FUTURE CIRCULAR COLLIDER

Technical Infrastructure

K Hanke, CERN

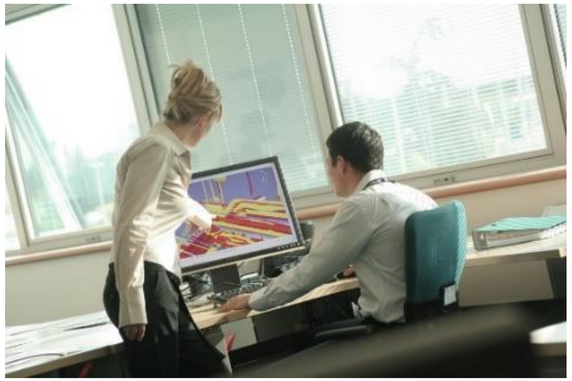
TECHNICAL INFFRASTRUCTURE

K Hanke, CERN




Technical Infrastructure Working Group

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

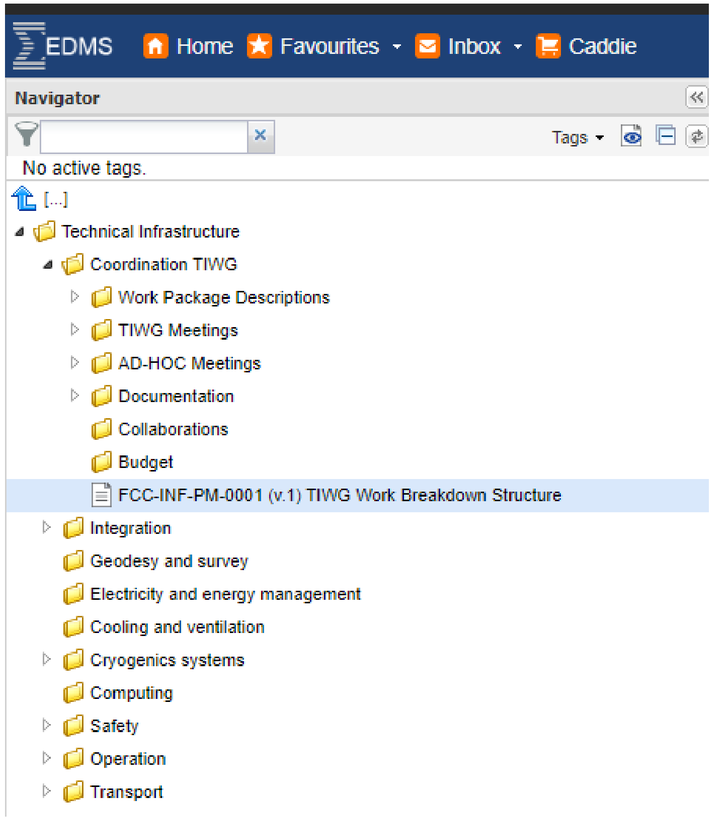



Coordination

Work Breakdown Structure WBS

Technical Infrastructure WG	responsible (in bold), WG members
1 coordination	**K Hanke (ATS-DO)** ex officio M Benedikt (ATS-DO), F Zimmermann (BE-ABP), J Gutleber (ATS-DO)
2 integration	**JP Corso (EN-ACE)** F Valchkova-Georgieva (EN-ACE) JP Tock (EN-ACE)
3 geodesy and survey	**H Mainaud Durand (BE-GM)** L Watrelot (BE-GM) Prof. Dr. A Wieser / ETH
4 electricity and energy management	**JP Burnet (SY)** N Bellegarde (EN-EL) M Parodi (EN-EL) D Aguglia (SY-EPC) F R Blanquez Delgado (SY-EPC), K Kahle (SY-EPC), M Colmenero Moratalla (SY-EPC)
5 cooling and ventilation	**G Peon (EN-CV)** M Nonis (EN-PAS), I Ruehl (EN-CV)
6 cryogenic systems	**L P Delprat (TE-CRG)** L Tavian (ATS-DO) K Brodzinski (TE-CRG), R van Weelderen (TE-CRG), P Tavares (TE-CRG)
7 computing and controls infrastructure, communication and networks	**P Saiz (IT-CM)** C Roderick (BE-CSS)
8 safety	**T Otto (ATS-DO)** S La Mendola (HSE-OHS), A Henriques (HSE-OHS) O Rios (HSE-OHS) G Roy (BE-ABP) M Widorski (HSE-RP) t.b.d. (HSE-ENV)
9 operation and maintenance, availability and reliability	**J Nielsen (BE-OP)**
10 transport & handling, installation concepts, logistics	**R Rinaldesi (EN-HE)** C Prasse / FIML

- WBS with responsible WP Holders
- Work Package Descriptions
- Bi-weekly Working Group Meetings
- Ad-hoc meetings to address specific topics
- Minutes & Documentation on EDMS
- Interfacing with Study Mgmt. and other Pillars



Collaborations

- Geodesy and Survey: ETH Zürich, Switzerland
- Transport and Logistics: Fraunhofer-Institut für Materialfluss und Logistik IML, Germany
- Safety: Presently setting up collaboration with University College London, UK

