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. SafetSafety for the FCC Feasibility Study (Thomas Otto)

Technical Infrastrucures 2

Chair A Wieser (ETHZ)

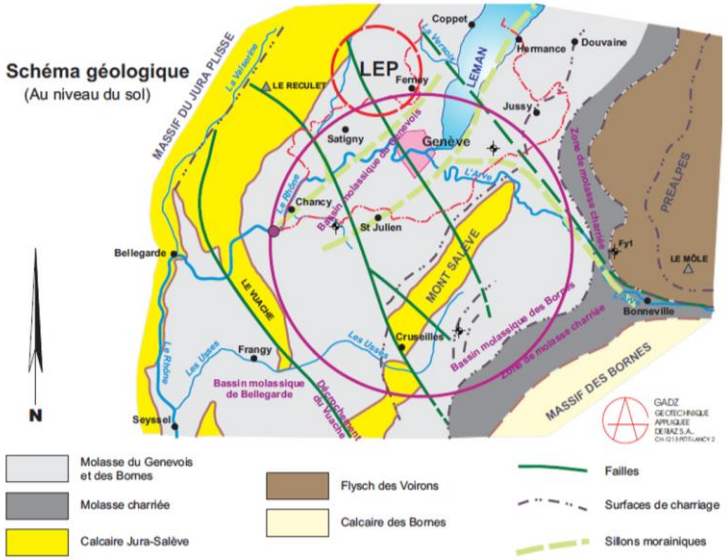
1. Status of Electricity and energy management work package (Jean-Paul Burnet)
2. Cooling and ventilation concepts for the FCC (Michele Battistin)
3. FCC-ee & hh cryogenic system conceptual design, status & perspectives (Laurent Paul Delprat)
4. Geodetic studies for FCC (Helene Mainaud Durand)

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

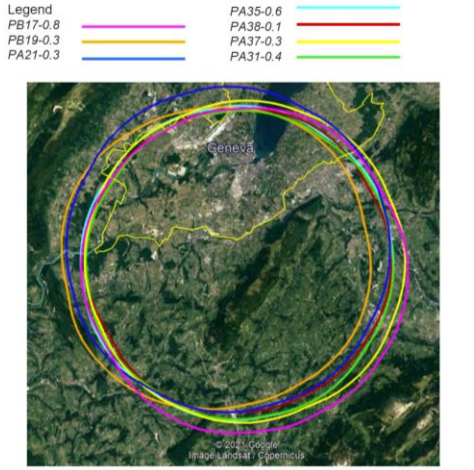
- 5 main scenarios retained
- (2 scenarios with 12 pts, 3 scnearions with 8 pts)
- constrained by natural features
- risk zones identified
- pre-construction schedule
- time lines for construction:
- 12 sectors using TBM
- 7 years total construction

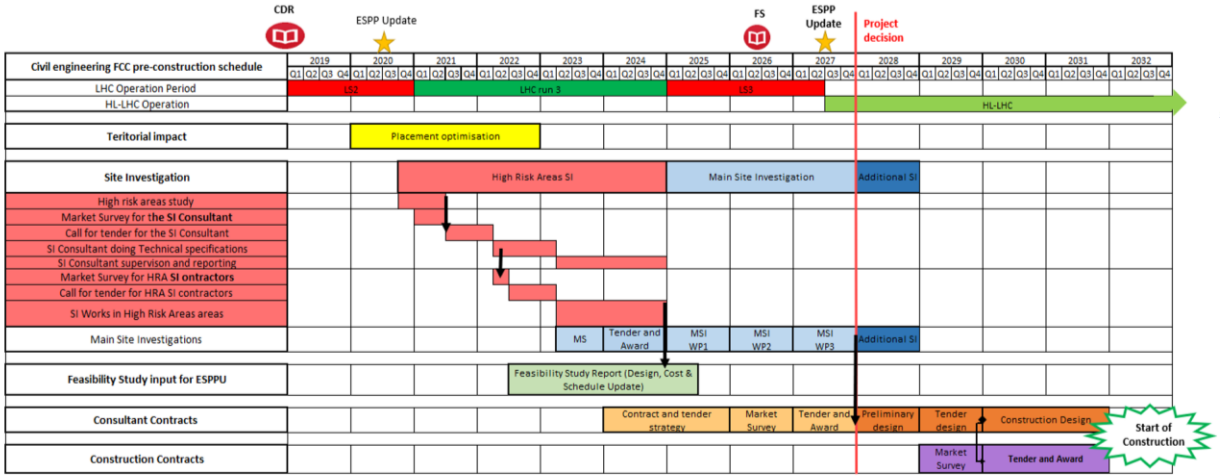
Scenarios reviewed at Placement studies workshop

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.





