FCC-ee installation planning: optimization proposals

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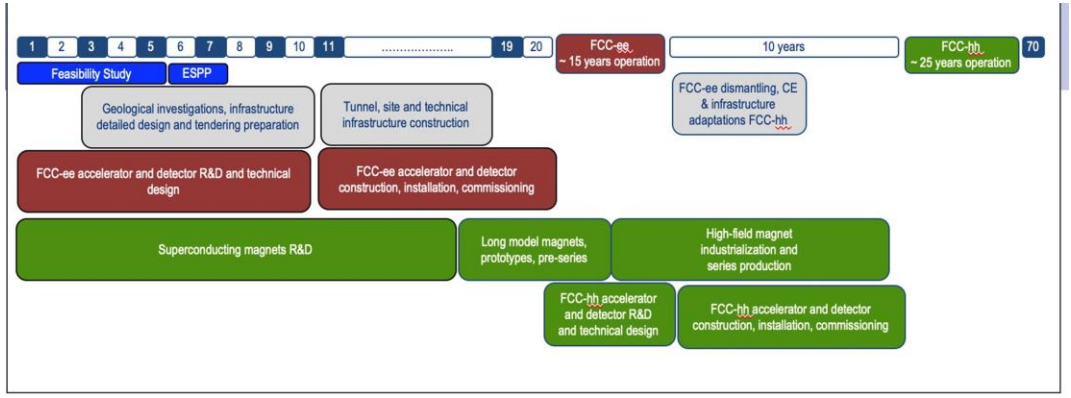
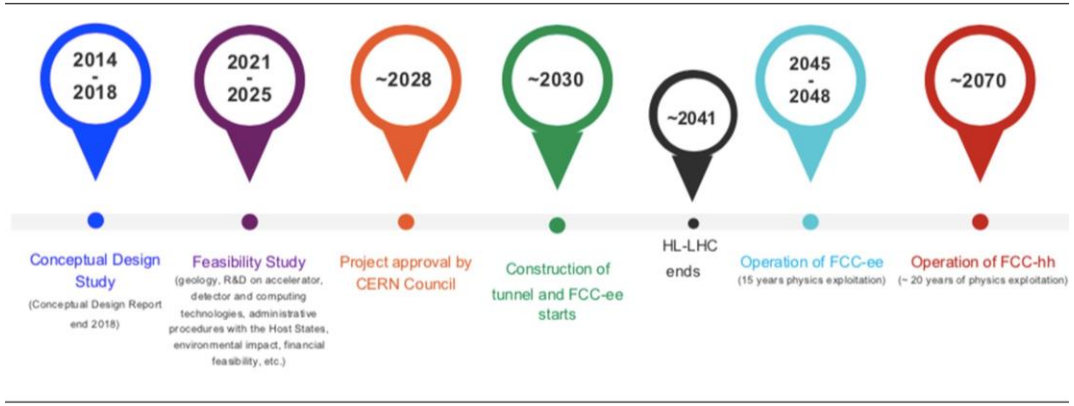
Outline

- FCC-ee milestones
- FCC-ee planning baseline
- Planning optimizations
  - Critical path
  - Main blocks overlapping
  - Learning curve and team reinforcement
  - Simulation of civil engineering inputs
- Overall planning output
- Overlook

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

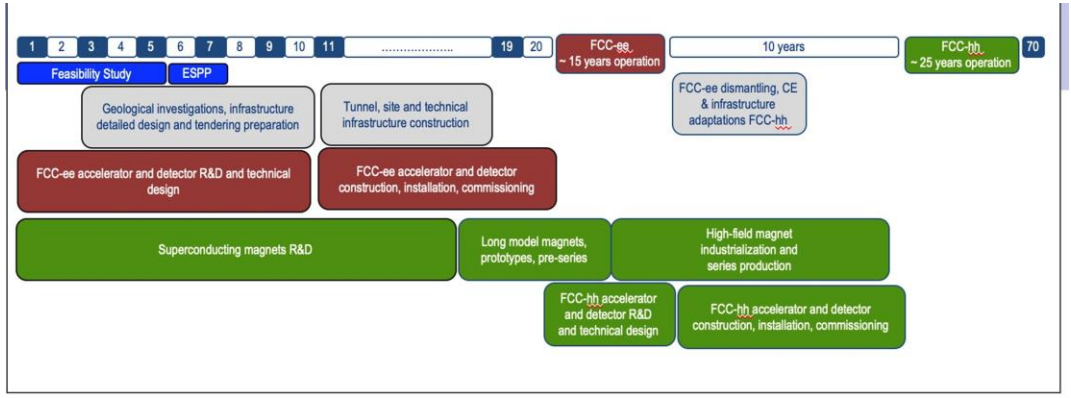
- Study and tendering prior to 2033
- Site preparation of civil engineering areas in 2032
- Start of civil engineering work in 2033

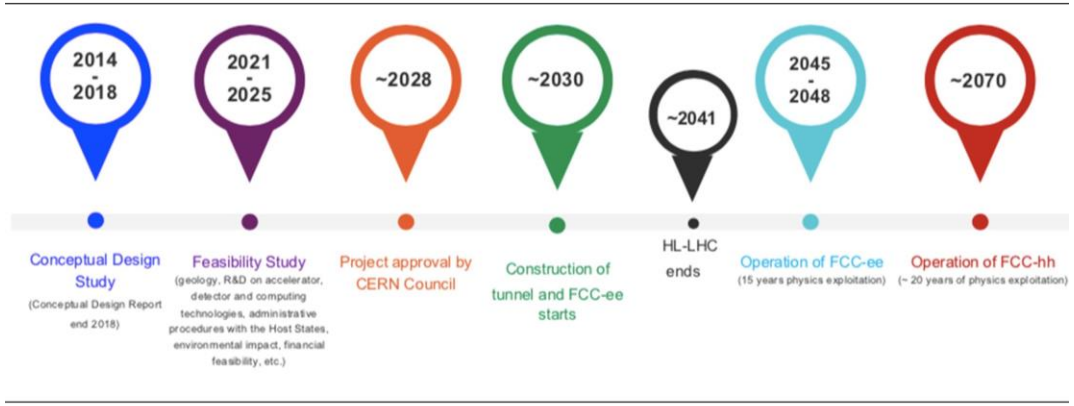
Start of operation

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

Courtesy of F. Gianotti, FCC Week 2023

Current milestones and impact





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Main milestones

- Phase I: Conceptual design: end in 2018
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- European Strategy for Particle Physics 2026
- Project approval by CERN Council in end of 2027

