TECHNICAL INFRASTRUCTURE SUMMARY

K Hanke, J-P Burnet, FCC Week 2023, 09/06/2023

Version: 0.28 Date: 26.05.2023

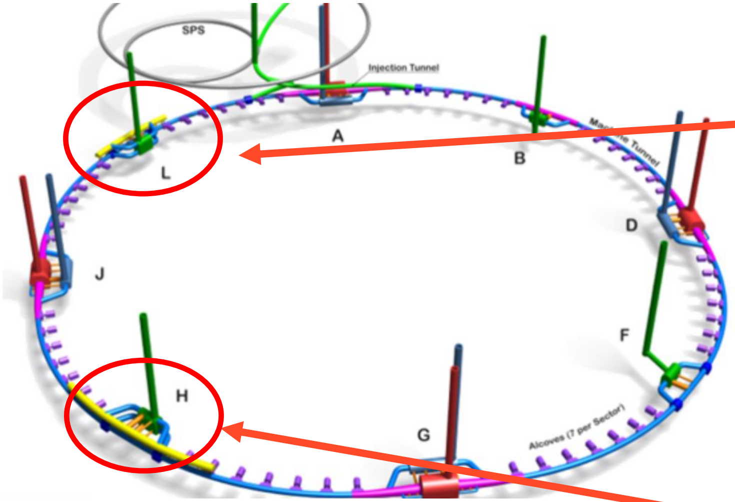
Day	Sunday	Monday	Tuesday					Wednesday					Thursday					Friday	Day
Time	Registration desk	Plenary	Parallel 1	Parallel 2	Parallel 3	Parallel 4	Governance	Parallel 1	Parallel 2	Parallel 3	Parallel 4	Governance	Parallel 1	Parallel 2	Parallel 3	Parallel 4	Governance	Plenary: **Summaries**	Time
Room	Santosa Suite	Orchard Suite	Orchard Suite	Cromwell 1+2	Cromwell 3+4	Kensington Suite	Cromwell 6	Orchard Suite	Cromwell 1+2	Cromwell 3+4	Kensington Suite	Cromwell 6	Orchard Suite	Cromwe 1+2	Cromwell 3+4	ensington Suite	Cromwell 6	Orchard Suite	
08:30-09:00		Opening	Baseline design	Physics Case + Theoretical calculations (I)	FCCIS WP3 Integrate Europe (I)	UK industrial event							Injector (II)	EPOL ( )	Electricity and Energy Management	SRF T chnology (I)		Civil Engineering Technical Infrastructures	08:30-09:00
09:00-09:30		CERN Council expectations for FCC FS																FCC-ee	09:00-09:30
09:30-10:00		Key note: Physics perspectives																FCC-ee injector FCC-hh & magnet	09:30-10:00
10:00-10:30			Coffee Break (Santosa Suite)										Coff e Break (Santosa Suite)						10:00-10:30
10:30-11:00		Coffee Break (Santosa Suite)	Collimation & collective effects	Physics Case + Theoretical calculations (II)	FCCIS WP3 Integrate Europe (II)	UK industrial event			Detector	Future	Communicati			Detectors (I)	Safety, Transport & Survey	SRF T chnology (II)		Coffee Break	10:30-11:00
11:00-11:30		FCC Feasibility Study status																MDI and EPOL	11:00-11:30
11:30-12:00		Baseline Scenario & Host States																PED	11:30-12:00
12:00-12:30		Civil Engineering																Closing remarks	12:00-12:30
12:30-13:00			Lunch break (Santosa Suite)										Lunch break (Santosa Suite)					END	12:30-13:00
13:00-13:30		Lunch break (Santosa Suite)																	13:00-13:30
13:30-14:00			Machi e Detect r Interfa e (I)	RF Points for FCC-ee	F CIS WP4 Impact & S stainability (I)									oftware and omputing / etectors	Technologies	FCC-eh	Scientific Advisory Committee		13:30-14:00
14:00-14:30		FCC Accelerator																	14:00-14:30
14:30-15:00																			14:30-15:00
15:00-15:30	Registration + as from 07:30am on Monday 5 June	Technical Infrastructure	Coffee Break (S ntosa Suite)										e Break (Santosa Suite)						15:00-15:30
15:30-16:00		Coffee Break (Santosa Suite)	Machi e Detect r Interfa e (II)	Integration and Cooling	F CIS WP4 Impact & S stainability (I)								Development	tors (II)	Technologies	Early Career Researchers			15:30-16:00
16:00-16:30		PED plenary: i) Physics case, ii) Theoretical calculation strategy, iii) Detector requirements from physics																	16:00-16:30
16:30-17:00																			16:30-17:00
17:00-17:30																			17:00-17:30

