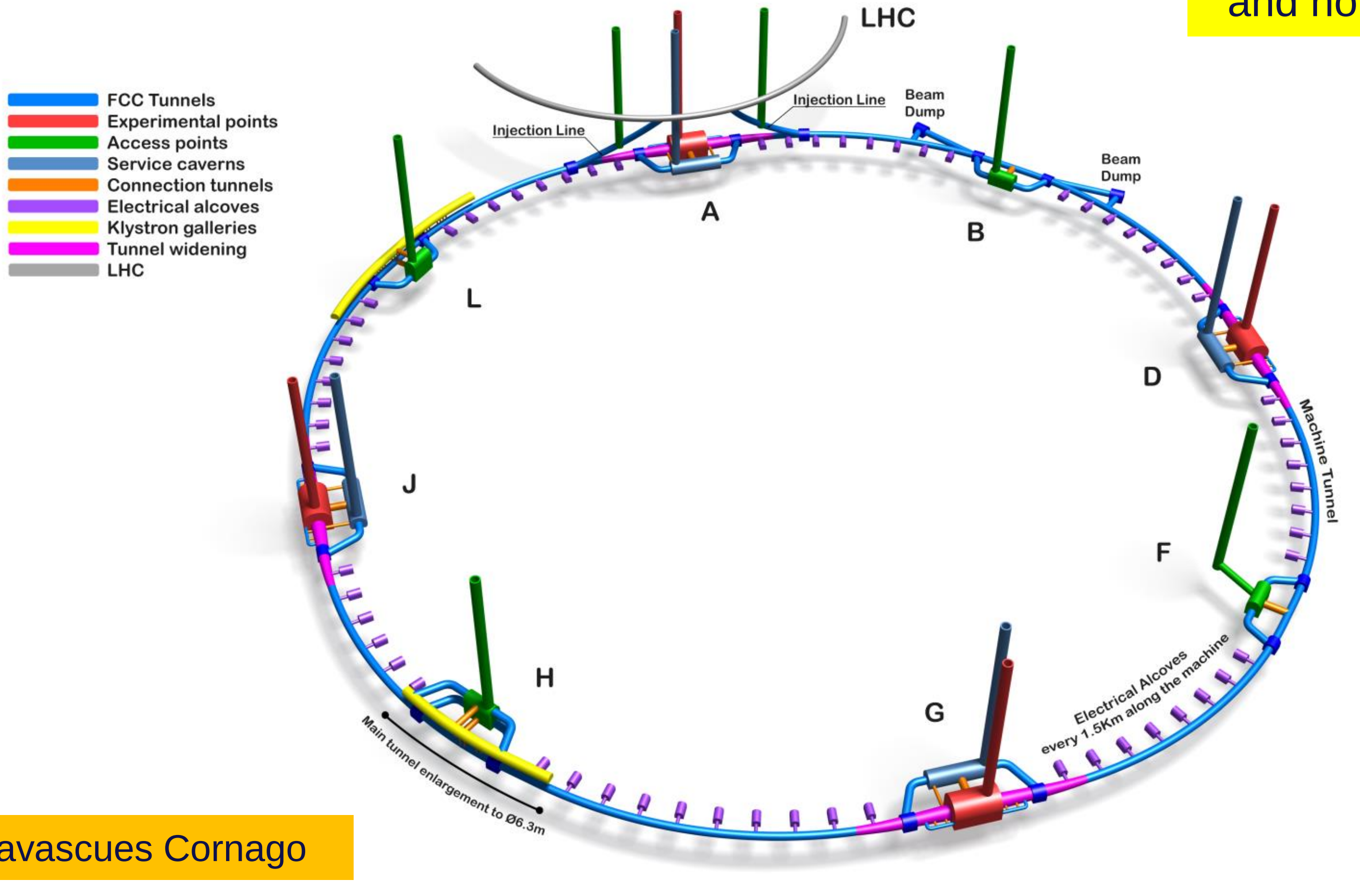
TUNNEL INTEGRATION

FCC-ee Underground Structure Overview

Only schematic, and not to scale.

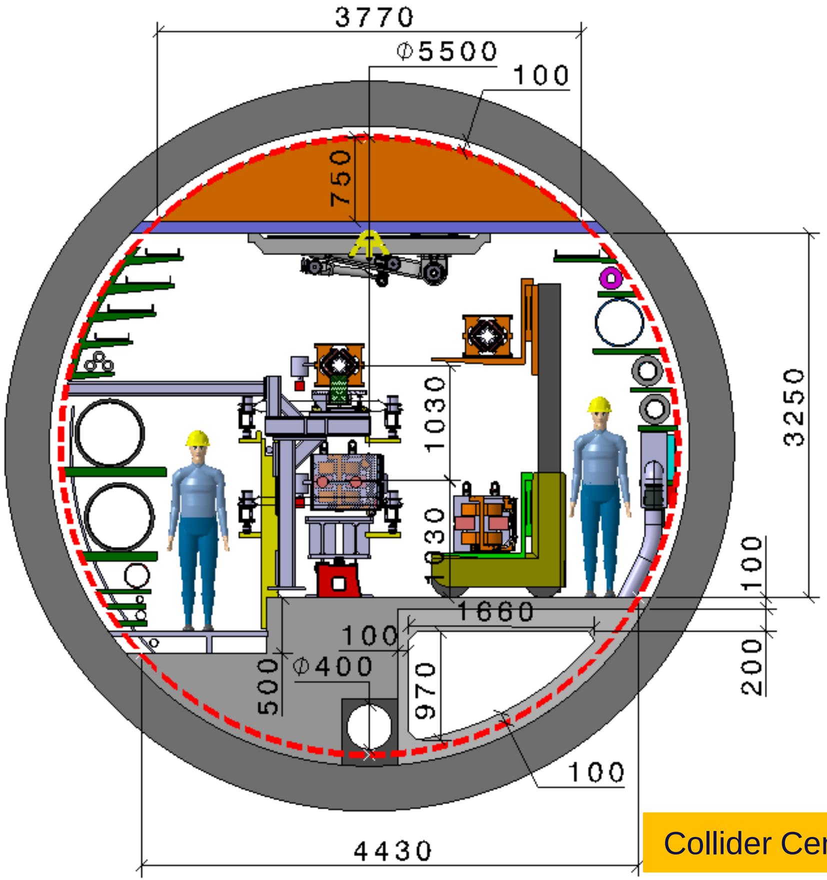


Courtesy A. Navascues Cornago

Integration of FCC-ee Arc Cell

Integration of FCC-ee machine elements (regular arc)

Machine tunnel 5.5m in diameter



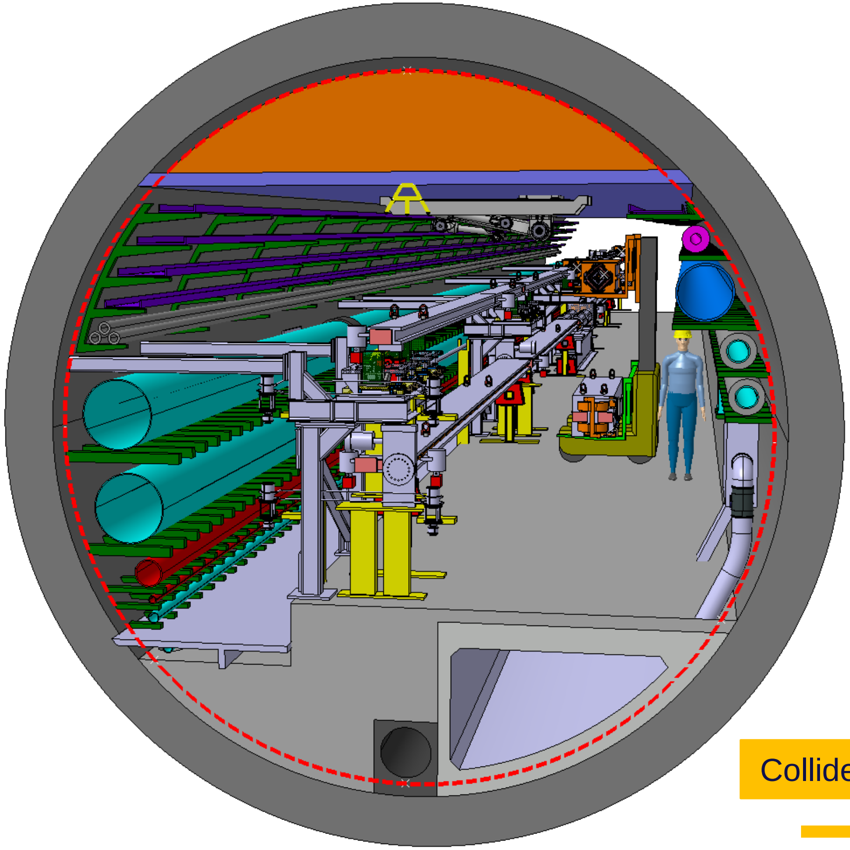
Main cross section as for FCC-hh
Main ring below of booster ring
Main ring and booster ring 1.03 m distant
Water distribution changed to DN550 + flange (ø630)

Collider Center

Integration of FCC-ee machine elements (regular arc)

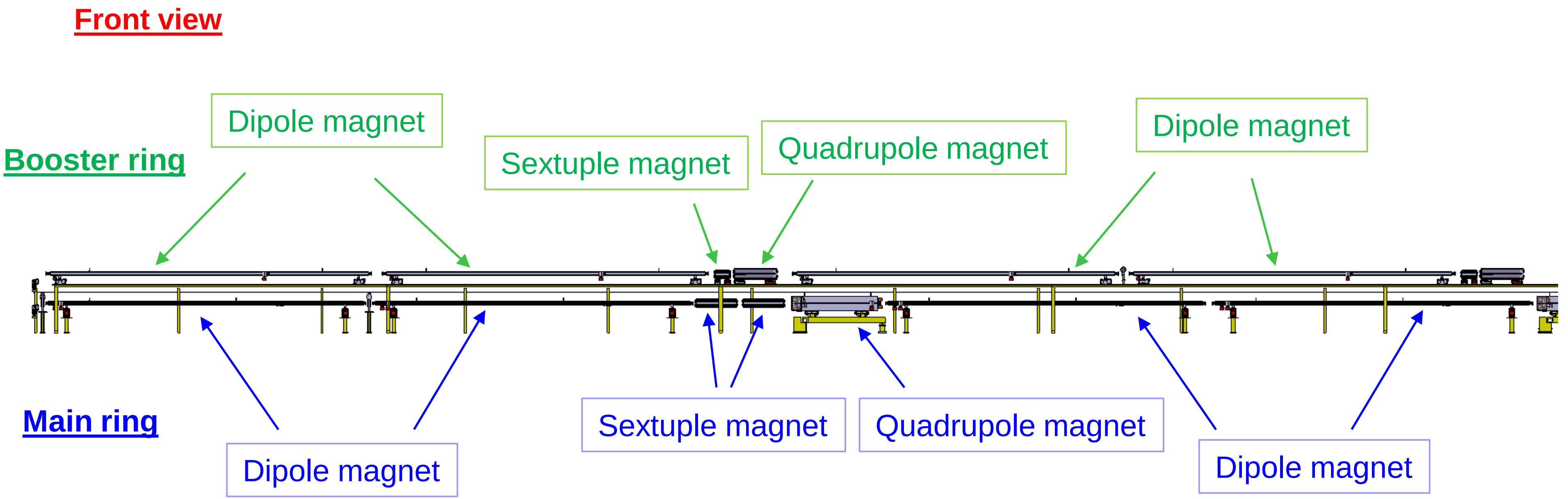
Perspective view

Machine tunnel 5.5m in diameter



Collider Center →

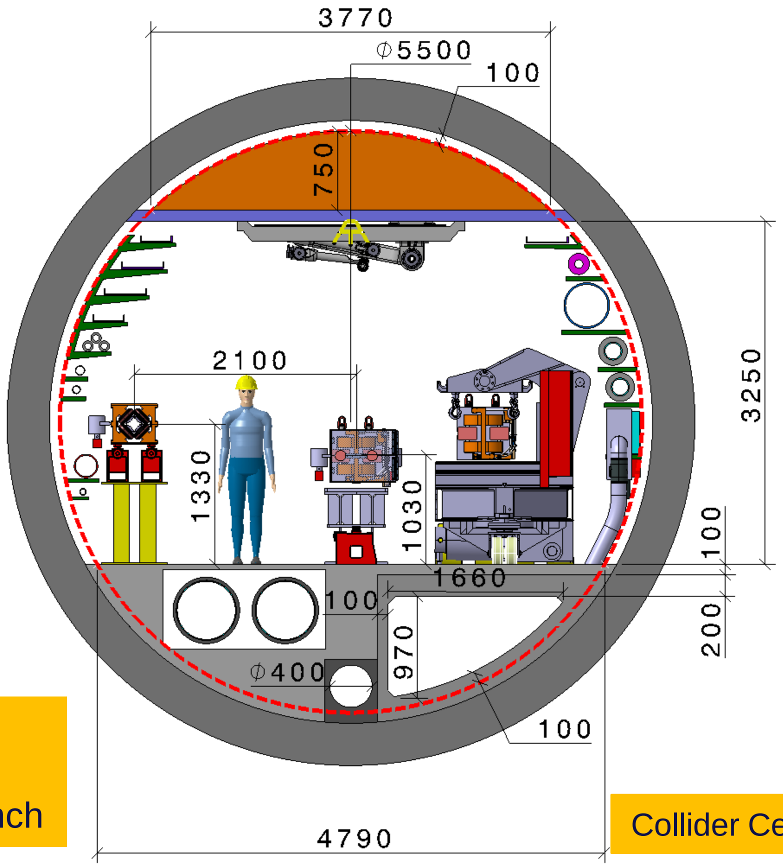
Integration of FCC-ee machine elements (regular arc)



Alternative Integration of FCC-ee Arc Cell

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

Machine tunnel 5.5m in diameter



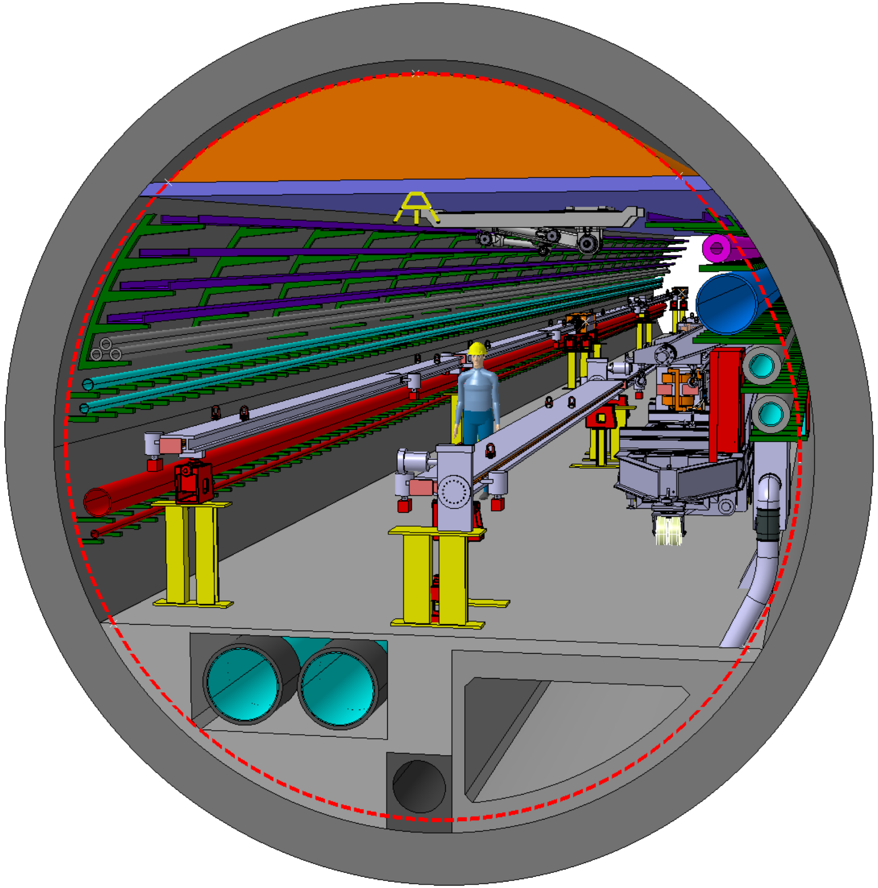
Booster ring next to the main ring
Main ring and booster ring 2.1 m distant
Demineralized water circuit DN 550 + flange (ø630) in a trench

