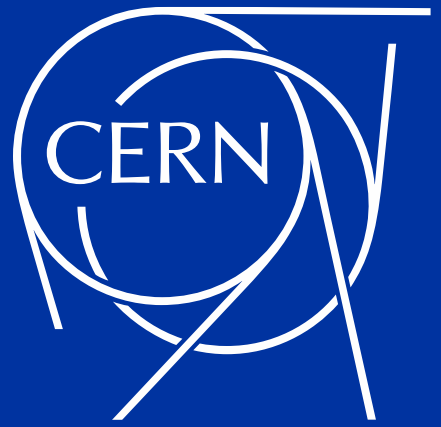


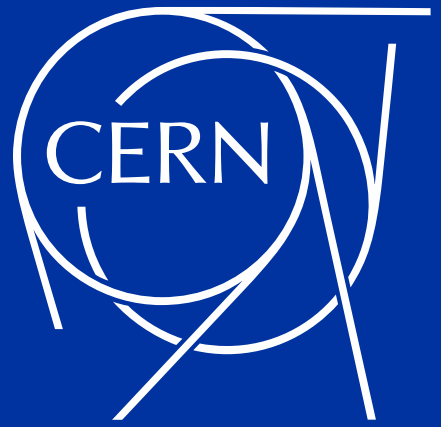
Linear and Muon Colliders at CERN

17th Feb 2025

John Osborne, Edward MacTavish

With thanks to Angel Navascues Cornago, Amine Mejri and Charlotte Desponds for the drawings and Geoprofiler.