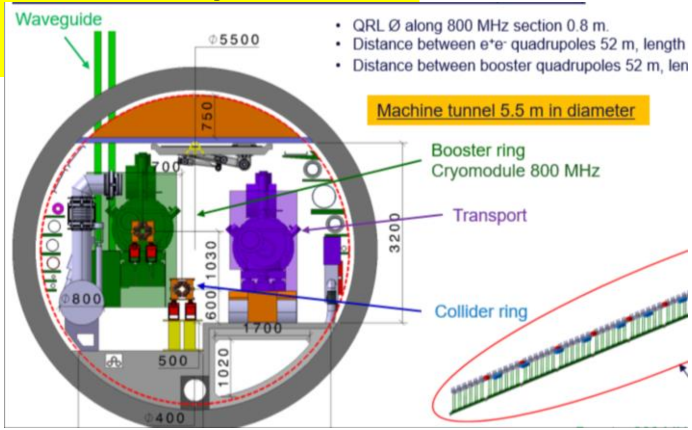
4 sessions
19 presentations

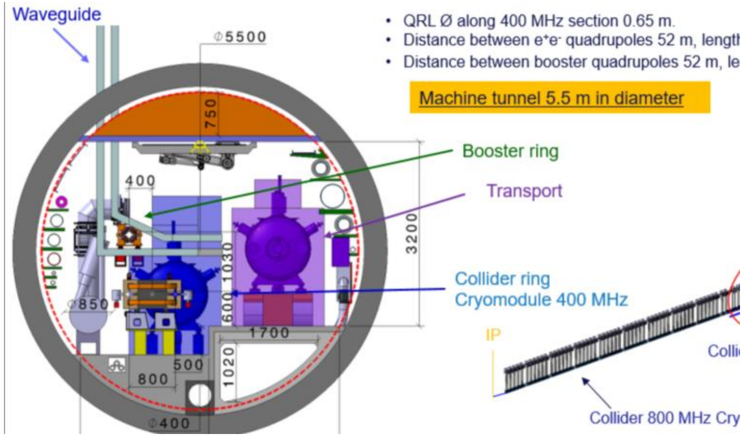
TECHNICAL INFRASTRUCTURE

RF POINTS

General Lay-out, integration update RF systems
Fani Valchkova



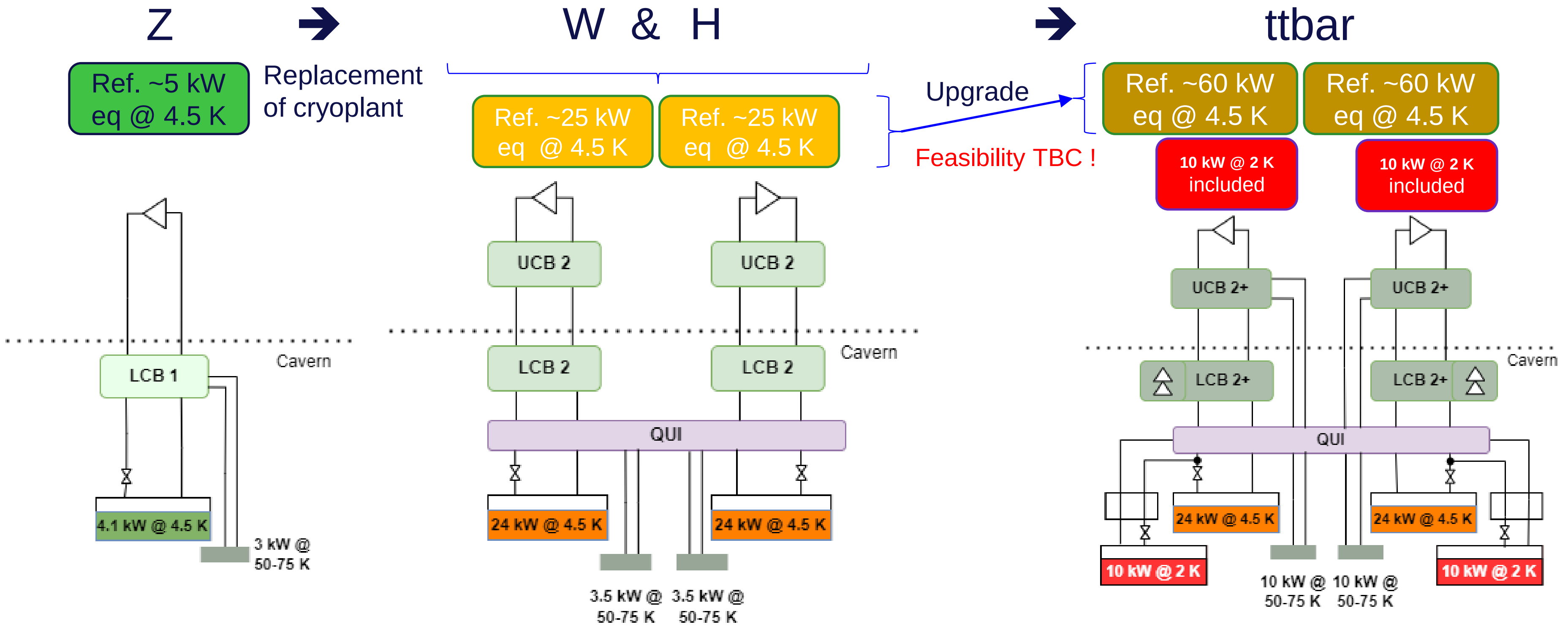




Two RF points, Booster and Collider separated
Booster RF, 800 MHz PL
Collider RF, 400 + 800 MHz PH

FCC cryogenics status, layout, and implementation studies
Boyan-Kaloyanov Naydenov Popov

- **Staging at point H**
  - Increased staging complexity.

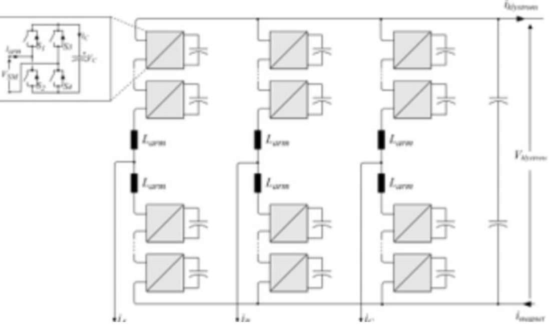


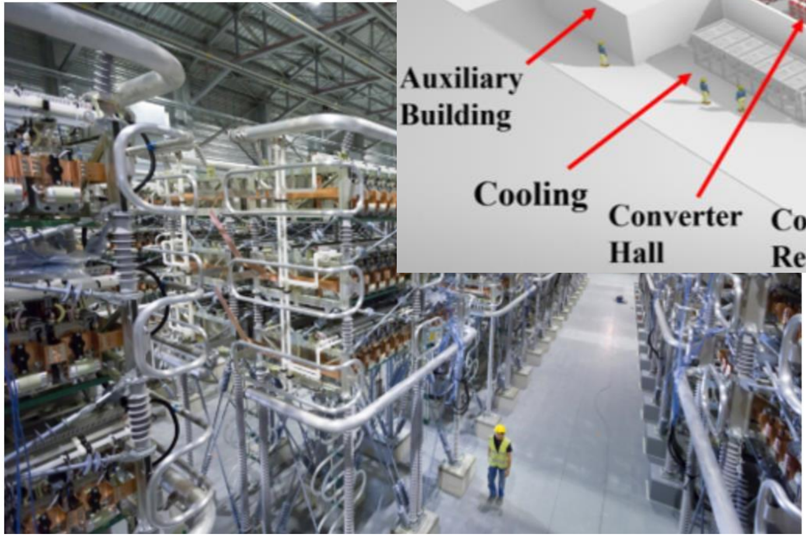
Powering of RF systems – Power converters and infrastructure
Davide Aguglia

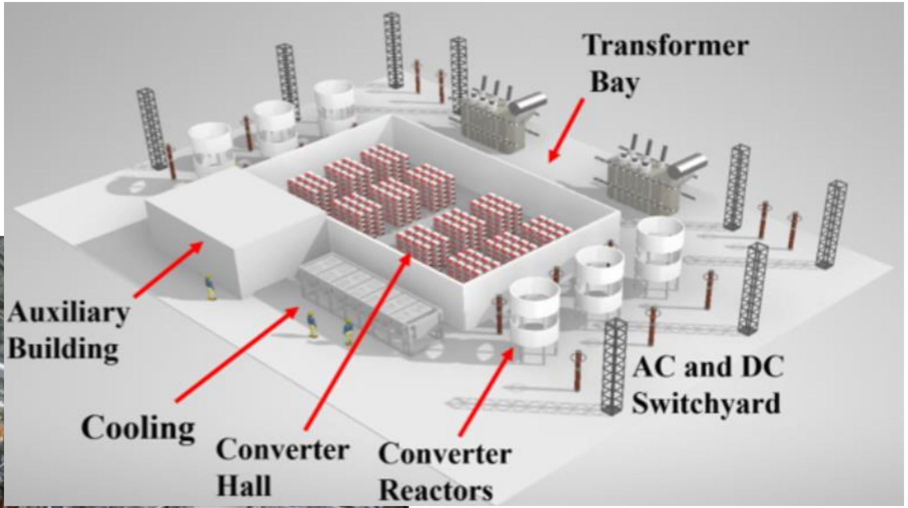
One PC per klystron vs one centralised PC

Proposed solution - centralised MMC on surface

- Modular Multilevel Converter (MMC)
- Industrially available now in the 100s of kV & GW range
- Advantages
  - High efficiency: 98 % – 99 %.
  - High availability (redundant modules)
- Special protection techniques needed







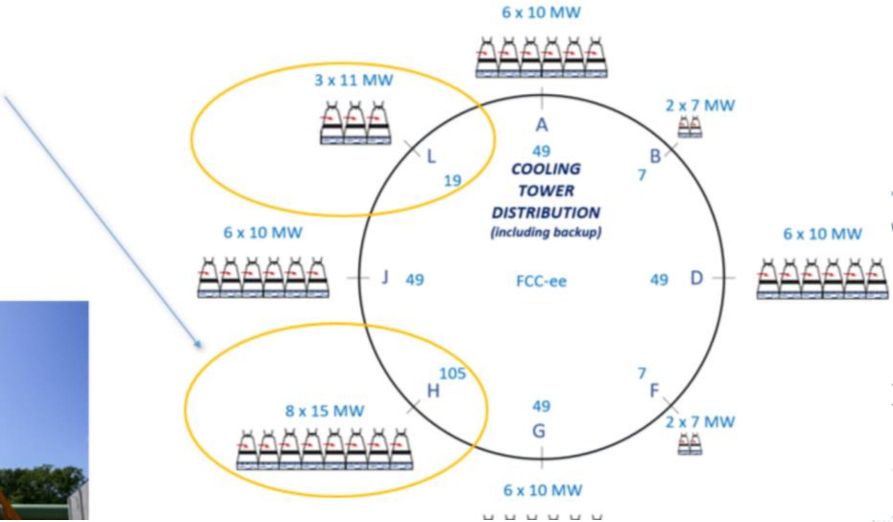
Cooling & ventilation for RF systems, surface and klystron galleries
Inigo Martin Melero

Primary Water: Cooling Towers.

