers

Collider magnets

Power supply

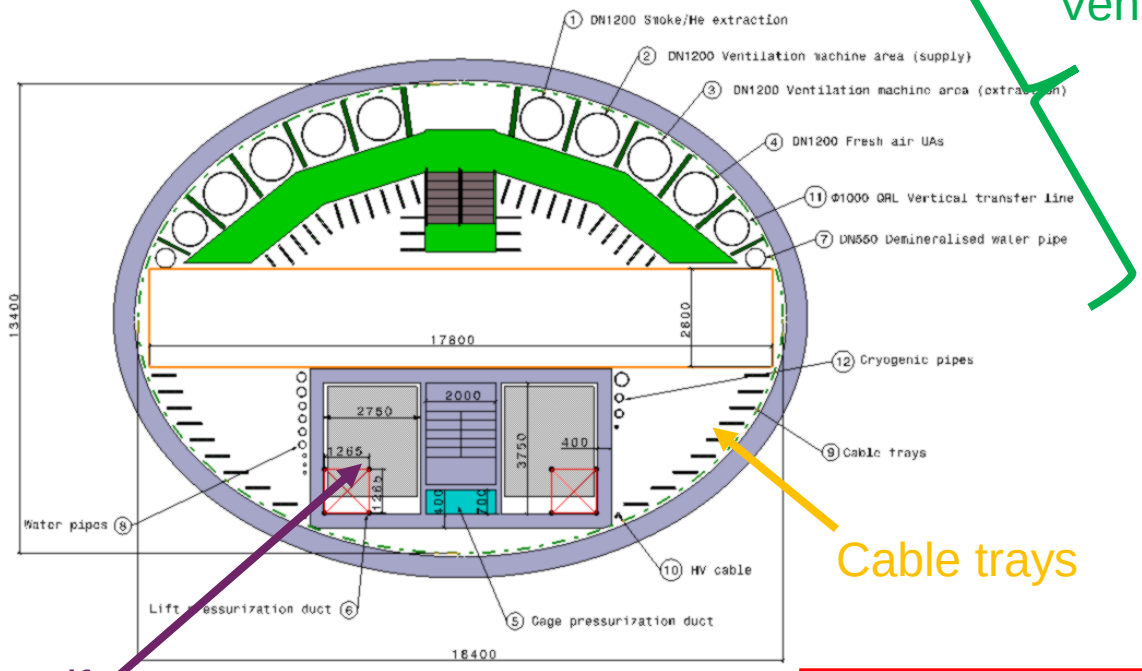
Collider girders

+ Safety equipment

Equipment to install: shaft and alcoves

5 small alcoves
2 big alcoves
per section

Smoke / He extraction
Ventilation & fresh air



Cable trays

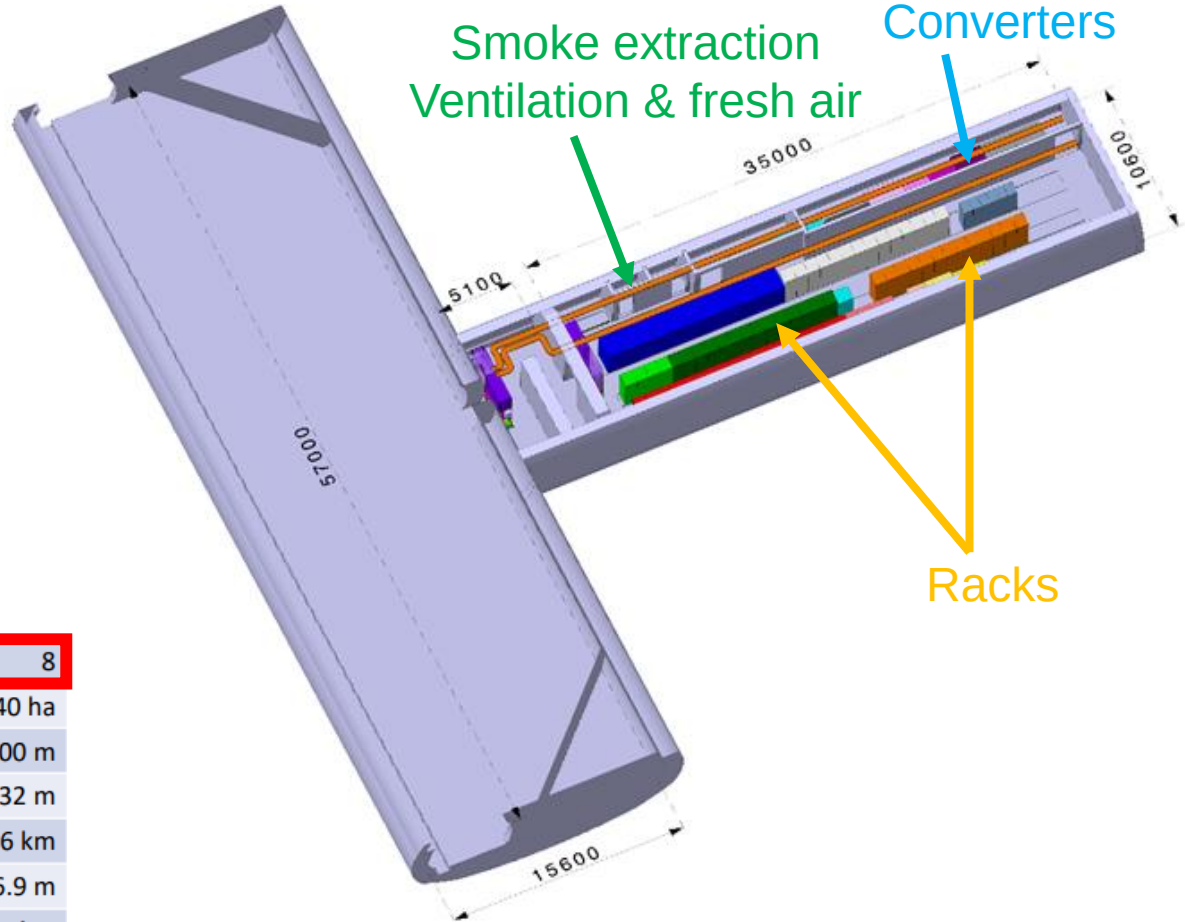
Lift

Experimental shaft point A

Number of surface sites	8
Surface requirements	~40 ha
LSS@IP (PA, PD, PG, PJ)	1400 m
LSS@TECH (PB, PF, PH, PL)	2032 m
Arc length	9.6 km
Sum of arc lengths	76.9 m
Total length	**90.7 km**