Collider Center

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

Perspective view

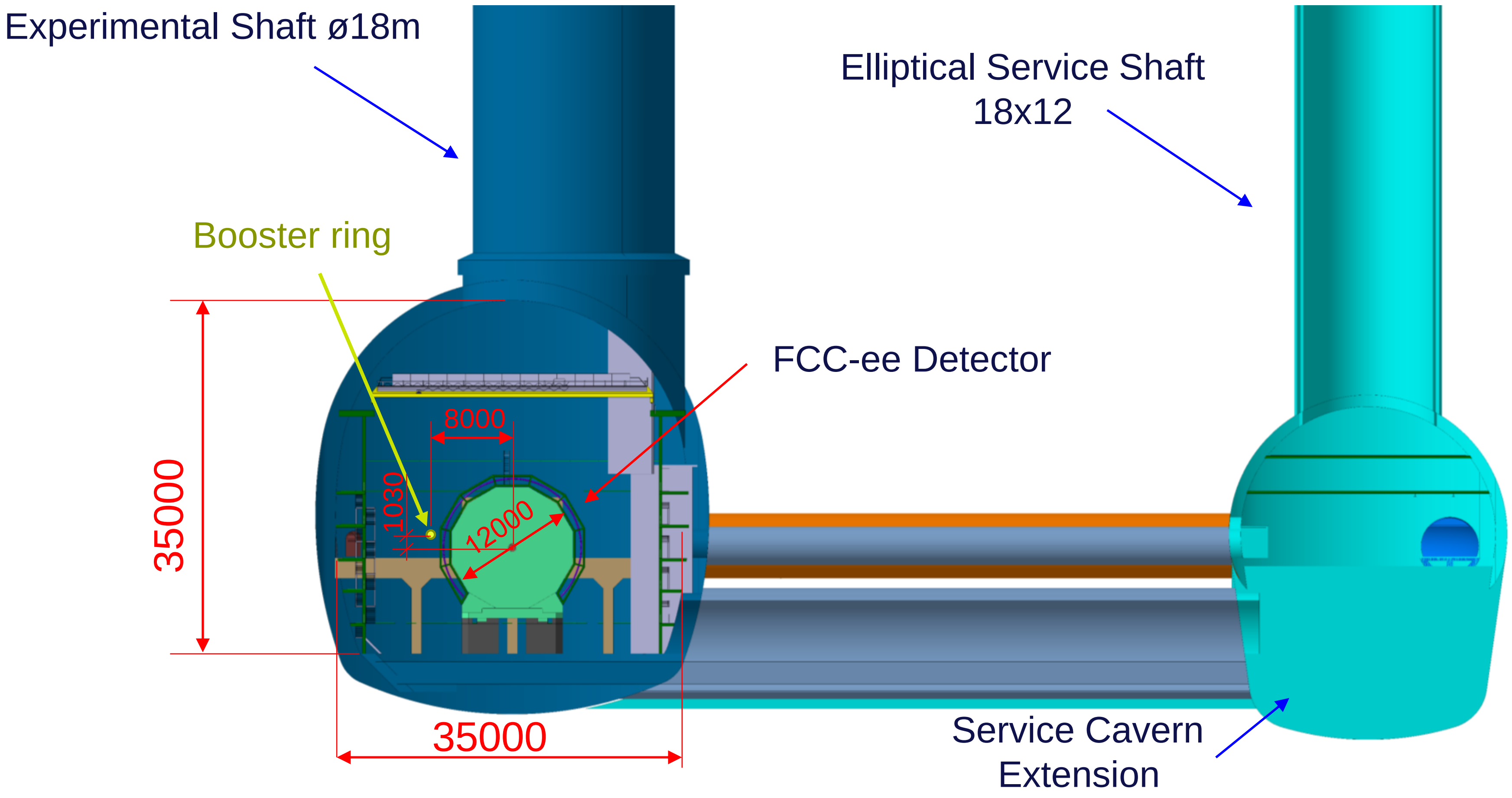
Machine tunnel 5.5m in diameter



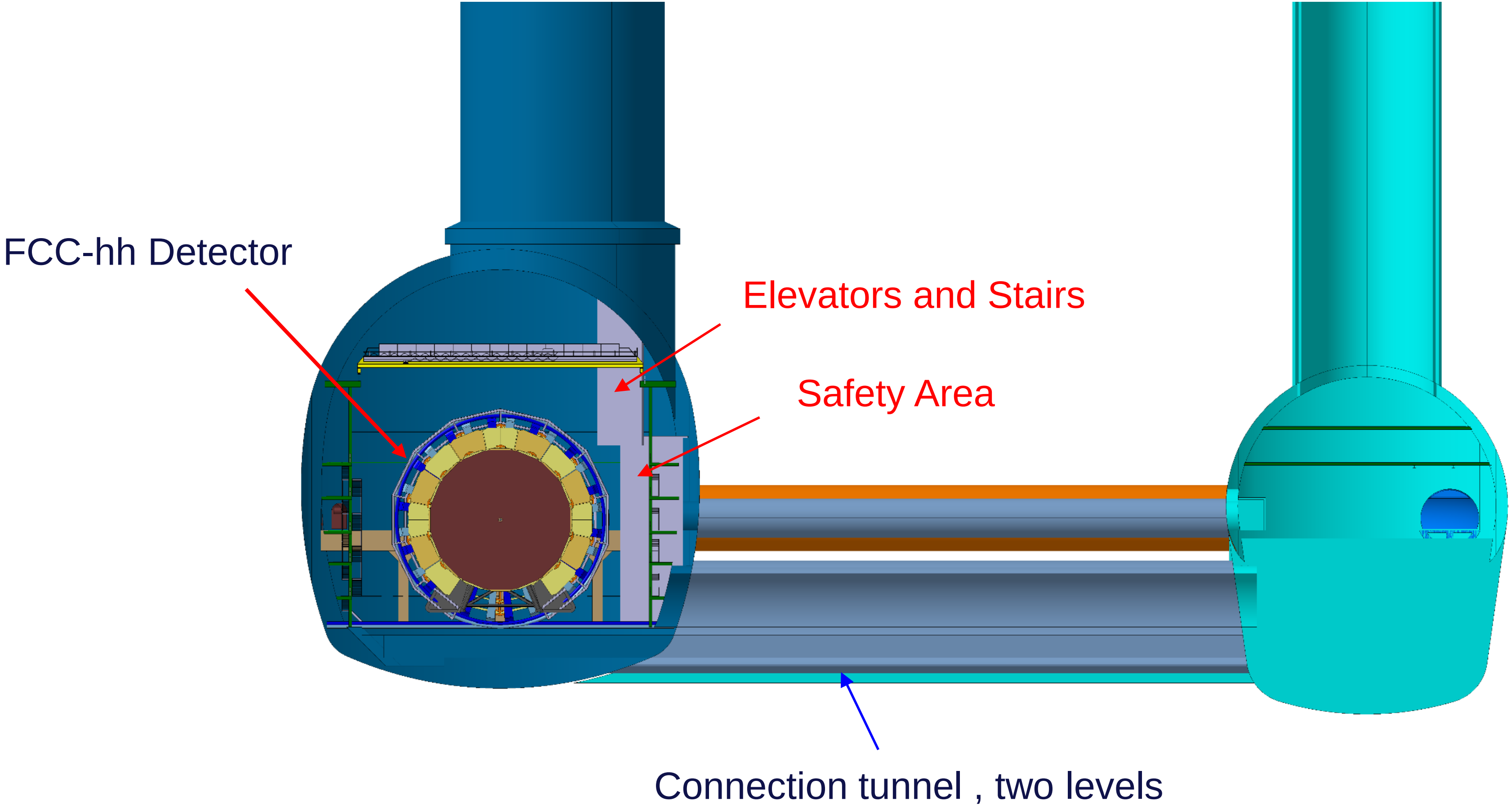
Collider Center

FCC-ee Underground Structure point A

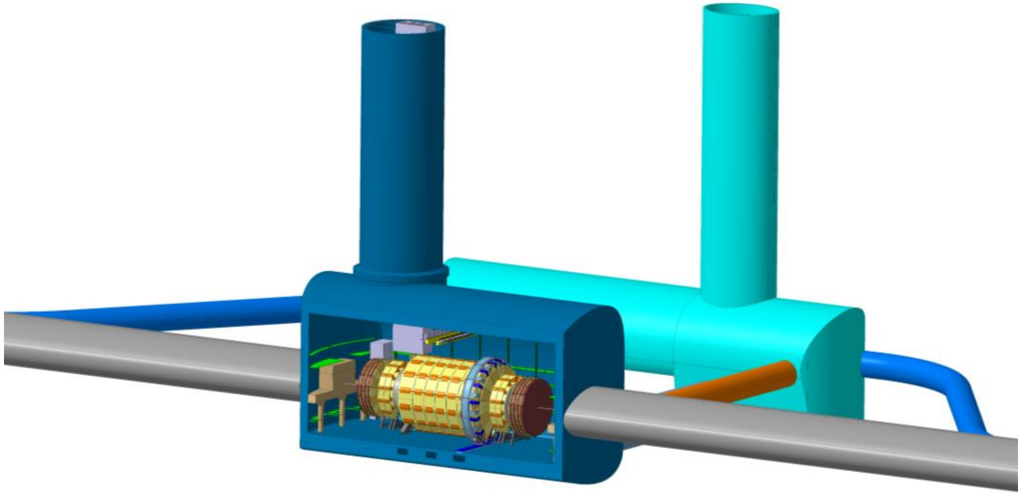
FCC Experiment Underground Structure version 2022