SCE-SAM-FS

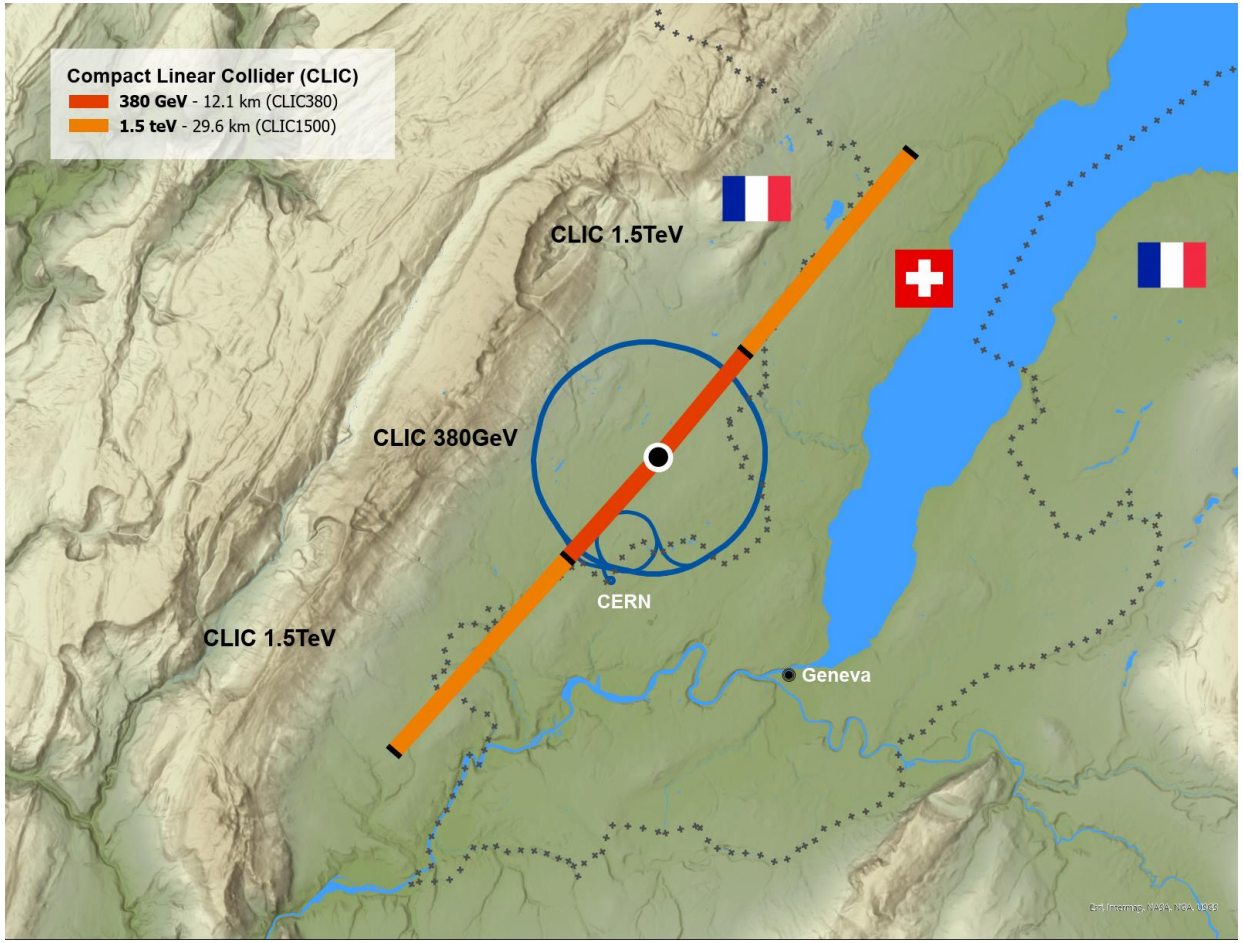


Linear Colliders

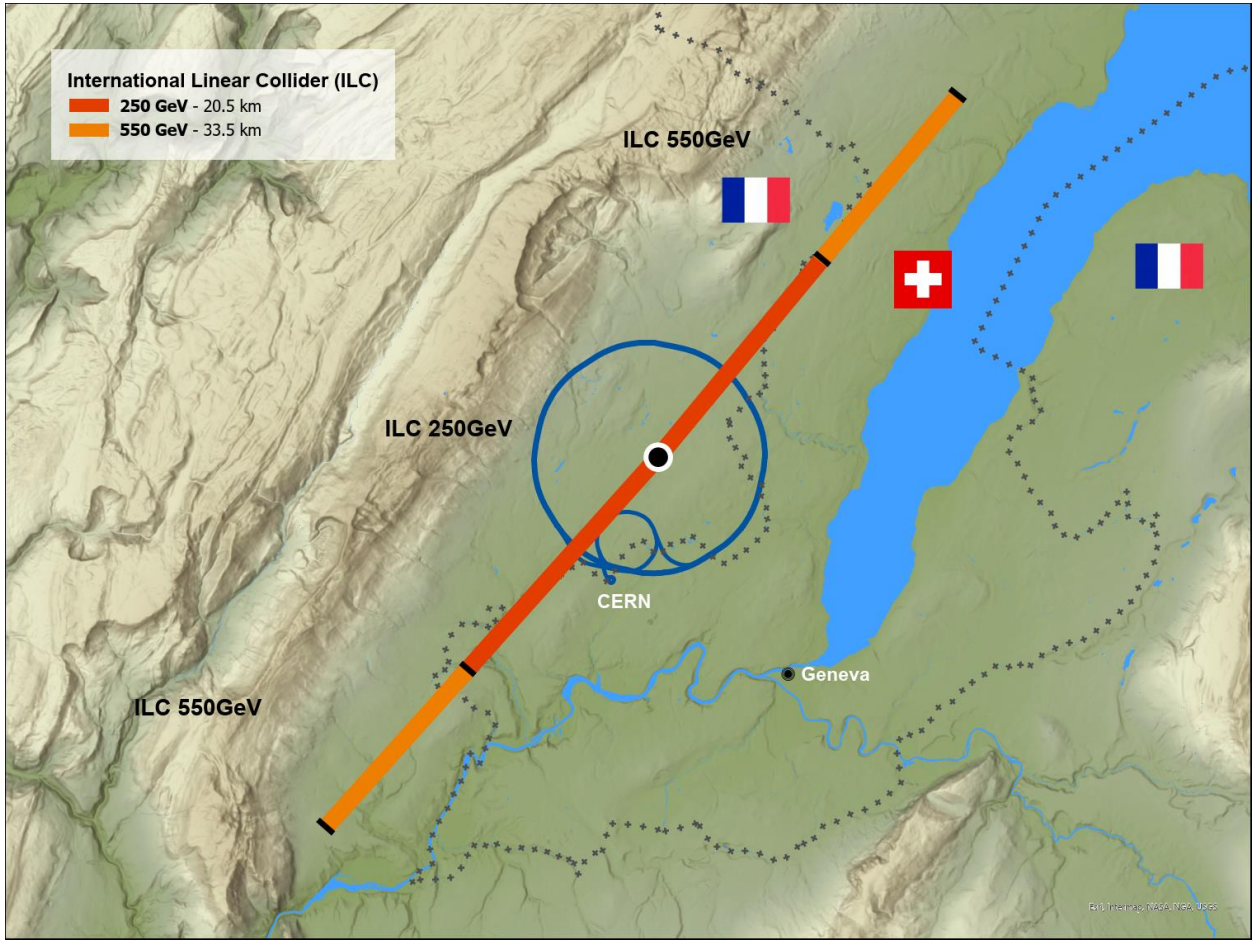
CLIC & ILC

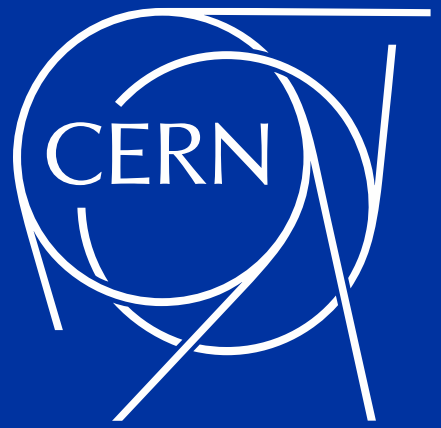
Geographical Layout

- CLIC at CERN



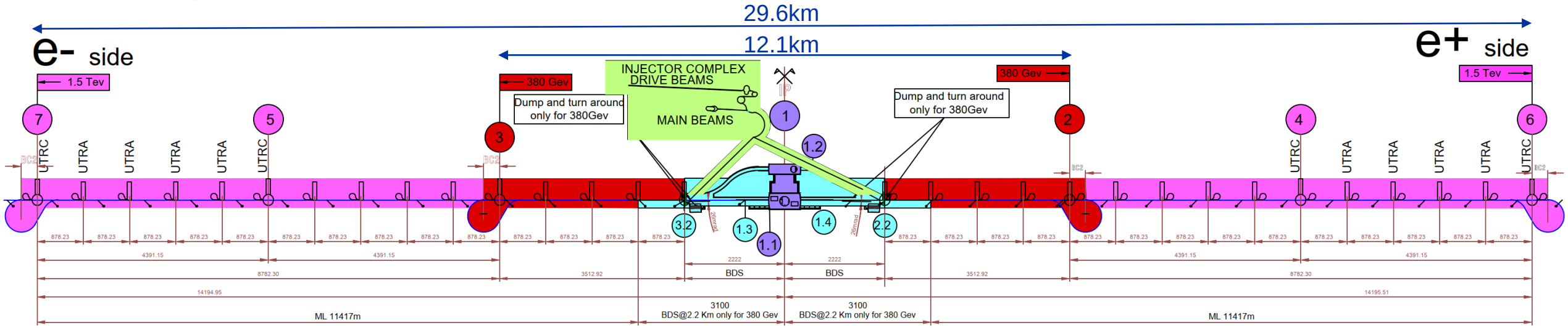
- Starting with ILC SRF Technology





CLIC

Underground Structures Schematic



Legend : 380Gev 1.5 Tev

ML
Main/Drive beam Injectors
BDS
Detectors Area

TOTAL TUNNEL LENGTHS (m)

	main beam turn-around	BC2	e- side ML	BDS	e+ side ML	TOTAL
380 Gev	3898	600	3513	4444	3513	15968
1.5 Tev	3898	600	11417	6200	11417	33532

main + drive beam injector complex
see drawing N°
CLIC.CE-1.1799.0002-M

MAIN TUNNEL LENGTHS (m)

	BC2	e- side ML	BDS	e+ side ML	TOTAL
380 Gev	600	3513	4444	3513	12070
1.5 Tev	600	11417	6200	11417	29634

TUNNELS SECTIONS

Area	beam turn-around	e- e+ sides ML	BDS
section dims.	Ø3 m	Ø5.6m	Ø5.6 m

SHAFTS

Point	1.1	1.2	2	2.2	3	3.2	4	5	6	7
Øm	18	12	9	9	9	9	9	9	9	9

SHAFT BASE CAVERNS (10 UTRC)

Point	2, 3, 4, 5, 6, 7,
(LxWxH) m	55 x 16 x 18 2 storeys

UTRA CAVERNS

Number	8 x	8 x	8 x
(LxWxH) m	40 x 10 x 7.2	45 x 10 x 7.2	50 x 10 x 7.2

SERVICE CAVERN & IP

Point	1	1.2
(LxWxH) m	.....	.....

DETECTORS HALL

Point	1.1
(LxWxH) m	60 x 30 x 33.5

MAIN BEAM DUMP CAVERNS & SERVICE HALLS ( )

Point	BDS CAVERNS 1.3, 1.4	BDS SERVICE HALLS 2.2, 3.2
(LxWxH) m	20 x 8 x 14 + 1 storey	49 x 16 x 18 3 storeys

DRIVE BEAM DUMP CAVERNS (↘)

Number	At each UTRAs, UTRCs and Tune-up 10 x	22 x	2 x
(LxWxH) m	6 x 9 x 5		

DRIVE BEAM RETURN LOOP

Number	10 x	26 x
(LxWxH) m	63 x 2.4 x 3	

BC2 CAVERNS

Number	2 x	2 x
(LxWxH) m	100 x 10 x 3	

UTR = Underground Technical Room

- Now only considering the Drive Beam option and not the Klystron option.
- The 3TeV stage is no longer being considered.
- Laser Straight
- 380GeV Main Tunnel length of 12.1Km (Displayed in Red).
- 1.5TeV Main Tunnel length of 29.6Km (Displayed in Pink).

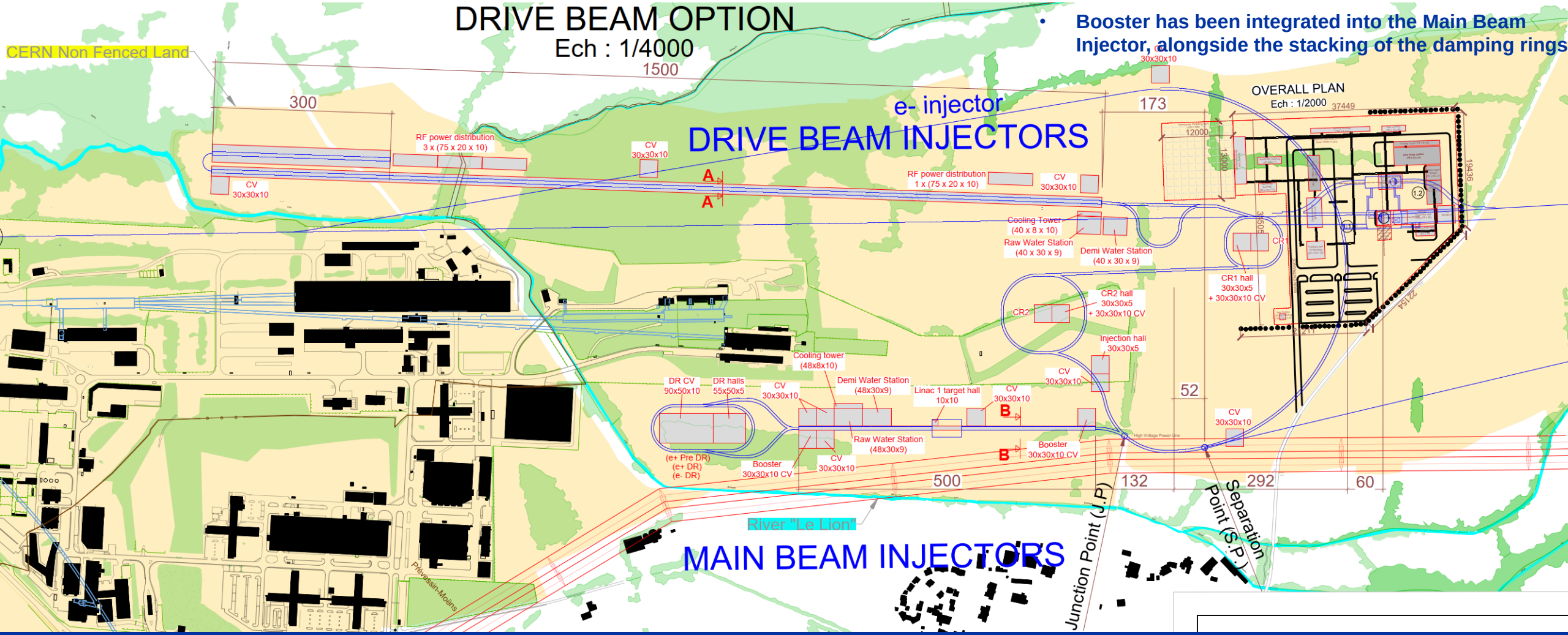
CLIC - UNDERGROUND STRUCTURES SCHEMATIC LAYOUT(COLOURED BY ZONES)