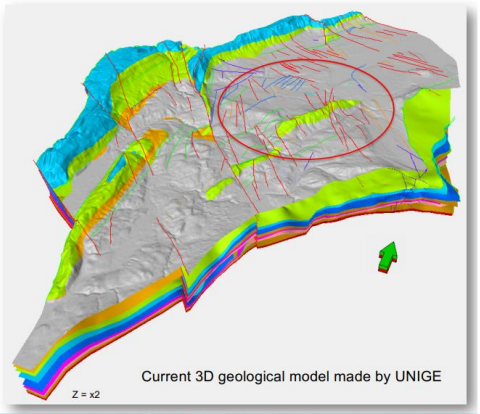
In addition, launching the permitting approval process and environmental impact studies.

3D geological modelling and subsurface uncertainties quantification to guide the optimal FCC placement (Andrea Moscariello)

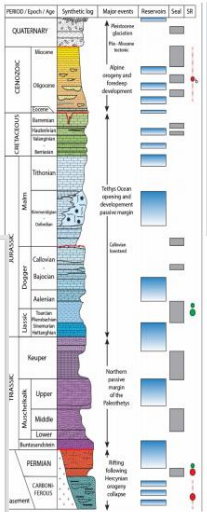
- state of the art 3D geological model
- faults are potential risk areas (example: Vuache fault)
- karstic structures (caverns, water)
- also risk of hycrocarbon (oil, gas..)

