



LCWS 2026

Overview of the Civil Engineering for an LCF at CERN

KEK, Tsukuba, Japan

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GIS Support: Felix Schachtschneider

Civil Engineering, Conventional Facilities & Siting

Presentation Overview:

Methodology from the ESPPU:

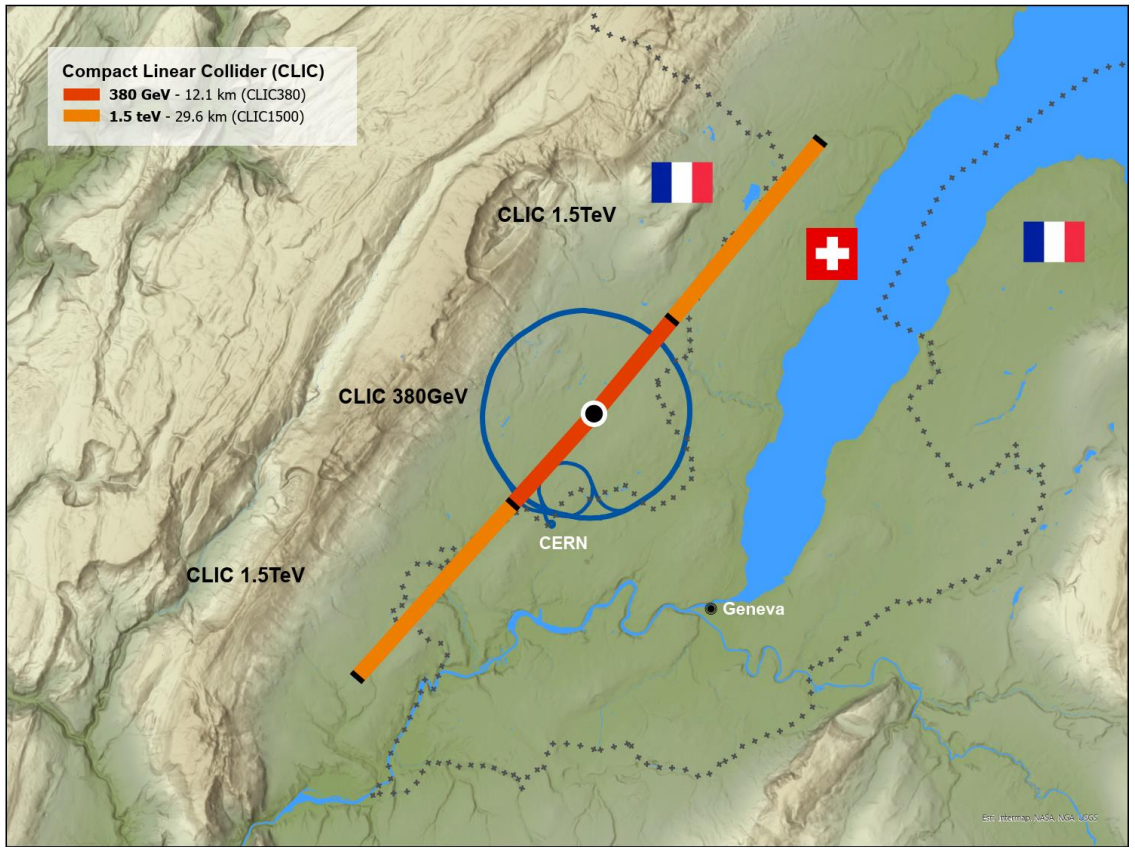
- Overview from the ESPPU where CLIC was used as the baseline for LCF Civil Engineering Design
- ‘How could the CE design be updated with CLIC no longer in picture?’

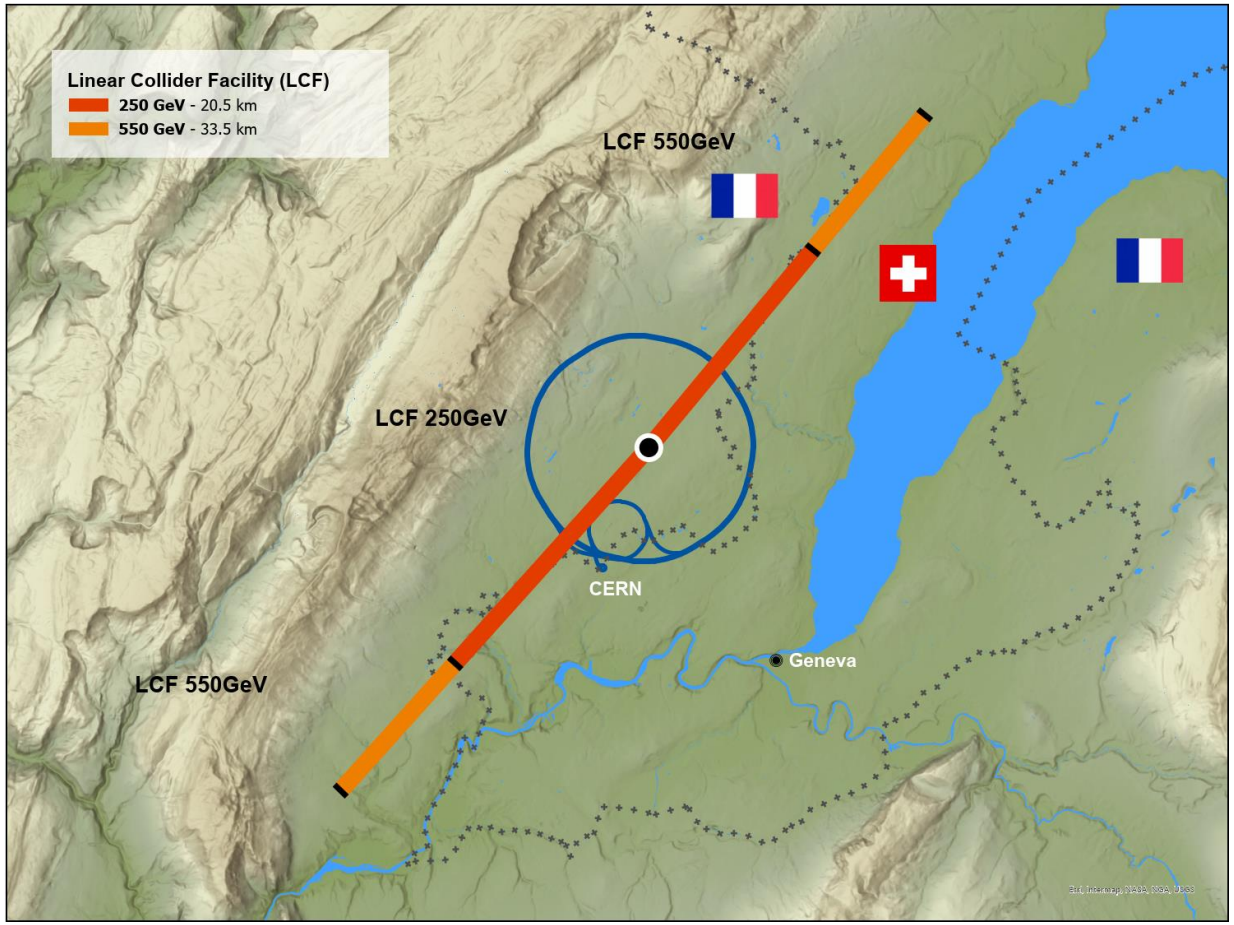
Status and upcoming decisions which will influence the CE design:

- Layout & Placement (Siting) Study
- Shaft Separation
- Tunnel diameter
- Alignment (LINAC Crossing angle) & Beam Delivery System (BDS)
- Interaction Region (IR)

Recap from ESPPU

- The Civil Engineering studies for CLIC and LCF were developed in tandem at CERN.
- The **laser straight** placement and configuration was shared for both studies with Interaction Region located around the CERN Prévessin site.
  - ‘Could the LCF fit within the CLIC civil engineering footprint’
  - Tunnel diameter, Interaction Region, BDS, Shaft Separation…

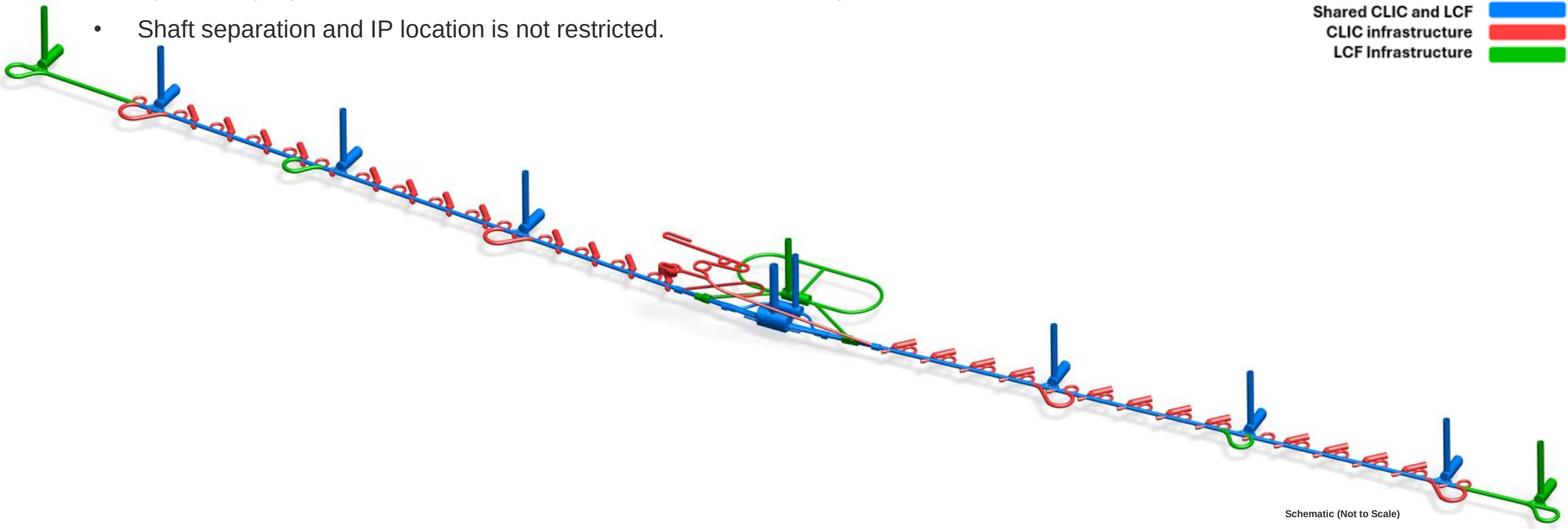




- **CLIC:**
  - 380GeV at 12.1km
  - 1.5TeV at 29.6km
- **LCF:**
  - 250GeV at 20.5km
  - 550GeV at 33.5km

