TECHNICAL INFRASTRUCTURE

K Hanke, FCC Week 2023, 05/06/2023
FCC Technical Infrastructure

integration ● geodesy ● electricity & energy management ● cooling & ventilation ● cryogenic systems ● computing infrastructure ● safety ● operation & maintenance ● transport, installation & logistics
Context

Technical Infrastructure based on alignment PA31-1.0, which features eight points with associated surface areas

4 experimental points
4 technical points B, F, H, L

B: Beam dump system
F: Collimation section
H: Collider RF
L: Booster RF

The present study focuses on FCC-ee, but wherever design choices are made which impact FCC-hh (in particular space requirements and dimensions) this is taken into account.
FCC-ee Schematic View
Electricity Supply

- Electrical Power from the French network fed into the FCC at three points (L, H and D)
- Further distribution via the FCC ring
- Covers all configurations of FCC-ee without need to built new sub-stations
- Possibility to operate the machine without one sub-station, which will ease the maintenance and repairs
- Points L, H and D are very close to power lines of the French network operator RTE, and a study has been launched by RTE on how to connect the FCC to the French network
**Alternative with present CERN connection**

**Point L with low charge**

Point L has not enough charge to justify a new delivery point. An alternative would be to reuse present connection (Prevessin) to Bois de Serves (installed power 220MW), and to built a new sub-station at point A.

A new line between Prevessin site and point A is needed (through the road or better through the beam transfer tunnel).

Bois de Serves, with a sub-station covering PJ – PL – PA - PB
Point D, with a sub-station covering PD – PF – PG
Point H with a dedicated sub-station for RF collider

<table>
<thead>
<tr>
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<th>Max power (MW)</th>
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<tbody>
<tr>
<td>PDL1</td>
<td>Bois de Serves</td>
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<tr>
<td>PDL2</td>
<td>PD</td>
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<tr>
<td>PDL3</td>
<td>PH</td>
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Cooling Water

- CERN CV Group with Contractors
- Potential sources of cooling water Geneva lake (PA), Rhone (PJ) and Arve (PD)
- Requested water flow rates have been presented to the authorities
- Pipework in the tunnel will connect the remaining points to points A, D and J
- As for the water drains, the flow rates will represent around 30 m$^3$/h in the RF points and a maximum of 11 m$^3$/h in the rest of the points
• Operation of the ventilation elements in one sector of the machine tunnel during normal operation
• Smoke and helium extraction in green, general extraction in red and air supply in blue
• Also considered special modes, underground caverns, RF sections etc.
Cryogenic Systems

- Technical points PH and PL are associated with the radio frequency (RF) system of the collider and of the booster

- Operation at 2 K and 4.5 K for PH, PL only at 2 K

- RF points are associated with the biggest cryogenic installations

- Experiment points PA, PD, PG and PJ also require an associated cryoplant that covers the needs of the detector magnet, as well as of the Machine Detector Interface (MDI) region magnets

- No cryogenics at points PB and PF
Transport: Material Transport

- Material vehicle will be a trailer pulled by a battery driven tractor and equipped with two robotic arms
- Logistics scenarios based on different boundary conditions such as the number of shafts used to transfer the material and the number of vehicles used to transport it in the underground
- Collaboration Fraunhofer-Institut für Materialfluss und Logistik IML, Dortmund, Germany
Transport: Personnel Transport

- Personnel vehicle will be based on an existing solutions and customized to meet the specific requirements and constraints of the FCC tunnel.

- There will be a mix of individual and scheduled transport systems.
Safety

• Studied evacuation in the underground, namely the minimum size of the safe area in the lift shafts within the designated safety criteria. The results show that having a safe area of 50 m² would be suitable both scenarios, within a 95% confidence level.

• Started to study the effect of the proposed safety systems in case of cryo leak in the tunnel. CFD simulations of helium releases from SRF cryomodules are being carried out and preliminary results will be available for the mid-term review.

• First results from simulations of the activation by synchrotron radiation show that ambient dose rates in the arcs of the tt-collider (beam energy 175 or 182.5 GeV) will be in the order of 10 microSv/h in the first hours after stopping the beam. Given the long distances, this would allow short accesses for corrective maintenance only after waiting one or two days.

• Magnetic stray fields of the detector magnets must be taken into account in the design of electrical and mechanical equipment in the UX caverns. On the surface, the effect of the magnets is of the same order of magnitude as the earth magnetic field and thus negligible.
Implementation of the primary surface geodetic network

A coordinate reference frame shall be established for the FCC.