Preparatory phase: 2026-2031

Civil engineering milestones

- Study and tendering prior to 2032
- Site preparation of civil engineering areas in 2031
- Start of civil engineering work in 2032

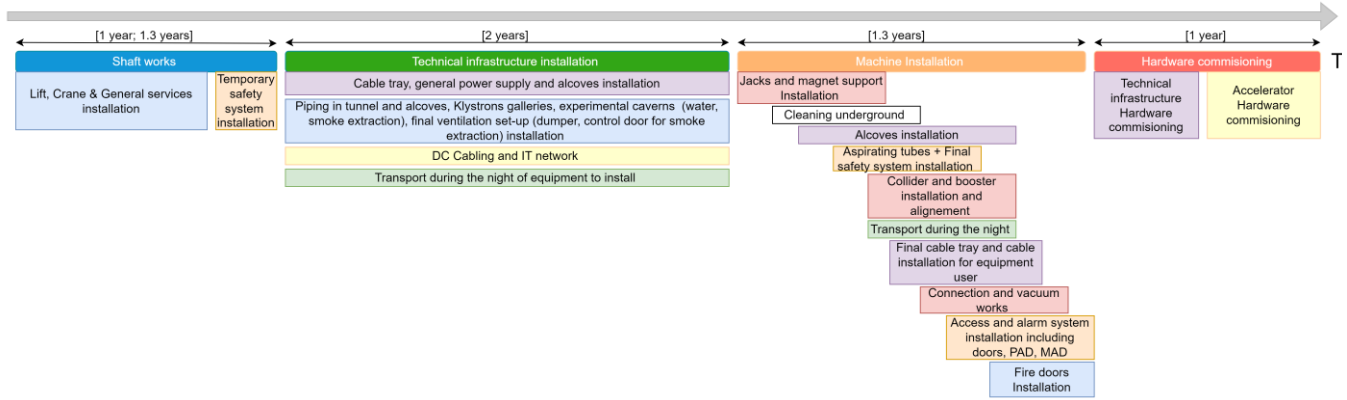
One year earlier with respect to 2023 Mid term review

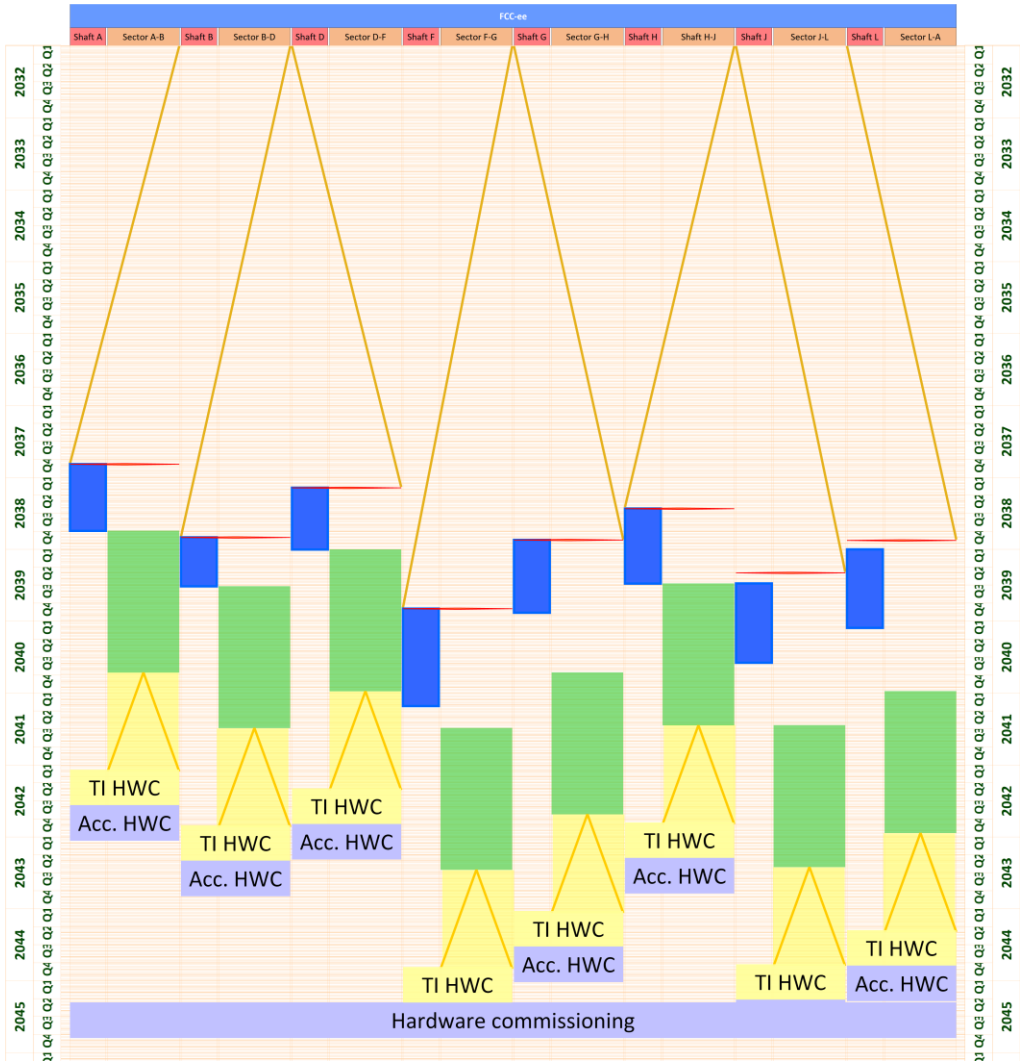
Start of operation in 2045

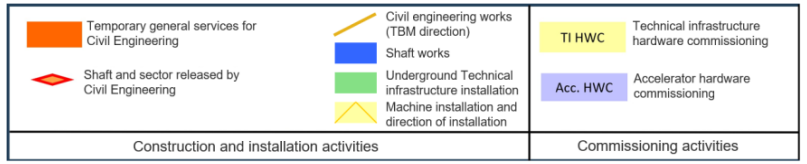
FCC-ee schedule baseline

- 8 different releases [shaft + sector] at 8 different dates
  - ➢ Release date depends on type of geology and shaft depth