CLIC & LCF ESPPU Civil Engineering

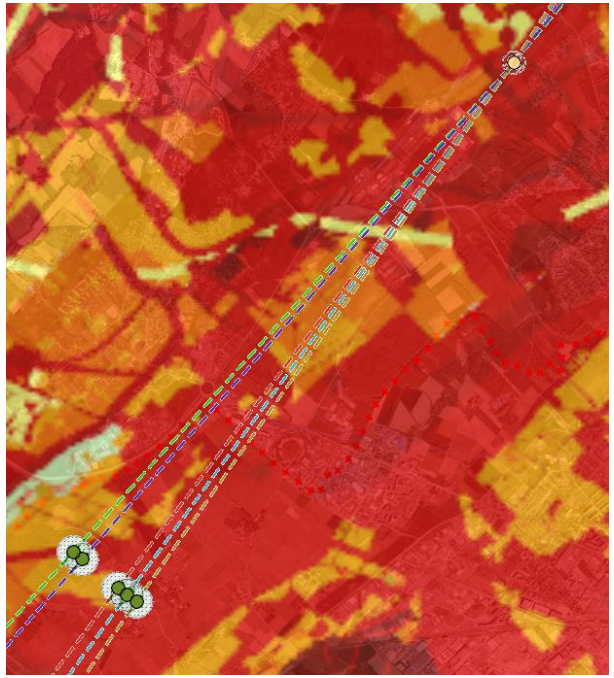
- Schematic overview comparing both studies.
- Shared & Unique Underground Infrastructure.
- The primary effort for the CERN CE study was to align both studies where possible.
  - Now just studying for the LCF, CLIC doesn't restrict the CE design.
    - Shaft separation and IP location is not restricted.

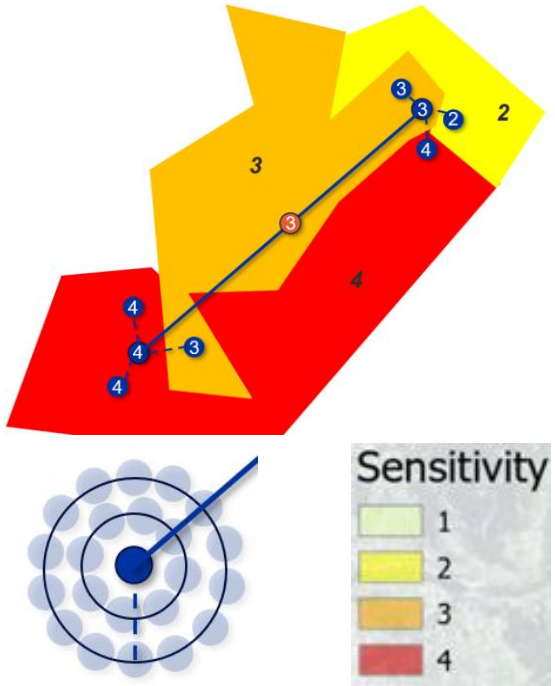


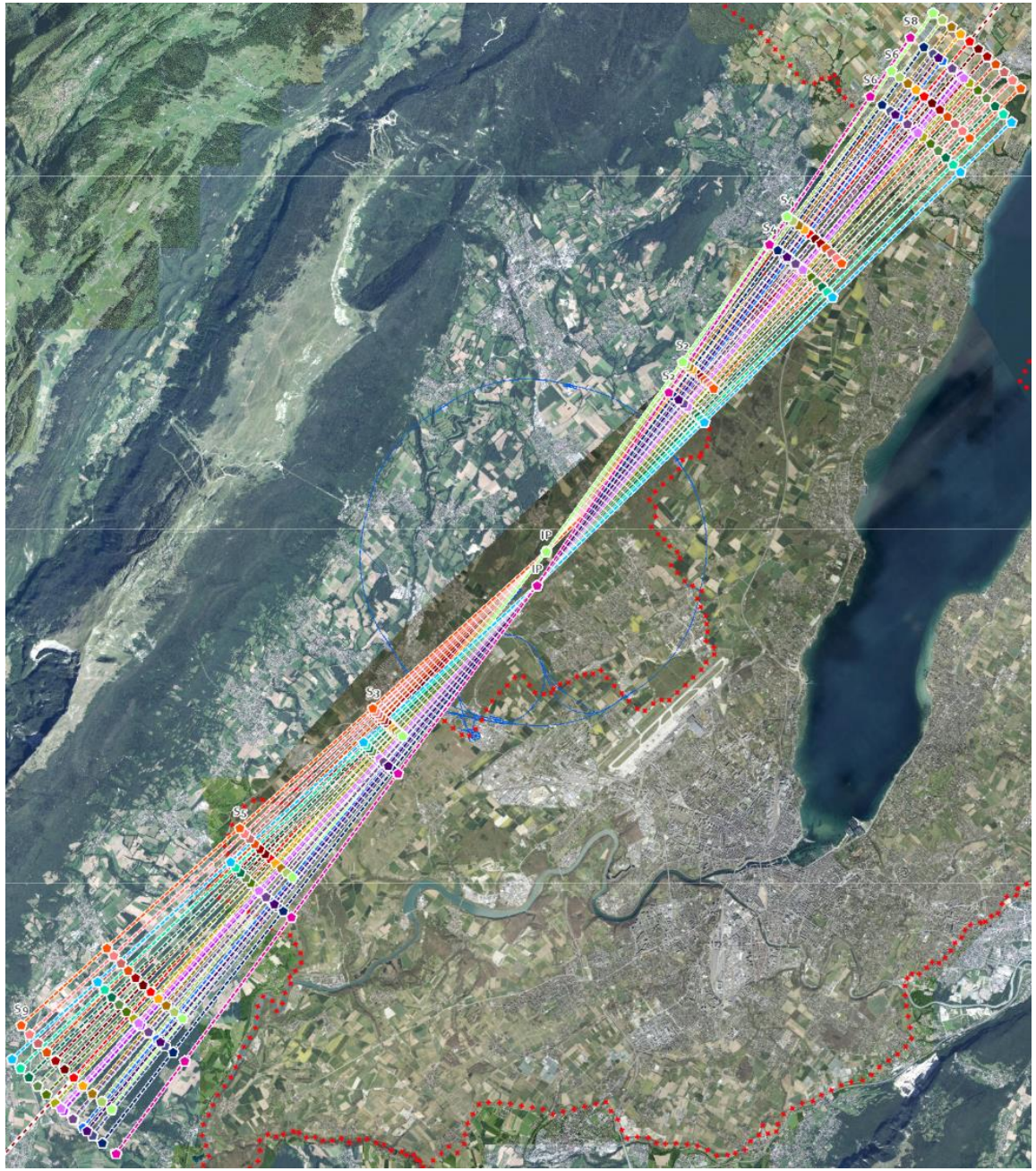
Layout and Placement Study

Placement Optimisation Tool

- No ‘official’ studies are permitted. (External cooperation)
- In-house development of ‘Placement Optimisation Tool’ aiming to:
  - Optimise the placement considering both the geographical and geological conditions.
  - Knowing the final layout (LINAC crossing angle, tunnel length, shaft separation & IP location)
  - It will take these into account to provide a series of solutions to compare.