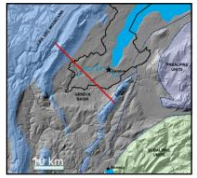
3D Geological model

- GeoMol project
- (UNIGE 2014-2019)
- Latest update 2020-21

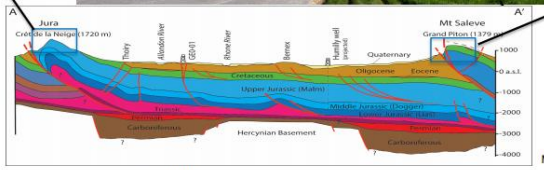


Clerc and Moscariello, 2020

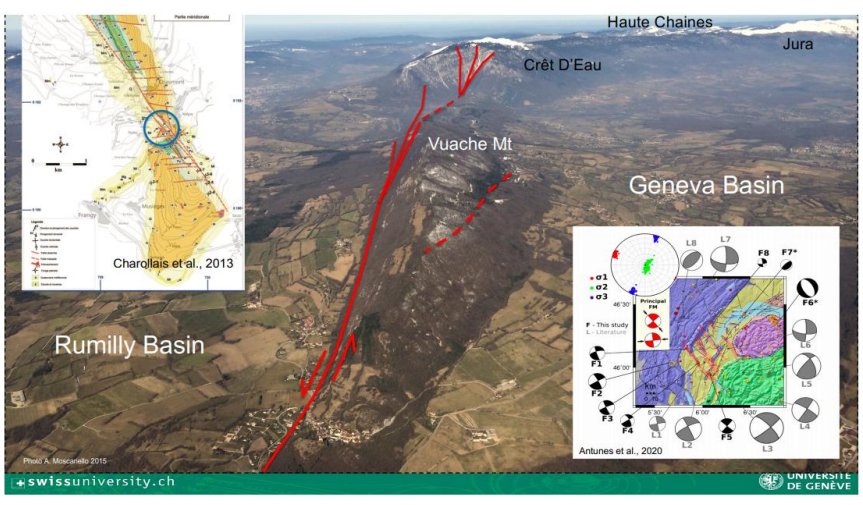




General geological framework

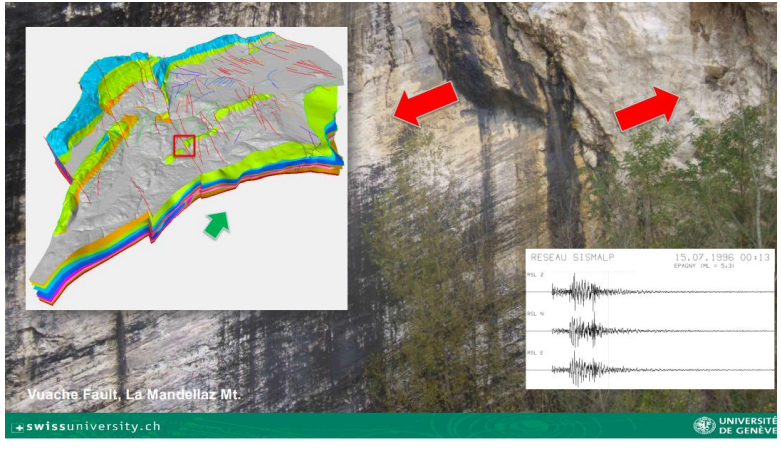


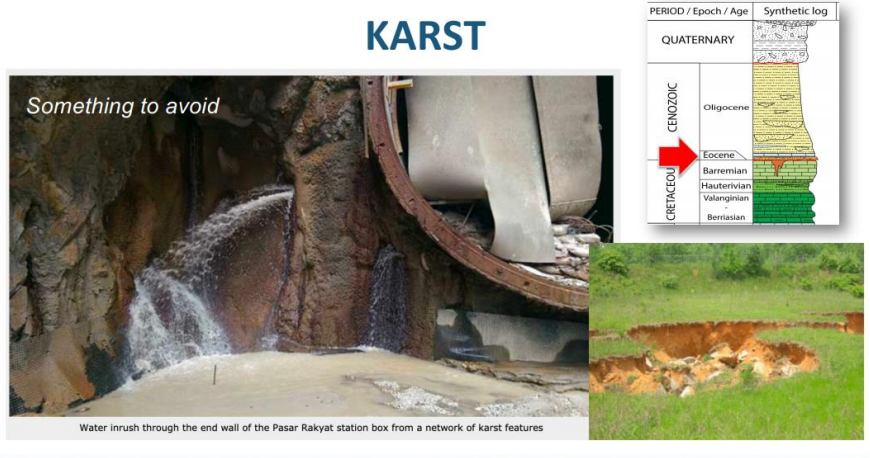
Moscariello el al. 2020



Vuache fault (group of faults)

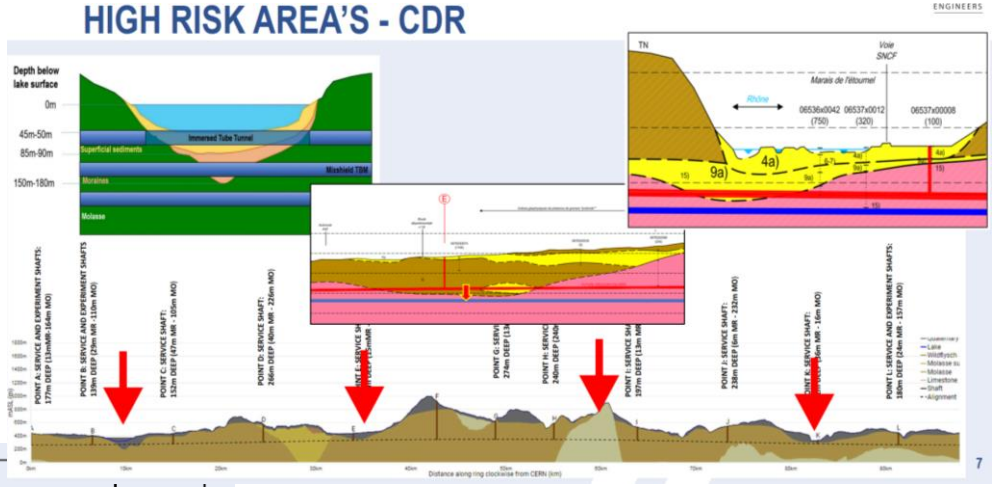
risk analysis and risk map being refined
area NW of Saleve well studied, SE much less





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)