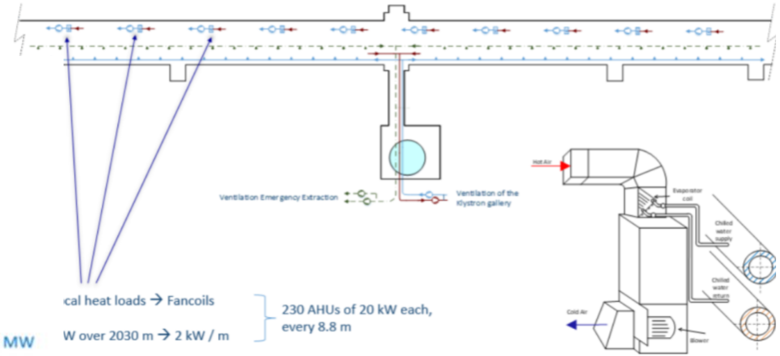
Largest cooling needs
~ x 2 Cooling tower power
respect to Experimental Points

T water coming to cooling tower: 40 ºC.

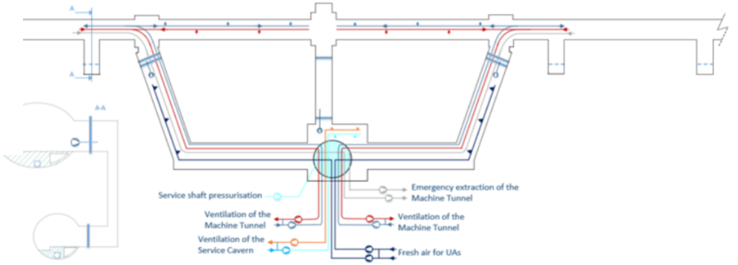
T water leaving cooling tower: 25 ºC.



Underground Ventilation Point H, Klystron Gallery



Underground Ventilation Point H, Tunnel



RF string or continuous cryomodule, impact on infrastructure and recovery time
Vittorio Parma

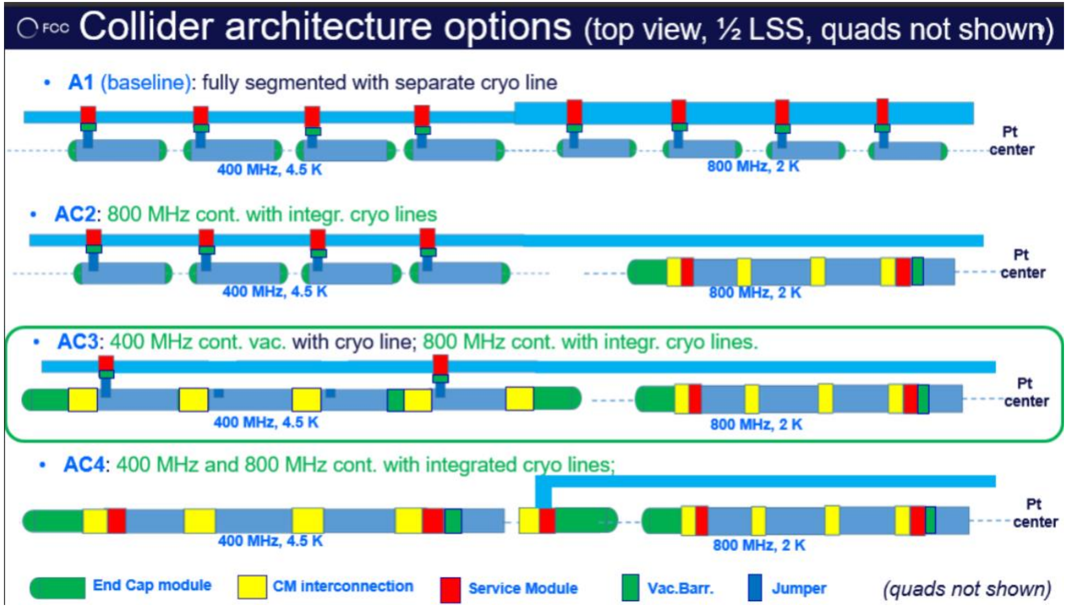
Present Baseline

- 366 CM (3 types), 1’464 SRF cavities (4 cavities/CM, present assumption):
  - 400 MHz single-cell (Nb/Cu), 4.5 K: 28 CM, 112 cavities (removed after Z)

  - 400 MHz two-cell (Nb/Cu), 4.5 K: 66 CM, 264 cavities

  - 800 MHz five-cell (bulk Nb), 2 K: 272 CM, 1’088 cavities

- By machine:
  - Collider (ttbar): 188 CM (264 cavities 400 MHz, 488 cavities 800 MHz)
  - Booster (ttbar): 150 CM (600 cavities 800 MHz)