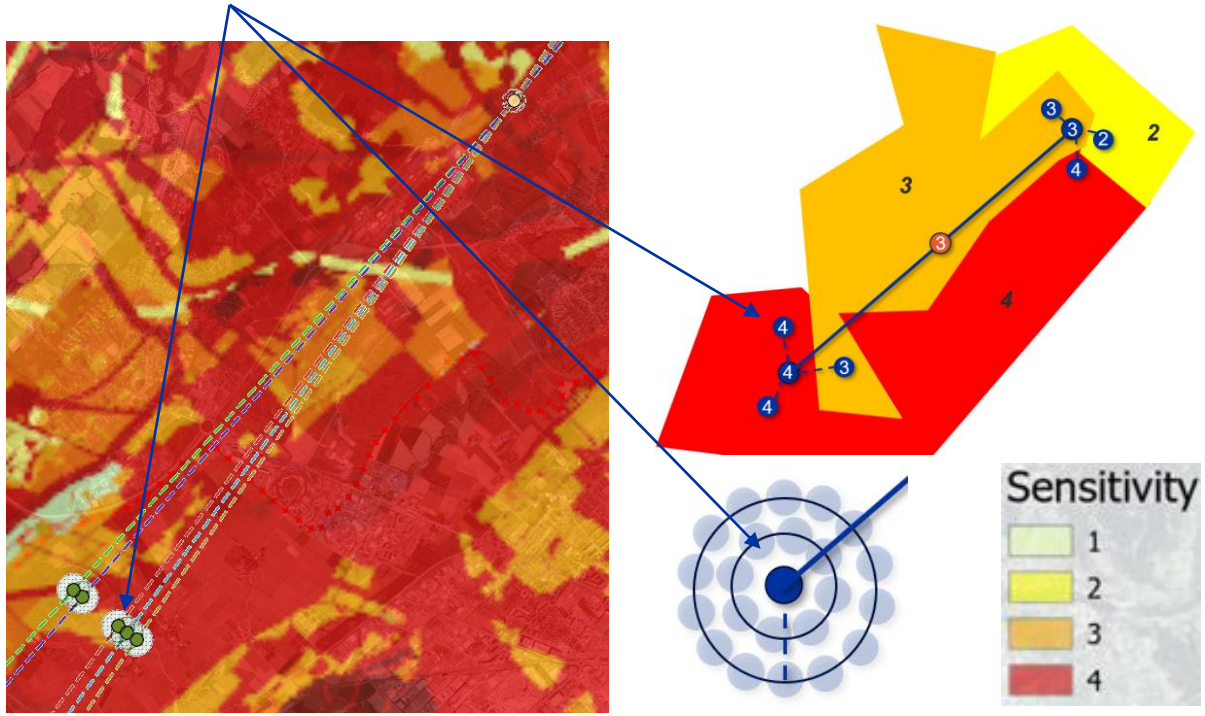


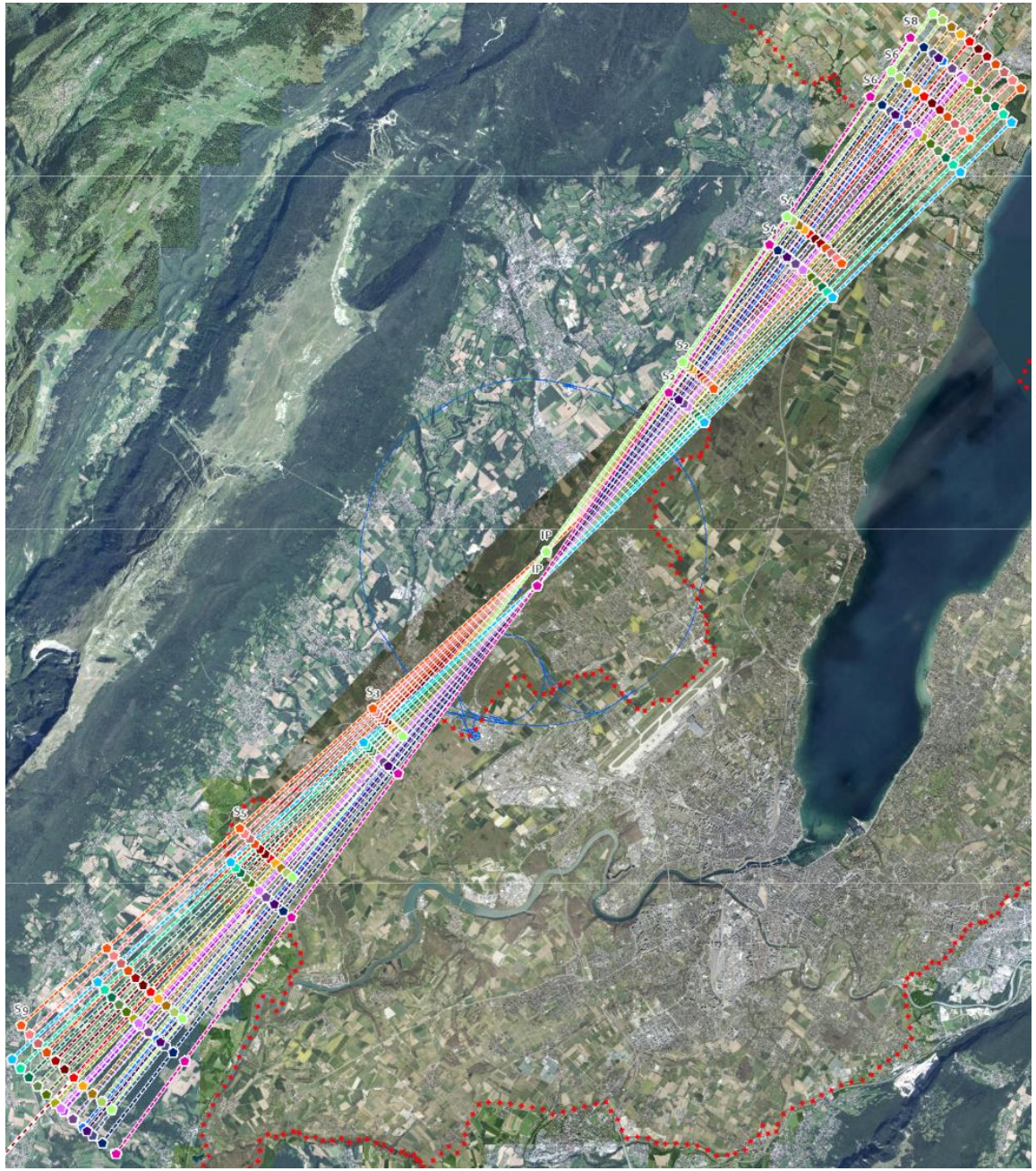


Layout and Placement Study

Placement Optimisation Tool

- The developed tool aims to identify the optimum alignment for the LCF
- Using the FCC land classification sensitivity map.
- This tool also provides freedom to move shaft locations along the tunnel.
- A radius defined around each shaft point permits connection tunnels if surrounding land is better for construction as opposed to directly above the tunnel itself. (Inducing additional cost for connection tunnels)