GROUP : SC-SMB
CIVIL ENGINEERING
SUPERVISOR : J.OSBORNE
DESIGNER : A.MEJRI

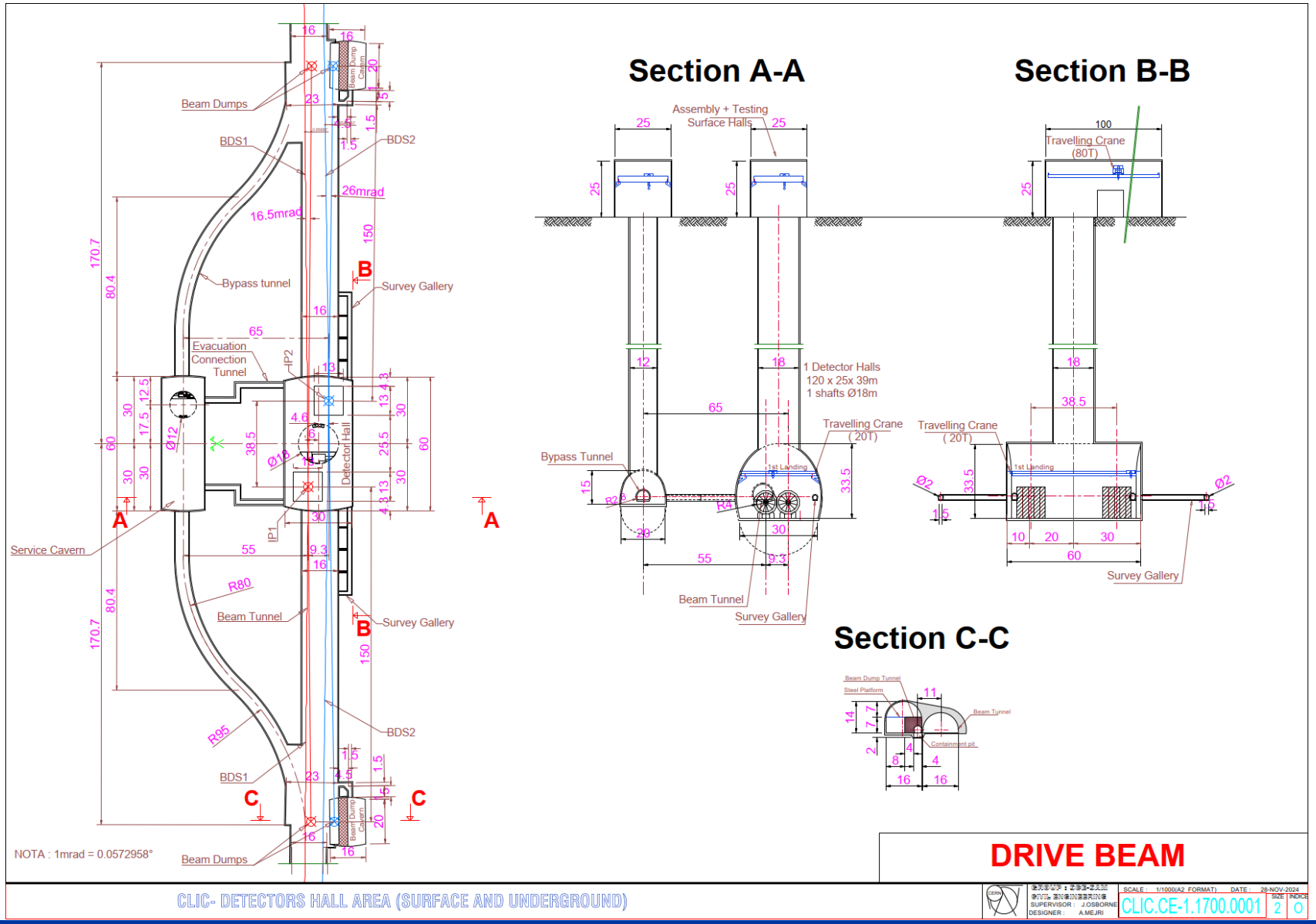
SCALE : 1/75000(A3_FORMAT) DATE : 28-NOV-2024
CLIC.CE-1.1749.0003 SIZE 3 INDICE Q

Injector Complex Layout on Prévessin Site

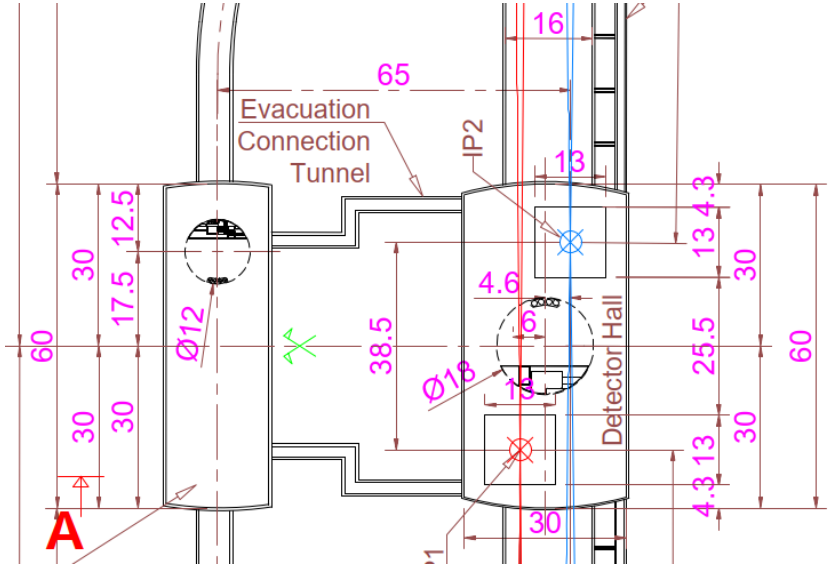
- Whole Injector Complex is located on CERN land.
- The complex now avoids all existing CERN infrastructure.
- Drive Beam Injectors location has been adjusted to avoid the river ‘Le Lion’.
- Booster has been integrated into the Main Beam Injector, alongside the stacking of the damping rings



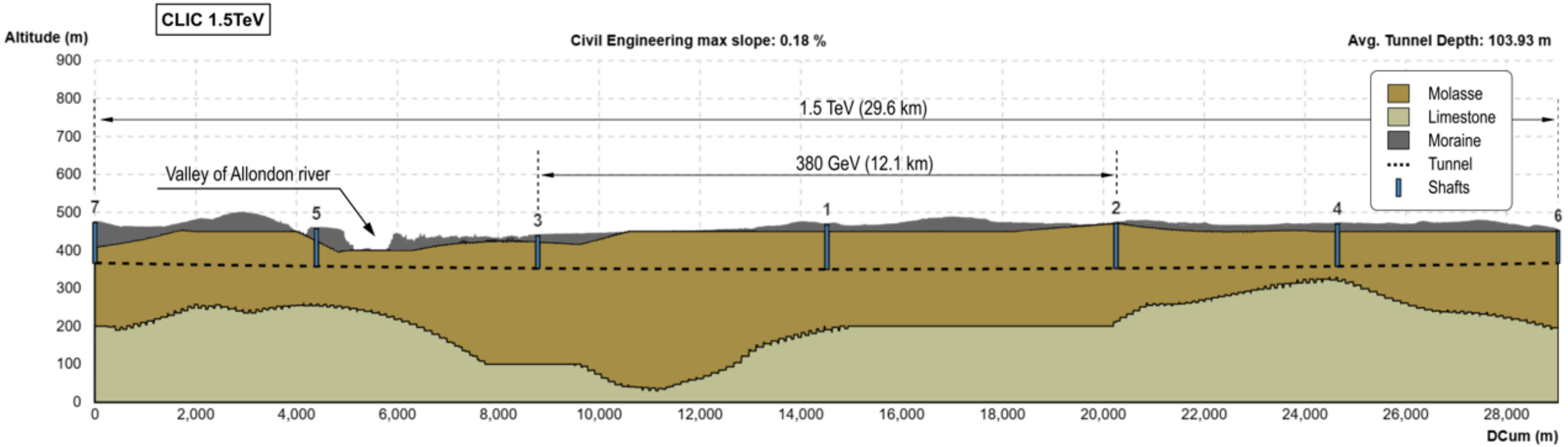
Interaction Region



- Updated to facilitate 2 Detectors.
- A 30m x 60m Detector Hall facilitates both detectors with their centers separated by 38.5m.
- Main LINAC's have a 20mrad crossing angle and the Beams have crossing angles of 16.5mrad and 26mrad.
- BDS Tunnel has been widened to 16m to account for both beam lines and the 9.3m separation between them.
- Tunnel Widening occurs over 2km either side of the Detector hall.



Geological Profile



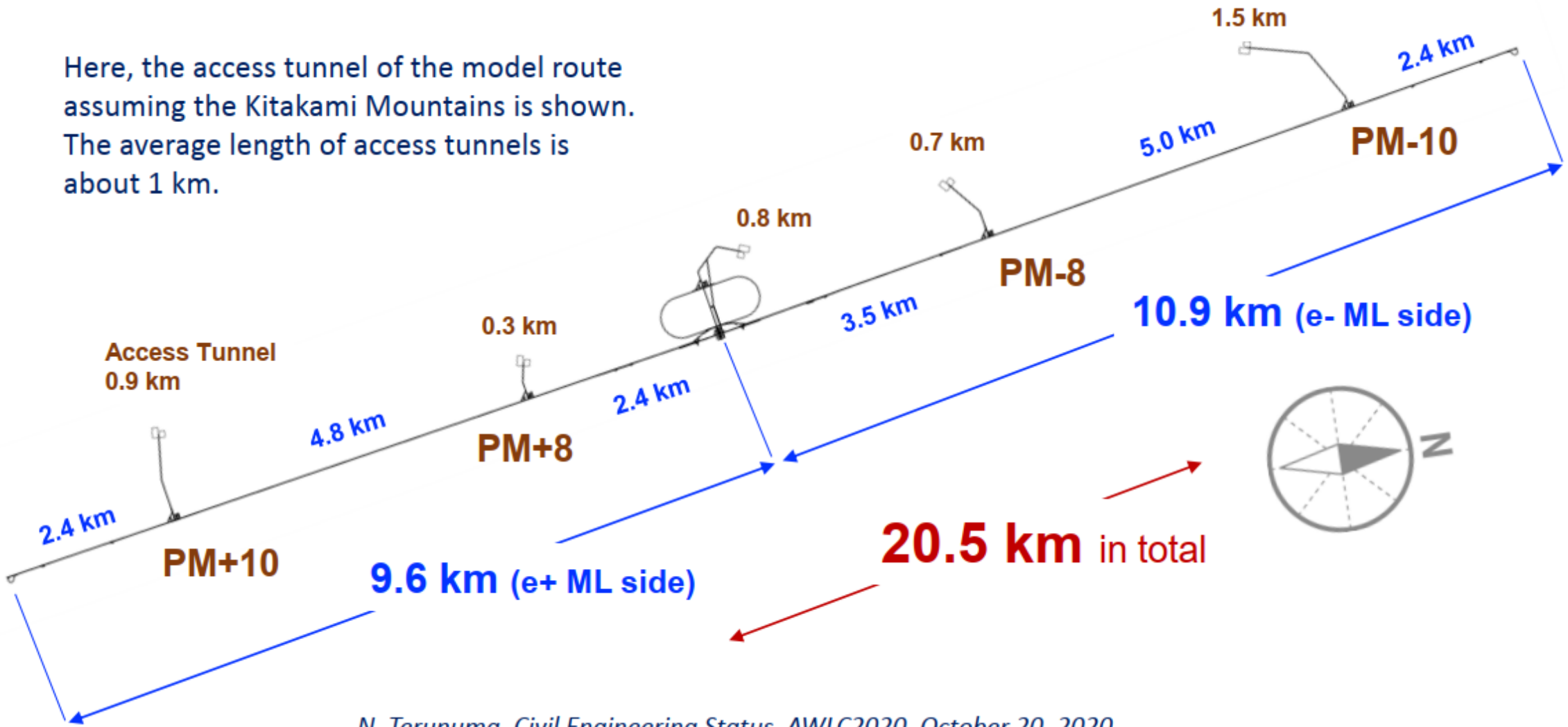
- Geological Profile for 380GeV and 1.5TeV stages with 3TeV removed.
- Comfortably housed within good Molasse rock. (no need for site investigation to confirm this)
- Gland Depression is no longer an issue, thus there is scope to reduce the shaft depths.