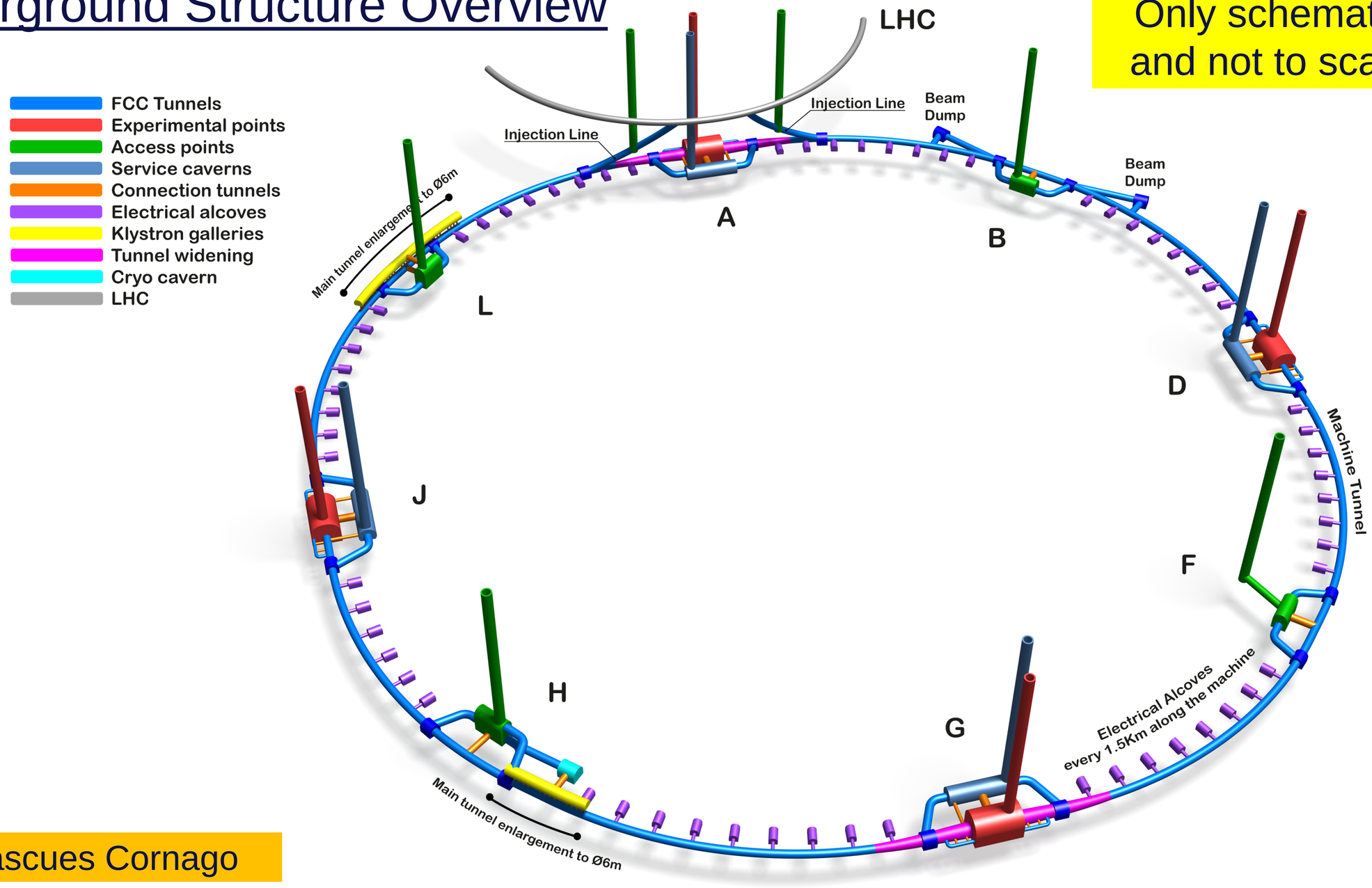
8-site baseline ”PA31”

Number of surface sites	8
LSS@IP (PA, PD, PG, PJ)	1400 m
LSS@TECH (PB, PF, PH, PL)	2143 m
Arc length	9.6 km
Sum of arc lengths	76.9 m
Total length	**91.1 km**

- 8 sites – less use of land, <40 ha instead 62 ha
- Possibility for 4 experiment sites in FCC-ee
- All sites close to road infrastructures (< 5 km of new road constructions for all sites)
- Vicinity of several sites to 400 kV grid lines
- Good road connection of PD, PF, PG, PH suggest operation pole around Annecy/LAPP

FCC-ee Underground Structure Overview

Only schematic, and not to scale.

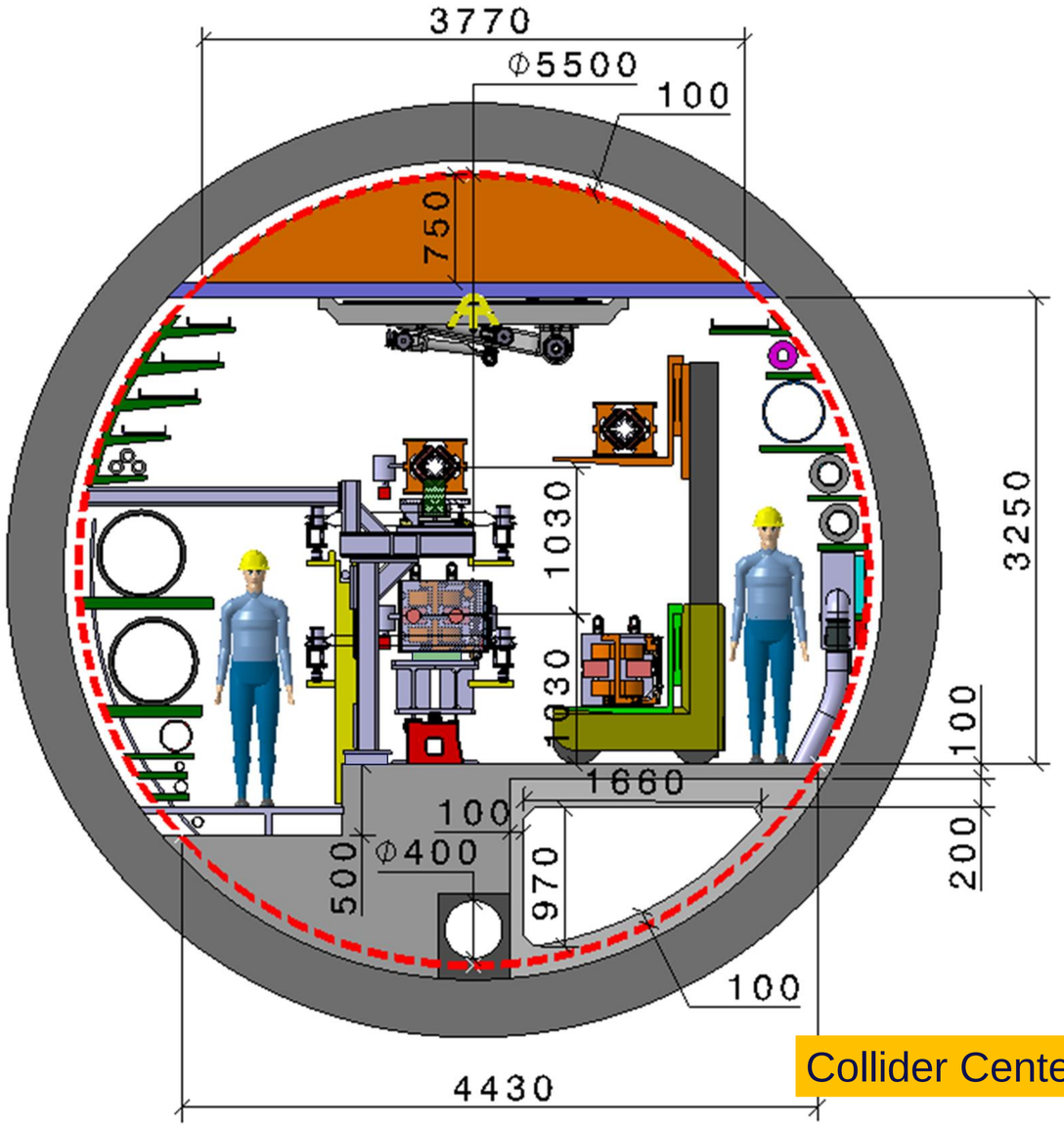


Courtesy A. Navascues Cornago

Integration of FCC-ee Arc Cell

Integration of FCC-ee machine elements (regular arc)