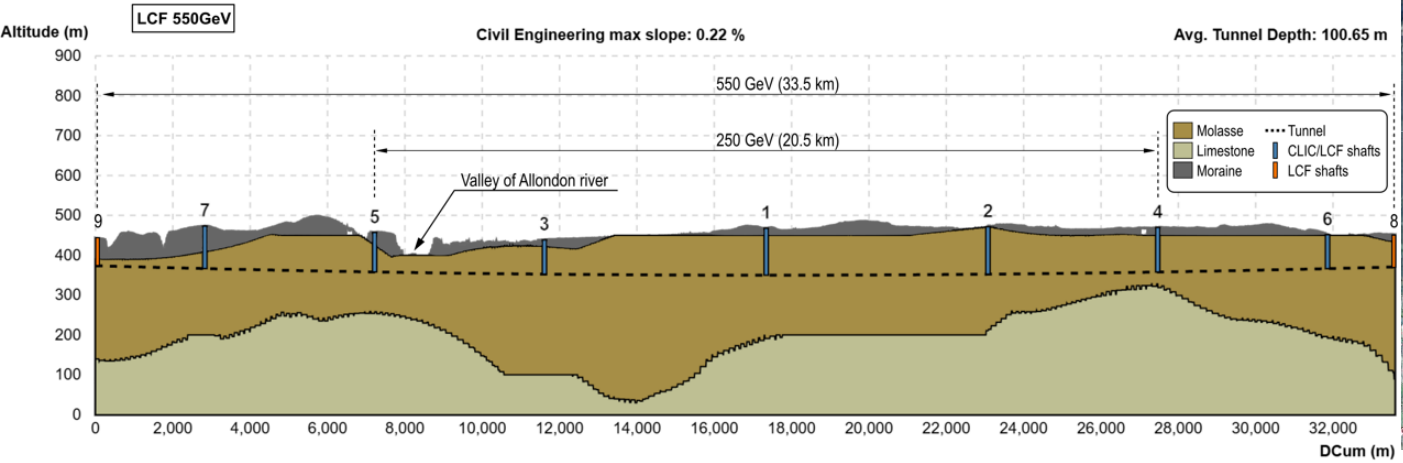


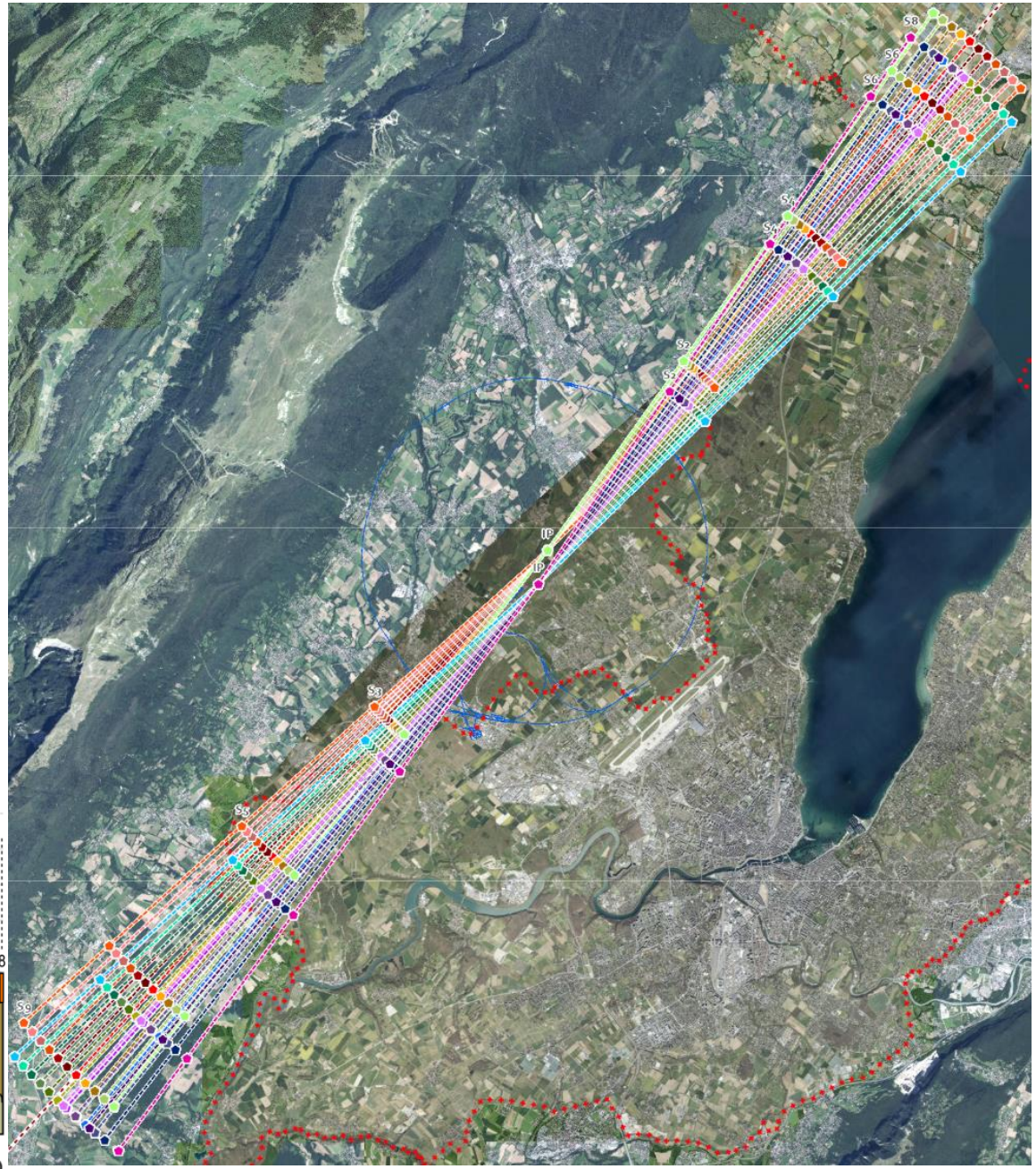


Layout and Placement Study

Placement Optimisation Tool

- Considering both the Geology and well as the Geographical placement.
- It can then be used to create optimised solution based on different scenarios including:
  - LCF 550GeV (Figure below optimised for EPSSU)
  - LCF 250GeV (Depth of tunnel suitable for extension to 550GeV)
  - LCF250GeV (Depth of tunnel optimised for 250GeV without laser straight extension possible to 550GeV, but reducing cost)
- As per **Laser straight** design, the tunnel will gradually slope to the surface away from the centre.





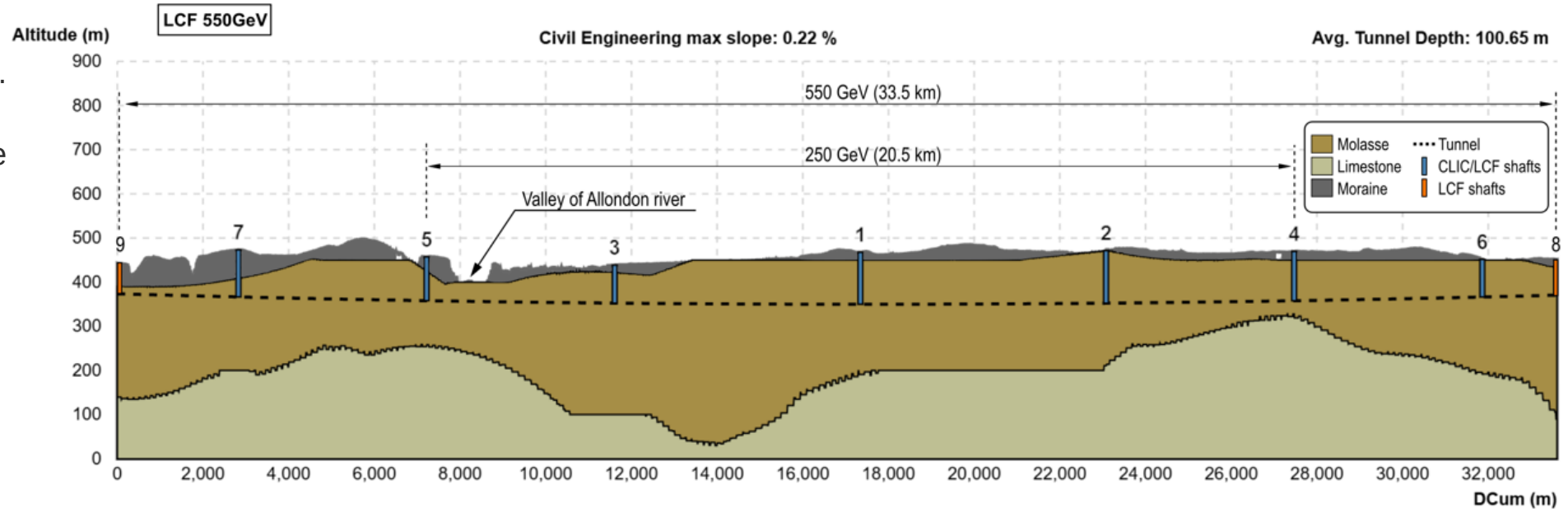
Shaft Separation

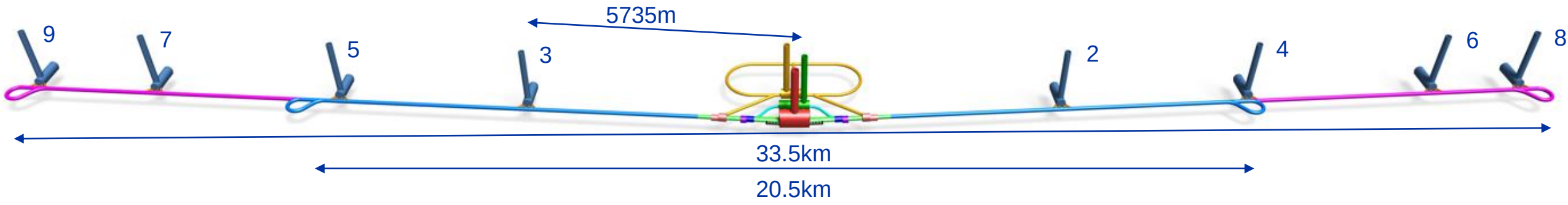
Shafts 4 & 5 can move to the end of LCF250GeV

- Shaft separation defined by CLIC.
- CERN prefer to have shafts at the end of tunnel.

Laser straight configuration:

- Shaft separation needs to be confirmed as appropriate for the Cryo distribution.
  - Longest span of 5.7km between shafts.
  - The shafts can be redistrubuted to be equidistant.