Smoke extraction
Ventilation & fresh air

Converters



Racks

Small alcoves with transport layby and safety refuge

Working Baseline: FCC-ee installation sequence

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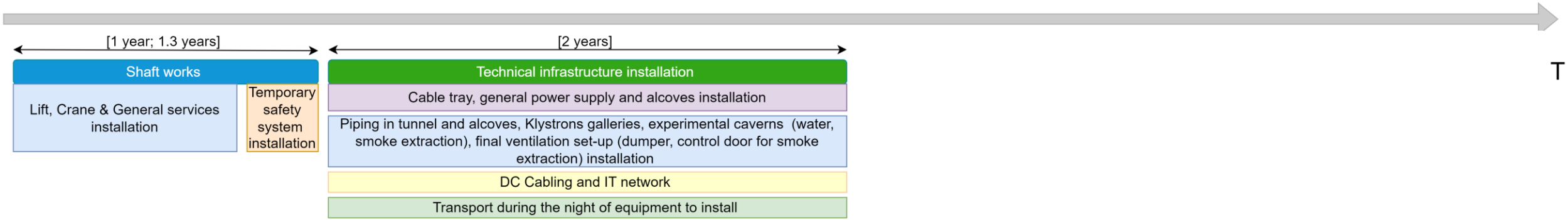
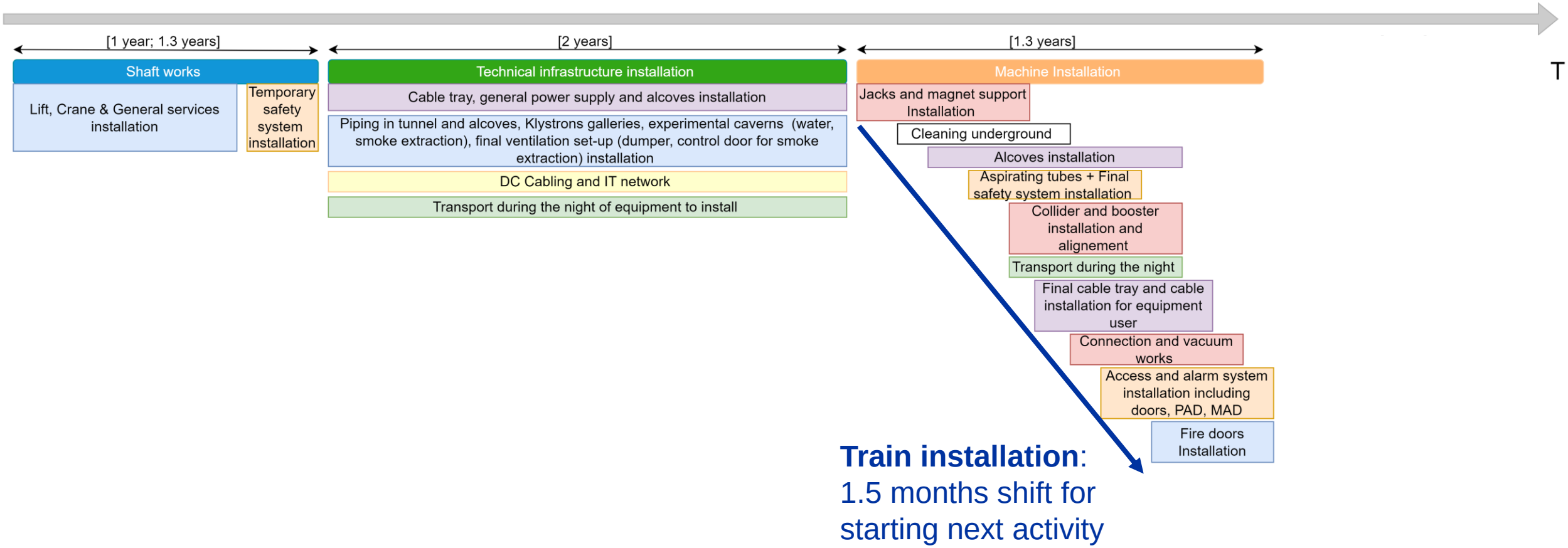
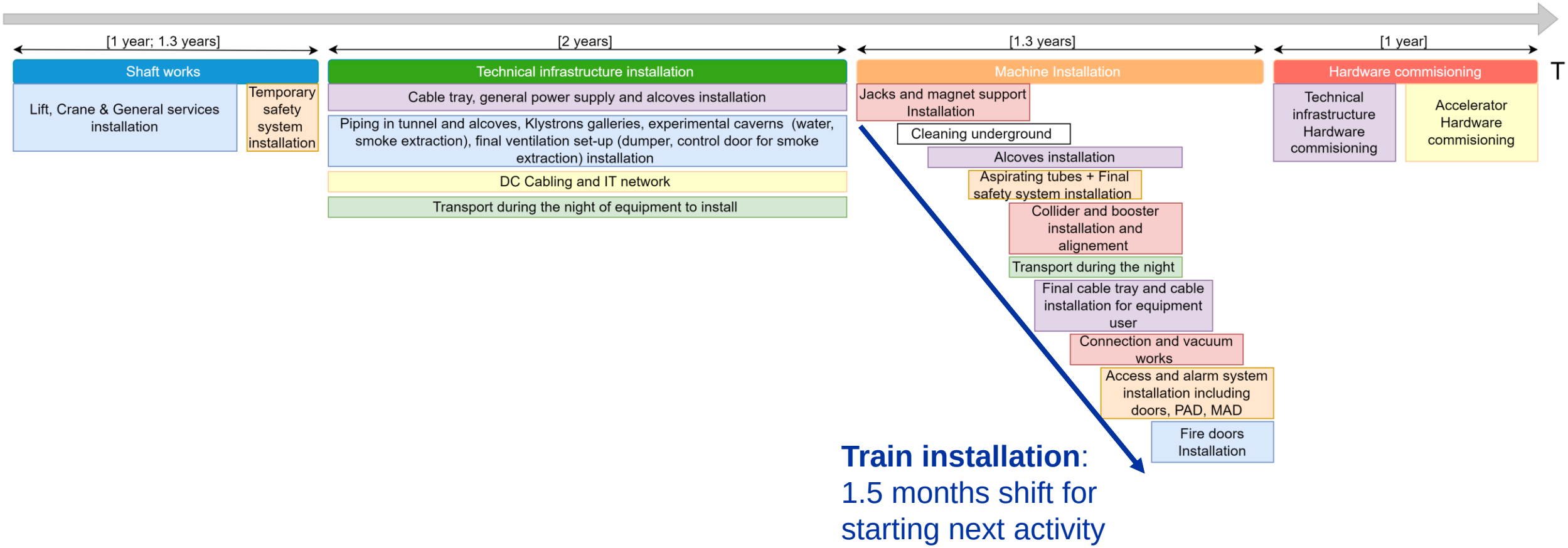


Working Baseline: FCC-ee installation sequence



Train installation:
1.5 months shift for starting next activity

Working Baseline: FCC-ee installation sequence



Train installation:
1.5 months shift for starting next activity

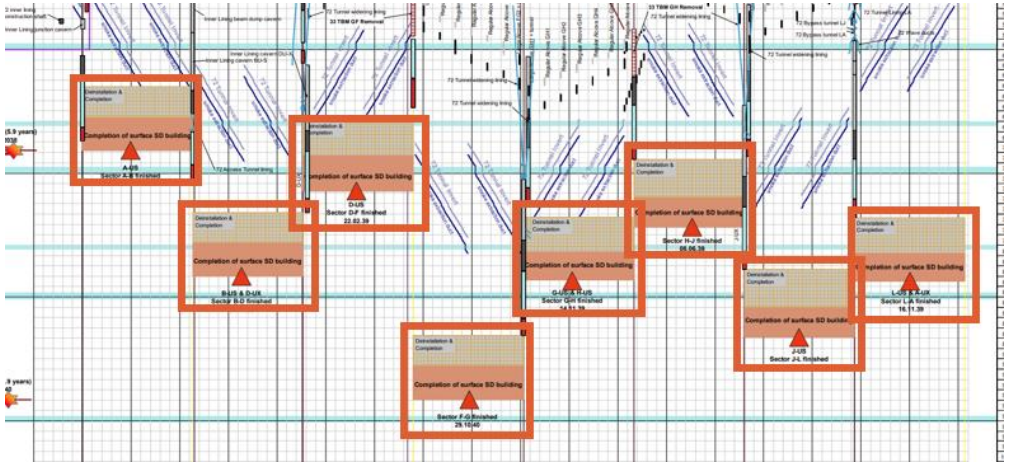
Working Baseline: ventilation

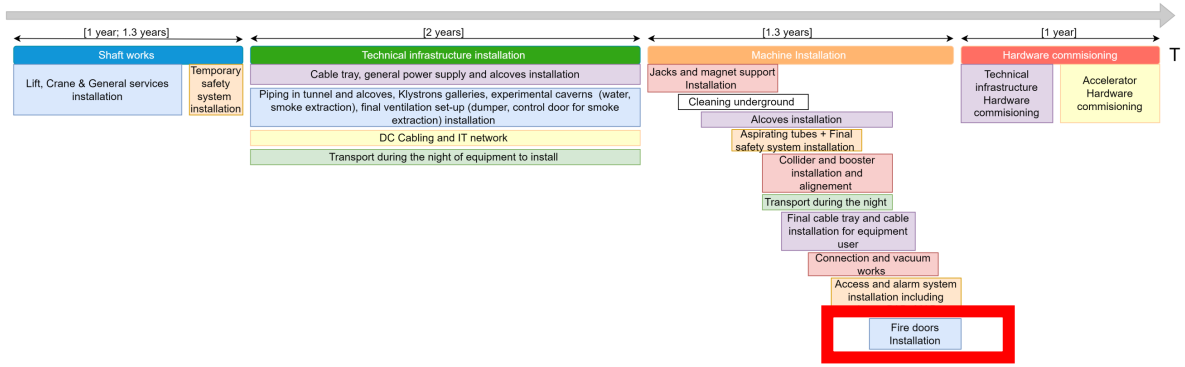
Ventilation configuration set-up during installation (half-sector ventilation principle)

- Shafts release order
- Fire doors needed for final ventilation system, and installed at the end of the sequence

→ Final ventilation system configuration available only at the end of the installation works underground