Machine tunnel 5.5m in diameter



Main cross section as for FCC-hh
Main ring below of booster ring
Main ring and booster ring 1.03 m distant
Water distribution changed to DN550

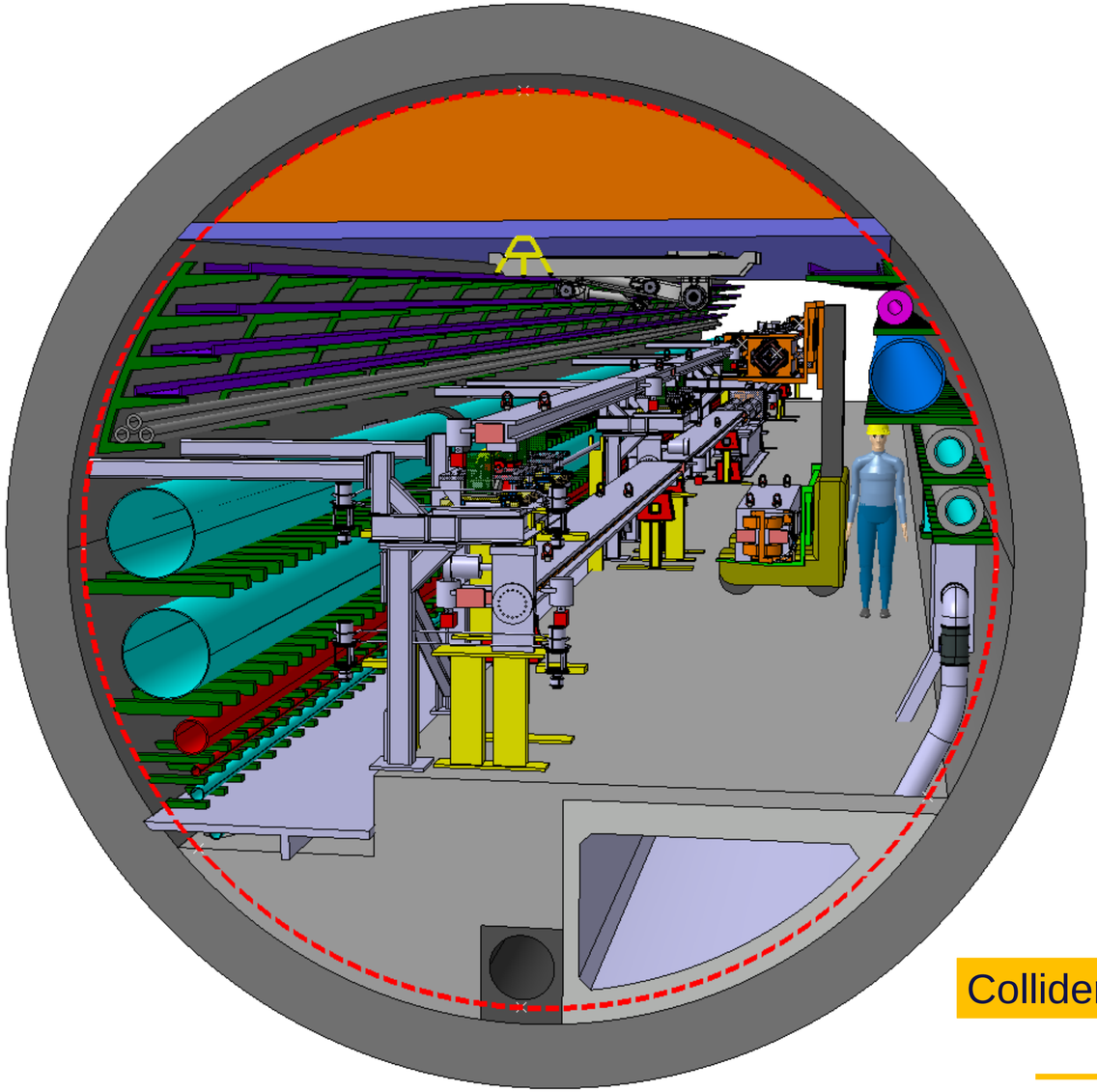
Courtesy F. Valckkova-Georgieva

Collider Center

Integration of FCC-ee machine elements (regular arc)