ILC Type Design at CERN

- The ILC type design at CERN is based on the ILC 250 GeV and 550 GeV designs from Japan.
- These designs are being adapted for the CERN region, notably,
  - The use of a circular main tunnel cross section.
  - A 2-IP option with offset detectors as used in CLIC.
  - Vertical shafts replacing the inclined access tunnels.

ILC Japan 250 GeV Schematic

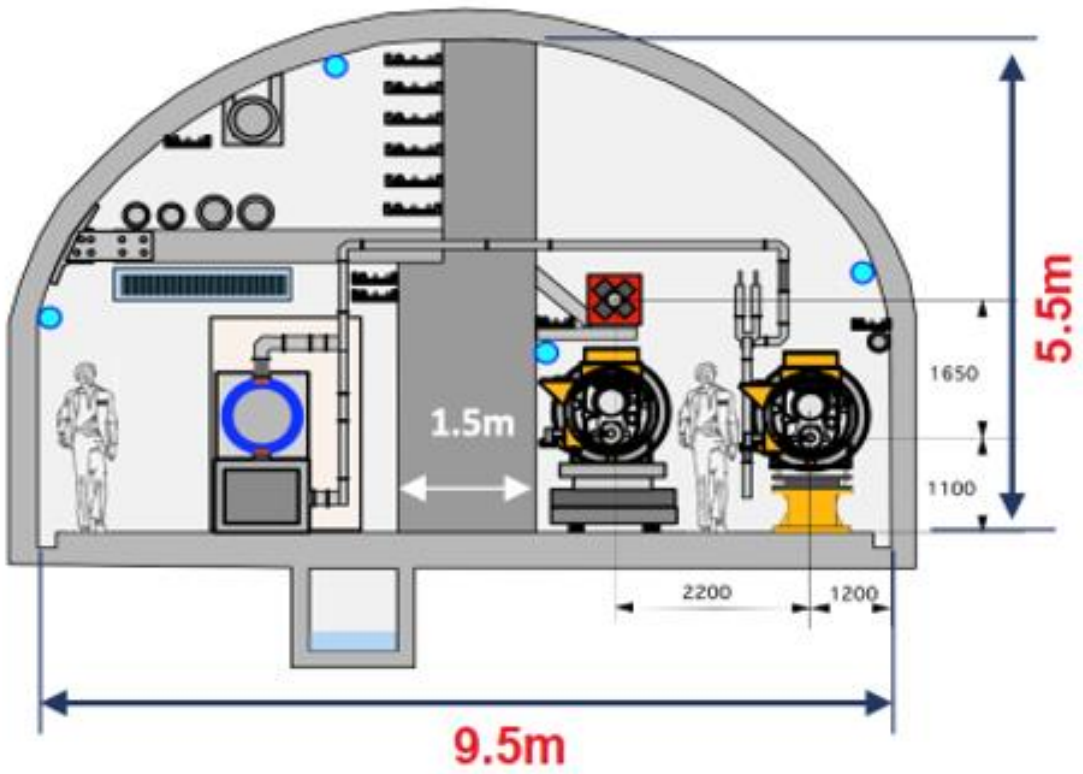
Here, the access tunnel of the model route assuming the Kitakami Mountains is shown. The average length of access tunnels is about 1 km.



N. Terunuma, Civil Engineering Status, AWLC2020, October 20, 2020

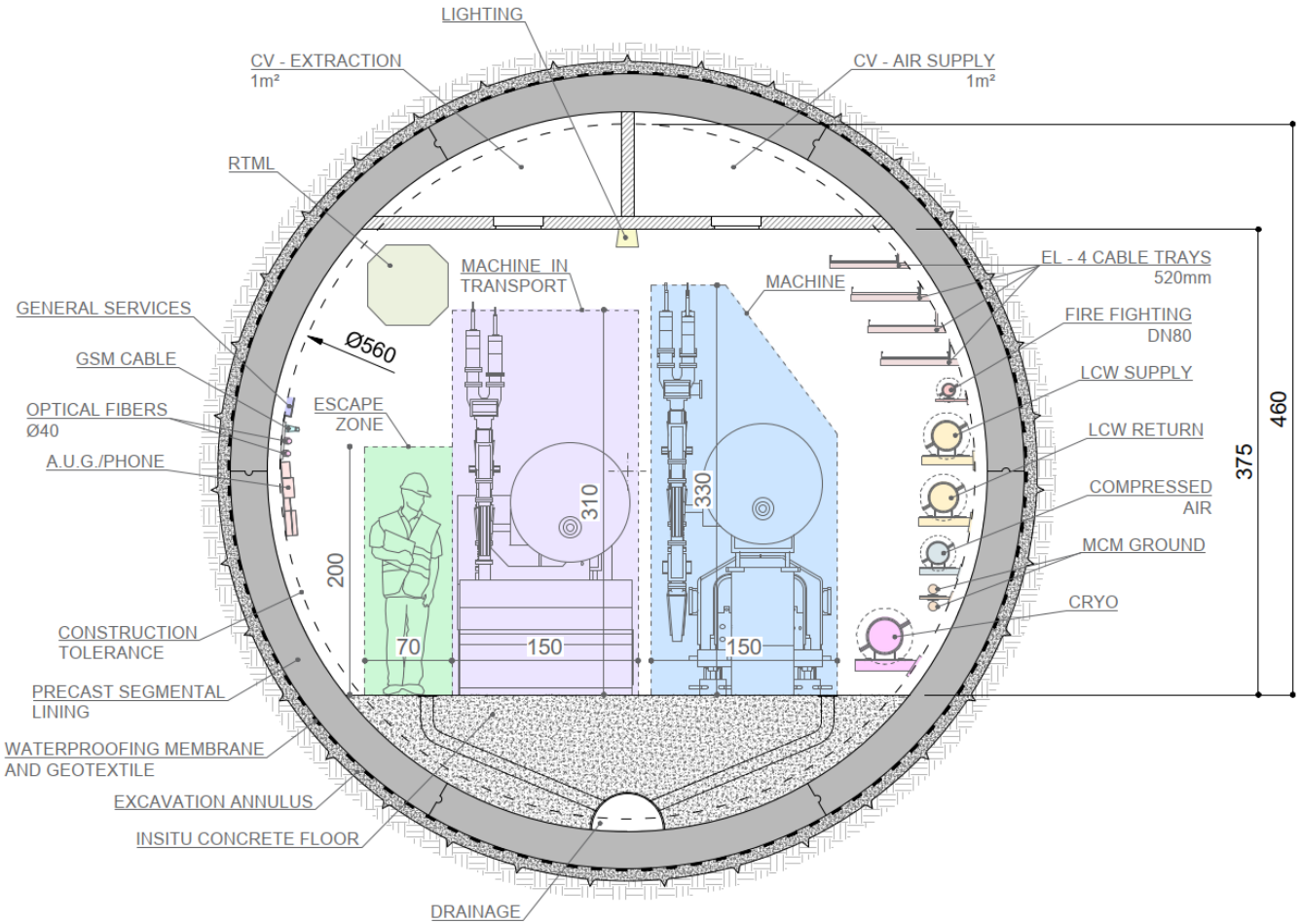
ILC Japan Typical Tunnel Cross Section

Arched 9.5m span. Tohoku region, Japan. (250GeV)