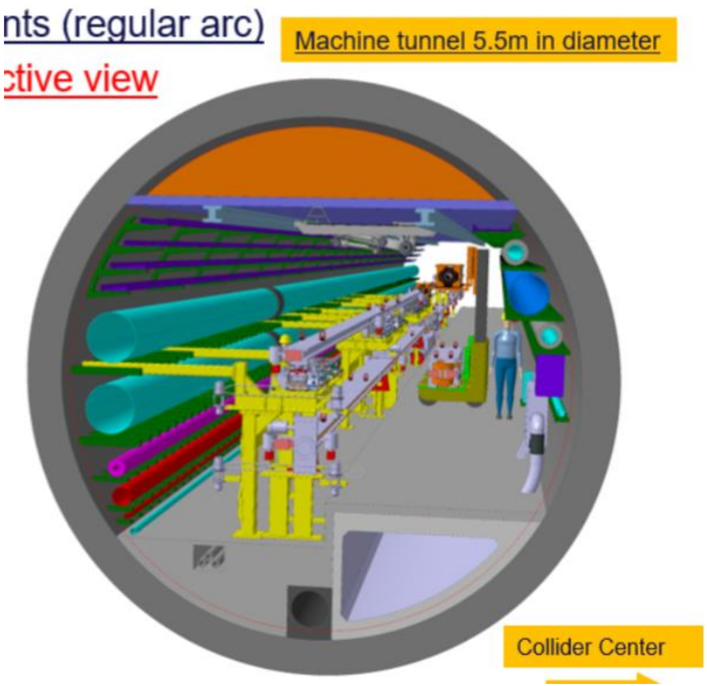


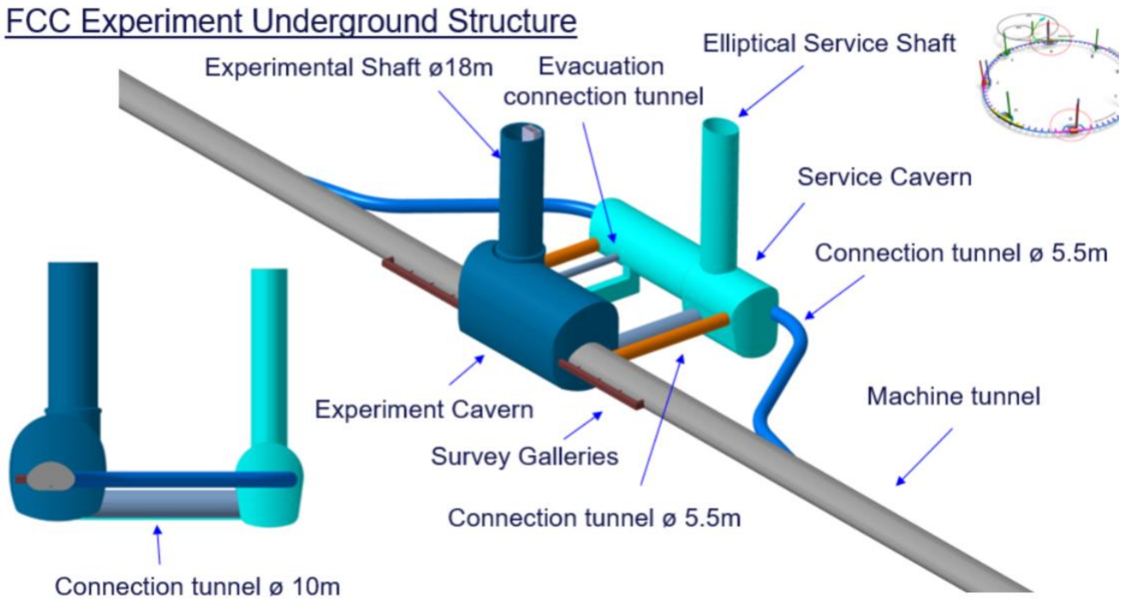
TECHNICAL INFRASTRUCTURE

INTEGRATION AND COOLING

Integration update tunnel and arcs, caverns, service caverns, etc.
Fani Valchkova

FCC-ee Regular Arc





Service caverns, alcoves, beam strahlung dump, first look at FCC-hh and transfer line

Alcoves requirement and integration, cabling concept
Charline Marcel

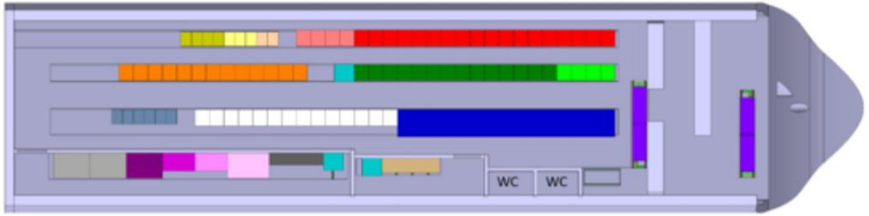
Accelerator of 91km: 1 alcove every **1,6km** (based on LHC repartition, that seems coherent for the machine)

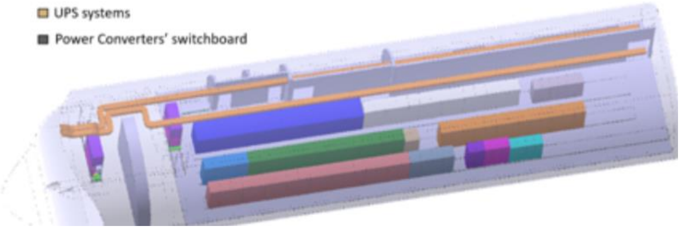
Total of **56 alcoves** all around the machine, **7 by sector**

Role of an alcove: host the converters for the magnets of the machine and all the equipment that need to be protected from the radiations present in the tunnel (including power centers)
Also serve as escape road and parking area for the transport

Two types of alcoves:

- **"big" alcoves**, that are at the end of the straight sections of each point and host the main converters for the magnets (for dipoles and quadrupoles)
- **"small" alcoves**, that are all along the arc, cover the distribution on 800m each side and host the other converters (for sextupoles)





300m² reserved for each alcove

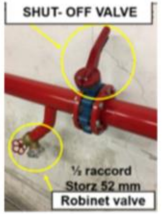
General layout and update of cooling and ventilation systems for arcs
Guillermo Peon

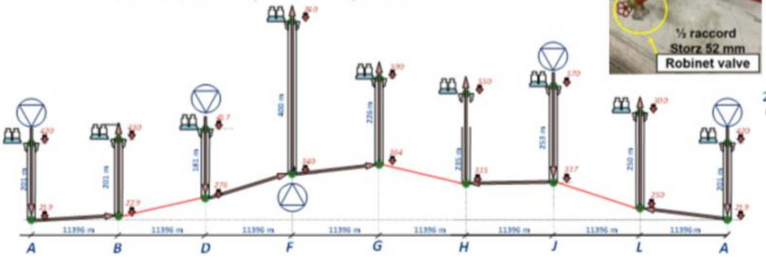
Concept for cooling water (raw water, demineralised water, chilled water)

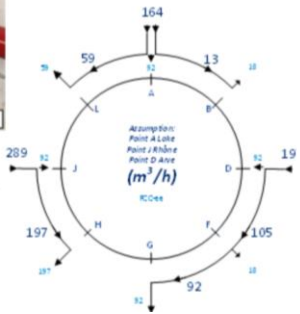
Ventilation, standard operation and special modes

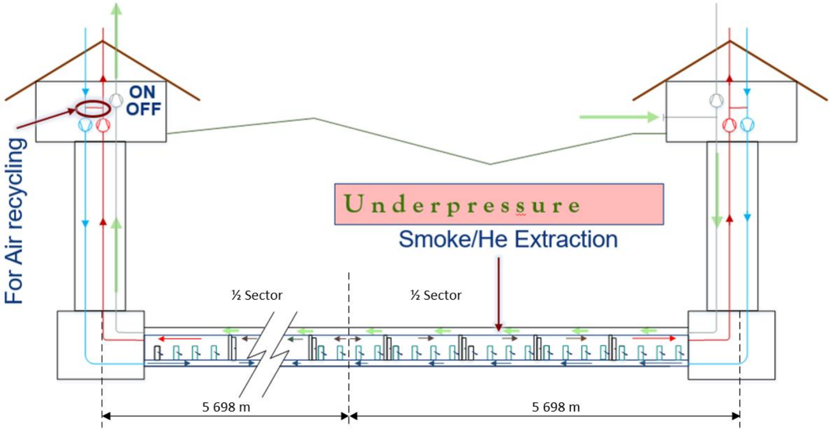
Raw water distribution and firefighting water in the tunnel

- All sectors except for BD, GH and JL have raw water pipes in the tunnel
- Dedicated firefighting pipes to be installed in BD, GH, and JL;
- High pressure ratings (PN40 and PN63) needed
- One booster pump needed at point F underground
- One storz connection evey 80 m → 143 per sector









What to do with the FCC Waste Heat ?