- Bottom-up exercise:
  - ➢ The installation sequence for one sector was defined and use for each sector for the overall planning



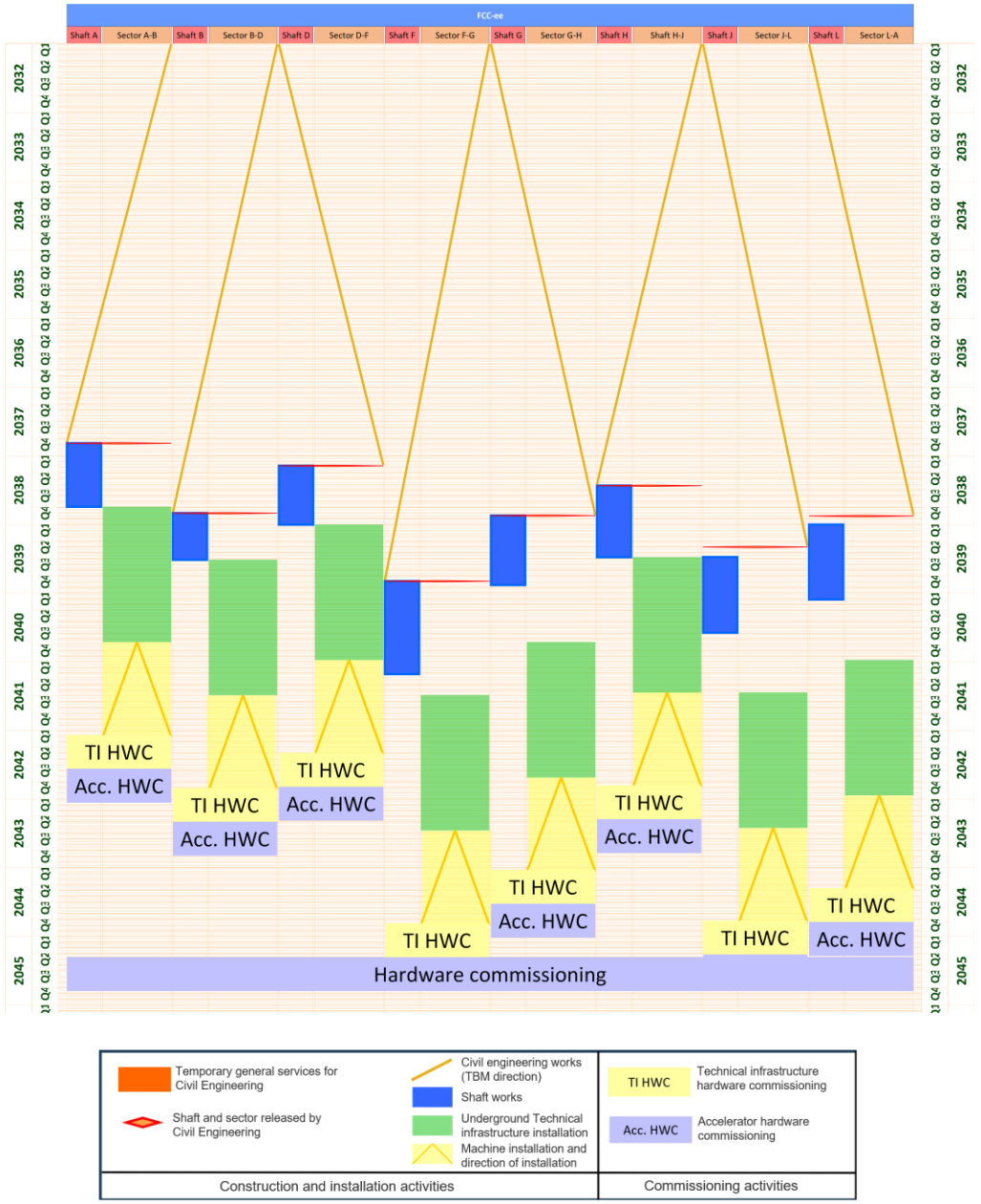




FCC-ee schedule baseline

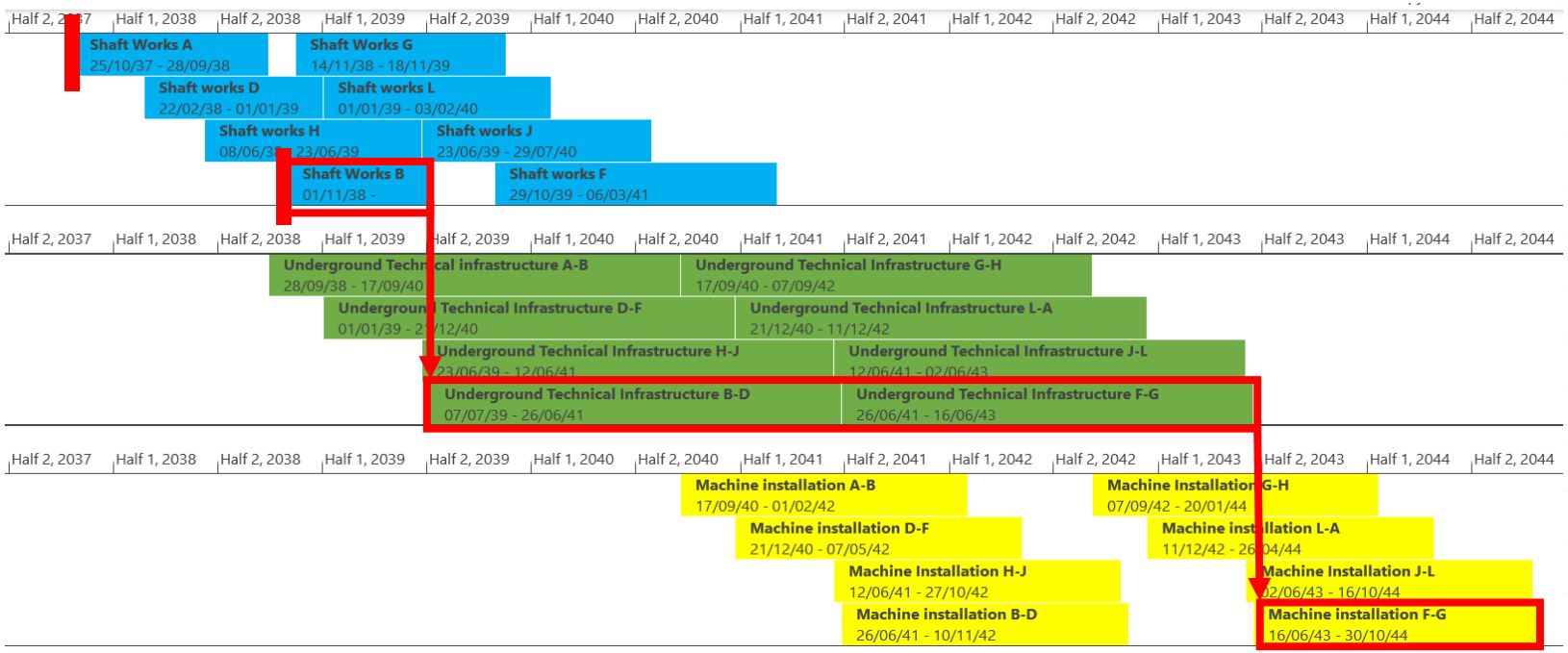
- Resource limitation:
  - ➢ Four teams in parallel maximum can work in the machine for the same type of activity