Perspective view

Machine tunnel 5.5m in diameter



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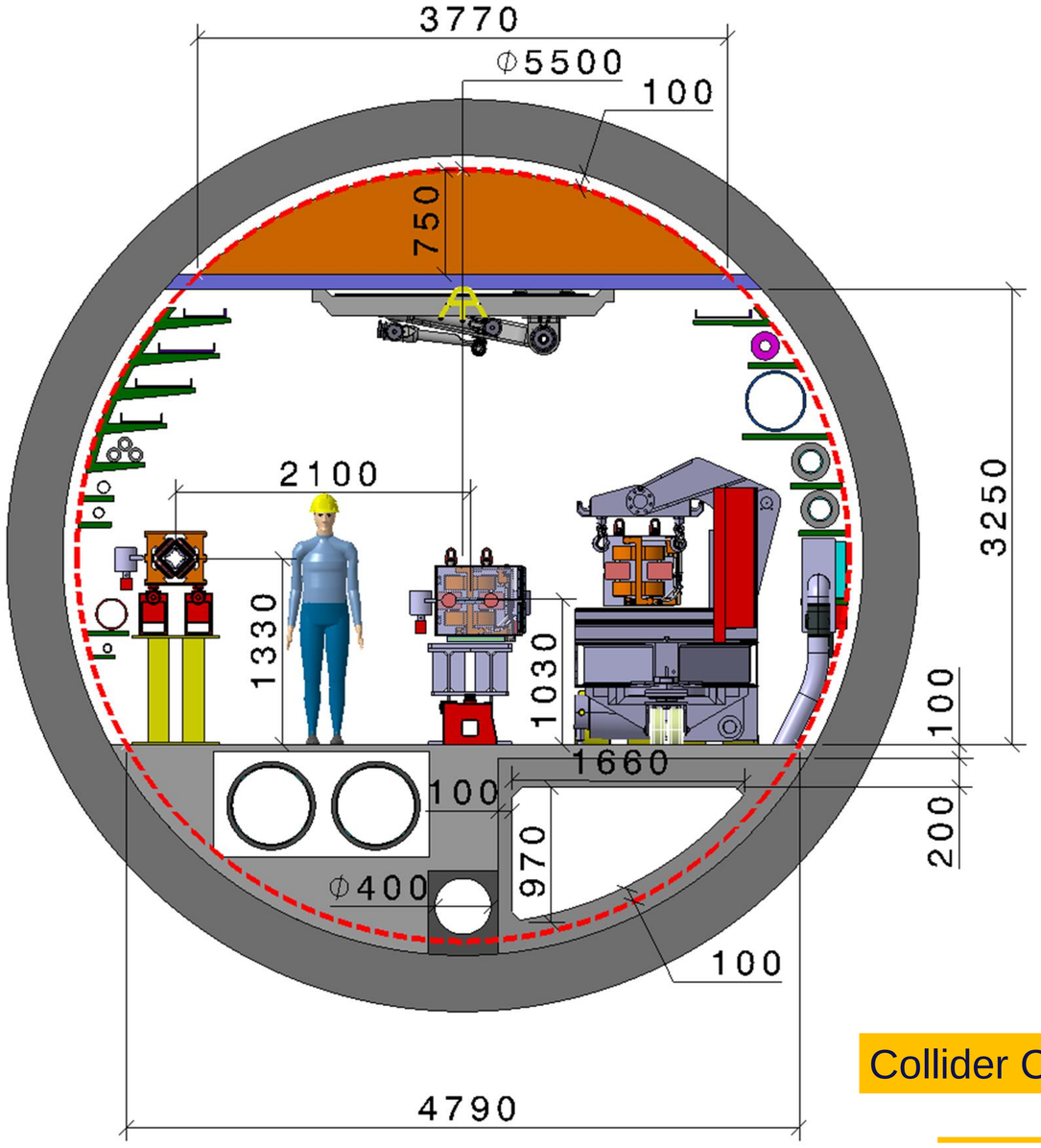
Courtesy F. Valckkova-Georgieva

Alternative Integration of FCC-ee Arc Cell

Alternative Integration of FCC-ee machine elements (regular arc)

Machine tunnel 5.5m in diameter



Booster ring next to the main ring
Main ring and booster ring 1.81 m distant
Demineralized water circuit DN 550 in a trench

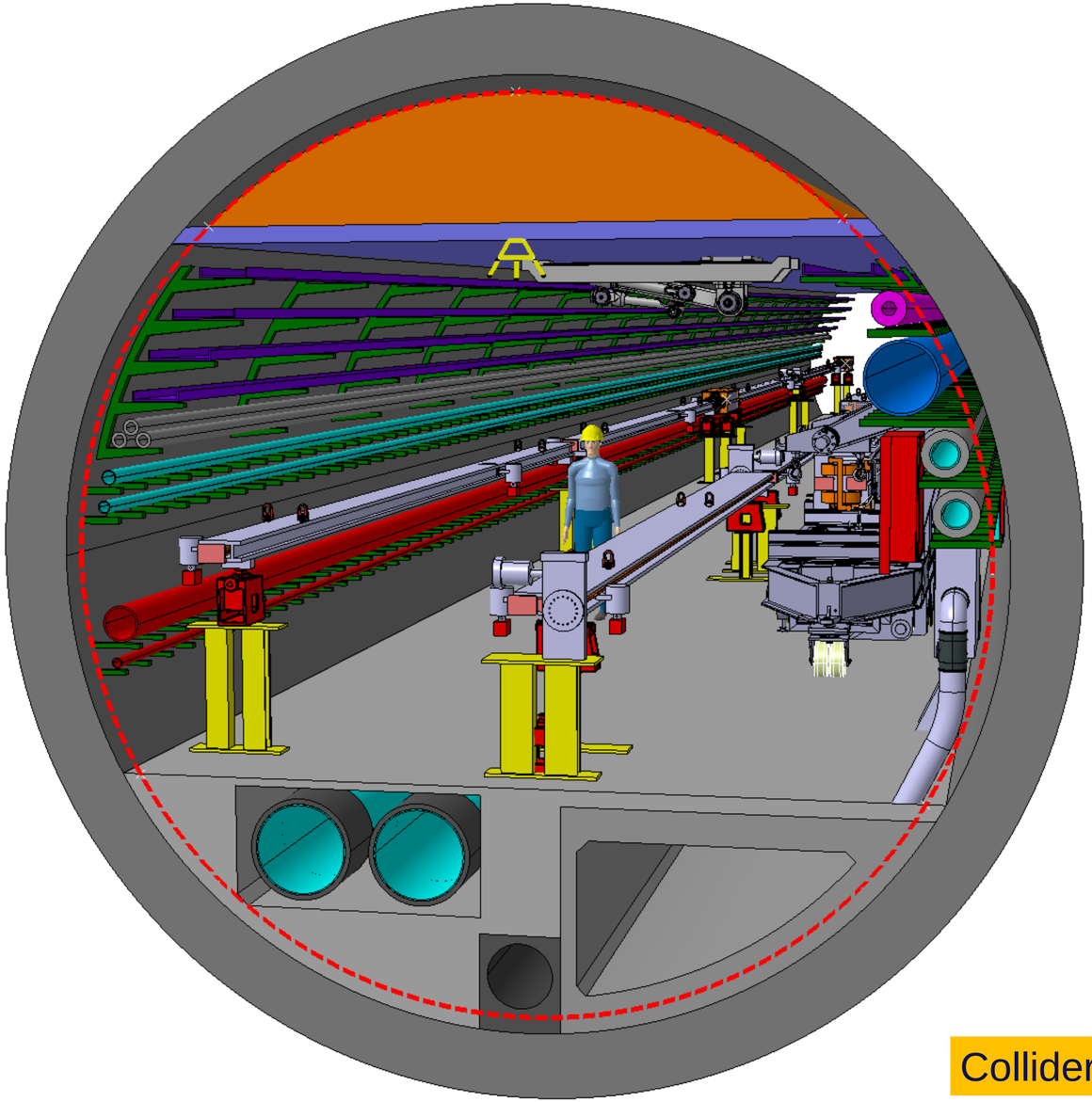
Courtesy F. Valckkova-Georgieva

Collider Center

Alternative Integration of FCC-ee machine elements (regular arc)