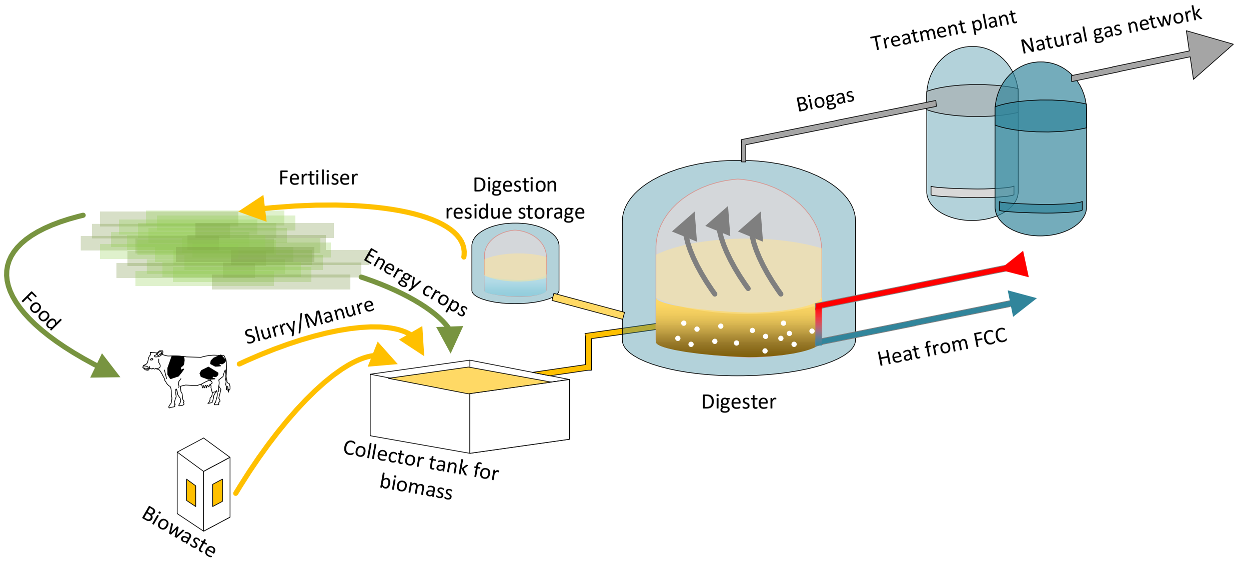
Heat recovery perspectives - Guillermo Peon

Heat Recovery in the Biogas production

Ref.: Mechanism of waste-heat recovery from slurry by scraped-surface heat exchanger in Applied Energy, Volume 207, 1 December 2017, Pages 146-155

The authors claim that recovering heat from slurry can increase the biogas production up to 8.5%.
But similar gains can be obtained when recovering heat from other processes.

Biogas production:
- The slurry is transferred to a closed tank (digester);
- The anaerobic digestion (AD) process for Biogas production can be
  - Mesophilic (Temperature around 37 °C) or
  - Thermophilic (55 °C) modes
- Recovered Heat from other processes can give the needed energy thus improving the efficiency of the process



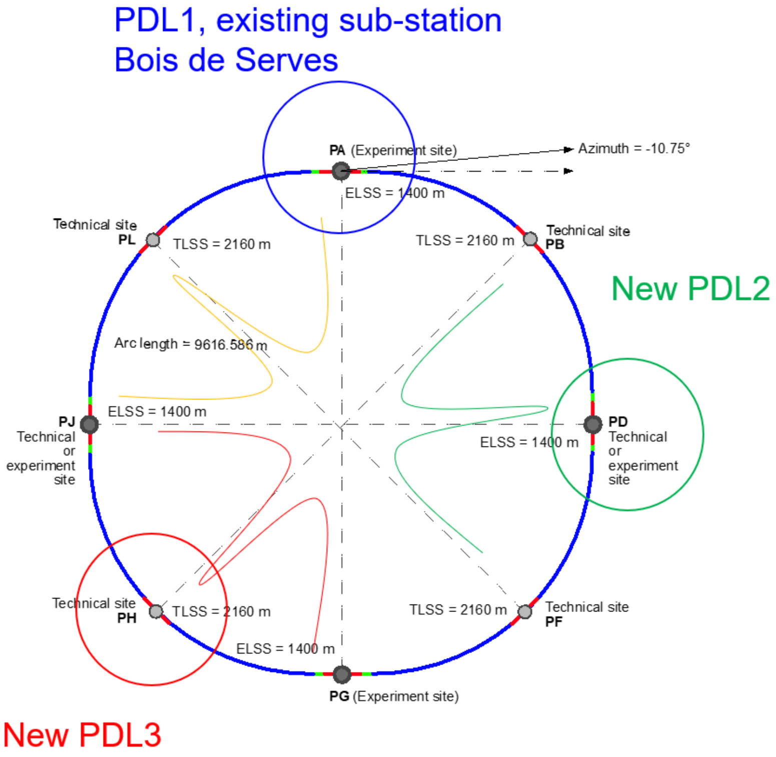
TECHNICAL INFRASTRUCTURE

ELECTRICITY AND ENERGY MANAGEMENT

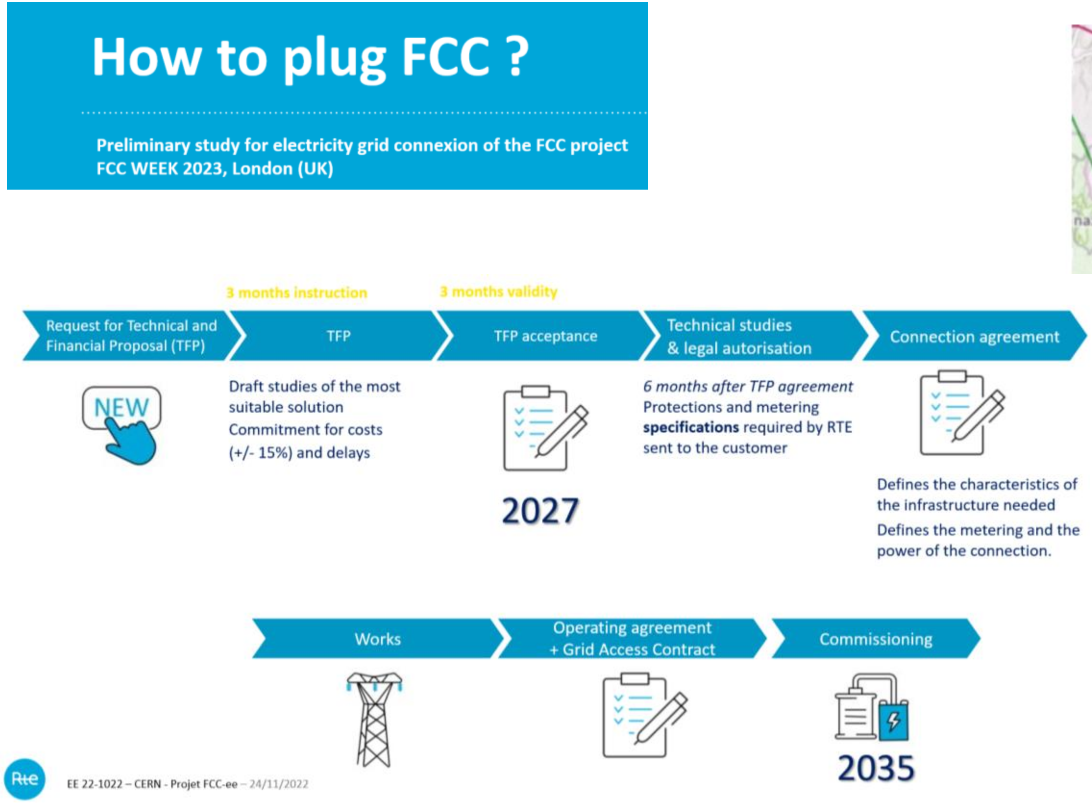
Update of the power demand and energy consumption, grid connection Jean-Paul Burnet