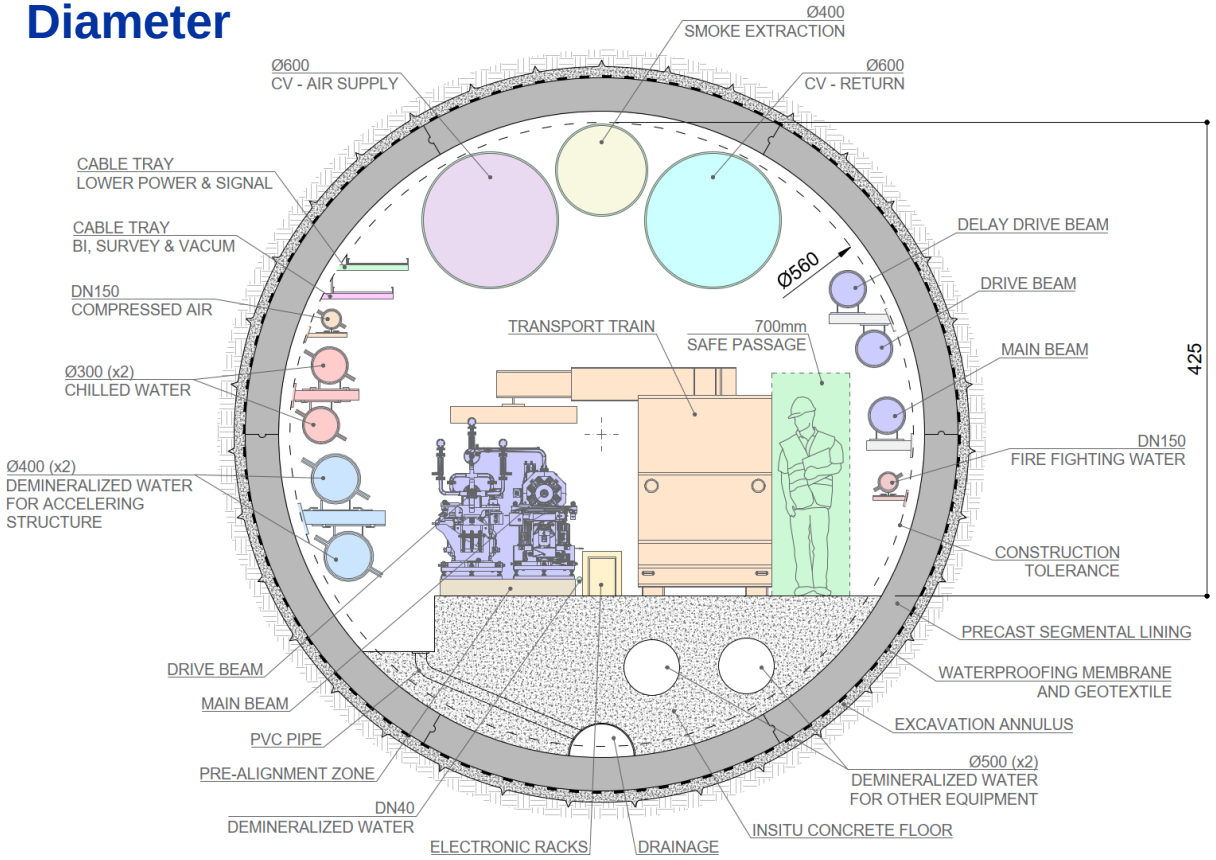
ILC Japan Cross section Implemented at CERN

5.6m Internal Diameter



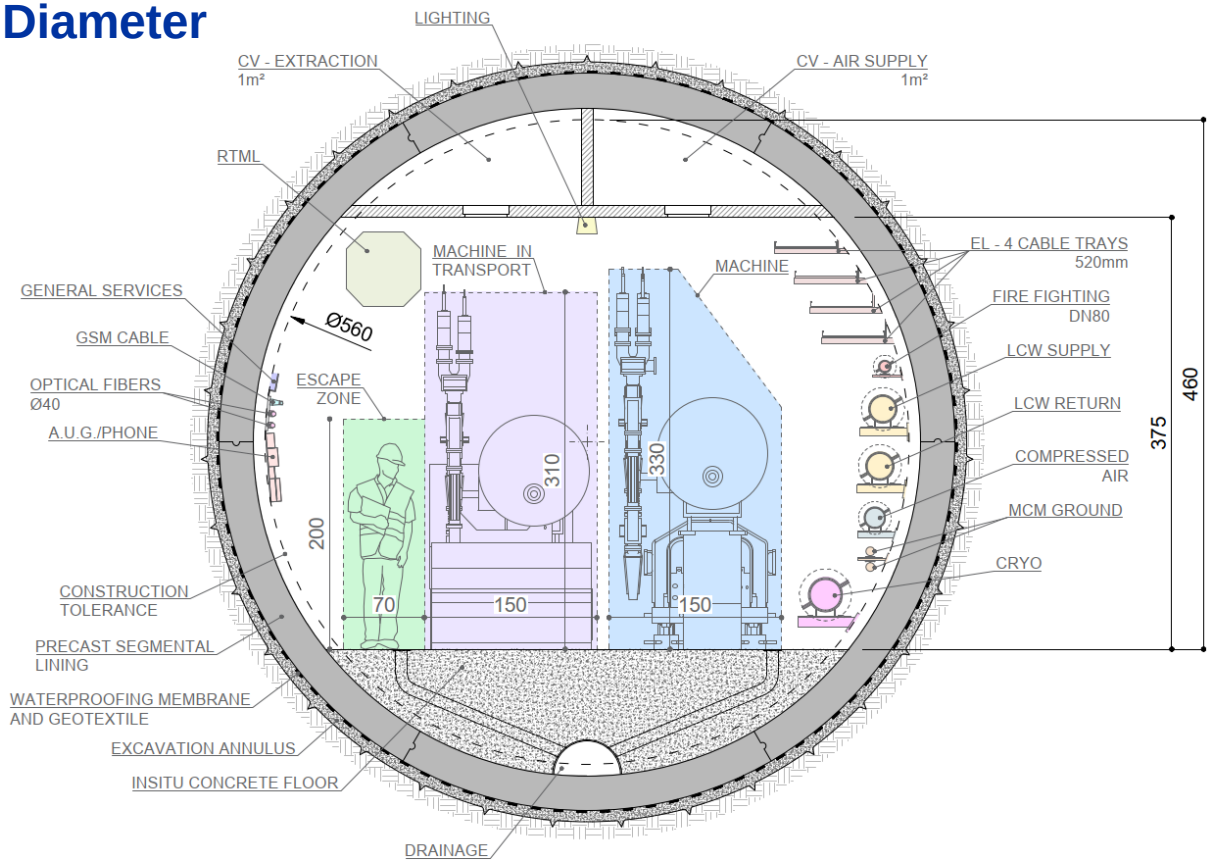
CLIC Typical Tunnel Cross Section

5.6m Internal Diameter



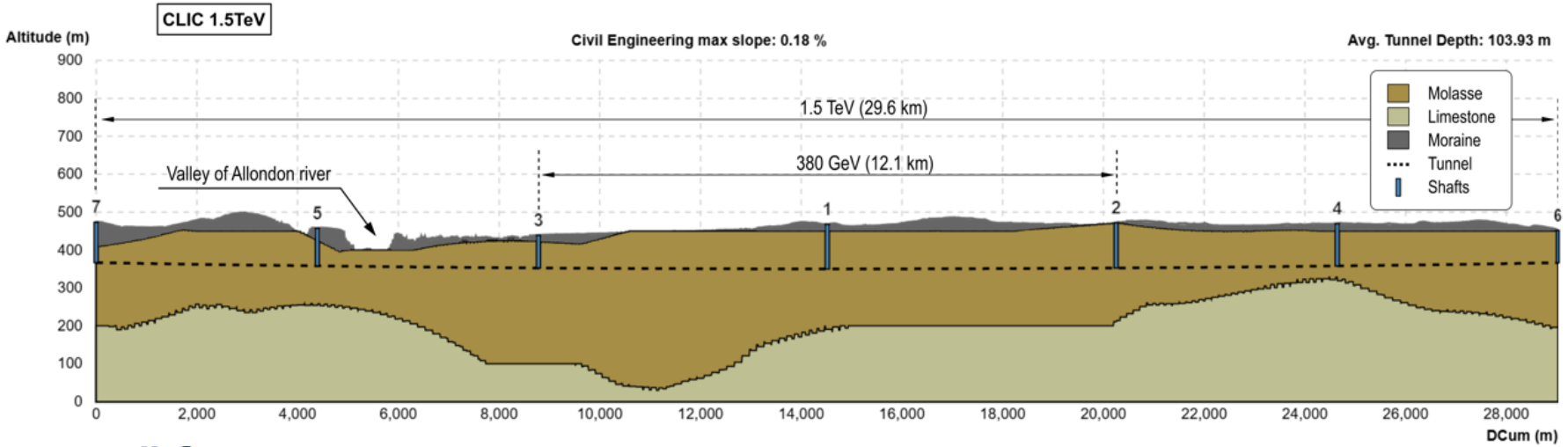
ILC Japan Cross section Implemented at CERN