  - ➢ Idle period induced by the resource limitation in the planning which allow to treat non-conformities and potential delays

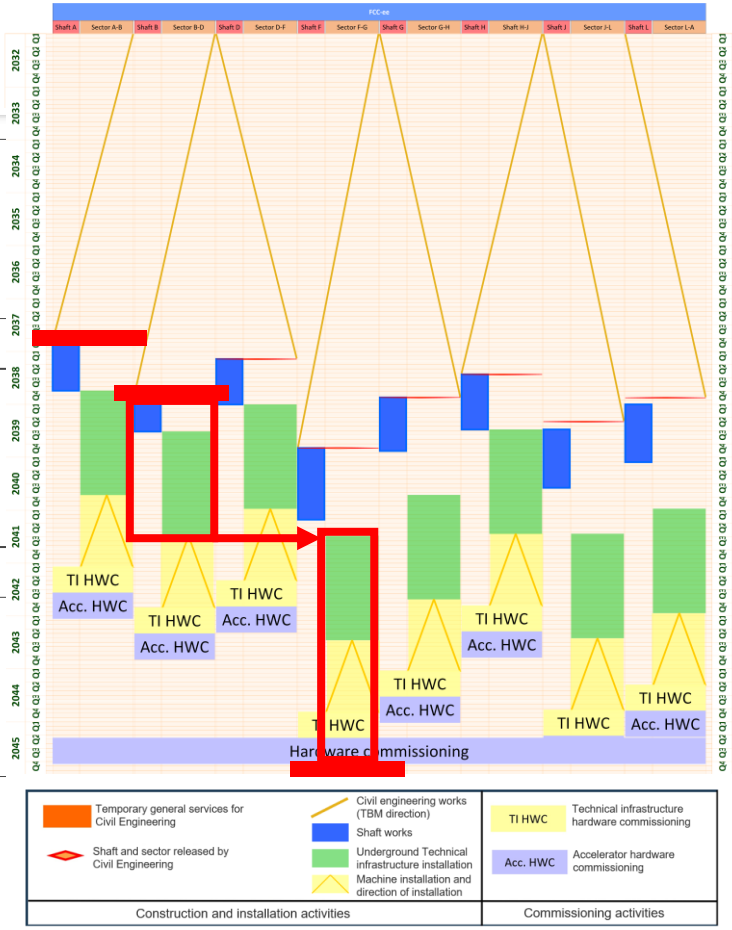
- Safety:
  - ➢ Maximum 200 persons at the same time underground



Planning critical path

Considering the current dates of civil engineering and the resource limitation (4 teams in parallel), the critical path is given by the following activities:



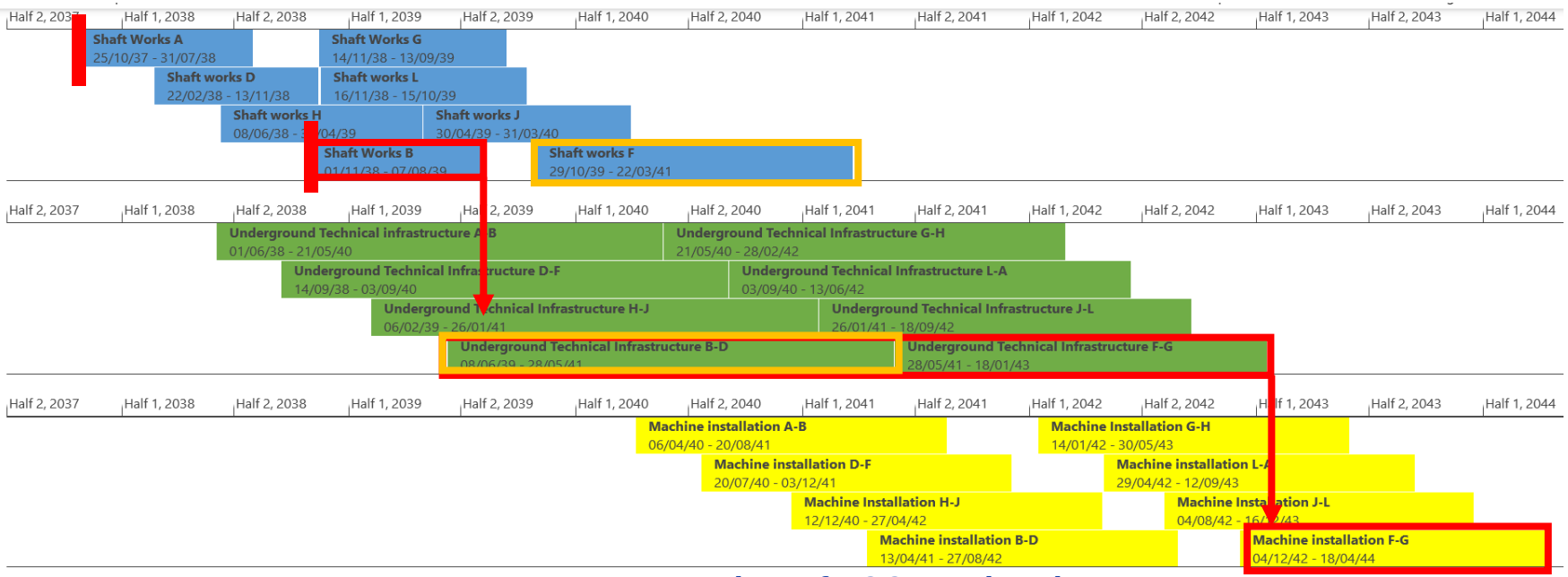


Resource view of FCC-ee planning

Planning critical path

Shaft work in point F is in the shadow of the technical infrastructure activity in sector B-D

- The shaft depth (400m) is not driving the critical path
- An earlier release (between 0 and 2 months) of the deepest and last shaft to be released (F), would not anticipate the readiness date BUT will allow to start works before and have more margin with the start of technical infrastructures
- Current margin of ~2 months on shaft F before the start of technical infrastructure installation

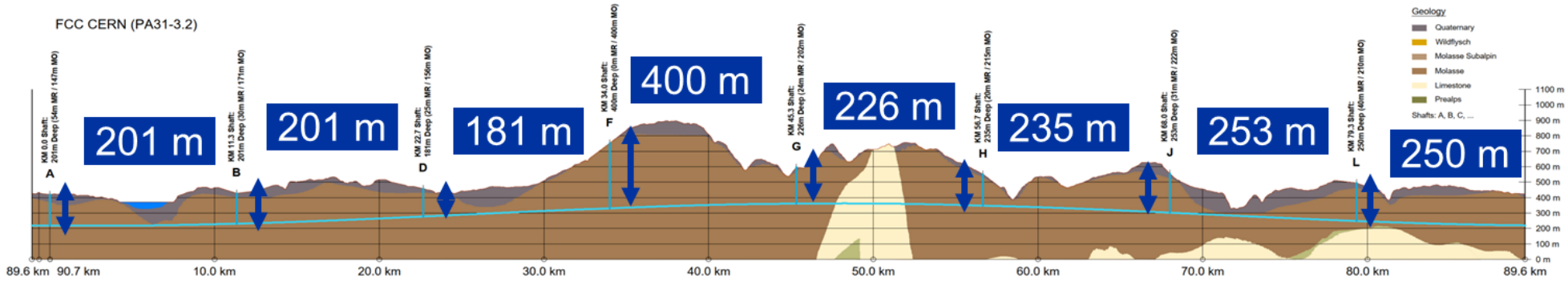


Resource view of FCC-ee planning

Proportional factor for shaft works

- **Different depths for the 8 shafts** induces **different durations of lift installation and general services**
  - Application of a proportional factor for both activities
  - Lift and crane installation between 5.3 months to 10.5 months
  - General services between 3 months and 6.5 months

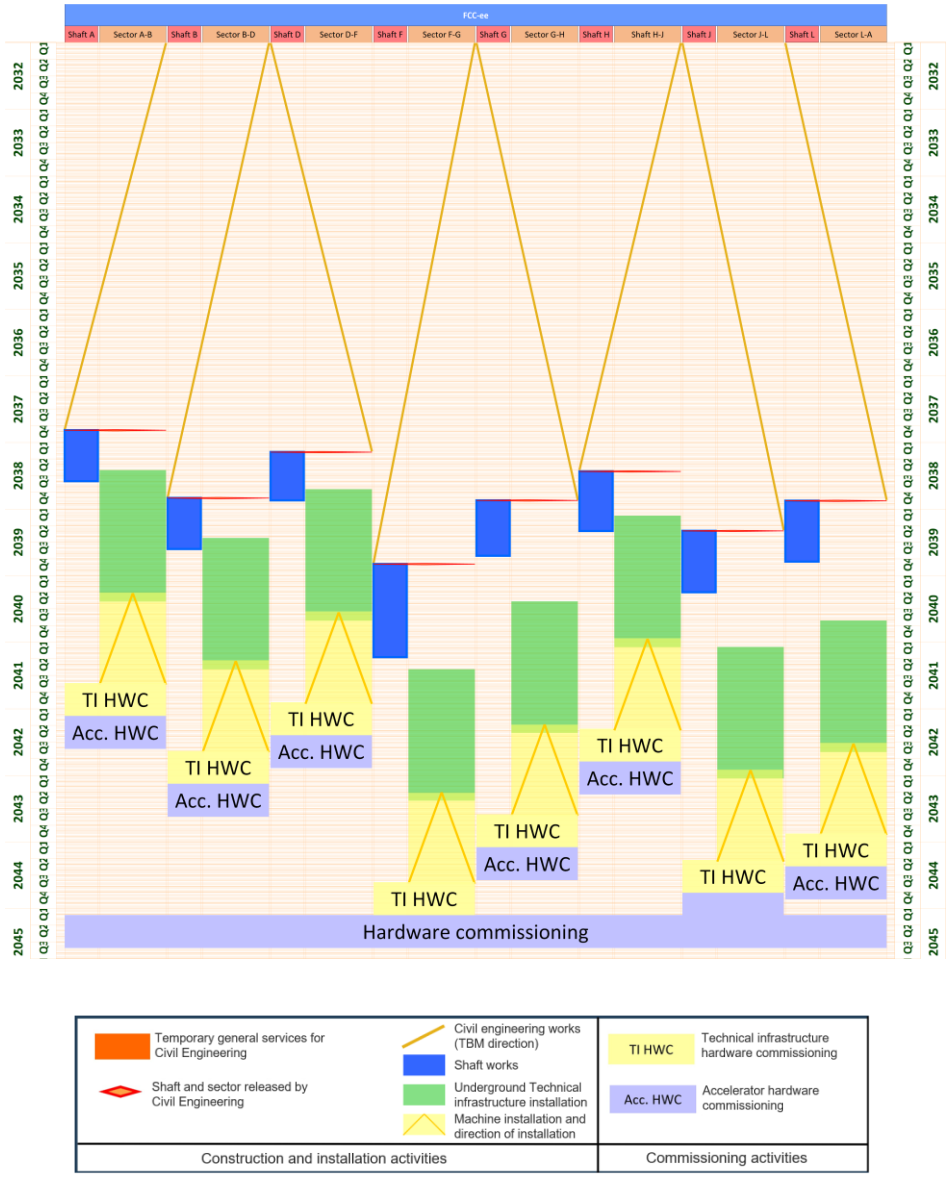
- No anticipation of the readiness for operation with application of the proportional factor but good initial estimation