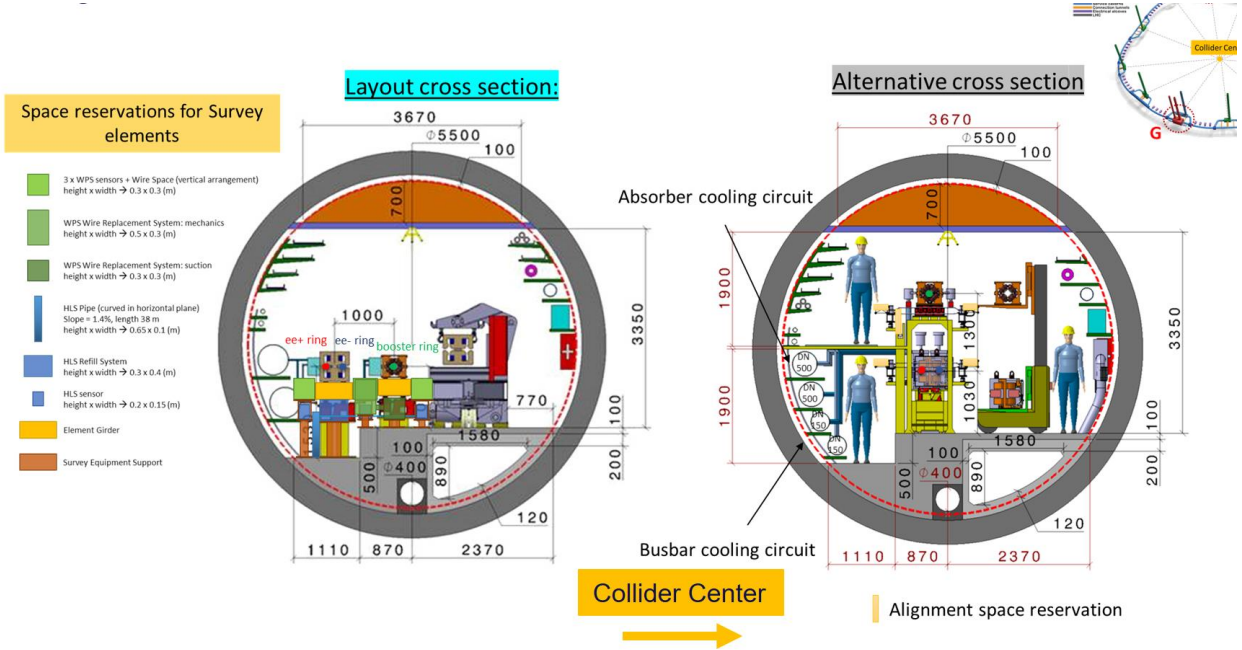


SECTOR	RISK	FINAL RISK INDEX							Std. Dev.*
		17-0.8	19-0.3	21-0.3	31-0.4	35-0.6	37-0.3	38-0.1	
LAKE	Quaternary soft ground, water bearing	47	28	54	29	65	79	40	20
ARVE	Quaternary soft ground, water bearing	12	4	9	6	6	4	5	3
MANDALLAZ	Limestone, water bearing karsts	96	96	96	96	96	96	96	0
USSES	Quaternary soft ground, water bearing	7	7	5	3	1	2	2	2
VUACHE	Limestone, water bearing karsts	24	442	240	12	50	12	12	16
RHONE	Quaternary soft ground, water bearing	18	5	8	11	8	11	12	4
JURA	Limestone, water bearing karsts	100	672	864	100	100	100	100	0
	TOTAL	304	1254	1276	257	326	303	267	29
	Std. Dev.* : witout P19-0.3 and P21-0.3	12	12	8	8	8	8	12	