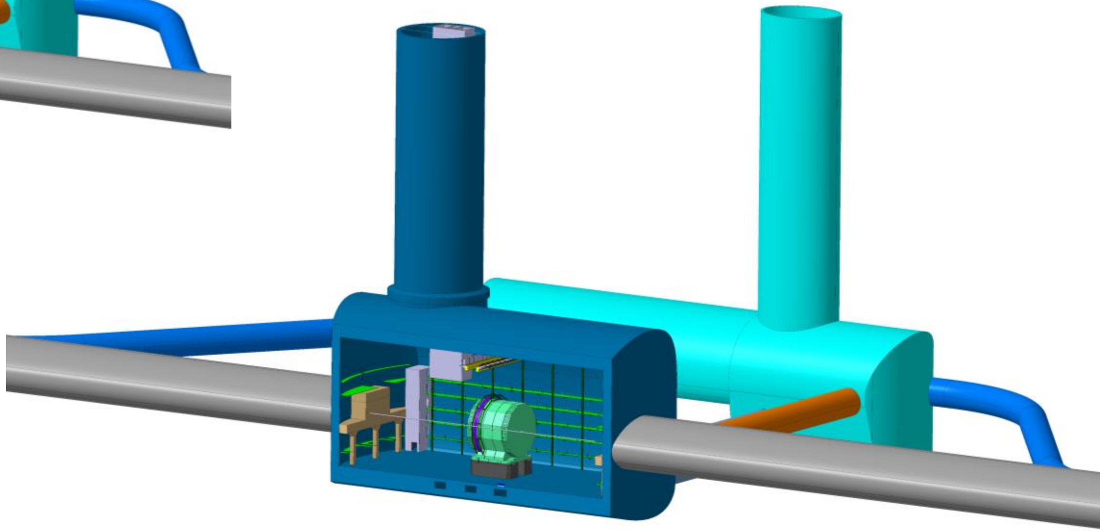


FCC Experiment Underground Structure version 2022

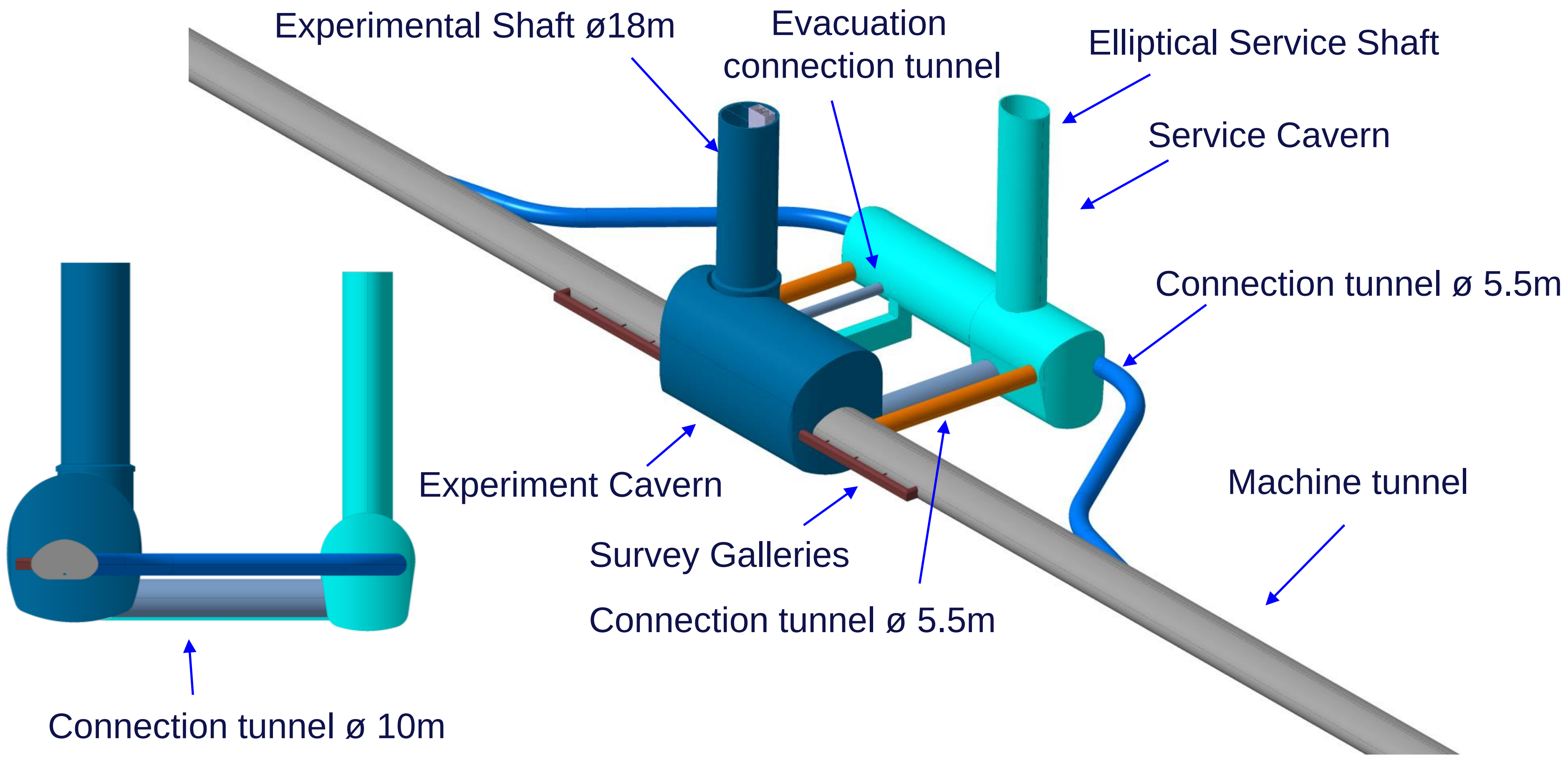


FCC Experiment Underground Structure version 2022

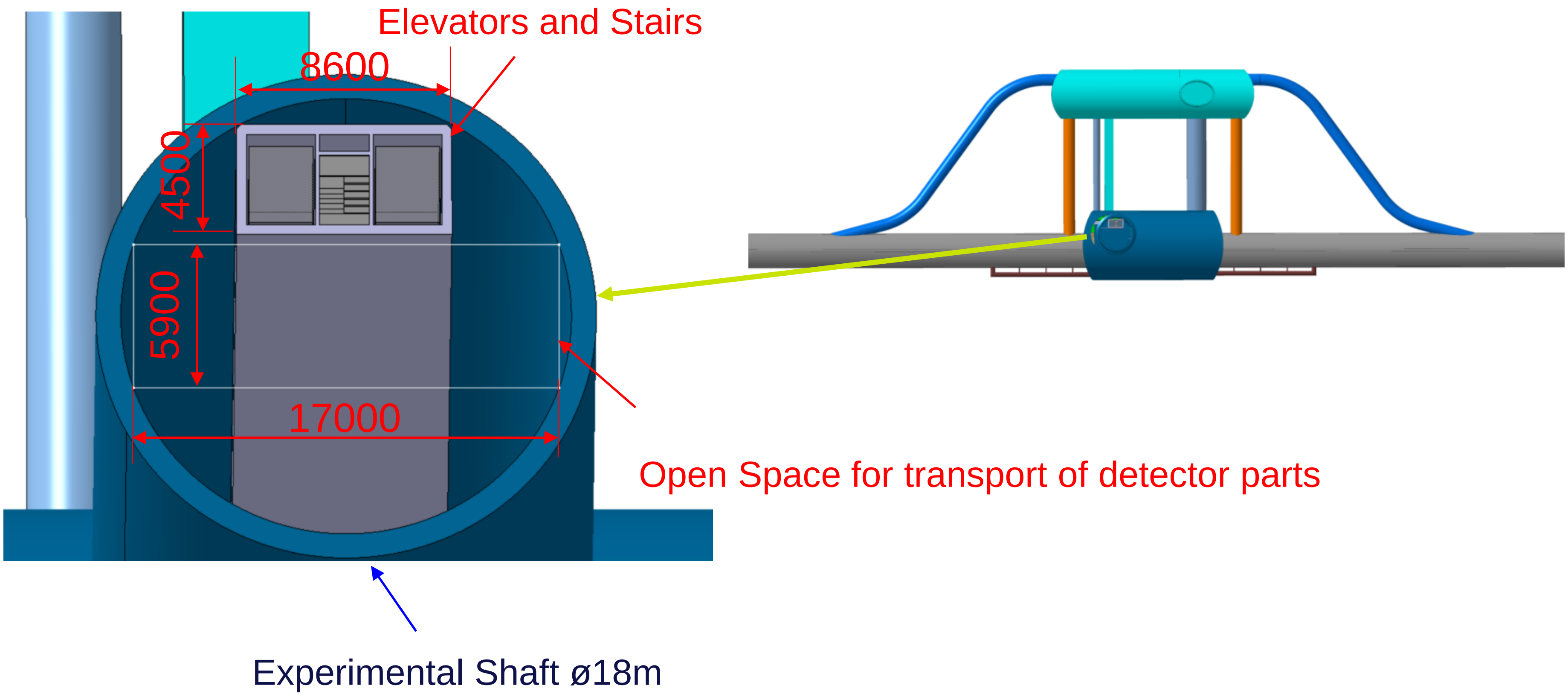




FCC Experiment Underground Structure version 2022



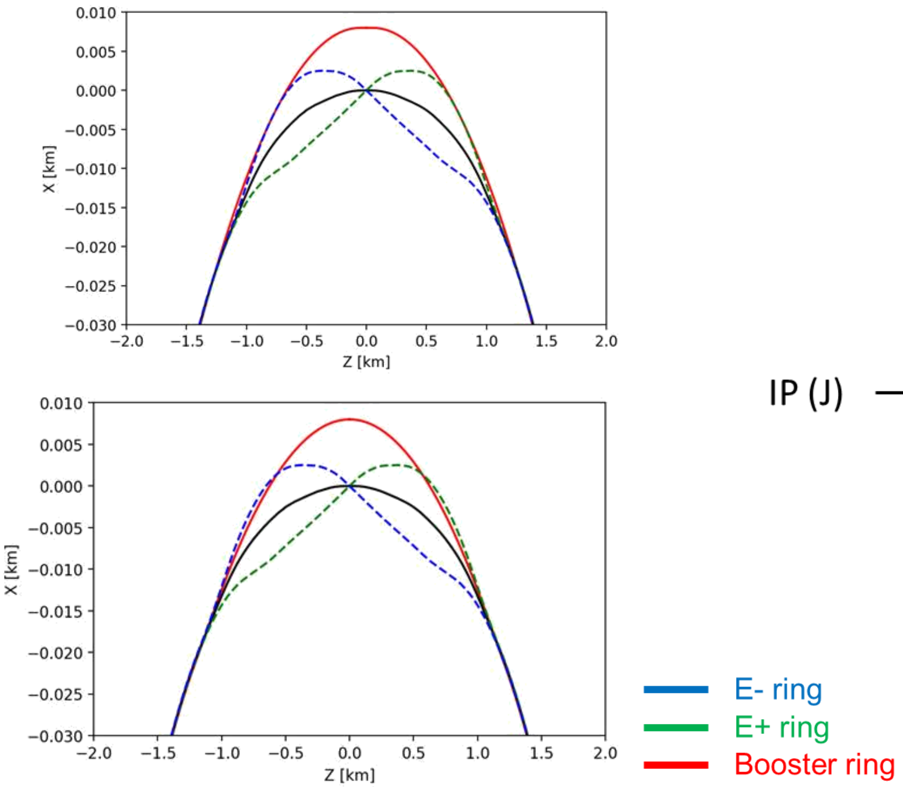
FCC Experiment Underground Structure version 2022



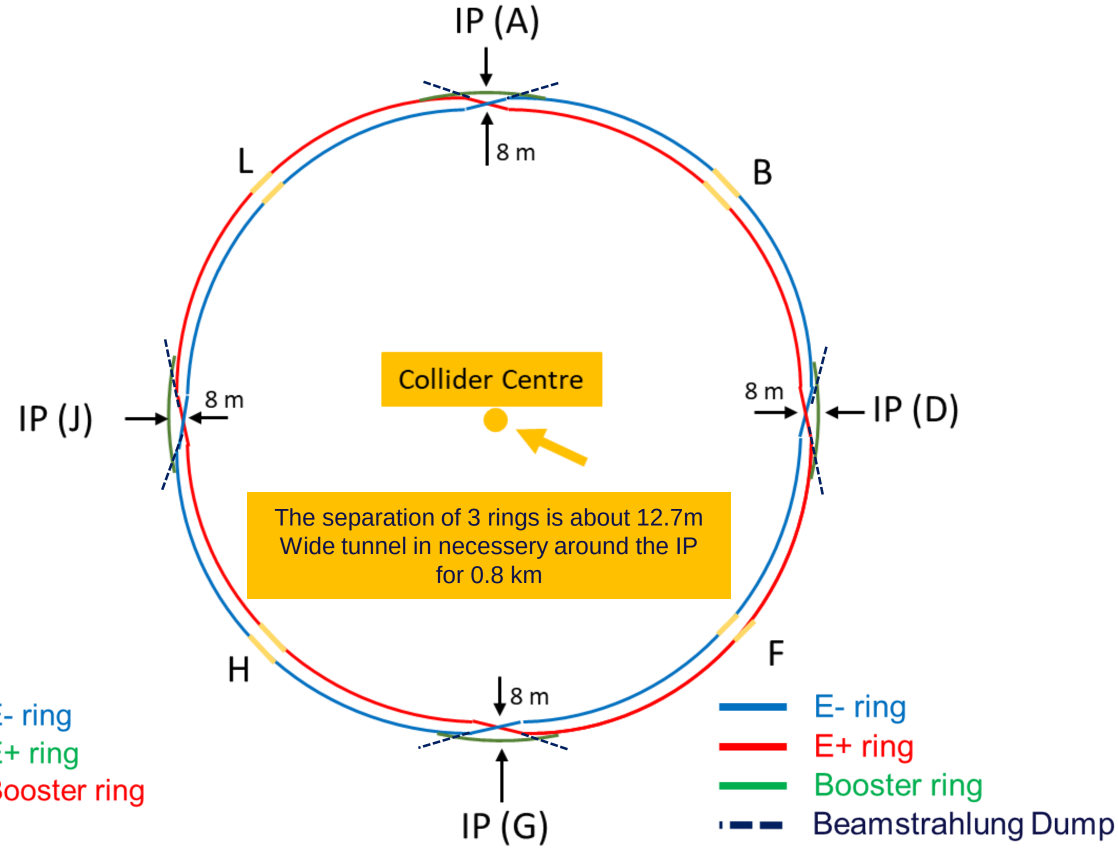
Integration of FCC-ee Beamstrahlung dump

FCC-ee main and booster rings Layout

Two different trajectories for booster ring

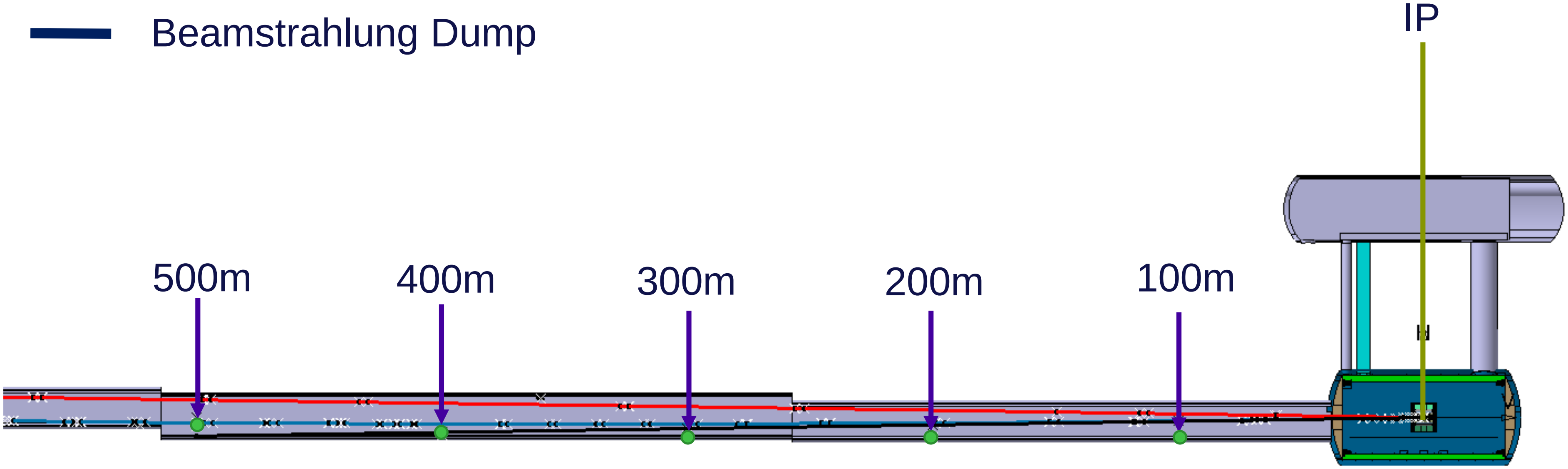


Courtesy K. Oide/ A. Chance

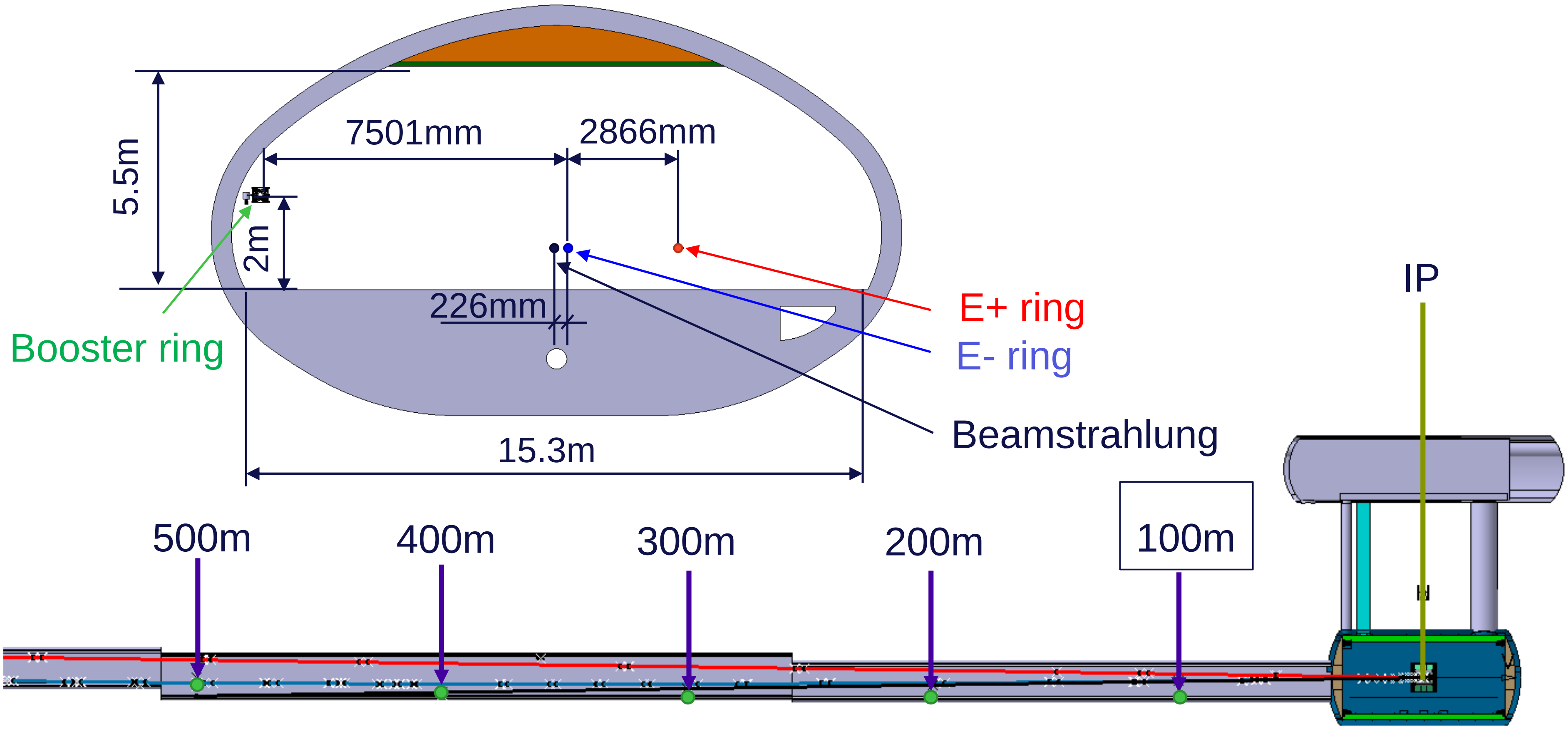


FCC-ee beamstrahlung dump integration at point A

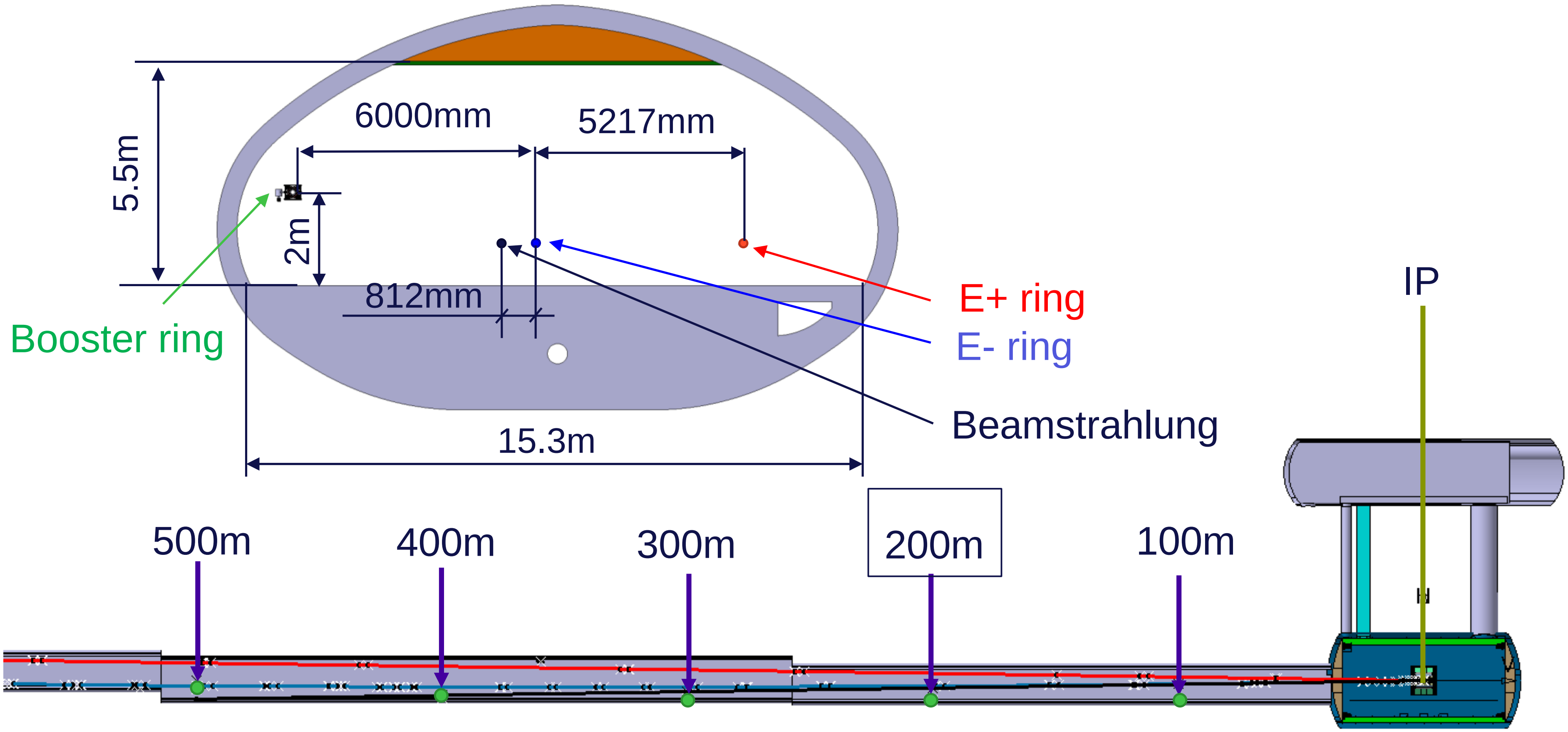
- E- ring
- E+ ring
- Booster ring
- Beamstrahlung Dump