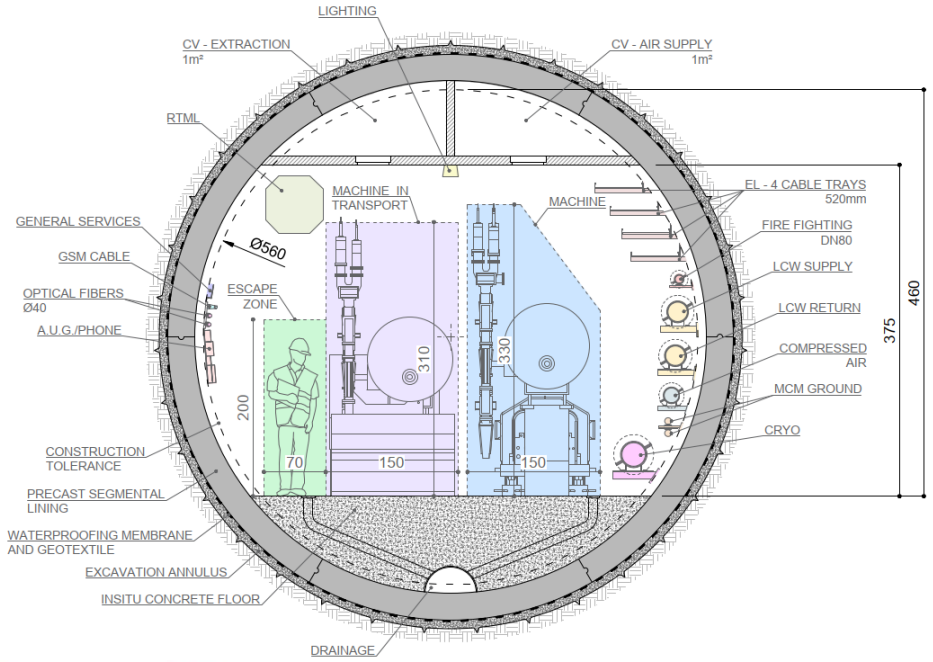




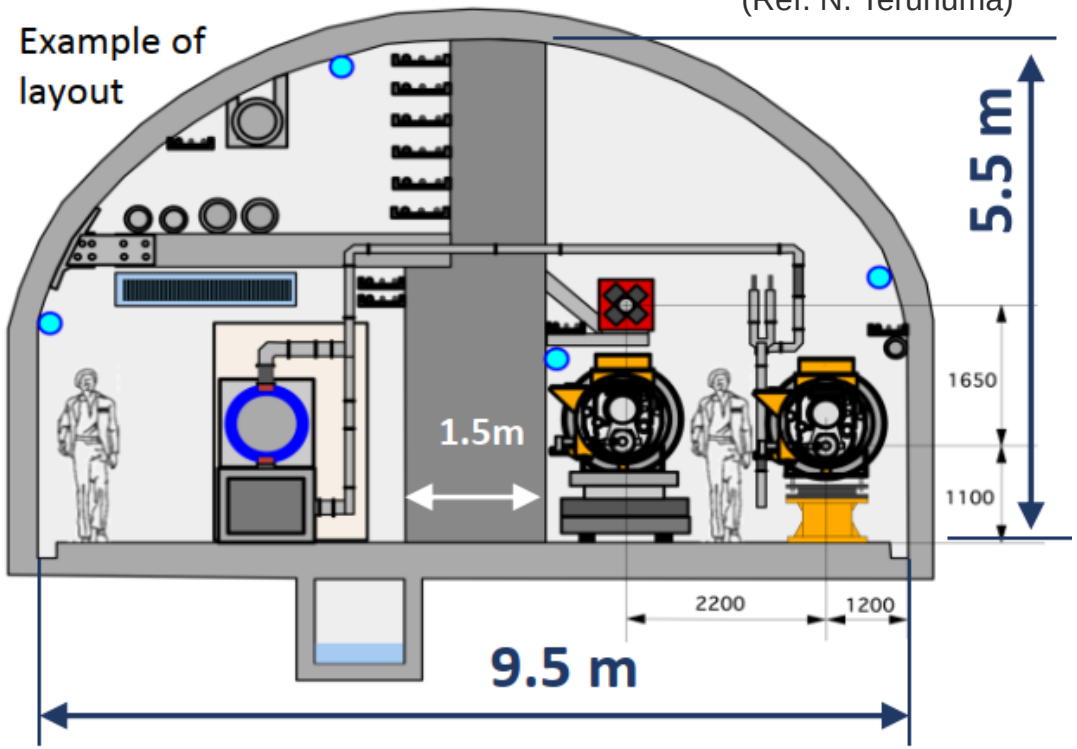
Main LINAC Tunnel Diameter

5.6m Internal Diameter

- CLIC internal diameter deduced to be sufficient for LCF as submitted to ESPPU.
- With CLIC not in the picture, do we stay at this 5.6m diameter?
- Will we need additional alcoves?
- Will a shielding wall be required?



(Ref. N. Terunuma)



- **66 kV distribution cables**
- **Colling water pipes**
- Fan Coil Units
- Low power and signal cables
- **RF klystrons and modulators**
- **Electric Power Stations**

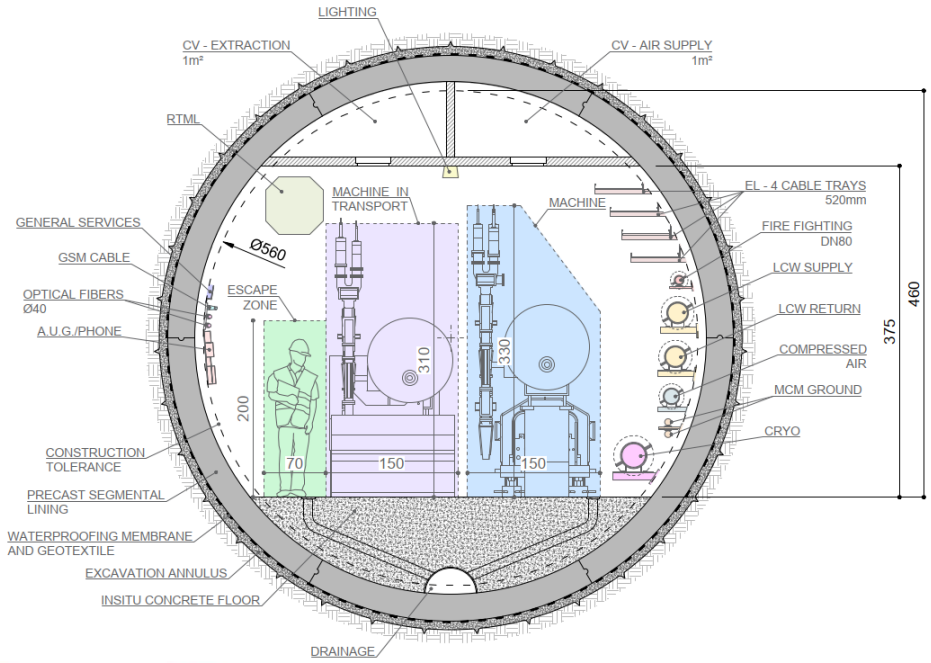
- **ML Cryomodules**
- **RTML**
- Low power and signal cables



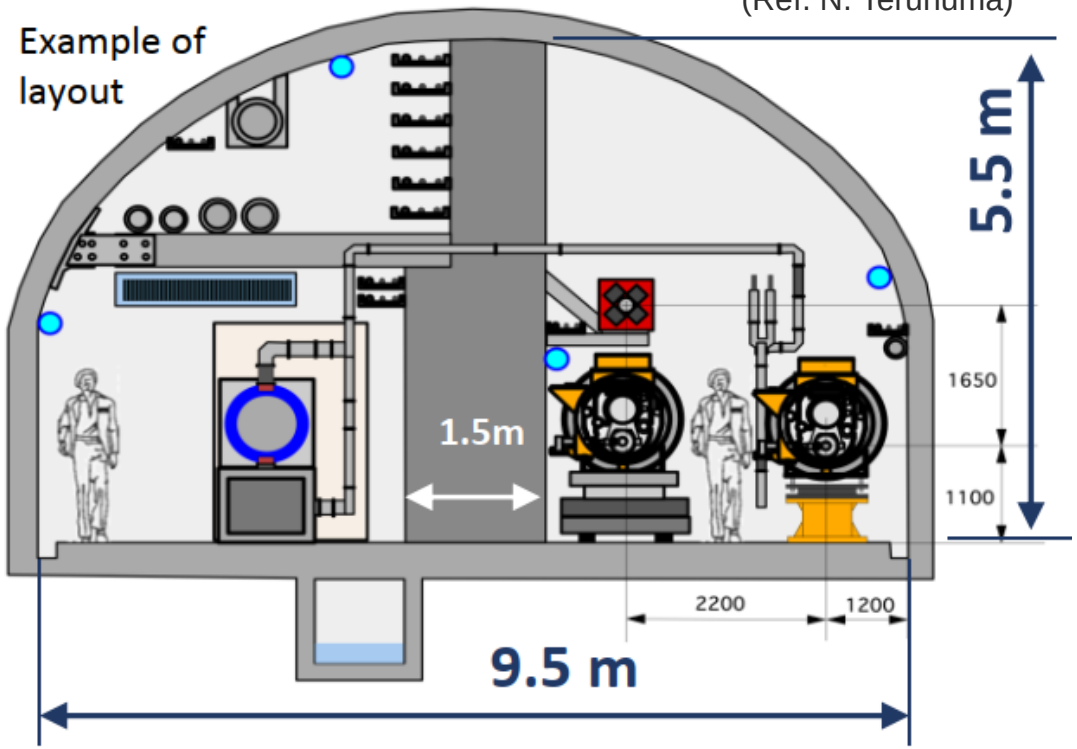
Main LINAC Tunnel Diameter

Integration studies are required:

- **Minimise diameter but require additional alcoves?**
- **Increase diameter to house all?**
- **Do we need a shielding wall at CERN?**



(Ref. N. Terunuma)



- **66 kV distribution cables**
- **Colling water pipes**
- Fan Coil Units
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- **RF klystrons and modulators**
- **Electric Power Stations**