Perspective view

Machine tunnel 5.5m in diameter



Courtesy F. Valckkova-Georgieva

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Alcoves

Under study

Present base line is alcoves every 1.5 km (from study 1), i.e. 60 alcoves

Users:

- Transport (parking, overtaking vehicles)
- Safety
- Cryogenics (minor user for FCC-ee, but a lot for FCC-hh!)
- Cooling & Ventilation
- Equipment groups (power supplies, racks, vacuum, BI, …)

The need for smaller trenches close the magnets / equipment around the ring was also discussed (in order to reduce cable length)

FUTURE CIRCULAR COLLIDER

ACCES POINT STUDY

FCC|DOI|EDMS|Other

Date: 27/09/2021

Future Circular Collider

SPECIFICATION DOCUMENT

REQUIREMENTS FOR ALCOVES FOR FCC-EE

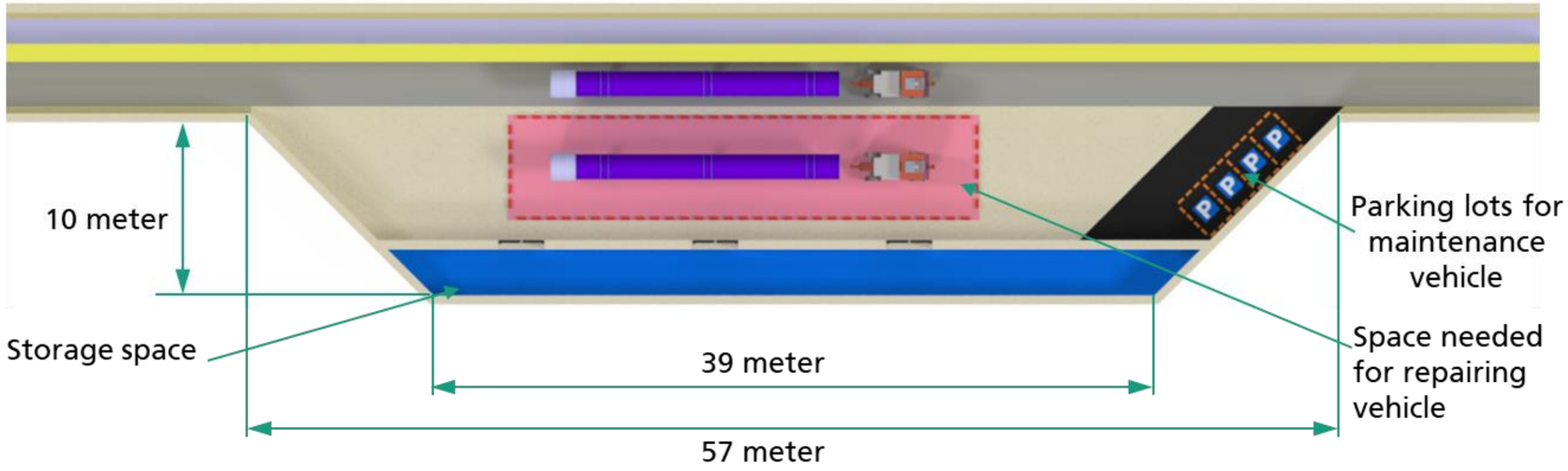
K. Hanke, …

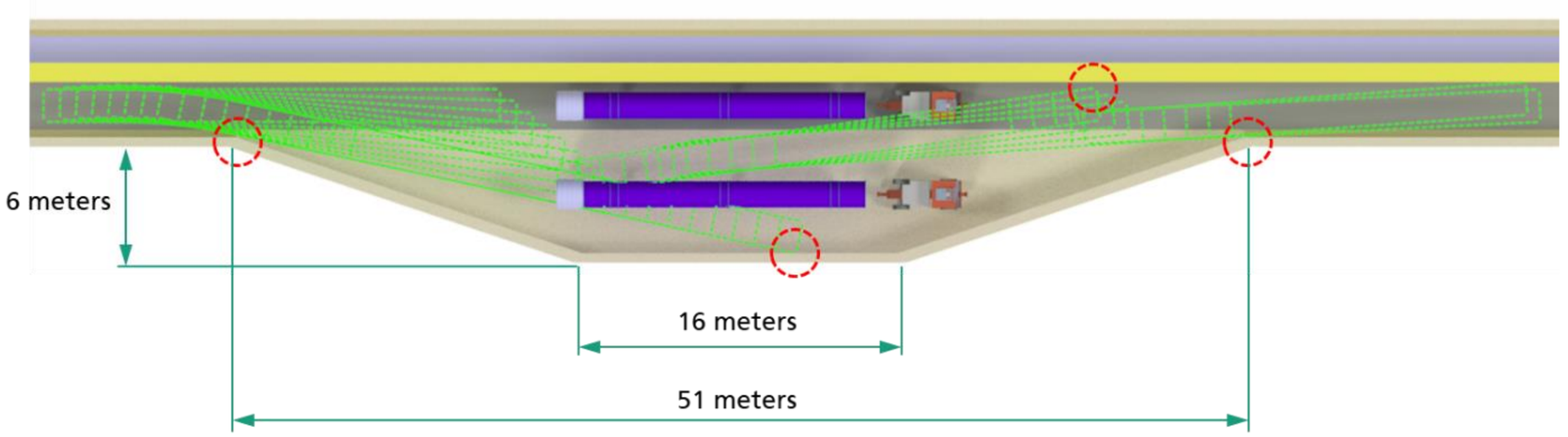
Abstract:

We shall assess the use, the number, spacing and dimensions of alcoves for FCC-ee while anticipating already the needs of FCC-hh.