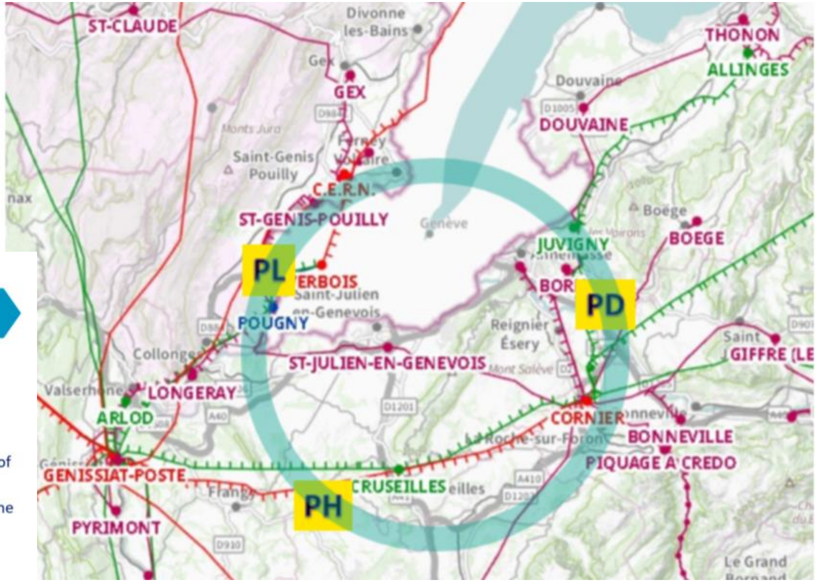
2023		Z	W	H	TT
Beam energy (GeV)		45.6	80	120	182.5
Magnet current		25%	44%	66%	100%
Power ratio		6%	19%	43%	100%
PRF EL (MW)	Storage	146	146	146	146
PRFb EL (MW)	Booster	2	2	2	2
Pcryo (MW)	Storage	1.2	11.5	11.5	27.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]40
					3
					9
					1
					0
					4
					6
					[illegible]57

- Shutdown: reduced power of all infrastructure systems, cryogenics at 20%, cooling at 50%, accelerators OFF.
- Commissioning: All infrastructure systems, and cryogenics at nominal. Start of accelerator systems, Booster ON, Collider at 50% load.
- Physics operation: all systems are ON. The electricity grid is loaded at 100%.
- Downtime: All infrastructure systems, and cryogenics at nominal. Booster and Collider systems are OFF.
- Technical stops: All infrastructure systems, and cryogenics at nominal. Booster and Collider systems are OFF.
- Machine development: all systems are ON. Reduced RF power to 15%, no physics.



RTE preliminary study for grid connection
Jean-François Billerot





Electrical distribution concept and layout
Charline Marcel

High Voltage network scheme

Innovation is to move the substations under ground

Underground High Voltage network scheme

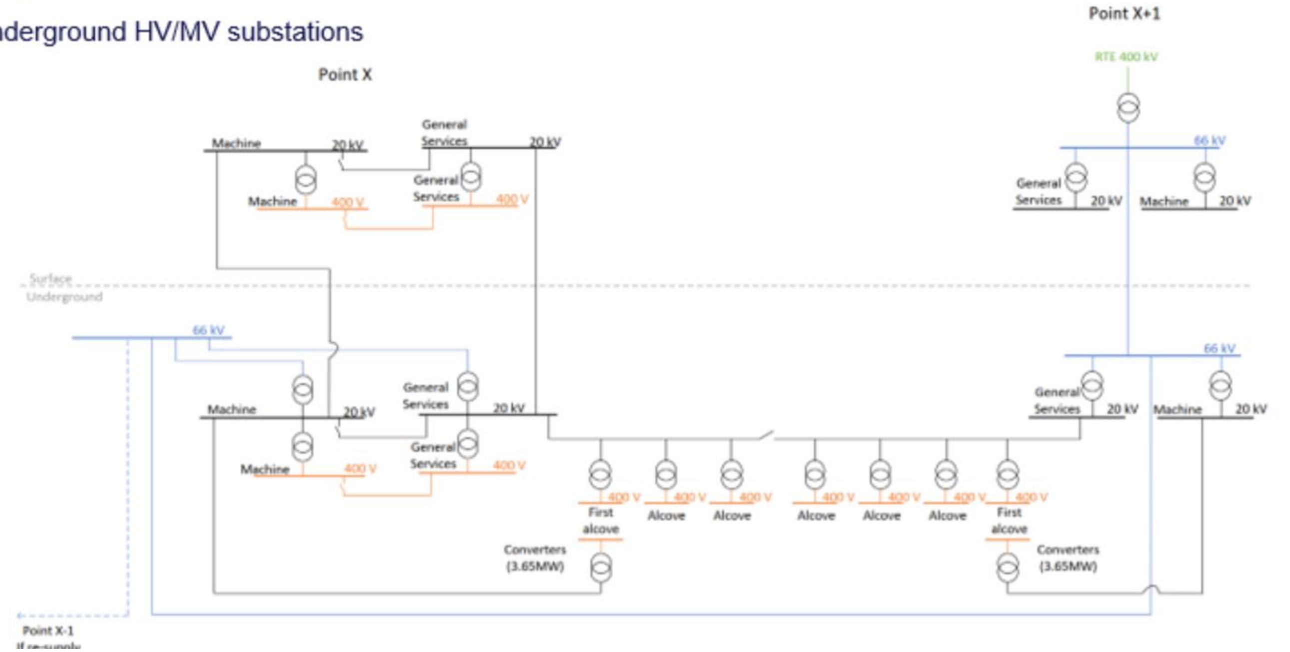
Solution in investigation: underground HV/MV substations

Benefits:

- Power at High Voltage (HV) closer to the main loads
- Avoid a double cabling between surface and underground

Disadvantages:

- Space occupation underground
- Technologies adapted for underground more expensive (and today considered feasible up to 72.5 kV)
- Cooling of the underground galleries