- **ML Cryomodules**
- **RTML**
- Low power and signal cables



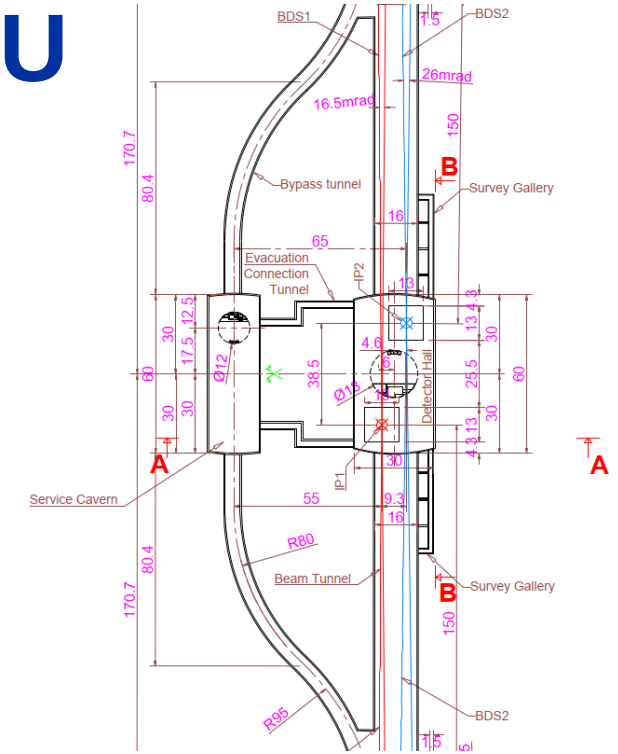
BDS and IR from ESPPU

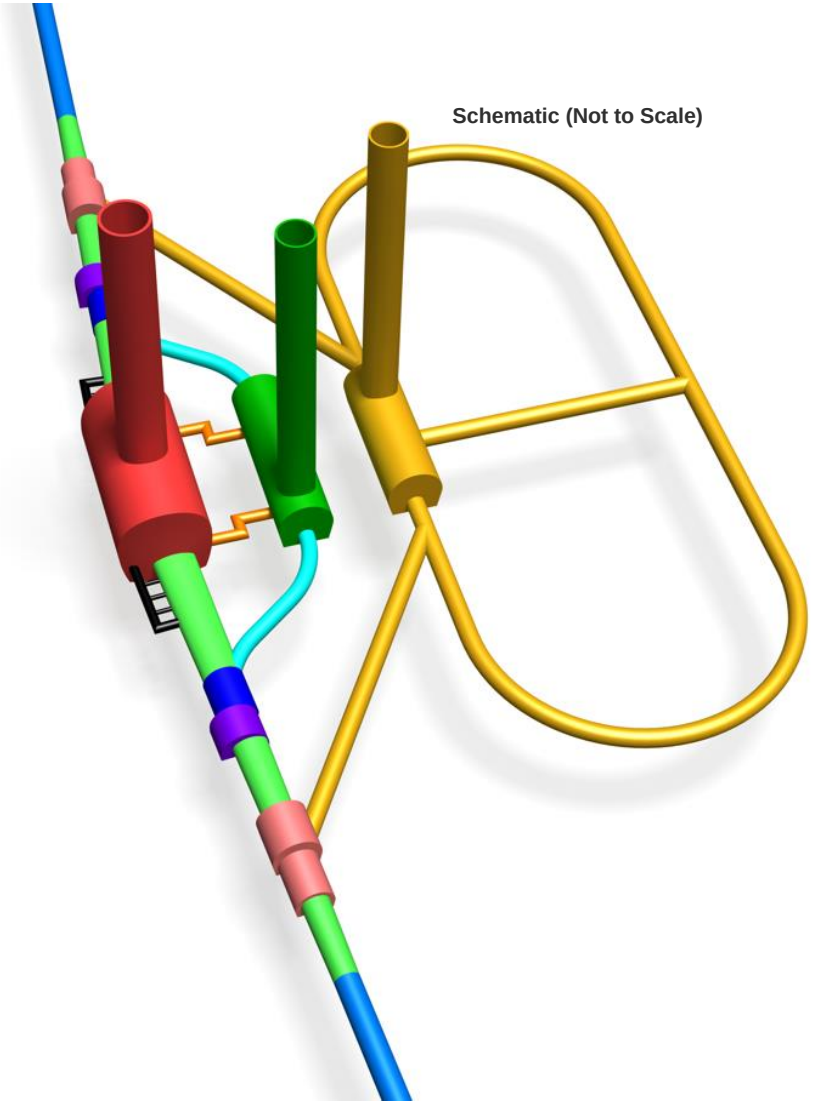
BDS Tunnel Widening

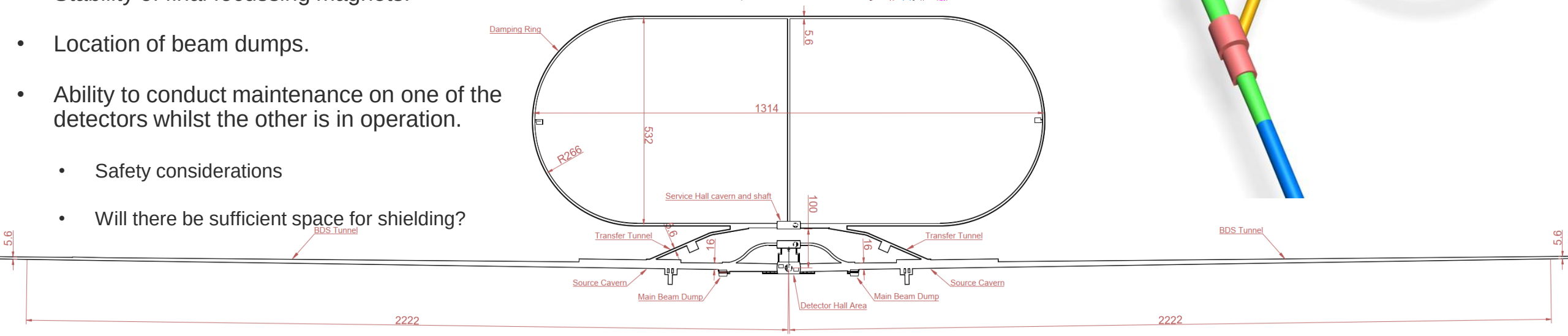
- Main LINACs had a 20mrad crossing angle.
- Upgrade to 2IP's, BDS Tunnel was widened to 16m to account for both beam lines and the 9.3m separation between them into the detectors.
- Beamlines in the IP's had 16.5mrad and 26mrad crossing angles.
- Offset of 38.5m between detectors longitudinally.

Key feedback:

- Stability of final focussing magnets.
- Location of beam dumps.
- Ability to conduct maintenance on one of the detectors whilst the other is in operation.
  - Safety considerations
  - Will there be sufficient space for shielding?







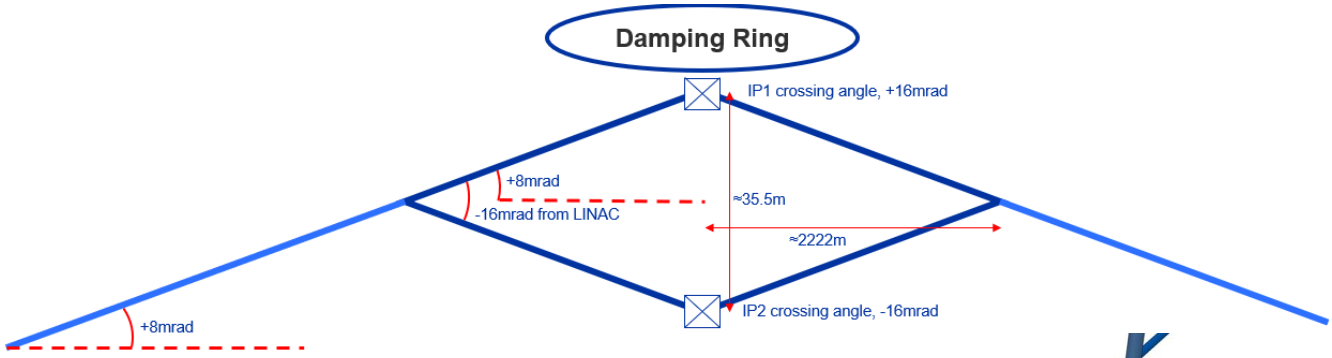
New (Preliminary) BDS and Alignment Proposal

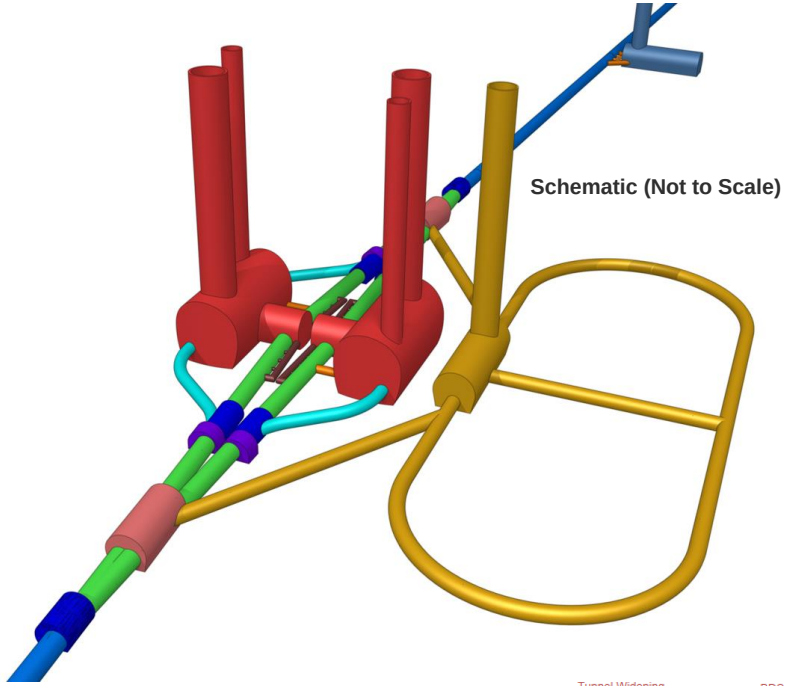
BDS with Twin Tunnels instead of Widening:

- New preliminary proposal is to have the LINACs at 8mrad then one tunnel splitting at -16mrad in the BDS to serve the second IP.
- Tunnel widens into a junction cavern before splitting into two separate 5.6m internal diameter tunnels.
- A large junction cavern will be required in the area surrounding the sources and damping ring connection

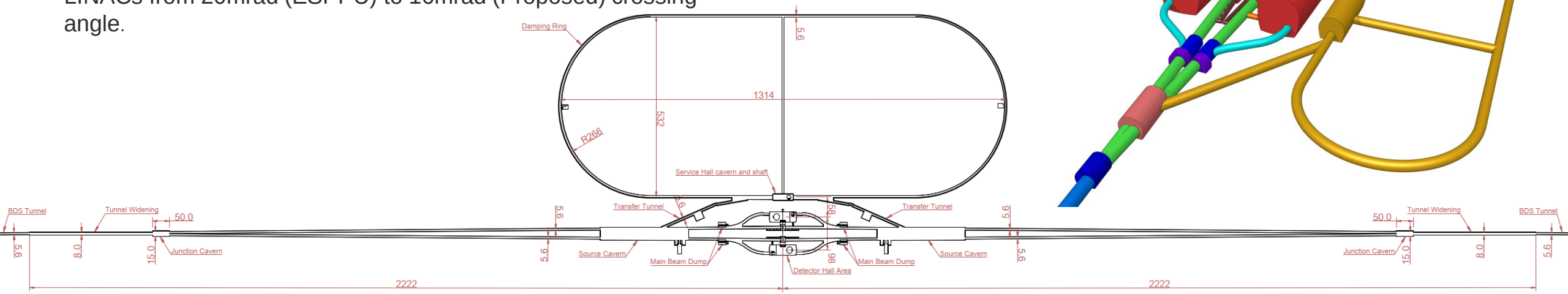
Alignment:

- LINACs from 20mrad (ESPPU) to 16mrad (Proposed) crossing angle.