5.6m Internal Diameter

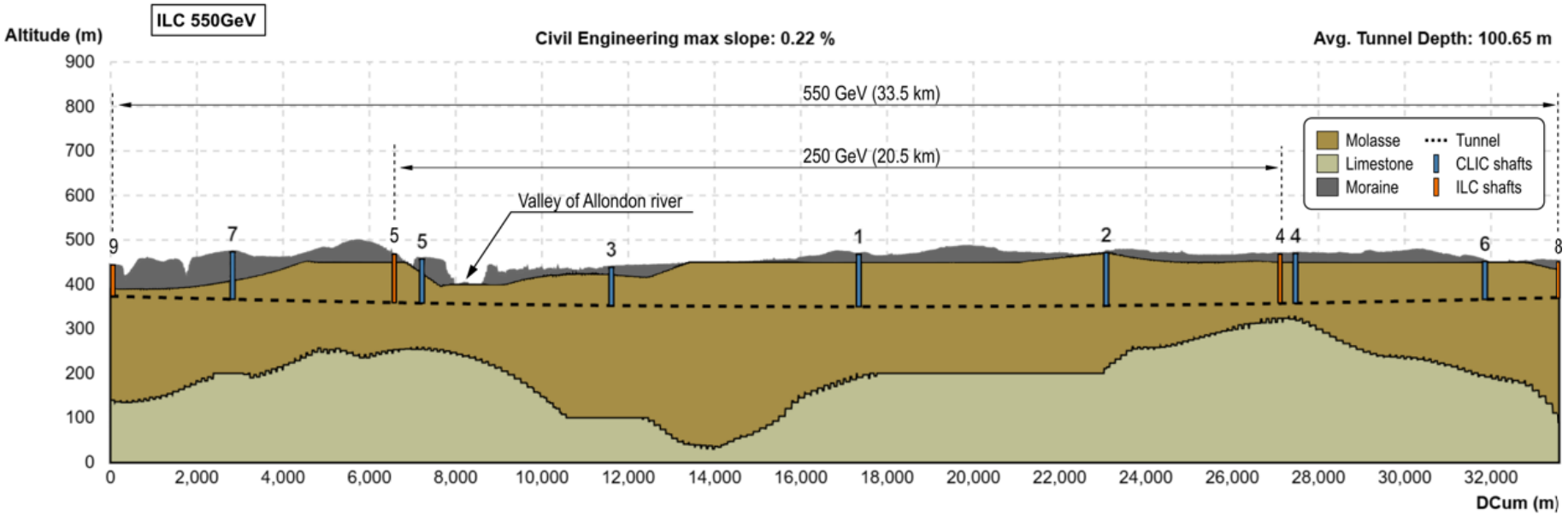


Geological Profile

- **CLIC**



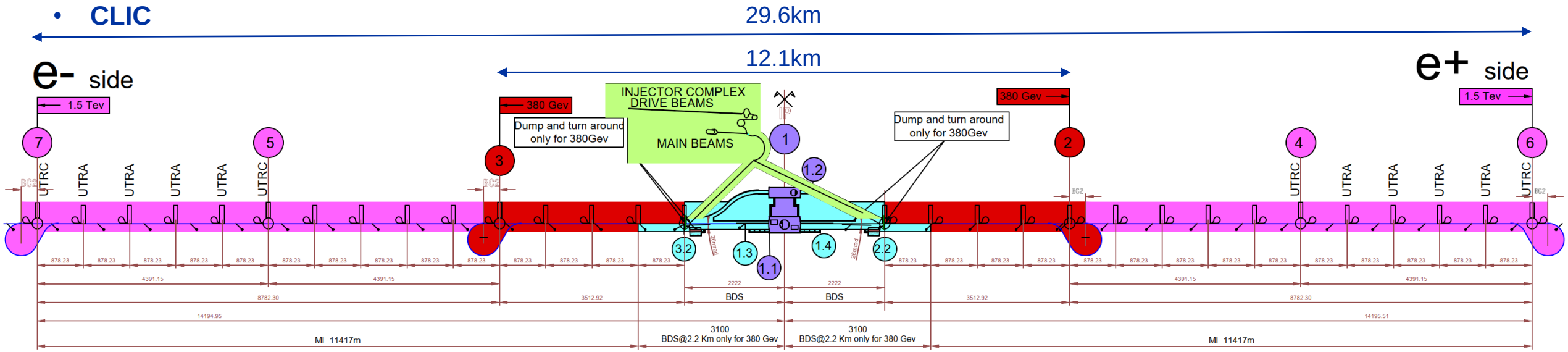
- **ILC**



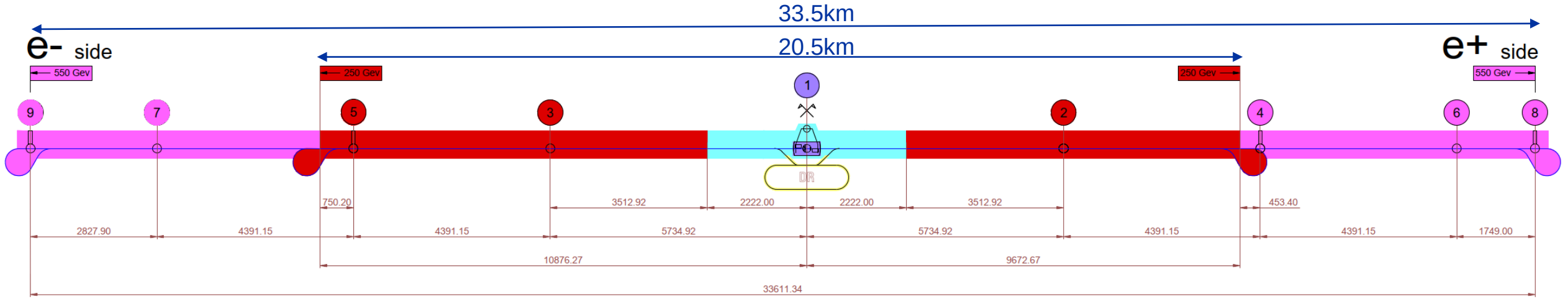
- Ongoing Geographical study to optimise and share common shaft locations between CLIC and ILC.
- CLIC is symmetrical either side of the interaction region.
- ILC is not symmetrical either side of the interaction region.
- Shafts at 4&5 for both studies will be unified.
- It is easier to adapt the CLIC shafts to the ILC design due to the Cryo design constraints of the ILC.

Underground Structures Schematic

- **CLIC**

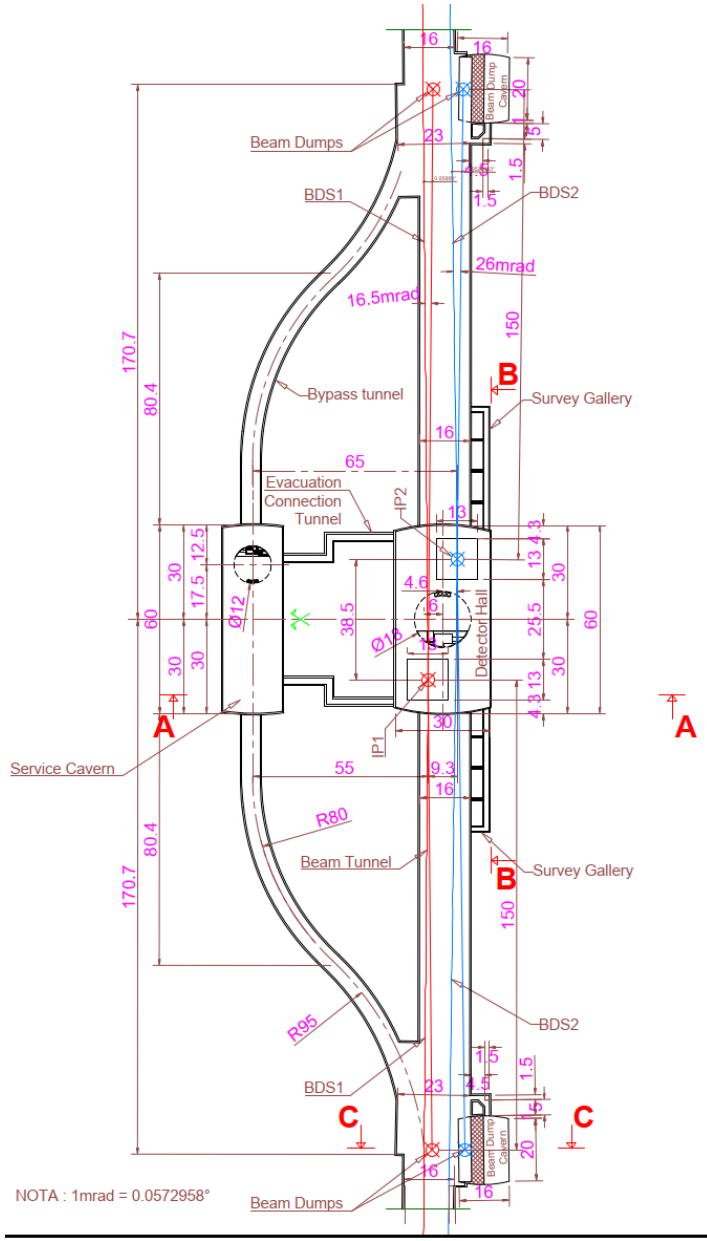


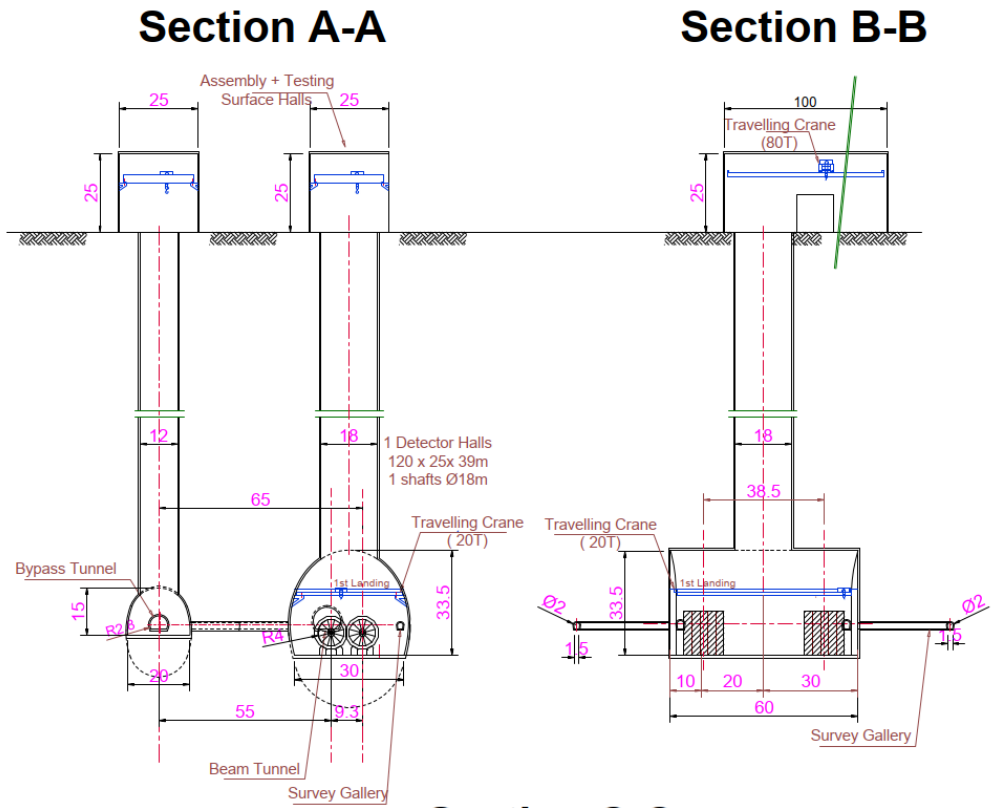
- **ILC**

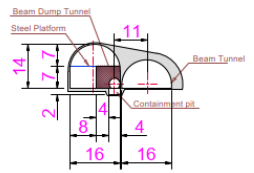


2-IP Design

- For ILC, alike CLIC the 2 detectors will be offset.
- Main LINAC crossing angle for both studies of 20mrad.
- IR region crossing angles :
  - 16.5mrad and 26mrad beam angles for CLIC
  - 14mrad and 26mrad beam angles for ILC