Ventilation
→ Different operational stages





Working Baseline: ventilation

One shaft sector ventilation

Ventilation with shaft duct and extraction with shaft

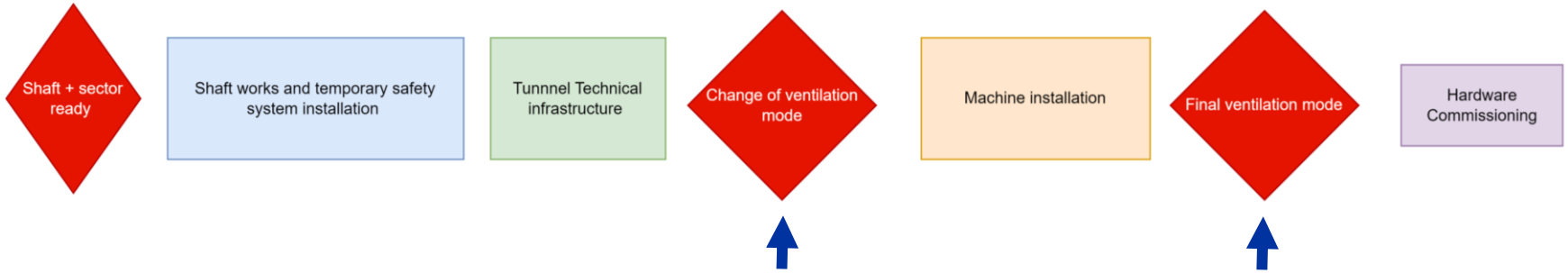
Shaft to shaft ventilation

Ventilation from shaft to shaft

Final system ventilation

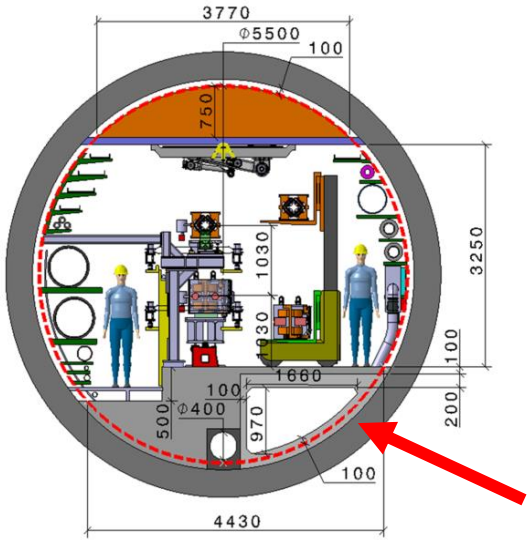
Ventilation with duct and half sector extraction

Shaft A + Sector A-B



Adjacent shaft available

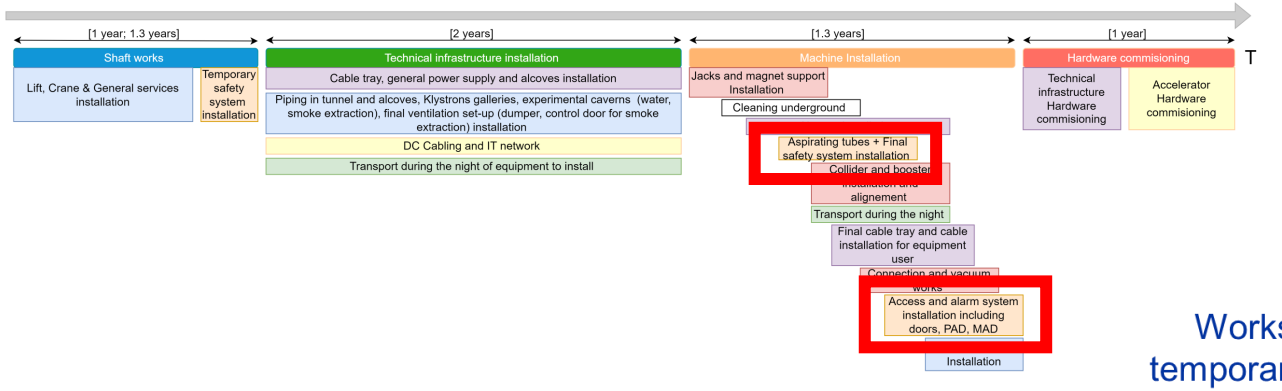
Final ventilation and safety equipment installed

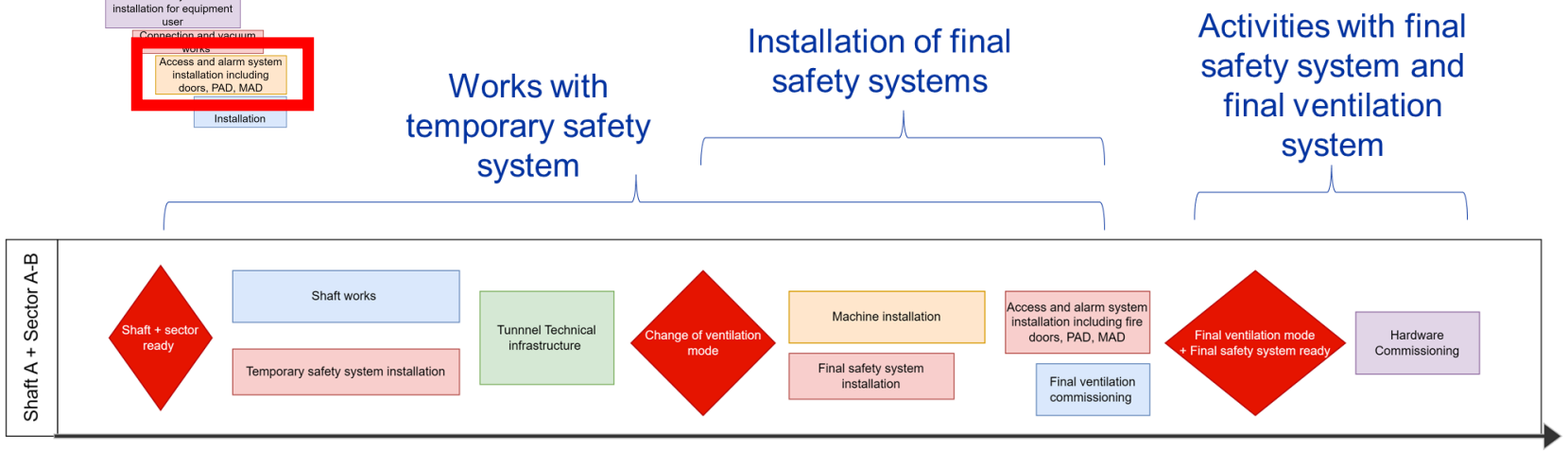


Working Baseline: safety

The final safety systems (fire doors and detectors) cannot be installed and commissioned at the first stages of installation → sensible to dust