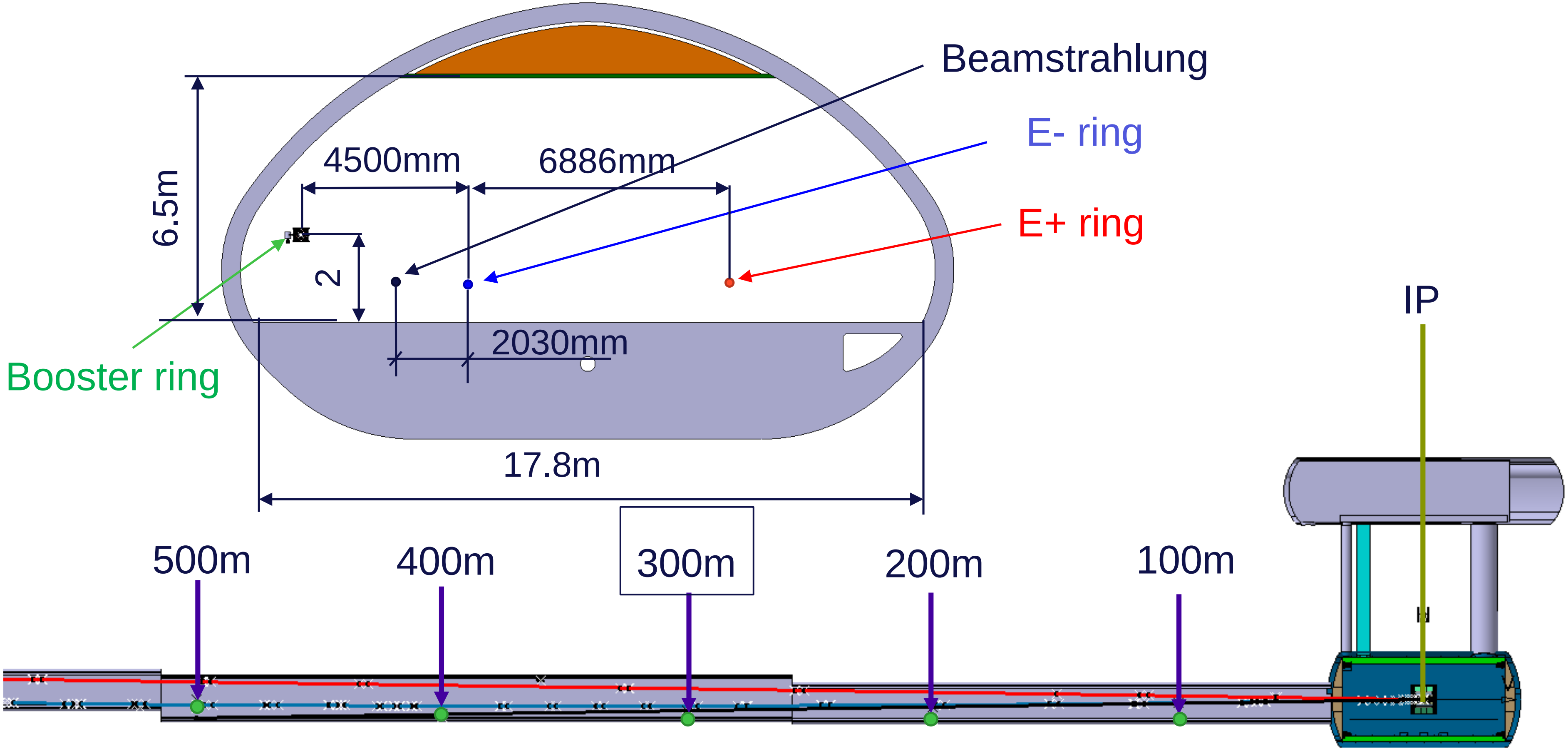
FCC-ee beamstrahlung dump integration at point A



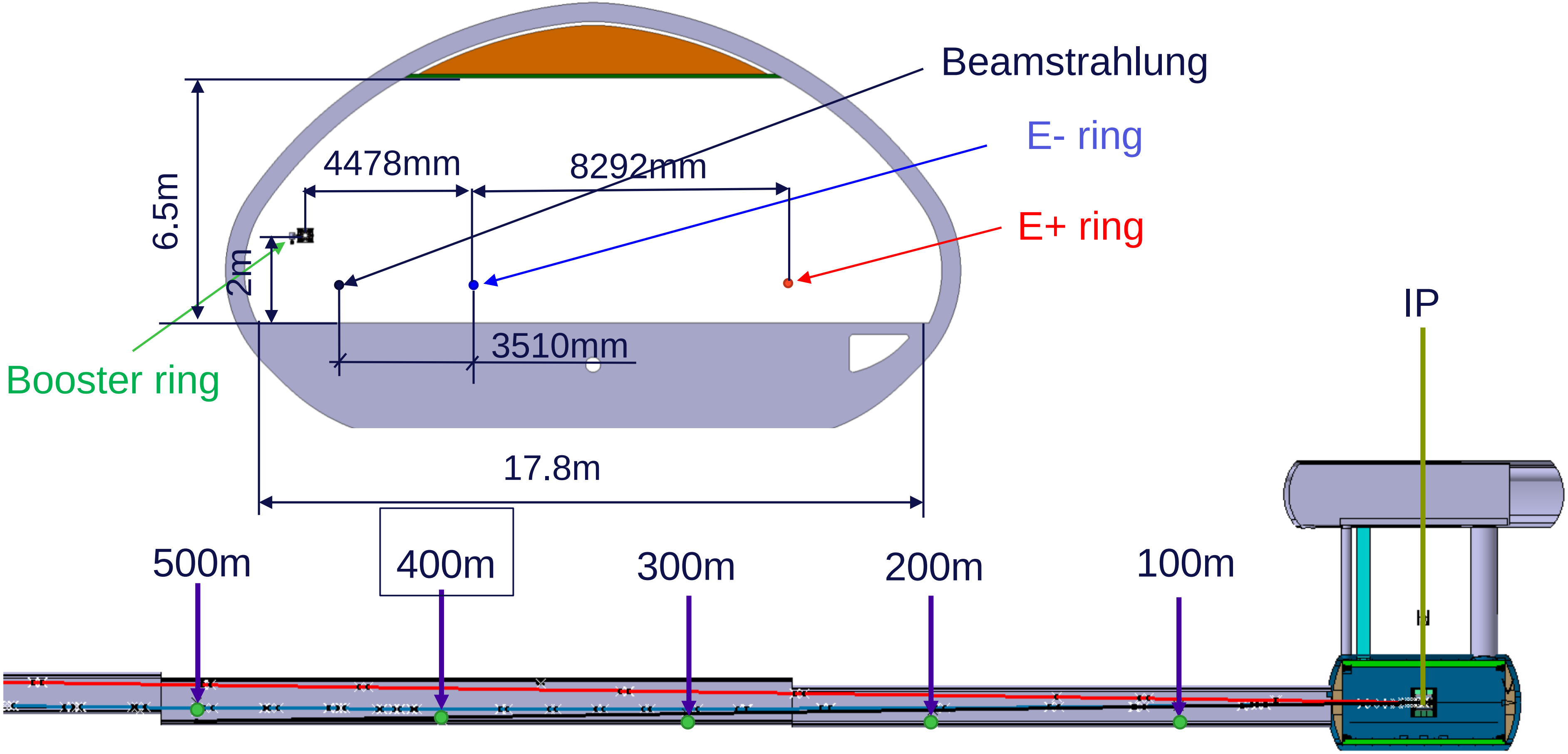
FCC-ee beamstrahlung dump integration at point A



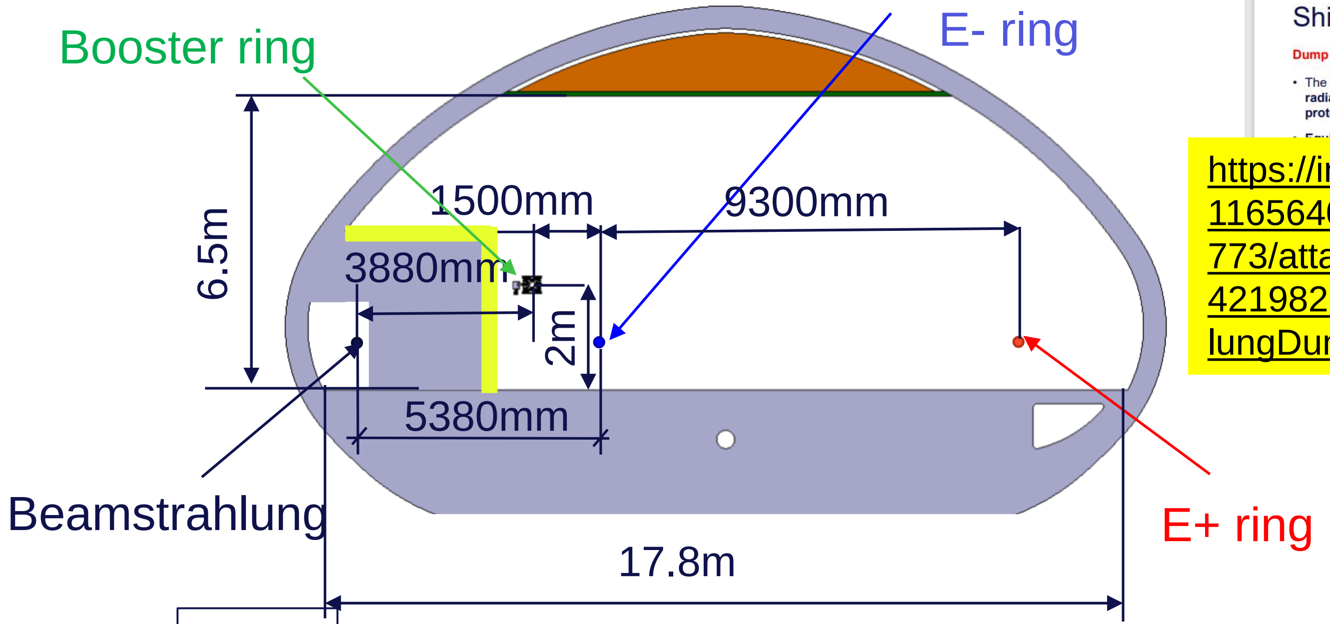
FCC-ee beamstrahlung dump integration at point A



FCC-ee beamstrahlung dump integration at point A



FCC-ee beamstrahlung dump integration at point A

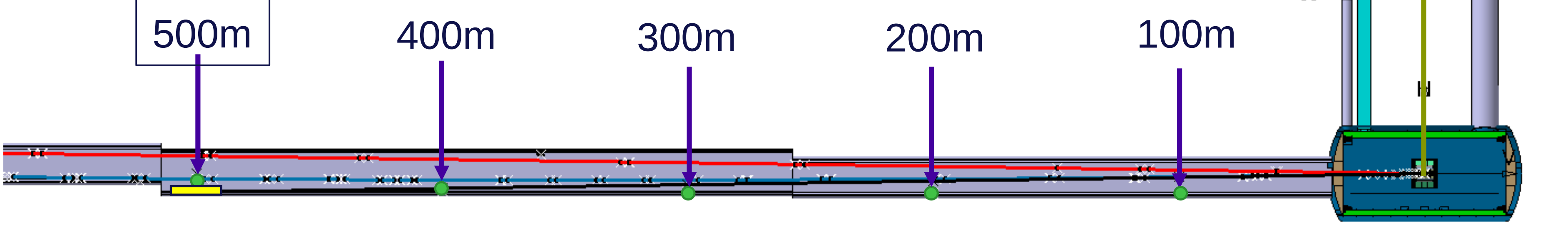



Shielding considerations

Dump cores need to be shielded:

- The shielding shall mitigate **instantaneous** and **cumulative radiation effects** in **nearby equipment** and ensure **radiation protection** of **personnel** during shutdowns/technical stops

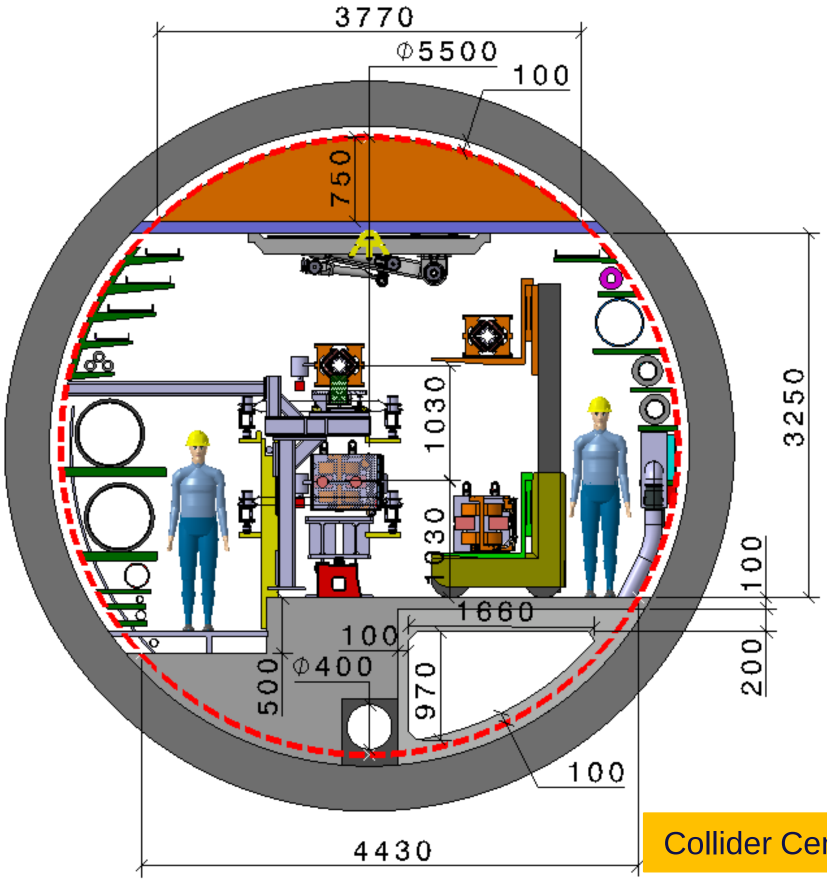
https://indico.cern.ch/event/1165640/contributions/4912773/attachments/2461229/4219826/FCCeeBeamstrahlungDump_13062022.pdf



Integration of FCC-ee RF sections

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 + flange (ø630)