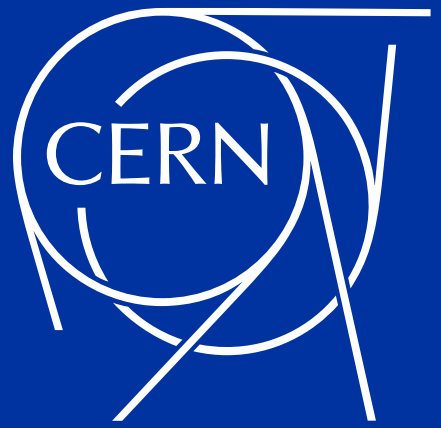


DRIVE BEAM

CLIC- DETECTORS HALL AREA (SURFACE AND UNDERGROUND)

Conclusions and Next Steps

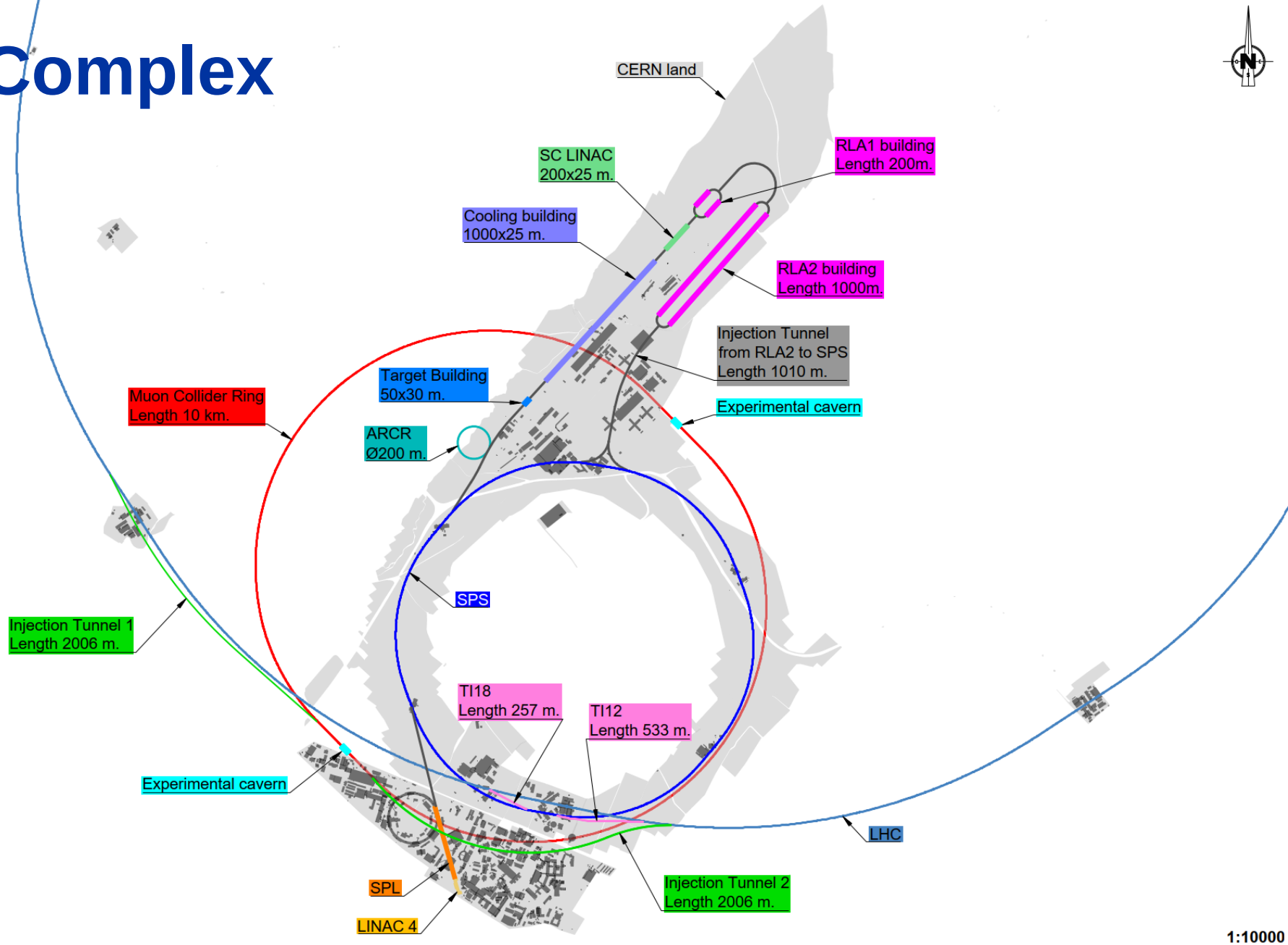
- **CLIC surface injection complex has been optimized in 2024 and avoids clashes with existing infrastructure.**
- **Design modifications are on-going to share alignments and shaft location for CLIC and ILC housed at CERN.**
- **Further studies required to ensure shafts are located in environmentally suitable locations.**
- **Conduct further work into the interaction region, finding a solution for the stabilisation of the final focus element QD0, and finding a solution for maintenance work (whilst the other detector is operational).**
- **Now we are getting close to a baseline design, a Cost & Schedule exercise can be completed for both studies at CERN.**
- **The ILC and CLIC designs at CERN are being optimised to have as much synergy as possible ready for an LCF decision at CERN.**



Muon Collider

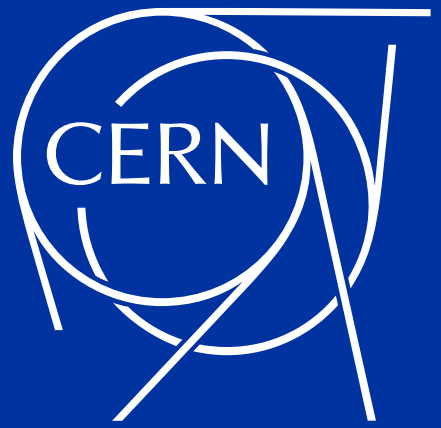
Muon Collider Complex

- Initiating at LINAC 4, ultimately, injecting into the Collider ring from the LHC.
- Focus around reusing existing CERN infrastructure.
- Entirety of the surface works are located on CERN owned land.

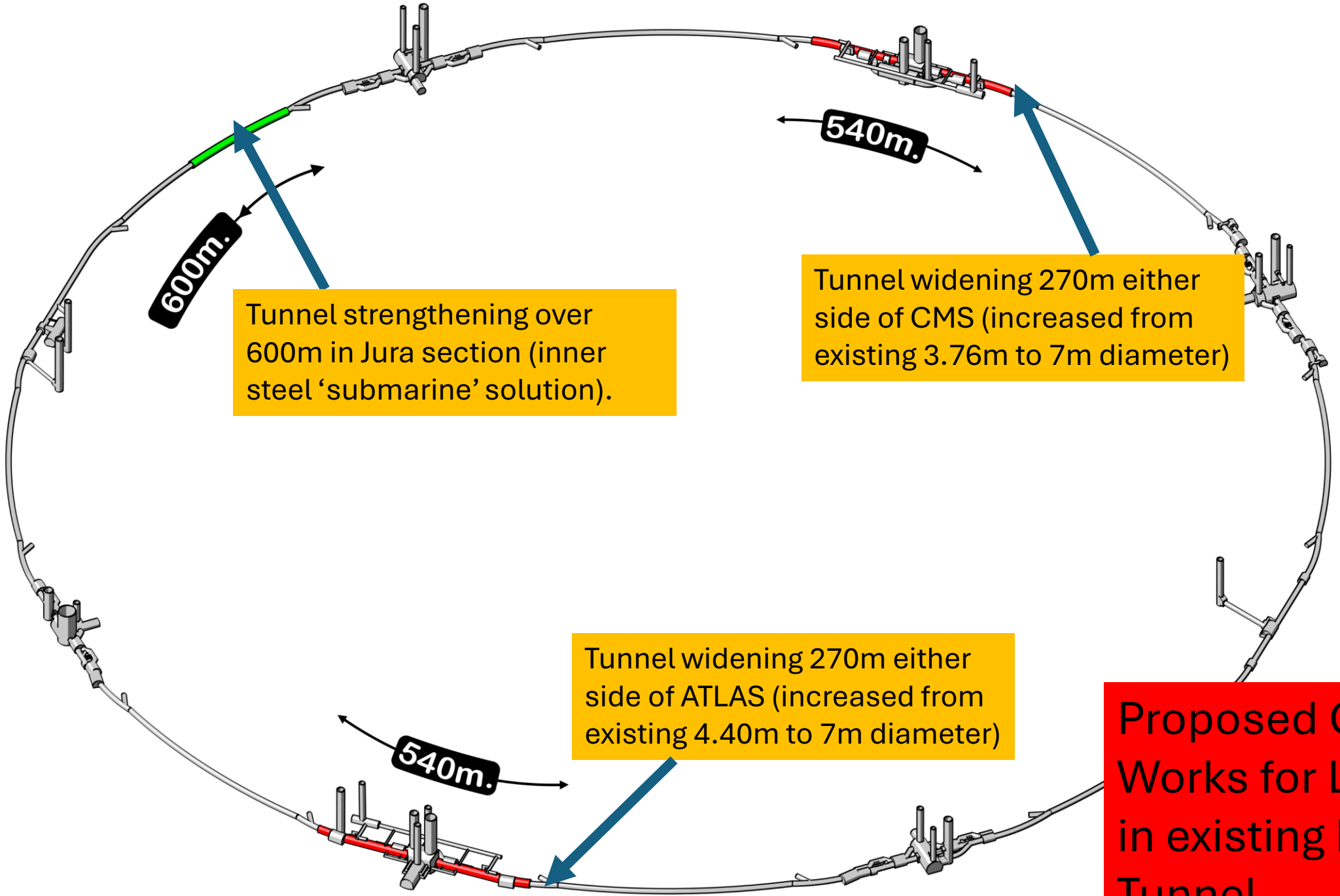


Conclusions and Next Steps

- **The Muon Collider complex will undergo further iterations on each component based on design changes and requirements.**
- **Additional surface works such as service buildings will be designed and integrated into the complex.**
- **Now we are getting close to a baseline design, a Cost & Schedule exercise can be completed for the study at CERN.**