- Equipment for FCC-ee
- Additional equipment for FCC-hh (cryogenics)
- Transport (parking and take over zone for vehicles)
- Safety
- …

Alcoves





Two possible layouts for a layby zones (FIML Dortmund)
Tentatively 8 out of the 60

Surface Sites

For all technical and experimental points the surface installations have been compiled in large tables
https://twiki.cern.ch/twiki/bin/viewauth/FCC/ProjectElements

These tables summarise to our best present knowledge the requirements in terms of surface, location, capacity etc. for all infrastructure services
Tables are continuously being updated and are the basis for a more detailed CE integration study
Good data available for FCC-ee, to be transferred to EDMS
FCC-hh still to be adressed

Surface Sites

Example: FCC-ee PA extract

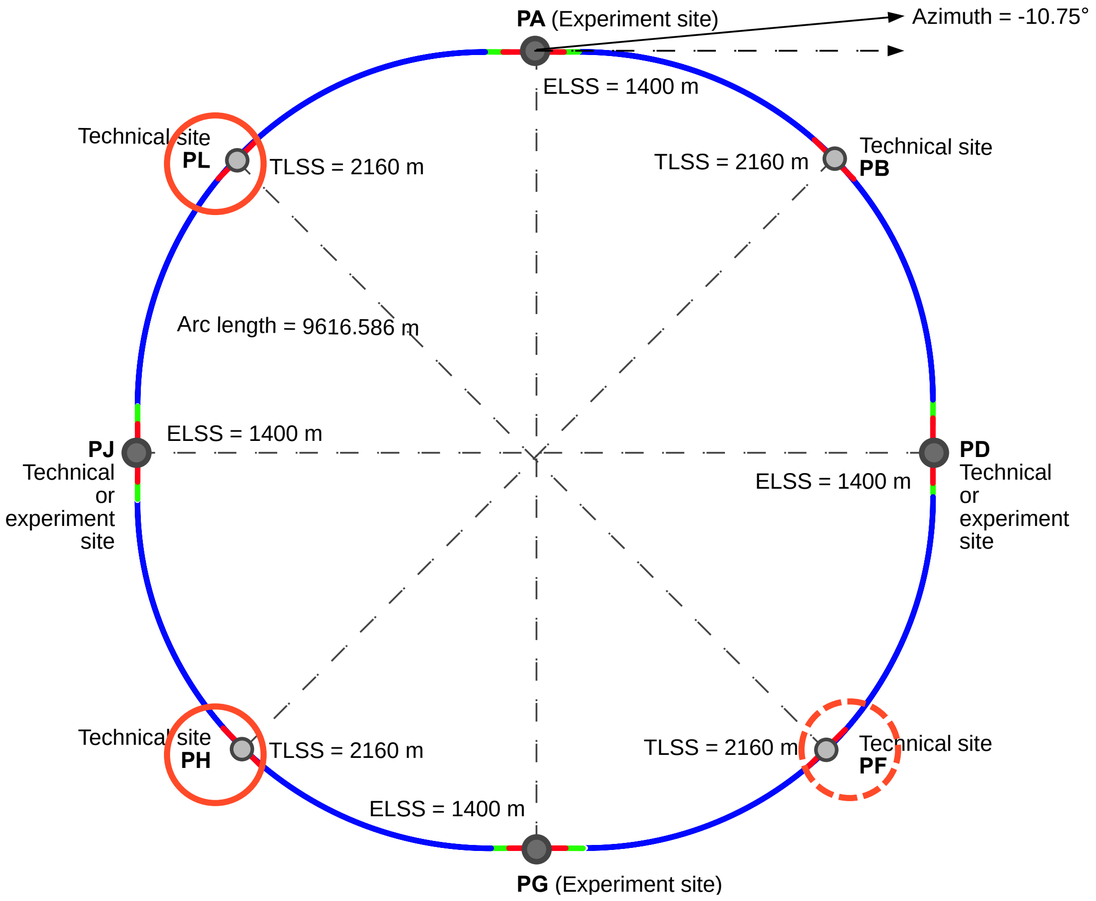
Status	Last changed	Responsible person	Element	Location	Construction type	Area	Size (W x L x H)	Capacity	Waste Heat
To be studied	10/08/2022	J-P Burnet	Electrical substation area	Electricity substation	Global area for electricity distribution	4000 m2	40 m x 100 m	135 kV lines coming from the tunnel, power transformers from 135 kV to 18 kV	
To be studied	10/08/2022	J-P Burnet	Service gallery	Gallery for power cables from substation 1 to shaft	Gallery			135kV / 18kV lines	
To be studied	10/08/2022	J-P Burnet	Emergency power	New diesel generators and tank (included on the 4000 m2 area)	Slab	400 m2	15 m x 25 m		
To be studied	10/08/2022	J-P Burnet	Emergency power building	Secure network building, emergnecy power / UPS (included on the 4000 m2 area)	Metal structure	400 m2	20 m x 40 m		
To be studied	10/08/2022	J-P Burnet	Power transformer	Set of power transformers	Slab	600 m2	20 m x 30 m		
To be studied	10/08/2022	J-P Burnet	double busbar system	Electric park	Slab	600 m2	20 m x 30 m		
To be studied	10/08/2022	J-P Burnet	SE building	New SE building (included on the 4000 m2 area)	Metal structure	400 m2	40 m x 10 m	18 kV switch board	
To be studied	10/08/2022	J-P Burnet	Power quality	New SVC/harmonics filters (included on the 4000 m2)	slab	600 m2	20 m x 30 m	Harmonic filters	
To be studied	10/08/2022	J-P Burnet	Grid connection to local distributor (ENEDIS)	Power line 15 MVA coming from outside	buried cables			24 kV line for civil engineering work / back-up for operation. No construction above.	
To be studied	10/08/2022	J-P Burnet	Energy storage	option for energy storage	slab	1000 m2	40 m x 25 m	energy stroage	

RF Points

The constraint is to have only one RF station for the “first phase” of FCC-ee (Z, WW, HZ, eeH)
The high energy (top) situation requires two RF stations each accelerating both e+ and e-
It is not a constraint that the two RF points be opposite points

We exclude Experiment Sites (**A, D, G, and J**). Furthermore we recommend that point B not be an RF site (highly sensitive area, difficult access, no resources).

Therefore, from an infrastructure point of view, three of the points are eligible to house the RF for FCC-ee (**H, L, and F**).