Schematic (Not to Scale)

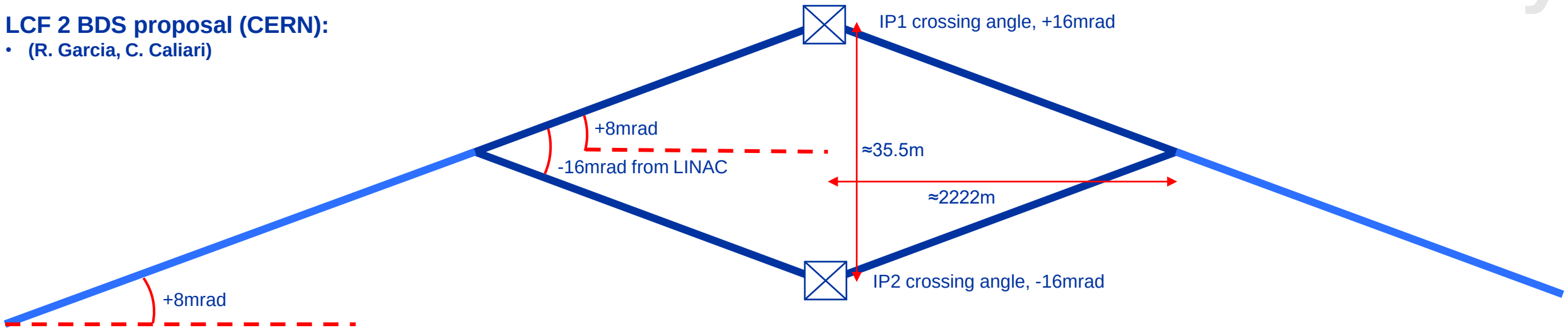


New BDS Comparison

Preliminary

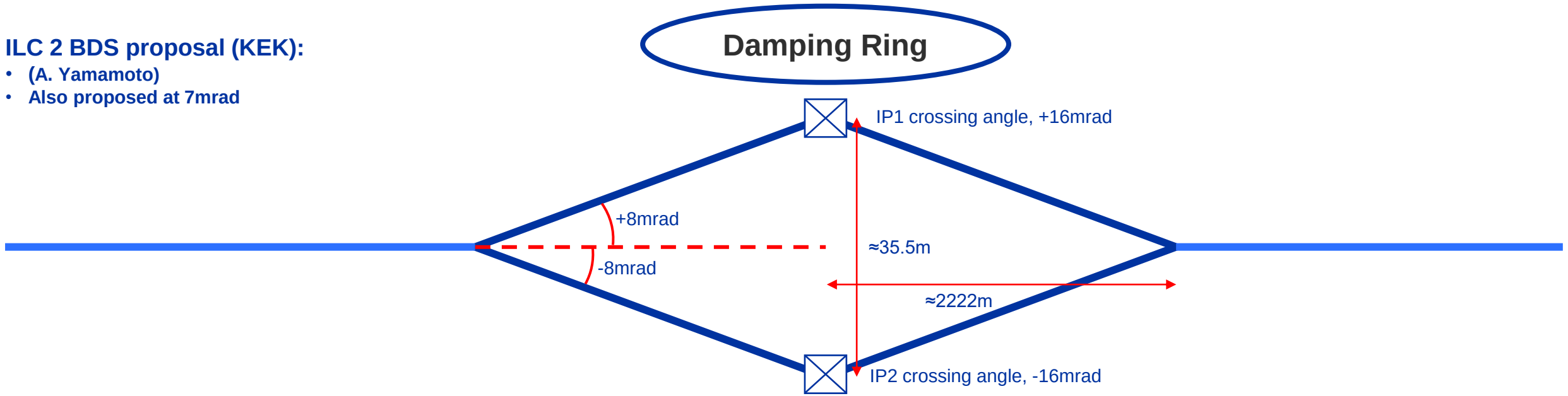
LCF 2 BDS proposal (CERN):

- **(R. Garcia, C. Caliari)**



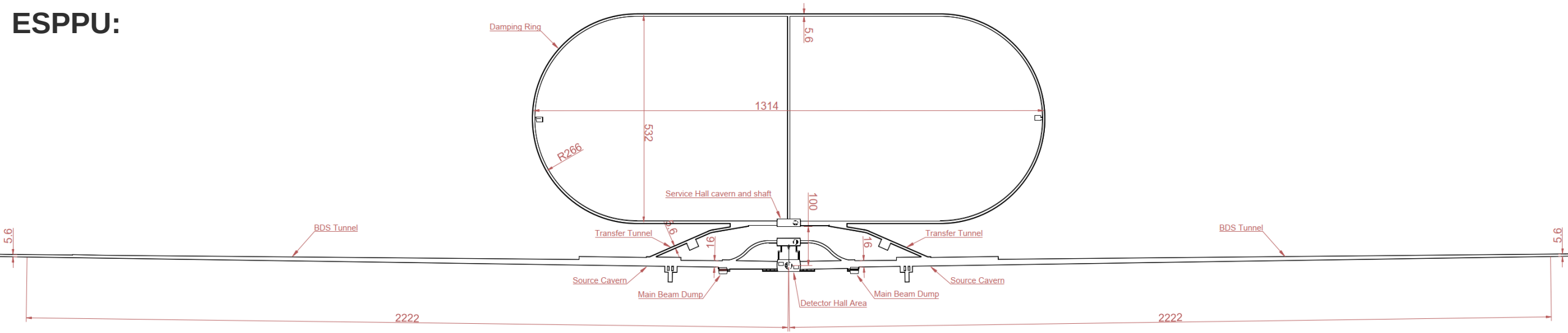
ILC 2 BDS proposal (KEK):

- **(A. Yamamoto)**
- **Also proposed at 7mrad**

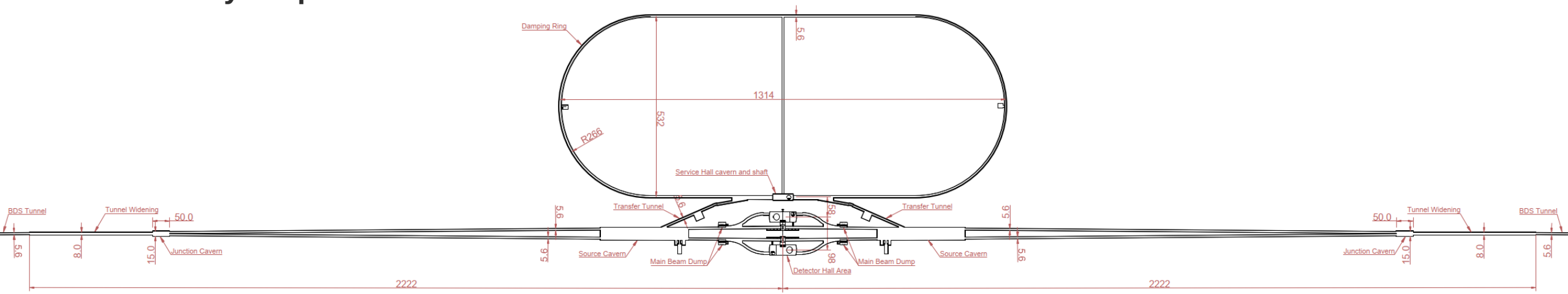


BDS and Alignment Comparison

ESPPU:



New Preliminary Proposal:

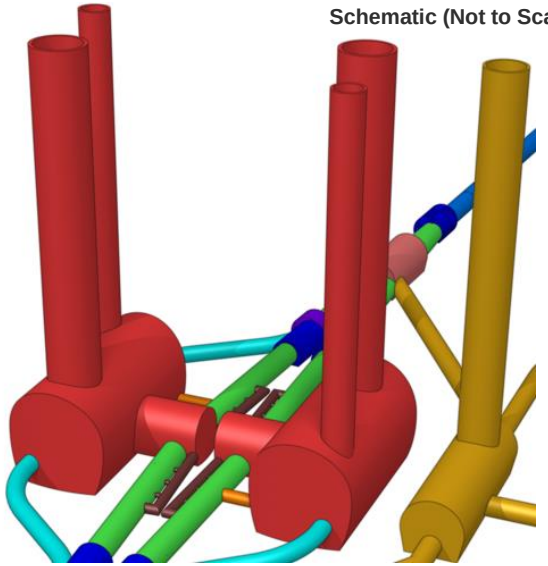


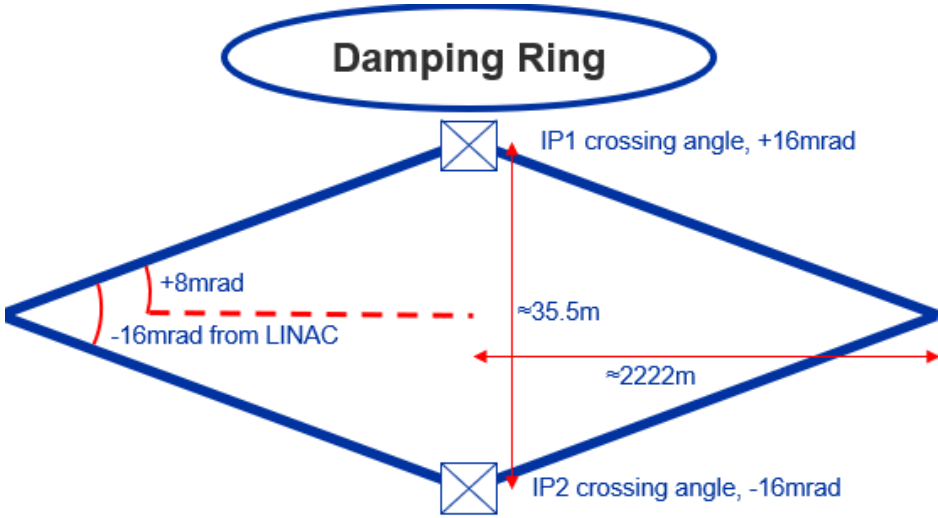
New (Preliminary) Interaction Region Proposal