LEP3

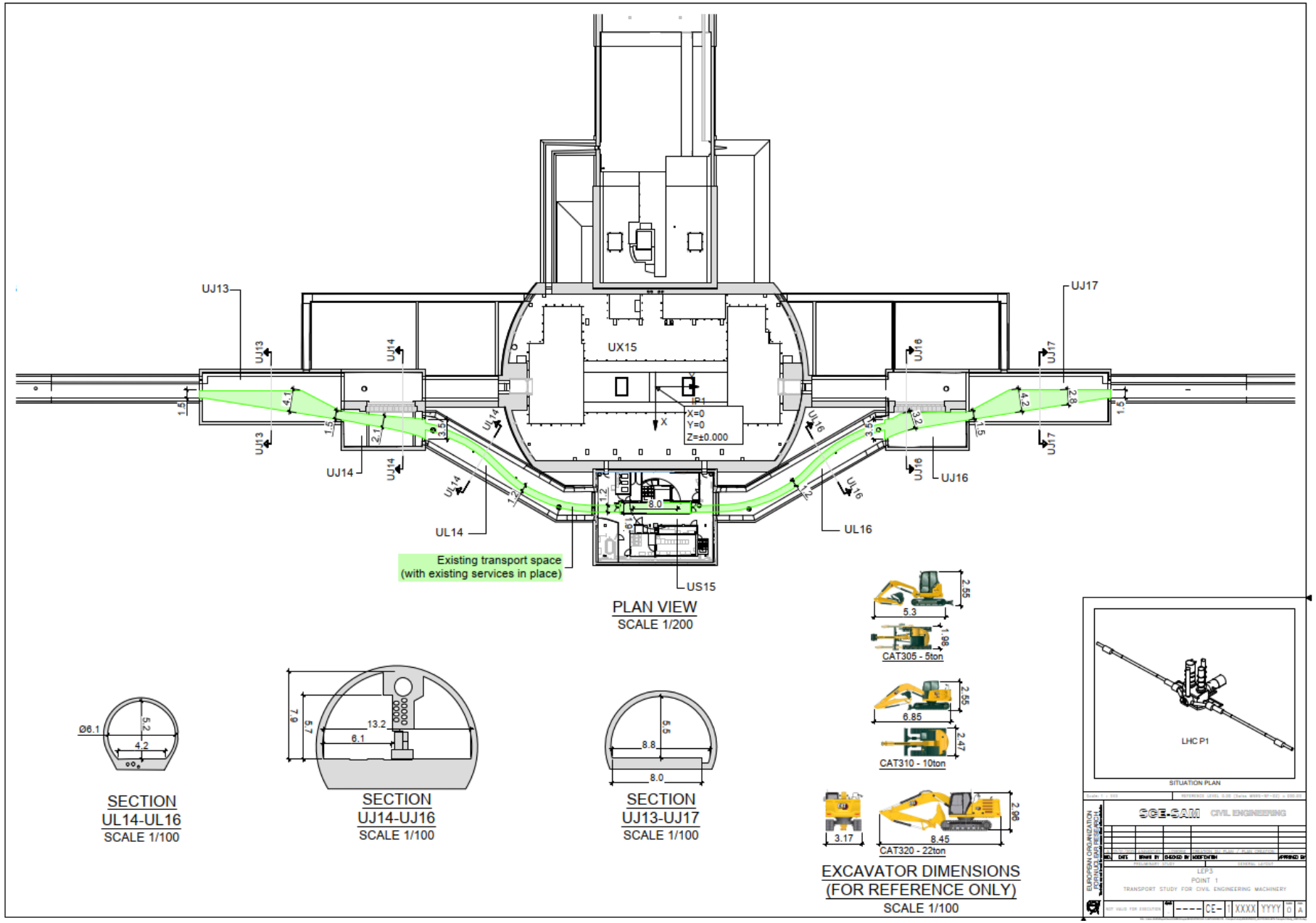


Tunnel strengthening over 600m in Jura section (inner steel ‘submarine’ solution).

Tunnel widening 270m either side of CMS (increased from existing 3.76m to 7m diameter)

Tunnel widening 270m either side of ATLAS (increased from existing 4.40m to 7m diameter)

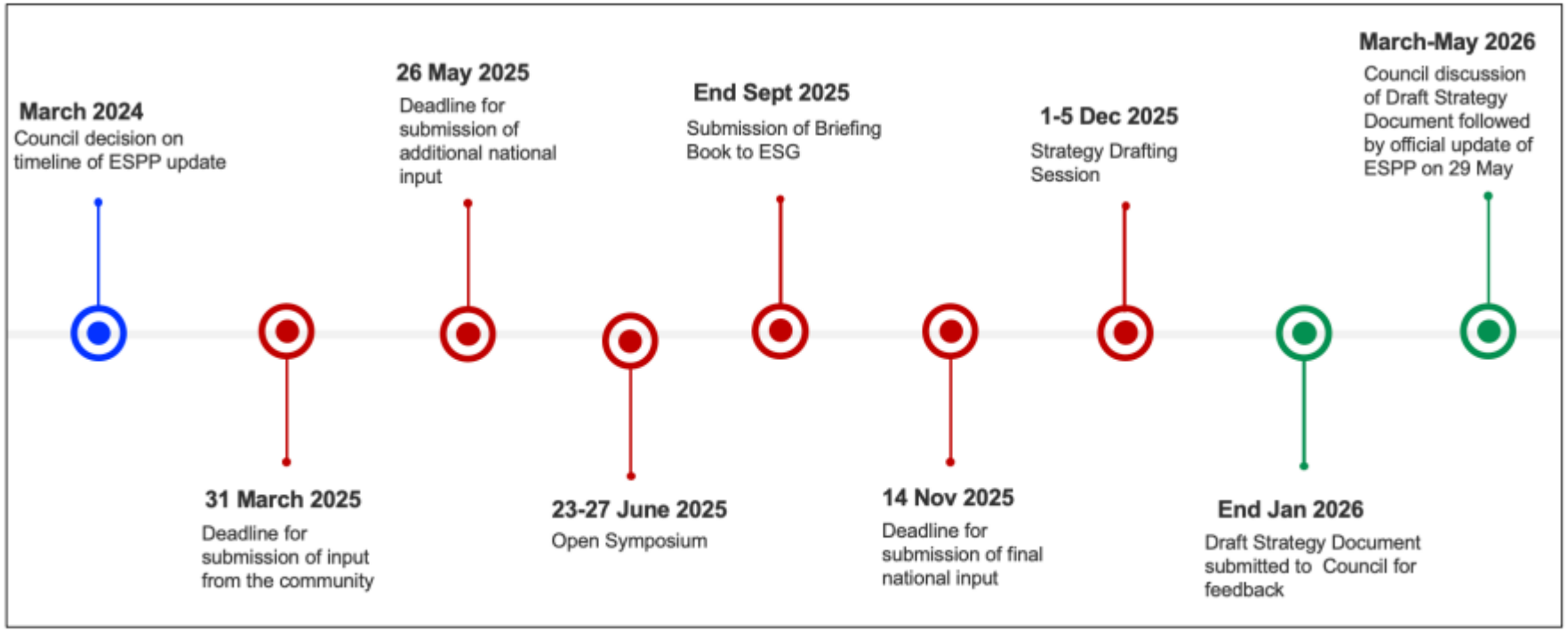
Proposed Civil Works for LEP3 in existing LHC Tunnel


UJ13
UJ14
UJ16
UJ17
UX15
IP1
X=0
Y=0
Z=±0.000
UL14
UL16
US15
Existing transport space
(with existing services in place)
PLAN VIEW
SCALE 1/200
SECTION
UL14-UL16
SCALE 1/100
SECTION
UJ14-UJ16
SCALE 1/100
SECTION
UJ13-UJ17
SCALE 1/100
CAT305 - 5ton
CAT310 - 10ton
CAT320 - 22ton
EXCAVATOR DIMENSIONS
(FOR REFERENCE ONLY)
SCALE 1/100
LHC P1
SITUATION PLAN
SCE-SAM CIVIL ENGINEERING
LEP3
POINT 1
TRANSPORT STUDY FOR CIVIL ENGINEERING MACHINERY

European Strategy for Particle Physics (ESPP): timeline

All work and steps of the ESPP update, but the Council approval, will take place in 2025. A major effort of our community!

- March 31: deadline for submission of the community input
- June 23-27: Open Symposium in Venise
- December 1-5: Strategy Drafting Session in Monte Verità, Ascona, Switzerland
- May 29, 2026: adoption of the Strategy update by CERN Council at an extraordinary session in Budapest → **conclusion of the process**



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