CIVIL ENGINEERING
TECHNICAL INFRASTRUCTURE

Summary of the sessions of 30 June and 1 July
**Wednesday 30 June**

**Civil Engineering**
Chair J A Osborne

1. Civil Engineering Status and Plans (Alexandra Tudora)
2. 3D geological modelling and subsurface uncertainties quantification to guide the optimal FCC placement (Andrea Moscariello)
3. Civil Engineering assessment of placement scenarios by ILF Consulting (Werner Dallapiazza)

**Thursday 1 July**

**Technical Infrastructures 1**
Chair C Prasse (FIML)

1. Integration of the FCC (Jean-Pierre Corso)
2. Transport and Logistics for FCC (Cristiana Colloca)
3. Technical Infrastructure operations today and in the future (Jesper Nielsen)
4. Safety for the FCC Feasibility Study (Thomas Otto)

**Technical Infrastructures 2**
Chair A Wieser (ETHZ)

1. Status of Electricity and energy management work package (Jean-Paul Burnet)
2. Cooling and ventilation concepts for the FCC (Michele Battistin)
3. FCC-ee & hh cryogenic system conceptual design, status & perspectives (Laurent Paul Delprat)
4. Geodetic studies for FCC (Helene Mainaud Durand)
Civil Engineering
Civil Engineering Status and Plans (Alexandra Tudora)

- status of studies, ongoing work, plans
- 80 - 100 km tunnel in the CERN region
- molasse rock good for tunneling, moraine, limb stone to be avoided (karstic structures)
- → 90 % in molasses
- lake-side option retained

Geology in the FCC region

Main geological units:

**Molasse**
- Mixture of sandstones, marls and formations of intermediate composition
- Relatively weak rock (Average compressive strength: 5.5-48 Mpa)
- Considered good excavation rock
- Relatively dry and stable
- Faulting due to the redistribution of ground stresses
- Structural instability (swelling, creep, squeezing)

**Moraines (Quaternary Deposits)**
- Glacial deposits comprising gravel, sands silt and clay
- Water bearing unit

**Limestone**
- Hard rock
- Normally considered as sound tunneling rock
- In this region fractures and karsts likely present
- High inflow rates measured during LEP construction (600L/sec)
- Clay-silt sediments in water
- Rockmass instabilities
• 5 main scenarios retained
• (2 scenarios with 12 pts, 3 scenarios with 8 pts)
• constrained by natural features
• risk zones identified
• pre-construction schedule
• time lines for construction:
• 12 sectors using TBM
• 7 years total construction

Scenarios reviewed at Placement studies workshop

5 MAIN scenarios
Two scenarios with 12 points:
Three scenarios with 8 points:

Additional 2 scenarios evaluated by ILF/GADZ and recommended to avoid because they intersect the Vuache and Jura limestone.

The aim is to identify one feasible scenario before starting tendering for SI.

In addition, launching the permitting approval process and environmental impact studies.
3D geological modelling and subsurface uncertainties quantification to guide the optimal FCC placement (Andrea Moscariello)

• state of the art 3D geological model
• faults are potential risk areas (example: Vuache fault)
• karstic structures (caverns, water)
• also risk of hydrocarbon (oil, gas..)

3D Geological model

• GeoMol project
• (UNIGE 2014-2019)
• Latest update 2020-21
Vuache fault (group of faults)

risk analysis and risk map being refined
area NW of Saleve well studied, SE much less
Civil Engineering assessment of placement scenarios by ILF Consulting (Werner Dallapiazza)

- risk assessment for different scenarios
- alignments as proposed in the CDR
- risk numbers for each alignment (relative numbers)
- one of the 8-pt scenarios and one of the 12-pt scenarios feature least risk
- presently still being refined (within next months)

### Final Risk Index

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Std. Dev.* : without P19-0.3 and P21-0.3
Technical Infrastructures
Integration of the FCC (Jean-Pierre Corso)

- integration work done during last years taking into account ee and hh options
- first view of layout point by point
  - A + G exp. areas for ee
  - C “standard” also E, F, H, I, K
  - D, J → RF
  - SSS, etc.
- tunnel lay-out for 2 configurations
Integration of the FCC (Jean-Pierre Corso)

Main topics and milestones for Integration activities

2021

Collection, review and update of EL, CV, GC, HE, BE, SY,TE and HSE user requirements for FCC-ee/hh for each surface and underground points

2022

Refined concept integration design of FCC-ee with bear in mind for later evolution to FCC-hh

2023

(Pre-) technical design of FCC-ee surface and underground infrastructure with inputs from EL, CV, GC, HE, BE, SY,TE and HSE and other systems

2024

- input for the Feasibility Design Report

2025

2026

Number of design choices to be frozen in the coming months / years...
Transport and logistics for FCC (Christiana Colloca)

• from study phase 1:
  • transport of cryomodules
  • less critical for ee option but keep in mind the constraints
  • (cranes, dimensions of shafts, etc.)
  • take into account not only installation but also magnet changes during exploitation phase!
  • transport includes also personal transport and evacuation!