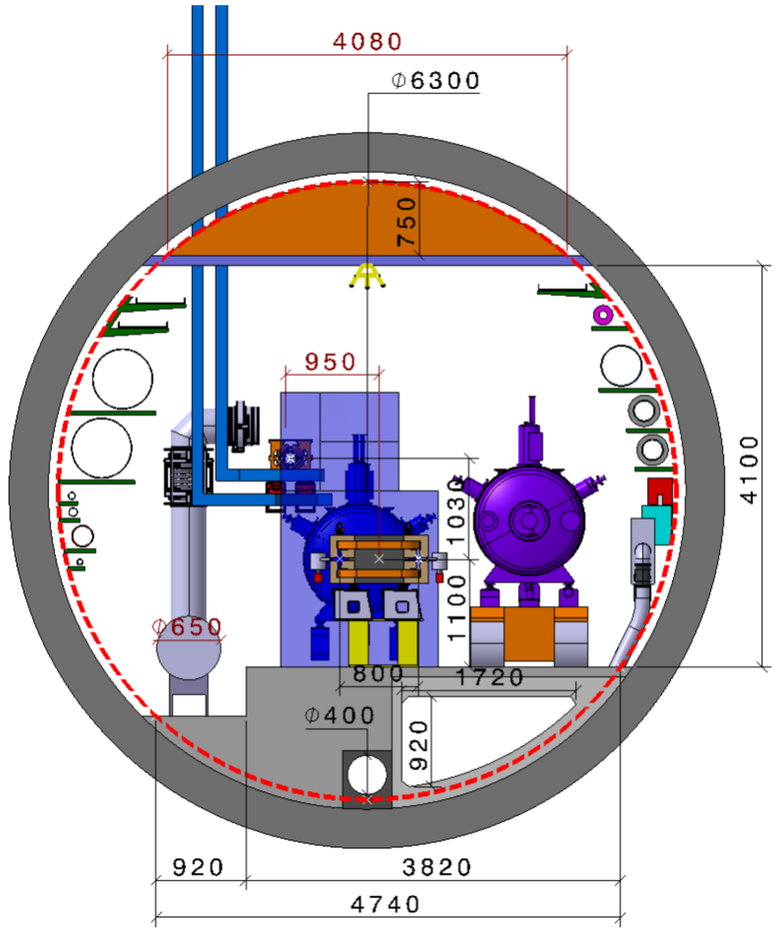


RF Points

RF Task Force convened throughout 2022
- Identify RF points for the different stages
- Integration of RF points
- Baseline layout for RF and Cryo systems

Review held October 2022

Task force resumed for remainder of 2022
Presently studying:
- Separation of Booster and Collider RF
- Horizontal alignment of Booster/Collider
- Propose a base line before FCC week 2023

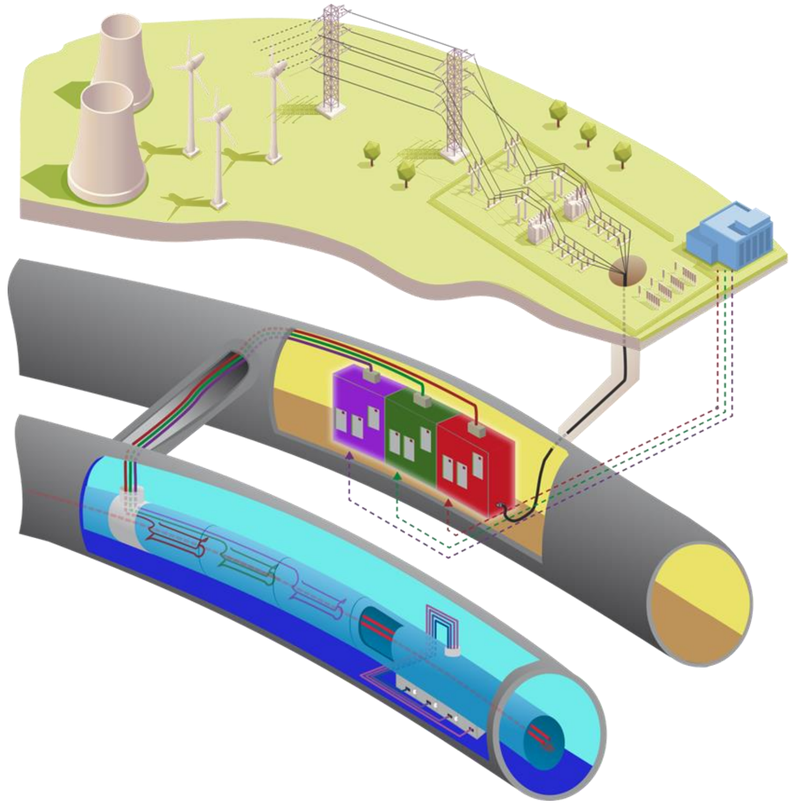


Example:
PL (Z,W, H machine)
400 MHz Collider RF
Booster Ring vertically stacked

See presentation by F. Valckkova-Georgieva

Electricity & Energy Management

Physics program		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)	all	1,3	12,6	15,8	47,5
Pcv (MW)	all	33	34	36	40.2
PEL magnets (MW)	Stroage	6	17	39	89
PEL magnets (MW)	Booster	1	3	5	11
Experiments (MW)	Pt A & G	8	8	8	8
Data centers (MW)	Pt A & G	4	4	4	4
General services (MW)		36	36	36	36
Max Power beam operation (MW)		237	263	292	385