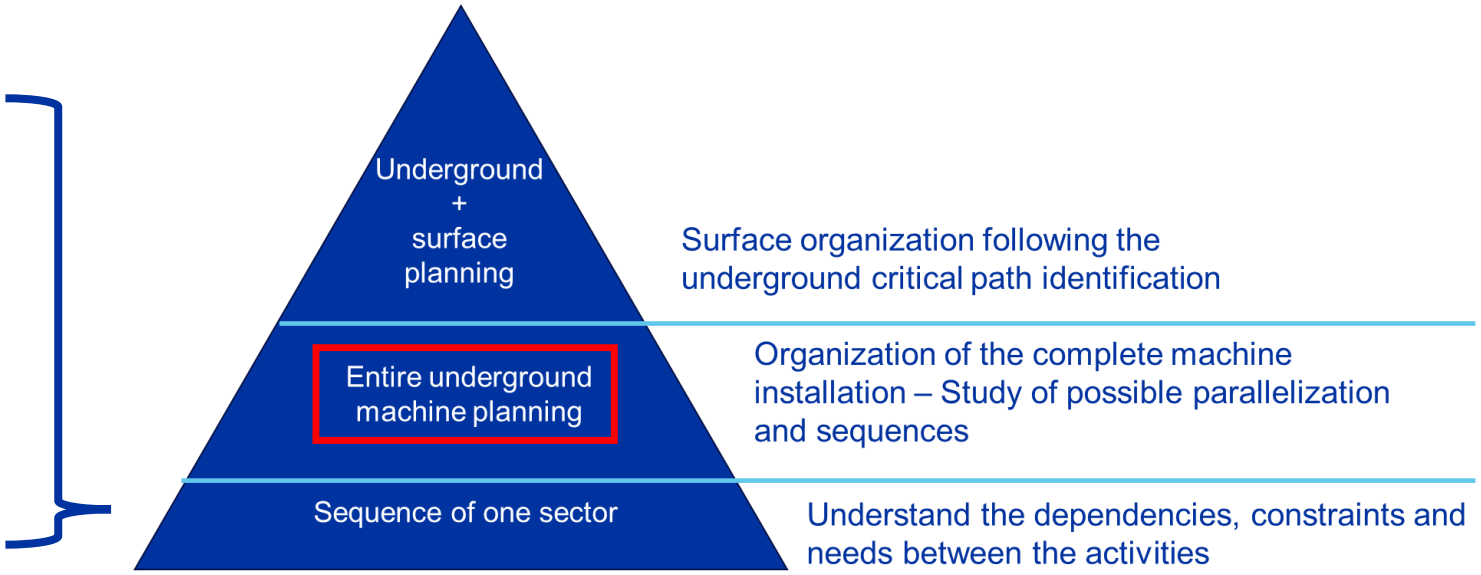
Temporary safety equipment



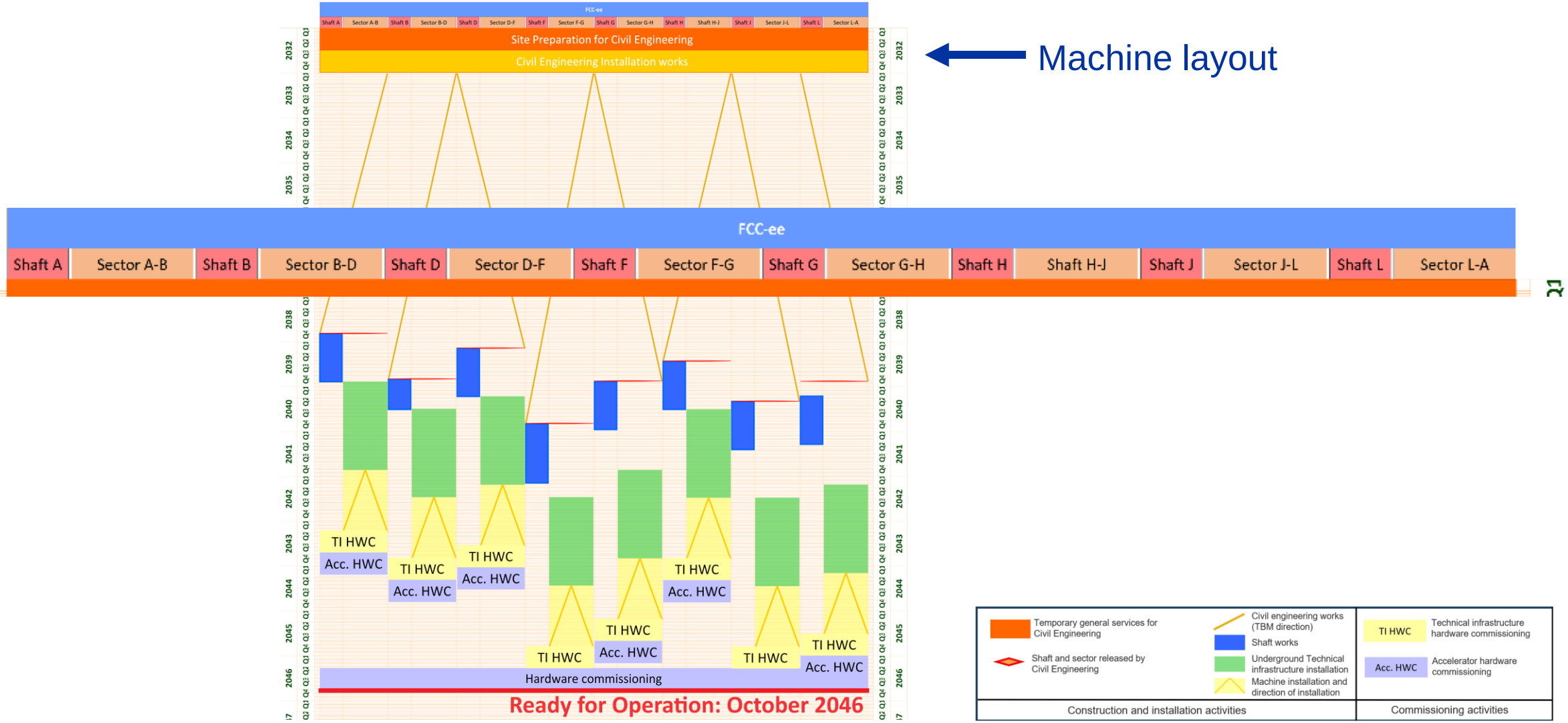


Working baseline: inputs for schedule analysis

- Civil Engineering strategy release
- Safety requirements
- Machine layout
- Equipment to install and locations
- Groups requirement and sequence

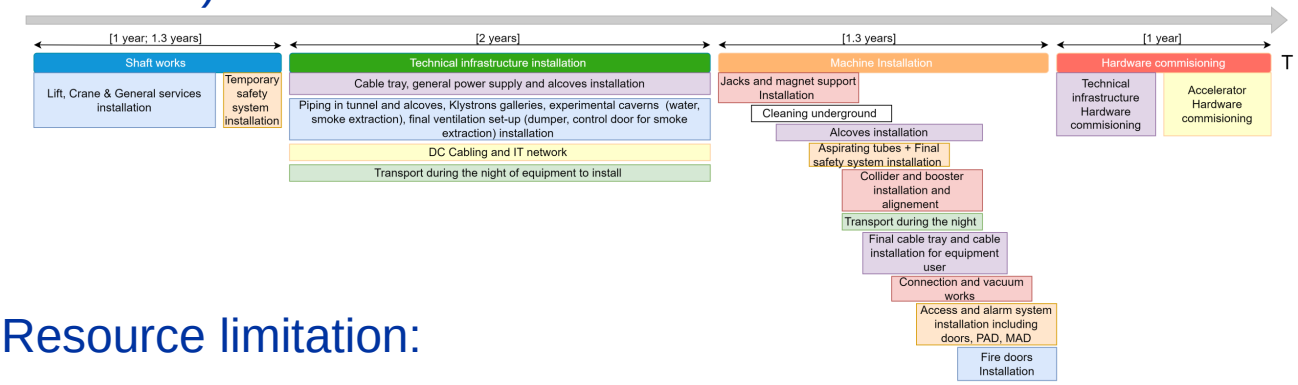


FCC-ee schedule: Layout



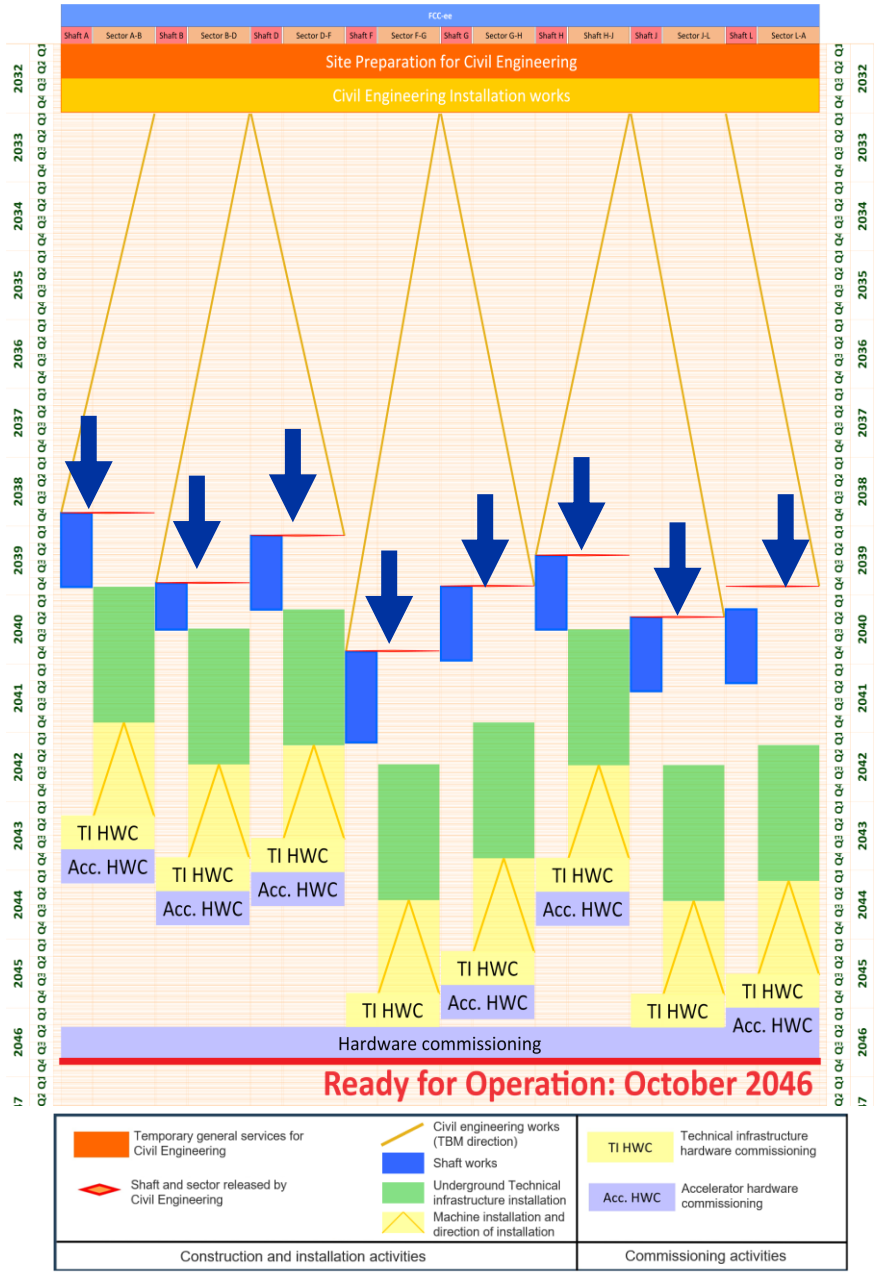
FCC-ee schedule: assumptions

- Bottom-up exercise:
  - The installation sequence for one sector was defined
  - It was used as base for each sector (including the shaft)