Possible overlapping

- Main blocks of activities have been put into sequence but **overlapping the main blocks is possible** for the following activities:
  - **General services installation in the shaft and temporary safety system** can start as soon as the shaft and crane as been installed using a temporary ventilation duct (experience from HL-LHC) to bring the air down if adjacent shaft not released
    - ➢ Temporary safety system duration is absorbed behind the general services installation in shaft (- 3 months for each sector timeline) installation
    - ➢ Further work of technical infrastructure installation in tunnel could be anticipated by 1.5 months
  - **Jack and support installation could be anticipated** by 1.5 months overlapping with technical infrastructure installation (mainly works generating dust)

➢ **~ [- 2.5 months] on readiness for operation**



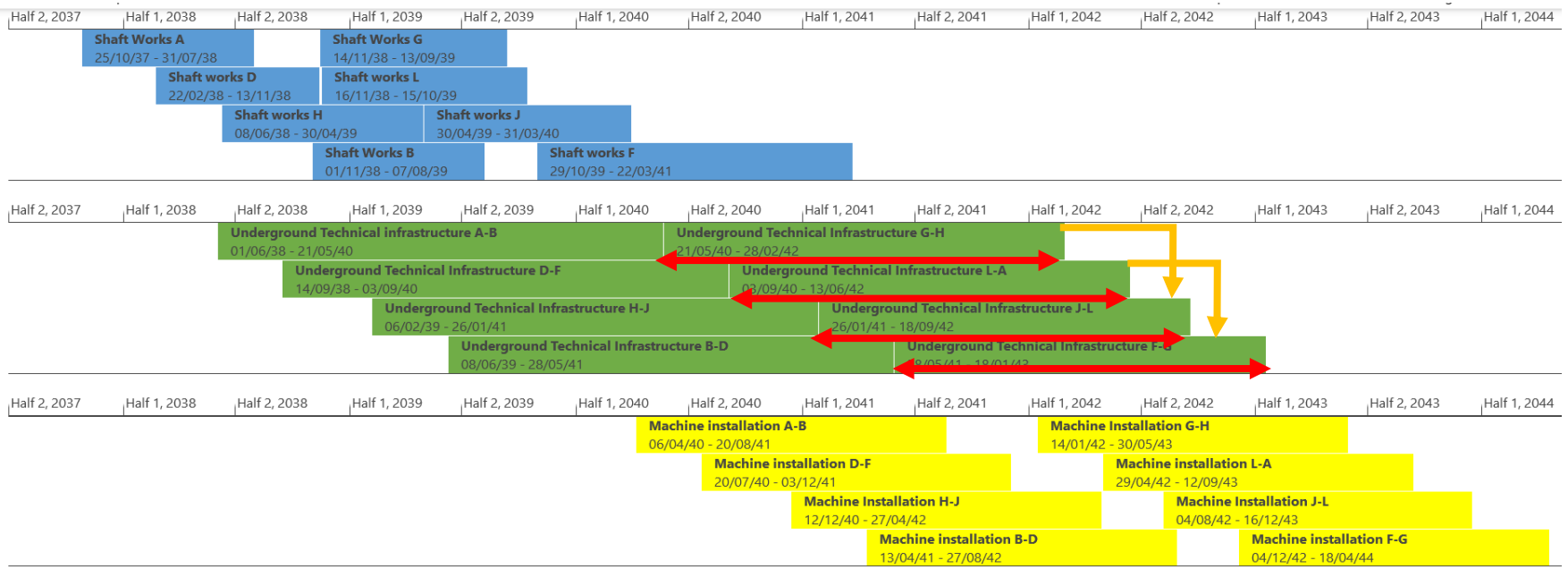
Learning curve and team reinforcement

- As one team of each main block will work on **two sectors consecutively,** a learning curve factor of 90% on the duration of all second sectors was on technical infrastructure

➢ **[- 3 months] on readiness for operation**

- **Team reinforcement to support and accelerate the work in the remaining sectors** still in installation for technical infrastructure (factor x1.5)