J.-P. Burnet

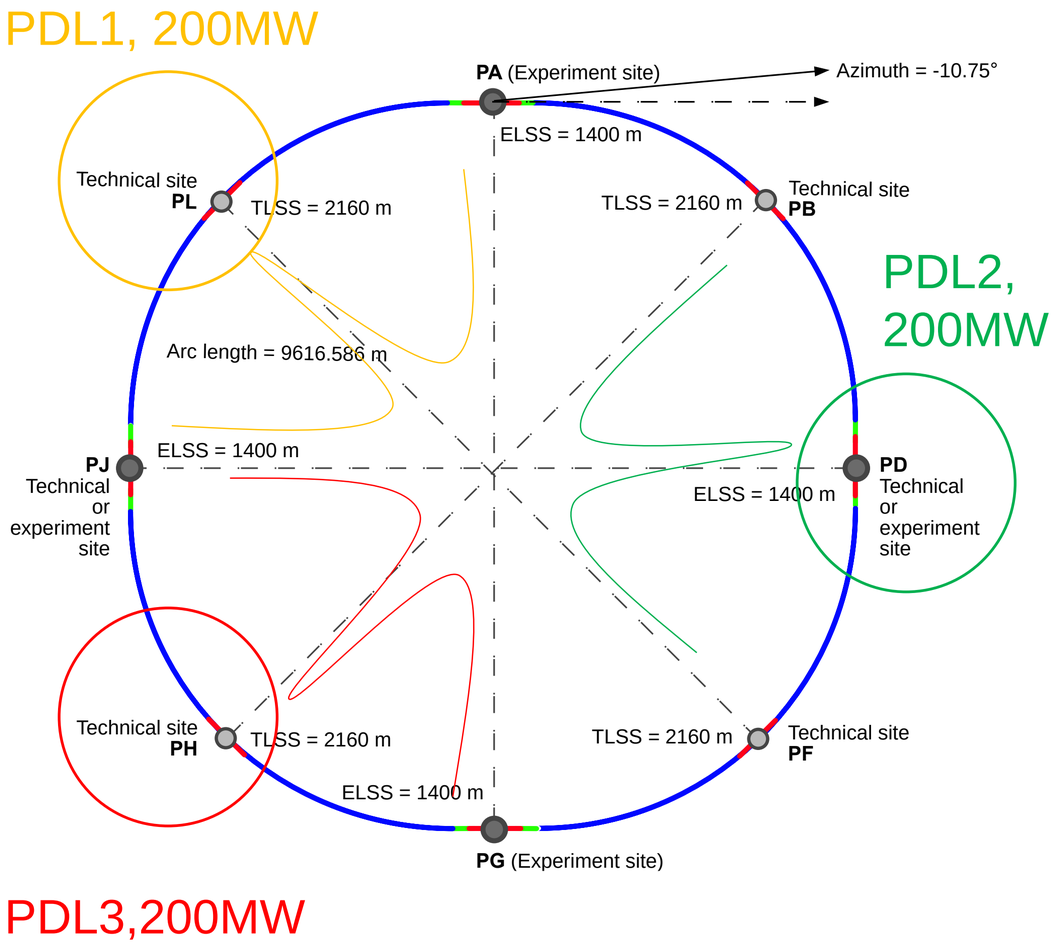
Proposal for grid connection points

Infrastructure needed to cover all FCC configuration

The goal is to built an electrical infrastructure which will cover all the configuration of the FCC machine without need to built new sub-stations.
This proposal includes also the possibility to operate the FCC-ee machine without one sub-station, which will ease the maintenance and repairs.

The proposal is to have 3 grid connection points rated at 200 MW.

Under study with French transmission system operator (RTE).



J.-P. Burnet

Ways to reduce energy consumption

Focus on reduction of the energy consumption

The management of the accelerator systems and of the infrastructure have a large input on the energy consumption.

Priority to physics (system readiness) but at the same level energy saving

A lot of energy is consumed without beams, this is also where energy saving can be developed.

Economic mode for magnets (Switch-off magnets during short or long stops)
Economic mode for cryoplant (Static losses represent less than 10%, can we operate cryoplants at 20%,50% for short or long stop?)
Economic mode for cooling an ventilation
can we reduce the tunnel ventilation when nobody is inside or regulated it on temperature? Different from fixed speed.
can we adapt the water flow rate depending on the power dissipation? Motor drive systems regulated on power demand.
can we modulate the cooling tower with the power dissipation? Motor drive systems regulated on power demand.
Economic mode for experiments
can we identify some systems that can be put in sleep mode?
…

Under discussion, a proposal for a working group on energy saving

Target 10% ? 200 GWh

J.-P. Burnet

Geodesy and Survey

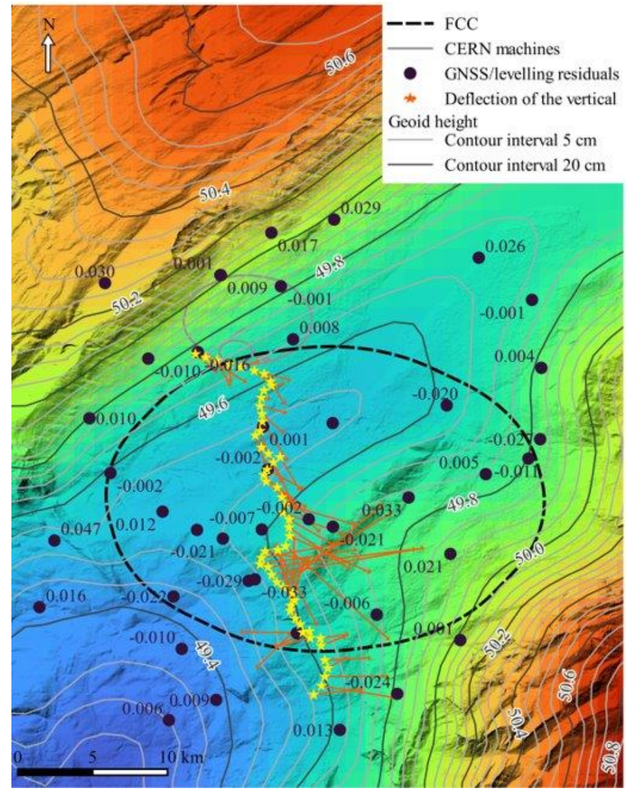
2022 achievements

Desk study and software development:
- Definition of new coordinate reference systems
- Implementation of a transformation model between MAD-X coordinate system and “real world”

Data acquisition:
- Relative gravity observations (densification of existing observations)

Data processing:
- Computation of geodetic-control profile (processing of GNSS, levelling and astro-zenithal observations)
- Computation of a first solution of local geoid model (master thesis project): accuracy improved by 30% compared to French and Swiss models

Gravity observation



Geoid model

B. Weyer

Other WPs

Cooling & Ventilation

- Consultant contract DAIs are waiting for signature
- Kick off meetings probably at the beginning of next week
- Discussions ongoing with electrical service for further input from our side
- Meeting with Beamstrahlung dump experts as clients of the demi water in the tunnel.
- Advancing on the logistics data for the tunnel

Transport

- CERN Transport Group in Collaboration with Fraunhofer-Institut für Materialfluss und Logistik Dortmund / Germany; regular meetings
- Logistics studies ongoing
- Design of a transport system for installation, interventions and evacuation ongoing

Safety

- Hazard Inventory
- Risks at the surface areas (radiation, magnetic field)
- Contributions in all areas

Next Steps

conceptual phase, towards a baseline

Dec 2022

Mid 2023 e & costing

Autumn 2023 e and cost of this baseline

refined technical work and costing exercise

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Thank you for your attention