IGN and Swisstopo will densify their national geodetic network in the vicinity of the FCC surface sites. 7 new geodetic pillars will be built in the coming months and GNSS observations of the network should be done by the end of the year 2023.

Geoid modeling

Final results of the geodetic control profil were delivered by ETHZ and Swisstopo (Deflection of the vertical, GNSS, levelling and gravity values).

Initial local geoid model is being computed
Working on an alignment monitoring for the MDI, aiming at 30μm for the internal alignment:

- Distance measurement network for the “External monitoring system”

- Deformation monitoring of the skeleton for the “Internal monitoring system” thanks to an in-line multiplexed and distributed sensor based on FSI.

Deformation monitoring system, based on an optical fiber network and an in-line multiplexed and distributed FSI sensor.
## Infrastructure Operation

### Input given on various subjects:
- Sustainable usage of water
- Safety, transport
- Remote operations of large electrical networks
- Robotics and operations
- Documentation of equipment and dependencies

### Work on improvements in operations on current accelerators with FCC in mind:
- Closer collaboration with robotics, thanks to FCC week! → Now operations group operate the TIM train in LHC tunnel!
- Work with experiments to add “powered by” for equipment → Vision is to make it visible in our tools, from what power supply an equipment is powered. This is even more relevant with big machine like FCC, therefore putting it in place already now is very useful
- Expand tools for energy monitoring, we work with EN-EL to have a much more clear picture of where the power goes.

### Hopes for next years
- Expand further "powered by" features, this information can be used many places, one idea is in the IMPACT documents.
- Test with TIM train done with success → Next steps of using all 4 trains in works now → **Idea**: drop drones with train!
- Intelligent tools to predict faults, when a pattern of alarms is received we could make suggestions to operators.
- Create new role for Energy Monitoring and follow up → Save Energy. Operators are becoming more involved.
- New operation models@CERN → Move towards 100% operations from control room, not on the field as today
Surface Sites

For every point we have compiled the infrastructure:
status / last changed / element / location / construction type / area / size (W x L x H) / capacity
covering all domains (Work Packages)

Example: PA FCC-ee

Based on this information, Civil Engineering is doing the integration of the surface sites
Main cross section as for FCC-hh
Main ring below of booster ring
Main ring and booster ring 1.3 m distant
Underground Areas: Arcs

Machine tunnel 5.5 m in diameter
**Underground Areas: RF Point L**

- QRL Ø along 800 MHz section 0.8 m
- Distance between e⁺e⁻ quadrupoles 52 m, length 3.1 m
- Distance between booster quadrupoles 52 m, length 1.5 m

*Machine tunnel 5.5 m in diameter*

*Boosters 800 MHz Cryomodules*

*Midpoint RF section*

*Collider Center*
Underground Areas: RF Point H

- QRL Ø along 400 MHz section 0.65 m.
- Distance between e⁺e⁻ quadrupoles 52 m, length 3.1 m.
- Distance between booster quadrupoles 52 m, length 1.5 m.

Machine tunnel 5.5 m in diameter

Transport Waveguide Booster ring Collider ring Cryomodule 400 MHz Collider 400 MHz Cryomodules Collider 800 MHz Cryomodules Collider Center
Underground Areas: Alcoves and Layby Zones

Cabling concept for control cables and general services and secured network

All control and signal cables start from an alcove to the tunnel in both directions left and right of the alcove, with a maximum length of 800m.

https://edms.cern.ch/document/2822196/0.2
Underground Areas: Alcoves and Lay-by Zones
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Big lay-by zone

Small «standard» lay-by zone

- Storage space
- Parking lots for maintenance vehicle
- Space needed for repairing vehicle

Dimensions:
- 10 meters
- 39 meters
- 57 meters
- 4.5 meters
- 12.5 meters
- 37.5 meters
Underground Areas: Service Caverns

https://edms.cern.ch/document/2851508/0.4
Underground Areas: Experimental Caverns

FCC-hh

FCC-ee
Summary

• Specification of the technical infrastructure for FCC-ee including the experimental and technical sites is well advanced

• Design choices have been taken e.g. relative position of Booster and Collider, lay-out of the RF section and klystron galleries, baseline scenarios for electricity supply, water intake and disposal, ventilation, cryogenics, transport

• All our work is carefully documented

• Next milestone is the mid-term review for which a report is in preparation

• Work on the technical details is in progress; four Infrastructure sessions at this conference!
Thank You