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

Feasibility Design Report

2021 | 2022 | 2023 | 2024 | 2025 | 2026

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

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

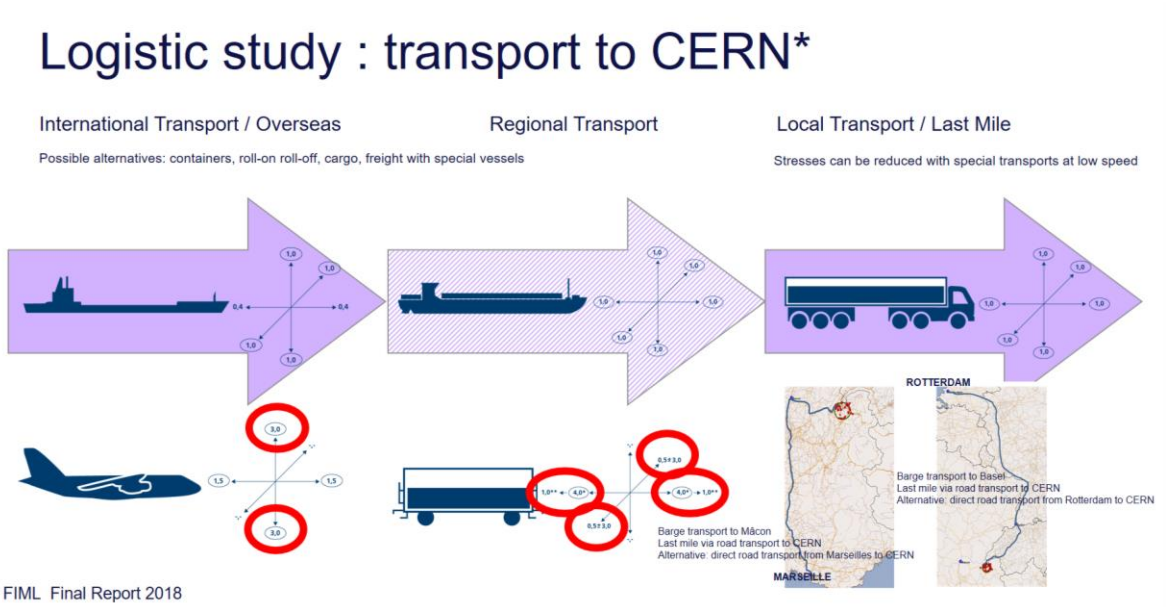
(Pre-) technical design of FCC-ee surface and underground infrastructure with inputs from EL, CV, GC,, HE, BE, SY,TE and HSE and other systems

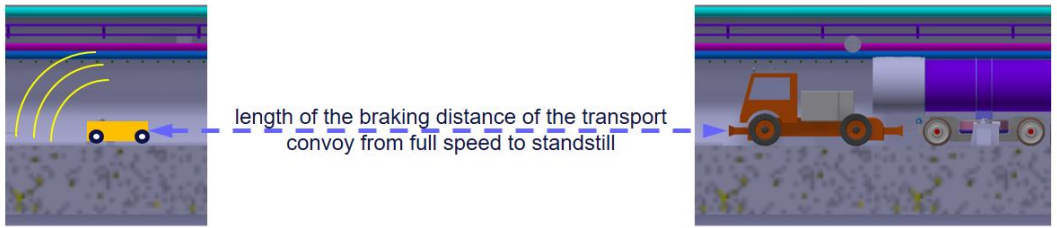
- input for the Feasibility Design Report

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!





underground transport

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

Conclusion: Interesting times ahead!

Eyes on the field: *Confirm a fault remotely*

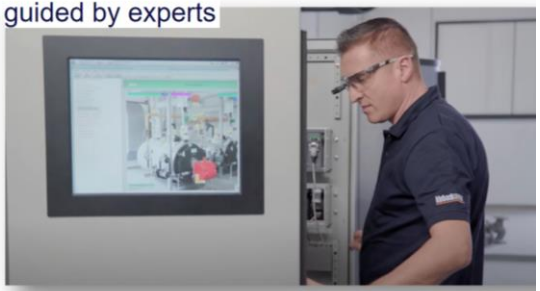
Remote operations: *Avoid travel time for simple operations*

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*

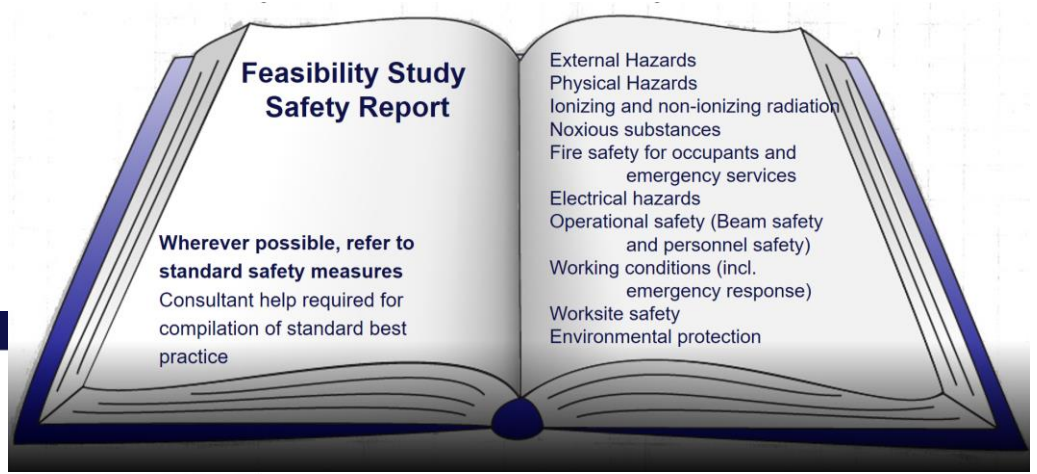
Virtual glasses

- 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



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



FCC Week 2021 Thomas Otto, CERN

Remote manipulation / Robotics

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

- For monitoring:
  - Monitoring of alignment, automatic re-alignment (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