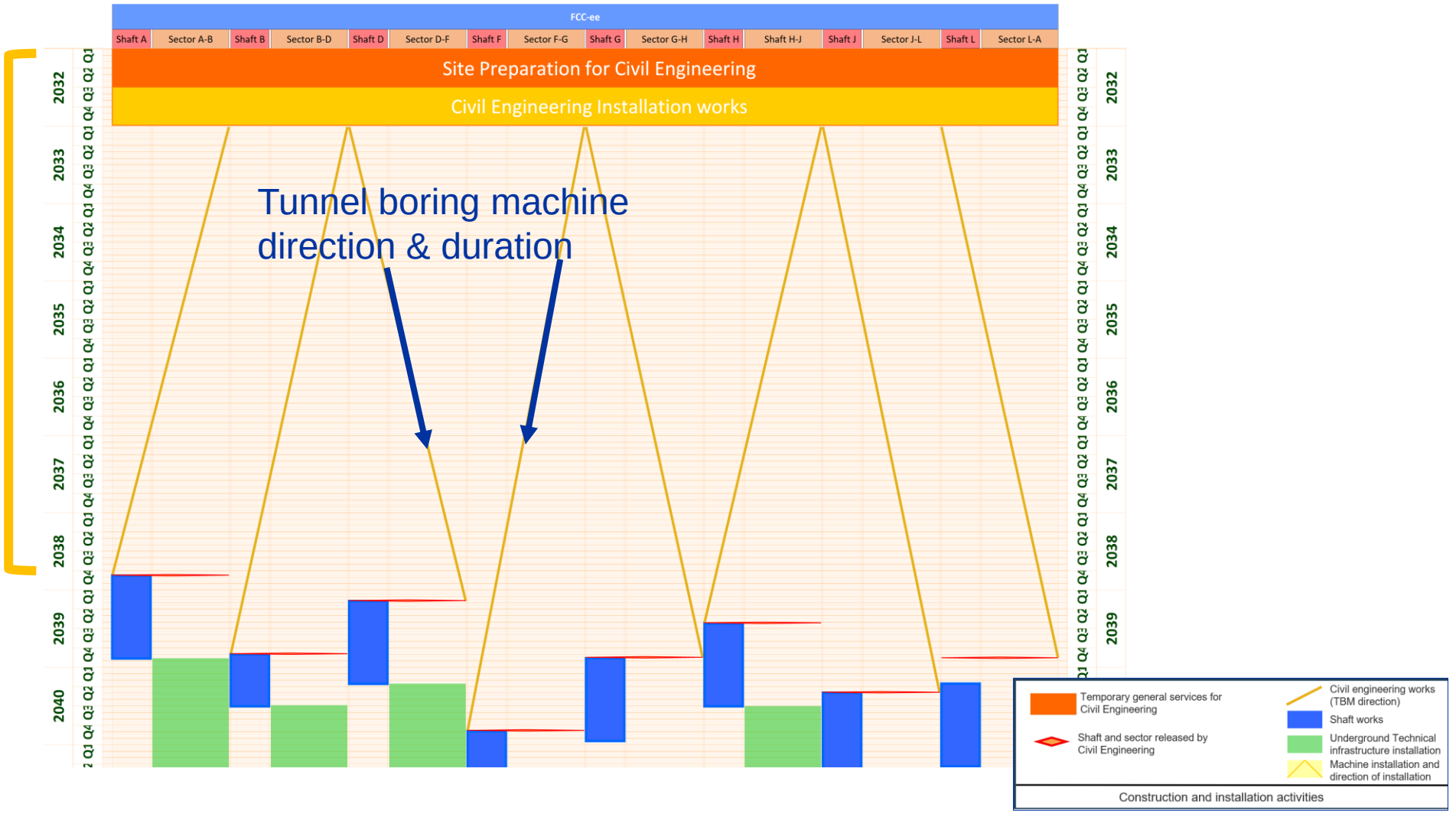
- Resource limitation:
  - Four teams in parallel maximum can work in the machine for the same type of activity