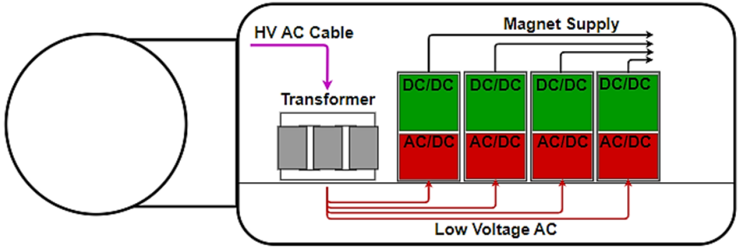


DC Networks for the Powering of the FCC-ee and FCC-hh
Manuel Colmenero Moratalla

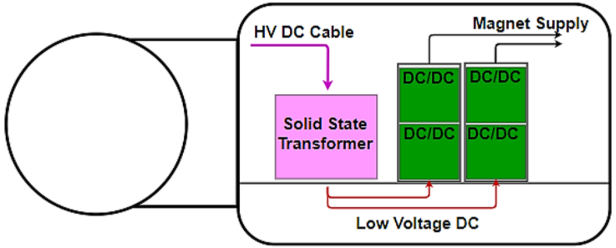
DC Microgrids for the FCC

- Optimization of the volume of the power converter alcoves

Conventional AC Solution

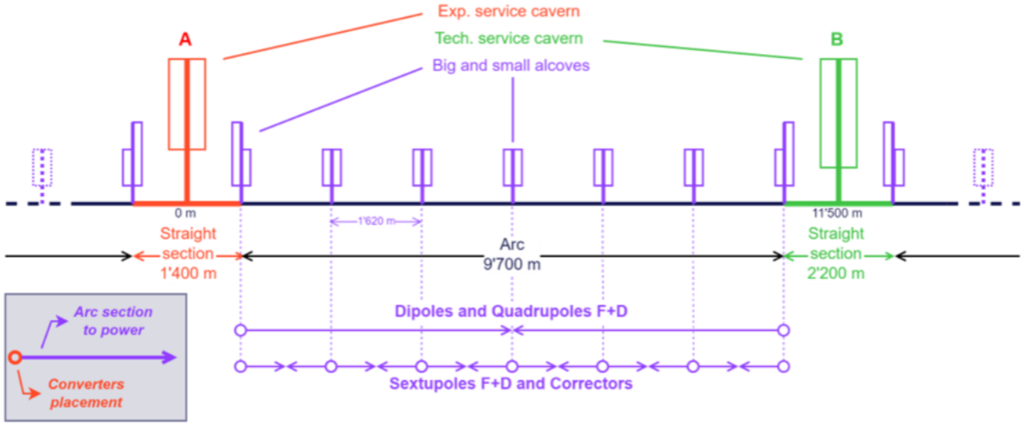


DC Solution



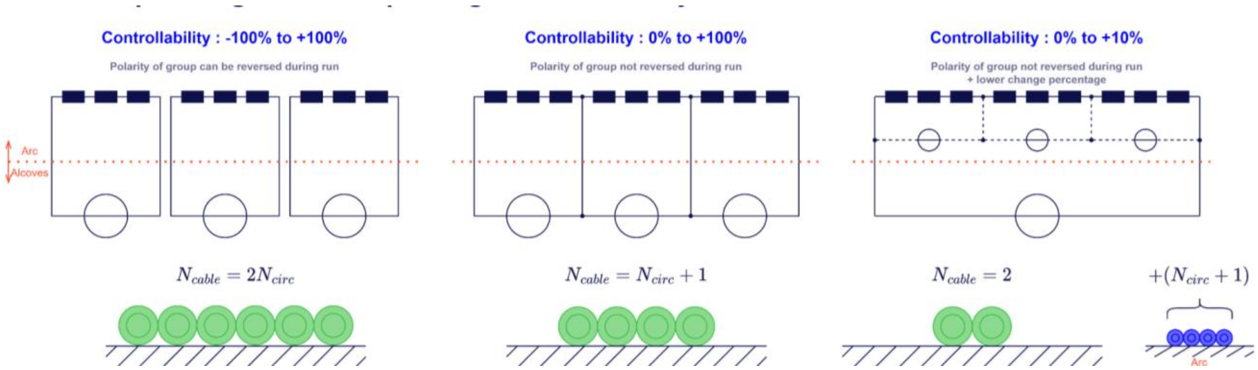
- AC/DC Converters centralized at the surface/technical galleries
- Solid State Transformers (SSTs) for Voltage Conversion
- Losses Transformer + Several LV AC/DC are higher than SST + HV AC/DC
- SST are very modular: easier transport, maintenance and scalability
- Comparative analysis with the AC baseline is difficult due to lack of expertise

Powering of magnet concept and requirements
Byamba Wicki



Large number of smaller power supplies (sextupoles, …)
Overall optimisation needed
Input for magnets needed

example:
sextupoles

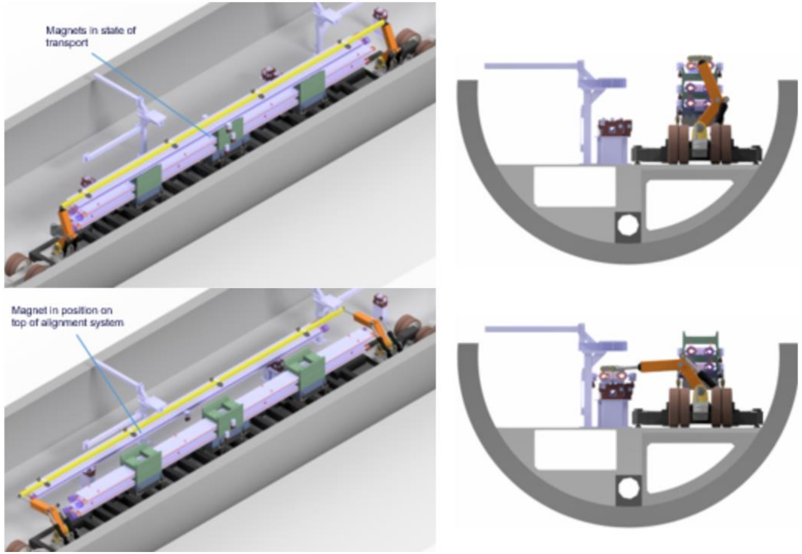


TECHNICAL INFRASTRUCTURE

SAFETY, TRANSPORT, SURVEY

Update of transport concept for personnel and material
Roberto Rinaldesi

Transport of accelerator components

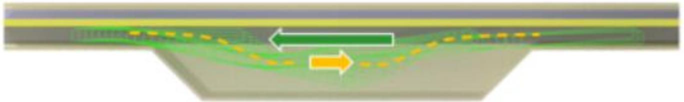


Traffic management

A traffic management system will be needed to coordinate the single maneuvers both in normal and emergency conditions of the people and the magnet transport vehicles.

The system shall:

- Be informed of all the vehicles running in the tunnel.
- Record in real-time any maneuver taking place in the tunnel (possible use of RFID technology).
- Manage the vehicles crossing in correspondence of the small laybys according to a predefined priority hierarchy. Example:
  - Normal conditions: magnet transport has priority with respect to people transport;
  - Emergency conditions: people transport has priority with respect to magnet transport.



Update on material logistic concept
Benedikt Oliver Müller

Fraunhofer IML

Material flow simulation with Plant Simulation

Simulation procedure and simulation tool

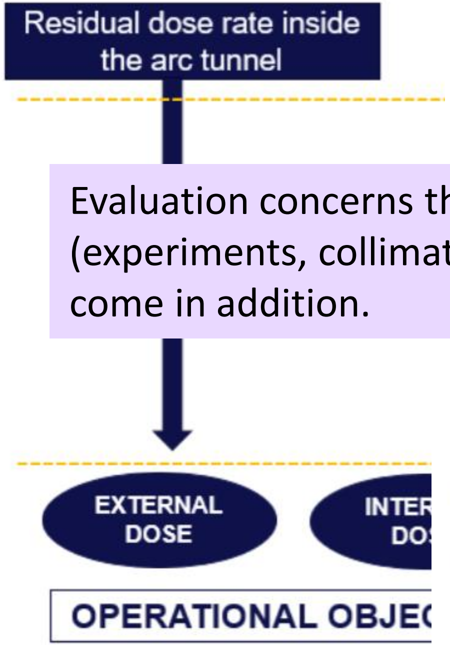
Summary	Scenario	2s2v	2s4v	4s2v	4s4v
	KPI	Value	Value	Value	Value
General	Overall simulation time [h]	5928*	5496*	2760*	2760*
Magnet transport	Transport time [h]	5424	4584	2304	2280
	Magnets transported per day and shaft	20	23	23	23
Magnet aligning and connecting	Aligning and connecting time [h]	5904*	5472*	2736*	2736*
	Magnets aligned and connected per day and shaft	18*	19*	19*	19*
Transporters waiting at shaft for crane with magnet	No. of times waiting for magnet	865	2440	865	1223
	Accumulated total waiting for crane time [hh:mm:ss]	735:21:59	3149:32:22	741:48:04	1734:48:20
	Avg waiting for crane time [hh:mm:ss]	0:51:00	1:17:27	0:51:27	1:25:07
Transporter waiting for other transporters to pass by	No. of encounters	0	2449	0	1221
	Accumulated total encounter waiting time [hh:mm:ss]	0:00:00	2664:00:52	0:00:00	1866:18:18
	Avg encounter waiting time [hh:mm:ss]	0:00:00	1:05:21	0:00:00	1:31:56

s = shafts

v = vehicles per shaft

- Magnet transport frequency is as high as magnet lowering frequency
- Low underground buffer utilization