Physics and experiments	Accelerators	Technical Infrastructures	Host State processes and civil engineering	Organisation and financing models	Study support and coordination
Physics programme	ee & FEB design	Electrical infrastructure	Administrative processes	Organisation model	Study/collaboration secretariat
Detector concepts	hh design	Cooling & ventilation	Placement studies	Financing model	Study support unit
Physics performance	Technology R&D	Cryogenics Transport and logistics	Environmental evaluation	Procurement strategy and rules	EU projects
Software and computing	ee MDI	**Safety**	Tunnel, subsurface design	In-kind contributions	Collaboration building
	ee injector	Technical Infrastructure Operation	Surface buildings design	Operation model	Communications
		Geodesy	Landplots and access		

Looking forward to fruitful collaboration

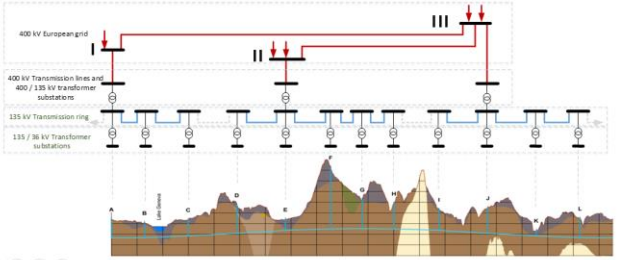
Status of Electricity and energy management work package (Jean-Paul Burnet)

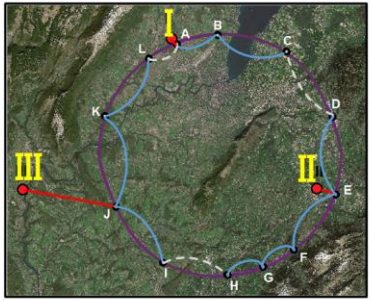
From first study 2014 – 2018:
- power estimate
- design with 3 400kV substations proposed

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

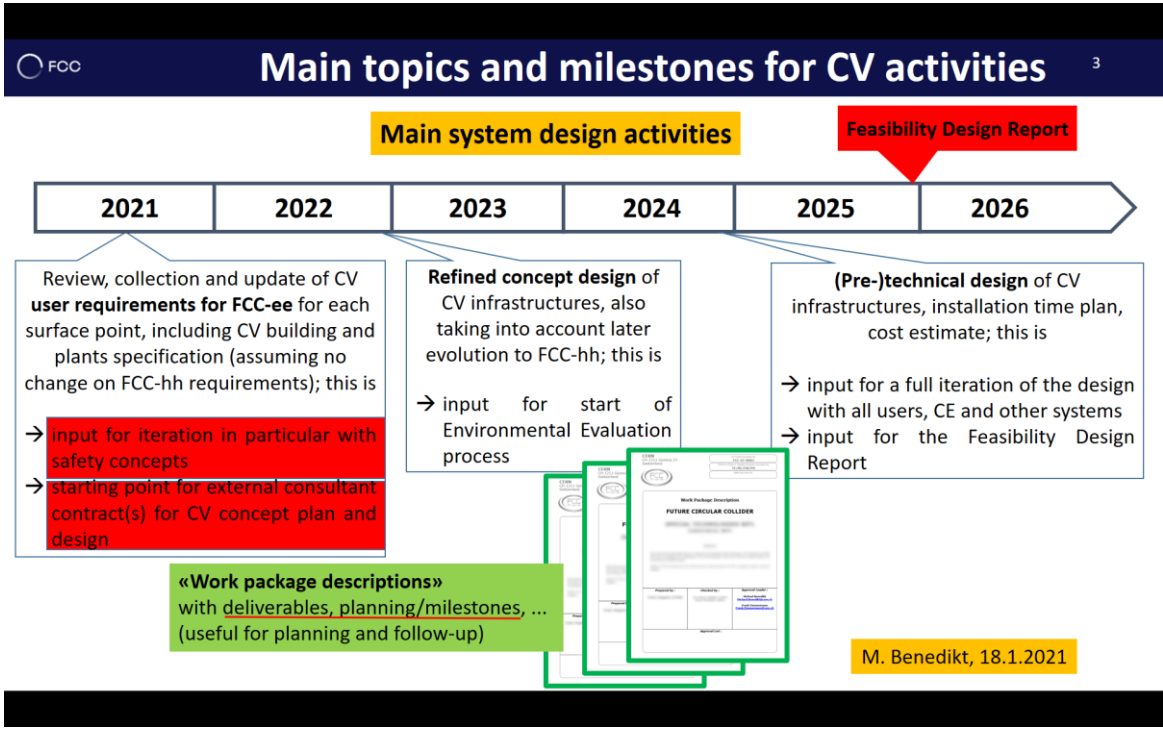
3 connection points to the French national grid at 400kV level were identified.
Point III needs new overhead 400kV lines.
Point II needs new buried 400kV lines.