Logistic study: transport to CERN*

- International Transport / Overseas
  - Possible alternatives: containers, roll-on roll-off, cargo, freight with special vessels

- Regional Transport
  - Stresses can be reduced with special transports at low speed

- Local Transport / Last Mile
  - Barge transport to Basel
  - Last mile via road transport to CERN
  - Alternative: direct road transport from Rotterdam to CERN

* FIML Final Report 2018
Technical Infrastructure operations today and in the future (Jeper Nielsen)

- review of today’s infrastructure operation (LHC and injectors), tools and procedures
- FCC calls for new technologies
- drones, robots, augmented reality…
- new technologies and new procedures
- documentation and naming conventions are key

Virtual glasses

- Sending live feed from what on-site technician sees to better guide him
- Specialist can guide first-on-scene interveners remotely
- Some companies use this already today
- Possible to work with local staff, guided by experts

Conclusion: Interesting times ahead!

Eyes on the field: Confirm a fault remotely
Remote operations: Avoid travel time for simple operations
Documentation, naming conventions: Simplify collaborations, make tools work together easily
Advanced tools: Make intelligent use of all the data we have and will have available
Safety for the FCC Feasibility Study (Thomas Otto)

- safety Working Group in place
- personal safety, radiological protection, fire safety, environmental protection, …
- remote manipulation will be key
- close link to other WPs

Remote manipulation / Robotics

Reduce exposure of personnel to hazards by increased use of remote technologies

- For monitoring:
  - Monitoring of alignment, automatic realignment (evolution from HL-LHC)
  - Routine radiation surveys
  - Safety patrol before operation with beam
- For standard repair:
  - Transport of material (see below)
  - Exchange of normalized components
- For emergency intervention (already in CDR)
  - First-line fire fighting
  - Assistance during evacuation of personnel
## Work packages with impact on safety

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Looking forward to fruitful collaboration
Status of Electricity and energy management work package (Jean-Paul Burnet)

From first study 2014 – 2018:
• power estimate
• design with 3 400kV substations proposed

Next steps:
• review power demand
• review grid connection
• review powering back-up
• power quality and availability
• energy management and sustainability
• infrastructure integration

Status of the electrical design

3 connection points to the French national grid at 400kV level were identified.
Point III needs new overhead 400kV lines.
Point II needs new buried 400kV lines.
Cooling and ventilation concepts for the FCC (Guillermo Peon)

- CV roadmap
- environmental aspects
- first step is to consolidate user requirements
- supply raw water, demineralized water, chilled air
- required infrastructure e.g. cooling towers
- environmental and safety aspects

Main topics and milestones for CV activities

- **Main system design activities**
  - Review, collection and update of CV user requirements for FCC-ee for each surface point, including CV building and plants specification (assuming no change on FCC-hh requirements); this is input for iteration in particular with safety concepts
  - starting point for external consultant contract(s) for CV concept plan and design
  - input for start of Environmental Evaluation process

- **Refined concept design of CV infrastructures, also taking into account later evolution to FCC-hh; this is**
  - input for full iteration of the design with all users, CE and other systems
  - input for the Feasibility Design Report

- **(Pre-)technical design of CV infrastructures, installation time plan, cost estimate; this is**
  - input for full iteration of the design with all users, CE and other systems
  - input for the Feasibility Design Report

«Work package descriptions» with deliverables, planning/milestones, ... (useful for planning and follow-up)

M. Benedikt, 18.1.2021
FCC-ee & hh cryogenic system conceptual design, status & perspectives
(Laurent Paul Delprat)

• Staged approach for ee option
  • Z, W: 1 cryoplant
  • H: 2 cryoplants
  • ttbar: 4 cryoplants
• hh option much more demanding, must be kept in mind
• strong interface with “placement”

FCC-ee conceptual design

Main considerations
• FCC-ee is designed for 4 physics working points:
  • Z, W, H and ttbar 1 & 2
• Staging of these 4 machines requires a gradual increase of the number of SRF modules (as well as the accelerating frequency), hence a staging of the cryogenic system
  • 400 MHz SRF cavities to be operated in LHe_{sat} bath @ 1.3 bar / 4.5 K
  • 800 MHz SRF cavities to be operated in LHe_{sat} bath @ 30 mbar / 2 K
FCC-hh conceptual design

General layout of the cryogenic system

- 10 refrigeration plants
  - One helium refrigerator
  - One 1.8 K refrigeration unit
  - One neon-helium refrigerator

- 6 technical sites

- Short sectors (5 km)

- Long sectors (10 km)

- Cryogenic distribution line components larger than for FCC-ee

12 point scenario preferred vs 8 point scenario for cryo reliability
Geodetic studies for FCC (Helene Mainaud Durand)

- underline importance of geodetic studies
- collaborations
- in-house manpower being increased

Status of geodetic studies

Determination of High-Precision gravity field models for the FCC region

- Doct. Student to start soon
- Profile measurement campaign well advanced:
  - Astro-zenithal measurements performed & analyzed
  - Levelling measurements done
  - GNSS measurements to be scheduled.
- Deflectometer under refurbishment

Collaboration with ETHZ
Some personal conclusions

- Study 1 is a solid basis to start from
- FCC week 2021 is baseline and kick-off for phase 2
- Good dynamics and enthusiasm (even virtually)
- Keep in mind the hh option where irreversible design choices are to be made
- Lots of interactions / interfaces not only within the TIWG but across the whole study
- Big thanks to the chairpersons and the speakers of the sessions!
Thank you for your attention.