Collider Center

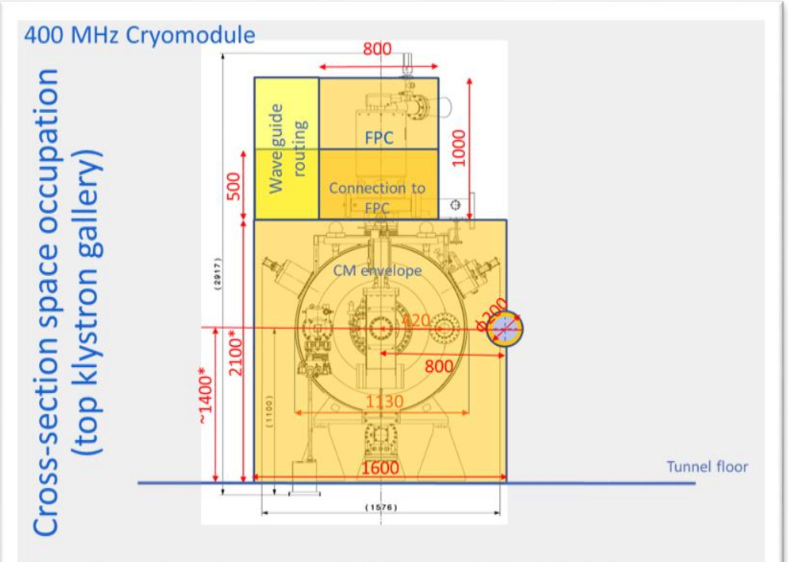
FCC-ee RF reference table

Courtesy F. Peauger and O. Brunner

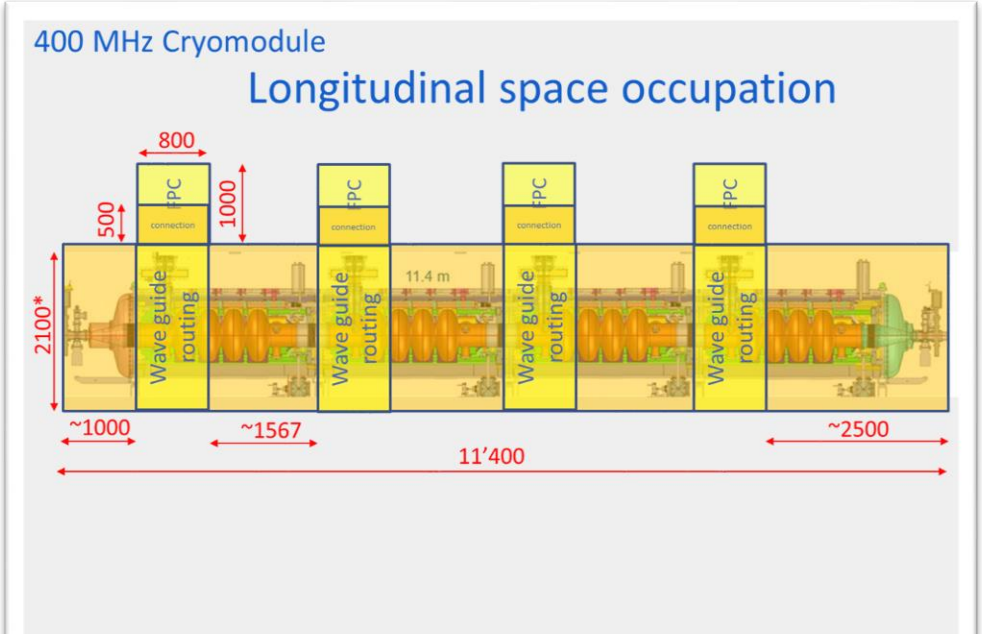
18-Nov-22	Z		W		H		ttbar2		
	per beam	booster	per beam	booster	2 beams	booster	2 beams	2 beams	booster
Frequency [MHz]	400	800	400	800	400	800	400	800	800
RF voltage [MV]	120	140	1050	1050	2100	2100	2100	9200	11300
Eacc [MV/m]	5.72	5.34	10.95	21.55	10.78	22.42	10.78	22.52	22.50
# cell / cav	1	5	2	5	2	5	2	5	5
Vcavity [MV]	2.14	5.00	8.20	20.19	8.08	21.00	8.08	21.10	21.08
#cells	56	140	256	260	520	500	520	2180	2680
# cavities	56	28	128	52	260	100	260	436	536
# CM	14	7	32	13	65	25	65	109	134
T operation [K]	4.5	2	4.5	2	4.5	2	4.5	2	2
dyn losses/cav [W]	22	0.3	163	4	158	5	158	32	5
stat losses/cav [W]	8	8	8	8	8	8	8	8	8
Qext	6.0E+04	2.5E+05	1.1E+06	8.3E+06	1.1E+06	8.6E+06	9.4E+06	4.2E+06	4.6E+07
Detuning [kHz]	9.777	5.606	0.472	0.131	0.096	0.025	0.031	0.028	0.005
Pcav [kW]	962	192	385	95	379	99	45	202	18
rhob [m]	9937	9937	9937	9937	9937	9937	9937	9937	9937
Energy [GeV]	45.6	45.6	80.0	80.0	120.0	120.0	182.5		182.5
energy loss [MV]	38.49	38.49	364.63	364.63	1845.94	1845.94	9875.14		9875.14
cos phi	0.32	0.27	0.35	0.35	0.88	0.88	0.56	0.96	0.87
Beam current [A]	1.400	0.140	0.135	0.0135	0.0534	0.005	0.010	0.010	0.001

FCC-ee RF 400 MHz Cryomodules space occupation

Courtesy V.Parma/E. Montesinos



* Beam height could be ~1000, but increased to 1400 for standardization with 800 MHz

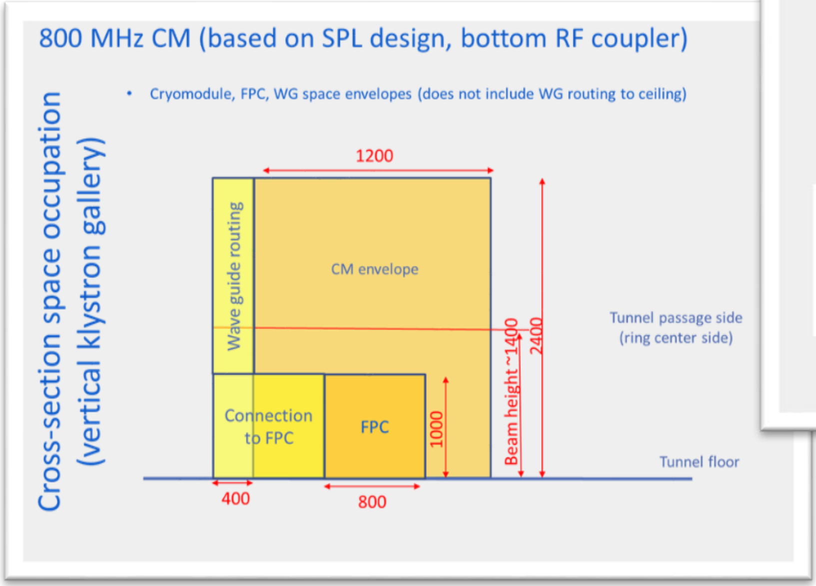


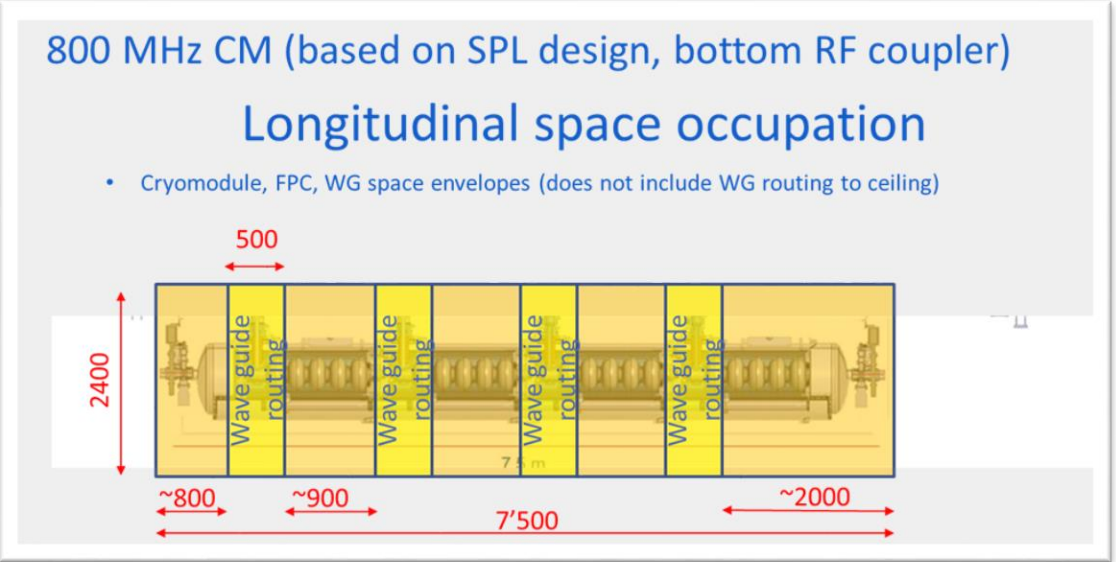
Note:
Overall CM length shall be the same for single-cell and four-cell cavities

- Consider only 2 types of CM
- Same CM design for 1_cells (Z) and 2_cells (W, H) 400 MHz systems – distance between WG must remain constant
- The use of half-height WG may allow to reduce the number of WG holes – to be studied in detail

FCC-ee RF 800 MHz Cryomodules space occupation

Courtesy V.Parma/E. Montesinos



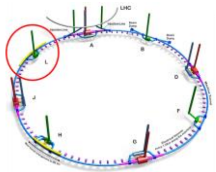


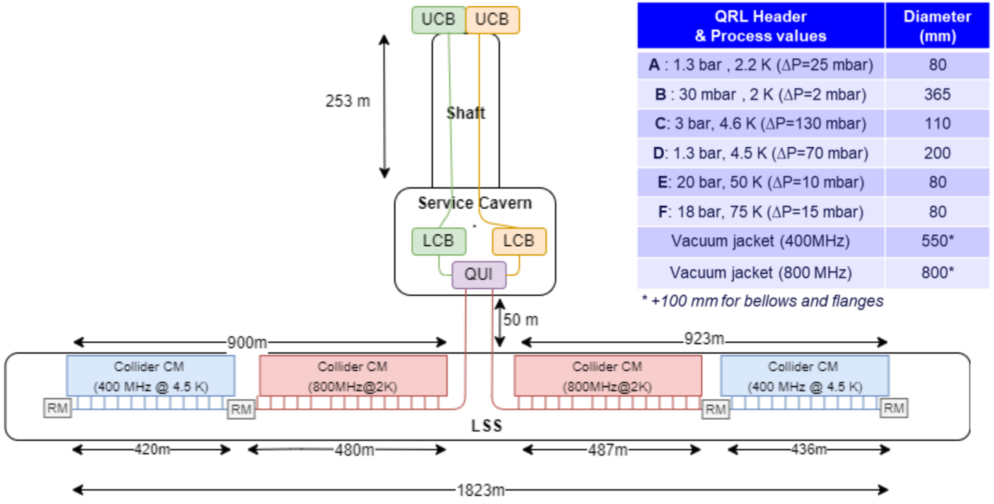
• The use of half-height WG may allow to reduce the number of WG holes – to be studied in detail

FCC-ee RF/Cryogenic Layout point L

Courtesy L.Delprat, B.Bradu and K.Brodzinski

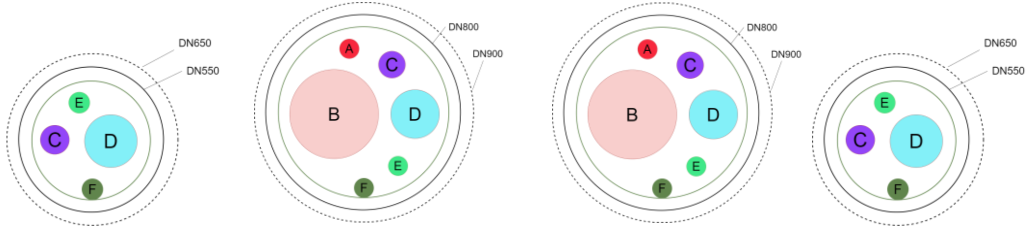
TLSS length: 2160 m

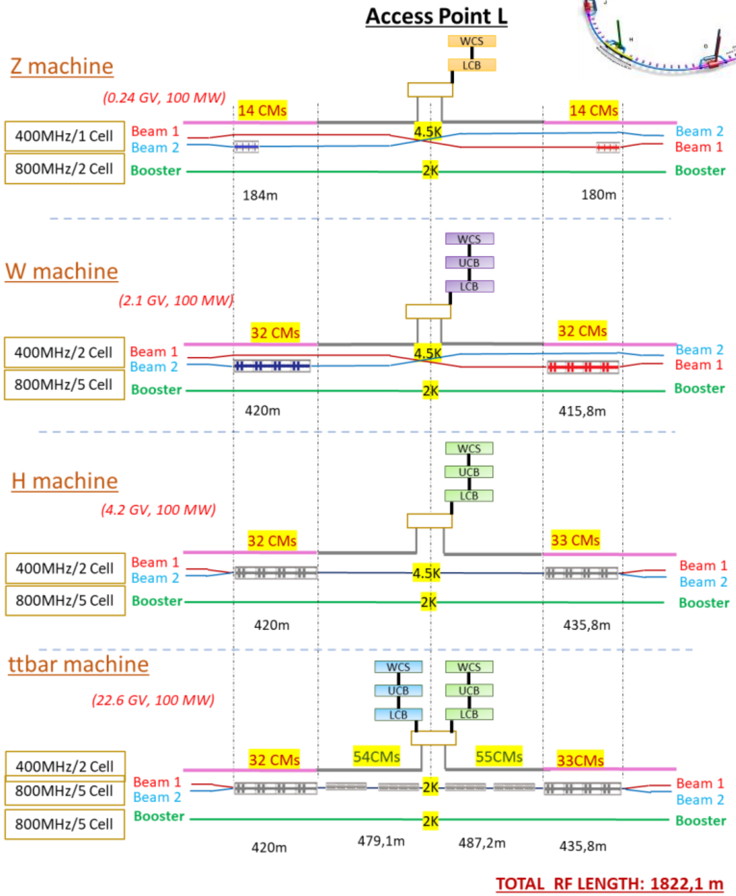




QRL Header & Process values	Diameter (mm)
A : 1.3 bar , 2.2 K (ΔP=25 mbar)	80
B : 30 mbar , 2 K (ΔP=2 mbar)	365
C: 3 bar, 4.6 K (ΔP=130 mbar)	110
D: 1.3 bar, 4.5 K (ΔP=70 mbar)	200
E: 20 bar, 50 K (ΔP=10 mbar)	80
F: 18 bar, 75 K (ΔP=15 mbar)	80
Vacuum jacket (400MHz)	550*
Vacuum jacket (800 MHz)	800*

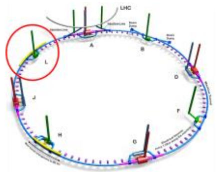
** +100 mm for bellows and flanges*





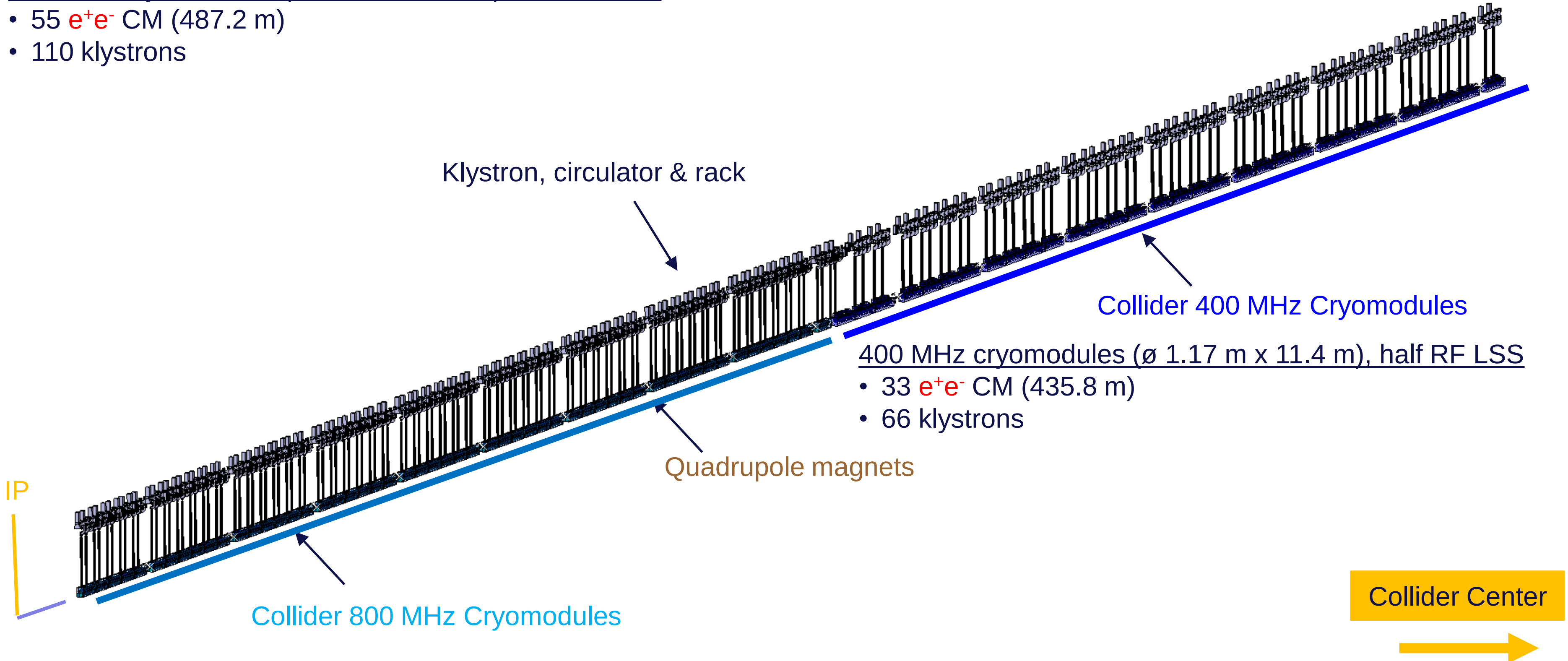
- 2K Collider CMs near to cryoplants then 2K Booster CM

FCC-ee RF Machine tunnel longitudinal view (ttbar machine)



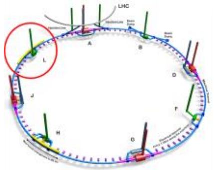
- Distance between e^+e^- quadrupoles 52 m, length 3.1 m.
- Distance between booster quadrupoles 52 m, length 1.5 m.