- Safety:
  - Maximum 200 persons at the same time underground



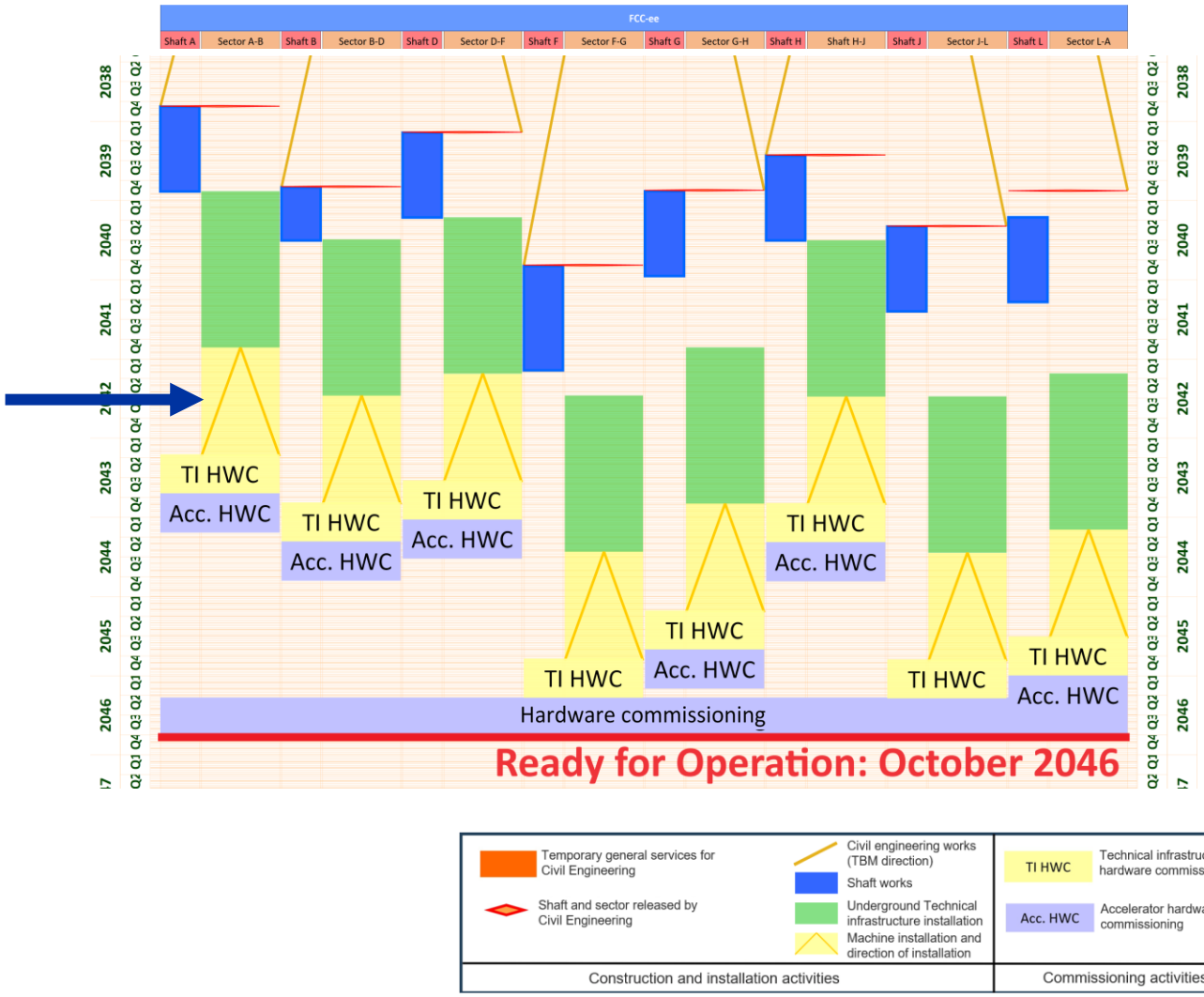
FCC-ee schedule: civil engineering

Civil engineering activities



FCC-ee schedule: installation strategy

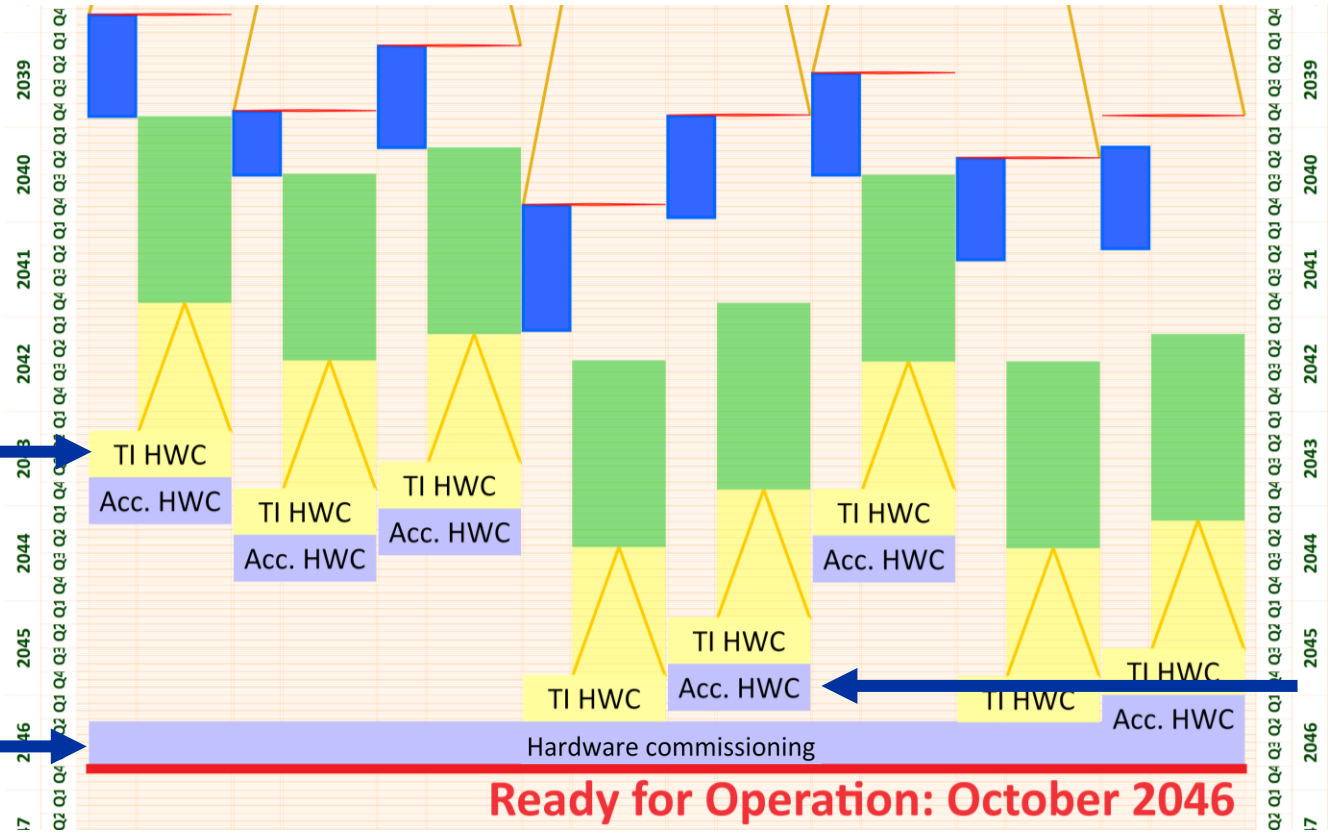
Installation from the middle of each sector to the adjacent shafts
→ Shorter distance for transport and workers



FCC-ee schedule: commissioning

Technical infrastructure hardware commissioning → 6 months

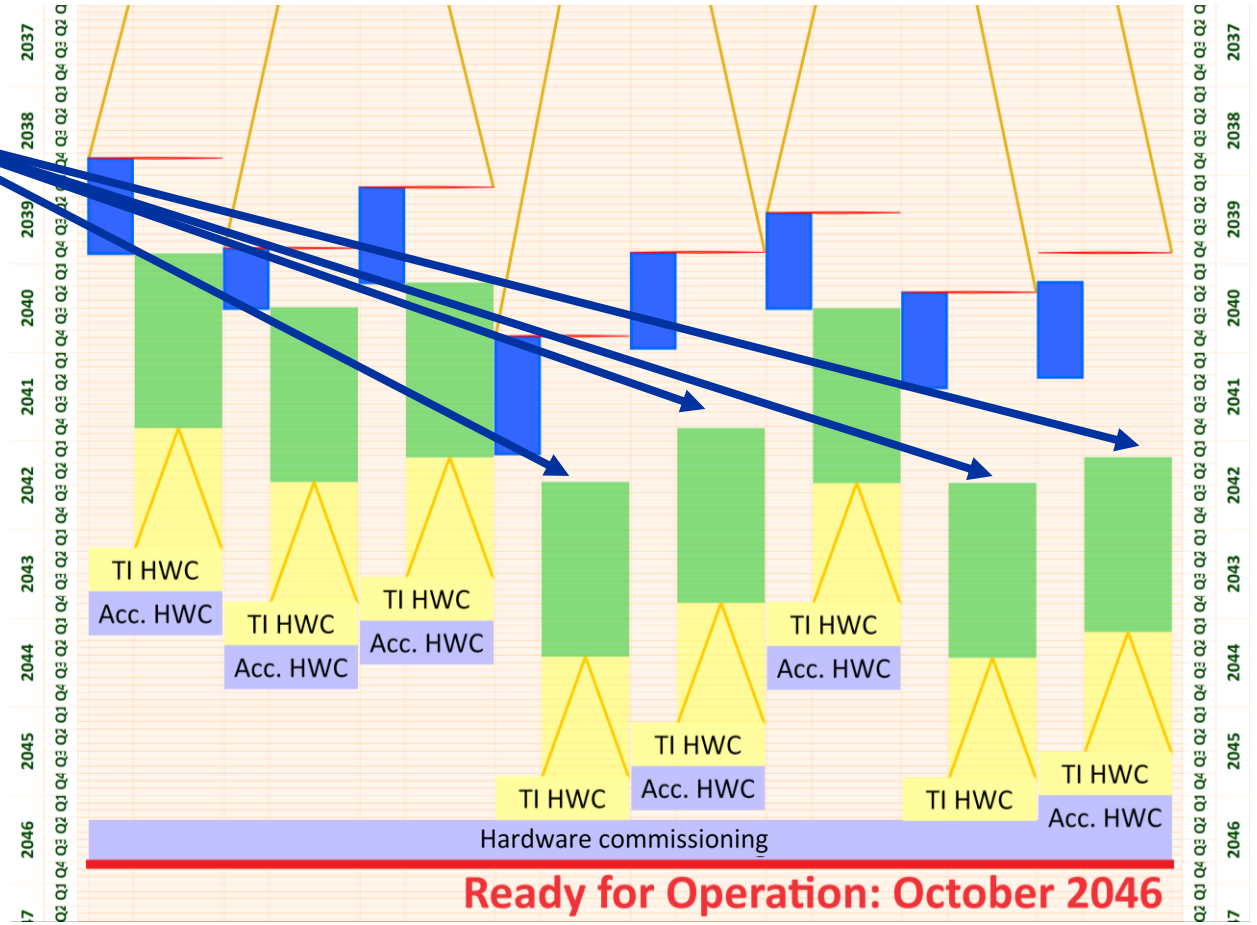
Whole accelerator hardware commissioning → 6 months for the overall machine

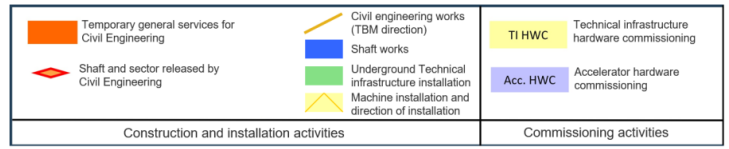


One sector accelerator hardware commissioning → 6 months

FCC-ee schedule: resource limitation

Resources limitations assumption
(4 teams in parallel max.)