➢ **[- 1 month] on readiness for operation**



Simulation from CE input

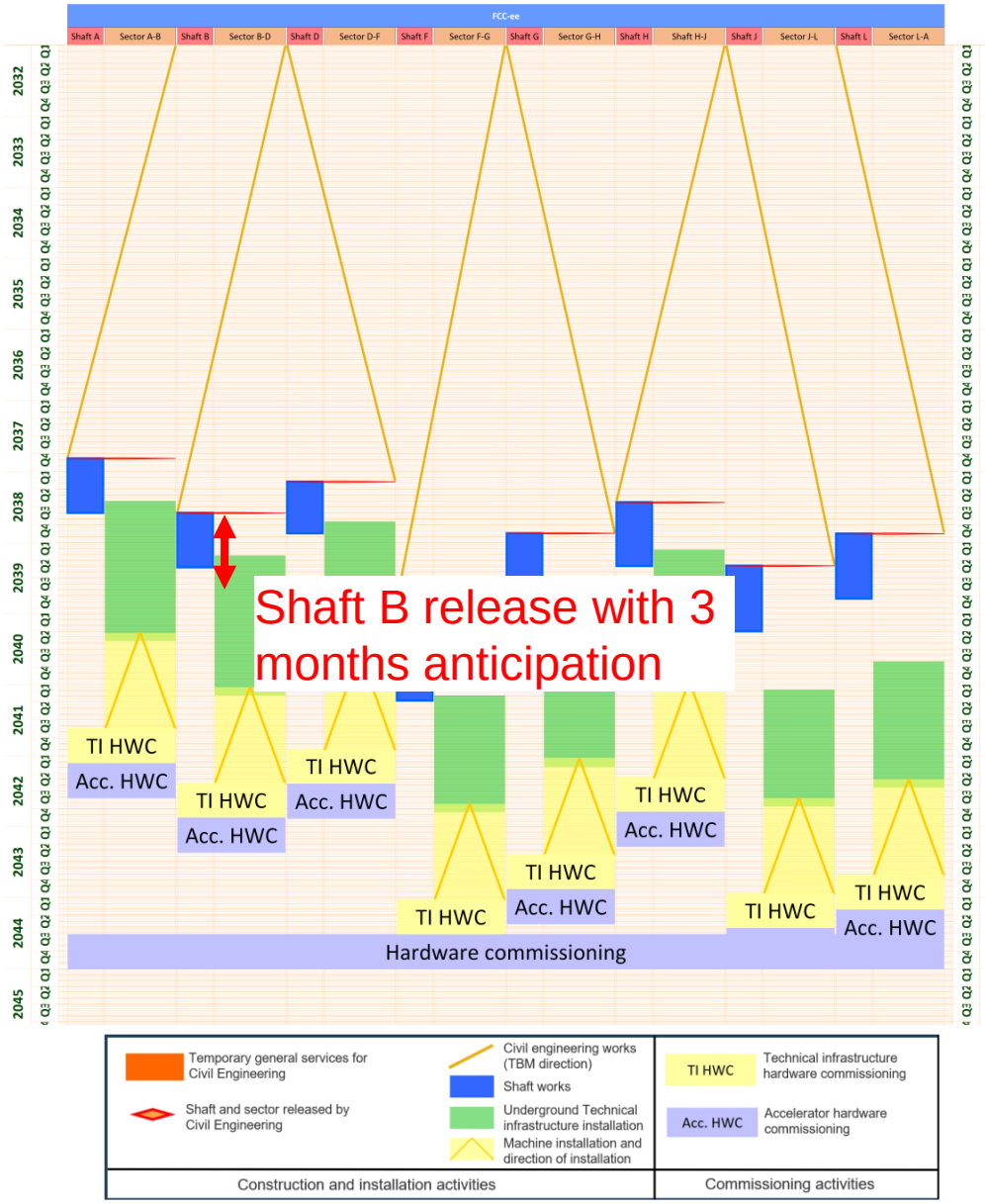
As the **civil engineering release** is the **starting point of installation**, a simulation on civil engineering release dates was performed to optimize the installation duration:

Anticipate as much as possible the release of the 4th shaft (Point B), that is driving the critical path duration:

- Possible to earn maximum 3 months on the readiness for operation
- If further anticipation of shaft B release can be realized, critical path is driven by Shaft F release and works

- **~ [- 3 months] on readiness for operation directly influence by the possible anticipation of shaft B release date**

- **Iterative work with civil engineering to optimize global duration of construction and installation**