800 MHz cryomodules (ø 1.09 m x 7.5 m), half RF LSS
- 55 e^+e^- CM (487.2 m)
- 110 klystrons



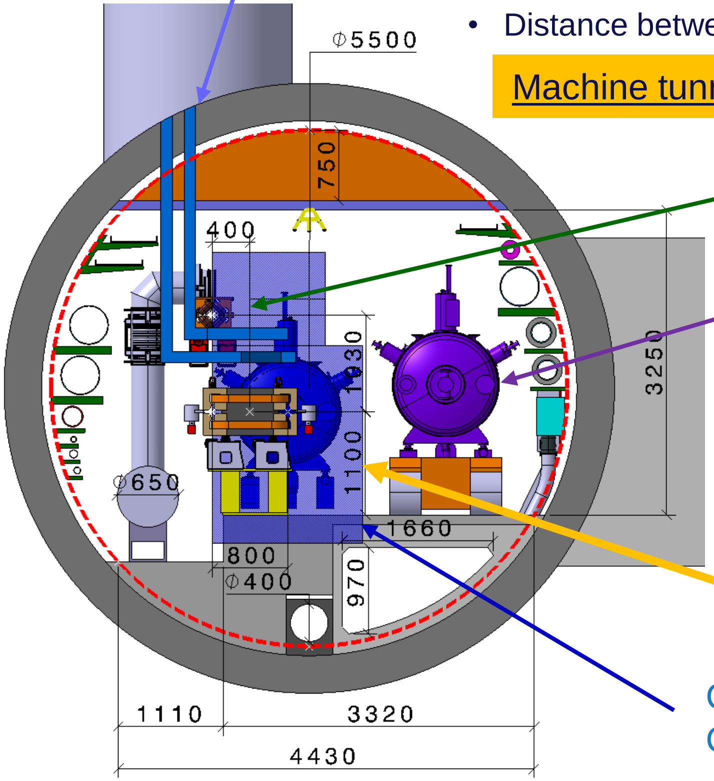
400 MHz cryomodules (ø 1.17 m x 11.4 m), half RF LSS
- 33 e^+e^- CM (435.8 m)
- 66 klystrons

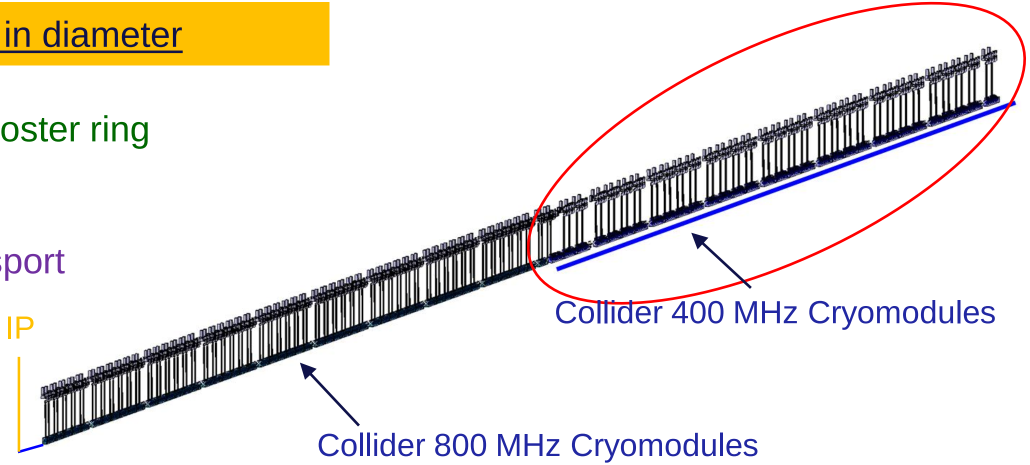
FCC-ee RF Machine tunnel cross section (Z,W,H machine)



- e^+e^- beam separation 0.40 m (needs quadrupole (model) with that spacing).
- 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.

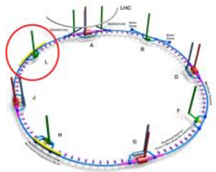
Machine tunnel 5.5 m in diameter





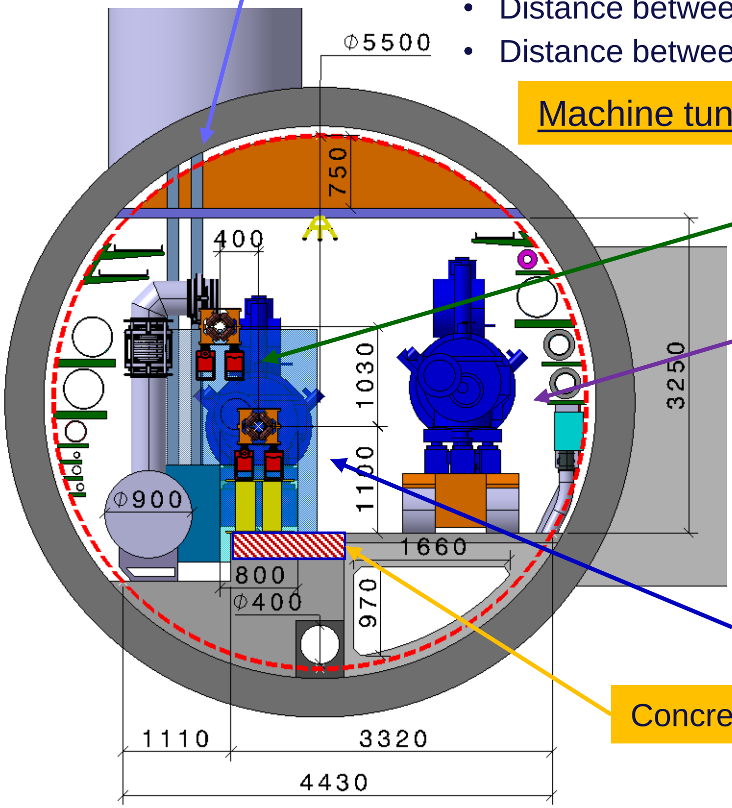
Collider Center

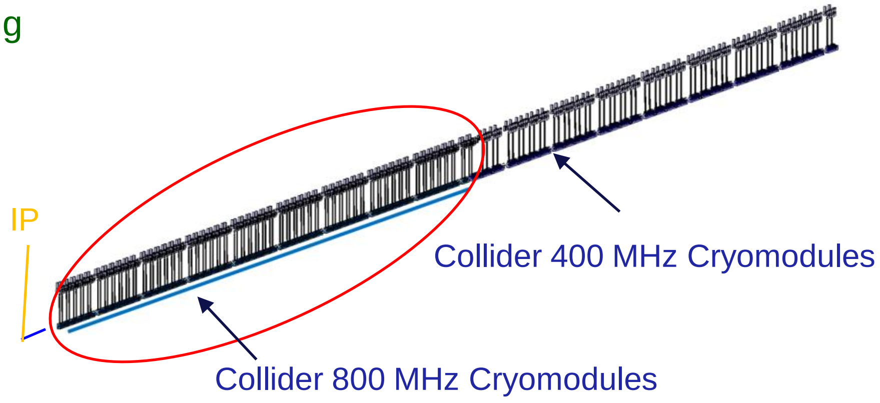
FCC-ee RF Machine tunnel cross section (ttbar machine)



- e^+e^- beam separation 0.40 m (needs quadrupole (model) with that spacing).
- QRL Ø along 800 MHz section 0.90 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





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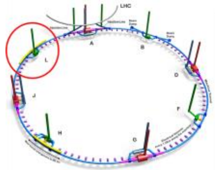
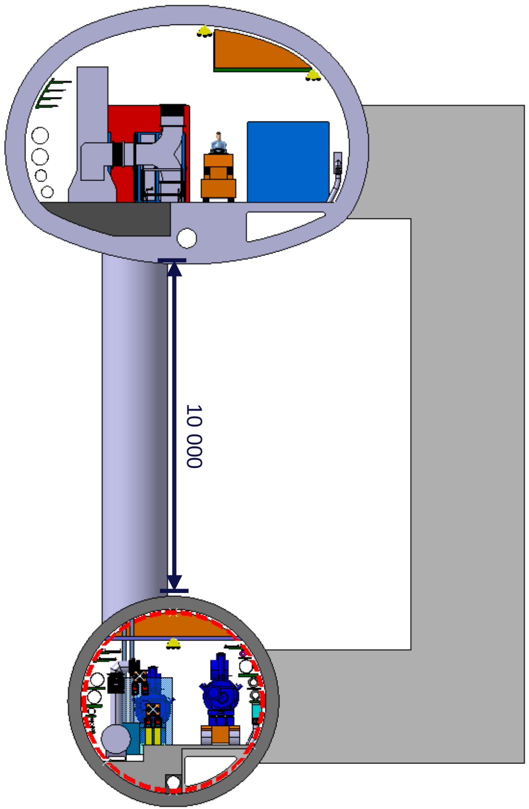
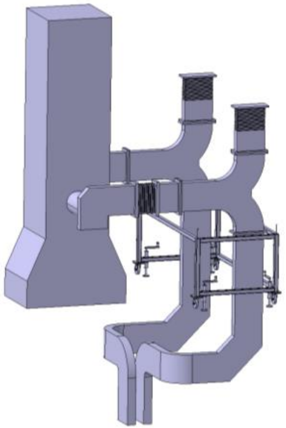
FCC-ee RF Machine tunnel & Klystron Gallery cross section (ttbar machine)

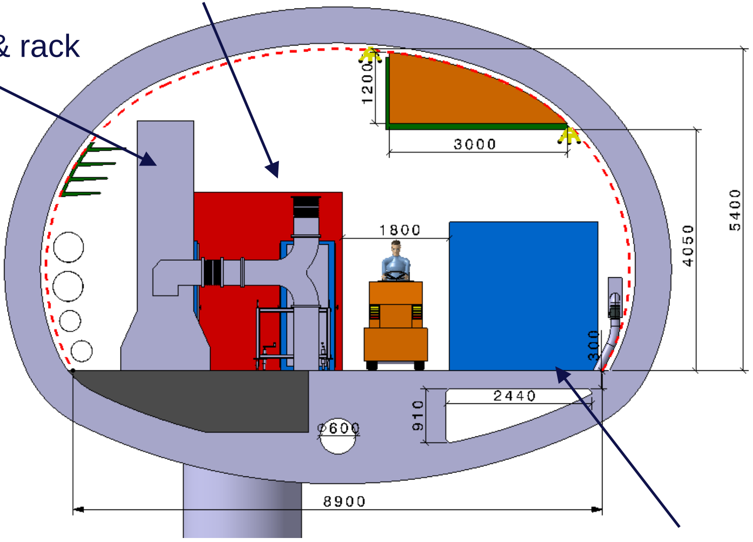




Bunker
(LxWxH=5x3x3 m)

Klystron, circulator & rack

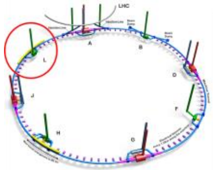


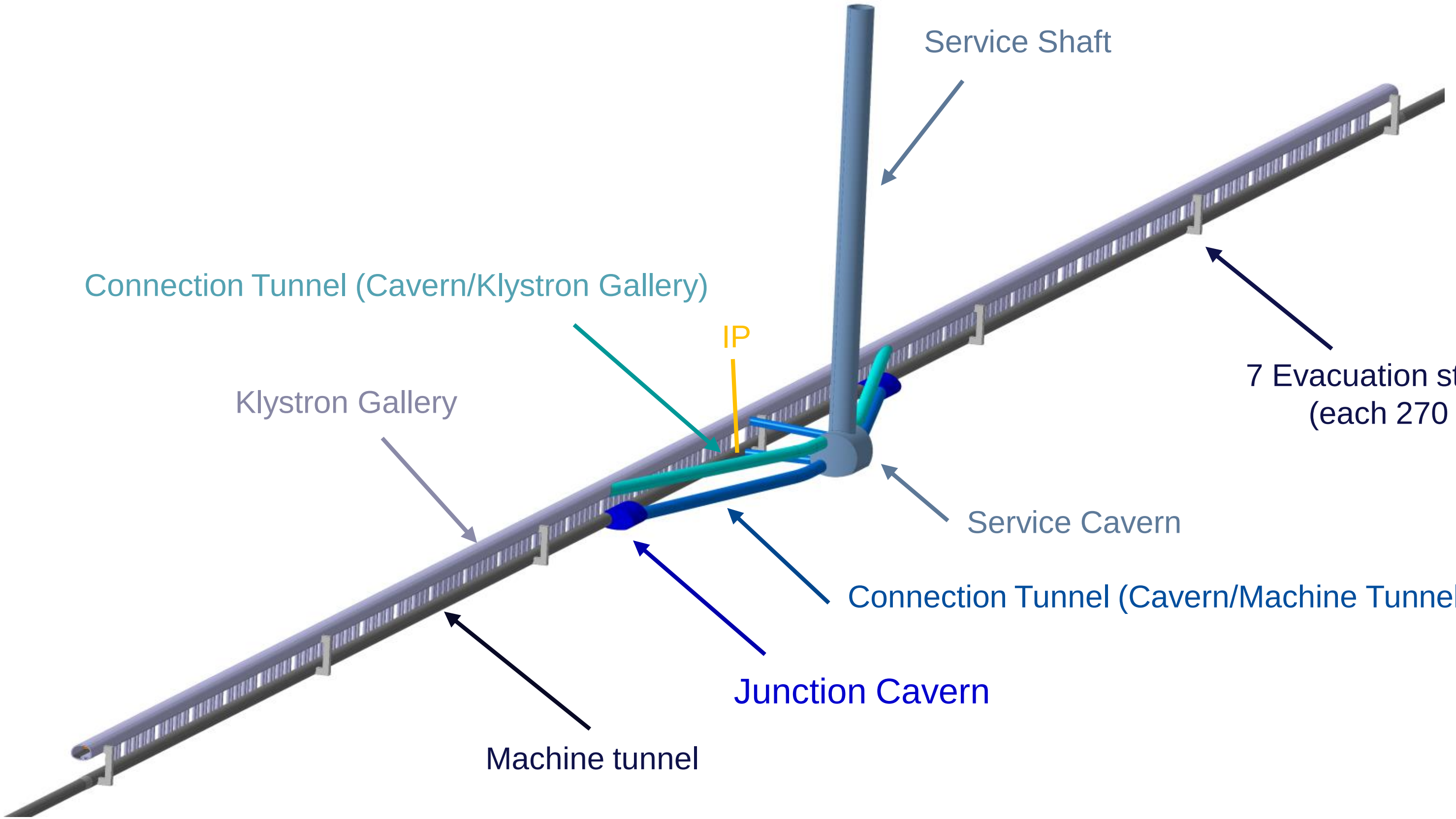


Faraday cage
(LxWxH=10x2x2.5m)