Radiation protection studies for the FCC-ee
Giacomo Lavezzari



- **External dose:**
  - Residual ambient dose equivalent rates (after 1 hour at 1-2 m distance from the beamline):
    - Z: values between 0.1 μSv/h and 1 μSv/h
    - W, H: values below 0.1 μSv/h

    } **no intervention constraints**
    - ttbar: relevant residual dose rates after short decay times: from 10 to 20 μSv/h. **Impact on interventions to be considered.**
- **Internal dose:**

for 1 hour of

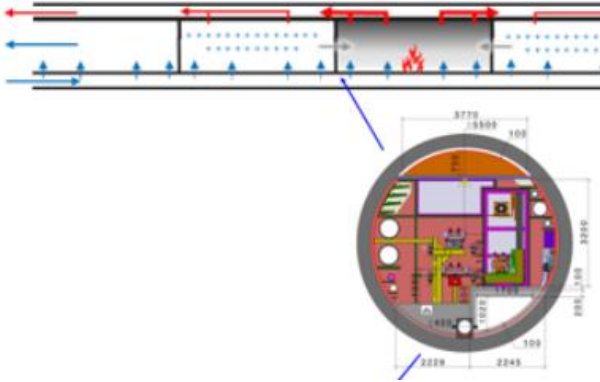
0 m³/h are sufficient

Evaluation concerns the arcs only. Contributions from the straight sections (experiments, collimators, beamstrahlung) are not yet estimated and will come in addition.

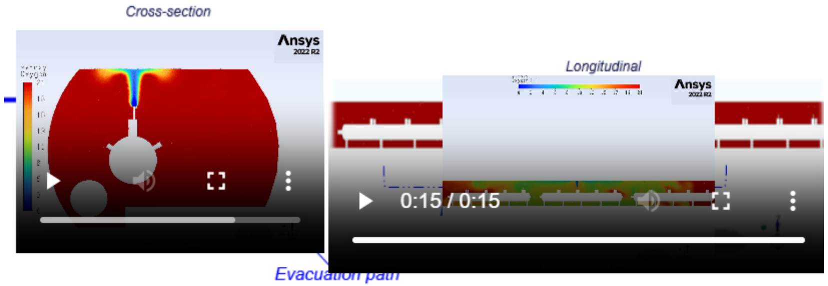
  - Strong dependence on the recycling factor
  - Major contributions to activity from short-lived emitters: Ar-41, C-11, N-13
  - ttbar can reach 10^6 MBq/year per release point without aerosol filters
  - For Z, W, H, the release varies from 10^2 to 10^5 MBq/year per release point without aerosol filters.
- **Released activity via water circuits:**
  - Not addressed here → water circuit model required
- **Materials activation:**
  - No relevant activation of tunnel walls and soil.
  - Accelerator materials: **critical activation only during ttbar**. Below clearance limits after ~4-5 years after ttbar operation.
  - There is an uncertainty on the evolution of the current legislative limits until FCCee goes into operation

Overview of safety systems and evacuation study in the FCC tunnel
Andre Henriques

Fire safety



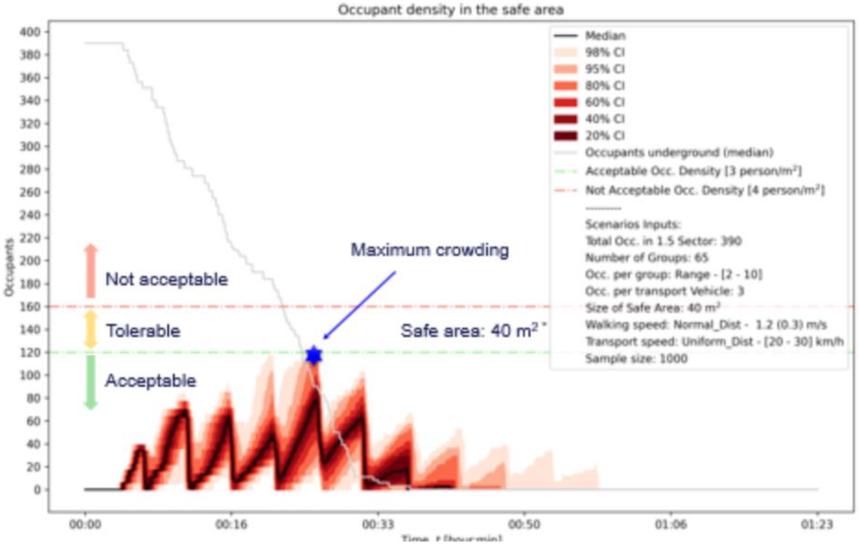
Fire compartments:
- 28 / sector



In a few seconds (4 – 10s) the O_2 levels reach limit at the evac path and for several meters

Cryo release

Evacuation simulations

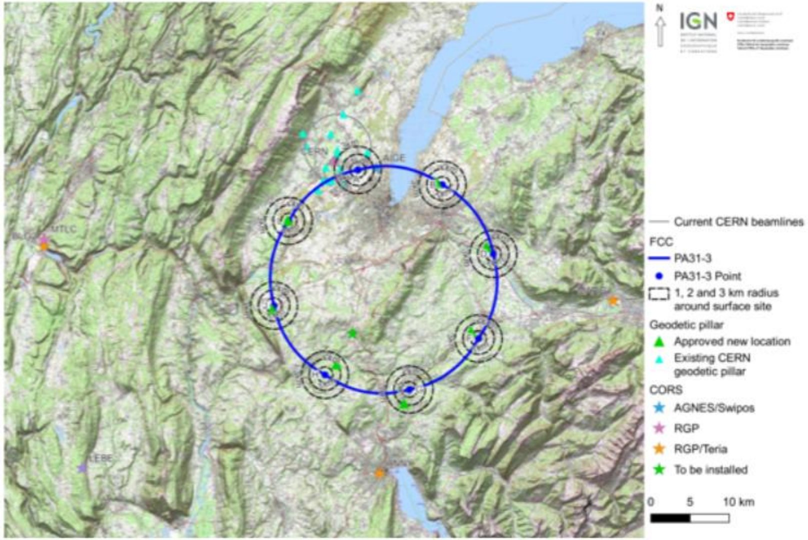


Geodesy and survey update
Benjamin Weyer

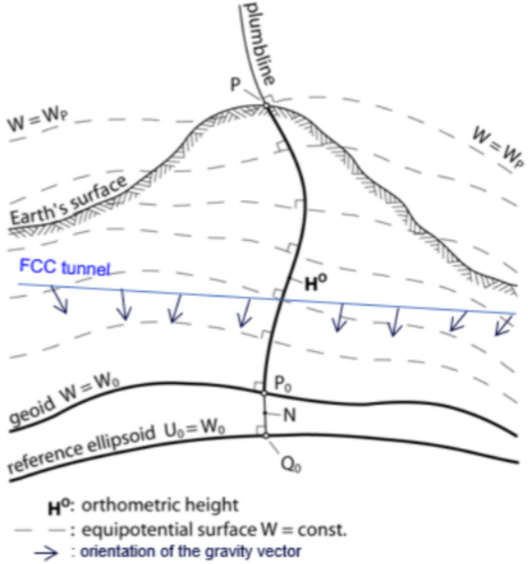
Primary Surface Geodetic Network

Implementation of P-SGN

- IGN and Swisstopo got an agreement to build the pillars
  - Point B: Choulex
  - Point D: Nangy
  - Point F: Etaux
  - Point G: Charvonnex
  - Point H: Cercier
  - Point J: Dingy en Vuache
  - Point L: Dardagny
  - New CORS: Jussy



Geoid modelling



Thank you for your attention

Big thanks to all speakers and chairpersons of the Infrastructure Sessions