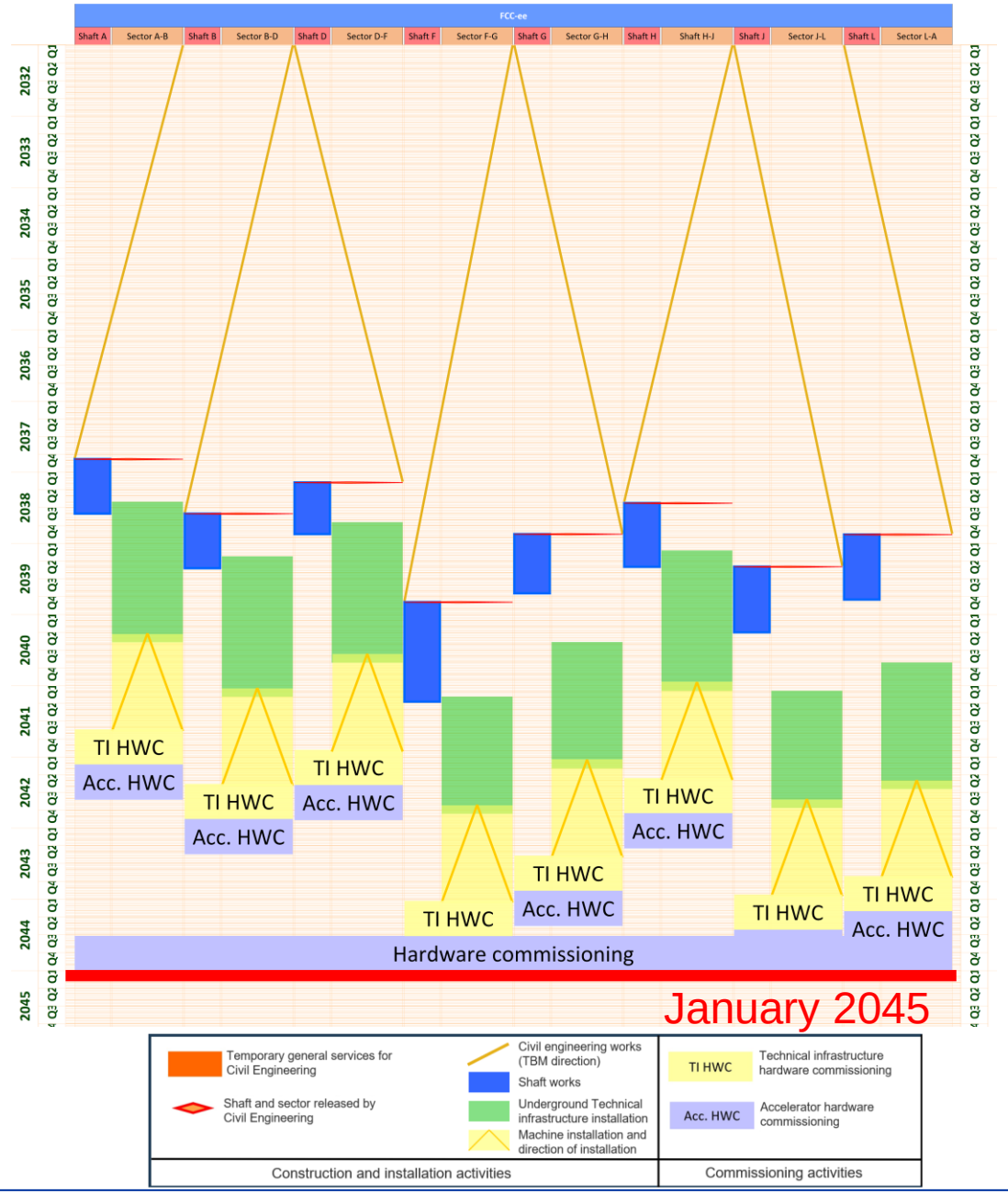


Overall planning result

Taking into consideration all optimization proposal presented:

- **Overlapping of main block of installation activities**
- **Learning curve and team reinforcement**
- **Civil engineering input simulation**

➢ **Possible readiness for operation in January 2045**
[-9.5 months] from the current baseline (with civil engineering start in 2032)



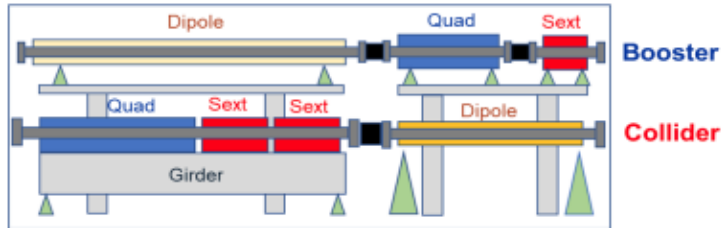
Magnet installation inputs

- **Dipoles can only be lowered on the experimental shafts** (4/8)
  - Work on installation strategy especially for the magnets considering the “train” machine installation
  - Transport strategy to be precised (storage in the underground, interference with other activities) studied by the transport team

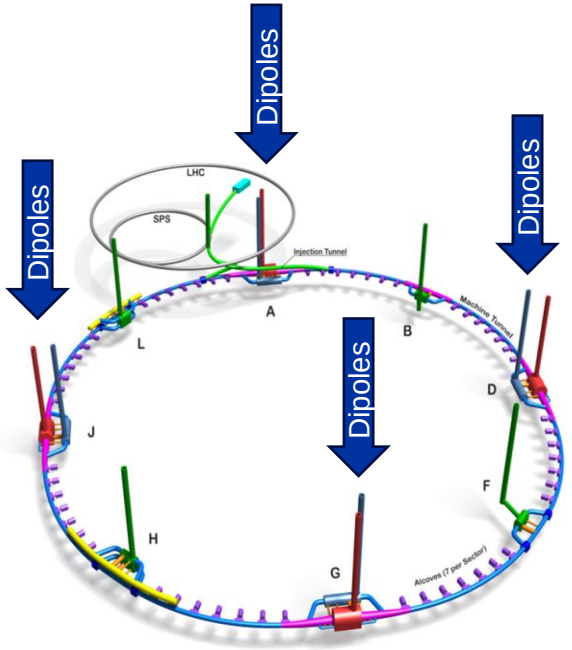
- Simulation of magnet transport gives 120 days for all sectors if the shafts are released at the same time
  - Further work and simulation to adapt with different release dates of sectors
  - Adapting the machine installation planning according to the results given by the simulation

- Simulation of installation time to be precised

- Production planning of magnets to be integrated in the schedule



Courtesy of F. Carra & Arc half-cell WG

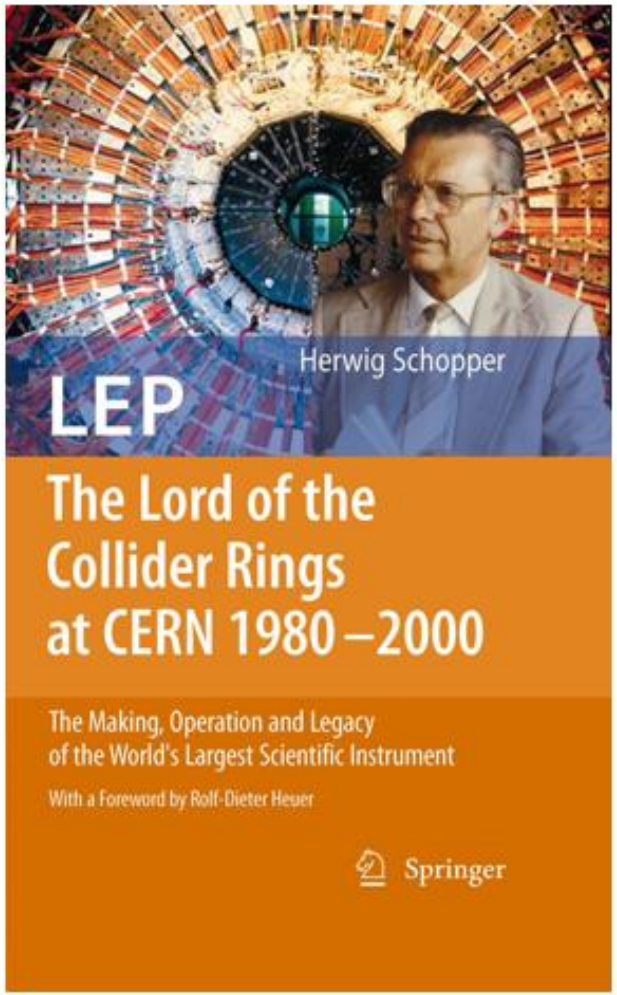


Next steps

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: iterative work on the possible release dates
- FCC-hh: develop strategy for the installation

The LEP case



"In only **2 years** the enormous job of installing the components of the main ring, connecting the different parts and putting in place all its infrastructure, such as cooling and ventilation, electrical power and control system, was achieved"

-Herwig Schopper