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



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

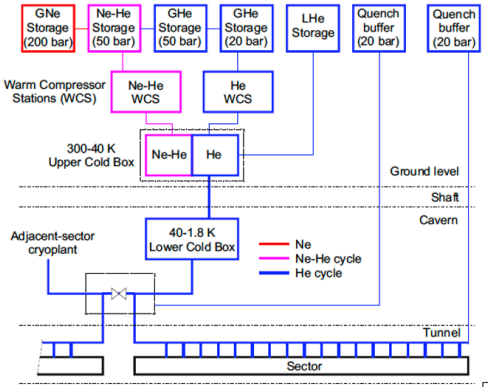
Main considerations

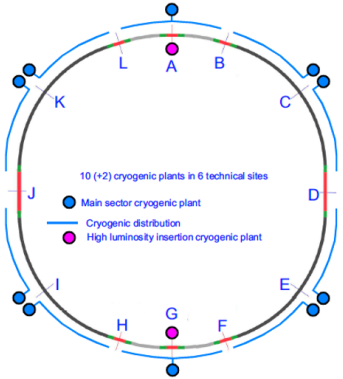
- FCC-ee is designed for 4 physics working points:
  - Z, W, H and ttbar1 & 2
- Staging of these 4 machines requires a gradual increase of the number of SRF modules (as well as the accelerating frequency), hence a staging of the cryogenic system
- 400 MHz SRF cavities to be operated in $LHe_{(sat)}$ 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



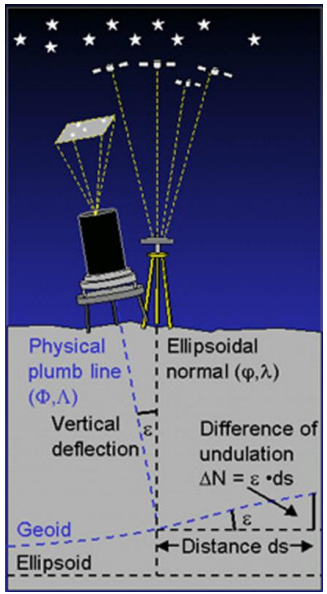


Component	Diameter (mm)
Line B	630
Line C	80
Line D	200
Line E	250
Line F	250
Vacuum jacket of pipe elements	1350
Flanges and bellows of pipe elements	1450
Vacuum jacket of service modules	1500

12 point scenario preferred vs 8 point scenario for cryo reliability

Geodetic studies for FCC (Helene Mainaud Durand)

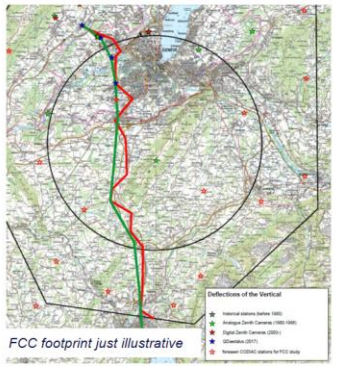
- underline importance of geodetic studies
- collaborations
- in-house manpower being increased



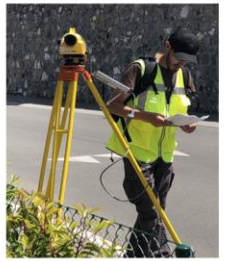
Status of geodetic studies

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



FCC footprint just illustrative



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.