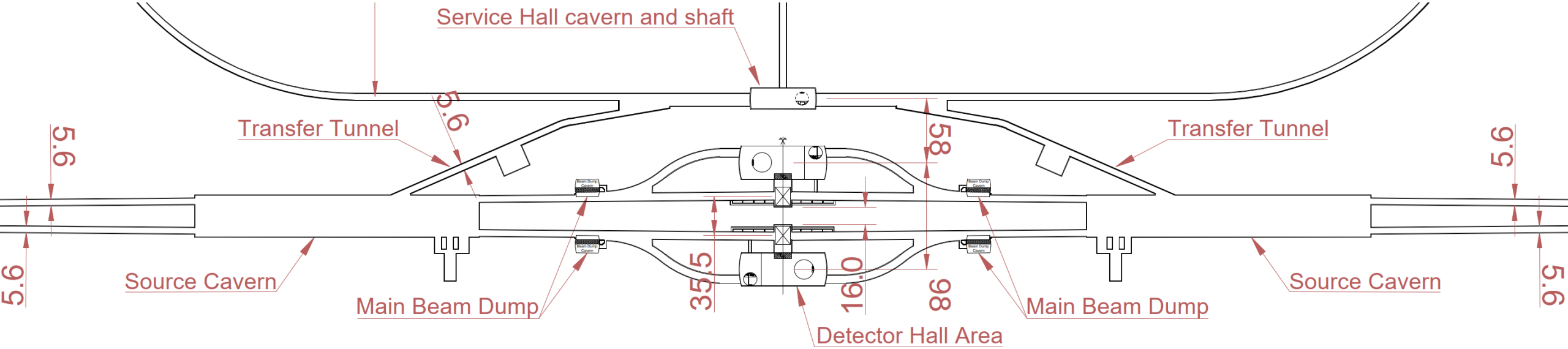
Interaction Region configuration in response to feedback:

- Detectors could now be opposite each other instead of previous longitudinal separation.
- Two independent detector areas provide serviceability of a detector whilst the other is operation.
- Smaller detectors caverns for increase magnet stability.
- Beam dumps located outside of the tunnel, no need to dig up / down.

Schematic (Not to Scale)







Plan View

New (Preliminary) Interaction Region Proposal

- **This BDS and IR configuration provides a separation of 35.5m between the IP's and 16m between the outsides of the caverns.**

- **Reference CMS Concrete pillar is 7m width:**
  - Access permitted during operation.
  - 16m should be sufficient to conduct maintenance on 1 detector whilst the other is in operation.

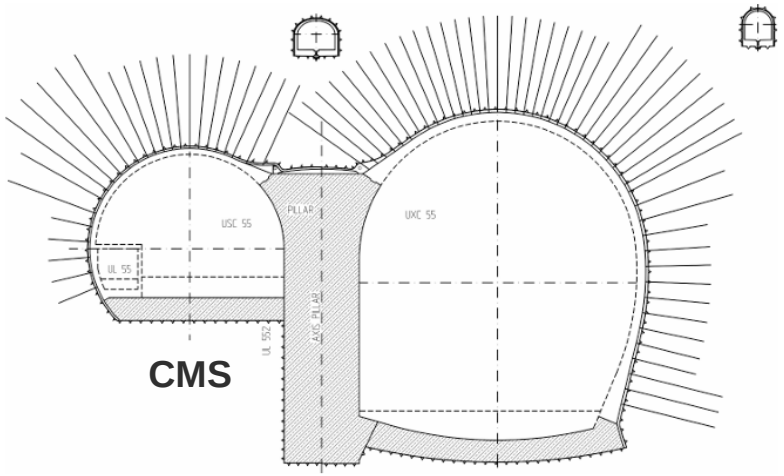
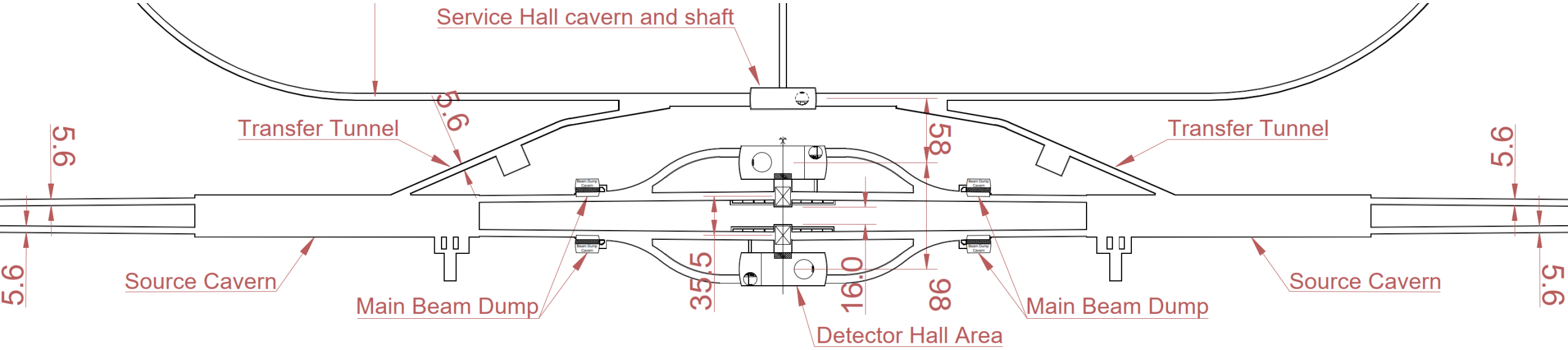


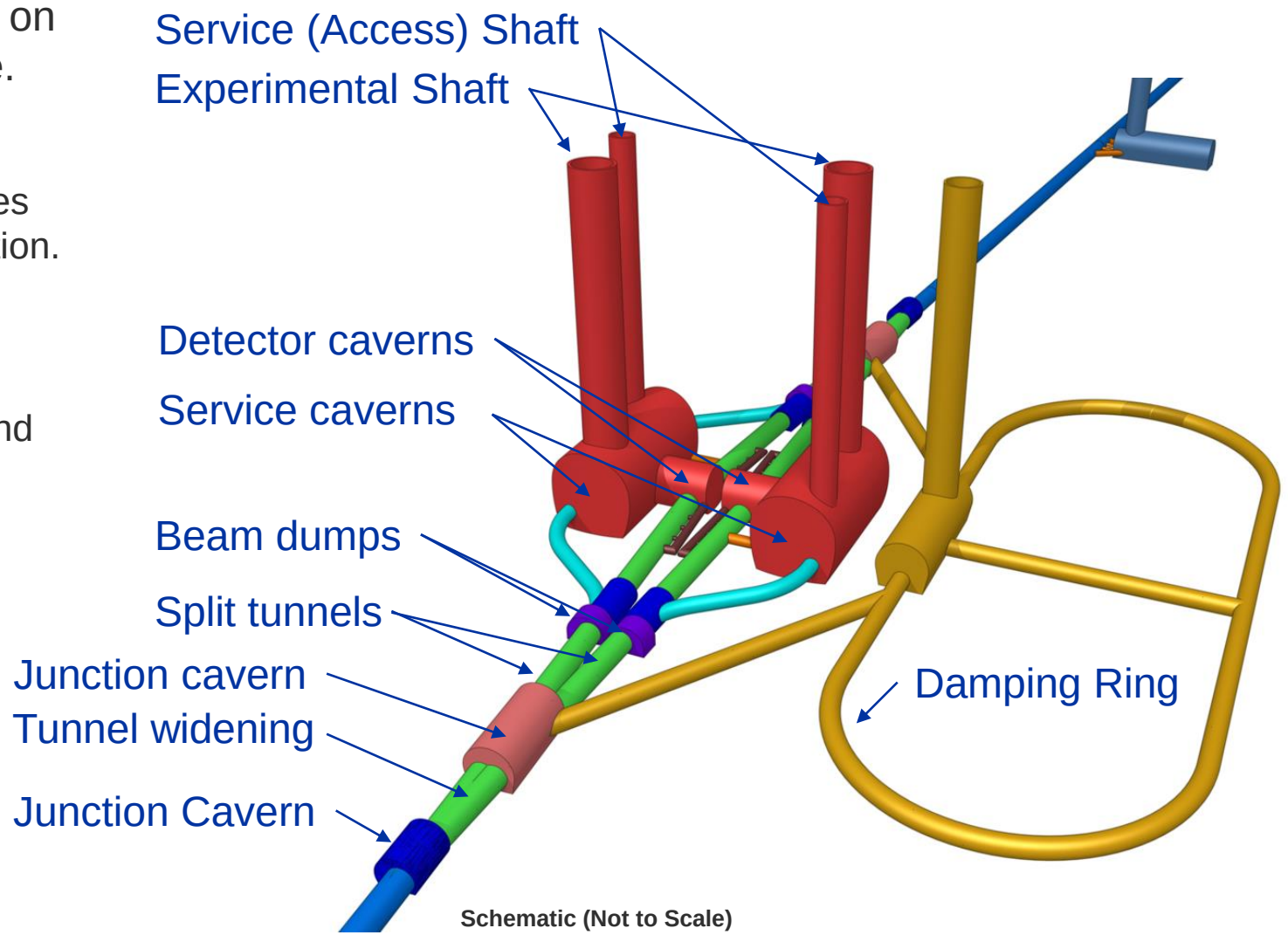
Figure 6 – Cavern cross section with typical rock support



Plan View

Next Steps

- Layout & Placement optimisation tool continuation in preparation for the decision on shaft separation and LINAC crossing angle.
- Decision on Beam Delivery System:
  - BDS & IR configuration, MAD-X beamline files required for precise civil engineering integration.
- Continue with sizing of the LINAC and all underground areas:
  - Including Junction caverns for the sources and DR connection, additional alcoves along the LINAC, and the Beam dumps.



Schematic (Not to Scale)





Thankyou

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