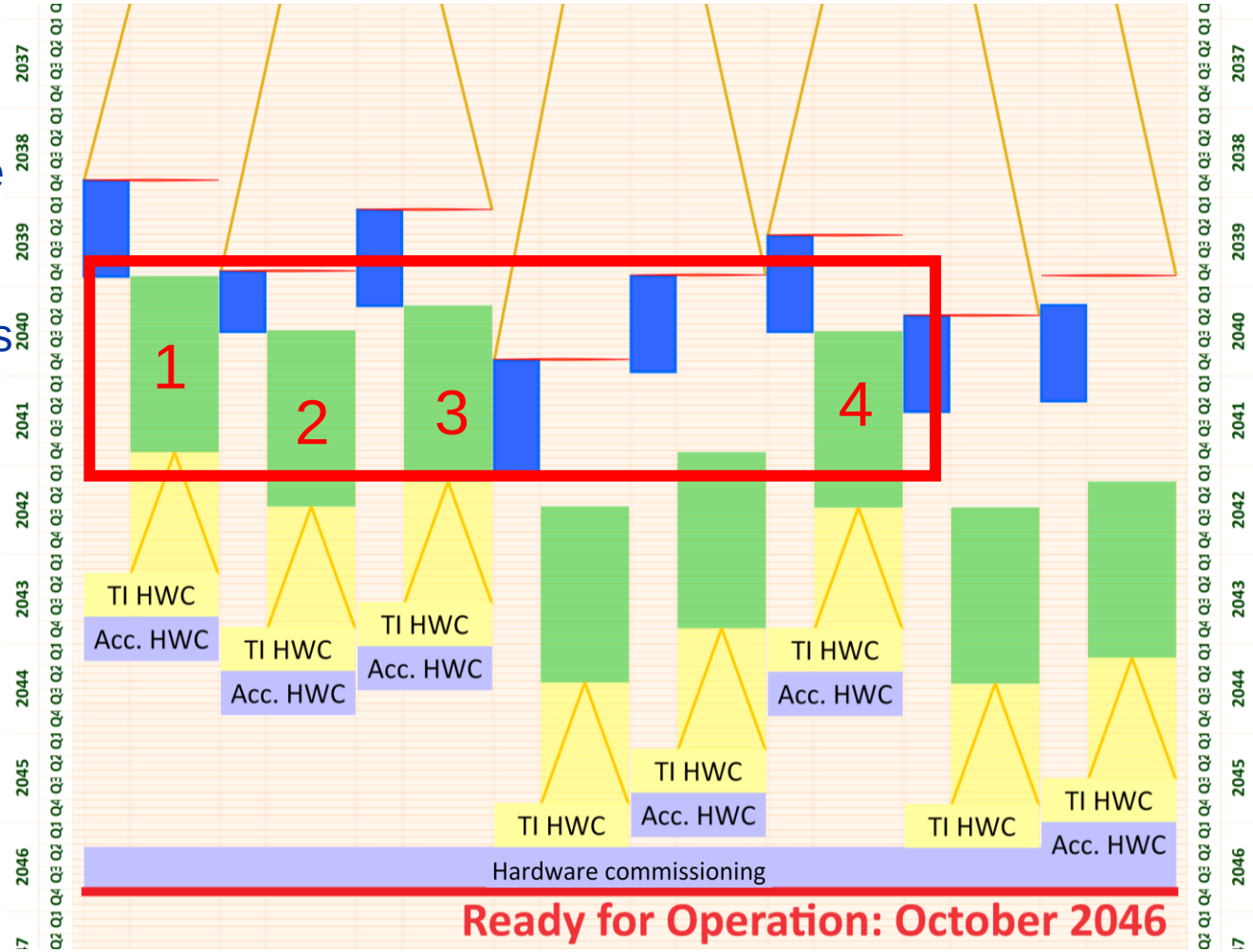


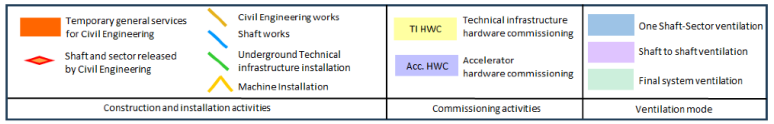


FCC-ee schedule: resource limitation

Example: for Technical infrastructure installation there are up to 4 teams in parallel

Same applied to all main blocks of activity
(shaft work, technical infrastructure installation and machine installation)

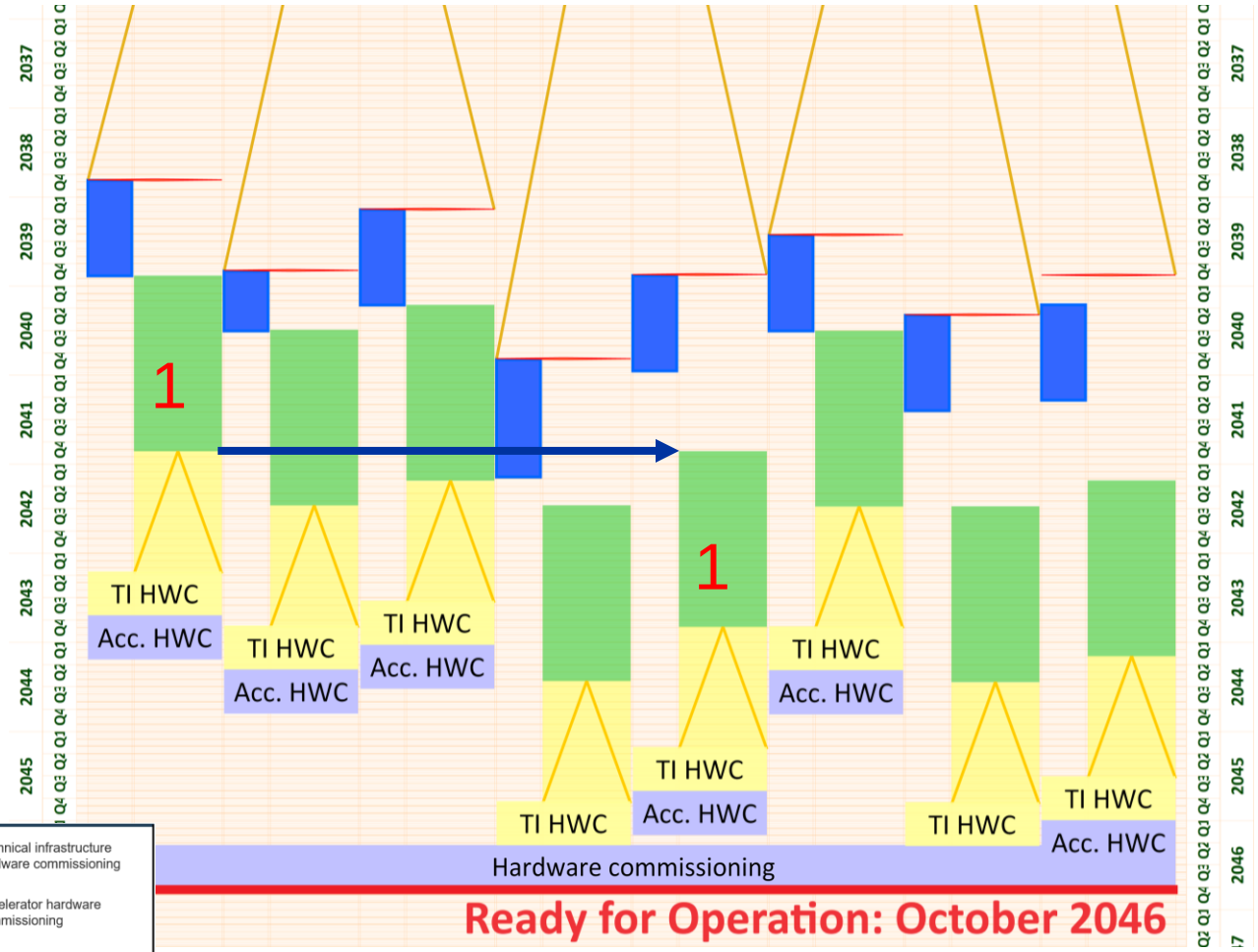


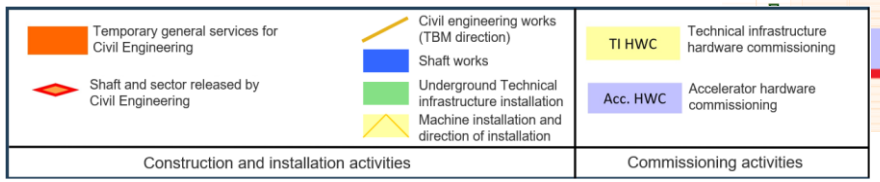


FCC-ee schedule: resource limitation

Example: Team 1 in Sector A-B for Technical infrastructure installation will then go to Sector G-H