Collider Center

FCC-ee Underground Structure





Collider Center

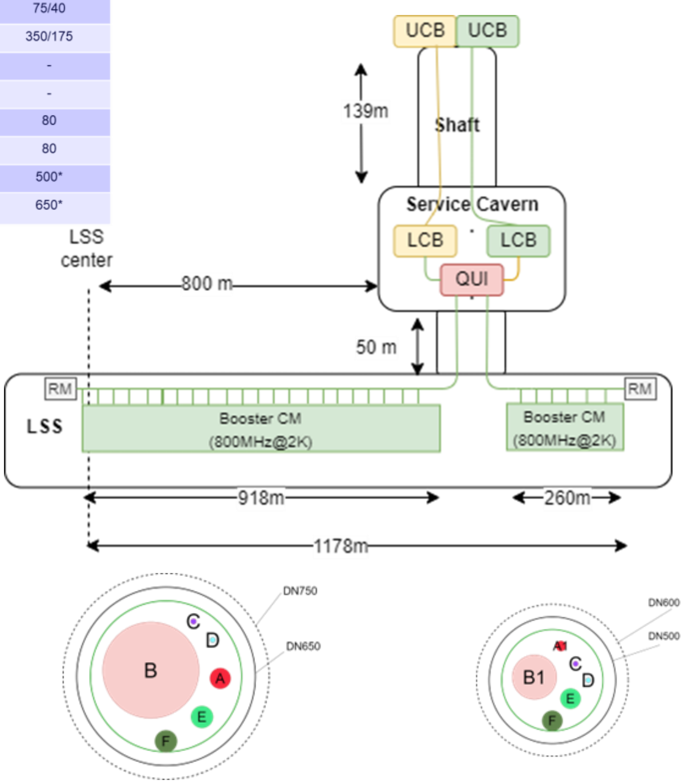
FCC-ee RF/Cryogenic Layout point H

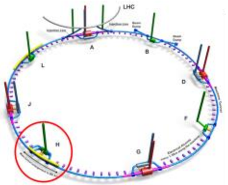
TLSS length: 2160 m

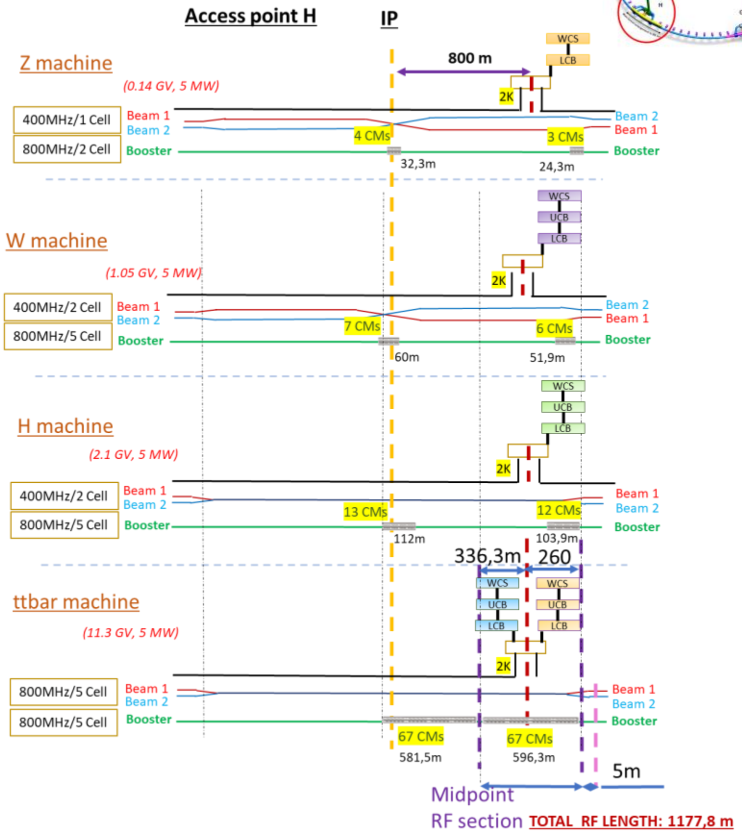
Courtesy L.Delprat, B.Bradu and K.Brodzinski

QRL Header	Diameter (mm)
A/A1 : 1.3 bar , 2.2 K (ΔP=25 mbar)	75/40
B/B1 : 30 mbar , 2 K (ΔP=2 mbar)	350/175
C: 3 bar, 4.6 K (ΔP=130 mbar)	-
D: 1.3 bar, 4.5 K (ΔP=70 mbar)	-
E: 20 bar, 50 K (ΔP=5 mbar)	80
F: 18 bar, 75 K (ΔP=10 mbar)	80
Vacuum jacket right	500*
Vacuum jacket left	650*

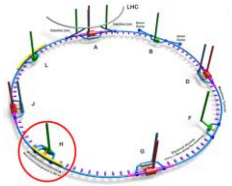
** +100 mm for bellows and flanges*







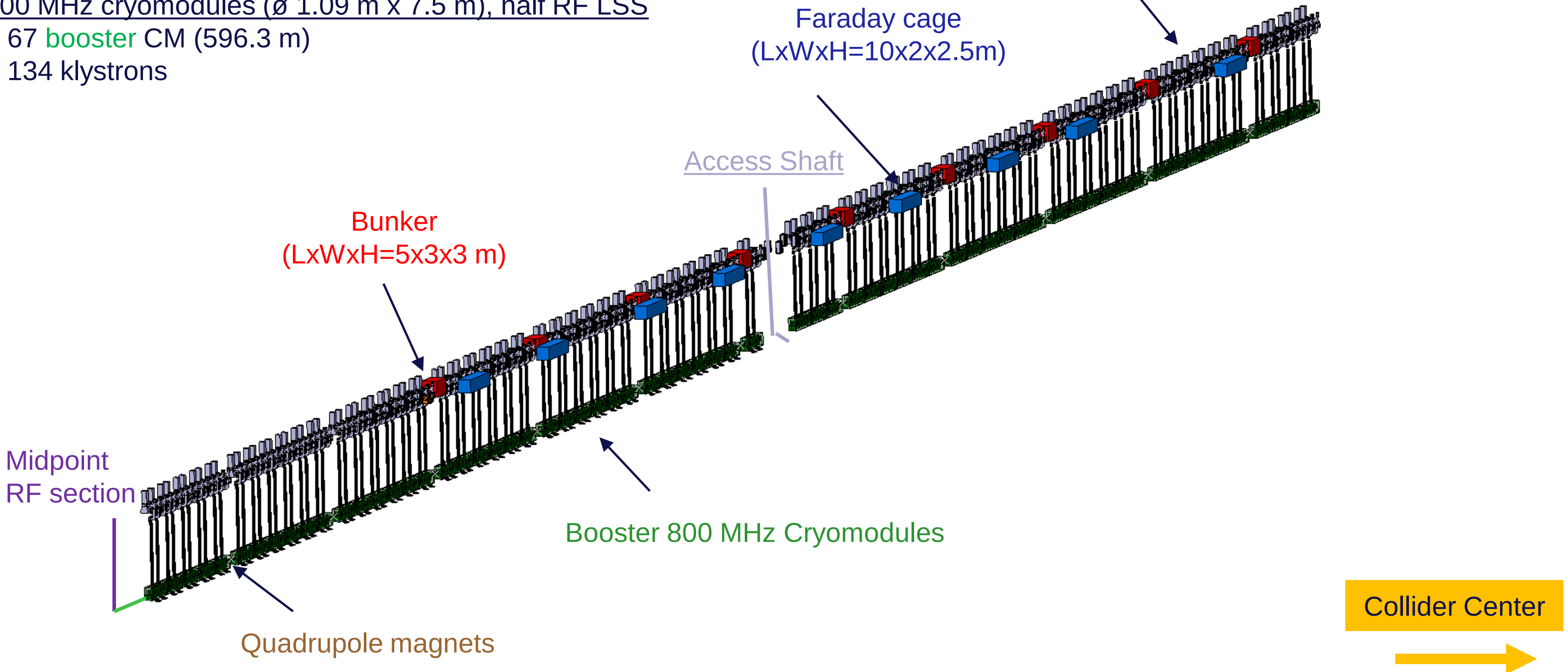
FCC-ee RF Machine tunnel longitudinal view (ttbar machine)



- Distance between e^+e^- quadrupoles 52 m, length 3.1 m.
- Distance between booster quadrupoles 52 m, length 1.5 m.

800 MHz cryomodules (ø 1.09 m x 7.5 m), half RF LSS

- 67 booster CM (596.3 m)
- 134 klystrons

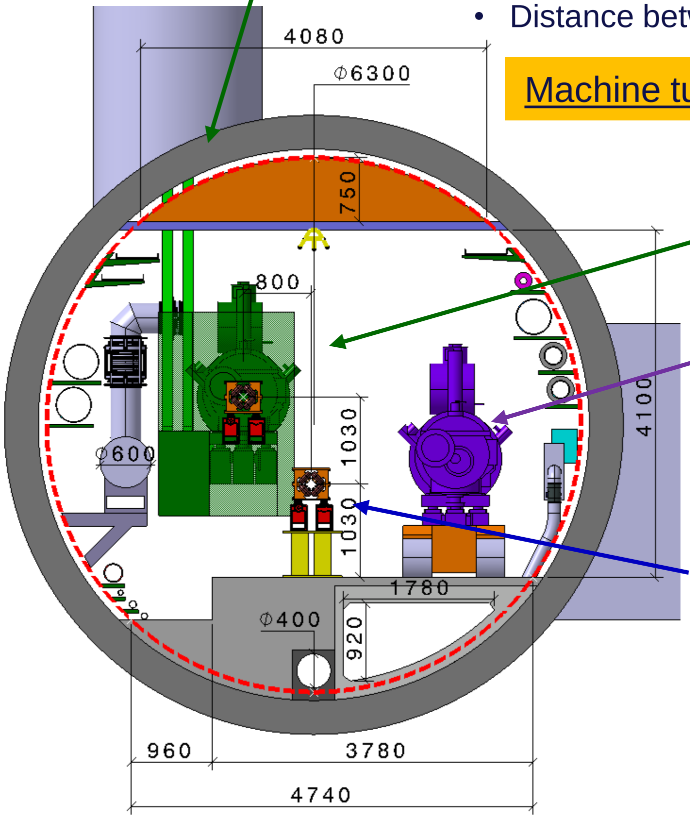


FCC-ee RF Machine tunnel cross section (ttbar machine)

- QRL Ø along 800 MHz section 0.6 m.
- Distance between e$^+$e$^-$ quadrupoles 52 m, length 3.1 m.
- Distance between booster quadrupoles 52 m, length 1.5 m.

Machine tunnel 6.3 m in diameter

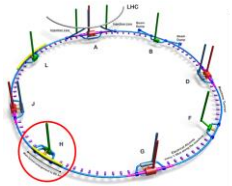
Waveguide



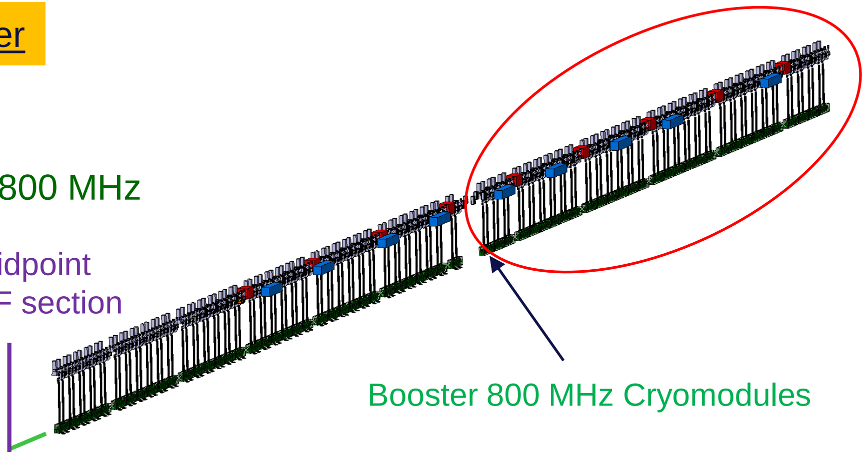
Booster ring
Cryomodule 800 MHz

Transport

Collider ring



Midpoint
RF section



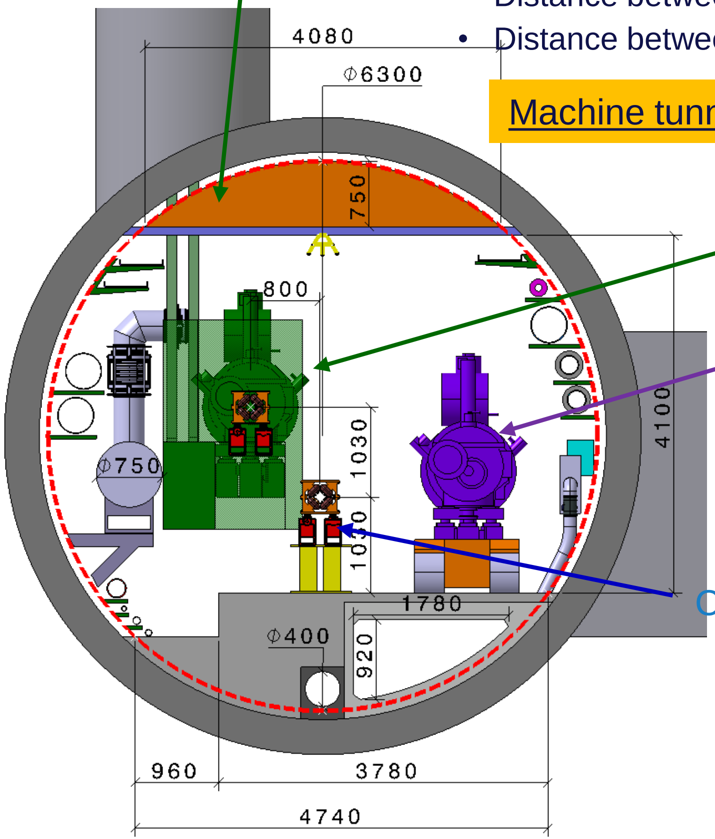
Booster 800 MHz Cryomodules

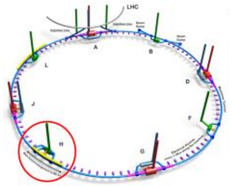
Collider Center

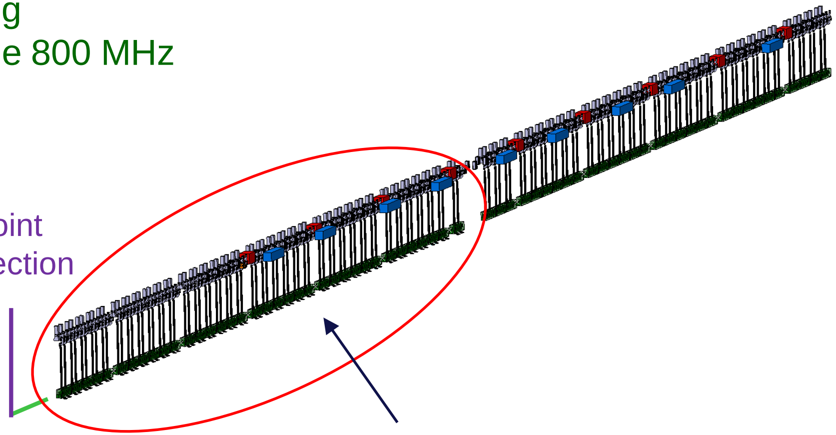
FCC-ee RF Machine tunnel cross section (ttbar machine)

- QRL Ø along 800 MHz section 0.75 m.
- Distance between e^+e^- quadrupoles 52 m, length 3.1 m.
- Distance between booster quadrupoles 52 m, length 1.5 m.

Machine tunnel 6.3 m in diameter

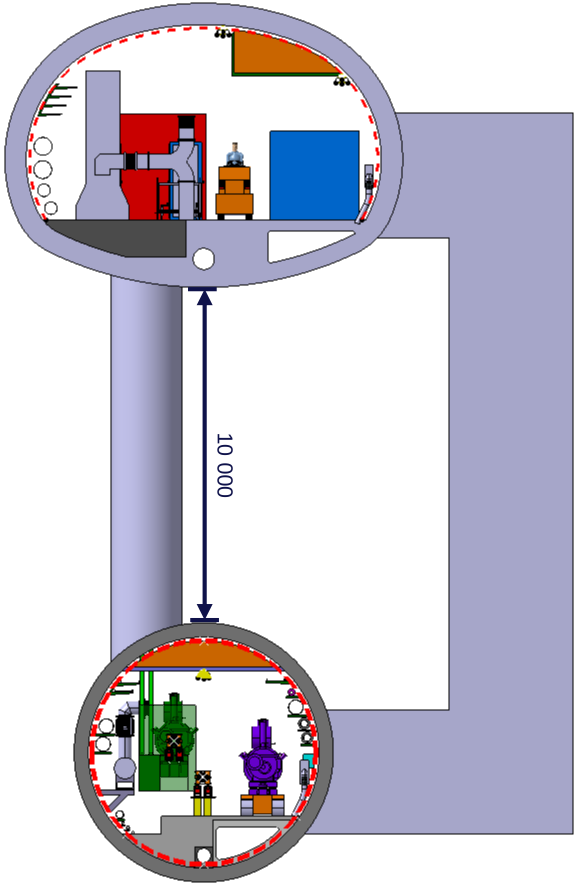


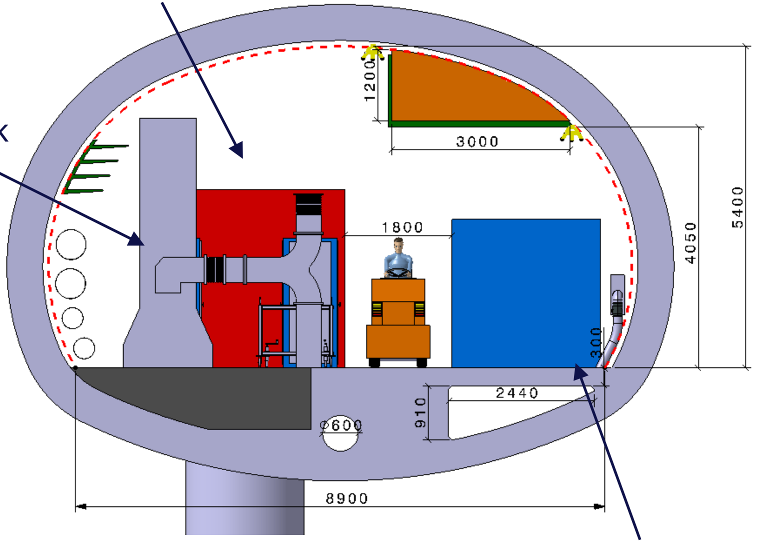




Collider Center

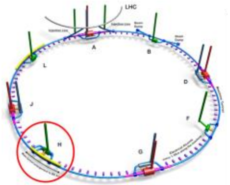
FCC-ee RF Machine tunnel & Klystron Gallery cross section (ttbar machine)

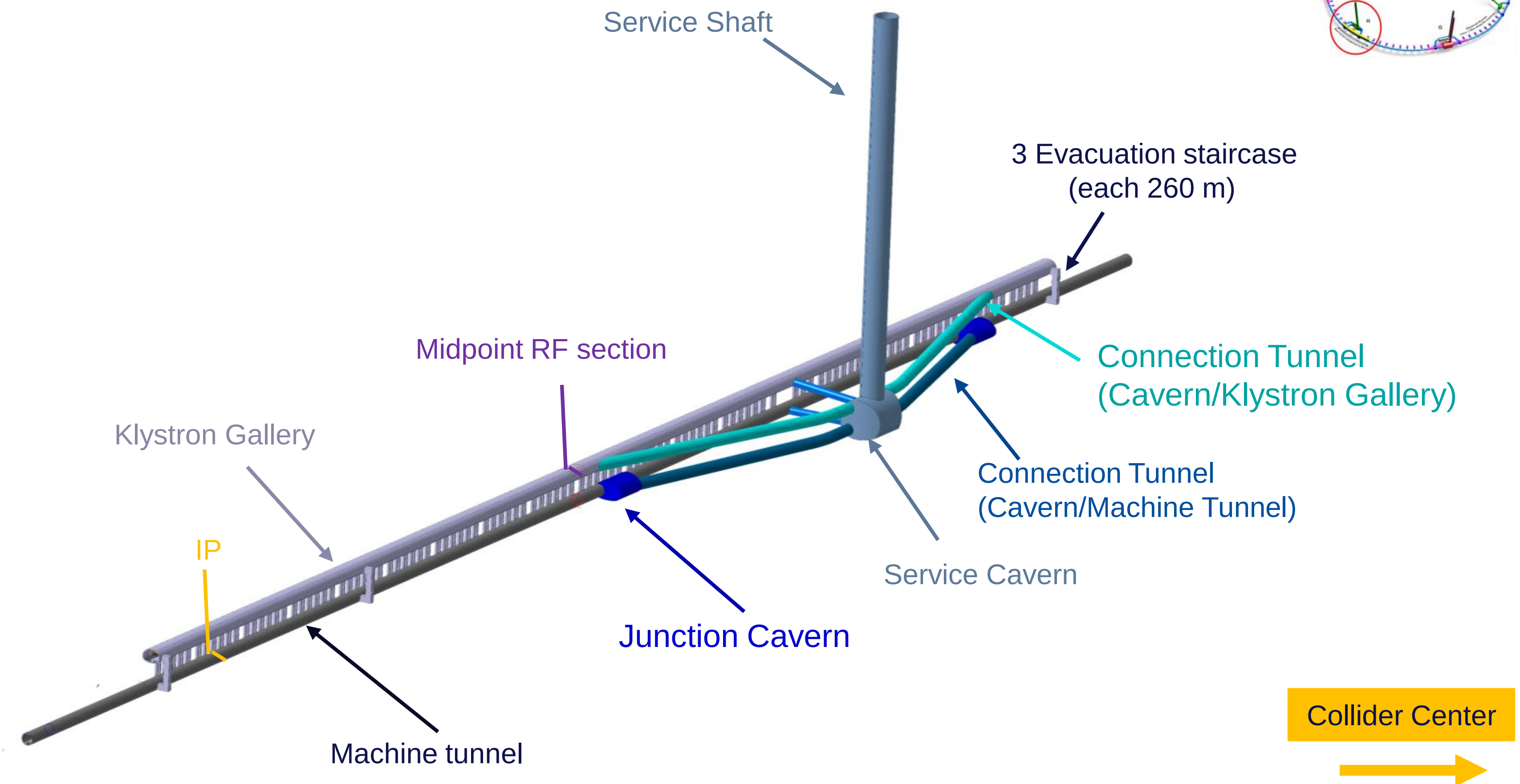




Collider Center

FCC-ee Underground Structure

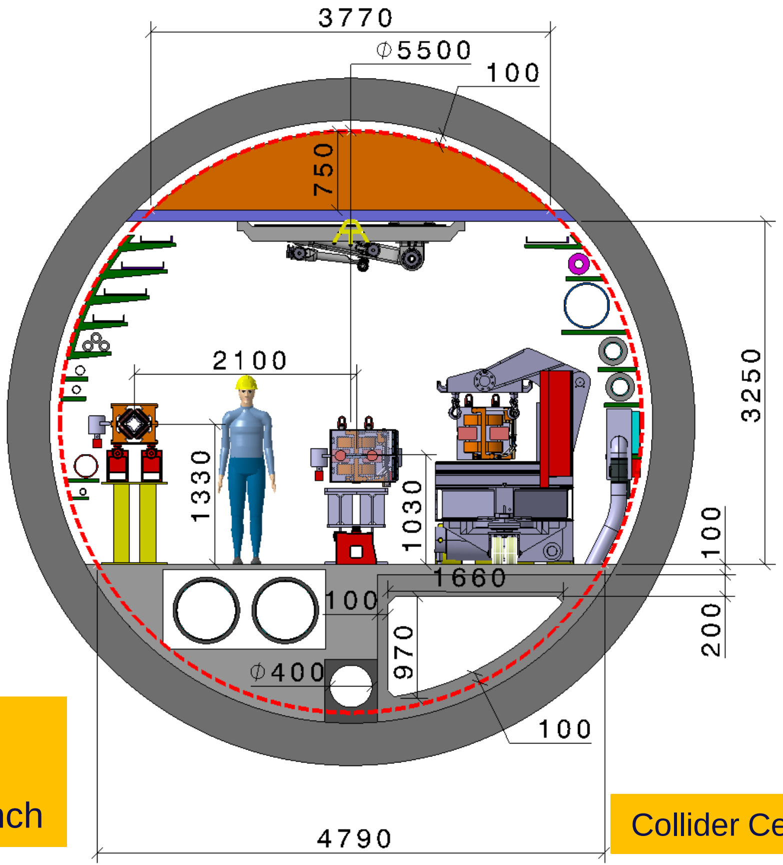




Alternative Integration of FCC-ee RF sections

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

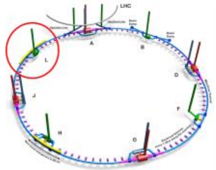
Machine tunnel 5.5m in diameter



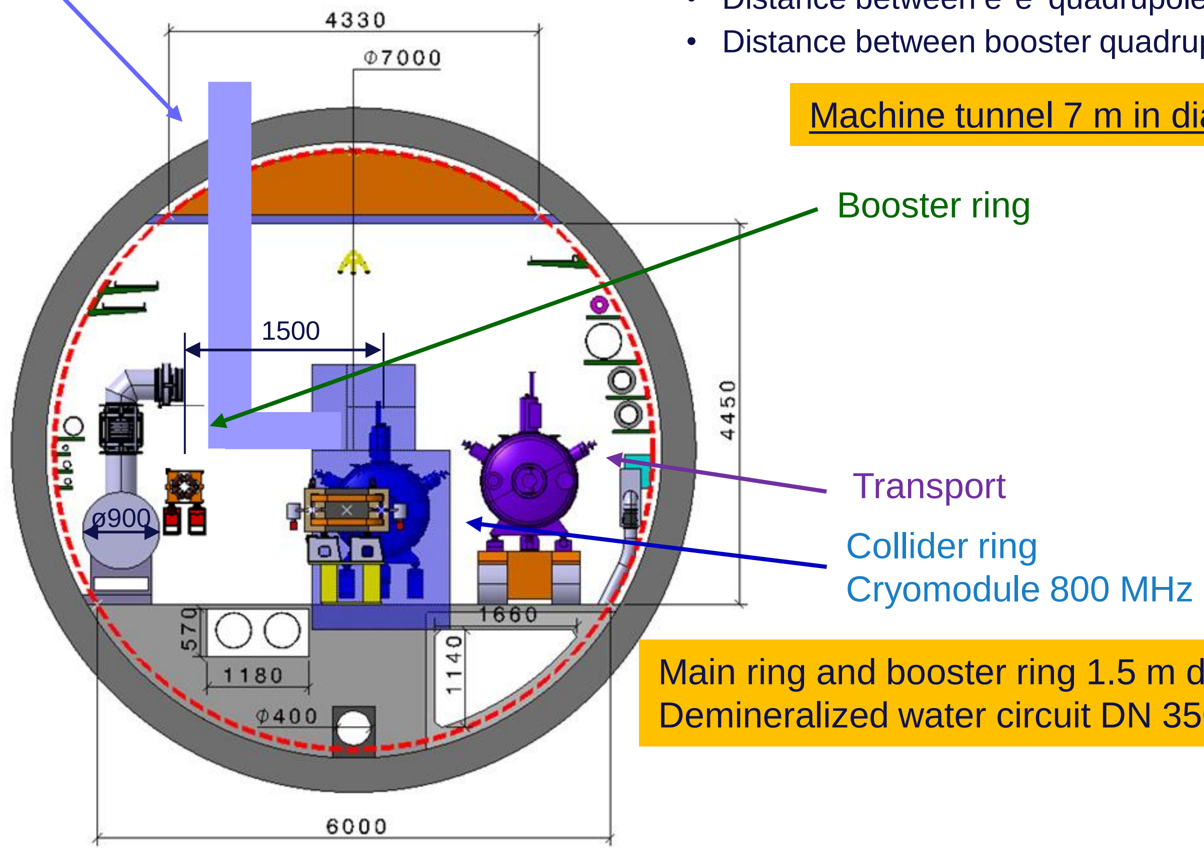
Booster ring next to the main ring
Main ring and booster ring 2.1 m distant
Demineralized water circuit DN 550 + flange (ø630) in a trench

Collider Center

FCC-ee RF Machine tunnel cross section (ttbar machine) point L



- QRL Ø along 400 MHz section 0.90 m.
- Distance between e^+e^- quadrupoles 52 m, length 3.1 m.
- Distance between booster quadrupoles 52 m, length 1.5 m.

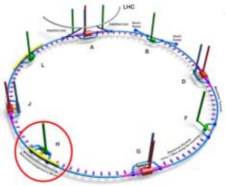


Machine tunnel 7 m in diameter

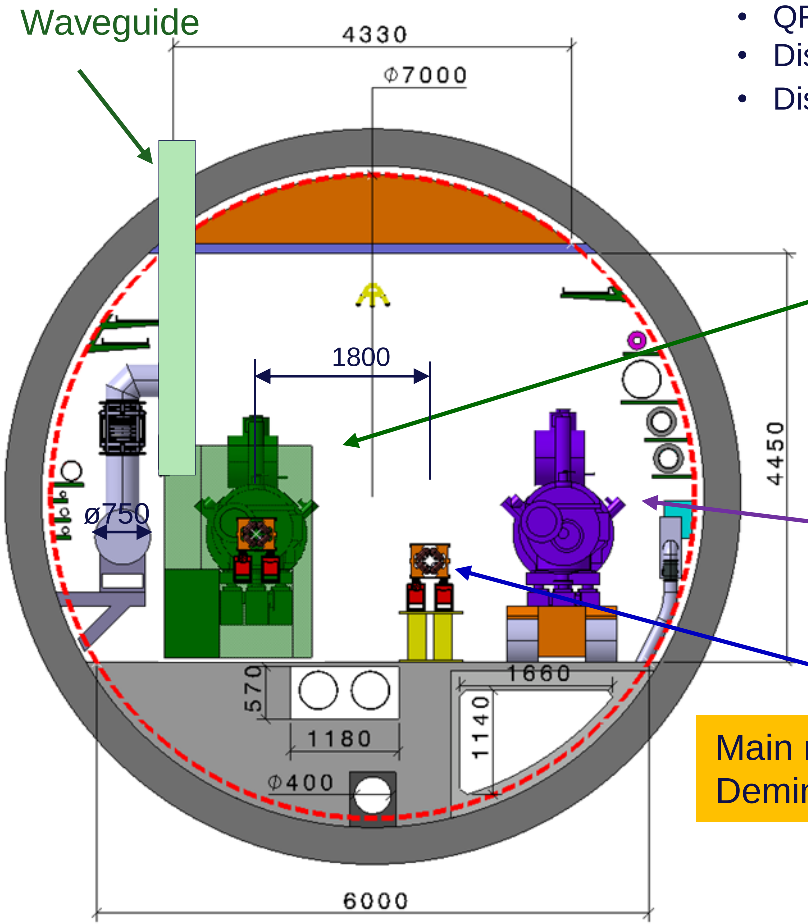
Main ring and booster ring 1.5 m distant
Demineralized water circuit DN 350 + flange (ø400) in a trench

Collider Center

FCC-ee RF Machine tunnel cross section (ttbar machine) point H



- QRL Ø along 800 MHz section 0.75 m.
- Distance between e^+e^- quadrupoles 52 m, length 3.1 m.
- Distance between booster quadrupoles 52 m, length 1.5 m.



Machine tunnel 7 m in diameter

Main ring and booster ring 1.8 m distant
Demineralized water circuit DN 350 + flange (ø400) in a trench

Collider Center

Thank you for your attention.