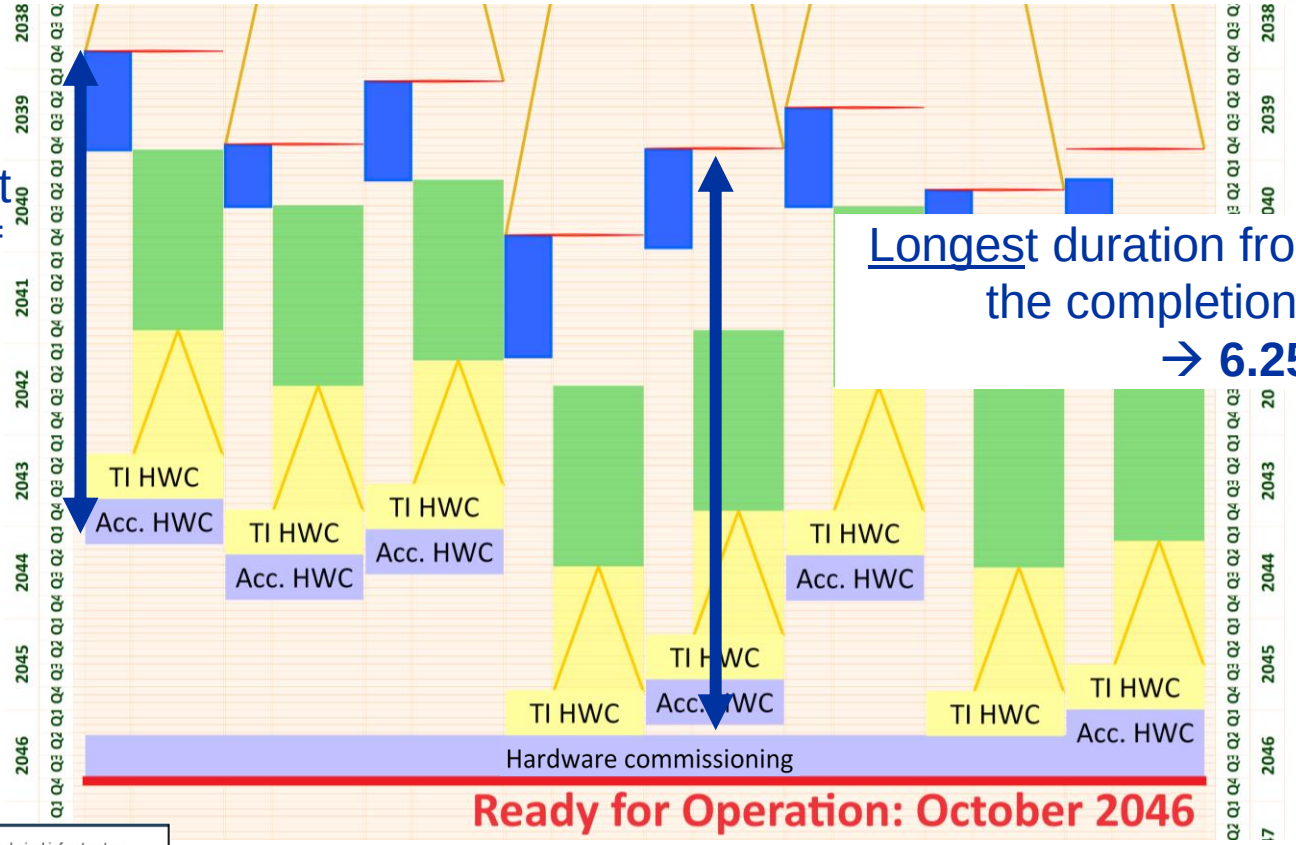
All the team will thus work on 2 sectors sequentially



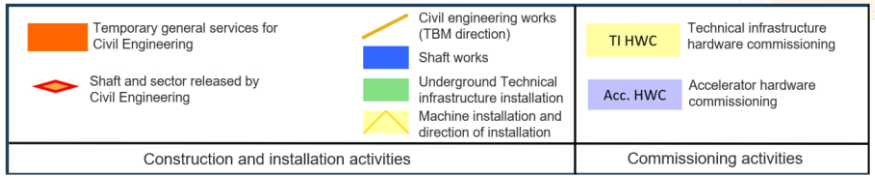


FCC-ee overall planning: resource limitation

Shortest duration from shaft availability to completion of sector HWC
→ **5.5 years**



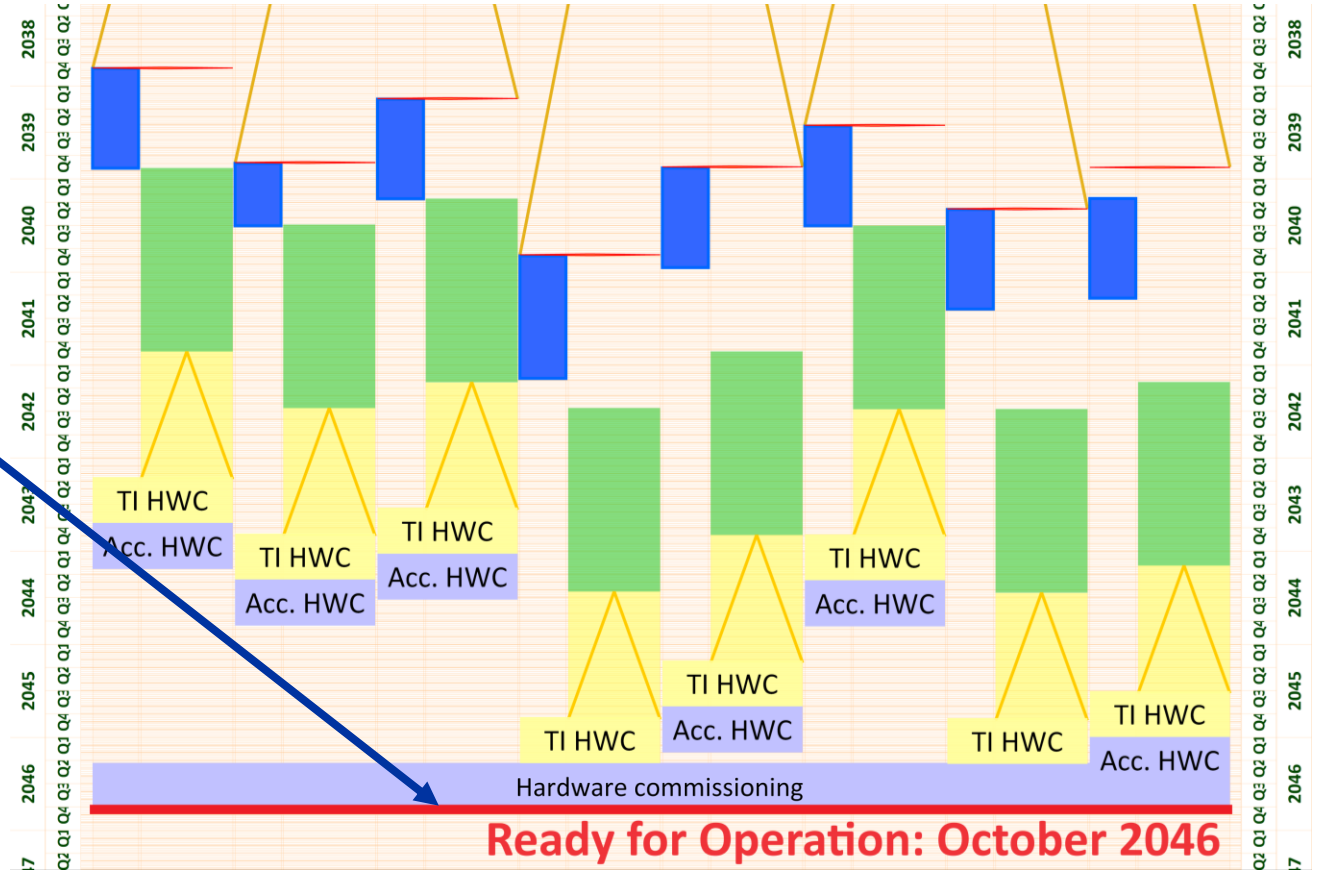
Longest duration from shaft availability to the completion of sector HWC
→ **6.25 years**

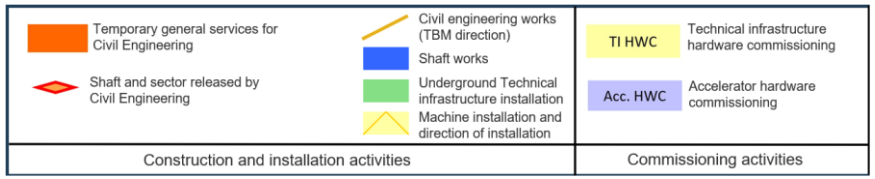


FCC-ee schedule: readiness for operation

Installation of infrastructure and machine
+
Hardware commissioning of each sector and of the overall machine

Machine ready for operation in October 2046

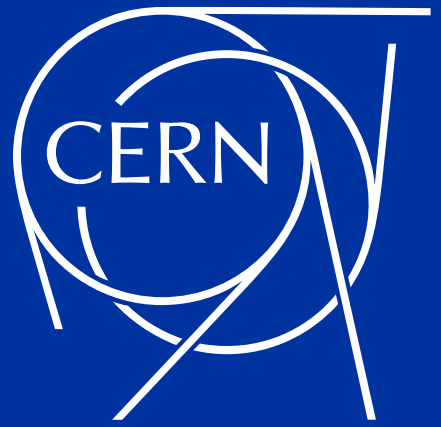




Next steps

Since the FCC Mid-Term report in November 2023, the FCC study is being deeply scrutinized.
Additional and more precise inputs should now be considered in the following areas:

- Installation Schedule: update and modify it according to the last equipment specifications
- WBS: create a coherent and integrated structure
- Project Schedule: create a Master Schedule, defining the work packages and work units
- Integration: finalize the Machine Layout considering the new needs for equipment and infrastructure
- Civil Engineering: consider the readiness for civil engineering tendering process
- FCC-hh: develop strategy for the installation



Thank you for listening !